DIRECT PHOTON PRODUCTION AT THE LHC

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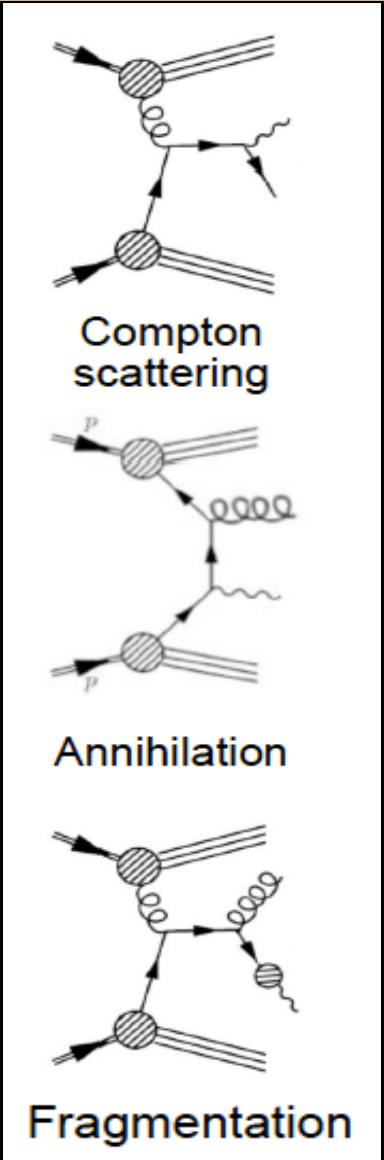
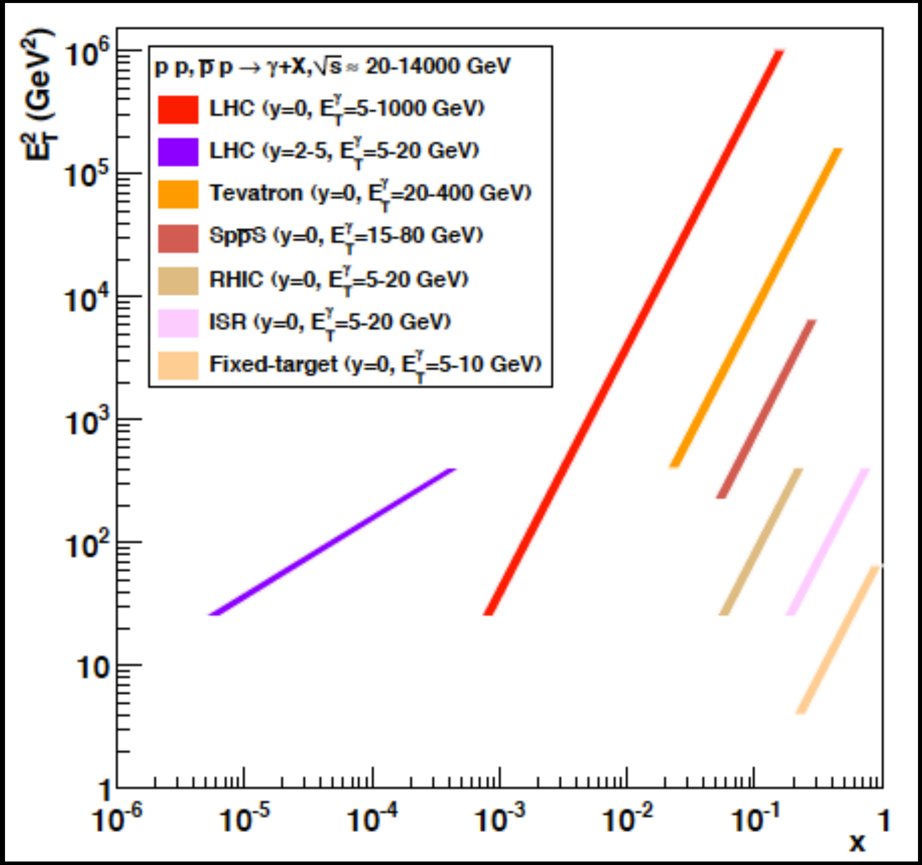
WHY DIRECT PHOTONS?

- A colorless test of QCD predictions.
- Sensitivity to the gluon parton distribution function through the Compton process over a variety of x and Q^2.
  - Differential distributions have different contributions from these diagrams.



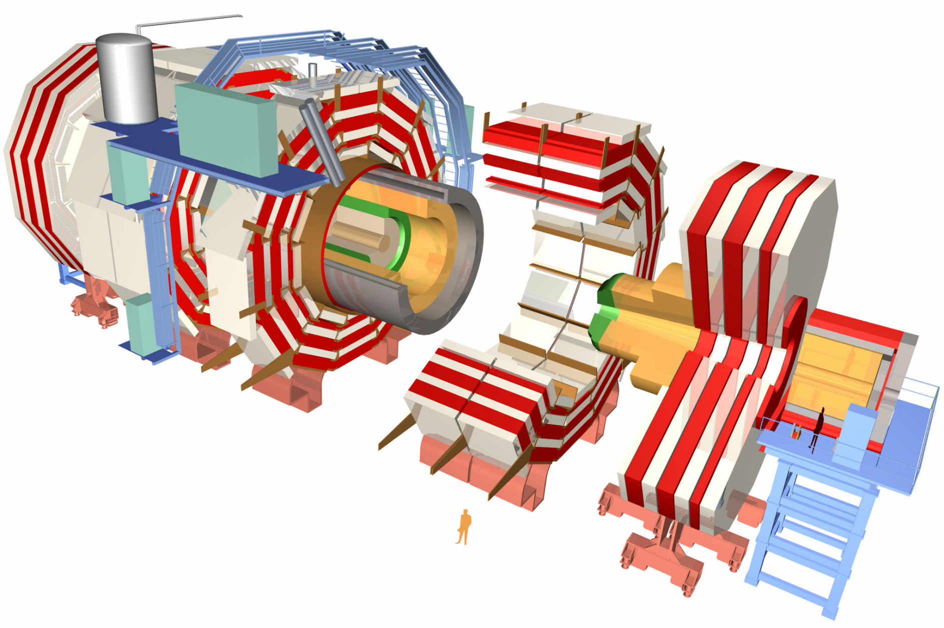
WHY DIRECT PHOTONS?

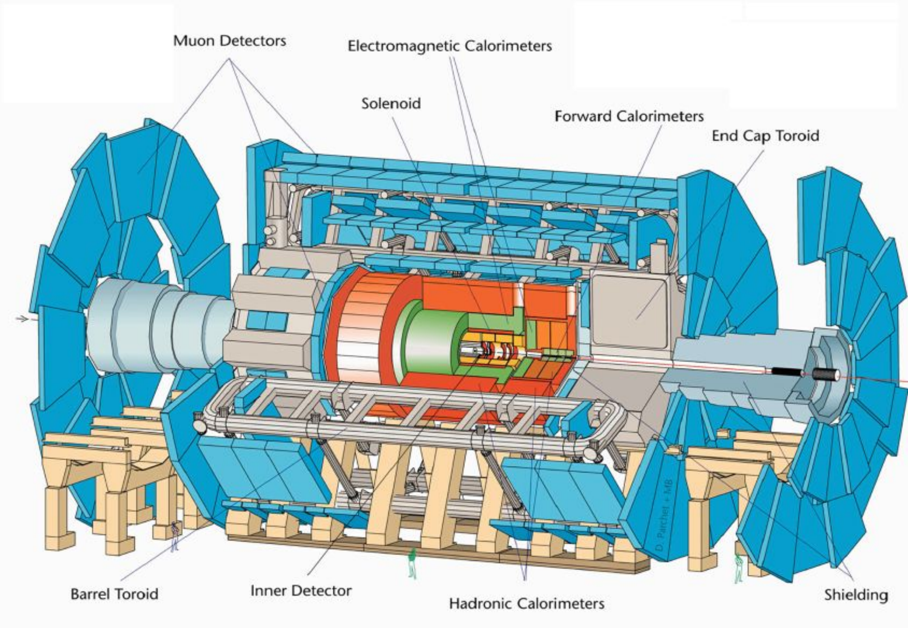
- A colorless test of QCD predictions.
- Sensitivity to the gluon parton distribution function through the Compton process over a variety of x and Q^2.
  - The gluon distribution is very important for predictions at the LHC!



arXiv:1005.4529

THE DETECTORS

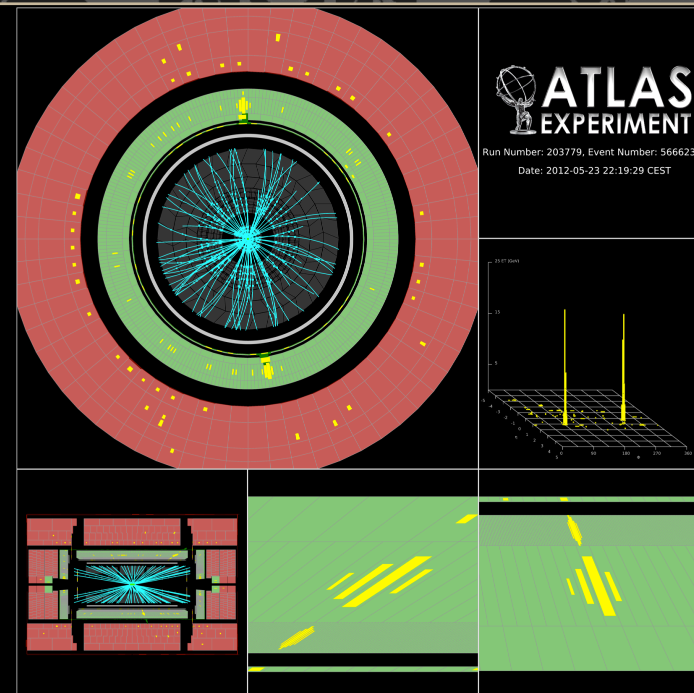


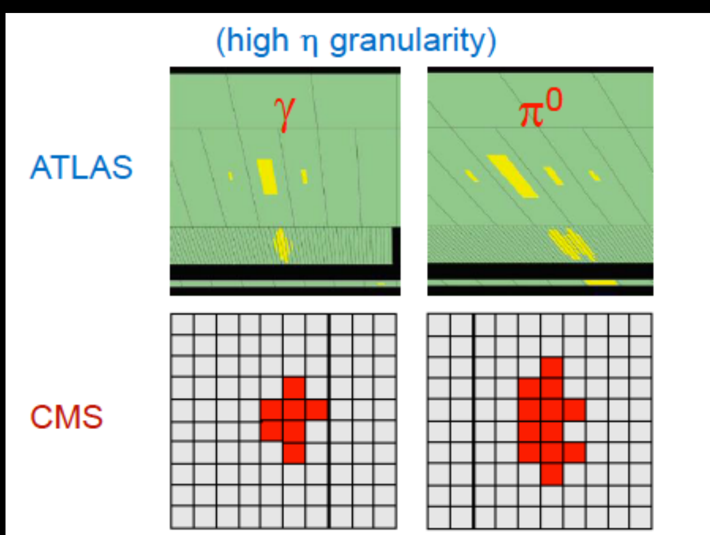


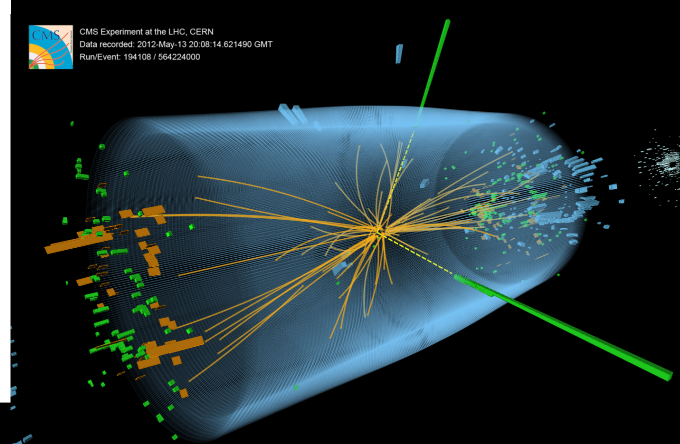
No talk is complete without at least a quick look at the two detectors. In this case, we'll be concerned primarily with the calorimeters and trackers.

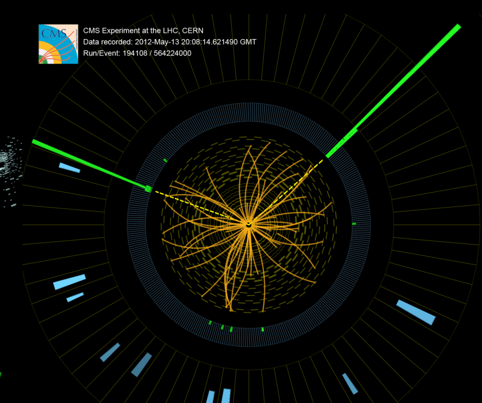
FINDING PHOTONS:

- I stress here that photon reconstruction is based on a limited amount of information. You have:
  - The shower shape in the calorimetry, modulo converted photon tracking information.
  - The surrounding energy depositions (isolation)









EXPLICIT VS. IMPLICIT ISOLATION?

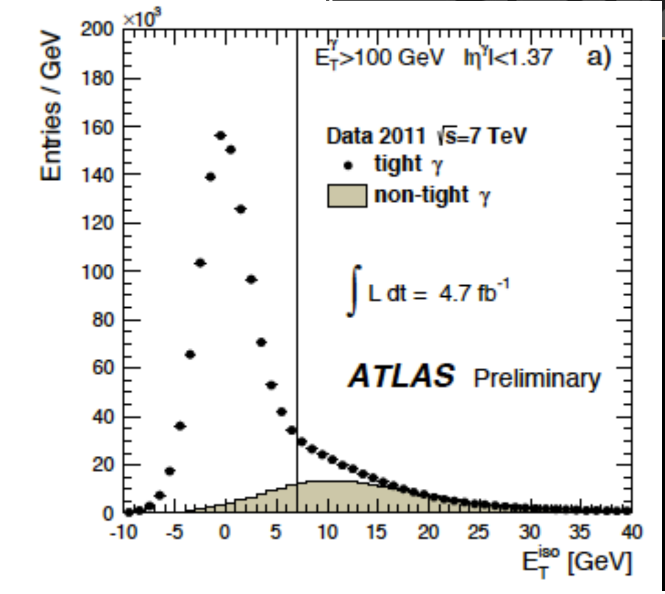
- As previously stated, in each different portion of photon E_T/η, one accesses some combination of the contributions from Compton, annihilation, and fragmentation portions of the cross section.
- If one uses photons which are only weakly isolated (H/E for instance), then the measurement is sensitive to more of the fragmentation component, and can be checked against more inclusive theory predictions, at the cost of reduced purity and increased systematics.
- If one uses **isolated** photons (explicit requirement of low surrounding energy), then the contribution from fragmentation photons is substantially decreased, and one gains improved purity and sensitivity to the Compton and annihilation processes, but these isolations have to be matched between the isolation applied in the theory at the parton level and the isolation as applied at the detector level.
- For the measurements shown today, CMS does the former, and ATLAS does the latter.

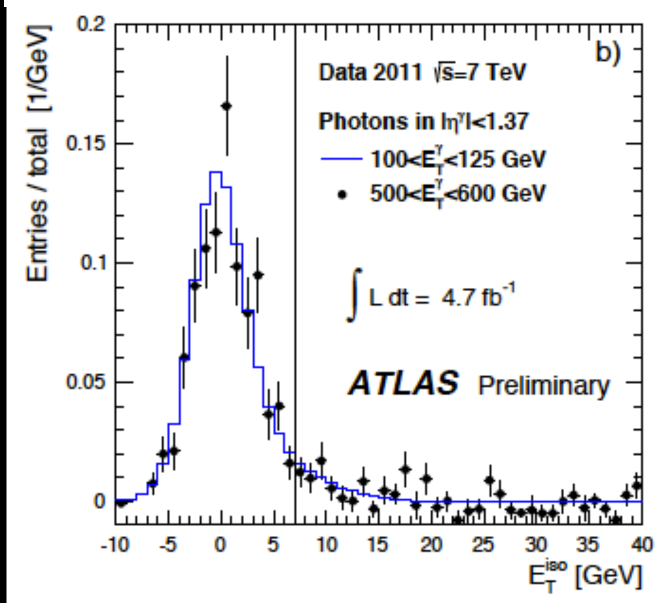
PURITY?

- The technique used to model the photon purity in data is similar between CMS and ATLAS.
- In each case, the surrounding "isolation" energy is used to estimate the contribution from jets.
  - Both use models for jets from the data.
  - CMS directly fits for the contribution due to jets, ATLAS uses the fractions passing the isolation and identification in a double-sideband (ABCD) method.

ATLAS BACKGROUND

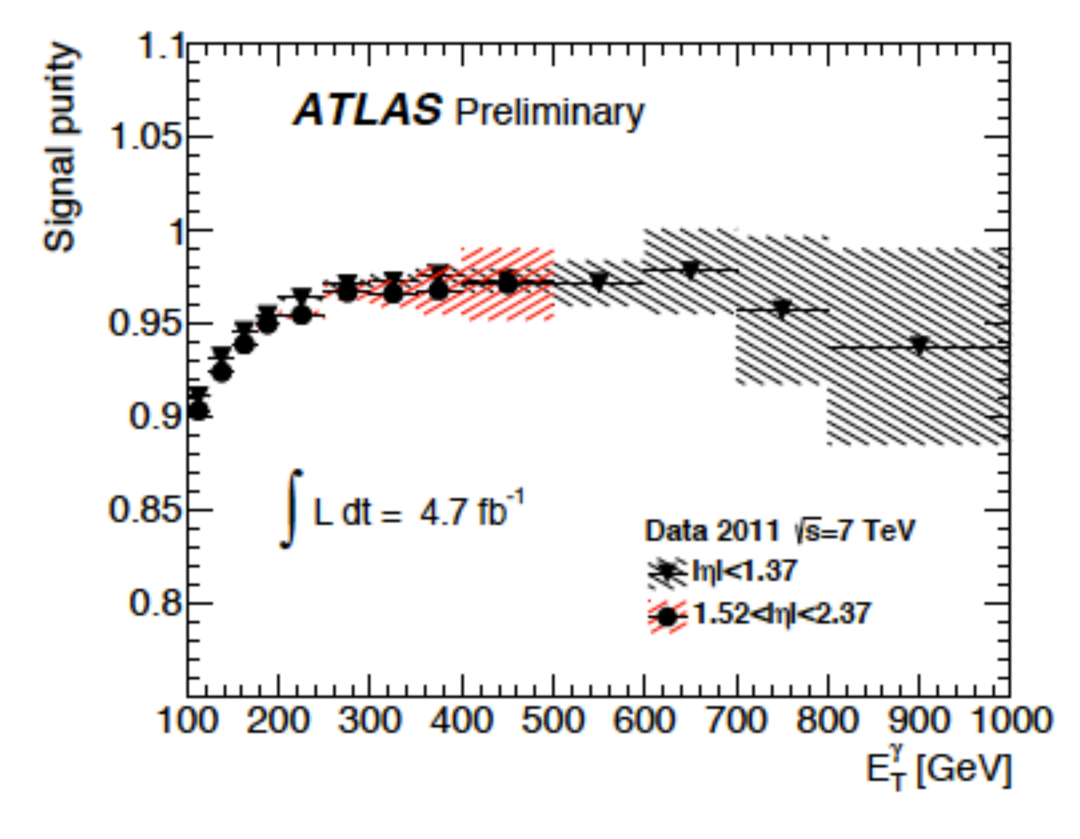
- Uses not-tight candidates, exploits the fact that isolation and shower shape should be mainly uncorrelated.
- Isolation values were subtracted based on the expected leakage and energy from additional interactions, and then confirmed using the subtracted values based on the shapes.





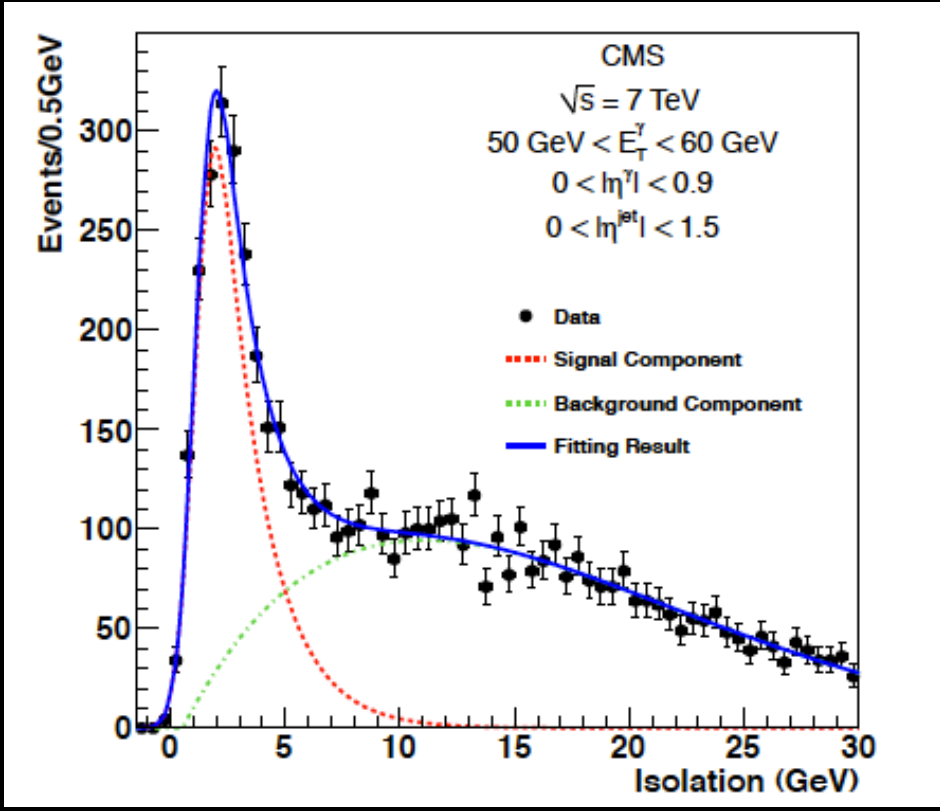
ATLAS PURITY:

- Final estimated purity for the different bins of photon η, as a function of the photon E_T
- Uncertainty band includes shape uncertainty due to modeling the isolation distribution in the data and other factors.

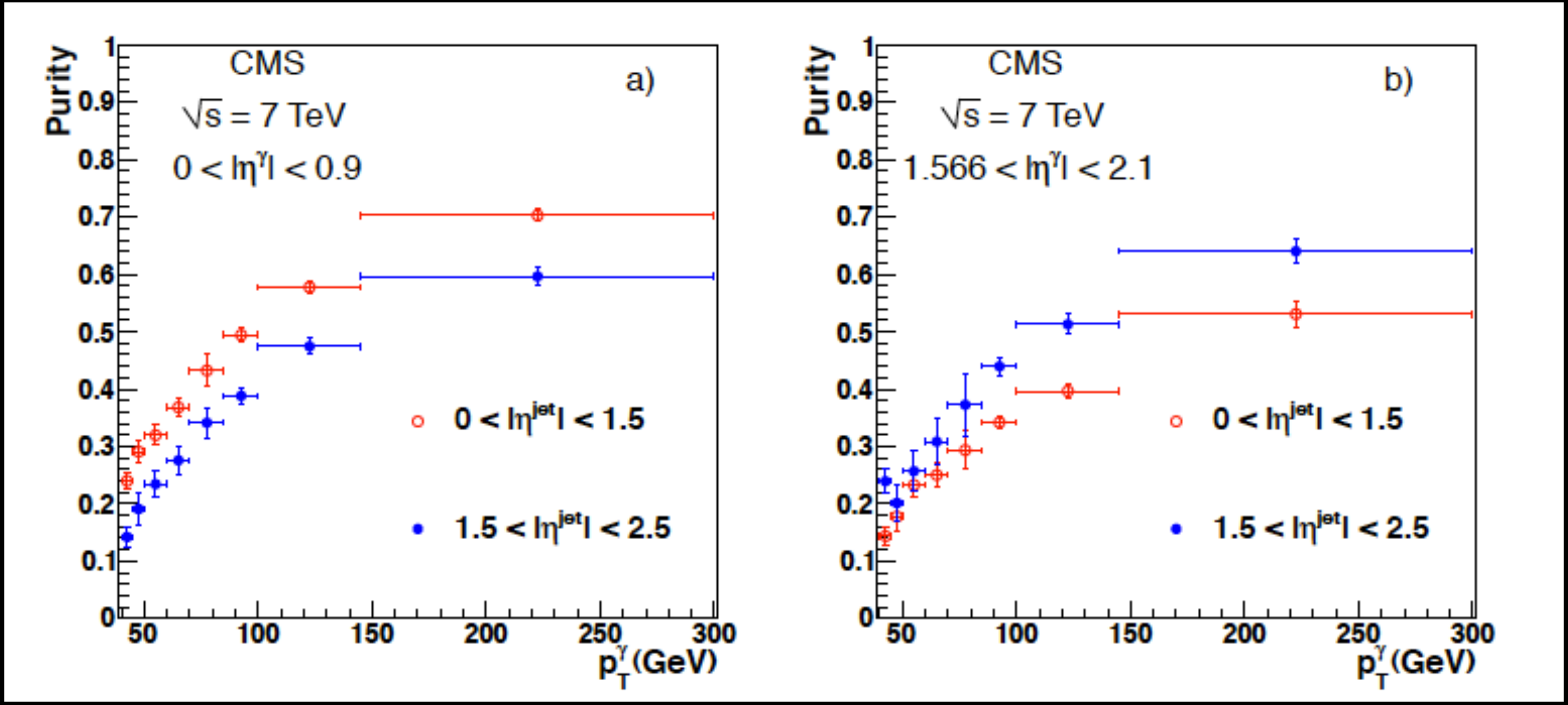


CMS BACKGROUND

- Background shape required to fail shower shape requirement, signal shape taken from Monte Carlo.
- Purity taken directly from the fit.
- Additional corrections taken for signal leakage, and background shape assessed as systematic uncertainties.
  - This measurement is performed using the lower instantaneous luminosity portion of the 2011 data.



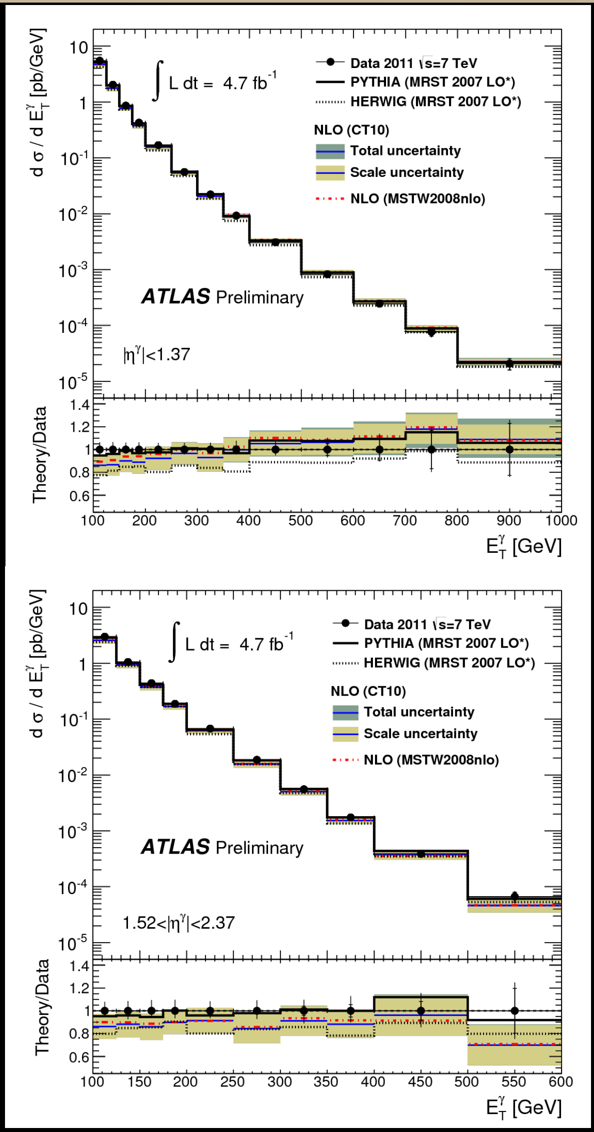
CMS PURITY:



- Fit direct photon purity for endcap and barrel for different jet configurations.

ATLAS RESULTS

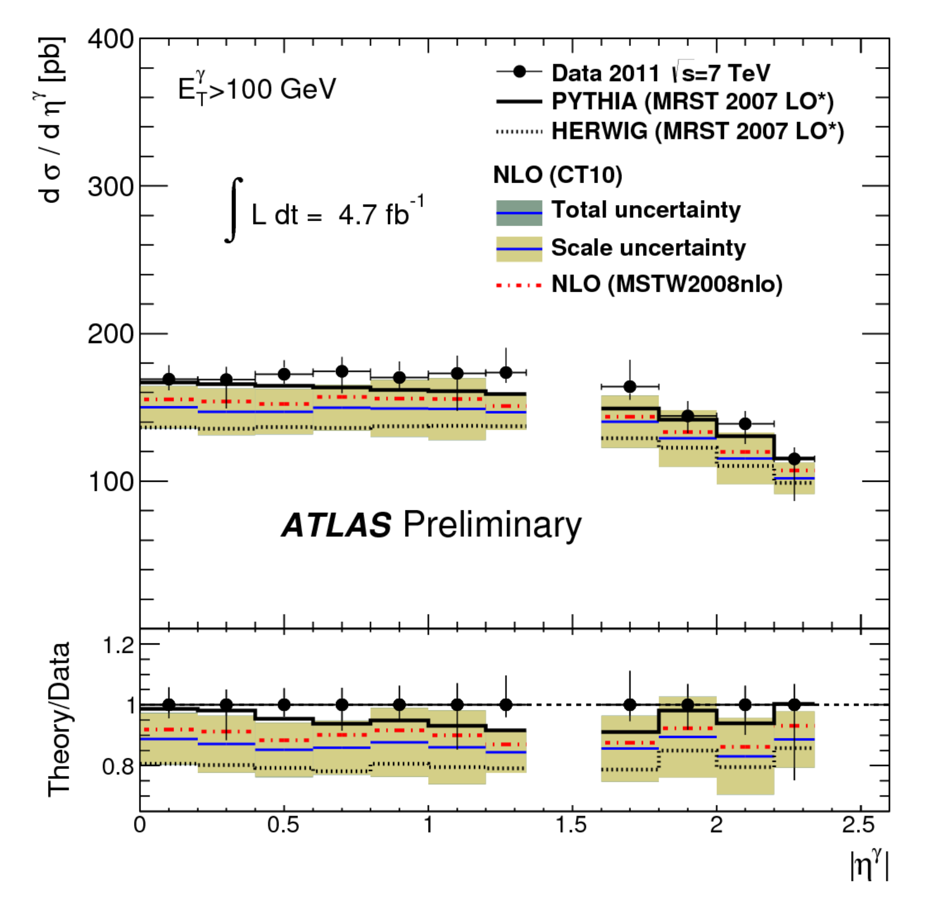
- Cross section results for the high E_T bin for both barrel and endcap photons within the ATLAS detector.
- Recall: isolated photon cross section.
  - Experimental isolation cuts matched with corresponding cuts in the theory prediction.



ATLAS-CONF-2013-22

ATLAS RESULTS

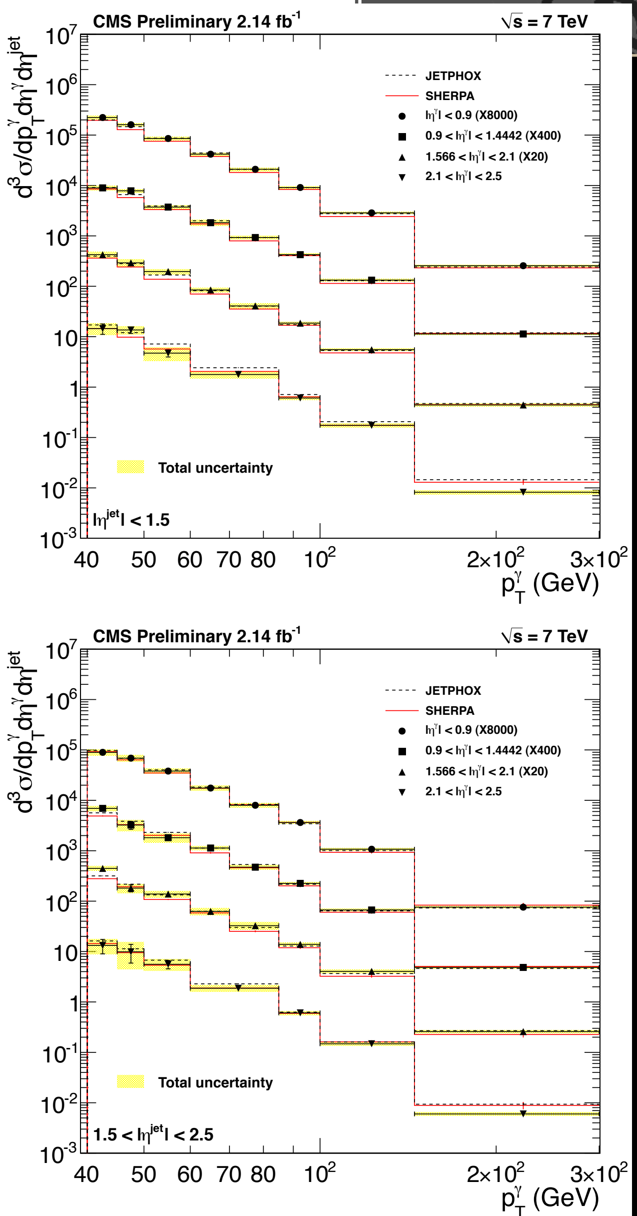
- Comparison against bins in photon rapidity.
- Multiple different comparisons included, slight excess over expected cross section observed.
- Additional kinematic information from 2010 data also available in ATLAS-CONF-2013-23.



ATLAS-CONF-2013-22

CMS RESULTS

- Differential cross sections with respect to jet η, photon η, and photon E_T.
  - Separate photon spectra for central jets in four bins of photon rapidity (top) and forward jets (bottom).

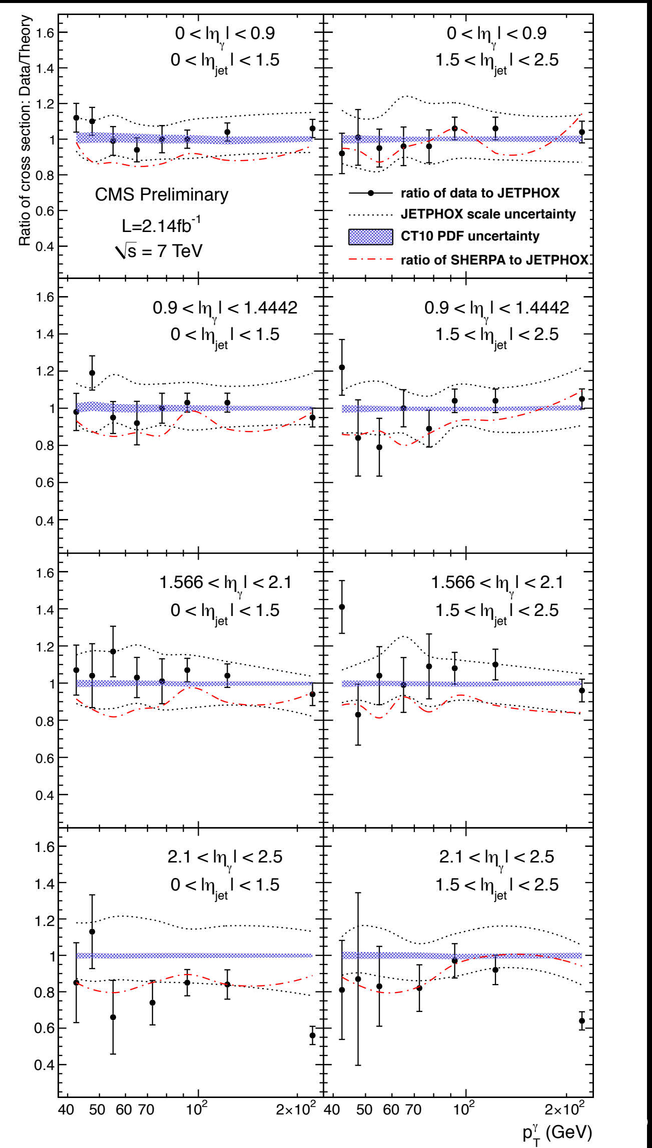


CMS-PAS-QCD-11-005

CMS RESULTS

- Comparisons between the data and multiple different theoretical calculations.
- Ratio of data to JETPHOX and data to SHERPA, using PDF functions from CT!0.
- JETPHOX scale uncertainty shown as the dotted green band.

CMS-PAS-QCD-11-005



SUMMARY

- Direct photon cross section has been measured at 7 TeV by both CMS and ATLAS:
  - CMS attempts to measure a more inclusive photon cross section, ATLAS uses isolated photon cross section.
- Both experiments still have an enormous store of data at 8 TeV, which will extend sensitivity in both x and E_T^2, which will refine our knowledge of the gluon parton distribution function.
- You'll be hearing more soon!

BACKUP: CMS EFFICIENCY