Exclusive Higgs and jet production at the LHC

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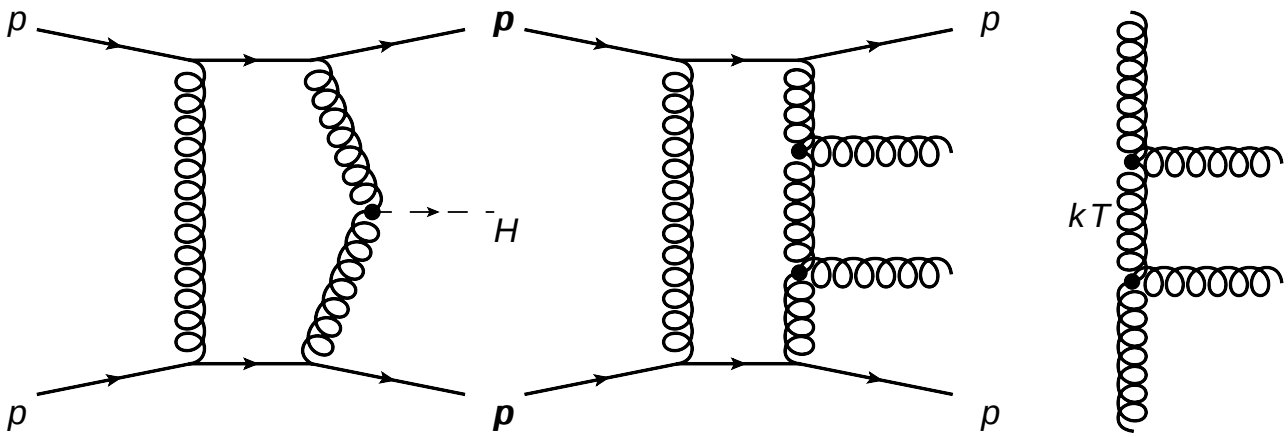
Contents:

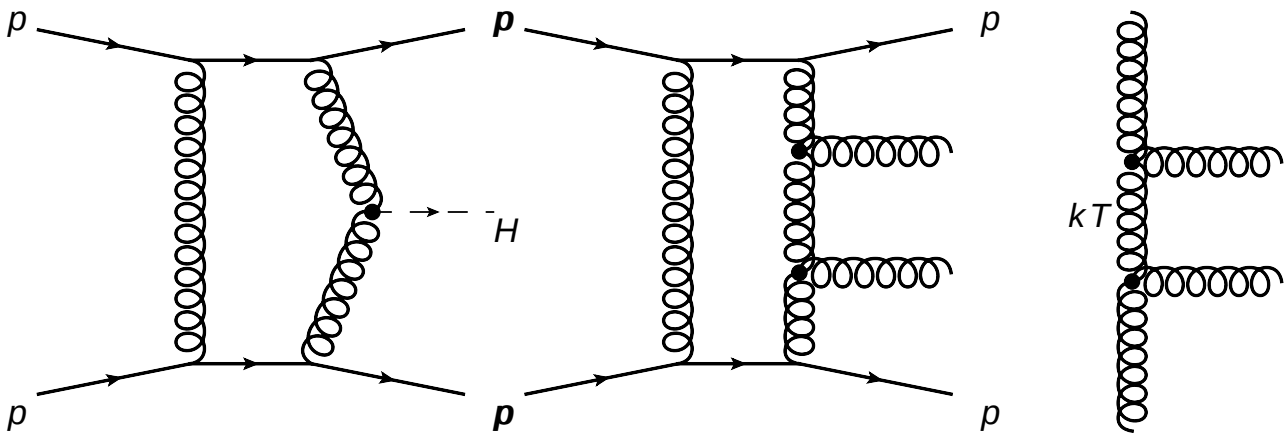
- Exclusive models in diffraction
- The Forward Physics Monte Carlo (FPMC)
- Exclusive jet production at the Tevatron and comparison with CDF data
- Exclusive jet and Higgs production at the LHC
- Uncertainties on Higgs production cross section

Exclusive models in diffraction and implementation in FPMC



- Two models considered: Khoze Martin Ryskin (KMR), Cudell Dechambre Hernández Ivanov (CHIDe) (NB: Szczurek et al. model being implemented)
- KMR and CHIDe models are similar, and there are only differences in detailed implementation:
  - Different upper limit in Sudakov factor for jets: gluon-gluon invariant mass s_{gg} for KMR, gluon k_{T_2} for CHIDe
  - Exact kinematics in CHIDe, collinear for KMR
  - Proton wavefunction included in CHIDe: In addition to Sudakov factor, presence of an additional impact factor regulating divergences by suppressing very soft gluon emissions from proton

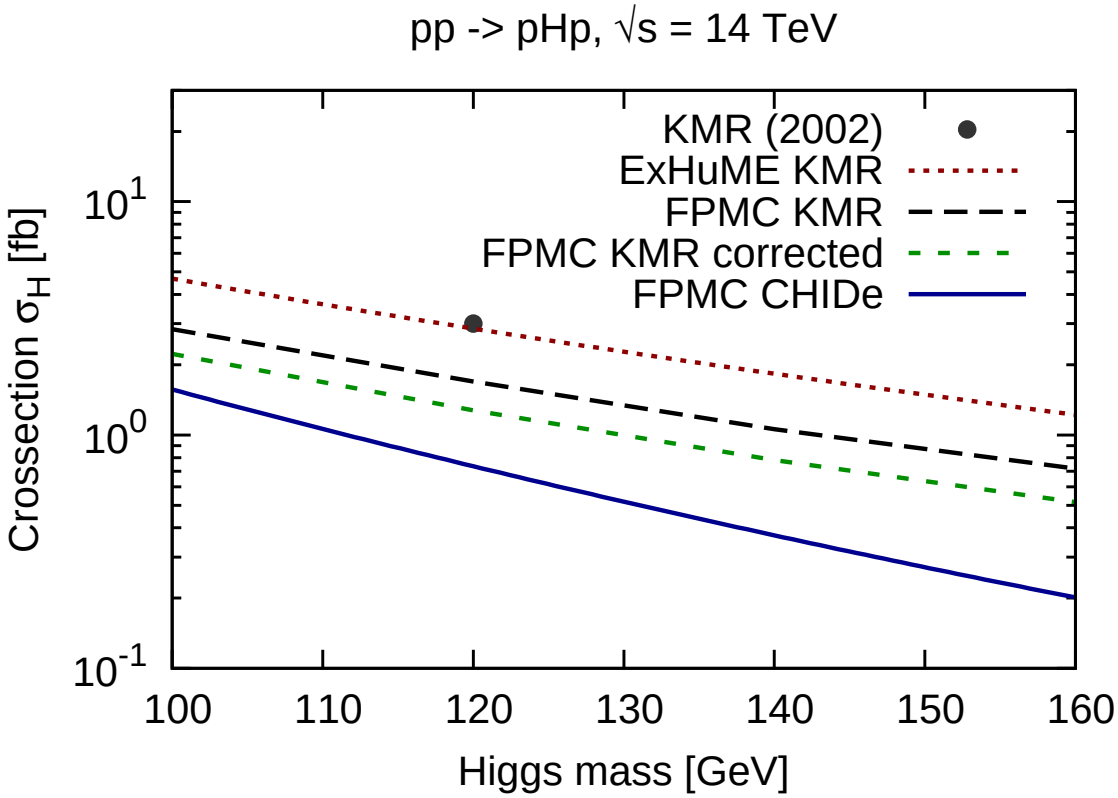
Exclusive models in diffraction and implementation in FPMC



- FPMC (Forward Physics Monte Carlo):
  - Implement all diffractive processes in one single Monte Carlo: inclusive diffraction, exclusive production (Higgs, jets, photons, χ_C...), photon induced processes (anomalous coupling studies)
  - Hadronisation and hard matrix elements: HERWIG
  - Interface to fast ATLAS simulation: AtlFast++
  - Experimental cuts: CDF cuts and jet algorithm, ATLAS Forward Physics acceptance
  - Manual in preparation: M. Boonekamp, O. Kepka, V. Juranek, C. Royon, R. Staszewski...

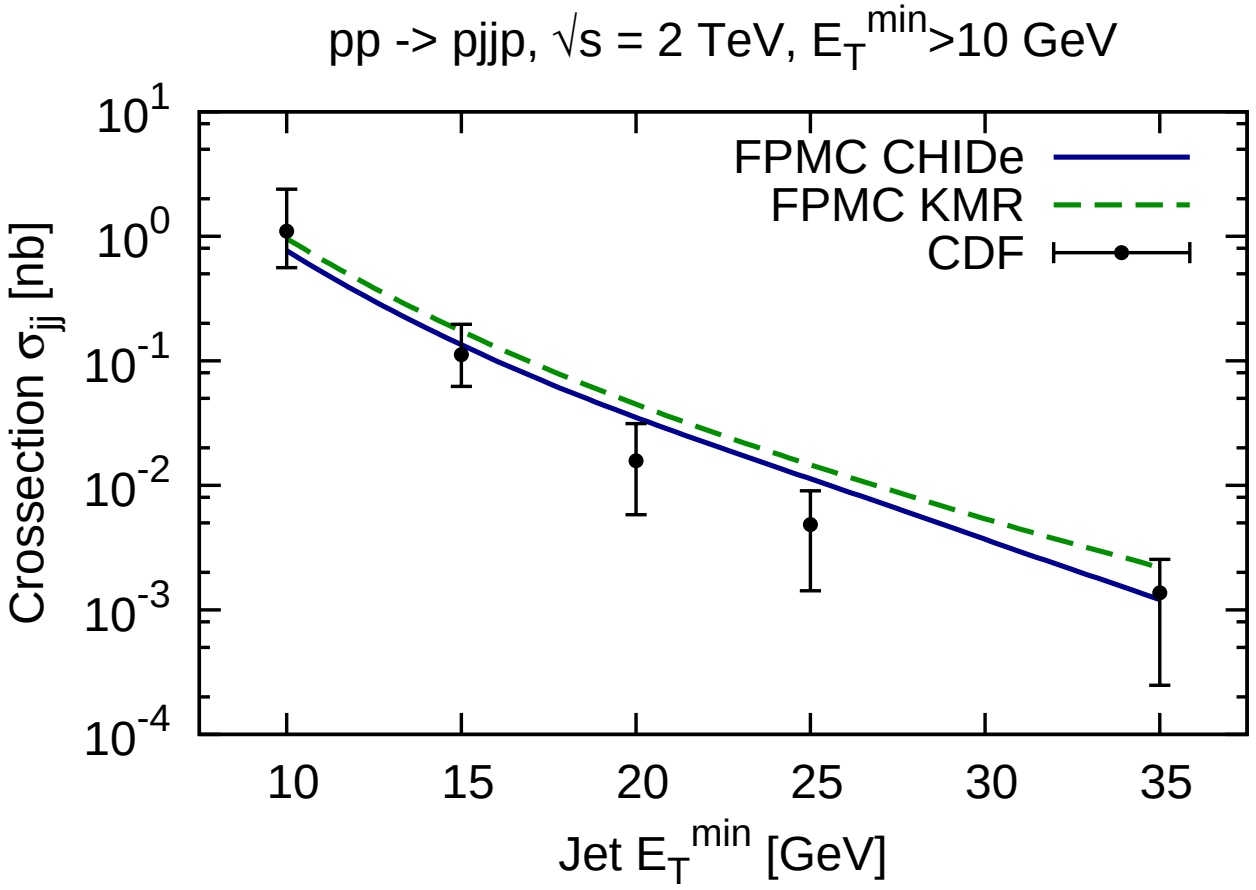
Comparison with implementation in ExHume

- Another implementation of KMR was performed using Pythia: ExHume (Andy Pilkington et al.)
- Differences of about 30-40% on Higgs cross section at LHC: due to different implementation of $gg \rightarrow H$ coupling in HERWIG
- CHIDe leads to lower cross sections and stronger mass dependence, well within model uncertainties (see following discussion)



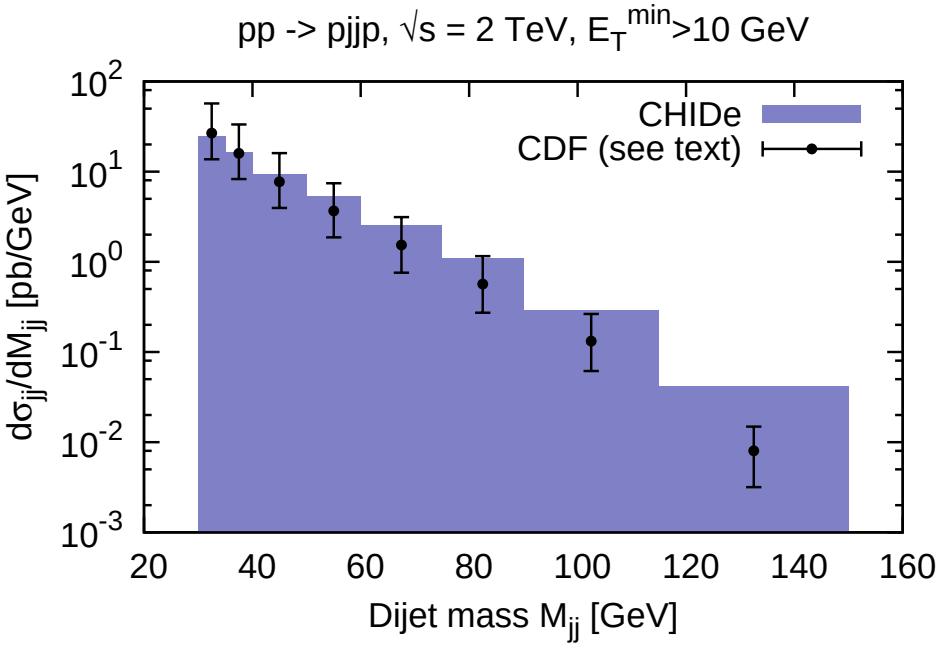
Comparison with CDF measurements

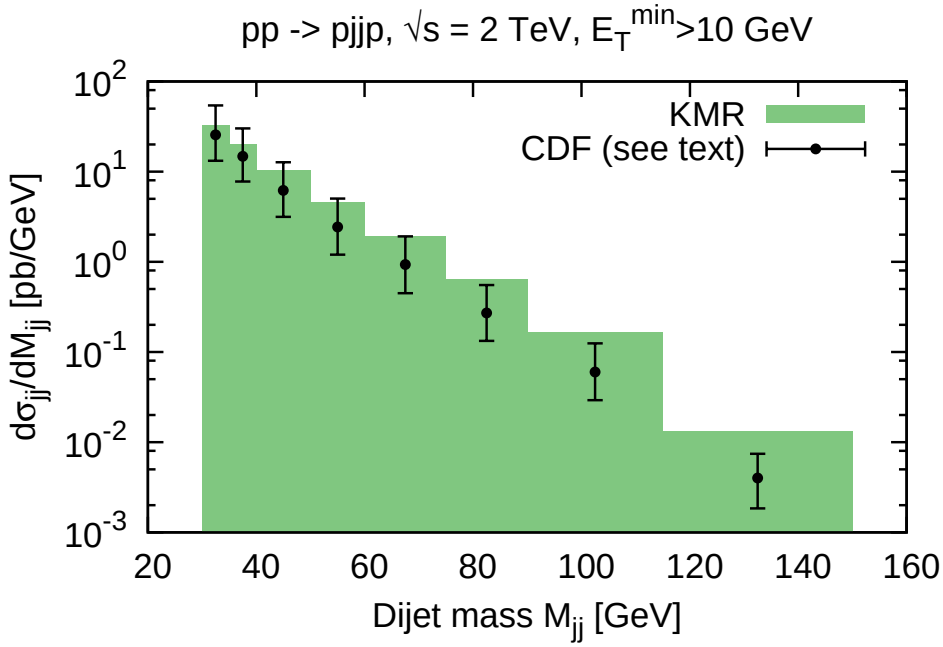
- CDF measured the dijet mass fraction for Double Pomeron Exchange events ($\bar{p}$ tagged, rapidity gap on p side)
- Good agreement between CDF measurement and KMR and CHIDe model



Comparison with CDF measurements

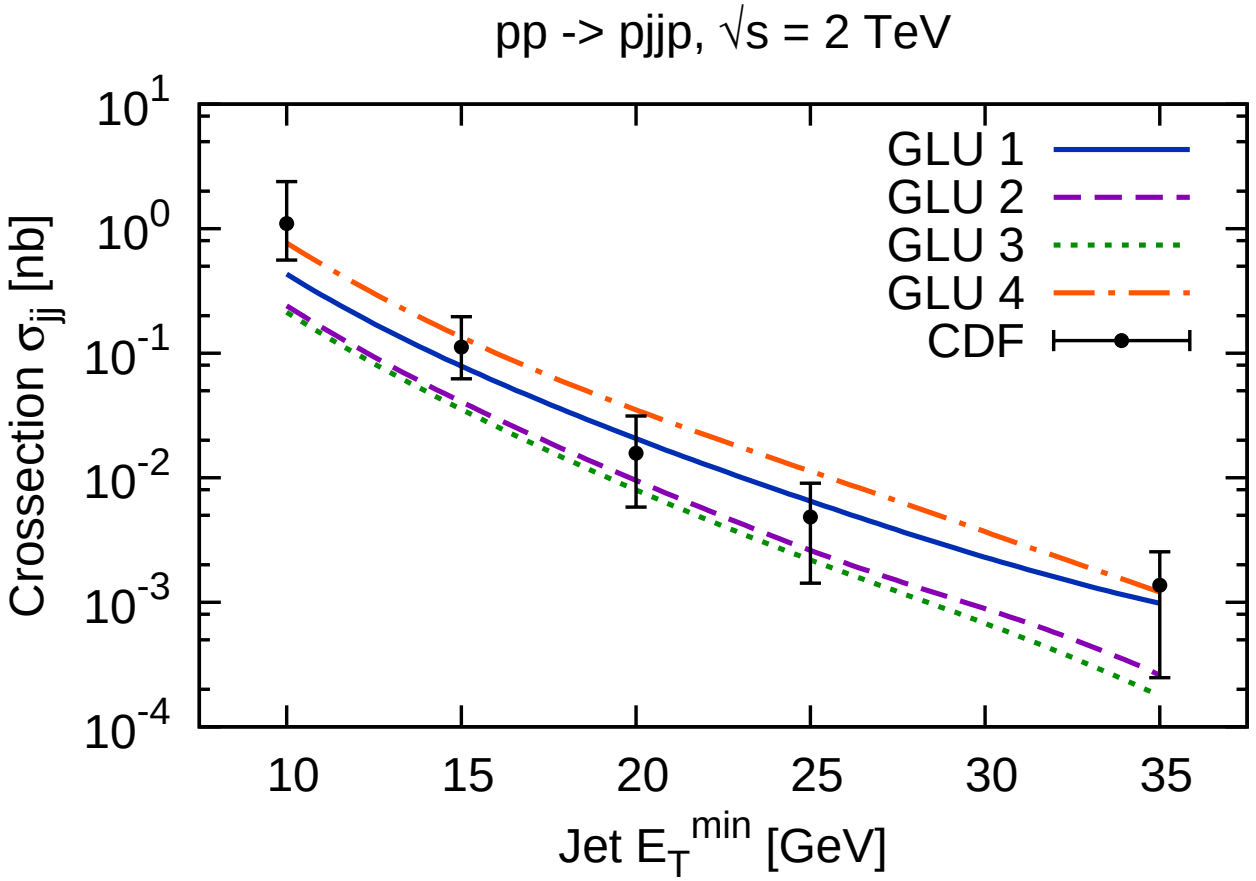
- CDF extracted the exclusive dijet mass cross section from the jet p_T dependence
- This extraction is model dependent: scale factor applied in each p_T^{min} bin on exclusive jet p_T cross section to extract dijet mass cross section
- Good agreement between KMR and CHIDe models and "measurement"





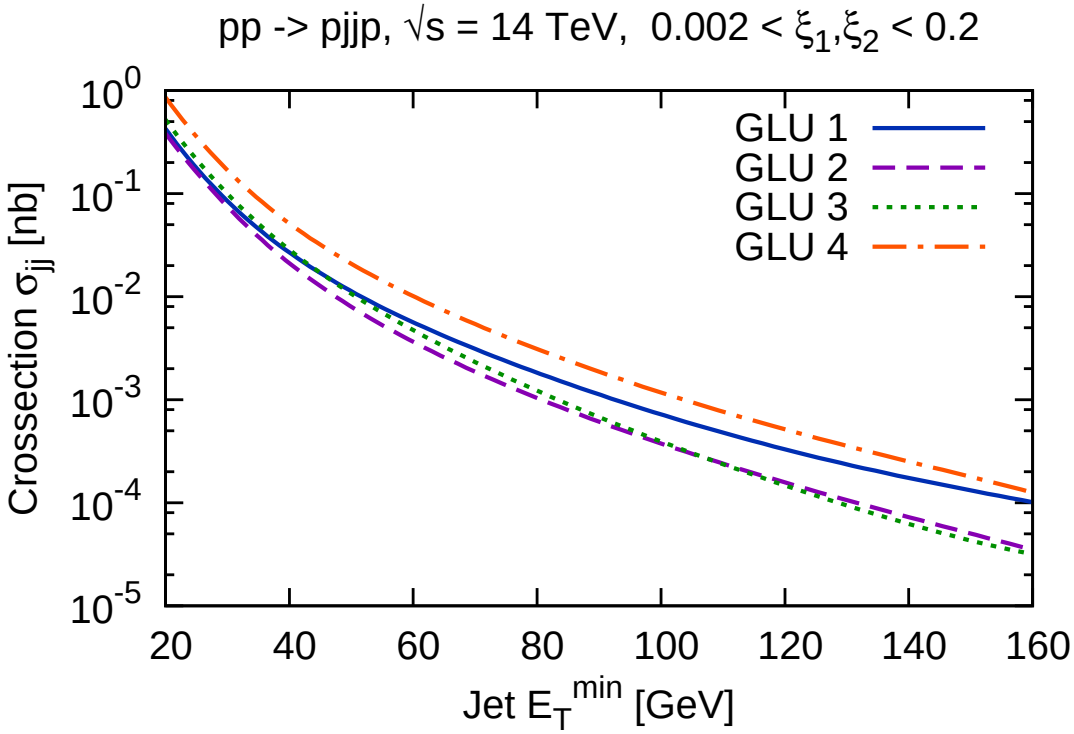
Model uncertainties - Survival probability and unintegrated gluon

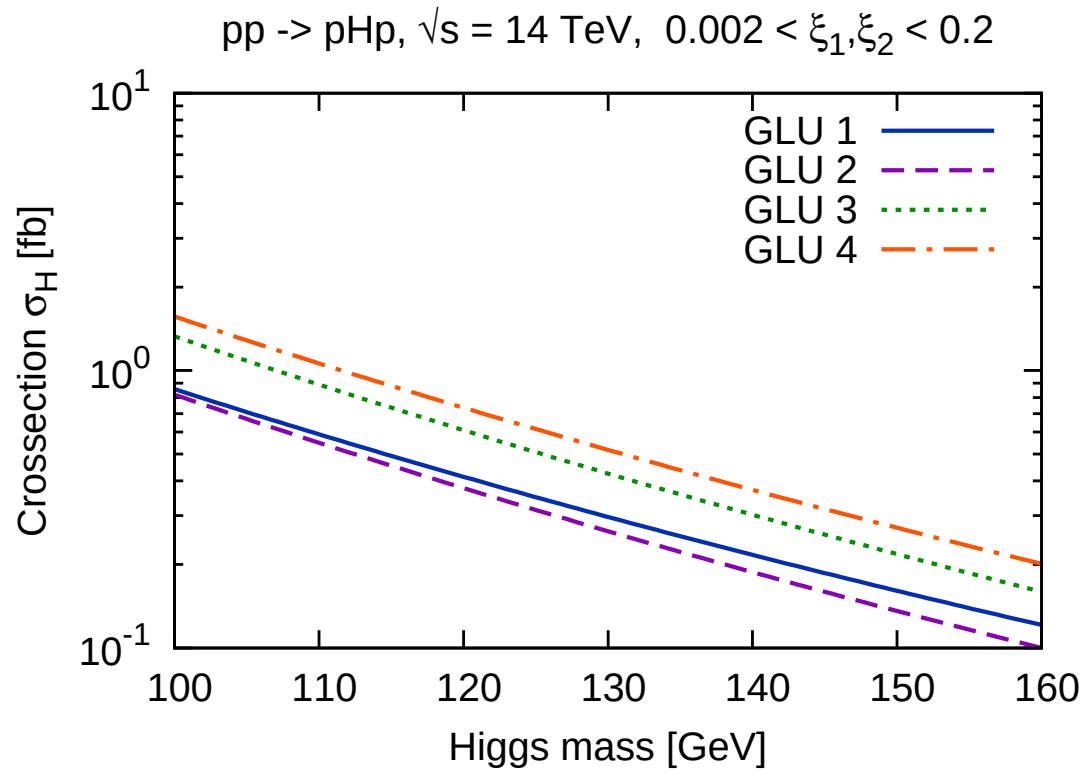
- Study model uncertainties by varying the parameters in CHIDe model
- Survival probability: 0.1 at Tevatron, 0.03 assumed at LHC (multiplication factor to exclusive cross sections, to be measured using first diffractive LHC data)
- Uncertainty on unintegrated gluon densities: 4 different gluon densities with same known hard contribution (GRV98) and different assumptions on soft contribution (represent the present uncertainty on soft part)



Effect of gluon uncertainties at LHC

Leads to about a factor 4 uncertainty on exclusive Higgs cross section at LHC



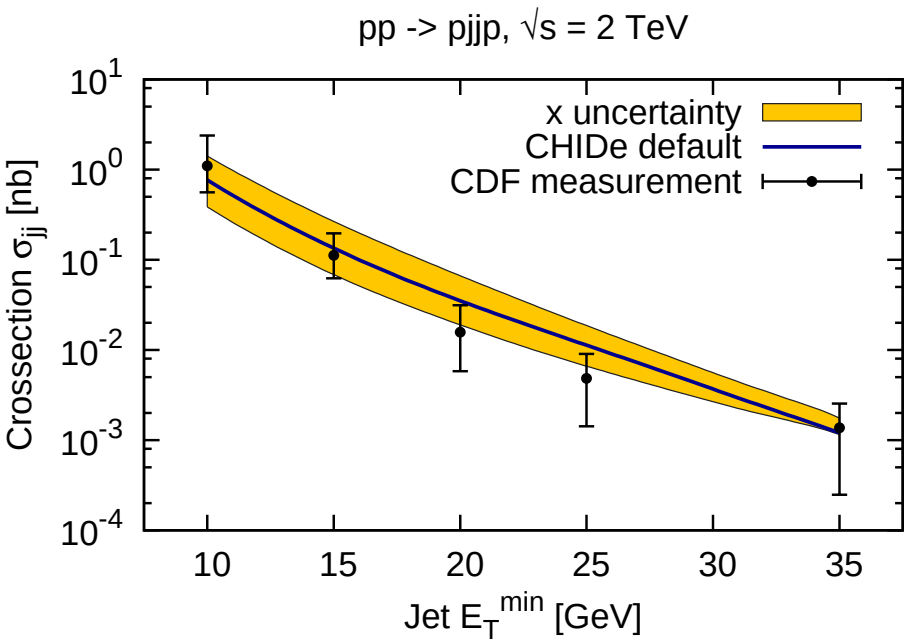


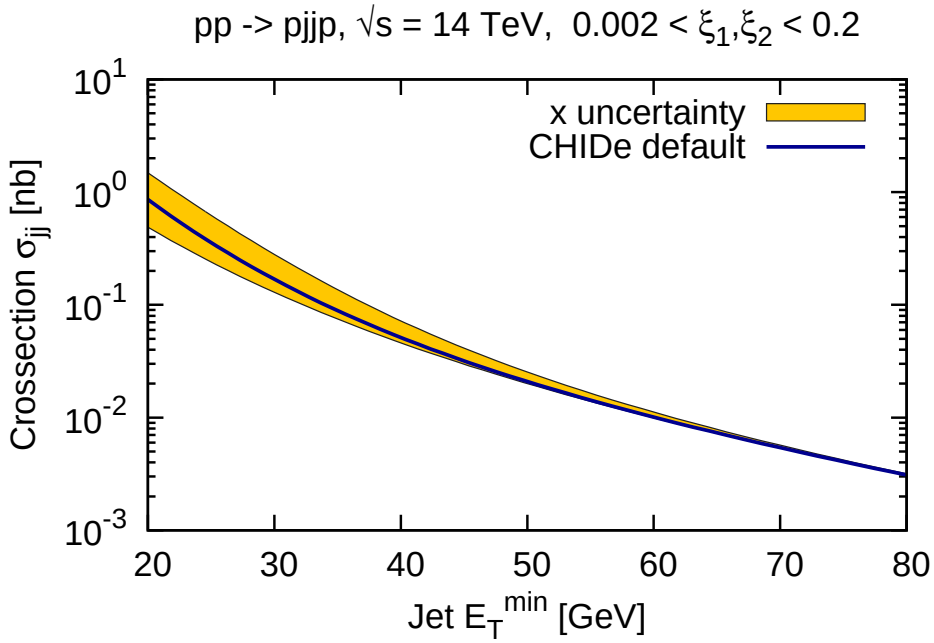
Modifying the Sudakov upper limit

- Variation of a factor 2 (0.25-1) of the upper limit x on the Sudakov factor

$$T(Q_T,\mu) = \exp\left[-\int_{Q_T^2/x'}^{\mu^2/x} \frac{\alpha_S(k_T^2)}{2\pi}\frac{dk_T^2}{k_T^2}\int_0^{1-\Delta} dz\,(zP_{gg}(z)+\Sigma_q P_{qg}(z))\right]$$

- Negligible effect for high p_T jets at LHC
- No upper limit ambiguity for Higgs production: $\mu = M_H$



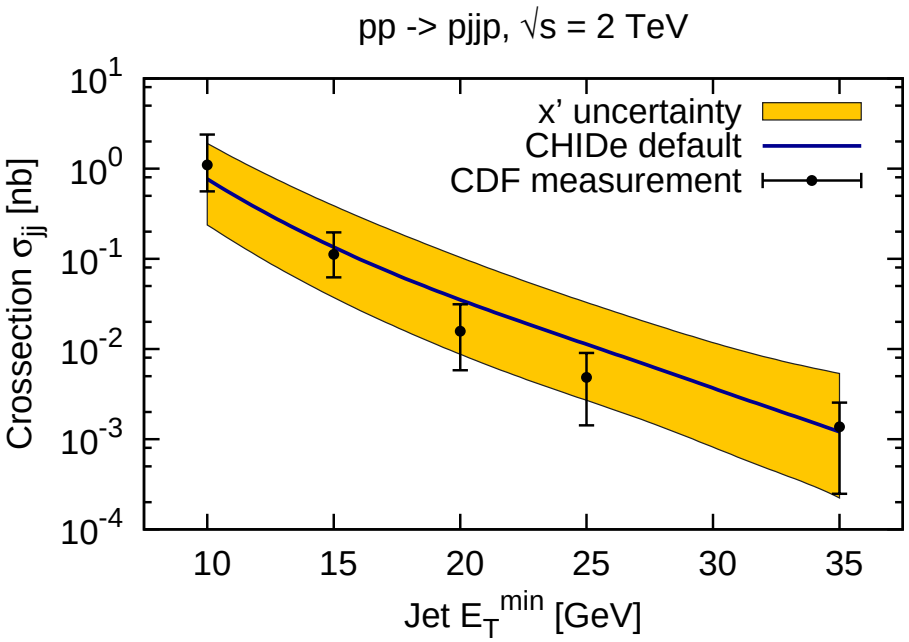


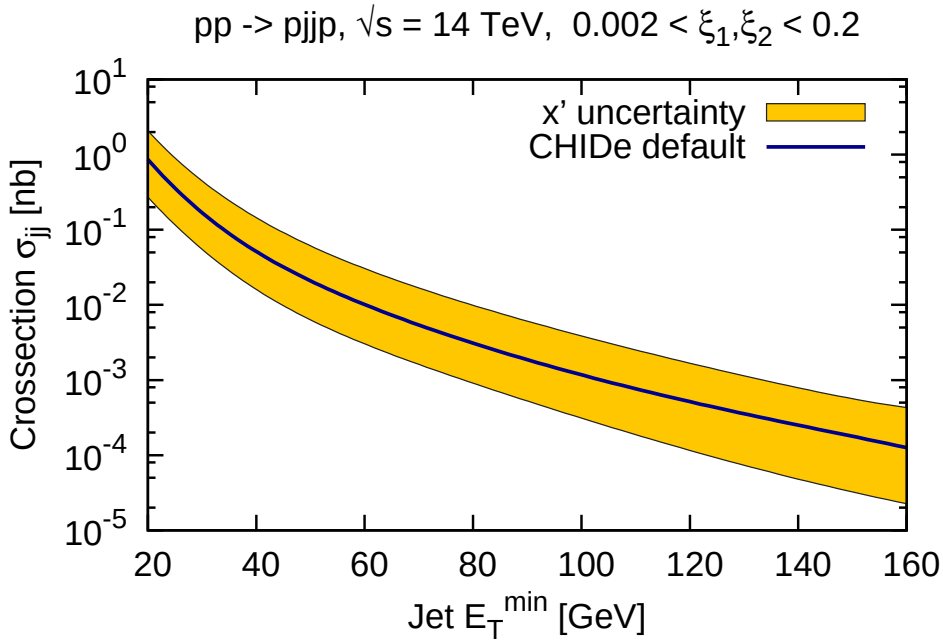
Modifying the Sudakov lower limit

- Variation of a factor 2 (0.25-1) of the lower limit x' on the Sudakov factor

$$T(Q_T,\mu) = \exp\left[-\int_{Q_T^2/x'}^{\mu^2/x} \frac{\alpha_S(k_T^2)}{2\pi}\frac{dk_T^2}{k_T^2}\int_0^{1-\Delta} dz\,(zP_{gg}(z)+\Sigma_q P_{qg}(z))\right]$$

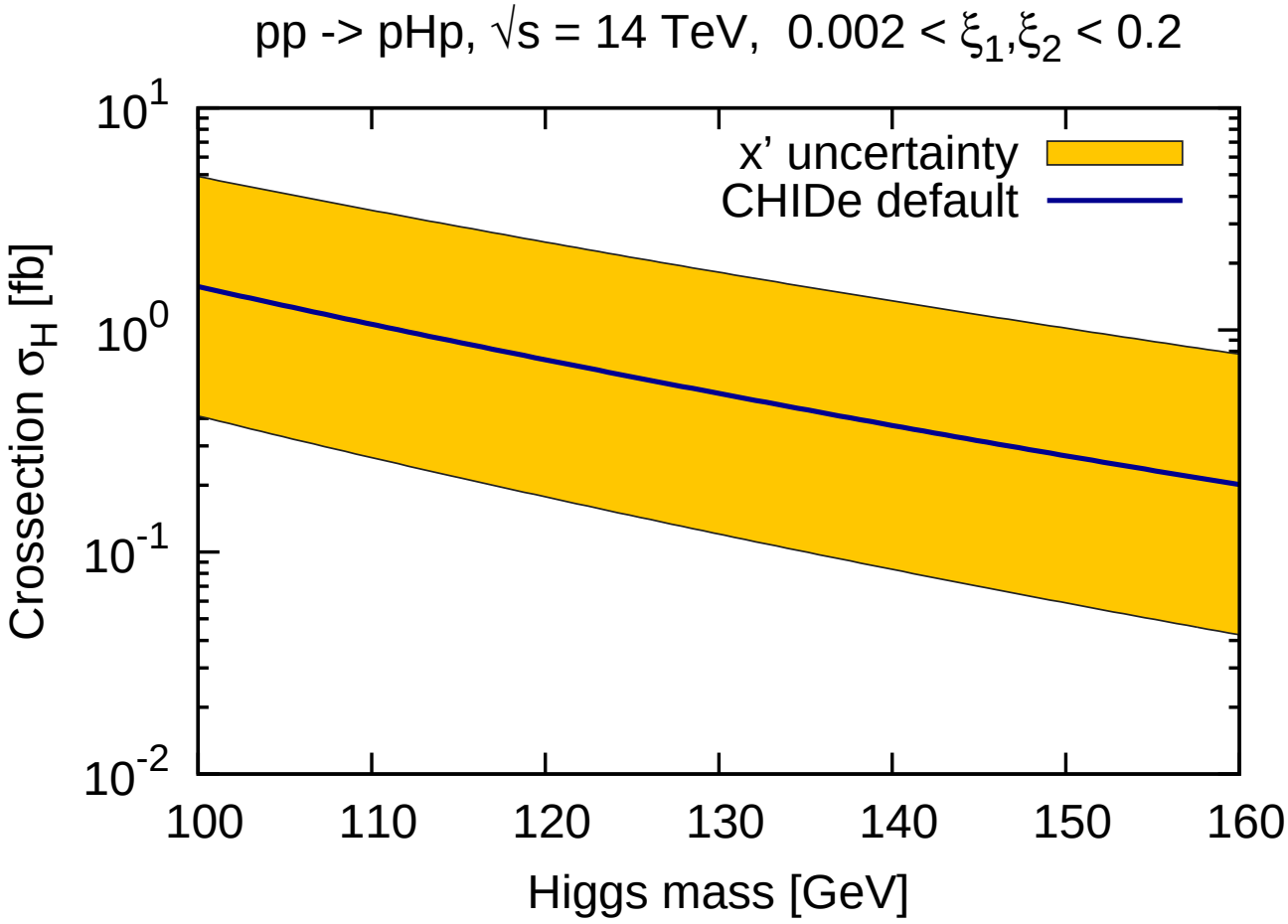
- Factor 10-20 difference for high p_T jet cross section at LHC, increases with jet p_T





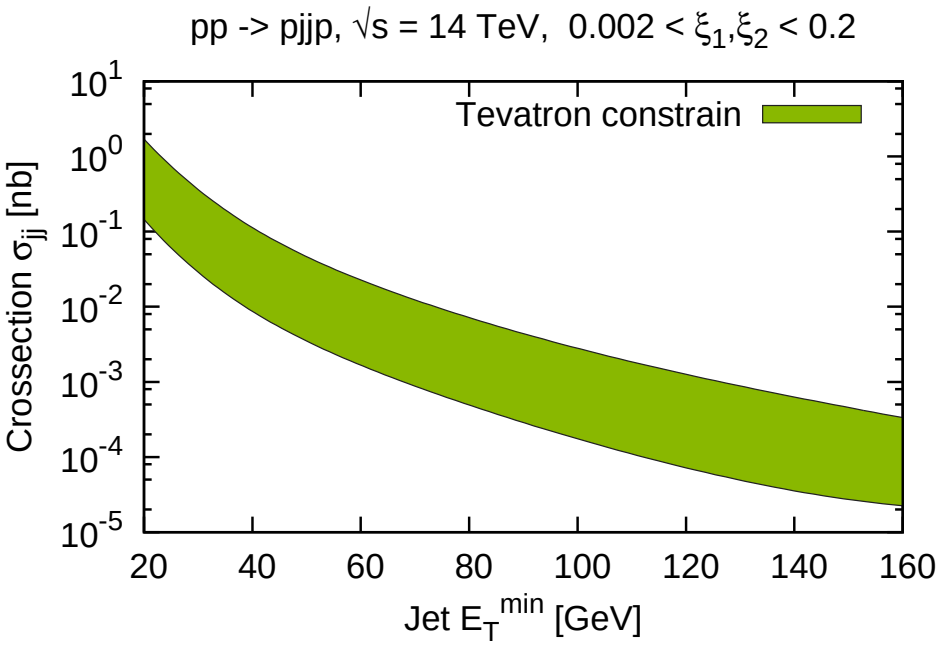
Modifying Sudakov lower limit

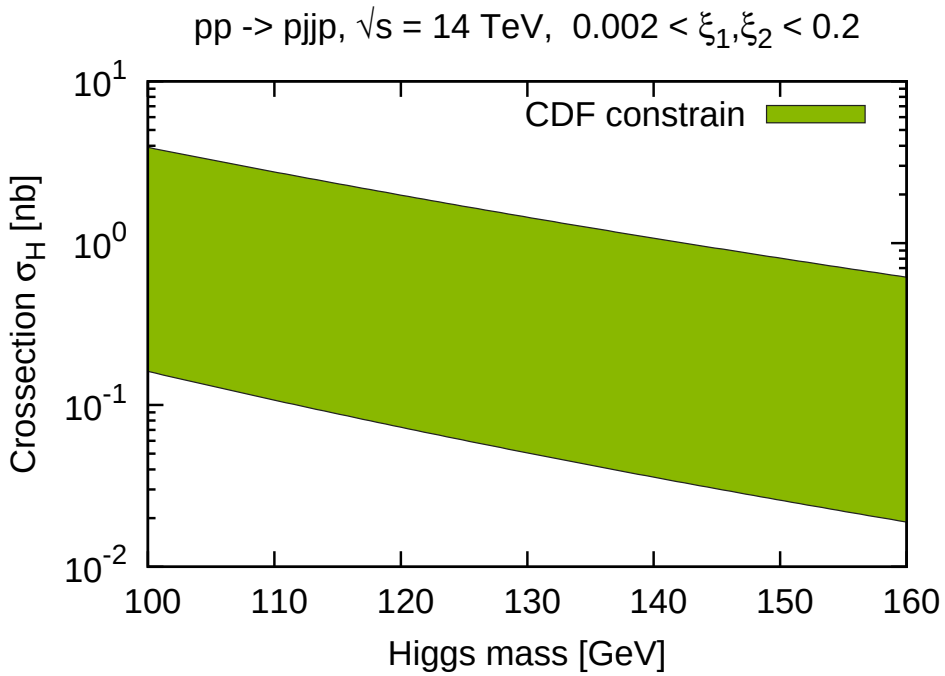
About a factor 20 difference on exclusive Higgs cross section



Impact of CDF data on model uncertainty

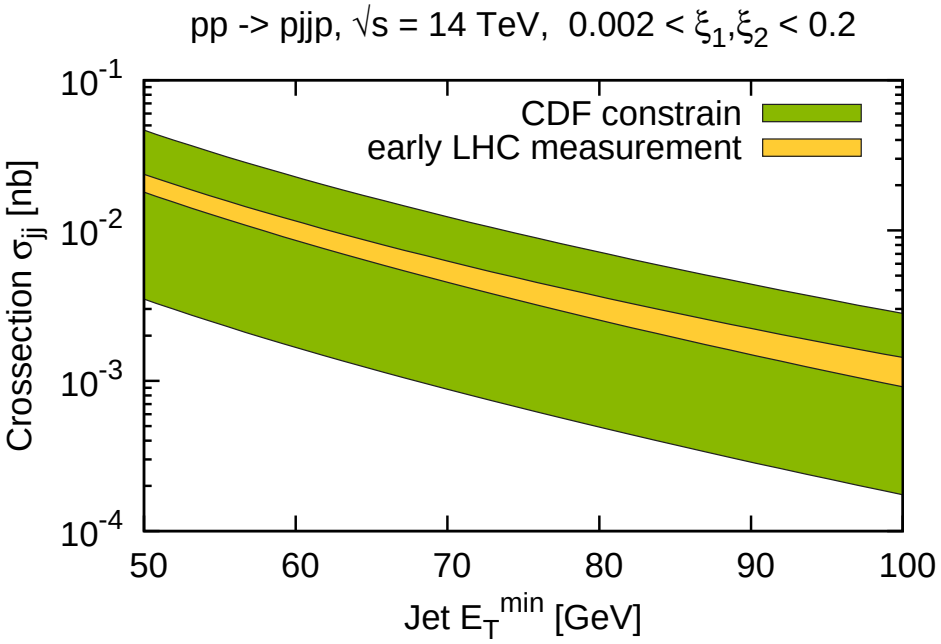
- Not all variation of paramters allowed by CDF measurement
- Method to obtain the model uncertainties:
  - For each gluon distribution, obtain a range of lower Sudakov limits (x'_{min} and x'_{max}) which agree within 1 σ with the CDF measurement
  - Use the same (x'_{min} and x'_{max}) values to obtain the uncertainties on LHC dijets and Higgs production
  - The final error band is defined by the largest differences using the 4 gluon densities
- About a factor 10 uncertainty on Higgs production at the :LHC

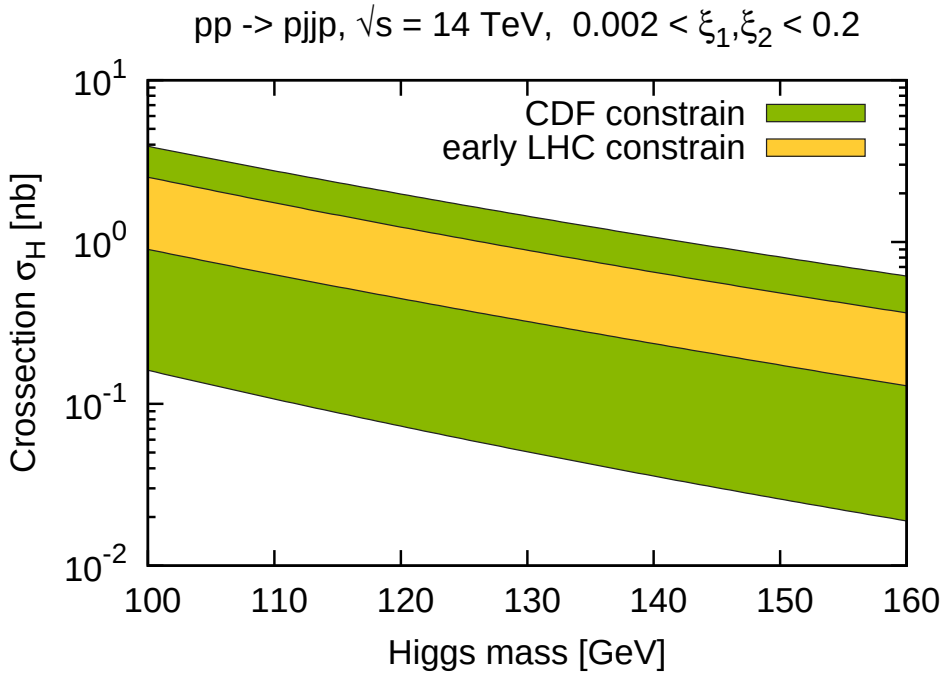




Impact of future LHC measurements on model uncertainty

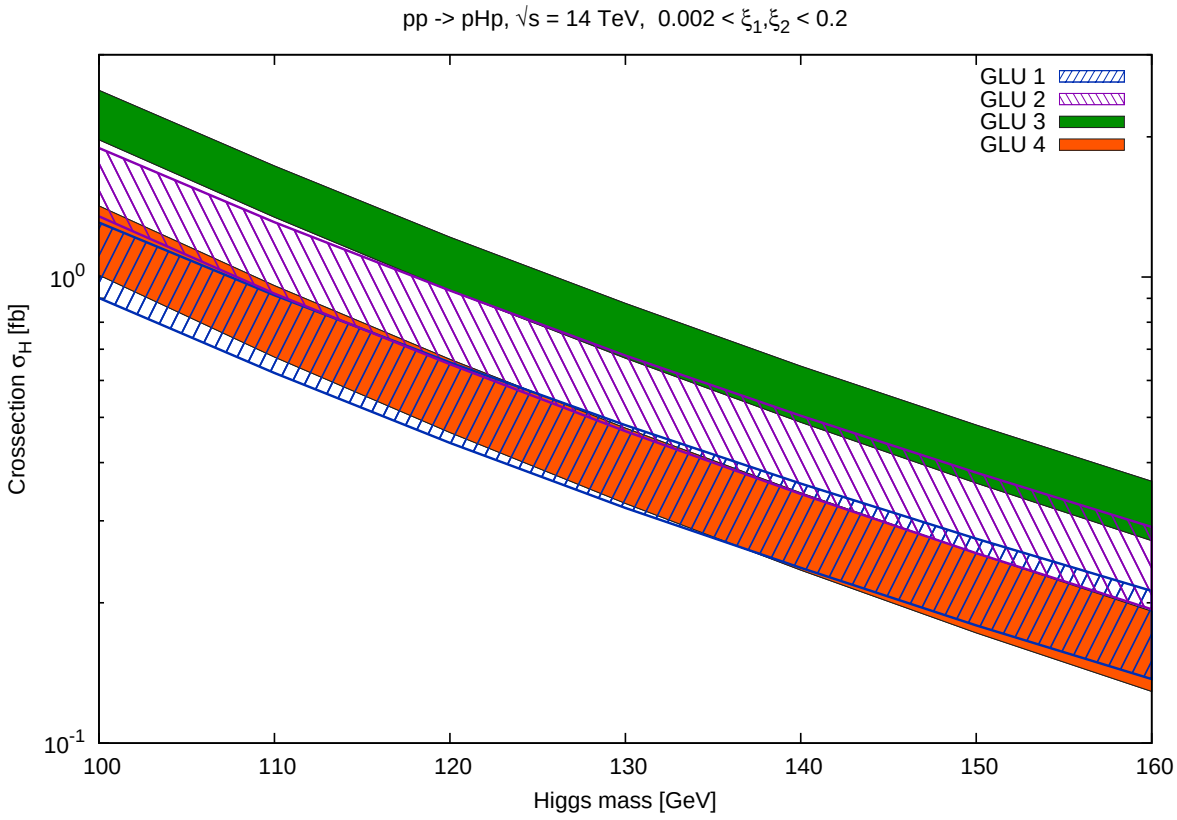
- Assume new measurement of exclusive jet production at the LHC: 100 pb^{-1}, precision on jet energy scale assumed to be $\sim$3% (conservative for JES, but takes into account other possible systematics)
- Use the same method as before to see the possible constraints on Higgs production: about a factor 2 uncertainty



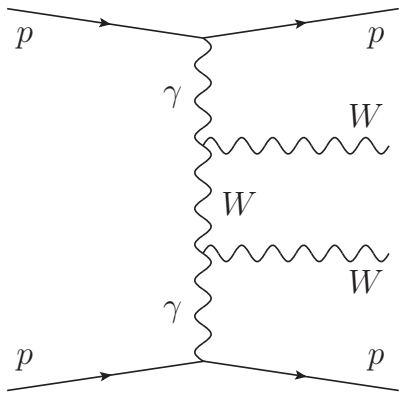


Contributions to final Higgs uncertainty

Contribution of gluon and scale uncertainties to final Higgs cross section prediction at the LHC



Tests of Higgsless models in FPMC



- Study of QED $pp \to pWWp$ and $pp \to pZZp$ processes at the LHC: allows to study quartic anomalous couplings $\gamma\gamma WW$ and $\gamma\gamma ZZ$
- Higgsless models predict anomalous coulings $\sim 5\ 10^{-6}$
- Improvement of LEP sensitivity by more than 4 orders of magnitude with 30/200 fb^{-1} at LHC by tagging forward protons (impossible to reach these sensitivities by other methods)!!!

Couplings	OPAL limits [GeV^{-2}]	Sensitivity @ $\mathcal{L} = 30$ (200) fb^{-1} 5σ	95% CL
a_0^W/Λ^2	[-0.020, 0.020]	5.4 10^{-6} (2.7 10^{-6})	2.6 10^{-6} (1.4 10^{-6})
a_C^W/Λ^2	[-0.052, 0.037]	2.0 10^{-5} (9.6 10^{-6})	9.4 10^{-6} (5.2 10^{-6})
a_0^Z/Λ^2	[-0.007, 0.023]	1.4 10^{-5} (5.5 10^{-6})	6.4 10^{-6} (2.5 10^{-6})
a_C^Z/Λ^2	[-0.029, 0.029]	5.2 10^{-5} (2.0 10^{-5})	2.4 10^{-5} (9.2 10^{-6})

Conclusion

- Forward Physics Monte Carlo program: Rapid development, contains now models for inclusive/exclusive diffraction with the possibility to study the impact of uncertainties on parameters, also contains photon induced processes
- CHIDe and KMR models lead to a good description of CDF measurements
- Present uncertainties on exclusive Higgs production at LHC: about a factor 10
- Possibility to reduce the uncertainties down to factor of 2 by measuring the exclusive jet cross section at LHC (additional uncertainty coming from survival probability)
- Possibility to reduce further the uncertainties using exclusive diphoton or b-jets productions
- Test of Higgless models using quartic anomalous couplings at the LHC (see E. Chapon, O. Kepka, C. Royon, arXiv:0808.0322, Phys. Rev. D78 (2008) 073005; arXiv:0908.1061; arXiv:0912.5161 Phys. Rev. D81 (2010) 074003)