Diffractive dijet production and *t*-distribution at CDF

Michele Gallinaro
The Rockefeller University / LIP Lisbon

for the CDF collaboration

Workshop on *Small-x* Physics, Fermilab, March 28-31 2007

Outline

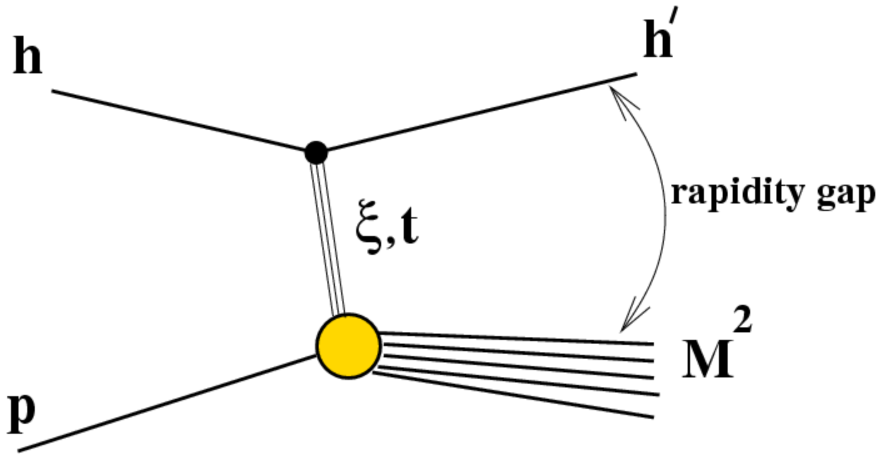
- Diffractive dijets
- DSF Q^2 dependence
- Roman pot alignment
- $|t|$-distribution

Hadronic diffraction

Small momentum transfer

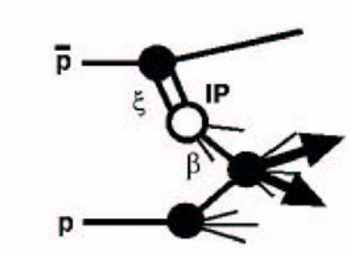
Elastic and diffractive processes
⇨ leading hadron emitted at small angle

The exchange ("pomeron") is colorless
⇨ large rapidity gap



Goal: understand the nature of the colorless exchange

Diffractive dijets



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

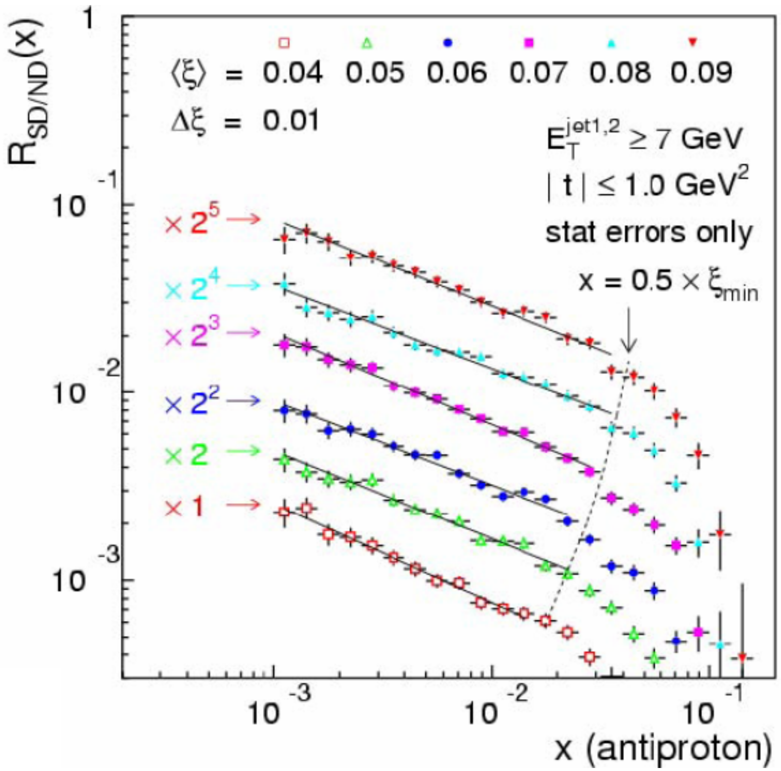
parton $x_{Bj} \equiv \beta \cdot \xi$

Measure SD/ND ratio of dijet rates

$$\frac{\sigma(SD_{jj})}{\sigma(ND_{jj})} = \frac{F^D_{jj}(x)}{F_{jj}(x)} \quad \text{(LO QCD)}$$

$$R_{SD/ND} = R_0 \cdot x^{-0.45}$$

⇨**no significant ξ dependence**

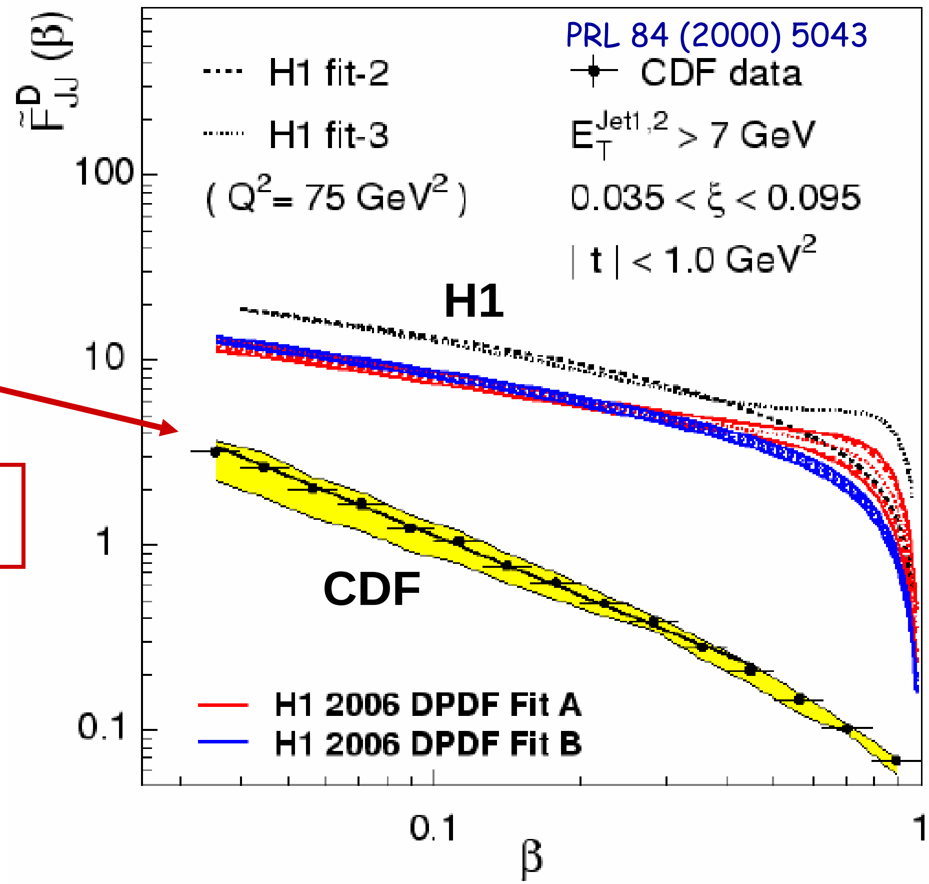


in the ratio SD/ND many systematic uncertainties cancel out

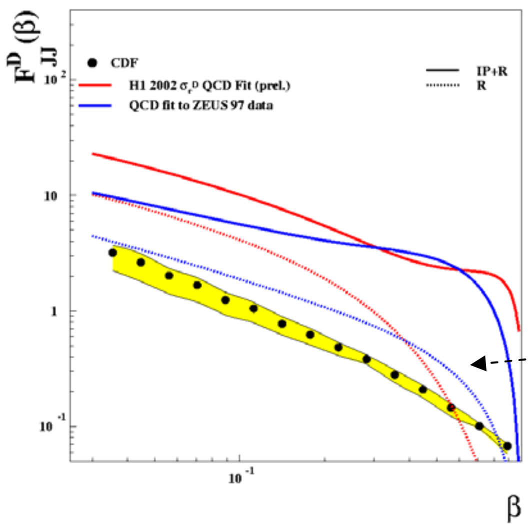
Diffractive structure function

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

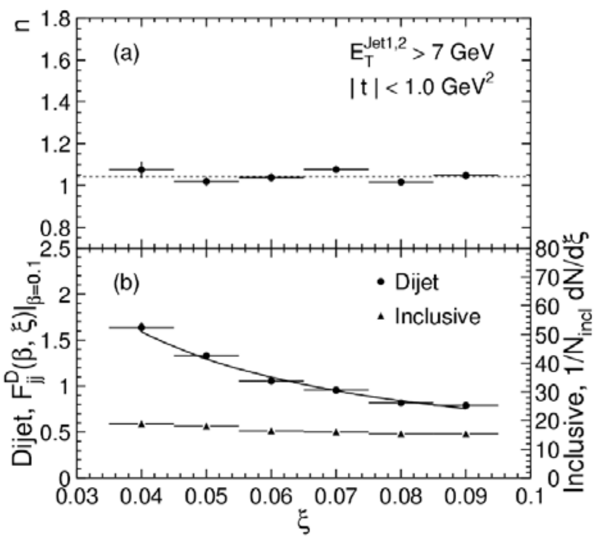
⇨breakdown of QCD factorization



a few comments



- large uncertainty at high β (no coverage!) but result stable at low β
- small reggeon contribution



- $F_{jj}^{D}(\beta, \xi) \sim 1/\beta^{n}$ [indep. of ξ]
  - ⇨ no change from IP to IR region
- $F_{jj}^{D}(\beta=0.1, \xi) \sim 1/\xi^{m}$ $m=1.0\pm0.1$ for dijets
  - ⇨ dijets are IP dominated, \`inclusive' more IR like

ξ-dependence is IP like (m for IP is ~1.1, for IR ~0 at Tevatron)

Motivation

Is the Pomeron a particle or made out of proton PDFs?

⇨understand Pomeron in terms of QCD

⇨characterize the exchange looking at Q^2 and *t* dependence

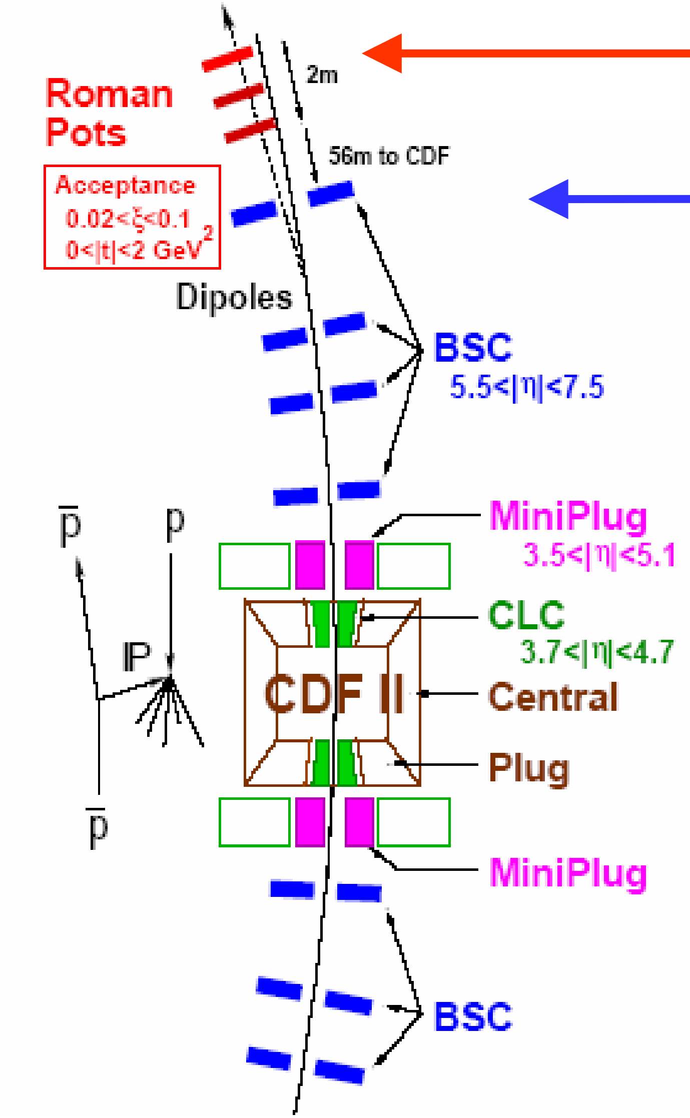
Measure:

1) DSF vs Q^2
2) *t*-distribution

From Run I to Run II

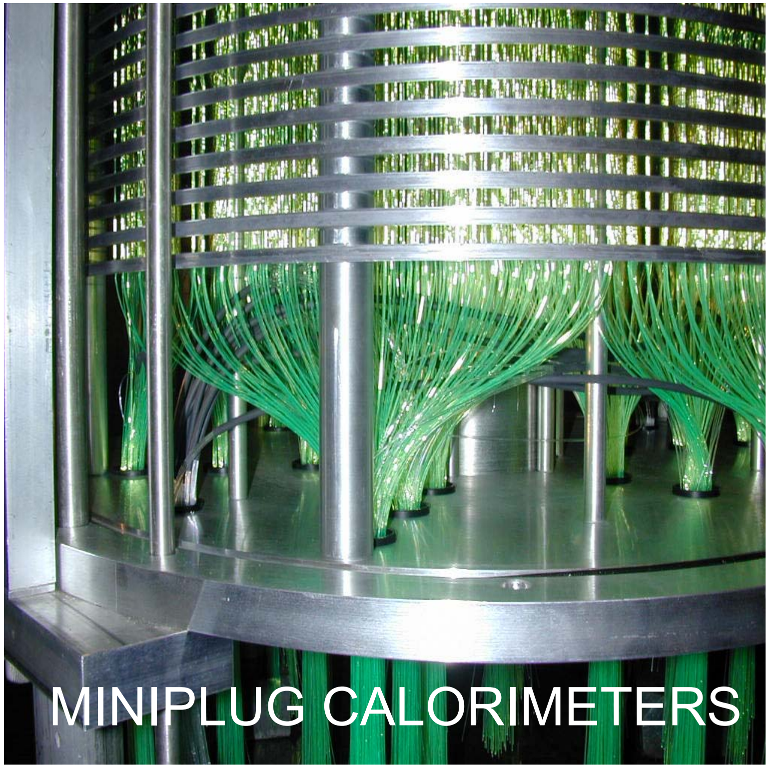
- improved detectors (BSC, MP)
- dedicated triggers
- more events at larger jet energies

Run II diffractive program



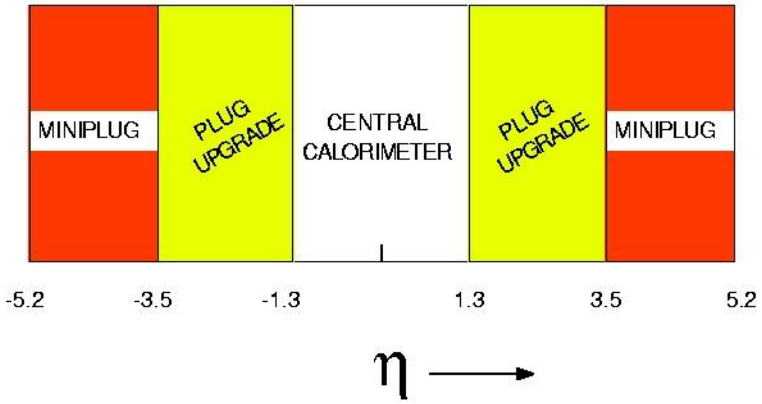
ROMAN POT DETECTORS

BEAM SHOWER COUNTERS: used to reject ND events

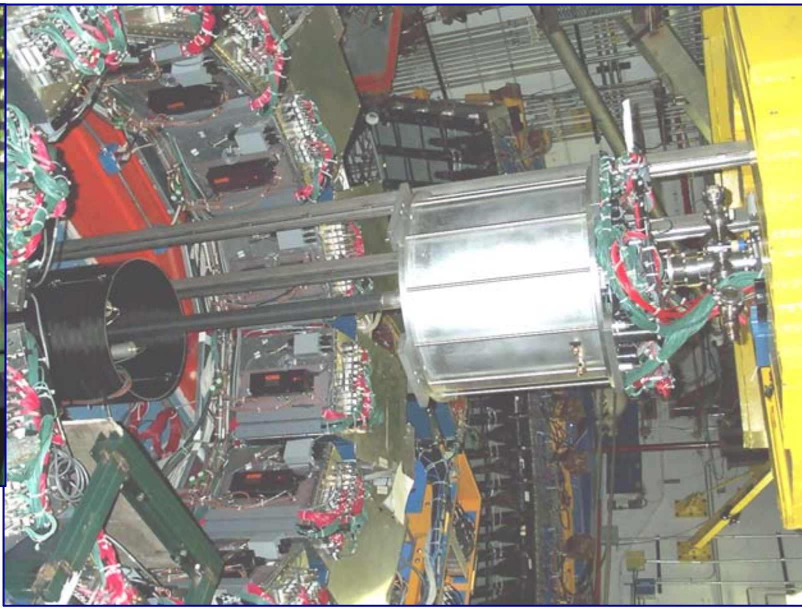


Miniplug calorimeters

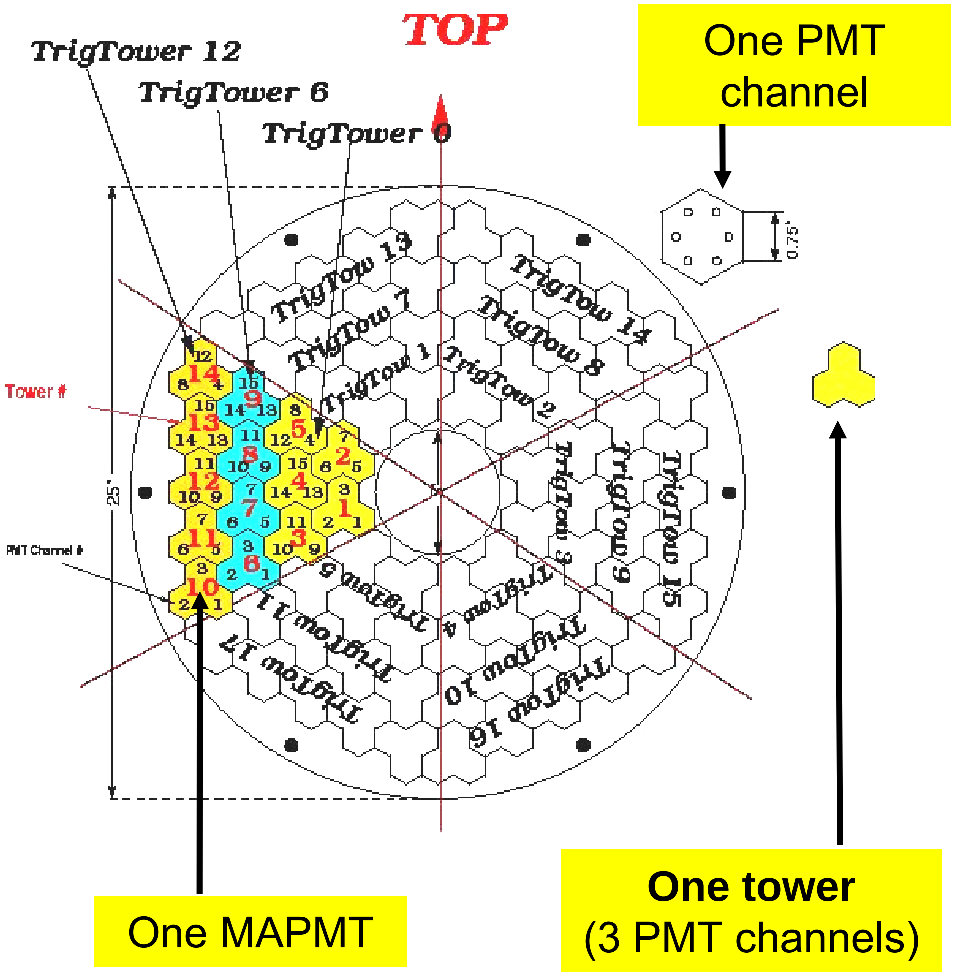
- liquid scintillator + lead
- flexible tower geometry
- full coverage (no dead regions)
- detect charged/neutral (32 X_0 , 1.3 λ)
- short to measure energy/position

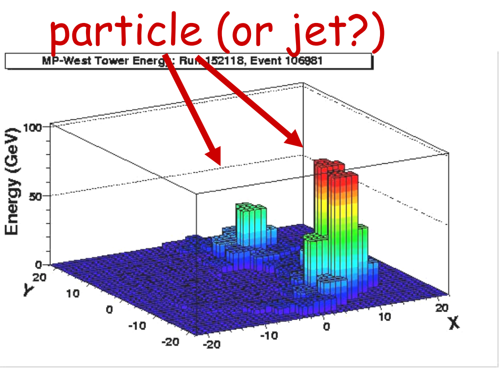


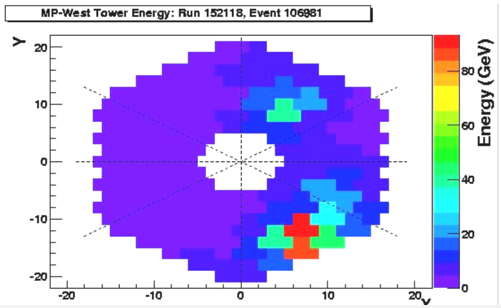
Group fibers
to form ”towers”

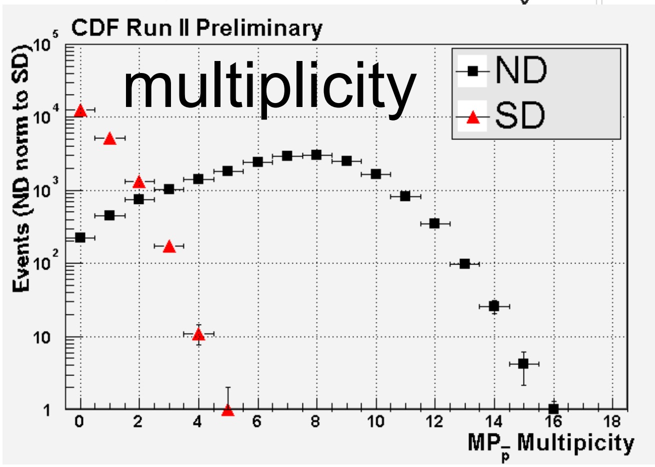


Particles/jets in MP

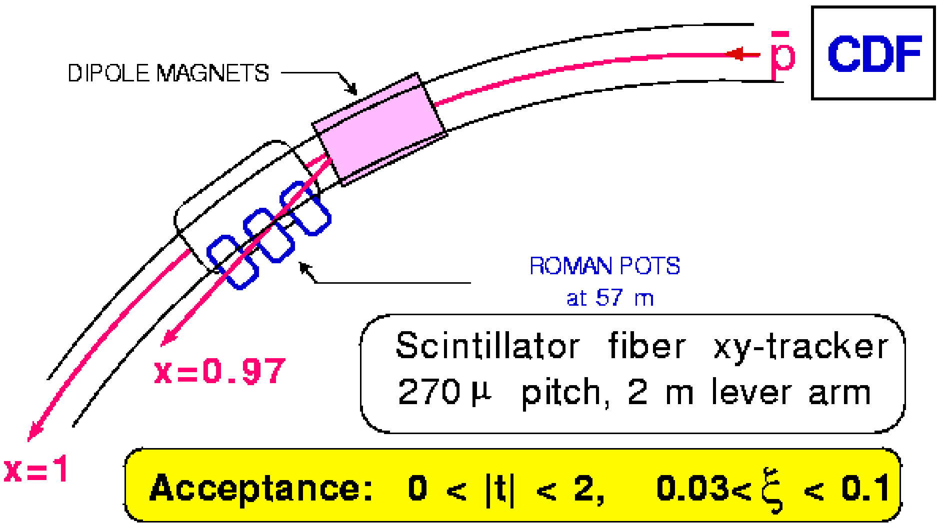








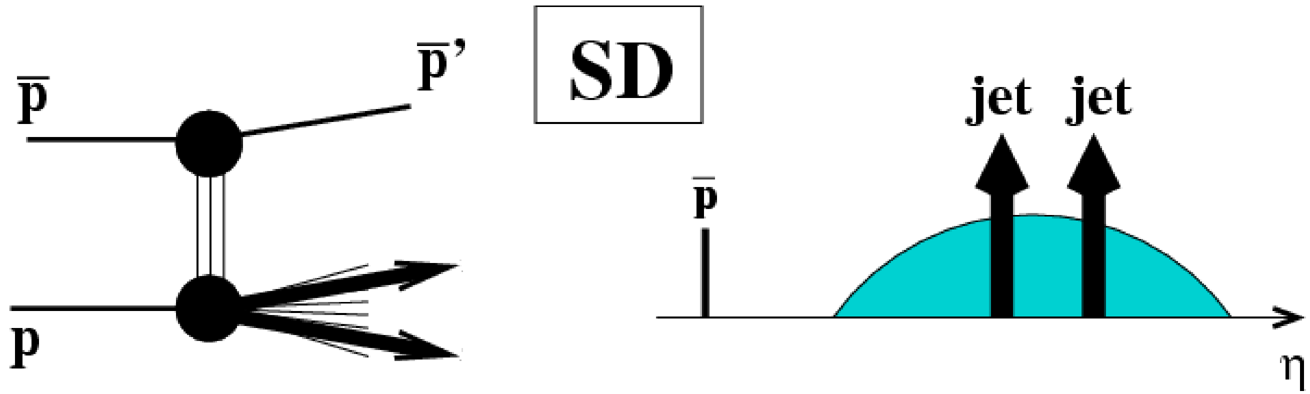
Data samples



require jets

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

Event selection

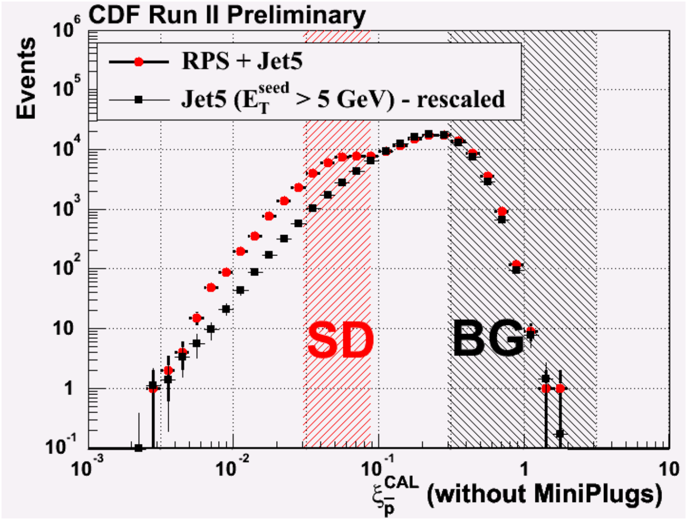


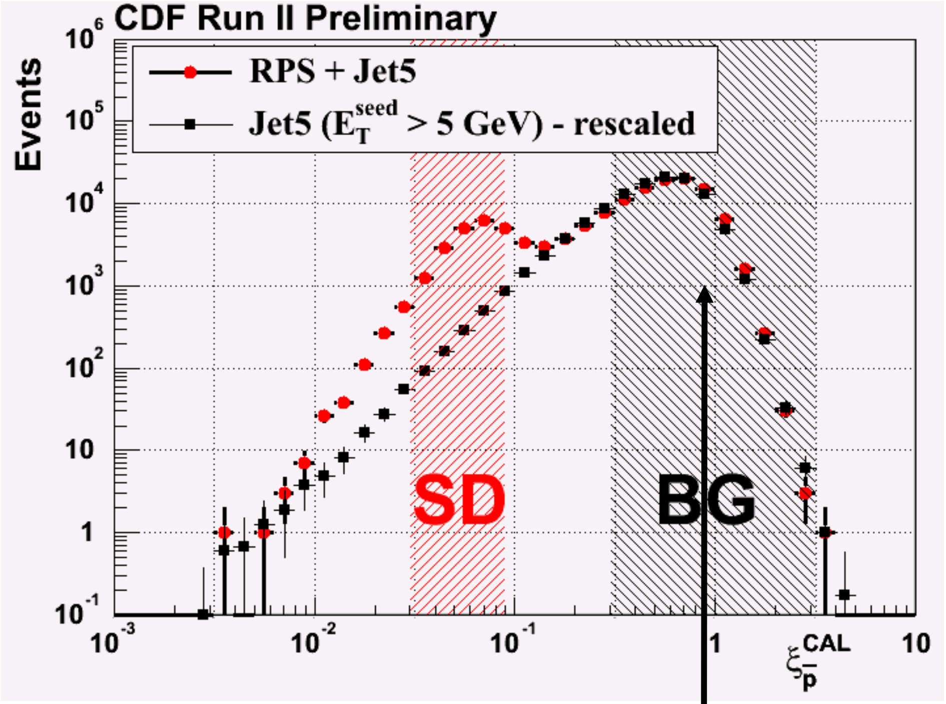
Selection cut	RP	RP+J5	RP+J20	RP+J50
Triggered events	1,634,723	1,124,243	1,693,644	757,731
Good run	1,431,460	955,006	1,421,350	561,878
$\not\!\!E_T$ significance $S_{\rm MET} < 2$	1,431,253	950,776	1,410,780	539,957
$N(jet) \geq 2$: $E_T^{1,2} > 5$ GeV, $\lvert\eta^{1,2}\rvert < 2.5$	59,157	557,615	1,168,881	521,645
"splash event" veto (SumRPT<5000 ADC counts)	27,686	259,186	541,031	215,975
RPS triple coincidence	27,680	259,169	541,003	215,974
SD ($0.03 < \xi_{\bar{p}} < 0.09$)	1,458	20,602	26,559	4,432

Diffractive dijets

ξ: momentum loss fraction of pbar

$$\xi = \frac{\Sigma_{(all\ towers)} E_T e^{-\eta}}{\sqrt{s}}$$

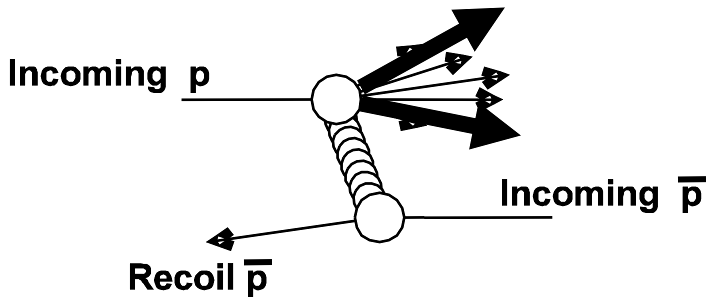


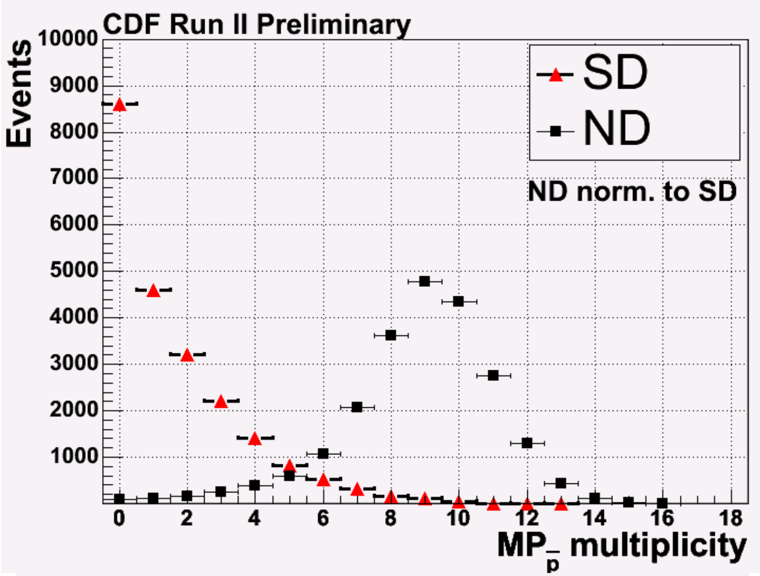


overlap events
(multiple $p\bar{p}$ interactions)

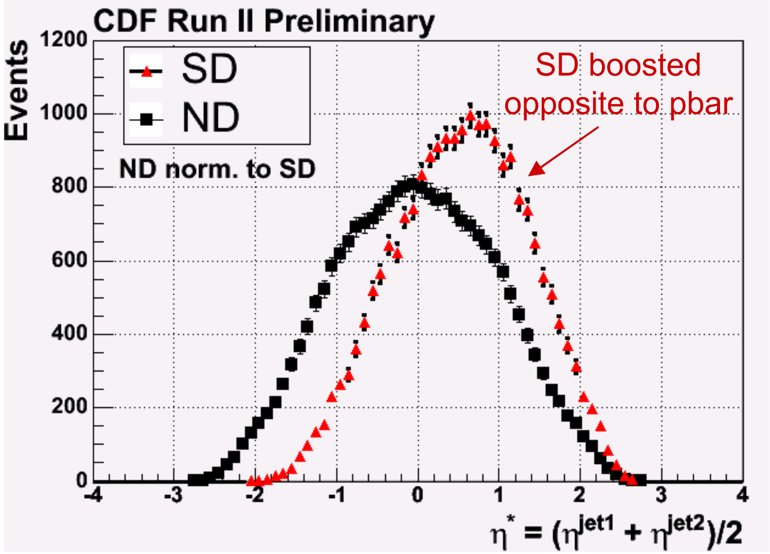
MP energy scale: ±30% →Δlogξ = ±0.1
RP acceptance (0.03<ξ< 0.09) ~ 80%

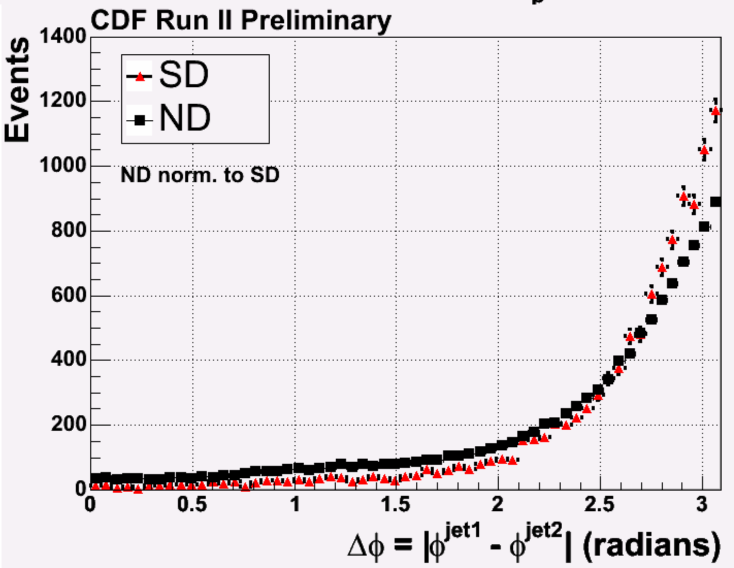
Kinematical properties



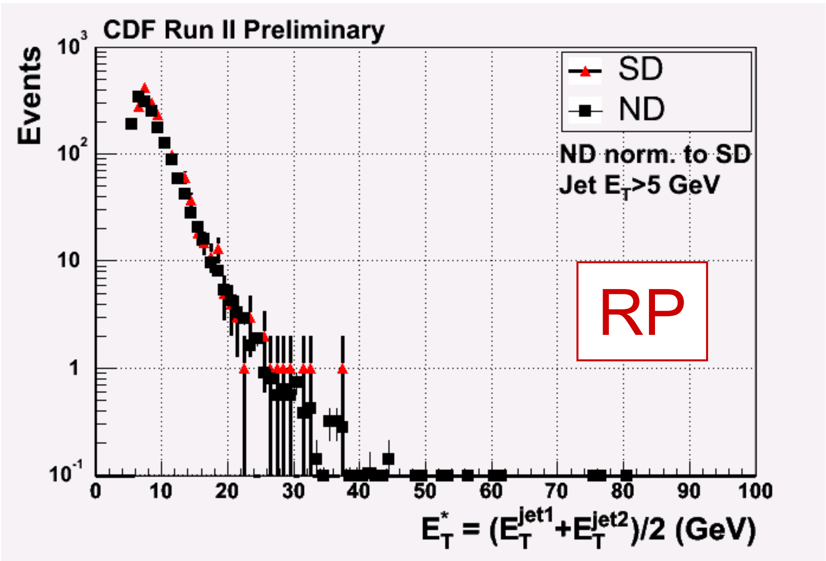


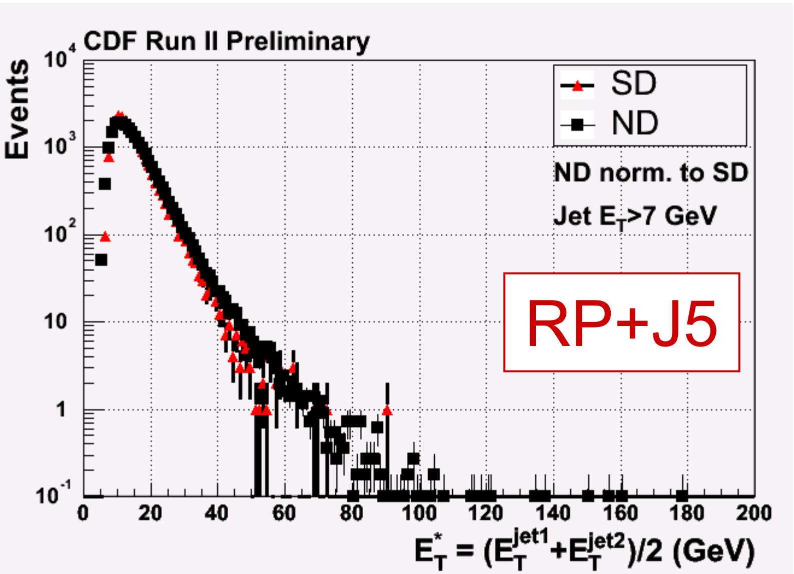
⇨compare ND and SD

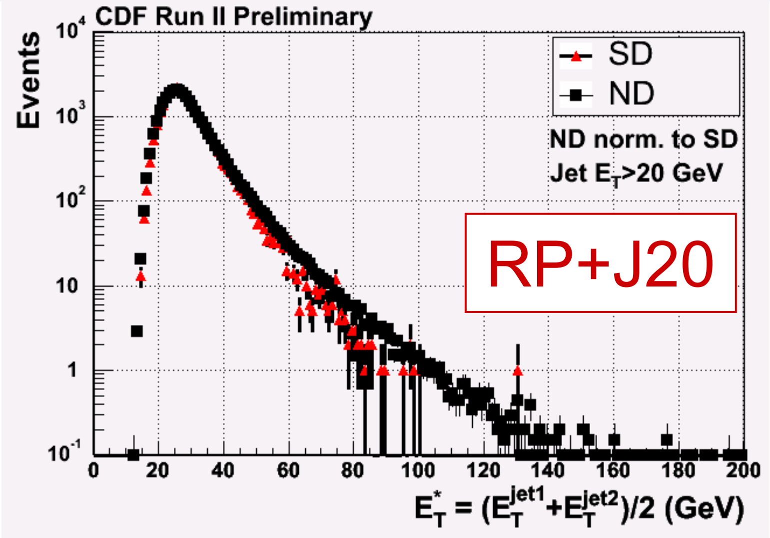


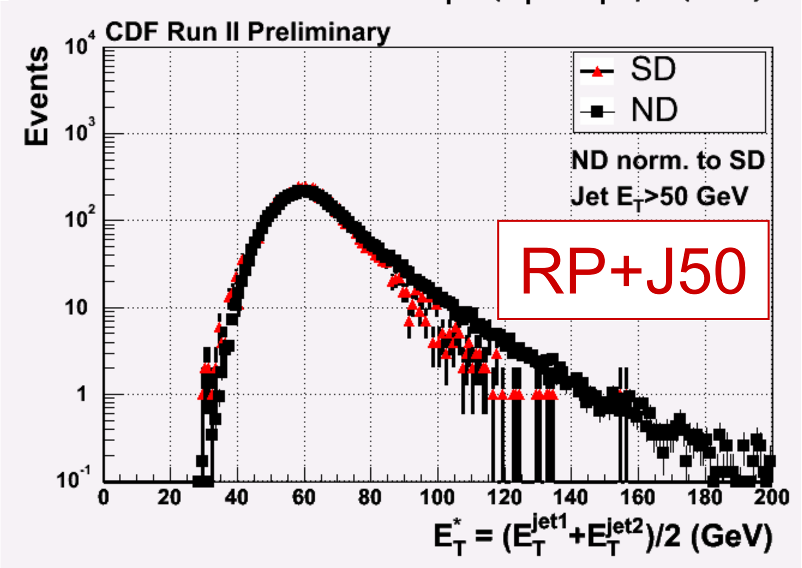


Transverse energy

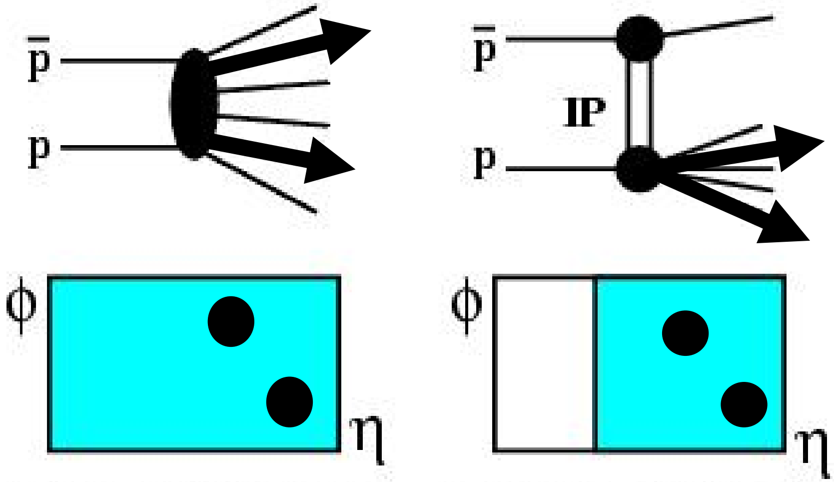








Diffractive structure function



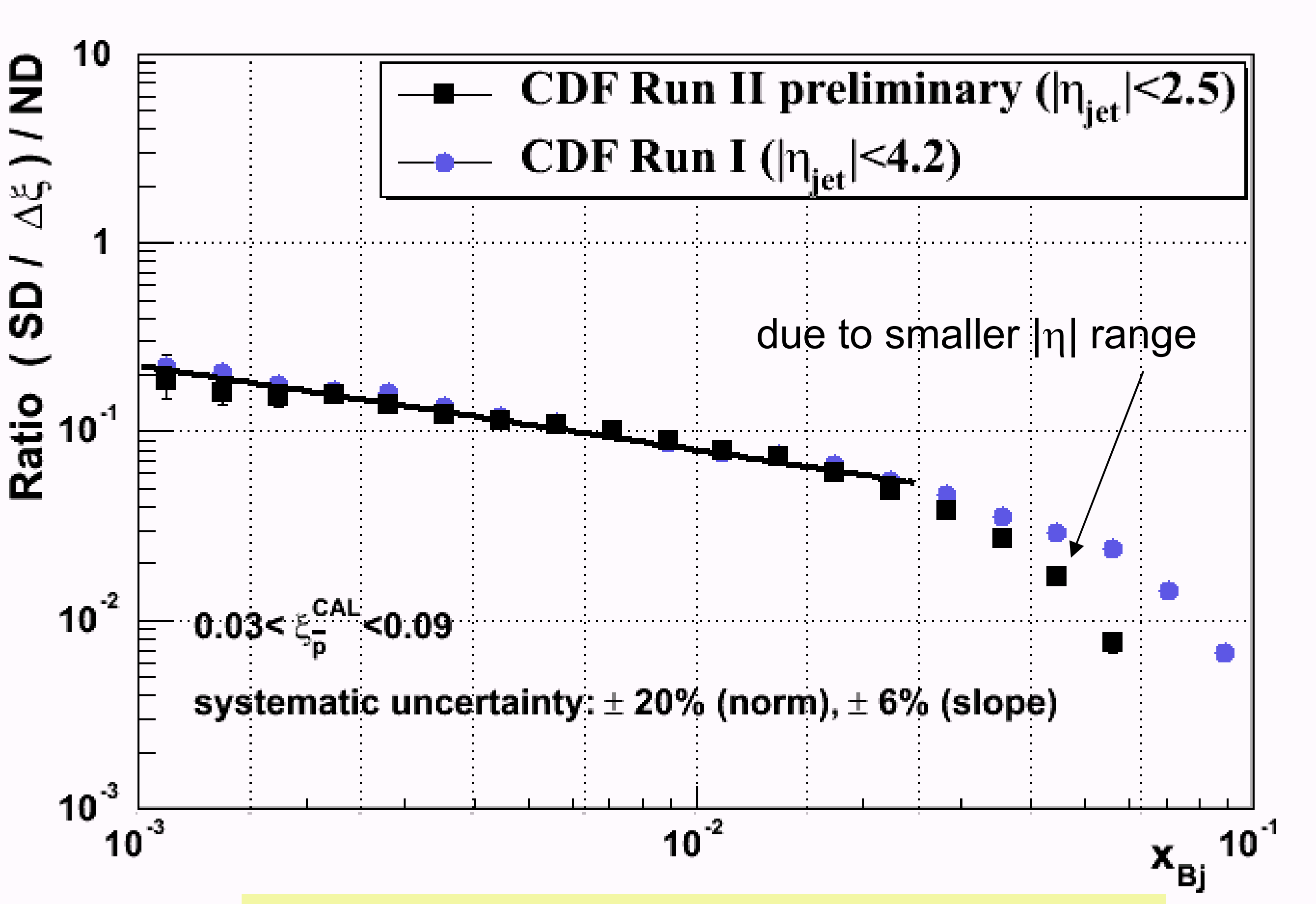
Non–Diffractive (ND)

Single–Diffractive (SD)

$$R(x_{Bj}) \equiv \frac{\mathrm{Rate}_{jj}^{SD}(x_{Bj})}{\mathrm{Rate}_{jj}^{ND}(x_{Bj})}$$

$$\Rightarrow \frac{F_{jj}^{SD}(x_{Bj})}{F_{jj}^{ND}(x_{Bj})}$$

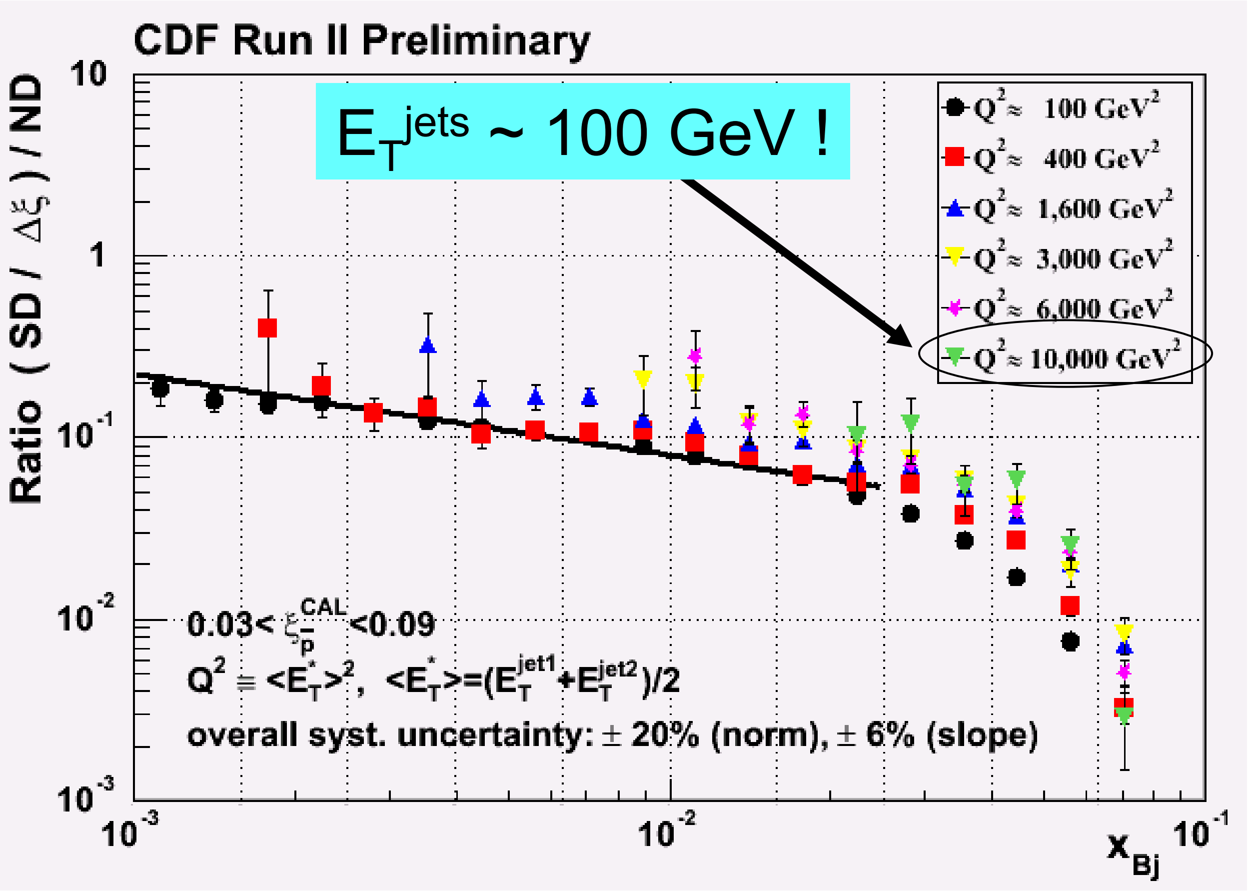
SD/ND ratio



ratio of SD/ND dijet event rates

⇨ confirms Run I results

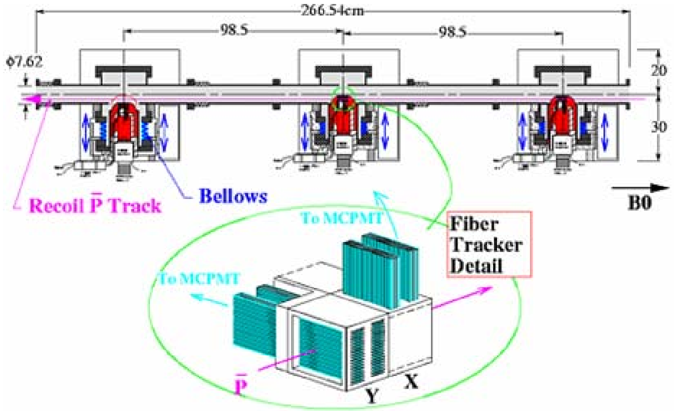
Q^2 dependence

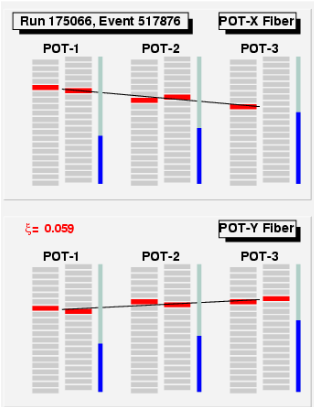


small Q^2 dependence for $100 < Q^2 < 10{,}000$ GeV^2

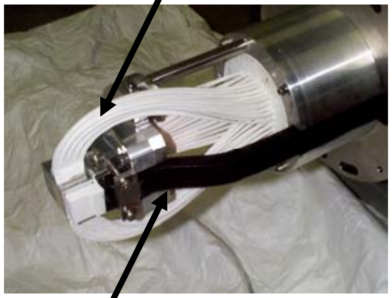
⇨ Pomeron evolves as proton

RPS tracking

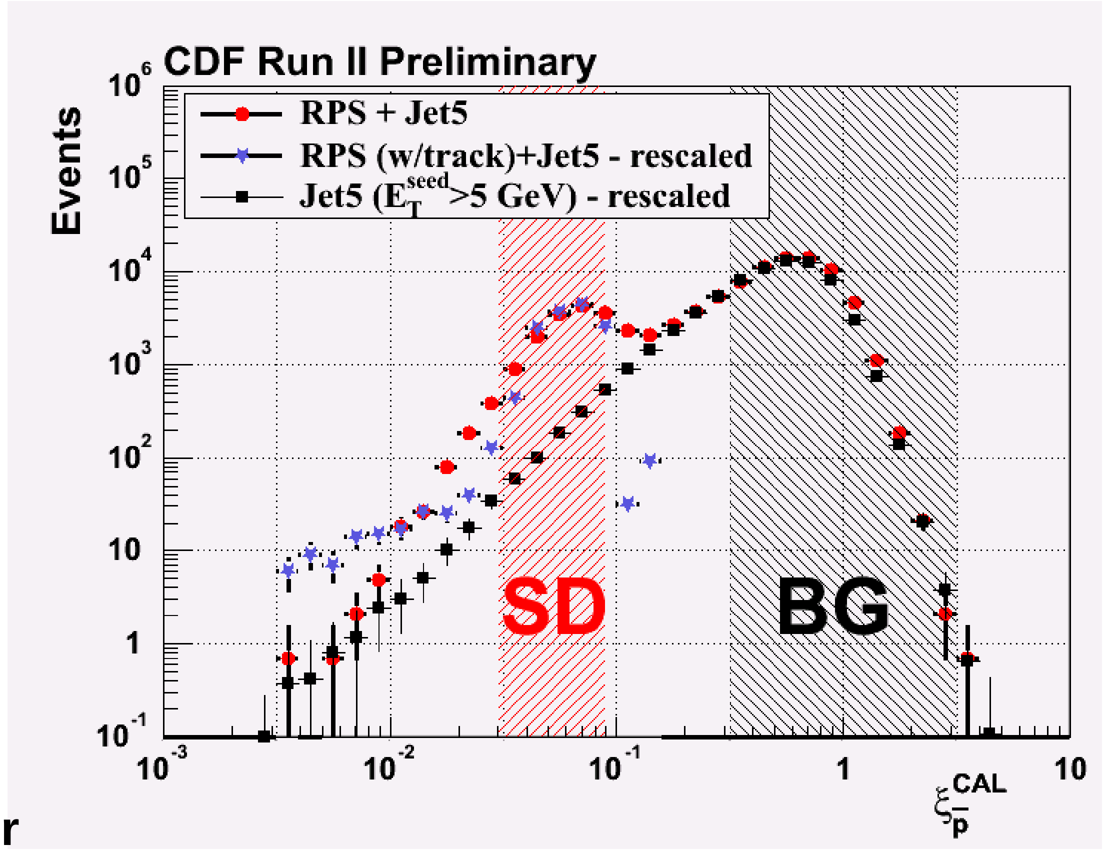




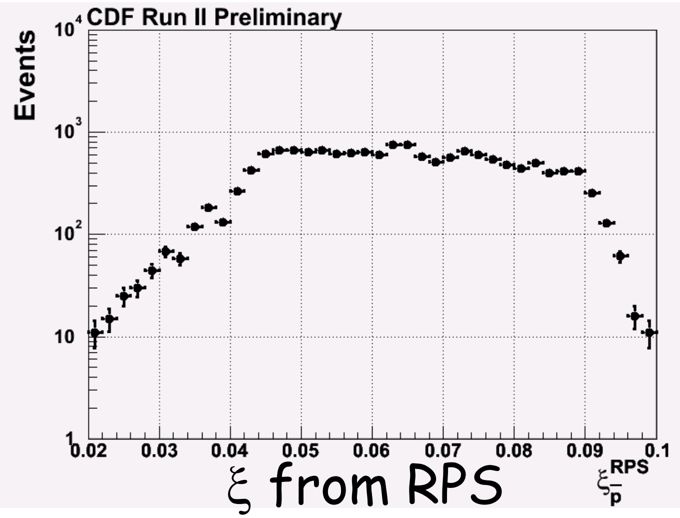
fiber tracker

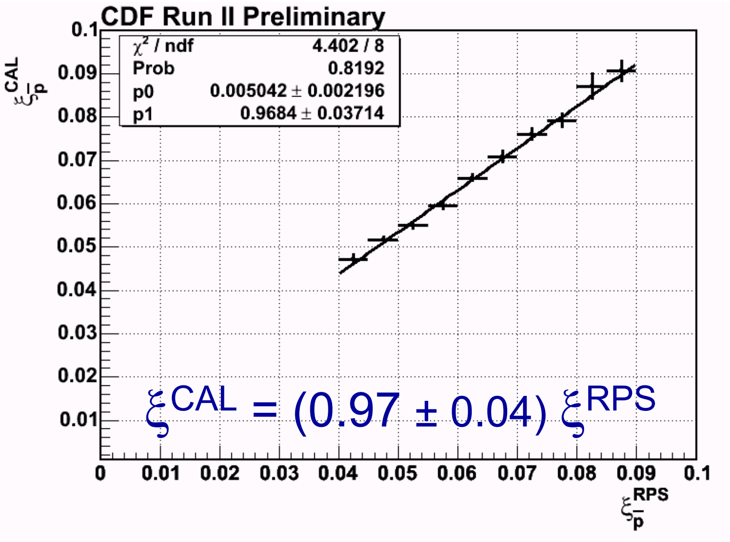


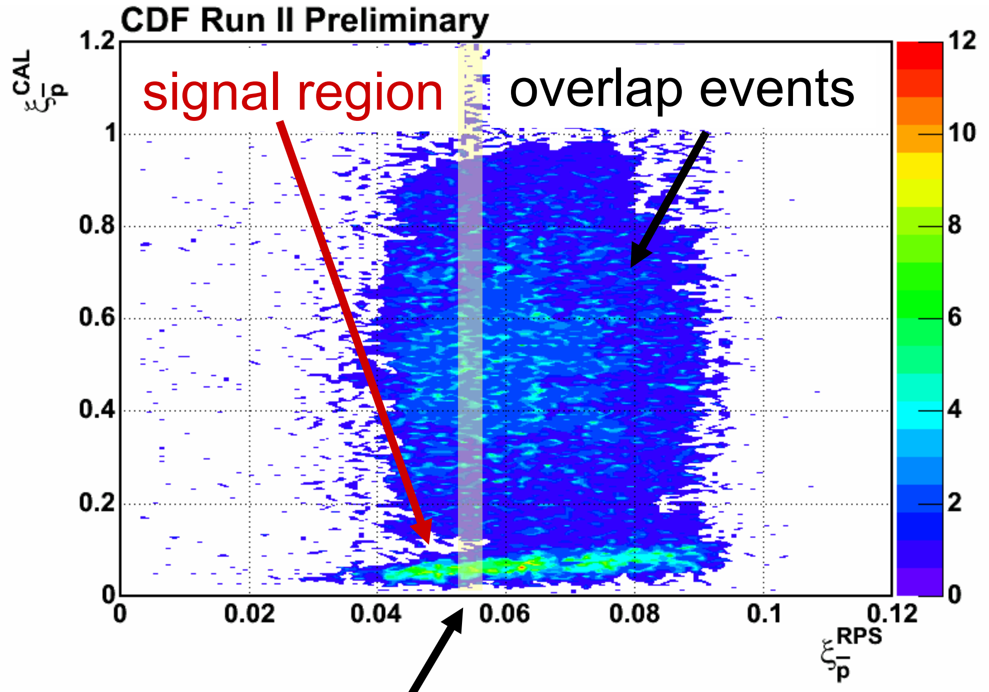
trigger scintillator

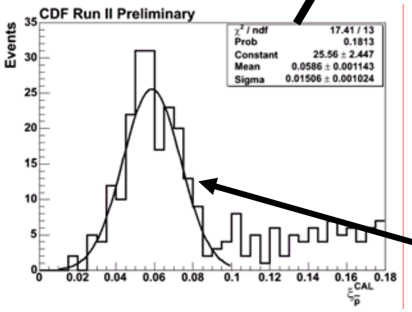


ξ: RPS vs calorimeter





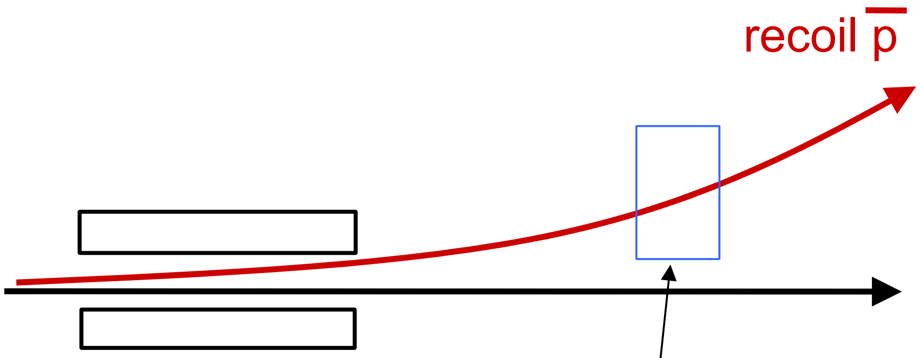


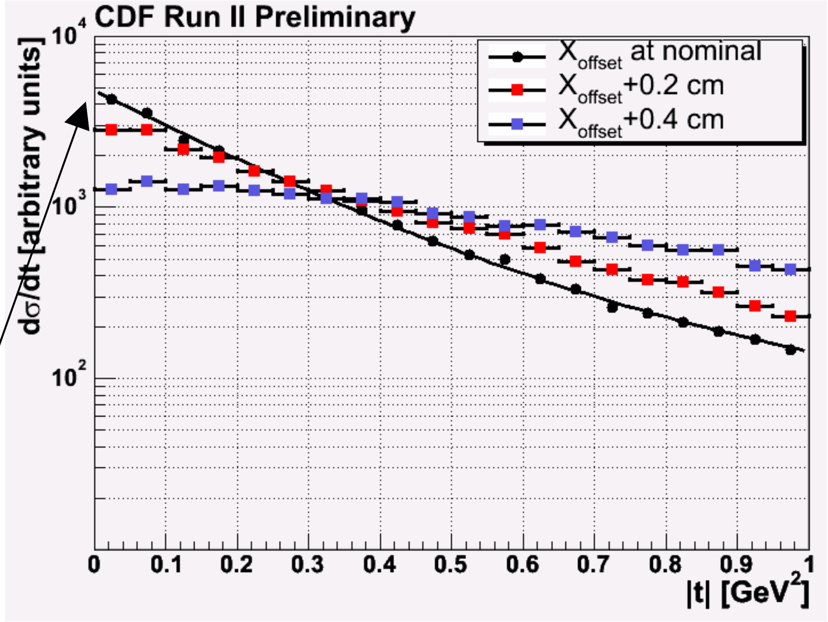


ξ^{cal} distribution for slice of ξ^{RPS}

σ / mean ~ 30%

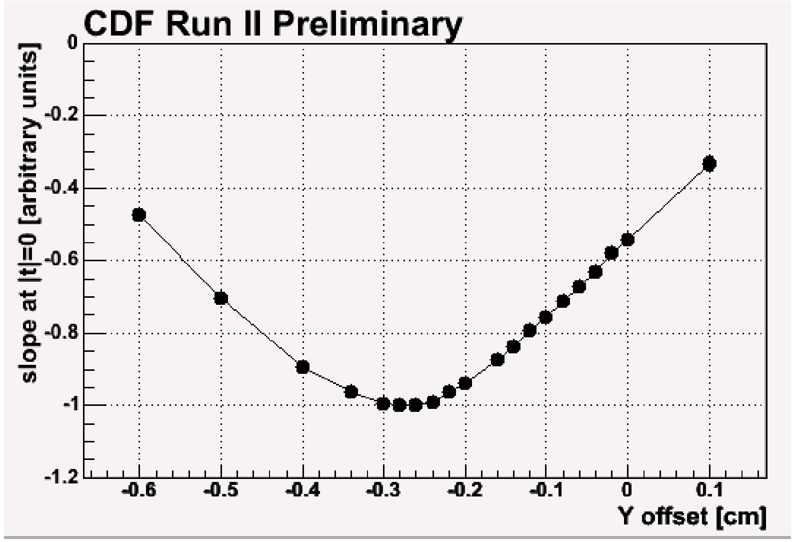
Dynamic alignment

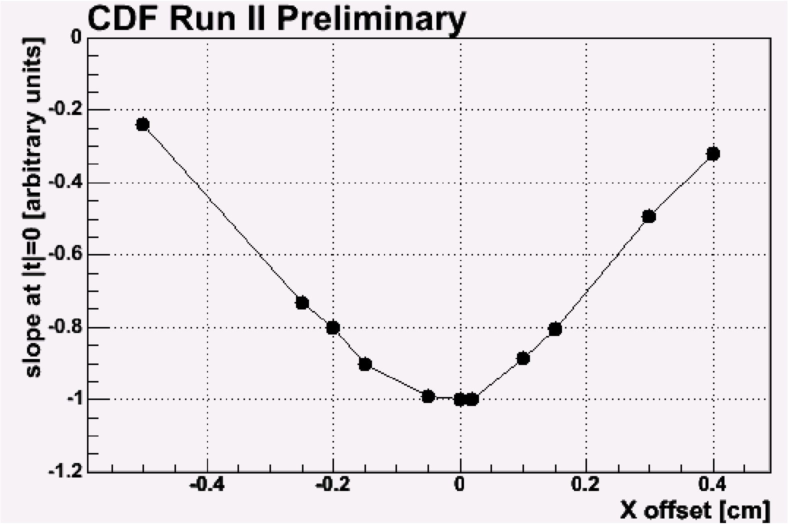




Shift detector to maximize the slope

RPS dynamic alignment



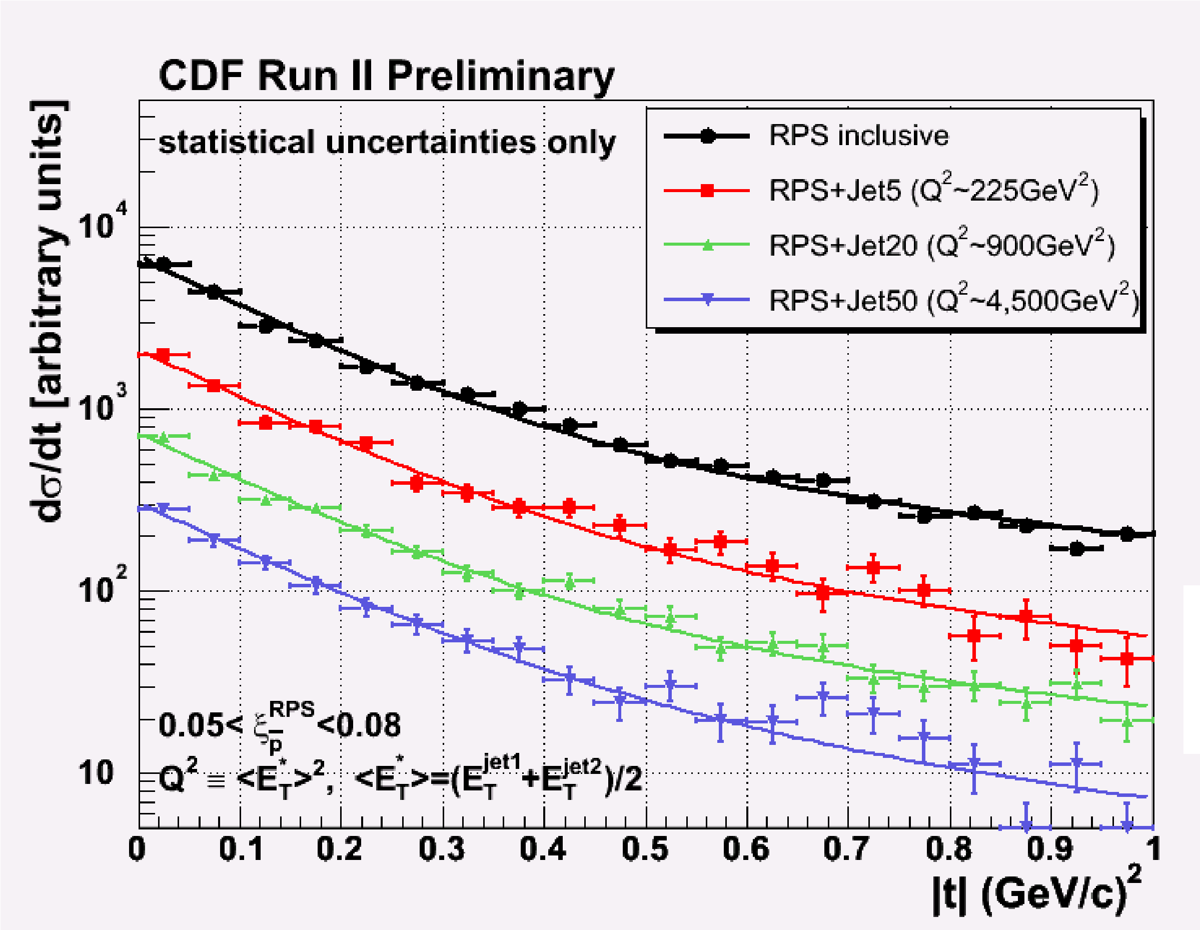


maximize the |t|-slope
(normalized to max slope)

⇨determine X and Y offsets

Accuracy:
$\Delta x \approx 30\mu m$, $\Delta y \approx 30\mu m$

t-distribution

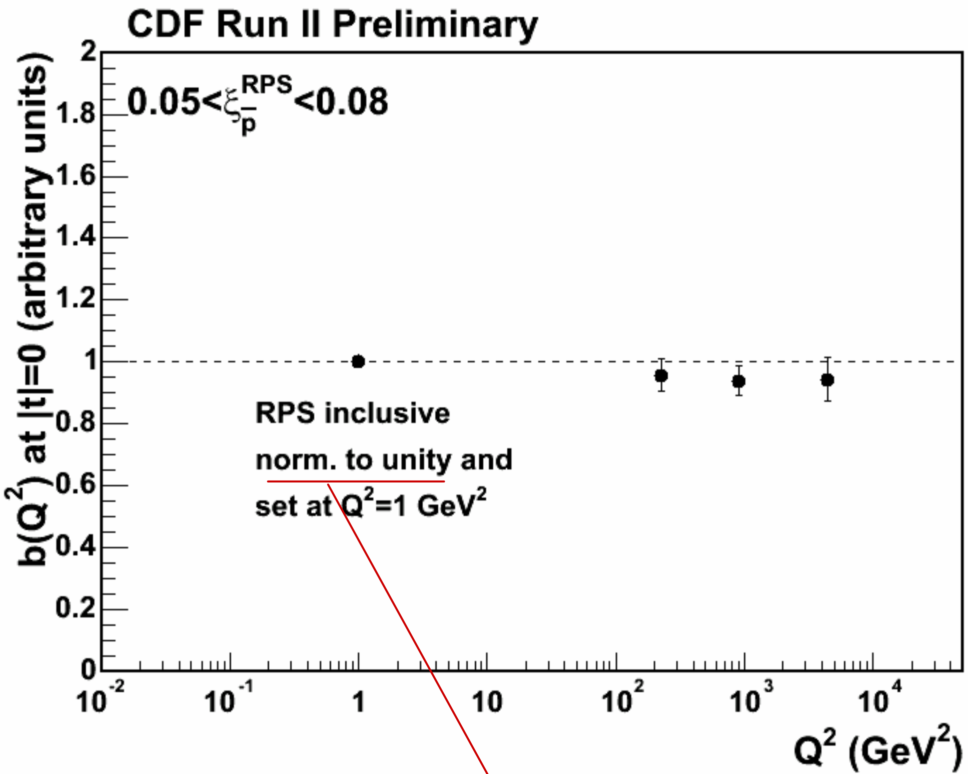


fit t-distribution to a double exponential

$$F = 0.9 \cdot e^{b_1 \cdot t} + 0.1 \cdot e^{b_2 \cdot t}$$

⇨ no diffraction ‘dips’ observed for |t|<1

t-slope vs Q^2



⇨ same slope over the region 0< Q^2 <4,500 GeV^2

Data sample	b_1	b_2	$< E_T >$ (GeV)	Q^2 (GeV^2)
RP inclusive	1.00 ± 0.02	1.00 ± 0.02	small	≈ 1
RP+J5	0.97 ± 0.05	0.97 ± 0.07	15	225
RP+J20	0.96 ± 0.04	0.97 ± 0.06	30	900
RP+J50	1.02 ± 0.06	0.93 ± 0.08	67	4,500

Thoughts on the alignment

Alignment method works well…

- different runs/stores (used beam position at B0)

  ⇨ alignment should be done run-by-run, but runs too short to do single run-calibration

  ⇨ better alignment resolution with fewer runs

- uncertainty of background at large |t|

  ⇨ not enough events at large |t| values to estimate shape

Low luminosity run

Taken in Jan 2006: ~24 hour store

Run	Integr. Lum	Inst Lum
211058	18 nb^{-1}	0.5-0.6
211073	11 nb^{-1}	0.5-0.5
211079	13 nb^{-1}	0.4-0.5

E30

- a single store/few runs
  - ⇨ alignment works well
- more events
  - ⇨ can study background
- low luminosity
  - ⇨ less overlap/background

Summary

measured DSF at different Q^2 values

- SD/ND ratio is consistent with Run I
- normalization is slightly increasing (same within unc.) with Q^2 (100-10000 GeV^2)

measured t-distribution in diffractive events

1. t-distribution slope remains constant in the range $0<Q^2<4{,}500\ GeV^2$
2. no diffraction dips observed for $|t|<1\ GeV^2$

Roman pot dynamic alignment

- a general tool which can be used at LHC

Prospects

Low-lum data yields similar results:

single store/few runs and large statistics

- Measure slope at $|t|=0$
- Extend measurement to larger $|t|$: diffractive minima?