Physics at the Tevatron
Part 1: Experience from Run 1
Part 2: Upgrades and Prospects for Run 2

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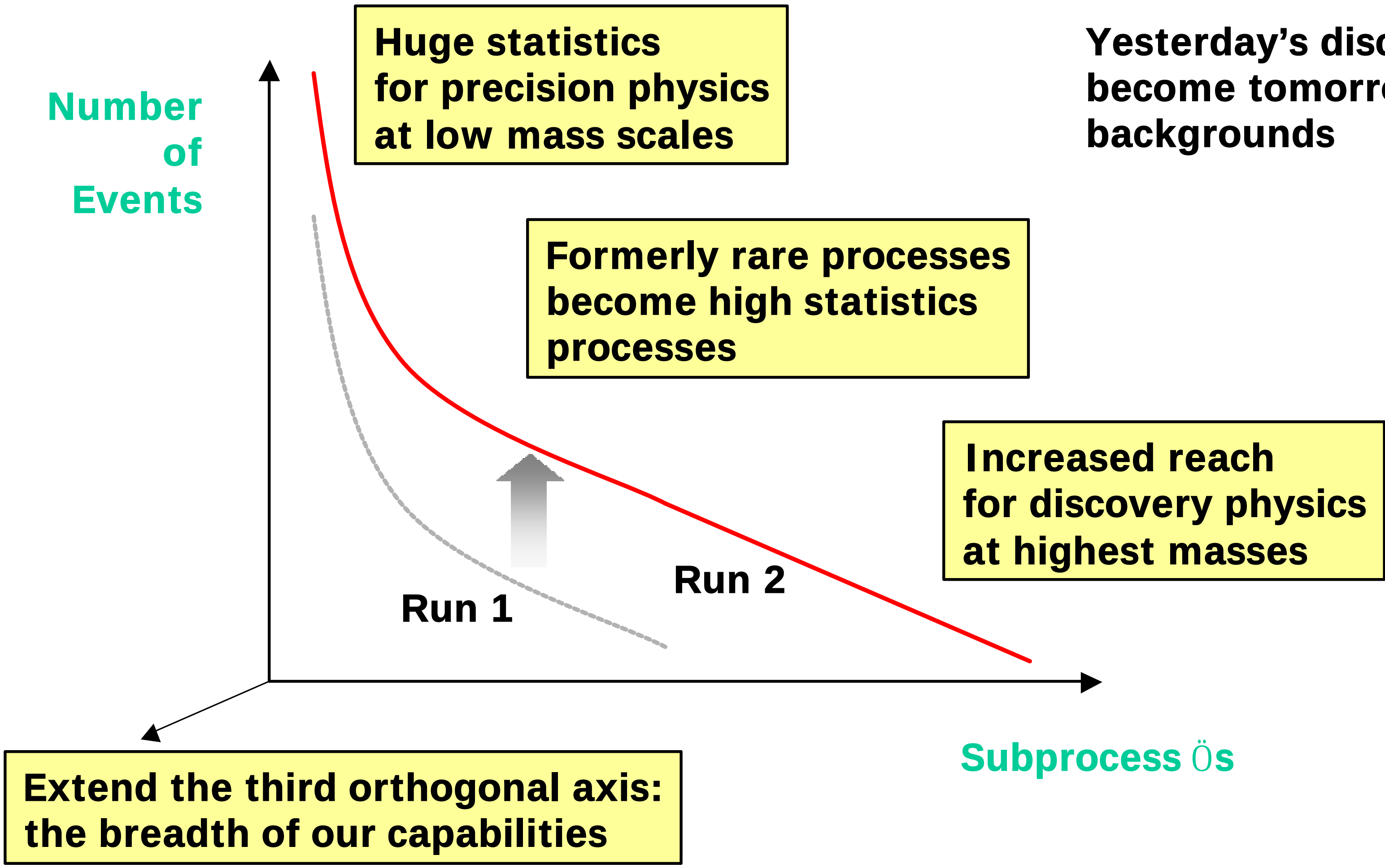
Outline

- **Part 1 Yesterday: Experience from Run 1**
  - ➢ Run 1 Tevatron performance
  - ➢ Run 1 CDF and D0 detectors
  - ➢ Overview of Run 1 Tevatron Physics and techniques
    - Physics range of Tevatron
    - QCD physics
    - Electroweak
    - B-physics
    - Putting it all together: top physics
    - Putting it together again: searches for new phenomena
- **Part 2 Today: Physics at the Tevatron in Run II**
  - ➢ Improvements to Fermilab Accelerator Complex
  - ➢ CDF and D0 Detector Upgrades
  - ➢ Current accelerator and detector status
  - ➢ Projections for Run II physics

Run 1 ® Run 2

- **The Tevatron is a broad-band quark and gluon collider**



Yesterday's discoveries become tomorrow's backgrounds

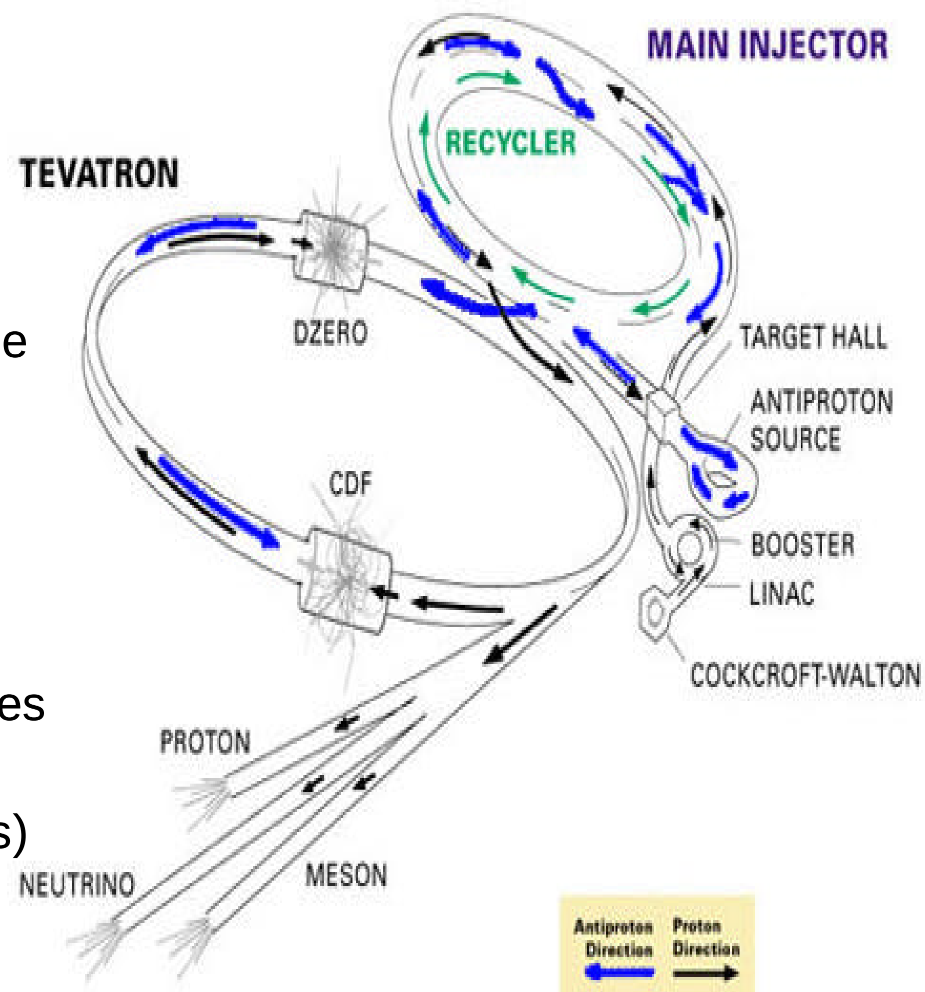
Accelerator Improvements

- Main Injector (150 GeV p storage ring) replaces Main Ring (original Fermilab accelerator). Factor of ~5.
- Completely revamped stochastic cooling system for p-bars.
- New permanent magnet Recycler storage ring for p-bars (Factor of ~2)
  - **2x 10^{11} antiprotons/hour**
  - **3x 10^{12} antiprotons**
  - **Re-cool antiprotons from the Tevatron**
- Increased number of p and p-bar bunches to keep multiple interaction managable:

  6 (3.5 μs) → 36 (396 ns) → >100 (132 ns)
- Higher energy collisions :

  E_{beam} 900 → 980 GeV

  σ_{tt} increases by ~ 40%



Tevatron Improvement

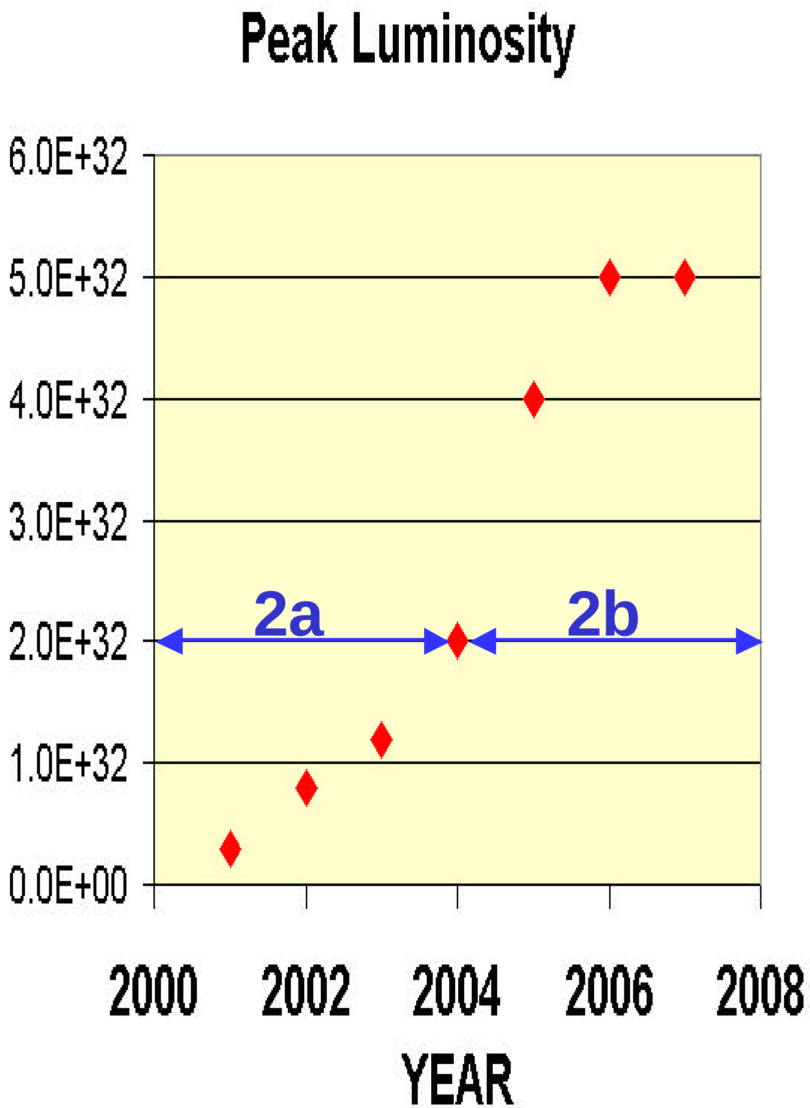
$$L = \frac{3\gamma_r f_0 N_B N_{\bar{p}}}{\beta^*}\left(\frac{N_p}{\varepsilon_p}\right)\frac{F(\beta^*,\sigma_x,\sigma_y,\varepsilon_p,\varepsilon_{\bar{p}},\sigma_z)}{\left(1+\varepsilon_{\bar{p}}/\varepsilon_p\right)}$$

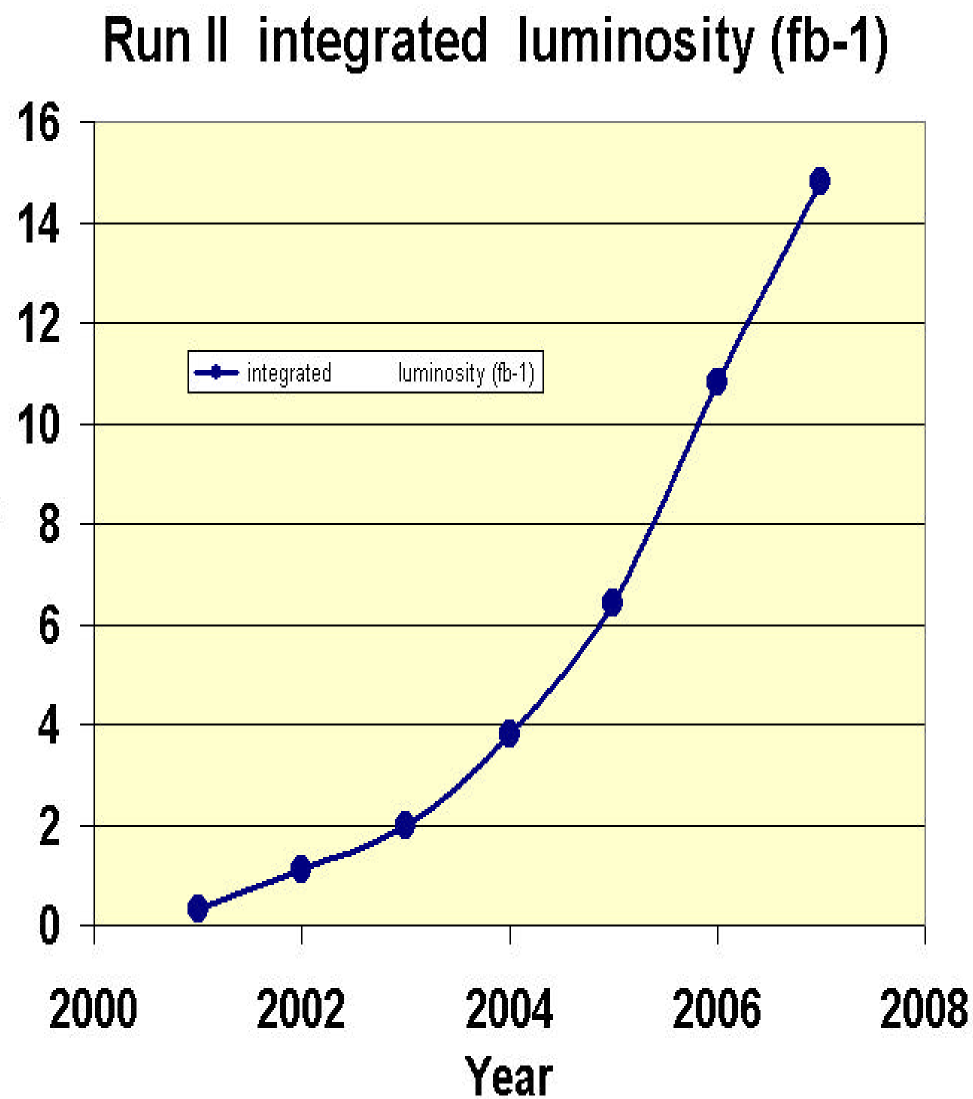
Total Antiprotons

Protons per bunch

Run	Ib(93-95) (6x6)	IIa (36x36)	IIa (140x103)	IIb (140x103)	
N_p	2.3×10^{11}	2.7×10^{11}	2.7×10^{11}	2.7×10^{11}	
$N_{\bar{p}}$	5.5×10^{10}	3.0×10^{10}	4.0×10^{10}	1.0×10^{11}	
$N_B\ N_{\bar{p}}$	3.3×10^{11}	1.1×10^{12}	4.2×10^{12}	1.1×10^{13}	
$\bar{p}$ prod. rate	6.0×10^{10}	1.0×10^{11}	2.1×10^{11}	5.2×10^{11}	hr^{-1}
L_{peak}	0.16×10^{31}	0.86×10^{32}	2.1×10^{32}	5.2×10^{32}	$cm^{-2}sec^{-1}$
Int. Lum	3.2	17.3	42	105	pb^{-1}/wk
Bunch spacing	~3500	396	132	132	nsec
N_{int}/crossing	2.5	2.3	1.9	4.8	

Run II Luminosity Profile

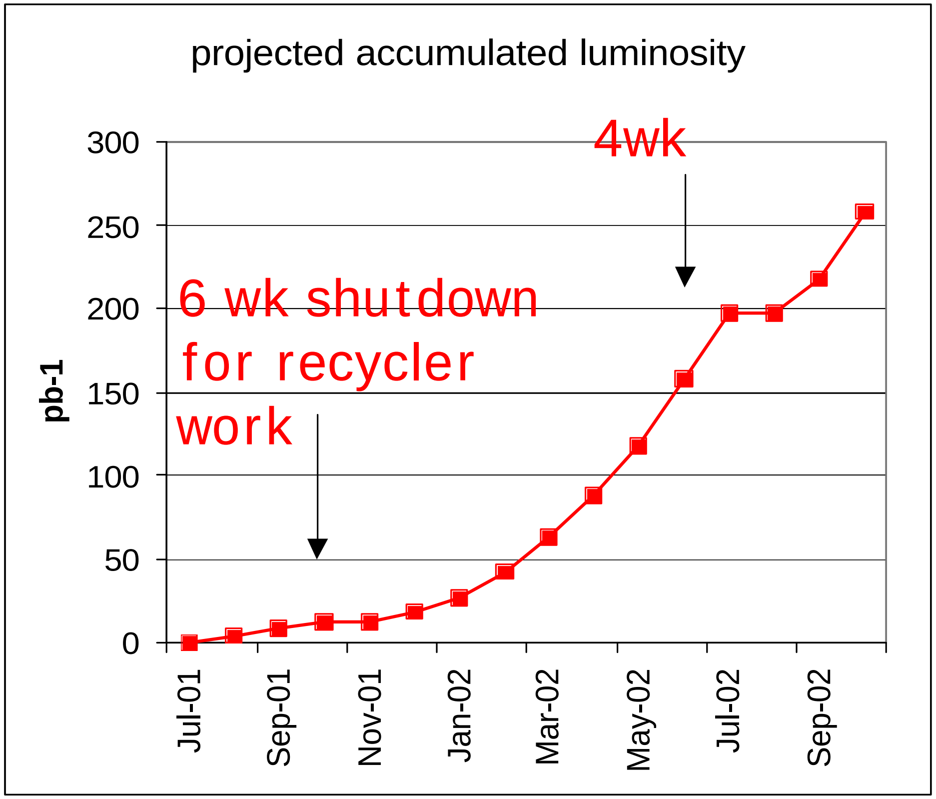




Run II 2001-2002

- Commissioning started in March 2001 for MI+Tevatron, CDF and D0

- Current performance
  - **$0.8-1.0 \times 10^{31}\ cm^{-2}\ s^{-1}$**
  - **integrated 17 pb^{-1}**
- Goal for early 2002
  - **$2-4 \times 10^{31}\ cm^{-2}\ s^{-1}$**
  - **~100pb^{-1} by summer**
- later 2002
  - **$8 \times 10^{31}\ cm^{-2}\ s^{-1}$**
  - **commission Recycler**
  - **400pb^{-1} during 2002**

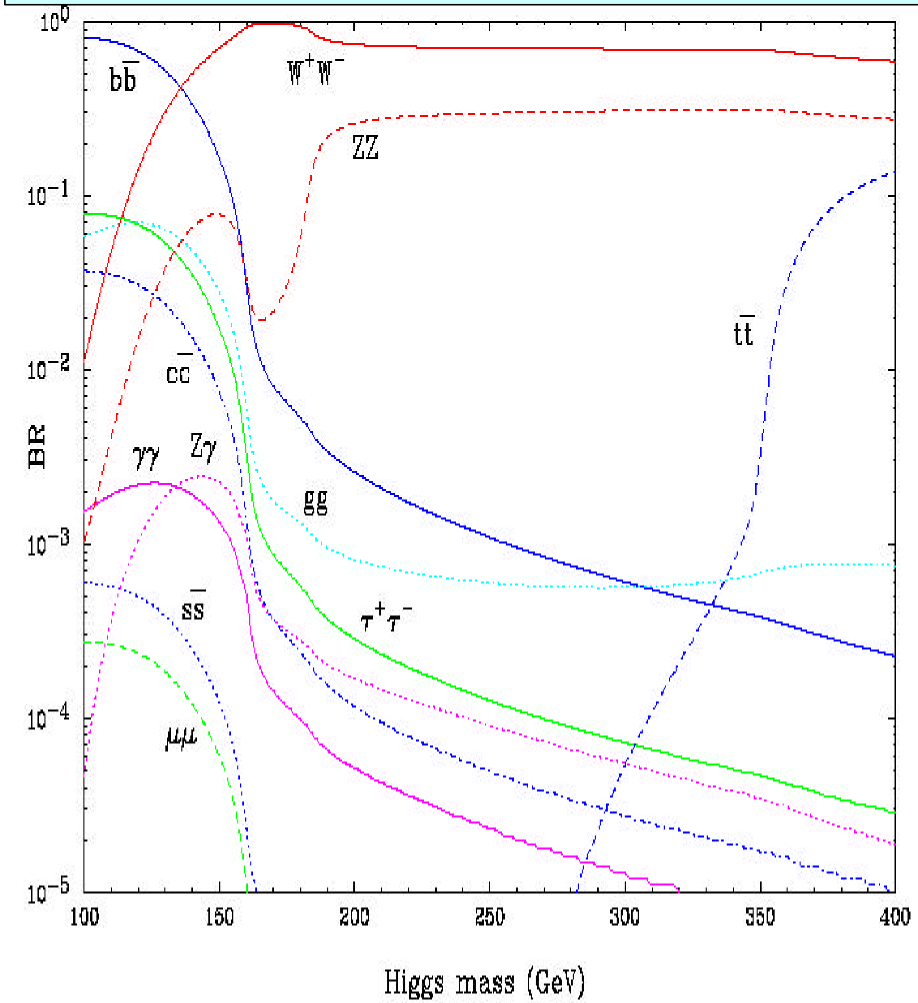


Projection from Oct 2001

The Run II Detectors

Overall Strategy

- $gg \to H$ dominates but swamped by dijets
- $qq' \to HV$ factor 5-10 lower but backgrounds are more rare ($t\underline{t}$, $Wb\underline{b}$, $Zb\underline{b}$, WZ)



Lepton id, b tagging and $\not E_T$ are vital to Tevatron Physics:

- **SM HIGGS: VH Associated Prod.**
  - $m_H < 130$: $H \to bb$ dominant:

    $\Rightarrow W(l\nu,qq')bb$, $Z(\nu\nu,ll,qq)bb$ final states
  - $m_H > 140$: $H \to WW$ dominant:

    $\Rightarrow W^+W^-, W^+W^-W^\pm, W^+W^- Z$:

    $l^+l^-\nu\nu$, $l^+l'^+\nu\nu jj$, $l^+l^-l'^\pm$ final states
- **MSSM Higgs:**
  - same channels as SM and possible enhanced association to bb at large $\tan\beta$
- **W mass, Top**
- **SUSY searches**
- **B physics – also requires excellent charged particle tracking and particle ID**

P.J. Wilson, 9 Jan 2002

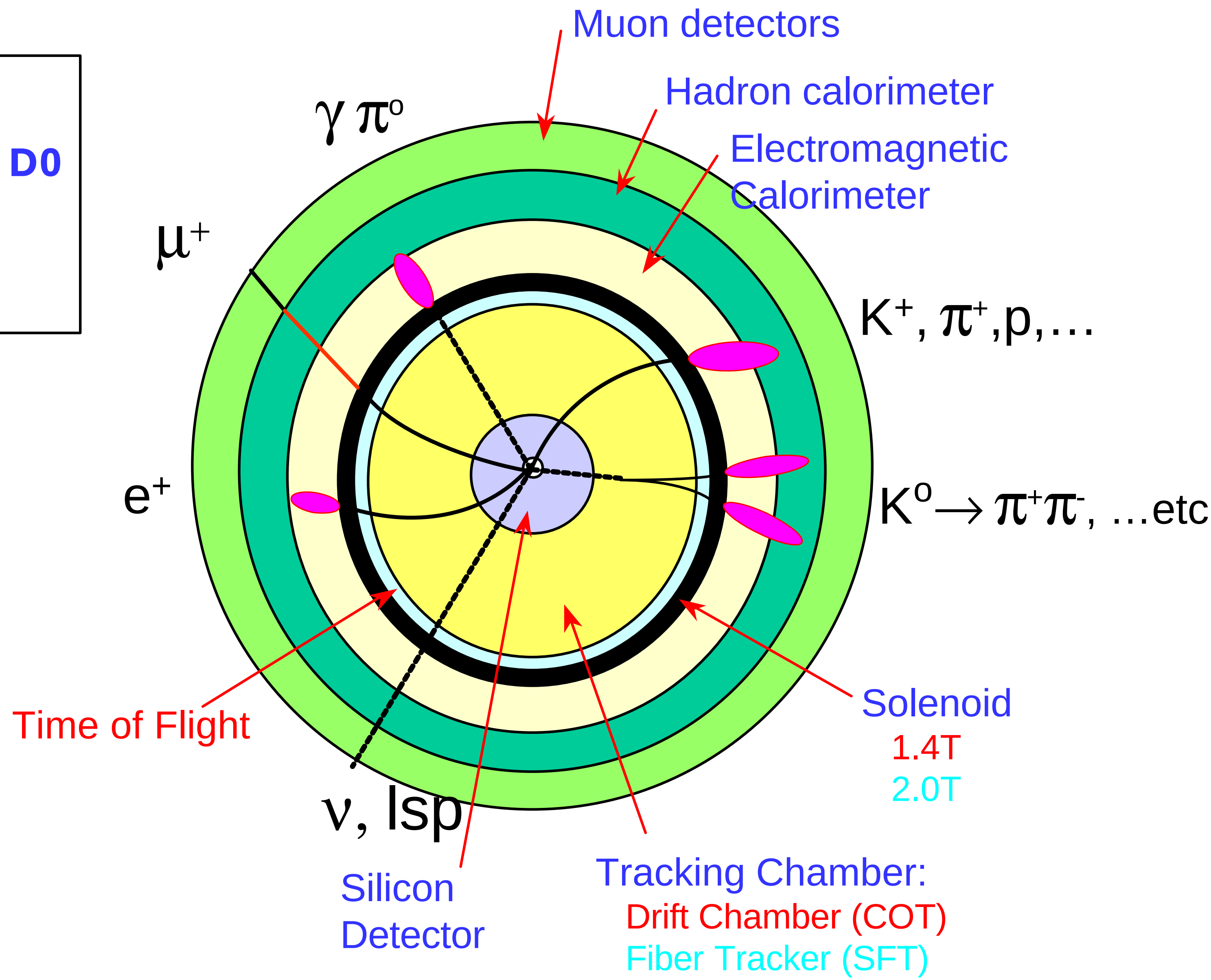
Run 2 Detector Schematic

Key

CDF and D0

CDF

D0



New

Old

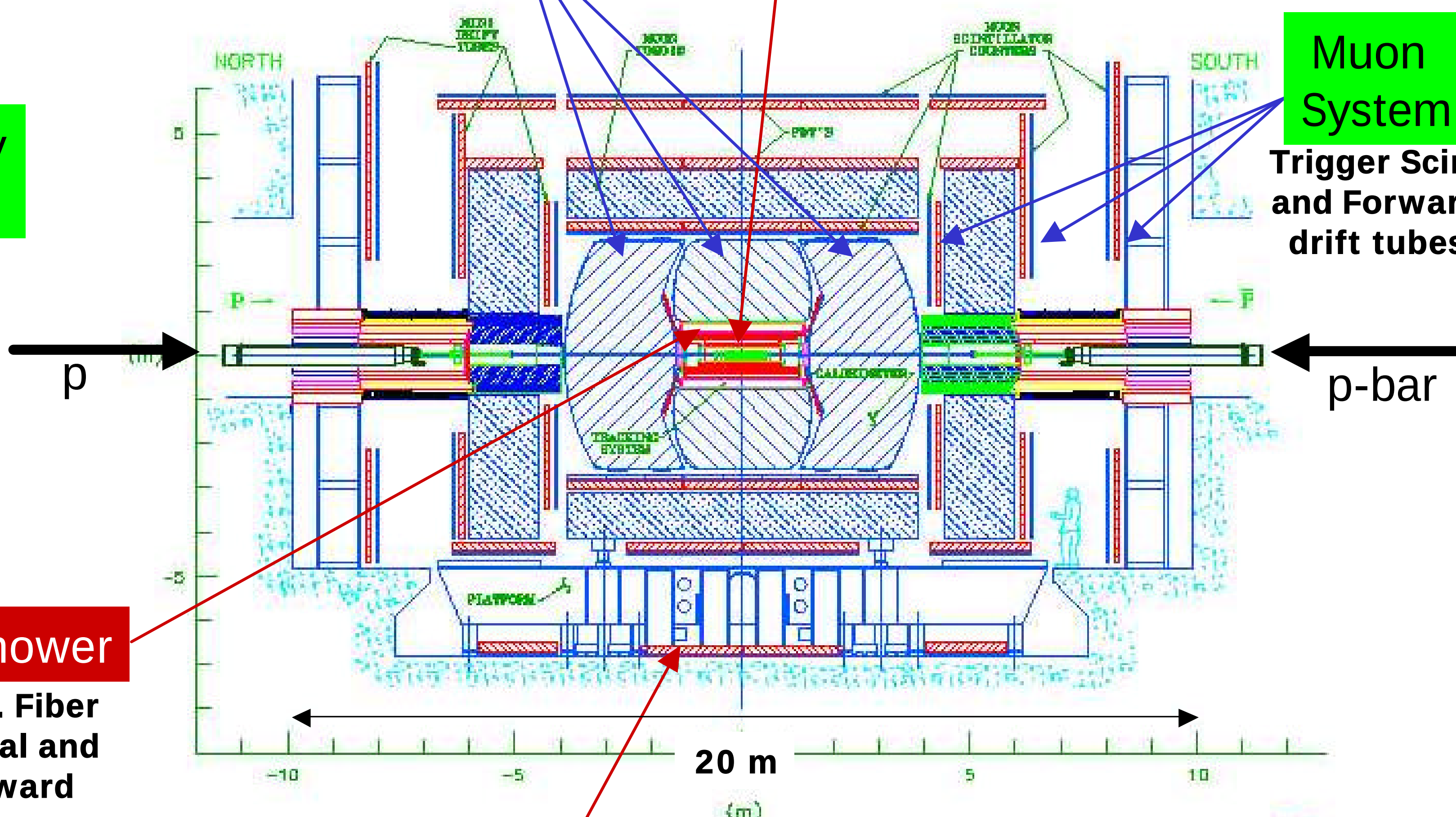
Partially New

Calorimeters

Tracker (Si, Fiber, Solenoid 2T)

Muon System

Trigger Scint and Forward drift tubes

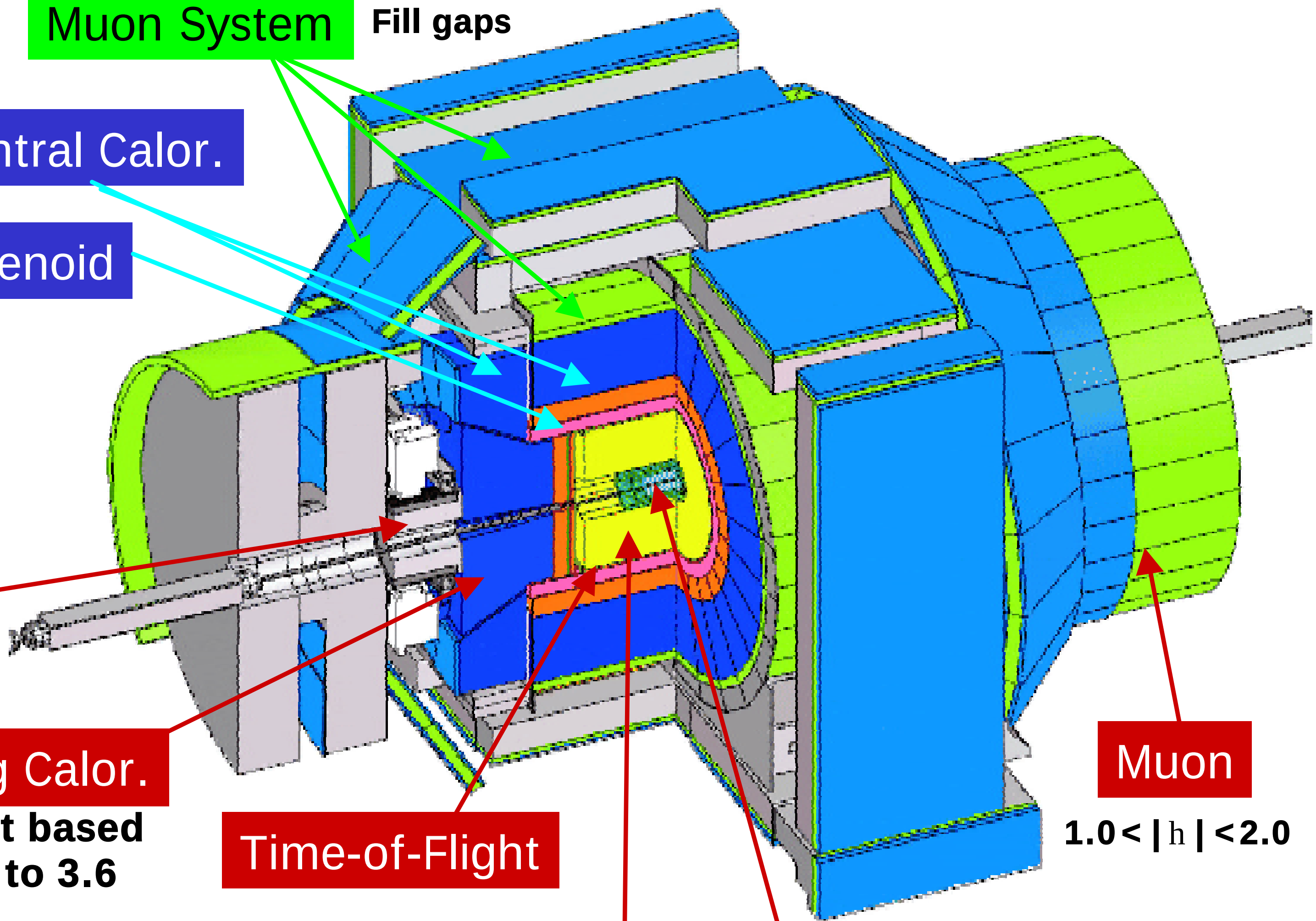


PreShower

Scint. Fiber Central and Forward

Electronics

Front End Electronics
Triggers / DAQ (pipeline)
Online & Offline Software

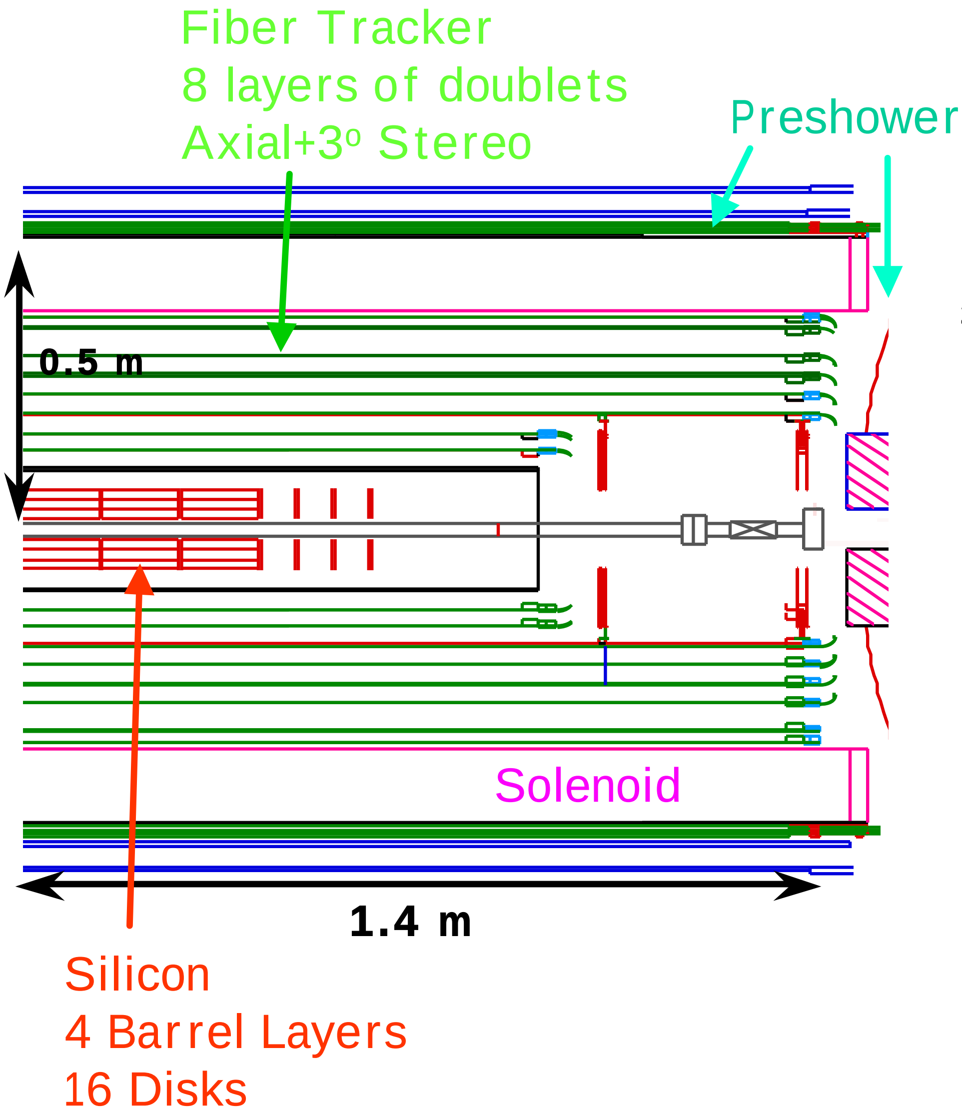


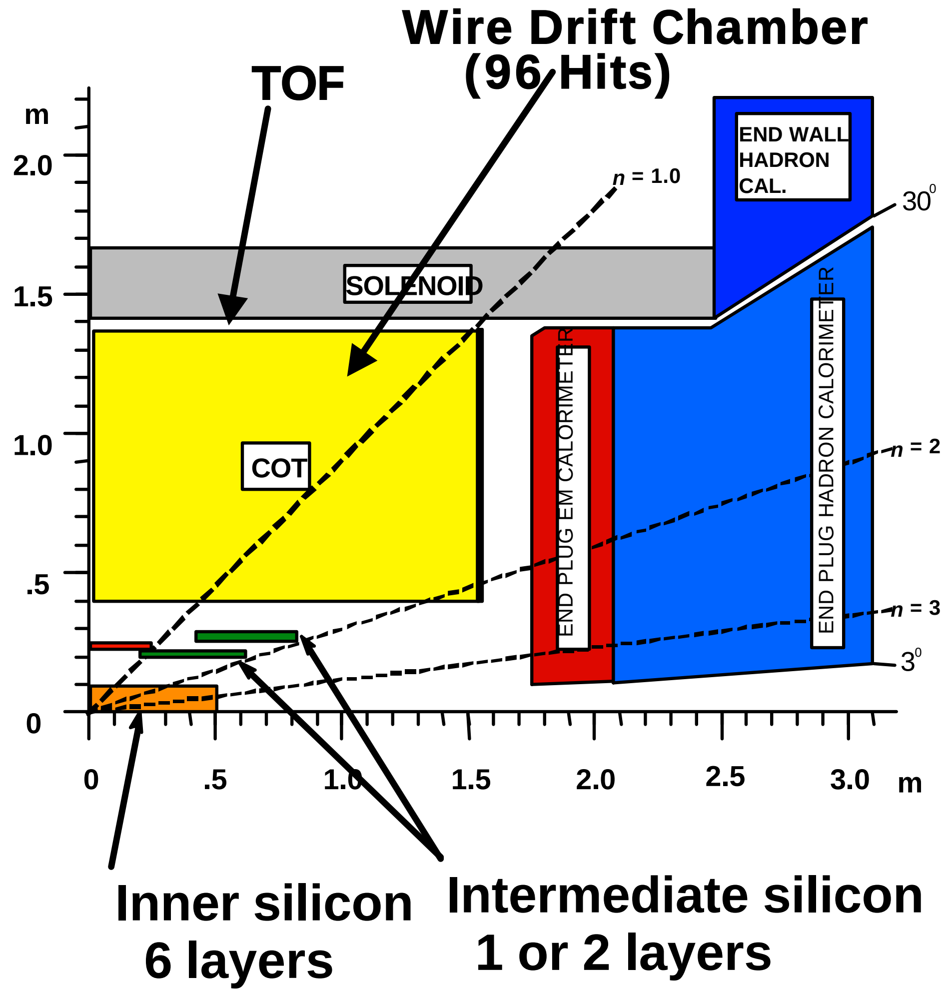
Front End Electronics
Triggers / DAQ (pipeline)
Online & Offline Software

CDF and D0 Very Similar

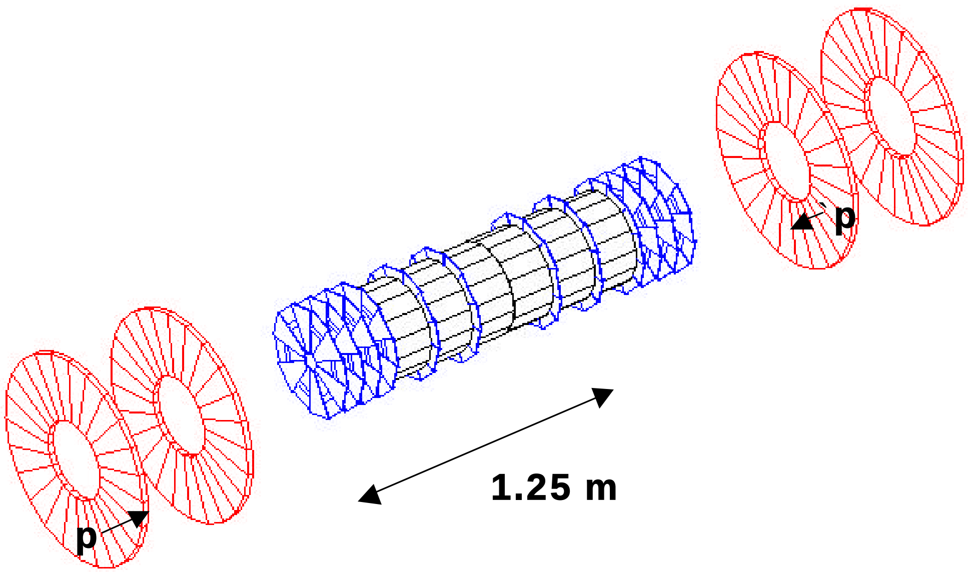
		Run 1		Run 2	
		CDF	D∅	CDF	D∅
Tracking	Silicon	2D Si	NO	3D |h|<2	3D |h|<1.7
	Dp$_t$/p$_t$	<0.1%p$_t$	No Field	<0.1%p$_t$	0.14%p$_t$ Å 1.5%
	Dd (mm)	19 Å 33/p$_t$	NO	6 Å 22/p$_t$	13 Å 50/p$_t$
Calorimetry	Coverage	|h|< 4.2	|h|< 4	|h|< 3.6	|h|< 4
	EM Res	16%/ÖE Å 1%	14%/ÖE Å < 1%	16%/ÖE Å 1%	14%/ÖE Å < 1%
	HAD Res	80%/ÖE Å 5%	50%/ÖE Å 4%	80%/ÖE Å 5%	50%/ÖE Å 4%
Muon	Coverage	|h|< 1.0	|h|< 1.7	|h|< 1.5	|h|< 2.0
Trigger	"Silicon"	L3	NO	SVX-III	SVX-II
	L1 Rate	1 kHz	150 Hz	50kHz	10kHz
	L2 Rate	10 - 100 Hz		>0.3kHz	1kHz
	L3 Rate	3-5 Hz	3.5 Hz	30-50 Hz	20-50 Hz

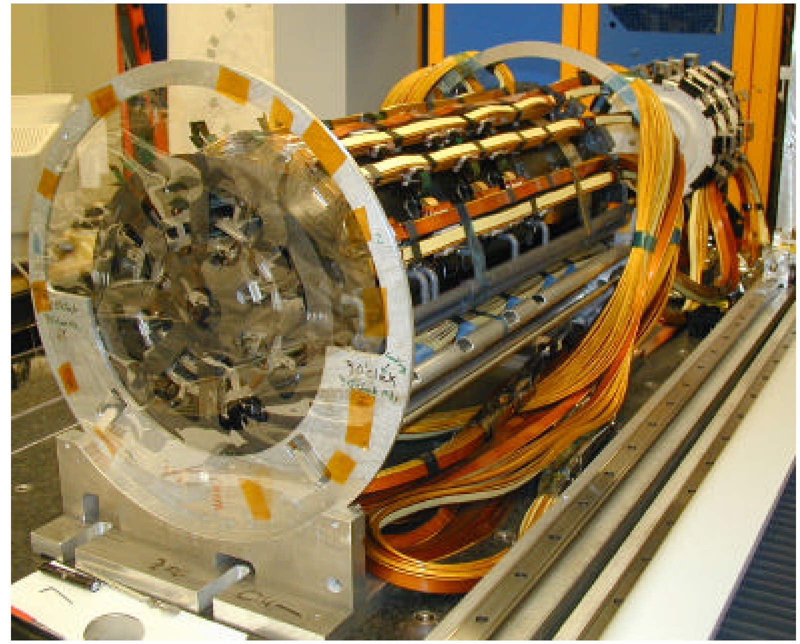
Tracking Systems





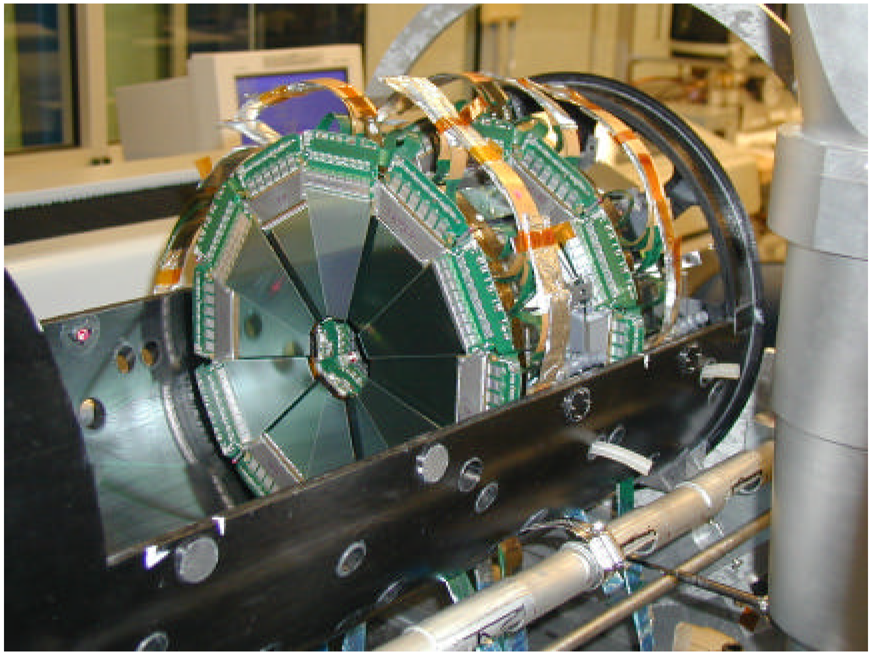
DØ Silicon Detector



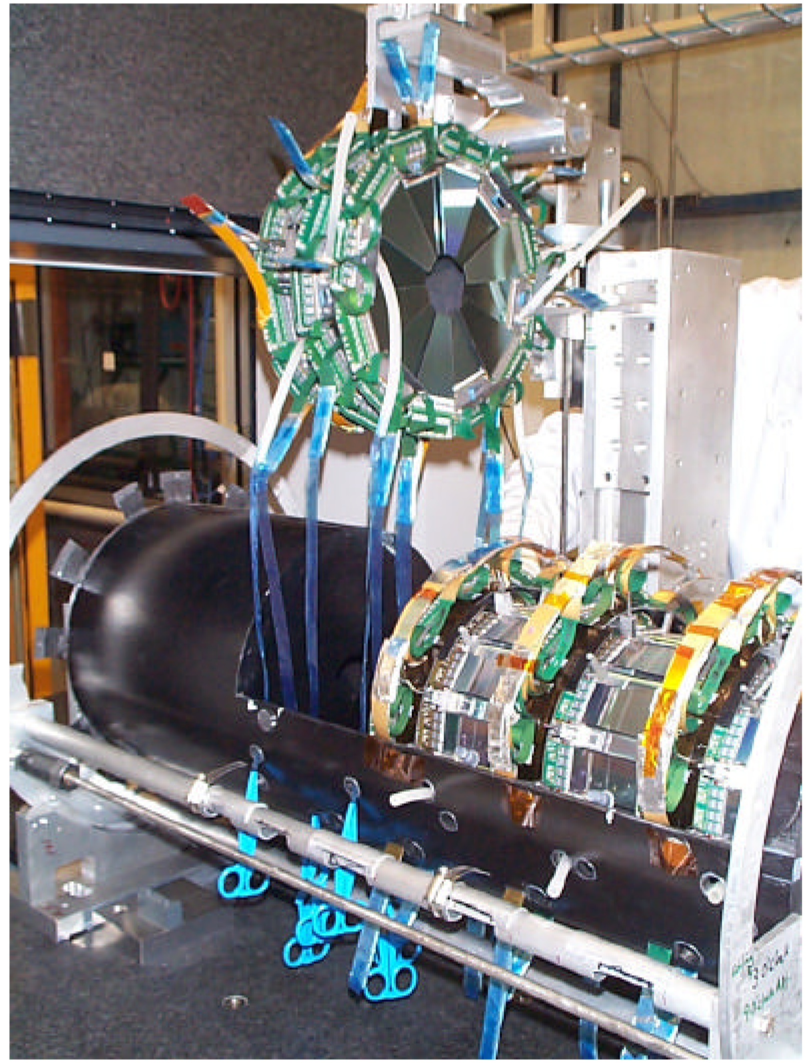


- **6 barrels (2 SS, 4 DS w/stereo) w/4 layers each**
- **12 Disks: tracking out to |h|=2.5**
- **793K channels of electronics (SVX-II chip)**
- **Expected tagging efficiency at p_T = 50 GeV/c**
  - ~ 50% for b-quark jets, ~ 10 % for c-quark jets
  - ~ 0.5% fake tag rate for u,d,s quark jets
- **>95% of channels now working**
- **Blown PS fuses on ~40% of detector: fixed by mid-January**

DØ Silicon Being Assembled

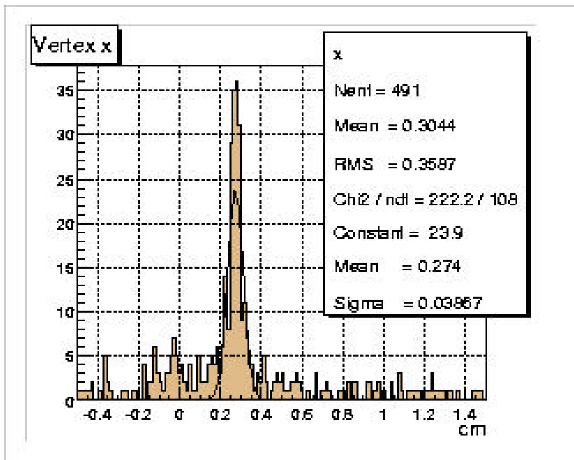


Two barrel/disk assemblies in place

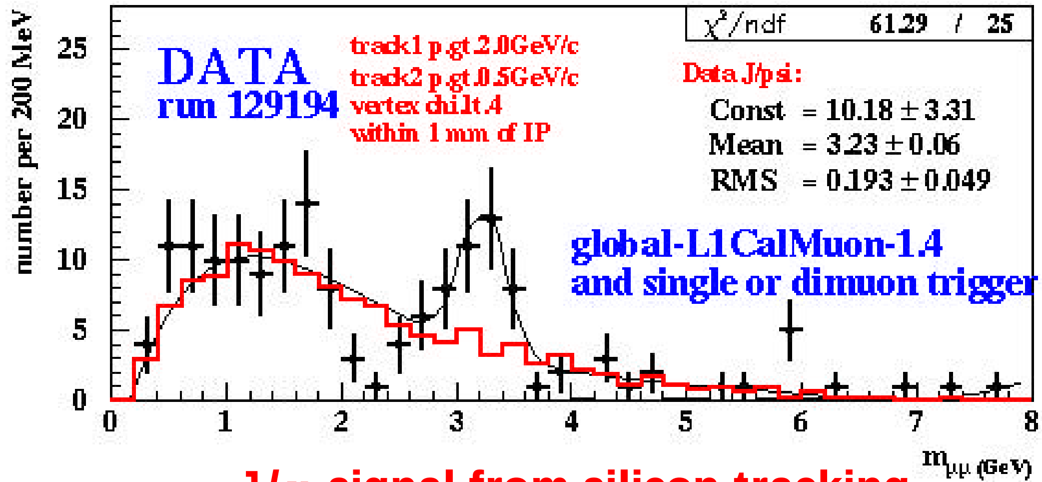


Insert forward disks

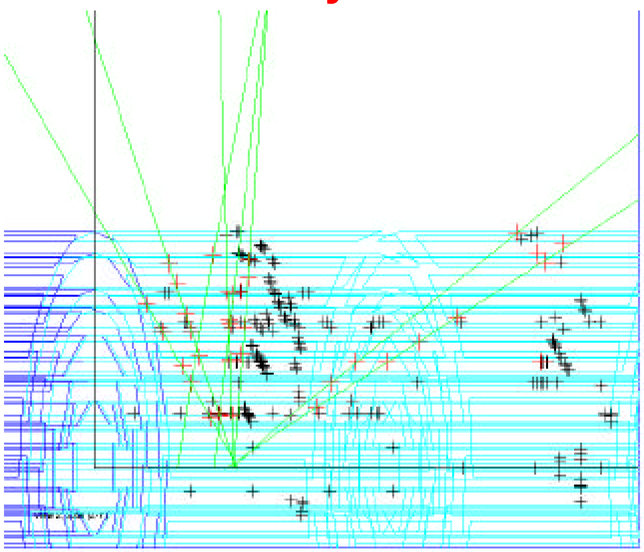
DØ silicon performance



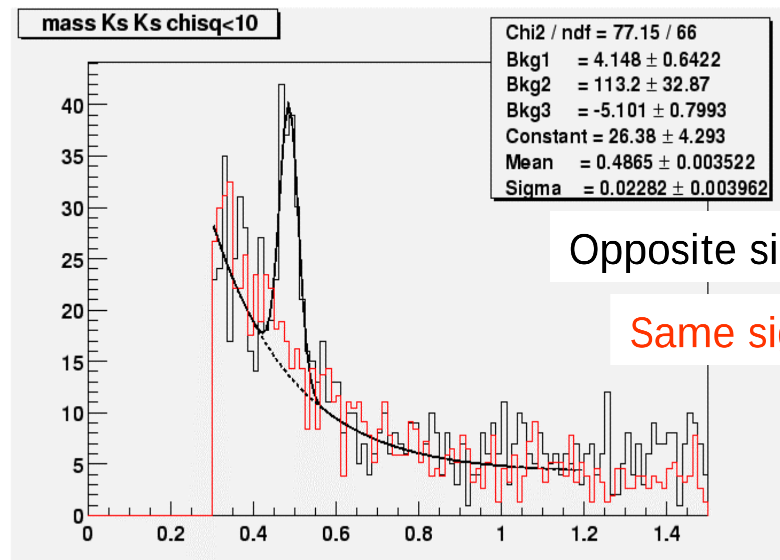
Primary vertex



J/ψ signal from silicon tracking



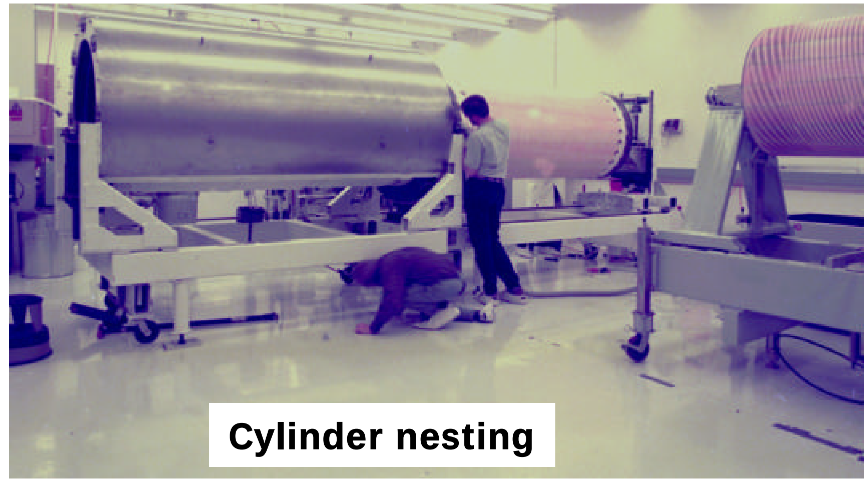
First reconstructed tracks
April 2001



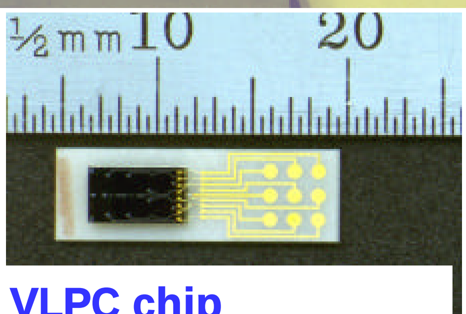
K^0 signal from silicon tracking

DØ Scintillating Fiber Tracker

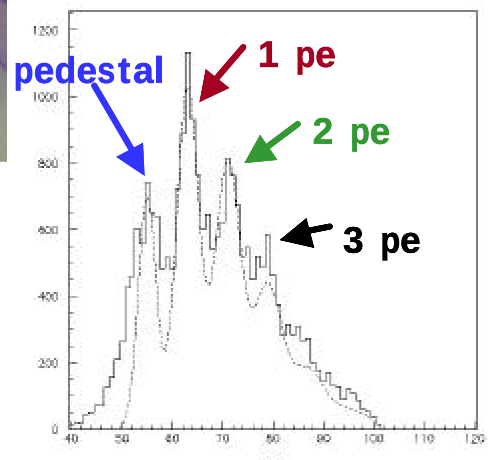
Ribbon manufacture



Cylinder nesting

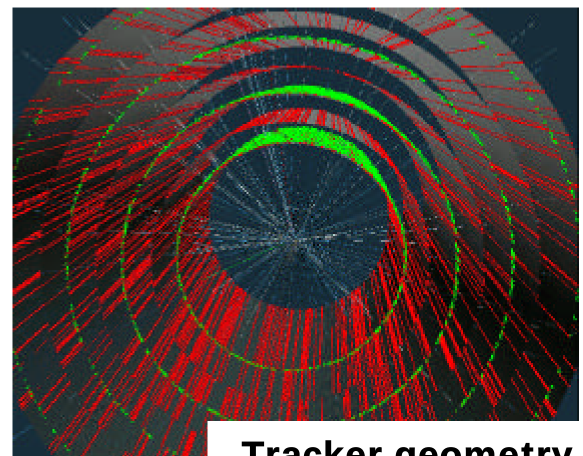


VLPC chip
- Operate at 9K
- QE ~ 80%
- Gain 17-65K / g
- ~8 g/MIP in CFT



1 pe ~ 7 fC ~ 15 ADC counts

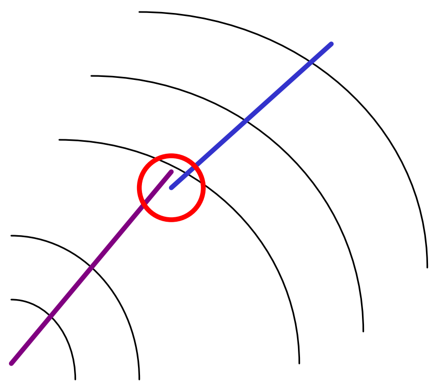
Excellent signal/noise performance

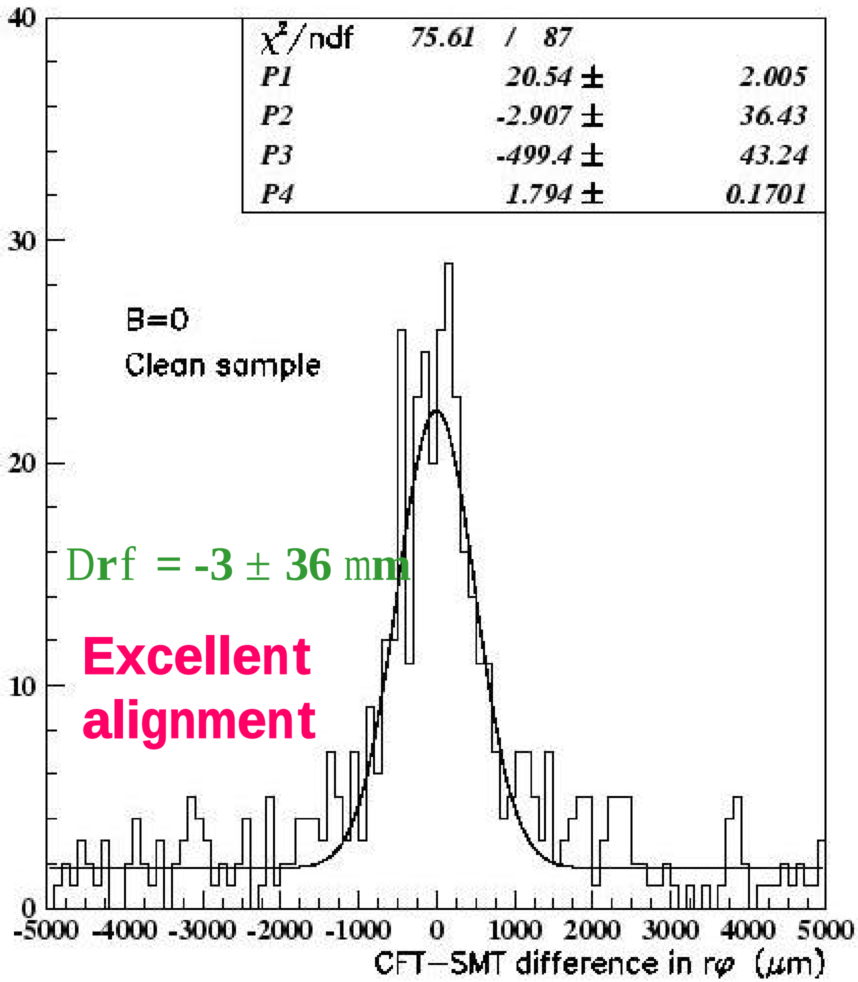


Tracker geometry and simulation of particle tracks

SMT-CFT alignment

- **Using partially instrumented CFT with prototype electronics**
- **Tracks were found separately in the SMT and the Central Fiber Tracker (CFT)**
- **SMT tracks were extrapolated to the CFT at which point the track offsets were measured**
- **Magnet off data**



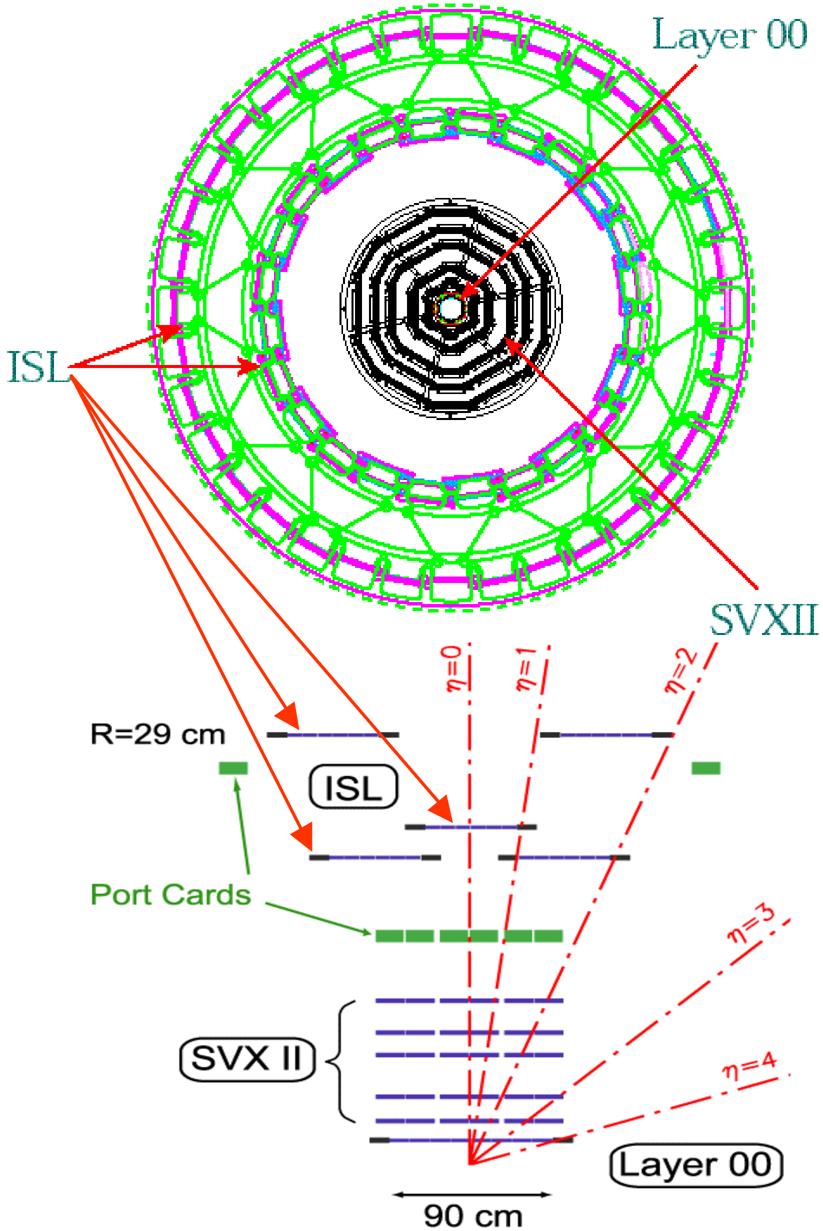


- **Now instrumented: Axial 100%**
  Stereo 50%

Expect to instrumentation by mid Feb 2002

P.J. Wilson, 9 Jan 2002

CDF II Silicon



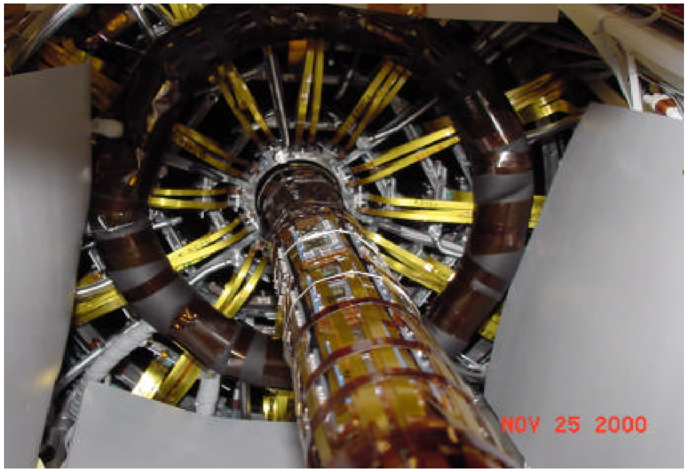
- **Layer 00 (L00)**
  - Improve $\delta(d_0)$ to ↑B tag efficiency
  - Extend CDF lifetime
- **SVXII (SVX)**
  - Longer and smaller gaps in z and ϕ
  - 3D vertexing
  - Level 2 trigger on 2d displaced tracks (w/L00)
- **ISL**
  - Extend b-tagging to |h| = 2
  - Help link tracks in COT to SVX
- **Performance:**

$\sigma_d = \sqrt{a^2 + (b/P_t)^2}$ (a =7μm, b =20-30μm)

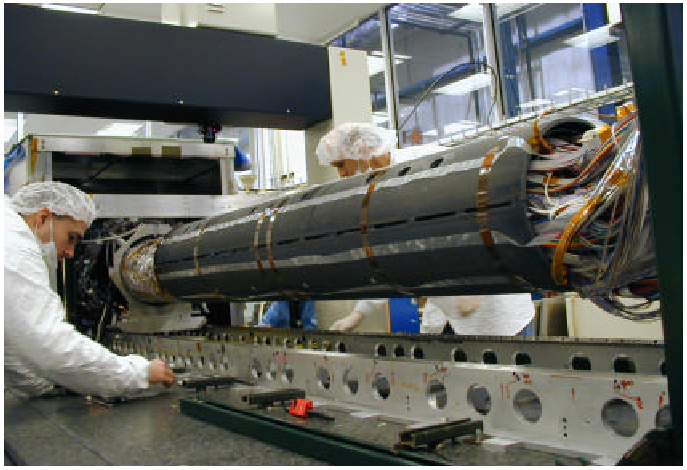
B tagging for t t:	Run I	Run II
single tag	25%	52%
double tag	8%	28%

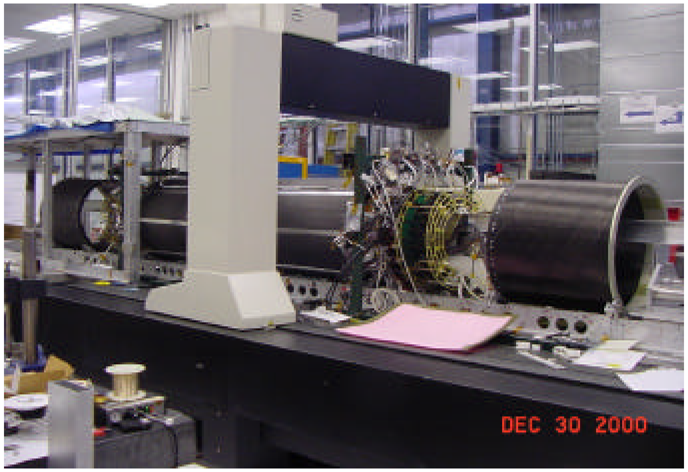
CDF Silicon Tracker Upgrade

L00 into SVXII

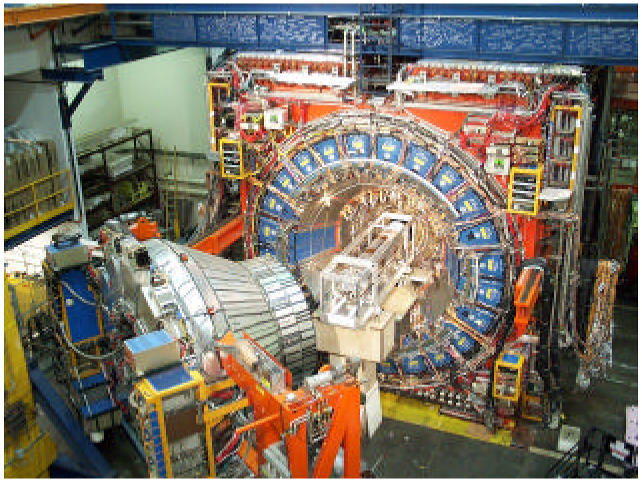


SVXII into ISL





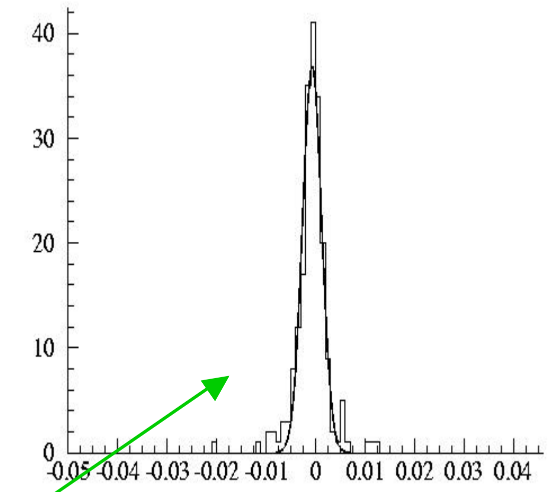
Final Assembly



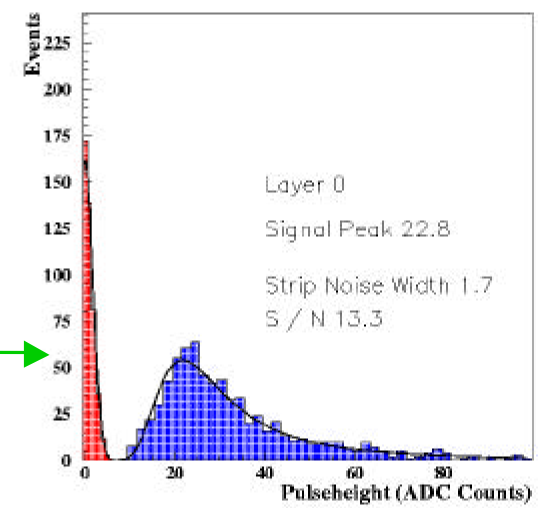
Installation

CDF Silicon Tracking Status

- **Silicon detectors are timed in and integrated with DAQ**
- **Current status:**
  - ➢ L00 (on beam pipe) off due to power supply problems (Vbias) and readout problems
  - ➢ 68(70?)/72 SVXII wedges operational for tracking
  - ➢ ~ 60% of ISL ladders operational (Central barrel has blocked cooling lines -> being fixed on accesses) Expect to fix by Summer 2002, need for high Lum
- **Measured hit resolution $\sigma \sim 19\ \mu$m before final alignment corrections**
- **Construction alignment tolerances for level 2 impact parameter trigger have been met**
- **Signal/noise as expected**



Unbiased residual (cm)



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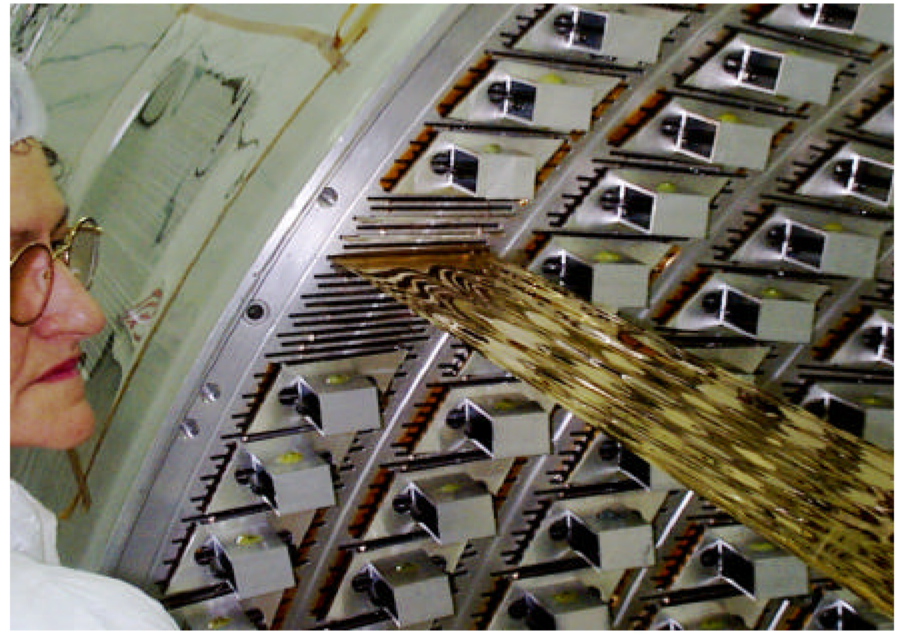
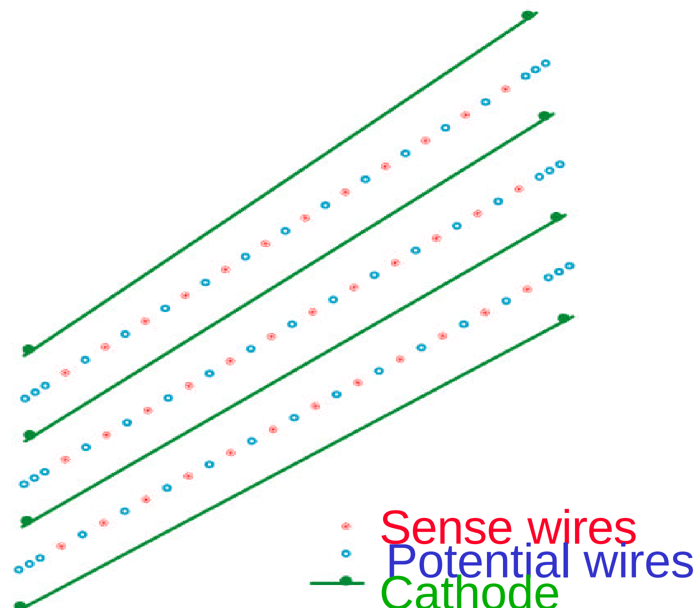
CDF Central Outer Tracker

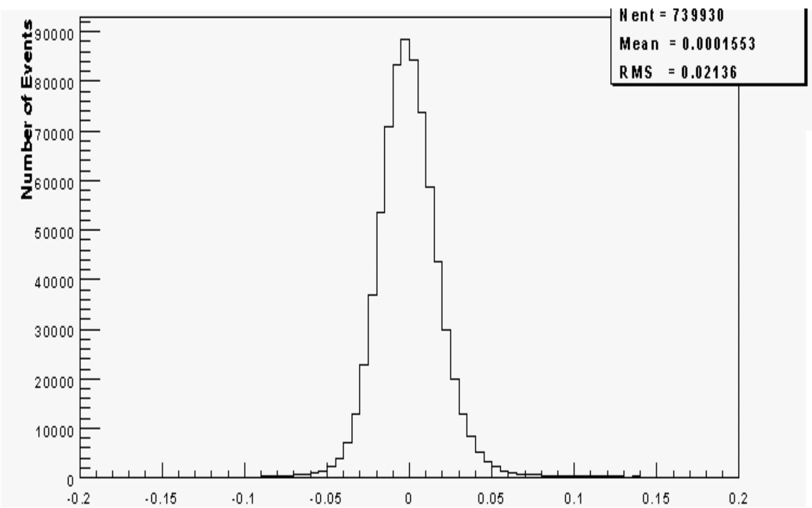


- **96 wire planes**
  - (8 superlayers)
  - 50% are 3^{o} stereo
  - Uniform drift (0.88 cm cell)
  - 30,240 sense wires



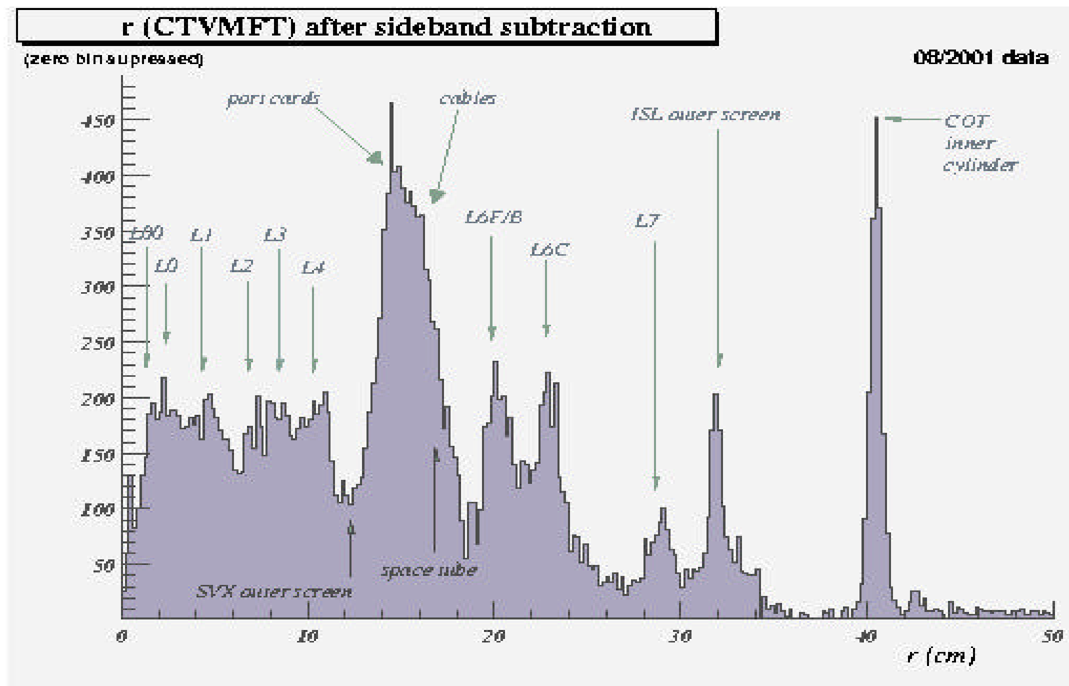
COT Performance

Only a handful of bad wires out of 32K



Hit Resolution
~200 µm
Goal : 180 µm

Photon e^+e^- pairs reconstructed with COT
Provide an x-ray of the detector



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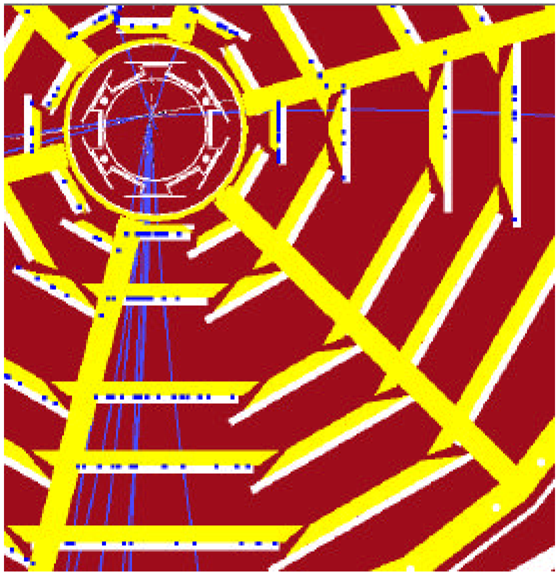
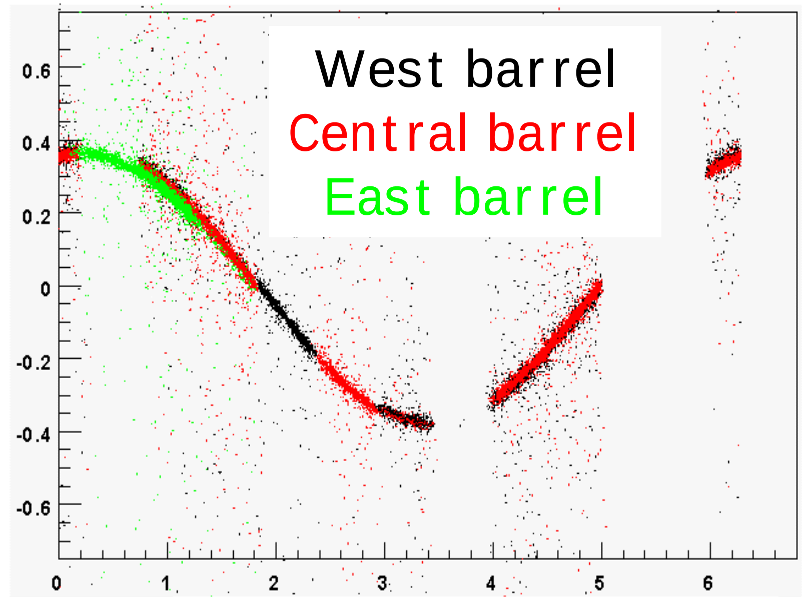
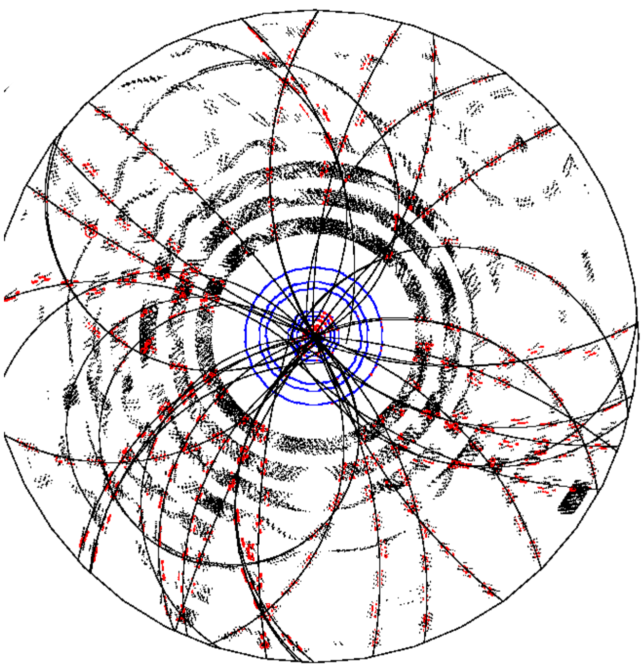
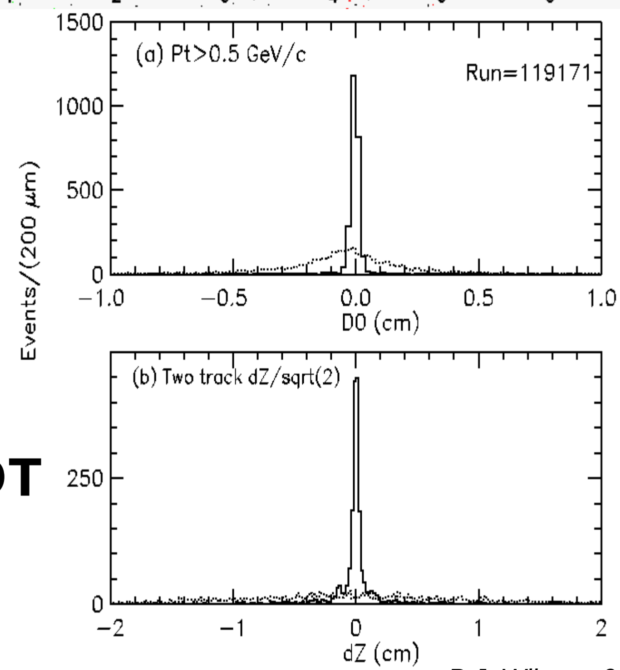
CDF Tracking Performance







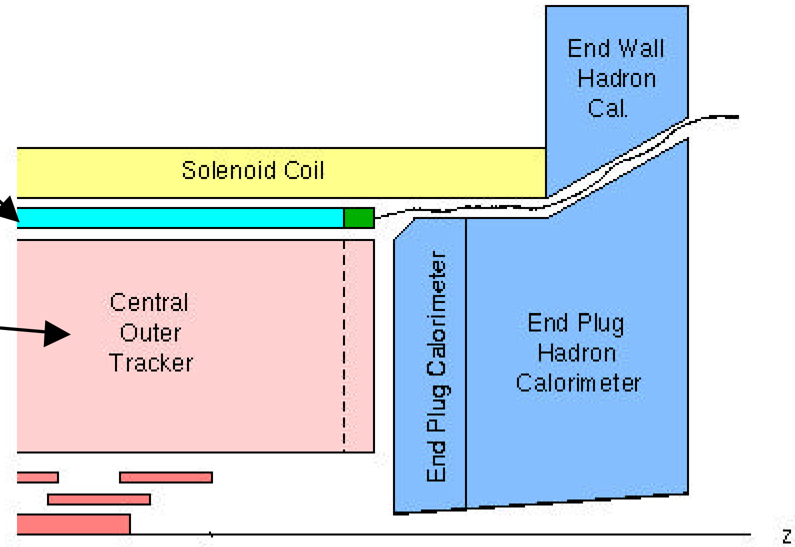


—— Si+COT
------ COT

CDF Particle ID Upgrade

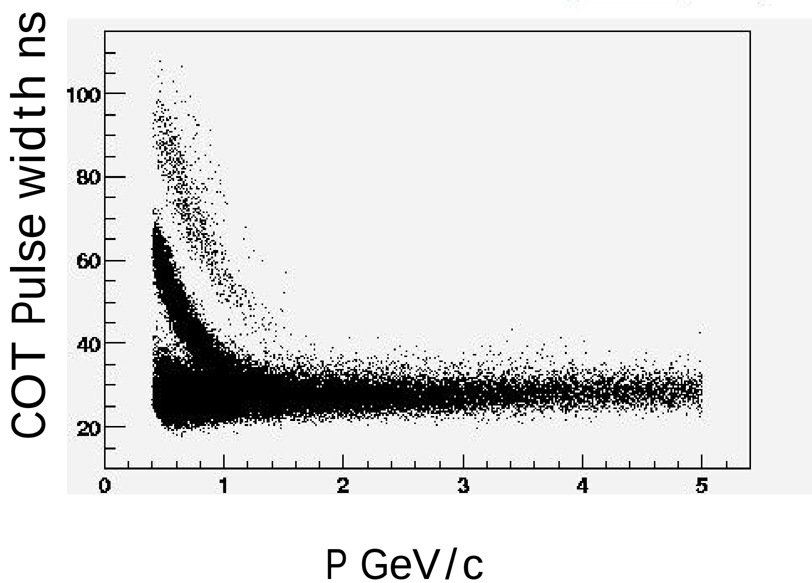
TOF scintillator bars

- 216 x 2 PMT channels
- 100ps timing resolution

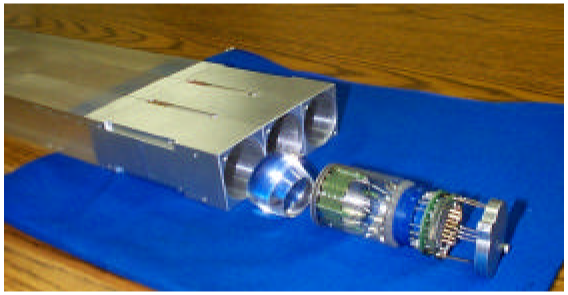


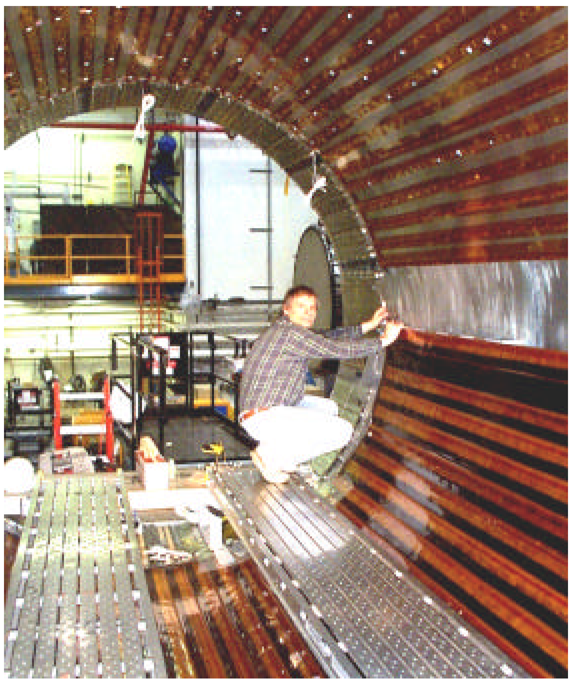
COT wires

- 96 pulse height measurements
- dE/dx measured from pulse width via new ASD + TDC electronics



CDF Time-Of-Flight





216 scintillators

Fine mesh PMTs

100 ps resolution → 2σ separation for:

– K/π, K/p, π/p for p < 1.6, 2.7, 3.2 GeV

Title:

Creator:
ROOT Version3.01/06
Preview:
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with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Expected improvement in flavor tagging for measurement of mixing in $B_s^o \rightarrow D_s\, n\pi$

	CDFI	CDFII	CDFII+TOF
εD^2	~ 3%	~5%	~10%

(ε efficiency for tag, D dilution)

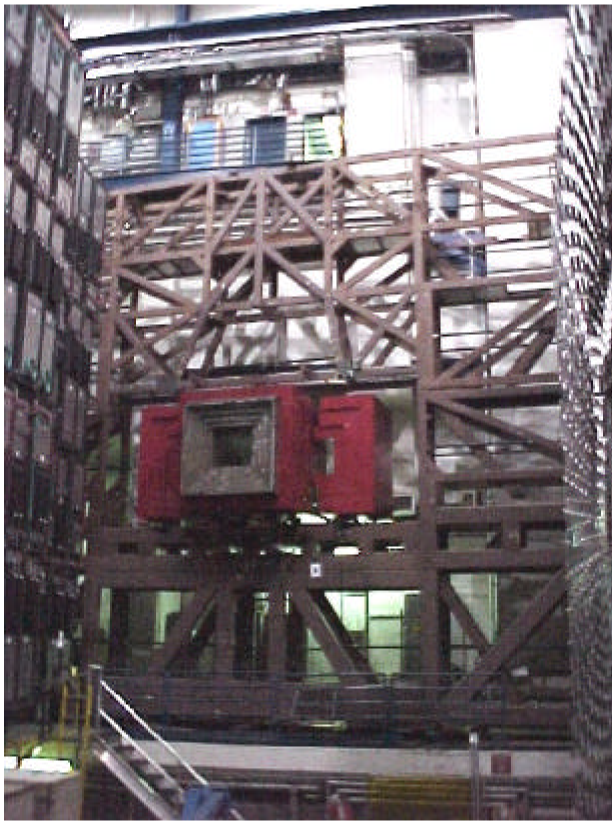
Calibration in progress

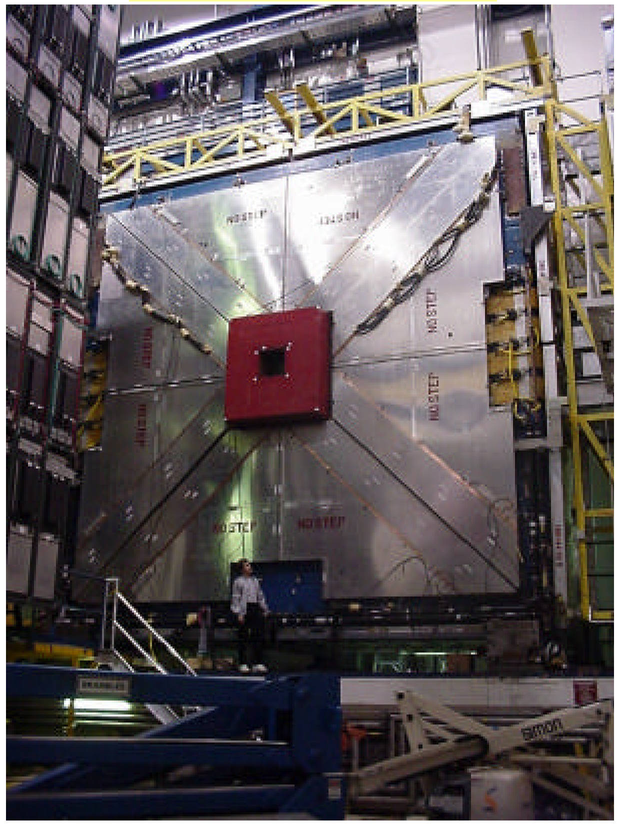
DØ Muon Detector Installation

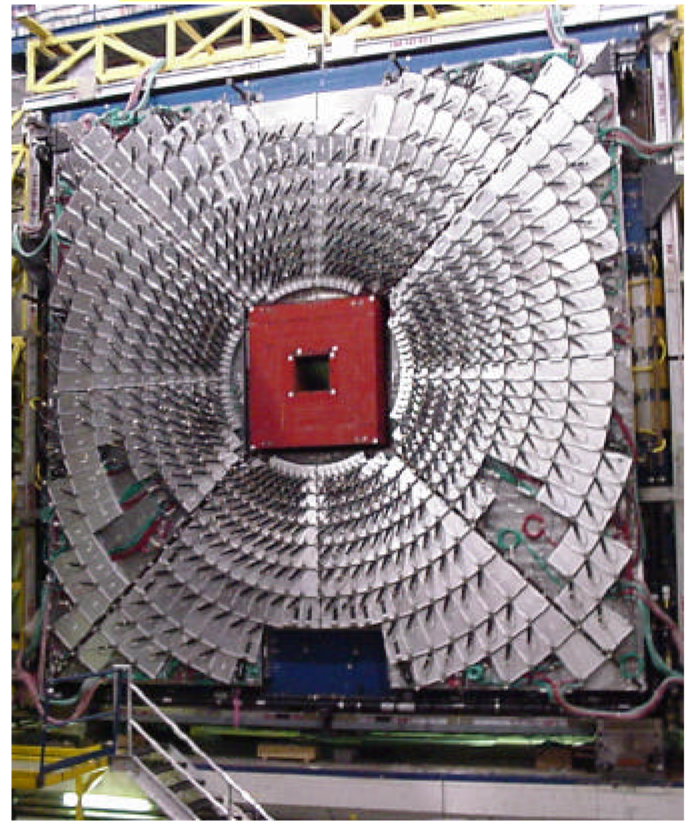
Shielding mounted on support truss

Mini drift tube plane complete (10m ´ 10m)

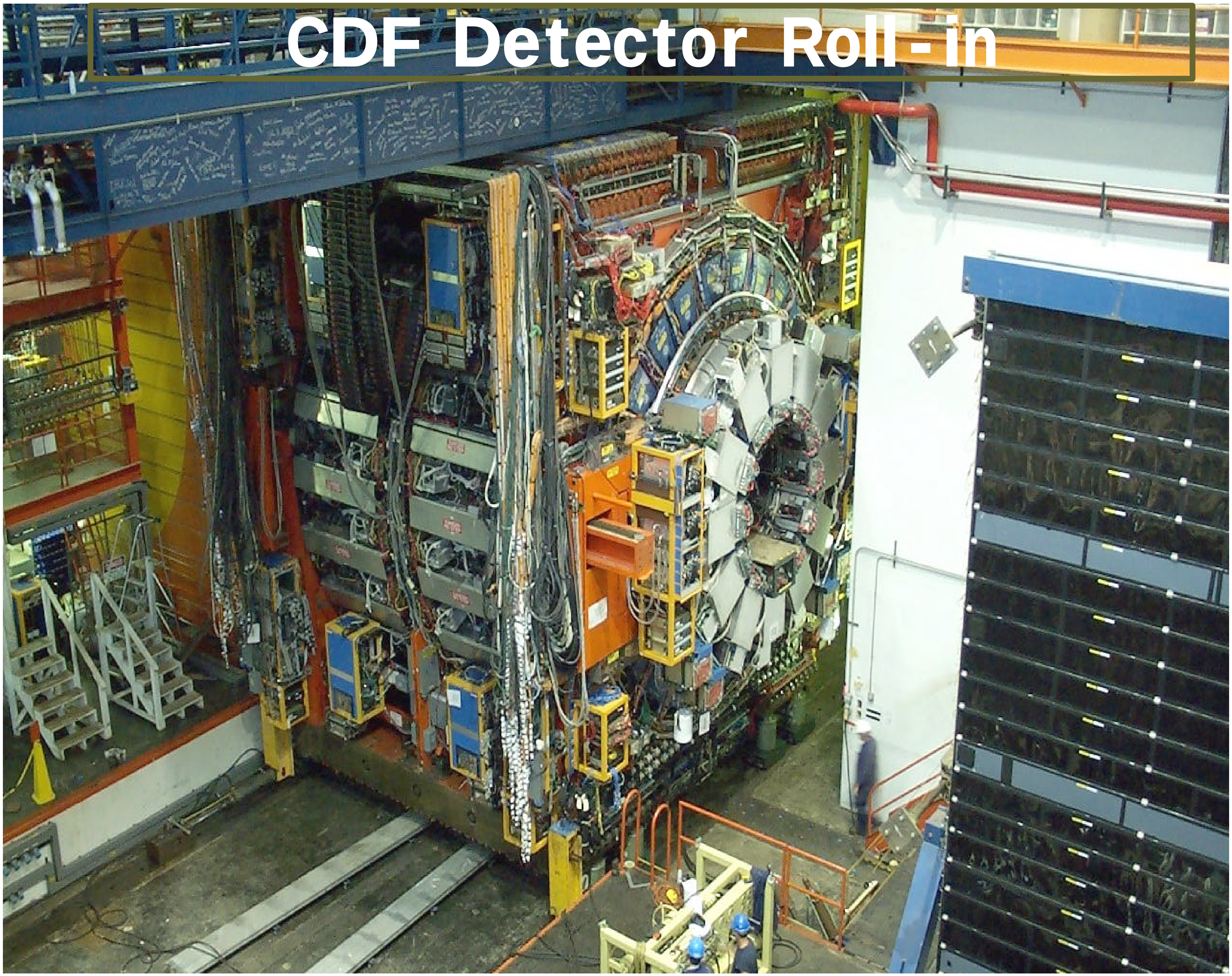
Trigger scintillator Plane complete (10m ´ 10m)



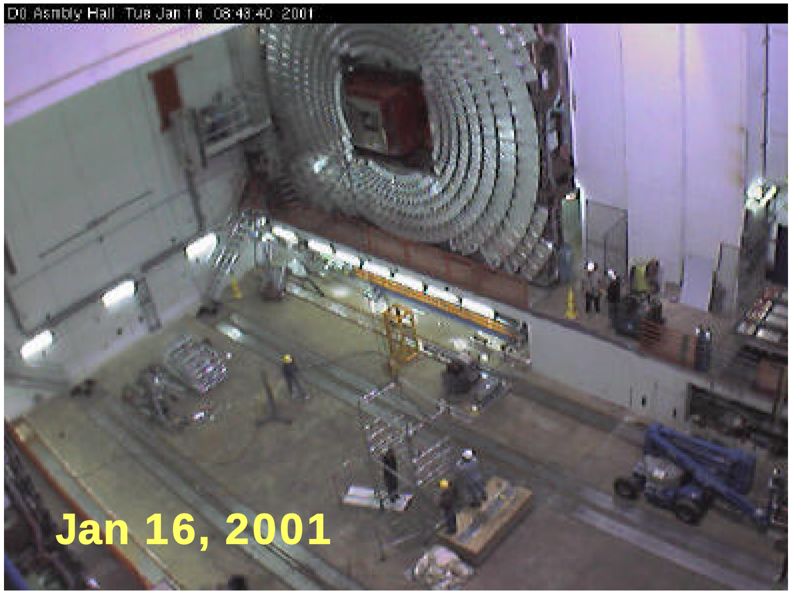


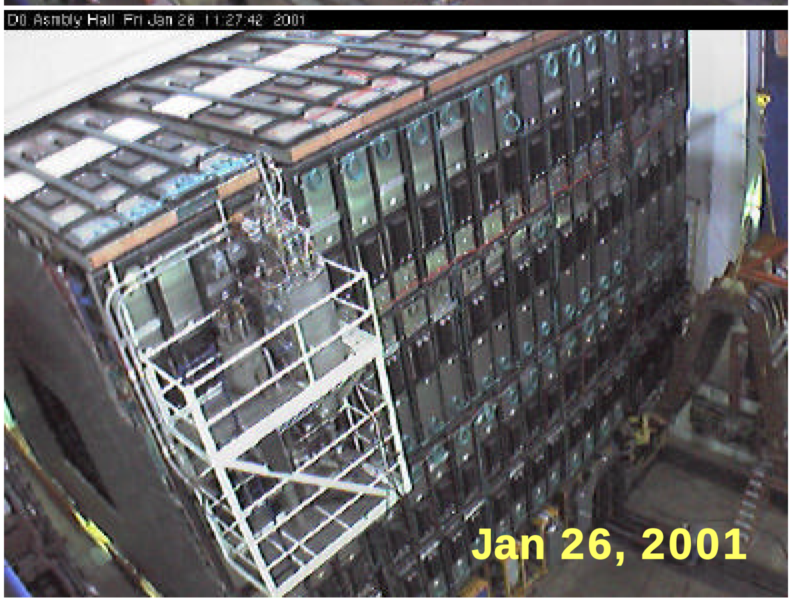


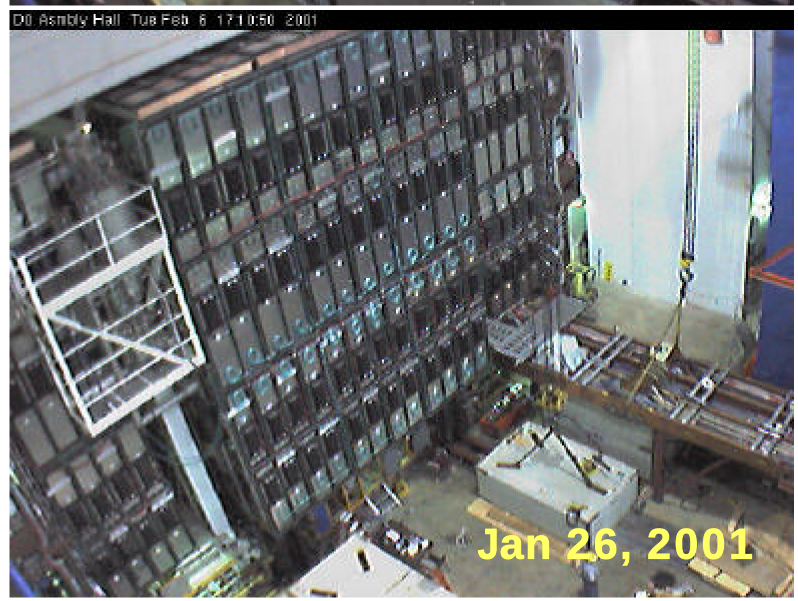
CDF Detector Roll-in



DØ Detector Roll-in

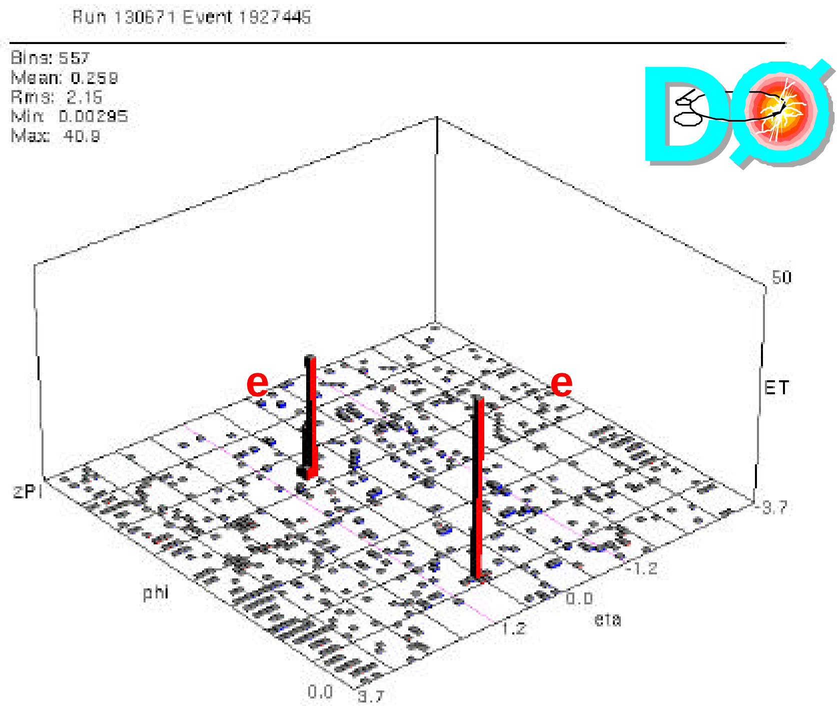


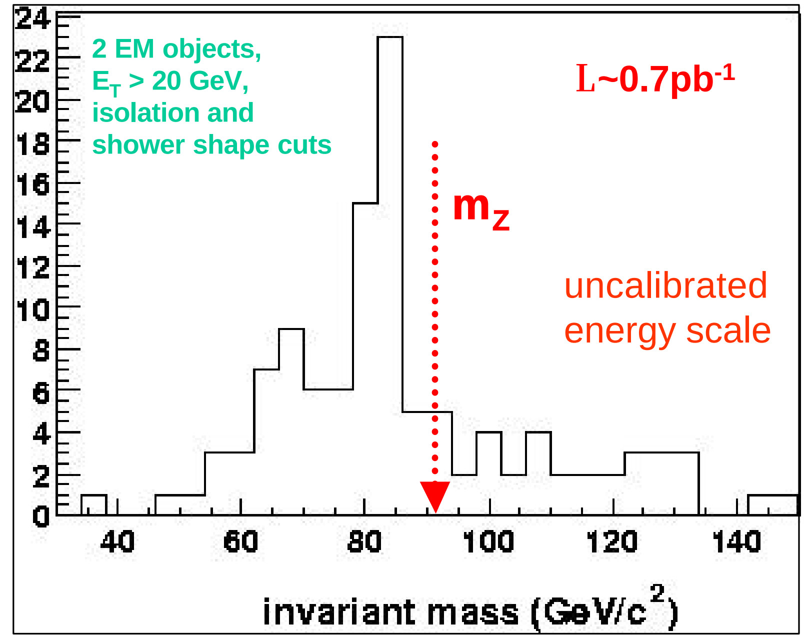


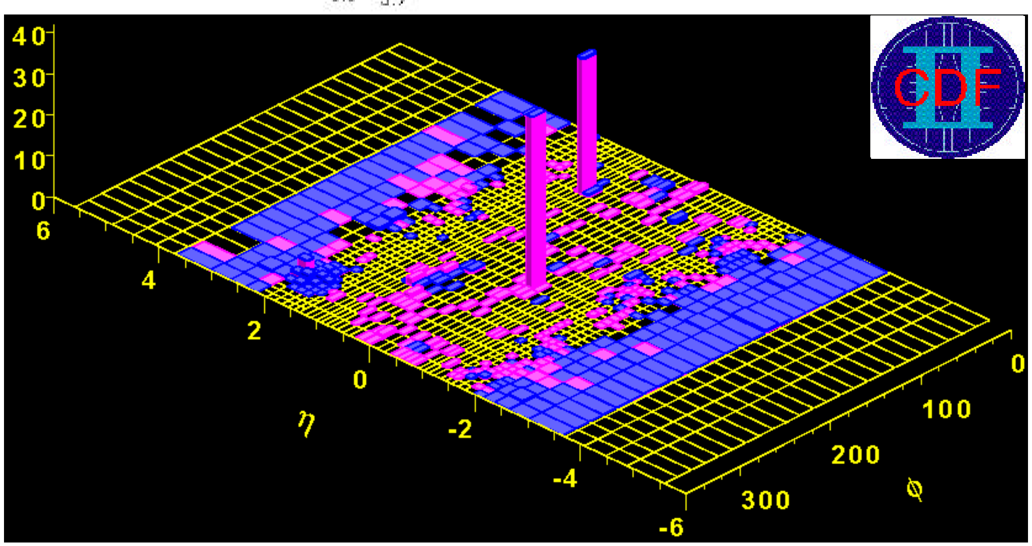


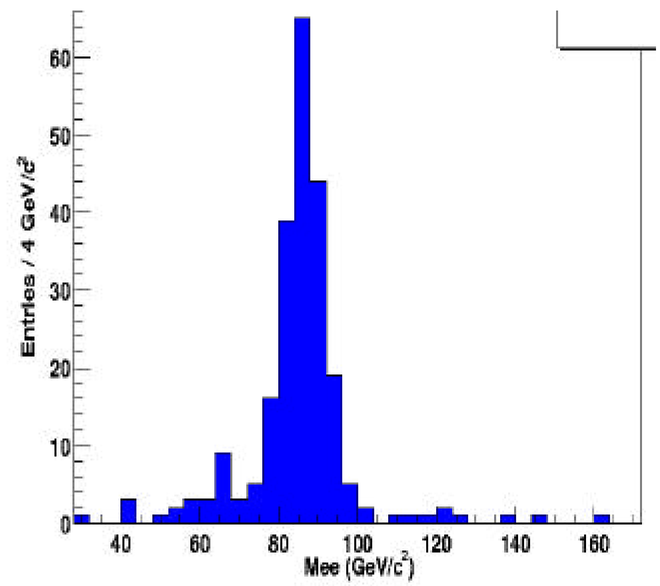
Early Run II Results:
Calibration ® Physics

Z ® e^+e^- Candidates



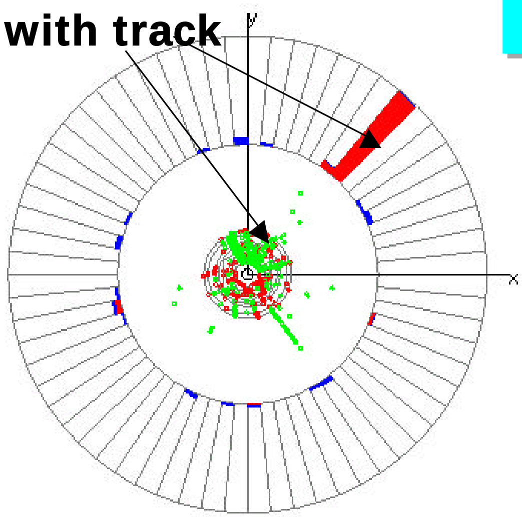


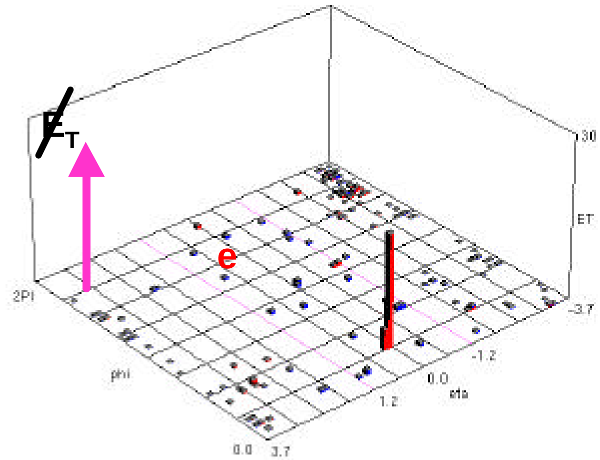


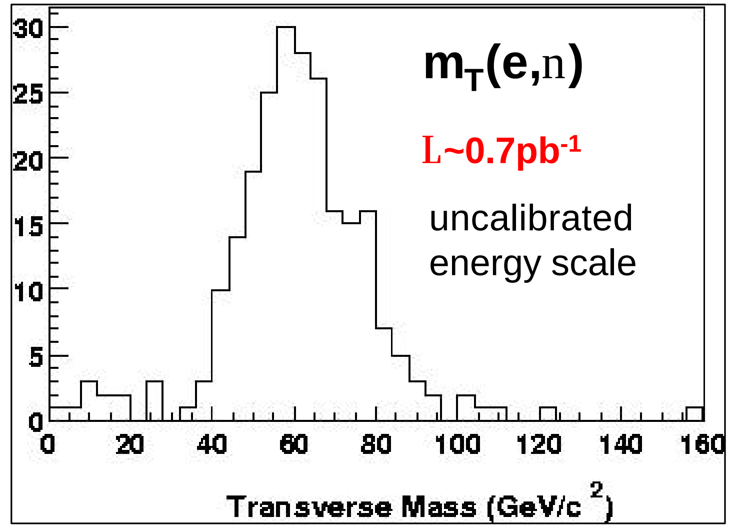


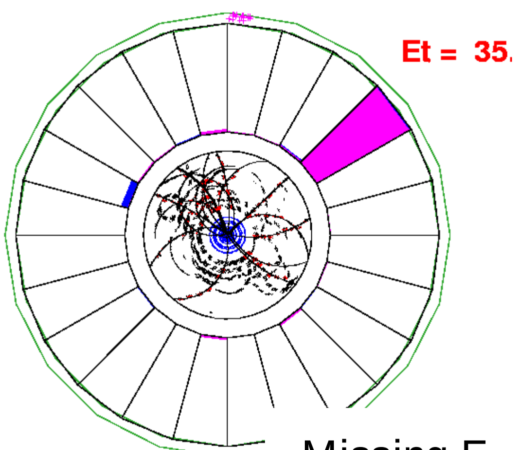
W ® en Candidates

EM cluster with track

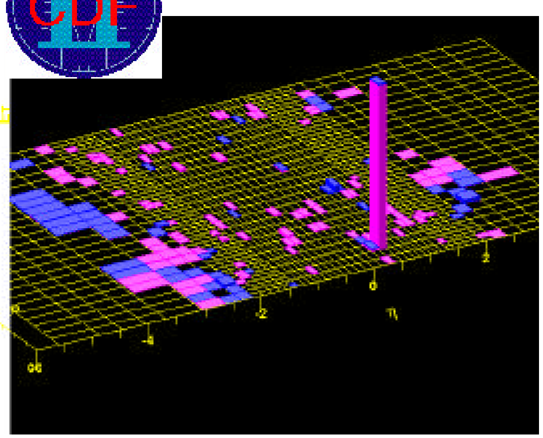


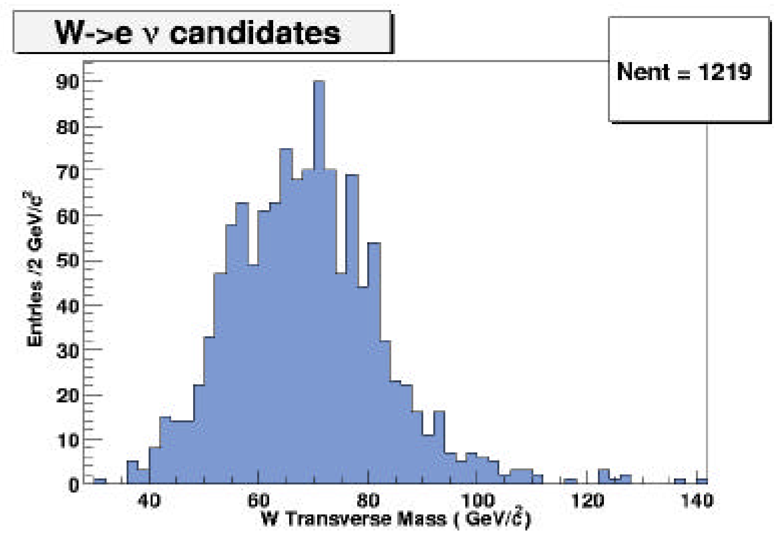






Missing E_t
= 38 GeV

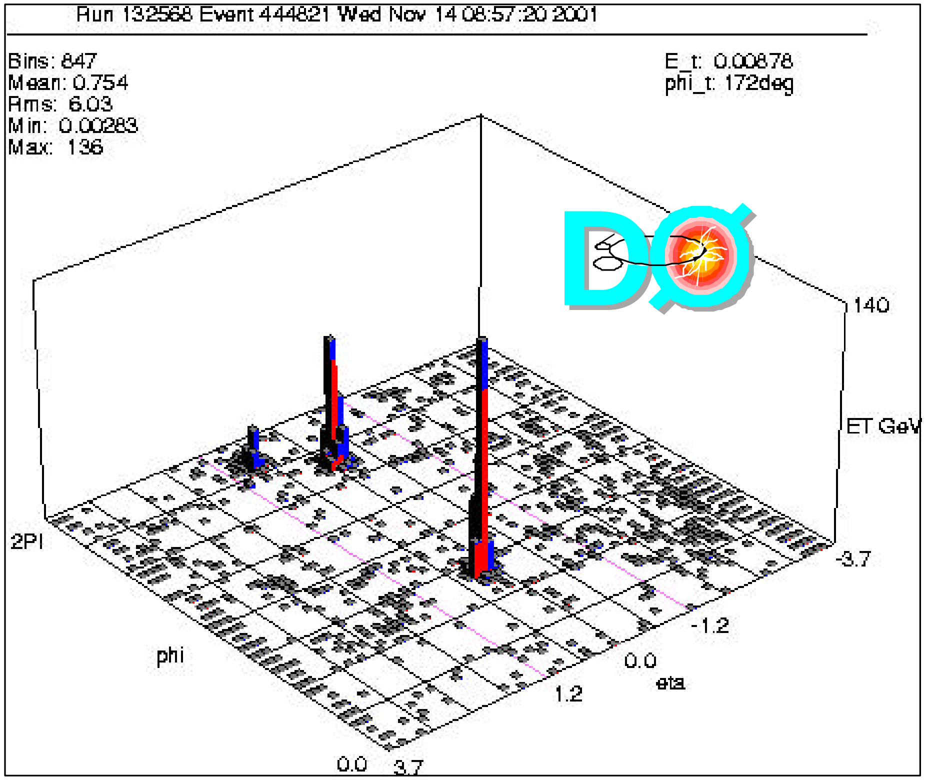




P.J. Wilson, 9 Jan 2002

Large E_T Jet Events

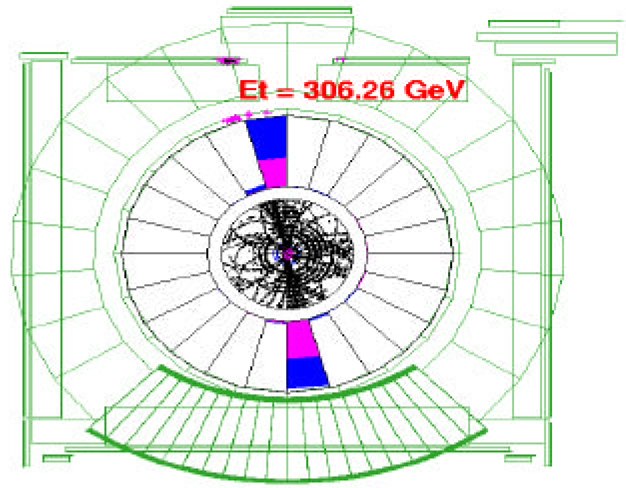
Using R=0.7 Cone Algorithm

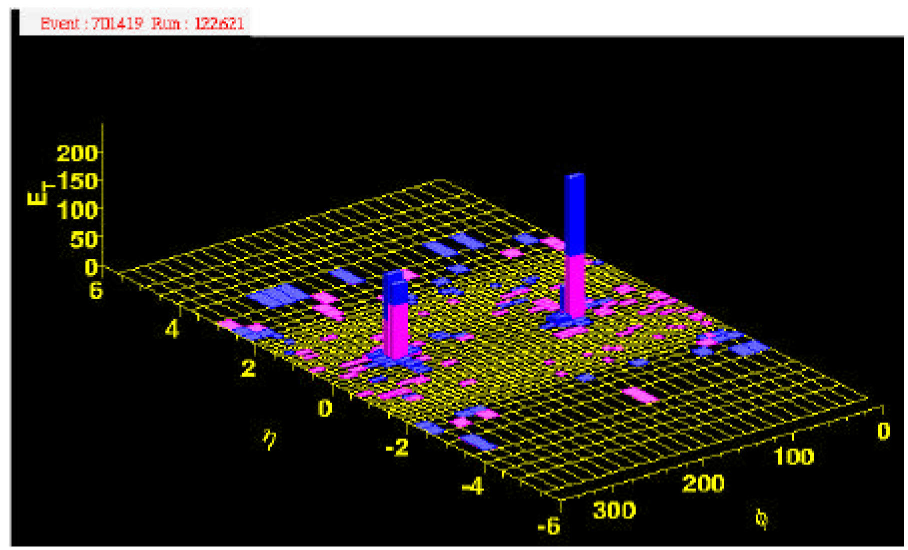


3-jet event

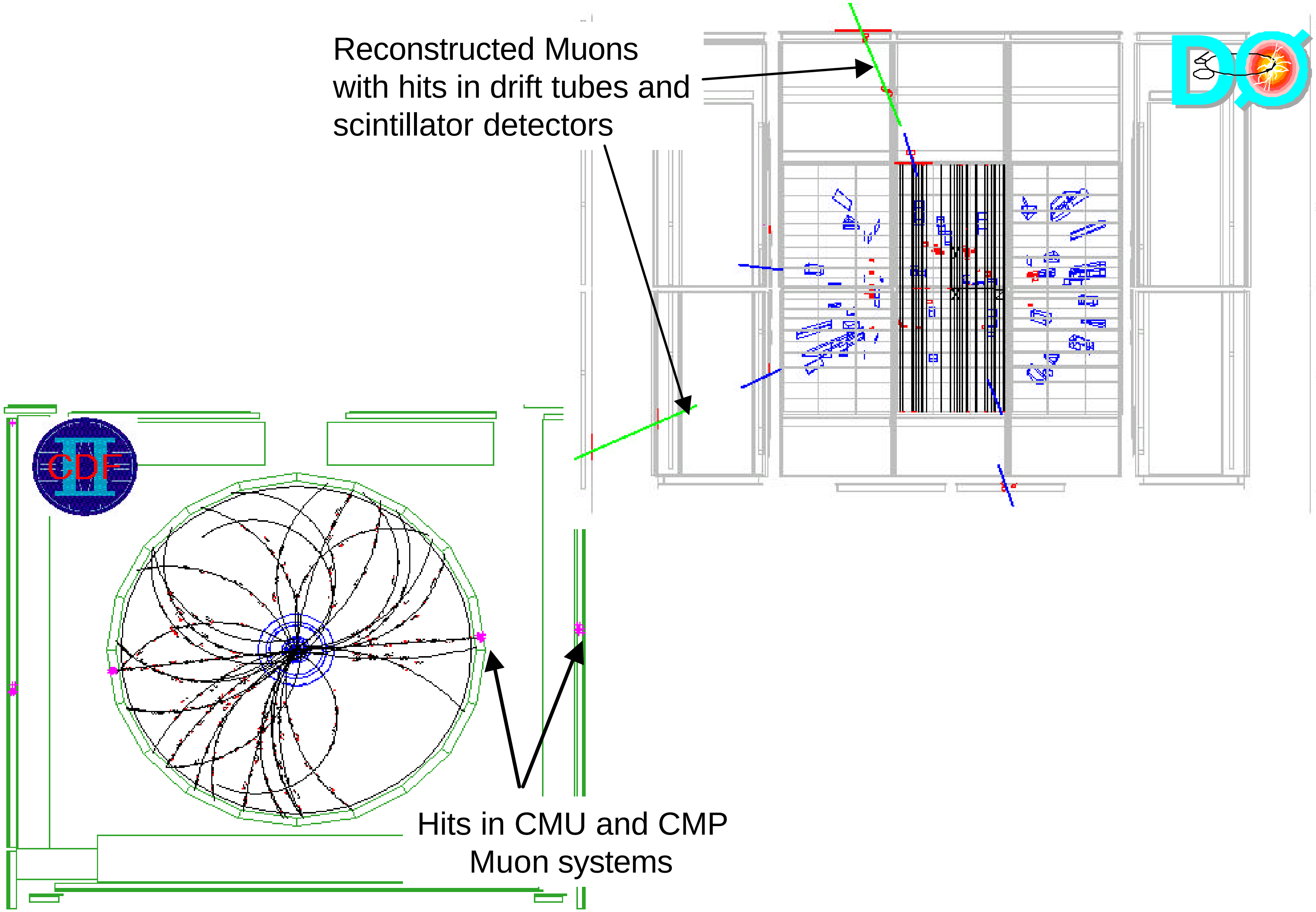
- E_T^{jet1}~310GeV
- E_T^{jet2}~240GeV
- E_T^{jet3}~110GeV
- E_T~8GeV

2-jet event



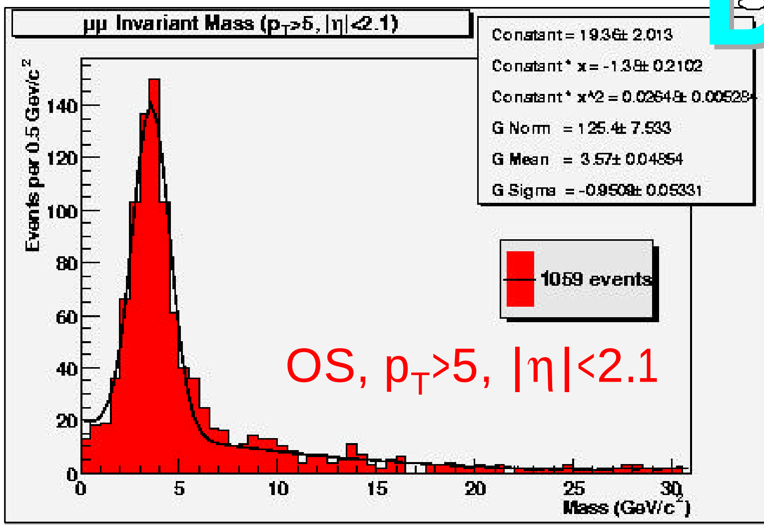


Z ® $m^{+}m^{-}$ Candidates

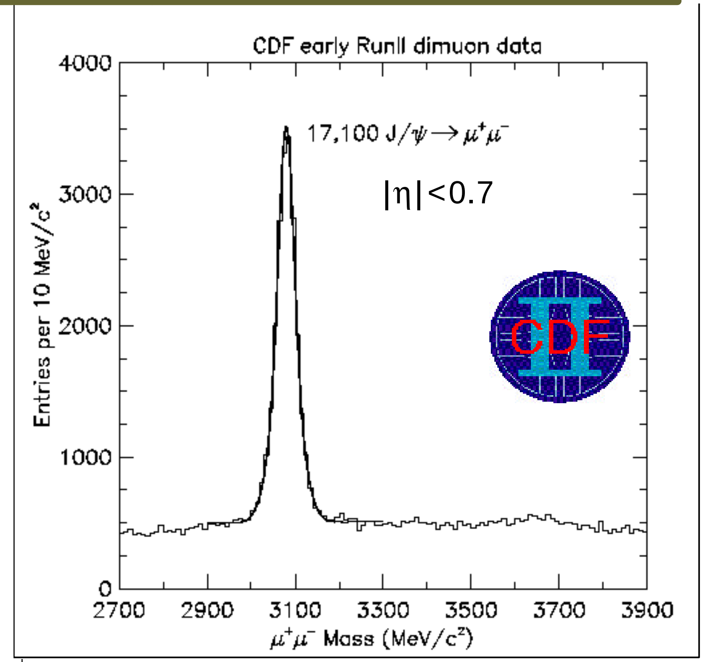


Reconstructed $J/\psi \rightarrow \mu^+\mu^-$

$\mu^+\mu^-$ in the forward region



Fitted mass = 3.57 ± 0.05 GeV/c²

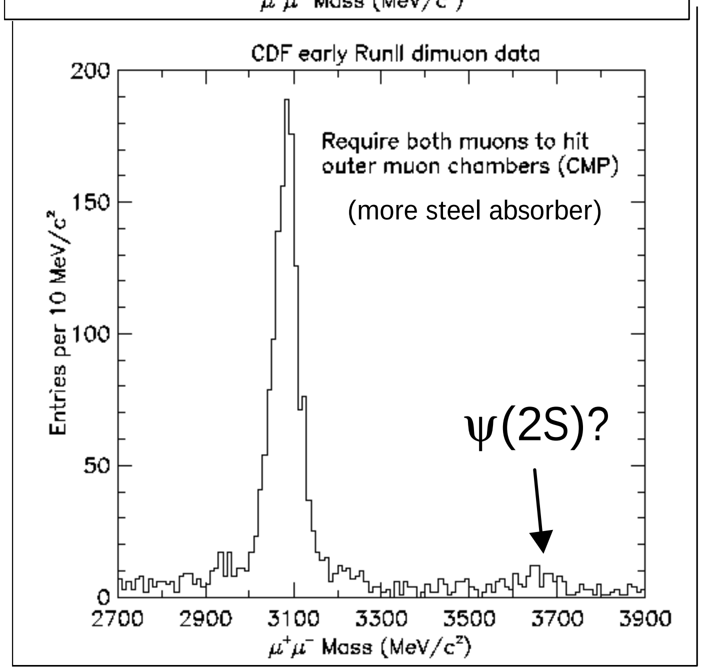


CDF rates for central ($|\eta|<0.7$):

$J/\psi \rightarrow \mu^+\mu^-$ as expected with new trigger ($P_T(\mu)$ 2 -> 1.5 GeV/c²).

For $0.7<|\eta|<0.9$ trigger working, under study

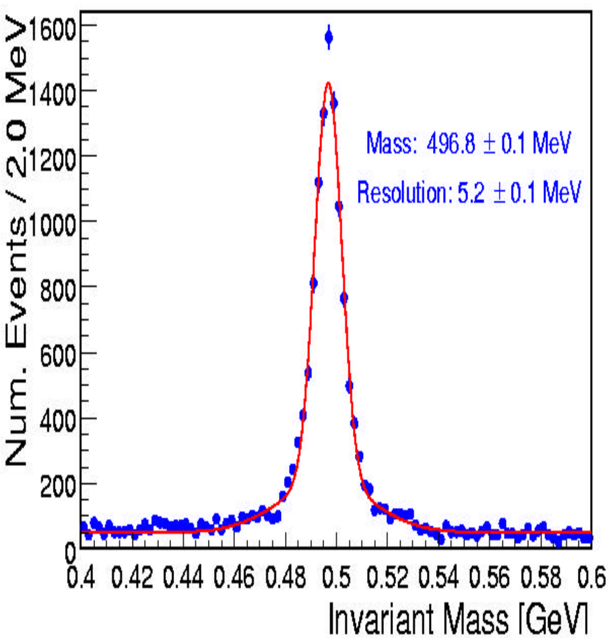
For $1.0<|\eta|<2.0$ trigger being commissioned



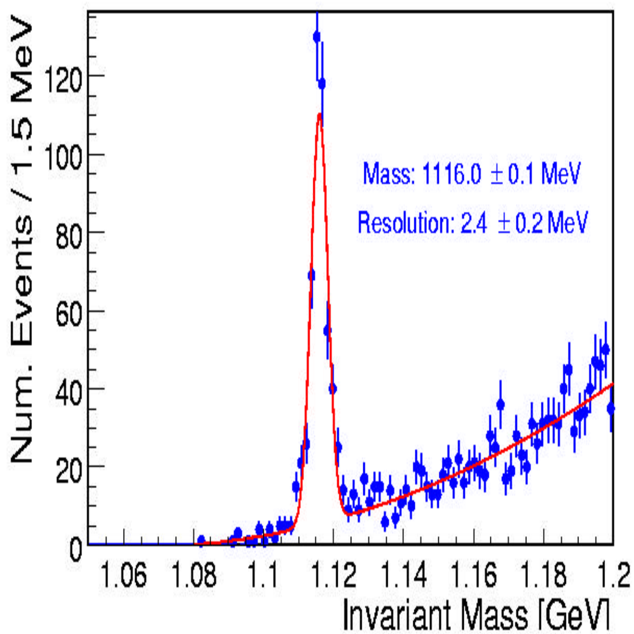
CDF Preparing for B Physics

Oppositely charged track pairs with large impact parameter and small z separation.

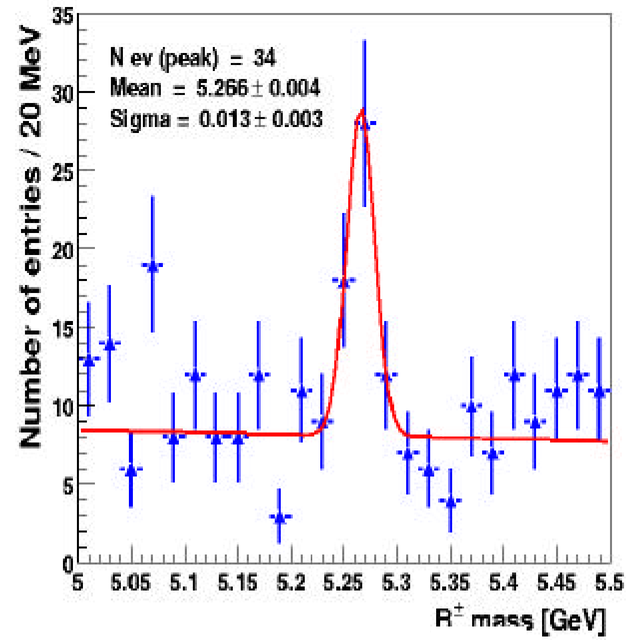
$K^o \rightarrow \pi^+ \pi^-$



$\Lambda \rightarrow p\ \pi$

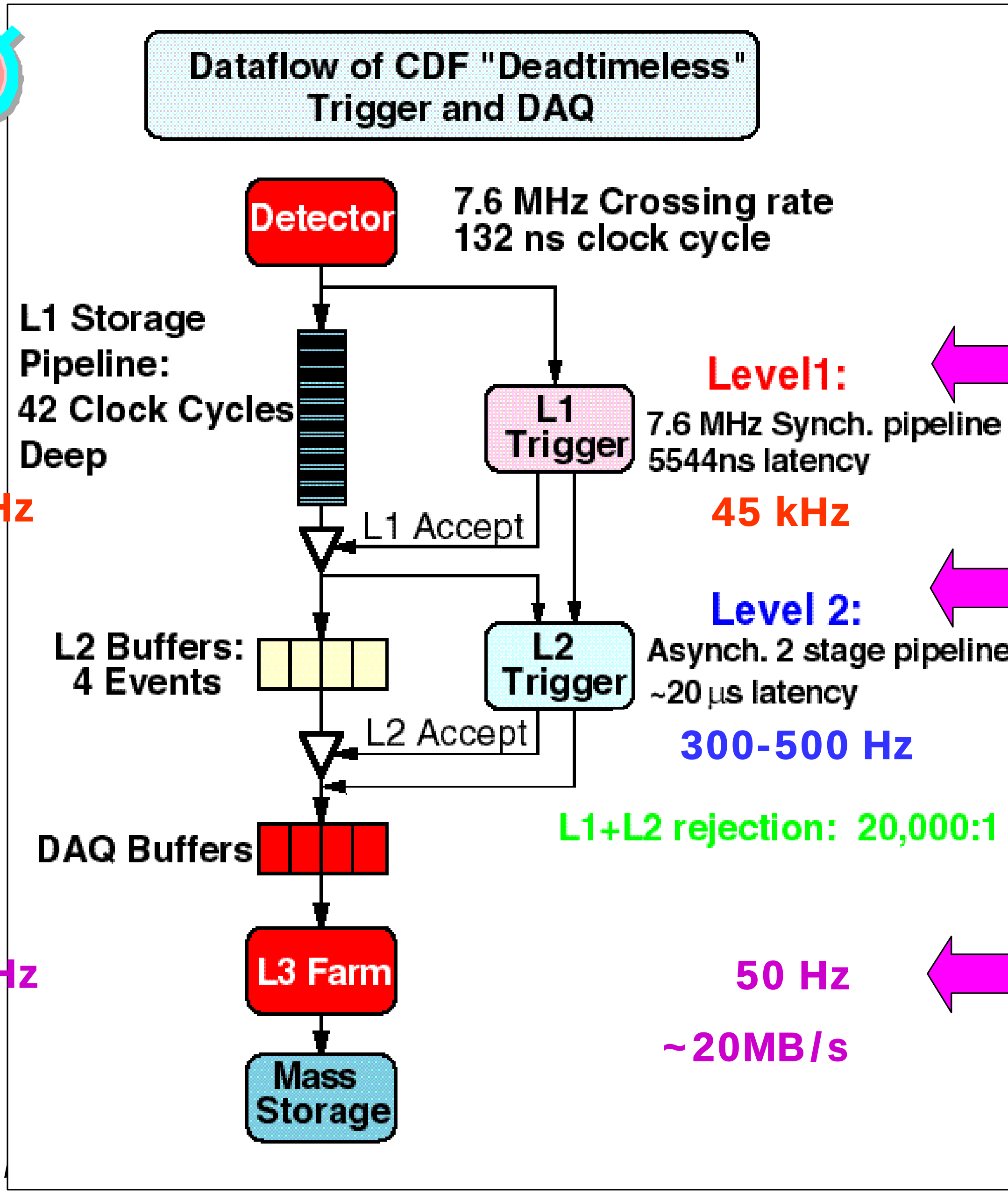


$B^\pm \rightarrow J/\psi\ K^\pm$



3 track vertex fit with $\mu\mu$ constrained to ψ mass

Triggering in Run 2



5-10 kHz

1 kHz

20-50 Hz

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

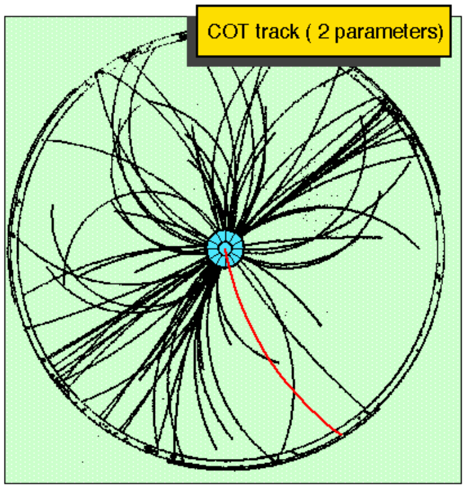
Si Secondary vertex
EM shower max, ISO
Jet Clustering
Multi object triggers

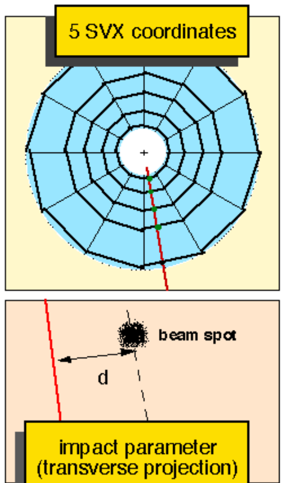
Farm of ~200 PC's running fast versions of Offline Code → more sophisticated selections

CDF L1 and L2 Trackers

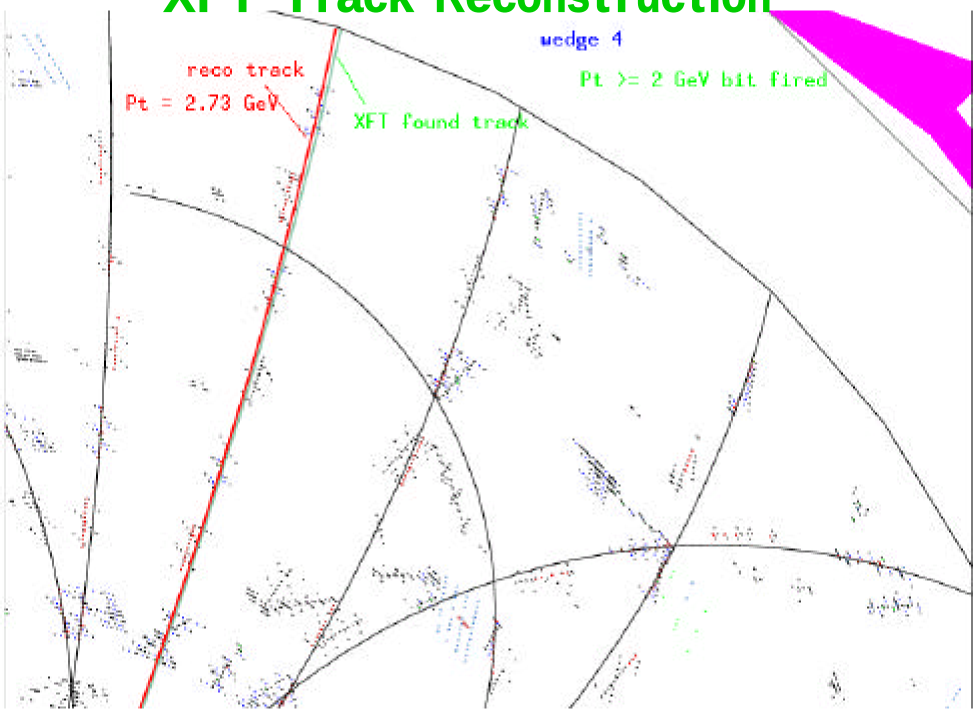
COT (XFT) defines track momentum cut at level 1
Min. P_T=1.5 GeV/c

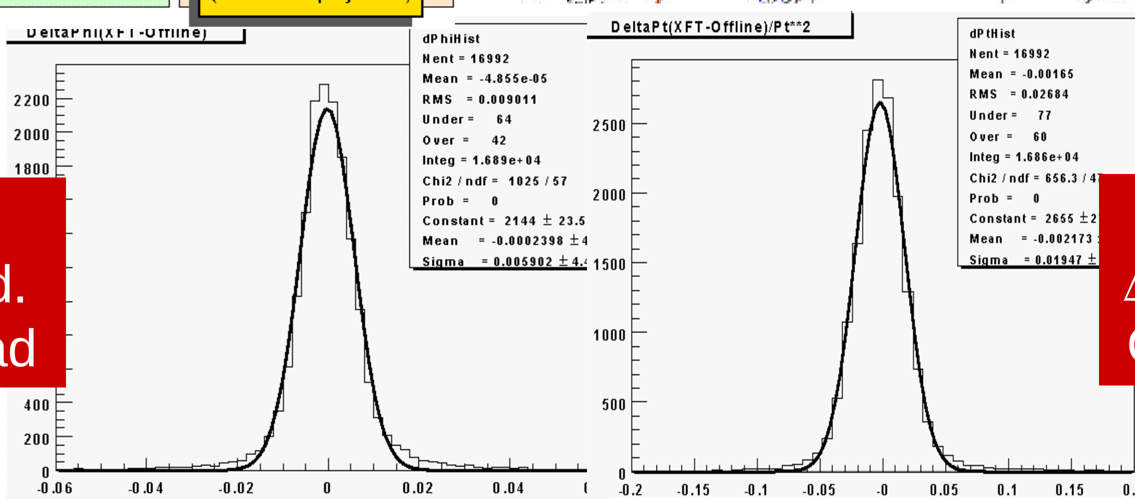
SVX measures impact parameter cut at level 2 (SVT)





XFT Track Reconstruction



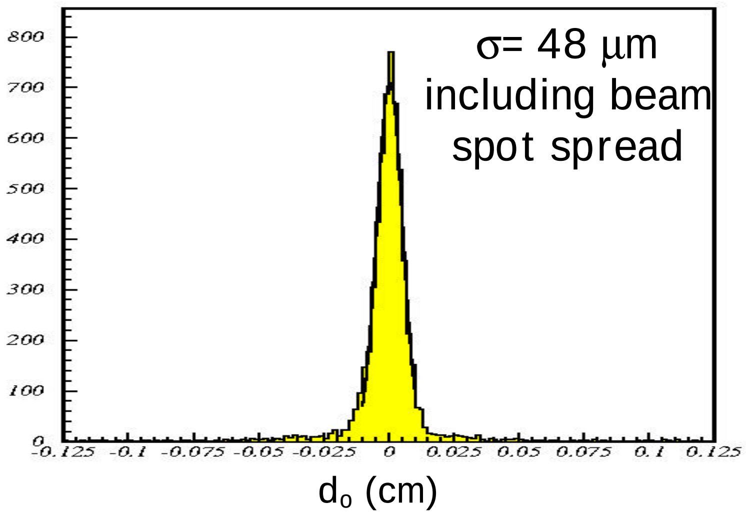


L1: XFT
$\Delta\phi$ = 6 mrad.
Goal : 8 mrad

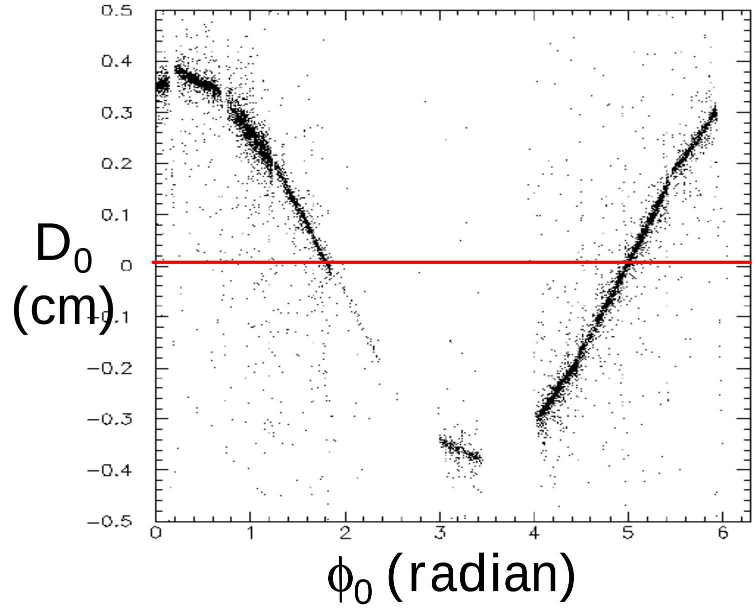
L1: XFT
ΔC = 0.016 GeV^{-1}
Goal : 0.02 GeV^{-1}

CDF L2 Silicon Trigger Performance

SVT impact parameter



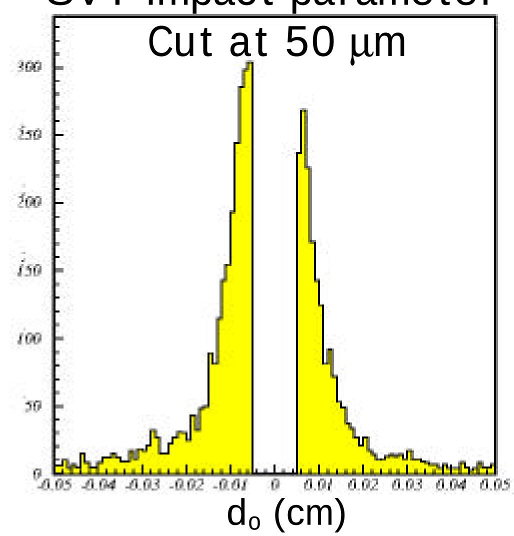
SVT Measures Beam Position



SVT Two track trigger test runs:

- **L1: 2 tracks with P_t > 2.0 GeV/c (XFT)**
- **L2: 2 tracks with impact parameter (SVT)**

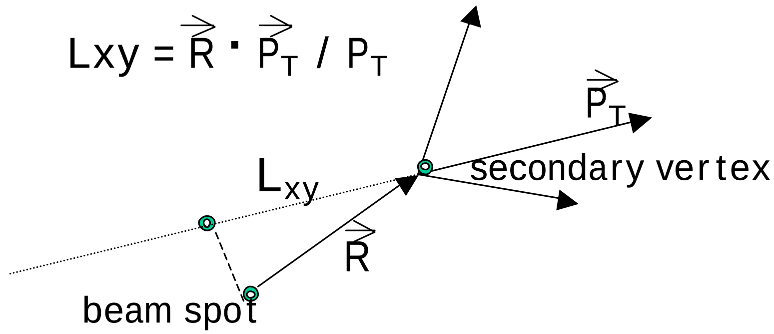
SVT impact parameter



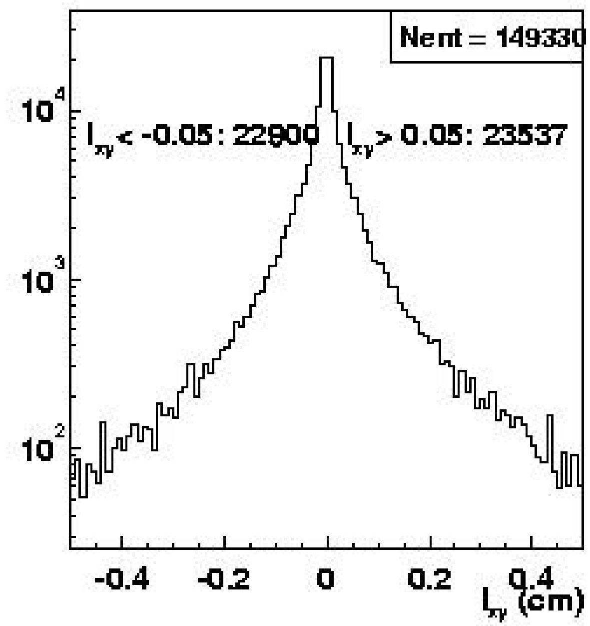
First evidence for heavy flavor selection using L1-L2 displaced vertex trigger

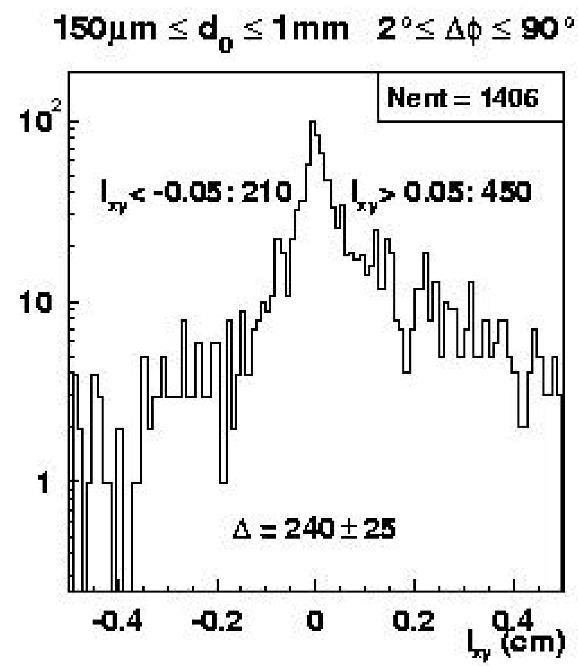
All done with less than ½ of Silicon turned on

CDF Silicon Trigger Results



l_{xy} before and after L2 Trigger Cuts

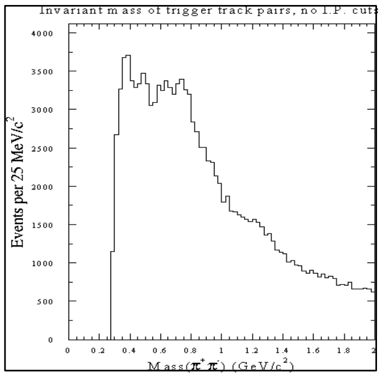


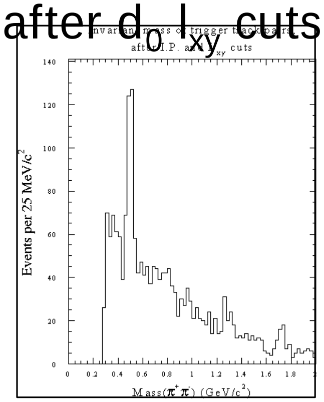


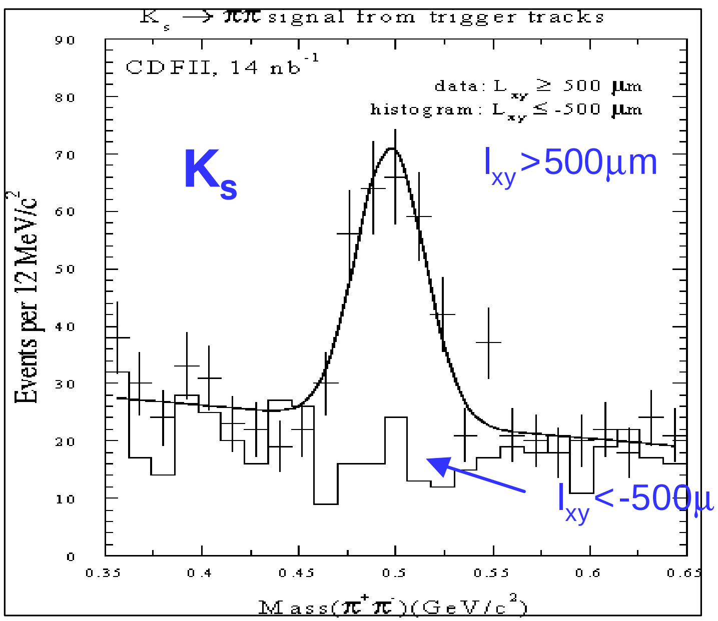
K_s and D^0 in SVT Data!

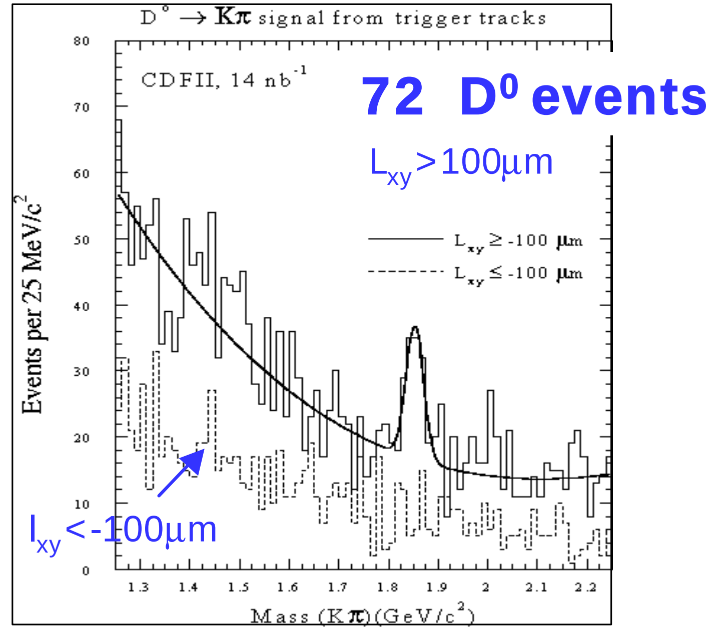
Data from Silicon Trigger test runs: L2 Silicon Tracks matched w/offline COT Tracks

Mass before and after d_0 l_{xy} cuts

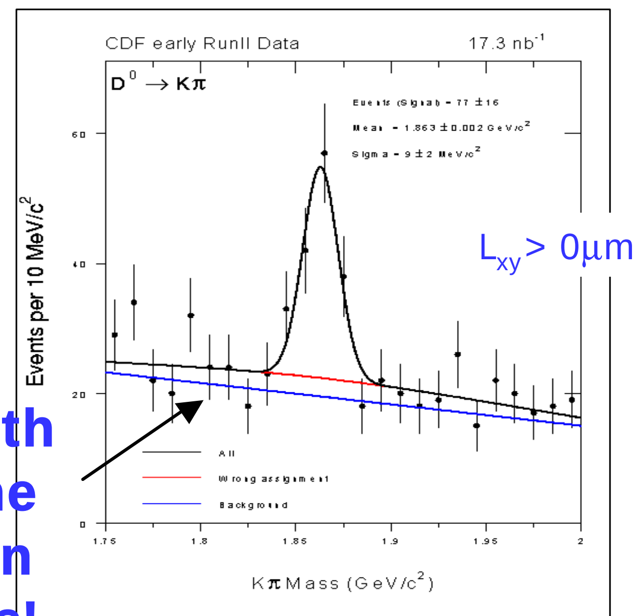








D^0 with Offline Silicon tracks!



What Run II May Bring....

Physics Potential for Tevatron Run II

The details depend on specific physics channels, but it is easy to understand the big picture.

Physics Potential for Run II =

[Run I Physics Results] x A x D x E x I > 400 ~ 900

Where

A = Accelerator improvements ~ 200 – 300 (assume 15 fb^{-1})

D = Detector upgrades ~ 2 – 3 (top, Higgs, B physics)

- **b-tagging**
- **Lepton coverage**
- **Particle ID's**

E = Experience working with the data > 1

- **e.g. attained ~2 in Run I top studies**

I = new Ideas > 1

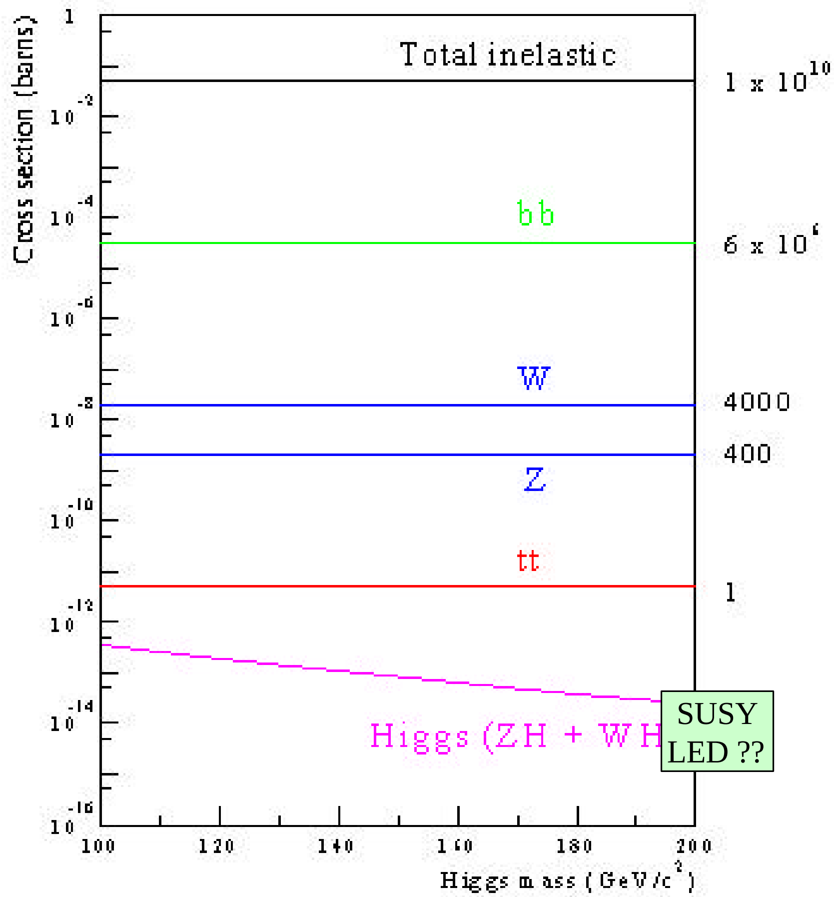
The Fermilab Particle Menu

- High b rates
  - ➢ $B \rightarrow J/\psi\ K_S \rightarrow \mu\mu\ K_S$
    - 10^4 (IIa) – 10^5 (IIb)
    - 400 events in Run I
  - ➢ challenge : triggers, flavor tagging

- Large W boson sample :
  10^6 (IIa) – 10^7 (IIb) events

- Largest/only $t\bar{t}$ sample :
  10^4 (IIa) – 10^5 (IIb) events
  - ➢ challenge : b tagging, jet energy

- Searches for Higgs, SUSY, ...
  - ➢ challenge : backgrounds, statistics



Run II Physics Goals

- **Understanding Electroweak Symmetry Breaking**
  - EW Measurements (M_W, M_{top})
  - Higgs Boson Search
    - the Standard Model
    - SUSY
- **Study CP Violation and the CKM Matrix**
  - X_s Measurement
  - Sin2β Measurement
- **Searches for New Phenomena**
- **Long list of other topics**

Run 2 Top Quark Measurement Projections

Top quark Property	Run 1 measurement	Precision: Run 1	Run 2a	Run 2b	LHC
Mass (CDF + DØ)	$174.3 \pm 3.3 \pm 3.9\,\mathrm{GeV}/c^2$	2.9%	1.2%	1.0%	1%
$\sigma_{t\bar{t}}$	$6.5^{+1.7}_{-1.4}$ pb	25%	10%	5%	5%
W helicity, F_0	$0.91 \pm 0.37 \pm 0.13$	0.4	0.09	0.04	0.01
W helicity, F_+	$0.11 \pm 0.15 \pm 0.06$	0.15	0.03	0.01	0.003
$R \equiv \frac{B(t\to Wb)}{B(t\to Wq)}$	$0.94^{+0.31}_{-0.24}$ > 0.61 at 90% C.L.	30%	4.5%	0.8%	0.2%
$\lvert V_{tb}\rvert$	$0.96^{+0.16}_{-0.12}$ (3-gen.) > 0.051 at 90% C.L.	> 0.05	> 0.25	> 0.50	> 0.90
σ(single top)	< 18.6 pb	–	20%	8%	5%
$\Gamma(t \to Wb)$	–	–	25%	10%	10%
$\lvert V_{tb}\rvert$	–	–	12%	5%	5%
BR($t \to \gamma q$) 95% CL	0.03	0.03	2×10^{-3}	2×10^{-4}	2×10^{-5}
BR($t \to Zq$) 95% CL	0.30	0.30	0.02	2×10^{-3}	2×10^{-4}

M_{top} Systematics

Improving M_{top}:

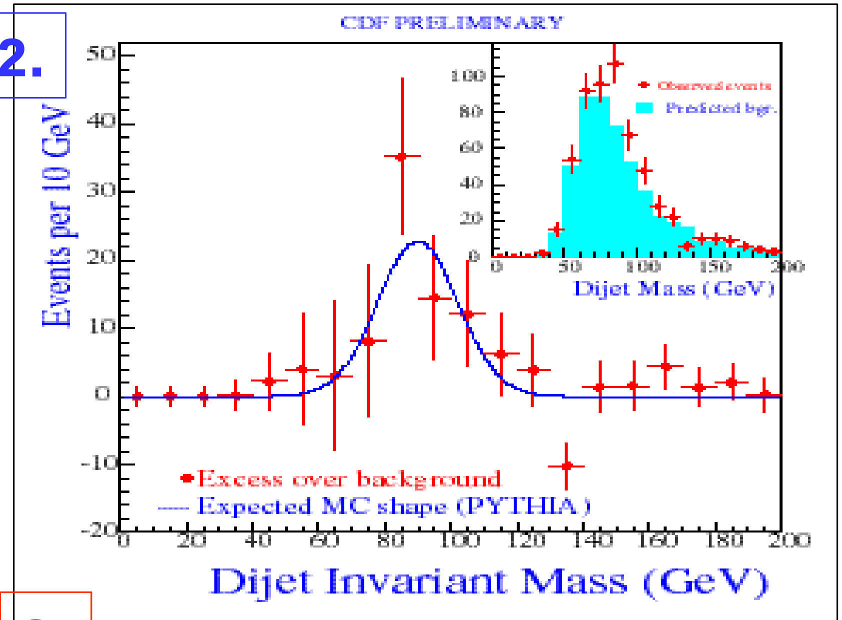
Statistics: more L, higher ε_{btag}

Better jet energy scales:

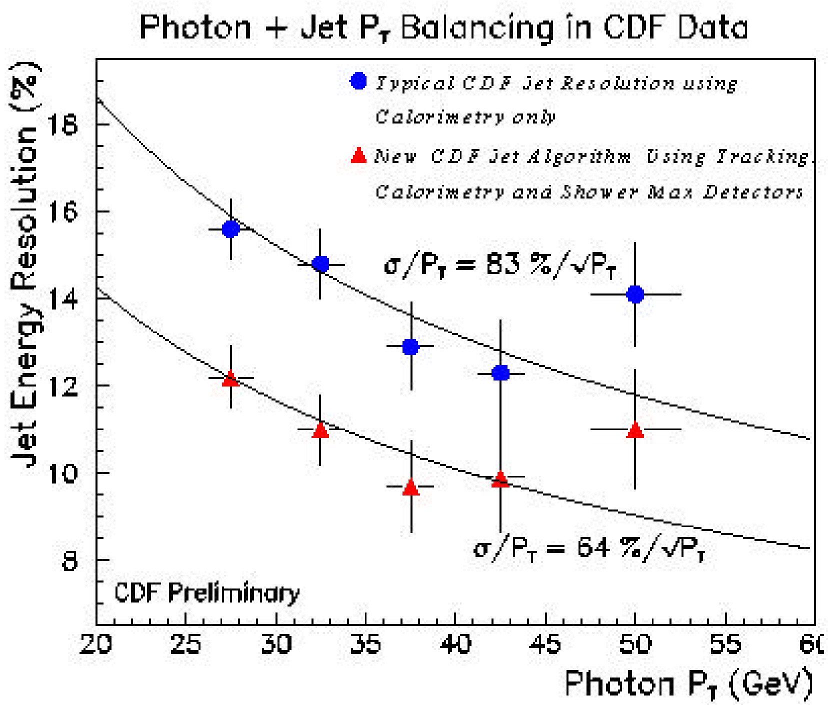
1. New corrections w/ tracks...
2. Calibrate b-jet w/ Z-> bb
3. Reconstruct W->JJ in top

Also helps Higgs search!

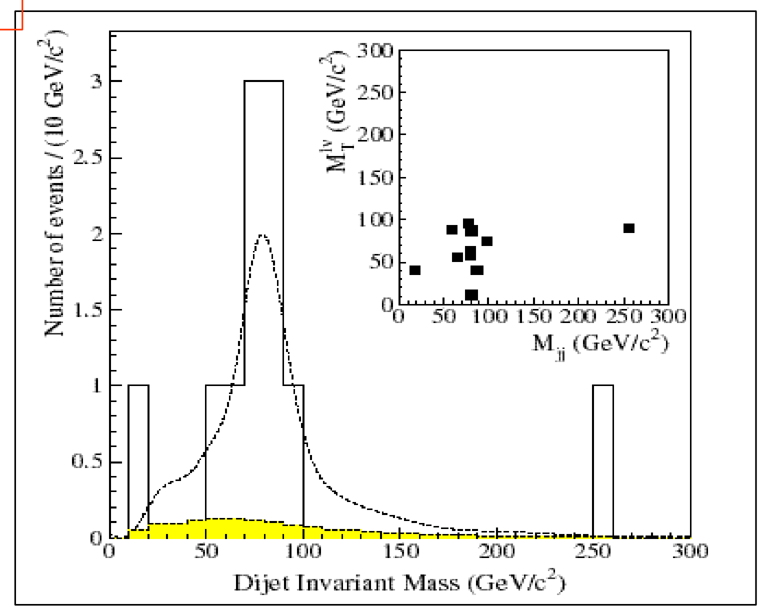
2.



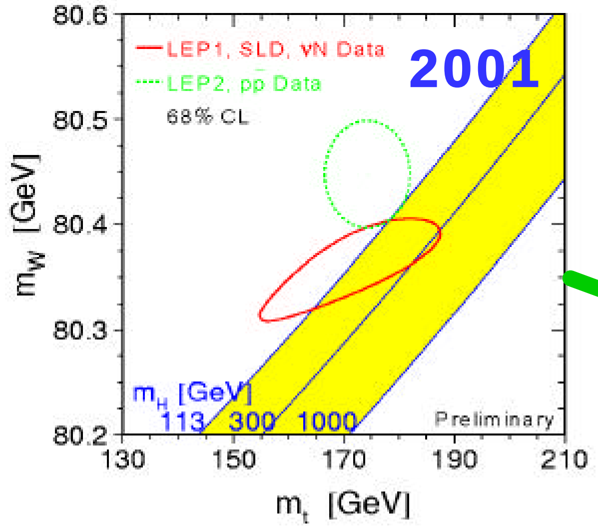
1.



3.

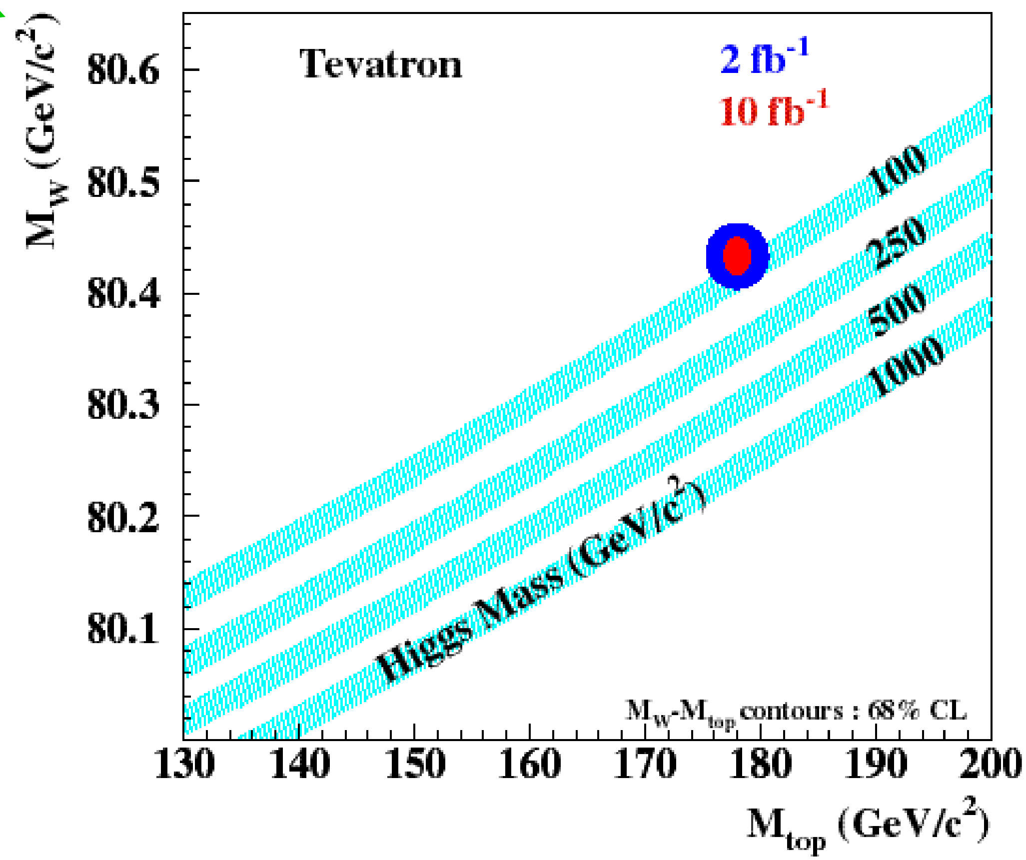


Precision EWK in Run 2



Run 2

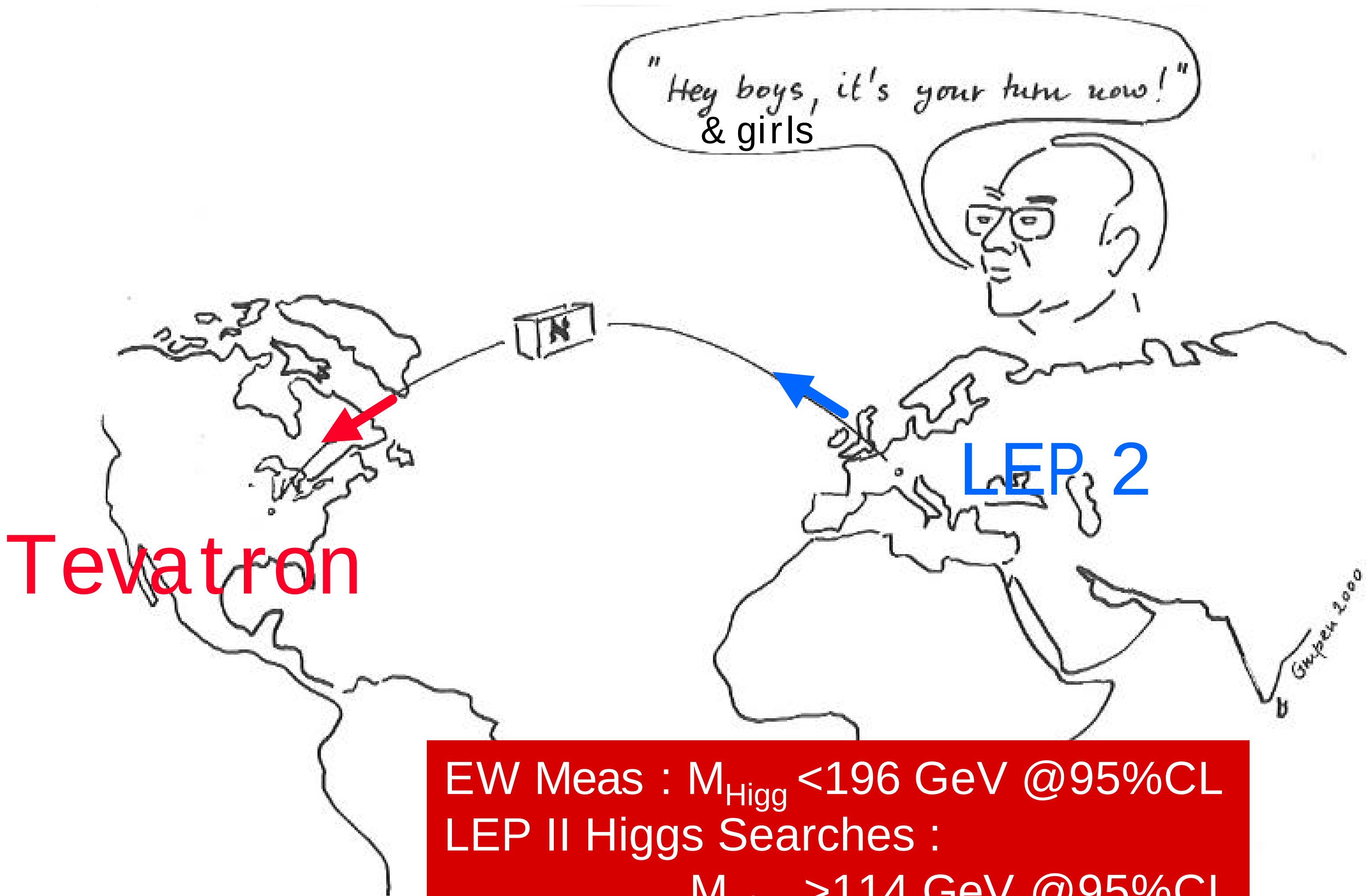
Precision measurements of top and W masses will severely constrain the mass of the Standard Model Higgs



Run 2:

- **M_W: CDF Å DÆ**
  - Improvement from increased statistics
  - δM ~ 35 MeV (2 fb^{-1})
  - δM ~ 20 MeV (10 fb^{-1})
- **M_{Top}: CDF Å DÆ**
  - δM ~ 2 GeV (2 fb^{-1})
  - δM ~ 1.7 GeV (10 fb^{-1})

Higgs Searches: LEP 2 → Tevatron



EW Meas : M_{Higg} <196 GeV @95%CL
LEP II Higgs Searches :
M_{Higg} >114 GeV @95%CL
LEP II Hint @ M_{Higg}= 116 GeV

Higgs Hunting at the Tevatron

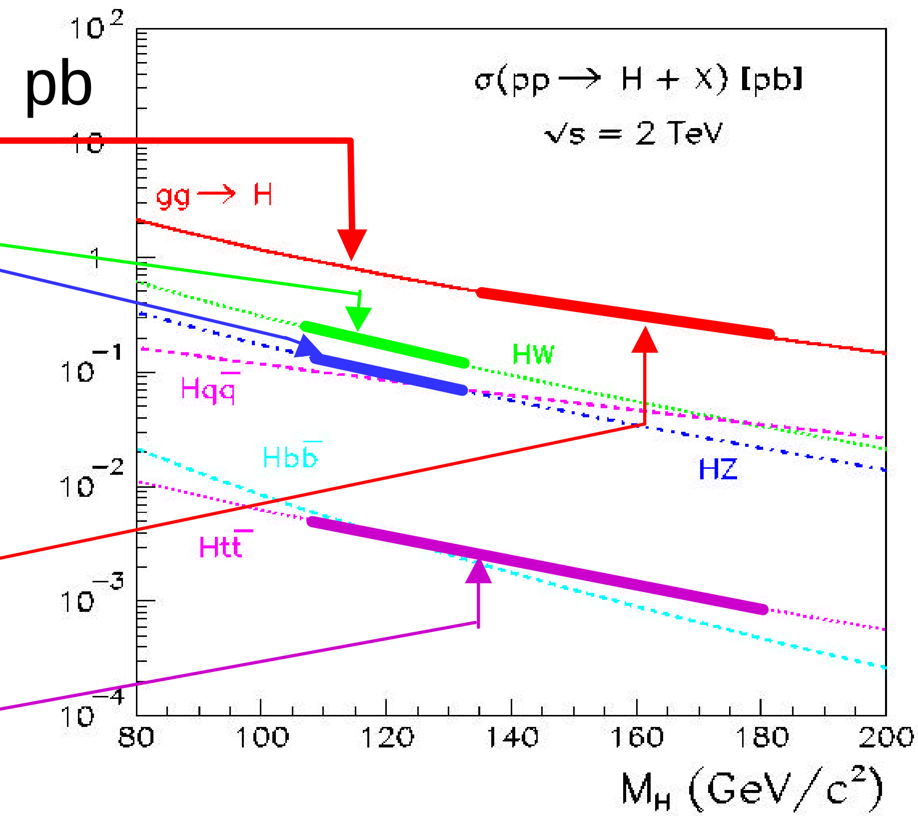
- Higgs cross sections:
  - **Inclusive ~ 1 pb**
  - **W/Z + H ~ 0.2 pb**
  - **$t\bar{t}$ + H ~ few fb**
- Dominant decay channels:

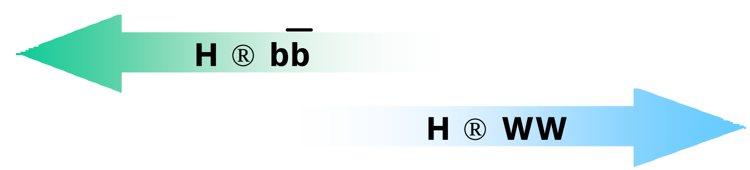
  M_{Higgs} < ~135 GeV: H→$b\bar{b}$
  Search in W/Z+H for reduced backgrounds

  M_{Higgs} > ~135 GeV: H→WW*
  Search in WW*
- Alternate mode: $t\bar{t}$ + H

  Small signal (few even<u>ts</u>) but also small background ($t\bar{t}$+jets)

s(Higgs + X) vs MHiggs





Dominant decay mode

Approach to the Higgs search...

The Higgs search will evolve out of studies of SM processes

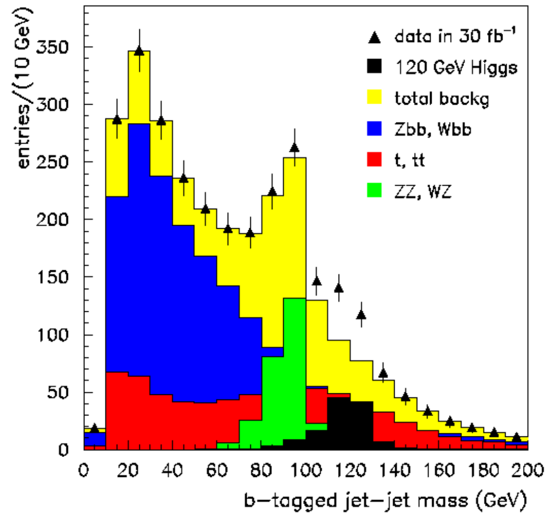
- e.g. p p → X Y where X, Y are color singlets: Wγ, Zγ, WW, WZ, Z Z
- Use these to:
  - ➢ Understand IS, FS radiation
  - ➢ Tune di-jet mass resolution with: Z → bb, W → cs
  - ➢ Refine cuts
- σ(p p → W Z) x BR (Z → bb)

~ 4 x σ(p p → W H) BR (H → bb)

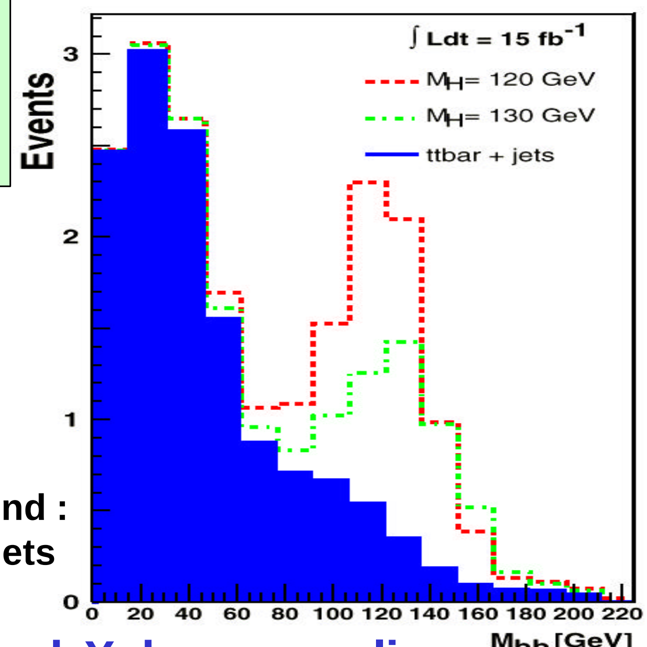
for MH = 120 GeV/c2

➡ Must discover the Z before the H !

D0 Simulation: 120 GeV Higgs for 30 fb^{-1}



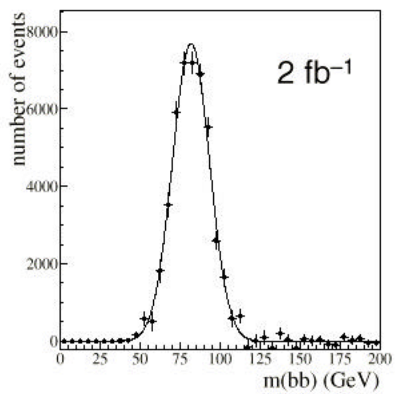
CDF Simulation: t t-bar + H for 15 fb^{-1}



Major background : t t-bar + jets

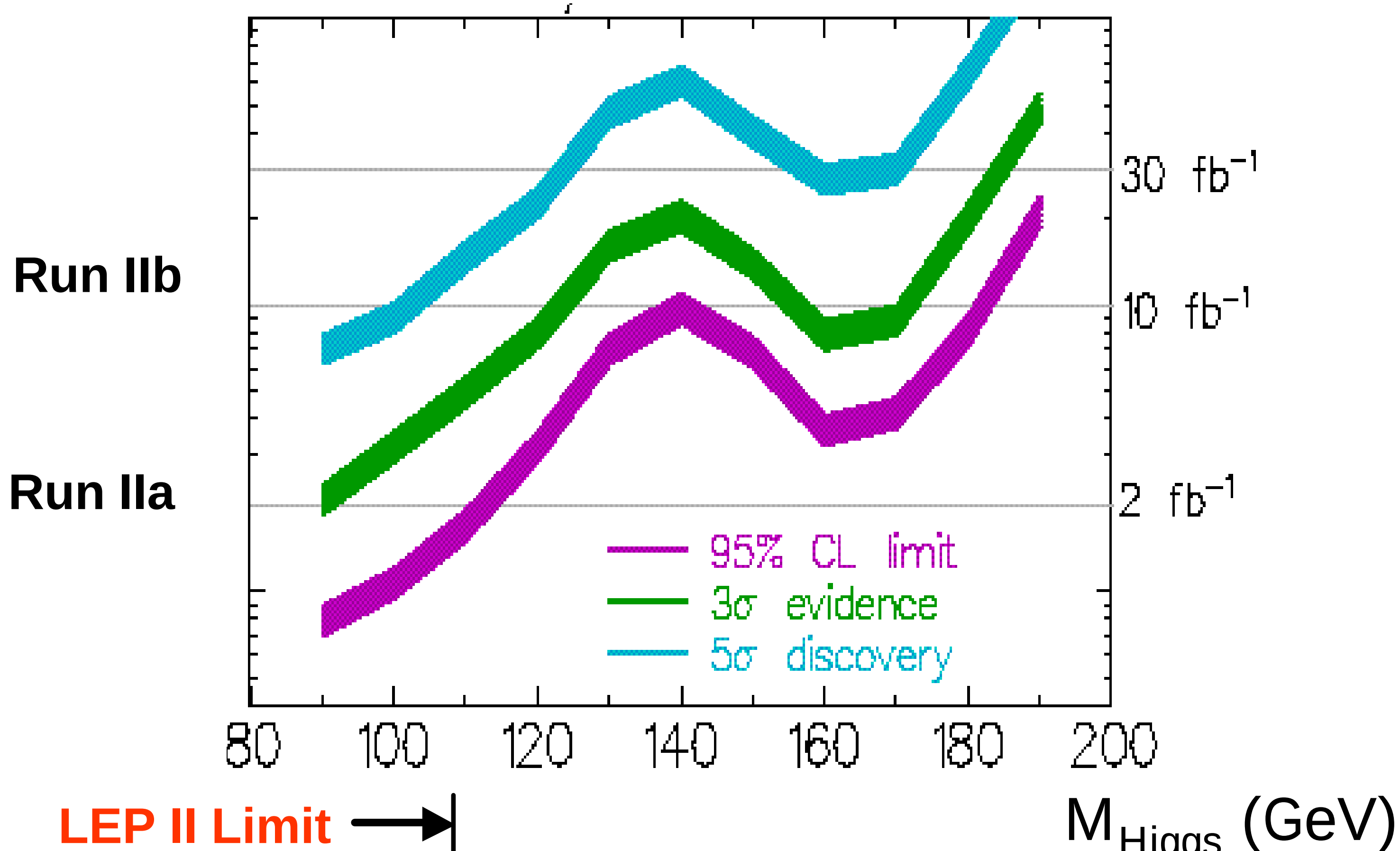
Tests top quark Yukawa coupling

D0 simulation: Z -> b b for 2 fb^{-1}



Tevatron Higgs Potential

Parameterized Simulation

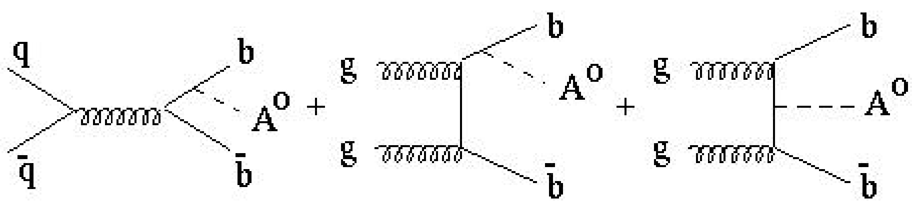


M_{Higgs} > 114 GeV/c² @ 95% CL

Need more than 2fb^{-1} to see the Higgs – beyond Run 2a reach

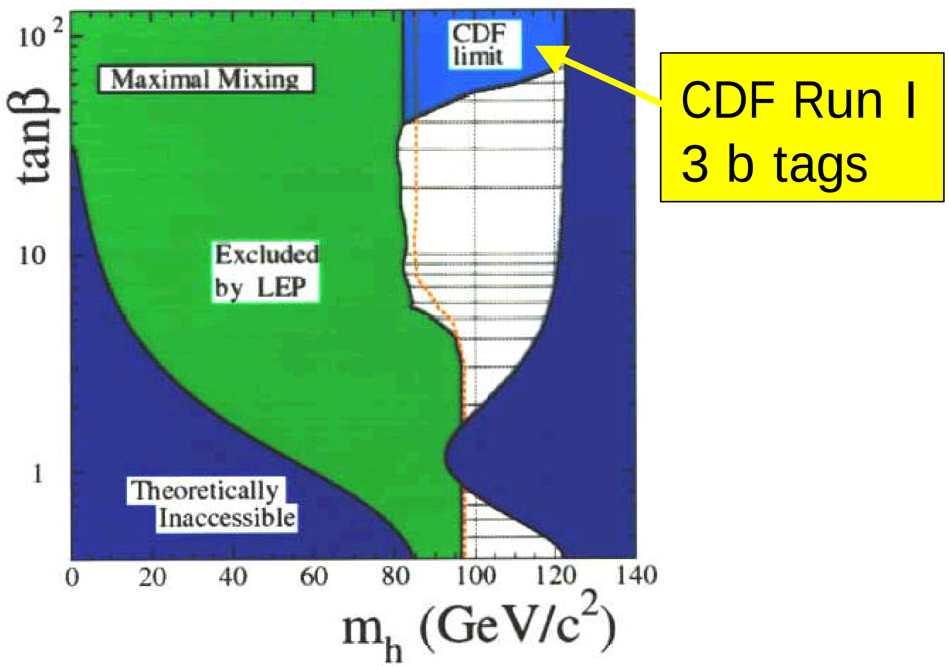
SUSY Higgs limits ($b\,\bar{b}$ decay)

$b\bar{b}$ + h/H/A enhanced at large tan β

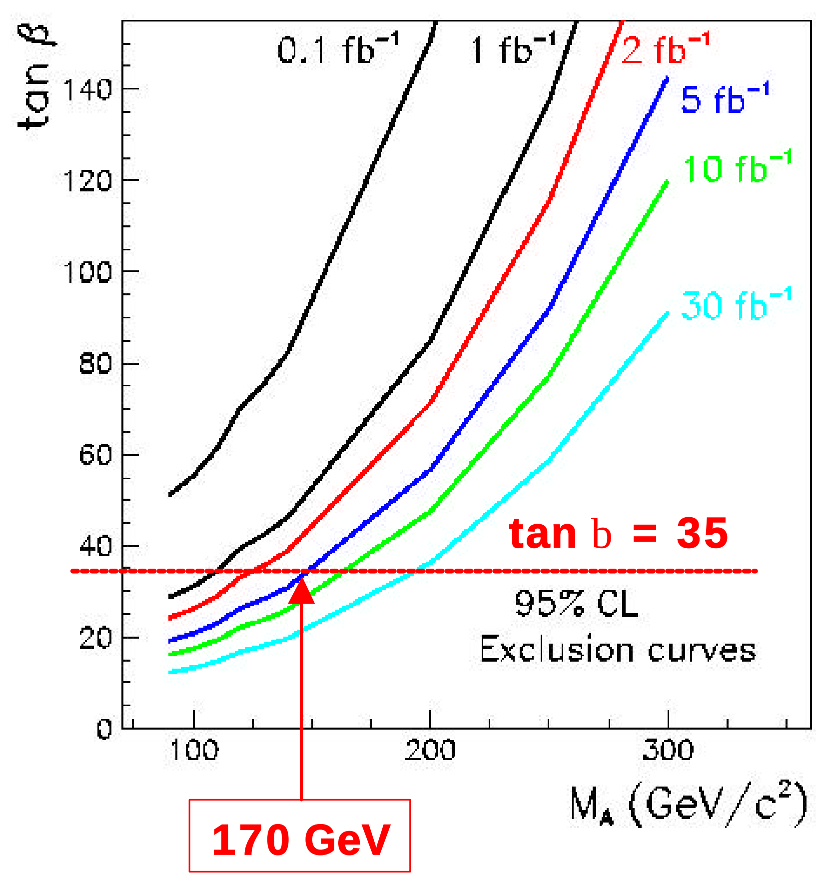


σ ~ 1 pb for tan β = 30 &

M_h = 130 GeV



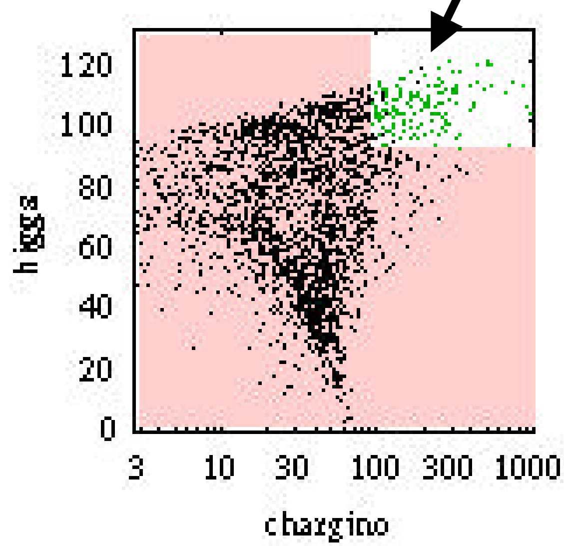
bb(h/A) ® 4b

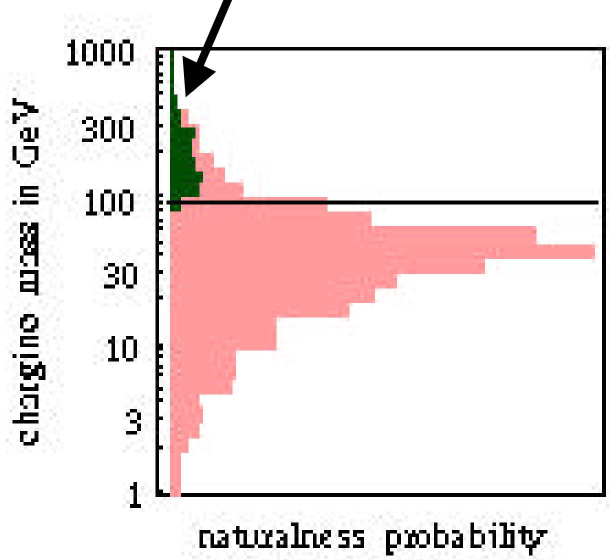


Squeezing out SUSY

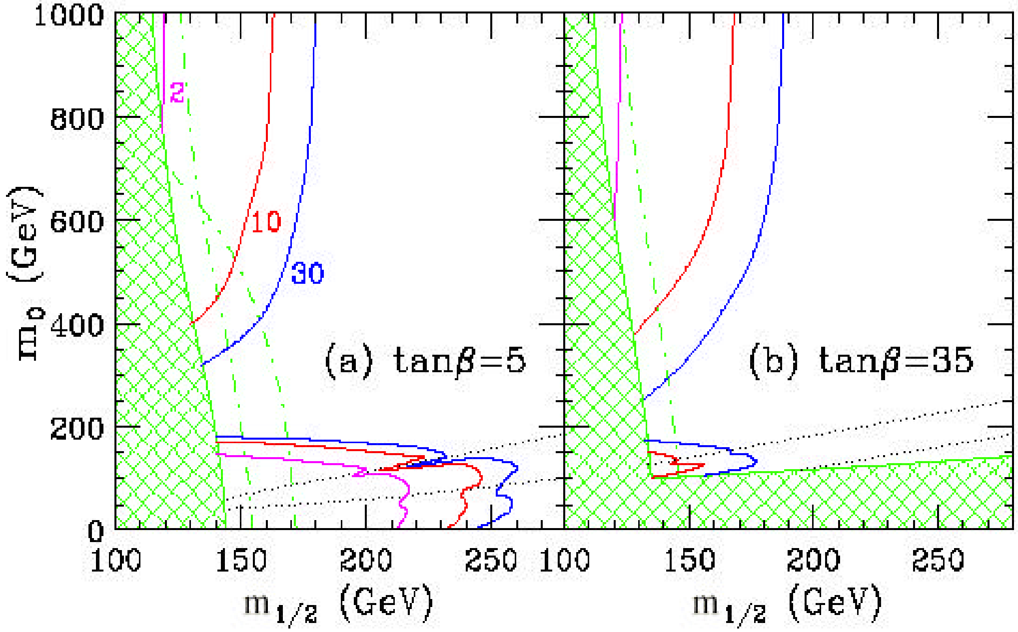
- Typical minimal supergravity-inspired SUSY models are already excluded at the 95% level (e.g. Strumia, hep-ph/9904247)

ALLOWED REGION





SUSY Gauginos and stop

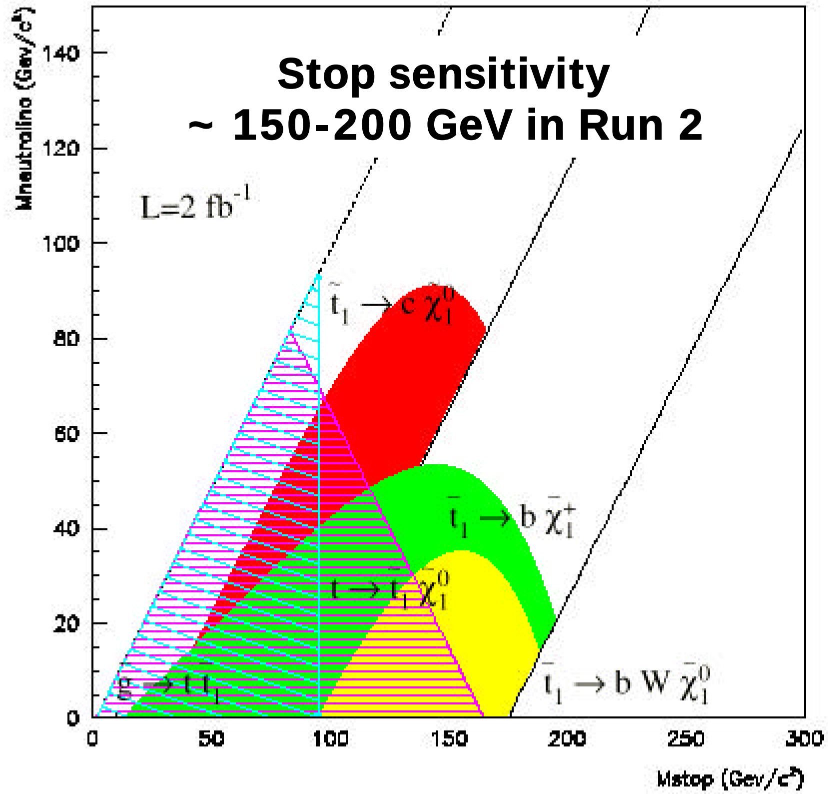


Exclusion contours in MSUGRA (A_0=0, m>0) using 3 $l^{\pm}$ final state for 2, 10, 30 fb^{-1}

Run 2 $c^{\pm}$ mass: ~ 180 GeV (tan b = 2, m<0)

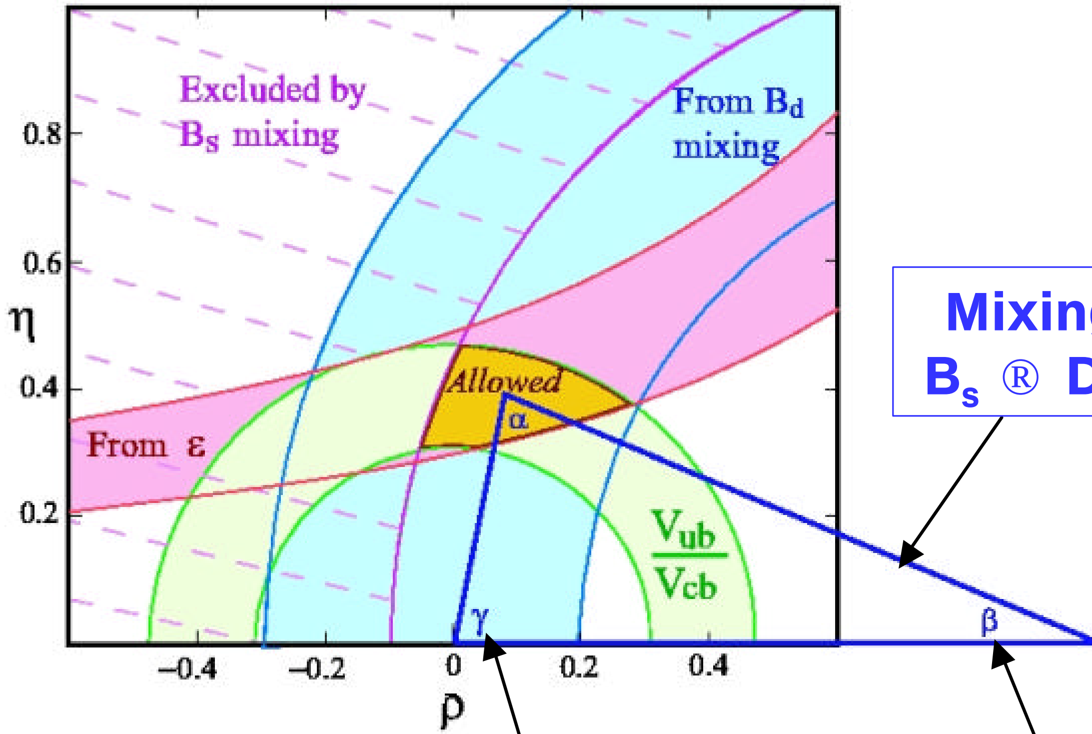
~ 150 GeV (large tan b)

(Current LEP II ~ 90 GeV)



Sbottom sensitivity
~ 200 GeV in Run 2

CKM Matrix and CP Violation



Mixing in
B_s ® D_s^-p$^+$

γ from
B_d ® p$^+$p$^-$
B_s ® K^+K^-

Sin2b from
B_d ® J/y K_s^0

Rare decays:
$B_{d,s}$ ® m$^+$m$^-$
B_d ® m$^+$mK^{*0}(K^+)

CDF and D0 tuned for B's:

- ✓ 3d vertex trackers
- ✓ Mass resolution
- ✓ Particle ID
- ✓ Trigger on all Hadronic modes
- ✓ Improved flavor taggers

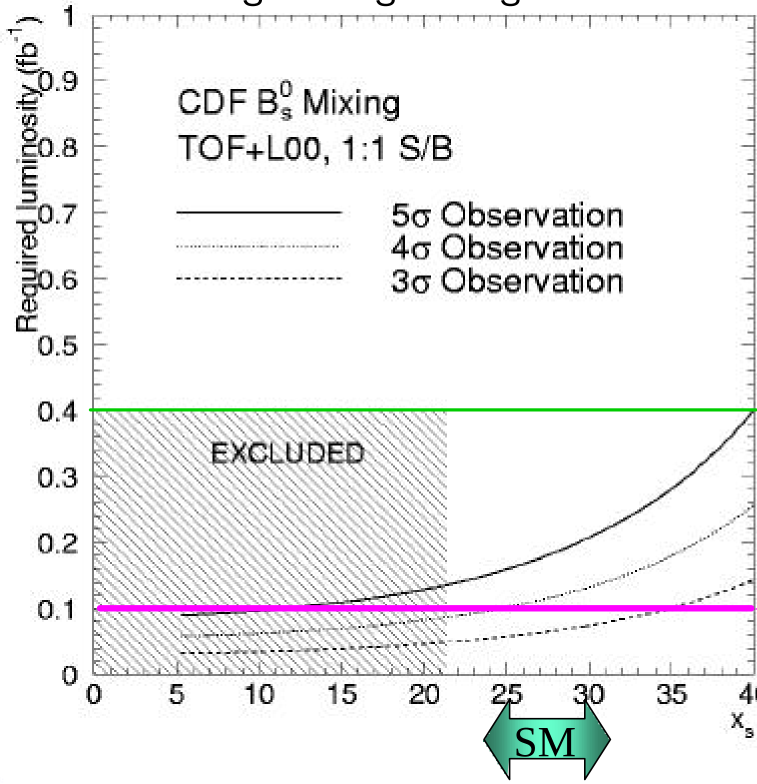
Bs Mixing

$A(t) = D\cos(\Delta m_s t)$

$B_s \Rightarrow D_s\, n\pi,\ D_S \rightarrow \phi\pi$

- 75,000 events in $2fb^{-1}$
- $\varepsilon D^2 = 11.3\ \%$
- $\delta t = 0.045\ ps \oplus t \bullet (\delta p_T/p_T)$
- Reach: $x_s \leq 60$

$B_S \rightarrow D_S\ \pi,\ D_S\ \pi\pi\pi$



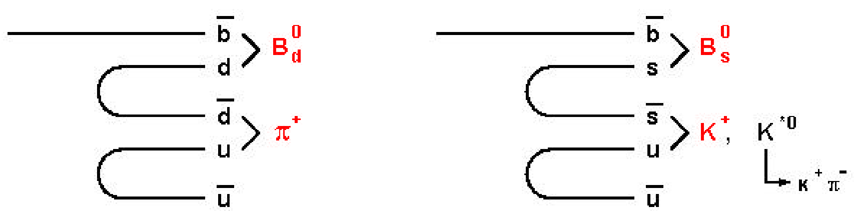
Goals for 2002:

$400pb^{-1}$ total

$100pb^{-1}$ by summer

Key to mixing and CP studies: same side tagging

Same side tagger



☞ fragmentation particle likely to be pion (kaon)

☞ charge identifies *b*-quark flavor

CP Violation in B Physics

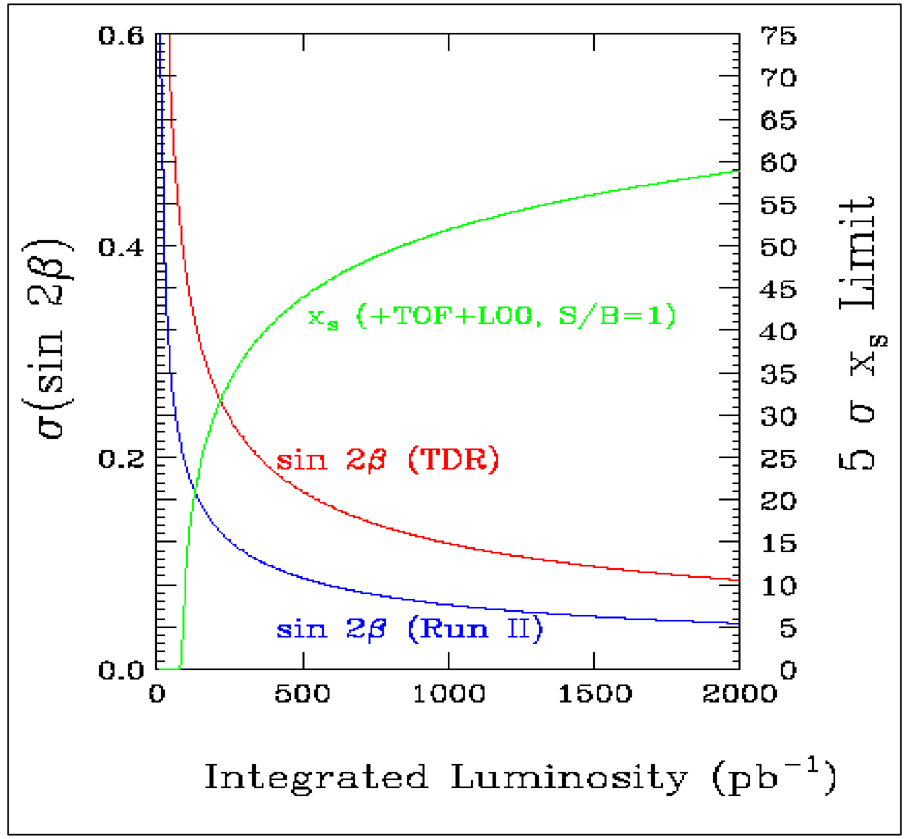
sin(2b) from B^0 ® J/y K_s

- 20,000 events ($J/\psi \rightarrow \mu^+\mu^-$)
- $\sigma(\sin(2\beta)) \sim 0.05$
- additional 10,000 $J/\psi \rightarrow$ ee ?

g from B^0 ® $p^+ p^-$ / B_s ® $K^+ K^-$

- ~ 5,000/~10,000 events
- $\sigma(\gamma) \sim 7^o$
- Assuming S/B ½; X_s = 40 ps^{-1}

CP studies in B_s ® J/y f



CDF existing limits and Run II estimates

Should see rare decays in Run 2

B Decay Mode	Standard Model	CDF Run I	CDF II
$\mu^+\mu^- K^+$	$(2-5)\times10^{-7}$	5.2×10^{-6}	2×10^{-7}
$\mu^+\mu^- K^{*0}$	$(1-2)\times10^{-6}$	4.0×10^{-6}	2×10^{-7}
$B_d \rightarrow \mu^+\mu^-$	$(0.6-2.4)\times10^{-10}$	8.6×10^{-7}	3×10^{-8}
$B_s \rightarrow \mu^+\mu^-$	$(2.5-4.5)\times10^{-9}$	2.6×10^{-6}	1×10^{-7}

Conclusion

- "Engineering" physics samples collected, commissioning almost complete
- Remaining systems will be completed in the next 1-2 months (L2 Triggers, Silicon, D0 Fiber readout)
- The initial physics program has already started for high Pt and will start in January for B-physics

Prospects Summary

With 400 pb^{-1}, DØ and CDF will achieve

- $\Delta \sin 2\beta \sim 0.10$ ← comparable to Summer 2002 values of BaBar and Belle
- SM prediction of B_s mixing parameter will be fully covered ← unique to the Tevatron
- Top - large statistics studies
- Larger Top and W samples to improve Higgs mass limit
- Extend SUSY particle and New Phenomena searches

With 2-15 fb^{-1}…

- Higgs search, SUSY, New Phenomena

Summary

- **The Tevatron has been upgraded**
  - CDF and D0 detectors are working and starting to show results
  - Beginning the process of understanding the detectors and working to get to "physics" quality data by July
  - First 36x36 stores with both detectors installed occurred just a few days ago!
- **Looking forward to great physics in the upcoming years:**

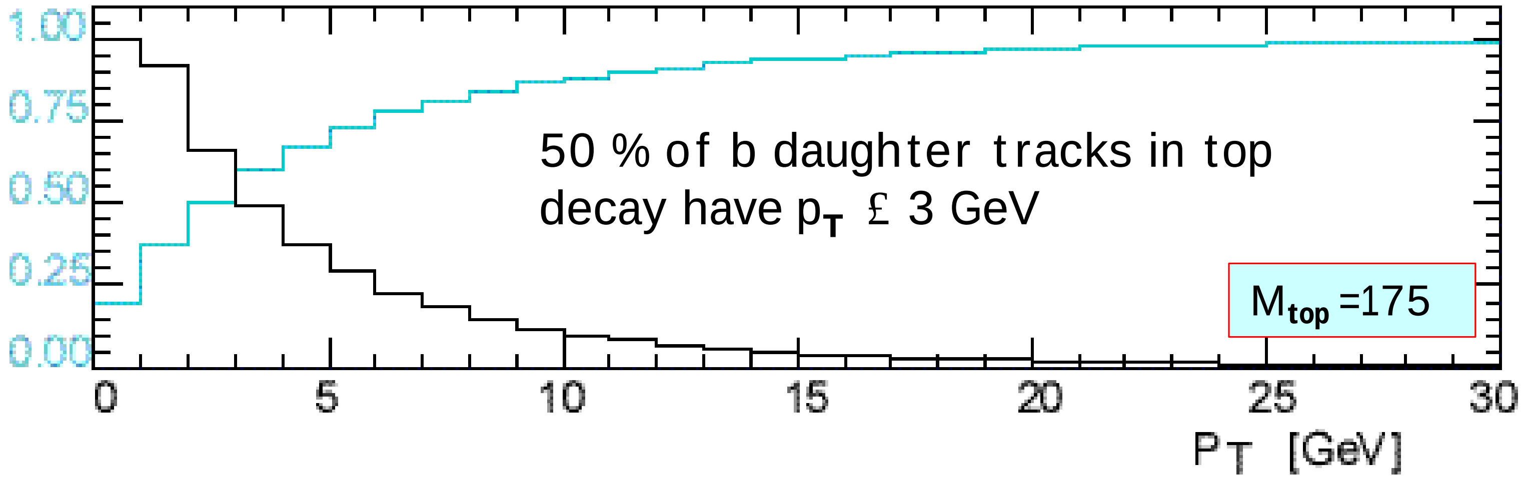
Possibly a major discovery

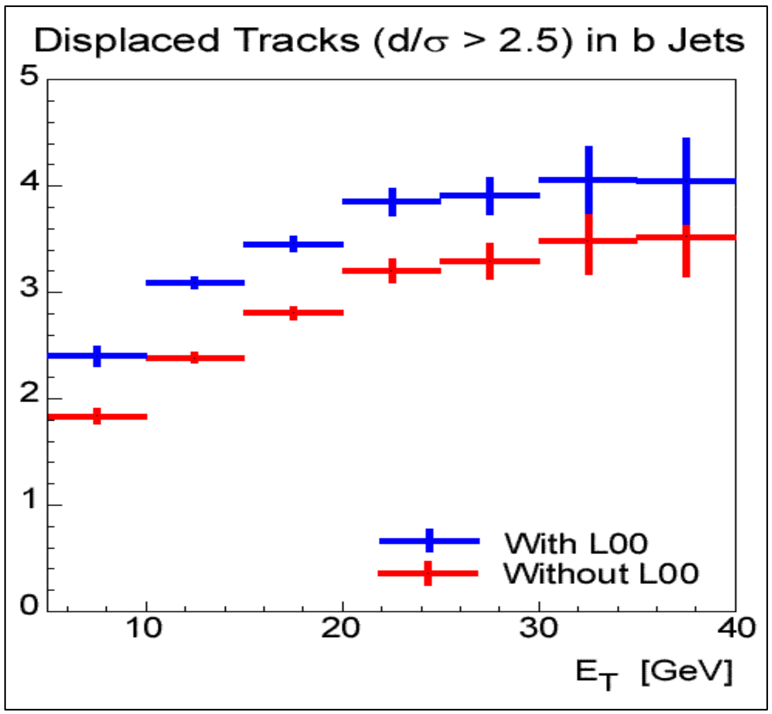
- Higgs ?
- SUSY or ~~SUSY~~ ?

Certainly some important high precision measurements:

- Top, W, B's…

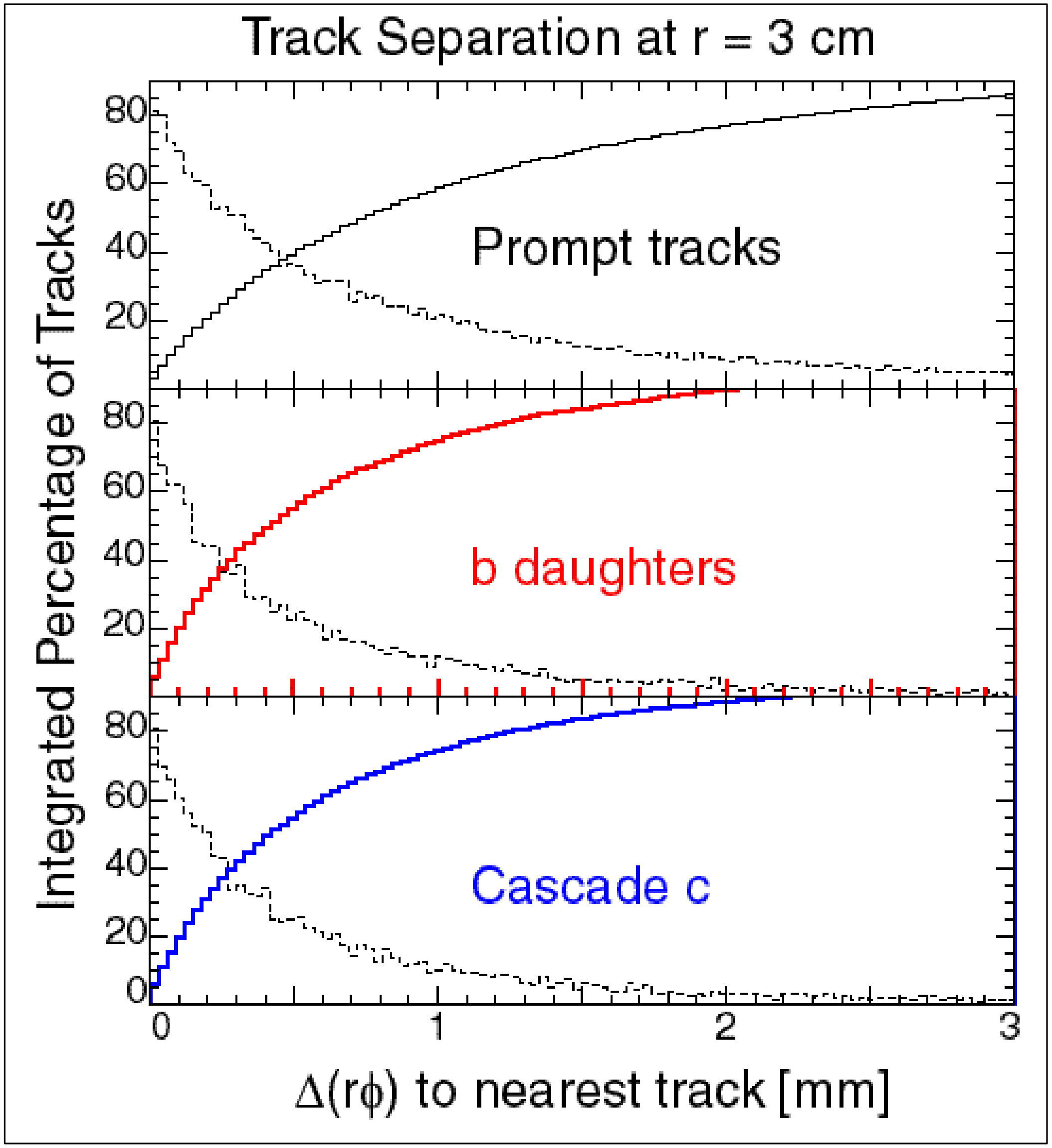
B tagging





- **Layer 00 increases the number of observed displaced tracks and hence b tagging and flavor tagging are improved.**

b jets from top decay



- **At small radii, tracks in high E_T b jets frequently overlap in rf-only view**
  - At a radius of 3 cm ~20% of b and cascade c daughters are separated by less than 100 μm in rϕ from another track.
- **This is significant for L00 (radius ~ 1.5 cm)**
  - ➢ Use 25 micron pitch and intermediate floating strip
    - Found that this gave better two track resolution even for relatively low S/N

Tevatron Collider Upgrades

- **Original Tevatron Design:**
  - ➢ 10^{30} cm^{-2} s^{-1}
- **Run I (ended Feb 1996)**
  - ➢ Lum > 10^{31} cm^{-2} s^{-1}
  - ➢ CDF integrated 110 pb^{-1}
- **Run II Upgrades:**
  - ➢ Main Injector (factor of ~5)
    - Initial Goal: 10^{32} cm^{-2} s^{-1}
  - ➢ Recycler (factor of ~2)
    - 2x 10^{11} antiprotons/hour
    - 3x 10^{12} antiprotons
    - Re-cool antiprotons from the Tevatron
  - ➢ Later
    - Electron cooling
    - Crossing angle
- **Bunches**
  - ➢ Initially 36x36 at 396 ns
  - ➢ Ultimately 141x121 at 132ns
- **Ös = 2 TeV (was 1.8 TeV)**