

Constraining the Higgs boson self-coupling from single- and double-Higgs production with the ATLAS detector using pp collisions at $\sqrt{s} = 13$ TeV

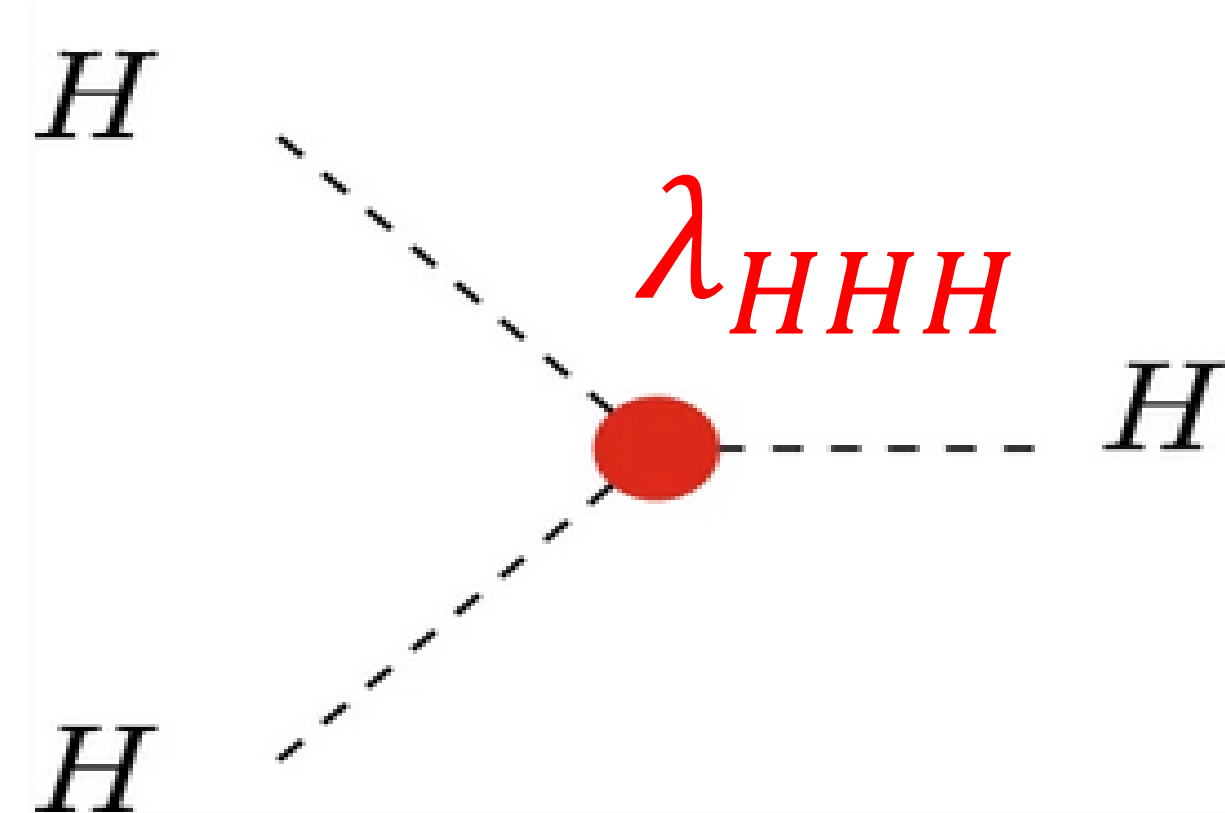
Mingxu He¹, on behalf of the ATLAS collaboration

¹IHEP, CAS



Motivation

- Higgs couplings to vector bosons and fermions have been discovered and studied through single Higgs production and decay.
- **Higgs self-coupling** has not been discovered by experiment.

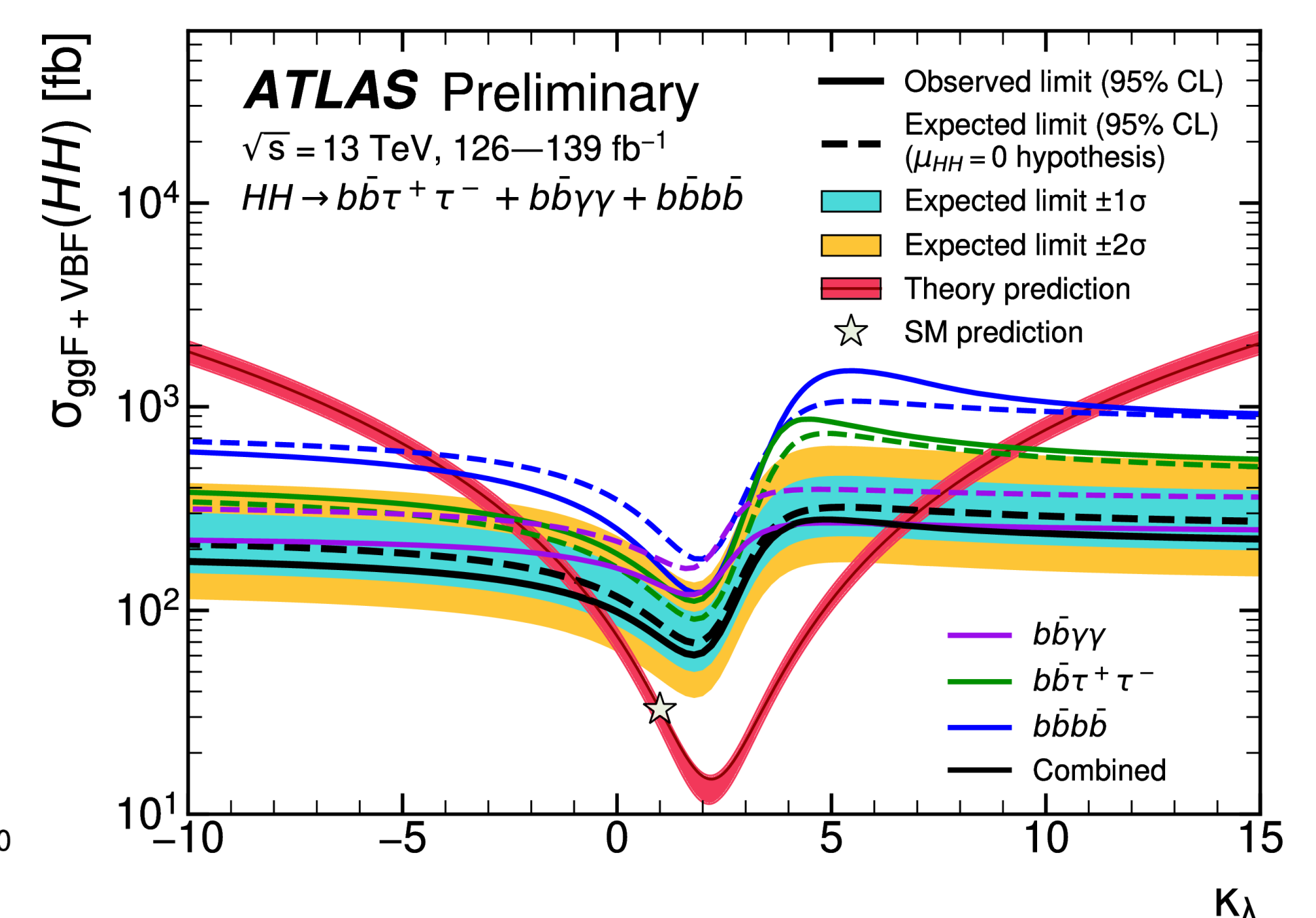
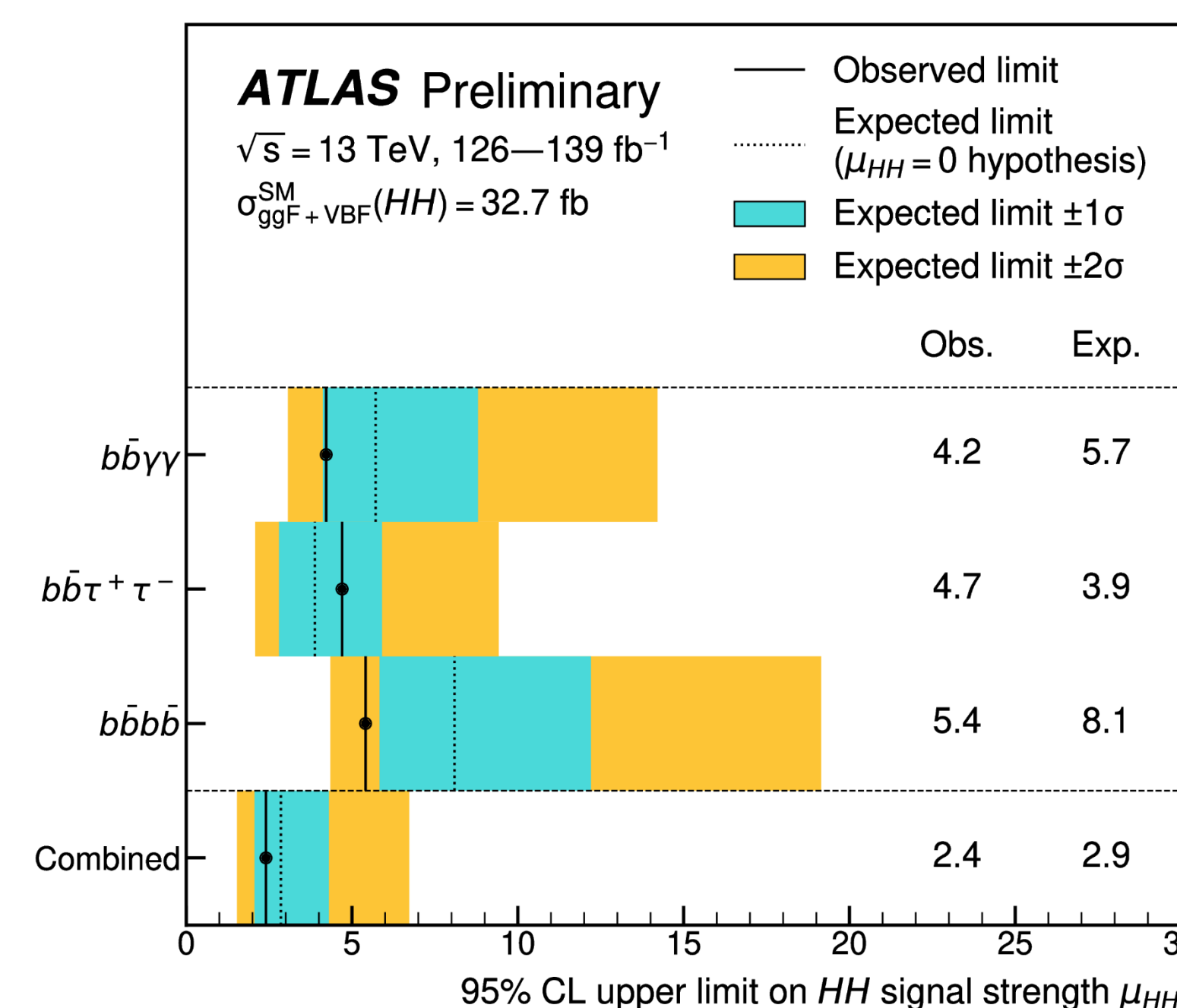


Di-Higgs SM signal strength and cross section

- As this is the first time to combine three full Run 2 di-Higgs channels, di-Higgs only results are presented

Observed and expected 95% CL upper limits on the signal strength for di-Higgs production

Observed and expected 95% CL exclusion limits for the di-Higgs combination



Higgs self coupling

- Study Higgs self-coupling through constraints on coupling modifier κ_λ

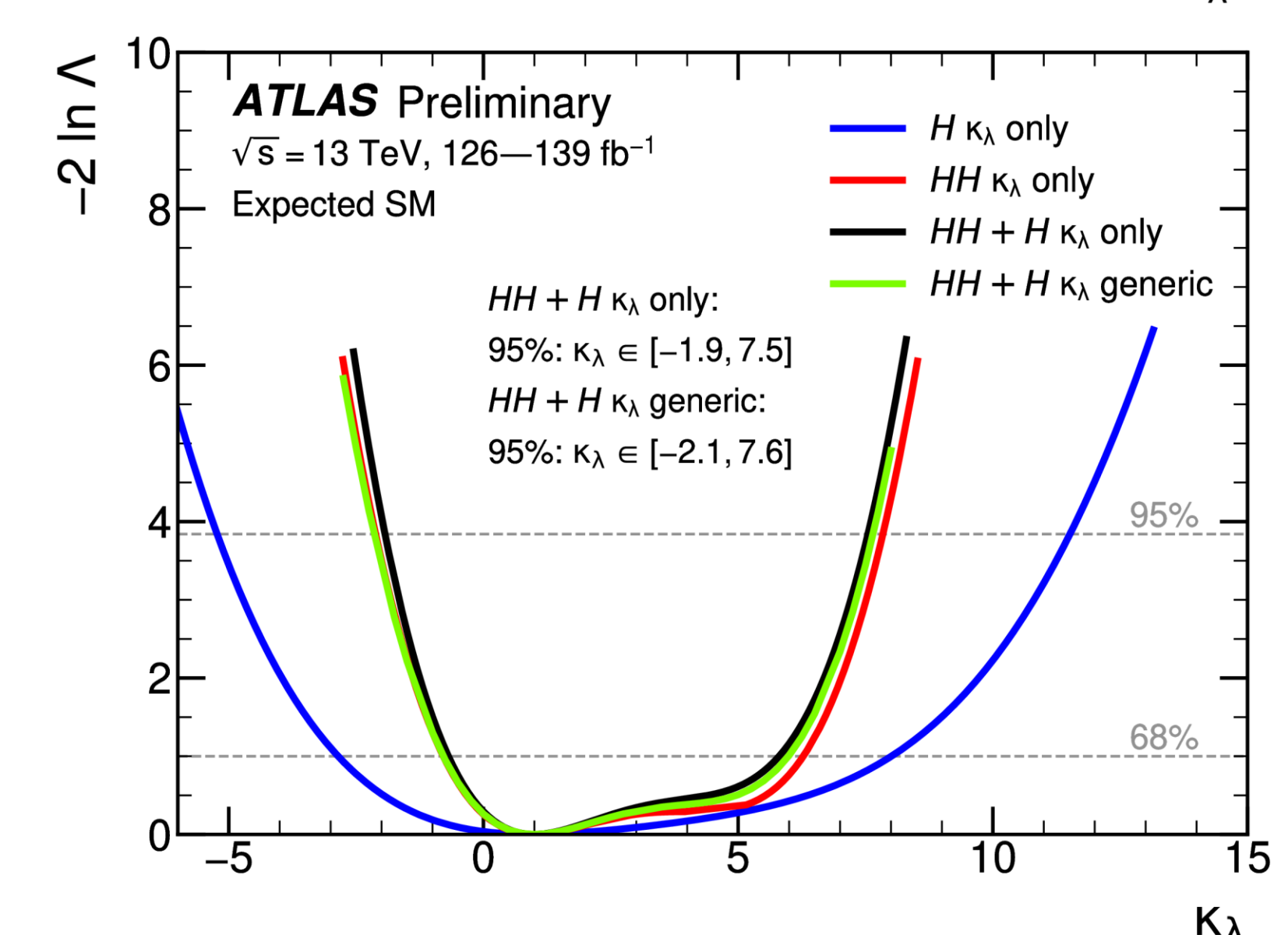
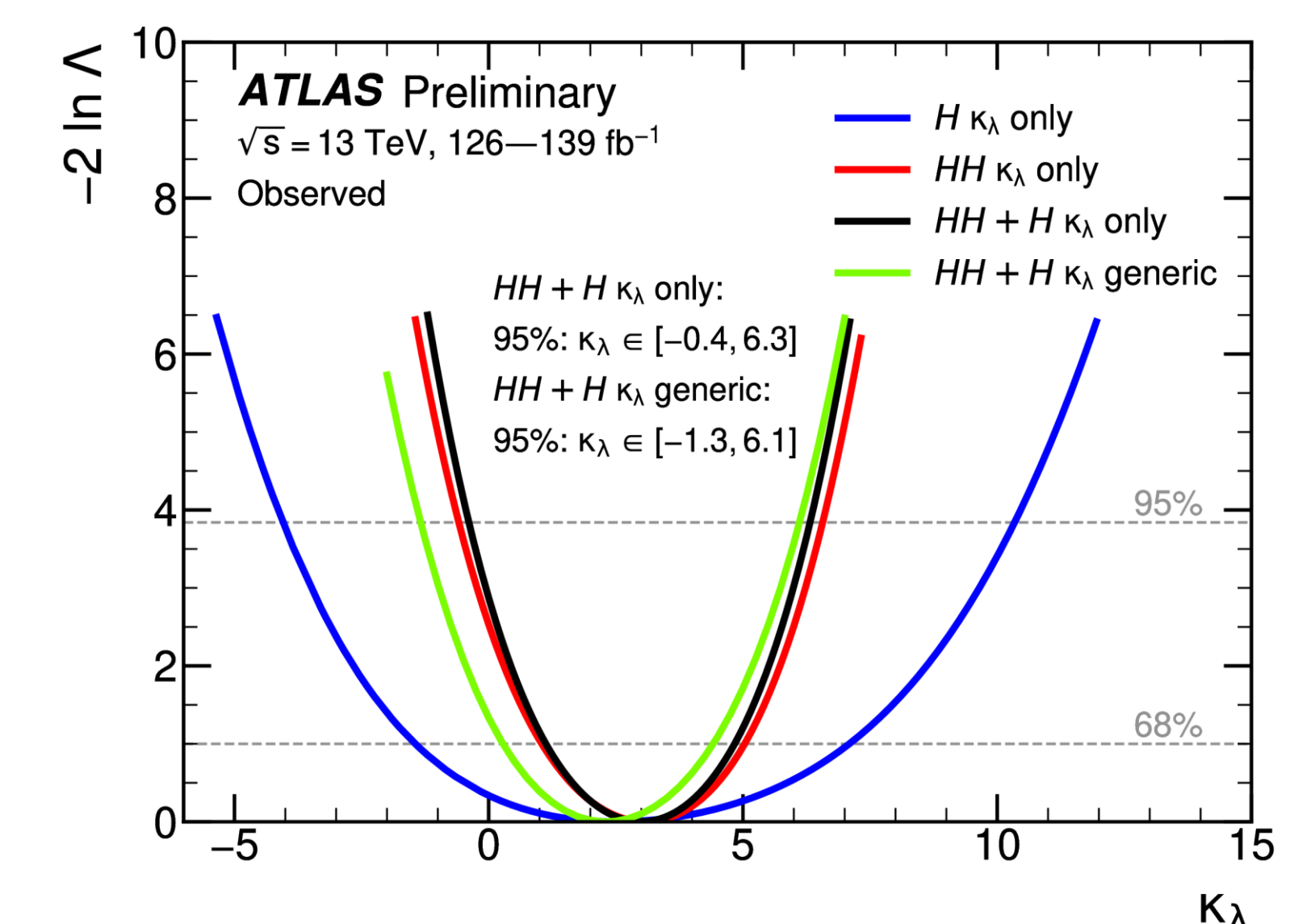
$$\kappa_\lambda \equiv \frac{\lambda_{HHH}}{\lambda_{HHH}^{SM}}$$

- In ATLAS experiment, Higgs self-coupling can be probed directly via di-Higgs production
- And indirectly probed via NLO electroweak corrections on single-Higgs production and decay
- Complete LHC Run 2 dataset of 13 TeV proton-proton collisions collected with the ATLAS detector

Channel	Integrated luminosity (fb ⁻¹)
$HH \rightarrow b\bar{b}\gamma\gamma$	139
$HH \rightarrow b\bar{b}\tau\tau$	139
$HH \rightarrow b\bar{b}b\bar{b}$	126
$H \rightarrow \gamma\gamma$	139
$H \rightarrow ZZ^* \rightarrow 4\ell$	139
$H \rightarrow \tau^+\tau^-$	139
$H \rightarrow WW^* \rightarrow e\nu\mu\nu$ (ggF,VBF)	139
$H \rightarrow b\bar{b}$ (VH)	139
$H \rightarrow b\bar{b}$ (VBF)	126
$H \rightarrow b\bar{b}$ ($\bar{t}tH$)	139

Single- and double-Higgs combination results

- Single Higgs and di-Higgs with full Run 2 dataset are combined for the first time
- Two assumptions:
 - HH+H κ_λ only: κ_λ is the only source of physics beyond SM
 - HH+H κ_λ generic: κ_λ , κ_V , κ_t , κ_b , κ_τ all included for the source of physics beyond SM



Combination assumption	Obs. 95% CL	Exp. 95% CL	Obs. value ^{+1σ} _{-1σ}
HH combination	$-0.6 < \kappa_\lambda < 6.6$	$-2.1 < \kappa_\lambda < 7.8$	$\kappa_\lambda = 3.1^{+1.9}_{-2.0}$
Single-H combination	$-4.0 < \kappa_\lambda < 10.3$	$-5.2 < \kappa_\lambda < 11.5$	$\kappa_\lambda = 2.5^{+4.6}_{-3.9}$
HH+H combination	$-0.4 < \kappa_\lambda < 6.3$	$-1.9 < \kappa_\lambda < 7.5$	$\kappa_\lambda = 3.0^{+1.8}_{-1.9}$
HH+H combination, κ_t floating	$-0.4 < \kappa_\lambda < 6.3$	$-1.9 < \kappa_\lambda < 7.6$	$\kappa_\lambda = 3.0^{+1.8}_{-1.9}$
HH+H combination, $\kappa_t, \kappa_V, \kappa_b, \kappa_\tau$ floating	$-1.3 < \kappa_\lambda < 6.1$	$-2.1 < \kappa_\lambda < 7.6$	$\kappa_\lambda = 2.3^{+2.1}_{-2.0}$

Summary

- LHC Run 2 dataset collected with the ATLAS detector
 - Three di-Higgs analyses are combined
 - HH signal strength and cross section upper limits
 - Single and di-Higgs are combined
 - The most stringent constraints on the Higgs boson self-interactions

- Three di-Higgs analyses with full Run 2 dataset are combined for the first time*
- Single and di-Higgs with full Run 2 dataset are combined for the first time*