



CDF Current Status and Future Prospects

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Fermilab

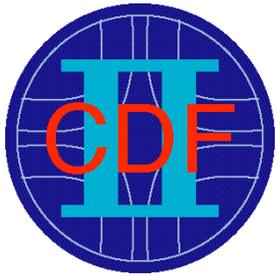
DOE review, May 2006



A story I learned in graduate school ...

- Long ago, a famous young HEP theoretical physicist kept having trouble finding a date for a long time ...
- He then complained about it to Hans Bethe
- Hans's advice:

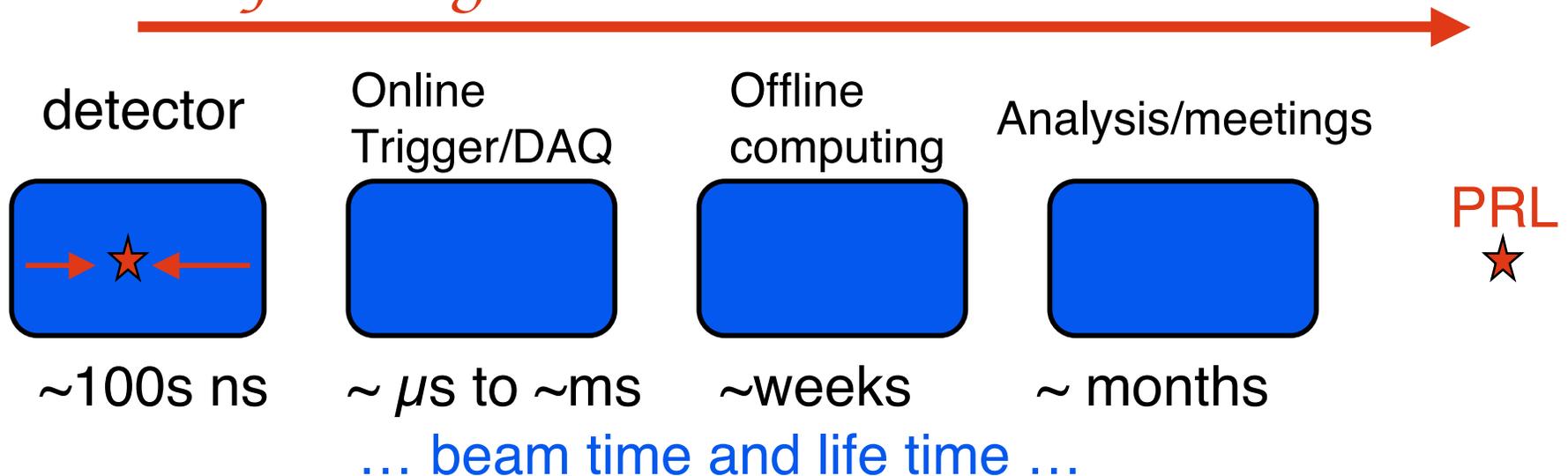
*“Young man, if the cross section is so low,
increase the luminosity !”*



For HEP experimental physicists, this is easier said than done

- Not only the luminosity has to be increased, but also the *bandwidth* ...
- from *collision point* all the way to *PRL* editors office ...

Improving bandwidth



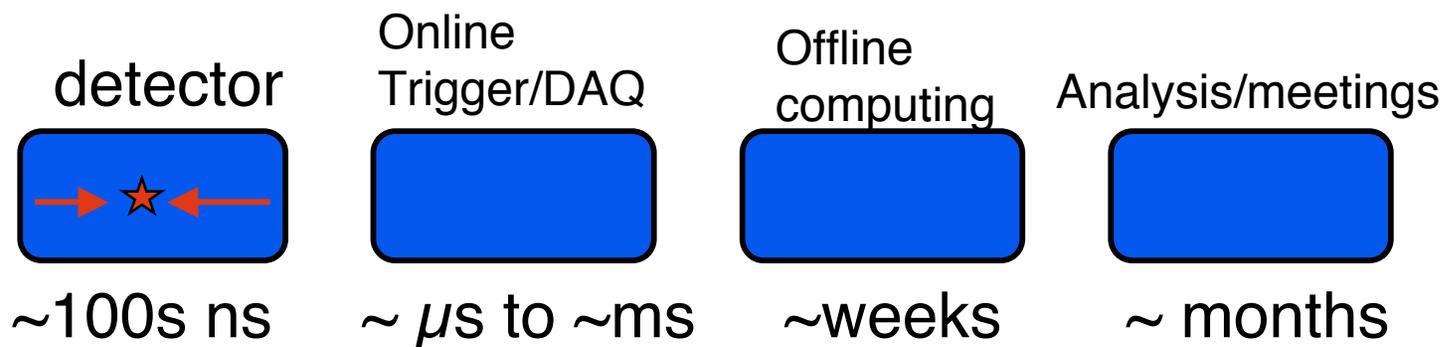


Goal is for: $3 \times 10^{32} \text{cm}^{-2}\text{s}^{-1}$

-- RunII: 2b or not 2b, no longer the question !

In this talk, we will show you that:

- Detector in good shape
- Trigger/DAQ upgrade done, work well
- Trigger Table performance great
- Offline Computing in good shape
- Fast turn-around of physics results
- CDF is ready for higher luminosity...

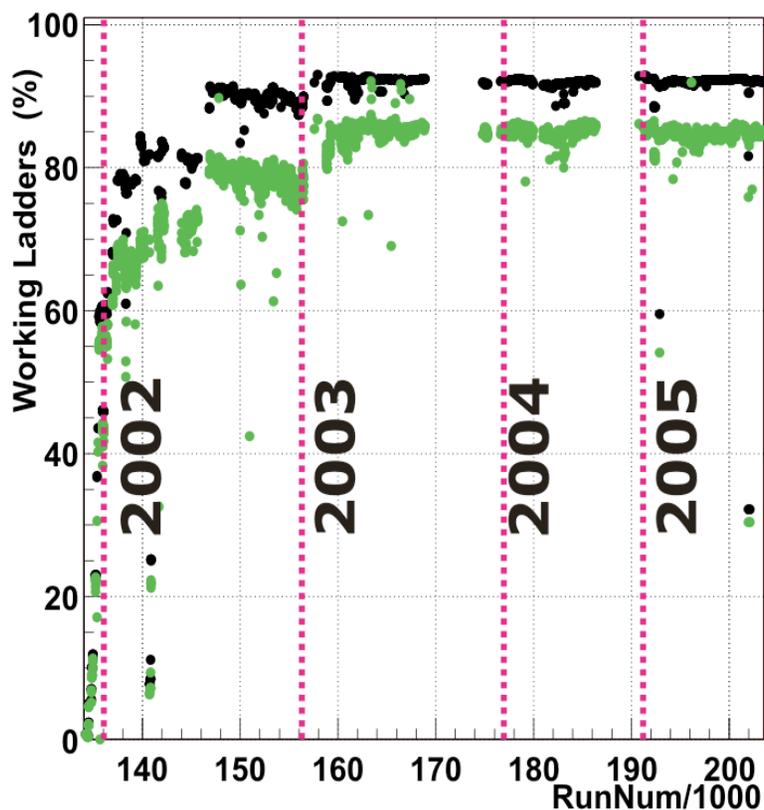




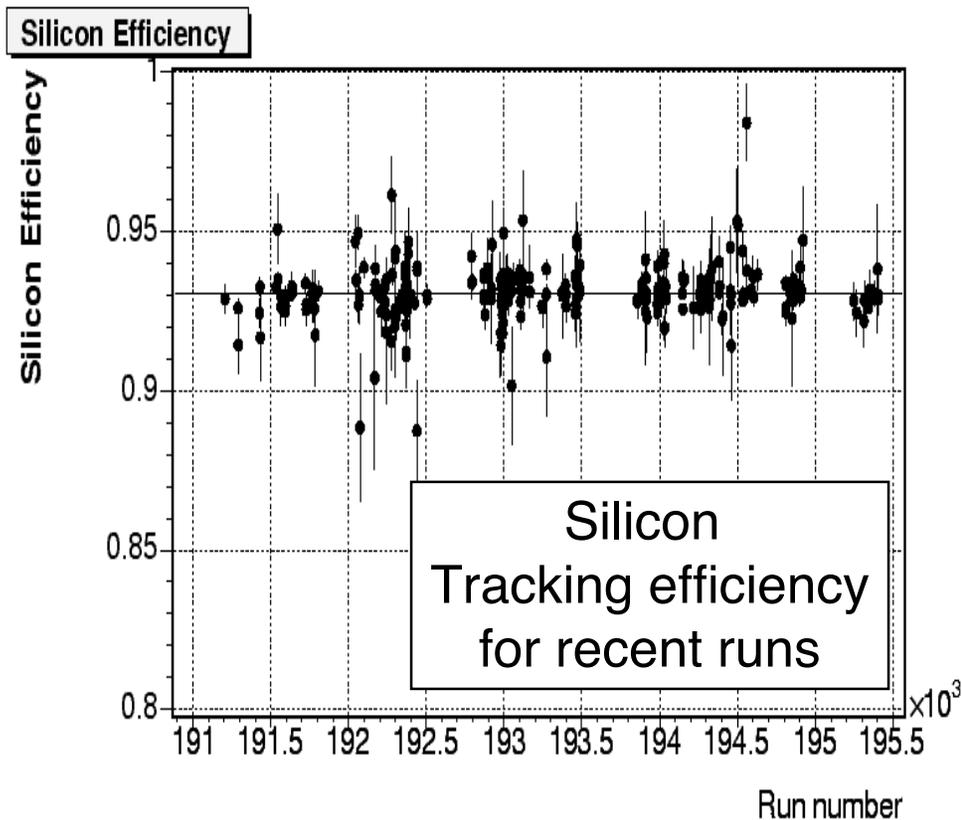
State of the Silicon Detector

-- good stable performance since 2003

L00 + SVX + ISL Ladders



- Powered: 92%
- Good: 85%

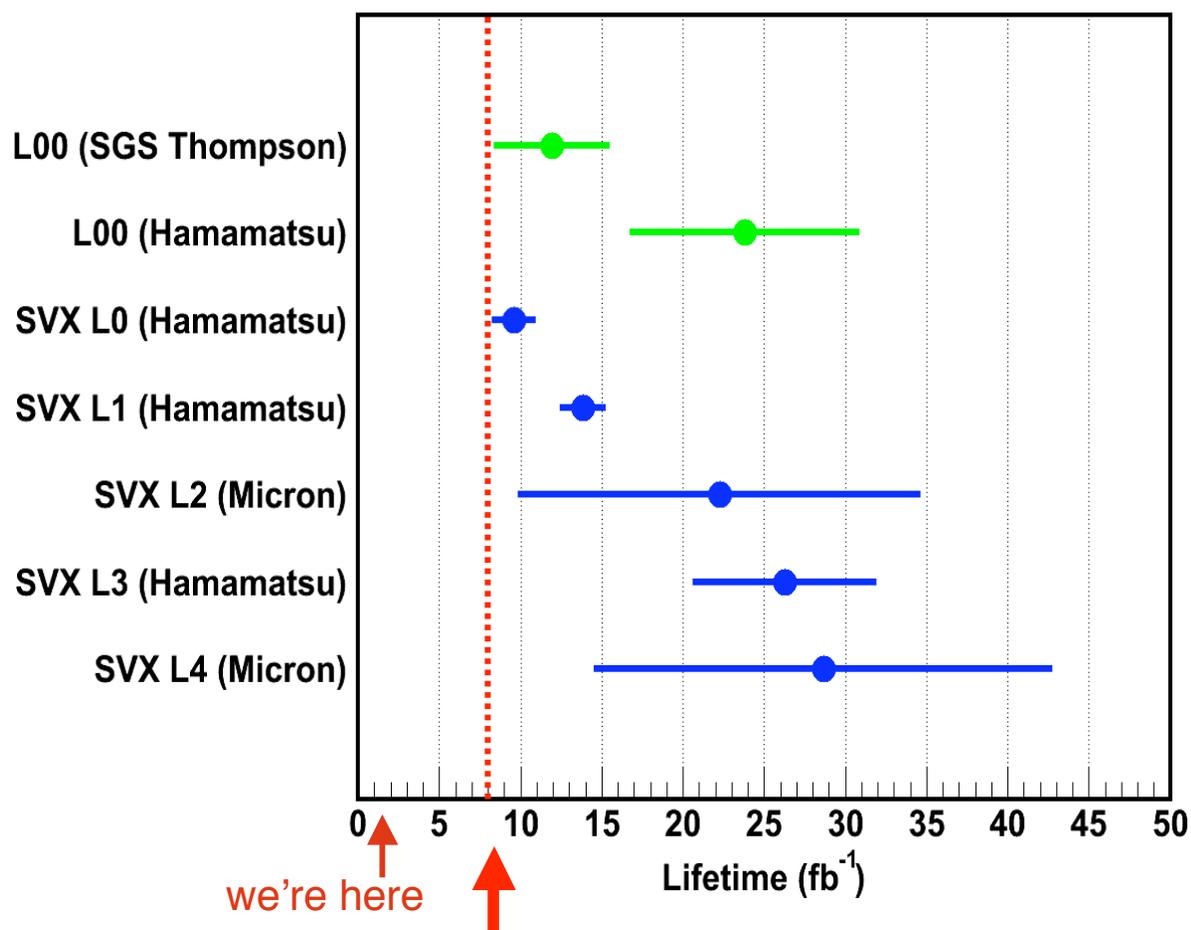


measured with muons from J/ψ decays



Silicon expected lifetime vs delivered luminosity

1.3 fb⁻¹ Bias Scan Results

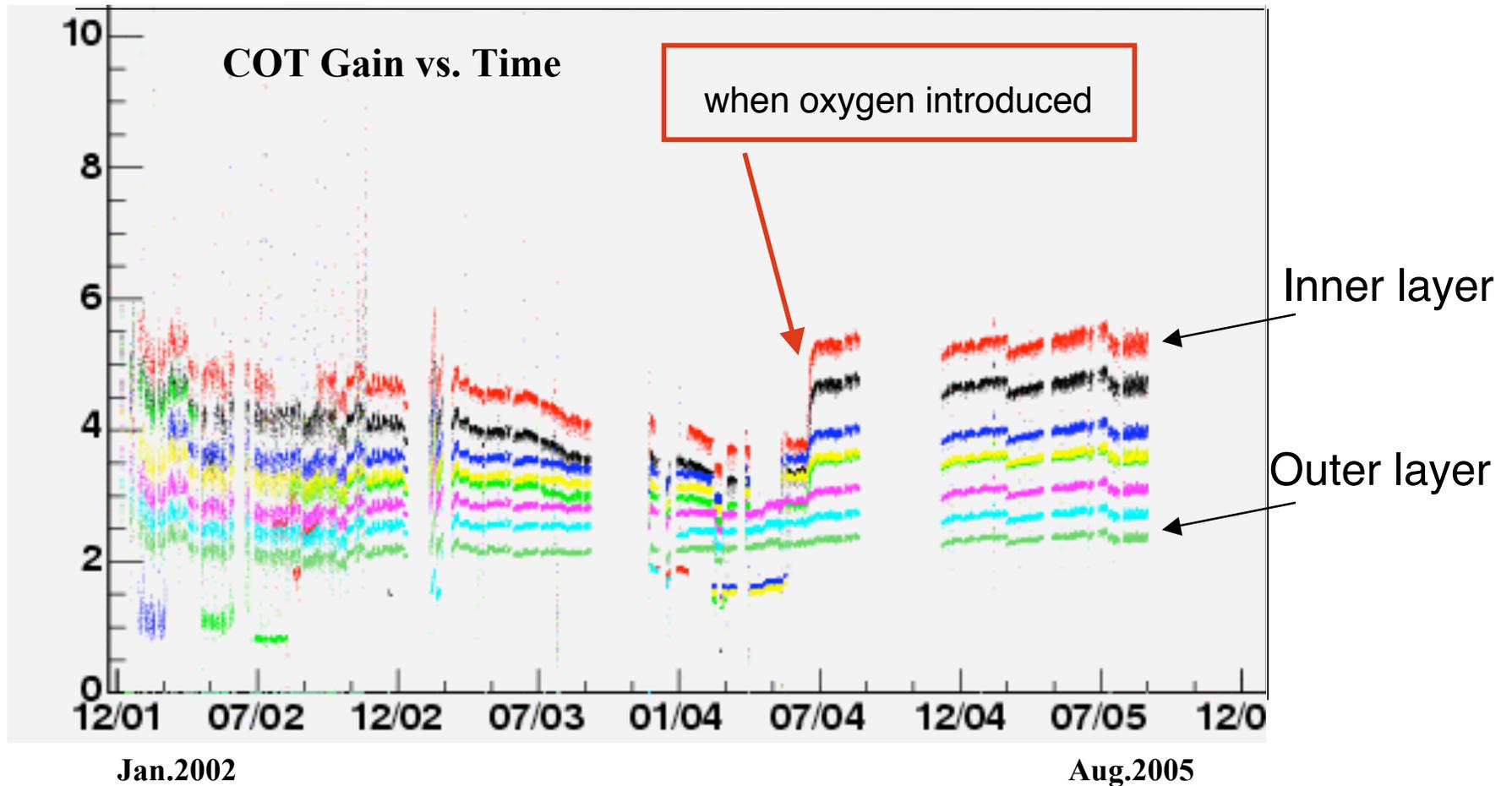


- Lifetime dominated by radiation due to collisions
- Regularly Monitored
- Evolving as expected

Run II projected delivered Luminosity



COT Aging is behind us -- all it needs: some oxygen or air!



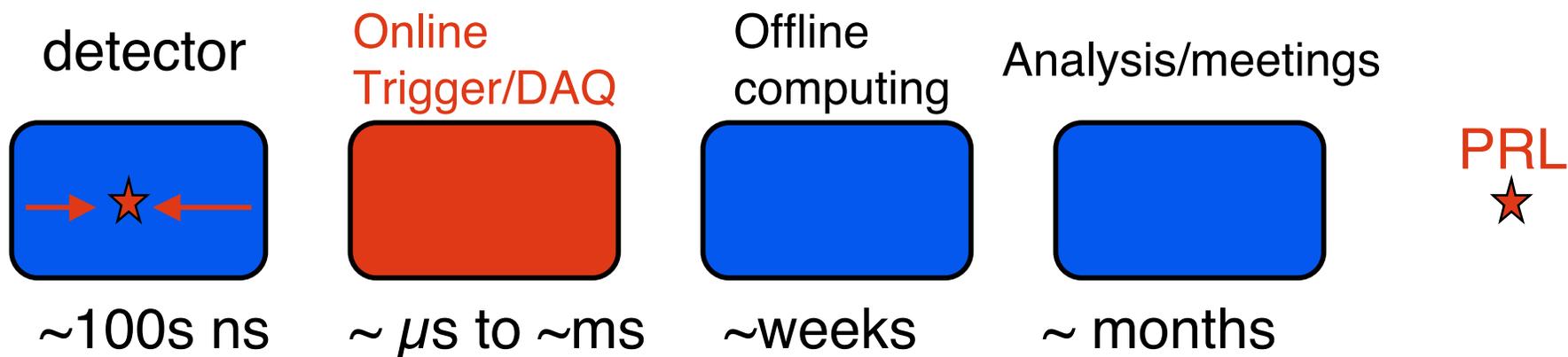


Preparations for High Luminosity

--Trigger/DAQ upgrade finished

- Trigger/DAQ is in good shape ...
- This is part of the RunIIb upgrade
 - ↘ project technical baseline achieved Dec. 2005.

Improving Trigger/DAQ bandwidth: by reducing the latency and improving the purity at different stages





Trigger/DAQ Upgrades for high luminosity

- Goals

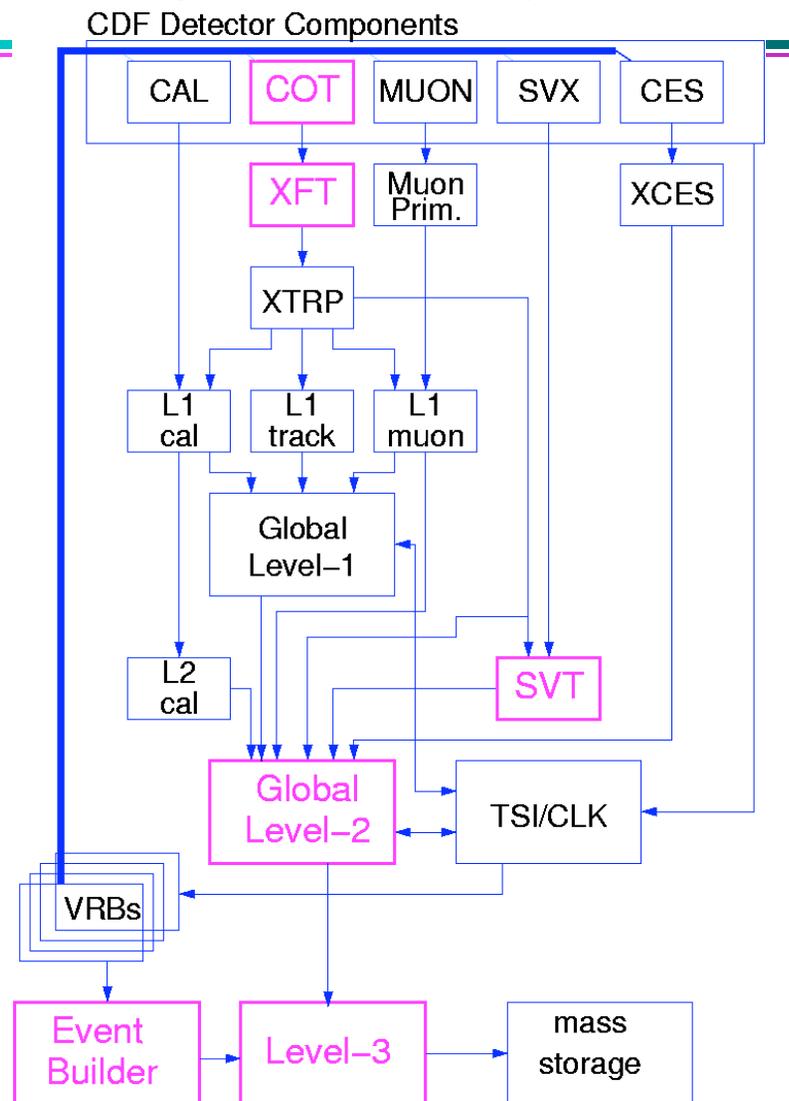
- Increase bandwidth at all levels
- Improve purity at L1

- Status - **Complete**

- **COT TDC -- readout latency**
- **COT Track Trigger (XFT)-- purity**
- **Silicon Vertex Trigger (SVT)-- latency**
- **L2/L3 trigger -- latency**
- **Event builder -- latency**
- **Data logger -- throughput**

* Track trigger installation done, being commissioned

* Data logger installation in progress

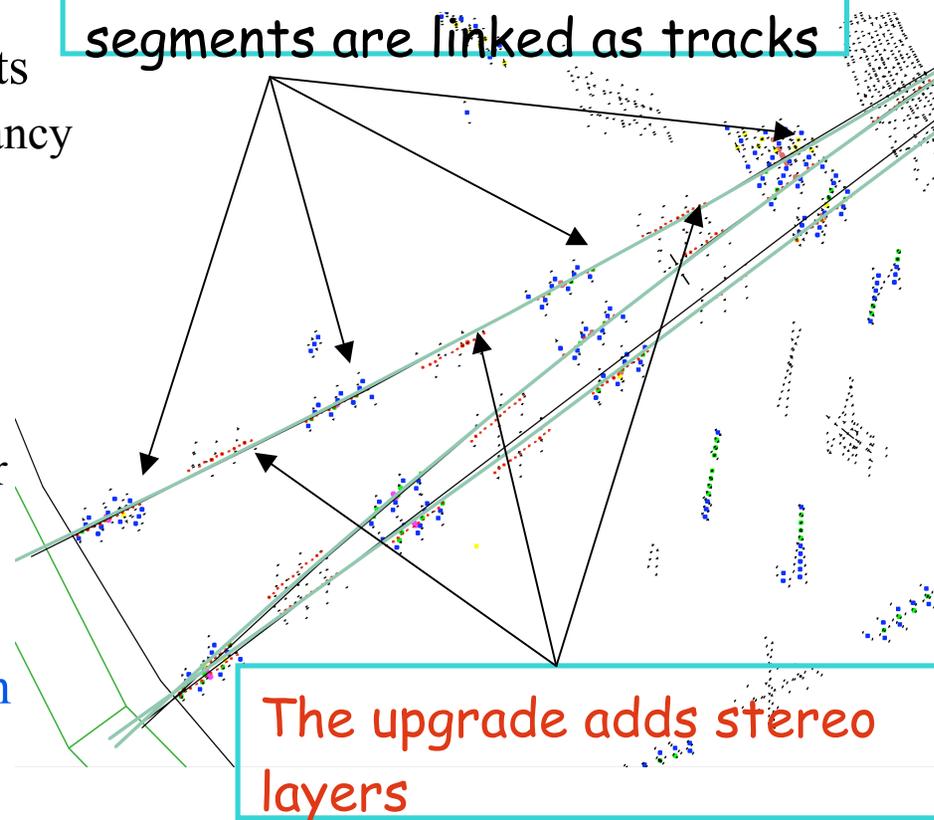




TDC and Track Trigger (XFT) Upgrade

- COT chamber is ready for high luminosity
- Readout+Trigger needed improvements
 - ↘ 396 ns crossing means high hit occupancy
- Existing TDC performance improved
- Track Trigger XFT
 - ↘ **add stereo layer information**
 - ↘ Increased information provides greater selectivity
 - ↘ Significant fake reduction at L1 & L2
- Installation finished, commissioning in progress...

Good axial hit patterns are identified as segment, then segments are linked as tracks



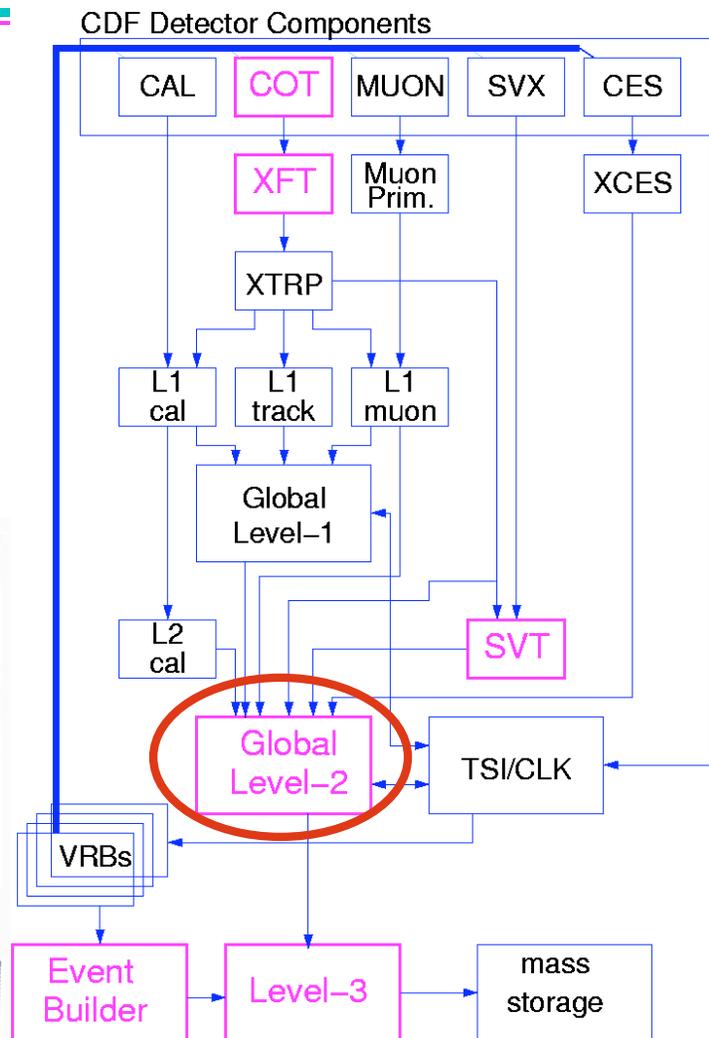
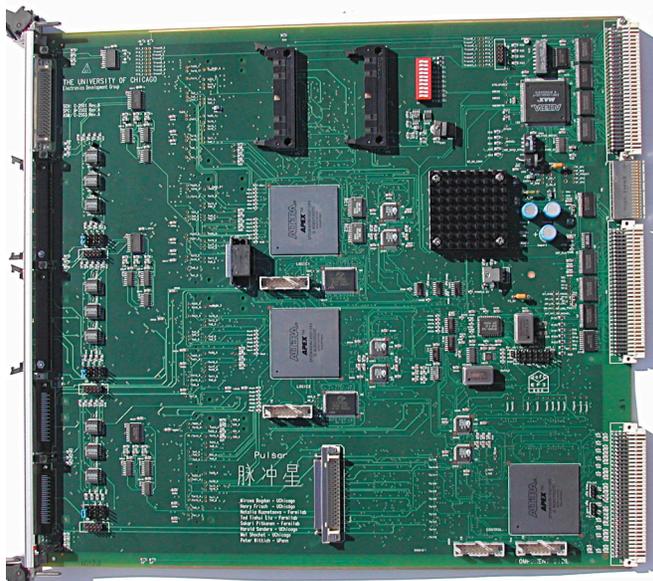
The upgrade adds stereo layers



Level 2 Decision Crate upgrade

- The L2 latency rises quickly w/ luminosity
- The new system is based on
 - Commodity processor replacing obsolete DEC alpha processor for L2 trigger decisions
 - Universal interface board design: **Pulsar**, replacing 6 different kinds of interface boards

Fully operational
Since early 2005

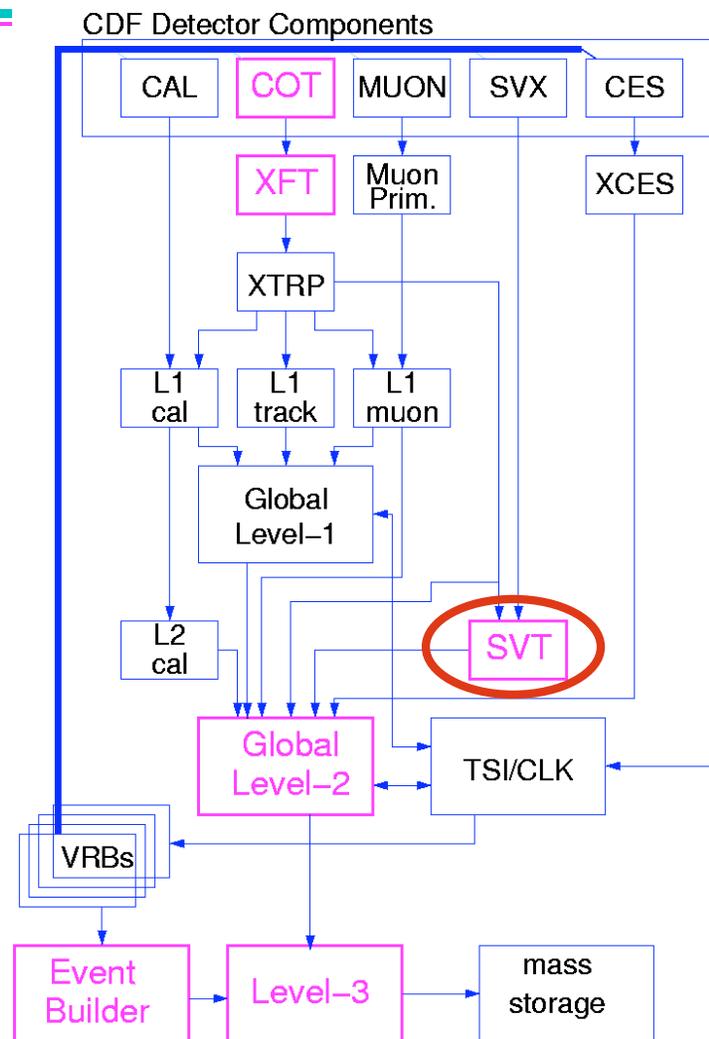


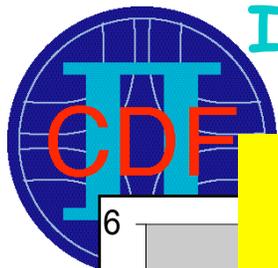


The Silicon Vertex Trigger (SVT) upgrade

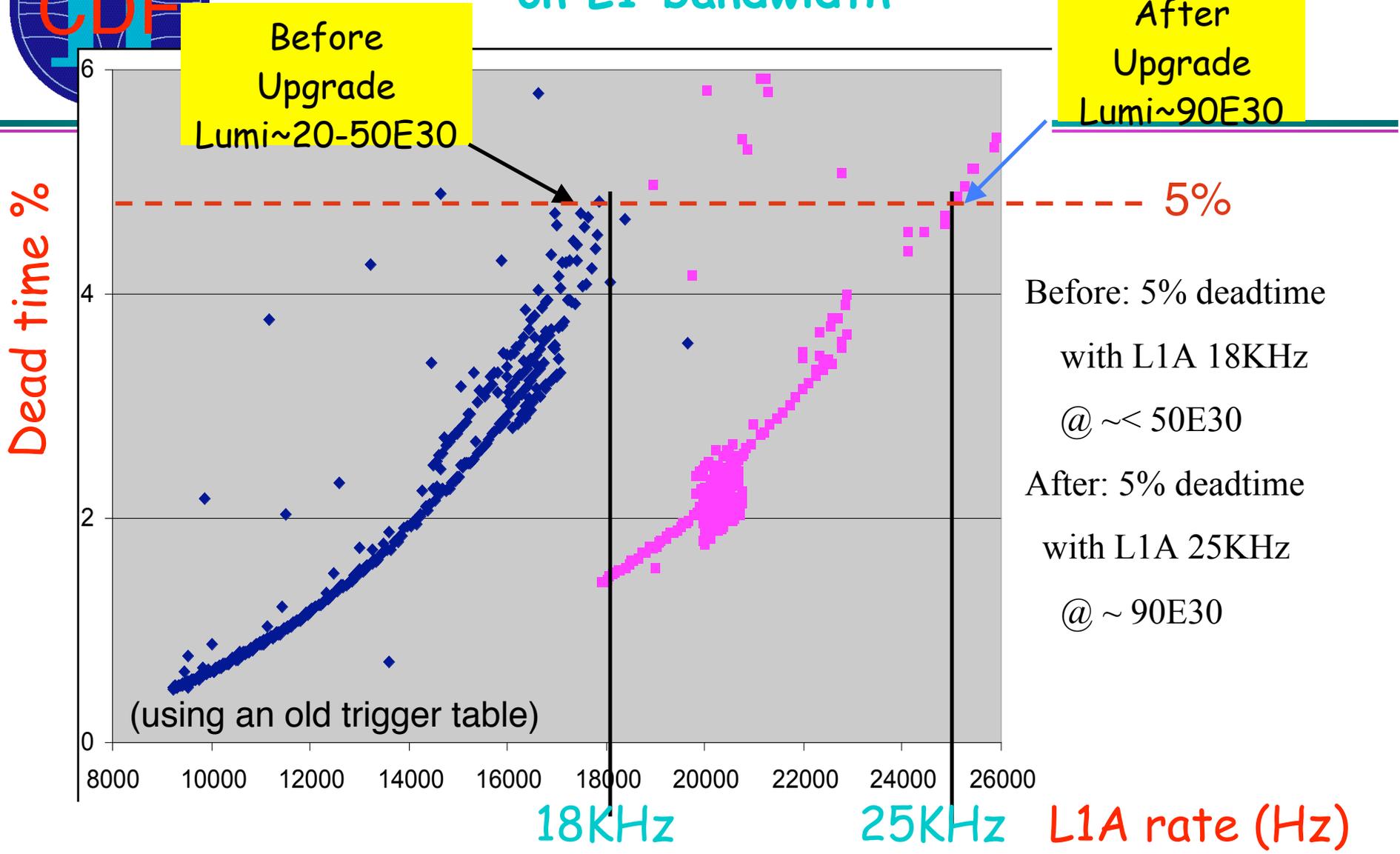
- The SVT has the same occupancy issues as the L1 track trigger
 - Longer processing latency
- Strategy
 - Improve pattern recognition (new AM++ boards)
 - Increase processing speed (36 Pulsar boards)

Fully operational since early 2006





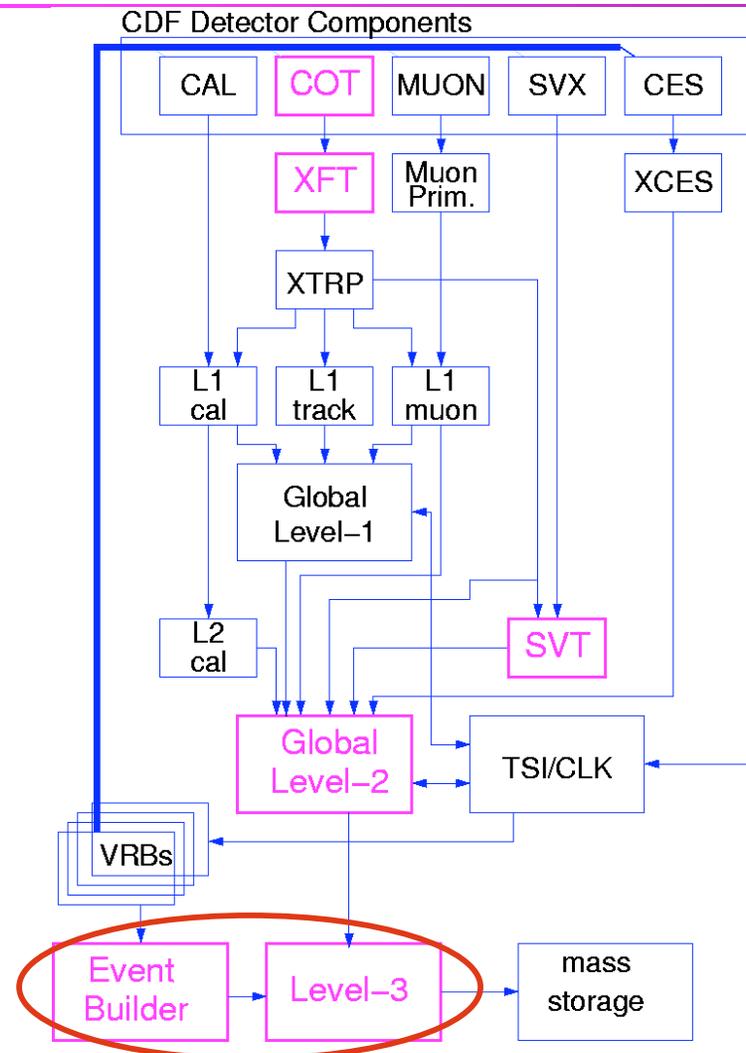
Impact of L2 decision crate & SVT upgrades on L1 bandwidth





The Event Builder and L3 farm upgrade

- Goal: ~1KHz input, ~60MB/s output to tape
- The Event builder organizes data from the many different subsystems and build a single event record.
 - New system uses Gigabit ethernet
 - full operations in August, 2005
- L3 processing power increased
 - 1THz --> 2.6THz
 - completed
- Data Logger
 - Processor/software upgrade
 - In progress

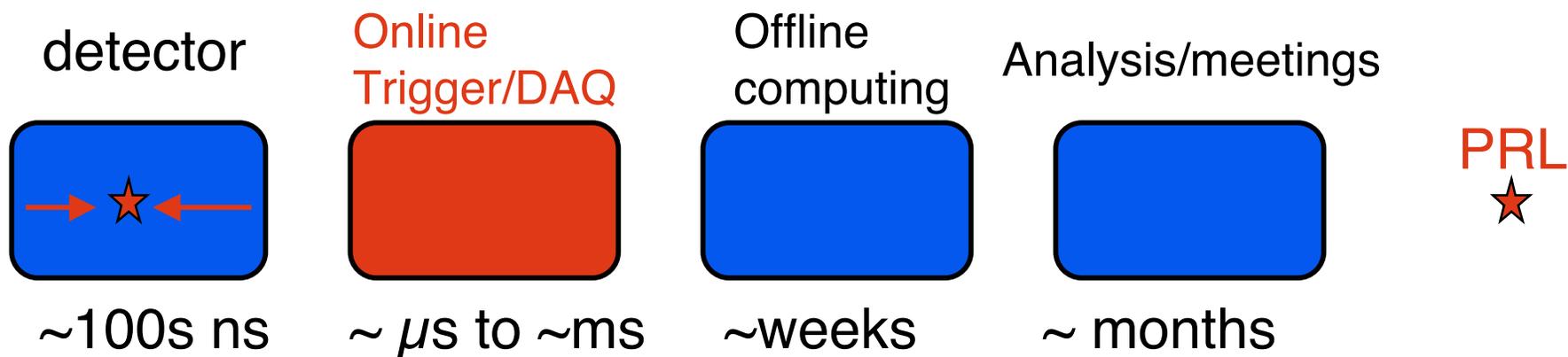




Preparations for High Luminosity

-- Trigger/DAQ upgrade

- We have upgraded the system to be able to handle highest luminosity
 - ↘ The upgraded Trigger/DAQ system is much more uniform and reliable
 - ↘ Usage of commercial devices and standards
 - ↘ Minimize board variations across the L2 trigger system (**Pulsar**)
 - ↘ Maintenance greatly reduced
- However, we have to make the right trigger decisions ! (see next)

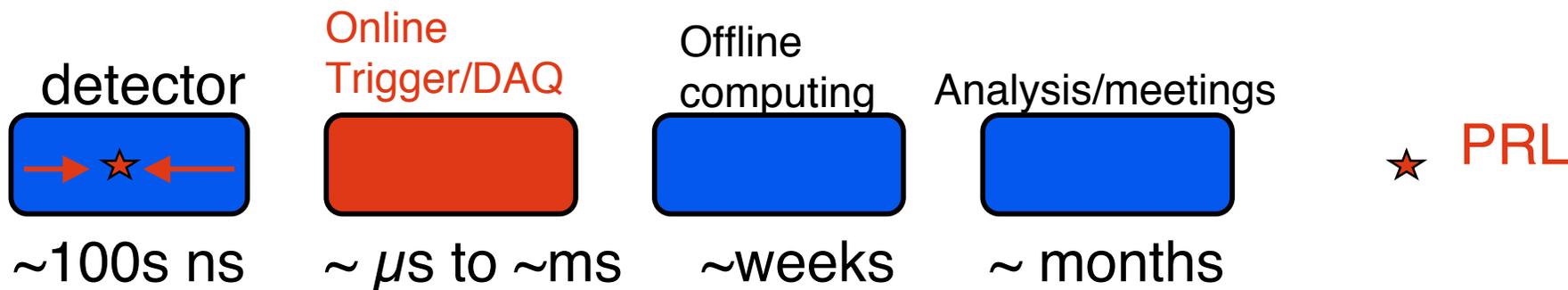




Trigger Table

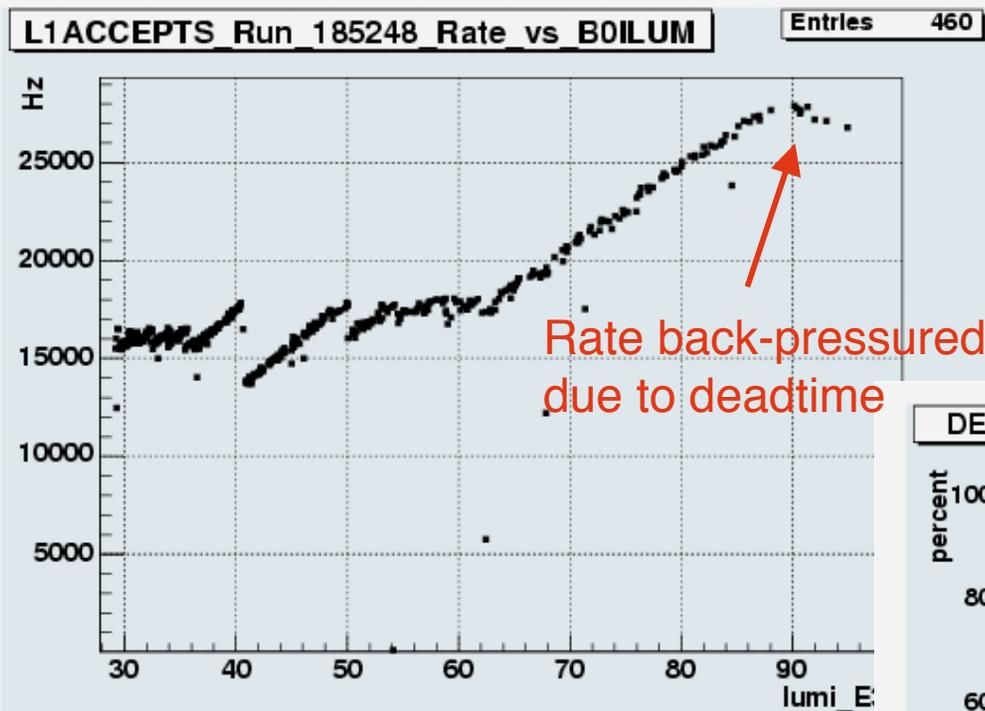
Trigger Table: a trigger “menu” to configure the trigger system to

- ↘ Select a list of physics triggers determined by L1/L2/L3 requirements
- ↘ determines the physics we can do (hadron collider physics ~ trigger table)
- In principle, a physics process trigger cross section, $\sigma = B$ (*constant*)
- In reality, a given trigger cross section, $\sigma = A/\mathcal{L} + B + C\mathcal{L} + D\mathcal{L}^2$
- CDF trigger table contains $> \sim 50$ L1 triggers, $> \sim 100$ L2 & L3 triggers...
- Solution - relax the effective prescale in real time as luminosity falls
 - ↘ High Pt physics triggers not prescaled



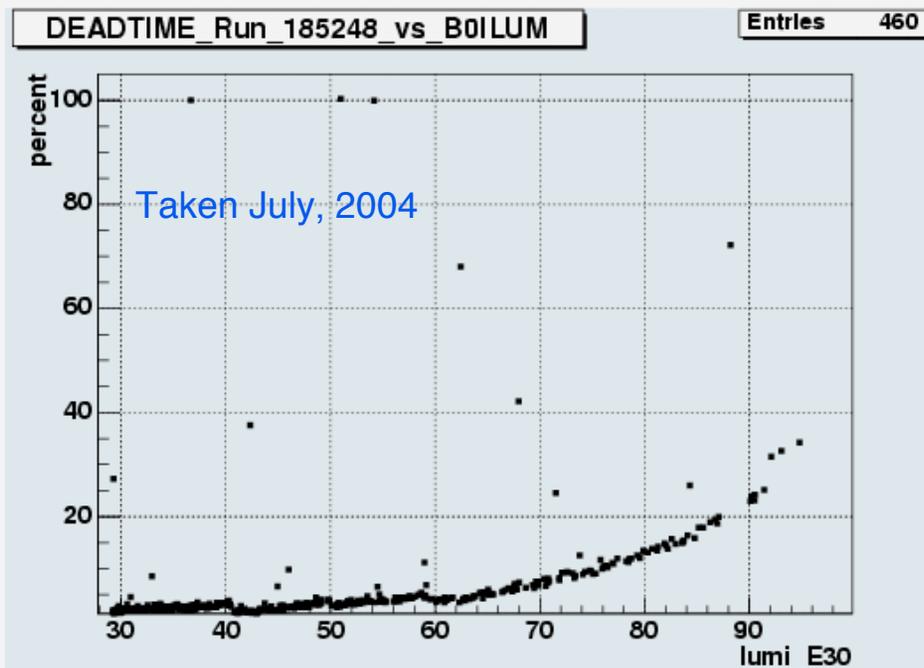


CDF Trigger Table performance in the old days (July 04)



Because of high deadtime, at luminosity above $90E30$, we had to run with a special trigger table with a smaller set of triggers:

the so called “high lumi table” ...

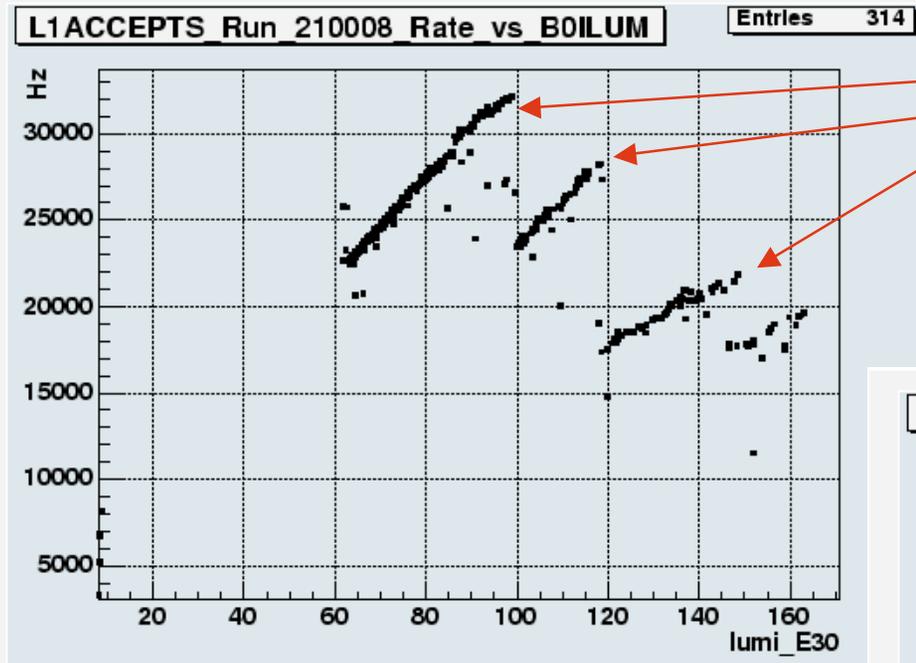


@ $\sim 90E30$, deadtime $> 20\%$

with L1A $\sim 28KHz$

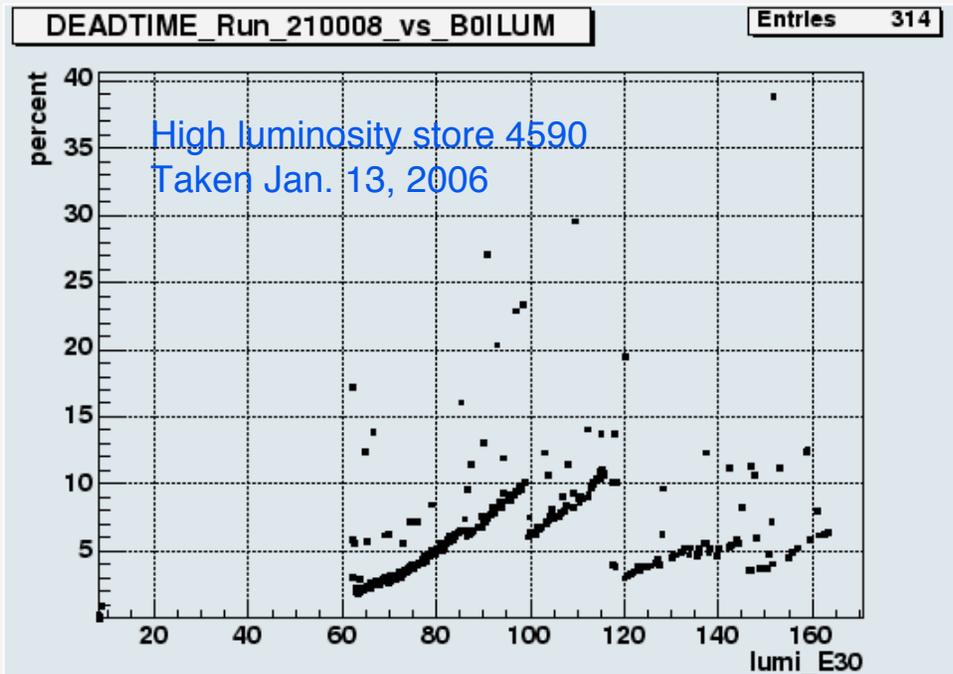


Trigger Table performance this year (Jan. 06)



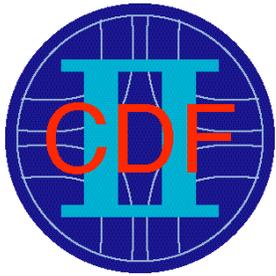
Dynamically enable high rate B triggers as luminosity falls (more bandwidth available at lower luminosity).

The current table will work up to 200E30... which contains all physics triggers.



- * Significant trigger table performance optimization/improvements in the past year
- * Take advantage of:
L2/SVT/EVB/L3 upgrade improvements

@ deadtime average over typical store: ~ 5%



How about above 200E30?

Plan ahead of time:
RunIIb Physics Priorities
and Trigger Committee



Identified “Core Physics” program for
luminosity above 200E30:

- (1) High precision measurements: W&Top mass
- (2) Single top production cross-section
- (3) Higgs: SM and SUSY
- (4) SUSY searches
- (5) High mass resonances
- (6) Bs to mu+mu-

All triggers related to the core physics program will be fully enabled
at the highest luminosity (300E30). Extensive studies for rate extrapolation
to higher luminosity in progress...

* As luminosity falls, will fully enable other triggers to fill the bandwidth for B and other physics



Offline Computing: from tape to reconstruction

- Speeding up data processing

- ↘ First pass for beamlines and calibration ntuples: ~few days
- ↘ 8 weeks for calibration and final production - will be even faster soon
- ↘ Can process 25M events per day (we take ~10M max per day)
- ↘ Common ntuples now produced on the farms
- ↘ Final (high lumi) reconstruction software version almost finished
(CDF is a mature experiment: ~ factory mode)





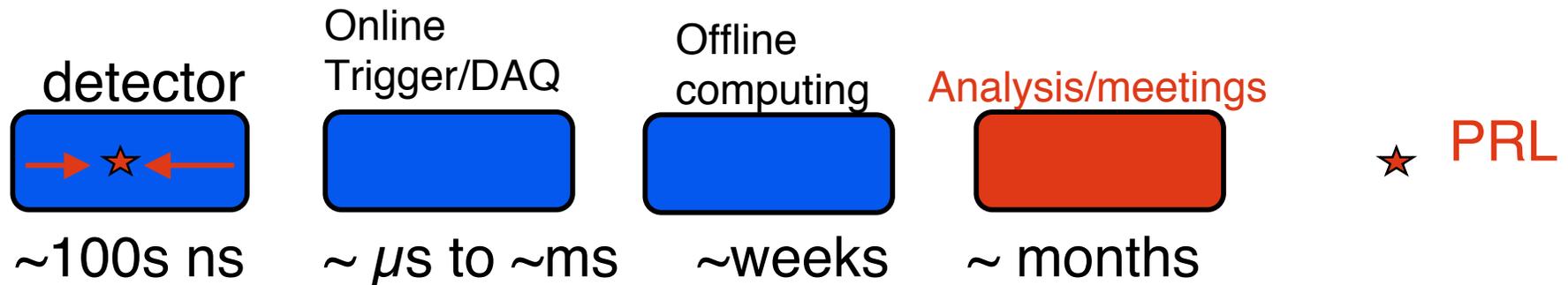
Data Analysis and physics results turn around time

- Data Analysis processing power:

- ↘ 8.2 THz - distributed among 10 Central Analysis Farms (CAFs)
- ↘ 5.8THz on-site (30% from non-FNAL funds), 2.4 THz off-site (for Monte Carlo)
- ↘ Improvement - use a single entry point for job submission to offsite CAFs
 - expands CPU resources available for CDF and increases efficiency of their use (world-wide CDF-Grid of CPU clusters)

- Physics results turn around time:

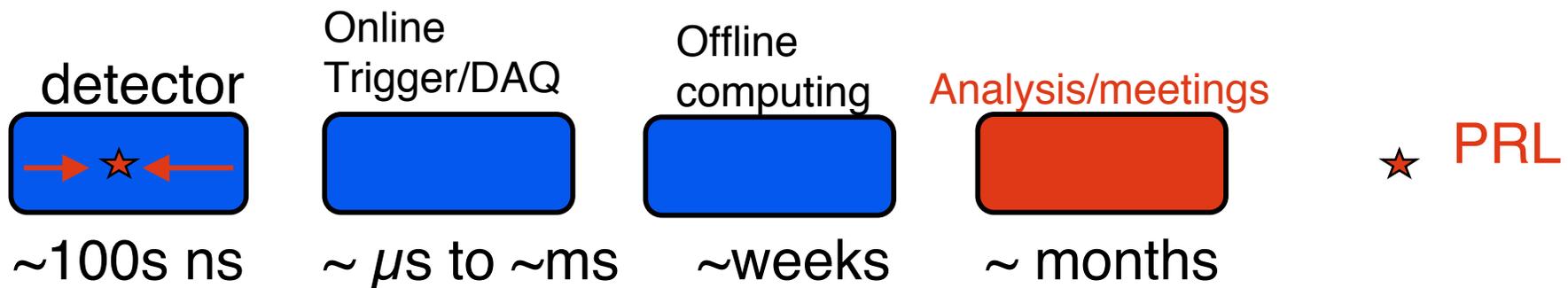
recent 1 fb-1 data to 1st physics result ~ 10 weeks





Preparation for doing physics at highest luminosity

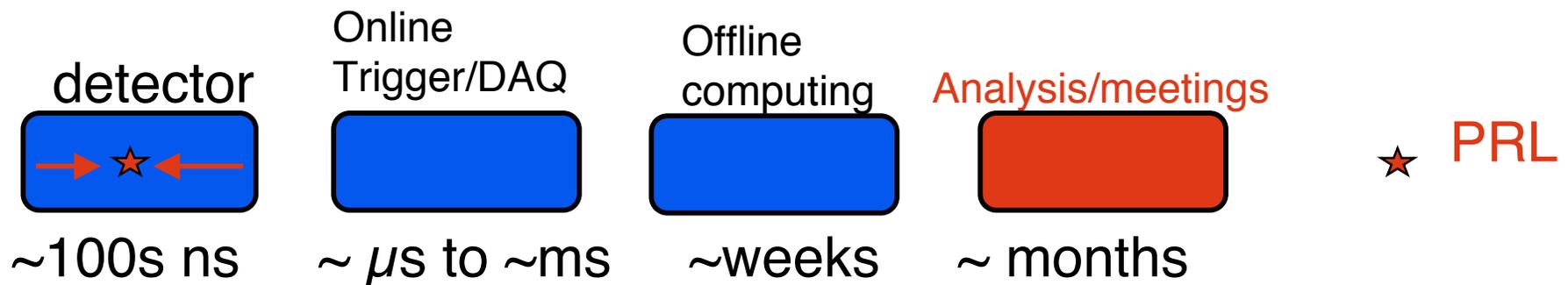
- Peak luminosity:
 - ↘ Best to date: 1.9 E32
 - ↘ Design 2006: 2.0 E32
 - ↘ Design > 2006: 3.0 E32
- Detector/Trigger/DAQ/Offline in good shape: can get the data on tape !
- Can we do good physics with higher luminosity data?
- Have begun to explore doing physics at the highest luminosity ...





Preparation for doing physics at highest luminosity

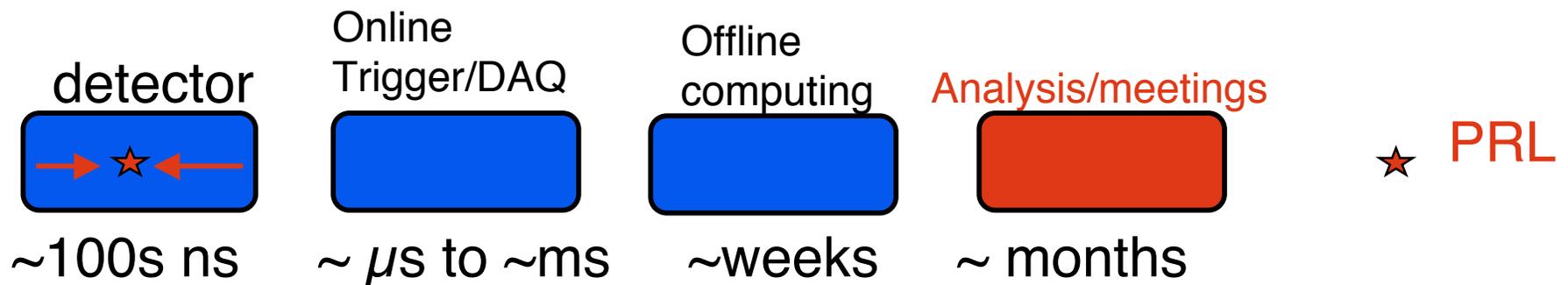
- Dedicated studies to understand evolution of Tracking, Lepton Identification, B-Jet Tagging, Missing Energy Resolution, Jet Corrections, etc.
- Strategy:
 - ↘ Use MC: over-lay additional minimum-bias events to simulate luminosity up to $3 \text{ E}32$
 - ↘ Use data: in bins of # of interactions/event; makes use of the bunch-to-bunch luminosity variations to gain a level arm to higher luminosity
 - ↘ Data vs MC comparison

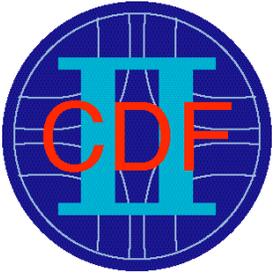




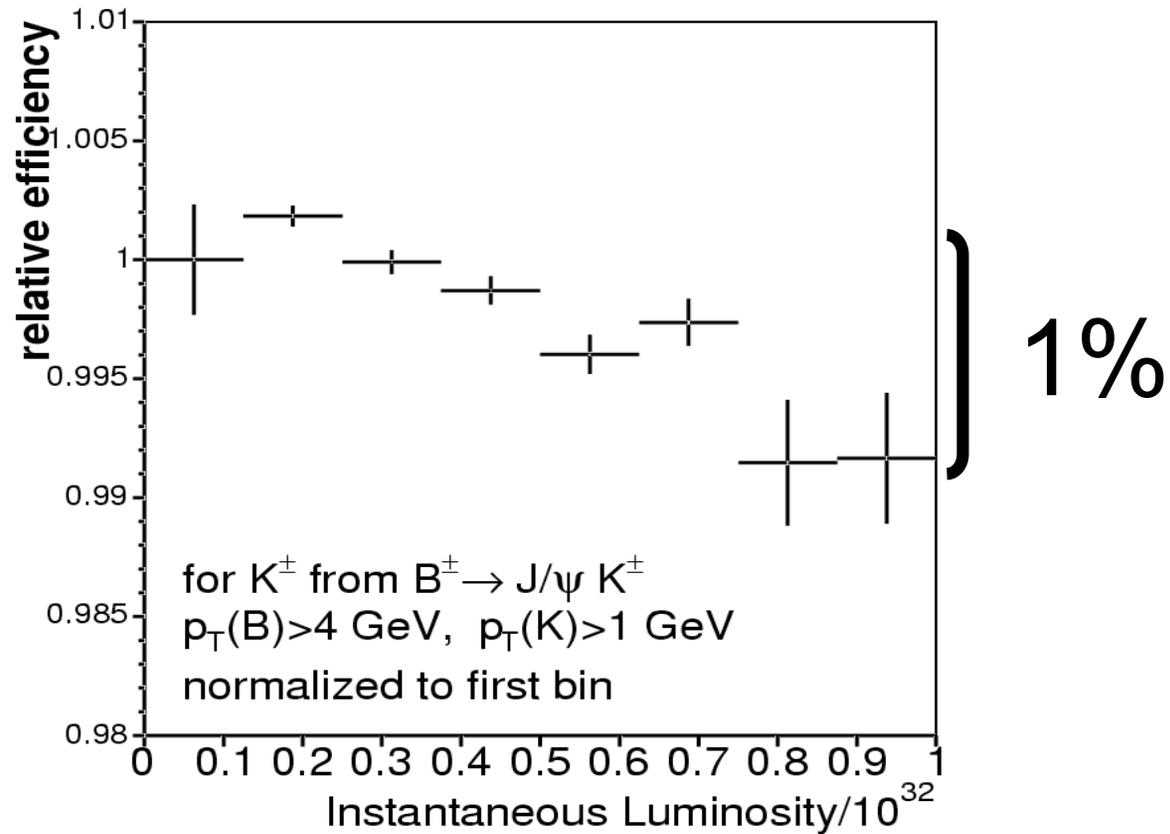
Preparation for doing physics at highest luminosity

- Bottom line: most physics objects minimally affected ($< 5\%$)
- Largest effects in tracking efficiency: depends on physics cases
 - ↘ Low occupancy physics (B physics and $W \rightarrow e\nu$, etc): small degradation
 - ↘ High occupancy physics (Top, Higgs etc): larger degradation





Tracking: Low Occupancy Physics

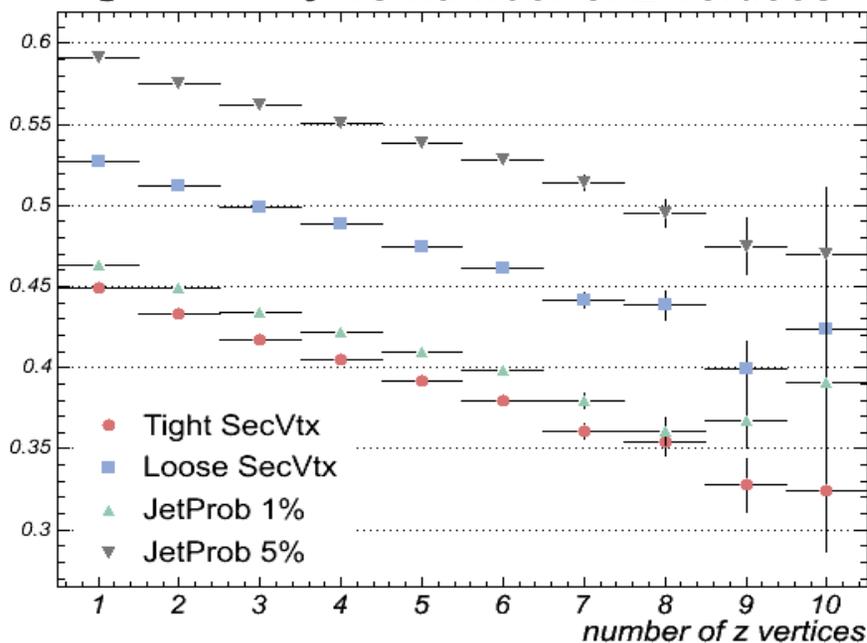


- No significant effect on this type of CDF physics program



Tracking: High Occupancy Physics

b-Tag Efficiency vs number of z vertices



cause understood
see next slide

↑
Avg
now

↑
Avg
2007-09

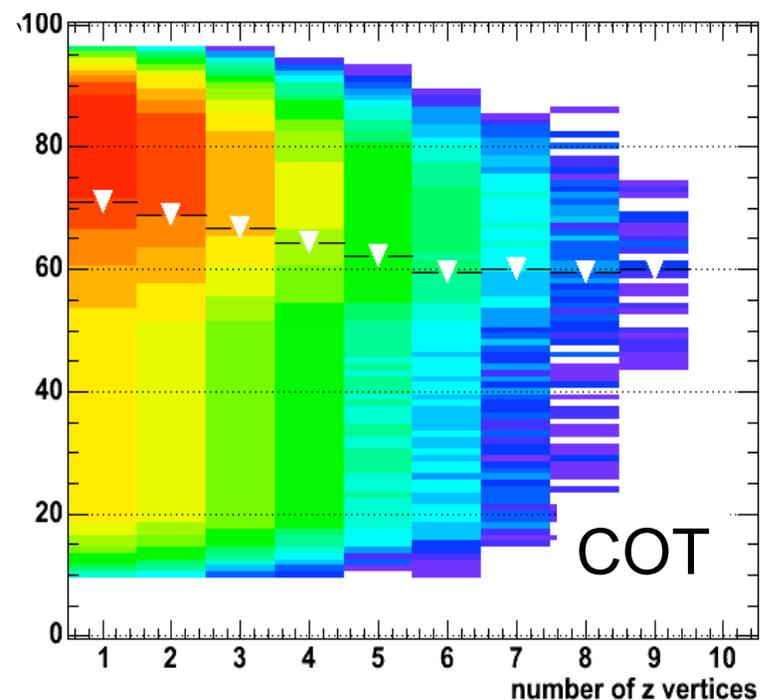
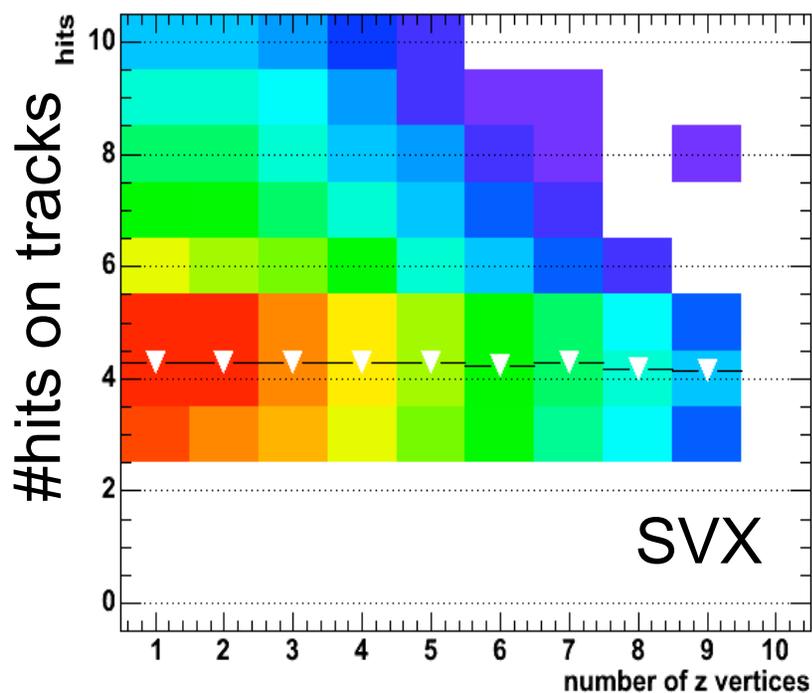
↑
Peak (3 E32)
2007-09

- on Average: 10% (relative) loss in B-tag efficiency



Tracking (SVX & COT): High Occupancy Physics

- At highest luminosities:
 - SVX efficiency minimally affected
 - COT efficiency more significantly impacted



Number of interactions per event



“Young man, if cross section is so low,
increase the luminosity!” -- Hans Bethe

- Detector performing well
- Online (Trigger/DAQ) and Offline ready for higher luminosity
- High luminosity physics program well defined
- Preparations for doing physics at higher luminosity well advanced
 - ↘ Largest effects in highest occupancy events
 - ↘ Studies in progress to mitigate these effects
- There could be surprises waiting for us, this is the nature of the game in HEP
- CDF confident it can carry-out full spectrum of world class physics at the design luminosity $3 \text{ E}32$



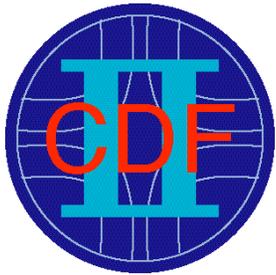
Backup slides

- 2 slides on RunIIb upgrade project



Run IIb Project Scope

- Silicon Detector Replacement (canceled)
- Calorimeter Upgrades
 - ↘ Preshower Upgrade
 - ↘ Electromagnetic Timing
- Data Acquisition and Trigger Upgrades
 - ↘ TDCs for the drift chamber
 - ↘ Level 2 Decision crate
 - ↘ Fast track trigger Upgrade
 - ↘ Event Builder Upgrade
 - ↘ Level 3 computer upgrade
 - ↘ Silicon Vertex Trigger upgrade



Run IIb Project Completion

- The Run IIb CDF Detector Project is now closing out.
- Technical baseline has been met
 - ↘ Achieved in Dec. 2005, ahead of the Level 1 Milestone.
 - ↘ Schedule has been met.
- Draft closeout document has been circulated
- Project costs are comfortably within the baseline
 - ↘ Final costs will be determined in June, 2006
- We will be ready to ask for CD-4 in June 2006.
 - ↘ Baseline is Nov. 2006