Status of the CDF II Experiment

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Outline of the talk

- Accelerator and detector upgrades
- Preliminary results from first data ~ 4-8 pb^{-1}
  - Tracking
  - Calorimeter system
  - Muon system
  - Trigger
    - SVT
- Plans for short and long term future
  - b physics
  - high pt : top/Higgs/exotica

Run 2 Detector Upgrades

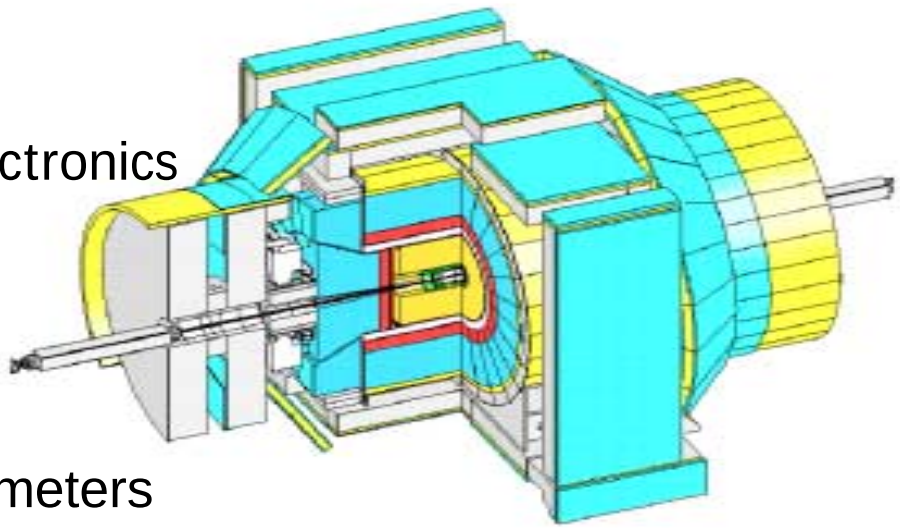
Accelerator configuration

$\sqrt{s}$ = 2.0 TeV (increased cross section - top 40%)
L up to 2×10^{32} cm^{-2} s^{-1} $\Rightarrow$ increased statistics

- The CDF detector has been upgraded to handle the Tevatron's increased collision rate (operation at p p crossing times of 132 or 396 ns).
- The capability for total integrated luminosity in run II is limited by radiation damage to the silicon tracker. This is estimated to survive to ~ 5 fb^{-1}
  - in 2004 a major shutdown is scheduled to replace the Si detector.
- CDF & D0 have been significantly rebuilt to qualitatively improve performance.

improvements from run I

- New central tracker drift chamber
  - $N_{axial}=N_{stereo}=48$,
  - $Dp_t/p_t<0.001p_t$
- New silicon vertex detector
  - **7 layer, 3-D reconstruction, $|\eta|<2$**



- New front-end, DAQ and trigger electronics
  - Fully digital trigger
  - L1 tracking trigger
  - L2 secondary vertex trigger
- New Scintillating tile end-plug calorimeters
- Increased $\eta\phi$ coverage for muon detectors
- New Scintillator time of flight system

Experiment status and plans

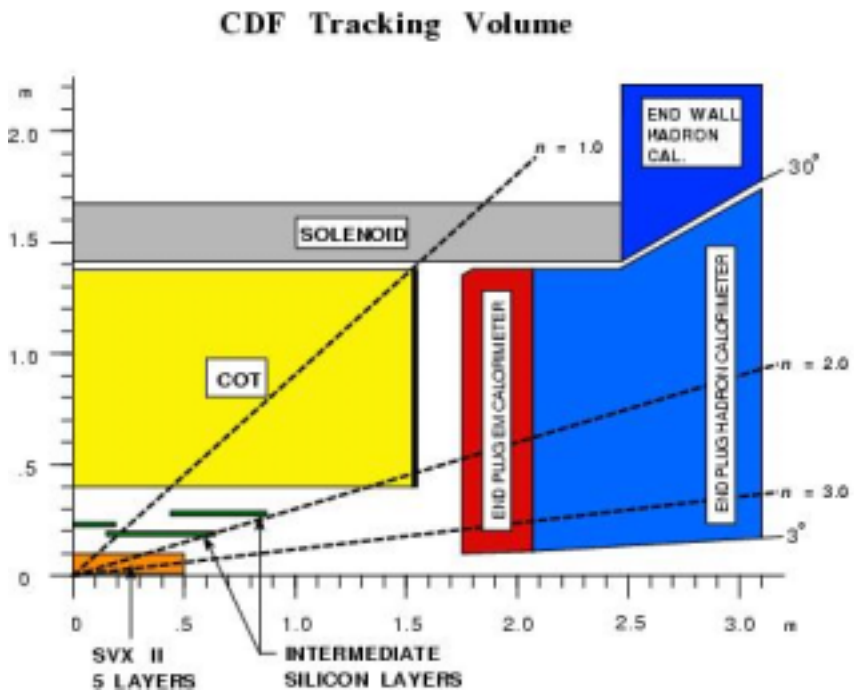
- Since operation start-up in the collision hall in March 2001, the CDF detector has been commissioned using ~ 20 pb^{-1} of data provided by the Tevatron (utilized about 4 to 8).
- Most detector components are ready for physics quality data.
- Goal is first physics results by summer-fall 2002

Detector roll-in February 2001

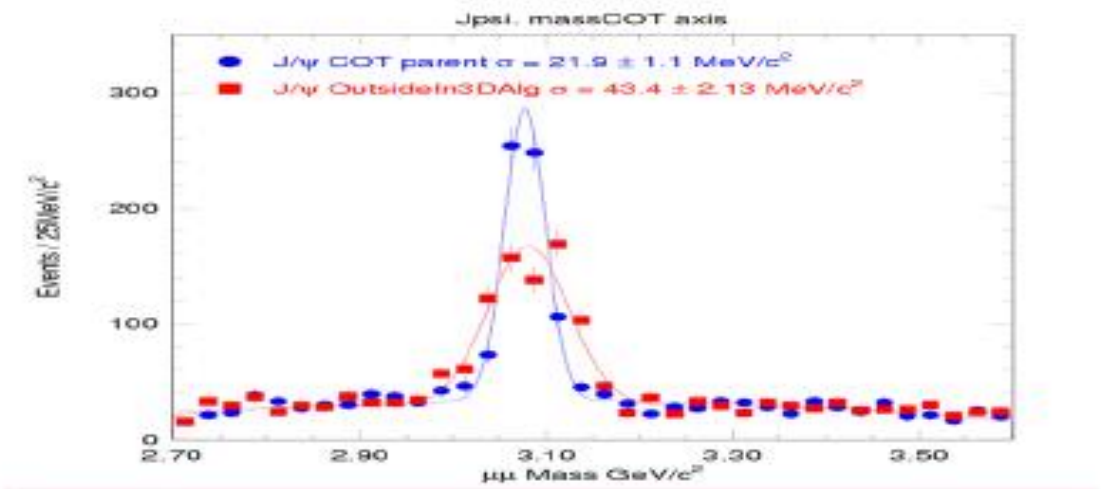
Tracking system

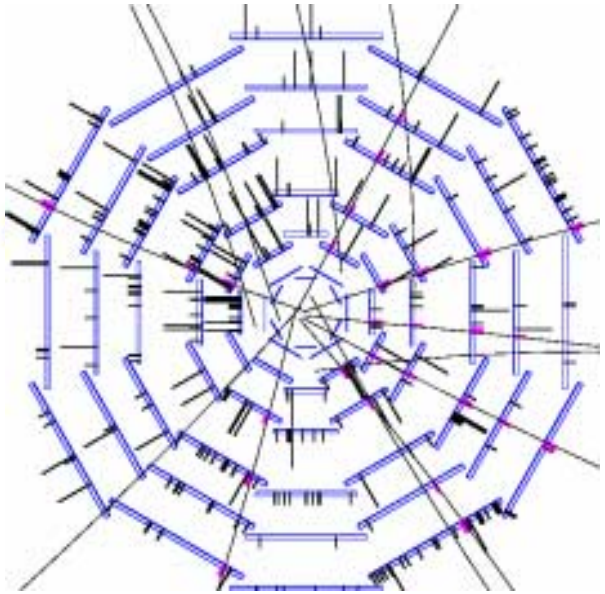
- Central Outer Tracker : open cell drift chamber with maximum drift time 100ns (< 132 nsec bunch spacing) -improved stereo capabilities.
- Silicon Tracker :
  - double sided microstrips detector (r-ϕ, r-z info)
  - η coverage up to $|\eta| < 2$
  - increase z coverage in the luminous region
  - 3-D track reconstruction
  - impact parameter resolution
    - σ_ϕ < 30 μm
    - σ_z < 60 μm
  - Inner most - Layer00, r = 2.5cm
  - SVXII - 5 layers 3 < r < 10cm
  - Intermediate Silicon Tracker 10 < r < 20 cm

Feeds Silicon Vertex Trigger at L2



Tracking data: J/ψ resolution



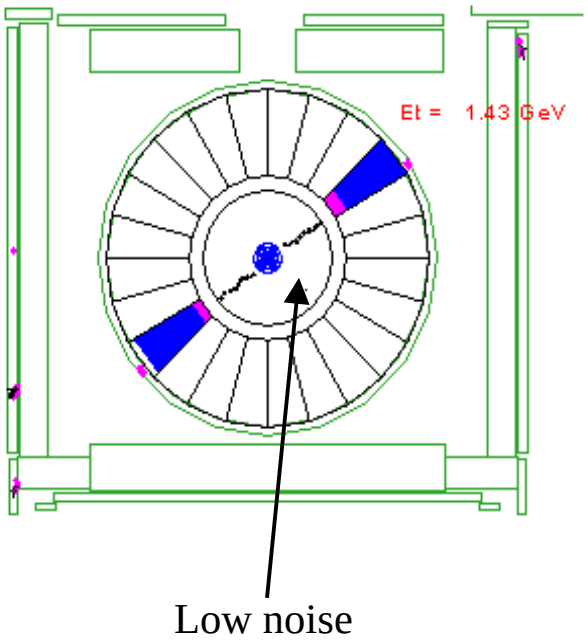


	Alignment	N(J/ψ)	σ(J/ψ)	ΔZ	S/B
COT	10.2	24409	22 MeV	800μ	1.62
+SVX rphi	10.2	10569	17 MeV	240μ	2.83
+3 Z hits	10.2	3288	16 MeV	160μ	4.28

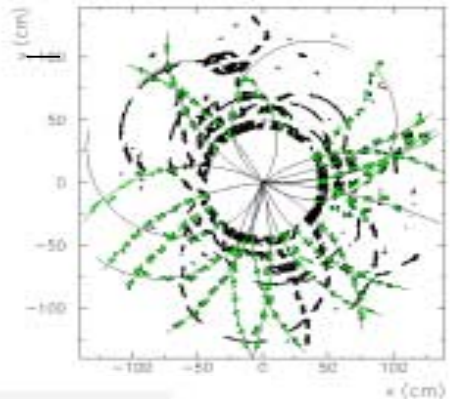
*Pre-shutdown data with 4.3.0int1
*Latest runs 138021 gives r-phi si coverage for Jpsi 70%

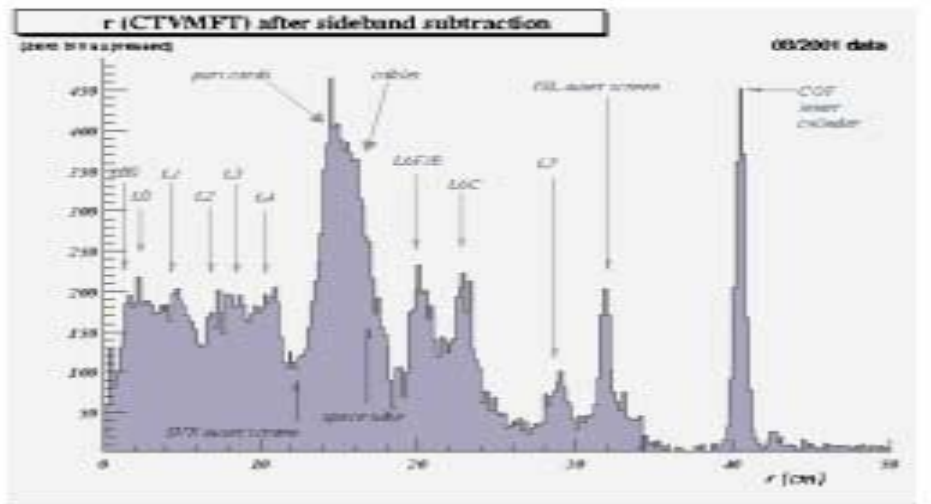
More tracking data

Cosmic ray tracks



Reconstructed tracks from
1.96 TeV p p collisions



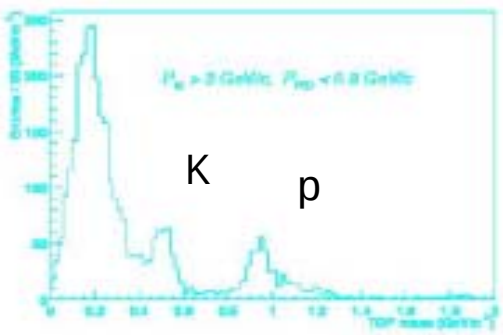


Photon e^+e^- pairs reconstructed with COT

Particle Identification

TOF scintillator bars

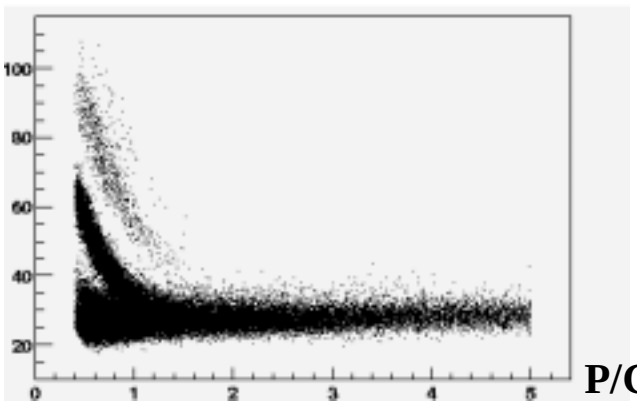
216 x 2 PMT channels
100ps timing resolution

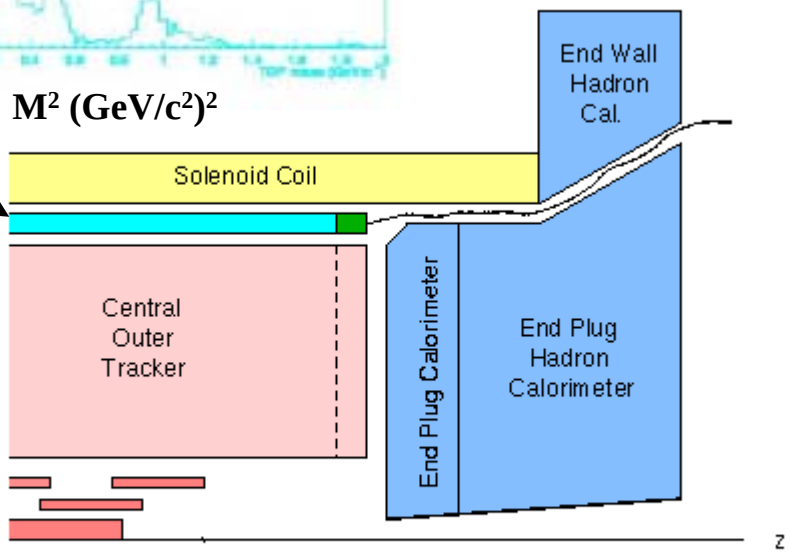


$P_{t0} > 3$ GeV, $P_{PID} < 0.8$

COT wires

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

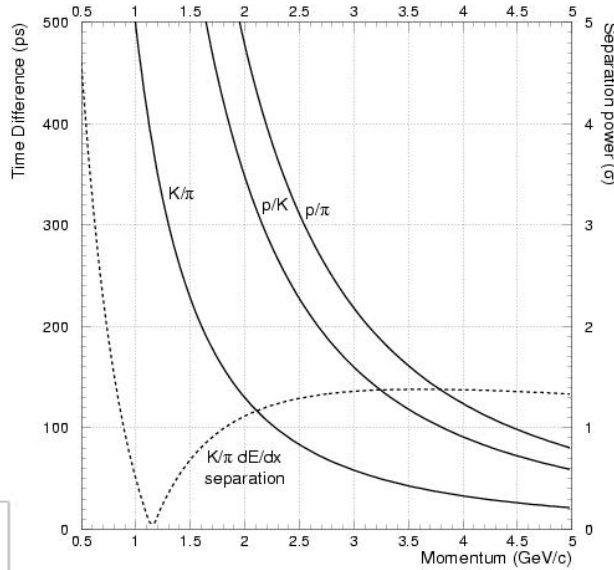




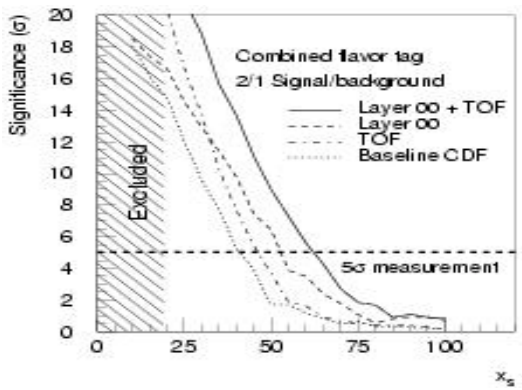
Final calibrations in progress

Impact on physics

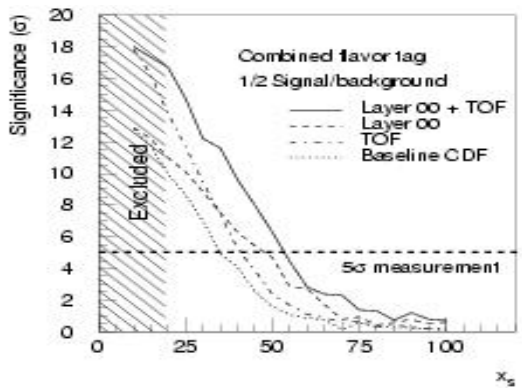
- A Time of Flight system allows for particle identification over a broad fraction of momentum spectra.
- Physics associated with B-meson, in particular B_s^0 and $\overline{B}_s^0$ mixing (unitary triangle verification)
- The average significance improves considerably: range of x_s (oscillation frequency) to observe B_s oscillations.



S:B = 2:1



S:B = 1:2



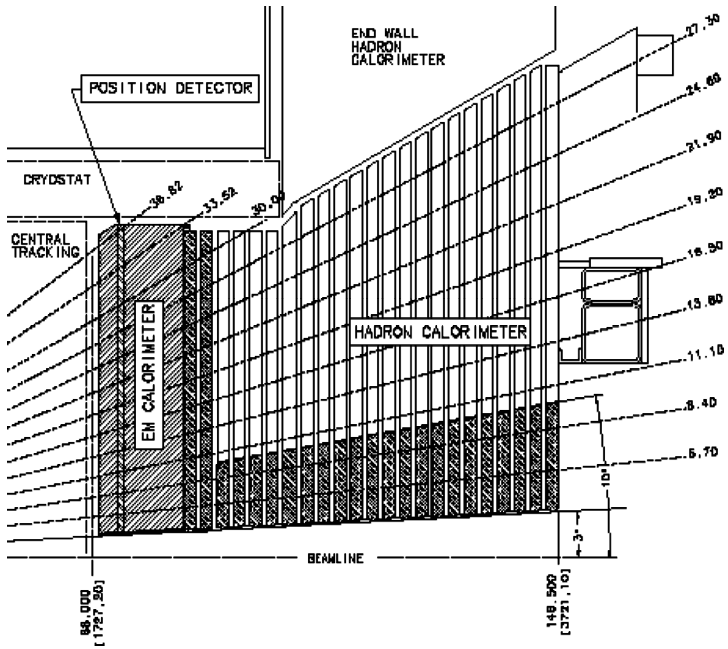
Efficiency improvement of factor 3

Calorimeter Upgrades

Central calorimeters retained from Run 1 with new readout electronics

- $|\eta|$ out to 1.0
- EM, hadronic and shower max readout
- projective towers with segmentation:

$\phi \times \eta = 15^0 \times 0.11$



New scintillator based plug calorimeter

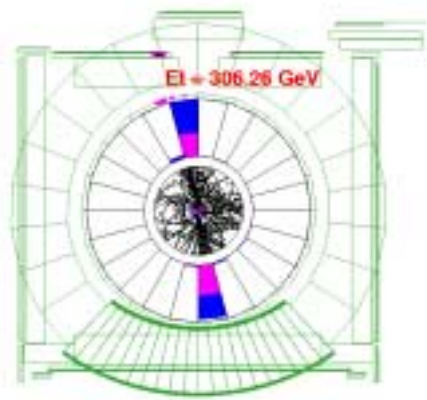
- $|\eta|$ out to 3.6
- EM, hadronic and shower max readout
- central calorimeter η ϕ segmentation maintained as far as possible.

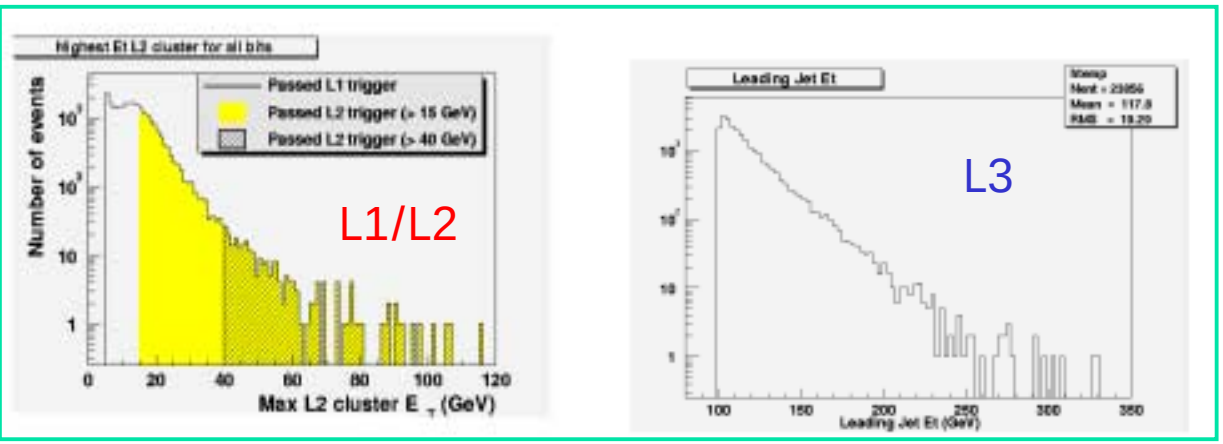
New forward calorimeter

- $|\eta|$ out to 5.5
- EM+hadronic showers

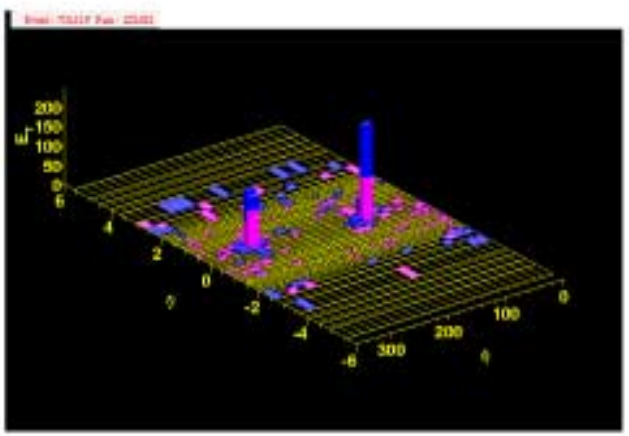
Calorimeter Data

- Jets being selected on-line and are reconstructed offline. Algorithms are in place and well advanced





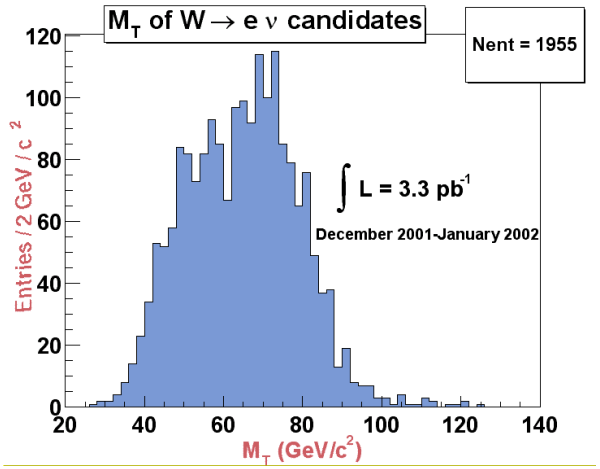
Dijets jets with Et ~ 400 GeV



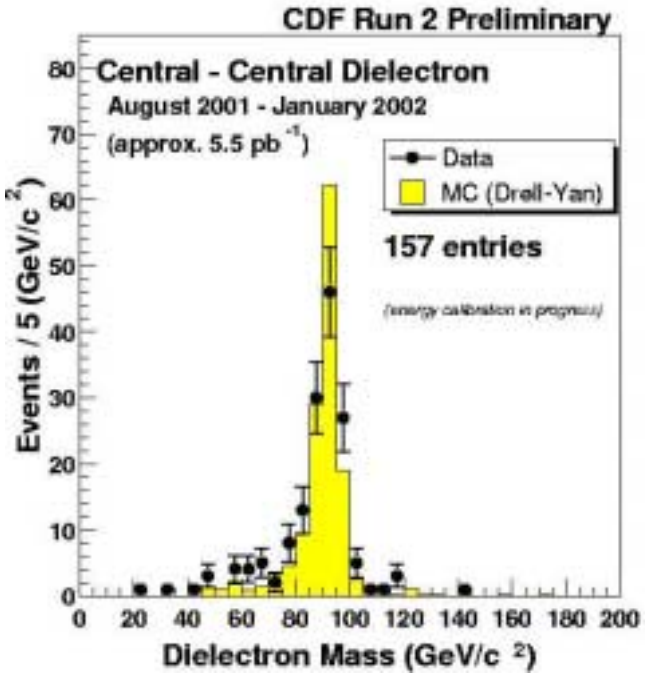
Energy scale calibration ongoing (top mass)

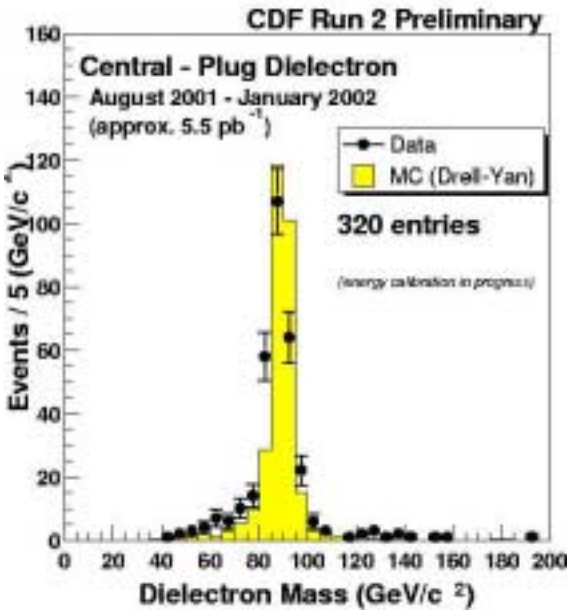
Toward high pt physics....

W -> e ν transverse mass

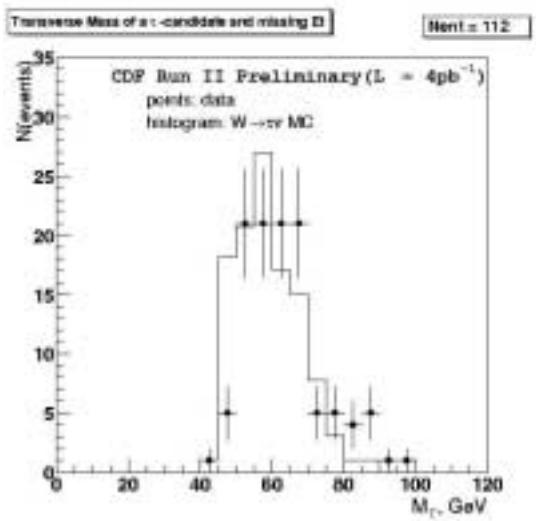


Z -> e^+ e^- invariant mass





EM energy calibration is still in progress.
Estimated numbers of
background events are approximately 4 for C-C and 20 for C-P.



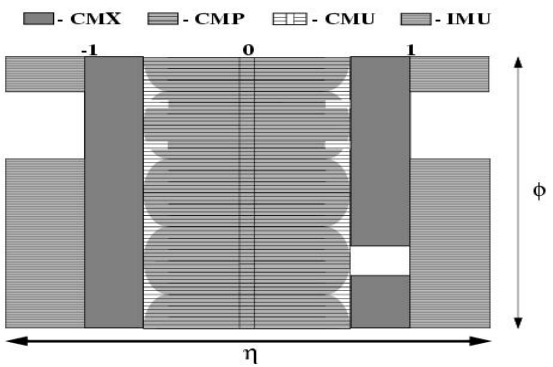
W->ντ trans mass

Muon system upgrade

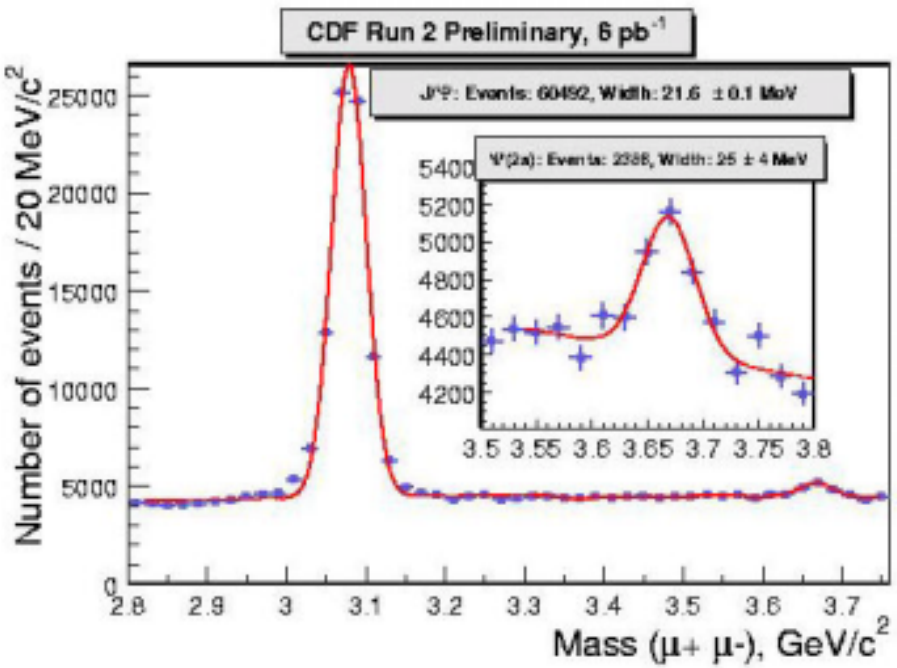
"Old" Run 1 central muon detectors performing well with new readout electronics

"New" extension and intermediate muon chambers will extend muon trigger from |eta| = 0.6 to 1.0

All muon detectors are in final position and included in level 1 trigger

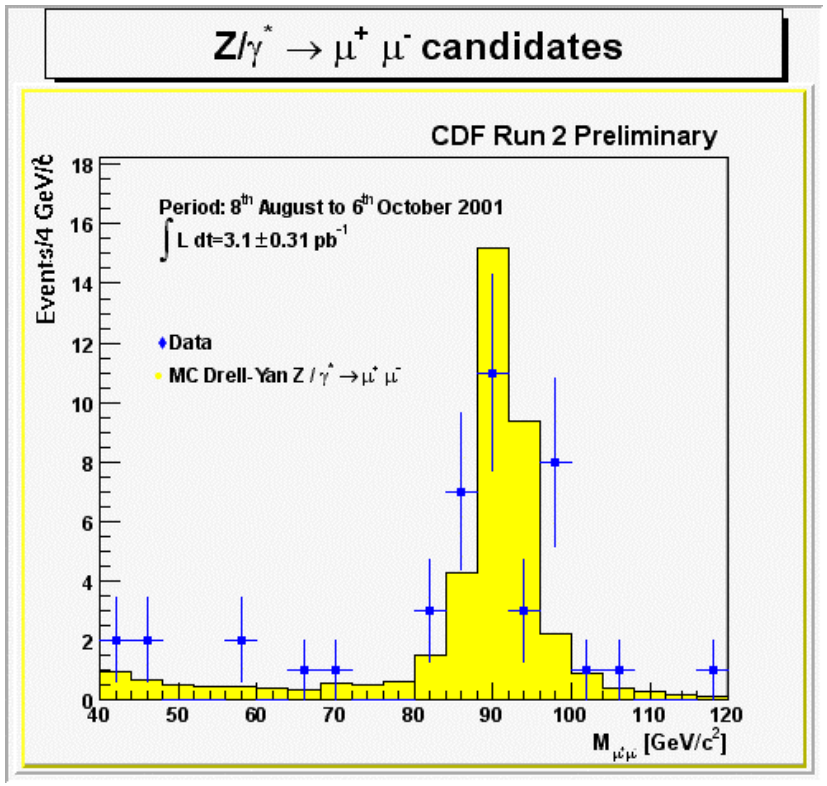


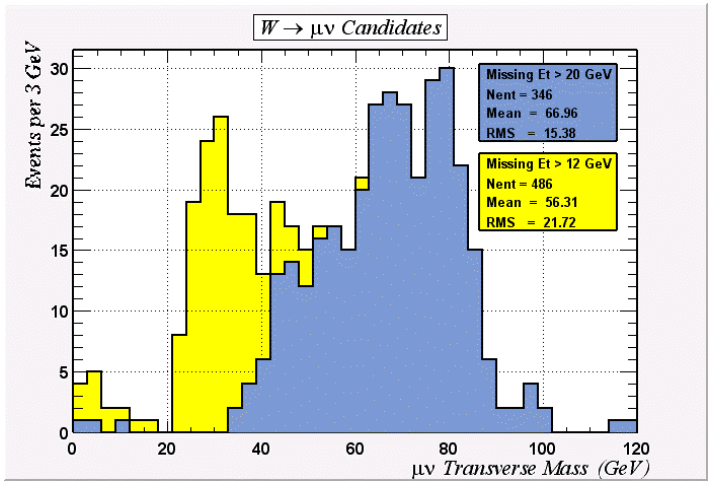
Total muon coverage increased by about 50%.

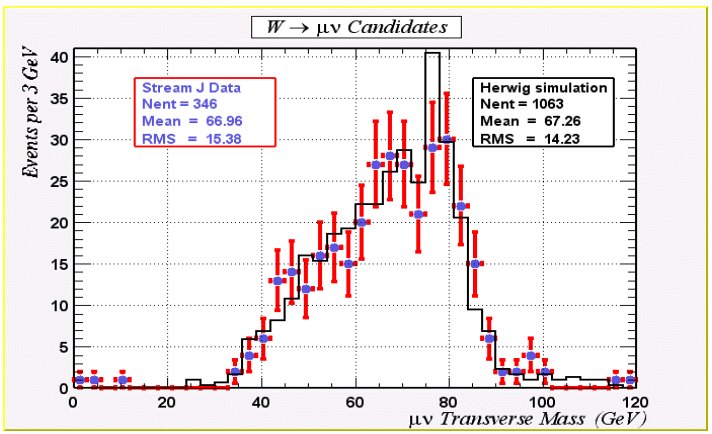


More Muon Data

- W -> μ ν transverse mass



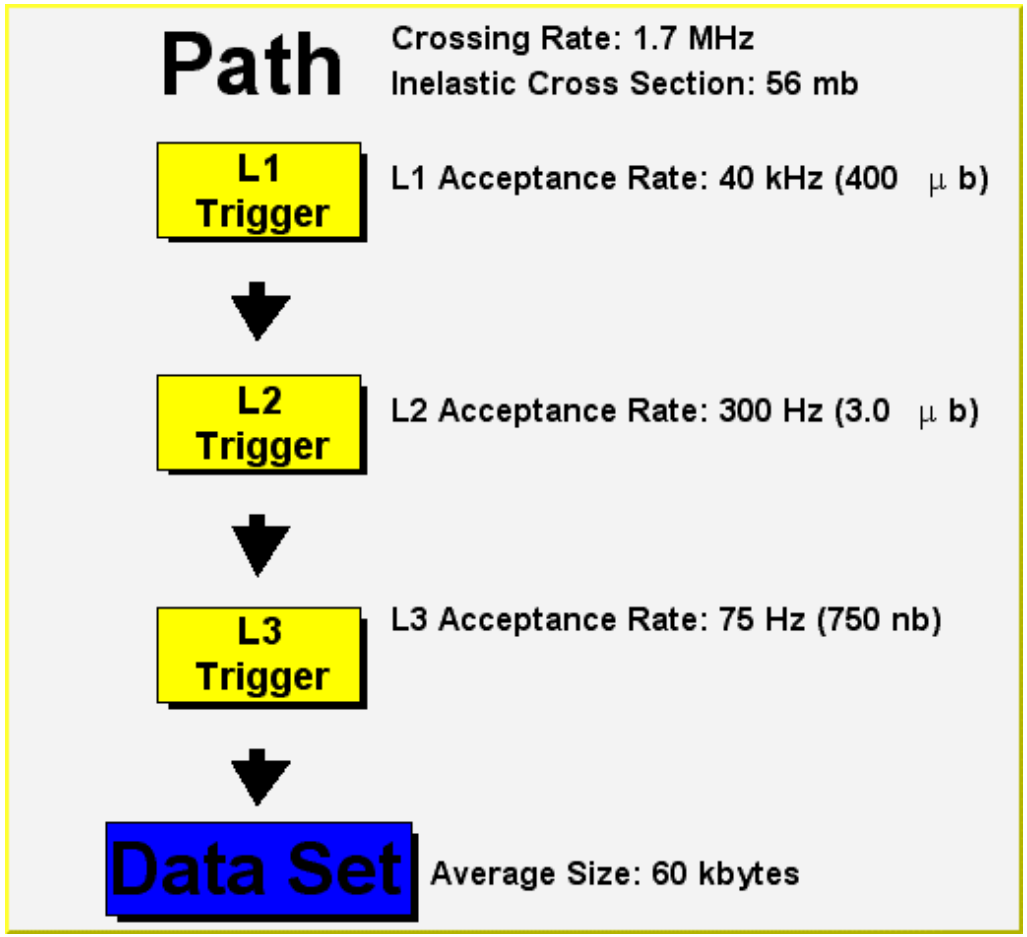




Trigger system

Three Levels:

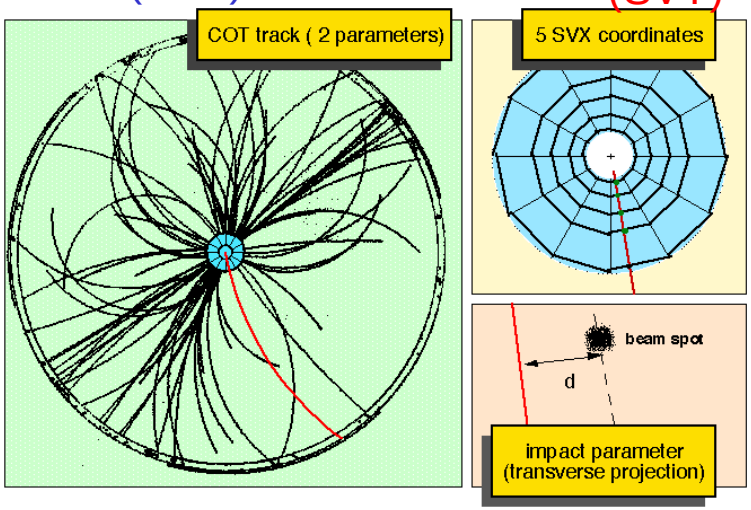
- Level 1:
  - Calorimeter:
    - Object triggers : threshold applied to individual towers(single tower);
    - Global triggers : threshold appliedafter summing energies from all towers (eg SumET).
  - eXtremly Fast Tracker (P_T>1.5 GeV)
  - Muons
- Level 2:
  - Calorimeter clustering:
  - Silicon Vertex Tracker
- Level 3: offline-like reconstruction



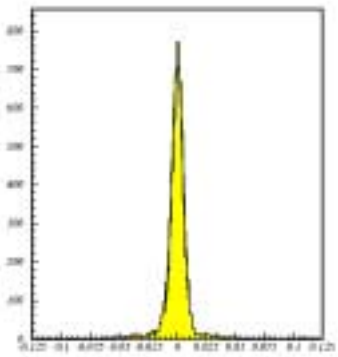
XFT and SVT trigger status

COT defines track momentum cut at level 1 (XFT)

SVX measures impact parameter cut at level 2 (SVT)



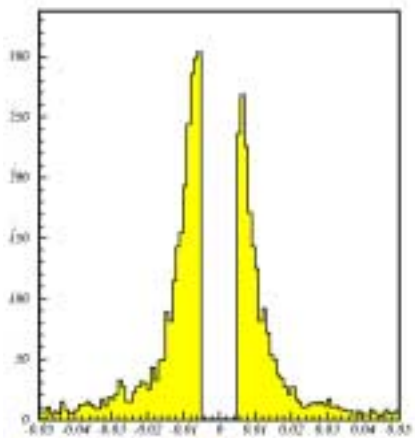
SVT impact parameter
σ= 48 μm
including beam spot spread



d_o (cm)

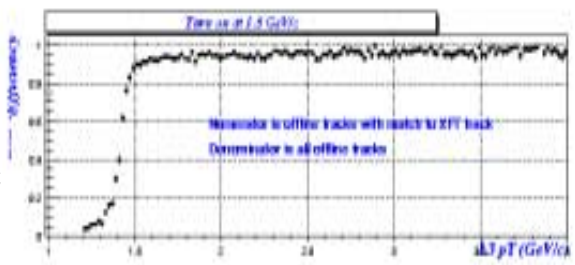
SVT impact parameter cut at 50 μm

two-track SVT trigger



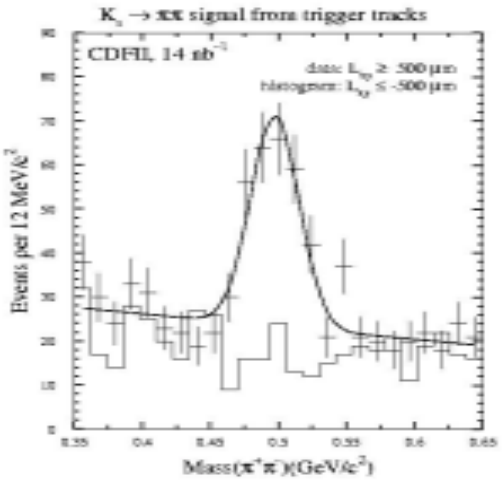
d_o (cm)

XFT cut at P_T = 1.5 GeV/c

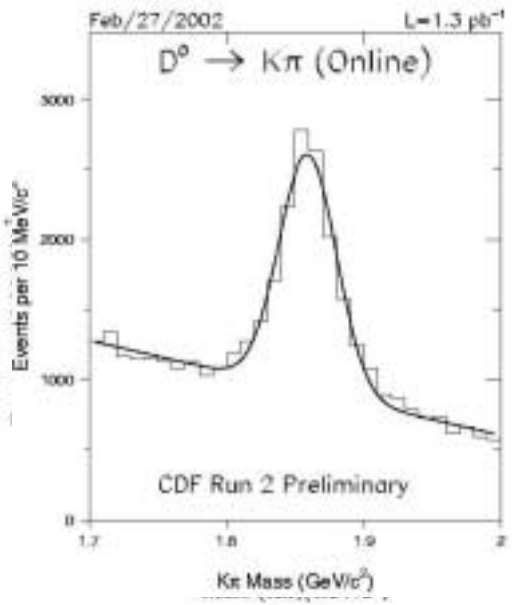


SVT data

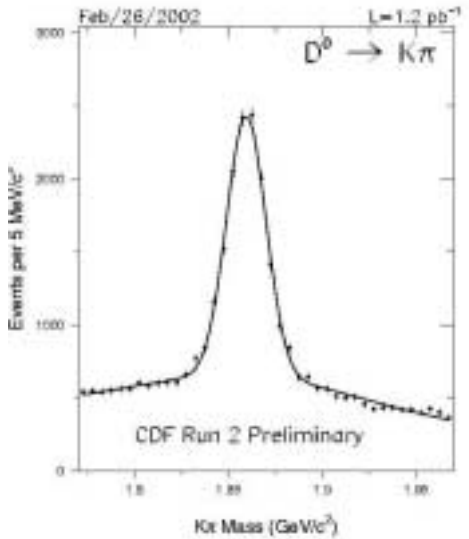
$K_S \rightarrow \pi\pi$



The invariant mass is formed using hybrid tracks (SVT/COT)



D0 -> K π



Reconstructed offline

The D0->Kπ events are reconstructed since the first CDF runs where the L2 SVT trigger was actively selecting events (October 2001).

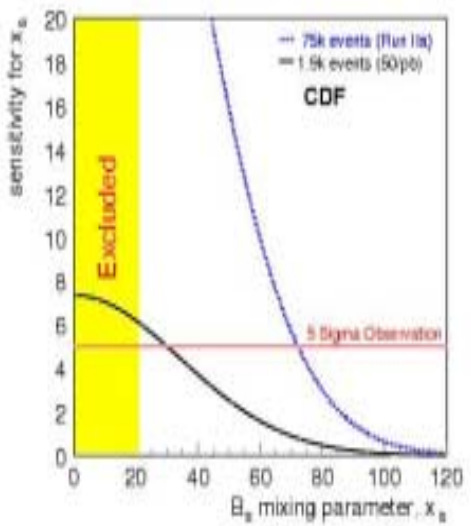
What next?

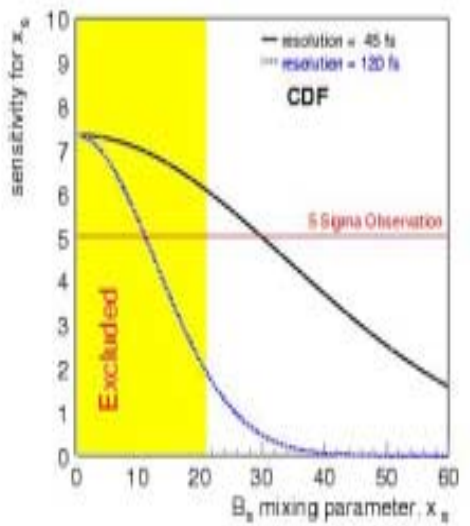
- B-physics
  - very competitive, already with low statistics
    - semileptonic yields
    - semileptonic lifetimes (especially B baryons with 100-200 pb^{-1})
    - production cross sections
    - charm physics ($8D^0$/nb from the 2Track Trigger!)
    - J/ψ physics
    - hadronic modes
- High Pt and exotica
  - Top physics (run IIa)
  - The Higgs quest (need run IIb)
  - SUSY ? (the run I anomalies...)

Beauty and charm at CDF II

The trigger allows to reconstruct hadronic decays of B_s. In hadronic decays it is possible to fully reconstruct the B meson, contrary to semileptonic decays where the ν is not reconstructed.

Even in the semileptonic decay there is already a factor 2 gain in acceptance (ex, $B \rightarrow eD^0$ using lepton + SVT trigger gives ~45 evts/pb)





$N(B_s)$ = 75k, 1.9k
εD^2 = 11.3%
σ_t = 45 fs, 120 fs
S/B = 1 : 2 – 2 : 1

Reach varies between 11 - 30

B_s mixing hadronic for 50pb^{-1}

Beauty and charm at CDF II (cont'd)

Inclusive Charm

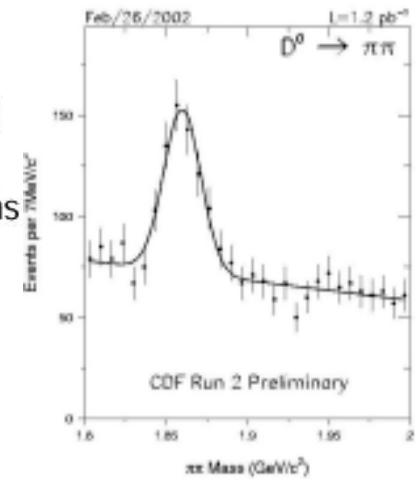
Just 1 pb^{-1} should be enough to do a measurement of charm mesons production in several channels

- The TTT yields about 8 D^0/nb
- Adding several assumptions coming from MC/Data estimates (all expressed in thousands of events!):

	D^0	$D^\pm$	$D^{*\pm}(2010)$	$D^{*0}(2007)$
B	240	160	65	110
Prompt	160	40	53	80

Half a million D^0 !!! (50 pb^{-1})

- And that's only $D^0 \to K\pi$
- We can do plenty of things:
  - Cross section measurements
  - $c\bar{c}/b\bar{b}$ yield in hadron collisions
  - Cabibbo suppressed decays:
    - ≈150 $D^0 \to K^+\pi^-$
  - 44400 $D^0 \to K^+K^-$
  - 15900 $D^0 \to \pi^+\pi^-$
  - $c\bar{c}$ mixing?

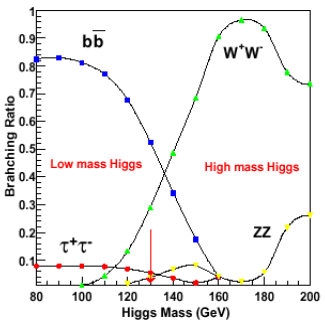


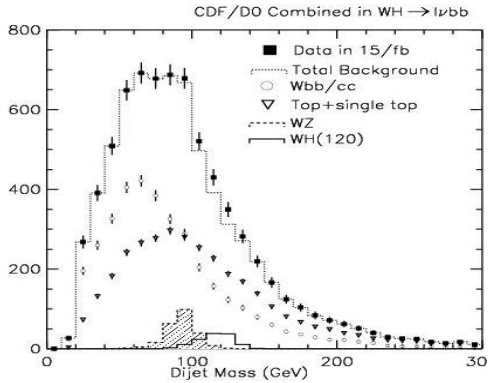
Top physics at CDF II

- For top physics an extra 30-35% in cross section is gained (1.8 to 2TeV). We also gain from acceptance/efficiency
  - 100pb^{-1} in Run II is equivalent to 150-300pb^{-1} in run I - *good*
  - need about 1 year to understand b-tagging and associated background -less good …
  - Top mass and W mass measurements will be done on a scale longer than 1 year from now.
- The dilepton decay mode will be the first to be looked at:
  - moderate excess of events in run I especially at large MET (check anomalies)
  - there will be 2 parallel paths:
    - cuts similar to run I " discovery" analysis for winter 2003
    - optimization for 2fb^{-1} (blind analysis??)

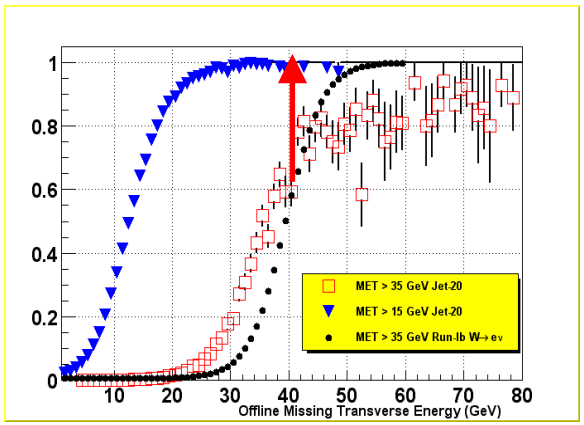
The quest for Higgs at run II

- Higgs production and decay
  - $gg \rightarrow H$ dominates over all mass ranges, but huge QCD backgrounds.
  - $M_H < 130$ GeV/c^2 "Low mass Higgs".
    - $H \rightarrow bb$ with Associated production mode is the most promising. The double b-tagging together with the signature of the additional boson helps to discriminate from the background.



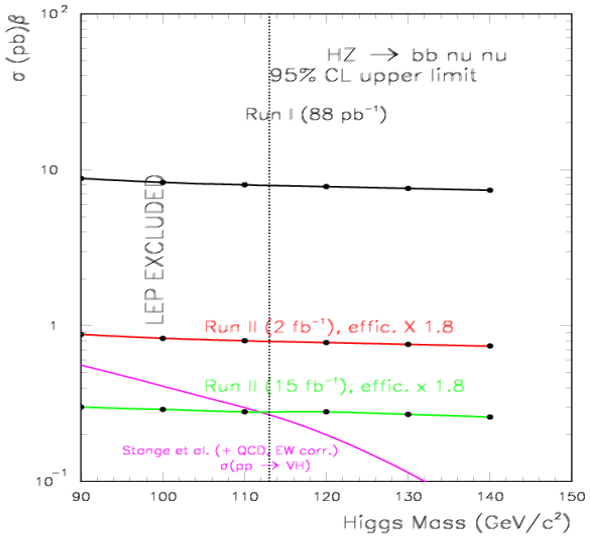


- Trigger strategies
  - SVT to select a sample enriched in heavy flavors
  - qqbb, MET + bb



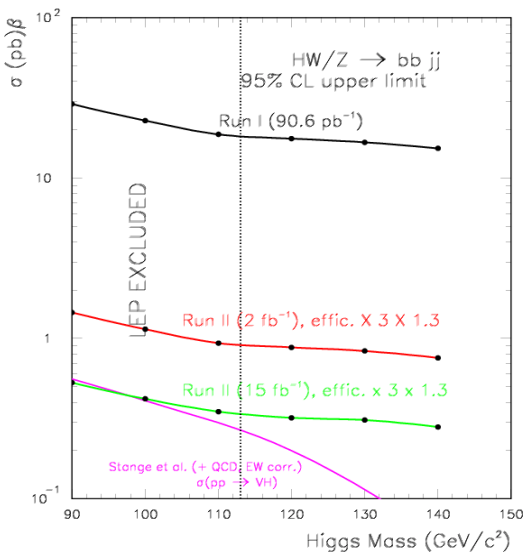
With MET>15 the Turn-on plateau is reach for $MET^{offline}$ >30 GeV For cuts $MET^{offline}$>40 an efficiency increase of **1.4** can be reached in respect to run I.

Run II extrapolations



MET + bb:
In respect to run I, factor 1.4 (turn-on) x 1.3.
(improved geometrical acceptance)

Multijets:
in respect to runI factor 3
(double b-tag efficiency)x1.3.

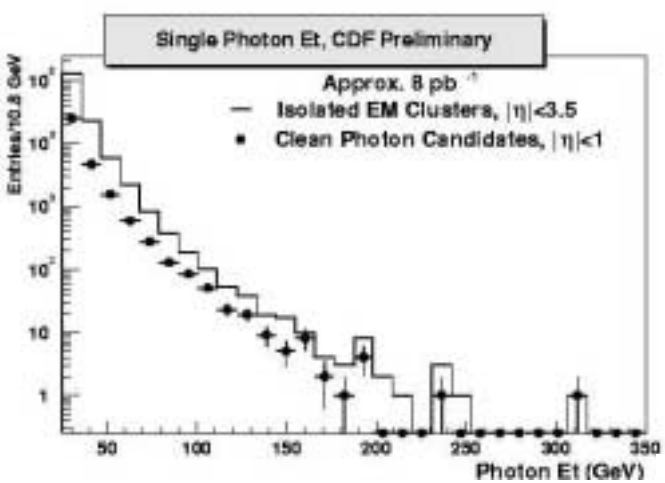


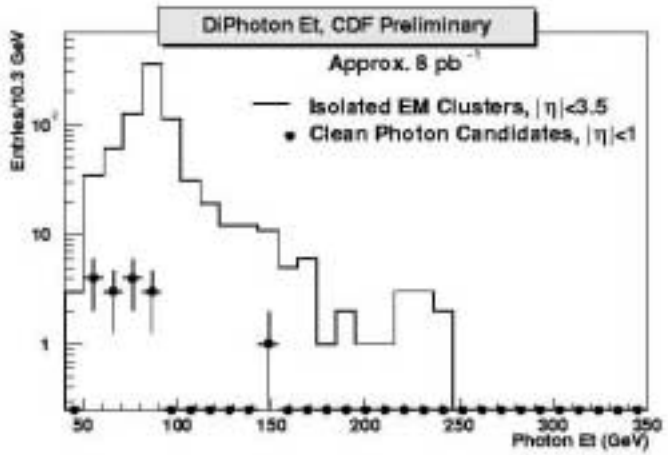
- Assuming the same Signal to Background ratio as in RUN-I, the cross section limit at 95 % confidence level has been scaled as

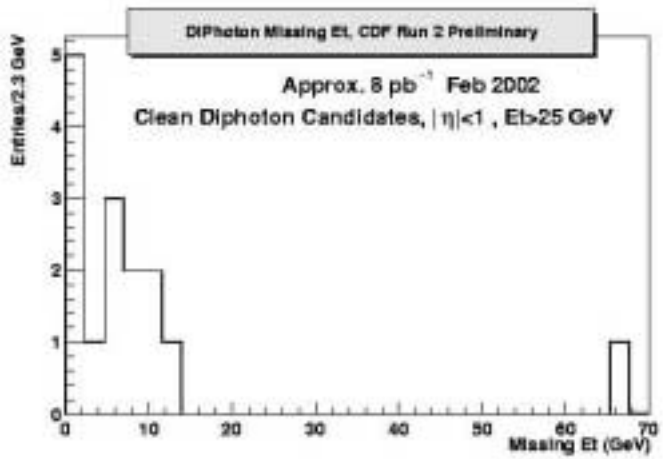
$$Eff_{RI} / Eff_{RII} \times \sqrt{(L_{R\text{-}I} / L_{R\text{-}I})}$$

Follow up on run I anomalies

Photons







Event at high Et appears to be a simple diphoton event with a jet pointing at a crack, causing the met.
There are no electrons or muons in the event :-(

Plans and Conclusions

- First ~ 200 pb^{-1} by end of 2002
  - Establish ba~~sic~~ physics program, understand detector performance
  - B_s mixing; B CP violation studies; CKM matrix elements
  - First stage of new physics searches (follow up Run 1 anomalies)

- Increase integrated luminosity to > 2 fb^{-1} by 2004
  - Precision studies of top and W physics
  - Stringent tests of the SM and interesting indirect M_{Higgs} constraints
  - Precision B physics program
  - Searches for SUSY and other new physics

- Proceed to highest attainable luminosity > 15 fb^{-1} by 2007+
  - Push high precision B, W and top studies to the limit
  - Follow up previous discoveries or hints
  - Complete search for low mass Higgs