Update talk
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Study of inclusive double pomeron exchange in Roman Pot triggered events

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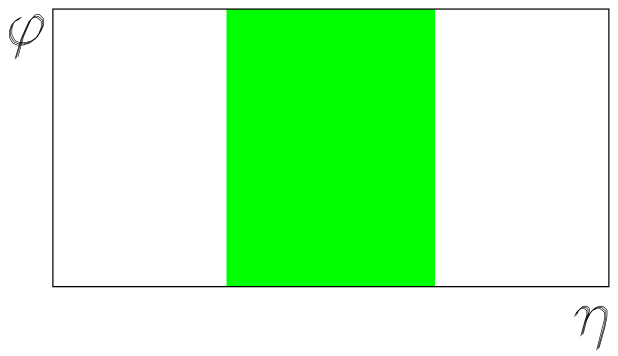
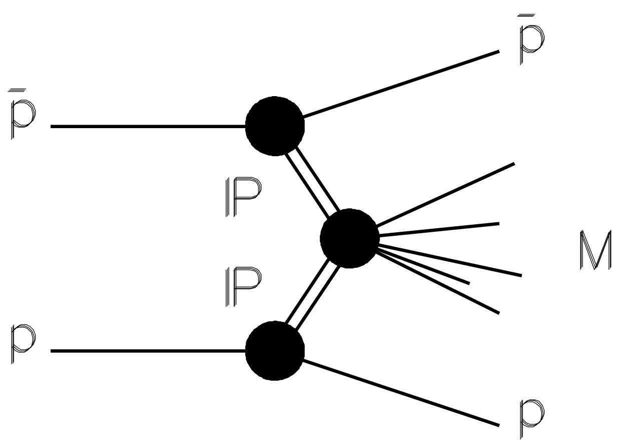
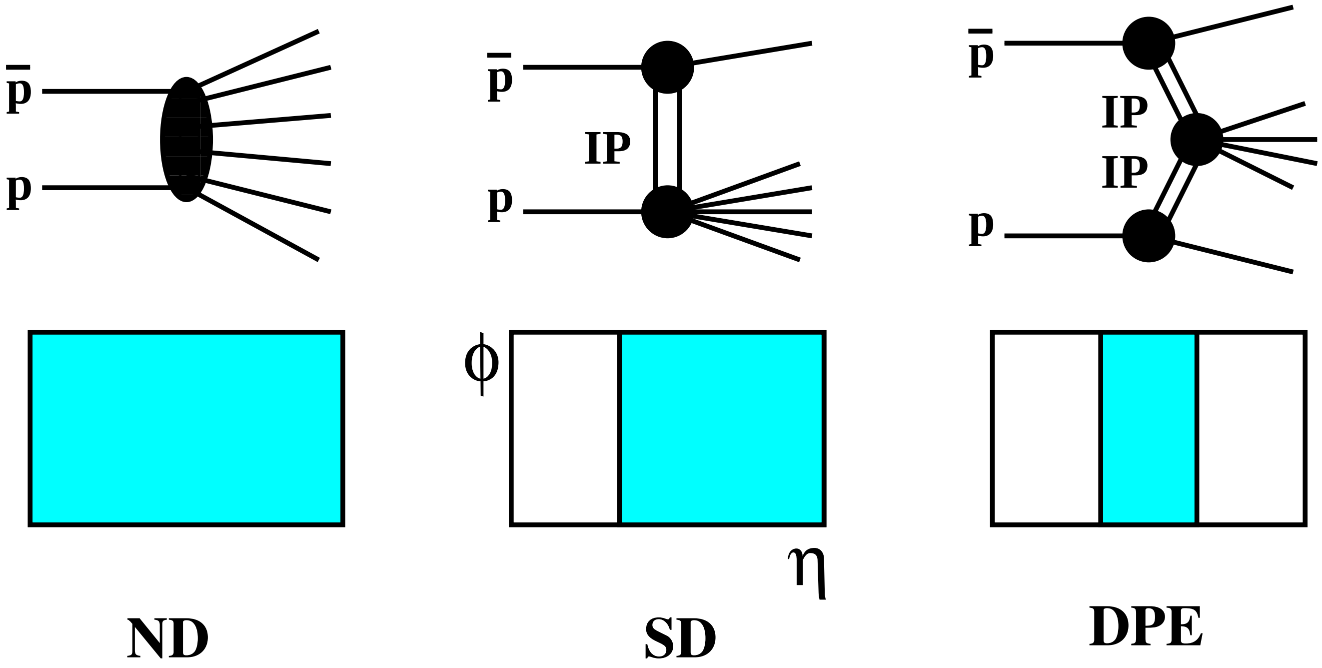




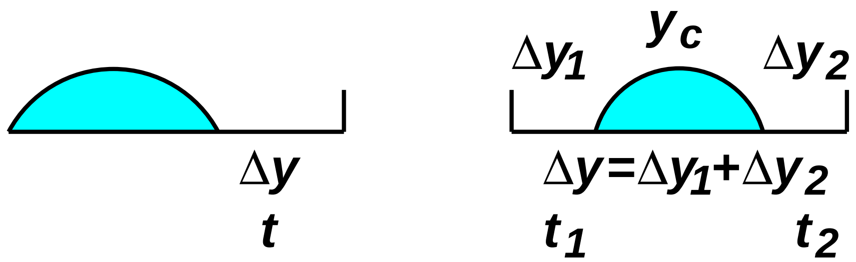
Introduction



Motivation of Studying Inclusive DPE

- ➜ The suppression of the diffractive structure function at the Tevatron relative to that at HERA is generally attributed to additional partonic interactions which spoil the diffractive signature of the event.
- ➜ In case of multi-gap events, if a single gap survives, additional gaps may be unsuppressed. (Dino's talk in the QCD meeting of Nov. 16, 2001.)
- ➜ In events with a leading antiproton, look at the rate of an additional "forward" gap on the proton out-going side
  - It is also interesting to look at the rate of an additional "central" gap within the proton dissociation products of events with a leading antiproton (Mary's talk in the QCD meeting on Nov. 16, 2001.)

Diffractive Cross Sections



➜ Regge theory prediction

$$\beta(t) \equiv \beta^{\mathbb{P}p}(t),\ \kappa \equiv g^{\mathbb{P}\mathbb{P}\mathbb{P}}/\beta(0)$$

$$\frac{d^2\sigma_{SD}}{dt\,d\Delta y} = \underbrace{\left[\frac{\beta(t)}{4\sqrt{\pi}}\,e^{[\alpha(t)-1]\Delta y}\right]^2}\ \underbrace{\kappa\beta^2(0)\left(\frac{s'}{s_0}\right)^{\epsilon}}$$

$$\frac{d^4\sigma_{DPE}}{dt_1dt_2d\Delta y dy_c} = \underbrace{\left[\prod_i \frac{\beta(t_i)}{4\sqrt{\pi}}\,e^{[\alpha(t_i)-1]\Delta y_i}\right]^2}\underbrace{\kappa^2\beta^2(0)\left(\frac{s'}{s_0}\right)^{\epsilon}}$$

$$\frac{\sigma_{DPE}}{\sigma_{SD}} \approx\ 0.32\ (0.21)\ \text{at}\ 1800\ (630)\ \text{GeV}\ \checkmark$$

➜ Renormalization model (both gaps are renormalized)

K. Goulianos, Phys. Lett. B353, 379 (1995)

$$\frac{\sigma_{DPE}}{\sigma_{SD}} \approx\ 0.036\ (0.035)\ \text{at}\ 1800\ (630)\ \text{GeV}$$

➜ Renorm. model (only one rapidity gap probability term in an event which needs to be renormalized)

K. Goulianos, hep-ph/0110240 (2001)

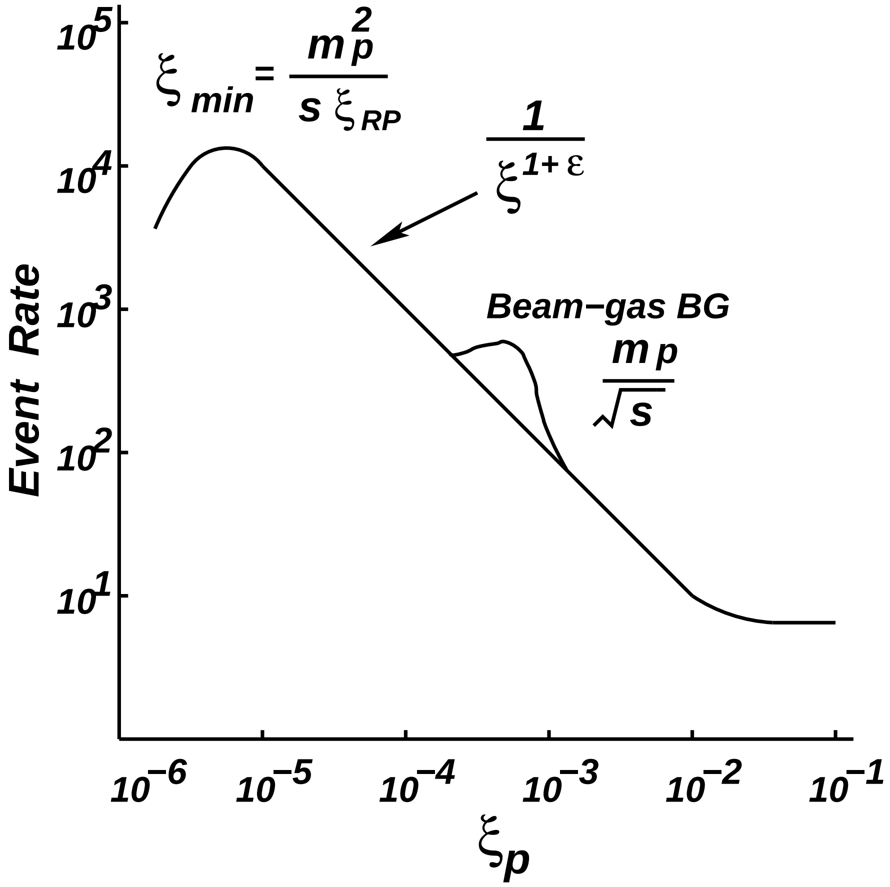
$$\frac{\sigma_{DPE}}{\sigma_{SD}} \approx \kappa = 0.17\ \ (0.18\ (0.14)\ \text{at}\ 1800\ (630)\ \text{GeV})$$

Analysis Strategy

➜ For events triggered on a leading antiproton in Roman Pots, reconstruct the value of ξ_p from the calorimeter and beam-beam counters (BBC)

➜"Beam-gas" events have $\xi_p = m_p/\sqrt{s}$, so they may be distinguishable in the ξ_p distribution

$$\boxed{\xi_p^X = \frac{\sum E_T \exp(+\eta)}{\sqrt{s}}}$$



$\xi_{p(\bar{p})}$ & $t_{p(\bar{p})}$: fractional momentum loss & 4-momentum transfer squared of the out-going p $(\bar{p})$

Progresses after the last QCD meeting

- A bug in the 630 GeV data selection was fixed
  ➜ $R[\frac{DPE}{SD}]$ decreased from ≈ 30 % to $15 \sim 20$ %
- Detailed studies of the ξ^X calibration and resolution were preformed for both 1800 GeV and 630 GeV data samples
- The bump in the ξ_p^X distribution around $\xi_p^X \sim 7 \cdot 10^{-4}$ was investigated in detail

Data and Event Selection

- Roman Pot triggered events at $\sqrt{s} = 630$ and 1800 GeV
- Events with ≤ 1 reconstructed vertex (of any class) – additional $\bar{p}p$ collisions spoil the gap
- $0.035 < \xi_{\bar{p}}^{RP} < 0.095$
- $|t_{\bar{p}}^{RP}| < 1.0$ (0.2) GeV^2 at 1800 (630) GeV

Cut	1800 GeV	630 GeV
Total Triggers	1,550 K	706 K
$\not{E}_T \leq 20$ GeV	1,550 K	706 K
$N_{vtx} \leq 1$	1,456 K	641 K
$\lvert Z_{vtx}\rvert \leq 60$ (cm)	1,375 K	587 K
Roman Pot Quality Cuts	970 K	286 K
$\xi_{\bar{p}}^{RP}$ & $t_{\bar{p}}^{RP}$ Cuts	874 K	157 K
West BBC Multi. Cut	756 K	136 K

Reconstruction of ξ_p^X

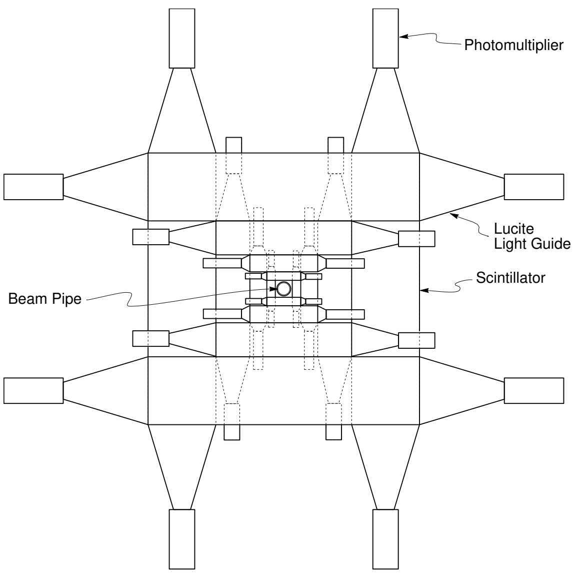
$$\xi_p^X = \frac{\sum_i E_{T\,i} \exp(+\eta_i)}{\sqrt{s}}$$

Calorimeter : use E_T and η of calorimeter towers above noise level (CDFnote-3753)

- tower E_T is multiplied by 1.6 to account for non-linearity

BBC : use hits in BBC scintillation arrays

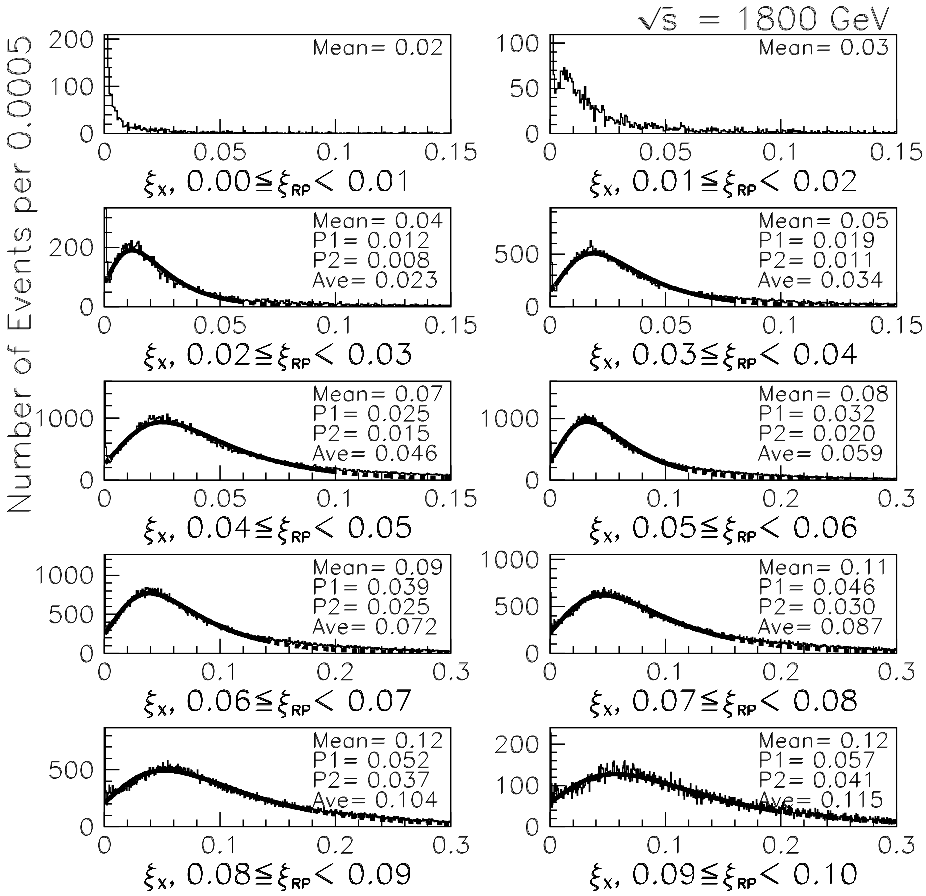
- p_T is chosen to follow the "known" p_T spectrum $d\sigma/dp_T = p_T(1 + p_T/1.27)^{-[4+35.8/\ln(M/0.3)]}$
- η is chosen randomly within the η range of the BBC counter which has a hit
- multiplicity is multiplied by $(3/2 \times 3/4)$ to account for neutral particles (which are not detected by the BBC) and the overlap of the BBC arrays



$\xi_{\bar{p}}^{RP}$ versus $\xi_{\bar{p}}^{X}$: 1800 GeV

Compare $\xi_{\bar{p}}^{RP}$ (determined by Roman Pot) and $\xi_{\bar{p}}^{X}$ (determined by BBC and calorimeter) in order to

- calibrate the value of $\xi_{\bar{p}\,(p)}^{X}$
- understand the resolution of $\xi_{\bar{p}\,(p)}^{X}$

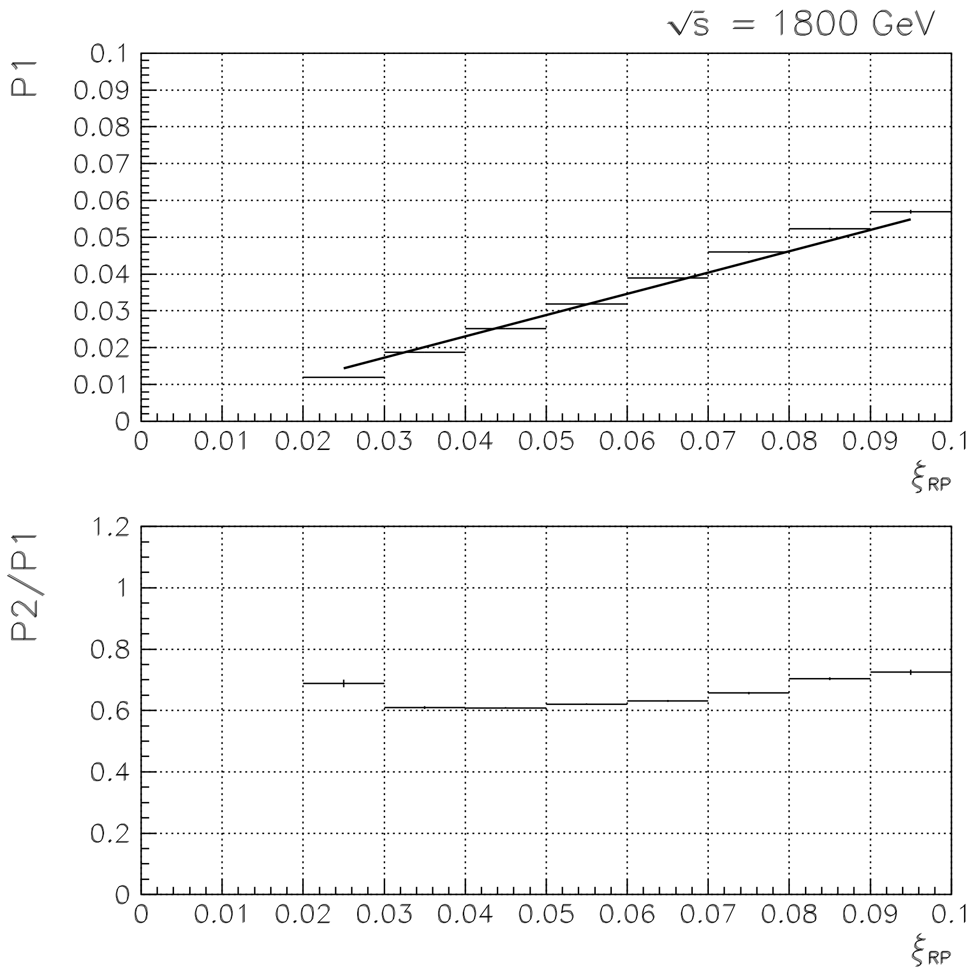


Distributions are fitted to

$$f(\xi) = P3 \cdot \exp(-0.5[\frac{\xi - P1}{P2} + \exp(-\frac{\xi - P1}{P2})])$$

in the region 0.002 or 0.003 $< \xi^{X} < 2 \cdot \xi^{RP}$

$\xi_{\bar{p}}^{RP}$ versus $\xi_{\bar{p}}^{X}$: 1800 GeV



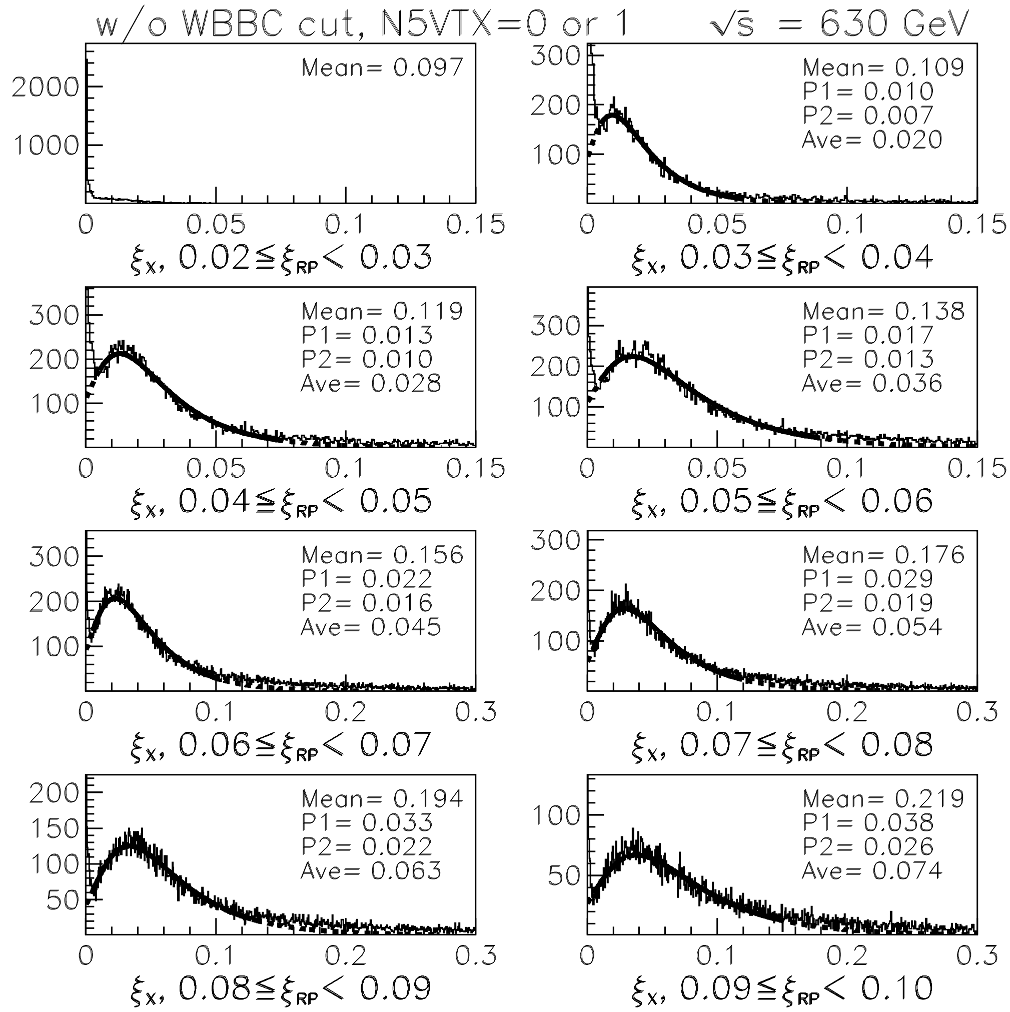
There is a good correlation between $\xi_{\bar{p}}^{RP}$ and $\xi_{\bar{p}}^{X}$

$$P1 \approx 0.6 \times \xi^{RP} \qquad P2/P1 \approx 0.7$$

➜ How much is the ξ_p^X distribution smeared then?

$\xi_{\bar{p}}^{RP}$ versus $\xi_{\bar{p}}^{X}$: 630 GeV

The same study was done for the 630 GeV data sample

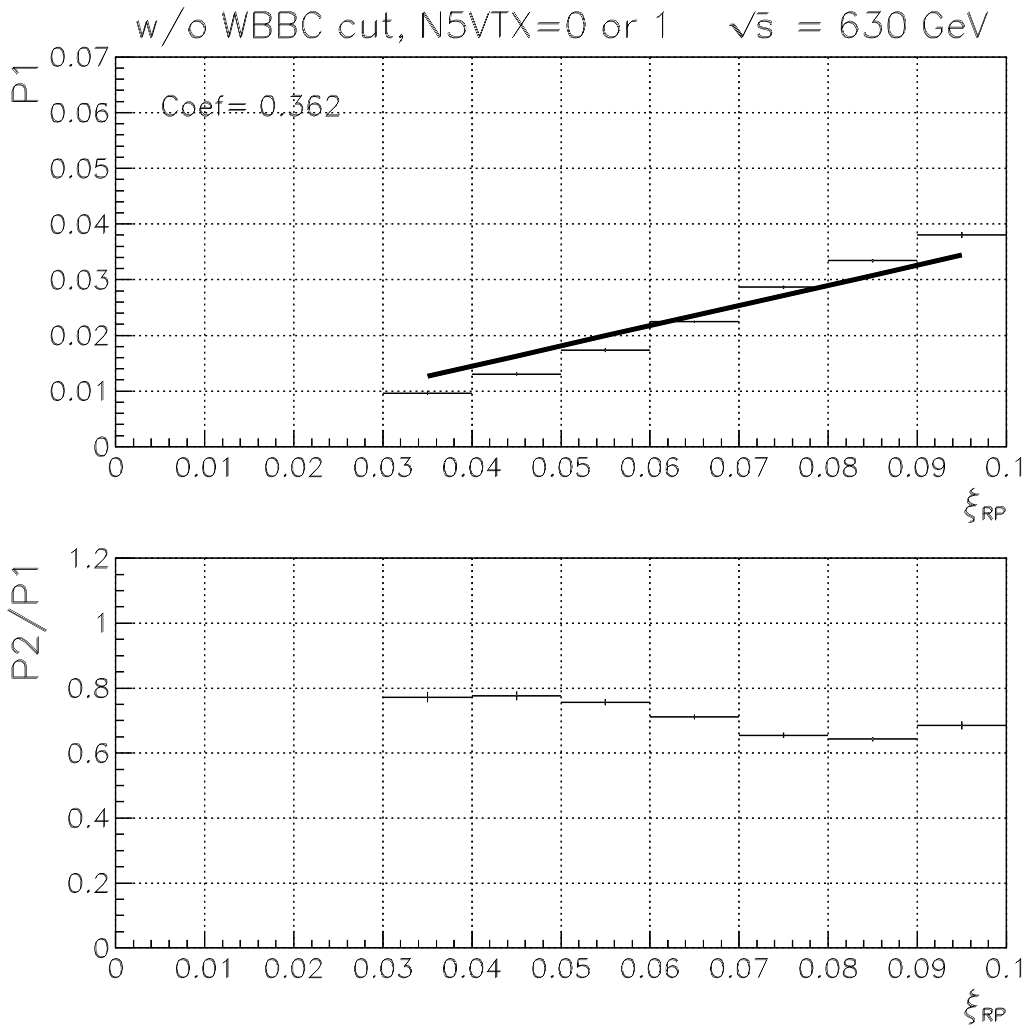


Distributions are fitted to

$$f(\xi) = P3 \cdot \exp(-0.5[\frac{\xi - P1}{P2} + \exp(-\frac{\xi - P1}{P2})])$$

in the region $0.005 < \xi^X < 1.5 \cdot \xi^{RP}$

$\xi_{\bar{p}}^{RP}$ versus $\xi_{\bar{p}}^{X}$: 630 GeV



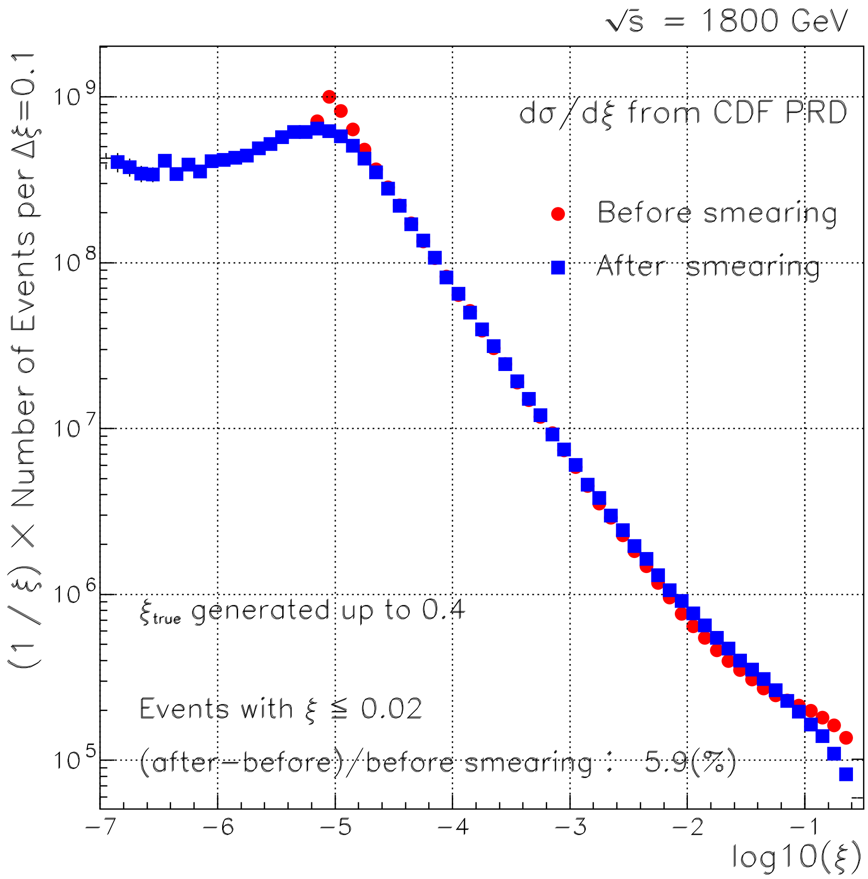
There is a good correlation between $\xi_{\bar{p}}^{RP}$ and $\xi_{\bar{p}}^{X}$

$$P1 \approx 0.36 \times \xi^{RP} \qquad P2/P1 \approx 0.7$$

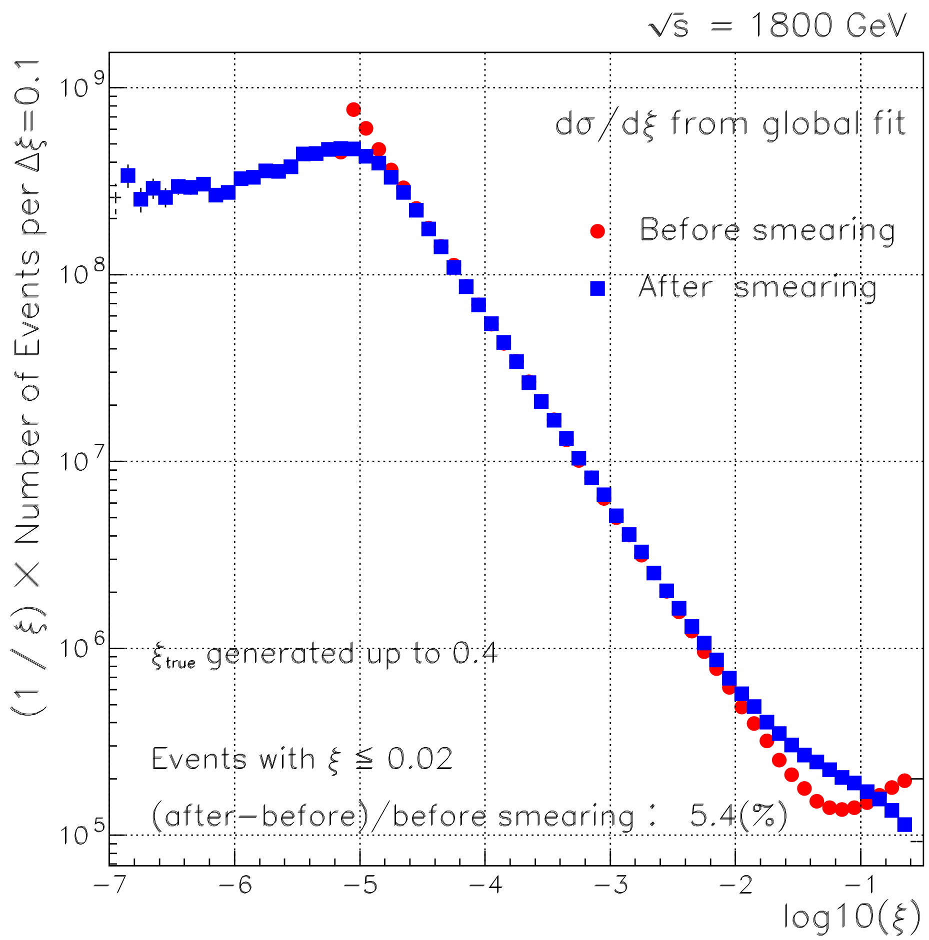
➜ How much is the x_p^X distribution distorted?

$\xi_{\bar{p}}^{X}$ smearing effect

- Generate ξ by using the $d\sigma/d\xi$ from
  - F. Abe et al., PRD **50**, 5535 (1994)
  - K. Goulianos et al., PRD **59**, 114017 (1999)
- Smear the ξ value according to the form
  $$f(\xi) = \exp(-0.5[\frac{\xi - P1}{P2} + \exp(-\frac{\xi - P1}{P2})])$$
  – $P1 \approx 0.6 \times \xi$, $P2/P1 \approx 0.7$ for 1800 GeV
  – $P1 \approx 0.36 \times \xi$, $P2/P1 \approx 0.7$ for 630 GeV
- Check how the ξ distribution changes



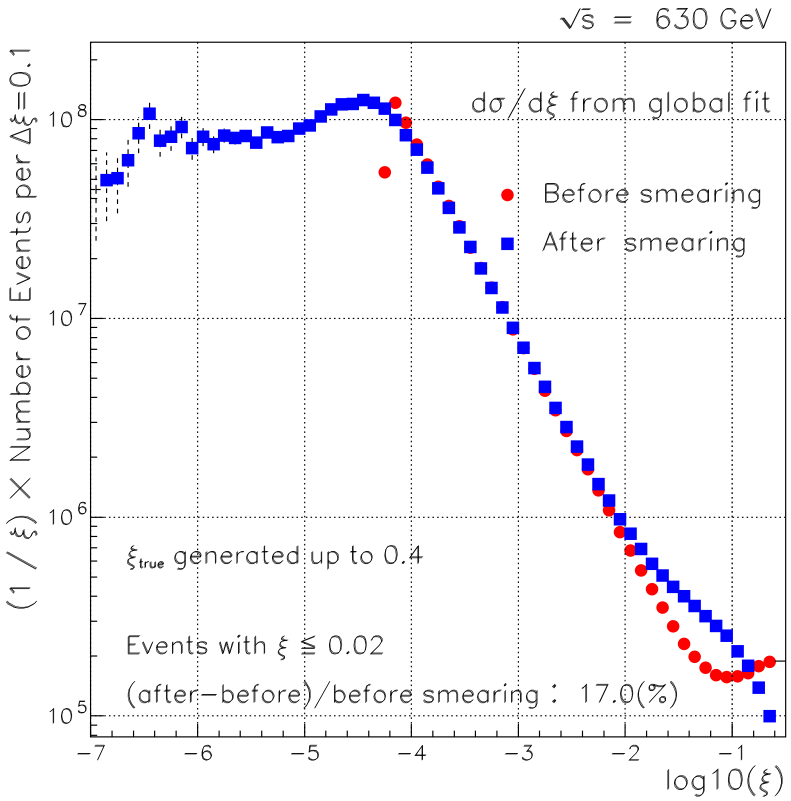
$\xi_{\bar{p}}^{X}$ smearing effect : 1800 GeV

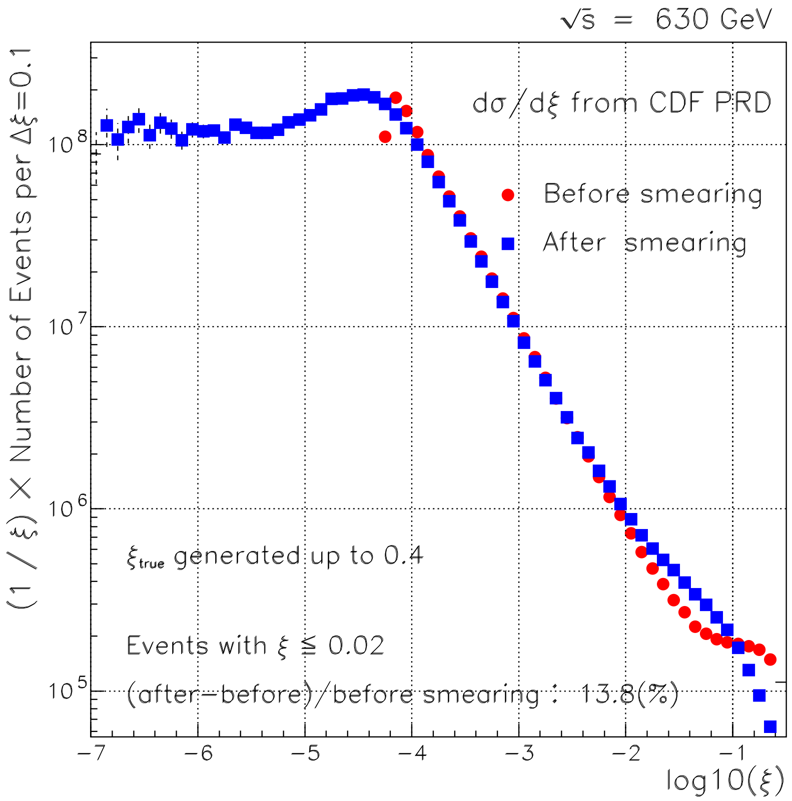


➜ The slope (power) in the region $10^{-5} < \xi < 10^{-2}$ changes very little

➜ The number of events with $\xi \leq 0.02$ increases about $5 \sim 6$ % after the smearing at 1800 GeV

$\xi_{\bar{p}}^{X}$ smearing effect : 630 GeV

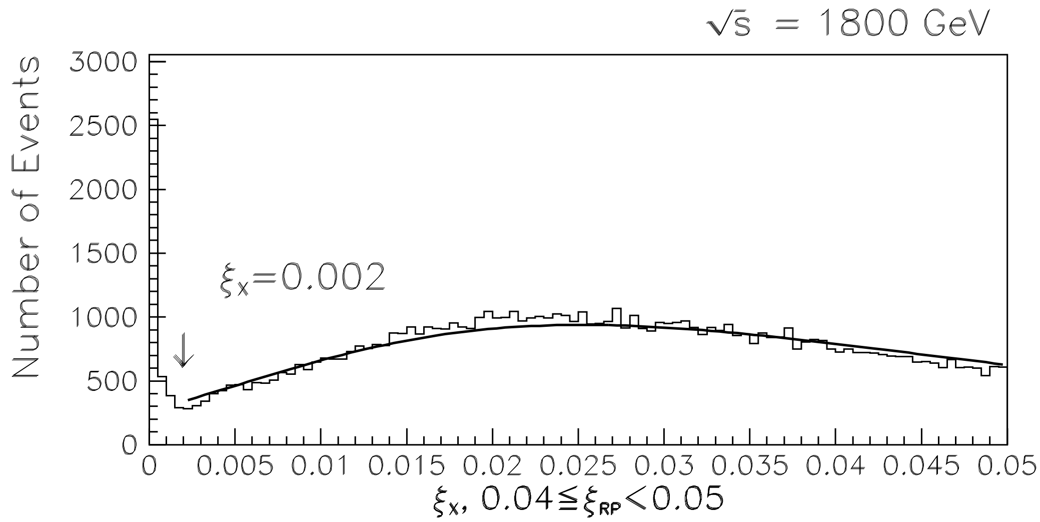


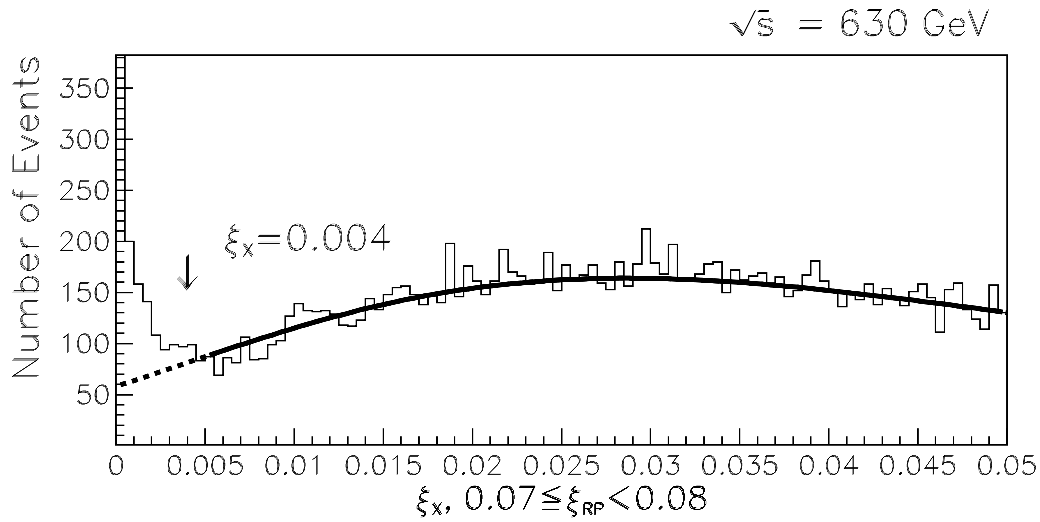


- ➜ The slope (power) in the region $10^{-4} < \xi < 10^{-2}$ changes very little
- ➜ The number of events with $\xi \leq 0.02$ increases about $13 \sim 17$ % after the smearing at 630 GeV

A spike near $\xi_{\bar{p}}^{X} = 0$ in the $\xi_{\bar{p}}^{X}$ dist.

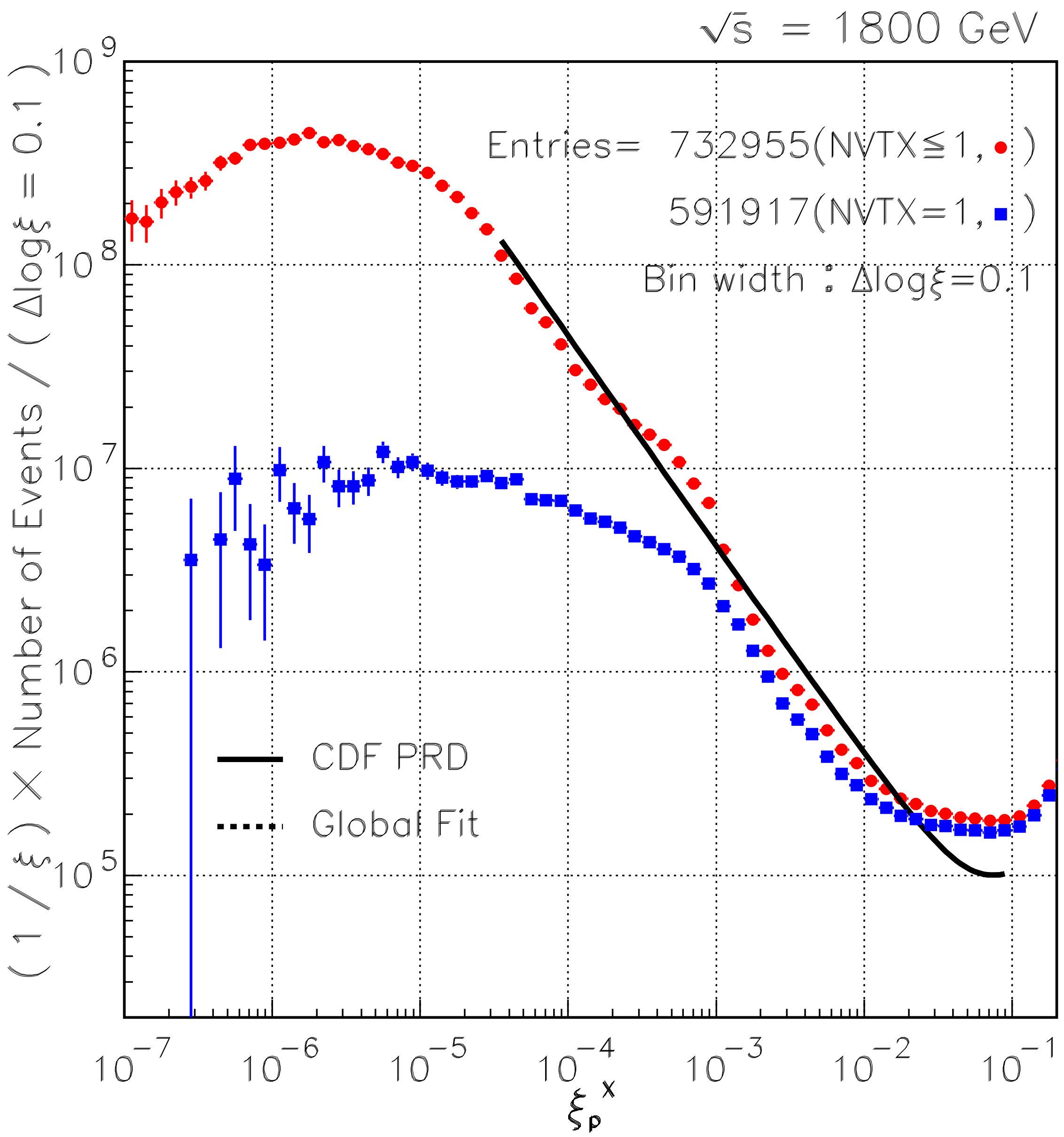
In the $\xi_{\bar{p}}^{X}$ distributions for several $\xi_{\bar{p}}^{RP}$ intervals, there is a peak near $\xi_{\bar{p}}^{X} = 0$.





Events in the peak are probably due to a fake Roman Pot track ➜ Exclude events with $\xi_{\bar{p}}^{X} \leq 0.02$ (0.04) at 1800 (630) GeV

ξ_p^X distribution



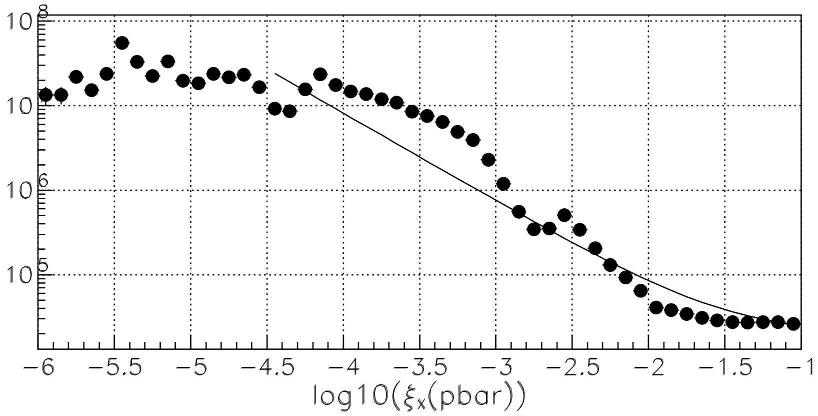
- The ξ_X distribution shows a $\sim 1/\xi$ dependence over about 3 decades
- What is the bump around $\xi \sim 7 \cdot 10^{-4}$?

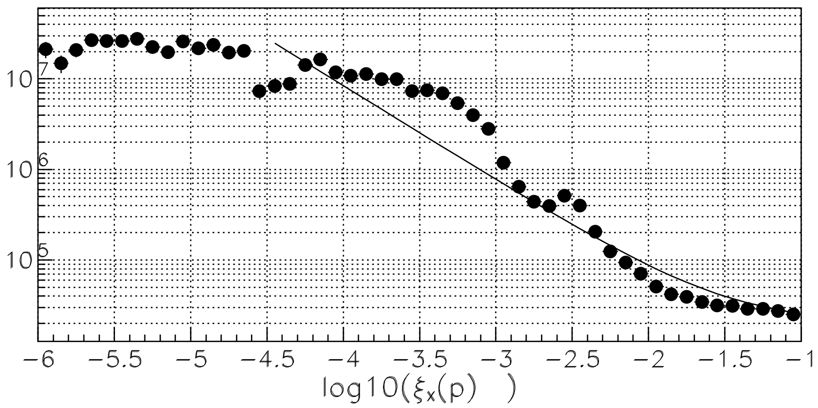
Bump in the ξ_p^X distribution

Is the bump due to the beam-gas BG?

Make ξ_p^X and $\xi_{\bar{p}}^X$ distributions for Run 1A beam crossing triggers (zero-bias events)

Since the densities of p and $\bar{p}$ beams are different, beam-gas BG rates for the $\bar{p}$ and p sides should be also different





The ξ_p^X and $\xi_{\bar{p}}^X$ distributions are almost the same ➜ The bump is not due to the beam-ga BG

Bump in the ξ_p^X distribution

Is the bump due to calorimeter noise?

A noise in the central calorimeter corresponds to $\xi \sim 0.0004$

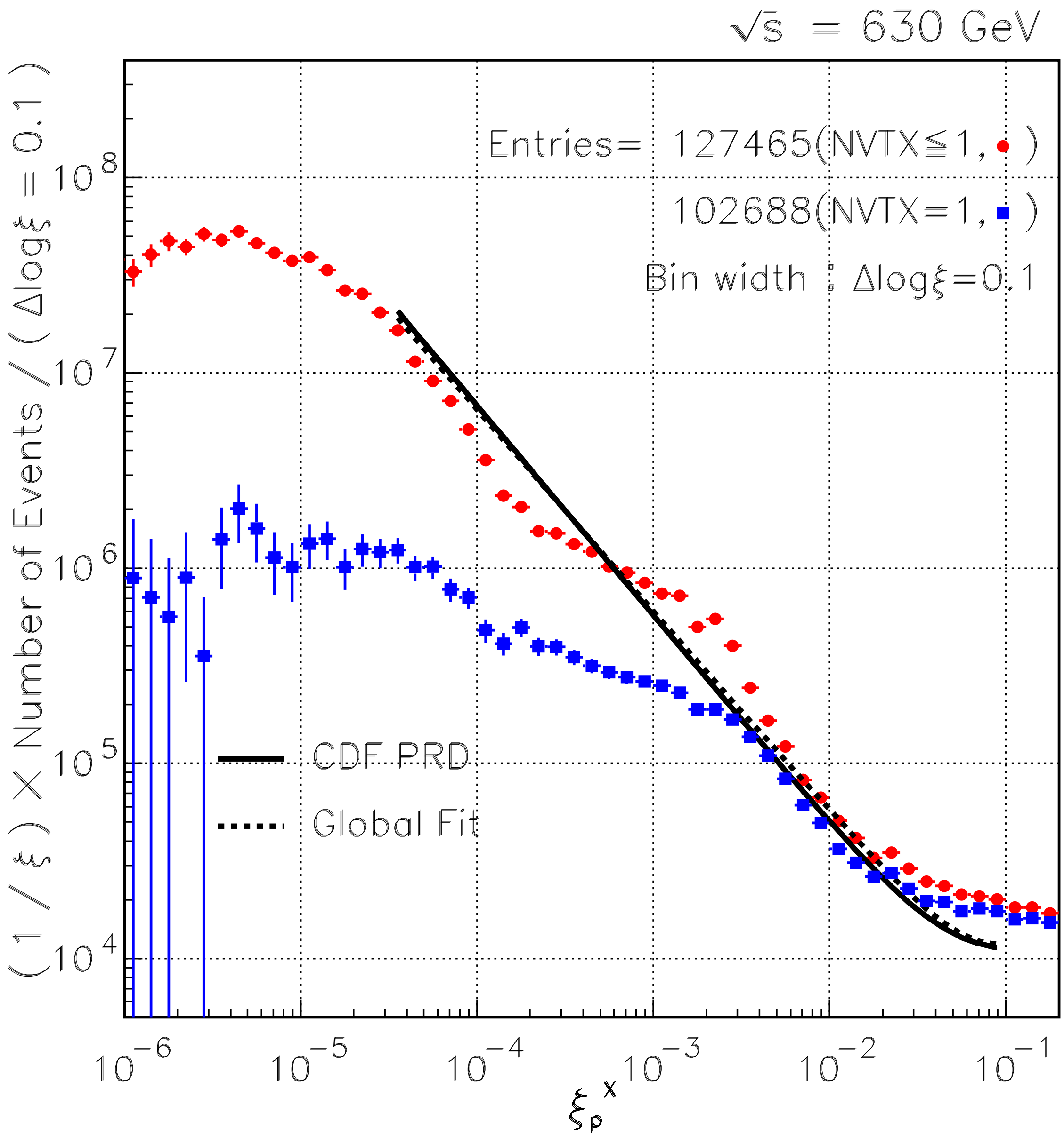
Use the Mary's calorimeter threshold (CDF4947) instead of the Suren's calorimeter threshold (CDF3697)

➜ The ξ_X distribution changes very little

- The bump may reflect the non-uniformity of the calorimeter (we miss some particles in the calorimeter crack regions which causes a shift in ξ_X)
- The shower effect of particles in the plug and forward calorimeter causes a shift in ξ_X

To be further investigated

ξ_p^X distribution



- The ξ_X distribution shows a $\sim 1/\xi$ dependence
- A bump is observed around $\xi_p^X = 2 \cdot 10^{-3}$

Ratio of $R[\frac{DPE}{SD}]$

At $\sqrt{s} = 1800$ GeV,

$$R[\frac{DPE}{SD}] = \frac{144665}{732954} = 0.197 \pm 0.0005\ (stat)$$

for $0.035 < \xi_{\bar{p}} < 0.095$ and $\xi_p < 0.02$.
(FYI : If events with $\xi^X_{\bar{p}} \leq 0.002$ are not excluded, the ratio is $R[\frac{DPE}{SD}] = 0.212$.)

The number of events with $\xi_p < 0.02$ increases after the smearing. $R[\frac{DPE}{SD}] = 0.197 \rightarrow 0.187$

- These ratios are in general agreement with predictions from the latest renormalization model (0.18)
- These ratios do not depend on $\xi_{\bar{p}}$ much; the variation is within ± 3 % over $0.015 < \xi_{\bar{p}} < 0.095$

Ratio of $R[\frac{DPE}{SD}]$

At $\sqrt{s} = 630$ GeV,

$$R[\frac{DPE}{SD}] = \frac{22099}{126702} = 0.174 \pm 0.001\ (stat)$$

for $0.035 < \xi_{\bar{p}} < 0.095$ and $\xi_p < 0.02$.

(FYI : If events with $\xi_{\bar{p}}^X \leq 0.004$ are not excluded, the ratio is $R[\frac{DPE}{SD}] = 0.195.$)

The number of events with $\xi_p < 0.02$ increases after the smearing. $R[\frac{DPE}{SD}] = 0.174 \rightarrow 0.151$

These ratios are in general agreement with predictions from the latest renormalization model (0.14)

Summary

We have found a signal of inclusive double pomeron exchange events in the Roman Pot triggered events.

- ξ_p^X distribution shows a nice $\sim 1/\xi$ dependence over a wide range of ξ_p^X
- Measured ratio of $R[\frac{DPE}{SD}] \sim 0.19$ (0.15) at 1800 (630) GeV (for $\xi_p < 0.02$ and $0.035 < \xi_{\bar{p}} < 0.095$) is closed to the prediction of the latest renormalization model (only one rapidity gap probability term in an event which needs to be renormalized)
- What has to be done?
  - Further investigate the bump in the ξ_p^X distribution
  - Study systematic uncertainties