Diffractive Higgs boson photoproduction by Double Pomeron Exchange

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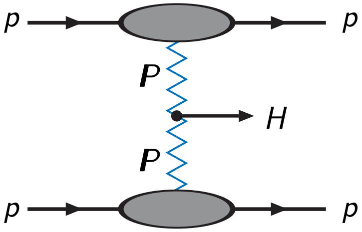
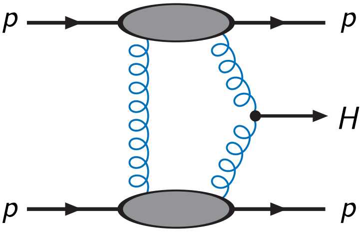
Motivations

- The existence of the Higgs boson is an open question in high-energy Physics;
- The Large Hadron Collider will allow study a new kinematic region never before reached — $\sqrt{s} = 14$ TeV!
  - It is expected that the proton-proton collisions in LHC will be able to produce the Higgs boson.
- Collisions will occur with **no** strong interaction in LHC
  - The peripheral collisions are a new way to study the Higgs boson production in heavy-ion collisions.
- Other processes of Higgs production by DPE allow another way to study its production
  - DPE allows the Higgs boson production by the leading ggH vertex in the mass range $M_H = 100 - 200$ GeV.

Diffractive Higgs production in *pp* collisions

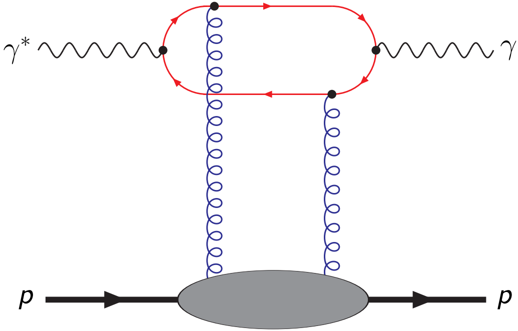
- **1991**: Bialas and Landshoff — PLB **256** (1991) 540
  - *Regge Theory* → non-perturbative gluons
- **1997**: Khoze, Martin and Ryskin — PLB **401** (1997) 330
  - *QCD Pomeron* → two-gluons exchange





Deeply Virtual Compton Scattering†

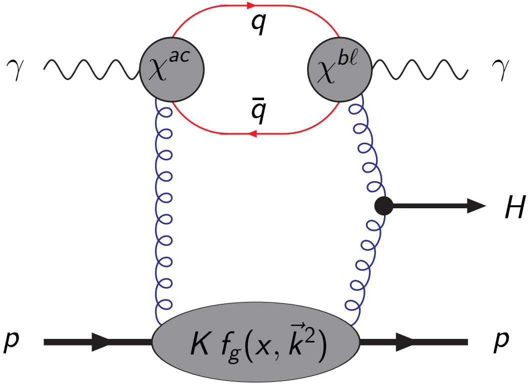
- **1998**: $\gamma^* p \to \gamma p$ by Pomeron exchange in *ep* collisions



†Frankfurt, Freund, Strikman, PRD **58** (1998) 114001

Diffractive Higgs photoproduction

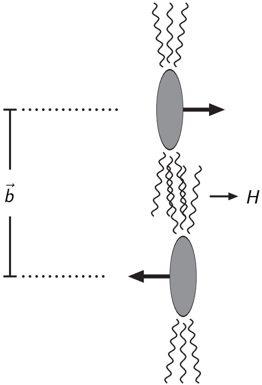
- **Proposal**: γp process by DPE in *pp* collision.



- The loop is treated in impact factor formalism at $t = 0$.

Peripheral collisions

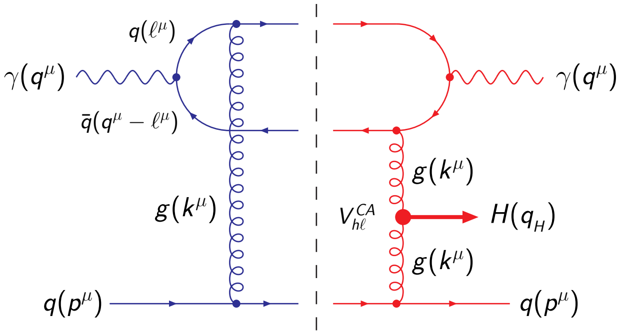
- The γp process is a subprocess in peripheral pp collisions



- **Impact parameter**: $b > 2R \Rightarrow$ **NO STRONG INTERACTION!**
- Only EM force acts between the protons $\Rightarrow$ **REAL PHOTONS**

Scattering amplitude

- **Partonic process**: $\gamma q \to \gamma + H + q$



- The scattering amplitude is obtained by the **Cutkosky Rules**

$$\mathrm{Im}\,\mathcal{A} = \frac{1}{2}\int d(PS)_3\, \mathcal{A}_{(left)}\, \mathcal{A}_{(right)} = \frac{20s}{9}\,\alpha_s^2\alpha\,\frac{M_H^2}{N_c v}\sum_q e_q^2 \underbrace{\left(\frac{\alpha_s\, C_F}{\pi}\right)}_{*} \int \frac{d\vec{k}^2}{\vec{k}^6}$$

Cross section for central rapidity

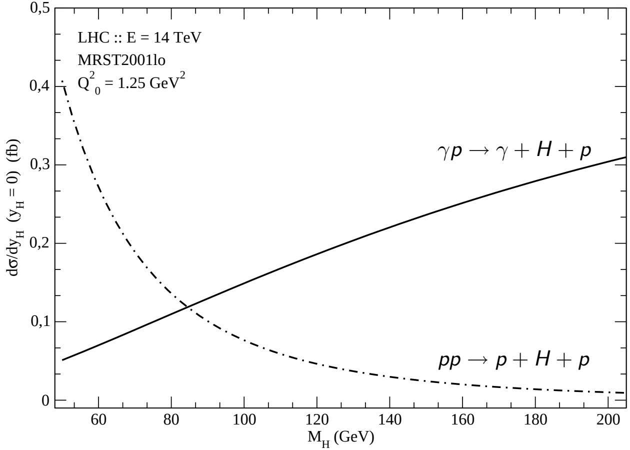
- The cross section is calculated for $y_H = 0$

$$\left.\frac{d\sigma}{dy_H}\right|_{y_H=0} = \frac{S^2_{gap}}{18\pi^3\, b}\left(\frac{M_H^2}{N_c\, v}\right)^2 \alpha_s^4\,\alpha^2\left(\sum_q e_q^2\right)^2\left[\int_{Q_0^2}^{\infty}\frac{d\vec{k}^2}{\vec{k}^6}\; e^{-S(\vec{k}^2, M_H^2)}\; f_g(x,\vec{k}^2)\right]^2$$

- * Quark contribution[1]: $\pi^{-1}\,\alpha_s\, C_F \quad\rightarrow\quad f_g(x,\vec{k}^2) = K\,\partial_{(\ell n\,\vec{k}^2)}\, xg(x,\vec{k}^2)$
- Gap Survival Probability[2]: $S^2_{gap} \rightarrow$ 3% (5%) for LHC (Tevatron)
- Gluon radiation supression[3]: Sudakov factor $S(\vec{k}^2, M_H^2) \sim \ell n^2\left(M_H^2/\vec{k}^2\right)$
- Cutoff Q_0^2: Necessary to avoid infrared divergencies.
- Electroweak vacuum expectation value: $v = 246$ GeV
- $p\mathbb{P}$-vertex impact parameter: $b = 5.5\ \text{GeV}^{-2}$

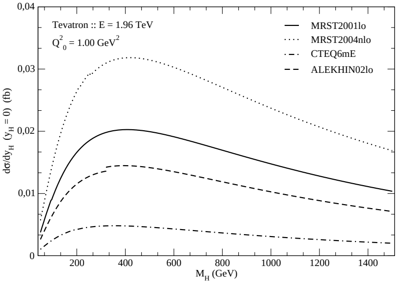
[1] Khoze, Martin, Ryskin, EJPC 14 (2000) 525
[2] Khoze, Martin, Ryskin, EJPC 18 (2000) 167
[3] Forshaw, hep-ph/0508274

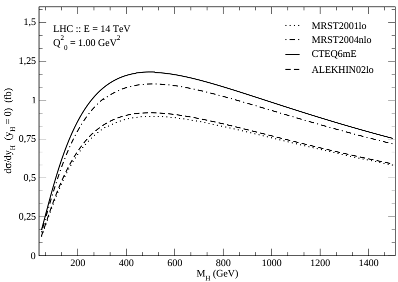
Results: pp vs. γp process



- Greatest event rate in the mass region expected for Higgs detection.

Results: Gluon distribution functions

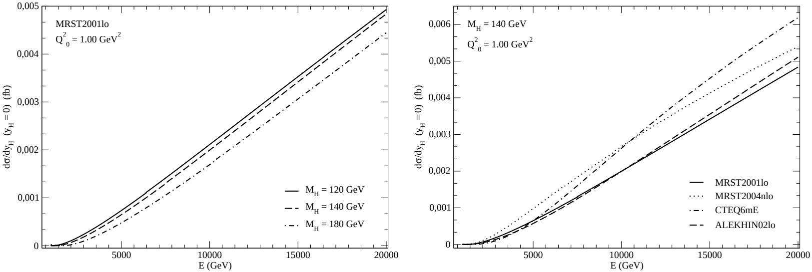




- **Tevatron**:
  Small difference between **LO** and **NLO** distributions;

- **LHC**:
  NLO distributions show a **greater** contribution than the LO ones.

Results: Energy dependence



- **Small** dependence on Higgs mass;
- Gluon distribution functions:
  - **NLO**: greater contribution in the region $\underbrace{E = 9 - 17 \text{ TeV}}_{\textbf{include LHC region}}$

Summary

- Substantial results for Higgs boson production in γp process present in peripheral collisions;
- An event rate three times bigger than the rate predicted by previous results in *pp* collisions;
- Clear difference between LO and NLO distributions in the kinematic region of LHC;
- Need of control the cross-section behavior in the very-high-energy limit;
- Analysis of this production mechanism in *pp* collisions:
  - Introduction of photon distribution in the proton;
- Include QCD and Electroweak corrections;
- Predict physical observables for other production processes.