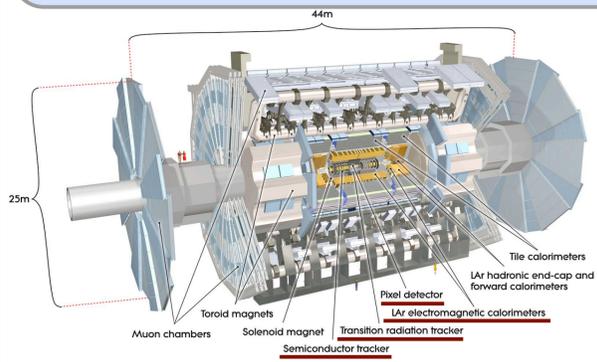


Search for Standard Model Higgs boson in the two-photon final state in ATLAS

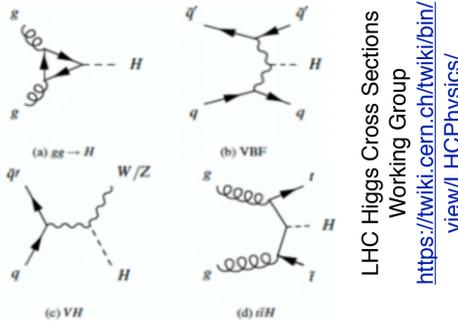
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LPNHE-Paris, on behalf of the ATLAS Collaboration - Hadron Collider Physics Symposium 2011

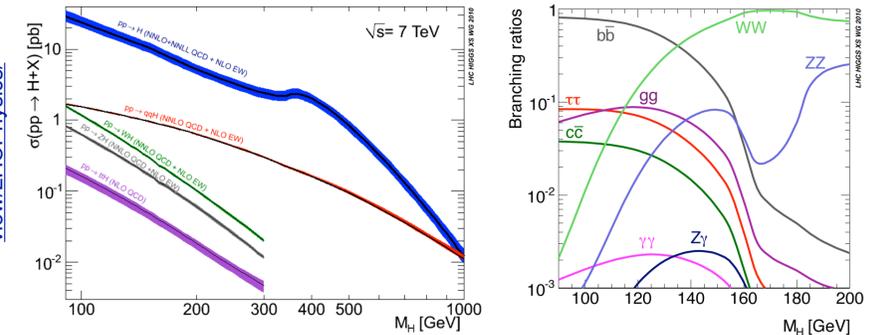
1. ATLAS — Measurement Principle



- ATLAS located on LHC ring at CERN
- Main subdetectors used: EM calorimeter (LAR) and Inner Detector



LHC Higgs Cross Sections Working Group
<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/>



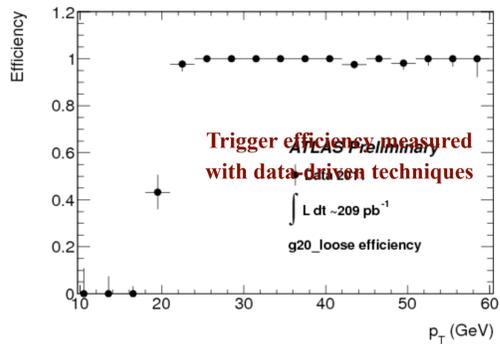
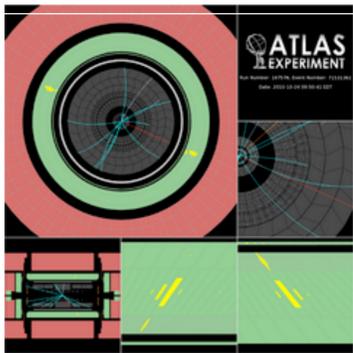
- **Production** of SM H through 4 main subprocesses (gluon fusion, VBF, associated production with W,Z or ttbar)
- **Decay** of H in gamma gamma studied
↳ Branching ratio O(10⁻³)
- **Mass** fully reconstructed

$$M_{\gamma_1\gamma_2} = \sqrt{2p_T^{\gamma_1} p_T^{\gamma_2} (\cosh(\eta_{\gamma_1} - \eta_{\gamma_2}) - \cos(\phi_{\gamma_1} - \phi_{\gamma_2}))}$$

2. Event selection

1.08 fb⁻¹ of data used

- **Trigger:** diphoton trigger p_T > 20 GeV/c + loose ID
- **Eta acceptance:** |η| < 1.37 or (|η| > 1.52 && |η| < 2.37)
- **Good Run List:** good detector conditions
- **Photon p_T:** cut on 2 leading photons p_T > 40, 25 GeV/c
- **Isolation:** Calo Isolation < 5 GeV
- **ID:** tight selection criteria
- **LAr error:** no HV trip, low noise
- **Mass window:** 100 < M_{γγ} < 160 GeV/c²

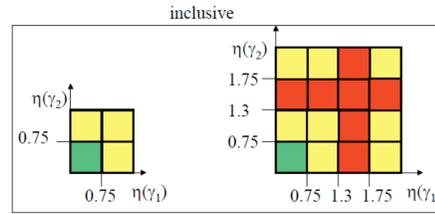


Below left: Event display for a simulated H → γγ with M=116 GeV/c². The leading photon is converted to an electron-positron pair
Below right: g20_loose photon trigger efficiency as a function of photon's p_T

3. η-conversion categories

Definition of 5 exclusive categories: motivated by resolution as a function of η and conversions

- both unconverted : |η_{1,2}| < 0.75
- -Unconverted central : |η_{1,2}| < 0.75
- -Unconverted rest : |η_{1,2}| > 0.75
- ≥1 converted : |η_{1,2}| < 0.75
- -Converted (≥1) central : |η_{1,2}| < 0.75
- -Converted (≥1) rest : |η_{1,2}| > 0.75
- -Converted (≥1) transition : ≥1 w/ 1.3 < |η| < 1.7



Fractions of Candidates in Data

Unconverted Central	8 %
Unconverted Rest	28 %
Converted Central	7 %
Converted Rest	41 %
Converted Transition	16 %

Expected signal yields for 1.08 fb⁻¹

m _H [GeV]	110	120	130	140	150
σ × BR [fb]	45	43	37	27	16
Signal yield	17.0	17.6	15.8	12.1	7.7
Unconverted central	2.6	2.6	2.3	1.7	1.1
Unconverted rest	4.6	4.7	4.2	3.4	2.1
Converted central	2.0	2.0	1.7	1.3	0.8
Converted transition	2.3	2.2	2.1	1.5	1.0
Converted rest	5.6	6.0	5.6	4.2	2.7

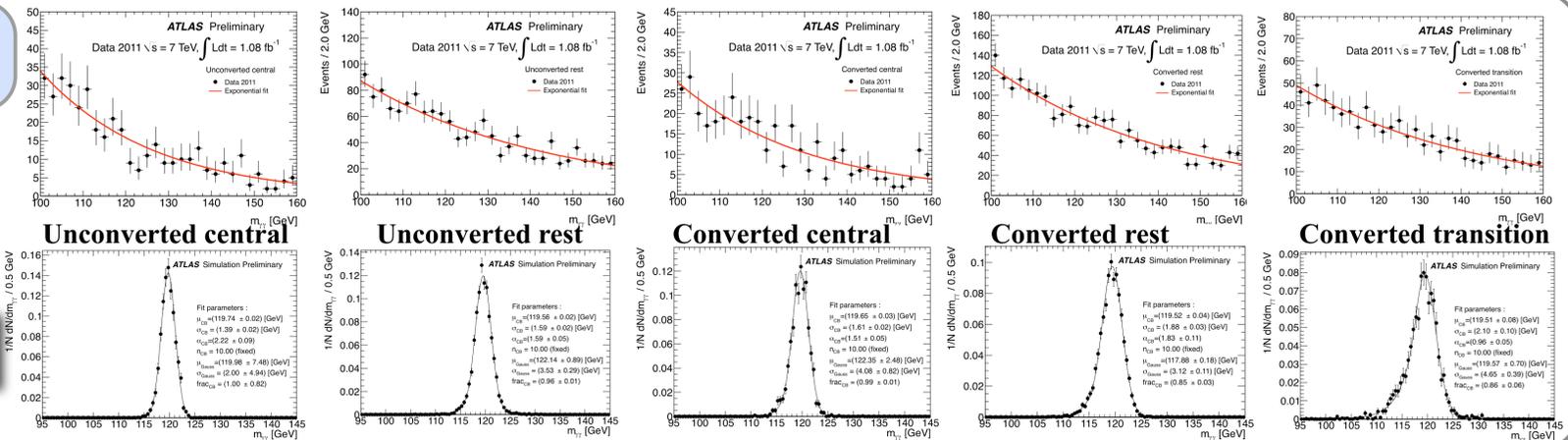
~15% improvement w.r.t. inclusive analysis (benefiting from different S/B in the categories)

4. Signal and Background Parametrizations

Background (data): exponential

Signal (MC): CB + gaussian

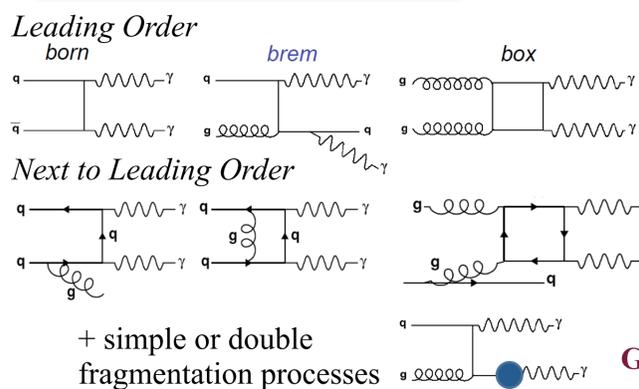
Inclusive Resolution @ M(Higgs)=120 GeV/c²: 1.7 GeV/c²



5. Background composition and extraction

Irreducible background

Reducible background



gamma-jet: ~ O(10³).σ_{γγ} - one jet misidentified as a photon

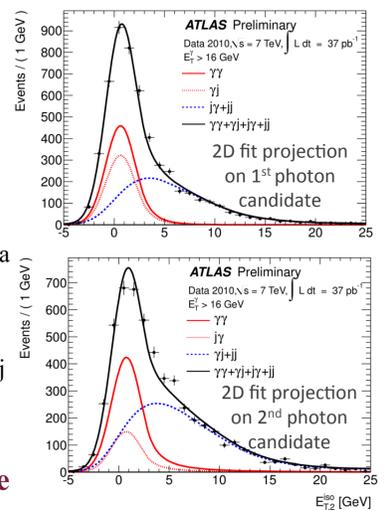
jet-jet: ~ O(10³).σ_{γγ} - two jets misidentified as photons

Drell-Yan, γ+Z/W: ~ O(10⁻¹) × σ_{γγ} electrons identified as photons

Good understanding of photon/jet discrimination and photon ID performance of the ATLAS detector

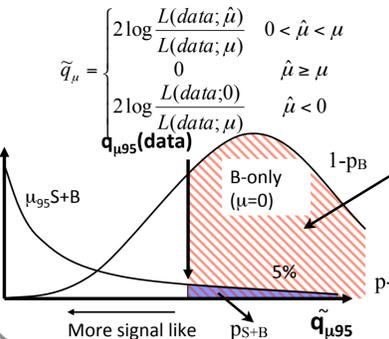
✓ Determination of 2D probability density function (pdf) for γγ, γj, jγ, and jj events calorimetric isolations. Product of 1D γ and jets pdfs except for jj : 2D pdf to avoid correlations

✓ 2D fit performed to data with the four 2D pdfs in order to deduce the proportion of each component γγ, γj, jγ, and jj



6. Statistical method and systematics

Profile likelihood statistic test



On Signal Yield **12%**

On Invariant Mass Reconstruction **14%**

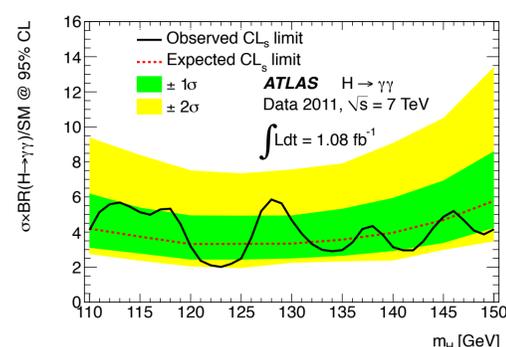
p-value: the probability, under the assumption of signal strength μ, of seeing data with equal or greater incompatibility, as measured by qμ, relative to the data actually obtained.

$$CL_s = 1 - p_s = 1 - \frac{P_{S+B}}{1 - P_B}$$

Systematics	Value
Reconstruction and identification efficiency	±11 %
Isolation cut efficiency	±3 %
Trigger efficiency	±1 %
Luminosity	±3.7 %
Effect of PT γγ modeling on the kinematical cut acceptance	±1 %
Constant term of the cluster energy resolution	±12 %
Photon calibration arising in the extrapolation of the energy scale calibration of electrons	±6 %
Contribution of pileup fluctuations to the cluster energy measurement	±3 %
Photon angle measurements	±1 %

7. Exclusion

Exclusion of Higgs production for cross sections between 2.0 and 5.8 times the SM



- Possible improvements:
- jet categories
 - use of discriminant such as p_T^{γγ} or cosθ*
 - exclusive categories