



Status of CDF and Prospects

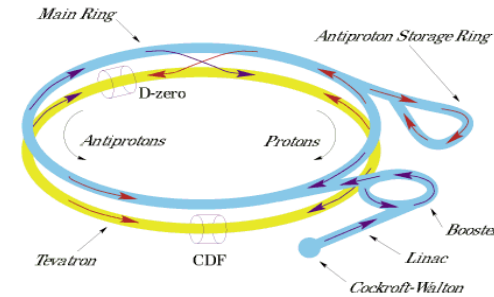
**Flavor Physics
and CP Violation**

Philadelphia

May 16-18, 2002

***Richard E. Hughes
Department of Physics
The Ohio State University***

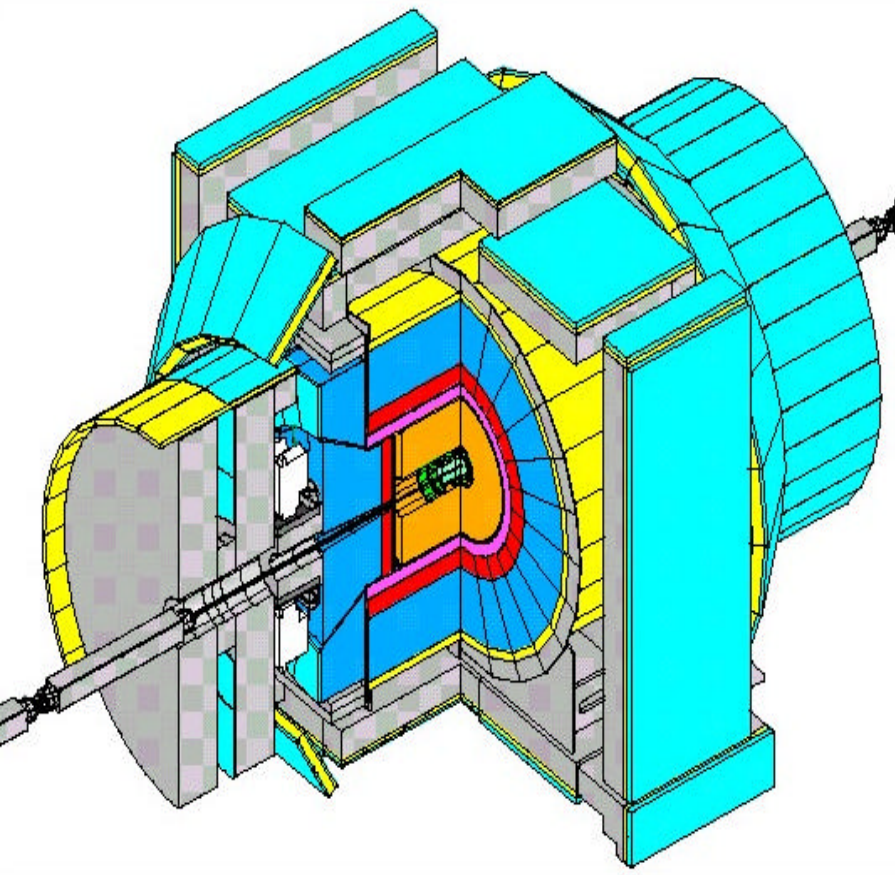
The CDF Collaboration for Run II



>500 Physicists from 52 Institutions Representing 11 Countries



CDFII Detector Systems



- **Tracking**
 - **Silicon**
 - 707k channels
 - Full coverage of luminous region
 - Radial coverage from 1.35-28cm
 - **Central Outer Tracker**
 - 30k sense wires, 44-132 cm
 - 96 dE/dx samples per track
- **Time Of Flight**
- **Expanded Muon Coverage**
- **Endplug Calorimeter**
- **Trigger (pipelined)**
 - Drift chamber tracks @L1
 - Silicon tracks @L2
- **Fully Digital DAQ (132 nsec)**



The Tevatron in Run II



Upgrades for Run II:

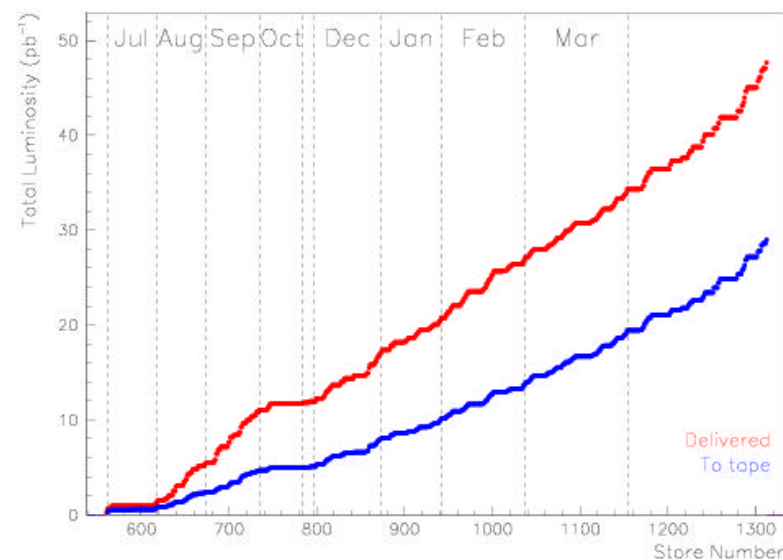
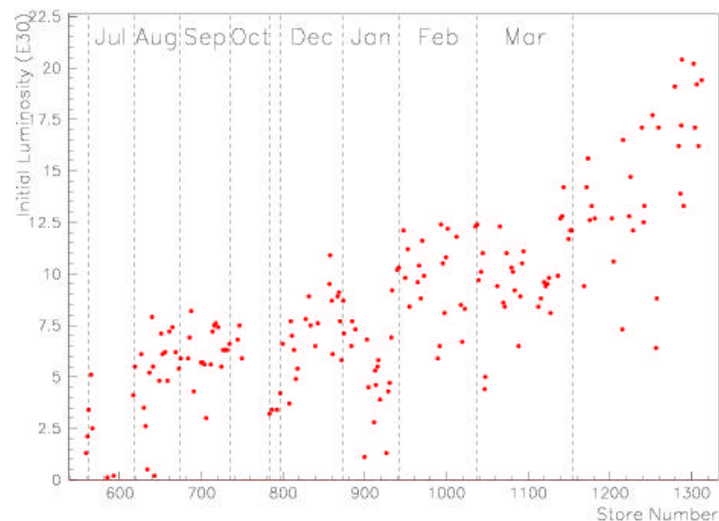
- ➔ Main Injector (150 GeV proton storage ring) replaces Main Ring
- ➔ Recycler for storing p-bars
- ➔ Shorter interbunch spacing (396ns)
- ➔ Beam energy \ddot{o} s 1.96 TeV

Luminosity:

- ➔ Peak 2.0×10^{31}
- ➔ $\sim 48 \text{ pb}^{-1}$ delivered
- ➔ $\sim 30 \text{ pb}^{-1}$ to tape

Near term:

- ➔ $> 60 \text{ pb}^{-1}$ by July shutdown
- ➔ $> 100 \text{ pb}^{-1}$ by end of 2002



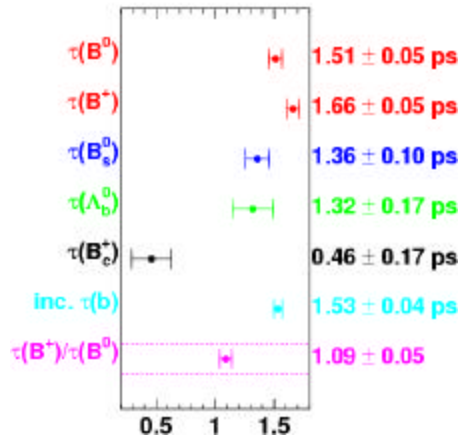


Building on Run I Successes

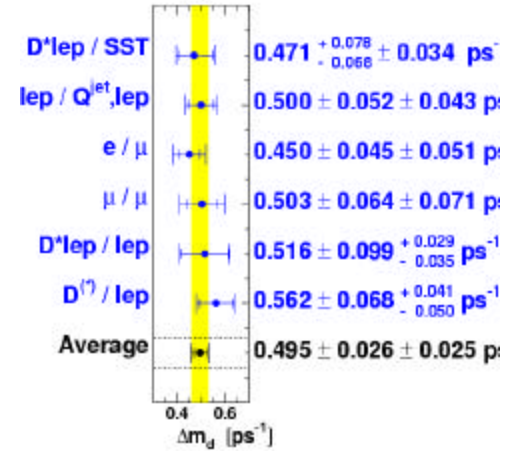


Many B physics
Results:
54 Publications

CDF B Lifetimes

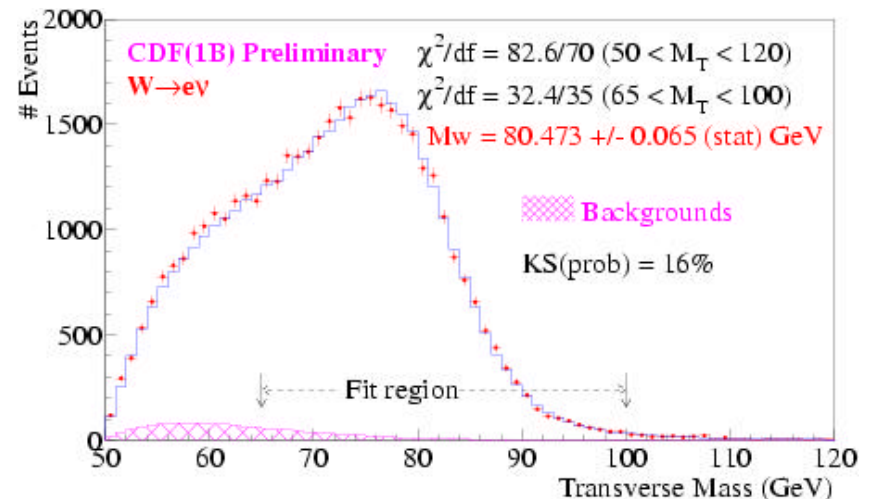
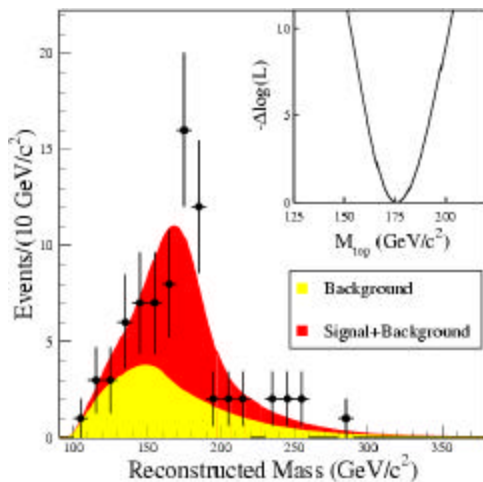


CDF Δm_d Results



Co-Discovery of the top quark

Measurement of the W Mass





Run II Physics Highlights



- **B Physics**

- x_s up to ~ 60
- CP violation using $B \otimes J/\psi K^0_s$
- CP violation using $B \otimes p^+ p^-$
- Rare Decays: e.g. $B^{+/-} \otimes \mu\mu K^{+/-}$

- **Charm Physics**

- Cross sections
- Rare Decays

- **QCD**

- Very High Et Jets

- **Electroweak**

- W mass measurement

- **Top Physics**

- Precise Mass Measurement
- Investigation of Properties

- **New Particle Searches**

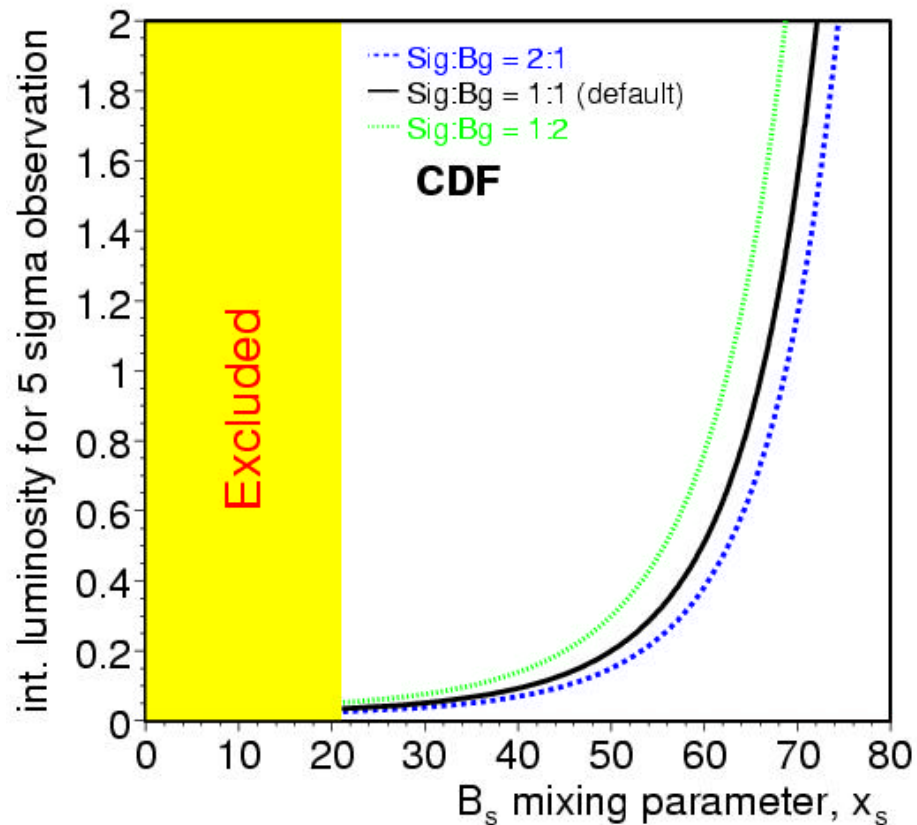
- Higgs
- Exotica



Example: Bs Mixing



- **Modes used:**
 - $B_s^0 \rightarrow D_s^- p, D_s^- 3p$
- **Signal ~ 75 k Events**
 - **Assumes hadronic trigger**
- **Flavor tagging: $eD^2 \sim 11.3\%$**
 - **Assumes TOF system**
- **Proper time resolution**
 - **With L00: $s_t \sim 45$ fsec**
 - **Without L00: $s_t \sim 60$ fsec**
- **Signal to background**
 - **From Data studies: 0.5 - 2.0**





Tools for the B Physics Program



Are the pieces in place for measuring Bs mixing?

What do we need?

- **Trigger**

- **Level 1 Tracking**

- **Level 2 Silicon**

- **Offline Tracking**

- **New Drift Chamber**

- **New Silicon System**

- **Base: SVX + ISL**

- **For B_s : L00**

- **Flavor Tagging**

- **Low Pt Electron and muon ID**

- **TOF, dE/Dx**

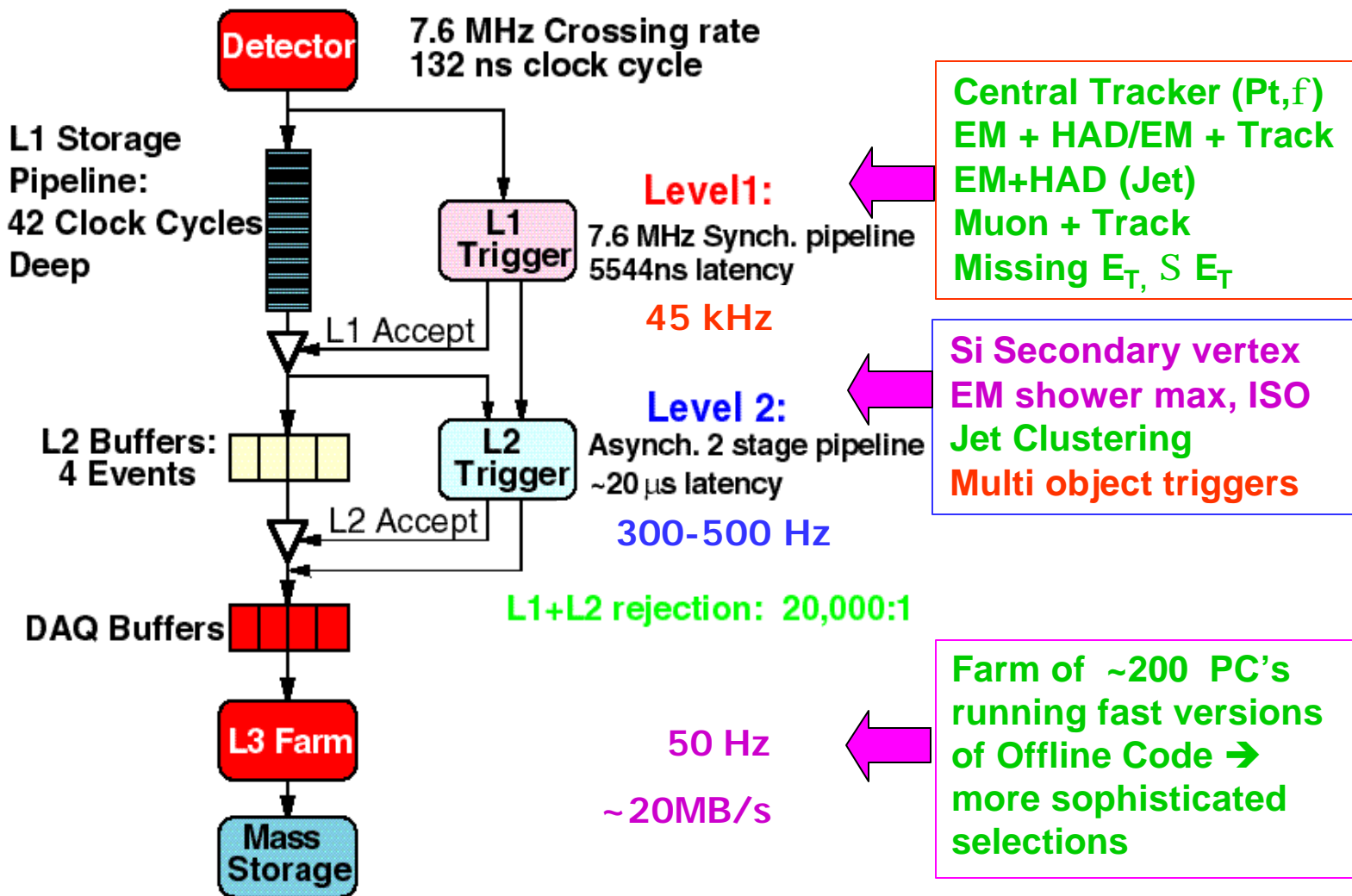
All of the upgrades which help the B program naturally contribute to the high Pt program as well.



Triggering in Run 2



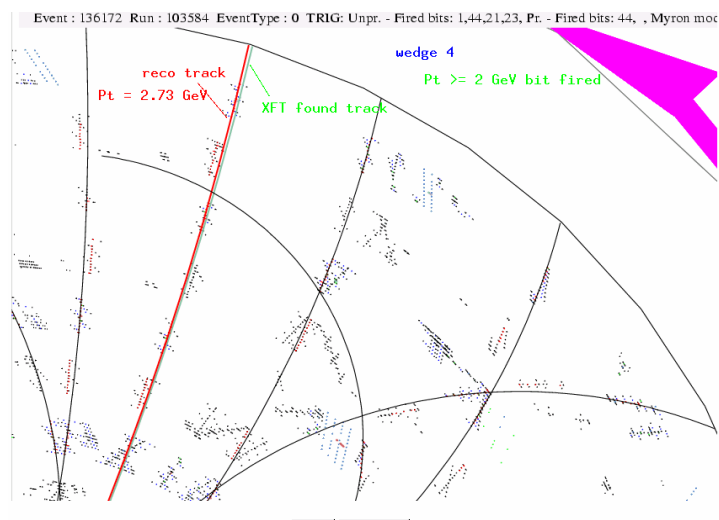
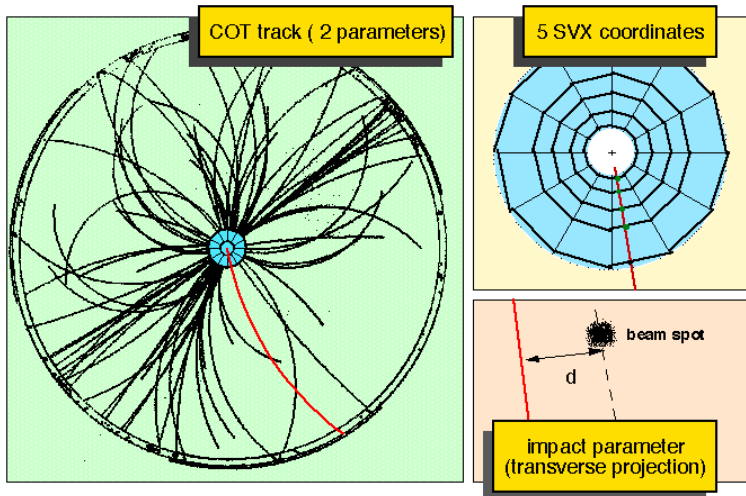
Dataflow of CDF "Deadtimeless" Trigger and DAQ



COT (XFT) defines track momentum cut at level 1
 Min. $P_T = 1.5 \text{ GeV}/c$

SVX measures impact parameter cut at level 2 (SVT)

XFT Track Reconstruction





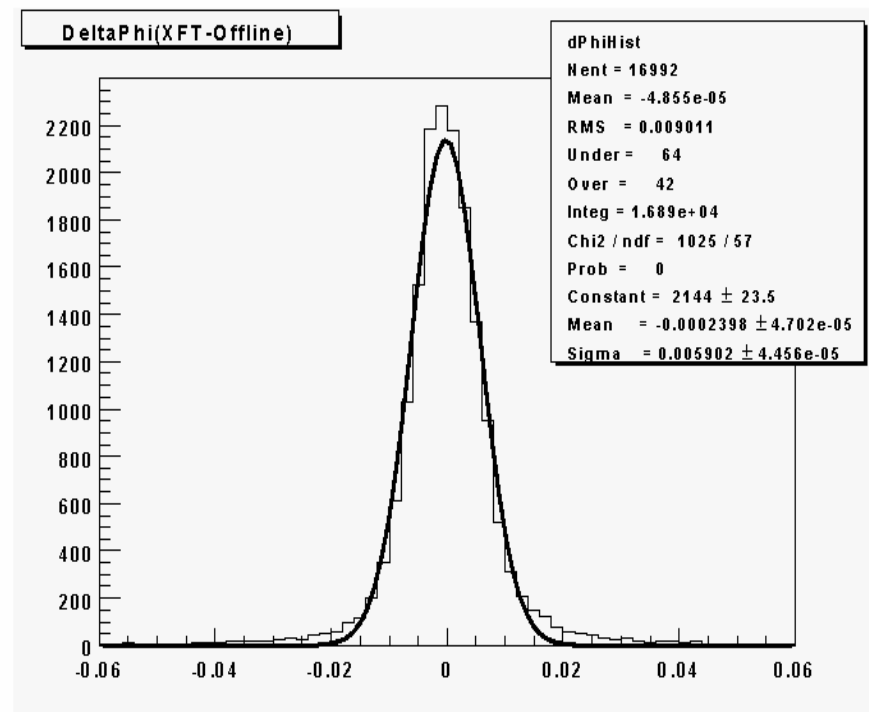
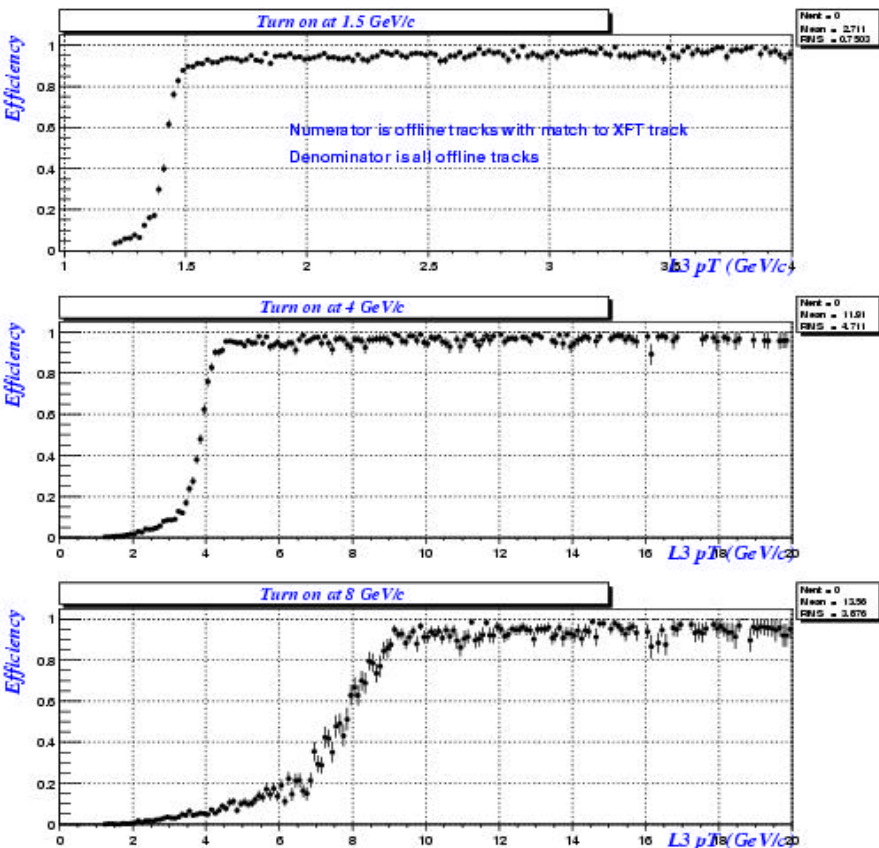
L1 Tracking Trigger Performance



Pt Turn on curves consistent with expected resolution ($< 1.8\%/GeV/c$) and efficiency ($> 95\%$)

Extrapolated Phi resolution consistent with expectations

Corrected ϕ resolution is 6 mrad, aim is < 8 mrad

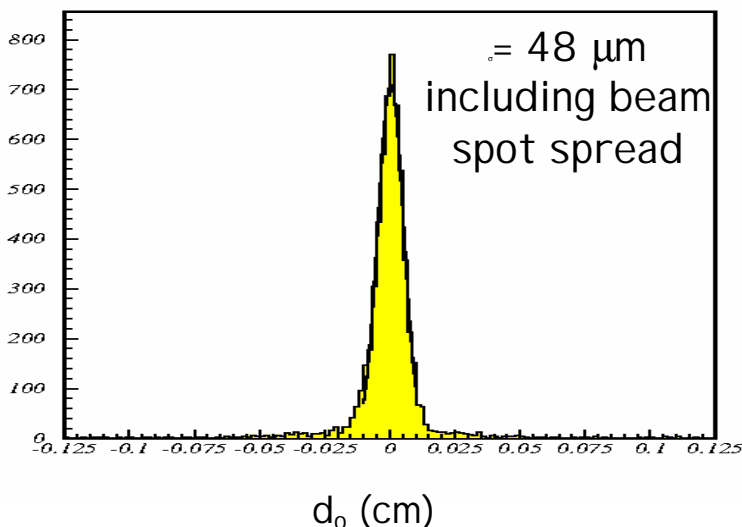




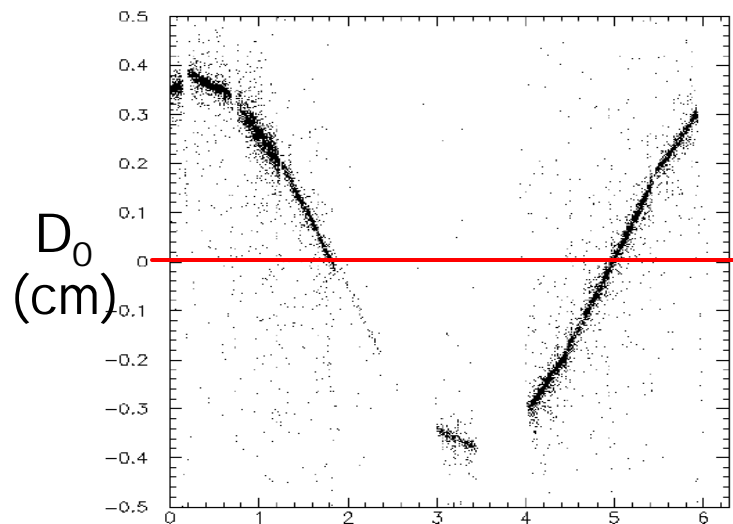
CDF L2 Silicon Trigger Performance



SVT impact parameter



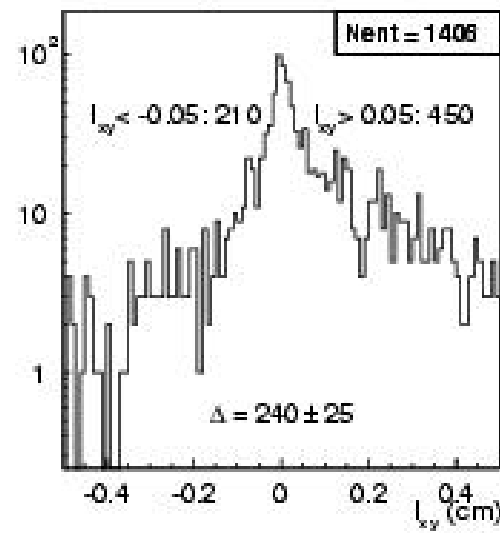
SVT Measures Beam Position



SVT is working well:

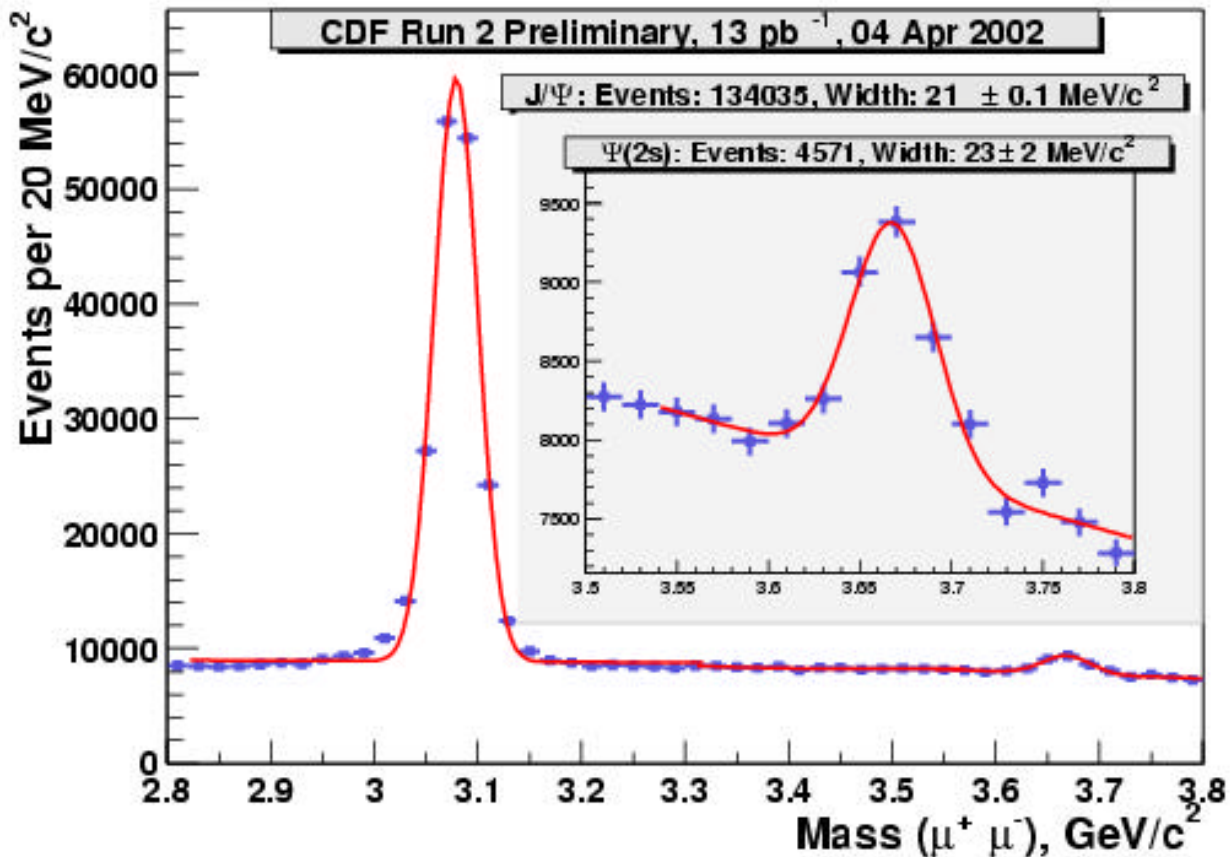
- Impact parameter resolution is as expected
- The SVT can handle a displaced beam spot (but not a slope!)
- With standard trigger level cuts, the SVT preferentially selects heavy flavor
 - $0.15\text{mm} < d_0 < 1\text{mm}$ (both tracks)
 - $100\text{mrad} < \Delta\phi < 90$ degrees
 - SVT chisquare < 10 (both tracks)

$150\mu\text{m} \leq d_0 \leq 1\text{mm} \quad 2^\circ \leq \Delta\phi \leq 90^\circ$





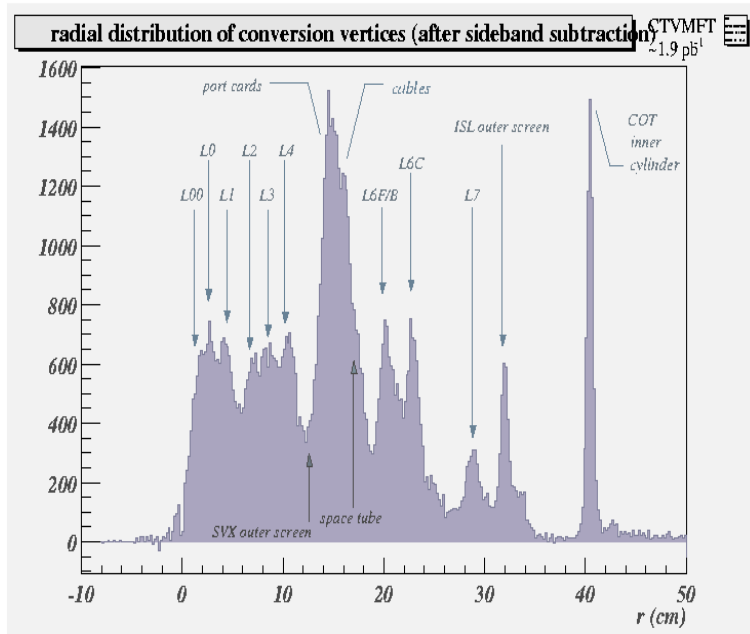
Muon Trigger and J/Psi Yield



**Improved J/psi Yield
-factor of 2-3 over
Run I**



Electron Identification

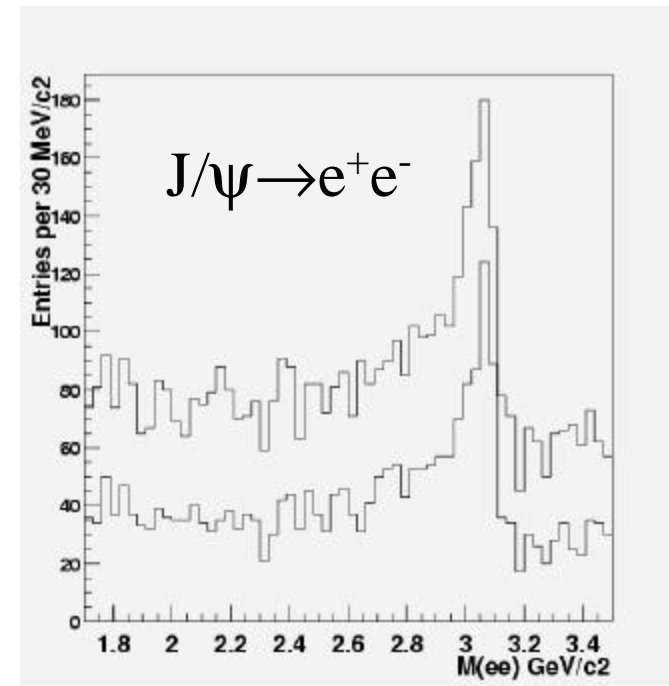


Identifying conversion electrons

- Require 1 low P_t electron ($>4 \text{ GeV}$)
- Look for opposite sign track

Electron Trigger Status

- Thresholds lower than Run I
 - e.g. 2 GeV dielectrons
- All Electron ID components in place
 - dEdx in COT, plus CPR, CES
- Level 2 triggers with CES are now working





Online vs Offline Tracking

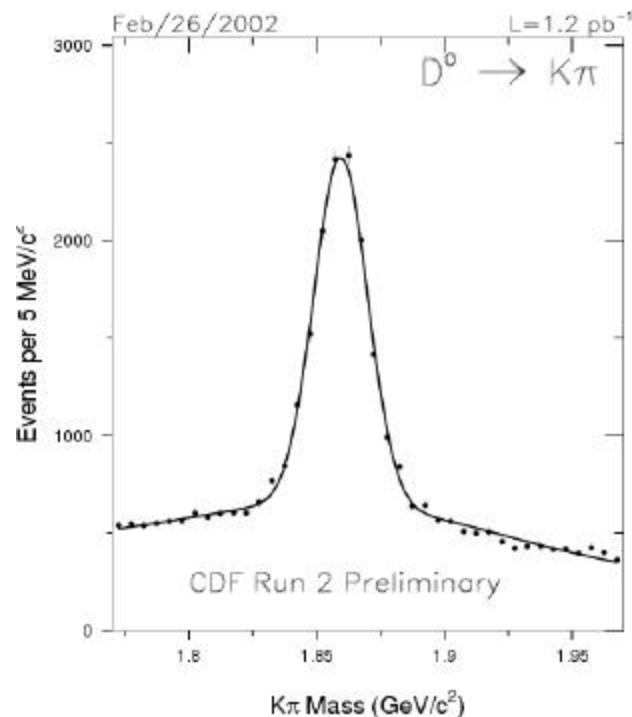
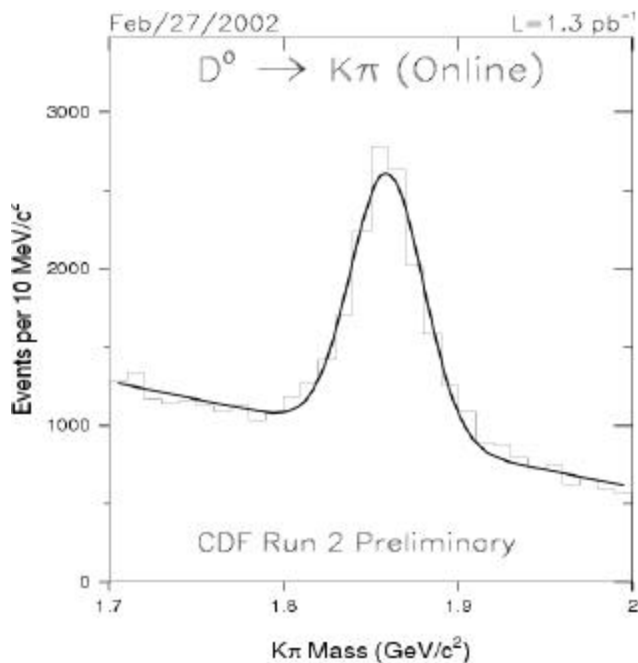


Online: using quantities available to the trigger (L2/L3):

- $P_t > 2.0$ GeV (each track)
- $|d|$ [100 μ m:1mm]
- L_{xy} [0:3]cm

Offline:

- $P_t > 1.5$ GeV (each track)
- $|d| > 100\mu$ m
- $L_{xy} > 0$

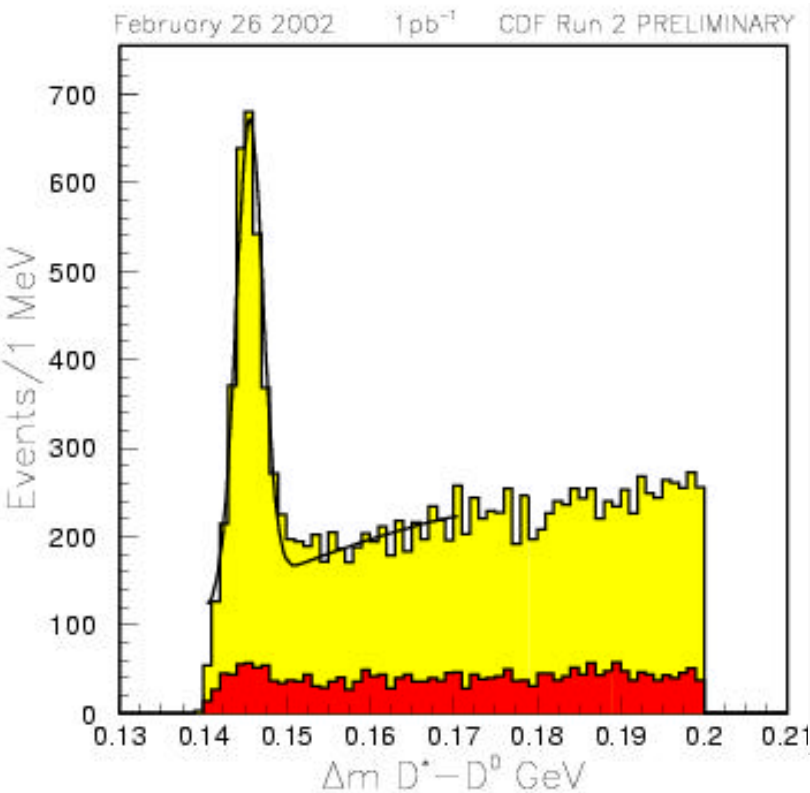




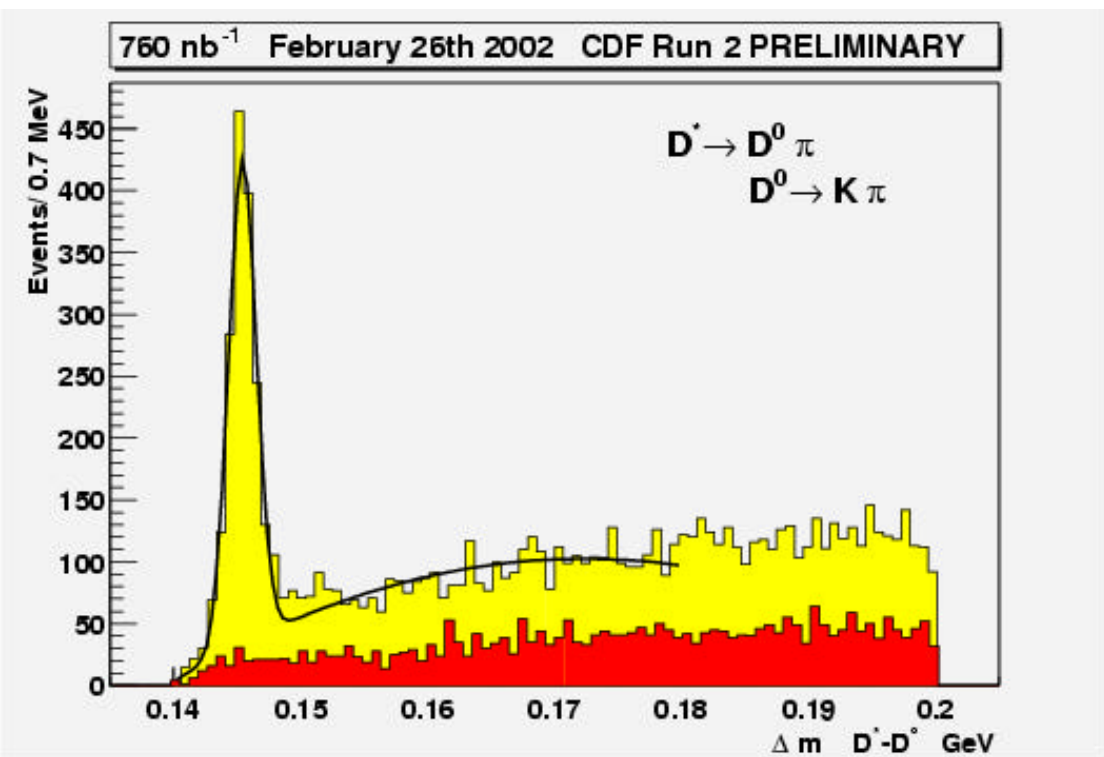
Online vs Offline Tracking



Trigger “hybrid” tracks:



Full offline tracking:

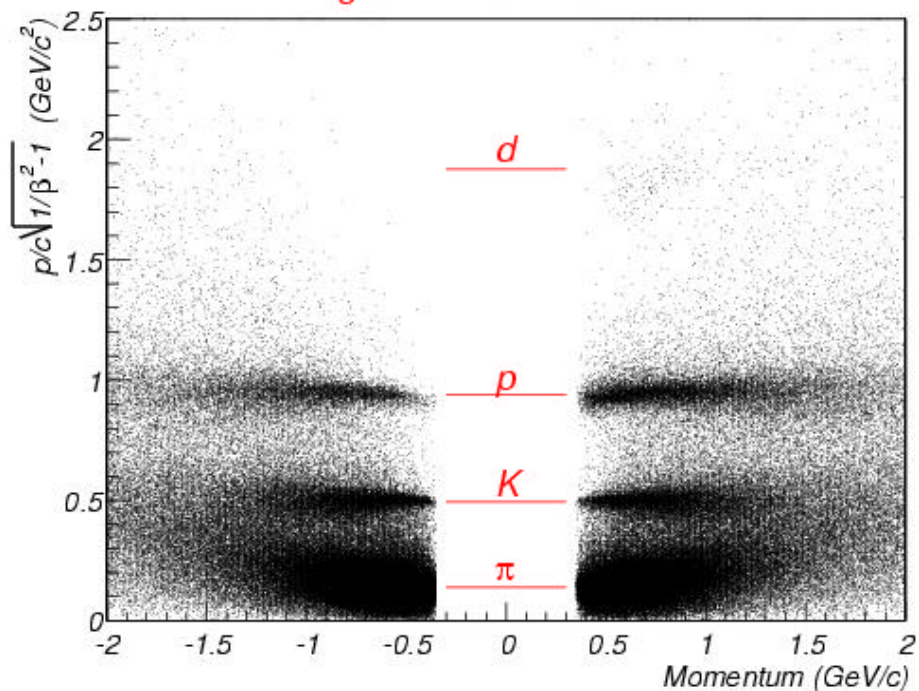




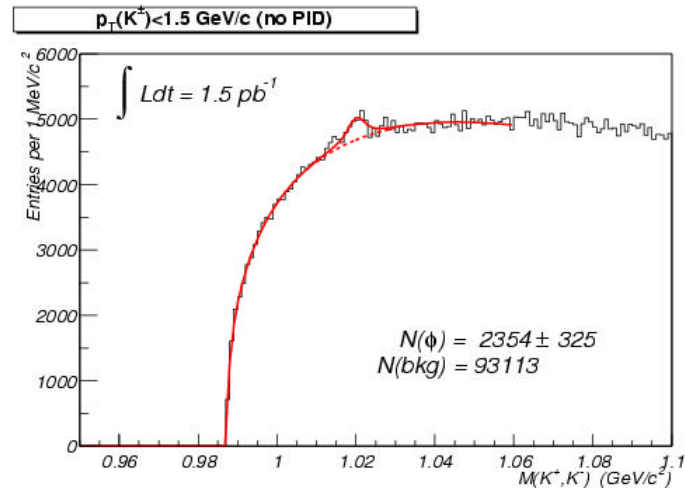
TOF System Performance



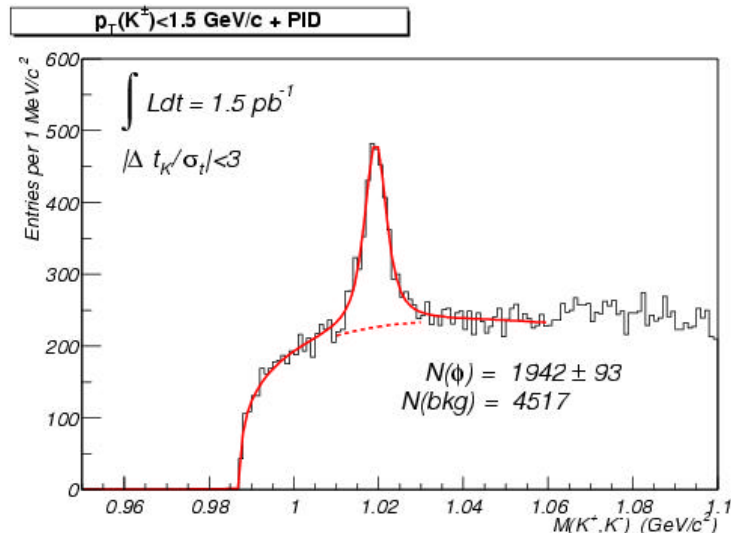
CDF Time-of-Flight : Tevatron store 860 - 12/23/2001



Require TOF info associated with tracks:



Cut on TOF info:



Preliminary calibrations:

- Indicate ~110psec avg resolution
- Goal of 100psec is still possible



Beginning to Look at Physics



- **Bottom/Charm Physics**

- **Reconstruction of B mesons**
- **Reconstruction of Charm**
- **Beginning to develop analysis tools, look at rates**

- **Electroweak**

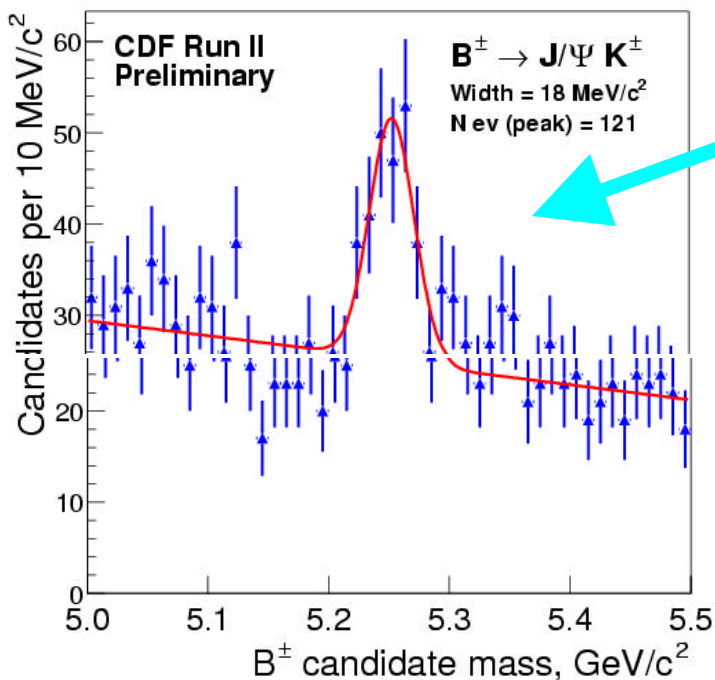
- **W samples**
- **Z samples**

- **Top**

- **We get an extra ~35% increase in xsec due to higher beam energy**
- **Plus detector improvements means each Run II pb^{-1} is ~1.5-3.0 Run I pb^{-1}**
- **Dileptons will be done first**
 - **Smaller backgrounds**
 - **Don't need b-tagging, which will take time to understand**



B Meson Reconstruction

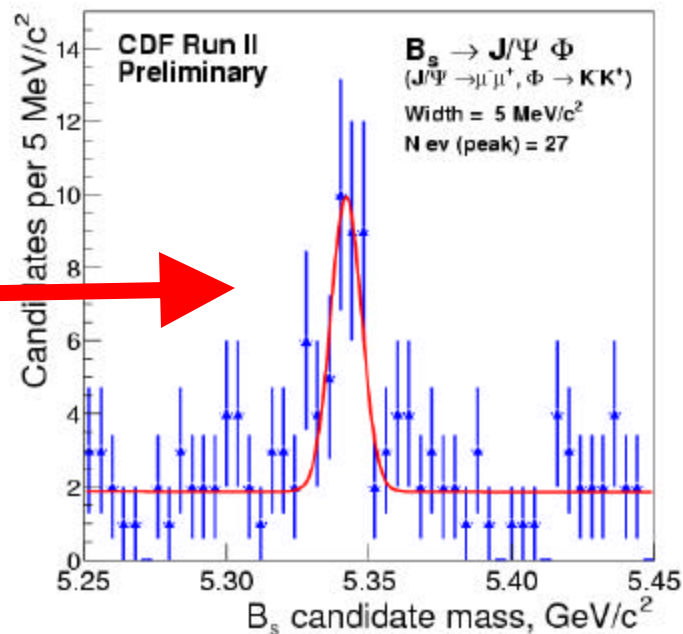


$B^{+/-}$ mesons

- Luminosity $\sim 11\text{pb}$
- Require:
 - $L_{xy} > 0$
 - $Pt(B) > 6.0\text{ GeV}$
 - Vertex quality cuts

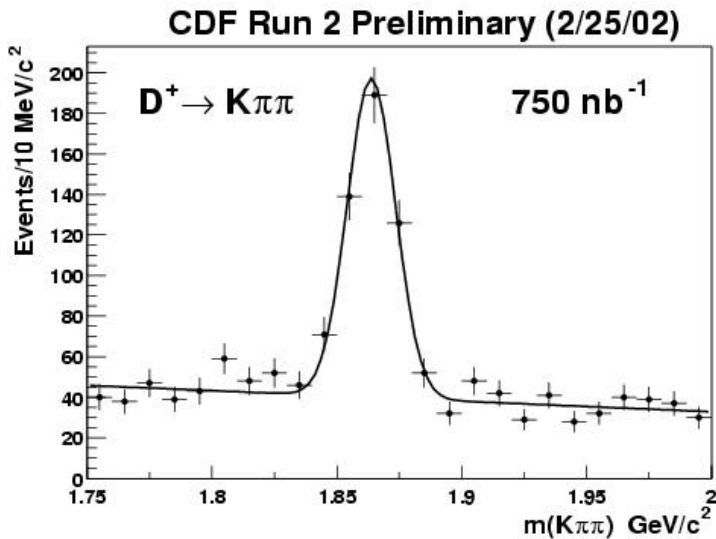
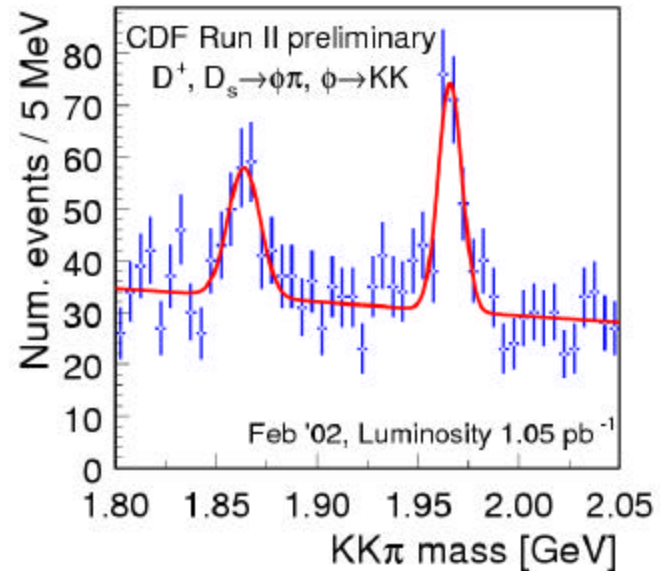
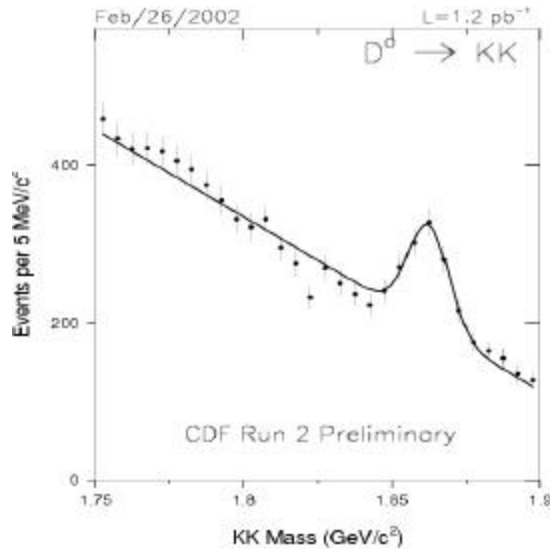
B_s mesons

- Luminosity $\sim 11\text{pb}$
- Require:
 - $L_{xy} > 0$
 - $Pt(B) > 5.0\text{ GeV}$
 - Mass window on Phi
 - Vertex quality cuts





Lots of Charm from the SVT!



Charm Studies in progress

- Cross section measurements
- How much charm is direct versus coming from B?
- Rare decays
- CP violation?



Hi Pt Electron ID

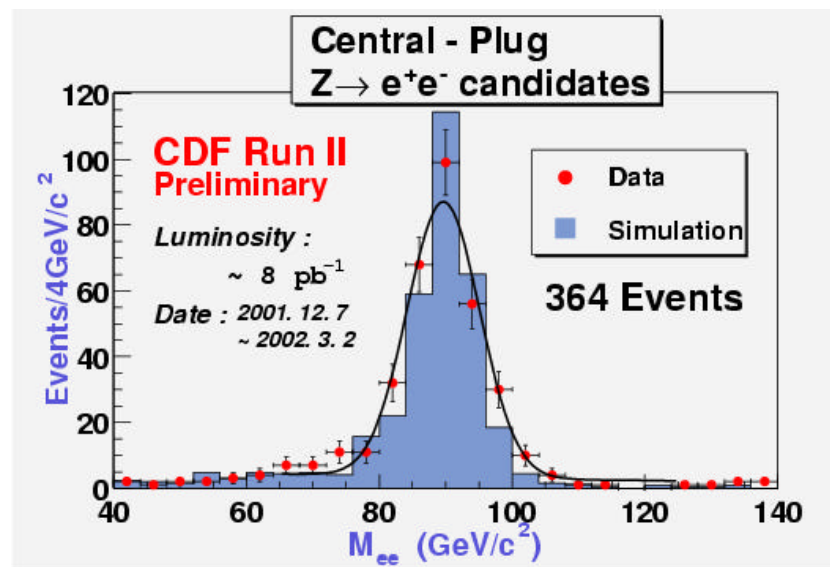
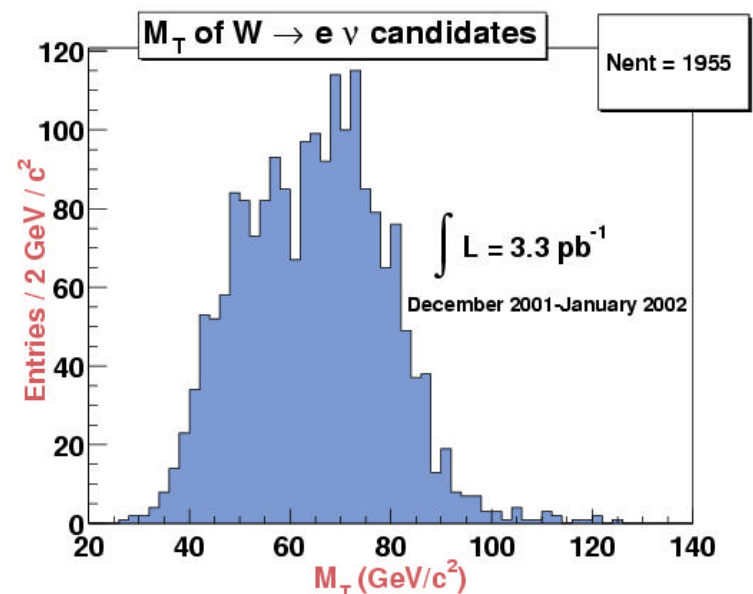


W sample

- Based on 3.3 pb^{-1} data
- Require 1 quality electron
 - $E_t > 20 \text{ GeV}$
 - E/P, Isolation
- Require missing $E_t > 20 \text{ GeV}$

Z Sample

- Based on about 8 pb^{-1} data
- Require 2 quality electrons
 - $E_t > 20 \text{ GeV}$ (Plug: 18 GeV)
 - Isolation (both)
 - E/P: 0.5-2.0 (Central only)





Hi Pt Muon ID

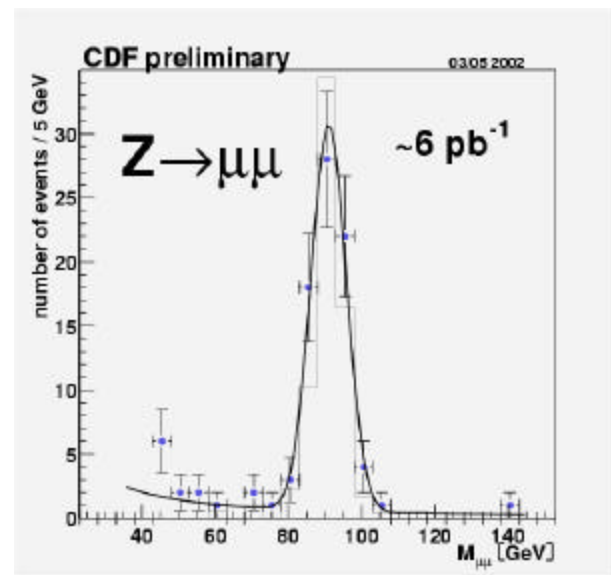
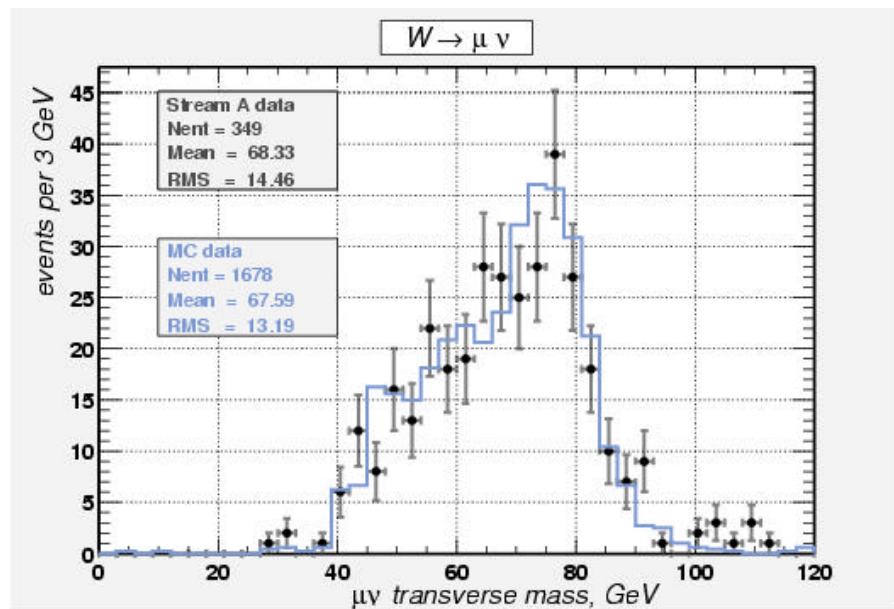


- **W sample**

- Based on 2.5 pb^{-1} data
- Require 1 quality muon
 - Pt > 18 GeV
 - Isolation
- Require missing Et > 20 GeV

- **Z Sample**

- Based on about 6 pb^{-1} data
- Require 2 quality muons
 - Pt > 18 GeV
 - Isolation
- Require pass cosmic filter





Our First Top Candidate?



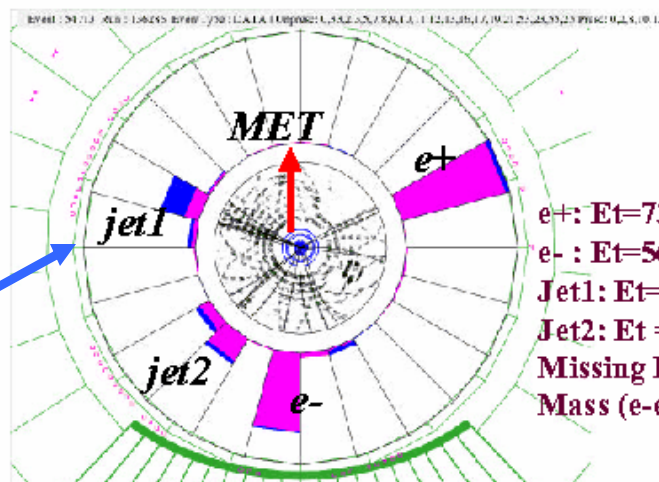
A top dielectron candidate

- e^+e^- , two jets with a large missing E_T -

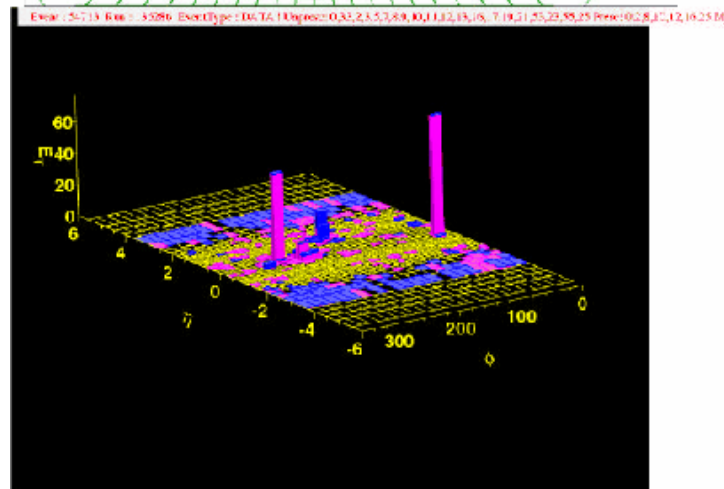
Run=136286, event=54713

Passes all of the Run 1
Top dilepton selection
Requirements.

Displaced vertex
as identified by Run 1
tagging algorithm



e^+ : $E_T=73$ GeV
 e^- : $E_T=56$ GeV
 Jet1: $E_T=35$ GeV
 Jet2: $E_T=34$ GeV
 Missing $E_T=43$ GeV
 Mass (e^+e^-)=118 GeV





Summary



- **At this stage, many things are working:**
 - **Trigger:** All of L1, much of L2
 - **Detector:** All major systems are working.
 - **Offline:** All major parts are working.
- **But some have problems:**
 - **Luminosity still too low**
 - **L00 is still working on pedestal problems.**
 - **SVX coverage is still not complete (for trigger performance)**
- **Starting 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**