D0 results on diffraction

Christophe Royon
IRFU-SPP, CEA Saclay, France

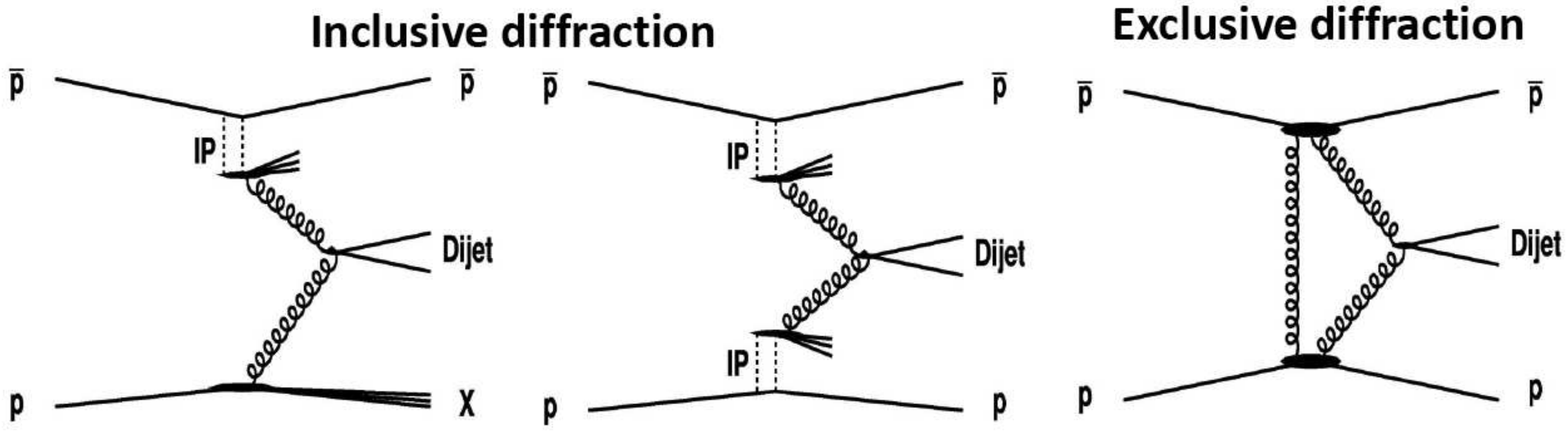
14th Workshop on Elastic and Diffractive Scattering
December 15-21 2011, Qui Nhon, Vietnam
On behalf of the D0 collaboration

Contents:

- Search for exclusive events in the jet channel at high dijet mass
- Forward Proton Detector
- Measurement of the elastic cross section

Inclusive and exclusive diffraction

- Distinguish between inclusive and exclusive diffractive productions
- Advantage of exclusive diffractive events: The whole Pomeron energy is transferred to the final state, in other words no energy loss in Pomeron remnant, Interesting processes for Higgs production at the LHC: mass and spin determinations
- CDF already obtained many results on exclusive diffraction using dijet, diphoton, b-jets, χ_C..., and generally for low mass objects

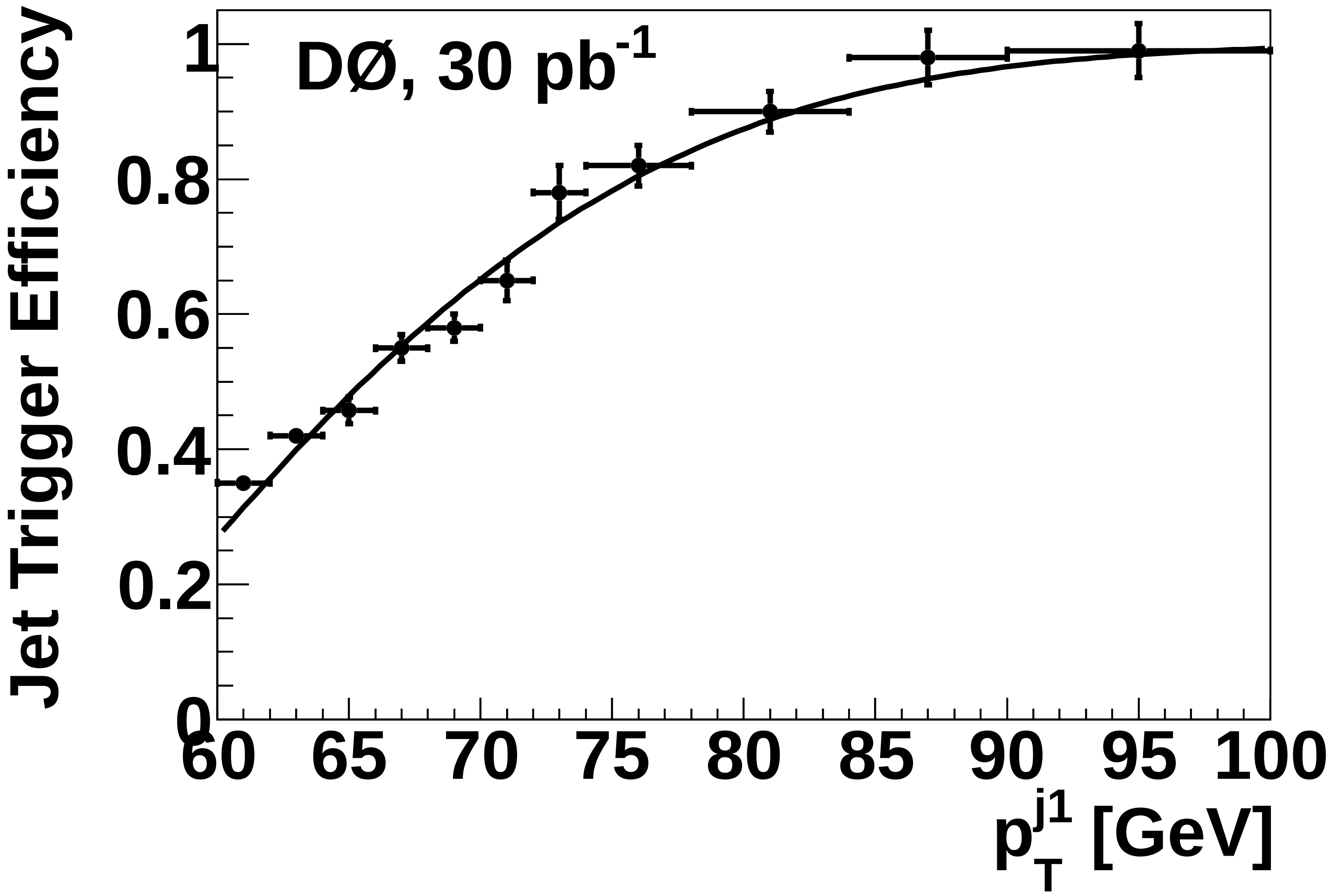


Event selection

- General idea: Look for exclusive events in the dijet channel at high dijet mass using the rapidity gap method
- Select inclusive jet p_T trigger with a threshold at 45 GeV
- Restrict to low instantaneous luminosity (5-100 10^{30} cm^{-2} s^{-1}) to limit the number of multiple interactions in the same bunch crossing (they would fill the rapidity gaps with large energy)
- Integrated luminosity: $\sim$30 pb^{-1}
- Data requirements: two jets (only), $|y_{1,2}| < 0.8$, p_{T_1} >60 GeV, p_{T_2} >40 GeV, M_{jj} >100 GeV, $\Delta\phi$ >3.1

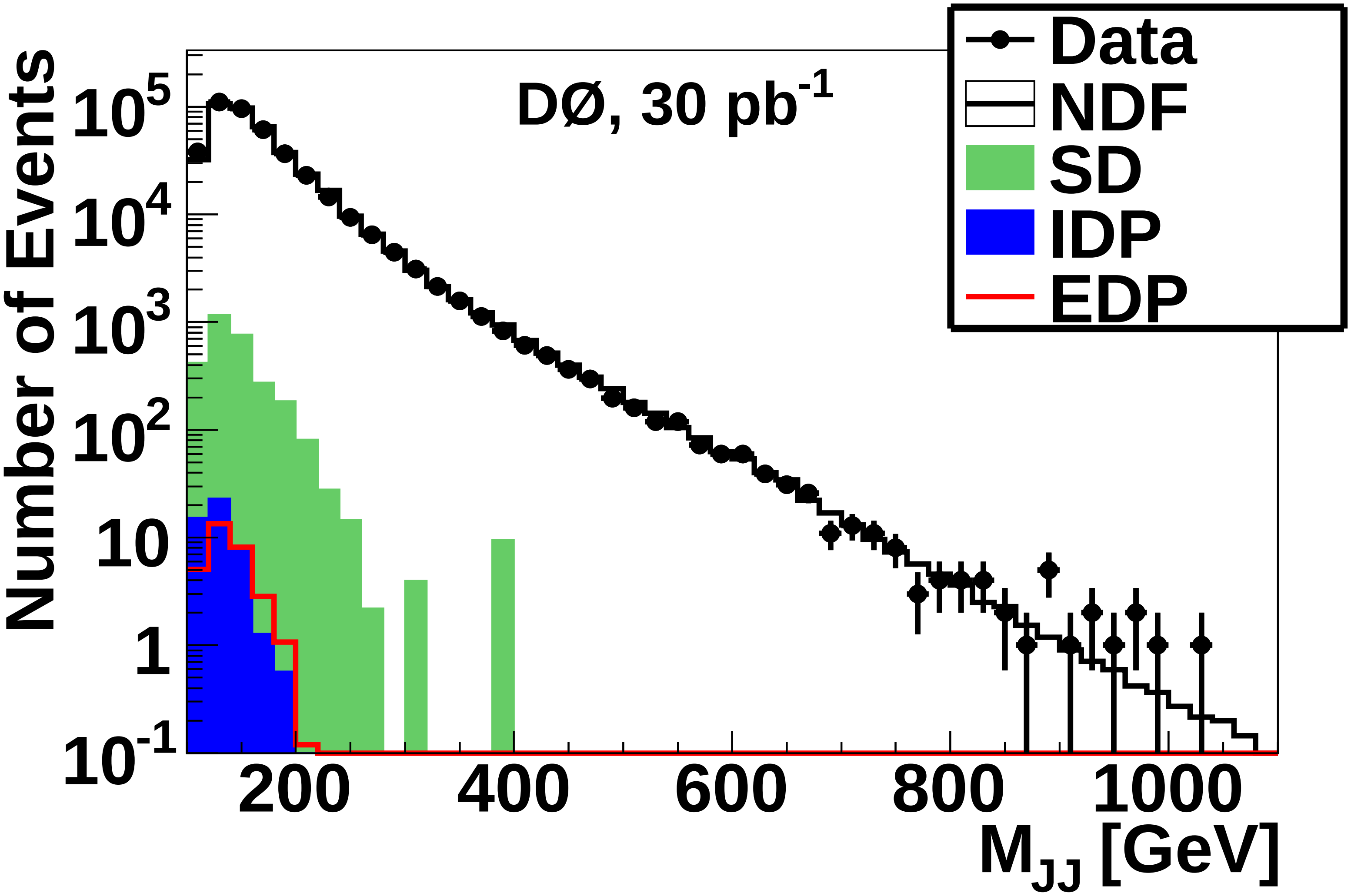
Jet p_T trigger

- Jet p_T trigger fully efficient above jet $p_T > 100$ GeV
- Jet trigger inefficiency below 100 GeV obtained by comparing with data acculumated with a lower p_T threshold: weight applied to MC events



Dijet invariant mass distribution

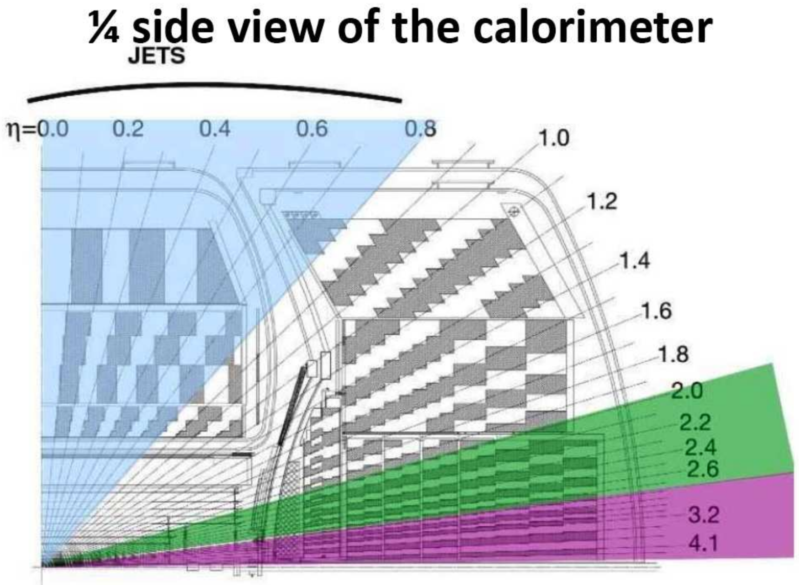
Dijet invariant mass distribution compared to MC expectation (non-diffractive (NDF): Pythia, single diffractive (SD): Pomwig, inclusive double pomeron exchange (IDP): FPMC, exclusive double pomeron exchange (EDP): FPMC)

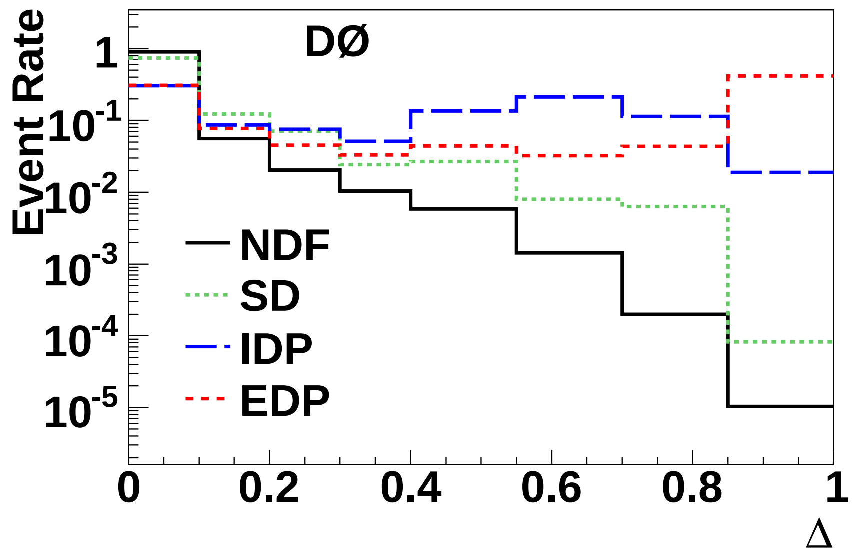


Separation of exclusive, inclusive diffraction from NDF background

- General idea: use the fact that the rapidity gap is larger for exclusive events since there is no pomeron remnants (gap between central jets and intact protons)
- Define a new (phenomenological) separation variable:

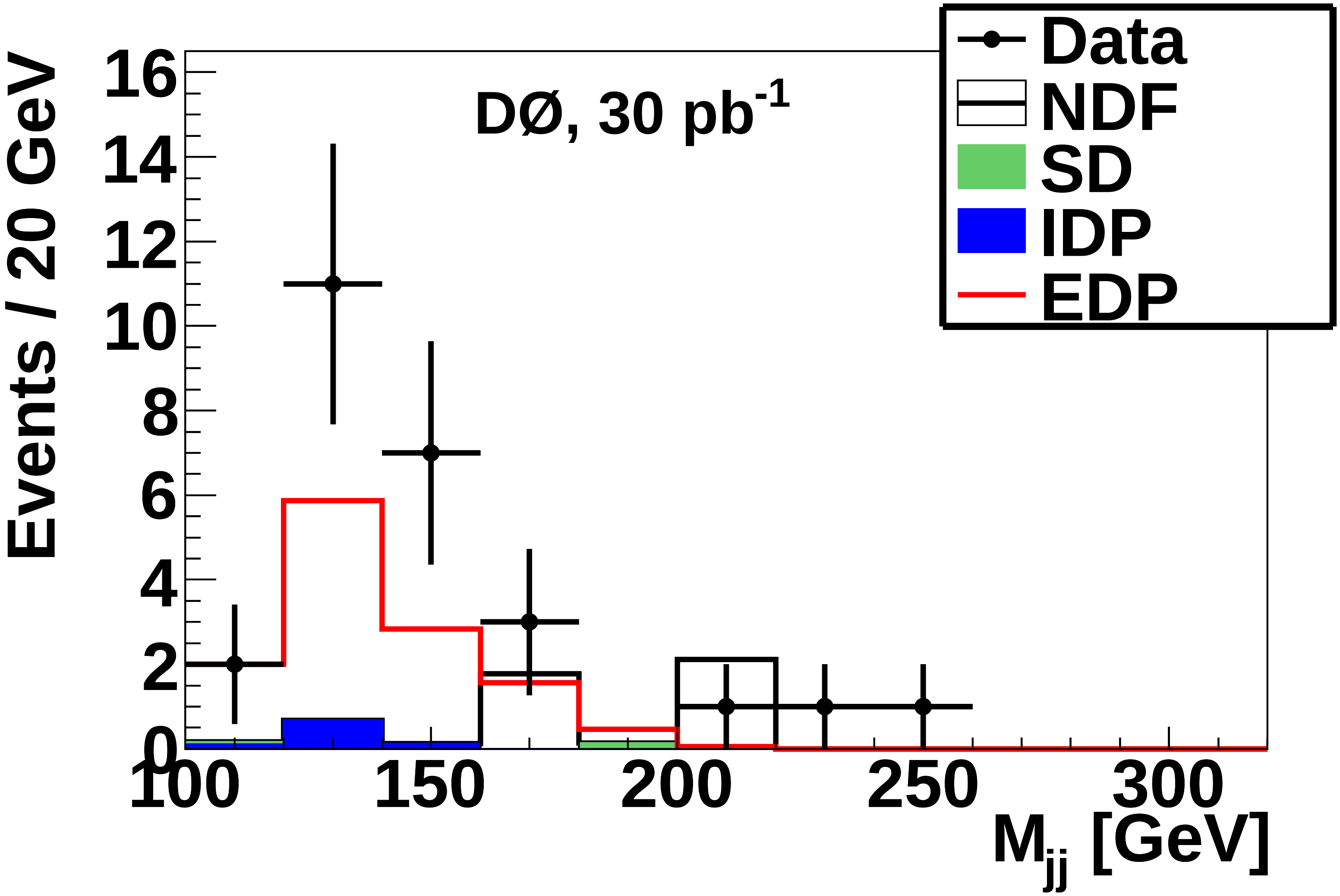
$$\Delta = \frac{1}{2}\exp\left(-\Sigma_{2.0<|\eta|<3.0}E_T\right) + \frac{1}{2}\exp\left(-\Sigma_{3.0<|\eta|<4.2}E_T\right)$$





Dijet invariant mass for $\Delta > 0.85$

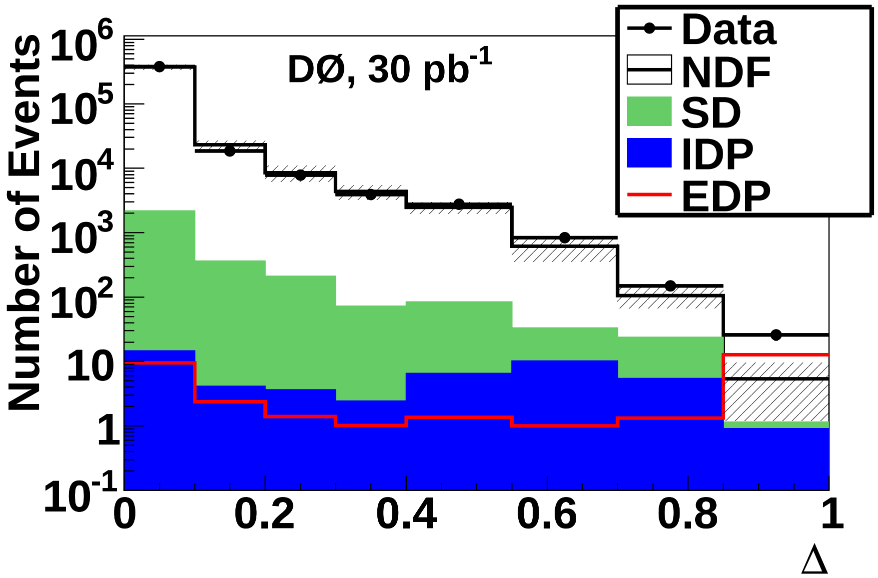
- A clear excess of data with respect to ND, SD, IDP
- Excess compatible with expectations from EDP: large uncertainties by a factor 3-4 (central value from KMR)

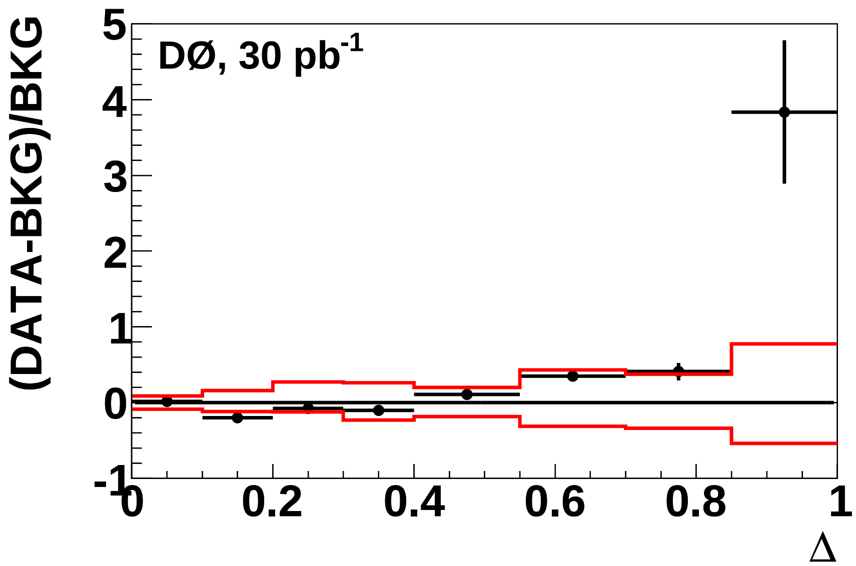


$\triangle$ distribution in data

- Modified frequentist method to estimate the excess significance:
- 4.1σ excess when one includes NDF, SD and IDP (probability for these events to be explained by non exclusive dijet production is 2 10^{-5}.

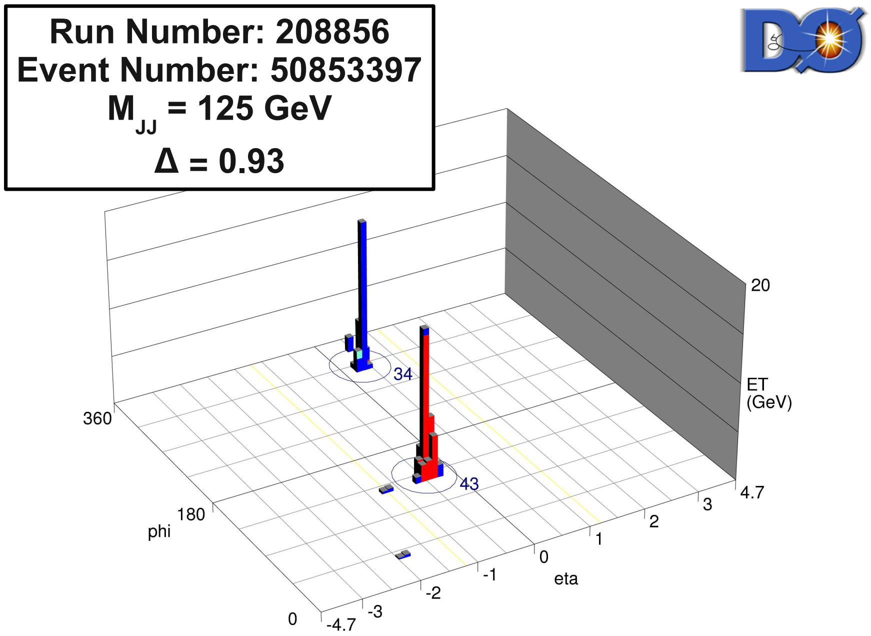
Sample	NDF	IDP	SD	EDP	BKG	DATA
All Δ	409527	48.3	2930	30.9	412505	412505
$\Delta \geq 0.85$	$4.2\ ^{+4.0}_{-2.9}$	$0.9\ ^{+0.4}_{-0.5}$	$0.2\ ^{+0.1}_{-0.1}$	$12.9\ ^{+1.0}_{-1.2}$	$5.4\ ^{+4.2}_{-2.9}$	26

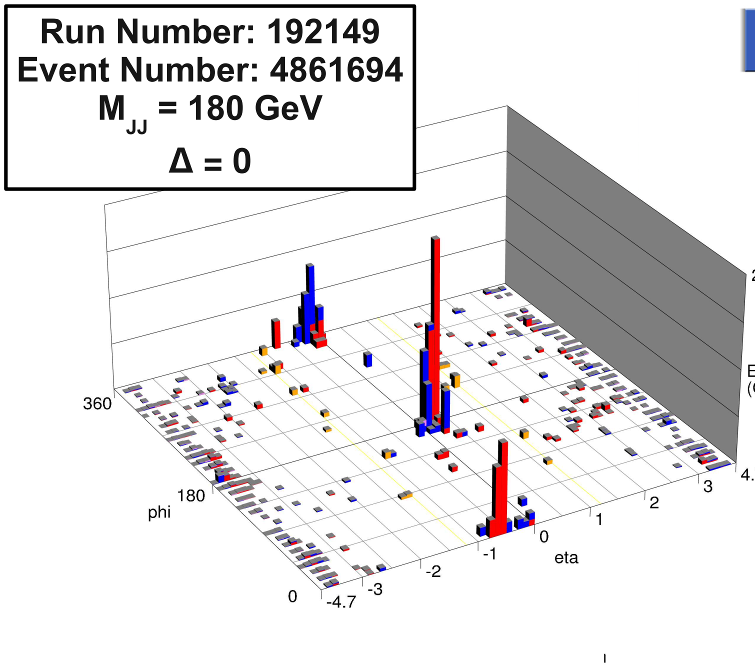




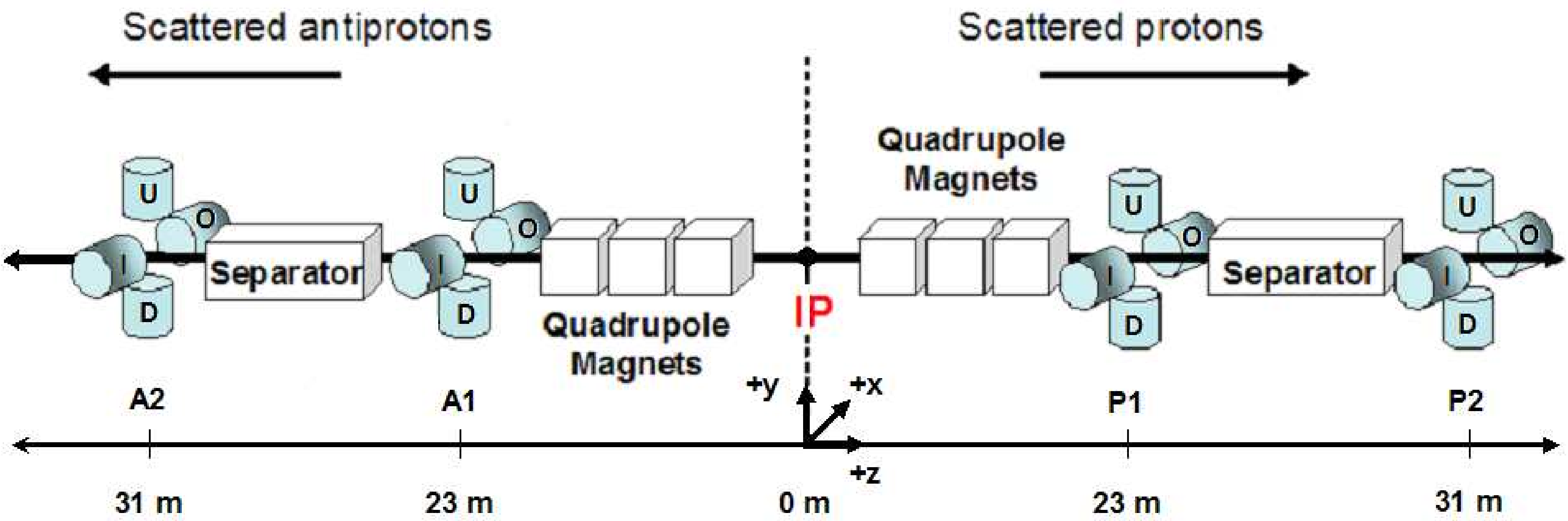
Event displays

- Event display of an exclusive event
- Event display of a background event



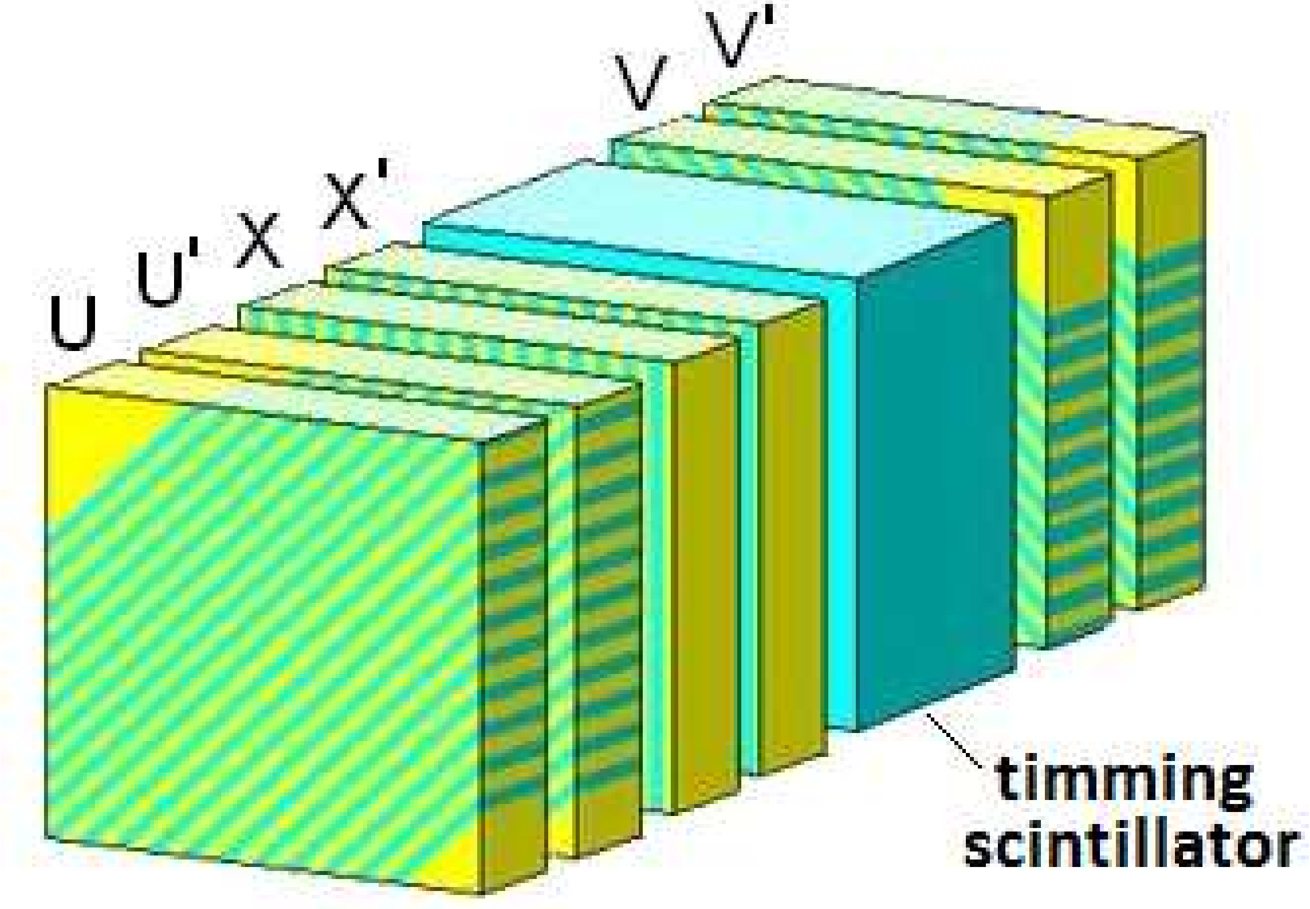


Elastic cross section measurement: the Forward Proton Detector



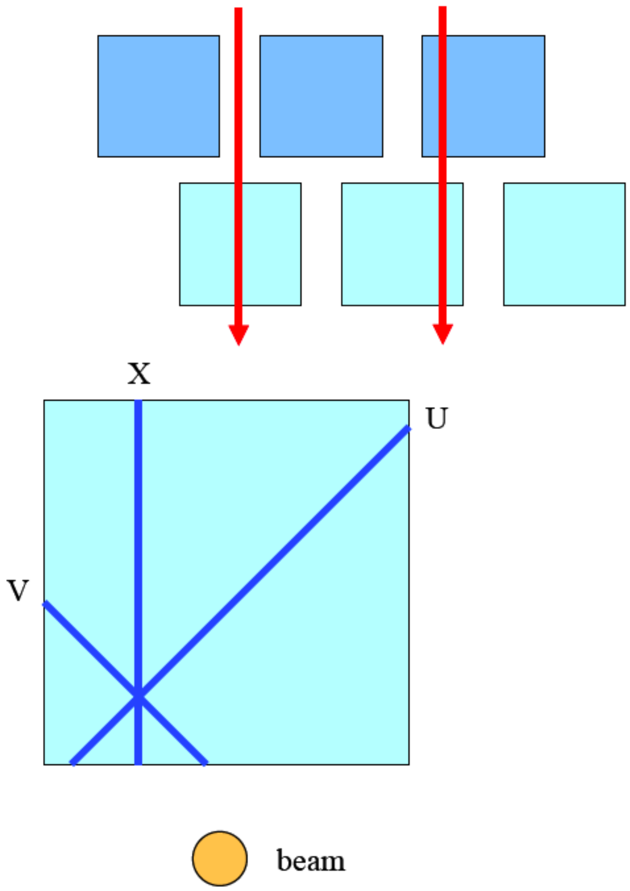
- 8 quadrupole spectrometers (Up, Down, In, Out) on the outgoing proton and antiproton sides
- Use Tevatron lattice and scintillating fiber hits to reconstruct ξ and t of scattered protons
- Special high $\beta^* = 1.6$m store (5 times larger than normal): single bunches of p and $\bar{p}$, integrated lumi of 30 nb^{-1}

FPD detectors



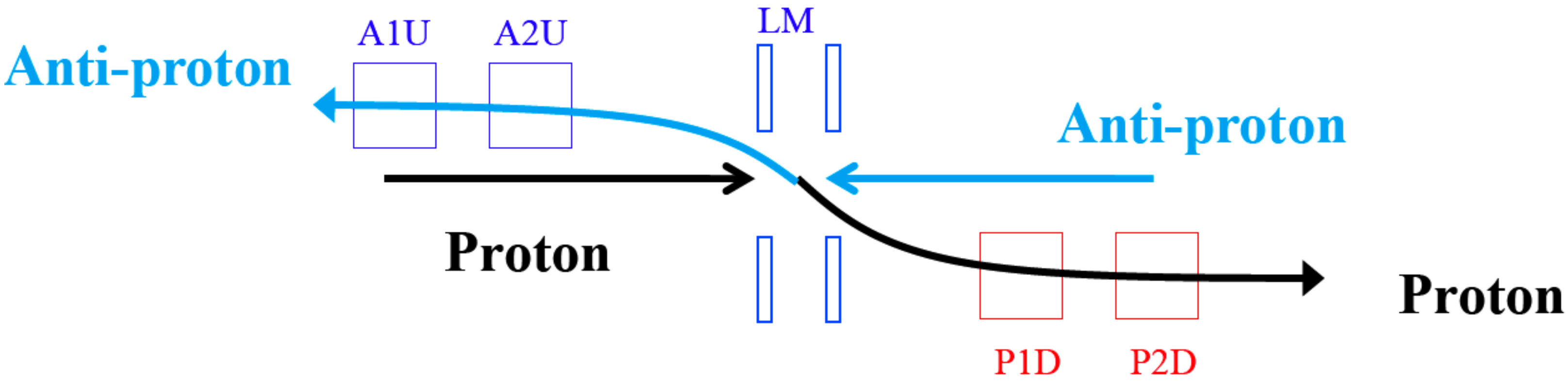
- 3 kinds of layers in detector: U and V at 45 degrees to X, 90 degrees to each other
- Each layer has two planes offset by 2/3 fiber (for example U, U')
- Central scintillator used for timing

Hit finding



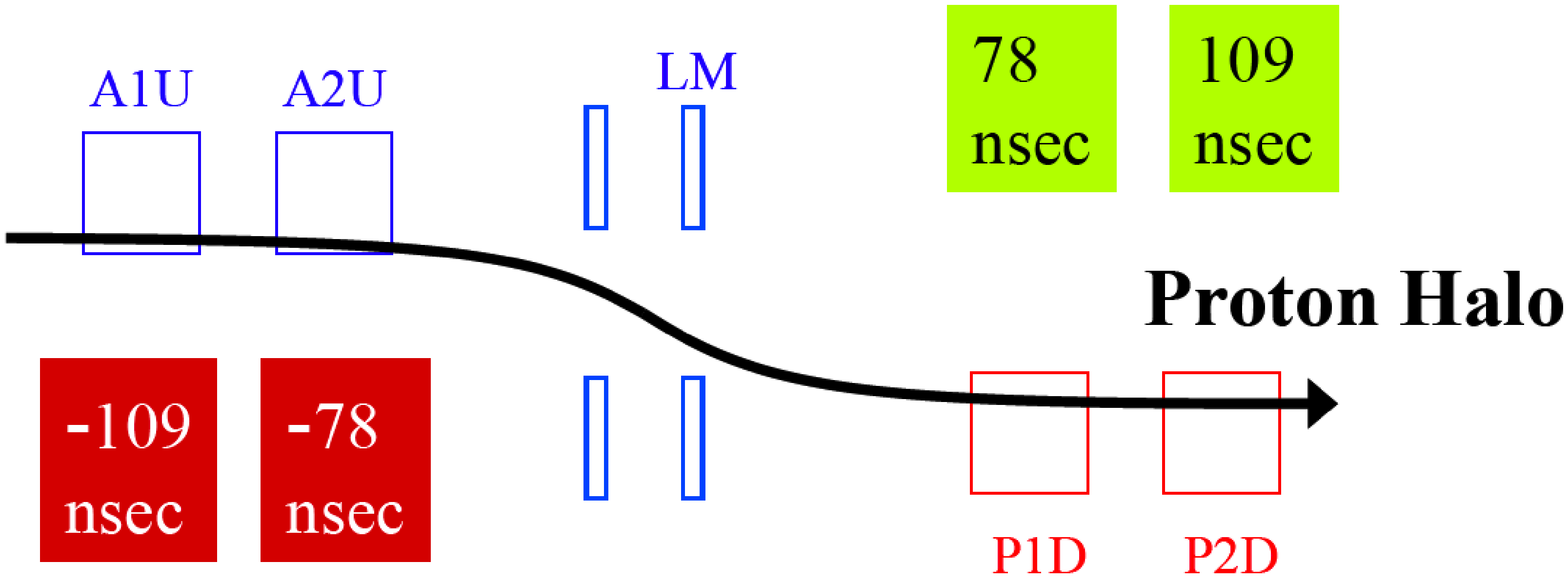
- fiber combination in 2 different planes give a segment
- Need two out of three possible segments to get a hit: U/V, U/X, X/V...: reconstruct x and y positions in detector
- Use alignment to go from detector to beam coordinates: use over-constrained tracks that pass through horizontal and vertical detectors to do relative alignement of detectors and use hit distributions to align detectors with respect to the beam

Elastic spectrometer combinations



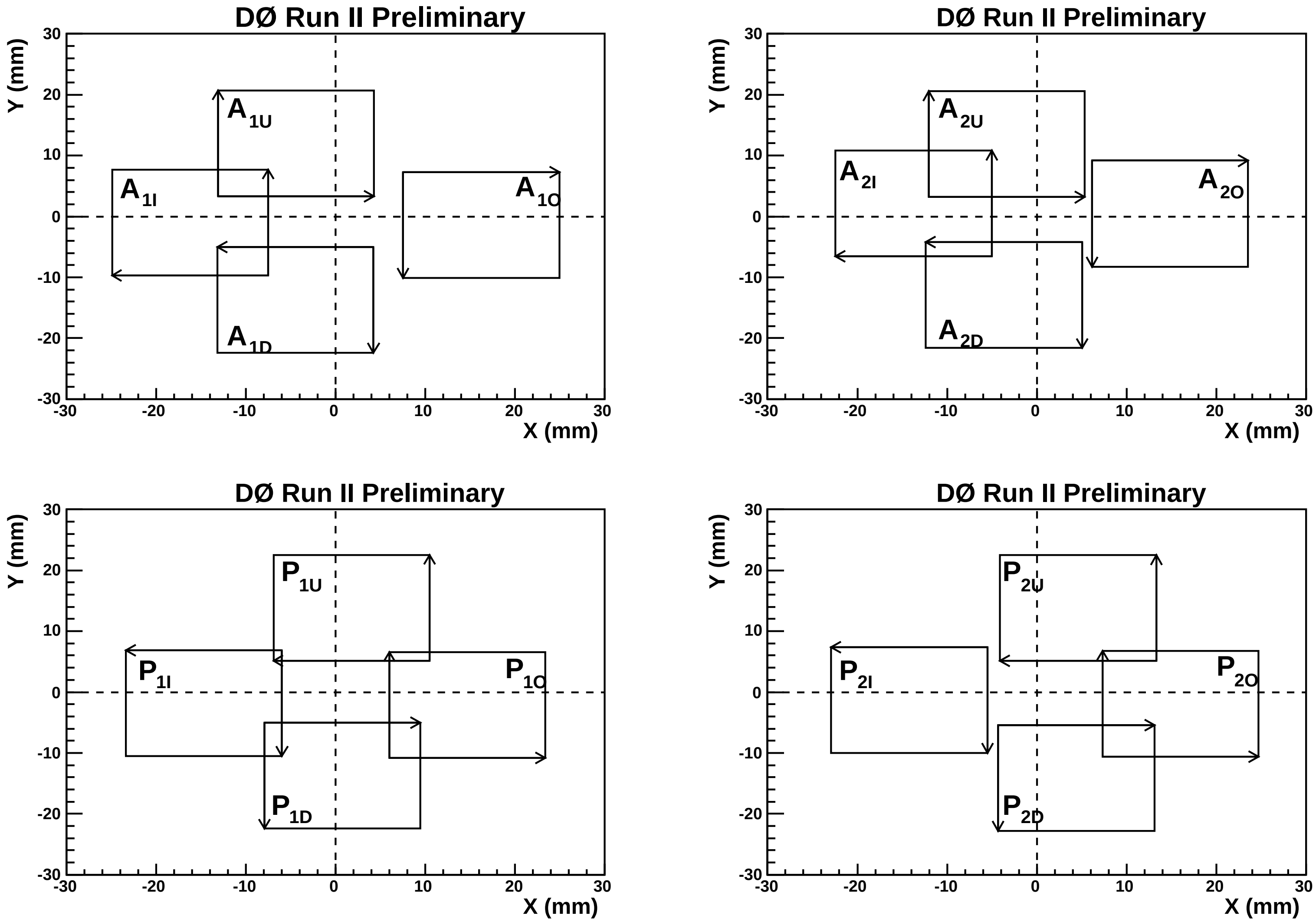
- Elastic events have tracks in diagonally opposite spectrometers
- Momentum dispersion in horizontal plane results in more halo (beam background) in the IN/OUT detectors, so concentrate on vertical plane AU-PD and AD-PU to maximize $|t|$ acceptance while minimizing background

Halo rejection



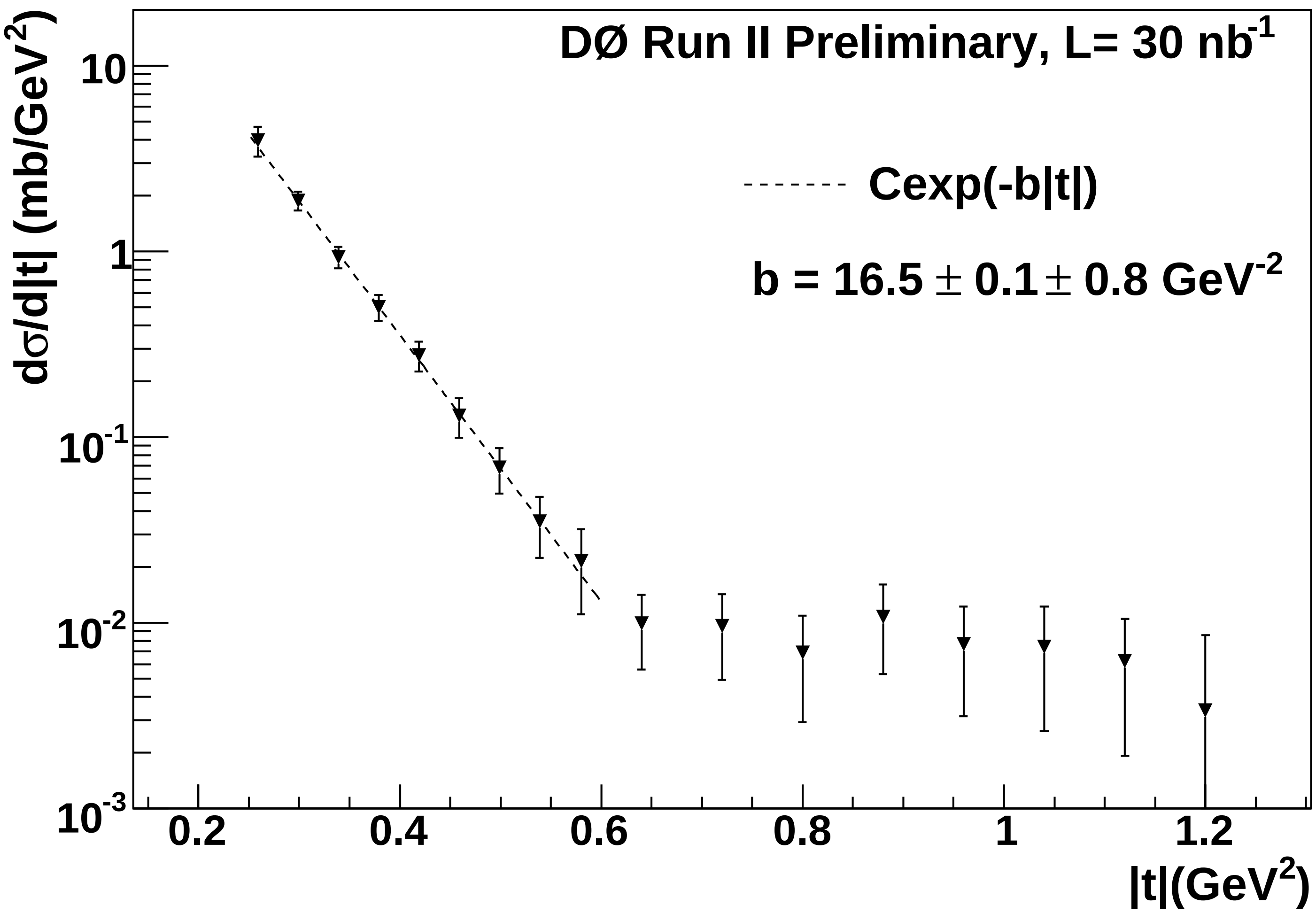
- In-time bit: set if a pulse is detected in the in-time window (consistent with a proton originating from the IP)
- Halo bit: set if a pulse is detected in the early time window (consistent with a halo proton)

Detector position after alignment



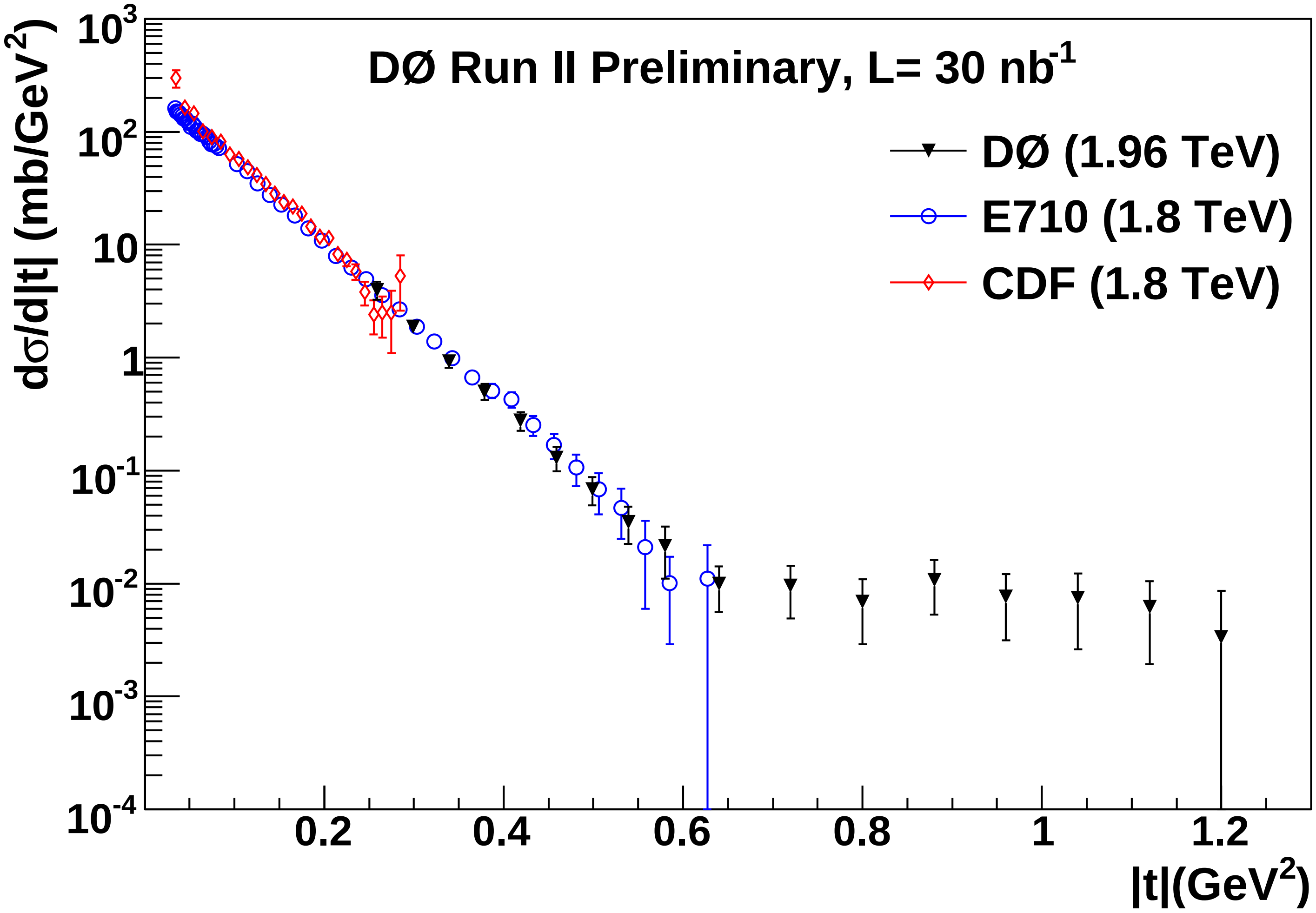
Meaurement of elastic slope

- First measurement of b-slope at $\sqrt{S}$=1.96 TeV
- Systematic error dominated by trigger efficiency corrections and by alignment



Measurement of elastic slope: comparison to E710 and CDF

Good agreement with previous E710 and CDF experiments



Conclusion

- Search for exclusive diffractive events at high dijet mass: 4.1 σ excess with respect to usual inclusive diffraction
- Important to constrain exclusive models in diffraction and make precise prediction for exclusive events at the LHC
- Measurement of the elastic slope at $\sqrt{s}$=1.96 TeV:
  $b = 16.5 \pm 0.1 \pm 0.8$ GeV^{-2}