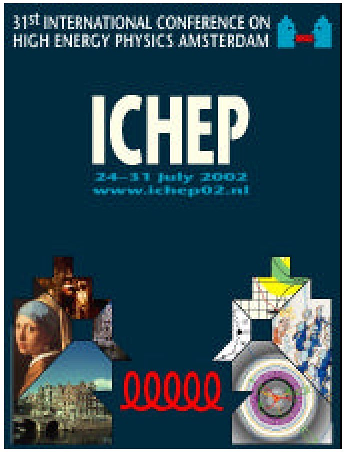
The DØ Detector for Run II

Levan Babukhadia

SUNY at Stony Brook
for the DØ Collaboration



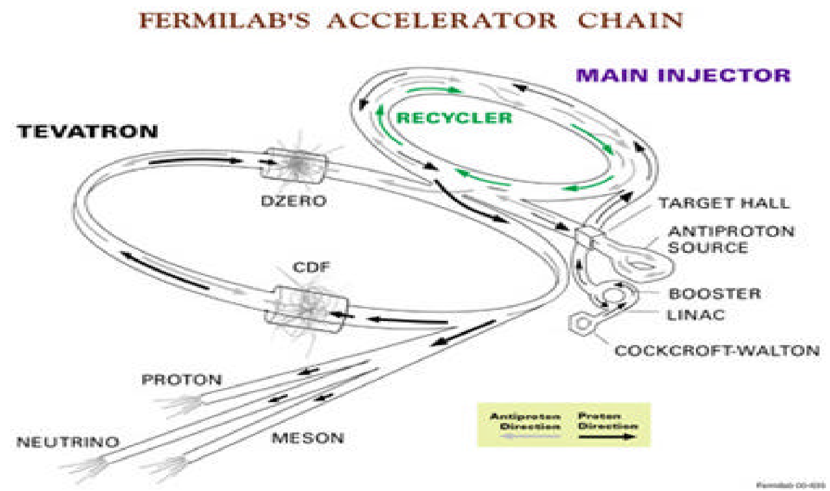
Physics Challenges ® The Upgraded Tevatron

Physics goals for Run 2

- precision studies of weak bosons, top, QCD, B-physics
- searches for Higgs, supersymmetry, extra dimensions, other new phenomena

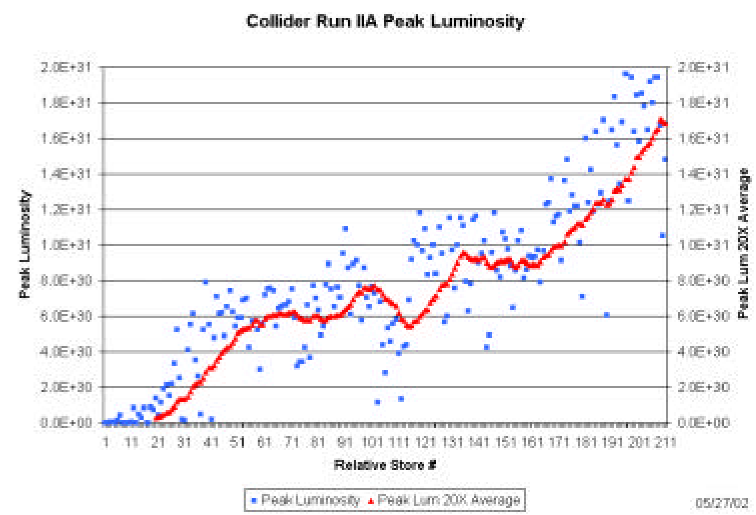
require

- electron, muon, and tau identification
- jets and missing transverse energy
- flavor tagging through displaced vertices and leptons
- luminosity, luminosity, luminosity…



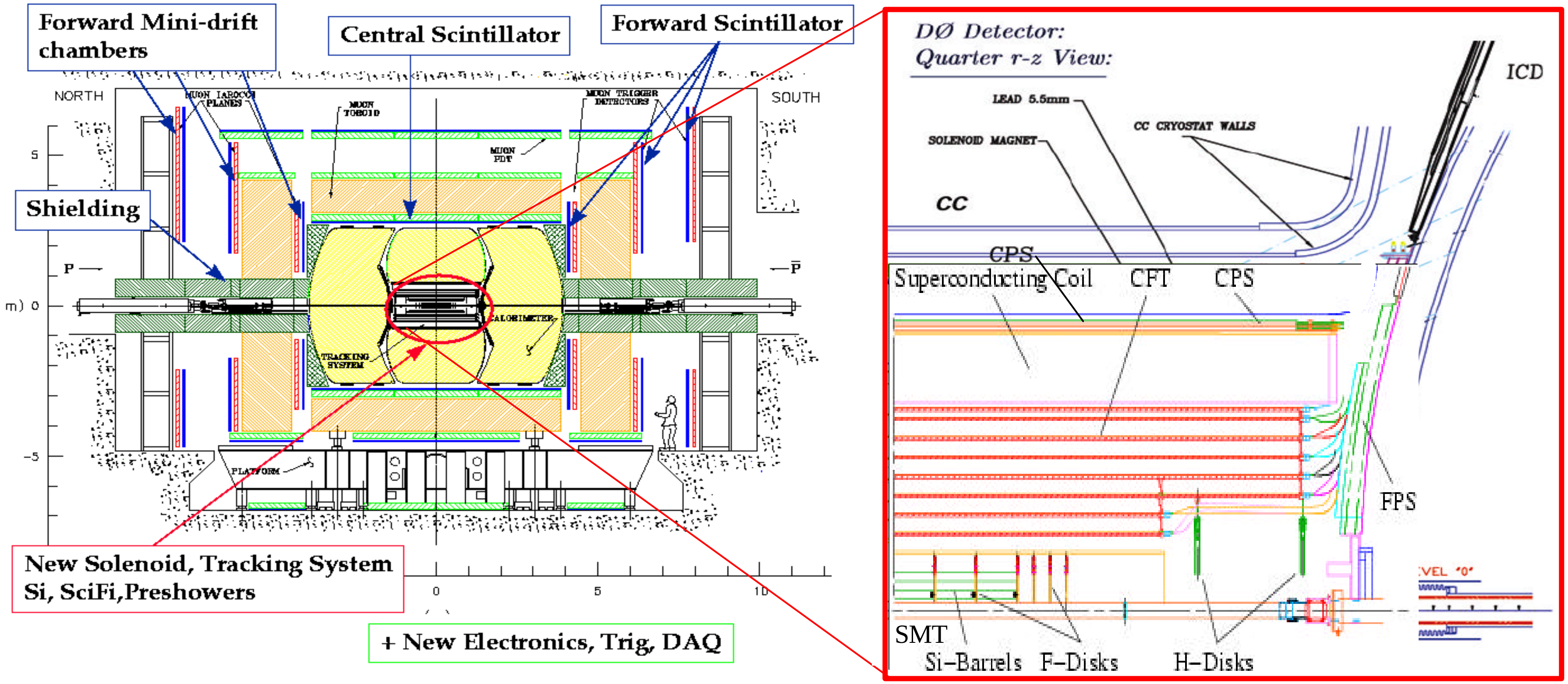
	Run 1b	Run 2a	Run 2b
Bunches in Turn	6×6	36×36	140×103
$\sqrt{s}$ (TeV)	1.8	1.96	1.96
Typical L ($cm^{-2}s^{-1}$)	1.6×10^{30}	8.6×10^{31}	5.2×10^{32}
$\int Ldt$ (pb^{-1}/week)	3.2	17.3	105
Bunch xing (ns)	3500	396	132
Interactions / xing	2.5	2.3	4.8

Run 1 → Run 2a → Run 2b
0.1 fb^{-1} → 2–4 fb^{-1} → 15 fb^{-1}



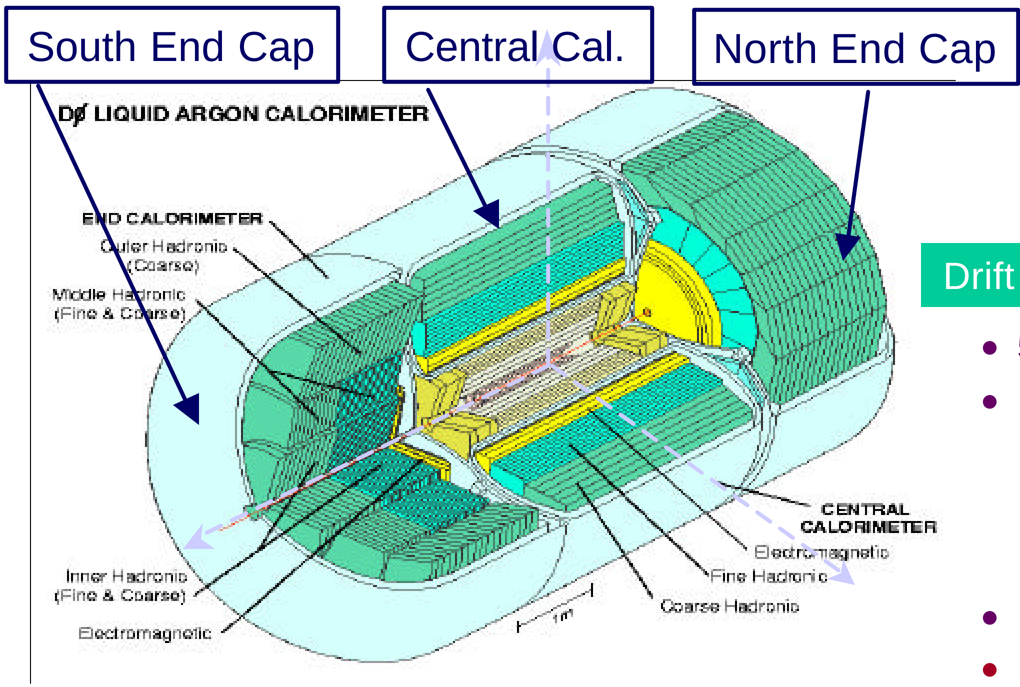
Peak Lum. achieved over 2×10^{31} $cm^{-2}s^{-1}$
Planned to reach Run 2a design
by Spring 2003

Physics Challenges ® The Upgraded Detector

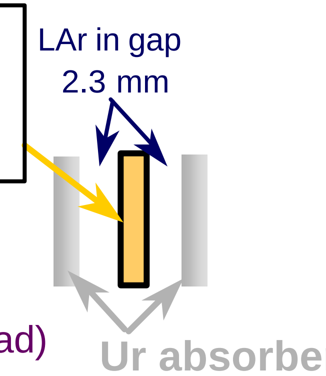


- New tracking devices, Silicon (SMT) and Fiber Tracker (CFT), placed in 2 T magnetic field (see also George Ginther's talk in this session)
- Upgraded Calorimeter electronics readout and trigger
- Added PreShower detectors, Central (CPS) and Forward (FPS)
- Significantly improved Muon System
- New forward proton spectrometer (FPD)
- Entirely new Trigger System and DAQ to handle higher event rate

Calorimeters



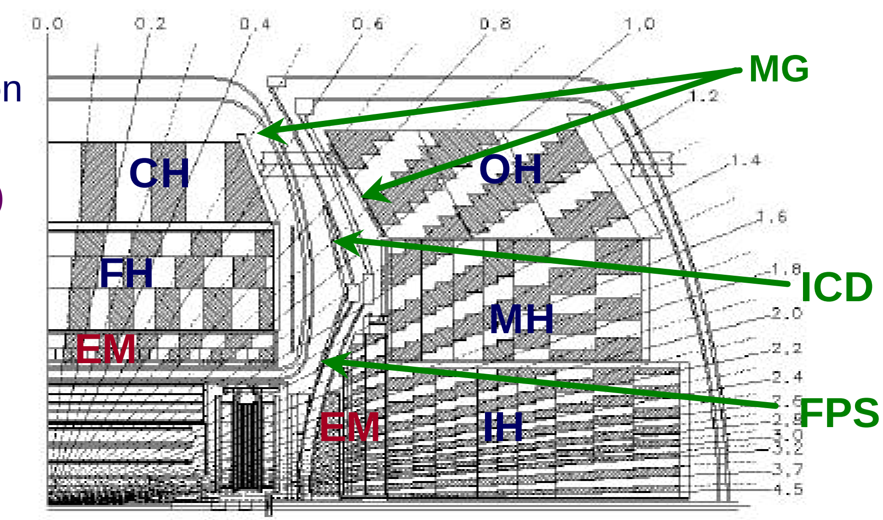
Readout Cell
Cu pad readout on 0.5 mm G10 with resistive coat epoxy



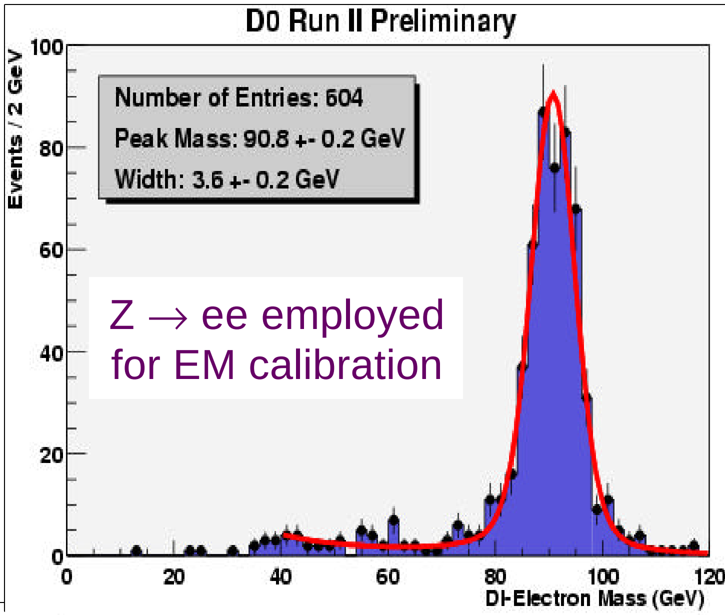
Drift time ~430 ns

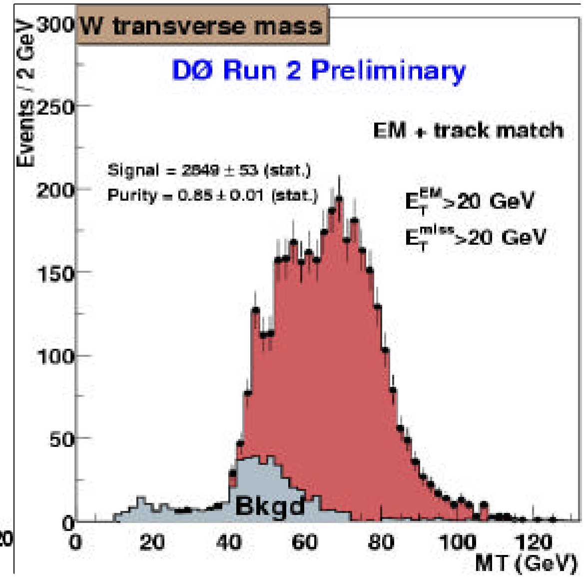
- 50k readout cells (< 0.1% bad)
- Fine segmentation
  - 5000 pseudoprojective towers (0.1×0.1)
  - 4 EM layers, shower-max (EM3): 0.05×0.05
  - 4/5 Hadronic (FH + CH)
- L1/L2 fast Trigger readout 0.2×0.2 towers
- Fully commissioned

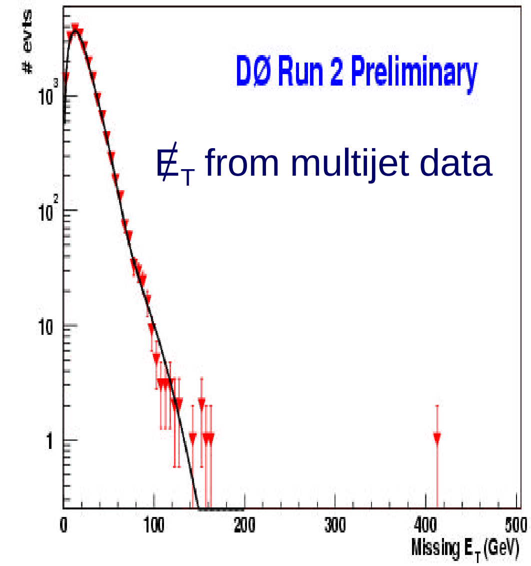
- Liquid Argon sampling
  - uniform response, rad. hard, fine spatial segmentation
  - LAr purity important
- Uranium absorber (Cu/Steel CC/EC for coarse hadronic)
  - nearly compensating, dense $\Rightarrow$ compact
- Uniform, hermetic with full coverage
  - $|\eta| < 4.2$ ($\theta \approx 2^{o}$), $\lambda_{int} \sim 7.2$ (total)
- Single particle energy resolution
  - e: $\sigma/E = 15\% / \sqrt{E} \oplus 0.3\%$ π: $\sigma/E = 45\% / \sqrt{E} \oplus 4\%$

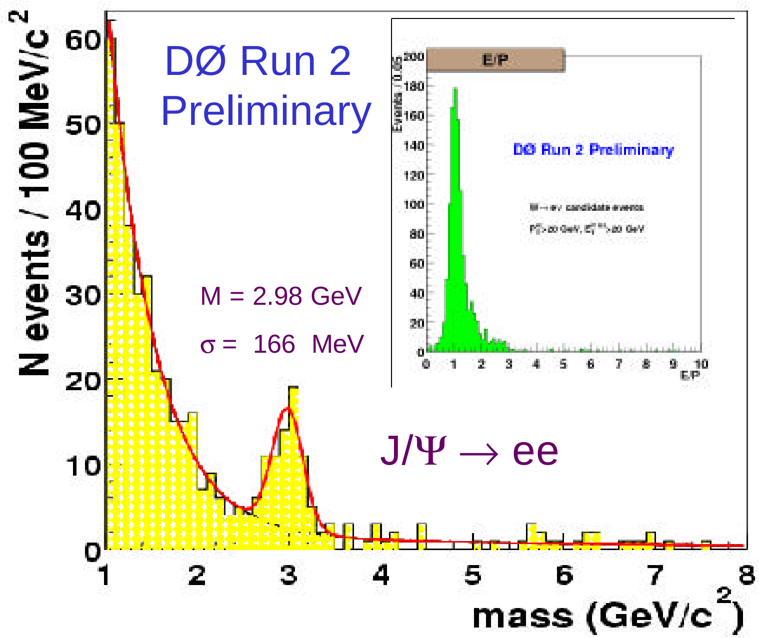


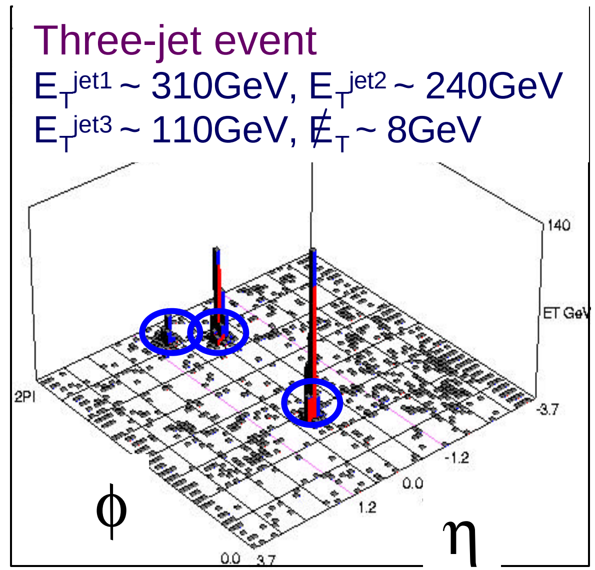
Calorimeter Performance

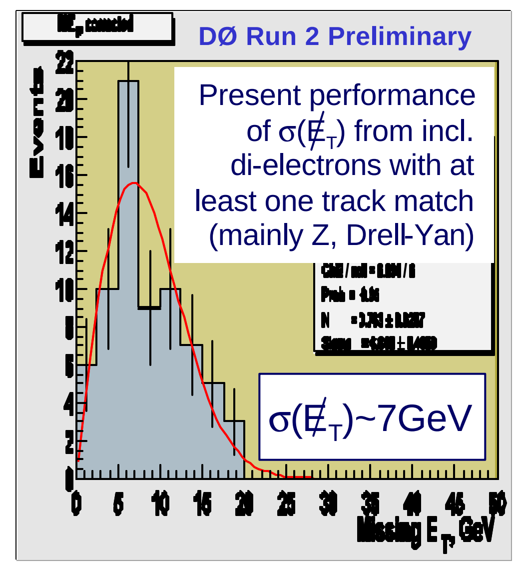




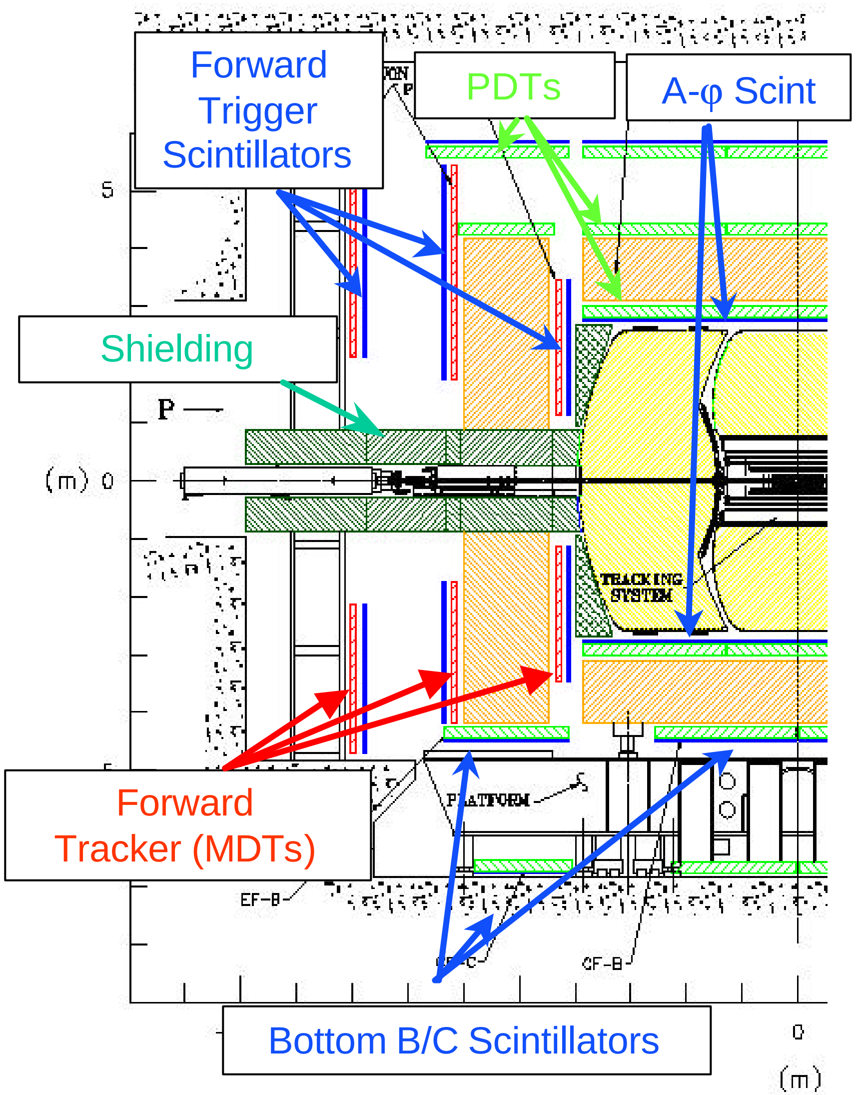








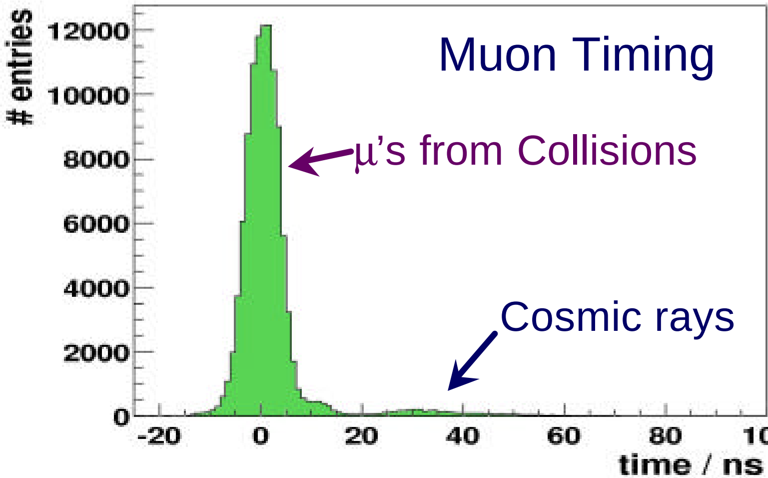
Muon System



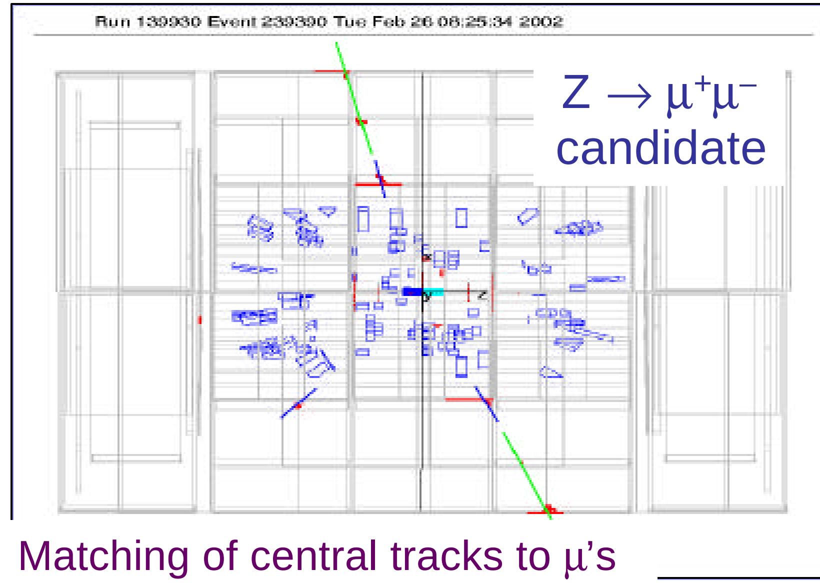
<u>Fully commissioned</u>

- Central and Forward regions, coverage up to $\eta = \pm 2$
- Three layers: one inside (*A*), two outside (*B*, *C*) the toroid magnets
- Consists of scintillators and drift tubes
- Central Proportional Drift Tubes (PDT's)
  - 6624 drift cells (10.1 × 5.5 cm) in 94 three- and four-deck chambers
- Central Scintillation Counters
  - 360 "cosmic ray" counters outside the toroid ($\Delta\varphi$ = 22.5°)
  - 630 "A–φ" counters inside ($\Delta\varphi$ = 4.5°), $\Delta\eta$ = 0.1
- Forward Mini Drift Tubes (MDT's)
  - 6080 8-cell tubes in 8 octants per layer on North and South side, cell cross-section 9.4 × 9.4 mm
- Forward Scintillation Counters (Pixels)
  - 4214 counters on the North and South side
  - $\Delta\varphi$ = 4.5° matches the MDT sector size

Muon System Performance



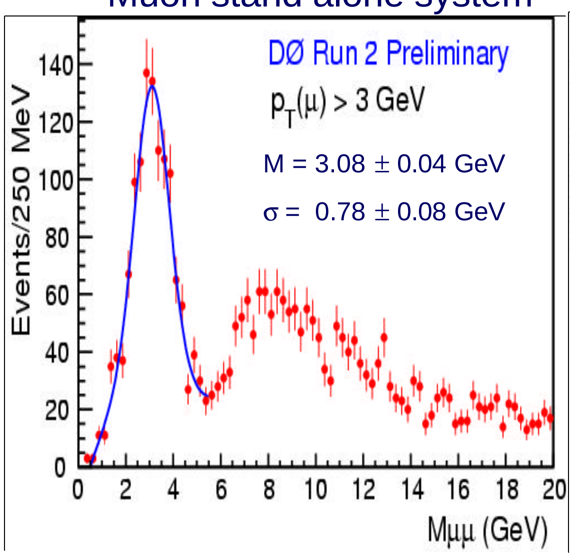
Timing cuts reduce cosmic bckg., could aid in detection of slow moving particles



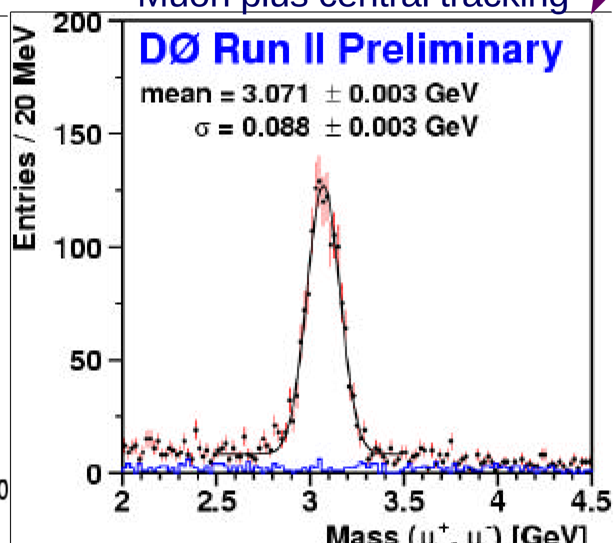
Matching of central tracks to μ's improves momentum resolution

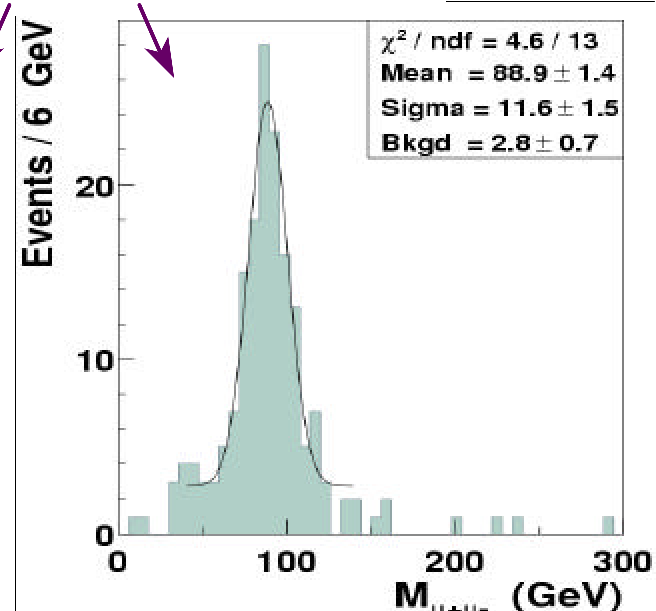
J/Ψ invariant mass

Muon stand alone system



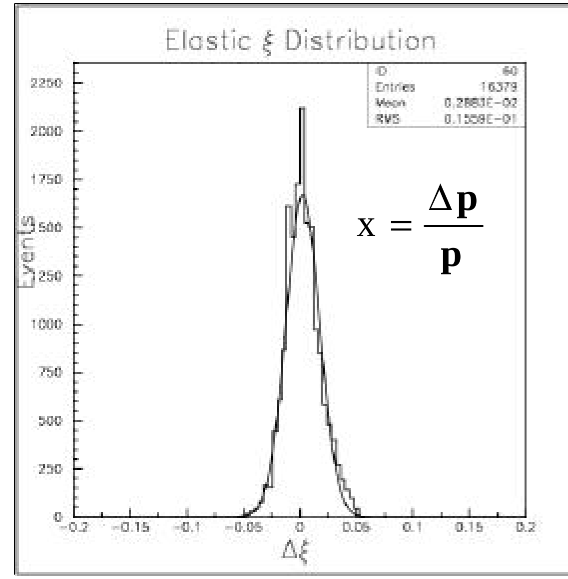
Muon plus central tracking

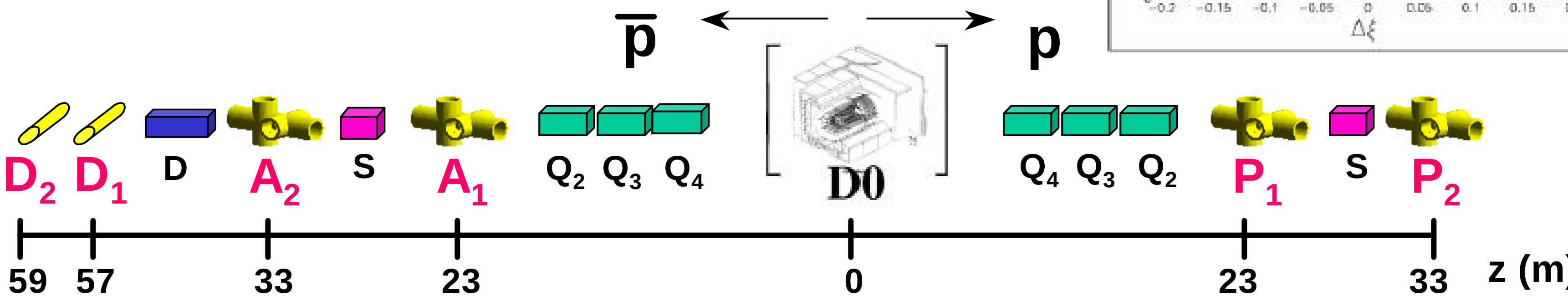




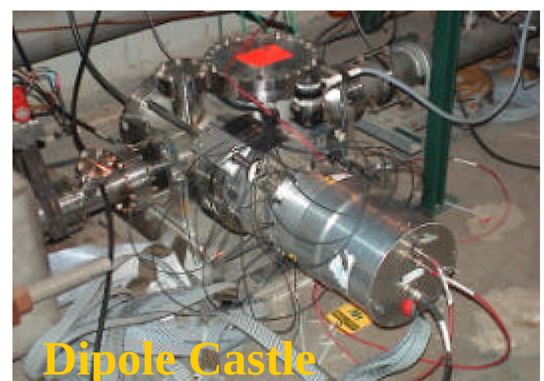
DØ Forward Proton Detector

- Diffractive and elastic physics program
  - need special detectors at very small angles: FPD
- FPD consists of 2 arms (outgoing proton and anti-proton)
  - 18 Roman pots in 4 quadrupole and 2 dipole “castles”
- From hits in scintillating fiber detectors installed in Roman pots
  - fractional energy lost by the proton and scattering angle
  - trigger on elastic, diffractive, double pomeron events

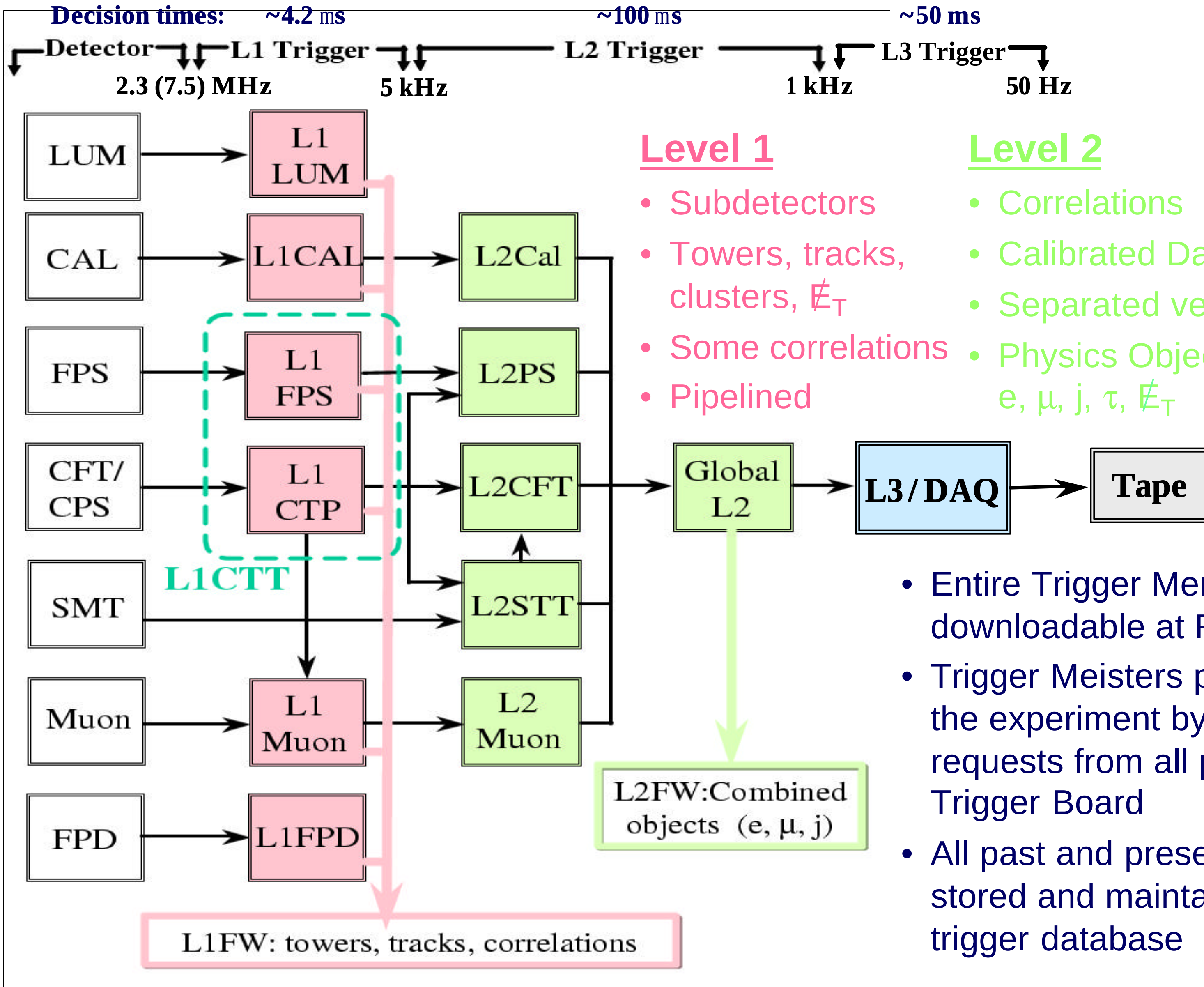




- Routinely insert pots during collisions
- Recorded > 2 M elastic events with stand-alone DAQ
- Working on integration of FPD with the rest of DØ
- First diffractive+jet data by December



DØ Trigger System



Level 1

- Subdetectors
- Towers, tracks, clusters, $\not{E}_T$
- Some correlations
- Pipelined

Level 2

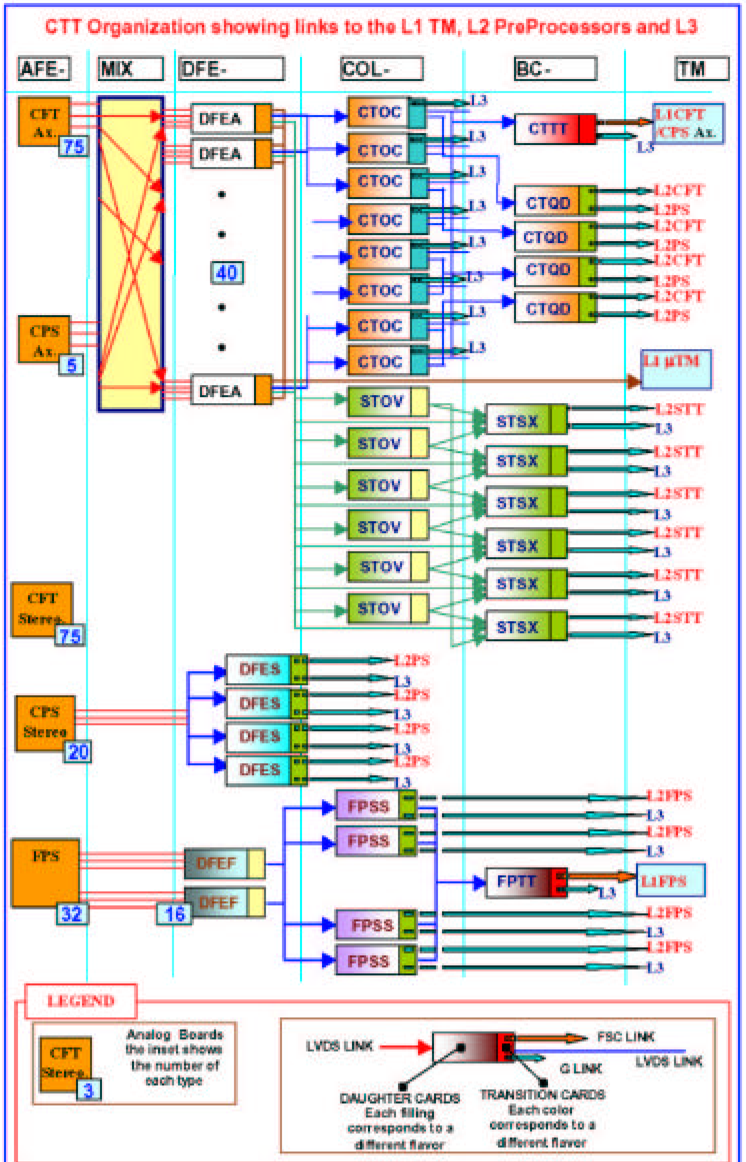
- Correlations
- Calibrated Data
- Separated vertex
- Physics Objects e, μ, j, τ, $\not{E}_T$

Level 3

- Simple Reconstruction
- Physics Algorithms

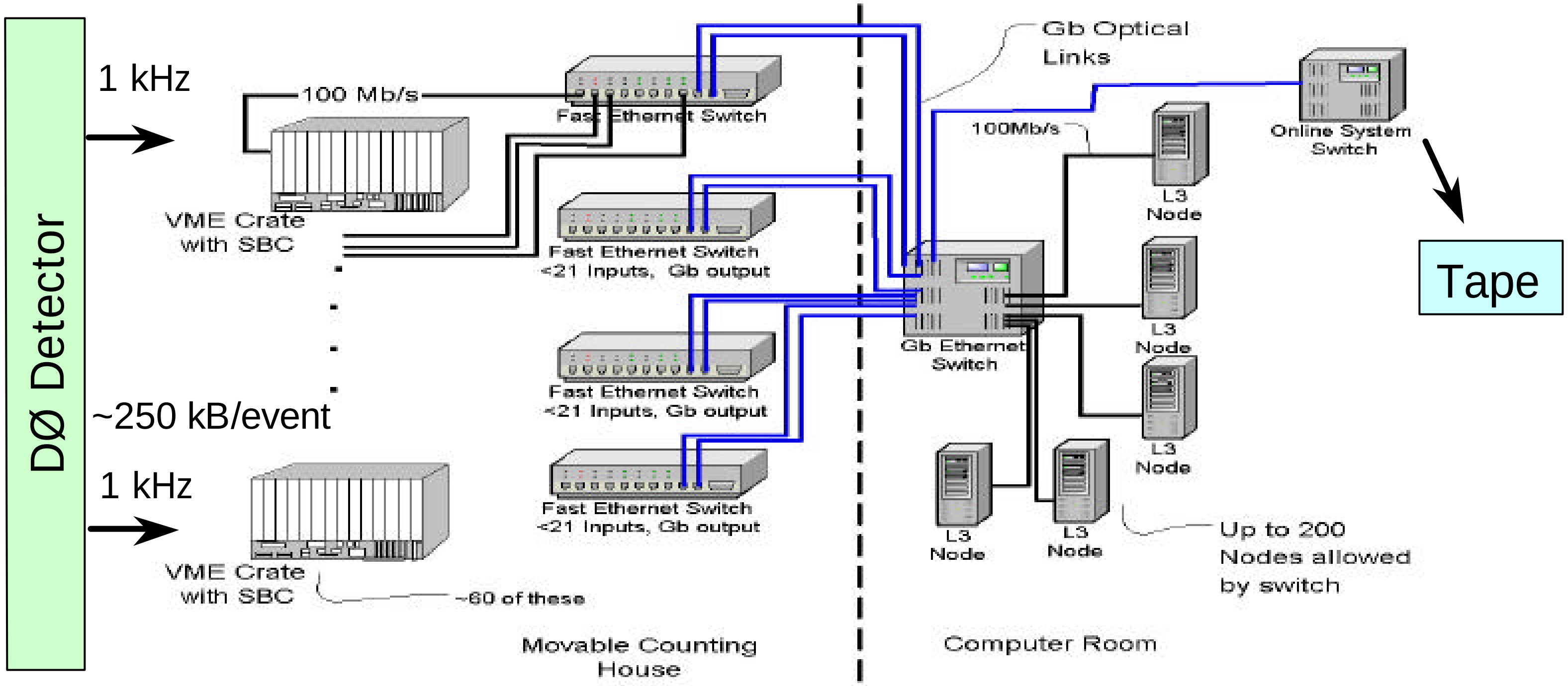
- Entire Trigger Menu configurable and downloadable at Run start
- Trigger Meisters provide trigger lists for the experiment by collecting trigger requests from all physics groups in the Trigger Board
- All past and present trigger lists are stored and maintained in the dedicated trigger database

DØ Track and Preshower Digital Trigger



- Implemented in ~100 digital boards with same motherboard and different flavors of daughter-cards with over 500 Xilinx Virtex FPGAs
- Provides charged lepton id in Level 1 by finding tracks in 4.5° azimuthal trigger sectors of CFT
- Helps with EM-id in Level 1 by reconstructing clusters of energy in CPS scintillator strips
- Helps with Muon-id in Level 1 by sending 6 highest p_T tracks to L1Muon in about 900ns
- Helps with EM-id in forward regions $|\eta| < 2.6$ by reconstructing clusters of energy in FPS strips
- Helps with charged lepton id in forward regions by confirmation in pre-radiator layers of FPS
- Facilitates matching of preshower and calori-meter objects at quadrant level
- Helps with displaced vertex id in Level 2 Silicon Track Trigger by providing the Level 1 CFT tracks for global SMT+CFT track fitting
- Currently being commissioned

Data Acquisition System

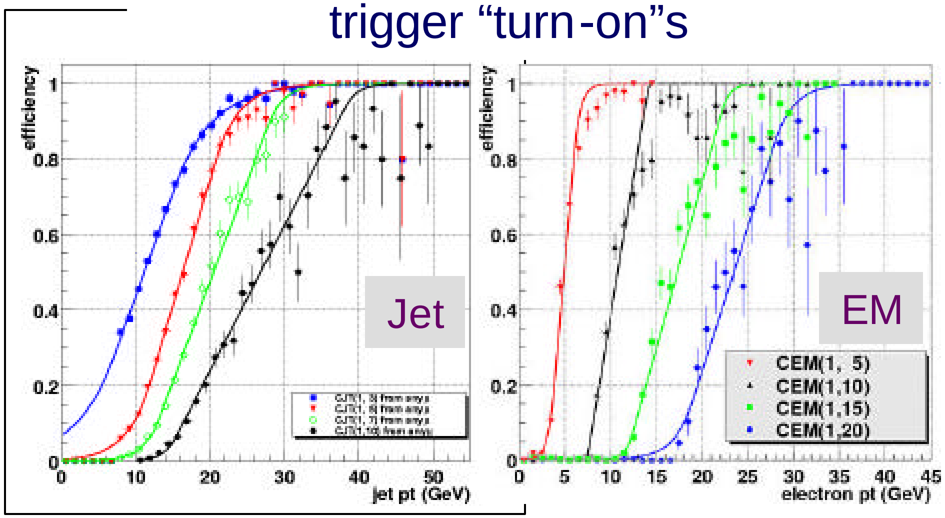


- Gathers raw data from the front-end crates following each Level 2 Accept
- Based on "off the shelf" components
- Single Board Computers (SBCs) read out Level 3 buffers: Intel 1GHz, VME based, dual 100Mb Ethernet, Linux OS
- SBCs send data to a Level 3 node over fast Ethernet switches according to instructions received from the Routing Master

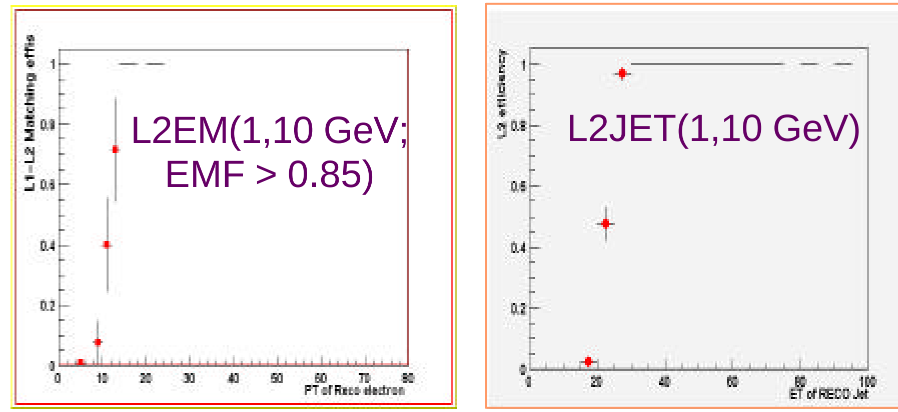
- The routing Master program runs on an SBC in a special crate receiving data from the Trigger Framework
- Cisco Switch sends data to Linux Level 3 Farm nodes
- Event building and Level 3 trigger selections performed by 48-node Linux farm

Level 1 and Level 2 Trigger Performance

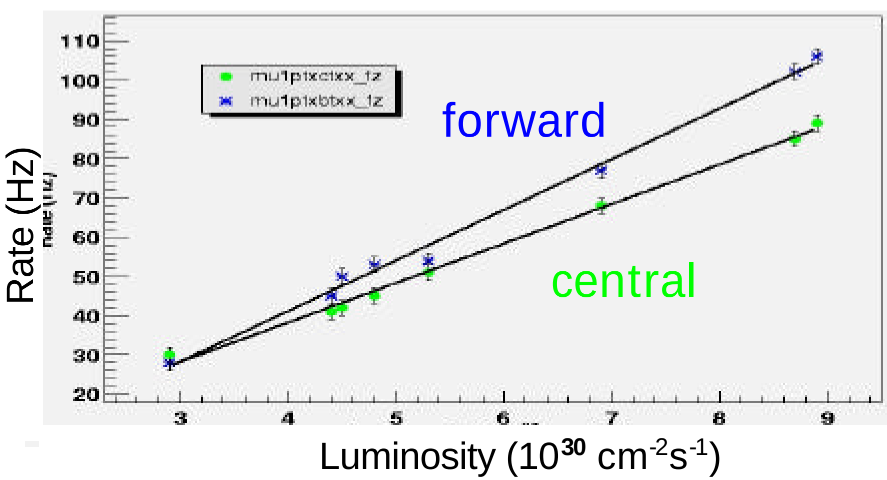
Level 1 Calorimeter Jet and EM trigger "turn-on"s



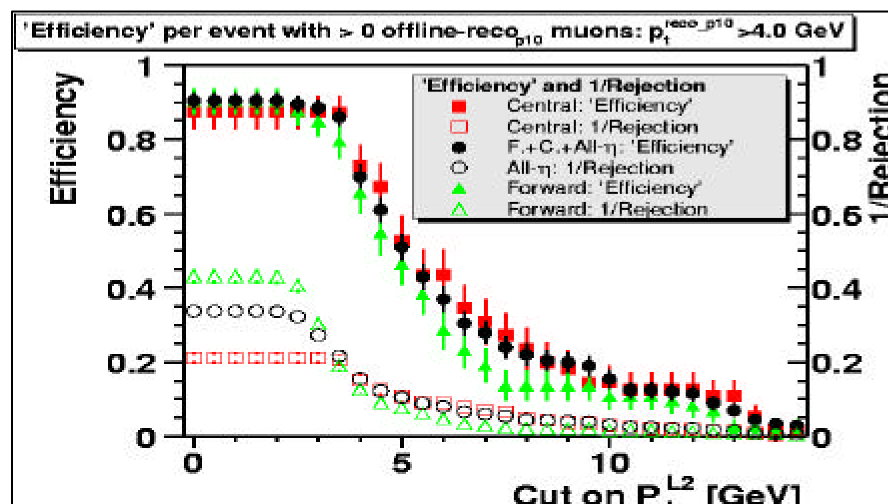
Level 2 Calorimeter Jet and EM trigger efficiencies



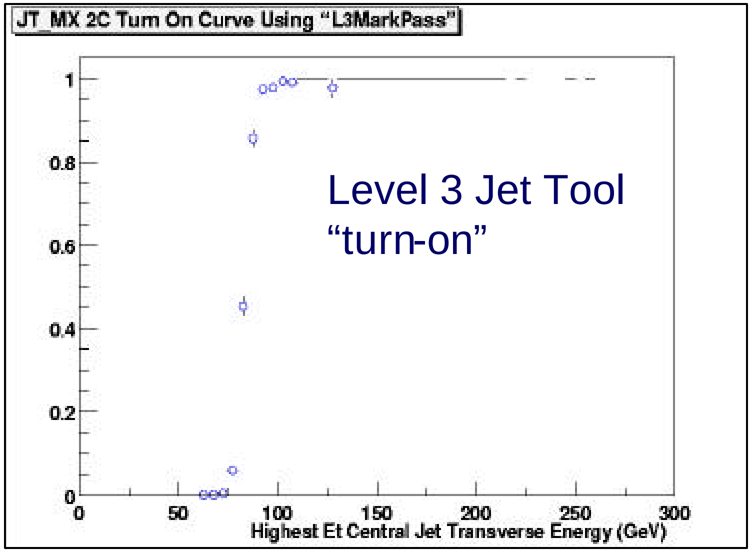
Level 1 Muon trigger rate dependence on Luminosity



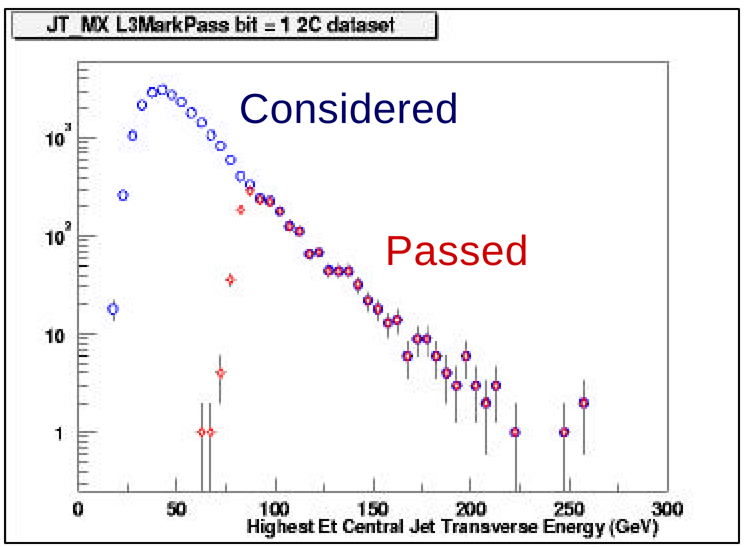
Level 2 Muon trigger efficiency and rejection

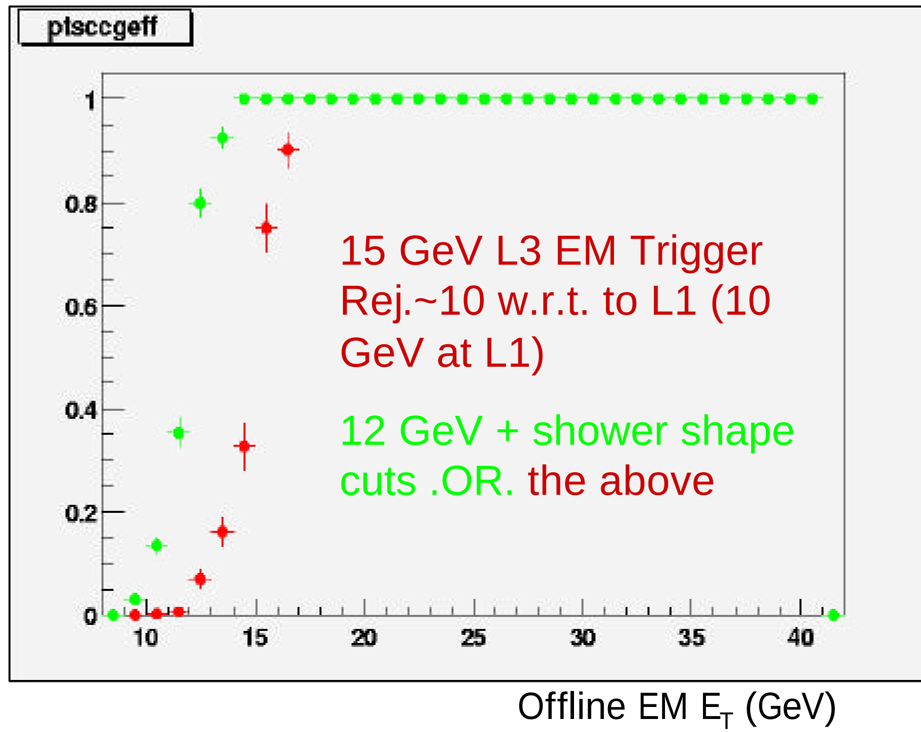


Level 3 Trigger Performance



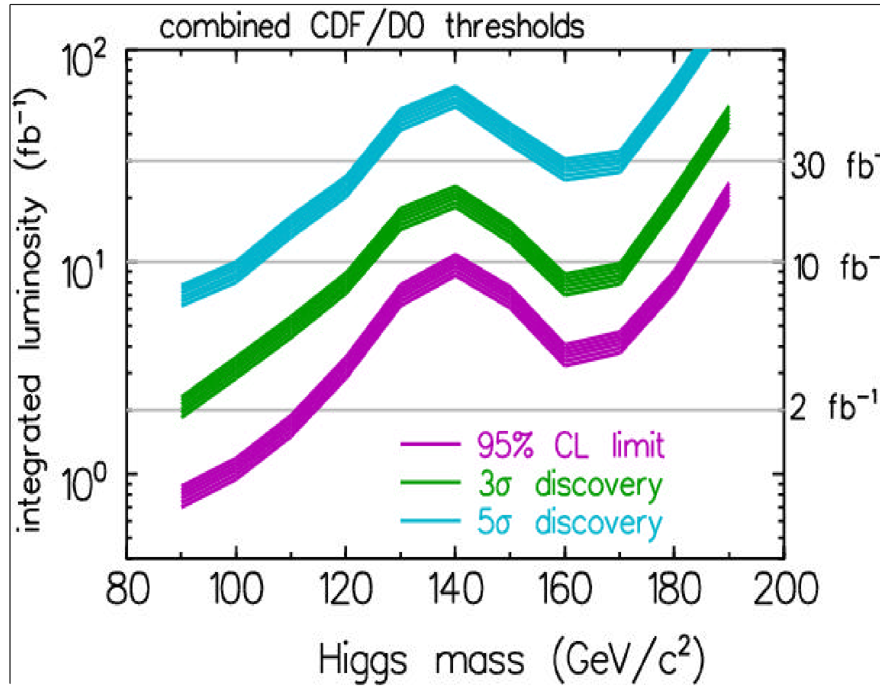
The 48-node Linux Level 3 farm working and selecting events, by triggering on Jets, EM objects, Muons, Taus





DØ Detector Run 2b Upgrade

- Present detector was designed for ~2–4fb^{-1} integrated and ~2×10^{32} $cm^{-2}s^{-1}$ instantaneous Luminosity
- Run 2b goal ~15fb^{-1} before LHC Physics
  - Physics motivations: Higgs and Supersymmetry
  - Exceeds radiation tolerance of existing Silicon detector
  - Requires higher instantaneous luminosities, ~5×10^{32} $cm^{-2}s^{-1}$, trigger upgrades



Silicon Upgrade

Replace Silicon Detector with a more radiation-hard version

New Silicon tracker with innermost layer at 1.78 cm (c.f. 2.71 in Run 2a)

Maintain good pattern recognition coverage $|\eta| < 2$

Trigger Upgrade

Upgrade L1 Track Trigger to narrow roads, improve Track-Cal. matching

Upgrade L1/2 Cal. Trigger to use digital filter, isolation, shape cuts

Incremental upgrades to Level 2, Level 3 Triggers and online system

Summary and Outlook

- The DØ Detector for Run 2 is operating and collecting physics data
- Enormous progress over the past year in installation, integration, commissioning of the detector and understanding the data
- Performance of the Run 2 DØ detector is very encouraging
  - all subdetectors are operating well
  - software and computing systems are working well
  - we are reconstructing electrons, muons, jets, missing E_T, J/ψ, W's and Z's and first results already presented at winter/spring and now at summer conferences
- We are working hard on what still needs to be done
  - complete commissioning of Level 1 Track Trigger
  - improve calibration and alignment
  - integrate Level 2 Silicon Track Trigger later this year
  - optimize detector, trigger, and DAQ performance
  - continue working on Run 2b Upgrade Project
- We are on the way to exciting physics, first physics results coming soon, exciting years are ahead!