DPF 2000
The Ohio State University
August 10, 1999

Double Diffraction Dissociation in $\bar{p}p$ Collisions at the Fermilab Tevatron

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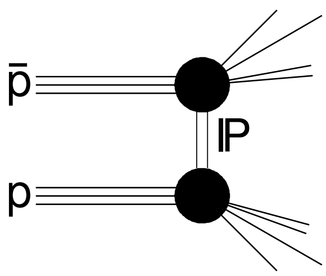
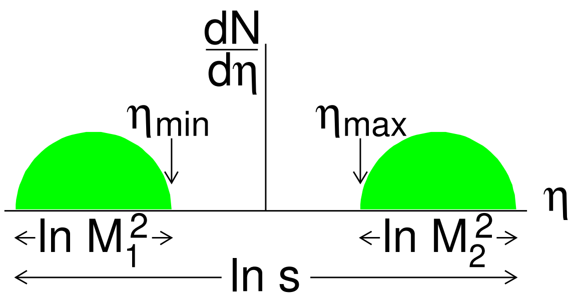
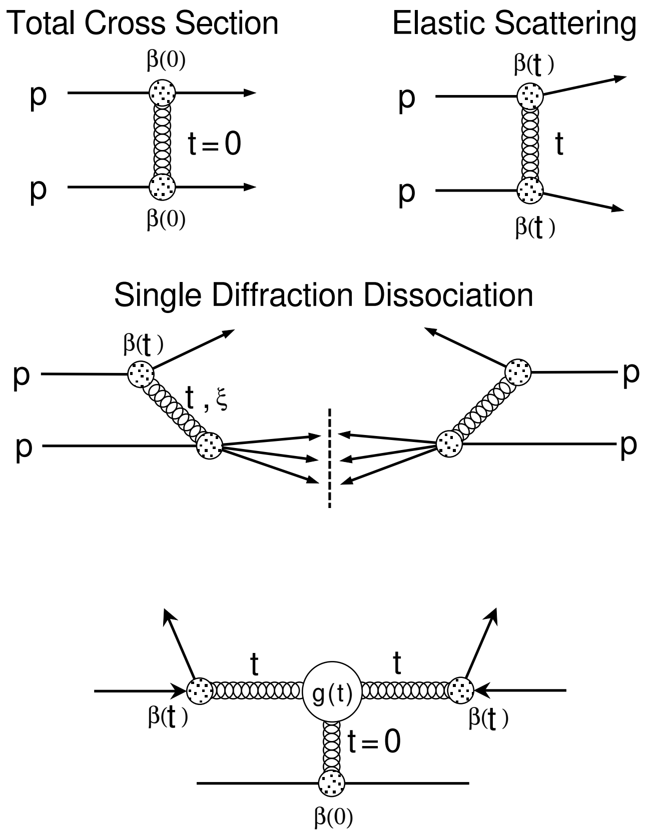




Regge theory based on Pomeron exchange



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

$$g(t) \approx g(0) \equiv \kappa\beta(0)$$

$$\xi = M^2/s$$

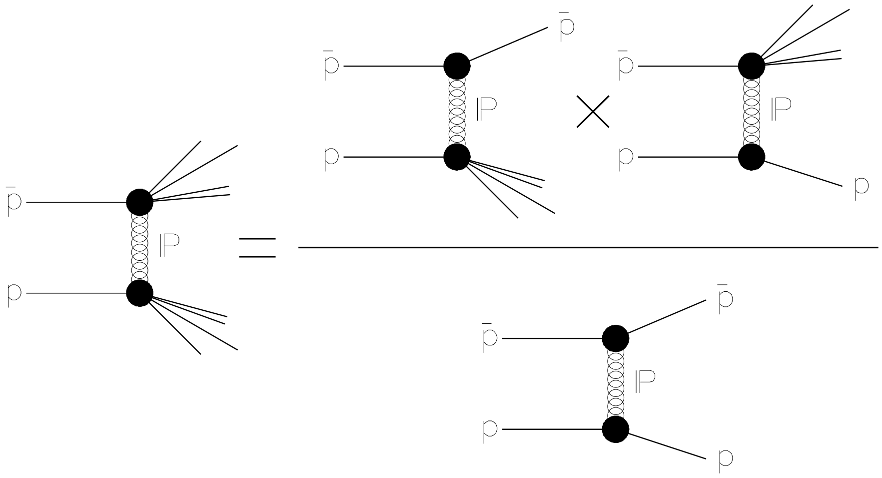
$$s_0 \equiv 1 \text{ GeV}^2$$

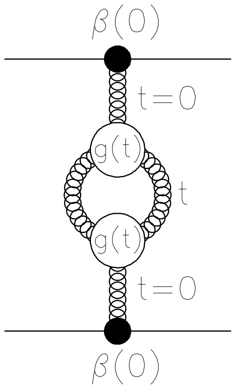
$$\sigma_T = \beta_1(0)\beta_2(0)\left(\frac{s}{s_0}\right)^{\alpha(0)-1}$$

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

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

Double Diffraction
(Regge theory and factorization)





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

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

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

$\kappa\beta^2(0) = 2.82$ mb, $\quad \epsilon = 0.104, \quad \alpha' = 0.25\ \mathrm{GeV}^{-2}$

Diffractive cross sections in terms of rapidity gap

gap width: $$\Delta y \approx \ln\left(\frac{s s_0}{M_1^2 M_2^2}\right) \underset{SD}{\Longrightarrow} \ln\frac{1}{\xi}$$

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

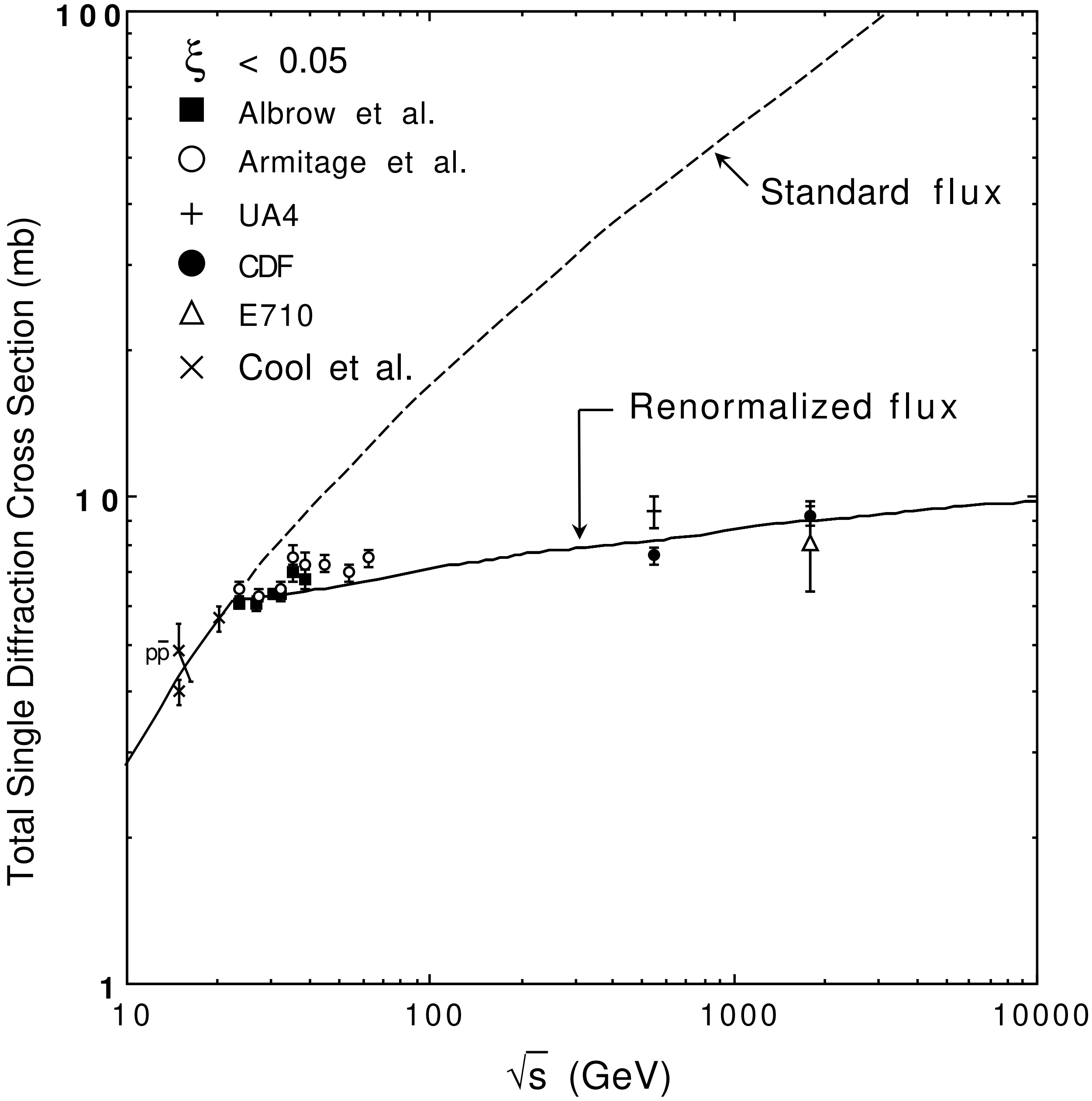
reduced energy: $$s' = s\, e^{-\Delta y}$$

$$\frac{d^3\sigma_{DD}}{dt\, d\Delta y\, dy_0} = \underbrace{\frac{\kappa\beta^2(0)}{16\pi}\, e^{2(\epsilon+\alpha' t)\Delta y}}_{\substack{P(\Delta y, y_0, t) \\ \text{gap probability}}} \underbrace{\kappa\beta^2(0)\left(\frac{s'}{s_0}\right)^{\epsilon}}_{\substack{\text{reduced energy} \\ \text{cross section}}}$$

$$\frac{d^2\sigma_{SD}}{dt\, d\Delta y} = \underbrace{\frac{\beta^2(t)}{16\pi}\, e^{2(\epsilon+\alpha' t)\Delta y}}_{P(\Delta y, t)} \underbrace{\kappa\beta^2(0)\left(\frac{s'}{s_0}\right)^{\epsilon}}$$

Total Single-Diffractive Cross Section

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



SD differential cross section from Regge theory ok, integral ($\sim s^{2\epsilon}$) too high

Monte Carlo event generation

Non-Diffractive – PYTHIA

Single-, Double-Diffractive – CDF min-bias MC:

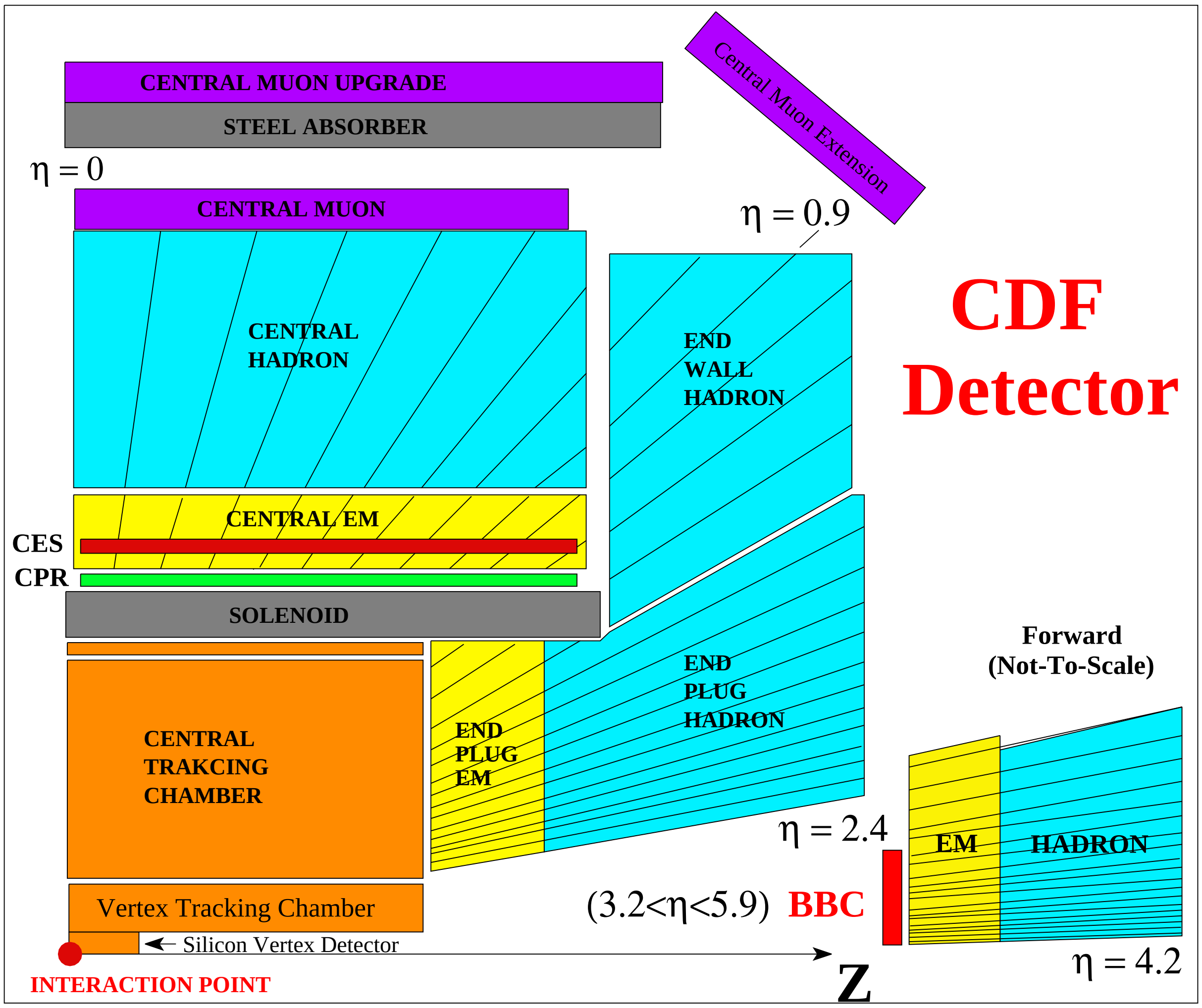
- specifically designed to reproduce soft-interaction results from lower-energy experiments
- differential cross sections as above
- used in CDF total cross section determination PRD **50**, 5550 (1994)

Monte Carlo detector simulation

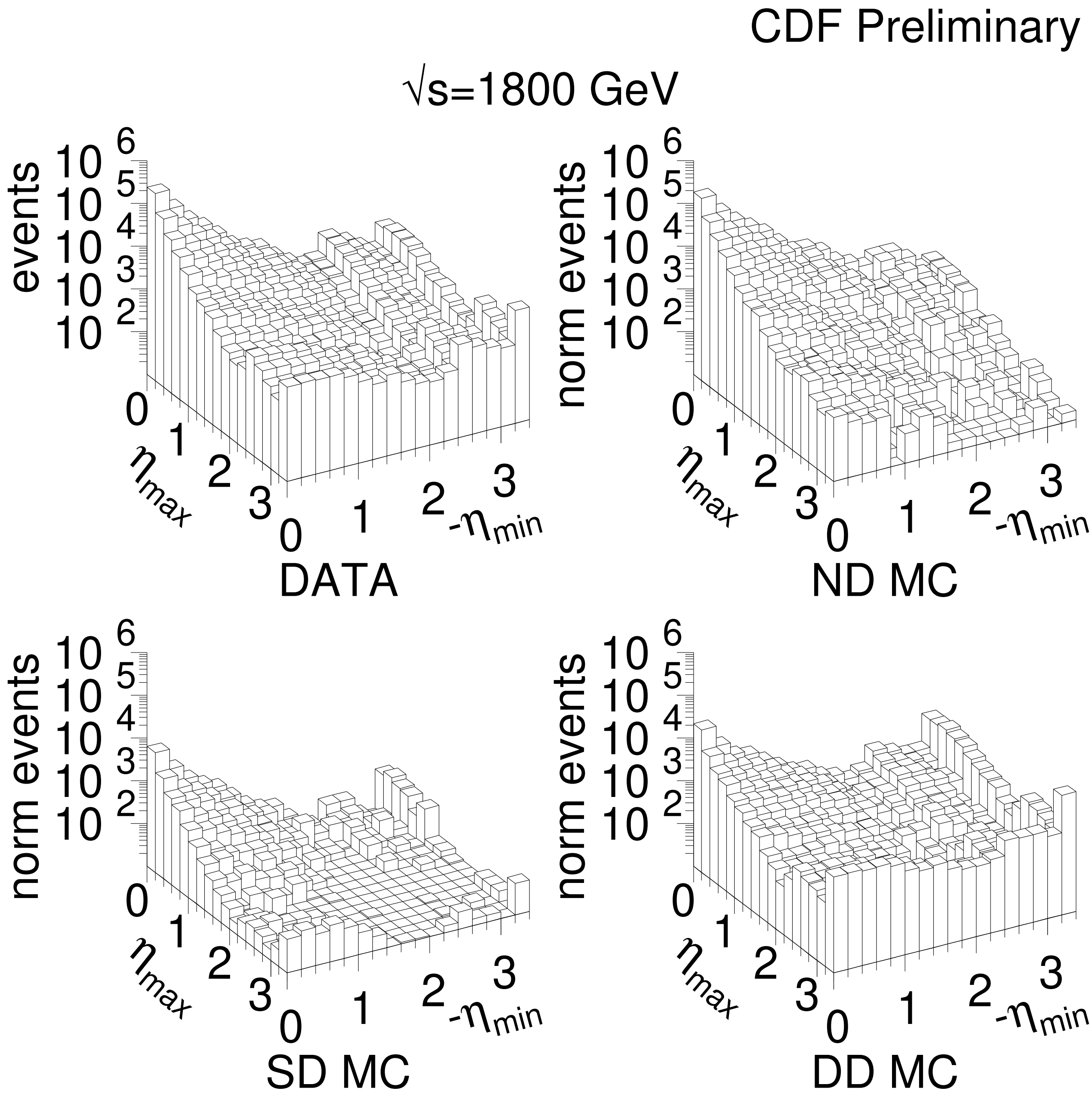
standard CDF tracking

calorimeter not well-calibrated for low p_T particles

- hit calorimeter towers are determined using calibrations determined specifically for low-p_T particles
- different calibrations are used for diffractive MC (different $\langle p_T \rangle$)

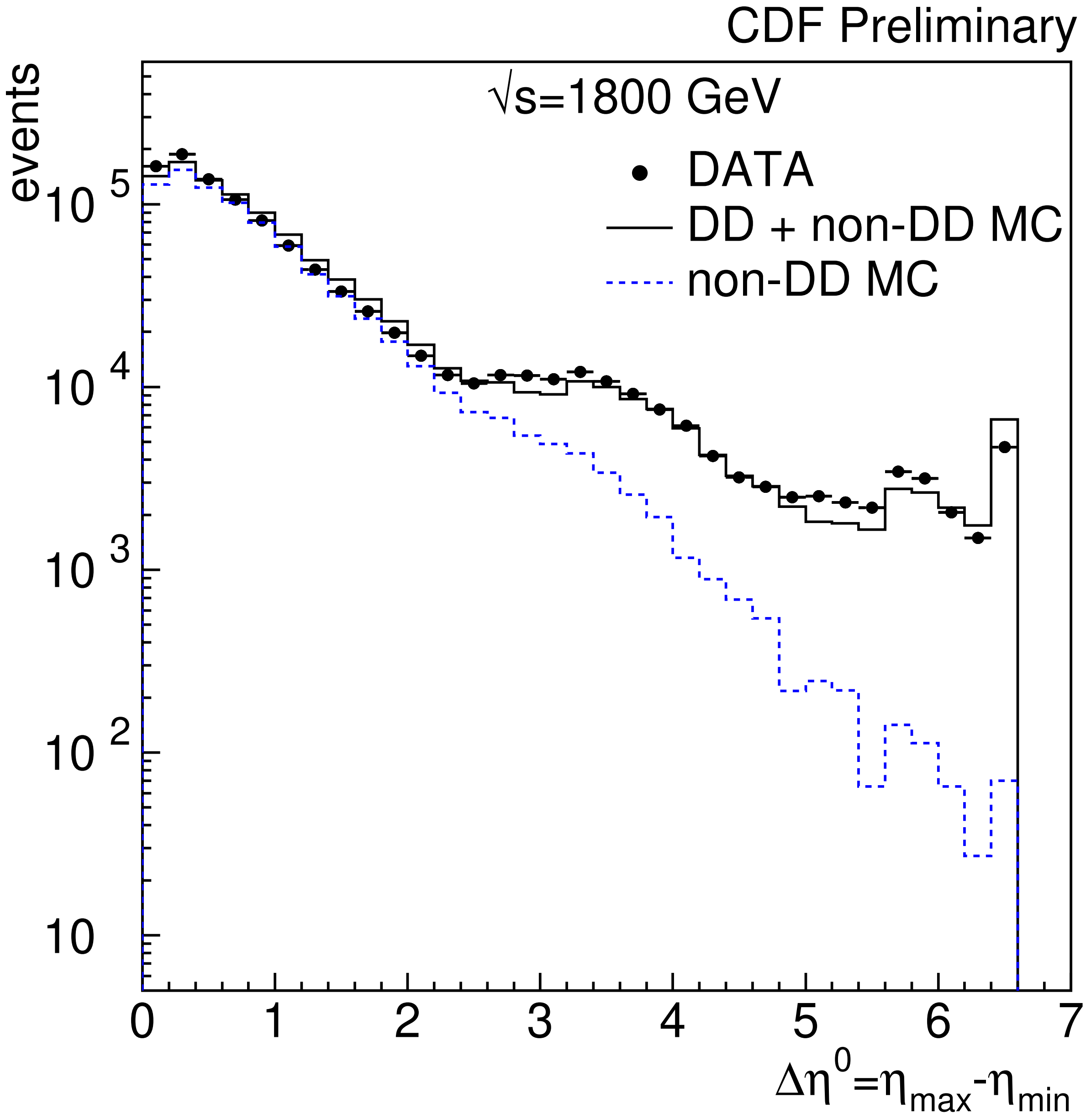

CENTRAL MUON UPGRADE
STEEL ABSORBER
Central Muon Extension
η = 0
CENTRAL MUON
η = 0.9
CENTRAL HADRON
END WALL HADRON
CDF Detector
CENTRAL EM
CES
CPR
SOLENOID
END PLUG HADRON
Forward (Not-To-Scale)
CENTRAL TRAKCING CHAMBER
END PLUG EM
η = 2.4
EM
HADRON
Vertex Tracking Chamber
(3.2<η<5.9)
BBC
Silicon Vertex Detector
INTERACTION POINT
Z
η = 4.2

Number of events as a function of η_{max} vs $-\eta_{min}$



Number of events as a function of

$\Delta\eta^0 = \eta_{max} - \eta_{min}$



CDF Preliminary

DD cross section at $\sqrt{s} = 1800$ GeV

$$\sigma_{DD}(\Delta\eta^0 > 3) = (51.2 \pm 1.7 \text{ mb}) \frac{91387 - 21561^{+11682}_{-10379}}{1006651(1.15)A}$$

$$= [3.08 \pm 0.01(\text{stat})^{+0.47}_{-0.53}(\text{syst}) \text{ mb}]/A$$

detector acceptance $A = (56.6 \pm 7.4)\%$

$$\sigma_{DD}(\Delta\eta^0 > 3) = 5.45 \pm 0.02(\text{stat})^{+1.10}_{-1.17}(\text{syst}) \text{ mb}$$

from differential cross section:

$\sigma_{DD}(\Delta\eta > 3)/\sigma_{DD}(\Delta\eta^0 > 3) = 1.43$

$$\sigma_{DD}(\Delta\eta > 3) = 7.78 \pm 0.03(\text{stat})^{+1.57}_{-1.67}(\text{syst}) \text{ mb}$$

CDF Preliminary

DD cross section at $\sqrt{s} = 630$ GeV

$$\sigma_{DD}(\Delta\eta^0 > 3) = (39.9 \pm 1.2 \text{ mb}) \frac{179846 - 53504^{+29854}_{-23700}}{1573527(1.11)A}$$

$$= [2.89 \pm 0.01(\text{stat})^{+0.55}_{-0.69}(\text{syst}) \text{ mb}]/A$$

$$A = (63.2 \pm 6.5)\%$$

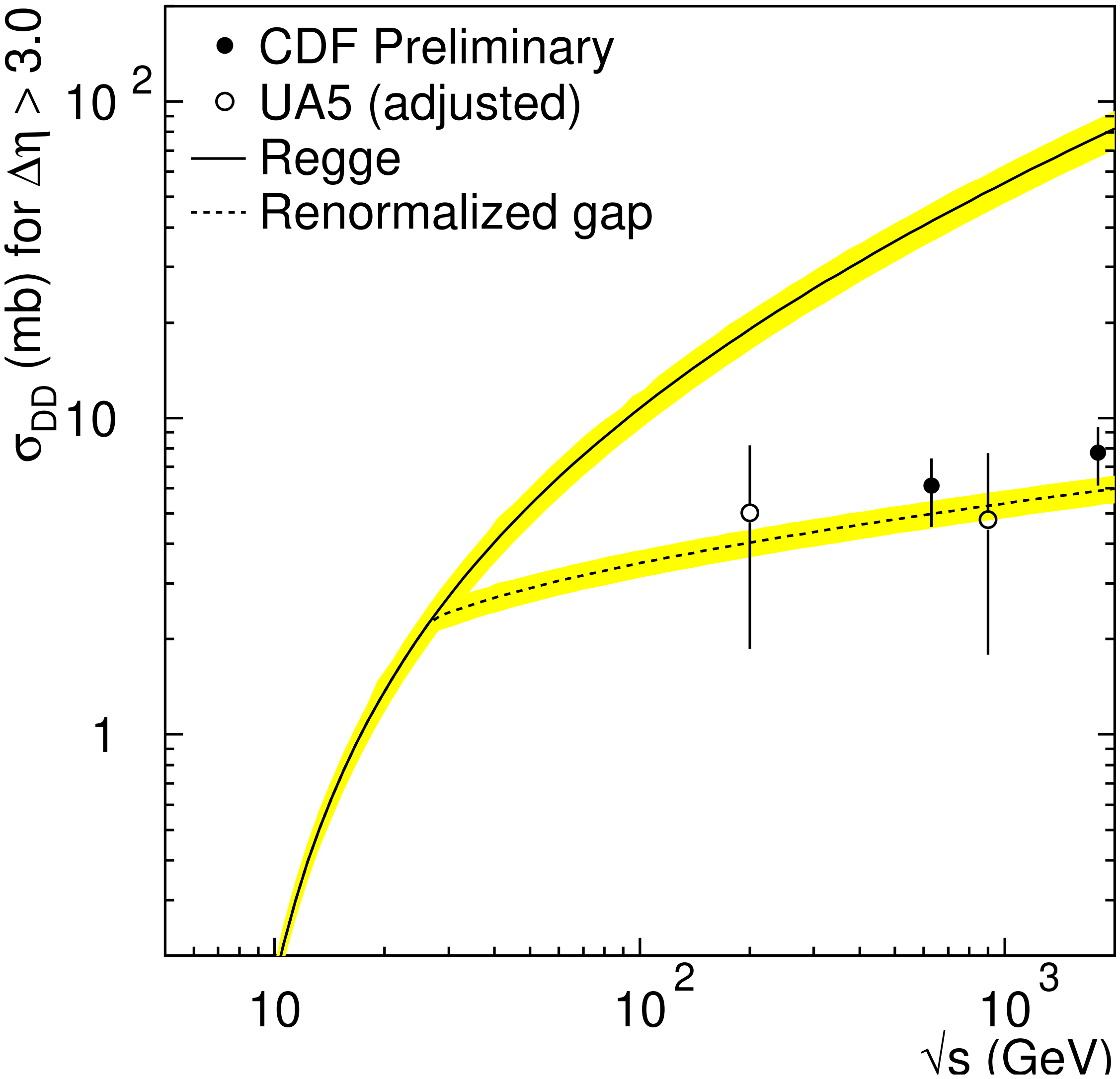
$$\sigma_{DD}(\Delta\eta^0 > 3) = 4.57 \pm 0.02(\text{stat})^{+0.99}_{-1.19}(\text{syst}) \text{ mb}$$

from differential cross section:

$$\sigma_{DD}(\Delta\eta > 3)/\sigma_{DD}(\Delta\eta^0 > 3) = 1.34$$

$$\sigma_{DD}(\Delta\eta > 3) = 6.12 \pm 0.03(\text{stat})^{+1.32}_{-1.59}(\text{syst}) \text{ mb}$$

Total Double-Diffractive Cross Section



Note: In the extrapolation of the UA5 data from the measured region to obtain $\sigma_{DD}(\Delta\eta > 3)$, we used a slope of $b = 2\alpha'\Delta\eta$ instead of the slope used by UA5, $b = 7\ \mathrm{GeV}^{-2}$.

$$\left(\frac{d^3\sigma_{DD}}{d\Delta\eta\, d\eta_0\, dt} \sim e^{2\epsilon\Delta\eta} e^{bt}\right)$$

Conclusions

total DD cross sections

$$\sigma_{DD}(\sqrt{s} = 1800 \text{ GeV}, \Delta\eta > 3) = 7.78^{+1.57}_{-1.67} \text{ mb}$$

$$\sigma_{DD}(\sqrt{s} = \ 630 \text{ GeV}, \Delta\eta > 3) = 6.12^{+1.32}_{-1.59} \text{ mb}$$

The measured double-diffractive cross sections at $\sqrt{s} = 1800$ and 630 GeV are ~ 10 times smaller than what is predicted using standard Regge theory based on the triple-Pomeron amplitude and factorization.
However, the shape of the gap-width distribution is in agreement with the differential cross section from Regge theory.