Soft Double Diffractive Excitation at CDF

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6/3/99

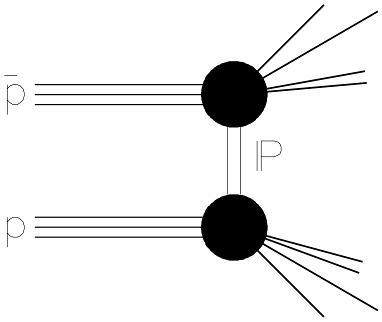
I. Introduction

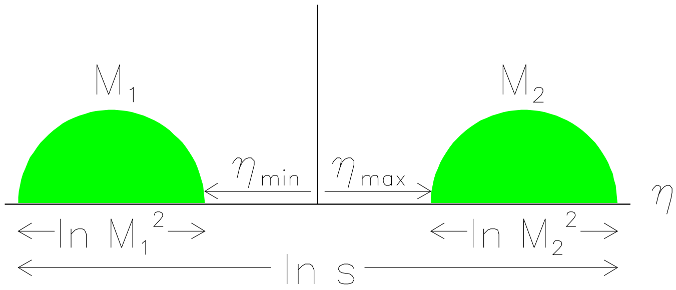
II. Data analysis

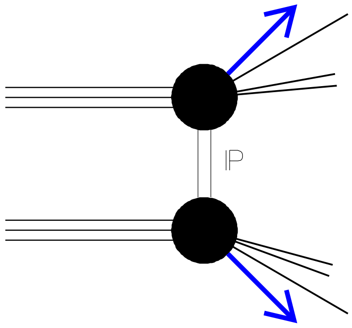
III. Results at 1800 and 630 GeV

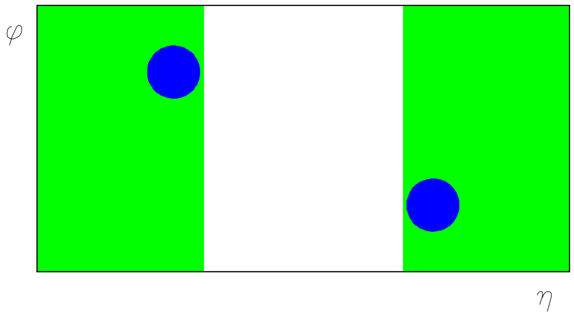
IV. Conclusions

Soft vs hard double diffraction



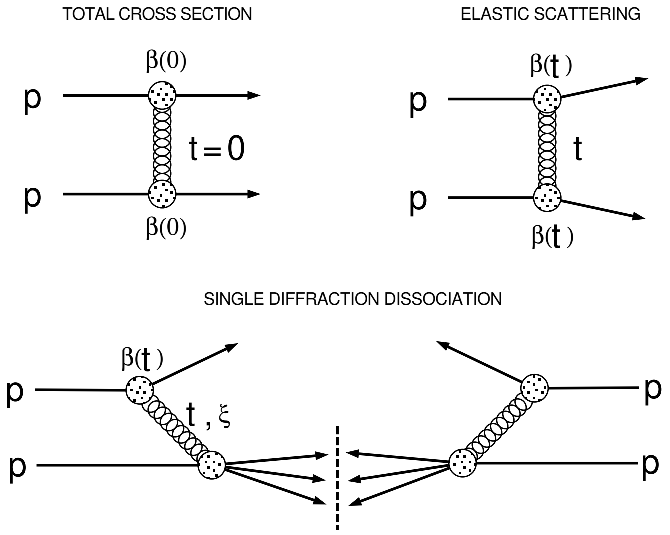


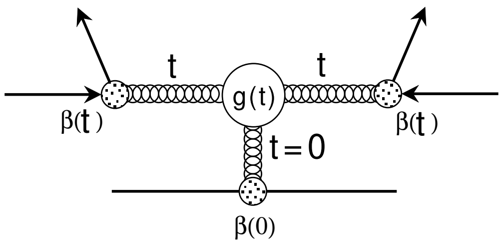




- survival probability?

Single Diffraction
(standard Regge theory)





$$\alpha(t) = 1 + \epsilon + \alpha' t$$

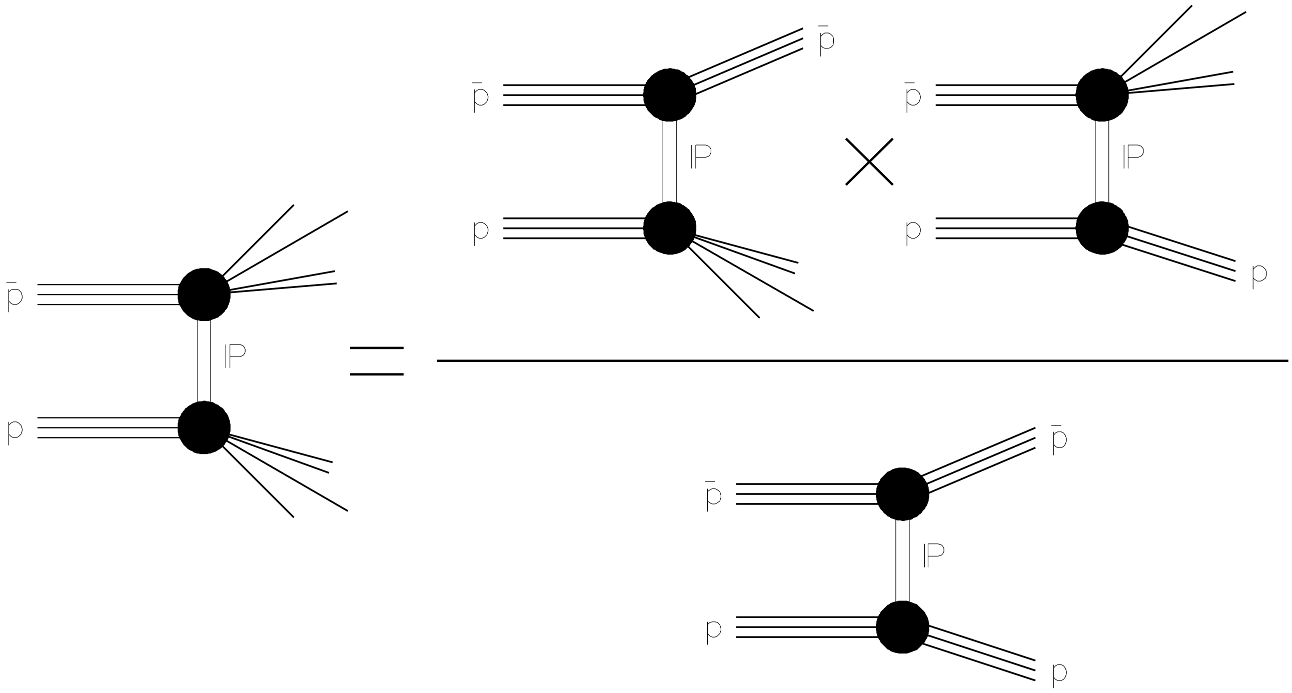
$$\sigma_T = \beta_1(0)\beta_2(0)(s/s_0)^{\alpha(0)-1}$$

$$\frac{d\sigma_{el}}{dt} = \frac{\beta_1^2(t)\beta_2^2(t)}{16\pi}\left(\frac{s}{s_0}\right)^{2[\alpha(t)-1]}$$

$$\frac{d^2\sigma_{SD}}{dt\, d\xi} = \underbrace{\frac{\beta_1^2(t)}{16\pi}\xi^{1-2\alpha(t)}}_{f_{I\!P/p}(\xi,t)}\ \underbrace{\beta_2(0)g(t)\left(\frac{s'}{s_0}\right)^{\alpha(0)-1}}_{\sigma^{I\!P p}(s',t)}$$

$$\xi = s'/s = M^2/s,\ \ s_0 = 1\ \mathrm{GeV}^2,\ \ g(t) \to g(0) = \kappa\beta_2(0)$$

Double Diffraction
(standard Regge theory and factorization)



$$\frac{d^3\sigma_{DD}}{dt\, dM_1^2\, dM_2^2} = \frac{d^2\sigma_{SD}}{dt\, dM_1^2}\,\frac{d^2\sigma_{SD}}{dt\, dM_2^2} \Big/ \frac{d\sigma_{el}}{dt}$$

$$= \frac{[\kappa\beta_1(0)\beta_2(0)]^2}{16\pi}\,\frac{s^{2\epsilon}}{(M_1^2 M_2^2)^{1+\epsilon}}\,e^{b_{DD}t}$$

$$b_{DD} = 2\alpha' \ln \frac{s s_0}{M_1^2 M_2^2}$$

$$\kappa\beta^2_{I\!\!Pp}(0) = 2.82 \text{ mb}, \quad \epsilon = 0.104, \quad \alpha' = 0.25 \text{ GeV}^{-2}$$

gap width: $\Delta y \sim \ln\left(\frac{s s_0}{M_1^2 M_2^2}\right)$

center of gap: $y_0 \sim \frac{1}{2}\ln\left(\frac{M_2^2}{M_1^2}\right)$

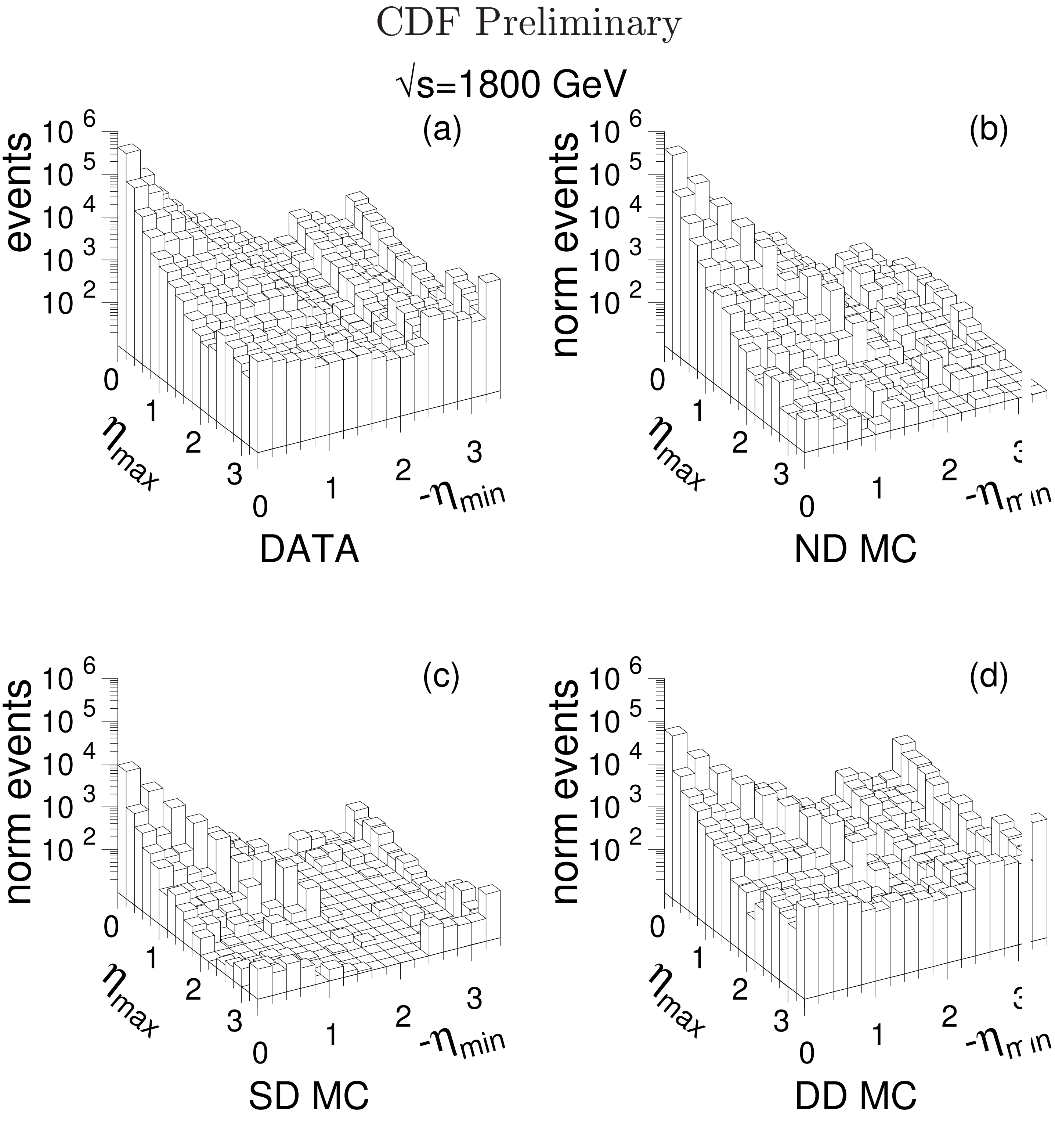
$$0 \leq \Delta y \leq \ln\frac{s s_0}{M_0^4}, \qquad |y_0| \leq \frac{1}{2}\left(\ln\frac{s s_0}{M_0^4} - \Delta y\right)$$

$$(M_{1,2}^2)_{min} = M_0^2 = 1.5\ \mathrm{GeV}^2$$

$$\frac{d^3\sigma_{DD}}{dt\, d\Delta y\, dy_0} = \underbrace{\kappa\beta_{I\!Pp}^2(0)\left(\frac{s'}{s_0}\right)^{\epsilon}}\underbrace{\frac{\kappa\beta_{I\!Pp}^2(0)}{16\pi}\, e^{2\epsilon\Delta y} e^{2\alpha'\Delta y\, t}}$$

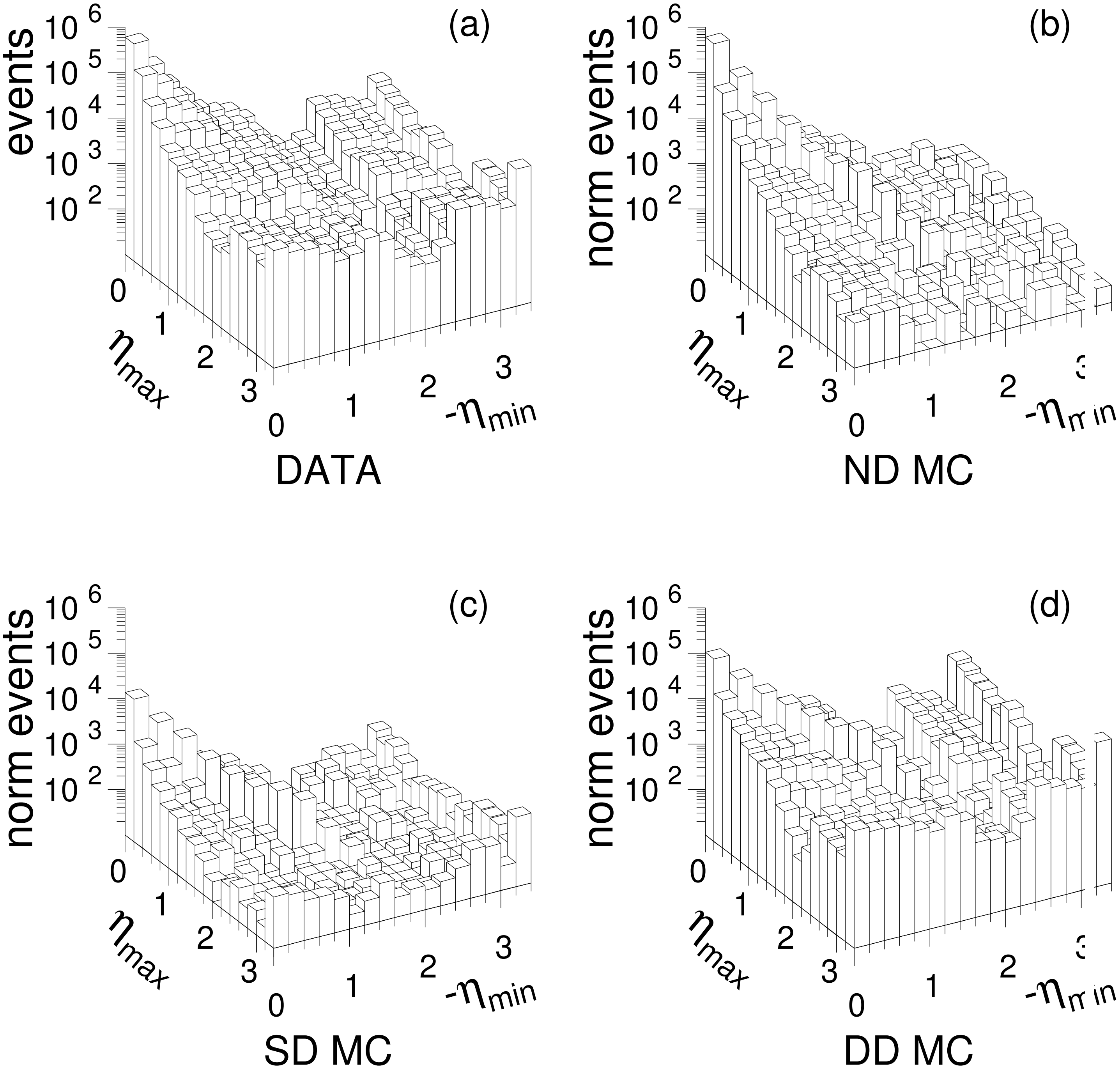
reduced energy $s' = M_1^2 M_2^2/s_0 = s\, e^{-\Delta y} = s\xi$

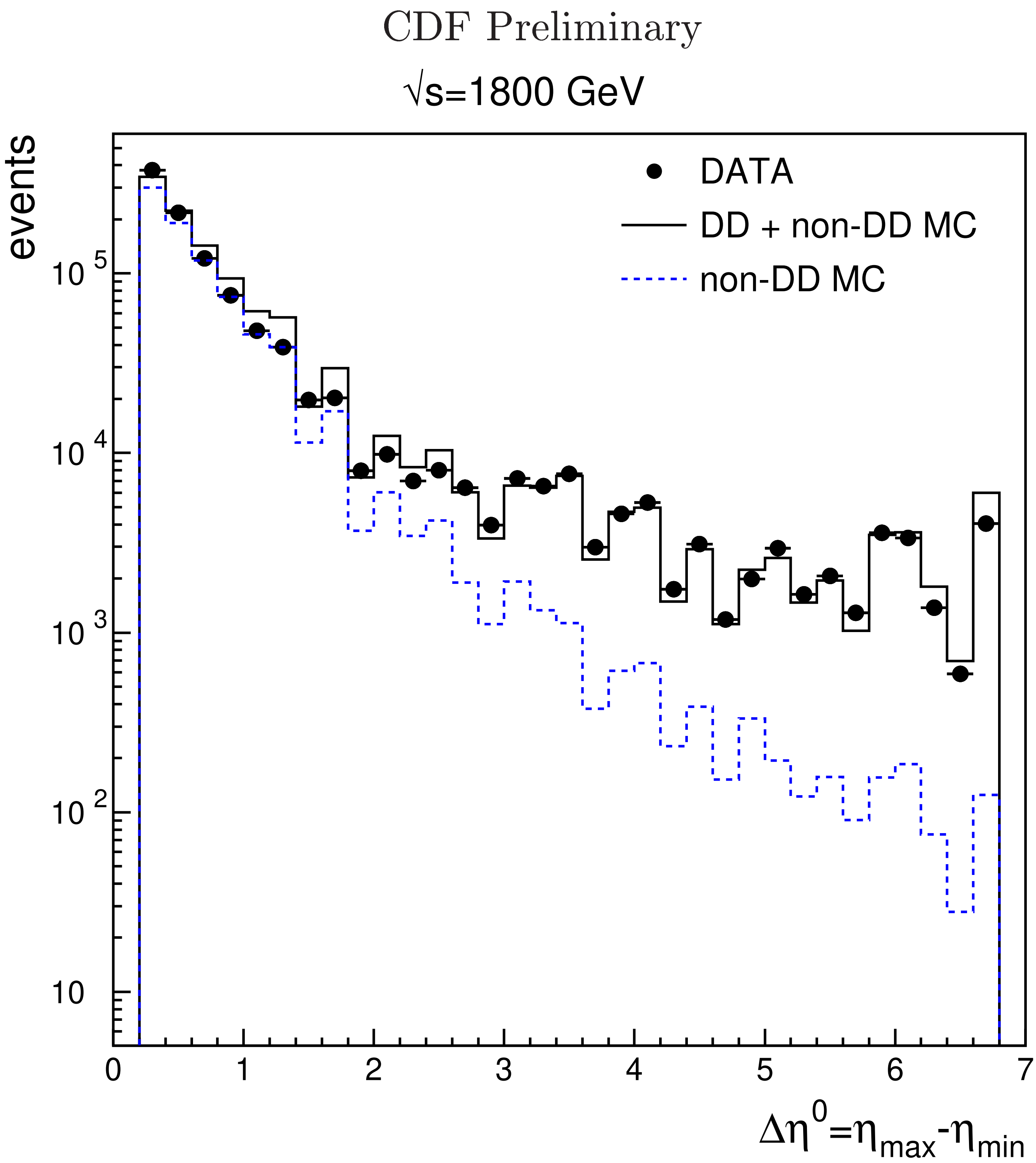
$$\frac{d^3\sigma_{DD}}{dt\, d\xi\, dy_0} = \underbrace{\kappa\beta_{I\!Pp}^2(0)\left(\frac{s'}{s_0}\right)^{\epsilon}}\underbrace{\frac{\kappa\beta_{I\!Pp}^2(0)}{16\pi}\, \frac{1}{\xi^{1+2\epsilon}} e^{-2\alpha' t \ln\xi}}$$


CDF Preliminary
√s=1800 GeV
(a)
events
DATA
(b)
norm events
ND MC
(c)
norm events
SD MC
(d)
norm events
DD MC
η_{max}
$-\eta_{min}$

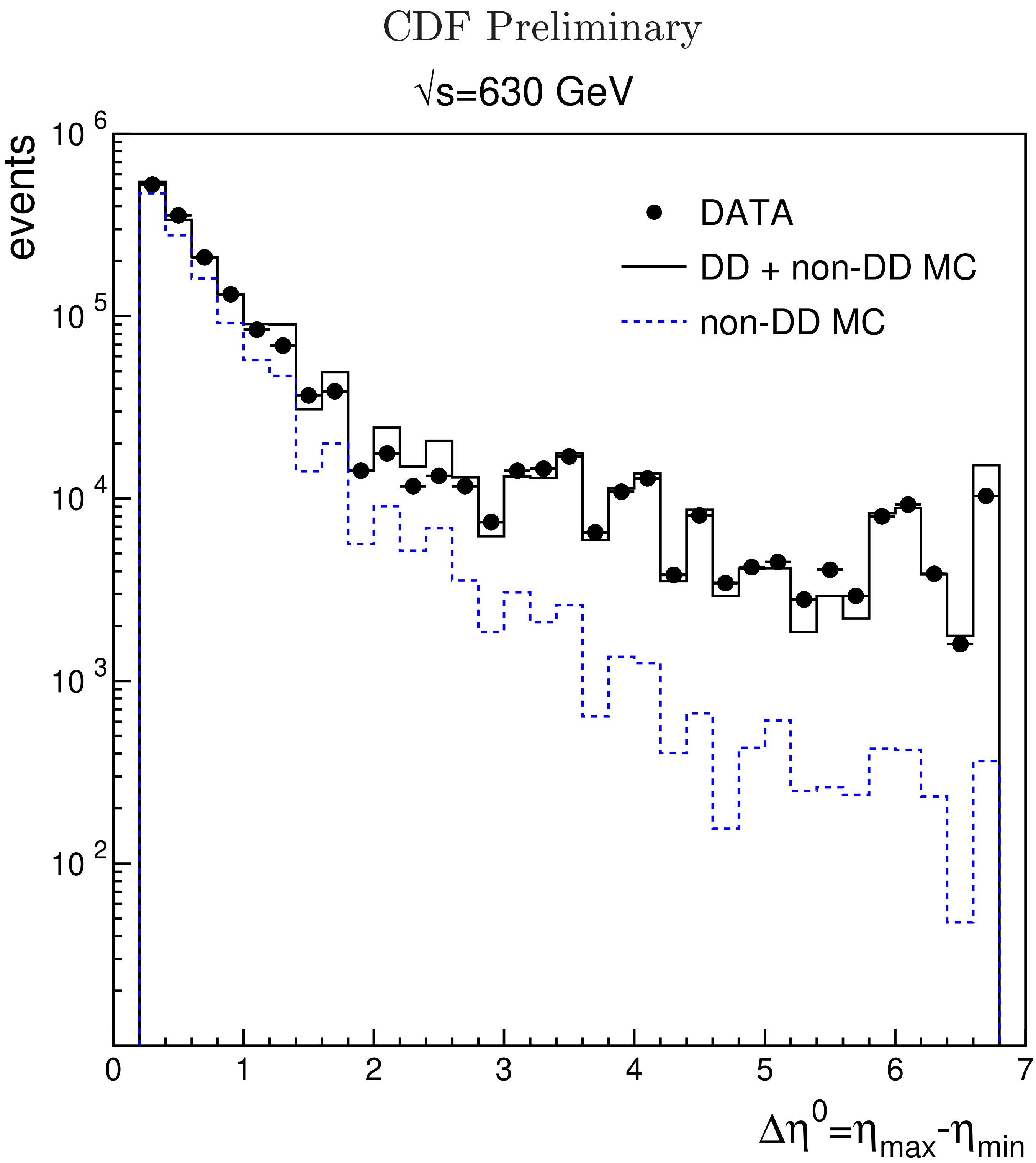
CDF Preliminary

$\sqrt{s}$=630 GeV





CDF Preliminary
√s=1800 GeV
events
DATA
DD + non-DD MC
non-DD MC
10
10 2
10 3
10 4
10 5
0
1
2
3
4
5
6
7
Δη0=ηmax-ηmin


CDF Preliminary
√s=630 GeV
events
DATA
DD + non-DD MC
non-DD MC
$\Delta\eta^0=\eta_{max}-\eta_{min}$

CDF Preliminary

DD cross section for central gaps greater than

3 units of rapidity

$\sqrt{s} = 1800$ GeV

$$\sigma_{DD}(\Delta\eta^0 > 3, \sqrt{s} = 1800 \text{ GeV}) =$$

$$= (51.2 \pm 1.7 \text{ mb}) \; \frac{59880 - 7199}{1021400(1.151)} \times 1/A$$

$$= 2.29 \pm 0.01(\text{stat}) \pm 0.07(\sigma_{BBC}) \pm \text{syst}(\text{bkgrd}) \text{ mb} \times 1/A$$

Standard Regge theory

$$\sigma_{DD}(\Delta\eta^0 > 3, \sqrt{s} = 1800 \text{ GeV}) = 23.1 \text{ mb} \times 1/A$$

$\rightarrow$ discrepancy factor $D = 0.10$

CDF Preliminary

DD cross section for central gaps greater than
3 units of rapidity
$\sqrt{s} = 630$ GeV

$$\sigma_{DD}(\Delta\eta^0 > 3, \sqrt{s} = 630 \text{ GeV}) =$$

$$= (39.9 \pm 1.2 \text{ mb}) \, \frac{136671 - 13802}{1670764(1.107)} \times 1/A$$

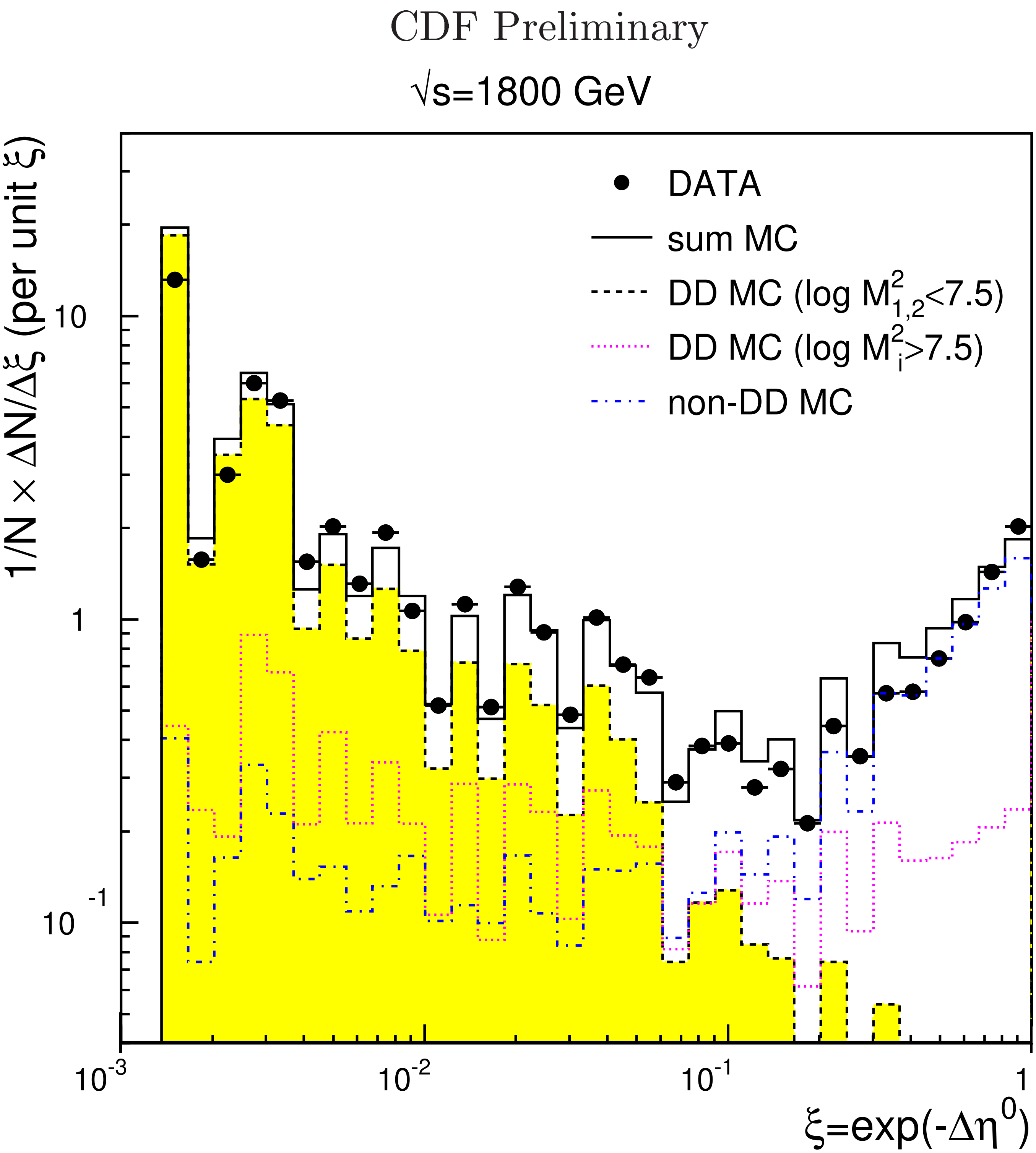
$$= 2.65 \pm 0.01(\text{stat}) \pm 0.08(\sigma_{BBC}) \pm \text{syst}(\text{bkgrd}) \text{ mb} \times 1/A$$

Standard Regge theory
$\sigma_{DD}(\Delta\eta^0 > 3, \sqrt{s} = 630 \text{ GeV})) = 17.6 \text{ mb} \times 1/A$

$\rightarrow$ discrepancy factor $D = 0.15$

$$\frac{D(630)}{D(1800)} \sim 1.5 \sim \frac{1}{s^{2\epsilon}}$$

Goulianos, Phys. Lett. B**358**, 379 (1995)



CDF Preliminary
√s=1800 GeV
DATA
sum MC
DD MC (log $M^2_{1,2}$<7.5)
DD MC (log M^2_i>7.5)
non-DD MC
1/N × ΔN/Δξ (per unit ξ)
ξ=exp(-Δη^0)
10
1
10^{-1}
10^{-3}
10^{-2}
10^{-1}
1

Preliminary Results for Central Rapidity Gaps in Minimum-Bias Events

The measured double-diffractive cross sections at $\sqrt{s} = 1800$ and 630 GeV are an order of magnitude smaller than what is predicted using standard Regge theory based on the triple Pomeron amplitude and factorization. However, the shape of the mass distribution is in agreement with the standard theory.