DØ Status and Upgrade Plans

HEPAP meeting, Fermilab, April 26, 2002

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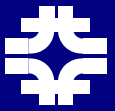
http://www-d0.fnal.gov/~womersle/womersle.html



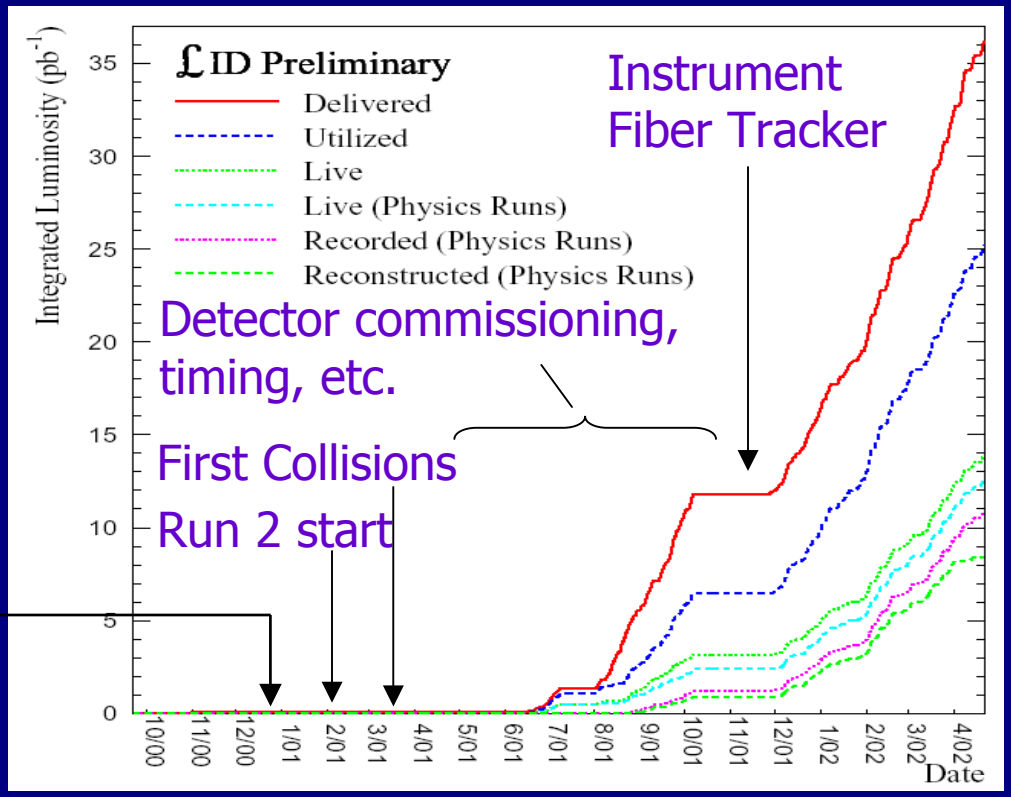
DØ

- DØ is an international collaboration of ~ 600 physicists from 18 nations who have designed, built and operate a collider detector at the Tevatron
- Physics goals
  - Precise study of the known quanta of the Standard Model
    - Weak bosons, top quark, QCD, B-physics
  - Search for particles, forces beyond those known
    - Higgs, supersymmetry, extra dimensions, other new phenomena
- Driven by these goals, the detector emphasises
  - Electron, muon and tau identification
  - Jets and missing transverse energy
  - Flavor tagging through displaced vertices and leptons

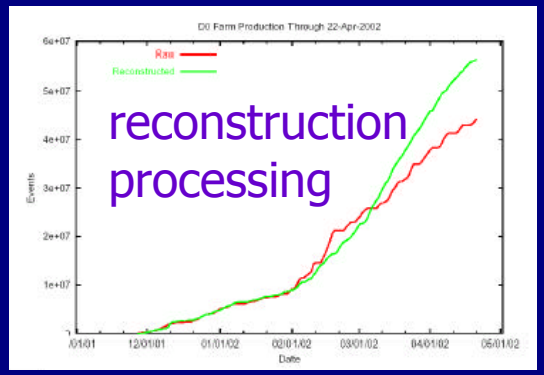
The past year

- About 35 pb^{-1} delivered so far
- Used for commissioning of
  - Detectors
  - Offline processing
  - Worldwide data access
  - Analysis
    - e, μ, jets, EM and jet energy scales, etc.

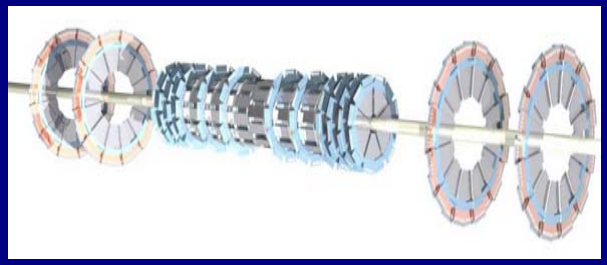
DØ detector roll-in



~ 11 pb^{-1}
now
on tape



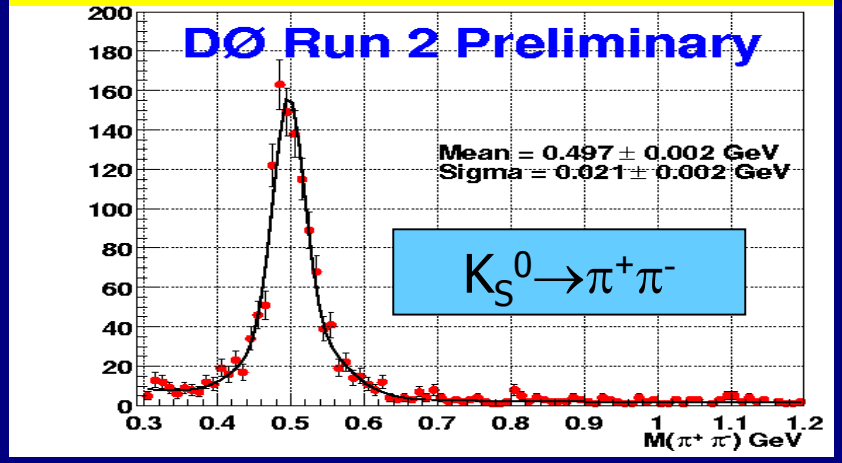
Silicon Microstrip Tracker Status

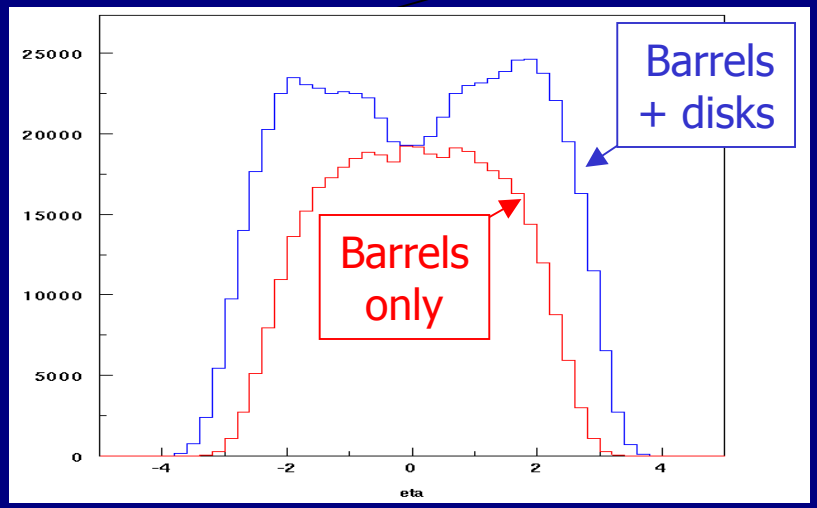


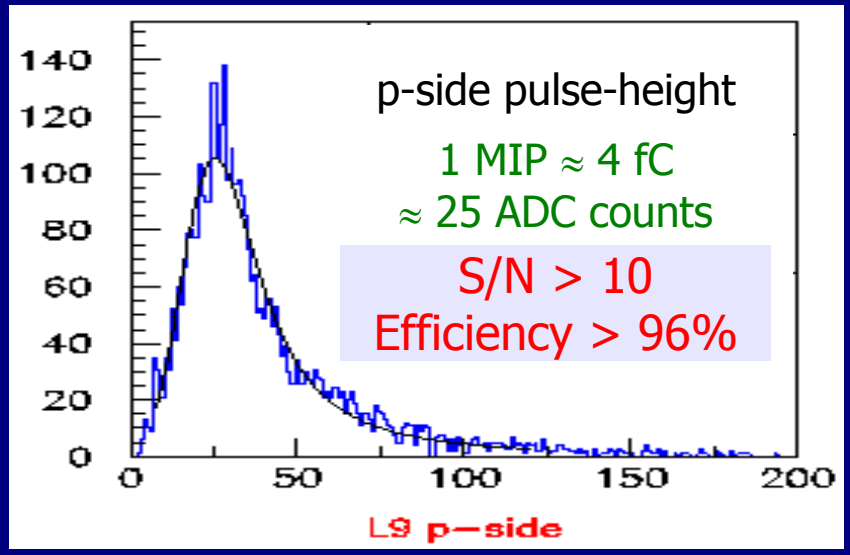
100% commissioned

Barrels: 93% operational
F-disks: 96% operational
H-disks: 89% operational

K^0 signal, silicon standalone tracking

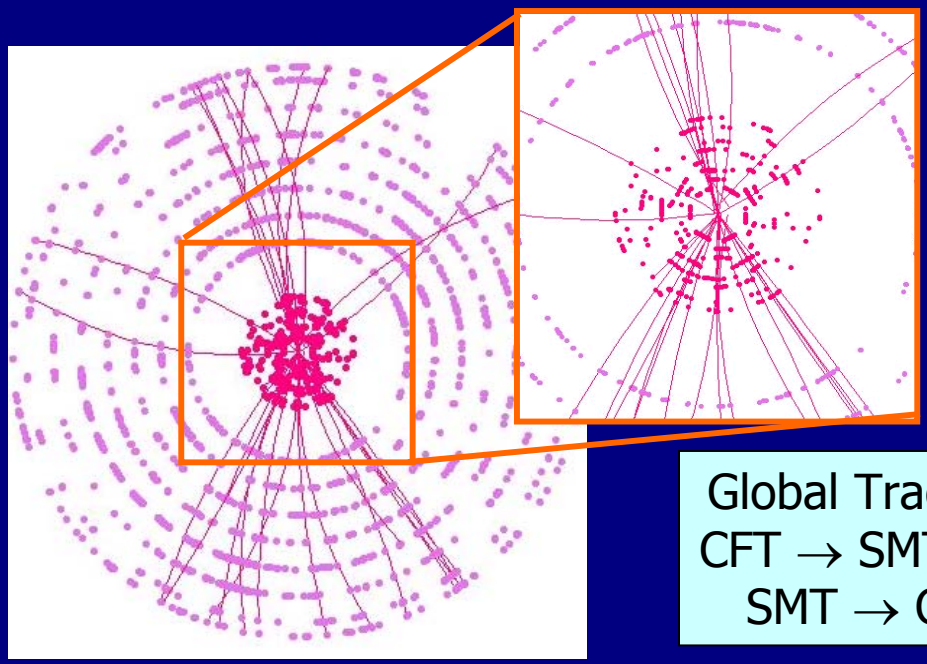




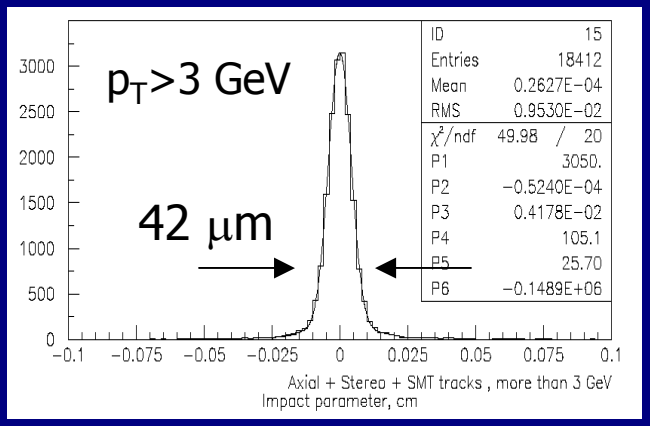


Work in progress:
Integrating disks into tracking

Tracking Status



Global Tracking
CFT → SMT and
SMT → CFT

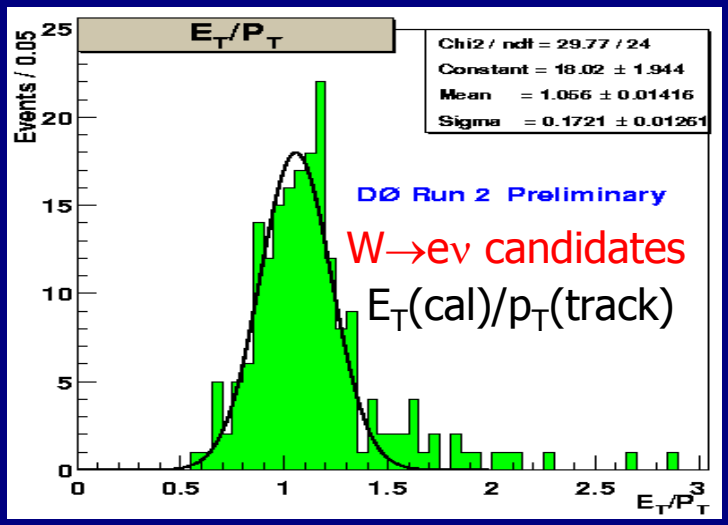


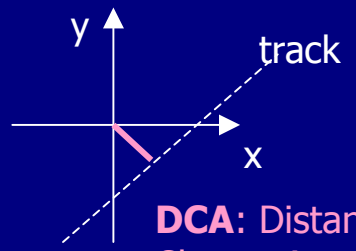
DCA resolution ~ 42 μm (using SMT + axial & stereo fibers)

beam spot ~ 30 μm

Fiber Tracker Electronics

100% installed and working





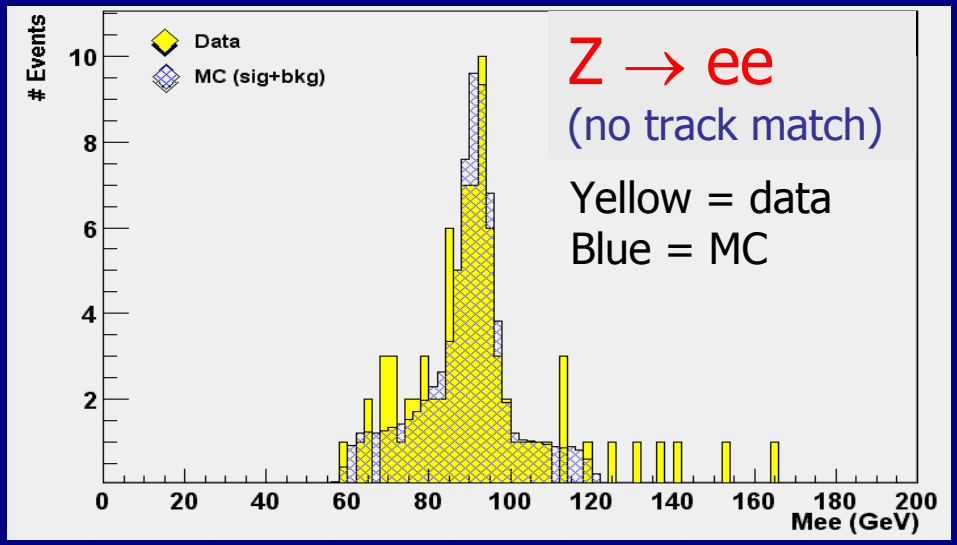
DCA: Distance of Closest Approach

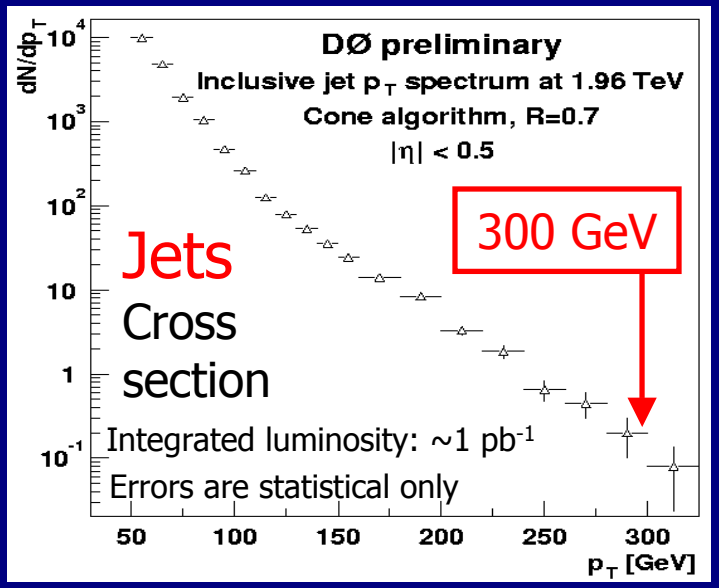
Starting to see impact parameter signal for b-quarks

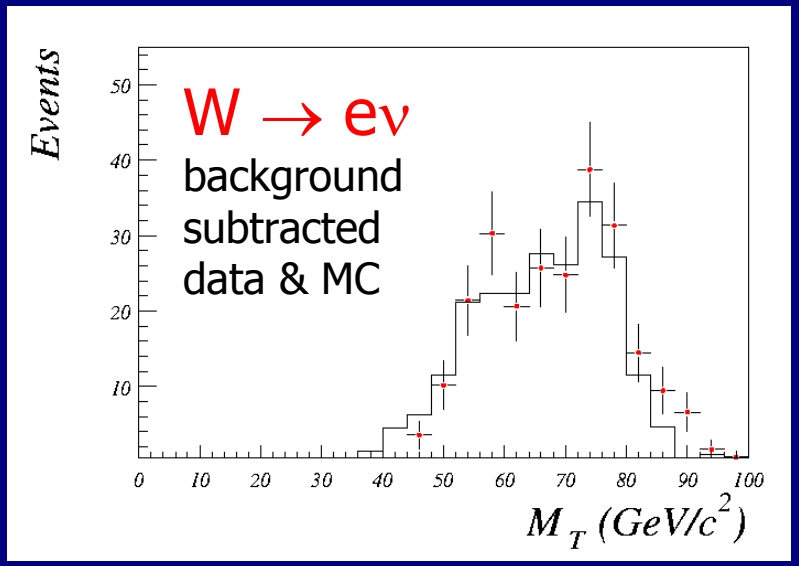
Calorimeter Status

100% commissioned
~55K readout channels
~0.1% dead/noisy

- As in Run 1, the EM energy scale is set by $Z \rightarrow e^+e^-$
  - EM resolution modeled well by Monte Carlo
- Jet E-scale from γ+jet events



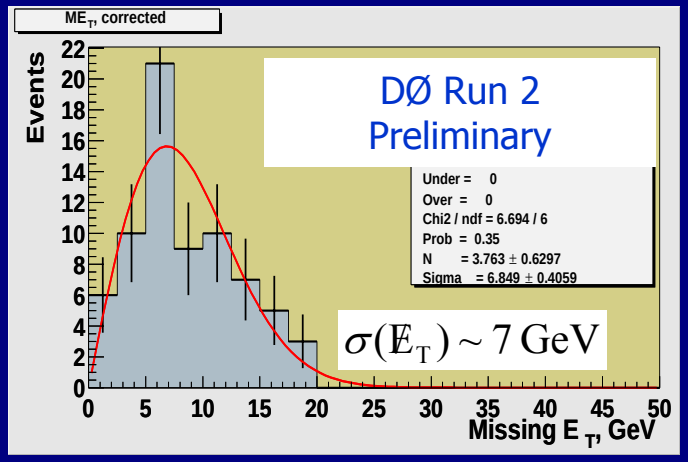




Missing E_T

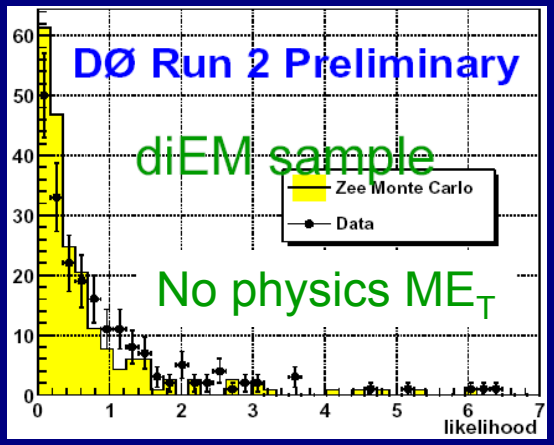
- Determine ME_T resolution from inclusive di-electron sample with at least one track match
  - Mainly Z, Drell-Yan

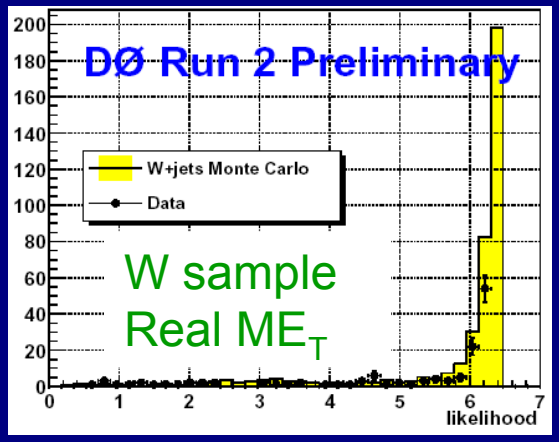
Snapshot of present performance →



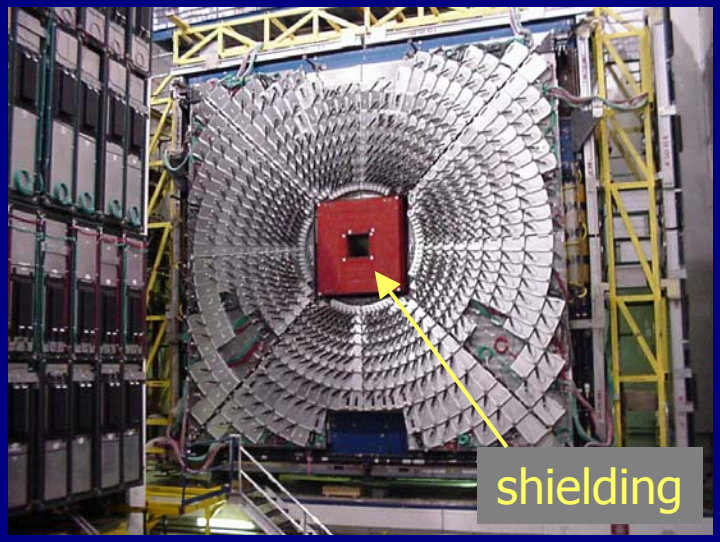
- Use ME_T significance to take into account event topology, found vertices, and known resolutions
  - Low significance – no physics ME_T
  - high significance - ME_T not likely due to mismeasurement

Significance is well described by Monte Carlo
→ *we understand the resolutions*





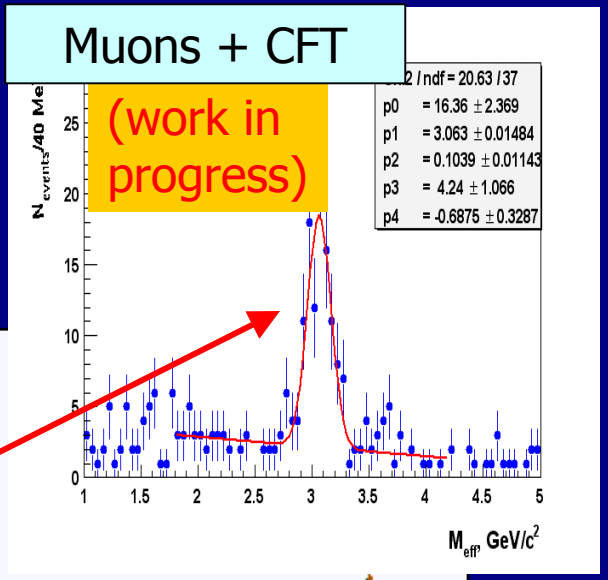
Muon System

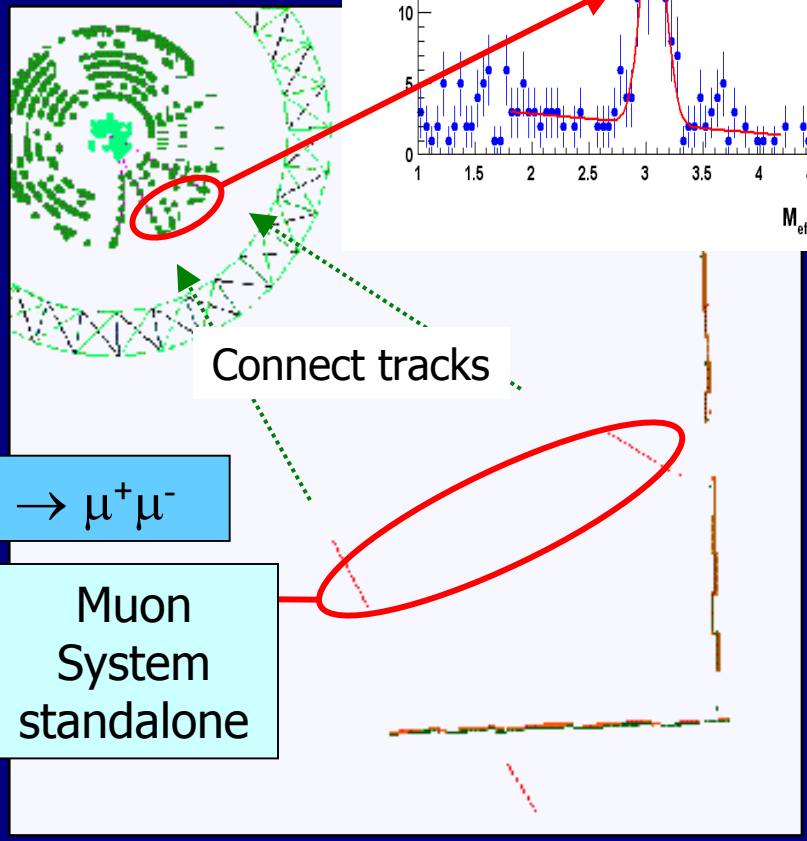


Muon system 100% commissioned

Muons + CFT

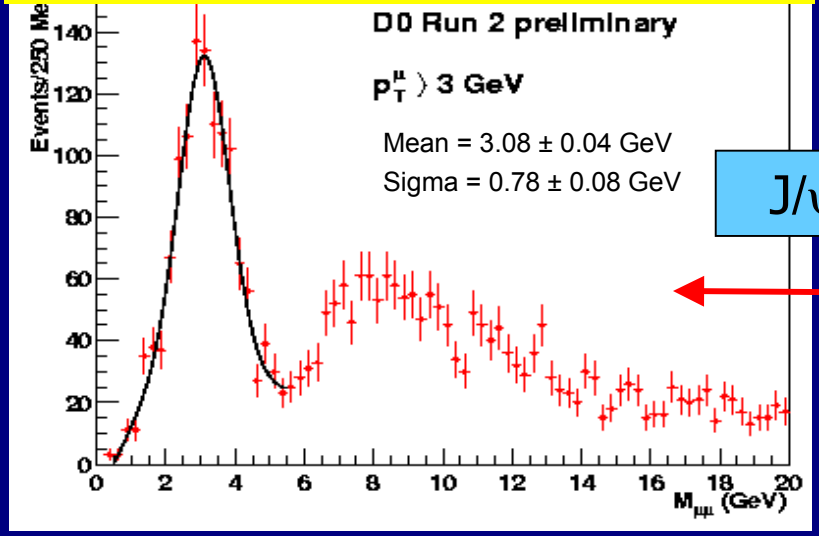
(work in progress)





Connect tracks

J/ψ signal, central + fwd μ triggers



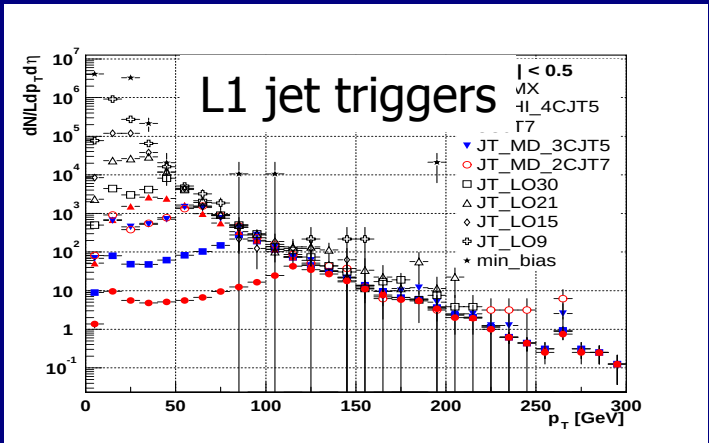
$J/\psi \rightarrow \mu^+\mu^-$

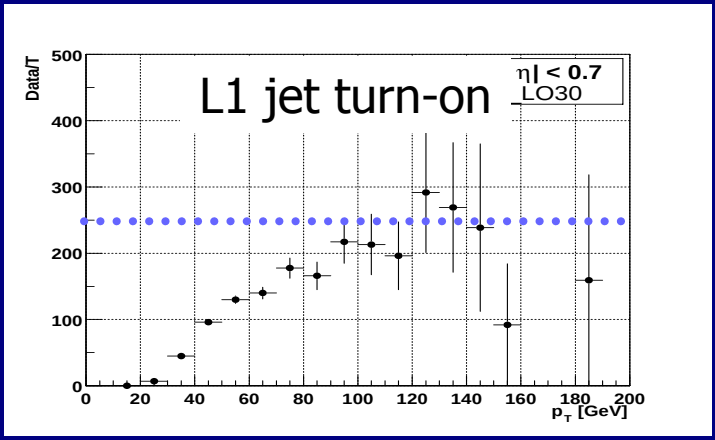
Muon System standalone

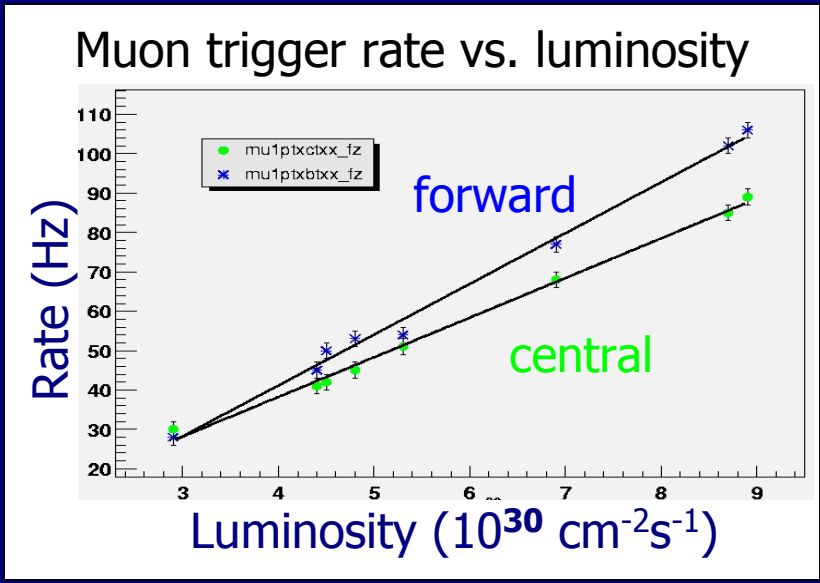
Trigger systems

One area where there is still work to be done

- Level 1
  - Calorimeter and muon system triggers working very well





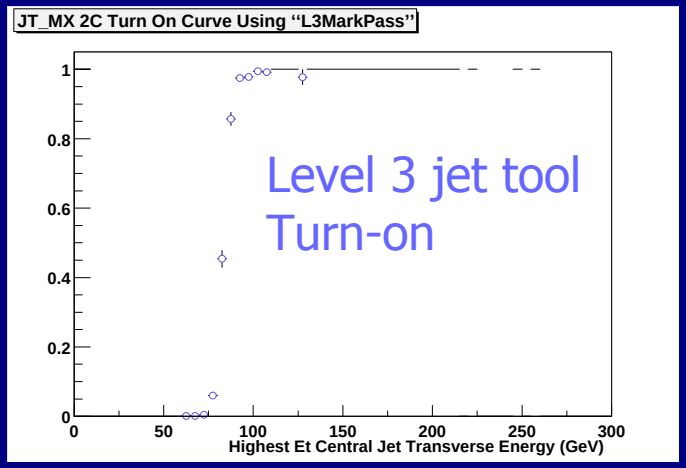


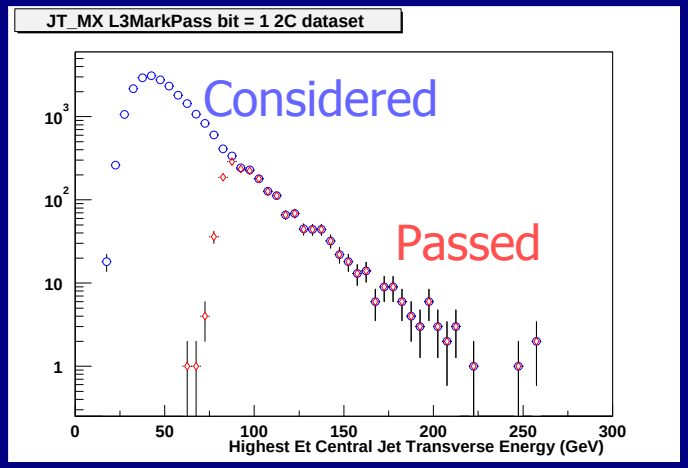
Level 1 central track trigger coming (first sector by May 1?)

Evolution of our trigger matches laboratory's 2002 luminosity plan

- Level 2
  - Ready to go, muon algorithms demonstrated, start rejecting next Monday
  - Silicon trigger coming as scheduled this summer (funded through NSF MRI)
- DAQ
  - Technical problems with baseline implementation led to decision to move to an ethernet based system
    - uses single-board computers in VME crates and Cisco switches
  - Strong team, good progress
    - excellent role played by Fermilab Computing Division
  - Adiabatic upgrade path with full system in place this summer
- Level 3
  - 48-node Linux level 3 farm installed, working and selecting events:

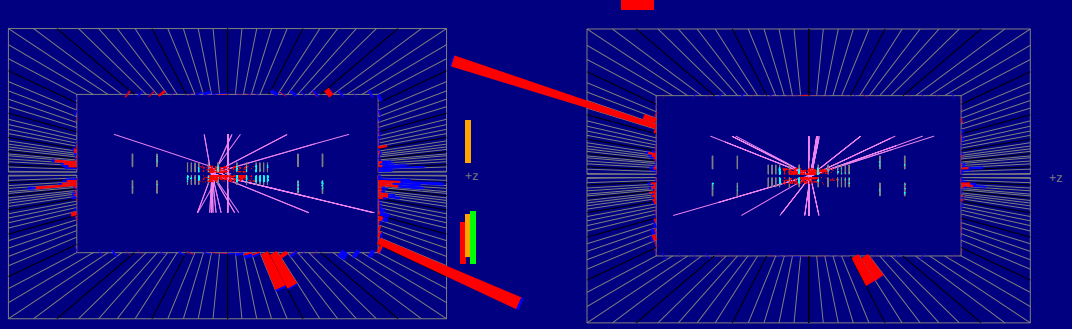
switched to new software at end of March

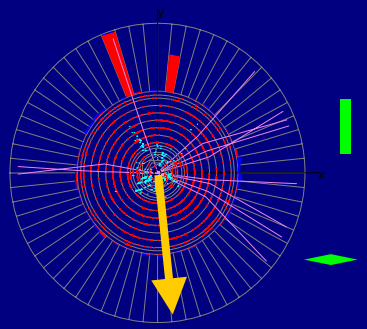




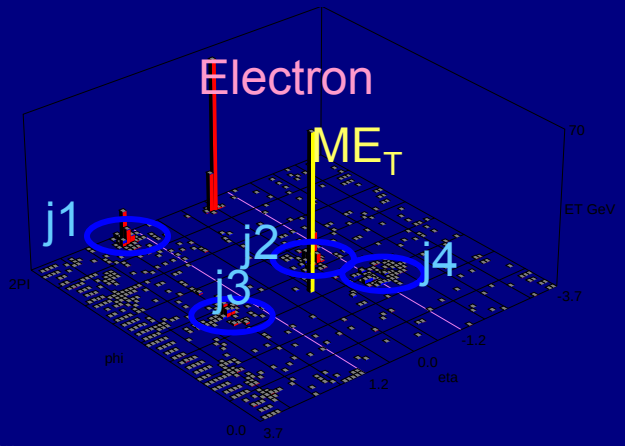
Physics analysis is starting

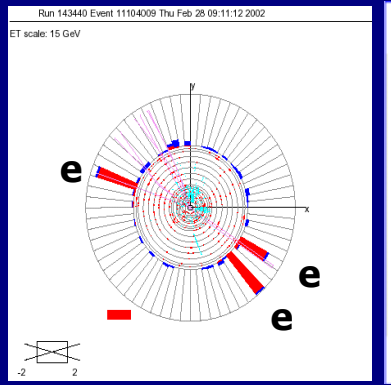
- Physics and object ID groups are very active
  - First two Run 2 PhD's with theses based on data
- Interesting events being collected, point to our future physics direction
  - $\gamma\gamma$+ME_T candidate
  - extra dimensions (ee+$\gamma\gamma$)
  - Wγ candidate





  - W+4jets candidates
  - trilepton candidates (SUSY)






Fermilab
Michigan St.
Michigan
Indiana
Boston
Kansas
Oklahoma
Arizona
Texas
La. Tech
SAM data transfer
Monte Carlo files
Lancaster
Imperial
NIKHEF
Lyon
Prague
Wuppertal
Munich
DØ worldwide data grid status March 2002
6 remote Monte Carlo generation sites + more coming
16 SAM stations for remote analysis + more coming

Upgrades

- The present detector was designed for ~ 2fb^{-1} and 2 $\times$ 10^{32} cm^{-2} s^{-1}
- The Director has set the goal of accumulating ~15 fb^{-1} before LHC physics
  - Physics motivation: Higgs and Supersymmetry
  - Exceeds radiation tolerance of existing silicon detector
  - Requires higher luminosities, ~ 5 $\times$ 10^{32} cm^{-2} s^{-1}, trigger upgrades

Replace Silicon Detector with a more radiation-hard version

Improve impact-parameter resolution (b-tagging)

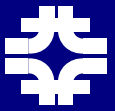
Maintain good pattern recognition
Cover $|\eta| < 2$

Upgrade Trigger

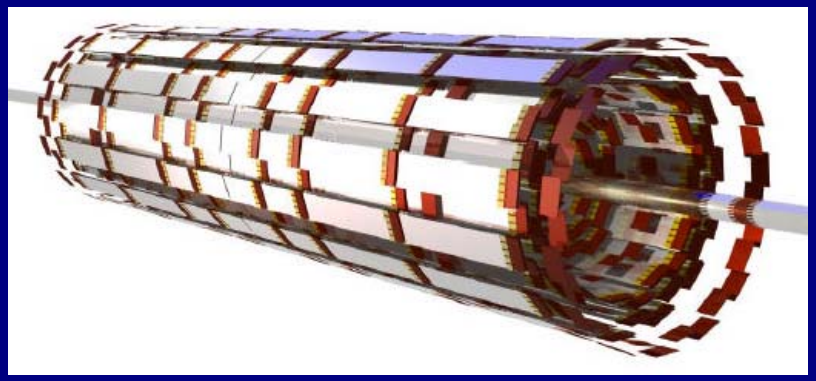
Shift functionality upstream and increase overall Level 1 trigger capability – contain rates, dead time

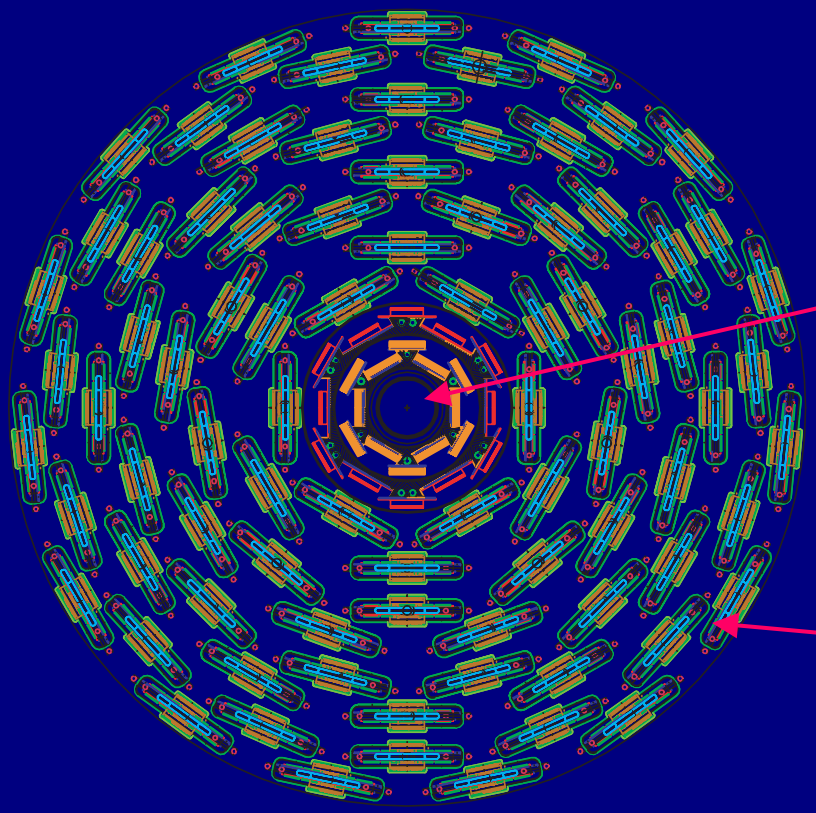
- Calorimeter clustering & digital filtering
- Enhance track trigger to respond to increased occupancies
- Calorimeter cluster match with track

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

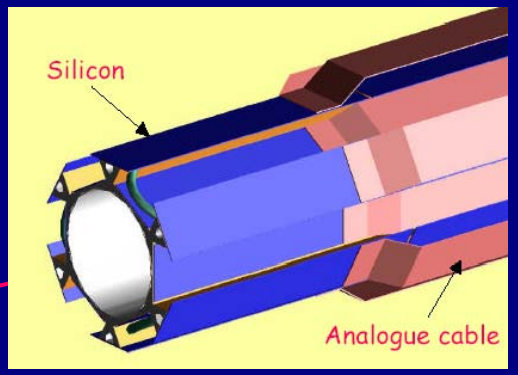


Silicon Detector

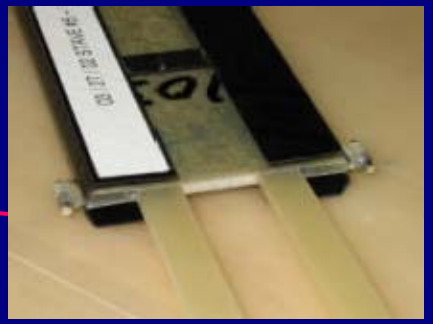




- Single sided silicon, barrels only
- Detector installed in two halves inside collision hall in ~7 month shutdown
- Inner (vertexing) layers L0, L1
  - Axial only
  - mounted on carbon support

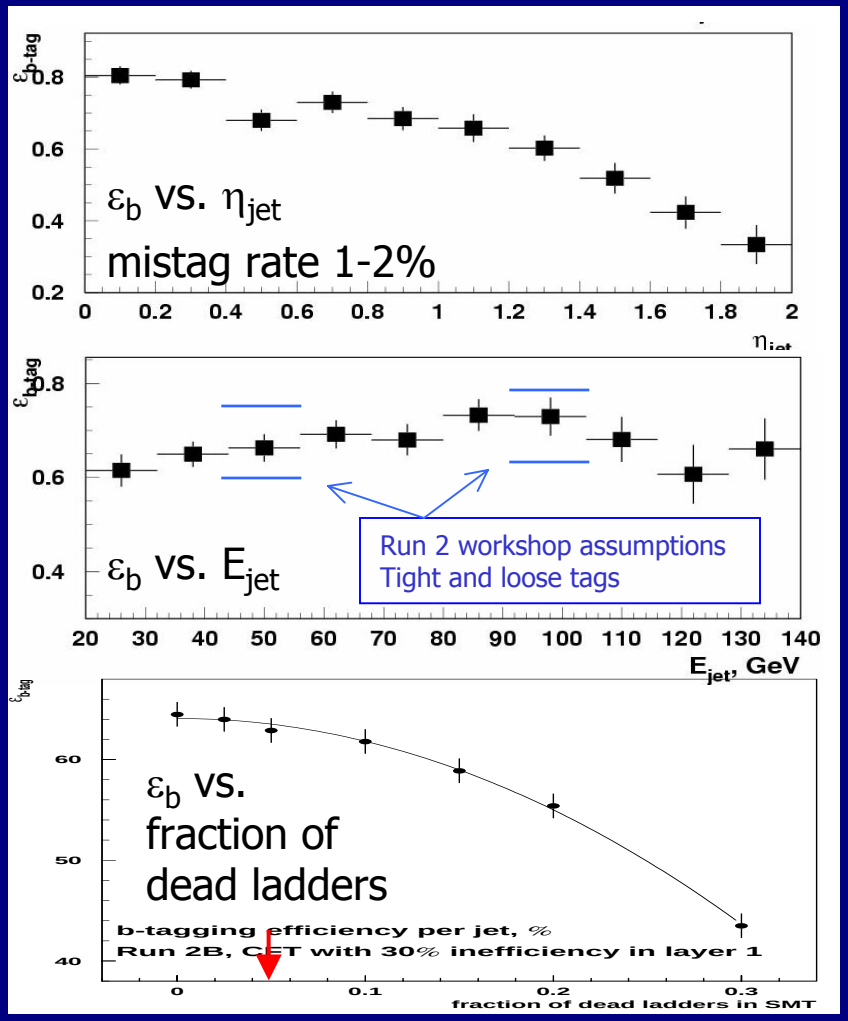


- Outer (tracking) layers L2-L5
  - Axial and stereo (tilted sensors)
  - Stave structures



Silicon Performance

Performance studied with full GEANT simulation and pattern recognition



Possible scope reductions investigated using efficiency for WH $\rightarrow l\nu bb$ as metric

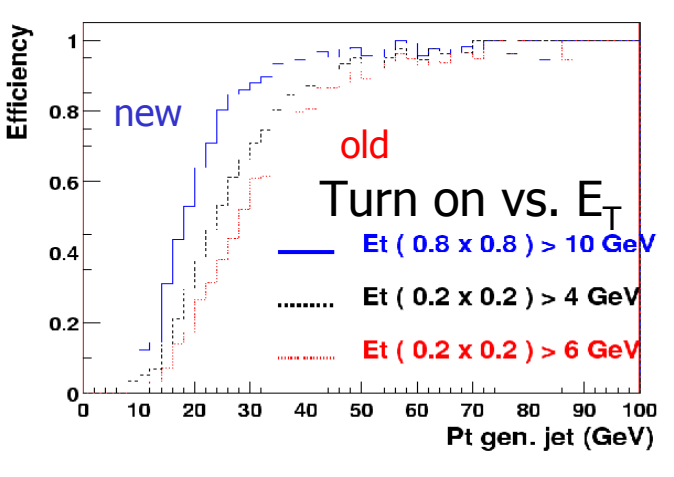
Change	Loss in luminosity relative to baseline
Omit layer 1	24% (no inefficiencies) 44% (realistic efficiency)
Omit Layer 4 Doubles number of poor quality tracks	12% (no inefficiencies) 14% (realistic efficiency) 38% (silicon standalone) needed for $\|\eta\|>1.6$
Shorten in z	27%

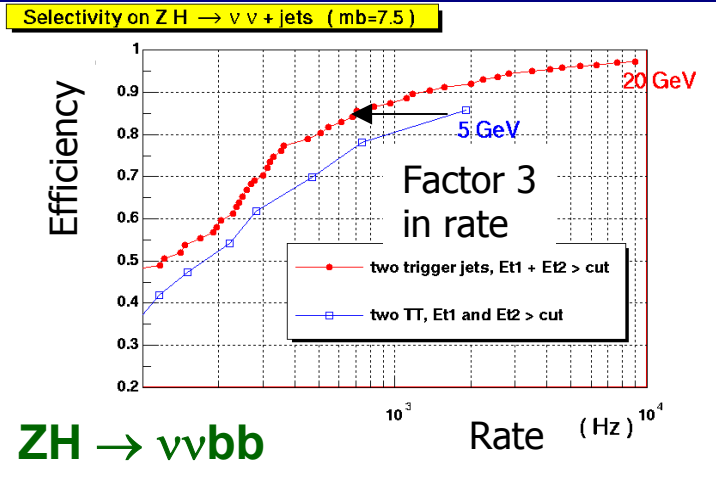
Silicon performance meets our requirements (Run 2 workshops) but would be seriously impacted by any descoping

Trigger upgrades

System	Problems	Solutions
Cal	1) Slow signal rise $\Rightarrow$ trigger on wrong crossing 2) Trig on $\Delta\eta\times\Delta\phi$=0.2×0.2 TTs $\Rightarrow$ poor resolution, slow turn-on	• Digital Filter • Clustering (jets) • Isolation and shape cuts (e/γ)
Track	Rates sensitive to occupancy (i.e. number of min bias events)	• Narrower Track Roads • Improve Cal-Track Match
Muon	No Additional Changes Needed	• Requires Track Trigger

- L1 calorimeter:

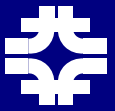




Effect of Level 1 upgrades

Bandwidth limit at level 1 is ~ 5kHz

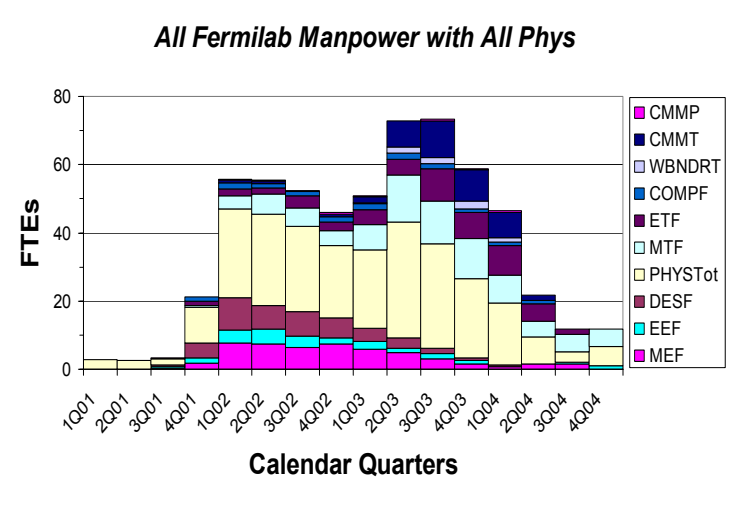
Trigger	Example physics channel	L1 rate (kHz) no upgrade	L1 rate (kHz) with upgrade
EM Trigger 1 trigger tower > 10 GeV	$W \rightarrow e\nu$	9	0.5
Jet Trigger 2 trigger towers > 4 GeV	$ZH \rightarrow \nu\nu bb$	2	0.5
Two Track Trigger 2 isolated tracks > 10, 5 GeV matched with EM energy	$H \rightarrow \tau\tau$	60	0.7
Muon trigger Muon scintillator matched with track > 10 GeV	$W \rightarrow \mu\nu$	6	2



Cost and schedule

- Fully resource-loaded schedule, cost estimate in place
  - Director's cost, schedule and management review April 23-25
  - Detailed, conservative approaches taken throughout
  - Time, other contingencies undergoing special scrutiny
  - Lab guidance being integrated as project develops

Example of the level of detail:

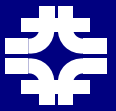


Total M&S cost = $16.3M (includes 37% contingency)
Total project cost ~ $30M
including non-DOE funds, labor, overhead, escalation, etc.

Project Status

- Run 2b upgrade has matured into a solid, well-defined project
  - Scope carefully crafted to Run 2b physics goals
  - Silicon design very advanced, TDR written, R&D underway
  - Trigger needs well established, TDR written, technical designs being aggressively pursued
  - Project management in place, lead individuals identified, major institutional assignments made
  - Strong personnel/groups in place at all levels
- Director's Technical Review in December
- Fermilab PAC meeting in April 2002
  - Endorsed both the silicon and trigger upgrades as "essential"

- NSF MRI award ($2.4M) for silicon in July 2001 (thanks!)
- NSF MRI proposal ($2.6M) for trigger submitted in January 2002
- We are looking forward to obtaining necessary approval for construction funds at DOE Baselining Review this summer



Outlook

- Great progress with installation, integration, commissioning of the detector and understanding the data
  - Fiber tracker electronics and new DAQ system have made great strides
- Preliminary results are very encouraging and indicate that the DØ detector will be able to fully exploit the rich physics opportunities of Run 2
  - We are reconstructing electrons, muons, jets, missing E_T, J/ψ, W's and Z's
  - We know what needs to be done and we are working very hard to
    - commission the remaining detector elements and optimize detector, trigger and DAQ performance
    - understand calibration and alignment
    - improve selection and reconstruction procedures
    - obtain approval and start construction of the upgrades

We are on the road to exciting physics