Measurement of Higgs boson couplings and properties in the diphoton, ZZ and WW decay channels using the ATLAS detector

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EUROPEAN PHYSICAL SOCIETY EPS HEP2017

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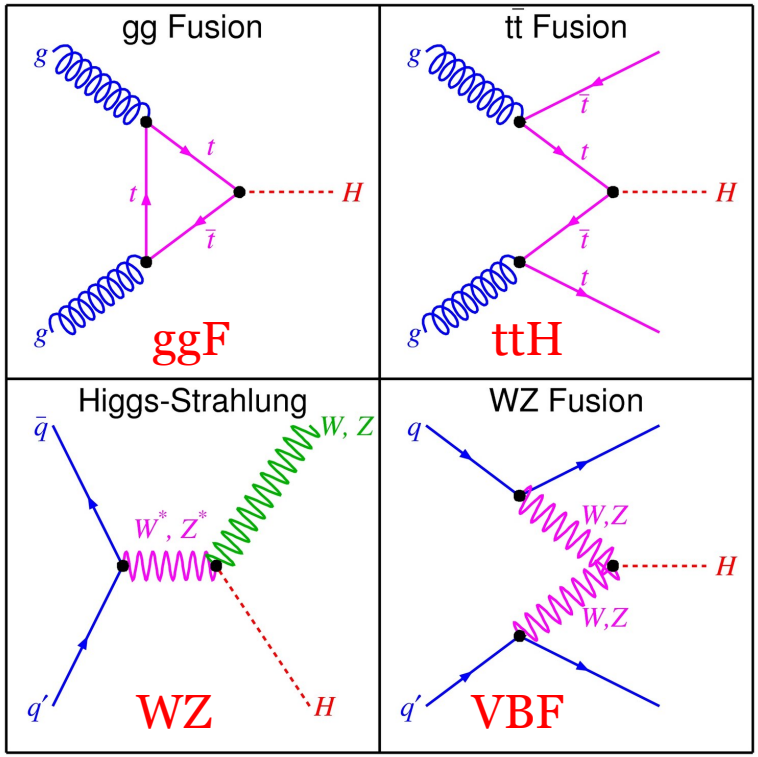
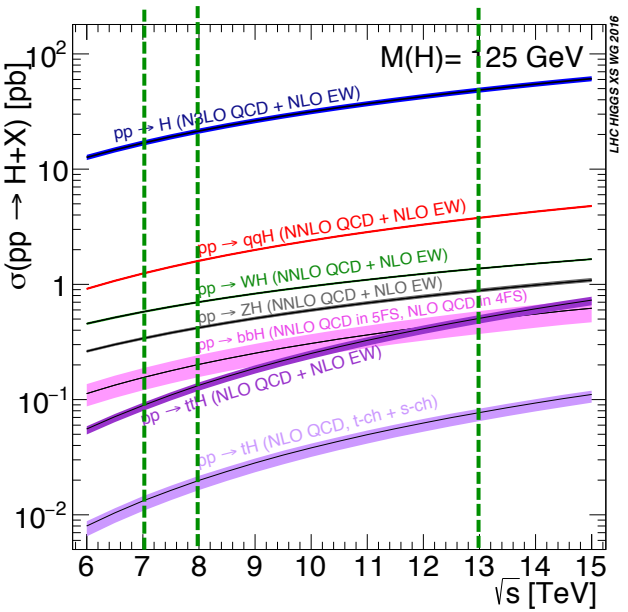
Higgs Production at LHC

- ggF : Gluon Gluon fusion, the dominant production mode.
- VBF : Vector Boson Fusion, the second most dominant production mode characterized by two forward jets produced along with higgs.
- VH : composed higgs produced in association with a vector boson.
- ttH : Higgs produced in association with ttbar pair.

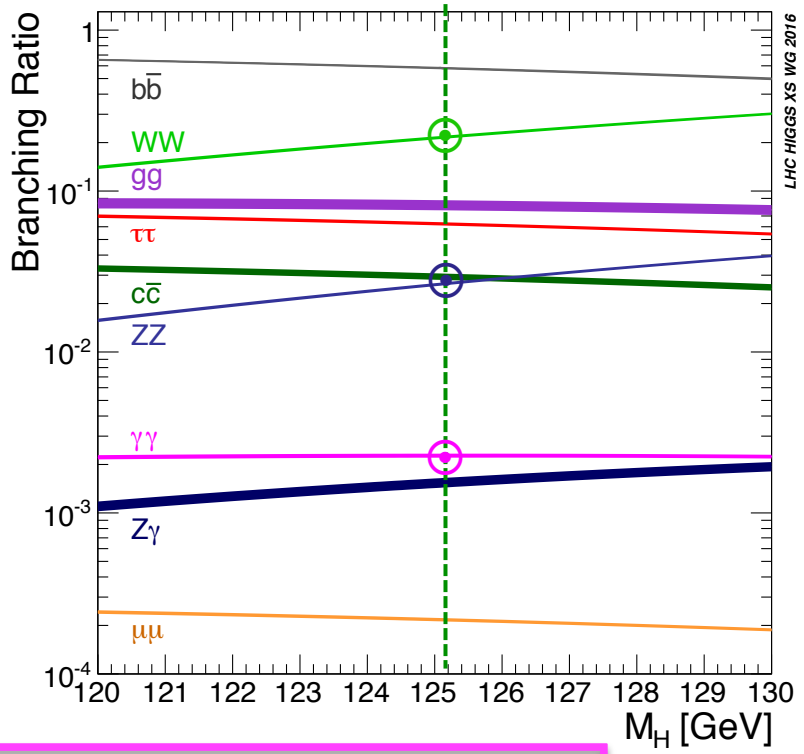


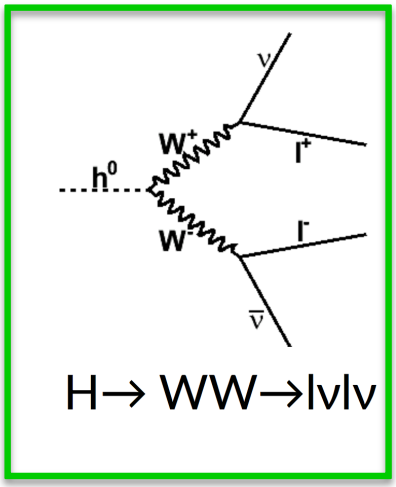


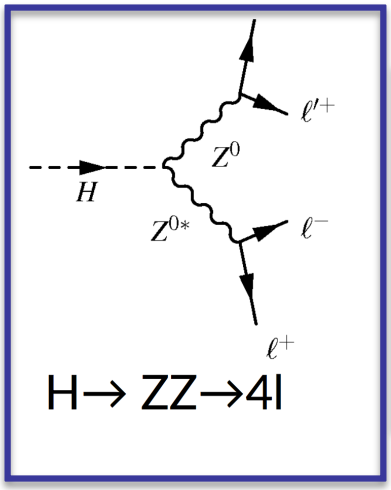
- Increased production cross-section for higgs at LHC in run2.
- Large amount of data collected by experiments. 36 fb^{-1}
- Enhanced sensitivity to production modes for coupling measurements.

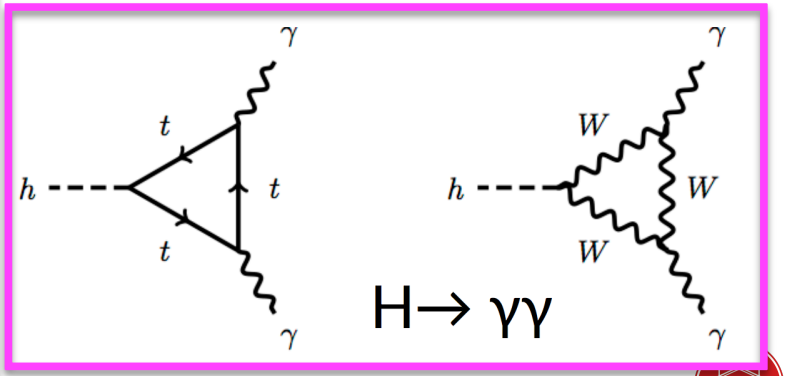
Higgs decay to bosons

- WW* : second highest branching ratio for higgs decay. Complicated and the most precise run1 measurement : No New Results(ATLAS_CONF_2016_112)
- ZZ* : high signal to background ratio.
- γγ : high rate as compared to ZZ* but lower S/B
- ZZ* and γγ : Ability to fully reconstruct higgs invariant mass.









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Higgs Coupling Measurement from Run1

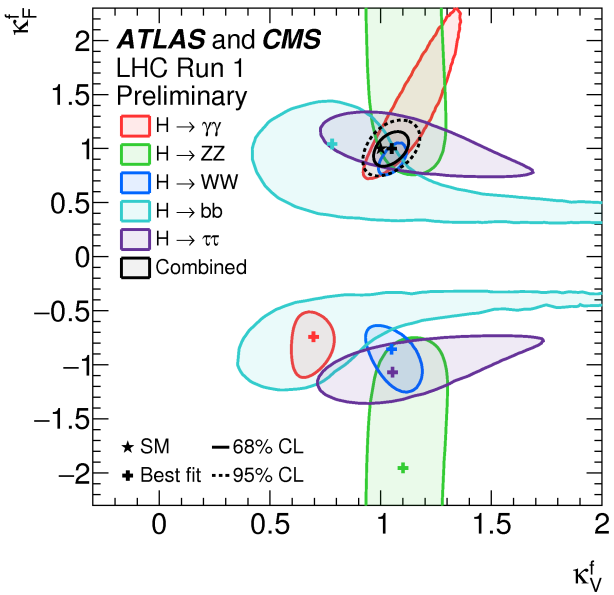
JHEP 08, 045 (2016)

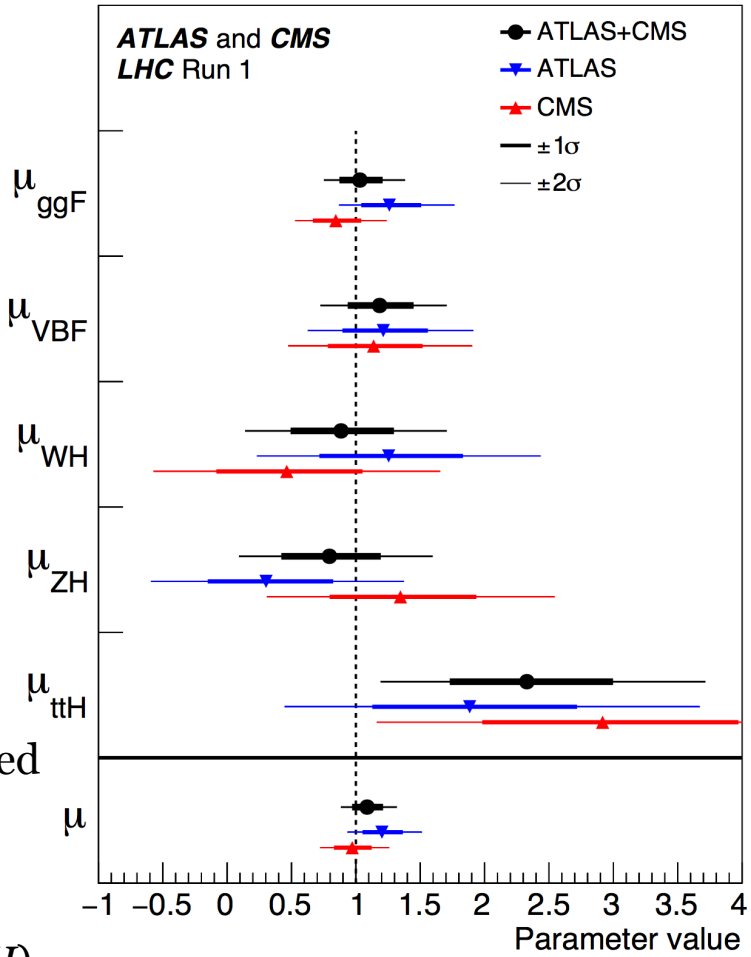
Signal Strength : defined as the ratio of the XS•BR with respect to the SM : $\mu = (\sigma \,.\, BR)_{obs}/(\sigma \,.\, BR)_{SM}$

Coupling modifiers (κ_j) : multiplying terms in the Higgs boson couplings to fermions and bosons in the SM Lagrangian, in order to take into account for New Physics (NP) effects that can occur both in production and decay:

$$\sigma_i \cdot \mathrm{BR}^f = \frac{\sigma_i(\vec{\kappa}) \cdot \Gamma^f(\vec{\kappa})}{\Gamma_H}$$

Where $\kappa_j^2 = \Gamma^j/\Gamma^j_{SM}$





Run1 Results expressed in terms of couplings with fermions (*ggF, bbH, ttH*) or vector bosons (*VBF, WH, ZH*)

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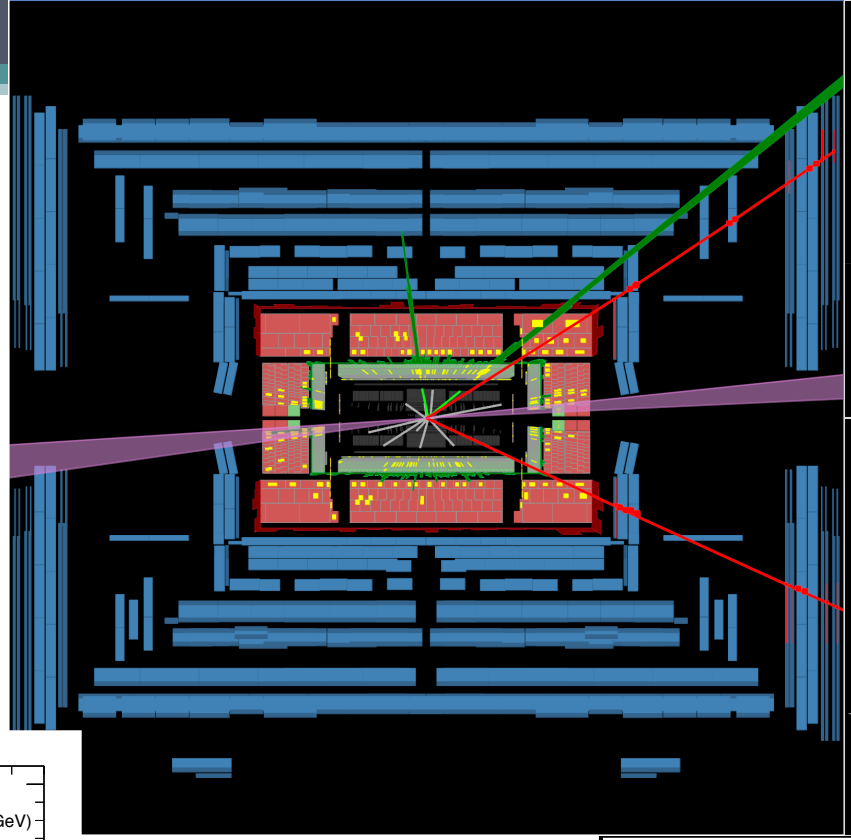
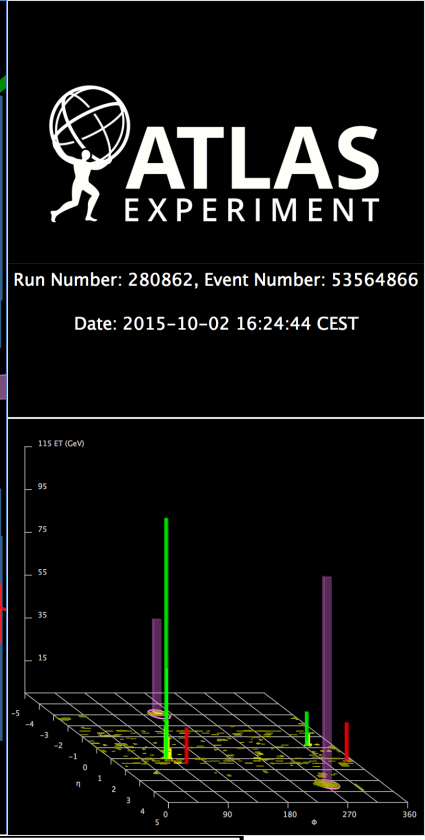
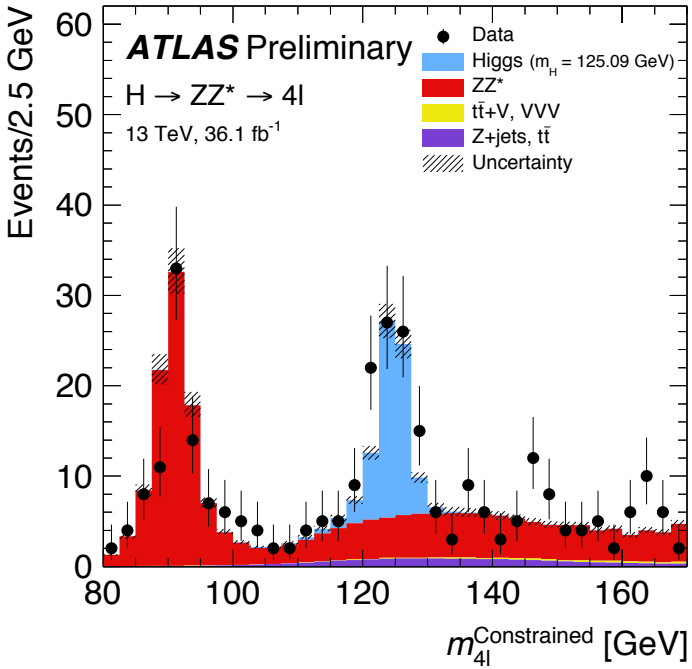
$H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$





NEW!



ATLAS_CONF_2017_032

- High purity channel (S/B ~2)
- Events with at least two same-flavour and opposite-charge lepton pairs.
- Signal extraction using four-lepton invariant mass spectrum in range 118-129 GeV
- Main backgrounds : non-resonant ZZ* process and Z+jets and ttbar

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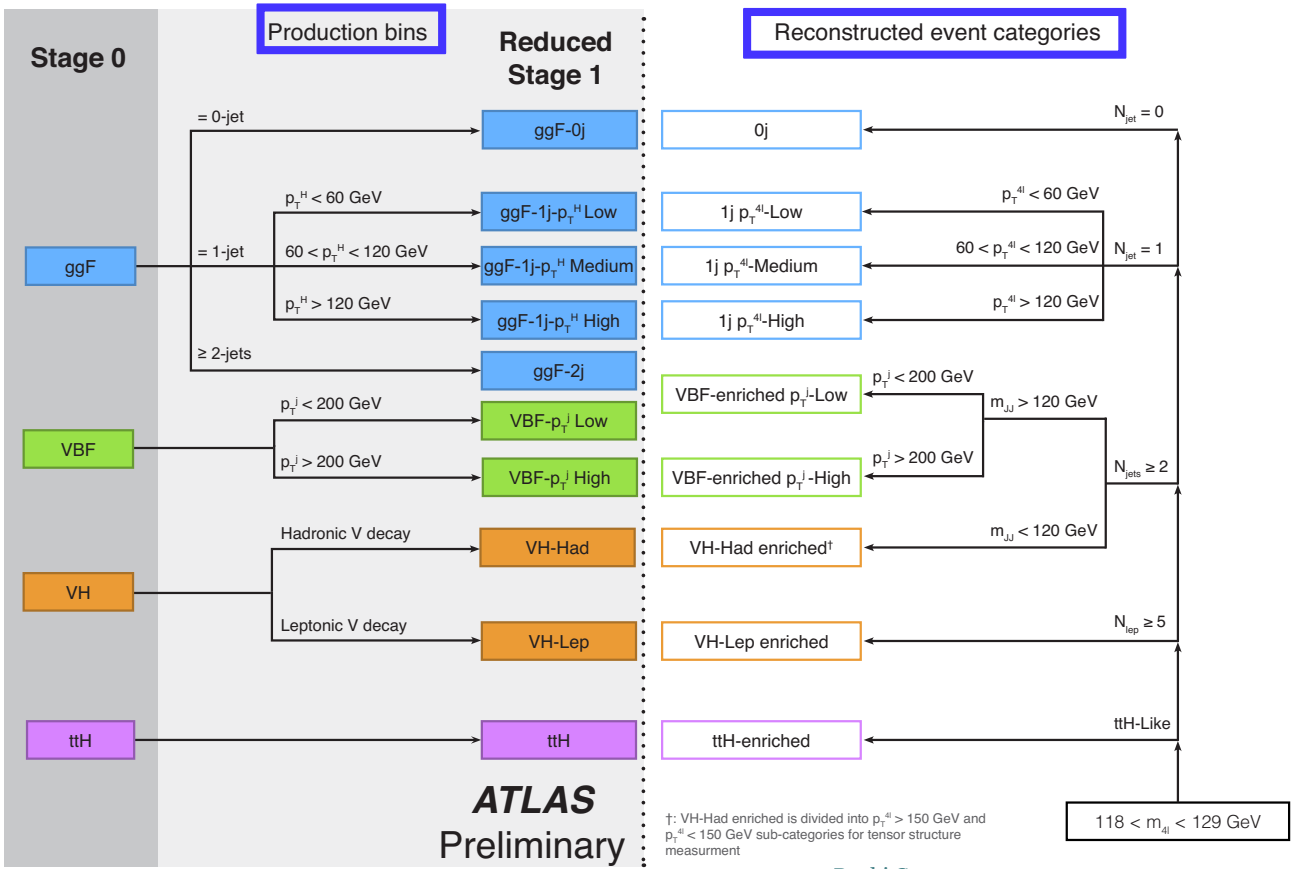
$H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$ Event Categorization

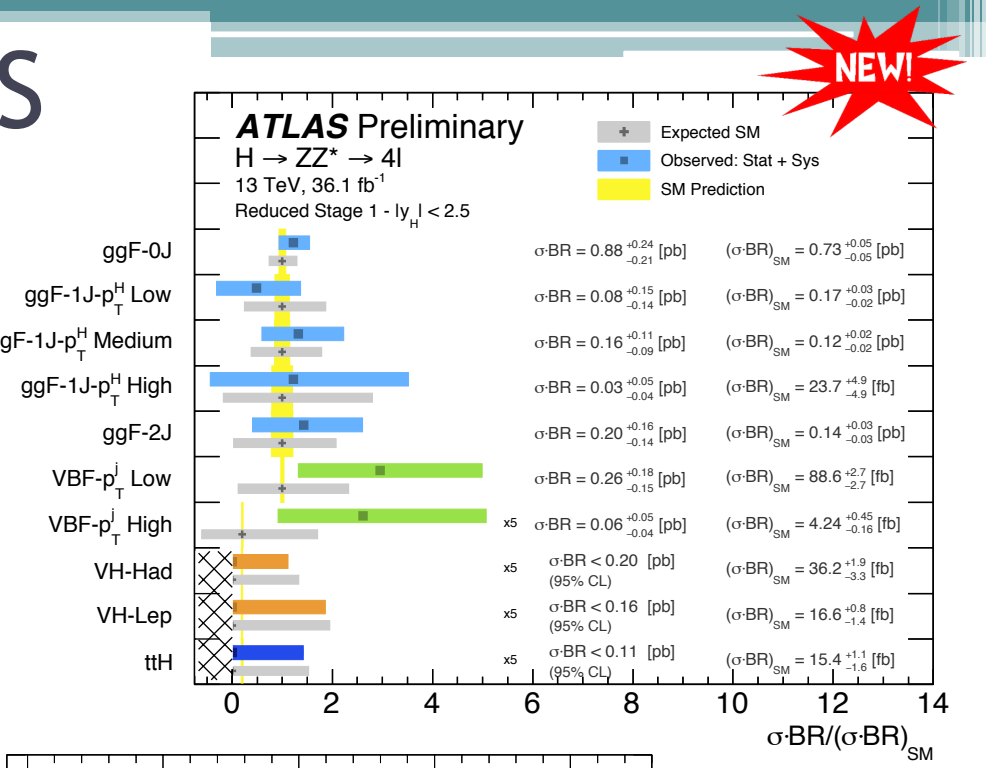
- Exclusive categories optimized for the best separation of the higgs boson production processes
- Maximize experimental sensitivity while minimizing theory dependence.
- Production Cross-Sections in simplified fiducial volumes and unfolded for detector effects.
- Template Cross sections serve as input to BSM interpretations like coupling scale factors.
- Dependence on theoretical models enters at the interpretation stage.



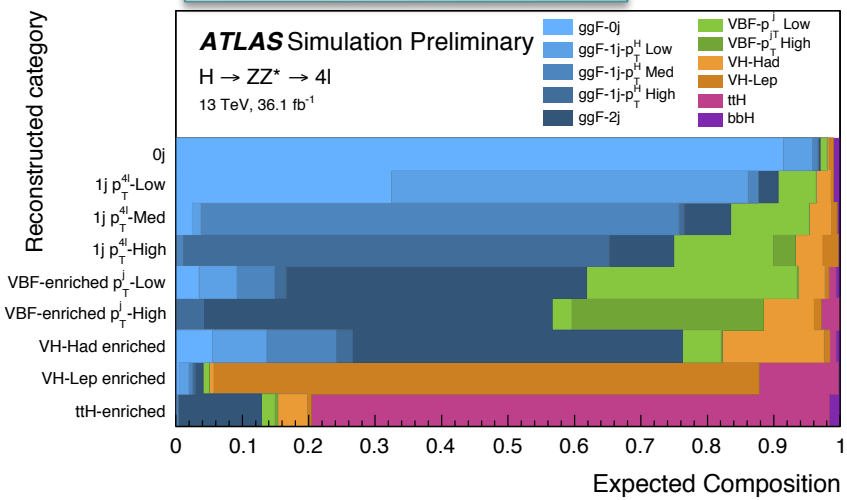
Simplified Template Cross Section STXS approach used for coupling measurements in $H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$ as well as $H \rightarrow \gamma\gamma$

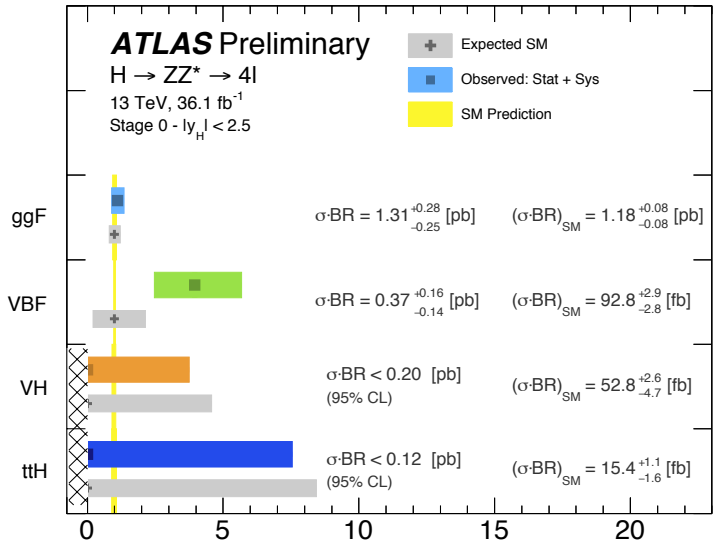
$H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$ STXS

- Template Cross Sections Measured for 9 stage-1 regions.
- Dominant Systematic Uncertainties : luminosity; lepton efficiency measurements.



Signal Composition in categories

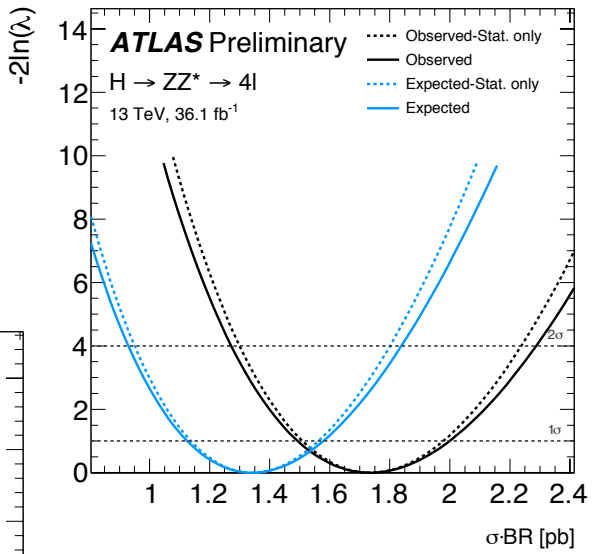


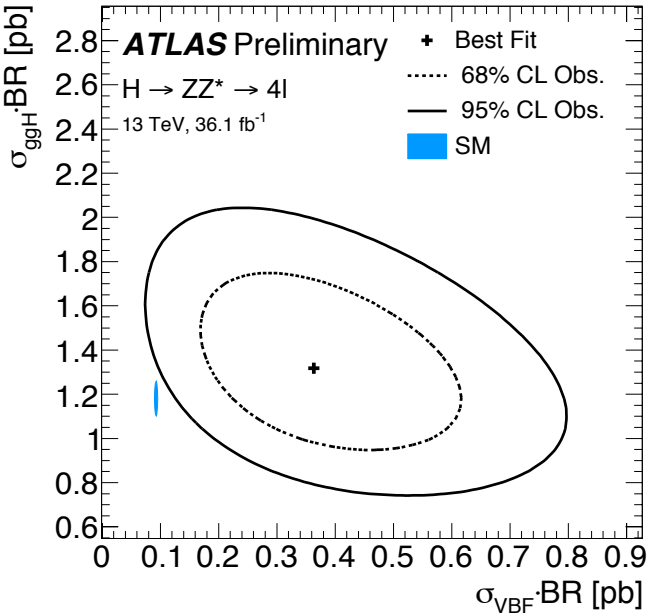


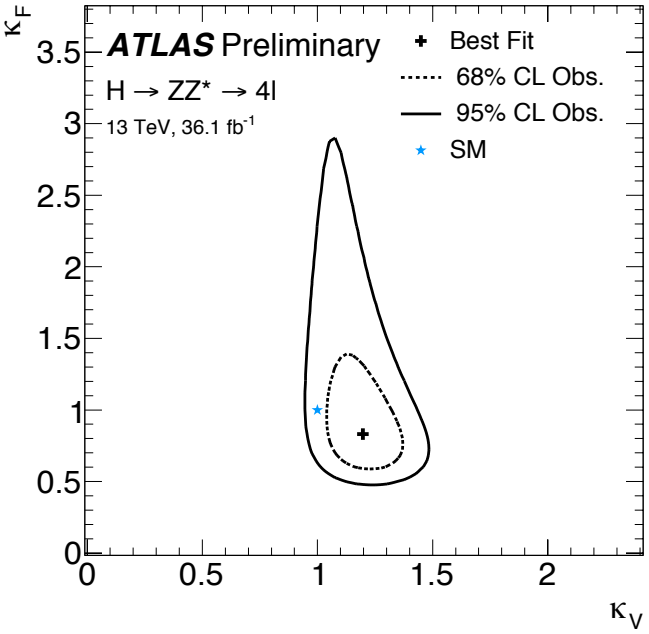
$H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$ Coupling Measurement

NEW!

- $H \rightarrow ZZ^*$ cross section : agreement with SM prediction at the level of 1.7σ
- The cross section results by production mode are interpreted in the κ framework.
- The compatibility with the Standard Model expectation : at the level of 1.4σ in $\boldsymbol{\kappa_F}$-$\boldsymbol{\kappa_V}$ plane and 2.3σ in $\boldsymbol{\sigma_{ggH}.BR - \sigma_{VBF}.BR}$ plane.







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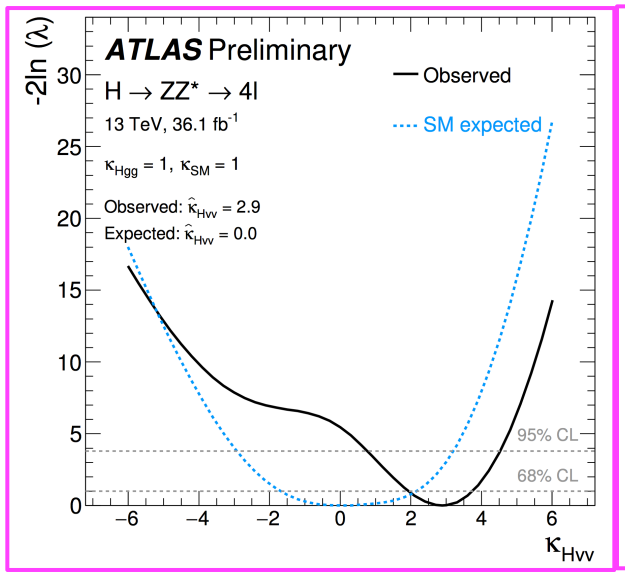
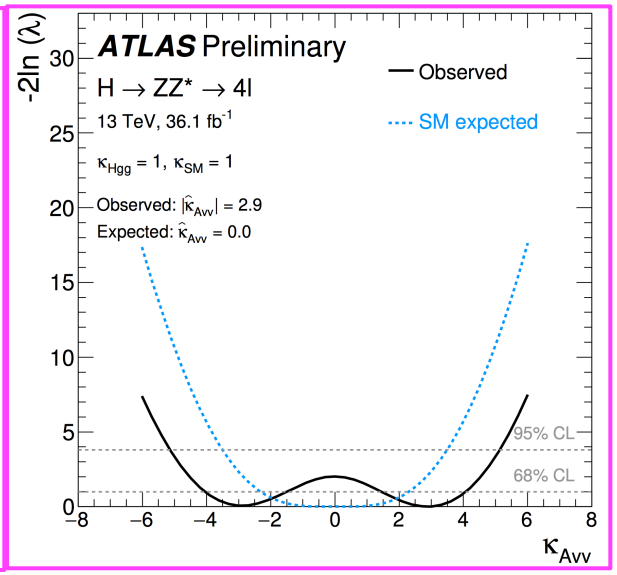
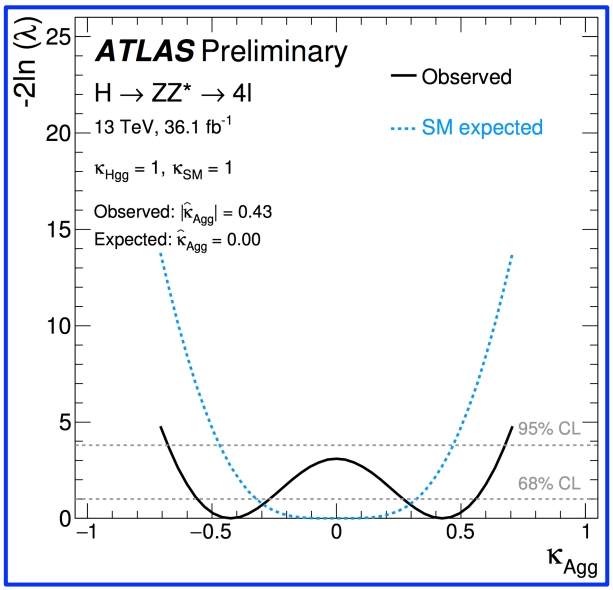
$H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$ coupling Measurements

NEW!

- Tensor structure of the Higgs boson couplings : effective Lagrangian approach for the description of BSM interactions – Higgs Characterization Model. (JHEP **1311** (2013) 043)
- Constraints placed on the BSM CP-even and CP-odd couplings to vector bosons (κ_{HVV} and κ_{AVV}) and on the CP-odd coupling to gluons (κ_{Agg}).







- Agreement with SM 1.8σ for κ_{Agg}, 2.3σ for κ_{HVV} and 1.4σ for κ_{AVV}
- κ_{HVV} and κ_{AVV} : strongly contribute to VH and VBF.
- κ_{Agg} : mostly affects the ggF production.

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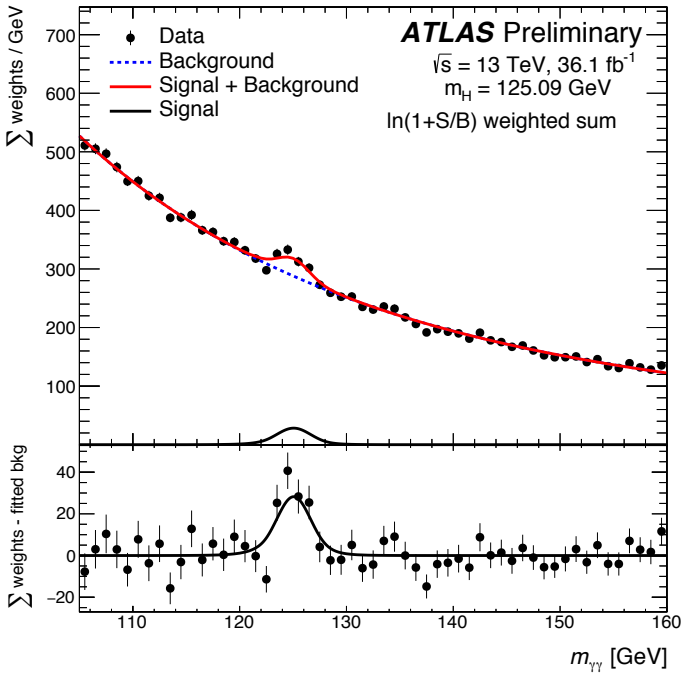
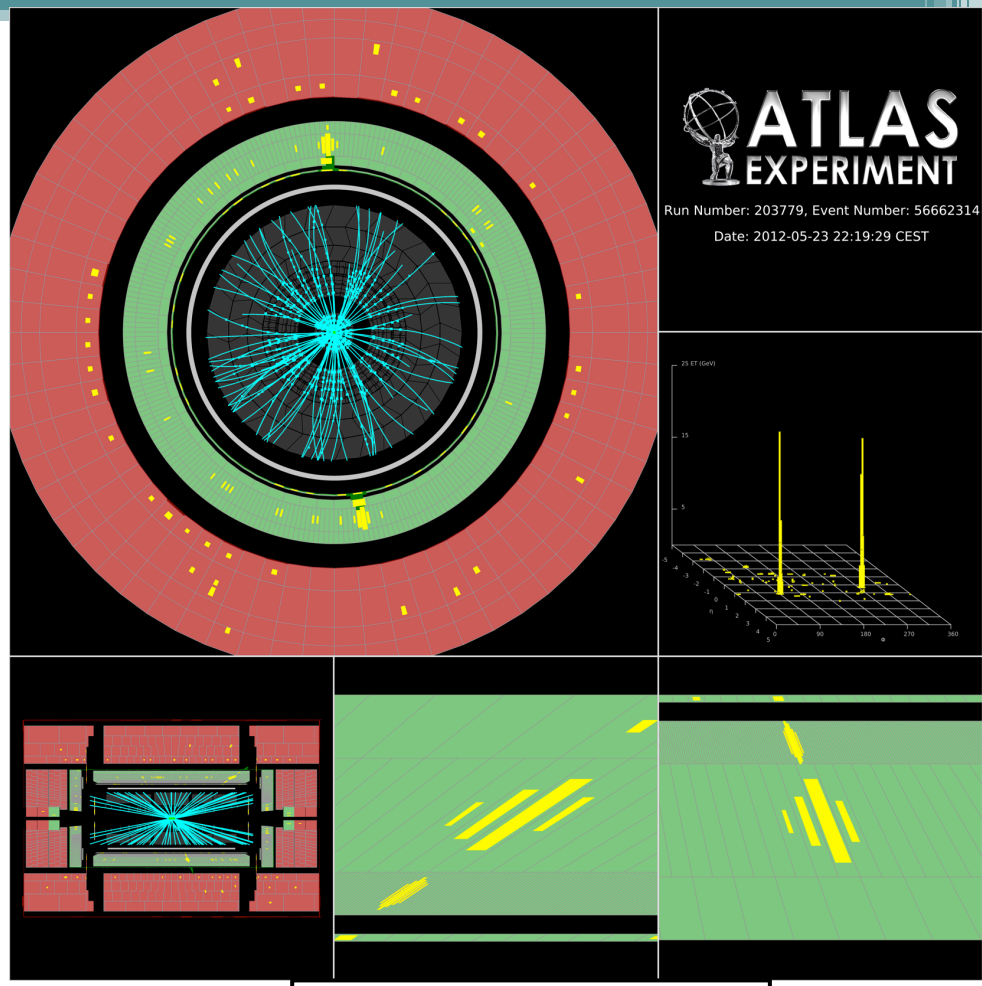
H→γγ

NEW!





ATLAS_CONF_2017_045

- Two photons selected with $E_T/m_{\gamma\gamma} > 0.35$ (0.25)
- Signal extraction using maximum-likelihood fit to diphoton invariant mass spectrum in range 105-160 GeV
- Diphoton Vertex identified using a neural network algorithm based on track/ vertex information.
- Major Backgrounds : γγ, γj and jj

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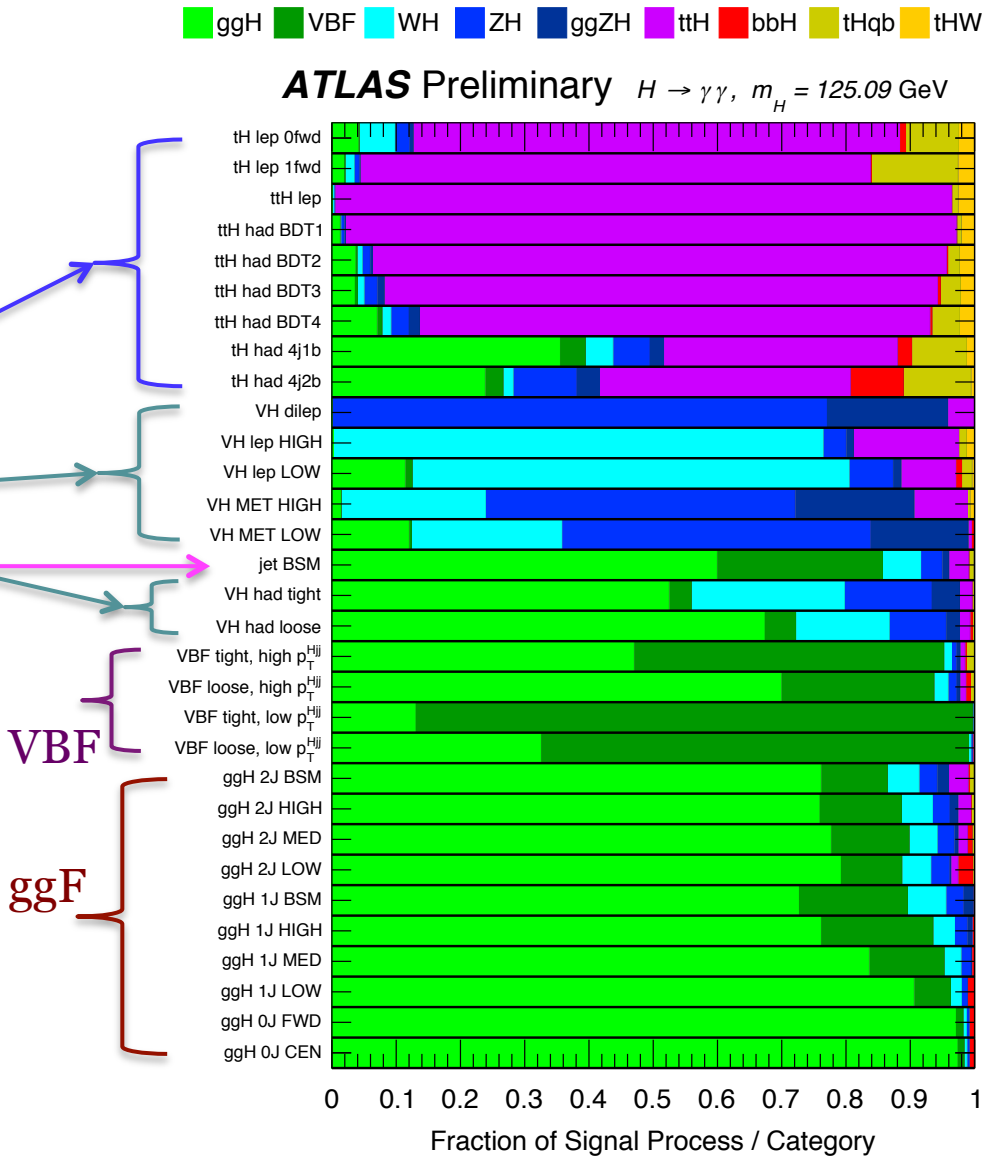
H→γγ Event Categorization

NEW!

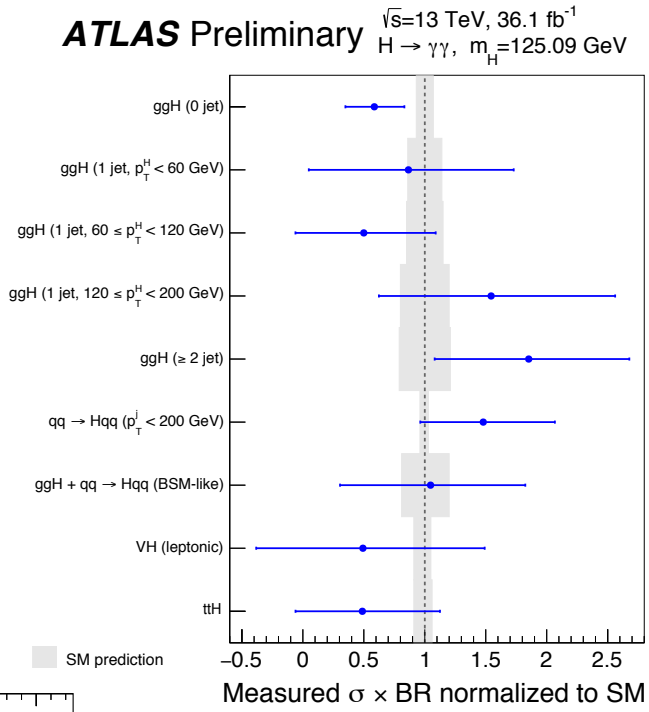
- STXS Regions :
  - the $t\bar{t}H$, $tHqb$, and tHW : 9 categories
  - VH : 7 categories
  - BSM : Events with a boosted leading jet with transverse momentum > 200 GeV.
  - VBF : 4 categories
  - ggF : 10 categories

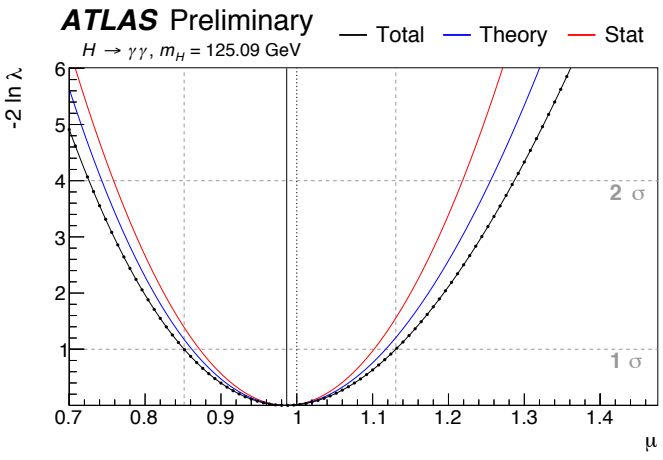


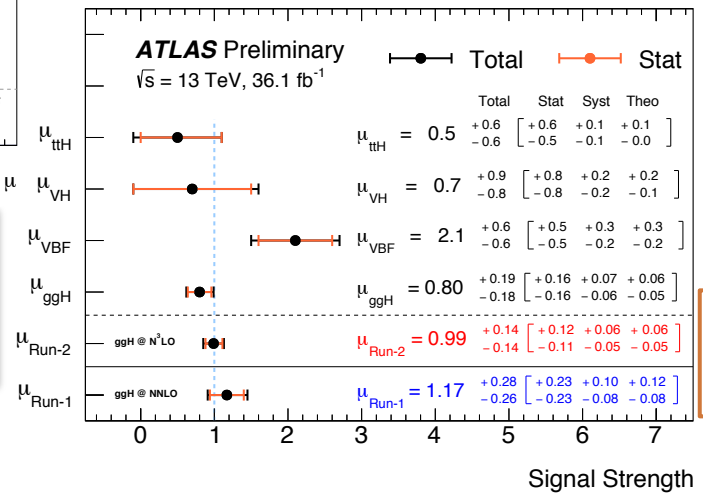
H→γγ STXS Measurement

NEW!

- Template cross sections reported for 9 phase space regions (by merging the initial 31 categories).
- Signal Strength Measurements : well in agreement with SM.
- Dominant Systematic Uncertainties : Jet Energy Scale and resolution; luminosity.







The signal strength measured for the different production processes as well as globally.

NNNLO (NNLO) SM ggF prediction in Run2 (Run1)

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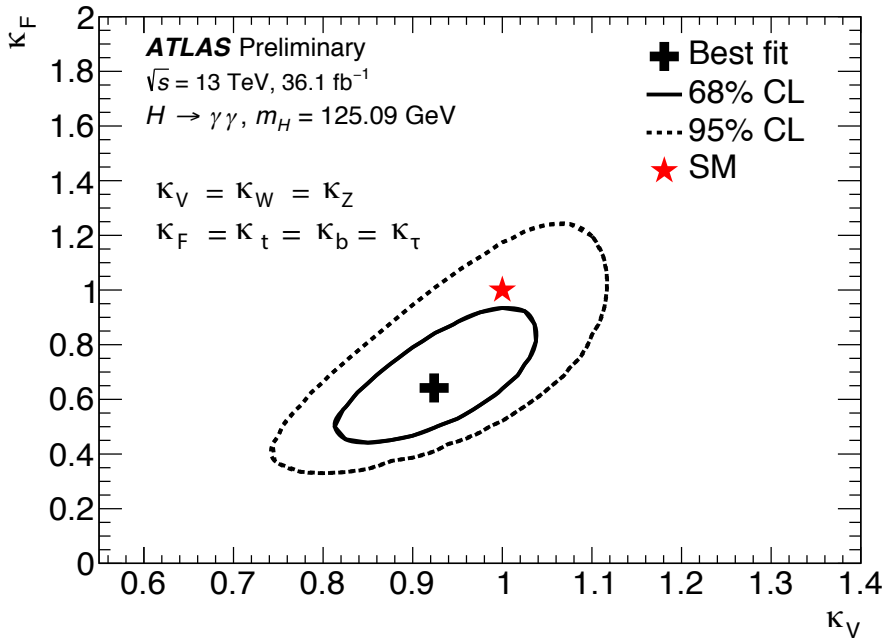
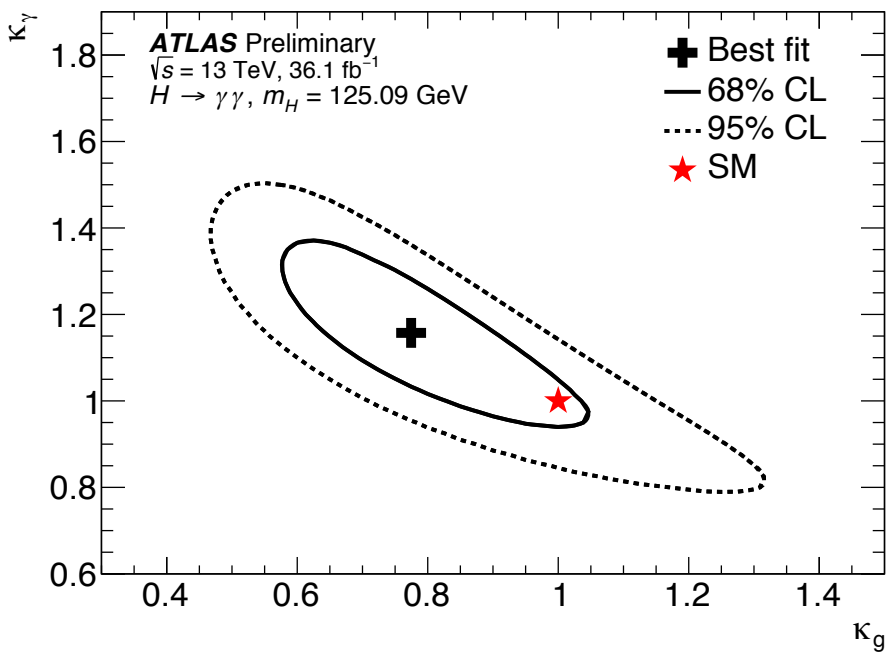
H→γγ Coupling Measurement

NEW!

- Limits set on higgs coupling modifiers within κ-framework.
- SM prediction within 68% CL two-dimensional contour for κ_g-κ_γ as well as for κ_V – κ_F plane.





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Conclusions

- Run2 results from higgs coupling measurements in bosonic decay channels presented.
- Simplified Template Cross Sections measured using 36 fb^{-1} of 13 TeV p-p collisions data for $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow l^+l^-l^+l^-$.
- Higgs couplings studied using measurements from different production mode categories.
- All measurements for 125.09 GeV higgs : in agreement with Standard Model.

- More New Results in upcoming talks!!!

- Higgs Cross-section Measurements : Talk by Andrea Gabrielli
- Higgs mass measurement : Talk by Karolos Potamianos
- Higgs Combination Results : Talk by Tamara Vazquez Schroeder

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