Diffractive Higgs Production at Tevatron and LHC

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Contents:

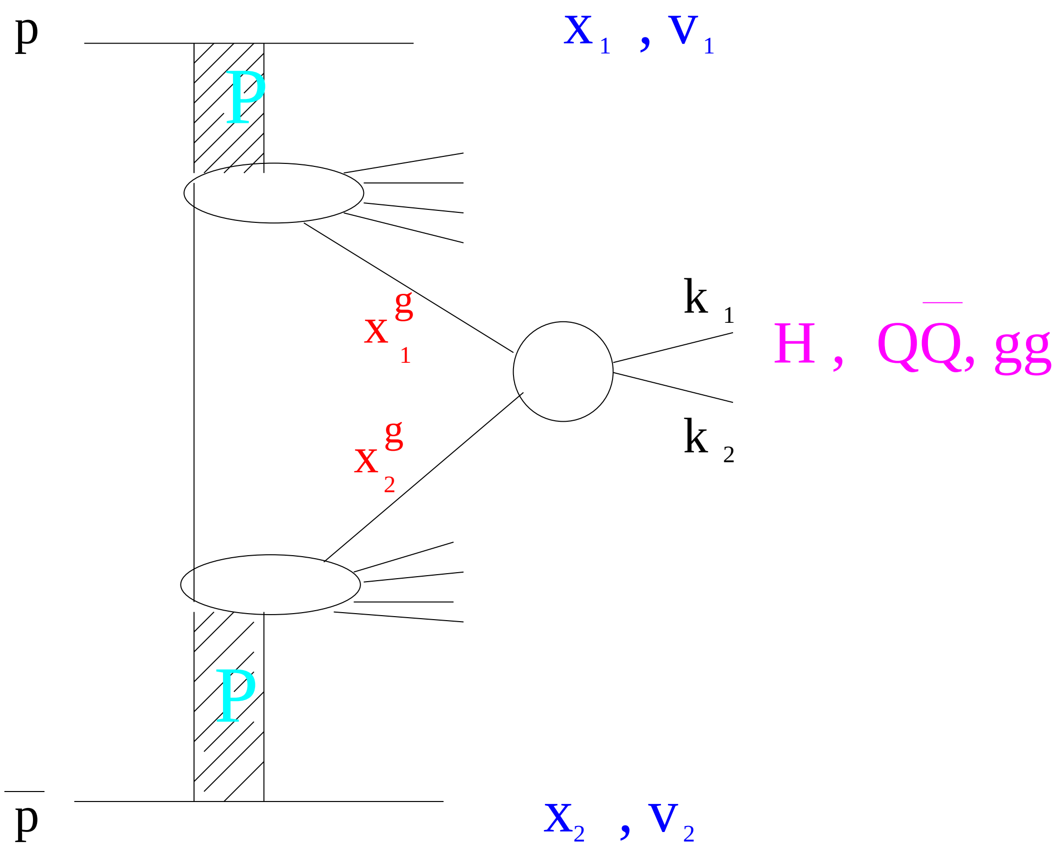
- Inclusive Higgs production: cross sections, tests of models, SUSY Higgs
- Exclusive Higgs production
- Higgs mass reconstruction at LHC using roman pots

Work done in collaboration with Maarten Boonekamp (Saclay/CERN), Robi Peschanski (Saclay), Albert de Roeck (CERN)

NB: Only diffractive Higgs produced via double pomeron exchange will be considered

Pomeron induced model - Non-factorizable case

Phys.Rev.Lett. 87 (2001) 251806, Phys. Lett. B550 (2002) 93, hep-ph/0301244, accepted by Nucl. Phys. B

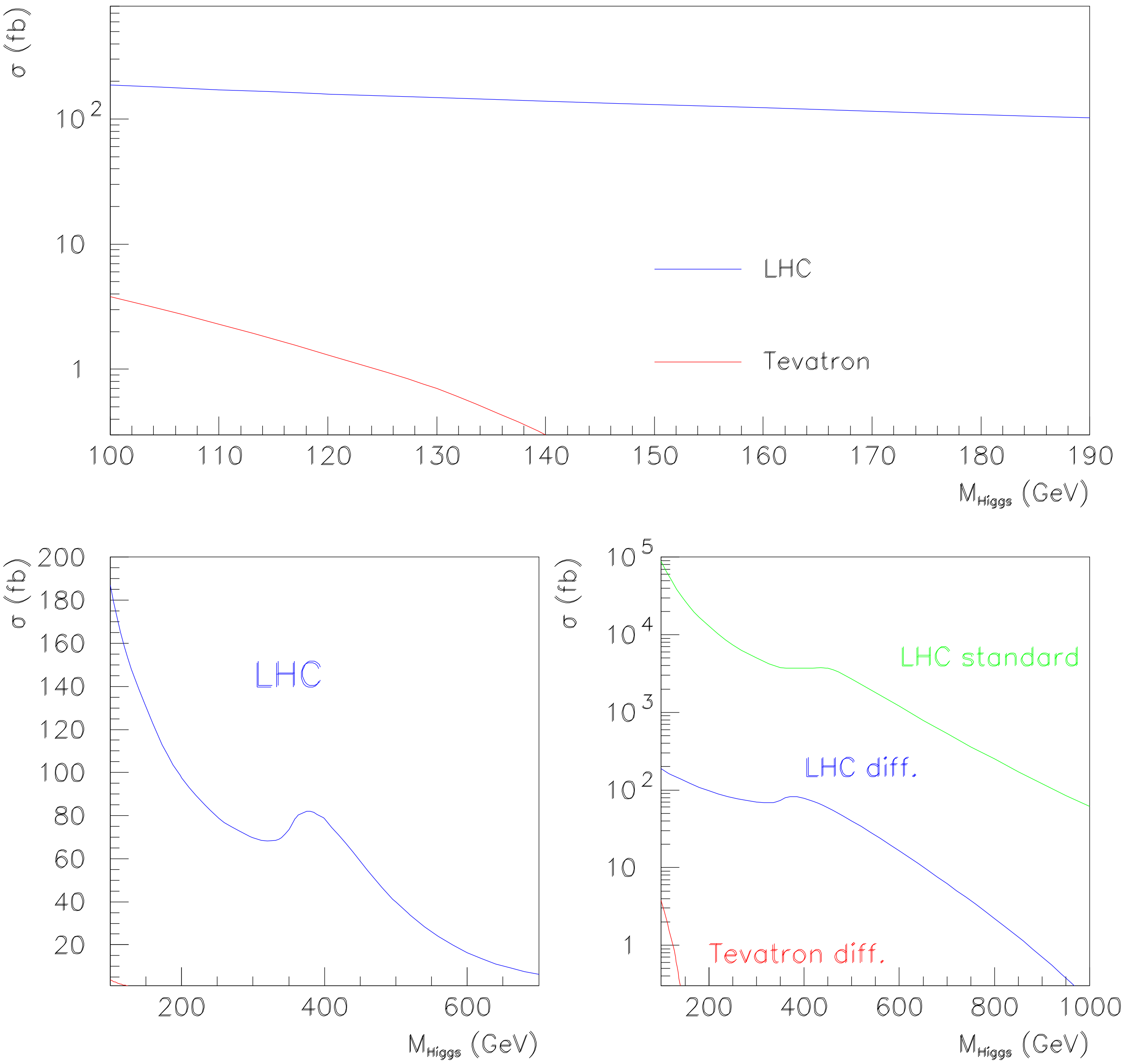


The idea of the model: Take the usual hadron-hadron cross section to produce the hard scattering (Higgs, dijets, $\gamma\gamma$) and convolute it with the parton densities inside the pomeron

Detector simulation and acceptance

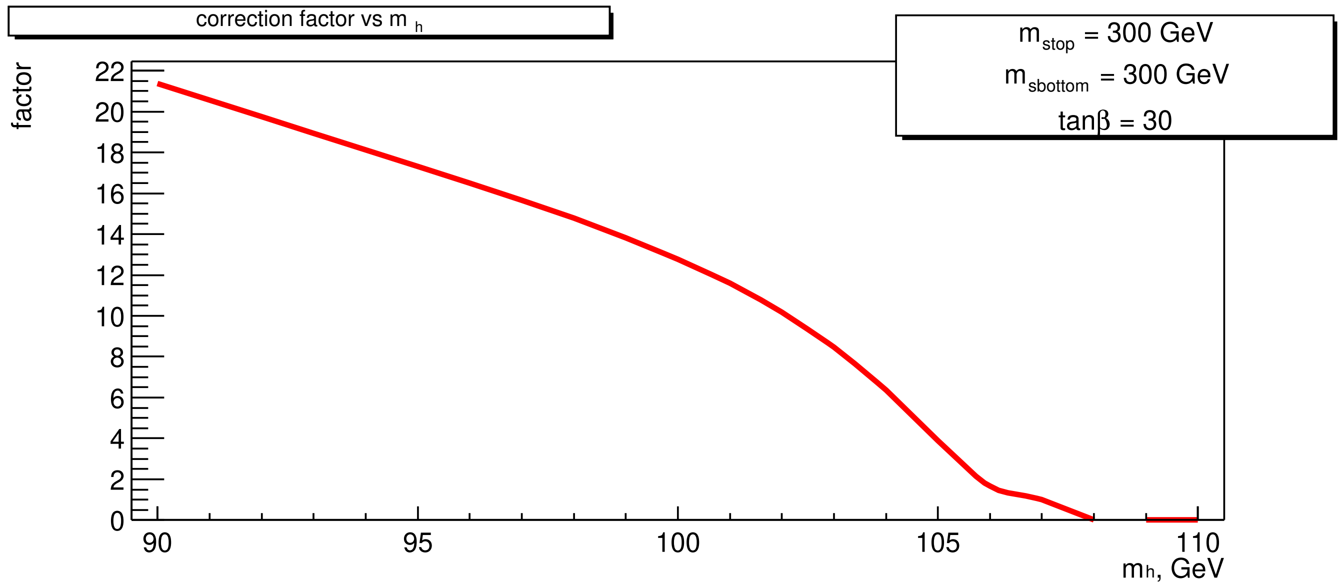
- Fast simulation (shw) of the CDF and DØ central detector
- Dijet CDF measurements
  - CDF Run I cuts: $\bar{p}$ tagged, $0.035 \leq \xi_{\bar{P}} \leq 0.095$, $|t| < 1$ GeV^2, $0.01 \leq \xi_p \leq 0.03$
  - CDF run I measurement: Total CDF cross section: $\sigma \sim 43.6 \pm 4.4(\mathrm{stat}) \pm 21.6(\mathrm{syst})\ nb$,
  - Numbers of the pomeron induced models rescaled to the CDF measurement

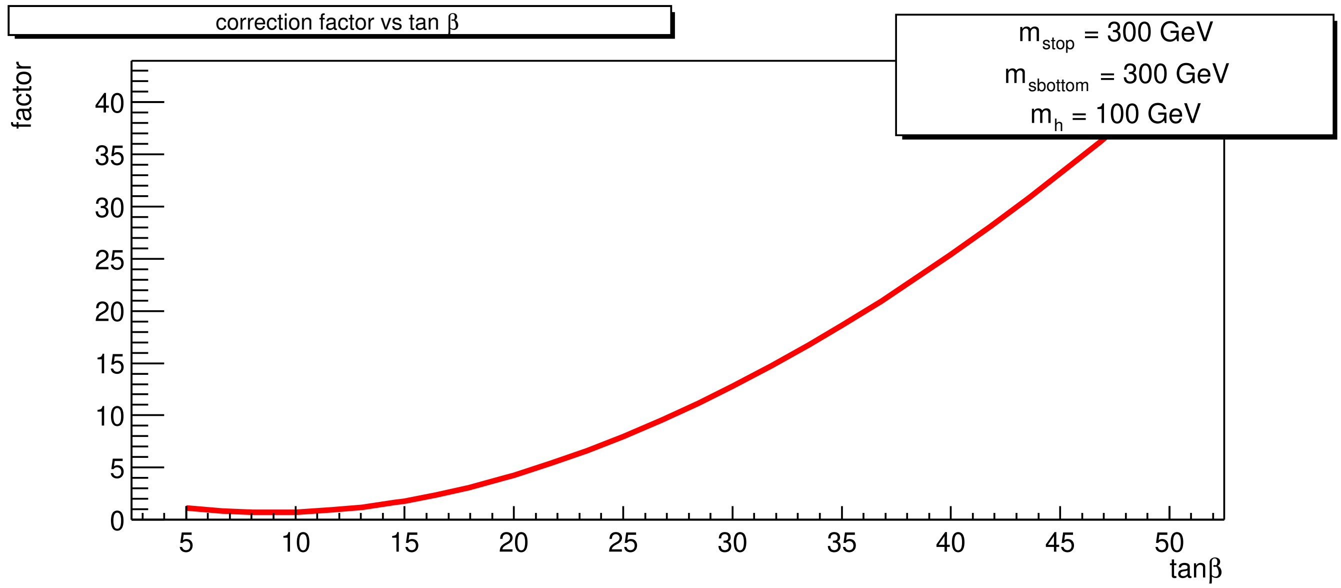
Tevatron and LHC cross sections



Diffractive SUSY Higgs production

High $\tan\beta$: top and bottom loops to be considered, enhance the cross section by up to a factor 50



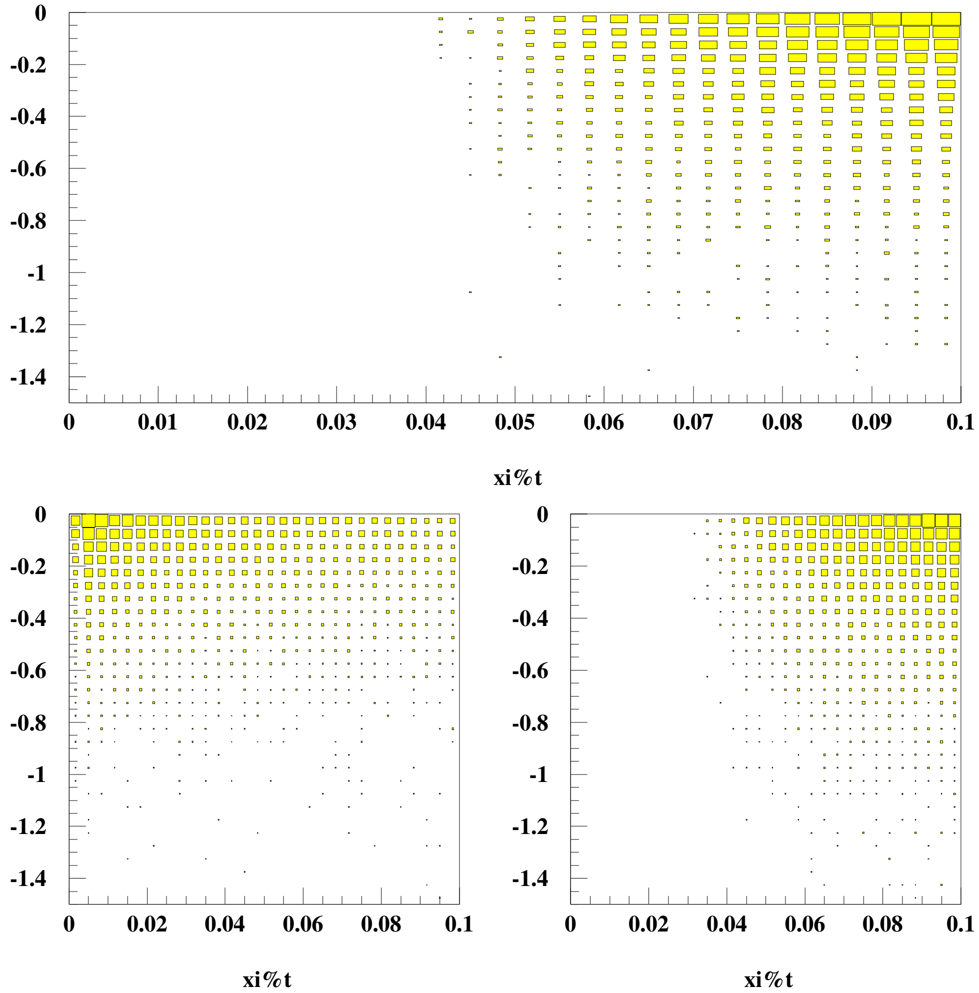


Discussion on inclusive Higgs predictions

- Where to put roman pot detectors or microstations? to get the best acceptance for Higgs
- Use of xG density measured at HERA: how to justify this hypothesis?
- Test of models: using diffractive cross section measurements at Tevatron (dilepton, diphoton, dijet double diffraction production)
- Survival gap probabilities: how to transfer Tevatron results to LHC?
- Factorisable and non-factorisable models: how to distinguish them?

Where to put roman pot detectors?

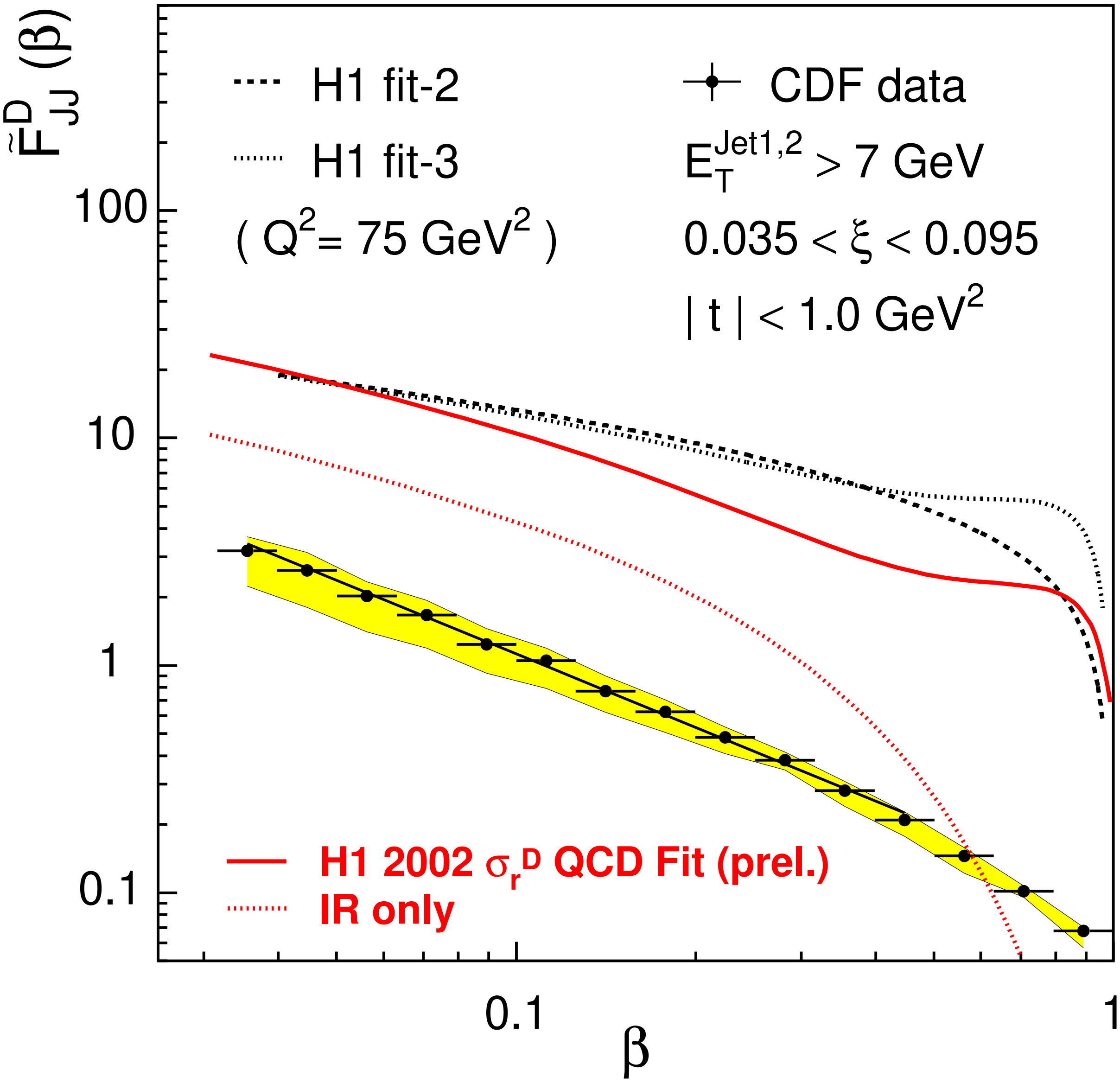
ξ vs t for Tevatron ($M_H = 120$ GeV) and LHC ($M_H = 120, 800$ GeV)



Conclusion: needs acceptance at low t, and high ξ (Tev.) and both low and high ξ (LHC)

Extraction of xG in pomeron from CDF data

~~Comparison of xG in pomeron from H1 (full red~~ line) compared to CDF measurement: Difference in normalisation, shapes similar



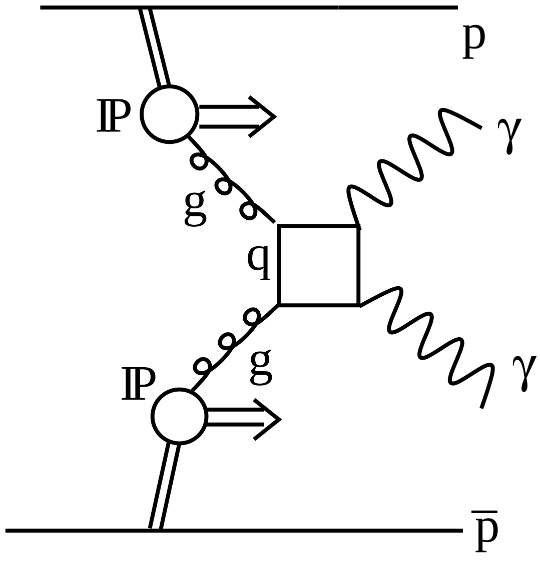
Survival Gap Probabilities

- From HERA to Tevatron: At HERA, about 10% of diffractive events, at Tevatron: about 1% of single diffractive events: Factorisation breaking
- From Tevatron to LHC: Needs to compute the survival probability at LHC: Non factorisable models: put the same normalisation factor between Tevatron and LHC, assumes the same survival probability
- Double diffraction vs single diffraction: the price to pay to get two gaps is smaller than the square price to pay for one gap (CDF)

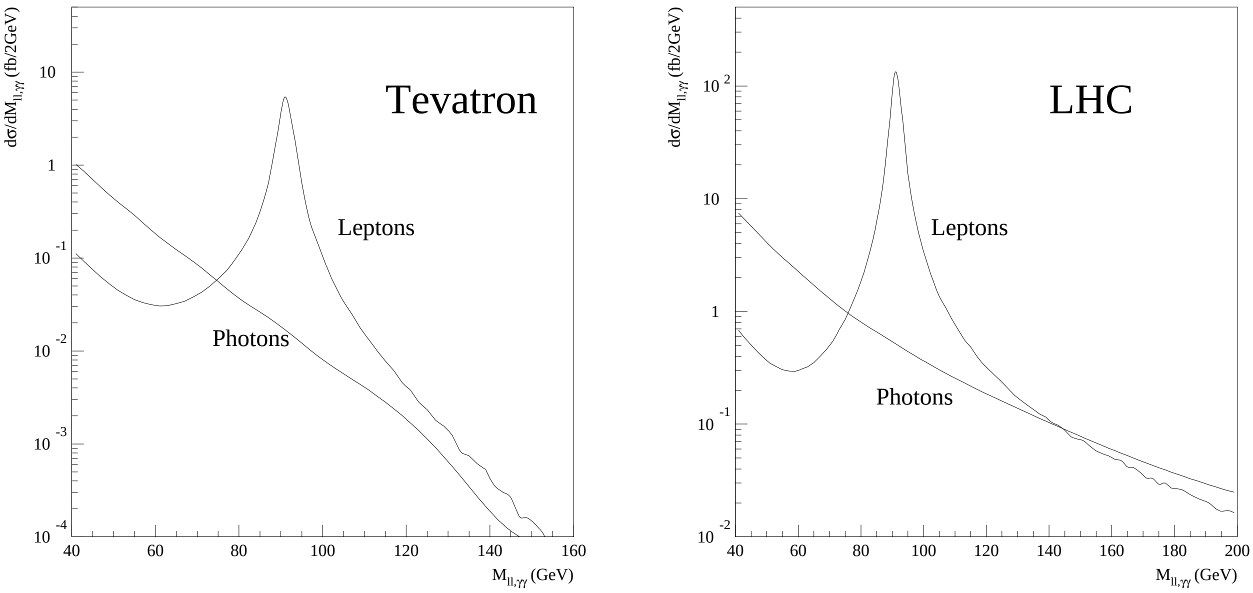
How to test the different models?

First idea: measure the dijet, $\gamma\gamma$ and ll cross sections:

All models predict values for the dijet, $\gamma\gamma$ and ll cross sections which will be a test of the models.



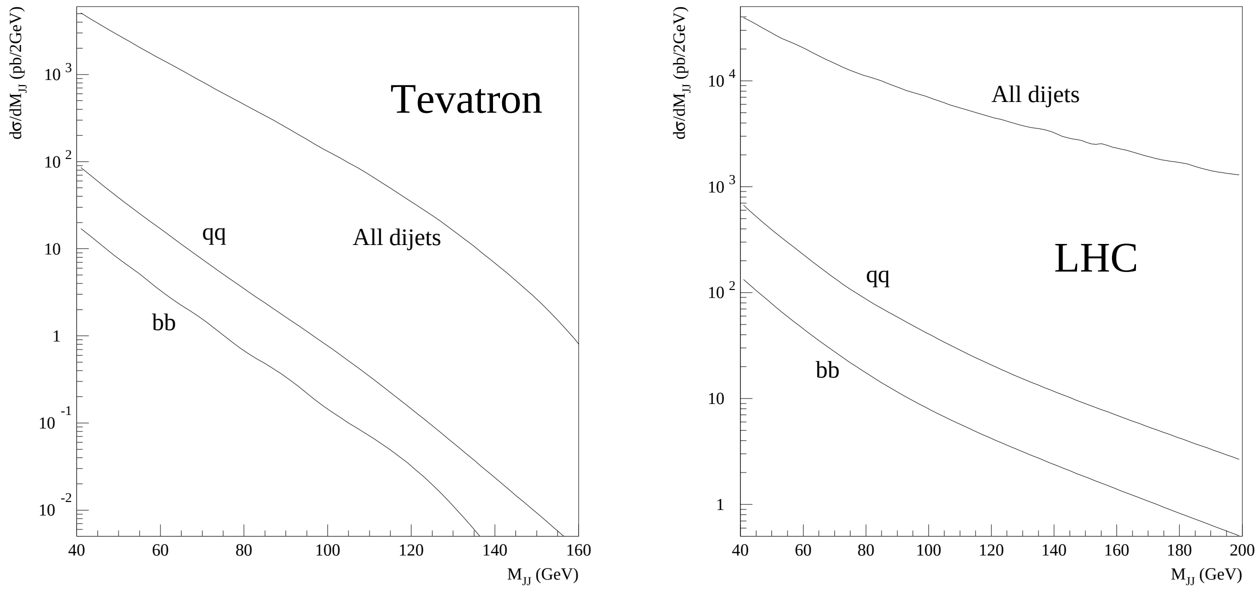
Diphoton and dilepton cross sections



Diphoton and dilepton production differential cross sections (pb) at the Tevatron and LHC.

$E_T > 10$ GeV, $|\eta| < 4$

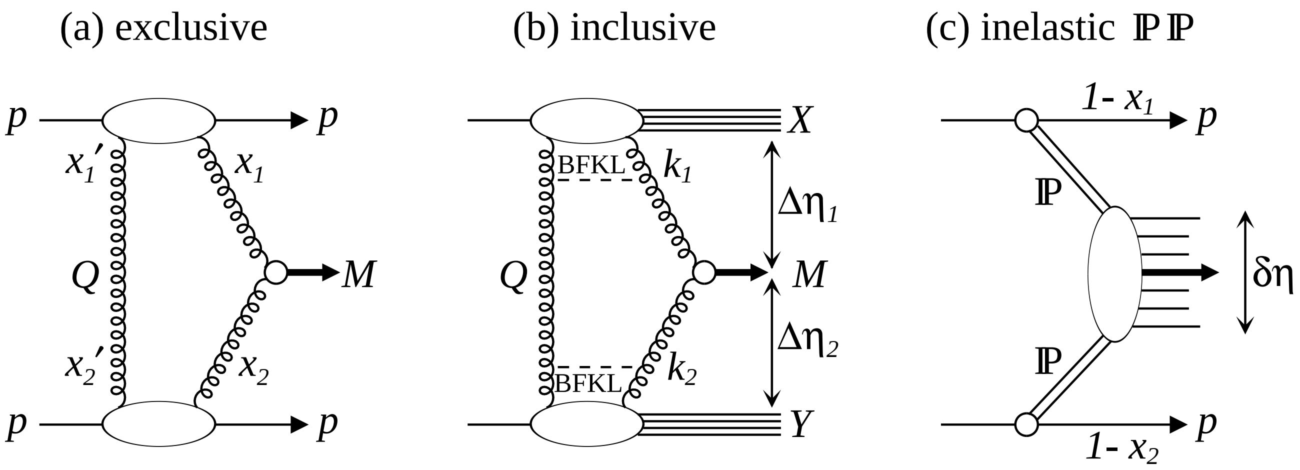
Dijet cross sections



Dijet production differential cross sections (pb) at the Tevatron and LHC. $E_T > 10$ GeV, $|\eta| < 4$

Exclusive events: Proton induced models

V.Khoze, A.Martin, M.Ryskin, hep-ph/0002072, hep-ph/0111078, hep-ph/0104230



Signal to be considered: "Exclusive signal":

$$p\bar{p} \rightarrow p \; gap \; H \; gap \; \bar{p}$$

Higgs production at Tevatron and LHC

Exclusive Higgs production cross section (in fb)

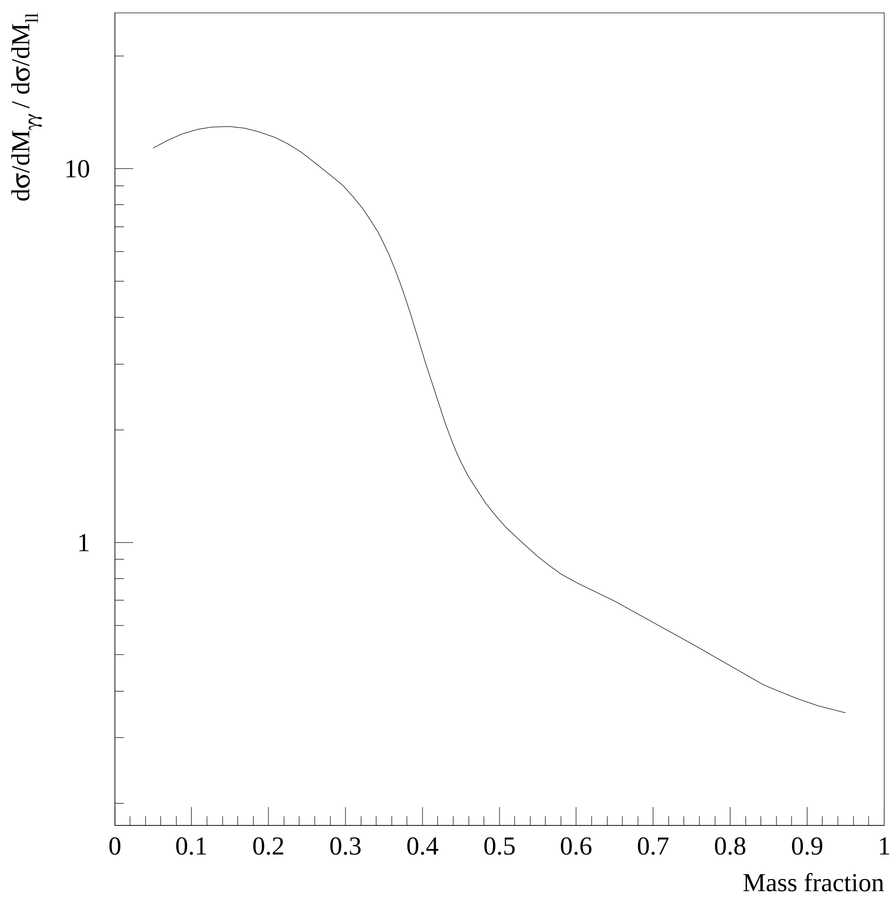
M_H	$\sigma_{excl}(TeV.)$	$\sigma_{excl} LHC$
120	0.2	2.
140		0.66
160		0.05

NB: for the LHC, the numbers are given for the $b\bar{b}$ channel

Conclusion: Almost impossible for Tevatron, feasible at the LHC provided the gap survival probability is not much smaller

Proton induced models

Test of the existence of the exclusive events



Dilepton and diphoton cross section ratio as a function of the diphoton/dilepton mass: no dilepton event for exclusive models: change of slope of ratio if exclusive events exist

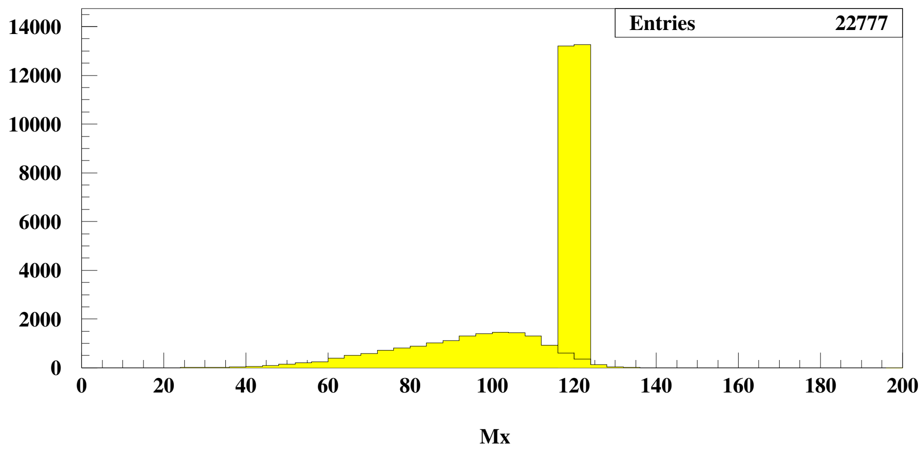
Advantage of diffractive events?

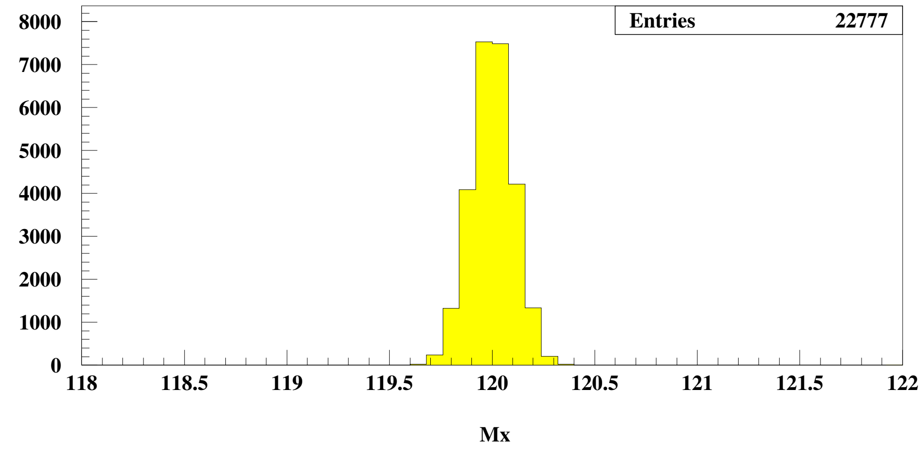
H mass reconstruction (missing mass method)

(M.Albrow, A.Rostovtsev, hep-ph/0009336)

For events without radiation ($p\bar{p} \to p\bar{p}H$,

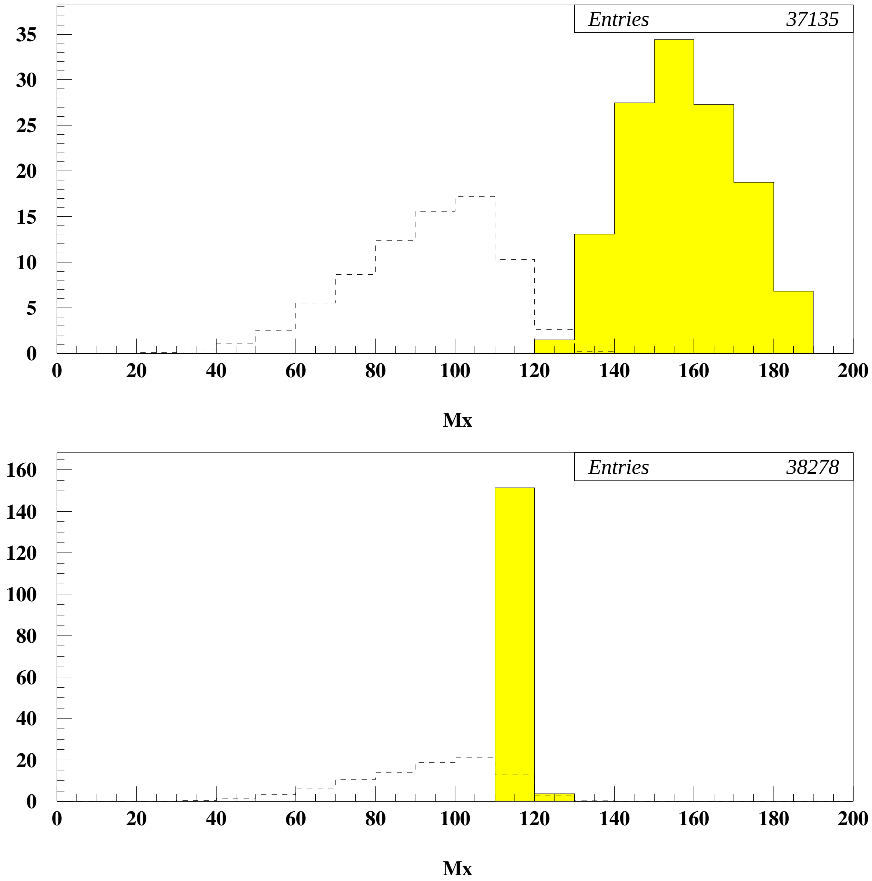
$M_H = \sqrt{\xi_p \xi_{\bar{p}} S}$, perfect reconstruction of the Higgs mass.





Advantage of diffractive events?

What about QCD radiation? The missing mass method does not work so nicely, since the total energy is used to produce the Higgs as before, but some of it is lost because of radiation ("pomeron remant")



Pomeron remnant tagging possibility

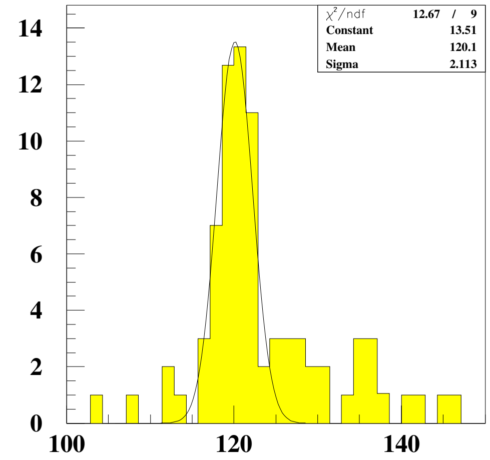
- Higgs mass reconstruction: $M_{Higgs} = \sqrt{\xi_1 \xi_2 S}$ nice method to reconstruct Higgs mass provided radiation is not too big. We just saw that the resolution is much worse without the possibility of measuring the pomeron remnants.

- Question: Where are the pomeron remnants going in pseudorapidity? Is it possible to tag them? New taggers at high η: CMS will have the possibility to install such taggers up to $\eta = 7.5$. In the simulated plots, we assume a resolution of $100\%/\sqrt{E}$ for the taggers

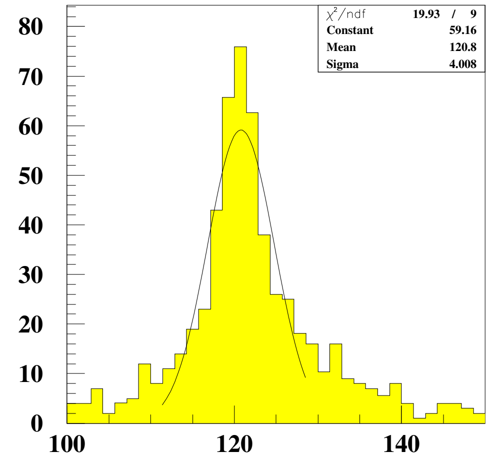
- Microstations/roman pot detectors in the cold region of the LHC: $|t| < 2$ GeV^2, $\xi > 0.002$

Resolution on Higgs mass

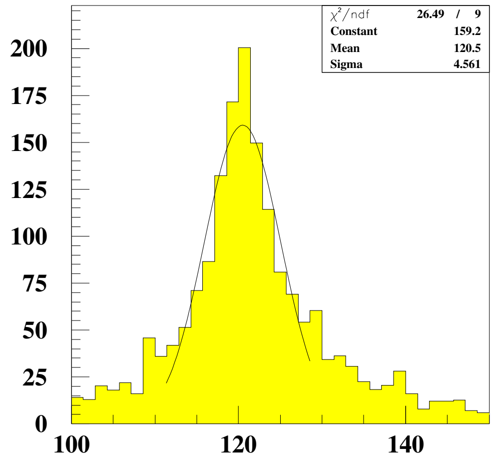
$M_{Higgs} = 120$ GeV at LHC at simulation level
(assumed resolution of taggers $\sim 100\%/\sqrt{E}$)



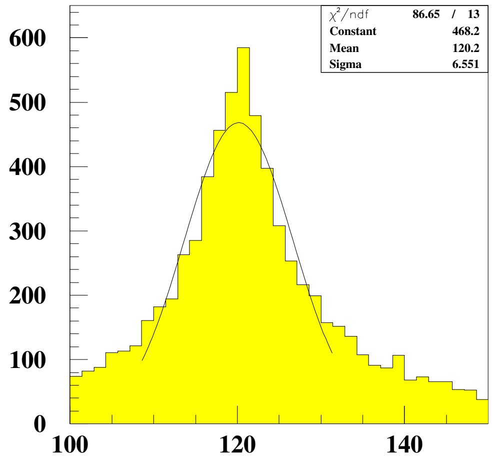
M Higgs - 20 GeV



M Higgs - 50 GeV



M Higgs - 100 GeV



M Higgs - 500 GeV

Summary

Higgs	(1)	(2)	(3)	(4)
115 GeV, Tev	1.7	0.029-0.092	0.2	0.00012
115 GeV, LHC	169.	379.-486.	2.8	0.19
160 GeV, LHC	123.	145.	1.0	-

- 1: pomeron induced model (non factorizable case)
- 2: pomeron induced model (factorizable case)
- 3: proton induced model ($b\bar{b}$ channel)
- 4: SCI
- Diffractive photon and lepton production allows to distinguish proton and pomeron induced models and SCI, and the dijet cross section measurement as a function of the dijet mass allows to distinguish between both pomeron based model

Conclusion

- Four different models studied: Quite low cross sections for Tevatron, high cross sections for LHC
- Test and distinguish between models: measure the diffractive photon and lepton production, and measure the pomeron intercept with the dijet cross section at Tevatron
- Advantages of the diffractive Higgs?: Mass constraint using the roman pot detectors (we get a good mass resolution at LHC if we are able to measure the pomeron remnants, useful at low luminosities), low background (negligible in the WW and $\tau\tau$ case)
- Open questions: Survival probability at LHC, direct measurement of gluon and quark densities in the pomeron at Tevatron, get more precise predictions and signal over background ratios for Higgs at LHC using Tevatron measurements