Backup slides

from now on only backup slides

Some Physics for 2fb^{-1}

with 2 fb^{-1} we expect to see (*per experiment*)

- ⇨ >3,000,000 W's (e and μ)
- ⇨ a few thousands Vγ
- ⇨ several hundreds VV (WW,WZ,ZZ)
- ⇨ O(10,000) ttbar pairs (hundreds of dilepton events)

☞ Δm_W~30 MeV/experiment

☞ Δm_t~3 GeV

- ⇨ Δm_H~±30%

Goals and current performance

$$L = \frac{10^{-6} fBN_p N_{pb} (6\beta_r \gamma_r)}{2\pi\beta^* (\varepsilon_p + \varepsilon_{pb})} H(\sigma_l / \beta^*)(10^{31} cm^{-2} s^{-1})$$

Protons/bunch	170 (140)	270	10^9
Pbar/bunch	22	30	10^9
Total Pbar	800	1080	10^9
Peak Pbar prod. rate	130	200	10^9/hour
Pbar:injection→ low β	0.75(0.54)	0.9	
Pbar:AA→ low β	0.60(0.32)	0.81	
P emittance	20	20	π mm-mr
Pbar emittance	18	15	π mm-mr
Beta at IP	0.35	0.35	m
Beam Energy	980	1000	GeV
Bunch length (p, rms)	0.61	0.37	m
Bunch length (pbar, rms)	0.54	0.37	m
Form Factor	0.62	0.74	
Typical lum.	3.2	8.1	$10^{31}cm^{-2}s^{-1}$
Integrated L	6.7	16	pb^{-1}/week

Cause for ladder failure

Silicon damage due to component failure (704 total ladders in L00+SVX+ISL)

- 2 DOIMS failed during L2 torture tests
  - Results in loss of entire ladder (r-φ and z sides)
  - No failures of this type after June 27, 2002
    - → Set 12 kHz limit on L1 accepts
    - → Ban on DAQ "torture" tests
  - Failure may be to Lorentz forces on wirebonds
- 12 jumpers have failed, some during normal operation
  - Results in loss of half ladder (z side only)
  - Failure mechanism known to be Lorentz forces on wirebonds
  - No failures since October 5, 2002
    - → Set 12 kHz limit on L1 accepts
    - → Implemented auto HRR second week in October
- **13 AVDD2 failures**
  - Results in partial ladder failures. Effects one chip and all behind it in a readout chain.
  - 6 failures due to beam incident on March 30, 2002
  - 2 failures due to beam incident on November 9, 2002
  - Reminder due to infant mortality or operation changes
- Dedicated Task Force in place
  - Reducing/eliminating causes of failures
  - Making good progress on understanding causes

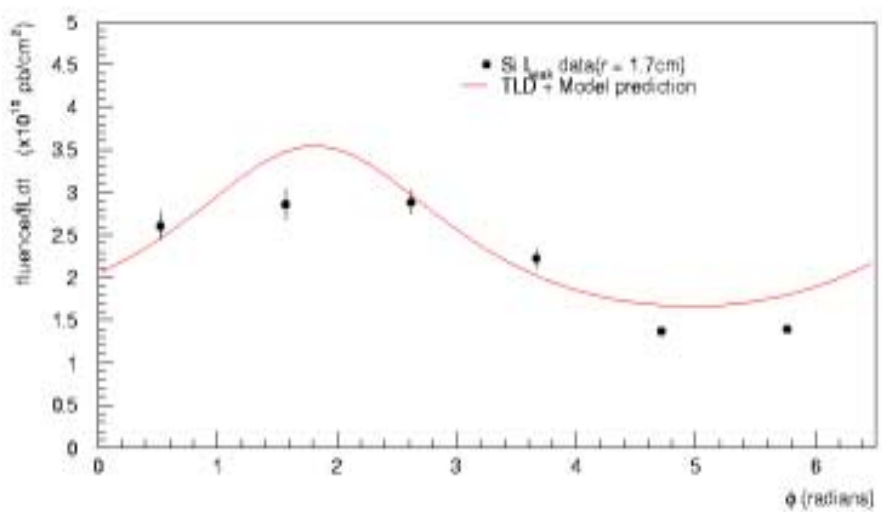
Radiation damage to silicon

Example: lifetime of CDF silicon detectors based on Run I experience:

Layer	safe fb^{-1}	cause
0 (SS)	7.4	Vdep
1 (DS)	4.3(5.6)	S/N(Vdep)
2 (DS)	8.5(10.9)	S/N(Vdep)
3 (DS)	10.7	Vdep
4 (DS)	23(30)	S/N(Vdep)
5(DS)	14	Vdep
6(DS)	>40	n/a
7(DS)	> 40	n/a

Run I data: $r^{-\alpha}$, α=1.7

Run 2 data: $r^{-\alpha}$, consistent with expectations

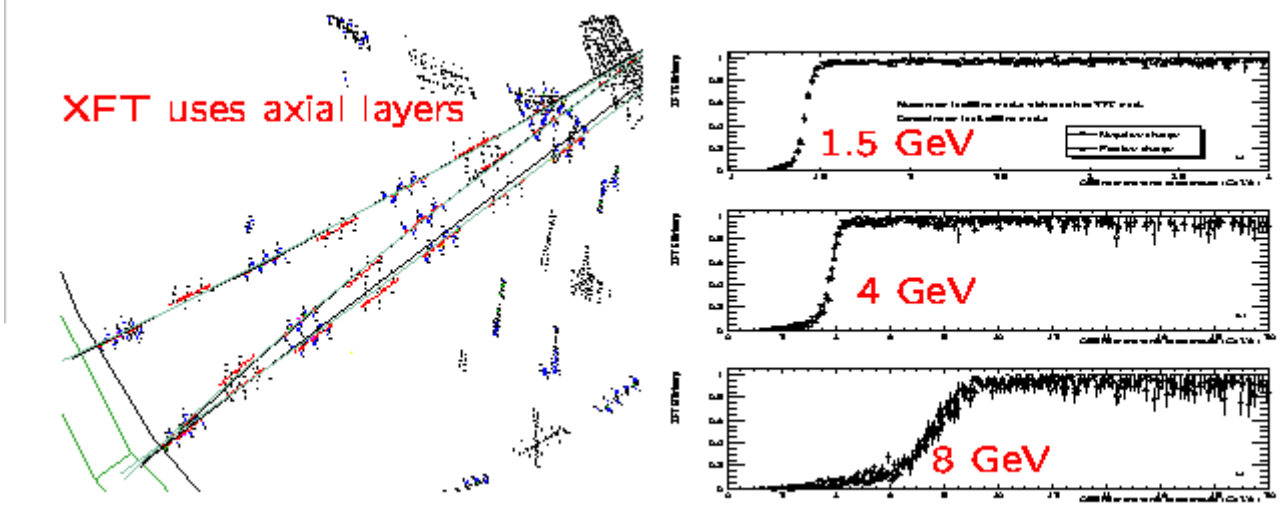


XFT

eXtremely Fast Tracker

☞exploits axial segments measured by COT

XFT P_t turn on

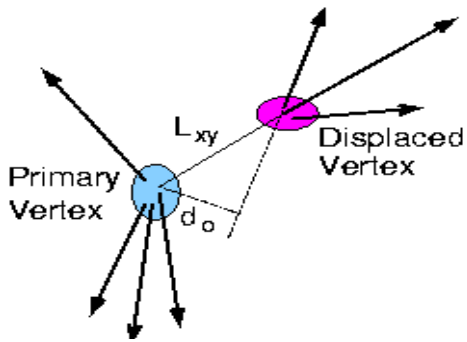


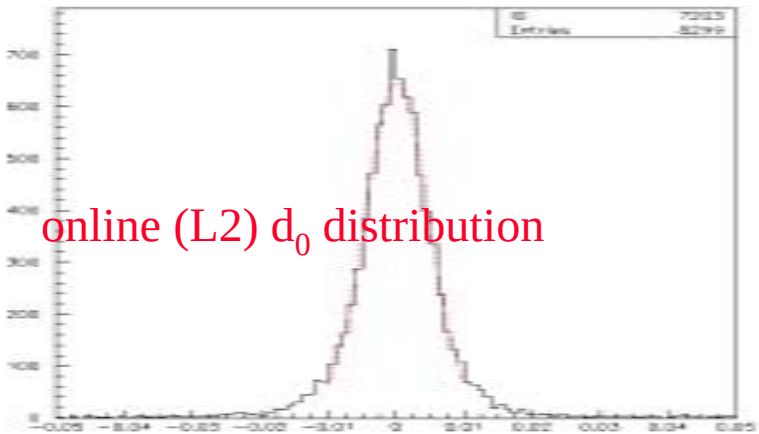
Measured XFT $\Delta P_t/P_t^2 = 1.65\%$
Measured angular resolution 5.1 mrad.

SVT

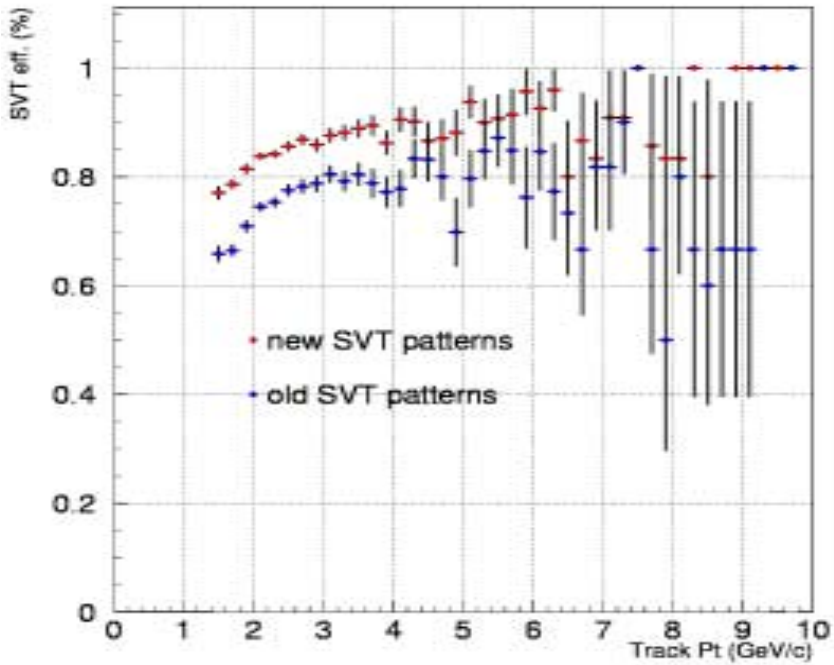
Secondary Vertex Trigger at L2 using SVX

- online primary vertex
- ε about 80 % (improving)
- d_o resolution as by design:





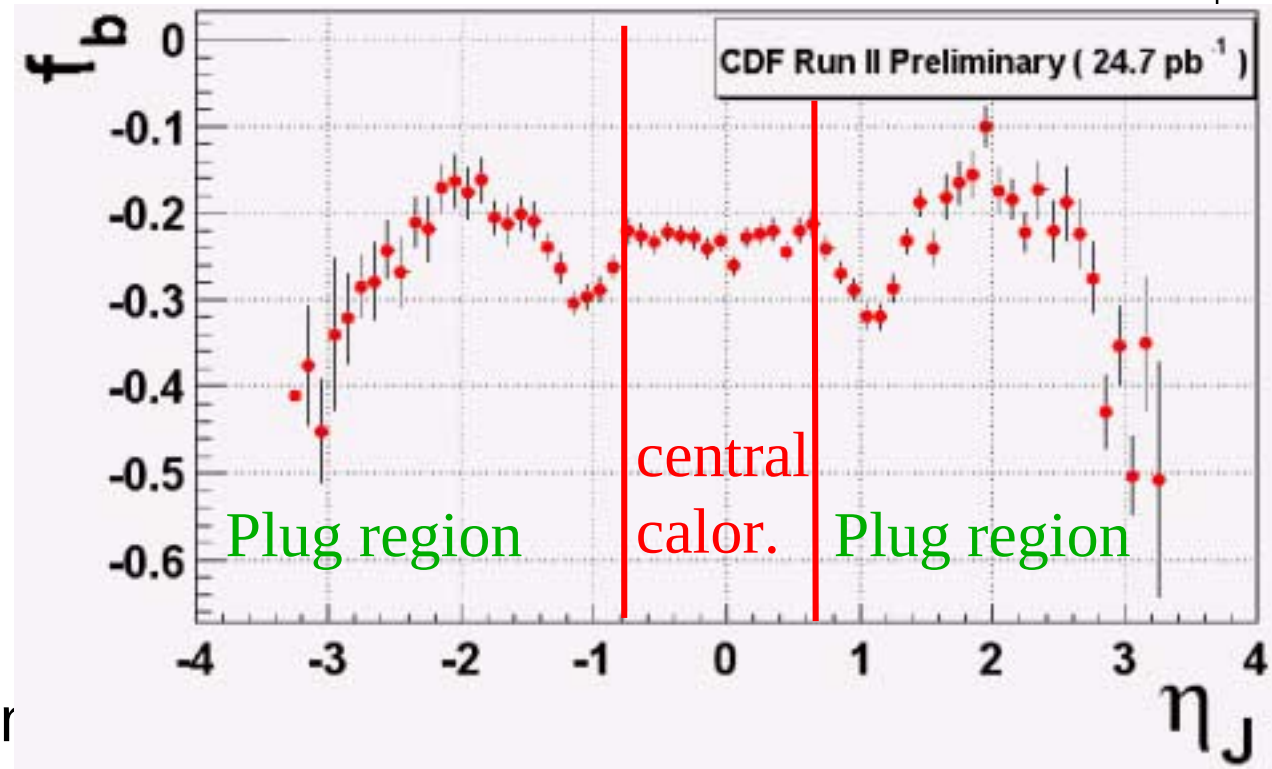
SVT Efficiency

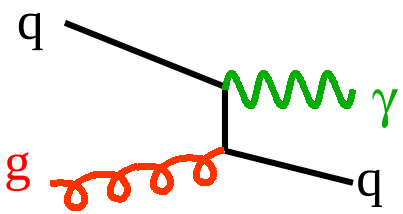


Hadronic Energy Scale

Use J/ψ muons to measure MIP in had. calorimeters

- (Run II)/(Run 1) = 0.96±0.05



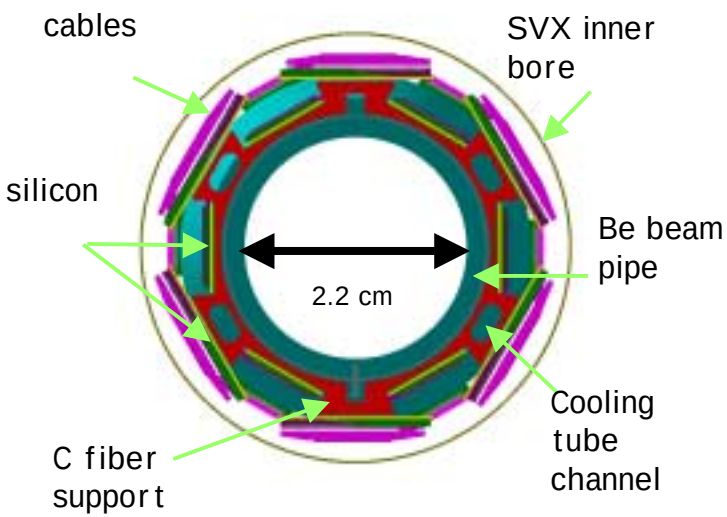


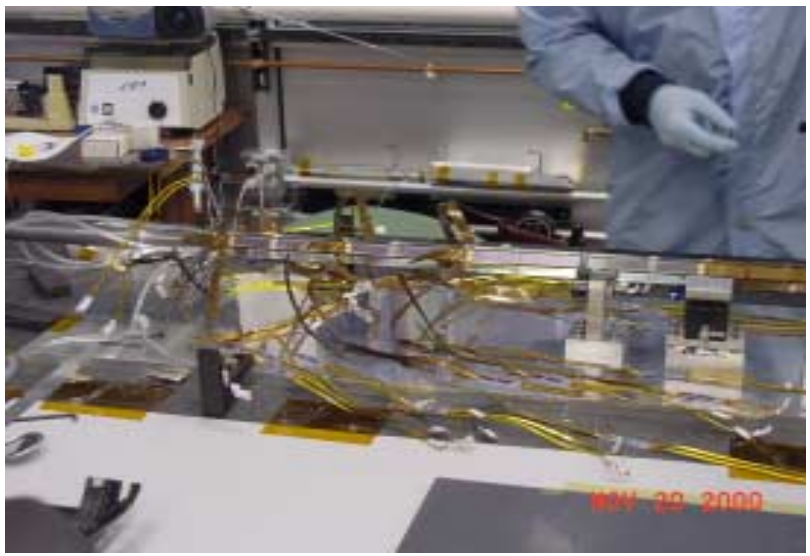
- Gamma-jet balancir
  - $f_b = (p_T^{jet} - p_T^{\gamma})/p_T^{\gamma}$
    - Run Ib (central): $f_b = -0.1980 \pm 0.0017$
    - Run II (central): $f_b = -0.2379 \pm 0.0028$

$\Delta f_b = (4.0 \pm 0.4)\%$

  - Plug region corrections in progress

Layer 00: Beampipe Layer



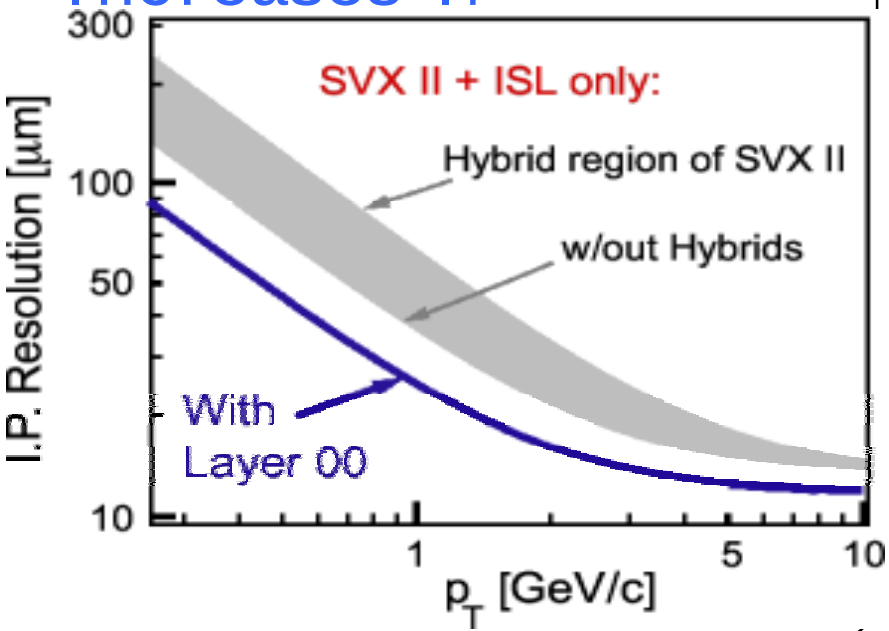


SS layer on beampipe

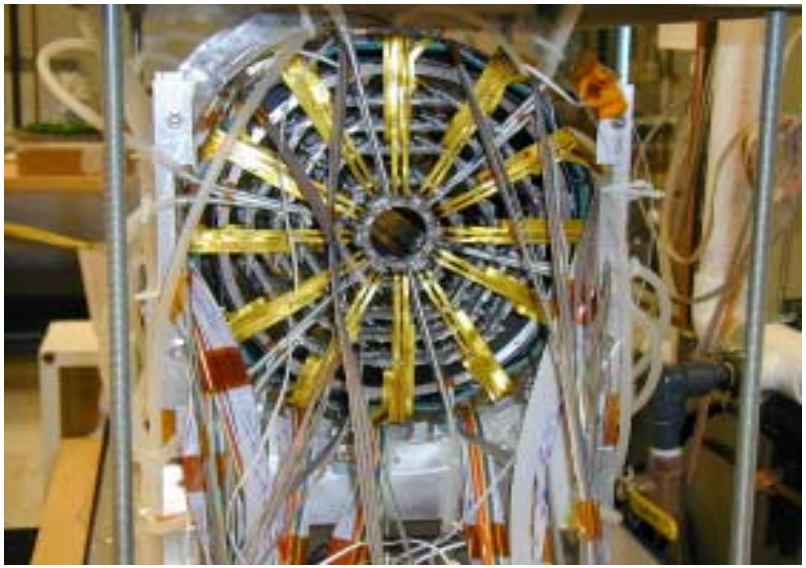
- ☞Rad hard, Cooling issues

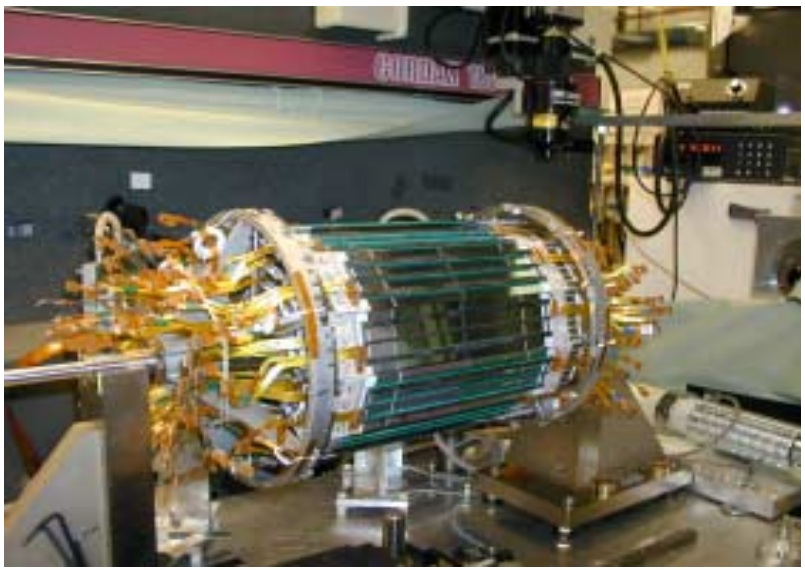
48 ladders, 13824 Chans

Increases IP



SVXII Barrels





5 DS Layers (3 90°, 2 1.2°), 2.5 <r< 10.6 cm, l=0.9 m

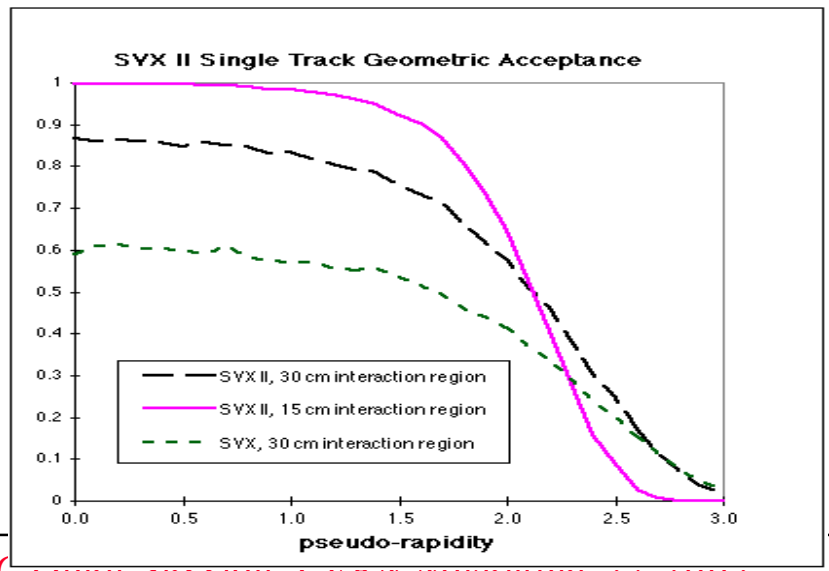
6 (z)x12(φ)x5 (r) =360 ladders, 405505 Chan

Standalone 3D tracking

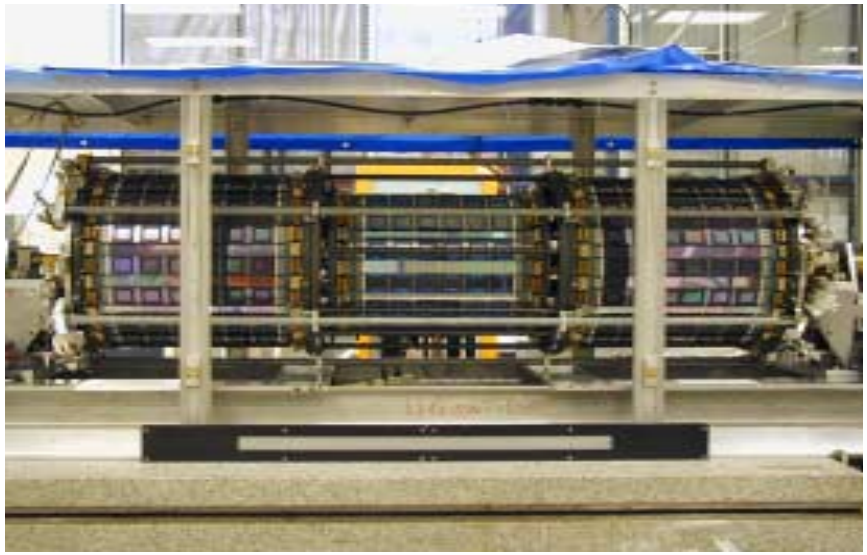
"Displaced track" trigger

- ☞ Alignment critical

Enhanced coverage



Intermediate Silicon Layers



The answer to "What about the space between the SVXII and the COT?"

2 DS 1.2° layers, r = 20,28 cm, l = 1.9 m!

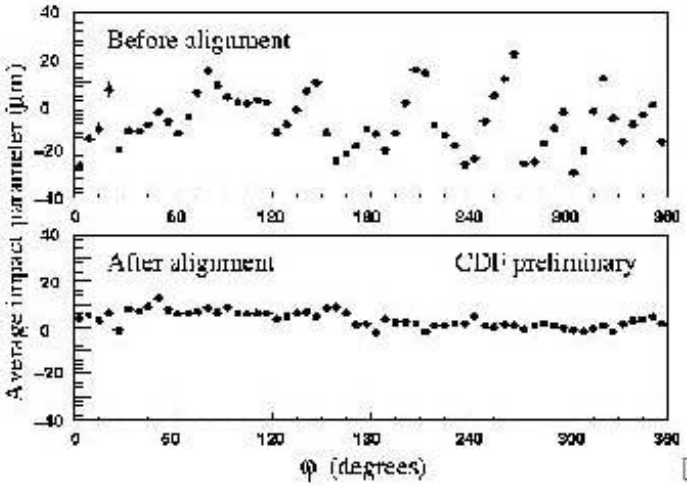
- ☞ Central layer: links to COT

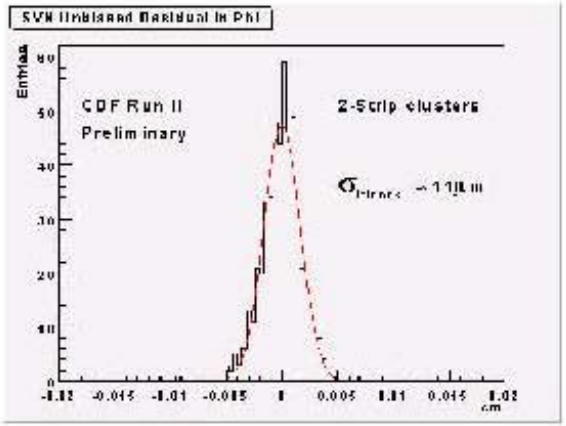
Outer layers: hits to $|\eta|<2$

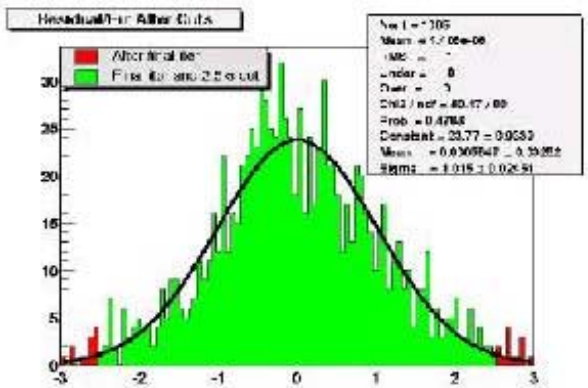
296 ladders, 303104 Chans

CDF Si Detector

Silicon Performance(2)



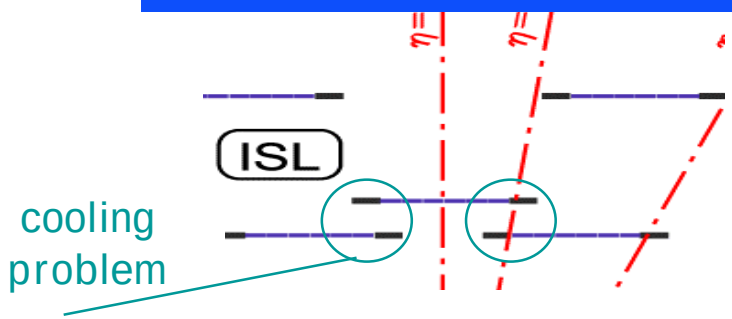




- **SVXII Alignment**
  - d0 vs. φ before and after
- **SVXII 2 Strip Resolution**
  - Deconvolute pointing resolution ⇒ residual ~ 11 μm
  - Track by track pull has σ = 1

CDF Run II Tracking– S. Nahn July 25, 2002 *ICHEP Parallel Session 13*

ISL Cooling Problem



Unable to cool central part of ISL:

- Solid blockage experienced
- Appears at Al elbows (glue blockage seen with boroscope)
- Laser successfully remove glue 9/12 lines so far, finish next long shutdown

Wirebond Failures

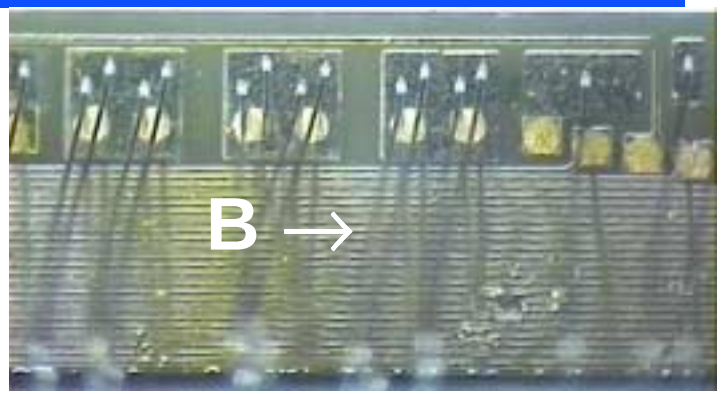
Loss of digital power on 13/360 SVXII Z sides

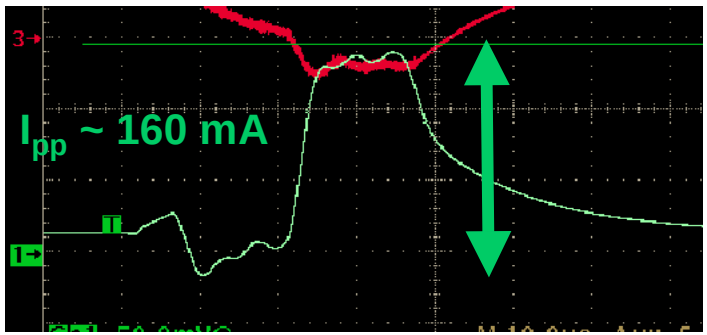
Theory: fatigue from Lorentz force

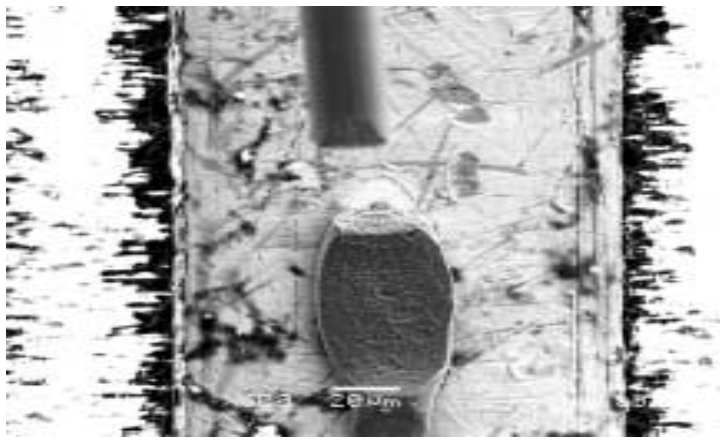
- ☞ Bond I orthogonal to **B**
- ☞ I ∝ occupancy
- ☞ L1A rate ⇒ Resonance?
- ☞ Tests convincing

Ongoing investigation

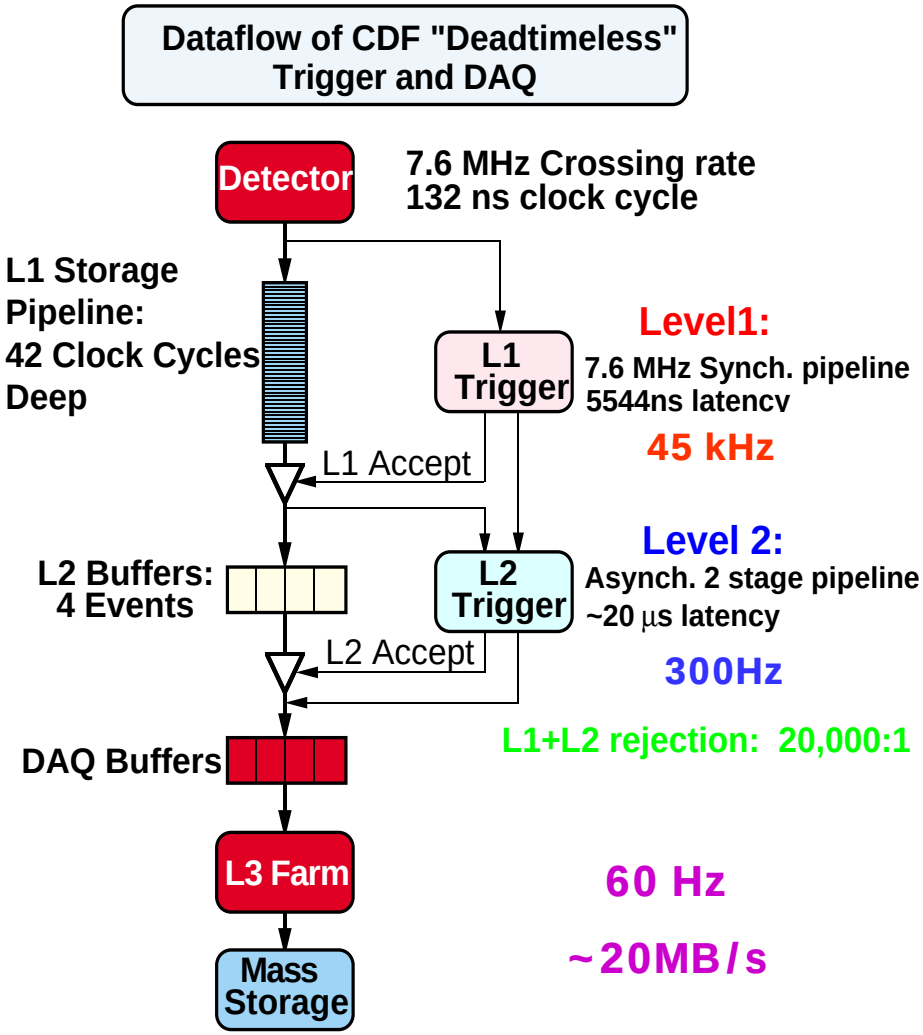
- ☞ Energy to blow bond from overcurrent not available (× 10)
- ☞ Aging tests ongoing
- ☞ Studies to reduce current and catch warning signs highest priority







Triggering in Run 2



Central Tracker (Pt,ϕ)
EM + HAD/EM + Track
EM+HAD (Jet)
Muon + Track
Missing E_T, ΣE_T

Si Secondary vertex
EM shower max, ISO
Jet Clustering
Multi object triggers

Farm of ~200 PC's running fast versions of Offline Code ➔ more sophisticated selections

Hadronic B decays with SVT

Two paths

@ 3×10^{31} cm^{-2} s^{-1}

~ 3 KHz

- **L1**:
  - Two XFT tracks
  - $P_t > 2.5$ GeV; $P_{t1} + P_{t2} > 6.5$ GeV
  - $\Delta\phi < 135°$

~ 5 Hz

- **L2**:
  - $d_0 > 100$ μm for both tracks
  - Validation of L1 cuts with $\Delta\phi > 20°$
  - Lxy > 200 μm
  - $d_0(B) < 140$ μm

Two body decays

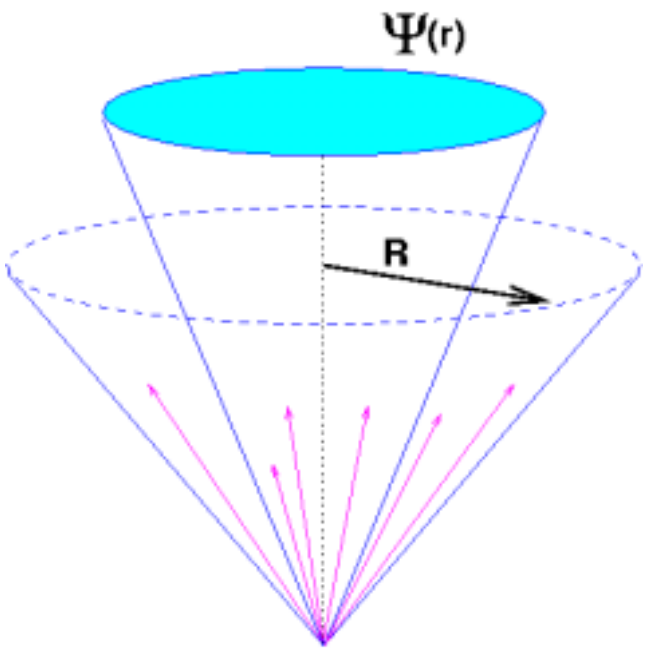
- **L1**:
  - Two XFT tracks
  - $P_t > 2.5$ GeV; $P_{t1} + P_{t2} > 6.5$ GeV
  - $\Delta\phi < 135°$
- **L2**:
  - $d_0 > 120$ μm for both tracks
  - Validation of L1 cuts with $\Delta\phi > 2°$
  - Lxy > 200 μm
  - ~~$d_0(B) < 140$ μm~~

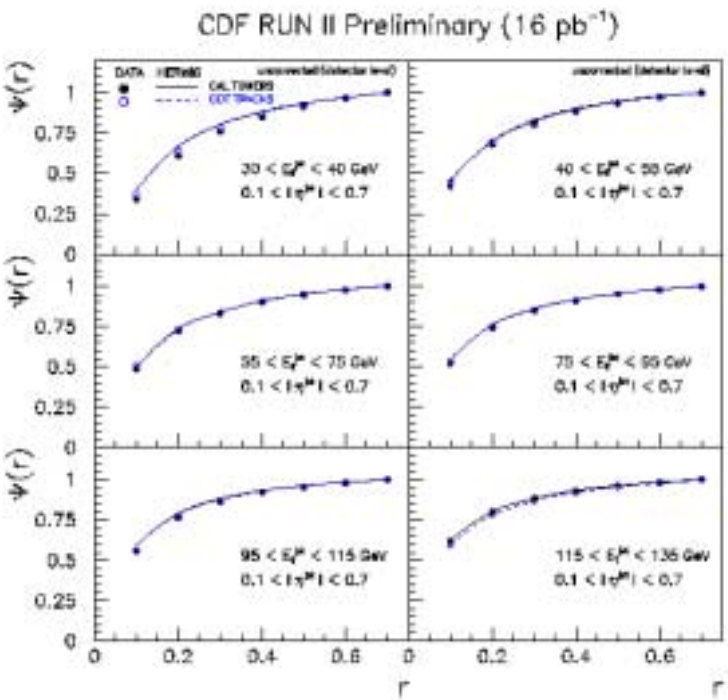
Many body decays

Jet Phyics

Study jet behaviour at 1.96 TeV and compare to MC distribution:

$$\Psi(r) = \frac{1}{N_{jets}} \Sigma_{jets} \frac{E_T(0,r)}{E_T^{jet}(0,R)}$$





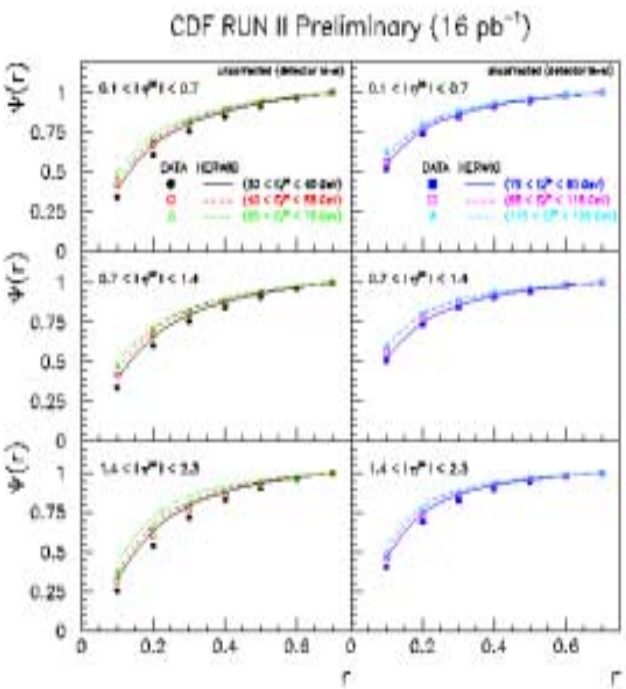
Still using fixed cone of R=0.7

Jet Phyics

Agreement good but not as good at large |η|

- compare different Et bins (calorimeter only) vs Herwig for various η bins:
  30<Et<135

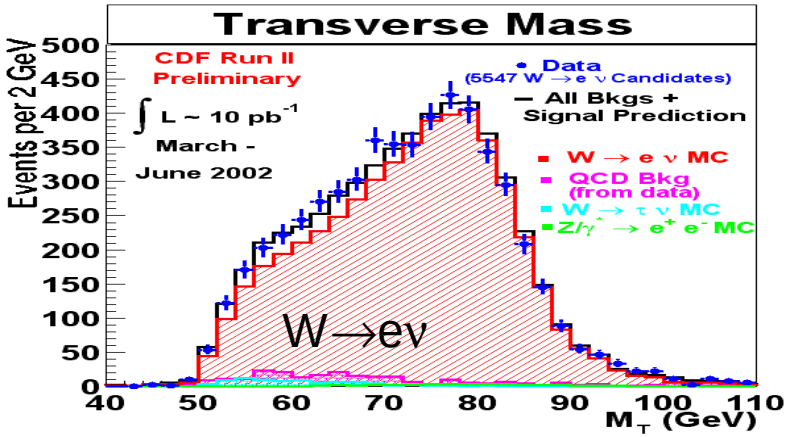
  0.1<η<2.3

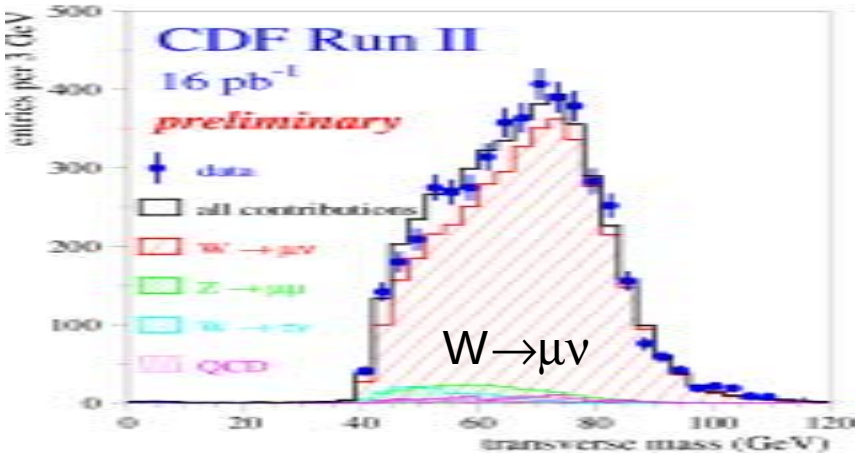


- jets get narrower with Et

- Herwig predics too narrov jets at large η

First EWK Physics Results





$\sigma x Br(W\to e\nu)$	2.60±0.07(stat)±0.11(syst)±0.26(lum) nb
$\sigma x Br(W\to \mu\nu)$	2.70±0.04(stat)±0.19(syst)±0.27(lum) nb

Expectation at $\sqrt{s}$= 1.96 TeV: 2.73 (Stirling, NNLO)

$$R_\mu = \frac{\sigma(p\bar{p}\to W)\,\Gamma(W\to\mu\nu)\,\Gamma(Z)}{\sigma(p\bar{p}\to Z)\,\Gamma(Z\to\mu\mu)\,\Gamma(W)}$$

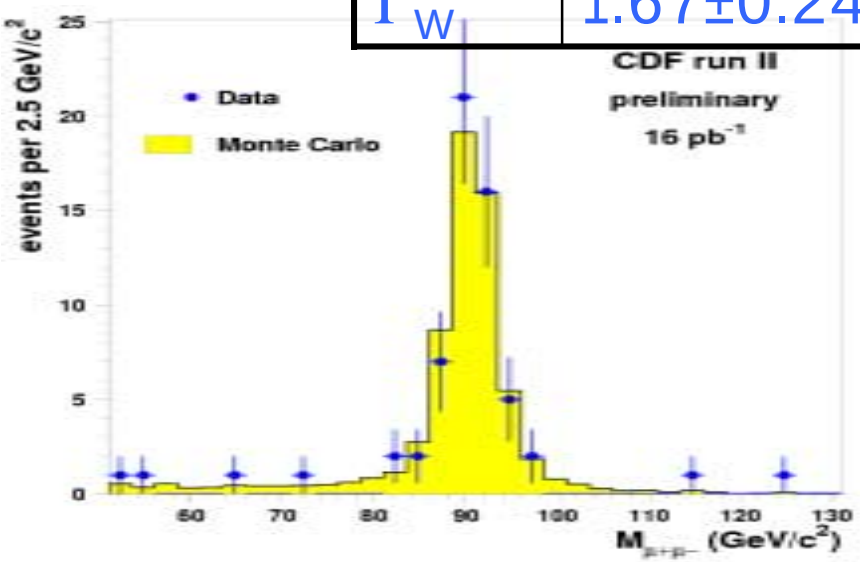
R_μ	13.66±1.94(stat)±1.16(syst)
Γ_W	1.67±0.24(stat)±0.24(syst)±0.01(th.)

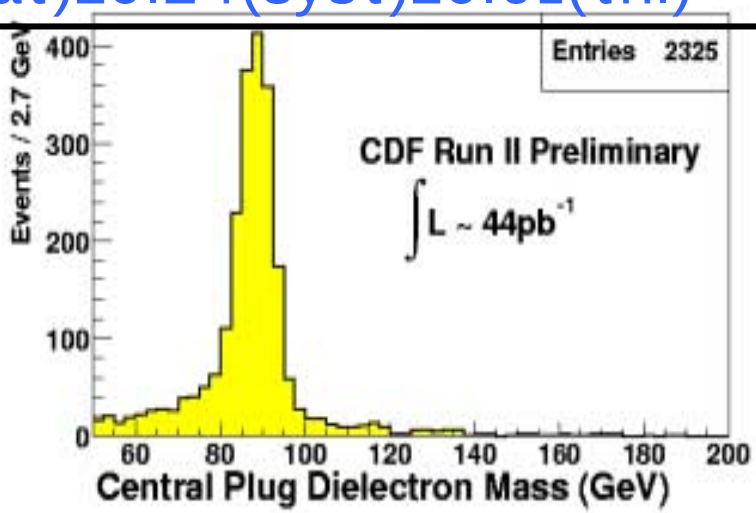
Electroweak Physics-Z

Z can be reconstructed using:

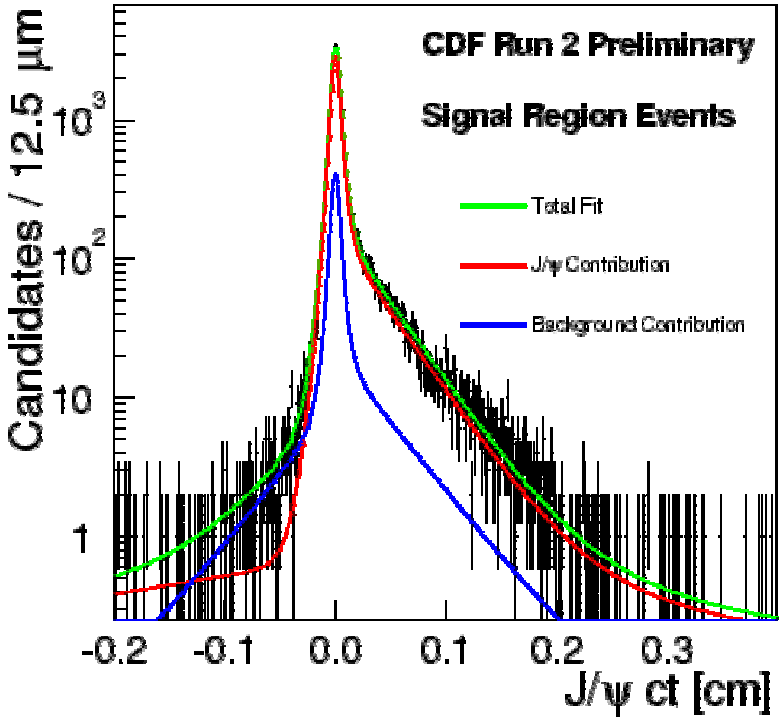
- two electrons
  - both in central calorimeter
  - one in central one in plug
  - both in plugs (in progress)
- two muons

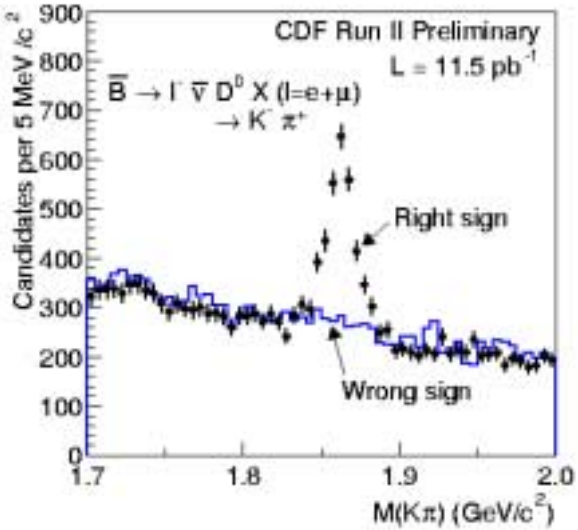
R_μ	13.66±1.94(stat)±1.16(syst)
Γ_W	1.67±0.24(stat)±0.24(syst)±0.01(th.)

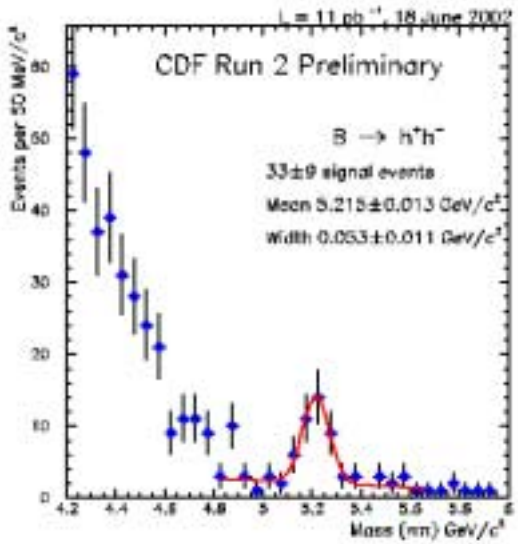




Other B Physics results







Inclusive B lifetime with J/ψ's

$c\tau = 458 \pm 10_{stat.} \pm 11_{syst.}$ μm (PDG: 469±4 μm)

Exclusive $B^+ \rightarrow J/\psi K^+$ lifetime

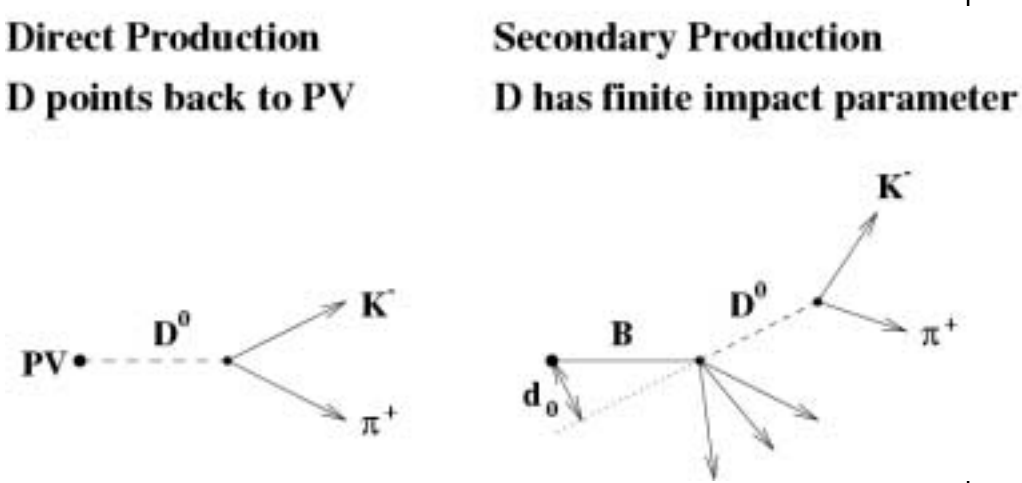
$c\tau = 446 \pm 43_{stat.} \pm 13_{syst.}$ μm (PDG: 502±5μm)

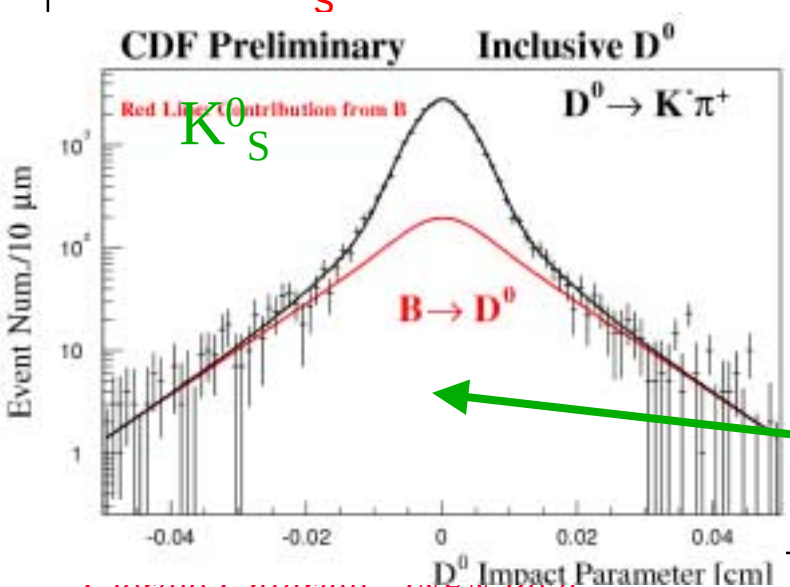
Clear B hadron peak

Hadronic b triggers 1

D mesons:

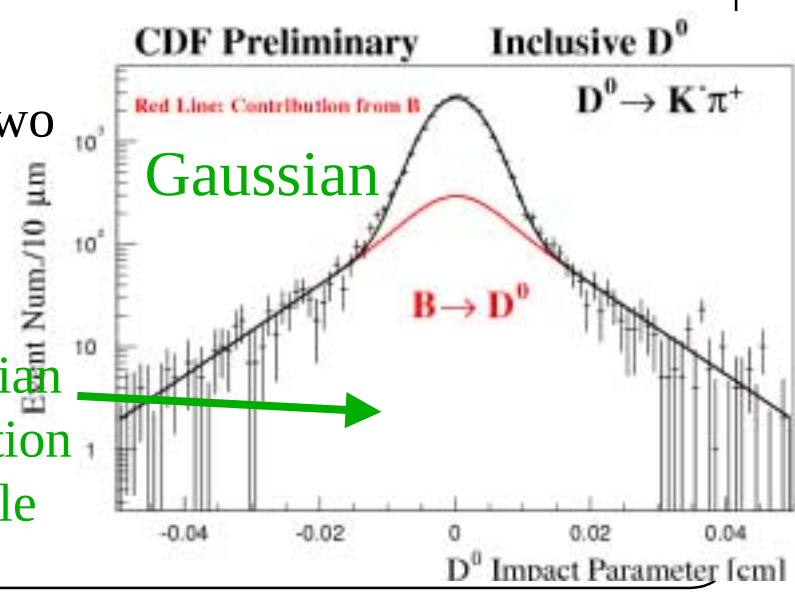
- What fraction from B?
  - D^0: 16.4-23.1%
  - D^{*+}: 11.4-20.0%
  - D^+: 11.3-17.3%
  - D_s^+: 34.8-37.8%



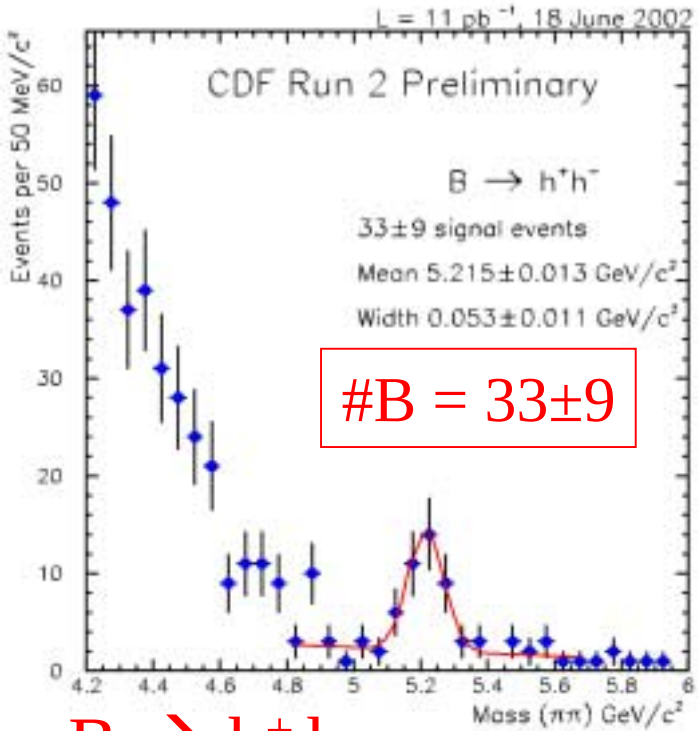


Range of fract. from B using two extreme resolutions functions:

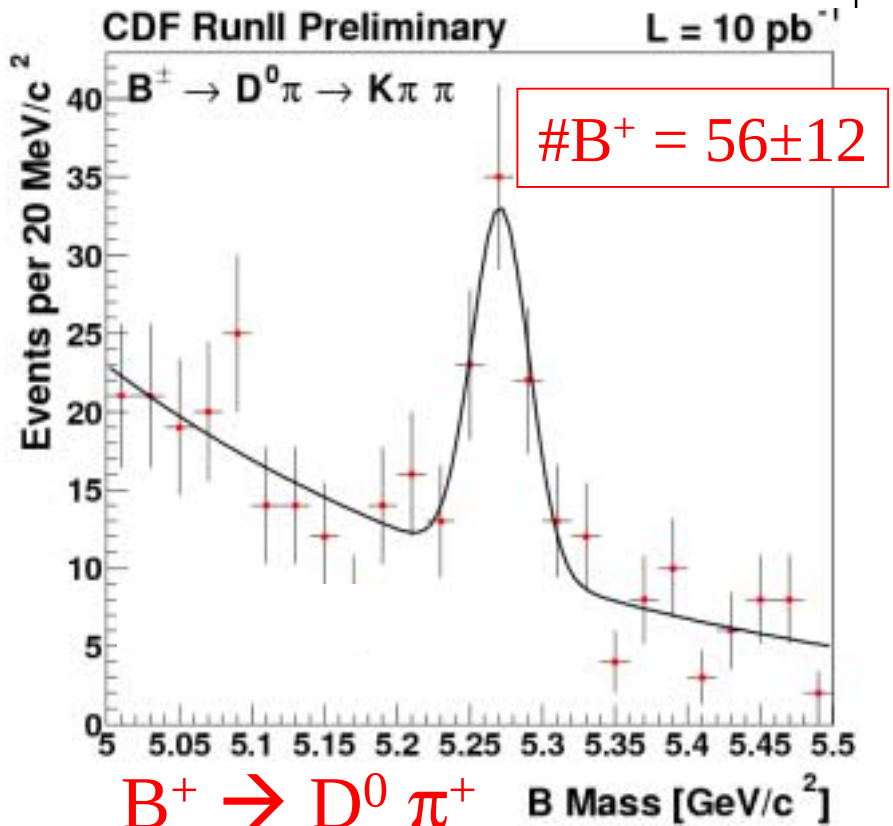
- single gaussian
- parametrization from K^0_S sample



Hadronic b triggers 2



$B \rightarrow h^+ h^-$



$B^+ \rightarrow D^0 \pi^+$

Hadronic B decays observed

- Yield lower than expected (silicon coverage/SVT efficiency > x 3)
- S/N better than expected
  - Better S/N dilution compensates reduced statistics

CDF exp.: sin2β with ψK^0_S

$$\delta(\sin(2\beta)) \approx \frac{1+x_d^2}{x_d}\frac{1}{\sqrt{\varepsilon D^2 N}}\sqrt{\frac{S+B}{S}}$$

- Scale from Run I
  - εD^2 (NO K-tag)
  - S/N ratio

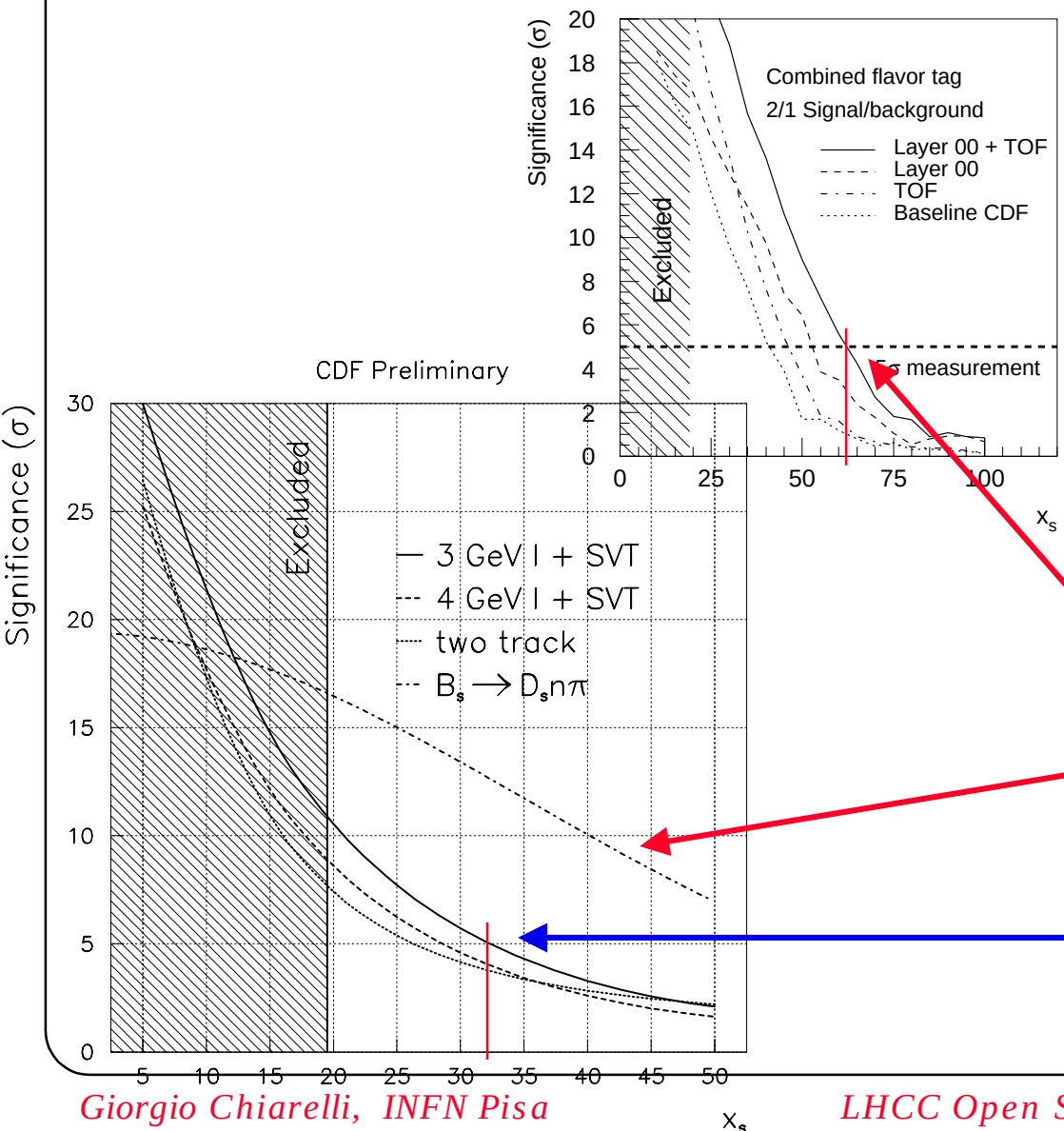
Time integrated error: ~ 1.5 better with time evolution

Scenario	εD^2	$N(\psi K_s)$	$\sigma(\sin 2\beta)$
μ trig., No K tag	6.3%	10,000	0.12
μ+e trig., No K tag	6.3%	15,000	0.10
μ+e trig., with K tag (TOF)	9.2%	15,000	0.08
Above + trigger improv.	9.2%	28,000	0.06

- Assume 2 fb^{-1}
- Systematic~0.5xstatistical
  - Scales with control sample statistics

- **$N(\psi K_s)$ from scaling run I data**
  - x20 luminosity 8,000 events
  - x1.25 tracks at Lv1 trigger 10,000 events
  - Trigger on $\psi \rightarrow e^+e^-$ 5,000 events
  - Other trigger improvements 28,000 events (e+μ)

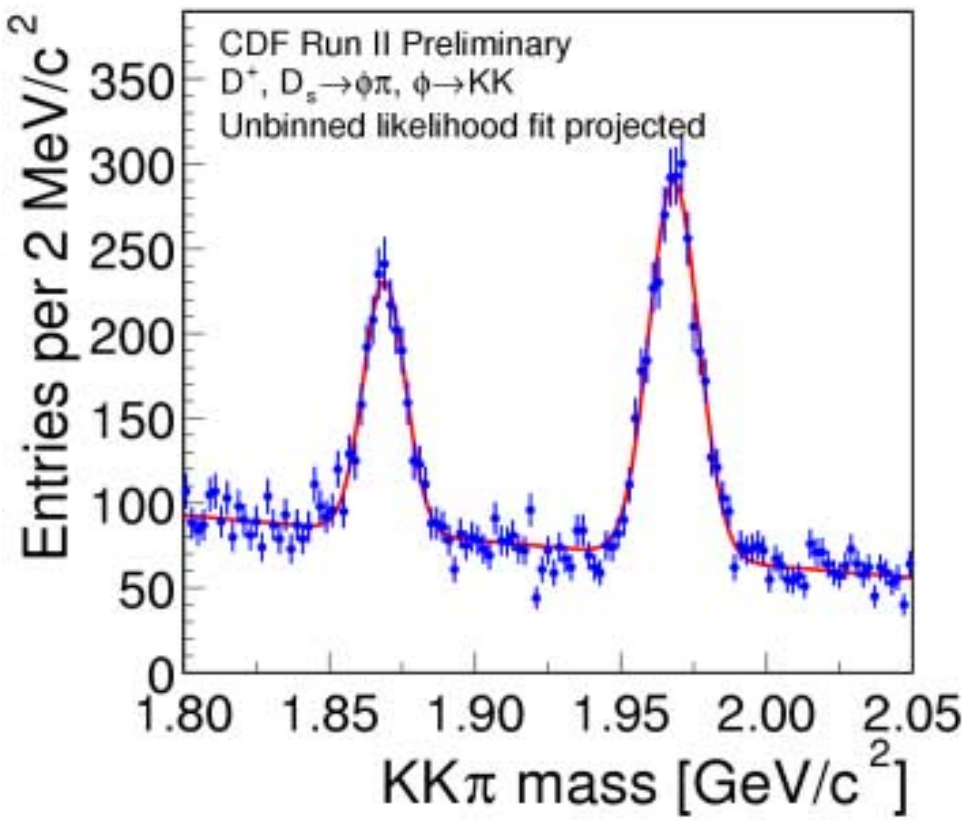
CDF expectation: Bs mixing



- x_s measurement
  - $B_s \rightarrow D_s \pi$, $D_s 3\pi$
  - Signal ~ 20,000 ev.
    - SVT trigger
    - εD^2 = 11.3 %
  - Resolution:
    - L00
      - → **σ_τ = 45fsec**
  - S/N:
    - 0.5 - 2 based on CDF data
  - 5σ sensitivity up to x_s=63 (S/N = 2/1)
    x_s=56 (S/N = 1/2)
  - Backup D_s lν
    - ~ 70,000 events
    - x_s = 32

Charm Physics

Another example of Charm Physics:



$D^{\pm}_s$-$D^{\pm}$ mass difference

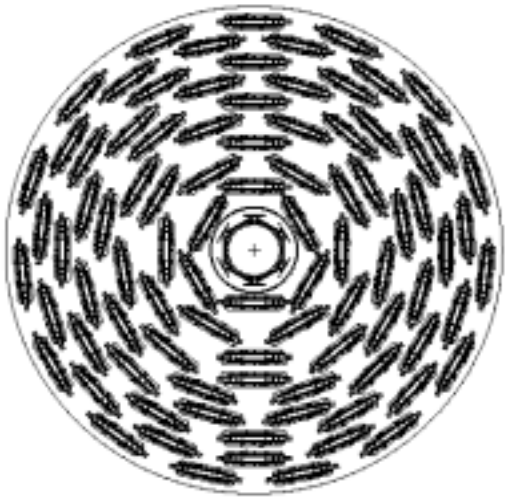
both $D \to \phi\pi$ ($\phi \to KK$)

$\Delta m = 99.28 \pm 0.43 \pm 0.27$ MeV

PDG: 99.2 ± 0.5 MeV

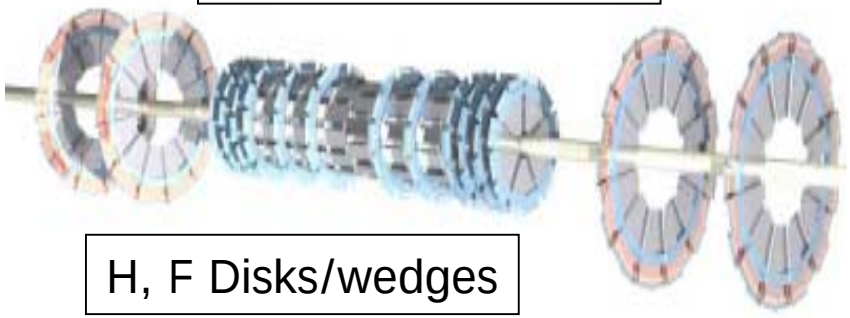
Snapshot of CDF Run2b Upgrade after June PAC Meeting

- Silicon replacement
  - no change to layout or capability
- Central Preshower Detector
  - no changes to design or capability
- Calorimeter EM timing
  - Split signals in cables, do not modify bases
- Time to Digital Converters for drift chambers
  - Replace TDC's with a design based upon commercial FPGA's
- Silicon Vertex Trigger
  - No change in design
  - Modifications to accommodate silicon geometry

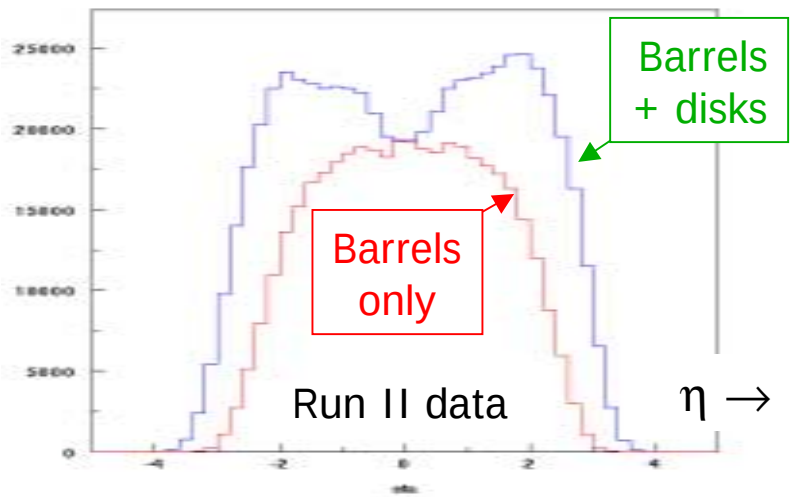


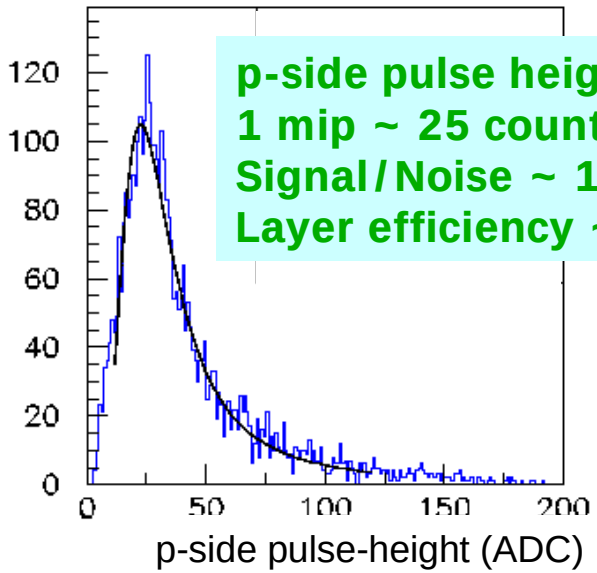
Silicon Microstrip Tracker Status

4 barrel layers
axial + stereo strips



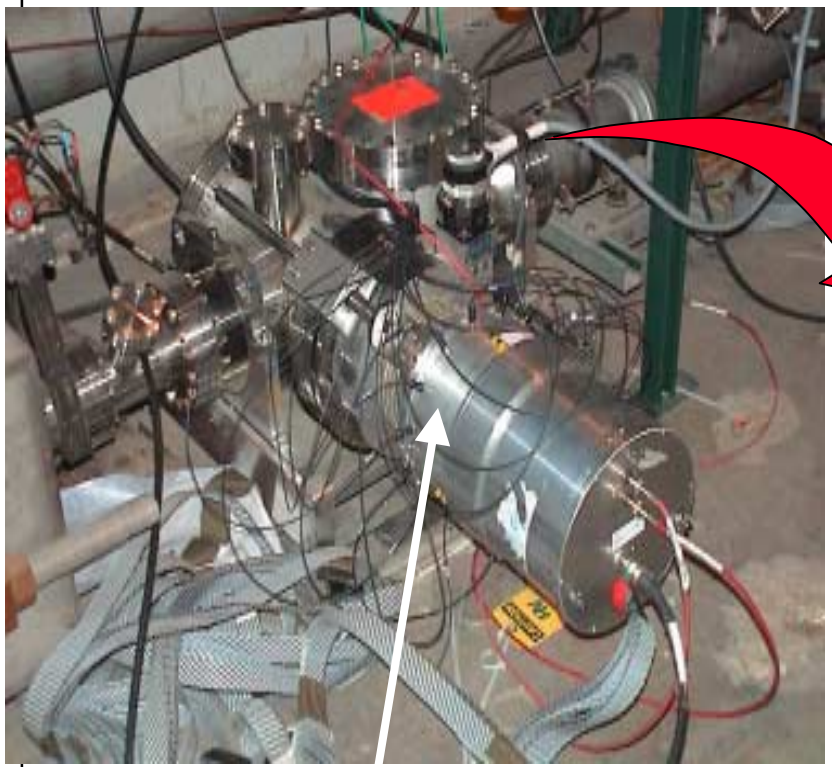
H, F Disks/wedges





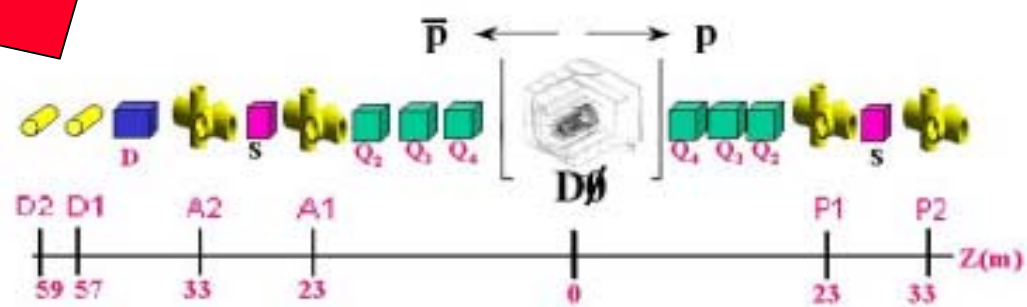
p-side pulse height
1 mip ~ 25 counts
Signal/Noise ~ 12
Layer efficiency ~ 97%

Forward Proton Detector D0

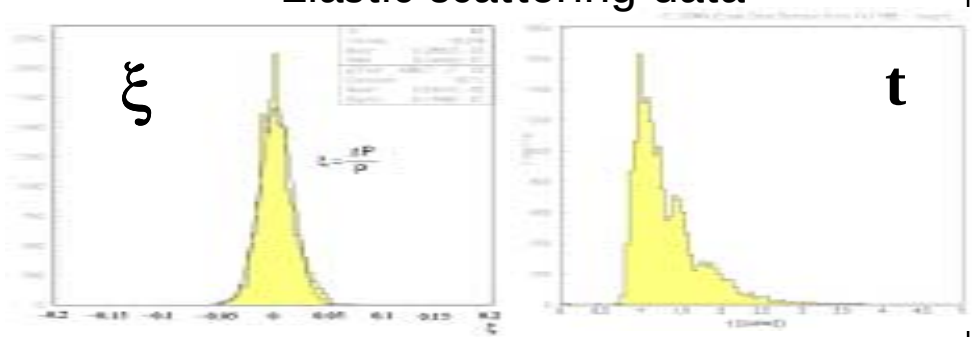


Scintillating fiber detector inside

- Heretofore standalone
- Integrating into trigger/daq



Elastic scattering data



Recent Performance: D0

Best Week (Nov 4-11)

Delivered: 3.8 pb^{-1}

Utilized: 3.7 pb^{-1} (97%)

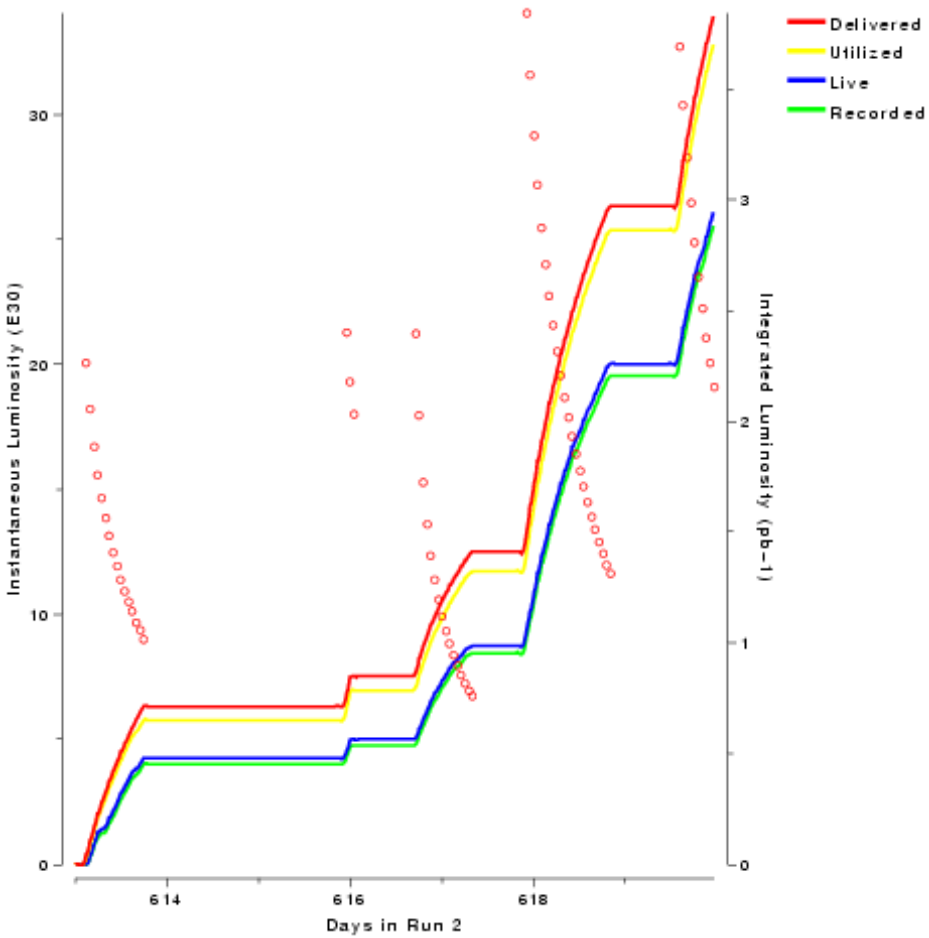
To Tape: 2.9 pb^{-1} (75%)

Best Day (Nov 9)

Delivered: 1.4 pb^{-1}

Utilized: 1.4 pb^{-1} (99%)

To Tape: 1.1 pb^{-1} (80%)



Run IIb Upgrade

The present detector was designed for ~ 2 fb^{-1} and 2×10^{32} cm^{-2} s^{-1}

- ☞ Exceeds radiation tolerance of existing silicon detector
- ☞ Requires higher luminosities, ~ 2-5 $\times 10^{32}$ cm^{-2} s^{-1}, trigger upgrades

Replace Silicon Detector with a more radiation-hard version

Improve impact-parameter resolution (b-tagging) through additional layers and smaller beampipe

Maintain good pattern recognition over |h| < 2

September 2002 Lehman Review recommended baselining of Run IIb upgrades.

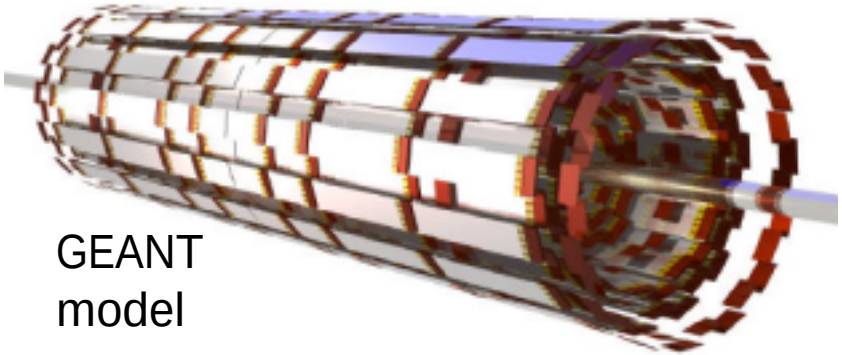
Upgrade Trigger

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

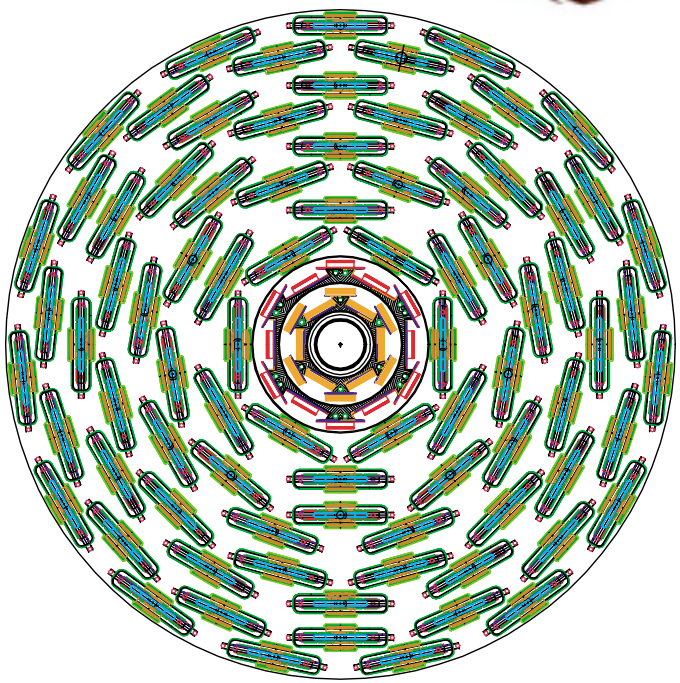
- Calorimeter clustering & digital filtering
- Enhance track trigger to respond to increased occupancies
- Calorimeter cluster match with track

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

Run IIb Silicon Detector D0



GEANT model



Single sided silicon, barrels only
Detector installed in two halves inside collision hall in ~7 month shutdown
Inner (vertexing) layers 0, 1
- ☞ Axial only
- ☞ mounted on carbon support

Outer (tracking) layers 2-5
- ☞ Axial and stereo (tilted sensors)
- ☞ Stave structures

Prototyping essentially done.