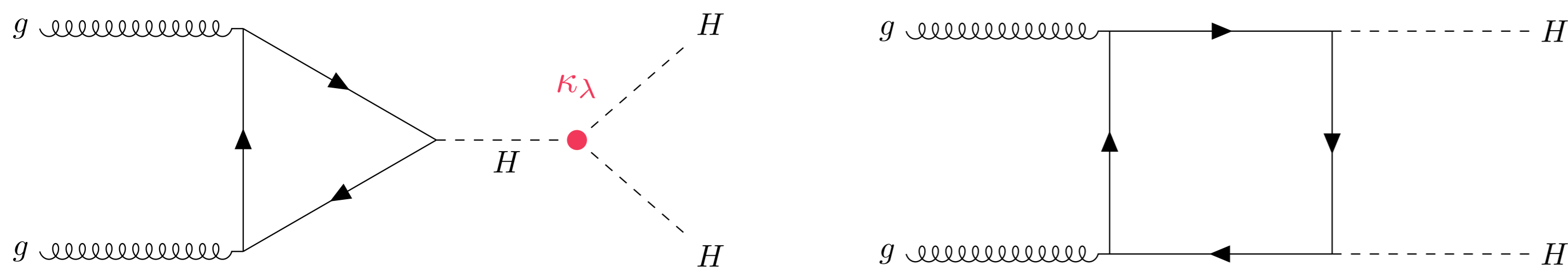


1. Introduction

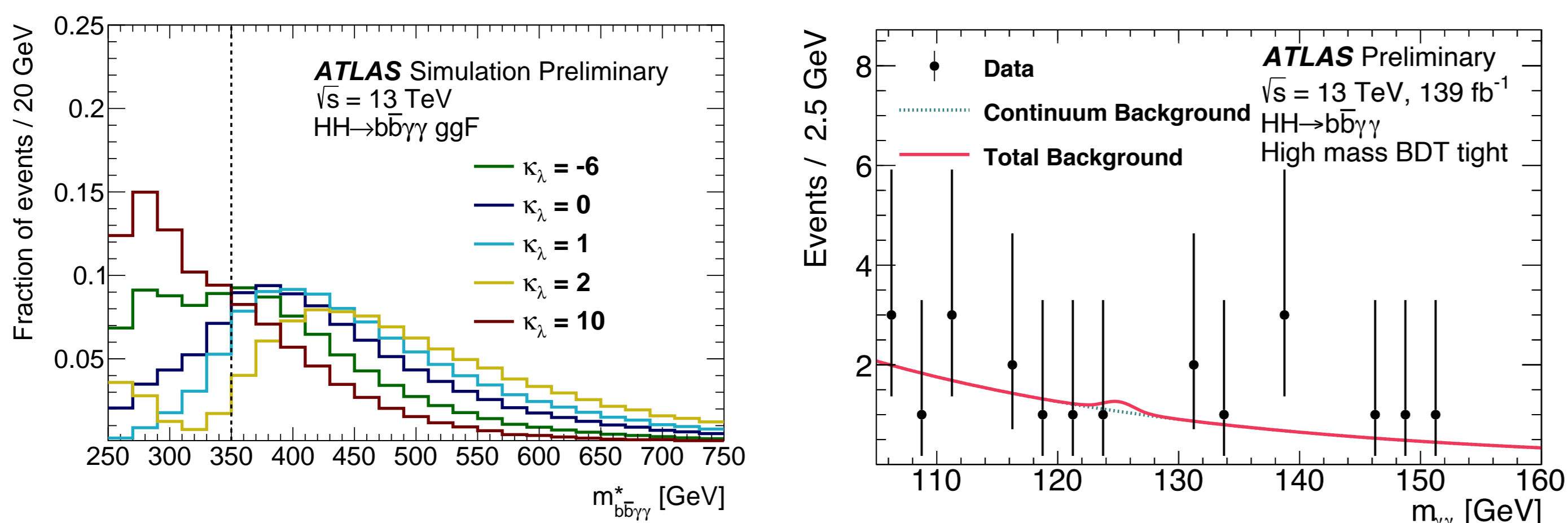
- ▶ The nature of the Higgs boson self-coupling can be probed through di-Higgs (HH) production at the LHC.
- ▶ In the SM at $\sqrt{s} = 13$ TeV, non-resonant HH production is extremely rare and proceeds mainly through gluon-fusion ($\sigma_{ggF} = 31$ fb).



- ▶ BSM modifications to the self-coupling modifier $\kappa_\lambda = \lambda_{HHH}/\lambda_{HHH}^{SM}$ can result in much higher cross-sections.

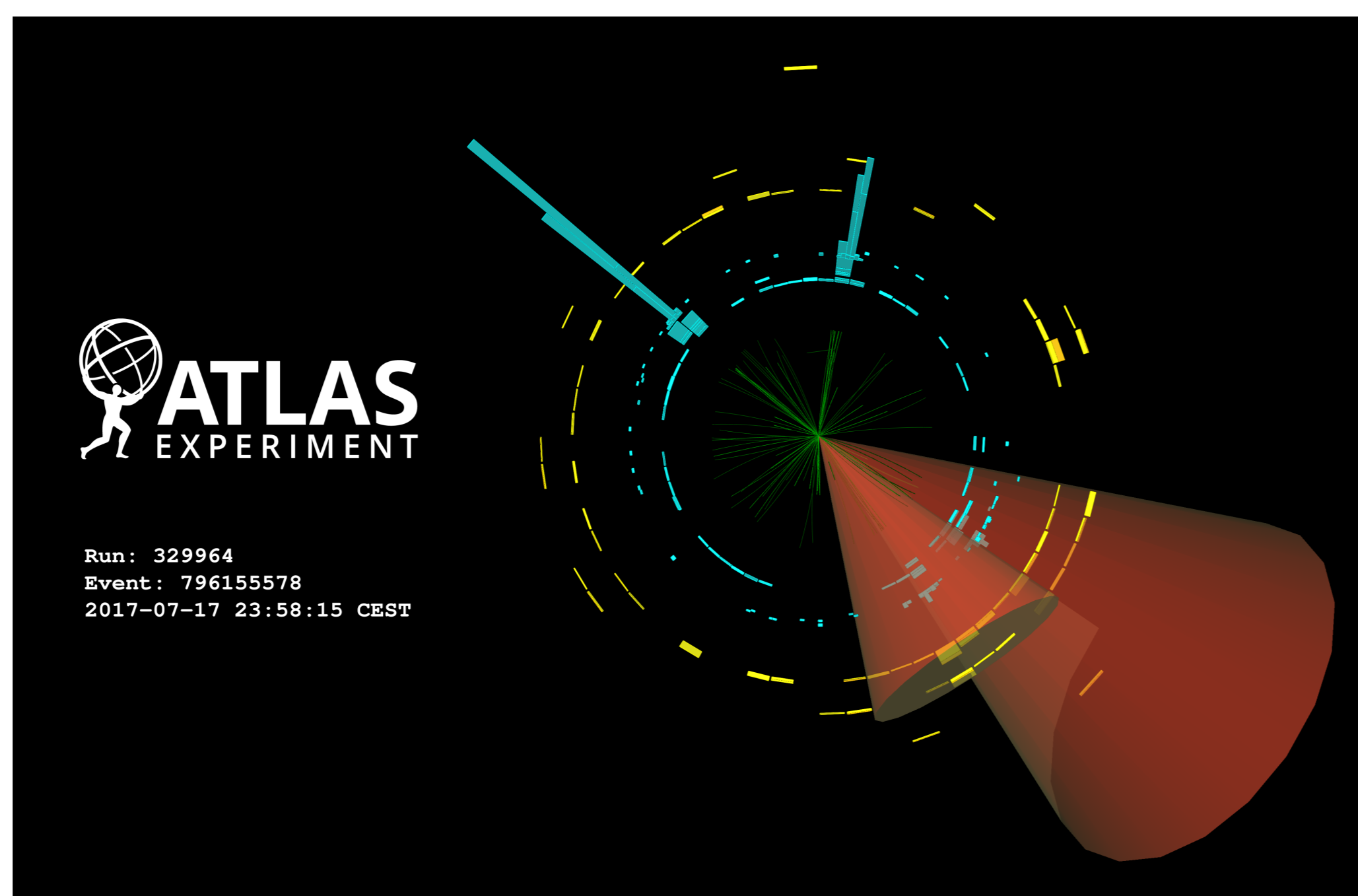
2. Run 2 $b\bar{b}\gamma\gamma$ Analysis Strategy

- ▶ ATLAS searched for HH production in the $b\bar{b}\gamma\gamma$ decay channel using Run 2 data (139 fb^{-1} at $\sqrt{s} = 13$ TeV).
- ▶ This channel combines the large $H \rightarrow b\bar{b}$ branching ratio (58%) with the excellent ATLAS photon resolution (~ 1.5 GeV $m_{\gamma\gamma}$ signal width for $H \rightarrow \gamma\gamma$).



- ▶ Events with two photons and two b-jets are categorized using boosted decision trees and the modified 4-body mass $m_{b\bar{b}\gamma\gamma}^* = m_{b\bar{b}\gamma\gamma} - (m_{b\bar{b}} - 125 \text{ GeV}) - (m_{\gamma\gamma} - 125 \text{ GeV})$.
- ▶ The expected HH signal is obtained from a fit to $m_{\gamma\gamma}$.

A candidate $HH \rightarrow b\bar{b}\gamma\gamma$ event in Run 2 data, showing two b-jets (red cones) and two photons (cyan towers).



- ▶ No significant excess was observed ([arXiv:2112.11876](https://arxiv.org/abs/2112.11876)).
- ▶ The potential of this channel with the future High Luminosity LHC (HL-LHC) dataset is obtained by extrapolating the performance of the Run 2 analysis.

3. Extrapolation to HL-LHC

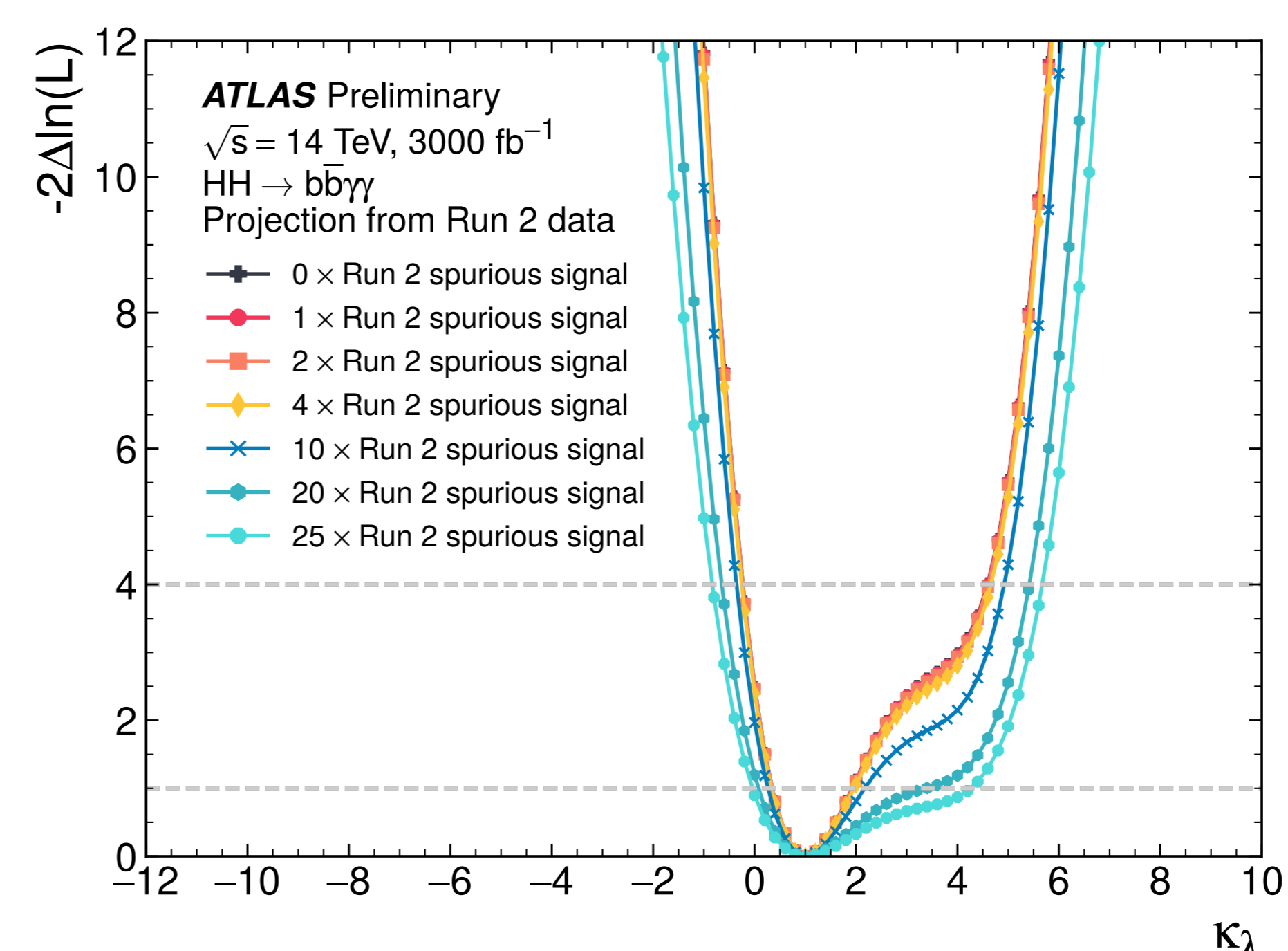
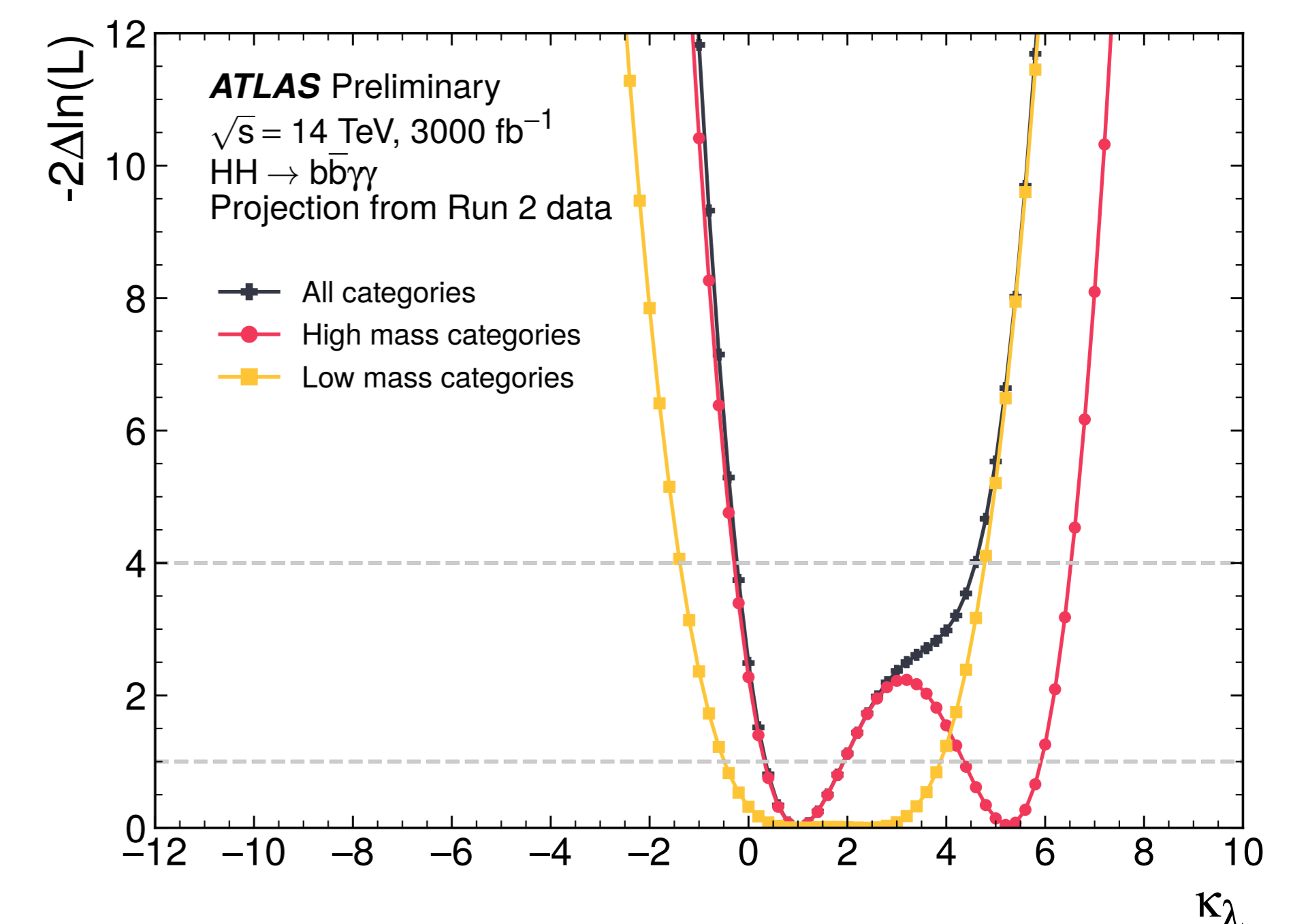
- ▶ Differences in conditions between Run 2 and the HL-LHC are taken into account while keeping the same analysis strategy.
- ▶ Run 2 signal and background yields are scaled to account for increases in luminosity (from 139 fb^{-1} to 3000 fb^{-1}) and energy (from $\sqrt{s} = 13$ TeV to $\sqrt{s} = 14$ TeV).
- ▶ The efficiency of the detector is assumed to remain the same as for Run 2.

Extrapolated yields per category	High Mass BDT Tight	High Mass BDT Loose	Low Mass BDT Tight	Low Mass BDT Loose
SM HH signal	22	9.0	1.2	1.8
Single H background	17	40	5.8	35
Continuum background	120	240	95	630

- ▶ Systematic uncertainties are reduced from Run 2 values assuming improved theory calculations or better constraints on experimental uncertainties.

4. Results

- ▶ Using only the $b\bar{b}\gamma\gamma$ channel, the projected significance for the SM HH signal is 2.2σ , with a precision of 50% on the signal strength measurement.
- ▶ The projected measurement of the Higgs boson self-coupling modifier is $\kappa_\lambda = 1.0^{+0.9}_{-0.7}$ at 68% C.L.
- ▶ High mass ($m_{b\bar{b}\gamma\gamma}^*$) and low mass categories provide sensitivity in different κ_λ regions.



- ▶ The performance of this channel depends on the background modelling uncertainty (spurious signal)

- ▶ For more details: [ATL-PHYS-PUB-2022-001](https://arxiv.org/abs/2202.001).