Background Material for Detector Research Activities at Argonne National Laboratory

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Introduction and Overview

This document describes the Detector R&D program in the HEP division at Argonne National Lab. It lists the ongoing activities in this area, describing the current status and achievements over the past few years, but concentrates on outlining the plans, directions and intentions for the future of this program. The program outlined is not only funded by DoE, but in many cases is also funded by Laboratory Directed R&D funds (LDRD) or other sources. Since this is an attempt to describe the program and not just the funding sources, all detector R&D done in the division is described and the funding source is always indicated. We also try to indicate what the status of the funding is: either funded or future funding has been requested. All this information is in the text, but to make it somewhat more easily accessible we start with an overview table listing all the R&D areas that are described in the document below and indicating what the funding status and sources are. The amount of funding for each, either in hand or requested can be found in the accompanying budget tables. No entry in Table 1 means: no funding requested.

Detector R&D area	**FY09**	**FY10**	**FY11**	**FY12**
Digital RPC HCAL	*DoE funded*	*DoE request*	*DoE request*	*DoE request*
Telescope design	*LDRD funded*	*LDRD funded*		
Large Area Photo detectors	*Univ. of Chicago funds; DoE funding starting*	*DoE funded*	*DoE funded*	*DoE funded*
Silicon Photo Multipliers	*LDRD funded*	*DoE request*	*DoE request*	*DoE request*
CCD testing	*LDRD funded*	*DoE request*	*DoE request*	*DoE request*
Transition Edge Sensors	*LDRD funded*	*LDRD funded*	*DoE request*	*DoE request*
Topological Trigger	*LDRD + DoE*	*DoE request*		
Future DAQ		*DoE request*	*DoE request*	*DoE request*
Wireless & Fiberless DAQ	*Supplemental request to DoE*	*DoE request*	*DoE request*	

Table 1: Funding status for Detector R&D

1. Major Achievements During 2007 – 2009:

1.A. Detector Systems:

1.A.1. Digital Hadron Calorimeter 2007 – 2009

Funding: DoE detector R&D

Overview

Particle Flow Algorithms (PFAs) attempt to measure all particles (originating from the interaction point of a typical colliding beam detector) individually, using the detector component providing the best momentum/energy resolution [1]. Within this context our group develops a finely granulated hadron calorimeter (HCAL) using Resistive Plate Chambers (RPCs) as active elements. The chambers are read out by 1 x 1 cm^2 pads to which a single threshold (corresponding to a 1-bit resolution) is applied. This device is commonly named a Digital Hadron Calorimeter (DHCAL).

The group initiated the project with R&D aimed at developing a suitable RPC design for imaging calorimetry and an affordable electronic readout system capable of handling large number of channels. This activity led to tests with a small scale calorimeter, in the following named Vertical Slice Test. After completion of another round of R&D, the group embarked on the construction of a Physics Prototype. The aim of the physics prototype is to proof the viability of the technical approach to imaging hadron calorimetry and to provide detailed measurements of hadronic showers with the goal to validate hadron shower models. The physics prototype will re-use the existing CALICE [3] absorber structure and movable stage. After yet another round of R&D the group plans to proceed with the assembly and test of a Technical Prototype. Such a prototype will address **all** R&D issues pertinent to a full size module of a hadron calorimeter. Eventually, the technical prototype will be followed by the construction of a Module 0, the first prototype of a module for a colliding beam detector.

The DHCAL project is part of the overall program of the CALICE collaboration [3], which develops imaging calorimetry for the application of Particle Flow Algorithms. Apart from Argonne, the DHCAL group includes Boston University, University of Iowa and Fermilab. The Argonne group is involved in both PFA-based ILC detector concepts: SiD [4] and ILD [5].

Past accomplishments

This section briefly lists the past accomplishments of the years 2007-2009, with emphasis on the papers published in refereed journals.

a) RPC studies

Utilizing RPCs in a finely granulated calorimeter imposes a number of constraints on the chamber design: the chamber needs to be thin, robust and to be able to operate at fluxes of a few hundred particles per second; the readout needs to provide high efficiency for the detection of

minimum ionizing particles (MIPs), a reasonable pad multiplicity for single particles and to be affordable, despite the large number of channels.

In order to develop the best possible chamber for the task, the group built and tested several RPCs, which were based on varying designs. In particular, the group invented a simplified chamber design based on a single glass plate, but also investigated the performance of more complicated chambers, such as multi-gap RPCs. Figure 1.1 shows a schematic of the default 2-glass RPC.

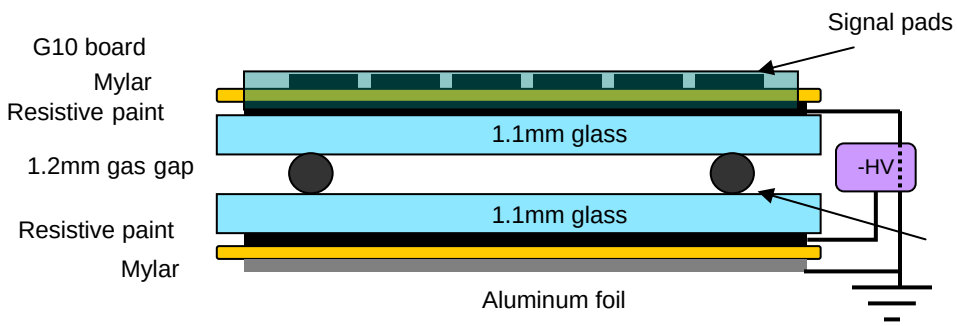

Figure 1.1: Schematic of the default 2-glass RPC design.

These studies were carried out with a system of 14-bit ADCs, thus allowing for detailed investigations of the signal charges and their distribution in the plane containing the pick-up pads.

As an example, Figure 1.2 shows the average charge distribution as a function of distance to the pad hit by a cosmic ray (identified as a the pad with the highest signal charge). The measurements are consistent with a fairly narrow distribution, which appears to be independent of the high voltage setting. These results have been published in [6].

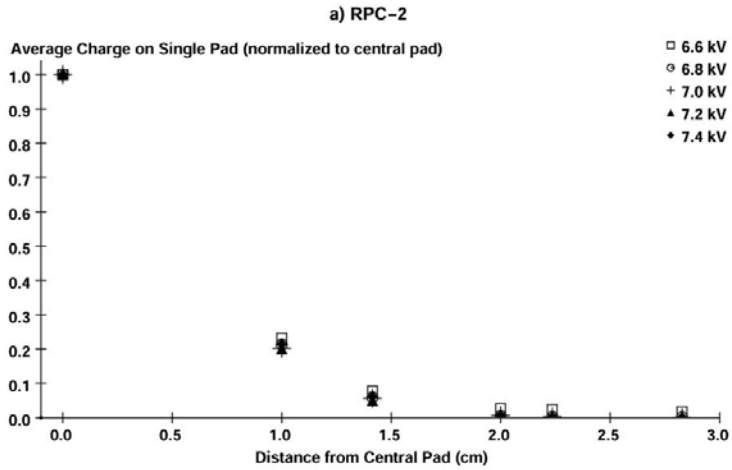

Figure 1.2: Charge distribution versus distance from the pad hit as measured with a 2-glass RPC operated at different high voltage settings.

b) Development of an electronic readout system

The electronic readout system was developed in two phases. First a VME-based system was designed, built and commissioned. The system provided a 1-bit resolution for each channel and was tested together with RPCs in the Fermilab test beam. These tests provided a basis for the design of an Application Specific Integrated Circuit (ASIC) for the front-end.

In a second phase the front-end ASIC, the DCAL chip, was designed (in collaboration with Fermilab) and prototyped. The DCAL chip serves 64 channels and provides a time-stamp (with a 100 ns resolution) and a hit pattern. The chip operates either in self-triggered mode or with an external trigger.

The chip was extensively tested. Figure 1.3 shows the response of the chip to the injection of a fixed charge as a function of threshold setting. The noise floor depends strongly on the details of the test set-up. In this particular test, the noise floor appears around a threshold of about 25 counts.

In addition to the front-end chip, the group designed, prototyped and commissioned the other parts of the electronic readout system: a pad-board (containing the readout pads), a front-end board (housing the DCAL chips and connected to the pads of the pad-board via conductive glue), a data concentrator (reading out 4 DCAL chips), a data collector (a VME based system reading out up to 12 data concentrators and developed and built by Boston University), and a Timing and Trigger Module. The Vertical Slice Test (VST), described below, utilized 1st prototypes of all these components, apart from the DCAL chip, which had already gone through a previous iteration.

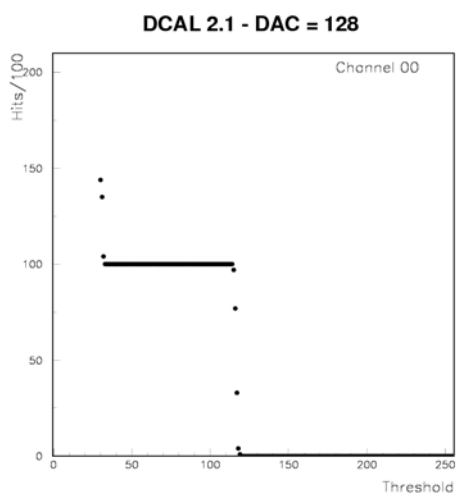

Figure 1.3: Threshold scan of the DCAL chip for a fixed injected charge. At each threshold setting 100 charges were injected.

c) The Vertical Slice Test (VST)

The purpose of the VST was to test the entire readout chain and to gain experience with the operation of RPCs in a calorimeter stack. The tests involved up to ten chambers each with the dimensions of 20 x 20 cm^2. One of the chambers was based on the 1-glass design; the others featured two glass plates. Each RPC was equipped with a pad- and front-end board with an active area of 16 x 16 cm^2, corresponding to 256 channels. The stack was commissioned with cosmic rays, later exposed to particles in the Fermilab test beam and, finally, brought back to the laboratory for further tests with cosmic rays. At the test beam the chambers were interleaved with absorber plates (16 mm steel plus 4 mm copper). Figure 1.4 shows the stack as configured for the Fermilab test beam. The following briefly lists the major results obtained with the VST.

Figure 1.4: Calorimeter stack of the Vertical Slice Test as configured for the Fermilab test beam.

d) Muon calibration

Muons, obtained with the 120 GeV primary beam and a 3 foot iron beam blocker, were used to measure the MIP detection efficiency and the average pad multiplicity of the chambers. Figure 1.5 shows the pad multiplicity versus efficiency for various 2-glass chambers and the 1-glass chamber. These results and detailed measurements of the noise rate have been published in [7].

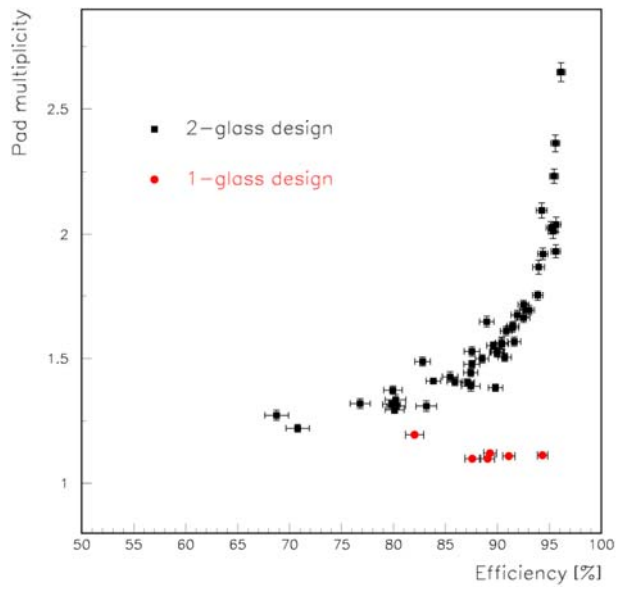

Figure 1.5: Pad multiplicity versus MIP detection efficiency as measured with muons at the Fermilab test beam. The black (red) dots correspond to chambers with 2-glass (1-glass) plates.

e) Positron showers

The stack was exposed to secondary beams with energies of 1, 2, 4, 8 and 16 GeV. Positrons were selected by requiring a signal in the Cerenkov counter. The samples were used to measure the response and resolution as function of energy and to measure the longitudinal and lateral shower shapes. As an example, Figure 1.6 shows the response, i.e. the sum of pads hits, of a six layer stack (corresponding to a depth of 7.2 radiation length) for the different beam energies. The measurements are compared to simulations by a GEANT4 program together with a standalone program (RPCsim) to simulate the details of the chamber response. The results have been published in reference [8].

f) Hadron showers in the DHCAL

Using the same secondary beam, in conjunction with a veto from the Cerenkov counters, samples of pions and muons were obtained. Due to the limited size of the stack, corresponding to 0.65 interaction lengths, hadronic showers could not be contained. Nevertheless, with an event selection tuned to select early showers in the stack, first measurement of hadronic showers in a DHCAL could be obtained. Figure 1.7 shows the response to pions of 1, 2, 4, 8, and 16 GeV, together with simulations of the positron (contamination) and pion response. At low energies the pion rate appears to be very low. The simulation provides an adequate description of the data. These results will be submitted for publication within the next few weeks.

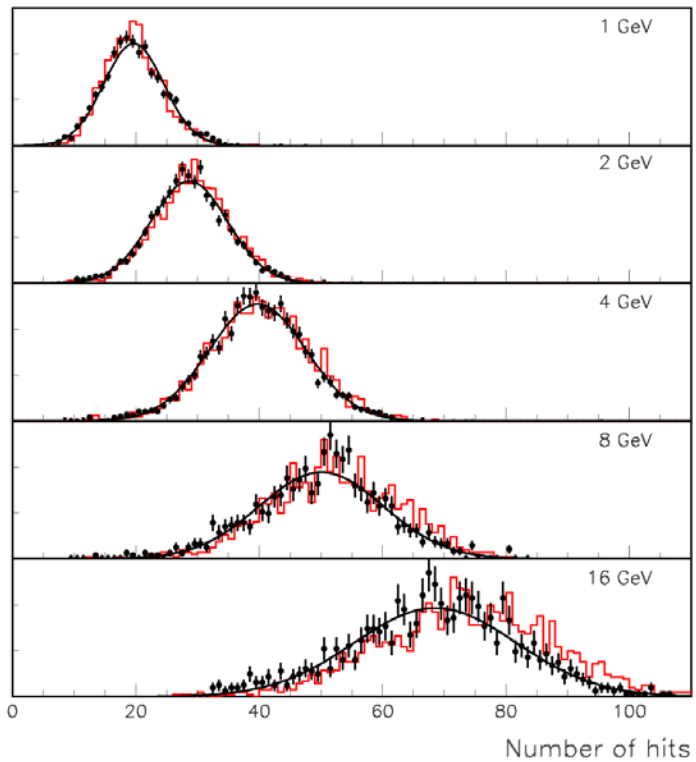

Figure 1.6: Response to positrons: data (black dots) and simulation (red histograms).

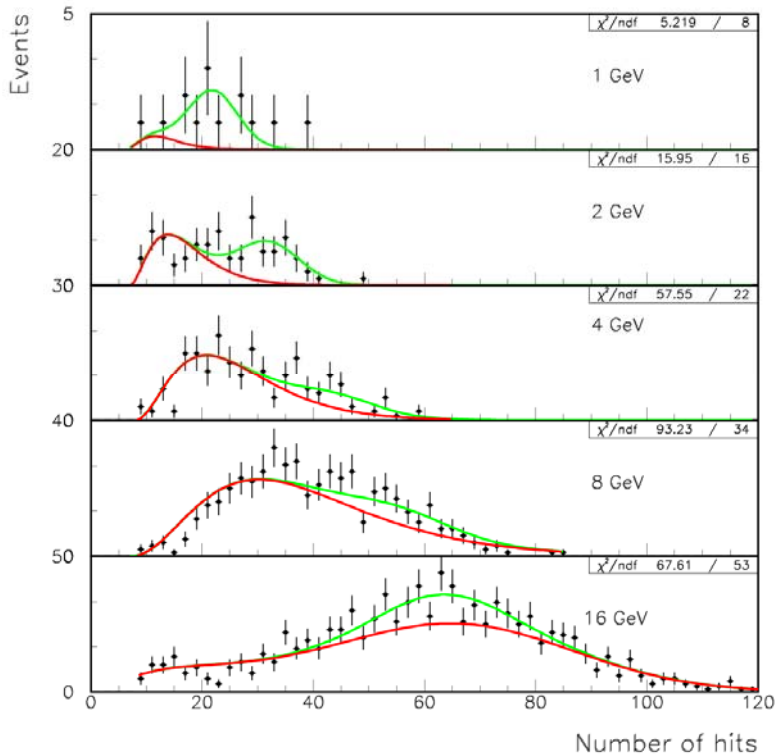

Figure 1.7: Response to pions: data (black dots), simulation of pions (red line) and positrons (green line).

g) Rate capability

The rate capability of the RPCs was measured utilizing the 120 GeV primary proton beam at varying beam intensity. Figure 1.8 shows the MIP detection efficiency as function of the time within a spill for different beam intensities. The red curves are predictions based on an analytical model developed by the group. Additional details and measurements can be found in reference [9].

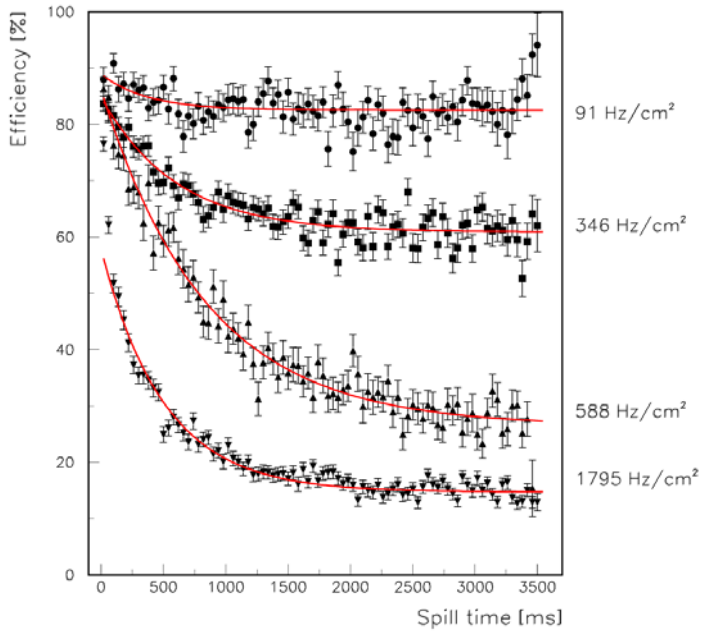

Figure 1.8: MIP detection efficiency versus time within a spill of particles for different beam intensities.

h) Environmental studies

The group operated the stack for almost two years, with only short interruptions. During this time period measurements of the noise rate and of the response to cosmic rays were performed. In addition, the environmental conditions, such as ambient temperature, barometric pressure and air humidity were recorded. The data were used to establish the average dependence of the chamber's performance on these environmental variables. Furthermore, using the entire data set, long-term effects, such as a drift in efficiency or pad multiplicity were looked for. As an example Figure 1.9 shows the noise rate, MIP detection efficiency and pad multiplicity for two selected chambers over a period of 13 months. A paper summarizing these findings is in preparation.

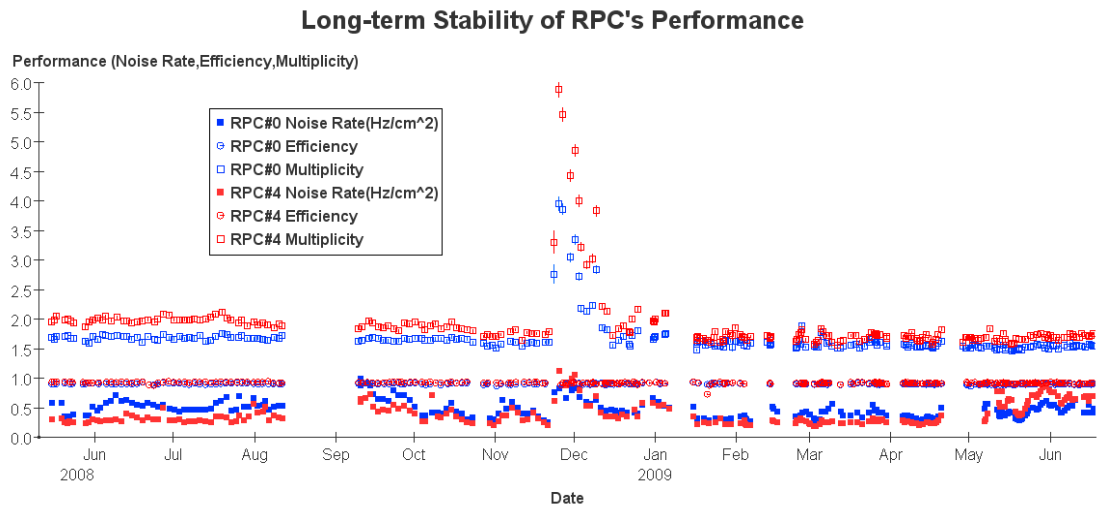

Figure 1.9: Noise rate, efficiency and pad multiplicity of two selected chambers over a period of 13 months. The excursions in December 2008 are due to a drastically reduced gas flow rate in the chambers.

i) Preparation for the construction of the physics prototype

Based on the success of the VST, the group prepared for the construction of the physics prototype. The following R&D topics were successfully addressed:

- Construction of larger size RPCs (32 x 96 cm^2)
- Design of a cassette structure to contain three larger size RPCs
- Re-design of the DCAL chip to eliminate a number of minor design flaws
- Tests of simplified Pad- and Front-end boards, which avoid costly buried vias
- Merging of the Front-end and data concentrator boards
- Design of a gas mixing system capable of providing the needed flow for the physics prototype
- Tests of LeCroy High Voltage supplies and development of a computer control program
- Design of a Low Voltage distribution box.

j) Understanding of the Fermilab Test Beam

Detailed understanding of the Fermilab test beam is absolutely essential for making measurements with controlled systematic errors. During the tests with the small scale prototype calorimeter, a significant decrease in the efficiency was observed at the beam spot for the first few layers. This decrease in efficiency appeared to be incompatible with the low intensity of the beam (as defined by scintillation counters in the beam), leading to the suspicion of a large flux of photons in the beam line with arrival times independent of the charge particles.

In June 2009 the group returned to the test beam with a pair of Scintillator counters (A and B) and a stack of steel absorber plates. The singles (A, B), coincidence (A·B) and anticoincidence (Abar·B) rates were measured with the secondary beam tuned to 2,4 8, and 16 GeV/c. The measurements were repeated with up to four absorber plates inserted between the counters. The data are still being analyzed, but a first look shows clear evidence for photons in the beam line.

Since these photons have an adverse effect on the performance of the RPCs, ways of reducing their flux need to be explored.

k) Development of Particle Flow Algorithms

The group developed two independent and complete Particle Flow Algorithms (PFAs) based on the SiD detector concept [4]. This has been a long term development with detailed studies of all aspects of the PFAs. The algorithms performed well and achieved very good resolutions. As an example, Figure 1.10 shows the reconstructed energy of dijets generated at the Z^0-pole. A resolution (commonly quoted as RMS_{90}) of 3.3 GeV is achieved, corresponding to 35.1%/√E (GeV). Results obtained with the Argonne algorithms have been included in the SiD Letter of Intent [10] submitted to the ILC Detector Advisory Group (IDAG) in April 2009.

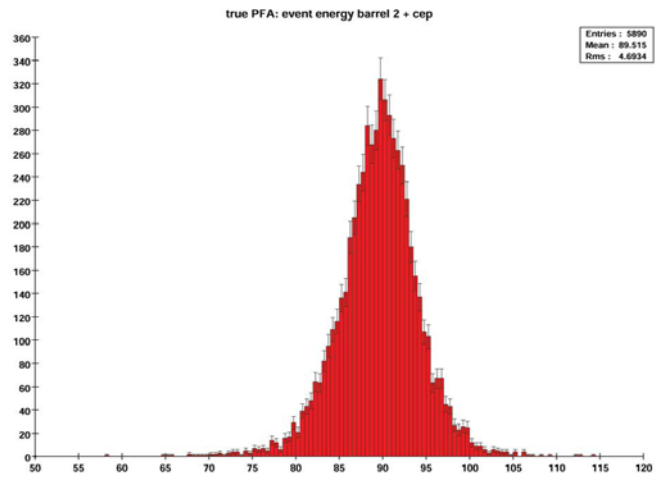

Figure 1.10: Reconstructed energy of dijets generated at the Z^0-pole and simulated with the baseline SiD detector.

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[2] J. Repond, Proceedings of the 10th Pisa Meeting on Advanced Detectors, La Biodola, Isola d'Elba, Italy, Nucl. Instrum. Meth, **A572**, 211 (2007).
[3] https://twiki.cern.ch/twiki/bin/view/CALICE/WebHome
[4] http://silicondetector.org/display/SiD/home
[5] http://www.ilcild.org/
[6] G.Drake et al., Nucl. Instrum. Meth, **A578**, 88-97 (2007).
[7] B.Bilki et al., JINST **3** P05001 (2008).
[8] B.Bilki et al., JINST **4** P04006 (2009).
[9] B.Bilki et al., JINST **4** P06003 (2009).
[10] http://silicondetector.org/display/SiD/LOI

1.A.2. Telescope Design 2008-2009

Funding: LDRD funded

As part of the division's interest in Very High Energy Gamma-ray Science, one of the detector R&D focuses at Argonne has been the mechanical design of future ground based telescopes. This work has been in collaboration with the University of California, Los Angeles, the Max Planck Institute in Heidelburg, and DESY Laboratory in Germany. The effort has been funded through LDRD and from external funding from DESY.

We have undertaken extensive mechanical design and analysis work for future ground based imaging Cherenkov telescopes including a novel 9-meter Schwarzschild-Couder (SC) telescope design and a more conventional 12-meter Davies-Cotton (DC) telescope design as well as designs of the motion systems required for these telescopes. This effort includes studies of basic telescope structure deformations under rotation including thermal expansion and contraction.

We completed a preliminary SC design of an optical support structure (OSS) which minimizes deflections while also minimizing the weight of the structure and which should be easy to construct. This is shown in Figure 1.11(a) and (b) [1]. We also completed a DC design which is shown in Figure 1.11(c) [2].

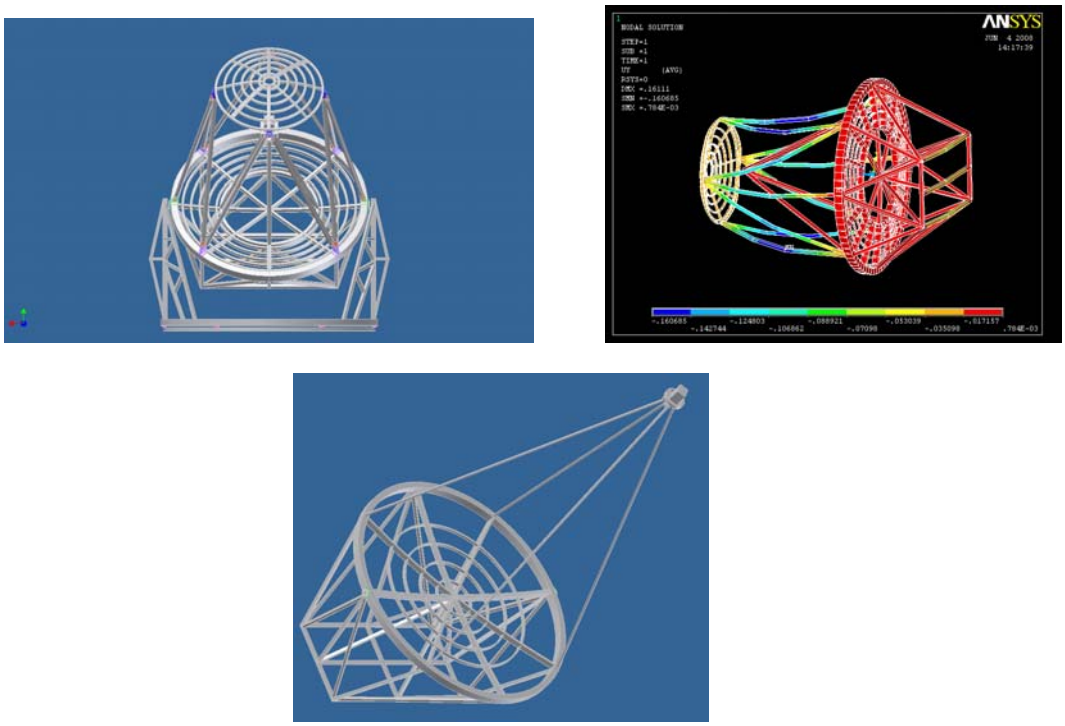


Figure 1.11: (a) top left is the mechanical design for a SC 9-meter telescope. The (b) right top colored figure shows the deformation in the horizontal orientation from finite element analysis. The bottom figure (c) is the mechanical design for a DC 12-meter telescope.

References

[1] http://www.hep.anl.gov/vjg/SC-OSS-Structure1.doc
[2] http://www.hep.anl.gov/vjg/DC-OSS-Structure1.doc

1.B. Sensors and Electronics:

1.B.1 Large Area Photo-Detectors 2007 – 2009

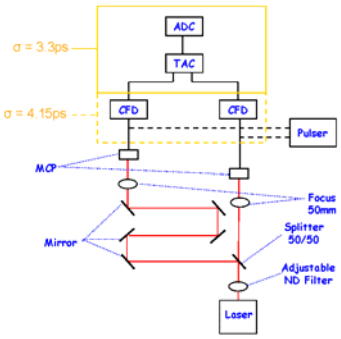
Funding: Univ. of Chicago funded so far; changing to DoE detector R&D

This R&D has focused on making critical steps to develop a device that will measure the transit time of particles ("time-of-flight" or "TOF") emerging from the collisions of particle beams colliding with other particle beams or targets of material approximately two orders of magnitude better than current large-scale systems. For highly relativistic particles, this translates into an order-of-magnitude improvement in the measurement of momentum. This R&D effort has been in collaboration with Henry Frisch's group at the University of Chicago, who received an ADR grant for their. Argonne funding has been through LDRD and through Univ. of Chicago funds. Beginning June 1, 2009, Henry Frisch holds a joint University of Chicago/ Argonne National Laboratory appointment.

In our original LDRD, we proposed to use the basic detection of Cherenkov light generated in the face window of a large array of custom, but commercial micro-channel plate photomultipliers (MCP-PMTs), a new charge-collection scheme at the anode of the tube under study, and custom readout electronics integrated with the anode, to measure the transit time of particles one-to-two orders of magnitude faster than has been currently used in high-energy physics. The electronics for signals at this fast (high-frequency) time resolution have to be mounted directly on the detector modules. For multi-anode MCP, this readout scheme will provide both time and position measurements at high resolution.

The LDRD effort has laid the groundwork for a future R&D program to develop a basic family of economical robust large-area photo-detectors that can be tailored for a wide variety of applications that now use photomultipliers. Earlier this year a proposal was submitted to DOE proposing to develop these large-area photo detectors. Although paperwork is still being processed, the large-area photo-detector R&D will become part of the future core-program and future plans will be described in those sections. The expected funding level is $8M for 3 years.

Our accomplishments over the period 2007 – 2009 include the development of a new laser test facility developed to perform precision timing measurements. The laser teststand is shown in Figure 1.12a [1]. An example of the types of precision measurements we are able to perform is shown in Figure 1.12b which shows the timing resolution for a 25 micron pore commercial MCP-PMT as a function of the number of photoelectrons for two wavelengths of light. Another accomplishment of the R&D is the development and testing of a proto-type printed circuit board transmission-line card to be used to read out the anode pads of a commercial MCP-PMT [2]. Figure 1.13 shows the proto-type transmission line card and Figure 1.14 shows the timing resolution.



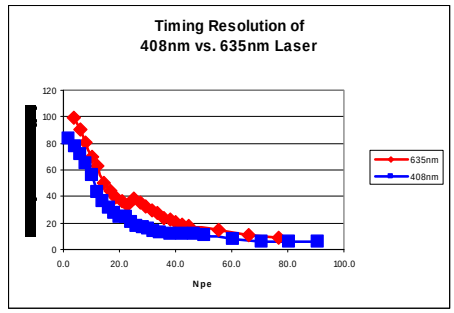


Figure 1.12a: (left) shows a schematic of the laser teststand facility. **Figure 112b:** (right) shows the timing resolution for a 25 micron pore MCP-PMT as a function of the number of photoelectrons for two wavelengths of light.

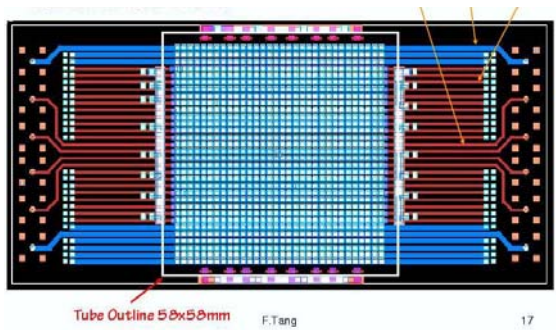


Figure 1.13: Proto-type printed circuit board transmission-line card [3].

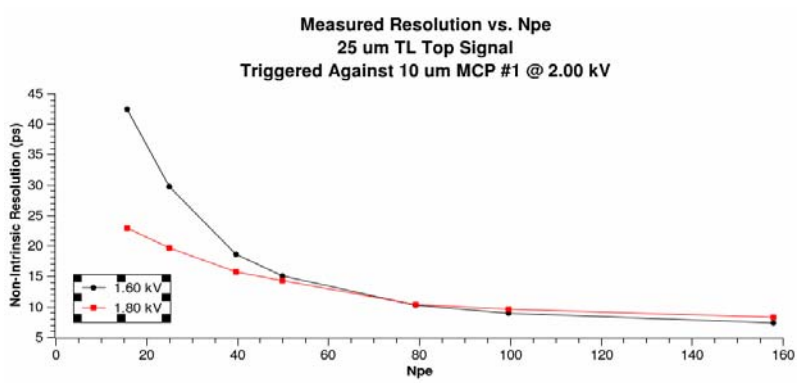


Figure 1.14: Timing resolution using the prototype board on a 25μm MCP.

References

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[2] New developments in fast-sampling readout of Micro-Channel Plate based large area pico-second time-of-flight detectors, Anderson et al; Nuclear Science Symposium Conference Record, 2008. NSS '08. IEEE 19-25 Oct. 2008 Page(s):2478 – 2481

[3] Signal processing for picosecond resolution timing measurements, Genat, et al, Submitted to Nuclear Inst. And Methods in Physics Research, A

1.B.2 Silicon Photomultiplier R&D 2008 – 2009

Funding: LDRD funded and DoE Detector R&D

Photo-sensor technology is the basis for many types of instrumentation and detectors used in scientific research, commercial applications, the medical field, and national security. The Silicon Photo-multiplier (SiPM) is a new silicon-based technology having certain novel properties compared to conventional photo-multiplier tubes, and offers exciting new possibilities for these fields. In this R&D, we are exploring several applications that might incorporate this new technology, including the fields of high-energy physics, synchrotron radiation experiments, medical instrumentation, national security, and other scientific research areas. ANL funding has been through LDRD (FY07/08) and through the DoE Detector R&D program (FY09).

For this R&D, we obtained different samples from several manufacturers, built test stands, and made precision measurements on their performance and properties with specific applications in mind. One of the most important performance criteria is the ability to resolve individual photons. One of best results is shown in Figure 1.15. The individual photon peaks can be clearly seen, demonstrating the capability of the device to function as a photon counter.

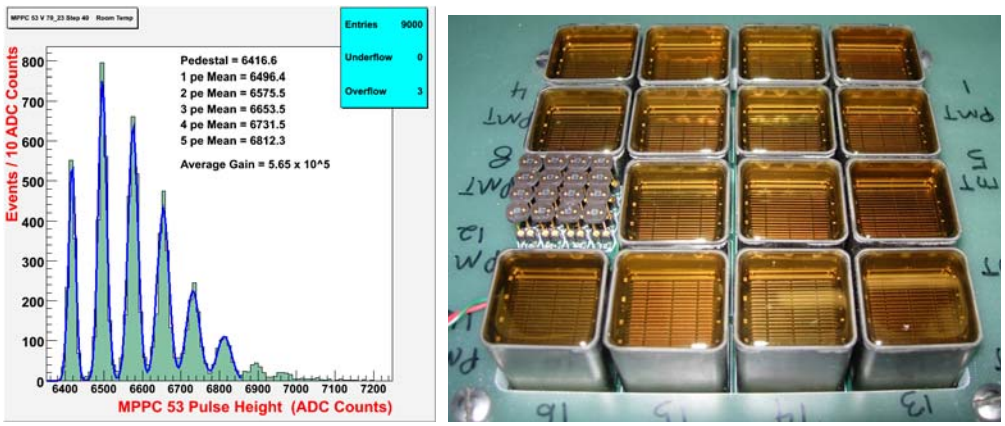


Figure 1.15: (left) Resolution of individual photons using a Hamamatsu SiPM. Right picture is a telescope camera incorporating a 4x4 array of SiPMs in an array of multi-anode photo-multiplier tubes.

We have concentrated on building proof-of-principle demonstrators for two applications. The first was to incorporate an array of SiPMs into a telescope camera. We had built a cosmic-ray telescope previously, which resides at Argonne [1]. The telescope is used to observe showers in the night sky from cosmic rays striking the upper atmosphere. The camera with the SiPM array is shown in Figure 1.15, where a 4x4 array of SiPMs is inserted into a 4x4 array of 16-channel multi-anode photo-multiplier tubes (MAPMT).

The SiPM array was designed to be a drop-in replacement for one MAPMT. After a series of calibration steps, we were successful in imaging cosmic rays with the hybrid camera. The advantage in using SiPMs in such a camera is the increased quantum efficiency, approximately a

factor of two better than regular PMTs. This was one of the first demonstrations of SiPM technology in this application, and this is of great interest for the gamma-ray community.

In the second application, we built a demonstrator for a PET application, as shown in Figure 1.16. We used the demonstrator with a ^{137}Cs radioactive source, to observe the back-to-back gammas from positron annihilations. This test was also a success. An energy spectrum acquired using a ^{22}Na source and an LYSO crystal coupled to a SiPM is shown in Figure 1.16.

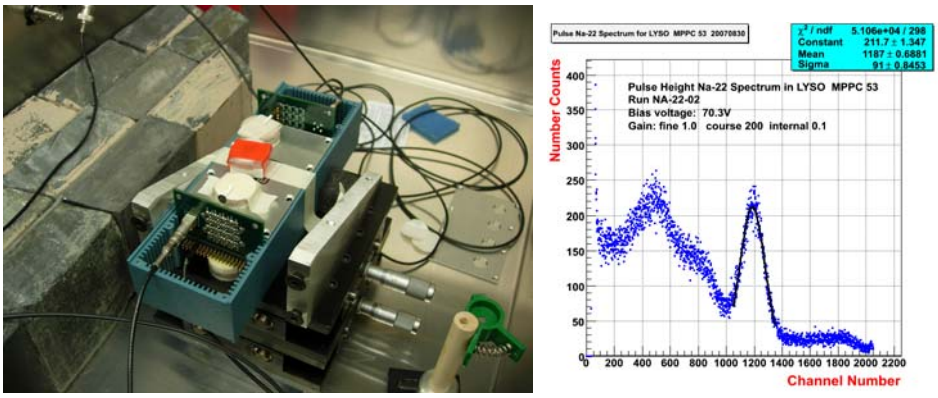


Figure 1.16: (left) is a PET demonstrator using ^{137}Cs & 2 SiPMs. The right figure is the energy spectrum obtained from the PET demonstrator, in response from a ^{22}Na radioactive source.

References:

[1] K. Byrum et al., arXiv:0710.0659

1.B.3 CCD Testing 2007 – 2009

Funding: LDRD

Charged-coupled device (CCD) technology is the basis for many types of instrumentation and detectors used in scientific research, commercial applications, the medical field, and optical and UV spectroscopy. In this R&D, we established a state-of-the-art test-stand to study various types of anomalies found in CCDs. In addition, our test-stand design included portability which enabled the exploitation of capabilities at Argonne, namely the Advanced Photon Source and its x-ray laboratories. This R&D has been funded solely through LDRD.

The CCD test-stand as configured in the HEP division is shown in Figure 1.17(a). It includes a halogen lamp, optical power meter, filter wheel, monochromator, shutter, integrating spheres, SDSU III DAQ system, and the CCD vacuum vessel. The test-stand is working reliably, and the HEP-designed (and HEP-machined) vacuum vessel has reached our required specifications for temperature and vacuum (-90 deg C and $5x10^{-7}$ atm). This test-stand is being used to study small non-science DES CCDs that come from the same wafers as the DES science CCDs and share the same types of anomalies in CCDs. One type of anomaly are charged traps which are defects in the CCD material that can trap charge from neighboring pixels, in the same vertical column during readout. Large traps can effectively remove all the charge from subsequent pixels in the same column. We have observed this effect in ^{55}Fe data taken at Fermilab. We developed the algorithms to perform and analyze pocket pumping (shifting vertical clocks before readout), which is the most efficient way to find charged traps. These are documented in reference [1].

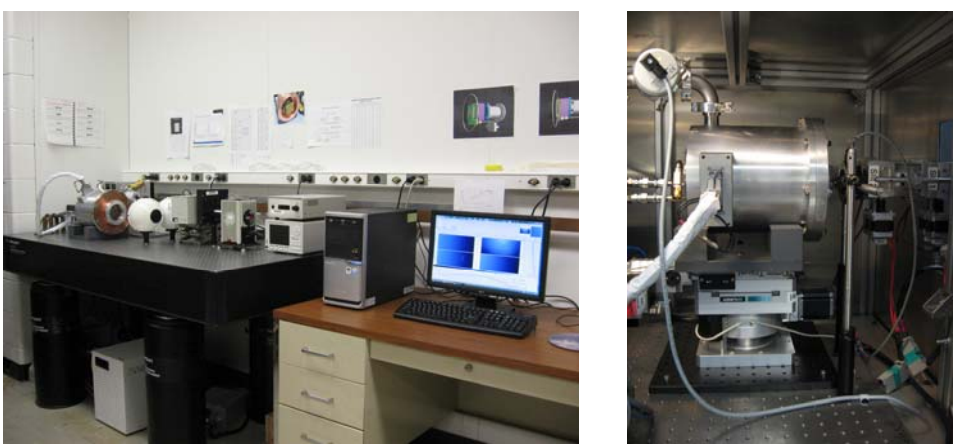


Figure 1.17: (a) The ANL/HEP CCD test-stand is shown on the left. (b) ANL/HEP CCD vacuum vessel in shielded box at Advanced Photon Source x-ray lab.

In order to study CCD diffusion and edge effects, we have taken data in the Advanced Photon Source x-ray laboratory. Figure 1.17 (b) shows the setup inside the shielded box, where 8 keV x-rays enter the box from the right. A series of tungsten slits and pinholes collimate the beam to less than 1 pixel RMS. The CCD vacuum vessel is on a precise xyz stage that allows CCD scans without disturbing the beam. We have taken data with two different CCDs, one that is backside-illuminated (normal configuration) and one which is frontside-illuminated. Since the

CCDs are 250 μm thick and 8 keV x-rays typically travel 50 μm in silicon, these two studies are effectively mapping the electric fields at the top and bottom of the CCD. We have observed differences between these two CCDs that are not expected from simulated electric fields. These studies will continue in July 2009. In addition, Figure 1.18 (a) shows the deviation of CCD centroids from the nominal location due to electric field distortion. Figure 1.18 (b) shows the simulated electric field and equi-potential maps.

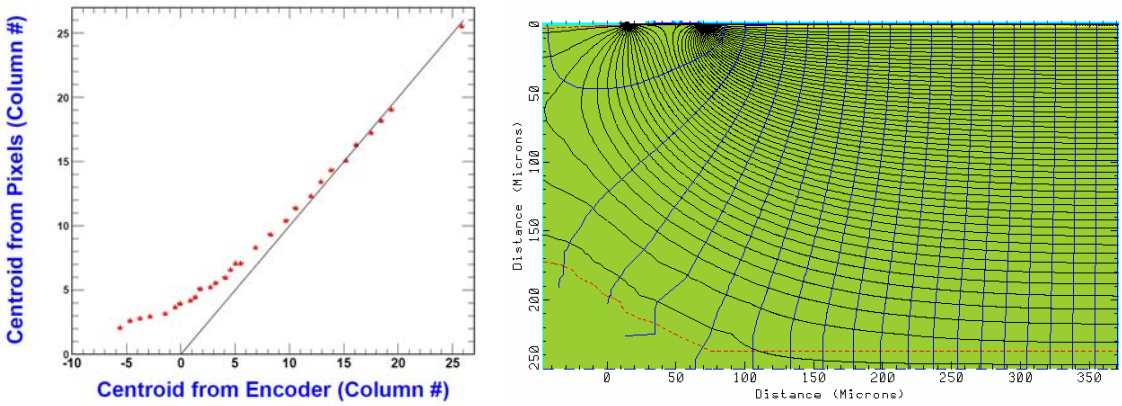


Figure 1.18: (a) CCD data taken at the Advanced Photon Source x-ray lab, showing the distortion of the electric field near the CCD edge. (b) Simulated electric field and equi-potential lines (courtesy Steve Holland LBNL).

References:

[1] Kuhlmann, S., H. Spinka, J. Estrada, D. Kubik, "Locating Traps in DES CCDs", DES technical report #1870, June 2008.

1.B.4 Transition Edge Sensor R&D 2007 – 2009

Funding: LDRD

Detectors are the enabling technology for pushing measurements to higher precision and lead to new, innovative experiments. One such example, extending our capabilities of detecting the Cosmic Microwave Background (CMB), will require the development of new technologies. TES bolometers are the most sensitive detectors for the spectral range of interest for CMB measurements and are well suited for array applications. The development of such new devices requires unique expertise and facilities that are available at a multi-purpose laboratory. Argonne has microfabrication and thin film growth technology capabilities within Materials Science Division at Argonne, and the use of microlithography facilities and expertise is available at the Experimental Facilities Division and the Center for Nanoscience Materials clean rooms. We have been pursuing R&D aimed at developing a next generation TES bolometer for future CMB Polarization measurements. This effort has been supported through the Astrophysics and Cosmology Strategic Initiative of the Argonne LDRD program. Of our particular interest is development of high sensitivity detectors that will enable next generation of precise measurements of the extremely small *polarization* anisotropies in the CMB signal. This effort will advance world-class science, both in cosmology and also in high-energy physics. Measurement of the so-called CMB B-mode polarization (CMB B-pol) signal, at the level of 0.1 □K or less, will drive refinements in the current Λ-CDM cosmological model and allow the first investigations of inflation-era physics. This will both set an upper limit upon the energy scale of Inflation, and provide valuable insights in the fields of high energy and elementary particle physics. Scientists in these fields today enjoy an extraordinary opportunity to make breakthrough discoveries by engaging with astrophysics and cosmology research which probes energies and physical conditions not available in terrestrial accelerator laboratories. Therefore, inflation-era probes, including especially CMB B-pol measurements, simultaneously test for new laws of nature while advancing our understanding of the origin, evolution, and future of the universe. In short, the scientific case for further CMB observations with increased sensitivity and angular resolution is very compelling.

A TES bolometer has a faster response time and increased linearity when compared to a semiconductor bolometer with similar sensitivity. The key difference between TES detectors and other thermal detectors is the superconducting thermometer. The choice of the superconducting material plays an important role in determining the detector characteristics. The thermal conductance G, heat capacity C, and the choice of the superconducting transition temperature Tc have important implications for device design. TES bolometers operate at their superconducting transition temperatures

We have initiated a program of R&D to develop the enabling technology for future CMB experiments. The milestones we have achieved through the period 2007-2009 are:

1. Development of fabrication procedures and masks to make an initial ‘dark’ suspended bolometer and TES
2. Fully test and characterize the test device.
3. Design fabrication procedures and masks to make an optically active bolometer.

4. Fully test and characterize the test device optically and electrically using external filters to define the optical bandpass.
5. Develop procedures and masks for array production.

Our efforts have led to the successful development of two type of TES prototypes for 1) for multicolor (150GHz, 220GHz, 270 GHz, and 350 GHz bands) measurements (Figure 1.19) and polarization-sensitive CMB measurements @ 95 GHz (Figure 1.20 and Figure 1.21). The multispectral devices are designed to study the spectral energy distribution of high redshift galaxies [2]. The polarization sensitive devices are designed to probe anisotropies in the CMB signal.

The polarization-sensitive devices will eventually be deployed for CMB observation on the South Pole Telescope.

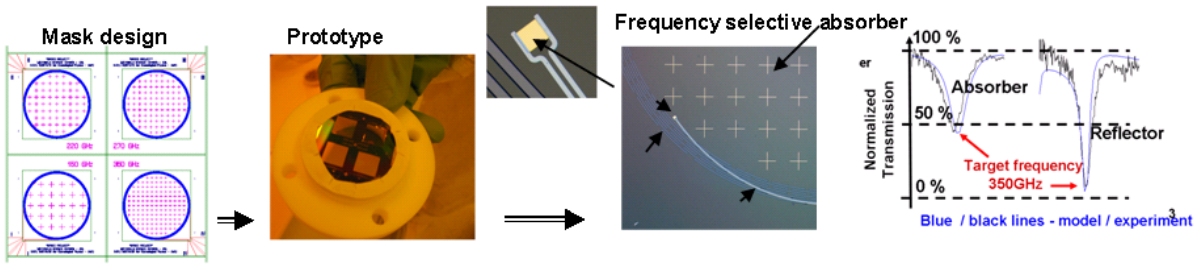


Figure 1.19: Successful prototyping of a multicolor TES array for spectral energy distribution measurements in the 150-375 GHz range, from mask design (left), device fabrication (center) to absorption efficiency measurements (right).

Figure 1.20: First generation of successfully fabricated TES devices with different geometry of support structure. Left: Membrane is suspended with 8 Si3N4 legs (1.32 mm, long, 60μm wide, 1 μm thick); Center: the same geometry, but with 16 Si3N4 supporting legs; Right: "spider web" type membrane support with bridge length of 200 μm, 10 μm wide. This demonstrates our ability to fabricate any configuration of membrane support which will be of critical importance in finalizing the geometry to produce a targeted thermal conductance G of 200-400 pW/K.

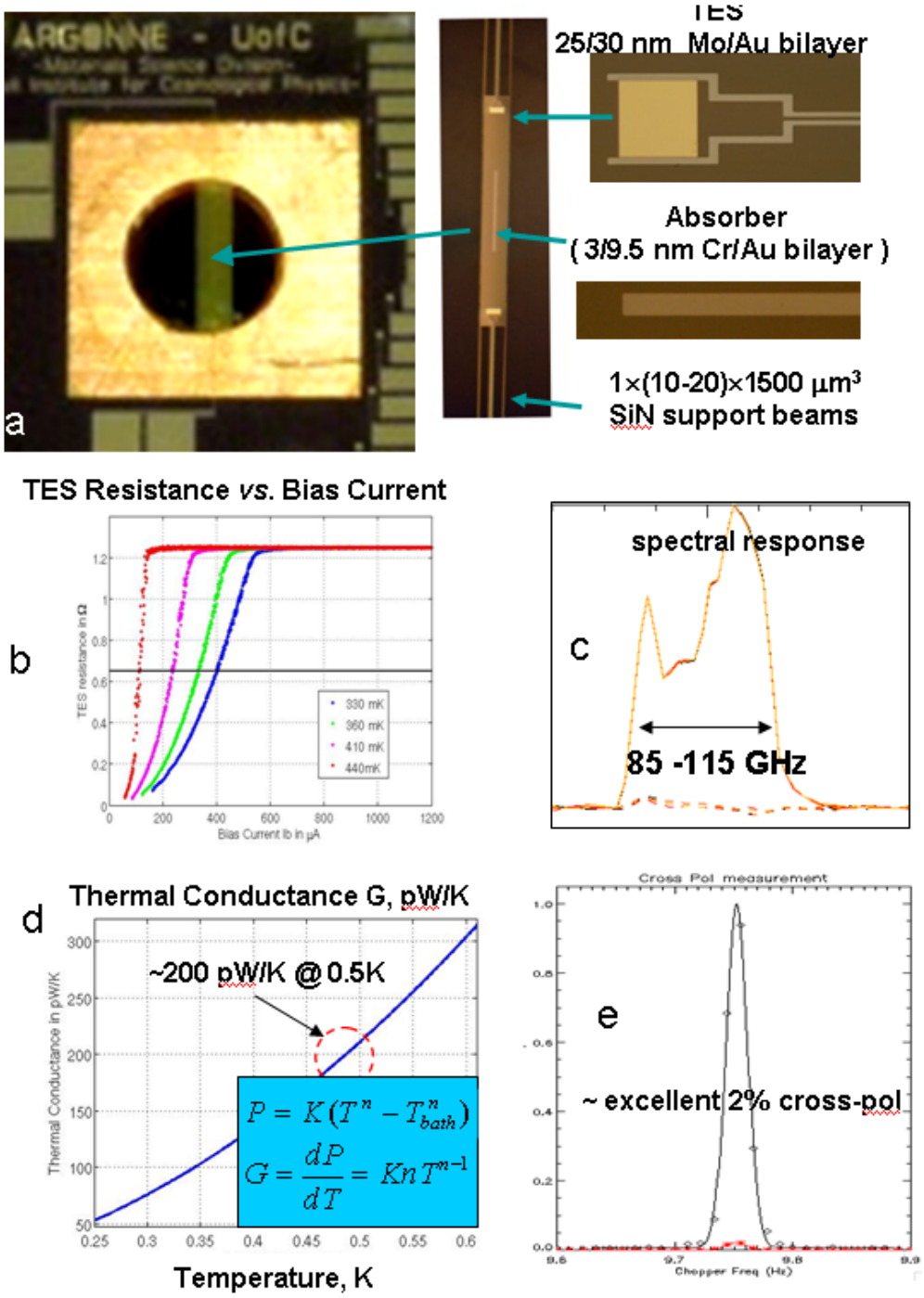


Figure 1.21: We have addressed the main aspects of materials synthesis and device prototype microfabrication. The figure above shows a) the the second generation of an optimized prototype of polarization sensitive TES detector, optical micrograph of patterned TES, Si4N4 beams, and absorber. We have demonstrated experimentally: b) stable operation in transition region (voltage-biased TES); c) sensitivity in the band of interest; d) the required thermal conductance of 100-200 pW/K (@ 0.5K), and e) excellent polarization sensitivity with < 2% cross-polarization, with an optical bandwidth > 200 Hz suitable for telescope deployment .

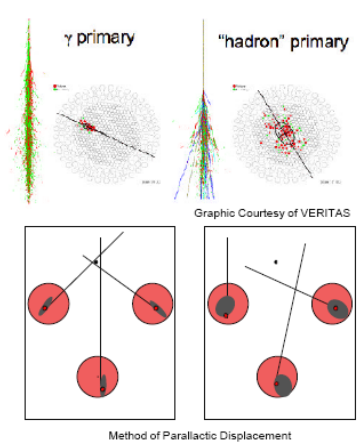
1.C. DAQ & Computing

1.C.1 Topological Trigger R&D 2008- 2009

Funding: LDRD funded and DoE Detector R&D

This R&D has focused on applying particle-physics detection techniques to develop a fast pattern trigger for real time analysis of nanosecond time scale phenomena to particle astrophysics experiments. This R&D has been a collaboration with Frank Krennrich at Iowa State University, who received an ADR grant for his contribution to this effort. ANL funding has been through LDRD (concept & development) and through the detector R&D program (hardware).

We have designed a trigger architecture that uses Cherenkov shower images from particle astrophysics experiments and the parallactic displacement of the reconstructed shower to provide gamma/hadron separation capabilities at the trigger level. The basic idea is shown in Figure 1.22(a).



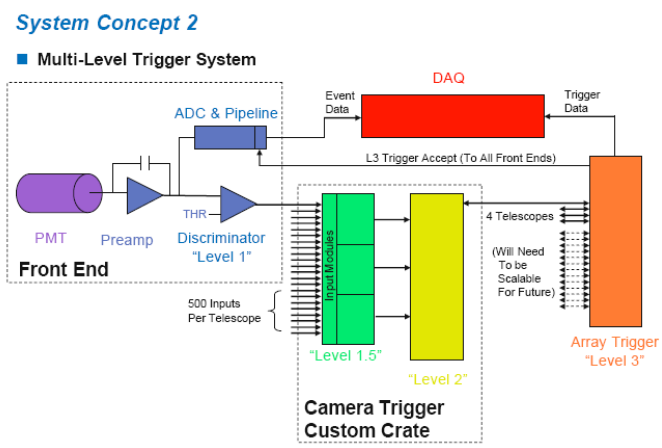


Figure 1.22(a): (left) illustrates the use of parallactic displacement for hadronic background suppression. The shapes of the electromaganetic component of a gamma-ray and a proton induced shower are shown and the effect on the shape and orientation of Cherenkov light images in the camera.
Figure 1.22(b): (right) is a block diagram of a proof-of-principle topological trigger demonstrator system.

We have designed a proof-of-principle topological trigger system that operates at an order of magnitude higher clock frequency than previous accelerator based pattern triggers. A Xilinx field programmable gate array (Virtex-5) with a clock frequency of more than 400 MHz provides the basis for the design of a nanosecond time scale trigger. To demonstrate the power and capability of our approach, we chose to incorporate our Level 2 trigger demonstrator system parasitically into one telescope of the VERITAS multi-telescope imaging array experiment. We have developed a methodology where we form cells composed of 7 pixels – a central pixel plus 6 neighbors, over the entire face of a VERITAS camera and form a sliding window of programmable length, and require 3-fold coincidence of hit pixels. Figure 1.22(b) shows the conceptual design of the demonstrator trigger which includes I/O boards to receive the signals onto a 10 layer circuit board custom layout backplane, a Level 1.5 processor to look for 3-fold

coincidence of neighboring pixels within a programmable time window, a Level 2 processor that sorts data based on timestamps, counts the number of pixels and calculates the first and second moments of the hit pixels. This information is passed to a central Level 3 process which calculates the parallax width parameters.

We have completed all of the board designs, have fabricated and assembled several of the boards of each of the system components, have developed 80% of the firmware and have performed many test measurements both in the laboratory and in the field. Figure 1. 23 shows several test measurements performed in March 2009 at the VERITAS experiment. In this test, the Level 2 moment analysis and the Level 3 topological analysis were not included.

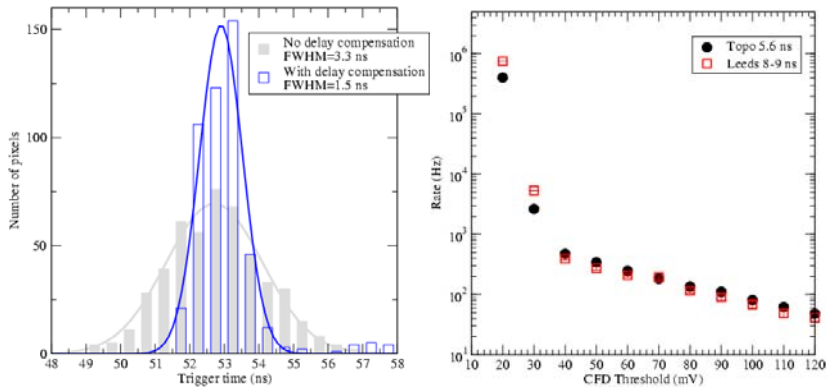


Figure 1. 23: The left figure is the distribution of the signal arrival time for all pixels on one telescope of the VERITAS telescope. The improvement in narrowing the pixel signal arrival time due to programmable adjustment capability of our Level 1.5 Module is shown. The right figure is the VERITAS Level 2 cosmic ray rate as a function of the VERITAS Level 1 signal threshold. The flat part of the spectrum (above 40mV) is due to signals (cosmic rays); the exponential rising edge is background (mostly due to night sky random starlight). In our initial test, we were able to narrow the trigger gate to 5.6ns which is about 3ns below the current VERITAS trigger gate of 8-9ns. This resulted in a reduction of about 20% random night sky background, but was greater than 100% efficient at retaining the cosmic ray signal.

2. Current Detector R&D Core Program

Funding: DoE Detector R&D

The Argonne Detector R&D Core program is that part of the program that is in principle a base program for pursuing detector R&D. It is driven by the needs of the field, for initially pursuing new directions that arise through interactions with others and new ideas etc. In addition to providing administrative and travel support, it consists of efforts that can be of a short nature and go away or enable the start of a new effort that has a longer term future. It also includes training and learning of new techniques and practices, purchase of instruments and software to keep tools up to date, purchasing ASIC design capability from Fermilab and other items to keep the necessary expertise and technology to be able to do meaningful and useful detector R&D at the detector frontier. Engineers and scientists supported by this core change and it is not always the same people that are supported, because the effort is more related to a direction than to a particular person. It allows the division to start an R&D project on a small scale and develop it to a point where it can either be abandoned, because it turns out to be impractical or developed to a point where one can apply for additional fund based on the initial studies/work.

Currently the detector R&D program is rather well defined within the division and most of the core efforts can be easily identified with "projects" listed in this document and in the accompanying spreadsheets. Therefore, in the spreadsheets for some projects, there will be no entries but it will say "core", which means that this project is covered by core funding. As can be seen the largest currently funded project is the "Digital RPC HCAL" and it receives a lot of support from the "core" program.

The core program consists of essentially one FTE of scientific effort, which is currently spread between the digital DHCAL and the Large Area photo detectors, and provides guidance to the program in general, in addition to division management. There is also support for electrical engineering and some smaller fraction of mechanical engineering, which are necessary for any detector R&D program. The combination of the scientific and engineering staff also provides guidance to the program and looks for new opportunities for collaboration with other divisions in Argonne in trying to apply their expertise to HEP problems. They also interact with Fermilab for example on developing ASICS. The core program also provides travel to conferences, workshops, etc. for people working on detector R&D.

3. Proposed Research Plan: 2010 – 2012

3.A. Detector Systems

3.A.1. Digital Hadron Calorimeter

Funding: DoE Dtector R&D request

1) Future activities: Construction of a physics prototype

a) Description of the project

The physics prototype will consist of 38 layers interleaved with stainless-steel absorber plates. Each layer will contain 96 x 96 = 9216 readout pads with dimensions of 1 x 1 cm^2 and will contain three chambers, each with an area of 32 x 96 cm^2. The chambers will be covered by two pad- and front-end board combinations containing 24 DCAL III chips. The data concentrator will be incorporated into the front-end board and will be connected via an Ethernet cable to the data collector system. Table 3.1 summarizes the number of components needed for the physics prototype (without spares):

Item	Number needed
RPCs	114
Cassettes	38
Pad-boards	228
Front-end/data concentrator boards	228
Data collectors	20
Timing and trigger modules	3
Total number of readout channels	350208
Gas mixing systems	1
Gas distribution system	1 with 19 lines
High Voltage systems	3
Low voltage systems	7 supplies
DAQ computer	1

Table 3.1: Summary of components needed for the physics prototype.

b) Building chambers

The construction of the RPCs involves several steps. For some of these steps, fixtures have been assembled to facilitate the task and to guarantee uniformity of the construction. In a first step, one side of each glass plate is coated with resistive paint. A fixture provides the constant speed for uniform spraying. Particular care is devoted to keep the surface resistivity between 1 – 5 MΩ/□. A completed glass plate is shown in Figure 3.1.

In a second step the individual pieces of the frame (extruded PVC) are cut (using a special fixture) and glued together. The fishing lines (acting as spacers and guide for the gas flow) are strung and the glass plates are glued to the frame. The assembly is completed by adding the gas flow tubes and the high voltage connections. All completed chambers are tested in a cosmic ray tests stand, which at the moment can hold up to ten chambers.

Figure 3.1: Glass plate with resistive paint.

To date, five chambers have been completed and are being tested in the cosmic ray test stand.

c) The front-end ASIC

The DCAL III ASIC has been submitted for production. Of the order of 12,000 chips have been produced and packaged. Initial bench tests (at Argonne) of a small number of chips were successful and showed not a single malfunction. Robotic testing of the chips is being prepared at Fermilab. All chips will be tested before the assembly of the production front-end boards.

d) Building and testing of the front-end

A first prototype of the combined front-end and data concentrator boards has been submitted for production. The first board is expected to be assembled and at least partially tested by the time of this review. Figure 3.2 shows the CAD design of this intricate board. A testing station and associated software are being prepared.

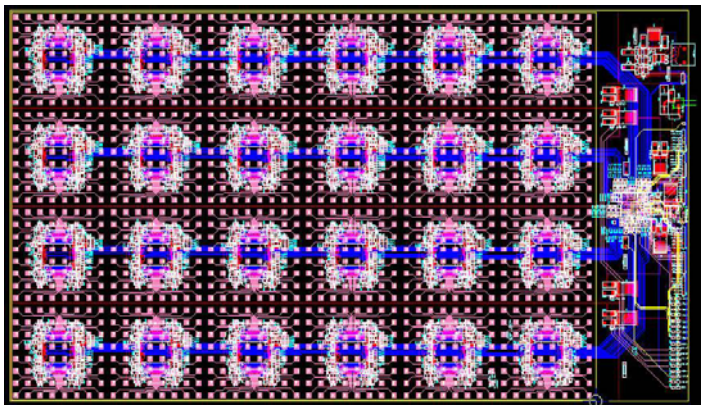


Figure 3.2: Layout of the combined front-end and data concentrator board.

e) Gluing of the Pad- and Front-end boards

Each pad- and front-end board contains 1536 pads which need to be interconnected. A fixture to dispense glue dots has been designed and built. The fixture has been trained with the smaller boards of the VST and worked very well. A photograph of the gluing fixture with a small board is shown in Figure 3.3.

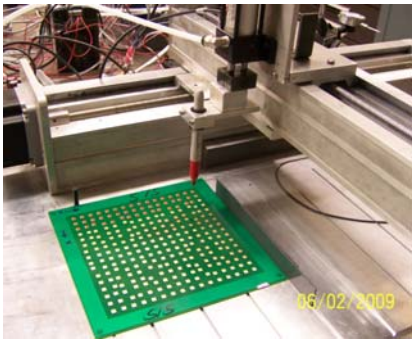


Figure 3.3: Photograph of the gluing fixture with a small Pad-board, as used in the VST.

f) Building and testing of the remainder of the readout system

All (20 + 15 spares) data collector modules have been produced and are currently undergoing testing at Boston University. Small modifications to the Timing and Trigger Module (contribution from Fermilab), as utilized in the VST, will be implemented before producing an additional handful of modules.

g) Preparing the peripherals

The high gas flow required for the physics prototype renders the previously employed pre-mixed gases unpractical. Instead, the three-component gas will be mixed on the fly. To this effect, a gas mixing station has been designed, built and tested by University of Iowa. Tests with the RPC gases will occur as soon as enough chambers are available to effectively utilize the minimum gas flow of this new mixing system.

The gas distribution system of the VST will be expanded from 17 to 27 lines, to accommodate at least one line per two layers. The changes to the system will be made in July (by University of Iowa).

The high voltage system is based on LeCroy 4032 units. Some of the high voltage generating pods still need to be repaired, which is expected to happen in July. A computer program to control and monitor the high voltages has been written and is being commissioned (contribution of University of Iowa).

The low voltage system supplies +5 Volts to the front-end boards. Part of the voltage supply units are in hand and the remainder has been ordered. A distribution system is being designed and is expected to be completed by September.

h) DAQ software

The DAQ software for the VST was developed within the CALICE software framework (in order to facilitate combined tests with other CALICE calorimeters). The new geometry and the increased number of channels of the physics prototype are being implemented. The work is expected to be completed by August.

i) Monte Carlo simulations

The physics prototype is being simulated with a GEANT4 based package and a standalone code (RPCSim) for the simulation of the response of RPCs. The simulations are used to optimize event selection criteria and to provide predictions of the response of the calorimeter. Figure 3.4 shows the prediction for the resolution of an extended calorimeter with virtually negligible leakage. The simulation takes into account the MIP detection efficiency (~90%) and average pad multiplicity (~1.5) of the default chamber design. At energies above 30 GeV, saturation effects lead to a departure from the $1/\sqrt{E}$ behavior of the stochastic term.

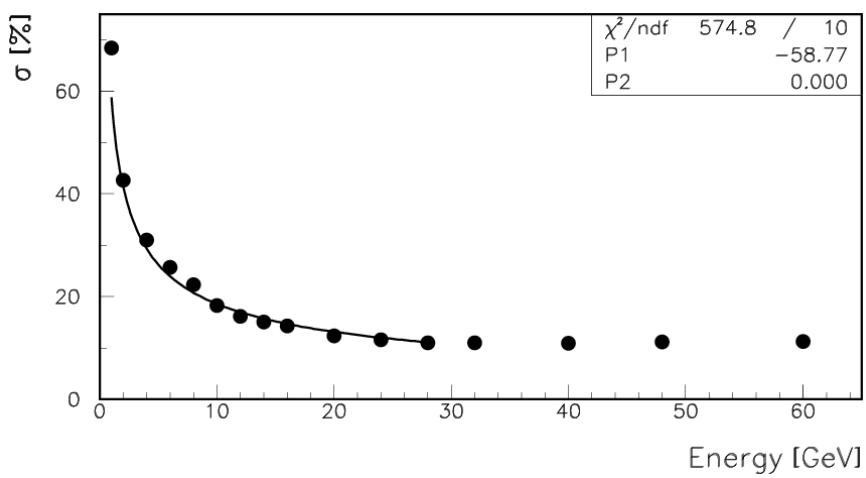


Figure 3.4: Prediction for the resolution to pions of varying energy for an extended calorimeter with virtually no leakage. The fit shown corresponds to $\sigma/E = 59\%/\sqrt{E}$.

j) Test beam data taking

After complete commissioning of the physics prototype with cosmic rays, the calorimeter will be transported to the Fermilab test beam. The layers will be inserted into the existing absorber structure and moving stage of the CALICE collaboration. The test beam activity will start with a standalone test of the physics prototype and the CALICE Tail Catcher and Muon Tracker (TCMT) for leakage control. To establish the operating parameters of the individual chambers the stack will be illuminated with broad band muons, to be followed by measurements with the secondary beam at various energies between 1 and 60 GeV. The particle selection (electron versus pions) will be made offline with the help of the information from the two Cerenkov counters placed upstream of the calorimeter.

In a second running period the CALICE Silicon-Tungsten electromagnetic calorimeter will be placed in front of the physics prototype and the detailed measurements with the secondary beam described above will be repeated.

k) Offline analysis

A framework for the offline analysis of the cosmic ray and test beam data is being developed. The framework utilizes the standard linear collider data format known as LCIO, which also offers the possibility to integrate the conditions data into the data stream**.**

The offline code will provide a framework for implementing the calibration constants, i.e. the MIP detection efficiency and average pad multiplicity determined with the broad band muons at the test beam, into the analysis of the electromagnetic and hadronic shower data analysis.

2) Future activities: R&D for a technical prototype

The technical prototype will address all relevant R&D issues in preparation for the design of a first prototype of an actual module of a hadron calorimeter. In the following we list the most important areas of R&D and our plans to address these issues:

a) Development of large, ultra-thin chambers

The current designs of the SiD[1] and ILD [2] detectors show a hadron calorimeter with active layers with large areas. To date our largest chambers measure 32 x 96 cm^2. The plan is to develop large area chambers (several square meters?) and to study the distribution of both the high voltage on the glass surface and the gas within the gas volume.

The dead zones of the chambers need to be minimized, as well as their thickness, as a deeper hadron calorimeter increases the inner radius of the superconducting coil. In the past, our group investigated 1-glass chamber designs (our own invention) and found them to be a viable option for calorimetry. Further effort is needed to increase the reliability of these chambers and possibly to further reduce their thickness by replacing the glass with other non-conductive materials.

b) Development of a wedge-shaped structure

Both the SiD and ILD detector designs feature wedge-shaped hadron calorimeter modules. There are two possible ways to accommodate the varying width of the readout element in a wedge-shaped structure: either the pads are varied in width from layer to layer or the pad width is kept constant, but the boards are designed such as to accommodate the varying width of a given layer. The two options have different advantages and draw-backs. We propose to study these two options in Monte Carlo simulations, in order to provide a solid basis for a decision between the two.

c) Development of an improved gas system

The preferred gas for the operation of RPCs in avalanche mode contains a large fraction of R-134A (95%), which is not ozone depleting, but has a large green house coefficient (a factor 1430 worse than CO_2). We plan to search for alternatives to the use of R-134A. A promising candidate is R-152A, which has recently been approved for use in automobile air conditioning systems and is an order of magnitude less damaging to the environment.

Currently the used gas is vented into the atmosphere. Doing so will not be practical for a larger system, as the cost for replacing the gas would be prohibitive. We, therefore, plan to investigate ways to purify and recirculate the used gas. This involves the assembly of a test station (with monitoring RPCs) and investigation of several options for gas purification. This work will be carried out by University of Iowa.

d) Development of a high voltage distribution system

Ideally the high voltage for each layer is generated in proximity to the layer. We plan (in collaboration with Unversity of Iowa) to investigate the possibility of generating the high voltage locally (e.g. utilizing Cockcroft-Walton technologies) and to devise a system which can control layers individually and monitor their high voltage setting and current.

e) Development of a low voltage distribution system

The low voltage system needs to supply the required voltages to the front-end electronics (for the physics prototype this is +5 Volts). We plan to develop a system which can distribute the voltages to all layers of a module, control which layer needs to be switched on or off and to monitor the currents drawn.

f) Development of an improved front-end readout system

The front-end readout system can be improved in several ways compared to the implementation in the physics prototype: a) the channel count could be increased from the current 64 channels per ASIC (if this is desirable), b) the chips can be linked together by a token ring, c) the chips' analog part can be power pulsed (to reduce the cooling needs), d) the reliability of the chips can be improved by providing cross connections and alternative circuitry, and e) the transmission to the back-end can be realized with more modern technologies, such as Gigabit transceivers. We plan to explore all these possibilities.

g) Tests in magnetic fields

Lastly, but not least: all hardware (chambers and readout systems) need to be tested in the presence of the strong magnetic fields as assumed by the detector concepts. (Preliminary tests performed by another group showed no dependence of the chamber performance on its orientation in a 3 Tesla field).

3) Future activities: Development of Particle Flow Algorithms

We plan to boost our effort in developing Particle Flow Algorithms. In the past, the Argonne group developed two independent algorithms. However, in the last two years effort has been diverted from this effort to the development of the DHCAL hardware. We plan to continue the development of the more promising of the two Argonne algorithms. In particular, we plan to pursue several promising ideas which need to be implemented into the algorithm. However, additional manpower (one postdoc) is needed to do so.

Furthermore, Graham Wilson (University of Kansas), who has received significant funding for PFA related work, indicated his intention to locate a postdoc at Argonne to work with the Argonne group on PFAs. We believe that progress in this field can be accelerated if this person can be supplemented by an Argonne postdoc, who would share her/his time among development of PFAs and hardware related work. The proximity of the DHCAL development effort might render this arrangement particularly effective.

4) Summary

Table 3.2 summarizes the various activities of the DHCAL group and shows their rough timelines. The analysis of the vertical slice test data will be completed in CY 2009 with additional 2 – 3 publications. The construction of the physics prototype is expected to be completed by late CY 2009, to be followed by testing in the Fermilab test beam and data analysis. R&D for the Technical Prototype has already begun and will lead to the construction of such a prototype beginning in 2012.

Activity	**2009B**	**2010A**	**2010B**	**2011A**	**2011B**	**2012A**	**2012B**
Analysis of Vertical Slice Test data	x						
Construction of physics prototype	x						
Testing of physics prototype		x	x	x	x		
Analysis of data from the physics prototype		x	x	x	x	x	
Chamber R&D			x	x	x	x	
Peripheral R&D	x	x	x	x	x	x	
Front-end development		x	x	x	x	x	
Construction of technical prototype						x	x
PFA development		x	x	x	x	x	x

Table 3.2: Timeline of the different activities of the DHCAL group.

References

[1] http://silicondetector.org/display/SiD/home
[2] http://www.ilcild.org/

3.A.2. Telescope Design

Funding: LDRD plus others

This R&D has focused on applying particle-physics large-scale mechanical engineering strengths to develop novel telescope designs and the motion systems required for these telescopes for future ground based astrophysics experiments. This research is funded with LDRD and with external funding from DESY Laboratory in Germany through 2010.

Year-2010 Goals:

a. Design a 11.5 meter SC telescope optical support system based on our previous 9-meter design.
b. Complete the design for a 12 meter DC telescope optical support system.
c. Complete and build a telescope azimuthal drive system for both DC and SC telescope designs.

This R&D is intended to position Argonne for a leading and critical role for a future ground based high energy gamma ray array, either in the US(AGIS) or Europe (CTA). This of course depends on the priorities that will come from PASAG and the 2010 Astronomy and Astrophysics Decadal Survey, both of which are ongoing at this time.

3.B. Sensors and Electronics:

3.B.1. Large Area Photo-Detectors (2010 – 2012)

Funding: DoE Detector R&D Funded

A proposal describing in detail the R&D to be pursued in this area was submitted in early 2009. The complete proposal can be found at:
http://www.hep.anl.gov/byrum/tof/Project_description_nobudgets.pdf
This proposal was reviewed and is in the process of being funded at the level of $8M for three years from stimulus funds. Below we simply list the overall goals of this R&D as well as the expected deliverables for the next three years. This R&D project uses the unique and modern material science techniques at Argonne and other labs to design and build large area, flat, new, cheap photo detectors. Preliminary work has been done to convince ourselves and reviewers that this is feasible, given the expertise in materials, in new deposition material techniques and existing vacuum assembly expertise. The goal is to produce a new type of photo-detector based on modern technology using the latest breakthroughs in material science, like for example atomic layer deposition (ALD).

We list below the goals of this effort. This research is funded by the detector R&D program and addresses the larger goals of the HEP Detector R&D by:

a. Developing large-area photo-detectors with sub-centimeter spatial and sub-nanosecond temporal resolution for improved performance and substantial cost savings in scientific, medical and nuclear non-proliferation applications.
b. Connecting the latest advances in nano-science, materials science, and integrated circuit production technology
c. Recapturing the lost US expertise in the design and production of large-area vacuum photo-detectors by building a community of university, National Laboratory, and industrial groups.
d. Closely linking exploratory research at the National Laboratories and universities to the delivery of marketplace-ready cutting-edge technology by collaboration with the community of interested US small-business high-tech industries.

Year-1 Guaranteed Deliverables:

These are the deliverables that are required to be met in the first year. Where appropriate the deliverable would be in the form of a written report and/or published papers.

Characterization of Material Properties:

a. Systematic characterization of Secondary Electron Emission (SEE) properties of materials for ALD-based micro-channel coatings.
b. Systematic characterization of Photo-electron Emission (PE) properties of materials for photocathode development.
c. Development of experimental approaches to understanding aging and burn-in (Scrubbing) for SEE and PE surfaces.

d. Demonstration of amplification with gain ≥ 300 with an ALD-functionalized micro-channel plate.
e. Fabrication of an Anodic-Aluminum Oxide substrate with pore diameters ≥ 0.4 microns and funnel openings, with a funnel Open-Area-Ratio of ≥ 50%.

The 8”-Square Prototype Module

a. Demonstration of an operational 8”-square photocathode with a viable path to a peak QE ≥ 15% at a wavelength between 300 and 450 nm.
b. The selection of materials and techniques for the mechanical construction of the 8”-square module.
c. Demonstration of the vacuum seal of the 8”-square window to the body
d. Upgrading existing collaboration vacuum-transfer facilities to match the 8”-square module assembly.
e. A design, including costing and interfacing with vendors of production sealed-glass tubes, for a vacuum-transfer/assembly facility for the 8”-square module.

Simulation

a. Simulation of the ALD-functionalized glass micro-channels selected for the 8”-squared module and comparison with test data
b. Simulation of the pulse-height and transit-time spreads for the AAO/ALD geometry.

Electronics and Integration

a. Achieving a differential time resolution < 10psec and space resolution ≤ 1 mm in vacuum with a 50-ohm transmission-line anode suitable for multi-photoelectron high-precision applications.
b. Design of a proto-type 2-channel ASIC with sampling rate ≥ 20GS/sec, analog bandwidth (ABW) .ge. 1.5GHz, and capacitor-sampling-chain and timing-generator blocks.
c. Design of the integrated front-end/DAQ electronics system

Management

a. Creation and implementation of a management organization chart
b. Implementation of project management cost/schedule software
c. Formation of a team and development of a work-plan for developing advanced photocathodes with higher QE and properties amenable for large-scale lower-cost assembly methods.

Year-2 Goals:

A comprehensive report on the project, including chapters on the individual technical achievements and knowledge gained.

a. Construct a facility for production and vacuum transfer of 8” x 8” conventional (bialkali) photo-cathodes with QE > 15%
b. Demonstration of amplification with gain .ge. 1000 with an ALD-functionalized micro-channel plate.

c. Continue and refine the development and characterization of novel materials for Photo-emission and Secondary Electron Emission (SEE): Higher quantum efficiency, nano-structures, photon trapping using wavelength tuning.
d. Achieve open-area ratios ≥ 80% and channel sizes ≤ 20 microns in glass substrates
e. Achieve straight pores with diameter ≥ 1 micron, 40 ≤ L/D .le. 100 and open-are ratio ≥ 70% (no funnel option) or ≥ 90% (funnel option) using Advanced substrates
f. Demonstrate gain >1000 and non-uniformity to < 15% using Atomic Layer Deposition
g. Completion of end-to-end simulation package
h. Construct working glass and ceramic 8" x 8" MCP-PMT's with gain ≥ 1 x 10^5.
i. Construct clock distribution and DAQ system for MTEST test-beam

Year-3 Guaranteed Deliverables:

e. A comprehensive report on the project, including chapters on the individual technical achievements and knowledge gained.

Year-3 Expected Deliverables:
These are the deliverables that are expected at the end of the third year. Where appropriate the deliverable would be in the form of a written report and/or published papers.

a. A comprehensive report on the project, including chapters on the individual technical developments and knowledge gained.
b. A dozen 8" x 8" modules with sub-centimeter spatial and sub-nanosecond temporal resolution.
c. A system with DAQ and clock distribution for four 8" x 8" modules.
d. A detector module composed of multiple 8" x 8" modules, with sub-centimeter spatial and sub-nanosecond temporal resolution.
e. The creation of a lab/industry/university collaborative effort charged with industrialization of the R&D, exploring other applications, and identifying new transformational developments.

3.B.2 Silicon Photomultiplier R&D (2010 – 2012)

Funding: DoE Detector R&D Fund request from core.

The Silicon Photomultiplier is a new silicon-based technology having certain novel properties compared to conventional photo-multiplier tubes and offering exciting new possibilities for HEP as well as many other fields of science. We list below the goals of this effort. This program addresses the larger goals of the HEP Detector R&D and is funded out of the Detector R&D program.

Year-2010 Guaranteed Deliverables:

a. Build a few prototype SiPM telescope camera modules and demonstrate them in the TrICE camera array.
b. Development of calibration techniques that can be used in the field for a SiPM telescope camera.

c. Development of applying SiPM to PET imaging setups using localization of gamma-ray interaction by charge distribution in bulk scintillating crystals.
d. An upgrade of our phototube testing facility to include quantum and photon detection efficiency measurement capabilities.

Year-2011 Goals:

a. Develop a prototype SiPM camera pixel array that incorporates stabilized gain and noise.
b. Continued development of a general SiPM and phototube testing facility.

Year-2012 Goals:

a. Development and testing of a prototype silicon photomultiplier camera module.

3.B.3 CCD Testing (2010-1012)

Funding: DoE Detector R&D Fund request.

Charged-coupled device (CCD) technology is the basis for many types of instrumentation and detectors used in scientific research, commercial applications, and the medical field and optical and UV spectroscopy. We have used LDRD funds to establish a CCD optical-wavelength testing facility in HEP and separately developed a precision x-ray testing lab at the Advanced Photon Source Facility at Argonne.

Year-2010 Guaranteed Deliverables:

a. Continued generic CCD R&D using our CCD test facilities in HEP and APS.

Year-2010 Goals:

a. Publication of an initial journal article concerning the analysis of charged traps and other anomalies found in DES CCDs.
b. Publication of an initial journal article concerning the response of the CCD in a finely-grained scan with x-rays and comparison with simulated electric field maps.

Year-2011 Guaranteed Deliverables:

a. Continued generic CCD R&D using our CCD test facilities in HEP and APS.

Year-2011 Goals:

a. Publication of a comparison of the diffusion of front-illuminated versus back-illuminated CCDs using x-ray beams.
b. Publication of the wavelength dependence of x-ray diffusion in back-illuminated CCDs.

Year-2012 Guaranteed Deliverables:

a. Continued generic CCD R&D using our CCD test facilities in HEP and APS.

Year-2012 Goals:

a. Record very-high quality x-ray data on diffusion and edge effects as input into DES image simulations.

3.B.4 Transition Edge Sensor R&D

Funding: LDRD in FY10, future DoE Detector R&D fund request

Detector technology will determine what is scientifically possible in far-infrared and millimeter-wave astrophysics in the next decade. Focal planes with large, background-limited detector arrays will be the enabling capability for studies of inflation via CMB polarization, the evolution of large-scale structure via CMB lensing and SZ surveys, the formation and evolution of galaxies, the early stages of star formation and the development of accretion and debris disks in stellar systems.[1]

Implementation of an instrumented focal plane array at the South Pole Telescope will complete one entire cycle of detector development and deployment, while simultaneously a) supporting an ongoing effort to build up a frontier, cross-disciplinary program in HEP in astrophysics/high-energy physics, and b) making valuable contributions to world-class astrophysical science. The experience captured during this final stage of that overall process will be invaluable to future detector development programs at Argonne. The principal objective of this effort therefore remains to capture knowledge regarding array instrumentation and deployment for the benefit of the Laboratory community. Argonne will continue to fund this R&D through a strategic investment using LDRD, at least through FY10.

Year-2010 Milestones:

The work plan calls for the following steps in the one year time frame, prior to focal plane deployment in late 2010:

1. Instrumentation of an existing optical cryostat at ANL with a 1x32 NIST time-multiplexed SQUID amplifier array for testing purposes.
2. Completion of final designs for detector mounts, feedhorns, and the focal plane array, with procurement and manufacture of same. Final iteration of detector design and procurement of microfabrication masks.
3. Refinement of a suitable flip-chip wire bonding scheme for contact to the polarimeter detector.
4. Design and construction of readout instrumentation for deployment to the South Pole.
5. Fabrication of 180 polarization-sensitive bolometer detector pairs on 4” substrates using deposition equipment procured especially for this task. Close monitoring of results during this process to ensure uniform results. Maintenance of statistics.
6. Dark and/or optical testing of as many mounted and finished detectors as possible in order to assure quality. The focal plane array will be assembled from individual pixels in order to assure 100% coverage.

Year 2011-2012 Milestones:

1. Deployment of an instrumented array of 700+ polarization-sensitive detectors to the South Pole Telescope. ANL will supply ~1800 of these dual-polarization detectors, operating in the 95 GHz window. NIST will supply another ~540 detectors, operating in the 150 GHz window. The chosen ratio between number of 95 and 150 GHz detectors is optimal for efficiently discriminating atmosphere background contribution.

Through LDRD funding from FY07 through FY10, Argonne has established an infrastructure and expertise to create low temperature ultra sensitive, low threshold sensors that can used in a variety of applications. We feel strongly that this expertise should be maintained at Argonne and will be needed for low threshold, very low noise special detectors that will be needed in the future for particle (astro)physics. In the funding table associated with this proposal we request funding to keep this expertise at Argonne for future detector development. No funding is requested until FY11. In the meantime HEP will complete the PASAG exercise, which will better define the astrophysics program supported by HEP and we will know the priorities set by the 2010 astronomy and astrophysics decadal survey. Currently we are asking for this be considered and give an estimate on how much funding would be required to maintain this expertise for future use.

References:

[1] *'Superconducting Detector Arrays for Far-Infrared to mm-Wave Astrophysics'*, white paper for Astro2010: The Astronomy and Astrophysics Decadal Review. James Bock, et. el (including V. Novosad) March 2009.

[2] "*Toward Using Galaxy Clusters to Constrain Dark Energy"*, Proposal submitted in response to DOE call titled "Discovering the Nature of Dark Energy / LAB 08-06" , Ref # 301-903-1759, by V. Novosad (MSD), H. Spinka (HEP), S. Meyer, J. Carlstrom (UofC), and G. Willson (UMass).

3.C. DAQ & Computing

3.C.1 Topological Trigger R&D (2010)

Funding: DoE Detector R&D Fund core request.

This R&D has focused on applying particle-physics detection techniques to develop a fast pattern trigger for real time analysis of nanosecond time scale phenomena to particle astrophysics experiments. This research is funded through the Detector R&D program.

Year-2010 Goals:

a. Completion of a proof-of-principle topological trigger demonstrator that operated at an order of magnitude higher clock frequency than previous accelerator based pattern trigger.
b. A comprehensive report on the project, including chapters on the individual technical achievements and knowledge gained.

This R&D is mostly complete and tested on one telescope. A decision by VERITAS is needed on whether to build a larger scale version for production. Completing the work on the R&D will be done from core detector R&D funds.

3.C.2 Future DAQ 2009

Funding: DoE Detector R&D fund request.

The current generation of detectors used in High Energy Physics colliding beam experiments such as CDF and D0 at Fermilab, and CMS and ATLAS at the LHC are highly complex, having high channel count (~100K-multi million channels), encompass multiple subsystems (electromagnetic, hadronic, inner tracking, muons, etc.), have high event rates (~25 nSec interaction times, 10-100 events per interaction), and occupy large expanses that make data collection difficult (~10^6 cubic meters.) The data acquisition systems used in these experiments are likewise complex, consisting of multiple levels of triggering, parallel processing, and complex event filtering algorithms. The next generation of experiments such as the LHC upgrades will require even greater bandwidth and processing power, estimated at factors of 10-100, requiring higher levels of parallel processing as well as a higher degree of sharing data between processors. Yet, the state-of-the-art in data acquisition system architecture has not advanced significantly since the 1990's, and the hardware currently in use incorporates relatively slow data transmission techniques (100T, SLINK, gigabit Ethernet), bandwidth-limited crate hardware (VME with 33 MHz, 64-bit bus), and a limited use of shared memory in custom hardware of the early stages of trigger and data processing. It is clear that new technologies, techniques, and architectures are needed for future experiments to handle the event rates envisaged, as well as enhance the capabilities to measure rare processes at these high event rates.

In this R&D, we are embarking on a program to study the general problems associated with high-bandwidth data acquisition processing for future High Energy Physics experiments. This program is part of a world-wide activity in the field to develop the next generation of data acquisition systems. Our past activities and accomplishments with DAQ and trigger systems, coupled with our division's involvement in a wide range of HEP experiments over the years (CDF, ZEUS, ATLAS, MINOS) place us in a strategic position to make significant contributions to this program. The areas of our investigations include:

- Data links: The state-of-the-art is going away from clumsy parallel data busses, favoring high-speed serial communication. 10 gigabit/sec Ethernet is standard in industry now. 100 gigabit/sec transmission is on the horizon. The use of optical transmission is advantageous between the detector and remote DAQ processing to reduce ground loops and enhance bandwidth. Error detection and correction will be essential, especially in radiation environments. Unlike the past, there is a push toward merging data readout, slow controls, and timing and triggering into a single data link, and this has implications in the nature of the links. One development in this area is the GBT at CERN, which operates at ~5 Gbps. Currently we are participating in this development, and are in the process of setting up a test stand to make performance measurements of the first devices.

- Crate hardware: VME is the current standard in the field, but is severely limited in the bandwidth of the backplane, and already may groups have designed custom enhancements to these crates for particular applications. A relatively new development

in industry is a new crate called ATCA (Advanced Telecommunications Computing Architecture.) It uses high-speed serial busses on the backplane, can incorporate high-speed processors (blades) as general-purpose cards, can use powerful rear-transition modules as I/O, and is available in several architectures, including dual star and full mesh. These features are highly desirable for future HEP DAQ applications. We are currently in the process of procuring hardware to evaluate performance for possible future applications.

- System architecture: Related to the crate hardware above, the ATCA crates can be configured for use in a variety of architectures. Certain parts of the DAQ system may favor a particular architecture over others in terms of efficiency, so there are multiple aspects of the problem. We have been participating in workshops that have been held within the community to study the problem. We have also written an LDRD this year to seek funding to engage in a design study. We would also like to incorporate this work as part of our Detector R&D base program for the future.

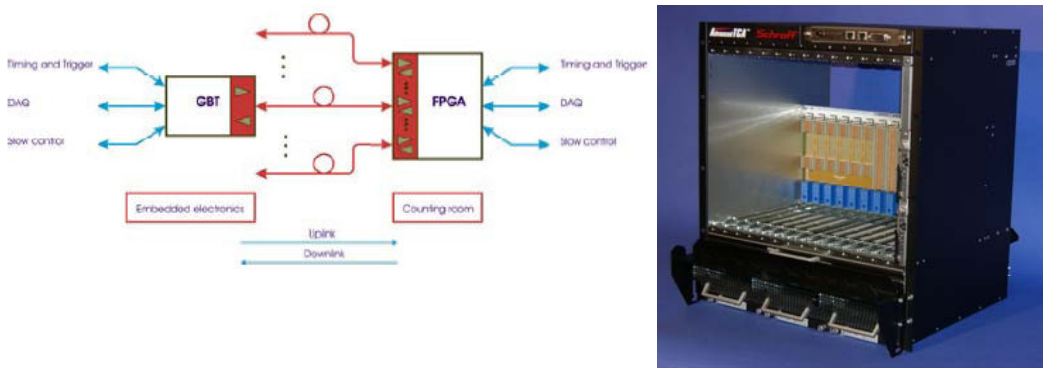
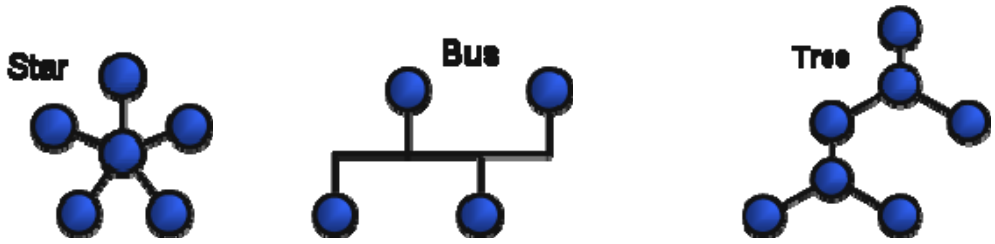


Figure 3.5: Left figure shows GBT architecture. Right figure shows ATCA crate.



Caption???

This R&D program is aimed at studying new technologies, techniques, and architectures for next-generation data acquisition systems, including possible upgrades at the LHC, and a new data acquisition system for the Linear Collider. The goals of this research are listed below.

Year-2010 Guaranteed Deliverables:

a. Construct a test stand to test the CERN GBT.
b. Perform characterization studies of the first version of the GBT. Write a report of the studies, and feed back to the chip designers. Participate in design discussions as appropriate.
c. Procure an ATCA crate. Construct a test stand to perform testing.
d. Perform characterization studies of ATCA, evaluating different data acquisition architectures. Present findings to the community in the appropriate forum.
e. Using our work and studies as a basis, participate in workshops and community forums to advance the state-of-the-art of data acquisition and trigger systems.

Year-2011 Goals:

a. Continue testing of data links. Continue participation in the design and characterization of the GBT. Work may include radiation testing.
b. Continue studies of data acquisition and trigger system architectures.
c. Continue participation in community-wide workshops. Seek leadership roles in one of the LHC upgrade projects. Depending on the state of the project, consider participation in data acquisition system design studies for the Linear Collider.

Year-2012 Goals:

a. Continue testing of data links. Prepare for testing of final GBT design before production. Set up small system to perform characterization measurements.
b. Continue studies of data acquisition and trigger system architectures. Set up small system of one or more parts of the architecture, and characterize performance.

Continue participation in community-wide workshops. Goal is to have established a leadership role in one of the LHC upgrade projects by this time.

3.C.3 Wireless and Fiberless data communication

Funding: DoE Detector R&D fund request (supplemental request in FY09)

Both existing and future experiments in Nuclear and High Energy Physics have performance limitations due to the mass of the electronics used to get the data out of tracking detectors. The mass interferes with the particles to be measured, converting interesting photons to electrons, changing the energy of electrons, converting background photons to huge numbers of charged tracks, etc. There is an urgent need to find ways to get more data out of the detectors while reducing the mass of the communications electronics. In addition to the actual electronics, a large part of the mass which interferes with the particle measurements is due to the cooling system. In the current ATLAS and CMS detectors at CERN, the cooling system mass is greater than the detector mass, and it is in front of the other layers of the detectors. Figure 3.6 shows the material in the ATLAS & CMS tracking systems, which in an ideal tracker would be zero and realistically a fraction of a radiation length. Thus power is mass, and we must reduce the power by large factors. A combination of extremely low-mass, low power light modulators coupled with active, micro-mirrors, steering of light beams, would go a long way toward solving these issues.

Extremely small size, low mass and low power light modulators are under development at MIT and IBM which are good candidates for our resolving these problems. They are extremely small, low power, and can be integrated into CMOS. The MIT prototype uses a core of GeSi that changes its absorption index to modulate the incoming light, see Figure 3.8(a). The IBM candidate is an extremely small interferometer (~ 100 um), which modulates the light by phase interference between the two arms of the interferometer, see Figure 3.8(b).

A conventional laser transceiver uses about 300 mw of power at 1 Gbit, an MIT Prototype modulator used 50 fw/bit or 0.05 mw of electric power. Of order 1 mw of power will be absorbed out of the laser beam, but this is still a huge improvement in heat load. An existing combined laser/modulator is a few mm long. Prototype modulators from both MIT and IBM are about 10^{-2} cm long (100 um), a volume ratio of roughly 10^{-4} to 10^{-5} and a mass ratio of this order.

As an example of the advantage of the higher bandwidth, 40K fibers of 20 MHz in CMS silicon could be replaced by of order 1K optical links. Conceivably, the on-board multiplexing could be replaced by using the switching capabilities of steerable Micro-Electro-Mechanical Systems (MEMS) mirrors. This might easily be done at ILC with the low duty factor, this saving mass.

Transmission by beam in air instead of fibers would be possible using MEMs mirrors and special light couplers to steer the light to the modulators. Figure 3.7 shows the proposed setup for the use of MEMs. The CNM Division at Argonne has expertise with MEMS technology including the tiny, electrically driven mirrors. An actual example of a MEMS mirror is shown in Figure 3.9.

The system we are exploring would utilize MEMS mirrors in a feedback loop for positioning and removing the effects of vibration and other shifts. This requires development of low mass MEMS mirrors, as well as the position detector and coupling elements. In the simplest version, the positioning would have to be on order microns to match the modulator couplings. However,

we will aim for an extreme low mass equivalent of the present couplers used in optical tables which would reduce this position sensitivity.

We are proposing to explore this data link concept in a number of steps.

We begin with present technology and change it step-by-step. We begin with two setups: one with green laser and a second with infrared laser. The infrared setup will allow us to test a simple system using commercial modulators and transceivers, and then to modify it to use remote modulators, and then to further modify it to use light beams instead of fibers.

There are further ways in which this project could be applied in High Energy Physics. This technology with modulators and mirrors could be critical in a new kind of tracking trigger utilizing back-to-back detector planes. In this geometry there is no space for connection of optical fibers (about 3 mm total space in air) and where electrical connections based on large numbers of vias in silicon cannot span the required distance (a few mm)and would have large mass over meters of area.

For ILC calorimetry where space inside the magnet is at a premium and space between calorimeter layers is at a premium, a fiber link with modulators could replace a large number of electrical connections.

For tracking in the e^+e^- collider environment such as ILC, low mass is essential, and one can use this technology to reduce mass. Due to the ILC duty cycle, one might do the multiplexing of various FEE chips in tracking by sequentially steering the laser (with MEMS, no fibers) at a modulator incorporated into each CMOS chip. This would require some local on-board memory, but fan-in/multiplexing chips probably have the equivalent memory on the detector.

This is a collaboration between the Center for Nanoscale Materials (CNM) and the HEP Division at Argonne.

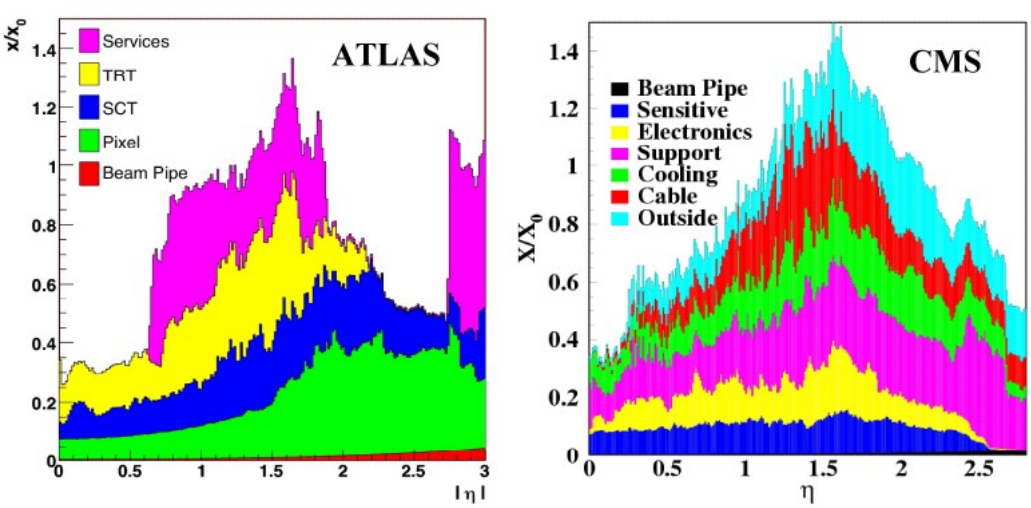


Figure 3.6: Examples of mass between interaction region and calorimeters in ATLAS and CMS as built.

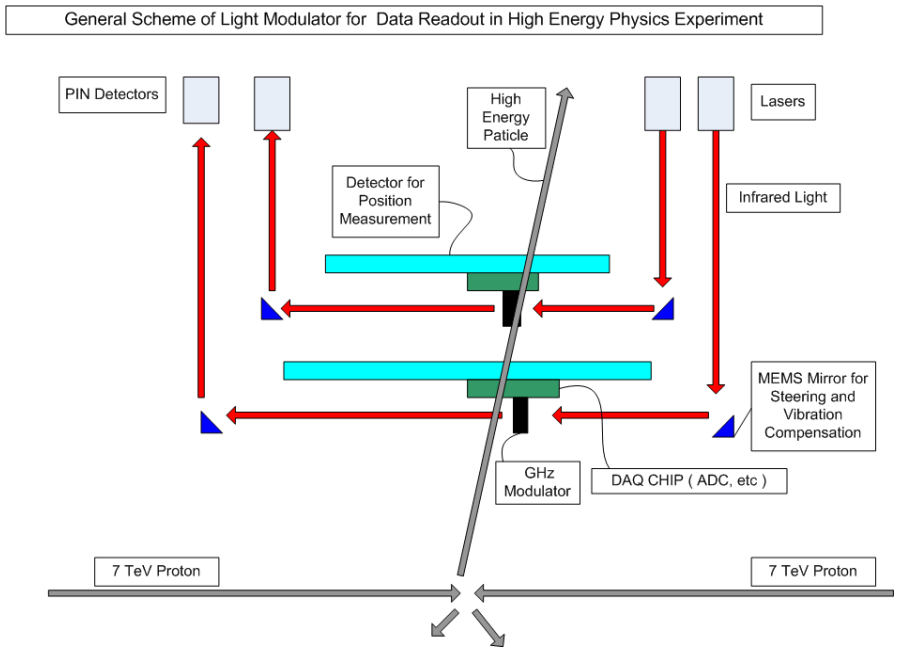
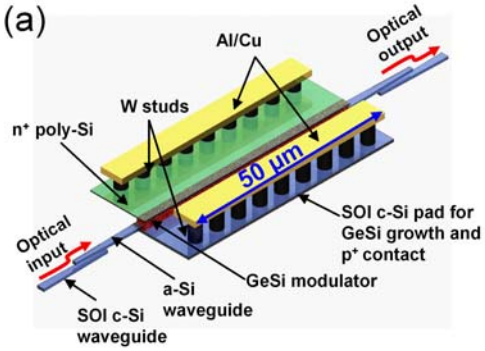


Figure 3.7: Our concept for low mass links. Low mass would be achieved by A) moving the lasers outside the tracking, b) using extremely low mass, low power light modulators in the tracking volume, and c) replacing fibers with optical links in air.



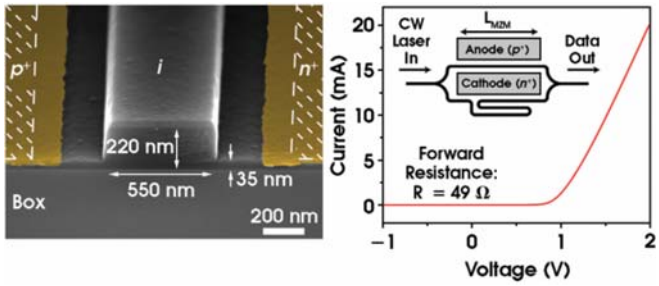


Figure 3.8(a): An example of a light modulator prototyped at MIT. Long dimension including couplings is about 100 microns, and it is integrated into a CMOS chip.

Figure 3.8(b): An example of a light modulator prototyped at IBM. Largest dimension is about 100 microns.

Figure 3.9

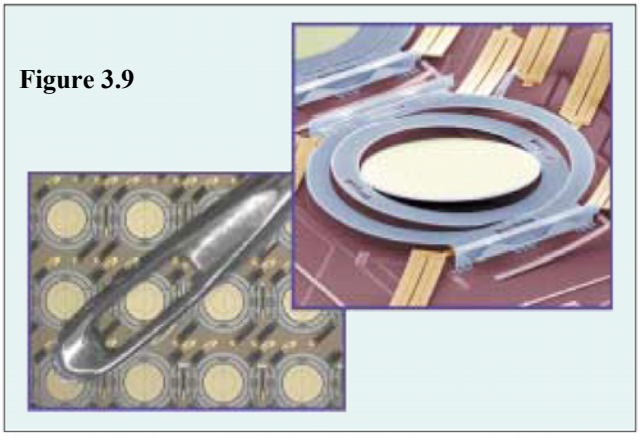


Figure 4. *Two images of MEMS-based OXC mirrors used in the Lucent LambdaRouter. The image in the upper right is a single mirror, and an array of mirrors is shown in the lower left. An eye of a needle is shown for comparison on the array.*

APPENDIX A: Curriculum Vita

Bernhard Werner Adams

X-Ray Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6454
E-mail: adams@aps.anl.gov

Education:

University of Karlsruhe (Germany), Vordiplom (equiv. BA) in Physics, 1986
University of Munich (Germany), Diploma (equiv. MA) in Physics, 1989
University of Munich (Germany), Doctoral degree (physics), 1995

Employment:

Lab and class teaching assistant, University of Munich, 1989 to 1995
Class teaching assistant, University of Hamburg, 1998-1999

Publications Related to Picosecond Instrumentation:

1. B.W. Adams, M.F. DeCamp, E.M. Dufresne, D.A. Reis, **Picosecond Laser-Pump, X-Ray Probe Spectroscopy of GaAs**, Rev. Sci. Instrum 73, 4150-4156 (2002)
2. B.W. Adams, **Femtosecond Synchronism of X-rays to Visible Light in an X-ray Free-Electron Laser**, Rev. Sci. Instrum. 76, 063304 (2005)
3. A. Grigoriev, D.-H. Do, D.M. Kim, C.-B. Eom, B. Adams, E. Dufresne, P.G. Evans, **Sub-nanosecond piezoelectric x-ray switch**, Appl. Phys. Lett. 89, 021109 (2006),
4. A. Grigoriev, D.-H. Do, D.M. Kim, C.-B. Eom, B. Adams, E.M. Dufresne, P.G. Evans, **Nanosecond Domain Wall Dynamics in Ferroelectric Pb(Zr,Ti)O3 Thin Films**, Phys. Rev. Lett. 96, 187601 (2006)
5. D.M. Fritz, D.A. Reis, B.W. Adams, R.A. Akre, J. Arthur, et al., **Ultrafast Bond Softening in Bismuth: Mapping the Interatomic Potential of a Solid with X-rays**, Science 315, 633-636 (2007)
6. A. Grigoriev, D.-H. Do, P.G. Evans, B. Adams, E. Landahl, E.M. **Dufresne Synchronizing fast electrically driven phenomena with synchrotron x-ray probes**, Rev. Sci. Instrum. 78, 023105 (2007)
7. B.W. Adams, **Femtosecond Synchronism of X-rays and Visible/Infrared Light in an XFEL**, Rev. Sci. Instrum. 78, 123302 (2007)

Other Selected Publications:

1. B.W. Adams (ed.), Nonlinear Optics, Quantum Optics, and **Ultrafast Phenomena with X-Rays**, subtitled Physics with X-Ray Free-Electron Lasers, Kluwer Acad. Publishers (2003), ISBN 1-4020- 7475-1.
2. B. Adams, D.V. Novikov, T. Hiort, G. Materlik, E. Kossel, **Atomic Holography with X-Rays**, Phys. Rev. B 57, 7526-7534 (1998)
3. B. Adams, P. Fernandez, W.-K. Lee, G. Materlik, D.M. Mills, D.V. Novikov, **Parametric down conversion of x-ray photons** J. Synchrotron Rad. 7, 81–88 (2000)
4. C. Ern, W. Donner, H. Dosch, B. Adams, D.V. Novikov, **Temperature-dependent interfacial stiffness of the disorder layer in a thin Cu3Au alloy film**, Phys. Rev. Lett. 85, 1926–1929 (2000)
5. B.W. Adams, **Time-Dependent Takagi-Taupin Eikonal Theory of X-Ray Diffraction in Rapidly Changing Crystal Structures**, Acta Cryst. A 60, 120-133 (2004)
6. A. Grigoriev, R. Sichel, H.N. Lee, E.C. Landahl, B. Adams, E.M. Dufresne, P.G. Evans, **Nonlinear Piezoelectricity in Epitaxial Ferroelectrics at High Electric Fields**, Phys. Rev. Lett. 100, 027604 (2008)
7. B.W. Adams, K. Attenkofer, O. Schmidt, **High-Resolution, Active-Optic X-ray Fluorescence Analyzer**, patent application filed by Argonne National Laboratory

John T. Anderson

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6081
Fax: 630-252-5782
E-mail: jta@anl.gov

Education:

BSECE, 1981, University of Wisconsin-Madison

Professional Employment:

2006-present : Argonne National Laboratory
1989-2006 : Fermi National Laboratory
1985-1989 : LeCroy Corporation
1983-1985 : University of Wisconsin Physical Sciences Laboratory
1982 : Wisconsin School of Electronics
1981 : Lunar Radiation Corporation

Awards, Memberships, and Professional Service:

Member of NIM committee 1993-1994
Member, VME International Trade Association, 1992

Selected Publications:

1. John T. Anderson, Renato Brito, Dionisio Doering, Todd Hayden, Bryan Holmes, John Joseph, Harold Yaver, Sergio Zimmermann**; "Data Acquisition and Trigger System of the Gamma Ray Energy Tracking In-Beam Nuclear Array (GRETINA)"**. IEEE Transactions on Nuclear Science, Vol. 56, No. 1, February 2009.
2. John T. Anderson, Lloyd Bridges, Brendan Casey, Yuji Enari, Johnny Green, Marvin Johnson, Rick Kwarciany, Chyi-Chiang Miao, Richard Partridge, Hwi Dong Yoo, Jigang Wang, **"Upgrade of the D0 luminosity monitor readout system"**. FERMILAB-CONF-06-470-E, Dec 2006.
3. Jamieson Olsen, John Anderson, Robert Angstadt, Levan Babukhadia, Mrinmoy Bhattacharjee, Gerald Blazey, Fred Borcherding, Brian Connolly, Michael Cooke, Satish Desai, David Evans, Paul Grannis, Stefan Grünendahl, Yuan Hu, Vivek Jain, Marvin Johnson, Stephan Linn, Juan Lizarazo, Yurii Maravin, Manuel Martin, Yildirim Mutaf, Carsten Nöding, Ricardo Ramirez-Gomez, Stefano Rapisarda, Kyle Stevenson, Makoto Tomoto, Brigitte Vachon, Thei Wijnen, Neal Wilcer, Graham Wilson, Qichun Xu, Kin Yip; **"The D0 Central Track Trigger"**; IEEE Trans.Nucl.Sci.51:345-350,2004.

Klaus Attenkofer

X-ray Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-0383
Fax: 630-252-0365
E-mail: Klaus.Attenkofer@anl.gov

Education:

The University of Hamburg: Ph.D. in Experimental Physics, 2000
Technical University of Munich: Diploma Thesis. in Experimental Physics, 1992 with honors

Professional Employment:

1993-1996 Member of the group of Prof. G. Schuetz
1997-2001 Beamline scientist at HASYLAB/DESY (Germany).
2001-2006 Assistant scientist at APS/USA (beamline scientist at 11-ID-D)
2006-present Scientist at APS/USA (beamline scientist at 11-ID-D)

Selected Publications:

1. **Attenkofer, K.**; Kodituwakku, N.; Ross, S.; Nielsen, T.; Nielsen, M.; Tiede, D.; Goerlich, M.; Adams, B.; "Using Coplanar Wave Guides To Excite Molecular Motions In The Frequency Range Of 10-1000GHz". *33rd International Conference on Infrared, Millimeter, and Terahertz Waves* **2008**.
2. Adams, B. W.; **Attenkofer, K**., "An active-optic x-ray fluorescence analyzer with high energy resolution, large solid angle coverage, and a large tuning range". *Review of Scientific Instruments* **2008,** 79, (2).
3. Chen, L. X.; Zhang, X. Y.; Wasinger, E. C.; **Attenkofer, K**.; Jennings, G.; Muresan, A. Z.; Lindsey, J. S., "Tracking electrons and atoms in a photoexcited metalloporphyrin by X-ray transient absorption spectroscopy". *Journal of the American Chemical Society* **2007,** 129, 9616.
4. **Attenkofer, K.**; Adams, B. W., "Tunable highly efficient crystal Analyzer based on active optics" - art. no. 63170R. *Advances in X-Ray/Euv Optics, Components, and Applications* **2006,** 6317, R3170-R3170.
5. Young, L. W.; Westcott, N. D.; **Attenkofer, K.**; Reaney, M. J. T., "A high-throughput determination of metal concentrations in whole intact Arabidopsis thaliana seeds using synchrotron-based X-ray fluorescence spectroscopy". *Journal of Synchrotron Radiation* **2006,** 13, 304-313.
6. **Attenkofer, K.**; Adams, B. W.; Beno, M. A., "Instrumentation for time-dependent x-ray resonant Raman scattering". *Synchrotron Radiation Instrumentation* **2004,** 705, 1138-1141.
7. Surgers, C.; Gajdzik, M.; Fischer, G.; von Lohneysen, H.; Welter, E.; **Attenkofer, K.**, "Preparation and structural characterization of ferromagnetic Mn5Si3Cx films". *Physical Review B* **2003,** 68, (17).
8. Lawniczak-Jablonska, K.; Suski, T.; Gorczyca, I.; Christensen, N. E.; **Attenkofer, K. E.**; Perera, R. C. C.; Gullikson, E. M.; Underwood, J. H.; Ederer, D. L.; Weber, Z. L., "Electronic states in valence and conduction bands of group-III nitrides: Experiment and theory". *Physical Review B* **2000,** 61, 16623-16632.

Patents:

Patent application by Argonne National Laboratory, named inventors B.W. Adams, **K. Attenkofer**, O. Schmidt, *High-resolution active-optic x-ray fluorescence analyzer*

Joseph P. Bernstein

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-7268
Fax: 630-252-5782
E-mail: jpbernst@anl.gov

Education:

University of Michigan, Ann Arbor, MI	Astronomy & Astrophysics	Ph.D. 2008
University of Michigan, Ann Arbor, MI	Astronomy & Astrophysics	M.S. 2002
University of Kentucky, Lexington, KY	Physics	M.S. 1998
University of Chicago, Chicago, IL	Physics	B.A. 1996

Professional Employment:

09/2007–present	Postdoctoral Researcher	Argonne National Laboratory
08/1999–04/2000	Adjunct Astronomy Faculty	Bluegrass Community & Tech. College

Awards, Memberships, and Professional Service:

01/2007–04/2007	Rackham Graduate School One-Term Dissertation Fellow, U. MI
09/2003–08/2006	NASA/GSFC Graduate Student Researchers Program Fellow
09/2000–04/2003	Rackham Graduate School Regents' Fellow, U. Michigan
08/1996–07/1997	U.S. Dept. of Ed. Areas of National Need Fellow, U. Kentucky
06/1996	General and Departmental Honors, The College, U. Chicago
1994-1996	Academic Year Dean's List, The College, U. Chicago

Selected Publications:

Peer Reviewed

1. J. P. Bernstein, I. M. Harrus, P. O. Slane, B. M. Gaensler, J. P. Hughes, D. Moffett, R. Dodson, **"Chandra Study of the Synchrotron Nebula in the Supernova Remnant MSH 11-62"**,Astrophysical Journal, in preparation (2009).

2. J. P. Bernstein & P. A. Hughes, **"Refining a relativistic, hydrodynamic solver: admitting ultra-relativistic flows"**, Journal of Computational Physics, accepted (2009).

3. J. P. Bernstein & S. P. Bhavsar, **"Models for the Magnitude-Distribution of Brightest Cluster Galaxies"**, Monthly Notices Royal Astronomical Society, Vol. 322, pp. 625-630 (2001).

Selected Proceedings

4. J. P. Bernstein, R. Kessler, S. Kuhlmann, H. Spinka, **"Dark Energy Survey Supernovae: Simulations and Survey Strategy"**, Moriond Cosmology proceedings, in press (2008).

5. J. P. Bernstein, **"Probing the Depths: Relativistic, Hydrodynamic Simulations and X-ray Observations of Pulsar Wind Nebulae"**, American Astronomical Society meeting #211, oral dissertation presentation #144.04. (2007)

6. S. P. Bhavsar & J. P. Bernstein, **"A Model for Brightest Galaxies Using Extreme Value Statistics"**, Statistical Challenges in Modern Astronomy III, Eric D. Feigelson & G. Jogesh Babu (Eds.), pp. 333-334, New York:Springer-Verlag (2002).

Karen Byrum

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6217
Fax: 630-252-5782
E-mail: byrum@anl.gov

Education:

B.S., Old Dominion University 1983
Ph.D., University of Wisconsin, Madison 1991

Professional Employment:

Physicist, ANL (2000-present)
Assistant Physicist, ANL (1995-2000)
Postdoctoral Fellow, ANL (1992-1995)

Awards, Memberships, and Professional Service:

D.O.E. Review panels (LBL, Dark Energy)
Conference organization (15+)
Invited talks (5 at international conferences)
Publications including conference proceedings (532).
Unpublished technical reports (43)
ANL service committee work (LDRD, Strategic Planning, Pacesetter)
ANL Strategic Initiative Leader for Astrophysics and Cosmology
Graduate of first cohort of Strategic Laboratory Leadership Program (2007-2008)
Elected Member of Fermilab Users Committee (1997-1999)
CDF Service work (convenerships, detector reviews, Shift Leader)
VERITAS Service work (Science Board, Speakers Committee, Shifts)

Selected Research Accomplishments:

Leader of Laboratory Astrophysics Program (2007-2010).
White Paper on the Status and Future of Ground-based Gamma-ray Astronomy (2007)
TrICE Telescope (2005/06).
Construction and operation of CDF shower maximum frontend electronics (1995-).
Shower max. e/γ level-2 trigger (1992-).
Observations of first forward/backward muons at CDF (1988-)

Selected Publications:

1. **"Discovery of Very High-Energy Gamma-Ray Radiation from the BL Lac 1ES 0806+524"**, Astrophysical Journal Letters, Vol 690, Issue 2, pp. L126-L129 (2009)
2. **"A Search for Dark Mtter Annihilation with the Whipple 10m Telescope"**, M.Wood et al, Astrophysical Journal, Vol. 678, Issue 2, pp 594-605 (2008)
3. **"The TrICE Prototype MAMPT Imaging Camera"**, K. Byrum et. el., 30th International Cosmic Ray Conference.arXiv:0710.0659v1 (2007)
4. **"Observation of Bs Oscillations",** Phys. Rev. Lett. 97 242003 (2006)
5. **"Measurement of sin 2β",** Phys. Rev. D61: 072005 (2000).
6. **"Measurement of B^+ and B^0 Lifetimes",** Phys. Rev. Lett. 76: 4462 (1996).
7. **"Shower Maximum Trigger for Electrons and Photons at CDF"**, K. Byrum, et. el Nucl. Instrum. Methods, A364 (1995).

8. **"Observation of Top Quark Production in ppbar Collisions with the Collider Detector at Fermilab"**, (CDF) Phys. Rev. Lett. 74, 2626 (1995).

Aaron M. Datesman

Materials Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-9154
Fax: 630-252-5219
E-mail: datesman@anl.gov

Education:

Ph.D. Electrical & Computer Engineering, University of Virginia, 2005
M.S. Electrical Engineering, University of Virginia, 1999
B.S. Applied Physics, Yale University, 1993

Professional Employment:

Post-Doctoral Researcher, Argonne National Laboratory, 2007-present
Principal Research & Development Engineer, Nokomis, Inc., 2006
Sr. Engineer (B), Bechtel Bettis Inc., 2005

Awards, Memberships, and Professional Service:

Engineers Without Borders (Executive Committee of Chicago Prof. Chapter)
IEEE, Eta Kappa Nu, Illinois Solar Energy Association

Selected Publications:

1. Yefremenko, Novosad, Datesman, Pearson, Gordiyenko, Shustakova, Fomenko, **"A broadband imaging system for research applications"**, *Rev. Sci. Inst.*, 2009.
2. Datesman, Wang, Yefremenko, Pearson, Novosad, Divan, Bleem, Chang, Crites, Downes, McMahon, Meyer, Carlstrom, Wilson, Perera, **"TES Development for a Frequency Selective Bolometer Camera"**, *IEEE Trans. App. Superconductivity,* 2009.
3. Wang, Yefremenko, Datesman, Pearson, Novosad, Divan, Bleem, Chang, Crites, Downes, McMahon, Meyer, Carlstrom, **"Absorber Type TES Bolometer for Polarimetry at Millimeter and Sub-millimeter Wavelengths"**, *IEEE Trans. App. Superconductivity,* 2009.
4. Yefremenko, Datesman, Wang, Pearson, Divan, Novosad, Chang, Crawford, Downes, McMahon, Miknaitis, Vieira, Meyer, Carlstrom, **"Control of Membrane Thermal Transport Supporting Superconducting Detector Development"**, *IEEE Trans. App. Superconductivity,* 2009.
5. Chang, Carlstrom, Datesman, Meyer, Novosad, Yefremenko, Crawford, Downes, McMahon, Miknaitis, Vieira, **"Design and Fabrication of Absorber Coupled TES Microbolometers on Continuous Silicon-Nitride Windows"**, *Journal of Low Temperature Physics*, vol. 151, iss. 1-2, pages 245-248, 2008.
6. Khovaylo, Kainuma, Ishida, Omori, Miki, Takagi, Datesman, **"New aspects of martensite stabilization in Ni-Mn-Ga high-temperature shape memory alloy"**, *Philosophical Magazine*, vol. 88, iss. 6, pp. 865-882, 2008.
7. Datesman, Schultz, Lichtenberger, Golish, Walker, Kooi, **"Fabrication and characterization of niobium diffusion-cooled hot-electron bolometers on silicon nitride membranes"**, *IEEE Trans. Appl. Superconductivity*, vol. 15, iss. 2, pp. 928-931, June 2005.
8. Datesman, Schultz, Cecil, Lyons, Lichtenberger, **"Gallium ion implantation into niobium thin films using a focused-ion beam"**, *IEEE Trans. Appl. Superconductivity*, vol. 15, iss. 2, pp. 3524-3527, June 2005.

Gary Drake

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-1568
Fax: 630-252-5047
E-mail: drake@anl.gov

Education:

B.S.E.E., University of Wisconsin – Madison, 1982
M.S.E.E., University of Wisconsin – Madison, 1983

Professional Employment:

Senior Engineer, ANL (2008-)
Engineer, ANL (1997-2008)
Engineer, Fermilab (1983-1997)

Awards, Memberships, and Professional Service:

Member, IEEE (1994)
Publications (18)
Additional published conference proceedings (25)
Unpublished technical reports (46)

Selected Research Accomplishments:

Design Engineer, development of electronics for the calorimeters of the CDF detector, Run I at Fermilab (1983-1989).
Design of custom integrated circuits (1994-1996).
Lead Project Engineer, design and production of front-end electronics for the Shower Maximum Detector for the CDF, Run II Upgrade at Fermilab (1995-1999).
Lead Project Engineer and Level 3 Manager, development of electronics for the MINOS Near Detector at Fermilab (1999-2005).
Lead System Engineer, design and production of readout instrumentation for Digital Hadron Detector R&D for CALICE (Detector R&D for the International Linear Collider) (2003-present).
R&D on detector development using silicon photomultipliers (2006-2008).
Lead engineer, development of switching power supplies for the Barrel Calorimeter of the ATLAS Experiment at the LHC at CERN in Switzerland (2006-present).
Lead engineer, design of high-speed topological trigger for telescope arrays for gamma-ray astronomy (2007-present).
Development of new switching power supplies for the upgrade of the Barrel Calorimeter of the ATLAS Experiment at the LHC at CERN in Switzerland (2008-present).
Development of new readout instrumentation for the upgrade of the Barrel Calorimeter of the ATLAS Experiment at the LHC at CERN in Switzerland (2008-present).

Selected Publications:

1. **"A New High-Speed Pattern Recognition Trigger for Ground-Based Telescope Arrays Used in Gamma-Ray Astronomy"**, *IEEE 2008 NSS Conf. Rec.,* 2008, 8 pages.
2. **"The MINOS Near Detector Front End Electronics"**, *IEEE Trans. Nucl. Sci.,* vol. 53, 2006, pp. 1347-1355.
3. **"A Digital Hadron Calorimeter with Resistive Plate Chambers for the Linear Collider"**, *Int. J. Mod. Phys,* Vol. A20, 2005, pp. 3830-3833.
4. **"DCAL: A Custom Integrated Circuit for Calorimetry at the International Linear Collider"**, *IEEE 2005 NSS Conf. Rec.,* 2005, 8 pages.
5. **"The Shower Maximum Front-End Electronics for the CDF Upgrade"**, *IEEE Trans .Nucl. Sci.,* vol. 49, 2002, pp. 2567-2573.

6. **"The Upgraded CDF Front End Electronics for Calorimetry",** *IEEE Trans. Nucl. Sci.*, vol. 39, 1992, pp. 1281-1285.
7. **"CDF Front End Electronics: The RABBIT System"**, *Nucl. Instrum. Meth.*, vol. A269, 1988, pp. 68-81.

Jeffrey W. Elam

Energy Systems Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-3520
Fax: 630-252-0868
E-mail: jelam@anl.gov

Education:

The University of Chicago: Ph.D. in Physical Chemistry, 1995
Cornell University: B.A. in Chemistry, *Summa cum Laude*, 1988

Professional Employment:

2000-2002 Senior Research Associate, University of Colorado
2002-2005 Visiting Scientist, Argonne National Laboratory
2005-2009 Chemist, Argonne National Laboratory

Selected Recent Publications :

1. J. W. Elam, G. Xiong, C. Y. Han, H. Hau Wang, J. P. Birrell,U. Welp, J. N. Hryn, M. J. Pellin, T. F. Baumann, J. F. Poco, and J. H. Satcher, Jr, **"Atomic Layer Deposition for the Conformal Coating of Nanoporous Materials"**, Journal of Nanomaterials, **2006**, 1–5, (2006).
2. T. W. Hamann, A. B. F. Martinson, J. W. Elam, M. J. Pellin, and J. T. Hupp, **"Atomic Layer Deposition of TiO_2 on Aerogel Templates: New Photoanodes for Dye-Sensitized Solar Cells"**, J. Phys. Chem. C, **112** (27), 10303–10307, (2008).
3. T. W. Hamann, A. B. F. Martinson, J. W. Elam, M. J. Pellin, and J. T. Hupp, **"Aerogel Templated ZnO Dye-Sensitized Solar Cells"**, Advanced Materials, in Press, (2007).
4. A. B. F. Martinson, J. W. Elam, J. T. Hupp, and M. J. Pellin, **"ZnO Nanotube Based Dye-Sensitized Solar Cells"**, Nano Letters, **7** (8) 2183-2187, (2007).
5. J. W. Elam, D. A. Baker, A. B. F. Martinson, M. J. Pellin, and J. T. Hupp, **"Atomic Layer Deposition of Indium Tin Oxide Films Using Nonhalogenated Precursors"**, J. Phys. Chem. C, **112**, 1938-1945, (2007).
6. S. O. Kucheyeva, J. Biener, Y. M. Wang, T. F. Baumann, K. J. Wu, T. van Buuren, A. V. Hamza, and J. H. Satcher, Jr., J. W. Elam and M. J. Pellin, **"Atomic Layer Deposition of ZnO on Ultralow-Density Nanoporous Silica Aerogel Monoliths"**, Appl. Phys. Lett., **86**, 083108 (2005).
7. J. W. Elam, D. A. Baker, A. J. Hryn, A. B. F. Martinson, M. J. Pellin, and J. T. Hupp, **"Atomic Layer Deposition of Tin Oxide Films Using Tetrakis(dimethylamino) Tin"**, J. Vac. Sci. Tech. A., **26** (2) 244-252, (2008).
8. J. W. Elam, J. A. Libera, P. C. Stair, and M. J. Pellin, **"Spatially Controlled Atomic Layer Deposition in Porous Materials"**, Appl. Phys. Lett., **91** 243105-1 – 243105-3, (2007).

Henry J. Frisch

Enrico Fermi Institute
5640 S. Ellis Ave
Chicago, IL 60637

Phone: (773)702-7479
FAX: (773)834-5959
E-mail: frisch@hep.uchicago.edu

Education and Training:
B.A. (Physics), 1966, Harvard University
Ph.D. (Physics), 1971, Univ. of California, Berkeley

Research and Professional Experience:
1984-present: Professor of Physics, University of Chicago
1977-84: Associate Professor of Physics, University of Chicago
1973-77: Assistant Professor of Physics, University of Chicago
1971-73: Instructor of Physics, University of Chicago

Selected Publications:

1. **A limit on the Branching Ratio of the Flavor-Changing Top Quark Decay t->Zc ,** with Alexander Paramonov and the CDF Run II Collaboration (A. Abulencia et al.). To be submitted to Phys. Rev. D., Spring 2009.
2. **Large area, pico-second resolution, time of flight detectors**, United States Patent 20070187596; (with Harold Sanders, Fukun Tang, and Timothy Credo).
3. **New Developments in Fast-Sampling Analog Readout of MCP-Based Large-Area Picosecond Time-of-Flight Detectors**, (with Fukun Tang et al.); Proceedings of IEEE 08, October 2008, Dresden Germany.
4. **Transmission-Line Readout with Good Time and Space Resolutions for a Planicon MCP-PMT**, with Fukun Tang et al.; Poster presented at the Topical Workshop on Electronics for Particle Physics (TWEPP), Prague, Czech Republic, Sept. 6, 2007.
5. **The Timing System for the CDF Electromagnetic Calorimeters**; with M. Goncharov, D. Toback, et al.; Nucl. Instrum. Meth. A **565:538-542**, 2006.
6. **MCP-PMT Anode Development of Psec-Resolution Time-of-flight Detectors**, with Timothy Credo et al.; IEEE 2006 Nuclear Science Symposium, San Diego, May 2006.
7. **A 96-channel FPGA-based Time-to-Digital Converter**, with M. Bogdan et al.; Nucl. Instrum. Meth. A **554**, 444 (2005).
8. **Virtual Prototype Method Used in Design of Electronic Circuitry for CDF**; with W. Ashmanskas et al.; Nucl. Instrum. Meth. A **518**, 491 (2004).

Synergistic Activities:
SLAC Experimental Program Advisory Committee, 1987-89 1989 HEPAP Subpanel: "HEP and SSC Over the Next Decade"
Chair, Nominating Committee, Division of Particles and Fields, APS, 1992
Fermilab Program Advisory Committee, 1990-94
Panofsky Prize Committee, American Physical Society, 1994-95
Divisional Councilor, Division of Particles and Fields, APS, 1/95-12/98
Committee on the International Freedom of Scientists, 1996-1998
Vice-Chair, Board of the Bulletin of the Atomic Scientists, 2003- 2005
Tanaka Prize Committee, American Physical Society, 2005
Board of the Bulletin of the Atomic Scientists, 2002- present
Spokesperson of the Committee of the Council of the University Senate (elected) 2004-2005
Organizing Committee: Aspen Winter Conference, ``New Physics at the Electroweak Scale and New Signals at Hadron Colliders", Jan. 8-13, 2007
Organizing Committee: Pico-Sec Timing Hardware Workshop; Chicago, IL, USA; 18 Nov., 2005
Organizing Committee: Pico-Sec Simulation Workshop; Chicago, IL, USA; 12 December, 2006
Organizing Committee: Workshop on Timing Detectors, March 8-9, 2007, Saclay, France
Organizing Committee: XXXXIIIth Rencontres de Moriond --Electroweak Interactions and Unified Theories, March 1-8, 2008, La Thuile, Italy
Organizing Committee: Workshop on Psec Timing, Chicago, IL, USA; March 17-18, 2008

Organizing Committee: Workshop on Picosecond Timing, Lyon, France; Oct. 15-16, 2008

Victor Guarino

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-3971
Fax: 630-252-5782
E-mail: vjg@anl.gov

Education:

B.S., Illinois Institute of Technology 1987
M.S., Illinois Institute of Technology 1988
Ph.D., University of Illinois at Chicago 1999

Professional Employment:

Engineer, ANL (1993-)
Assistant Engineer, ANL (1989-1993)

Awards, Memberships, and Professional Service:

- Licensed Illinois Professional Engineer
- U.S. ATLAS Tilecalorimeter Project Engineer – responsible for all US structural design, fabrication, and assembly on the ATLAS Tilecalorimeter at the LHC
- NOvA Project Engineer – responsible for the analysis of the NOvA structure and the design and fabrication of all construction equipment for the detector
- MINOS Project Engineer – responsible for the design and fabrication of machinery for constructing MINOS modules.

Selected Publications:

1. **"Stability of the EB When Cryostat Load is Applied"** Argonne National Laboratory Technical Report ANL-HEP-TR-04-65; June 23, 2004
2. **"Analysis of the Connections Between Modules in the EB"** Argonne National Laboratory Technical Report ANL-HEP-TR-02-056; May 16, 2002
3. **"Stress Analysis Of The Welds In The Girder"** Argonne National Laboratory Technical Report ANL-HEP-TR-98-06; December 1, 1997
4. **"Extended Barrel Support Saddle Design and Analysis"** presented at the Atlas engineering meeting at The European Center for Nuclear Research (CERN), Geneva, Switzerland; August, 2001
5. **"Proposal for the Completion of the Outstanding Work, Scheduling and Alignment of the SDC Central Calorimeter"** Argonne National Laboratory Technical Report ANL-HEP-TR-93-101; November 1993

Zinetula (Zeke) Insepov

Mathematics and Computer Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-5049
Fax: 630-252-5986
E-mail: insepov@anl.gov

Education:

D.Sc. (Chemical Physics) **Semyonov Chemical Physics Institute, Moscow Russia 1994 ; Ph.D.** (Semiconductor Physics) **Lebedev Physics Institute, Moscow Russia 1977; MS** (Semiconductor engineering) **Moscow Power Engineering Institute, Moscow Russia 1972** (Summa Cum Laude)

Professional Employment:

Computational Materials Scientist (April, 2006-present), Mathematics and Computer Science Division of Argonne National Laboratory (ANL); **Visiting scientist (**April, 2003-April, 2006), Energy Technology Division of ANL; **Manager for Research and Development** (April, 2000 - March, 2003), Epion Japan Corp. Japan; **Chair of New Materials Research (**August, 1992– March, 2000**)**, Ion Beam Engineering Experimental Laboratory of Kyoto University, Japan.

Awards, Memberships, and Professional Service:

Kyoto University Ion Beam Engineering Awards, to hold a New Materials Research Chair at Kyoto University, Japan (1992/93, 1994/95, 1995/96, 1997/98, 1998/99, 1999/2000)

Selected Publications:

1. A.T. Wu, D.R. Swenson, P. Kneisel, G. Wu, Z. Insepov, et al, in the book **"Particle Accelerators: Research, Technology, and Applications"**, 7/29-2008.
2. Z. Insepov, M. Terasawa, K. Takayama, Phys. Rev. A 77 (2008) 062901.
3. Z. Insepov, J. Norem, D. Swenson, A. Hassanein, Vacuum 82 (2008) pp. 872–879.
4. Z. Insepov, J. Norem, D.R. Swenson, A. Hassanein, M. Terasawa, Nucl. Inst. Meth. in Phys. Res. B 258 (2007) 172-177.
5. Z. Insepov, A. Hassanein, J. Norem, D.R. Swenson, Nucl. Inst. Meth. in Phys. Res. B 261 (2007) 664-668.
6. Z. Insepov, J. Norem, D.R. Swenson, A. Hassanein, Materials Science Problems of the SCRF Q-Slope, AIP Conf. Proc. Vol. 877 (2006) pp. 288-296.
7. A. Hassanein, Z. Insepov, J. Norem et al., Phys. Rev. ST AB 9 (2006) 062001.
8. Z. Insepov, J. Norem, A. Hassanein, Phys. Rev. ST AB 7 (2004) 122001

Andrew Scott Kreps

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-5671
Fax: 630-252-5782
Email: akreps@anl.gov

Education:

Bachelor of Science in Computer Engineering
University of Illinois, Champaign-Urbana, IL

Professional Employment:

Argonne National Laboratory, Argonne, IL 60439
High Energy Physics Division - Engineering Specialist (2004 - Present)
Electronics & Computing Technologies Division - Engineering Specialist (2000 - 2004)

Awards, Memberships, and Professional Service:

None

Selected Publications:

1. **A topological array trigger for AGIS, the Advanced Gamma-ray Imaging System.**
   F. Krennrich *et al.* 2009. 4pp.
   Published in AIP Conf.Proc.1085:894-897, 2009.
2. **A new high-speed pattern recognition trigger for ground-based telescope arrays used in gamma ray astronomy**
   Anderson, John; Byrum, Karen; Dawson, John; Drake, Gary; Haberichter, Bill; Horan, Deirdre; Krennrich, Frank; Kreps, Andrew; Madhavan, A.; Schroedter, Martin; Smith, Andy;
   Nuclear Science Symposium Conference Record, 2008. NSS '08. IEEE
   19-25 Oct. 2008 Page(s):2773 - 2780
3. **Calibration of a digital hadron calorimeter with muons.**
   Burak Bilki *et al.* FERMILAB-PUB-08-066-E, Feb 2008. 17pp.
   Published in JINST 3:P05001, 2008.
4. **A new readout system for "Digital Hadron Calorimetry" for the International Linear Collider**
   Butler, J.; Cundiff, T.; Drake, G.; Haberichter, W.N.; Hazen, E.; Hoff, J.; Holm, S.; Kreps, A.; May, E.; Repond, J.; Underwood, D.; White, A.P.; Shouxiang Wu; Lei Xia; Jaehoon Yu;
   Nuclear Science Symposium Conference Record, 2007. NSS '07. IEEE
   Volume 3, Oct. 26 2007-Nov. 3 2007 Page(s):2145 - 2153
5. **2-D scintillation position-sensitive neutron detector**
   De Lurgio, P.M.; Farrar, K.A.; Kreps, A.S.; Madden, T.J.; Naday, I.; Weizeorick, J.T.; Hammonds, J.P.; Miller, M.E.; Schultz, A.J.;
   Nuclear Science Symposium Conference Record, 2005 IEEE
   Volume 2, 23-29 Oct. 2005 Page(s):648 - 653
6. **A new detector for time-resolved small angle X-ray scattering studies**
   De Lurgio, P.M.; Hessler, J.P.; Weizeorick, J.T.; Kreps, A.S.; Molitsky, M.J.; Naday, I.; Drake, G.R.; Jennings, G.;
   Nuclear Science Symposium Conference Record, 2005 IEEE
   Volume 2, 23-29 Oct. 2005 Page(s):1215 - 1222

Stephen Kuhlmann

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6284
Fax: 630-252-5782
E-mail: Kuhlmann@anl.gov

Education:

- Purdue University (1988, Ph.D. Physics)
- Wichita State University (1984, B.S. Physics)

Professional Employment:

- Argonne National Laboratory – High Energy Physics Division
  - Physicist (October 1997 until Present)
  - Assistant Physicist (October 1992 – October 1997)
  - Enrico Fermi Fellow (October 1990 – October 1992)
  - Postdoctoral Appointee (July 1988 – October 1990)

Awards, Memberships, and Professional Service:

- Dark Energy Survey ANL group leader
- Member SDSS Supernova group
- Member LSST Supernova group
- Member American Astronomical Society
- Airfly/Auger Collaboration member (April 2004 – December 2007)
- Former DOE Level 2 Manager CDF Calorimeter Upgrade
- Former Project Leader CDF Preshower Detector Upgrade
- Former CTEQ Co-Spokesperson
- Former Physics Coordinator CDF QCD Group
- SSC Fellowship

Selected Publications:

1. **"SNANA: a Public Software Package for Supernova Analysis"**, R. Kessler *et al.,* submitted to Publications of the Astronomical Society of the Pacific
2. **"Dark Energy Survey Supernovae Simulations and Survey Strategy"**, J. P. Bernstein, R. Kessler, S. Kuhlmann, H. Spinka, Dark Energy Survey Collaboration, in "Cosmology. Proceedings of the 43rd Rencontres de Moriond", Eds. J. Dumarchez, Y. Giraud Heraud, and J. Tran Thanh Van, World Publishing Company, Hanoi, Vietnam, 2009
3. **"Global QCD Analysis Of Parton Structure Of The Nucleon: CTEQ5 Parton Distributions"**, H.L. Lai *et al.,* Eur.Phys.J.C12:375-392,2000
4. **"Observation of Top Quark Production in Anti-P P Collisions"**, CDF Collaboration (F. Abe *et al.*), Phys.Rev.Lett.74:2626-2631,1

Edward May

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6222
Fax: 630-252-5782
E-mail: may@anl.gov

Education:

- Ph.D Physics, May 1976, University of Rochester, Rochester, New York, USA
- B.Sc Physics, June 1968, Clarkson College, Potsdam, New York, USA

Professional Employment:

- Dec 1985 - present, Physicist, High Energy Physics Division,
  - Argonne National Laboratory, Argonne IL, USA
- Dec 1980 - Dec 1985, Assistant Physicist, High Energy Physics Division,
  - Argonne National Laboratory, Argonne IL, USA
- Dec 1977 - Dec 1980, Post Doctoral Appointment, High Energy Physics Division,
  - Argonne National Laboratory, Argonne IL, USA
- June 1976 - November 1977, Post Doctoral Appointment,
  - Physics Department, University of Rochester, Rochester, New York, U

Selected Recent Publications :

1. **"Beam test- of a Tiime-of-Flight detector prototype"**, J. Va'vra, D.W.G.S. Leith, B. Ratcliff, E. Ramberg, M. Albrow, A. Ronzhin, C. Ertley, T. Natoli, E. May, K. Byrum, Nuclear Inst. and Methods in Physics Research, A 606 (2009) pp. 404-410

2. **"Testing a silicon photomultiplier time-of-flight (TOF) system in Fermilab Test Beam Facility"**, Ronzhin, A.; Ramberg, E.; Albrow, M.; Vavra, J.;Frisch, H.; Natoli, T.; Ertley, C.; Kim, H.; Kobach, A.; Tang, F.; Wilbur, S.; Genat, J.-F.; May, E.; Byrum, K.; Anderson, J.; Drake, G.; Nuclear Science Symposium Conference Record, 2008. NSS '08. IEEE 19-25 Oct. 2008 Page(s):2392 – 2394.

3. **"New developments in fast-sampling readout of Micro-Channel Plate based large area pico-second time-of-flight detectors",** Anderson, John T.; Byrum, Karen; Drake, Gary; Ertley, Camden; Frisch, Henry J.; Genat, Jean-Francois; May, Edward; Salek, David; Tang, Fukun; Nuclear Science Symposium Conference Record, 2008. NSS '08. IEEE 19-25 Oct. 2008 Page(s):2478 – 2481.

4. **"Calibration of a digital hadron calorimeter with muons"**, Burak Bilki et al. FERMILAB-PUB-08-066-E, Feb 2008. 17pp. Published in JINST 3:P05001,2008.

5. **"A data skimming service for locally resident analysis data"**, J. Cranshaw (Argonne) , R.W. Gardner (Chicago U., EFI) , G. Gieraltowski, D. Malon (Argonne) , M. Mambelli (Chicago U., EFI) , E. May (Argonne) . 2008. 9pp. Published in J.Phys.Conf.Ser.119:072011, 2008.

6. **"GSIMF: A web service based software and database management system for the next generation grids"**, Nanbor Wang, Balamurali Ananthan (Tech-X, Boulder) , Gerald Gieraltowski, Edward May, Alexandre Vaniachine (Argonne) . 2008. 7pp. Published in J.Phys.Conf.Ser.119:062049,2008.

Val Novosad

Materials Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-5507
Fax: 630-252-7777
E-mail: novosad@anl.gov

Education:

- Postdoctoral Fellow, Materials Science Department, Tohoku University, Japan (1998-2001).
- Ph.D. in Physics, Verkin Institute for Low Temperature Physics and Engineering, National Academy of Sciences, Kharkov / Ukraine (1998).
- State Diploma in Mechanical Engineering (with Honors), Zhukovsky National Aerospace University of Ukraine (1993).

Professional Employment:

- 2005 - Present: Materials Scientist, Mat. Sc. Div., Argonne Nat. Laboratory (MSD/ANL)
- 2001 - 2004: Assistant Scientist, MSD/ANL.

Awards, Memberships, and Professional Service:

- Post-doctoral Fellowship of Japanese Ministry of Education, 1998.
- Best PhD Student Award, International Science Soros Foundation (USA-Ukraine), 1996.
- Referee, Journal for Chemistry and Physics of Solids, Journal of Magnetism and Magnetic Materials, Journal of Applied Physics, Applied Physics Letters, Physical Review B, Physical Review Letters, Journal of Nanotechnology and Nanoletters.
- Reviewer for U. S. Department of Energy's SBIRR/ STTR programs (2007-08).

Selected Publications:

1. V. Yefremenko, G. Wang, V. Novosad, A. Datesman, J. Pearson, R. Divan, C. Chang, T. Downes, J. McMahon, L. Bleem, A. Crites, S.S. Meyer, and J.E. Carlstrom, **"Low Temperature Thermal Transport in Partially Perforated Silicon Nitride Membranes"**, Appl. Phys. Letter, **94**, 183504 (2009).
2. V. Yefremenko, A. Datesman, G. Wang, J. Pearson, V. Novosad, R. Divan, C. Chang, T. Downes, L. Bleem, A. Crites, S.S. Meyer, and J.E. Carlstrom, **"Control of Membrane Thermal Transport Supporting Superconducting Detector Development",** IEEE Trans. of Applied Superconductivity, accepted.
3. V. Yefremenko , E. Gordiyenko , G. Shustakova , Yu. Fomenko , A. Datesman , G. Wang, J. Pearson, E.E. W. Cohen, and V. Novosad, **"A broadband imaging system for research applications",** Review of Scientific Instruments, **80**, 056104 ,2009.
4. G. Wang, V. Yefremenko, A. Datesman, J. Pearson, V. Novosad, R. Divan, C. Cheng, T. Downes, J. McMahon, L. Bleem, A. T. Crites, S. S. Meyer, and J. E. Carlstrom , **"Absorber Type TES Bolometer for Polarimetry at Millimeter and Sub-millimeter Wavelength",** IEEE Trans. of Applied Superconductivity, accepted.
5. A. Belkin, V. Novosad, M. Iavarone, J. Fedor, J. Pearson, A. Petrean-Troncalli, and G. Karapetrov, **"Tunable transport in magnetically coupled MoGe/Permalloy hybrids"**, Appl. Phys. Lett., **93**, 072510 (2008).
6. A. Datesman, J. Pearson, G. Wang, V. Yefremenko, R. Divan, T. Downes, C. Chang, J. McMahon, S. Meyer, J. Carlstrom, D. Logan, T. Perera, G. Wilson, and V. Novosad, **"Frequency selective bolometer development at Argonne National Laboratory",** *Millimeter and Submillimeter Detectors and Instrumentation for Astronomy IV*, Book Series: Proc. of SPIE, Vol. **7020**, pp 2029-2029, 2008.
7. A.Datesman, T. Downes, C. Chang, T. Perera, D. Logan, S. Meyer, G. Wilson, G. Wang, V. Yefremenko, V. Novosad, J.Pearson, R.Divan, L. Bleem, A. Crites, J. McMahon, and J. Carlstrom, **"TES Development for a Frequency Selective Bolometer"**, IEEE Trans. of Applied Superconductivity, accepted.
8. V. Yefremenko, E. Gordiyenko, V. Pishko, and V. Novosad, **"METHOD FOR DETECTION AND IMAGING OVER A BROAD SPECTRAL RANGE"**, US Patent # 7,274,019 B2, Sept. 25, 2007.
9. V Yefremenko, E. Gordiyenko, G Shustakova, S D Bader, G Karapetrov and V Novosad, "**Optically activated**

high Tc superconducting microbolometer”, Journal of Physics: Conference Series vol.**43**, no.1 : 1342-5, 2006.

John E. Pearson

Materials Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-7738
Fax: 630-252-7777
E-mail: Pearson@anl.gov

Education:

Aug. 1987	M.S. degree in Engineering Mechanics and Materials from Southern Illinois University at Carbondale. (Thesis Title: Elastic Softening and Structural Changes of Silicon and Zr_3Al due to Ion Irradiation)
May 1985	B.S. degree in Engineering Mechanics and Materials with a minor in Mathematics from Southern Illinois University at Carbondale.

Professional Employment:

2009- present	Principal Materials Engineer in the Materials Science Division at Argonne National Laboratory at Argonne, Illinois. Independently develops experimental facilities for depositing lithographically patterned films and magnetic properties measurement.
2005- 2009	Engineer in the Magnetic Films Group of the Materials Science Division
2000- 2005	Senior Scientific Associate in the Magnetic Films Group of the Materials Science Division
1994-2000	Scientific Associate in the Magnetic Films Group of the Materials Science Division
1987-1994	Scientific Assistant in the Magnetic Films Group of the Materials Science Division

Awards, Memberships, and Professional Service:
Member American Vacuum Society

Outstanding Scientific Accomplishment in Solid State Physics category in the Department of Energy's 1992 Materials Sciences Research Competition.

Recipient of 2008 UChicago Argonne, LLC Board of Governors, Outstanding Service Award

Selected Publications:

1. **"Magnetic Phase Transition of Ultrathin Fe films on Ag (111)"**, Z.Q. Qiu, J. Pearson, and S.D. Bader, Phys. Rev. Lett. 67, 1646 (1991)
2. **"Interfacial Roughness of Sputtered Multilayers: Nb/Si"**, Eric E. Fullerton, J. Pearson, C.H. Sowers, S.D. Bader, X.Z. Wu, and S.K. Sinha, Phys. Rev. B 48, 17432 (1994).
3. **"Subwavelength Focusing and Guiding of Surface Plasmons",** L. Yin, V. K. Vlasko-Vlasov, J. Pearson, J. M. Hiller, J. Hua, U. Welp, D. E. Brown, C. W. Kimball, Nano Lett. 5(7), 1399-1402 (2005)
4. **"Multiplexing Surface Plasmon Polaritons on Nanowires"**, A Imre (ANL/MSD-CNM), V. K. Vlasko-Vlasov, J. Pearson, J. M. Hiller, U. Welp, Appl. Phys. Lett. 91, 83115 (2007)

Thomas Proslier

Materials Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-8457
Fax: 630-252-5782
E-mail: prolier@anl.gov

Education:

University Pierre et Marie Curie Physics	BS	2003
University Pierre et Marie Curie Condensed matter Phys.	Ph.D.	2006
Argonne National Laboratory - Condensed matter Phys.	Postdoc.	2009

Professional Employment:

Argonne National Laboratory	Postdoc	2007-2009
Argonne National Laboratory	Assistant scientist	2009-present

Selected Publications:

1. **"Tunneling spectroscopy on cavity grade niobium: possible evidence of magnetic scattering**"Th.Proslier, J.Zasadzinski, J.Moore, L.Cooley, C.Antoine, M.Pellin, J.Norem, K.E.Grey APL 92 2105947 (2008)
2. **"Improvement and protection of Niobium surface superconductivity by Atomic layer deposition"** Th.Proslier, J.Zasadzinski, M.Pellin, L.Cooley, C.Antoine, J.Moore, J.Norem, K.E.Grey. APL 93 192504 (2008)
3. **"Mapping the superconducting condensate surrounding a vortex"** N.Bergeal, Y.Noat, T.Cren, Th.Proslier, V.Dubost, F.Dupontridder, A.Zimmers, D.Roditchev, W.Sacks, J.Markus. PRB 78 140507 (2008)
4. **"Tunneling spectroscopy and Atomic Layer Deposition for SRF cavities**" Th.Proslier, J.Zasadzinski, J.Moore, L.Cooley, C.Antoine, M.Pellin, J.Norem, K.E.Grey ASC IEEE proceedings (2008)
5. **" Probing the superconducting state on a nanometer scale "** Th. Proslier, A. Kohen, Y. Noat, T. Cren, D. Roditchev and W. Sacks. EPL.(2005)

José Repond

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-7554
Fax: 630-252-5782
E-mail: repond@hep.anl.gov

Education:

Year	*Degree*	*Institution and Location*	*Field of Study*
1980	Diploma.	Basel University, Basel, Switzerland	Physics
1985	Ph.D.	Basel University, Basel, Switzerland	Physics (High Energy Physics)

Professional Employment:

- Jul. 2001- Present: Group Leader of Digital Hadron Calorimeter, Argonne National Laboratory, Argonne, IL
- Jul. 1997 – Present: ZEUS Group Leader, Argonne National Laboratory, Argonne, IL
- Mar. 1993 – Present: Physicist, Argonne National Laboratory, Argonne, IL
- Oct.1988 – Mar. 1993: Assistant Physicist, Argonne National Laboratory, Argonne, IL
- Oct. 1985 – Oct. 1988: Postdoctoral Research Associate, Argonne National Laboratory, Argonne, IL

Awards, Memberships, and Professional Service:

International Advisory Committee for the Deep Inelastic Scattering Workshop series.

Selected Publications:

1. J.Repond, **"The International Linear Collider and its Detectors"**, BPL **16**(1), 296 (2009).
2. B.Bilki et al., **"Measurement of Positron Showers with a Digital Hadron Calorimeter"**, ArXiV 0902.1699. JINST **4** P04006 (2009).
3. B.Bilki et al., **"Measurement of the Rate Capability of Resistive Plate Chambers"**, ArXiV 0901.4371. JINST **4** P06003 (2009)
4. J.Repond et al., **"Design and Electronics Commissioning of the Physics Prototype of a Si-W Electromagnetic Calorimeter"**, JINST **3** P08001 (2008).
5. B.Bilki et al., **"Calibration of a Digital Hadron Calorimeter with Muons"**, JINST **3** P05001 (2008).
6. G.Drake et al., **"Resistive Plate Chambers for Hadron Calorimetry: Tests with Analog Readout"**, Nucl. Inst. and Meth. **A578**, 88 (2007).
7. G.Drake et al., **"A Digital Hadron Calorimeter with Resistive Plate Chambers for the Linear Collider"**, Int. J. Mod. Phys, **A20** 3830 (2005).
8. S.Chekanov et al., **"Dijet Production in Neutral Current Deep Inelastic Scattering at HERA"**, Eur. Phys **C23**, 13 (2002).

Andrew W. Smith

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6313
Fax: 630-252-5782
E-mail: awsmith@hep.anl.gov

Education:

2007 Ph.D. High Energy Astrophysics
University of Leeds/Smithsonian Astrophysical Observatory
Leeds, UK/Tucson, AZ
Thesis Title: "Multiwavelength Observations of The TeV Binary LS I +61 303 with VERITAS, Swift, and RXTE"

2002 M.Sc. Particle Physics
University of Durham
Durham, UK
Dissertation Title: "Braneworld Scenarios"

2001 B.A. Astrophysics
University of California at Berkeley
Berkeley, CA

Professional Employment:

Postdoctoral Researcher
Argonne Laboratories
Argonne, IL
2008-current

Awards, Memberships, and Professional Service:

2005-2008
Harvard-Smithsonian Center for Astrophysics Predoctoral Fellow

Selected Publications:

1. Acciari, V. .....Smith, A. **"Multiwavelength Observations of LS I +61 303 with VERITAS, Swift, and RXTE"** Accepted for publication in ApJ
2. Smith, A. et al. **"Long Term X-ray Monitoring Of The TeV Binary LS I +61 303 with RXTE"** ApJ, 693, 1621
3. Smith, A. et al. **,"Whipple 10m Observations of LS I +61 303: 2004-2006"** Journal of Astrophysics and Space Sciences, 309, 299-303
4. Acciari, V. et al. **"VERITAS Observations of the Gamma-Ray Binary LS I +61 303"** , Astrophysical Journal, 629, 457

Harold Spinka

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6317
Fax: 630-252-5782
E-mail: hms@anl.gov

Education:

Northwestern University, B.A. Physics, 1966.
California Institute of Technology, Ph.D. Physics, (minor astronomy) 1970.

Professional Employment:

Aug. 1987 – present: Senior Physicist, HEP Division, Argonne National Laboratory
Oct. 1976 – Aug. 1987: Physicist, HEP Division, Argonne National Laboratory
Mar. 1973 – Oct. 1976: Adjunct Assistant Professor, Physics Department, University of California at Los Angeles
Dec. 1970 – Feb. 1973: Postdoctoral Fellow, HEP Division, Argonne National Laboratory

Awards, Memberships, and Professional Service:

Fellow, American Physical Society
Member, Sigma Xi and Phi Beta Kappa

Selected Publications:

1. "Experimental Determination of the Total Reaction Cross Section of the Stellar Nuclear Reaction $^{16}O + ^{16}O$," H. Spinka and H. Winkler, Nucl. Phys. **A233**, 456 (1974).
2. "Observation of Structures in the pp Total Cross-Section Difference of Pure Helicity States in the Mass Range of 2100 to 2500 MeV," I.P. Auer et al., Phys. Rev. Lett. **41**, 1436 (1978).
3. "Measurements of Triple- and Double-Spin Parameters in Elastic p-p Scattering at 6 GeV/c," I.P. Auer et al., Phys. Rev. **D32**, 1609 (1985).
4. "Measurement of C_{LL} and C_{SL} in np Elastic Scattering at 484 and 634 MeV," G.R. Burleson et al., Phys. Rev. Lett. **59**, 1645 (1987).
5. "Analyzing Power in Inclusive π^+ and π^- Production at High x_F with a 200 GeV/c Polarized Proton Beam," D.L. Adams et al., Phys. Lett. **264B**, 462 (1991).
6. "Measurement of the Differences in the Total Cross Section for Antiparallel and Parallel Longitudinal Spins and a Measurement of Parity Nonconservation with Incident Protons and Antiprotons at 200 GeV/c," D.P. Grosnick et al., Phys. Rev. **D55**, 1159 (1997).
7. "Evidence From d + Au Measurements for Final State Suppression of High p_T Hadrons in Au + Au Collisions at RHIC," STAR Collaboration (J. Adams et al.), Phys. Rev. Lett. **91**, 072304 (2003).

Bob Stanek

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-7616
Fax: 630-252-5782
E-mail: bob@hep.anl.gov

Education:

PhD Physics, March 1980, University of Illinois, Chicago, USA
BS Physics, June 1970, University of Illinois, Chicago, USA

Professional Employment:

1986-present Physicist, High Energy Physics Division, Argonne National Laboratory
1983-1986 Assistant Physicist, High Energy Physics Division, Argonne National Laboratory
1980-1983 Post Doctoral Appointment, High Energy Physics Division, Argonne National Laboratory

Selected Recent Publications:

1. **The ATLAS Experiment at the CERN Large Hadron Collider,** The ATLAS Collaboration, G. Aad et al.; JINST 3 (2008) S08003.
2. **Testbeam Studies of Production Modules of the ATLAS Tile Calorimeter,** P. Adragna et al.; ATL-TILECAL-PUB-2009-002, Submitted to JINST.
3. **Effects of ATLAS Tile Calorimeter Failures on Jets and Missing Transverse Energy Measurements**, P. Mermod, G. Arabidze, D. Milstead, R. Stanek; ATL-TILECAL-PUB-2008-011-1.
4. **A Precise Measurement of 180 GeV Muon Energy Losses in Iron**, P. Amaral et al.; Eur. Phys J. C20 (2001) 487-95.

Synergistic Activities:
ATLAS Tile Calorimeter Project Leader at CERN, 2005-2009
ATLAS Tile Calorimeter Testbeam Coordinator at CERN, 1999-2004

Richard Talaga

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-7094
Fax: 630-252-5078
E-mail: rlt@anl.gov

Education:

B.S., University of San Francisco 1971
MS., The University of Chicago 1973
Ph.D.,The University of Chicago 1977

Professional Employment:

Physicist, ANL (1989- present)
Assistant Professor, University of Maryland (1982-1988)
Postdoctoral Staff, LANL (1979-1981)
Postdoctoral Staff, LBNL (1978-1979)
Postdoctoral Staff, UCLA (1977-1978)

Awards, Memberships, and Professional Service:

Co-spokesperson for Parity Violation experiment at LAMPF (1980-81)
ZEUS Service work (Run Coordinator, 1992)
University of Maryland Summer Grant (1983)
ANL service committee work (LMS R&D Process, Pacesetter Awards, Astrophysics Initiative)
MINOS Service Work (WBS Level 3 manager)
NOvA Service work (WBS Level 2 manager, EVMS certification, Exec. Board)

Selected Research Accomplishments

Built low noise ion chambers & electronics to detect parity violation with proton beams (1973-80)
Designed and built highly efficient veto wall and electronics for LAMPF neutrino experiment (1979-81)
Detected electron-neutrino scattering interaction with electrons LAMPF (1986)
Detected electron-neutrino transmutation of carbon nucleus to nitrogen at LAMPF (1987)
Designed CYGNUS cosmic ray experiment muon detection electronics at LAMPF (1985-6)
Designed & built ZEUS First Level Calorimeter Trigger (1989-1992)
Designed and built ZEUS small rear tracking detector Trigger (1993-1995)
Led ANL prototype beam tests for MINOS detector (1996-7)
Developed extruded scintillator for MINOS (1998-2001)
Led MINOS Near Detector Scintillator Assembly Factory (2000-2001)
Led OMNIS and ADONIS supernova neutrino detector design group (2002-2005)
Developed highly reflective PVC extrusions for NOvA (2006-2007)

Selected Publications:

1. **"Measurement of Neutrino Oscillations with the MINOS Detectors in the NuMI Beam"**, Phys. Rev. Lett. 101, 131802 (2008).
2. **"The magnetized steel and scintillator calorimeters of the MINOS experiment"**, NIMA 596, 190 (2008).
3. **"OMNIS, The Observatory of Multiflavor Neutrinos from Supernovae"**, Nucl. Phys. A718,222 (2003)
4. **"Search for Lepton Flavor Violation in e-p collisions at 300 GeV cm energy"**, Z. Phys C73, 613 (1997)
5. **"Measurement of the Exclusive Cross Section $^{12}C(\nu_e , e^-)\ ^{12}N(g.s.)$"**, Phys. Rev. Lett. 64, (1990).
6. **"First Observation and Cross Section Measurement of $\nu_e + e^- \rightarrow \nu_e + e^-$"** Phys. Rev. Lett. 55, 2401 (1985).
7. **"Central Collisions with a Projectile of 1.8 GeV/Nucleon ^{40}Ar"**, Phys. Lett. 79B, 325 (1978).

8. **"Limit on Parity Violation in p-Nucleus Scattering at 6 Gev/c"**, Phys. Rev. Lett. 34, 1184 (1975).

David G. Underwood

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6305
Fax: 630-252-5782
E-mail: dgu@hep.anl.gov

Education:
Ph.D. University of Chicago, 1973 (Physics)
M.S. University of Chicago, 1968 (Physics)
B.S. Massachusetts Institute of Technology, 1967 (Physics)

Professional Employment:
1980-Present: Staff Physicist, HEP, Argonne National Laboratory
1976-1980: Assistant Physicist, HEP, Argonne National Laboratory
1972-1976: Research Associate, University of Rochester, NY

Awards, Memberships, and Professional Service:
Member of APS, Member of IEEE
Occasional reviewer for Physics proposals and Rev. Sci. Inst.
Served on various reviews within STAR experiment
One Patent

Selected Publications:

1. **"Longitudinal double-spin asymmetry for inclusive jet production in p+p collisions at s**(1/2) = 200-GeV"**, By STAR Collaboration (B.I. Abelev et al.). Phys.Rev.Lett.100:232003,2008.
2. **"The optical instrumentation of the ATLAS tile calorimeter"**,ATLAS TileCal Collaboration (J. Abdallah et al.). ATL-TILECAL-PUB-2008-005, ATL-COM-TILECAL-2007-025, 2009.
3. **"Beam Performance of Tracking Detectors with Industrially Produced GEM Foils"**, F. Simon, et al, arXiv:0808.3477, 2008
4. **"RPC R&D for DHCAL at ANL"**, D. Underwood, et al, Paris LCWS2004
5. **"Comparison of spin asymmetries and cross-sections in pi0 production by 200-GeV polarized anti-protons and protons"**, E704 Collaboration (D.L. Adams et al.). Phys.Lett.B261:201-206,1991
6. **"Measurement of the isolated prompt photon cross-sections in anti-p p collisions at s**(1/2) = 1.8-TeV"**, CDF Collaboration (F. Abe et al.). Phys.Rev.Lett.68:2734-2738,1992.
7. **"The Design And Performance Of The Fnal High-Energy Polarized Beam Facility"**, FNAL-E581/704 Collaboration (D.P. Grosnick et al.). Nucl.Instrum.Meth.A290:269,1990.
8. **"Large Doppler shift in RADAR Detection of Ultra High Energy Cosmic Rays"**, D. Underwood, Proceedings IEEE Radarcon2008

Igor V. Veryovkin

Materials Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-3586
Fax: 630-252-9555
E-mail: verigo@anl.gov

Education:

- Academy of Sciences of Uzbekistan — *Ph.D. in Physics and Mathematics*, 1993
- Tashkent Polytechnic Institute — *Diploma Thesis in Physical Engineering (physical electronics)*, summa cum laude degree, 1985

Professional Employment:

1985-1990 **Engineer** *(engineer → engineer-technologist of 3rd category)*, Special Bureau for Design and Technology at Arifov Institute of Electronics, Academy of Sciences of Uzbek Soviet Socialist Republic, Tashkent 700143, USSR

1990-1995 **Staff Scientist** *(assistant scientist* → scientist → senior scientist) Arifov Institute of Electronics, Academy of Sciences of Uzbek Soviet Socialist Republic / Republic of Uzbekistan, Tashkent 700143, USSR / Uzbekistan

1997-1998 **Visiting Scientist**, Department of Chemistry, University of Antwerp (UIA), B-2610 Antwerp, Belgium

1998-present **Staff Scientist** *(visiting scholar → visiting scientist → assistant chemist → chemist)*, Materials Science Division, Argonne National Laboratory, Argonne 60439, USA

Awards, Memberships, and Professional Services:

Awards:

International Science Foundation (ISF) subsistence grant (1993)
STA Fellowship (Science and Technology Agency, Japan, 1996)
DWTC/OSTC Scholarship (Office for Scientific, Technical and Cultural Affairs, Belgium, 1997)

Memberships:

American Geophysical Union and American Society for Mass Spectrometry

Services:

Refereeing manuscripts for Analytical Chemistry, Nuclear Instruments & Methods in Physics Research Sections A and B, Review of Scientific Instruments;
Reviewing proposals for DOE and NASA

Selected Recent Publications :

1. **"Efficient multiple beam ion optics for quantitative surface analysis: from simulations to a fully operational instrument", Veryovkin I. V.**, Tripa C. E., Pellin M. J., *Physics Procedia*, 1 (2008) 379-389 (*invited*)
2. **"Laser-Driven Acoustic Desorption of Organic Molecules from Back-Irradiated Solid Foils"**, Zinovev, A.V., **Veryovkin, I.V.**, Moore, J.F., and Pellin, M. J., *Analytical Chemistry*, Vol. 79, (21), (2007), 8232-8241
3. **"Detection of In-Situ Derivatized Peptides in Microbial Biofilms by Laser Desorption 7.87 eV Postionizaton Mass Spectrometry"**, P. D. Edirisinghe, J. F. Moore, K. A. Skinner-Nemec, C. Lindberg, C. S. Giometti, **I. V. Veryovkin**, J. E. Hunt, M. J. Pellin, L. Hanley, *Analytical Chemistry*, Vol. 79 (2) (2007), 508-514
4. **"Development of a cesium sputter ion source compatible with commercial SIMS instruments"**, Belykh, S. F.; Palitsin, V. V.; **Veryovkin, I. V.**; Kovarsky, A. P.; Chang, R. J. H.; Adriaens, A., Dowsett M., Adams, F.; *Review of Scientific Instruments*, 78, 085101 (2007) 9 pages
5. **"Vacuum Ultraviolet Postionization of Aromatic Groups Covalently Bound to Peptides"**, Edirisinghe, P. D.; Moore, J. F.; Calaway, W. F.; **Veryovkin, I. V.**; Pellin, M. J.; and Hanley, L.; *Analytical Chemistry* Vol. 78 (16) (2006) 5876-5883

Robert G. Wagner

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6321
Fax: 630-252-5782
E-mail: rgwcdf@hep.anl.gov

Education:

Undergraduate:	University of Illinois-Urbana Physics	B.S.	1972
Graduate:	University of Illinois-Urbana Physics	M.S.	1973
	University of Illinois-Urbana Physics	Ph.D.	1978
Postdoctoral:	Argonne National Laboratory Particle Physics		1977-80

Professional Employment:

Argonne National Laboratory	Physicist	(1984–present)
Argonne National Laboratory	Assistant Physicist	(1981-84)

Awards, Memberships, and Professional Service:

Member, American Association of Physics Teachers

Selected Publications:

1. **VERITAS Observations of a Very High Energy Gamma-ray Flare from the Blazar 3C-66A**, V.A. Acciari *et al.* (VERITAS Collaboration), accepted for publication in ApJL, (2009).
2. **A Search for Dark Matter Annihilation with the Whipple 10 m Telescope**, M. Wood *et al*. (VERITAS Collaboration), ApJ **678**, 594-605 (2008).
3. **The TrICE Prototype MaPMT Imaging Camera,** K.Byrum, J.Cunningham, G.Drake, E.Hays, D.Kieda, E.Kovacs, S.Magill, L.Nodulmann, R.Northrop, S.Swordy, R.Wagner, S.Wakely, S.Wissel, Proc. 30th Int. Cosmic Ray Conf. (Merida), Vol. 2 (OG part 1), 469-472 (2008)
4. **The Timing System for the CDF Electromagnetic Calorimeters**, M Goncharov *et al.*, Nucl. Instr. And Meth., **A565**, 543 (2006).
5. **Observation of Top Quark Production in pbar-p Collisions with the Collider Detector at Fermilab**, F. Abe *et al.* (CDF Collaboration), Phys. Rev. Lett. **74**, 2626 (1995).

Gensheng Wang

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-5650
Fax: 630-252-9595
E-mail: gwang@anl.gov

Education:

PhD 1999 – 2004 **Experimental Particle Physics**, Case Western Reserve University, Cleveland, Ohio
MSc 1986 – 1989 **Semiconductor Physics and Devices**, Lanzhou University, China
BSc 1982 – 1986 **Condensed Matter Physics**, Lanzhou University, China

Professional Employment:

08/2007 – present **Senior Postdoctoral Researcher,** Argonne National Laboratory, Chicago, Illinois
09/2004 – 08/2007 **Postdoctoral Scholar**, California Institute of Technology, Pasadena, California
09/1999 – 06/2000 **Teaching Assistant** (part time), Case Western Reserve University, Cleveland, Ohio
06/1998 – 06/1999 **Visiting Scholar**, Cavendish Laboratory, Cambridge University, England
07/1991 – 05/1998 **R&D Engineer**, Low Temperature Department, Lanzhou Institute of Physics, China
07/1989 – 06/1991 **Assistant Engineer**, Lanzhou Institute of Physics, P. R. China

Awards, Memberships, and Professional Service:

American Physical Society, 2001- present
The American Association for the Advancement of Science, 2006-present
The American Astronomical Society, 2006-present

Selected Publications:

1. **Thermal Properties of silicon nitride beams below 1K**, G. Wang, *et. al*., CEC-ICMC 2009 conference Proceedings;
2. **Development of Absorber Coupled TES Polarimeter at Millimeter Wavelengths,** G. Wang et al., IEEE Transactions on Applied Superconductivity; Special Issue from the Applied Superconductivity Conference 2008, in press
3. **Low Temperature Thermal Transport in Partially Perforated Silicon Nitride,** V. Yefremenko, et. al., Appl. Phys. Lett., 94, 1(2009);
4. **Search for Weakly Interacting Massive Particles with the First Five-Tower Data from the Cryogenic Dark Matter Search at the Soudan Underground Laboratory**, Z. Ahmed et al., Physical Review Letters 102, 011301 (2009)
5. **Surface Event Rejection Using Phonon Information in CDMS,** G. Wang (corresponding author), Nuclear Physics B - Proceedings Supplements, Volume 173, 2007

Hsien-Hau Wang

Materials Science Division
Argonne National Laboratory
9700 South Cass Avenue, Argonne, IL 60439

Phone: (630)-252-3461
Fax: (630)-252-9151
Email: hau.wang@anl.gov

Professional Interests:
Material chemistry including synthesis, characterization, and assembly of nanoscale materials such as nanowires and nanotubes with use of anodized aluminum oxide templates for electronics, sensors, and photonic research. Fundamental understanding of energy and electronic transport related processes.

Education:

1981 **Ph.D.** Organometallic/Inorganic Chemistry, University of Minnesota, Minneapolis, MN
1975 **B.S.** Chemistry, National Tsing-Hua University, Taiwan

Professional Experience:

1990 – Present Chemist, Argonne National Laboratory, Materials Science Division
1985 – 1990 Assistant Chemist, Argonne National Laboratory, Materials Science Division
1983 – 1985 Postdoctoral Appointee, School of Chemical Sciences, University of Illinois, Urbana-Champaign, IL

Honor and Awards:

2001 Decade of Discovery Award presented by the Department of Energy for sustained outstanding work in the area of organic superconductivity.
1990 DOE-BES/Division of Materials Science, Award for Outstanding Scientific Achievement in Materials Chemistry.
1985 DOE-BES/Division of Materials Science, Award for Outstanding Scientific Achievement in Materials Chemistry.

Professional Committees and Activities:
Participate (PI) in the DOE Center of Excellence for the Synthesis and Processing of Advanced Materials: *Smart Structures Based Upon Electroactive Polymers*, lead PI G.J. Exarhos (PNNL), 2000-2005.
Participate (PI) in the DOE/BES Complex Systems: Science for the 21st Century*: Laterally Confined Nanomagnets*, lead PI S.D. Bader (ANL), 2000-2004.
Participate in the NSF Nanoscale Science and Engineering Center at Northwestern University, *Center for Soft Matter Architecture Research and Technology (SMART)*, lead PI C.A. Mirkin 2001-2005.
University of Chicago/Argonne National Laboratory seed grant "Synthetic Quantum Confined Materials", 1997-1999.

Selected Publications:

1. **Facile synthesis of highly aligned multi-walled carbon nanotubes from polymer precursors**, C.Y. Han, Z.L. Xiao, H.H. Wang, X.-M. Lin, S. Trasobares, R.E. Cook, *J. Nanomaterials*, **2009** in press, http://www.hindawi.com/journals/jnm/aip.562376.html
2. **High-Performance, Flexible Hydrogen Sensors That Use Carbon Nanotubes Decorated with Palladium Nanoparticles**, Yugang Sun and H. Hau Wang, *Adv. Mater.* **2007** *19* 2818-2823.
3. **Control of the Anodic Aluminum Oxide Barrier Layer Opening Process by Wet Chemical Etching**, C. Y. Han, G. A. Willing, Z. Xiao, H.H. Wang, *Langmuir* **2007** *23* 1564.
4. Z.L. Xiao, C.Y. Han, W.K. Kwok, H.H. Wang, U. Welp, J. Wang, and G.W. Crabtree, **"Tuning the Architecture of Mesostructures by Electrodeposition"** *J. Am. Chem. Soc.* **2004** *126* 2316.
5. H. Wang, W. You, P. Jiang, L. Yu and H.H. Wang, **"Supramolecular Self-Assembly of Conjugated Diblock Copolymers"** *Chem. Eur. J.* **2004** *10* 986.
6. J.M. Williams, A.J. Schultz, U. Geiser, K.D. Carlson, A.M. Kini, H.H. Wang, W.-K. Kwok, M.-H. Whangbo, J.E. Schirber, **Organic Superconductors-New Benchmarks**, *Science*, **1991** *252* 1501.

Matthew Wetstein

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-5333
Fax: 630-252-5782
E-mail: mwetstein@anl.gov

Education:
B.S., Rutgers University 2001
PhD., University of Maryland 2009

Professional Employment:
Post-doctoral fellow, ANL and University of Chicago, 2009-present

Awards, Memberships, and Professional Service:
Calorimeter expert at D0
W boson Mass and Width Analysis at D0
Speaker at EPS 2007
Henry Rutgers Scholar, 2001
Mary Wheeler Wigner Scholar, 2001
Phi Beta Kappa Society
Rutgers Honors Program

Selected Publications:
1. *A Novel Method for Modeling the Recoil in W Events in Hadron Colliders*, D0 Collaboration (NIM draft in preparation)
2. *A Precision Measurement of the W Boson Width in 1 fb^{-1} at the Run II D0 Detector*, D0 Collaboration (PRL draft in preparation)
3. *A Precision Measurement of the W Boson Mass in 1 fb^{-1} at the Run II D0 Detector*, D0 Collaboration (PRL draft in preparation)
4. *Microstrip Sensors Based on CVD Diamond*, W. Adams et al. Nucl. Instrum. Meth. A **476**, 706 (2000)

Lei Xia

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6633
Fax: 630-252-5782
E-mail: lxia@hep.anl.gov

Education:

Ph.D. in physics	Caltech, 2002
B.Sc. in physics	Peking University, 1996

Professional Employment:

Assistant Physicist	ANL-HEP, 2007
Term Assistant Physicist	ANL-HEP, 2006 – 2007
Postdoctoral Appointee	ANL-HEP, 2002 – 2006

Awards, Memberships, and Professional Service:

None

Selected Publications:

1. **Measurement of Positron Showers with a Digital Hadron Calorimeter.** Burak Bilki, et al., Published in **JINST 4**:P04006, 2009. [doi:10.1088/1748-0221/4/04/P04006]
2. **Measurement of the Rate Capability of Resistive Plate Chambers.** Burak Bilki, et al., Jan 2009. 12pp. Accepted by **JINST**, e-Print: arXiv:0901.4371
3. **Calibration of a Digital Hadron Calorimeter with Muons**. Burak Bilki *et al.* Published in **JINST 3**:P05001,2008. [doi:10.1088/1748-0221/3/05/P05001]
4. **Resistive Plate Chambers for Hadron Calorimetry: Tests with analog readout**. Gary Drake, Jose Repond, David Underwood, Lei Xia (Argonne). 2007. 10pp. Published in **Nucl. Instrum. Meth. A578**:88-97, 2007.
5. **Search for Scalar Leptons and Scalar Quarks at LEP**. **Phys.Lett.B** 580:37-49,2004
6. **Search for Scalar Leptons in e+e- collisions at sqrt(s)=189 GeV**. **Phys.Lett.B** 471:280-292,1999

Volodymyr Yefremenko

Materials Science Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-5470
Fax: 630-252-7777
E-mail: yefremenko@anl.gov

Education:

1975 M.S. Kharkov Aviation Institute, Ukraine/ Electronic Engineering
1987 Ph.D. Kharkov Aviation Institute, Ukraine/ Electronic Engineering

Professional Employment:

- 2007 - present, Senior Engineer ; MSD, Argonne National Laboratory, Argonne, IL
- 2003-2007 Visiting Scientist, MSD, Argonne National Laboratory, Argonne, IL
- 1997-2003 Group Leader, Infrared (IR) Devices Group, B. Verkin Institute for Low Temperature Physics and Engineering, National Academy of Sciences of Ukraine (ILTPE), Kharkov, Ukraine
- 1989-1997 Senior researcher, Department of Superconducting Electronics, ILTPE, Ukraine.
- 1975-1989 Engineer Department of Infrared Devices, Special Research and Development Bureau for Cryogenic Technologies, ILTPE, Ukraine

Selected Publications:

1. V. Yefremenko, G. Wang, V. Novosad, A. Datesman, J. Pearson, R. Divan, C. Chang, T. Downes, J. McMahon, L. Bleem, A. Crites, S.S. Meyer, and J.E. Carlstrom, **"Low Temperature Thermal Transport in Partially Perforated Silicon Nitride Membranes"**, Appl. Phys. Letter, **94**, 183504 (2009).
2. V. Yefremenko, A. Datesman, G. Wang, J. Pearson, V. Novosad, R. Divan, C. Chang, T. Downes, L. Bleem, A. Crites, S.S. Meyer, and J.E. Carlstrom, **"Control of Membrane Thermal Transport Supporting Superconducting Detector Development",** IEEE Trans. of Applied Superconductivity, accepted.
3. V. Yefremenko , E. Gordiyenko , G. Shustakova , Yu. Fomenko , A. Datesman , G. Wang, J. Pearson, E.E. W. Cohen, and V. Novosad, **"A broadband imaging system for research applications",** Review of Scientific Instruments, **80**, 056104 ,2009.
4. G. Wang, V. Yefremenko, A. Datesman, J. Pearson, V. Novosad, R. Divan, C. Cheng, T. Downes, J. McMahon, L. Bleem, A. T. Crites, S. S. Meyer, and J. E. Carlstrom , **"Absorber Type TES Bolometer for Polarimetry at Millimeter and Sub-millimeter Wavelength",** IEEE Trans. of Applied Superconductivity, accepted.
5. A. Datesman, J. Pearson, G. Wang, V. Yefremenko, R. Divan, T. Downes, C. Chang, J. McMahon, S. Meyer, J. Carlstrom, D. Logan, T. Perera, G. Wilson, and V. Novosad, **"Frequency selective bolometer development at Argonne National Laboratory",** *Millimeter and Submillimeter Detectors and Instrumentation for Astronomy IV*, Book Series: Proc. of SPIE, Vol. **7020**, pp 2029-2029, 2008.
6. A.Datesman, T. Downes, C. Chang, T. Perera, D. Logan, S. Meyer, G. Wilson, G. Wang, V. Yefremenko, V. Novosad, J.Pearson, R.Divan, L. Bleem, A. Crites, J. McMahon, and J. Carlstrom, **"TES Development for a Frequency Selective Bolometer"**, IEEE Trans. of Applied Superconductivity, accepted.
7. V. Yefremenko, E. Gordiyenko, V. Pishko, and V. Novosad, **"METHOD FOR DETECTION AND IMAGING OVER A BROAD SPECTRAL RANGE"**, US Patent # 7,274,019 B2, Sept. 25, 2007.
8. V Yefremenko, E. Gordiyenko, G Shustakova, S D Bader, G Karapetrov and V Novosad, **Optically activated high Tc superconducting microbolometer"**, Journal of Physics: Conference Series vol.**43**, no.1 : 1342-5, 2006.
9. V. Yefremenko, E. Gordiyenko, J. Pearson, S. Bader and V. Novosad, **"Superconducting microbolometer with controllable coordinate sensitivity: an alternative approach to FPA design"**, Infrared Technology and Applications XXXI, 28 March 2005, Orlando, FL, USA. Proceedings of the SPIE - The International Society for Optical Engineering vol.**5783**, no.1 : 967-73, 2005.

Zikri Yusof

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-6280
Fax: 630-252-5076
E-mail: zyusof@anl.gov

Education:

Illinois Institute of Technology: Ph.D. Physics, 1999
University of Wisconsin-Madison: B.Sc. Physics 1985

Professional Employment:

1999-2002 Postdoctoral Fellow, University of Connecticut.
2002-2005 Postdoctoral Fellow, Argonne National Laboratory.
2005-Present Assistant Physicist, Argonne National Laboratory.

Selected Recent Publications :

1. S. Antipov, L. Spentzouris, W. Gai, M. Conde, F. Franchini, R. Konecny, W. Liu, J.G. Power, Z. Yusof, and C. Jing, **"Observation of wakefield generation in left-handed of metamaterial-loaded waveguide",** J. Appl. Phys. 104, 14901 (2008).
2. Z. Yusof, B.O. Wells, T. Valla, P.D. Johnson, A.V. Fedorov, Q. Li, S.M. Loureiro, and R.J. Cava, **"Angle-resolved photoemission study of the metal-insulator transition in bismuth cobaltates"**, Phys. Rev. B 76, 165115 (2007).
3. C. Jing, A. Kanareykin, J.G. Power, M. Conde, Z. Yusof, P. Schoessow, and Wei Gai, **"Observation of Enhanced Transformer Ratio in Collinear Wakefield Acceleration"**, Phys. Rev. Lett. 98, 144801 92007).
4. Zikri M. Yusof, Manoel E. Conde, and Wei Gai, **"Schottky-Enabled Photoemission in a rf Accelerator Photoinjector – Possible Generation of Ultralow Transverse Thermal-Emittance Electron Beam"**, Phys. Rev. Lett. 93, 114801 (2004).
5. J.G. Power, W. Gai, S.H. Gold, A.K. Kinkead, R. Konecny, C. Jing, W. Liu, and Z. Yusof, **"Observation of Multipactor in an Alumina-Based Dielectric-Loaded Accelerating Structure"**, Phys. Rev. Lett. 92, 164801 (2004).
6. J.F. Zasadzinski, L.Coffey, P. Romano, and Z. Yusof, **"Tunneling Spectroscopy of $Bi_2Sr_2CaCu_2O_{8+\square}$: Eliashberg Analysis of Spectral Dip Feature"**, Phys. Rev. B 68, 180504 (2003).
7. T. Valla, P.D. Johnson, Z. Yusof, B.O. Wells, et al., **"Coherence-Incoherence and Dimensional Crossover in Layered Strongly Correlated Metals"**, Nature 417, 627 (2002).
8. Z. Yusof, B.O. Wells, T. Valla, A.V. Fedorov, P.D. Johnson, Q. Li, C. Kendziora, S. Jian, and D.G. Hinks, **"Quasiparticle Liquid in Highly Overdoped $Bi_2Sr_2CaCu_2O_{8+\delta}$,"** Phys. Rev. Lett. 88, 167006 (2002).

Huyue (Allen) Zhao

High Energy Physics Division
Argonne National Laboratory
Argonne, IL 60439

Phone: 630-252-0975
Fax: 630-252-5782
E-mail: hzhao@anl.gov

Education:

Ph.D.	**Northwestern University**	**Mechanical Engineering**	**2008**
M.S.	**University of Maine**	**Mechanical Engineering**	**2002**
B.S.	**Huazhong Univ of Sci Tech, China**	**Mechanical Engineering**	**1996**

Professional Employment:

Mechanical Engineer, HEP, Argonne National Laboratory 2007 – present

Adjunct Professor, Mechanical Engineering Department, Northwestern University, 2009 – present

Awards, Memberships, and Professional Service:

Level 3 Manager, International Collaboration of NuMI Off-Axis νe Appearance Experiment, 2007-present

Level 3 Manager, International Collaboration of Dark Energy Survey (DES), 2007-present

Selected Publications:

1. D. L. DePoy, T. Abbott, S. Kuhlmann, H. Zhao, et al, **"The Dark Energy Camera (DECam),"** SPIE 2008, Marseille, France, June 23-28, 2008.
2. H. Cease, S. Kuhlmann, H. Zhao, et al, **"The dark energy survey CCD imager design,"** SPIE 2008, Marseille, France, June 23-28, 2008.
3. PH. Hu, H. Zhao, KF. Ehmann, "**Third-octave-mode chatter in rolling, Part 1, chatter model,"** Proc. IMechE, Part B: J. Engineering Manufacturing, Vol. 220, No. 8, 2006, p 1267-1277.
4. PH. Hu, H. Zhao, KF. Ehmann, **"Third-octave-mode chatter in rolling, Part 2, stability of a single-stand mill,"** Proc. IMechE, Part B: J. Engineering Manufacturing, Vol. 220, No. 8, 2006, p 1279-1292.
5. PH. Hu, H. Zhao, KF. Ehmann, **"Third-octave-mode chatter in rolling, Part 3, stability of a multi-stand mill,"** Proc. IMechE, Part B: J. Engineering Manufacturing, Vol. 220, No. 8, 2006, p 1293-1303.
6. S. Vel, V. Caccese, H. Zhao, **"Elastic coupling effects in tapered sandwich panels with laminated anisotropic composite facings,"** Journal of Composite Materials, Vol. 39, No. 24, 2005, p 2161-2183.

APPENDIX B. Personnel and Funding Tables

The budget tables are provided as a separate Excel spreadsheet with several worksheets, as requested and are on the same WEB page as this document.

APPENDIX C: Publications and Talks for Detector Systems

DHCAL:

"Resistive Plate Chambers for Hadron Calorimetry: Tests with Analog Readout", G.Drake et al., Nucl. Instr, Meth. A578, 88 (2007).

"A New Readout System for Digital Hadron Calorimeter for the International Linear Collider", J.Butler et al., Proceedings of the 2007 IEEE Nuclear Science Symposium, Honolulu, Hawaii (2007).

"Calibration of a Digital Hadron Calorimeter with Muons", B.Bilki et al., arXiv: 0802.3398, 2008 JINST **3** P04001.

"Measurement of Positron Showers in a Digital Hadron Calorimeter", B.Bilki et al., arXiv: 0902.1699, 2009 JINST **4** P04006.

"Measurement of the Rate capability of Resistive Plate Chambers", B.Bilki et al., arXiv: 0901.4371, 2009 JINST **4** P06003.

"The International Linear Collider and its Detectors:, J.Repond, BPL 16(1), 296 (2009).

Talks:

"Progress with CALICE", J.Repond, Linear Collider Workshop LCWS 2007, DESY, Hamburg, Germany (June 2007).

"Digital Hadron Calorimetry with Resistive Plate Chambers", J.Repond, Linear Collider Workshop LCWS 2007, DESY, Hamburg, Germany (June 2007).

"Data Analysis of the DHCAL Vertical Slice Test", L.Xia, ALCPG07 Meeting, Fermilab, Batavia, IL (October 2007).

"The Vertical Slice Test of the RPC-DHCAL" J.Repond, ALCPG07 Meeting, Fermilab, Batavia, IL (October 2007).

"PFA Jet Measurement and Digital HCAL", L.Xia, Seminar at CALTECH, Pasadena, CA (November 2007).

"A Digital Hadron Calorimeter with Resistive Plate Chambers", J.Repond, International Conference on Calorimetry for High Energy Physics, CALOR08, Pavia, Italy (May 2008).

"The International Linear Collider and its Detectors", J.Repond, International Conference on Particle Physics, Istanbul, Turkey (October 2008)

"Status of the DHCAL Prototype Construction", L.Xia, Linear Collider Workshop, LCWS 2008, Chicago, Il (November 2008).

"Environmental Dependences of RPCs', Q.Zhang, Linear Collider Workshop, LCWS 2008, Chicago, Il (November 2008).

"Analysis of Test Beam data from the Vertical Slice Test of a Digital Hadron Calorimeter", J.Repond, Linear Collider Workshop, LCWS 2008, Chicago, Il (November 2008).

Telescope Design:
Publications, Technical Notes:

[1] "Schwarzschild-Couder Telescope Mechanical Design", V. Guarino, E. Davis, Aug 20, 2008; ANL Technical Note.
http://www.hep.anl.gov/vjg/SC-OSS-Structure1.doc

[2] "Investigations of Azimuth Drive Systems", V. Guarino, A. Zhao, Mar 4, 2009; ANL Technical Note.
http://www.hep.anl.gov/vjg/DC-Telescope-Drives2a.pdf
http://www.hep.anl.gov/vjg/AzimuthDrives1.pdf

Talks & Posters:

"The Advanced Gamma-ray Imaging System (AGIS) – Telescope Mechanical and Optical System Design", V. Guarino, et. el; Poster at APS, Denver Colorado, May 2-5, 2009
http://www.hep.anl.gov/veritas/posters/AGIS-OSS-APS09-v2.ppt

"ANL Mechanical Engineering Capabilities"; V. Guarino, Heidelberg, Germany Sept 2008
http://www.hep.anl.gov/byrum/agis/Heidelberg2.ppt

"ANL Mechanical Engineering Capabilities and DC and SC Designs"; V. Guarino, CTA Collaboration Meeting, Italy Nov 2008
http://www.hep.anl.gov/vjg/Transfer/Padova1.ppt

"AGIS Optical Mechanical Structure", V.Guarino, K. Byrum, R.G.Wagner, et el, Poster at APS, St. Louis, MO, Apr 2008
http://www.hep.anl.gov/veritas/posters/APS08-AGIS_mechanics_v2.ppt

"AGIS Optical Mechanical Structure", V. Guarino, talk at Towards the Future of Very High Energy Gamma-ray Astronomy, SLAC November, 2007
http://www.hep.anl.gov/veritas/posters/agis_mechanics_v5.pdf

APPENDIX D: Publications and Talks for Sensors and Electronics

Publications, Conference Proceedings and Technical Notes:

Large Area Photo-Detectors

Signal processing for picosecond resolution timing measurments, Jean-Francois Genat, Gary Varner, Fukun Tang, Henry Frisch, Submitted to Nuclear Inst. And Methods in Physics Research, A

Beam test of a Time-of-Flight detector prototype, J. Va'vra, D.W.G.S. Leith, B. Ratcliff, E. Ramberg, M. Albrow, A. Ronzhin, C. Ertley, T.Natoli, E.May, K. Byrum, Nuclear Inst. And Methods in Physics Research, A 606 (2009) pg. 404-410

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