Higgs Mass Measurement...

Why measure m_H?

- Crucial input parameter in SM
- Related to SM vacuum stability
- Required for precision EW calculation
- Important parameter for coupling structure of Higgs

Why HZZ* channel?

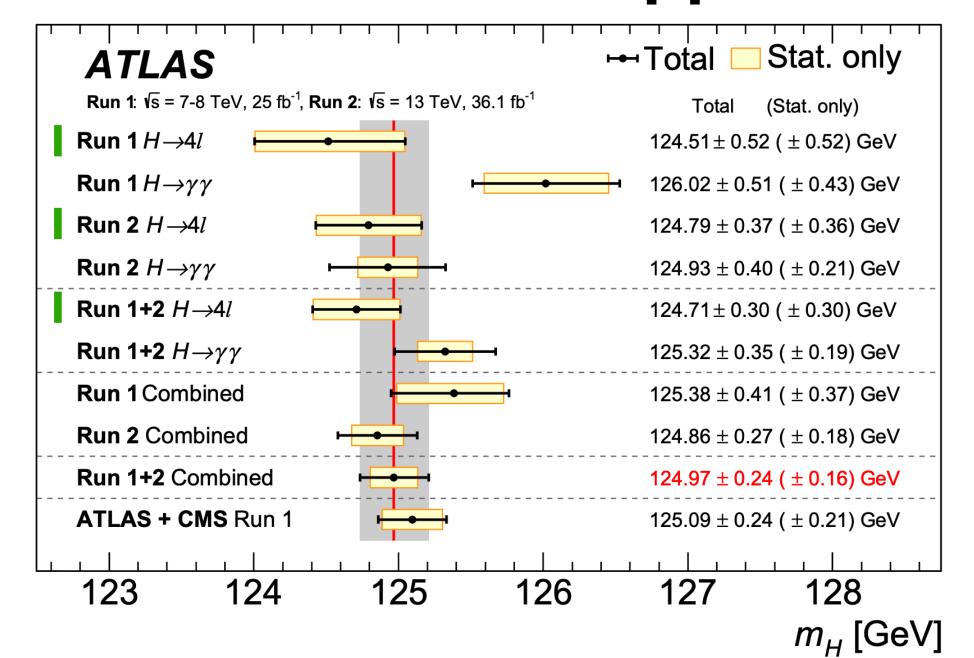
- H \rightarrow ZZ* \rightarrow 4l(e, μ): Fully reconstructeable final state
- Excellent mass resolution and S/B ratio

How did we improve?

- Largest collected dataset (139 fb⁻¹)
- Significant improvement in lepton resolution
- muon p_T scale error: factor of 4 reduction!
- Better theory modelling

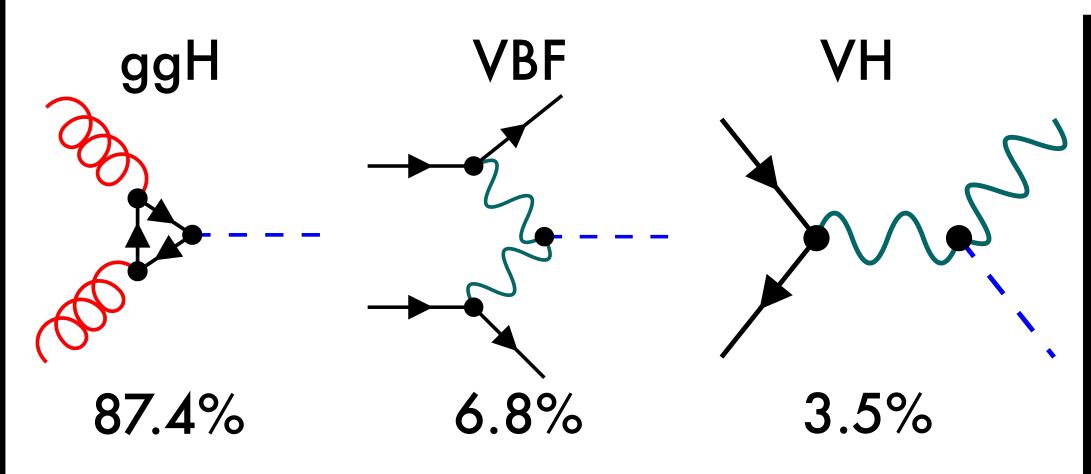
What was done before?

Higgs mass measurement with 36 fb⁻¹ with ATLAS detector [1]



...in $H \rightarrow ZZ^* \rightarrow 4$...

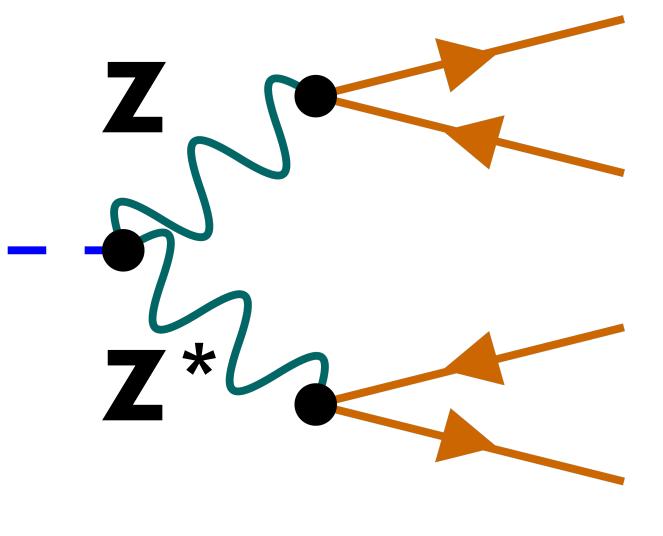
...With signal:



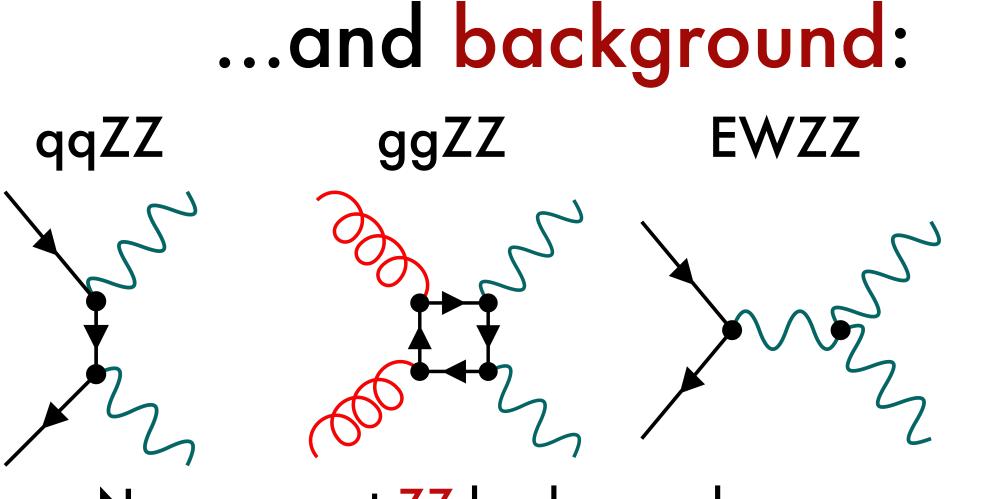
(The rest 2.3% are ggZH, ttH, bbH, tH...)

In this final state:

2 pairs of opposite charge, same flavour leptons $(p_T > 20, 15, 10, 0 \text{ GeV})$ $50 < m_Z < 106 \text{ GeV}$ $12 < m_{Z^*} < 115 \text{ GeV if } m_{4l} < 140 \text{ GeV, else}$ $50 < m_{Z^*} < 115 \text{ GeV}$ Jpsi suppression: veto if alternate $m_{\parallel} < 5$ GeV



With these observables:



Non-resonant ZZ background About 30% of signal region (SR)

The rest are Z+jets, ttbar (3% of SR), and tXX, **VVV** (0.2% of SR)

m_{4l} Events 120 100 90 100 110 120 130 140 150 160 170 $m_{\scriptscriptstyle AI}$ [GeV]

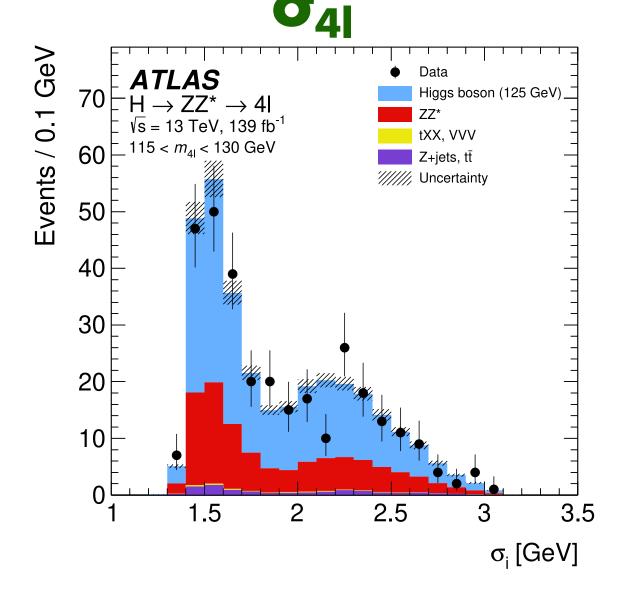
Reconstructed 4-lepton invariant mass

- Final state radiation recovery - Constrain on-shell lepton pair

- using Z boson lineshape

ATLAS $\sqrt{s} = 13 \text{ TeV}, 139 \text{ fb}^{-1}$ $80 - 115 < m_{41} < 130 \text{ GeV}$ 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

> Neural net discriminant - Input: pT^{4l} , η^{4l} , KDZZ



Per-event resolution Estimated by quantile regression NN

...with 139 fb⁻¹ from the ATLAS detector

Signal and background modelling

For signal:

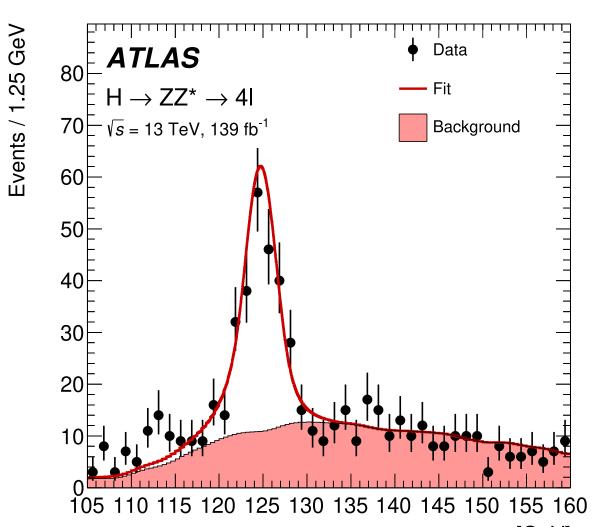
3D (m_{Al} , D_{NN} and σ_i) simplified to 2D likelihood

- m₄₁ modelled by double sided crystal ball
- Both m_{Al} and D_{NN} conditional on σ_i

Remaining m_H dependency parametrised in fit terms

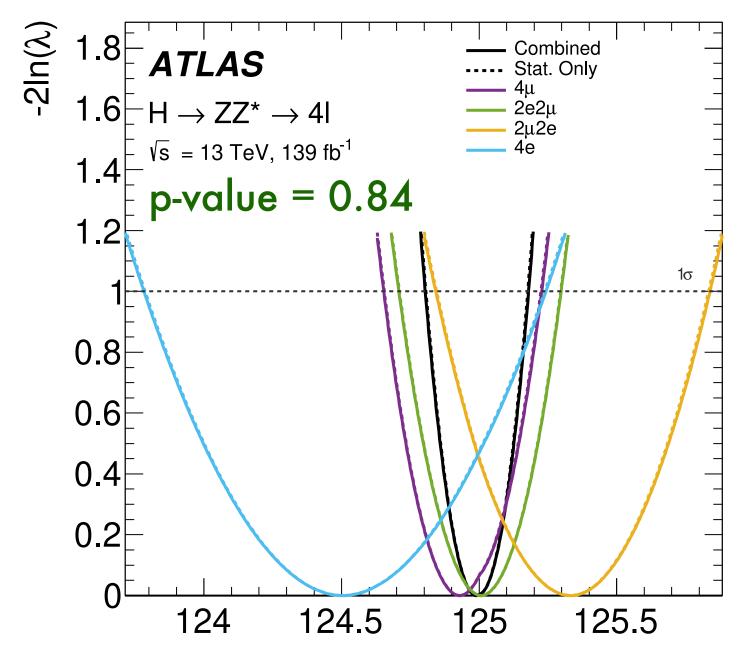
For background:

Construct 2D PDF for m_{Al} and D_{NN}



m₄₁ data distribution with signal and background post-fit PDF

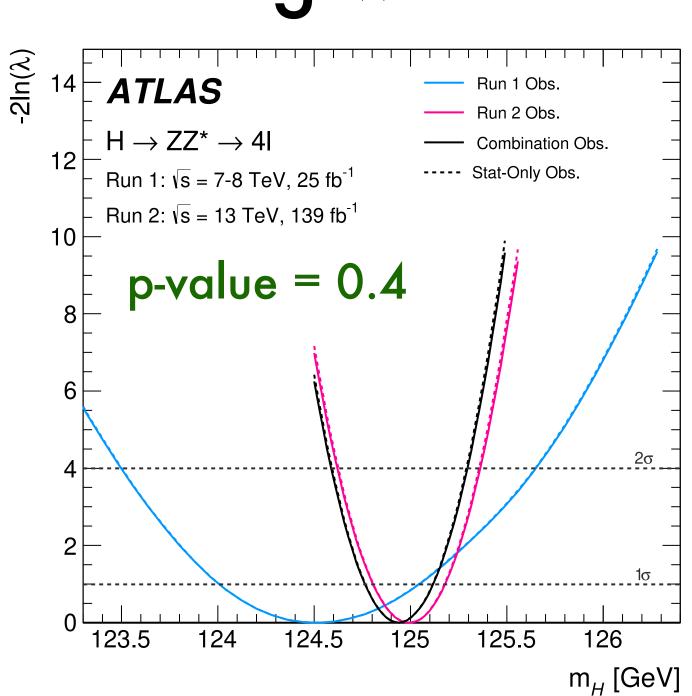
Run 2 result: $m_H = 124.99 \pm$ 0.18 (stat) ± 0.04 (sys) GeV



m_H [GeV] 50% (20%) total (systematic) uncertainty reduction!

Systematic Uncertainty	Contribution [MeV]
Muon momentum scale	±28
Electron energy scale	±19
Signal-process theory	±14

Combining with Run 1



Run 1+2 result: $m_H = 124.94 \pm$ 0.17 (stat) ± 0.03 (sys) GeV

[1] The ATLAS Collaboration, "Measurement of the Higgs boson mass in the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ channels with TeV pp collisions using the ATLAS detector", Physics Letter B, V 784, p 345-366

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