Prospects for diffraction at DØ

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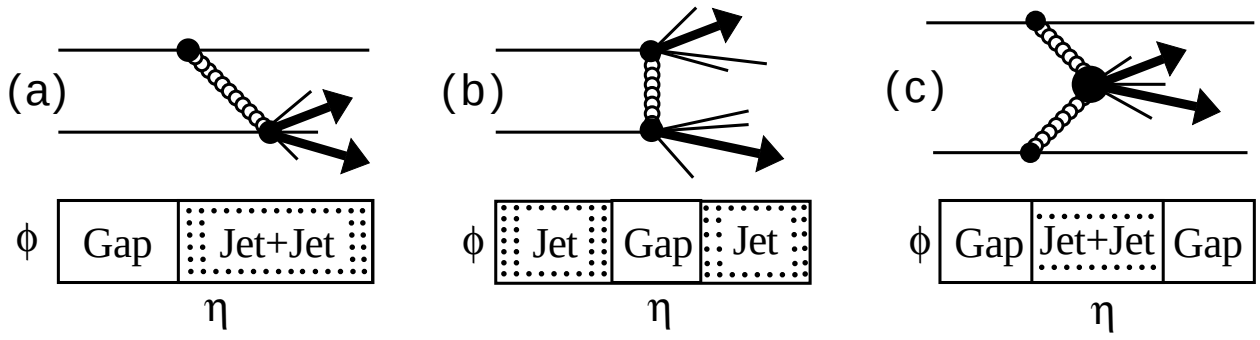
Contents:

- Rapidity gap measurements
- Forward Proton Detectors (FPD)
- Prospects on measurements using FPD

Diffraction at Tevatron/LHC

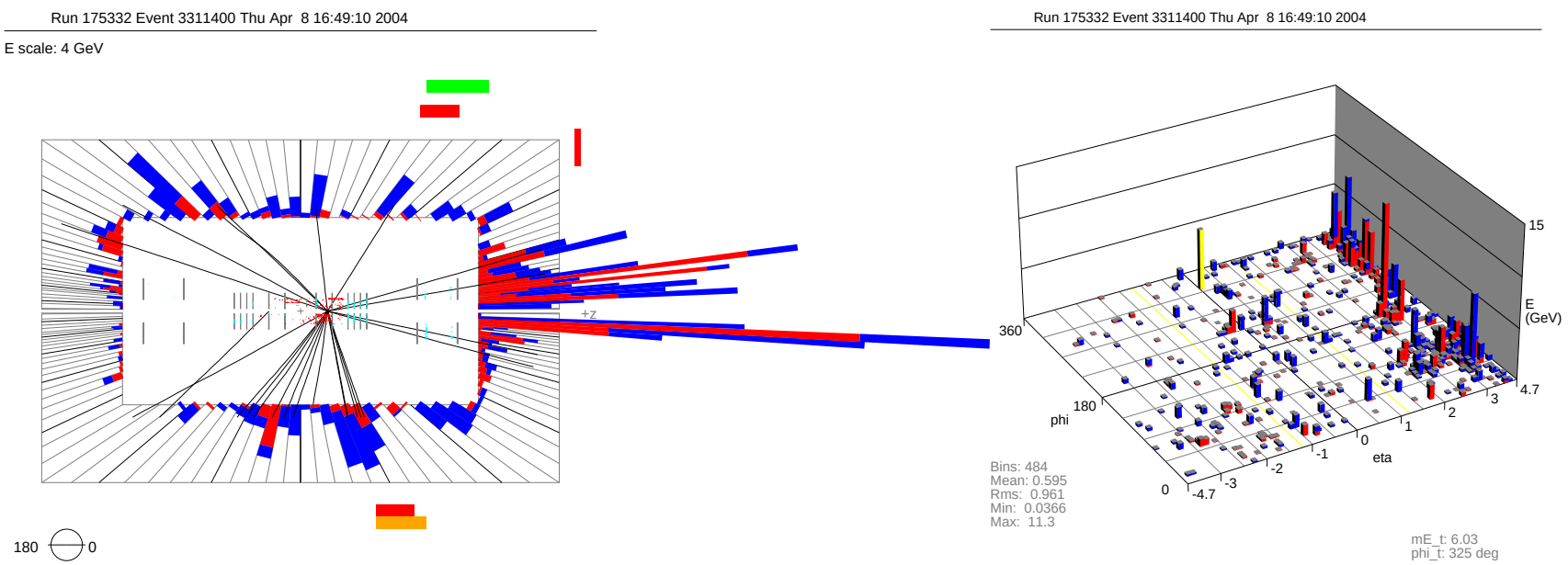


Kinematic variables

- t: 4-momentum transfer squared
- ξ_1, ξ_2: proton fractional momentum loss (momentum fraction of the proton carried by the pomeron)
- $\beta_{1,2} = x_{Bj,1,2}/\xi_{1,2}$: Bjorken-x of parton inside the pomeron
- $M^2 = s\xi_1\xi_2$: diffractive mass produced
- $\Delta y_{1,2} \sim \Delta\eta \sim \log 1/\xi_{1,2}$: rapidity gap

Experimental signature: Rapidity gaps

- Proton destroyed after interaction: Large energy deposits in south side detectors
- Antiproton intact after interaction (or dissociates at very small angle): low energy deposition in north side detectors
- Two high p_T muons in main detector: Candidate single diffractive events $Z \rightarrow \mu^+\mu^-$

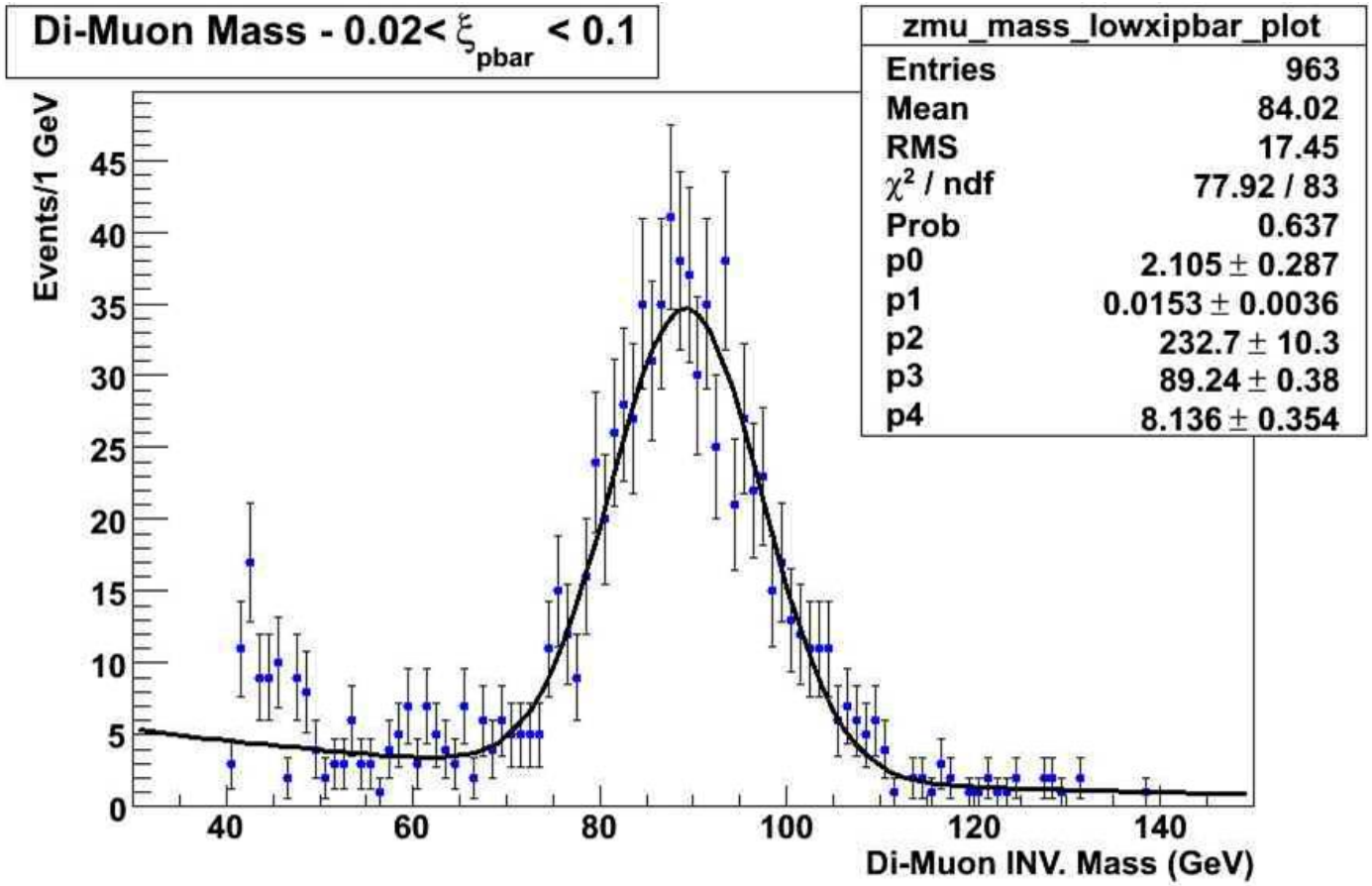


Single diffractive production of Z bosons

- Measure ξ using calorimeter data:

$$\xi_{\bar{P}} = \frac{\Sigma E_T \exp(-\eta)}{\sqrt{S}}$$

- Events selected via $Z \rightarrow \mu^+\mu^-$ decay
- Minimum accessible ξ : $\xi \sim M_X^2/S$
- Diffracted system boosted



Background suppression

- Require low energy in forward detectors
- Depending on mass of central object, presence of a gap or not: gap size $\sim \log 1/\xi < \log S/M_X^2$ Tuning low activity / energy cuts in detector: correlation plot between energy in calo and multiplicity in luminosity detector

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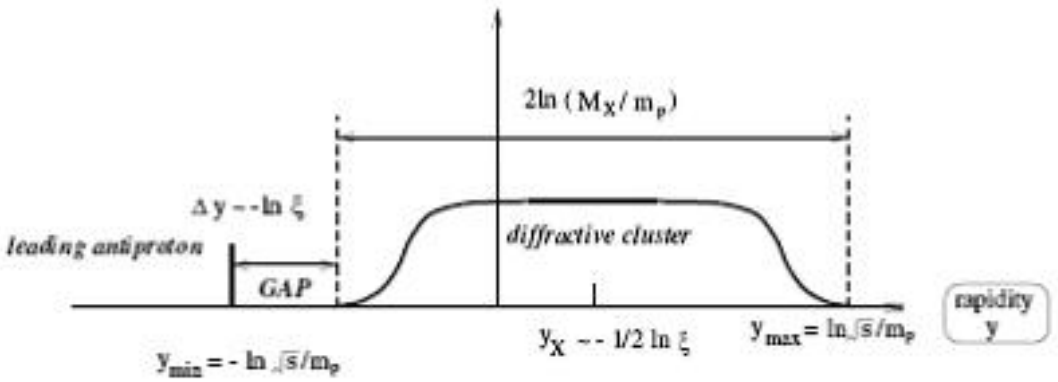
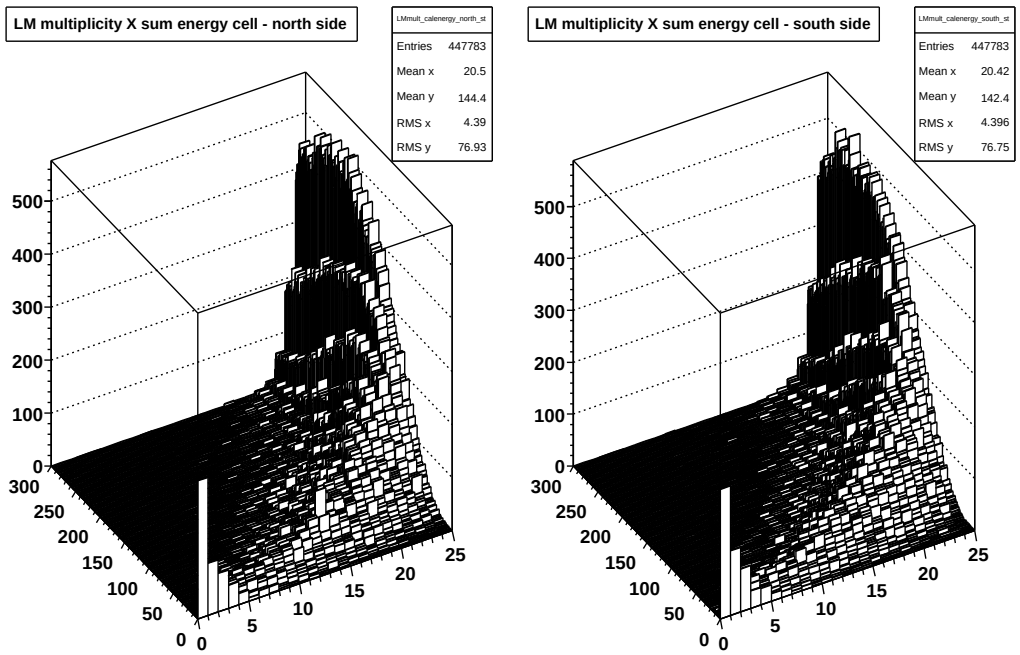
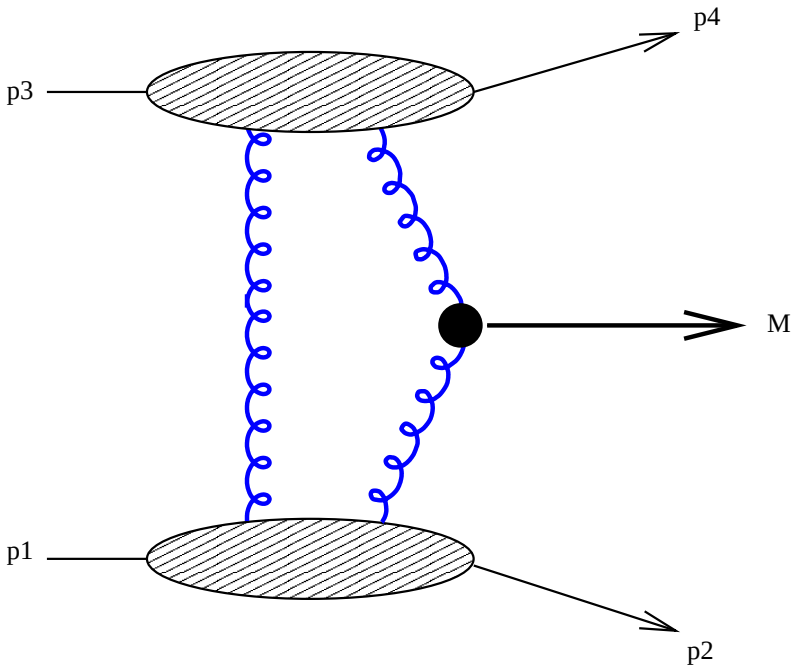
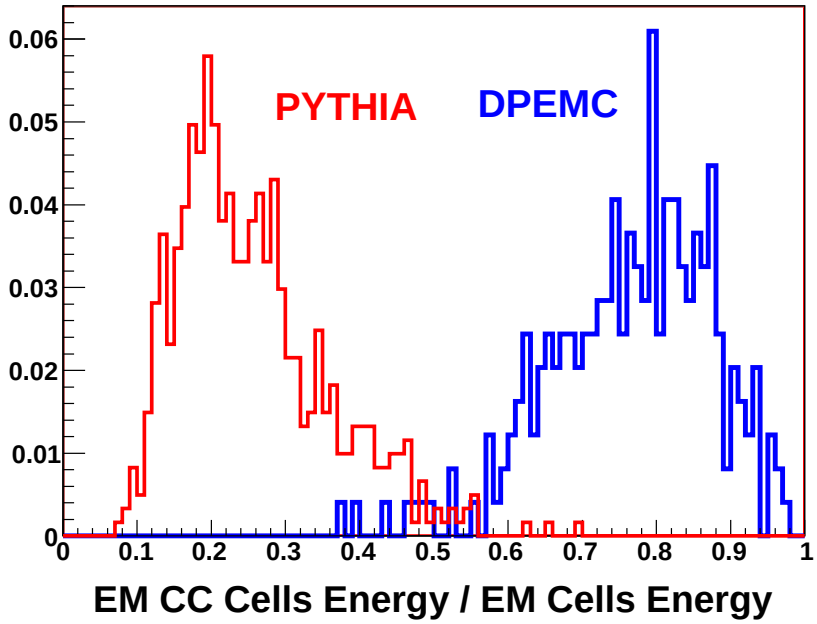




Application: Look for exclusive event production

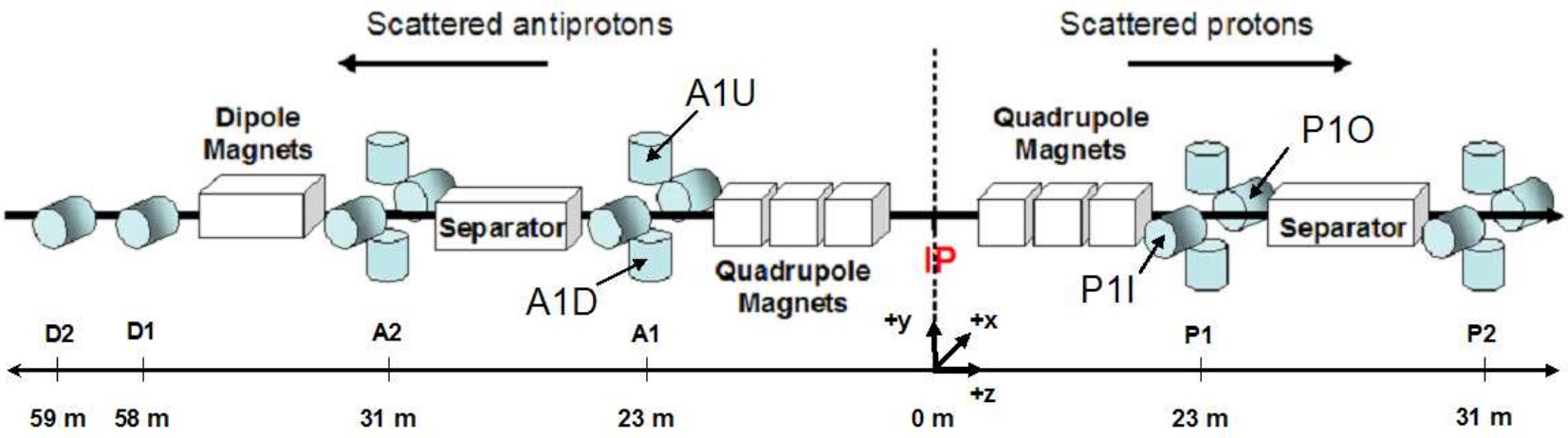
- Search for exclusive production of central systems
- Look for the energy deposited in central detector (EM layers) and compare with non diffractive/diffractive MC: the tails around 1 will be due to exclusive events





Forward Proton Detector (FPD)

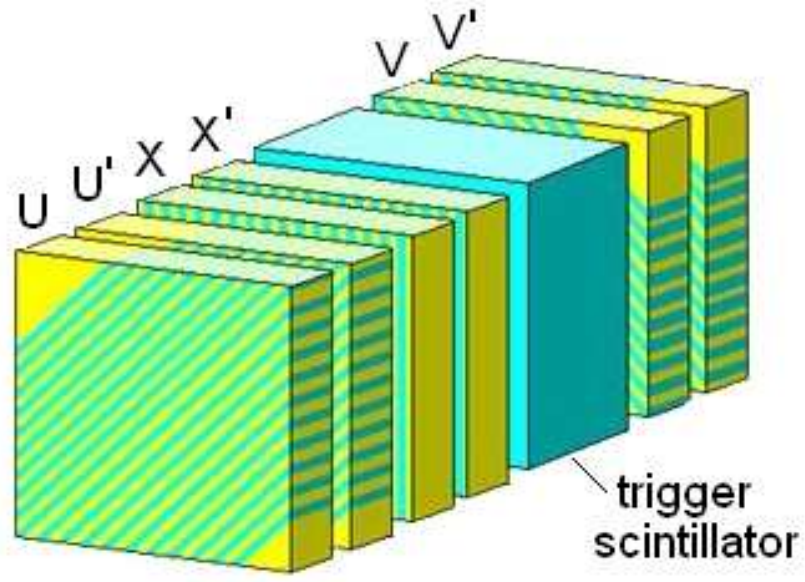
- Nine momentum spectrometers, each comprised of 2 scintillating fiber detectors
- Detectors (scintillating fibers and scintillators used for triggering) housed inside roman pots: UP, DOWN, IN, OUT for "quadrupole" detectors (both outgoing p and $\bar{p}$), IN for "dipole" detectors (only outgoing $\bar{p}$)
- Detectors operate a few mm from beam



Forward Proton Detectors

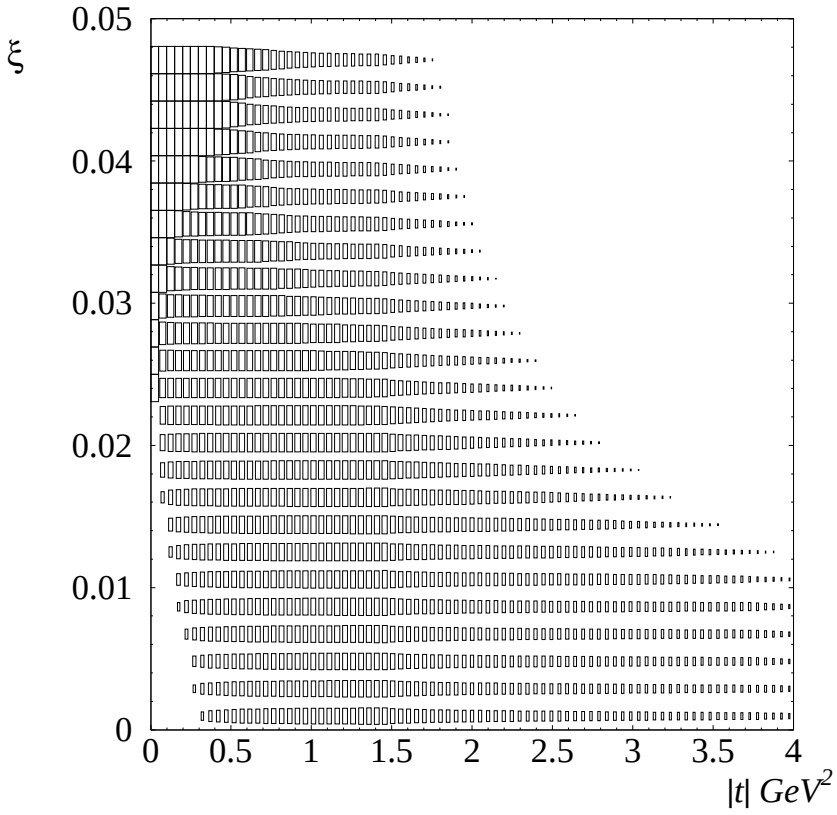
Detectors used in roman pots

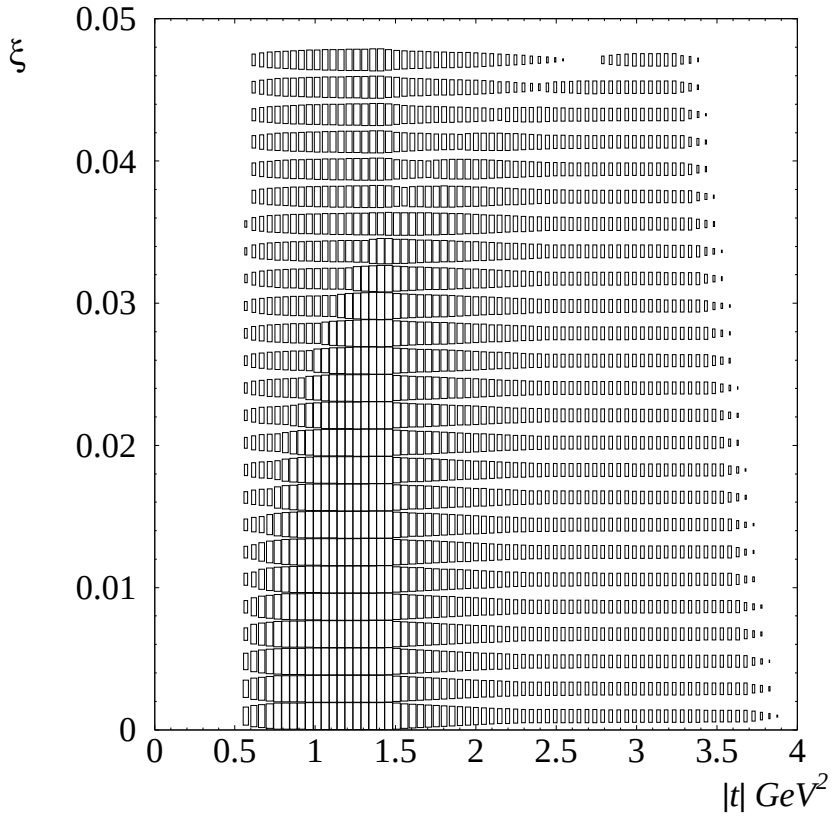
- 6 layers of scintillating fibers per detectors: U,U',X,X',V,V' (channels of U and V orientated a 45 degrees with respect to X), each individual channel is made up to 4 fibers for the readout
- 20 fiber channels in U and V layers; 16 fiber channels in X layers
- Primed and unprimed channels offset by 2/3 of a fiber with respect to each other to obtain a finer hit resolution
- Timing measurement performed using a trigger scintillator: fast photomultiplier readout
- All detectors fully installed since January 2004 and taking data until 2006 Summer shutdown



FPD acceptance

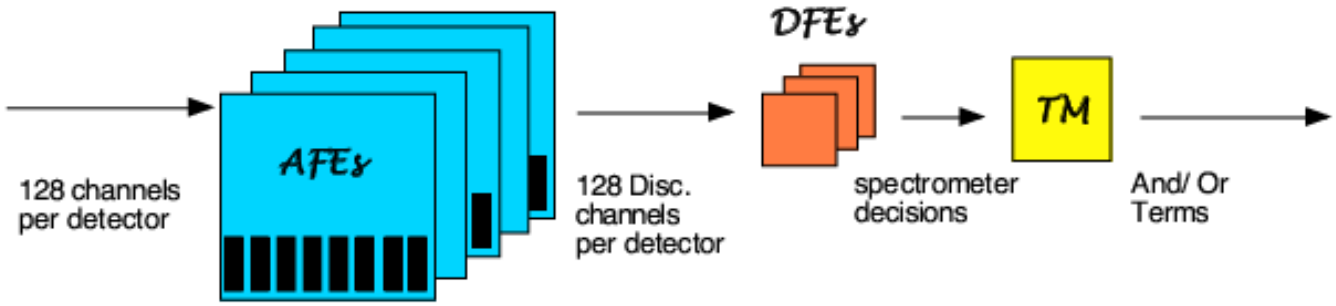
Acceptance for a typical store, dipoles: acceptance at small t, medium ξ, quadrupole: higher t, small ξ





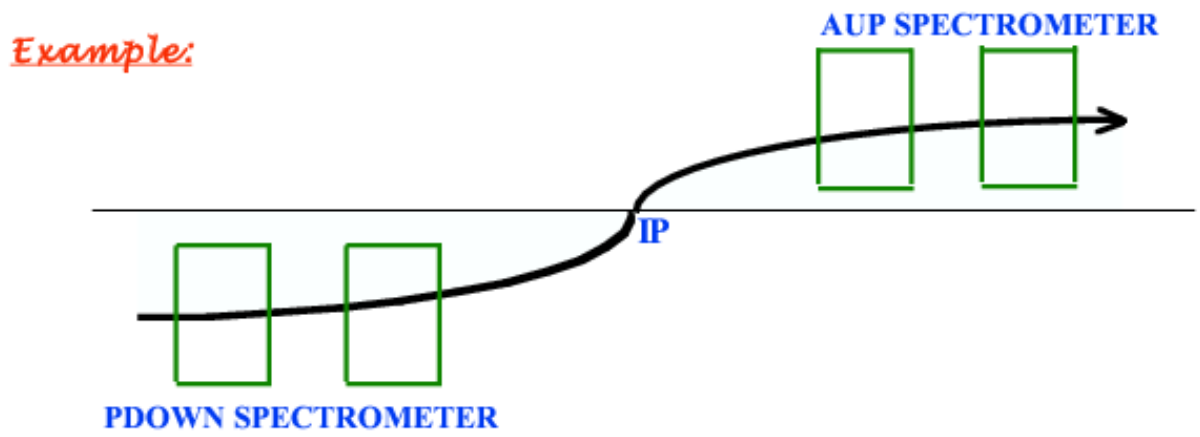
FPD trigger

- Level 1 trigger based on detector fiber information: more precise information (space resolution)
- Digital front end: calculate the number of interesting regions in each detectors (wide segment hits), and forms the spectrometer decision based on product of hit multiplicities
- Trigger manager: coincidence between different detectors (DPE or elastic triggers)

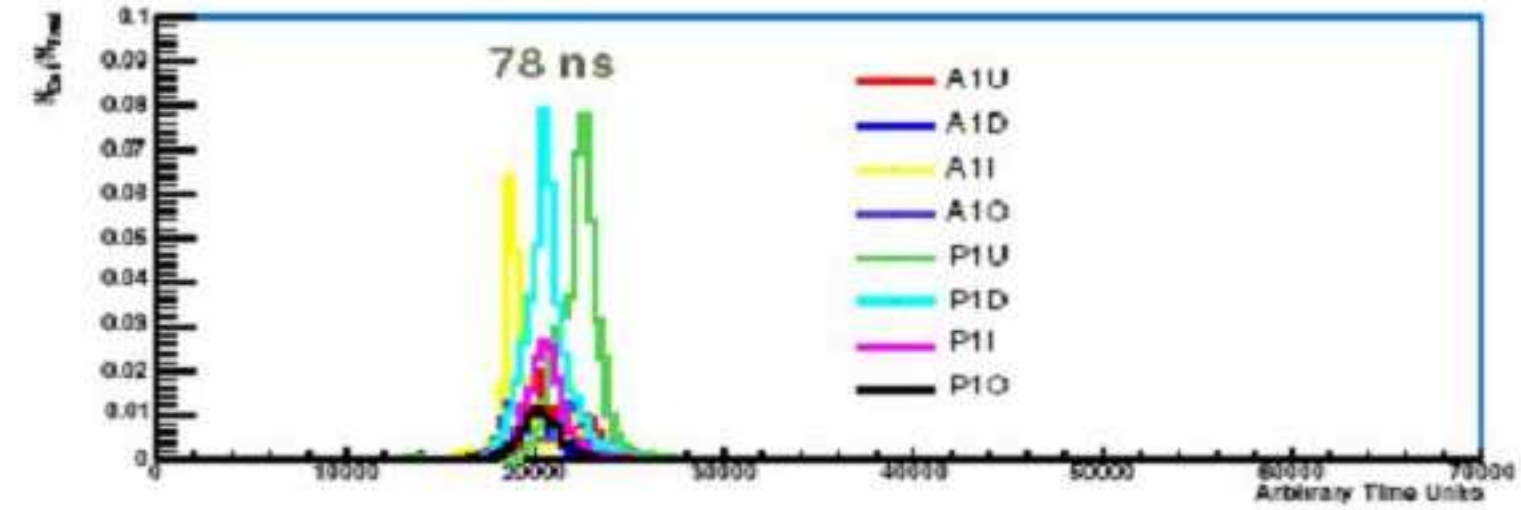


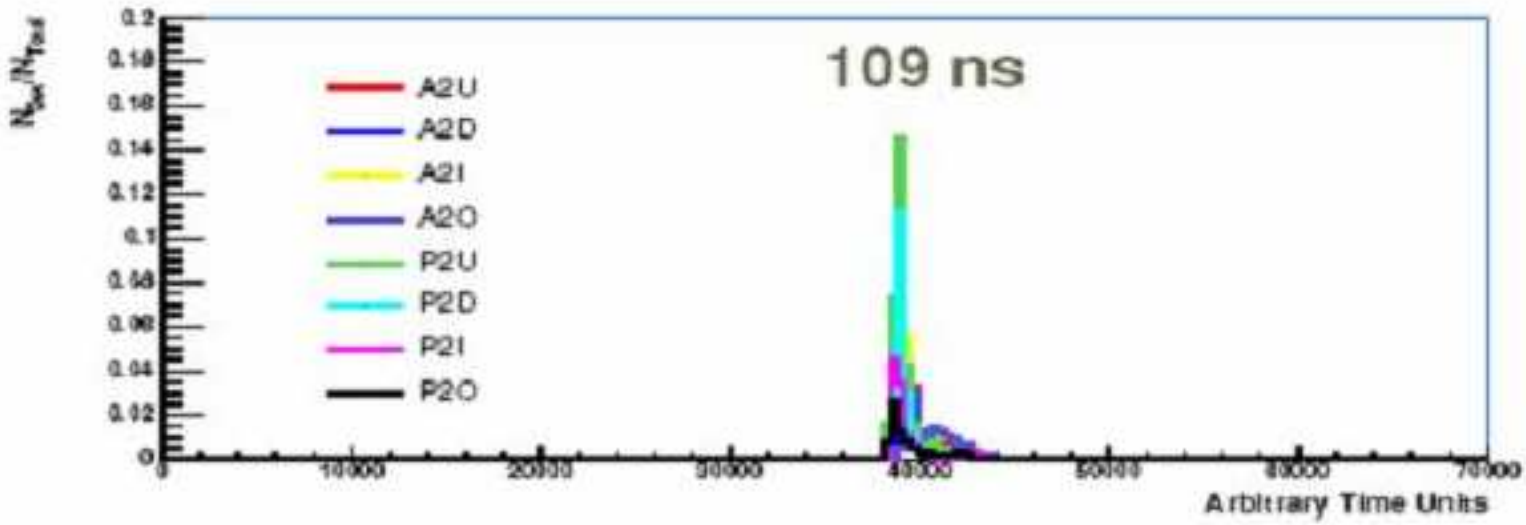
Halo background suppression

- Halo events: Particles passing on time through one given spectrometer pass at an earlier time through the opposite spectrometer
- Timing is given by FPD scintillators
- Signal bit: defined if pulse received on time
- Halo bit: defined if pulses detected both in signal window and also in earlier timing window



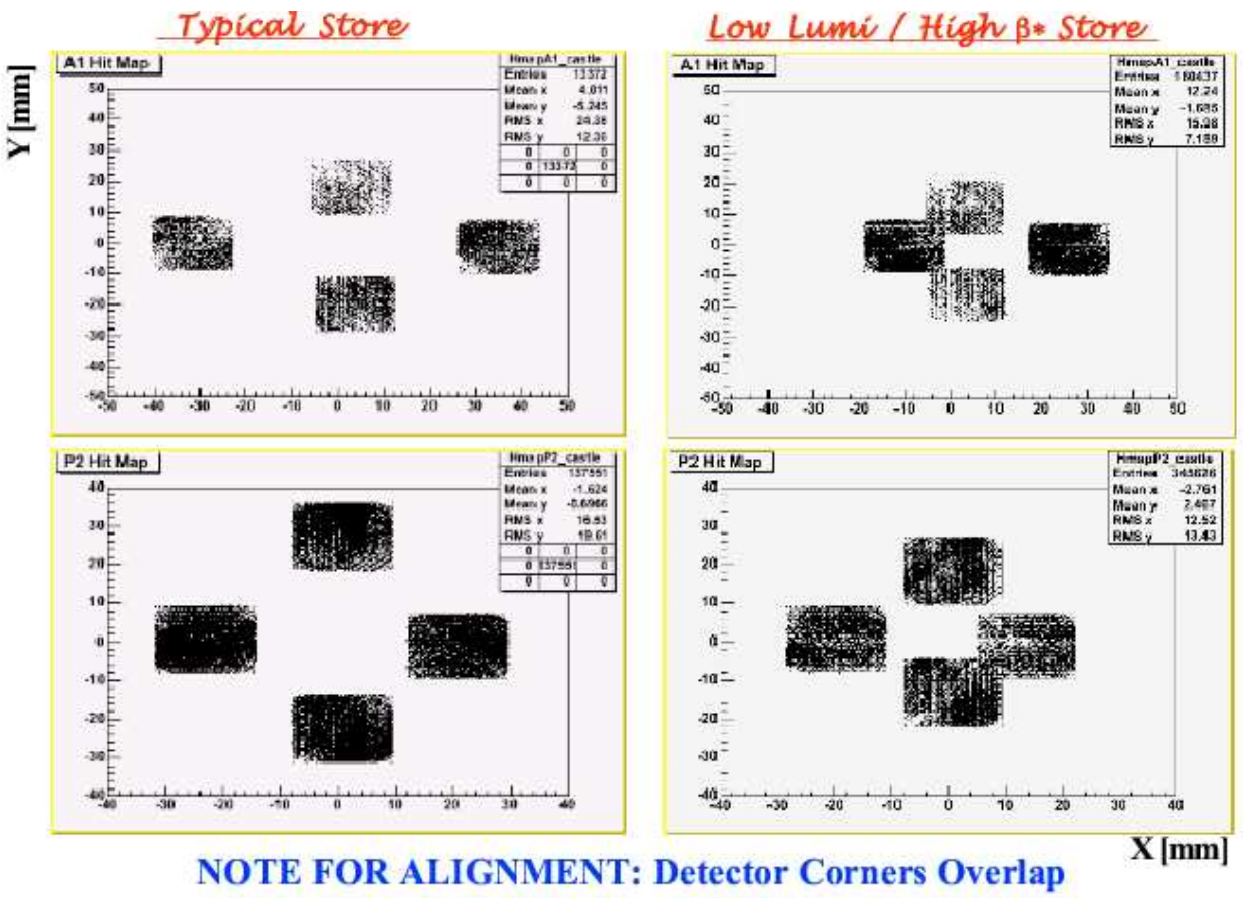
Detector timing distributions





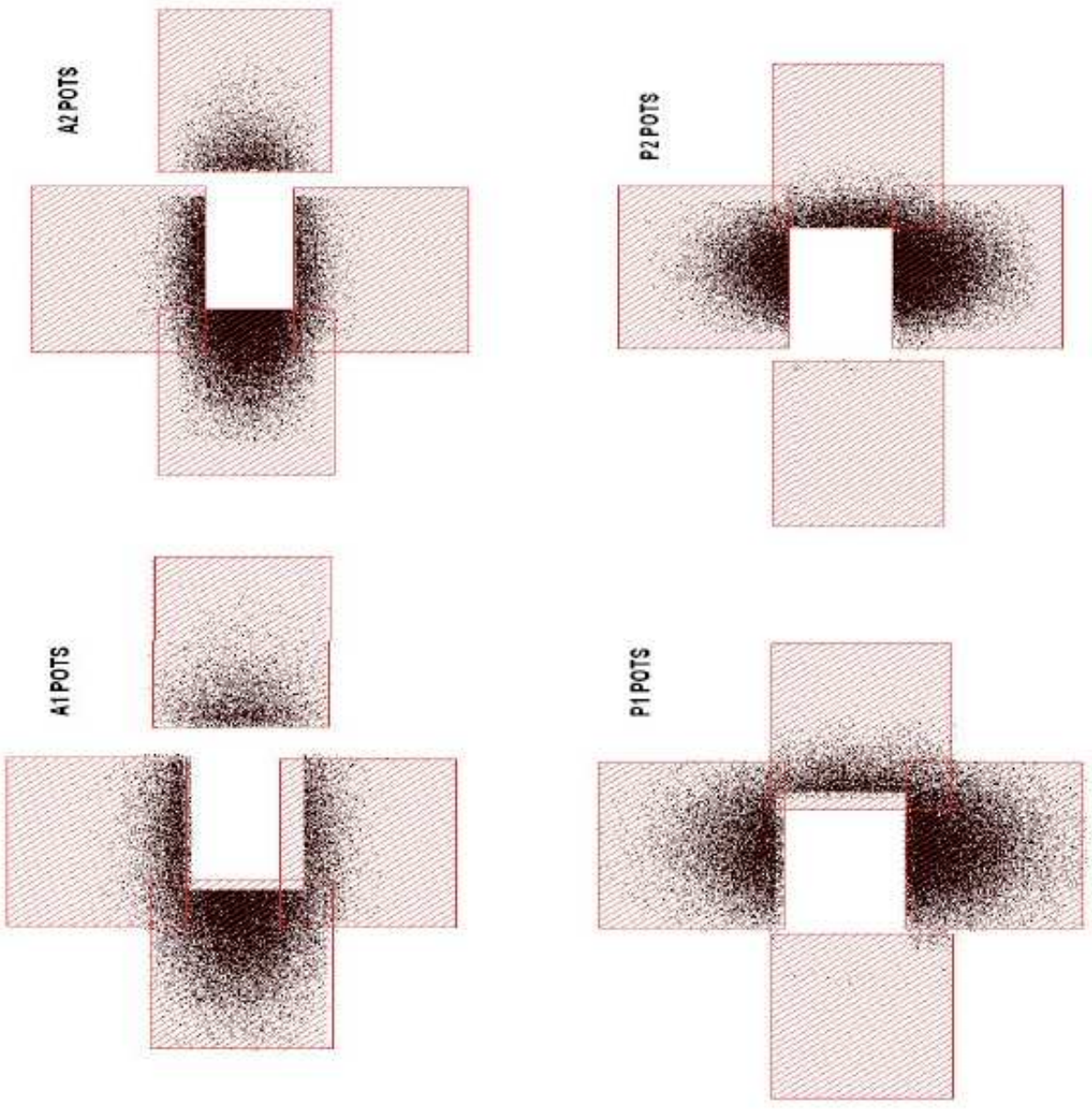
Tevatron special stores

- Special Tevatron stores performed: High $\beta^* \sim 1.6m$, low luminosity
- Narrower beam at detectors, $p\bar{p}$ collisions at DØ only, 1 on 1 bunch collision only: allows to move the detectors closer to the beam and access lower t
- Detectors overlap: useful to check alignment



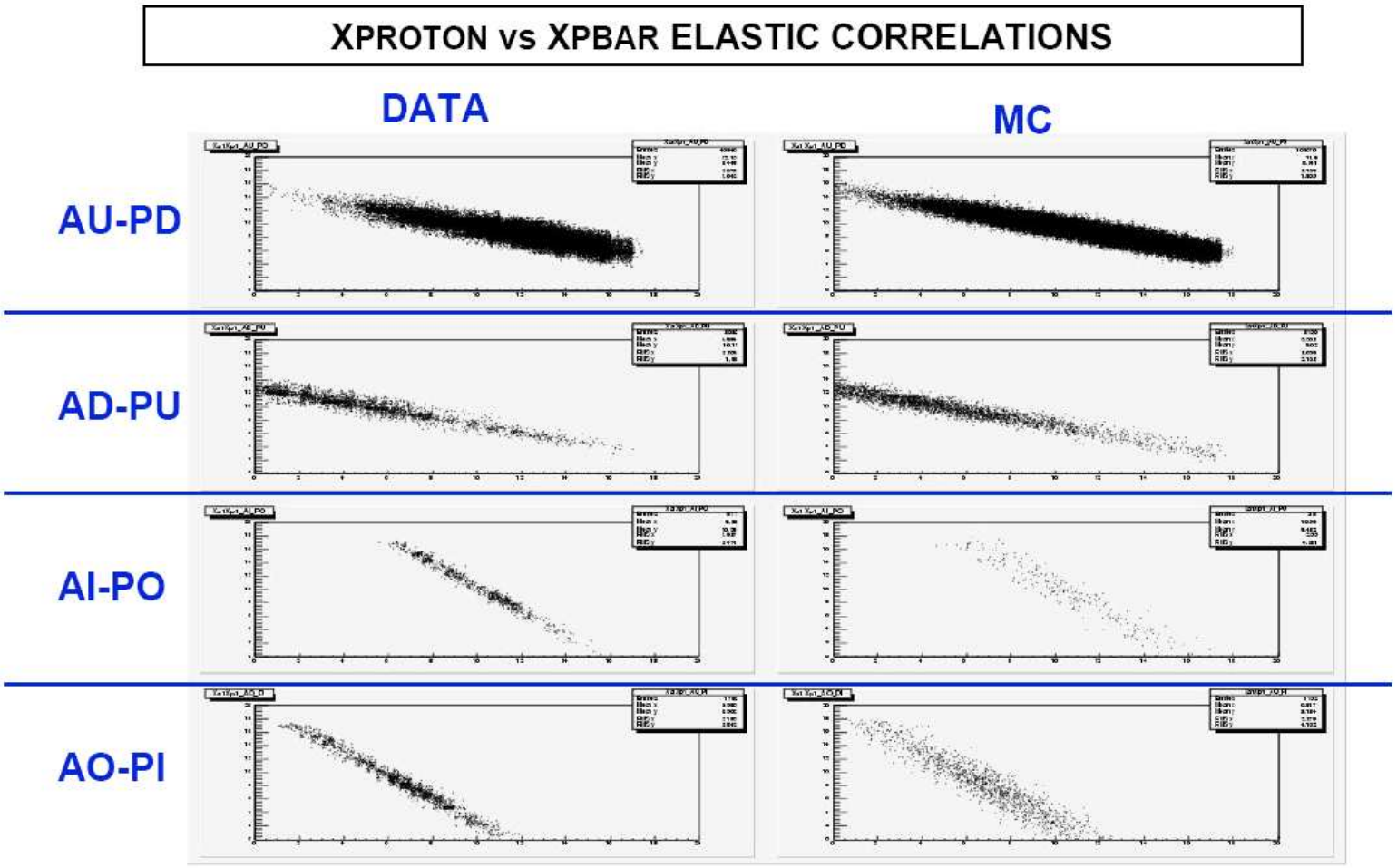
Tevatron special stores

Use overlap between detectors to align them



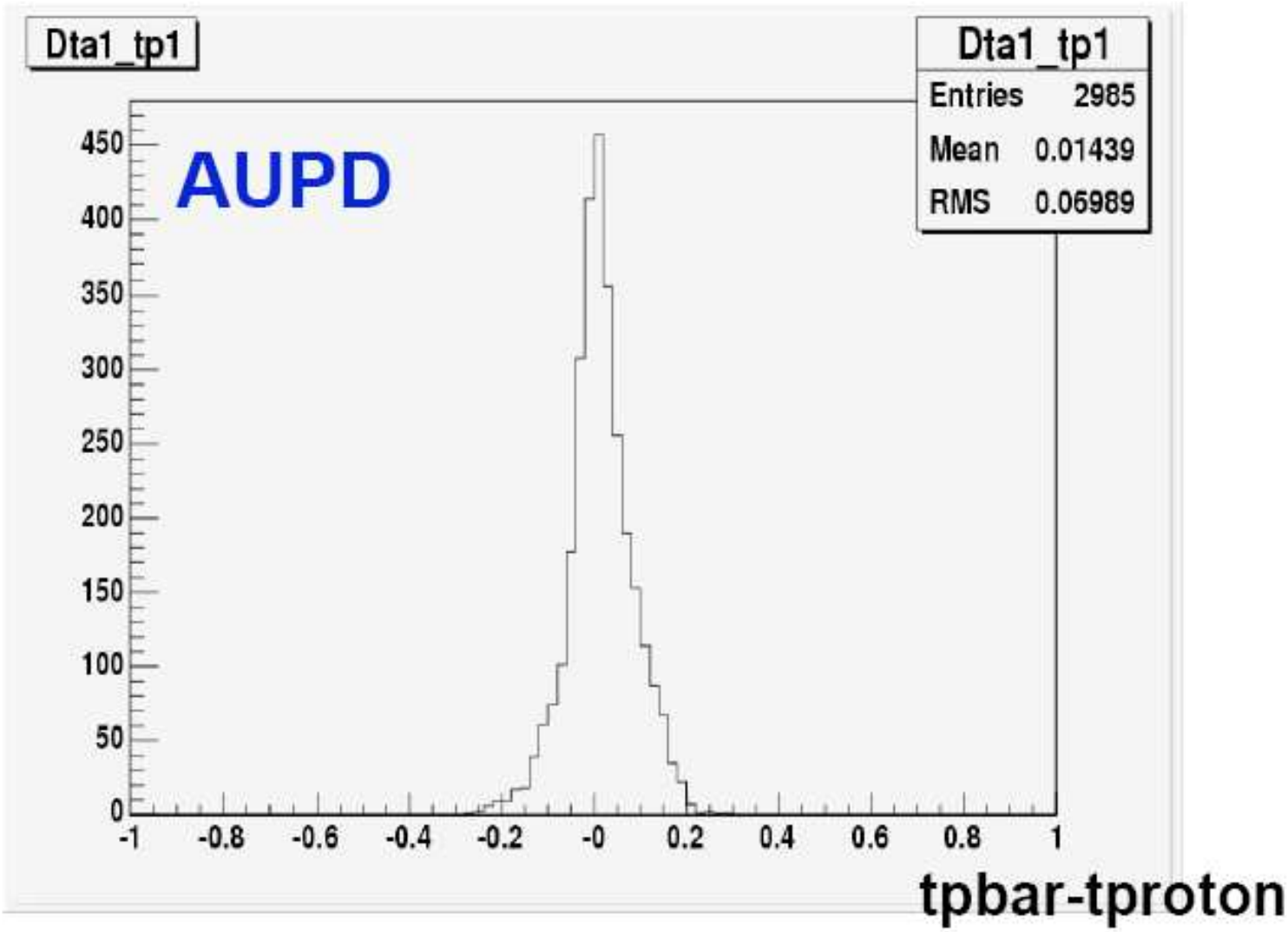
Tevatron special stores

About 20 million events on tape for $d\sigma/dt$ measurement, data follow MC expectations



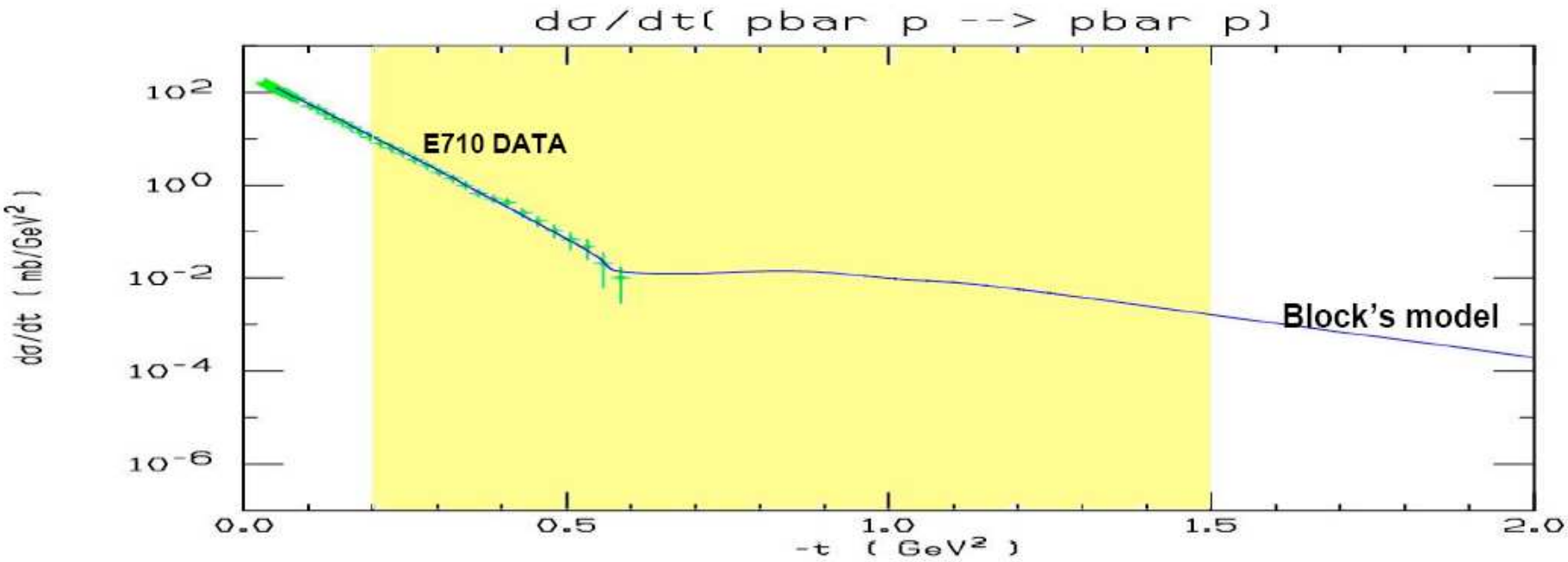
Tevatron special stores

Good t reconstruction after alignement



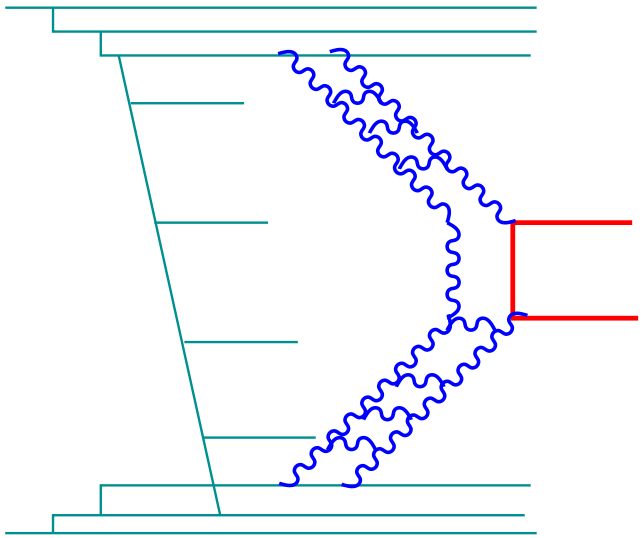
FPD alignment and measurement of $d\sigma/dt$

- Use elastic events to align quadrupole detectors
- Measurement of elastic cross section $d\sigma/dt$ using special runs in progress

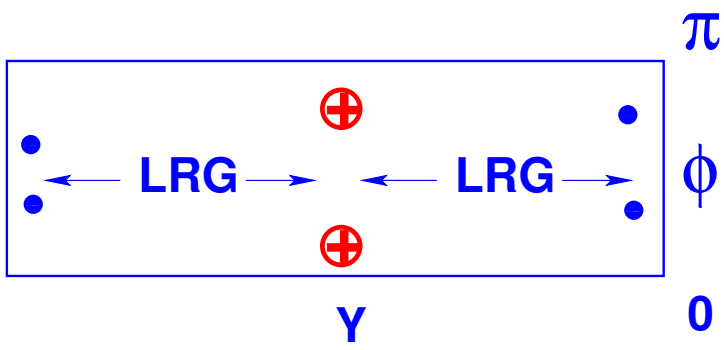


Concept of survival probability

- Survival probability: Probability that there is no soft additional interaction, that the diffractive event is kept
- Important to measure the survival probability in data: estimated to be of the order of 0.1 at the Tevatron



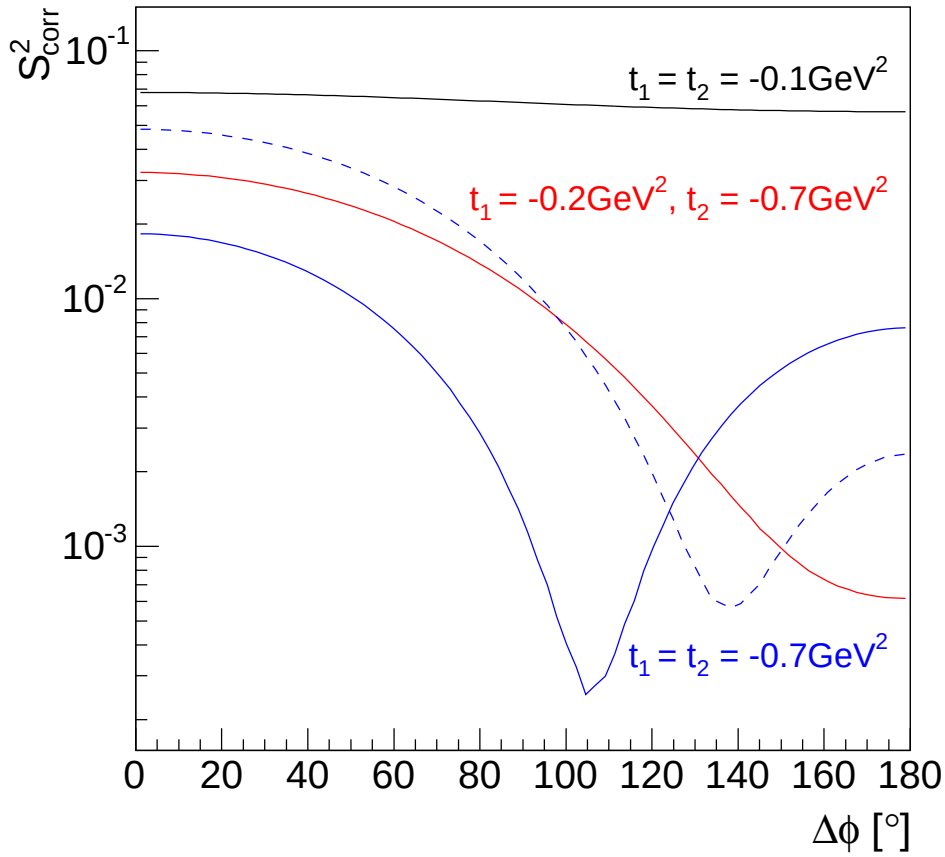
a)



b)

$\Delta\Phi$ dependence of survival probabilities

Survival probability strongly $\Delta\Phi$-dependent where $\Delta\Phi$ is the difference in azimuthal angles between p and $\bar{p}$



An additional possible measurement at DØ

- Diffractive cross section ratios in different regions of $\Delta\Phi$ at the Tevatron
- same side: $\Delta\Phi < 45$ degrees, opposite side: $\Delta\Phi > 135$, middle: $45 < \Delta\Phi < 135$ degrees;
- 1st measurement: asymmetric cuts on t (dipole and quadrupole), 2nd measurement: symmetric cuts on t (quadrupole on both sides)
- Possible to distinguish between SCI and pomeron-based models, and test the survival probabilities

Configuration	model	middle/same	opp./same
Quad. + Dip.	SCI	1.3	1.1
	Pom.	0.36	0.18
Quad. + Quad.	SCI	1.4	1.2
	Pom.	0.14	0.31

Conclusion

- Rapidity gaps:
  - Rapidity gap selection restricted to low diffractive masses, low energy selection extends this selection to higher masses: low energy present between Pomeron remnants and centrally produced objects (Z, jets...)
  - Many analyses being finalised: Diffractive heavy flavour, Z, jets...
  - Exclusive event production in DPE in jet channel
- FPD:
  - FPD working fine and has been taking data for more than 2 years
  - Technical studies being performed: Elastics to perform alignment, fiber efficiencies, track reconstruction
  - Many topics being studied: standard double pomeron exchange (inclusive, jets...), single diffraction
  - Dedicated low luminosity runs from Tevatron being analyzed: Measurement of $d\sigma/dt$ in progress, inclusive double pomeron exchange studies
- Many results expected very soon now using either rapidity gap or tagging in FPD methods!