# Some Theory Issues for Direct Photons

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Confronting Theory with Experiment
Puzzles, Challenges and Opportunities

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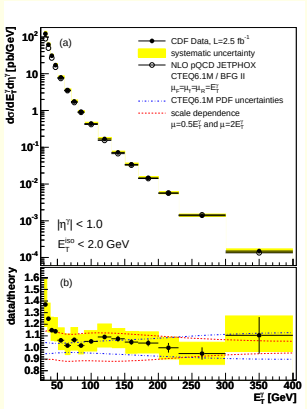
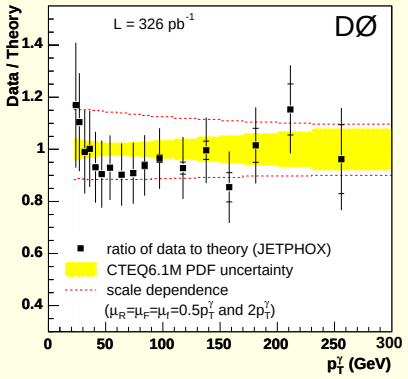
# Outline

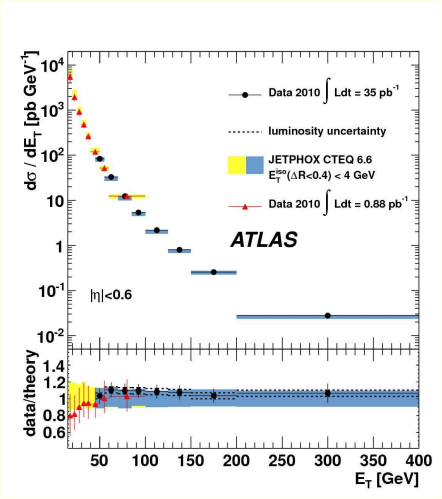
- Photons and PDFs (David d'Enterria - covered in Thursday's PDF session)
- Inclusive Photons
- Photon Isolation
- Diphotons (Daniel de Florian)

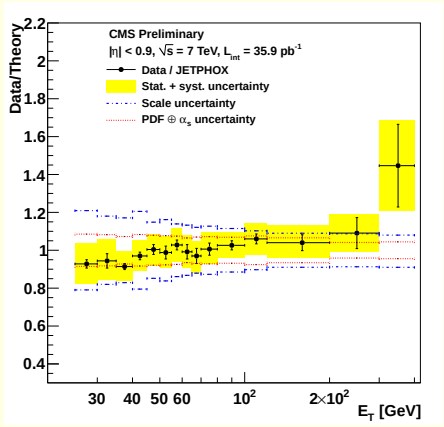
# Inclusive Photons




Excess of experiment over theory is evident at the low end of the $p_T$ scale for the Tevatron data



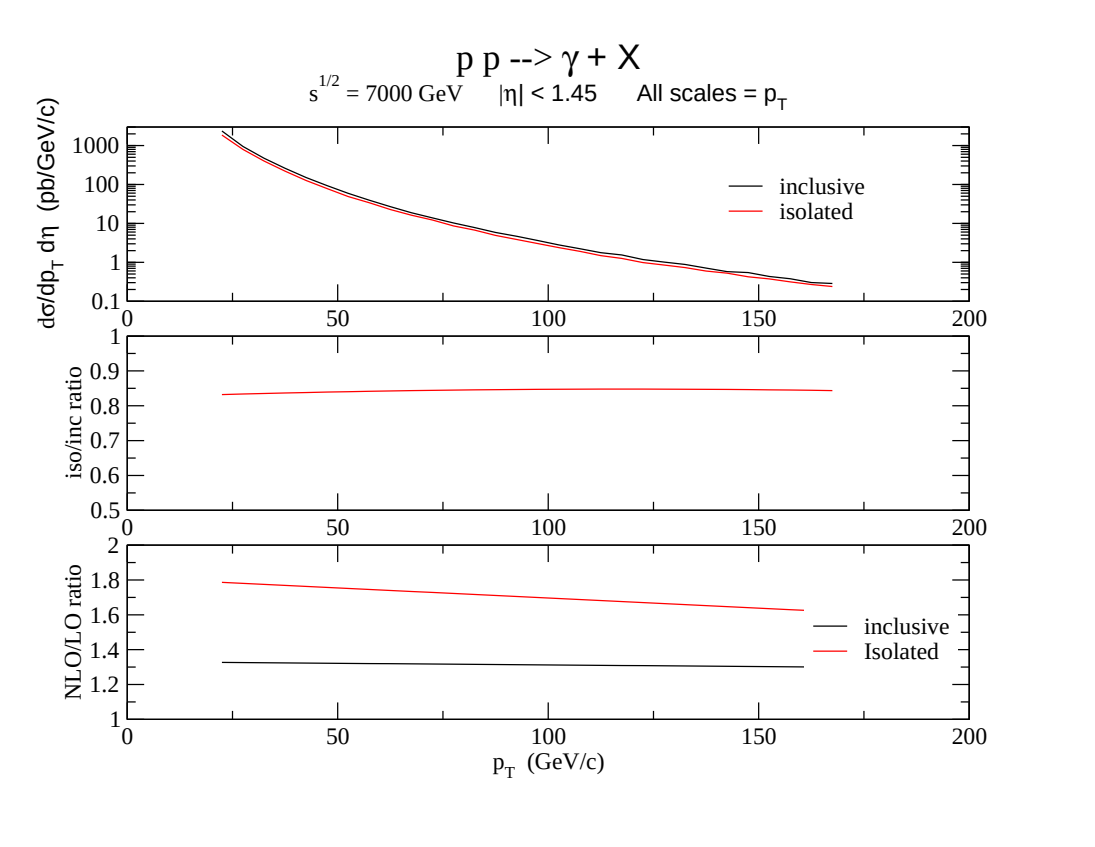




Theory is slightly *below* the data at the the low-$p_T$ end for the LHC

# Comments

- Discrepancy at the LHC is within errors - more data will refine the story
- $x_T \approx .003(.0015)$ for the Tevatron (LHC)
- $qg \to \gamma q$ dominates at the low $p_T$ end of the $p_T$ distribution for both LHC and Tevatron data
- Conventional subprocesses would not show such a rapid $p_T$ dependence nor such a rapid energy dependence

# Isolation Cuts




- The predictions seem well behaved - nothing stands out
- Isolation used is up to 5 GeV hadronic transverse energy in a cone of radius .4
- Reduces the cross section by about 15 % over the range shown

# Problems?

Fragmentation functions are *inclusive* by design. All information about the angular distribution of the associated energy is integrated out.

- If the cone size is made too small, then one is essentially excluding some of the associated energy from the nonperturbative fragmentation functions
- There is a perturbative logarithmic dependence on the cone size which could generate large logs if the cone is too small
- For a fixed energy cut inside the cone as $p_T$ grows there should be large logs of $p_T/E_{cut}$ developing
- Algorithms such as that of Frixione put restictions on the energy fraction as a function of the cone radius and rely on treating the fragmentation function associated energy as being totally collinear to the parent parton

- By putting tight restrictions on the associated energy one may miss fragmentation contributions which remain in the data (the energy is outside the cone) but which are excluded from the calculation (the energy is inside the cone since it is treated as being collinear)
- The perturbative contributions can be corrected by the inclusion of higher order terms – but we are at present only at NLO

Do we even need isolation cuts at large values of $p_T$ ?

Can one measure a fully inclusive photon cross section?

Having the inclusive *and* isolated cross sections would allow one to test the theoretical treatment of the isolation. Useful also to test the dependence on the isolation parameters.