REVIEW OF DIFRACTION STUDIES AT DØ

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On behalf of the D0 Collaboration.

Two types of studies:

1) Pseudo rapidity Gaps - Hard diffraction

a) Difractive dijet production *(Phys. Lett. B 531 (2002) 52)*

b) Difractive W, Z production *(Phys. Lett. B 574 (2003) 169)*

c) High mass exclusive diffractive dijet production *(Phys. Lett. B 705 (2011) 193)*

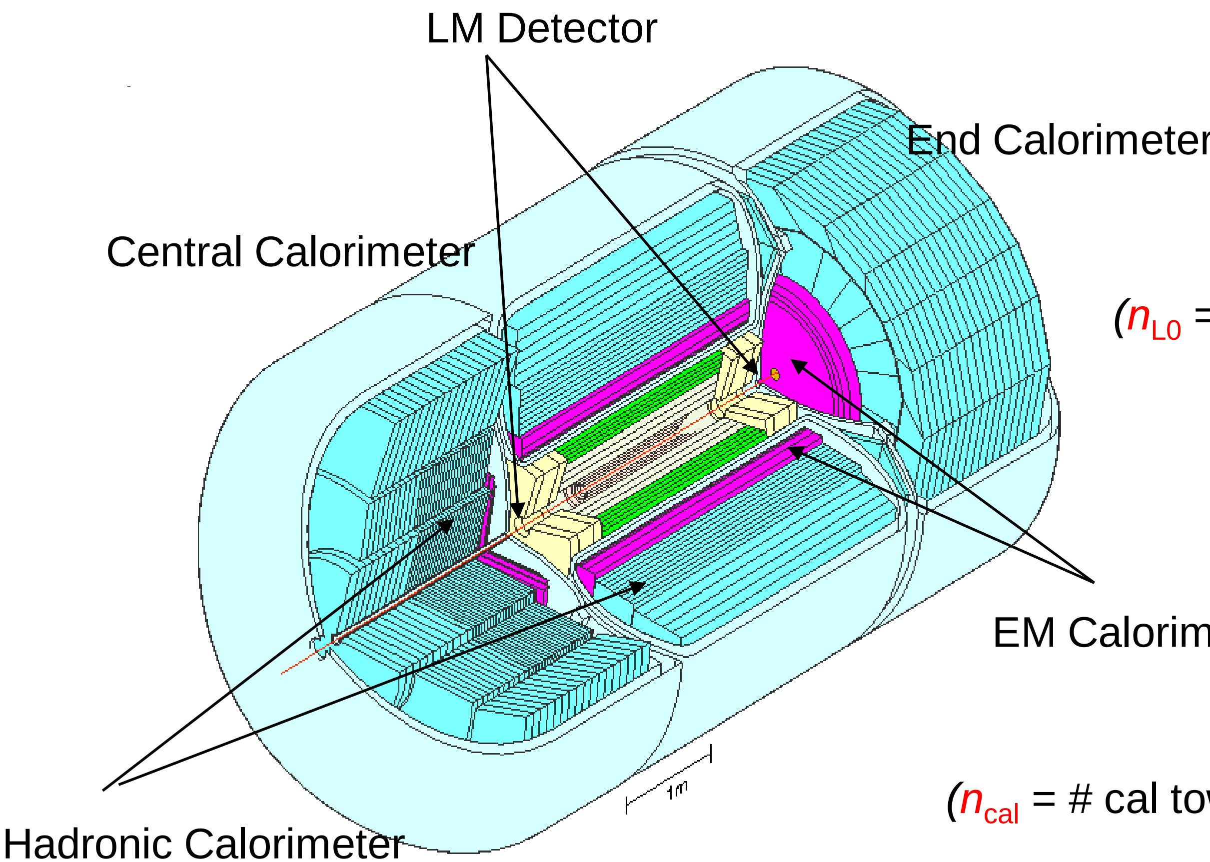
2) Proton and pbar tagging – Soft diffraction

a) Measurement of p-pbar elastic $d\sigma/dt$ *(Phys. Rev. D 86 (2012) 012009)*

b) Measurement of single diffractive cross section

(still under approval not public yet, I will not talk about it today)

DØ Calorimeter

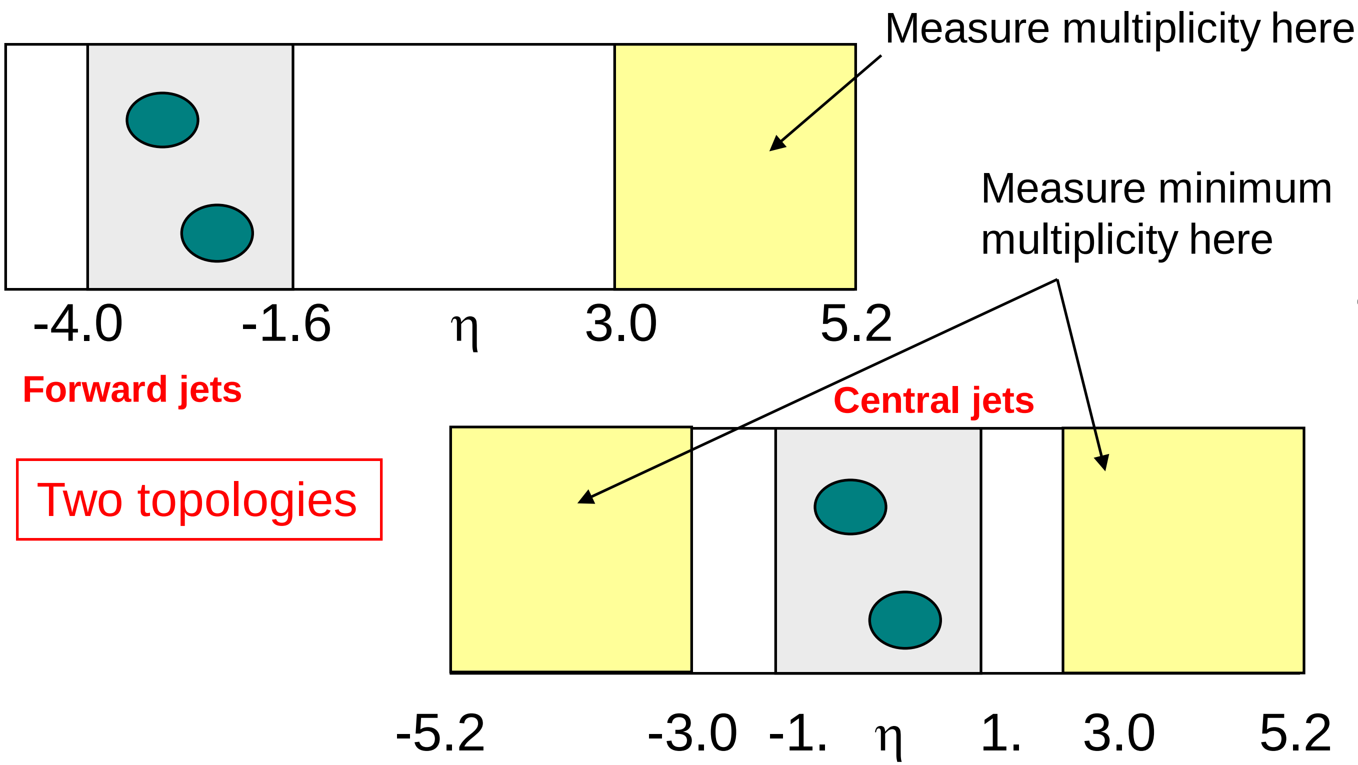


(n_{L0} = # tiles in LM detector with signal $2.3 < |\eta| < 4.3$)

(n_{cal} = # cal towers with energy above threshold)

$$\Delta\eta \times \Delta\varphi = 0.1 \times 0.1$$

1. Diffractive Dijet Production



Jet E_T's > 12, 15 GeV

Single veto trigger: no hits on the LM.

Single p-pbar collision

Seudorapidity Gaps

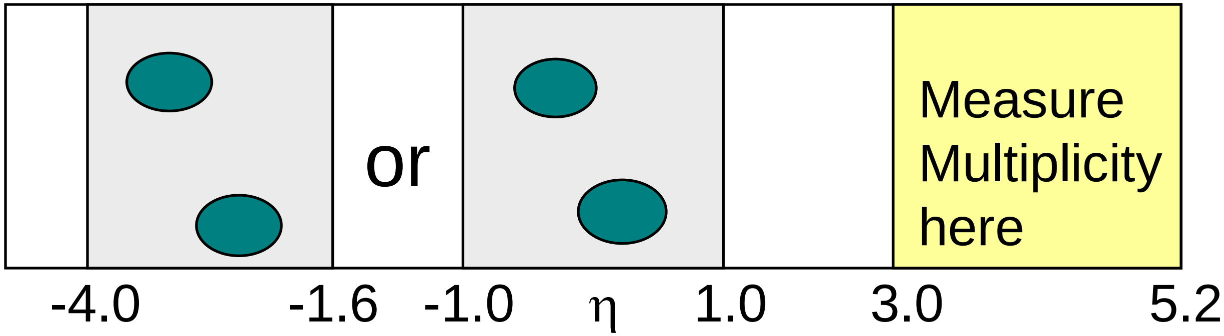
EM Calorimeter

E > 150 MeV;

Had. Calorimeter

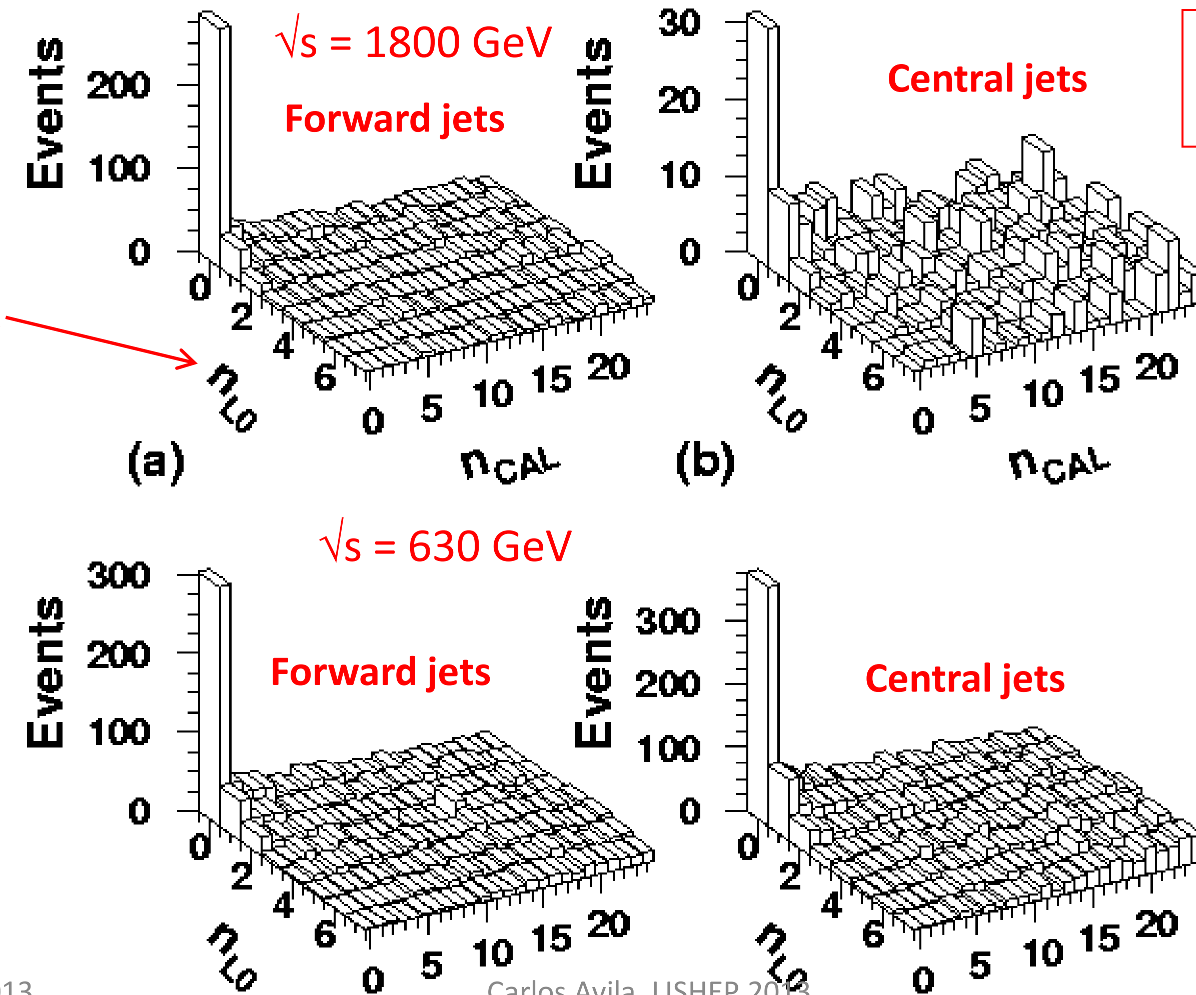
E > 500 MeV

$3.0 < |\eta| < 5.2$

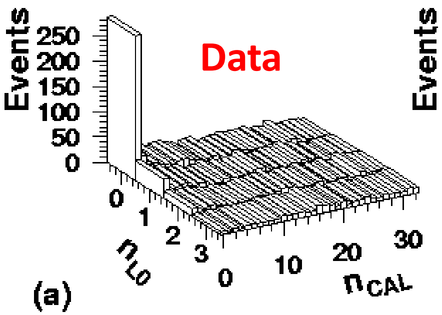


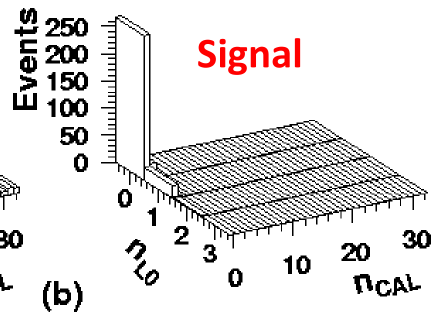
2-D Multiplicity distributions

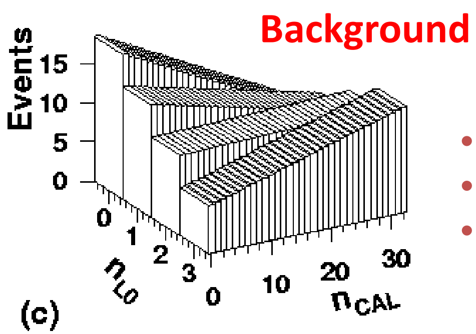
LM scintillator tiles used now



Diffractive dijet production







<u>Signal extraction</u>

- Forward 1800 GeV example
- Signal: 2D falling exponential
- Background: 4 parameter polynomial surface

<u>Lessons</u>

- **Forward Jets Gap Fraction > Central Jets Gap Fraction**
- **630 GeV Gap Fraction > 1800 GeV Gap Fraction**

<u>Gap Fraction</u>

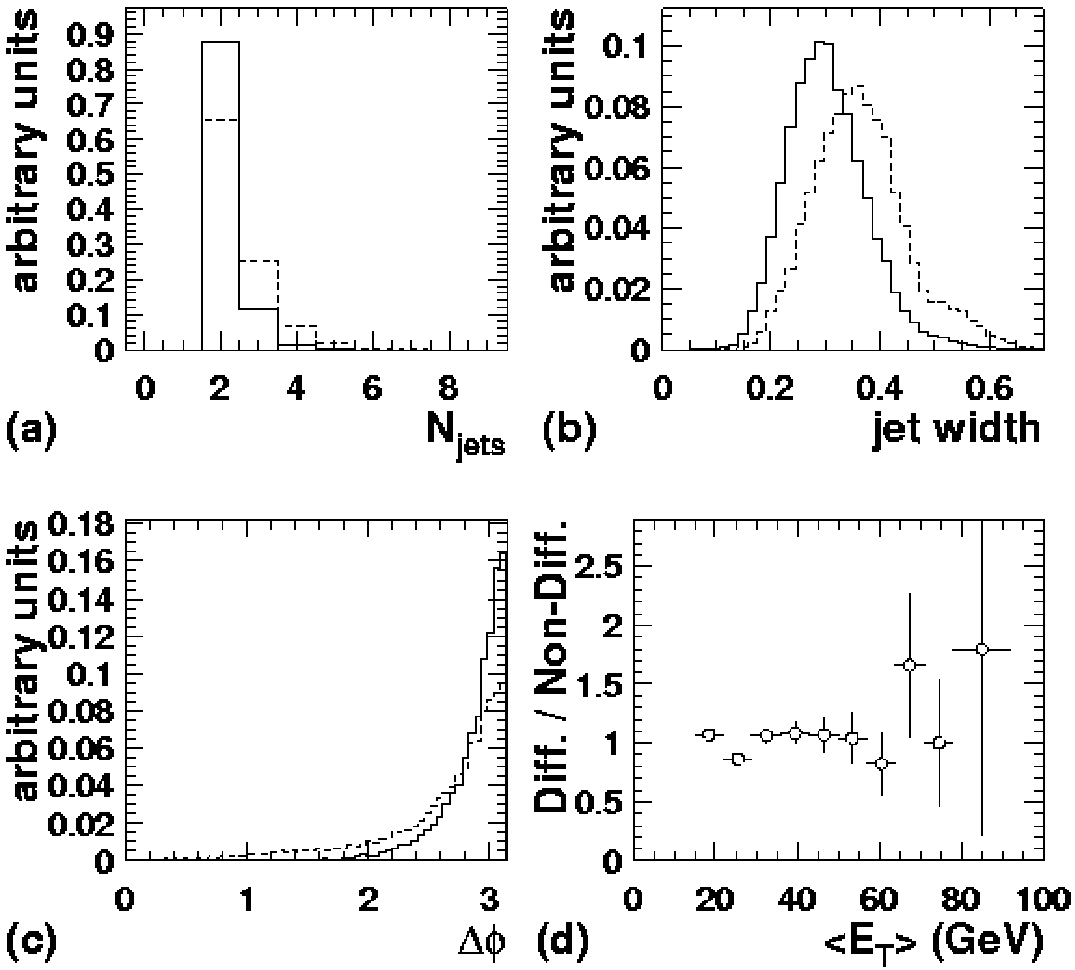
diffractive Dijet Events / # All Dijets

Data Set	**Measured Gap Fraction**
1800 Forward Jets	$(0.65 \pm 0.04)\%$
1800 Central Jets	$(0.22 \pm 0.05)\%$
630 Forward Jets	$(1.19 \pm 0.08)\%$
630 Central Jets	$(0.90 \pm 0.06)\%$

Data Sample	**Ratio**
630/1800 Forward Jets	1.8 ± 0.2
630/1800 Central Jets	4.1 ± 1.0
1800 Fwd/Cent Jets	3.0 ± 0.7
630 Fwd/Cent Jets	1.3 ± 0.1

Hard Single Diffraction

1800 Forward Jets

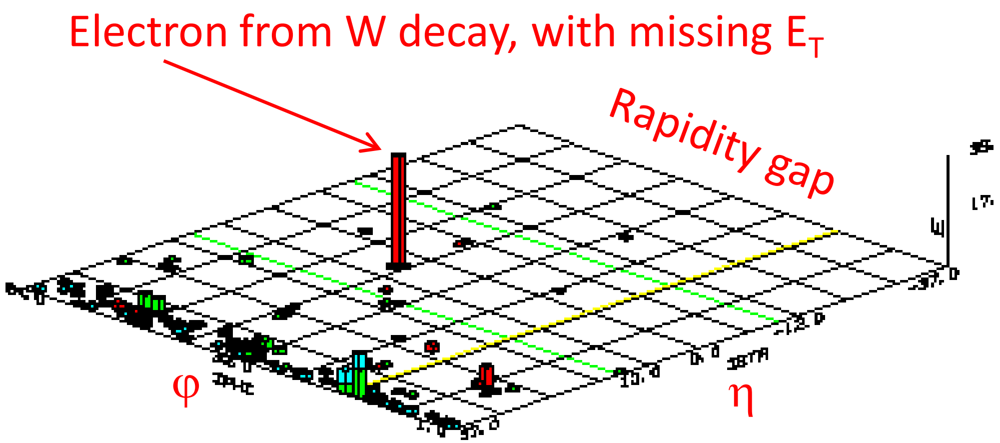


Event Characteristics

- Fewer jets in diffractive events
- Jets are narrower and more back-to-back (Diffractive events have less overall radiation)
- Gap fraction has little dependence on average jet E_T

- Solid lines show sdiffractive dijet candidate events
- Dashed lines show non-diffractive events

Diffractively Produced W and Z



$W \rightarrow e\nu$

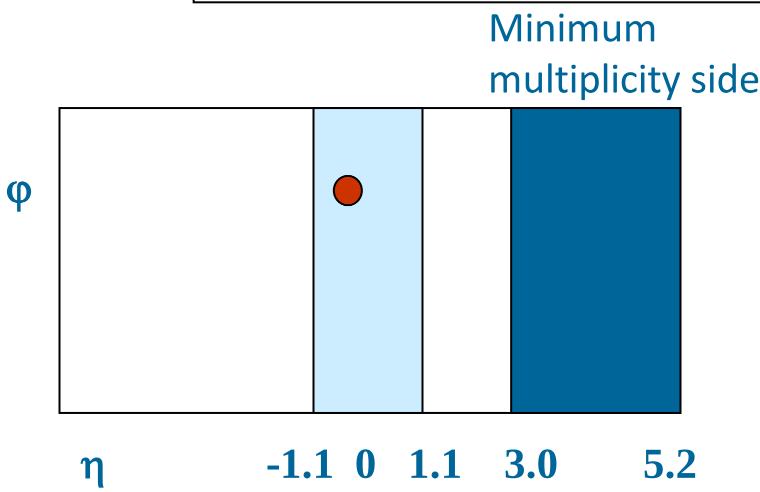
$Z \rightarrow e^+e^-$

considered

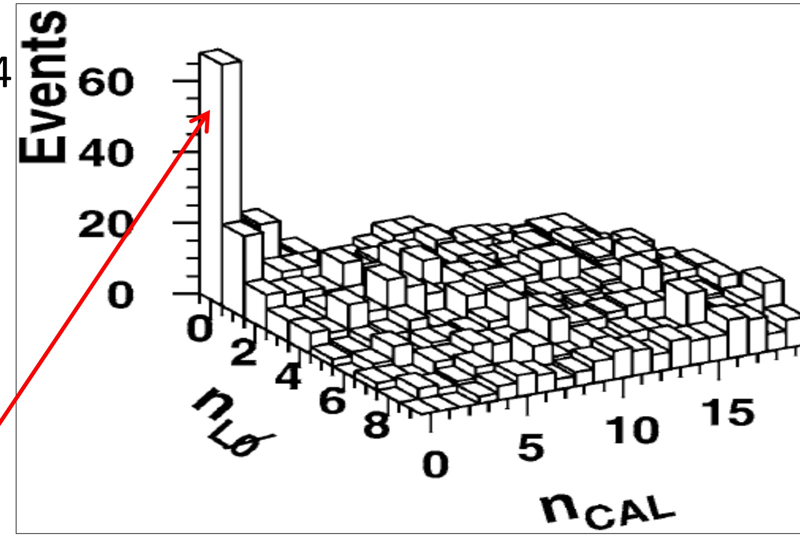
<u>and</u>

require single interaction to preserve possible rapidity gaps (reduces available stats considerably)

2. Diffractive W production

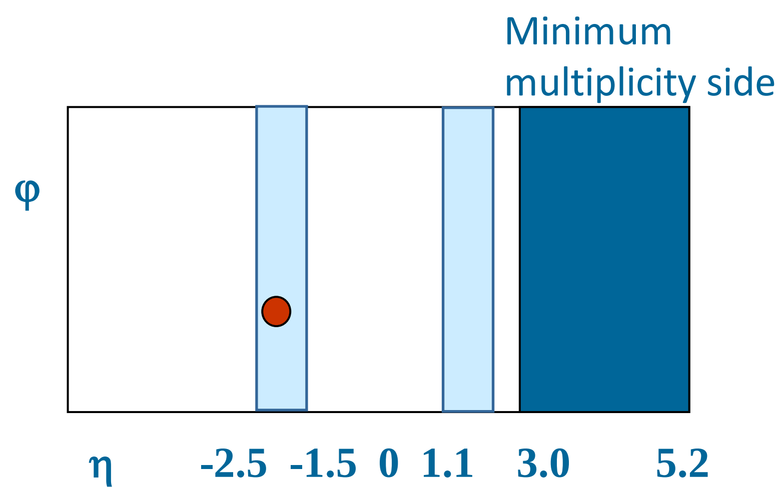


68 of 8724
in (0,0)

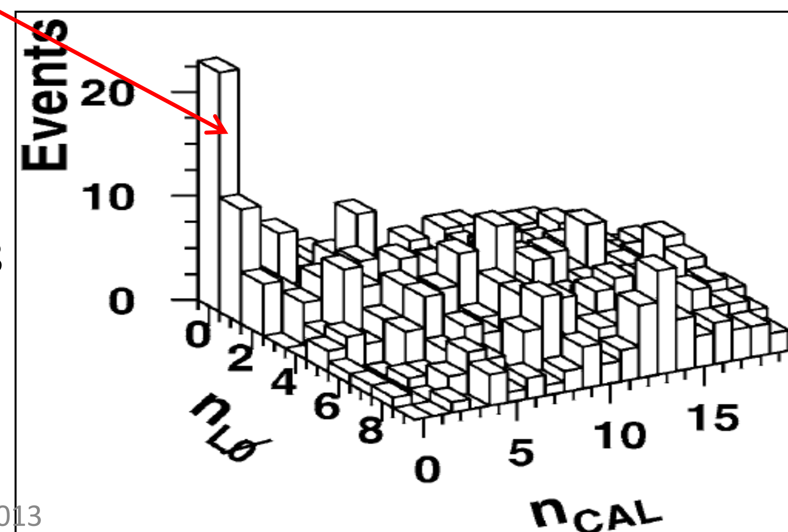


Central and forward electrons considered

Peaks in (0,0) bins indicate diffractive W



23 of 3898
in (0,0)



Plot multiplicity in 3<|η|<5.2 (minimum side)

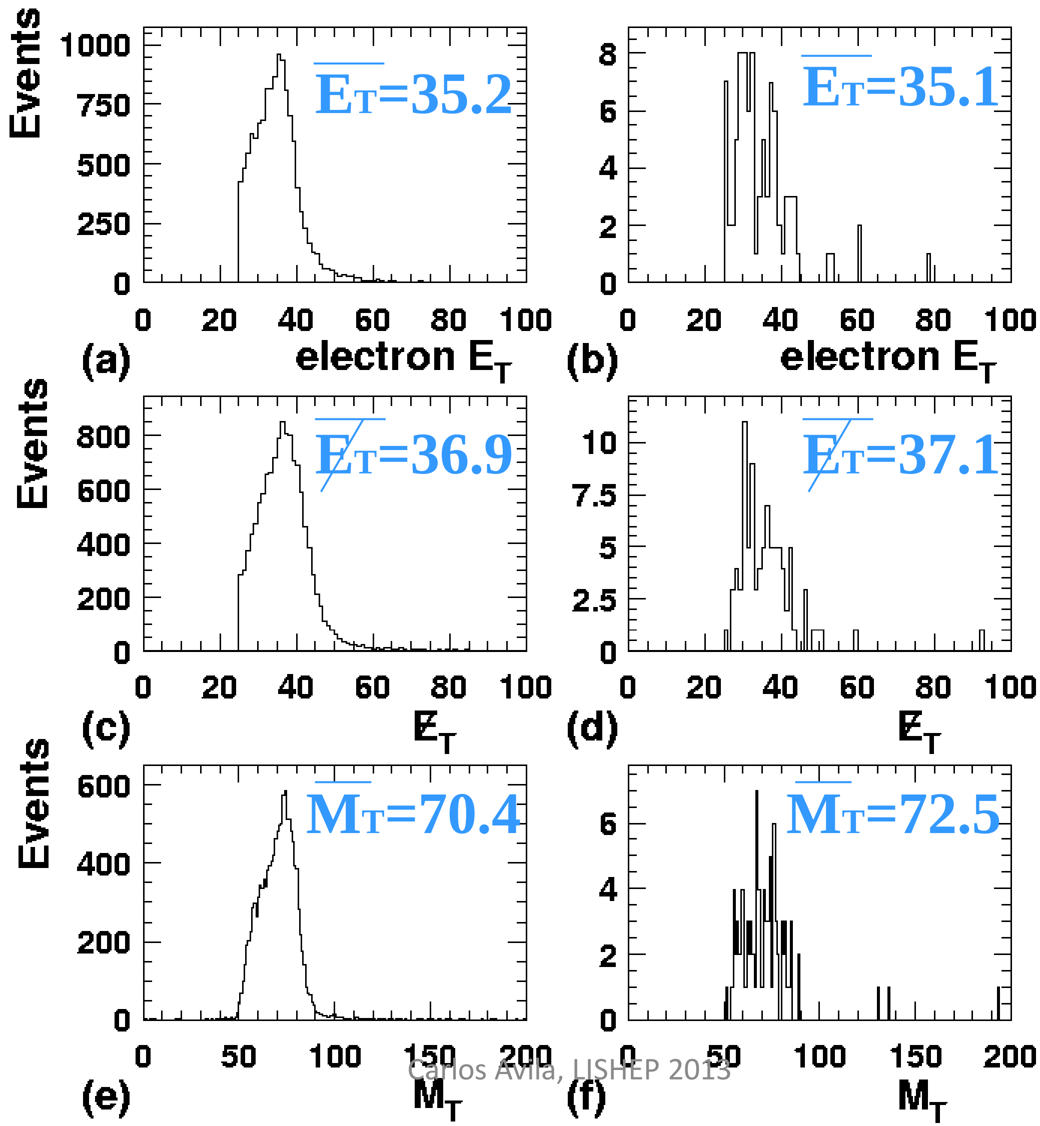
Compare diffractive W characteristics to all W's

Standard W Events | **Diffractive W Candidates**

Electron E_T

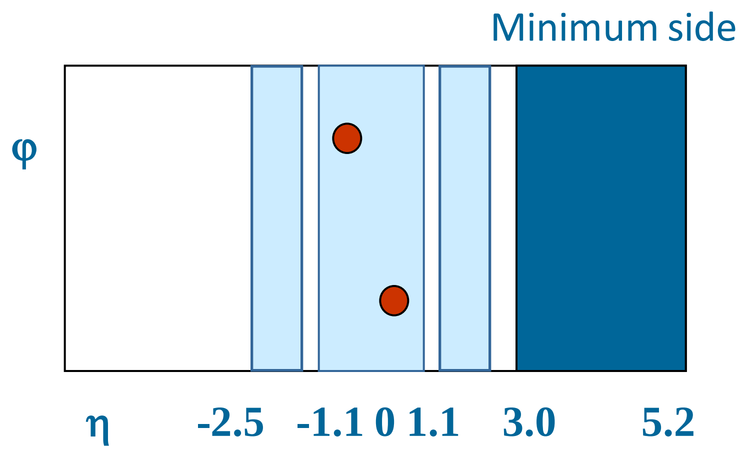
Missing E_T

Transverse mass

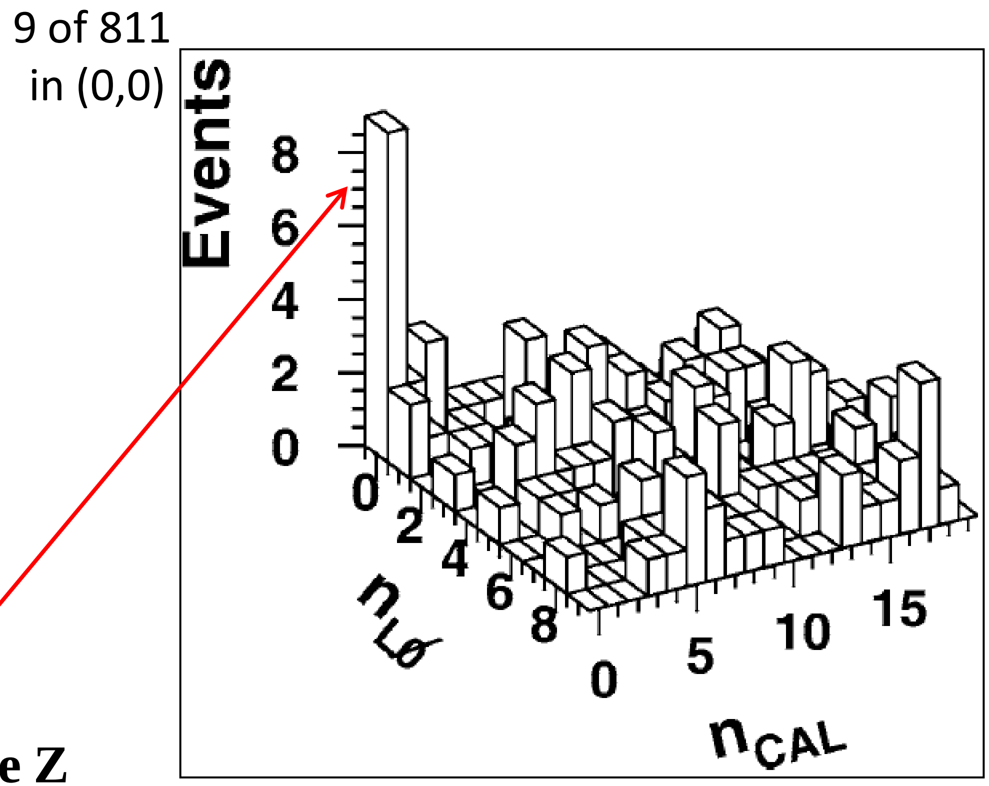


Good agreement given lower diffractive statistics

Diffractively Produced Z's

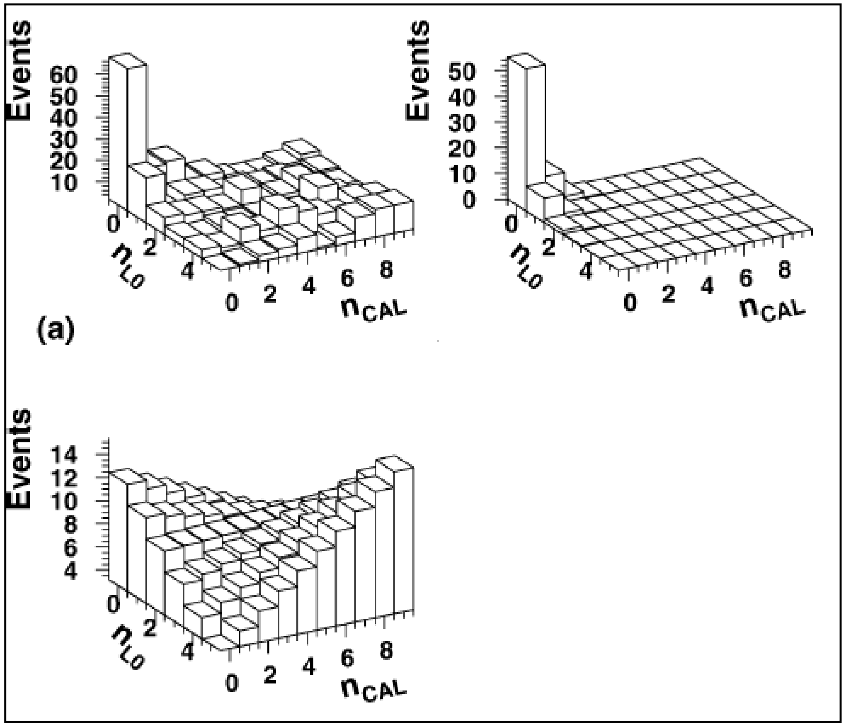


Plot multiplicity in 3<|η|<5.2
(minimum side)



Peak in (0,0) bin indicates diffractive Z

Fraction of diffractively produced W/Z



- Diffractive W/Z signals extracted from fits to the 2-D multiplicity distributions, similar to hard single diffraction dijet analysis

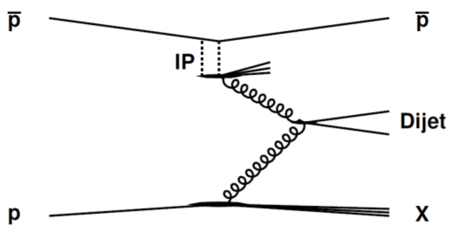
- Corrections due to jets misidentified as electrons and Z's which fake W's very small

Opposite trend compared to hard diffractive dijet case

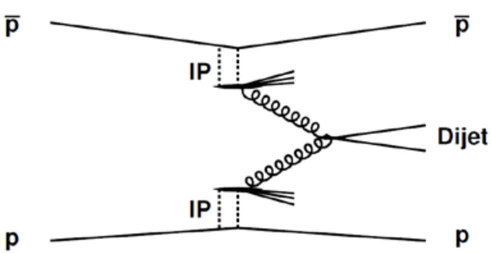
Sample	Diffractive / All	Probability Background Fluctuates to Data	
Central W	(1.08 + 0.19 - 0.17)%	1×10^{-14}	**7.7σ**
Forward W	(0.64 + 0.18 - 0.16)%	6×10^{-8}	**5.3σ**
All W	**(0.89 + 0.19 – 0.17)%**	3×10^{-14}	**7.5σ**
All Z	(1.44 + 0.61 - 0.52)%	5×10^{-6}	**4.4σ**

3. High mass exclusive diffractive dijet production at E_{CM}=1.96 TeV.

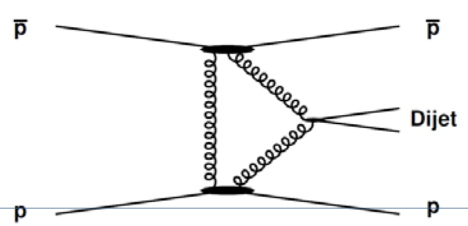
Single Diffraction Production:



Inclusive Diffraction Production (IDP):

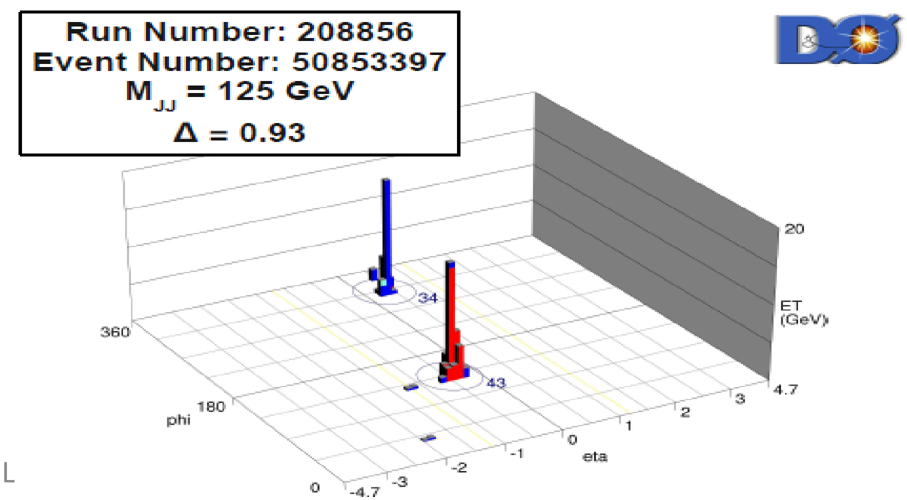


Exclusive Diffraction Production (EDP):



p + p → p +X + p

- Kinematic properties of new channel X can be measured from the proton (pbar) momentum loss.
- p + p → p +X + p is a good channel to study Higgs properties.
- Study based on rapidity gaps.
- Backgrounds: single diff. + IDP + NDF.



Data vs MC

Data Selection

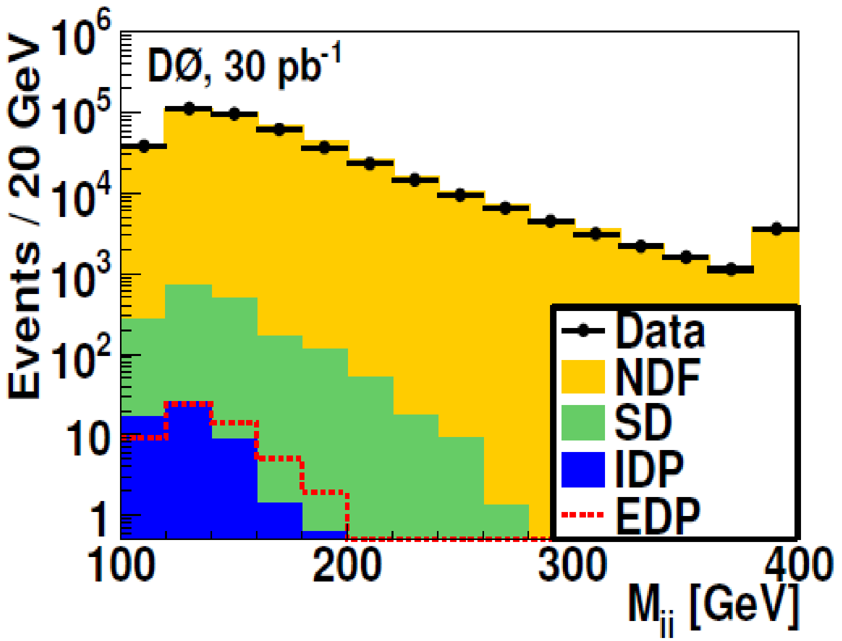
-Inclusive jet trigger with P_T>45 GeV.

- Restrict instantaneous luminosity (5-100)x 10^{30} $cm^{-2}s^{-1}$ to limit number of multiple interactions in same BX.

-Integrated luminosity of the sample ~ 30 pb^{-1}.

- Two jets $|y_{1,2}|$<0.8, p_{T1}> 60 GeV, p_{T2}>40 GeV, M_{jj}> 100 GeV, $\Delta\phi$>3.1.

Dijet invariant mass in data and MC



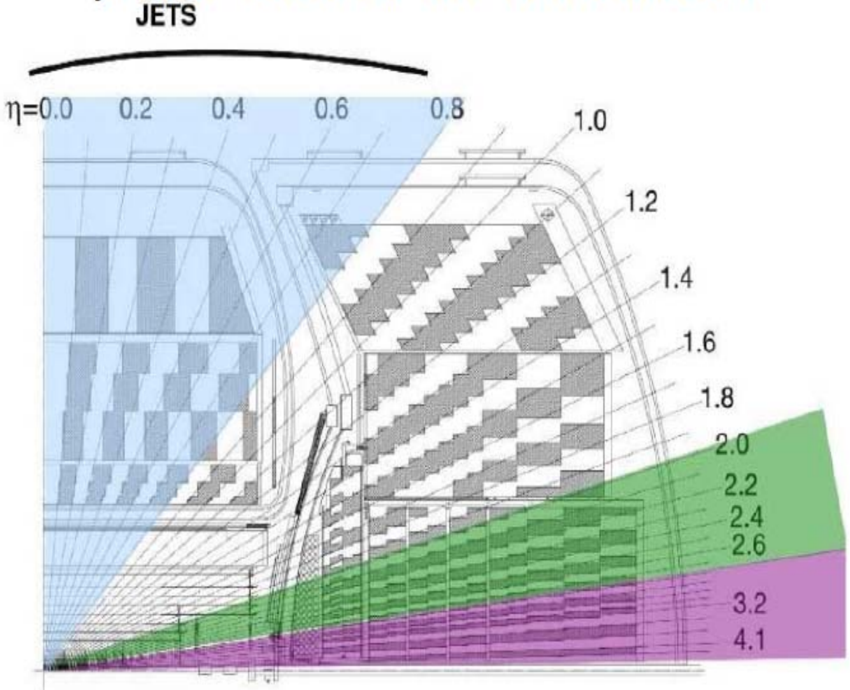
MC Models:
NDF = Pythia, SD = POMWIG
IDP = FPMC, EDP = FPMC

EDP and background separation

Separation variable: Sum of energy in the calorimeter cells.

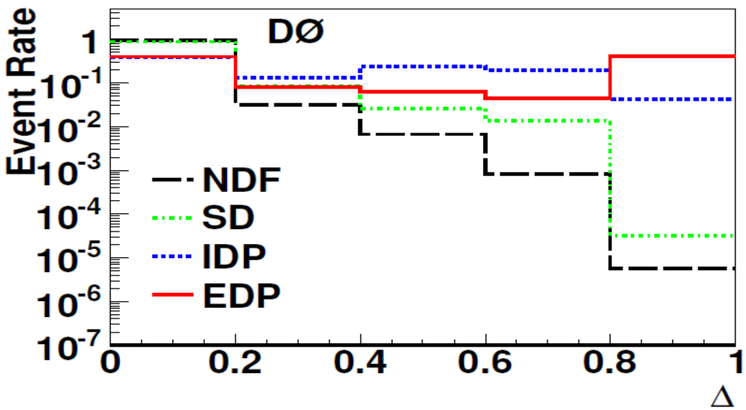
$$\Delta = \frac{1}{2}\exp\left(-\sum_{2.0<|\eta|\leq 3.0} E_T\right) + \frac{1}{2}\exp\left(-\sum_{3.0<|\eta|\leq 4.2} E_T\right)$$

¼ side view of the calorimeter

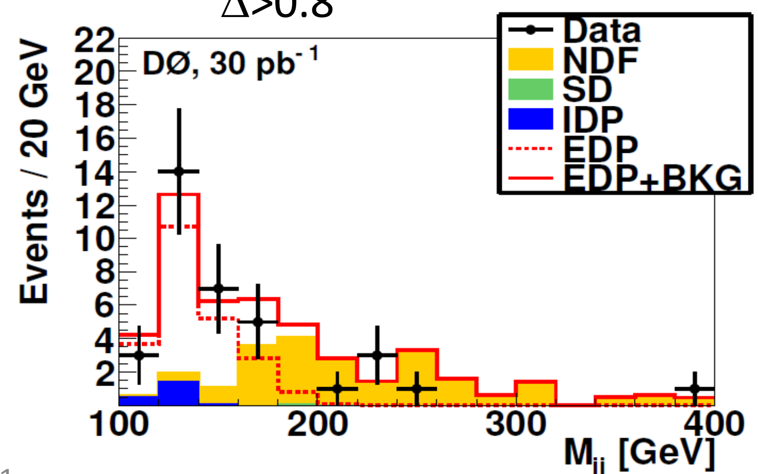


-Dijet in the central part of the calorimeter

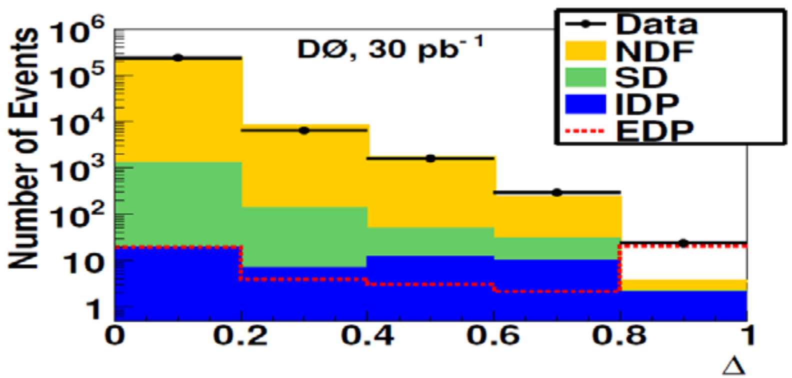
- No energy deposition in the forward part: Rapidity gap.

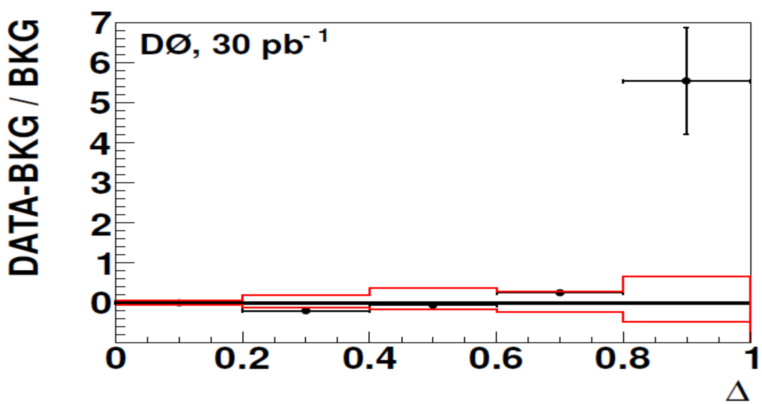


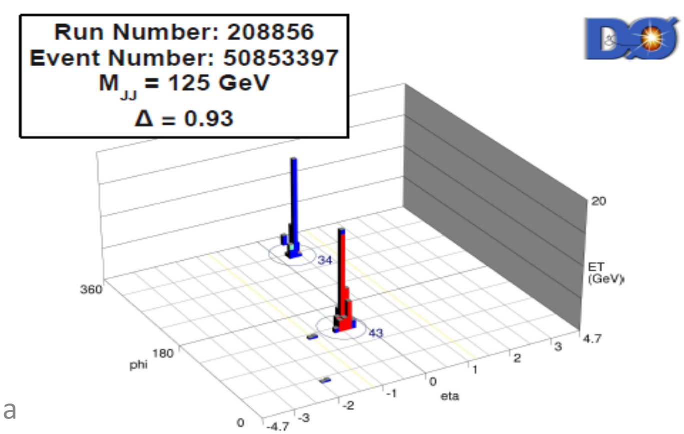
Δ>0.8



SIGNIFICANCE OF THE EXCESS







Systematic uncertainties:
- Cell calibration : 25%
- Jet energy scale uncertainty: 12%
-Trigger efficiency: 3%
- MC to data normalization: 5%
- Uncertainty of SD & IDP MC norm.: 50%

Estimation of the significance of the excess: From seudoexperiments with signal+back and back only hypotheses, count how many times back produces cross section seen in data:

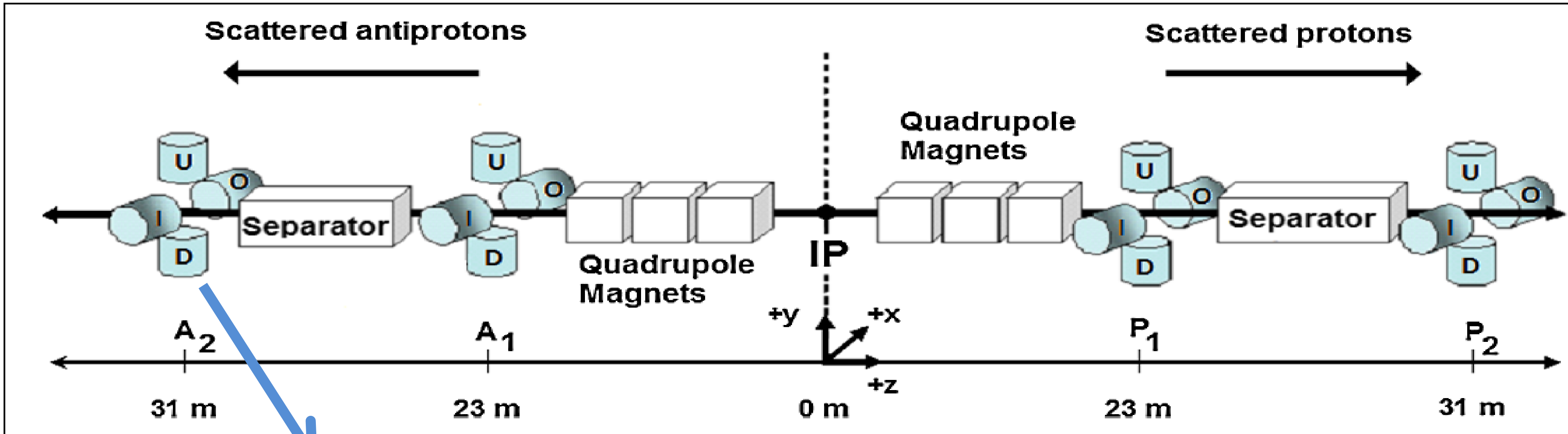
2.0×10^{-4} % → 4.7σ.

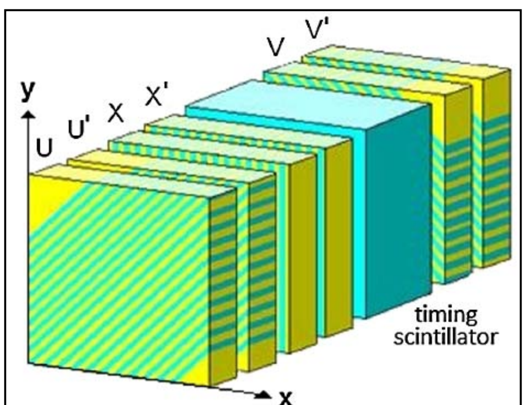
Sample	NDF	IDP	SD	EDP	DATA
All Δ	243145	52.2	1484.9	49	244682
Δ>0.8	$1.4^{+1.0}_{-0.8}$	$2.2^{+1.8}_{-1.5}$	$0.05^{+0.04}_{-0.03}$	$20.4^{+1.8}_{-1.7}$	24

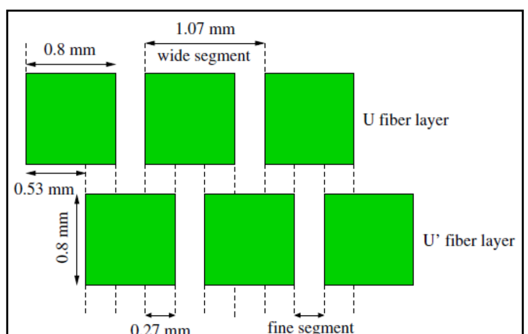
Ma

4. Measurement of the differential cross section $d\sigma/dt$ in elastic p-pbar scattering at E_{CM}=1.96 TeV

Forward Proton Detector in the D0 Experiment:





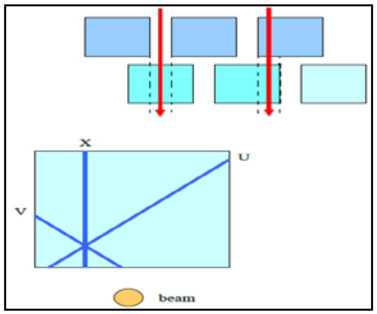


- ➢3 planes of 0.8 mm Scintillating fibers with different rotations: U = 45°, X=90°, V=135°
- ➢Each plane with 2 fiber layers (prime and unprimed) offset by 2/3 fiber.
- ➢ 112 channels per detector
- ➢ Trigger scintillator provides timing information.

DATA SAMPLE

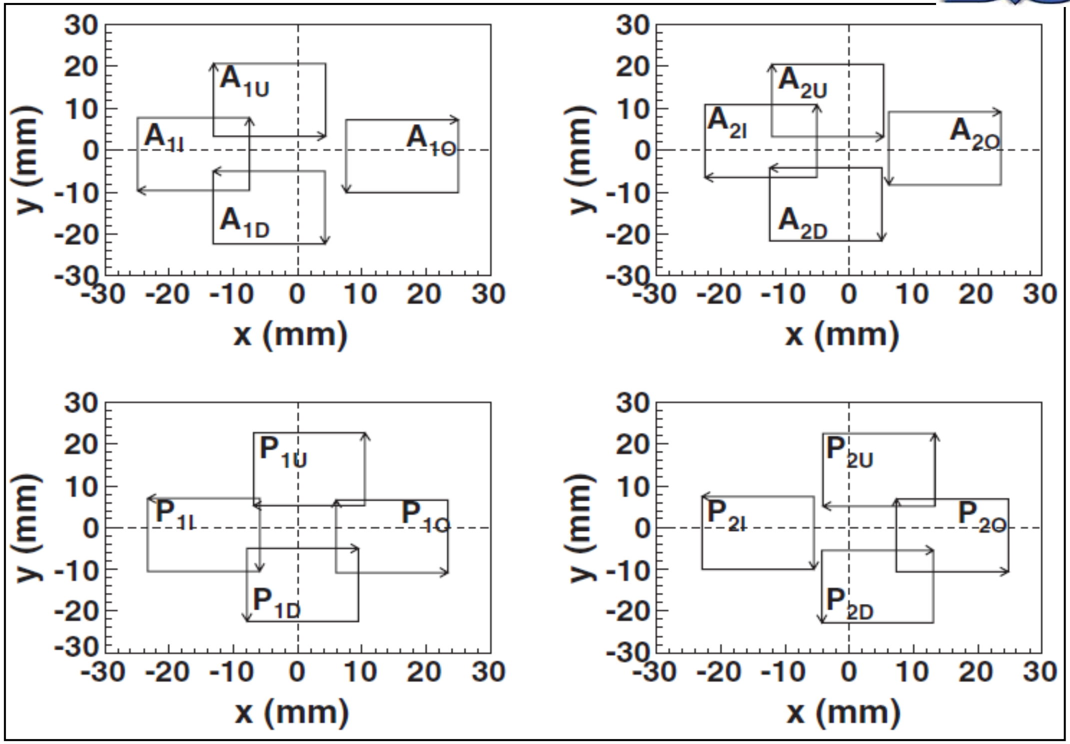
- Special store: Tevatron injection tune lattice : β^*=1.6 m
- Only 1 proton and 1 antiproton bunch colliding.
- Heavy scraping and electrostatic separators OFF

HIT FINDING

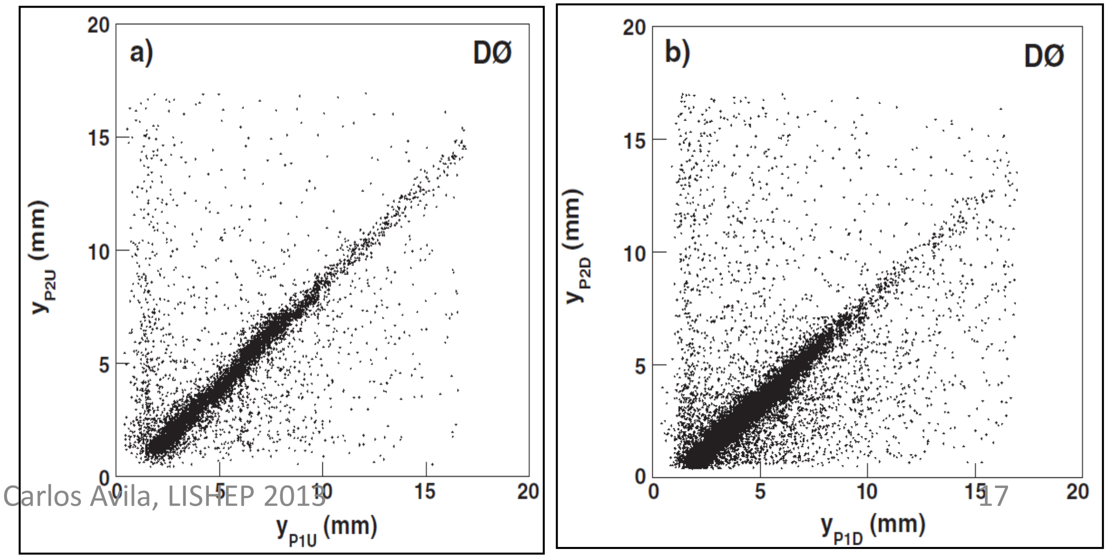


- Combining the two layers from a plane define a fiber segment.
- Need two out of three fiber segments (UV, UX, XV or UVX) to determine the hit coordinates.
- *Use alignment to get coordinates with respect to the beam.*
- *X can be gotten directly from X fiber segment. Resolution is determined by comparing x measurements.*

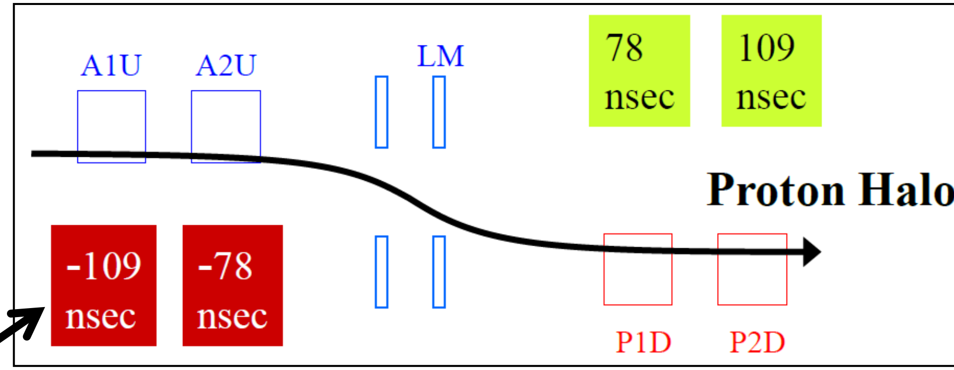
ALIGNMENT

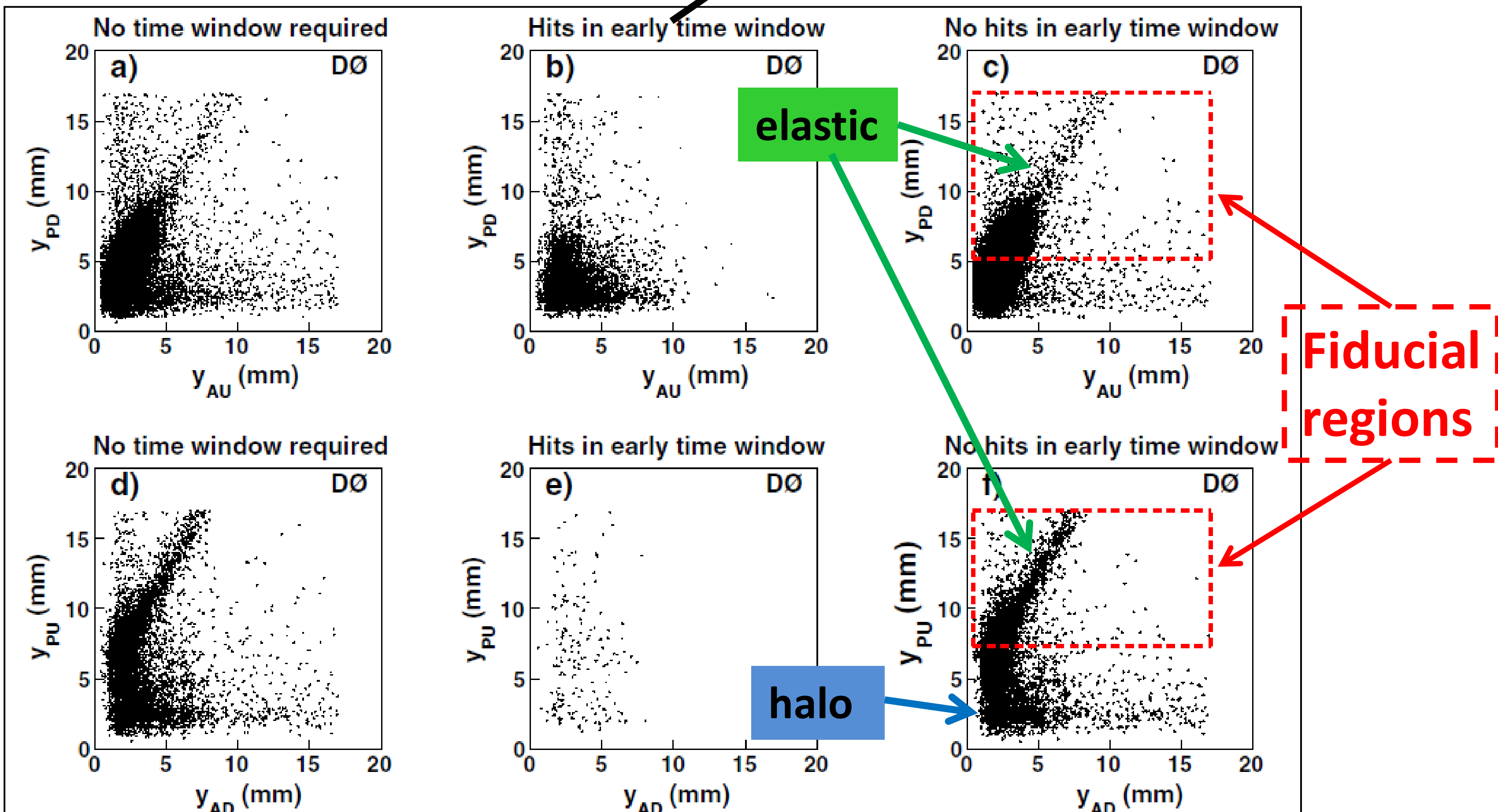


DETECTOR CORRELATIONS

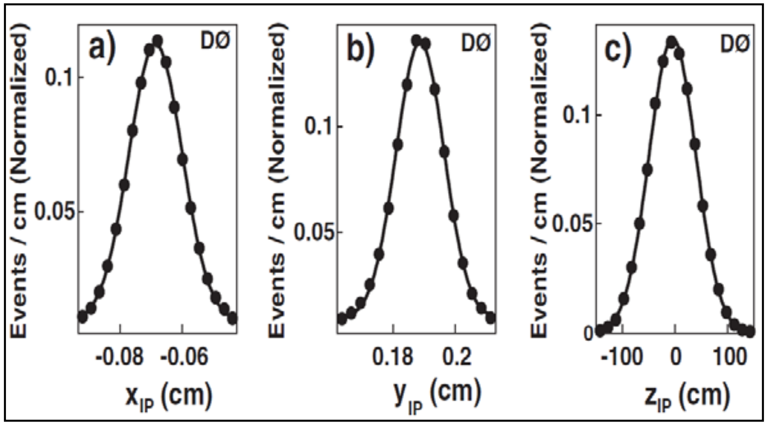


ELASTIC EVENT CORRELATIONS AND HALO BACKGROUND

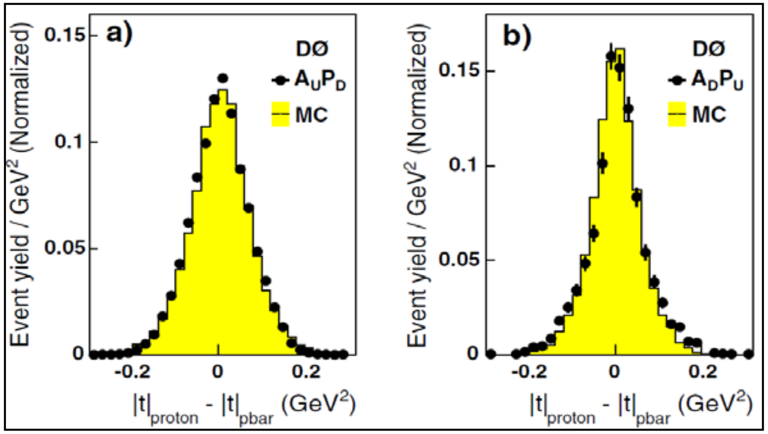




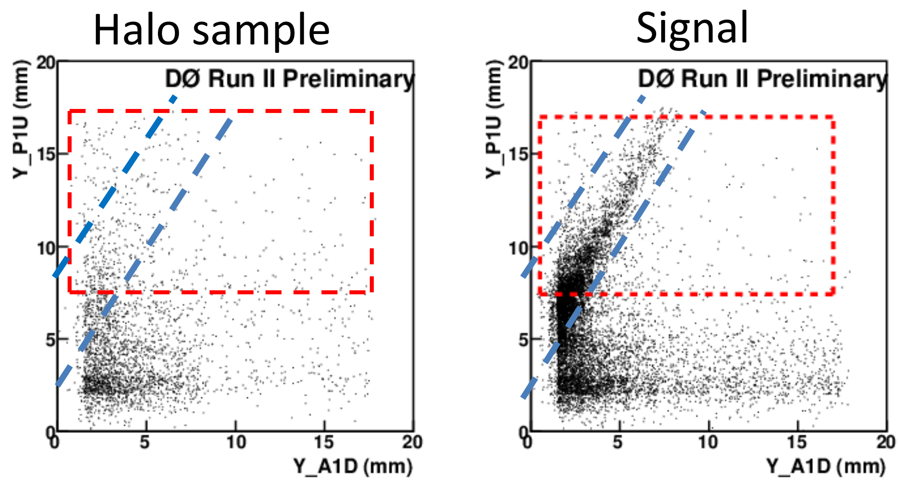
SIZE OF THE INTERACTION POINT



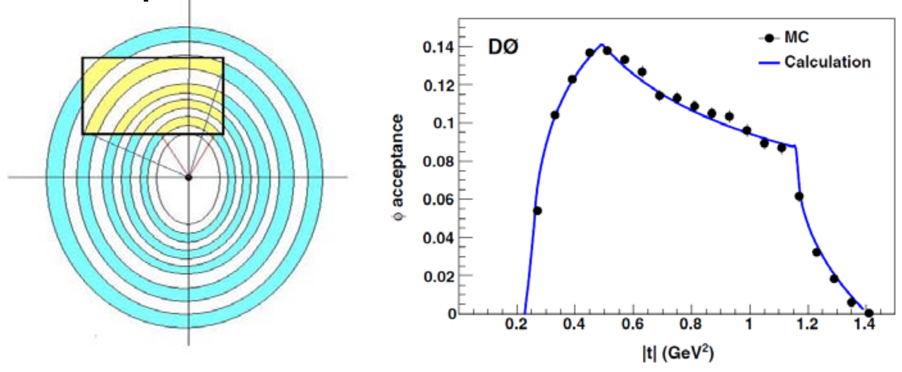
Δ t DISTRIBUTIONS

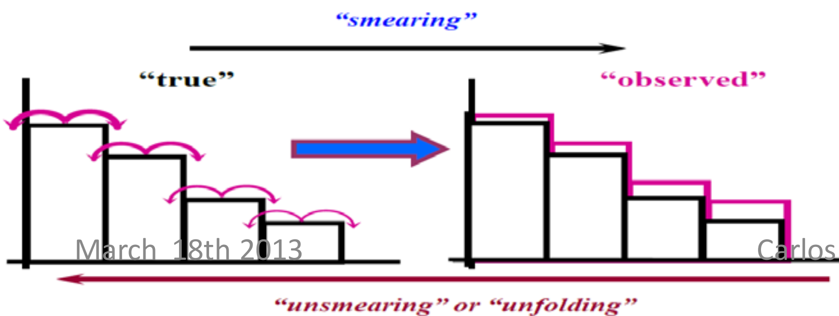


BACKGROUND SUBTRACTION



ϕ ACCEPTANCE CORRECTION



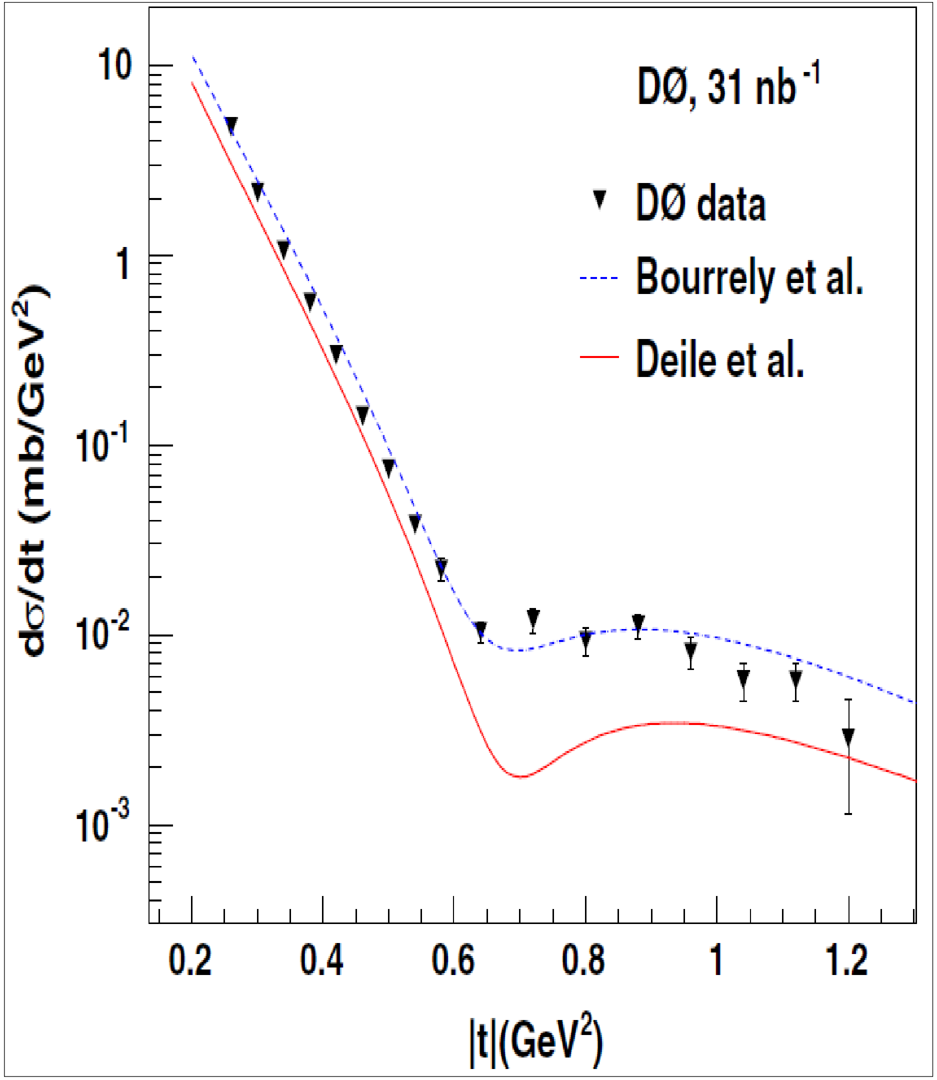


Unsmearing is done throug MC

Measurement of dσ/d|t|

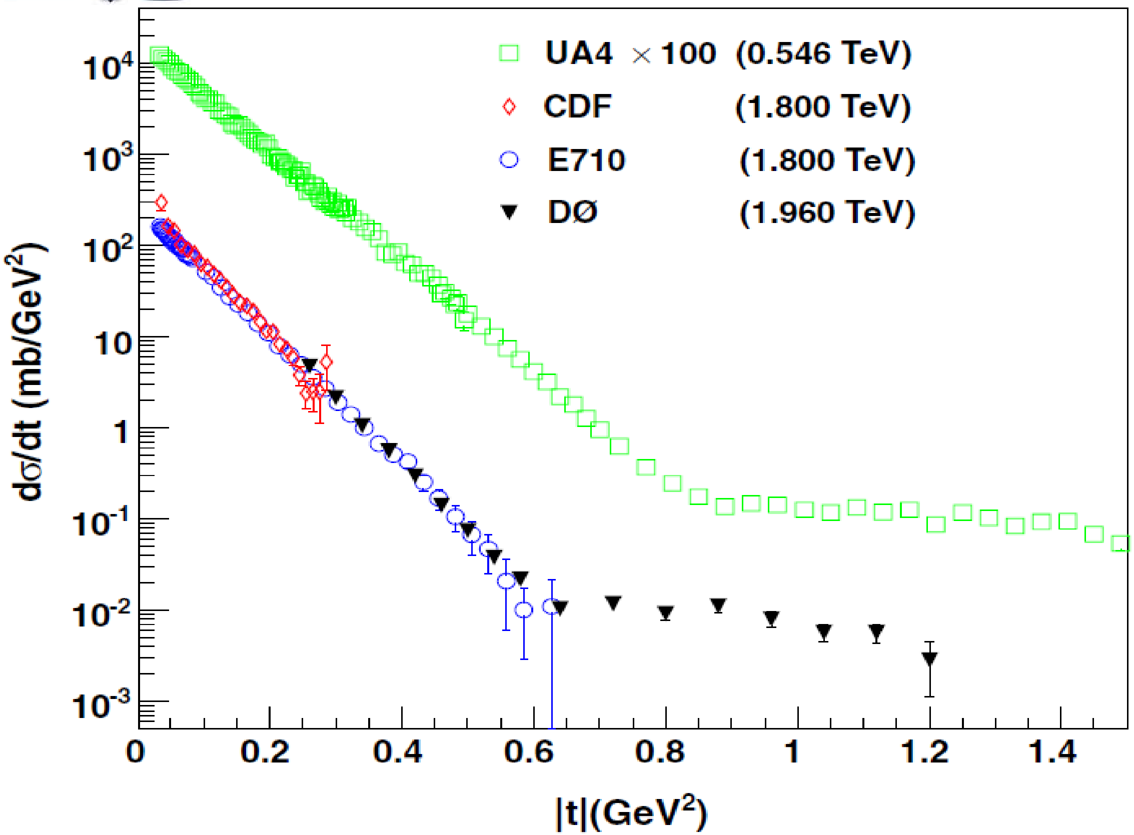
1. Count number of elastic events as a function of t.
2. Subtract residual background.
3. Divide by Luminosity
4. Correct for acceptance and efficiencies
5. Correct for bin smearing
6. Take weighted average over 4 measurements:
   2 elastic combinations (AUPD, ADPU) X 2 detector positions.

$$\frac{d\sigma}{dt} = \frac{1}{L}\frac{1}{Acc}\frac{1}{\varepsilon}\frac{1}{smearing}\frac{dN}{dt}$$

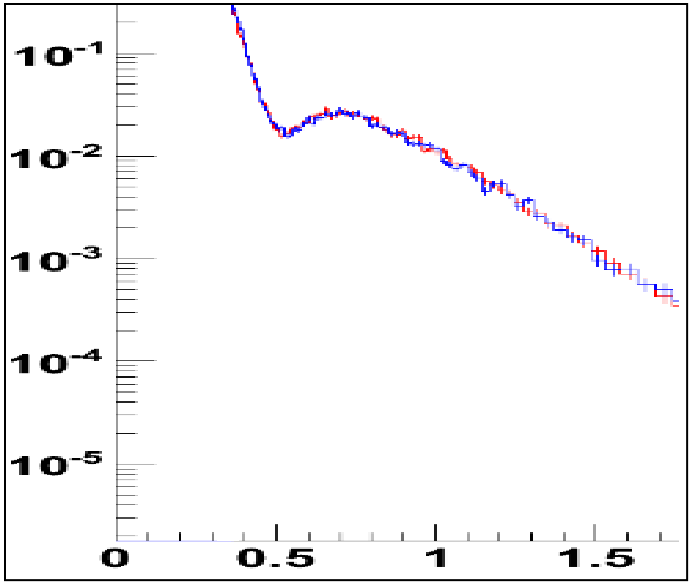


Slope in the forward region: B = 16.86 ± 0.10 (stat) ± 0.20 (syst)

COMPARISON TO OTHER EXPERIMENTS



TOTEM RESULT



- Diffraction minimum is less pronounced in p-pbar compared to p-p collisions.
- As energy increases:
  - Slope in the forward region increases.
  - Diffraction minimum moves towards lower values of |t|

CONCLUSIONS AND FINAL REMARKS

We have shown that the D0 experiment has contributed with relevant measurements to understand soft and hard difraction in p-par collisions at High energies:

- Gap fractions for difractive dijet and W/Z production.

- Observation of High Mass exclusive diffractive production

- Measurement of elastidc dσ/dt.