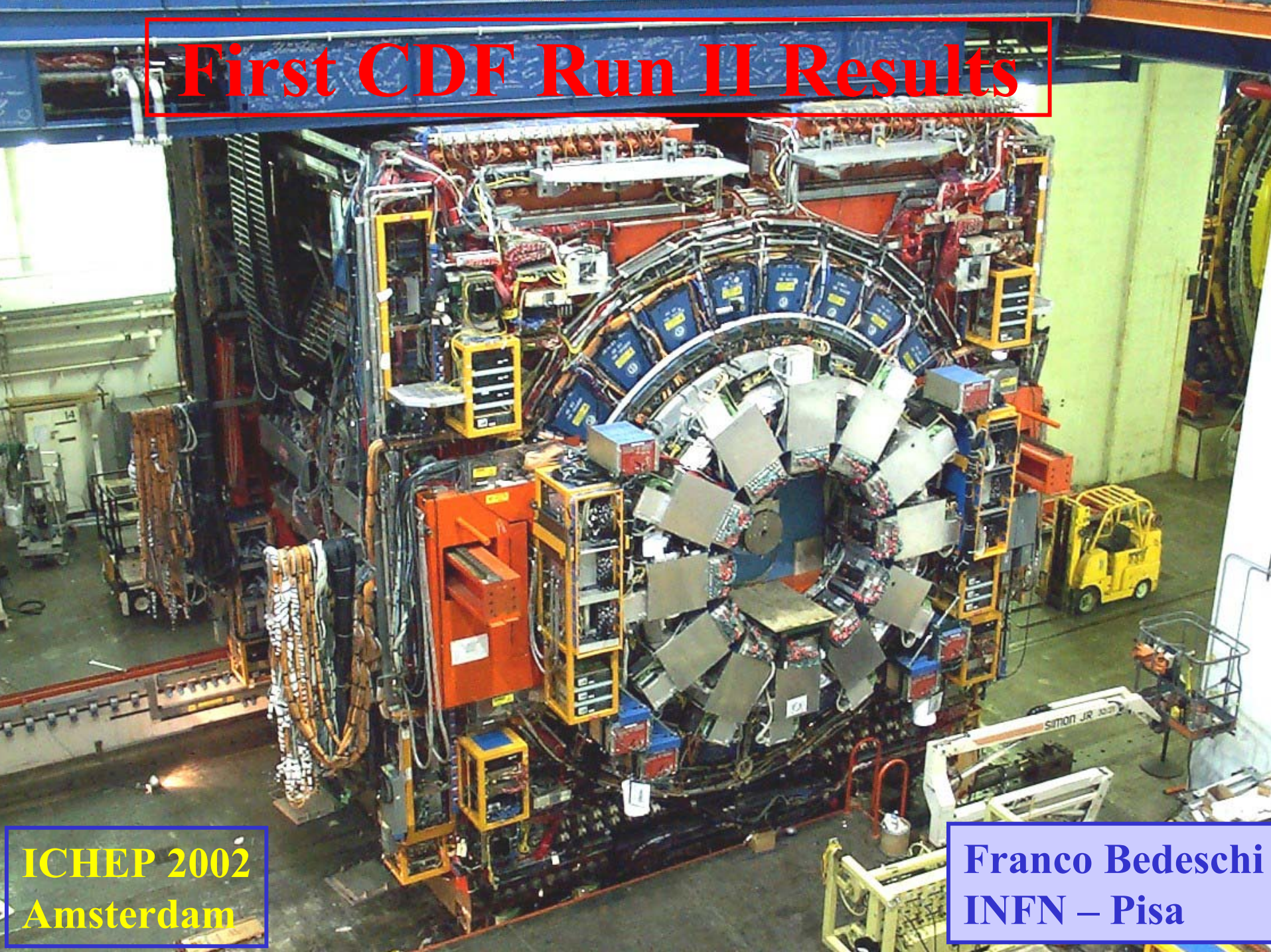
First CDF Run II Results

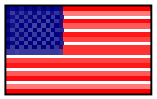


ICHEP 2002
Amsterdam

Franco Bedeschi
INFN – Pisa

The CDF Collaboration

North America



3 Natl. Labs
28 Universities

1 Universities

Europe

1 Research Lab
6 Universities

1 University

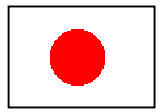
4 Universities

2 Research Labs

1 University

1 University

Asia



5 Universities
1 Research Lab

1 University

3 Universities

Totals

12 countries

58 institutions

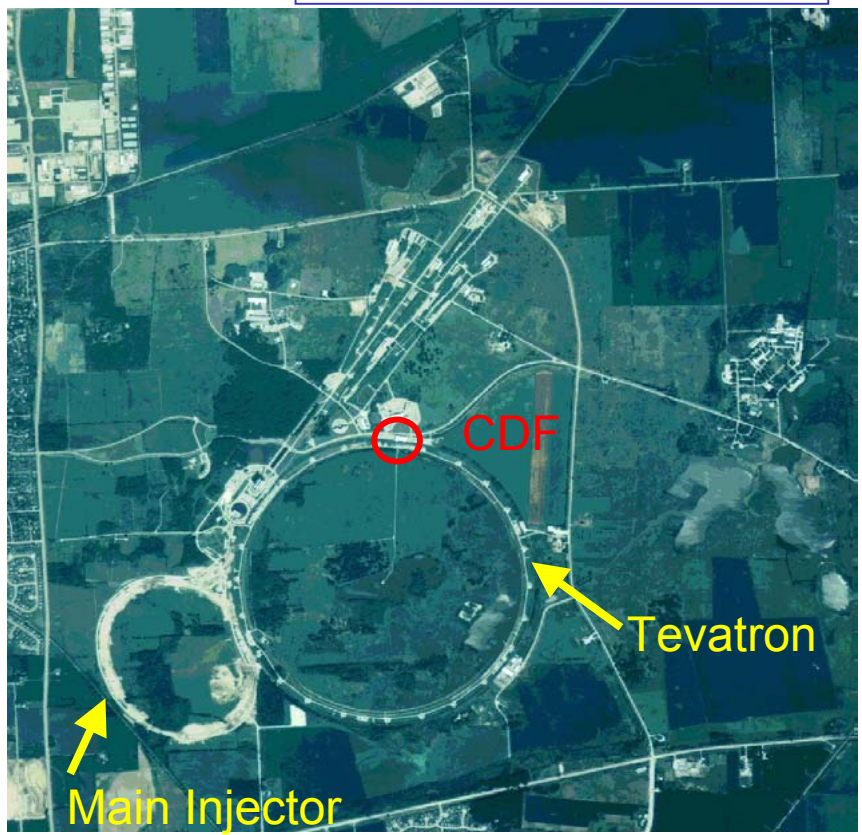
581 physicists

First CDF Run II Results

Outline

Franco Bedeschi
CDF Collaboration
INFN - Pisa

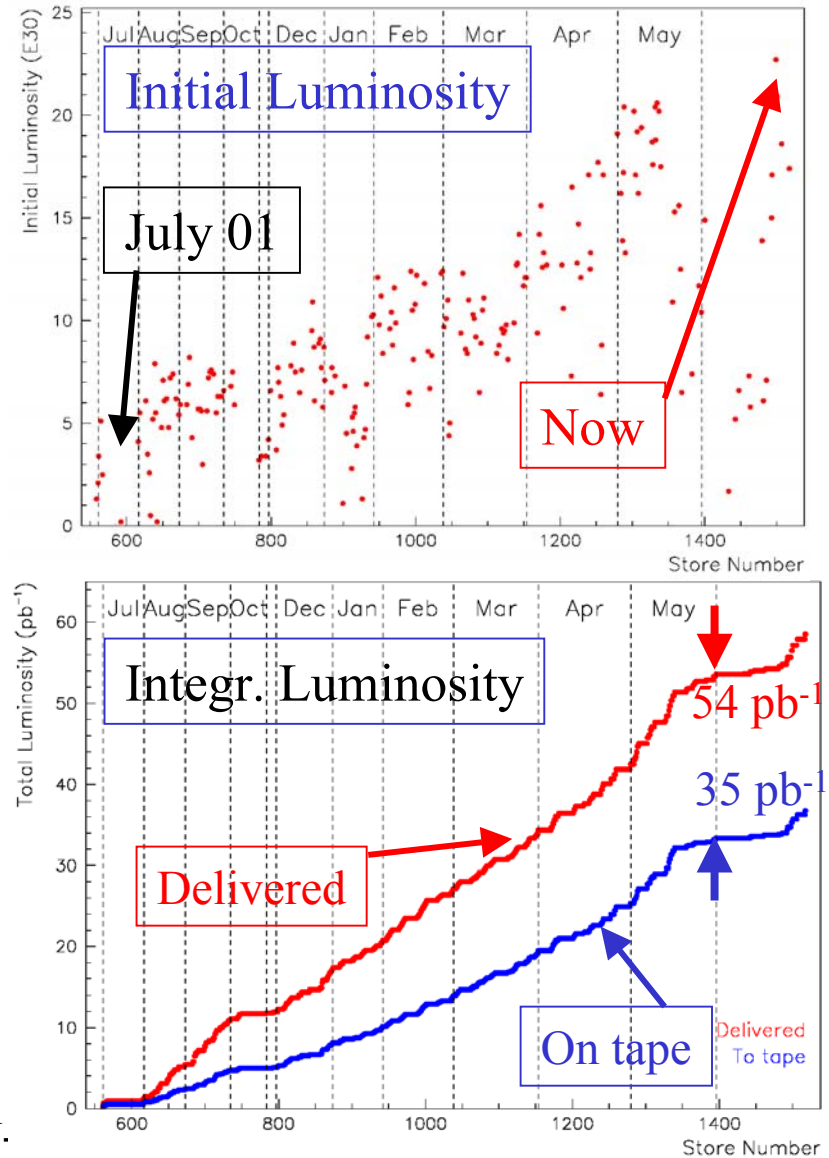
- Status of the Tevatron
- Status of the CDF detector
- First results with Run II data
- Outlook and conclusions



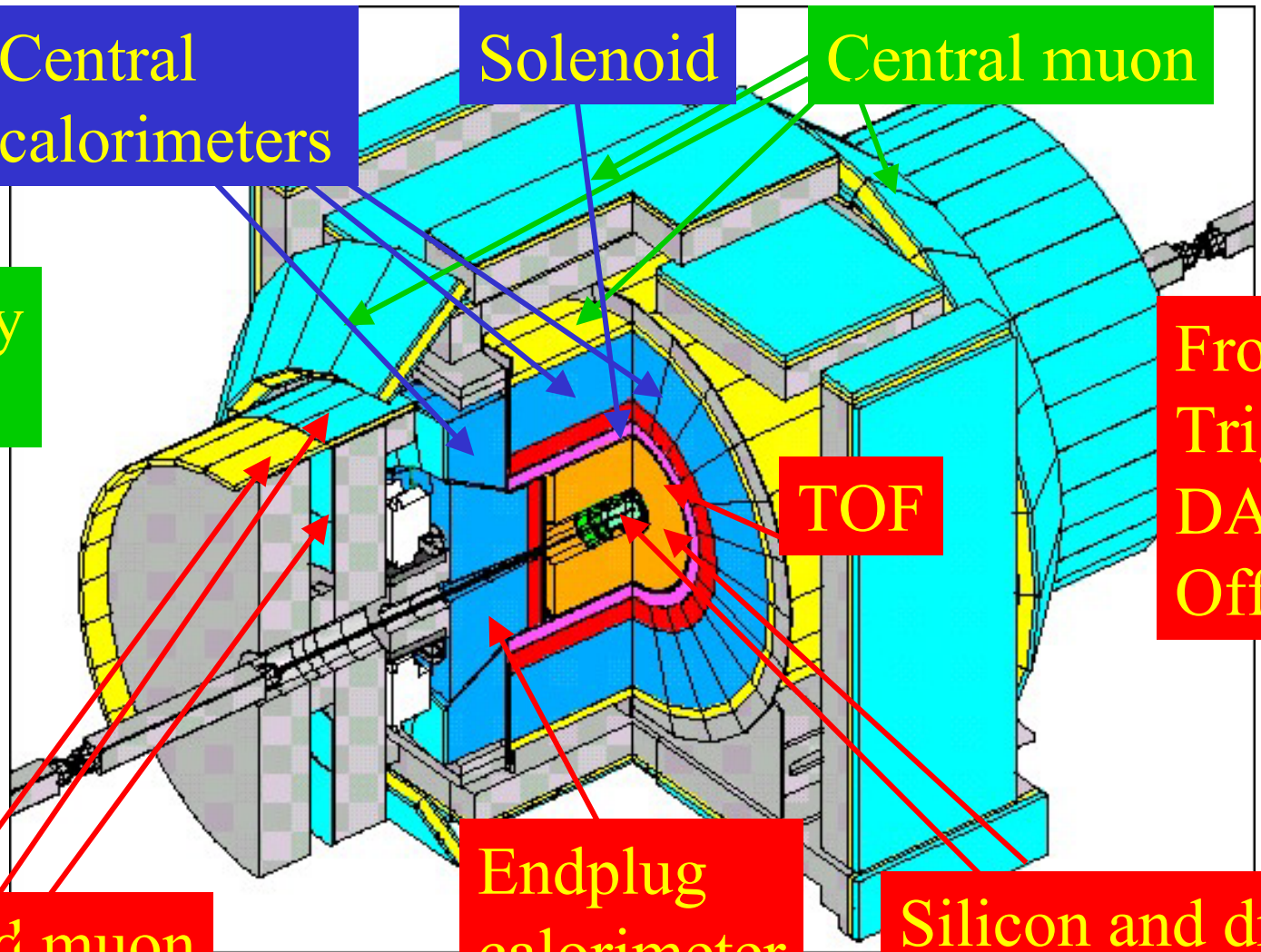
Tevatron status

- Tevatron operations started in March 2001
  - Luminosity goals for run 2a:
    - 5-8x10^{31} $cm^{-2}sec^{-1}$ w/o Recycler
    - 2x10^{32} $cm^{-2}sec^{-1}$ with Recycler
  - Achieved:
    - 2.2x10^{31} $cm^{-2}sec^{-1}$ in July '02
    - Now recovered from June shutdown to improve p-bar cooling
    - 54 pb^{-1} delivered until early June
      - 35 pb^{-1} are on tape
      - 10 – 20 pb^{-1} used for analyses shown at this conference (details)

plans



The Upgraded CDF Detector

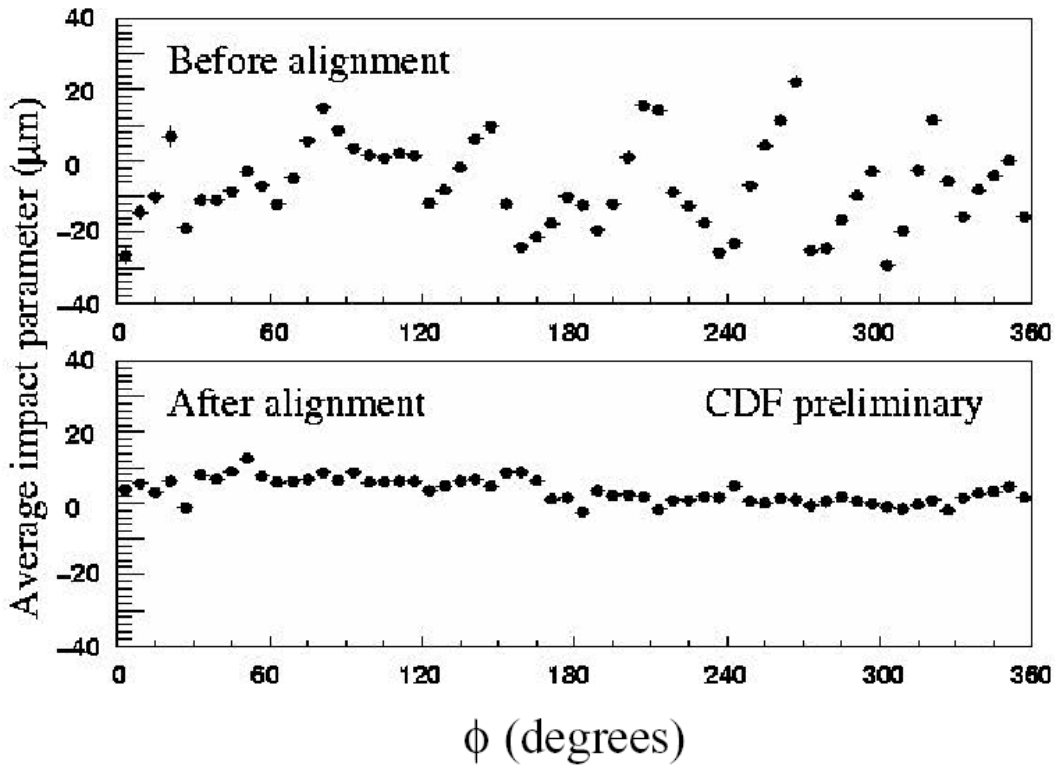


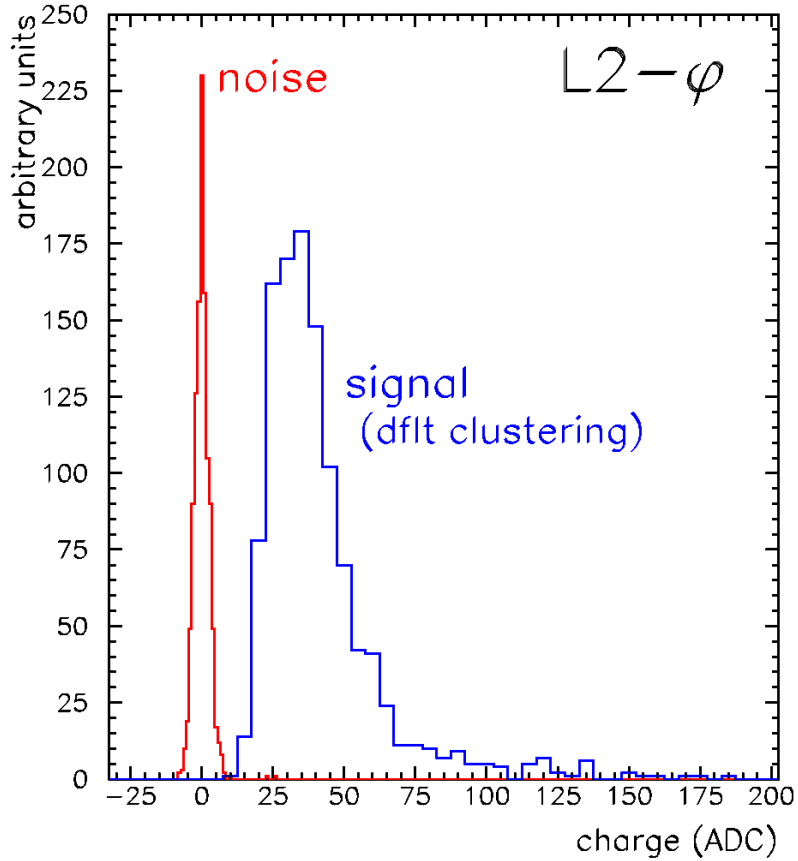
The Upgraded CDF Detector

- Major qualitative improvements over Run 1 detector:
  - Whole detector can run up to 132 nsec interbunch
  - New full coverage 7-8 layer 3-D Si-tracking up to $|\eta| \sim 2$
  - New faster drift chamber with 96 layers
  - New TOF system
  - New plug calorimeter } Forward region restructured
  - New forward muon system
  - New track trigger at Level 1 (XFT)
  - New impact parameter trigger at Level 2 (SVT)
- **All systems working well**
  - Silicon and L2 took longer to commission

Detector Performance

- Silicon detectors:
  - Typical S/N ~12
  - Alignment in R-ϕ good
    - R-z ongoing



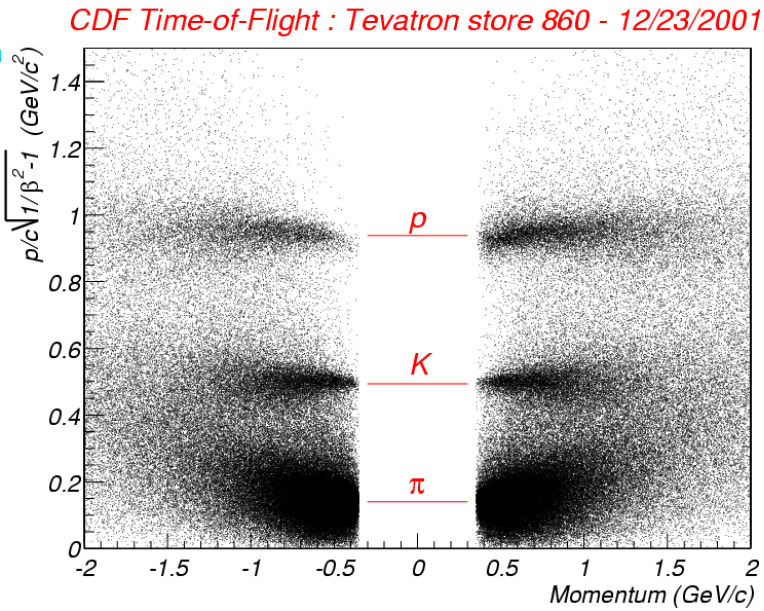


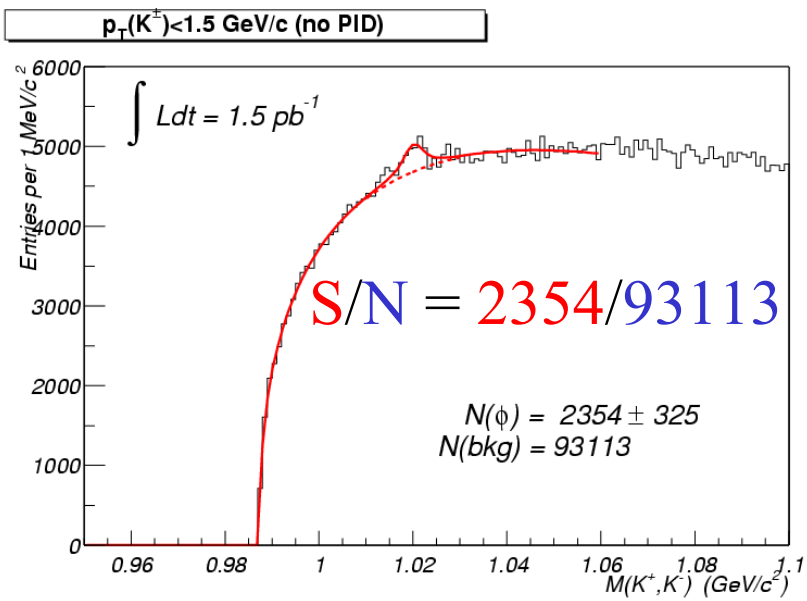
sa

Details

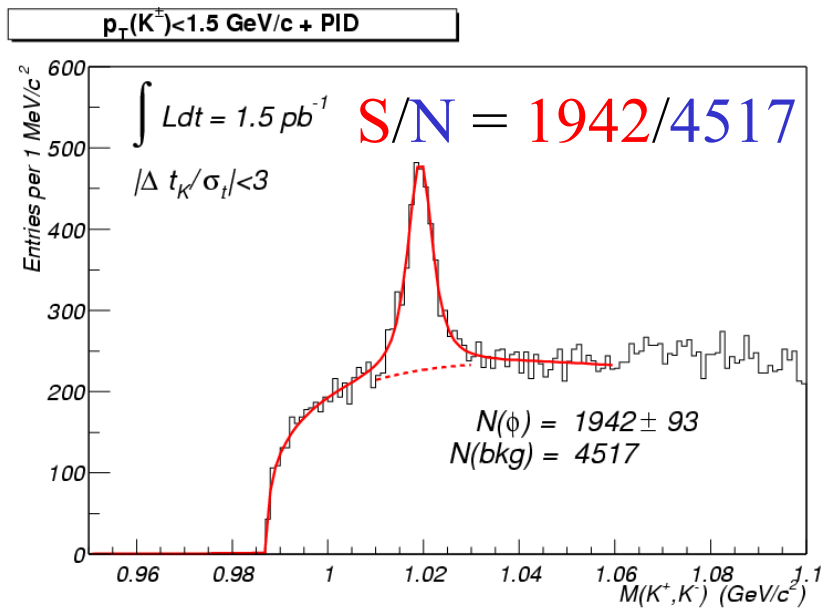
Detector Performance

- TOF resolution within 10 –20% of design value
  - Improving calibrations and corrections

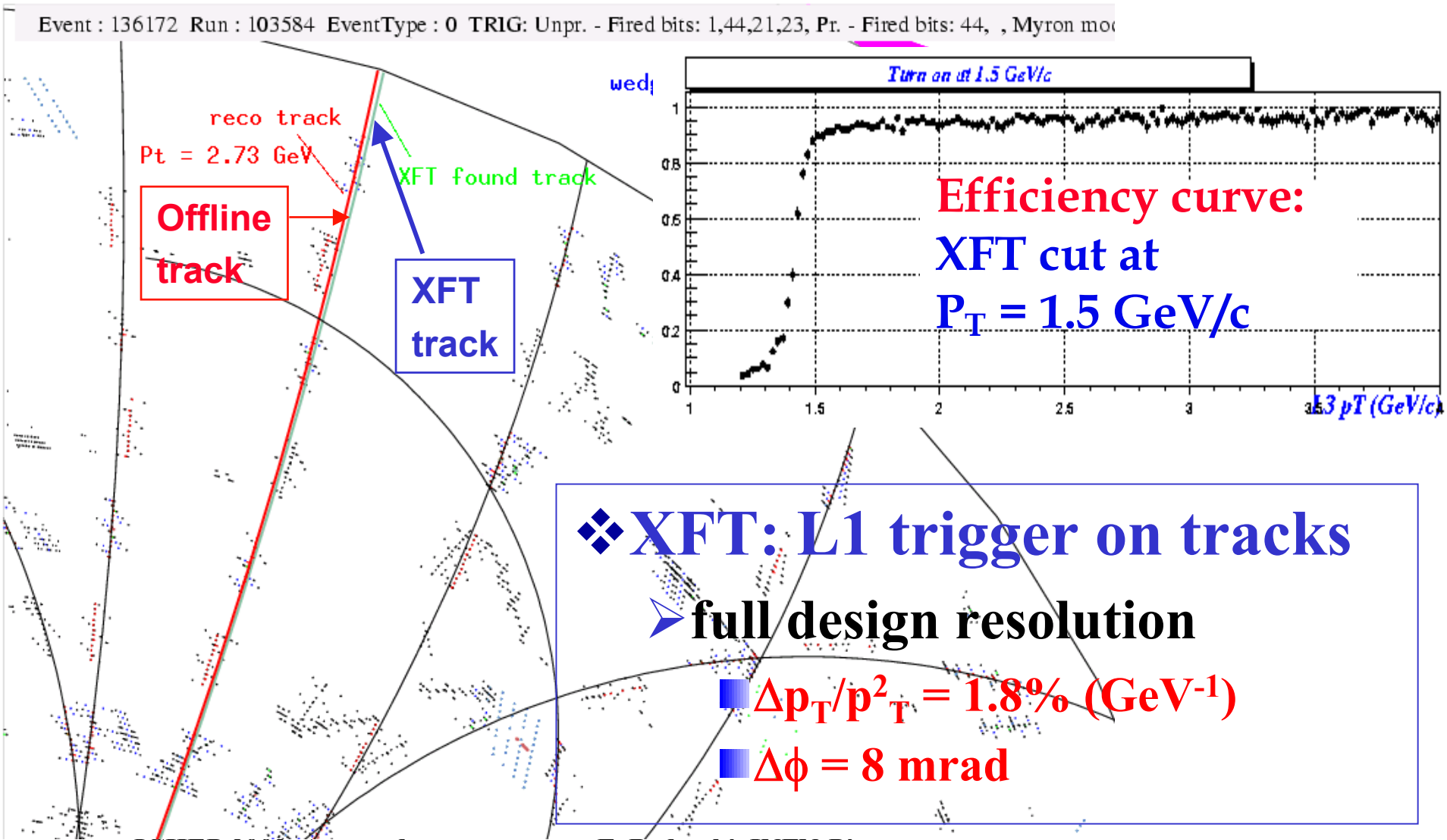




TOF



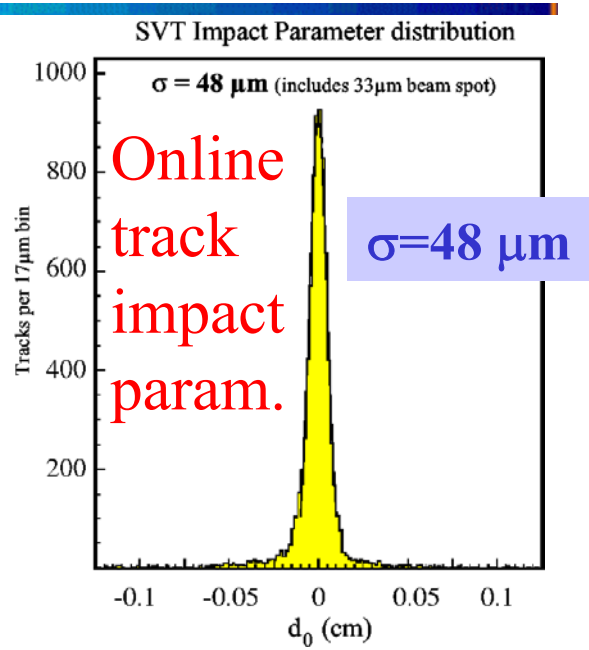
Detector Performance



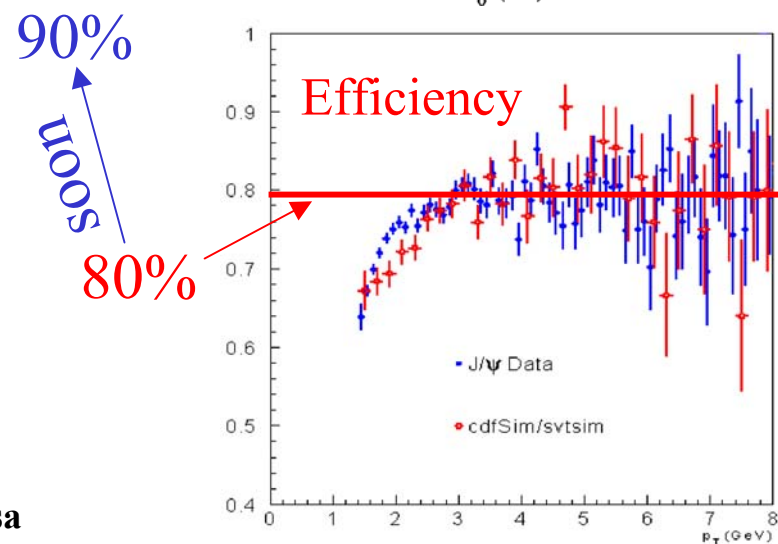
- **XFT: L1 trigger on tracks**
  - **full design resolution**
    - $\Delta p_T/p^2_T = 1.8\%$ (GeV^{-1})
    - $\Delta\phi = 8$ mrad

Detector Performance

8 VME crates
Find tracks in Si in 20 μs with offline accuracy



- **S**econdary **V**er**T**ex L2 trigger
  - Online fit of primary Vtx
  - Beam tilt aligned
  - D resolution as planned
    - 48 μm (**33 μm** beam spot transverse size)

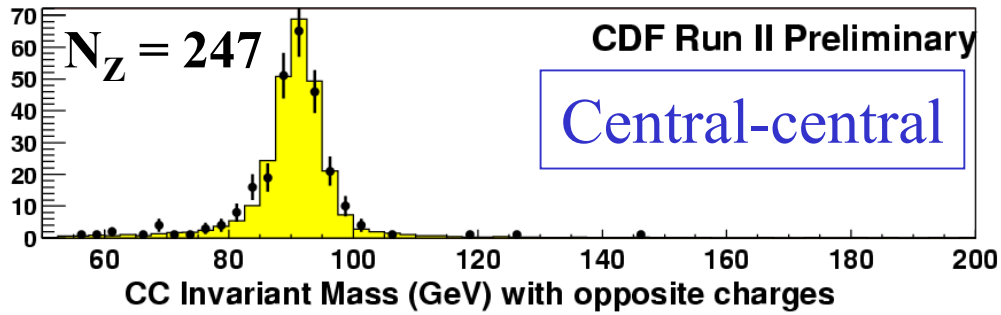


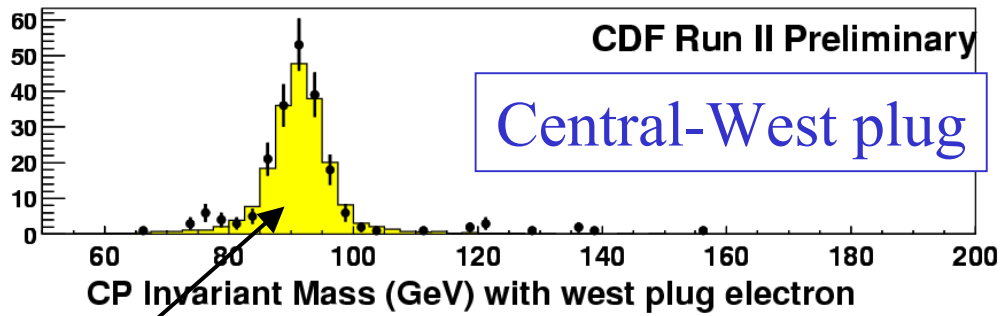
Physics with CDF-II

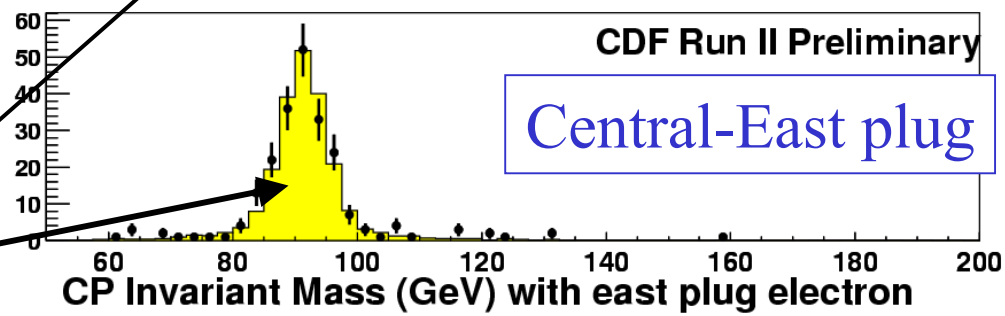
- Use data to understand the new detector:
  - energy scales in calorimeter and tracking systems
  - detector calibrations and resolutions
  - tune Monte Carlo to data
- Use data to do **physics analyses**
  - Real measurement beyond PR plots
  - Quality of standard signatures
  - Rates of basic physics signals
  - **Surprisingly some results are already of relevance in spite of the limited statistics**
    - **Several CDF presentations made in the parallel sessions** list
    - **In the following brief/incomplete summary of a lot of work**

EM Calorimeter scale

- **638 Z → e^+e^-** in 10 pb^{-1}
  - $\sigma(M) \sim 4$ GeV FB asymmetry
- Check **Z mass** in data and simulation after corrections
  - Central region:
    - Mean: +1.2% data, -0.6% sim.
    - Resolution: +2% simulation
  - Forward region (Plug):
    - Mean: +10/6.6% data, +2.0% simulation
    - Resolution: +4% simulation





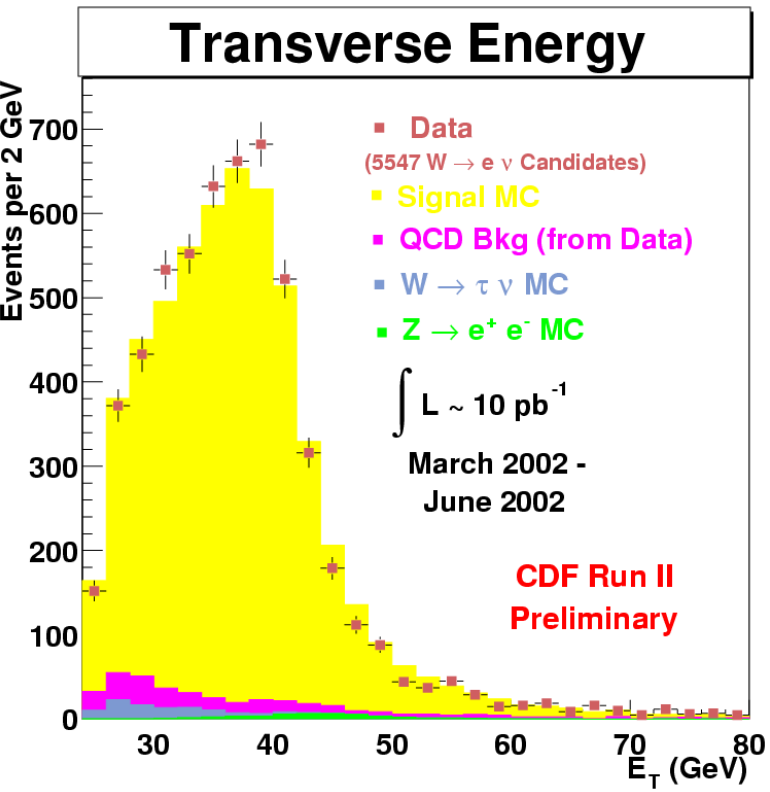


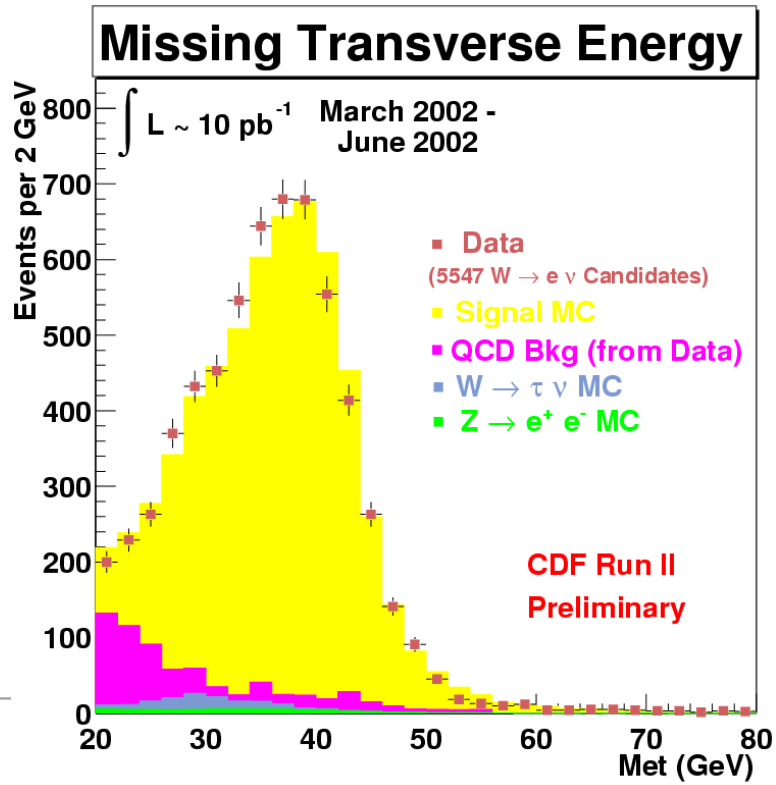
N_Z (W+E) = 391

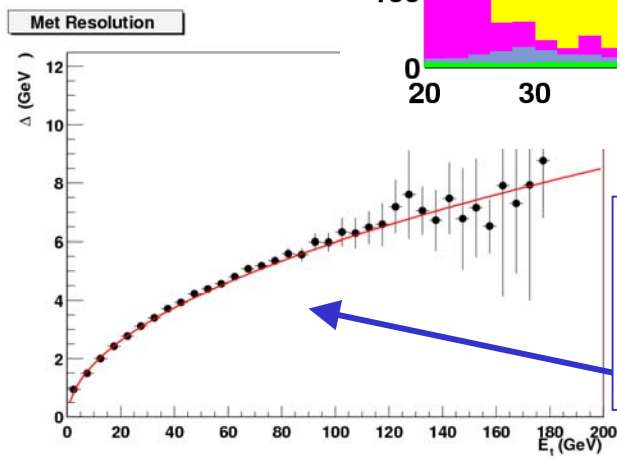
Measurements with high Et $e^{\pm}$

- Good modeling of observed **W→ eν** distributions

Selection details







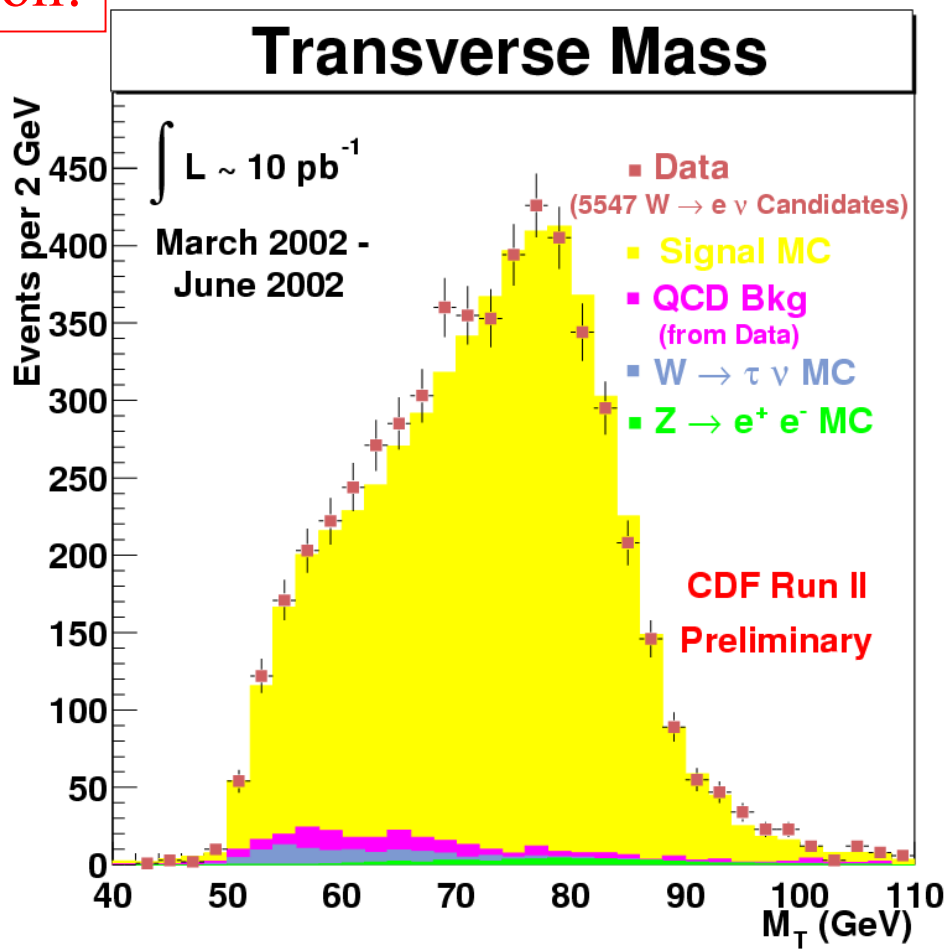
MET resolution from MB data consistent with Run 1

MET detail

Measurements with high Et $e^{\pm}$

- W cross section:
  - σ_W*BR(W→eν) (nb) = $2.60 \pm 0.07_{stat} \pm 0.11_{syst} \pm 0.26_{lum}$
  - Consistent with Run 1 results rescaled for higher energy: $2.72 \pm 0.02_{stat} \pm 0.08_{syst} \pm 0.09_{lum}$ (use Sterling et al. NNLO predictions)

0.16 soon!



Nr. Candidates:

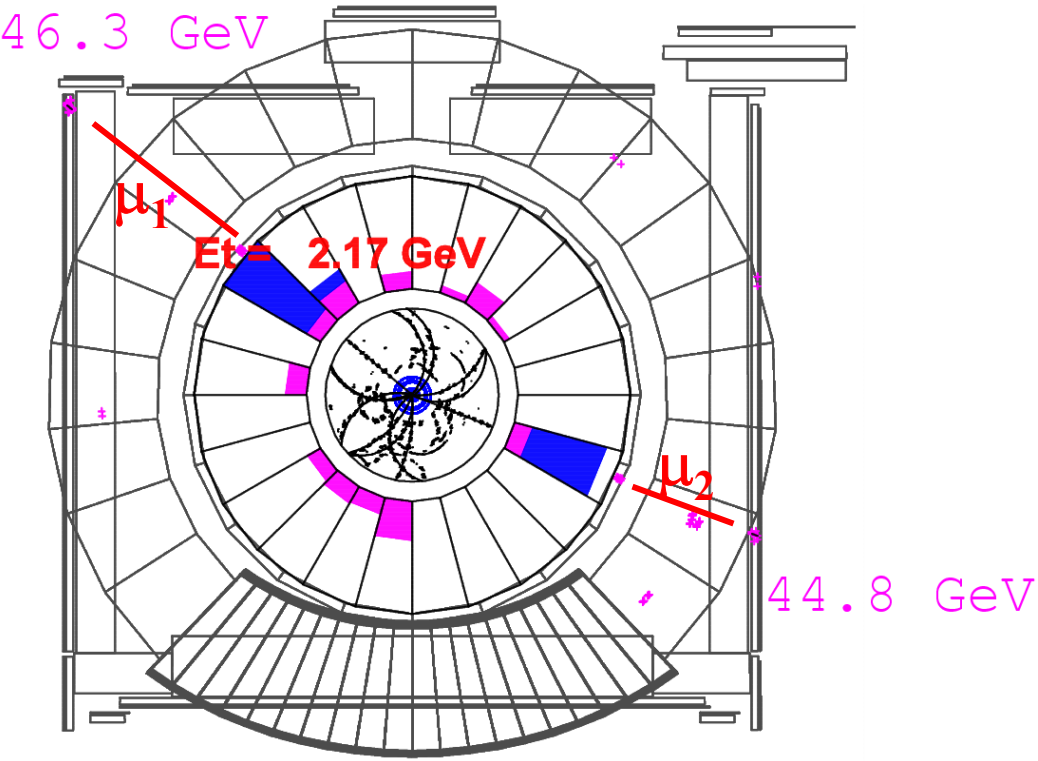
- **5547 in 10 pb^{-1}**

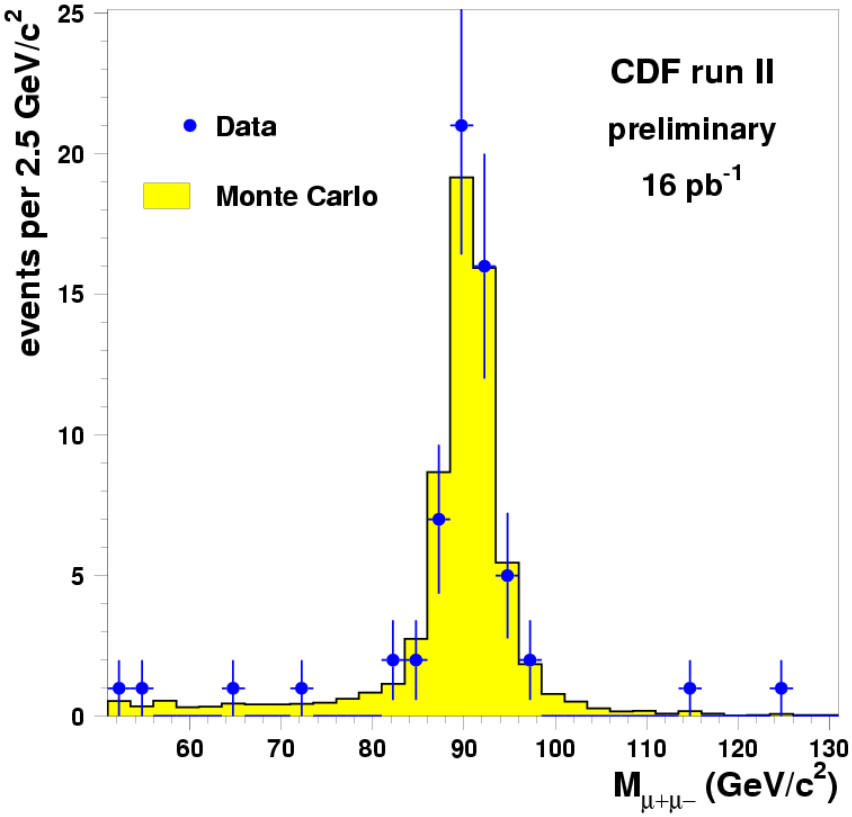
Background:

- **QCD:** 260 ± 34 ± 78
- **Z→ee:** 54 ± 2 ± 3
- **W→τν:** 95 ± 6 ± 1

Measurements with high Et $\mu^{\pm}$

- Clear evidence of $Z \rightarrow \mu^+\mu^-$
  - Signal shown for OS muons detected in both inner and outer muon chambers



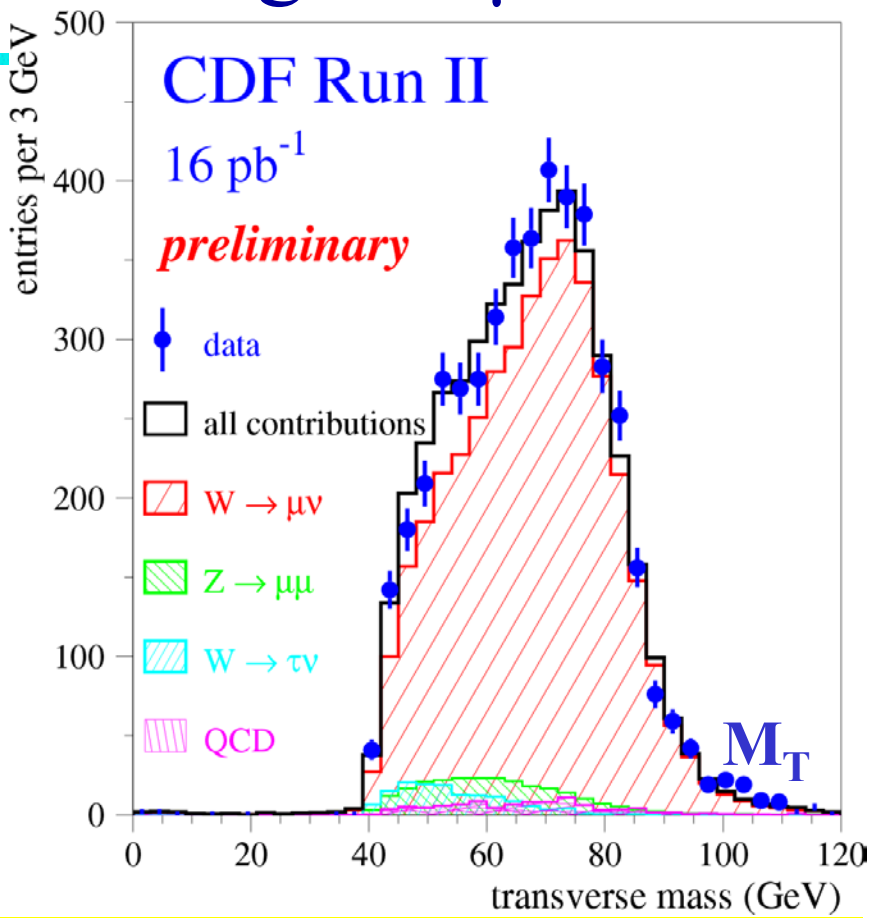


- 57 candidate events in $66<M_{inv}<116$ range
- $N_Z = 53.2 \pm 7.5 \pm 2.7$

Measurements with high Et $\mu^{\pm}$

- W cross section: Details
  - σ_W*BR(W→μν) (nb) = $2.70 \pm 0.04_{stat} \pm 0.19_{syst} \pm 0.26_{lum}$
  - Consistent with Run 1 results rescaled for higher energy: $2.41 \pm 0.08_{stat} \pm 0.15_{syst} \pm 0.16_{lum}$ (use Sterling et al. NNLO predictions)

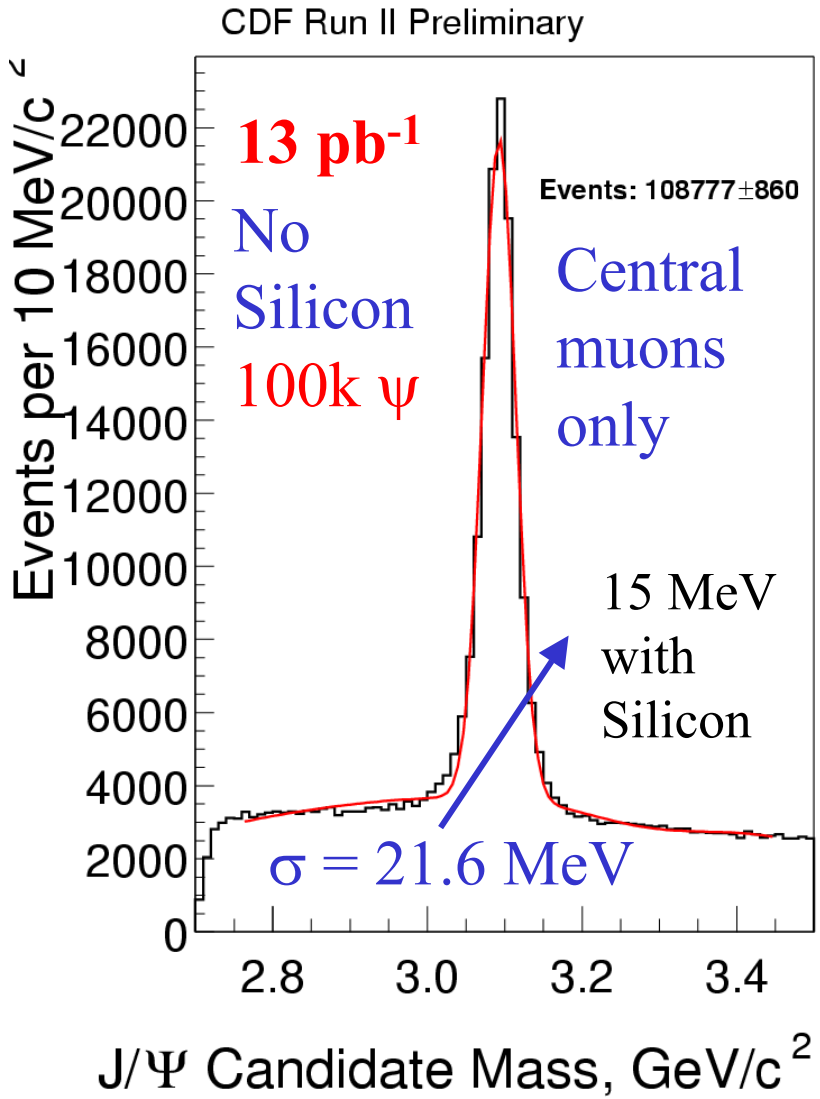
Nr. Candidates:
- 4561 in 16 pb^{-1}
Background:
- **QCD:** 104 ± 53
- **Cosmics:** 73 ± 30
- **Z →μμ:** 247 ± 13
- **W→τν:** 145 ± 10



- **R=σ(W→μν)/σ(Z→μμ) = $13.66 \pm 1.94_{stat} \pm 1.12_{syst}$**
  - Consistent with Run 1 results

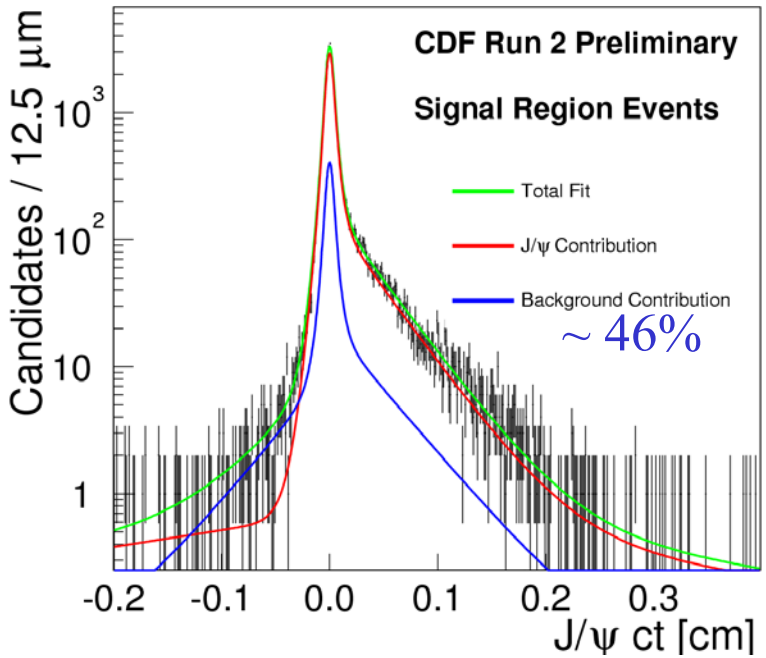
Measurements with low Et $\mu^{\pm}$

- ψ trigger improved
  - $p_T^{\mu} > 2.0 \rightarrow 1.5$ GeV
  - $\Delta\phi > 5^{\circ} \rightarrow 2.5^{\circ}$
- Observed ψ rates are consistent with expected increase due the lowering of the thresholds

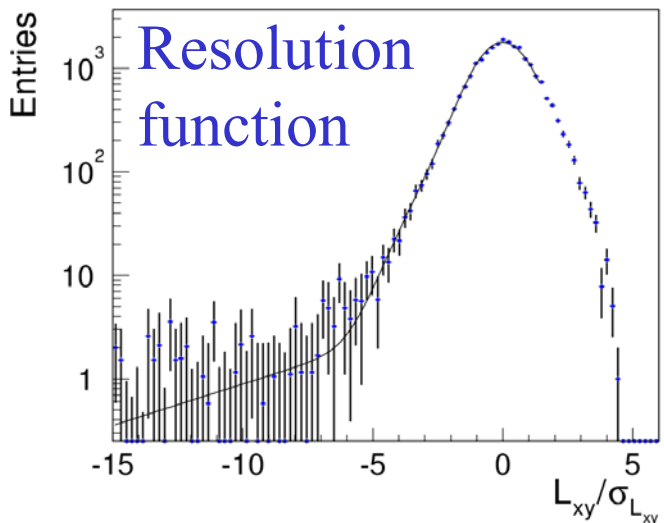


Measurements with low Et $\mu^{\pm}$

- Inclusive B lifetime with ψ's
  - Fit pseudo-$c\tau = L_{xy}^{\psi} * F_{MC} * M^{\psi}/p_T^{\psi}$ distribution
    - Output: b lifetime, fraction of ψ from B
      - $c\tau$=458±10 stat. ±11 syst. μm (PDG: 469±4 μm)
      - ψ from B = 17% ($p_T^{\psi} > 4$ GeV)

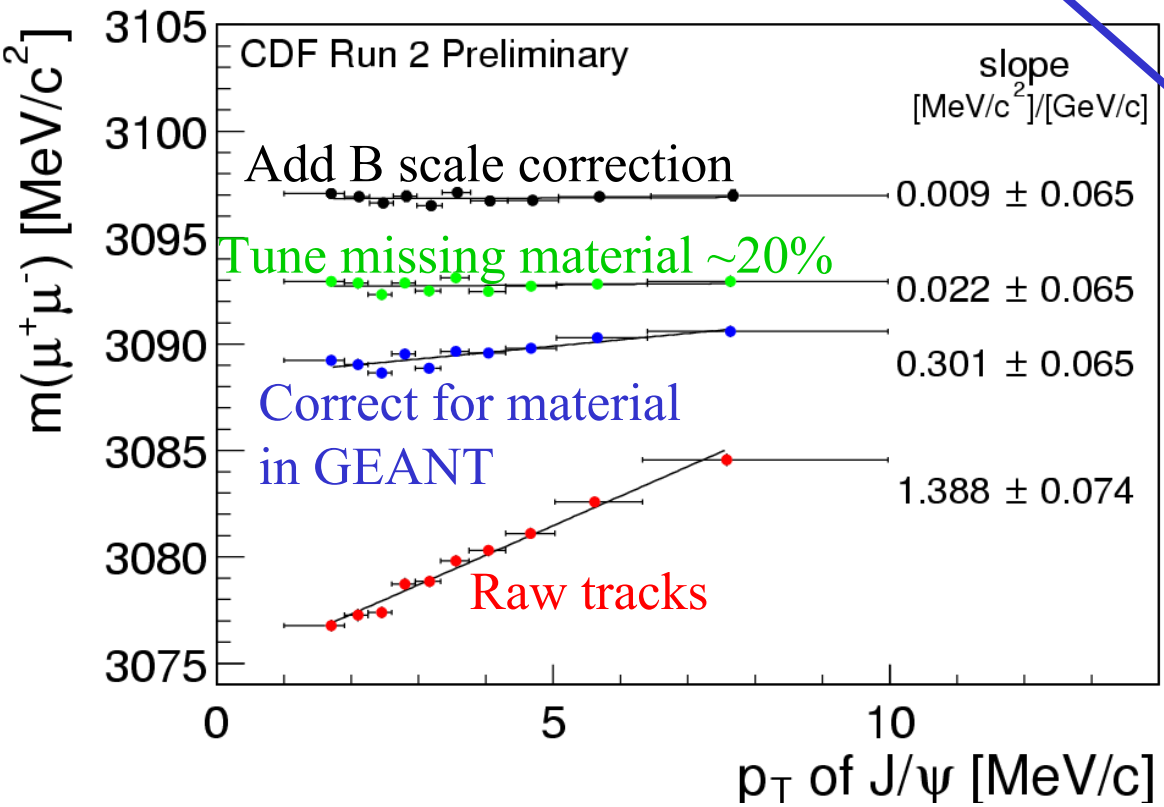


- Resolution function from large prompt component
  - R = narrow + wide Gaussian (19%) + exponential tails (1.2%)
  - Scale factor on error returned from vertex fit **1.069**

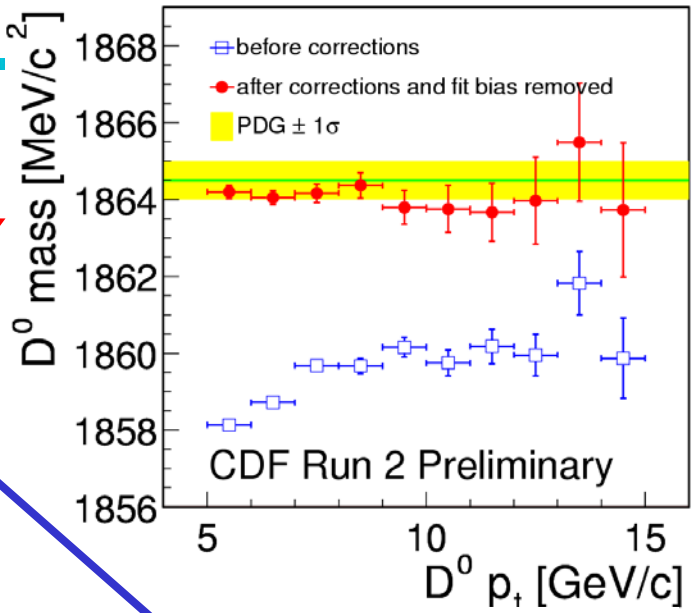


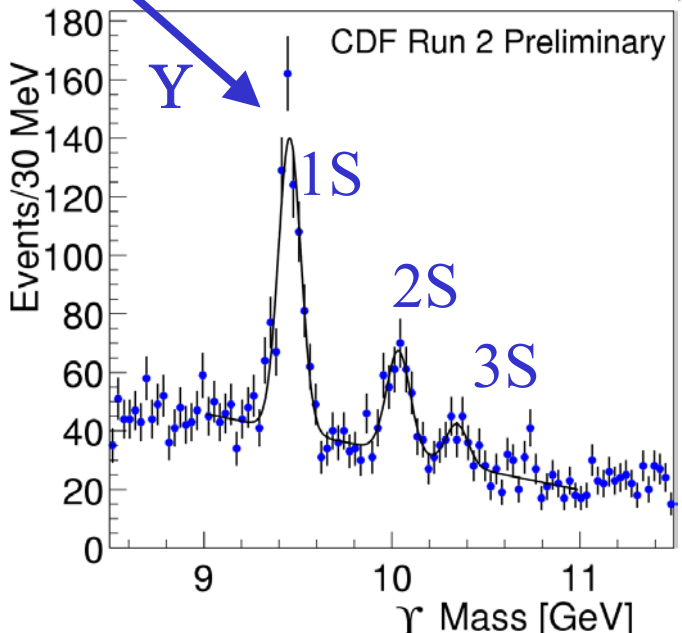
Measurements with low Et $\mu^{\pm}$

- Use ψ's to understand E-loss and B-field corrections
- Check with other known signals



D^0

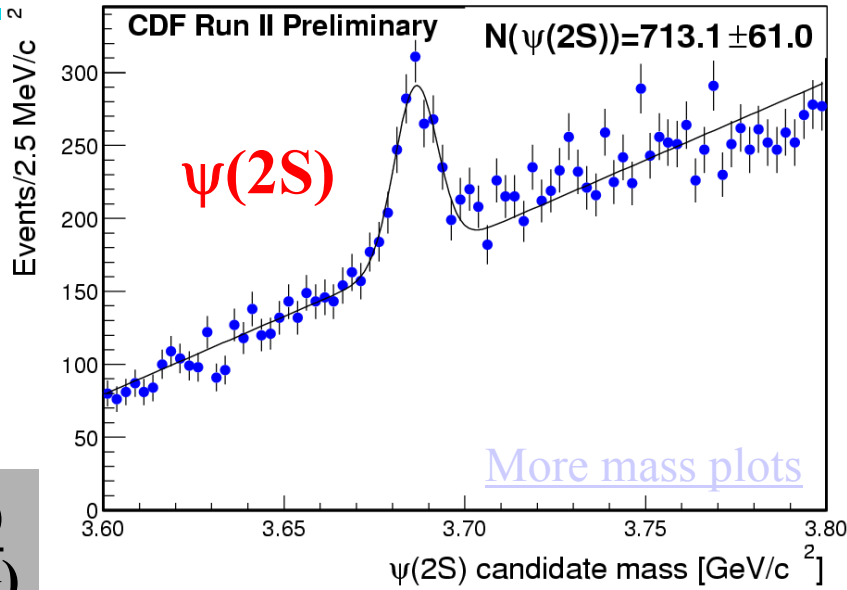


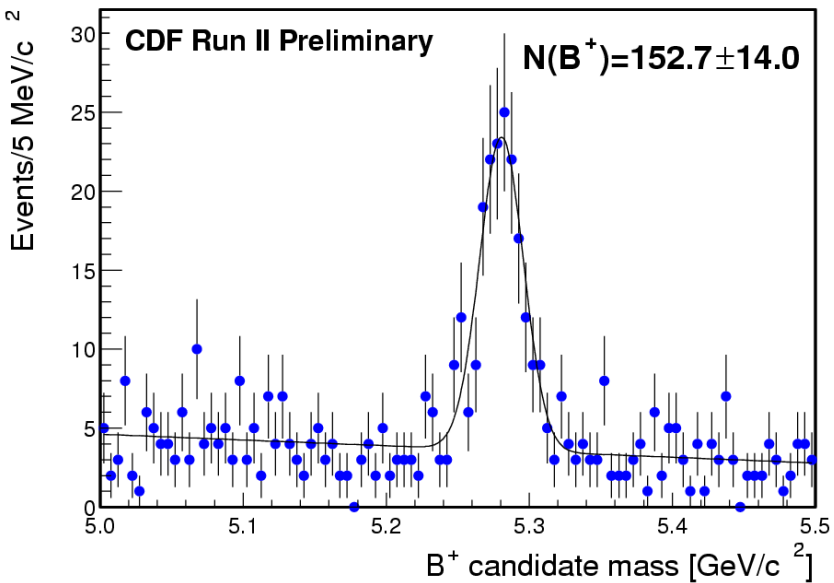


Measurements with low Et $\mu^{\pm}$

- B masses: semi-leptonic B
  - $\psi(2S) \rightarrow J/\psi\ \pi^+\pi^-$ (control)
  - $B_u \rightarrow J/\psi\ K^+$ lifetime
  - $B_d \rightarrow J/\psi\ K^{0*}$ $(K^{0*} \rightarrow K^+\pi^-)$
  - $B_s \rightarrow J/\psi\ \phi$ $(\phi \rightarrow K^+K^-)$

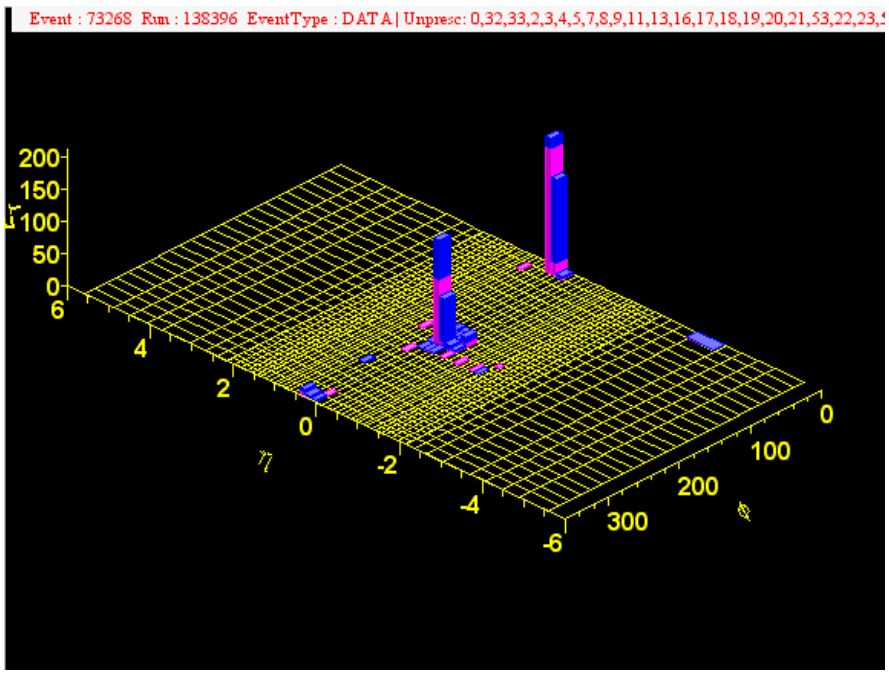
	CDF 2002	ΔPDG/σ	σ(CDF)/σ(PDG)
ψ(2S)	3686.43±0.54	0.86	6.00
Bu	5280.60±1.70±1.1	0.77	4.05
Bd	5279.80±1.90±1.4	0.17	4.72
Bs	5360.30±3.80± 2.10 2.90	-1.81	1.90

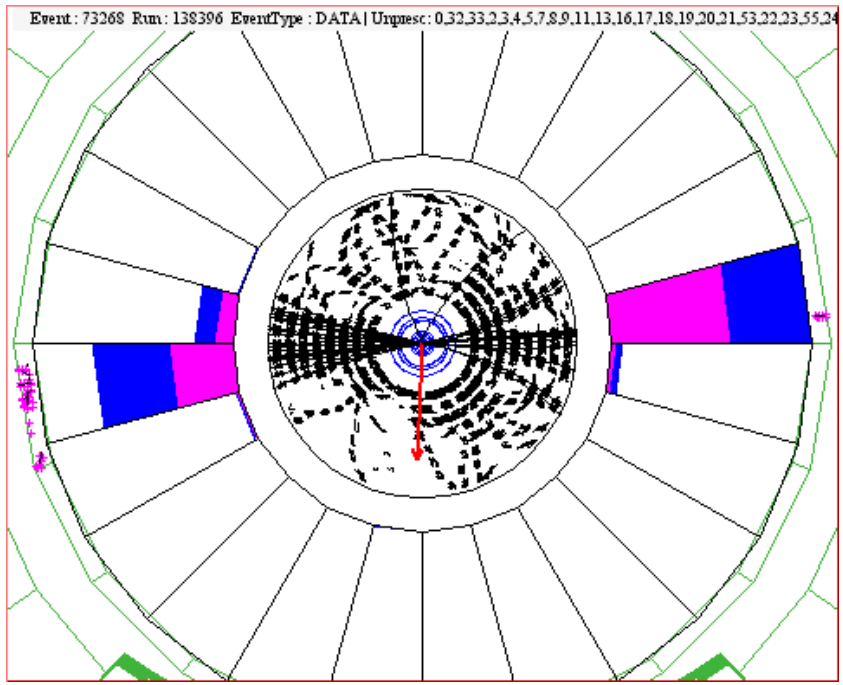




Measurements with jets

- Raw Et only:
  - Jet 1: ET = 403 GeV
  - Jet 2: ET = 322 GeV

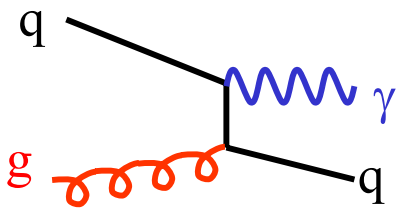




Jet expectations
Raw jet distributions

Hadronic Energy Scale

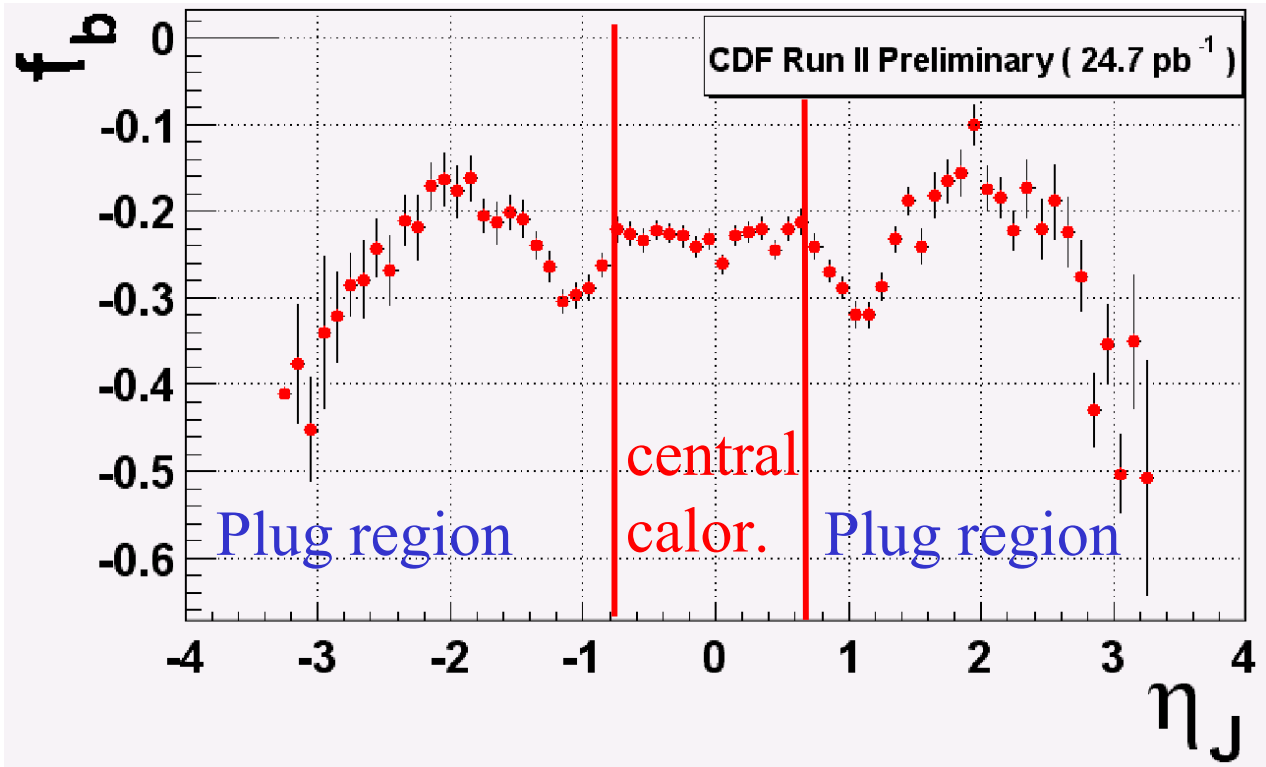
- Use J/ψ muons to measure MIP in hadron calorimeters
  - (Run II)/(Run 1) = 0.96±0.005



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

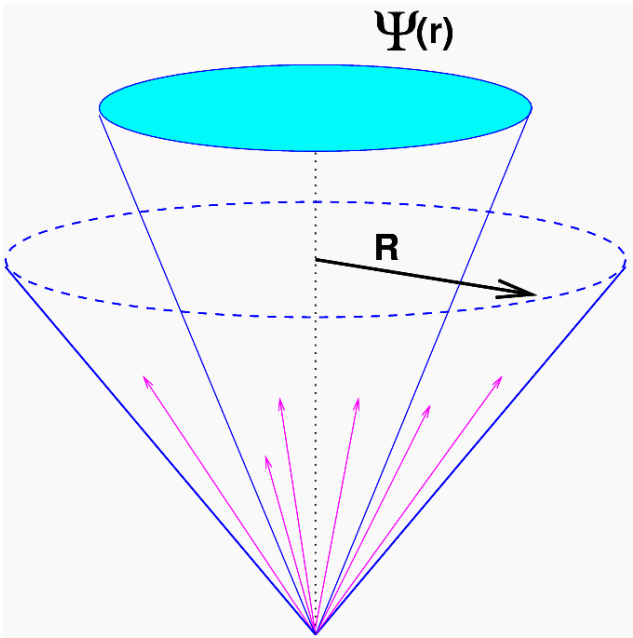
$\Delta f_b = (4.0 \pm 0.4)\%$

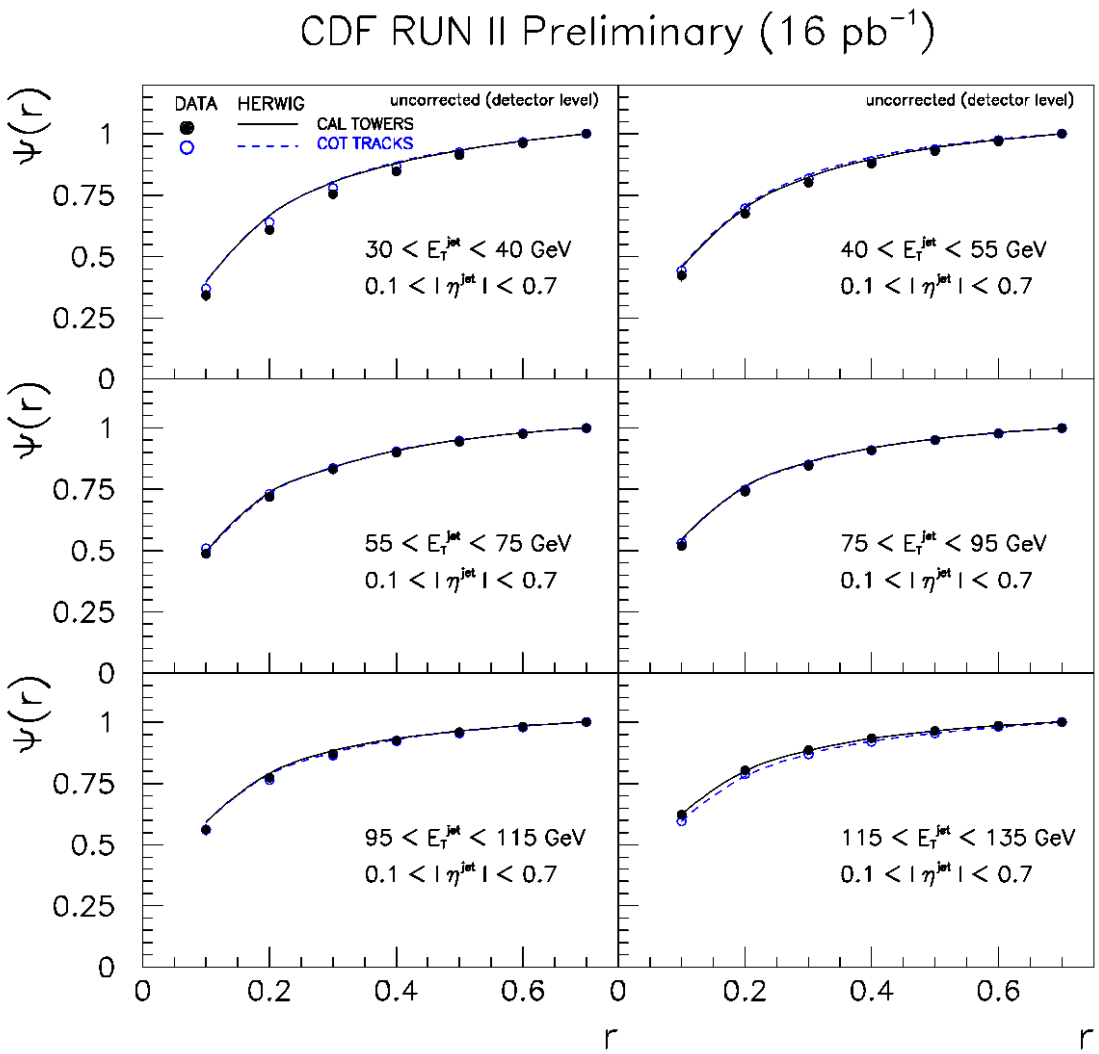
  - Plug region corrections in progress



Measurements with jets

- Jet shapes:
  - Narrower at higher E_T
  - Calorimeter and tracking consistent
  - Herwig modeling OK

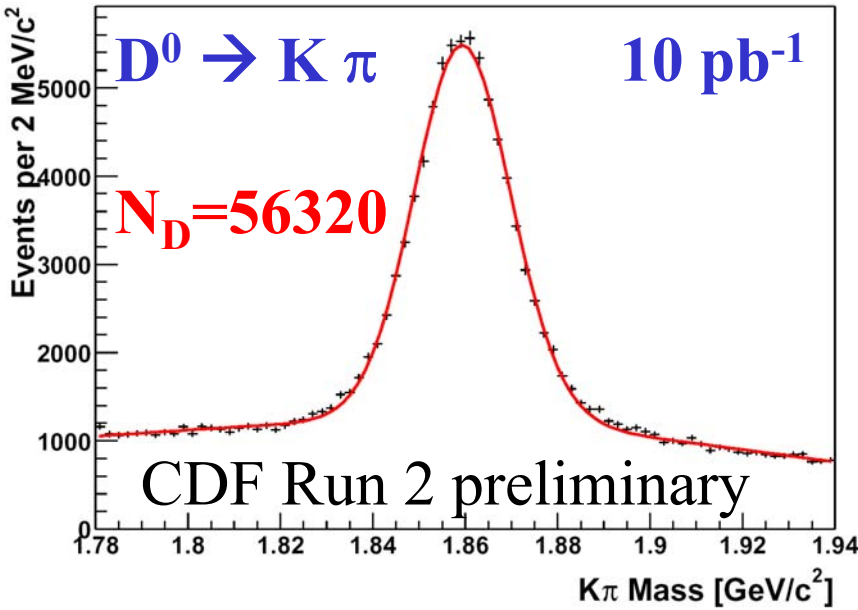


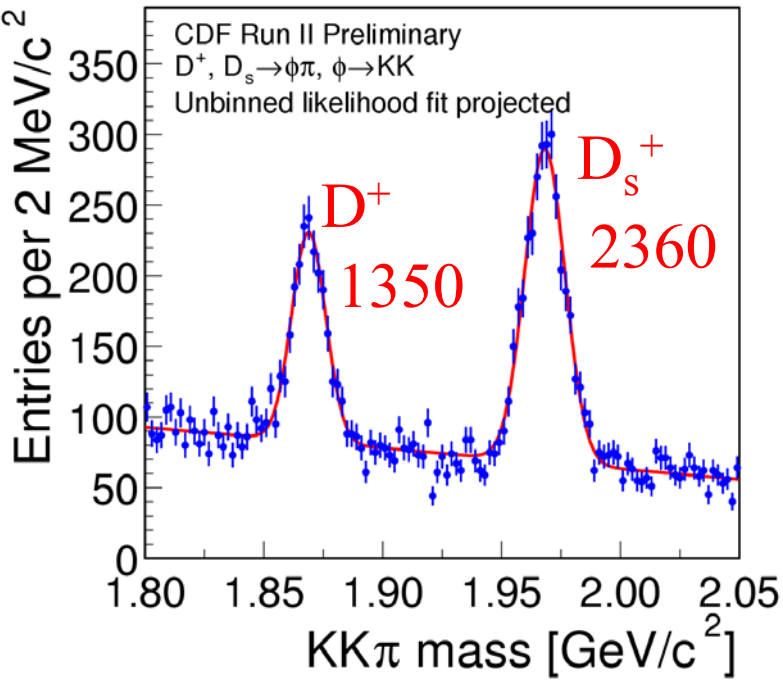


16 pb^{-1} used for this study

Measurements with hadronic b triggers

- L2 trigger on 2 tracks:
  - pt > 2 GeV
    - |D| > 100 μm (2 body)
    - |D| > 120 μm (multibody)
- Swamped by D mesons!
  - But see B's as well….

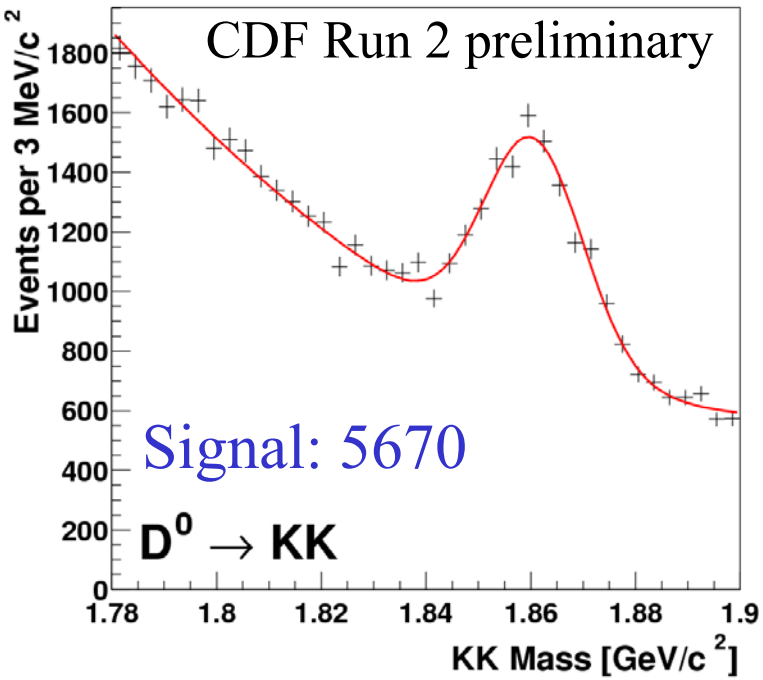




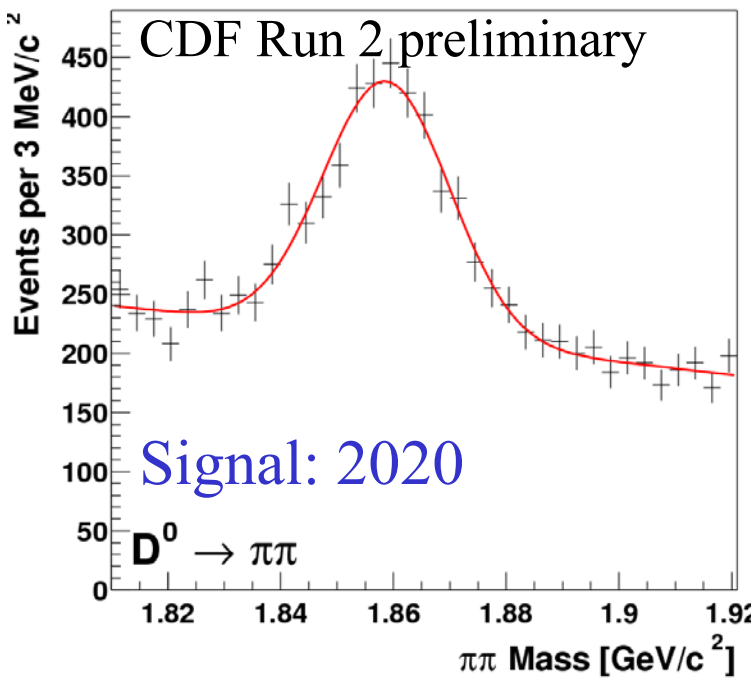
- $D_s^{\pm}$ - $D^{\pm}$ mass difference
  - Both $D \rightarrow \phi\pi$ $(\phi \rightarrow KK)$
  - $\Delta m = 99.28 \pm 0.43 \pm 0.27$ MeV
    - PDG: 99.2±0.5 MeV
  - Systematics dominated by background modeling

Measurements with hadronic b triggers

- Measure ratios of CKM suppressed decays
  - $\Gamma(D \to KK)/\Gamma(D \to K\pi) = (11.17 \pm 0.48 \pm 0.98)\%$ (PDG: 10.84 ± 0.45)
    - Main systematics (8%): background modeling
  - $\Gamma(D \to \pi\pi)/\Gamma(D \to K\pi) = (3.37 \pm 0.20 \pm 0.16)\%$ (PDG: 3.76 ± 0.20)
    - Main systematics (4%): relative acceptance



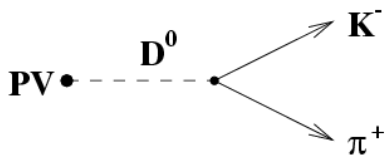
L = 10 pb^{-1}



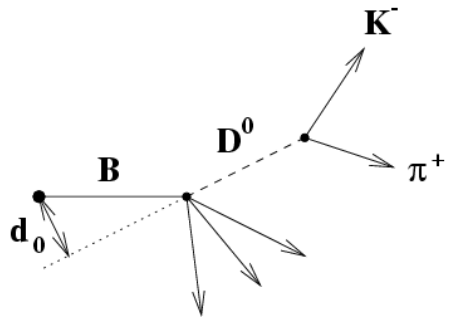
Measurements with hadronic b triggers

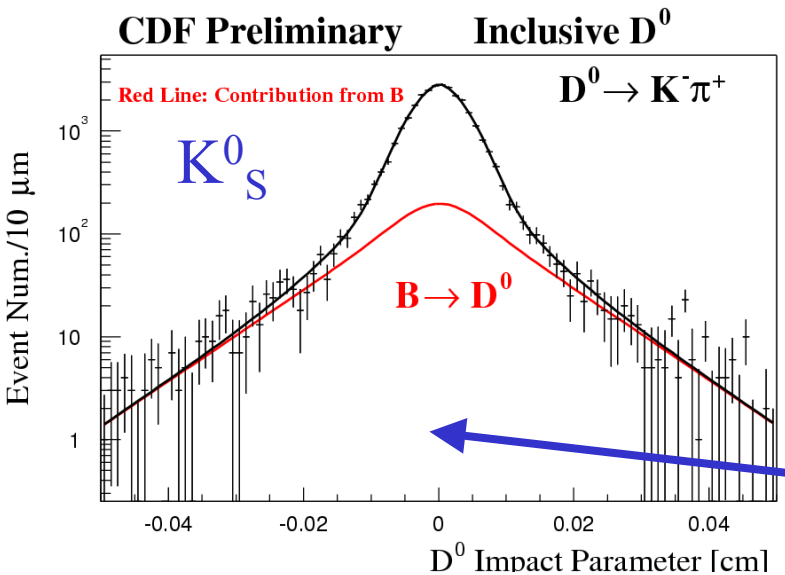
- D mesons:
  - What fraction from B?
    - D0: 16.4-23.1%
    - D^{*+}: 11.4-20.0%
    - D^{+}: 11.3-17.3%
    - D_s^{+}: 34.8-37.8%

Direct Production
D points back to PV

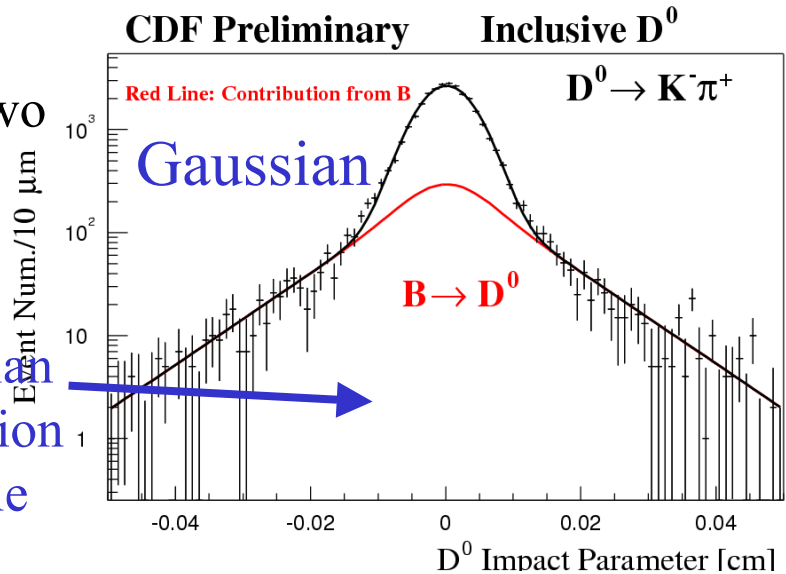


Secondary Production
D has finite impact parameter

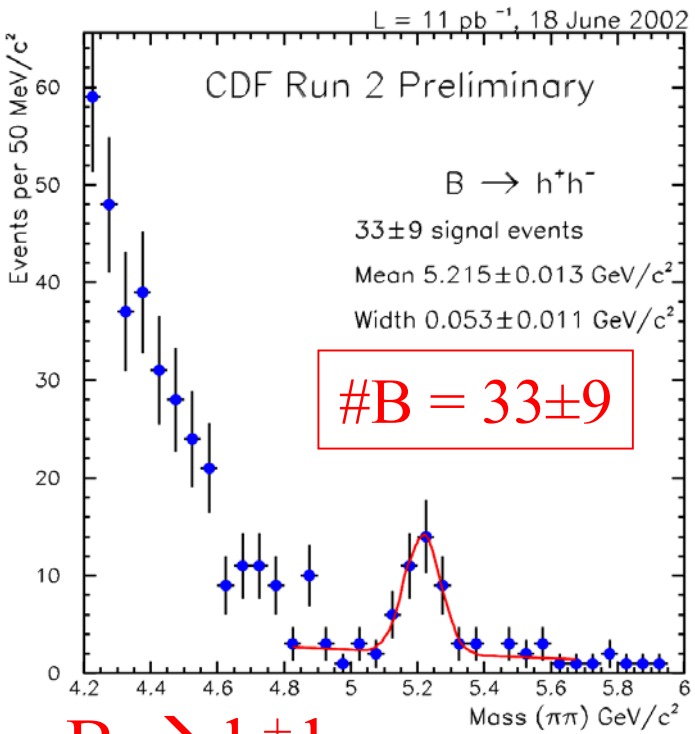




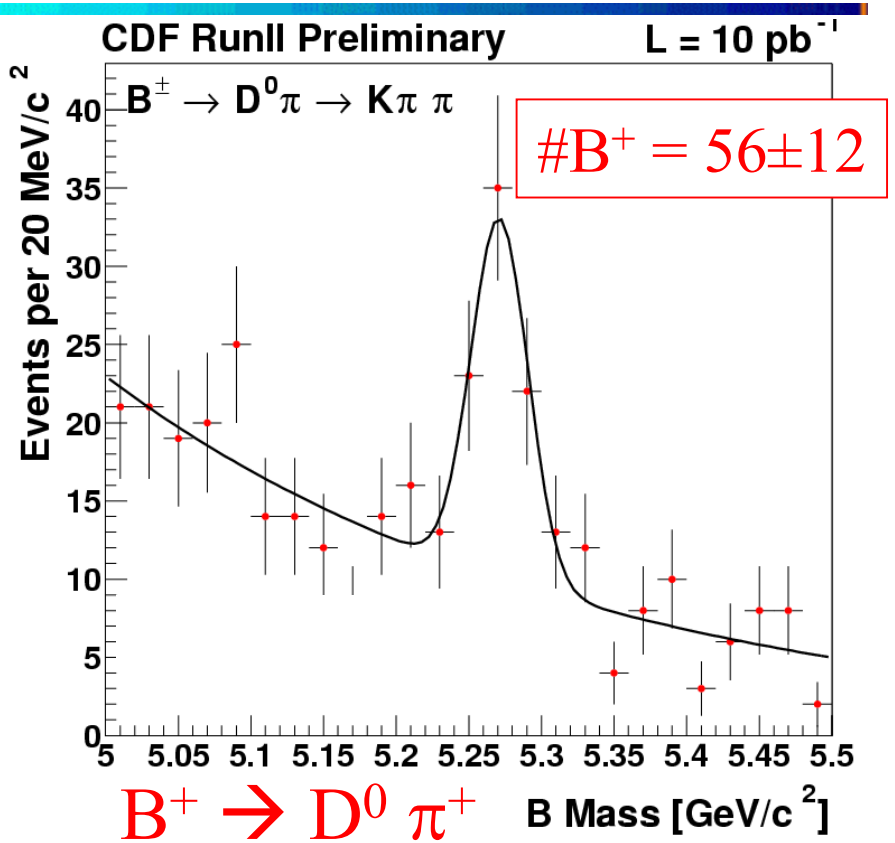
Range of fract. from B using two extreme resolutions functions:
- single gaussian
- parametrization from K^0_S sample



Measurements with hadronic b triggers



$B \rightarrow h^+ h^-$



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

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

Conclusion

- The CDF detector is fully functional and accumulating proton anti-proton data
- Tevatron is moving toward reaching performance goals
- Understanding of detector is advanced
- Many early physics results
  - sometimes competitive in spite of limited statistics
- Ready to exploit full Tevatron potential as luminosity increases

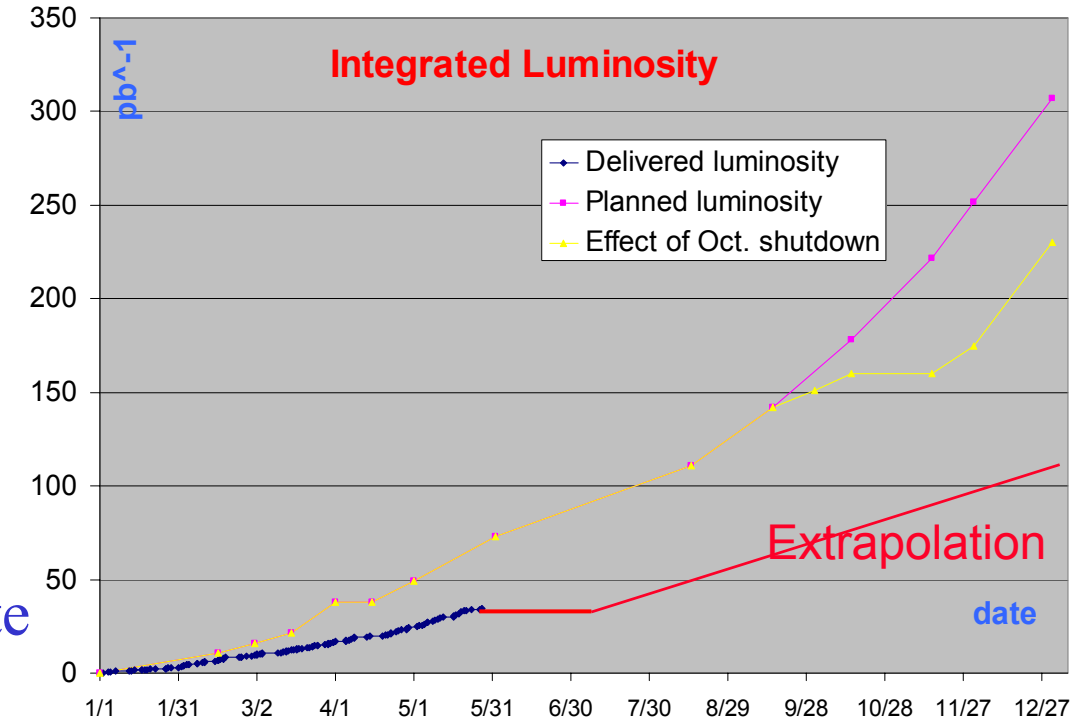
CDF is back !

Backup slides

- Tevatron plans
- Silicon detector performance
- Trigger and DAQ details
- Data sample
- Talks in parallel sessions
- Z→ ee FB asymmetry
- W → eν selection details
- W → μν details
- W→τν
- MET resolution
- B mass plots
- B^+ lifetime
- Semileptonic B's
- Jet expectations
- Jet raw Et distributions

Tevatron status

- Short term plans:
  - Run until October
    - Reach goal w/o Recycler:
      - 5-8x10^{31} $cm^{-2}sec^{-1}$
  - 1-2 months shutdown
    - Complete Recycler work
  - Commission and integrate Recycler during 2003
    - Mostly in parallel with Tevatron colliding beam operation



- Expect 100 – 200 pb^{-1} delivered in 2002 ~ Run 1 data set

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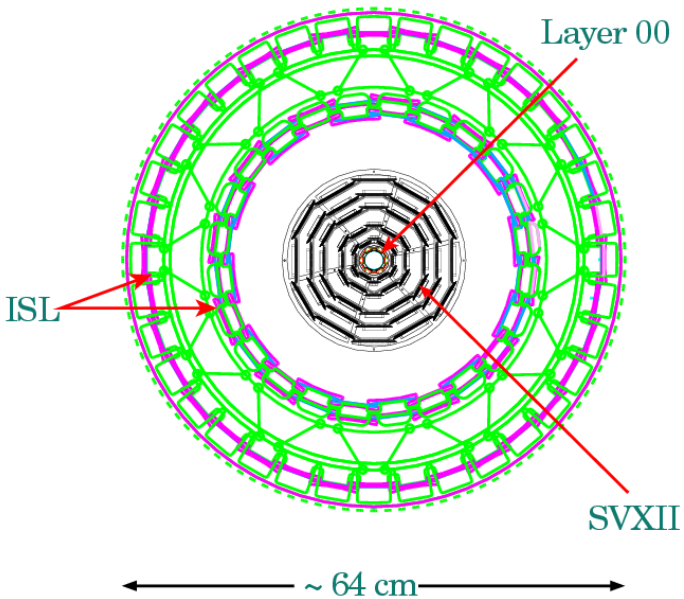
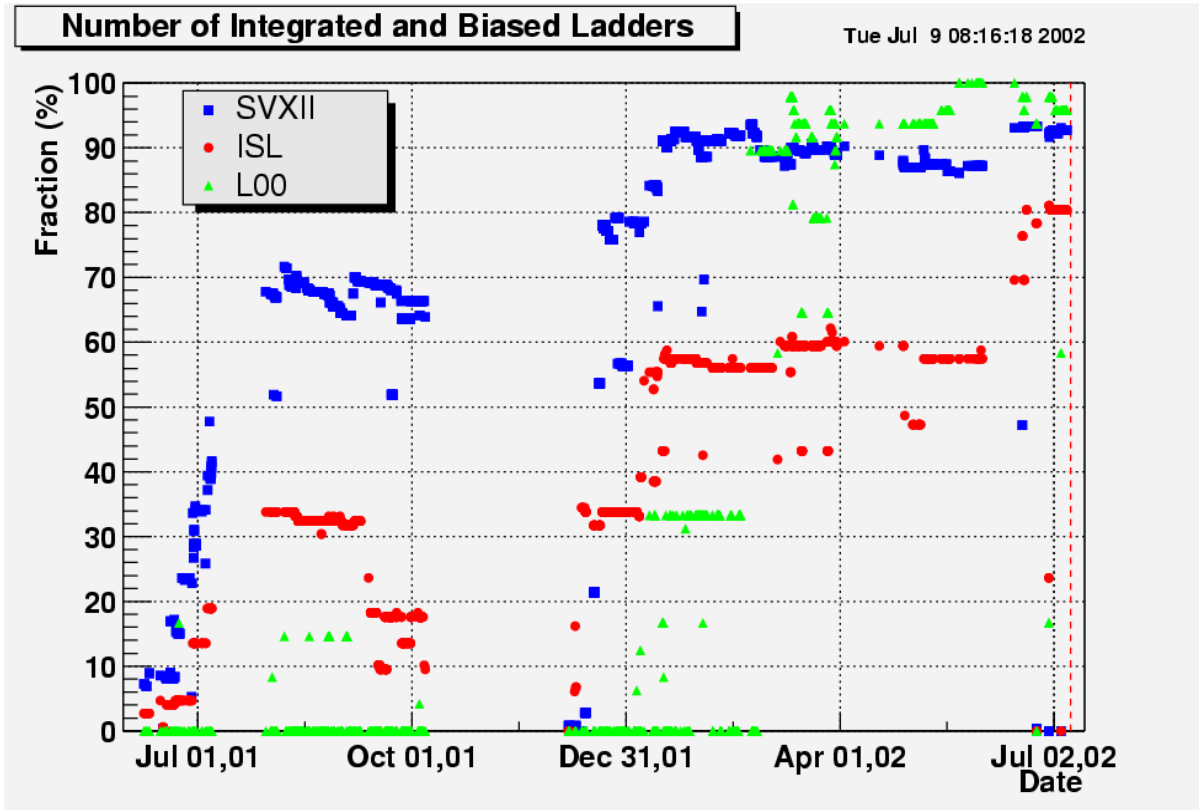
Detector Performance

- Commissioning:
  - **L00** > 95%
  - **SVXII** > 90%
  - **ISL** > 80%
    - Completing cooling work





% of silicon ladders powered and read-out by silicon system vs. time

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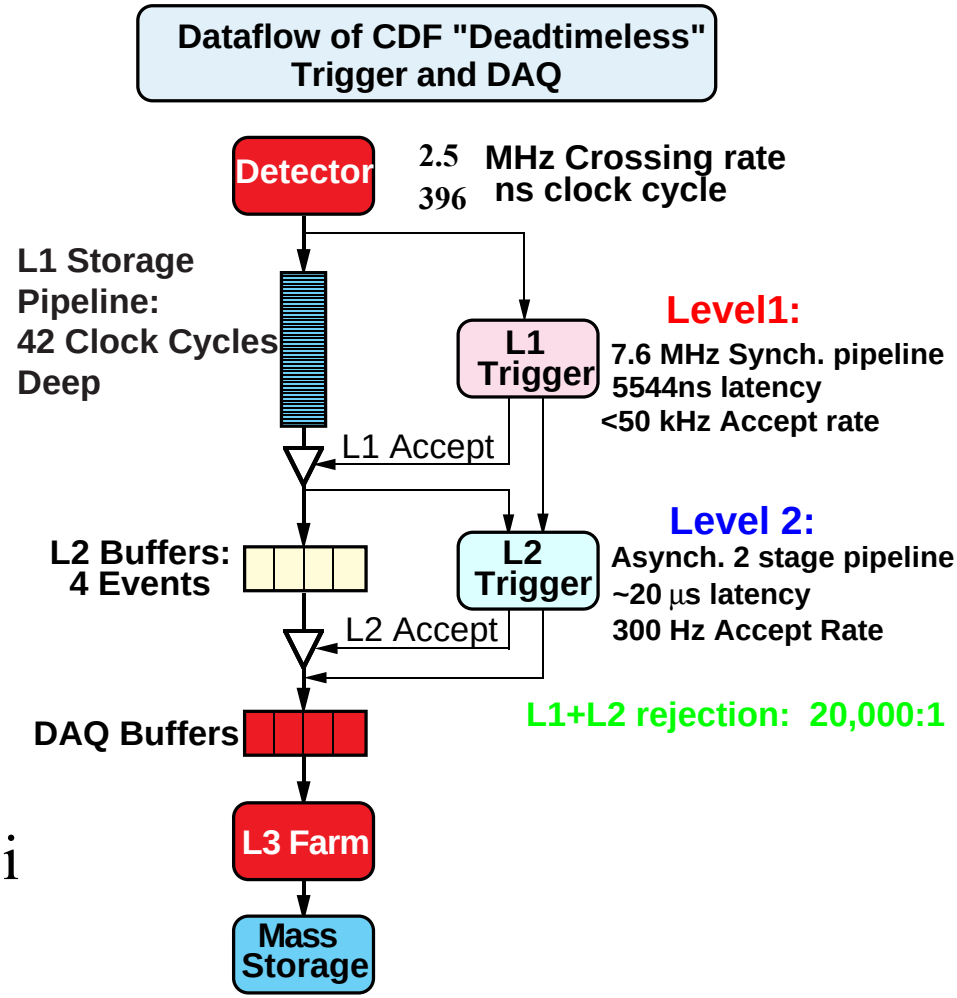
Detector Performance

- Trigger:
  - Goal rates for L = 2×10^{32}
    - L1/L2/L3 = 50,000/300/50 Hz
  - Typical now for L ~ 10^{31}
    - L1/L2/L3 = 6,000/240/30 Hz
- DAQ
  - Logging data at the planned rate of ~ 20 Mbyte/sec
- Offline:
  - Data is reconstructed in quasi real time on a dedicated production farm



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Data Sample

- Stable physics trigger table established since January '02

Trigger/DAQ details

- Summary of data used for this conference:
  - Data period: January – June, 2002
  - Delivered luminosity: 33.0 pb^{-1}
  - Live (to-tape): 23.5 pb^{-1}
  - "Good runs": 23.3 pb^{-1}
  - "Good runs" with all systems ~ 10.0 pb^{-1} (cfr. 110 pb^{-1} Run 1)
    - Radiation induced COT/SVX VME power supply failures (fixed!)
    - Instabilities in Silicon readout (much improved)

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CDF-II results in parallel sessions

- Electroweak, session 4:
  - Prospects for EW physics in Run 2 (D. Glenzinski)
  - W boson cross section and decay properties (K. Bloom)
- QCD, session 5:
  - Jet and gamma physics (J. Dittmann)
  - Heavy Flavor at CDF (C. Paus)
- Heavy Quark, session 8:
  - First results with a hadronic trigger (A. Cerri)
- New Phenomena, session 10:
  - MSSM Higgs at the Tevatron (A. Connoly)
  - CHAMP searches (B. Orejudos)
- R&D, session 13:
  - Calorimetry (R. Erbacher)
  - Tracking (S. Nahn)

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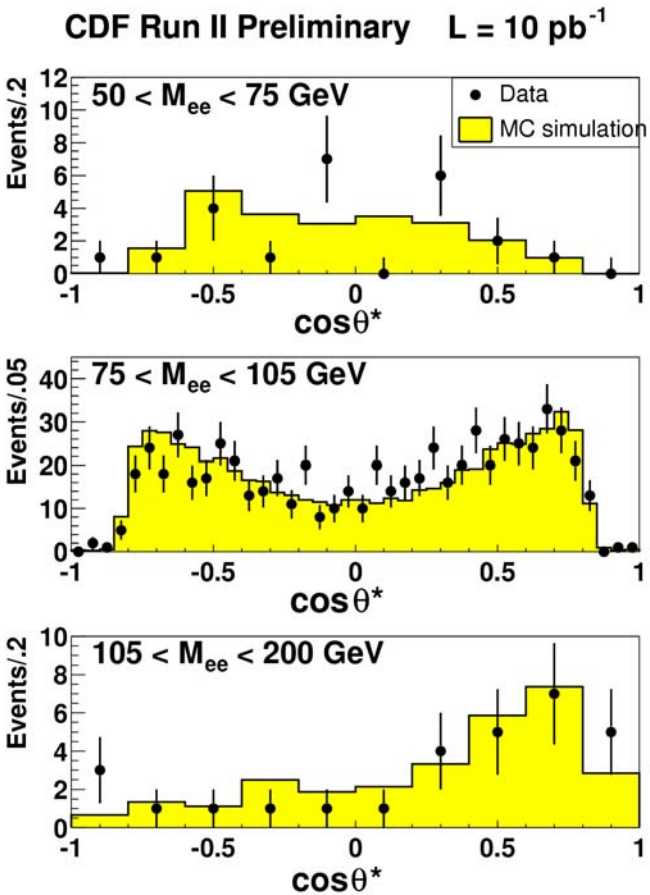
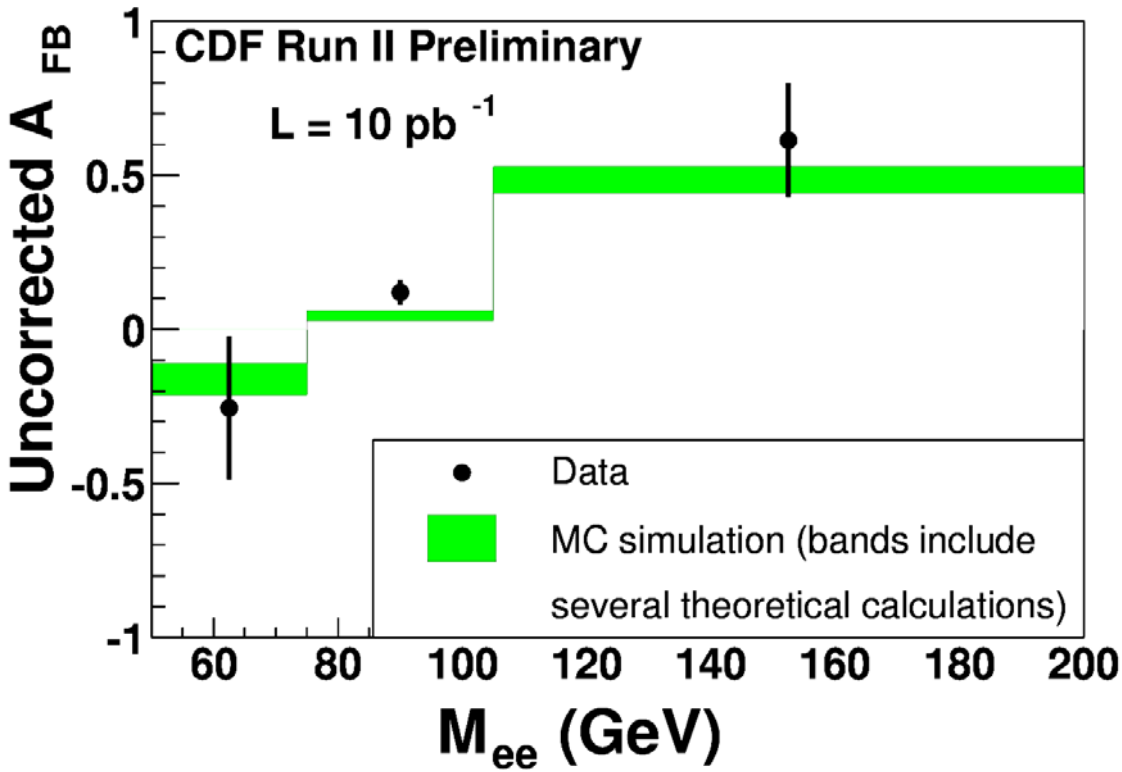
Measurements with high Et $e^{\pm}$

- Uncorrected $Z \rightarrow e^+e^-$ angular distributions and asymmetries





Measurements compared with Pythia/CTEQ5L prediction

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Measurements with high Et e±

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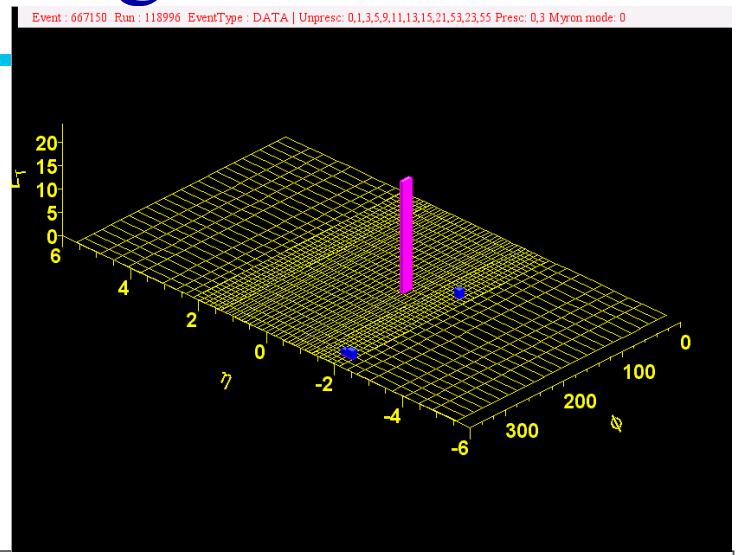
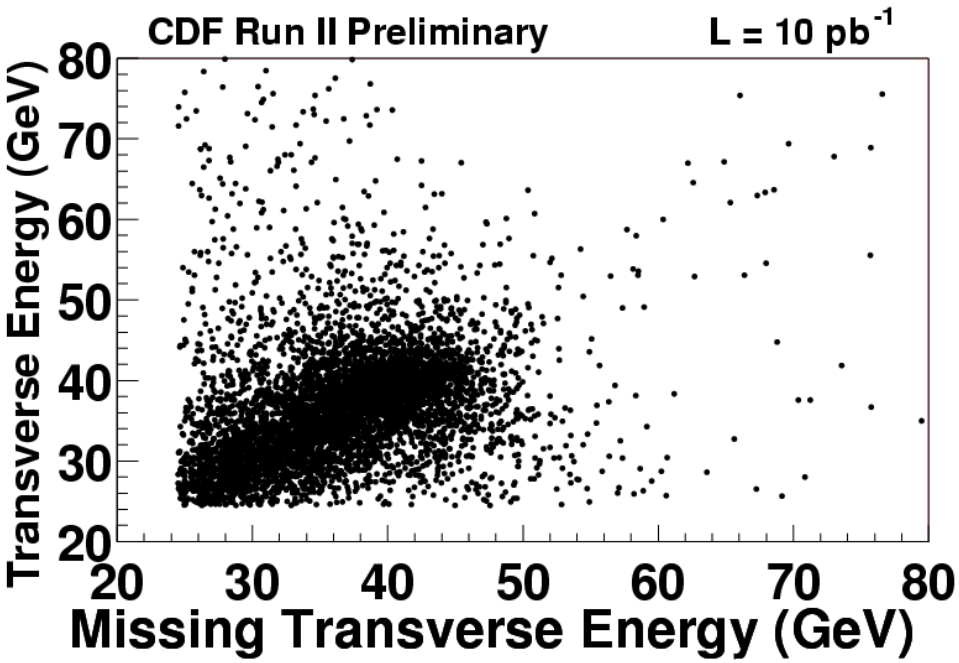
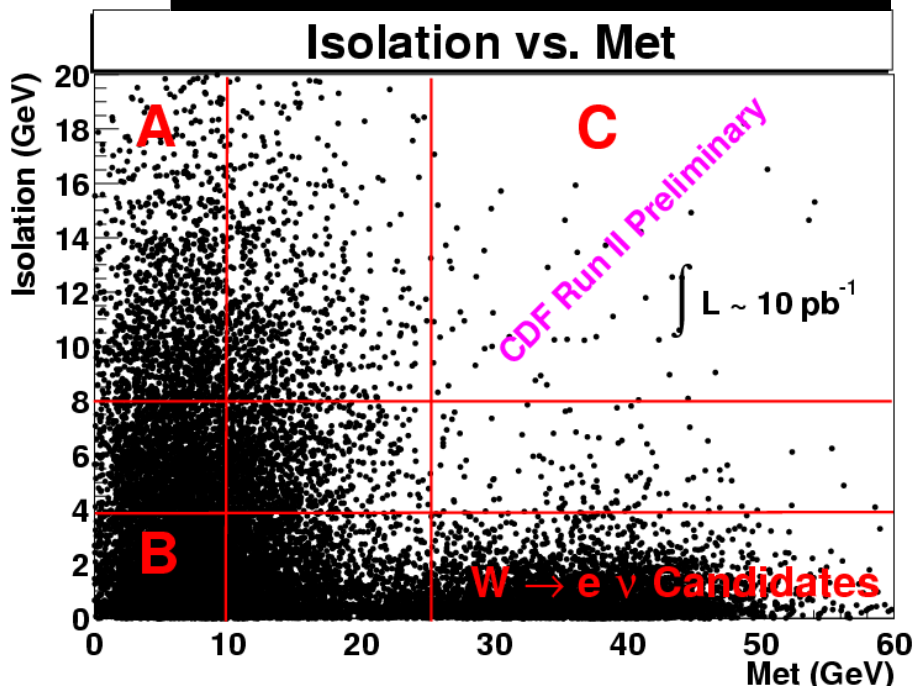
- Clear evidence for **W→ eν signal**
  - Isolated central electron
  - Et > 25 GeV, $\not{E}_t$ >25 GeV

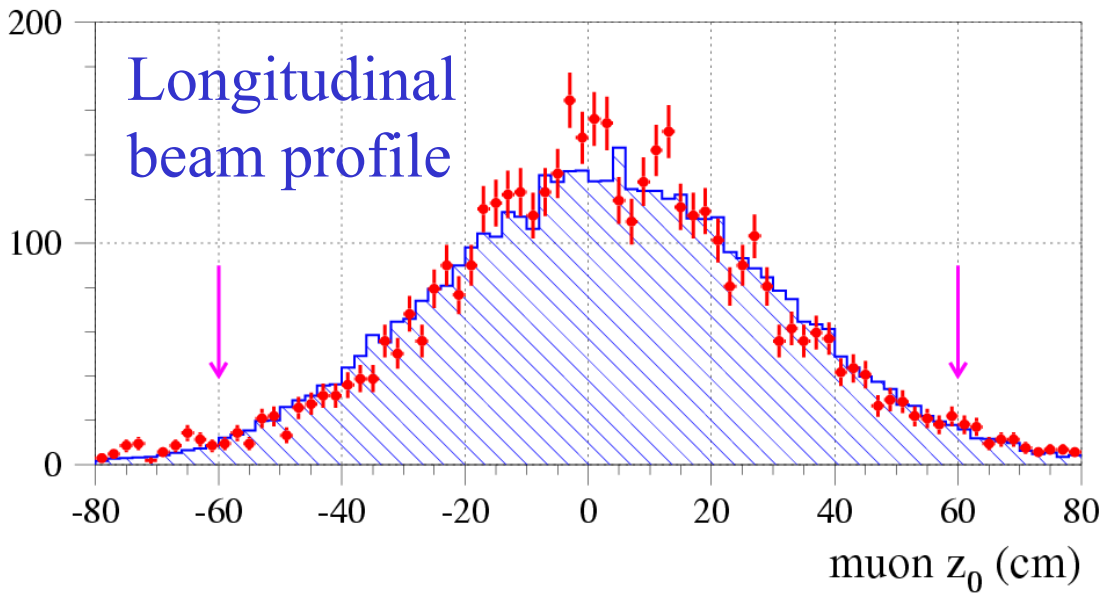


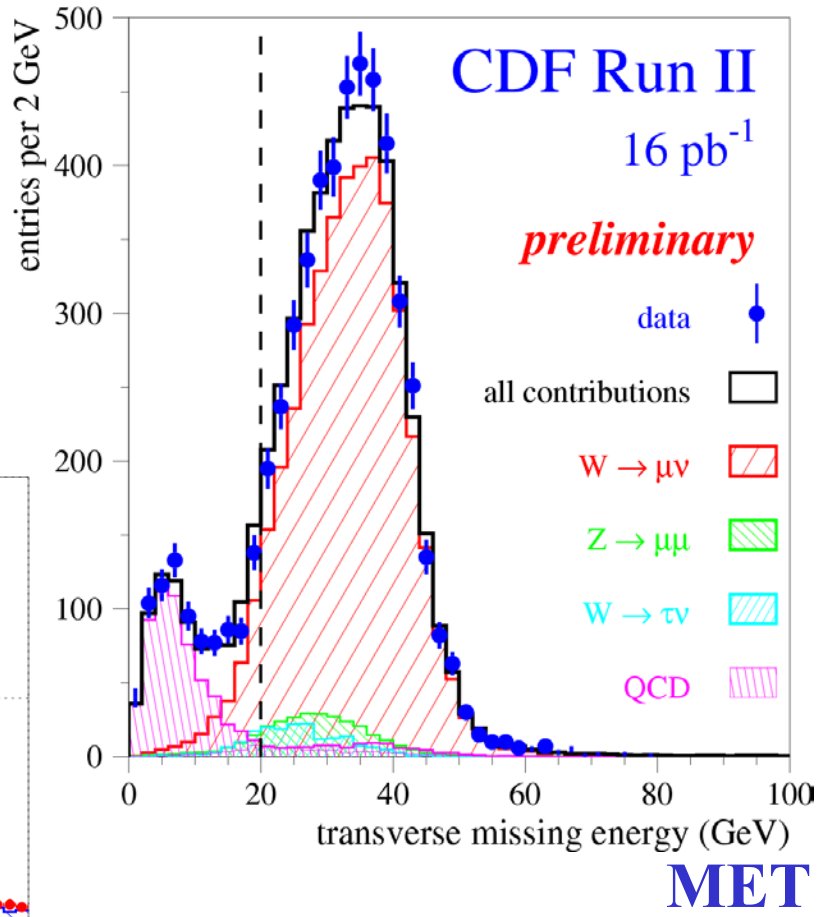




Measurements with high Et $\mu^{\pm}$

- Good modeling of observed **W→μν** distributions
- Measure **σ(W→μν)** and **R=σ(W→μν)/σ(Z→μμ)**





MET

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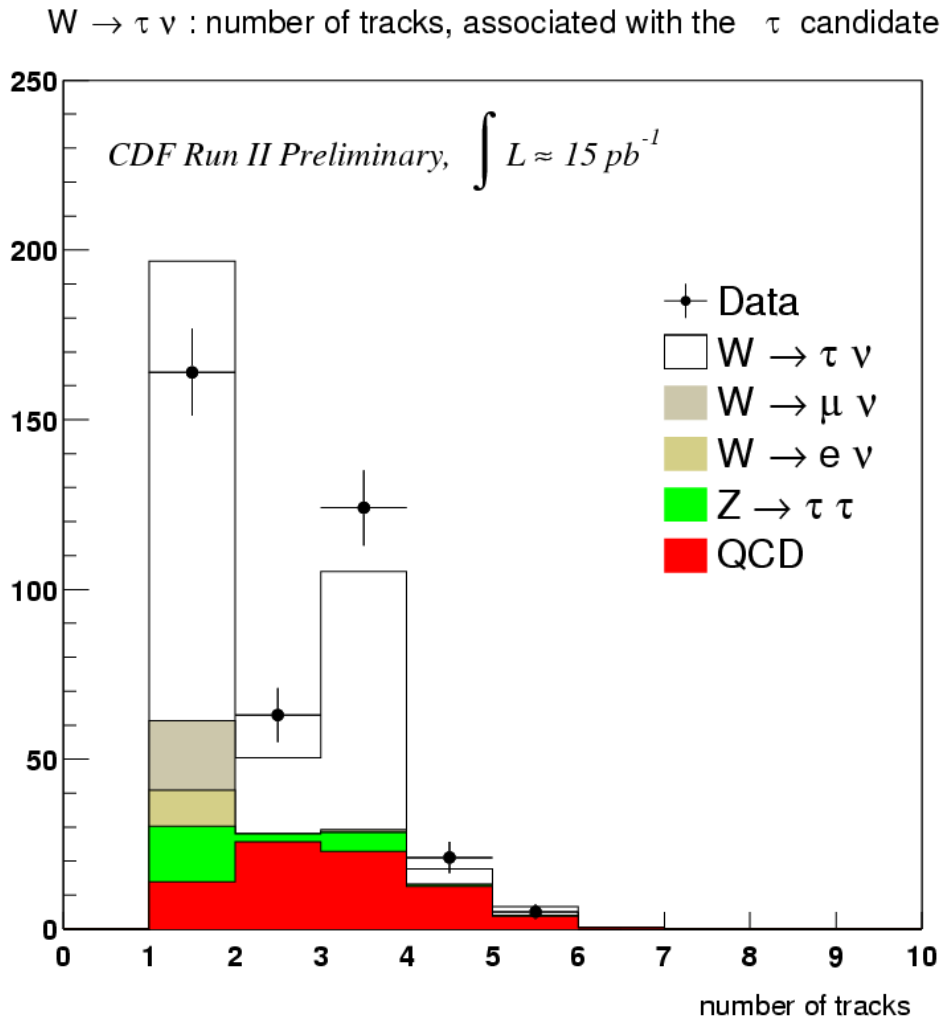
$W \rightarrow \tau \nu$

- Evidence for typical τ decay multiplicity in $W \rightarrow \tau \nu$ selections



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MET resolution

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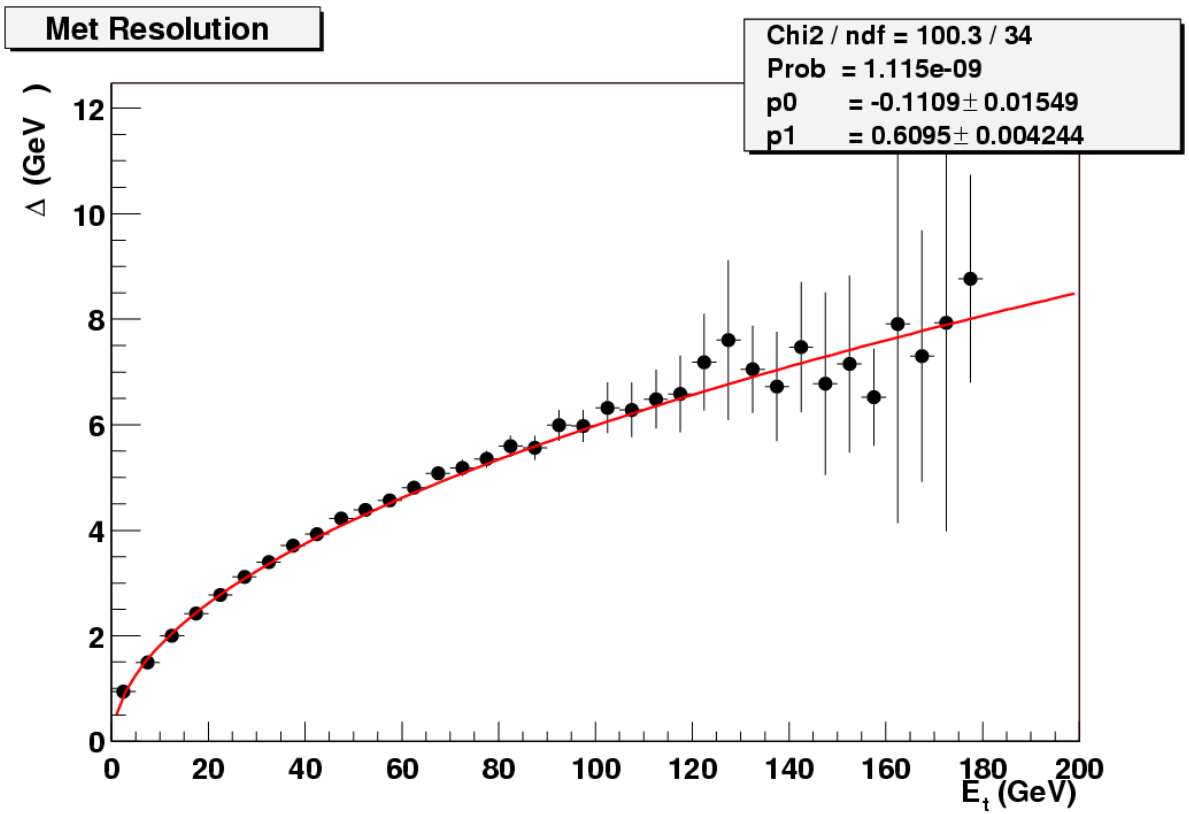
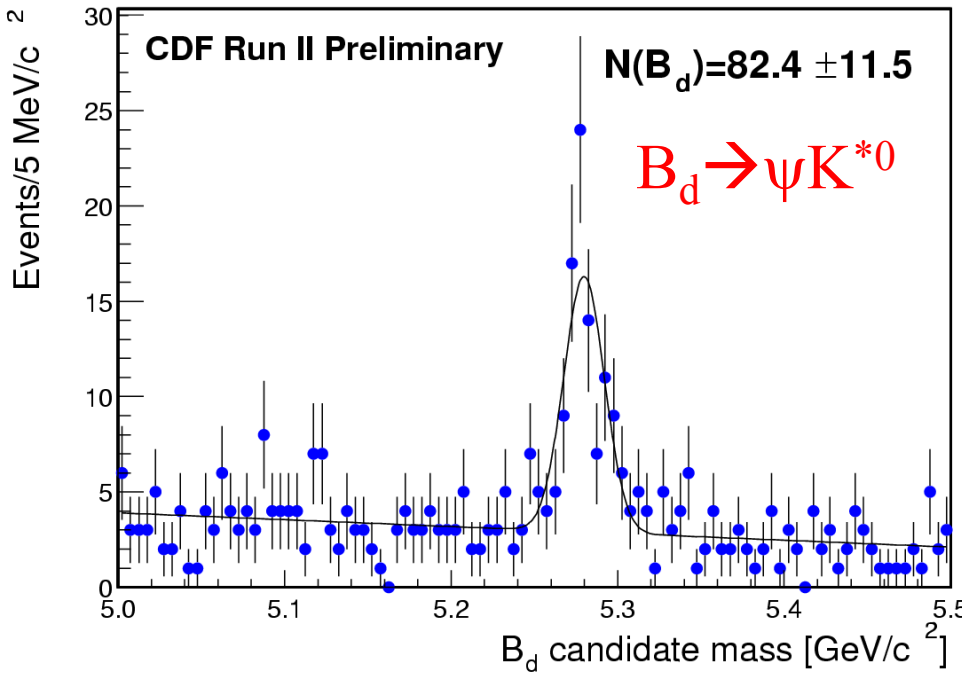
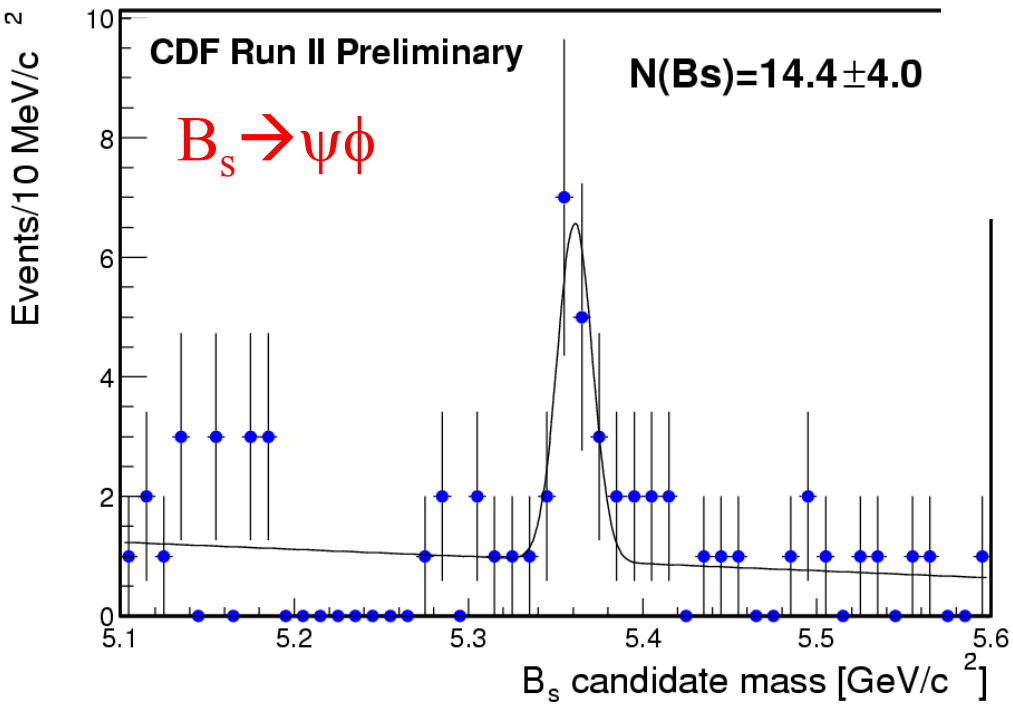
- Minimum bias events
  - Run 1: $0.53/\sqrt{\Sigma\ Et}$ with forward cal. Use $|\eta|<4.2$
  - Run II: $0.60/\sqrt{\Sigma\ Et}$ with plug only $|\eta|<3.6$
    - With miniplug $|\eta|<5.5$



Measurements with low Et $\mu^{\pm}$

- More mass plots:
  - Bd, Bs





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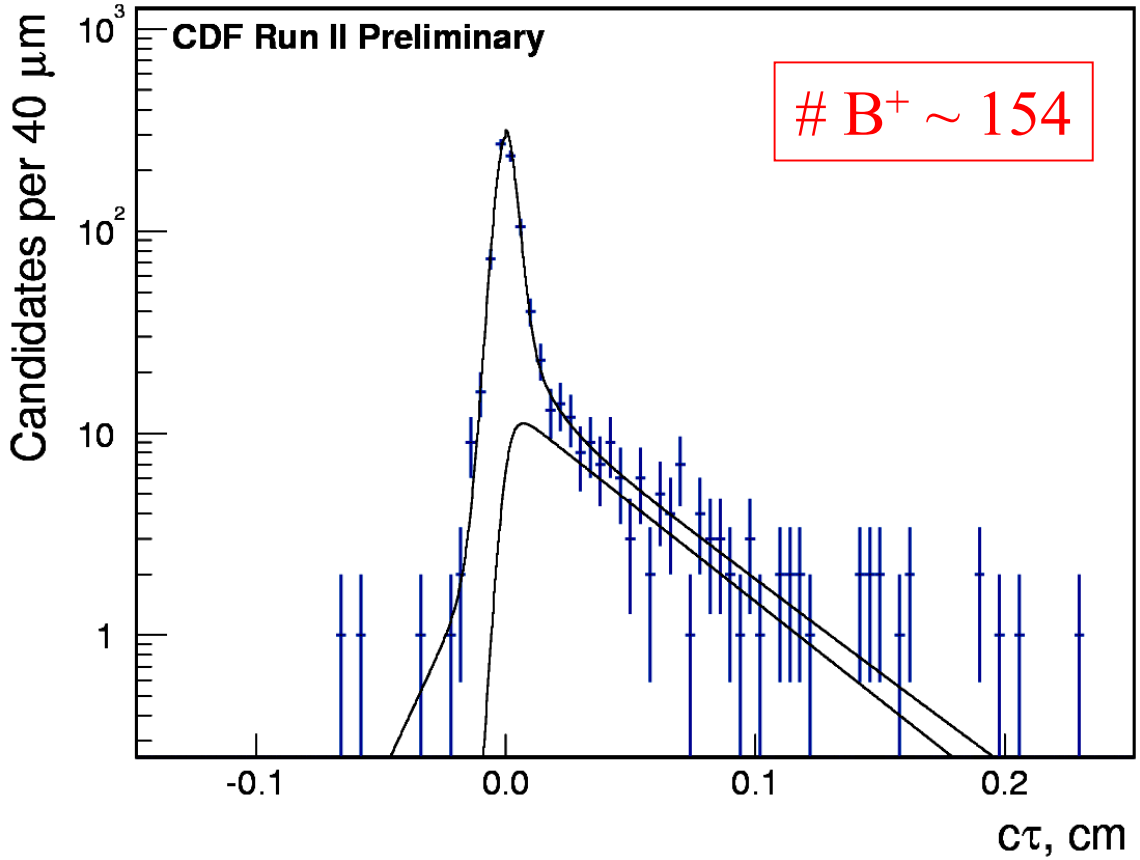
Measurements with low Et $\mu^{\pm}$

- B^+ lifetime:
  - $B^+ \rightarrow J/\psi\ K+$
  - Fit results:
    - $c\tau = 446 \pm 43 \pm 13\ \mu m$
      (Δ PDG/σ = 1.2)
    - Res. scale factor 1.16
    - Conservative systematic error



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Measurements with inclusive leptons

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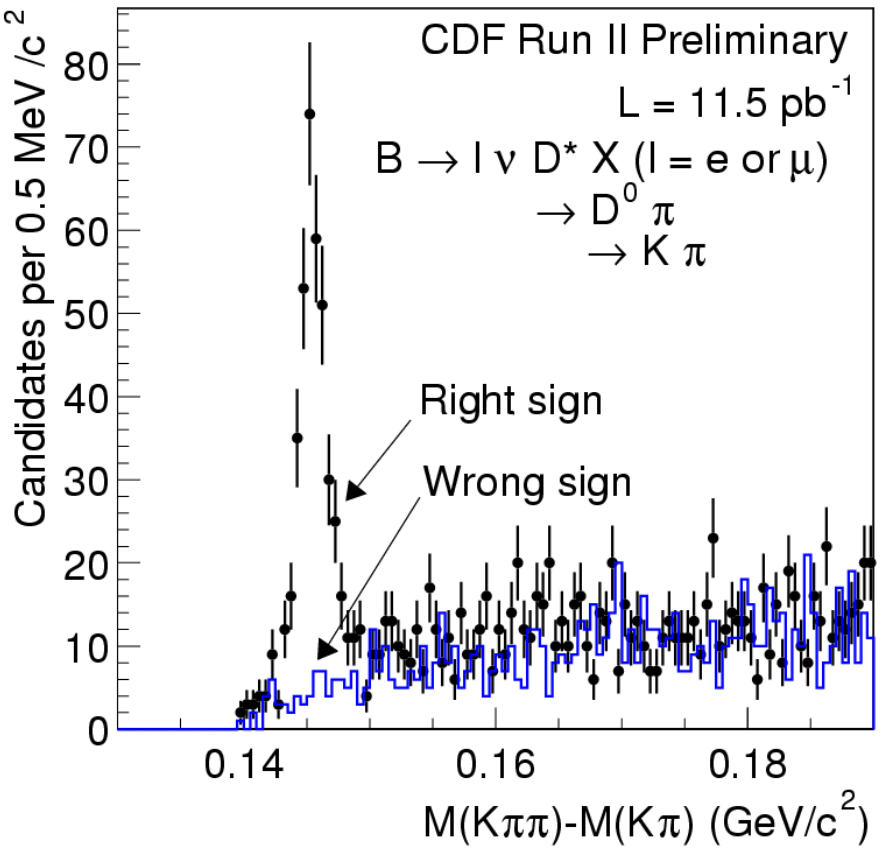
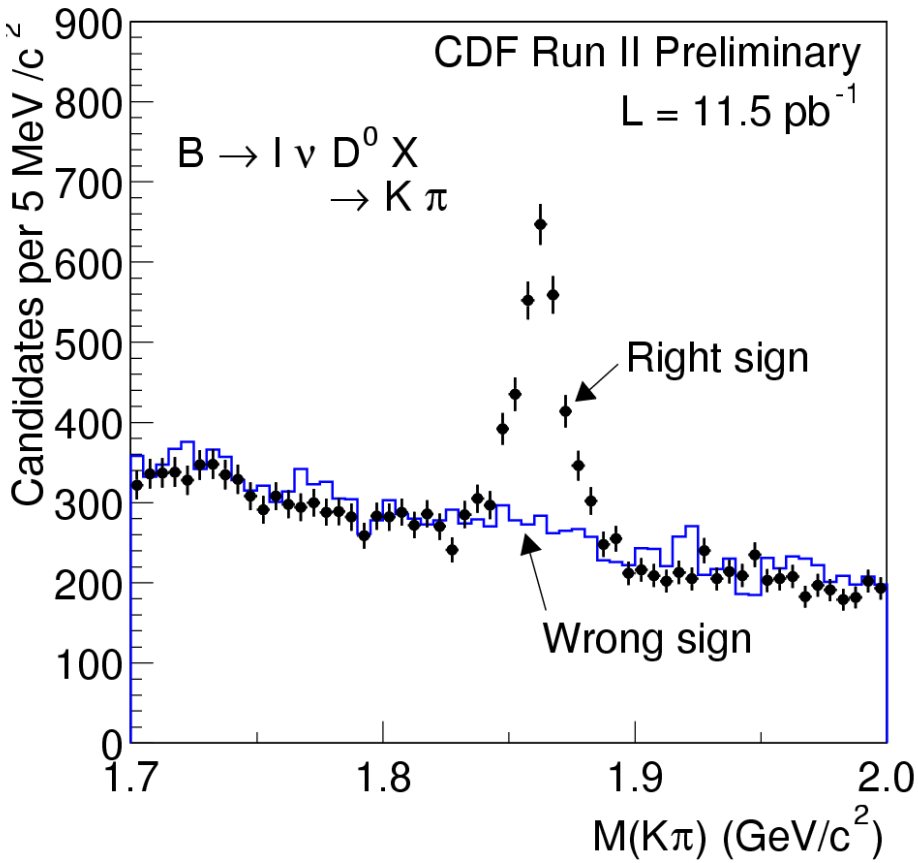
- Find large samples of semileptonic B decays





Measurements with jets

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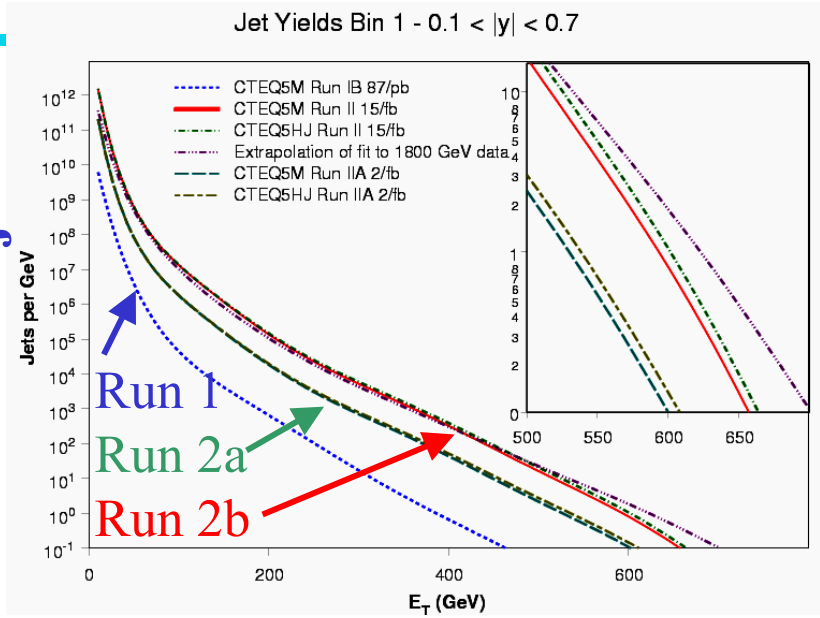
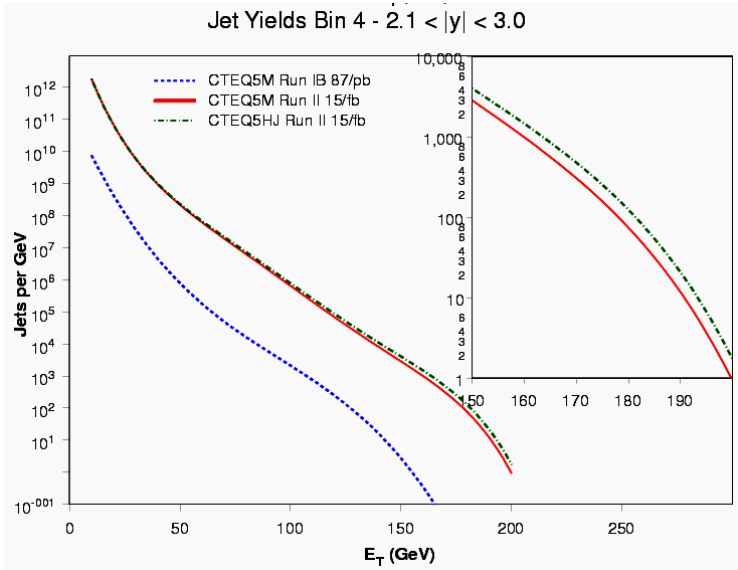
- Expectations:
  - Increase max. energy reach
  - Study both central and forward
    - New physics is mostly central
    - Pdf's affect both regions
- Current work:
  - Accumulate large samples
  - Understand energy corrections
    - E-scale, jet shapes, MC tuning

Central jets

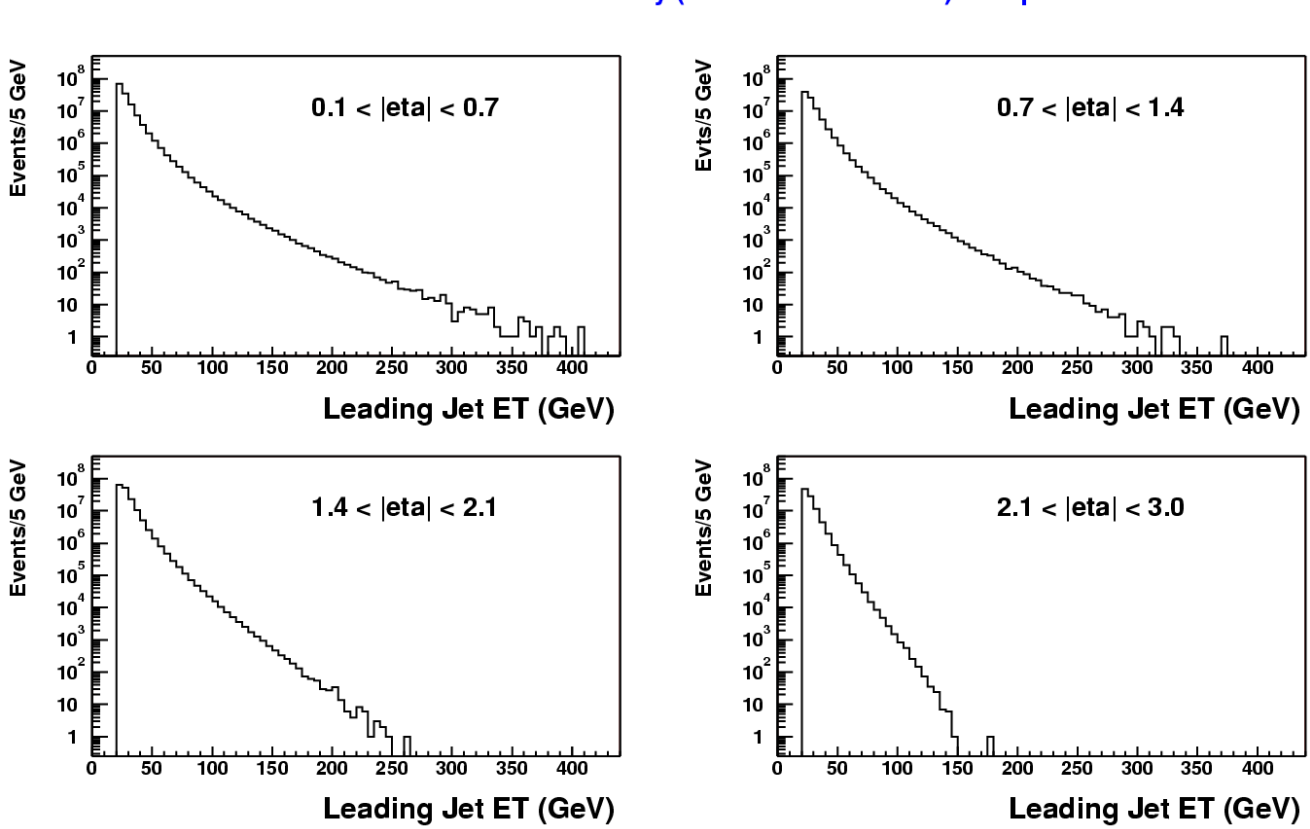


Forward jets



Measurements with jets

- Jet distr. from data
  - Raw E_T
  - Each trigger rescaled for pre-scale factor



Fixed cone algorithm: R = 0.7

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