CDF Physics Analysis and Publication Overview

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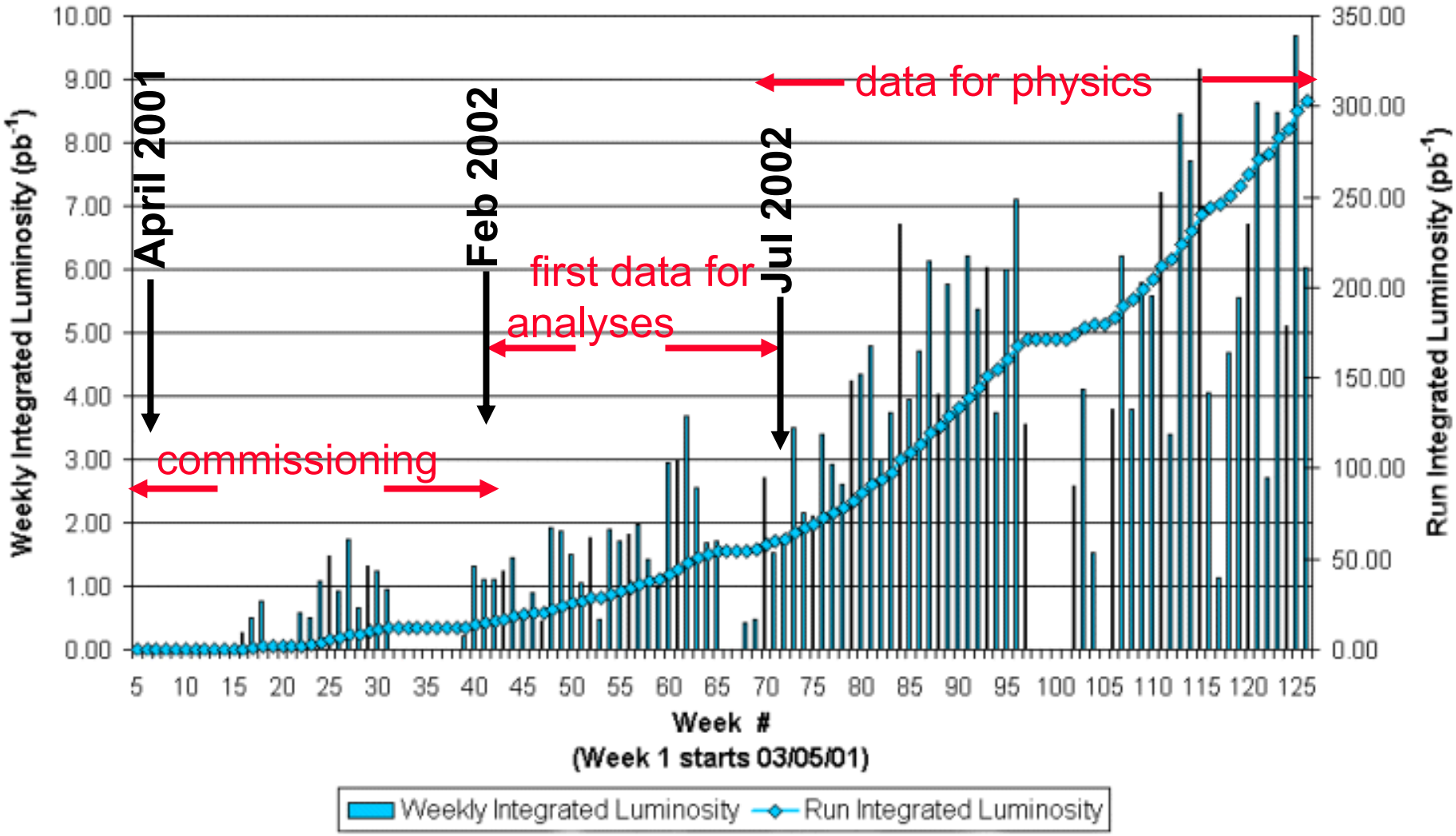
PAC Meeting
December 13th, 2003

Outline

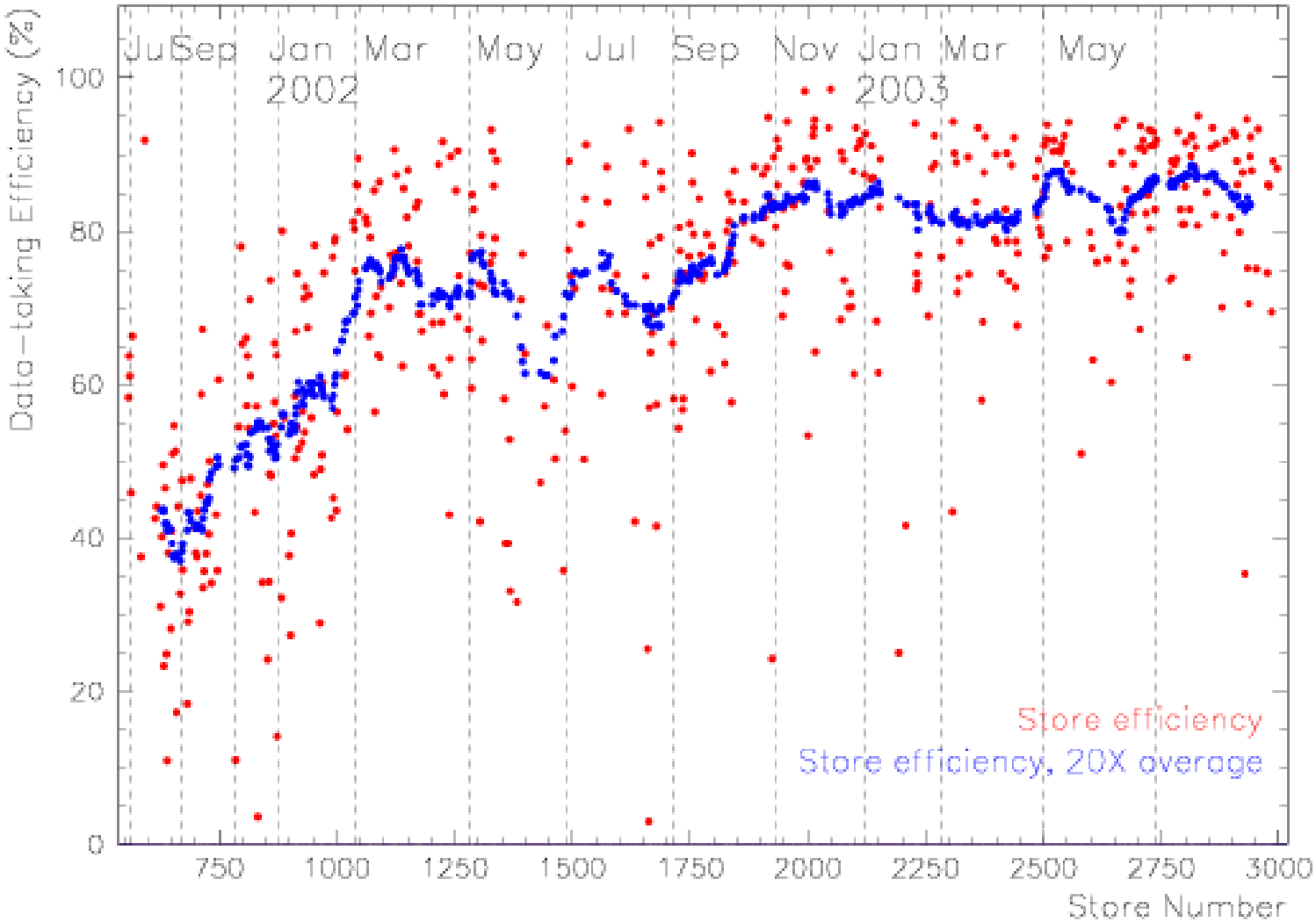
- Status of CDF detector
- Status of analysis and publication plan
  - Heavy Flavors
  - Exotics
  - Electroweak
  - QCD
  - Top
- Motivation for improvement of the trigger & DAQ

Collider Run IIA Integrated Luminosity

~220 pb^{-1} on tape



Data Taking Efficiency



CDF status

- CDF detector working extremely well
- Always concerned about silicon safety
  - Recent beam incidents highlight concerns
- Beam position off center 6mm vertically seriously impacts B physics efficiency
  - Moving it this weekend
- Offline production proceeding well
  - ~8 million events/day
- Central Analysis Facility (CAF) big success

Publication plans

- We have recorded about 220 pb^{-1} of physics quality data up to the end of August 2003
- We consider this a complete dataset - twice Run1
- All physics groups are planning to publish analyses on this dataset
- The time scales for publication vary from short term (next few months) to the end of the year
- This is due to different degrees of sophistication required by each particular analysis
- We expect to publish > 50 papers on this dataset

The path to publication

- Most of our analyses were blessed for presentation purposes for the winter and summer conferences 2003
- These analyses were based on about 100 pb^{-1} or less
- A few analyses were assigned godparents at this stage
- Analyses are now being updated to include the full dataset
- Next blessing is intended to be for publication
- Godparent committees are assigned after the final blessing to review the paper draft and move the analysis to publication
- This last step is typically a few months

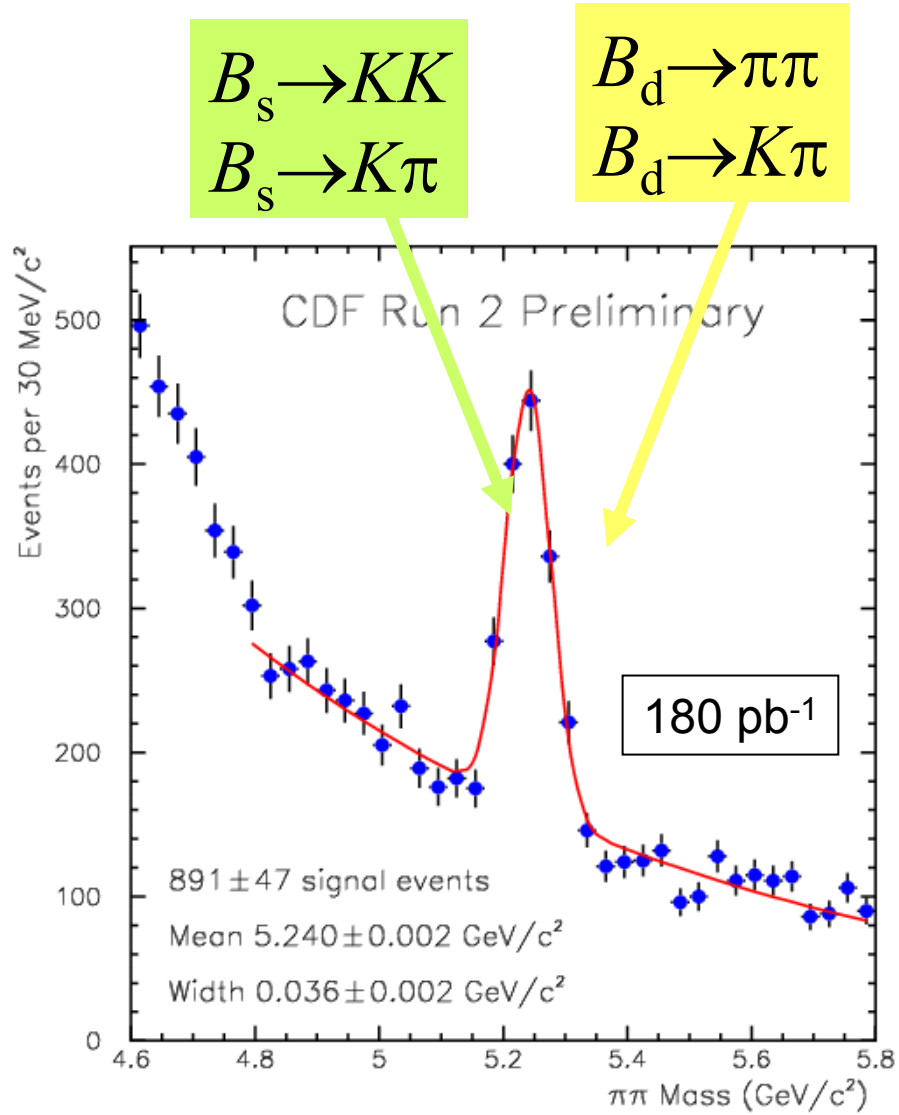
Heavy Flavors

Heavy Flavors

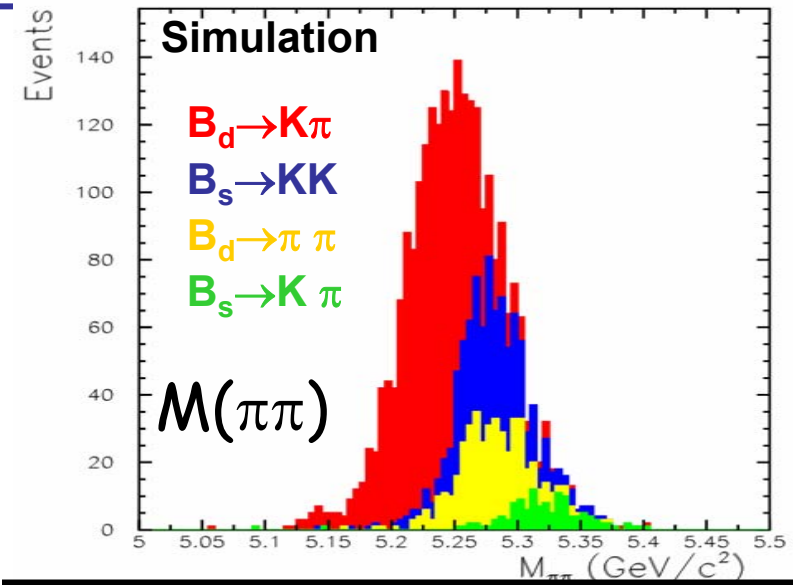
- 4 papers submitted or published
  - Ds, D^+ mass difference (Phys. Rev. D68, 072004, 2003)
  - Search for $D \rightarrow \mu\mu$ (Phys. Rev. D68, 091101, 2003)
  - Prompt Charm cross section (accepted to PRL)
  - Observation of X(3872) - used $220pb^{-1}$
- 6 papers in godparent publication review
  - D* relative BR and CP asymmetry
  - Inclusive J/Psi cross section
  - B hadron masses (including Bs and Λb)
  - BR of $\Lambda b \rightarrow \Lambda c\ \pi$
  - BR of $Bs \rightarrow Ds\ \pi$
- 3 analyses blessed – godparents soon
- 10 more papers moving towards blessing and pub

$B \to h^+h^-$ Decays

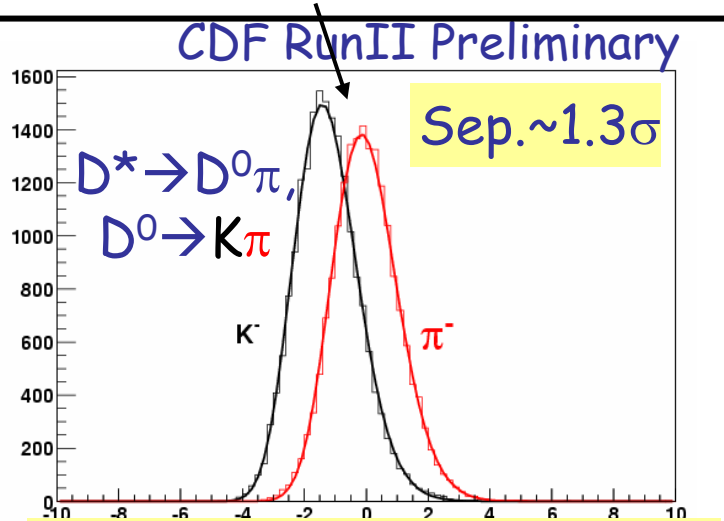
- $B_d \to \pi\pi$ and $B_s \to KK$ modes are sensitive to CP angle γ.
- $B_{(d,s)} \to K\pi$ and above modes are separated statistically by kinematics and particle ID.
- $B(B_d \to \pi\pi)/B(B_d \to K\pi) = 0.26 \pm 0.11 \pm 0.055$.
- First observation of $B_s \to K^+K^-$.



$BR(B_s \to K^+K^-)$



kinematics & *dE/dx* to separate contributions



Fitted contributions:

mode	Yield (65 pb^{-1})
$B^0 \to K\pi$	148±17(stat.)±17(syst)
$B^0 \to \pi\pi$	39±14(stat.)±17(syst)
$B_s \to KK$	90±17(stat.) ±17(syst)
$B_s \to K\pi$	3±11(stat.) ±17(syst)

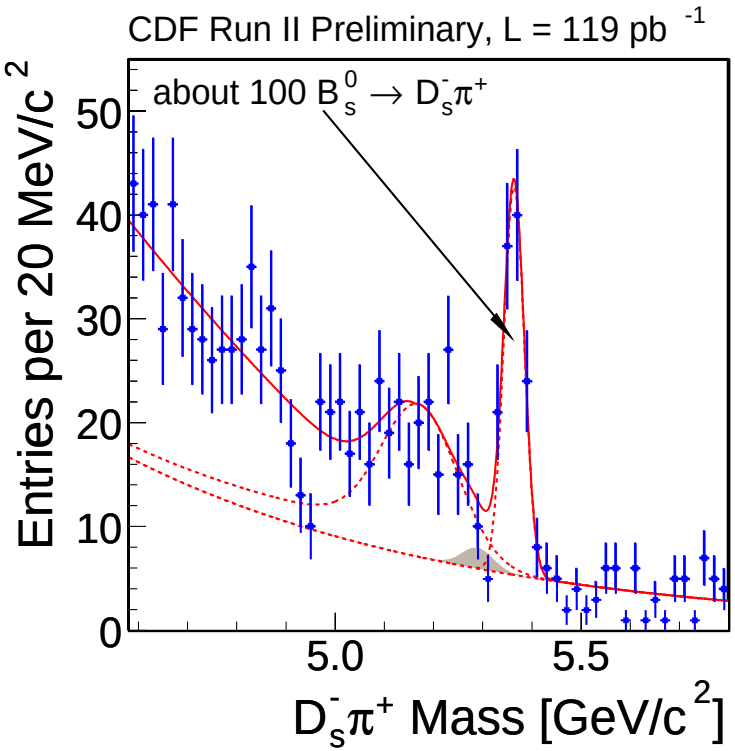
First observation of $B_s \to K^+K^-$!!

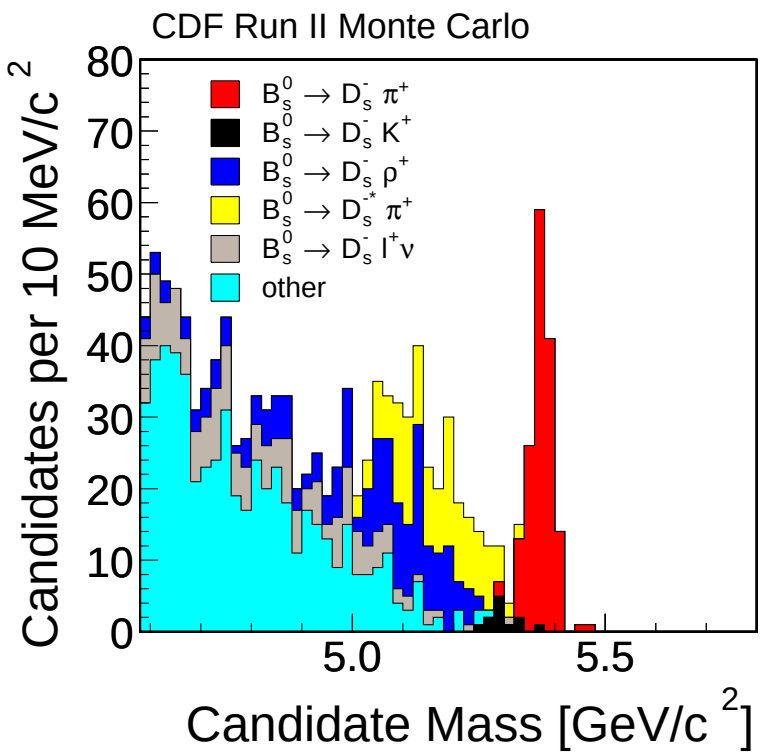
Result: $$\frac{f_s BR(B_s \to KK)}{f_d BR(B^0 \to K\pi)} = 0.74 \pm 0.20 \pm 0.22$$

Measure A_{CP}

$$\frac{N(\bar{B} \to K^-\pi^+) - N(B \to K^+\pi^-)}{N(\bar{B} \to K^-\pi^+) + N(B \to K^+\pi^-)} = 0.02 \pm 0.15 \pm 0.02$$

B_s hadronic yields



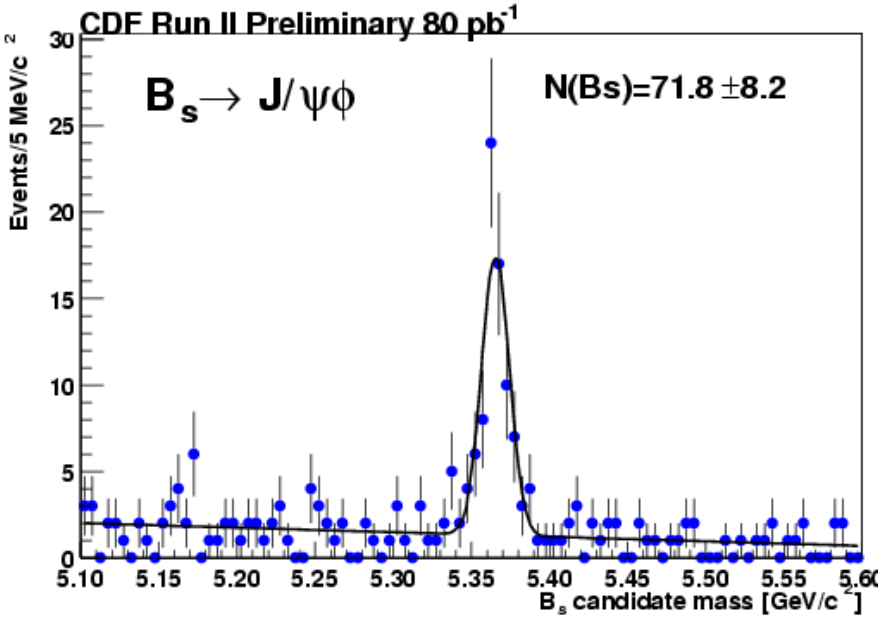


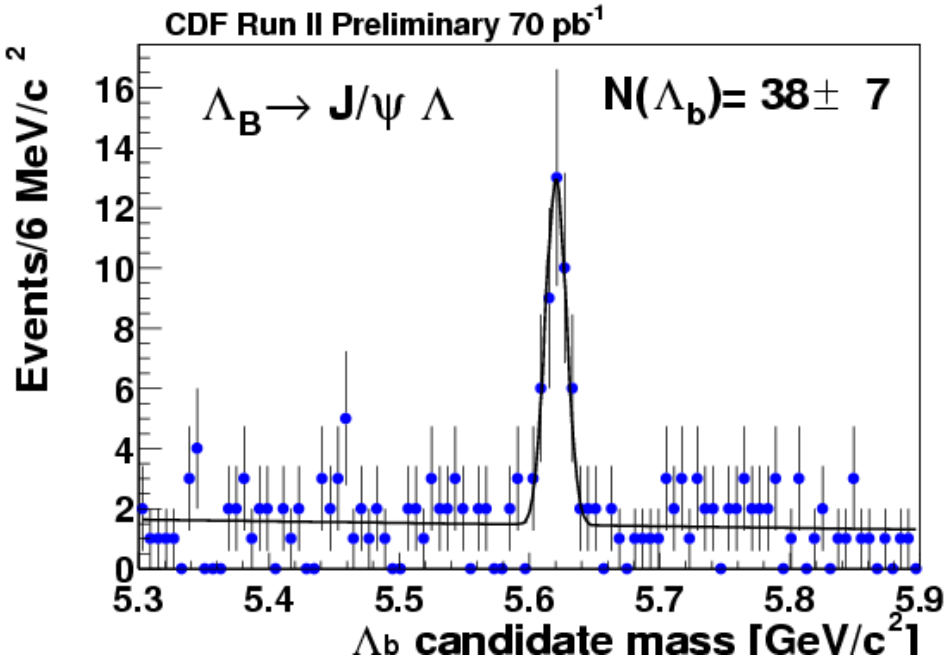
$B^0_s \to D^-_s \pi^+$ with $D^-_s \to \phi \pi^-$ and $\phi \to K^- K^+$

$$\frac{f_s \, BR(B_s^0 \to D_s^- \pi^+)}{f_d \, BR(B^0 \to D^- \pi^+)} = 0.35 \pm 0.05(stat) \pm 0.03(syst) \pm 0.09(BR)$$

$$\frac{BR(B_s^0 \to D_s^- \pi^+)}{BR(B^0 \to D^- \pi^+)} = 1.4 \pm 0.2(stat) \pm 0.1(syst) \pm 0.4(BR) \pm 0.2(PR)$$

B Hadron Masses





- World's best mass measurements for B_s and Λ_B:

$M(B_s) = 5365.50 \pm 1.29 \pm 0.94$ MeV and $M(\Lambda_B) = 5620.4 \pm 1.6 \pm 1.2$ MeV

- Lifetime measurements for B_s and Λ_B:

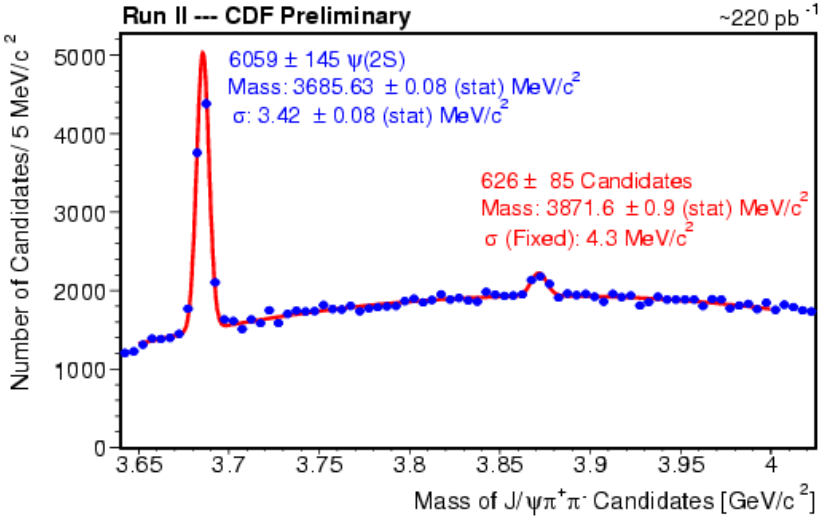
B_s lifetime $1.33 \pm 0.14_{(stat)} \pm 0.02_{(sys)}$ ps (PDG 1.461 ± 0.057 ps)

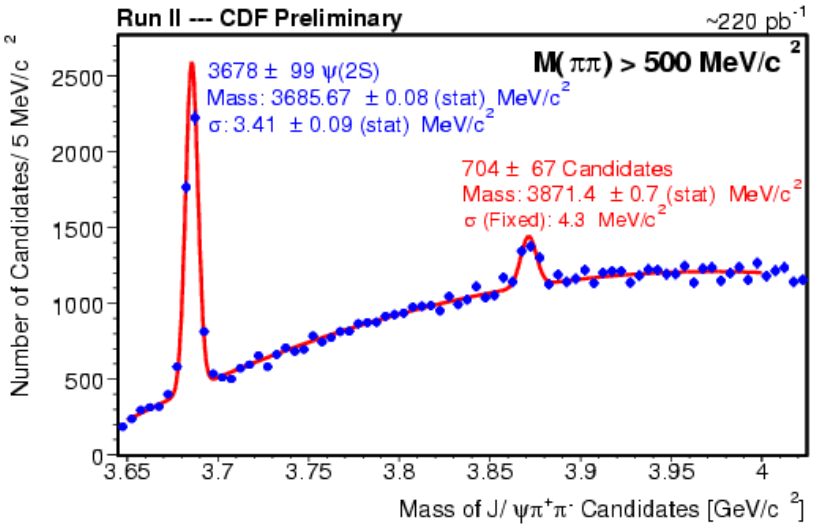
Λ_B lifetime $1.25 \pm 0.26_{(stat)} \pm 0.10_{(sys)}$ ps (PDG 1.229 ± 0.08 ps)

First lifetime from fully reconstructed Λ_b decay!

X(3872)

- New state observed by Belle in $B \rightarrow XK \rightarrow J/\psi\ \pi^+\pi^- K$ final state of narrow width.
- Tevatron: this state produced directly, or via *B* decays.
- CDF observes this state at the same mass.
- Belle reports that $M(\pi\ \pi)$ distribution suggests a ρ resonance.
- Submitted to PRL Dec 4th
- M = 3871.3 ± 0.7 (stat) ± 0.4(sys) MeV



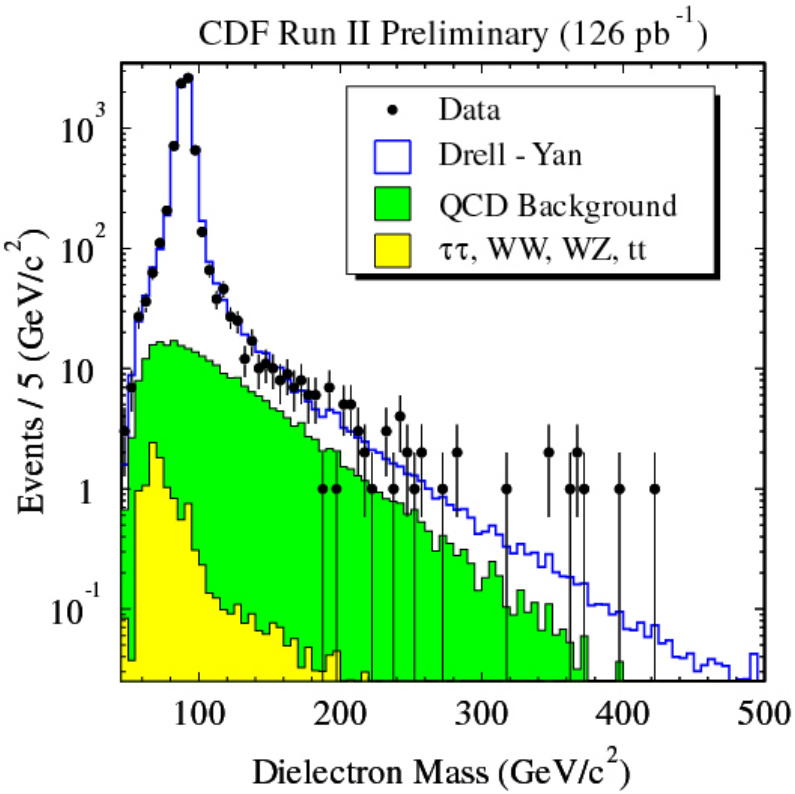


Exotics

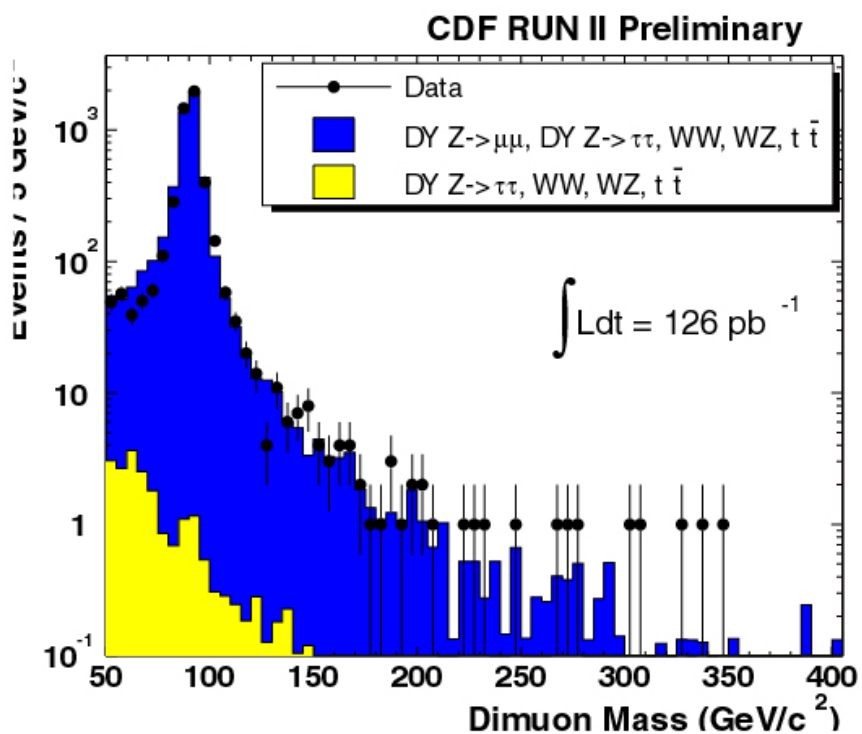
Exotics

- 2 papers in godparent publication review
  - Bd, Bs $\rightarrow$ μμ
  - W/Z + gamma
- Forming godparent committees for 5 analyses
  - Z' $\rightarrow$ ee, μμ
  - Leptoquark $\rightarrow$ jet jet MET
  - e* $\rightarrow$ e gamma
  - sbottom $\rightarrow$ b LSP
  - H++ $\rightarrow$ ee, μμ, eμ
- 12 analyses moving towards final blessing
- ~ 20 additional analyses under way

Z' and RS Gravitons

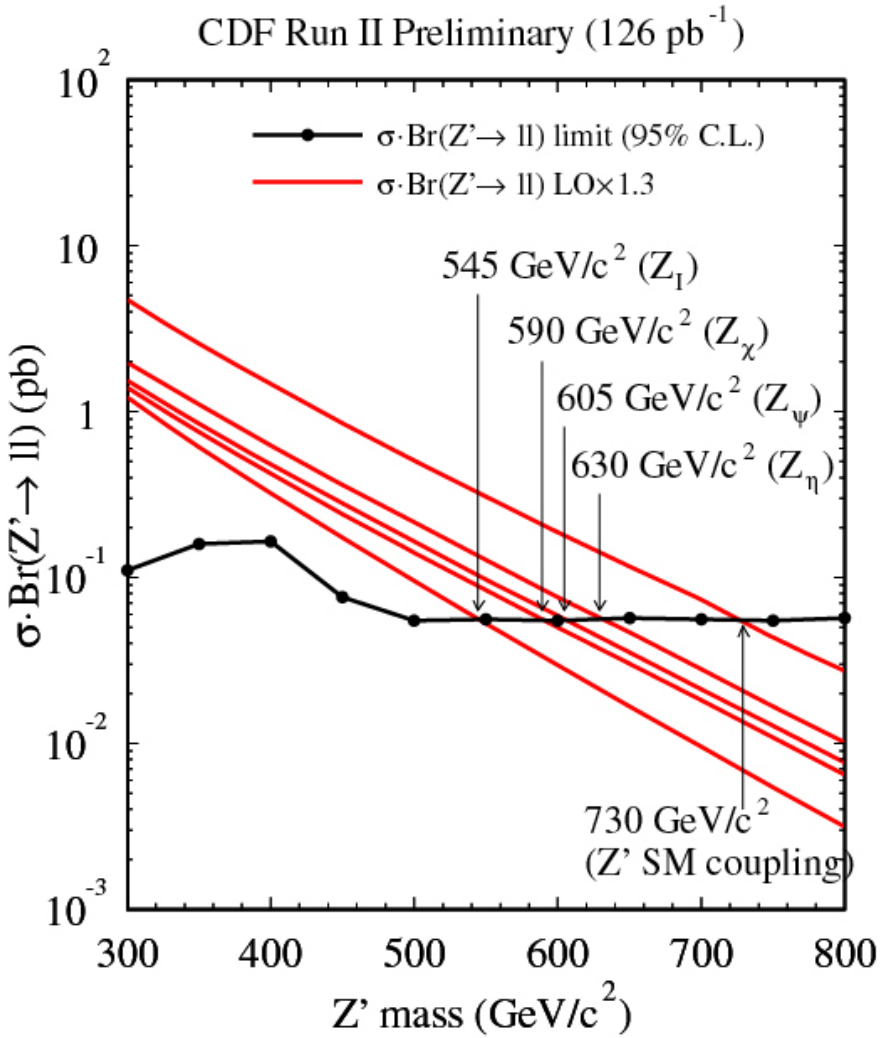


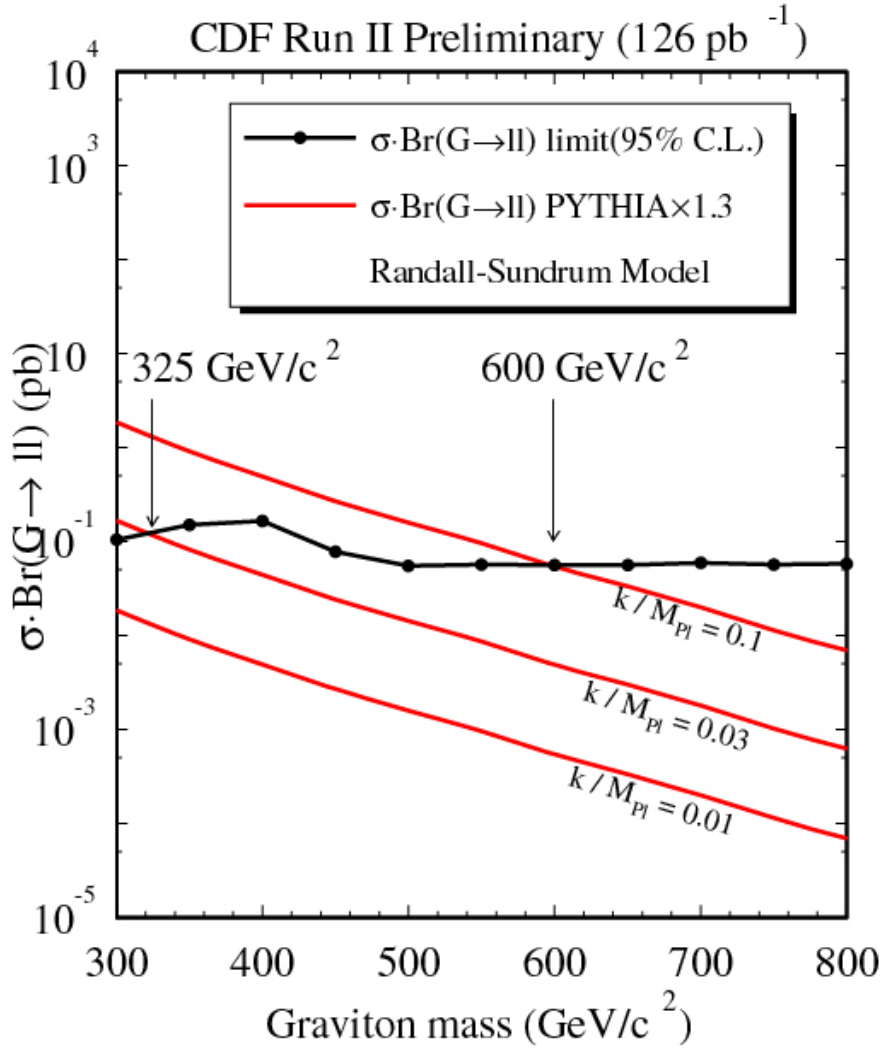
- Search for high mass opposite sign dilepton pairs
- Assume narrow resonance



Z' and RS Graviton Mass Limits

e^+e^- and $\mu^+\mu^-$ combined



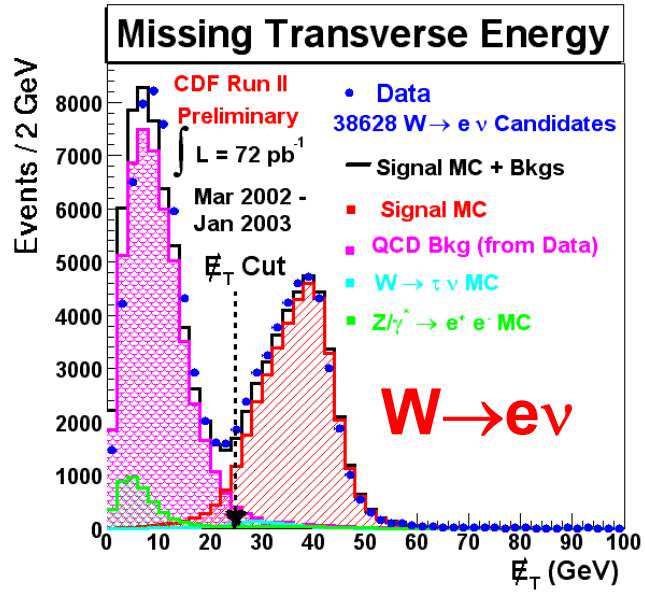


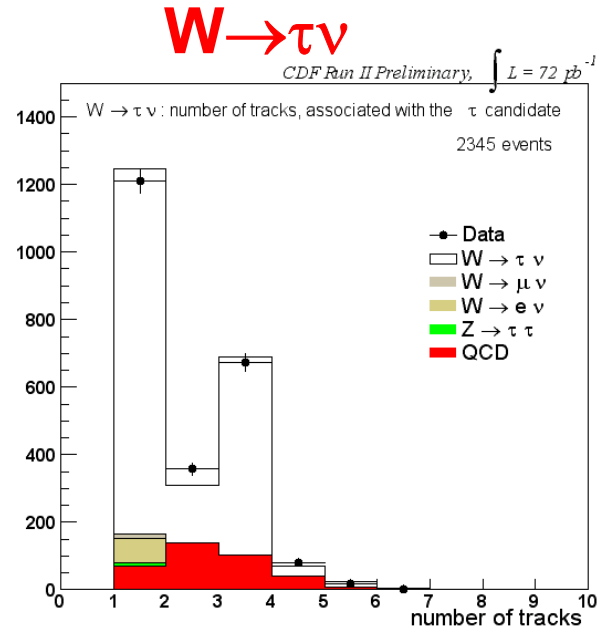
Electro-Weak

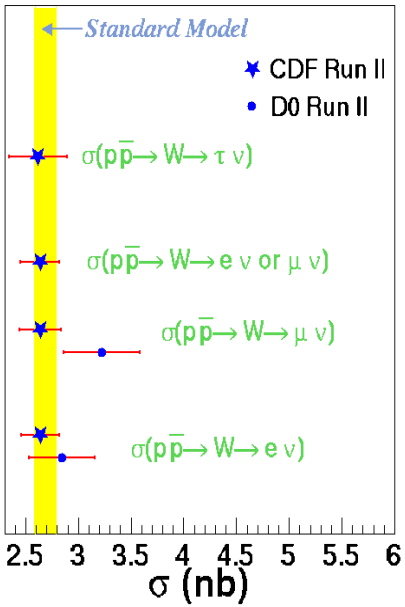
Electro-Weak

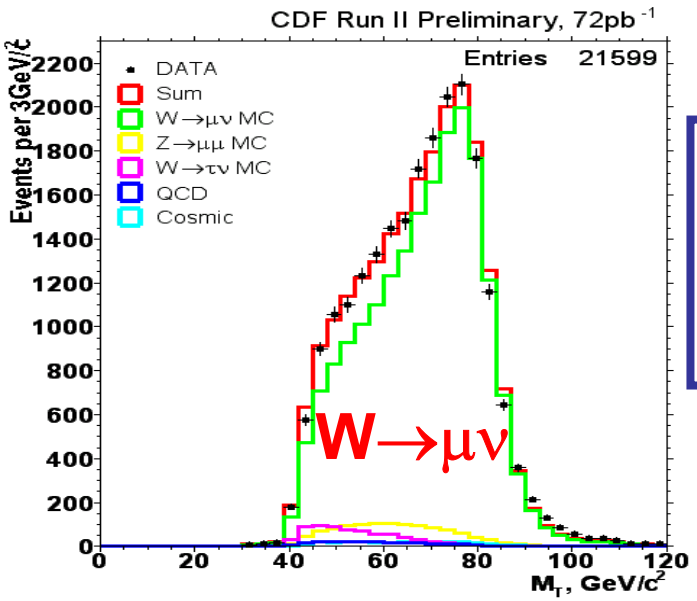
- 2 papers in godparent publication review
  - Forward-backward asymmetry in $Z \rightarrow e^+e^-$
    - First draft ready for Collaboration in ~2 weeks
  - W/Z cross section e, μ
    - First draft ready in about a month
- Forming godparent committees
  - WW cross section in dilepton channel
  - W/Z cross section in tau channel
- Moving towards final blessing
  - W mass

W Cross Section (e, μ, τ channels)



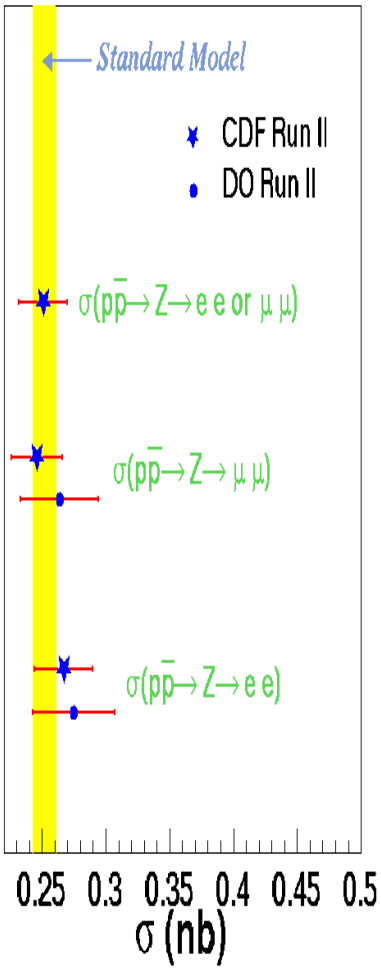


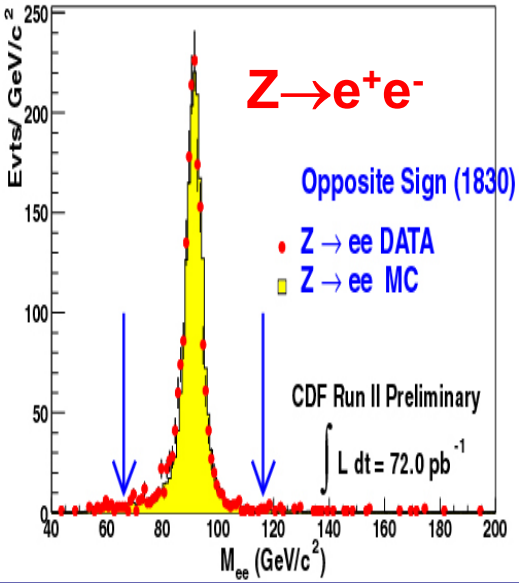


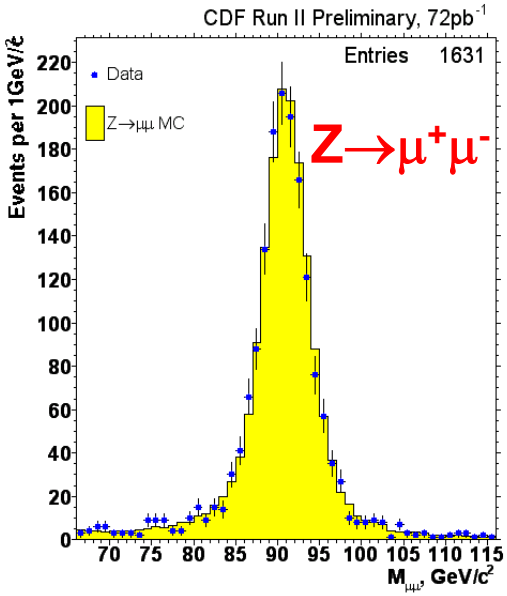


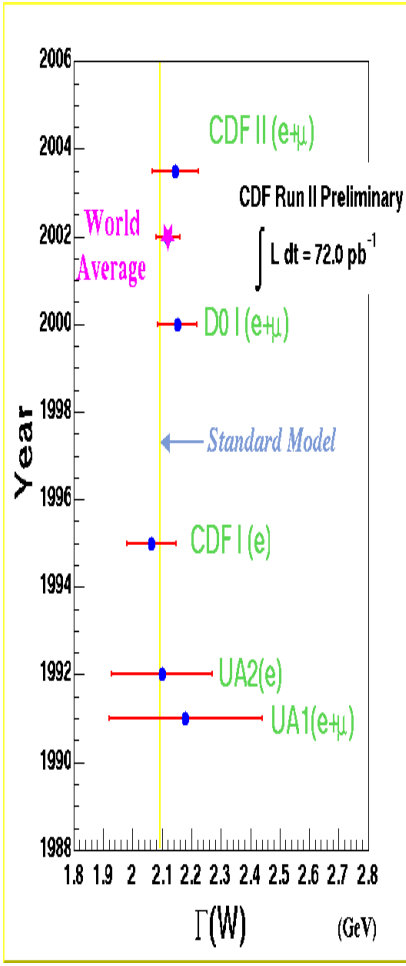
$\sigma \bullet Br(W \to e\nu)$	=	2.64	±	.01	±	.09	±	.16	nb
$\sigma \bullet Br(W \to \mu\nu)$	=	2.64	±	.02	±	.12	±	.16	nb
$\sigma \bullet Br(W \to \tau\nu)$	=	2.62	±	.07	±	.21	±	.16	nb
				stat		syst		lumi	

Z Cross Section, R, Γ(W)









$\sigma \bullet Br(Z \to e^+e^-)$	=	267	±	6.3	±	15.2	±	16	pb
$\sigma \bullet Br(Z \to \mu^+\mu^-)$	=	246	±	6	±	12	±	15	pb
				stat		syst		lumi	

$$R = \frac{\sigma_W}{\sigma_Z} \cdot \frac{\Gamma(Z)}{\Gamma(Z \to \ell^+\ell^-)} \cdot \frac{\Gamma(W \to \ell\nu)}{\Gamma(W)}$$

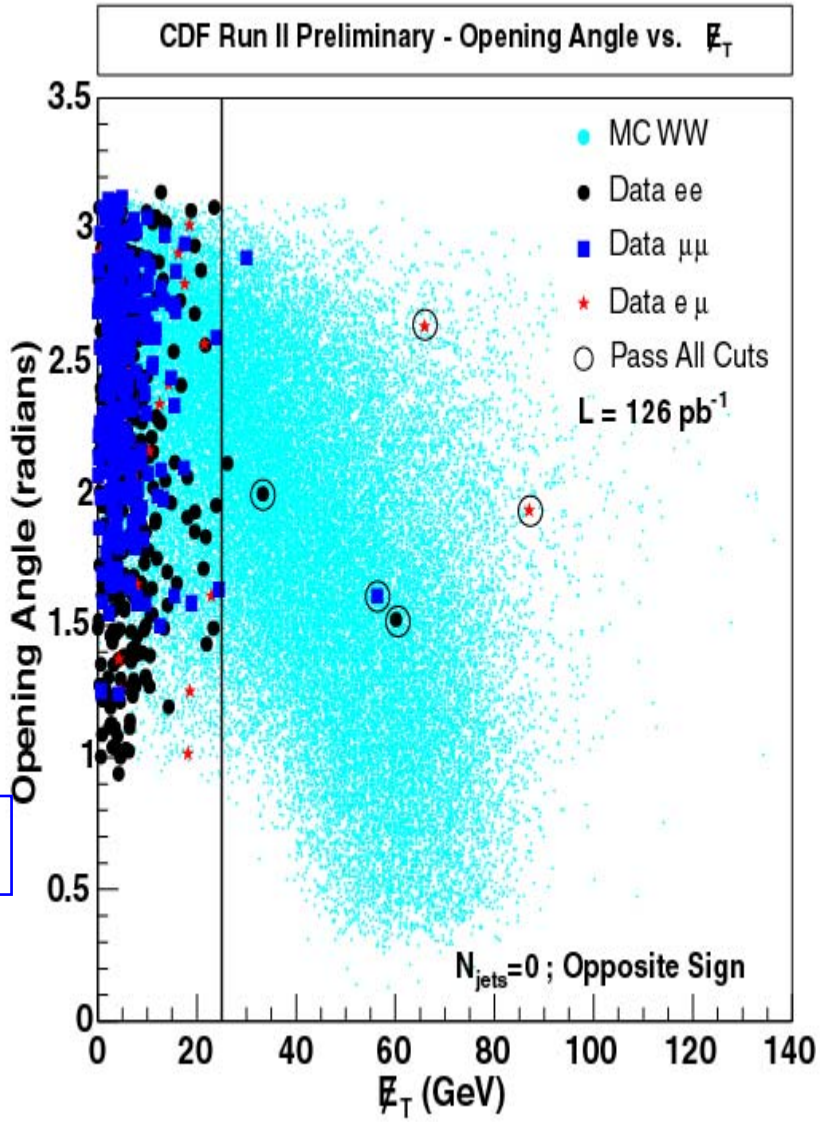
NNLO LEP measure

VVV Coupling: WW

- Opposite-charge, high p_T iso lepton (μ, e) pair
- $E_T^{miss} > 25$ GeV
- ...
- 5 events seen
- 9.2 events expected

$$\sigma = 5.1^{+5.4}_{-3.6}(\text{stat}) \pm 1.3(\text{syst}) \pm 0.3(\text{lumi})\text{pb}$$

✓ **In agreement with SM prediction**



QCD

QCD

- Form godparents early next year
  - Underlying event studies
  - Jet shapes/energy flow
- Form godparents by summer
  - Inclusive jet cross-section
  - Dijet mass
  - Heavy Flavor + gamma
- Form godparents by fall
  - Diffractive exclusive χ_c production…
  - W+jets cross section
  - B jet cross section
  - Dijet angular distributions

Highest E_T Jets Ever

Run 152507 event 1222318

Dijet Mass = 1364 GeV (corr)

cos θ* = 0.30

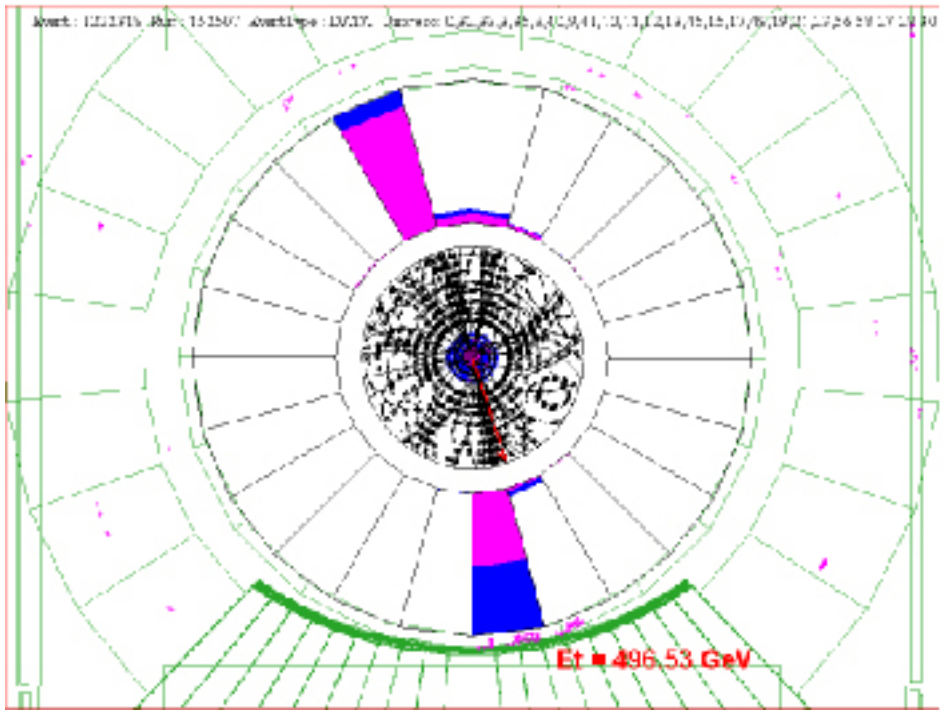
z vertex = -25 cm

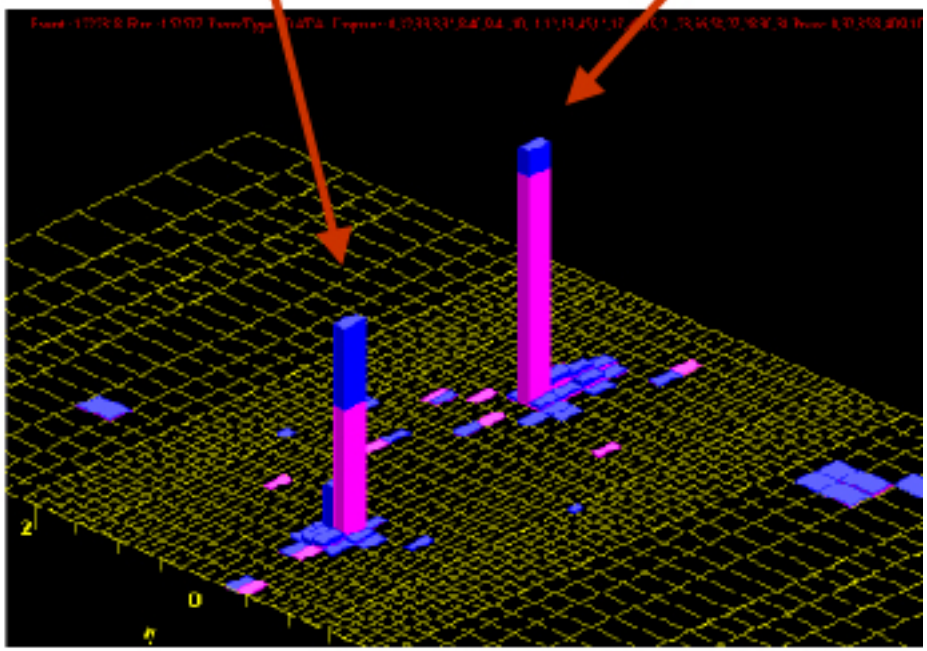
J2 E_T = 633 GeV (corr)
546 GeV (raw)

J2 η = -0.30 (detector)
= -0.19 (correct z)

J1 E_T = 666 GeV (corr)
583 GeV (raw)

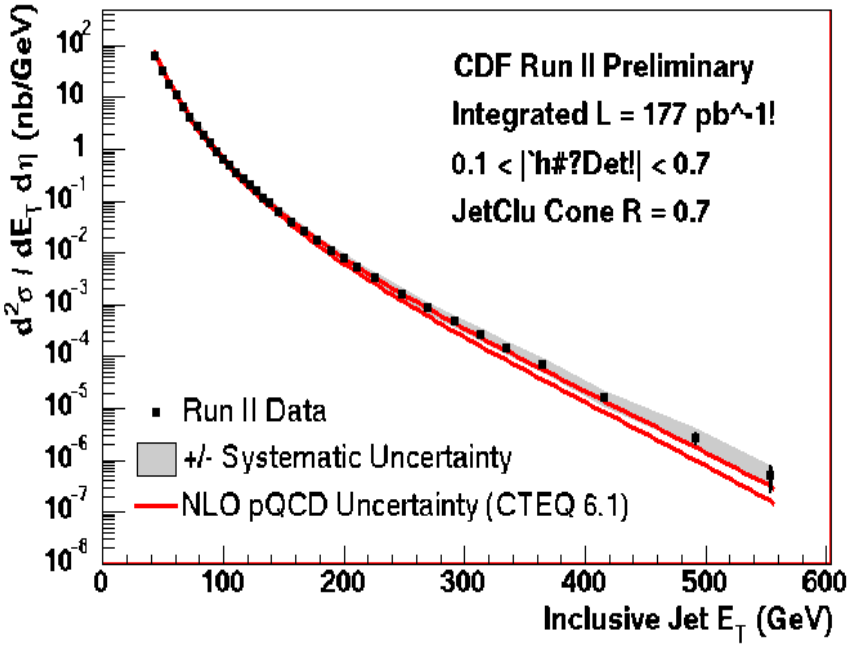
J1 η = 0.31 (detector)
= 0.43 (correct z)

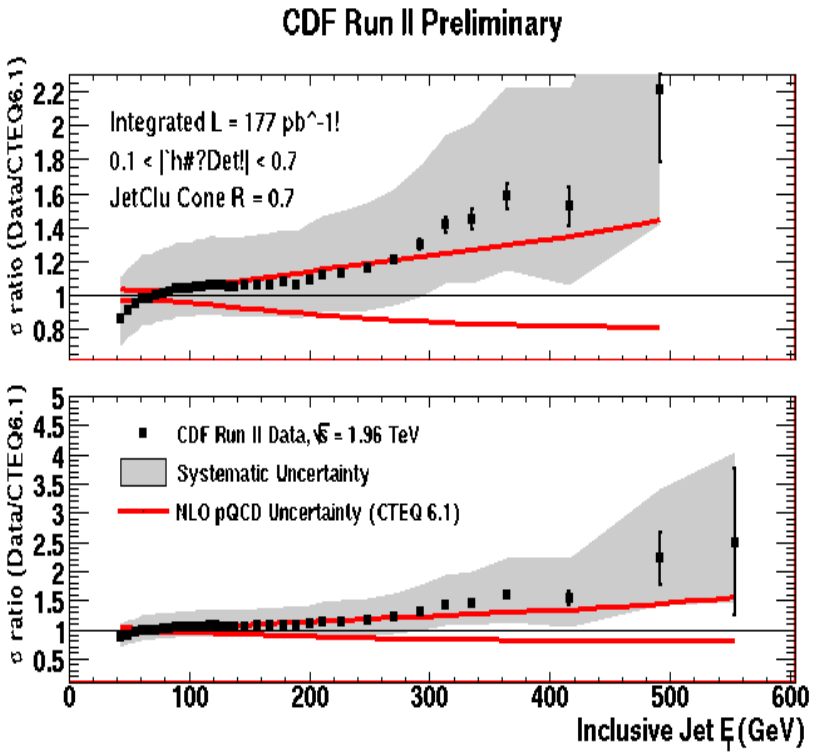




CDF Run 2 Preliminary

Inclusive Jet Cross Section vs NLO QCD





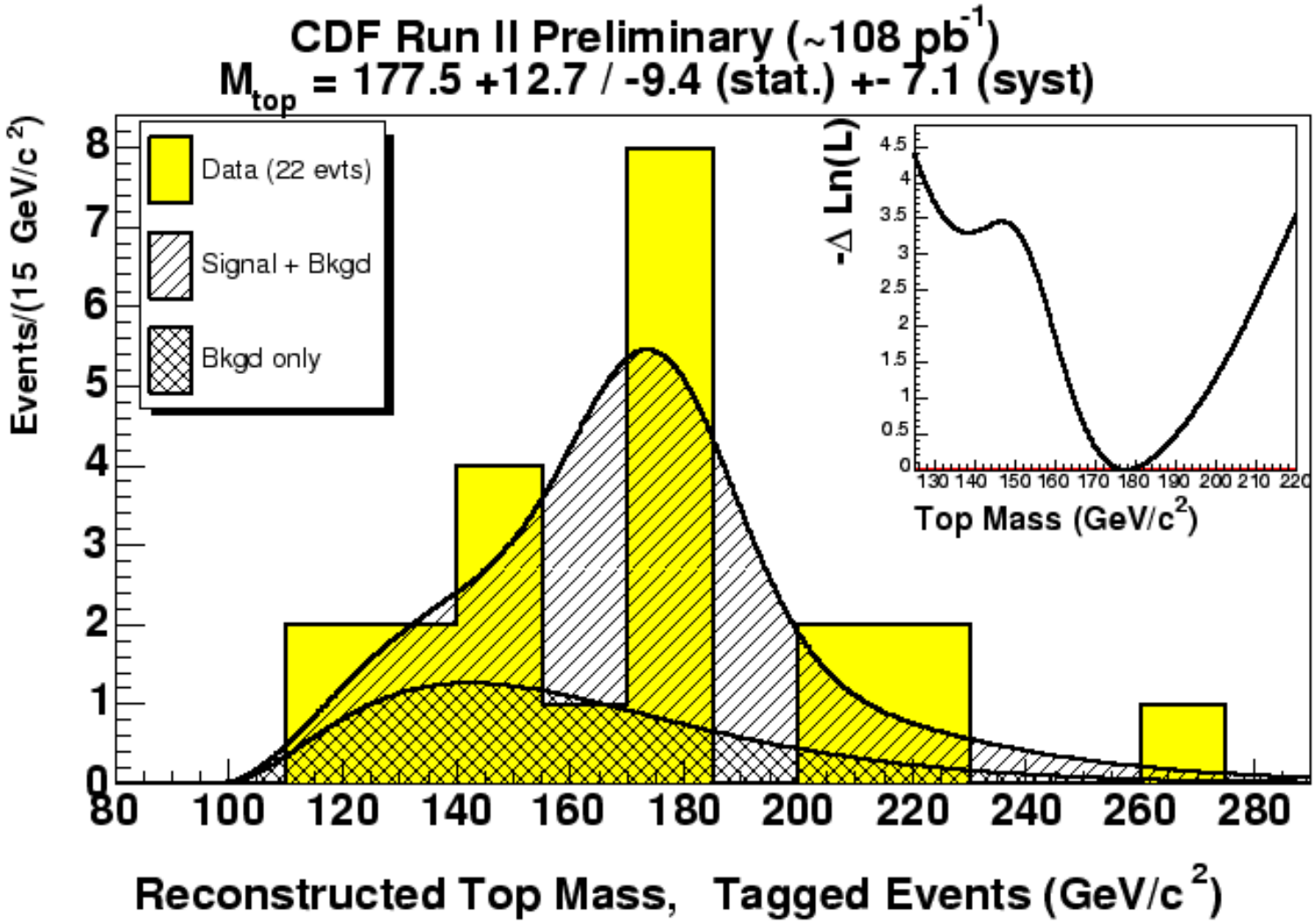
- Theoretical error dominated by PDF's
- Data currently agrees with NLO prediction within estimated errors

Top

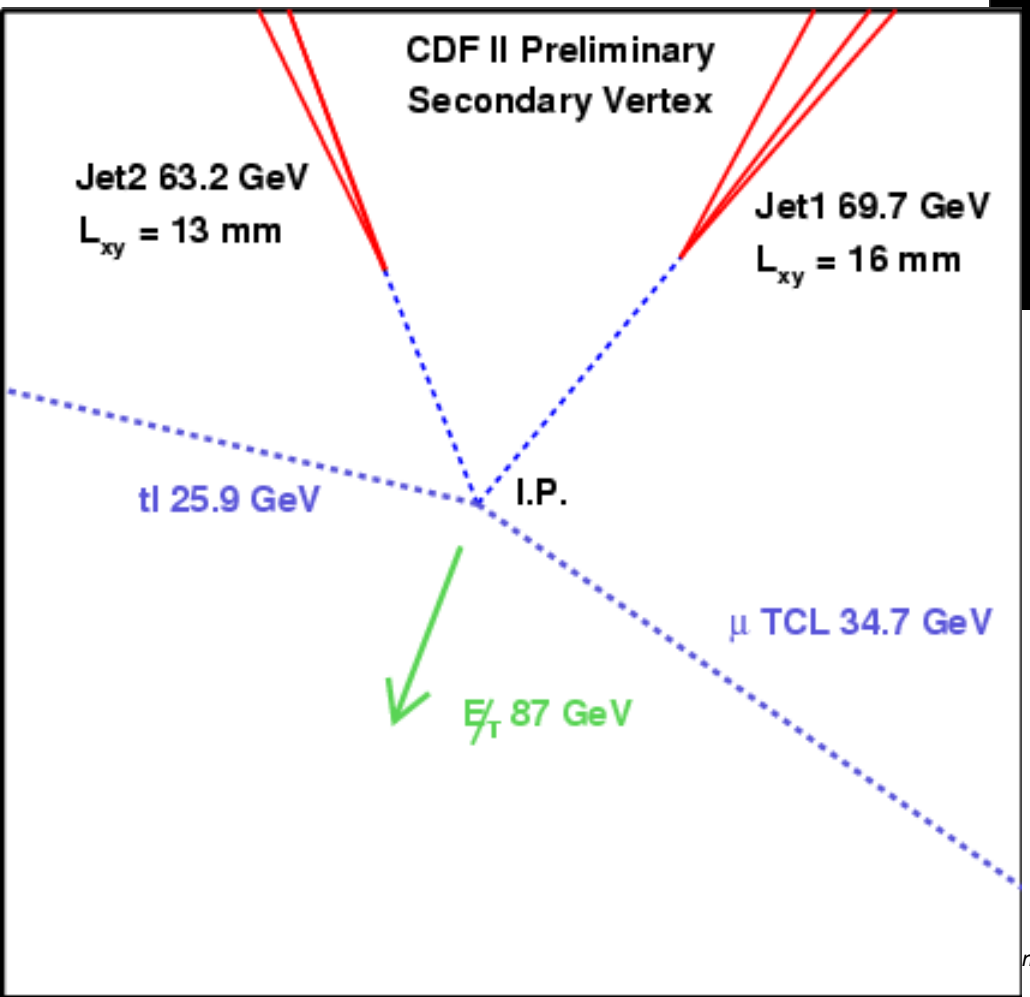
Top

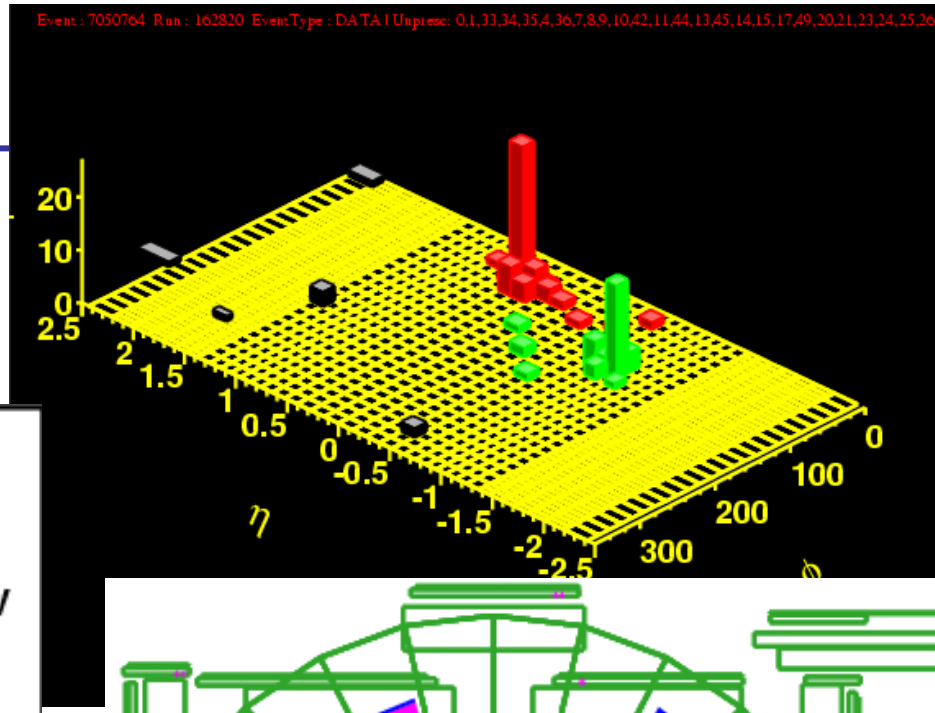
- Formed godparent committee for Top dilepton cross section
- Forming godparent committees for Top cross-section
  - Kinematic cross-section (Ht, Et)
  - W+jets – vertex tagged B-jets
  - W+jets – lepton tagged
- Forming godparent committees for Top mass
  - Expect to publish by end of year
- Moving towards final blessing
  - W helicity
  - Single top

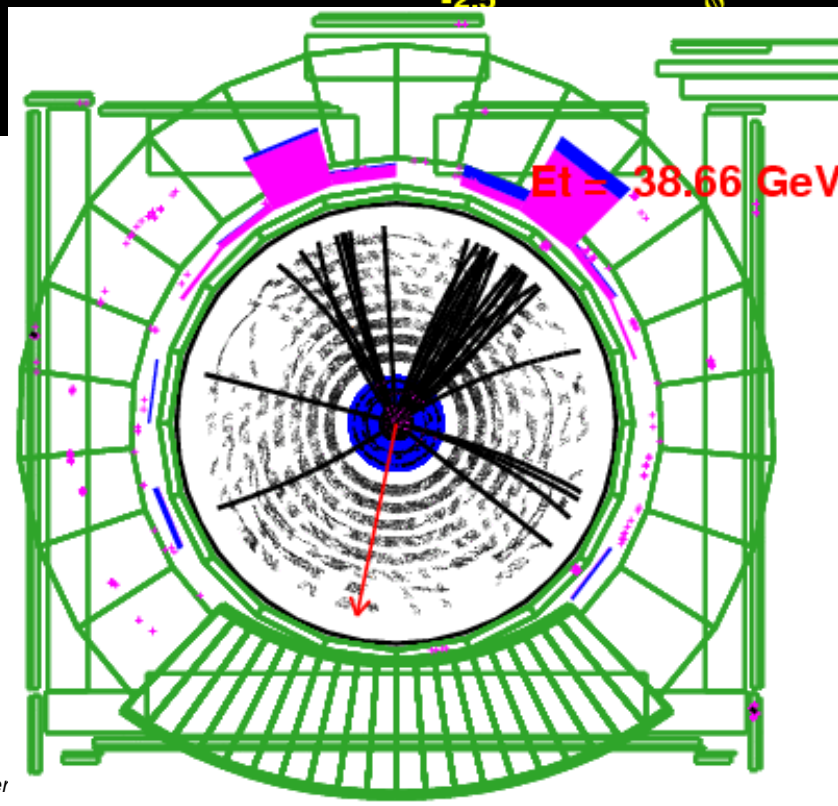
Run II Top Mass: lepton + jets



Double b-tagged Lep+Trk event at CDF

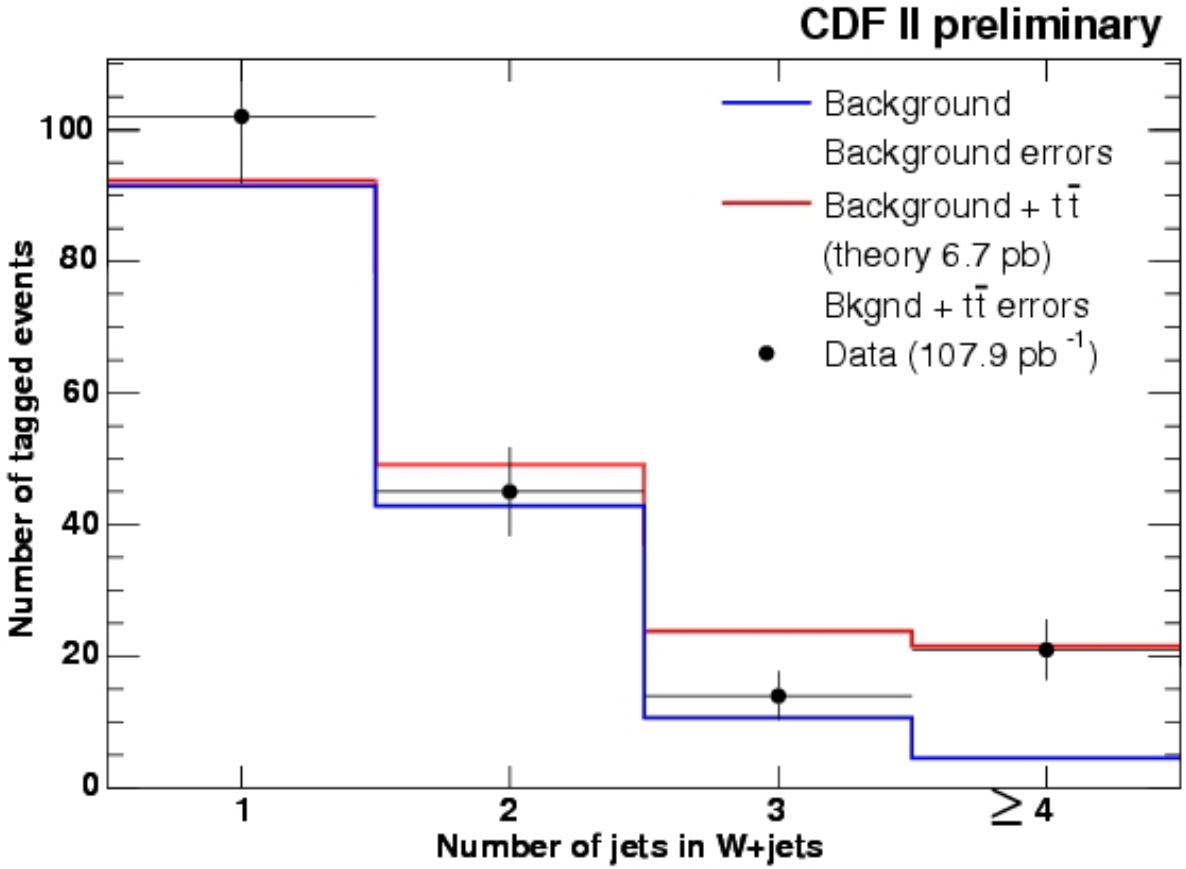






n Over

Jet Multiplicity (with top contribution)

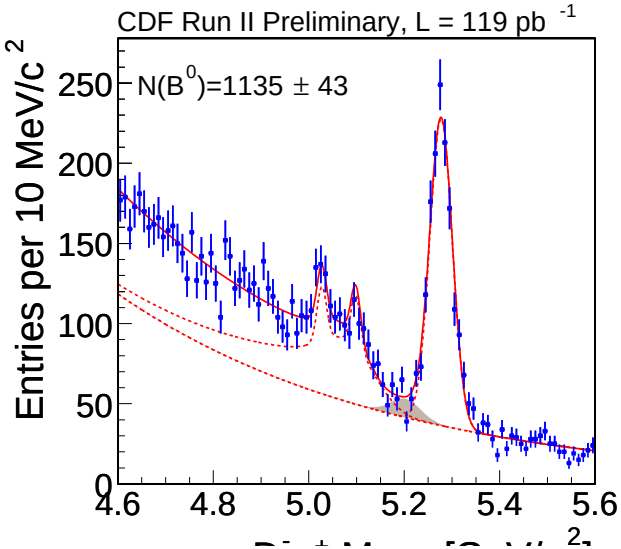


$$\sigma_{l+jets} = 4.5 \pm 1.4(stat) \pm 0.8(syst)\ pb$$

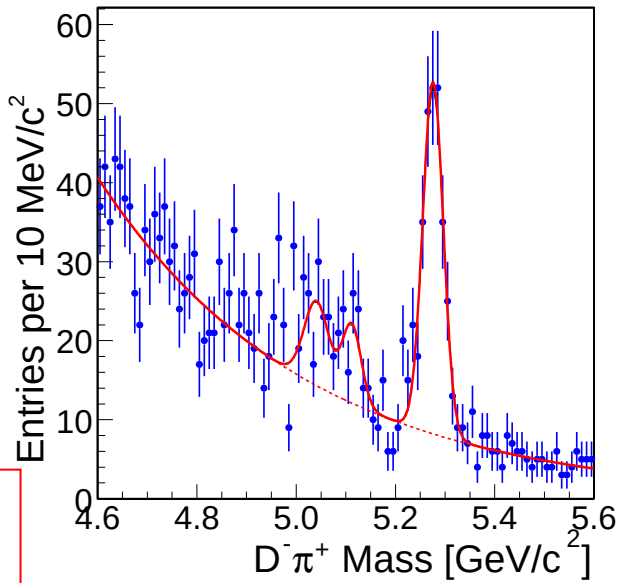
Trigger and DAQ Extensions

Hadronic Trigger paths

- Scenario A
  - Two tracks Pt > 2 GeV/c
  - Impact parameter 120μm < d < 1 mm
  - Opposite charge
  - Sum of Pt > 5.5 GeV/c
  - Opening angle < 135^0



- Scenario Low (prescaled)
  - Two tracks Pt > 2 GeV/c
  - Impact parameter 120μm < d < 1 mm
  - Opening angle < 90^0
- S/B is similar in both plots
- Scenario Low is good for physics



Please note the integrated luminosities of Two plots are not equal.

Increasing the number of events to tape

- Trigger and DAQ extensions are aimed to preserve the CDF high-Pt physics program at higher luminosity
- Bandwidth must be large enough to ensure full efficiency for high priority triggers at peak luminosity at start of store
- Bandwidth is filled with lower priority triggers as the luminosity falls during the course of a store
- The added data sample is statistically significant and of only slightly lower purity
  - Scenario A = 400nb (not prescaled)
  - Scenario Low = 1000nb - adds ~66% more signal (prescaled)
  - Scenario A is a subset of Scenario Low
  - Relative figure of merit is 66% x 400/(1000 – 400) = 44%
- 1nb from “Low” is worth 0.44 nb from “A”

Extensions of the CDF trigger & DAQ

- Program of trigger improvement and optimization
  - SVX reduced readout time – implemented
  - SVT “4 out of 5” logic – implemented
  - Level1 & Level2 relaxed triggers with dynamic prescale – implemented
  - Über-Prescale – testing
  - XFT upgrade – under construction
  - L2 decision crate upgrade – under construction
  - SVT upgrade– under construction
- Removal of Level3/CSL bandwidth limitations
  - Full SVX tracking in Level3 – implemented
  - Data compression in Level3 – implemented
  - Consumer Server Logger (CSL) upgrade – implemented soon
  - COT reduced readout time – under construction
  - Event Builder upgrade – under construction

Bs yield

- Assume Tevatron luminosity profile as in May 2003
- May was a month of excellent Tevatron performance
- Typical prescale factor for Scenario Low is 1.5
  - Gain from prescaled trigger = 66% / 1.5 = 44%
- We measure a yield of $Bs \rightarrow Ds\ \pi$ ~ 1600 events/fb^{-1}
- After improvements we expect ~ 2000 events/fb^{-1}
- With no trigger improvements, at luminosities above $5x10^{31}$ Scenario A would have to be prescaled and the Bs yield per fb^{-1} would drop
- In this case bandwidth improvement becomes critical

Summary

- CDF physics is limited by trigger/DAQ bandwidth
- Any significant increase in luminosity will force us to prescale our B physics triggers even more
- Trigger and DAQ upgrades are in the pipeline
  - See Ted Liu's status talk
- Larger datasets will require greater computing resources
- We expect continued strong support from CD
- We plan to get the additional resources from outside Fermilab – CDFGrid
  - See Frank Würthwein's talk

We are asking for your endorsement of this plan