Exclusive higgs production consistent with MSSM baryogenesis

Michal Deák

IFAE, Barcelona

Baryogenesis in SM

- baryon density of the Universe is much bigger than antibaryon one

$$\eta \equiv \frac{n_B}{n_\gamma} = \frac{n_b - n_{\bar{b}}}{n_\gamma} \equiv 7\,\frac{n_B}{s}$$

$$\eta = (6.11 \pm 0.19) \times 10^{-10}$$

- possible dynamical origin - Sakharov conditions
  - baryon number violation
  - C and CP violation
  - non-equilibrium phase

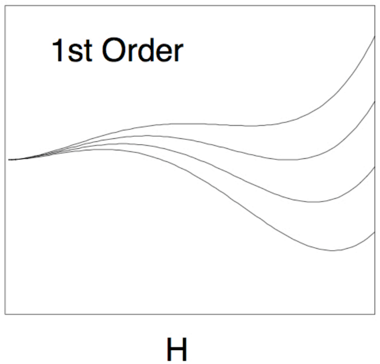
Baryogenesis in SM

- baryon density of the Universe is much bigger than antibaryon one

$$\eta \equiv \frac{n_B}{n_\gamma} = \frac{n_b - n_{\bar{b}}}{n_\gamma} \equiv 7\,\frac{n_B}{s}$$

$$\eta = (6.11 \pm 0.19) \times 10^{-10}$$

- possible dynamical origin - Sakharov conditions
  - baryon number violation - in SM - anomalies
  - C and CP violation - in SM - CKM
  - non-equilibrium phase - in SM - 1st order phase transition



Baryogenesis in SM

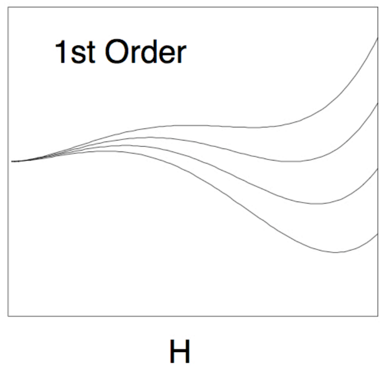
- baryon density of the Universe is much bigger than antibaryon one

$$\eta \equiv \frac{n_B}{n_\gamma} = \frac{n_b - n_{\bar{b}}}{n_\gamma} \equiv 7\,\frac{n_B}{s}$$

$$\eta = (6.11 \pm 0.19) \times 10^{-10}$$

- possible dynamical origin - Sakharov conditions
  - baryon number violation - in SM - anomalies
  - C and CP violation - in SM - CKM
  - non-equilibrium phase - in SM - 1st order phase transition

- problem in SM: the cubic term in the higgs potential too small - $O(g^3)$



Light stop MSSM scenario

- the electroweak phase transition is first order in the light stop scenario ($m_{\tilde{t}_R} < m_{top}$) for m_H<130 GeV
- light stops contribute to the finite temperature effective potential

$$m^2 = m_0^2 + m^2(\Phi) + \Pi(T)$$

$$\Delta V(\Phi, T) \equiv m^2(T)\ \Phi^2 - cT\,(m_0^2 + \Pi(T) + \alpha\ \Phi^2)^{3/2} \ldots$$

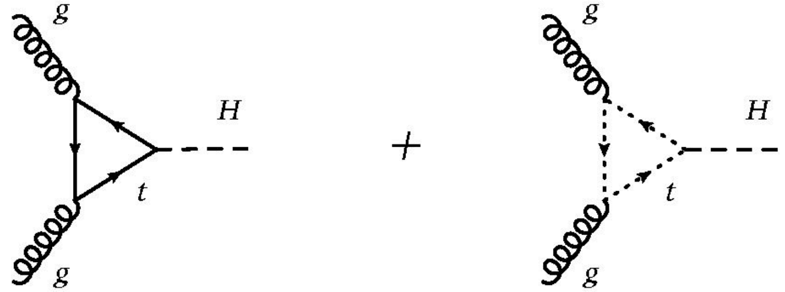
- large contribution to the cubic term when $m_0^2 + \Pi(T)$ is small
- m_0^2 can be negative for dominantly right stops which corresponds to light stops

Higgs production in MSSM light stop scenario

- dominant channel for higgs production at the LHC is via gluon-gluon fusion
- light stop will contribute to the vertex

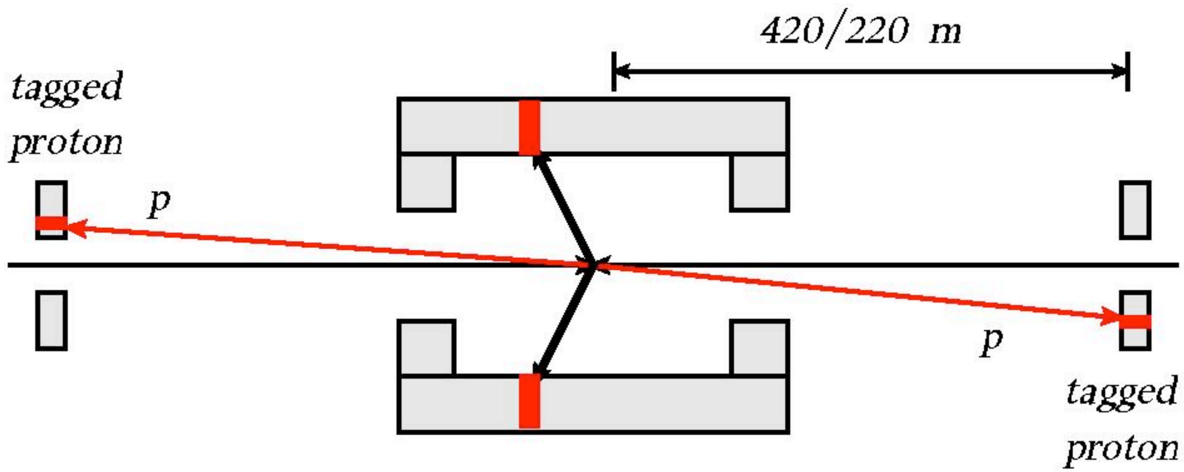
- all other superpartners very heavy with mass $\sim M >> \Lambda_{EW}$
- the higgs-stop-antistop coupling gets logarithmic corrections $\sim log(M/\Lambda_{EW})^n$
- need to solve RGE with boundary conditions in different scales

Carena, Nardini, Quiros, Wagner
Nucl.Phys.B812:243-263,2009



Exclusive production at hadron-hadron colliders

- processes $p + p \to p + X + p$ in which the protons stay intact
- typical exclusive event in a detector:



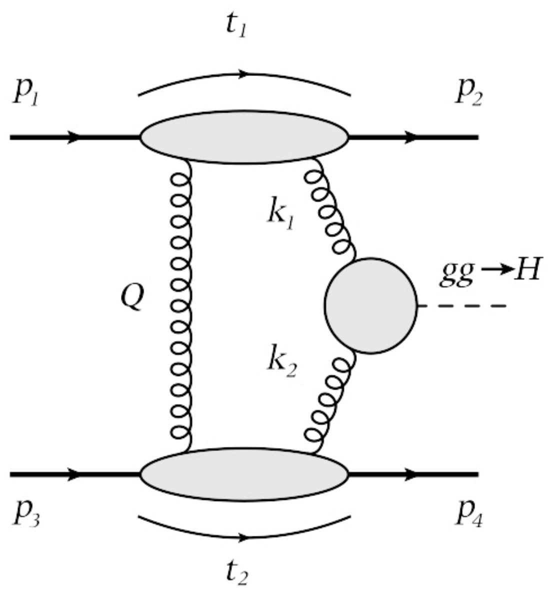
- scattered protons tagged in very forward detectors near the beam pipe, two rapidity gaps and a final state X detected in the central detector

Exclusive production at hadron-hadron colliders

- $J_z=0$ and CP even selection rule
  - production of CP odd higgs suppressed
- suppression of backgrounds; very clear signals
  - different threshold behavior of pairs fermion-antifermion (~velocity^3) and scalar pairs (~velocity^1)
  - suppression of bb background to $H \rightarrow bb$

Exclusive higgs production in Durham model

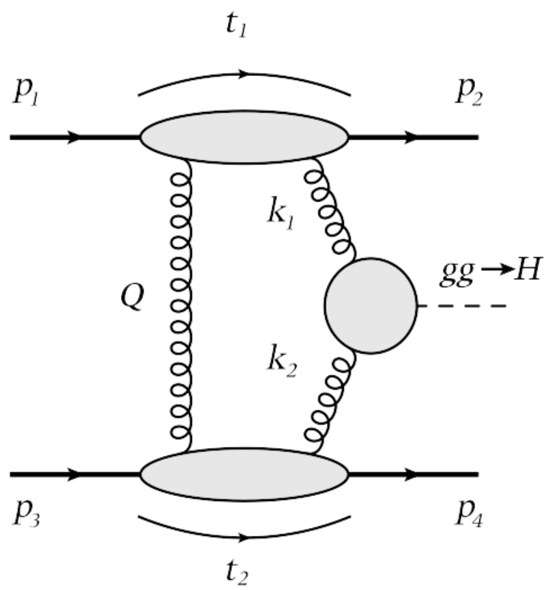
- rapidity gaps due to 2 gluon exchange in singlet state
- double gluon parton density functions (skewed PDFs) needed - approximated by a product of 2 PDFs
- summation over spin and colour on amplitude level



Exclusive higgs production in Durham model

- the formula for the cross section

$$\frac{d\sigma}{dy} = \frac{1}{256\pi b^2}\frac{\alpha_S^2 G_F\sqrt{2}}{4}\left[\frac{d^2\mathbf{Q}_\perp}{\mathbf{Q}_\perp^4}\tilde{f}(x_1,Q_\perp)\tilde{f}(x_2,Q_\perp)\right]^2 |A_V|^2$$



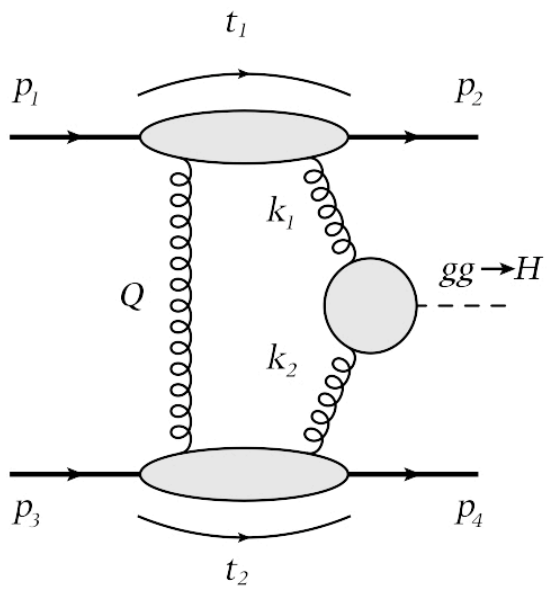
- A_V is an amplitude characterising the hgg vertex:

$$A_t(\tau_t)+g_{h\tilde{t}\tilde{t}}\frac{(\sqrt{2}G_F)^{-1/2}}{2m_{\tilde{t}}^2}A_{\tilde{t}}(\tau_{\tilde{t}})$$

Exclusive higgs production in Durham model

- the formula for the cross section

$$\frac{d\sigma}{dy} = \frac{1}{256\pi b^2}\frac{\alpha_S^2 G_F\sqrt{2}}{4}\left[\frac{d^2\mathbf{Q}_\perp}{\mathbf{Q}_\perp^4}\tilde{f}(x_1,Q_\perp)\tilde{f}(x_2,Q_\perp)\right]^2 |A_V|^2$$



- A_V is an amplitude characterising the hgg vertex:

$$A_t(\tau_t) + g_{h\tilde{t}\tilde{t}}\frac{(\sqrt{2}G_F)^{-1/2}}{2m_{\tilde{t}}^2}A_{\tilde{t}}(\tau_{\tilde{t}})$$

top contribution

stop contribution

Exclusive higgs production in Durham model

- the formula for the cross section

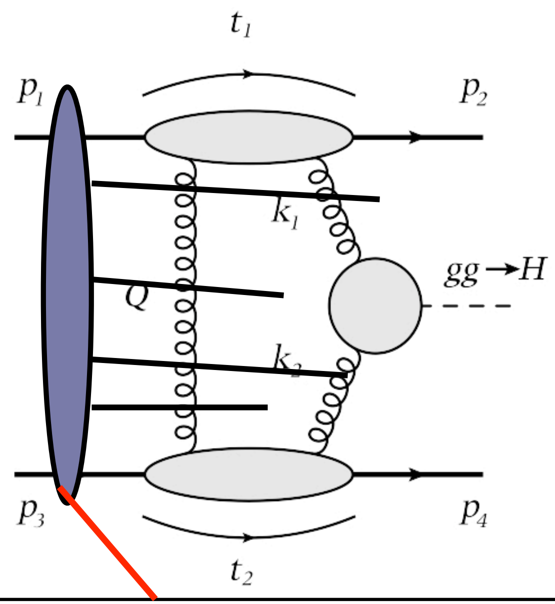
$$\frac{d\sigma}{dy} = \frac{1}{256\pi b^2} \frac{\alpha_S^2 G_F \sqrt{2}}{4} \left[\frac{d^2\mathbf{Q}_\perp}{\mathbf{Q}_\perp^4} \tilde{f}(x_1, Q_\perp) \tilde{f}(x_2, Q_\perp) \right]^2 |A_V|^2$$

- A_V is an amplitude characterising the hgg vertex:

$$A_t(\tau_t) + g_{h\tilde{t}\tilde{t}} \frac{(\sqrt{2} G_F)^{-1/2}}{2m_{\tilde{t}}^2} A_{\tilde{t}}(\tau_{\tilde{t}})$$

top contribution

stop contribution



rapidity gap survival Factor - estimated to be 0.03 for LHC energy

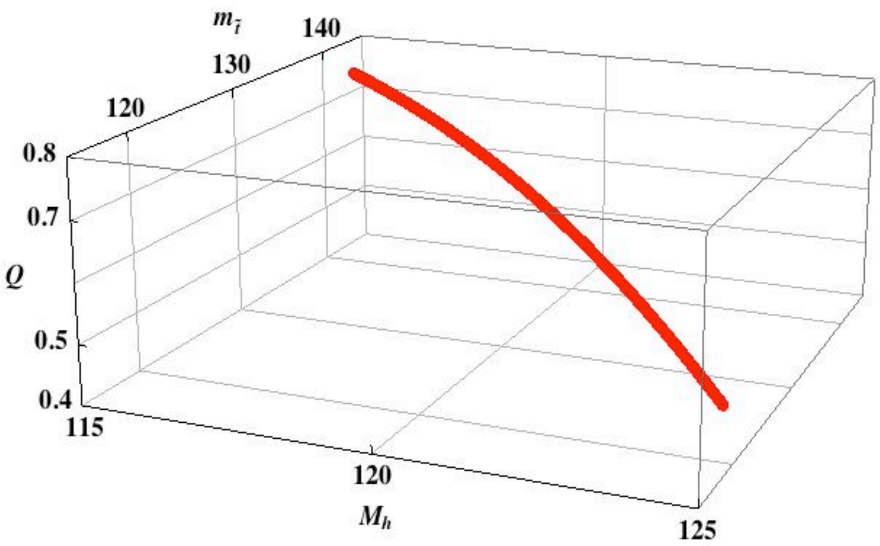
Results

- the cross section depends on m_{stop}, M_h and $g_{h\tilde{t}\bar{\tilde{t}}}$
  - $g_{h\tilde{t}\bar{\tilde{t}}}$ depends on parameters of MSSM in very non-trivial way - obtained from solution of RGEs

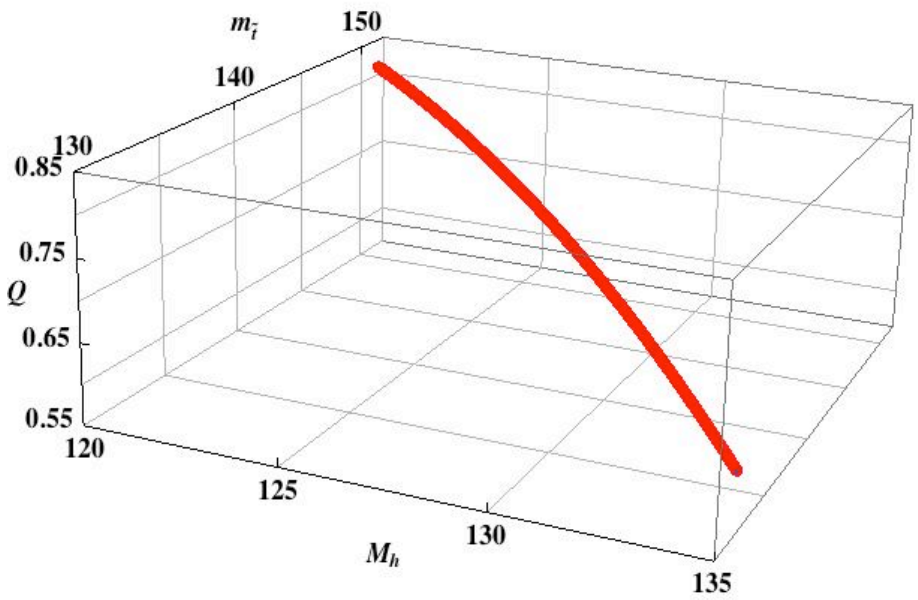
$$g_{h\tilde{t}\bar{\tilde{t}}} = \sqrt{2} v Q$$
$$m_{\tilde{t}}^2 = m_0^2 + v^2 Q$$

m_0^2=-(80 GeV)^2 ***s= (14000 GeV)^2***

M=10 TeV



M=1000 TeV



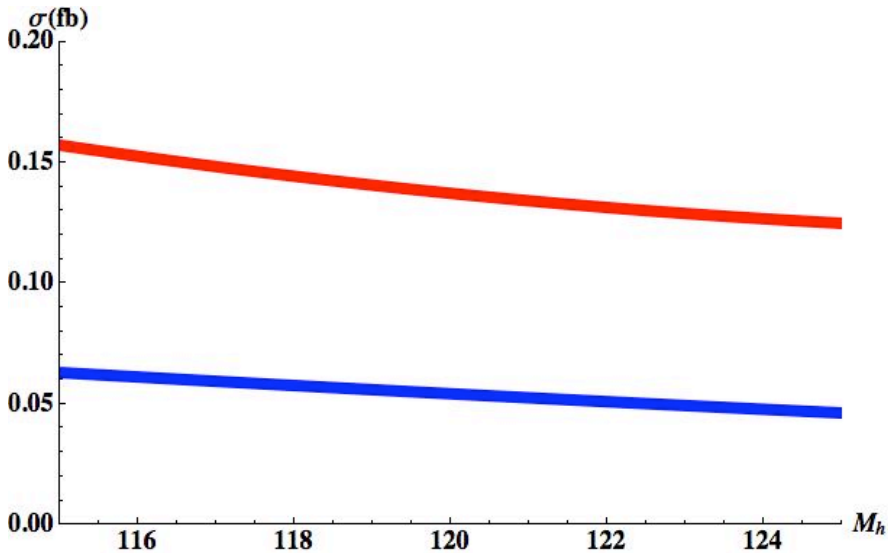
Menon, Morrissey **Phys.Rev.D79:115020,2009**

Results

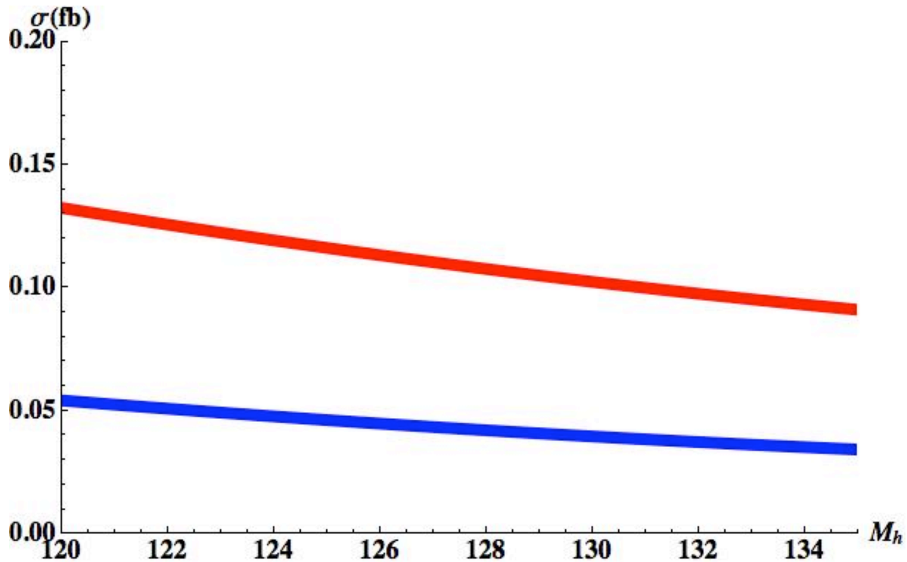
- cross sections depending on M_h (red)
- compared to SM cross section (blue)

$m_0^2 = -(80\ GeV)^2$ $s = (14000\ GeV)^2$

M=10 TeV



M=1000 TeV

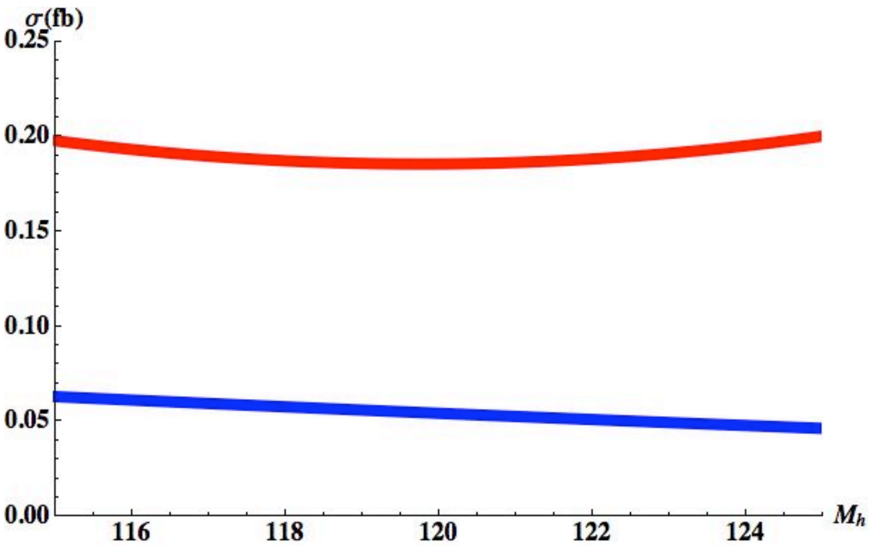


Results

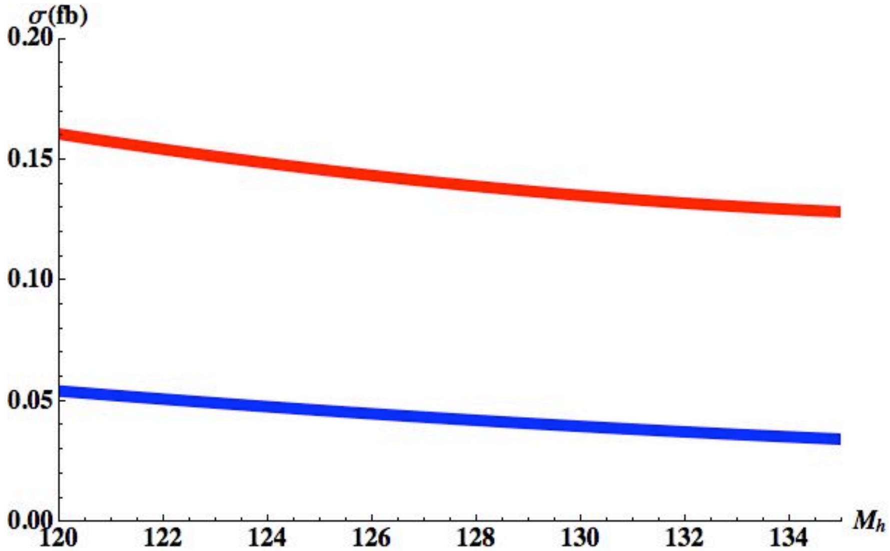
- cross sections depending on M_h (red)
- compared to SM cross section (blue)

m_0^2=-(40 GeV)^2 ***s= (14000 GeV)^2***

M=10 TeV



M=1000 TeV



Summary and Outlook

- cross sections of exclusive higgs production in light stop MSSM scenario as a function of higgs and stop masses calculated for different parameters of the model
- ratio between the SM and MSSM cross section ~ 3 to 4
- further studies with backgrounds to this process