

Status of the DØ Detector

- Tevatron, DØ operations and performance – Alan Stone
- DØ Trigger – Ron Lipton
- L3/DAQ – Andy Haas
- Future running – Dmitri Denisov

This talk

- SMT
- CFT
- Preshowers
- Calorimeter
- ICD
- Muon
- FPD

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DØ Collaboration Workshop
University of Oklahoma, Norman, OK



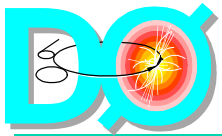
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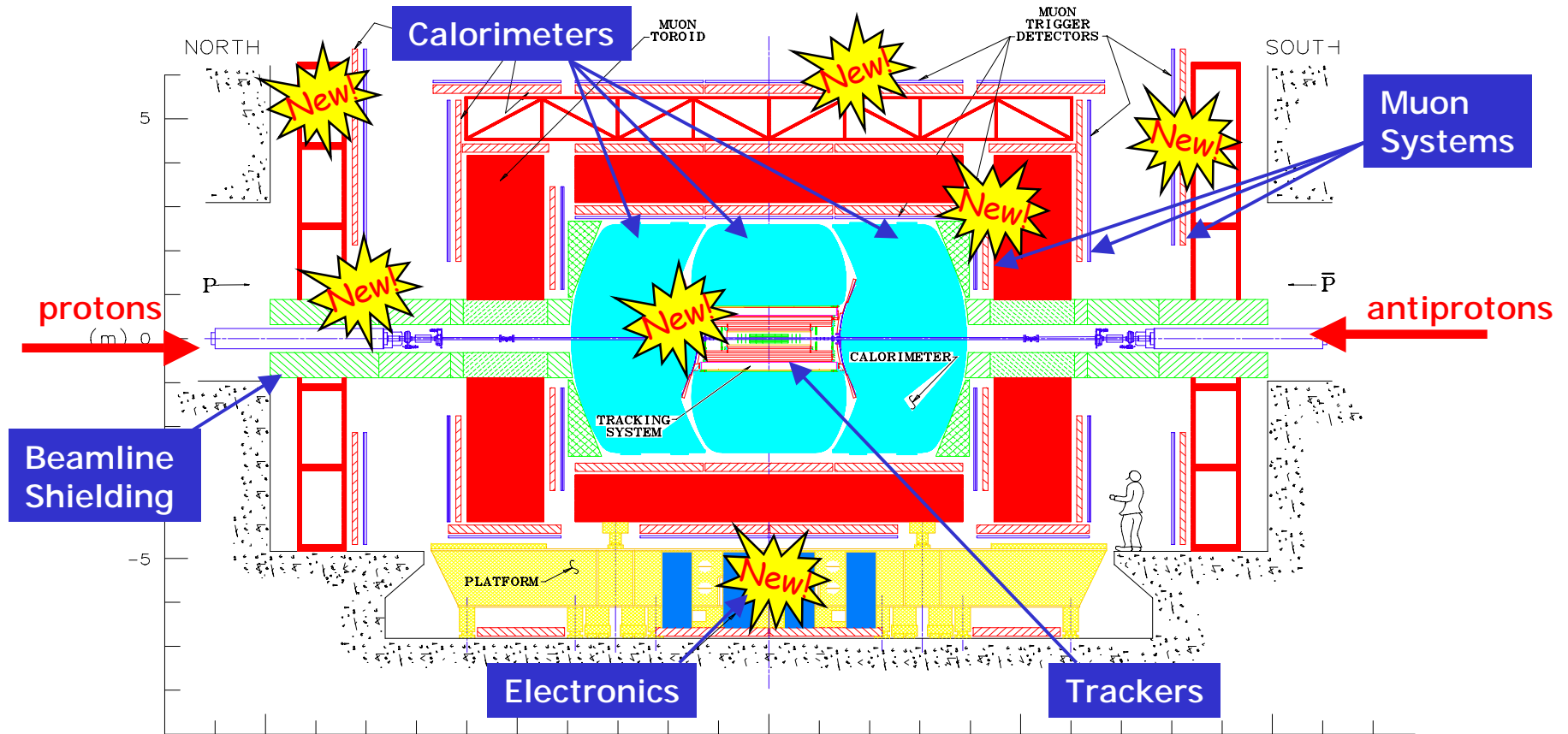
Status of the DØ Detector

July 8, 2002

DØ Collaboration Workshop, Oklahoma
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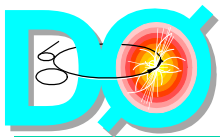


The Run 2a DØ Detector

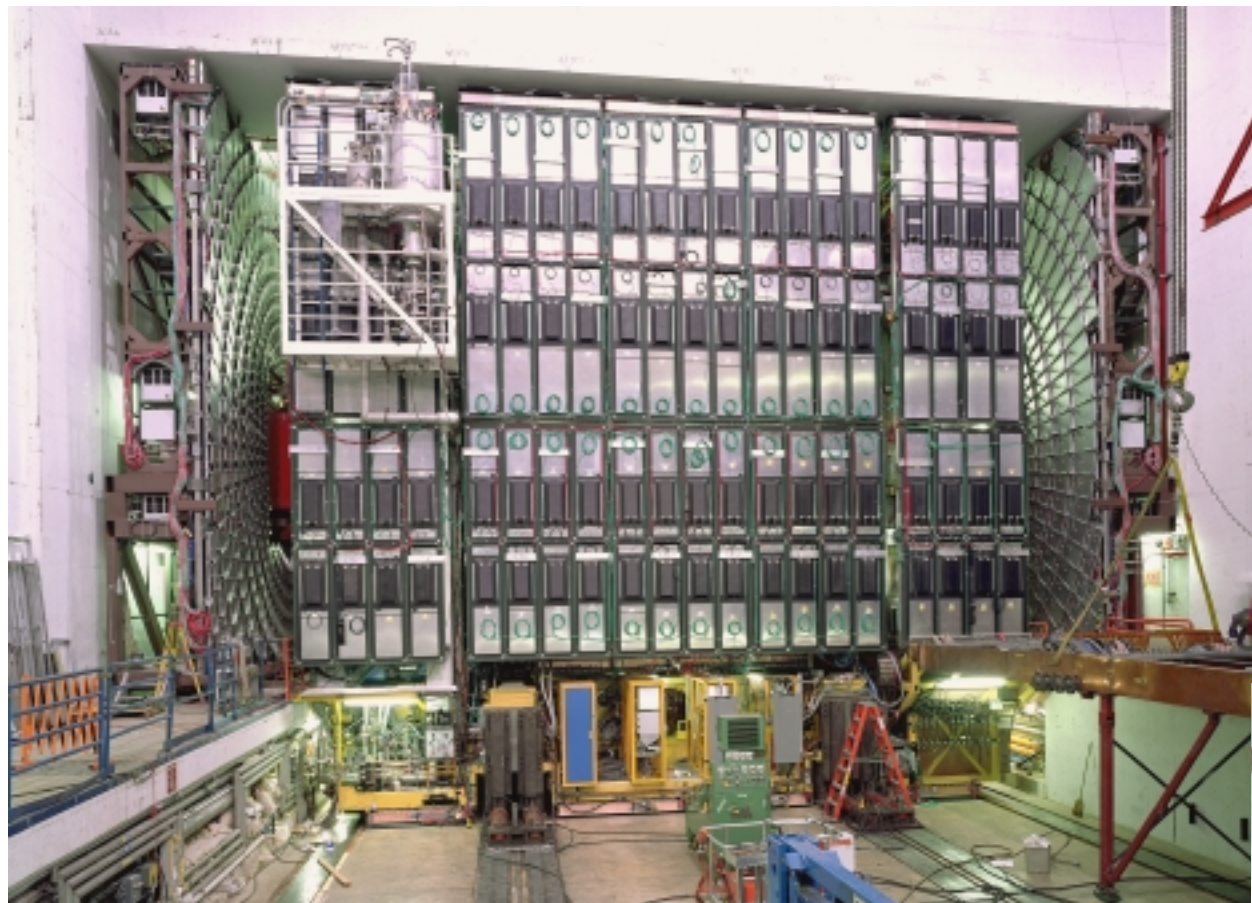


- Silicon Microstrip Tracker (SMT)
- Central Fiber Tracker (CFT)
- Superconducting Solenoid
- Central/Forward Preshowers (PS)
- Inter-Cryostat Detectors (ICD)
- Muon central and forward scintillator
- Muon central proportional drift tubes (PDT)
- Muon forward mini-drift tubes (MDT)
- Forward Proton Detector (FPD)
- Shielding
- Front-end readout electronics, trigger, DAQ,...

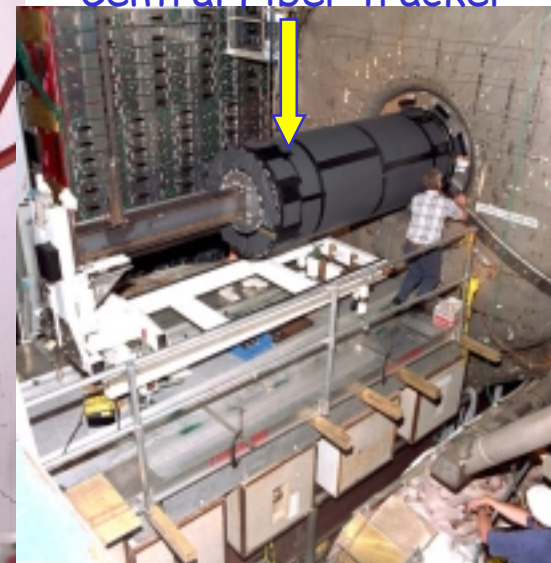




Detector rolled in...



Central Fiber tracker



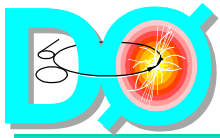
SMT cylinder



- Fiber tracker installed Dec 2000
- SMT ½ barrels installed
- Detector installed in collision hall Jan 2001...still needed cabling
- H Disk installation was completed Feb 2001
- **Cabling (~15,000 connections) and electronics installation completed in May 2001**



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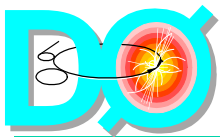


Major achievements in June shutdown

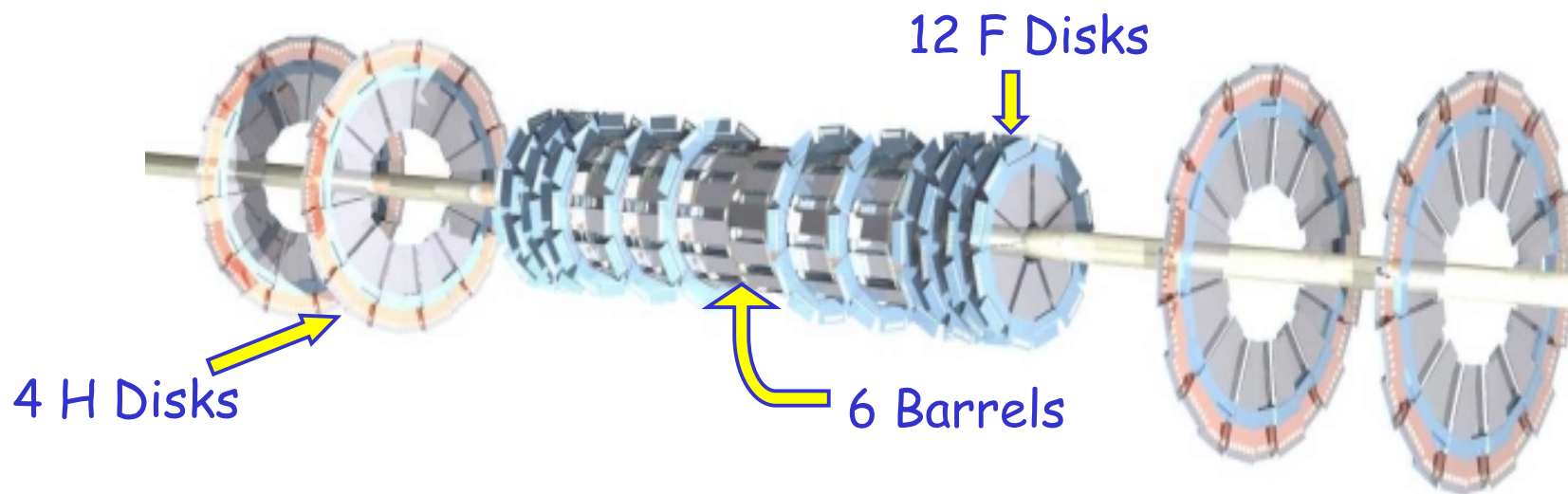
- Shutdown June 3-14 for antiproton stochastic cooling tank installation
- Major tasks for DØ
 - ◆ Refurbished all SMT IB LVPS
 - ◆ Repaired a number of muon readout channels and HV + checked calibrations
 - ◆ Almost all Preshower AFE boards installed (195/198) + temp and bias control revisions
 - ◆ Significant progress on L1CTT
 - ◆ Installed L1CAL trigger to $\eta < 2.4$
 - ◆ New Timing and Control boards for calorimeter readout
 - ◆ New Muon Fanout Cards installed
 - ◆ All L1 muon cards installed
 - ◆ L3 SBC replacement completed for all readout crates
 - ◆ Continuing integration of L2 trigger systems
 - ◆ Extensive debugging of multibuffer readout to get to > 100 Hz readout
- Very efficient operation from mechanical and electrical support personnel
- **Finished shutdown safely and on schedule with all critical jobs completed**
- Been ready for collisions since June 15

- Planning beginning for October (or later?) shutdown...





Silicon Microstrip Tracker



793k channels

Percentage of working devices:

Barrel: ~95%

F-disks: ~95%

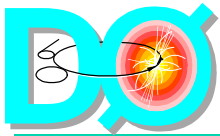
H-disks ~87%

Total: 93%

	Barrels	F-Disks	H-Disks
sngl/dbl	sngl + dbl	double	single
Stereo	0, 2, 90	+/-15	+/-7.5
Channels	387072	258048	147456
Modules	432	144	96
Rin/Rout	2.7/9.4cm	2.6/10.5cm	9.5/26cm



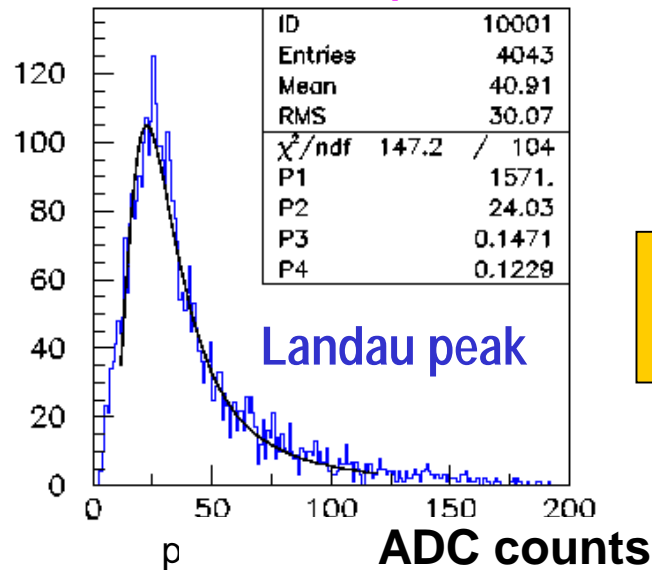
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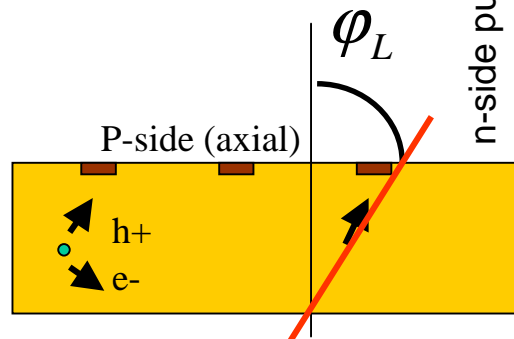
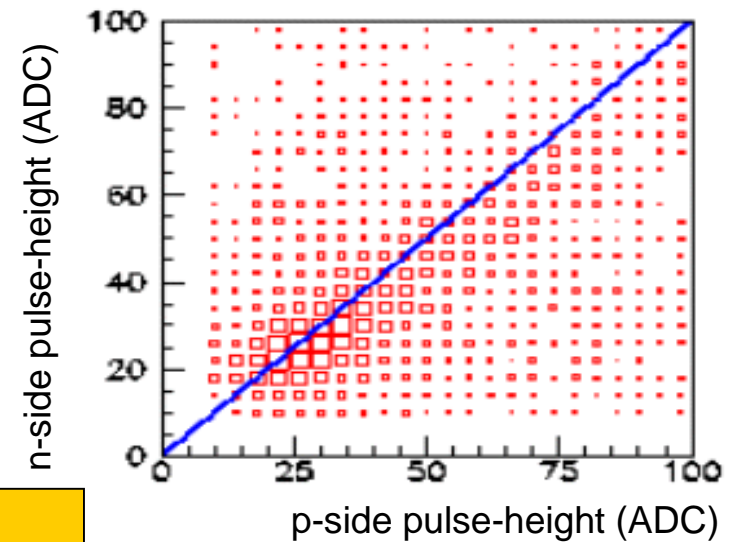
SMT Charge Collection

- Cluster charge (corrected for track angle):

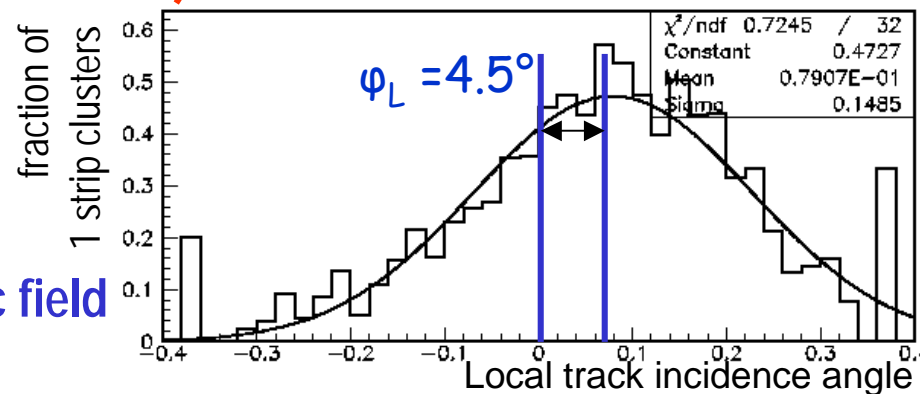
- ◆ 1 mip ~ 4fC ~ 25 ADC counts.
- ◆ Noise < 2ADC counts
- ◆ S/N > 10 as expected

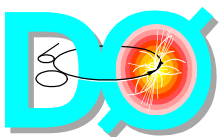


- Charge correlation between p- and n-side of a detector



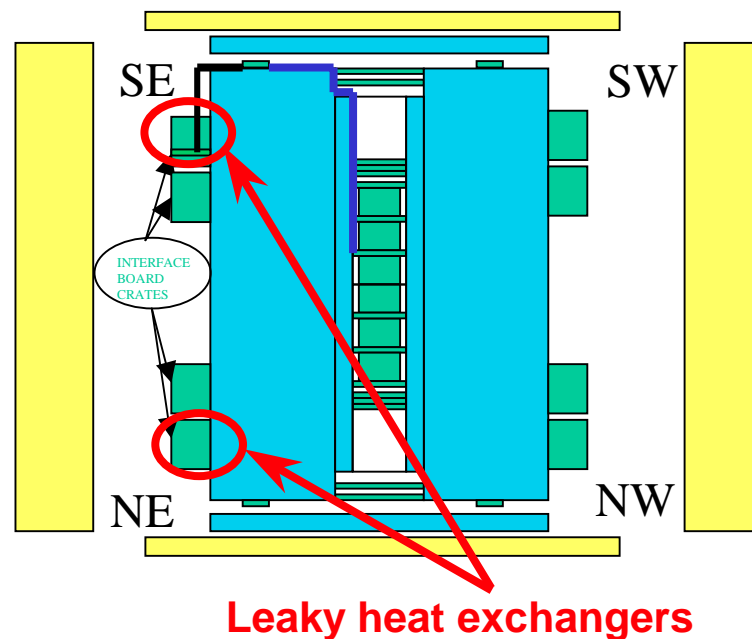
- Lorentz angle: The charge deflection due to the magnetic field





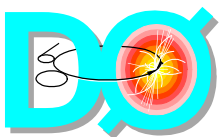
SMT Status

- Some operational “hiccups” due to restricted access
 - ◆ Developed resistive fuses – replaced
 - ◆ Problems with LVPS for Interface boards
 - ▲ refurbished in June shutdown
 - ◆ Water leaks from heat exchangers
- Installed grounding straps on IB crates and repaired some HDIs during June shutdown
- Observing occasional trips on HV due to humidity
 - ◆ New improved HV fanout boxes on order
- Hit efficiencies for good single silicon detectors is $97.6 \pm 0.2\%$
- Systematic studies performed to understand the pedestal shifts for different bunch crossings
- Working on geometry and alignment, improved monitoring and data quality



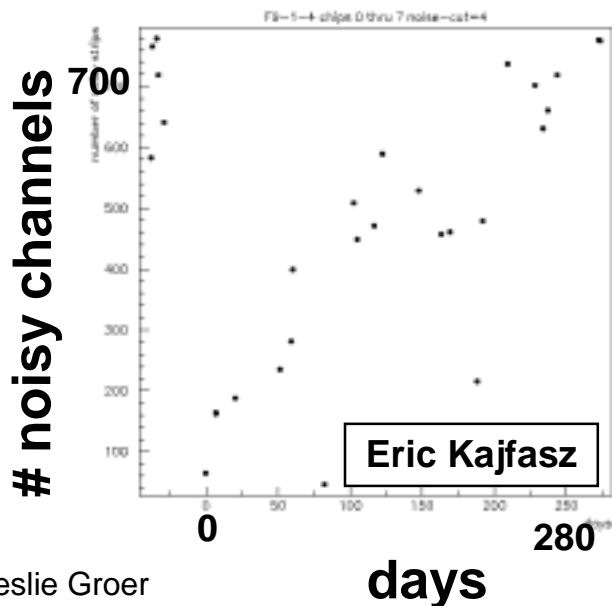
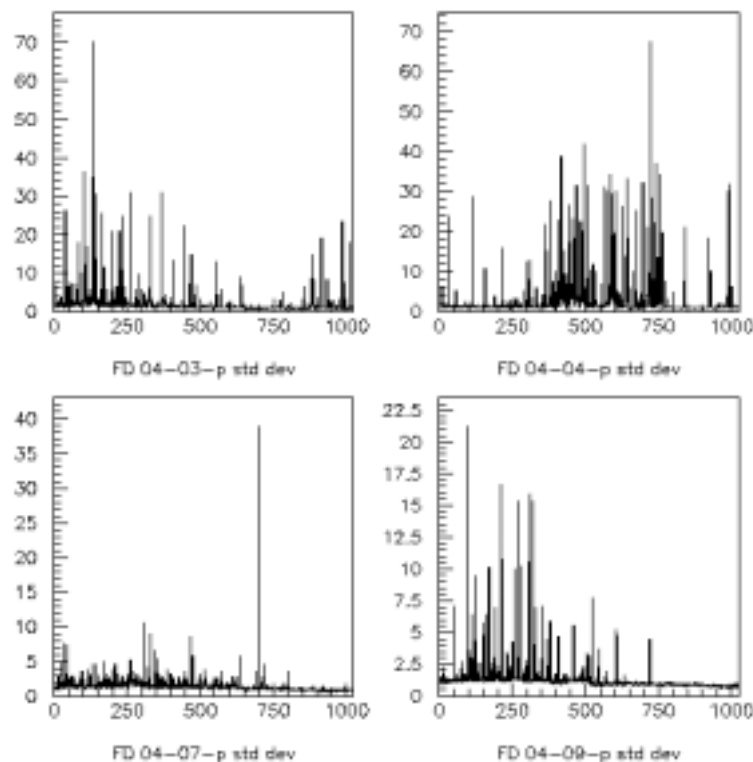
- Work on detailed modeling of charge sharing and clustering to improve position resolutions with effects of cross-talk, B-fields, charge diffusion, angular dependence etc.
- Investigating source of noise problems (“grassy noise”) in Micron F-wedge





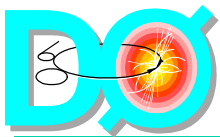
SMT F-Wedge Noise

- 96 of 144 F-wedges are from Micron
- 35 exhibit “grassy” noise (10-80% of channels) that developed over time + 2 ladders
- Typical rms noise values ~ 2 ADC counts
- Initial theory was microdischarges
 - ◆ Did not remove problem by shifting bias voltage
 - ◆ Increased operating temperatures temporarily from -10°C to 0°C to investigate but expected reduction of noise not seen

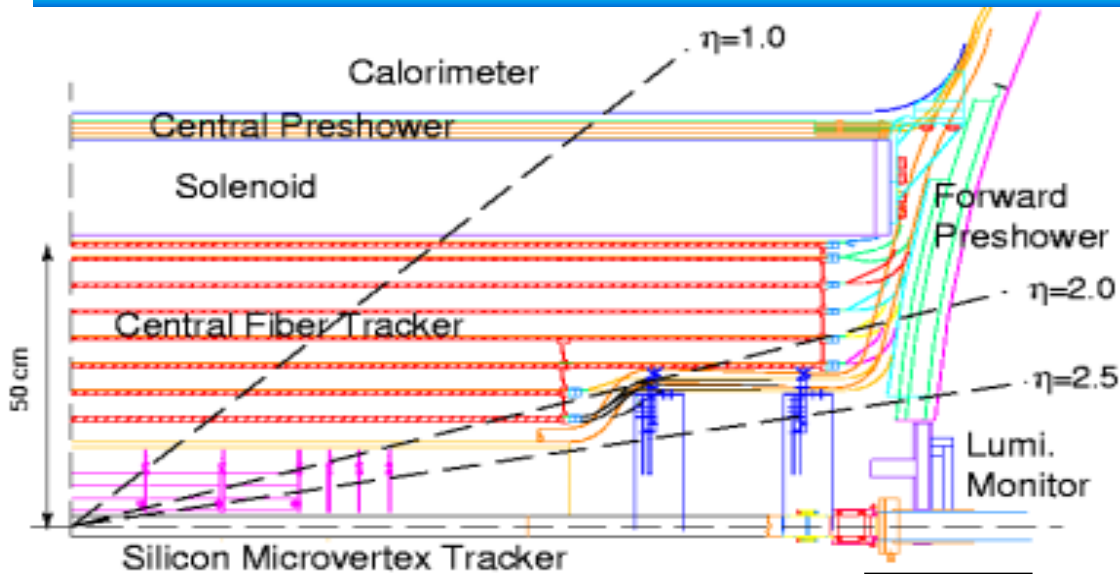


- Current suspicion:
 - ◆ Surface charge build up due to low humidity environment
- Test stand at SiDet being setup to investigate further

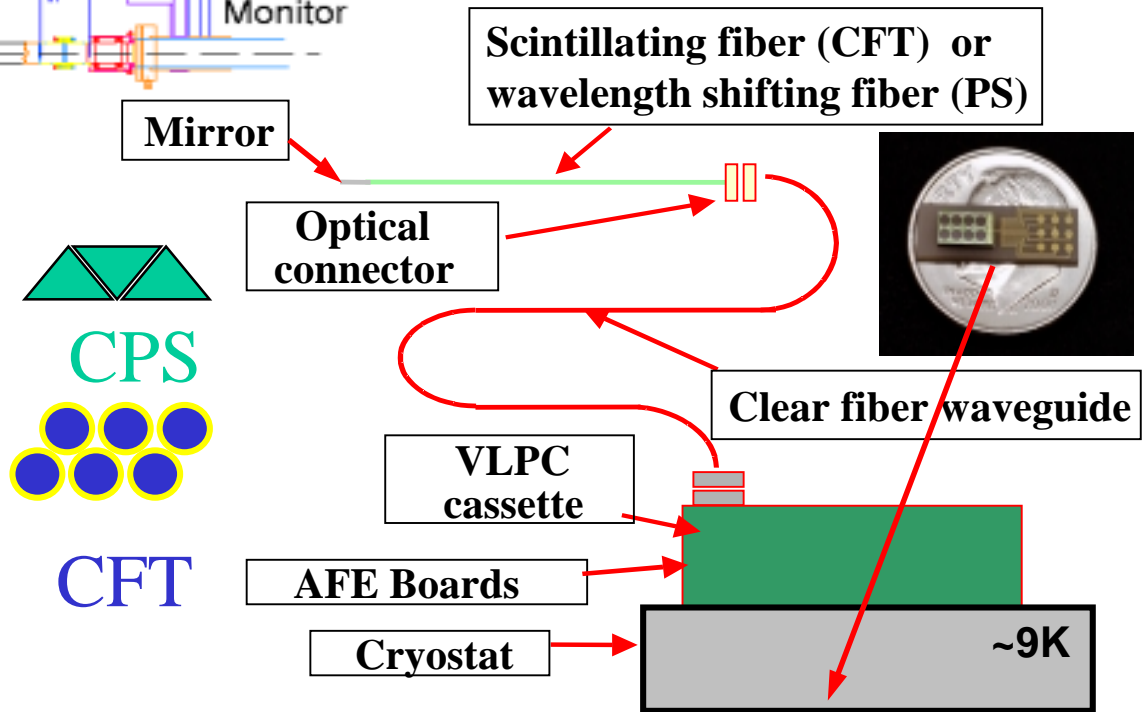
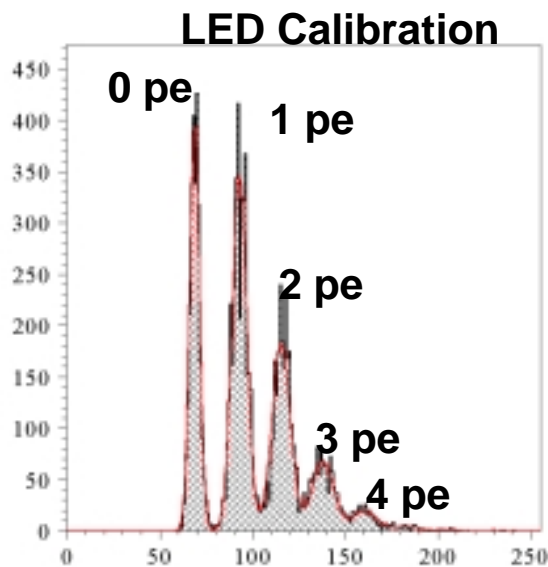




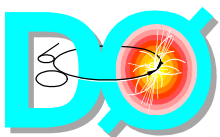
CFT+CPS+FPS



76,800 channels in the CFT readout
 7,680 channels in the CPS readout
 14,884 channels in the FPS readout

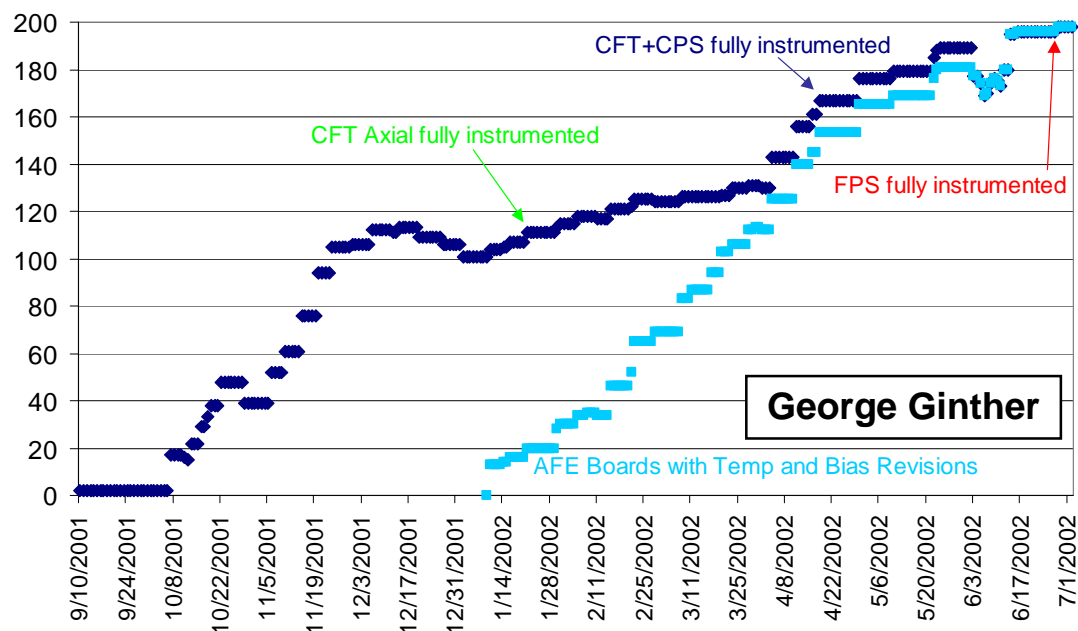


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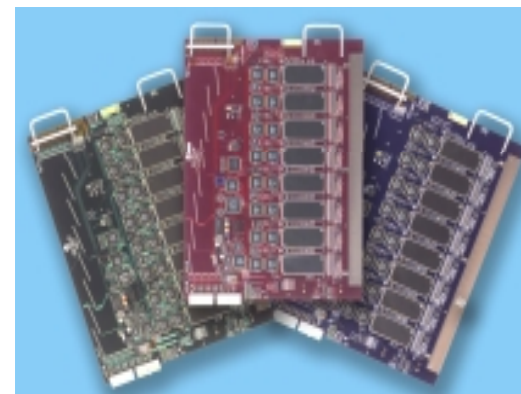
CFT + CPS + FPS

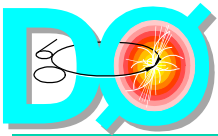
Number of Installed AFE Boards



- CFT+CPS fully instrumented by mid-April 2002
- FPS fully instrumented end June 2002
- Readout system is generally stable and well behaved
- Substantial progress developing, testing, and integrating components of the L1 Central Track Trigger

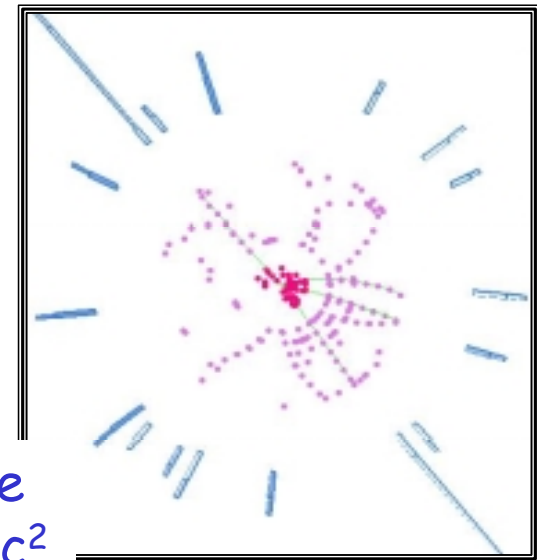
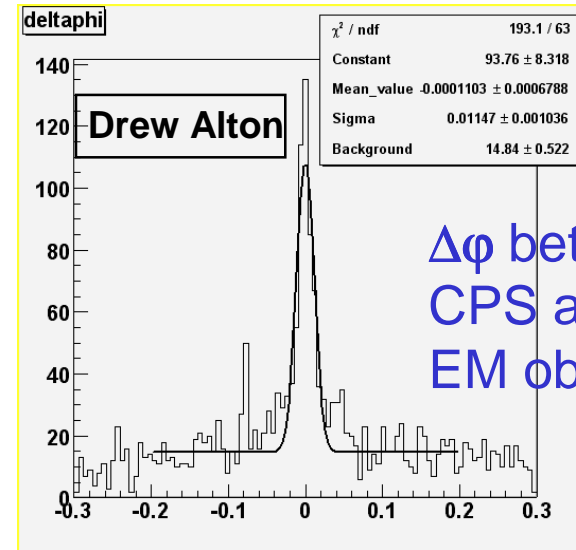
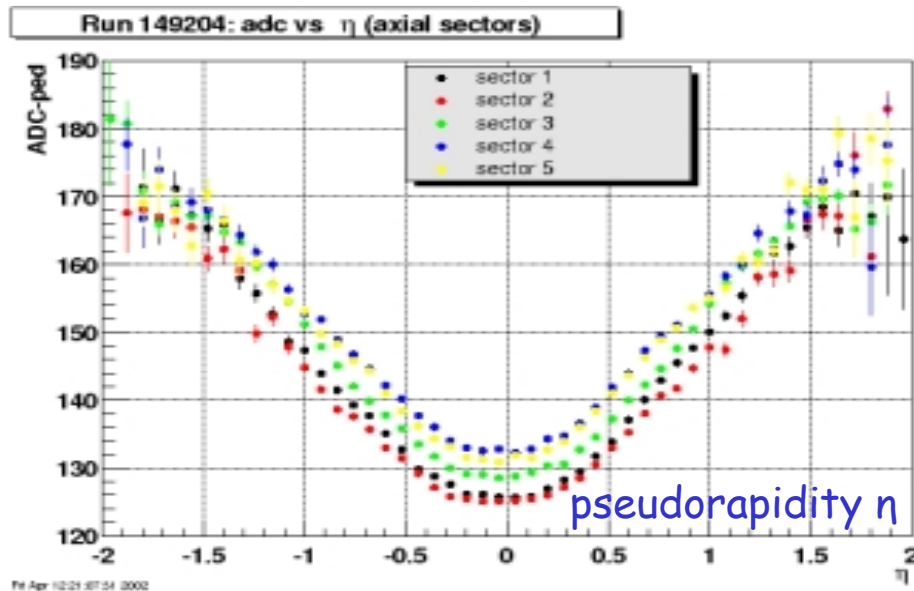
- Initial commissioning of CFT+PS (and waveguide testing) performed using prototype boards
- Installation and commissioning of AFE boards began during the October 2001 shutdown





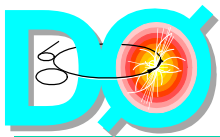
CFT + PS Status

Light yield per sector



- Detectors appear to be performing well
 - ◆ CFT hits detected on tracks with > 98% efficiency
- Tracks are routinely reconstructed, and results are incorporated into higher level analyses





CFT + PS Status

- There is still plenty of work to get CFT+PS readout and trigger system fully operational, study and address undesirable features of the system, and to optimize performance of the system

- ◆ **Volunteers are welcome!**

- **Near Term Activities**

- ◆ Address timing issues
- ◆ CTT development, testing and commissioning
- ◆ Optimize operating parameters
 - ▲ Discriminator thresholds and gains
 - ▲ SVX thresholds and gains
 - ▲ Bias voltages
 - ▲ Temperature control

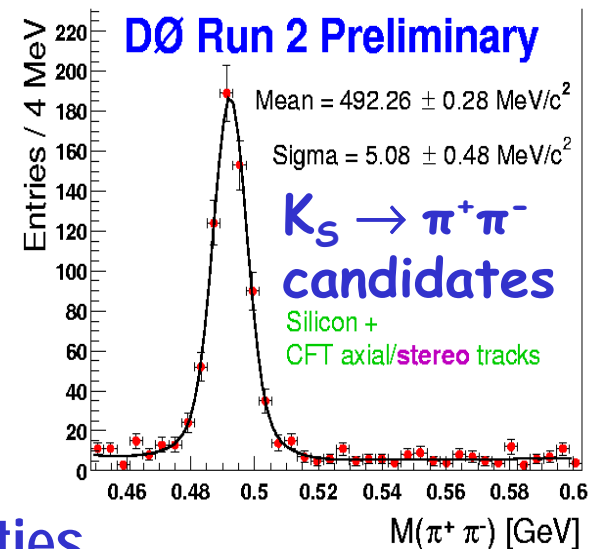
- ◆ Enhance reliability

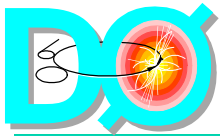
- **Other Activities**

- ◆ Streamline operations and improve efficiency
- ◆ Integrate FPD readout into system

- **Other Concerns**

- ◆ Limited number of spares
- ◆ Software support needed to provide timely feedback
 - ▲ FPS reco?
 - ▲ Calibration databases

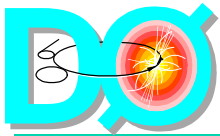




CTT Status

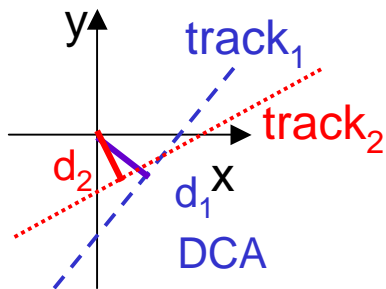
- All hardware is installed and cabled up
- Integration tests are in progress at the Combined Test Stand and on the platform
- Relative timing of control signals at Mixer Box has been verified on the platform for all five trigger supersectors
- ✓ Fake tracks (generated in the AFE) have been propagated through the Mixer and the DFEA to the input of L1Muon
 - ◆ BUT the signals were 230 nsec late getting to L1Muon
 - ◆ Expect to gain 132 nsec by change to trigger timing
 - ◆ Firmware development underway to modify SVX pipeline clock so that the CFT+PS can retain data over a longer time period (to accommodate the change to trigger timing)
 - ◆ Mixer firmware has since been updated to save a clock tick (19 nsec)
- L1CTT VRB crate has been exercised in the DAQ system
- Firmware testing and development in progress
- Development of monitoring tools in progress
- **Commissioning of this system represents a substantial challenge due to the complex nature of the task and the limited access and resources**



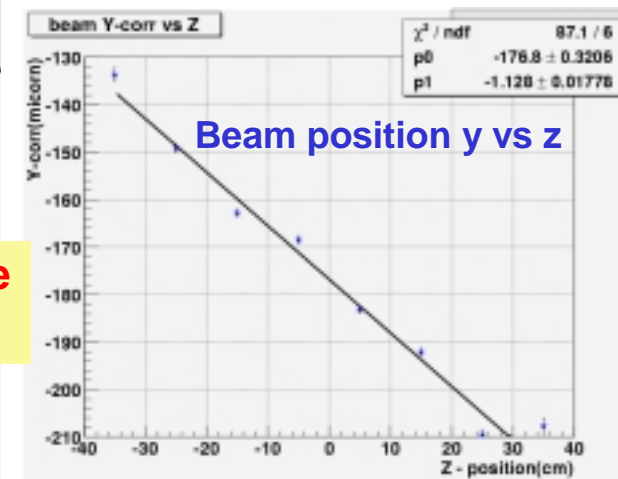
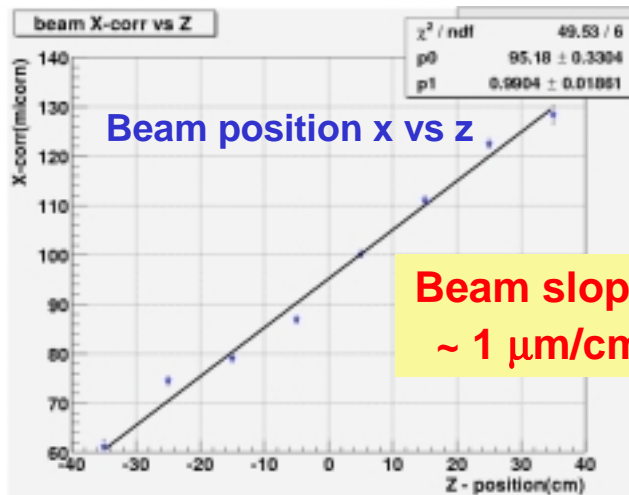
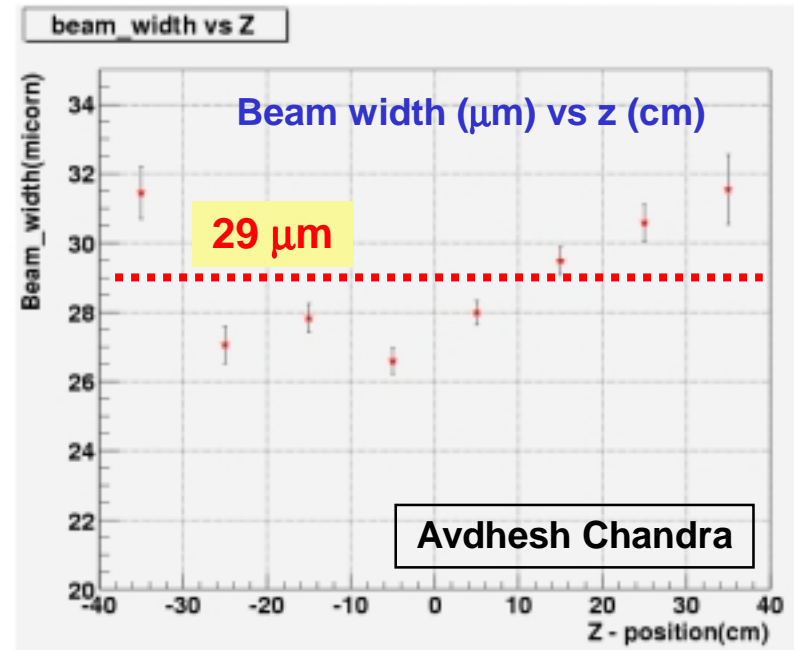
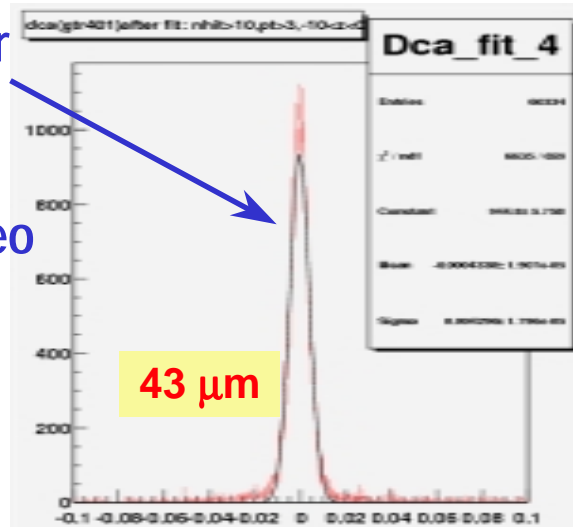


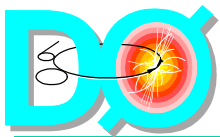
Beam position and Alignment

- Impact parameter resolution (DCA) for global tracks (CFT axial + stereo + SMT) with $p_t > 3$ GeV



- Compare $d_1 d_2$ vs $\cos \phi_{12}$ to extract beam width

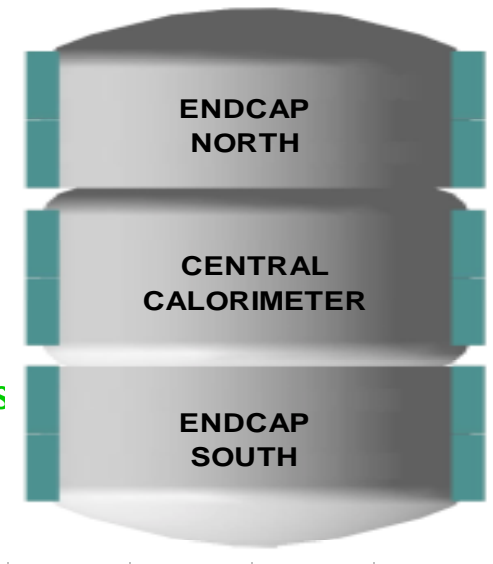




Calorimeter/ICD

- Calorimeter – 55k readout channels

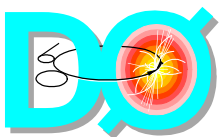
- ◆ Very stable running – occasional power supply or board replacement needed
- ◆ LAr temperature and purity being continuously monitored
- ◆ About 50 bad/noisy channels (0.1%)
- ◆ L1 Trigger readout now out to $|\eta| < 2.4$
 - ▲ Noise filtering may need to be added on all BLS and receiver cards
- ◆ New version of Timing and Control boards and timing adjusted



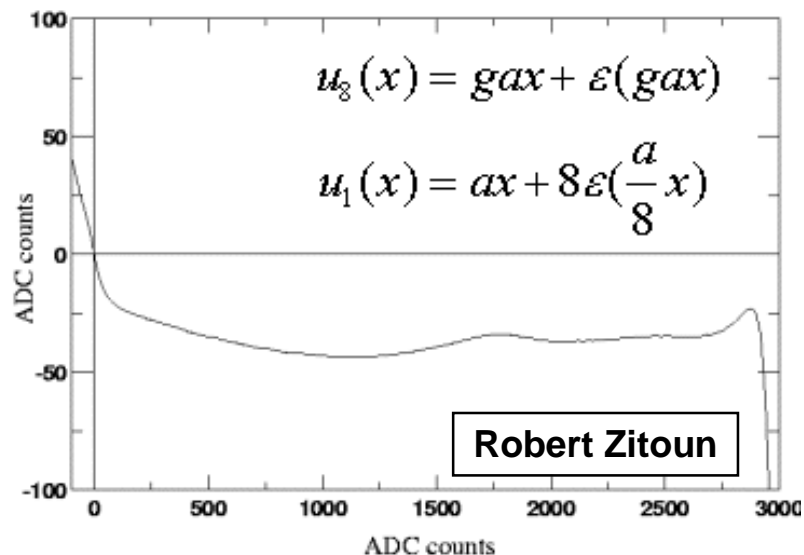
- ICD – 384 readout channels

- ◆ Spare PMTs (~100) – characterize and assemble to replace weaker tubes in October
- ◆ Verified and modified address map for ICD channels
- ◆ LED calibrations
- ◆ Channel to channel variation based on test stand data for combined tile/fiber/PMT being introduced into reconstruction
- ◆ Improve MC geometry and material representation
- ◆ Some issues with occasional incorrect gain readout for ICD channels being investigated





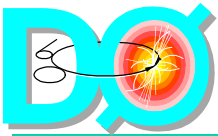
Calorimeter Calibration



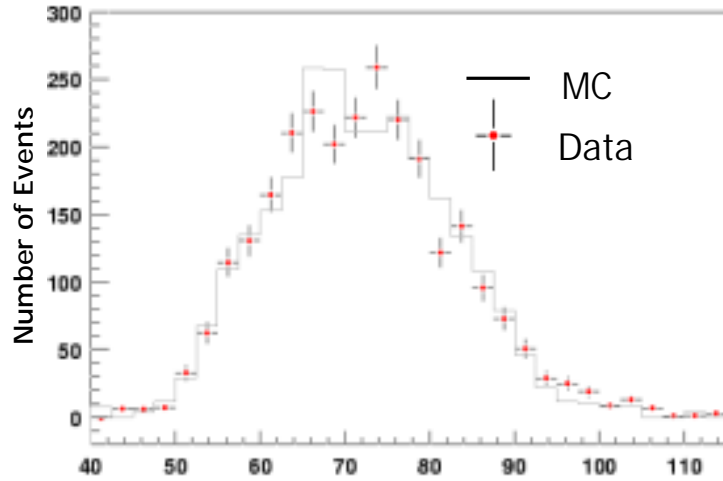
- Non-linearity < 0.3% for $E > 2$ GeV
- In lower energy domain the effect is significant but can be parameterized
 - ◆ 3 parameters per readout cell implemented in p11.08.00 + L3
- Z mass measured at DØ changes from 82.80 GeV to 88.00 GeV after the non-linearity correction

- Timing of signal measurement within 10 ns
- Ongoing effort to understand the electronics and signal gain calibration using pulser:
 - ◆ Hardware exists and tested
 - ◆ Calibration code to compute parameters, database design finalized and preliminary version exists
 - ◆ Software interface to database being worked on
- Non-linearity also affects zero-suppression thresholds
 - ◆ Recently lowered from $2.5 \times \sigma$ to $1.5 \times \sigma$ (increases occupancies from about 4-5% to 20%)
 - ◆ This will need to be studied over the next few months



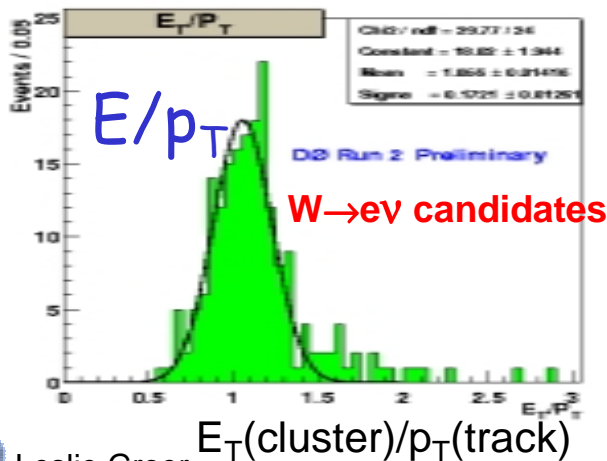
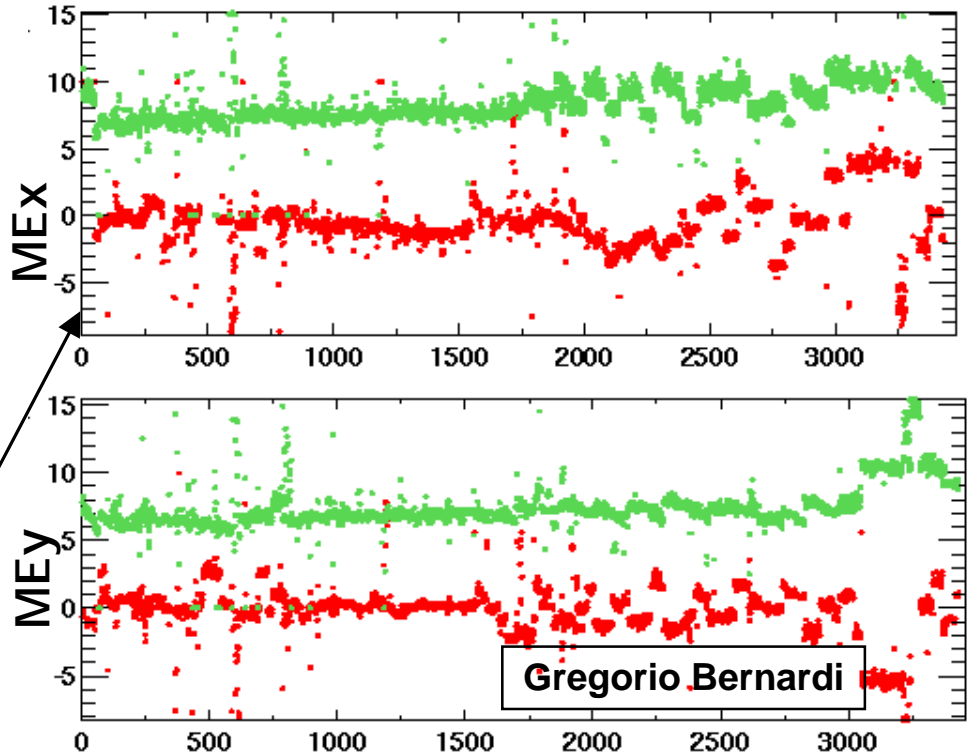


Calorimeter Stability



W Transverse Mass

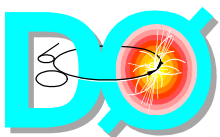
Agreement between data and MC very good but we need to monitor and understand problems like this better.



- Problem of missing Energy offset seems to be fixed after internal timing adjustments
- Effects of bunch number on average energy due to overlays under investigation
- → need to get the tick-and-turn number into the rootfiles!



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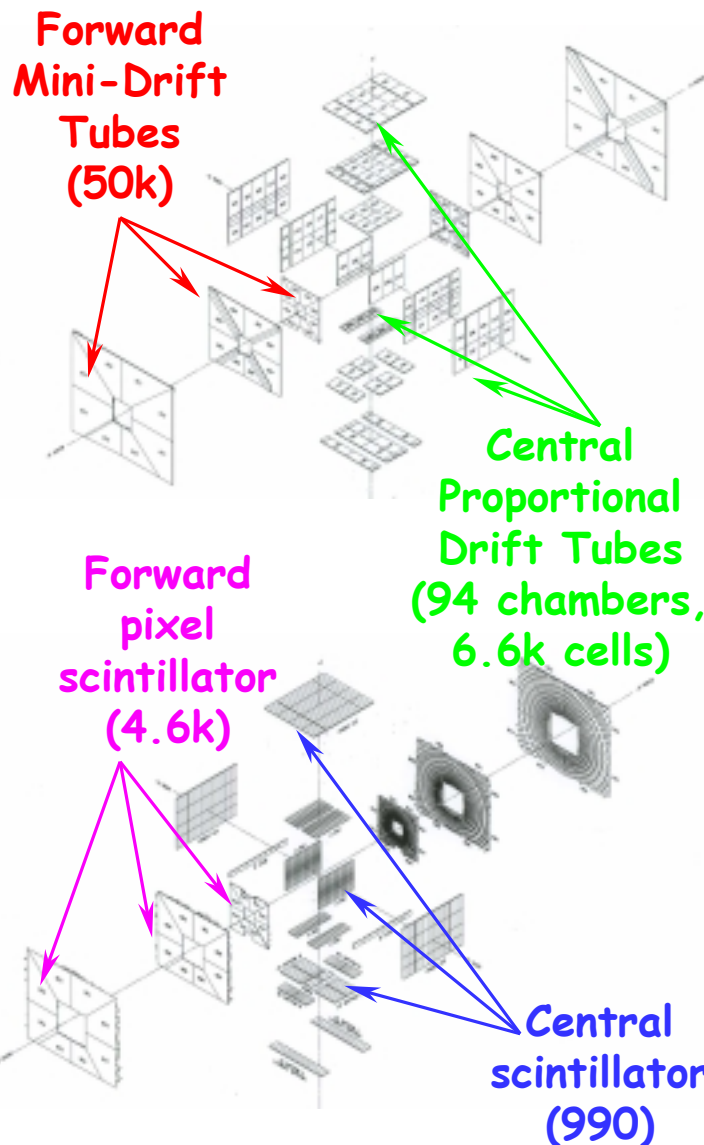
Muon Systems

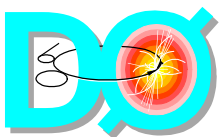
CENTRAL

- Proportional Drift Tubes (PDT's) – Central
 - ◆ 6624 drift cells (10.1 cm x 5.5 cm) in 94 three- and four-deck chambers
- Central Scintillation Counters
 - ◆ 360 “cosmic cap” counters outside the toroid ($\Delta\phi=22.5^\circ$)
 - ◆ 630 “A- ϕ ” counters inside ($\Delta\phi=4.5^\circ$, $\Delta\eta=0.1$)

FORWARD

- Forward Tracking (MDT's)
 - ◆ 6080 eight-cell tubes in 8 octants per layer on north and south side, cell cross-section 9.4 mm x 9.4 mm
- Forward scintillation counters (pixels)
 - ◆ 4214 counters on the north and south side of the detector
 - ◆ $\Delta\phi=4.5^\circ$ matches the MDT sector size. $\Delta\eta=0.1$ except the last three rows where $\Delta\eta=0.07$

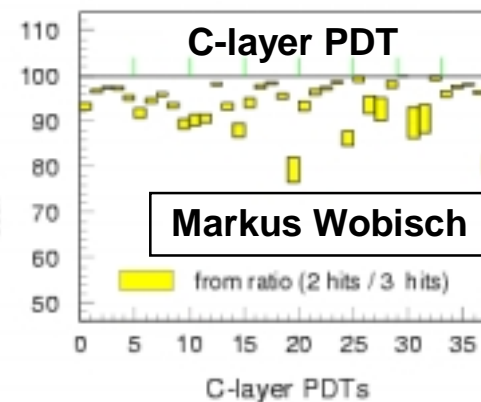
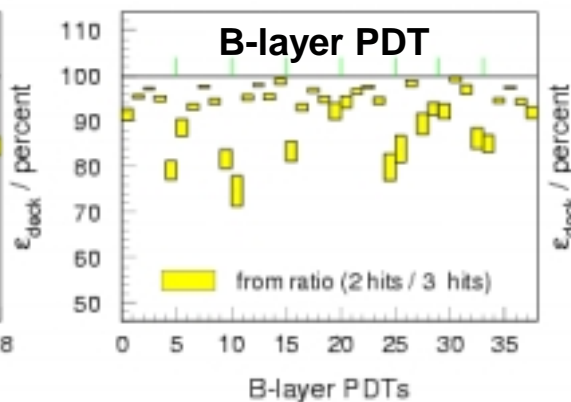
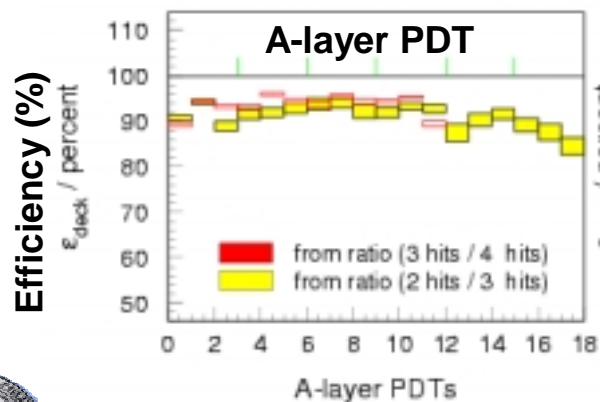


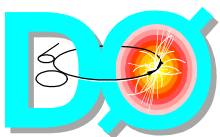


Central Muon Performance

- Iteratively replacing bad front-end electronics
- Scintillator: All B & C layers alive, 1 dead for A layer
 - ◆ Set individual scintillator thresholds
 - ◆ Replaced 3 A-phi tubes, 3 fibers and 1 SFE
- PDT Performance – mostly stable running
 - ◆ All channels calibrated and t_0 values adjusted
 - ◆ Cabling installed to adjust PDT split timing
 - ◆ Rewiring HV for B- and C-layer → increased efficiency in case of HV trips
 - ◆ Replaced 3 PDT control boards and several FEB's due to dead channels
 - ◆ 99.5% working, > 98% in operation (very few noisy cells)
 - ◆ Efficiencies for segments with one or two hits: > 95% (typically 99%)
 - ◆ Reason for spontaneous turn-on of PDT pulsers found and fixed!

- To do:
 - ◆ Investigate why some PDTs cause trouble for the L2 trigger



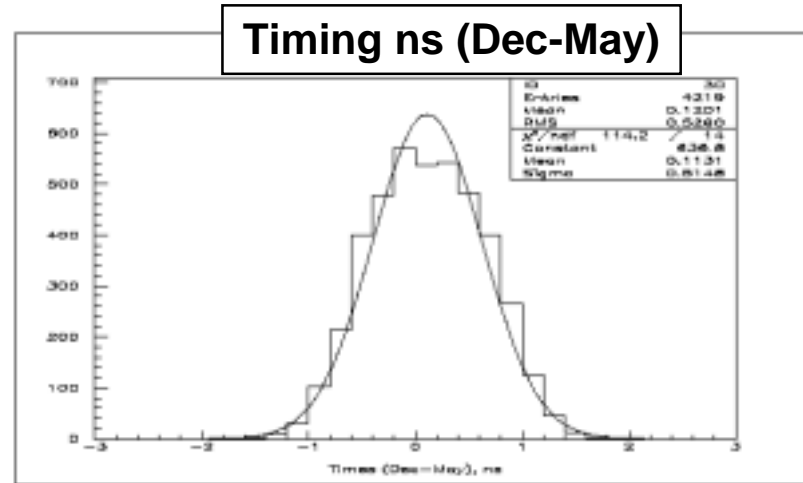
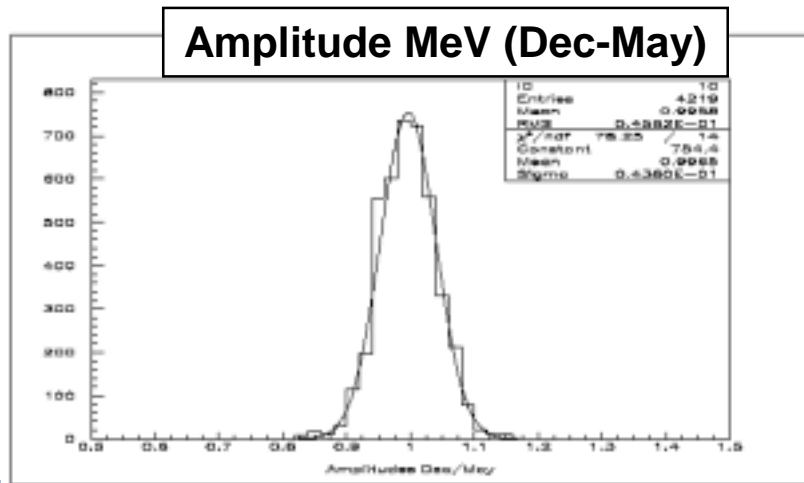
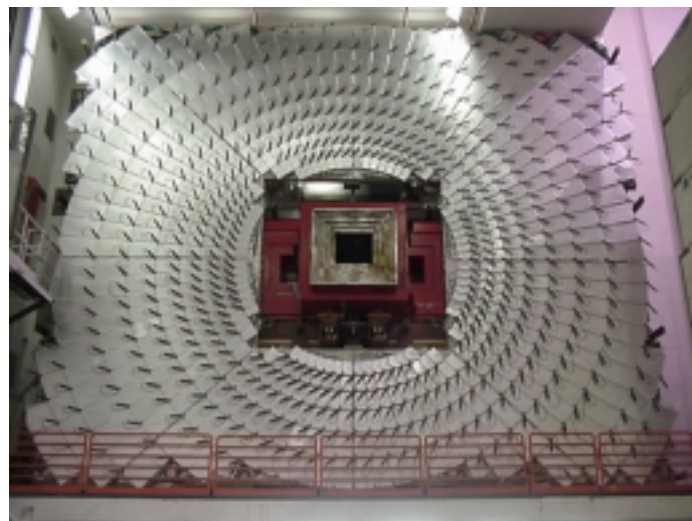


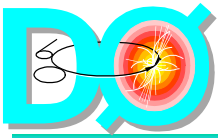
Forward Muon Trigger System (Pixel)

- Very stable operation
 - ◆ Less than 0.2% dead channels
 - ◆ Long term stability of amplitude (~5%) and timing (better than 1ns)
 - ◆ MIP detection efficiency is > 99%
 - ◆ No radiation aging up to well above 15fb^{-1}

June shutdown

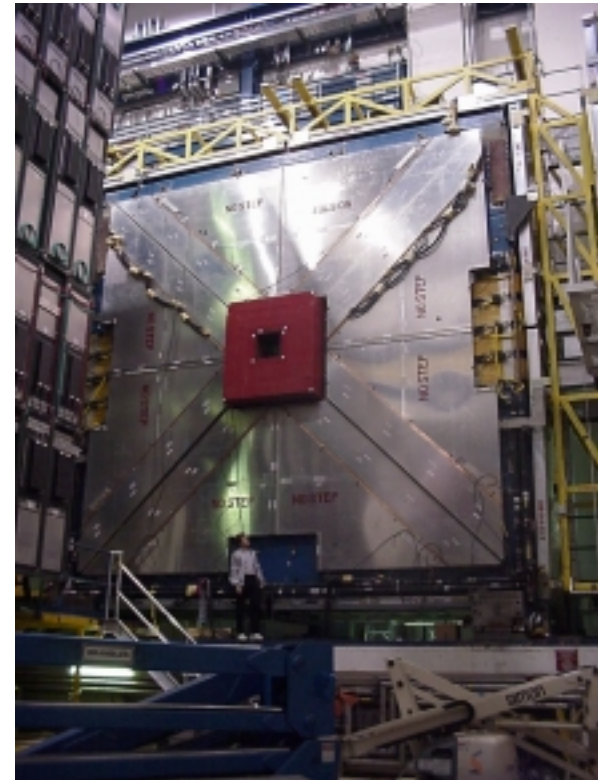
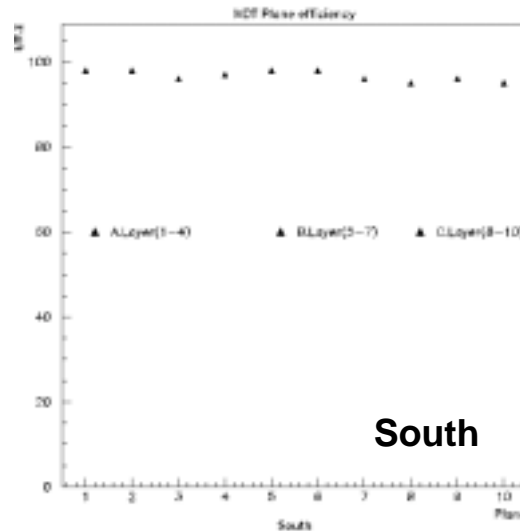
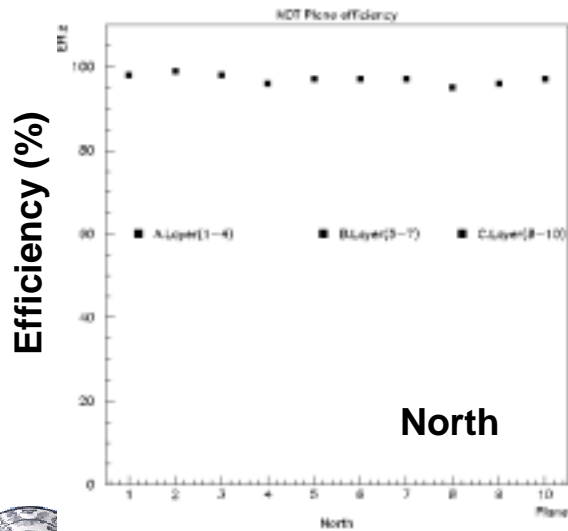
- ◆ Replaced 1 PMTs (out of ~5k)
- ◆ Replaced a few electronics boards with dead channels
- ◆ Recalibrated HV (< 10V)
- ◆ Rechecked signal amplitude stability with ^{90}Sr source (< few mV)

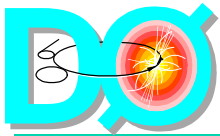




Forward Muon Tracker (MDT)

- 50,000 channels mini-drift tube based system is operating smoothly
 - ◆ Efficiency of drift cells > 98%
 - ◆ Total number of dead/noisy channels is 0.6%
 - ◆ No radiation aging concerns to well above 15 fb⁻¹
- June shutdown
 - ◆ New FE code reloaded and stable
 - ◆ HV calibrated (<0.25%)
 - ◆ Repaired gas leaks (reduced leak by 25%)





Muon Readout and Trigger

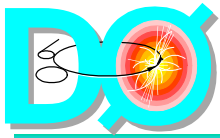
- DAQ

- ◆ All new MFC installed and debugged
- ◆ Resolved a number of issues in VME readout software
- ◆ Still some work to port readout software from 68k to PPC
- ◆ Occasional synch problems
 - ▲ Under investigation
 - ▲ → Choose not to run L2muon in normal global data taking

- Trigger

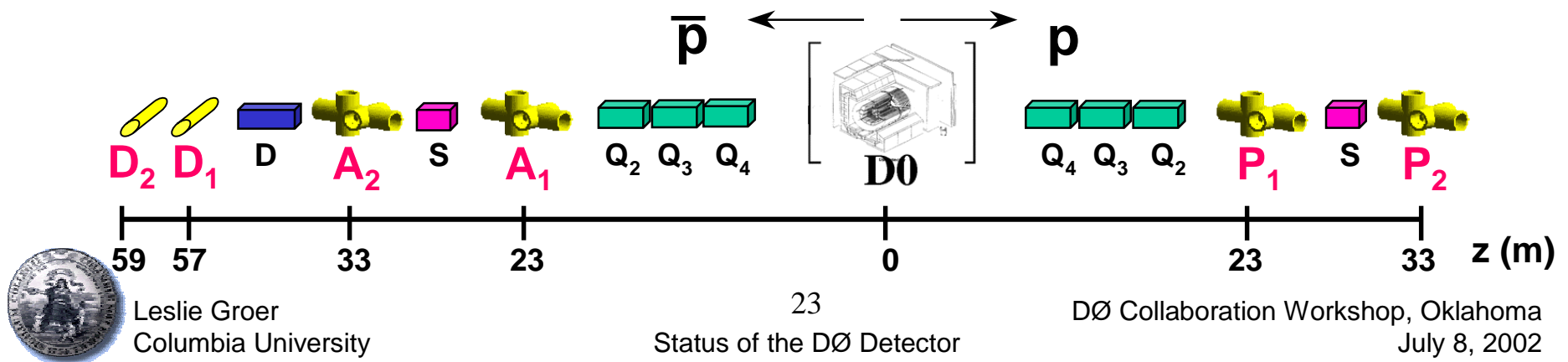
- ◆ All L1Muon cards now installed
- ◆ Able to run in multi-buffer mode at high rate
- ◆ Need to resolve L1CTT&L1MUO latency issue to fully study muon track trigger
- ◆ L2 Trigger in operation but sensitive to missing inputs
 - ▲ Developing extra debugging and ability to dump an event and continue

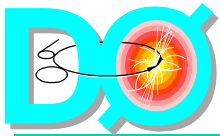




Forward Proton Detector

- 8 detectors installed after June:
 - ◆ D1, D2, A1I, A2I, P1D, P2D, P1U, P2U
- 4 pseudo-detectors (Trigger counters):
 - ◆ A1U, A1D, P1O, P2O
- Taking diffractive data:
 - ◆ Require hits in the Dipole detectors and Luminosity Monitor and Veto counters on the proton side
 - ◆ Veto on Luminosity Monitor and Veto counters on the pbar side
 - ◆ Preliminary analysis compatible with MC
- Multiplexors allow the motion of 18 pots
- Repaired a vacuum leak at A2 bellows
- Installation of full readout for D spectrometer – requires one AFE board
- Fiber efficiency is close to 100%
- Better understanding of halo backgrounds
- Rapidity gap + jet triggers added to DØ global list

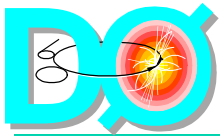




FPD/DØ Integration Issues

- **Integration of FPD into DØ is top priority of FPD**
 - ◆ Due to location of FPD, Sequencer delays needed to include FPD into readout chain (solutions, including “simple” delay board, near completion)
 - ◆ Transition Patch Panel to connect ribbon cables to AFE undergoing final tests and will be installed soon: shapes the signals, discards excess charge and isolates ground
 - ◆ Intend to have the dipole spectrometer in the readout chain soon and AFE/DFE for 10 detectors in October
(2 D's + 4 A's + 4 P's, requires 3 AFE boards)
 - ◆ Need LUM TDC boards to include trigger scintillator information
 - ◆ FPD Trigger Manager should be programmed soon to include LUM, DFE, Veto Counter information and provide FPD AND/OR terms
 - ▲ AND/OR terms allow proton+X triggers in DØ global list
 - ◆ Final integration with CFT+PS operation



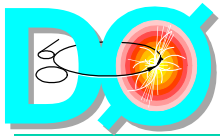


Conclusions

- DØ detector has come a long way in the last couple of years, but...

- Still a long way to go for fully integrated, calibrated, smoothly running and understood subsystems
- Progress and manpower required in the next few months to achieve the stated goals by October
- Additional capabilities need to come online with minimal disruption to current operations and accumulating luminosity





A Personal Note

- Jae Yu shepherded us through the initial roll in and start up of Run 2a
- I took over the role of Commissioning Coordinator along with Michael Begel this time last year
 - *It's been fun!*
- ...but it's time to move on (to physics!)
- I want to thank everyone in the detector, computing, physics/id, operations, management and support groups for putting up with me and not letting me get in the way of getting their job done!

Good luck to Alan Stone, Ron Lipton,
and Dmitri Denisov

