Tevatron Accelerator and CDF Detector

Particle Physics at High Energy Frontier

Yukawa Institute for Theoretical Physics, Kyoto University
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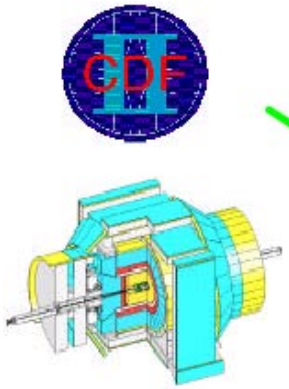
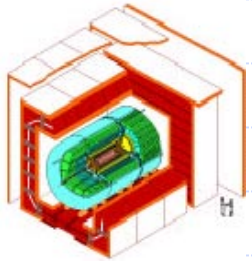
Tevatron





Fermilab Tevatron : R = 1 km, E_{beam} = 1 TeV

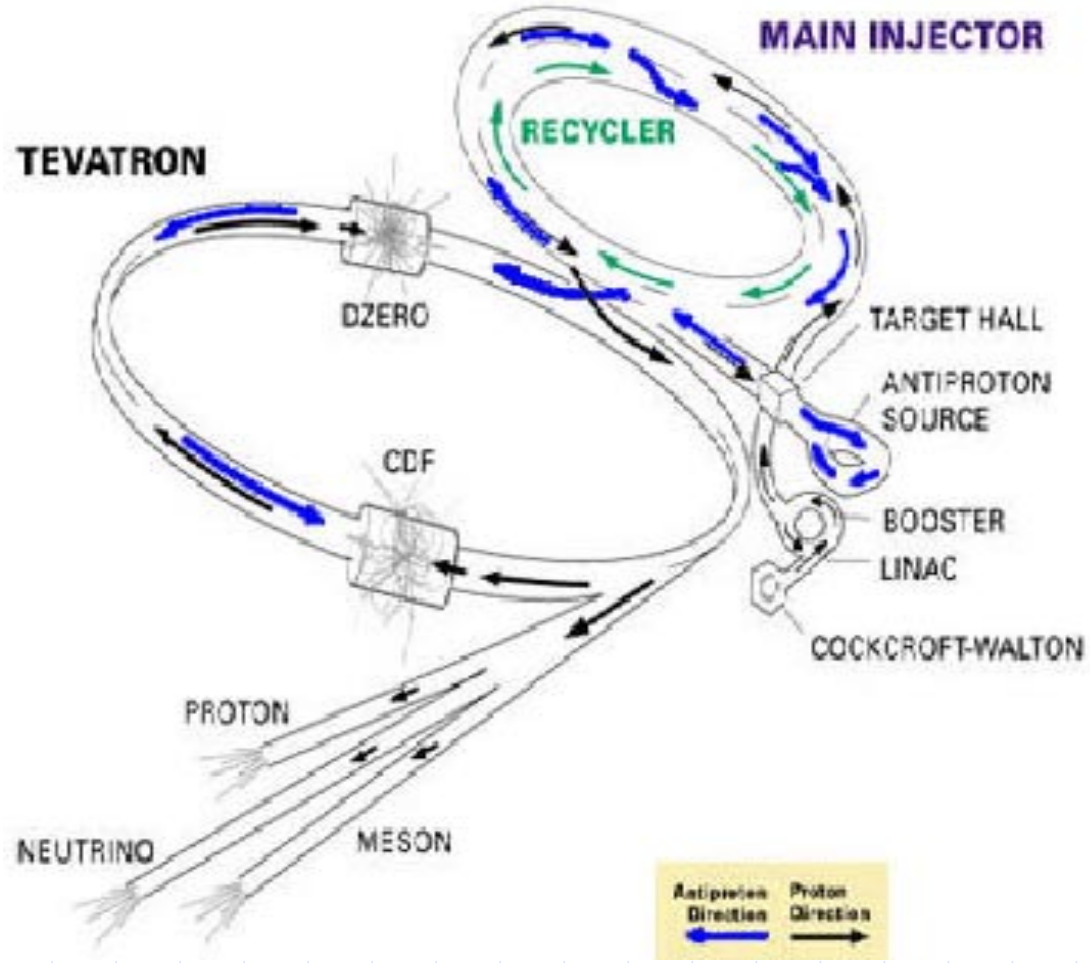
Run II Upgrade

- Main Injector (150 GeV proton storage ring) replaces Main Ring : x 5
- New stochastic cooling system for antiprotons
- Permanent magnet Recycler ring for antiprotons : x 2
  - Will be integrated this summer
- Higher Energy: 900 -> 980 GeV
- Number of bunches: 6x6 (3500 ns) -> 36x36 (396 ns)
- After 2005: electron cooling etc. : x 2

Run II started in April 2001

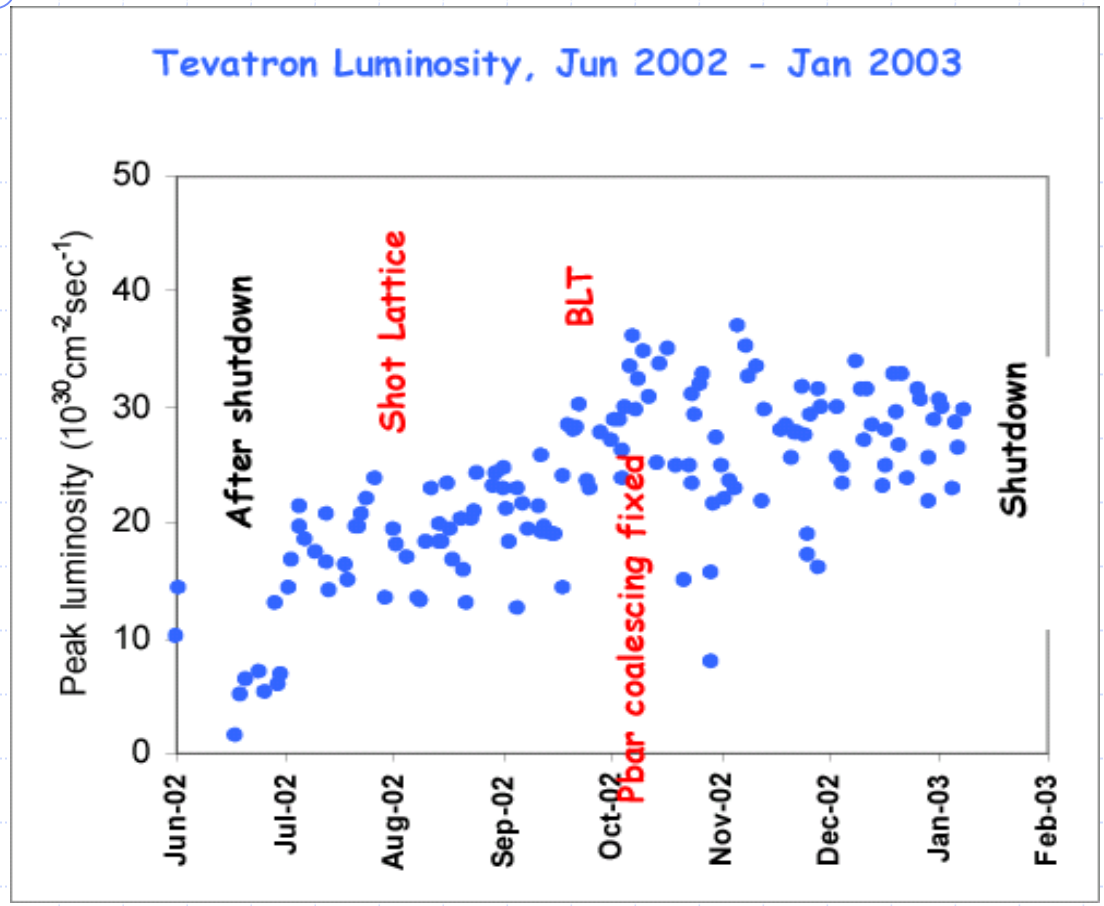
Stable physics running established early 2002

Accelerator Complex



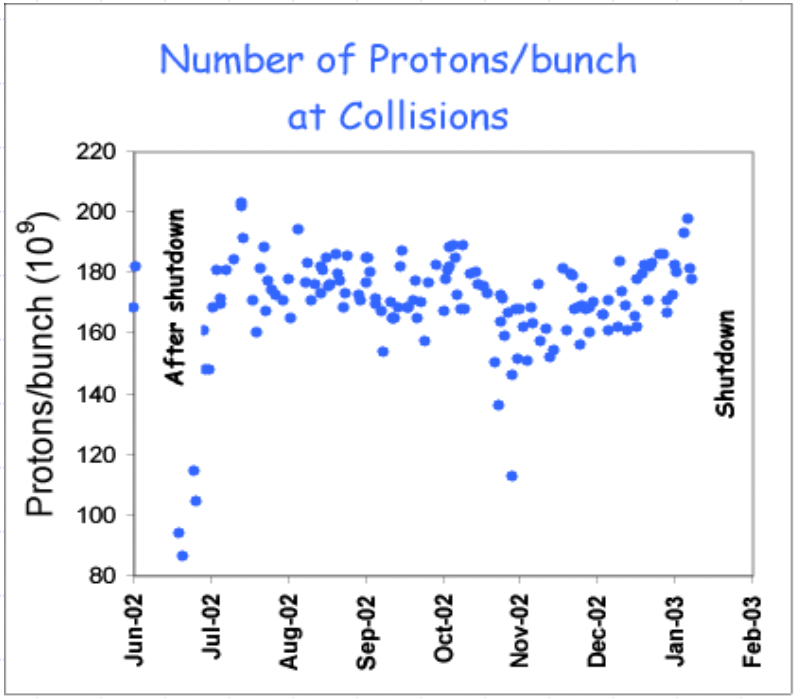
- P injection to MI
- AP production
  - cooling
  - accumulating
- Coalesced P bunches : MI -> Tevatron
- AP from pbar ring : MI -> Tevatron
- AP -> recycler

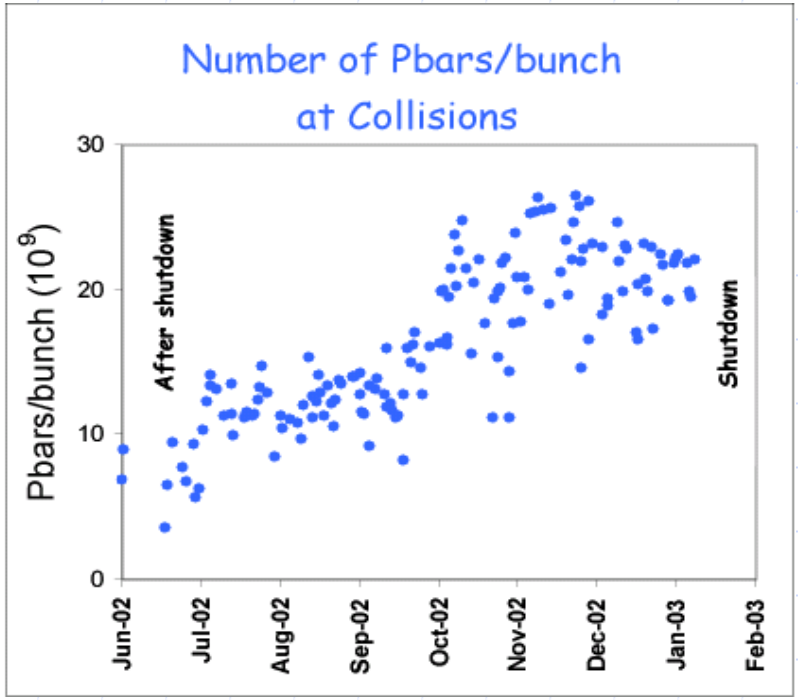
Tevatron Luminosity since June 2002



- 151 stores
- 170 pb^{-1} to each detector (130 pb^{-1} recorded)
- Increase in luminosity from 20e30 to 36.9e30
- Run I record of 36.9e30 broken on 7/26/2002

Beam Intensities





Number of protons

-> Mostly steady

Number of antiprotons

-> Increase factor of ~2.5

Operations Status and Plan

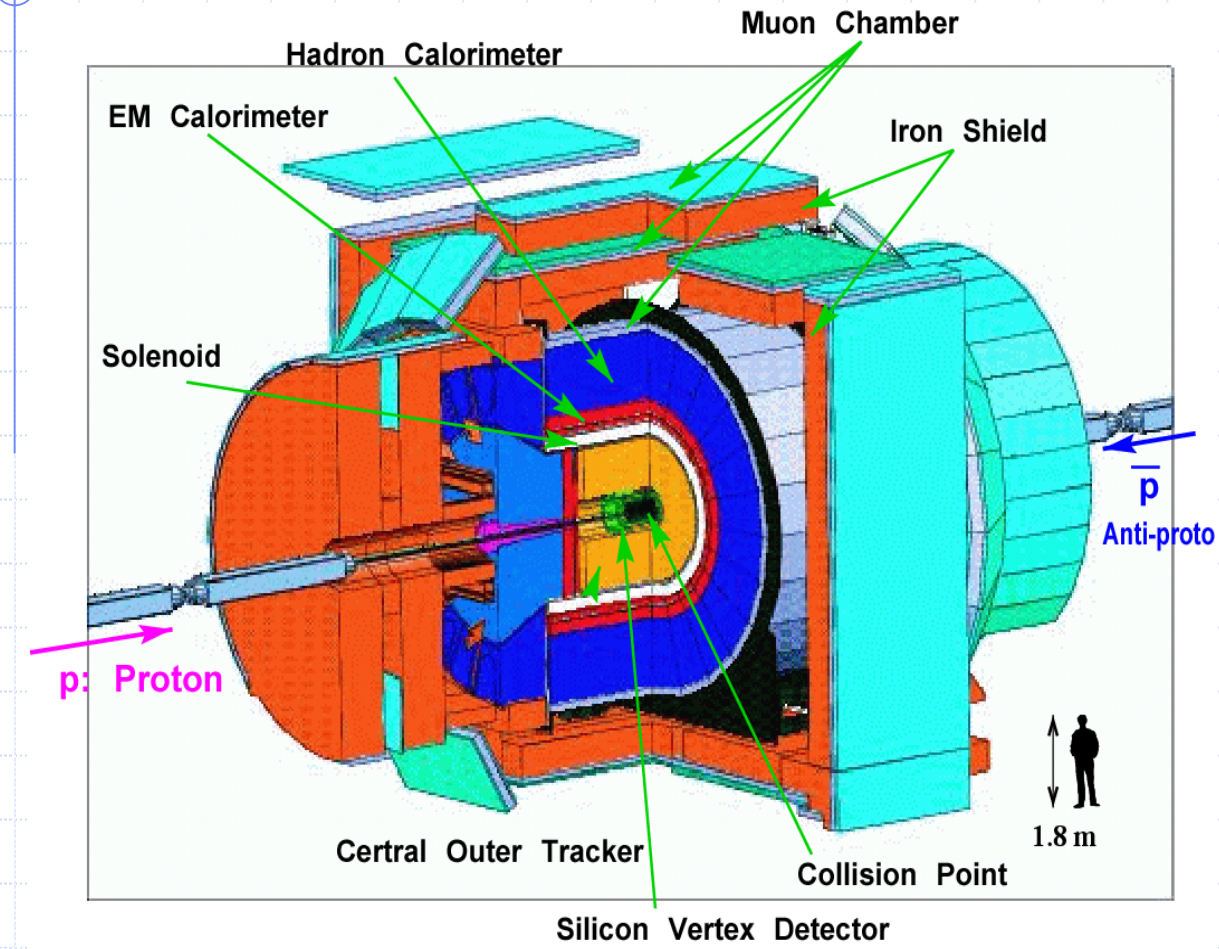
Parameter	Current Status	FY03 Goal	Run II Goal	(Units)
Typical Luminosity	3.2e31	6.6e31	33e31	$cm^{-2}sec^{-1}$
Integrated Luminosity	6.0	12.0	70.0	Pb^{-1}/week
Protons/bunch	170e9	240e9	270e9	
Antiprotons/bunch	22e9	31e9	135e9	

For Higher Luminosity

Current problems :

- Emittance growth on transfers
- Instabilities
- Aperture limitation for beam-beam separation
- Pbar coalescing, bunch length
- Reliability
- Alignment, vacuum
- …
- Integrate Recycler into operations

Run II CDF Detector



Faster detector

Better Performance

Most components

Renewed :

- Tracking
- Calorimetry
- TOF
- Muon system
- Front-end, Trigger
- Software

CDF Tracking system

- Silicon : SVX, ISL, L00
- Drift chamber : COT (Central Outer Tracker)

$|\eta|<1.0$

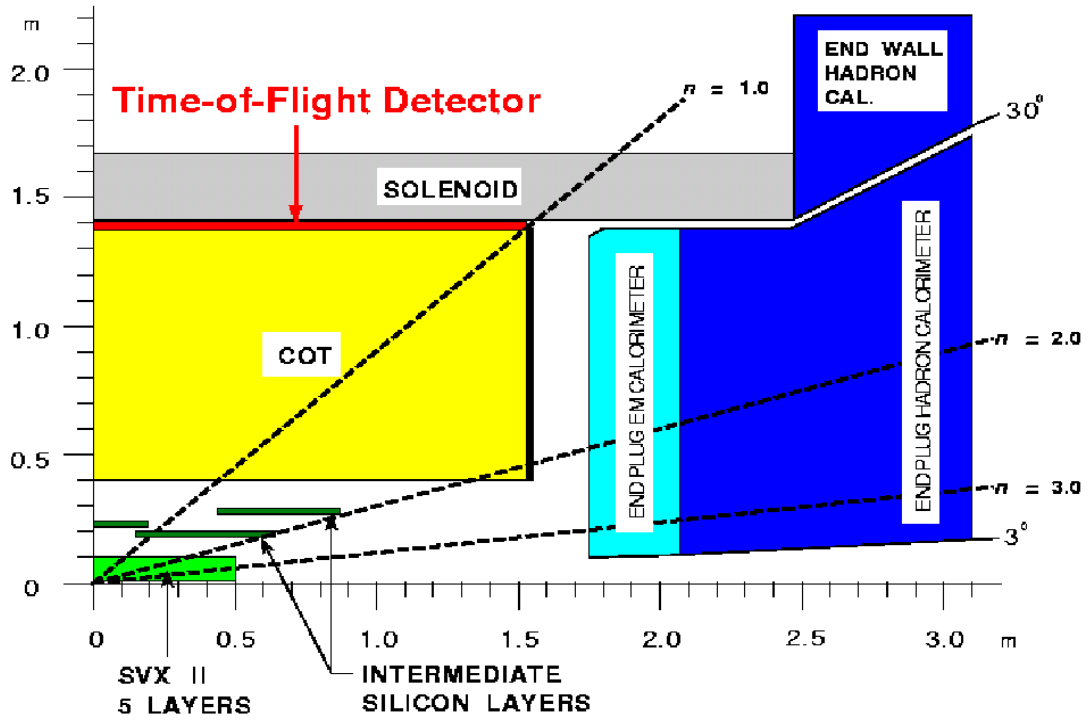
(COT, ISL, SVX)

$\delta p_T/p_T^2 \sim 0.1\%$

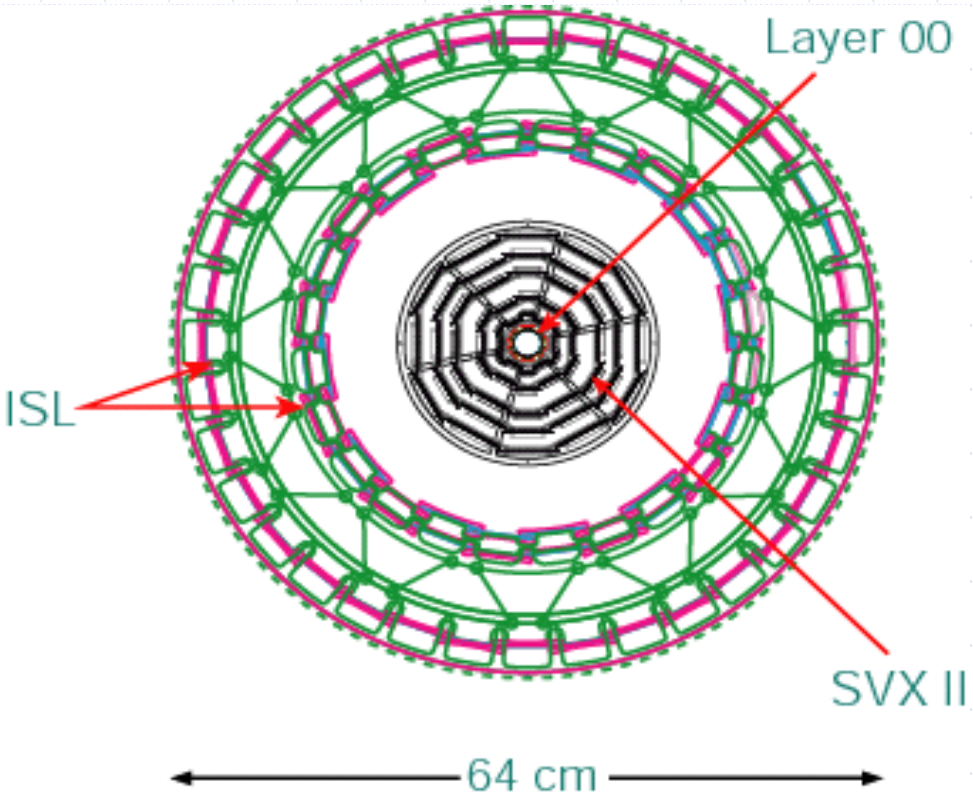
$1.0<|\eta|<2.0$

(ISL,SVX)

$\delta p_T/p_T^2 \sim 0.4\%$

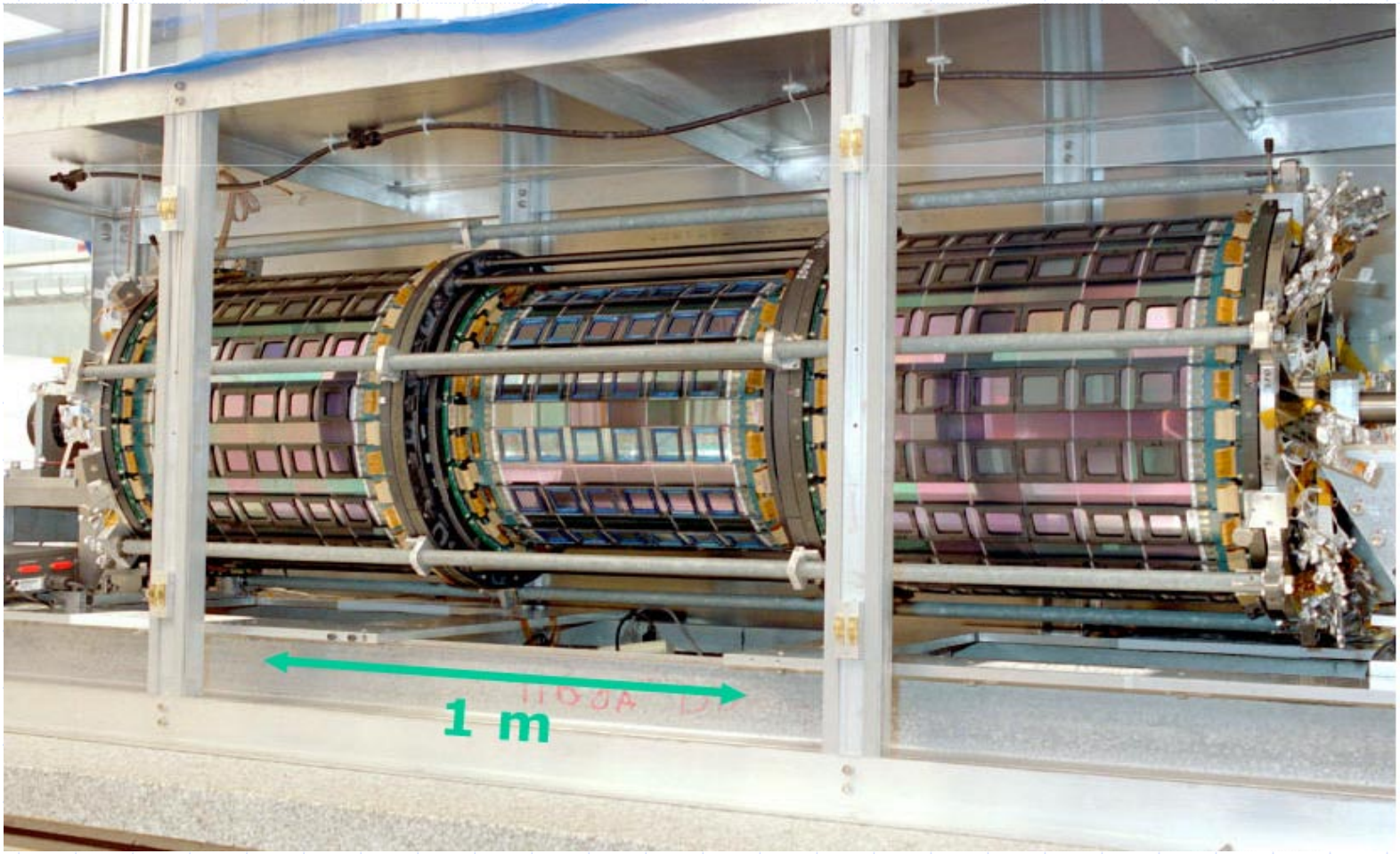


CDF II Silicon System

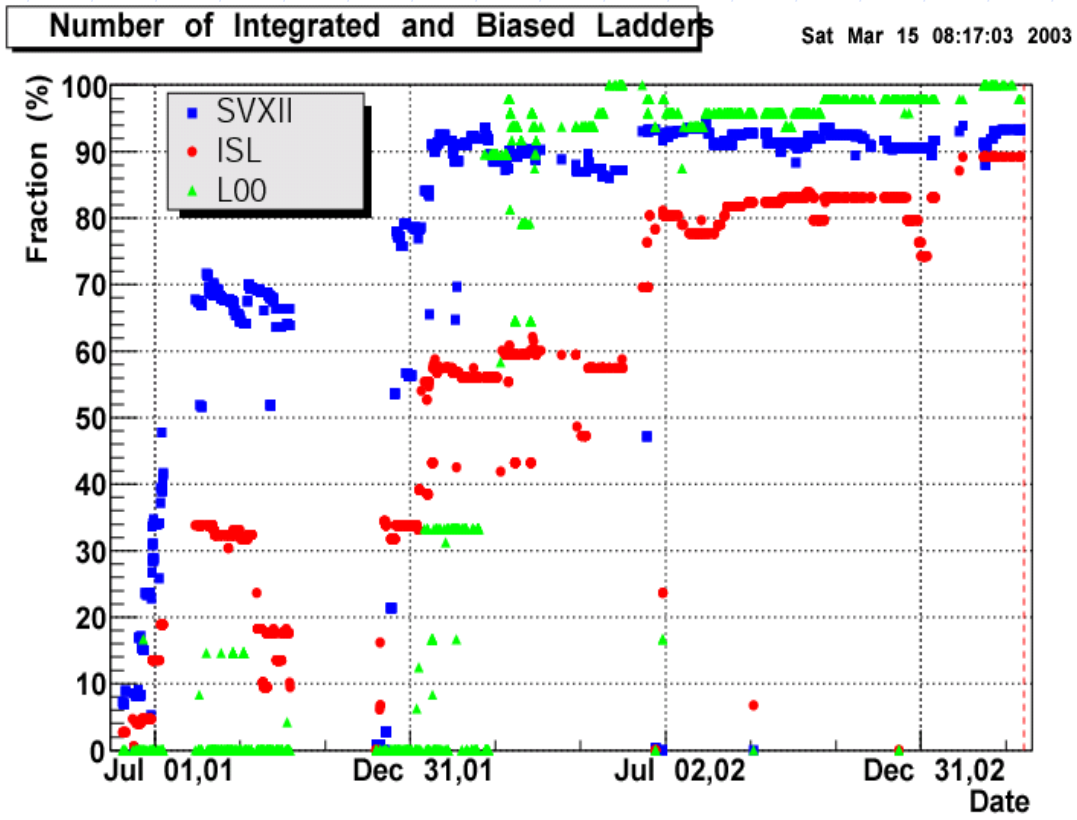


- Layer00
  - 1 single-sided layer
  - 1.35cm < R < 1.65cm
  - Improve IP resolution
- SVX II
  - 5 double-sided layers
  - 2.5cm < R < 10.6cm
  - 3D tracking
- ISL
  - 2 double-sided layers
  - 20cm < R < 28cm

ISL Side View



Silicon Detector Status



Now operating >90% of silicon

Slow commissioning was due to :

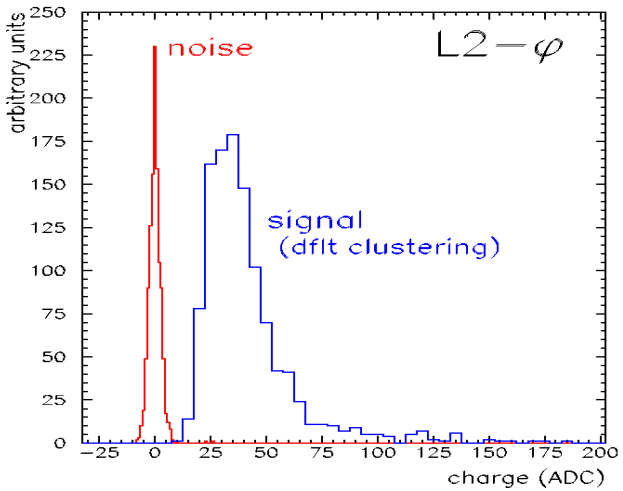
- Optical transmission problem
- Delays in PS deliveries, and radiation-related PS failures
- Cooling trouble in the central ISL

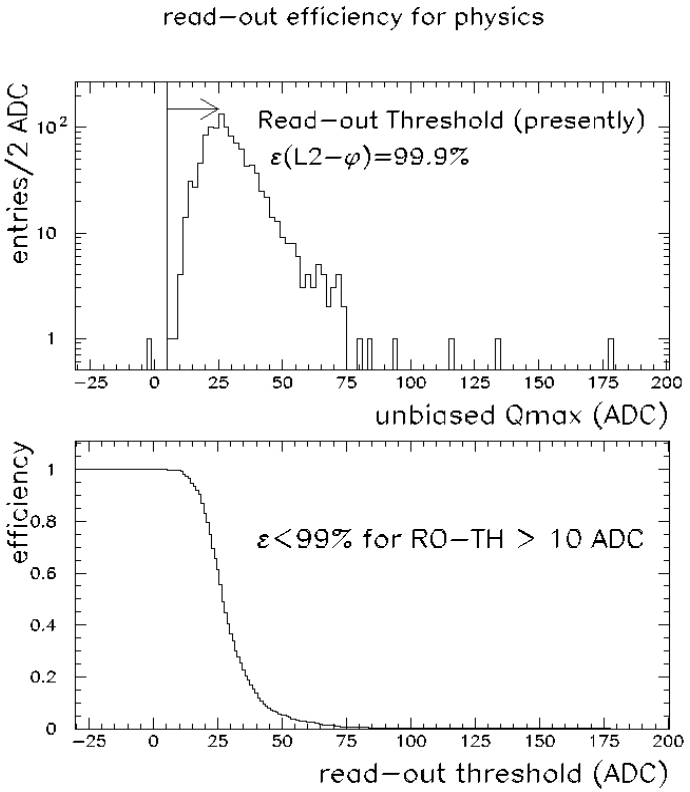
Silicon Performance (1)

Signal to Noise > 10

Efficiencies :

Single Hit ε > 99%

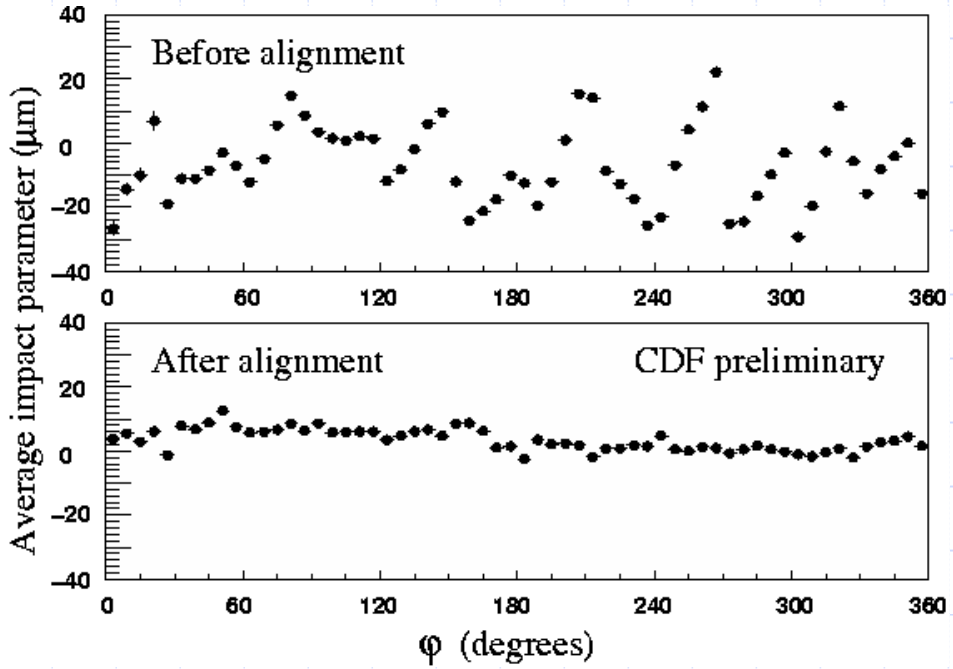




Silicon Performance (2)

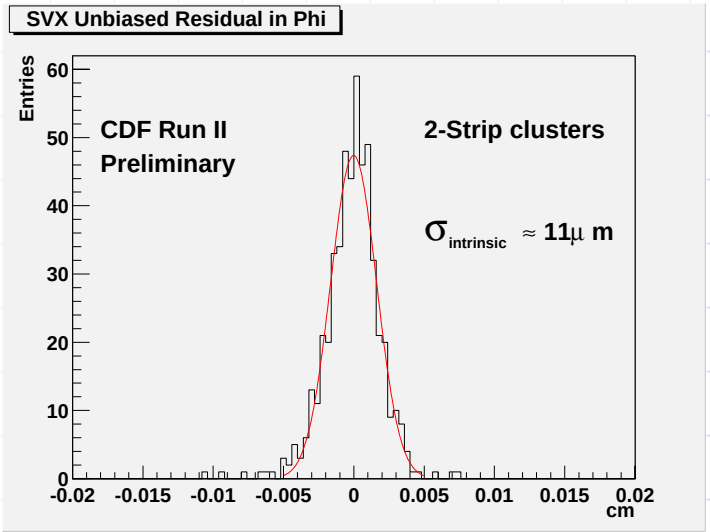
Alignment : d0 vs. ϕ

before and after

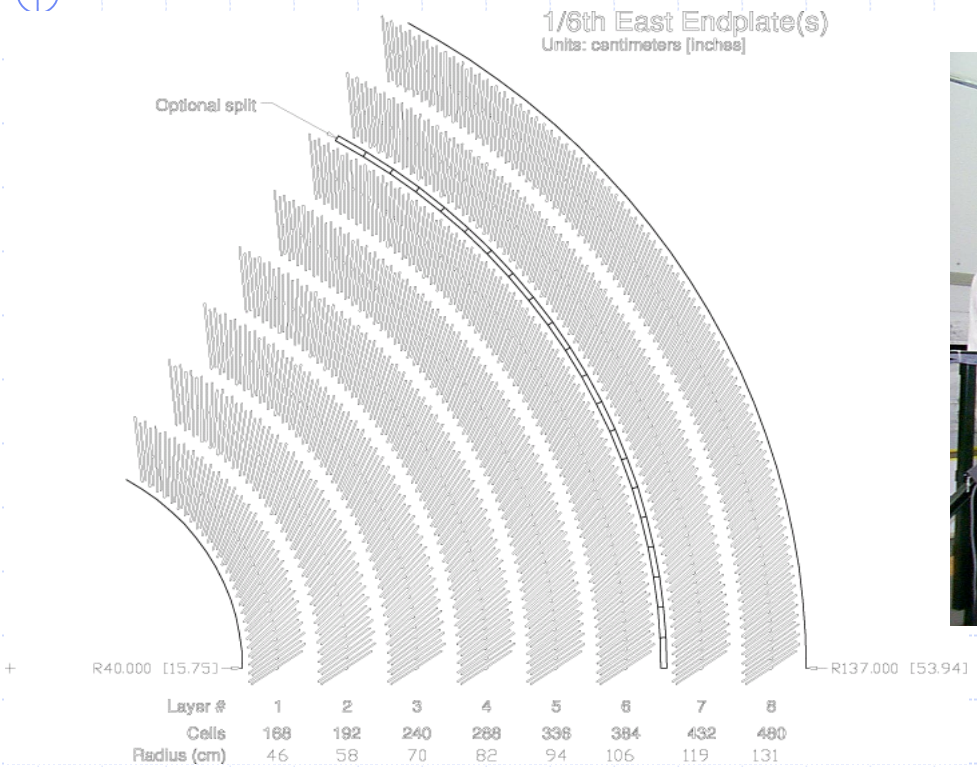


SVX II resolution

residual ~ 11μm



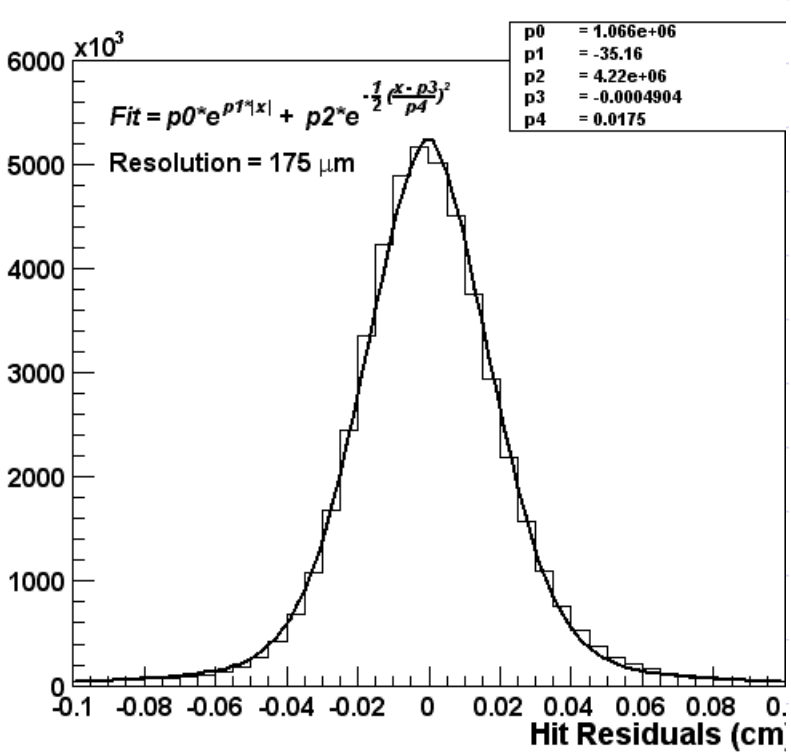
COT (Central Outer Tracker)

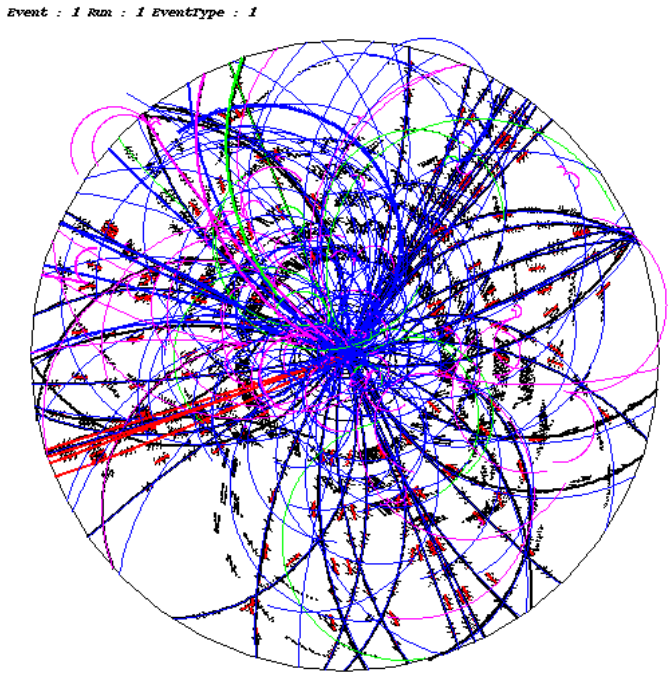


- Small (open) cells, Maximum drift distance = 0.88cm
- Maximum drift time = 100ns
- 8 Super Layers x 12 wires = 96 points

COT Tracking

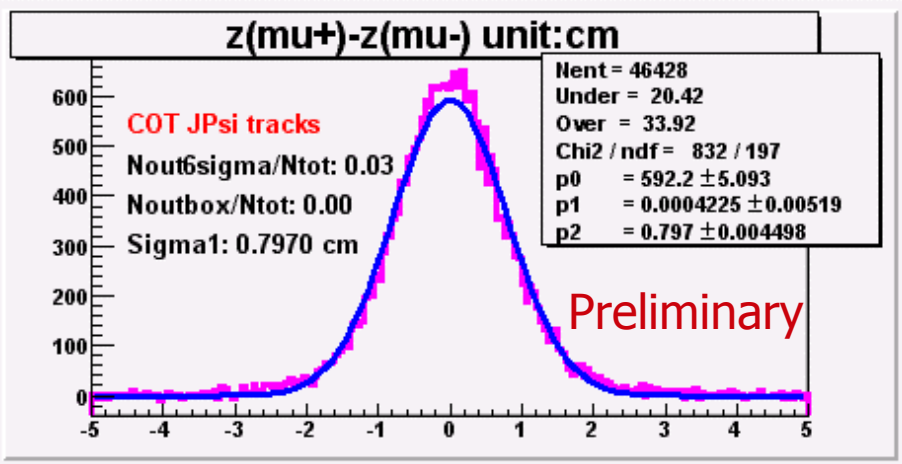
- σ = 175 μm
- Maintain Run I momentum resolution



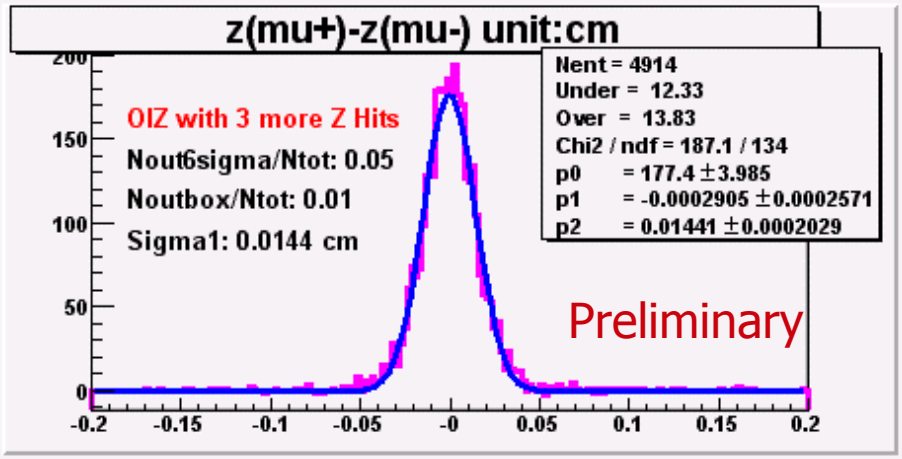


Z Resolution

ΔZ distributions for J/ψ -> μμ tracks

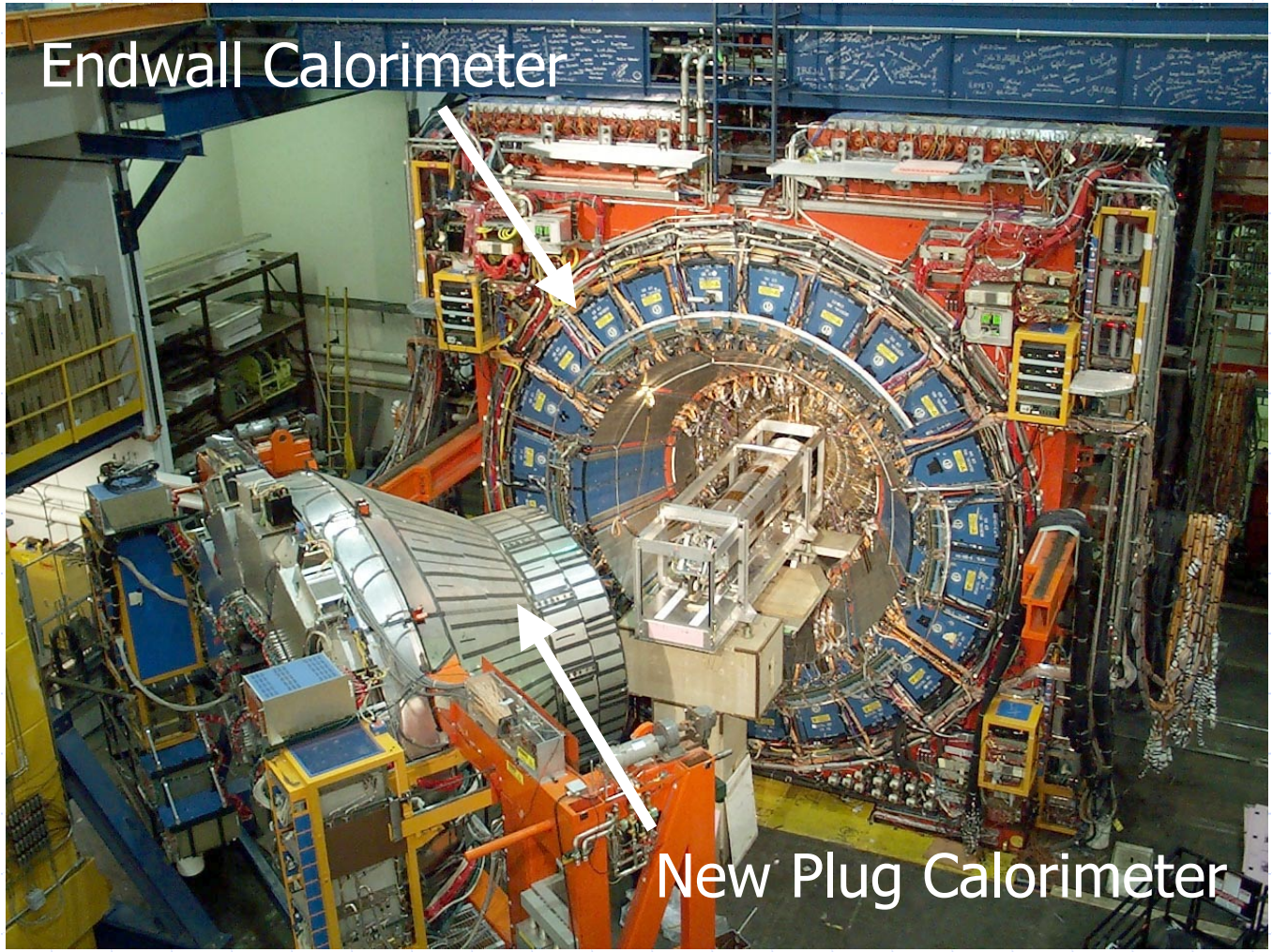


COT only



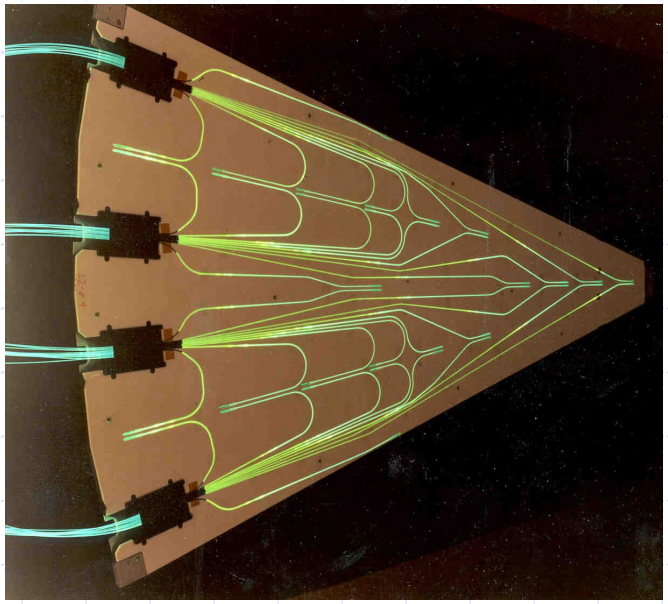
High quality SVX tracks

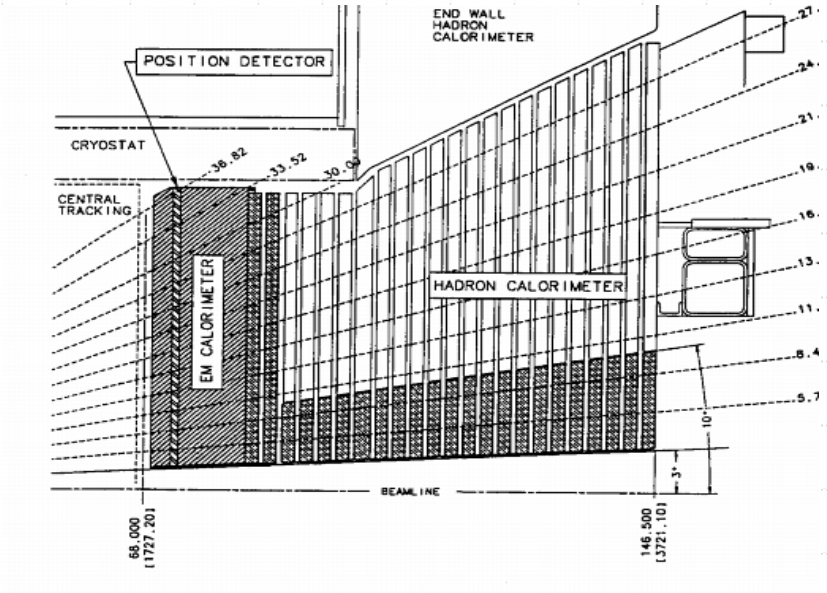
Calorimeters



Plug Upgrade Calorimeter

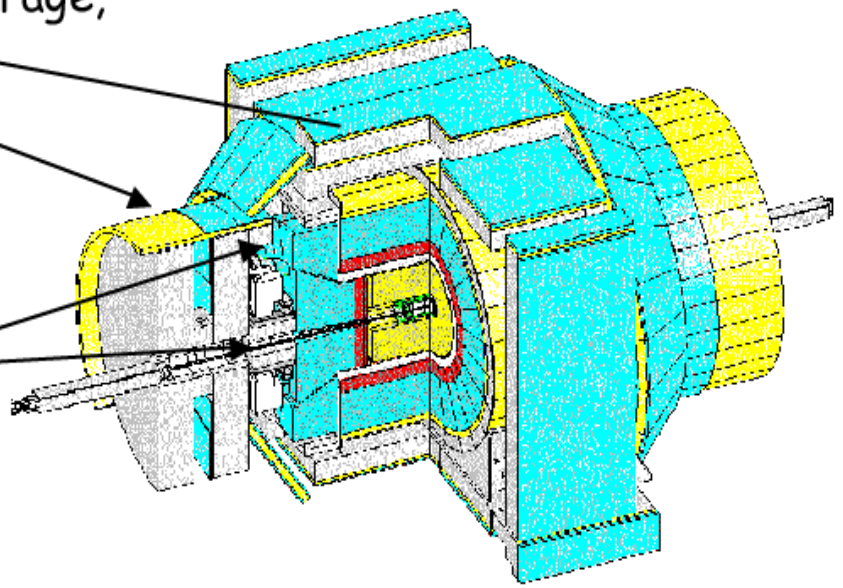
- Scintillator + WLS with lead(EM)/steel(Hadron)
- Fast and hermetic ($1.1 < |\eta| < 3.6$)
- Segmentation : $\Delta\phi = 15^{o}, 7.5^{o}$, $\Delta\eta = 0.1 \sim 0.6$





Muon Detector Upgrade

- Increase eta and phi coverage,
- Higher rate capabilities
- Better trigger shielding

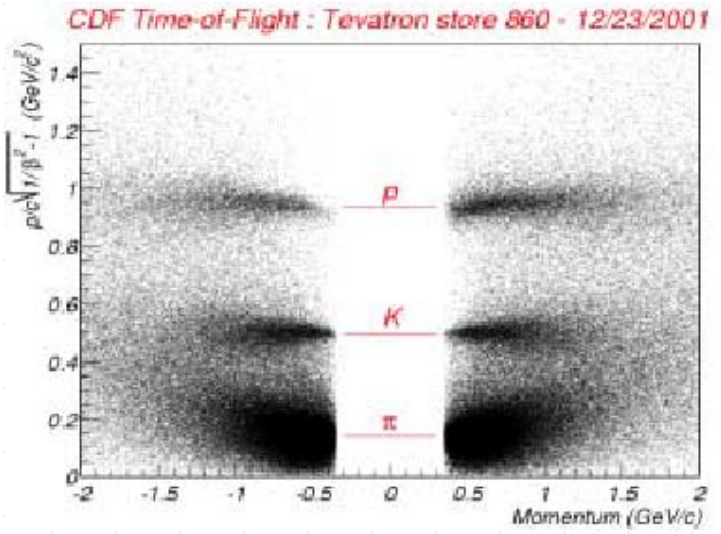


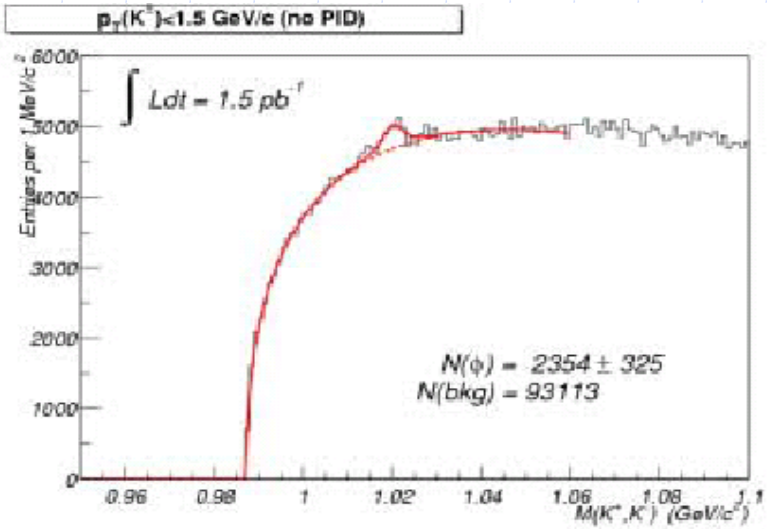
CDF total muon coverage increases by about 50%

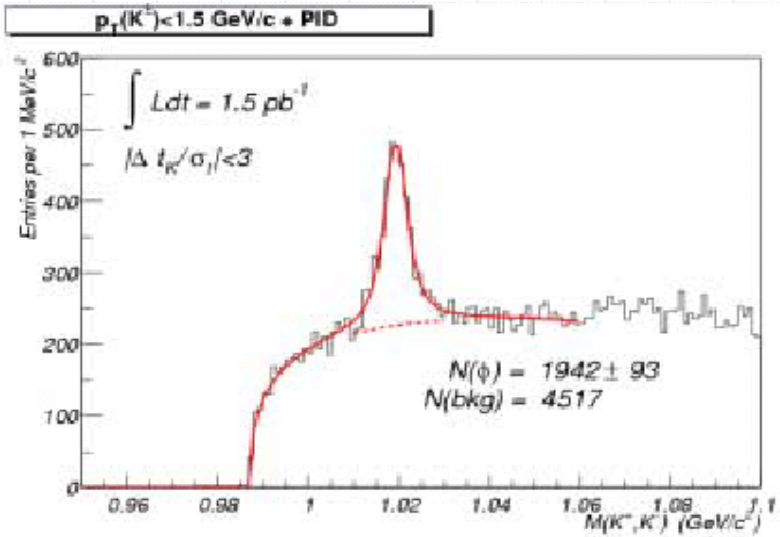
TOF Detector

TOF resolution :110ps (getting close to design 100ps)

Tag Kaons in ϕ -> KK

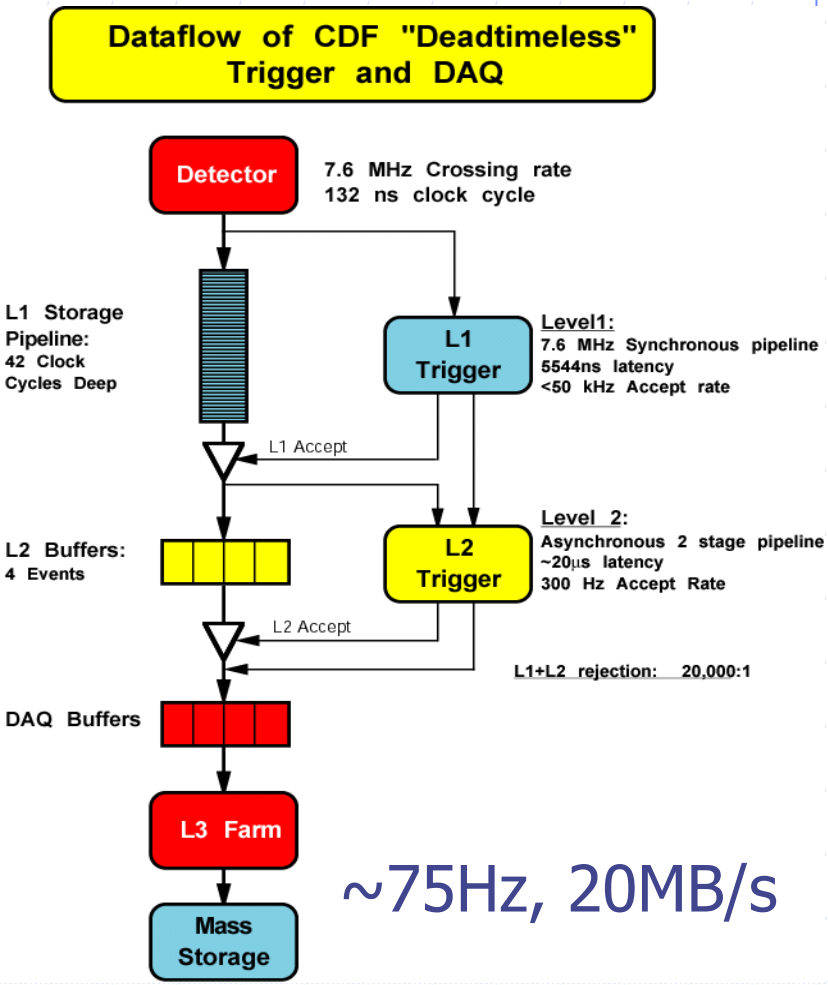






Run II Trigger System

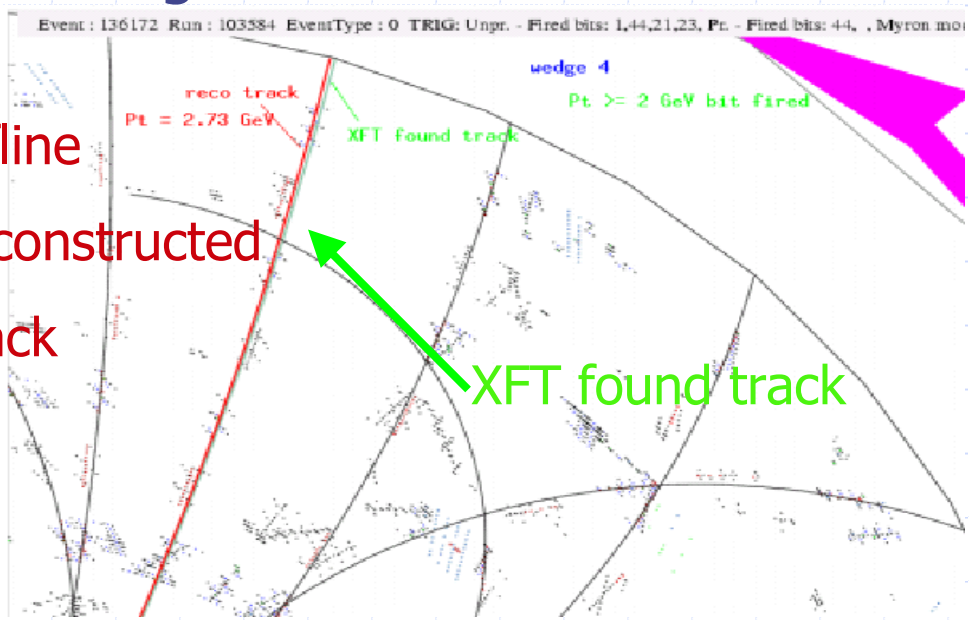
- Level 1 (5.5 μs latency)
  - Hardware Trigger
  - 50 kHz accept rate
- Level 2 (asynchronous)
  - Nominal 20μs decision time
  - Mostly hardware trigger
  - 300 Hz accept rate (-> 1kHz)
- Level 3
  - Linux boxes
- "Deadtimeless"



~75Hz, 20MB/s

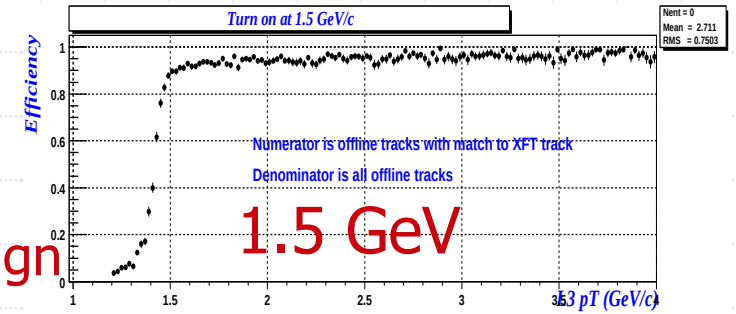
XFT (eXtremely Fast Tracker)

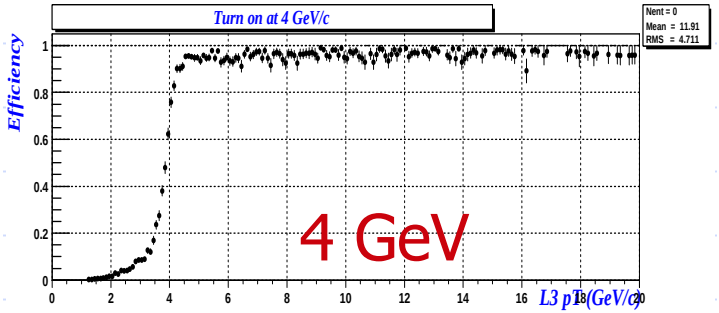
- Track trigger in Level 1
- High efficiency / purity
- $\Delta P_T/P_T^2 = 1.65\%$ Better than design
- angular resolution = 5.1mrad

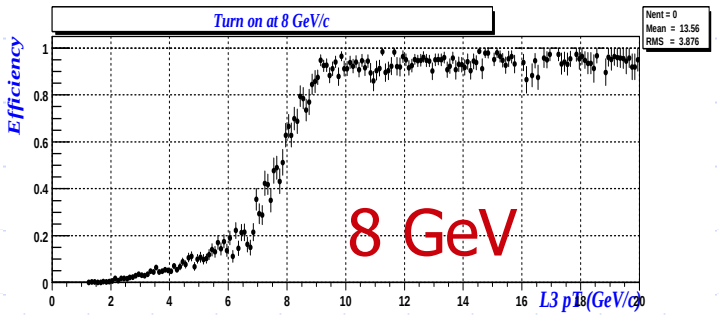


Offline Reconstructed Track

XFT found track

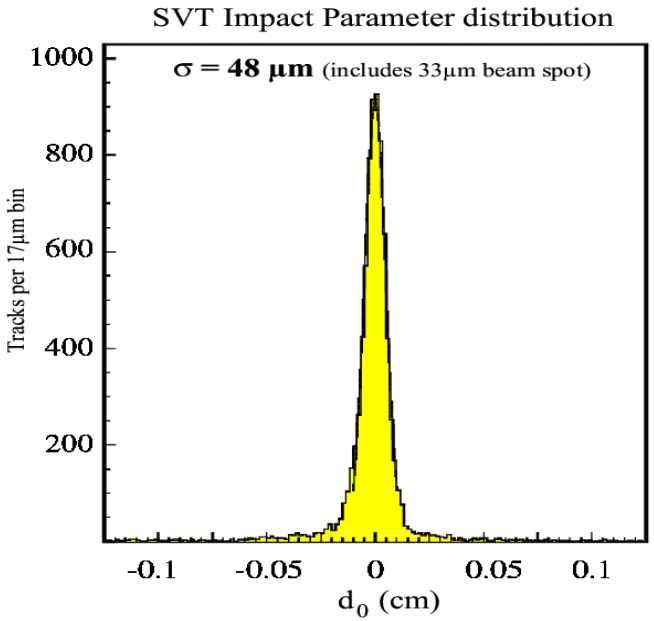


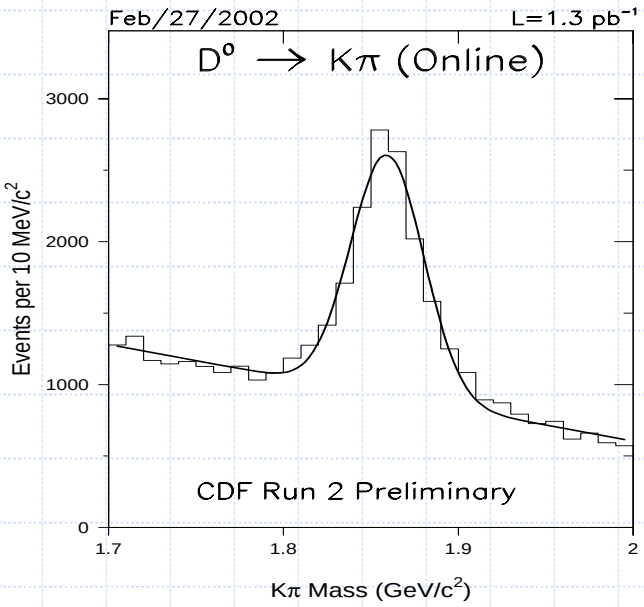




SVT (Silicon Vertex Trigger)

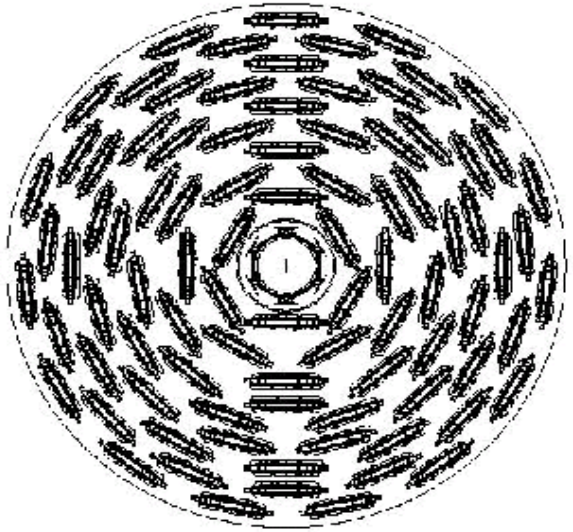
- Level 2 trigger using SVX hits and tracks from XFT trigger
- look for large d_0 in 2D
- d_0 resolution : σ = 48 μm incl. ~33 μm beamspot





Run IIb Upgrade Plan

- SVX replacement
  - Single-sided
  - Rad-hard
- Central preshower detector
  - scintillator-based
- TDCs for COT
- Level 3 trigger



Summary

- Significant luminosity improvement
  - Still need to continue progress
- CDF detector performing well
- Early physics results are ready to present