Roman or Greek?

Distinguishing gg from $\gamma\gamma$ Fusion

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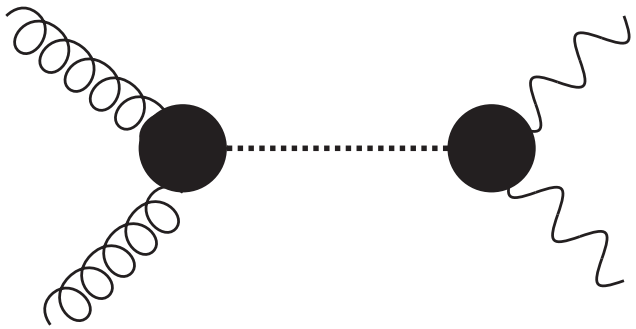
Outline

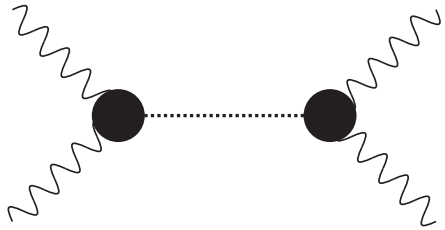
- Introduce Photon PDF
- Constraints on Photon PDF
- Distinguish gg fusion from $\gamma\gamma$ fusion

Models to Explain Excess



Gluon Fusion:

- Composite Models
- Vector-Like Quarks
- etc.

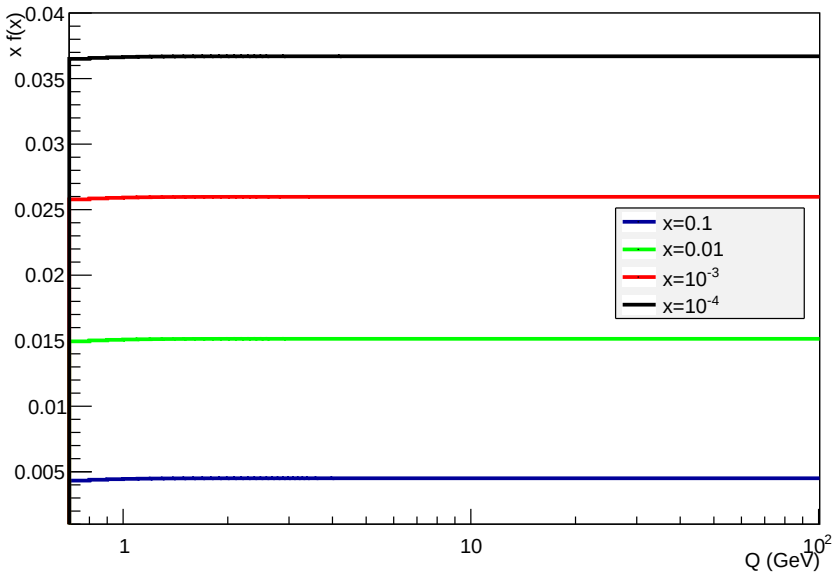


Photon Fusion:

- Effective Theories worked out by S. Fichet, et. al. (1512.05751) and C. Csáki, et. al. (1512.05776)
- Strongly interacting models
- etc.

Equivalent Photon Approximation (EPA)

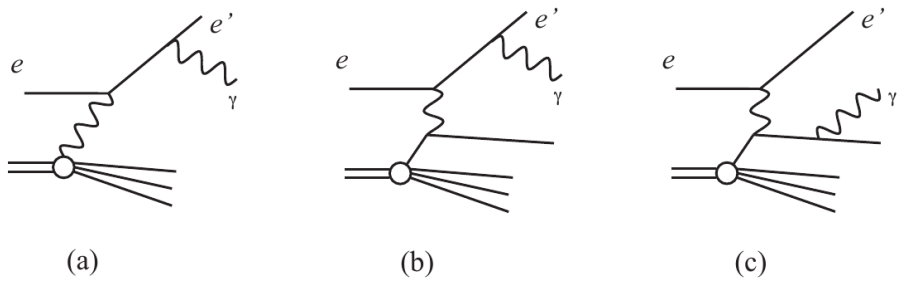
$$f\left(x,Q\right)=\frac{\alpha}{\pi}\frac{1-x}{x}\left[\phi\left(x,\frac{Q^2}{Q_0^2}\right)-\phi\left(x,\frac{Q_{min}^2}{Q_0^2}\right)\right]$$



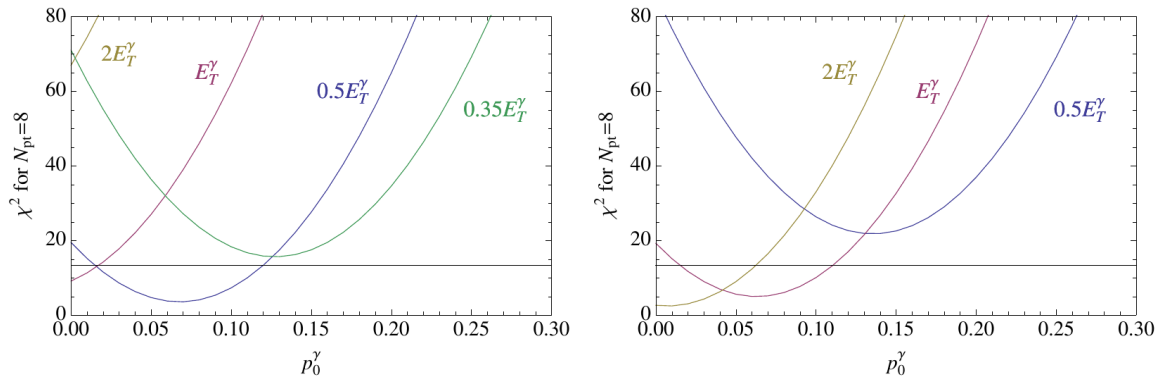
No evolution after a few GeV

V.M. Budnev, I.F. Ginzburg, G.V. Meledin, V.G. Serbo Phys.Rept. 15(1975) 181-281

Fitting CT14 Photon PDF: ZEUS Constraints



ZEUS required at least one track $\rightarrow$ Inelastic scattering



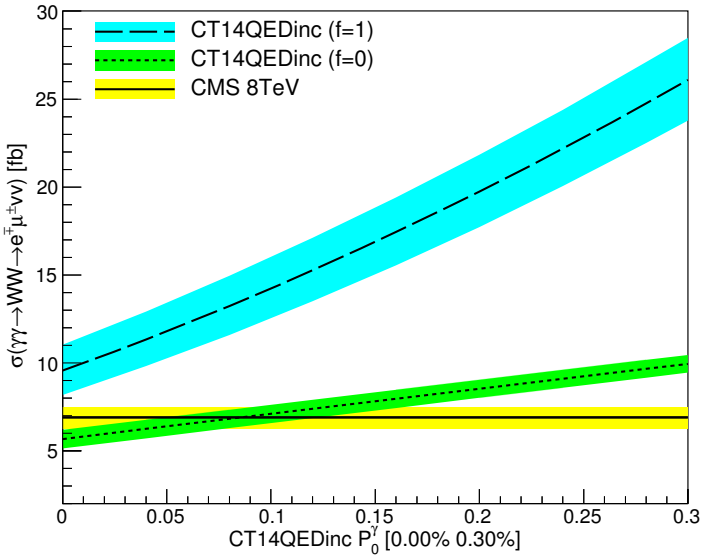
C. Schmidt, J. Pumplin, D. Stump, C.-P. Yuan 1509.02905

Fitting CT14 Photon PDF: CMS Constraints

- Inelastic Piece obtained from ZEUS Data (Constraint to 0.00% to 0.14% Inelastic contribution)
- Elastic Piece obtained from EPA, used to constrain the fit at initial momentum scale

CMS-FSQ-13-008

- $pp \to p^{(*)}W^+W^-p^{(*)}$ $\to p^{(*)}\mu^{\pm}e^{\mp}p^{(*)}$
- Zero Additional Track Cut ($|\eta| < 2.4$)

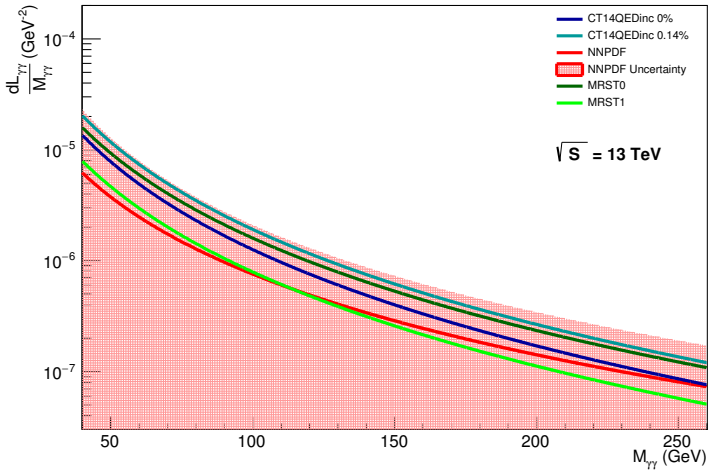


$$\text{PDF} \otimes \text{PDF} = f\text{PDF}_I^2 + \text{PDF}_E^2 + 2\text{PDF}_I \times \text{PDF}_E$$

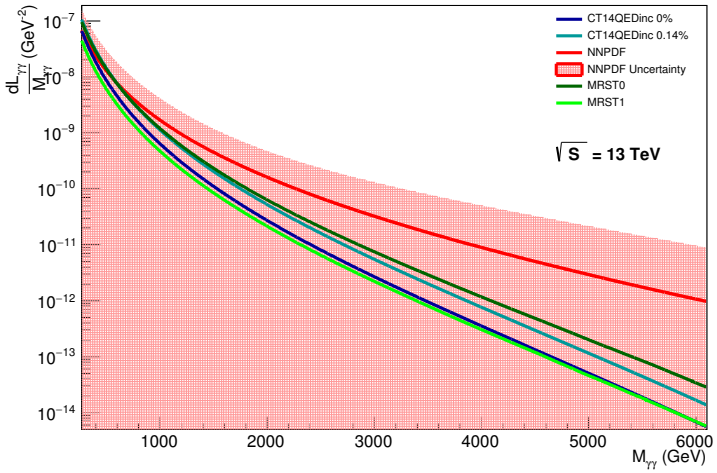
M. Ababekri, S. Dulat, JI, C. Schmidt, C.-P. Yuan 1603.04874

Photon Luminosity

Photon PDF is taken to be inclusive (includes both the elastic and inelastic scattering)



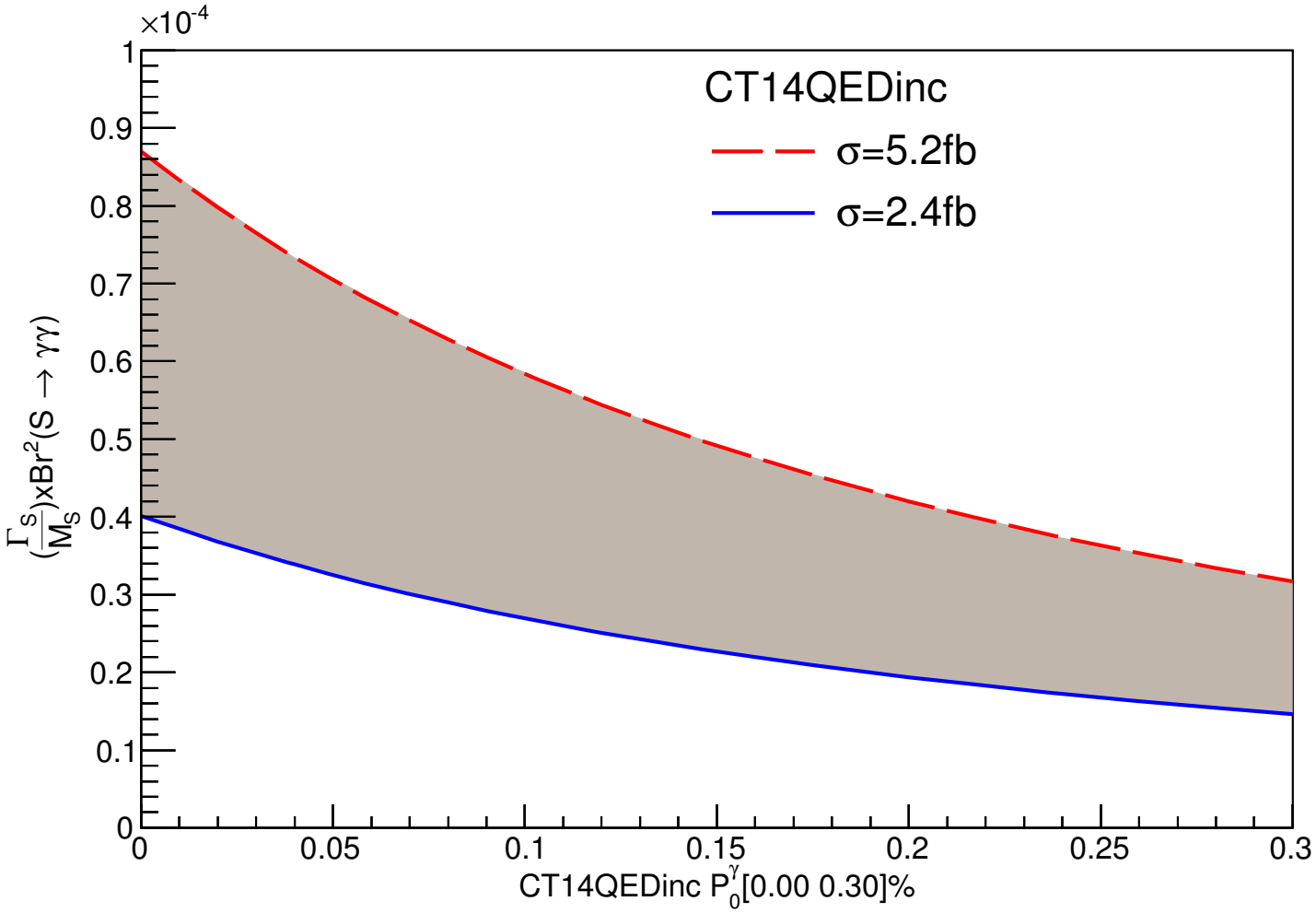
Low Invariant Mass



High Invariant Mass

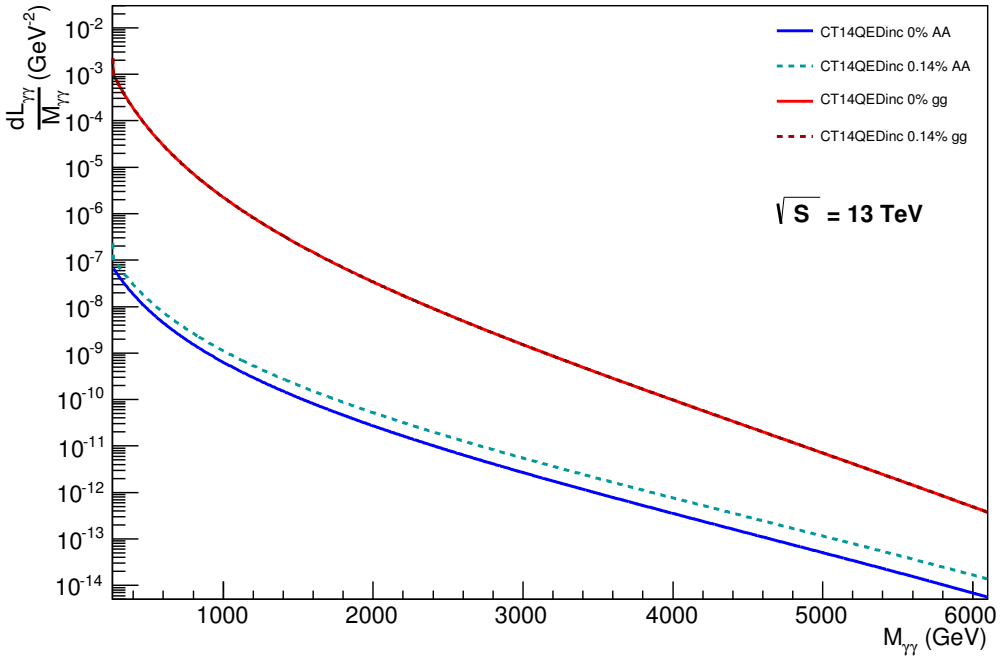
CT14 PDFs

Needed $\frac{\Gamma}{M_S}\left(Br^2\right)$



$\gamma\gamma$ Vs. gg Luminosities

- $L_{\gamma\gamma}\left(\frac{8TeV}{13TeV}\right) \approx 3$
- $L_{gg}\left(\frac{8TeV}{13TeV}\right) \approx 5$

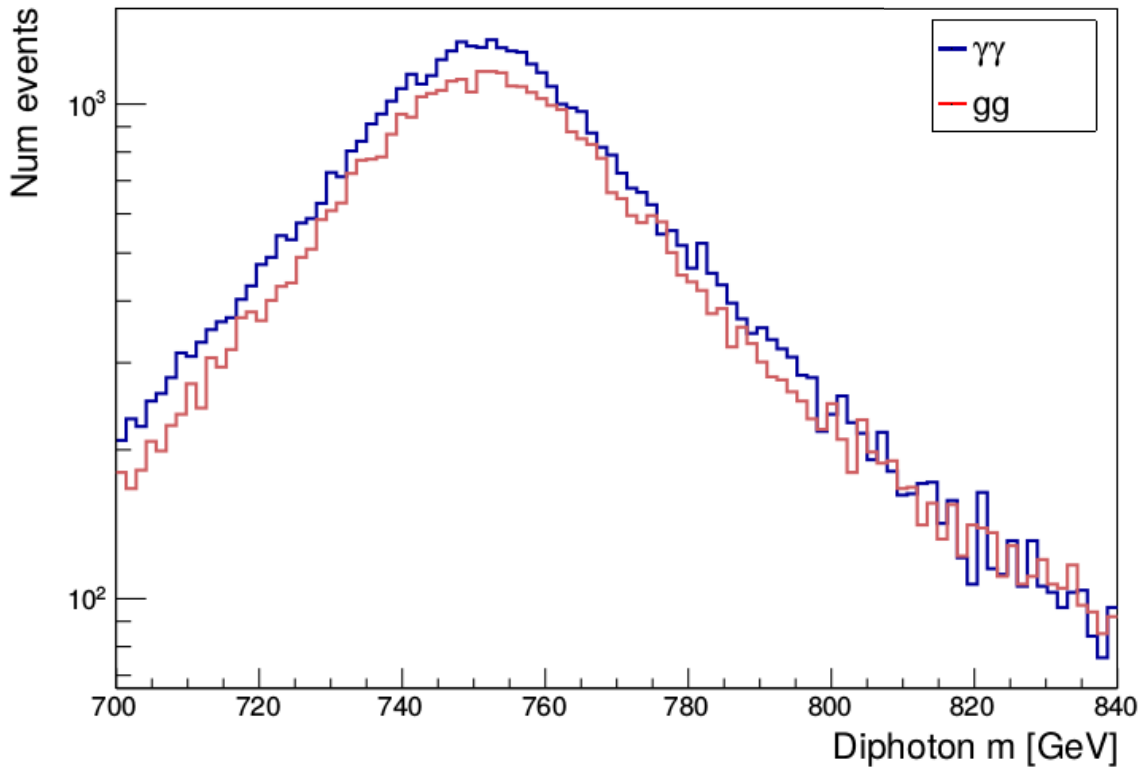


Generic Model

Possible to explain the excess with either $\gamma\gamma$ or gg fusion. How to distinguish the two?

- Pythia
- Look only at shape differences
- Scalar
- $M_S = 750$ GeV
- $\Gamma_S = 45$ GeV

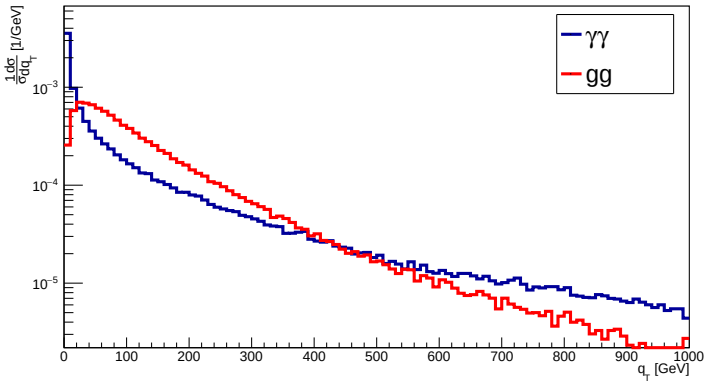
Distinguishing $\gamma\gamma$ from gg Production

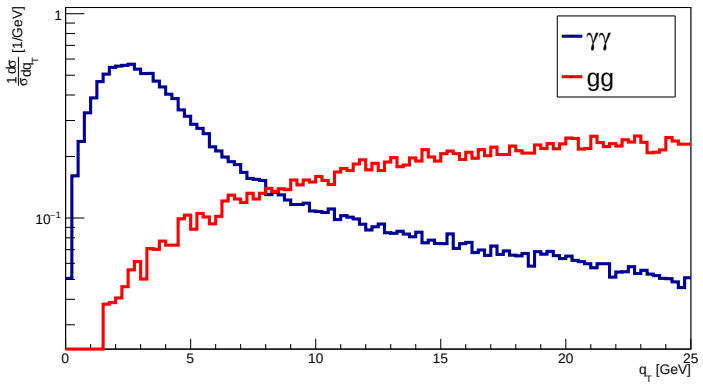


- Impossible to distinguish channels from invariant mass distribution

J. Huston, JI, I. Progrebnyak, and ATLAS Group at Witswatersrand

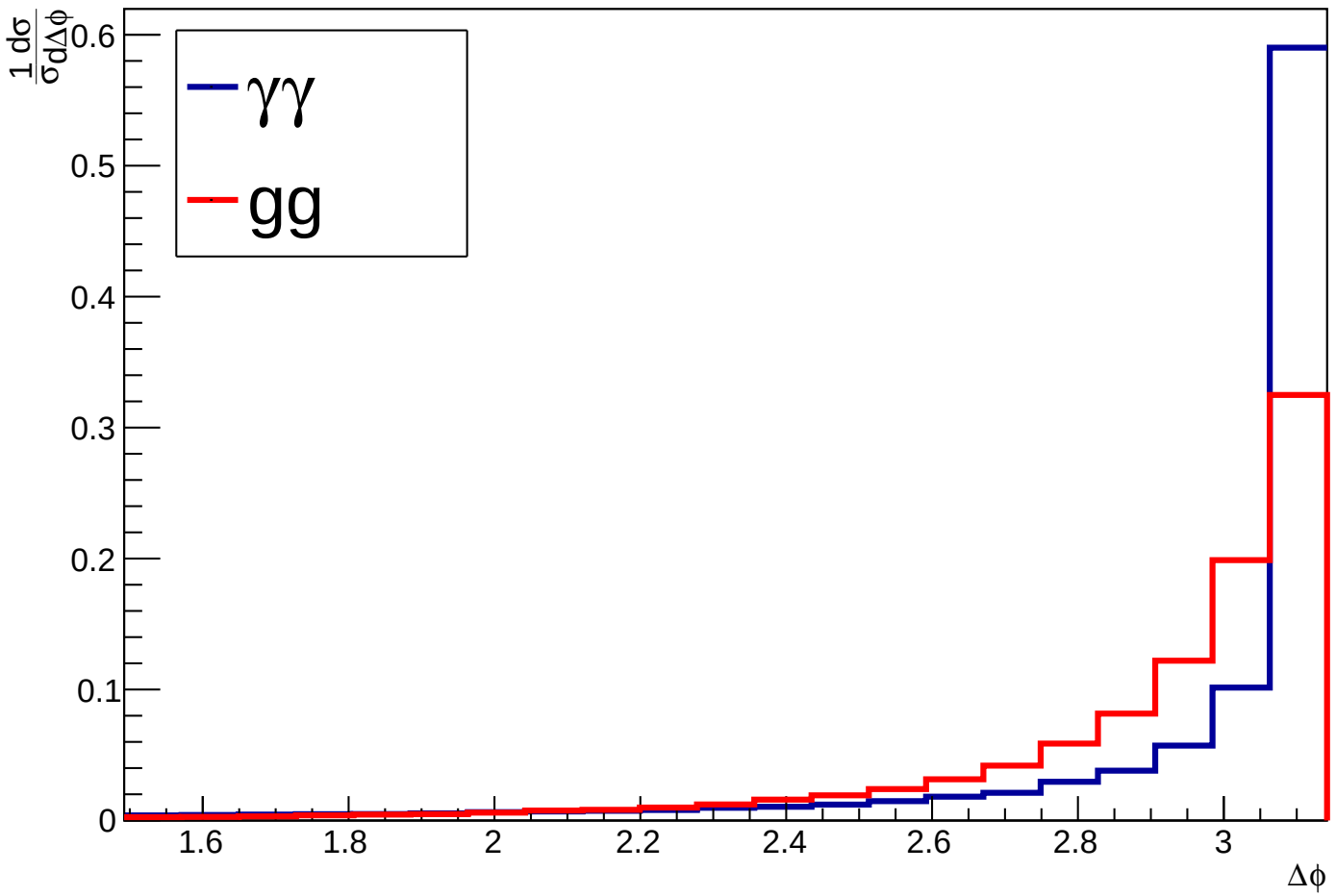
$\gamma\gamma$ Final State Distributions



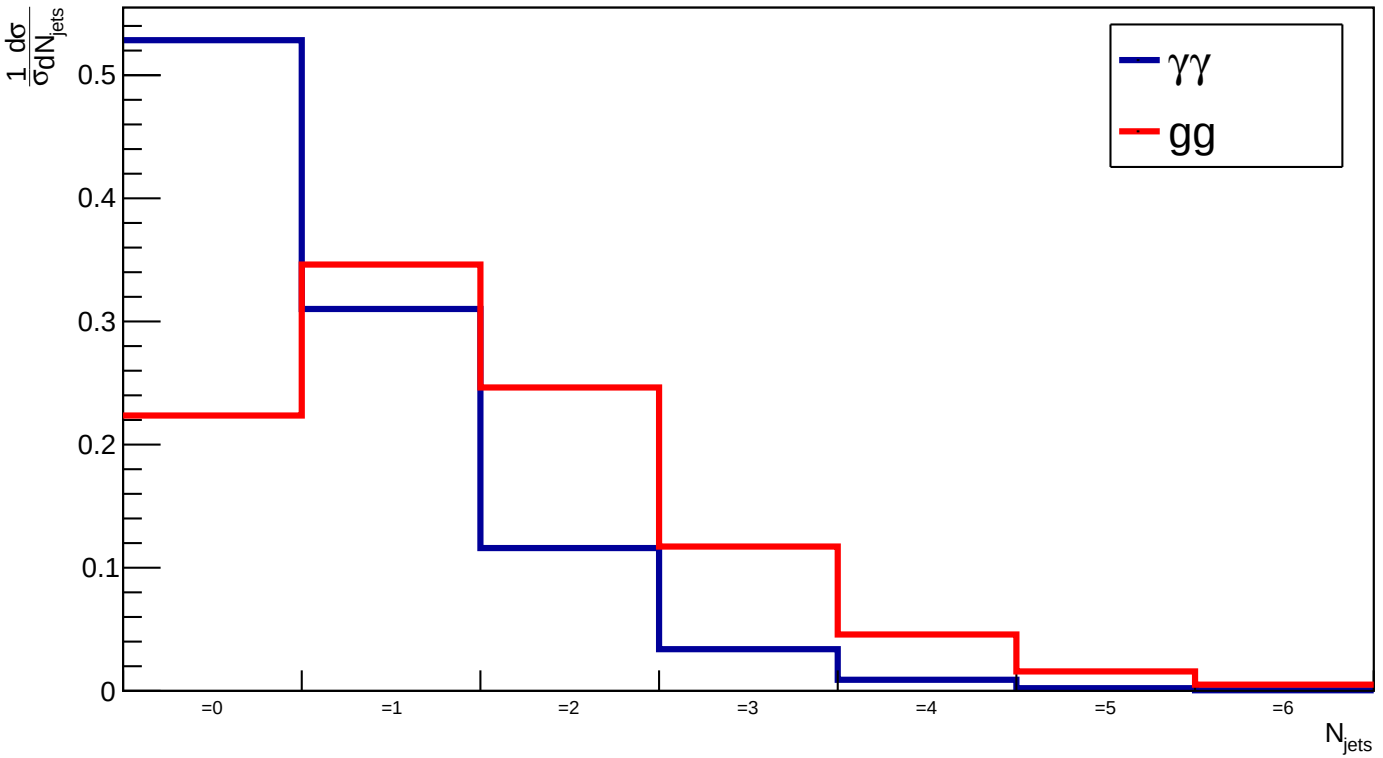


- Different locations of Sudakov peak for p_T of diphoton system

$\Delta\phi$ Distribution

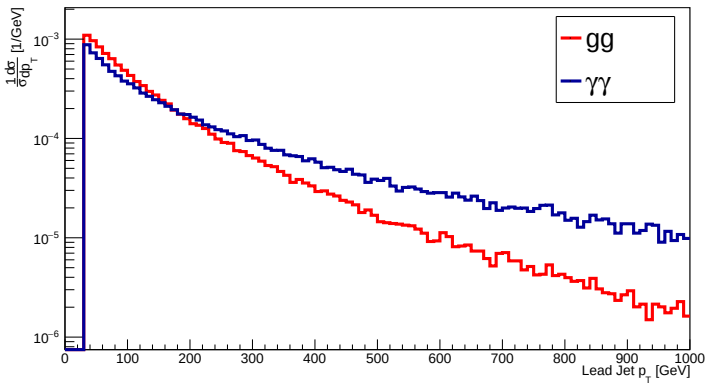


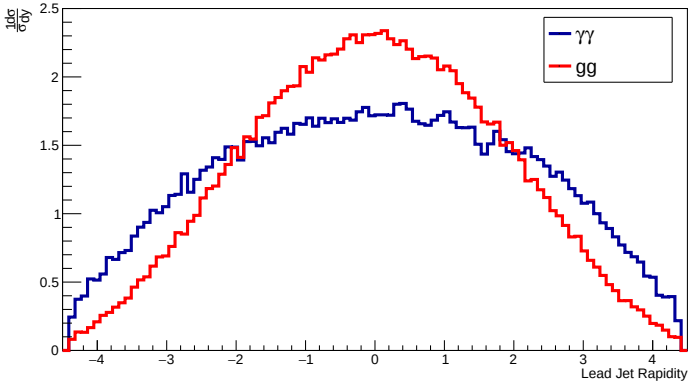
Number of Jets



- The photon fusion process has about 50% of events with zero jets.

Jet Distributions





- p_T of the hardest jet tends to be harder for photon fusion
- Rapidity for photon fusion is flatter than for gluon fusion

Subleading Jets

- 2nd Jet has some differences in p_T and Rapidity but smaller
- 3rd and higher jets have no differences between the two channels

Conclusions

- Possible to explain the excess through either gluon or photon fusion
- To determine which is the initial state, jet distributions become important

Backup Slides

PDF First Moment