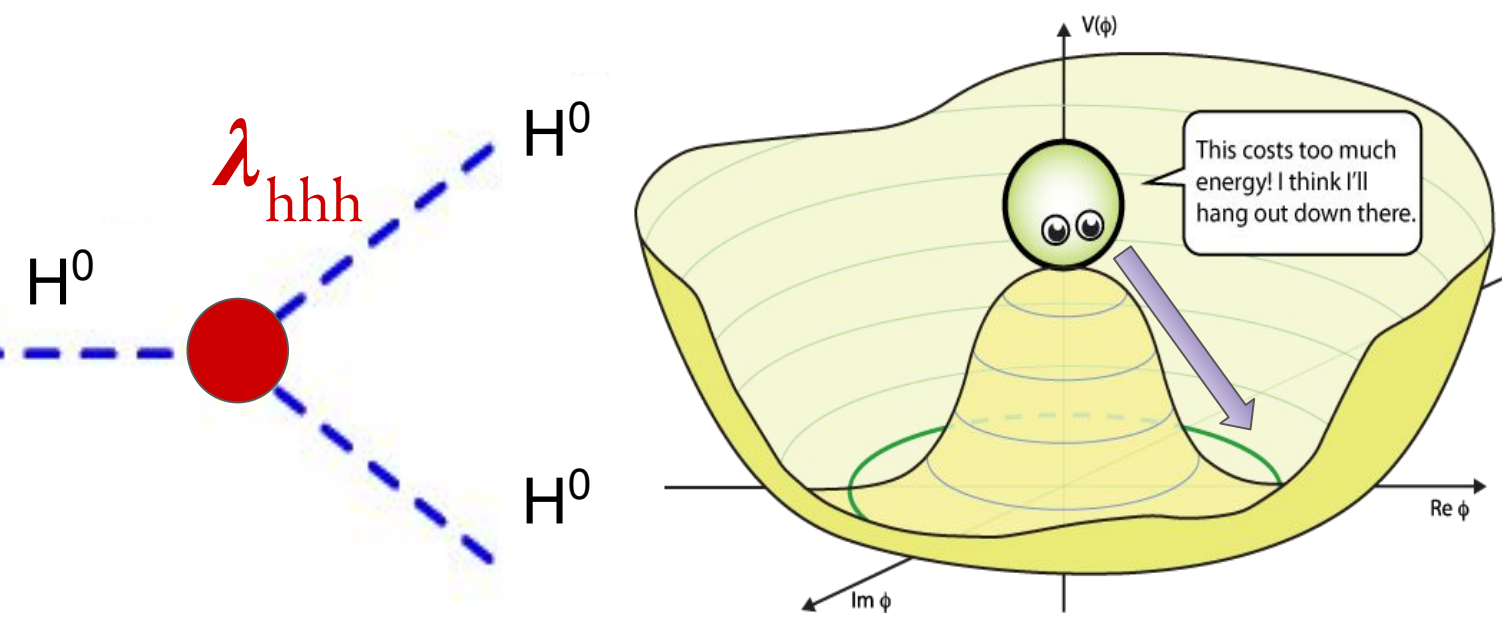


HH-PRODUCTION & DECAY CHANNELS

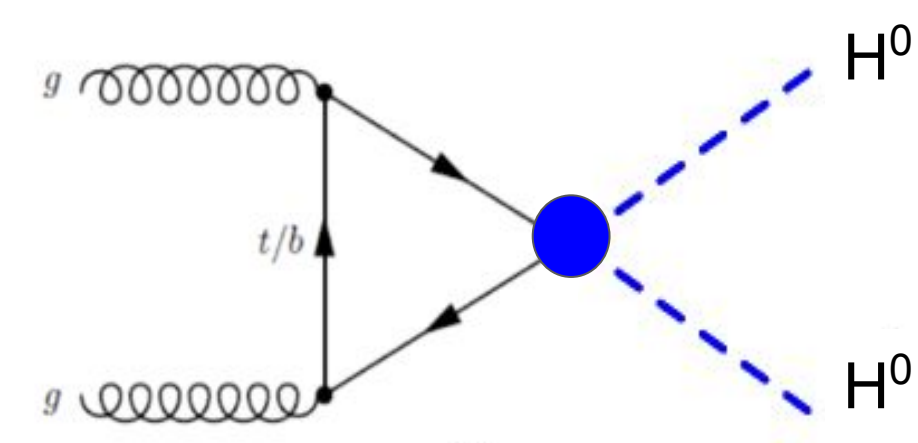
Importance for SM Higgs physics

- Higgs trilinear coupling (λ_{hhh})
- Shape of Higgs-potential



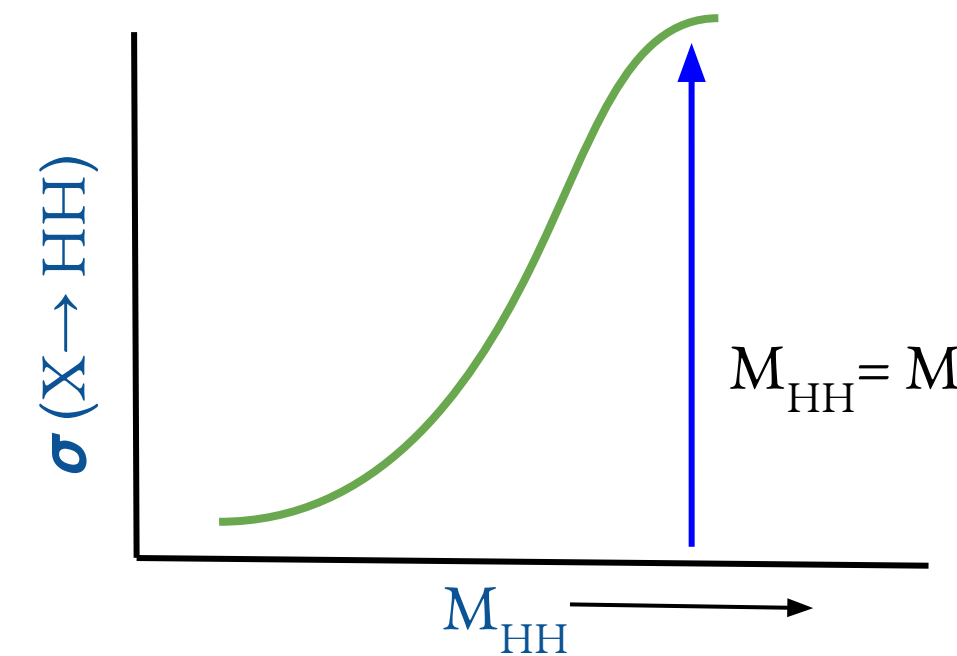
BSM Non-Resonant Production

- Via contact interaction with a heavy BSM mediator
- Modify λ_{hhh} or introduce new vertices



BSM Resonant Production

- Higgs coupling with heavy resonance X
- Cross section enhancement on resonance



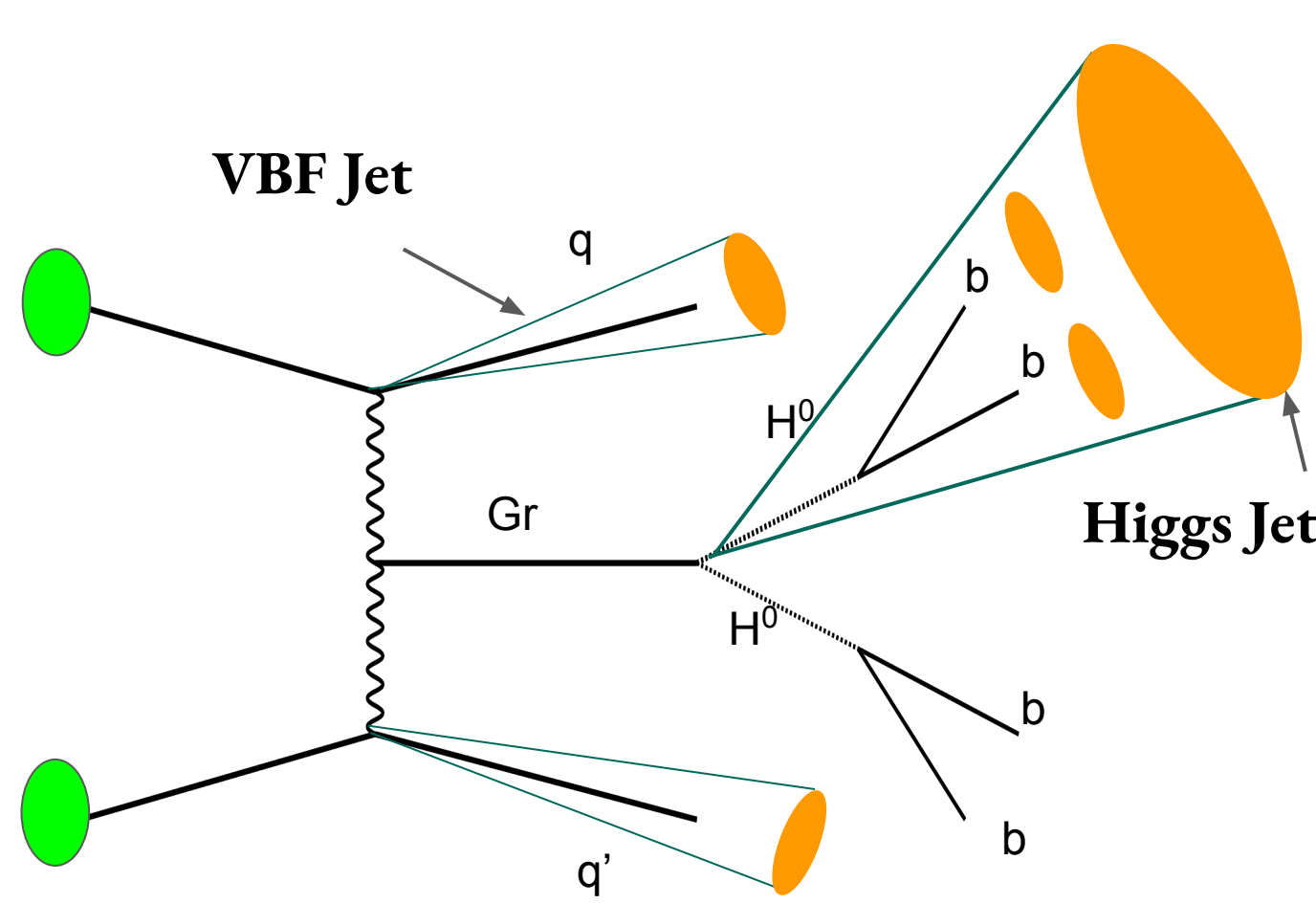
HH \rightarrow 4b Decay Channel

- Highest branching ratio (33%):
 - plenty of signal for study.
- With MIP timing detector (MTD):
 - Assume improvement in b-tagging performance
- Challenges:
 - Huge Multijets background contribution
 - Need proper background modelling

RESONANT SEARCHES

Warped Extra Dimension BSM Model:

- Predict spin-2 KK-Graviton particle
- Resonance may not couple to quarks and Gluons
 - VBF production might be dominant



Motivation:

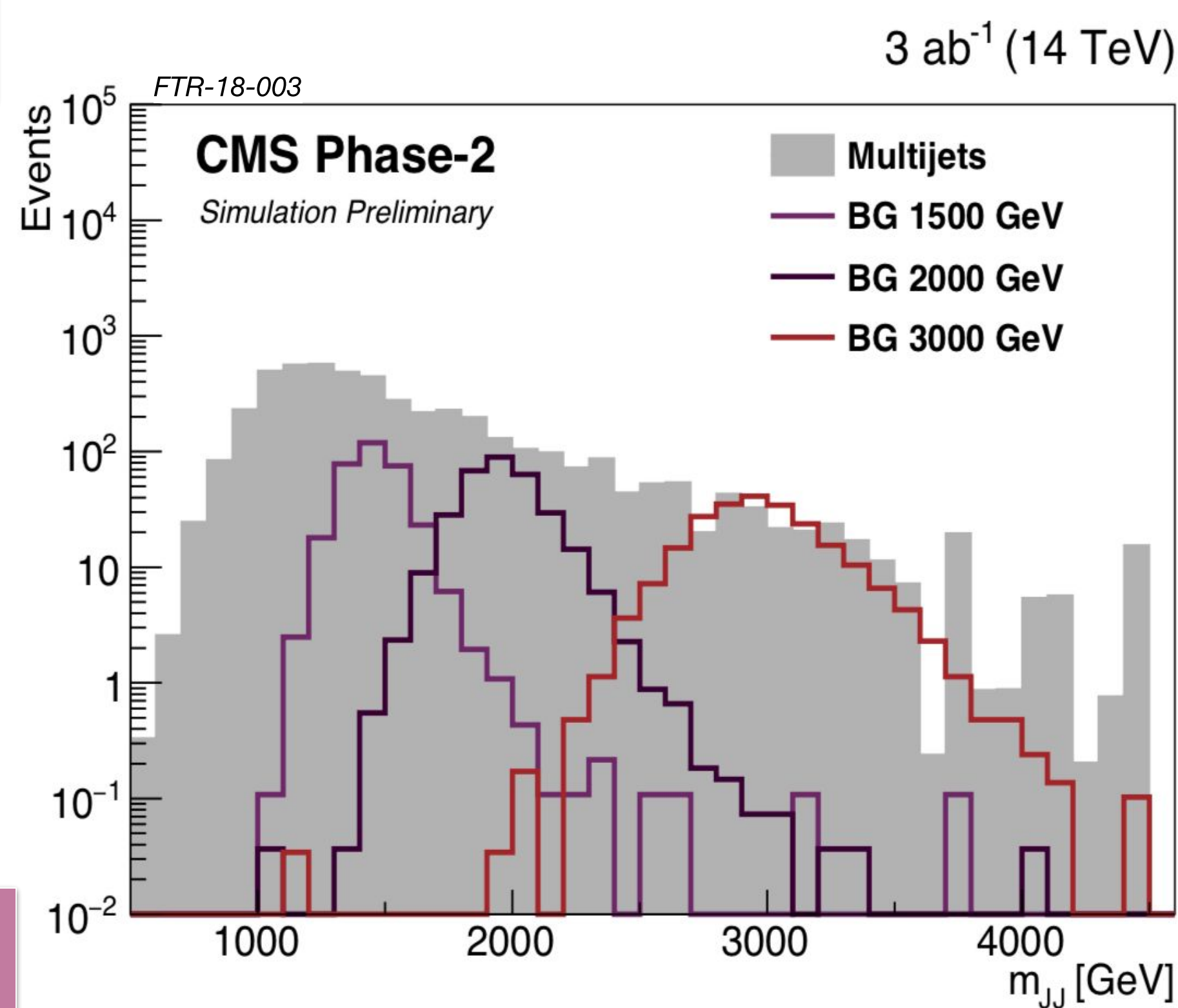
- VBF channel accessible at HL-LHC
- With CMS Phase-2 analysis benefits in:
 - Boosted $H \rightarrow bb$ tagging with extended tracker coverage
 - VBF Jets identification with HGCal

Event selections:

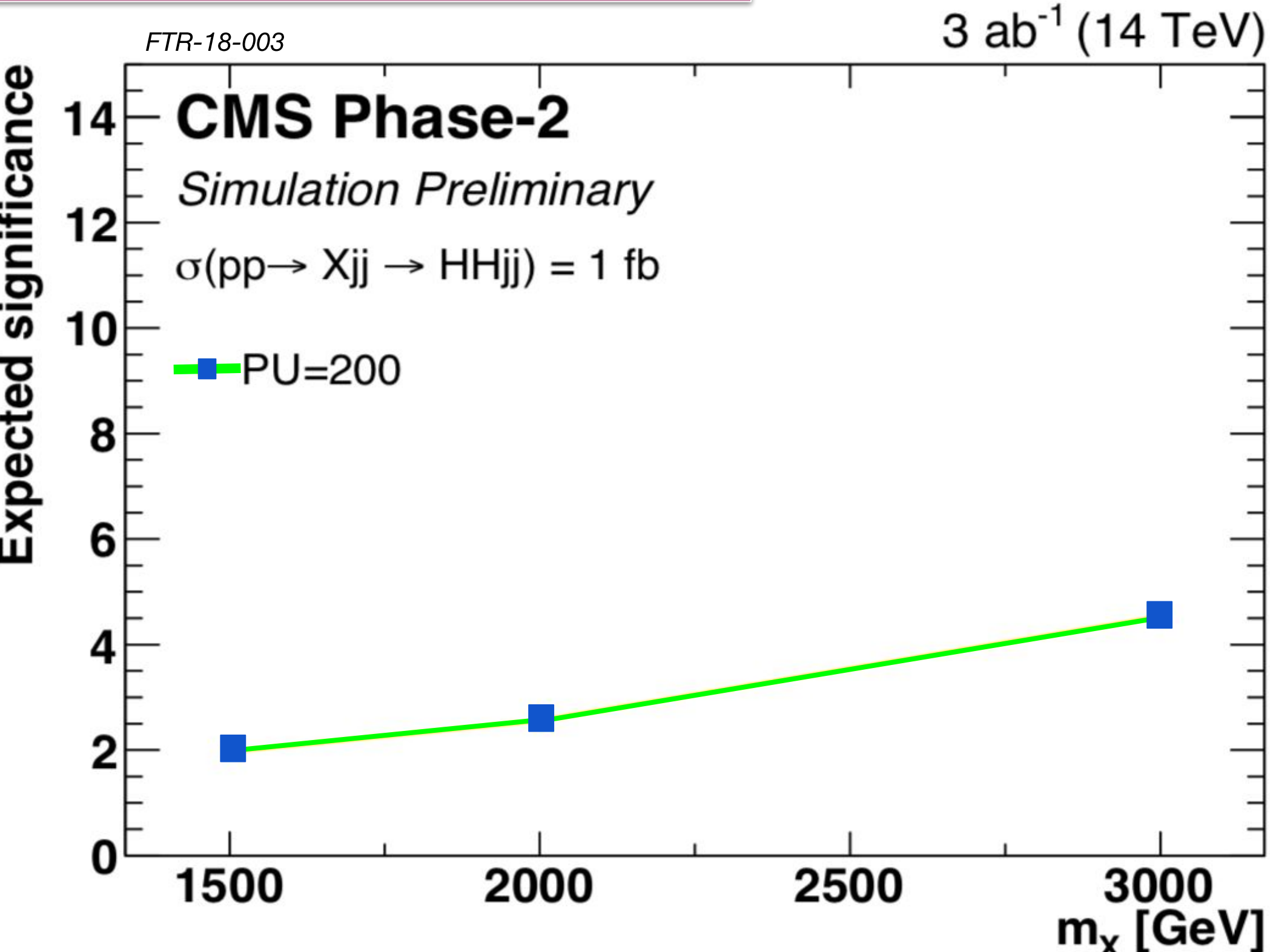
- Higgs Jet Selection:
 - AK8 Jets with $p_T > 300$ GeV
 - $|\eta| < 3$
 - NSubjettiness < 0.6
 - Soft-Dropped Mass = [90, 140]
 - Subjet b-tagging with DeepCSV
- VBF Jet Selection:
 - AK4 Jets with $p_T > 50$ GeV
 - $|\eta| < 5, \Delta\eta < 5$ & $\eta_{j1} * \eta_{j2} < 0$
 - $M_{jj} > 300$ GeV
 - $dR(Higgs\ Jet, AK4\ Jet) > 1.2$
- Categorisation based on b-tagged subjets: 3b and 4b

Results: M_{JJ} spectrum

- Background Estimation:
 - Background reweighted with subjet b-tagging efficiency for M_{JJ} -distribution

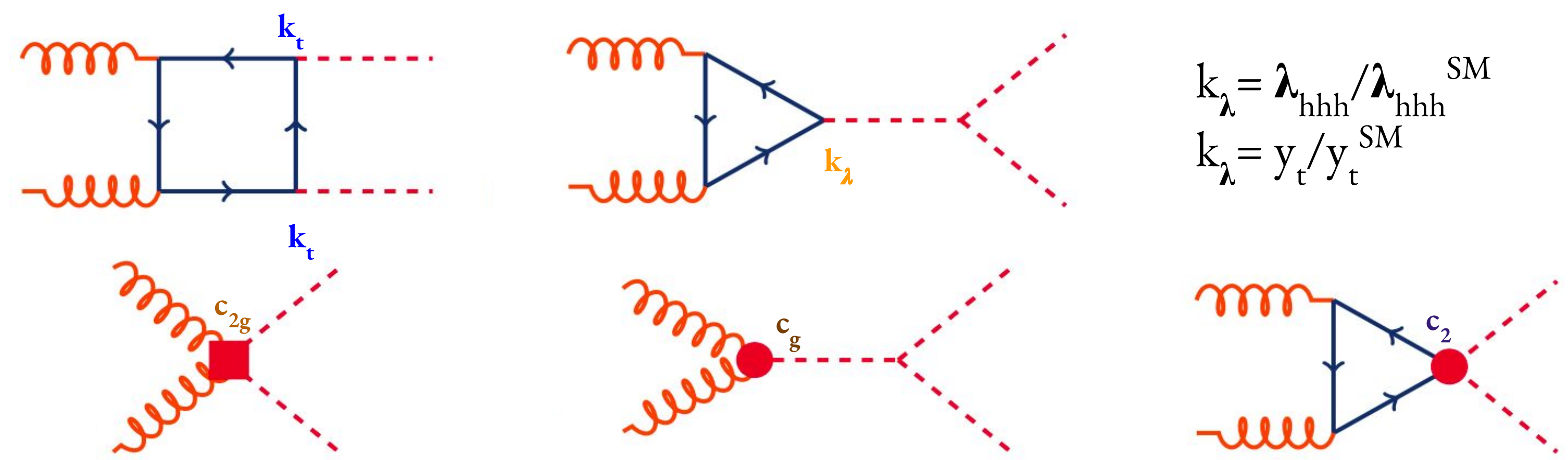


Results: Significance



- Calculated with 3b and 4b categories combinely.
- Possible Evidence of 3 TeV Graviton.

NON-RESONANT SEARCHES



Two analysis strategies: 1) Resolved 2) Boosted

Resolved topology

large sensitivity for SM HH signal

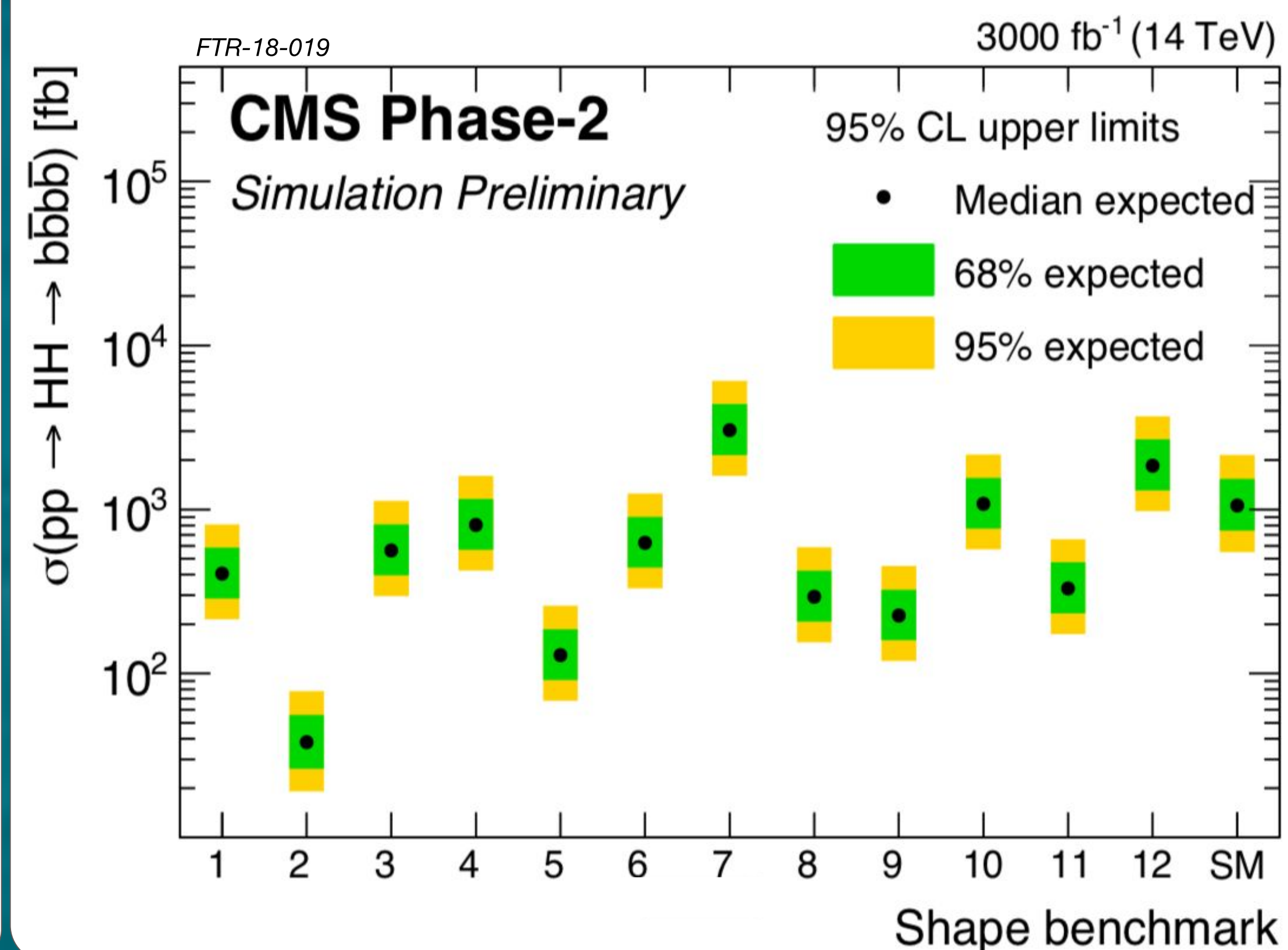
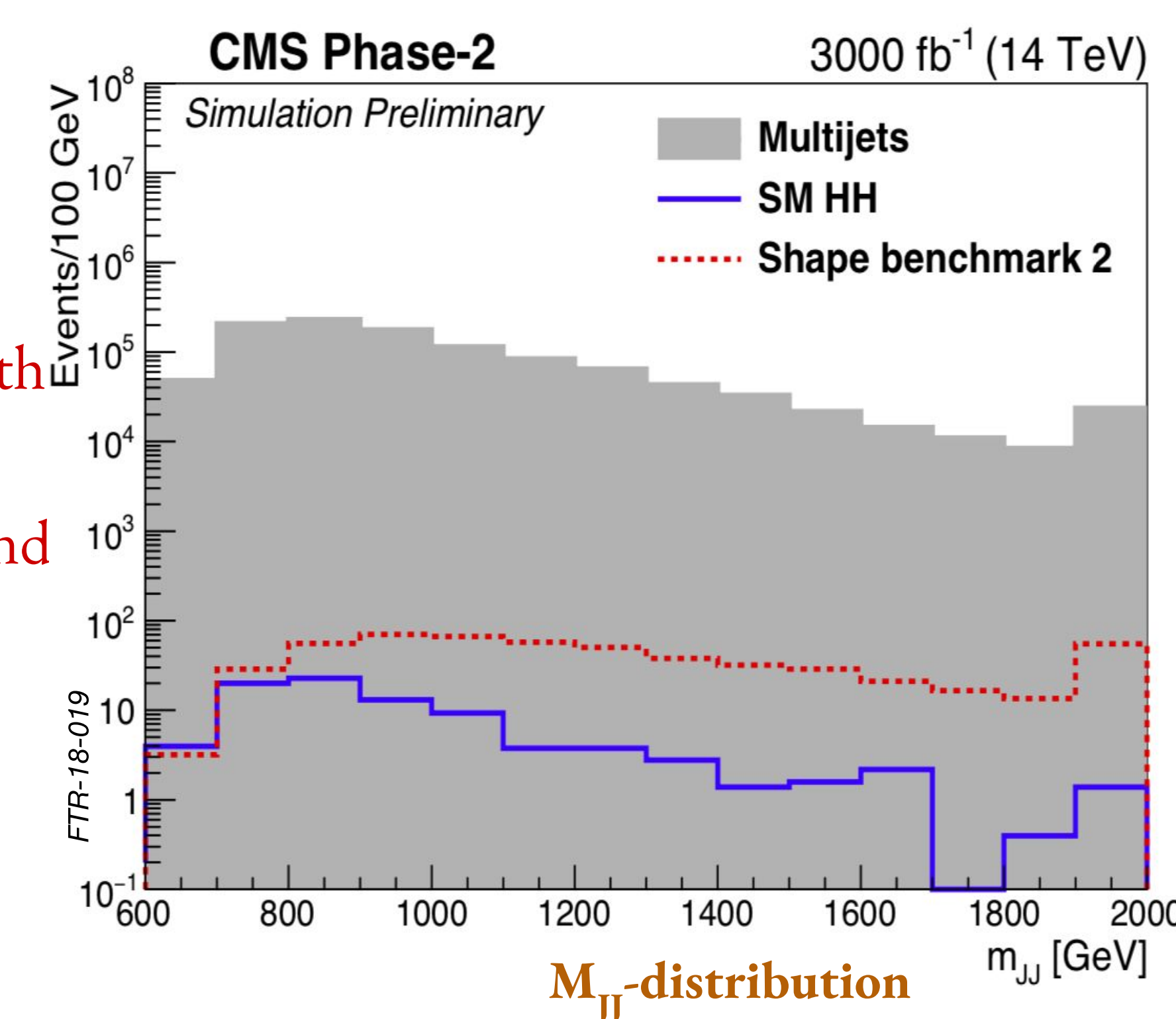
- Selections: Four jets with
 - $p_T > 45$ GeV & $|\eta| < 3.5$
 - Working point medium b-tagged including MTD information
- Multivariate Discriminator:
 - Boosted Decision trees (BDT) is used with optimized parameters

Channel	Significance		95% CL limit on $\sigma_{HH}/\sigma_{HH}^{SM}$	
	Stat. + syst.	Stat. only	Stat. + syst.	Stat. only
bbbb	0.95	1.2	2.1	1.6

- Projected confidence interval for k_λ , assuming SM like HH signal
 - [-1.0, 7.27] at 68% CL: bbbb channel
 - [0.35, 1.9] at 68% CL: combination of all HH decay channel

Boosted topology

- Suppress multijet backgrounds
- Enhancement in cross-section with EFT contact interactions
- Focus on anomalous couplings and BSM shape benchmarks:
 - depends on sets of coupling parameters ($k_\lambda, k_t, c_g, c_{2g}, c_2$)
- Similar analysis strategy as Resonant searches



- Upper limits on the cross section for SM+BSM shape benchmark with boosted regime

REFERENCES:

1. Search Sensitivity for BSM resonances in 4b final state at HL-LHC - CMS PAS FTR-18-003
2. HH measurements at HL-LHC - CMS PAS FTR-18-019

3. Gravity Particles from Warped Extra Dimensions, Prediction for LHC, arXiv:1404.0102
4. Analytical parametrization and shape classification of anomalous HH production in the EFT approach - LHCHSWG-2016-001, arXiv:1608.06578