ATLAS EXPERIMENT

Search for rare and exotic Higgs boson decay modes and Higgs boson pair production with the ATLAS detector

Jason Veatch
University of Göttingen
(AG Lai)

on behalf of the ATLAS collaboration

Bundesministerium für Bildung und Forschung

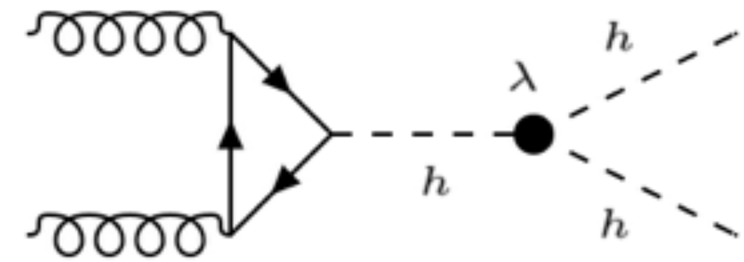
BMBF-Forschungsschwerpunkt ATLAS-EXPERIMENT
Physik bei höchsten Energien mit dem ATLAS-Experiment am LHC

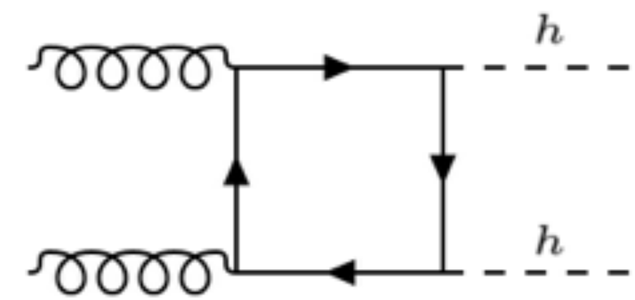
FSP 103 ATLAS

Di-Higgs searches

SM (non-resonant) di-Higgs production:

- Direct measurement of λ_h
- Interference with box diagram





Di-Higgs searches

SM (n

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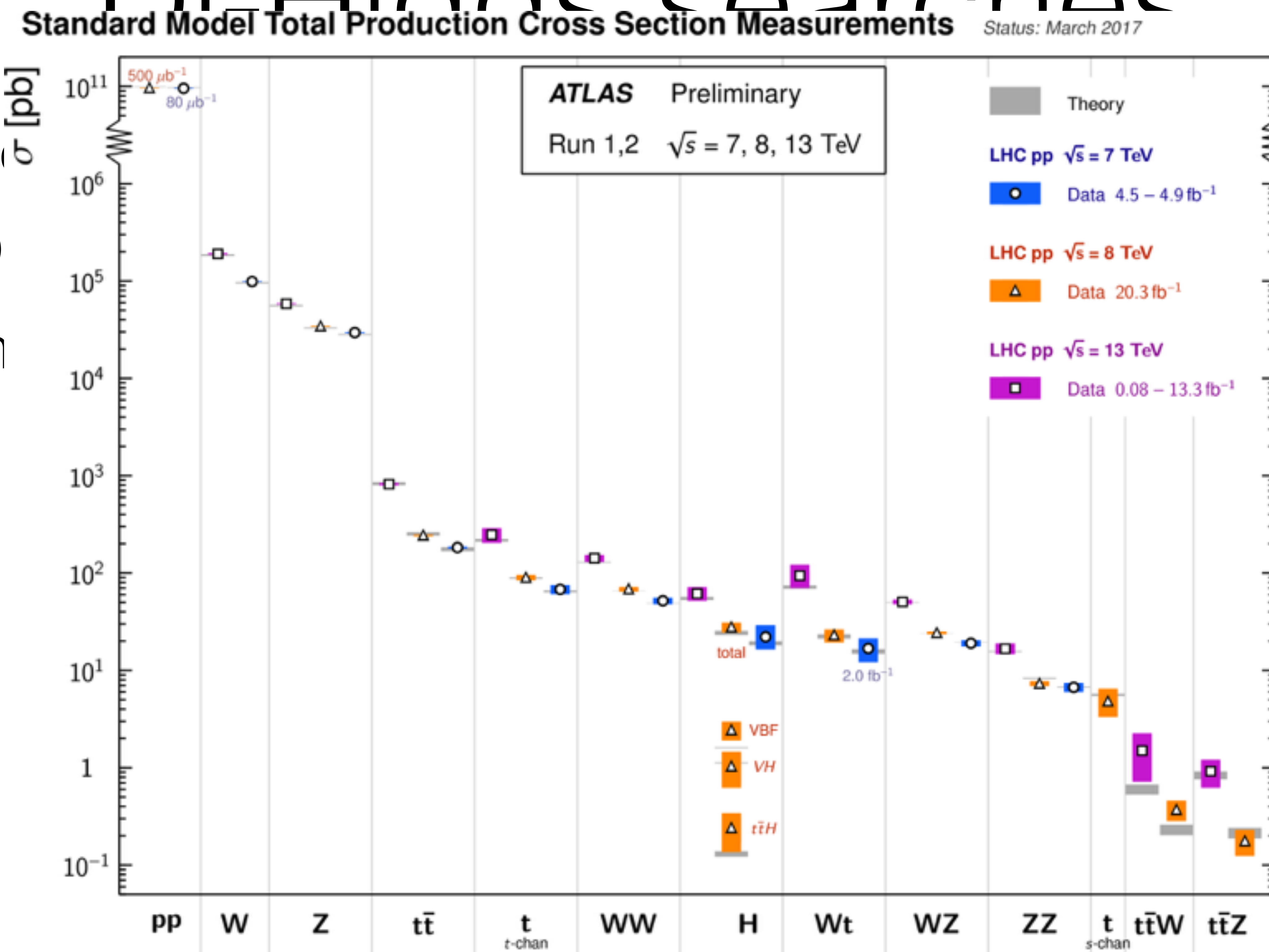

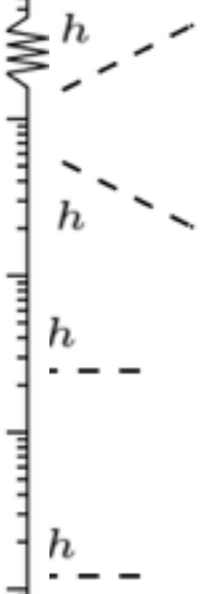

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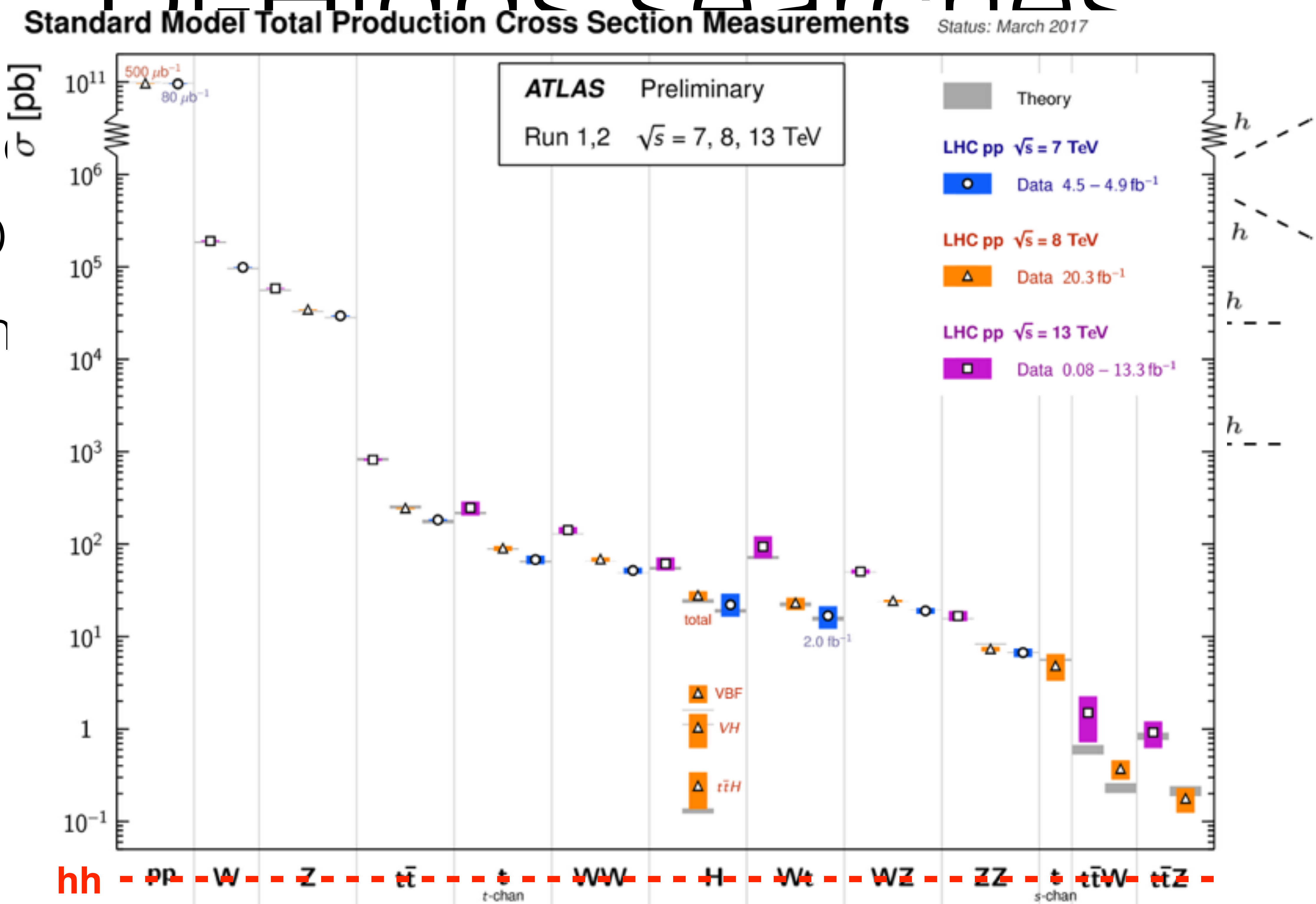

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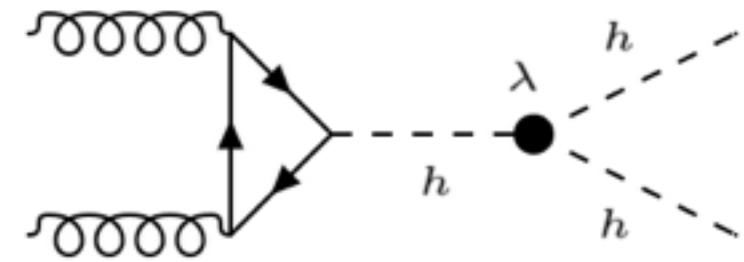

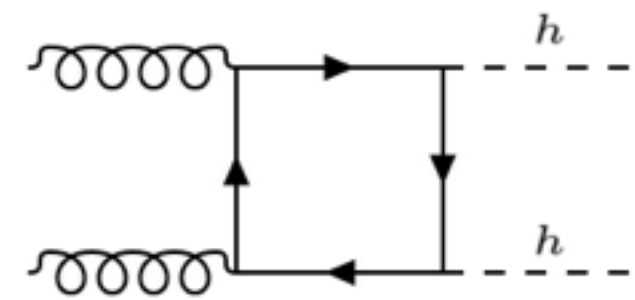

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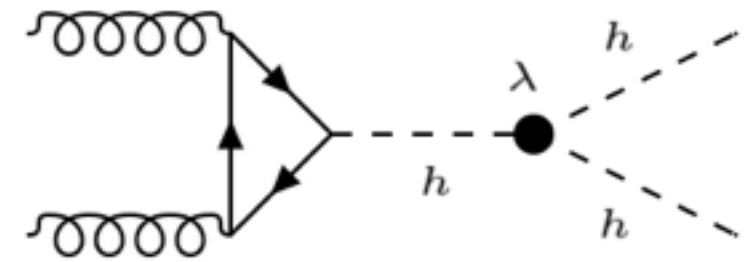

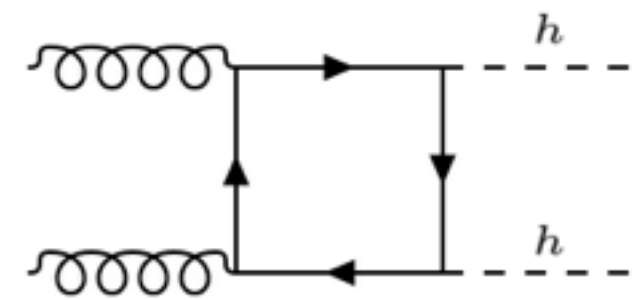

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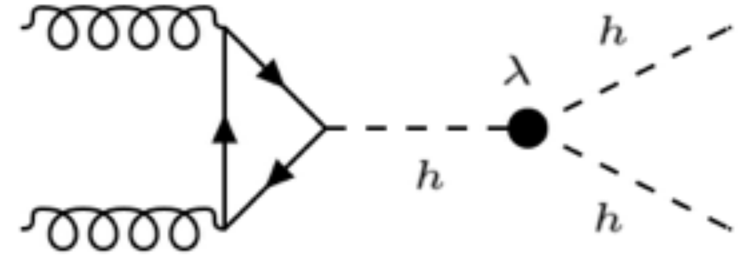

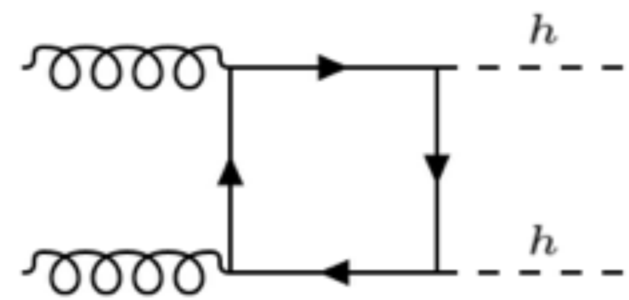

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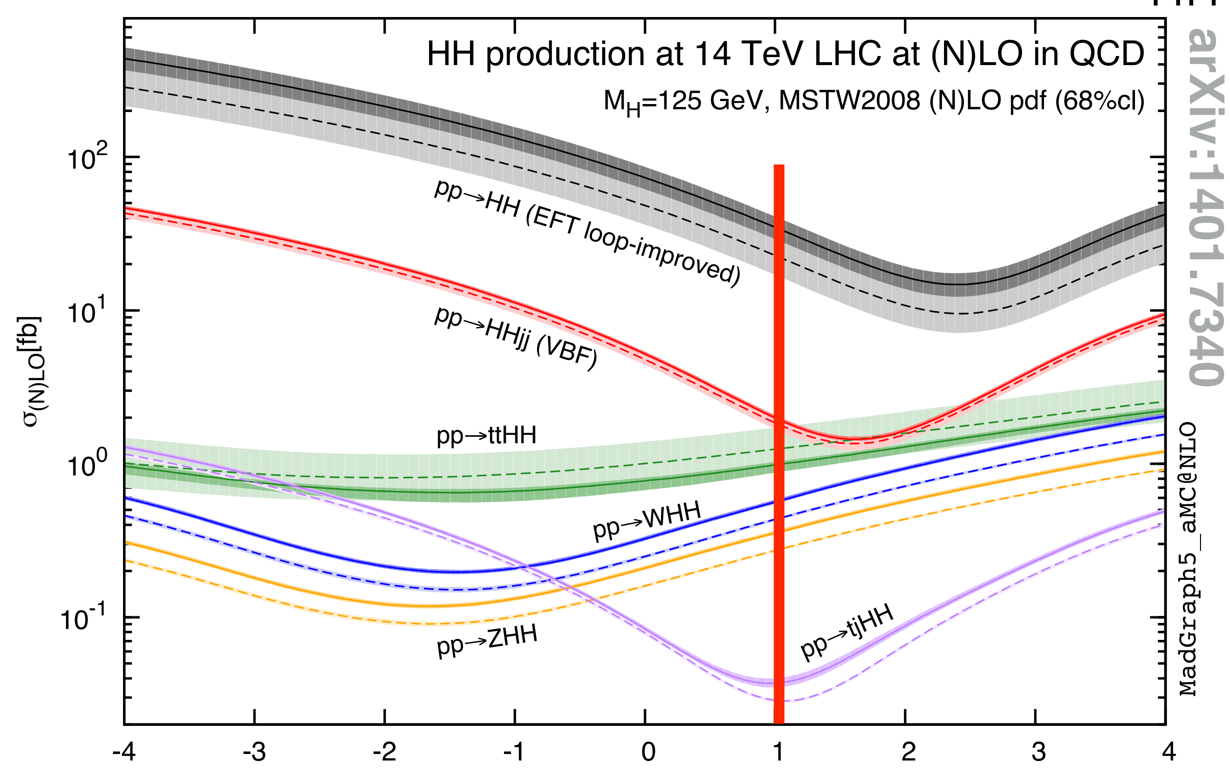

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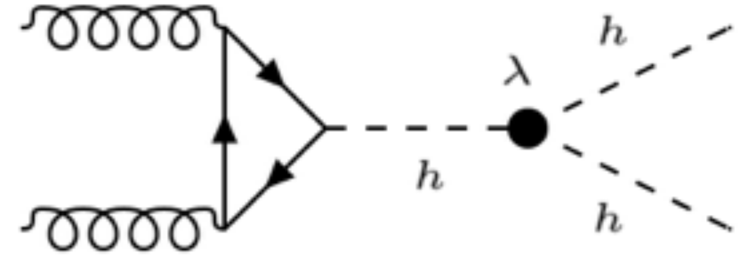

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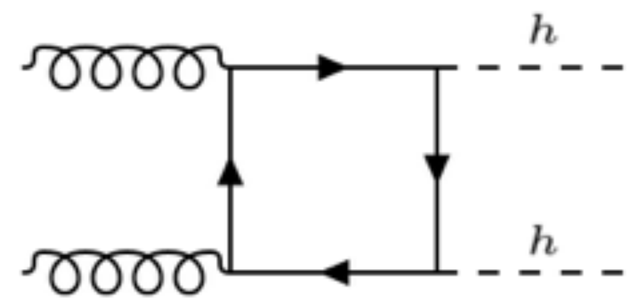

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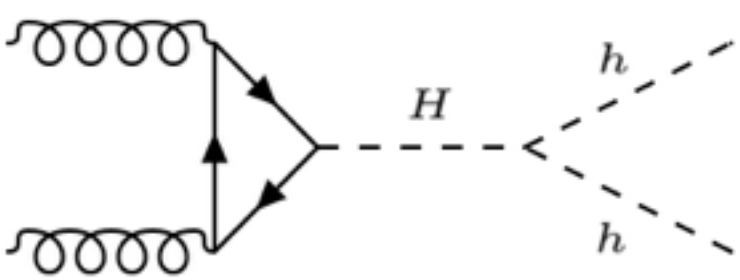

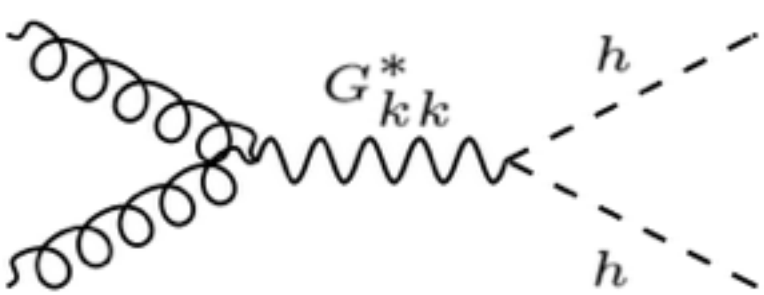

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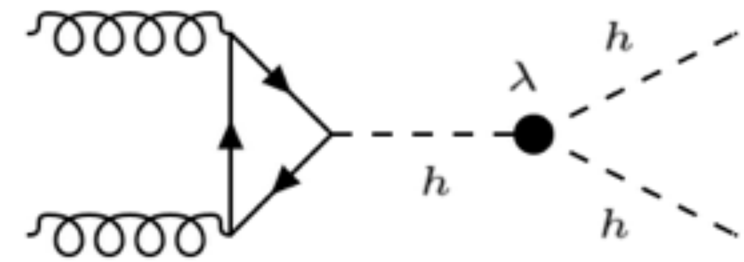

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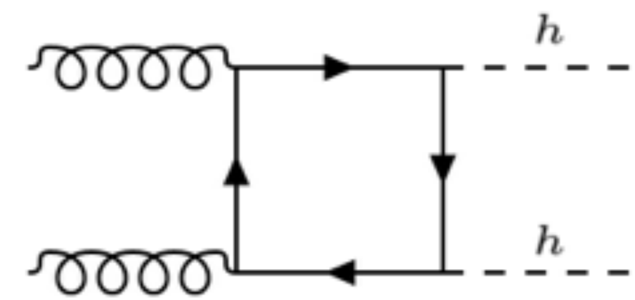

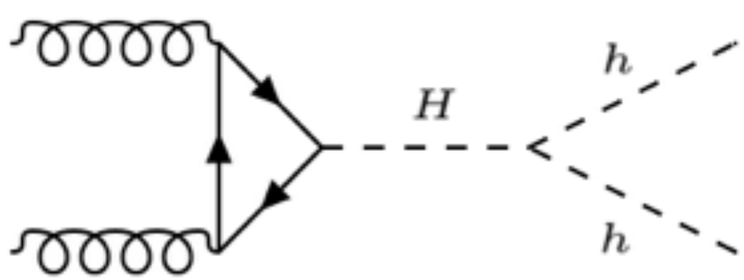

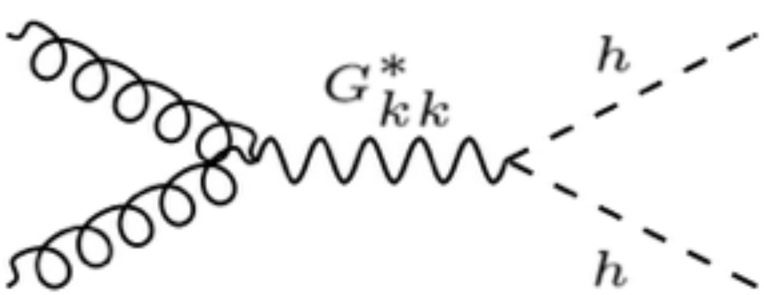

Resonant BSM di-Higgs production:

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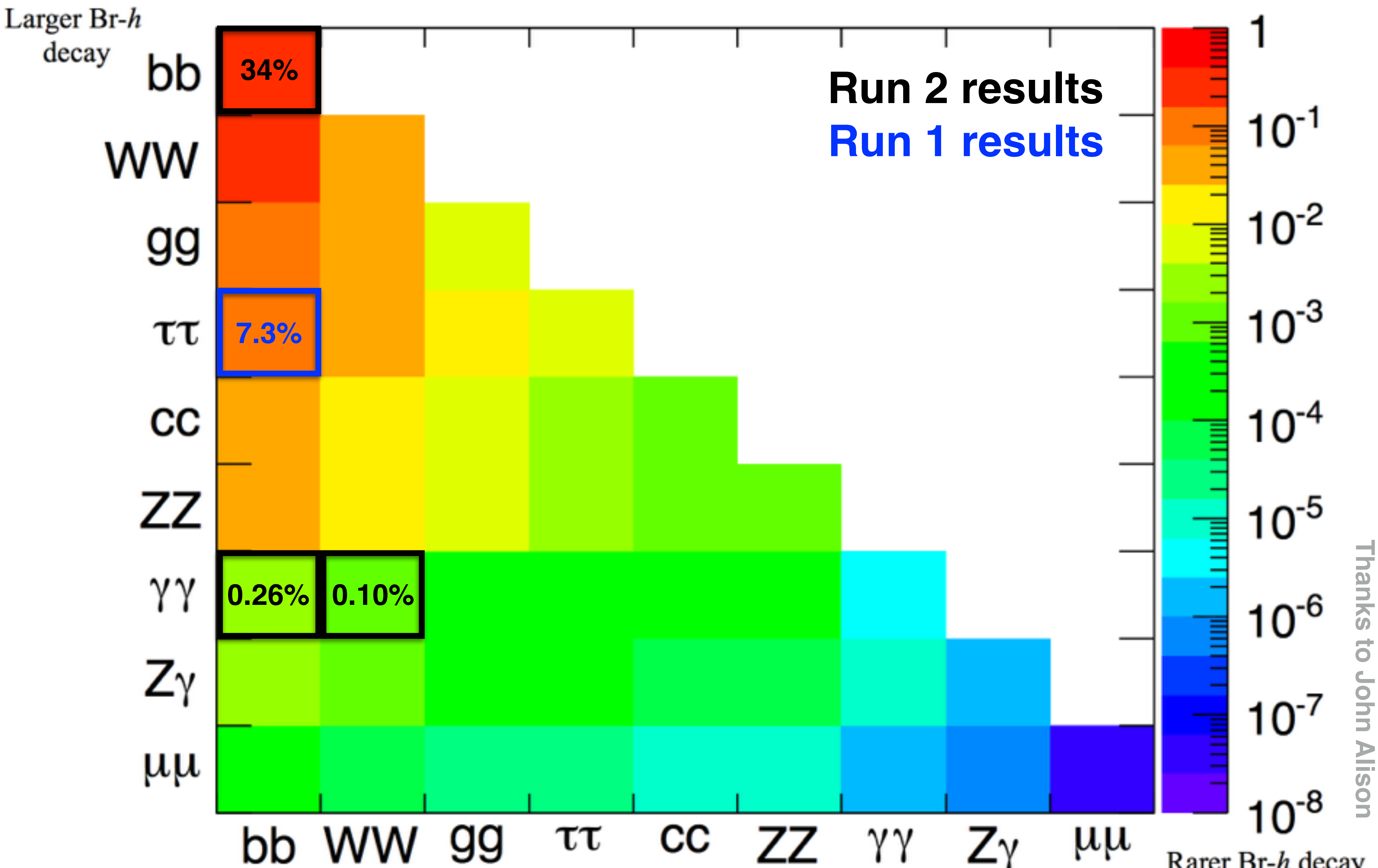
- Boosted topologies can be used
  - Background suppression

Di-Higgs search channels



hh → 4b

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- **ATLAS-CONF-2016-049** - 13.3 fb^{-1}

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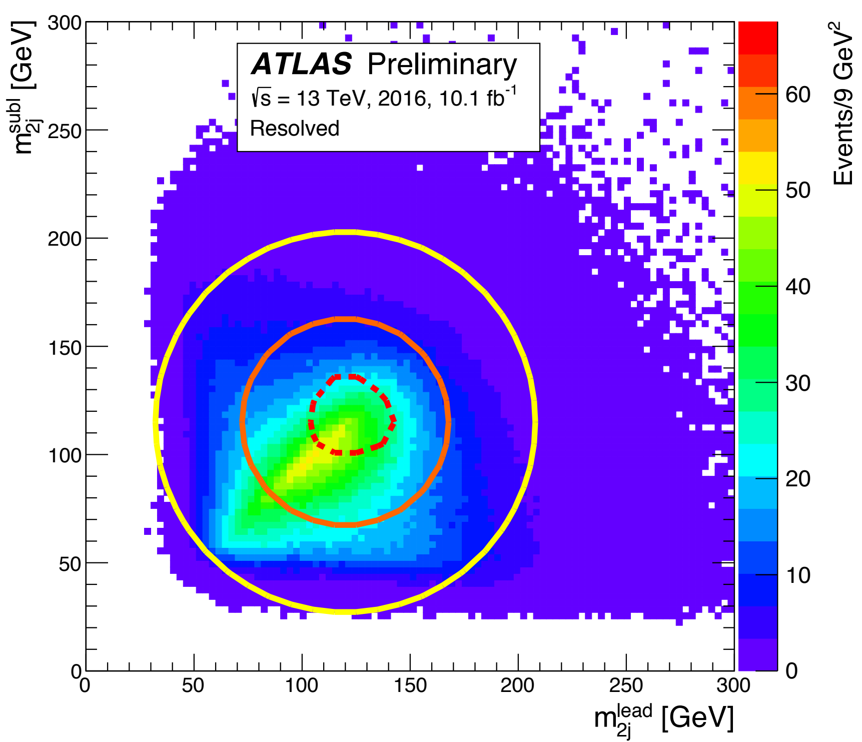

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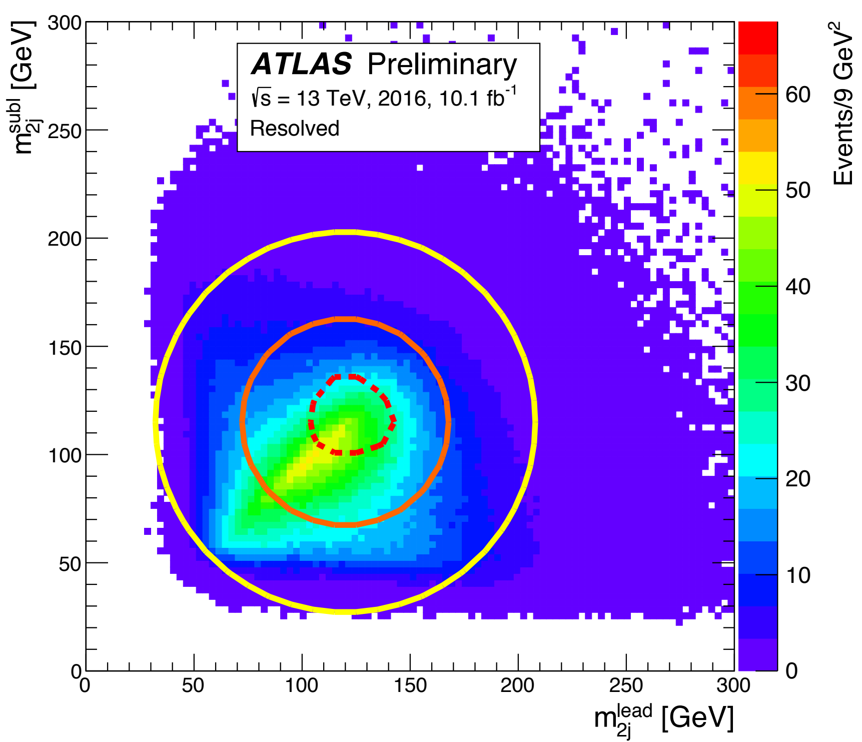

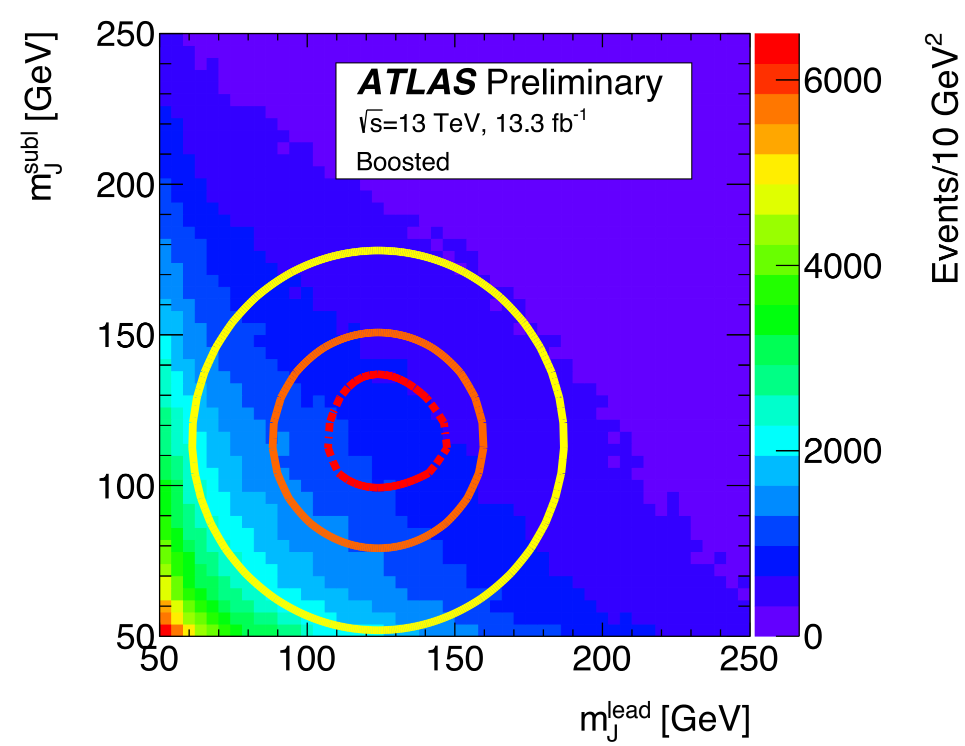

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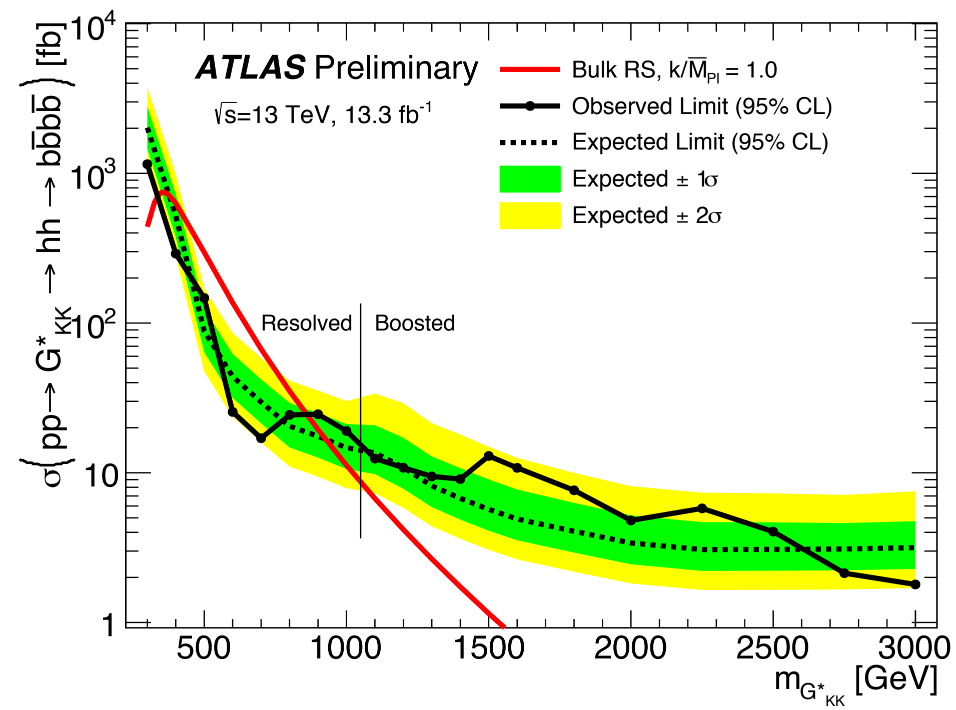

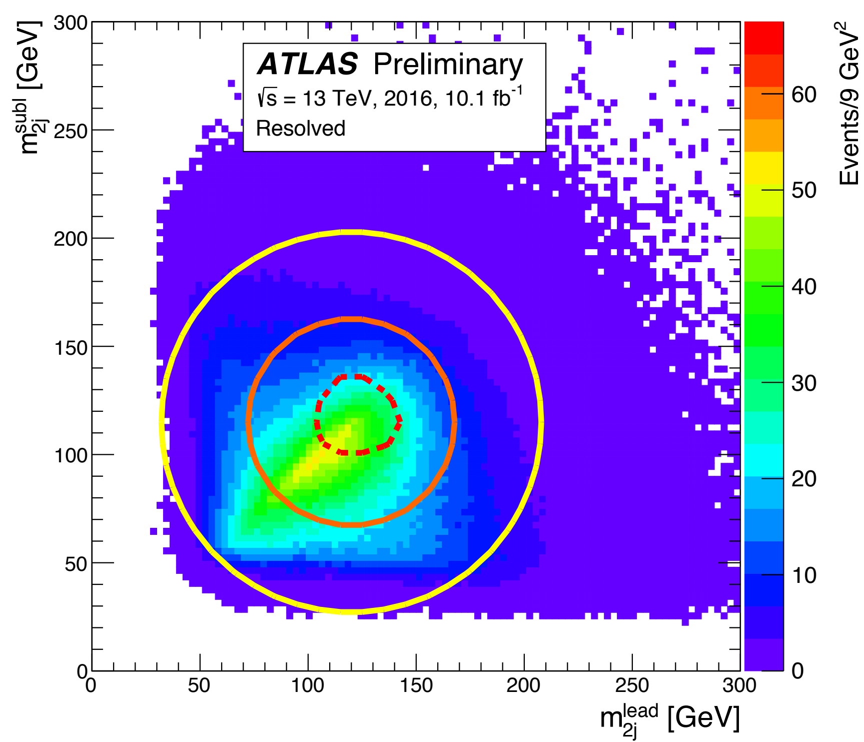

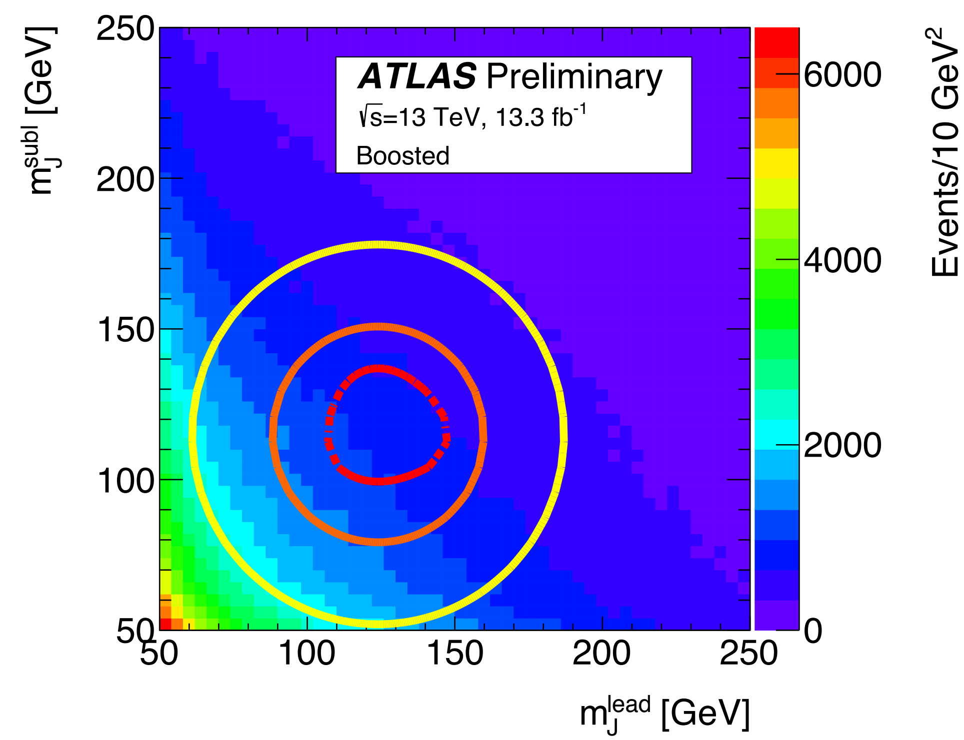

hh → γγbb

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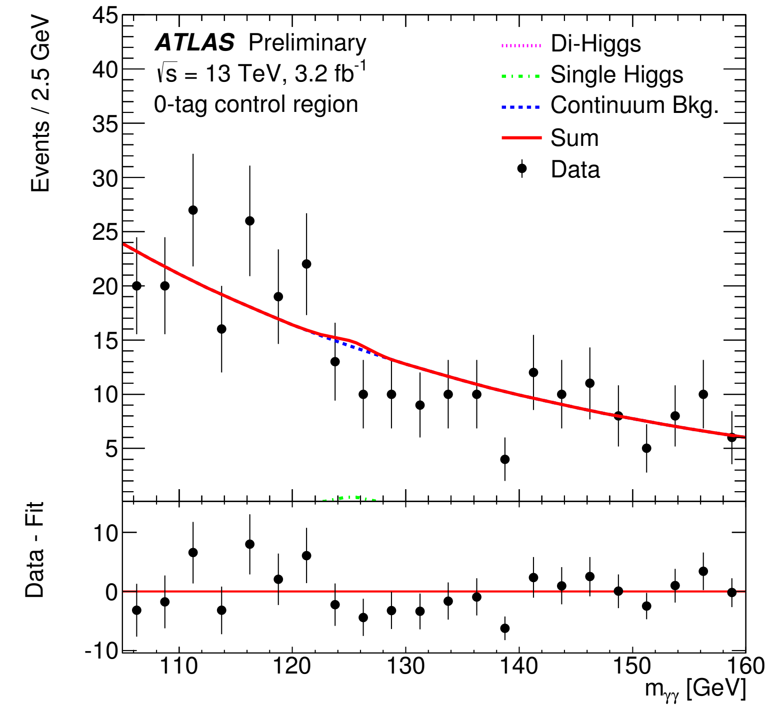

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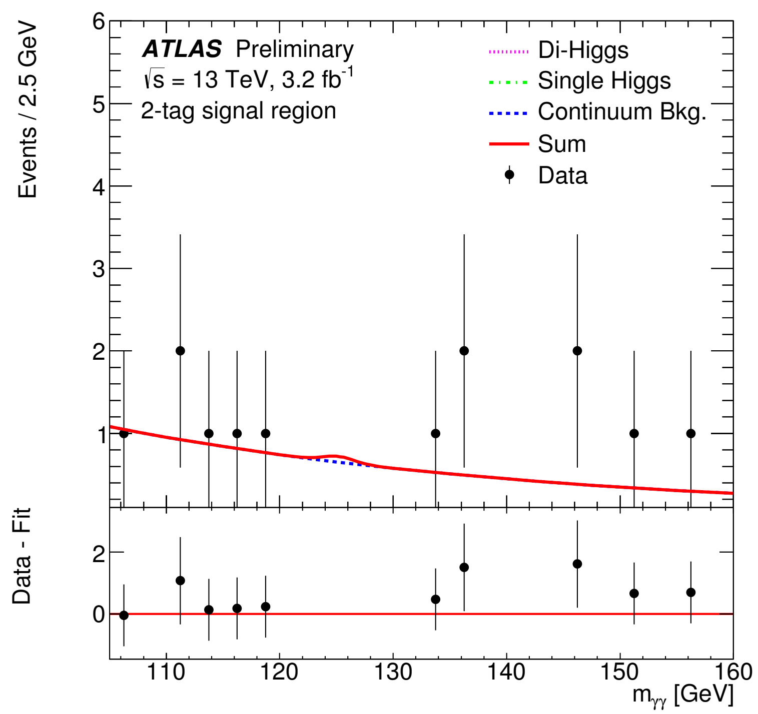
  - Shape in 0 b-tag region, normalization obtained in the signal region



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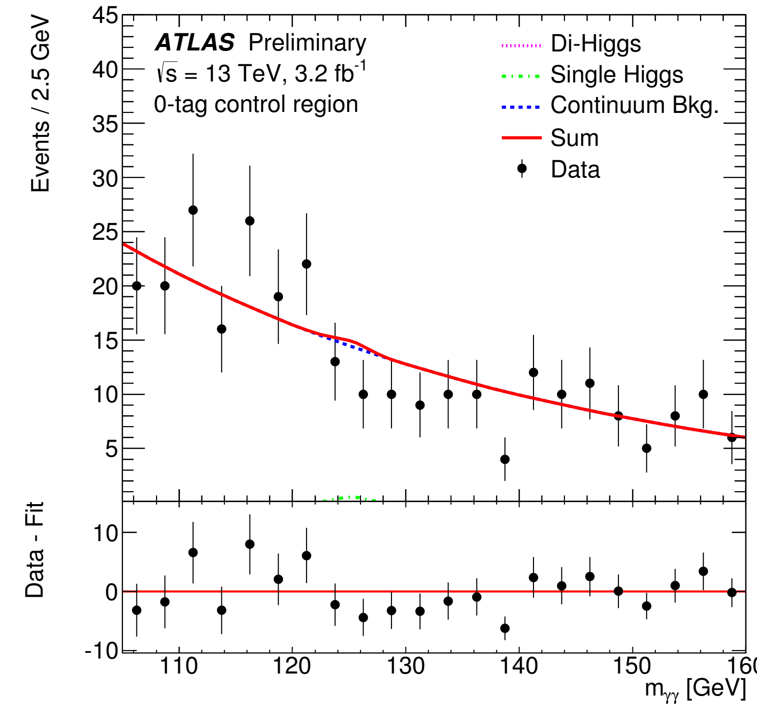
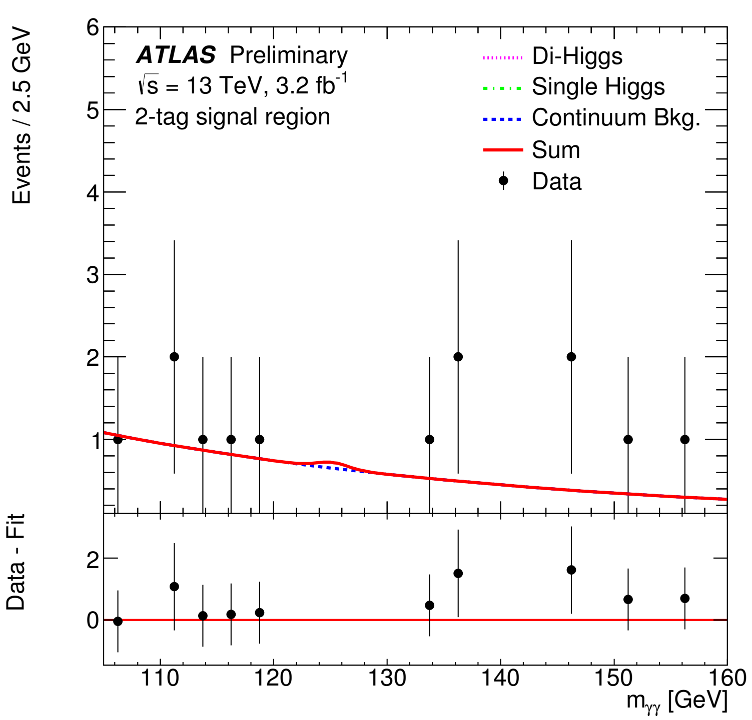
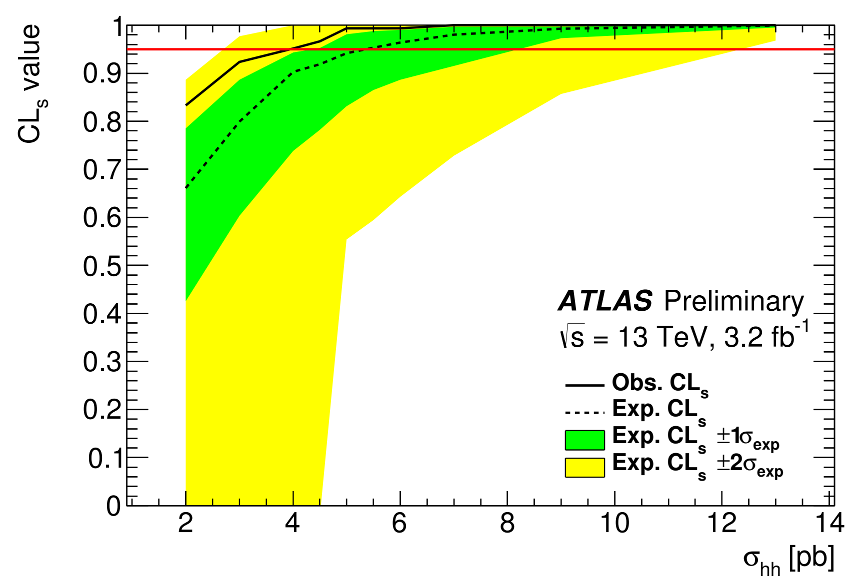
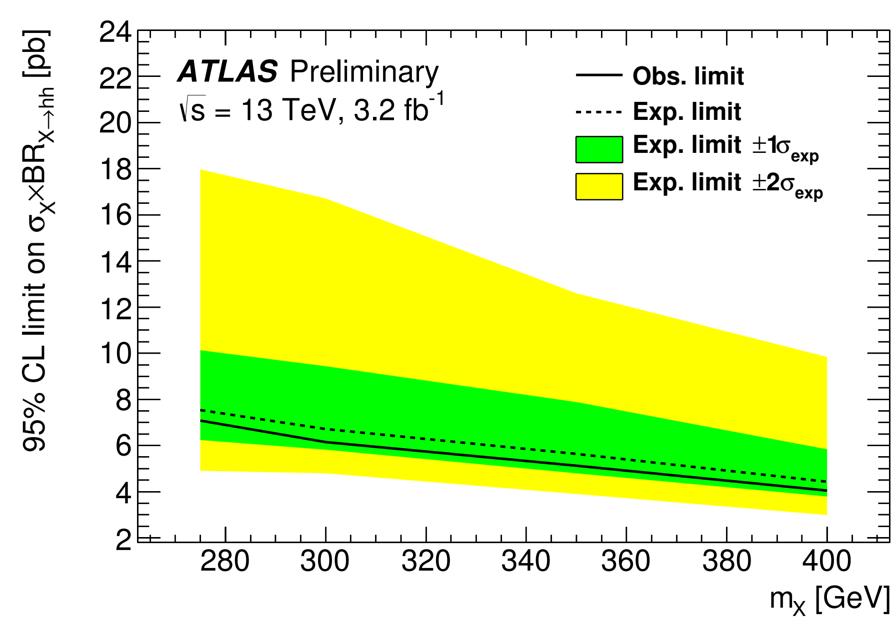


Obs. non-res limit:
$\sigma/\sigma_{SM} < 117$







hh → γγWW*

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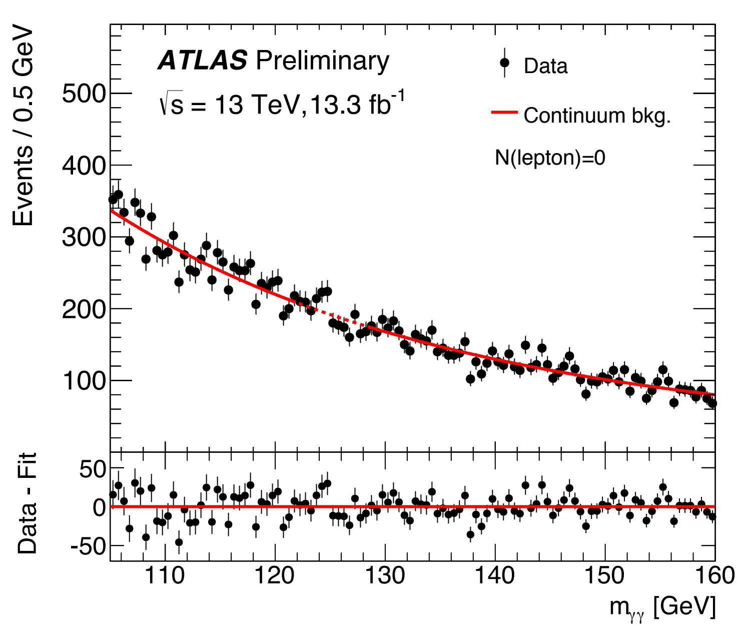

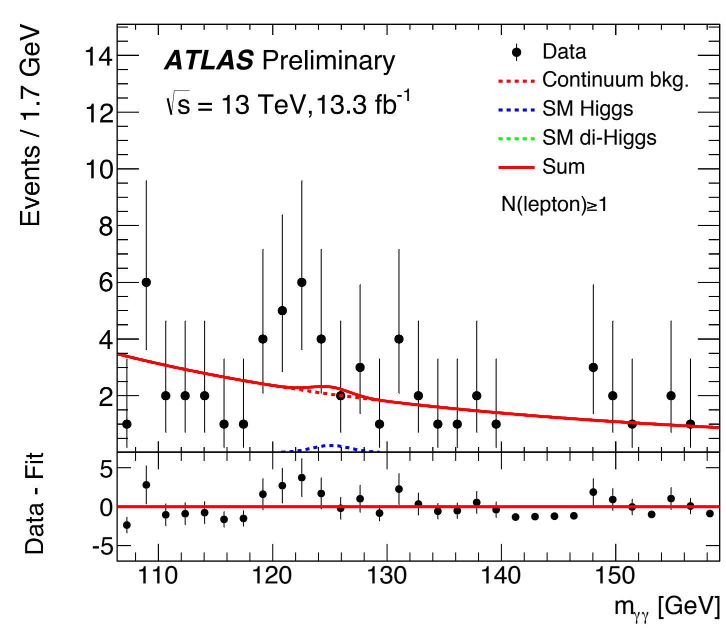

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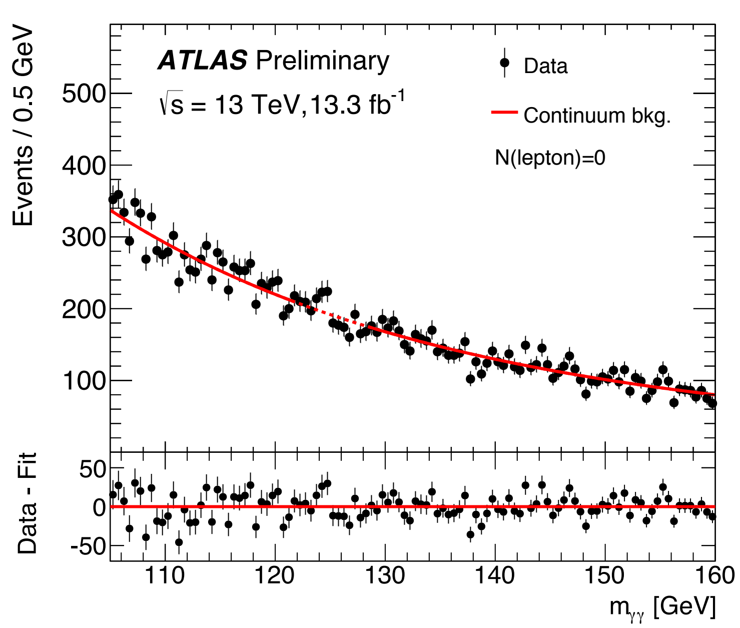

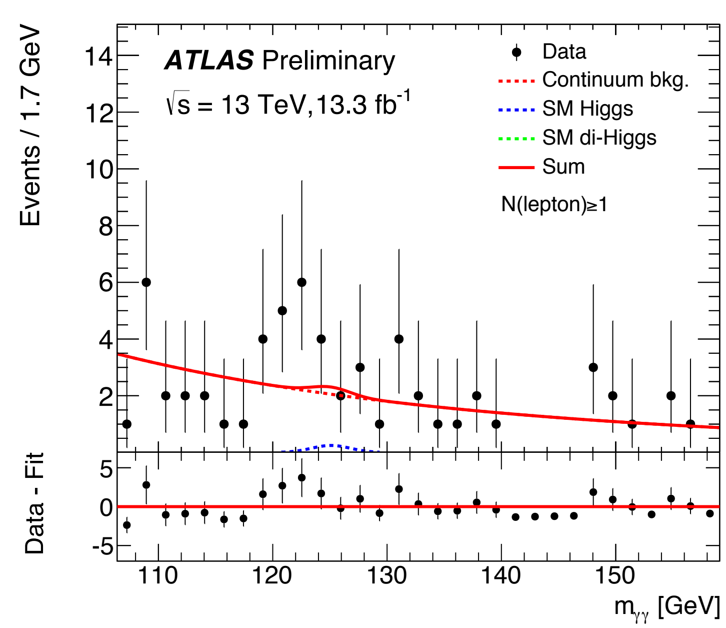

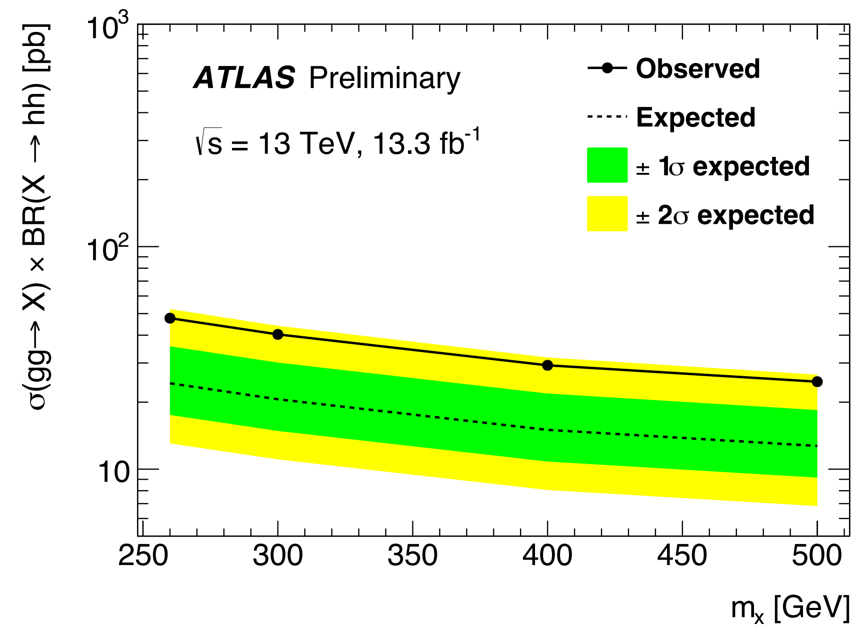

Obs. non-res limit: $\sigma/\sigma_{SM} < 747$

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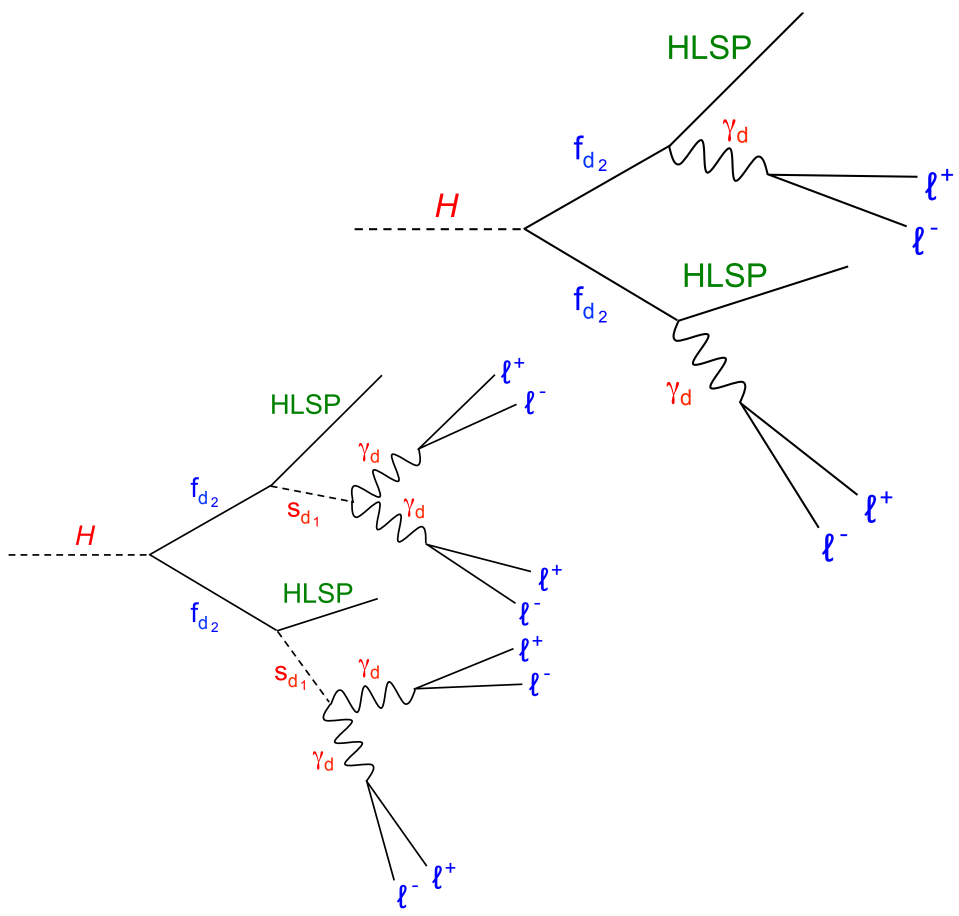

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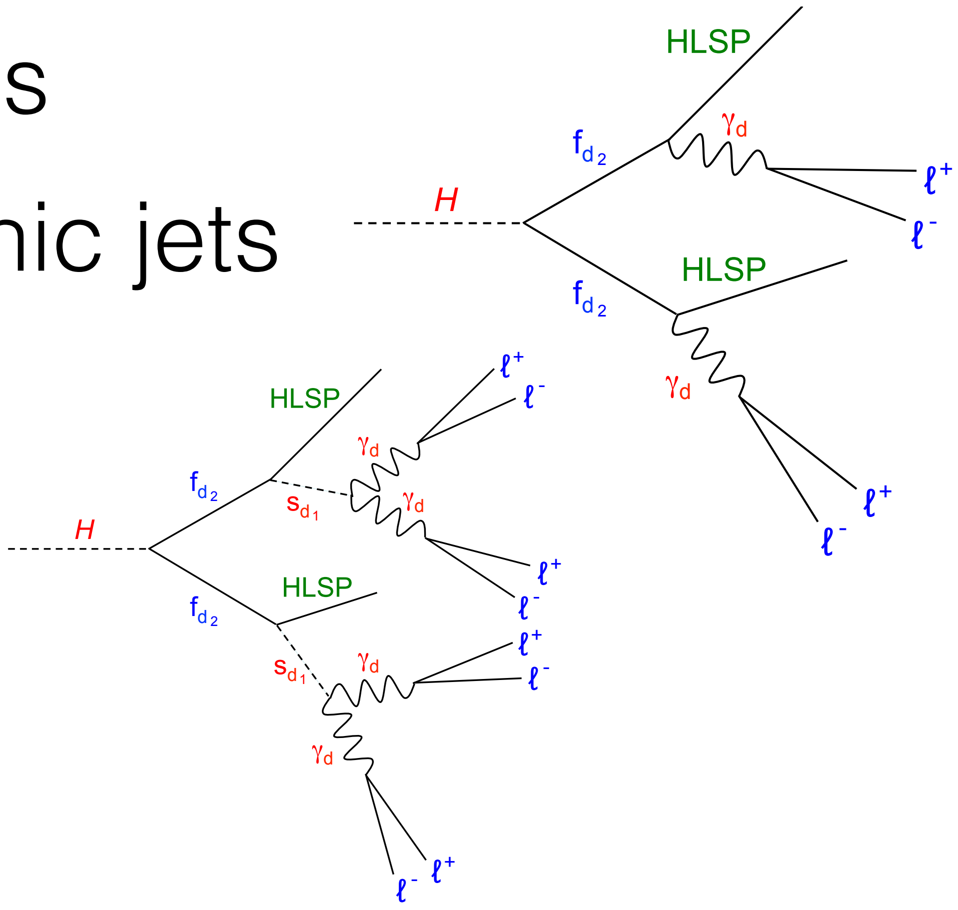

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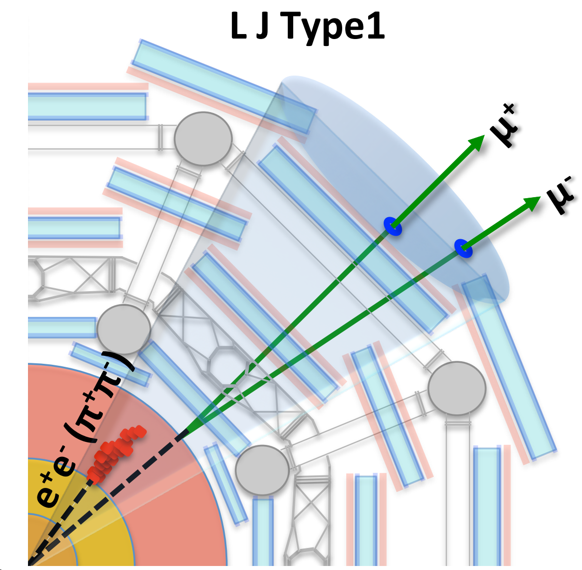

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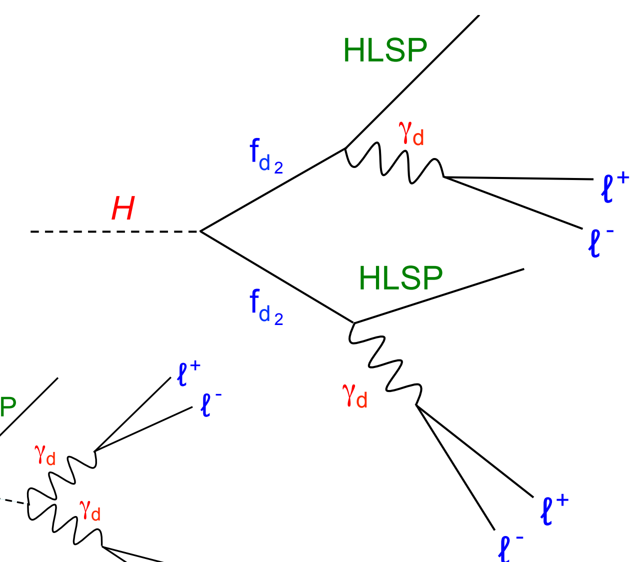

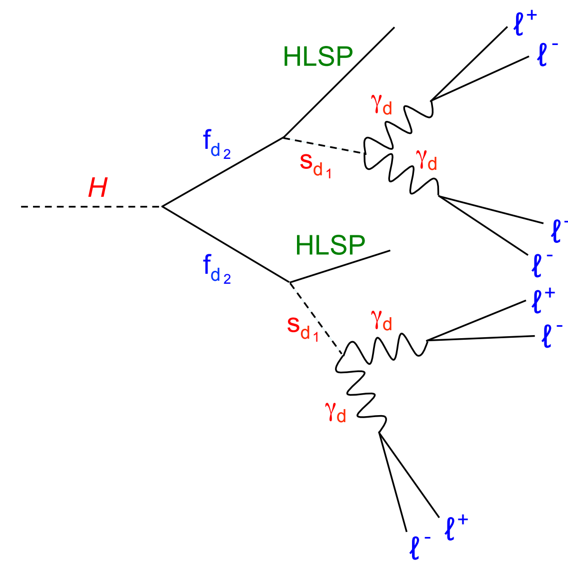

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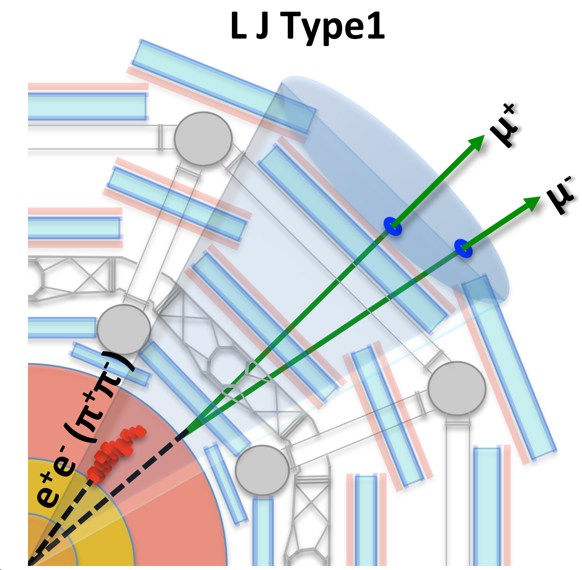

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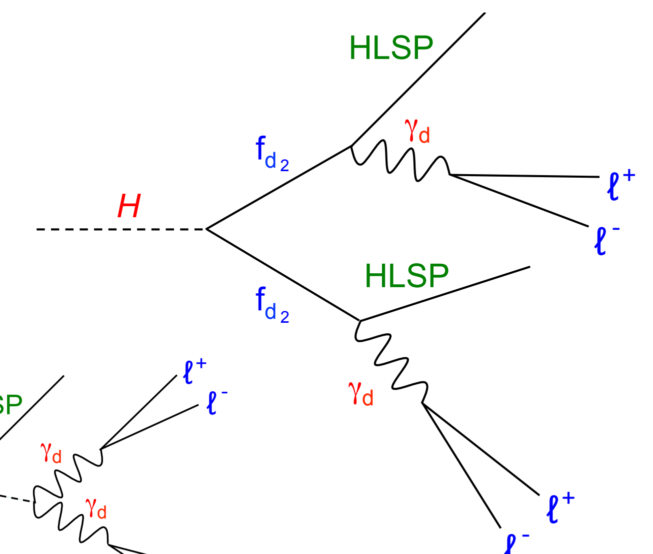

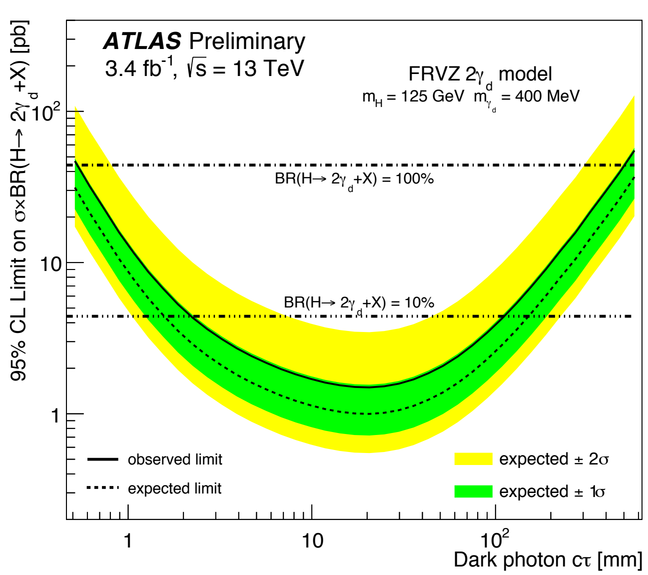

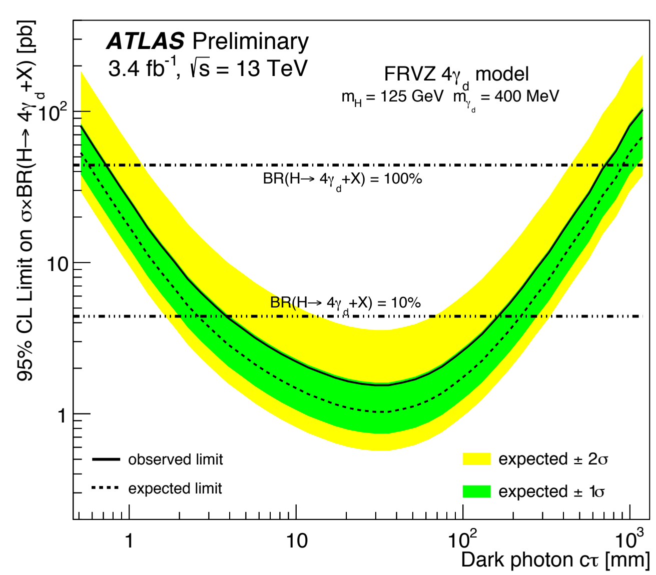

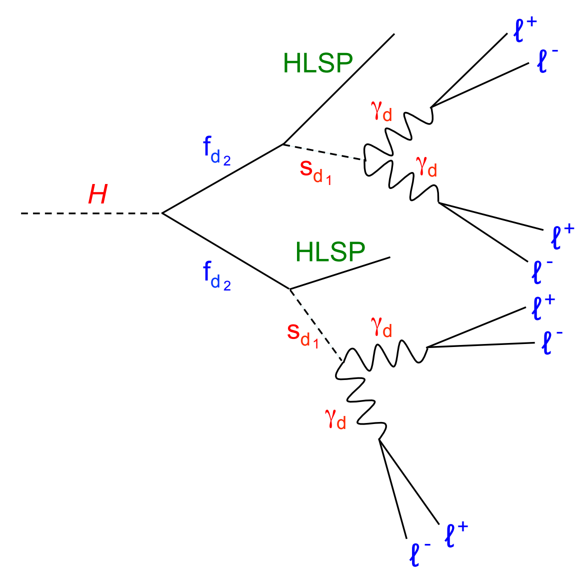

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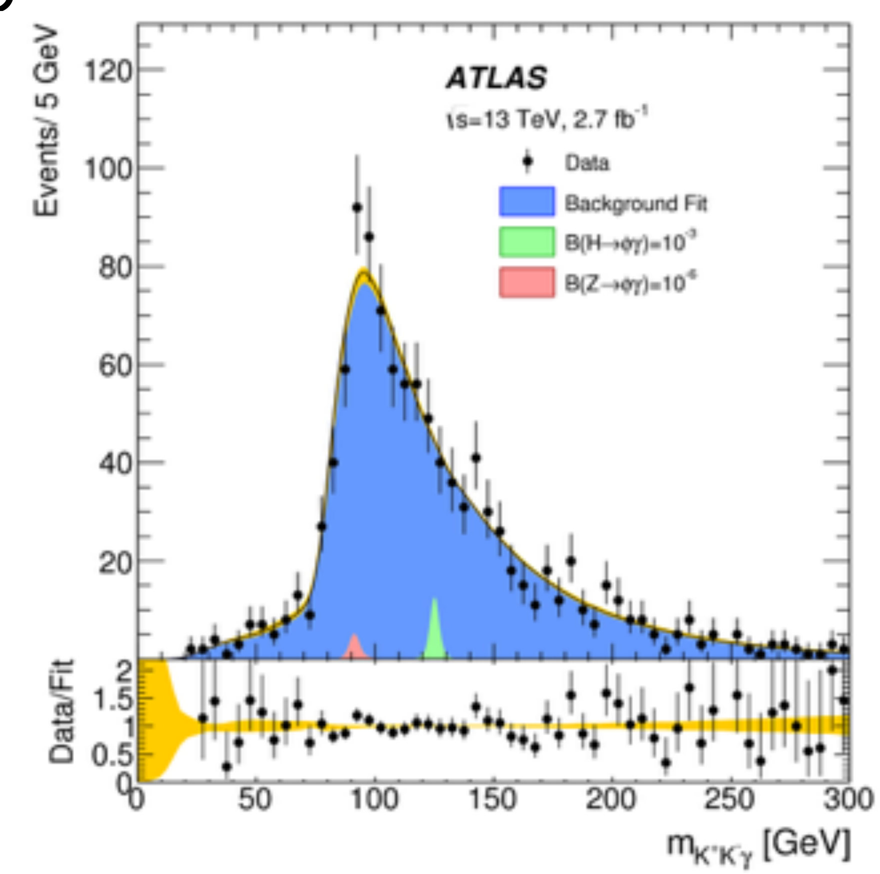

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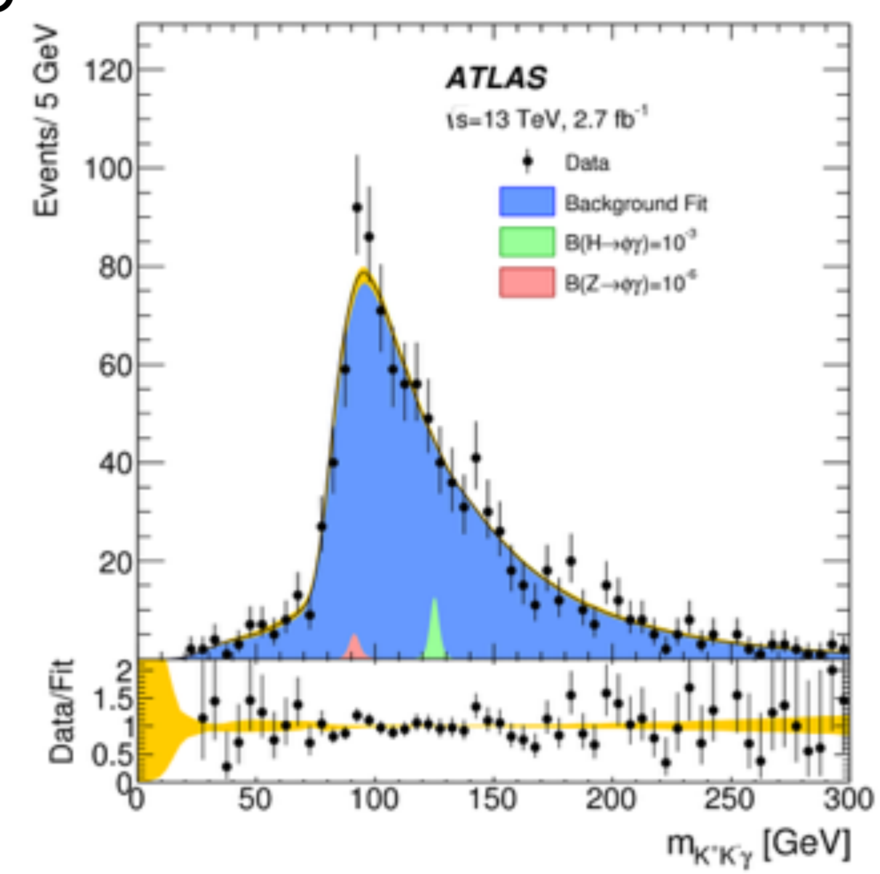
Observed limits:

$BR(h \rightarrow \phi\gamma) < 1.4 \times 10^{-3}$

$BR(Z \rightarrow \phi\gamma) < 8.3 \times 10^{-6}$



h → aa → 4b

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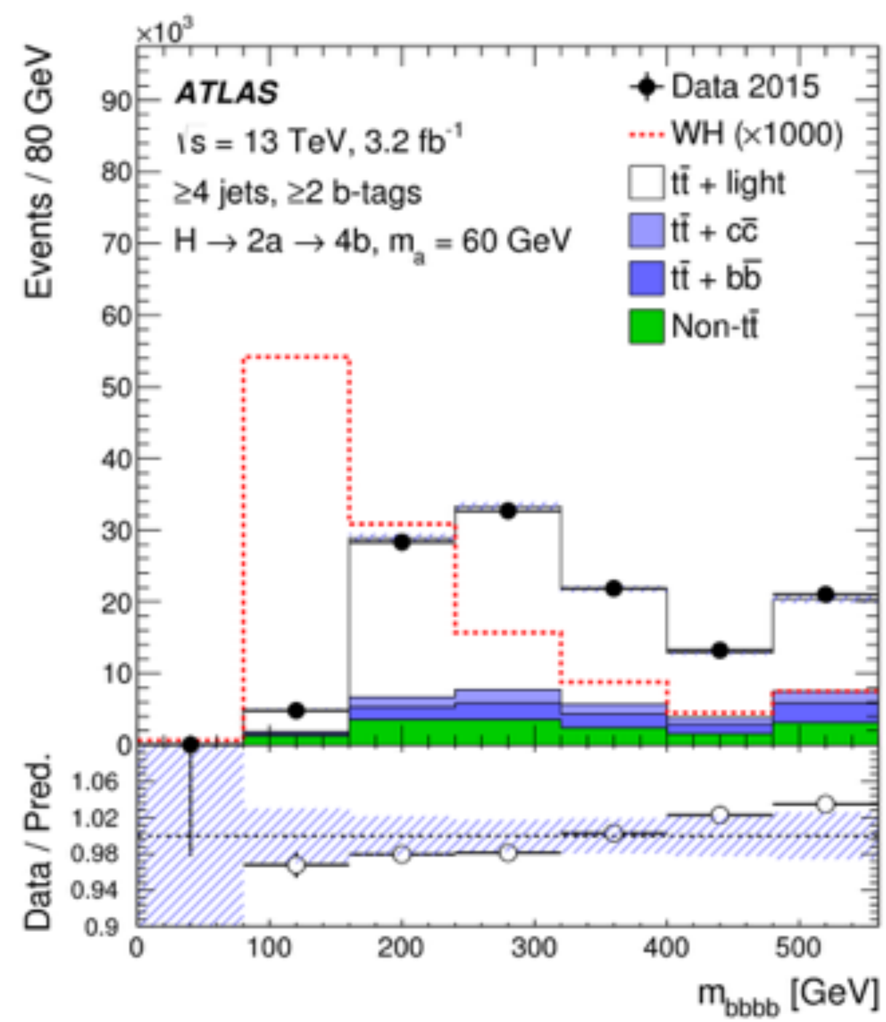

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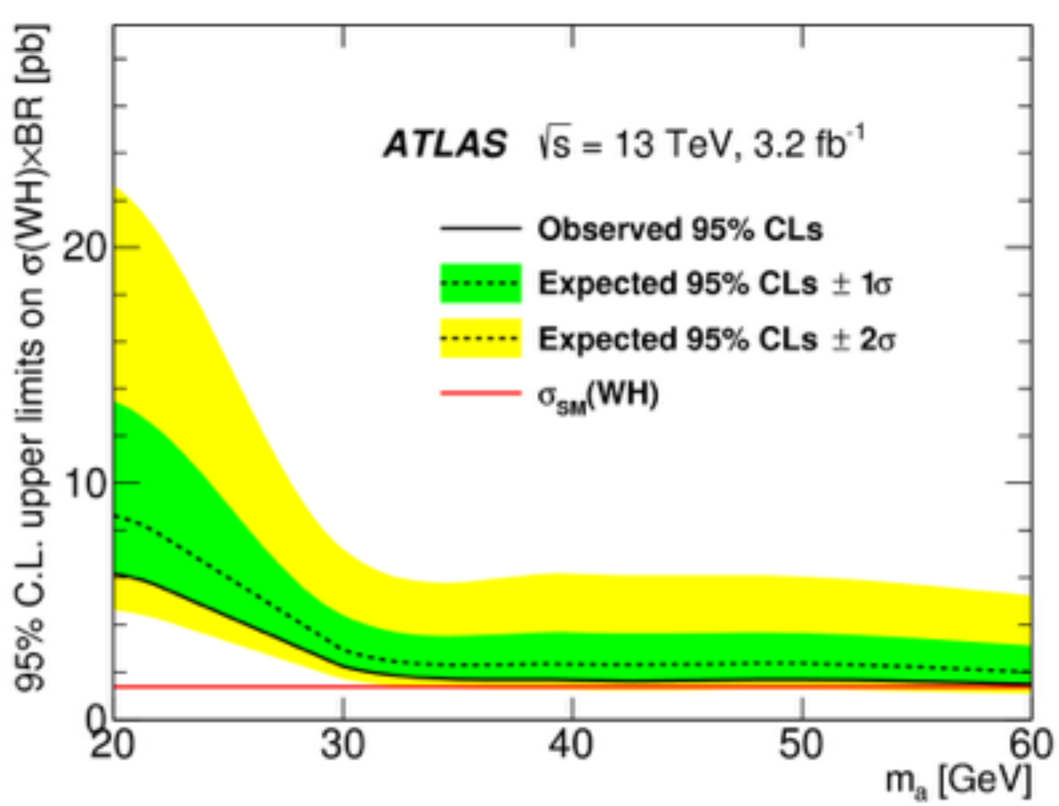
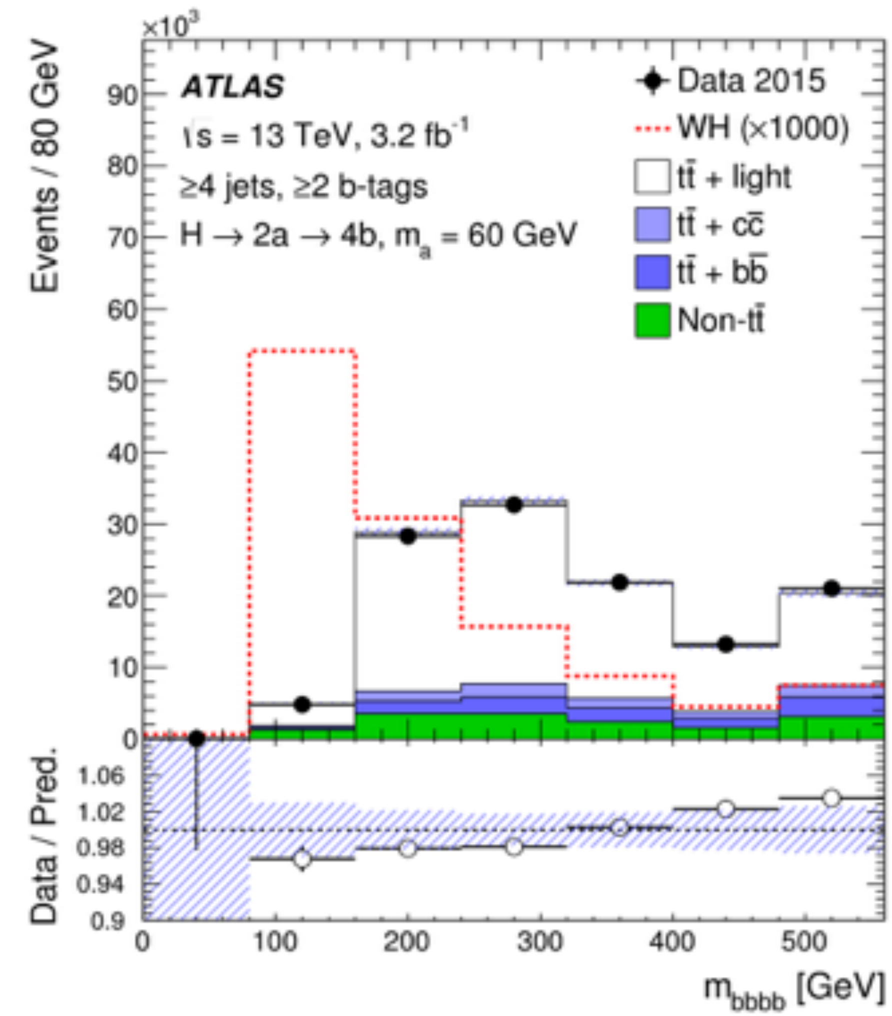




Conclusion and Outlook

- Ongoing searches for hh production
  - Resonant and non-resonant
  - Many channels under investigation
    - Combination expected soon
- Searches for rare and exotic higgs decays
  - Direct measurement of coupling to light quarks
  - Search for evidence of new physics
- Many exciting possibilities in the near future

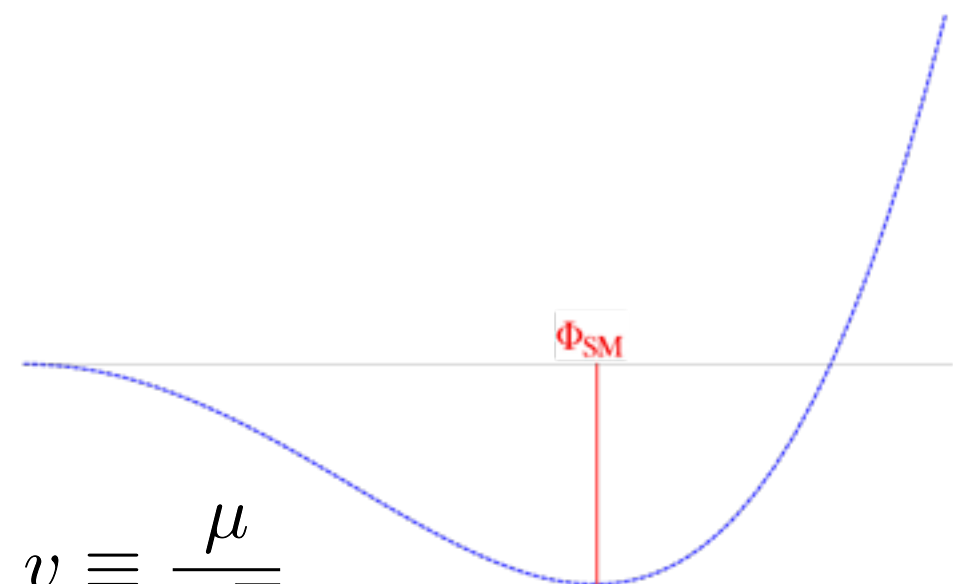
Thank you for your attention

Backup slides

Probing the Higgs Potential

Higgs potential: $V(\phi) = -\mu^2\phi^2 + \lambda\phi^4$

Expand around the minimum:

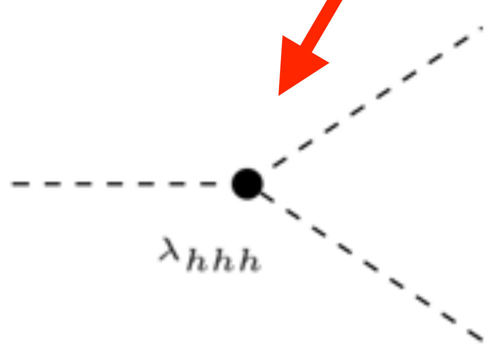


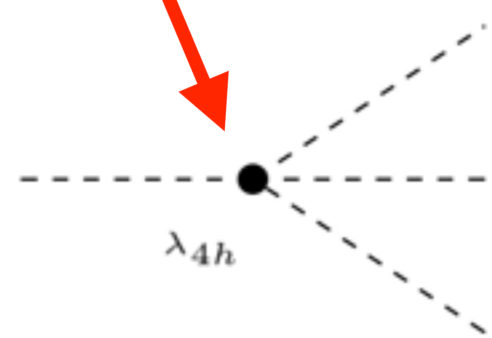
arXiv:1209.5609

$$V(\phi) \to V(h + \phi)$$

$$\begin{aligned} V &= V_0 + \lambda v^2 h^2 + \lambda v h^3 + \frac{\lambda}{4} h^4 \\ &= V_0 + \frac{1}{2} m_h^2 h^2 + \lambda_{hhh} h^3 + \lambda_{4h} h^4 \end{aligned}$$

$$\begin{aligned} v &\equiv \frac{\mu}{\sqrt{\lambda}} \\ &= (\sqrt{2} G_F)^{-1/2} \approx 246 \text{ GeV} \end{aligned}$$



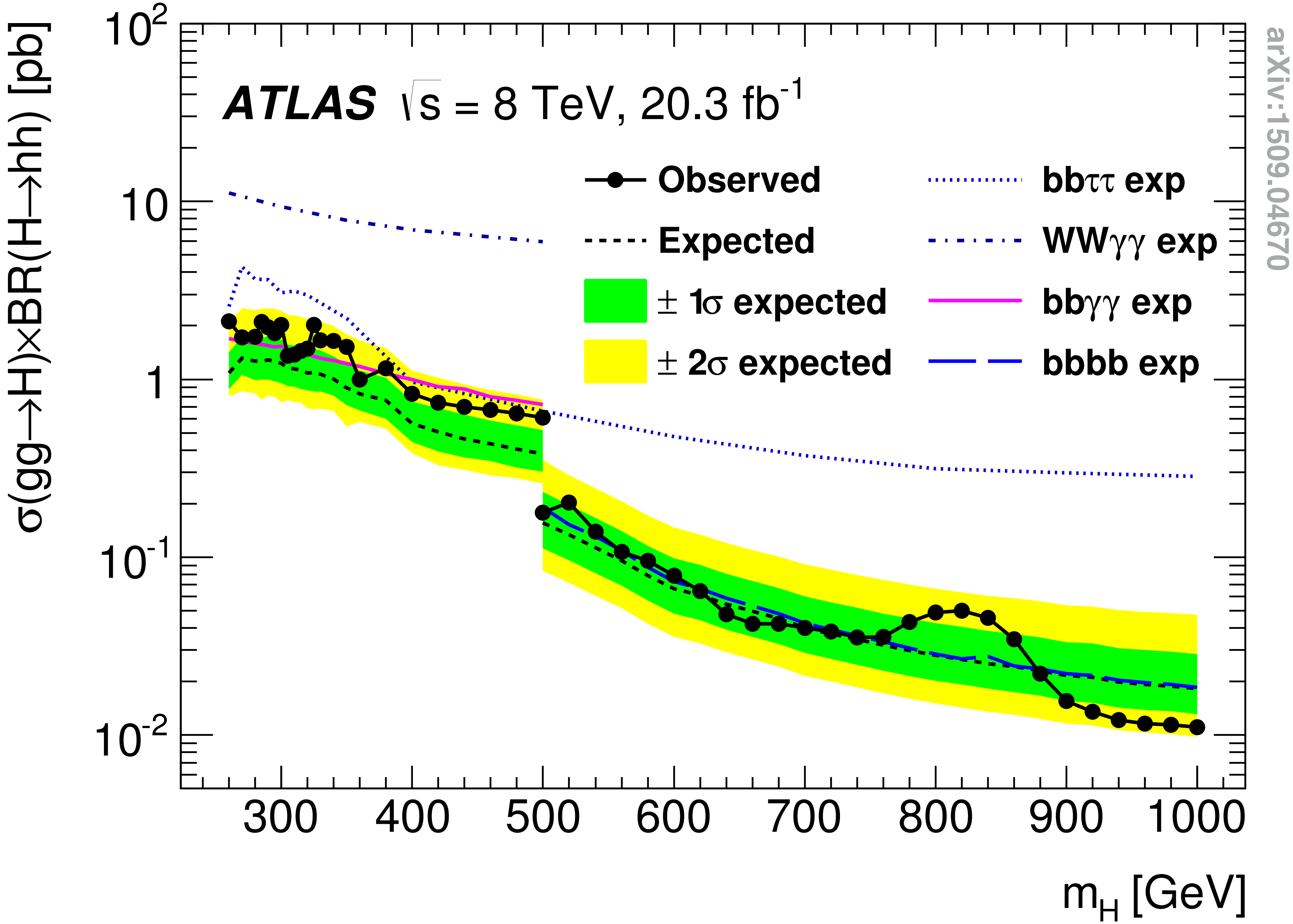


$$\lambda_{hhh} \equiv \frac{m_h^2}{2v}$$

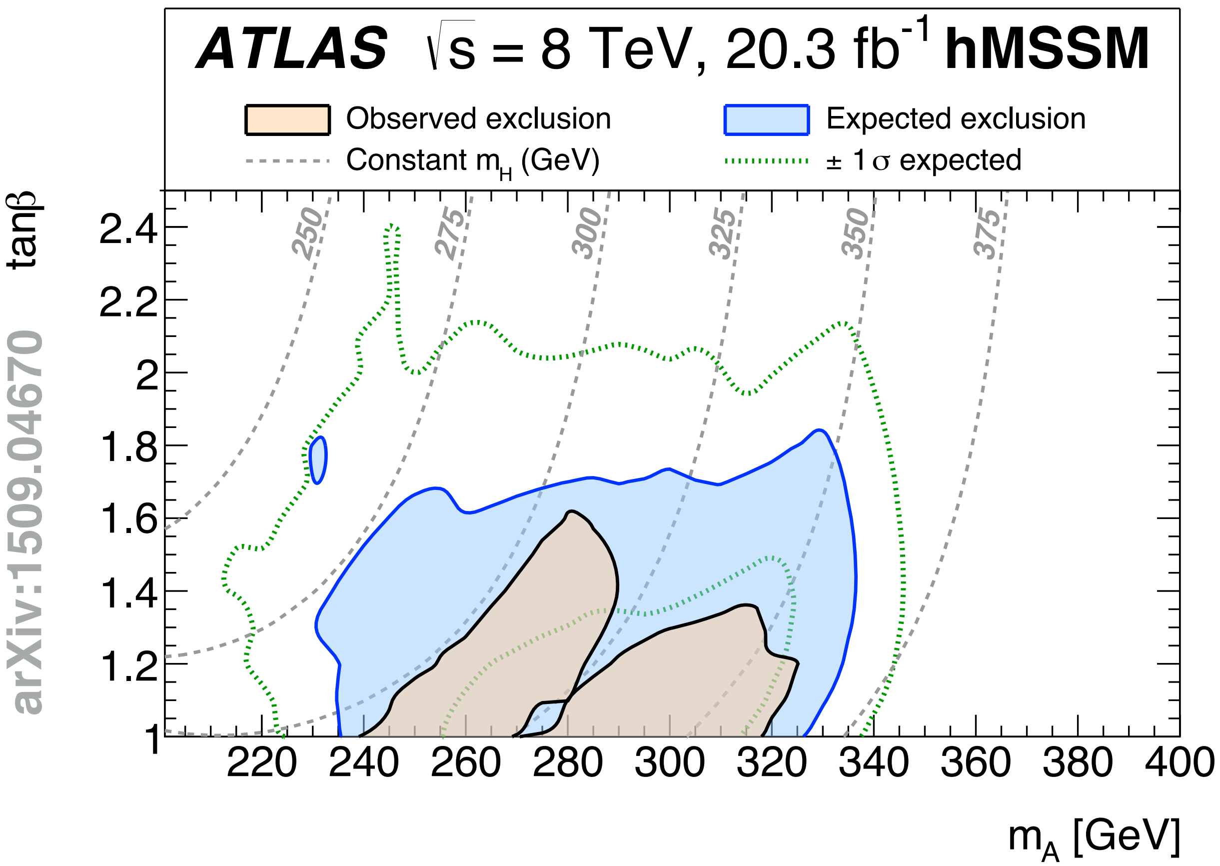
$$\lambda_{4h} \equiv \frac{m_h^2}{8v^2}$$

Measuring *hh* and *hhh* production helps us understand *V*

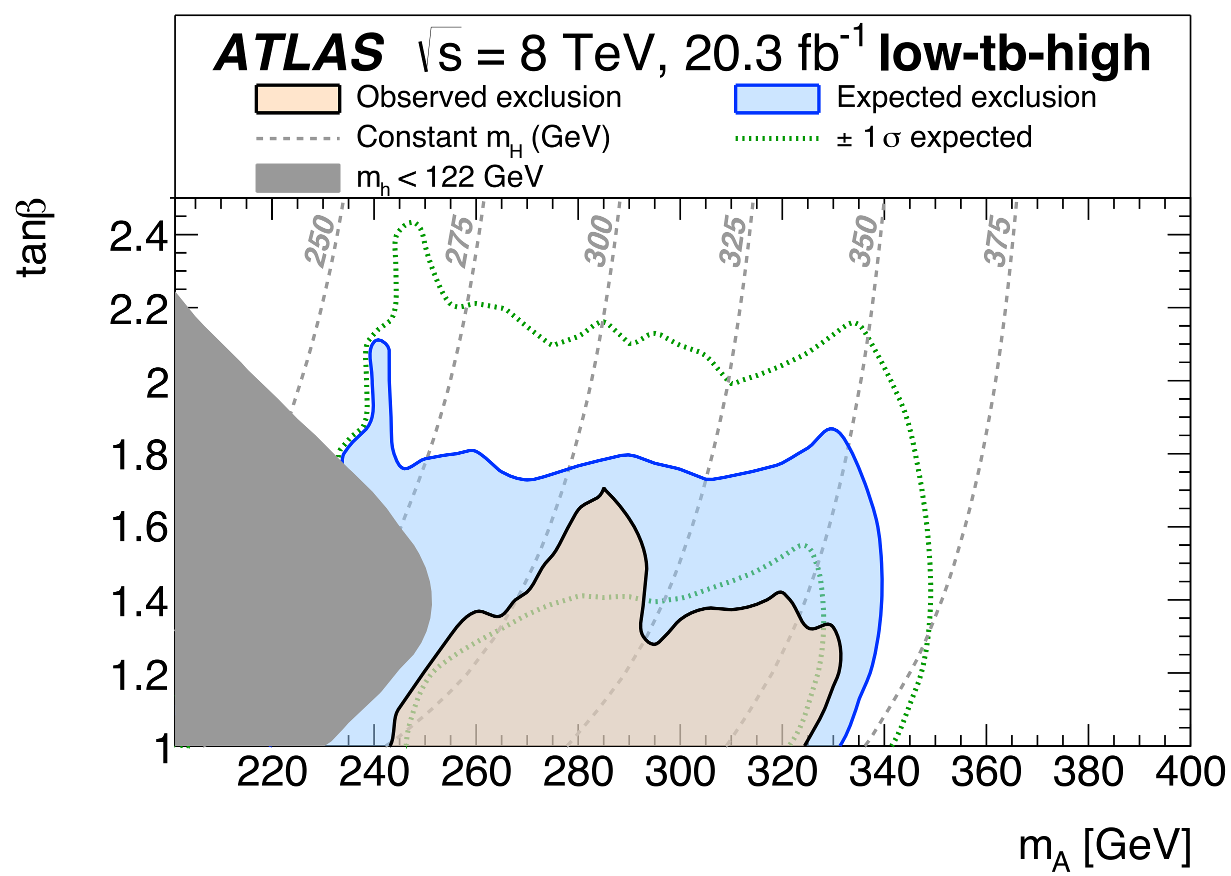
Channel Combination



MSSM Interpretations



Two MSSM scenarios considered



Prospects for Observation

Will we observe SM *hh* production at the HL-LHC (3000 fb^{-1})?

Maybe….

From the experiments (σ/σ_{SM}):

From the theorists:

CMS-PAS-FTR-15-002 ATL-PHYS-PUB-2016-024
ATL-PHYS-PUB-2014-019 ATL-PHYS-PUB-2015-046

Channel	ATLAS Simulation	CMS Extrapolation	1512.08928 1212.5581	1410.2794 1308.6302 1209.1489	1206.5001	1311.2931v1
4b	2.0 (11.5)	2.9 (7.0)	3σ	2σ	Hopeless	Hopeless
bbγγ	- (2.6)	1.3 (1.3)	5σ	2.3σ	-	5σ
bbττ	- (4.3)	3.9 (5.2)	5σ	-	5σ	Hopeless
WWbb	-	4.6 (5.8)	μ < 3	5σ	Hopeless	-

stat-only (stat+syst)

Prospects for Observation

Snowmass estimates ~30% precision after combination of all channels and experiments

From the experiments (σ/σ_{SM}):

From the theorists:

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stat-only (stat+syst)

ATL-PHYS-PUB-2016-024 CMS-PAS-FTR-15-002
ATL-PHYS-PUB-2015-046 ATL-PHYS-PUB-2014-019