Can the 750 GeV enhancement be a signal of light magnetic monopoles?

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V. A. Mitsou and V. Vento

1. Introduction

Eur. Phys. J. Plus (2012) 127: 60

Looking for magnetic monopoles at LHC with diphoton events

a)Dirac monopoles with conventional and beta couplings.
b)Monopolium described as a scalar

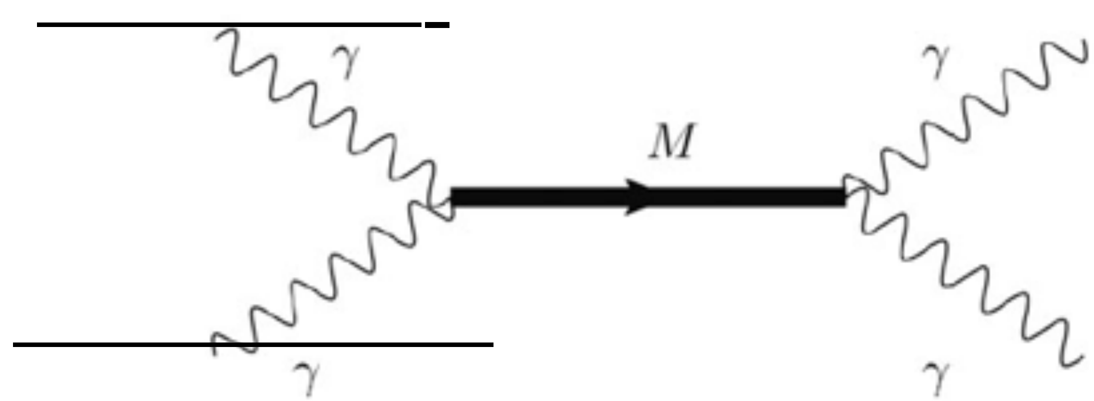


Fig. 10. Diagrammatic description of the monopolium production and decay.

Monopolium: the key to monopoles
Luis N. Epele, Huner Fanchiotti, Carlos A. Garcia Canal, Vicente Vento, Eur.Phys.J. C56 (2008) 87-95

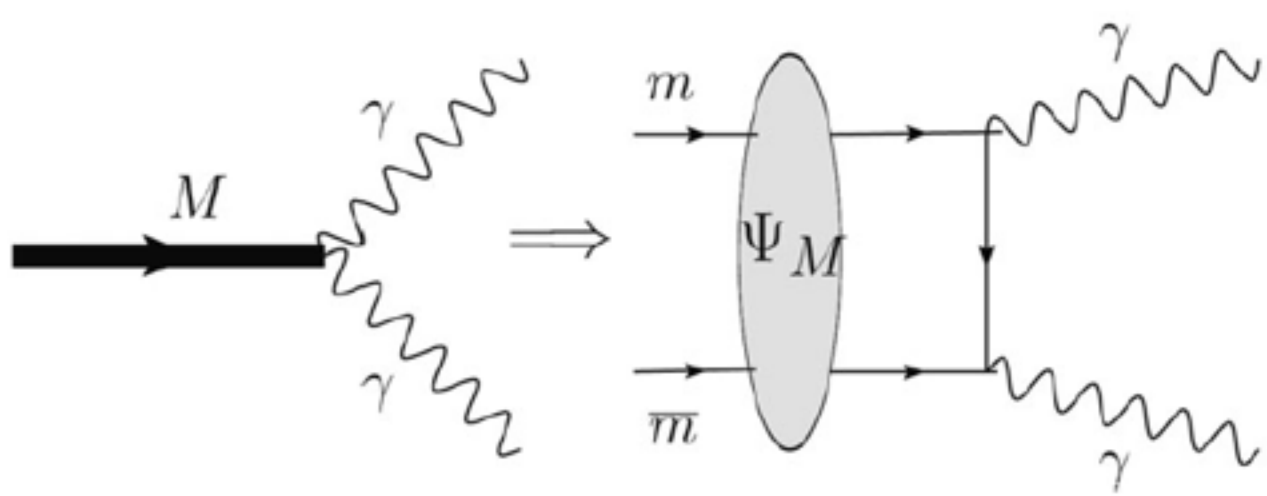


Fig. 11. The monopolium vertex and its microscopic description.

Monopole - antimonopole production and annihilation

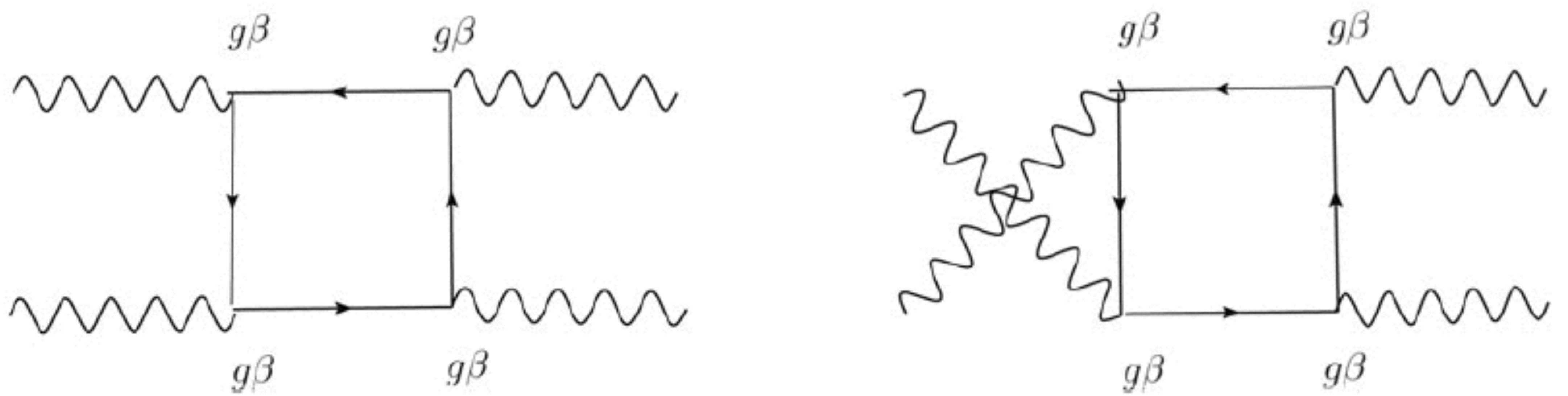
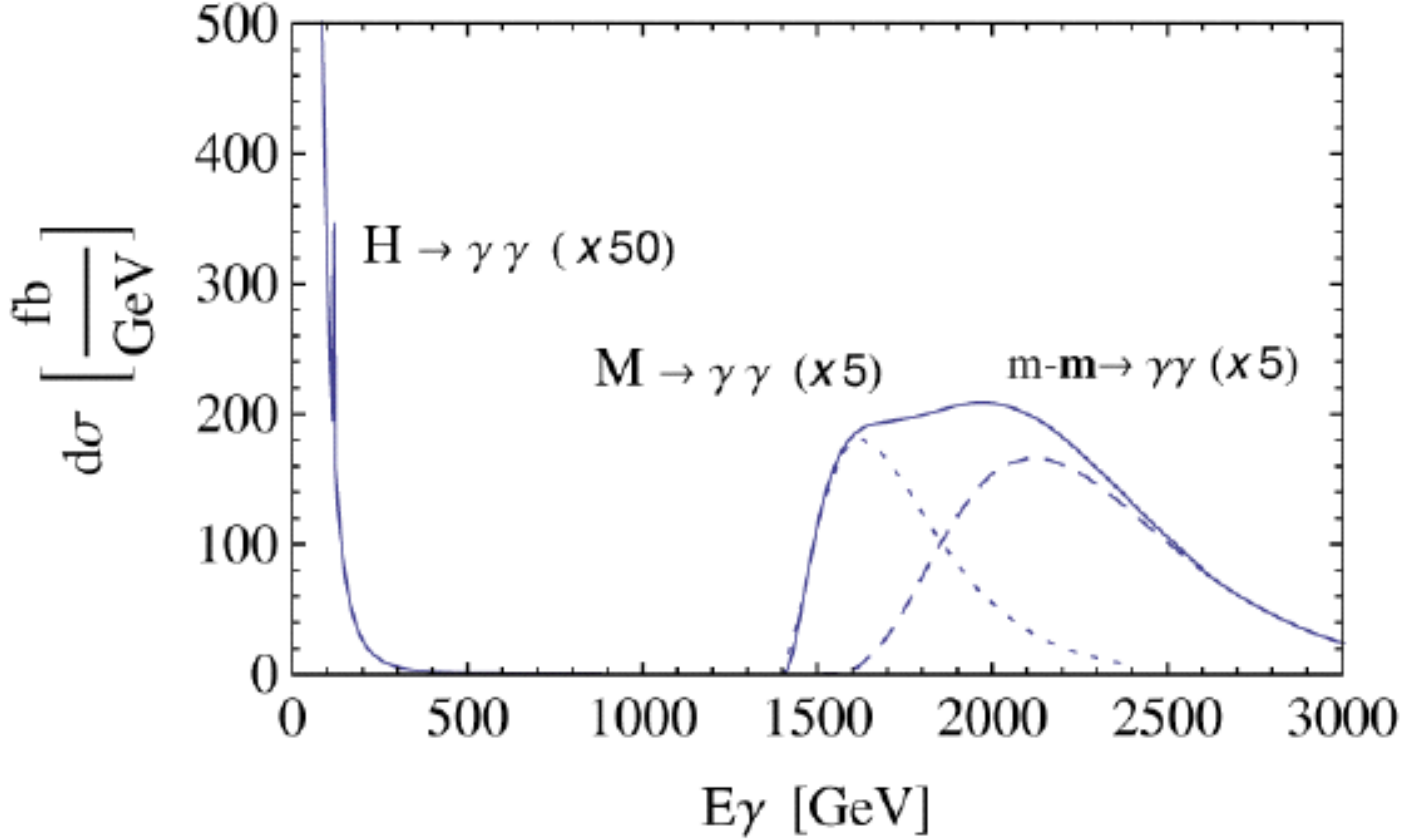
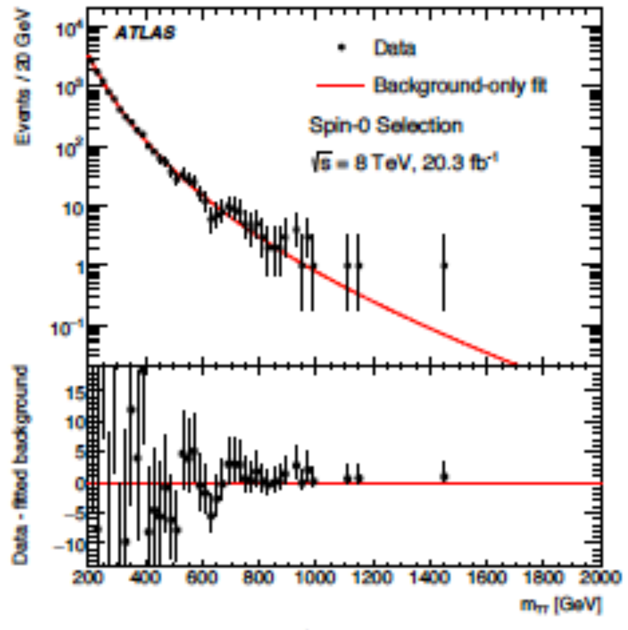


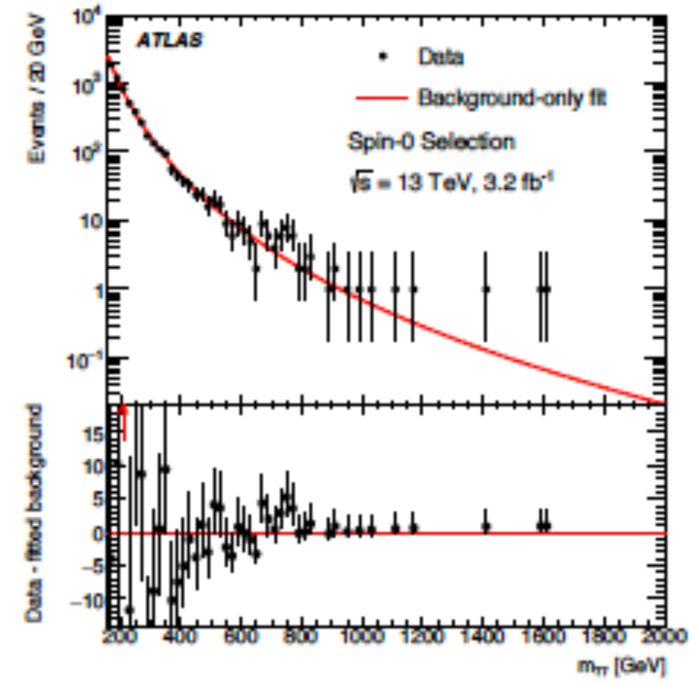
Fig. 4. Elementary processes for monopole-antimonopole production and annihilation into photons.

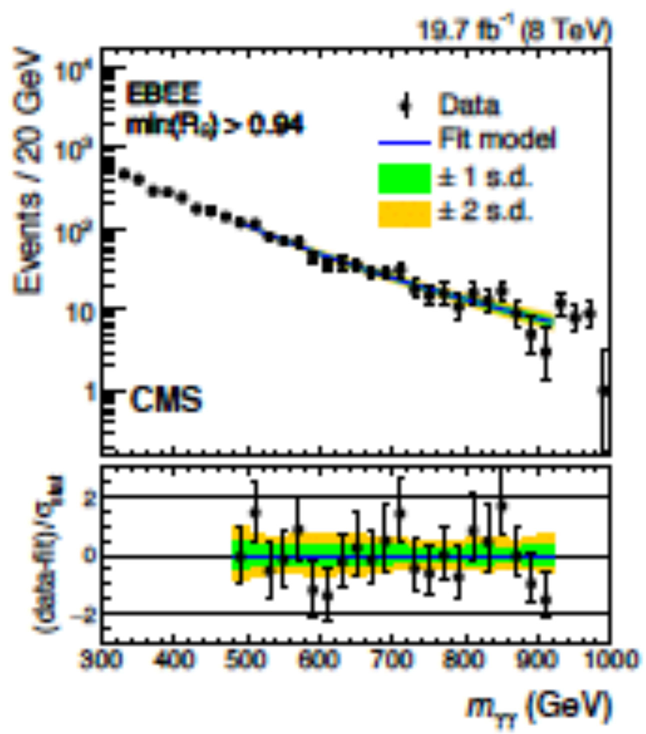


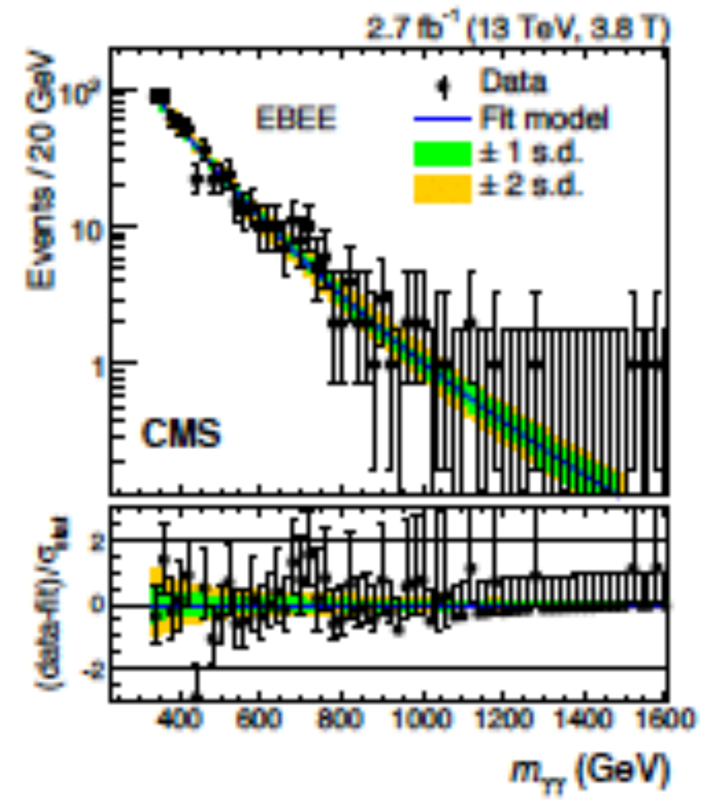
H → γ γ (x 50)
M → γ γ (x 5)
m-**m**→ γγ (x 5)
dσ [fb/GeV]
Eγ [GeV]
0
100
200
300
400
500
0
500
1000
1500
2000
2500
3000

2. Data analysis for a scalar









Mass ~750 GeV   Width ~45 GeV   less than 3 standard deviations

First idea: trivial application of previous result!

The resulting cross-section and width are huge!!!

Moreover, at 8 TeV with the large accumulated statistics it should have been seen without any doubt!!!

3. Analysis

a) monopole-antimonopole annihilation must follow monopolium decay.
b) monopolium has two parameters: monopolium mass and monopole mass; monopole-antimonopole only one the monopole mass
c) we were discussing a pure Dirac theory,i.e. only em couplings. We gain additional freedom for monopolium in GUTs through branching ratios.

But: monopole-antimonopole annihilation, obtained from a microscopic calculation, has still only one parameter the monopole mass.

The production of a diphoton resonance via photon-photon fusion
L. A. Harland-Lang, V. A. Khoze, M. G. Ryskin
arXiv:1601.07187
They analyze a scalar resonance:

$$M_X = 750\ \mathrm{GeV} \qquad \Gamma_{\mathrm{tot}} = 45\ \mathrm{GeV},$$

$$\mathrm{Br}(R \to \gamma\gamma) = 3.1 - 4.4\,\% \,.$$

$$\frac{\mathcal{L}^{\mathrm{inc}}_{\gamma\gamma}(\sqrt{s} = 13\,\mathrm{TeV})}{\mathcal{L}^{\mathrm{inc}}_{\gamma\gamma}(\sqrt{s} = 8\,\mathrm{TeV})} = 2.9$$

Thus for monopolium we change the Dirac expression for:

$$\sigma(\gamma\gamma \to M \to \gamma\gamma) = \frac{4\pi}{E^2}\frac{M^2\,\Gamma(E)\Gamma_{\gamma\gamma}}{(E^2 - M^2)^2 + M^2\,\Gamma_{Tot}^2}.$$

where the production cross section is given as before

$$\Gamma(E) = 2\left(\frac{\beta_s^2}{\alpha}\right)^2 \left(\frac{m}{M}\right)^3 \left(2 - \frac{M}{m}\right)^{3/2} E.$$

We have to introduce the elementary cross section into a p-p scattering formalism

$$\frac{d\sigma(E)}{dE} = \frac{2E}{s}\,\sigma(\gamma\gamma \to M \to \gamma\gamma)\,\mathcal{L}(E),$$

where the luminosity arises in photon fusion from three processes:

i)elastic

ii)semi-elastic

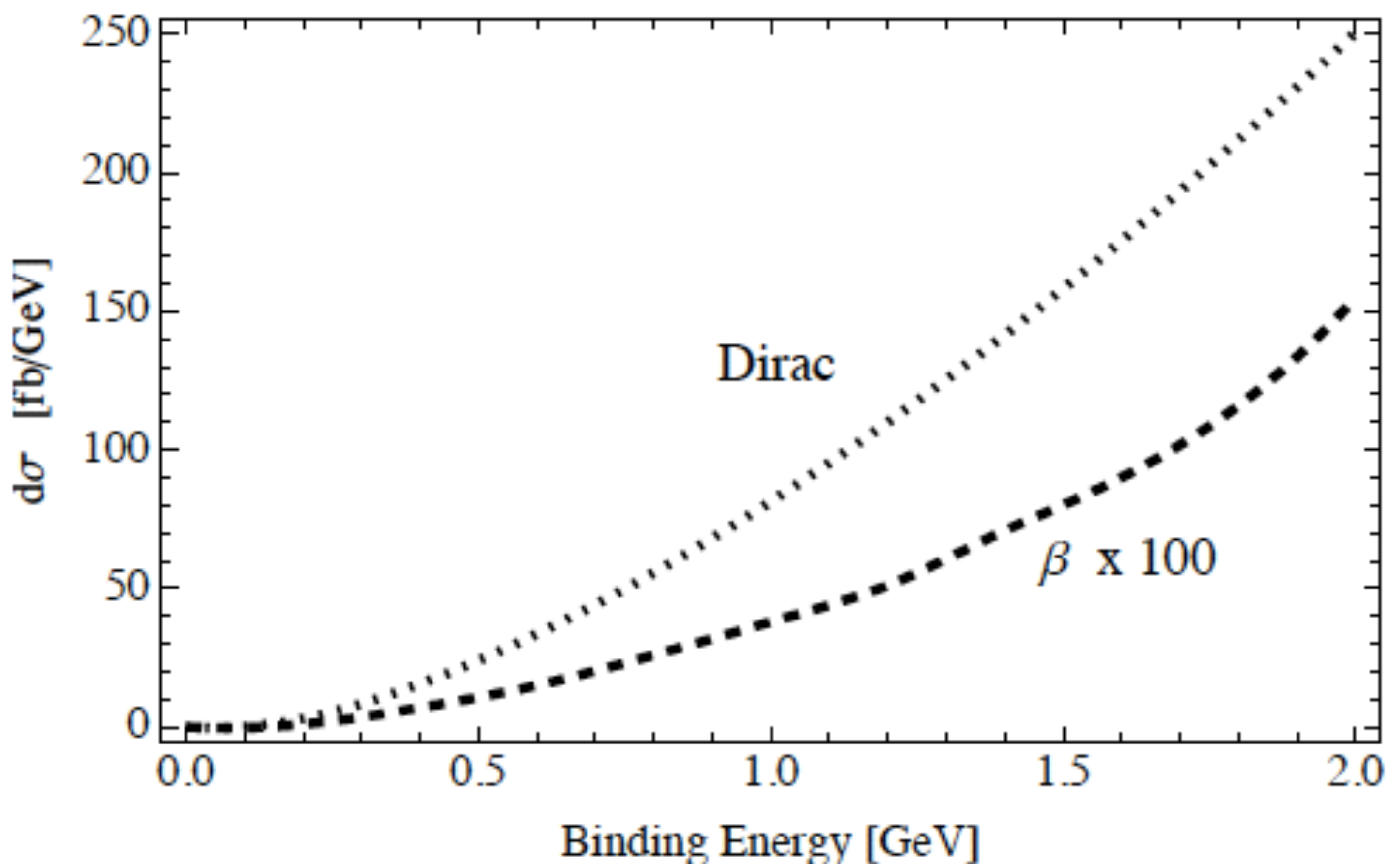
iii)inelastic

Inelastic

$$\mathcal{L}(E) = \int_{\frac{M^2}{s}}^{1} du \int_{\frac{M^2}{s}}^{u} dt \int_{\frac{M^2}{s}}^{t} dr \frac{1}{r\,t^2\,u} F(r) F(\frac{t}{r}) f(\frac{u}{t}) f(\frac{v}{u})$$

4. Results

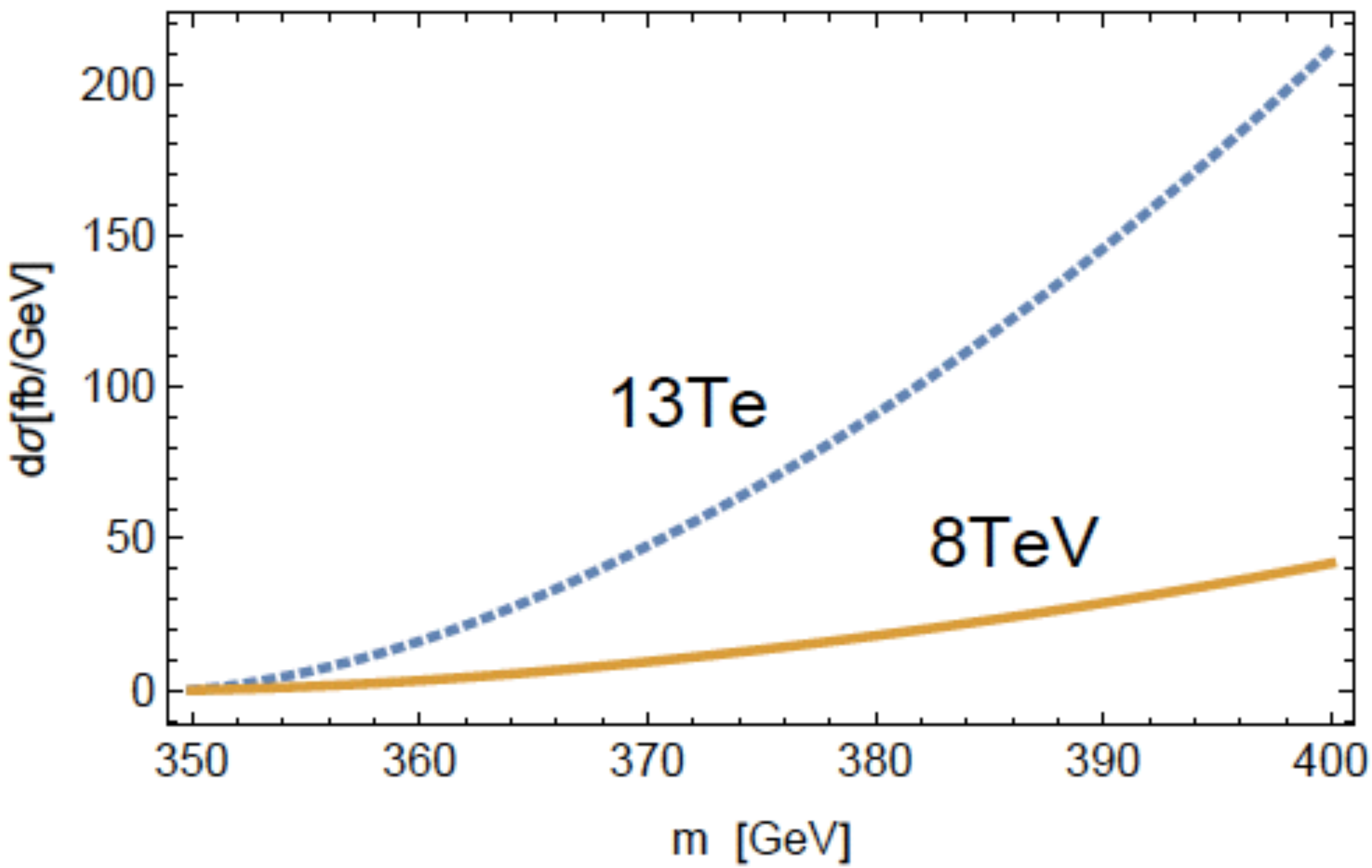
a)Dirac coupling is too large



Only solution: complicated monopolium system with small binding energy but then monopole-antimonopole annihilation would follow very close by giving rise to a wide bump not seen.

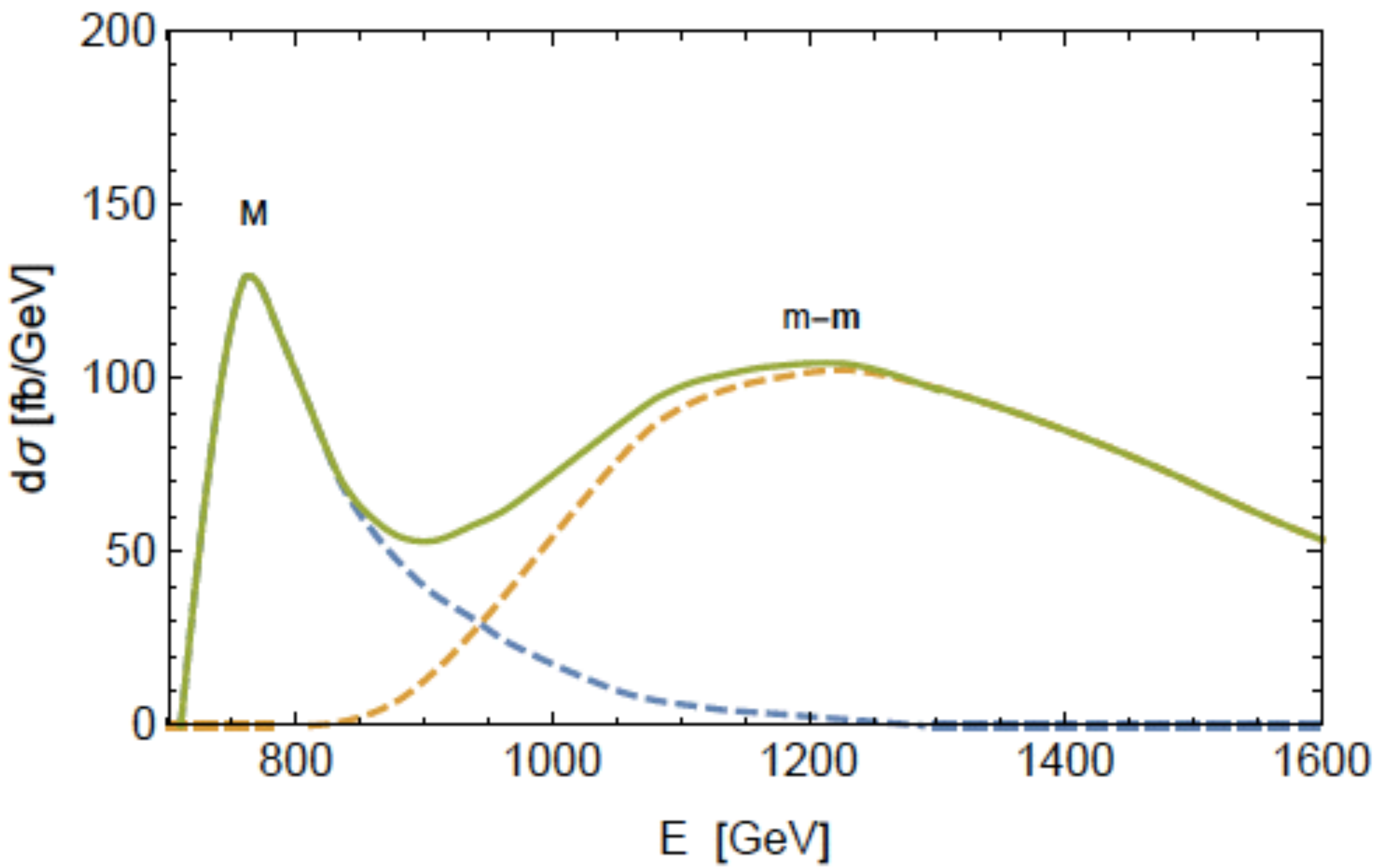
We follow with beta coupling (dynamical mechanism for effective coupling reduction)

b) Luminosity Consistency



c) monopolium as the 750 GeV resonance in beta coupling

The only way to have an independent resonance away from the monopole-antimonopole bump is to have large binding, but a larger binding increases the cross-section: thus we have to arrive at a very fine compromise.



5. Conclusions

a) We have analyzed in this paper the possibility that the 750 GeV enhancement could be a monopolium state. In order to have that possibility the mass of the monopole has to be low by conventional standards < 400 GeV. This low mass leads to the immediate conclusion that a monopole with Dirac coupling cannot be the origin of the enhancement. We have therefore limited our discussion to the so called beta-coupling scheme.

b) In the beta scheme there is a way out of the low mass slavery, namely to embed our model into a GUT scenario where monopolium can decay not only to photons but to many other particles and has a relatively small width to photons. Assuming this possibility we are able to obtain small cross sections as required signaling a monopolium state at $700-710$ GeV.

c)The existence of a monopolium state implies automatically a threshold for monopole-antimonopole production relatively close by. Therefore this monopolium pic should be accompanied by a m-\bar{m} broad bump. The existence of the latter puts additional restrictions on the model parameters to keep this bump also small. In order to keep both cross sections low the monopole mass must be in the range $370-400$ GeV.

d) Lower cross section to the ones shown in this paper can only be achieved by increasing the total decay width above 45 GeV, and/or reducing the 2 gamma branching ratio even more. This mechanism would automatically reduce the monopolium cross section, would allow for larger binding energies and larger monopole masses, and thus would diminish also m-\bar{m} annihilation cross section.

A monopole scenario for the 750 GeV enhancement leads to a double bump, the second associated to m-\bar{m} annihilation into photons. Thus a 750 GeV enhancement followed by a soft rising background, signaling the 2 m threshold, would be a possible signal for monopole discovery. The theoreticians would have a tough time finding the low energy effective theory.