ATLAS Higgs Results
Update

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LHC Discussion, Dec. 17, 2012

News

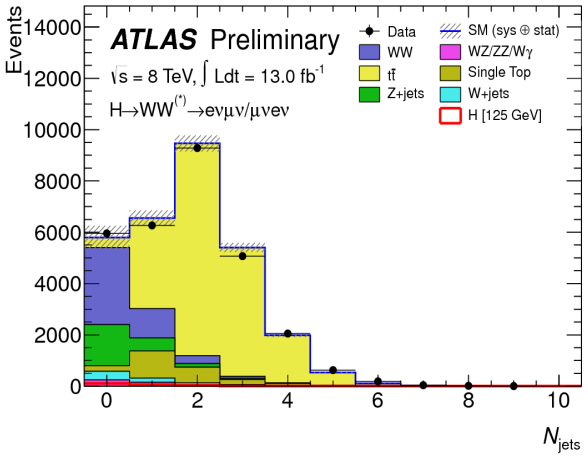
- Fermionic channels update (HCP)
- New $\gamma\gamma$ and 4l results
- Spin/Parity Measurements
- Updated Combination

Atlas HCP Update

- Data:
  - 7TeV 5 fb^{-1} + 8TeV 13 fb^{-1}
- H→WW*→lνlν
  - 8TeV only
- W,Z H→bb reoptimized
  - 7TeV + 8TeV
- H→ττ reoptimized
  - 7TeV + 8TeV
- Couplings (based on observation paper data)

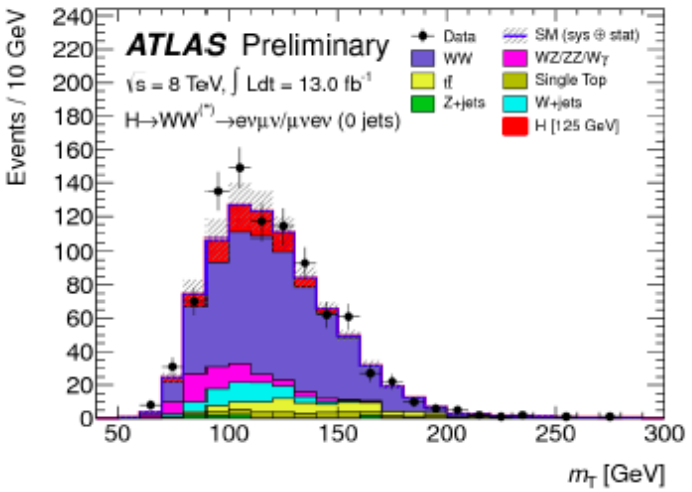
H→WW*→ lνlν

- At least 1 lepton passes single-lepton trigger with 24 GeV threshold
- Exactly 2 OS leptons opposite flavors (eμ or μe).
  - Same flavor has much larger background from Z+jets, suppress W+jets
- Both leptons satisfy track and calorimeter isolation, impact parameter cuts, and tight id
  - P_T > 25 GeV and 15 GeV for the two leptons
- Apply P_T(jet) > 25 GeV for |η|<2.5
  30 GeV for 2.5<|η|<4.5
- Require no b-tagged jet based on MVA tagger
  - 85% efficiency (suppress top)
- Require jet-vertex-fraction greater than 0.5
  - Suppress pileup
- Define 4 categories:
  - eμ and μe (highest P_T 1st)
  - 0-jet and 1-jet
- Signal region requirements:
  - 0-jet category: Δφ(ll, ETmiss) > π/2, PT(ll) > 30 GeV, m(ll) < 50 GeV, Δφ(ll) < 1.8
  - 1-jet category: Z -> ττ veto |mττ – mZ| > 25 GeV, m(ll) < 50 GeV, Δφ(ll) < 1.8

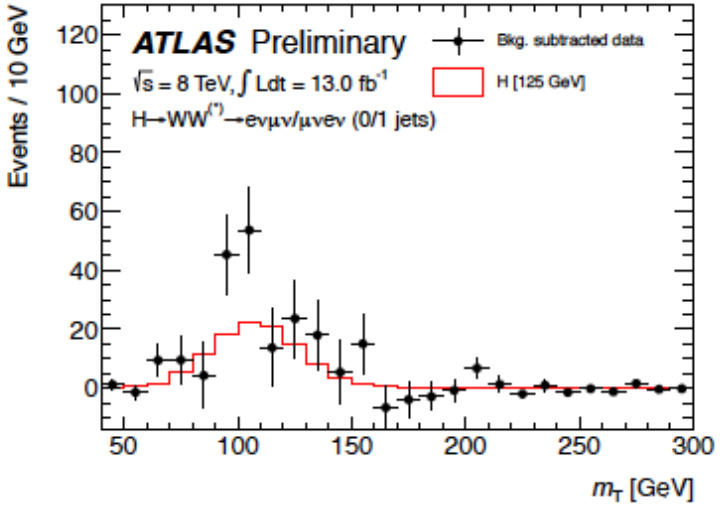


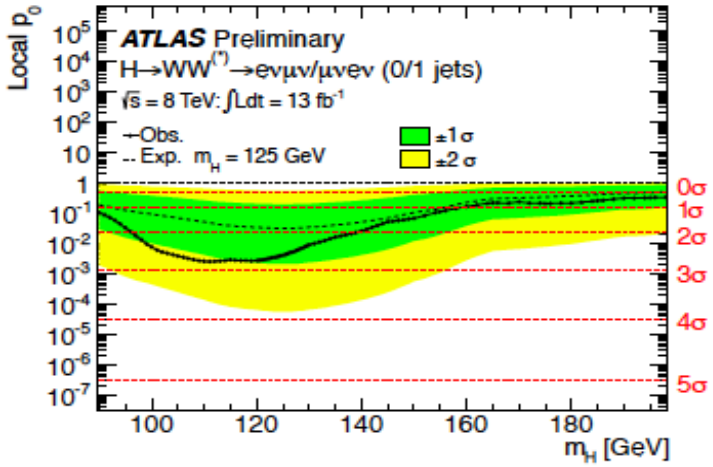
H→WW*→ lvlv

Transverse mass



Background subtracted m_T





μ (125Gev) = 1.5 ± 0.6

Observed Significance (125GeV) = 2.6σ

Expected Significance = 1.9σ

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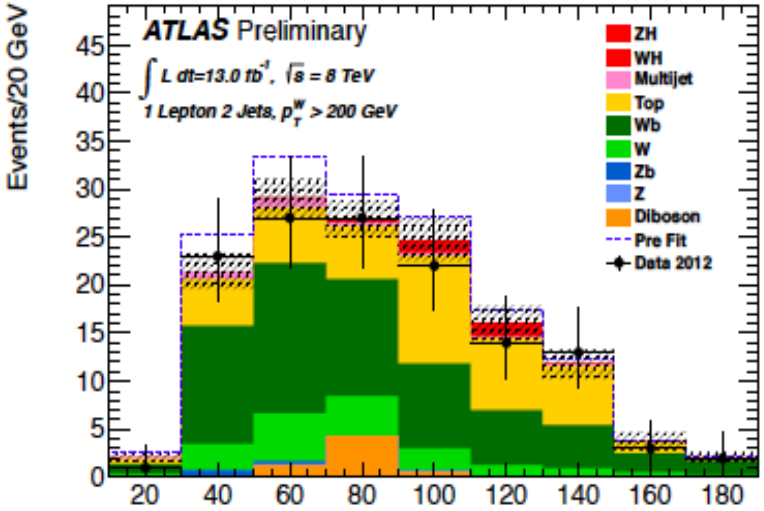
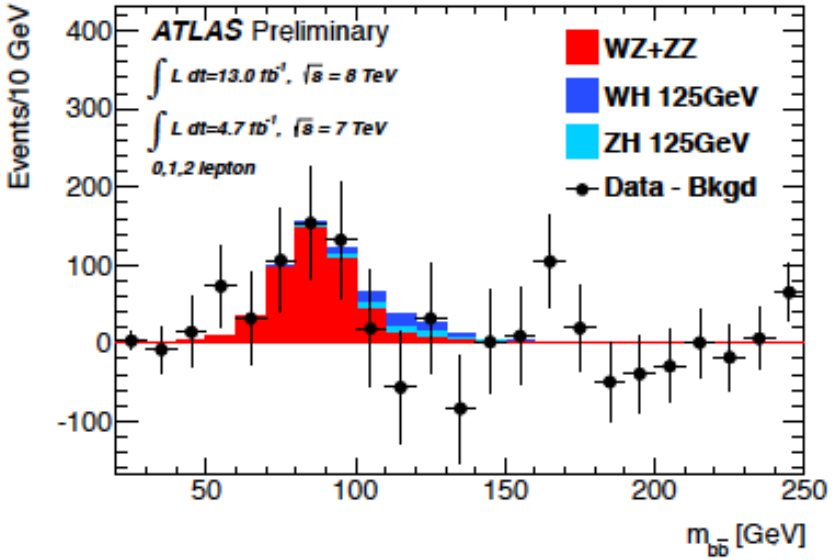
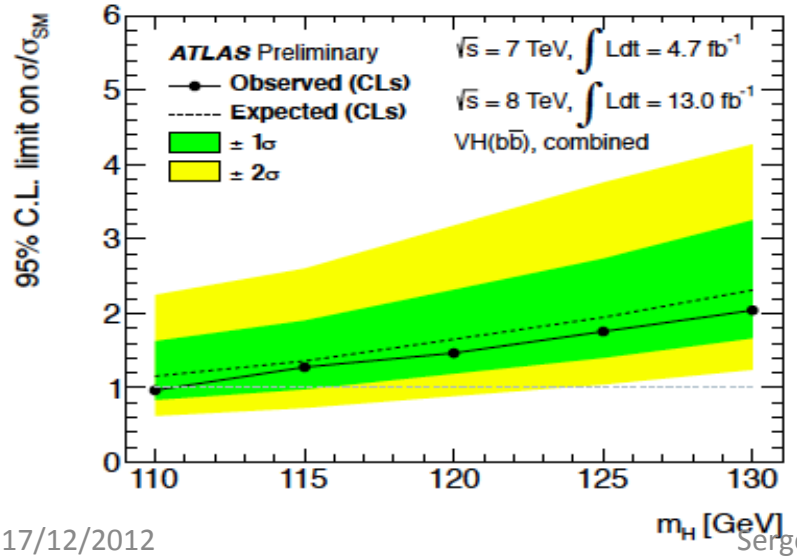
W,Z H→bb

- Require 2 b-tag jets using mva tagger
- 0-lepton channel:
  - Trigger on Etmiss
  - Veto using loose leptons, allow up to one extra jet
  - Etmiss > 120 GeV, Ptmiss > 30 GeV, extra topological cuts
  - Backgrounds: W+jets, Z+jets, Top. All significant
- 1-lepton channel:
  - Require one isolated tight lepton, veto on additional loose leptons, veto on extra jets
  - Require mT < 120 GeV
  - Backgrounds: W+jets and Top. Use MC shape, normalize to data in CRs.
- 2-lepton channel (same flavor):
  - Trigger on single lepton or di-lepton
  - Require one medium, one loose lepton, with 83 < m(ll) < 99 GeV
  - Require Etmiss < 60 GeV
  - Background: Z+jets. Use MC shape, normalize to data in CR

W,Z H→bb







μ (125Gev) = -0.4 ± 0.7 ± 0.8

95% CL (125) = 1.8 (exp 1.9) × SM

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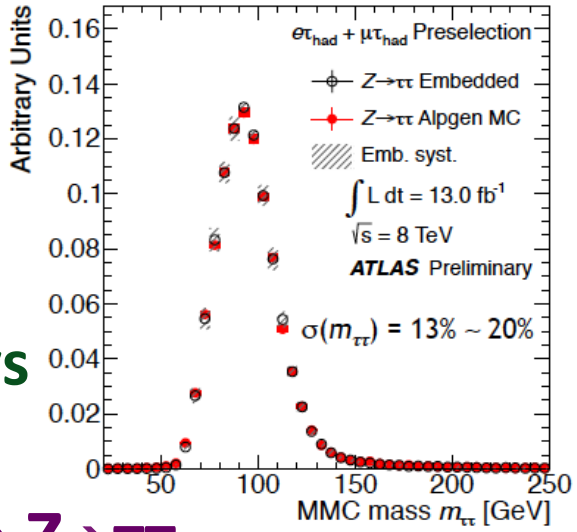
ATLAS-CONF-2012-135 (ttbar+H)

H→ττ

- **Exclusive categories:**
  - **lep-lep, lep-had, had-had and jets 0, 1 (boosted/not boosted), 2 (VBF,VH)**
- **BDT tau-ID**
- **Missing Mass Calculator (MMC) discriminant to estimate $m_{\tau\tau}$**
  - **kinematics consistent with τ decays**
  - **13%-20% resolution**
- **Use data embedding to estimate Z→ττ**
  - **Replace muons in data with simulated taus**
  - **Reduce underlying event systematics**



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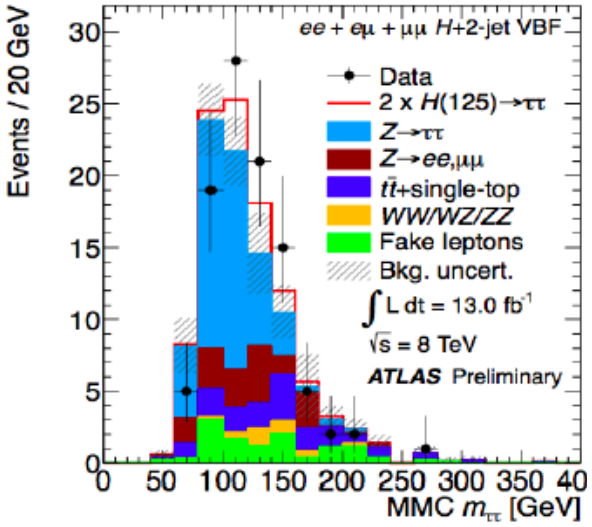
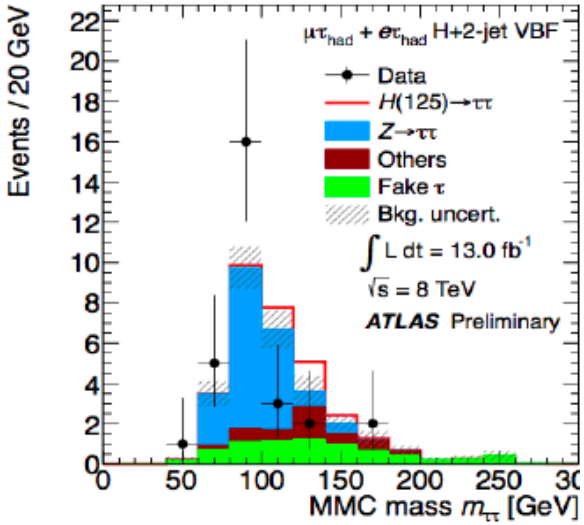
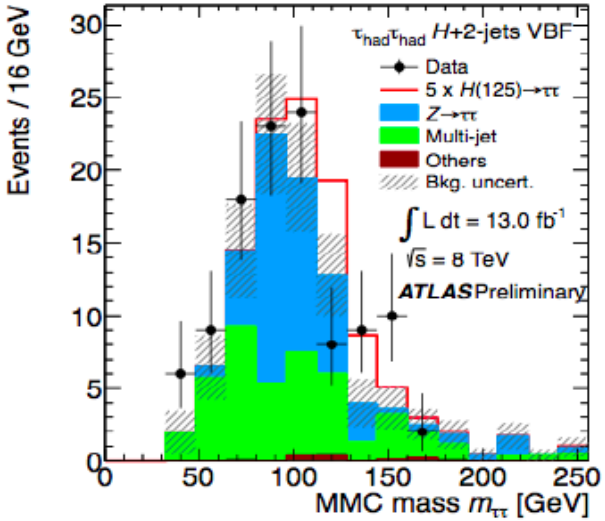
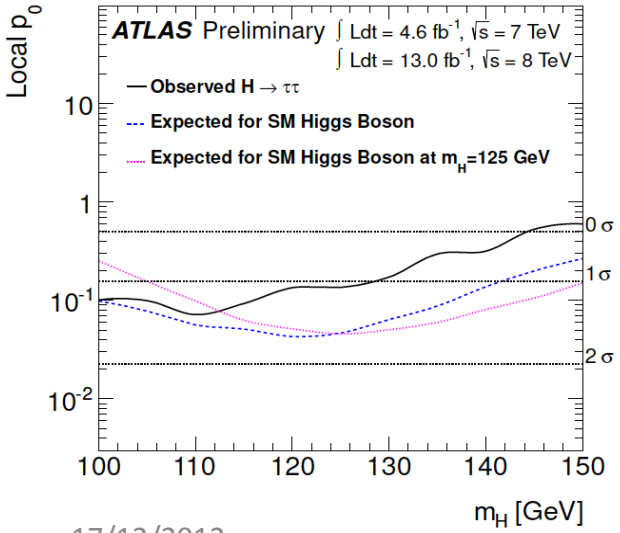
H→ττ









Significance (125GeV): 1.1σ (exp. 1.7σ)

95% CL Limit (125GeV): 1.9 (exp. 1.2)×SM

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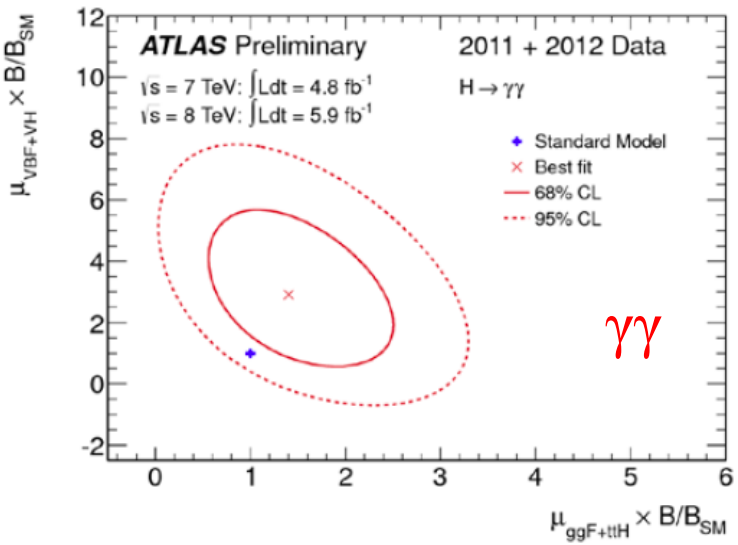
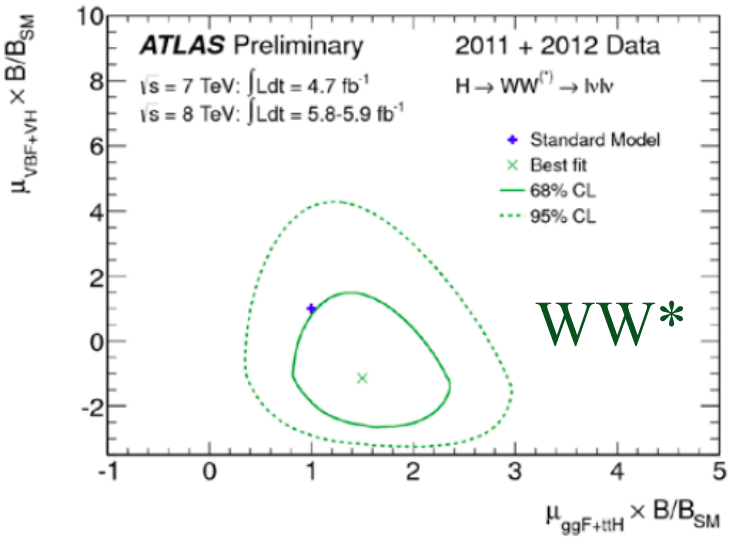
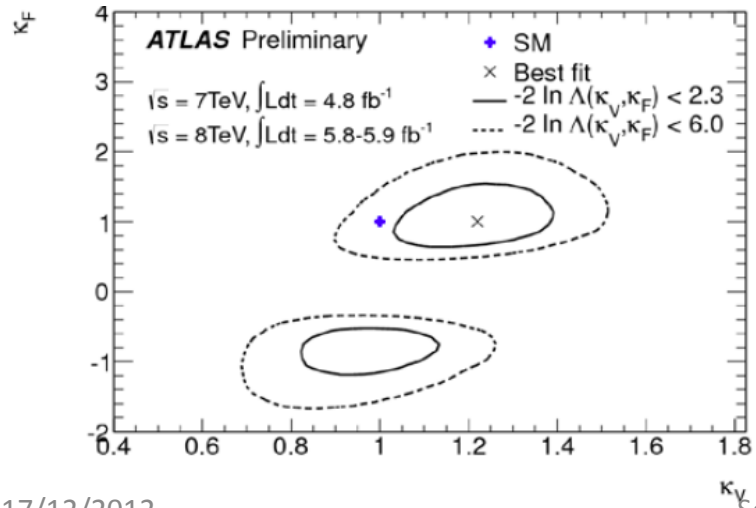
Couplings







Fermionic vs. bosonic couplings

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Latest ATLAS Results

- 1st Updates since the discovery paper for

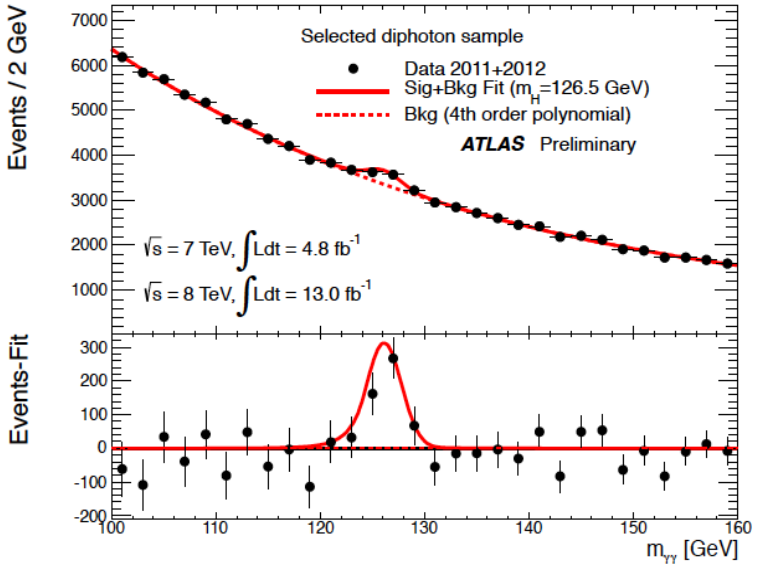
  $H \to \gamma\gamma$ and $H \to ZZ^*$

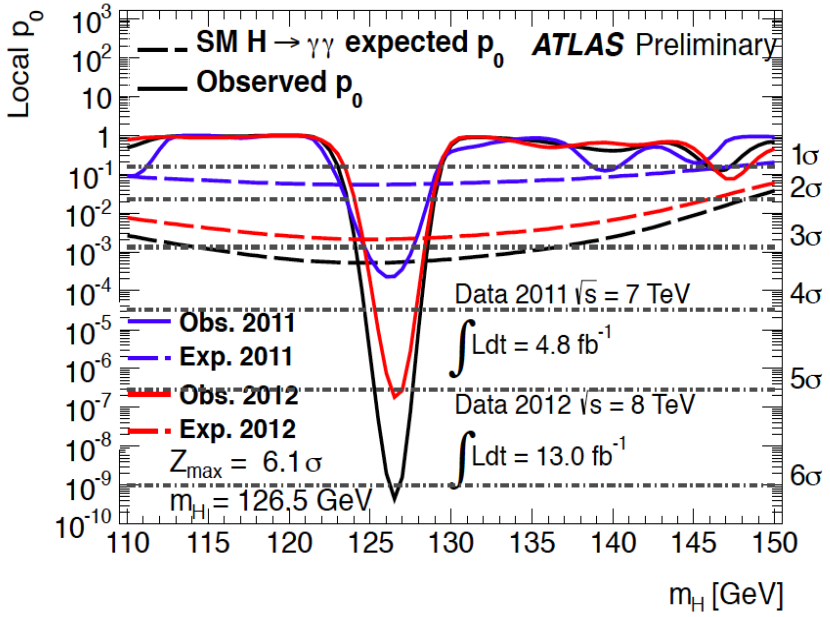
  - New Spin and Parity results
  - Updated combination
  - Presented at the CERN Council Jamboree last Thursday

Updated H→γγ

- 12 exclusive categories:
  - γ rapidity, converted/unconverted, p_{Tt} ($p_T^{\gamma\gamma}$ perp to γγ "thrust" axis)
  - 2 forward jets (mjj 400GeV) targeting VBF
  - NEW: 1 lepton (W/Z/ttH)
  - NEW: Low-mass dijet (60 <mjj< 100) targeting W/ZH
- Main Background: irreducible γγ
  - Composition from data (75% γγ, 22% γj, 3%jj)
- Photon efficiency ~85%

H→γγ Results





Observed Local Significance = 6.1σ
Expected Local Significance = 3.3σ

Single Channel Discovery!

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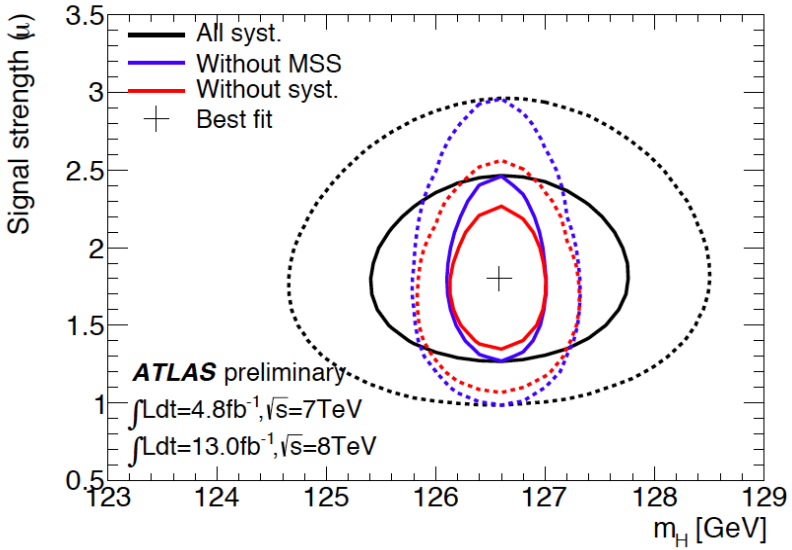
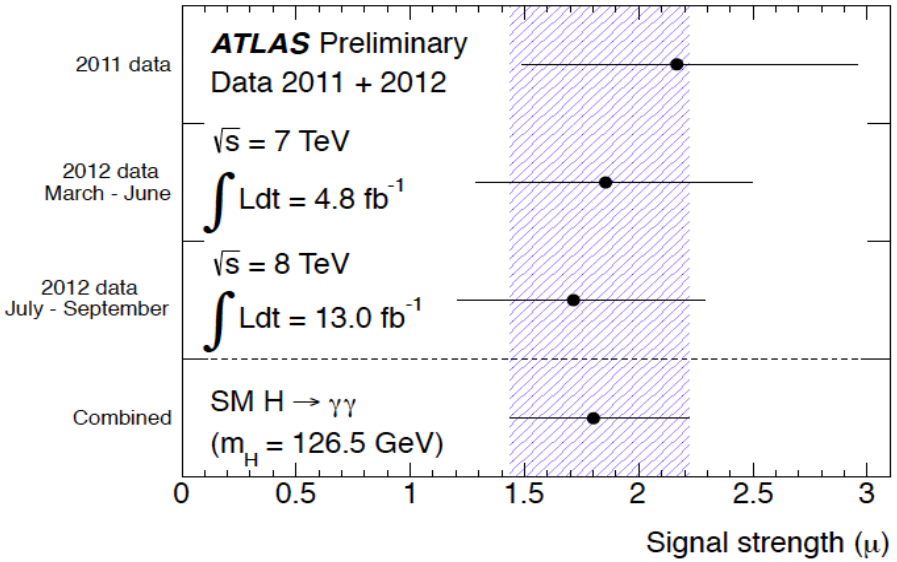
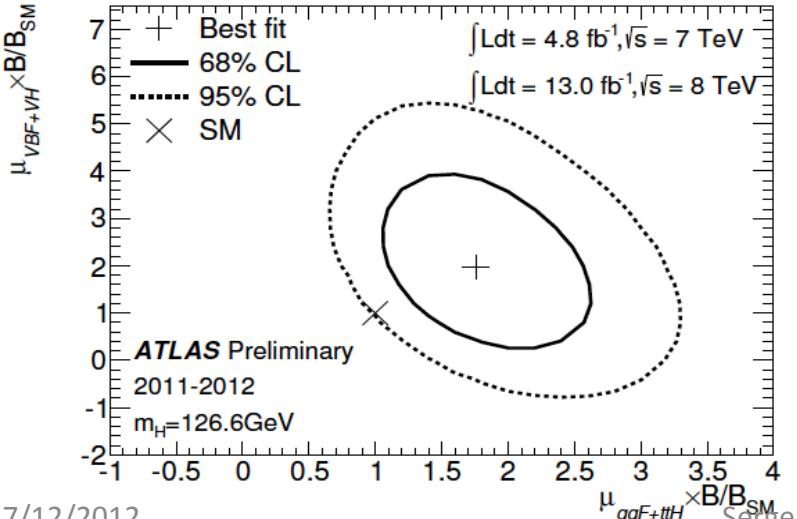
2011: 126GeV 3.5σ (1.6 exp)
2012: 127GeV 5.1σ (2.9 exp)

Mass and Signal Strength







m_H = 126.6±0.3(stat)±0.7(syst) GeV

$$\hat{\mu} = 1.8 \pm 0.3\ (stat)^{+0.29}_{-0.21}\ (syst)$$

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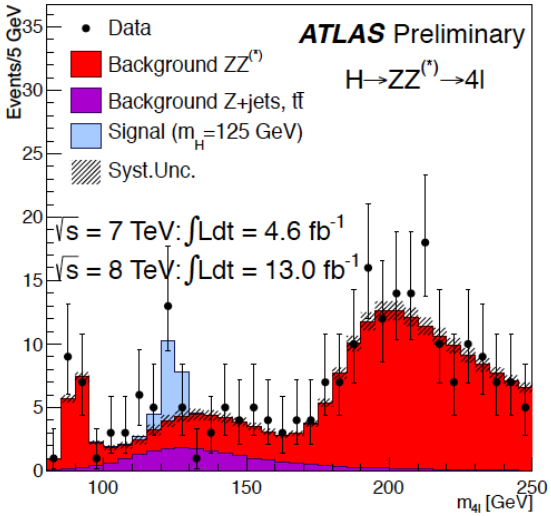
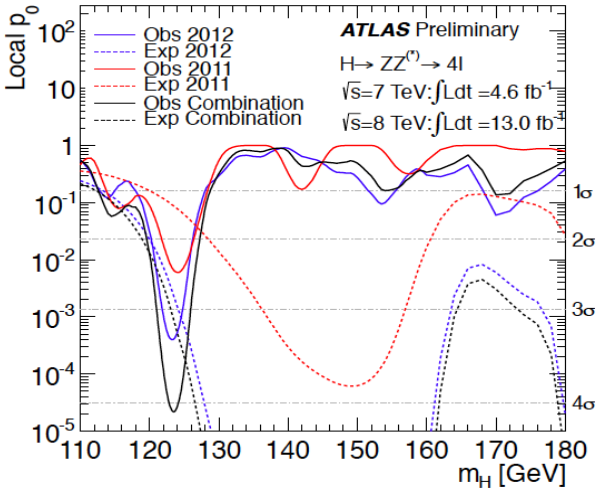
H→ZZ*→4l

- **Selection:**
  - 4 leptons $p_T^{1,2,3,4} > 20,15,10,6$ GeV
  - $50 < m_{12} < 106$ GeV
  - $m_{34} > 17.5$ GeV
- **In the signal region 125 ± 5GeV**
  - Observed: 18 events
  - Expected bnd: 8.3 ± 0.3
  - SM Higgs: 9.9 ± 1.3
- **Observed Local Significance: 4.1σ**
- **Expected Local Significance: 3.1σ**
  - 2011 124.1 GeV 2.5σ (exp. 1.4σ)
  - 2012 123.3 GeV 3.4σ (exp. 2.8σ)





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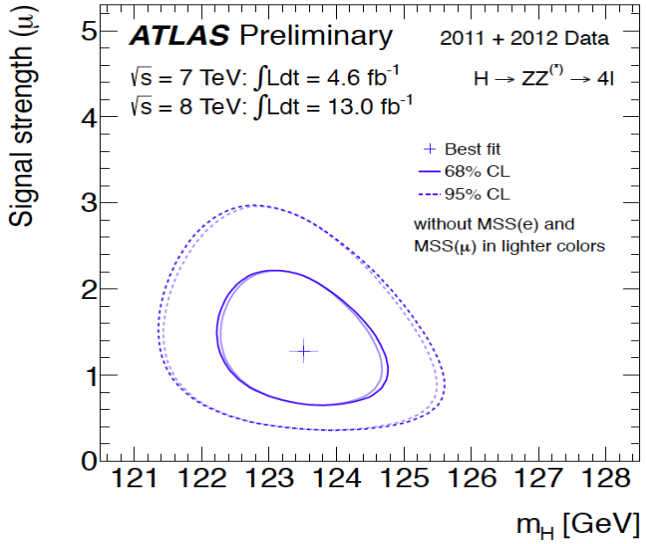
Mass and Signal Strength



$$m_H = 123.5 \pm 0.9\ (stat)\ ^{+0.4}_{-0.2}\ (syst)\ \text{GeV}$$

$$\hat{\mu} = 1.3 \pm 0.4$$

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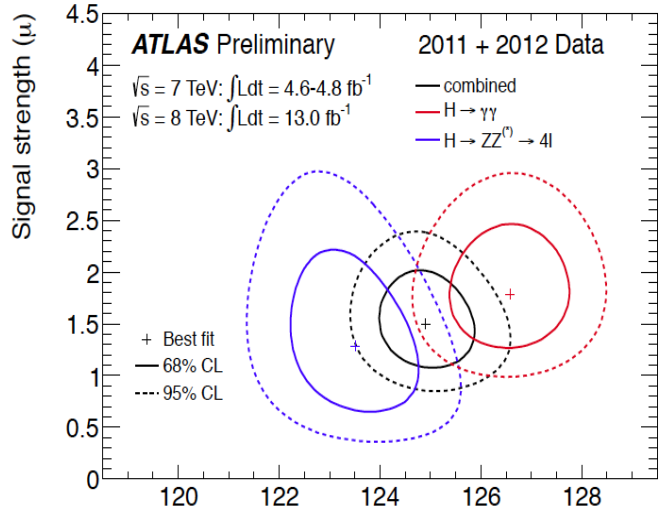

Combined γγ and 4l:
m_H = 125.2±0.3(stat)±0.6(syst) GeV

Best fit signal strength $\hat{\mu} = 1.5^{+0.33}_{-0.29}$

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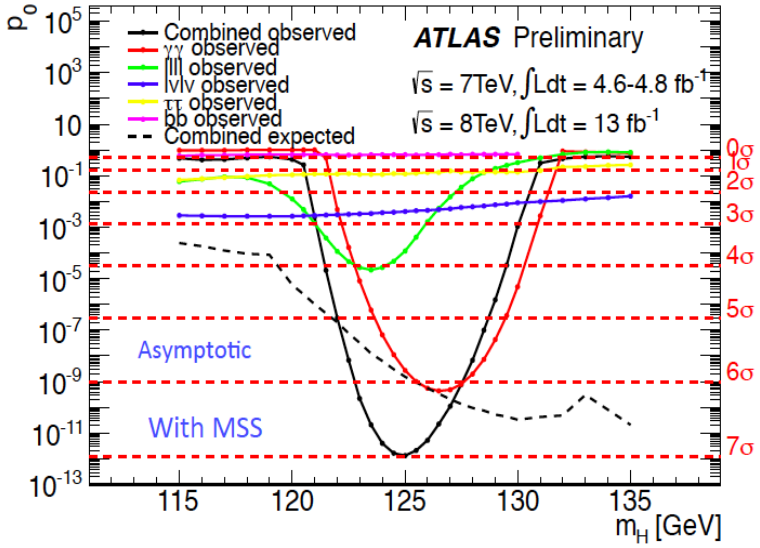
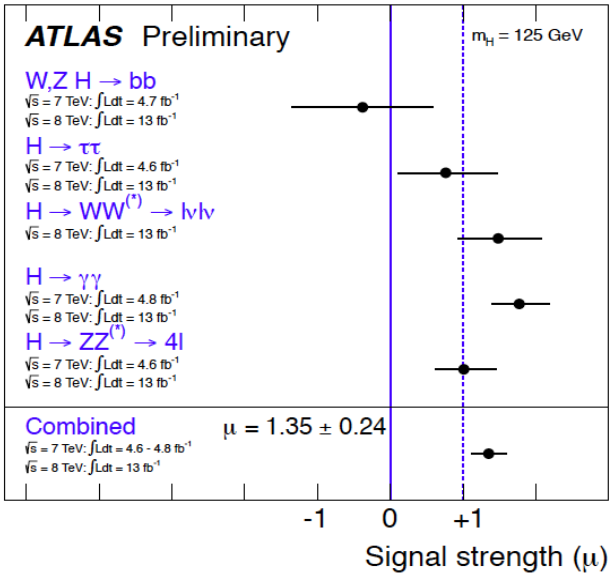
Combination All-Channels





Observed Local Significance

with mass scale syst.: 7.0σ

no mass scale syst.: 6.6σ

Expected Local Significance: 5.9σ

$$\hat{\mu} = 1.35 \pm 0.19\ (stat) \pm 0.15\ (syst)$$

Overall agreement w. SM Higgs Hypothesis

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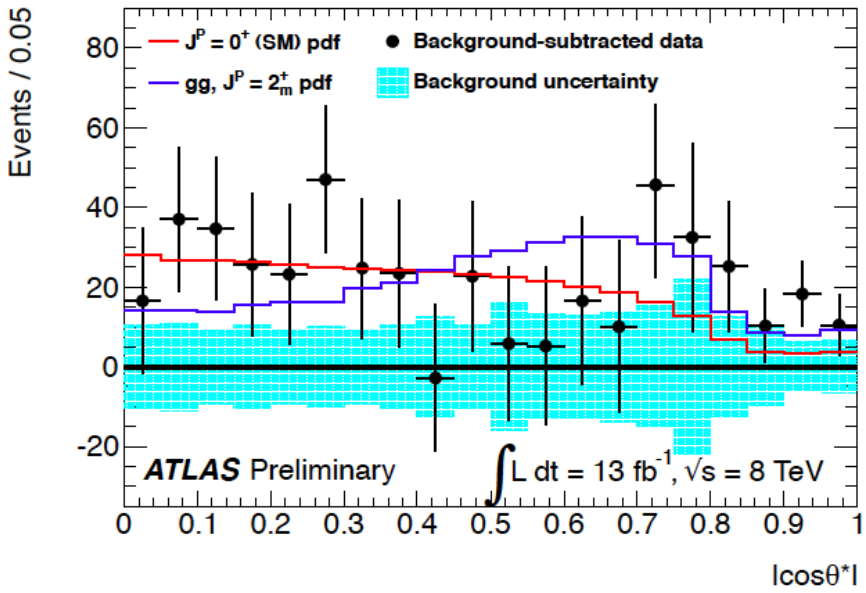
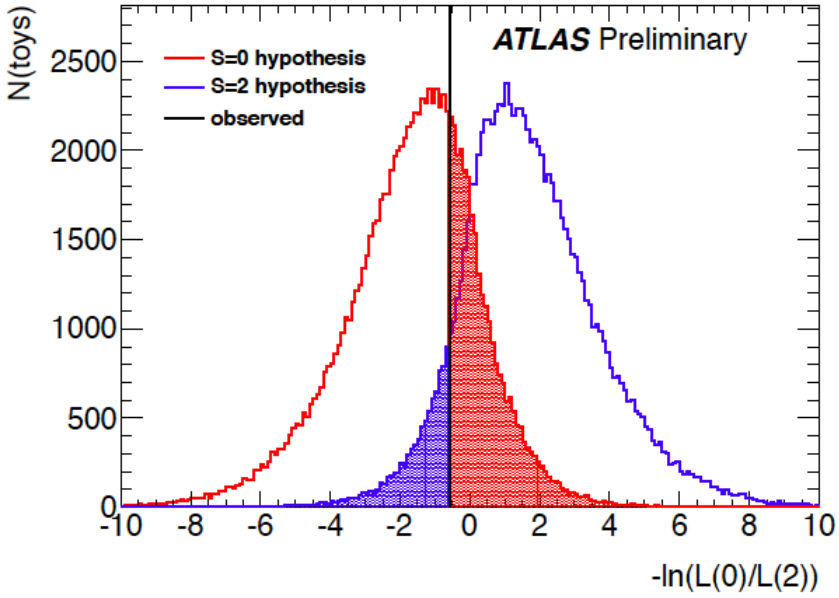
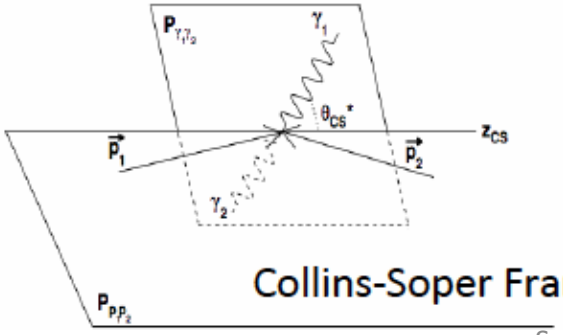
H→γγ spin





Use cos θ* in Collins-Soper Frame



Observed exclusion of spin 2^+ at 91% CL

Spin 0 compatible within 0.5σ

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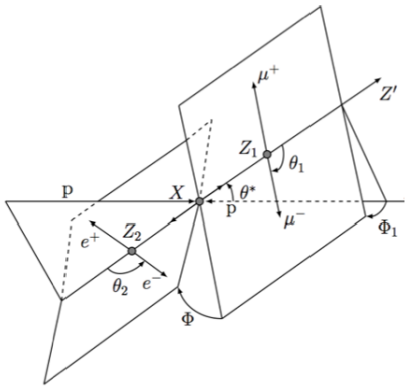
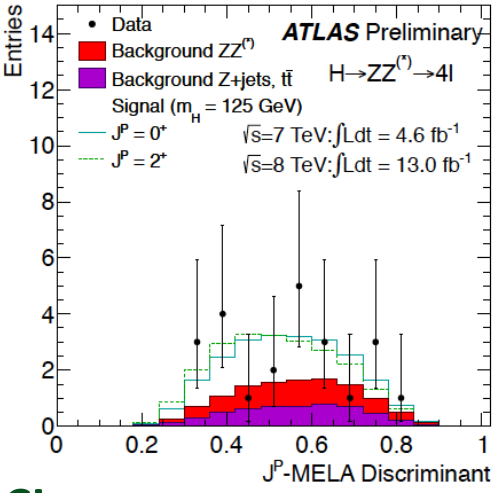
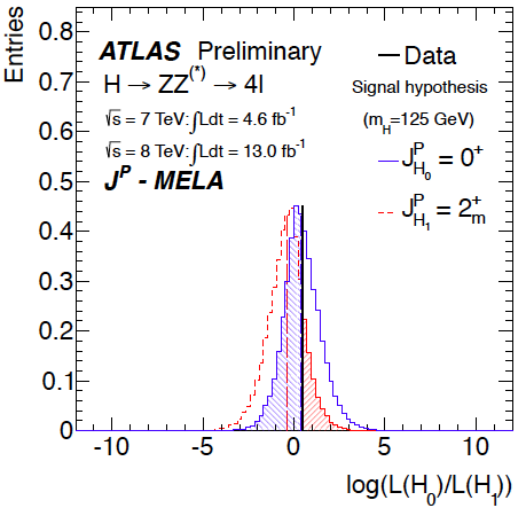
H→ZZ* Spin+Parity

- Combine angles in BDT or MELA

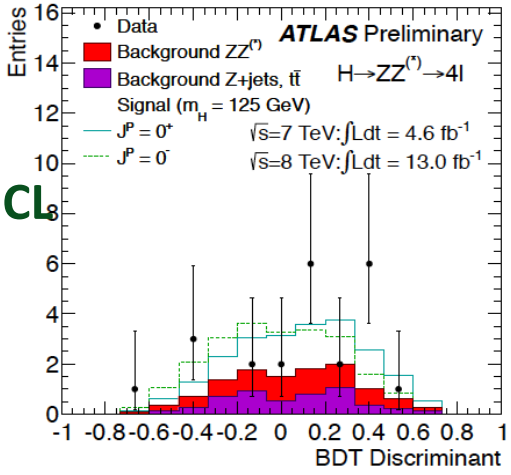


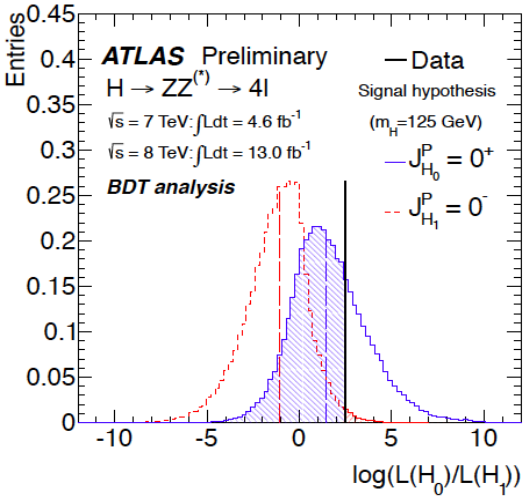




- Observed exclusion of 2^+ at 85% CL
- Spin 0 compatible within 0.18σ

- Observed exclusion of 0^- at 99% CL
- Spin 0 comaptible within 0.5σ





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Conclusions

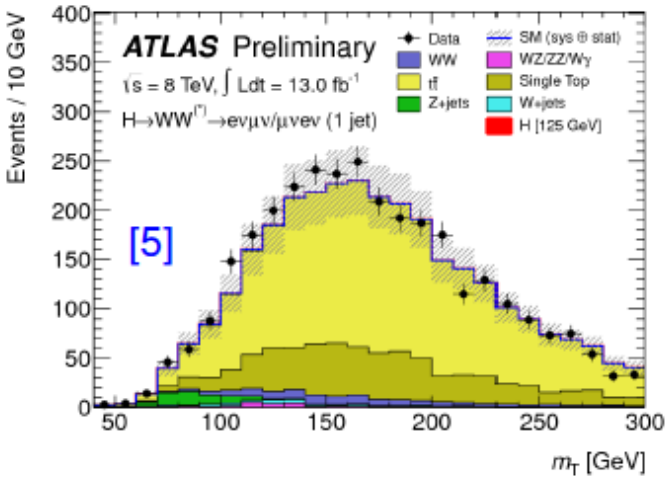
- Higgs signal confirmed
- Latest updates in $\gamma\gamma$ and 4l channels
- Cross-checks in progress
- New spin and parity measurements
- New all-channel combination
- Next significant update: Moriond

Backup

H→WW*→ lνlν

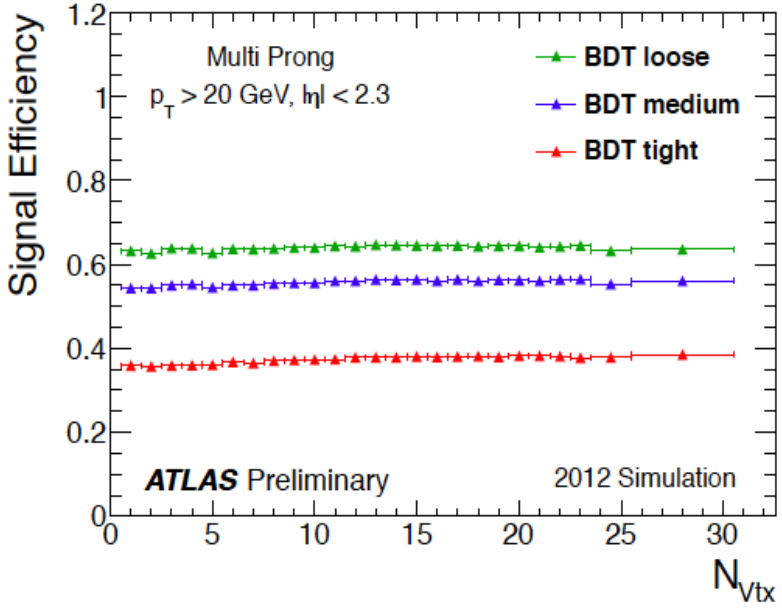
Control of large backgrounds crucial: suppressed by selection and measured in data control regions

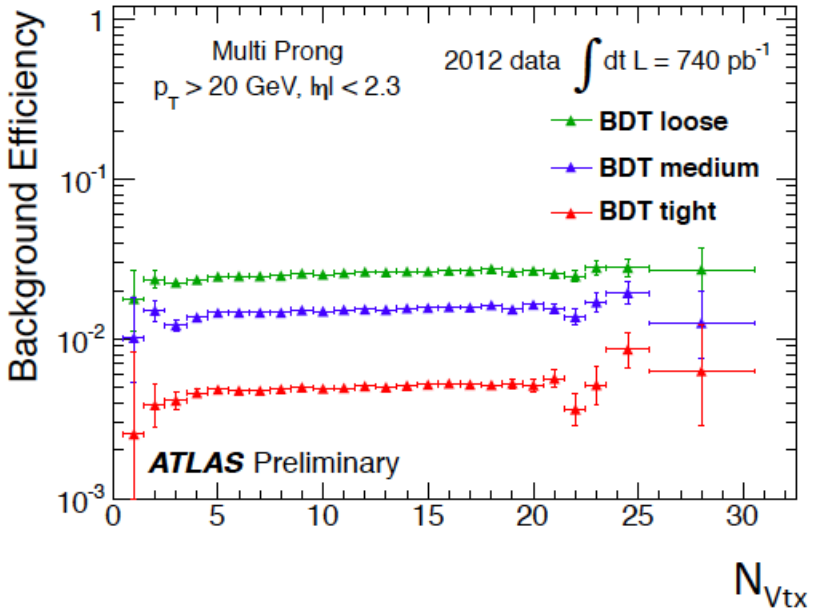
- SM WW suppressed by topological cuts ($m_{\ell\ell}$, $\Delta\phi_{\ell\ell}$, m_T). For low m_H constrained from signal free region with modified topological selection.
- W+jets suppressed by lepton selection (isolated, opposite sign). Estimated from region enriched in fake leptons.
- Drell-Yan suppressed by large E_T^{miss}, Z veto. Estimated from Z peak.
- top suppressed by b-jet veto and controlled by categorization into jet bins. Estimated from b-tagged events.



Tau BDT Efficiency

Tau BDT reconstruction efficiencies versus number of vertices





Normalization Systematics

Theory (PDF, scales, a_s)	~12% (overall)
g Efficiency	5.3%
Background Model	~3%
Luminosity	3.9% and 3.6%
Trigger	0.5%
Isolation	1%
Energy Scale	0.5%
JES	4% - 19% (HM 2-jets)
pTt Modeling	0.8%
Material mis-modeling	~4%
UEPS	7% - 30% (LM HM 2-jets)
Leptons	~2%

$H \rightarrow \gamma\gamma$

Mass Scale Systematics

Main Mass Scale systematic uncertainties (considered in also ICHEP studies) :

Source	Relative Mass Scale Effect
Absolute Energy scale calibration from Z	0.3%
Upstream material simulation inaccuracies	0.3%
Pre-Sampler energy scale	0.1%

Further investigation and extensive checks lead to find additional sources of systematic uncertainties :

- LAr Strips relative calibration (0.2%)
- Photon energy resolution (0.15%)
- Calibration of the high gain (0.15%)
- Mis-classification due to fake conversions (0.13%)
- Backgound modeling (0.1%)
- Lateral shower development simulation (0.1%)
- Effect of PV choice (0.03%)

→

Main 4l Mass Scale systematic uncertainties :

Source	Relative Mass Scale Effect
Absolute Energy scale calibration from Z	0.4%
Low transverse energy electrons	0.2%
Muon momentum scale	0.2%

Further investigation and extensive checks have not lead to additional substantial sources of systematic uncertainty :

- Measurement with MS and ID alone
- Local detector biases checked event by event
- Local resolution effects checked using event-by-event error;
- kinematic distributions in agreement with expectation
- FSR simulation
- Different mass reconstruction using Z-mass constraint (+400 MeV shift)

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