New Diffractive Results from the Tevatron

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(CDF collaboration)

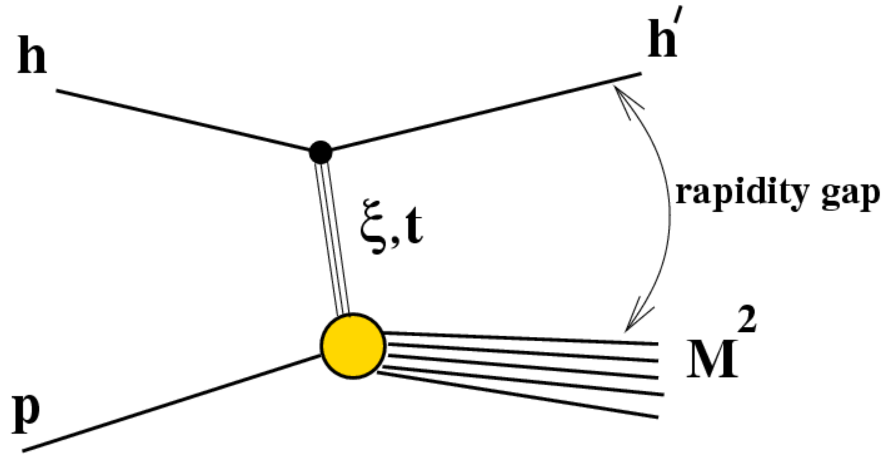
- ✓ Introduction
- ✓ Exclusive production (dijets, χ_c, $\gamma\gamma$, ...)
- ✓ Diffractive structure function
- ✓ Flavor dependence (W/Z)

Hadronic Diffraction

Small transferred momentum

Elastic and diffractive processes:
leading hadron emitted at small angle

the exchange ("pomeron") is colorless
⇨ rapidity gap



Diffractive processes

- **Non-diffractive interactions:**

  rapidity gaps are formed by multiplicity fluctuations

  Poisson statistics:

  $P(\Delta y) = e^{-\rho \Delta y}$ (ρ=particle density)

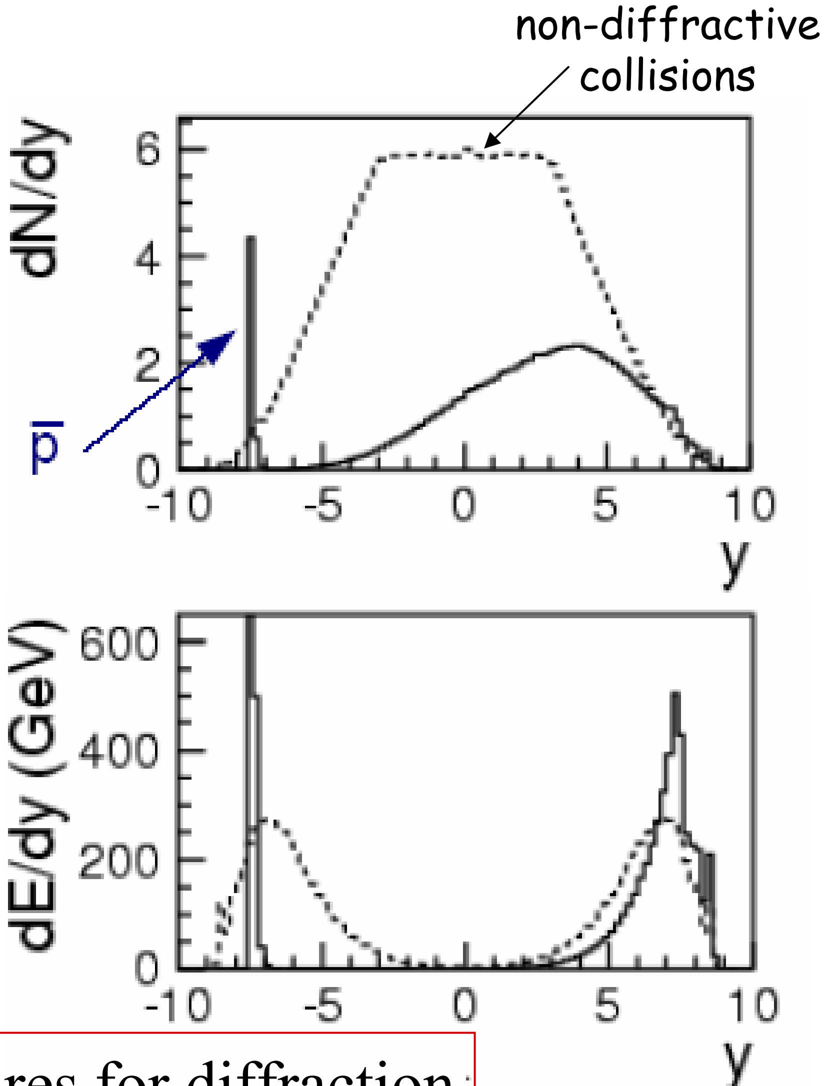
  ⇨gaps are exponentially suppressed

- **Diffractive interactions:**

  colorless exchange

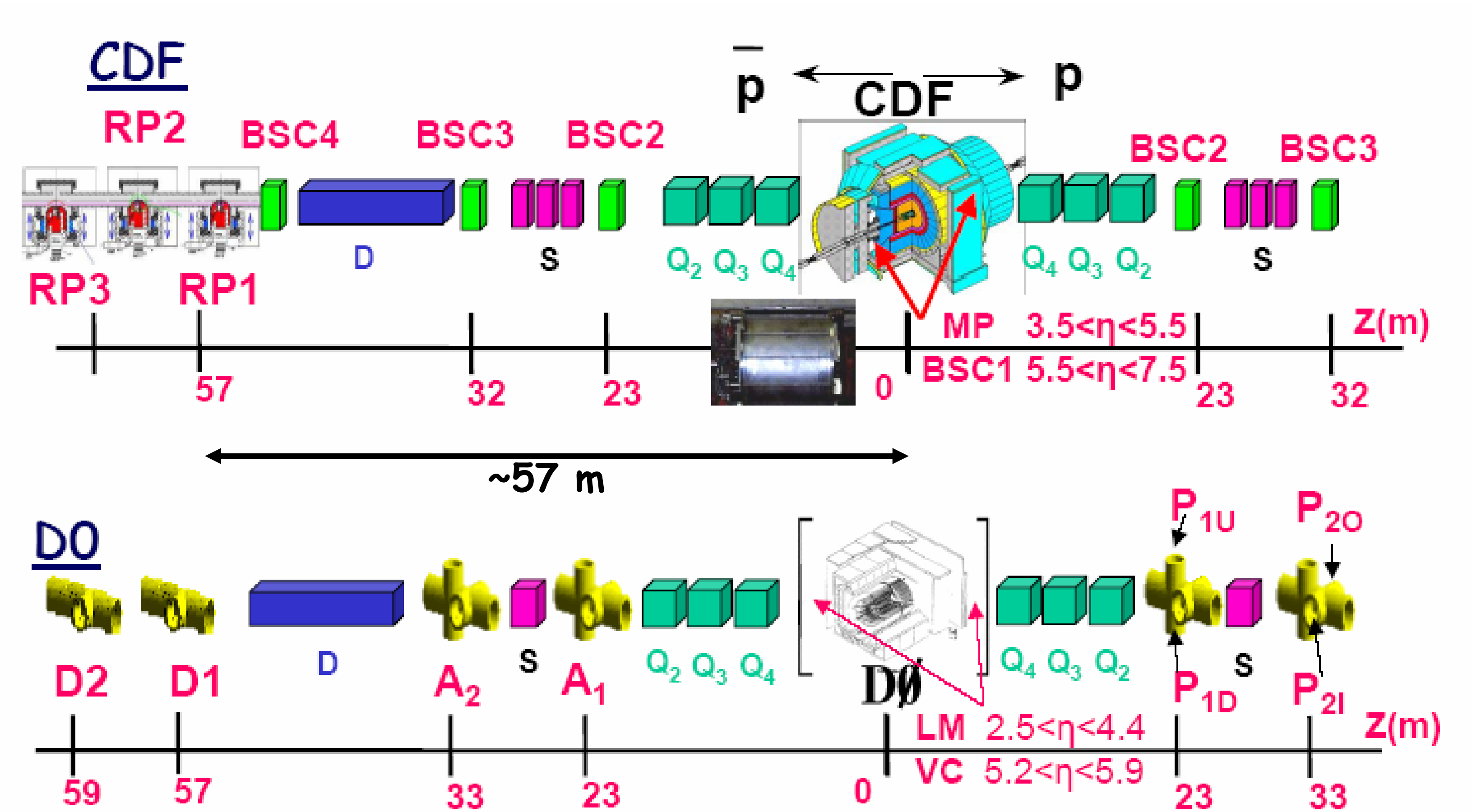
  $\Delta y \sim \ln 1/\xi$ (ξ=momentum loss fraction)

  ⇨ rapidity gaps survive (Δy>3)

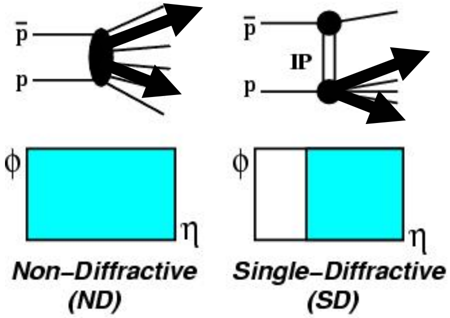


⇨ large rapidity gaps are signatures for diffraction

Run II detectors



Diffractive dijets

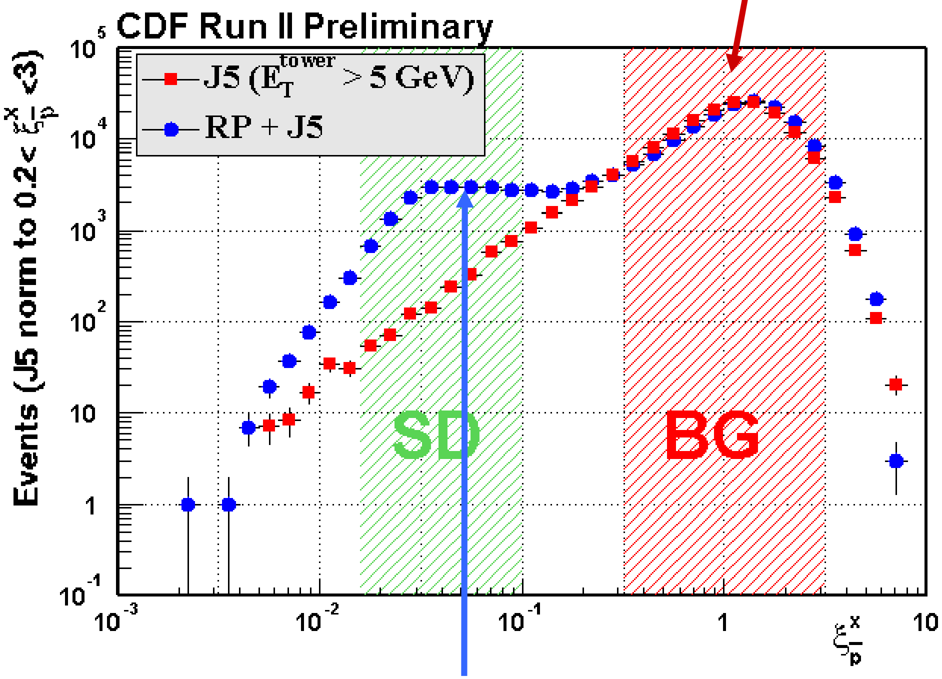


ξ : momentum loss fraction of pbar

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

MP energy scale: ±25% →Δlogξ = ±0.1
RP acceptance (0.03<ξ< 0.1) ~ 80% (Run I)

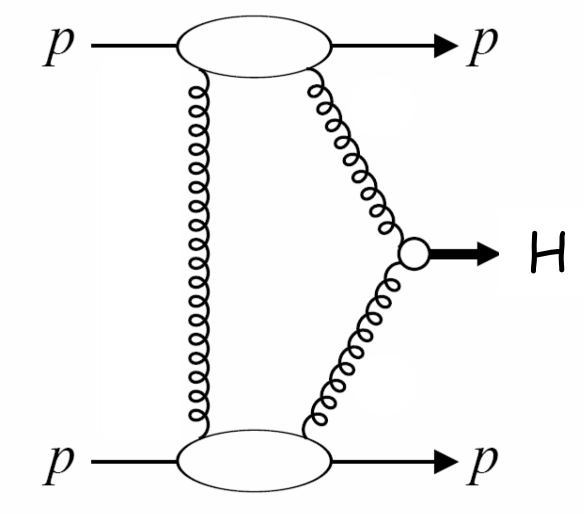
overlap events



Approx. flat at ξ<0.1

$$\frac{d\sigma}{d\xi} \propto \frac{1}{\xi} \rightarrow \frac{d\sigma}{d(\log\xi)} = \text{const}$$

Exclusive Higgs at LHC



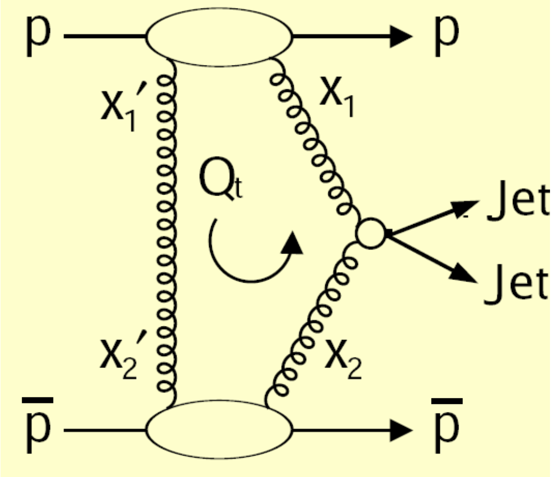
- hard gg→H process
- color neutral exchange
  - ⇨ rapidity gap signature
- clean process
- M_H= "missing mass" = $(s\ \xi_1\ \xi_2)^{1/2}$

Theory predictions:
⇨σ_H(LHC)~3 fb, signal/bkg~3 (if ΔM_{miss}=1 GeV)
Khoze, Martin, Ryskin

Bialas, Landshoff:
PLB 256,540 (1991)
Boonekamp, Peschanski, Royon:
PRL 87, 251806(2001)
Khoze, Martin, Ryskin:
Eur. Phys. J. C23, 311 (2002);
C25,391 (2002);C26, 229 (2002)

Attractive Higgs discovery channel at the LHC

Exclusive Dijets at Tevatron



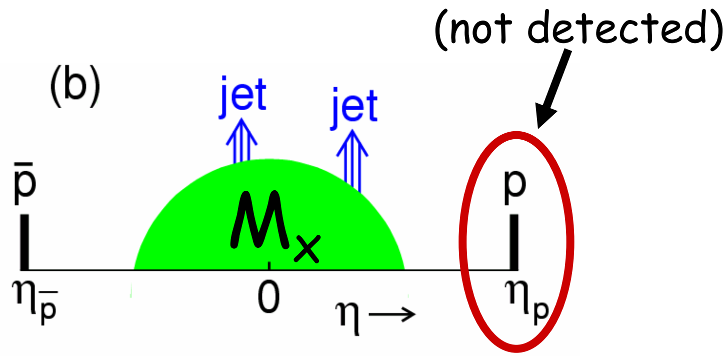
- similar to exclusive Higgs
- much larger cross section

...not observed yet...

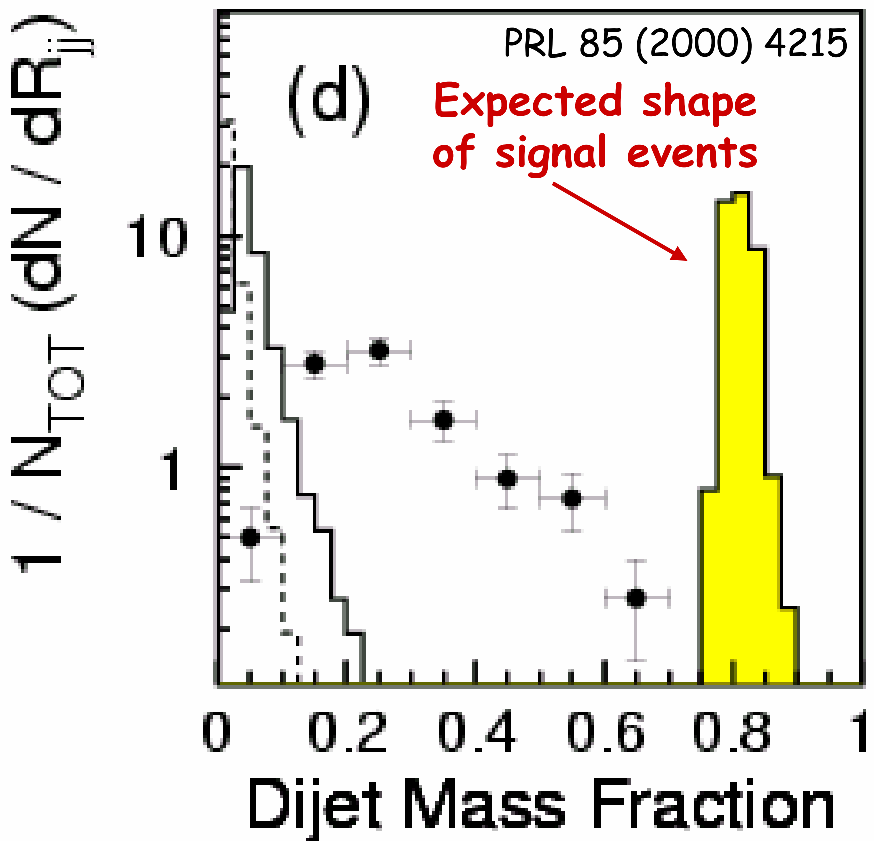
Goal:

- find exclusive dijet production (if it exists)
- measure cross section/upper limit
- calibrate Higgs predictions at LHC

Exclusive Dijets in Run I



Mass fraction: $R_{jj} = \frac{M_{jj}}{M_X}$

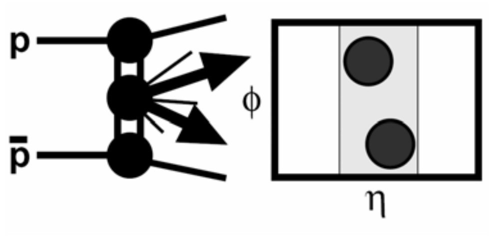


Exclusive dijet limit:
Run I: PRL 85 (2000) 4215
⇨ σ_{jj} (excl.) < 3.7 nb (95% CL)

theory expectns ~1 nb (Run I kinematics)

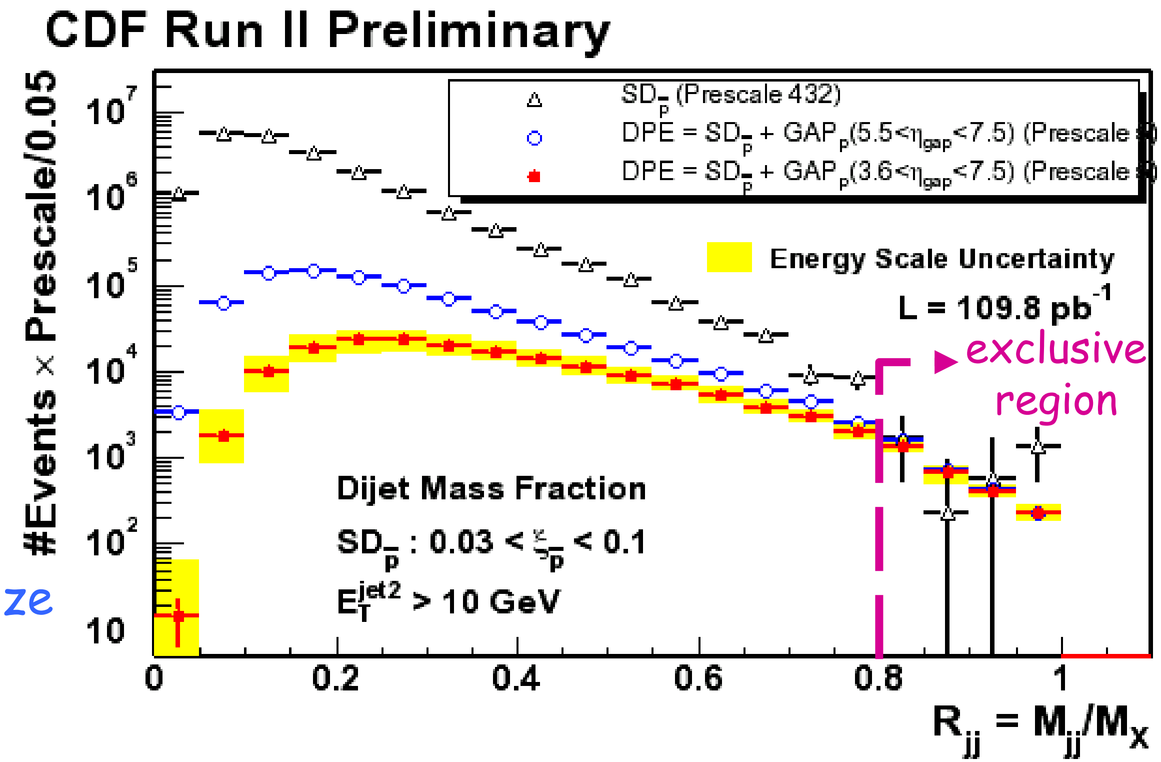
Dijet Mass Fraction

Double Pomeron Exchange (DPE)



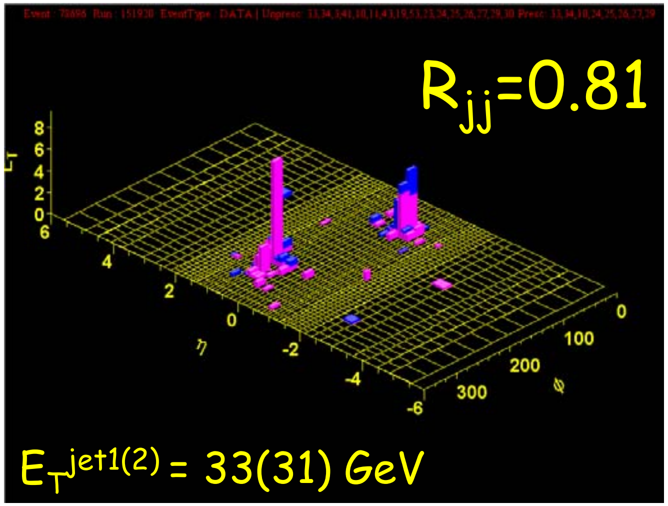
rate falls smoothly as $R_{jj} \rightarrow 1$
no excess at large R_{jj}

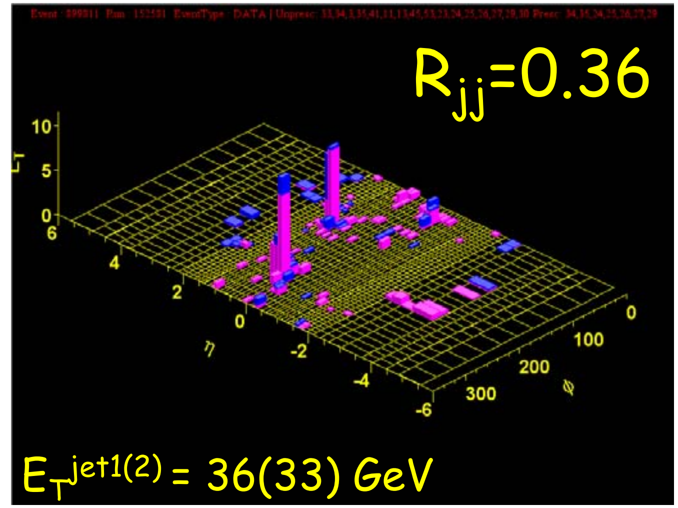
independent of rapidity gap size

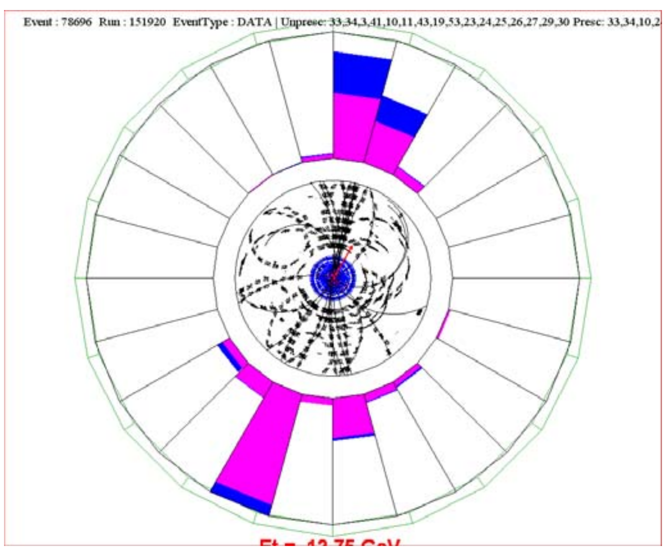


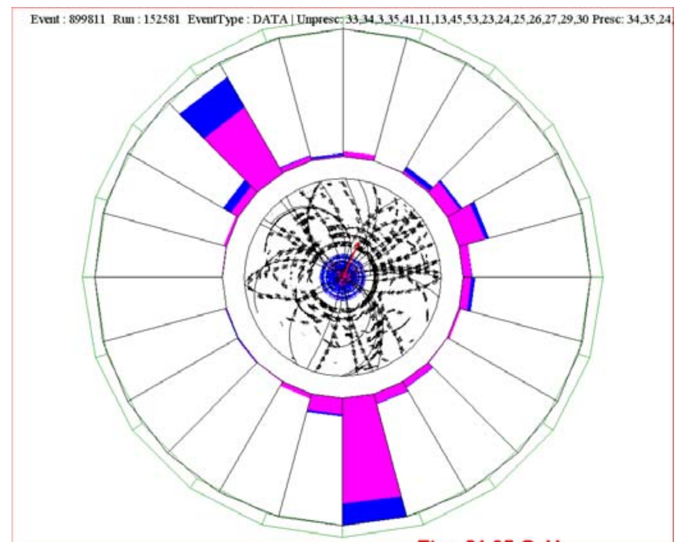
Minimum E_T(Jet1)	Cross section (R_{jj}>0.8)
10 GeV	1.1 ± 0.1(stat) ± 0.5(syst) nb
25 GeV	25 ± 3(stat) ± 10(syst) pb

Exclusive Dijet Events ?

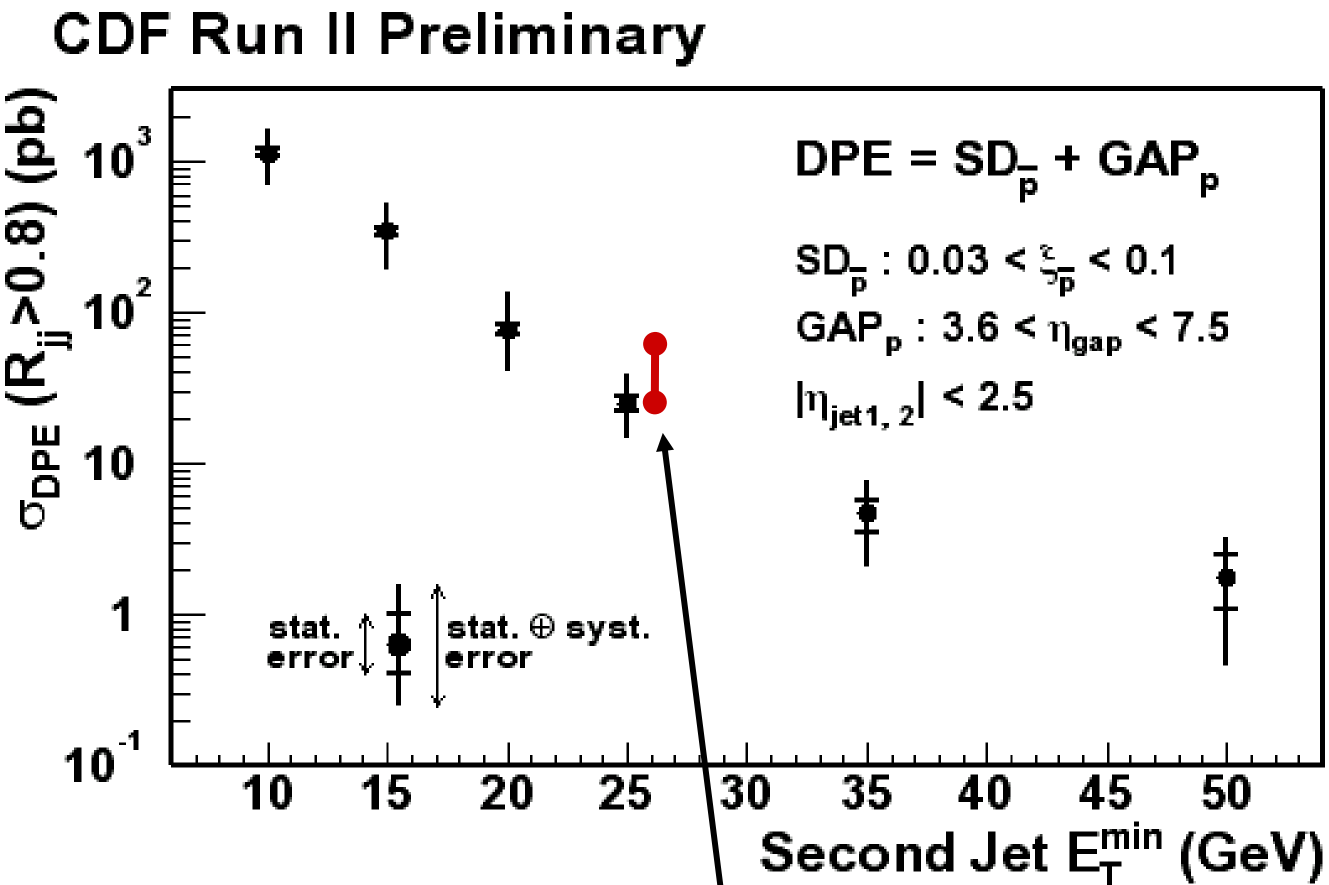








Limits on Exclusive production



Martin, Kaidalov, Khoze, Ryskin, Stirling
(hep-ph/0409258): ~ 40 pb (E_T>25 GeV) (factor ~2 uncertainty)

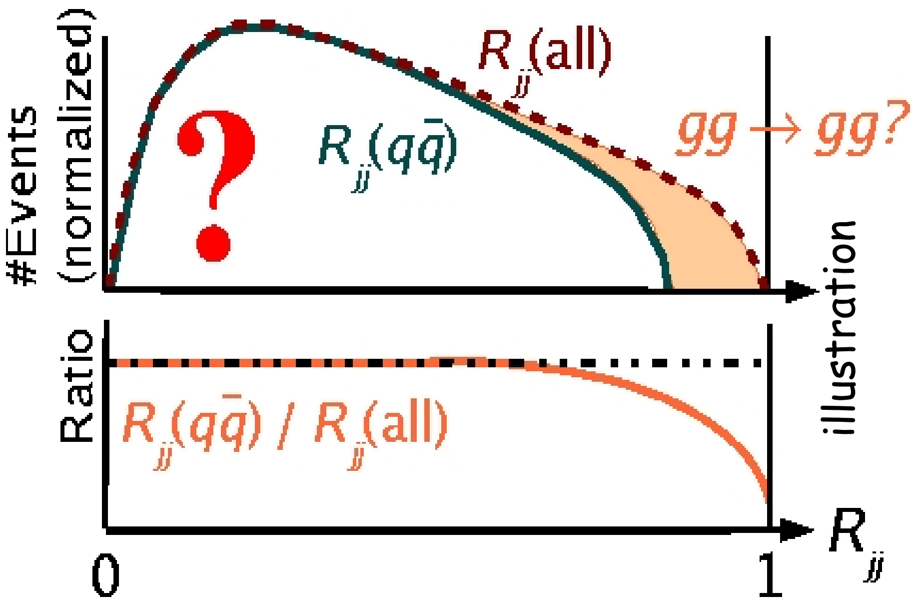
Heavy flavor exclusive dijets

Theory:
J_Z=0 spin selection rule
$gg \rightarrow gg$ dominant contribution at LO
$gg \rightarrow q\bar{q}$ suppressed when $M_{jj} \gg m_q$

Experimental method:
normalize R_{jj} for $q\bar{q}$ to R_{jj} for all jets
⇨look for event suppression at large R_{jj}

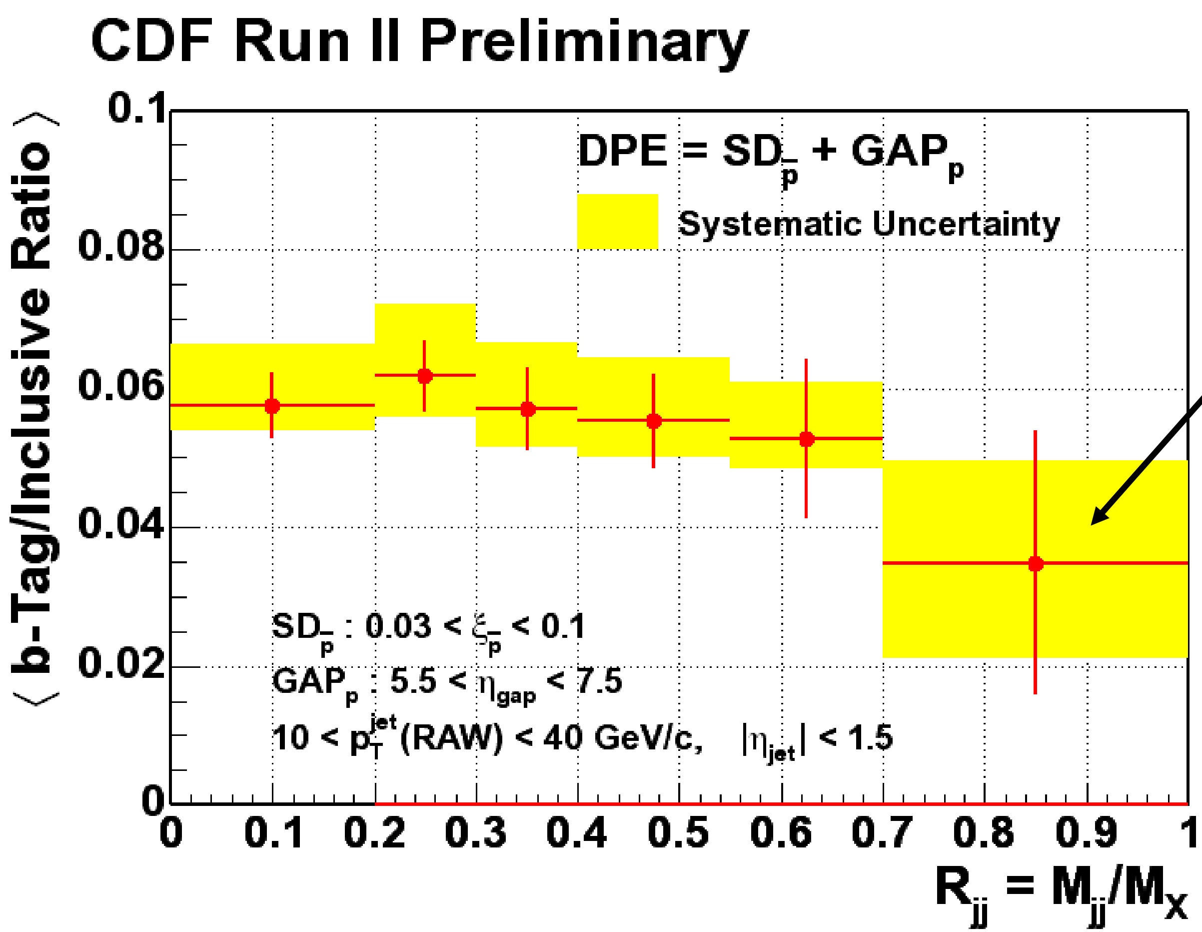
Pros: many systematics cancel out
good HF quarks id
small g mistag O(1%)

Cons: heavy quark mass:
contribution from exclusive b/c



⇨ use b-quark jets

HF tagged jet fraction



exclusive production?
need:
- to compare to MC
- more data !

$R_{btag}(>0.7)/R_{btag}(<0.4) = 0.59 \pm 0.33\ (stat) \pm 0.23\ (syst)$

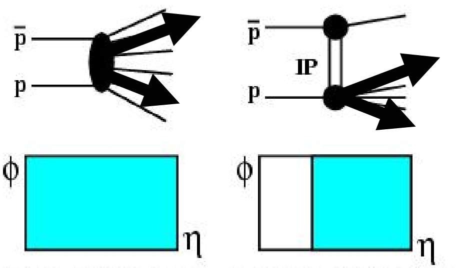
Future plans

Increase data sample:

⇨new exclusive b-jet trigger

- ➢~ 80% efficiency for SecVtx tagged jets
- ➢expect 900 tagged b-jets in 300 pb^{-1} at $L=3x10^{31}cm^{-2}s^{-1}$

⇨how does R_{btag}(>0.7) /R_{btag}(<0.4) look like in $b\bar{b}$ events?



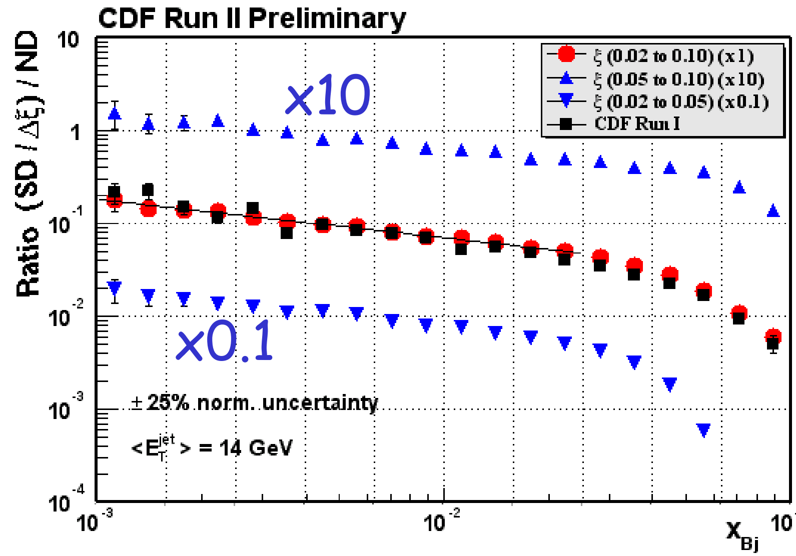
Non–Diffractive (ND)   *Single–Diffractive (SD)*

Diffractive dijets

ratio of SD/ND dijet event rates

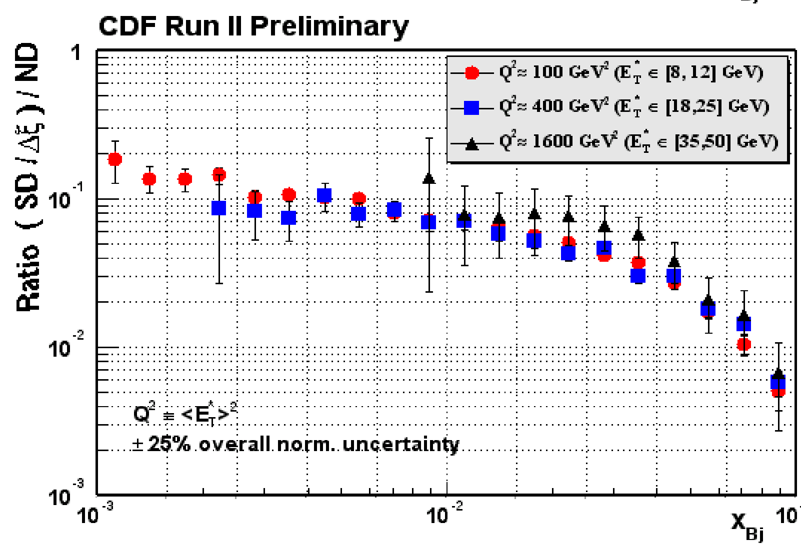
- slope and normalization agree with Run I result
- no ξ dependence observed 0.03<ξ<0.1

⇨ confirms Run I results



no appreciable Q^2 dependence observed within $100 < Q^2 < 1{,}600$ GeV^2

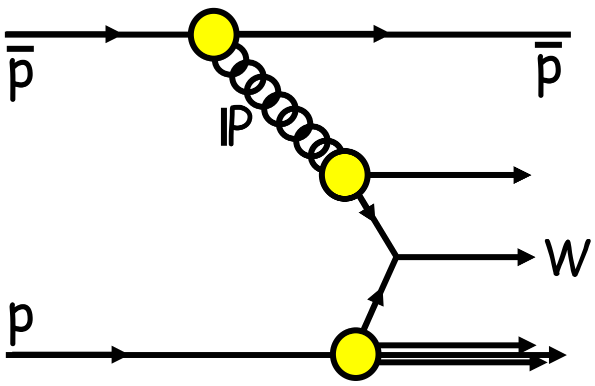
⇨ pomeron evolves similarly to proton



Diffractive W

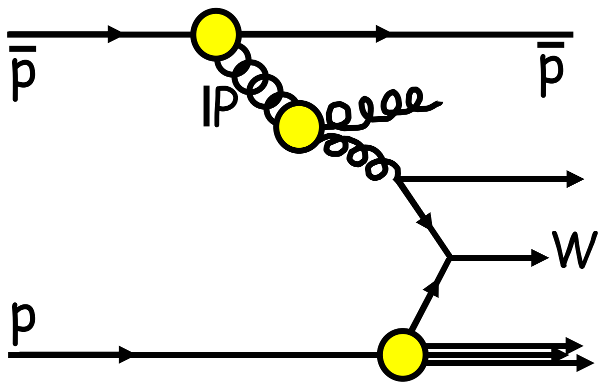
Study diffractive W-boson production, and the partonic structure of the Pomeron by a comparison to the diffractive di-jet production

- Run I: 8,246 W(eν) events - PRL 78 (1997), 2698
- R_W (SD/ND)= 1.15 ± 0.51(stat) ± 0.20(syst) %



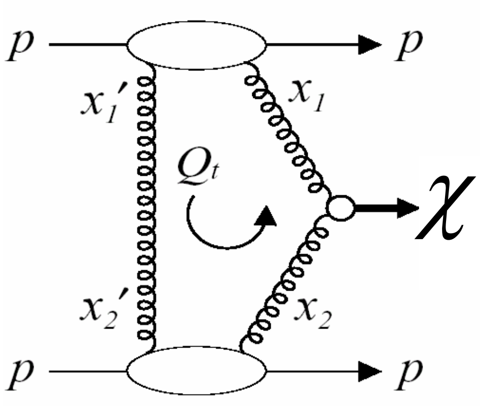
hard-quark dominated Pomeron

or



hard-gluon dominated Pomeron
(rate lower by α_s)

Exclusive low-mass states

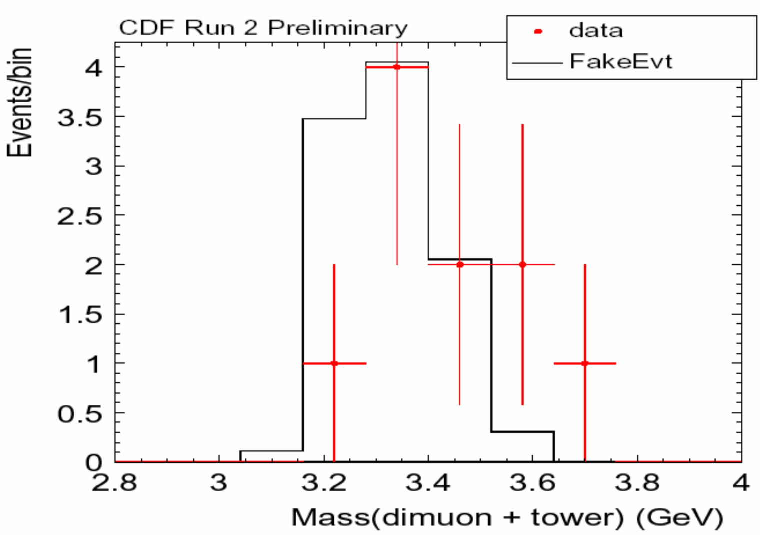


$p\bar{p} \rightarrow p\chi\bar{p}$

$\hookrightarrow J/\psi\,\gamma \rightarrow \mu\mu\gamma$

(γ is soft)

(same quantum numbers as Higgs boson)



✓bkg from multiplicity fluctuations (under threshold)
✓difficult to estimate noise contribution

cross section **upper limit** for exclusive production

⇨ $\sigma_{excl}(J/\psi+\gamma) = 49 \pm 18(stat) \pm 39(syst)$ pb

~70 pb Khoze, Martin, Ryskin, Stirling
Eur. Phys. J. C 35, 211 (2004)

new trigger implemented

Exclusive diphotons

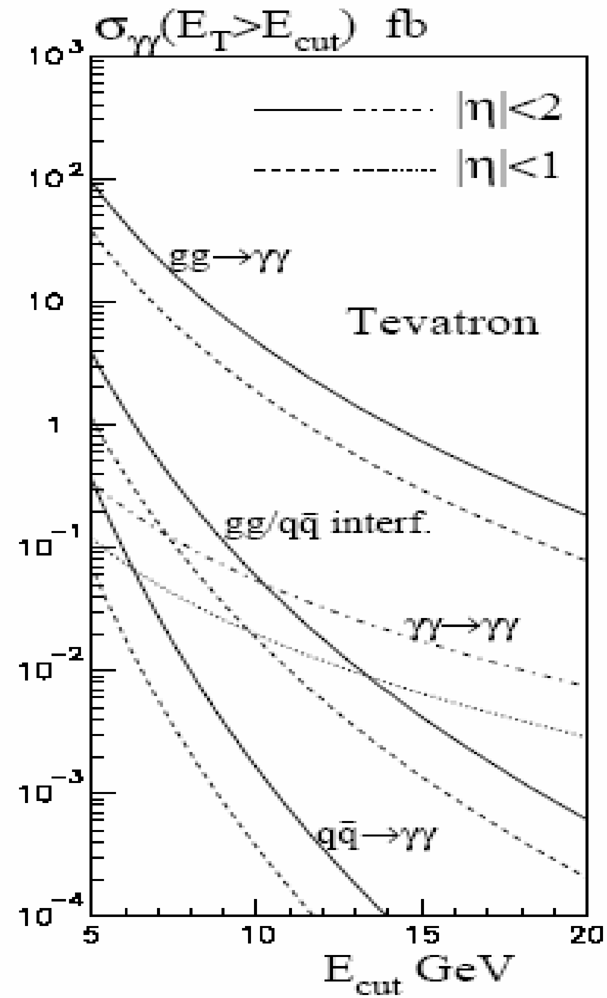
$\sigma(gg \rightarrow \gamma\gamma, |\eta|<1, E_T>5\ GeV)=40\ fb$

⇨ in 100 pb^{-1} expect ~5 events

new trigger implemented

<u>Work in progress:</u>

- estimate background
- study low-pt photon ID
- study efficiencies
- …more data



Summary

forward detectors working well
dedicated diffractive triggers

improved limits for exclusive production (dijets, χ_c)

attempted to extract signal using b-quarks
new DPE b-trigger

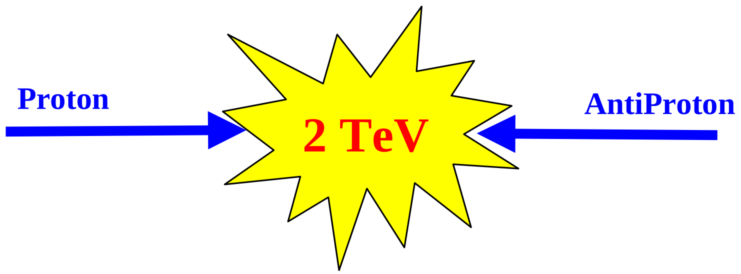
diffractive structure functions, W/Z, etc.
(gluon/quark ratio, q^2, ξ dependence)

BACKUP

Proton-Antiproton Collisions

$$\sigma_{tot} = \sigma_{el} + \sigma_{in}$$

$$\sigma_{in} = \sigma_{SD} + \sigma_{DD} + \sigma_{HC}$$



- ~25% of the time the proton and antiproton elastically scatter
- ~10% of the time single diffraction occurs
- ~1% of the time double diffraction occurs
- ~56% of the time a "hard" collision occurs