



36th International Conference on High Energy Physics

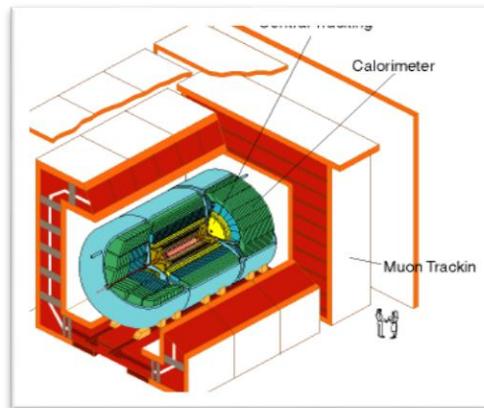
4 – 11 July 2012
Melbourne Convention and Exhibition Centre



Measurement of the differential cross section $d\sigma/dt$ in elastic antiproton-proton scattering at $\sqrt{s} = 1.96$ TeV

V. Šimák D0 experiment and CTU Prague

for D0 experiment



Motivation

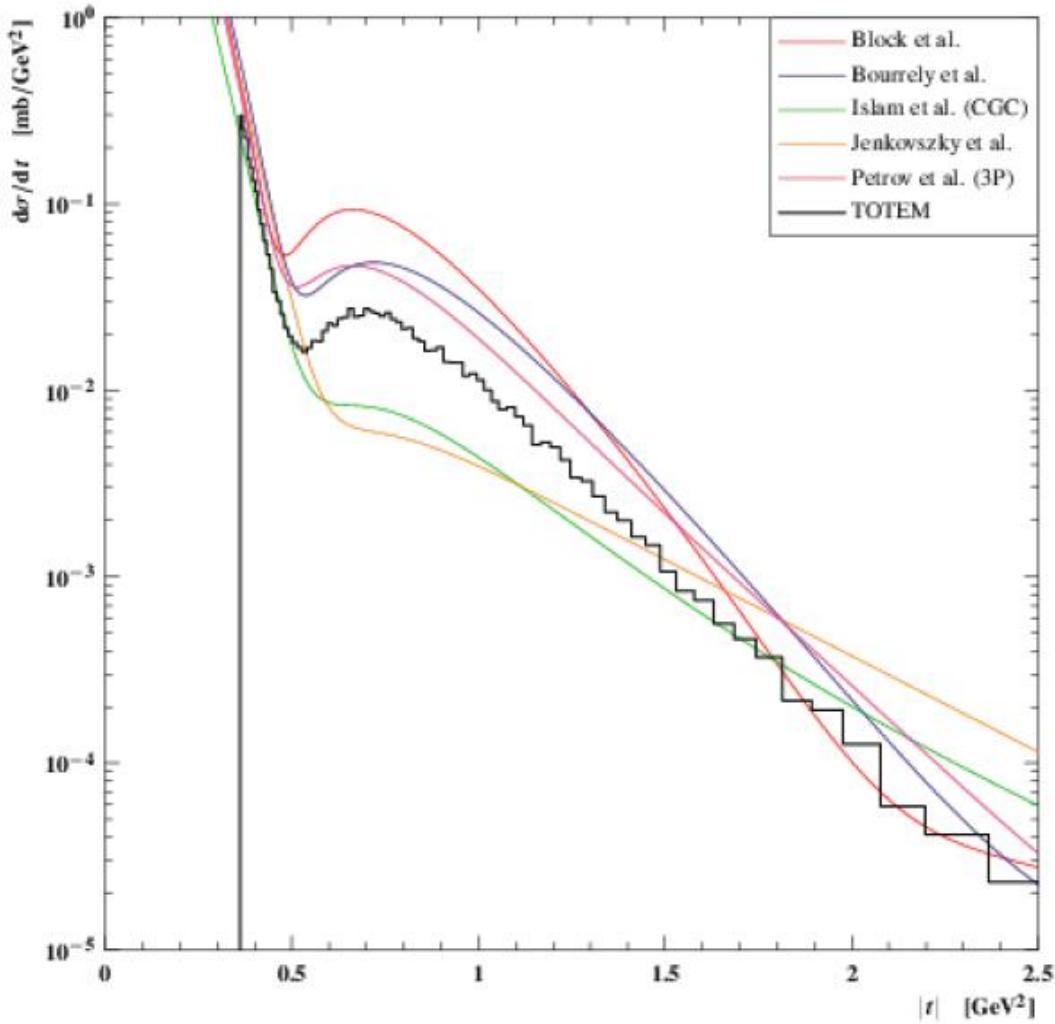
Elastic scattering - first results in any hadrons' experiment

$$\frac{d\sigma(s)}{dt} = \frac{1}{16\pi s^2} |A|^2 = \frac{1}{16\pi s^2} (\text{Im} A(s, t))^2 (1 + \rho^2(s, t)).$$
$$\rho(s, t) = \frac{\text{Re} A(s, t)}{\text{Im} A(s, t)}.$$

$$\frac{d\sigma}{dt} / \left(\frac{d\sigma}{dt} \right)_{t=0} = e^{Bt} \approx e^{-Bp^2\theta^2}. \quad -t = 2p^2(1 - \cos\theta) \approx p^2\theta^2 \approx p_t^2 \quad (\theta \ll 1)$$

$$B(s, t) \approx \frac{d}{dt} \left[\ln \frac{d\sigma(s, t)}{dt} \right]. \quad \left(\frac{d\sigma}{dt} \right)_{t=0} = \frac{\sigma_t^2(s)(1 + \rho_0^2(s))}{16\pi}$$

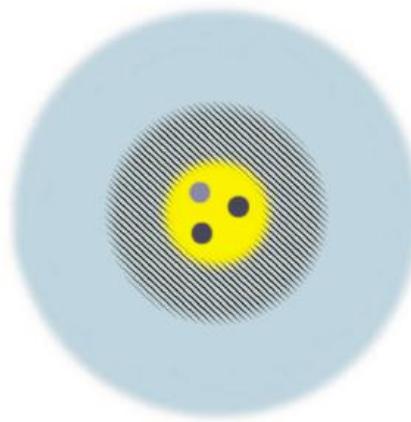
$$\langle b^2(s) \rangle_{el} = 4 \int_{t_{min}}^0 dt |t| \left| \frac{d}{dt} A(s, t) \right|^2 / \int_{t_{min}}^0 dt |A(s, t)|^2.$$



Several phenomenology models:

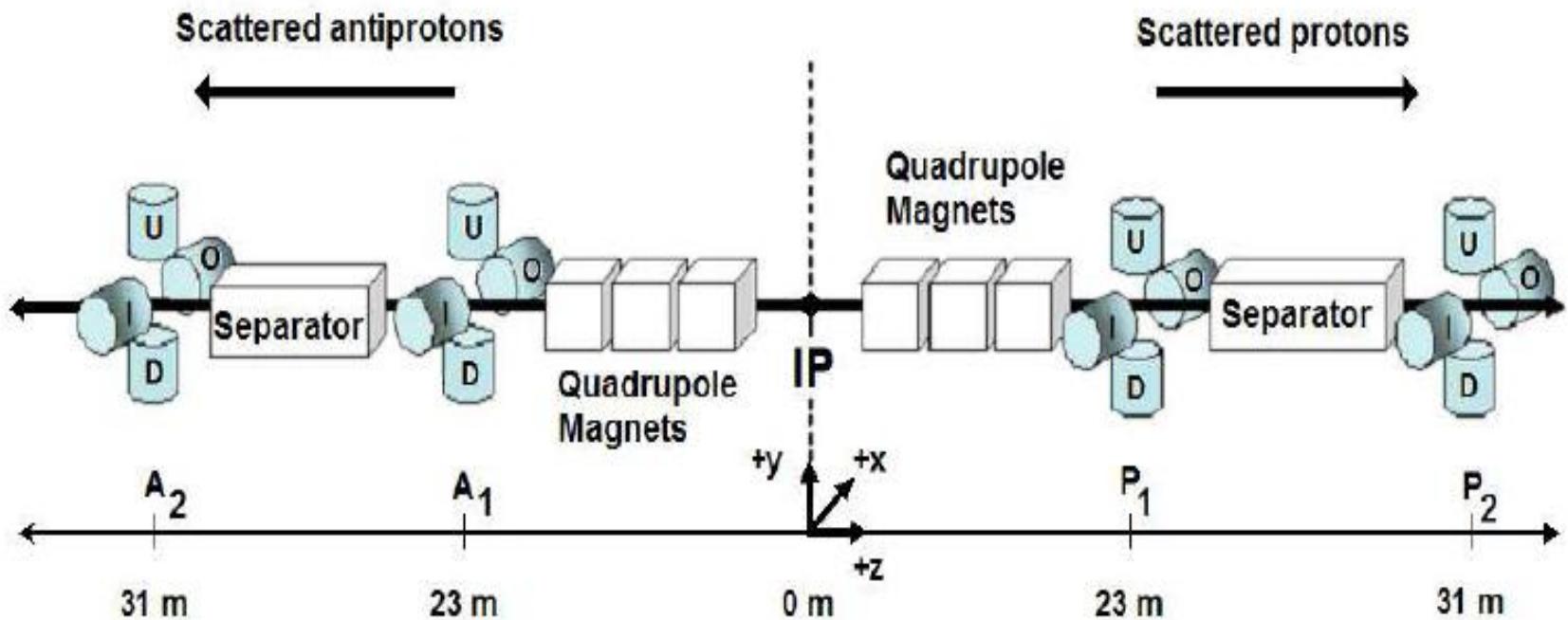
- Geometrical scaling
- Clouds structure

-



L.M. Dremin: aXiv. 1206.5474v1 [hep] 24. Jan. 1012

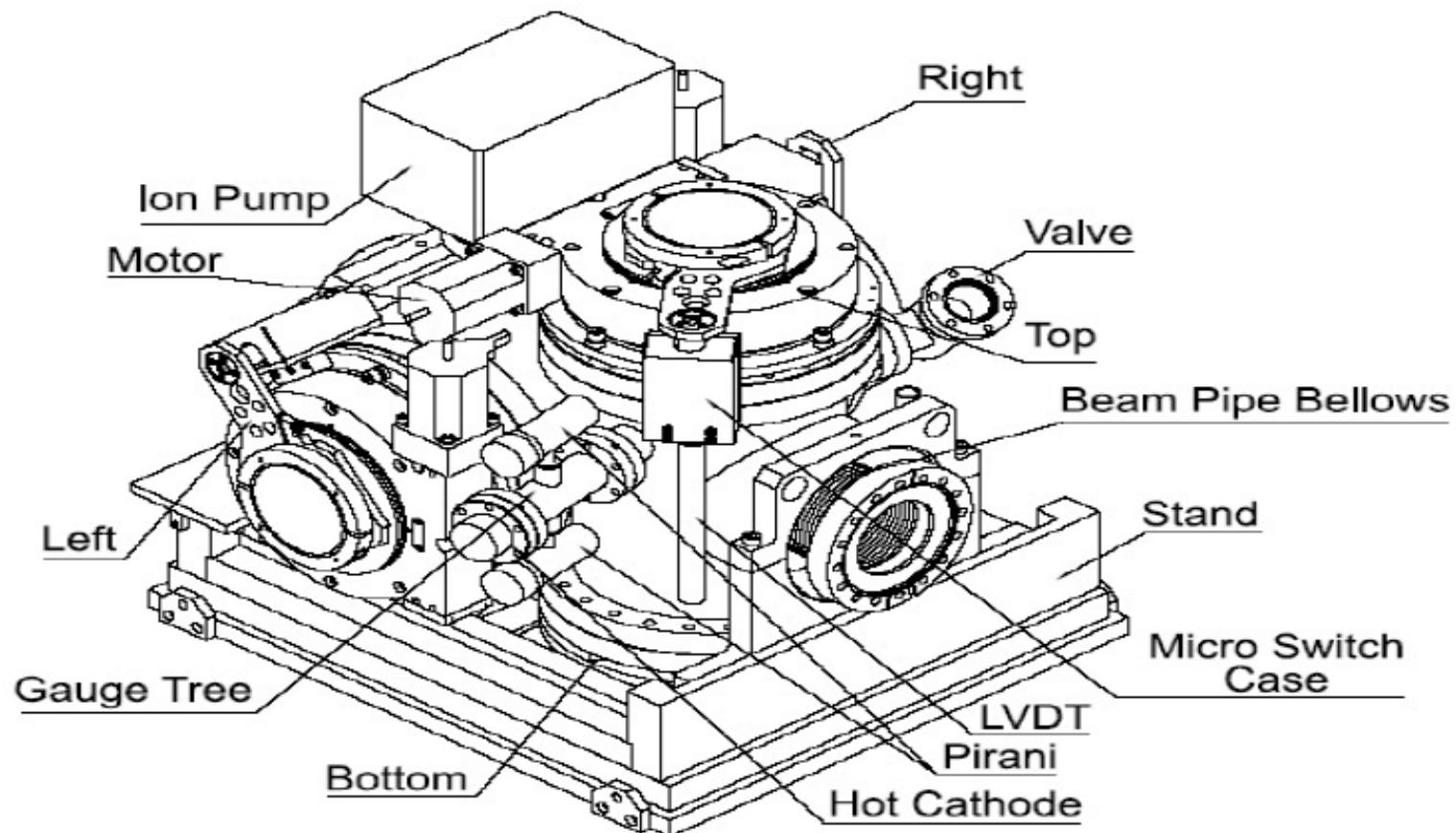
In Run II at Tevatron: D0 + PFD (2002)



$$7.3 < |\eta| < 8.6$$

Covered regions for scattered protons/antiprotons

FPD Pot station



FPD Pot station

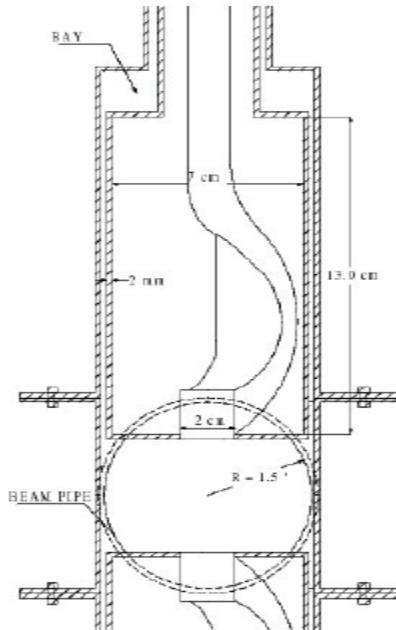
- 200 um kapton foil window separating UHV and normal atmospheric pressure condition.

Beam properties at IP

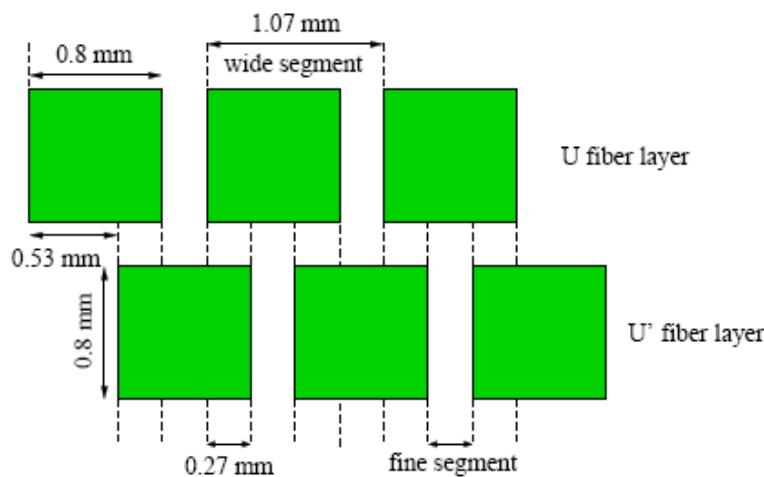
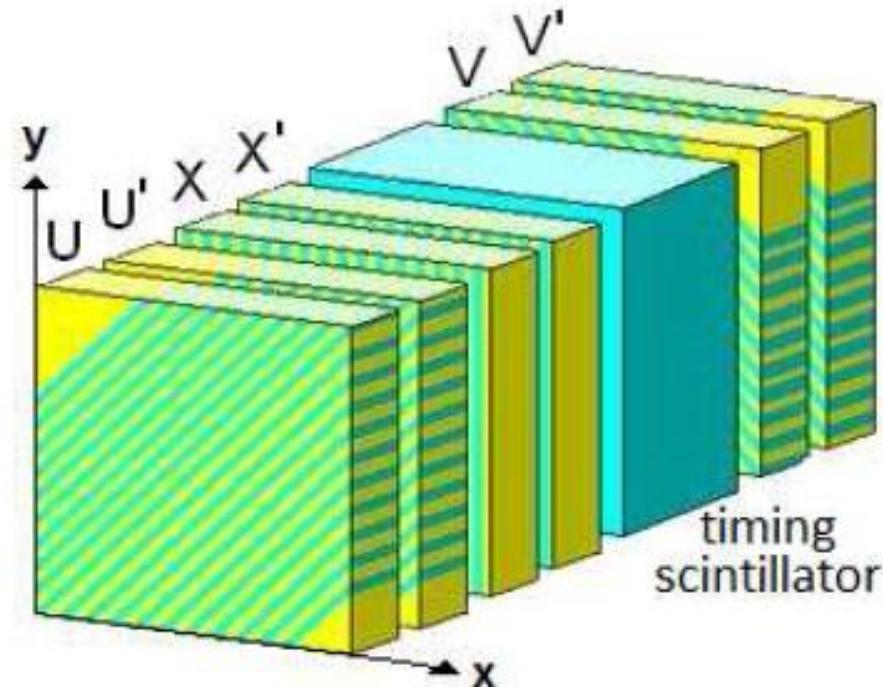
- Beta* ~1, 5m
- Beam width (at IP) ~70um.
- Beam divergence angle (IP) ~40urad
(compare for elastics event with $t=0.5 \text{ GeV}^2$ angle is 0.7mrad)

- 95% normalized emittance:

beam	emittance ϵ_{n95} [$\pi \text{ mm mrad}$]
\bar{p}	17 ± 1
p	20 ± 1

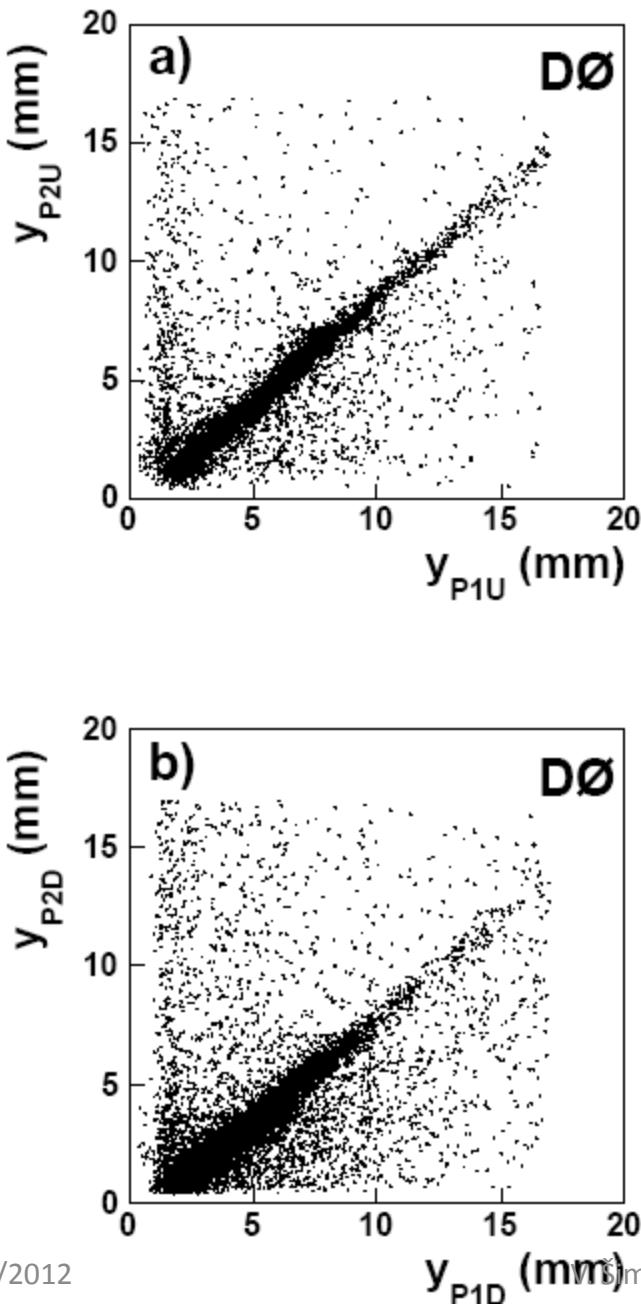


FPD scintillating fiber detector



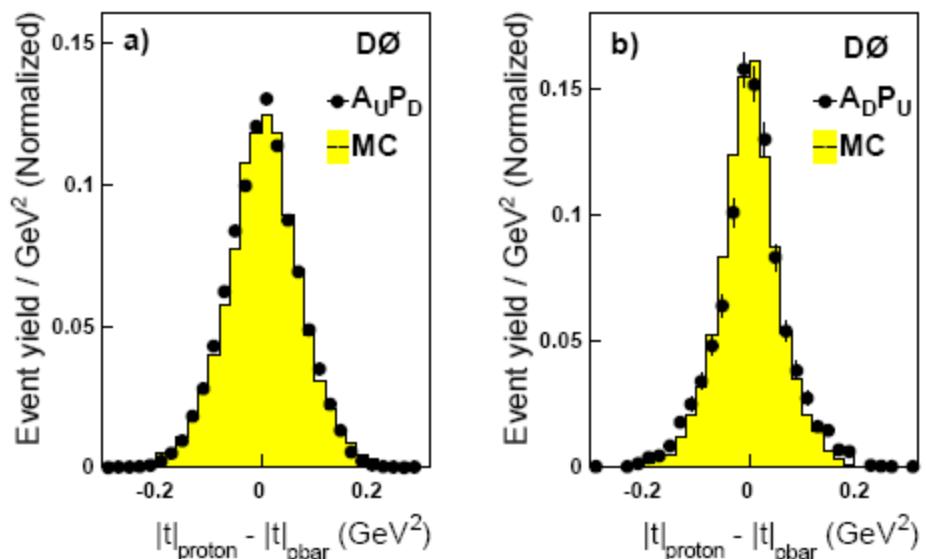
Layers

U, U', V, V', X, and X'



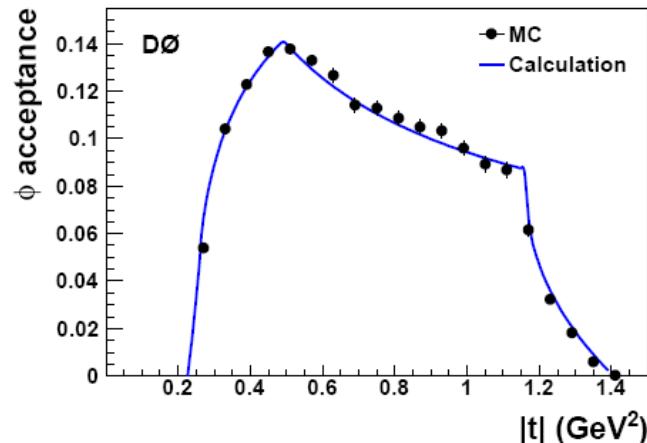
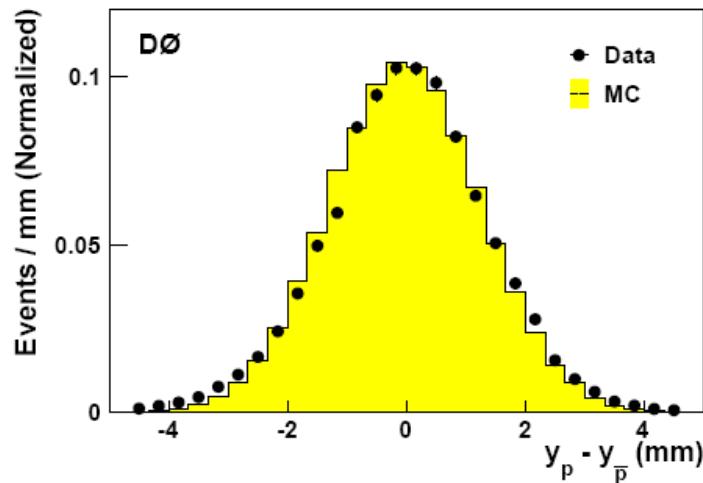
Comparison of detector y coordinates In the spectrometers Pu and Pd

Difference in reconstructed t between
proton and antiproton,
comparison of Monte Carlo with the data

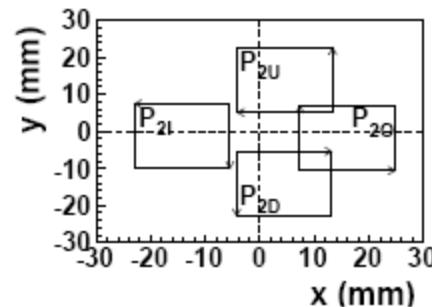
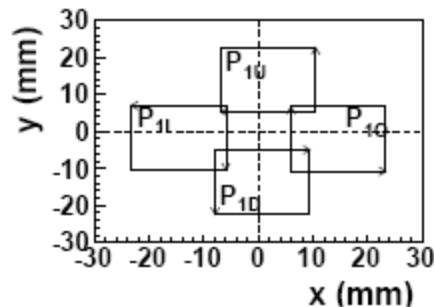
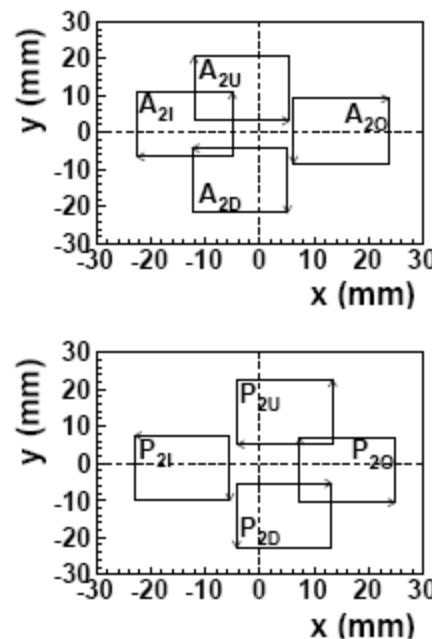
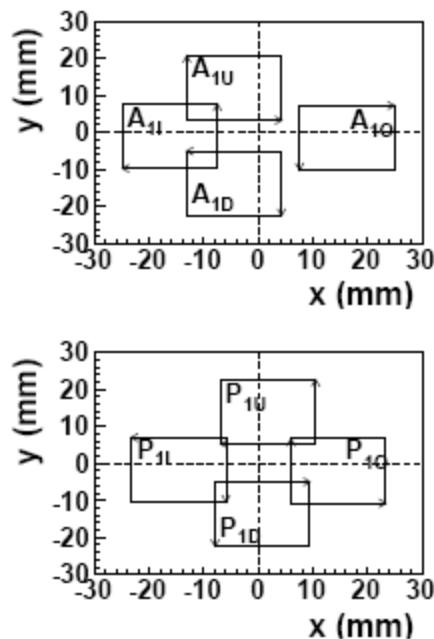


Uses special run FPD run (2006) with high β^* and one bunch of protons and anti-protons. About 20 million events.

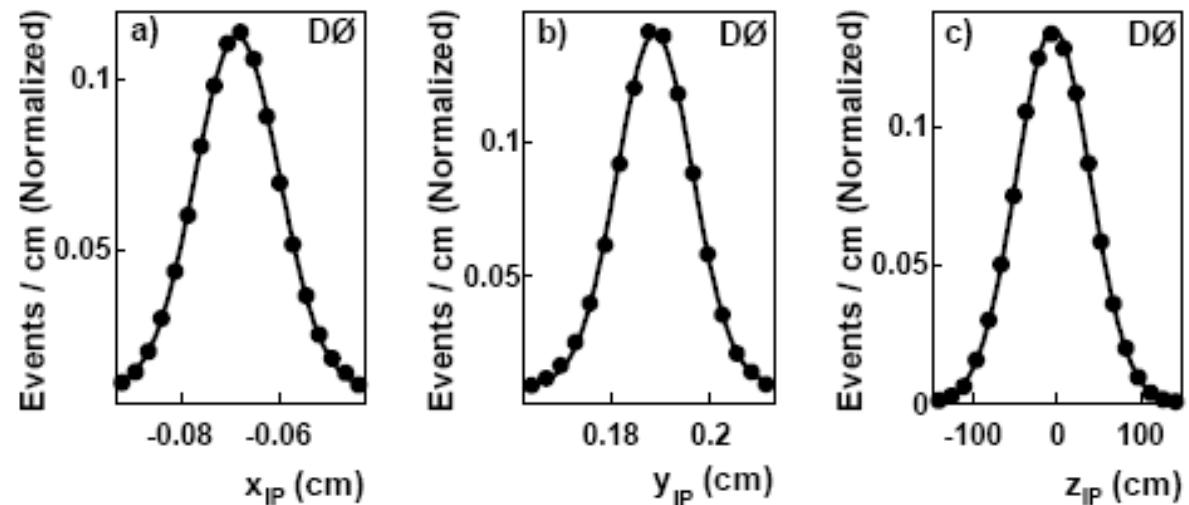
Monte Carlo comparison



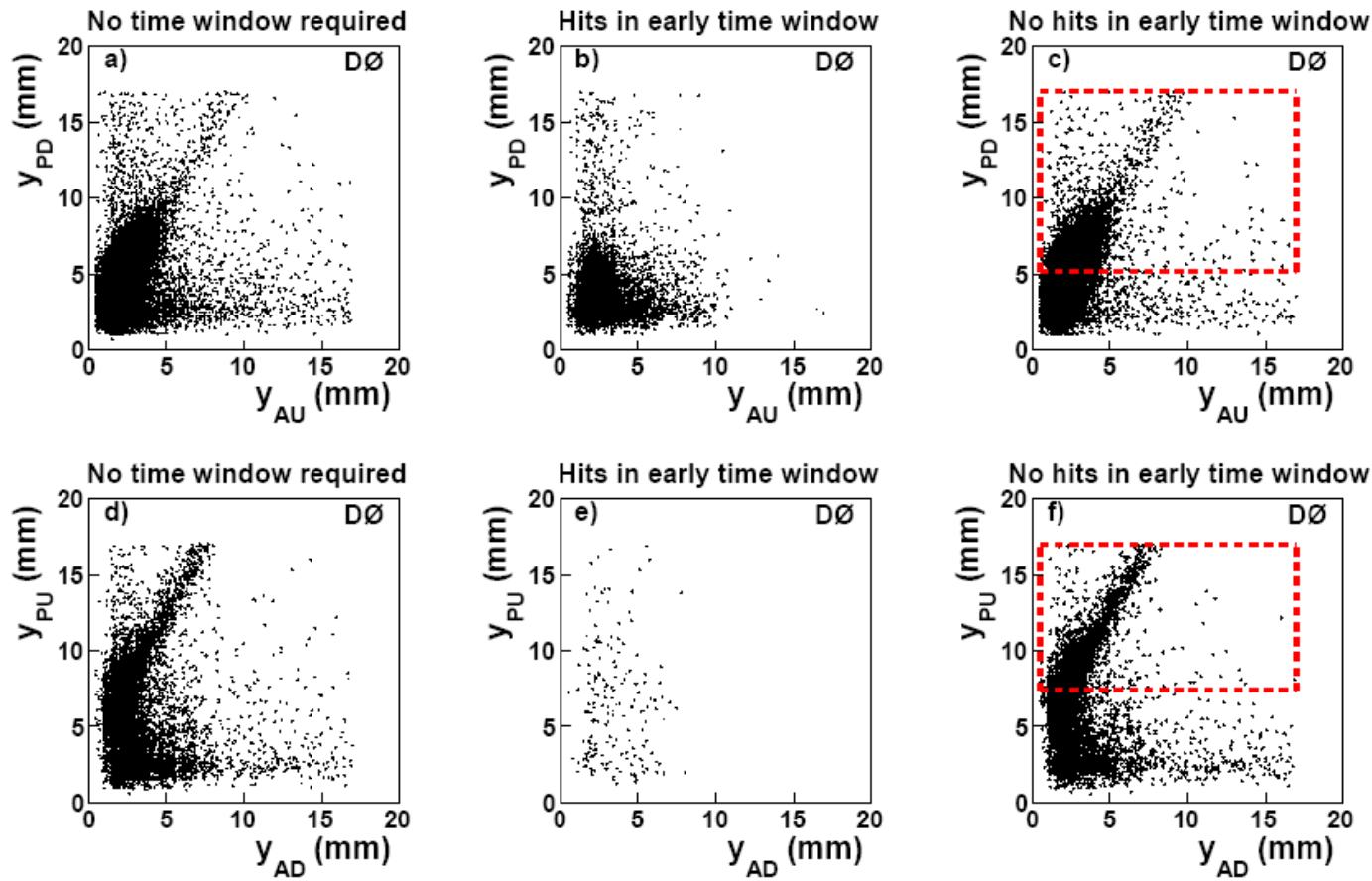
Trigger efficiencies for detectors: 50% to 70%



Primary vertex reconstruction

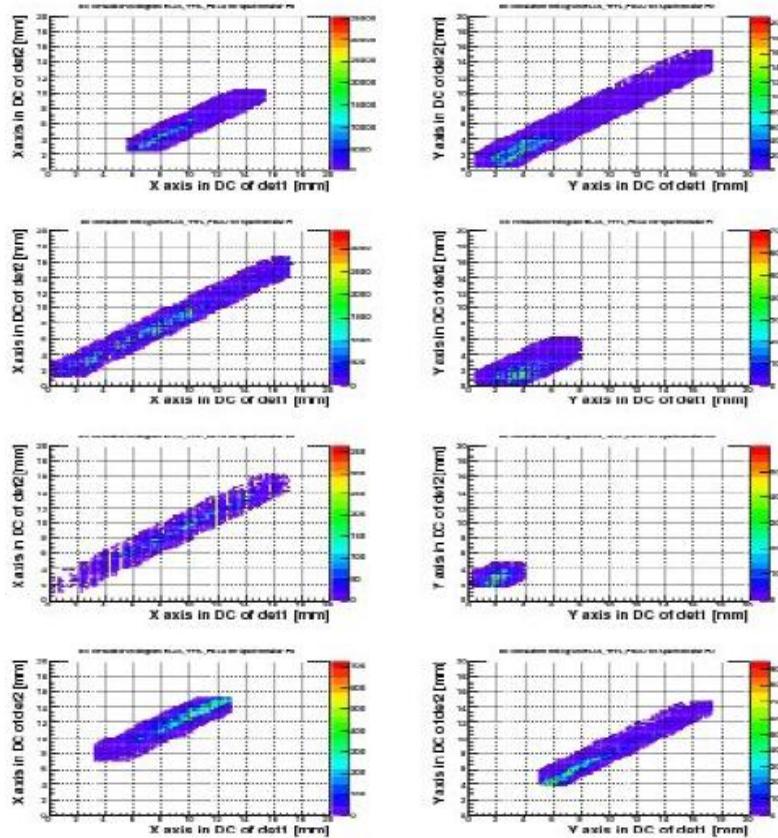


Position of detector with respect to beam center



**The correlation plots y -p vs y -ap for the first detectors .
The dashed lines correspond to the fiducially requirements applied**

Elastics analysis - signal selection P side SET1

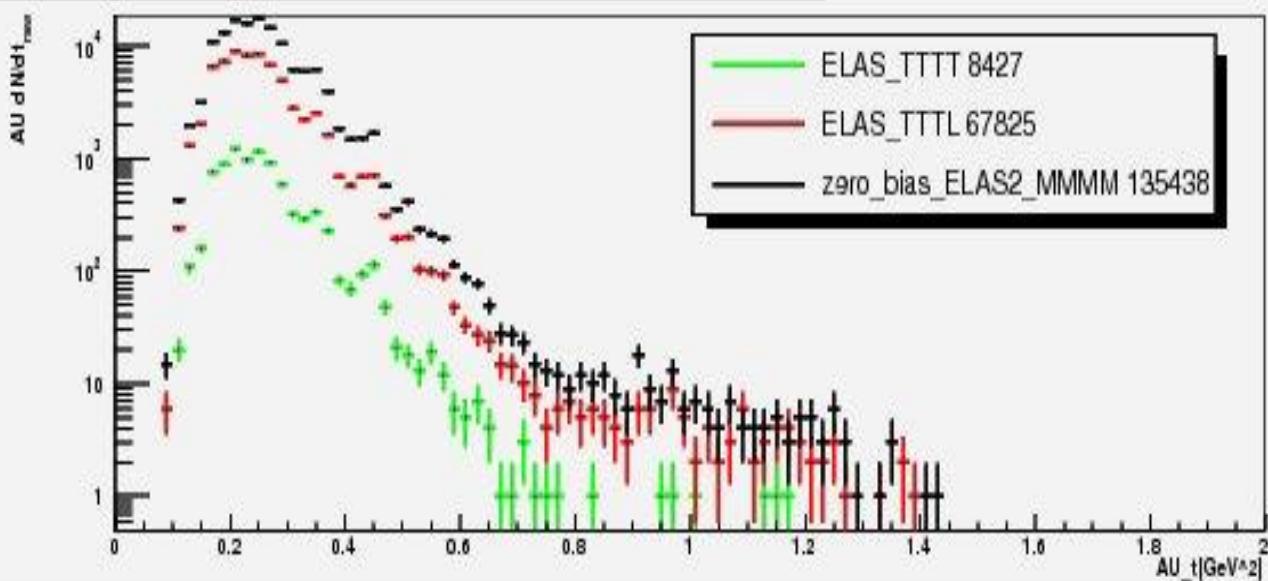


FPD Trigger system

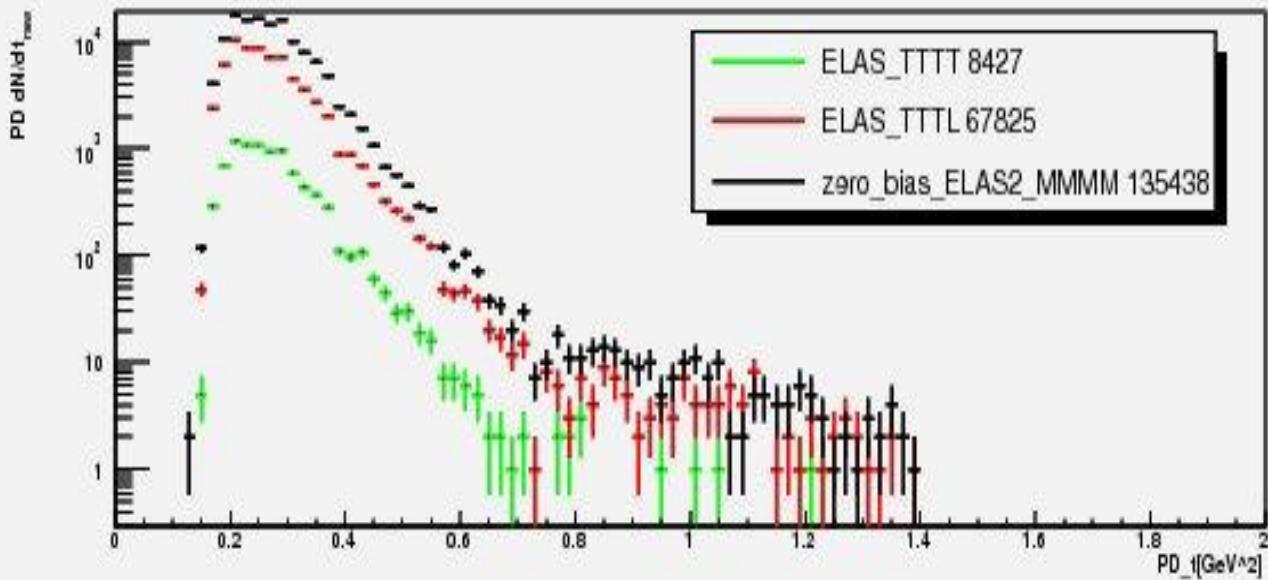
- Trigger system:
- Dedicated L1 trigger (DFE , TM)
- In total 3 layers (U,V,X) per detector each with two sub-layer (prime ,un-prime)
- Wide hit = fiber+gap (over prime,un-prime)
- Wide hit combination over 3 or 2 planes
(Tight , Loose, Medium)
(Loose trigger= all A2* less performing detectors)

Trigger efficiencies for first four detectors: 50% to 70%

dN/dt elas distribution in PDAU for side A as function of requested triggers

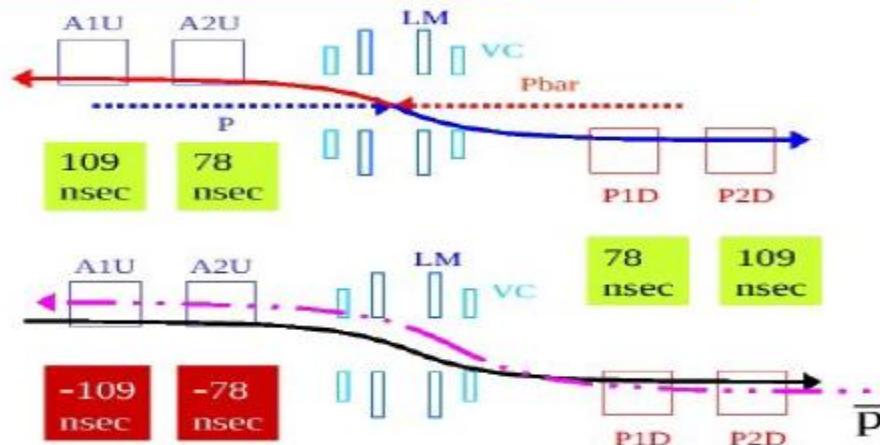


dN/dt elas distribution in PDAU for side P as function of requested triggers



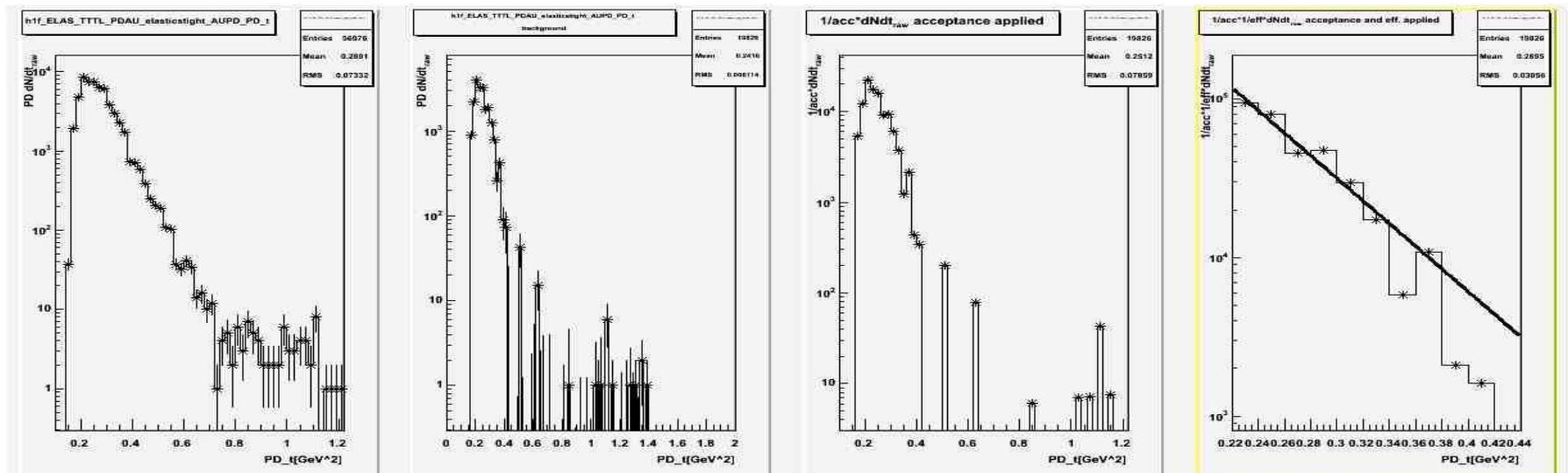
Elastics/Halo Background

Elastic



Proton Halo

dN/dt raw signal selection , background , applied acceptance,
applied eff. and acceptance:

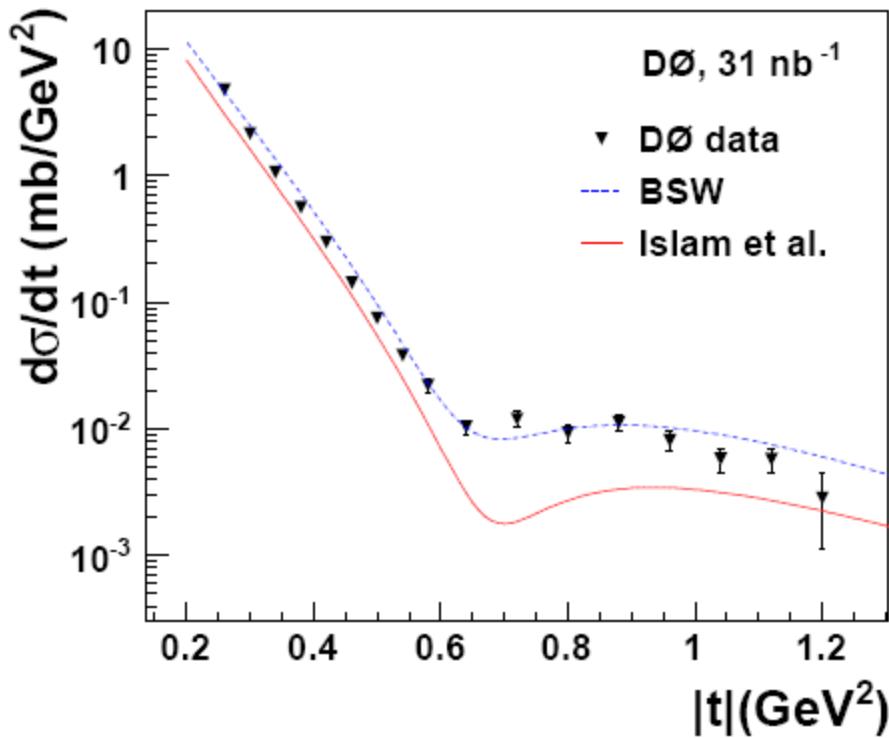


Results

$0.26 < |t| < 1.2 \text{ GeV}^2$

Change of slope at
 $|t| \approx 0.6 \text{ GeV}^2$

A. Brandt, C. Avila



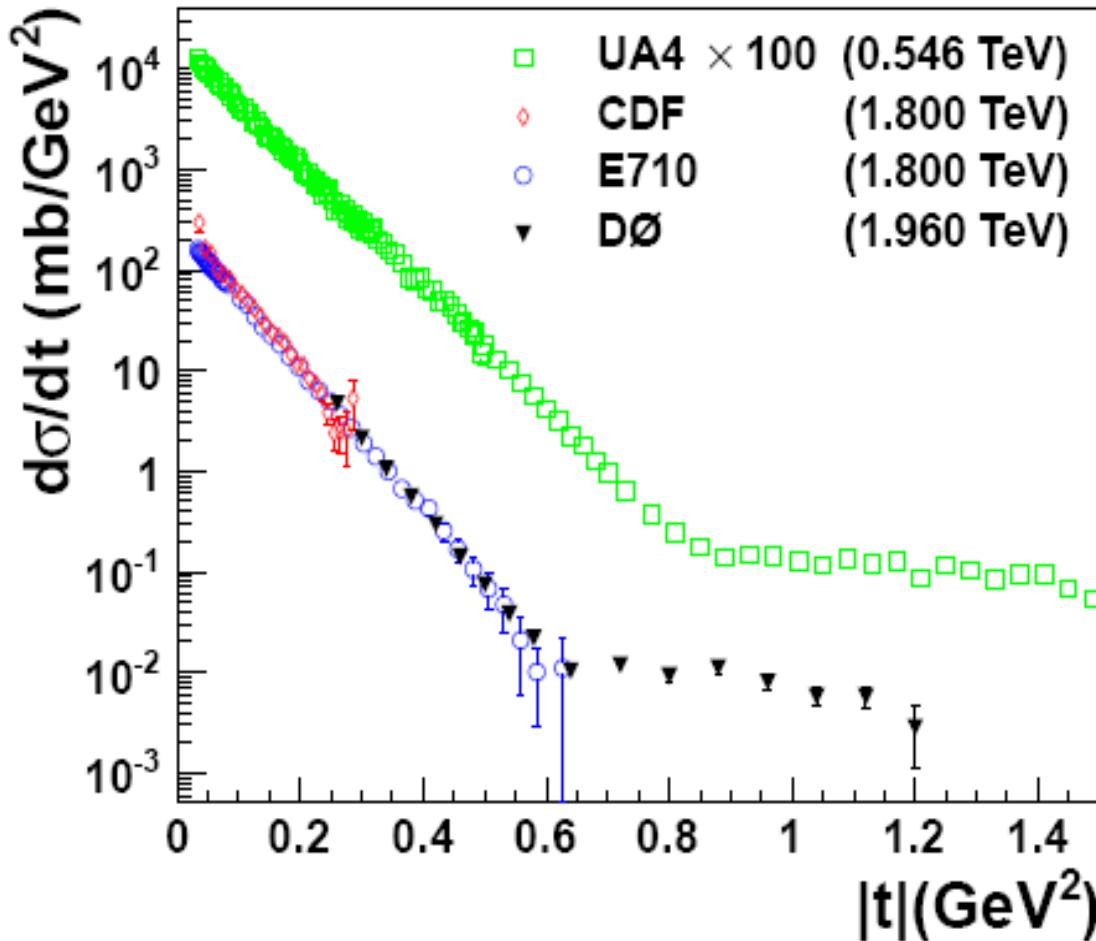
fit to the $d\sigma/dt$ distribution $Ae^{-b|t|}$ range $0.26 < |t| < 0.6$

$$b = 16.86 \pm 0.10 \text{ (stat)} \pm 0.20 \text{ (sys)} \text{ GeV}^{-2}$$

Fermilab-Pub-12-263-E

Submitted to PRD

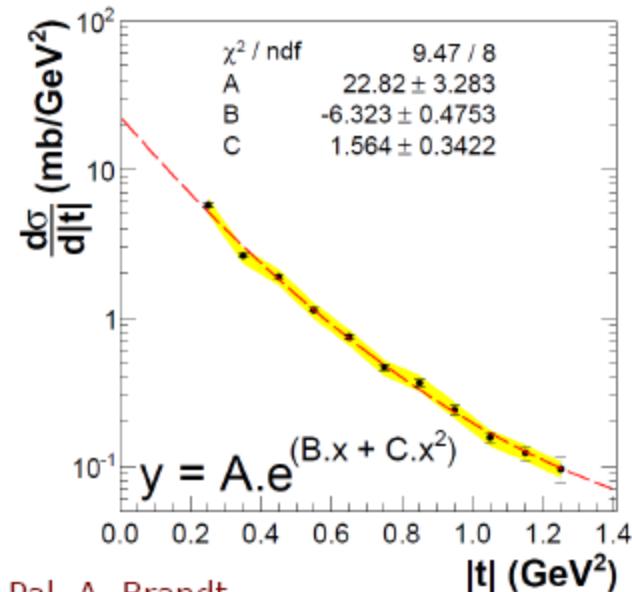
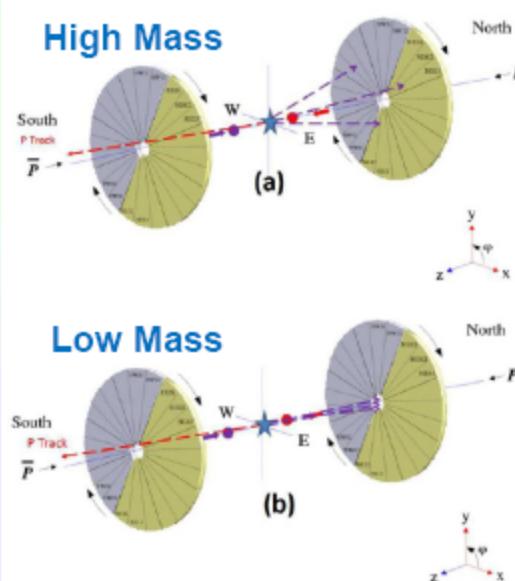
Comparison of result with other experiments



Measurement of elastic scattering with FPD cover larger $|t|$ and higher \sqrt{s} that experiments: UA4, UA8, CDF

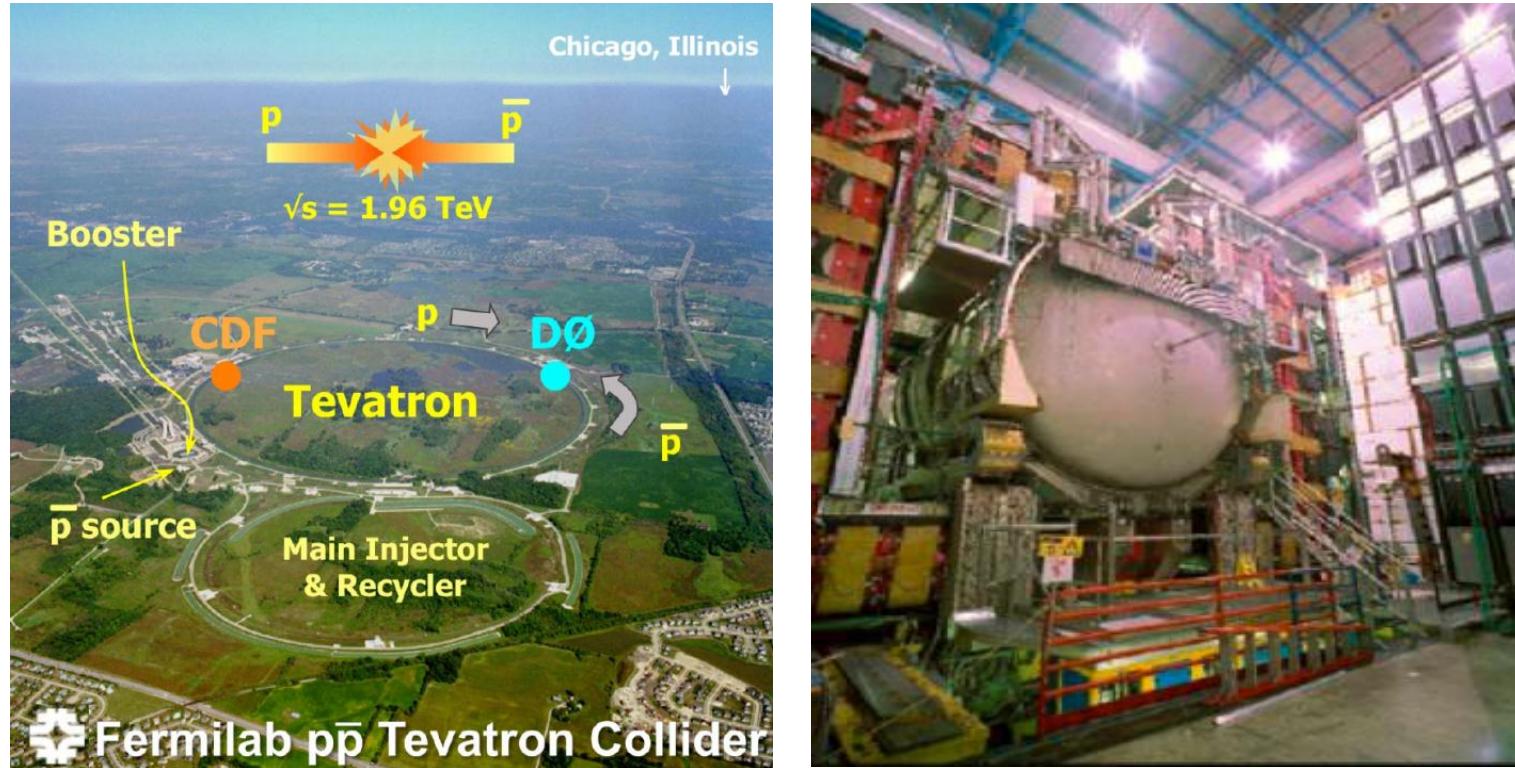
Single Diffractive

- Uses FPD data
- Probes nucleon structure and non-perturbative effects.
- Important and large contribution to total inelastic x-section.
- Low mass SD has large halo contamination.
- Select high mass SD by demanding hits in the opposite side luminosity monitors.



A. Pal, A. Brandt

In summary, we have presented the first measurement of $d\sigma(p\bar{p} \rightarrow p\bar{p})/dt$ as a function of $|t|$ at $\sqrt{s} = 1.96$ TeV.



**TEVATRON and D0 detector have finished all data collection
but the analyses of full set of data is continuing**

Thank you