Diffractive Higgs and prompt photons: Soft Colour Interaction models

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Overview

- Soft Colour Interactions (SCI)
- SCI @ Tevatron and Hard diffraction (hep-ph/0106246, in PRD)

  $\longrightarrow$ W, Z, J/ψ, $b\bar{b}$

  $\longrightarrow$ dijets
- Diffractive Higgs production (hep-ph/0203267, in PRL)
- Diffractive $\gamma\gamma$ production

The Soft Colour Interaction model (SCI)

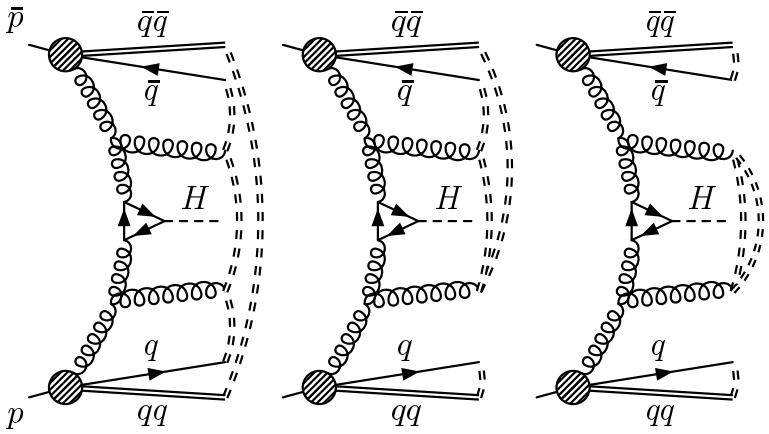
Colour charged partons interacting with the soft proton colour field

$\longrightarrow$ Implemented in the MC's LEPTO and PYTHIA

ME + DGLAP PS	$\rightarrow$	SCI/GAL reconnections	$\rightarrow$	Hadronization
color ordered partons		rearranged color order		complete final states

$\rightarrow$ single model describing all final states, transition diffractive - nondiffractive

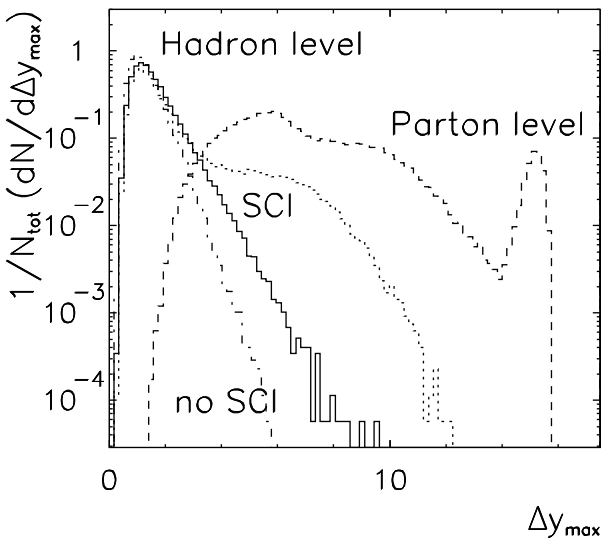
$\rightarrow$ two slightly different models: SCI and GAL



Lund string drawings before and after 1 or 2 soft interactions $\rightarrow$ rapidity gaps

SCI and hard diffraction at the Tevatron: W, Z, $b\bar{b}$, J/ψ

(Enberg, Ingelman, Tîmneanu)



W production @ 1800 GeV.

Dashed: parton level, others: hadron level.

Dash-dotted: PYTHIA default,

Solid: SCI, Dotted: SCI with $m_W = 8$ GeV.

SCI/GAL reproduce well measured gap fractions

$$R_{\rm hard} = \frac{1}{\sigma^{\rm tot}_{\rm hard}} \int_{x_{F\,\rm min}}^{1} dx_F \, \frac{d\sigma_{\rm hard}}{dx_F}$$

R_{hard}	Exp.	SCI	GAL
W	1.15 ± 0.55	1.2	0.8
$b\bar{b}$	0.62 ± 0.25	0.7	1.4
Z	$1.44\ ^{+0.62}_{-0.54}$	1.0	0.5
J/ψ	1.45 ± 0.25	1.4	1.7

↑ predictions

SCI/GAL account for :

- producing gap/leading proton
- producing J/ψ (colour singlet)

SCI and hard diffraction at the Tevatron: dijets in SD & DPE

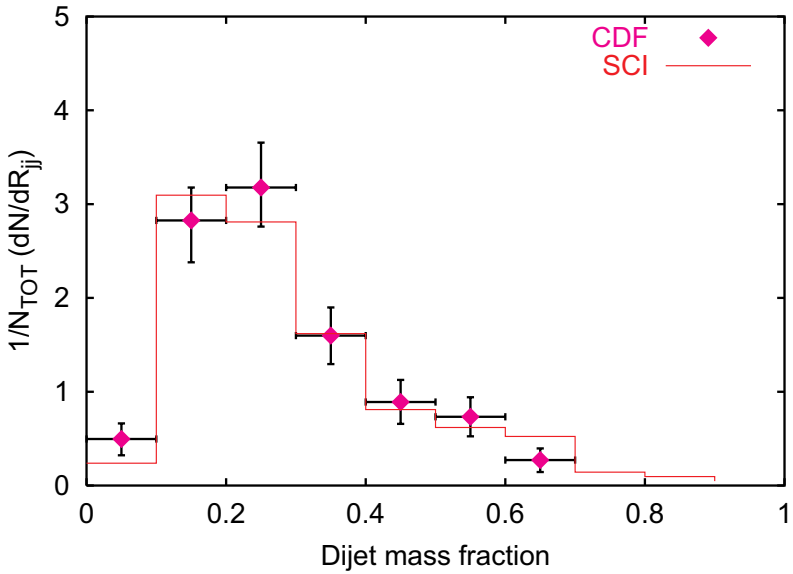
SCI/GAL reproduce well single diffractive ratios for dijets with gaps or leading anti-protons.

Also in DPE (Double Pomeron Exchange) the models give good ratios and cross-sections.

	$\tilde{R}_{SD}^{DPE}$ $[\%]$	σ^{DPE} $[nb]$
CDF	0.80 ± 0.26	$43.6 \pm 4.4 \pm 21.6$
SCI	0.54 ± 0.05	$5 - 25$
GAL	0.44 ± 0.05	$6 - 40$

↑ proton ↑ gap

While reproducing the overall behaviour, the models have a strong dependence on remnant treatment.



Dijet mass fraction in DPE

CDF data well reproduced by SCI

SCI and Higgs in hadron-hadron collisions

(Enberg, Ingelman, Kissavos, Tîmneanu)

- We have already seen that the SCI/GAL models give good descriptions of cross sections for diffractive processes

  $\rightarrow$ Apply it to diffractive Higgs

- LEP has a 2.1σ indication of a 115.6 GeV Higgs.
  Electroweak data favours $114.1 < m_H < 212$ GeV.

- $gg \rightarrow H$ accounts for 50–70% of the cross section,
  but include all subprocesses in PYTHIA 6

- Uncertainty of a factor two: details of hadron remnant treatment and choice of PDF's. K-factor of 2 from NNLO not included.

Results for diffractive Higgs

Diffractive criteria: gap $(2.4 < |\eta| < 5.9)$ or leading proton $(x_F > 0.9)$

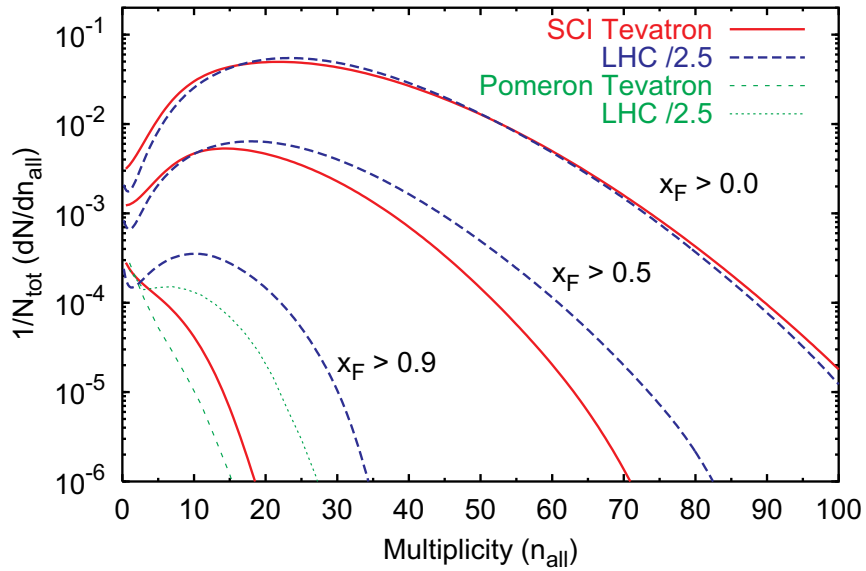
In Khoze-Martin-Ryskin nomenclature : "Central inelastic production"

		Tevatron	LHC
	σ[fb] Higgs-total	600	27000
SD	σ [fb] leading-p	1.2	190
	σ [fb] gap	2.4	27
	# H + leading-p	24	5700
	$\hookrightarrow$ # H $\rightarrow \gamma\gamma$	0.024	6
DPE	σ [fb] leading-p's	$1.2 \cdot 10^{-4}$	0.19
	σ [fb] gaps	$2.4 \cdot 10^{-3}$	$2.7 \cdot 10^{-4}$
	# H + leading-p's	0.0024	6

large m_H + large x_F proton $\longrightarrow$ kinematical conflict $\longrightarrow$ reduced cross-section

Diffractive events cleaner at LHC?

Energy = production of hard subsystem + one/two leading protons + particles in forward η regions



Particle multiplicity in the rapidity region $2.4 < |\eta| < 5.9$ of the expected gap, in the hemisphere of a leading proton.

"clean" diffractive Higgs events

↓

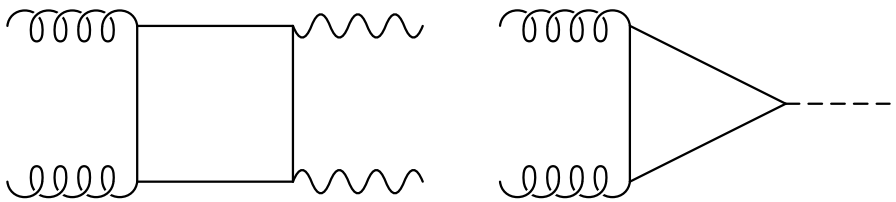
price of a lower cross section

factor 10 for SD

factor 100 for DPE

Two-photon production

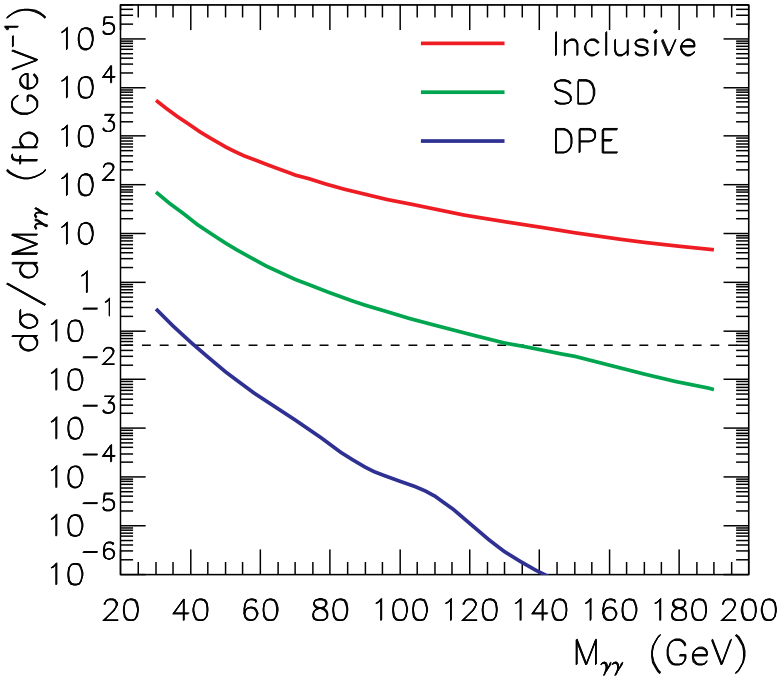
- Apply exactly the same Monte Carlo model to prompt two-photon production
- $gg \to \gamma\gamma$ similar to $gg \to H$:



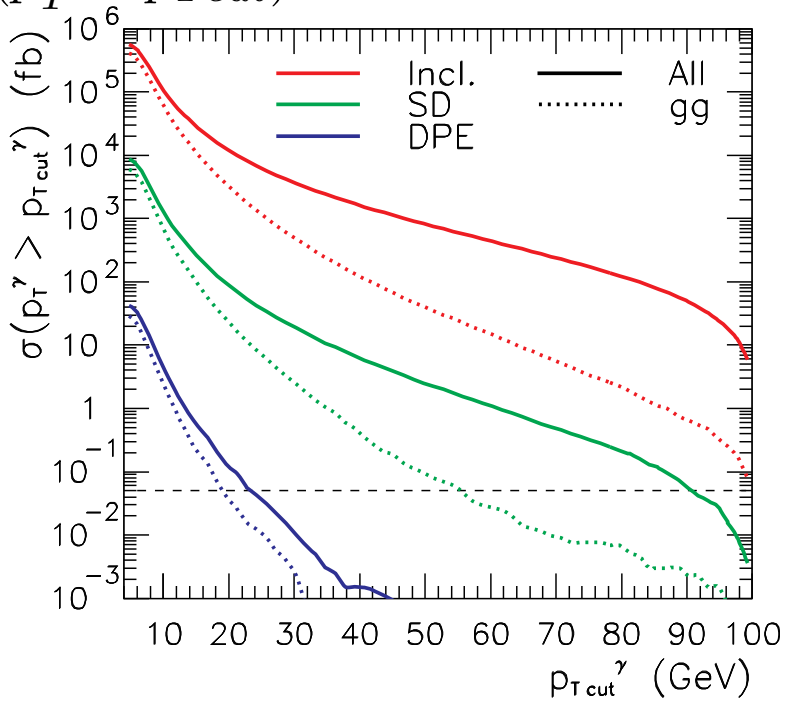
- But: There is also $q\bar{q} \to \gamma\gamma$
- Background processes to $H \to \gamma\gamma$
- Use this to test models for diffractive Higgs production?
  $\to$ we are interested in $M_{\gamma\gamma} \sim M_H$

TEVATRON: (dashed line = 1 event in Run II)

$d\sigma/dM_{\gamma\gamma}$



$\sigma(p_T^\gamma > p_{T cut})$



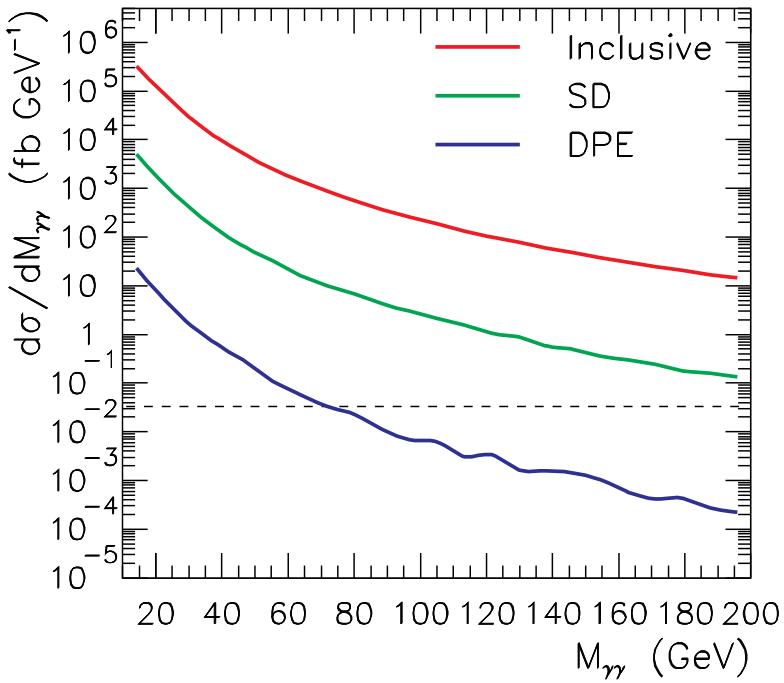
→ For large $M_{\gamma\gamma}$ the process is dominated by the $q\bar{q}$ channel

$$\sigma_{\gamma\gamma}^{DPE}(p_T^\gamma > 12 \text{ GeV}) = 2 \text{ fb}$$

but integrated in mass range $M_H \pm$ 1 GeV, $\sigma_{\gamma\gamma}^{DPE} \sim 10^{-5}$ fb

LHC: (dashed line = 1 event in low luminosity run)

$d\sigma/dM_{\gamma\gamma}$



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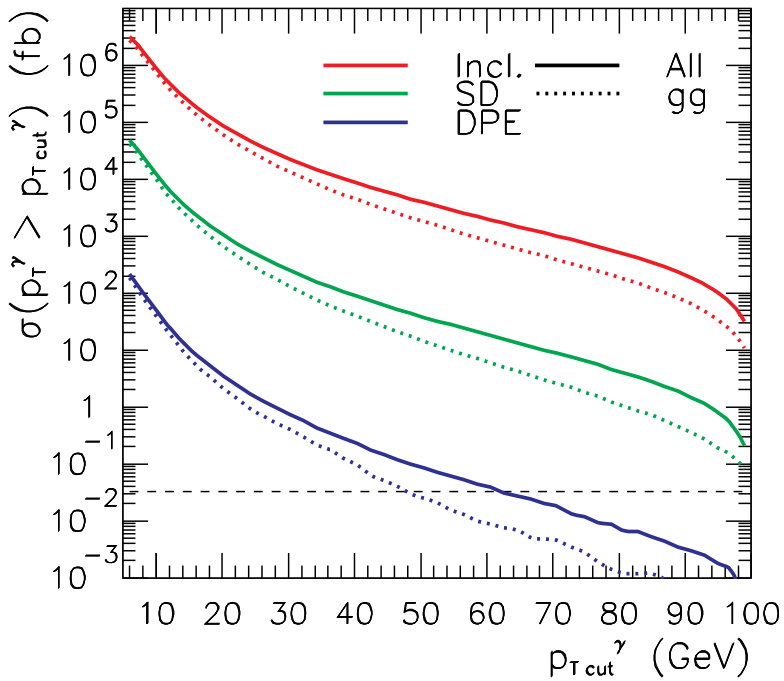

$$\sigma_{\gamma\gamma}^{DPE}(p_T^\gamma > 12 \text{ GeV}) = 30 \text{ fb}$$

Summary

- SCI describes well all hard diffraction rates at HERA and Tevatron
- SCI's @ Tevatron
  - Cross section of single diffractive Higgs events is too low to be useful
  - Higgs in DPE events are far below an observable rate
- SCI's @ LHC
  - Diffractive events are not as clean as expected
  - Studies of Higgs in single diffraction and DPE can be made
- Prompt photons:
  - cross section is small at Tevatron
  - not that similar to Higgs: $q\bar{q}$ is important/dominant