CDF 1979-2008

Barry Wicklund

December 12 2003

Planning Exercise

“Long range plans are useless but long range planning is essential”

(Mont. 03)

ANL CDF group point of view

- We want to participate in CDF physics
  - Best physics this decade, luminosity goals will be in out years (->2008)
  - Years of work/investment on Run II upgrades
  - Years of invaluable experience vital to physics goals
  - Precision CDF physics will not be eclipsed by LHC
- CDF people already looking into other future initiatives
  - Typically 50-60% CDF, total of ~6 FTE on CDF
  - Of course we want to prepare for next decade, but this Division must have a strong role in real-time experiments.
- Run IIb upgrades in progress (calorimeter/level-2)
  - These are endorsed by Lab/P5/CDF, minimal impact on up time
- Must maintain reasonable effort level through ~4 fb-1
  - Support detector operations, lead physics analyses

Options for ANL Involvement in CDF

National, FNAL perspective

"The Tevatron is the forefront facility in high-energy physics, not just nationally but in the world, and it will continue to be the forefront facility for most of this decade…The overriding priority of the Tevatron physics program should be to maximize the physics quality data recorded by each experiment by the end of 2008..P5 strongly endorses the upgrades of the trigger, DAQ, and offline systems."
(Gilman report for P5, Sep. 2003)

FNAL plan:

Run collider for CDF/D0, switch to BTeV (~2009??)
Why collider? Tevatron facilities op's= 248M$ (FY04DOE) of 303M$ total.
Plenty of incentive, including physics, to run for ~10 years.

ANL-HEP plan:

(1) Preshower upgrade (firm obligation), complete by end 2005
(2) Maintenance for shower max, preshower, calibrations
(3) Leadership responsibilities (operations, physics..) run shifts,
(4) Carry out physics analysis (eg., Photon searches, Bs mixing, W/Top mass)

What would be good reasons to terminate ANL participation?

(1) Calamity- SVX fries, no replacement.
(2) Tevatron- no chance to get to 2 fb-1 needed for W, top, Bs mixing
(3) BTeV is built, commissioned, working well by LHC turnon- terminate CDF+D0.
(4) LHC is up and running well- including Lhcb, no new physics at CDF

What are some reasons to stay?

(1) Good luminosity, physics goals achievable, maybe sign of new physics.
(2) Continual upgrade for DAQ for B physics- unique opportunity

Time Lines in HEP Division

Late 1970's original planning exercise for post ZGS:

- (B. Cham.)=>HRS=>(TRISTAN)=>ZEUS=>LC
- (Counter) => SOUDAN => MINOS=>?
- (Counter) => CDF => (SDC) => ATLAS/LHC
- (Counter) => Polarized protons (RHIC)

Missed (?) – D0, BaBar/Belle, LEP/SLD, Cleo…

General Requirements:

- Roles= design, construct, test, commission, run
  - Physics leadership, upgrades, more test, comm.,run
- Pick projects that are attractive for recruiting
- Ensure collaborations with strong groups:
  - CDF=first real collaboration with UC
- Choose projects with strong physics (still true, now P5)

CDF Impact on Division and HEP

Because of strong physics potential and diverse program, CDF has grown continuously:

500/44 institutions (1999)=>770/62 institutions (2003)

ANL-HEP personnel who came to work on CDF or through CDF association:

Larry Nodulman, Paul Schoessow, Jim Proudfoot
Bob Blair, Steve Kuhlmann, Karen Byrum, Tom LeCompte,
Gary Drake, Masa Tanaka, Bill Ashmanskas…

Currently ~7 (non-ANL) CDF people have applied for 2004 Compton

ANL-HEP has maintained a strong physics role in CDF, this has attracted good people to come here.

Valuable connections with students who have gone on to faculty roles in CDF, for example W. Trischuk (Toronto), R. St.Denis (Glasgow), F. Ukegawa (Tsukuba), D. Saltzberg (UCLA)..

1985- First Collisions, then DOE Review

CDF: Argonne has been a "heavy player" in the historical development of the CDF at Fermilab. From now on, major recognition (invited papers at the key International conferences, for example) will likely go to those physicists with important roles in the data-analysis stream. It was the unanimous conclusion of DOE's three consultants that Argonne's data analysis resources appear inadequate, and that the Lab may soon find itself with a "shadow" role to play. The anticipated departure of R. Diebold, Argonne's group leader for the CDF effort , brings this program to a critical juncture: *unless a major analysis effort can be put forward, under a high-visibility leader*, consideration should be given to deploying Argonne's resources to strengthen other projects, relieving overall financial pressures thereby."

Timeless advice !

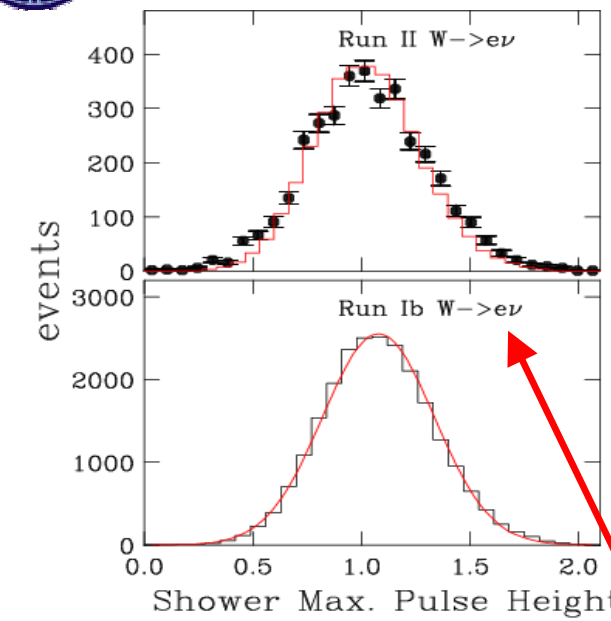
Argonne Roles in CDF

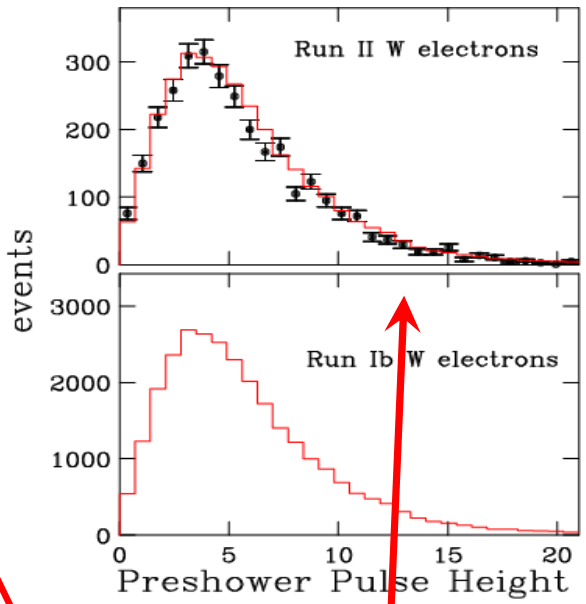
- Long Term (1979-2003)
  - Central EM, Shower max, preshower, crack detectors
  - Run IIb frontend readout (->132 nsec, QIE)
- Past physics
  - Leaders in developing B physics program
  - Leaders in photon physics, QCD and searches
    - CTEQ connection (Steve Kuhlmann Spokesperson)
  - Leaders in precision EWK (M_W)
  - Filled about 10% of Physics Convener 2 year terms
- Run II Operation Support
  - Management, shift leaders, SubProject Leaders
  - Central EM Calorimeter calibration, maintenance, online calib's.
  - Maintain Shower Max Electronics (central/plug) + online code
  - Commission/Support Level 2 Triggers (incl. Shower max/ Isolation)
- Electron/Photon ID= major part of Run II physics program
  - High p_T (W/Z, top, exotics) and Low p_T (B's, J/ψ, η, π^0)

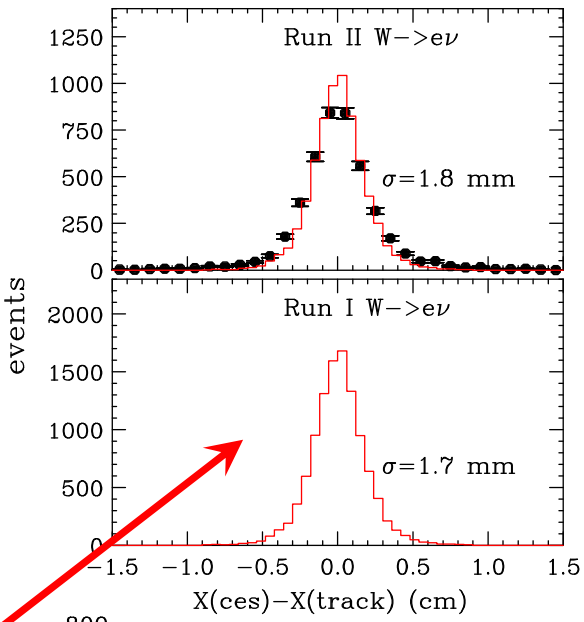
ANL roles in CDF Organization

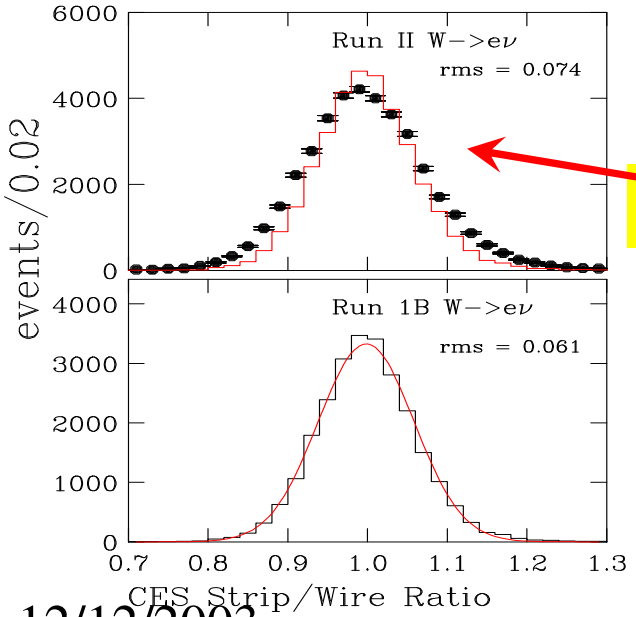
- Deputy Head of CDF Detector Operations (Proudfoot)
  - Coordination of detector work, op's efficiency, trigger plan
- Operations manager (Tanaka)
- Calorimeter Group co-head (SPLs) (Byrum, Nodulman)
  - Plan access work, weekly meetings, daily op's, data quality
- Electron/calorimeter offline/ Level3 reconstruction (Wagner)
- Physics Group Reps at Trigger/Dataset Working Group (Wicklund (B), Nodulman (top/EWK))
- B Physics subgroups
  - J/ψ Group (Tom LeCompte, former RunII muon upgrade mgr)
  - Semileptonic group (Masa Tanaka)
- Dijet mass group (Kuhlmann) (calorimeter energy flow, ->Higgs)
- Run IIb Calorimeter upgrade L2 Manager (Kuhlmann)

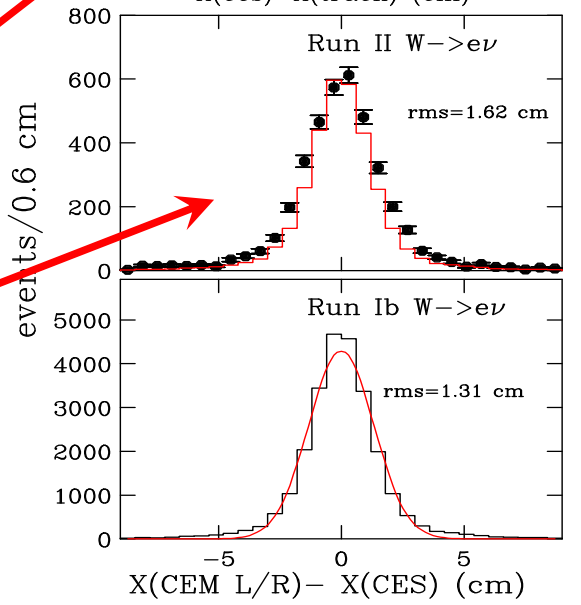
Central Shower Max & PreShower Detectors











Preshower

Shower Max

CEM left/right

Run I vs Run II

CDF Program

- Bottom and Charm Physics well underway
  - Silicon Trigger
  - B_S mixing (crucial CKM test) Require 3 fb-1
- Precision EWK (Top, M_W)
  - Improve SM Higgs constraint Require 2 fb-1
- QCD, exotics=>
  - Prompt photons, e/μ ID, jets, mets, b's
  - Expect 2-3 fb-1 might reveal "hints", might not
- Luminosity projections=> probably 2007 to reach these goals

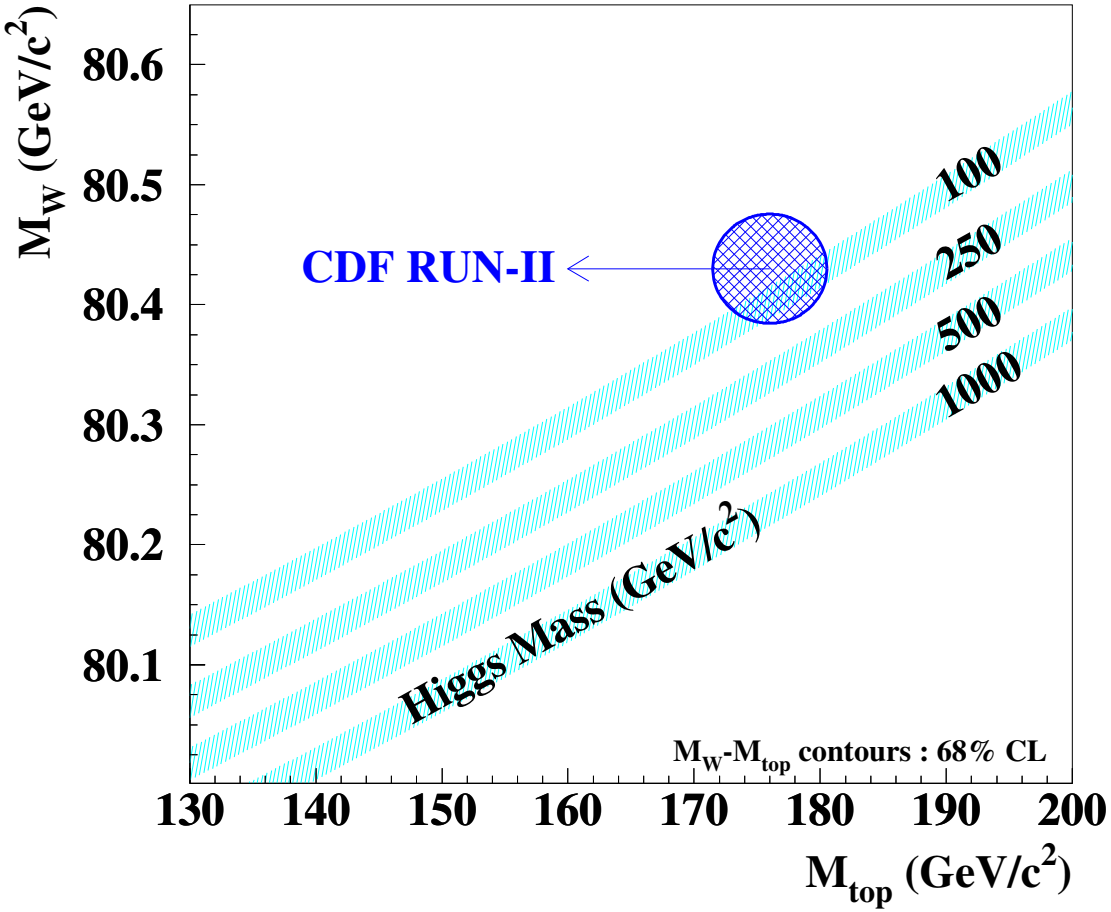
Note on B physics Hadron Collider versus BaBelle

B factories measure β and V(ub)

Bs decays (CDF) measure γ and V(td)

Hope is that different channels=> different answers for these

Higgs Constraints with 2 fb^{-1}

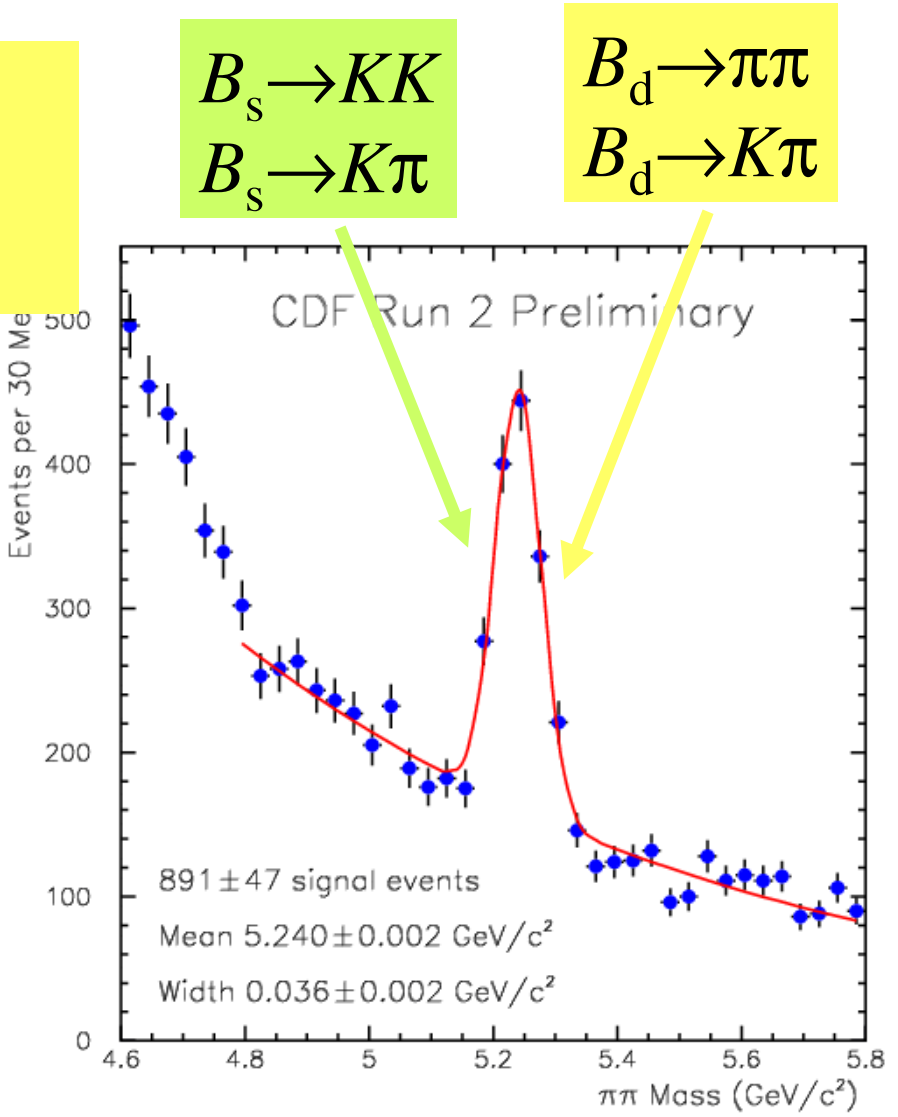


$B \to h^+h'^-$ Decays

190 pb-1/ 900 signal events

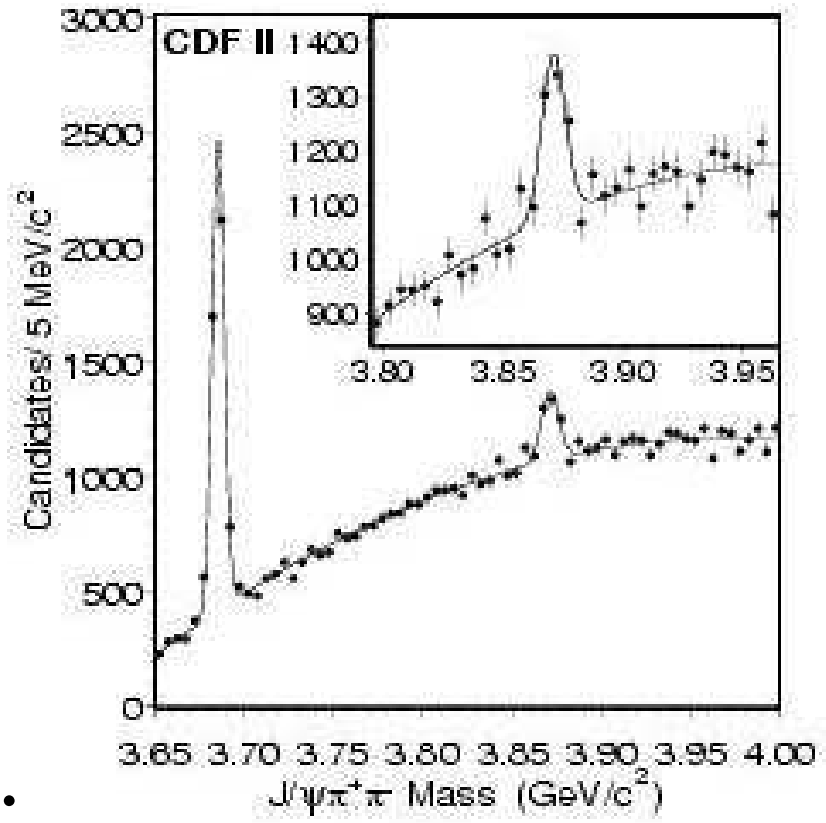
SVT trigger efficiency has ~doubled since these data were taken.

- $B_d \to \pi\pi$ and $B_s \to KK$ modes are sensitive to CP angle γ.
- $B_{(d,s)} \to K\pi$ and above modes are separated statistically dEdx
- $B(B_d \to \pi\pi)/B(B_d \to K\pi) = 0.26 \pm 0.11 \pm 0.055$.
- First observation of $B_s \to K^+K^-$.



Latest Discovery- Confirm Belle state χ(3870)

- Belle sees χ(3872) in B decays
- CDF sees in B's and direct Charmonium production
- What is it?

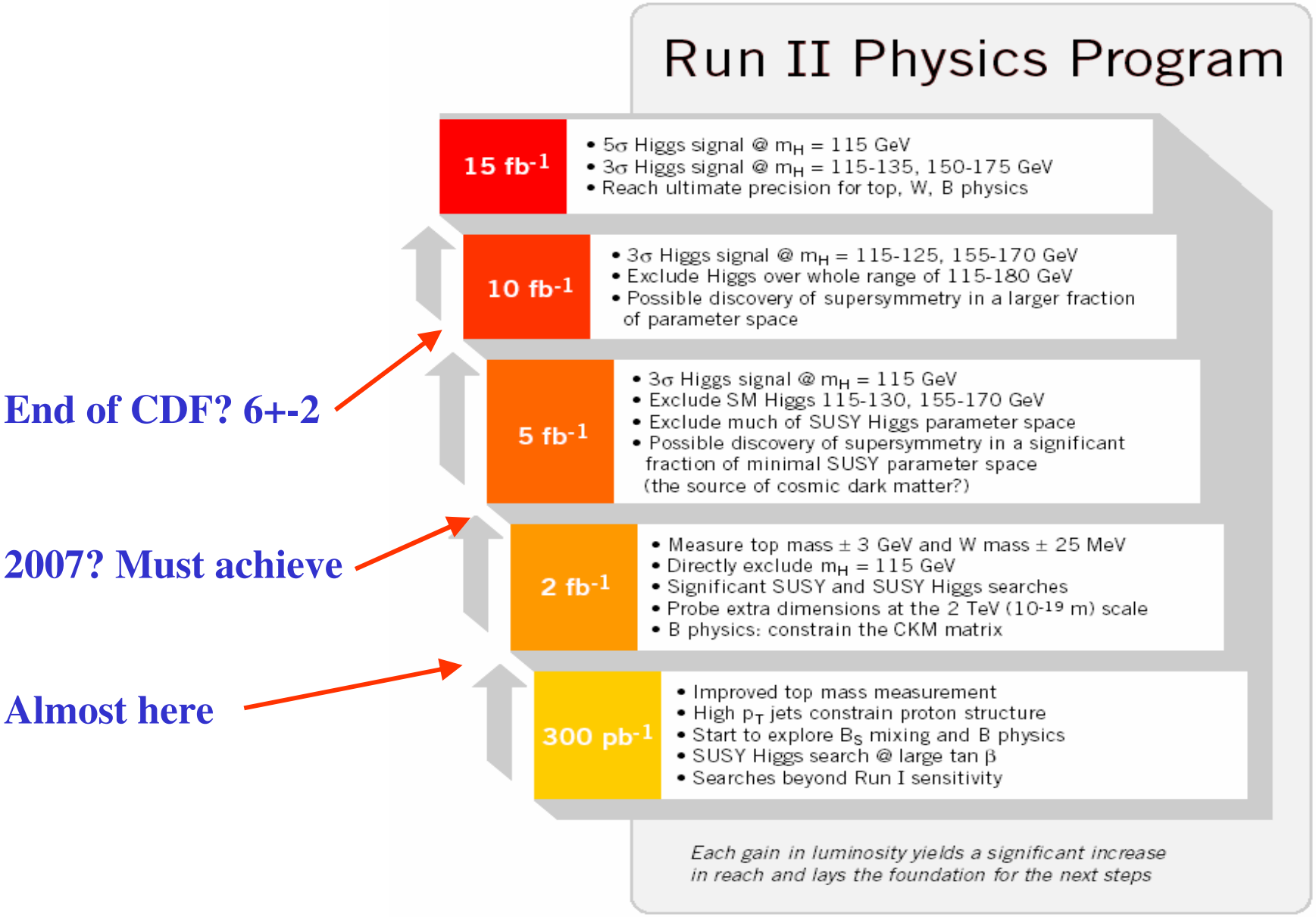


Occasionally we find new things that are fun but not on the roadmap.

Flagship B Physics in Run II

- J/ψ modes
  - Sin 2β (J/ψ K_S) = calibration
  - Sin $2\beta_S$ (J/ψ φ) = SM test
  - ΔΓ(J/ψ φ, J/ψ η)= SM test
- B->ππ, B_S->KK = CKM angle γ
  - Fleischer strategy- 4 asymmetries (A_{DIR}, A_{MIX} for B_S, B^0)
  - Note, B^0 ->ππ asymmetries already constrained by B factories
- B_S -> $D_S\pi$ (ππ) = Mixing X_S, crucial for all B_S physics
  - Signal yields (full use of trigger BW, SVT efficiency)
  - Flavor tagging efficiency from semileptonic samples
  - Time resolution (L00)
- Unique to CDF, important CKM physics
  - CDF works well, steady BW improvements are in process
  - Forward B detectors? When? S/B? no experience except Hera-b

Advertised Luminosity and Physics Steps



End of CDF? 6+-2

2007? Must achieve

Almost here

Office Management+Budget HEP Goals

HEP Long Term Goals

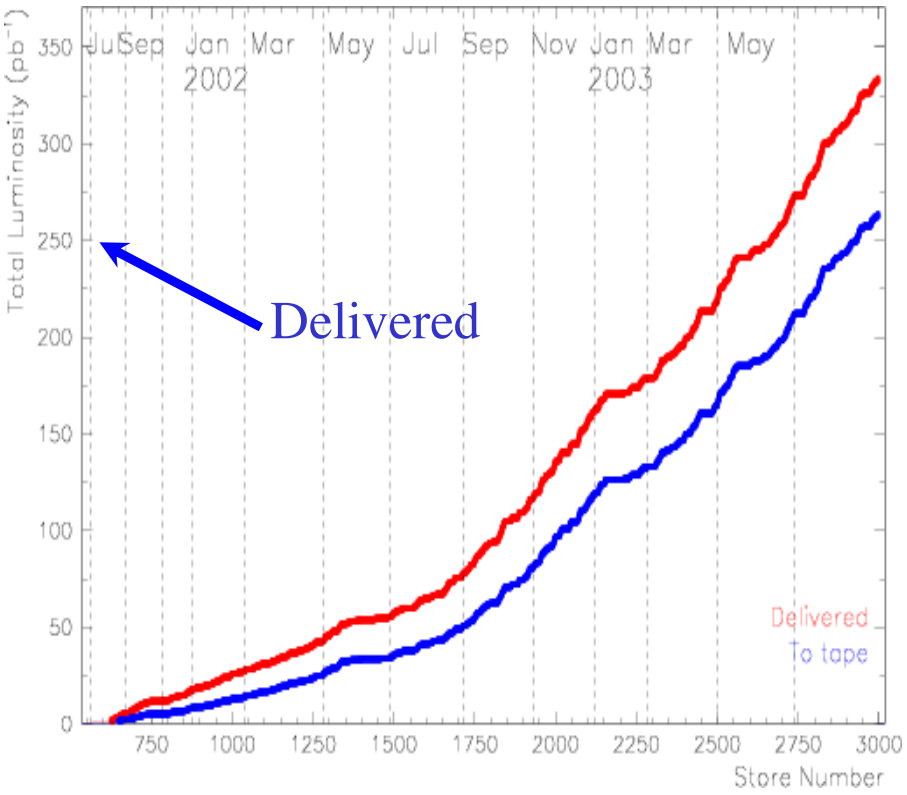
The following indicators establish specific long-term (10 year) goals in Scientific Advancement that the HEP program is committed to. They do not necessarily represent the research goals of individual experiments in the field. These goals correspond very roughly to current research priorities, but are meant to be representative of the program, not comprehensive. The definitions of "success" and "minimally effective" for each broad goal establish the metrics by which progress of the field as a whole can be measured.

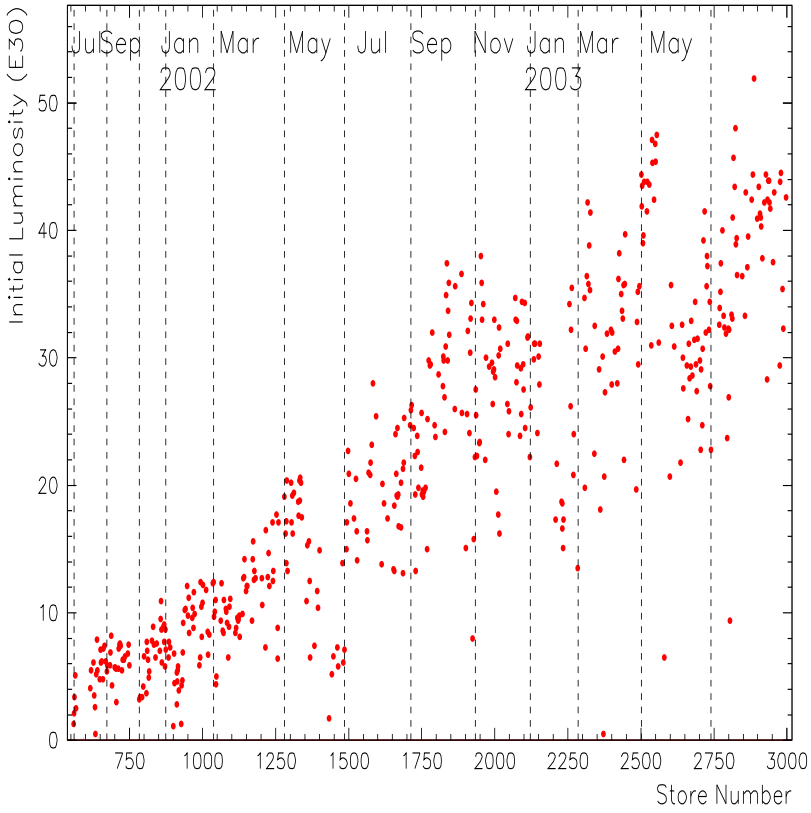
CDF roles, carefully negotiated

HEP Long-term Goal (Rough Priority Order)	*Definition of: "Success"*	*"Minimally Effective"*
• **Measure the properties and interactions of the heaviest known particle (the top quark) in order to understand its particular role in the Standard Model.**	Measure the top quark mass to +/- 3 GeV and its couplings to other quarks with a precision of ~10% or better.	Measure the top quark mass to +/- 4 GeV and its couplings to other quarks with a precision of 15% or better.
• **Measure the matter-antimatter asymmetry in many particle decay modes with high precision.**	Measure the matter-antimatter asymmetry in the primary (B → J/psi K) modes to an overall relative precision of 4% and the time-integrated asymmetry in at least 15 additional modes to an absolute precision of <10%.	Measure the matter-antimatter asymmetry in the primary modes to an overall relative precision of 7% and the time-integrated asymmetry in at least 10 additional modes to an absolute precision of <15%.
• **Discover or rule out the Standard Model Higgs particle, thought to be responsible for generating**	If discovered, measure the mass of the Standard Model Higgs with a precision of a few percent or better. Measure other properties of the Higgs (e.g., couplings) using several final states.	Discover (>5 standard deviations) or rule out (>95% CL) a new particle consistent with the Standard Model Higgs from a mass of 114 GeV, up to

mass of elementary particles.		a mass of 800 GeV.
• **Determine the pattern of the neutrino masses and the details of their mixing parameters.**	Confirm or refute present evidence for additional neutrino species. Confirm or rule out the current picture of atmospheric neutrino oscillations. If confirmed, measure the atmospheric mass difference ($|\Delta m^2|$) to 15% (full width at 90% CL); and measure a non-zero value for the small neutrino mixing parameter ($\sin^2(2\theta_{13})$), or else constrain it to be less than 0.06 (90% CL, ignoring CP and matter effects)	Measure atmospheric neutrino mass difference $|\Delta m^2|$ to 25% using accelerator neutrino beams. Improve current limits on neutrino oscillations.
• **Confirm the existence of new supersymmetric (SUSY) particles, or rule out the minimal SUSY "Standard Model" of new physics.**	Extend supersymmetric quark and/or gluon searches to 2 TeV in a large class of SUSY models. For masses below 1 TeV, measure their decays into several channels and determine masses of SUSY particles produced in those decays.	Extend supersymmetric quark and/or gluon searches to 1.5 TeV for some SUSY models (i.e. mSugra and similar models).
• **Directly discover, or rule out, new particles which could explain the cosmological "dark matter".**	Discover (>5 standard deviations) the particle responsible for dark matter, or rule out (95% CL) many current candidates for particle dark matter (e.g., neutralinos in many SUSY models)	Rule out (90% CL) new particle(s) consistent with cosmological dark matter with a nuclear interaction cross-section larger than 10^{-7} cm^2.

Luminosity through September 2003



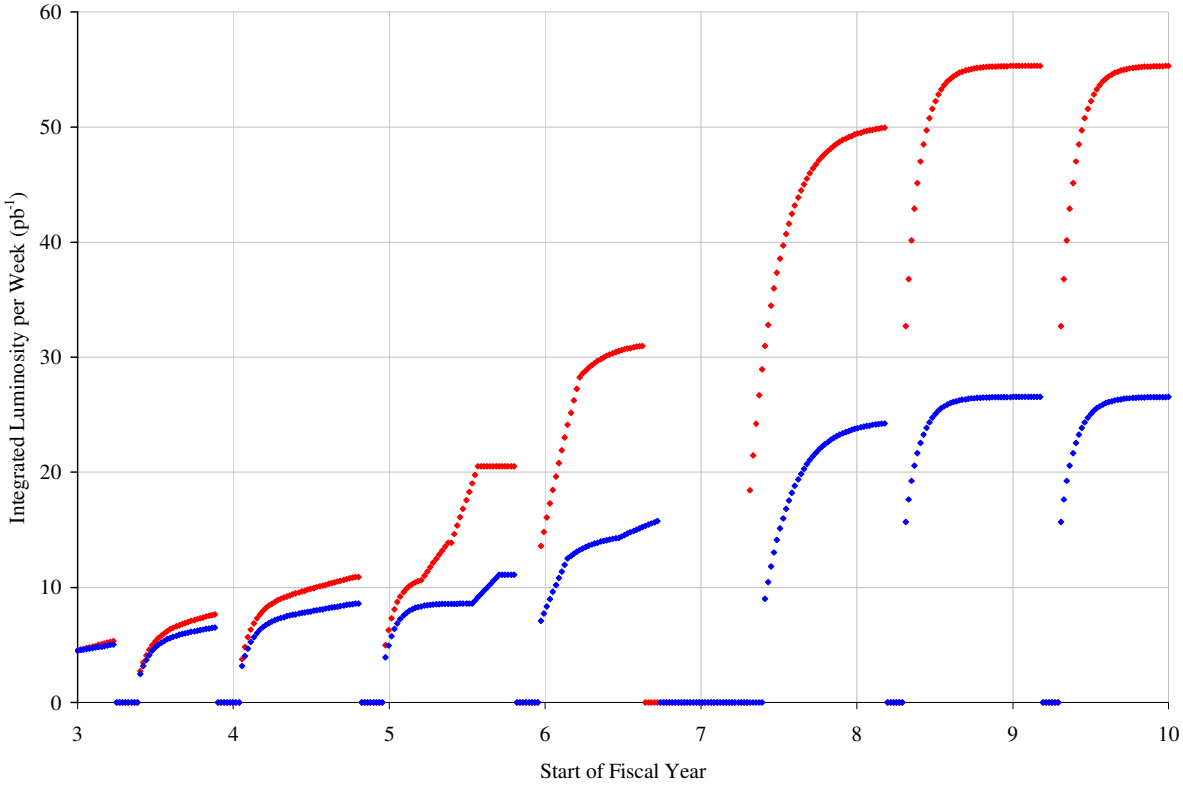


Luminosity Plans (Base/ Stretch)

Integrated Luminosity (fb^{-1})				
	Design Projection		Base Projection	
	per year	Accum-ulated	per year	Accum-ulated
FY03	0.22	0.30	0.20	0.28
FY04	0.38	0.68	0.31	0.59
FY05	0.67	1.36	0.39	0.98
FY06	0.89	2.24	0.50	1.48
FY07	1.53	3.8	0.63	2.1
FY08	2.37	6.15	1.14	3.25
FY09	2.42	8.57	1.16	4.41

Integrated luminosity expected to be skewed to out years,
Hence, same for physics.
Base projection is probably more likely than stretch

Luminosity Base/Stretch



Fermilab Long-Range Schedule

Year		2003	2004	2005	2006	2007
Tevatron Collider		CDF & DZero	CDF & DZero	CDF & DZero	CDF & Dzero	6TeV CDF & Dzero
Neutrino Program	B	MiniBoone	MiniBooNE	MiniB	OPEN	OPEN
	MI			MINOS	MINOS	MINOS
Meson 120	MT	Test Beam	Test Beam	Test Beam	Test Beam	Test Beam
	MC	E907/MIPP	E907/MIPP	E907/MIPP	OPEN	OPEN

Year		2008	2009	2010	2011	2012
Tevatron Collider		6TeV CDF & DZero	6TeV CDF & DZero	6TeV OPEN	6TeV OPEN	6TeV OPEN
Neutrino Program	B	OPEN	OPEN	OPEN	OPEN	OPEN
	MI	MINOS	MINOS	OPEN	OPEN	OPEN
Meson 120	MT	Test Beam	Test Beam	Test Beam	Test Beam	Test Beam
	MC	E906	E906-DrellYan	E906-DrellYan	E906-DrellYan	OPEN
	MEP	OPEN	CKM	CKM	CKM	CKM / OPEN

RUN or DATA
STARTUP/COMMISSIONING
INSTALLATION
M&D (SHUTDOWN)

Scratch CKM (for now),
Scratch long shutdown in 2006

Calorimetry Upgrade

Steve Kuhlmann, Level-2 Manager

Joey Huston, Level-3 Manager Preshower

Dave Toback, Level-3 Manager EM Timing

Preshower/Crack

- University of Tsukuba
- INFN (Pisa, Rome)
- JINR (Dubna)
- Argonne National Laboratory
- Michigan State University
- Rockefeller University
- FNAL

Electromagnetic Timing

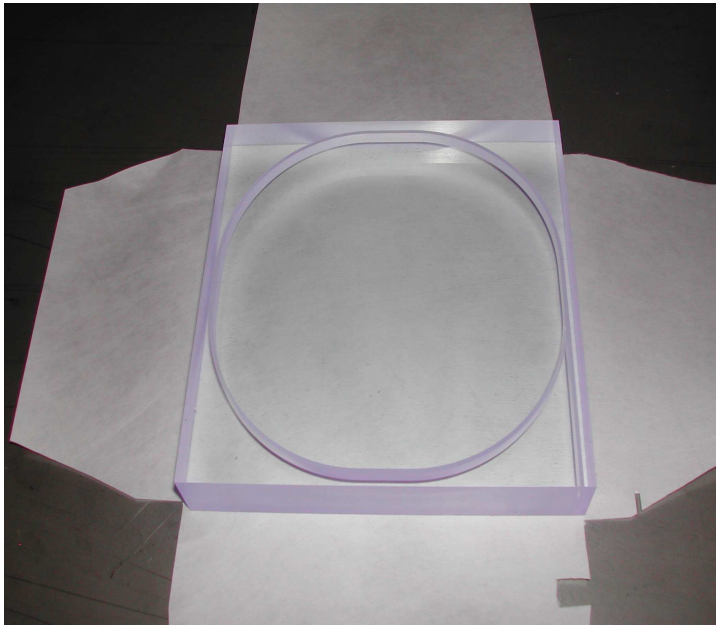
- Texas A&M
- INFN (Frascati)
- University of Chicago
- University of Michigan
- Argonne National Lab
- FNAL

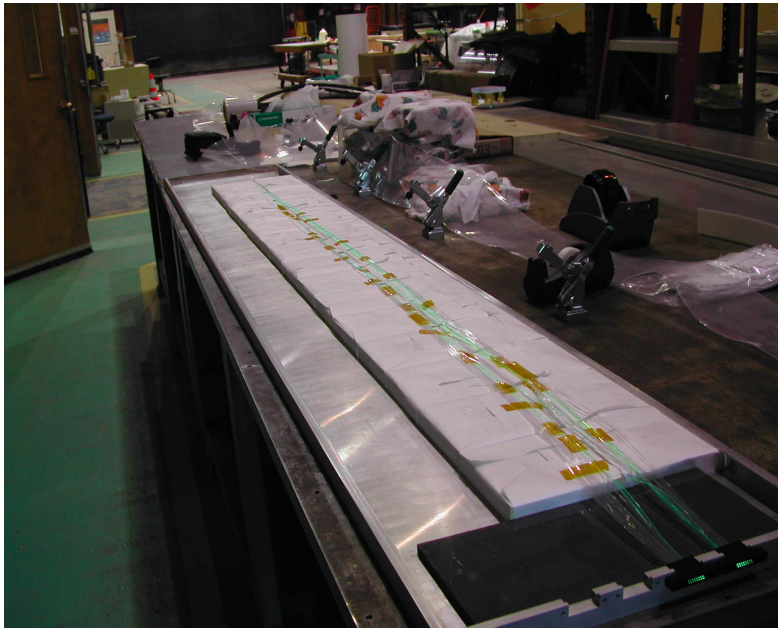
Assembly at ANL in 366 (2004)

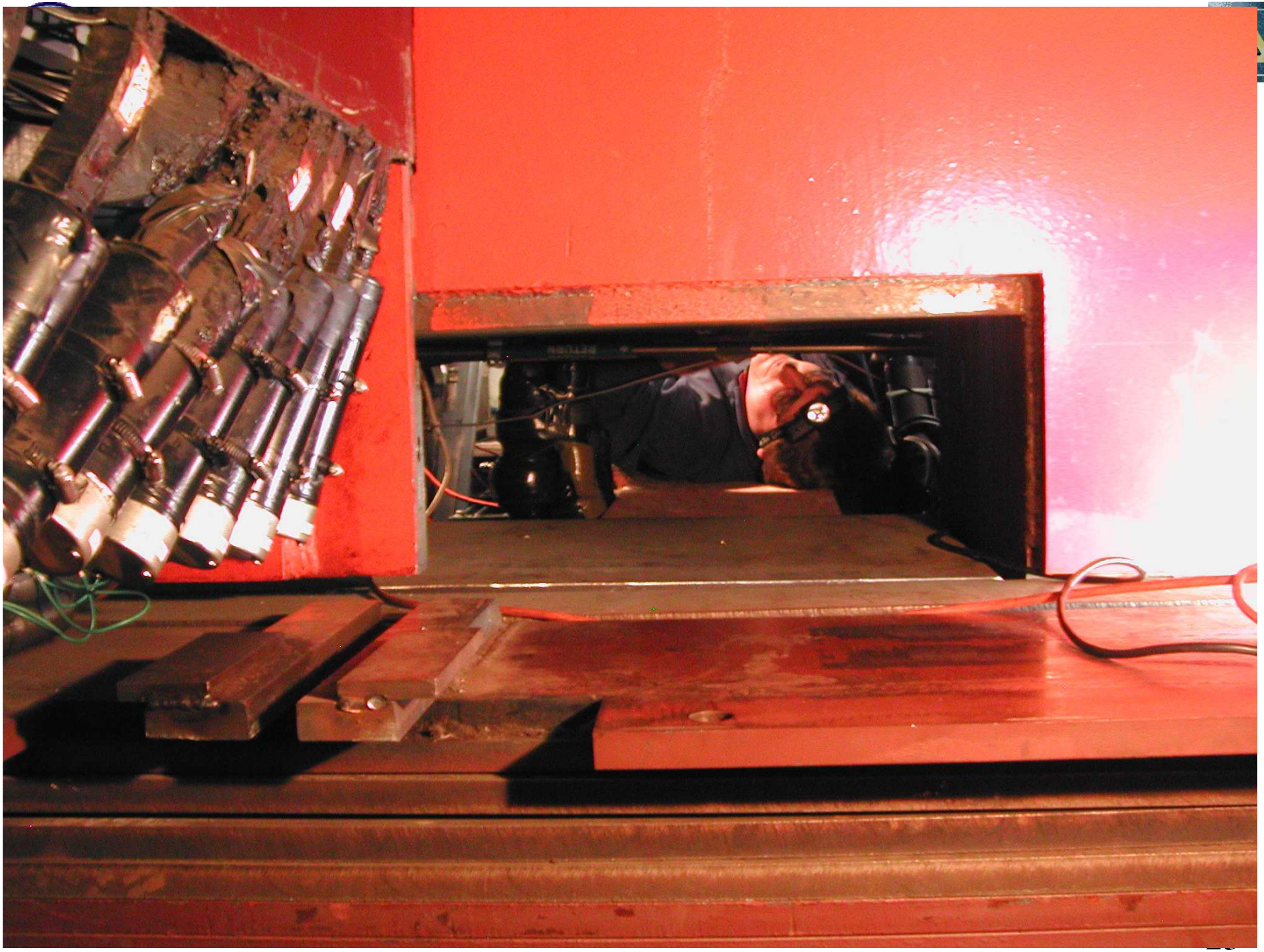
Partial or complete installation in B0 fall 2004 shutdown

Preshower Progress

- Assembly-fest held at ANL April 10th, attended by MSU, INFN, and Rockefeller.
- 32/54 tiles of first Full-scale Preshower Prototype instrumented that day







Recommendations for ANL-CDF

- Barring catastrophe, expect total luminosity to double each year.
  - FNAL plan = continue collider program, merge into BTeV
  - CDF/D0 goals require 2-4 fb-1, ~ end 2008 (hope= 6+-2 fb-1)
  - Strong physics program at CDF through this decade- we want to participate in the physics at CDF (why not?)

- ANL staffing
  - Current effort (Karen, Jimmy, Bob1, Bob2, Tom, Larry, Steve) split with Atlas,Veritas, Minos, LC, Auger… =>~6 FTE in 800 collaboration
  - Mech. (CPR2), elec.(showermax electronics) support- see Vic/Gary talks.
  - To do physics, must maintain detector support and visible leadership roles.
  - Postdoc (Masa Tanaka) has been crucial for ANL and CDF
    Operations manager, Level-2 expert/pager, physics convener, interface with students and other postdocs, "24/7".

- It makes no sense to plan to ramp down to "1 CDF FTE" in 2008
  (unless CDF fails completely or there are clearly better physics projects)

- Recommend: must maintain strength in CDF through 2008
  - Physics leadership
  - Adequate support for detector operations

Argonne Roles in CDF

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  - Run IIb frontend readout (->132 nsec, QIE)
- Past physics
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