Diffractive W Production

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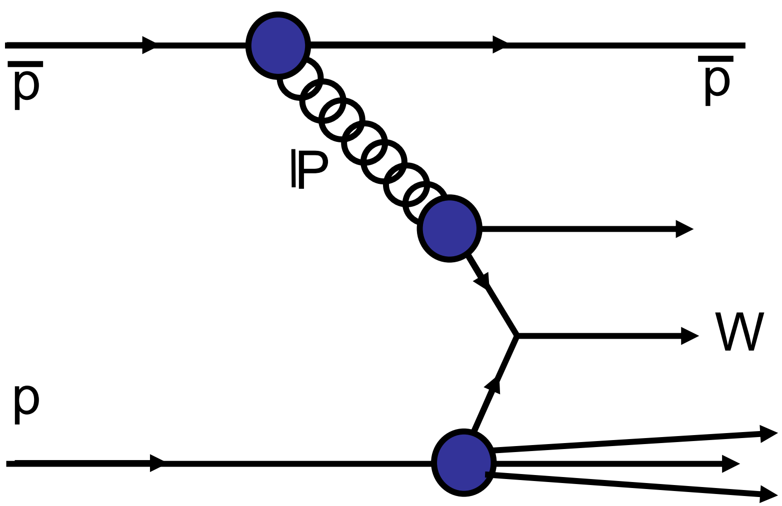
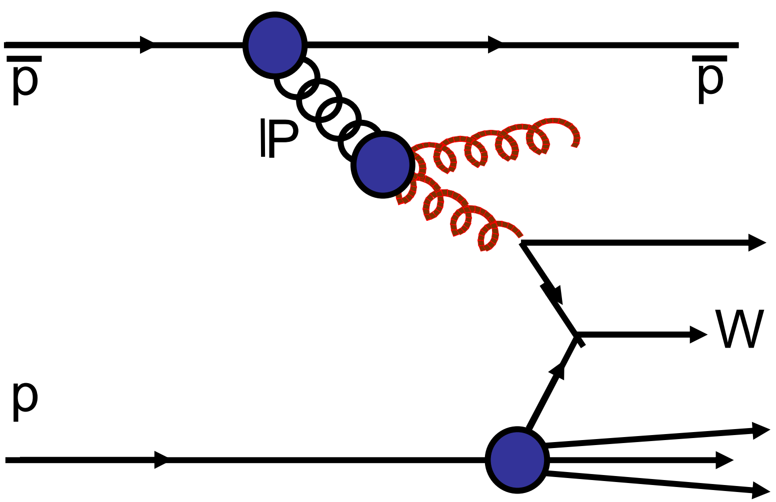
Diffractive W Production

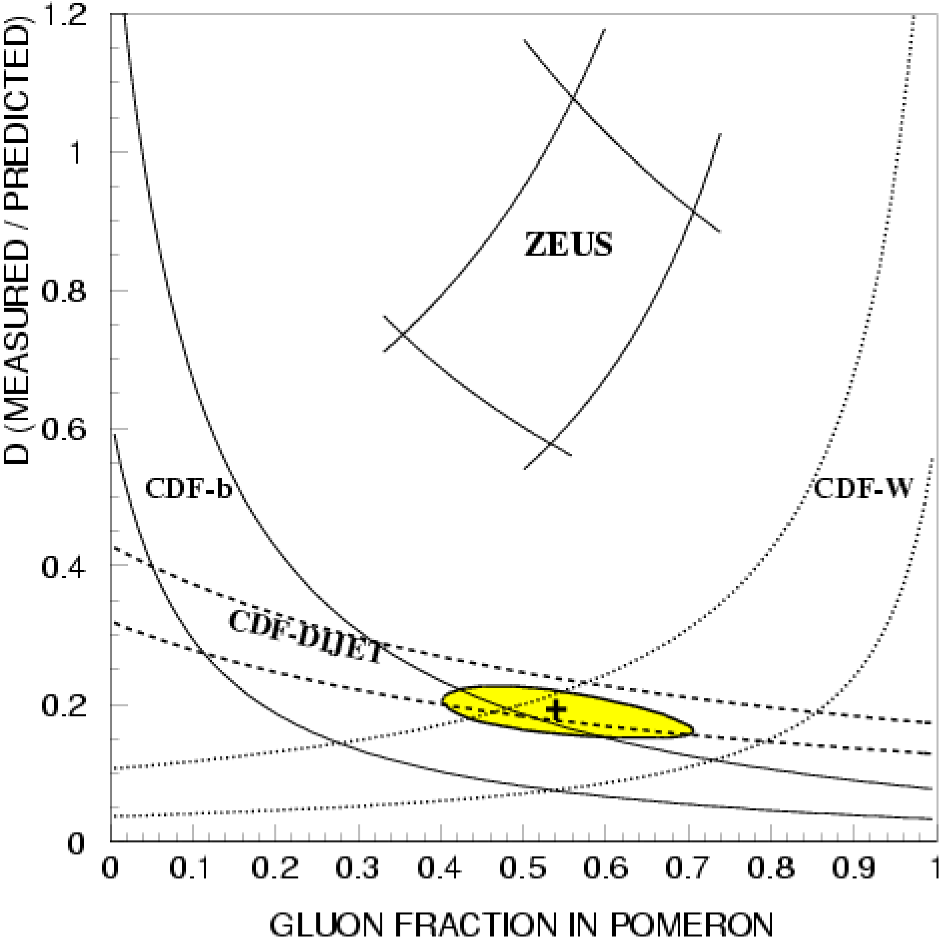
- The study of diffractive W production helps to determine the quark content of the pomeron
  - To leading order, the W is produced by a quark in the pomeron
  - Production by gluons is suppressed by a factor of α_S, and can be distinguished from quark production by an associated jet





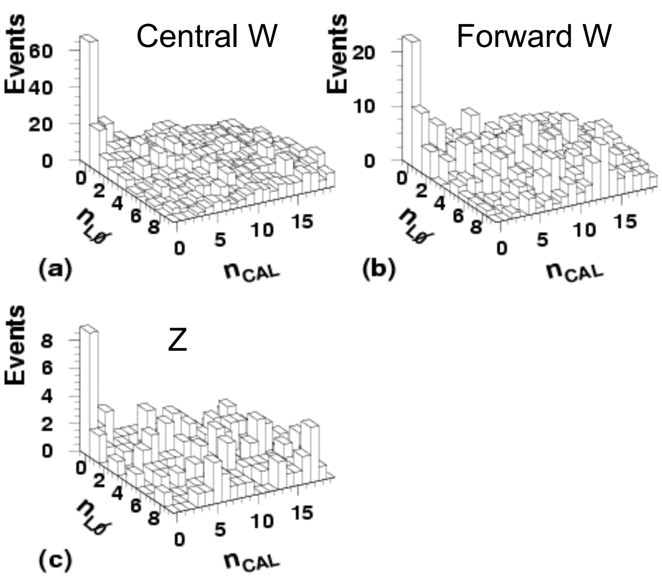
Partonic structure of the Pomeron

- Combining diffractive dijet production with diffractive W production can be used to determine the quark/gluon content of the Pomeron



Diffractive W production – Run I

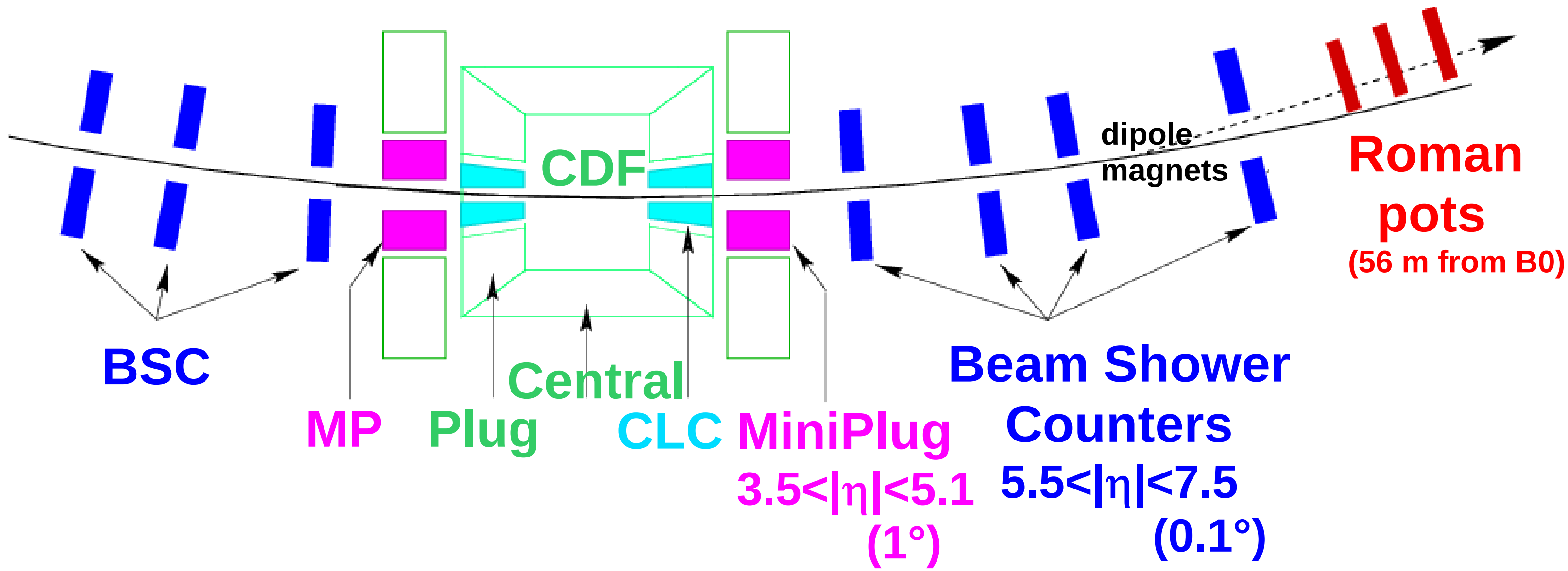
- Run I studies used rapidity gaps instead of Roman-pots
- CDF Phys Rev Lett **78**, 2698 (1997)
  - Fraction of W events due to SD [1.15±0.51(stat)±0.20(syst)]%
  - Observed fraction of events with a jet consistent with production via quarks
- DØ Phys Lett B **574**, 169 (2003)
  - Fraction of events with rap gap (uncorrected for gap survival)
  - W: [$0.89^{+0.19}_{-0.17}$]%
  - Z: [$1.44^{+0.61}_{-0.52}$]%



Diffractive W Production – Run II

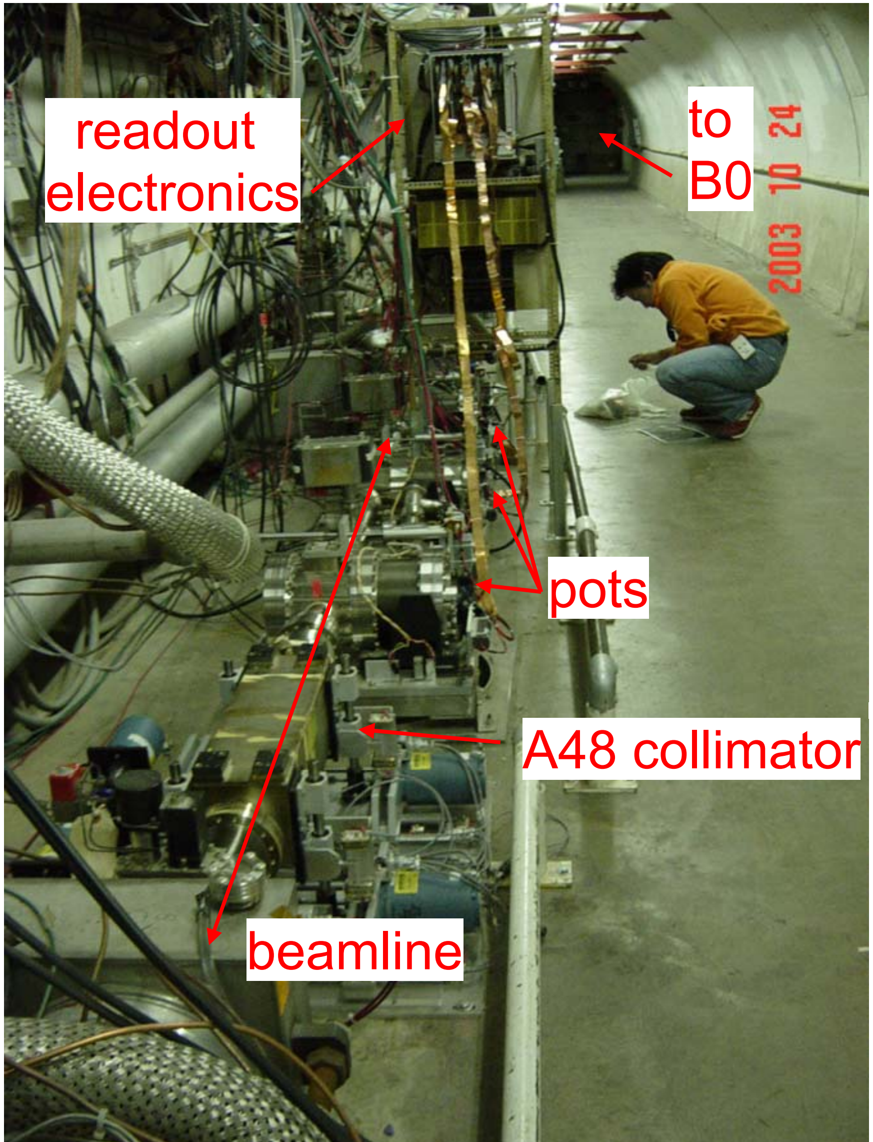
- Analysis using Roman-pot information:
  - No background from gaps due to multiplicity fluctuations
  - No gap survival probability
  - RPs provide accurate event-by-event ξ measurement
  - Have devised a method to determine the kinematics of diffractive W production by comparing the momentum carried by the diffractive exchange, ξ, determined from the RP track to the ξ calculated from the energy in the calorimeter – difference should be due to the ν, allowing us to determine its kinematics
    - W mass
    - x_{Bj}
    - Will determine the diffractive structure function

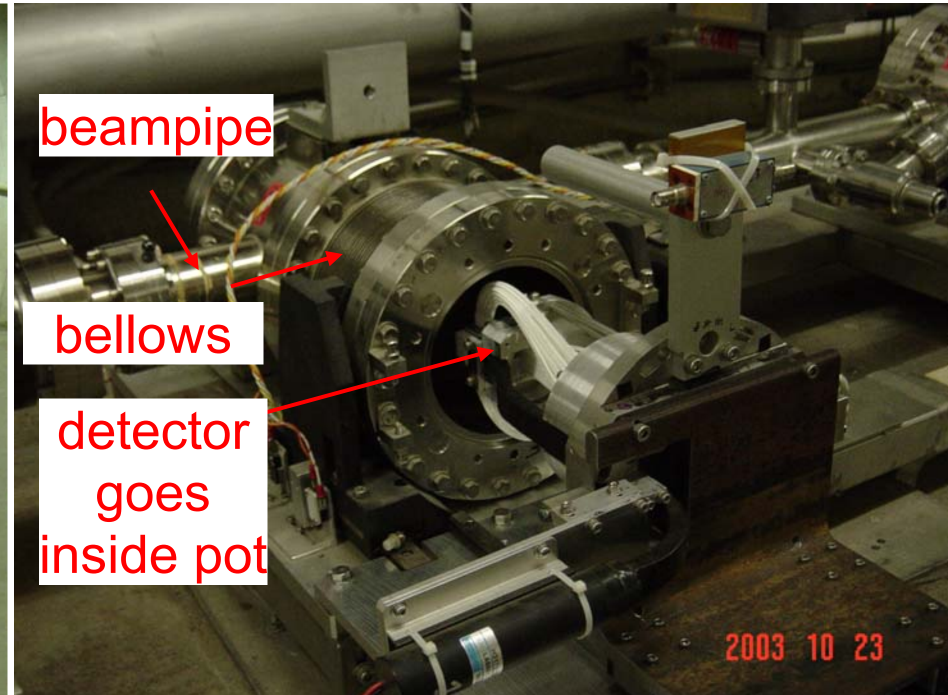
CDF Run II Forward Detectors

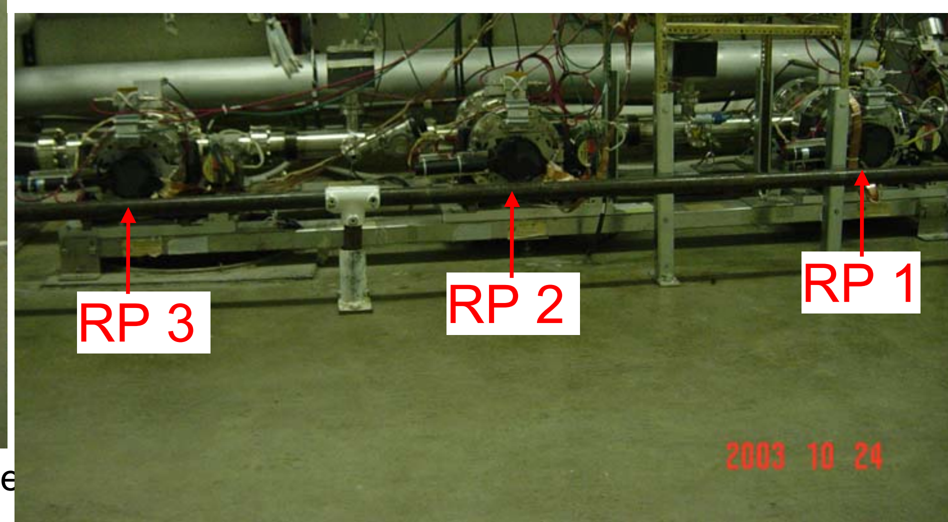


- 3 Roman pots ~56m downstream in antiproton direction
- The Tevatron dipoles bend diffractive antiprotons with ~90-97% of the beam momentum into the RP detectors
- The CDF Roman-pots were used in Run Ic (1995-96) and were operated in Run II from 2002 to February 2006

CDF Roman-pot detectors



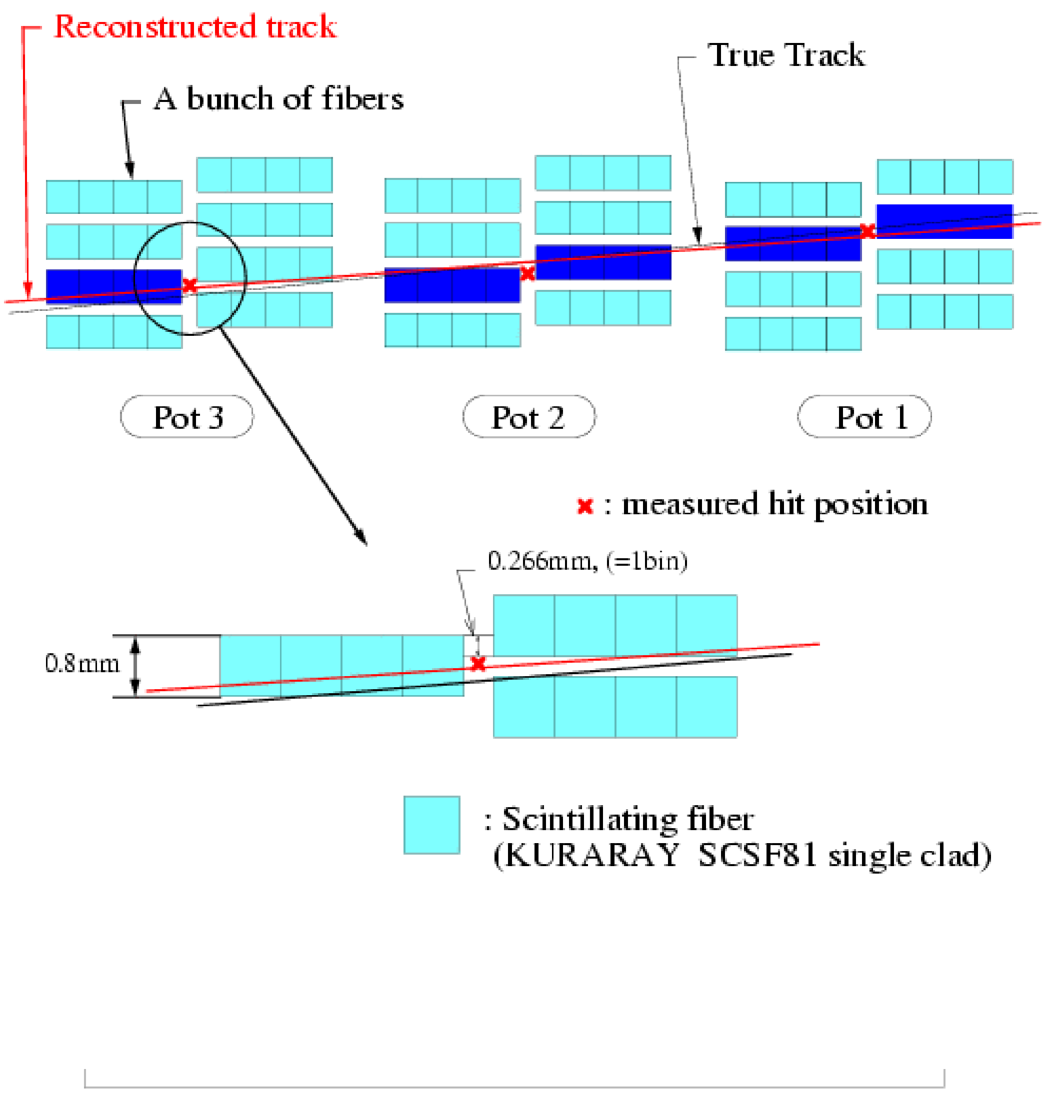




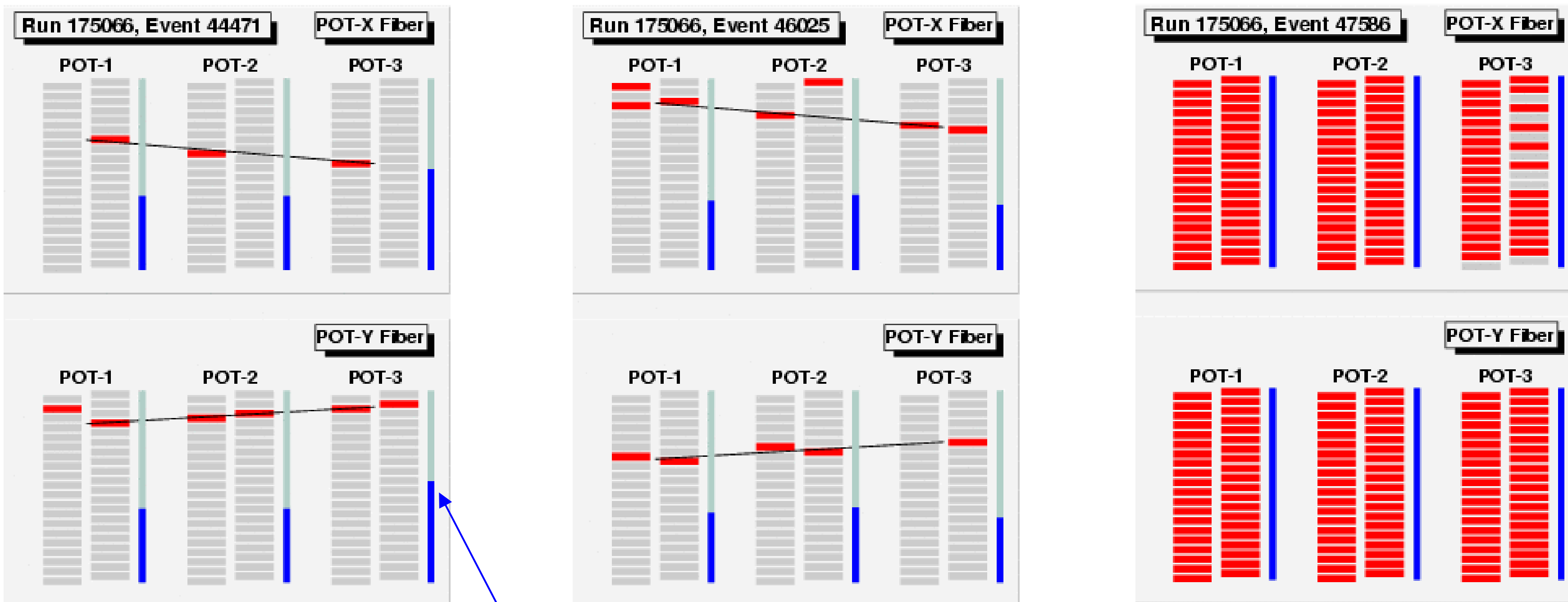
CDF Roman-pot detector design

The 3 Roman pots each contain detectors consisting of:

- Trigger scintillation counter 2.1x2.1x0.8 cm^3
- 40 X + 40 Y fiber readout channels
  - Each consists of 4 (→ bigger signal) clad scintillating fibers 0.8x0.8 mm^2 (new technology at the time)
  - X,Y each have 2 rows of 20 fibers spaced 1/3 fiber width apart for improved position resolution (3x better position resolution than with a single row)



RP fiber tracking

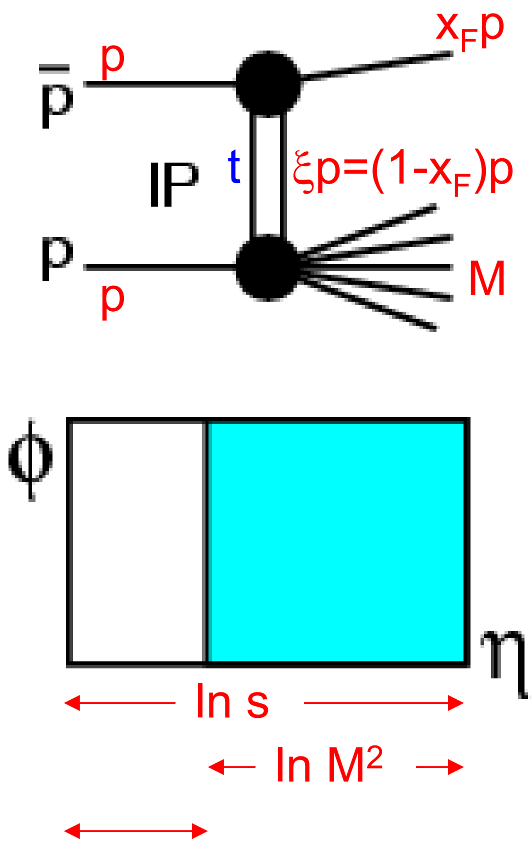


Height represents amount of energy in trigger counter

"Splash" event: high energy in trigger counters

- Reconstruct a track in ~75% of "non-splash" RP-triggered events
- A large fraction of RP triggers are due to background such as
  - Diffractive pbar outside RP acceptance showers in material near RP
  - Beam-induced interactions in nearby material (more in 2005-6, possibly correlated with DØ putting their dipole pots in farther!)

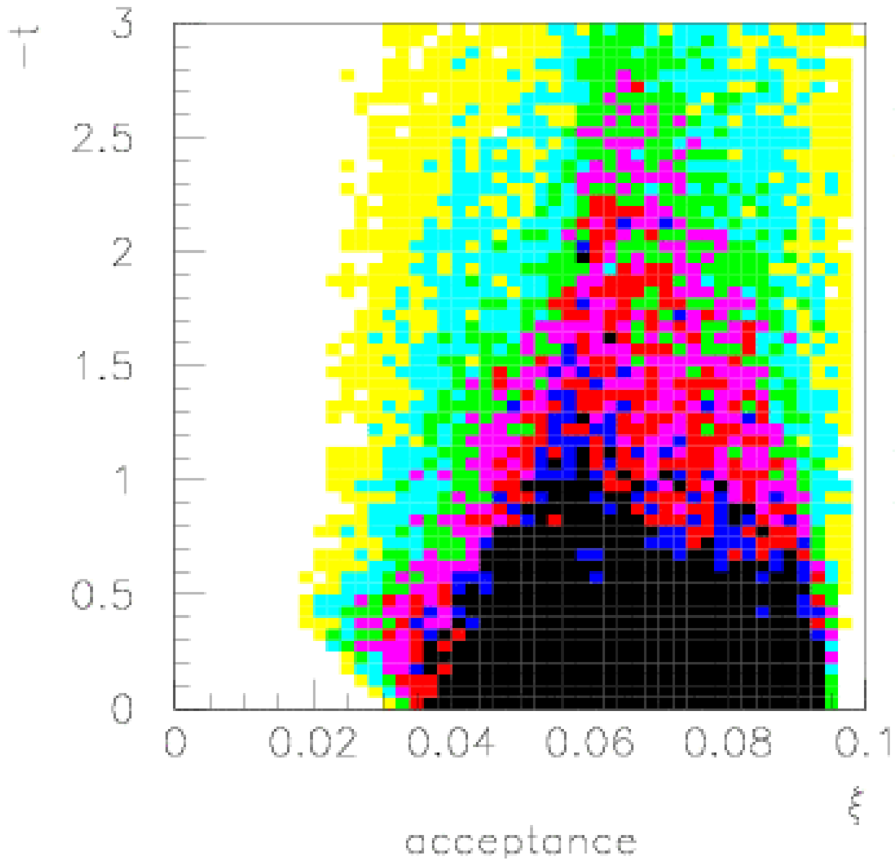
Kinematics of a diffractive interaction



$\Delta\eta = -\ln \xi = \ln(s/M^2)$

- ξ = fractional momentum loss of (anti)proton
- t = four-momentum transfer squared
- CDF Roman pot acceptance: ~ $0.03<\xi<0.10$, $0<|t|<1$
- The diffractive exchange is colorless (vacuum quantum numbers), creating a gap in rapidity space of width $\Delta\eta$ void of particles, referred to as a "rapidity gap"

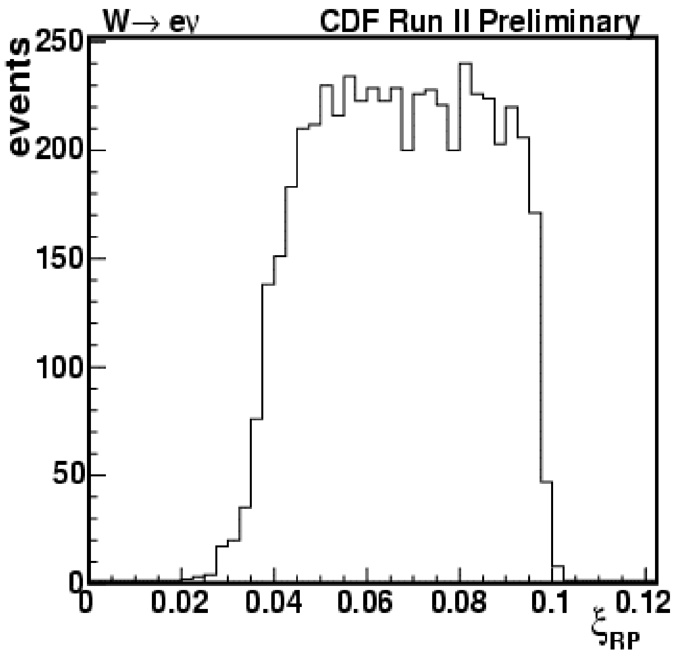
RP acceptance from simulation

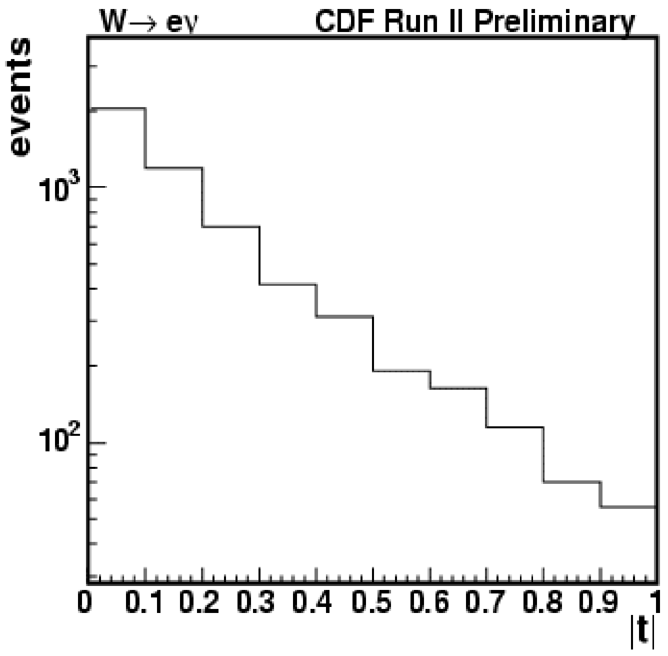


Region of good acceptance 0.035<ξ<0.095, |t|<1

Roman-pot track kinematics

- Roman-pot tracking used to determine ξ, t of diffractive anti-proton (plots from sample of W events, no single-interaction requirement)

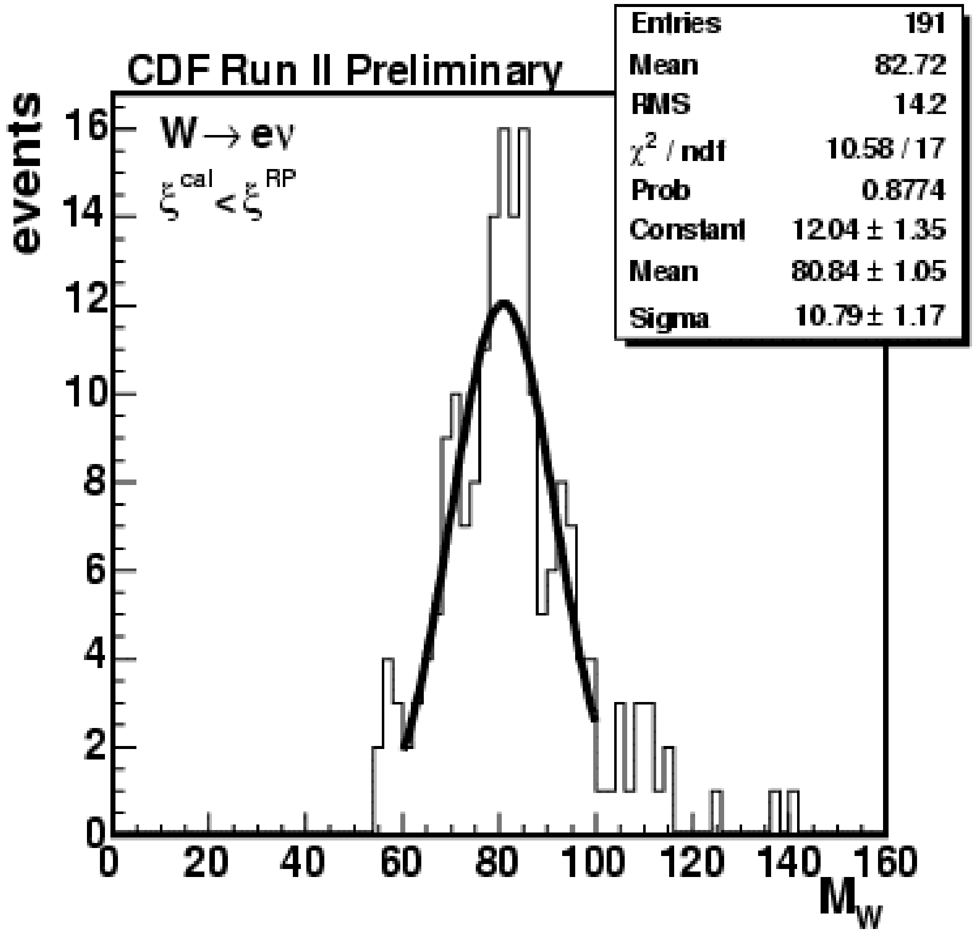




Diffractive *W* production analysis

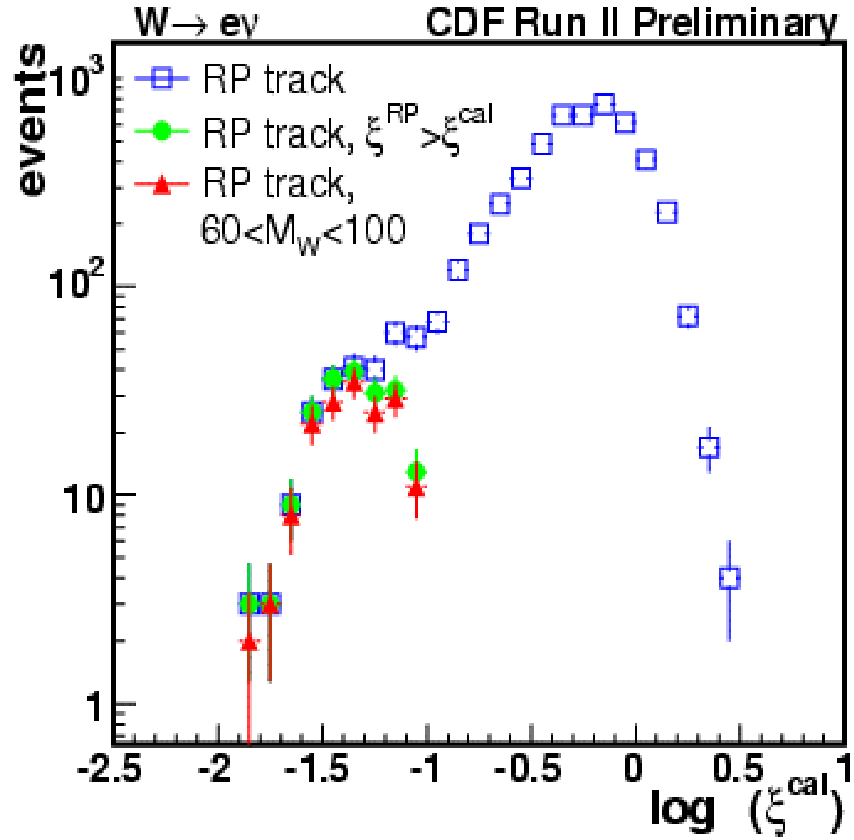
- As in diffractive dijet production, we can calculate ξ from the energy in the calorimeter $\xi^{cal} = \sum_{towers} \frac{E_T}{\sqrt{s}} e^{-\eta}$
- In this case, the missing energy from the neutrino yields a difference compared to the true ξ determined from the RP track
  - Experimentally infer missing E_T, but don't know E_z
- The difference between the calorimeter and RP ξ allows us to determine the neutrino kinematics, and therefore the W kinematics $\xi^{RP} - \xi^{cal} = \sum_{towers} \frac{\not{E}_T}{\sqrt{s}} e^{-\eta_\nu}$
- Will be able to determine the structure function from diffractive W production

Reconstructed diffractive W mass



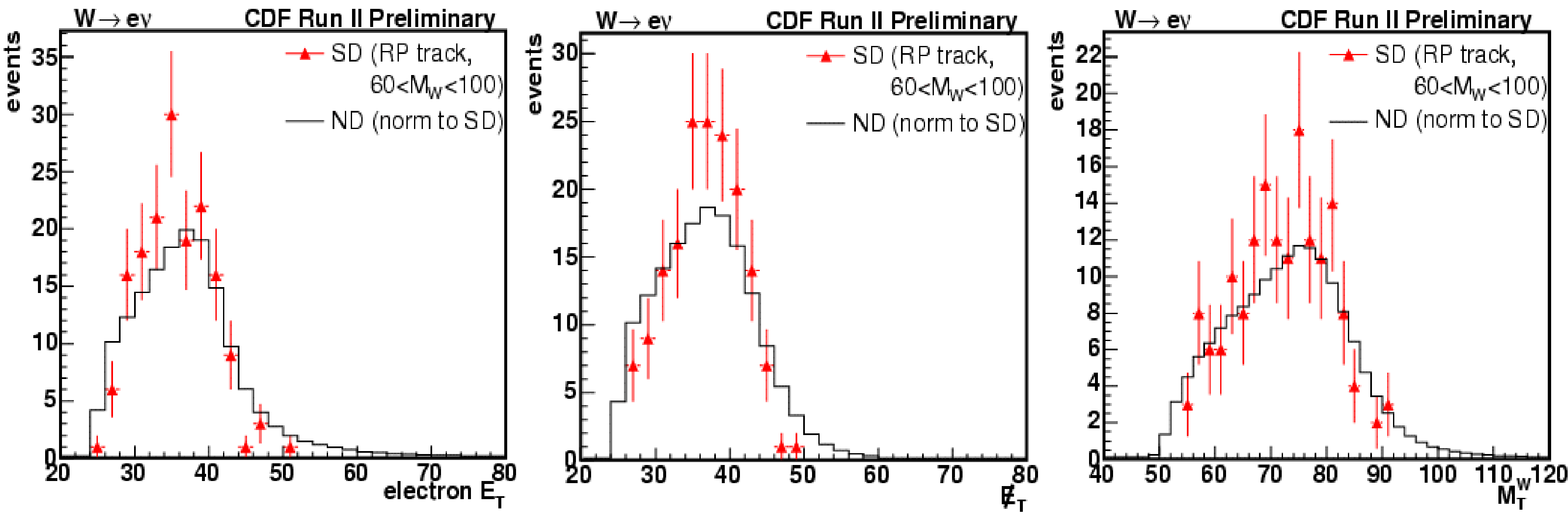
Rejection of multiple interaction events

- Want to make sure the W and the diffractive antiproton in the RP come from the same interaction
- Requiring $\xi^{cal} < \xi^{RP}$ removes most events with multiple pbar-p interactions
- Cutting on the reconstructed W mass $60 < M_W < 100$ GeV/c^2 cleans up remaining events



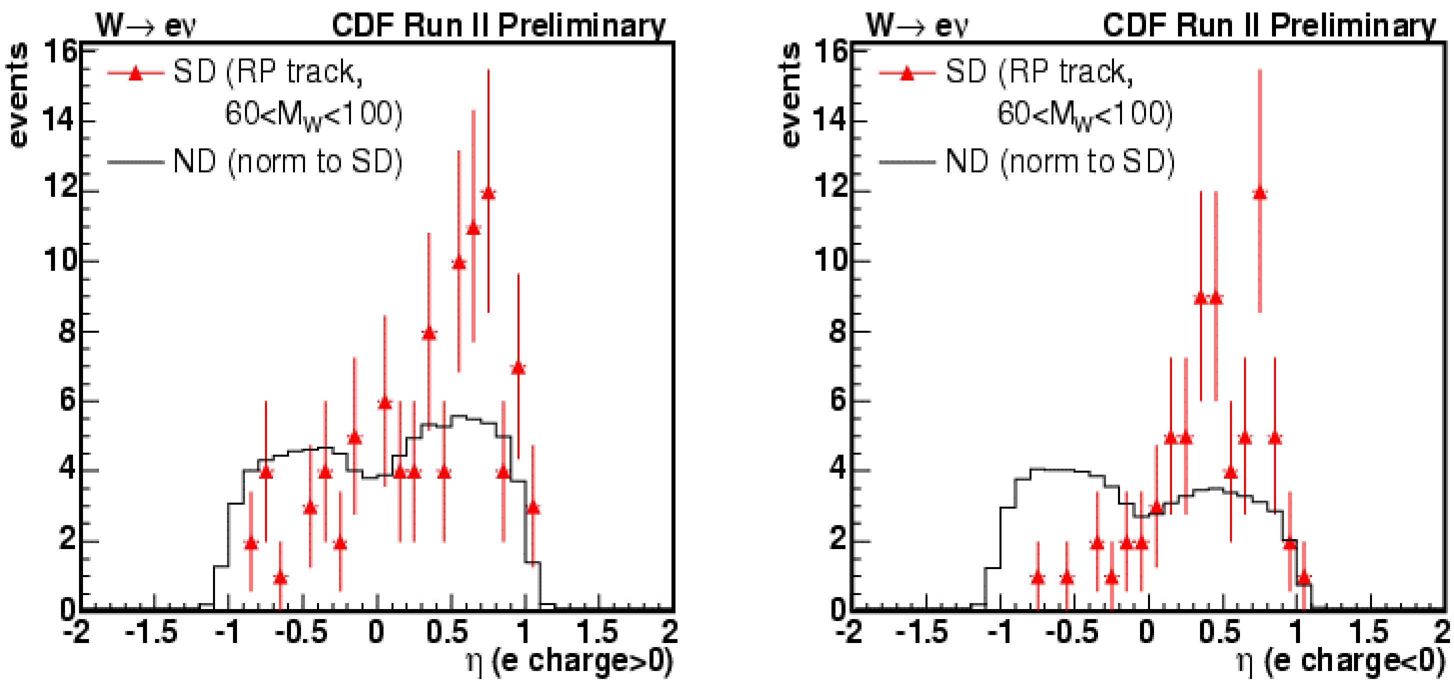
W→eν kinematics

- Kinematics of diffractive W→eν events similar to non-diffractive: electron E_T, missing E_T, W transverse mass



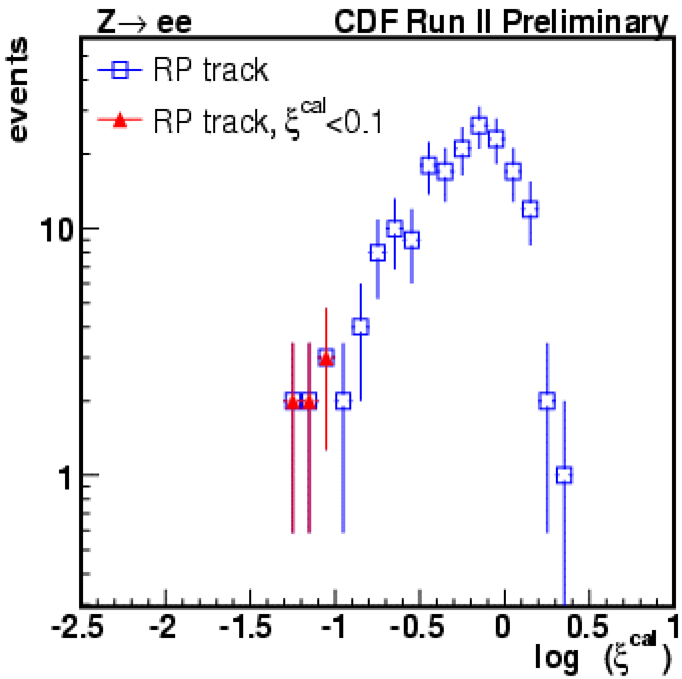
Angle-charge asymmetry

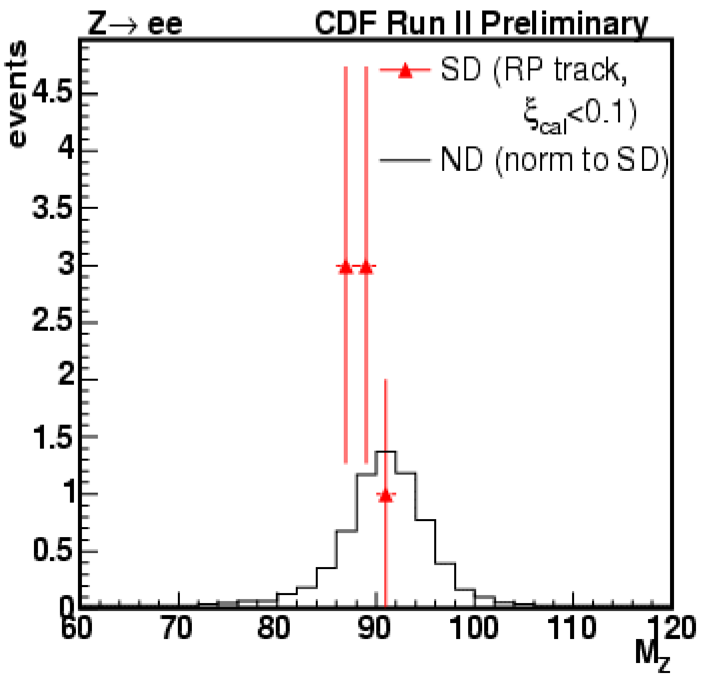
- CDF Run I analysis exploited the angle-gap, charge-gap asymmetry of the $e^{\pm}$ in diffractive W production
- For diffractive antiproton (z<0), expect
  - Gap at $\eta<0$ (not required in RP analysis), $e^{\pm}$ at $\eta>0$
  - More positrons than electrons



Diffractive Z

- 7 diffractive Z→ee candidates (RP track, ξ^{cal}<0.1)
  - No estimate of background due to multiple interactions
- Have not yet looked at Z→μμ





Summary

- Have devised a method to reconstruct the W kinematics in diffractive W production
  - Have shown reconstructed W mass using this method
  - Will use to determine diffractive structure function
- Will look at jets in diffractive W events to determine the quark/gluon fraction with better precision than Run I
- Plan to measure the fraction of Z production which is diffractive