Early QCD analyses with photons in CMS

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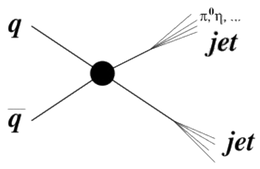
Motivations

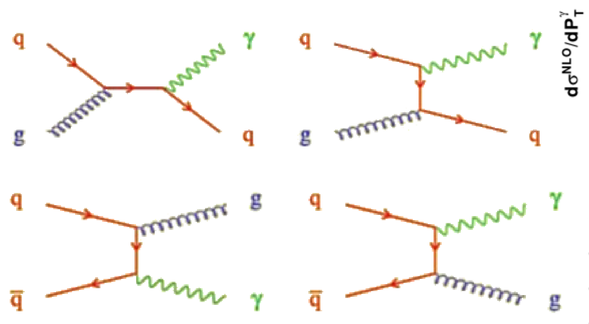
Many searches for New Physics at the LHC are performed using photons. Standard Model processes producing one or two prompt photons are irreducible backgrounds to these searches. The measurement of such processes is crucial to establish photon identification techniques and to measure the rate of these backgrounds

Inclusive photon production in pp collisions

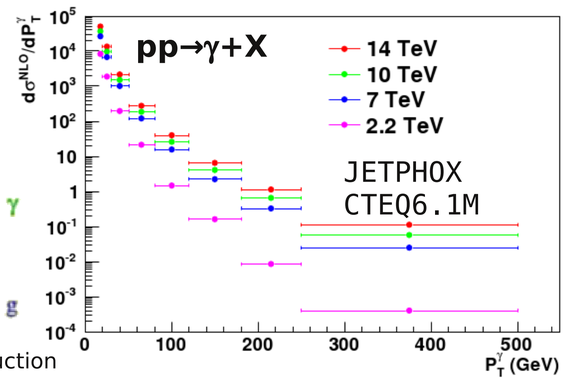
The Measurement of inclusive photon production is a test of perturbative QCD and it can provide useful inputs to constrain gluon PDFs.
At LO in the SM photons produced mainly through qg→qγ (QCD Compton-scattering) and qq→gγ (quark annihilation).

The main background is due to jets with large electromagnetic component.





Tree-level diagrams contributing to photon production in hadronic collisions



Inclusive photon production in pp collision calculated using the JETPHOX generator [1]

Photon reconstruction and identification in CMS

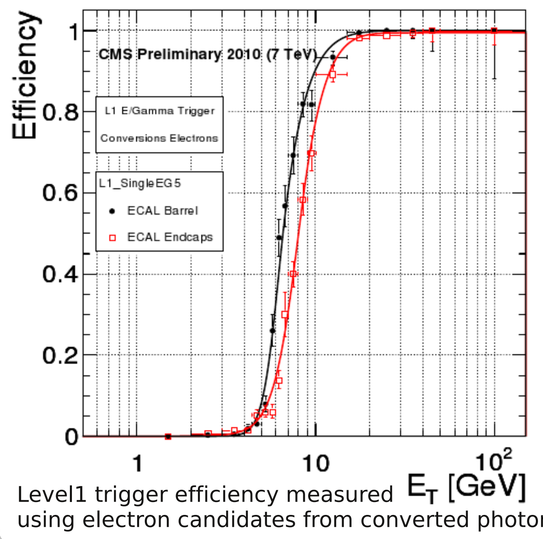
In the CMS detector[2], photons are reconstructed through energy deposits in the Electromagnetic Calorimeter (photon candidates). The detector is organised in a barrel ($|\eta|<1.479$) and an endcap ($1.479<|\eta|<2.5$) region.

A robust selection has been designed for commissioning and early analyses [3].
- E_T > 30GeV
- Small ratio of hadronic to electromagnetic energy deposit. H/E < 0.05.
- Candidate required to be isolated in the calorimeters and the tracker.
  - ECAL isolation < 4.2 GeV
  - HCAL isolation < 2.2 GeV
  - Track Isolation < 2 GeV/c
- No matching with tracks from interaction region (pixel seed match) allowed.
- Size of the shower in η direction should be compatible with a single photon deposit. $\sigma_{i\eta i\eta}$ < 0.01 (0.03) in barrel (endcaps).

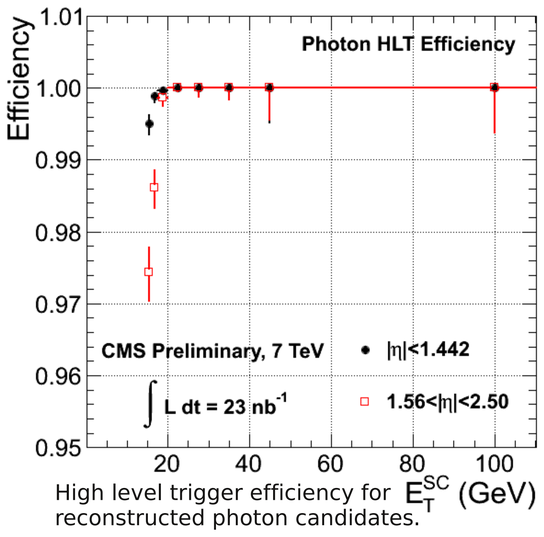
The selection efficiency for signal was estimated using MonteCarlo simulation to be roughly 90%(80%) in the barrel (endcaps) region.
The purity of the selected sample is predicted to vary between 40% and 100%.

Trigger

Trigger: a minimal transverse energy deposit in the ECAL of 5(15) GeV is required at the Level1 (High Level) Trigger. The efficiency has been measured to be fully efficient for candidates with E_T>20GeV.



Level1 trigger efficiency measured using electron candidates from converted photons

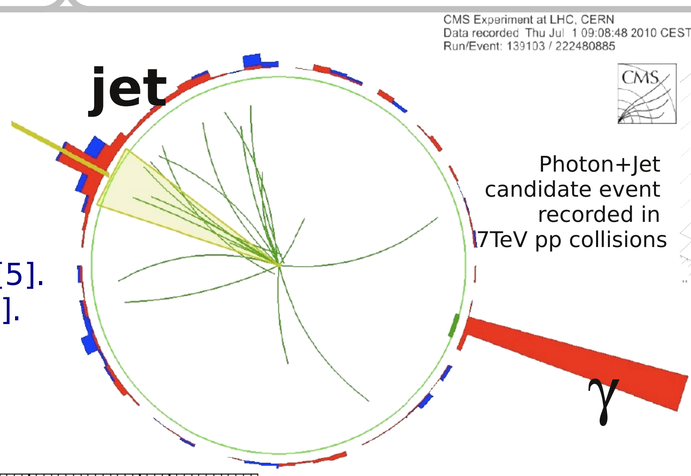


High level trigger efficiency for reconstructed photon candidates.

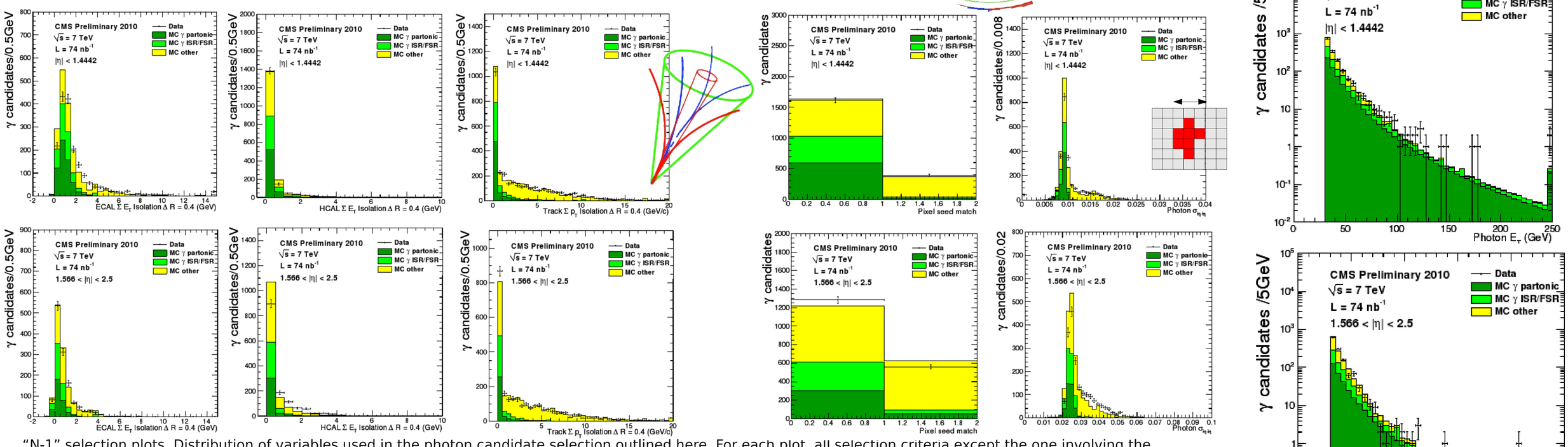
Selection commissioning in 7TeV collisions

The selection outlined above has been evaluated using pp collisions at $\sqrt{s}$ = 7 TeV delivered by the LHC. The analysed data amounts to a total integrated luminosity of 74 nb^{-1}.

Data were compared to MC simulation obtained using the PYTHIA 6.432[4] D6T tune[5].
Detailed simulation of the CMS detector was performed with the GEANT4 package [6].
Overall good agreement between data and MC is observed.
Some small discrepancies observed are due to imperfect detector alignment and inaccuracies in the detector simulation of detector noise.



Photon+Jet candidate event recorded in 7TeV pp collisions



"N-1" selection plots. Distribution of variables used in the photon candidate selection outlined here. For each plot, all selection criteria except the one involving the variable shown are applied. Distributions in data are compared to MC simulation.

Conclusions

The measurement of inclusive photon production in pp collisions represent a crucial step towards physics with photons at LHC. A robust selection for early analyses have been developed.
The selection has been commissioned using 74 nb^{-1} of pp collisions at $\sqrt{s}$ =7 TeV. Good agreement between data and simulation has been observed.

Photon candidates spectra after all selection criteria. (top) Barrel, (bottom) Endcaps. Data distributions are compared to MC predictions

References:
[1] Catani, S. et al, "Cross section of isolated prompt photons in hadron-hadron collisions", doi:10.1088/1126-6708/2002/05/028
[2] CMS Collaboration, "The CMS experiment at the CERN LHC", doi: 10.1088/1748-0221/3/08/S08004
[3] CMS Collaboration,"Photon reconstruction and identification at √s=7TeV",CMS PAS EGM-10-005
[4] T. Sjostrand, et al, "PYTHIA 6.4 Physics and Manual", doi:10.1088/1126-6708/2006/05/026.
[5] R. Field, "Studying the underlying event at CDF and the LHC", arXiv:1003.4220.
[6] GEANT4 Collaboration, "GEANT4: A simulation toolkit", doi:10.1016/S0168-9002(03)01368-8.