Status of the DØ Detector

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on behalf of the DØ Collaboration

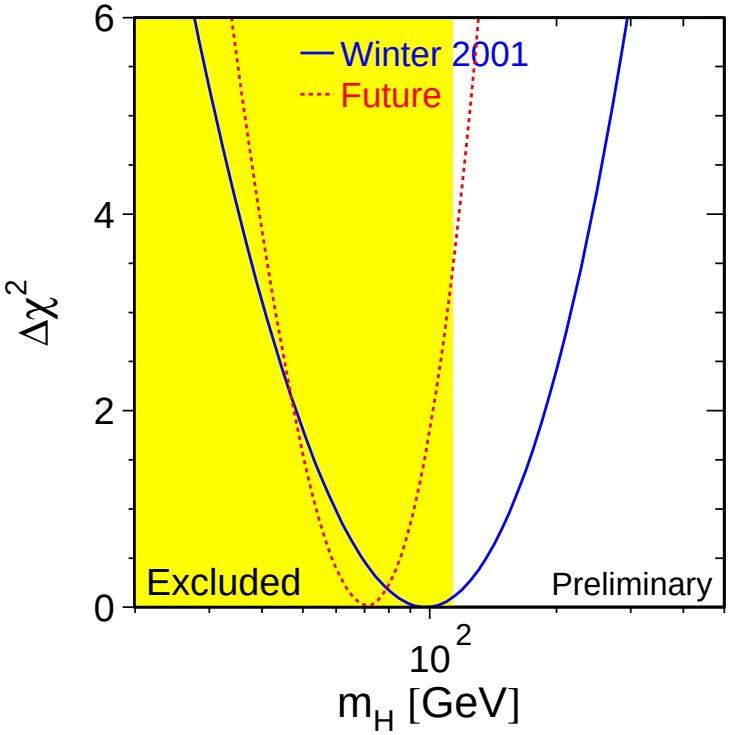
- Run II Physics Challenges
- D0 Detector Upgrades
- Tracking Detectors
- Calorimeters
- The Muon System
- Triggers, DAQ and Data-Taking
- Conclusions

DØ Detector Status – Introduction

The Run II Physics Program

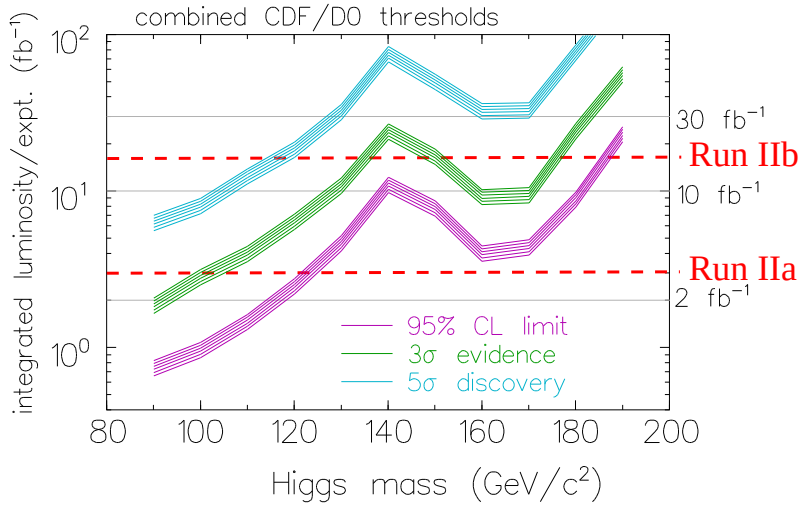
- Precision measurements of m_W and m_t
- The Higgs Search
- Searches for new physics: Supersymmetry, Extra Dimensions, Leptoquarks, Black Holes...
- Study properties of heavy quarks (B physics, top physics) and of W/Z Bosons
- QCD Studies, Diffractive Physics

(Grünewald et al.)

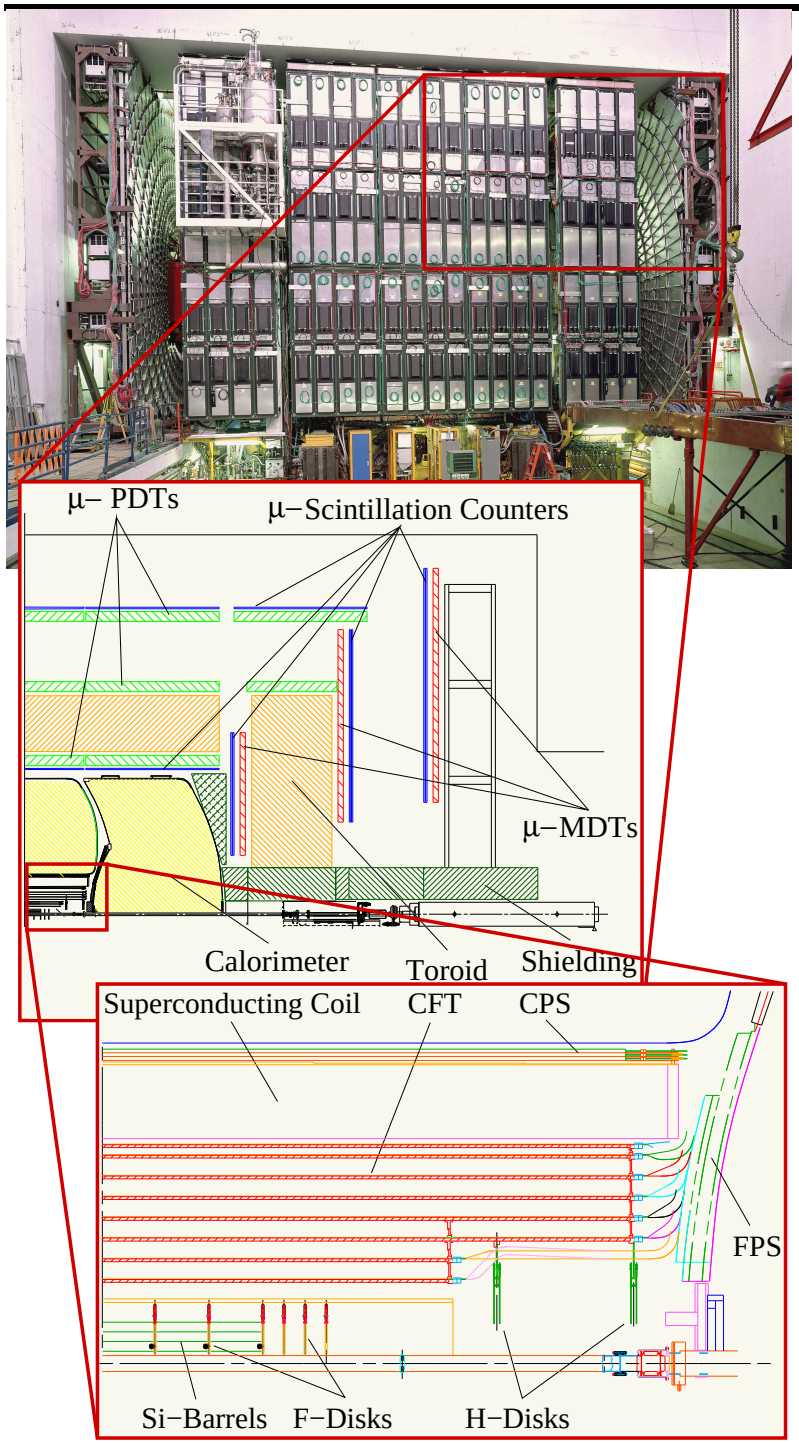


Challenges for the upgraded detector

- high peak luminosity ($\rightarrow$ high trigger rates)
- bunch spacing 396 ns ($\rightarrow$ fast electronics)
- high integrated luminosity ($\rightarrow$ radiation hardness)
- need efficient b-tagging
- maintain/improve acceptance for e, μ, τ

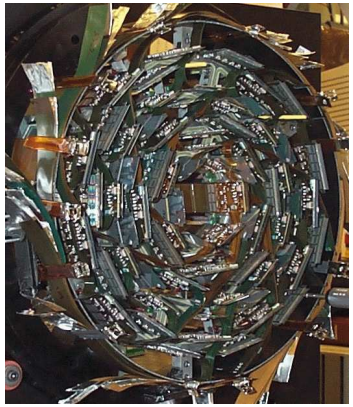


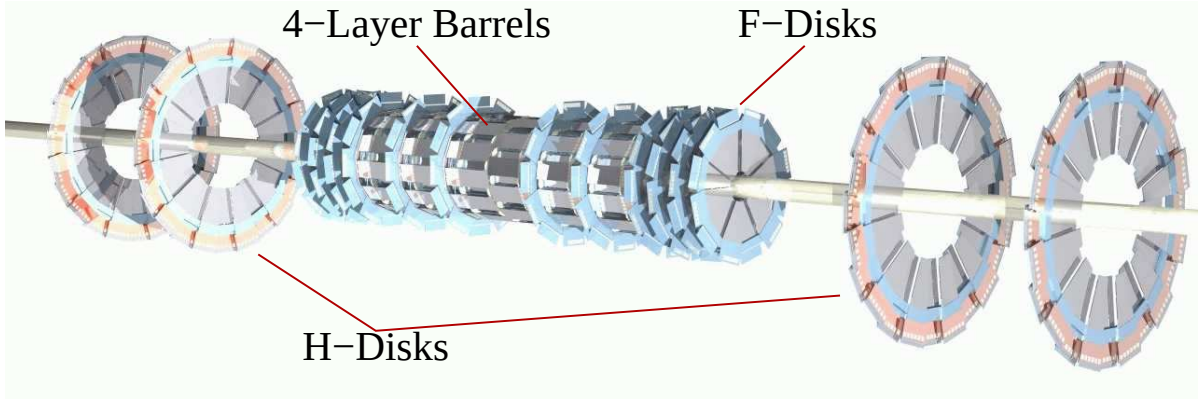
DØ Detector Status – Overview

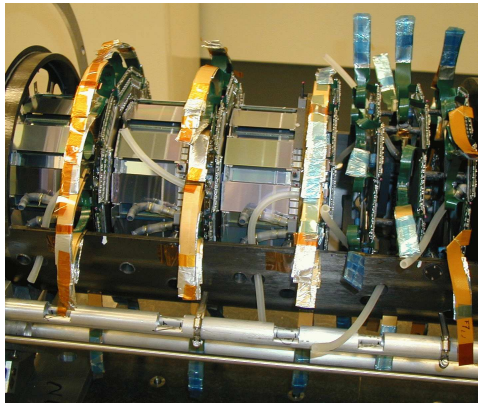


- New Tracking System:
  - Silicon Microstrip Tracker (SMT)
  - Central Fiber Tracker (CFT)
  - Superconducting Solenoid (2 Tesla)
- Upgraded readout electronics of the Liquid Argon Calorimeter
- Added Central Preshower (CPS) and Forward Preshower (FPS) detectors
- Significantly improved Muon System
  - new forward muon system
  - new electronics+scintillators in central region
  - new shielding
- New forward proton spectrometers (FPD)
- Entirely new Trigger System and DAQ

DØ Detector Status – Silicon Microstrip Tracker



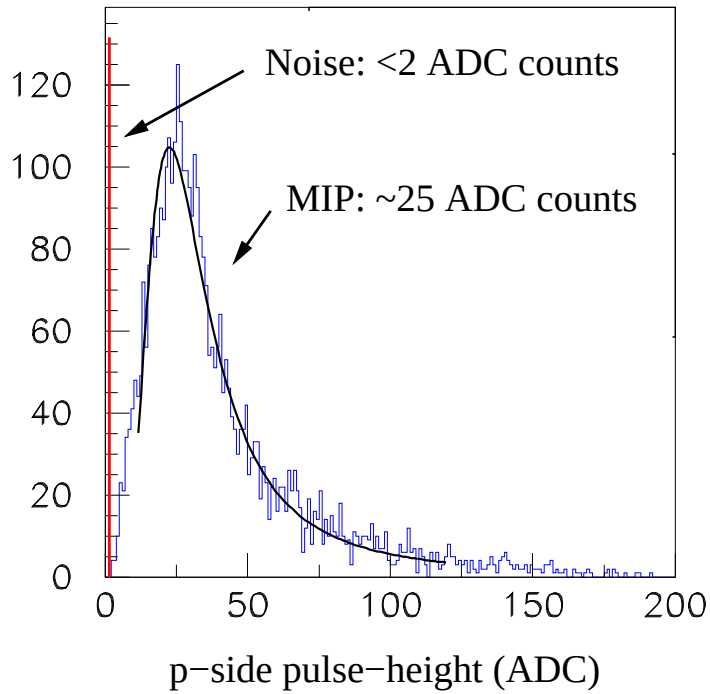




Detector		Stereo	#Channels	Coverage
Barrels	sgle/dble-sided	0°,2°,90°	387072	2.7<R<9.4cm
F-Disks	double-sided	±15°	258048	2.6<R<10.5cm
H-Disks	single-sided	±7.5°	147456	9.5<R<26cm

- full system allows silicon tracking up to η=3.0
- about 800k channels, $3m^2$ of silicon
- more than 2.3 million wirebonds
- detectors aligned to <20μm using CMM
- ADC and L1 Pipeline in rad-hard SVX Chip
- Number of channels operational:
  - 95% (F-Disks), 90% (Barrels), 85% (H-Disks)
  - very stable with time

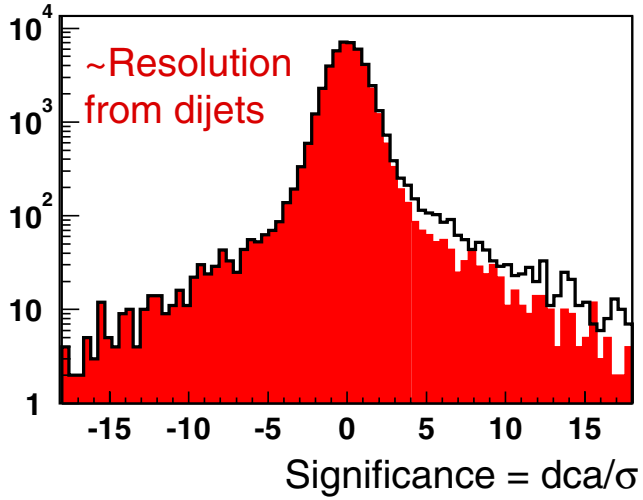
- Signal/Noise ratio is ≈12
- Hit efficiency measured: >97%



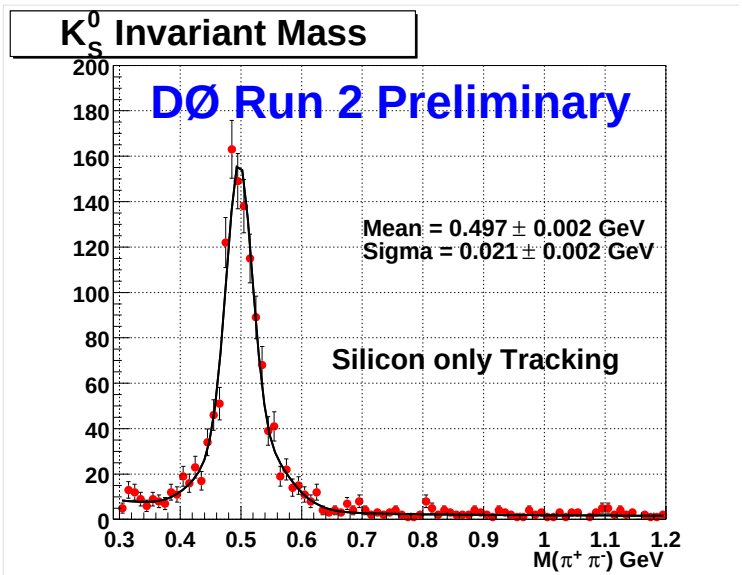
DØ Detector Status

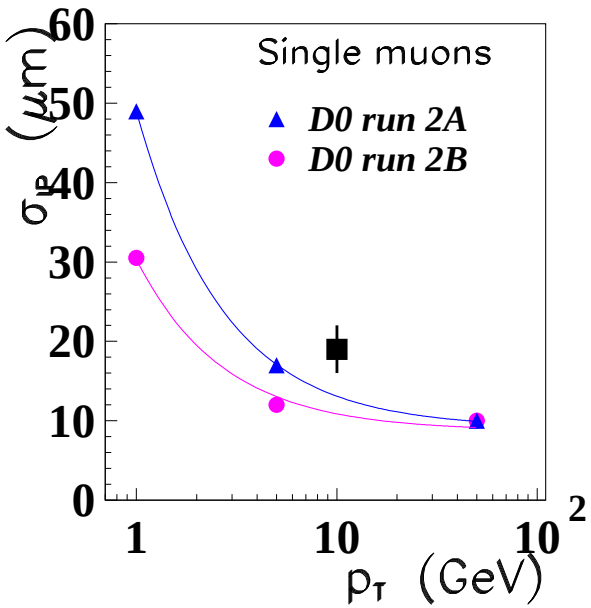
Silicon Microstrip Tracker

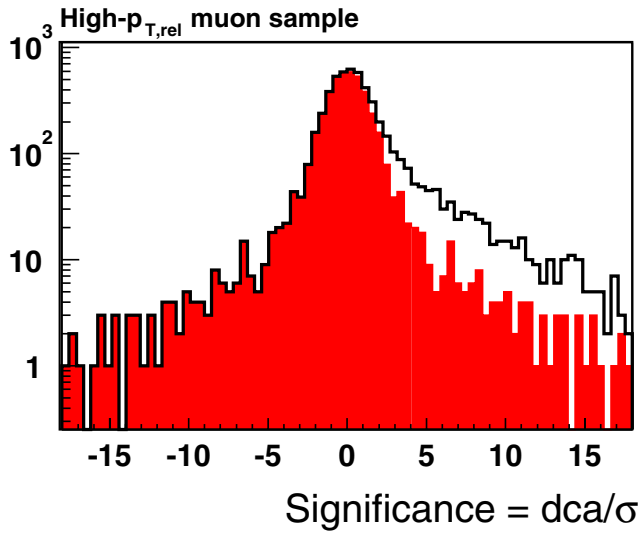
- 1st pass alignment completed
- Impact parameter resolution (full tracking):
  - full width 38μm
  - includes beam width $\approx$ 30μm
- imp. par. significance clearly sensitive to b-decays
- Further improvements expected from
  - 2nd pass alignment
  - more sophisticated cluster algorithms



DØ Run 2 Preliminary

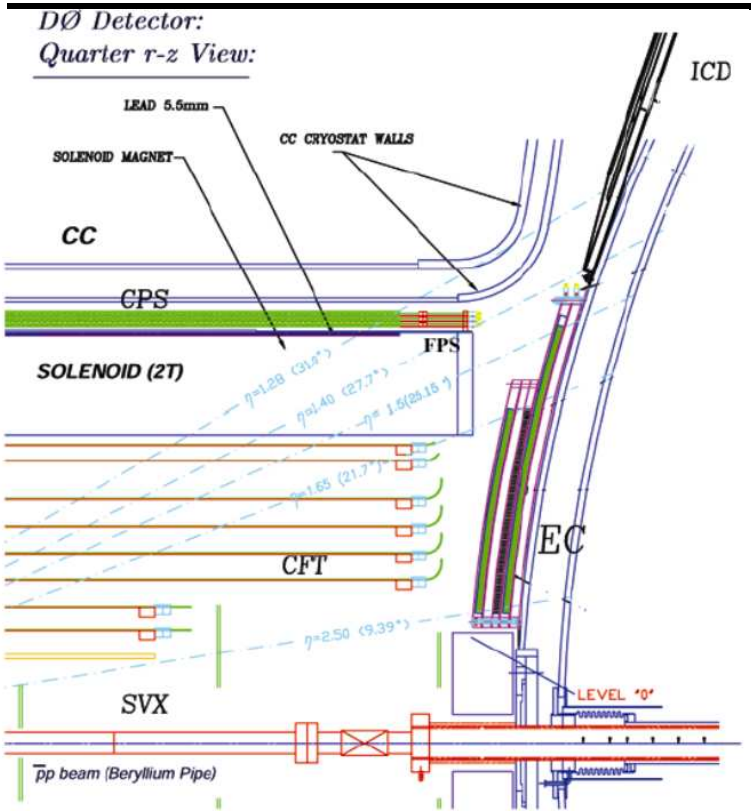


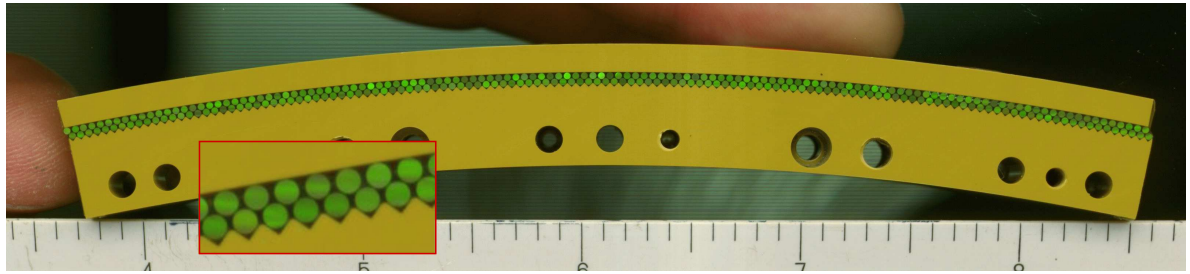




DØ Detector Status

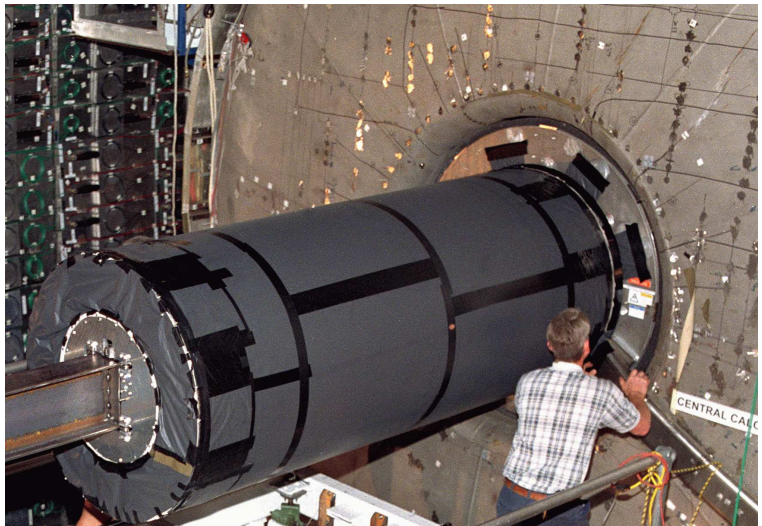
Central Fiber Tracker and Preshower Detectors





Central Fiber Tracker

- 8 double layers (axial+stereo) of scintillating fibers (diameter 835μm, stereo angle $\pm 3°$)
- coverage: 20<R<52cm, η<1.6
- doublet hit resolution $\approx$100μm
- radiation hard (up to 30fb^{-1})

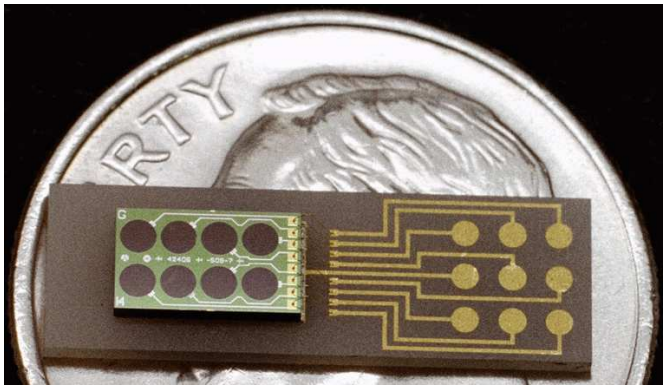


Central and Forward Preshower

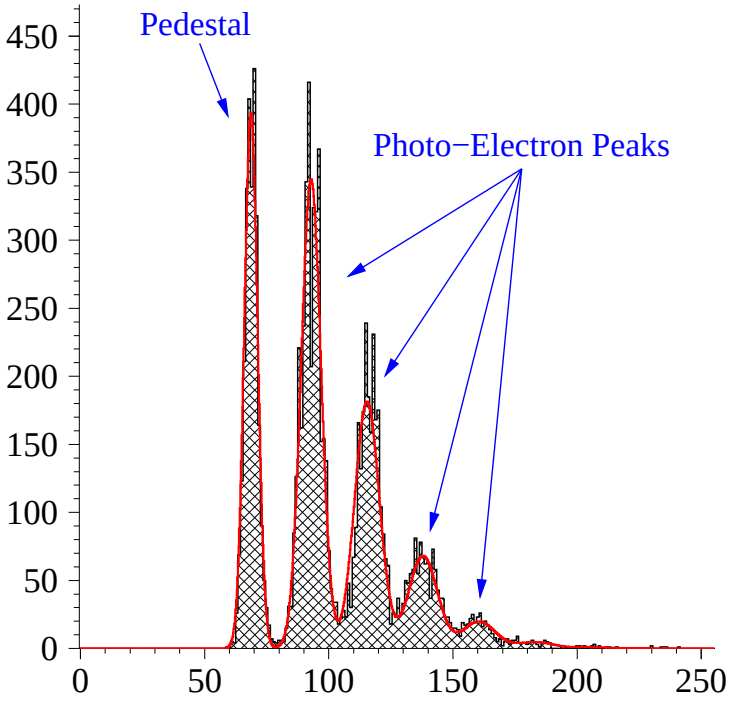
- 3 layers of scintillator strips with embedded WLS fiber
- providing 3D spacepoint, energy measurement and Electron-Tirgger for η<1.3 and 1.5<η<2.5

DØ Detector Status

Central Fiber Tracker and Preshower Detectors

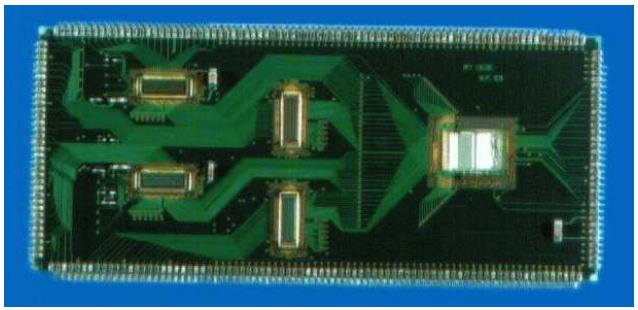


VLPC Pixel array



VLPC pulse-height (ADC)

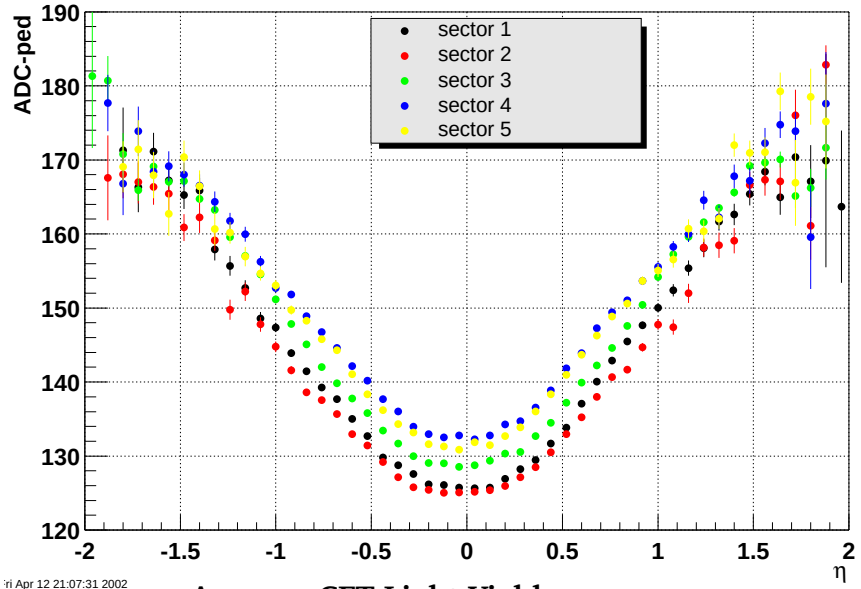
- about 100k CFT and PS channels routed through clear waveguides (8.2–11.4m length) to solid-state photo-detectors (VLPCs)
- VLPCs are situated in LHe cryostat at a temperature of 9$\pm$0.05 K
- function at high rates, with low gain dispersion
- quantum efficiency $\approx$ 85% (>8 photo-electrons per MIP), gain 30k–60k electrons per p.e.
- charge is digitized and buffered in SVX chips
- fast discriminator signal available for L1 tracking



Multi-Chip-Module with SVX and SIFT Chips

DØ Detector Status

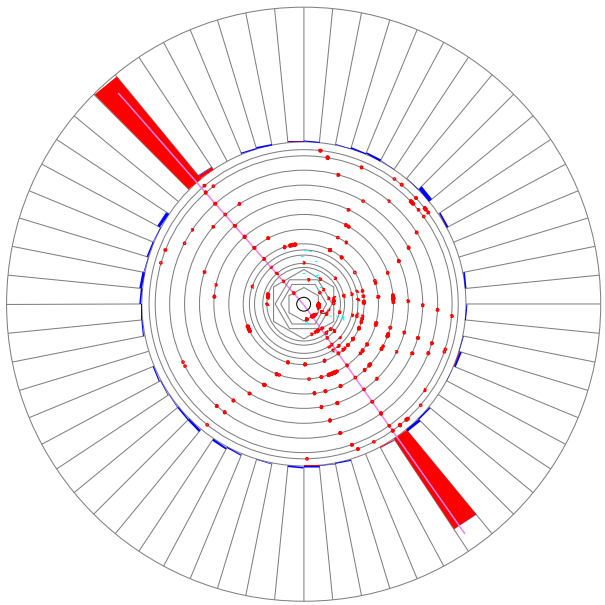
Central Fiber Tracker and Preshower Detectors



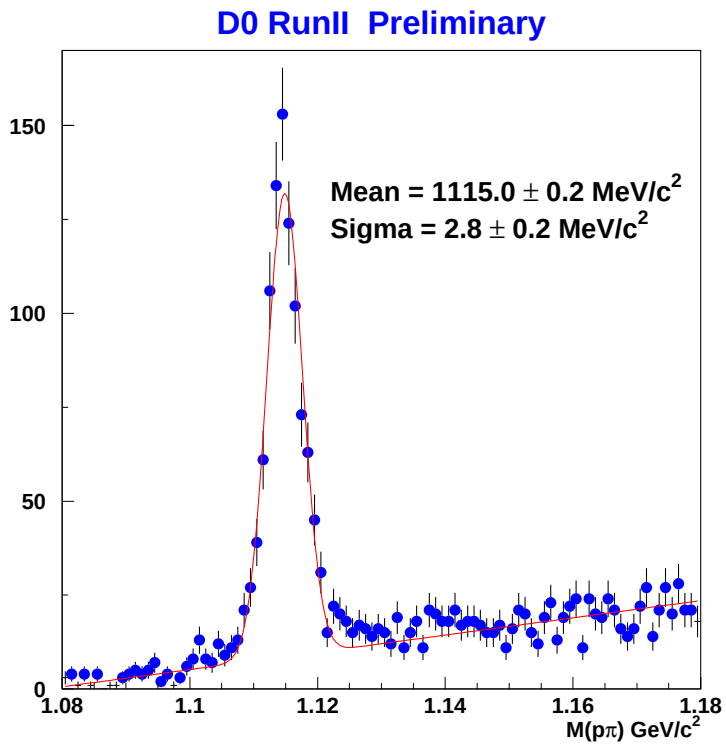
Average CFT Light Yield versus η

- less than 1.5% bad channels
- light yield measured as a function of rapidity
- hit efficiency measured as >98%
- In combination with SMT:

  momentum scale and resolution consistent with expectations, will improve further



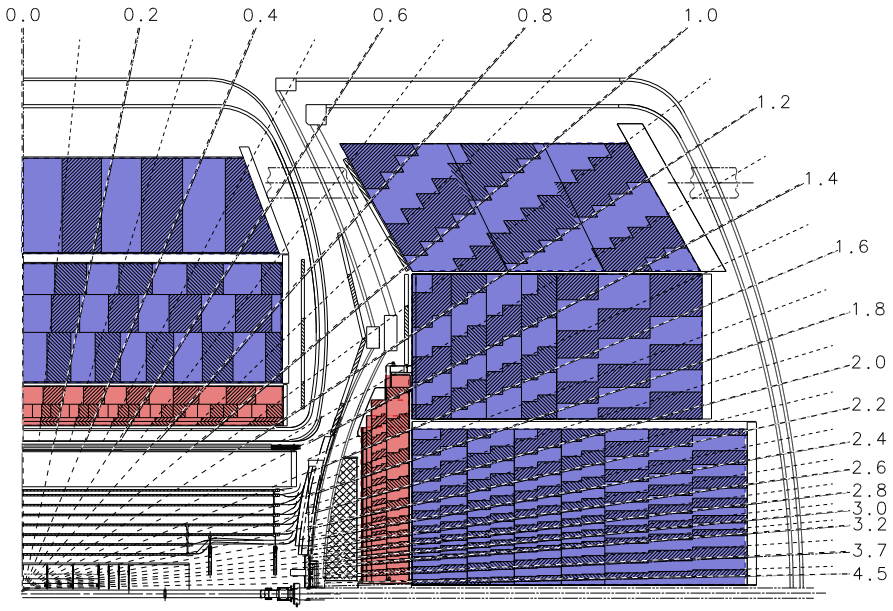
$Z \rightarrow e^+e^-$ Candidate



$\Lambda \rightarrow p\pi$ (PDG Mass 1115.68 MeV)

DØ Detector Status

Calorimeter



- Liquid Argon Sampling
- Uranium absorber (Cu/Steel for coarse hadronic
- projective tower geometry
- fine granularity: 0.1x0.1 (0.05x0.05 at shower max.) segmentation in η, Φ
- hermetic coverage up to η<4.2 ($\lambda_{int} > 7.2$)

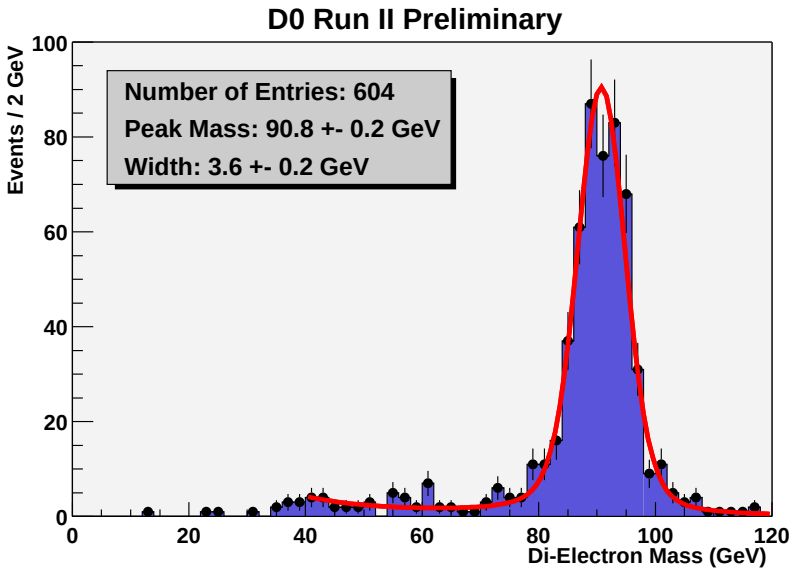
- $\sigma_E/E = 15\%/\sqrt{E} + 0.3\%$ (EM)
- $\sigma_E/E = 45\%/\sqrt{E} + 4\%$ ($\pi^{\pm}$)
- new readout electronics to accomodate faster bunch crossing time
- 55k channels, <0.1% bad channels
- Central- and Forward Preshower, Intercryostat Detector provide additional sampling of shower to improve energy resolution

DØ Detector Status

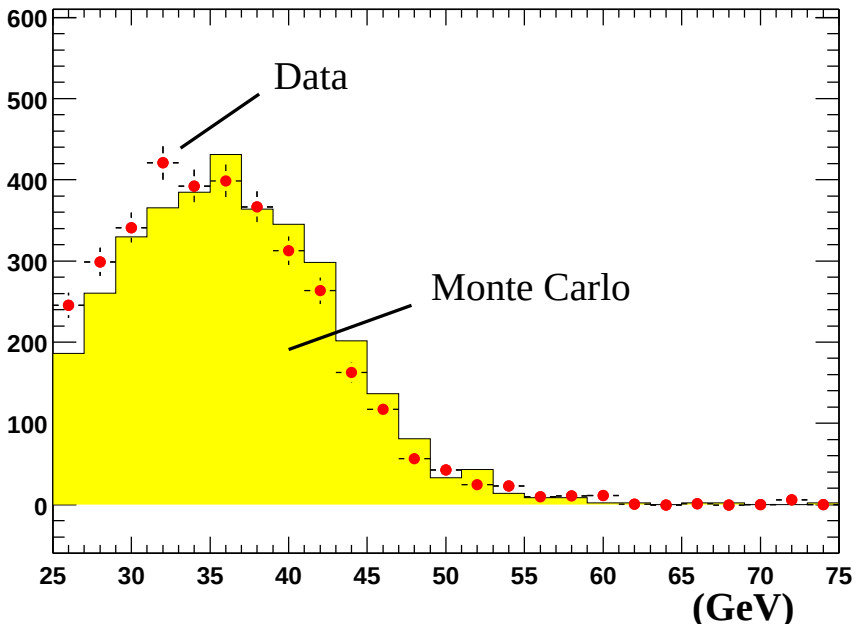
Calorimeter

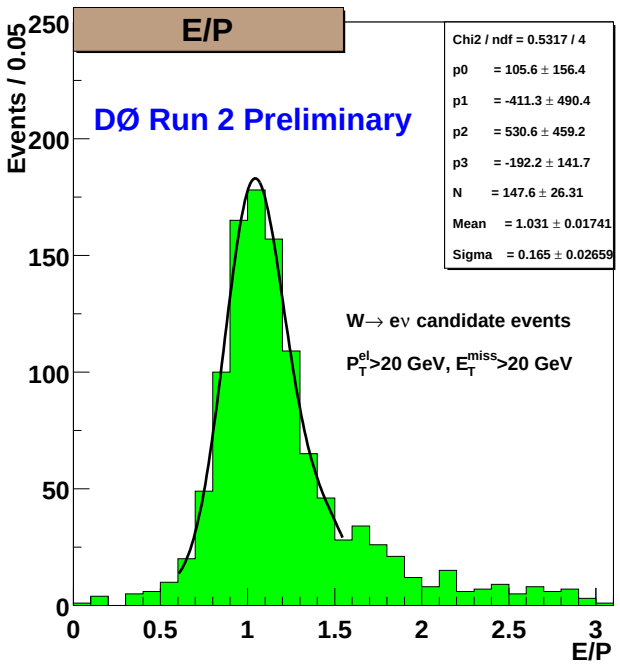
1st pass calibration has been completed

- linearity, gain corrections from pulser calibration
- EM scale determined from $Z \to e^+e^-$ events
- E/p from $W \to e\nu$ events confirms corrections
- jet energy scale measured in γ+jet events



Missing E_t in $W \to e\nu$ events



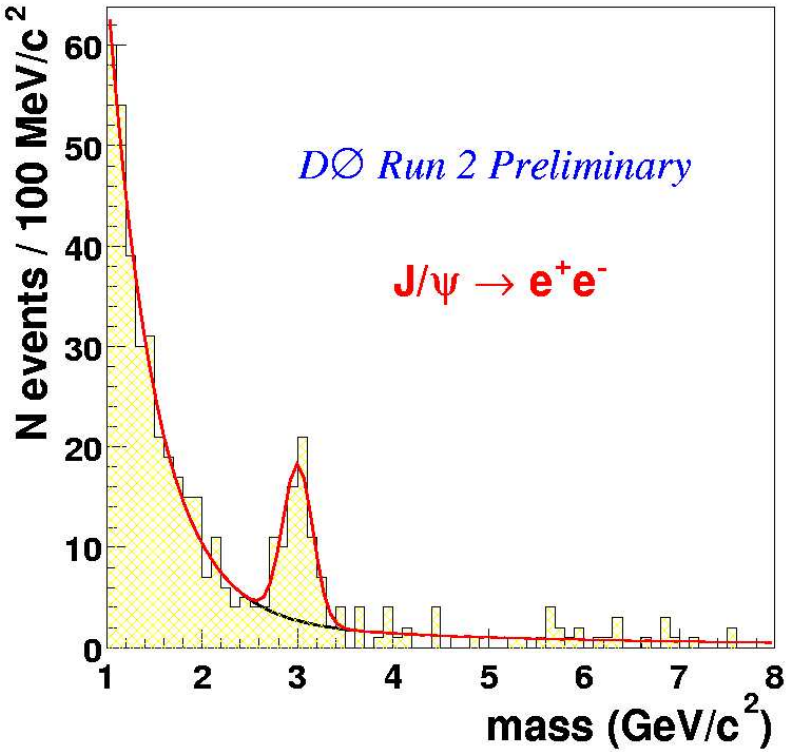


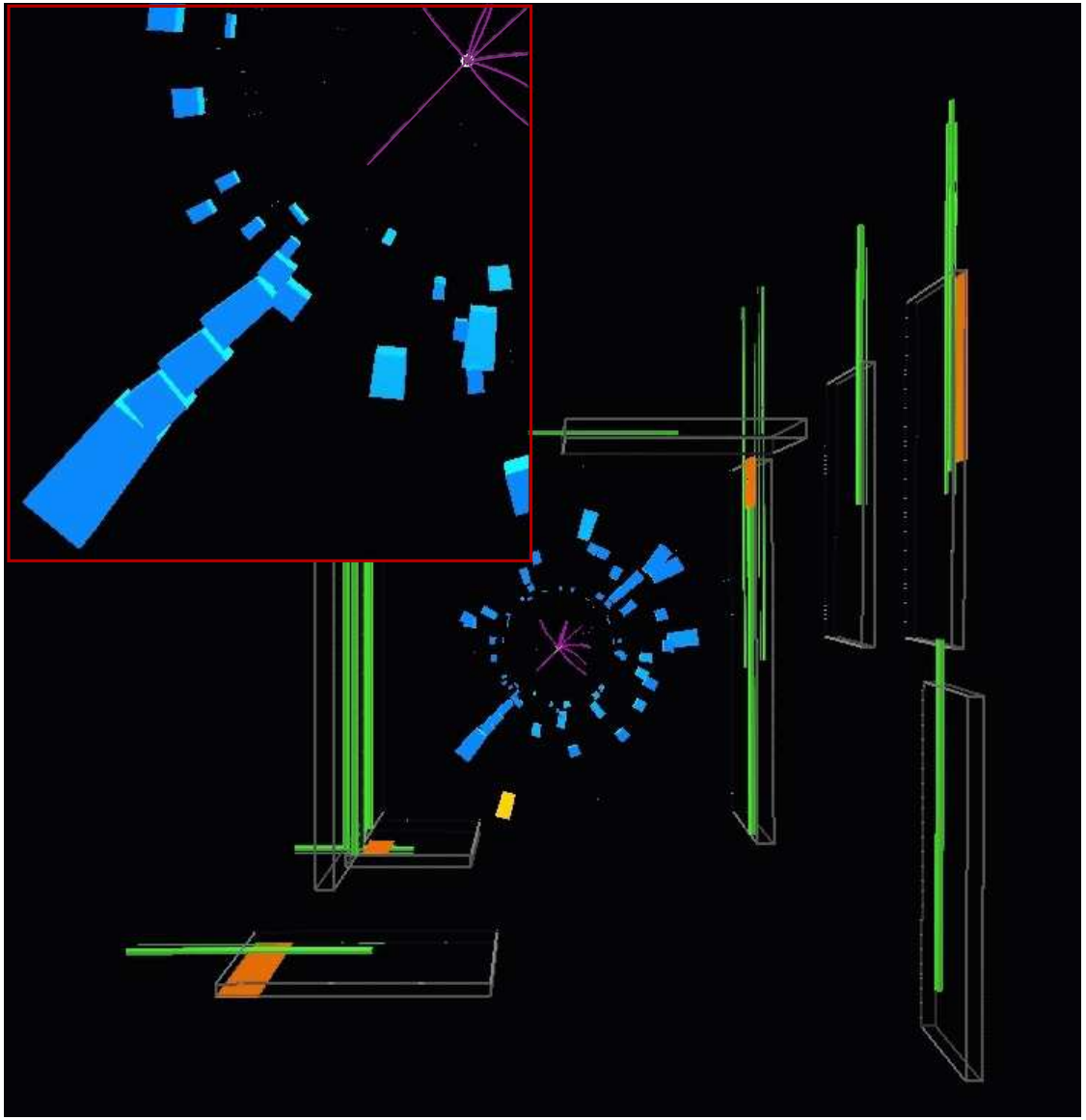
DØ Detector Status

Calorimeter

Reconstruction algorithms using calorimeter cell energies along track extrapolation are working well:

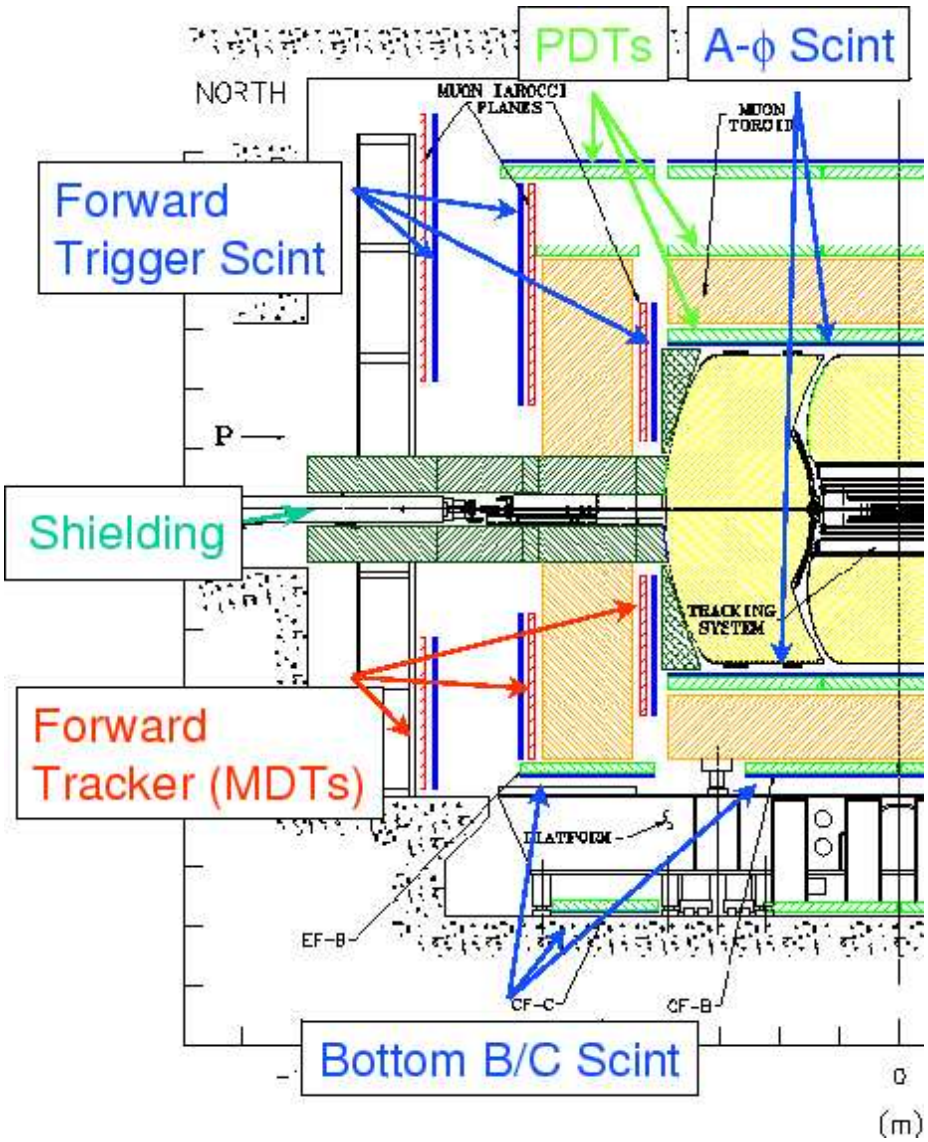
- → Electron identification in jets
- → Muon identification and confirmation



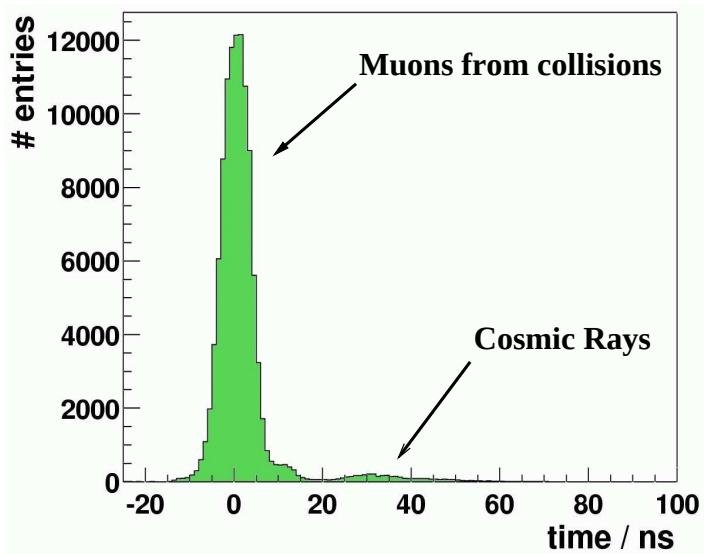


Z→$\mu^+\mu^-$ event

DØ Detector Status – Muon Detectors



- 3 layers of drift tubes + scintillators ($\eta \leq 2$)
- Toroid magnets between 1st+2nd layer allow stand-alone momentum measurement
- Central Proportional Drift Tubes (PDTs):
  - 6624 drift cells (10.1x5.5cm)
  - stacked in 3- and 4-deck chambers
- Forward Mini Drift Tubes (MDTs):
  - 6080 8-cell tubes (9.4x9.4mm)
  - provide fast L1 trigger signal
- Scintillation Counters (central+forward):
  - 4214 forward, 630 central counters
  - segmentation 0.1x4.5 in η x Φ
  - provide fast L1 trigger signal



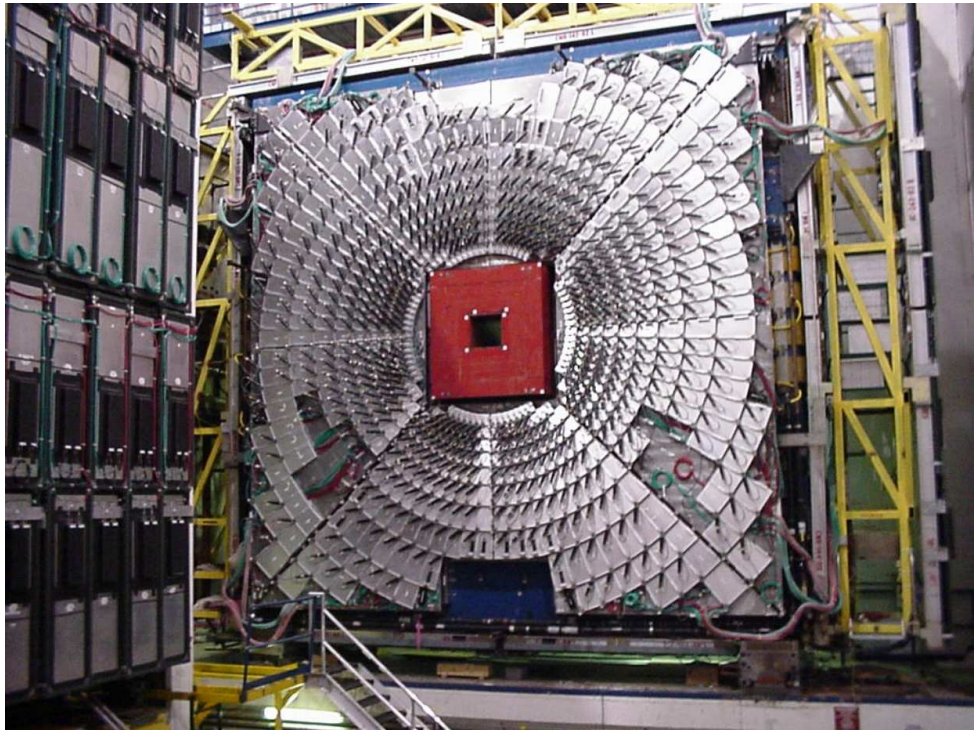
DØ Detector Status

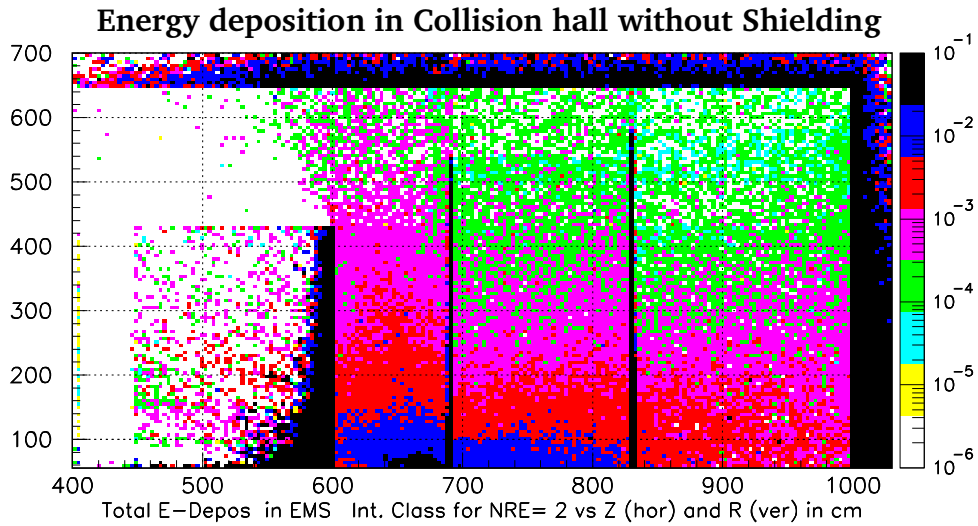
Muon Detectors

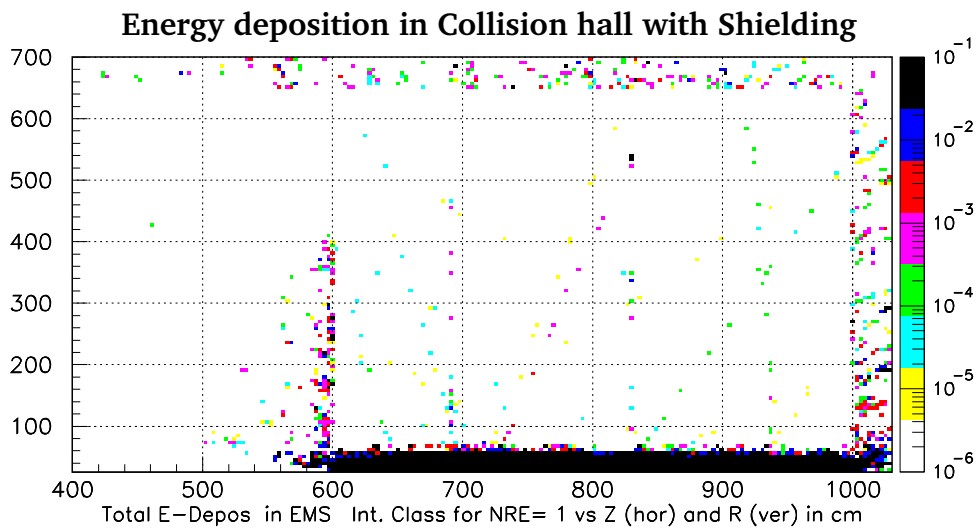
New Shielding installed around beampipe:

- consisting of iron, polyethylene and lead
- designed for factor 100 in rate reduction
- confirmed in Run II operation:

  hit occupancies at 0.1% (Run I: 10%)



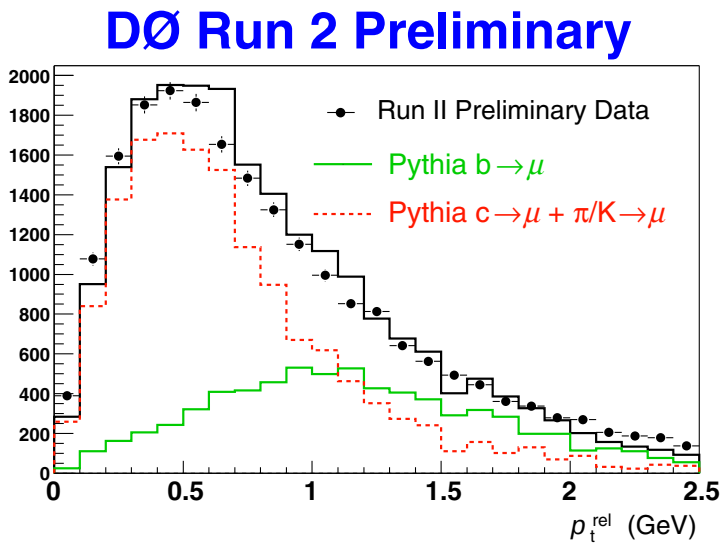




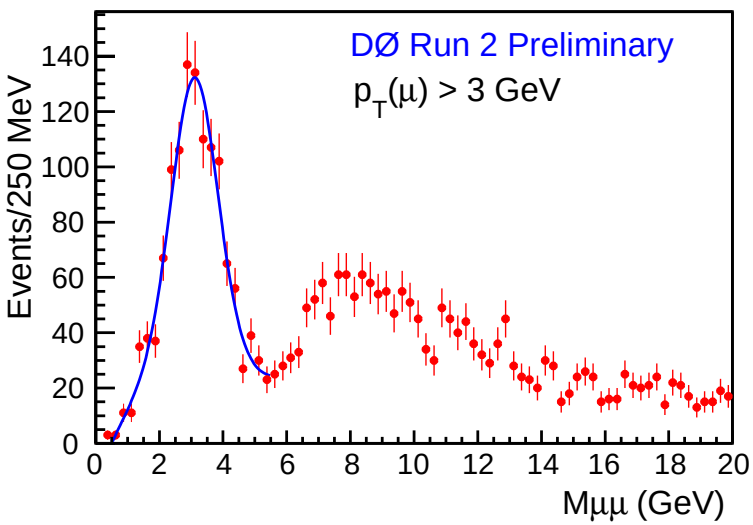
DØ Detector Status

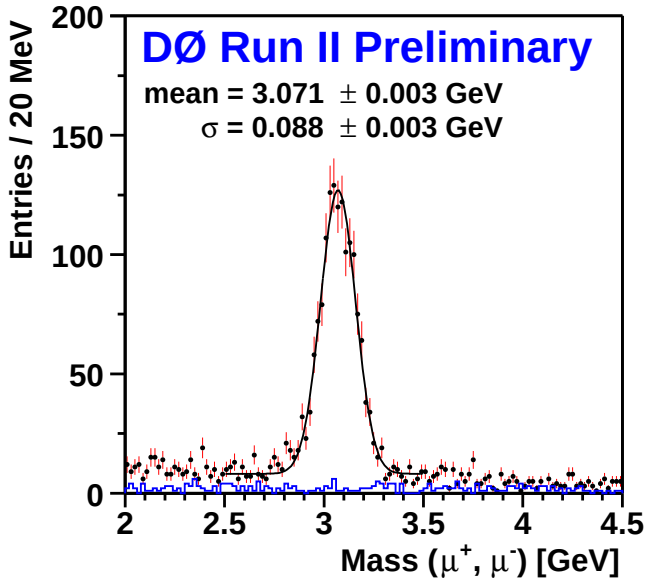
Muon Detectors

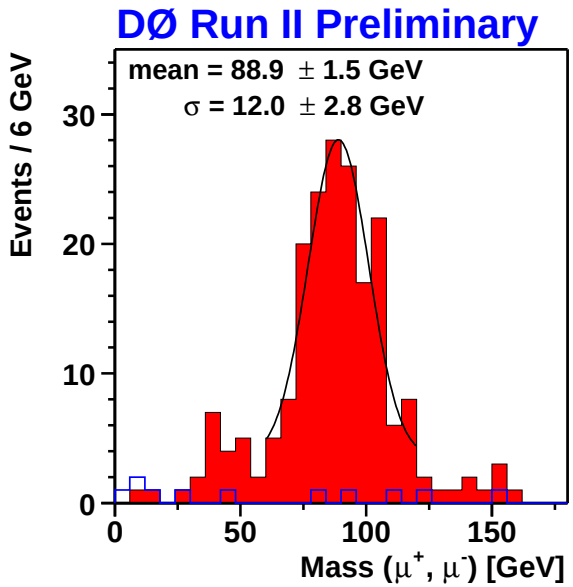
- less than 0.7% dead/noisy channels
- very stable with time
- hit efficiencies >99% (PDT), >97% (MDT)
- muons are reconstructed with stand-alone and global tracking
- b-tagging with muons has been established



$J/\Psi \rightarrow \mu^+\mu^-$ (stand-alone muon tracking)

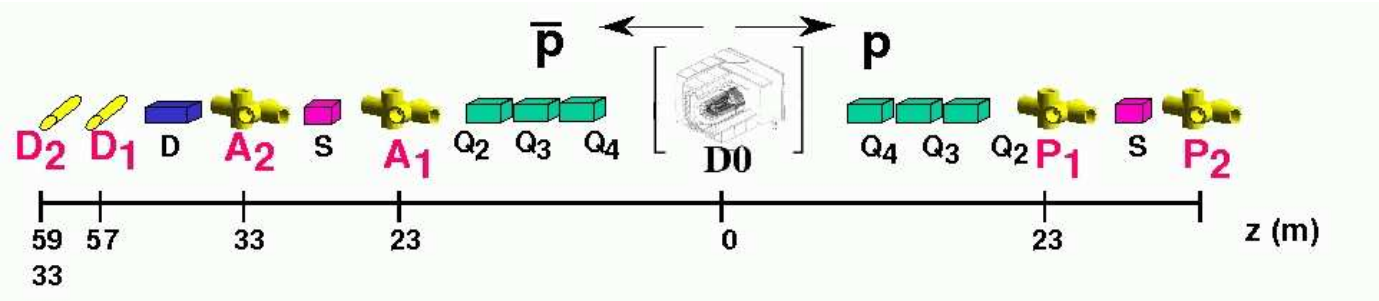


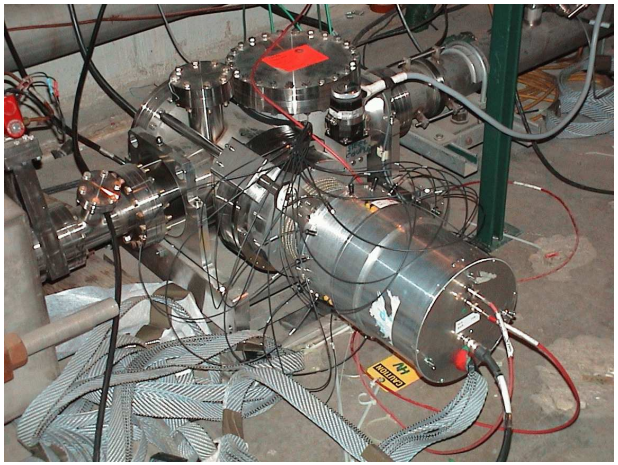




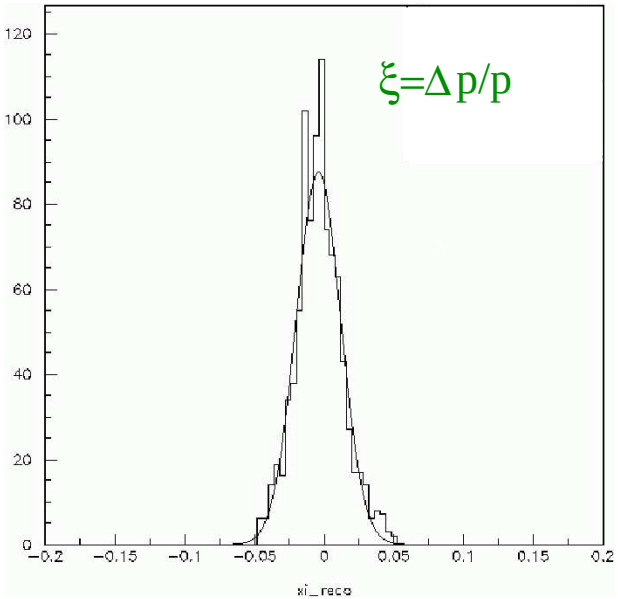
DØ Detector Status

Forward Proton Detectors





- Forward Proton Detectors for diffractive/elastic physics
  - 2 arms to measure outgoing proton and anti-proton
  - 18 roman pots in 4 quadrupole and 2 dipole castles
- Hits in scintillating fiber detectors are used to
  - trigger on elastic, diffractive, double pomeron events
  - measure p scattering angle + fractional energy loss
- recorded >2 million elastic events (stand-alone DAQ)
- integration with rest of DØ coming soon



DØ Detector Status

Trigger Systems

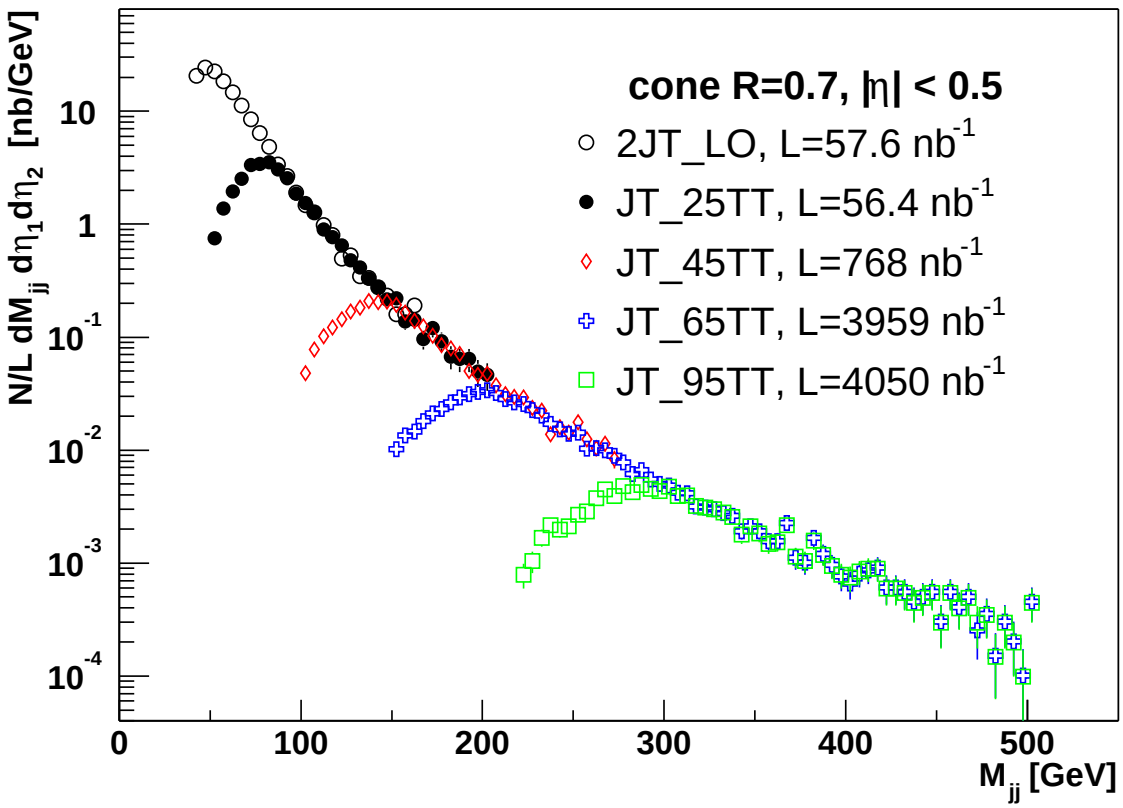
Trigger Level 1

- hardware trigger (mostly FPGA), 4.2μs
- output rate 5kHz (current max. 2kHz, typical 0.5kHz)
- cal towers, tracks, muons, $\not{E}_t$ – some correlations
- fully operational except track trigger (being commissioned)

Trigger Level 2

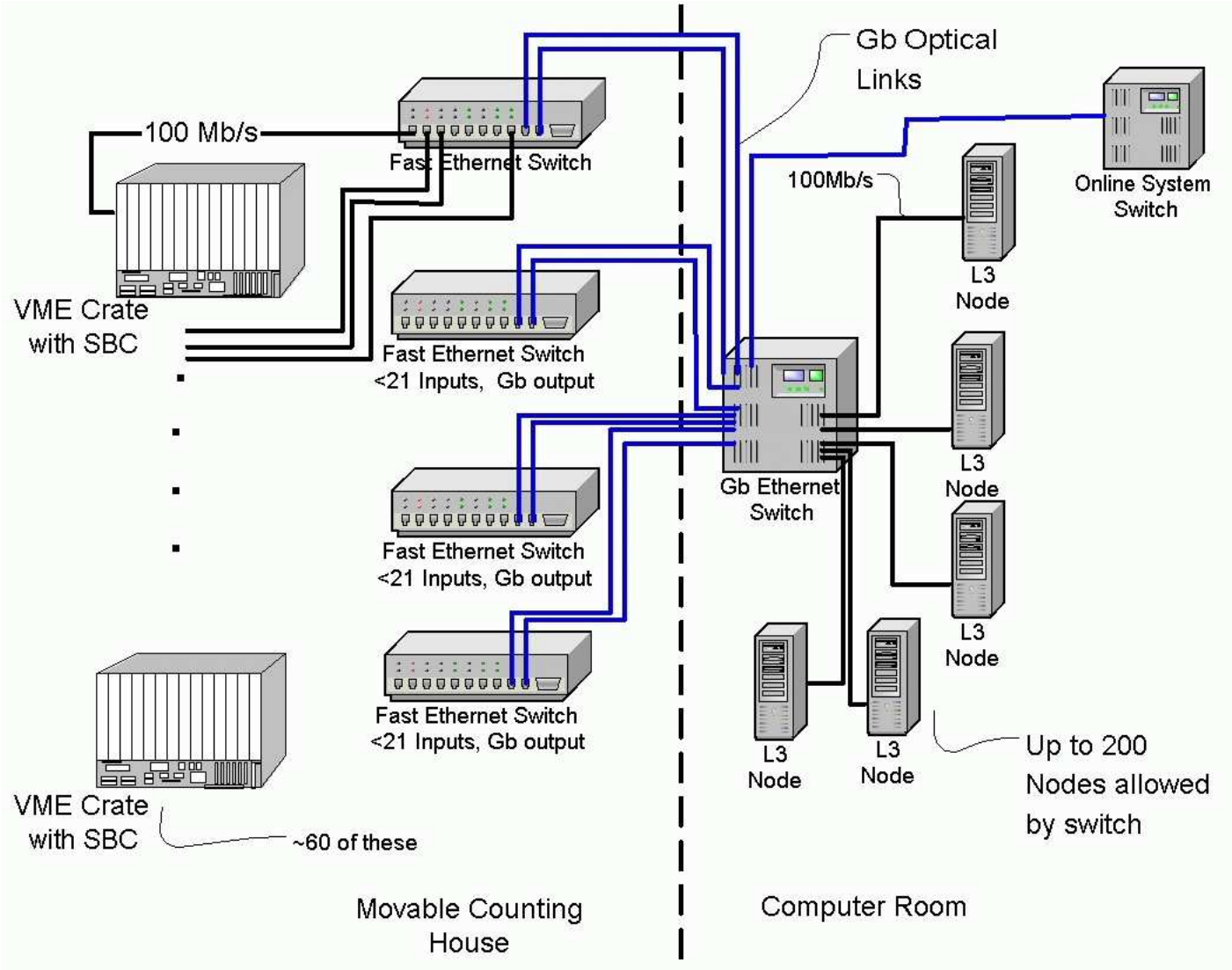
- single board computers (Linux, C++), 100μs
- output rate 1kHz (typical 250Hz)
- cal clustering, muon tracking, impact parameter – combining subdetectors
- fully operational except silicon track trigger (in production)

Dijet Mass Spectrum by Trigger

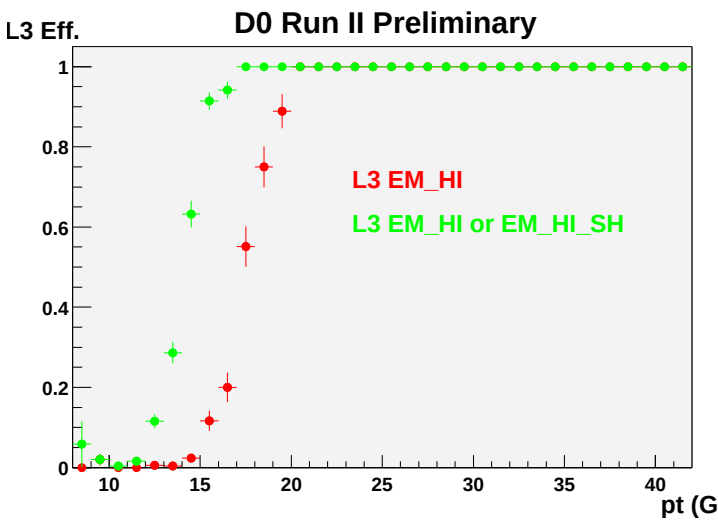


DØ Detector Status

Level 3 Trigger



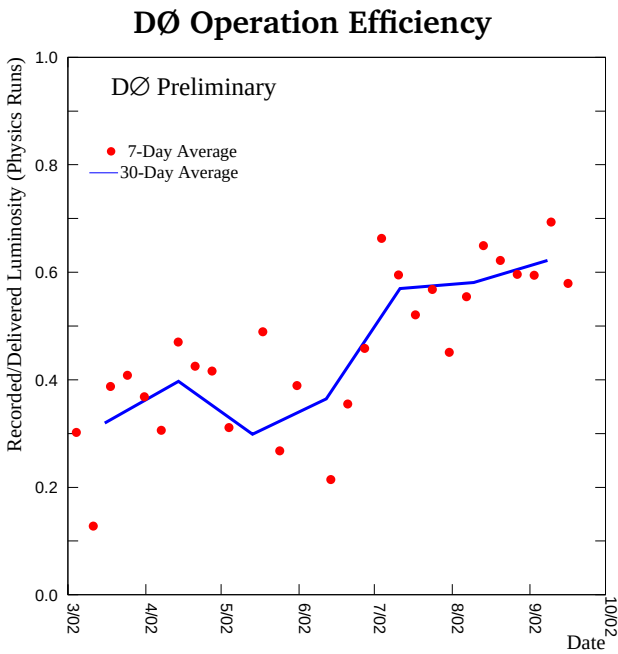
- 48-node PC farm running Linux (C++), 50ms/event
- output rate 50Hz
- access to full detector readout
- simplified event reconstruction (e, γ, μ, τ, jets, $\not{E}_t$, b)
- fully operational

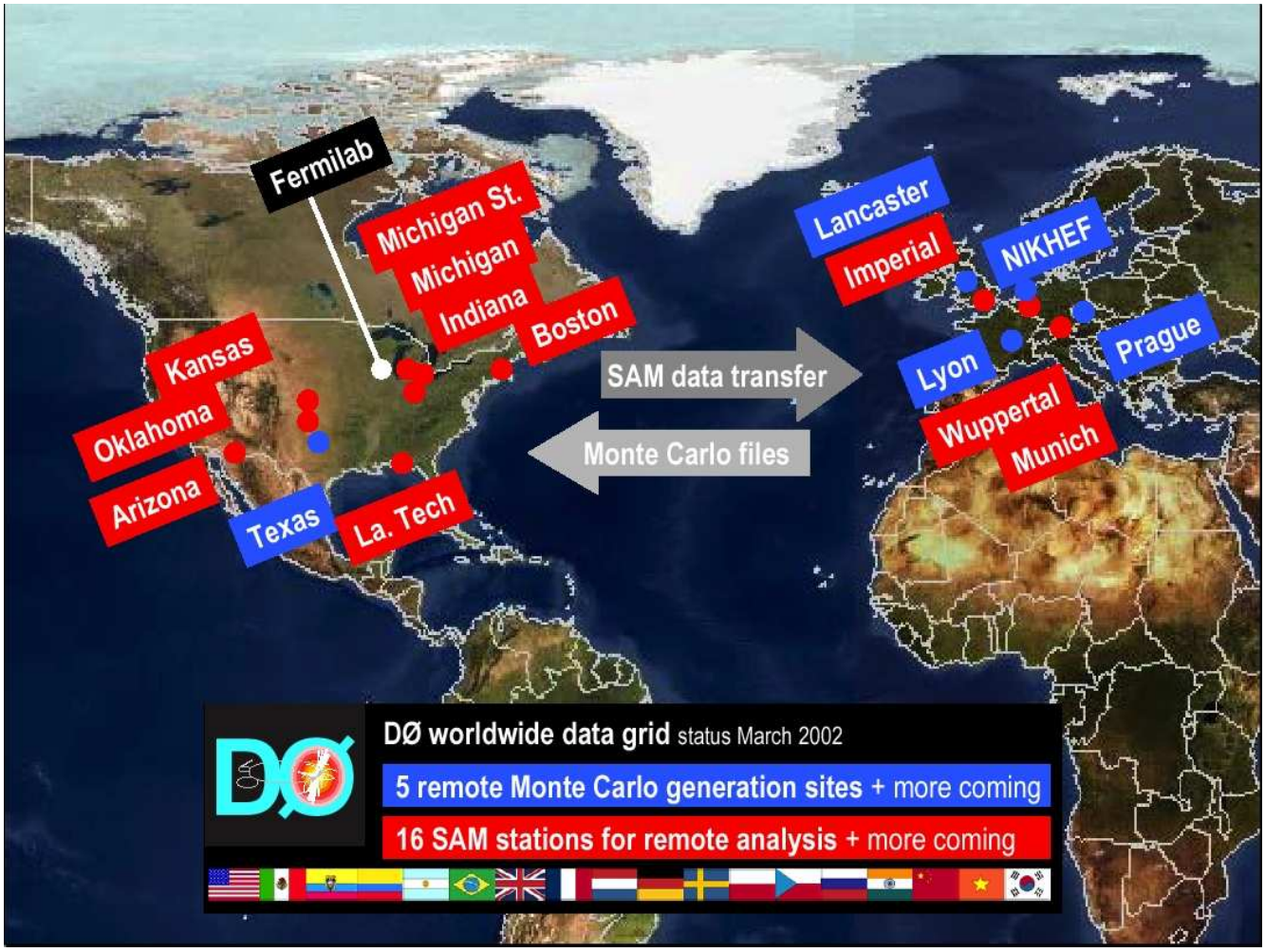


DØ Detector Status

Data Aquisition and Distribution

- $\approx 35 \mathrm{pb}^{-1}$ recorded in physics runs
- some early luminosity invested into special runs
- data taking efficiency is rising
- taking $\approx$7.5 million events / week
- worldwide data distribution using "grid-enabled" resource management system (SAM)





DØ Detector Status

Run IIb Upgrades

The Goal:

Maintain high-pt physics program at high integrated and instantaneous luminosity

Peak luminosities $>4\times10^{32}$:

- high rates require partial upgrades of trigger and front-end electronics:

$\rightarrow$ upgrade L1 Calorimeter Trigger (cal clustering)

$\rightarrow$ upgrade L1 Track Trigger (narrow roads)

$\rightarrow$ incremental upgrades to L2, L3 Triggers and online system

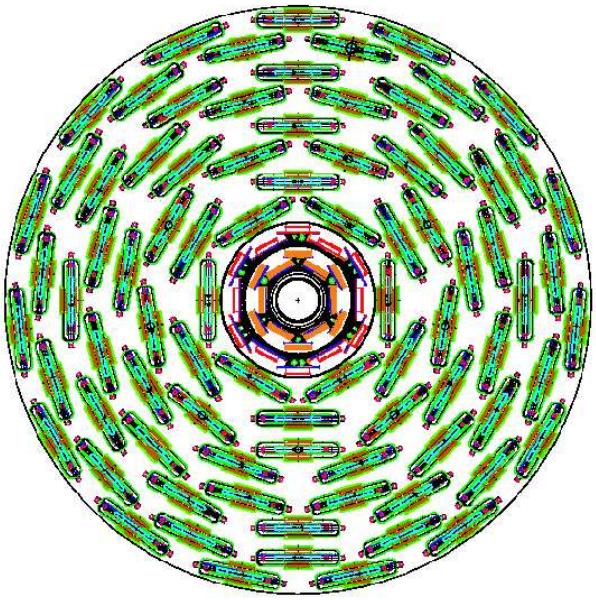
Integrated luminosities $>15\text{fb}^{-1}$:

- radiation damage to silicon detectors after 4fb^{-1}

$\rightarrow$ need to build new silicon tracking system:

$\rightarrow$ single-sided radiation hard detectors

$\rightarrow$ innermost layer at 1.78cm to improve impact parameter resolution



DØ RunIIb Silicon Detector

DØ Detector Status

Conclusions

- The D0 Run II Detector is operating and collecting physics data
- All subdetectors are fully commissioned and perform to specifications
- 1st pass calibration and alignment completed
- Working hard on commissioning the L1/L2 track triggers
- Trigger and reconstruction algorithms verified with physics signals
- First set of physics results is available (see 9 more talks this week)

- Looking forward to another 14.95fb^{-1} of data!