New results on diffractive t-distributions from CDF

Konstantin Goulianos
The Rockefeller University

(for the CDF Collaboration)

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- ☐ **MOTIVATION**
  - **diffraction in QCD**
  - **diffraction in CDF: factorization breaking**
  - **how does factorization breaking affect *t* distributions?**
- ☐ ***t* DISTRIBUTIONS : *inclusive* and *dijet* data**
  - **forward detectors with/roman pot spectrometer (RPS)**
    - **dynamic alignment of RPS**
  - ***t*-distributions vs. $Q^2 \approx (E_{T,jet})^2$ over a wide range:**

    $\sim 1 \lesssim Q^2 \lesssim 10^4$ GeV^2 and t_{min} (~0) $\lesssim -t \lesssim 4$ GeV^2
  - **search for a diffraction minimum**
- ☐ **SUMMARY**

DIFFRACTION IN QCD

Non-diffractive

- color-exchange ➔ gaps exponentially suppressed

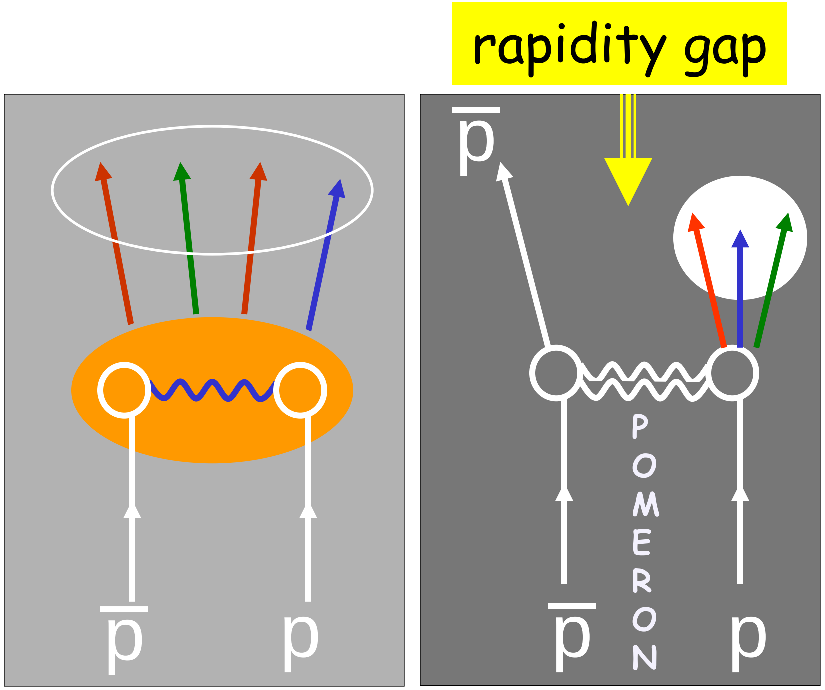
Diffractive

- Colorless vacuum exchange

➔ large-gap signature

Incident hadrons acquire color and break upart

CONFINEMENT



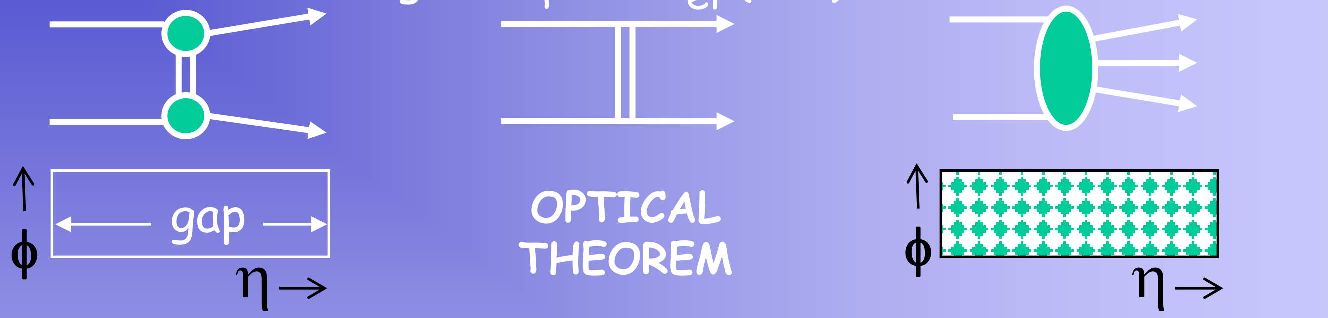
Incident hadrons retain their quantum numbers remaining colorless

pseudo-DECONFINEMENT

Goal: probe the QCD nature of the diffractive exchange

DIFFRACTION IN CDF

Elastic scattering $\sigma_T = \text{Im}\, f_{el}\,(t=0)$ Total cross section



OPTICAL THEOREM

Single **D**iffraction or **S**ingle **D**issociation

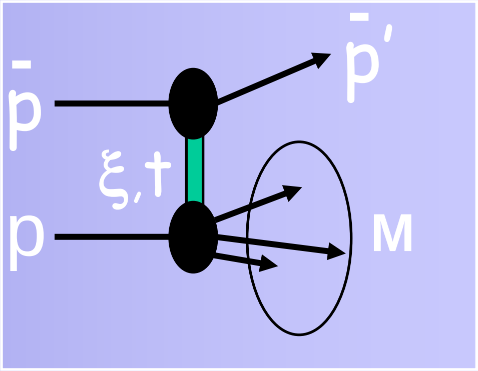
Double **D**iffraction or **D**ouble **D**issociation

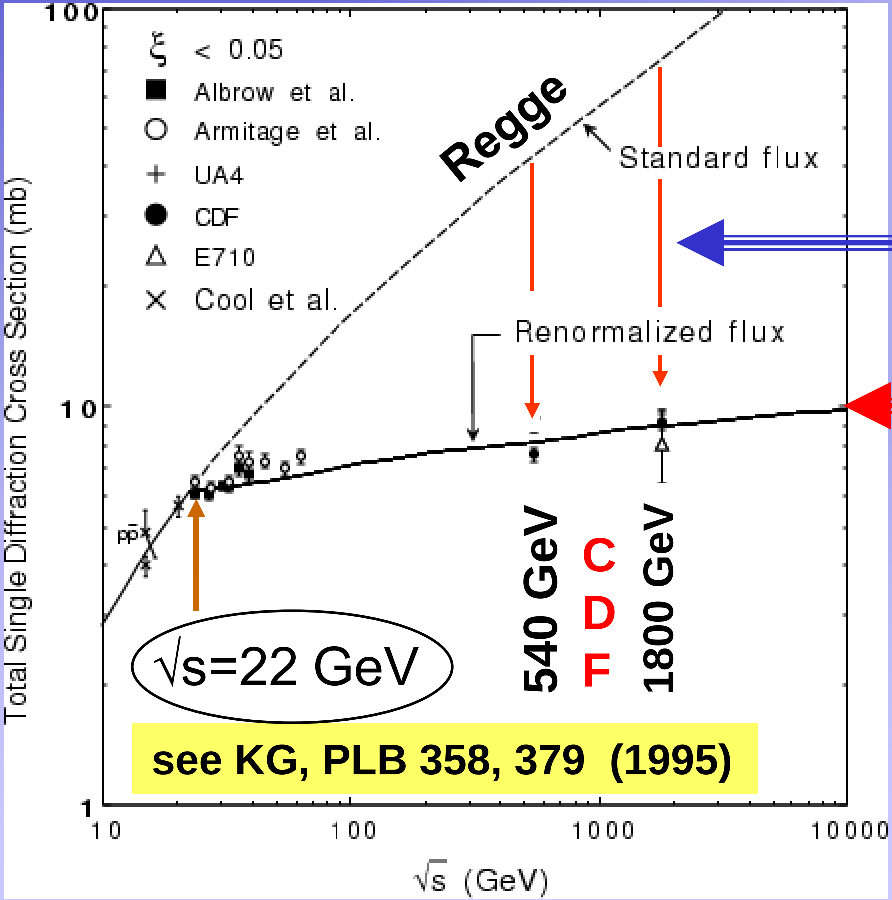
Double **P**om. **E**xchange or **C**entral **D**issociation

Single + **D**ouble **D**iffraction (**SDD**)

EXAMPLE OF FACTORIZATION BREAKING IN DIFFRACTION

➔diffractive x-section suppressed relative to Regge prediction as √s increases





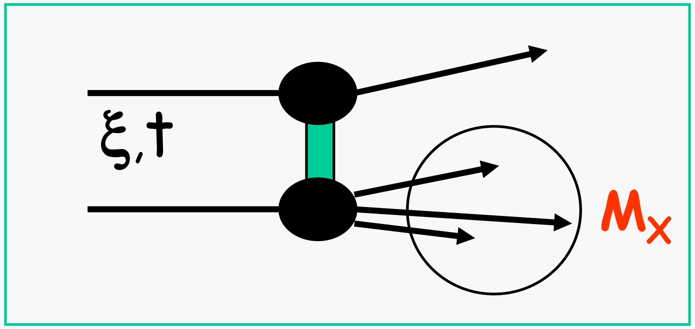
see KG, PLB 358, 379 (1995)

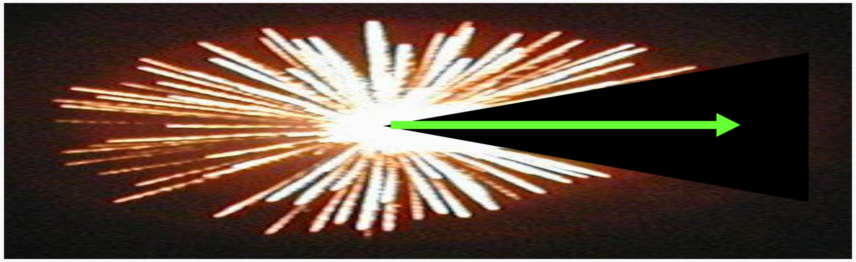
Factor of ~8 (~5) suppression at √s = 1800 (540) GeV

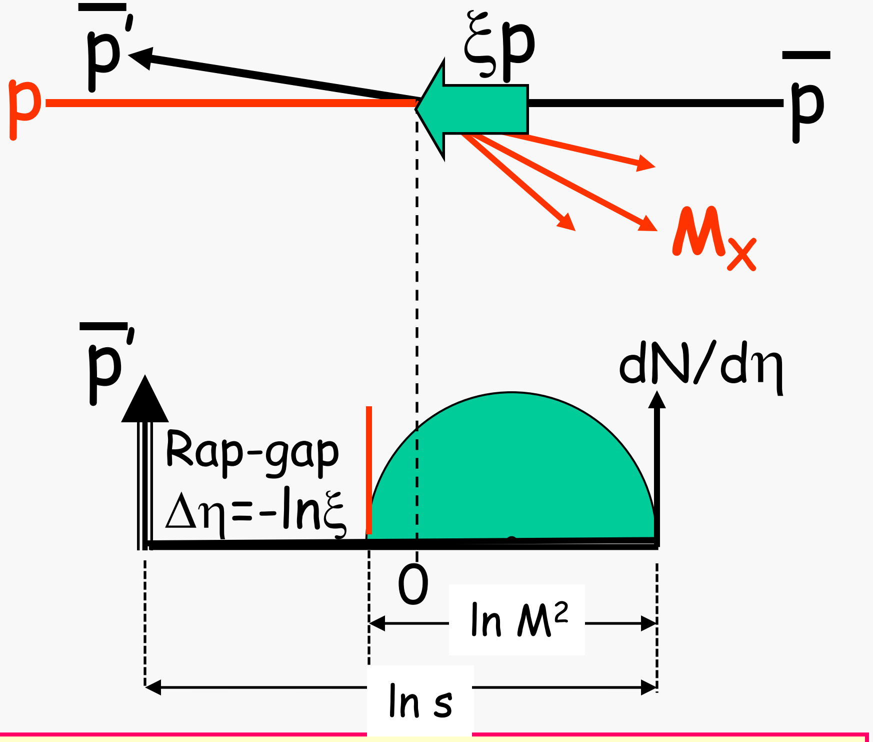
RENORMALIZATION

☐ **Question**:
does factorization breaking affect *t* distributions?

SINGLE DIFFRACTION







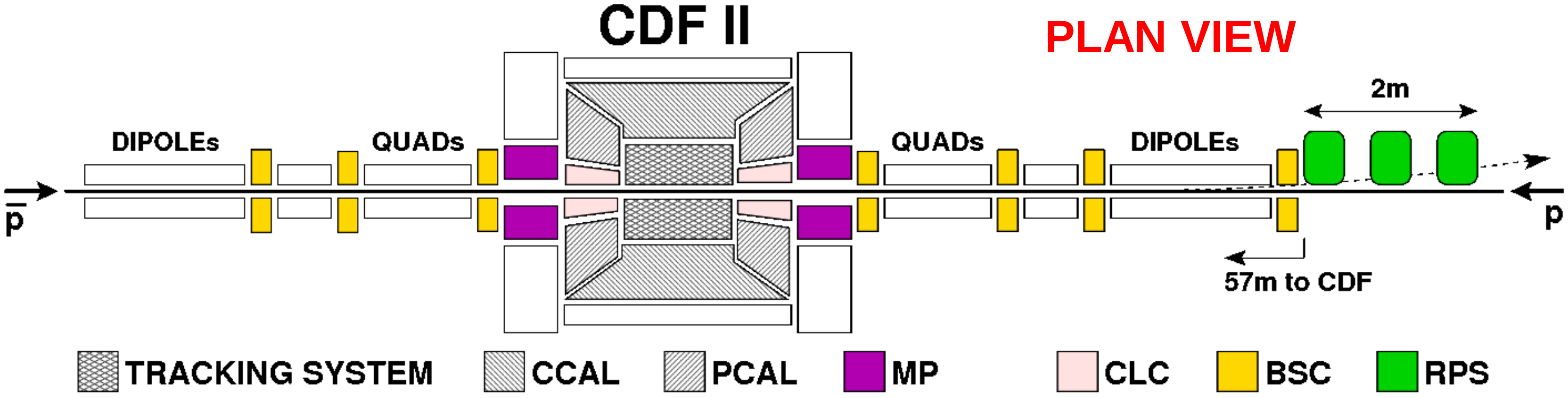
$$1 - x_L \equiv \xi = \frac{M_X^2}{s}$$

$$\xi^{CAL} = \frac{\sum_{i=1}^{\text{all}} E_T^{\text{i-tower}} e^{-\eta_i}}{\sqrt{s}}$$

No radiation →
no price paid for increasing
diffractive gap size

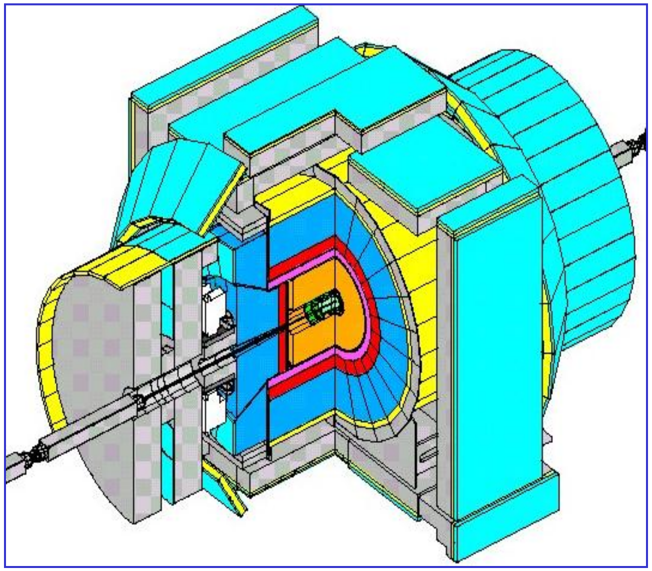
$$\left(\frac{d\sigma}{d\Delta\eta}\right)_{t=0} \approx \text{constant} \Rightarrow \frac{d\sigma}{d\xi} \propto \frac{1}{\xi} \Rightarrow \frac{d\sigma}{dM^2} \propto \frac{1}{M^2}$$

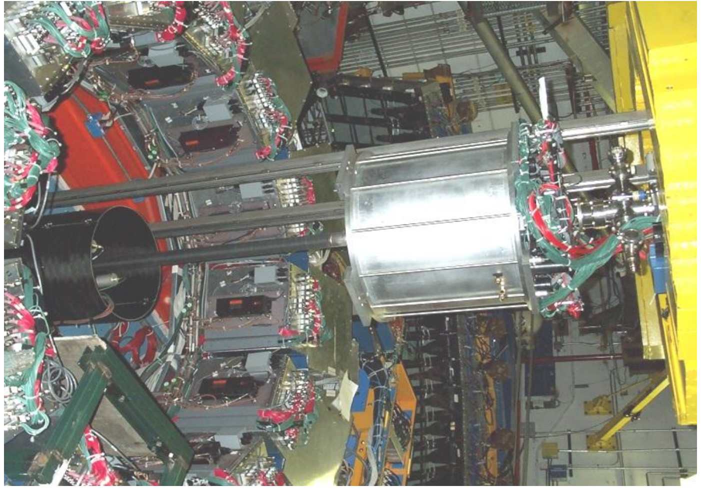
The CDF II Detector



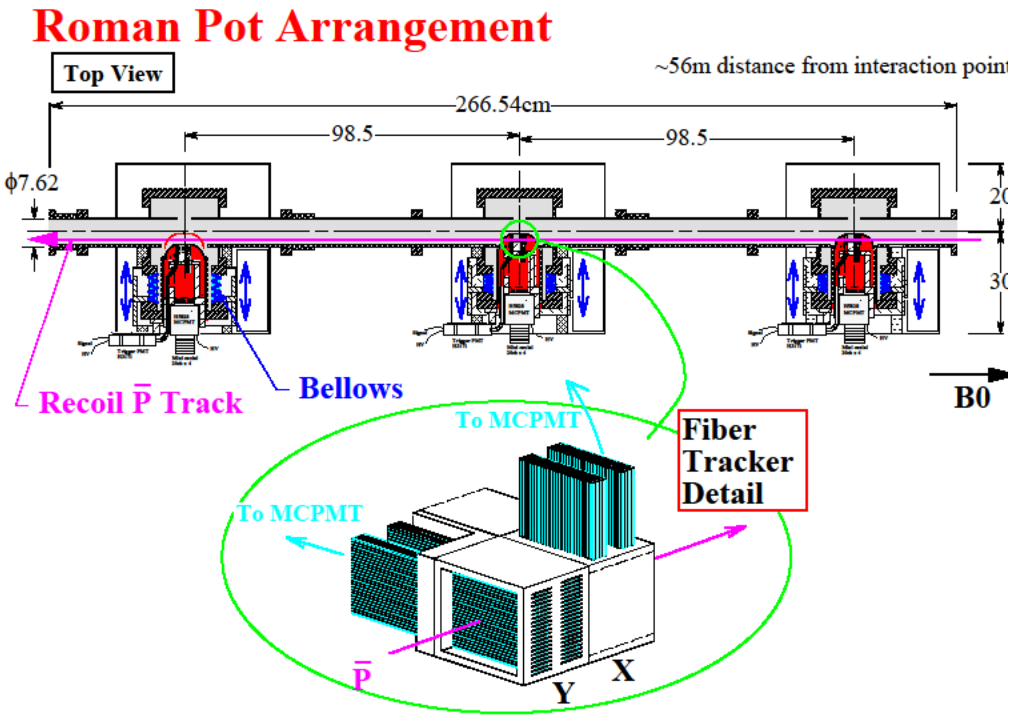
$|\eta|<2$ ← $|\eta| <3.6$ → $3.5<|\eta|<5.1$ $5.4<|\eta|<7.4$

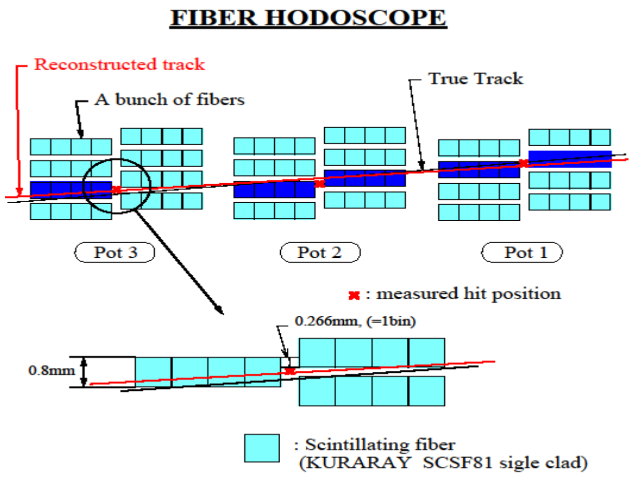
~$0.02<\xi<0.1$ $0 < t <4$ GeV^2





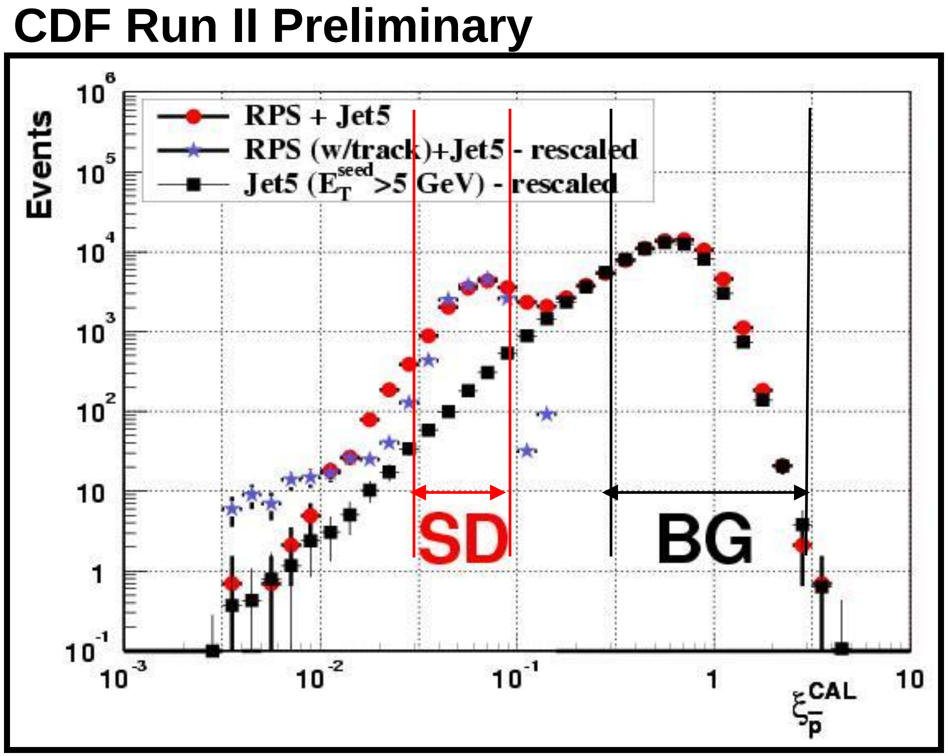
The RPS IN CDF II

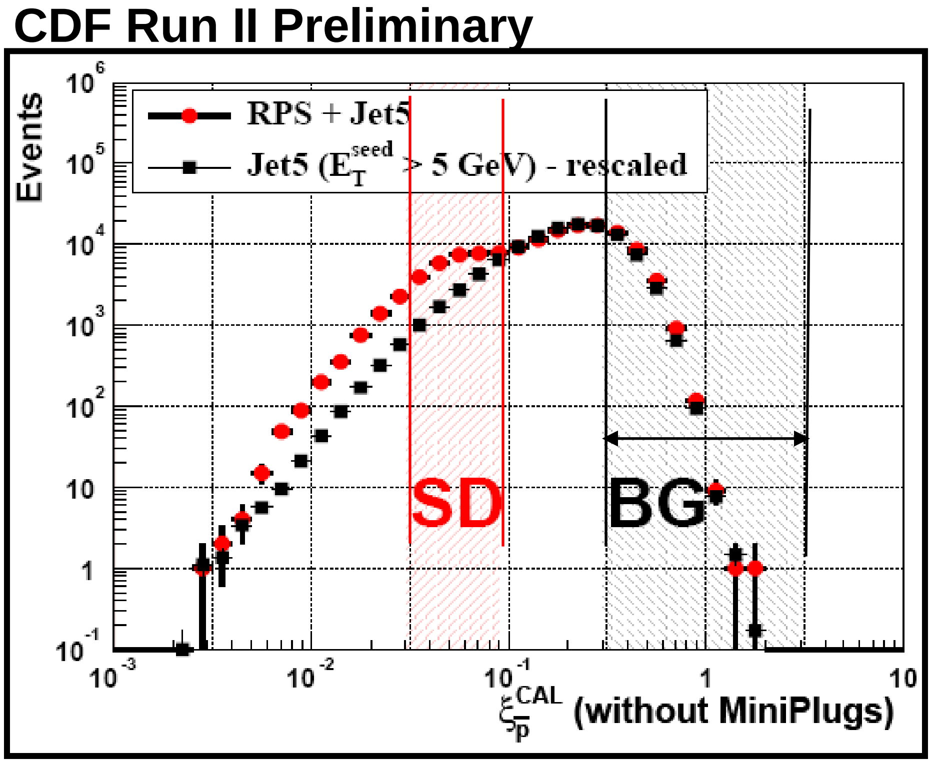




Expected position resolution	80 µm
Expected angle resolution	60 µrad

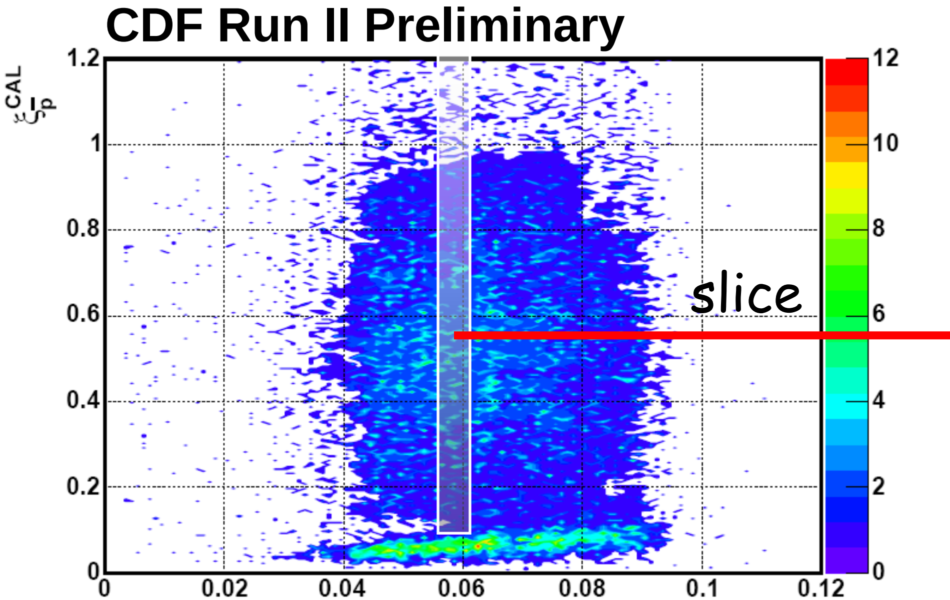
The MiniPlugs

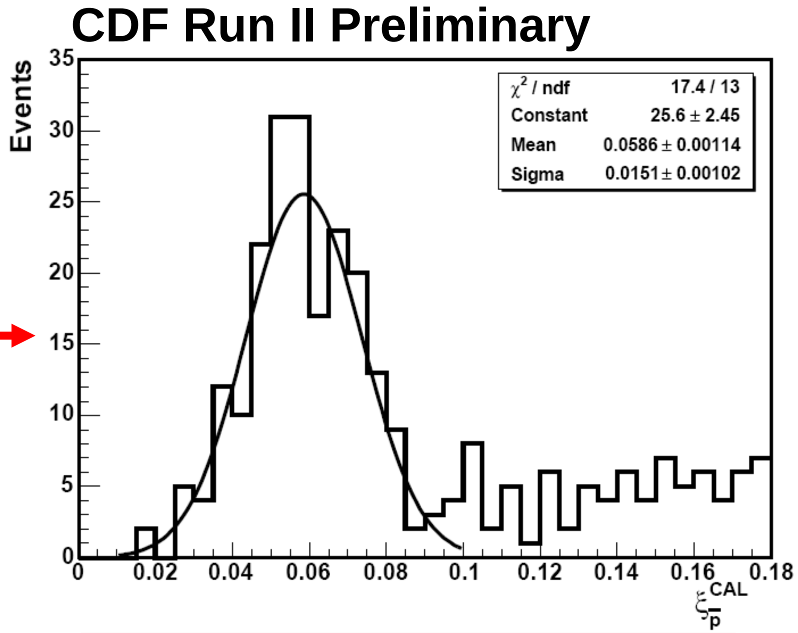




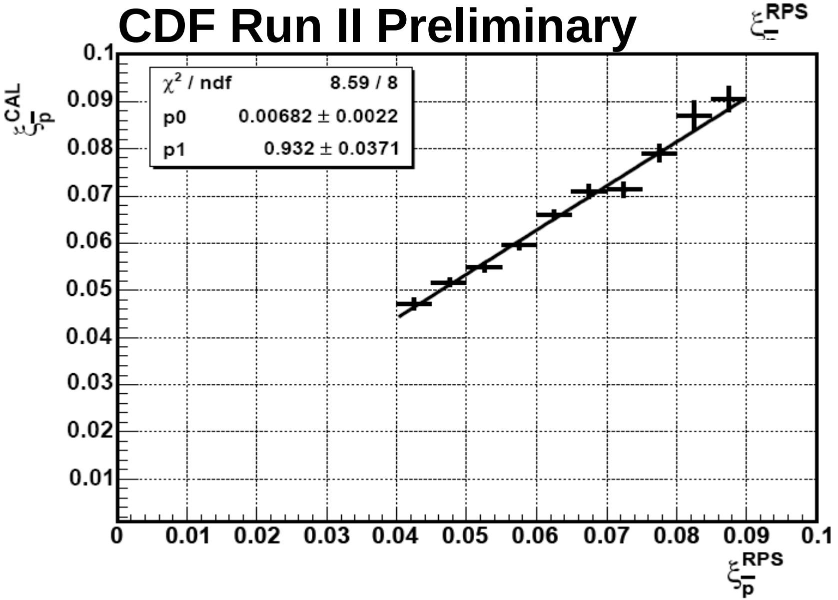
➔ overlap bgnd (BG) is reduced by including the MPs in the ξ^{CAL} calculation

ξ^{CAL} vs. ξ^{RPS}





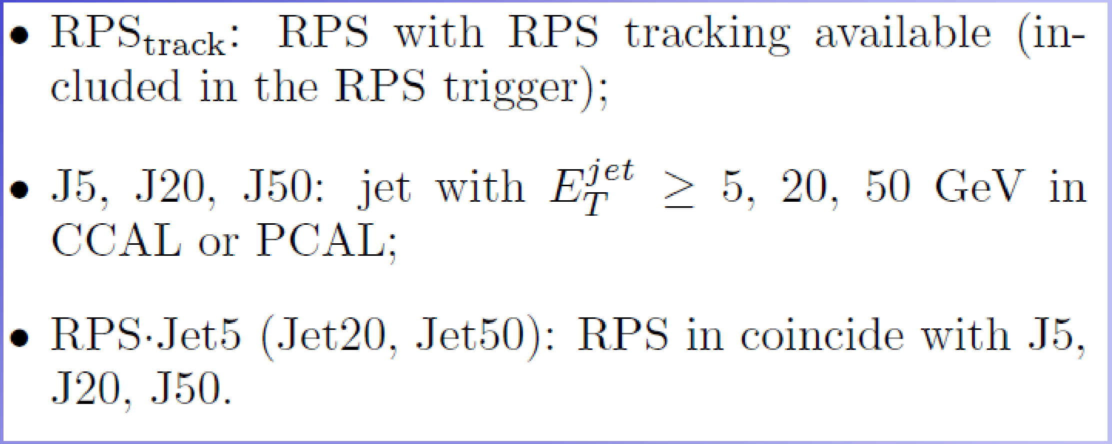
$$0.04 < \xi_{\bar{p}}^{\mathrm{RPS}} < 0.09$$



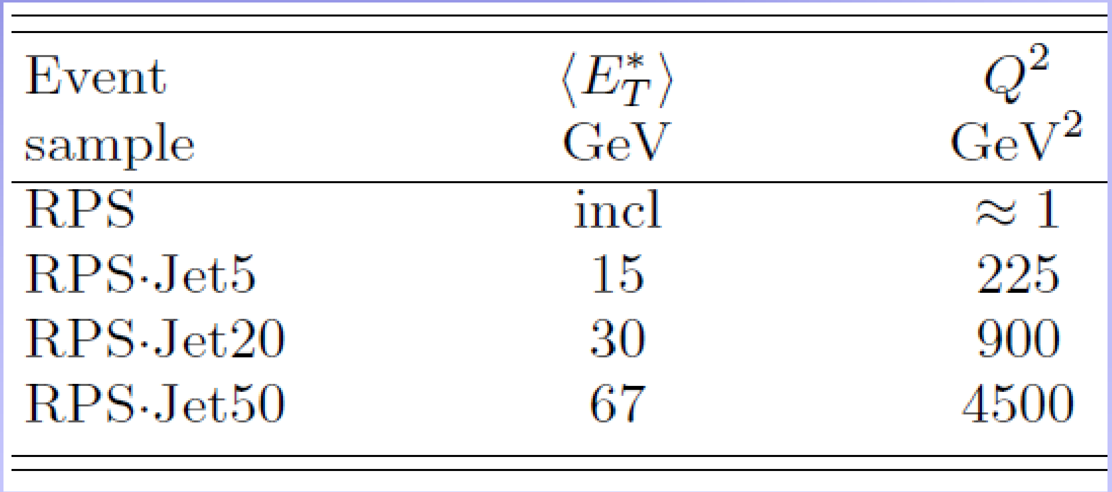
$$\xi_{\bar{p}}^{\mathrm{CAL}} = p^0 + p1 \cdot \xi_{\bar{p}}^{\mathrm{RPS}}$$

$$p^0 = 0.007 \pm 0.002 \text{ and } p1 = 0.97 \pm 0.04$$

TRIGGERS AND EVENT SAMPLES



- $\mathrm{RPS}_{\mathrm{track}}$: RPS with RPS tracking available (included in the RPS trigger);
- J5, J20, J50: jet with $E_T^{jet} \geq 5, 20, 50$ GeV in CCAL or PCAL;
- RPS·Jet5 (Jet20, Jet50): RPS in coincide with J5, J20, J50.

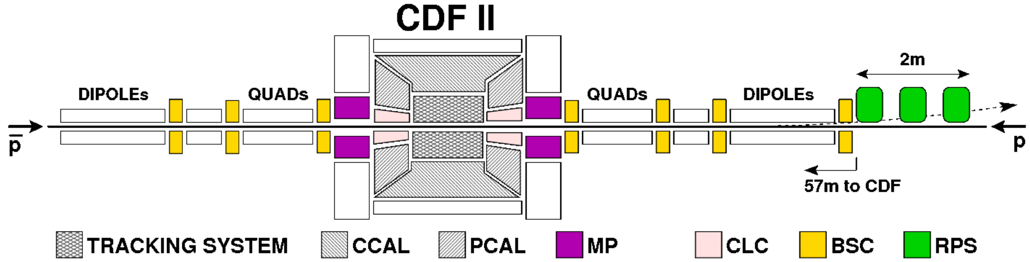


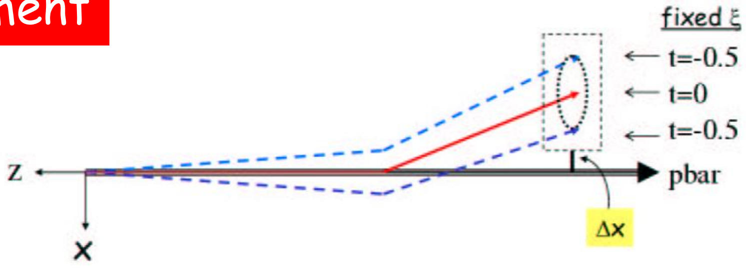
Event sample	$\langle E_T^* \rangle$ GeV	Q^2 GeV^2
RPS	incl	≈ 1
RPS·Jet5	15	225
RPS·Jet20	30	900
RPS·Jet50	67	4500

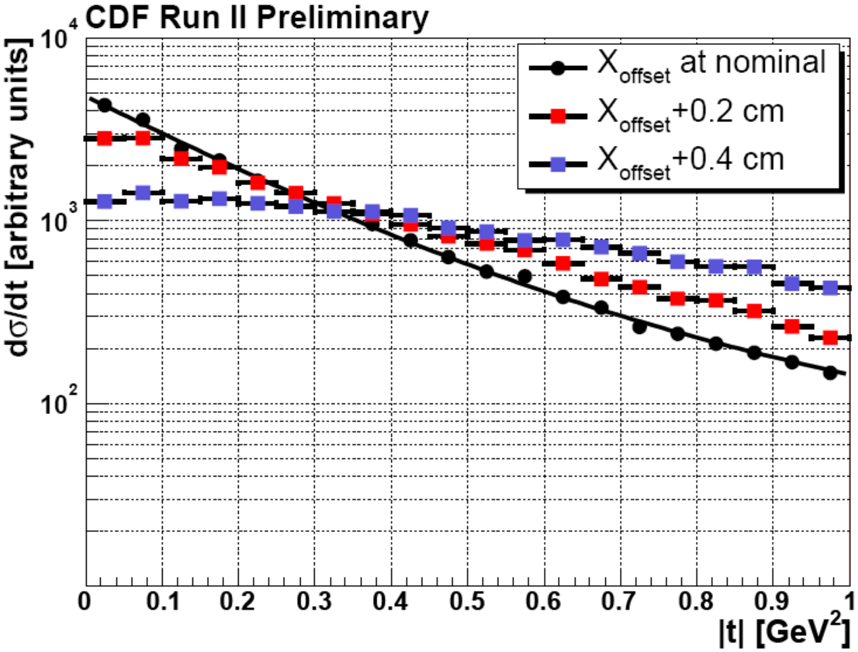
Dynamic Alignment of RPS

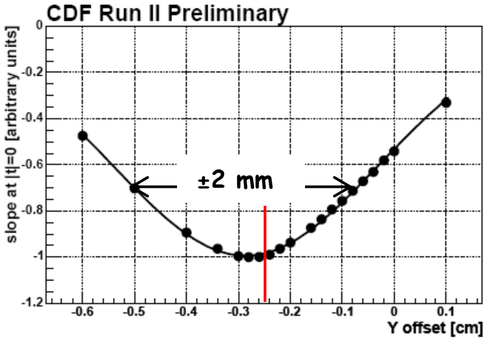
Method: iteratively adjust the RPS X and Y offsets from the nominal beam axis until a maximum in the b-slope is obtained @ t=0.

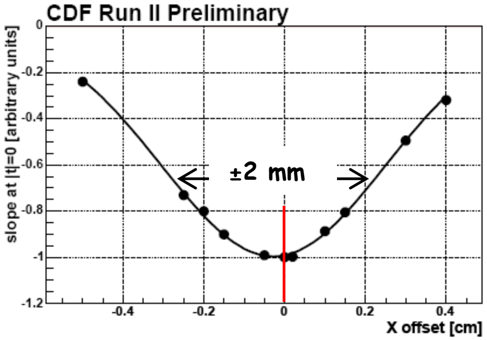
New: uncertainty in the slope due to alignment









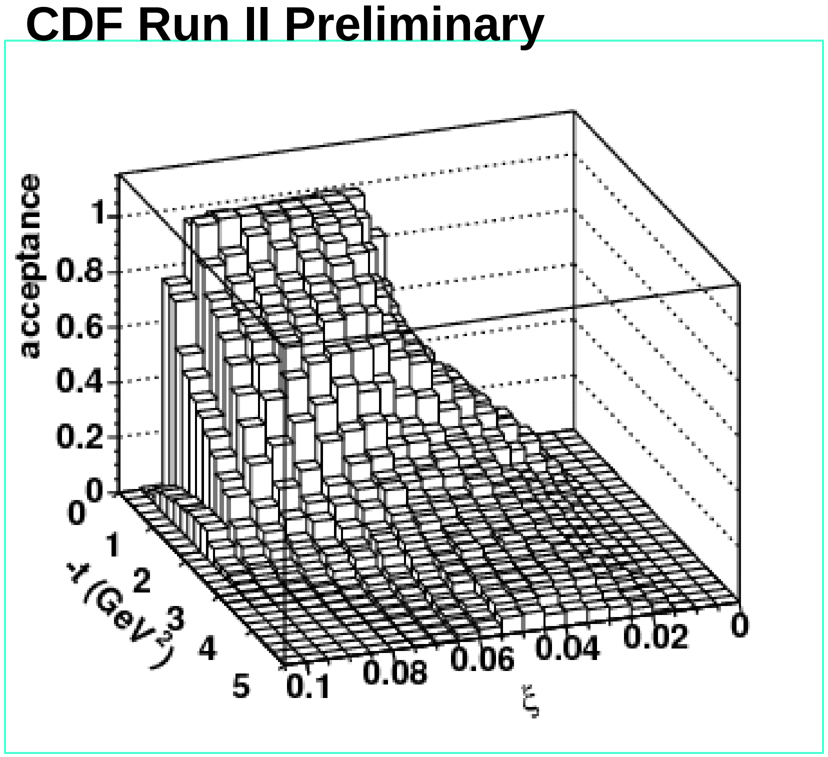


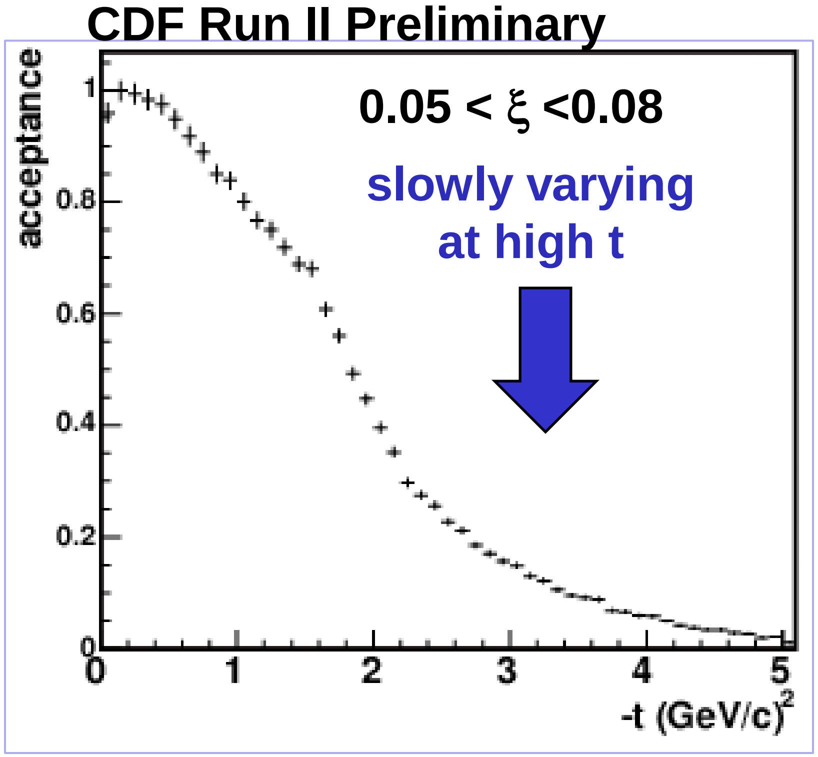
Limiting factors

1-statistics
2-beam size
3-beam jitter

use RPStrk data
width~ 2 mm/√N
N~1 K events
ΔX,ΔY = ± 60 μ

RPS ACCEPTANCE





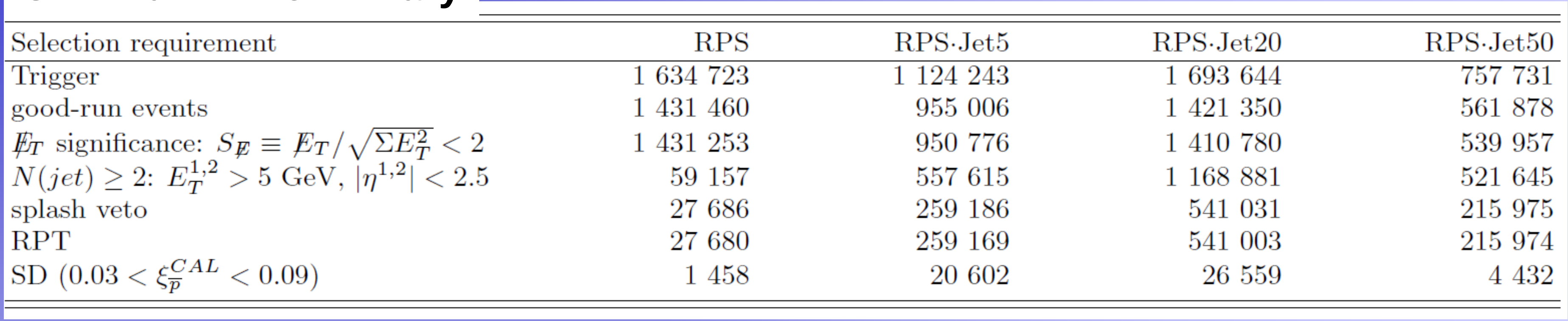
$0.05 < \xi < 0.08$

slowly varying at high t

- ❑ **acceptance beyond 4 GeV^2 minimizes edge effects**

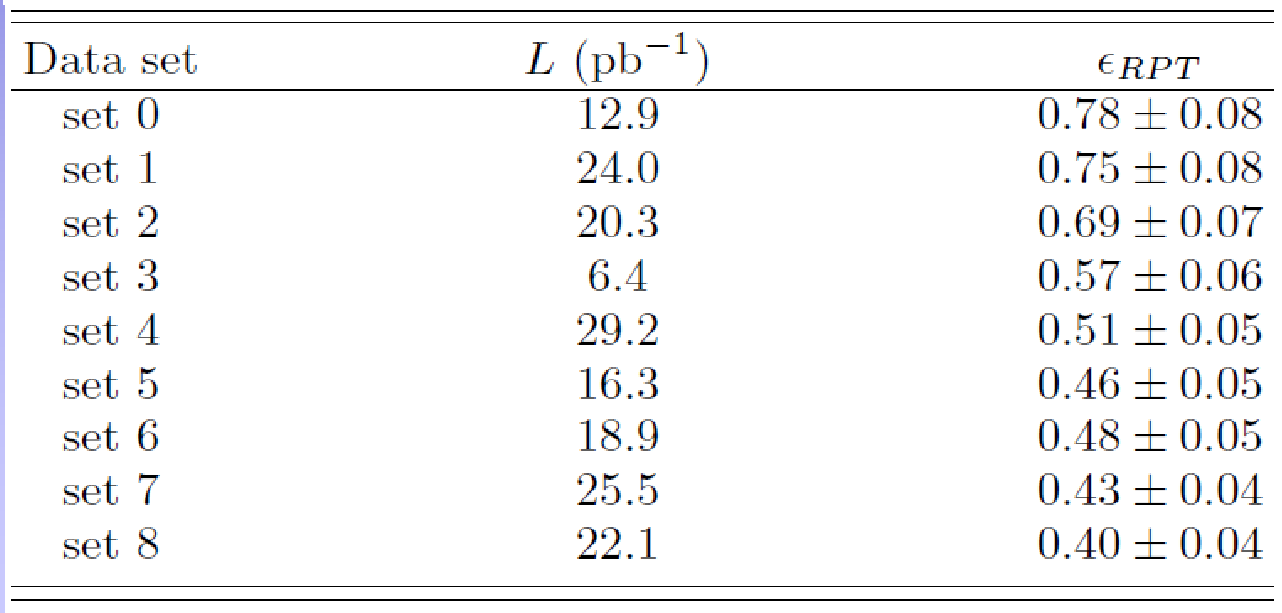
DATA REDUCTION

CDF Run II Preliminary



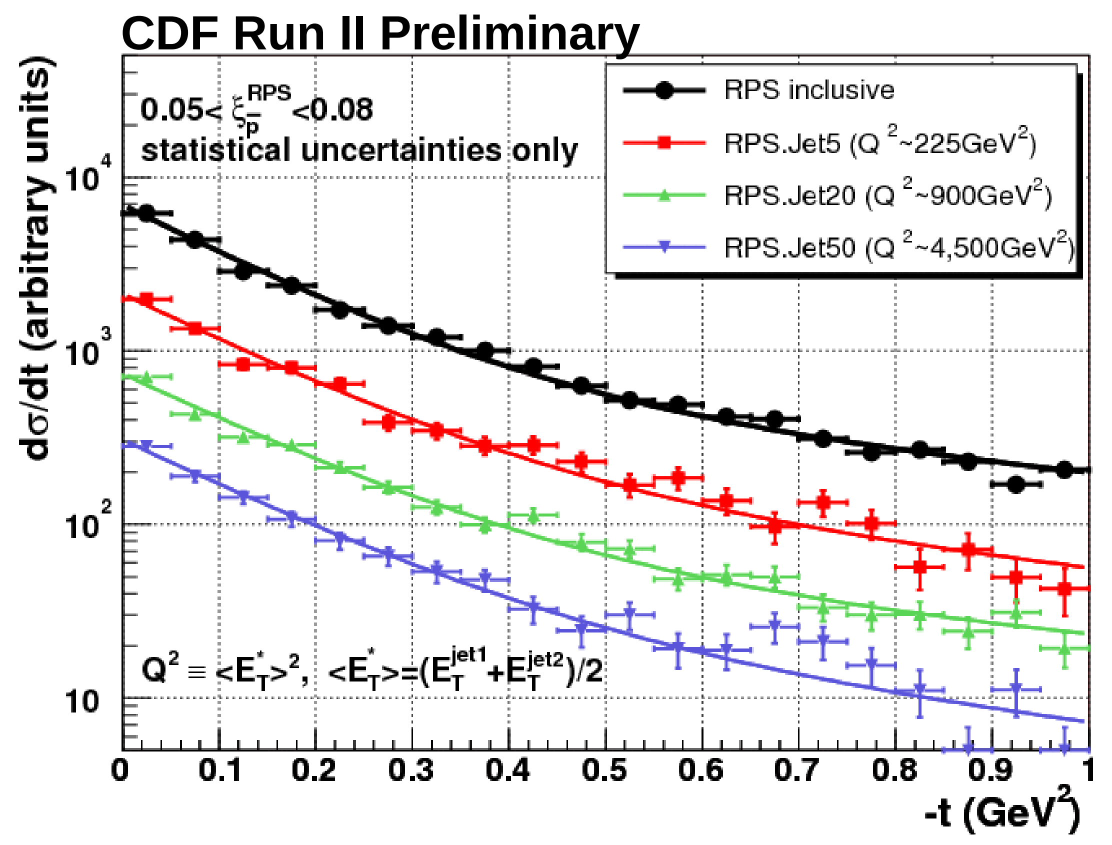
Selection requirement	RPS	RPS·Jet5	RPS·Jet20	RPS·Jet50
Trigger	1 634 723	1 124 243	1 693 644	757 731
good-run events	1 431 460	955 006	1 421 350	561 878
$\not\!\!E_T$ significance: $S_{\not E} \equiv \not\!\!E_T/\sqrt{\Sigma E_T^2} < 2$	1 431 253	950 776	1 410 780	539 957
$N(jet) \geq 2$: $E_T^{1,2} > 5$ GeV, $\lvert\eta^{1,2}\rvert < 2.5$	59 157	557 615	1 168 881	521 645
splash veto	27 686	259 186	541 031	215 975
RPT	27 680	259 169	541 003	215 974
SD $(0.03 < \xi_{\bar{p}}^{CAL} < 0.09)$	1 458	20 602	26 559	4 432

CDF Run II Preliminary



Data set	L (pb^{-1})	ϵ_{RPT}
set 0	12.9	0.78 ± 0.08
set 1	24.0	0.75 ± 0.08
set 2	20.3	0.69 ± 0.07
set 3	6.4	0.57 ± 0.06
set 4	29.2	0.51 ± 0.05
set 5	16.3	0.46 ± 0.05
set 6	18.9	0.48 ± 0.05
set 7	25.5	0.43 ± 0.04
set 8	22.1	0.40 ± 0.04

t-distributions for -*t*≤1 GeV^2



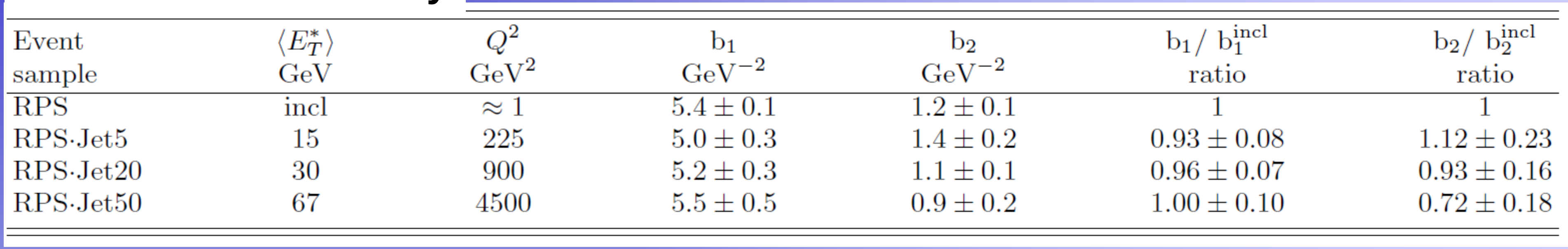
Fit dσ/dt to a double exponential:

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

- No diffraction dips
- No Q^2 dependence in slope from inclusive to Q^2~10^4 GeV^2

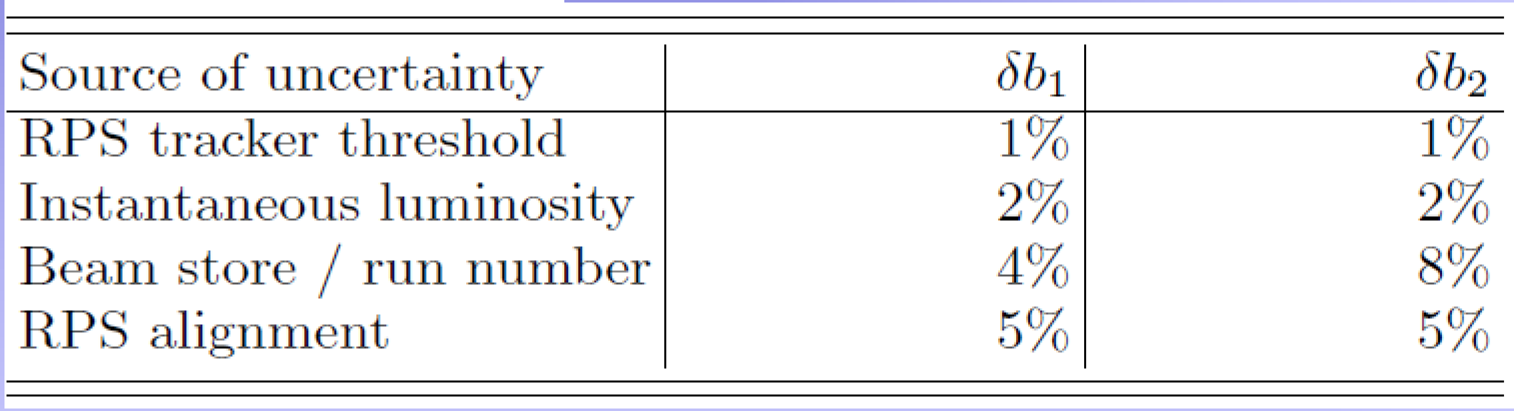
b-slopes for $-t \leq 1$ GeV^2 (1)

CDF Run II Preliminary



Event sample	$\langle E_T^* \rangle$ GeV	Q^2 GeV^2	b$_1$ GeV^{-2}	b$_2$ GeV^{-2}	b$_1$/ b$_1^{\text{incl}}$ ratio	b$_2$/ b$_2^{\text{incl}}$ ratio
RPS	incl	≈ 1	5.4 ± 0.1	1.2 ± 0.1	1	1
RPS·Jet5	15	225	5.0 ± 0.3	1.4 ± 0.2	0.93 ± 0.08	1.12 ± 0.23
RPS·Jet20	30	900	5.2 ± 0.3	1.1 ± 0.1	0.96 ± 0.07	0.93 ± 0.16
RPS·Jet50	67	4500	5.5 ± 0.5	0.9 ± 0.2	1.00 ± 0.10	0.72 ± 0.18

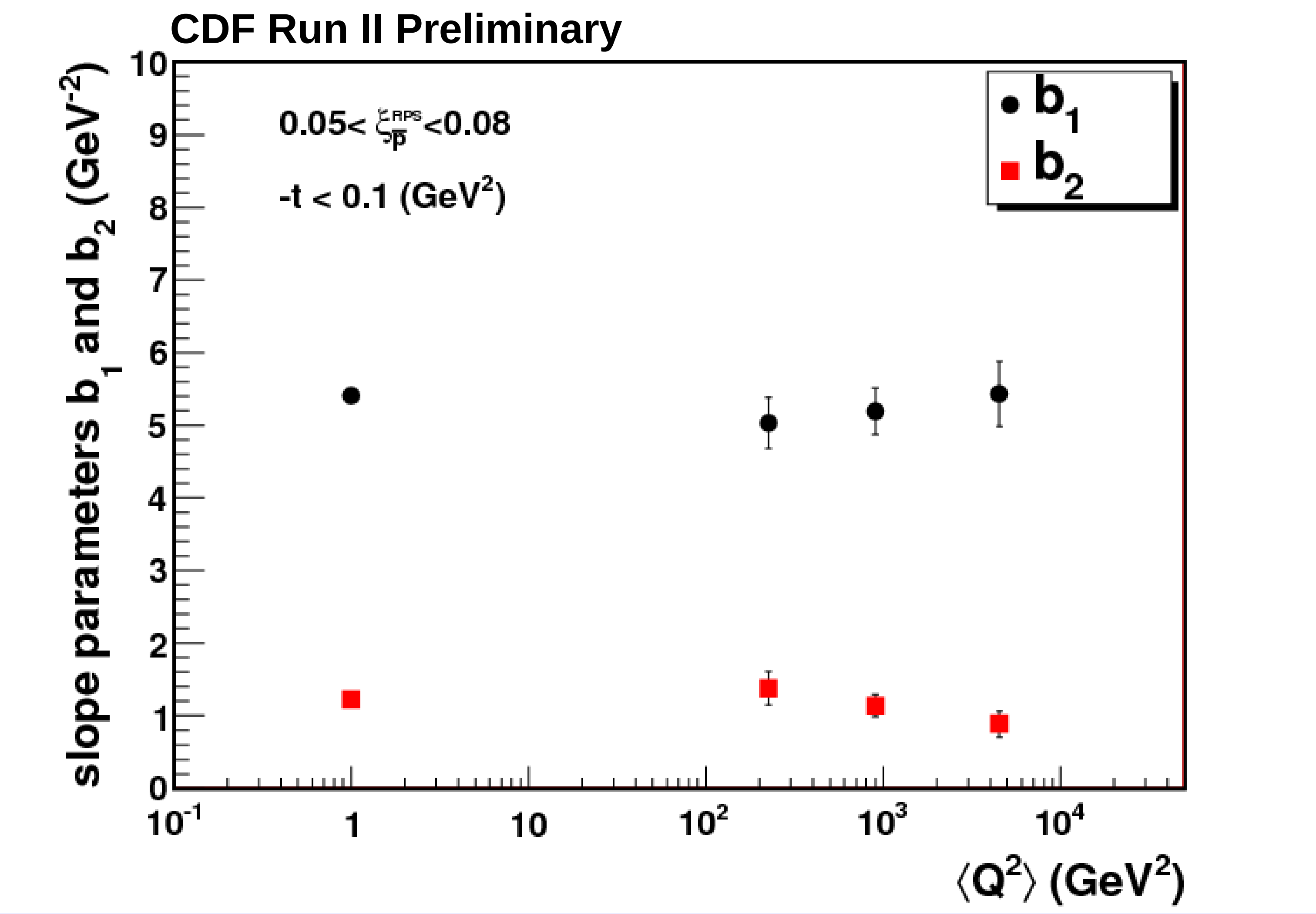
CDF Run II Preliminary



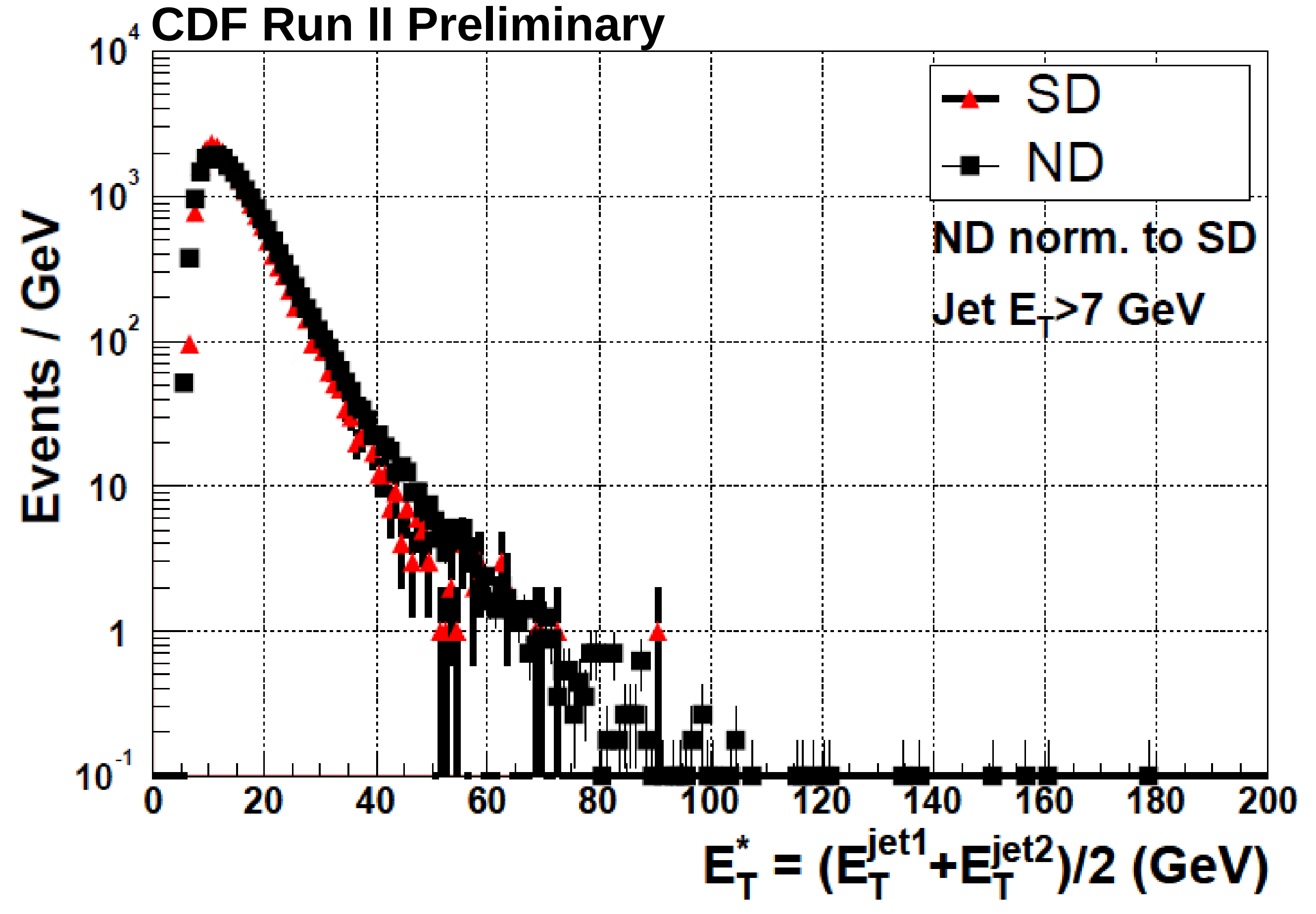
Source of uncertainty	δb_1	δb_2
RPS tracker threshold	1%	1%
Instantaneous luminosity	2%	2%
Beam store / run number	4%	8%
RPS alignment	5%	5%

- **$\leq$ 20% dependence on Q^2 over ~ 4 orders of magnitude**

b-slopes for -t≤1 GeV^2 (2)



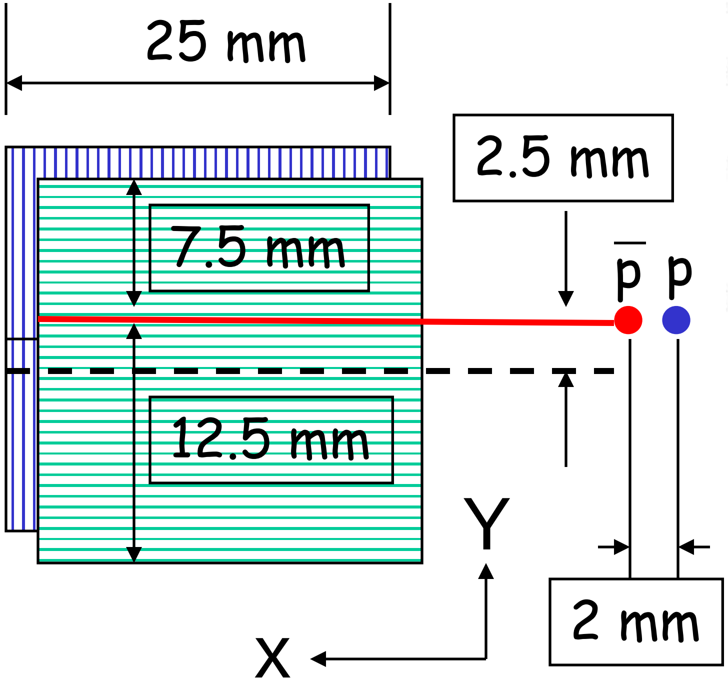
Dijet E_T*-distributions:



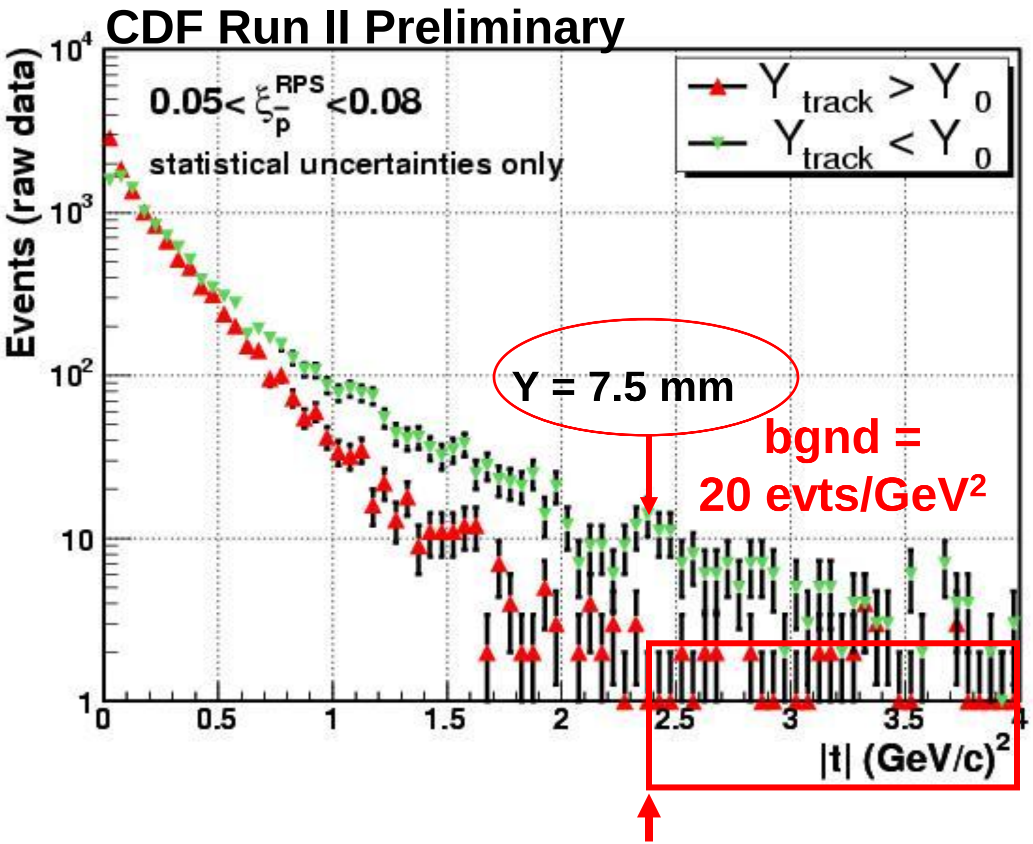
➔ similar for SD and ND over 3 orders of magnitude!

t >1 GeV^2: asymmetric *t*-distributions as a tool for evaluating bgd at high *t*

schematic view of fiber tracker



t-distributions

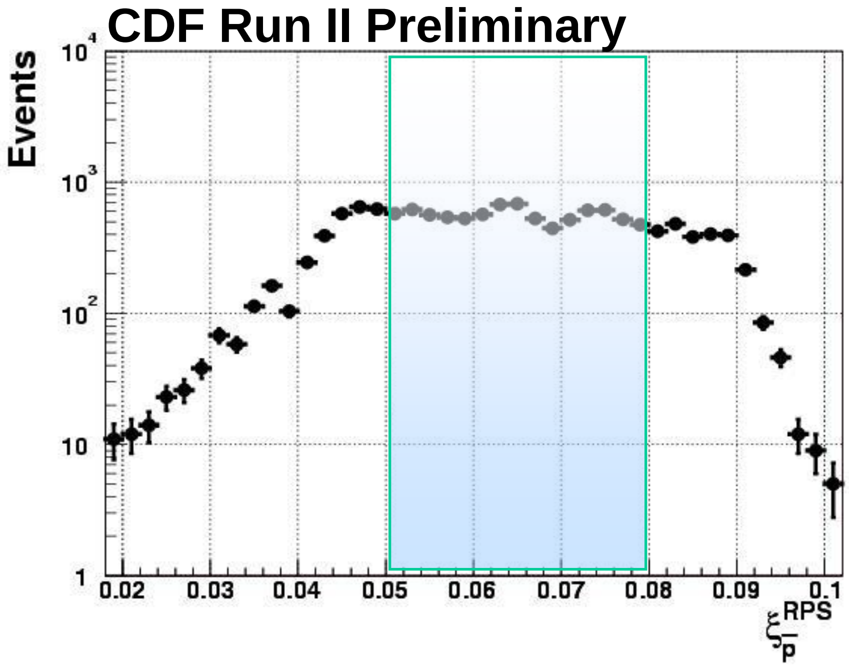


Y = 7.5 mm

bgnd = 20 evts/GeV^2

- tracker's upper edge: $|t|=2.3$ GeV^2, estimated from $t \sim \theta^2$
- the lower edge is at $|t|=6.5$ GeV^2 (not shown)
- background level: region of $Y_{track}>Y_o$ data for $|t|>2.3$ GeV^2

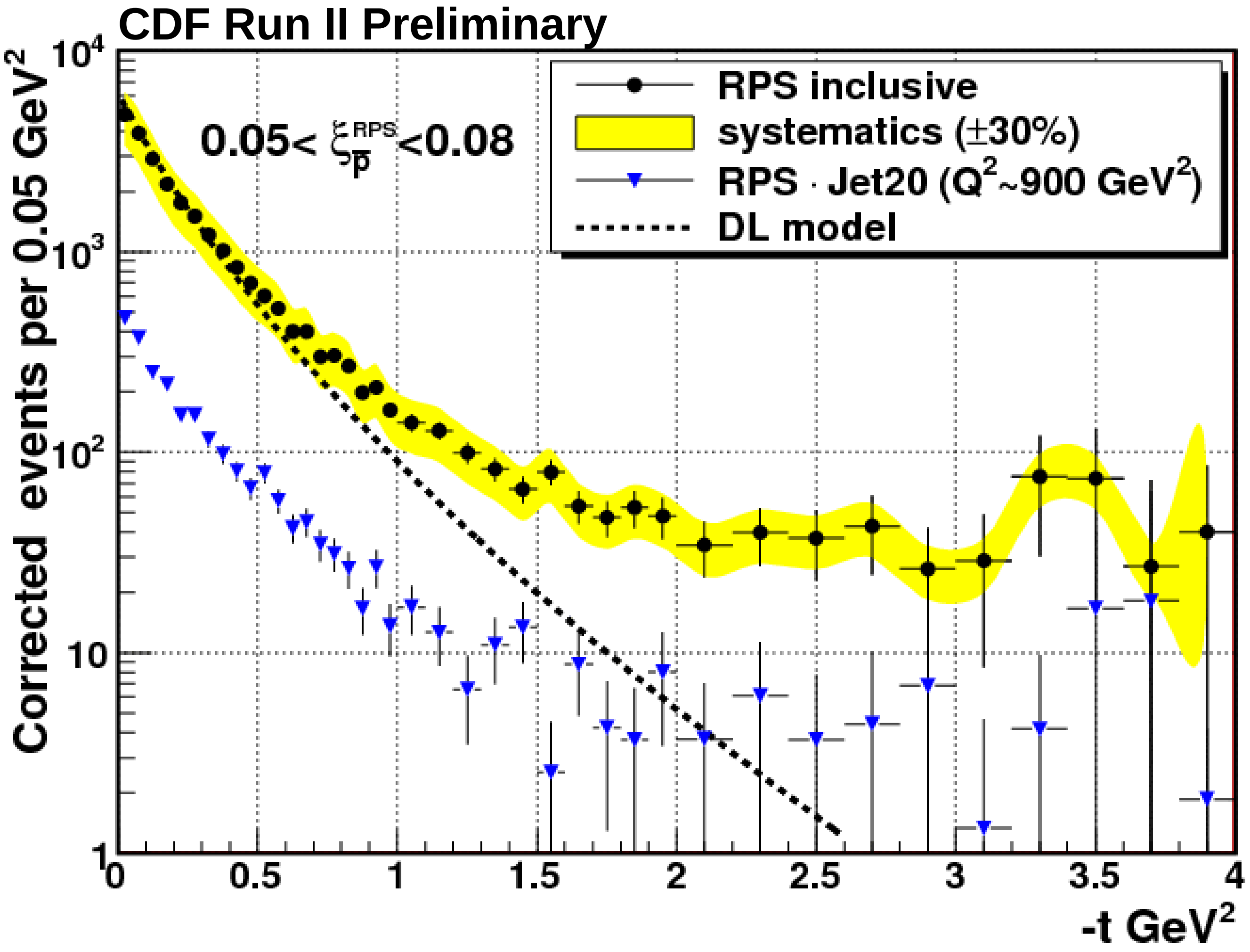
Why select $0.05<\xi_{pbar}<0.08$?



- ☐ be on the plateau of the ds/dlnξ distribution
- ☐ allow enough room to avoid edge-effects
- ☐ accept enough events for good statistics

- ☐ **estimated width resulting from the $\Delta\xi$: $\Delta\tau \approx 0.47$**

t-distributions for -*t*≤4 GeV^2



CONCLUSION

- ☐ **t DISTRIBUTIONS : *inclusive* and *dijet* data**
  - ***measured over a wide range of $Q^2 \approx (E_{T,jet})^2$:***

    $\sim 1 \lesssim Q^2 \lesssim 10^4$ GeV^2 and t_{min} $(\sim 0) \lesssim -t \lesssim 4$ GeV^2
  - **independent of Q^2**
  - **agree with the DL model at $-t \lesssim \sim 0.5$ GeV^2**
  - **flatten out beyond $-t$ ~1.5 to become a factor of ~10 larger than the DL model prediction**

THANK YOU FOR YOUR ATTENTION