Moving Forward: DØ Diffraction to LHC

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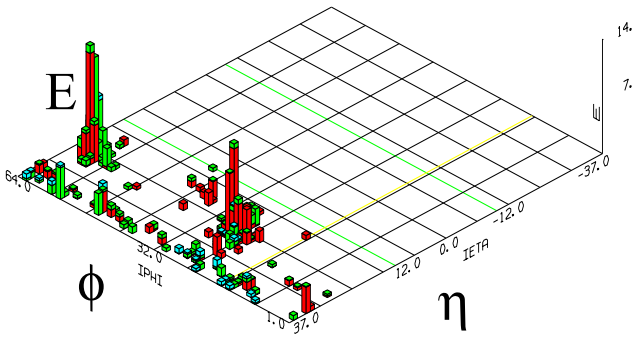
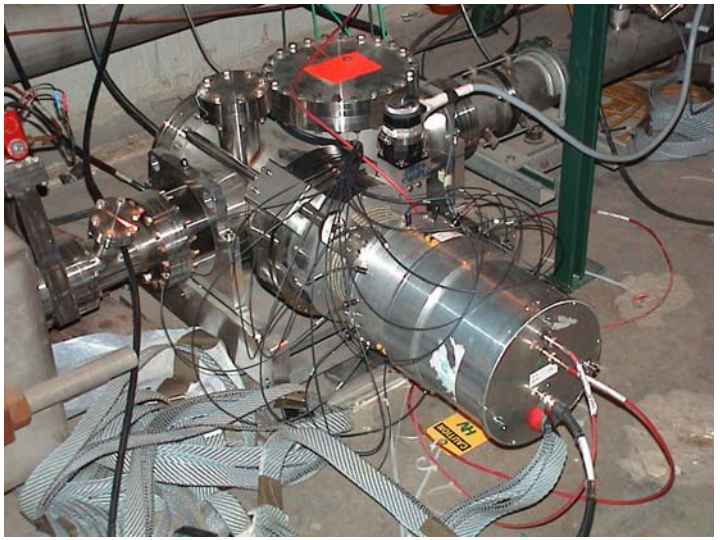
Run I



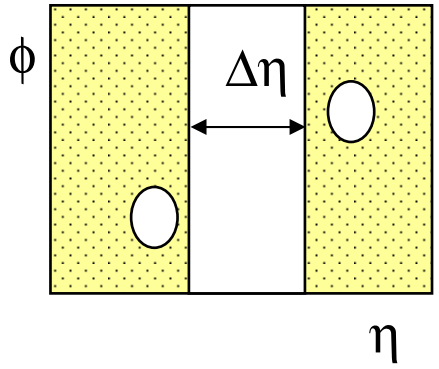


Run II

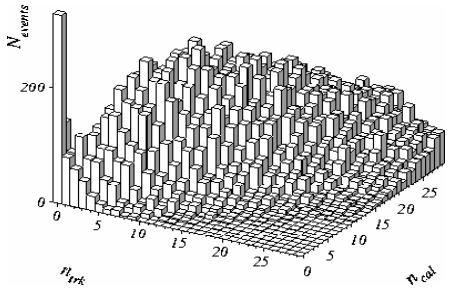
Goals of talk:
Present DØ diffractive/FPD status
Tie into LHC forward program

TeV4LHC Workshop
February 4, 2005
Brookhaven, NY

DØ Run I Gaps

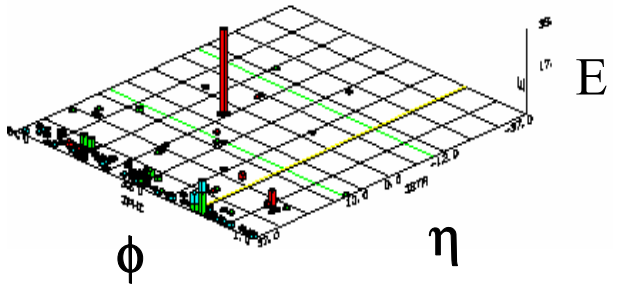


•**Pioneered central gaps between jets:** Color-Singlet fractions at $\sqrt{s}$ = 630 & 1800 GeV; Color-Singlet Dependence on $\Delta\eta$, E_T, $\sqrt{s}$ (parton-x). **PRL 72, 2332(1994); PRL 76, 734 (1996); PLB 440, 189 (1998)**



•**Observed forward gaps in jet events at $\sqrt{s}$ = 630 & 1800 GeV.** Rates much smaller than expected from naïve Ingelman-Schlein model. Require a different normalization and significant soft component to describe data. Large fraction of proton momentum frequently involved in collision.
PLB 531, 52 (2002)

•**Observed W and Z boson events with gaps:** measured fractions, properties first observation of diffractive Z.
PLB 574, 169 (2003)



- **Observed jet events with forward/backward gaps at $\sqrt{s}$ = 630 and 1800 GeV**

Run II Improvements

- Larger luminosity allows search for rare processes

- Integrated Forward Proton Detector (FPD) allows accumulation of large hard diffractive data samples

- Measure ξ, t over large kinematic range

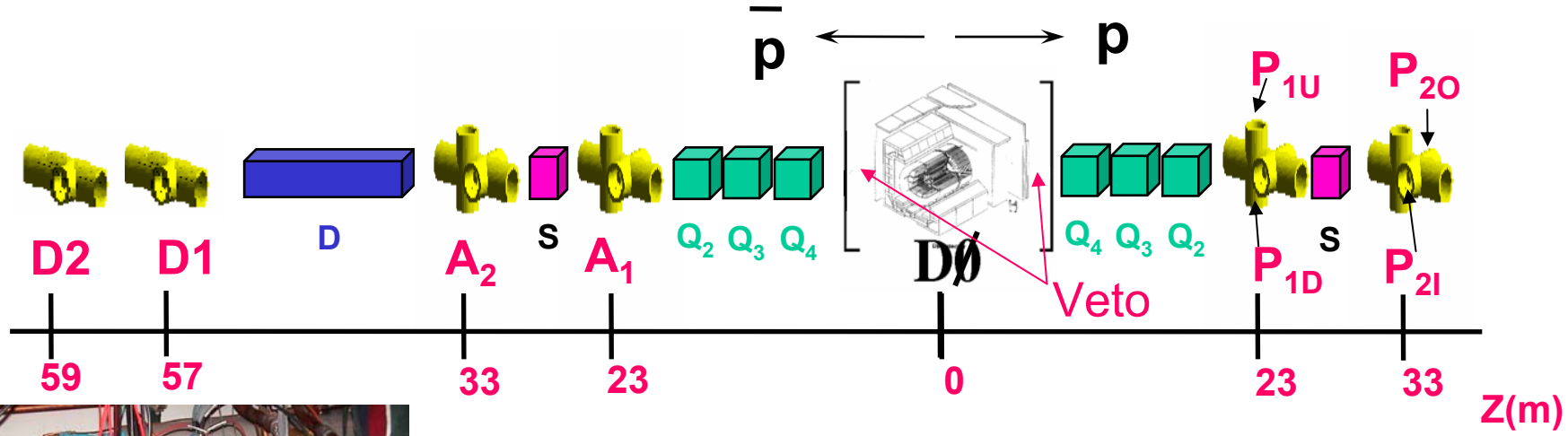
- Higher E_T jets allow smaller systematic errors

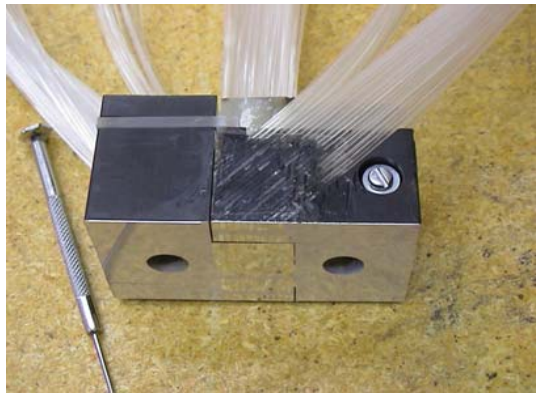
- Comparing measurements with track tag vs. gap tag yields new insight into processes

Diffractive Topics and Students!

Student (Year)	Institute	Advisor	Subject
Tamsin Edwards (2005)	Manchester	Cox	Diffractive Z (gaps)
Vlatislav Hynek (2007)	CTU	Simak	Diffractive Forward jets
Ana Carolina de Jesus (2007)	UERJ	Santoro	Diffractive Heavy Flavor
Helena Malbouisson (2007)	UERJ	Santoro	Diffractive structure fct
Luis Mendoza (2007)	Bogotá	Avila	Diffractive W, Z
James Monk (2006)	Manchester	Cox	Double Pomeron+jets
Murilo Rangel (2008)	UFRJ	Barreto	Diffractive Pomeron+jets
Renata Rodrigues (2007)	UERJ	Santoro	Inclusive Double Pomeron
Roman Otec (2007)	CTU	Simak	Diffractive jets
Michael Strang (2005)	UTA	Brandt	Diffractive jets

Forward Proton Detector (FPD)

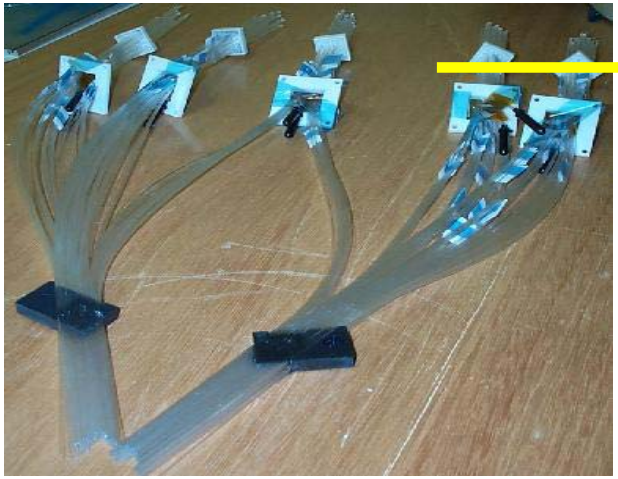


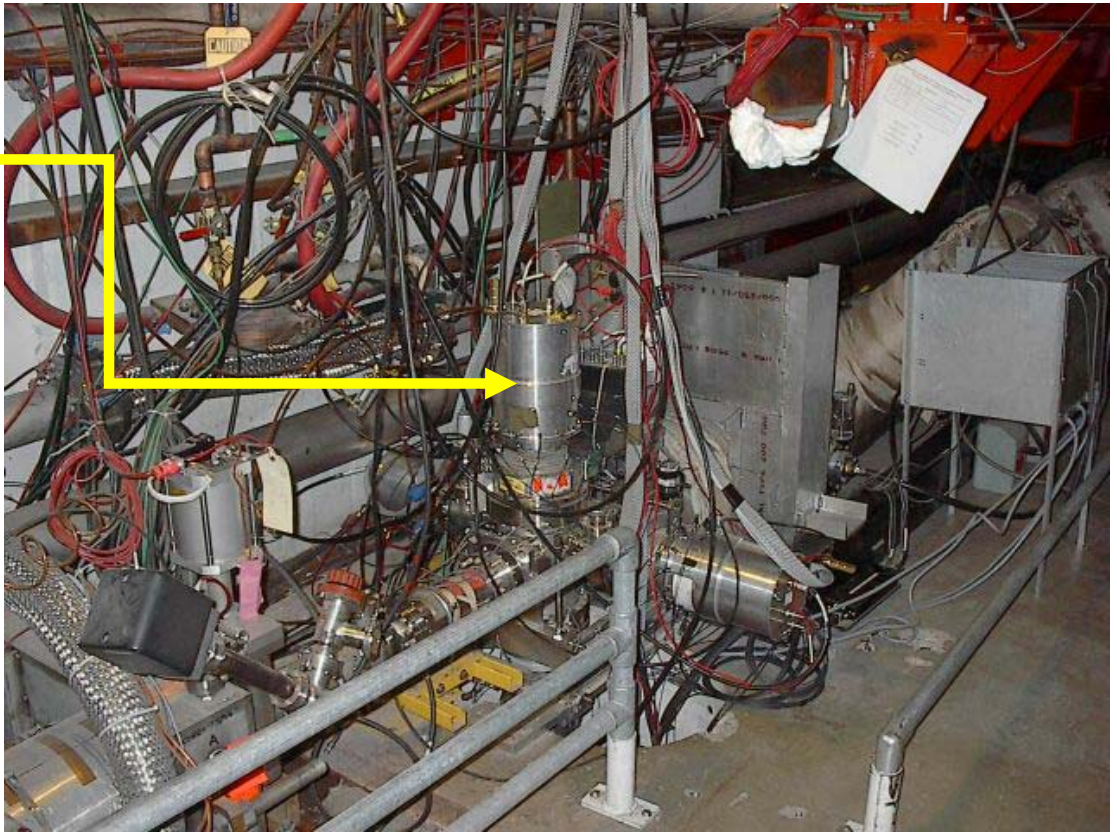


- 9 momentum spectrometers comprised of 18 Roman Pots
- Scintillating fiber detectors can be brought close (~6 mm) to the beam to track scattered protons and anti-protons
- Reconstructed track is used to calculate momentum fraction and scattering angle
  - Much better resolution than available with gaps alone
- Cover a t region ($0 < t < 3.0$ GeV^2) never before explored at Tevatron energies
- Allows combination of tracks with high-p_T scattering in the central detector

Detector/Castle Status

- All 6 castles with 18 Roman pots comprising the FPD were constructed in Brazil, installed in the Tevatron in fall of 2000, and have been functioning as designed.
- **20 detectors built over a 2+ year period at UTA**
- **In 2001-2002, 10 of the 18 Roman pots were instrumented with detectors.**
- **During the fall 2003 shutdown the final eight detectors and associated readout electronics were installed.**



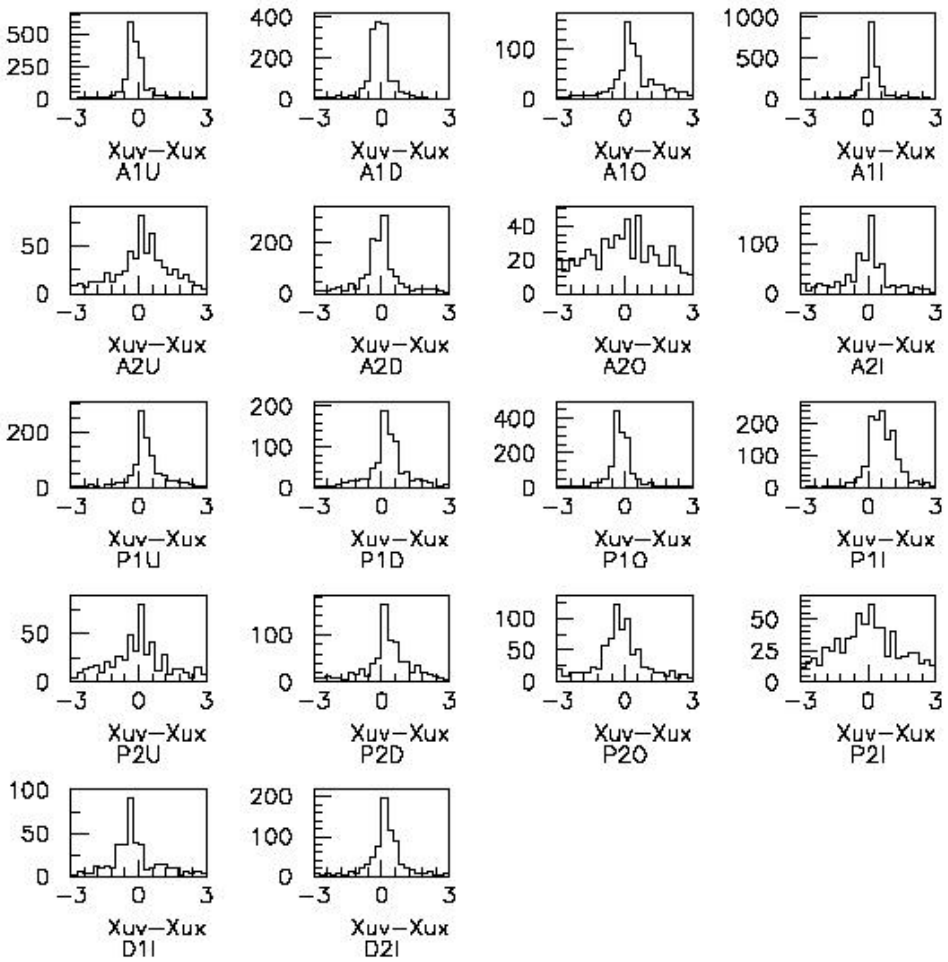


A2 Quadrupole castle with all four detectors installed

Operations

- Operations in 2004 were routine, only occasional minor problems, less than average sub-detector (and avg. detector worked well!)
- 2005 operations recently restarted
- Currently FPD expert shifters inserts pots and Captains remove pots and set system to standby
- 18 pots inserted every store when lum<45E30, read out for all events
- Combine shifts with CFT, since similar readout system, standard FPD fiber plots incorporated into CFT online examine program
- Working towards automated pot insertion by shift captain

Detector Hit Resolutions



- Starting in January 2004, all 18 detectors regularly inserted (dipoles since February 2003)
- 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
- With detectors integrated in readout, focus turns to trigger

Current Diffractive Triggers

Jet +Gap(s):
15 GeV jet + 1 or 2 gaps; 2 gap trigger has low prescale up to intermediate lums

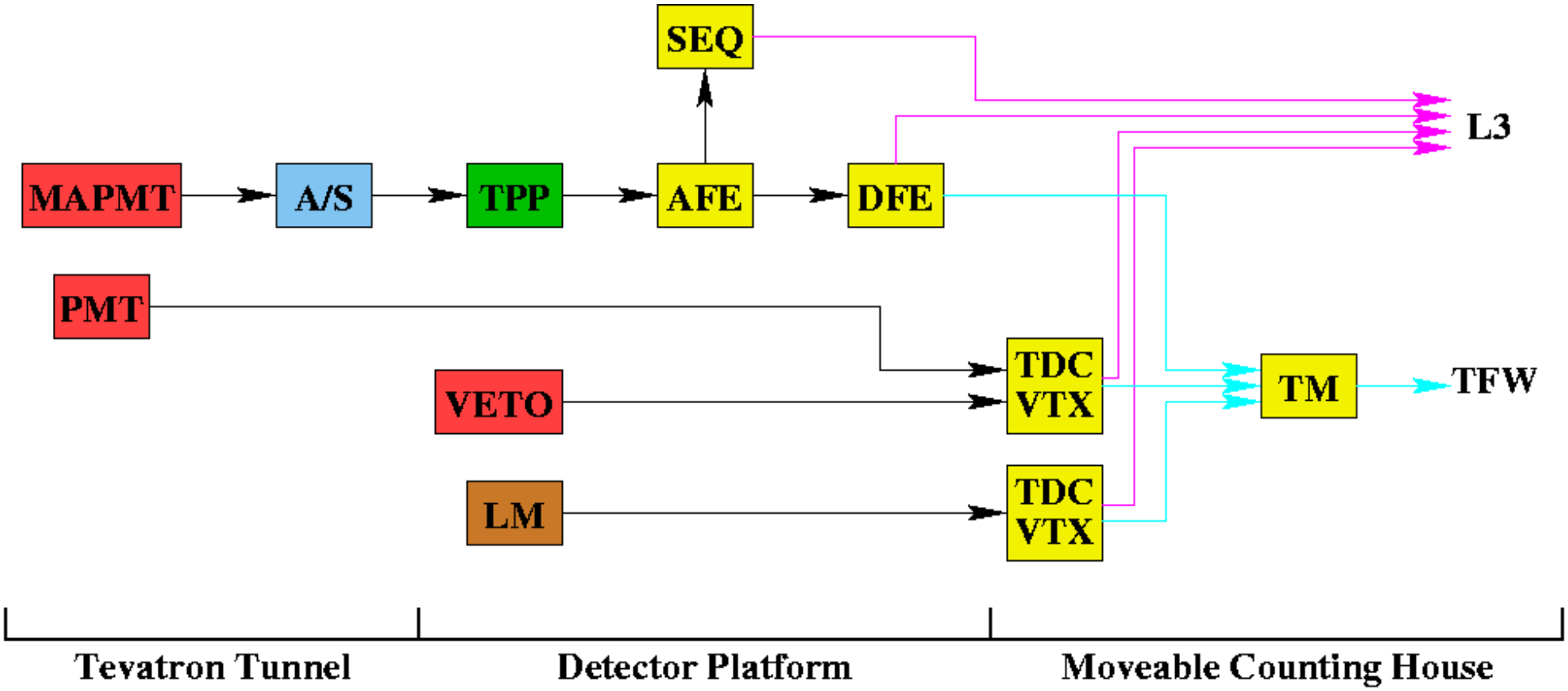
45 GeV jet + 1 or 2 gaps; prescale of 2 for single gap up to 60E30, double gap unprescaled at all lum

J/ Ψ +Gap(s):
2 low p_T muons+1 or 2 gaps; unprescaled at all luminosity

Elastic:
Recently added elastic global list trigger, previously restricted to special runs

These triggers are being used to search for exclusive dijets and exclusive **χc** (among other things), a key step towards validating diffractive Higgs models. No results for public display yet.

FPD Trigger and Readout



Trigger Strategy

Input information:

- LM Vertex board (to include trig. scint. in trigger) is delayed
- DFE boards and TM work and ready to be commissioned
- Main background not from pileup (multiple interactions) but from halo spray

Strategy:

- Instead of calculating bins of ξ and t, use fiber hit patterns to demand 2 or 3 out of 3 planes of each detector have valid hits; replaces trigger scintillator, simpler algo
- Use multiplicity cut to reject halo spray, code several multiplicity levels
- NOTE: fiber ADC threshold must be high enough to avoid noise, low enough to retain efficiency and allow vetoing of halo
- One advantage is pot positions not needed at trigger level

Status:

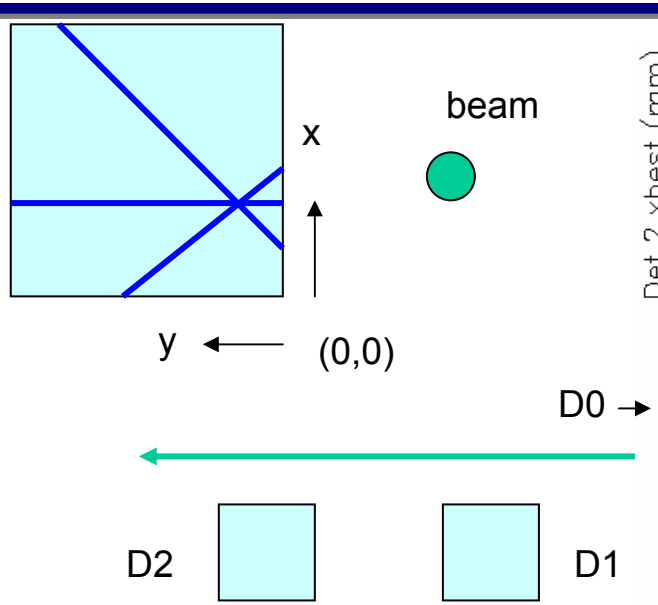
- Hardware+Firmware ready, waiting for trigger database updates

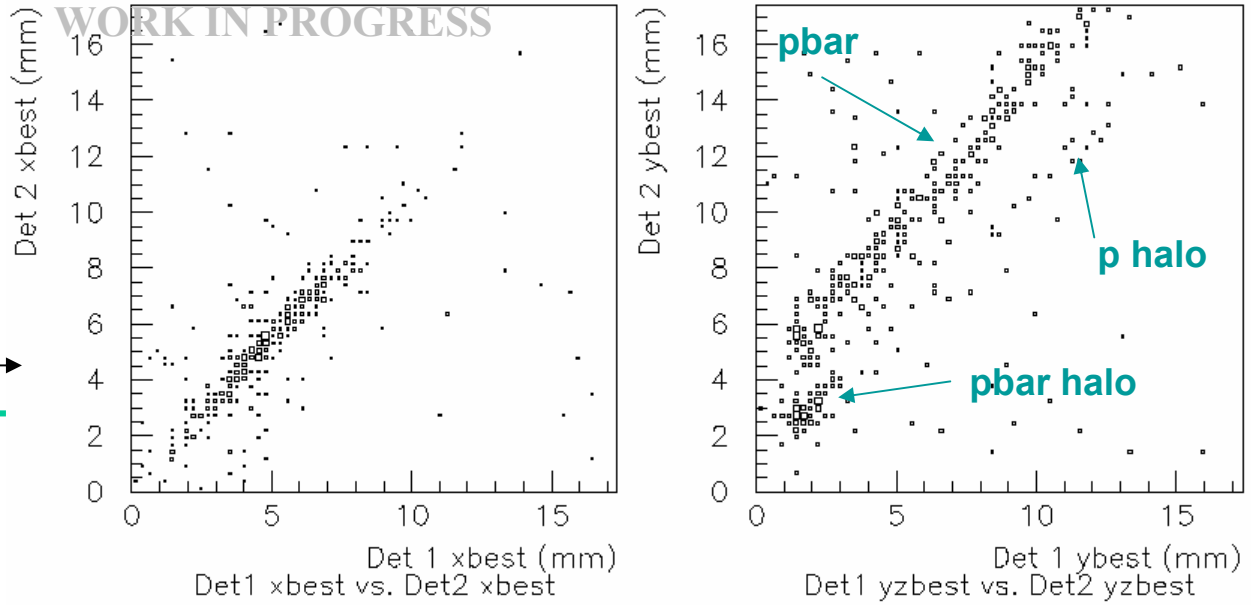
FPD Trigger List

Tentative L1 FPD V14 trigger list (spring 2005)

1) Elastic (diag opposite spectrometers) +GAPSN
2) Soft Diffraction (single spectrometers)+GAPS or GAPN
3) Overconstrained track (pbar in quadrupole +dipole spectrometers)+GAPN
4) Double Pomeron (up-up, dn-dn etc.)+GAPSN if needed
5) Jet + FPD Track (DIFFQ or DIFFD) +GAPS or GAPN if needed
6) EM +FPD track +GAP (if needed)
7) CFT Track(1.5) +FPD track +GAP
8) Muon +FPD track +GAP

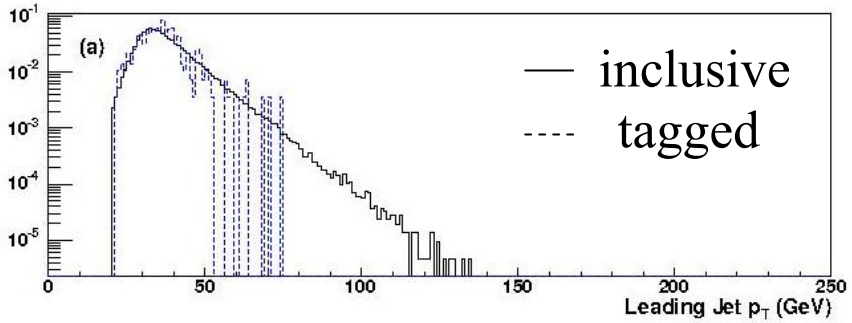
FPD Dipole Jet Data





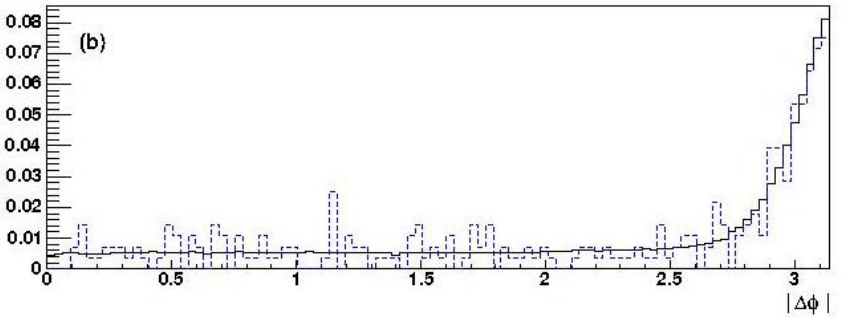
- Trigger one jet with p_T > 25 GeV and Gap on North (pbar side)

jet p_T

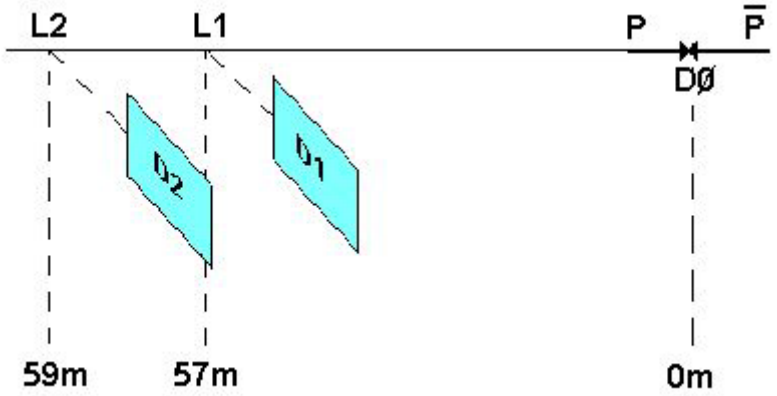


- Read out using AFE (Analog Front End) board; FPD info extracted from raw data

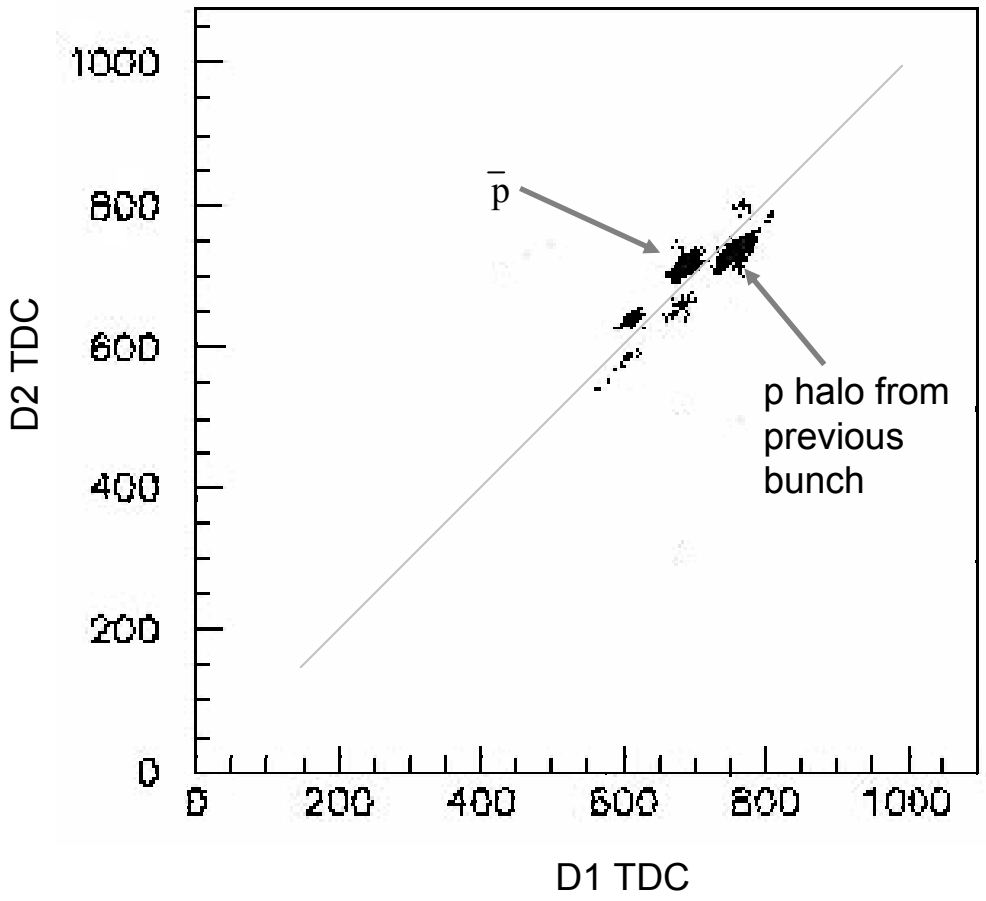
jet $\Delta\varphi$



Dipole TDC Resolution



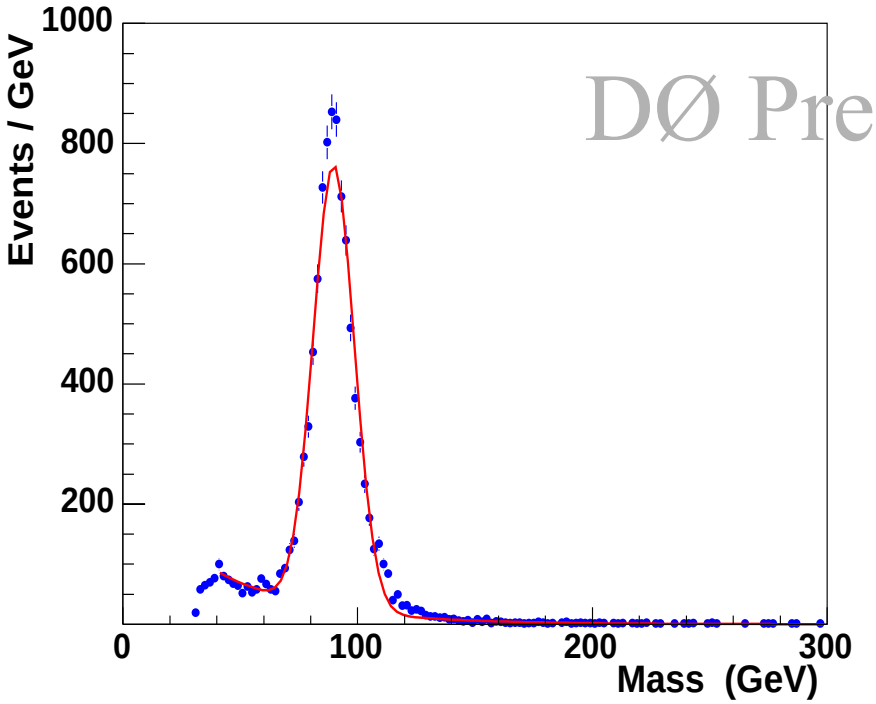
- Can see bunch structure of both proton and antiproton beam
- Can reject proton halo at dipoles using TDC timing



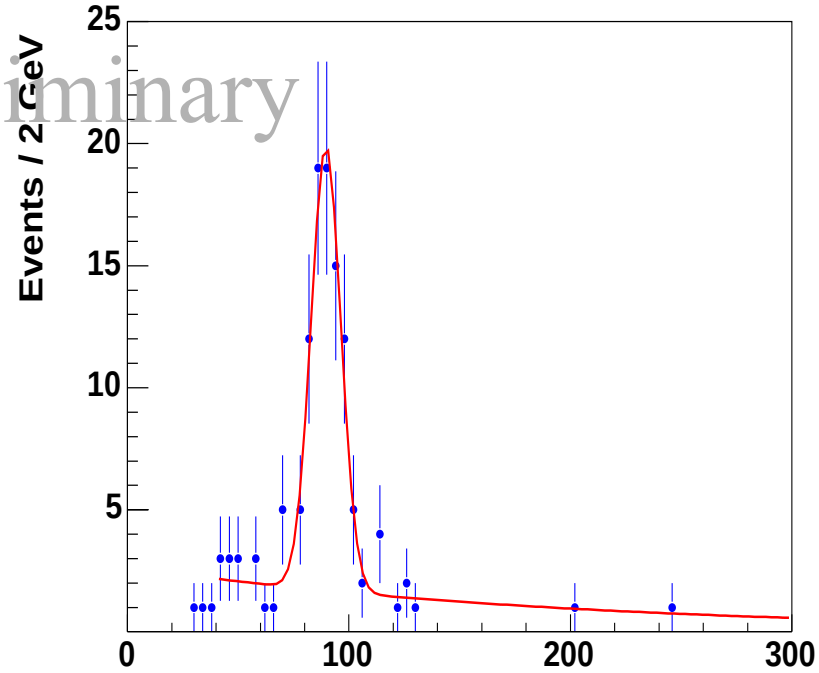
Diffractive Z (Gap tag)

Event Selection: $Z \rightarrow \mu^+\mu^-$ Events from 2003 data sample
Two good (P_T > 15GeV) oppositely charged muons (at least one isolated), cosmic ray rejection

Demand Activity North and South



Forward Gap (North or South)



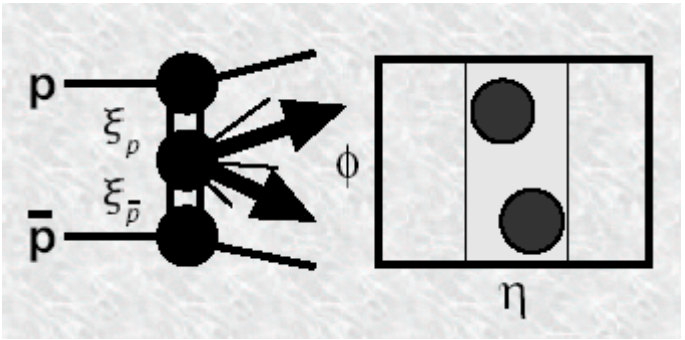
Tamsin Edwards (Manchester) thesis work, expected to be completed in next couple months

Tie in to LHC

Search for central exclusive diffraction:
events with tagged proton, anti-proton, 2 jets, and nothing else

Interest in diffractive Higgs production
(requires LHC for sufficient cross section)

Calibrate with exclusive dijets
(only DØ can measure full event)



REQUIREMENTS:
- Exclusive Monte Carlo (ready)
- 18 FPD detectors integrated in DØ readout (check)
- Dedicated FPD trigger (close)

Diffractive structure measurements being done at CDF and DØ provide important inputs to background processes, also can be a part of broad LHC physics program

Lessons Learned

FPD operational lessons learned could be very useful for potential forward upgrades to ATLAS and CMS (already have had many discussions with Brian+Albert):

•Bigger project than you (I) might think: more manpower, time, cost, CABLES
•Need a sufficient budget and some level of priority (Beyond the Baseline Syndrome)
•Using other people's electronics is risky (minor adaptations often aren't, make sure their schedule is much earlier than yours)
•Early integration (software+hardware) is essential
•Good contacts in the Accelerator Division are crucial

•Halo not well-understood (expert simulations, but…), collimators not optimized, using bpm's as found not so good—do you know how to get bpm's into data stream, etc.
• Commissioning phase long and personnel intensive, must have sufficient physicists and engineers on-site
•Grounding issues (long cables in tunnel plugged into detector might cause problems—actual or perceived)
•Elastics for alignment critical, every store if possible
•Late trigger -> late calibration sample
•Need more access than you might think

Not to mention software effort: track reconstruction, Monte Carlo database, online, etc.

Outlook and Plans

- Finish Level 1 Trigger Commissioning
- Continue routine data collection, add new triggers=new data samples
- Emphasis on physics/publishing mature results and obtaining new preliminary results
- Plan a special low-t (0.1-1) run soon, get your predictions of if/where the dip(s) will be for SD,DPE+Elastic

DiffWG Goals for TeV4LHC?

What I'd like to come out of this series of workshops:

- A write up including physics remaining to be done at Tevatron
- List of special runs at Tevatron with physics motivation, leading to joint CDF/DØ proposal
- A clear connection between Tevatron and LHC diffraction
- A U.S. effort to participate in ATLAS/CMS forward physics (especially ATLAS)