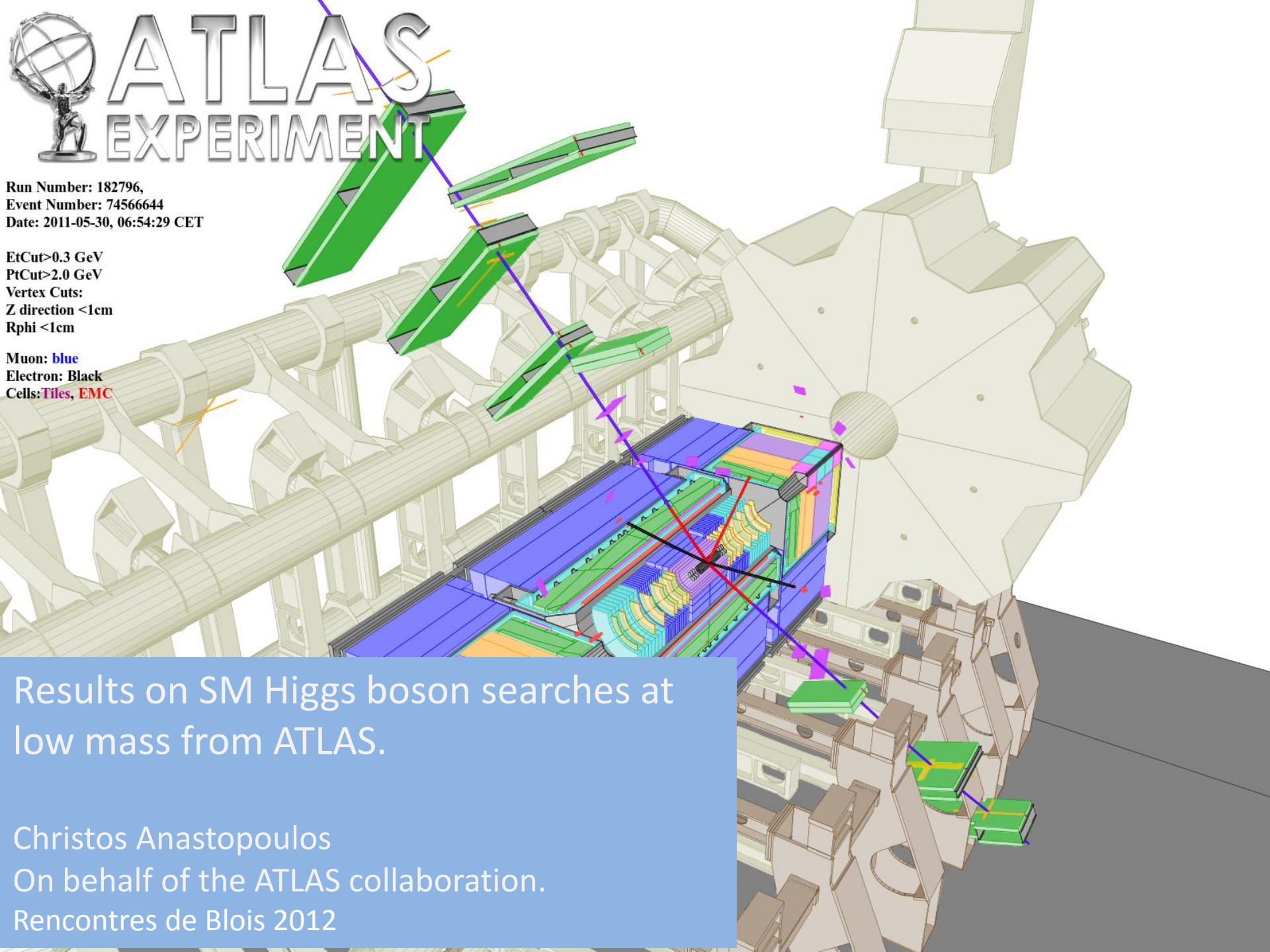Run Number: 182796,
Event Number: 74566644
Date: 2011-05-30, 06:54:29 CET

EtCut>0.3 GeV
PtCut>2.0 GeV
Vertex Cuts:
Z direction <1cm
Rphi <1cm

Muon: blue
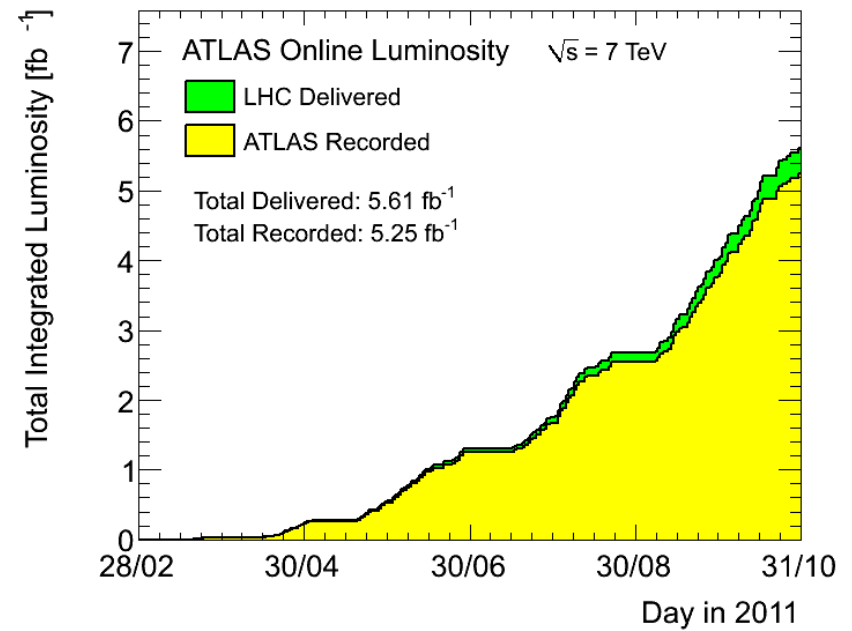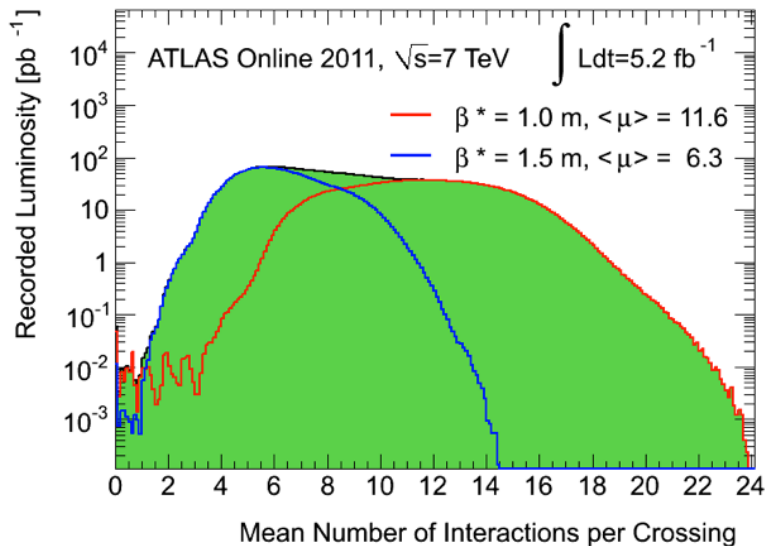Electron: Black
Cells:Tiles, EMC

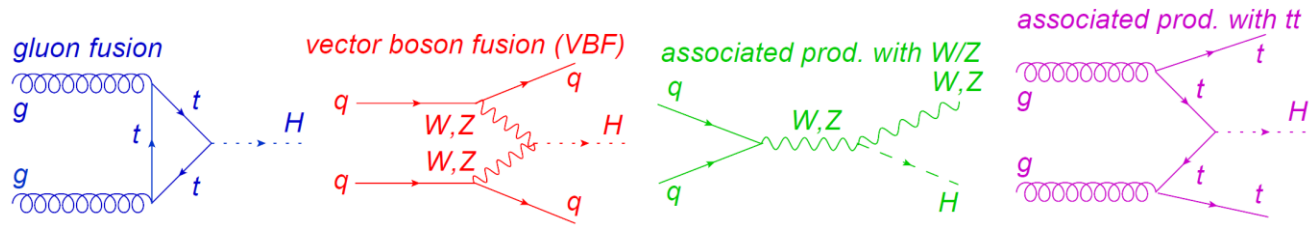# Results on SM Higgs boson searches at low mass from ATLAS.

Christos Anastopoulos
On behalf of the ATLAS collaboration.
Rencontres de Blois 2012

Introduction

❏ 5.25 fb^{-1} @ 7TeV recorded during 2011.
❏ Luminosity uncertainty is 3.9%.
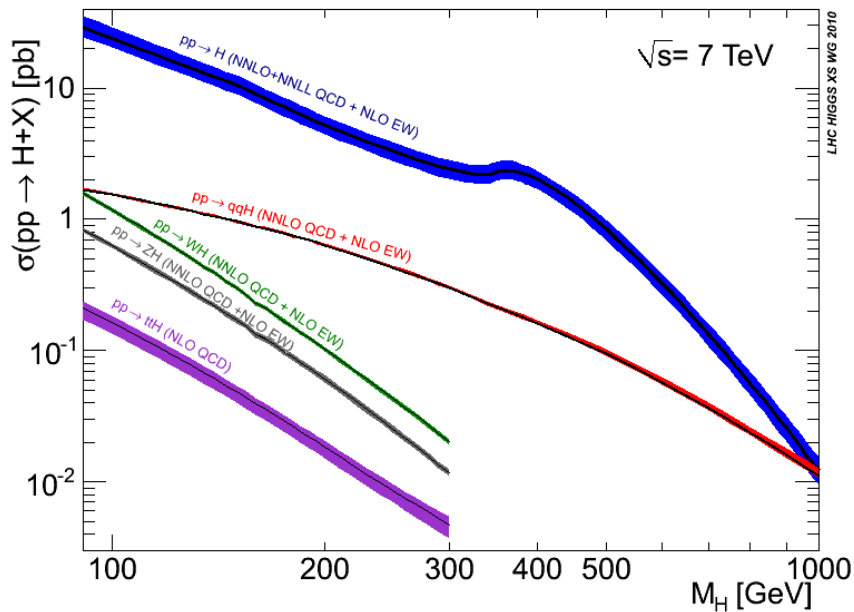❏ 90-95% of the data used for analysis.
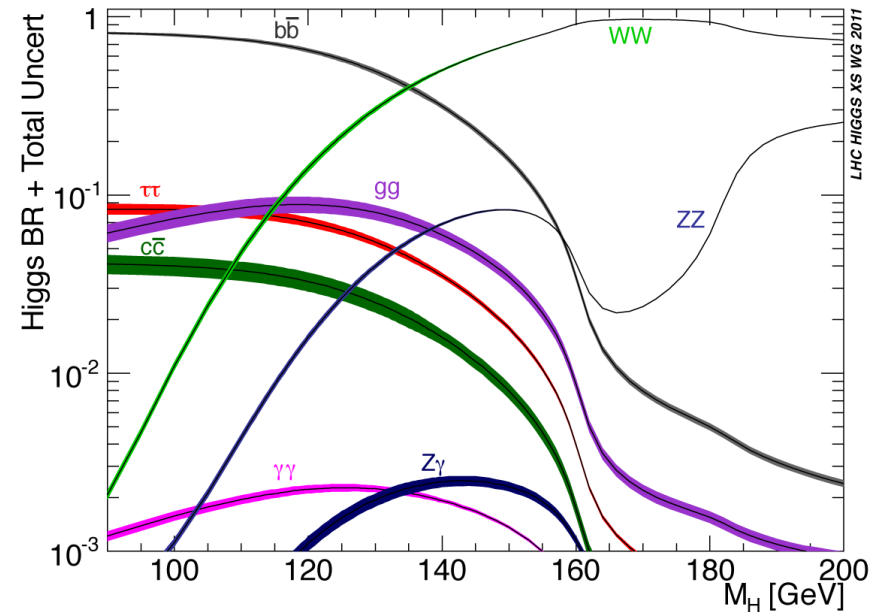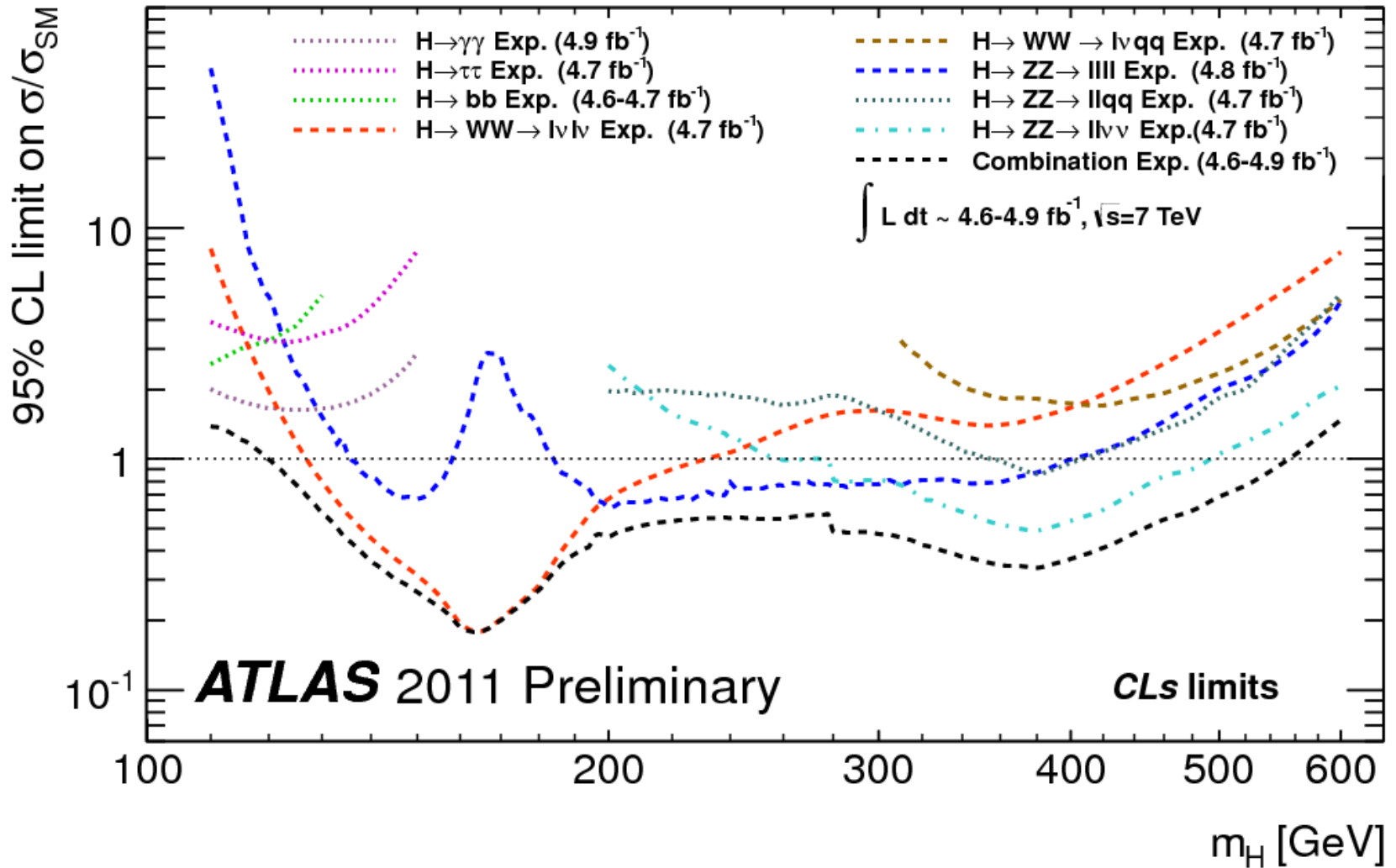
Higgs Boson Production and decays

LHC 7 TeV

Production x-section

Decay BR

Overview of ATLAS Higgs searches

Overview of ATLAS low mass Higgs searches

Channel	mH range (GeV)	Int. Lumi. (fb^{-1})	Main Backgrounds	Reference
(W/Z)H, H→bb	110-130	4.7	W/Z+jets, top	CONF-2012-015
H→ττ (ll,lh,hh)	110-150	4.7	Z→ττ, top	CONF-2012-014
H→WW$^{(*)}$→lvlv	110-600	4.7	WW$^{(*)}$, top, W/Z+jets	CONF-2012-012
H→γγ	110-150	4.9	γγ, γj	Phys. Rev. Lett. 108, 111803
H→ZZ$^{(*)}$→4l	110-600	4.8	ZZ$^{(*)}$, Z+jets	Phys.Lett. B710 (2012) 383-402

(W/Z)H→bb

- Search in 110 GeV≤mH≤130 GeV region.

- Final states :
    - ZH→llbb   (background: Z+jets ,top)
    - WH→lvbb (background: W+jets, top)
    - ZH→vvbb   (background: W+jets, top)

- m_{bb} is the final discriminant . Using P_T and MET categories.

- Requirements:
    - Exactly two b-tagged jets: E_T>45 GeV and >25 GeV.
    - ZH→llbb : reconstructed Z , MET<50GeV
    - WH→lvbb: MET>25GeV, extra lepton veto, mT(l,MET)>40GeV
    - ZH→vvbb: MET>120GeV, leptons veto, track-based MET> 30GeV

- Systematics :
    - b-tagging efficiency uncertainty (~10-20% on signal), jet energy scale (~5-10%) and background normalization (~5%)

Christos Anastopoulos
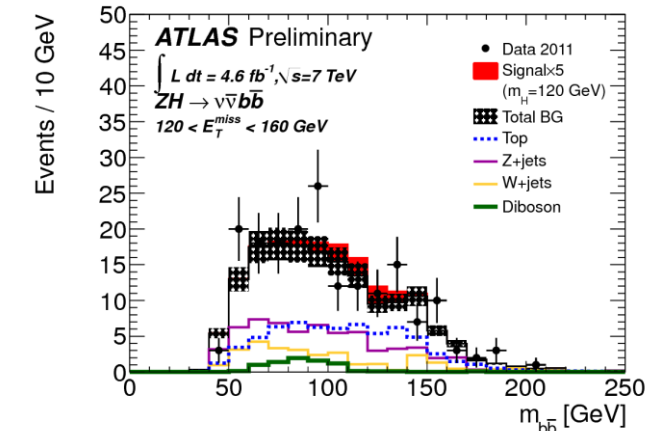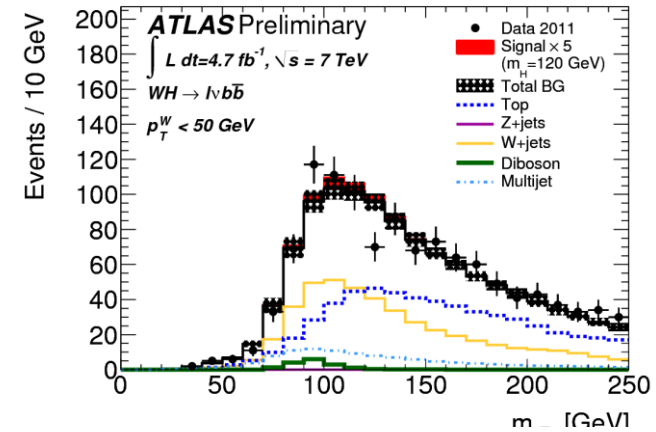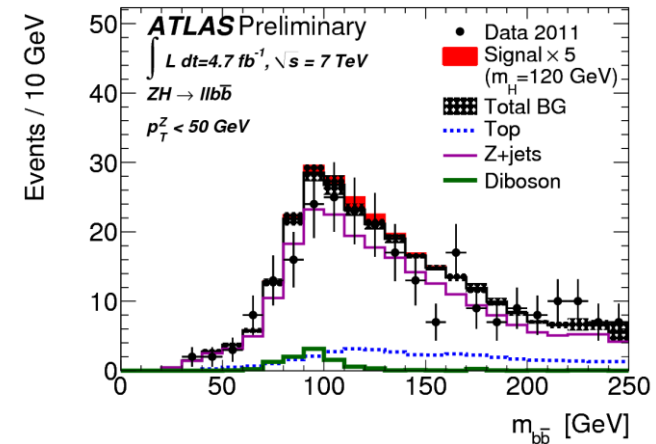
(W/Z)H→bb
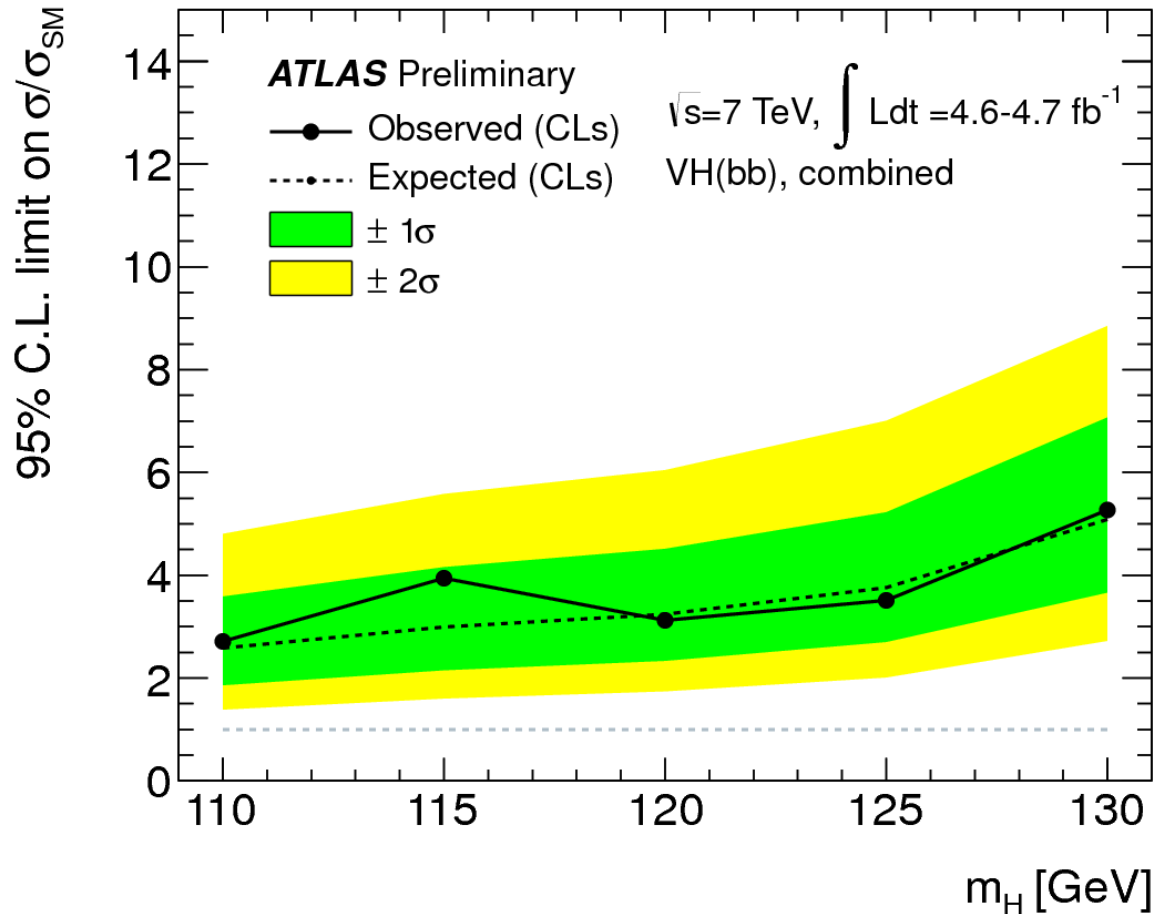


❑ Expected 95% CL upper limit 2.6-5.1 x σ_{SM} between 110 - 130 GeV

❑Observed 95% CL upper limit follows expectation

❑ ZH→vvbb is the most sensitive channel and WH→lvbb follows

H→ττ

- ❏ Search in 100 GeV≤mH≤150 GeV region
- ❏ Three final states:
    - ❏ H→ττ→ll+4ν
    - ❏ H→ττ→lh+3ν
    - ❏ H→ττ→hh+νν
    - ❏ Categorized in 12 sub-channels, depending on lepton flavor, number of jets, MET.
- ❏ $m_{\tau\tau}$ is the final discriminant:
    - ❏ Collinear approximation for ll hh.
    - ❏ lh : :Missing Mass Calculator → requires that mutual orientations of the neutrinos and other decay products are consistent with the mass and kinematics of a τ lepton
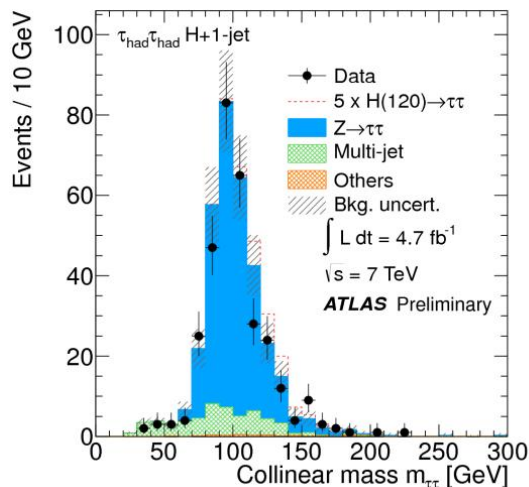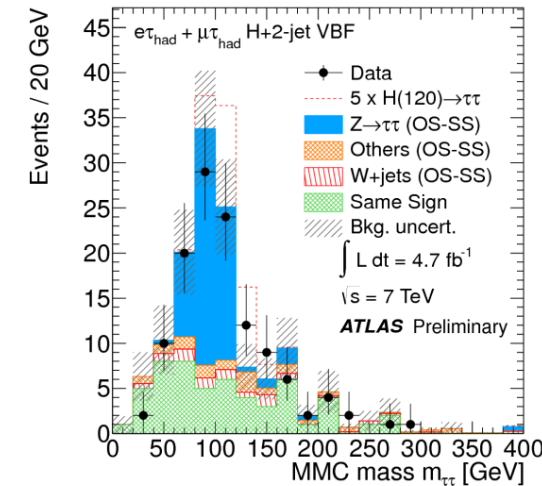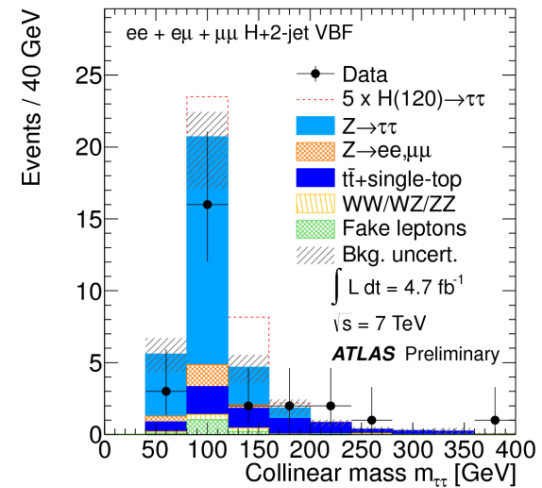
H→ττ
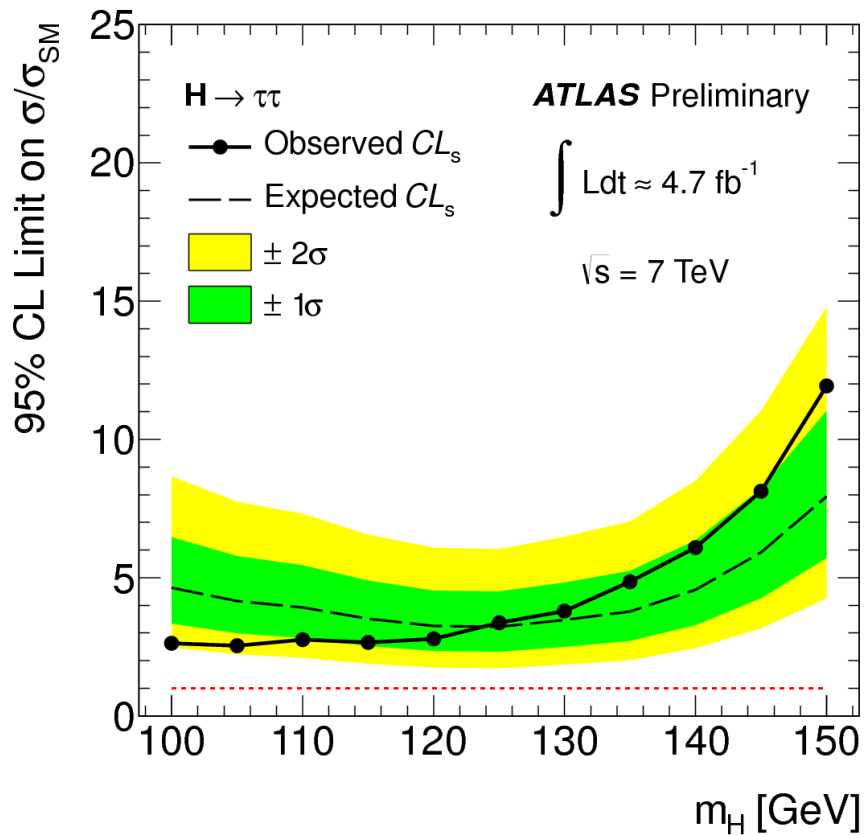
- Most sensitive sub-channels:
    - ll :2-jet VBF
    - lh :2-jet VBF
   - hh :1-jet

- Expected limit between 3.2-7.9 × σ_{SM}
    - Most sensitive at ~126 GeV

- Observed limit ~2.5-11.9×σ_{SM}

H→WW→lνlν

- Search in the region 110 - 600 GeV
  - 3 sub-channels (ee,eμ,μμ) $\otimes$ (0j,1j,2j) = 9 channels
  - H+2 jets includes VBF cuts
- Main Backgrounds: WW, top and W/Z+jets
- Optimized in 3 m_H bins: <200, 200-300 and >300 GeV

Requirement	Background
Two isolated opposite-sign leptons (p_T>20,15 GeV)	W+jets, QCD
MET > 45 (25) GeV 2e , 2μ (eμ) Z veto $|m_{ll}-m_{ZPDG}|$ < 15 GeV .	Drell-Yan/Z+jets
Jet Multiplicity, b-jet veto	top
Topological cuts (m_{ll}, $\Delta\phi_{ll}$).	WW
Additional jet-independent Requirements (pT_{ll}, pT_{tot})	DY/Z
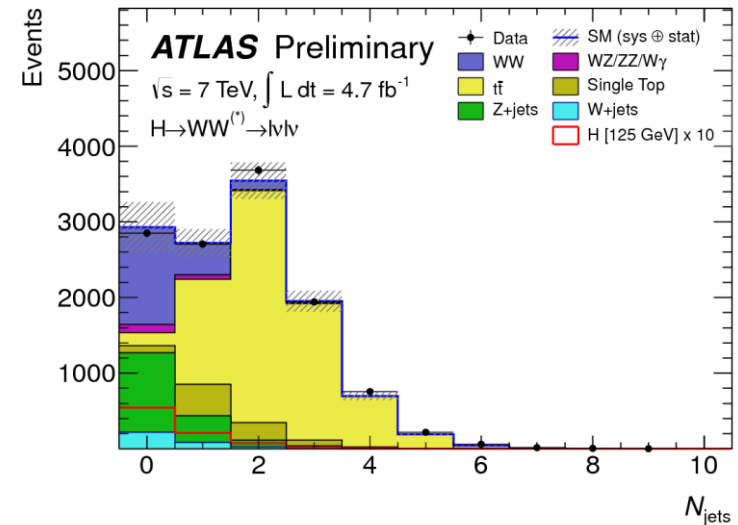
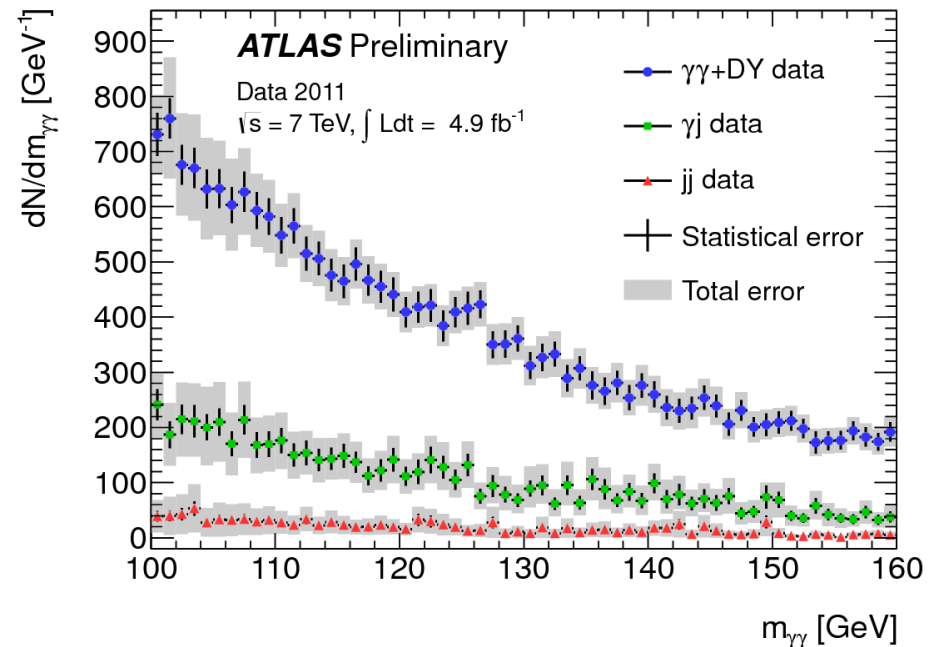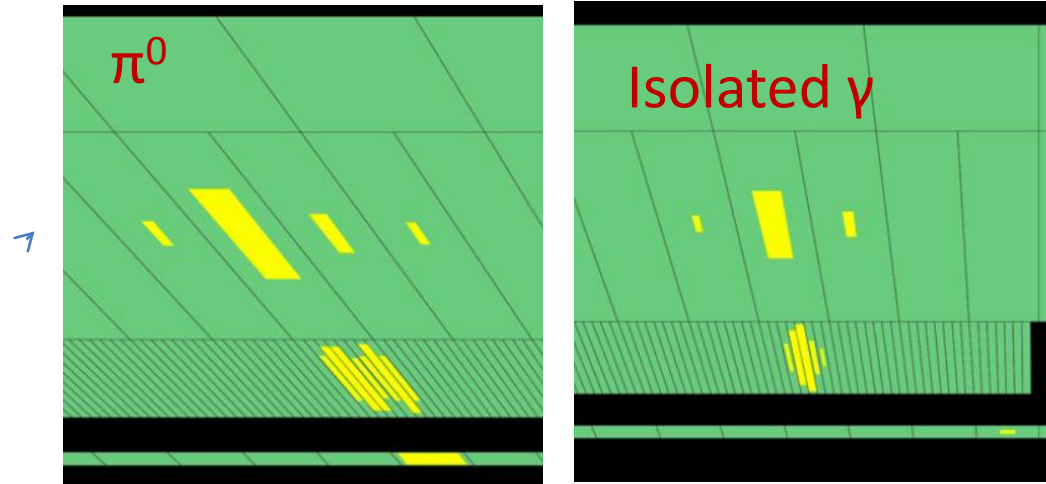Multiplicity of jets with Pt> 25 GeV, after the cut on MET.

H→WW→lνlν
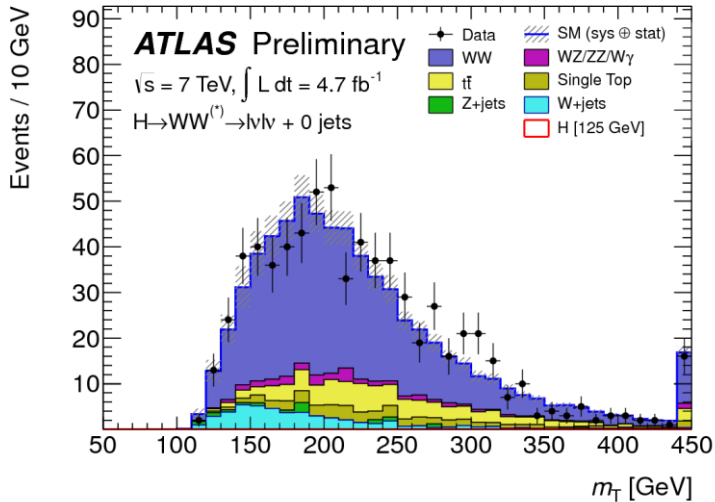
- Most sensitive channel for 130<mH<190 GeV.
- Cut and count approach.
- Expected exclusion: 127 - 234 GeV.
- Observed exclusion: 130 - 260 GeV.
- No excess over the expected background observed.

H→γγ
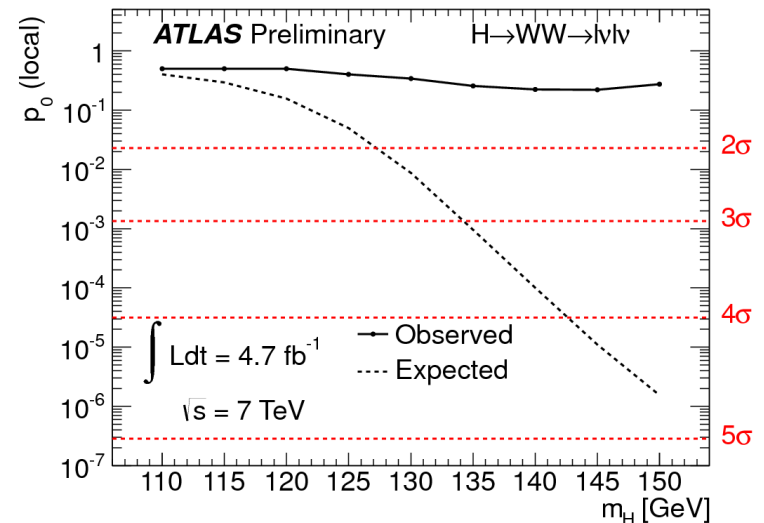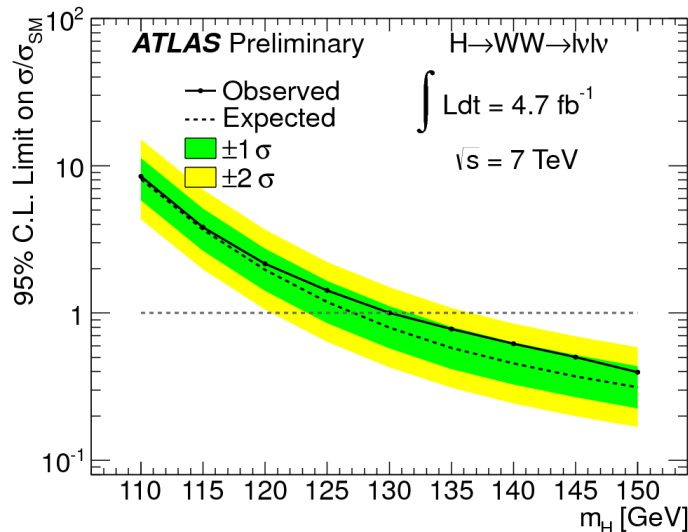
- Most important channel for low mass. Excellent mass resolution.

- Main backgrounds:
  - irreducible γγ (30 pb)
  - reducible γj (200 nb);
  - reducible jj (500 μb).

π^0

Isolated γ

- Powerful /jet separation is crucial. Fine granularity in strips to reject π^0. EM shower shape to reject fake photons from jets → O(8000) jet rejection, for 85% photon efficiency.

ATLAS Preliminary
Data 2011
√s = 7 TeV, ∫ Ldt = 4.9 fb^{-1}

- γγ+DY data
- γj data
- jj data
- Statistical error
- Total error

$dN/dm_{\gamma\gamma}$ [GeV^{-1}]

$m_{\gamma\gamma}$ [GeV]

H→γγ

- Requires excellent energy resolution.
  - Using the longitudinal (and lateral) segmentation of the calorimeter to measure photon direction.
- Two isolated photons $E_T(1) > 40$ GeV, $E_T(2) > 25$ GeV
- Categorize events to optimize signal/background based on:
  - Detector region.
  - conversion status
  - and P_{Tt}

.

Category	CB	FWHM	S/B
Unconverted central, low P_{Tt}	1.4	3.4	0.05
Unconverted central, high P_{Tt}	1.4	3.3	0.11
Unconverted rest, low P_{Tt}	1.7	4.0	0.02
Unconverted rest, high P_{Tt}	1.6	3.9	0.04
Converted central, low P_{Tt}	1.6	3.9	0.03
Converted central, high P_{Tt}	1.5	3.6	0.08
Converted rest, low P_{Tt}	2.0	4.7	0.01
Converted rest, high P_{Tt}	1.9	4.5	0.03
Converted transition	2.3	5.9	0.01
All categories	1.7	4.1	0.02

ATLAS (Simulation)

$H\to\gamma\gamma$
$m_H = 120$ GeV

$\sigma_{CB} = 1.7$ GeV

FWHM = 4.1 GeV
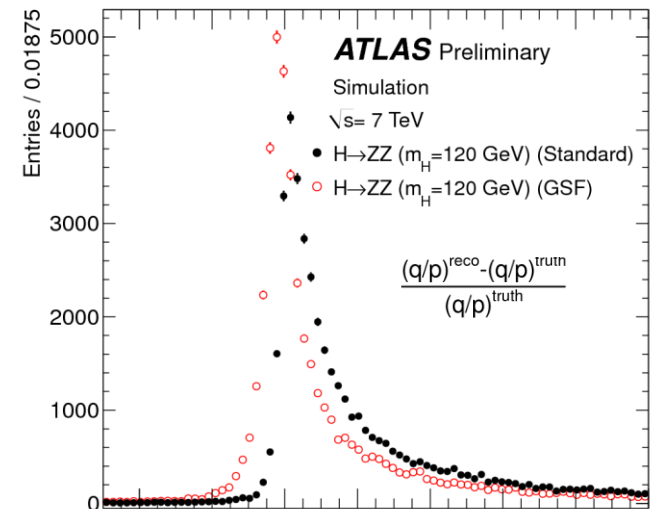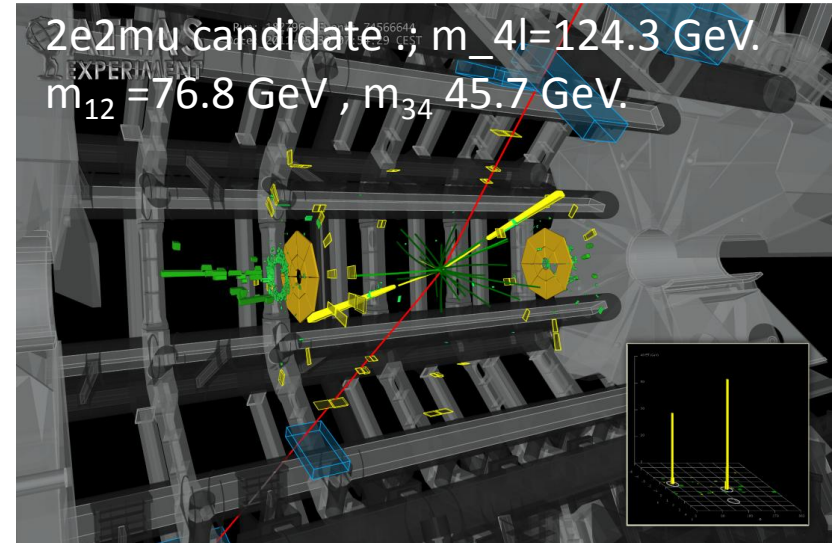
$1/N\ dN/dm_{\gamma\gamma} / 0.5$ GeV

$m_{\gamma\gamma}$ [GeV]

H→γγ
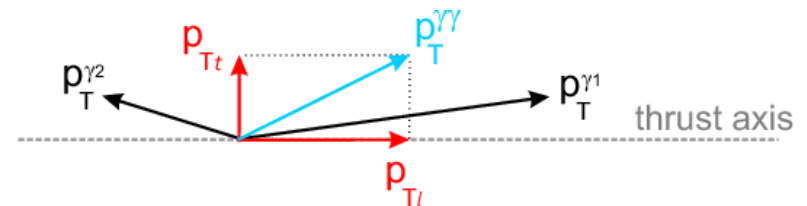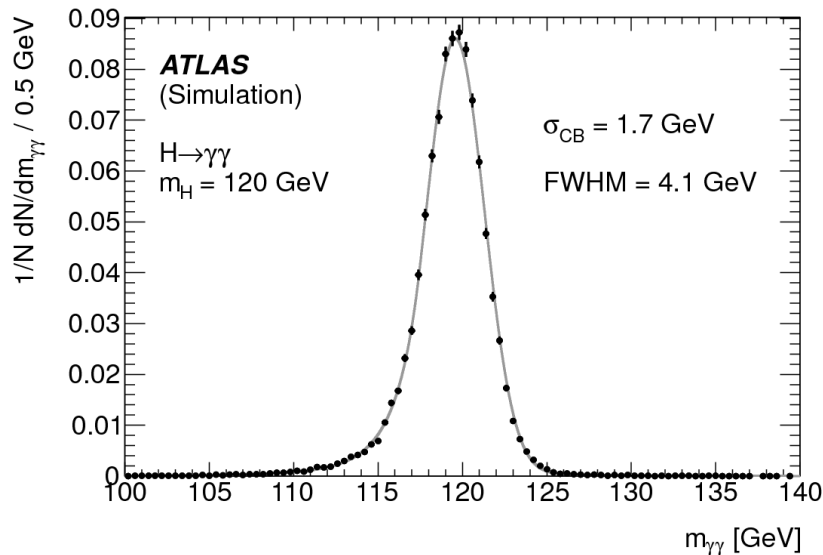
- Background model exponential function
- Signal model parametrized by Crystal Ball + Gaussian
- Expected limit ~1.5-2.5 x σSM between 110 and 150 GeV
- Observed exclusion 113-115 GeV, 134.5-136 GeV
- Largest excess observed at 126.5 GeV
  - Local significance: 2.8σ
  - Global significance: 1.5σ for m_H =110-150 GeV
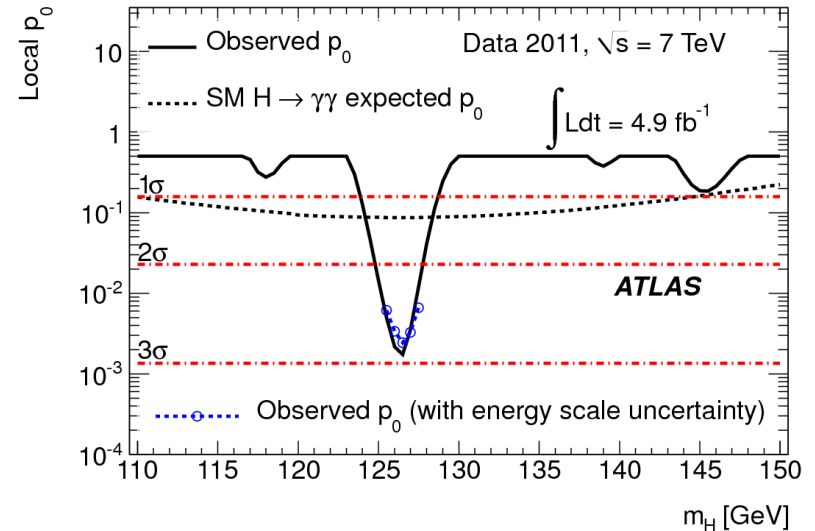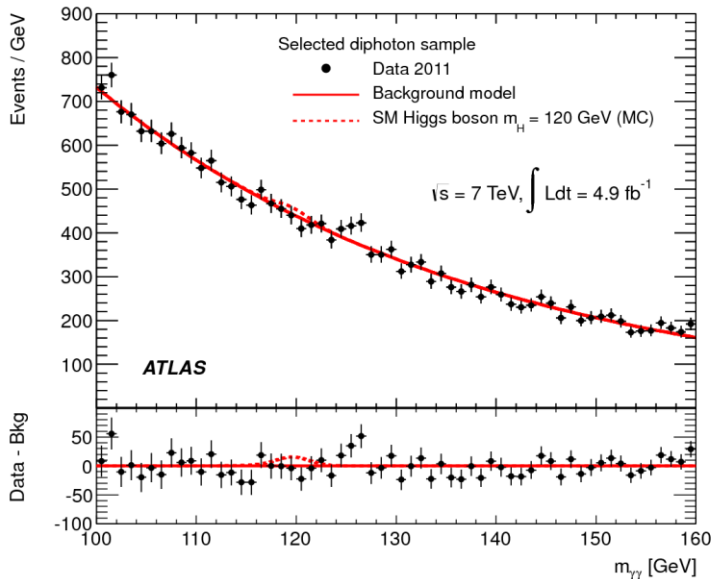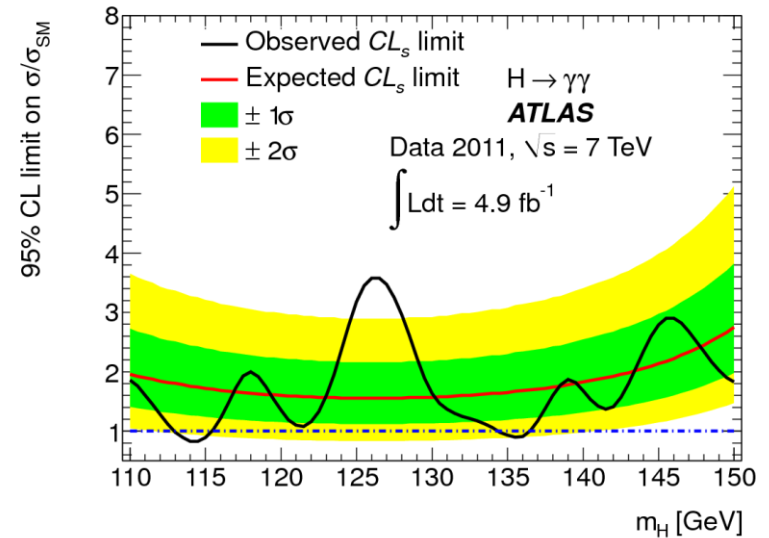
H → ZZ$^{(*)}$ → 4l

- The "golden" channel : clean but small rates.
- Very sensitive to lepton performance!

- Two same-flavour/opposite-charged pairs of isolated leptons :
  - 2 P_t > 20 GeV
  - 2 P_t > 7 GeV
- One/both compatible with Z boson mass
  - $|m_{12}-m_{ZPDG}|$ < 15 GeV.
  - $m_{min}<m_{34}<115$ GeV, where m_{min} is a function of the reconstructed m_{4l}. Example: m_{min}= 15 GeV for m_{4l}=120 GeV.

- Backgrounds:
  - Irreducible SM ZZ$^{(*)}$
  - Reducible Z+jets and ttbar.

2e2mu candidate .; m_4l=124.3 GeV. m_{12}=76.8 GeV , m_{34} 45.7 GeV.

ATLAS Preliminary
Simulation
√s= 7 TeV
◆ H→ZZ (m_H=120 GeV) (Standard)
○ H→ZZ (m_H=120 GeV) (GSF)

$$\frac{(q/p)^{reco}-(q/p)^{trutn}}{(q/p)^{truth}}$$

H → ZZ⁽*⁾ → 4l

- ❏ Normalize ZZ production to MC expectation :
  - ❏ Including both qq/gq→ZZ and gg→ZZ.
  - ❏ Overall theory uncertainty ~15%.

- ❏ Normalize top production to MC expectation :
  - ❏ Verified in eμ control region.
  - ❏ Theory uncertainty 10%.

- ❏ Normalize Z+Jets production using control regions :
  - ❏ Z(→ll) + μμ/ee(→no isolation/impact parameter requirements).
  - ❏ Separate different components (heavy flavor, fakes, electroweak).
  - ❏ Extrapolate to signal region
  - ❏ Uncertainties 40 - 45%.
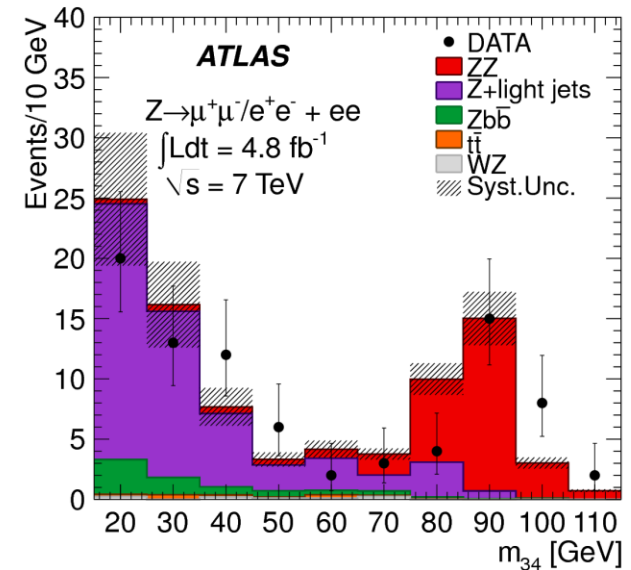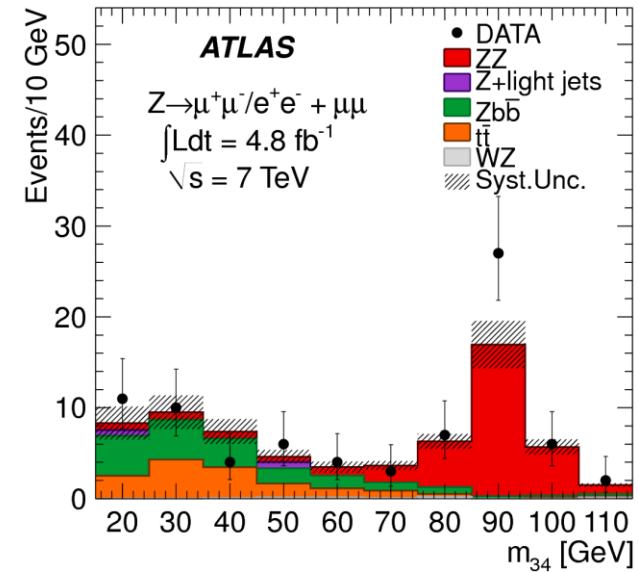
H → ZZ$^{(*)}$ →4l

- Observed 71 events :
  - 24 4μ
  - 30 2e2μ
  - 17 4e
- Expected 62 ± 9 events:
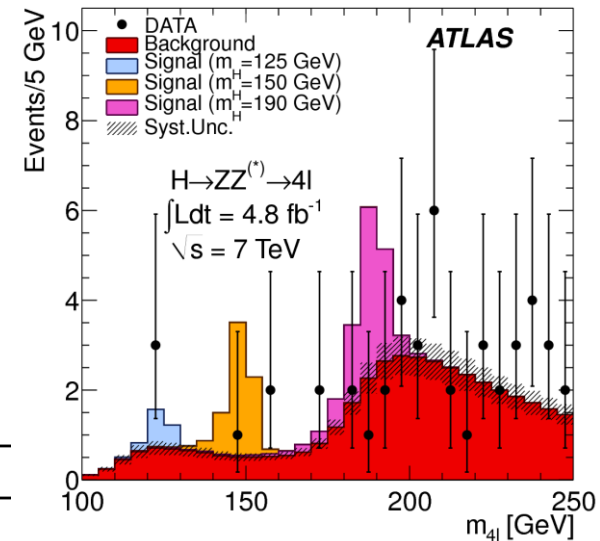 - 18.6 ± 2.8 4μ
  - 29.7 ± 4.5 2e2μ and
  - 13.4 ± 2.0 4e
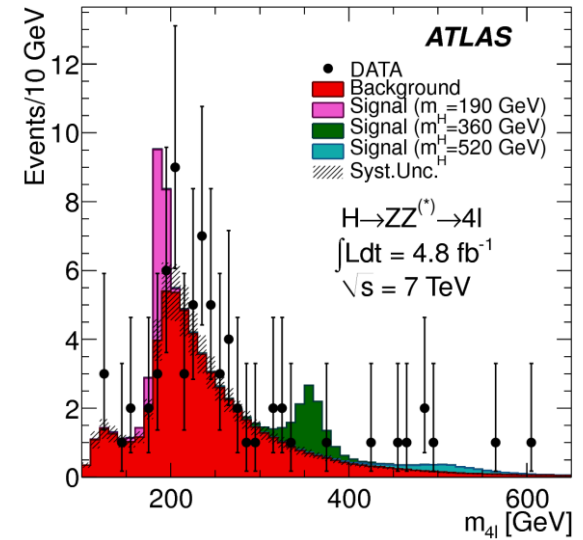- The observed events near m4l=125 GeV are:
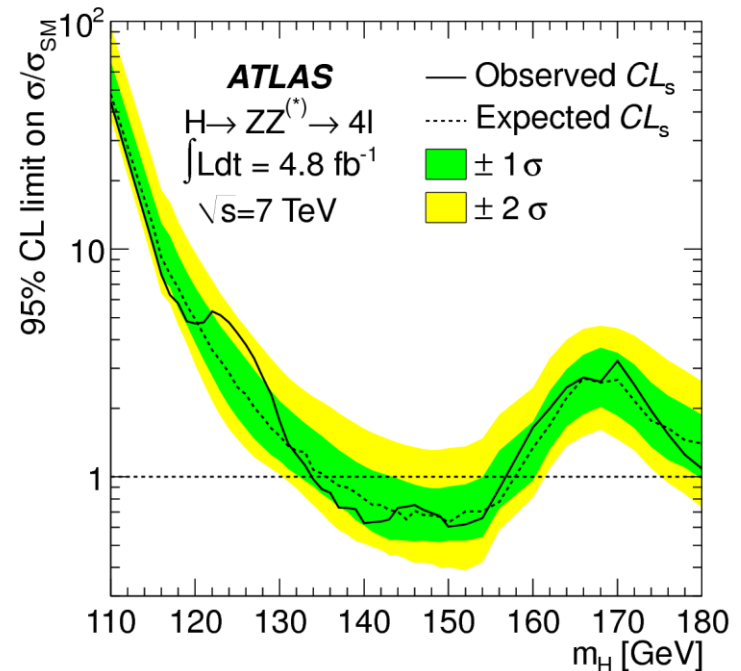 - Two 2e2μ (124.3 GeV, 123.6 GeV)
  - One 4μ 124.6GeV

100 GeV <M$_{4l}$ < 180 GeV

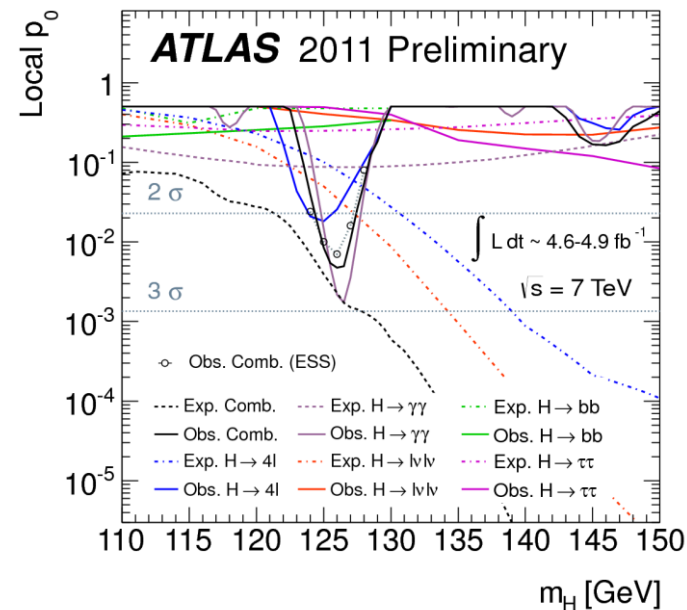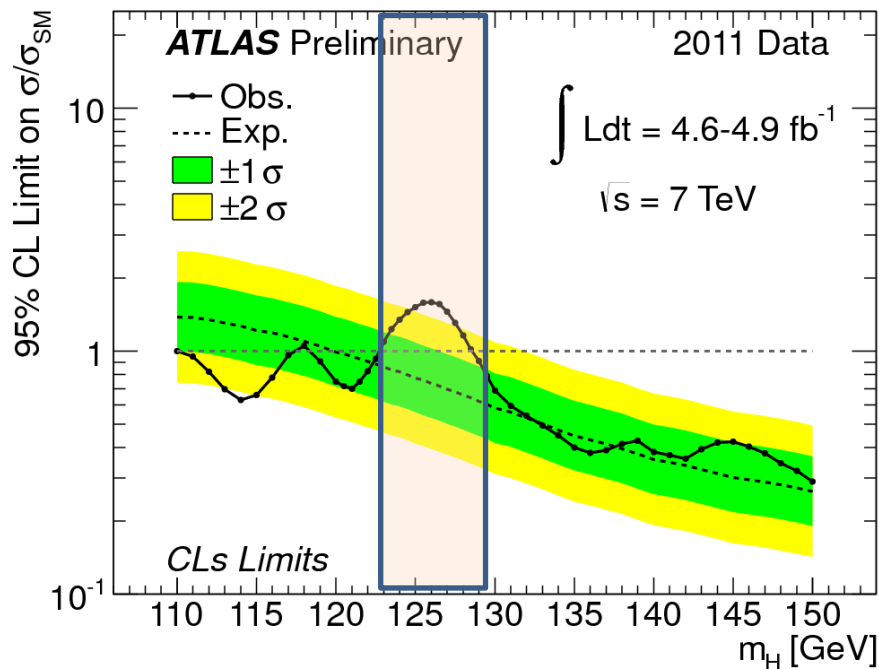|	4μ	$2e2\mu$	$4e$
Total Bkg.	2.2 ± 0.3	4.3 ± 0.8	2.8 ± 0.8
$m_H = 130$ GeV	1.00 ± 0.17	1.22 ± 0.21	0.43 ± 0.08
Data	3	3	2

H → ZZ(*) →4l
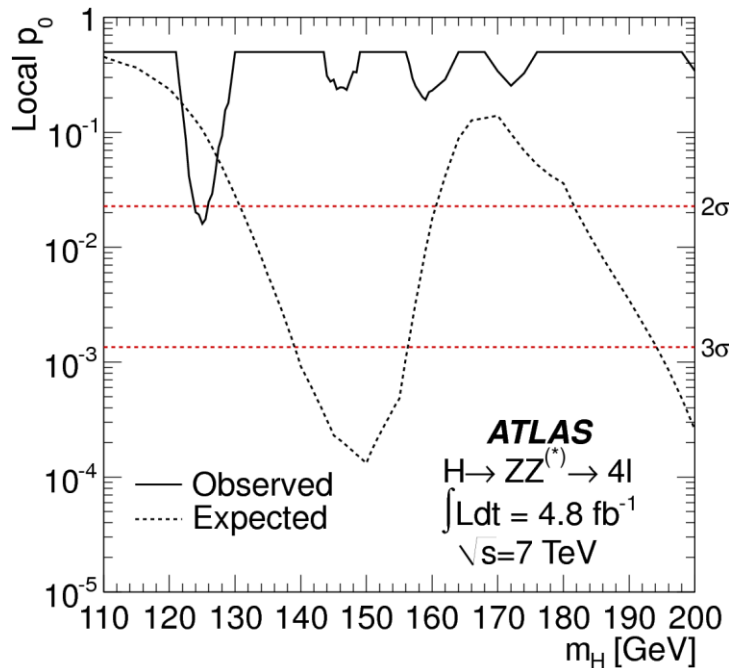
- ❏ Expected exclusion : 137-157, 184-400 GeV.
- ❏ Observed exclusion : 134-156, 182-233, 256-265, 268-415 GeV.
- ❏ Largest excesses at : 244, 125 and 500 GeV.
- ❏ Local significance   : 2.2, 2.1 and 2.1σ
    - ❏ expected   : 3.0, 1.3 and 1.5σ.

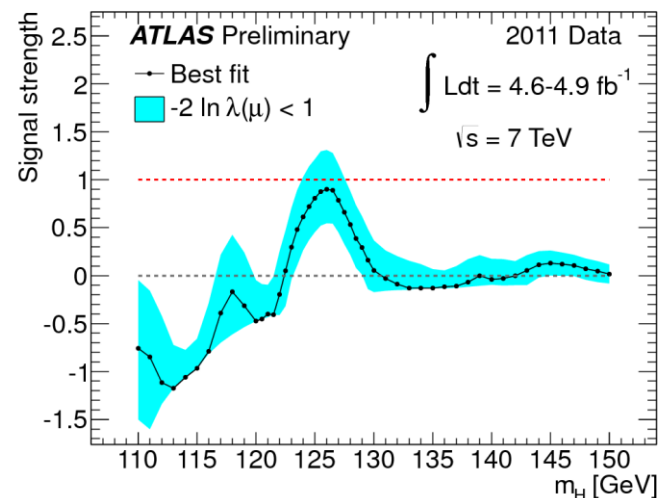- ❏ After including the look-else-where effect non of these is significant.

Overview of searches

❑The observed exclusion at the 95% CL extends from :

    ❑ 110.0 GeV to 117.5 GeV

    ❑ 118.5 GeV to 122.5 GeV and

    ❑ 129 GeV to 539 GeV ranges.

❑ Only a small gap of ~7 GeV not excluded .

❑ 2012 could be exciting!

BACKUP