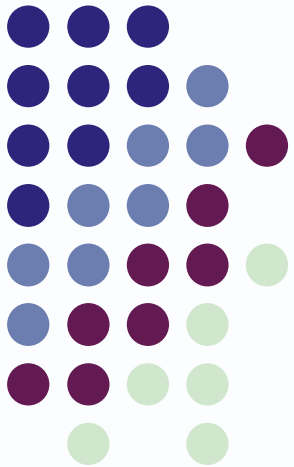
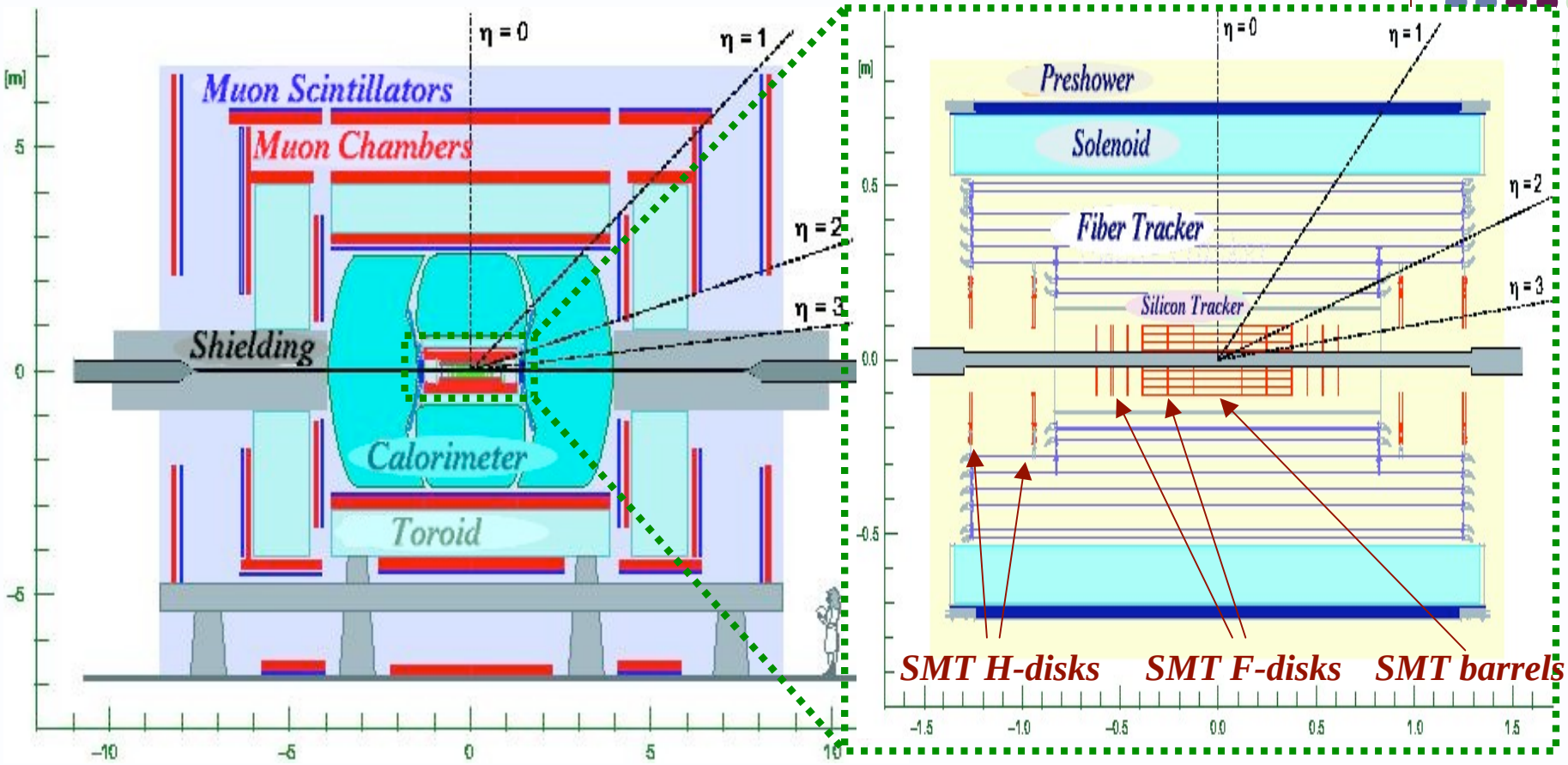
# DØ Trigger Matters

Rick Jesik
Imperial College London

IoP HEPP Group meeting:
"Tevatron for LHC"
31/1/07



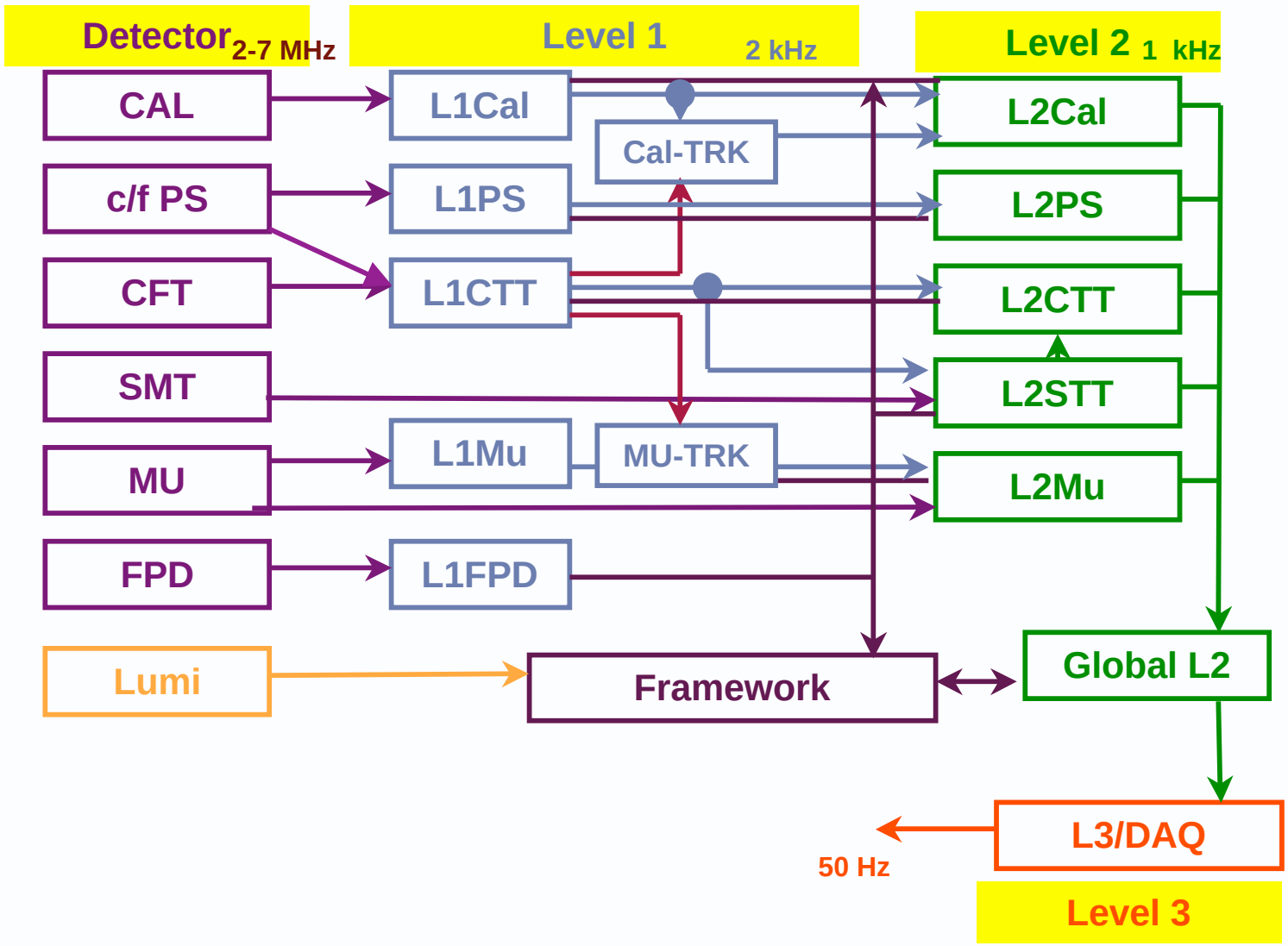
# The DØ RunII detector




- Muon system with good coverage |η|<2 and excellent shielding

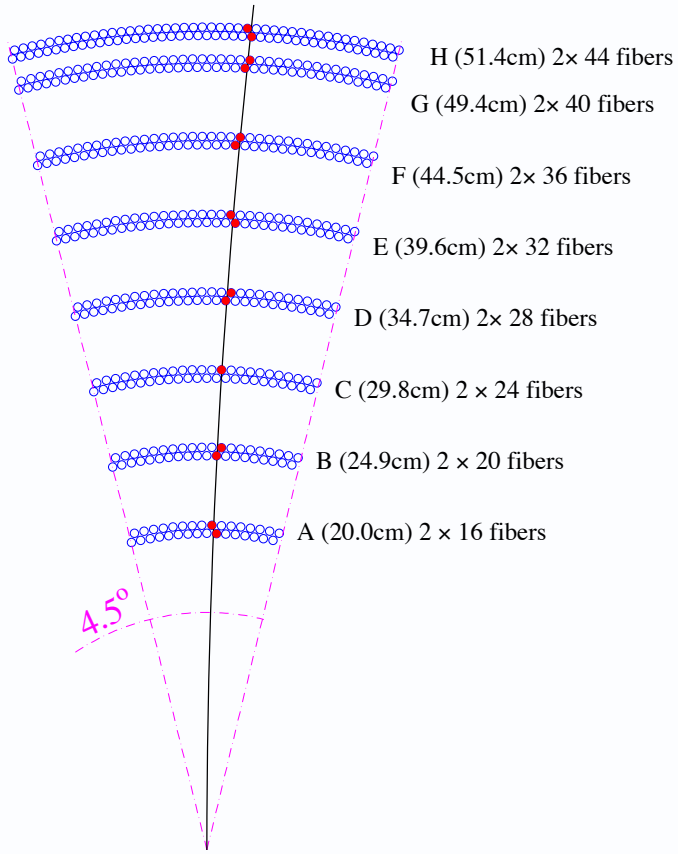
- Excellent tracking coverage
  - Silicon Tracker: |η|<3
  - Fiber Tracker: |η|<1.6

# The DØ RunIIb trigger



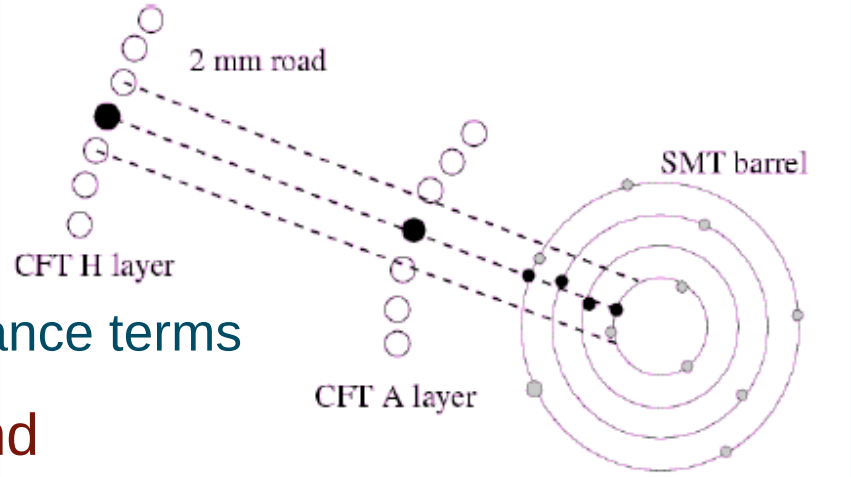
# Level 1 trigger system

- Central Track Trigger (CTT) uses axial layers of the Central Fiber Tracker
  - provides track terms in 4 pT bins, isolation terms, and sends track lists to L1 cal and L1 muon
- Calorimeter
  - course 0.2 x 0.2 eta-phi towers
  - Cal-CTT match (L1 tau trigger now!)
- Muon
  - Scintillator and wire hits
  - Muon-CTT match
- No silicon
- Pass rate of 2 kHz set by silicon digitization (no extra event buffer) and muon readout (5% busy)



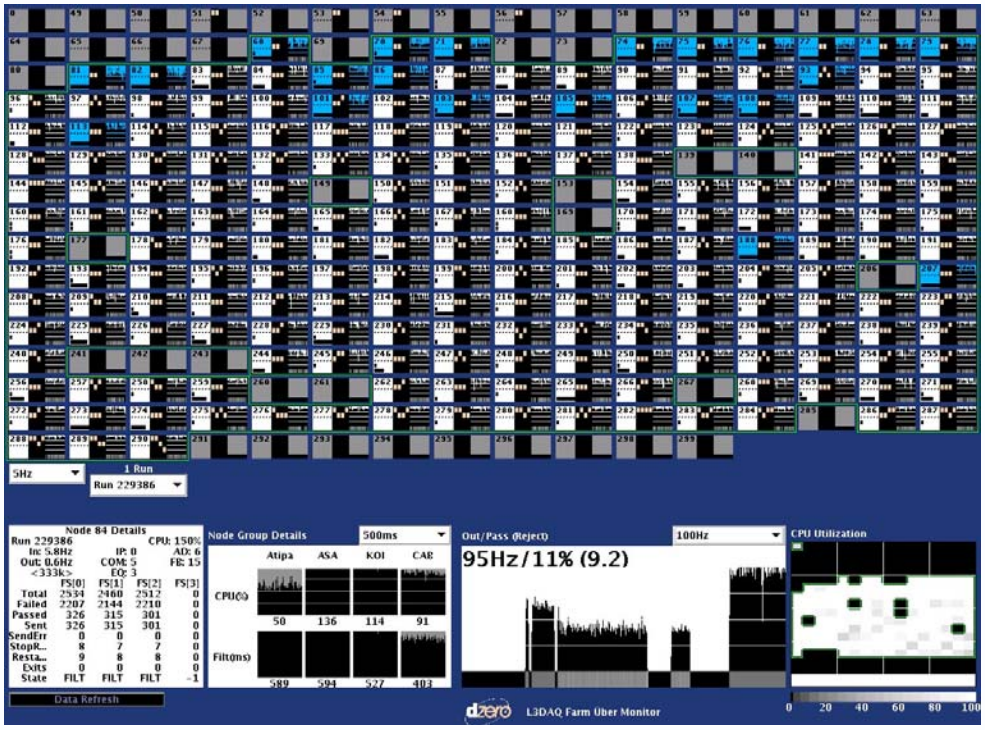
# Level 2 trigger system

- Silicon track trigger
  - Better track pT resolution
  - Primary vertex finding
  - Track impact parameter significance terms
- L1 Muon and Calorimeter (jet and electron) objects are refined
- Global variables allowing combinations of objects
- Must provide at least a factor of 2 rejection to get to output rate limit of 1 kHz, set by precision calorimeter readout and level 3 cpu considerations



# Level 3 trigger system

- Software triggers run on Linux pc farm - 200 nodes now, additional nodes arriving soon
- Provides fast reconstruction of the event - all physics objects
  - Muons,
  - Electrons,
  - Jets,
  - Tracks,
  - Taus,
  - MET,
  - Isolation,
  - Vertexing,
  - B-tagging,
  - Isolation,
  - Invariant mass,
  - And any combination of the above

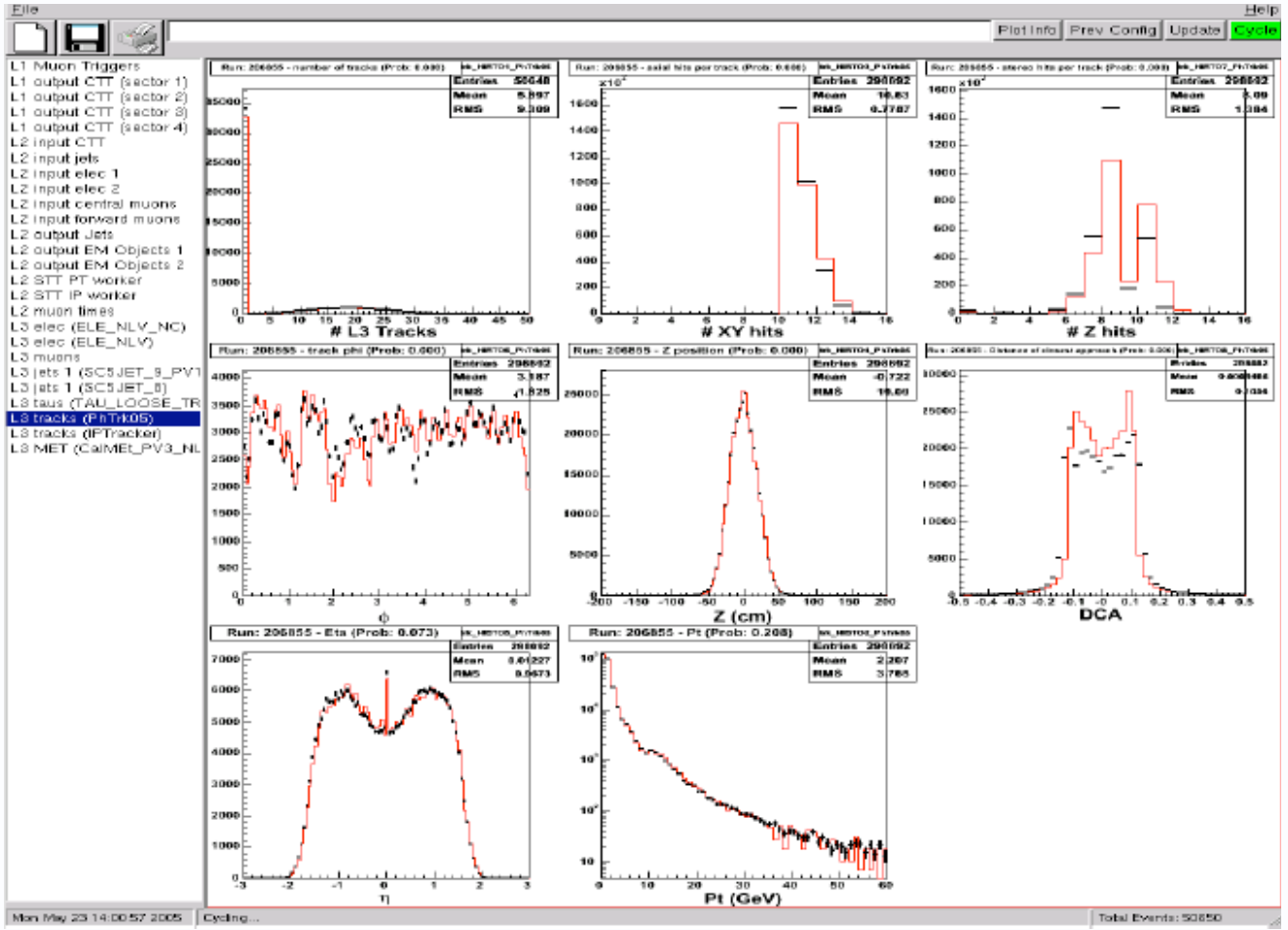


# Rate to tape speed limit

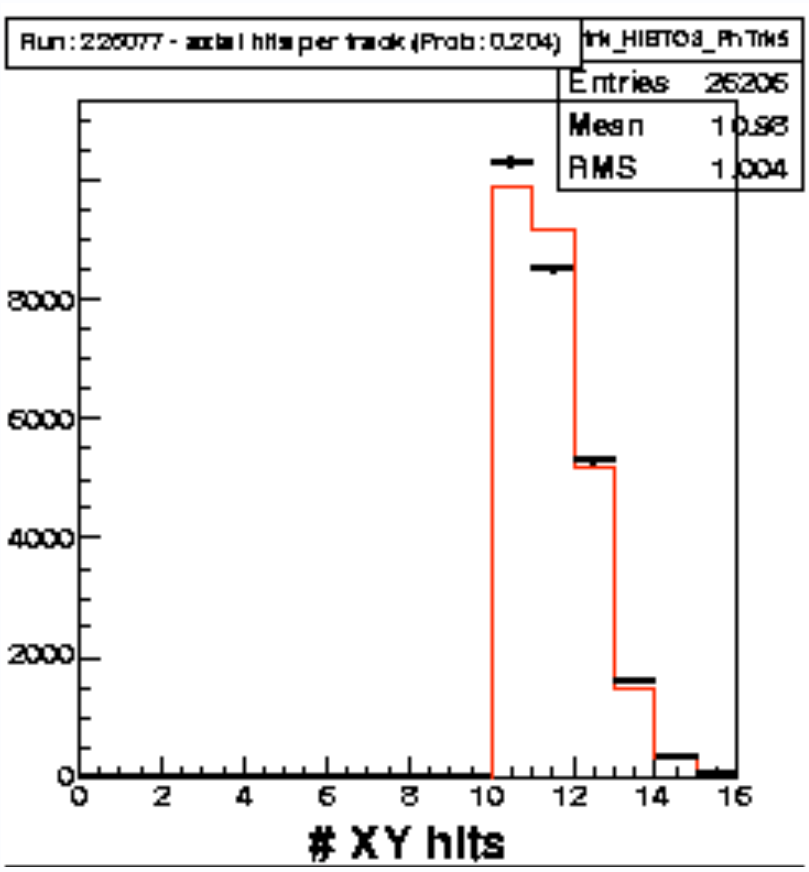
- The DØ data acquisition system could write as much as 200-300 Hz to tape (depending on event size).
- We have, however, decided to limit our rate to tape to an average of 50 Hz
  - Tape cost
  - Offline reconstruction speed - we want to be able to look at this data in a reasonable amount of time.
  - Reprocessing time - our reconstruction code is an evolving entity. The more data we take, the more we learn. And we do sometimes make mistakes. Almost all of the 2 $fb^{-1}$ of data we have taken so for has (or will be) reprocessed at least once.
- But speed limits are meant to be broken….

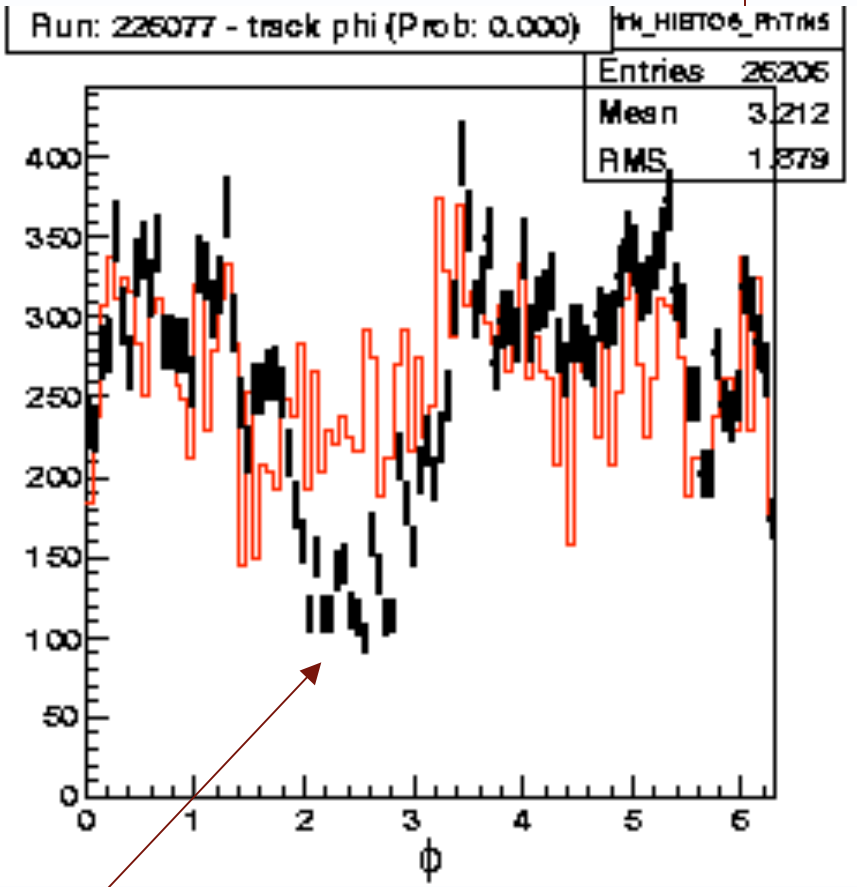
# Trigger examine

- Real time monitoring of trigger object distributions in the control room (and on the web).
  - Histograms are filled extremely fast



# Real time, fast problem diagnosis




silicon readout problems

# Trigger database

- Oracle database - all official trigger lists stored in and built from
  - expert only database entry - quite complex and tedious in general. Recent development has helped with some of this, but sometimes that has bumped up against practical needs.
  - also provides reports and descriptions to non expert physicists

## Trigger List Report

Permanent Link
Trigger List Name input: [ intlname , intlversion ] = [ GLOBAL_CMT , 15.30 ]
**TRIGGER LIST Name/Version= global_CMT / 15.30** , Use_Status= **unused** , Current_Status= **local**
Implementation in: **primary** DAQ system , Configuration Type = **physics** , autopause= **yes** , comics_runtype= **data** , l3_type= **regular** , num_nodes= **0** , Trigger_count= **612** , Link to **RunsDB** using this TriggerList.
Created by Mverzocc on 2007-01-22 14:48:53
Description: **Derived from global_CMT-15.29**
**Triggerlist version number changed to reflect the firmware change done to increase the rate of the Cal_unsuppressed trigger.**

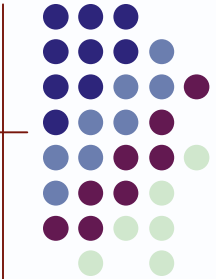
Group 1 | allcrates / 1 | **regular** | **0**

L1 Cal Trigger Tower Programming (L1Dialog): **Config_TAB_algorithms**

| L1 detector Neotypes: (Link to Neoterms) | CFT/CPS cft/2.00 | Calorimeter em/2.00 | Calorimeter iso_em/2.00 | Calorimeter jet/2.00 | Calorimeter miss_et/2.00 | Calorimeter nco/1.00 | Calorimeter tau/2.00 | L1CalTrack ctk/1.00 | Muon mu2b/1.00 | Special (Named) And/Or specterm/2.00 |
|---|---|---|---|---|---|---|---|---|---|---|

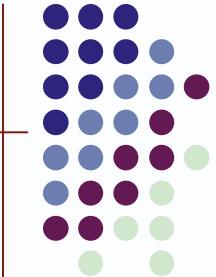
| L2 filters: | none | emcalib | calcalib | MUON | RANDOMPASS | TRACK | TRACK | TRACK | TRACK | TRACK | TRACK | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TRACK | TRACK | EM | EM | EM | EM | EM | ETA | TRACK | EM | ETA | TRACK | EM | ETA | TRACK | EM | ETA |
| | TRACK | EM | ETA | TRACK | EM | ETA | TRACK | EM | ETA | TRACK | EM | ETA | TRACK | EM | ETA | TRACK | EM | |
| | EM | ETA | TRACK | EM | ETA | TRACK | EM | JET | ETA | EM | ETA | TRACK | EM | ETA | TRACK | EM | ETA | |
| | TAU | PHISEP | TAU | ETA | PHISEP | TAU | ETA | PHISEP | ETA | TRACK | EM | MUON | TRACK | MUON | MUON | | | |
| | MUON | ETAPHISEP | MUON | ETA | EM | EM | ETA | TRACK | EM | JET | JET | JET | TRACK | ETA | TAU | | | |
| | PHISEP | TAU | ETA | PHISEP | TAU | ETA | PHISEP | ETA | HT | JET | ETA | MJT | PHISEP | JET | HT | Spher | | |
| | JET | ETA | ETA | JET | HT | MJT | ETA | JET | MJT | PHISEP | PHISEP | TAU | ETA | PHISEP | ETA | | | |
| | PHISEP | ETA | ETA | TAU | ETA | TAU | PHISEP | ETA | ETA | ETA | ETA | JET | INVMASS | JET | ETA | TAU | | |
| | JET | INVMASS | INVMASS | INVMASS | TRACK | TRACK | TRACK | | | | | | | | | | | |

# DØ trigger management



- Trigger Board - all decisions regarding triggers are made by this body which meets every week.
  - Trigger Board Chair (makes final decisions in case of disputes)
  - 2 Trigger Meisters who provide 24 hr operational support and implement triggers and prescale sets.
  - Each physics group provides a representative
  - Spokespersons, run coordinators, trigger algorithm leaders, and “at large” members also participate.
  - Its not easy to satisfy everyone and these are some of the most heated meetings we have, but this setup has worked fairly well for us.
- Trigger Studies Group - also meets every week.
  - Provides forum for more technical discussions, common tools, and object based efficiency calculations across physics groups (helps avoid duplicate work)

# Trigger list design

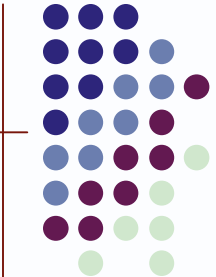


- Complex problem balancing various physics needs with rate limits and available cpu power, hardware upgrades, and algorithm development
- Constant process keeping up with the accelerator - rate limits remain the same, but the instantaneous luminosity increases
- Design tools
  - TrigSim - full blown (up) trigger simulator - expert use only
  - Trigger Rate Tool - rate predictions based on data
    - Works great except for non-linearities
- Recent development time on the order of a year and resulting trigger list is often obsolete by the time it is perfected.
  - The present trigger list (v15) was initially designed to work up to luminosities of 200E30. The final L1/L2 suite has just now been implemented and the L3 suite is still being optimized - we are regularly getting stores starting around 250E30

# Trigger list evolution

- That's right, we are on our 15th major trigger list revision
  - Well to be fair, we started taking physics data with version 8
- To make matters worse, there are 10 to 20 minor changes to each, along with several prescale set changes.
- In the pursuit of increased efficiency and redundancy, our trigger lists are quite complex - some say out of control
  - Present list has 612 triggers, about half of which are single electron triggers
    - All possible combinations of pT thresholds (hi, med, low) track matches, preshower reqs, isolation, shower shape, etc.
- Trigger efficiency calculations are, needless to say, quite complex. In practice only a trigger few combinations have been used for physics analyses so far.

# Present trigger strategy



- At high instantaneous luminosities, high pT triggers dominate with a few B physics triggers running which are very tight (muon + tracks with significant impact parameters), as the luminosity decreases, the looser B physics triggers are turned on and they dominate the available bandwidth to tape.

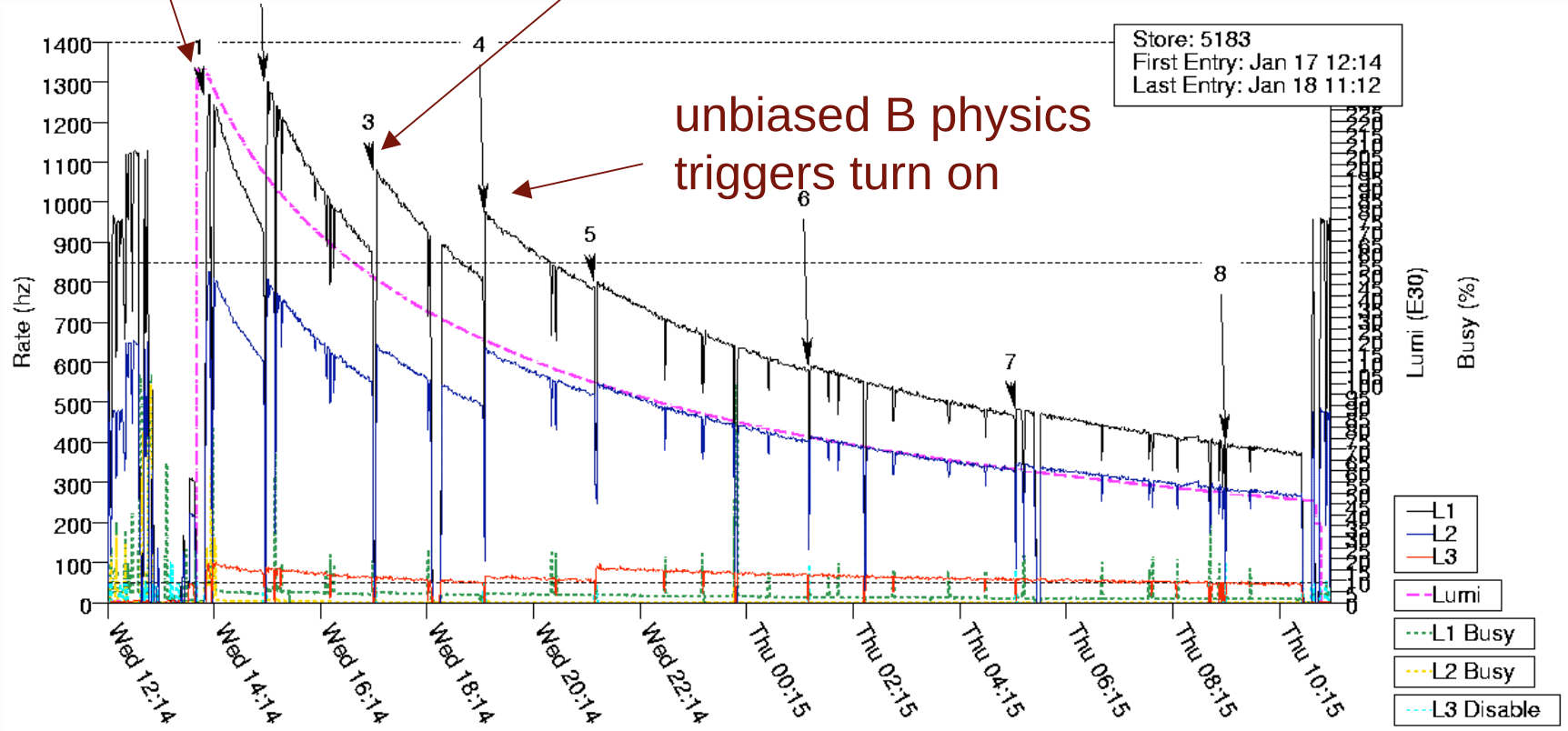
- We presently can not run the L3 tracking down to a pT threshold of 0.5 GeV due to L3 cpu consumption at the very highest luminosity (above 200E30) and the single muon triggers with pT thresholds of 5 GeV start to explode at L1 at luminosities above 250E30, so these triggers are highly prescaled here.

# A recent store

Highest priority
high pT triggers only

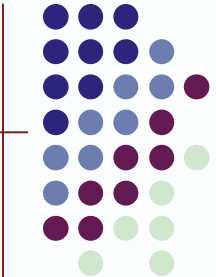
L3 track pT threshold
lowers to 0.5 GeV

unbiased B physics
triggers turn on




Try not to ruin your triggers just so they run in the first hour of the store, but…

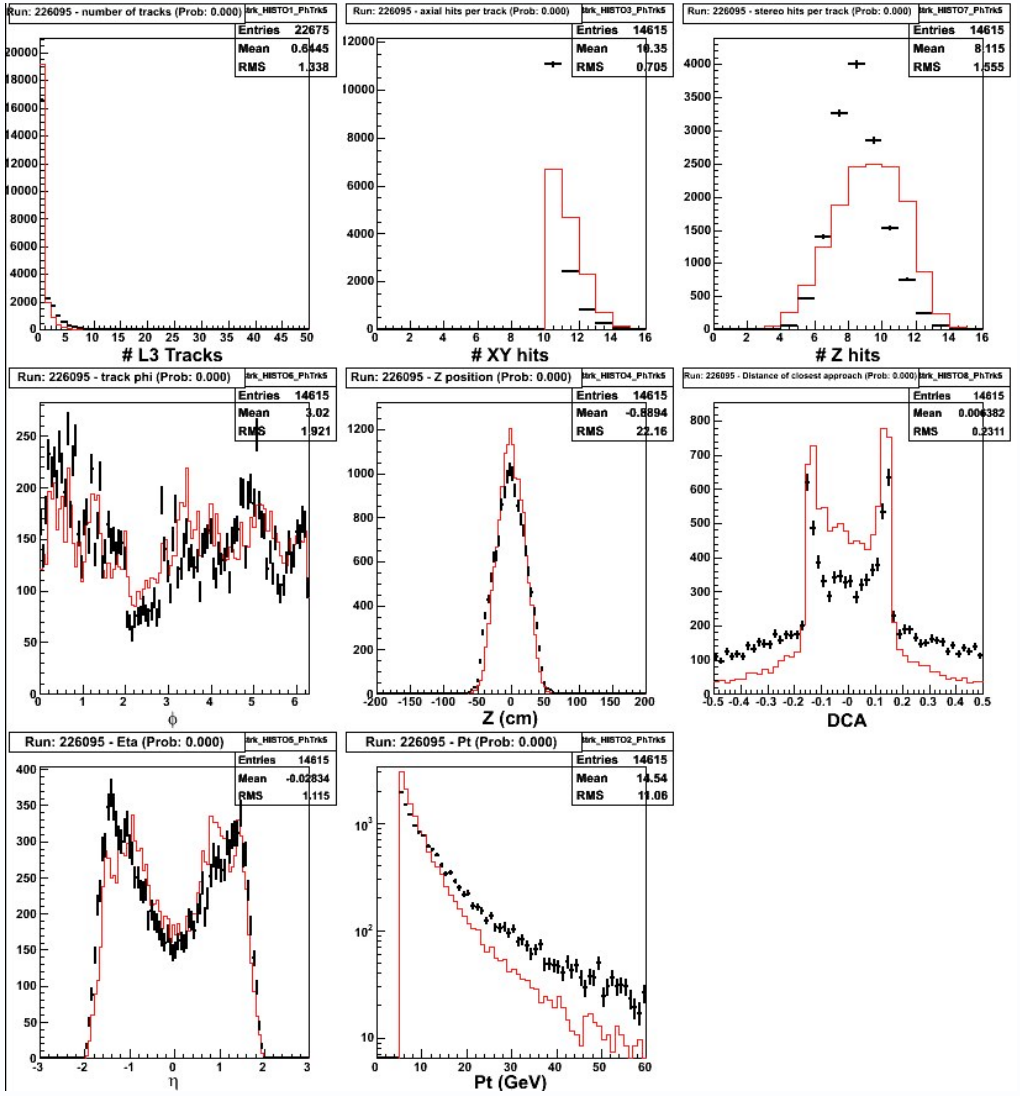
# The luminosity dilemma



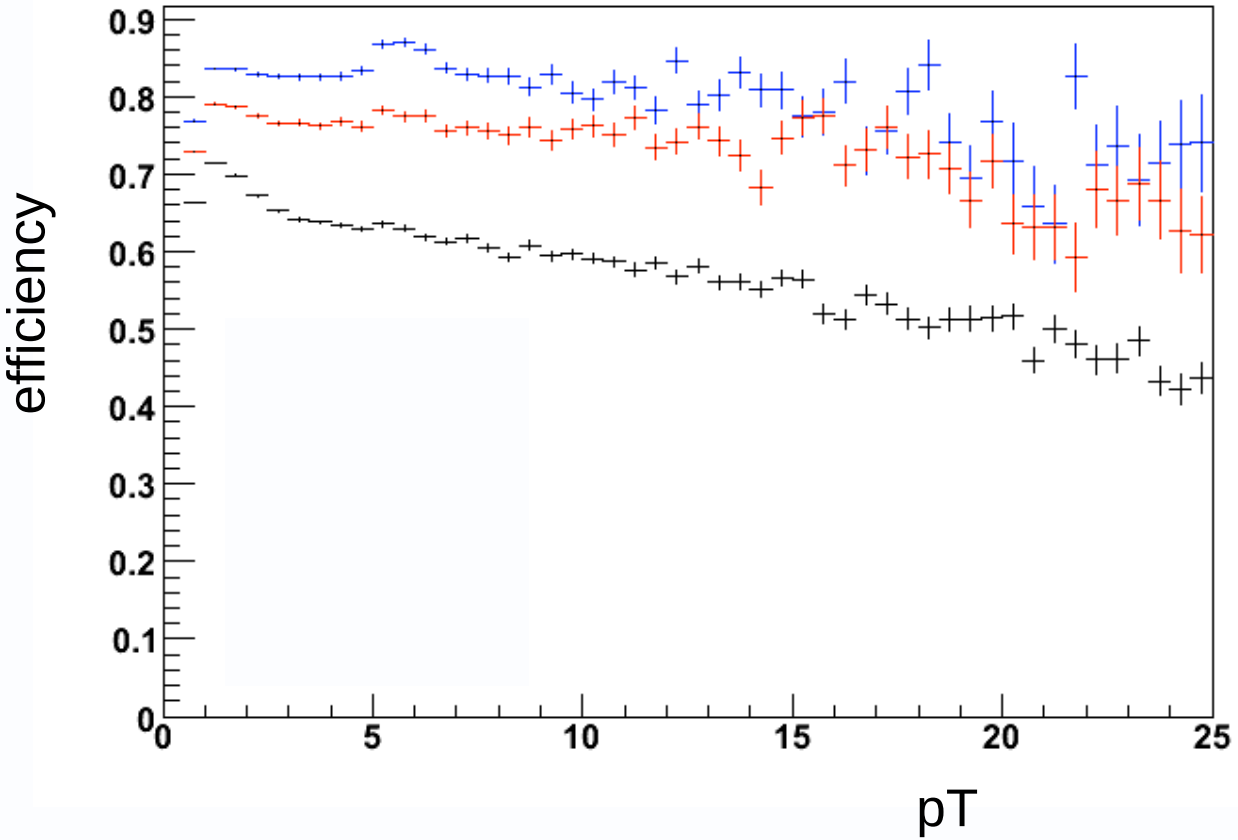
- …. the first hour of today's store is the medium luminosity operation point of next year

- We need high instantaneous luminosity to find the Higgs, etc., but we are reaching the limits of our abilities to trigger effectively
  - L1 track triggers are expected to saturate and fire for every event at 300E30, that's a loss of a factor of 5 rejection.
  - Single muon and electron rates go through the roof
    - Occupancy veto's are under investigation

# L3 tracking distributions at 200E30

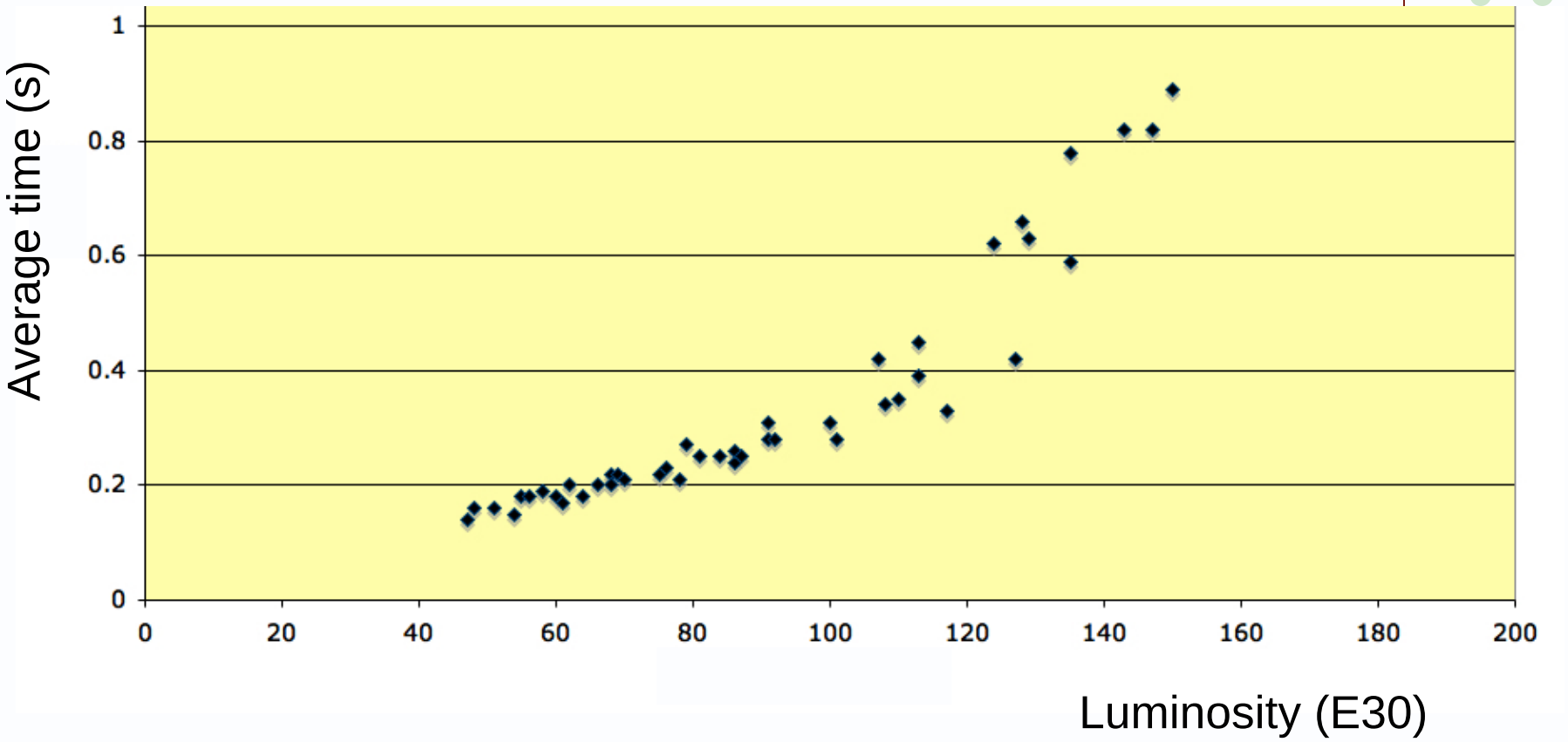


# L3 tracking efficiency vs. lumi



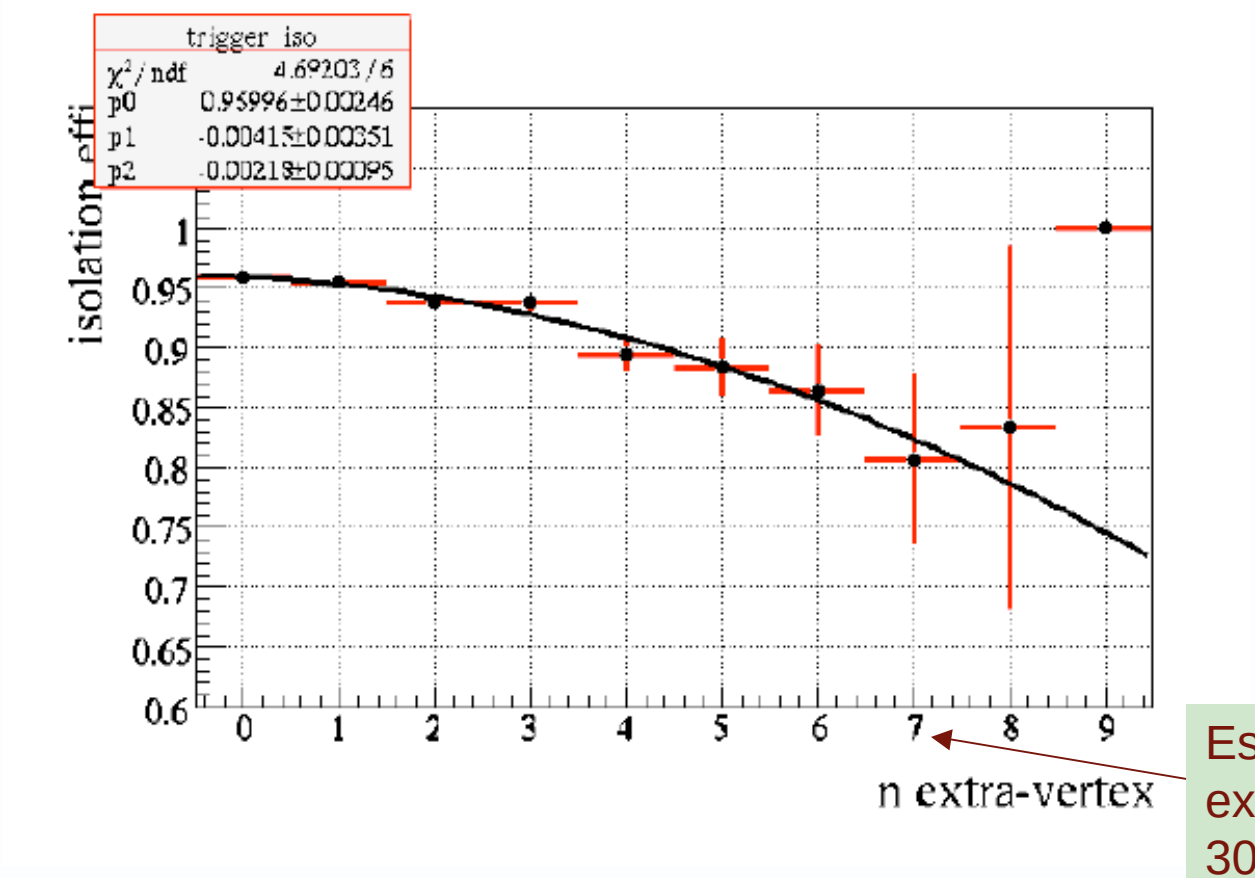

- 60E30, ε = 80%
- 90E30, ε = 75%
- 150E30, ε = 67%

# Time taken by L3 tracking is going, going, ….




Even with a factor of 3 speed up over the previous version

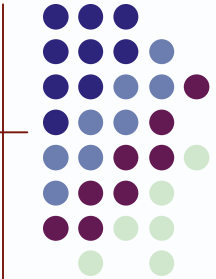
# L3 isolation at hi luminosity




Estimated number of extra vertices at 300E30

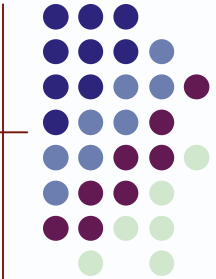
- Isolation requirements also have problems at very high luminosity

# New trigger strategy



- New trigger list design has begun - aimed to run at a luminosity of 400E30, which we have seen is highly problematic
  - To maintain efficiency for Higgs and new phenomena triggers, sacrifices to basic physics program during hi luminosity running will have to be made
    - B physics, precision electroweak, even low deltaM searches will suffer, if stores do not last long enough
  - Occupancy cuts will have to be implemented
  - Luminosity leveling is being discussed with the accelerator experts

# Conclusions



- Triggering in high energy hadronic collisions is a difficult, challenging, never-ending, thankless task
- But, it is one of the most important tasks in getting at the physics
  - It's a dirty job, but someone has to do it
- We are learning a lot at the Tevatron and are excited about transferring our knowledge and experience to the LHC.