Diffractive Physics at CDF II:
diffractive structure function

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(for the CDF collaboration)

Small-x and Diffraction, Fermilab

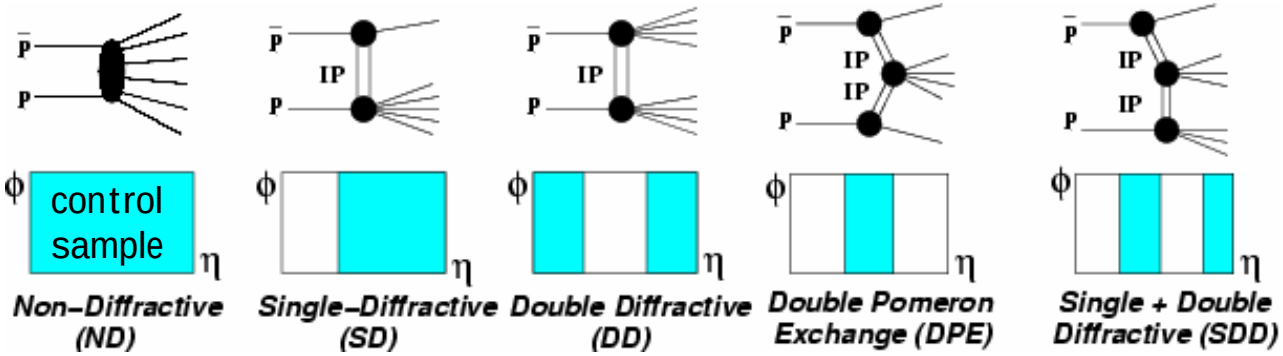
- ✓ Diffraction in Run I
- ✓ New Detectors for Run II
- ✓ Diffractive dijets: Q^2 dependence

Diffraction in Run I

➢ Large rapidity gaps are signatures for diffraction

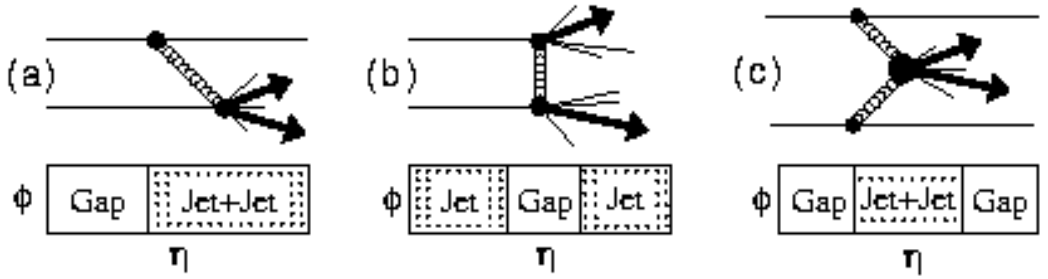
Soft diffraction

- ✓SD
- ✓DD
- ✓DPE
- ✓multi-Gap



Hard diffraction

- ✓SD (W, jet-jet, b-quark, J/ψ)
- ✓SD (w/RP) dijets (630 GeV and 1.8 TeV)
- ✓Forward jets (Jet-Gap-Jet)
- ✓DPE dijets



SD dijets

If you want to know more…

Soft diffraction	SD	PRD 50 (1994) 5535
	DD	PRL 87 (2001) 141802
	DPE	to be submitted to PRL
	multi-gap	PRL 91 (2003) 011802
Hard diffraction	W	PRL 78 (1997) 2698
	b-quark	PRL 84 (2000) 232
	J/ψ	PRL 87 (2001) 241802
	jet-jet	PRL 79 (1997) 2636
	jj w/RP	PRL 84 (2000) 5043, PRL 88 (2002) 151802
	forward jets	PRLs 74 (1995) 855; 80 (1998) 1156; 81 (1998) 5278
	DPE dijets	PRL 85 (2000) 4217

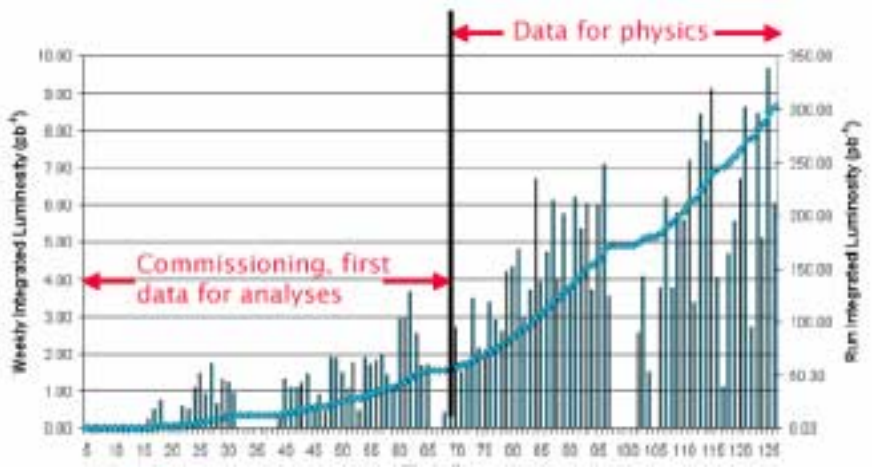
for a review: hep-ph/0306085
…see Goulianos' talk tomorrow !

First Goals for Run II

✓Diffractive structure function
⇨ Q^2 and ξ dependence

✓Exclusive production
⇨ dijet, heavy flavor, low-mass

Tevatron Collider

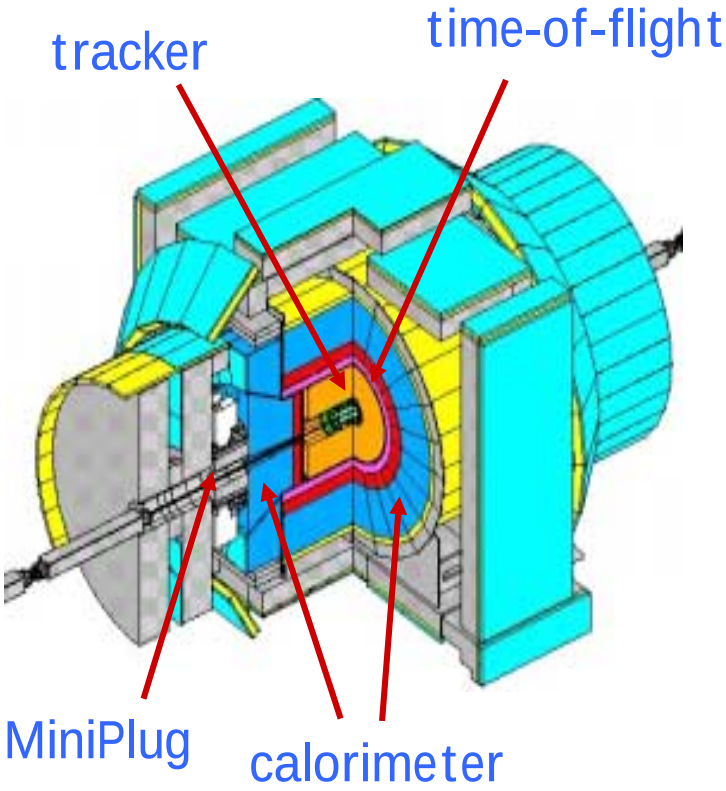


- high (low ?) inst. luminosity
  ($L \sim 2\text{-}3 \times 10^{31}\ cm^{-2}sec^{-1}$)
- multiple interactions

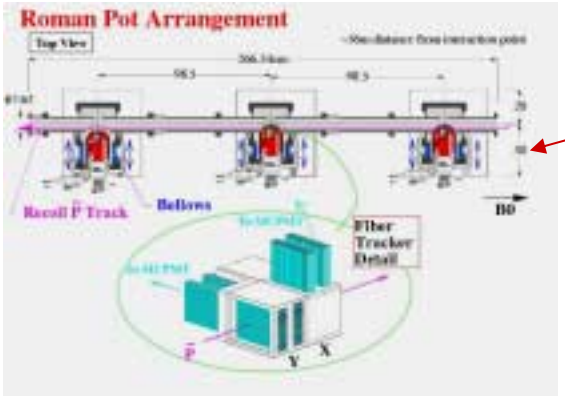
- Tevatron and detector upgrades
  - ✓C.M. energy 1.96 TeV
  - ✓ 396 nsec bunch spacing

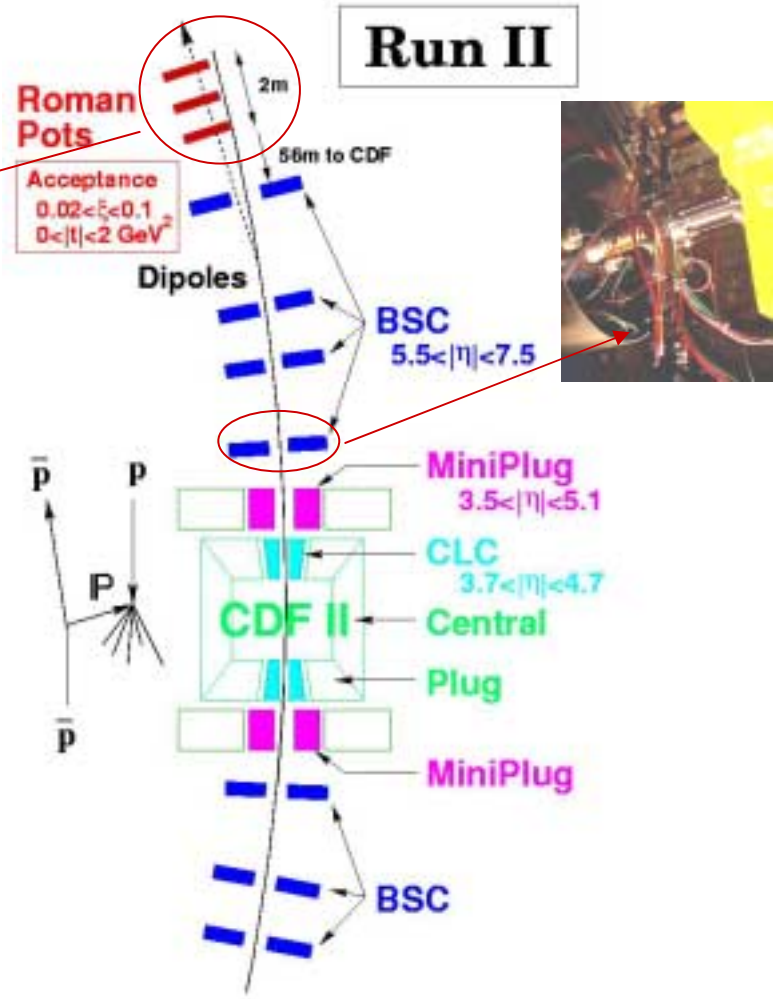
New Detectors for Run II

- Tracking
  - ✓ Silicon
  - ✓ Central Outer Tracker
- Time of Flight
- Expanded Muon Coverage
- Endplug Calorimeter
- Forward Detectors
- Trigger
  - ✓ Tracks @ L1
  - ✓ Silicon Tracks @ L2
- DAQ (132 ns)



Forward Detectors

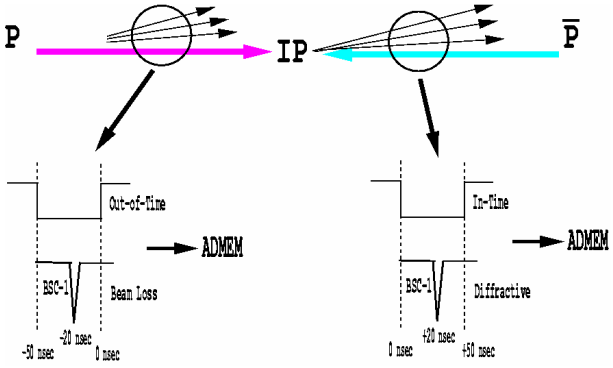




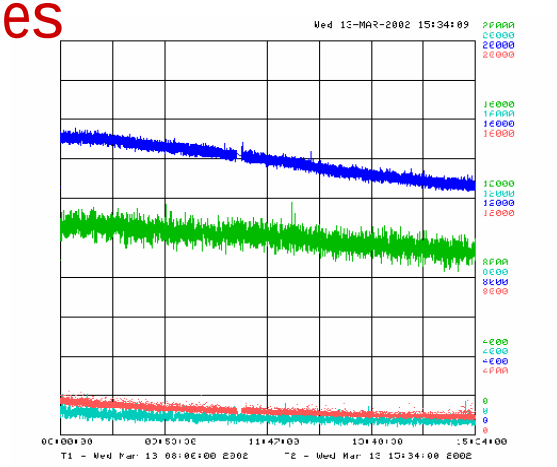
- ✓Roman Pots Spectrometer
- ✓Beam Shower Counters
- ✓MiniPlug Calorimeter

⇨ Larger η coverage for rapidity gaps and jets

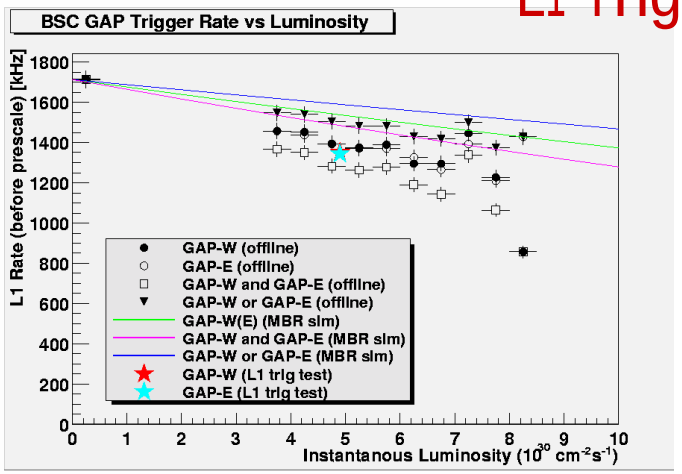
Beam Shower Counters



Beam Losses



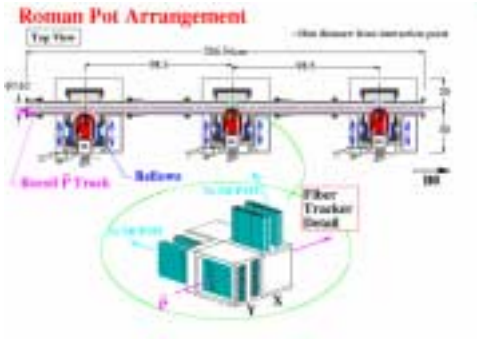
L1 Trigger

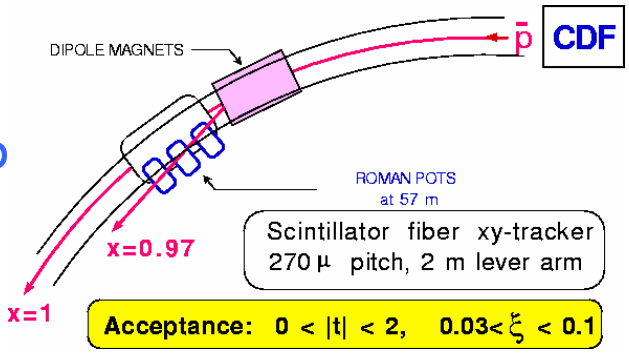


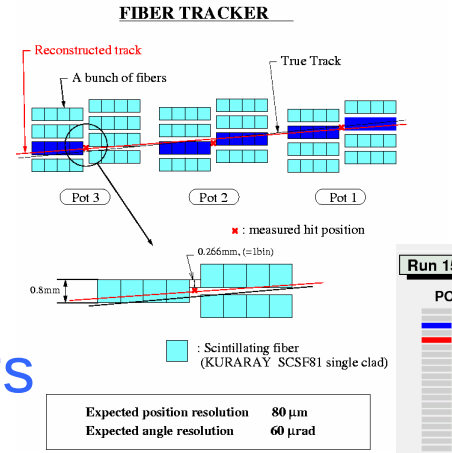
Roman Pot Spectrometer

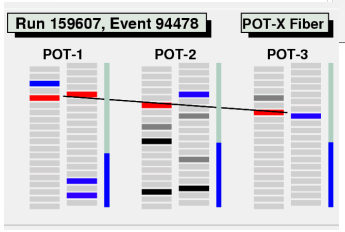
Fiber Tracker

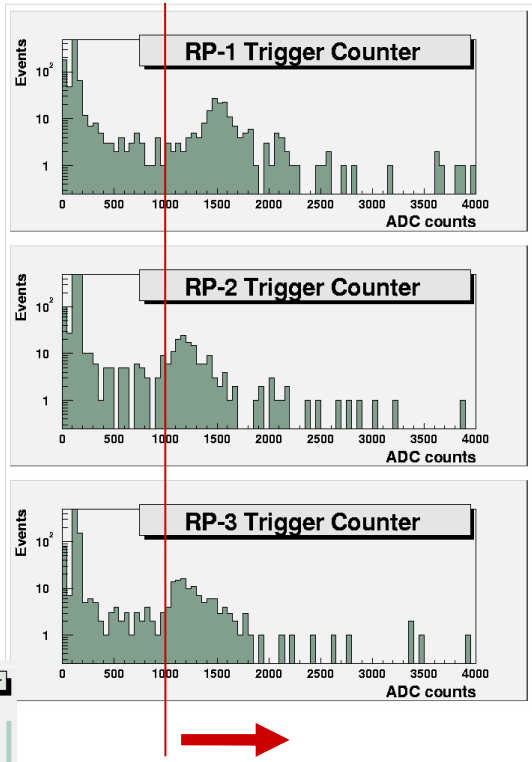
- 3 stations
- 57 meters from IP









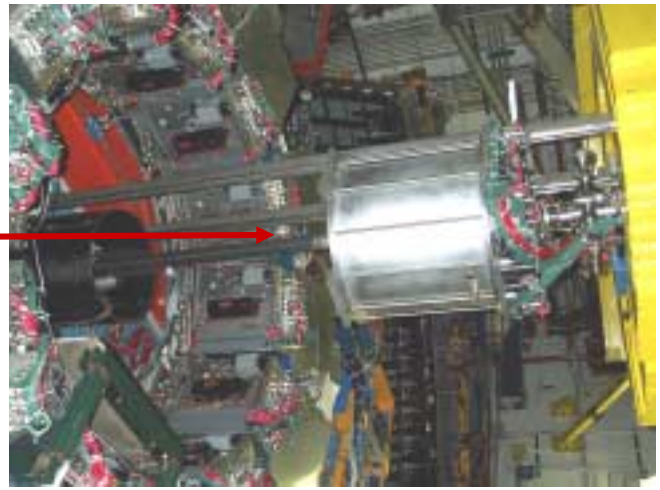


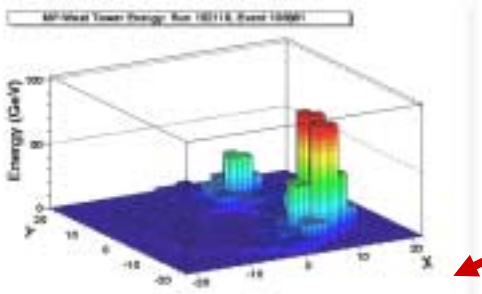
MIPs (>1000 counts)

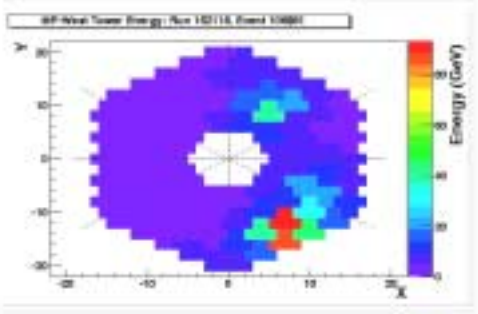
- 3 trigger counters
- 240 channels

New MiniPlug Calorimeter

- liquid scintillator + lead
- towerless geometry
- full coverage: $3.5 < |\eta| < 5.1$



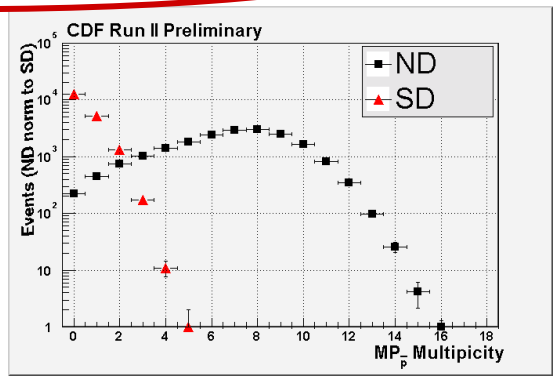




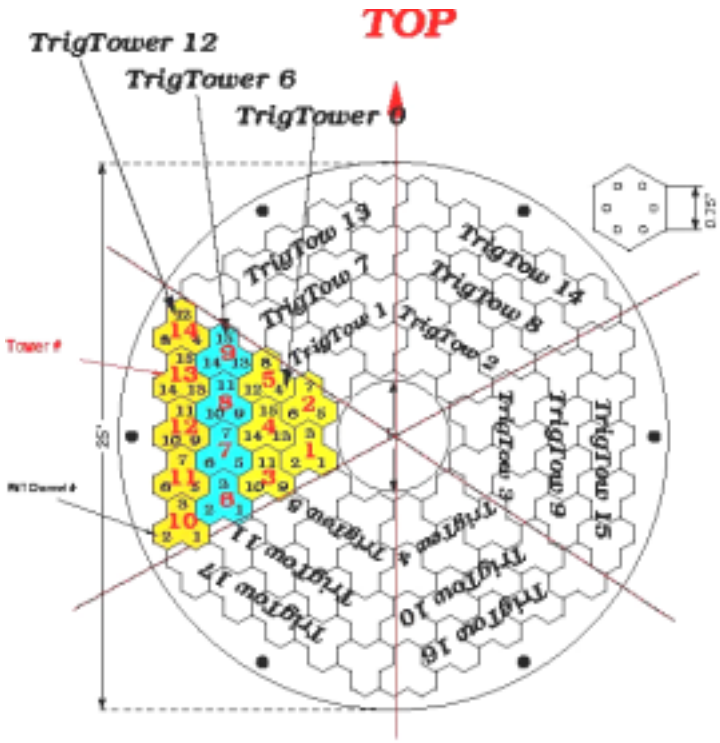
Measure:

very forward jet energies and position

multiplicity



MiniPlug Design



East MP (viewed from IP)

Path to diffractive results

1) Detectors

- installed (MP/November 2001)
- triggers implemented
- fully instrumented

⇨ ready in September 2002

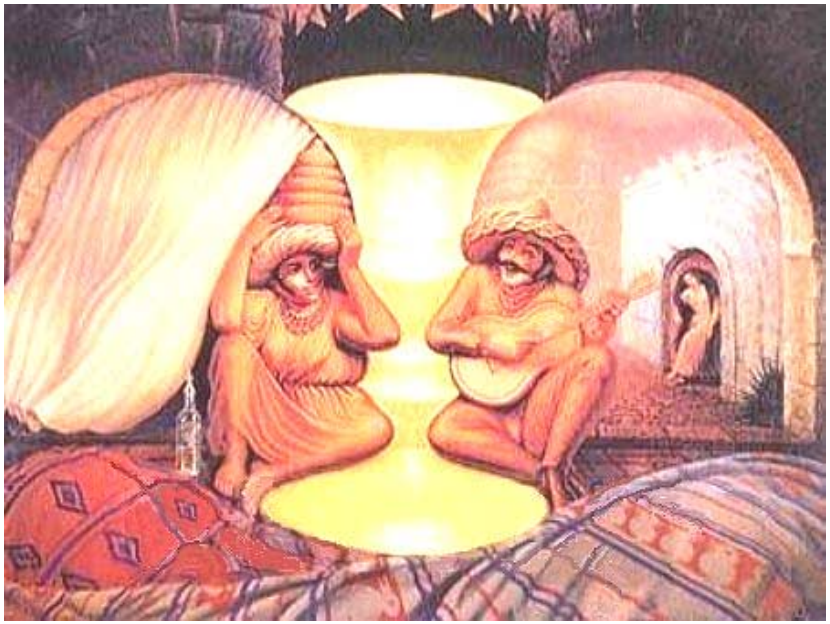
2) Data

- triggers are prescaled
- more than 100 pb^{-1} collected

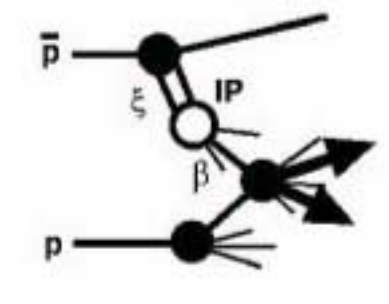
3) Results

- what do we find?
  (what do you see?)

⇨ next



Diffractive Dijets

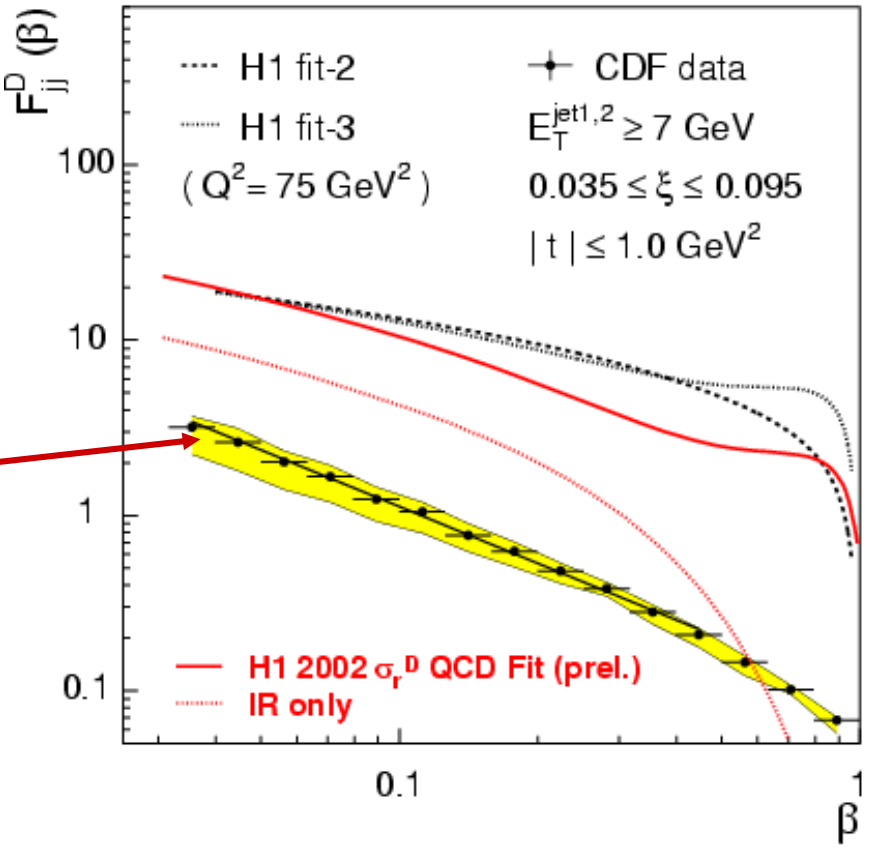


ξ: fraction of anti-proton momentum loss
β: fraction of pomeron momentum carried by parton

parton $x_{Bj} \equiv \beta \cdot \xi$

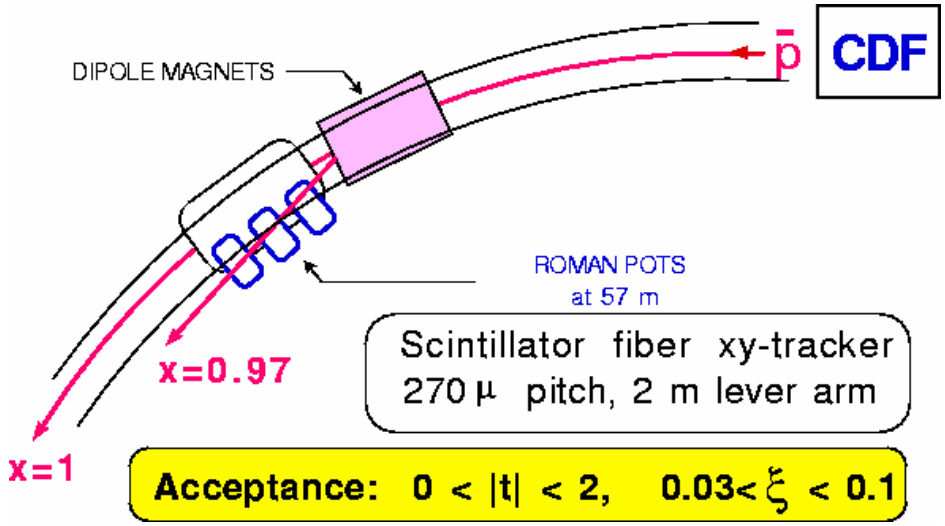
$$\frac{\sigma(SD_{jj})}{\sigma(ND_{jj})} = \frac{F_{jj}^{D}(x)}{F_{jj}(x)}$$ (LO QCD)

CDF Run I result suppressed
by a factor of ~10 relative to HERA



⇨breakdown of QCD factorization
(renormalization removes s-dependence)
K. Goulianos, PLB 358 (1995) 379

Trigger

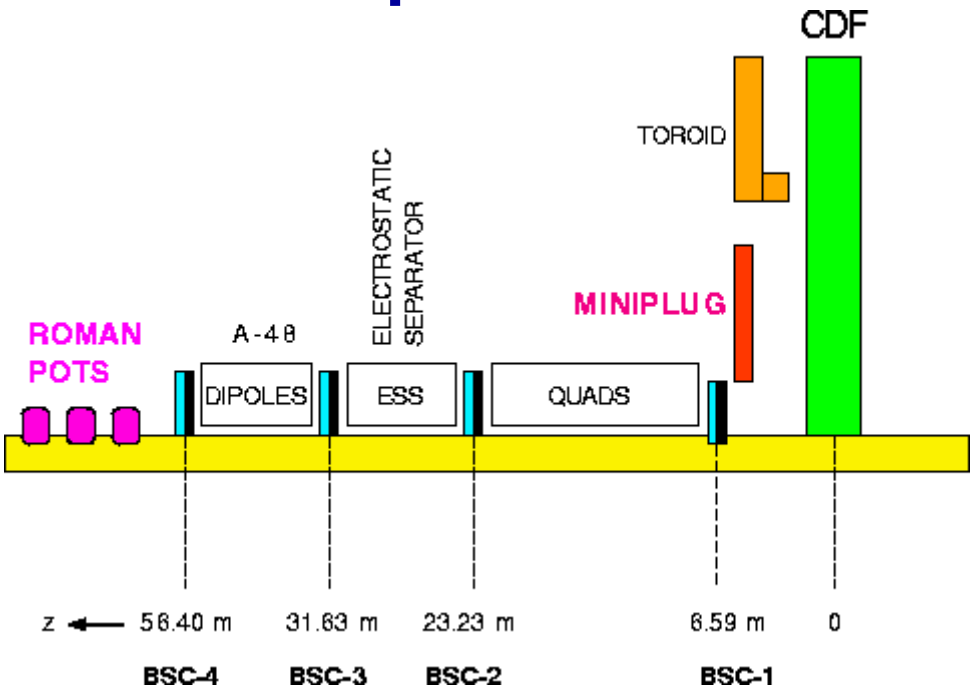


require jets

- RP is triggered on leading antiprotons
- Use RP + jet triggers

Event Samples

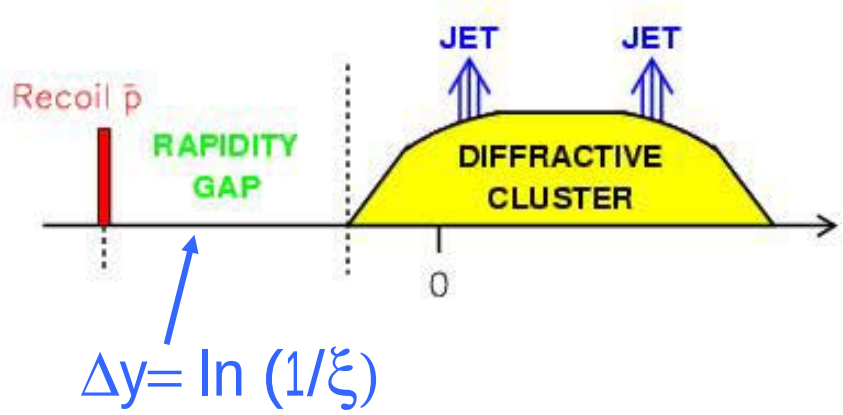
Dedicated triggers
⇨ total rate ~3Hz



ND (J5)	at least one calorimeter tower with E_T>5 GeV
RP inclusive	three-fold coincidence in RP counters
RP+J5	RP inclusive together with J5

ξ : Momentum Loss Fraction

Measure fractional momentum loss of anti-proton



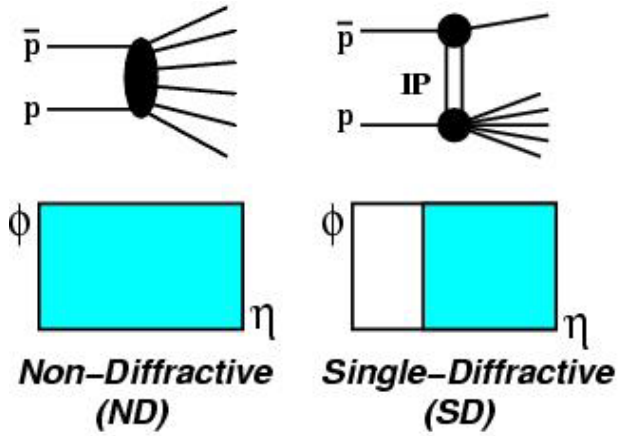
$$\xi = \frac{M_X^2}{s}$$

$$\Rightarrow \xi = \frac{\Sigma E_T e^{-\eta}}{\sqrt{s}}$$

Diffractive events are boosted towards positive η

$\Rightarrow$ small ξ

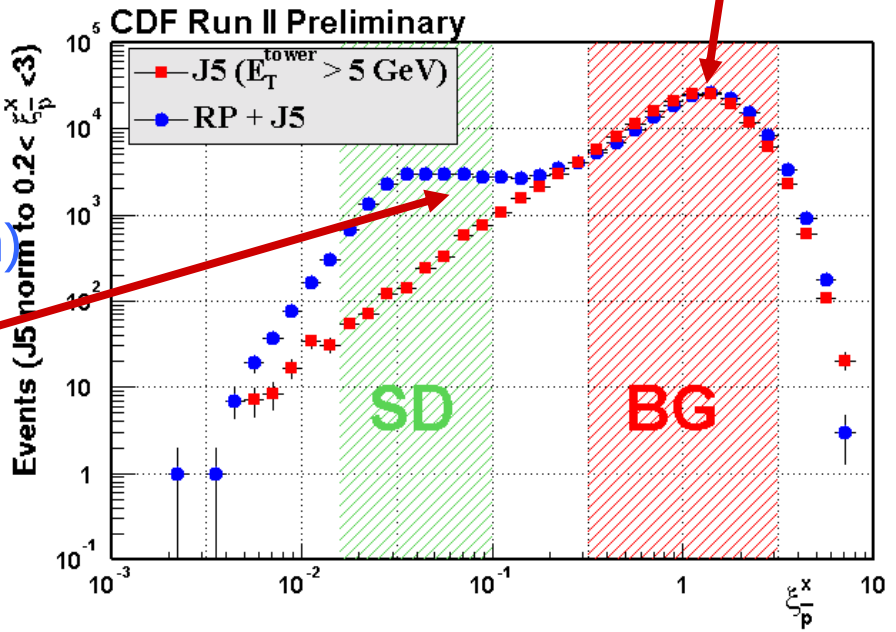
Single Diffractive Dijets



- Compare diffractive events to ND
- Measure diffractive structure function from $R_{SD/ND}$ vs x_{Bj}

overlap events

Measure ξ ($\bar{p}$ momentum loss fraction) from calorimeter information



Approx. flat at ξ<0.1

$$\frac{d\sigma}{d\xi} \propto \frac{1}{\xi} \rightarrow \frac{d\sigma}{d(\log\xi)} = \text{constant}$$

SD: Event Selection

Data presented from 8 pb^{-1}:

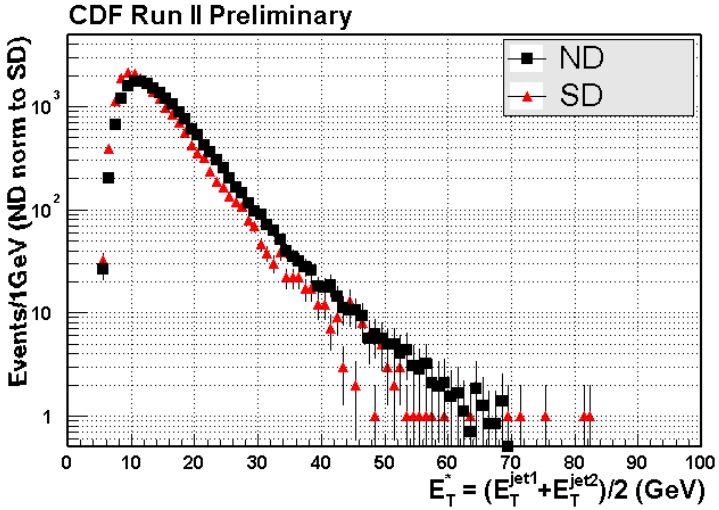
RP+J5	352,359 events
$\geq$ 2 Jets (E_T>5 GeV, $|\eta|$<2.5)	175,292 events
RP offline coincidence	168,153 events
SD (0.02<ξ<0.1)	15,209 events

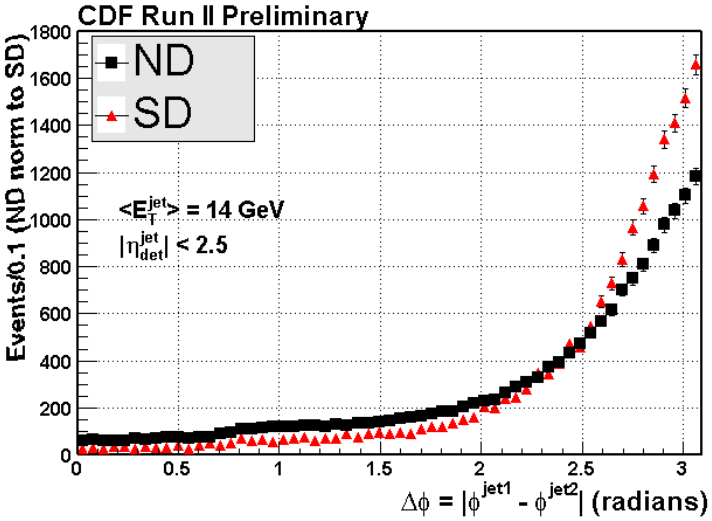
✓RP acceptance ~80% (from Run I)

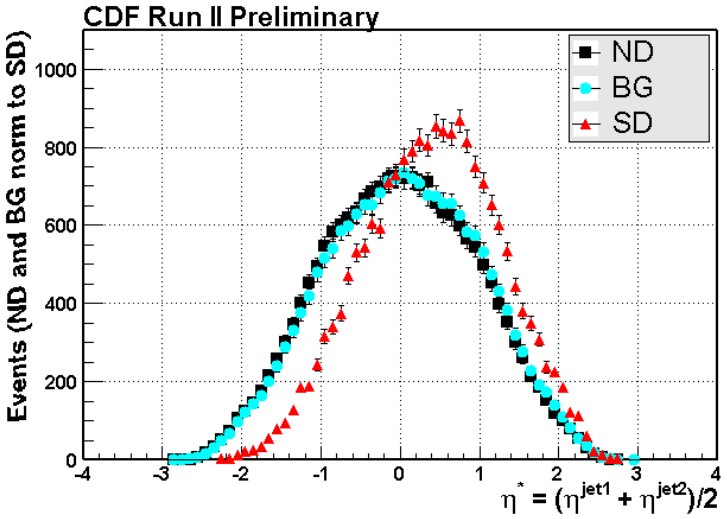
✓negligible (< 1-2%) RP background trigger

Kinematic Properties

Compare ND and SD





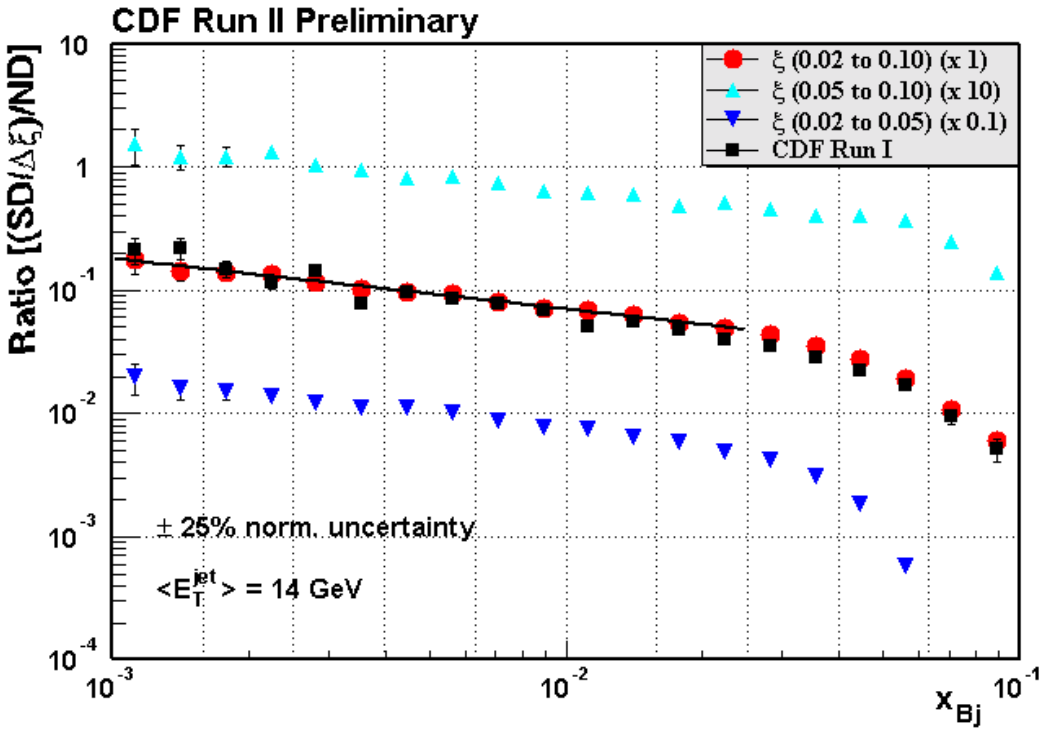


Ratio of SD/ND Events

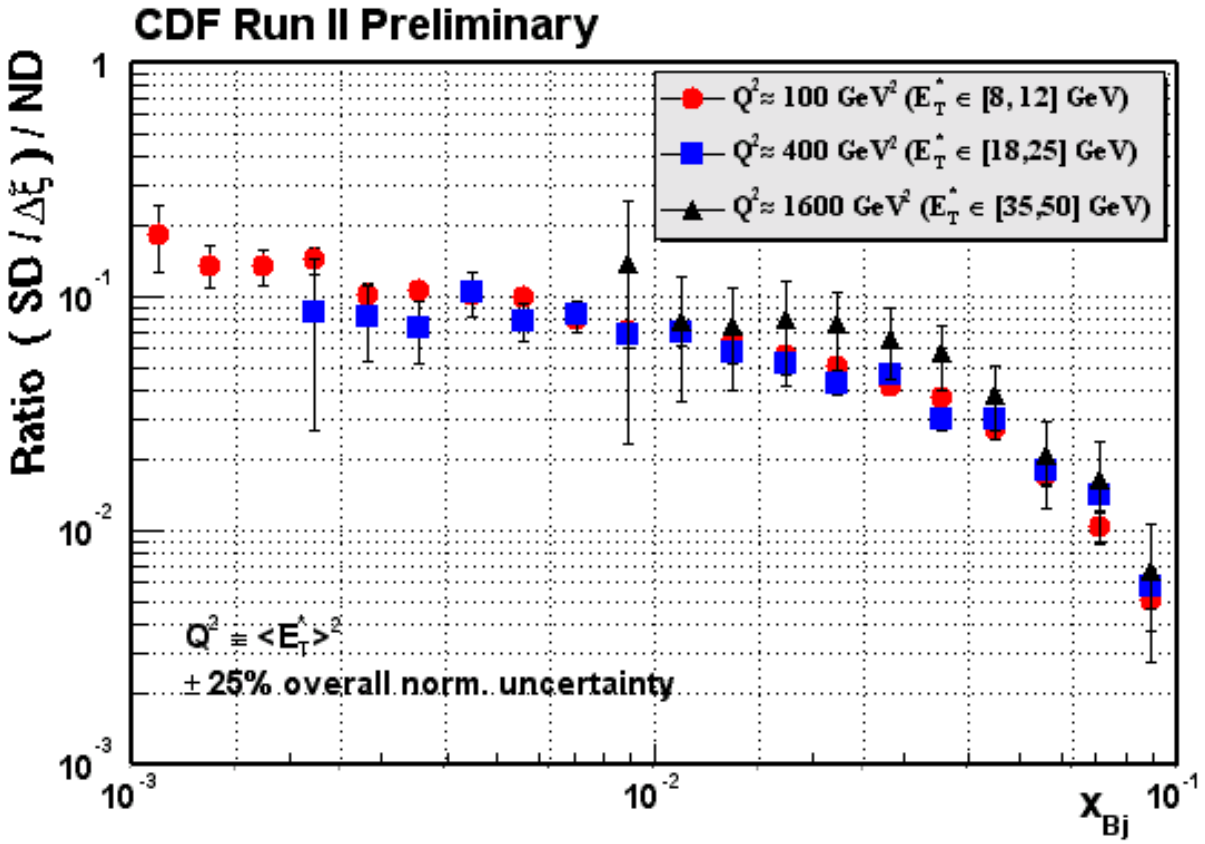
$$x_{Bj} = \frac{\Sigma_{jet} E_T e^{-\eta}}{\sqrt{s}}$$

(jet=1,2,3 if E_T>5 GeV)

- slope and normalization agree with Run I result
- work in progress to evaluate ratio at smaller ξ values



Q^2 dependence



$$E_T^* = \frac{E_T^1 + E_T^2}{2}$$

- select energy intervals
- overall norm. only

⇨ no significant Q^2 dependence

Pomeron evolves similarly to proton (?)

Summary

- CDF forward detectors working well
- dedicated diffractive triggers
- re-established Run I measurements
- no significant Q^2 dependence in SD/ND ratio

Run II analyses are well underway !

More CDF Run II results in the following talks…