CDF Run II Status and Prospects

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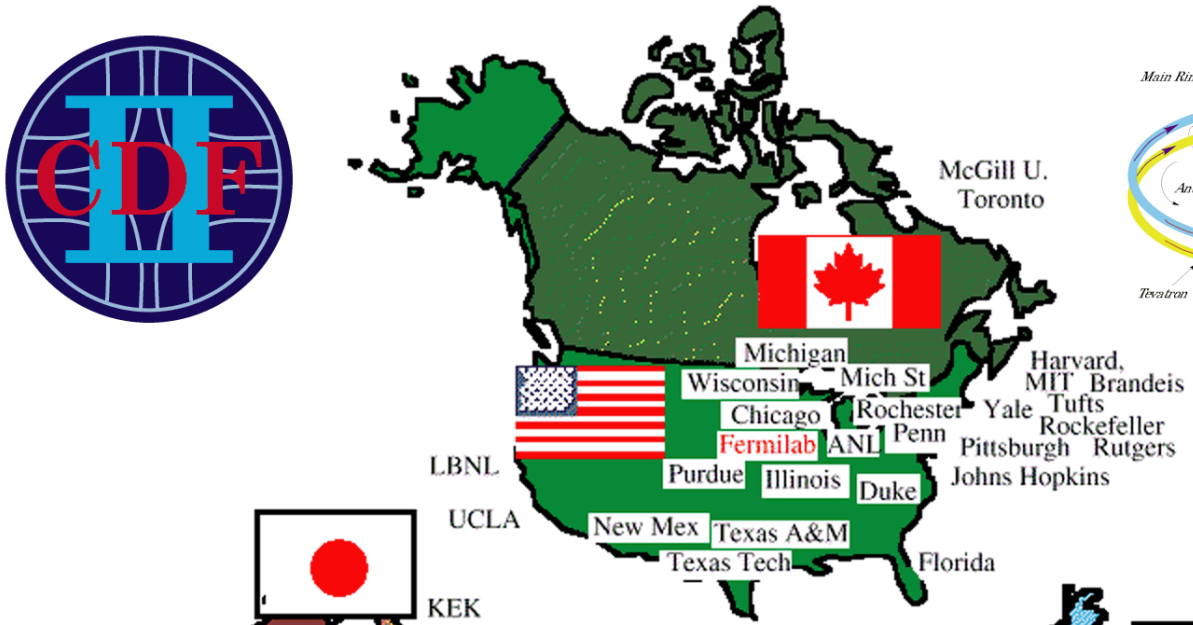
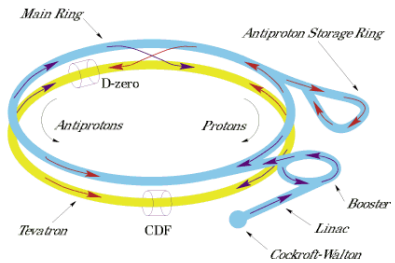
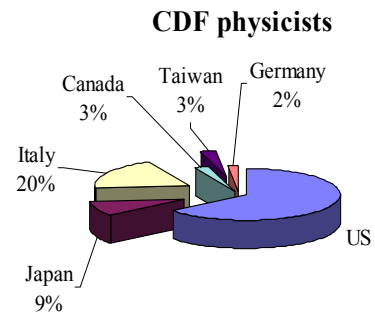
On the behalf of the CDF Collaboration

the CDFII Collaboration

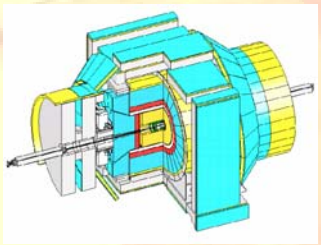


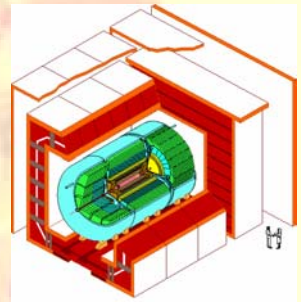




490 physicists from 41 institutions representing 8 countries

Fermilab Tevatron Collider





Booster

$\bar{p}$ source

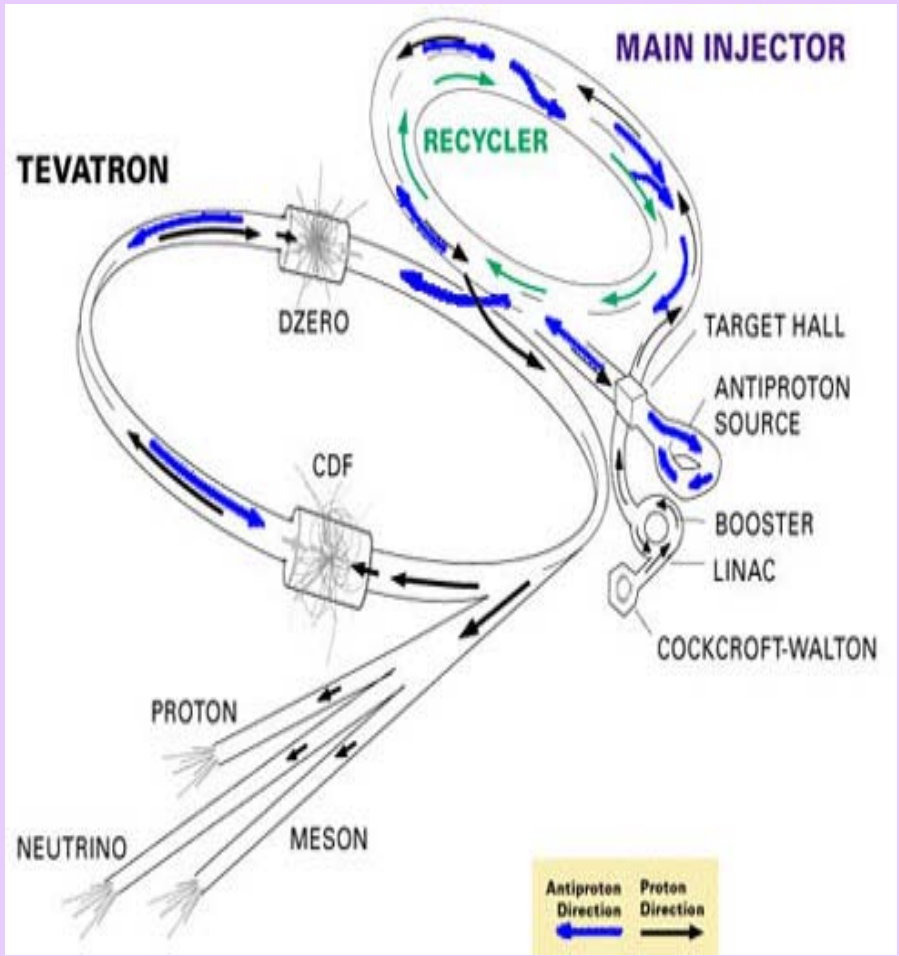
Main Injector
and Recycler

The Fermilab Accelerator Complex

- Main Injector (150 GeV proton storage ring) replaces Main Ring (the original accelerator);
- Completely revamped stochastic cooling system for antiprotons;
- A new permanent magnet Recycler storage ring for antiprotons;
- Increased number of p and p-bar bunches :

  6 → 36 (396 ns) → ~100 (132 ns)
- Higher center of mass energy 2 TeV achived increasing the beam Energies

  900 → 980 GeV



Tevatron Collider Improvements

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

Total Antiprotons

p per bunch

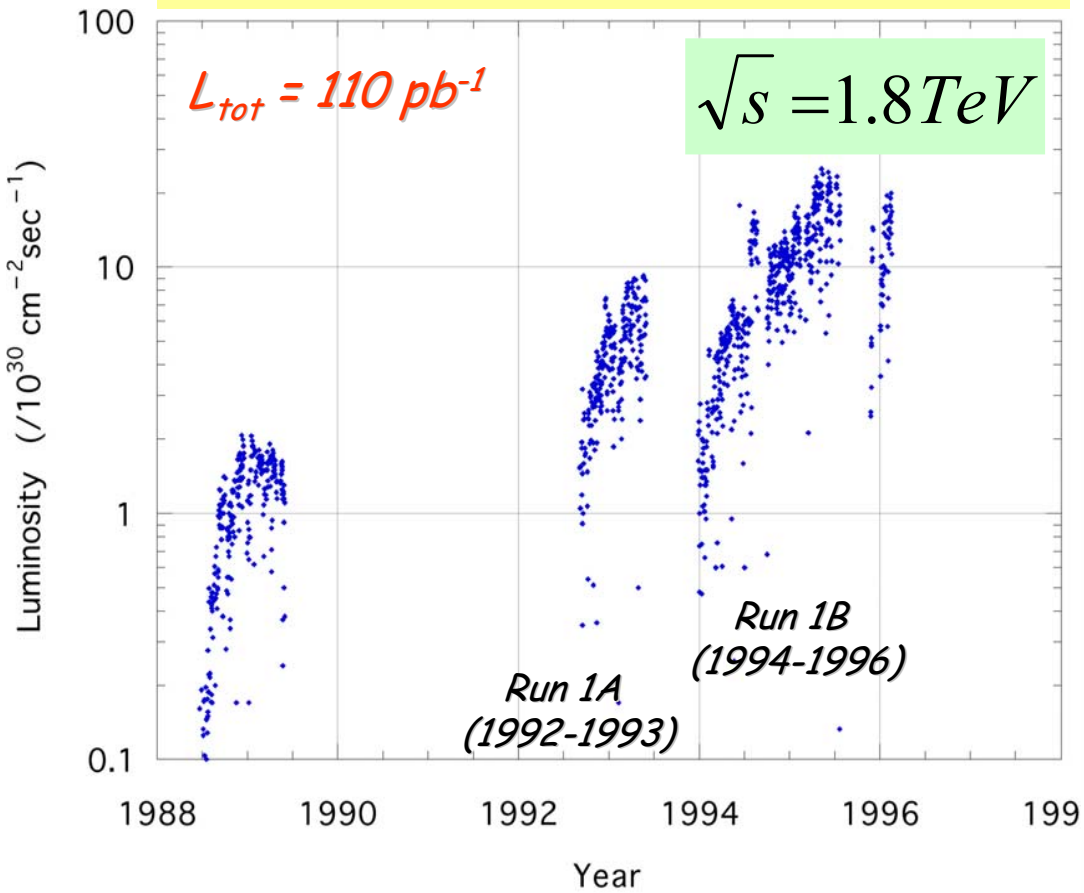
Physics Opportunites

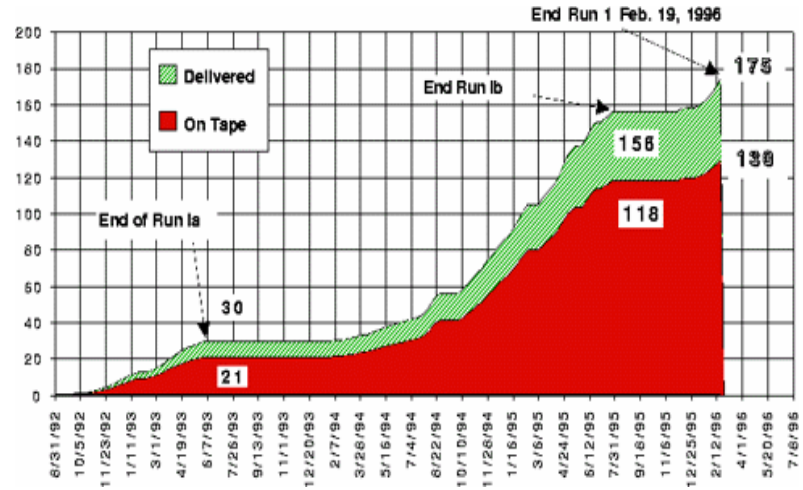
- Top
- Higgs
- QCD
- Electroweak
- B Physics
- New Phenomena

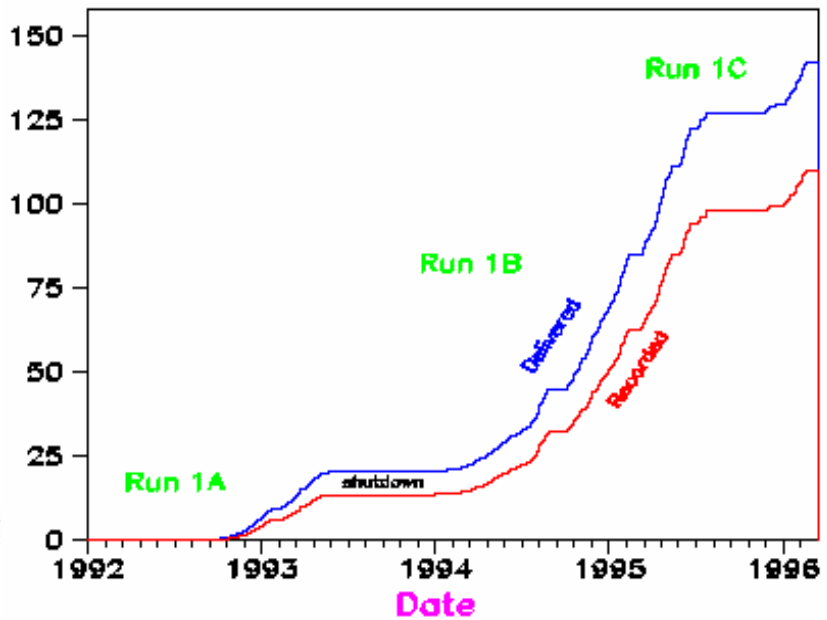
	Run 1b	Run 2a	Run 2b
#bunches	6x6	36x36	140x103
√s (TeV)	1.8	1.96	1.96
typ L ($cm^{-2}s^{-1}$)	1.6×10^{30}	8.6×10^{31}	5.2×10^{32}
∫Ldt (pb^{-1}/week)	3.2	17.3	105
bunch xing (ns)	3500	396	132
interactions/xing	2.5	2.3	4.8

Tevatron Run I History

Discovered: top, B_c, diffractive...
Measured: M_W, M_{top}, $\sigma(t)$, sin2β, ...





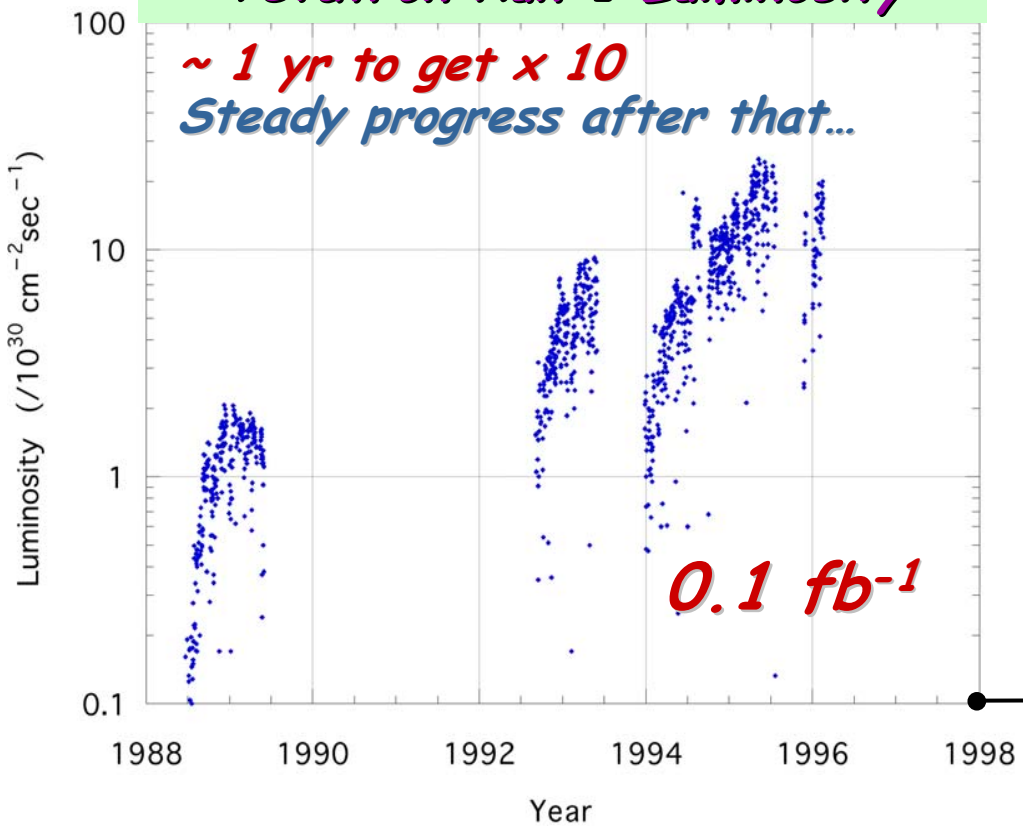


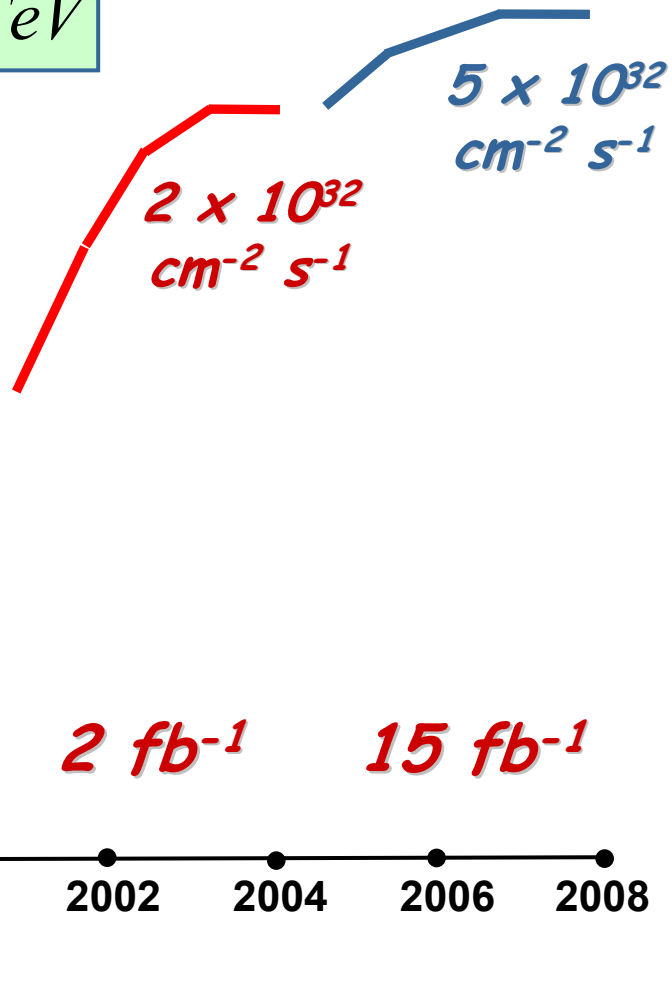
Run II Luminosity Expectations

Run I (Oct 92 → Feb 96)
~ 120^{-1} pb/Detector

$\sqrt{s} = 2TeV$

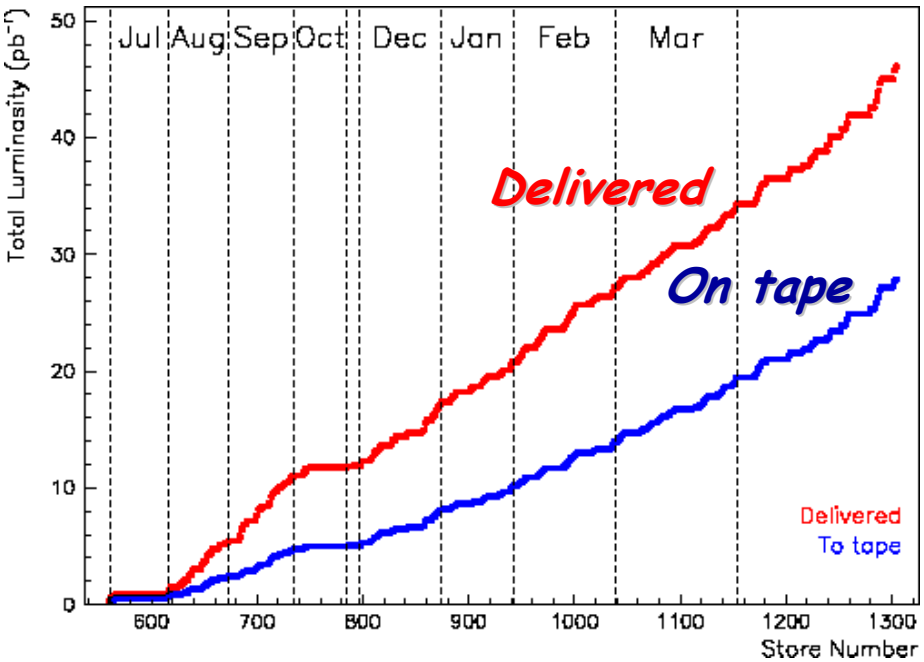
Tevatron Run 1 Luminosity



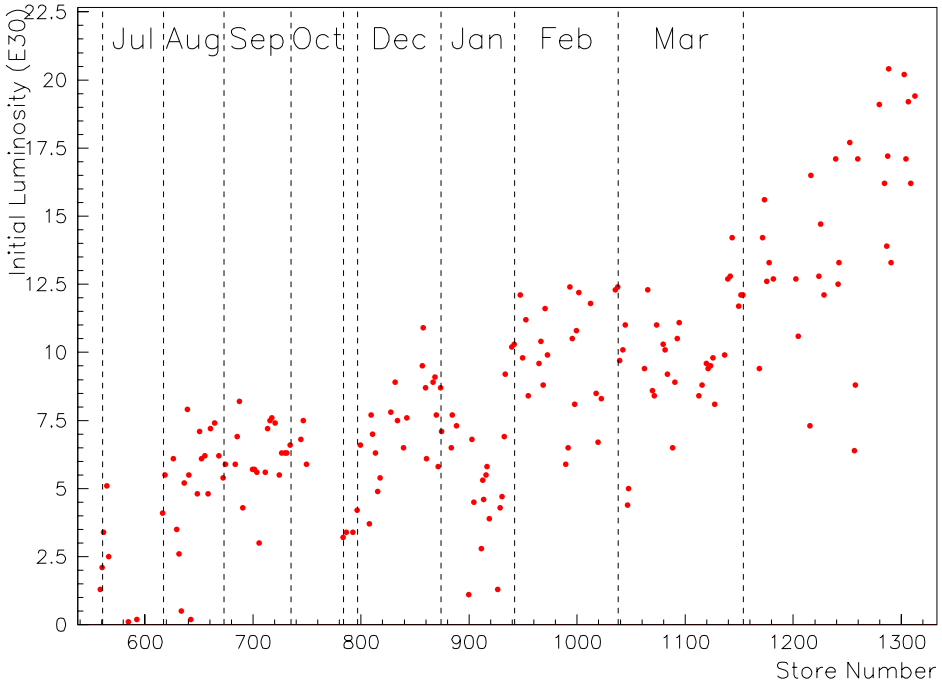


Recent Machine Performance

- **Peak luminosity still low but improving**
  - X2 since January 2002
  - Best $2x10^{31}$
- **Delivered/on tape**
  - 40/25 pb^{-1}



2001 2002



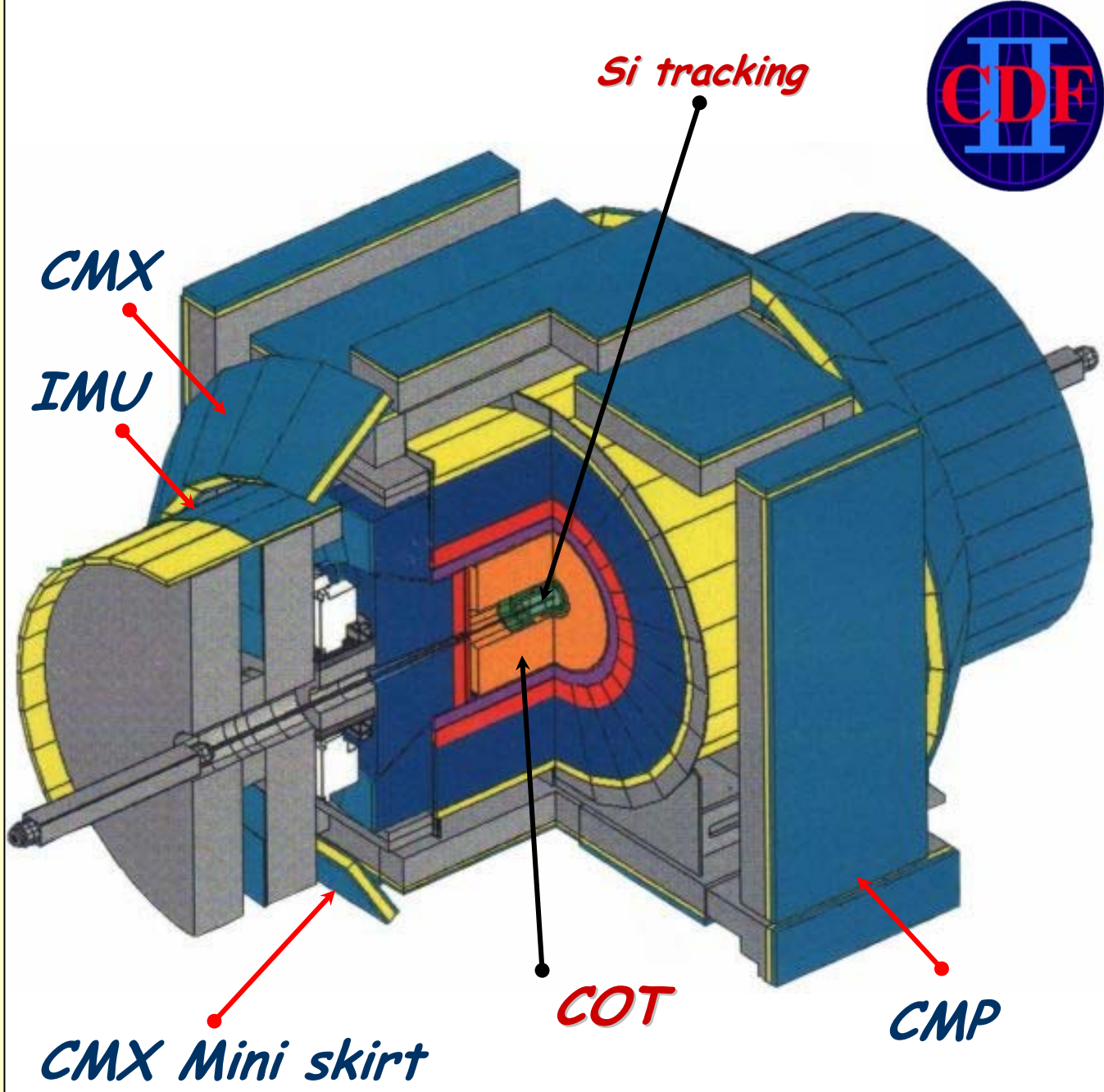
- **Near Term**
  - > 60 pb^{-1} by July shutdown
  - > 100 pb^{-1} by end of 2002

Short term Luminosity Prospects

- Massive effort put into understanding and improving Luminosity
  - Fixed Accumulator → MI optics
  - Much work on stabilizing tunes in injection and low beta squeeze
  - Fight large antiproton emittances
  - Work on accumulator lattice to reduce beam heating
    - Access early June to add transverse cooling to accumulator is expected to improve L by factor 2-4
    - Max luminosity achievable without Recycler ~8×10^{31} (maybe by the end of 2002)
- Need recycler to get to 2×10^{32}
  - Major shutdown in October '02 to finish Recycler work
  - Full benefits of Recycler ~Summer 2003

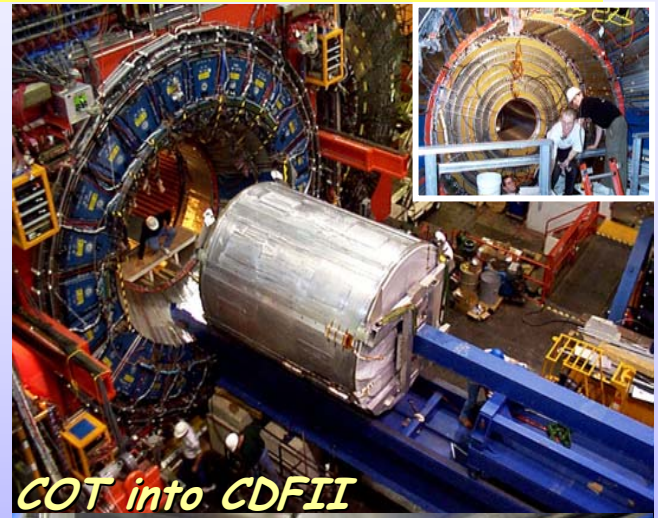
CDF II

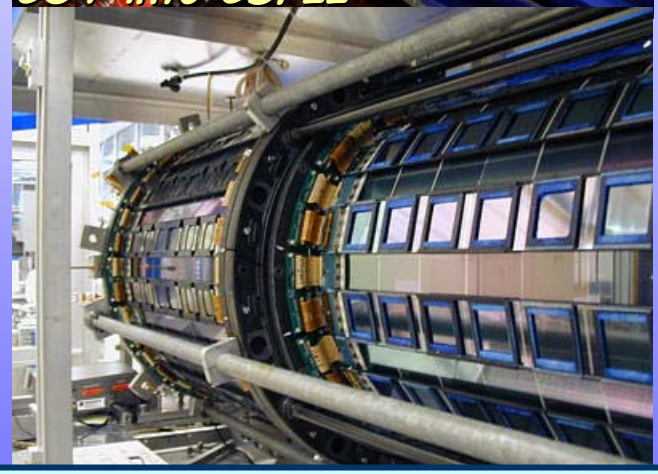
- Endplug Calorimeter
- Tracking
  - Layer 00
  - SVX II
  - ISL
  - COT
- Front End Electronics
- Trigger (pipelined)
- DAQ System
- Muon Systems
- Luminosity Monitor
- TOF
- Offline Software



The CDFII Tracking System

- **Central Outer Tracker (COT):**
  - open cell drift chamber
  - maximum drift time 100ns
    - Small cell size, Fast gas
  - single hit resolution ~200 μm
  - excellent pattern recognition
  - improved stereo capabilities
- **Silicon Tracker System:**
  - increased z coverage (length ~ 1m)
  - η coverage up to $|\eta| < 2$
  - 3-D track reconstruction
  - impact parameter resolution
    - $\sigma_\phi < 30$ μm
    - $\sigma_z < 60$ μm
- 3 different detectors: ≈750,000 channels
  - L00: inner most, R= 2.5 cm, rad-hard, SS
  - SVXII: 5 layers, 3<R<10 cm, DS (90 and sas)
  - ISL: 2 layers, 10<R<20 cm and large η, DS


COT into CDFII



Trigger System: two main improvements
- XFT: track reconstruction at L1
- SVT: displaced track triggering at L2

Run II detector improvements

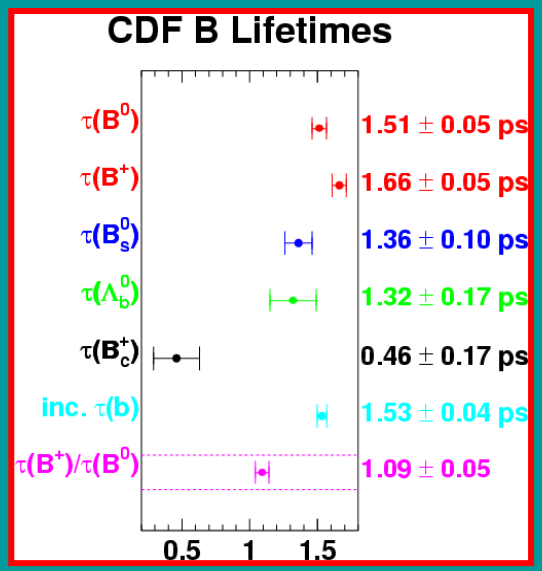
- Improved z coverage of Silicon tracker ⇨
  +50% of Run I geometrical acceptance (…top)
- 3D vertexing capabilities ⇨
  better fake rejection
- Track reconstruction can be extended to $1<\eta<2$ ⇨ **several major effects:**
  - b-tagging (recover ~30% of b's in tt events)
  - lepton ID (electrons in Plug calorimeter)
- Increased muon system acceptance by 12% ⇨
  affects trigger, ID and SLT efficiency

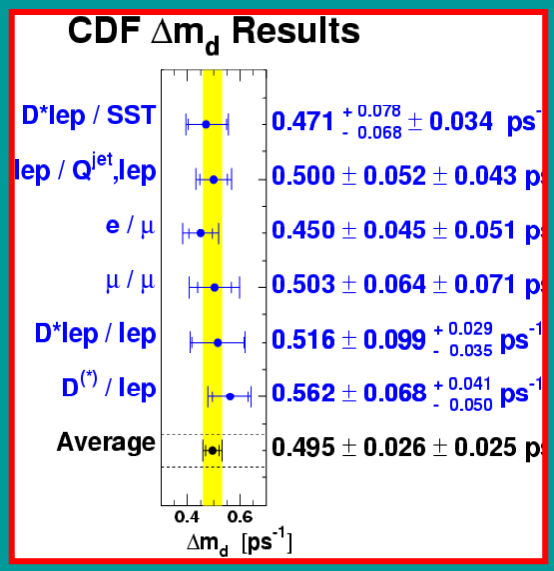
Efficiencies (%)	Run I	Run II
SVX(b-jet)	44	65
SLT(b-jet)	13	13

CDF-II Status

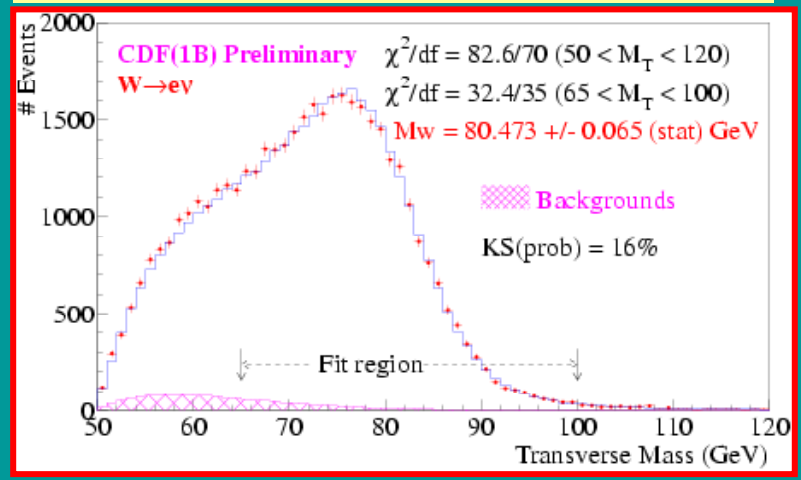
- **Detector:**
  - All systems installed and commissioned;
- **DAQ and trigger:**
  - Running physics trigger table with > 100 trigger paths since Feb '02
    - New SVT very successful
  - Typical running conditions:
    - L1: 3.5KHz L2: 200 Hz L3: 20 Hz
- **Data processing:**
  - Reconstruction farm keeps up with data logging
  - Physics groups skim data:
    - Observe signals from low and high P_T triggers: ψ, D, B, W, Z

Run I Successes

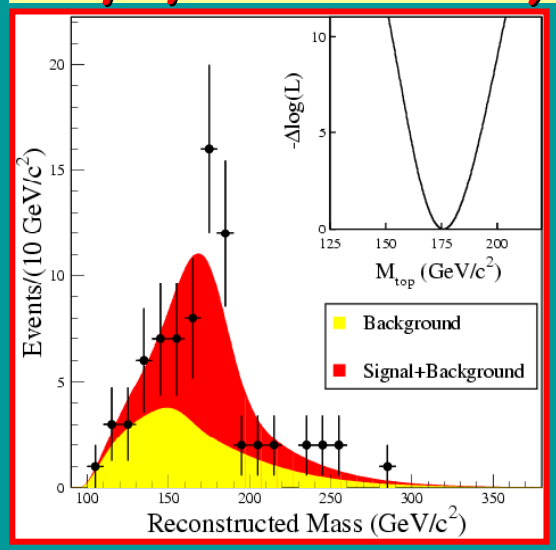


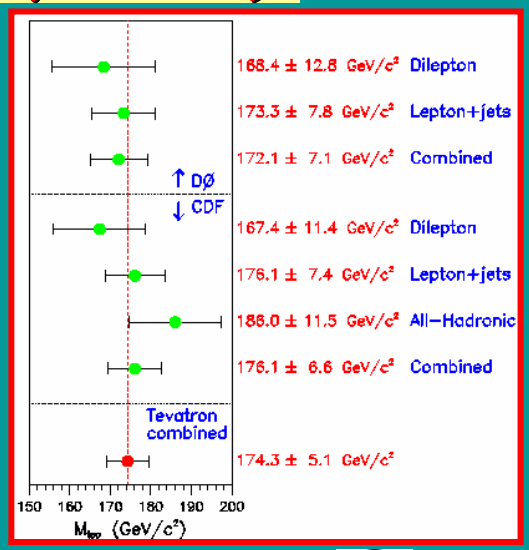


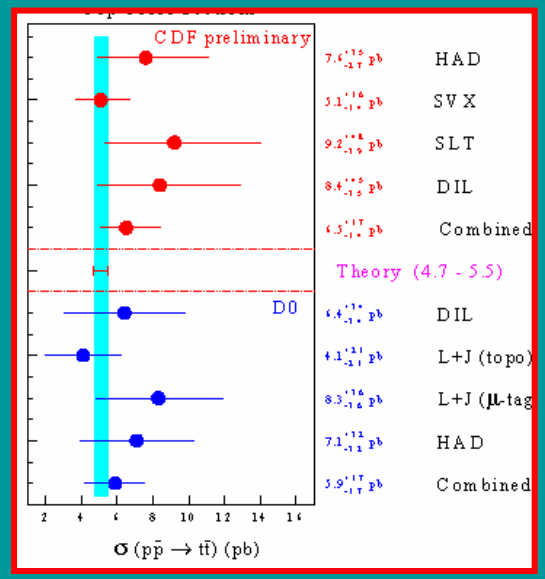
W Mass Measurement



Top quark discovery (CDF&DO)







Run II Physics Highlights

- *Study Electroweak Symmetry Breaking*
  - *Precision EW Measurements*
    - *Precise M_W measurement (10^7 (IIa) – 10^8 (IIb) events);*
    - *Better M_{top} measurement (10k (IIa) – 75k (IIb) events - $\Delta M_{top} \approx$ 2-3 GeV/c^2);*
    - *Better top Cross Section Measurement ($\Delta\sigma(tt) \approx$ 8%);*
    - *Investigation of the Top properties;*
  - *Direct Searches for EWSB mechanisms*
    - *the Standard Model Higgs*
    - *SUSY*
- *Searches for New Phenamena*
  - *SUSY;*
  - *Large Extra Dimensions;*
  - *QCD tests: probe distance scales below 1 milli fermi;*
- *Study CP Violation and the CKM Matrix*
  - *X_s Measurement (up to ~60);*
  - *sin2β Measurement, + α, γ*
    - *CP violation using $B \rightarrow J/\psi\ K^0_s$ ($B \rightarrow J/\psi\ K_S \rightarrow \mu\mu\ K_S$ 15k(IIa) – 100k (IIb))*
    - *CP violation using $B \rightarrow \pi^+ \pi^-$*
  - *Rare Decays: e.g. $B^\pm \rightarrow \mu\mu\ K^\pm$*

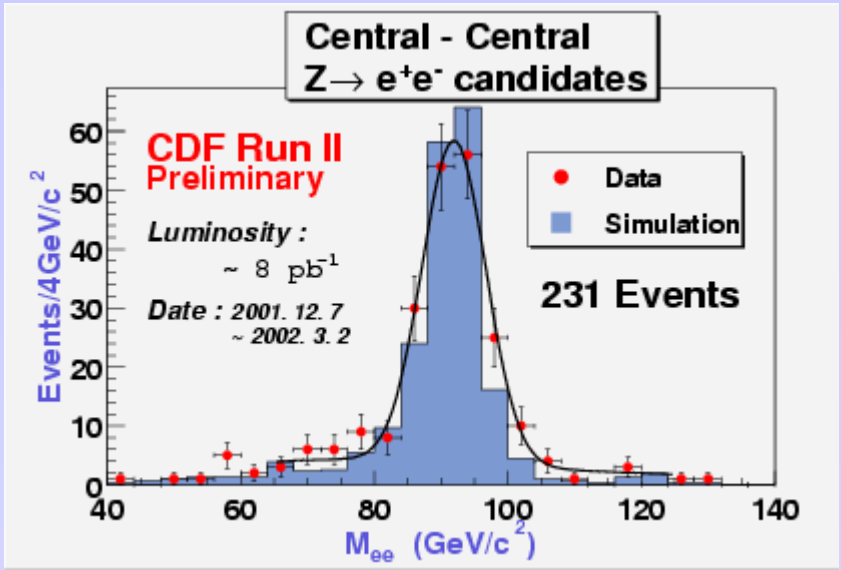
Beginning to look at Physics

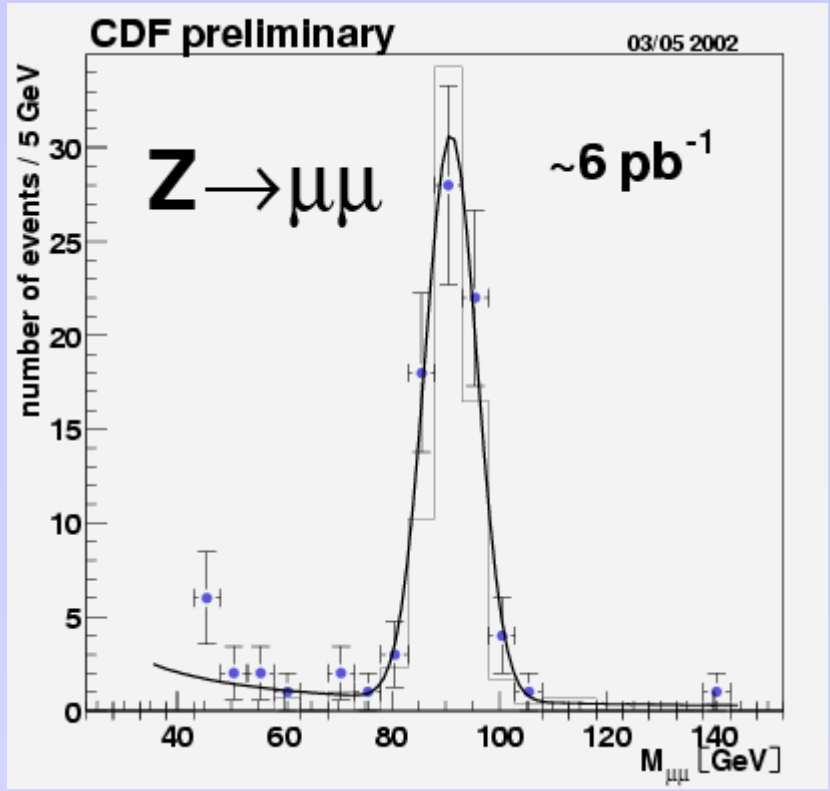
- *Electroweak:*
  - *$Z \rightarrow ee$, $\mu\mu$ Samples;*
  - *$W \rightarrow e\nu$ and $W \rightarrow \mu\nu$ Samples;*
  - *$W \rightarrow \tau\nu$ better samples fom better τ–ID;*

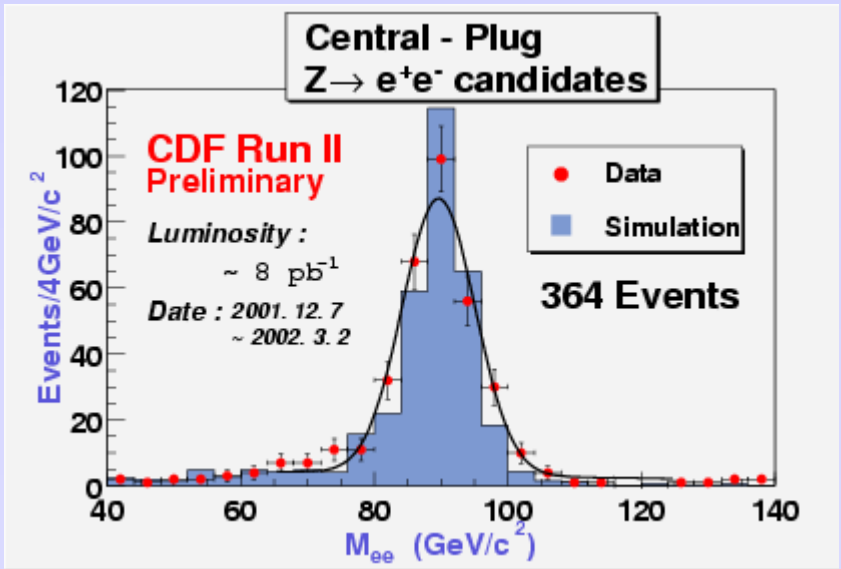
- *Top Physics*
  - *First top candidates;*
  - *top in dilepton will be done first*
    - *No b-tag is necessary;*
    - *Smaller backgrounds.*

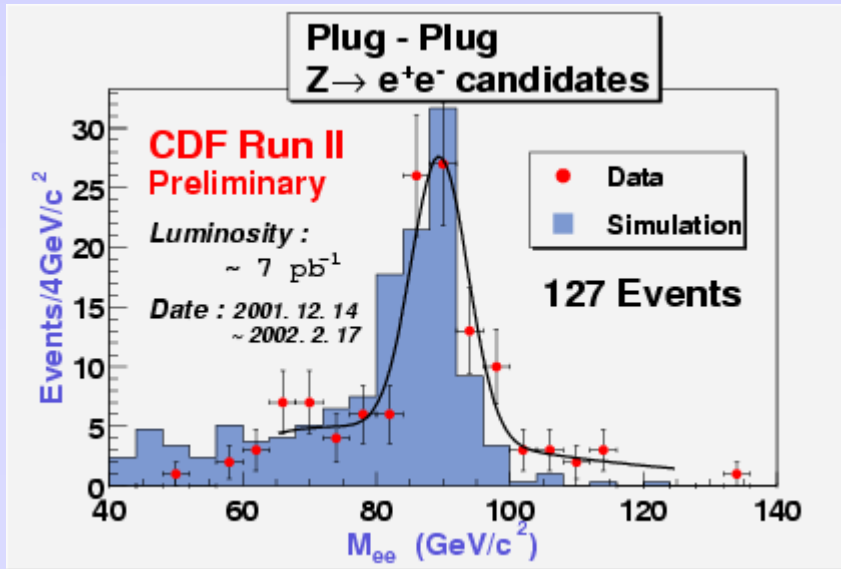
- *Bottom/Charm Physics*
  - *Reconstruction of B mesons;*
  - *Reconstruction of Charms*
  - *Beginning to develop analysis tools, look at rates*

$Z \rightarrow ee, \mu\mu$ Candidates

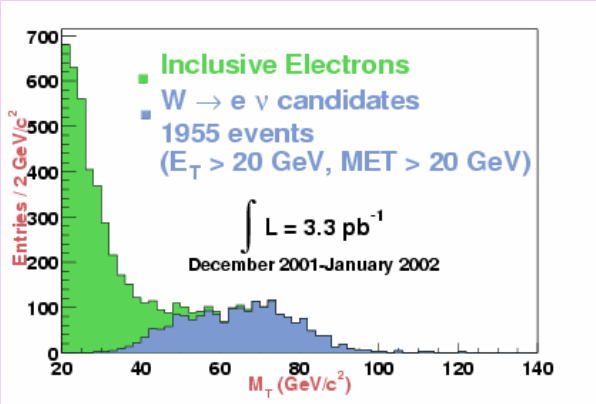


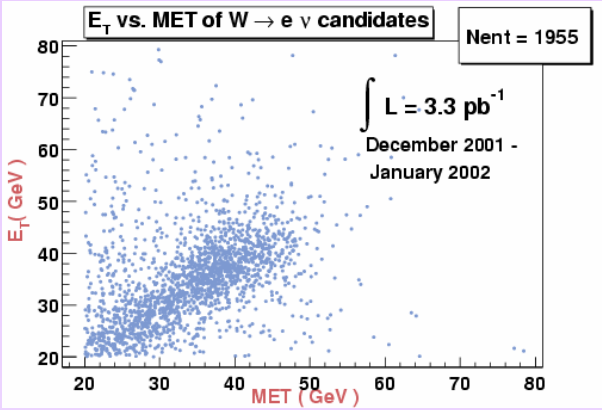


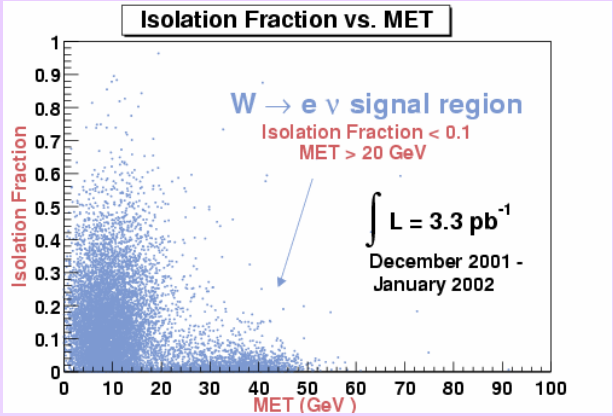


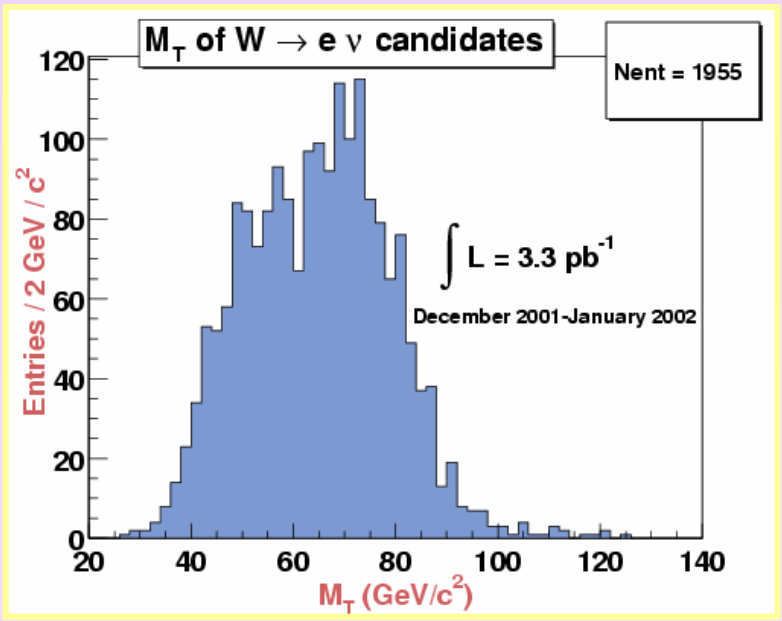


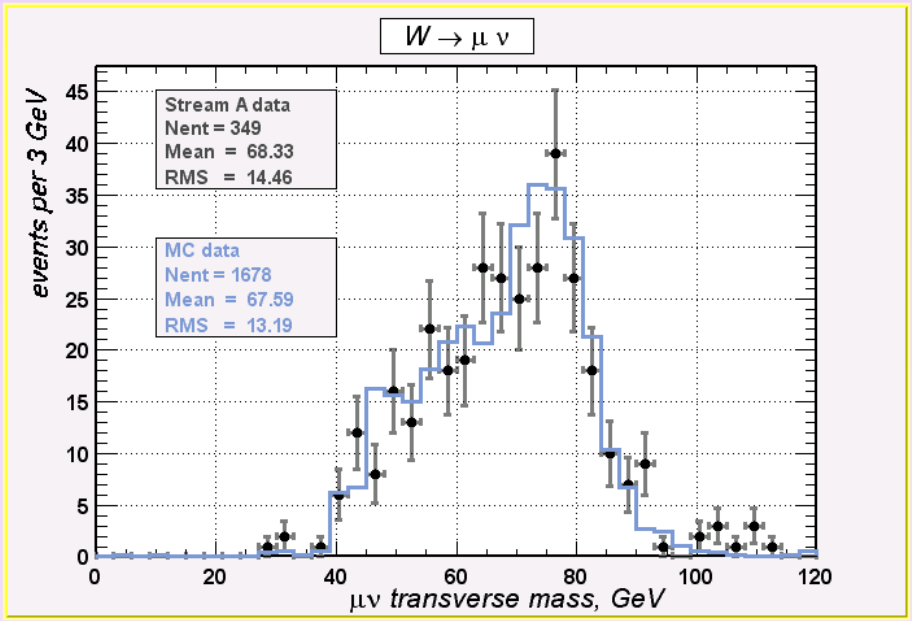
$W \rightarrow e\nu$ and $W \rightarrow \mu\nu$ Candidates



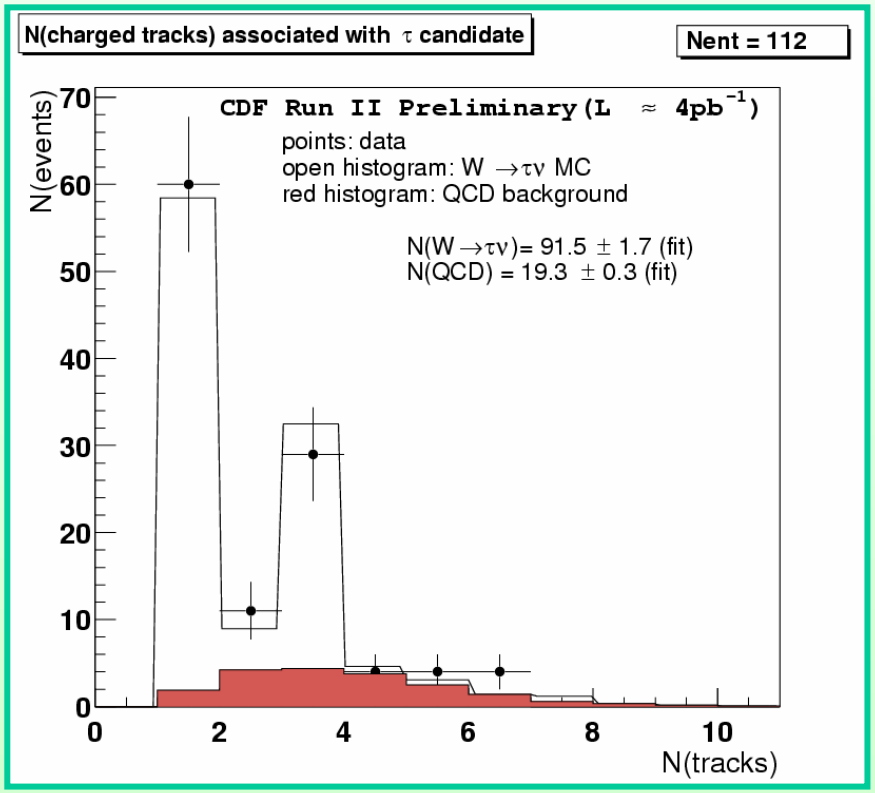


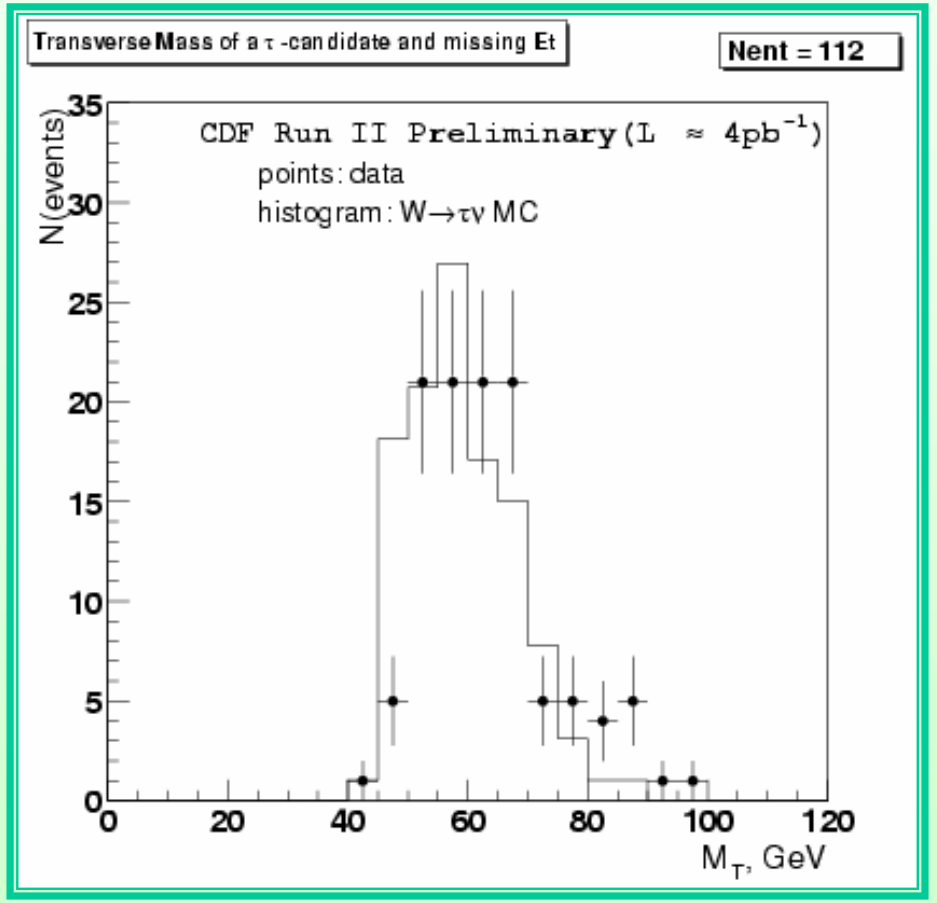






$W \rightarrow \tau\nu$ Candidates





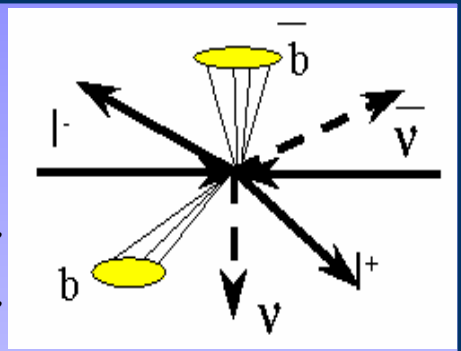
Very clean tau samples:

- Increased detector performances
- better tau ID algorithms;

Top dielectron candidate

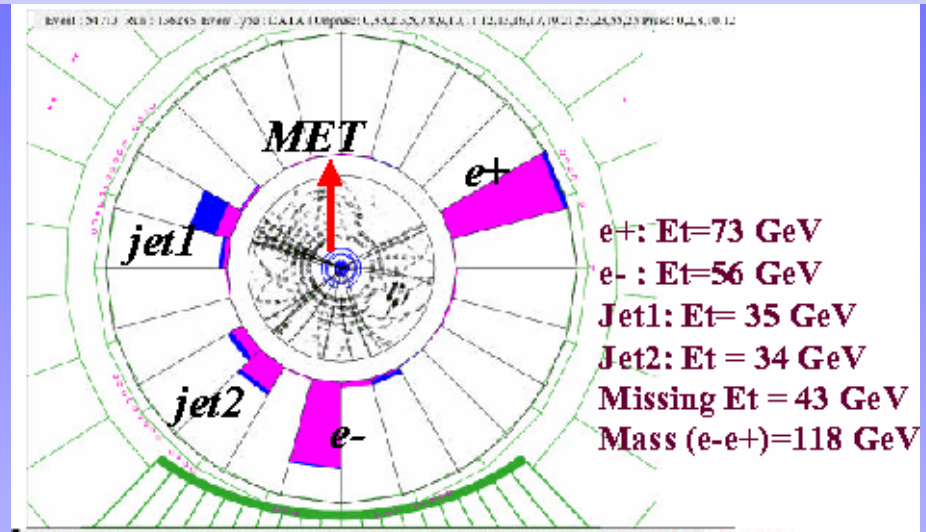
$$t\bar{t} \rightarrow e^+e^- \; j' \; j'' + E_T$$

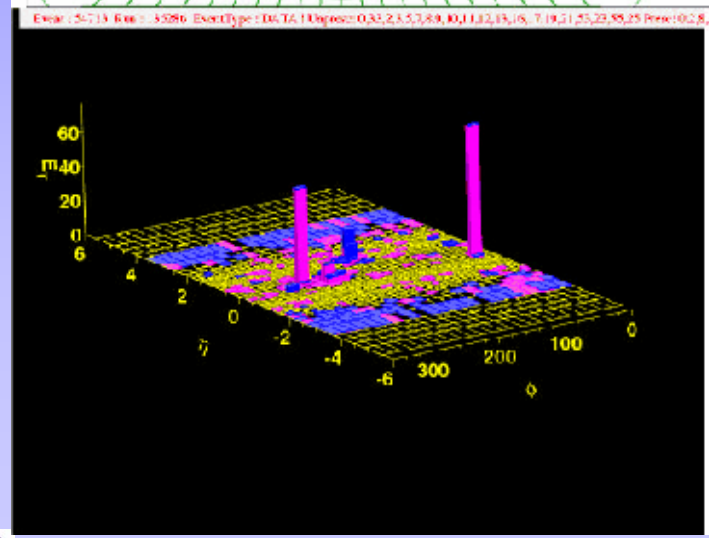
$E_T(e^+) = 73$ GeV
$E_T(e^-) = 56$ GeV
MET = 43 GeV
$E_T(jet^1) = 35$ GeV
$E_T(jet^2) = 34$ GeV



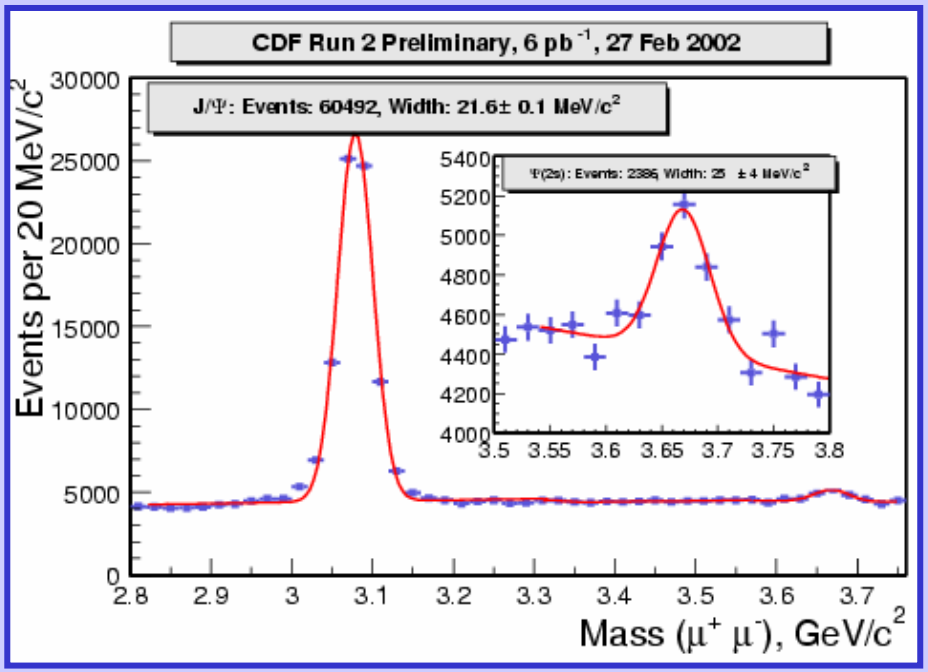
- ⇨ pass Run I dielectron Analysis cuts;
- Displaced vertex as expected from the b's;

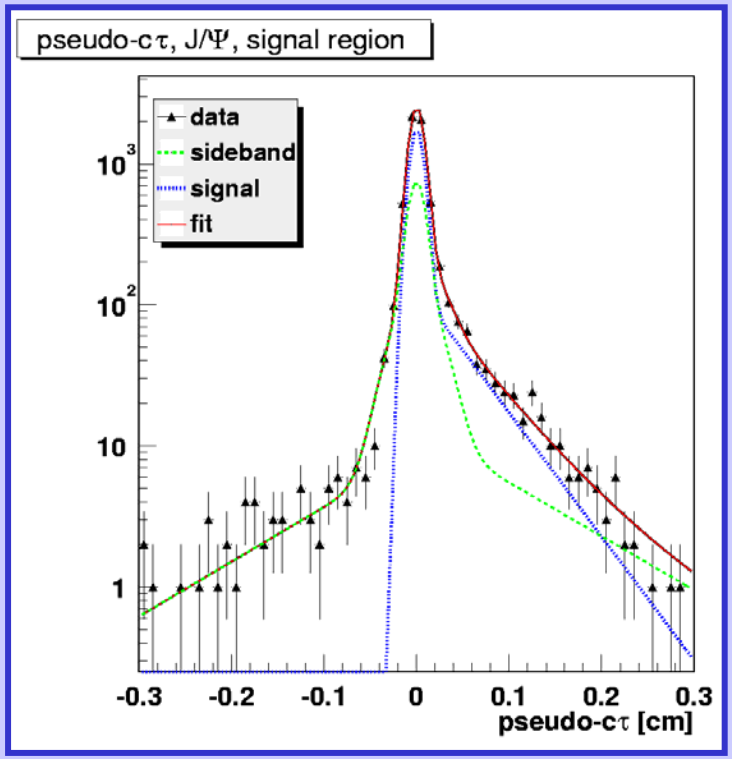
Run= 136286 - Event= 54713





$J/\Psi \rightarrow \mu^+\mu^-$





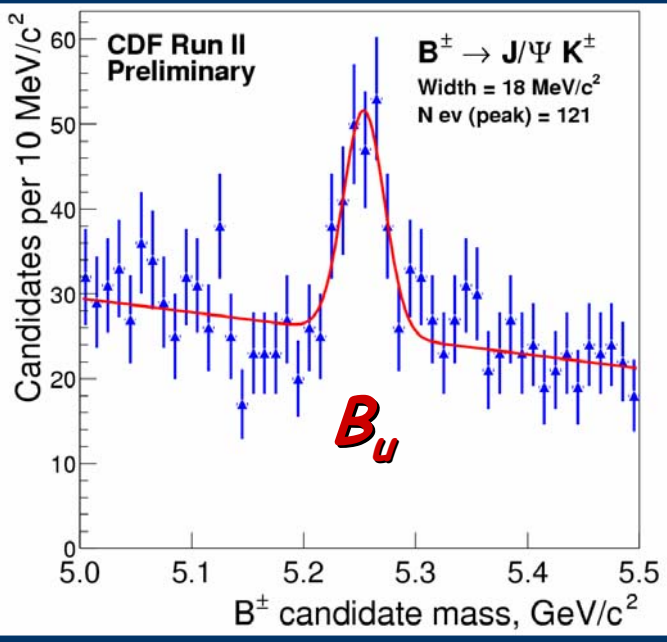
A clear J/Ψ signal:

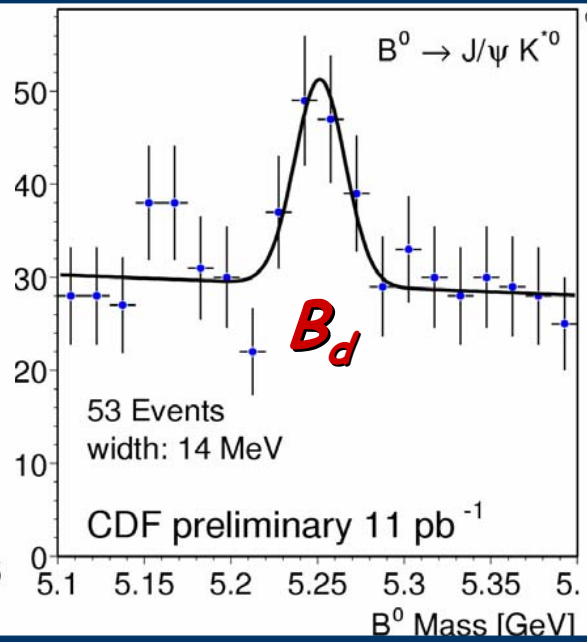
- Improved J/Ψ yield (factor 2-3 over Run I);
- CMU or CMX Muons;
  - Sample of 60,492 J/ψ;
  - cross section as expected (~9nb);
  - Γ = 21.6 ± 0.1 MeV/c^2;
  - $\Gamma \approx 16$ with SVX II;

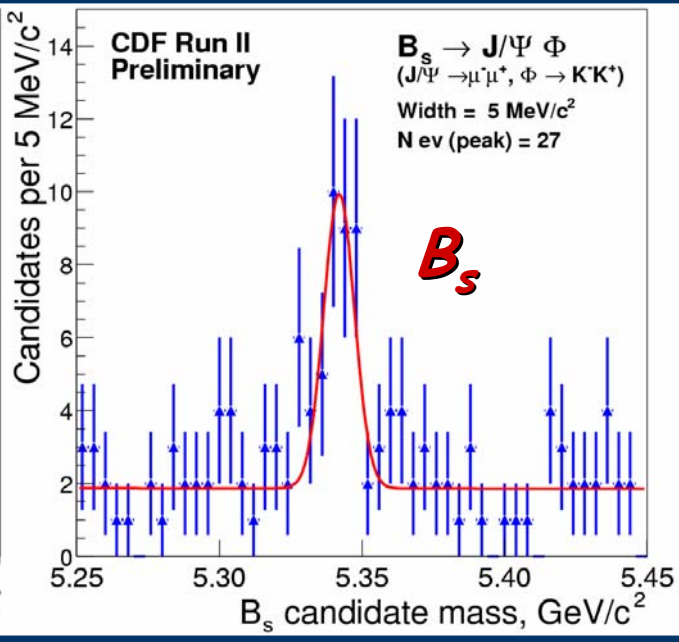
First checks on physics:

- Inclusive B lifetime from J/ψ consistent with expectations:
  - $c\tau_B$ ~ 470 mm (unbinned fit)
    - Systematics still out of controll !
  - Prompt ψ fraction ~ 85%
    - Consistent with lower P_T cut relative to Run I;

First B_u, B_d, B_s signals

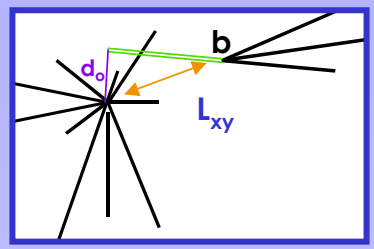






$B^{\pm}$ Mesons ($L \approx 11pb$)

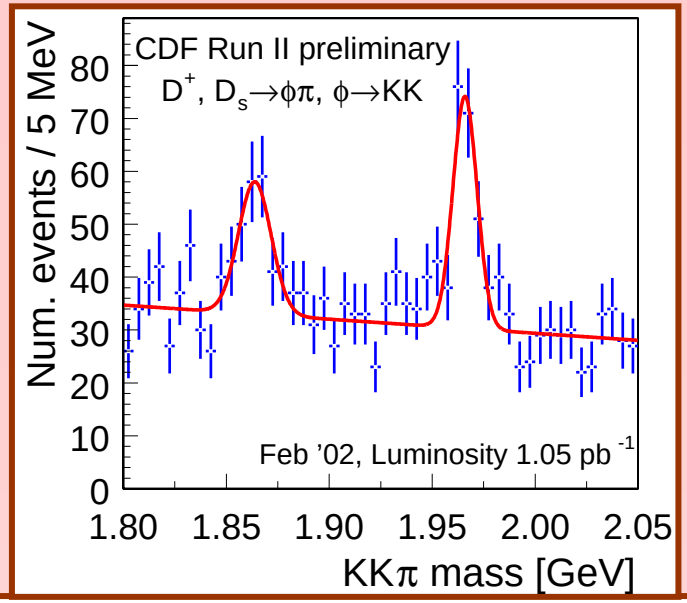
- Selection cuts
  - $L_{xy} > 0$;
  - $P_T(B) > 6.0$ GeV/c
  - Vertex quality cuts

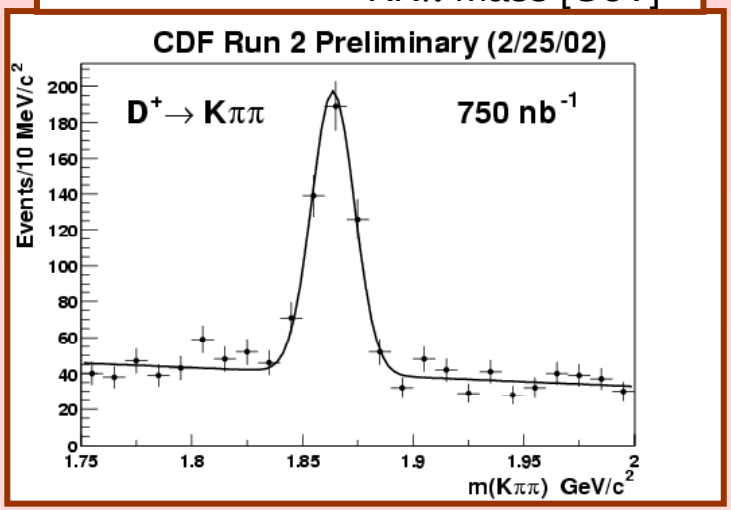


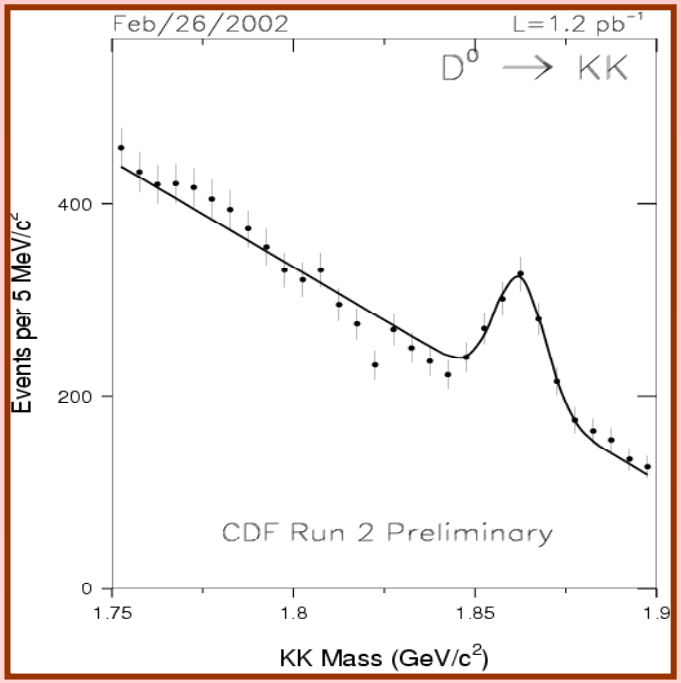
B_s Mesons ($L \approx 11pb$)

- Selection cuts
  - $L_{xy} > 0$;
  - $P_T(B) > 5.0$ GeV/c
  - Vertex quality cuts
  - Mass window on Phi

Side Effects: Lots of Charms from SVT…







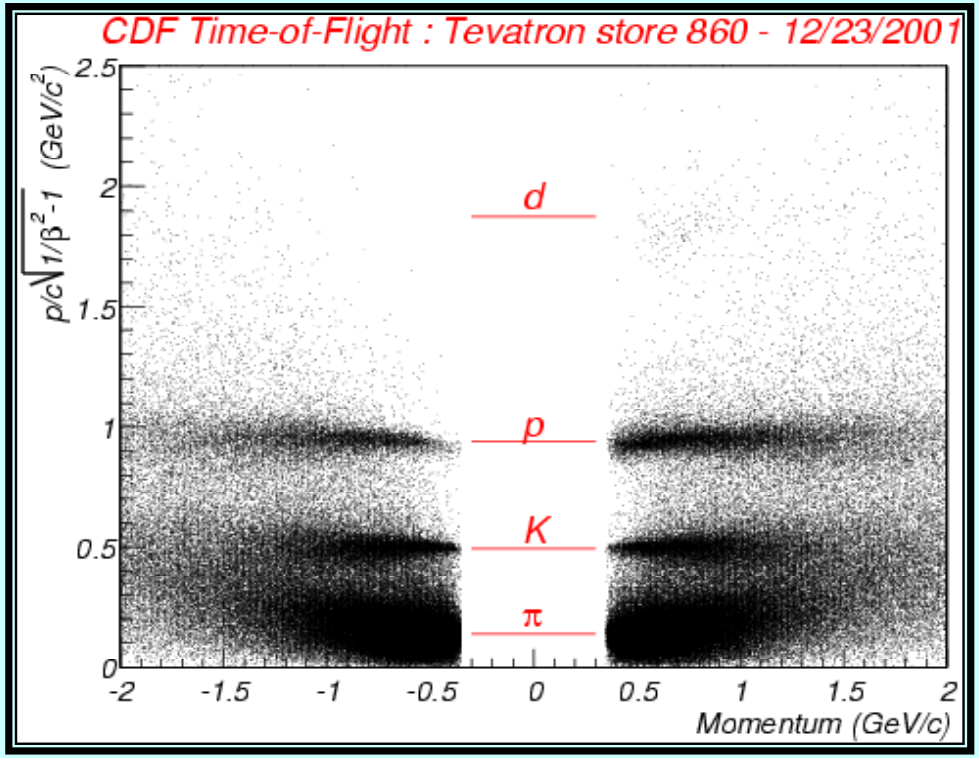
- *Large charm yield* **BUT**
- *poor particle ID;*
- *Trigger bias;*
- *Prompt and secondary charm*

Charm Studies in progress:

- *Understanding best use of the sample*
- *Cross section;*
- *Ratio of direct versus B produced*
- *Rare decays*
- *CP Violation*

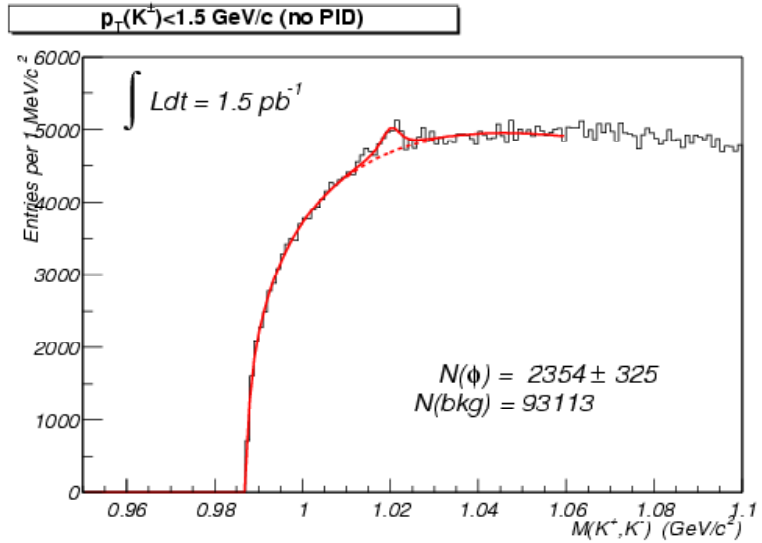
6 pb^{-1}	100pb^{-1}	2 fb^{-1}	E791	Focus
60 K	1 M	20 M	40 K	120 K

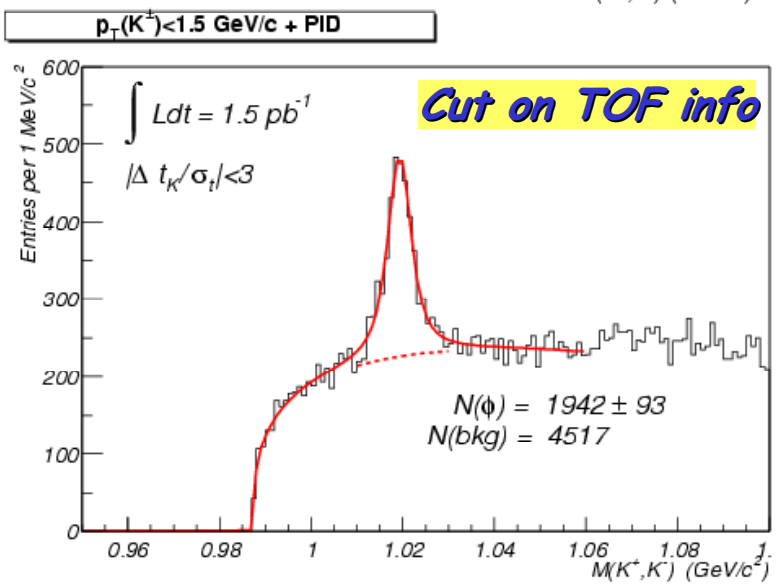
TOF System Performance



- **110 ps** of average resolution (from preliminary calibration)
- Getting close to **100 ps** goal;

TOF + track informations





Carmine Elvezio Pagliarone

Conclusions

- **CDF Detector is working well:**
  - **Trigger:** All of L1, much of L2;
  - **Detector:** All major systems are working;
  - **Offline:** All major parts are working;
- **(still) Some concern becouse:**
  - Tevatron Collider Luminosity is still too low;
  - L00 is still working on pedestal problems;
  - SVX coverage is still not complete (for trigger performance)
- **Started to look at Physics**
  - Reconstruction of bottom/charm, investigation of tools (TOF, vertexing, etc)
  - W's, Z's, and top candidates
- **Luminosity Expectations**
  - Possibly 100-200 pb-1 by end 2002, 2fb-1 by 2004