Status of Diffractive Physics at DØ Run II

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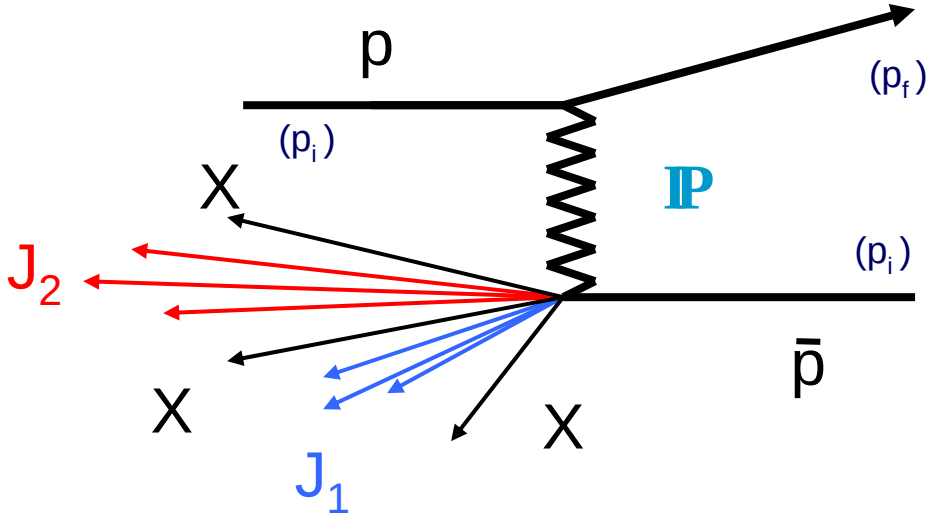
DPF 2004 Meeting – Riverside CA

Color Singlet Exchange (Diffraction)

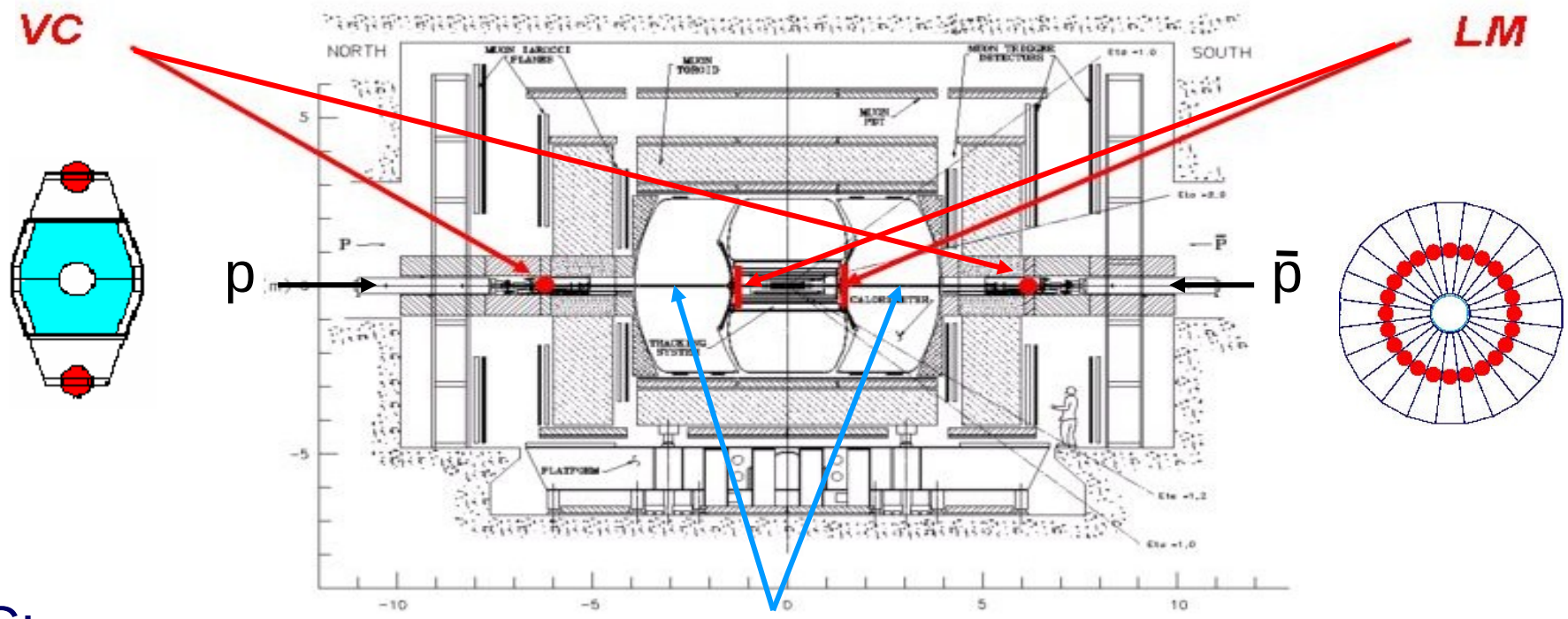
- The Tevatron collides protons and antiprotons at $\sqrt{s}$ = 1.96 TeV at a crossing rate of 1.7 MHz
- About 40% of the total $p\bar{p}$ cross-section is elastic or diffractive scattering
- Diffractive processes involve the exchange of a color singlet:
  - Quantum numbers of the vacuum
  - Often referred to as Pomeron exchange

$$|t| = (p_f - p_i)^2$$
$$\xi = 1 - p_f / p_i$$

- Diffractive studies used to probe nature of the Pomeron
- Experimental Signature
  - Rapidity Gap: absence of particles or energy above threshold in some region of rapidity in detector
  - Tagged proton: p or pbar scattered at small angle from the beam measured in a detector far from the interaction



Measuring Rapidity Gaps at DØ Run II



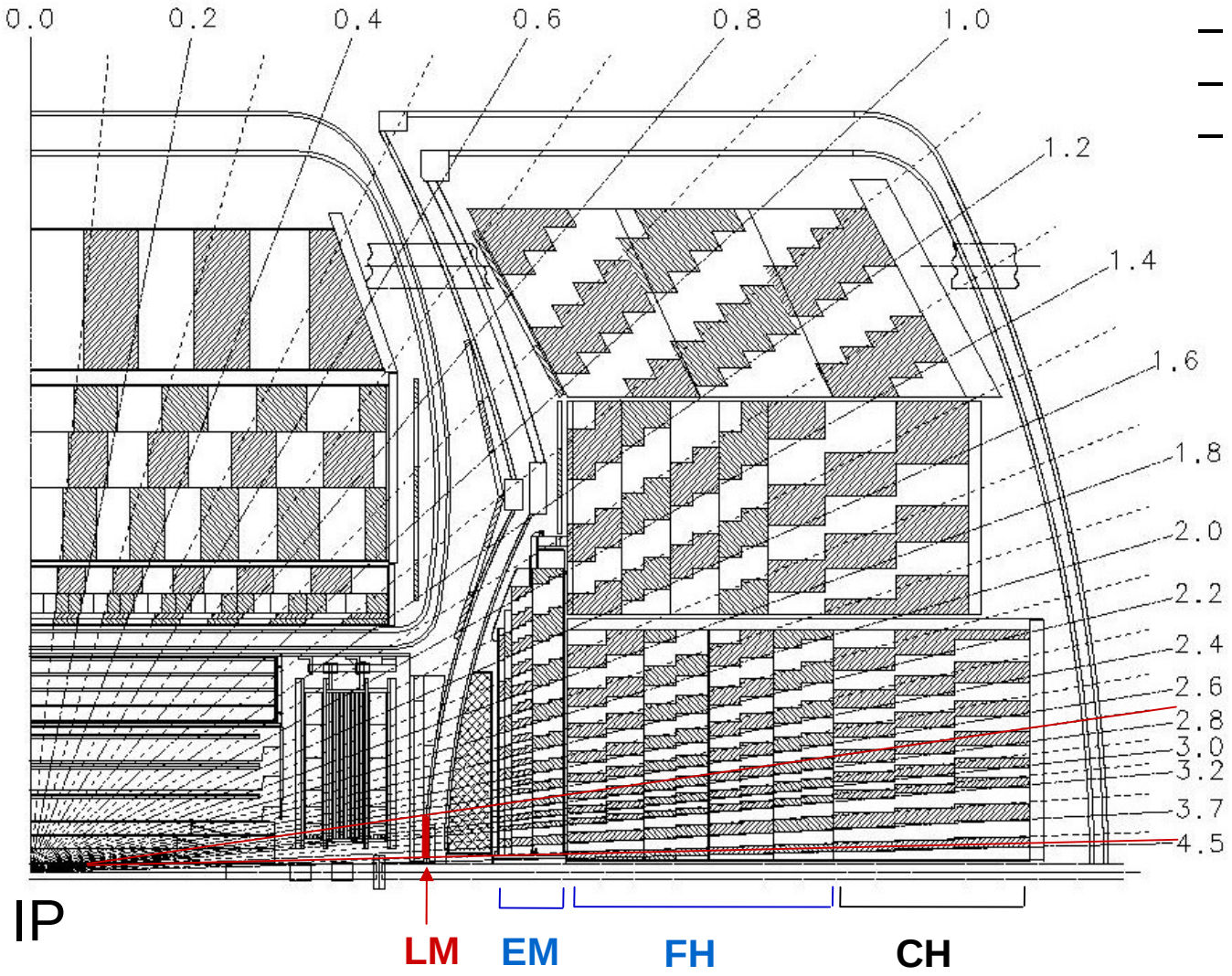
VC:
$5.2 < \eta < 5.9$

LM:
$2.7 < \eta < 4.4$

- Use the following detectors to identify rapidity gaps:
  - Forward Calorimeters
  - Luminosity Monitors (LM)
  - Veto Counters (VC)

Calorimeter

Liquid argon/uranium calorimeter



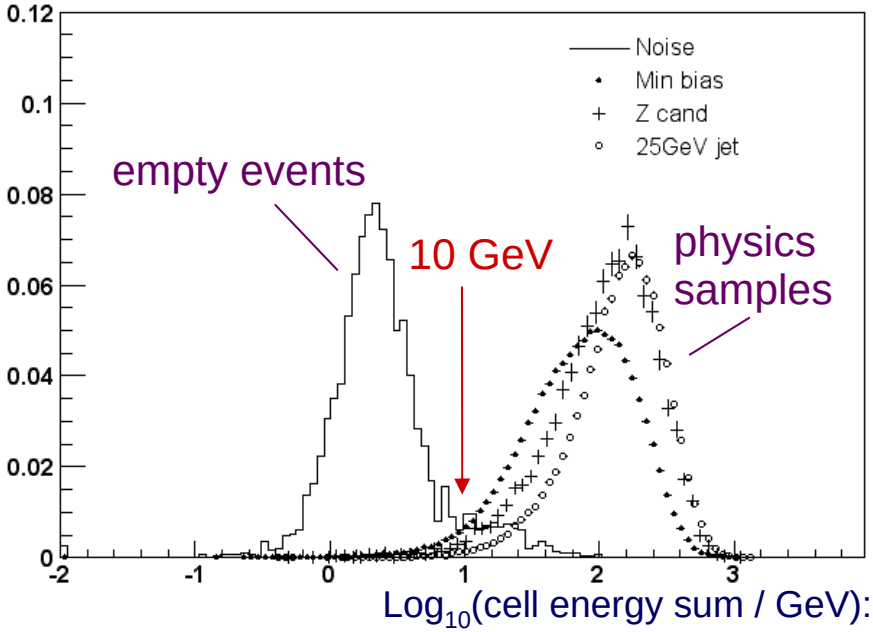
Cells arranged in layers:
- electromagnetic (EM)
- fine hadronic (FH)
- coarse hadronic (CH)

➢ Sum E of Cells in EM and FH layers above threshold:
E_{EM} > 100 MeV
E_{FH} > 200 MeV

2.7	**2.6**
LM range	**Esum range**
4.4	**4.1 - 5.3**

Calorimeter Energy Sum

- Use energy sum to distinguish proton break-up from empty calorimeter:



Areas normalized to 1

- Esum < 10GeV for current study
- Final value will be optimized using full data sample

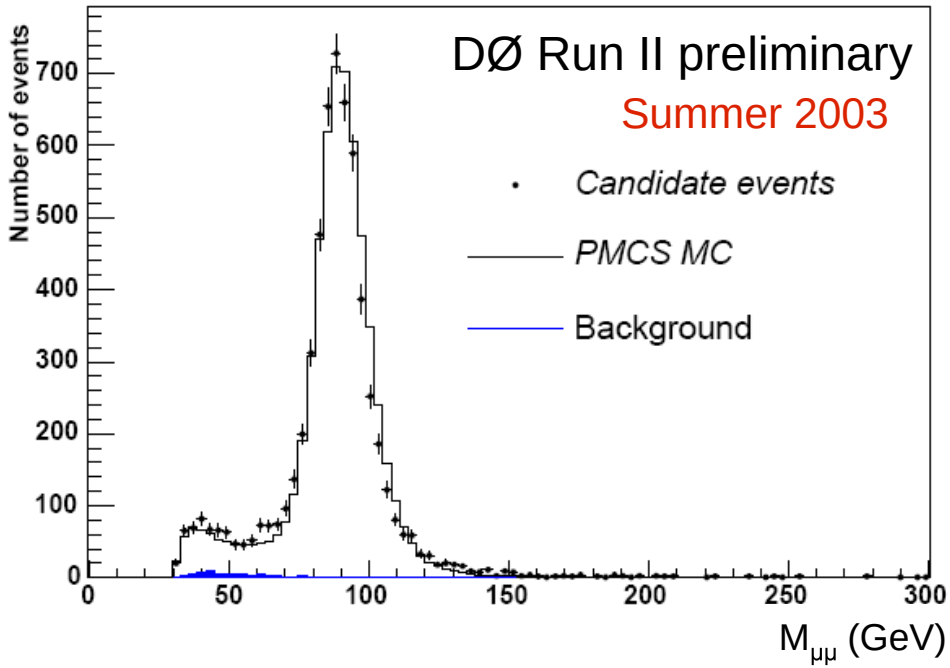
- Compare 'empty event' sample with physics samples:
  - Empty event sample: random trigger. Veto LM signals and primary vertex, i.e. mostly empty bunch crossings
  - Physics samples: minimum bias (coincidence in LM), jet and Z→μμ events

Search for diffractive Z→μμ

- Run I publication "*Observation of diffractively produced W and Z bosons in $\bar{p}p$ Collisions at sqrt(s)=1.8 TeV*", Phys. Lett. B 574, 169 (2003)
  Nine single diffractive Z→e+e- events. No result in muon channel.

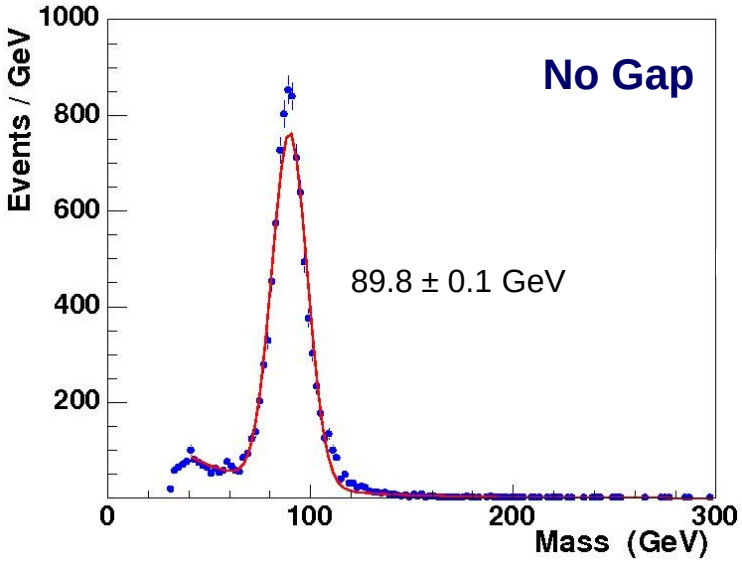
- Run II: first search for forward rapidity gaps in Z→μ+μ- events

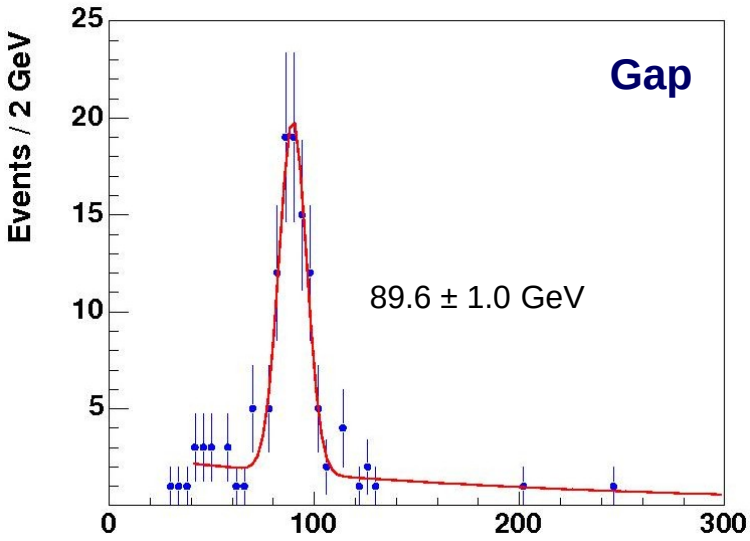
- Inclusive Z→μμ selection:
  - –di-muon (|η|<2) or single muon (|η|< ~1.6) trigger
  - –2 muons, p_T > 15GeV, opposite charge
  - –at least one muon isolated in tracker and calorimeter
  - –cosmics cuts



Z Mass of rapidity gap candidates

WORK IN PROGRESS

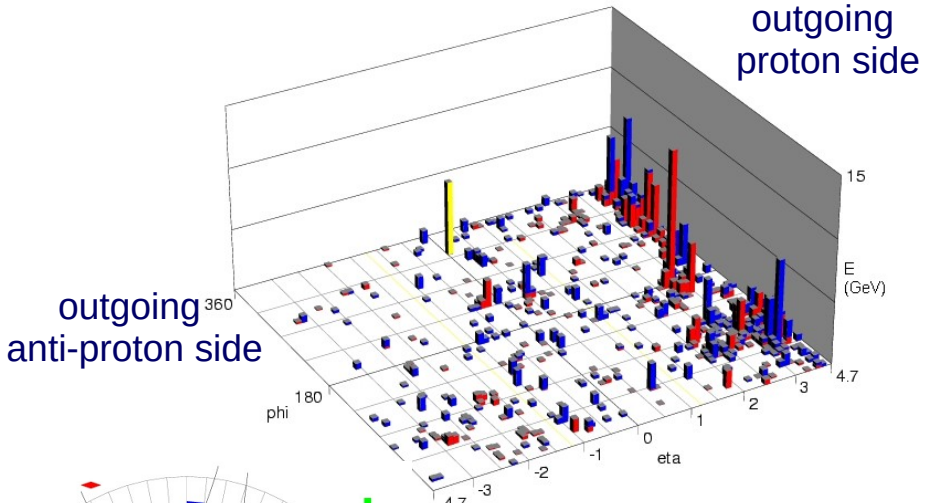


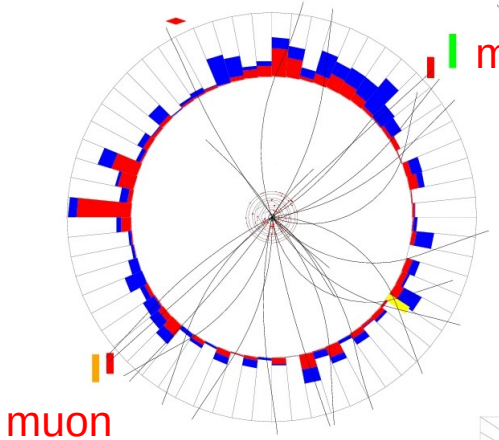


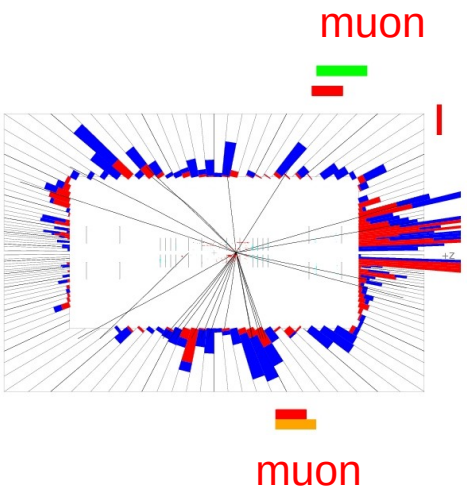
- Add Esum requirement to define gap
- Invariant mass peak consistent with Drell-Yann/Z events
- Will be able to compare Z boson kinematics (p_T, p_z, rapidity)

Z→μμ with rapidity gaps: Summary

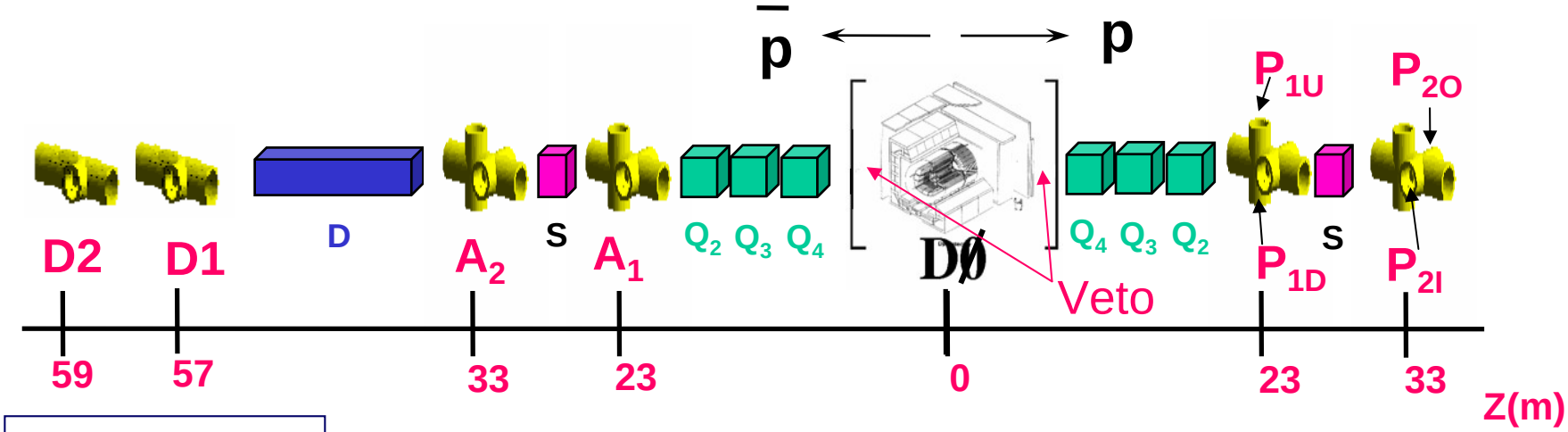
- Preliminary definition of rapidity gaps at DØ Run II
- Study of Z→μ+μ- events with a rapidity gap signature
- Current Status
  - Evidence of Z events with a rapidity gap signature
  - Quantitative studies of gap definition, backgrounds, efficiency in progress
- Plans
  - Measurement of the fraction of diffractively produced Z events
  - Diffractive W→μν, W/Z→electrons, jets and other channels
  - Use tracks from Forward Proton Detector





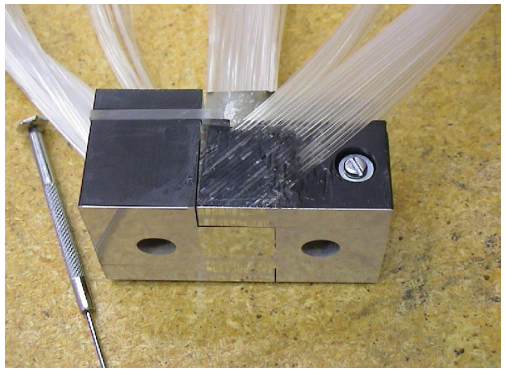


Forward Proton Detector Layout



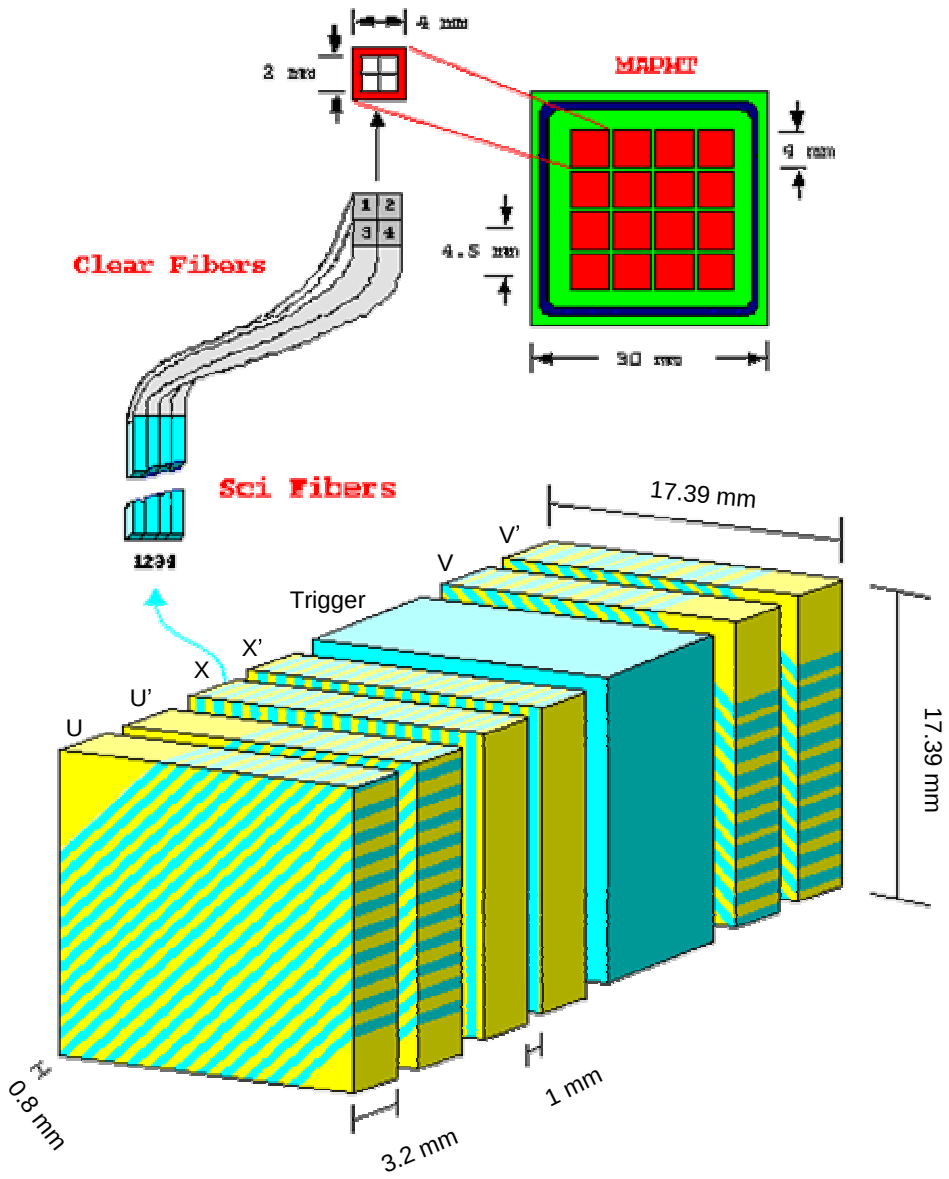
$$|t| = (p_f - p_i)^2$$
$$= -2k^2(1-\cos\theta)$$
$$\sim \theta^2 \text{ (small angles)}$$

$$\xi = 1 - x_p = 1 - p_f / p_i$$
$$< 0.05 \text{ (diffraction)}$$



- 9 momentum spectrometers each composed of 2 Scintillating fiber detectors housed in (Roman Pots) can be brought close (~6 mm) to the beam.
- Reconstruct scattered protons and anti-protons to calculate their momentum fraction and scattering angle
  - Much better resolution than available with gaps alone
- Combine tracks with central high-p_T scattering (main detector)
- Cover a kinematic region $0 < |t| < 3$ GeV^2 never before explored at Tevatron energies

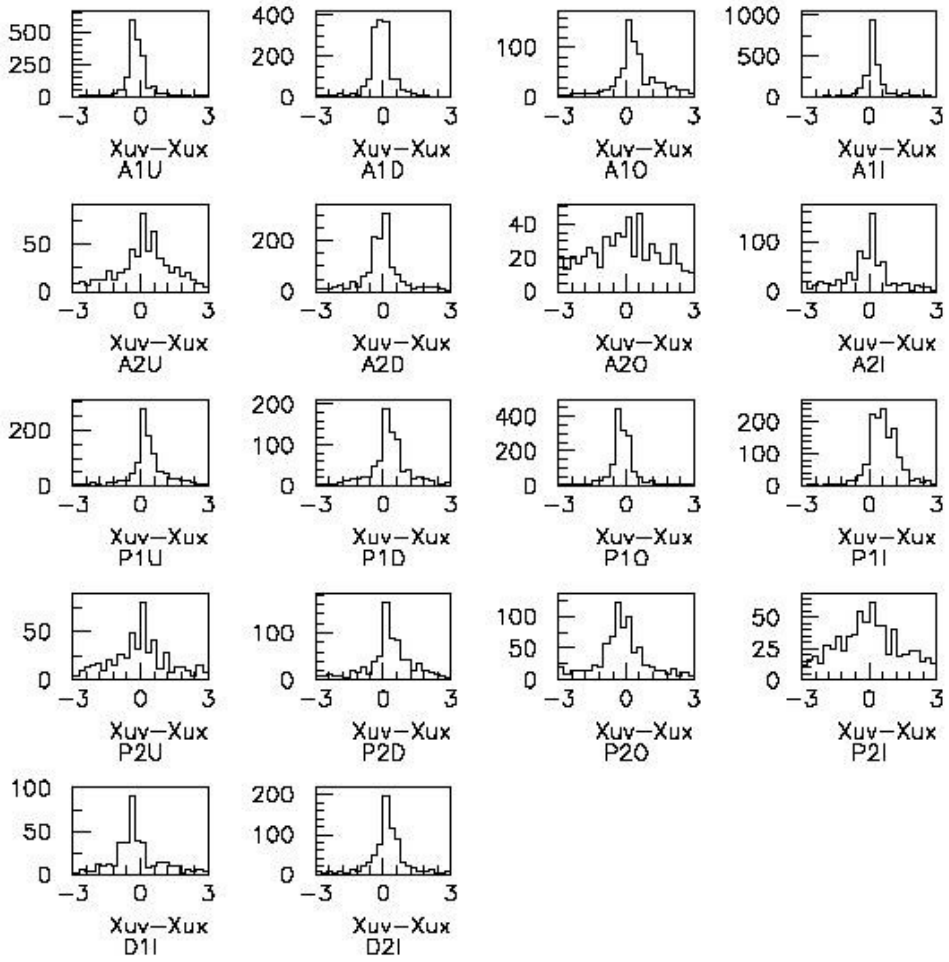
FPD Detector Setup



- 6 layers per detector in 3 planes and a trigger scintillator
- U and V at 45 degrees to X, 90 degrees to each other
- Layers in a plane offset by ~2/3 fiber. Fibers in each layer of a plane taken together define a segment (0.27mm) used to define hits.
- 2 detectors in a spectrometer. Hits used to define tracks.

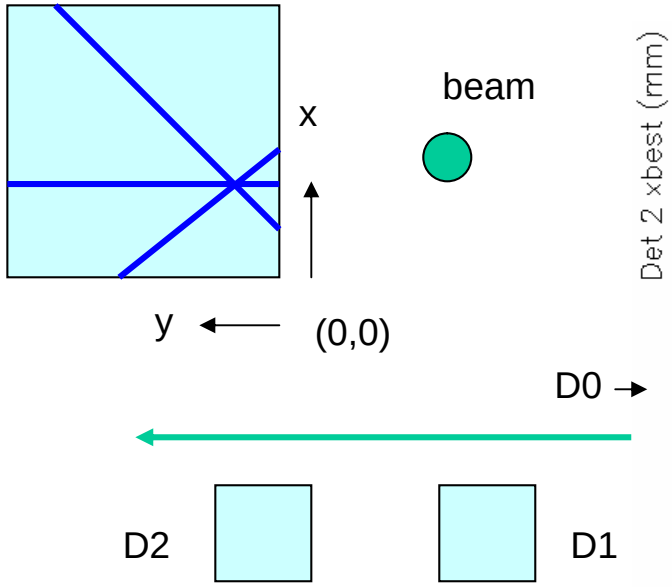
Detector Hit Resolutions

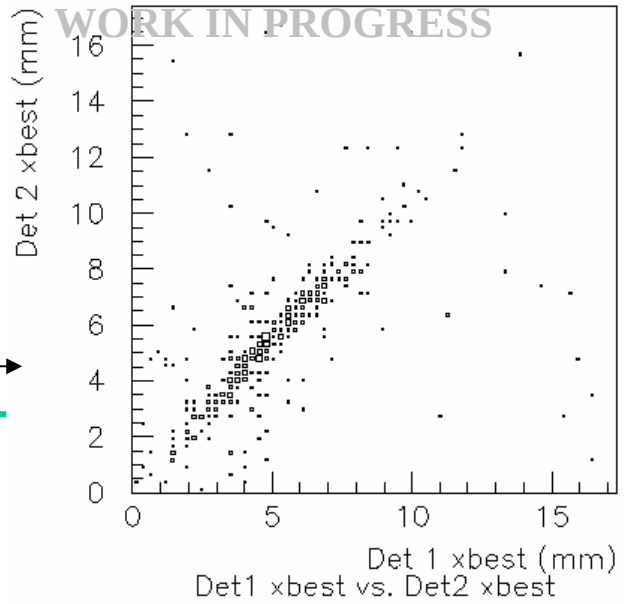
WORK IN PROGRESS

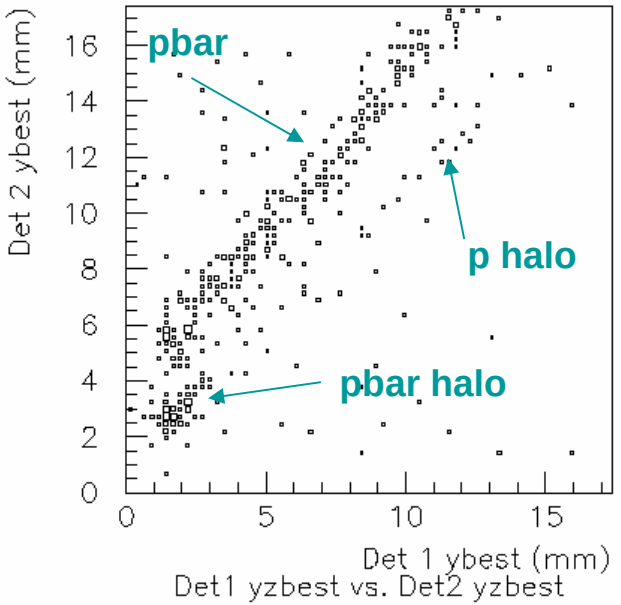


- Starting in January 2004, all 18 detectors regularly inserted (dipoles since February 2003)
- Commissioning underway on quadrupoles
- Resolutions calculated by the difference of the x value of a hit calculated from u/v segments compared to the x value of the x segment show that most of the detectors are working as expected

FPD Dipole Data Analysis



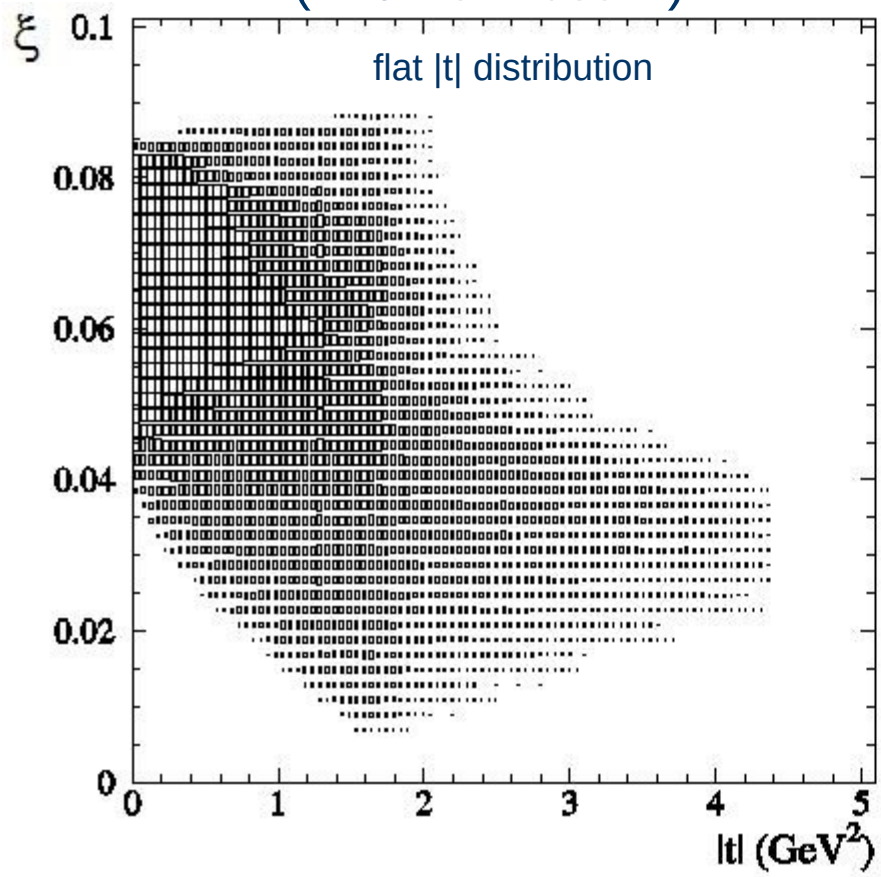




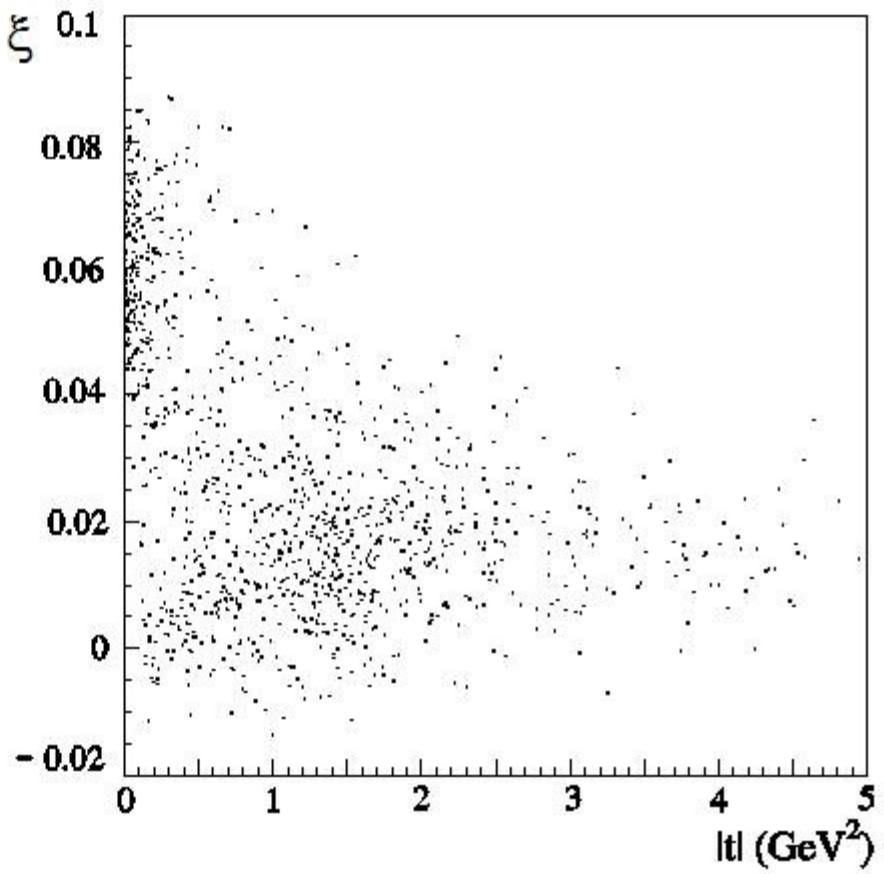
- Read out using AFE (Analog Front End) board
- Trigger minimum of one jet with p_T > 25 GeV and North luminosity counters not firing
- Harsh multiplicity cut applied on number of segments (1) allowed to fire to help deal with spray background
- This correlation is from a small sample

Dipole Diffraction Acceptance

Simple MC Geometrical Acceptance
(14σ from beam)



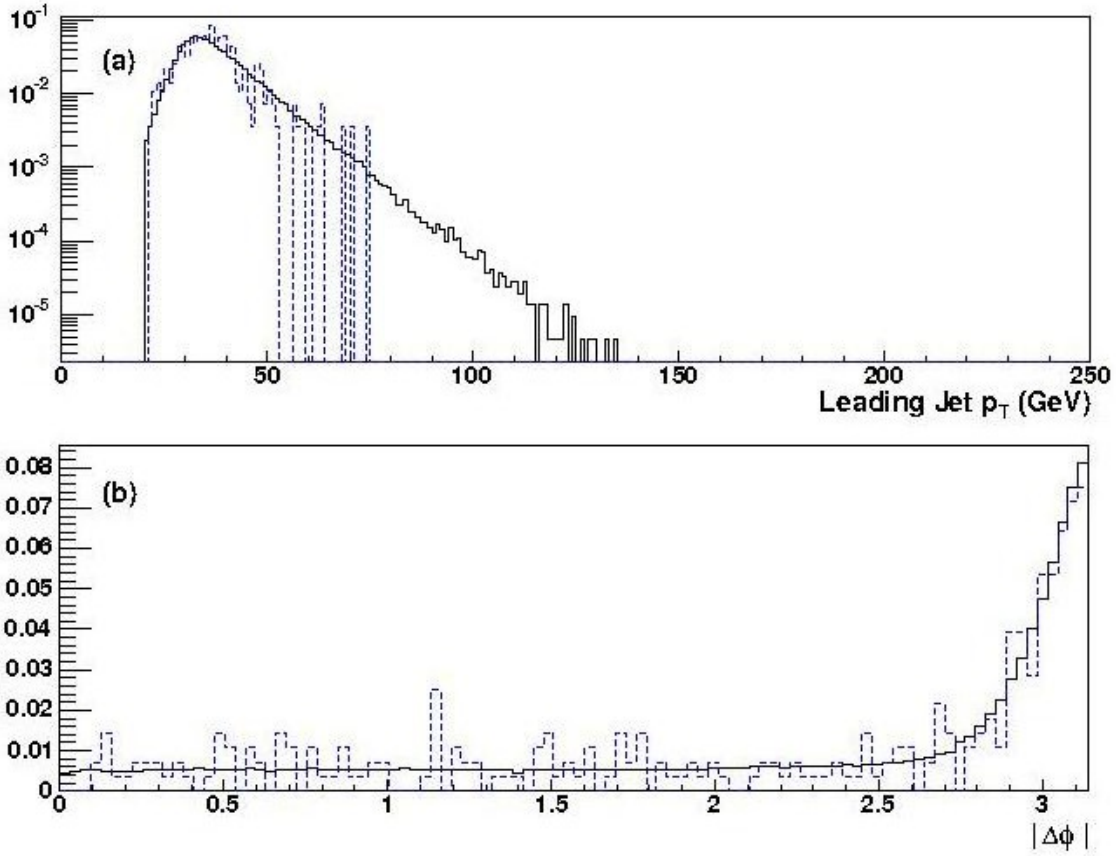
Data



- Fair agreement between data and MC

Dipole Tagged Dijets

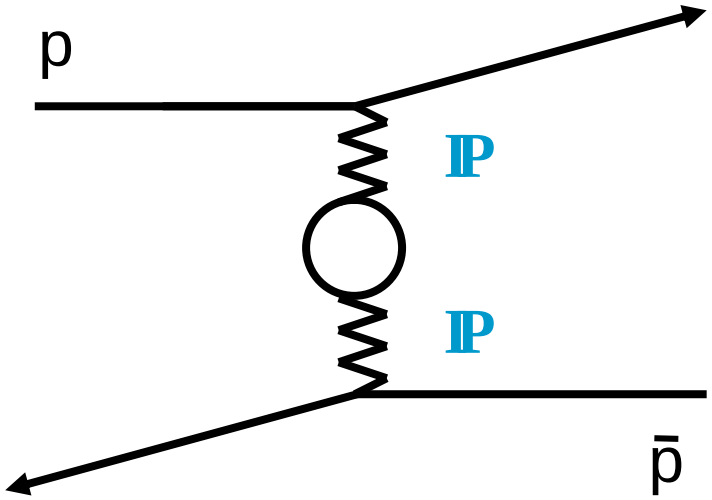
WORK IN PROGRESS



- Comparison of dijet events with (dashed) and without (solid) tags in the dipole detectors
  - areas normalized to one
- Studies underway to calibrate detectors and refine tag definition

Summary

- The full FPD system has been installed and is working as designed
- Full commissioning studies
  - Detector alignment and calibration
- Initial analysis using FPD data:
  - Dijets using dipole tags
  - Z→ μμ using tags
  - b physics
  - Double Pomeron



- Initial definition of a gap in the calorimeter made
- Evidence of Z→ μμ with gap signature found, further work needed to finalize results and interpretation in terms of diffractive physics