R&D Proposal for AGIS

Jim Buckley
Washington University

Future of Very High Energy Gamma-Ray Astronomy
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Outline

- We should work towards an R&D proposal for the Imaging ACT component of AGIS with a goal of submission of a first proposal this Fall, for $4-5M.
- Building a prototype of a 2-mirror telescope would be one possible way to proceed and would be complementary to the CTA design study.
- I give some ideas as a starting point for discussion, although the detailed proposal should be decided through a series of conference calls.

Existence Proof

- The CTA group has just submitted an R&D proposal, put together over a few months time-scale and bringing together two groups (HESS and MAGIC)
- In the U.S., a number of us have already been submitting technology development proposals (DOE ADR proposals, MRI proposals by WU and Chicago).
- The HAWC proposal can serve as an R&D proposal for a water Cherenkov component of AGIS. But there should be a parallel effort for an IACT.
- Our structure in the U.S. is that of a rather loose confederation of scientists, with no clear hierarchy. But, the scientific collaboration on the Whitepaper has been quite effective, and a similar effort for technology development should prove fruitful.

A Proposal

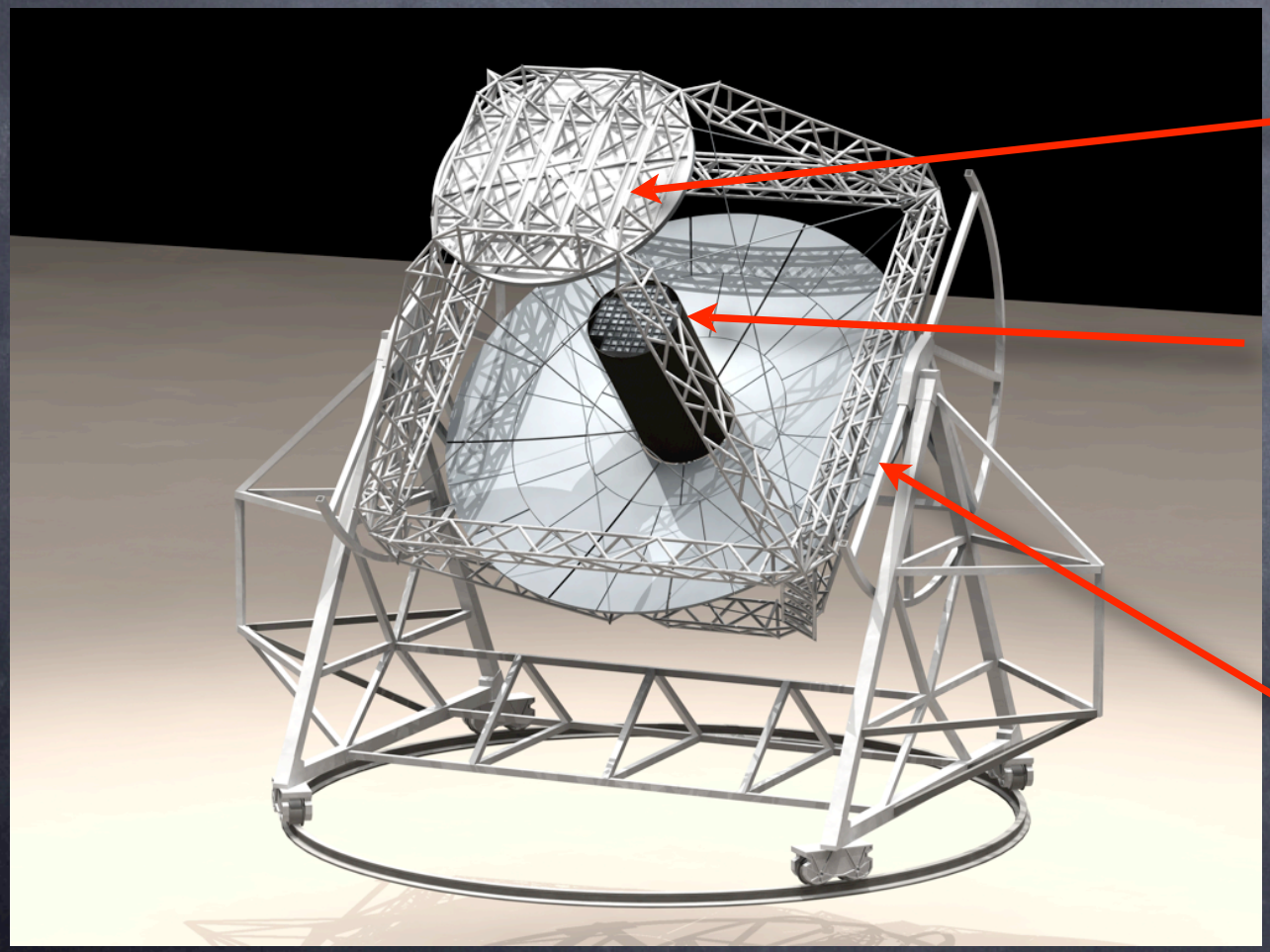
- I propose to act as a coordinator of a first R&D proposal to develop technology for the ACT component of AGIS.
- Initially, I ask all interested parties to e-mail me with an informal message expressing:
  - The name of the institution and participants
  - Areas of interest, and past experience/capabilities in this area
- I will start a biweekly conference call to begin to discuss the approach, work breakdown, and to identify the leaders of a number of different WBS tasks.
- Our goal should be to produce a proposal this fall, and in the subsequent years until we are funded.

Straw Man

- The scientific requirements should be the main drivers for our technological development.
- We should start with simulations to determine the optimum array configuration, angular resolution, FOV, and mirror diameter
- We should identify areas where a technological demonstration, design trade study, or simulation effort would benefit a future large proposal, and would be complementary to similar work in Europe on the CTA (minimize duplication of effort). Possible areas of development:
  - Wide-field-of-view optics or high-angular-resolution optical design.
  - Development of lightweight aspheric mirrors (cold slumping, electroforming, etc.) including extensive environmental testing.
  - Modular/multiplexed camera with objectives of cost minimization, reliability and high speed data acquisition from a large number of telescopes
  - Methods for synthesis of images and trigger information from a large number of telescopes with flexible configurations
  - Very fast-slewing mount/OSS for GRBs
  - New camera photodetectors (high QE MAPMTs, SiPMs)
  - Operation at high altitude (>3km)

An Example

In principal, the straw man could be a conventional single mirror Davies Cotton telescope, but this may not be the basis for the most natural R&D proposal - we should carefully determine the most fruitful areas of new technology development, then work towards a demonstration of the higher risk or more technically challenging components

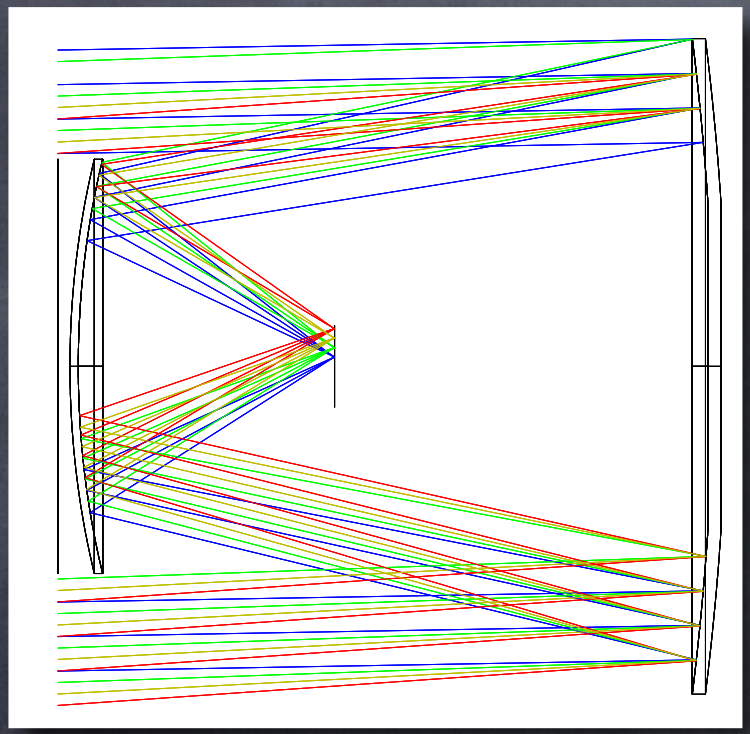


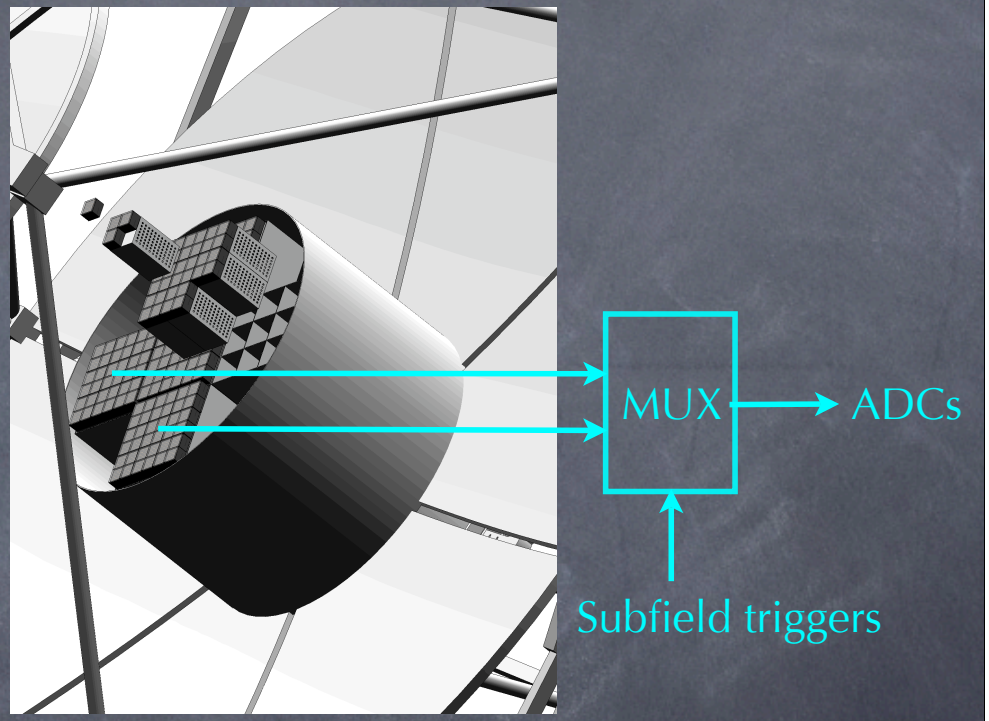
RC two-mirror design - secondary made of lightweight, aspheric segments

Demagnifying optical design with camera between primary and secondary reduces the plate scale and can also reduce astigmatism or field curvature

Mechanical design should minimize moment of intertia and cost of mass production

Modular Camera Design





- Demagnifying optical design with low field curvature lends itself to a modular camera, and small plate scale multipixel detectors
- Need approaches to reduce electronics and photodetector cost for a large field of view - ASICs, multiplexing. Also need new methods for handling high data rates.

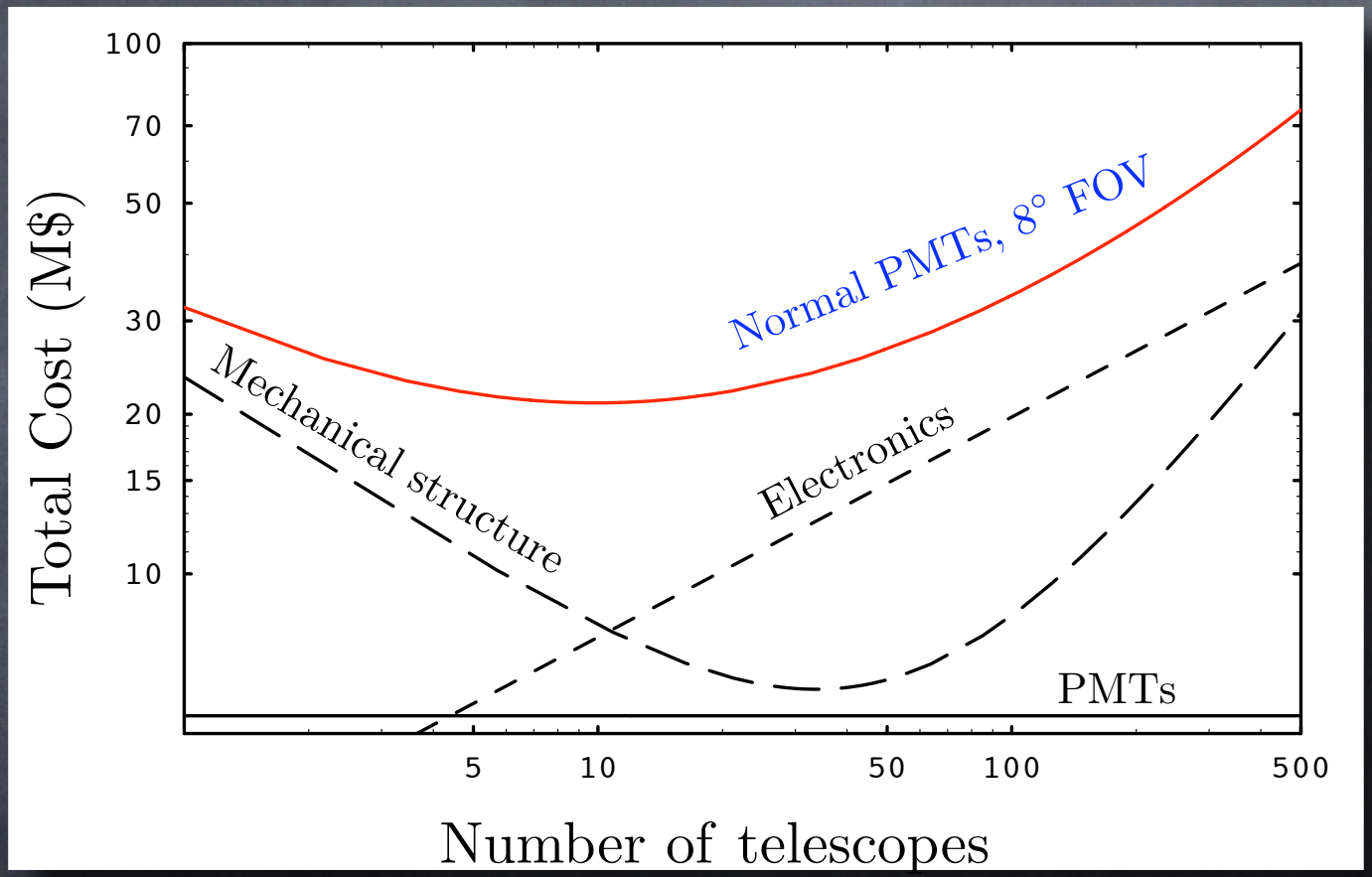
Conclusions

- If we continue submitting uncoordinated R&D proposals, we run the risk of duplicating efforts, pursuing efforts that are not on a critical path for the next generation experiment, and having all of our proposals fail due to review by our competing groups.
- I will try to act as a coordinator for a first IACT R&D proposal. Please send me an expression of interest: buckley@wuphys.wustl.edu describing the area in which you think your group is best qualified to contribute, and the people at your institution who would like to participate.
- Through biweekly conference calls we will converge on a proposal plan.
- Construction of a working prototype instrument would go a long way toward producing a viable proposal for a large array. This effort would be an important first step to begin to nucleate small groups of experimentalists to start doing some real work on a future ACT project.

AGIS R&D

Back-up Transparencies

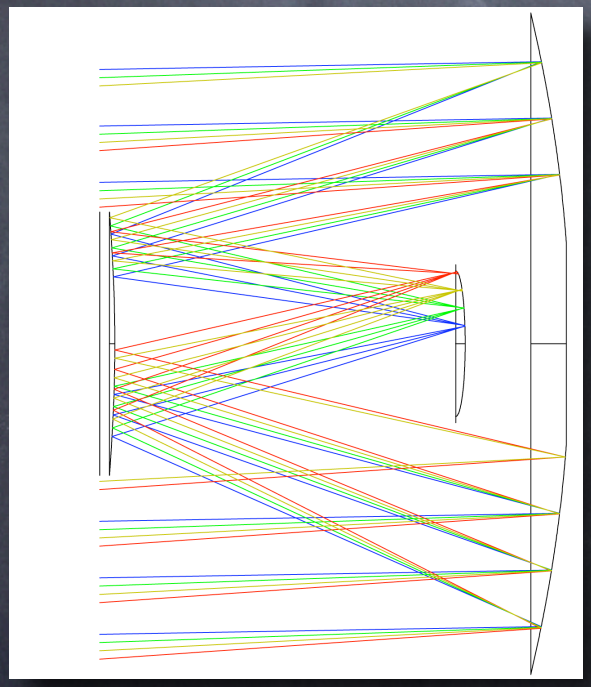
Many Small vs. one Large?



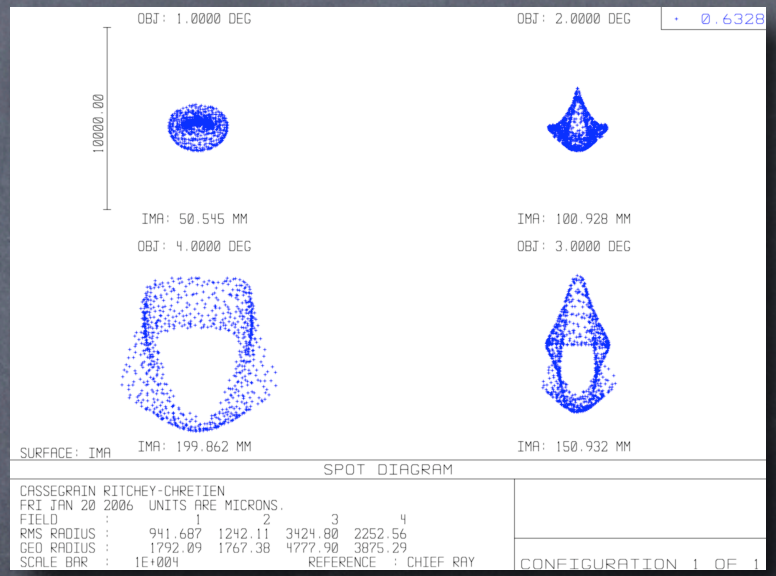
- Can make a 30m telescope with one large dish, or many small dishes - may be advantage for angular and energy resolution (Hofmann, Paris Cherenkov05)
- Optimum when camera cost ≈ telescope cost ⇒ 5-10 telescopes with diameter of 9-13m diameter

Optical Design: Magnifying RC

- Conventional *magnifying* Ritchey Chretien with small secondary, no vignetting on-axis, some vignetting at large angles (as I proposed for VLACT, and for VERITAS in 1996)



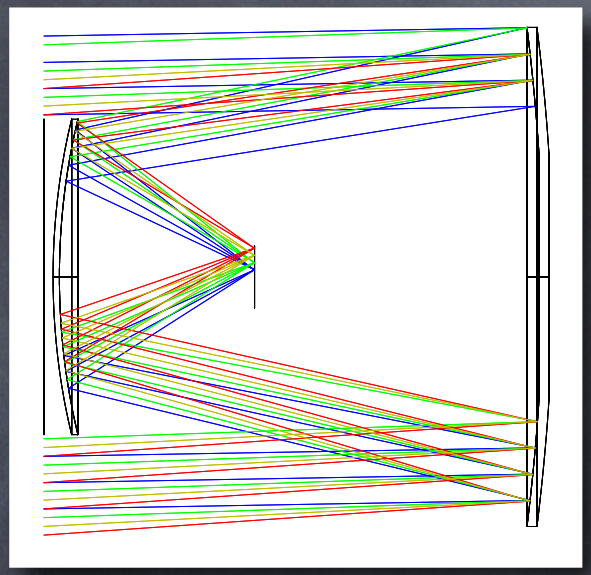
Modified RC design

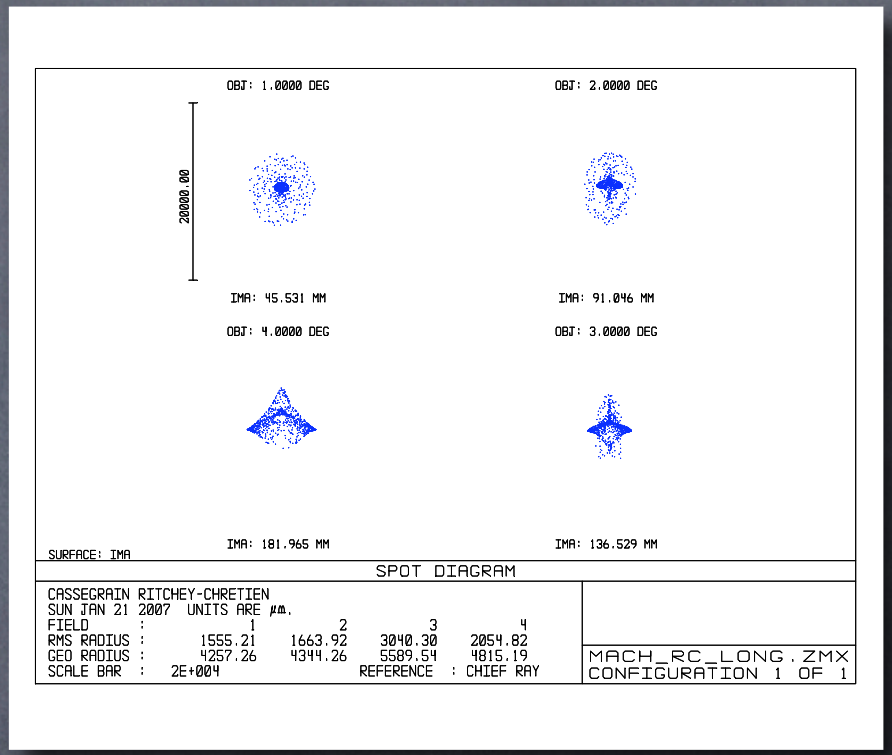


Spot size : 0.020° at a field angle of 1°
(radius) 0.026° at a field angle of 2°
0.047° at a field angle of 3°
0.072° at a field angle of 4°

$D_1 = 9\text{m},\ F_1 = 9\text{m},\ D_2/D_1 = 0.34,\ f = 1.2$

Optical Design: Flat-field RC

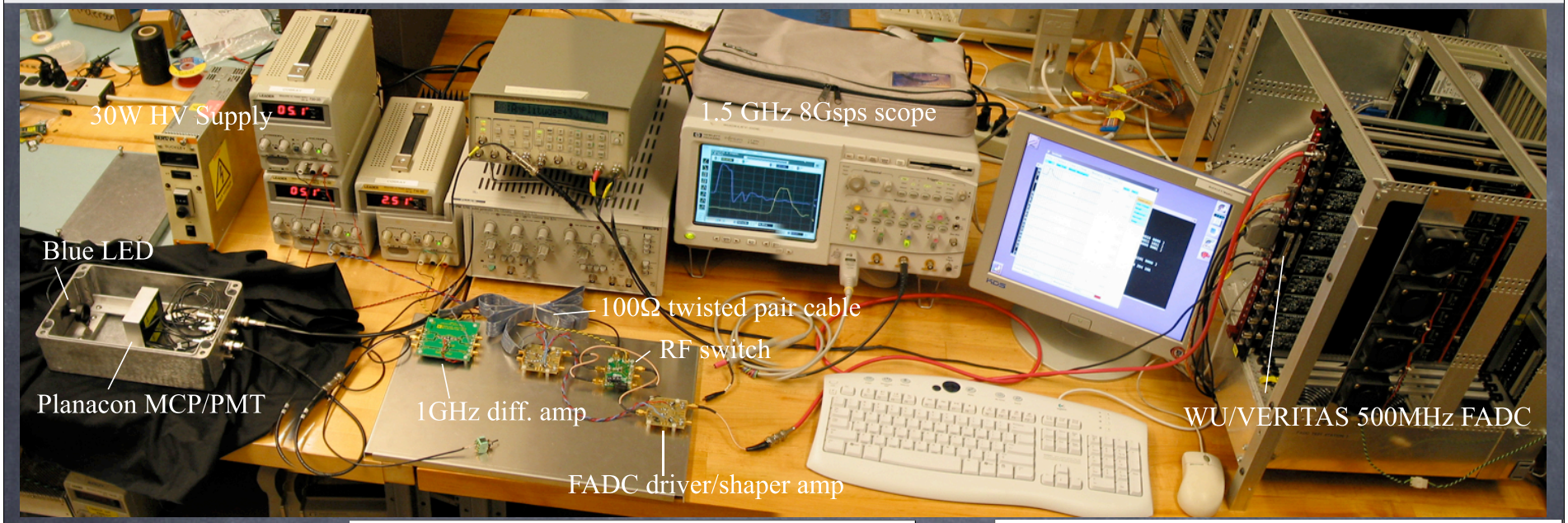


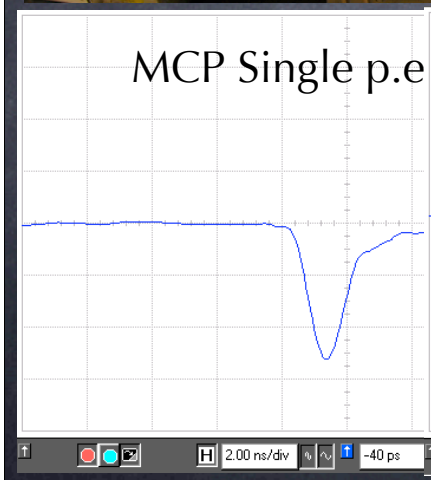


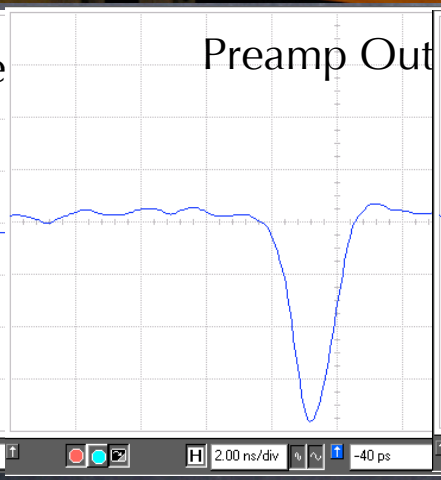
- Flat-field RC, similar to Couder - demagnifying design lends itself to MAPMTs
- Flat camera simplifies modularity

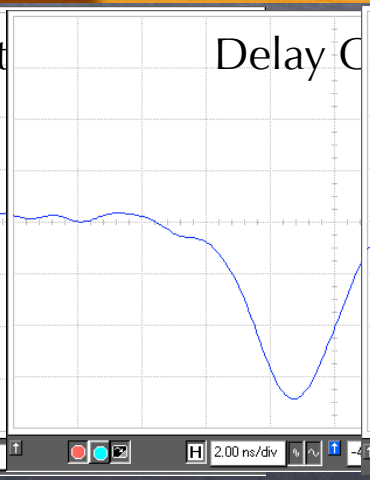
0.034° at a field angle of 1°
0.036° at a field angle of 2°
0.045° at a field angle of 3°
0.067° at a field angle of 4°

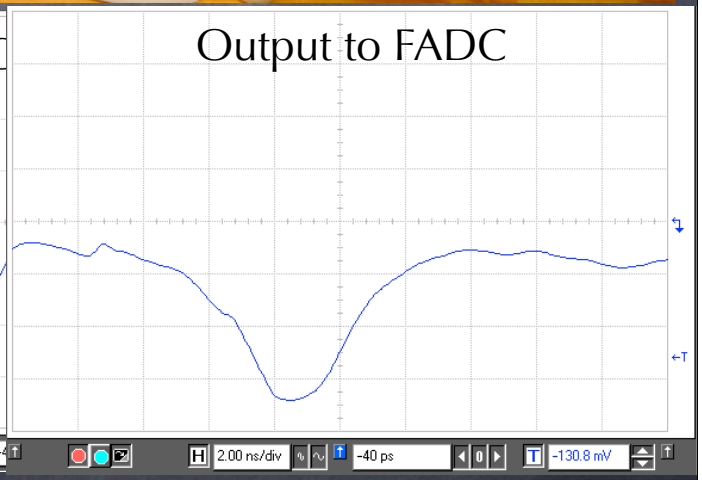
Multiplexer Circuit



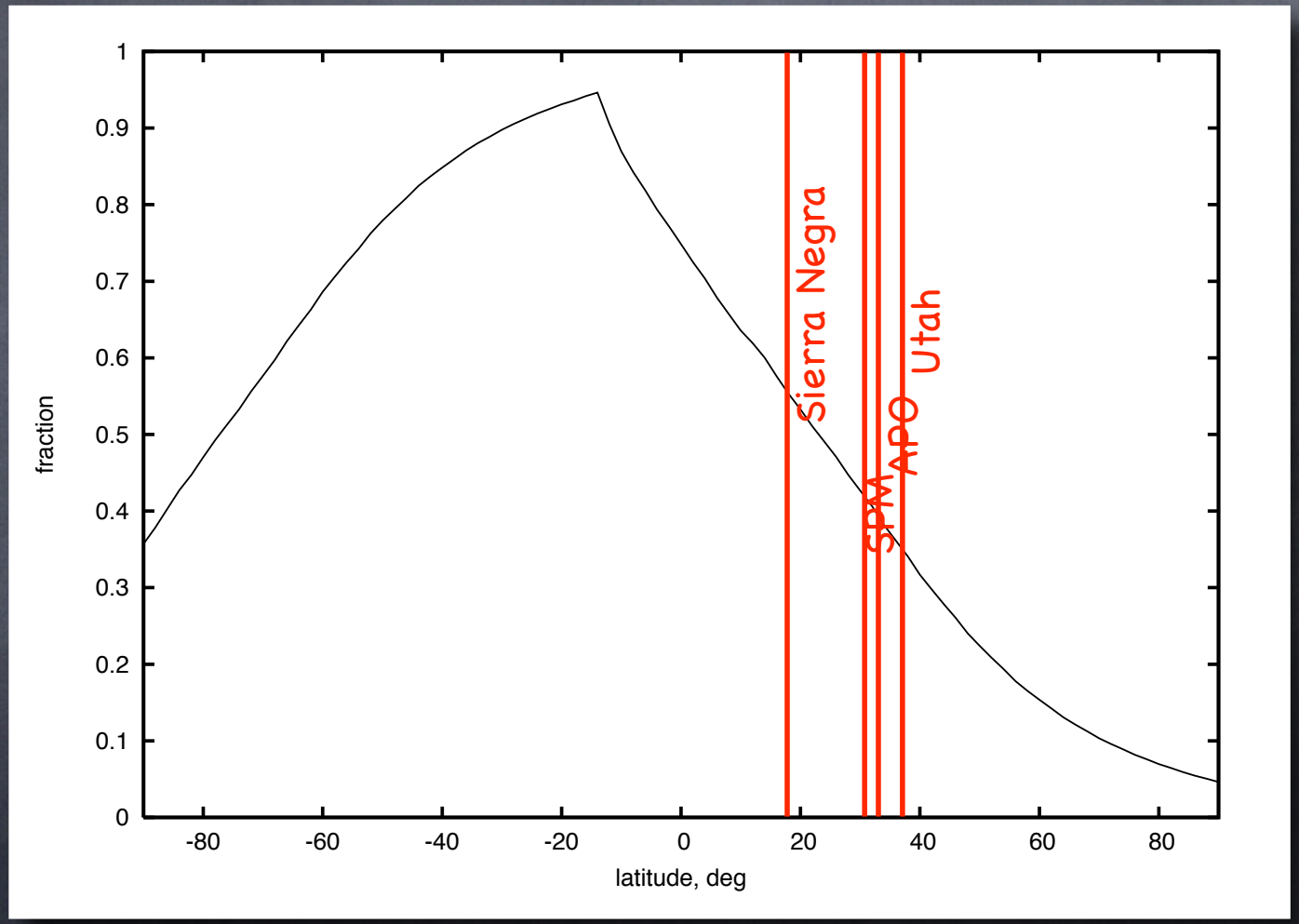








Site Location



- Visible fraction of Pulsar population versus geographic latitude (Bugaev, 2006)

Rough Cost Estimate

- VERITAS
  - camera cost: Current FADCs cost about $2M for 2300 channels, crates and chiller add about $300k, total cost of FADCs including engineering is about $1000/channel, equipment cost of boards was about $500/channel. Total camera cost is hard to estimate - perhaps $1.5k/channel (equip.)
  - telescope cost: was very roughly $1M/telescope or $2M with personnel
- HESS-I (no accounting for personnel)
  - camera cost: 670k€=$1.0k/channel
  - telescope cost: 770k€=$1.1M/telescope
- HESS-II (no personnel)
  - camera cost: $1.35k/channel
  - telescope cost: 7.25k€=$10.1M/telescope

Mirrors

- Mirror Options:
  - Ground-glass 1.2 k€/m² (HESS mirrors)
    - Robust, heavy, easy to recoat, difficult to polish with aspheric surface
  - Cold-slumped mirrors 2.5 k€/m²
    - Fast production rate, but composites have a bad track record, aspheric shapes are easy
  - Diamond-turned mirrors
    - Lightweight, improvements in scattered light, aspheric mirrors are easy, but relatively expensive 6k€/m²
  - Electroformed mirrors