Activities in egamma WG

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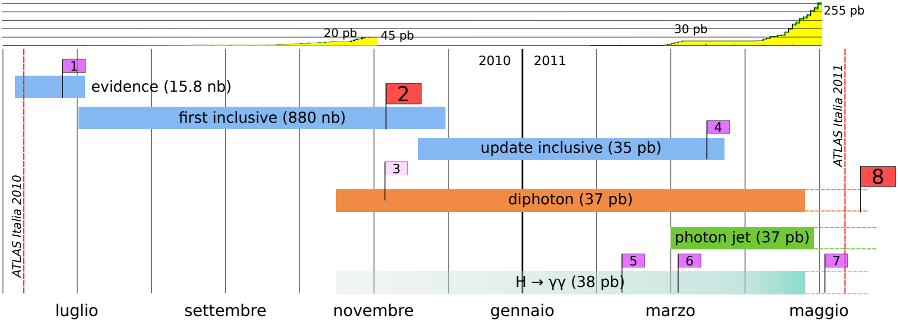

1 ATLAS-CONF-2010-077 "Evidence for prompt photon production in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector"

2 CERN-PH-EP-2010-068 "First measurement of the inclusive isolated prompt photon p cross section in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector", published by Phys. Rev. D.

3 ATL-COM-PHYS-2010-905 "First evidence of direct diphoton production in pp collision at $\sqrt{s}$ = 7 TeV in ATLAS"

4 ATLAS-CONF-2011-058 "Measurement of the inclusive isolated prompt photon cross-section in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector using 35 pb^-1"

5 ATLAS-CONF-2011-004 "Measurement of the backgrounds to the H → γγ search and reappraisal of its sensitivity with 37 pb -1 of data recorded by the ATLAS detector"

6 ATLAS-CONF-2011-025 "Search for the Higgs boson in the diphoton final state with 38 pb −1 of data recorded by the ATLAS detector in proton-proton collisions at $\sqrt{s}$=7 TeV"

7 ATLAS-CONF-2011-071 "Update of the Background Studies in the Search for the Higgs Boson in the Two Photons Channel in pp Collisions at $\sqrt{s}$=7 TeV"

8 ATLAS-STDM-2011-05-001 "Measurement of isolated di-photon cross section in pp collision at $\sqrt{s}$ = 7 TeV with the ATLAS detector" to be submitted to Phys. Rev. D.

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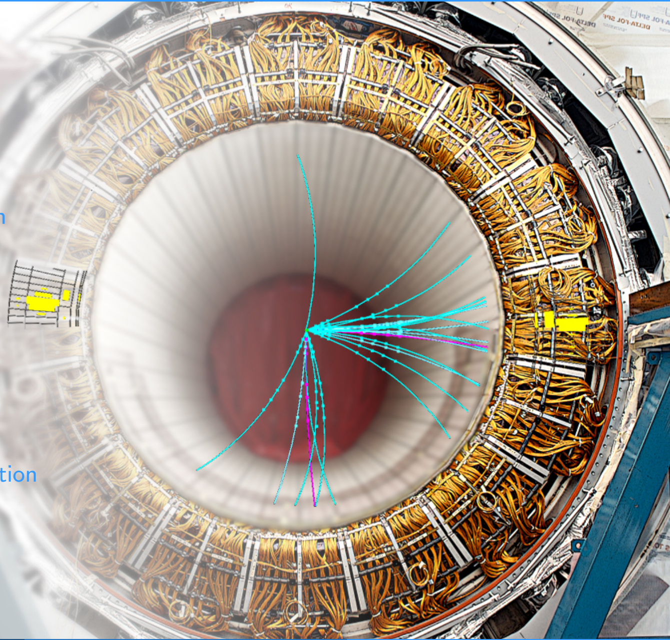
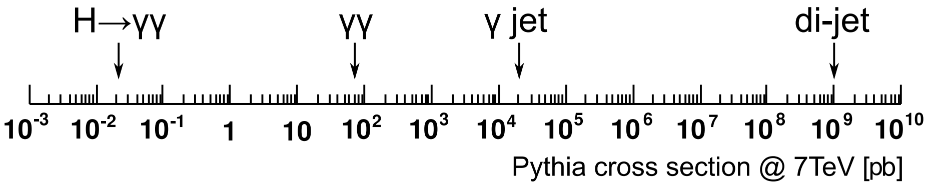
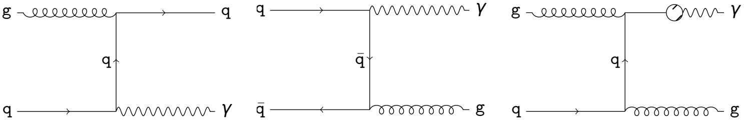


- QCD dijet production cross section is order of magnitudes larger than the signal: excellent jet rejection ($\sim 10^3 - 10^4$) capability of the detector is required to extract the signal over the background
- In general don't want to trust too much on the MC information and try (as much as possible) data driven techniques to estimate the photon yields
- No clean source of photons (as $Z \to ee$) to be used to check photon efficiency using some tag and probe technique



Section 2

Inclusive prompt photon



(a) compton (b) annihilation (c) fragmentation

Motivation:

- colorless probe of the hard-scattering process, and it can also be used to constrain parton density functions in particular for the gluon content
- important for many physics signatures, including searches for Higgs boson decay into two photons and physics beyond Standard Model

Isolation:

- the isolation energy is the additional hadronic activity near photon axis
- reduces fragmentation ($\sim$30% of total xsec at 15 GeV, $<$10% above 35 GeV)

Inclusive prompt photon analysis

Two analysis with 2010 data:

- 880 nb^{-1}, $15 < p_T < 100\,\text{GeV}$, 3 eta bins: $[0.00, 0.60)$, $[0.60, 1.37)$, $[1.52, 1.81)$
- 35 pb^{-1} $45 < p_T < 400\,\text{GeV}$, 4 eta bins: $[0.00, 0.60)$, $[0.60, 1.37)$, $[1.52, 1.81)$, $[1.81, 2.37)$

Signal definition:

- prompt γ with true (E_T, η) in acceptance, truth-particle-level $E_T^{\text{isol, part}} < 4\text{GeV}$ in a radius $R = \sqrt{\Delta\eta^2 + \Delta\phi^2} < 0.4$

"Measurement of the inclusive isolated prompt photon cross section in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector" CERN-PH-EP-2010-068, Phys. Rev. D

"Measurement of the inclusive isolated prompt photon cross section in *pp* collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector using 35 pb^{-1}" ATLAS-CONF-2011-058

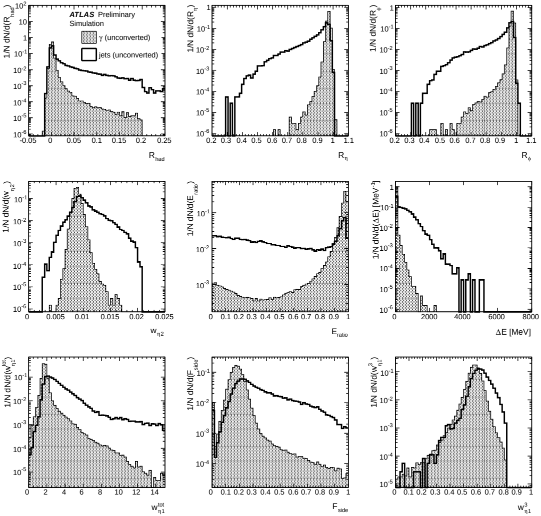
$$\frac{d\sigma}{dE_T^\gamma} = \frac{N_{\text{yield}}\,U}{(\int \mathcal{L}\,dt)\Delta E_T^\gamma\,\varepsilon_{\text{trigger}}\,\varepsilon_{\text{reco}}\,\varepsilon_{\text{ID}}}$$

- N_{yield} = number of candidates after background subtraction
- $\varepsilon_{\text{reco}}$ = photon reconstruction efficiency (vs true E_T)
- ε_{ID} = photon identification efficiency (vs reco E_T)
- $\varepsilon_{\text{trig}}$ = trigger efficiency for photons passing the full selection
- U = unfolding matrix (close to one)

- g10_loose (880 nb^{-1})
  g40_loose (35 pb^{-1})
- GRL
- vertex with at least three tracks
- $15 < E_T < 100\,\mathrm{GeV}$ (880 nb^{-1})
  $45 < E_T < 400\,\mathrm{GeV}$ (35 pb^{-1})
- $|\eta| < 1.81$ (880 nb^{-1})
  $|\eta| < 2.37$ (35 pb^{-1})
  except $1.37 < |\eta| < 1.52$
- object quality
- jet cleaning with $\Delta R = 0.4$
- tight photon selection
- calorimetric $E_T^{\mathrm{isol}} < 3\,\mathrm{GeV}$

Selected candidates:

- 110×10^3 $15 < E_T < 100\,\mathrm{GeV}$, $|\eta| < 1.81$ (880 nb^{-1})
- 174×10^3 $45 < E_T < 400\,\mathrm{GeV}$, $|\eta| < 2.37$ (35 pb^{-1})



Selection

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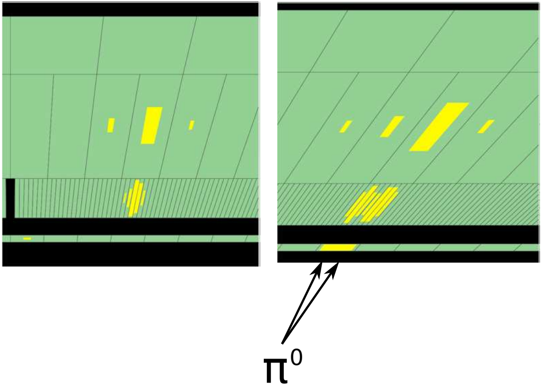

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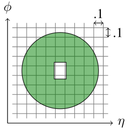
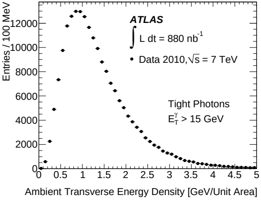
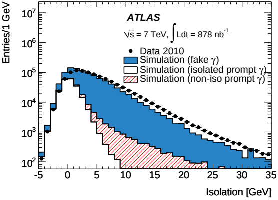
Calorimetric isolation E_T^{isol}

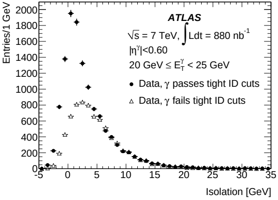
The calorimetric isolation is the energy measured in a cone $R = \sqrt{\Delta\eta^2 + \Delta\phi^2} < 0.4$ centered around the candidate direction minus the energy of the candidate removing the cells in a 5x7 cluster.
Two corrections are applied:



- Residual leakage of photon energy using single photon MC samples
- Energy from the underlying event using ambient energy density estimated with low-pT jets[1]. The average correction ∼ 500 MeV.







[1] following M. Cacciari, G. P. Salam, S. Sapeta, "On the characterisation of the underlying event", JHEP 04 (2010) 65

Purity estimation

The purity is estimated with the 2D-sideband data driven method using isolation variable and isEM cuts.

Define one signal region and three control regions:

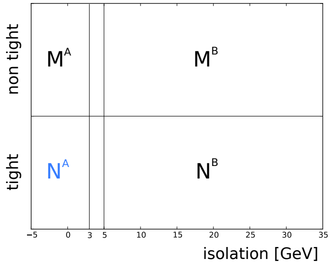
- N_A (signal region) tight and $E_T^{\text{isol}} < 3\,\text{GeV}$
- N_B tight and $E_T^{\text{isol}} > 5\,\text{GeV}$
- M_A non-tight and $E_T^{\text{isol}} < 3\,\text{GeV}$
- M_B non-tight and $E_T^{\text{isol}} > 5\,\text{GeV}$

Basic assumptions:

- isEM variables independent from isolation $\rightarrow$ taken as systematics
- no signal leakage (signal only in the signal region) $\rightarrow$ corrected with MC

$$N^A_{\text{sig}} = N^A - N^B \frac{M^A}{M^B}$$

$$P = \frac{N^A_{\text{sig}}}{N^A} = 1 - \frac{N_B M_A}{N_A M_B}$$



Purity results

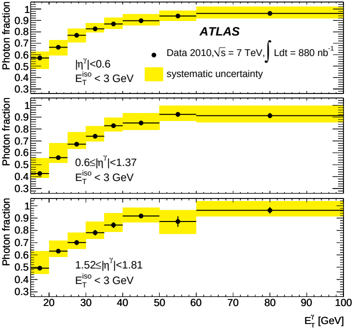


Figure: $880\,\mathrm{nb}^{-1}$, $p_T > 15\,\mathrm{GeV}$

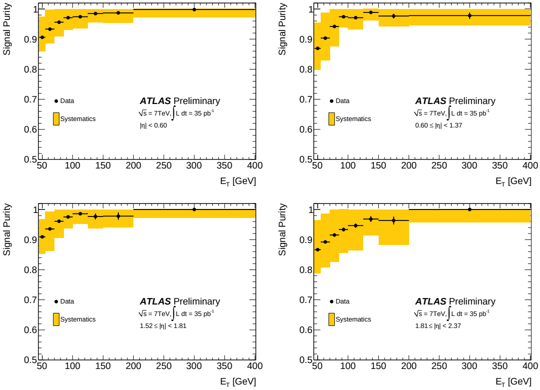


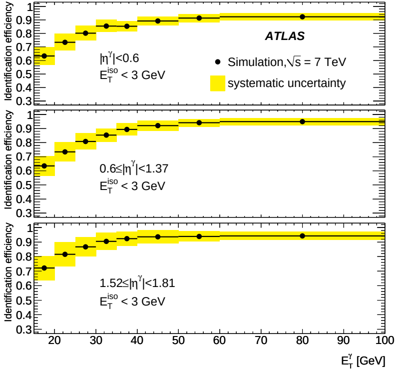
Figure: $35\,\mathrm{pb}^{-1}$, $p_T > 45\,\mathrm{GeV}$

- Good agreement, very high purity for $p_T > 100\,\mathrm{GeV}$
- Main systematics from: MC inputs ($\lesssim 10\%$), background control region definition ($\lesssim 6\%$)
- Results cross-checked with isolation template fit (signal template: e from W/Z in data; bkg template: photons failing the tight ID criteria). Agreement within 5%.

Photon efficiency

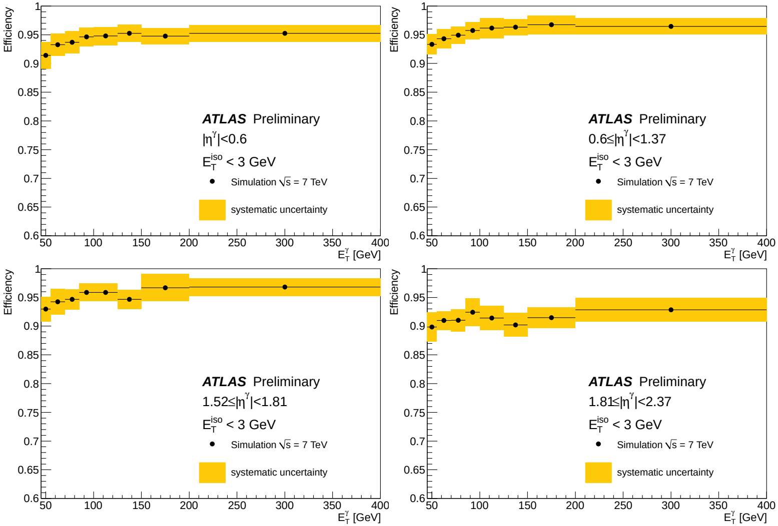
- Trigger efficiency: $\sim 100\%$ for photons passing offline selection
- Photon reconstruction efficiency $\varepsilon_{\rm rec}$: from MC $\sim$ 80 − 85% in the barrel $\sim 70\%$ in the endcap. Uncertainties from : extra material not in MC (1-2%), generator and fraction of fragmentation photons ($< 2\%$), experimental isolation efficiency (3-4%)

- Photon identification efficiency from MC with shower shapes shifted to match data:
  - very high efficiency at high E_T
  - separately for converted/unconverted candidates
  - validated with e from $W \to e\nu$ in data
  - main systematic uncertainties:
    - method and selection ($\sim 5\% \to 2\%$)
    - extra material ($\sim 6\% \to 1\%$)
    - pileup, generator ($\sim 2 - 3\%$)
    - conversion fraction ($\sim 2 \to 1\%$)



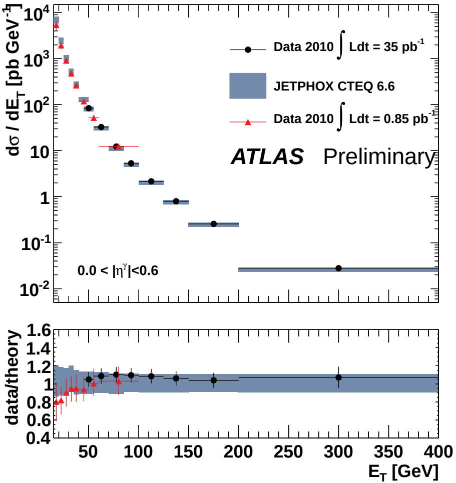
Photon efficiency

35 pb^{-1}



Consistent with previous determination between 45 and 100 GeV

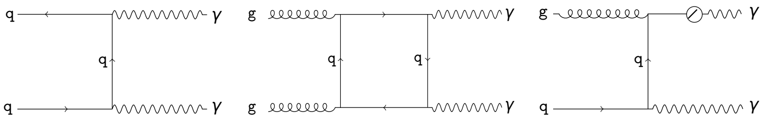
- compared to NLO pQCD prediction by JetPhoX
- CTEQ 6.6 PDFs (PDF uncertainty: 4% $\rightarrow$ 2%)
- scales (fragmentation/factorization/renormalization) $= E_T(\gamma)$, varied between .5 and 2 $E_T(\gamma)$ (scale uncertainty: 20% $\rightarrow$ 8%)
- parton isolation energy < 4GeV in cone $\Delta R = 0.4$ (varied between 2 and 6 GeV: $\pm 2\%$)
- Some discrepancies at low E_T:
  - difficult region: in particular for photon efficiency estimation
  - theoretical computation not fully under control



Section 3

Isolated diphoton

Isolated diphoton



(a) QED (b) box (c) fragmentation

Motivation:

- probe to the QCD especially in some particular kinematic regions
- irreducible background for searches for Higgs boson or graviton decays to photon pairs and others

Signal definition for 2010 analysis:

- two prompt photons with true (E_T , η) in acceptance, truth-particle level $E_T^{\text{isol, part}} < 4\,\text{GeV}$ with separation between them $\Delta R > 0.4$
- acceptance: $E_T > 16\,\text{GeV}$, $|\eta| < 2.37$ except $1.37 < |\eta| < 1.52$

Studied quantities: invariant mass $m_{\gamma\gamma}$, total transverse momentum $P_{T,\gamma\gamma}$, azimuthal separation $\Delta\phi_{\gamma\gamma}$

"Measurement of isolated di-photon cross section in pp collision at $\sqrt{(s)}$=7 TeV with the ATLAS detector" ATLAS-STDM-2011-05-001

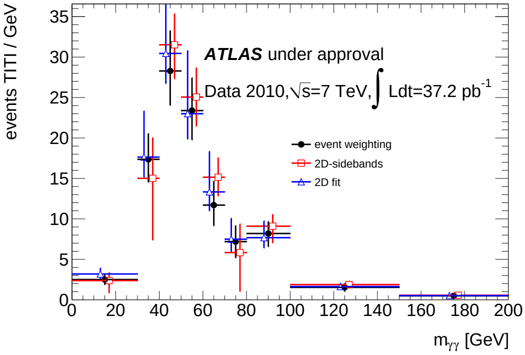
Selection and yield estimation

- 2g15_loose
- $E_T > 16\,\text{GeV}$
- $|\eta| < 2.37$ except $1.37 < |\eta| < 1.52$
- $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2} > 0.4$
- photon tight selection
- $E_T^{\text{iso}} < 3\,\text{GeV}$ in a cone $R < 0.4$

Three methods to estimate decompose the candidates in $\gamma\gamma$ (signal) and γj, $j\gamma$, jj:

- 4×4 matrix (Milano)
- 2D sidebands (LPNHE, LAL, LAPP, ...)
- template fit (LPNHE-Paris)

$\rightarrow$ agreement



Additional method to remove fake γ from Drell-Yan process from $\gamma\gamma$.

4×4 matrix method

- Used by CDF and DØ, data driven method
- Events containing two photon candidates can be due to di-photon, photon-jet and di-jet final states
- For every Tight-Tight event test if the two photons pass the isolation cut ($E_T^{iso} < 3\,\mathrm{GeV}$), four pass/fail outcomes are possible: PP, PF, FP, FF
- count the number of N_{PP}, N_{PF}, N_{FP}, N_{FF}
- Compute the number of events for each final state $W_{\gamma\gamma}$, $W_{\gamma j}$, $W_{j\gamma}$, W_{jj} solving the linear system:

$$\begin{pmatrix} N_{PP} \\ N_{PF} \\ N_{FP} \\ N_{FF} \end{pmatrix} = E \begin{pmatrix} W_{\gamma\gamma} \\ W_{\gamma j} \\ W_{j\gamma} \\ W_{jj} \end{pmatrix}$$

  where elements of E describe the probabilities that a given final ($\gamma\gamma$, γj, $\ldots$) state produce a certain pass/fail combination (PP, PF, $\ldots$).
- the method is applied event by event so the matrix E depend on (η, E_T) of the two photons.

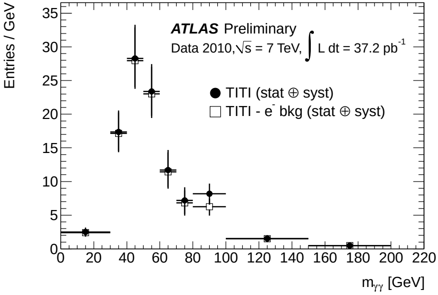
4×4 matrix method

$$E = \begin{pmatrix} \epsilon_1\epsilon_2 & \epsilon_1 f_2 & f_1\epsilon_2 & f_1 f_2 \\ \epsilon_1(1-\epsilon_2) & \epsilon_1(1-f_2) & f_1(1-\epsilon_2) & f_1(1-f_2) \\ (1-\epsilon_1)\epsilon_2 & (1-\epsilon_1)f_2 & (1-f_1)\epsilon_2 & (1-f_1)f_2 \\ (1-\epsilon_1)(1-\epsilon_2) & (1-\epsilon_1)(1-f_2) & (1-f_1)(1-\epsilon_2) & (1-f_1)(1-f_2) \end{pmatrix}$$

- ε_i "efficiency": probability that a signal photon pass the isolation cut
- f_i "fake rate": probability that a fake candidate pass the isolation cut
- $i = 1, 2$ refers to the leading and sub-leading candidate
- ε_i and f_i are estimated data driven using a non-tight sample

Due to correlations between the isolation energies of the two candidates the matrix is modified, accounting for all the observable effects.

- electrons are removed afterwards with a data driven method looking at ee, γe under the Z peak

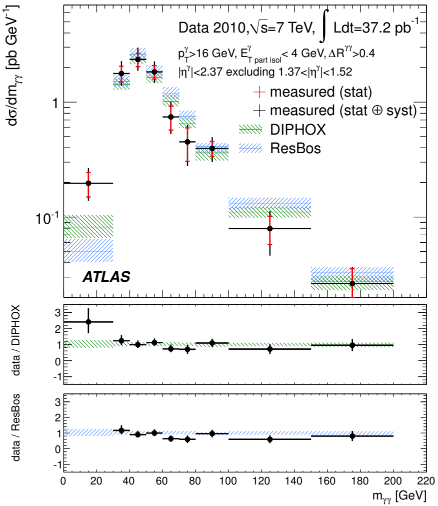


Cross section

- Photon efficiency is evaluated from MC as in the inclusive analysis
- $\varepsilon_{\text{trigger}} \sim 99\%$
- $\varepsilon_{\text{rec}} \sim 50 \rightarrow 60\%$, main inefficiencies:
  - detector failure ($\sim -18\%$)
  - calorimetric isolation ($\sim -20\%$)
- $\varepsilon_{\text{ID}} \sim 55 \rightarrow 80\%$

Main systematics:

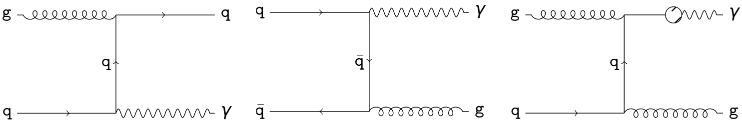
- definition of the non-tight sample
- normalization of the non-tight sample
- electron fake rate
- identification efficiency
- unfolding
- Good agreement over the mass range, except for low region, dominated by low $\Delta\phi$ events



Section 4

Photon-jet

Milano + Pisa



(d) compton (e) annihilation (f) fragmentation

- tests of pQCD in different regions of parton momentum fraction x and large hard-scattering angles Q^2
- gluon PDF extraction down to low $x \sim 10^{-3}$
- reducible background for $H \rightarrow \gamma\gamma$ and searches for new heavy resonances
- Use only central photon (like DØ), $|\eta^{\gamma}| < 1.37$
- Jets in three bins: $0 < |\eta^{j}| < 1.2$, $1.2 < |\eta^{j}| < 2.8$, $2.8 < |\eta^{j}| < 4.4$
- divide same side $\eta^{j}\eta^{\gamma} \geqslant 0$ (SS), opposite side $\eta^{j}\eta^{\gamma} < 0$ (OS)

Event selection:

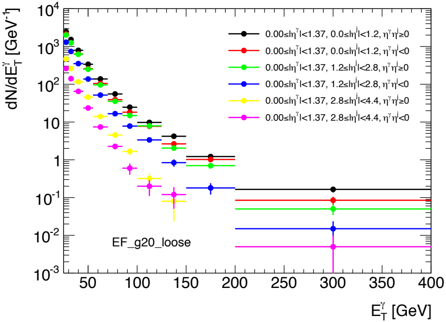
- g20_loose for $25 < p_T \lesssim 45\,\text{GeV}$ or g40_loose for $p_T \gtrsim 45\,\text{GeV}$
- dedicated GRL e/γ + SMjet
- vertex > 3 tracks

Leading photon:

- photon cleaning (coherent LAr noise burst and OQ cuts)
- photon tight selection
- $P_t > 25\,\text{GeV}$
- $\eta_\gamma < 1.37$ (only central photons)

Leading jet (following recommendation from jet/Etmiss and SMjets):

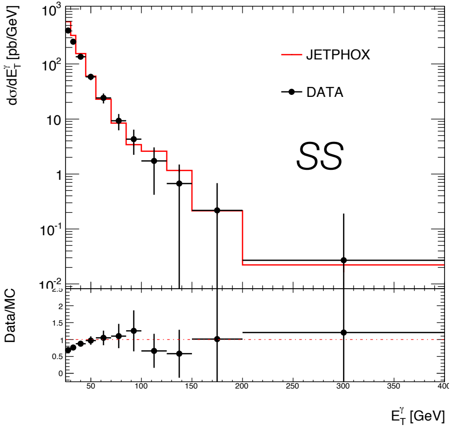
- Jet calibration `AntiKtTopoEM` object with $R = 0.4$
- Jet cleaning
- $P_T > 20\,\text{GeV}$
- $|\eta| < 4.4$
- $\Delta R > 0.4$ with the photon



- Purity from 2D sidebands method
- Efficiency from MC

- JetPhoX 1.2.2 (NLO)
- CT10 pdf
- no systematics

central jet



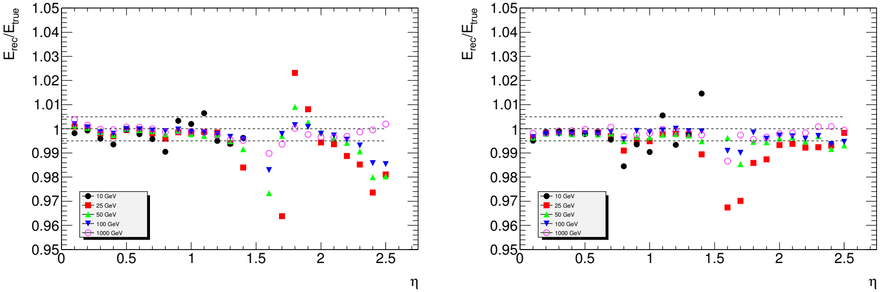
Section 5

Electromagnetic calibration

Electromagnetic calibration with CalibHit method

MonteCarlo-based: use “calibration hits” (special runs where energy hits in dead/inactive material are saved)

- Optimized with GEO-16 for electrons and photons (converted/unconverted separately)
  $5\,\mathrm{GeV} \leqslant E \leqslant 1\,\mathrm{TeV}$
- Coefficients extracted for 2011 data taking (v8)



(g) v7 (h) v8

Figure: Electron linearity

Linearity deviation $\lesssim 0.5\%$, improvement respect previous version.

Conclusions and future

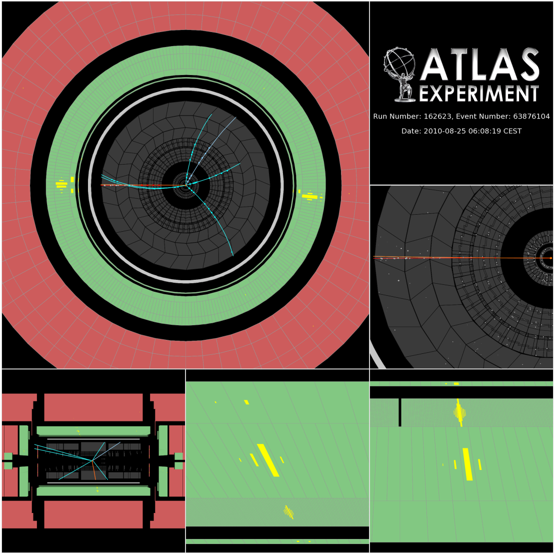
- The cross-section measurements of the main SM processes involving photons are well established
- The main discriminant variables have been extensively studied and validated.
- All the channels studied are the background components containing photons in the $H \to \gamma\gamma$ search
- Several activities:
  - first inclusive photon analysis paper has been published
  - diphoton paper is under discussion
  - update of the inclusive photon and photon-jet papers are coming in the short period
- Strong participation in the analysis
  - editor for the inclusive photon analysis paper
  - editor for the diphoton analysis paper
- We are already focusing into the $H \to \gamma\gamma$ analysis[2]. Presently we are contributing in:
  - improving the photon direction measurement (calorimetric pointing and vertex choice)
  - background decomposition: with 4×4 matrix method as in the diphoton analysis, exploiting the experience from previous analyses

[2] See tomorrow Stefano Rosati talk

Section 6

Backup

Diphoton high mass

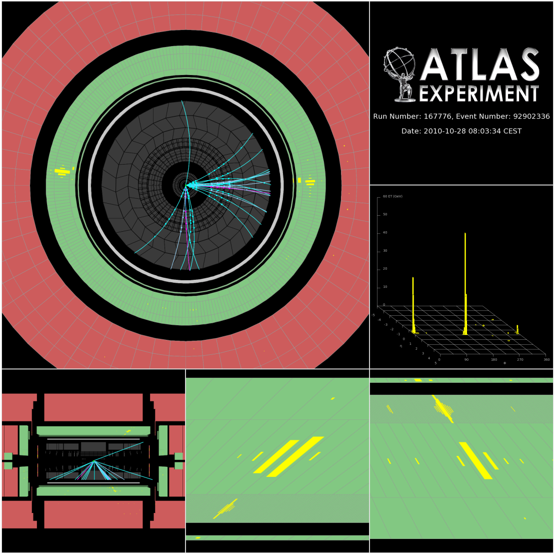


- P_t^{clus} leading: 94.5 GeV
- P_t^{clus} subleading: 83.0 GeV
- isol leading: 2133 MeV
- isol subleading: 1208 MeV
- mass: 188.76 GeV
- radius convertion leading: 136.1 mm
- P_t conversion: 50.2, 39.2 GeV

Diphoton small $\Delta\phi$

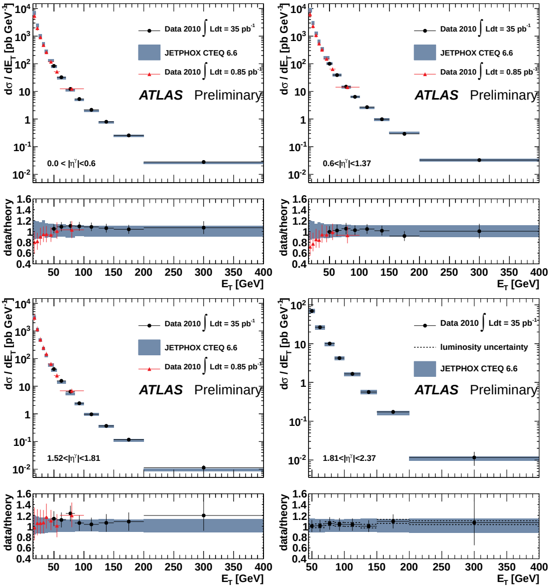
- P_t^{clus} leading: 94.3 GeV
- P_t^{clus} subleading: 72.8 GeV
- isol leading: -790 MeV
- isol subleading: -1630 MeV
- mass: 143.1 GeV
- $\Delta\phi$: 1.53

Diphoton non isolated

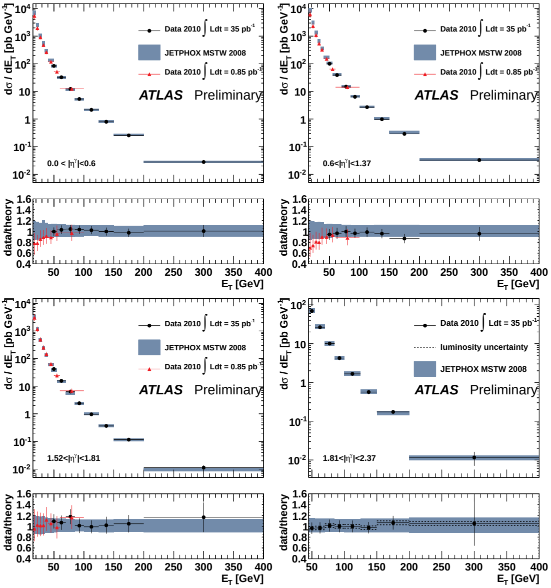


- P_t^{clus} leading: 129 GeV
- P_t^{clus} subleading: 83 GeV
- isol leading: 995 MeV
- isol subleading: 19 GeV

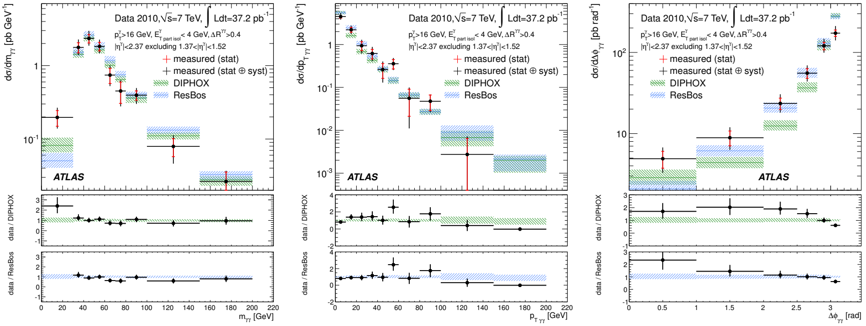
Inclusive cross section CTEQ 6.6



Inclusive cross section MSTW 2008

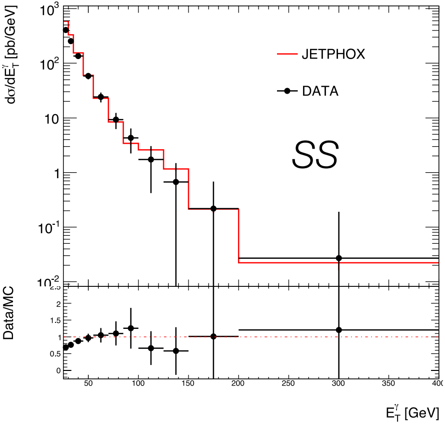


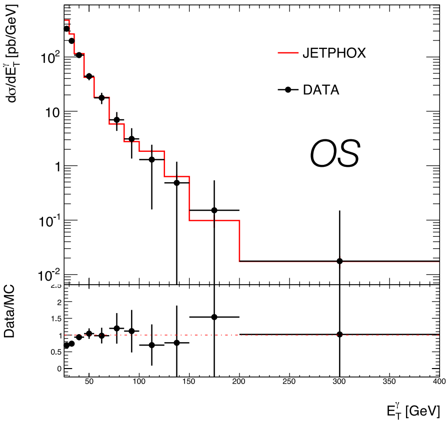
Diphoton cross sections

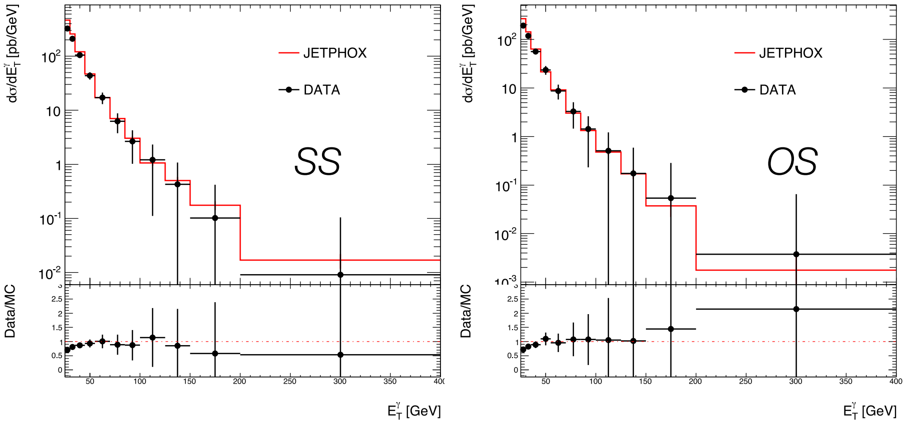


Photon-jet cross section

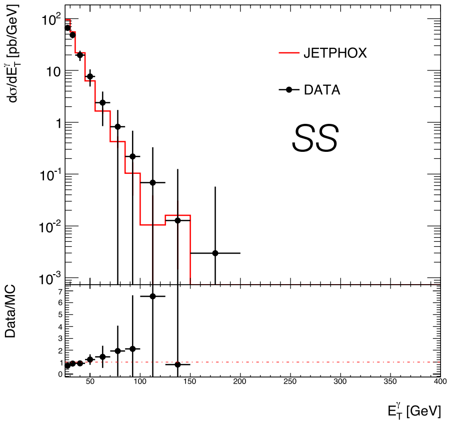
Central jet

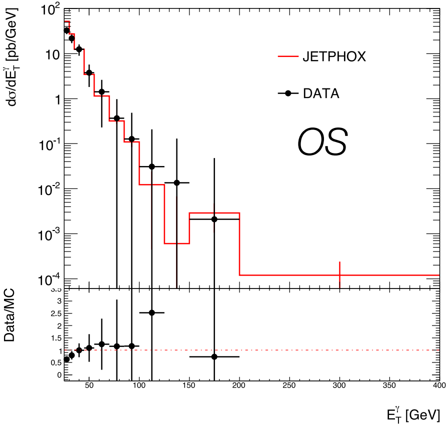






$d\sigma/dE_T^\gamma$ [pb/GeV]
JETPHOX
DATA
SS
Data/MC
E_T^γ [GeV]
$d\sigma/dE_T^\gamma$ [pb/GeV]
JETPHOX
DATA
OS
Data/MC
E_T^γ [GeV]

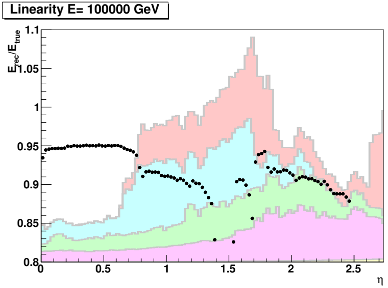

JETPHOX
DATA
SS
$d\sigma/dE_T^\gamma$ [pb/GeV]
Data/MC
E_T^γ [GeV]

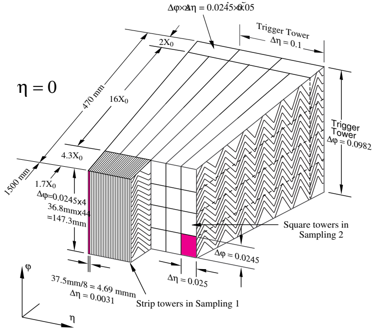

JETPHOX
DATA
OS
$d\sigma/dE_T^\gamma$ [pb/GeV]
Data/MC
E_T^γ [GeV]

- Front energy

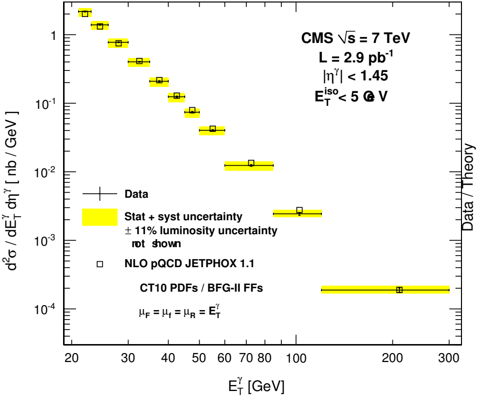
$$E_{\text{reco}}^{\text{cal}} = a(E_{\text{reco}}^{\text{acc}}, \eta) + b(E_{\text{reco}}^{\text{acc}}, \eta) E_{\text{ps}}^{\text{cl LAr}} + c(E_{\text{reco}}^{\text{acc}}, \eta)(E_{\text{ps}}^{\text{cl LAr}})^2$$
$$+ \frac{1}{S_{\text{acc}}(X, \eta)} \times \left(\sum_{i=1}^{3} E_i^{\text{cl LAr}}\right) \left(1 + f_{\text{leak}}(X, \eta)\right) \times F(\eta, \varphi)$$

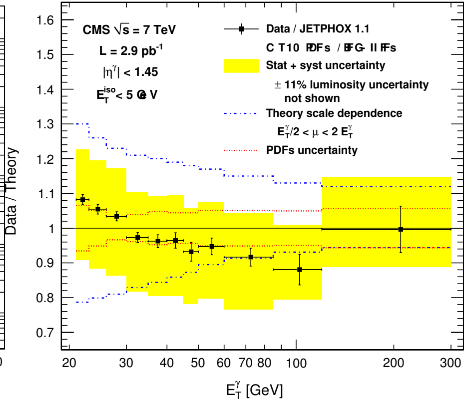
- $X = \frac{\sum_{i=1}^{4} E_i^{\text{LAr}} X_i}{\sum_{i=1}^{4} E_i^{\text{LAr}}}$
- Sampling correction and out of cluster
- Accordion energy
- Longitudinal leakage
- Impact midpoint modulation


Linearity E= 100000 GeV
E_rec/E_true
1.1
1.05
1
0.95
0.9
0.85
0.8
0
0.5
1
1.5
2
2.5
η


Δφ×Δη = 0.0245×0.05
Trigger Tower
Δη = 0.1
2X0
η = 0
470 mm
16X0
Trigger
Tower
Δφ = 0.0982
4.3X0
1500 mm
1.7X0
Δφ=0.0245x4
36.8mmx4
=147.3mm
Square towers in
Sampling 2
Δφ = 0.0245
φ
37.5mm/8 = 4.69 mmm
Δη = 0.0031
Δη = 0.025
Strip towers in Sampling 1
η

2.9 pb^{-1}, $|\eta| < 1.45$ $E_T > 21$ GeV, $E_T^{iso} < 5$ GeV





Lar HV DCS

- Sviluppo e manutenzione del DCS (Detector Control System) per l'operazione e controllo del calorimetro LAr di ATLAS (barrel e endcaps; elettromagnetico e adronico)
  - Operatività (on call, experts)
  - Aggiornamenti, implementazione di nuove features
  - Sviluppi futuri su sistemi di test in laboratorio a Milano e al CERN
- Il dati del DCS immagazzinati nel Condition DB forniscono anche una lista sempre aggiornata di canali non a tensione nominale per successive correzioni offline
- Grosso sforzo (ancora in corso) per fronteggiare un elevato numero di trip di canali HV durante il data-taking:
  - Modifiche ai moduli di alta tensione,
  - Riduzione delle inefficienze dovute al trip e alla successiva rampa