Search for new Bosons at the LHC

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SAIP 2015, UCT, July 4th-8th 2016

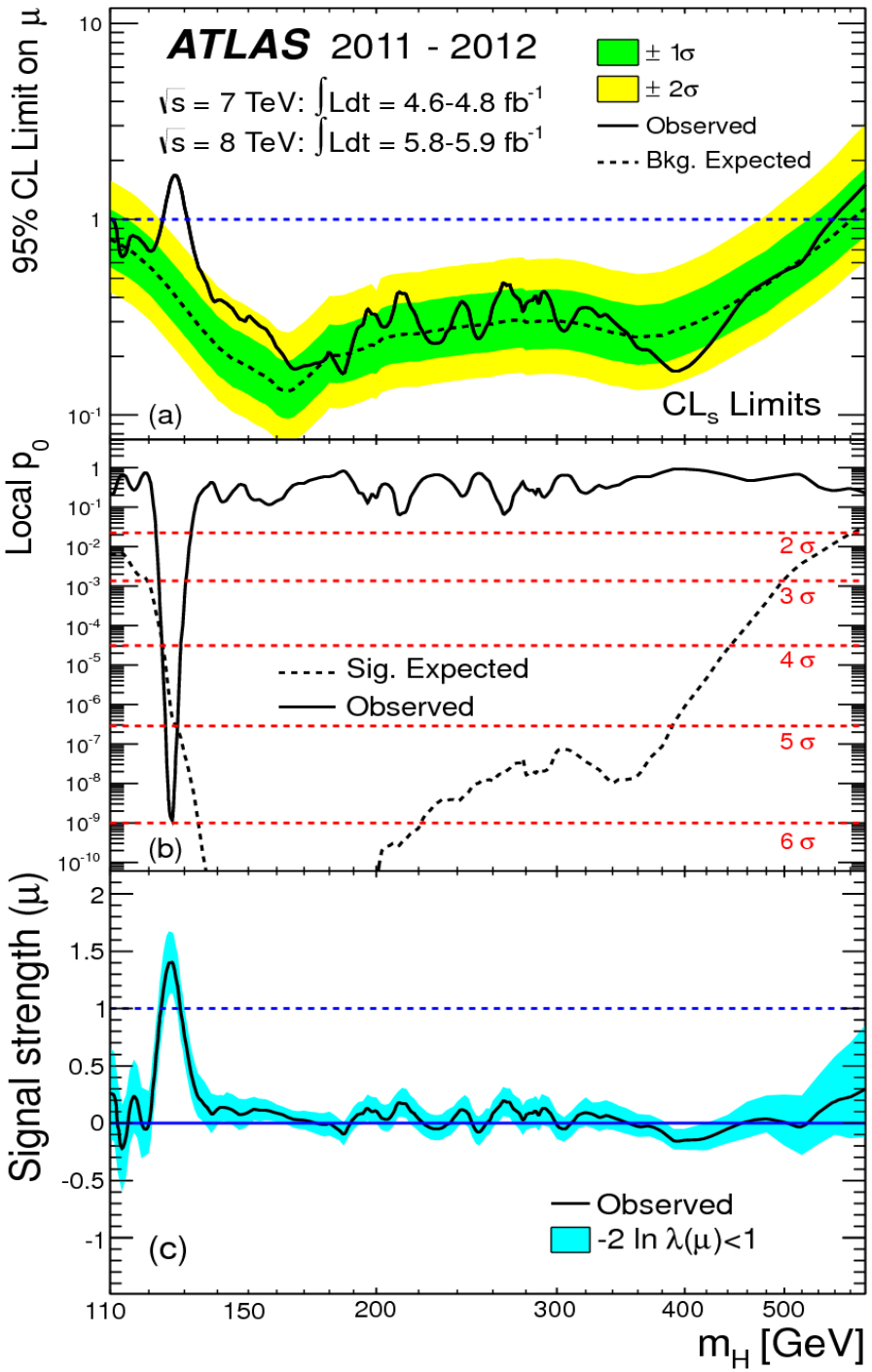
Outline

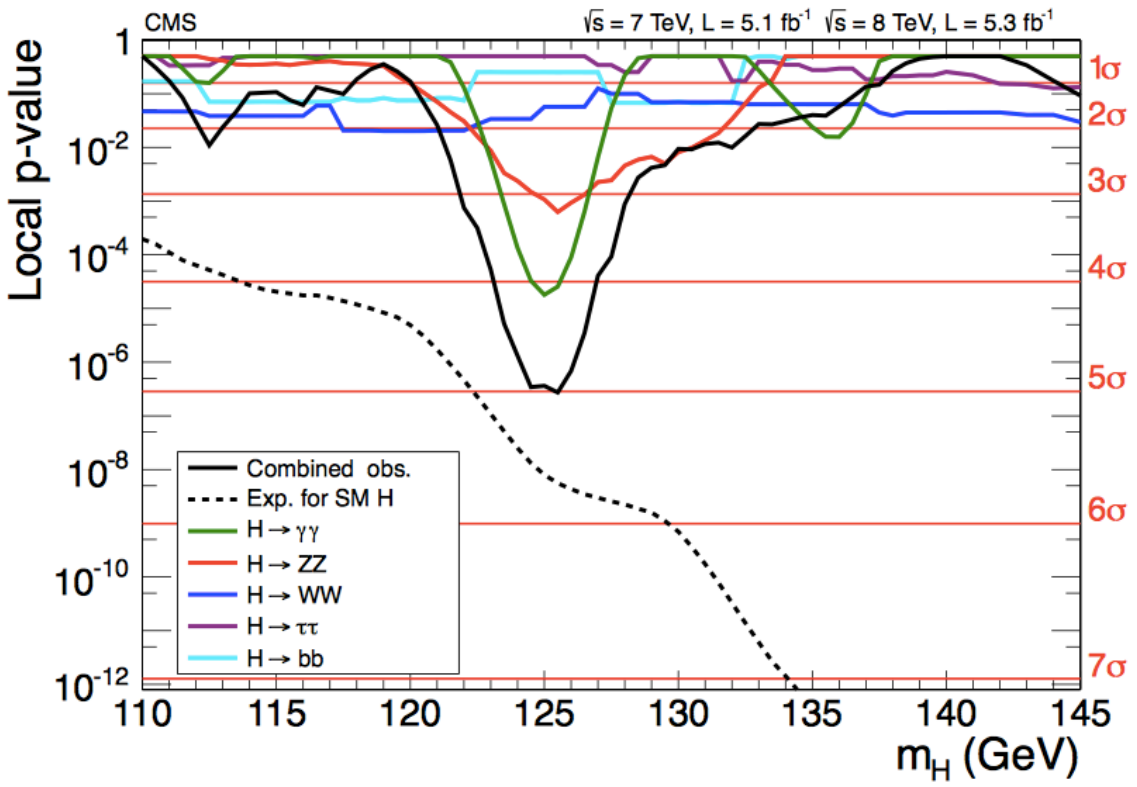
- Habemus Novum Boson
- Search in the high mass di-photon spectrum
  - Anatomy of the excess
- ZZ, WW resonances
- hh resonances
- Heavy scalar and DM
- Prospects

Habemus novum Boson

Phys.Lett. B716 (2012) 1-29
Phys.Lett. B716 (2012) 30-61

On July 4th 2012 reported both experiments reported ~5σ effects





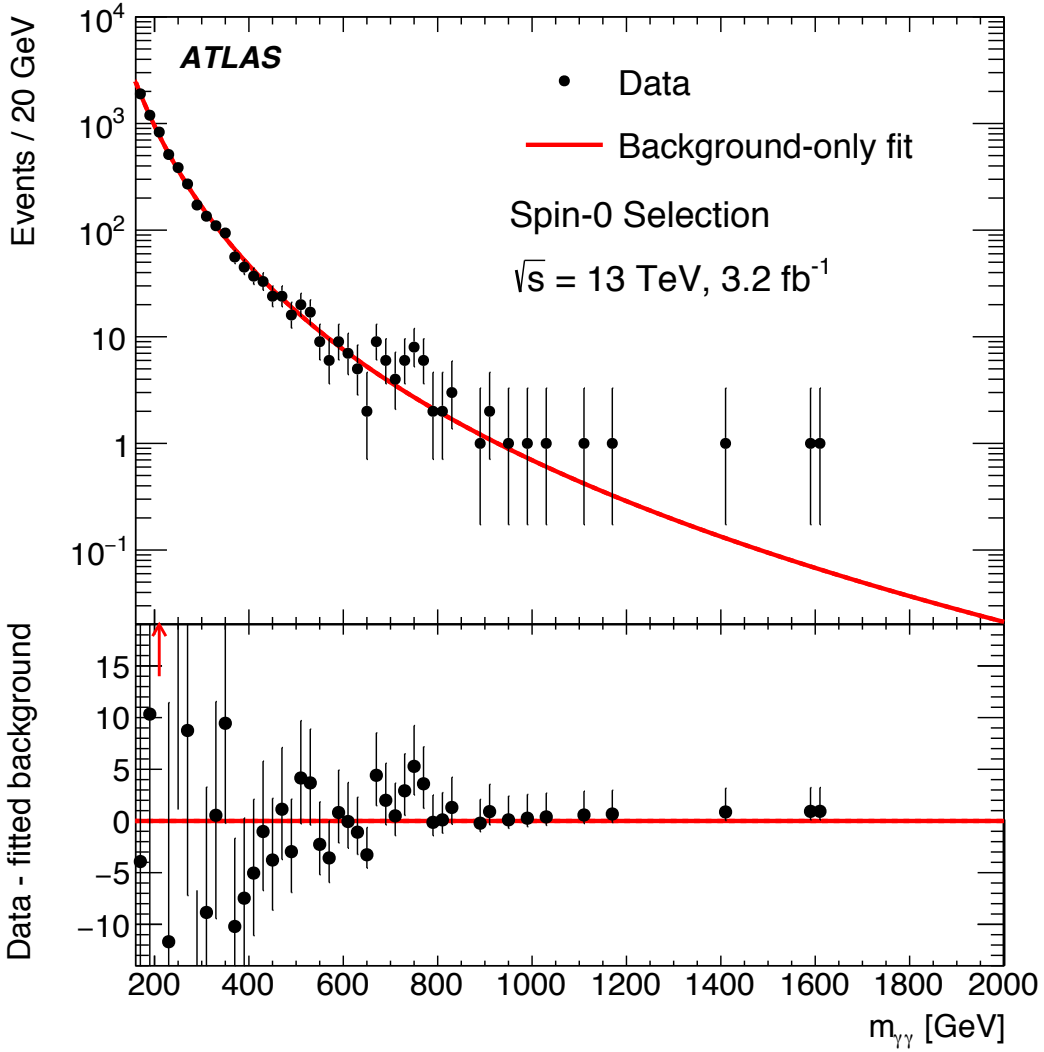
The search for heavy bosons in the di-photon invariant mass spectrum

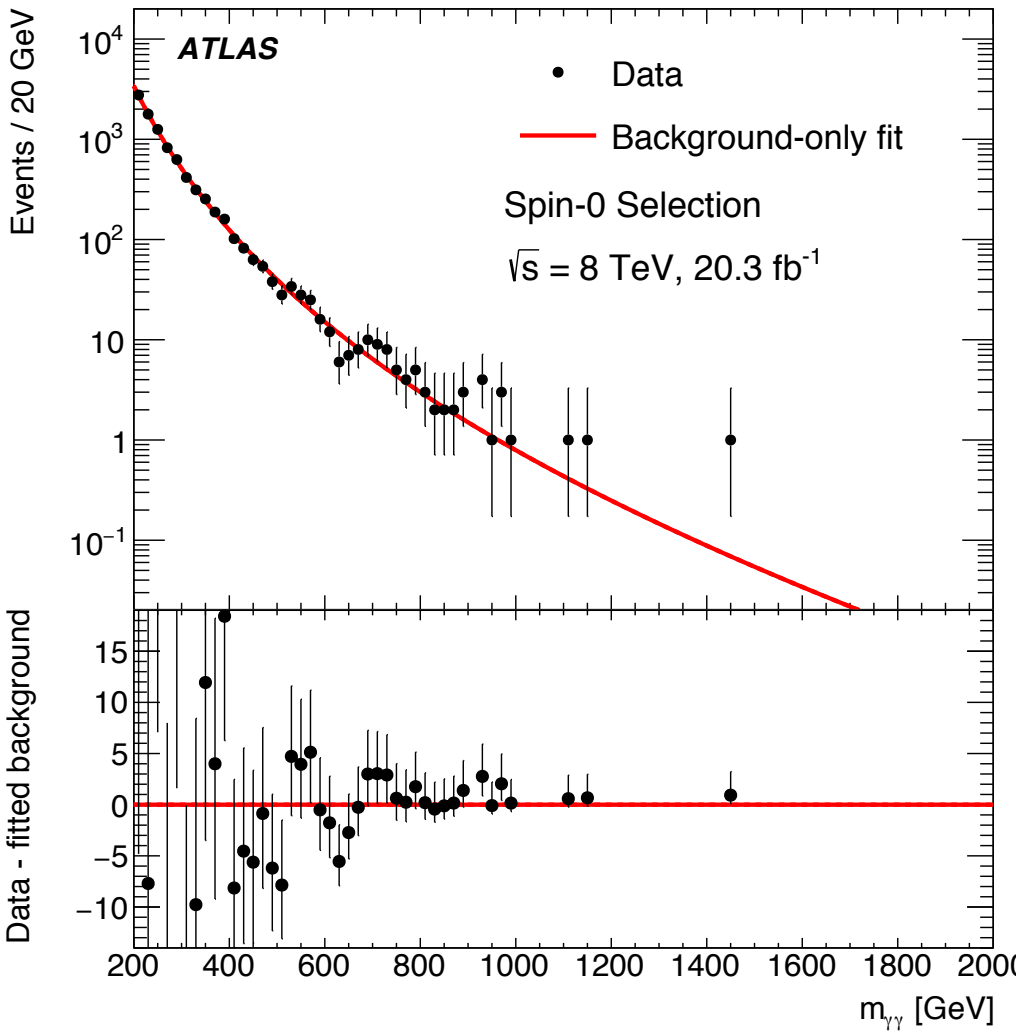
Back in December 2015 the ATLAS and CMS collaborations reported similar excesses in the region of 750 GeV in the di-photon invariant mass spectrum

These excesses have triggered a burst of theoretical papers (over 400)

Major updates coming from experiments expected in August at ICHEP 2016, in Chicago.

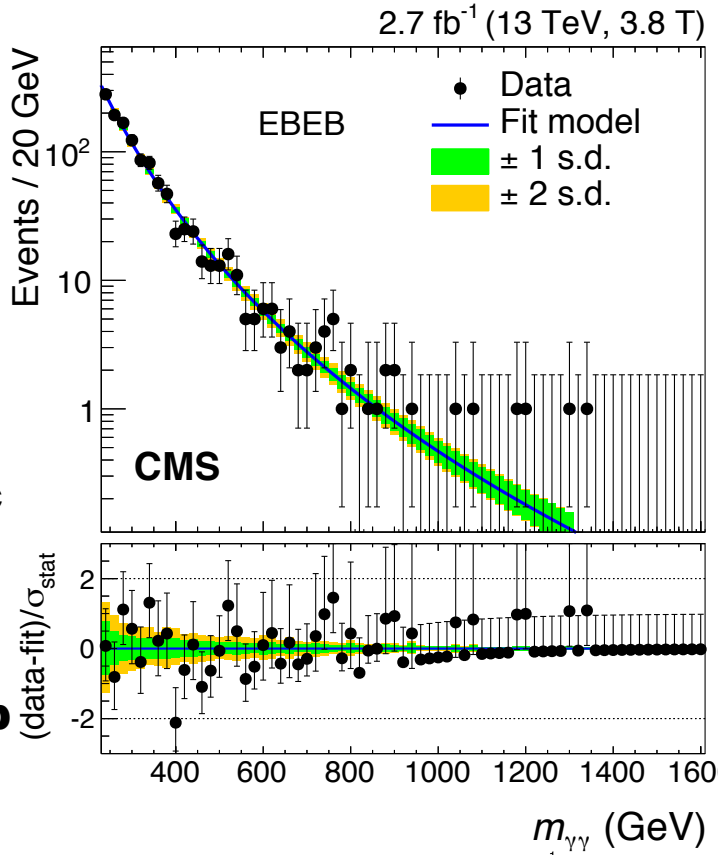
Photons are selected with dedicated Identification and isolation criteria. Spectrum fitted with background-only unbined likelihood fit Results for Spin-2 search yield similar excess in the 13 TeV data

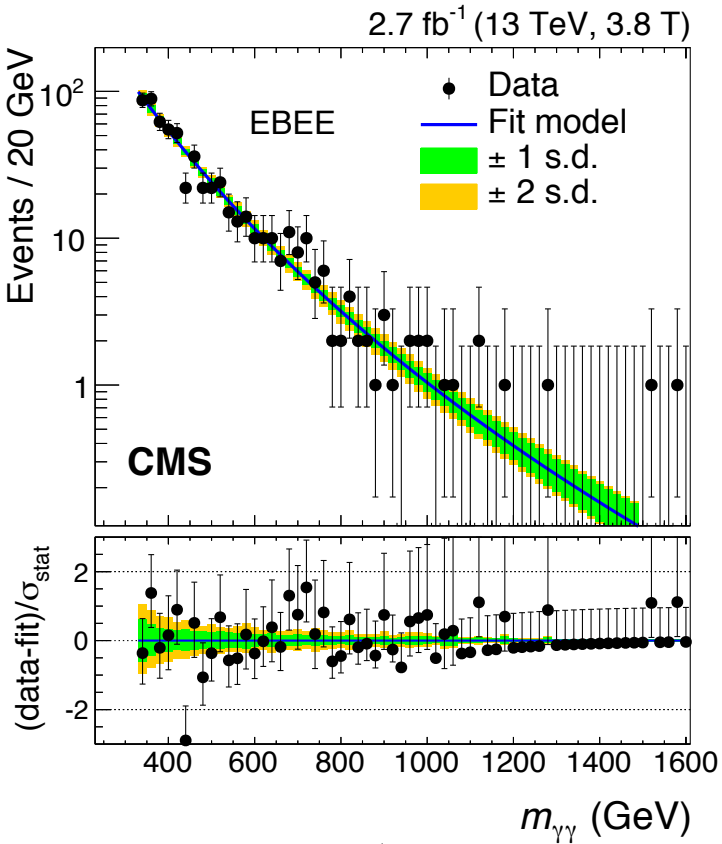




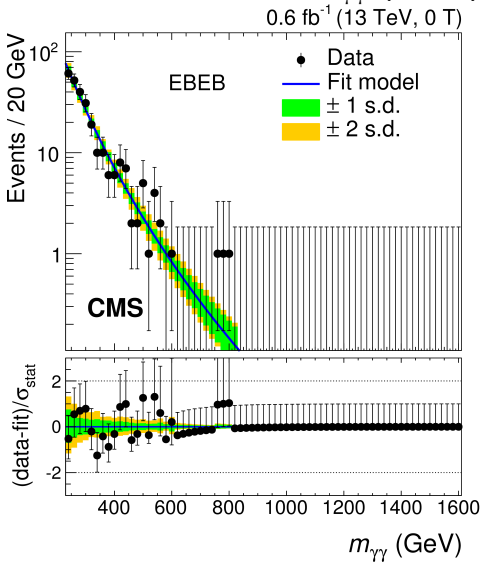
No events observed with M>2 TeV

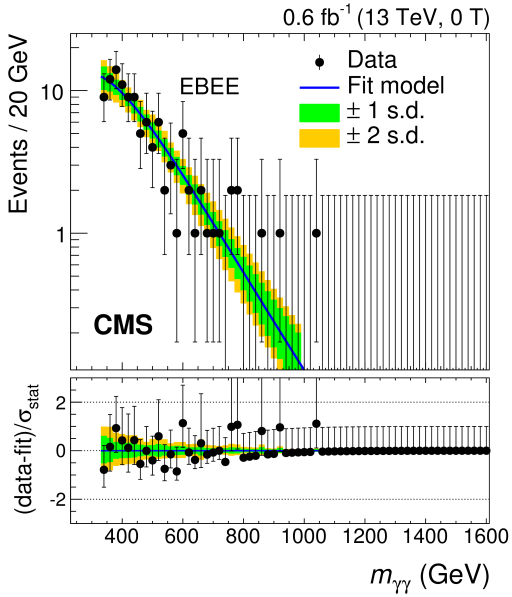
The CMS experiment classifies the photon pairs according to two categories, denoted as EBEB when both photons are reconstructed in the barrel electromagnetic calorimeter and as EBEE when one of the two photons is observed in the endcap

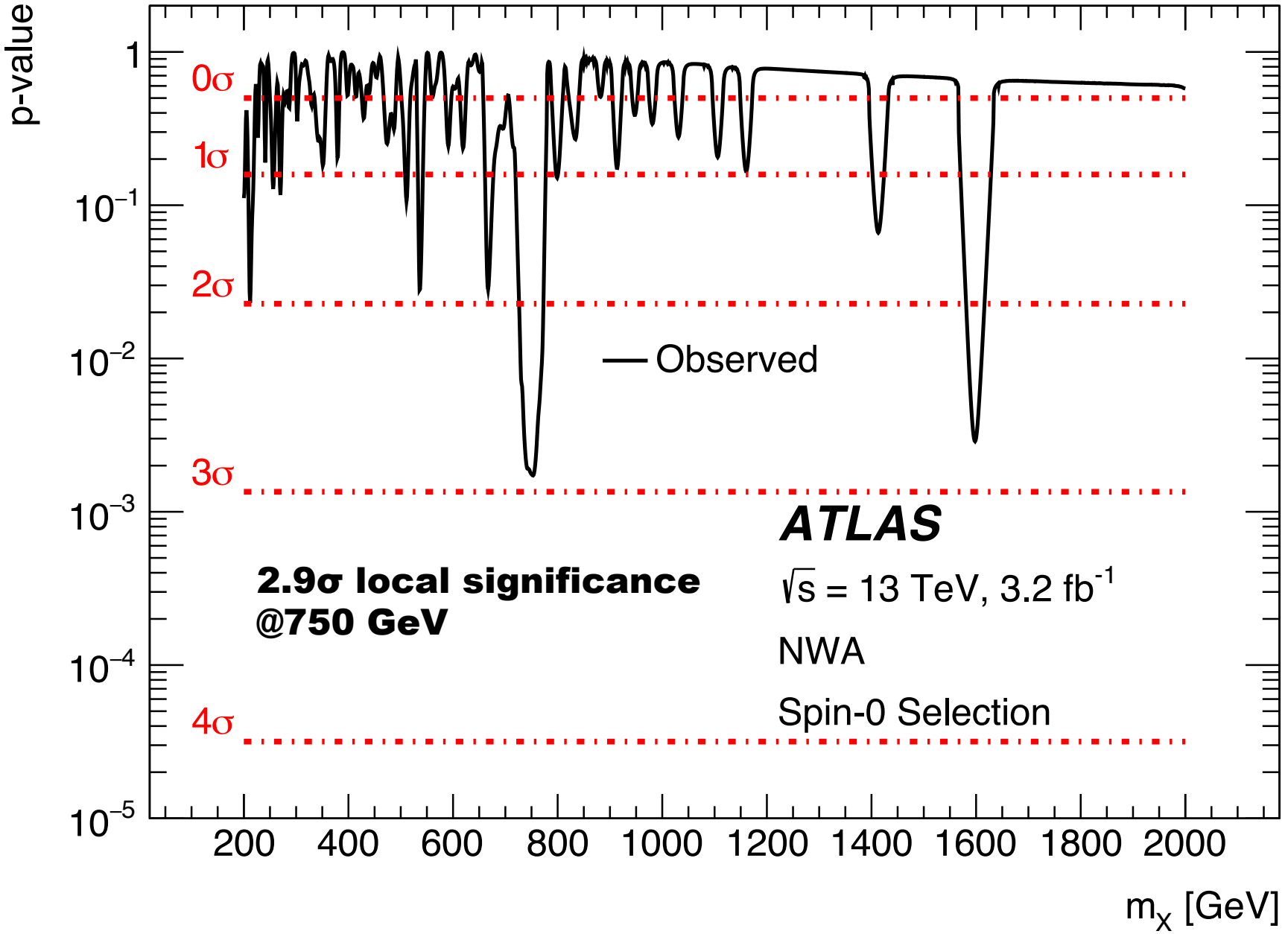




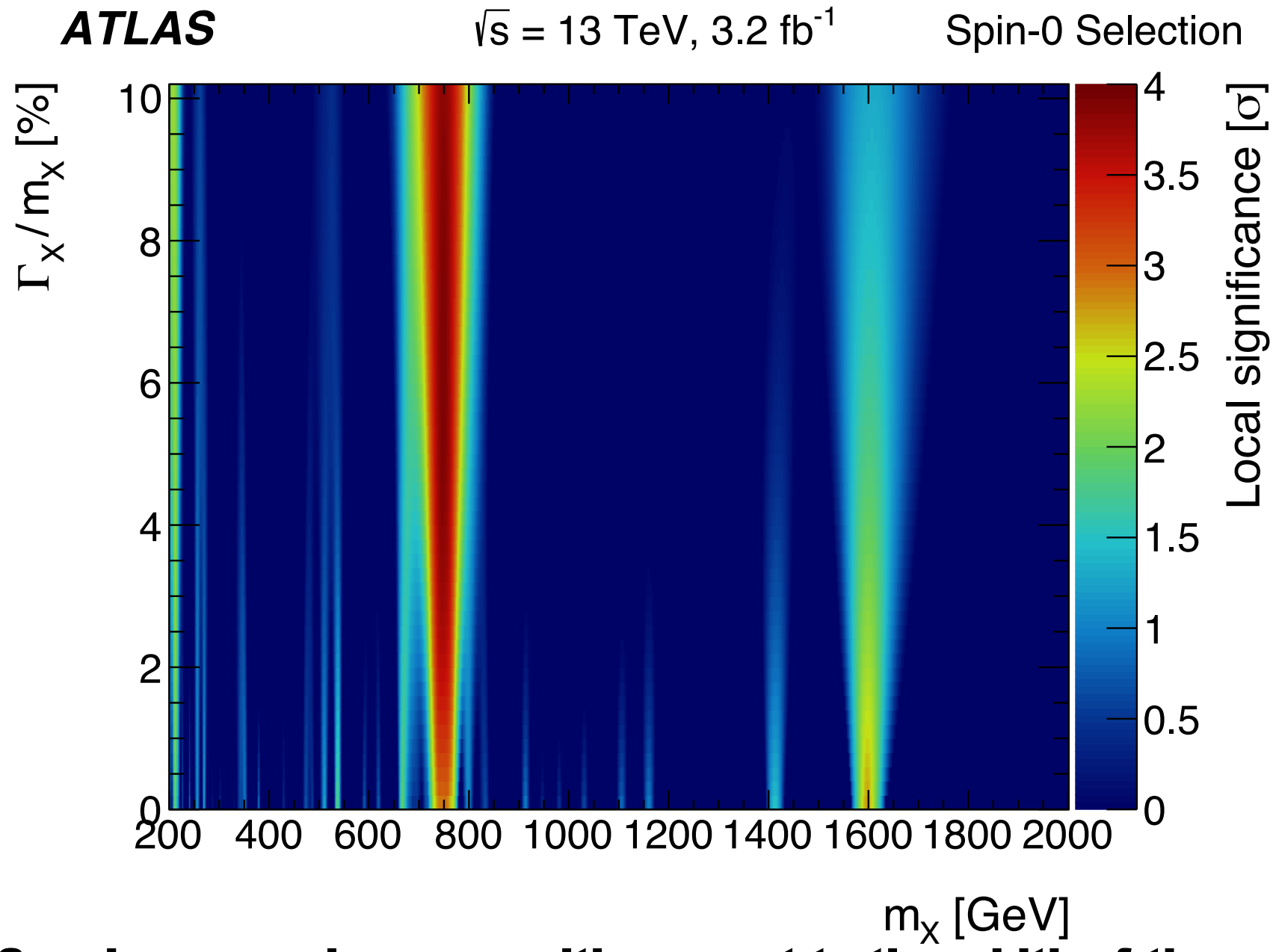
Each category is further subdivided into events recorded with de full magnetic field of 3.8 Testla and when it was switched off.



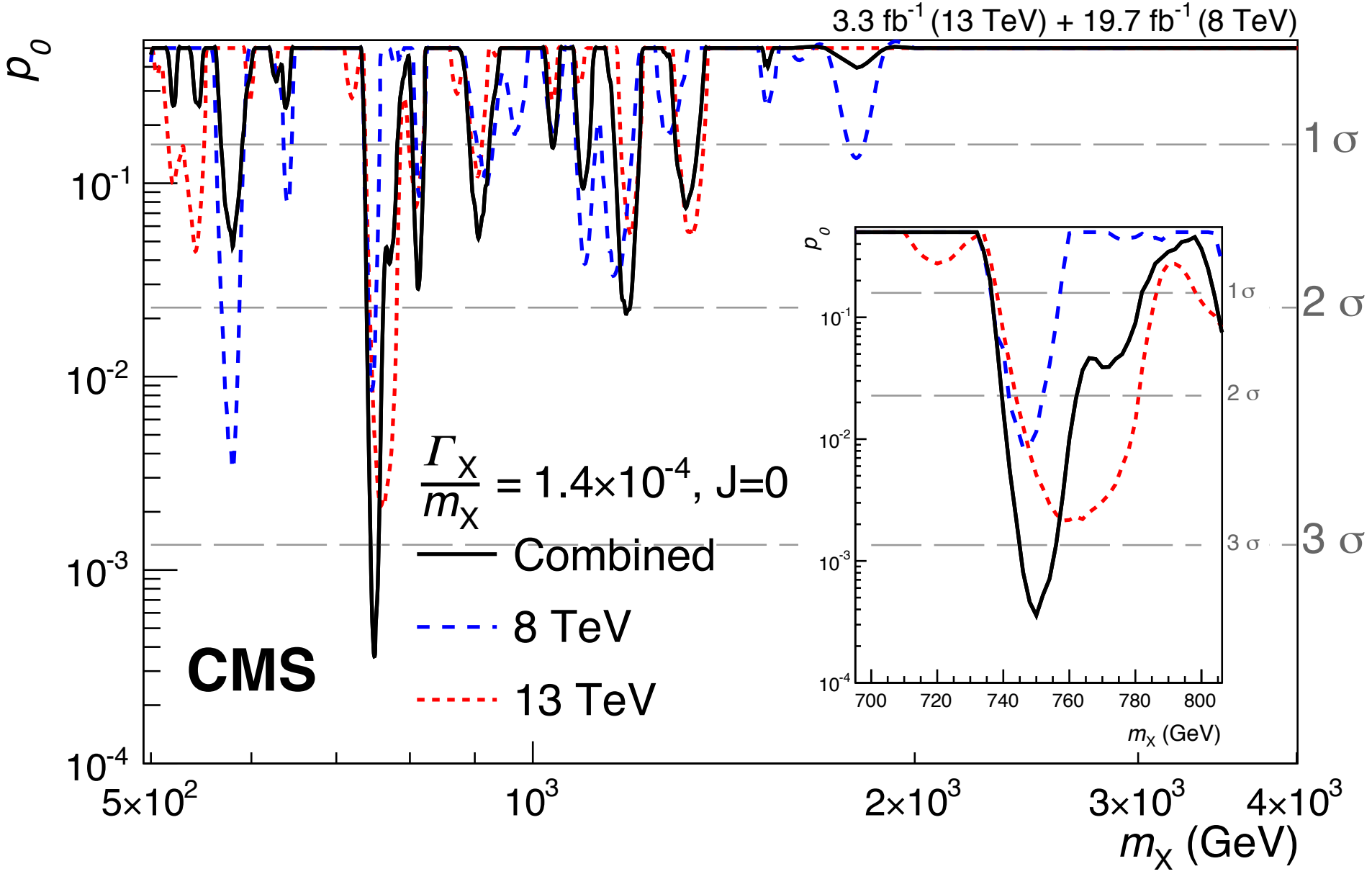




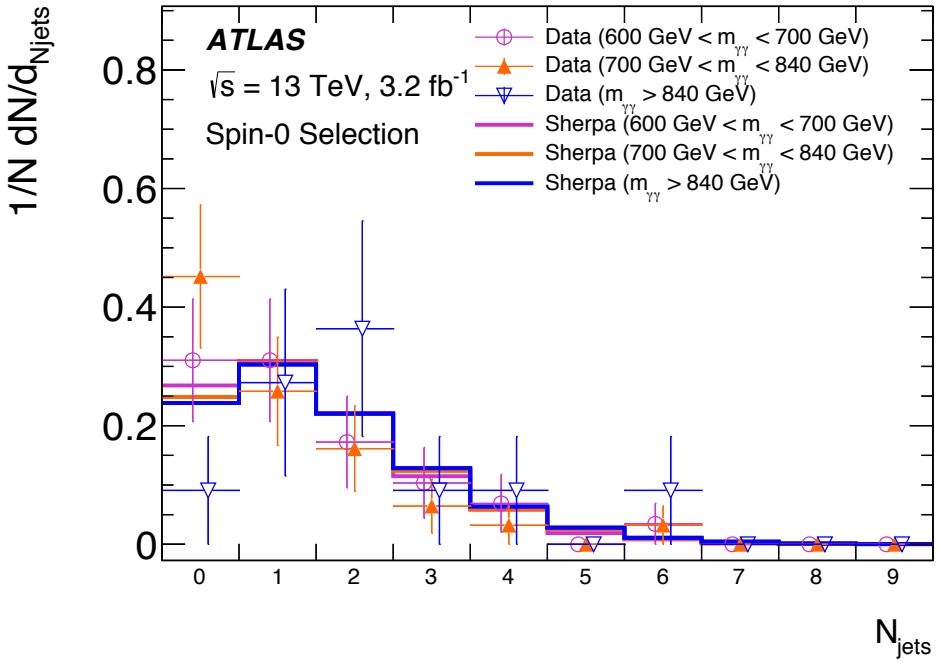
p-values for search of a narrow scalar with 13 TeV data

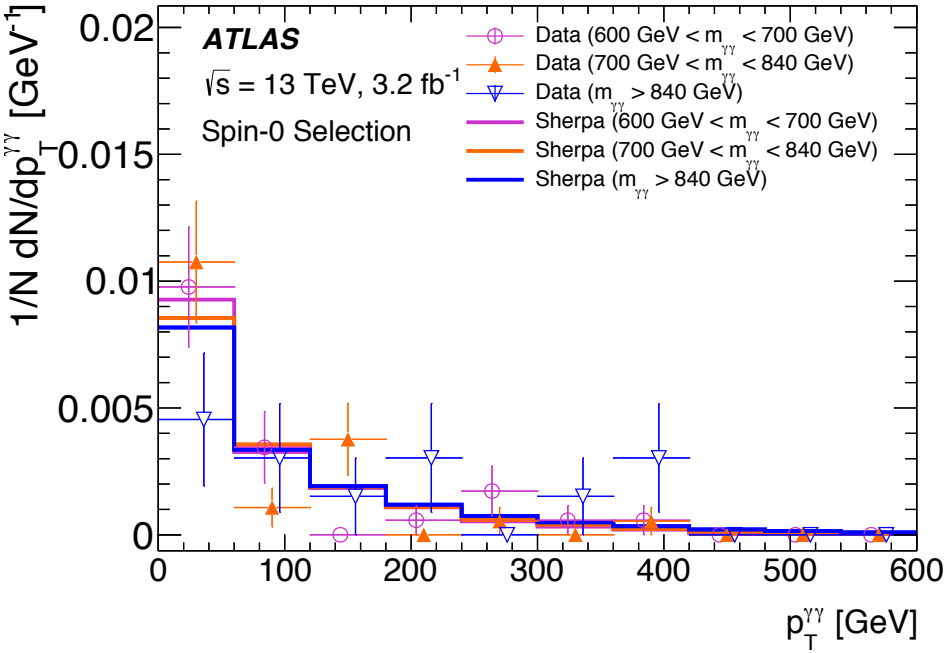


ATLAS makes a p-value scan with respect to the width of the scalar resonance. Maximum significance 3.9σ local (2.1σ global)

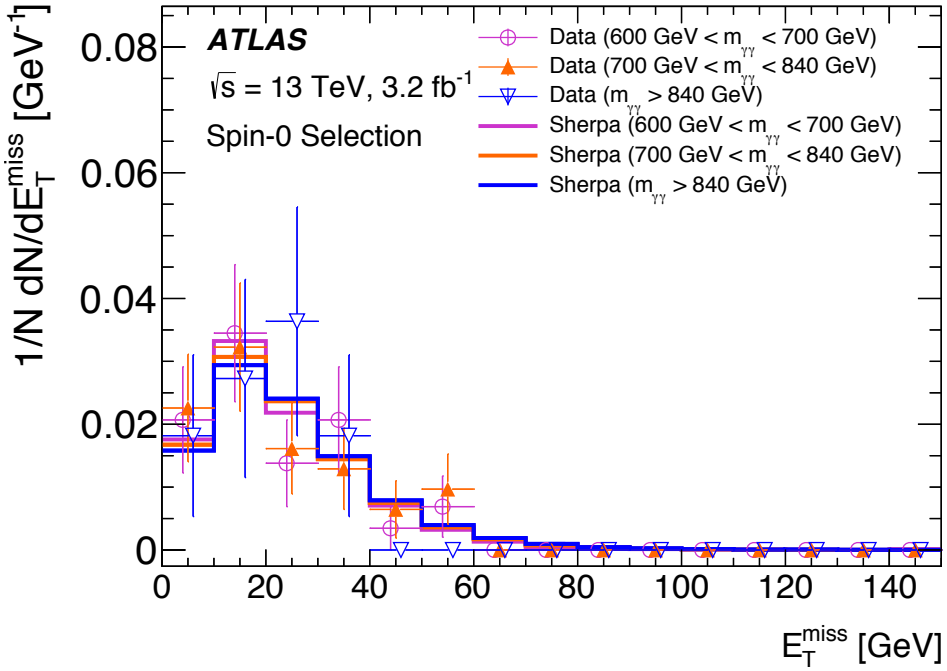


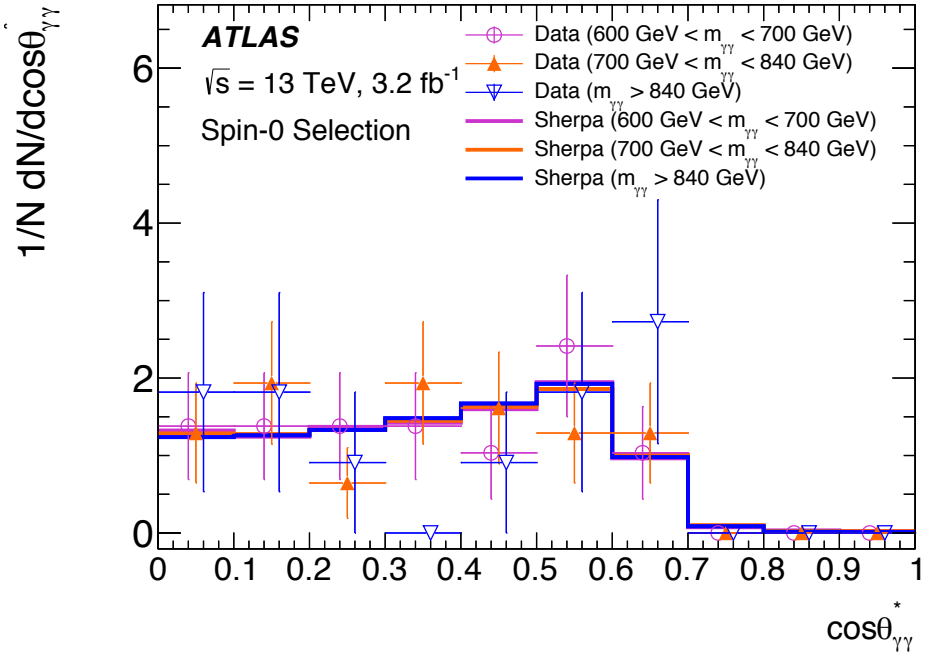
p-values for search of a narrow scalar with 8 and 13 TeV data
Local significance of 3.4σ (1.6σ global) @750 GeV





Kinematics of events in the excess region compatible with background

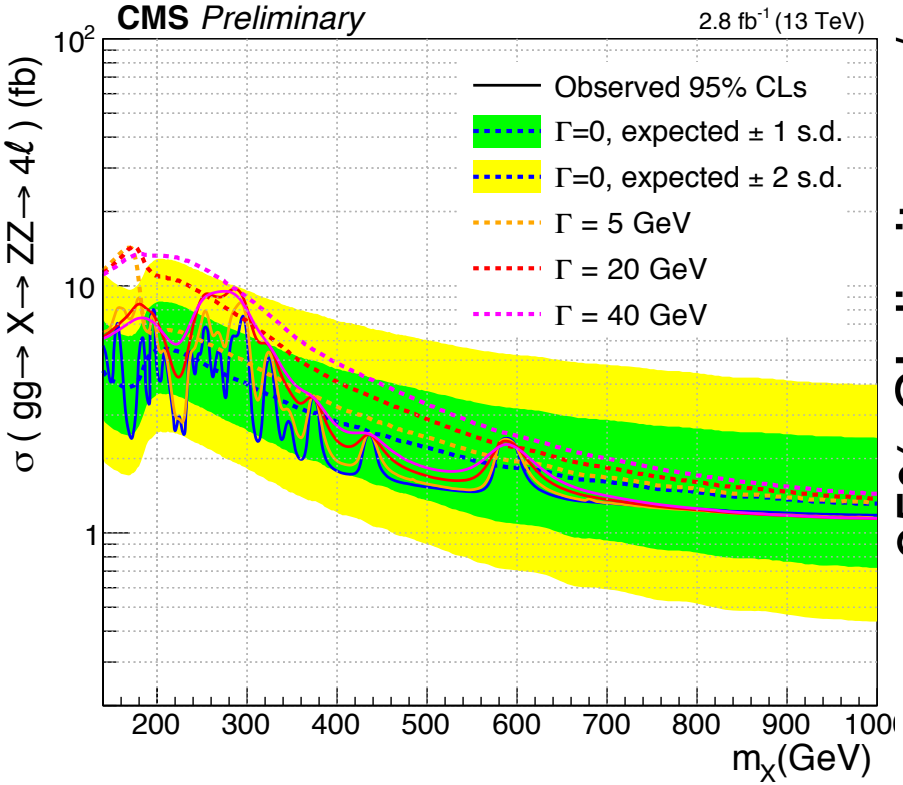




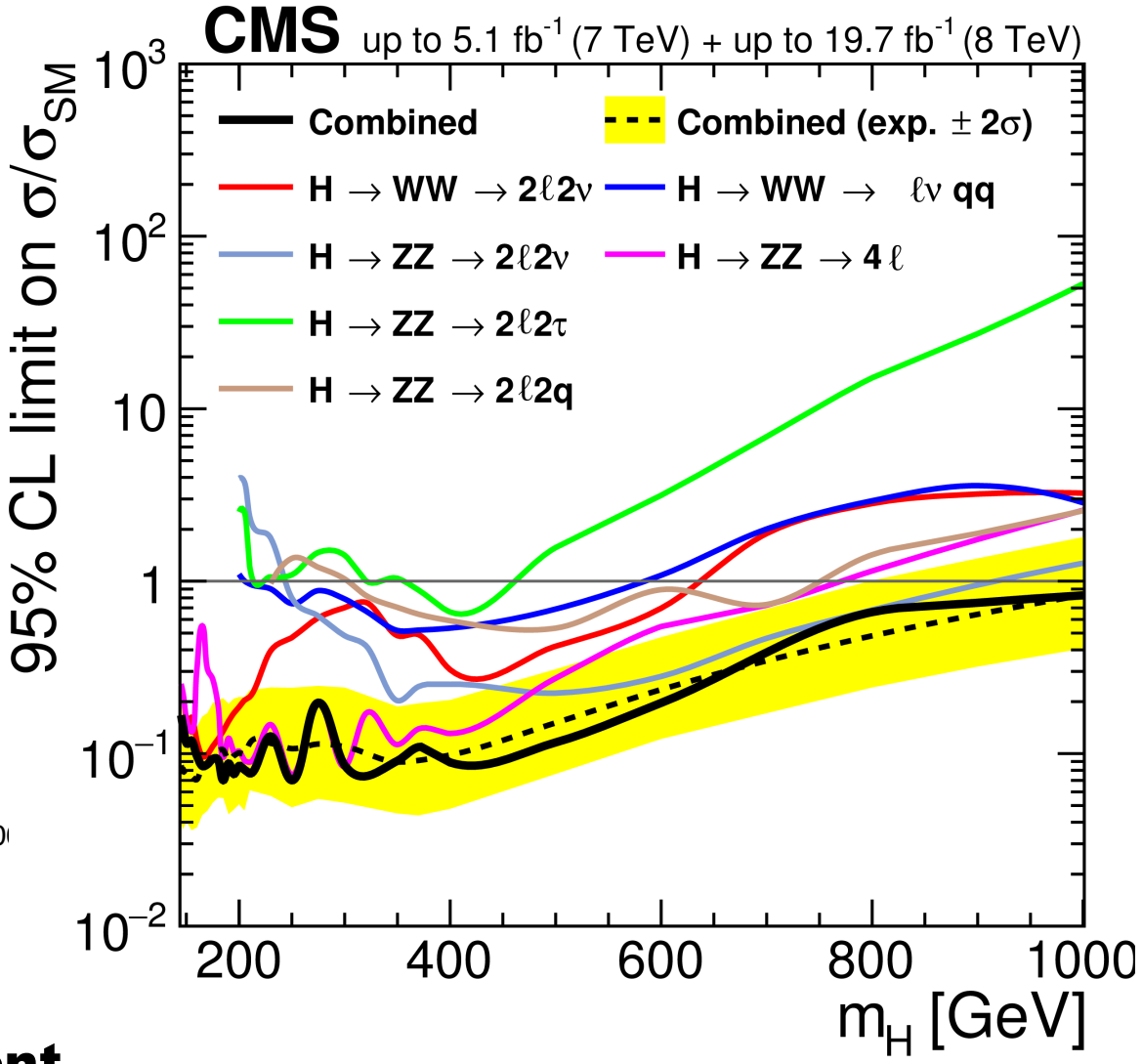
ZZ and WW resonance searches

CMS-PAS-15-004

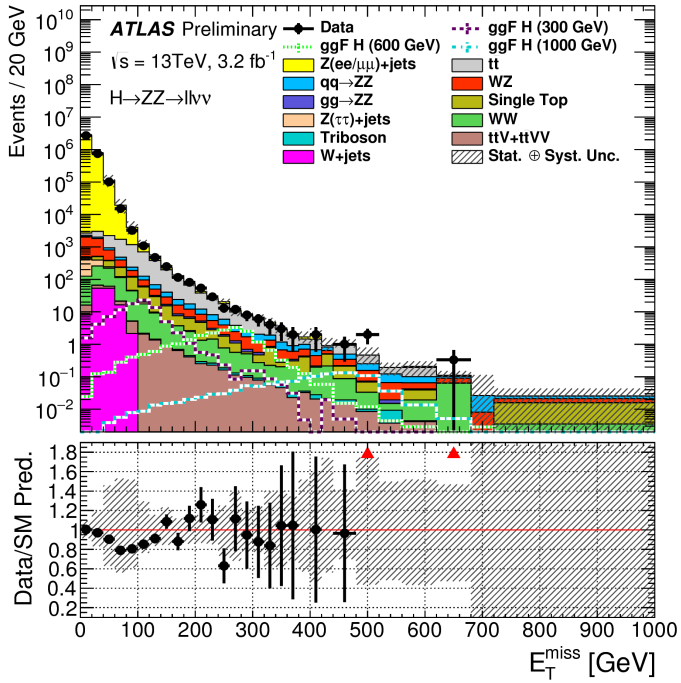
$$H \rightarrow 4\ell$$

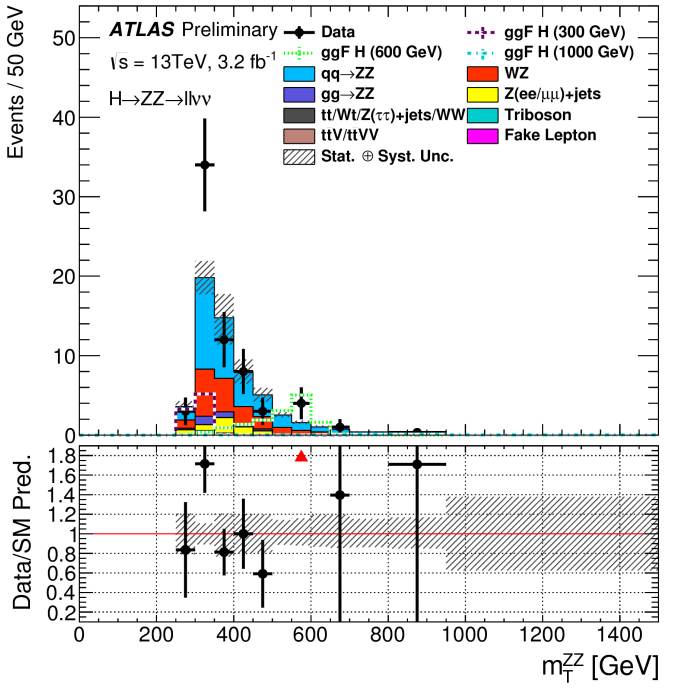


H→ZZ,WW combination Run I



First Run II study with CMS
Analysis performed for different assumptions of widths





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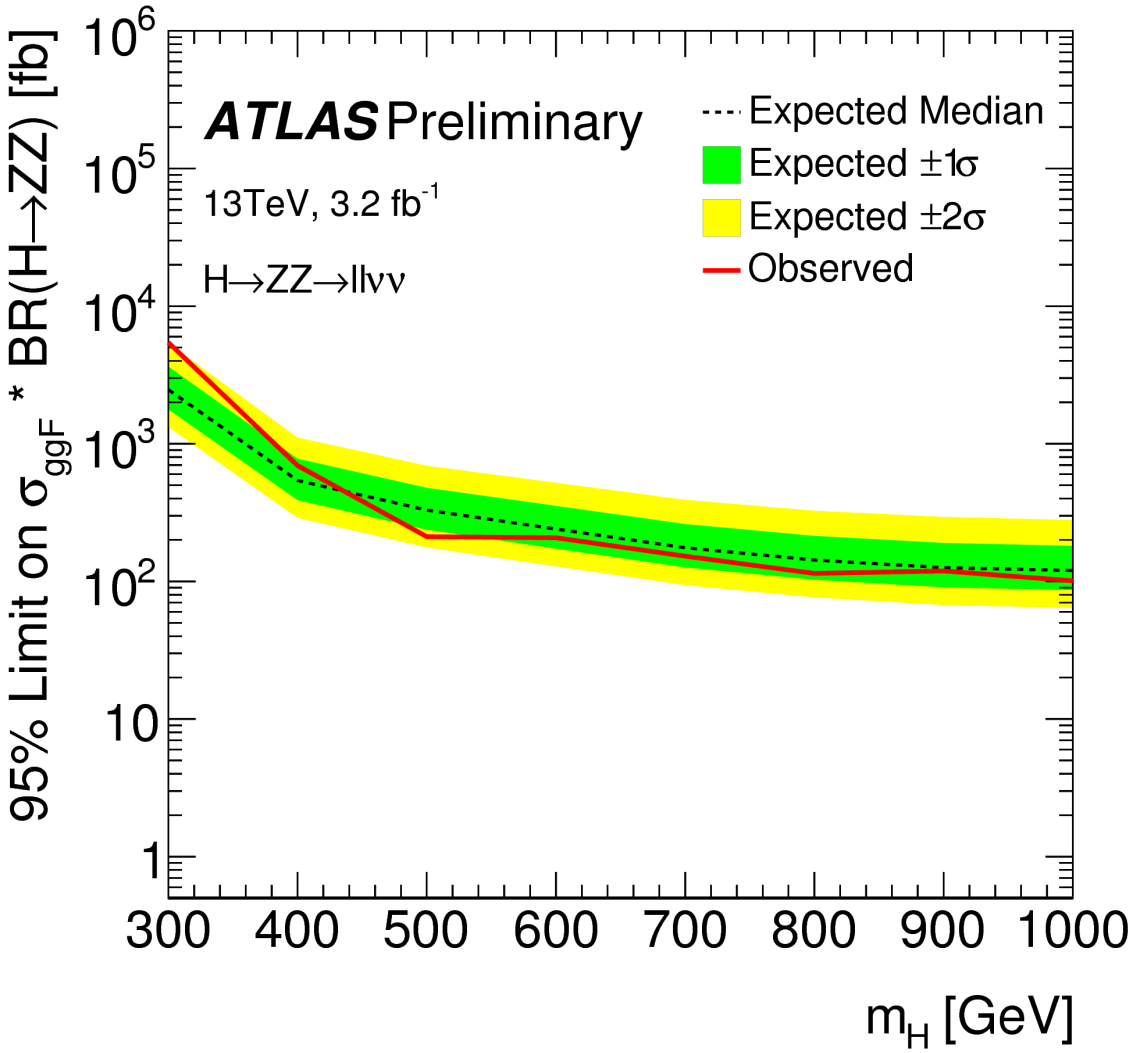
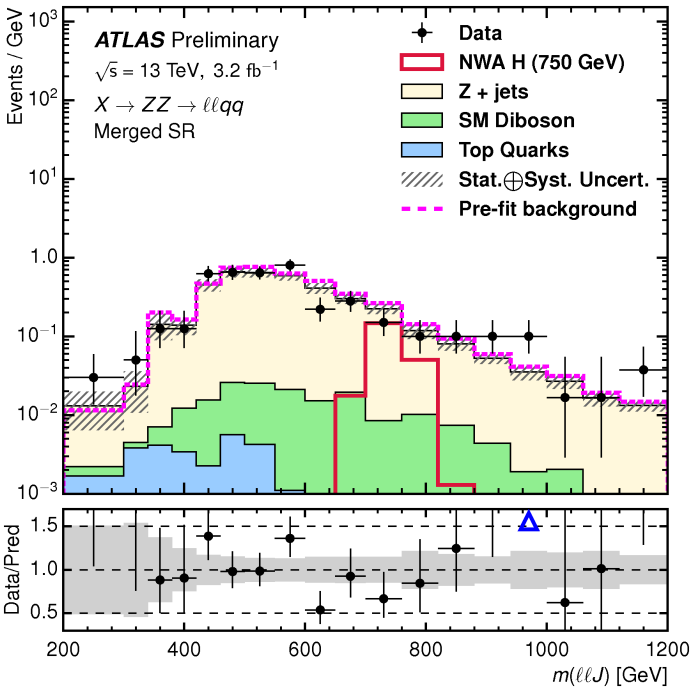
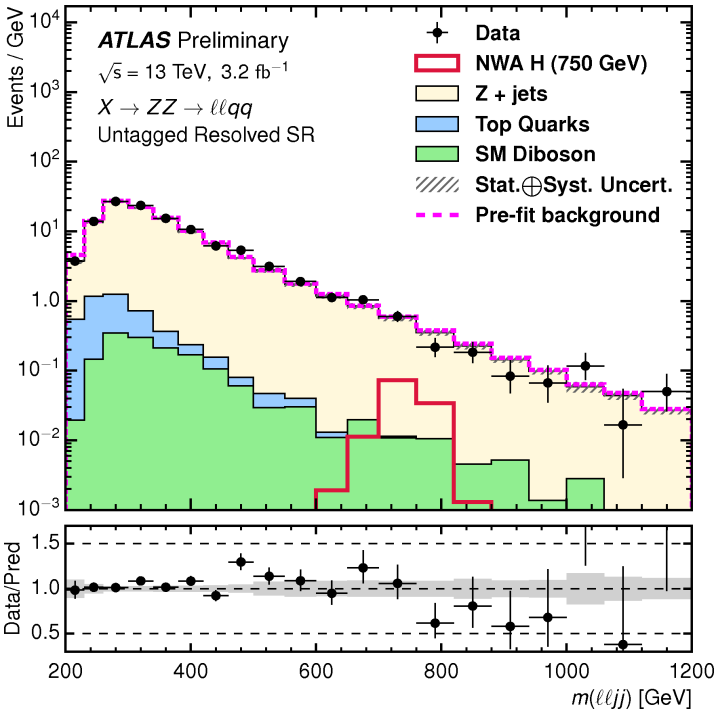
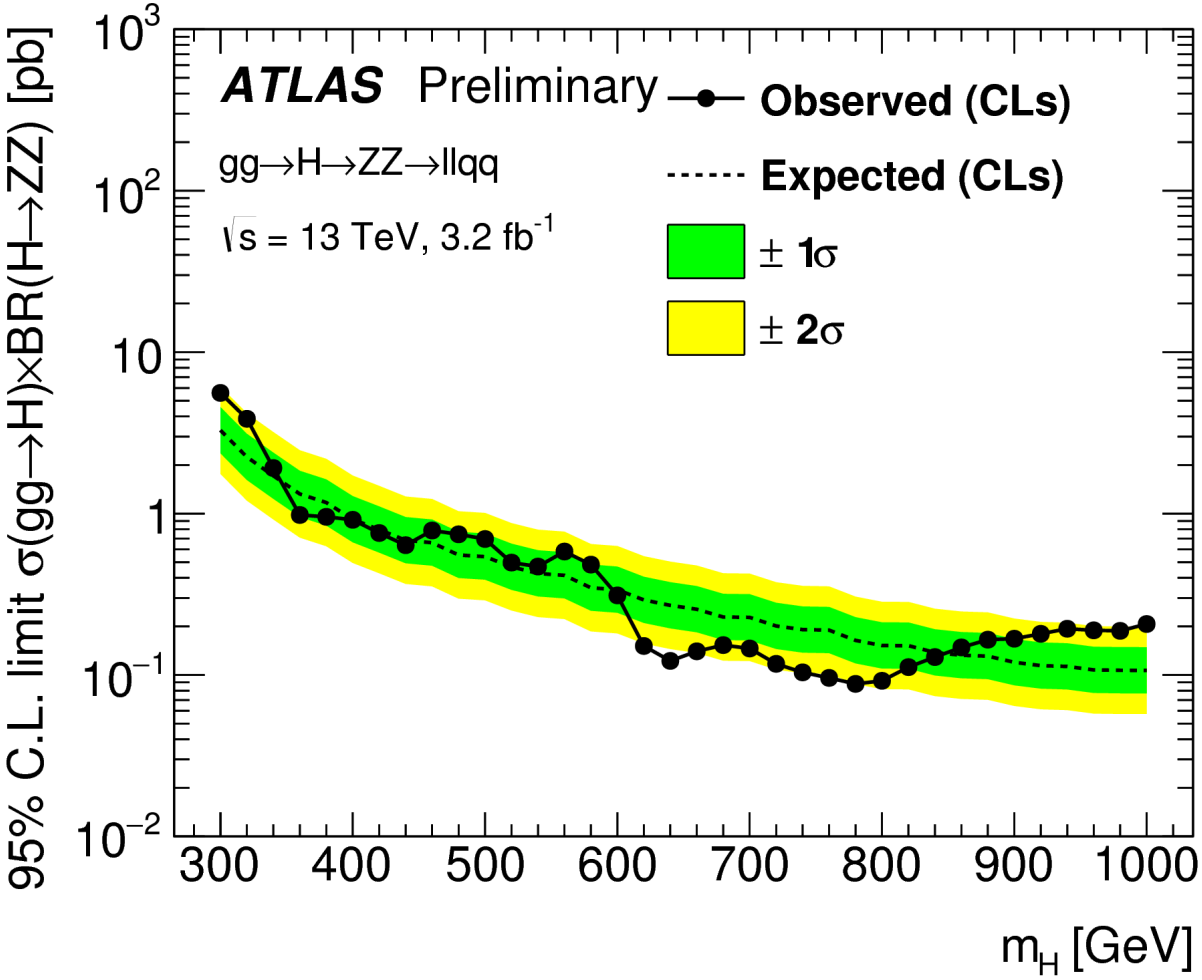


Good understanding of MET essential, achieved already with first Run II data

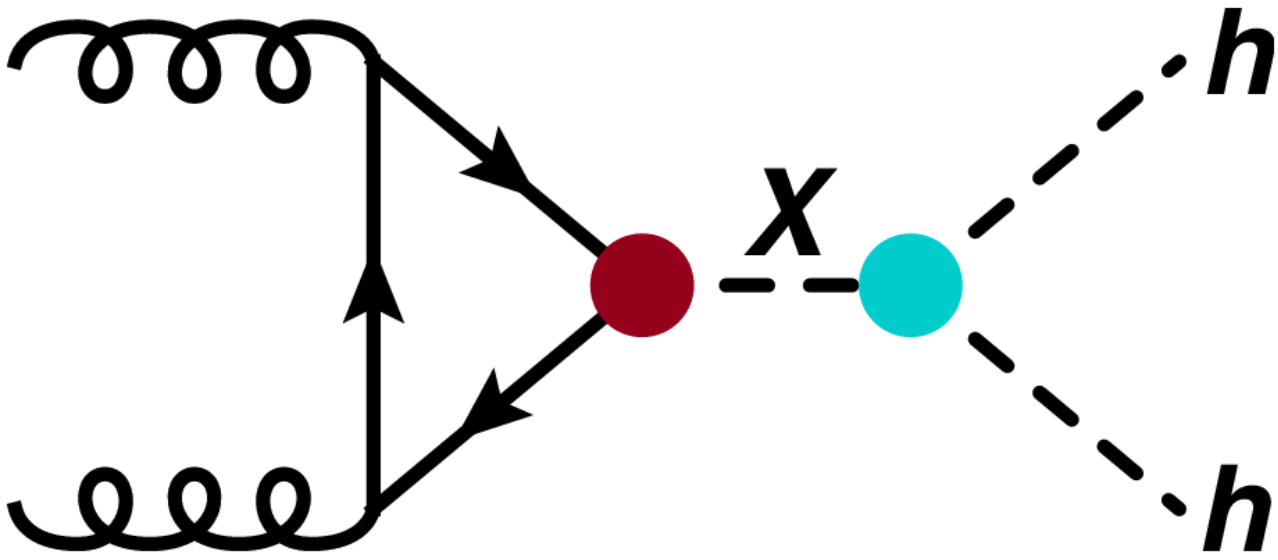
ATLAS-CONF-2016-016



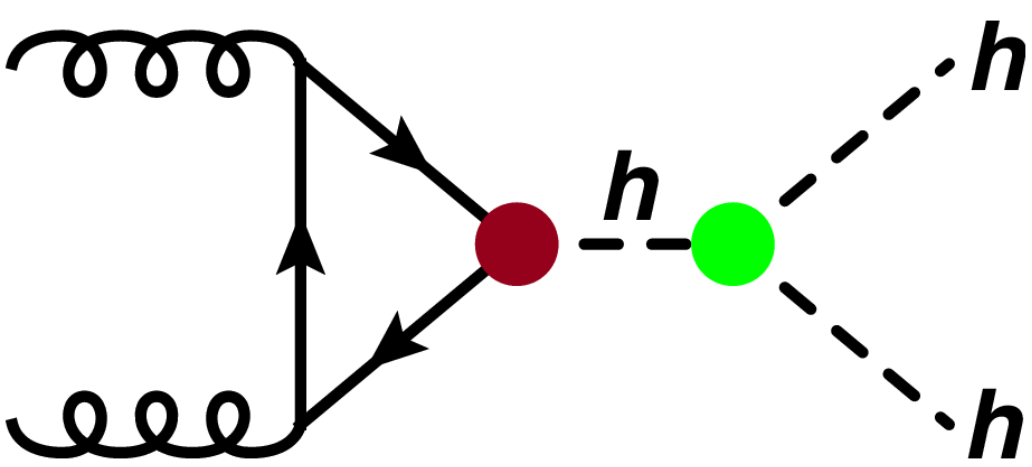


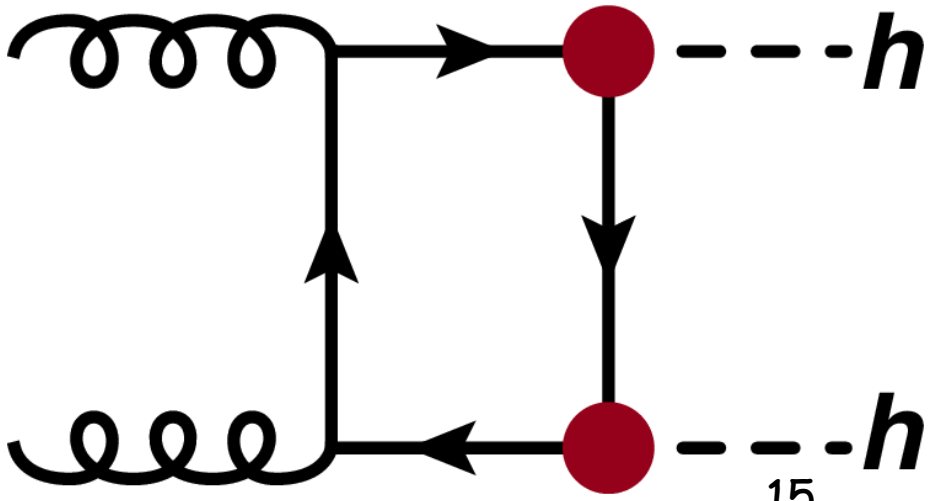


Complex analysis that includes b-tagging and boosted (fat) jets

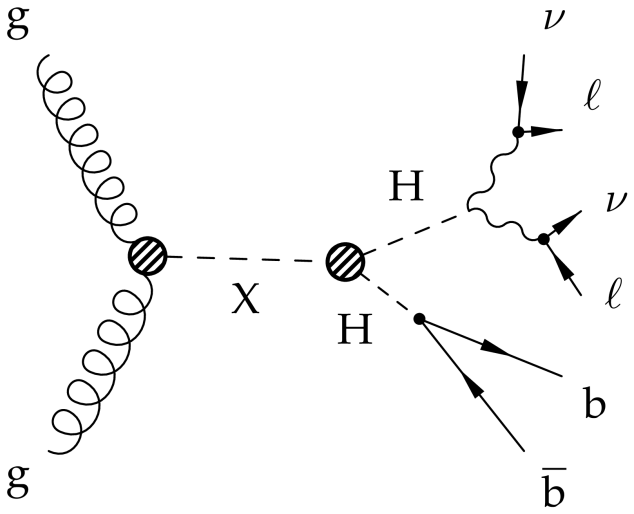


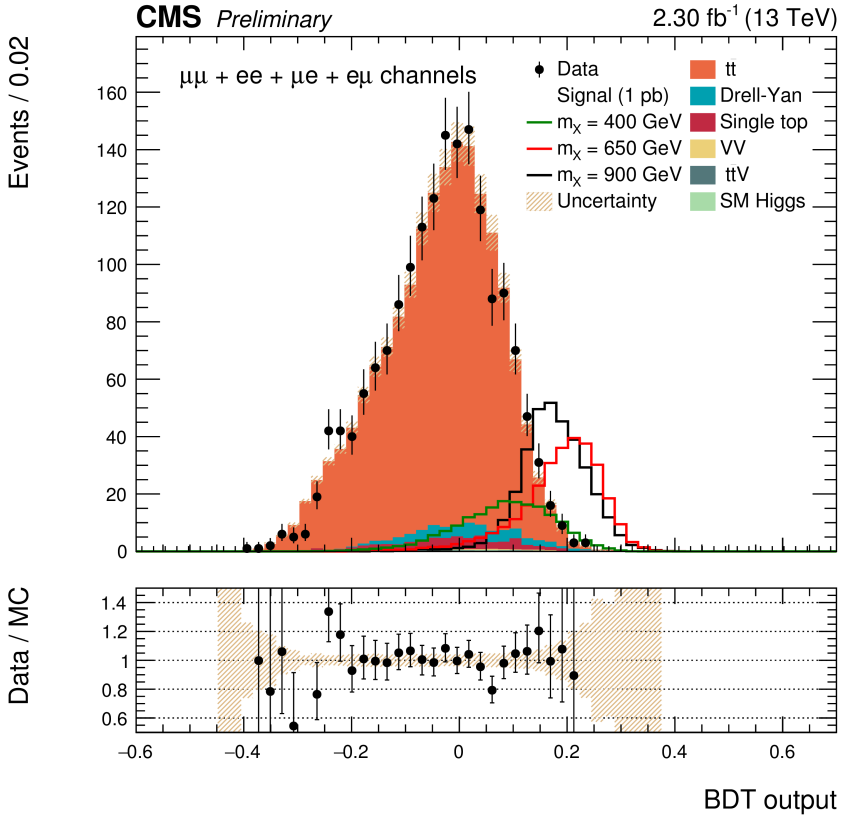
hh resonance searches

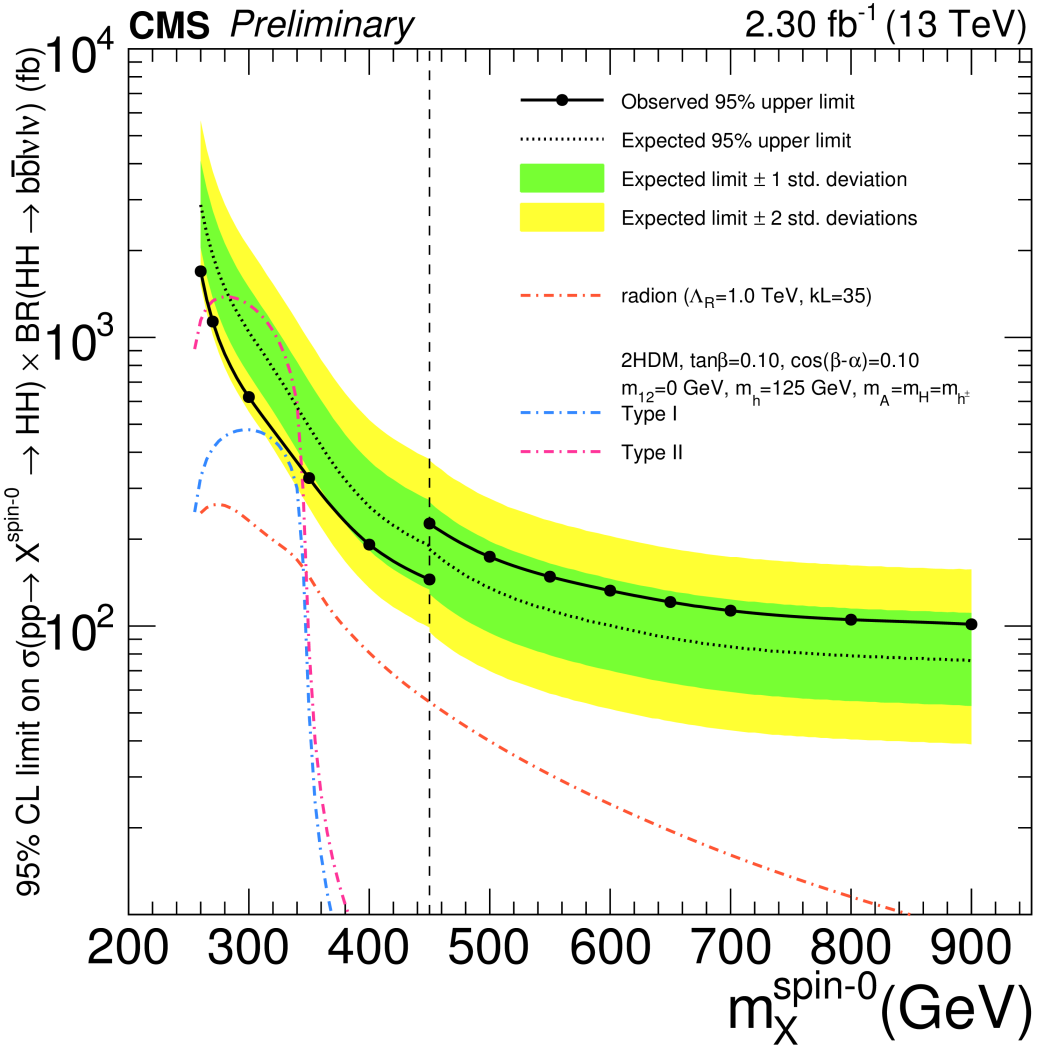




CMS-PAS-HIG-16-011

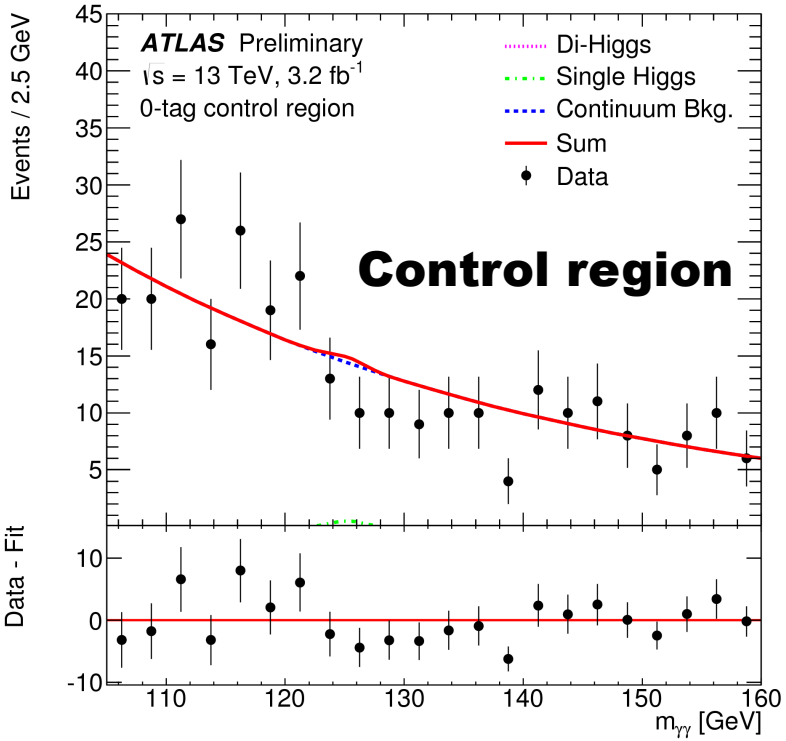


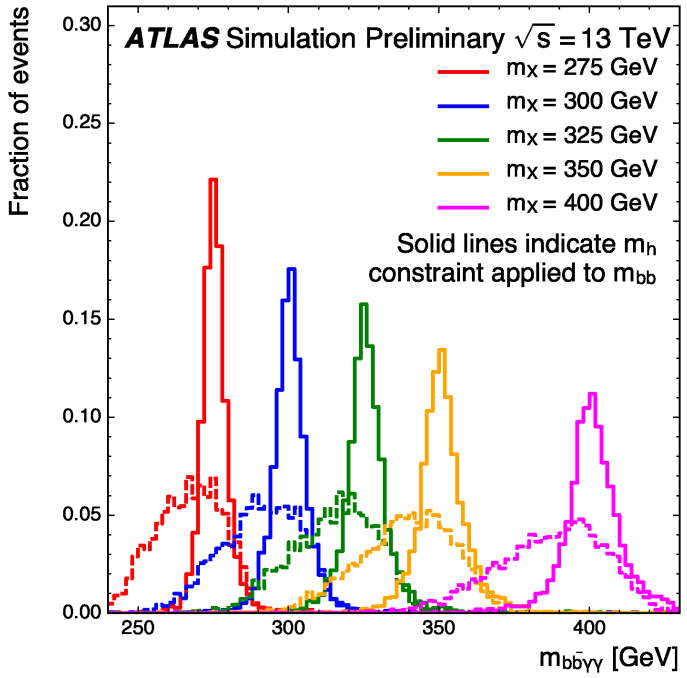


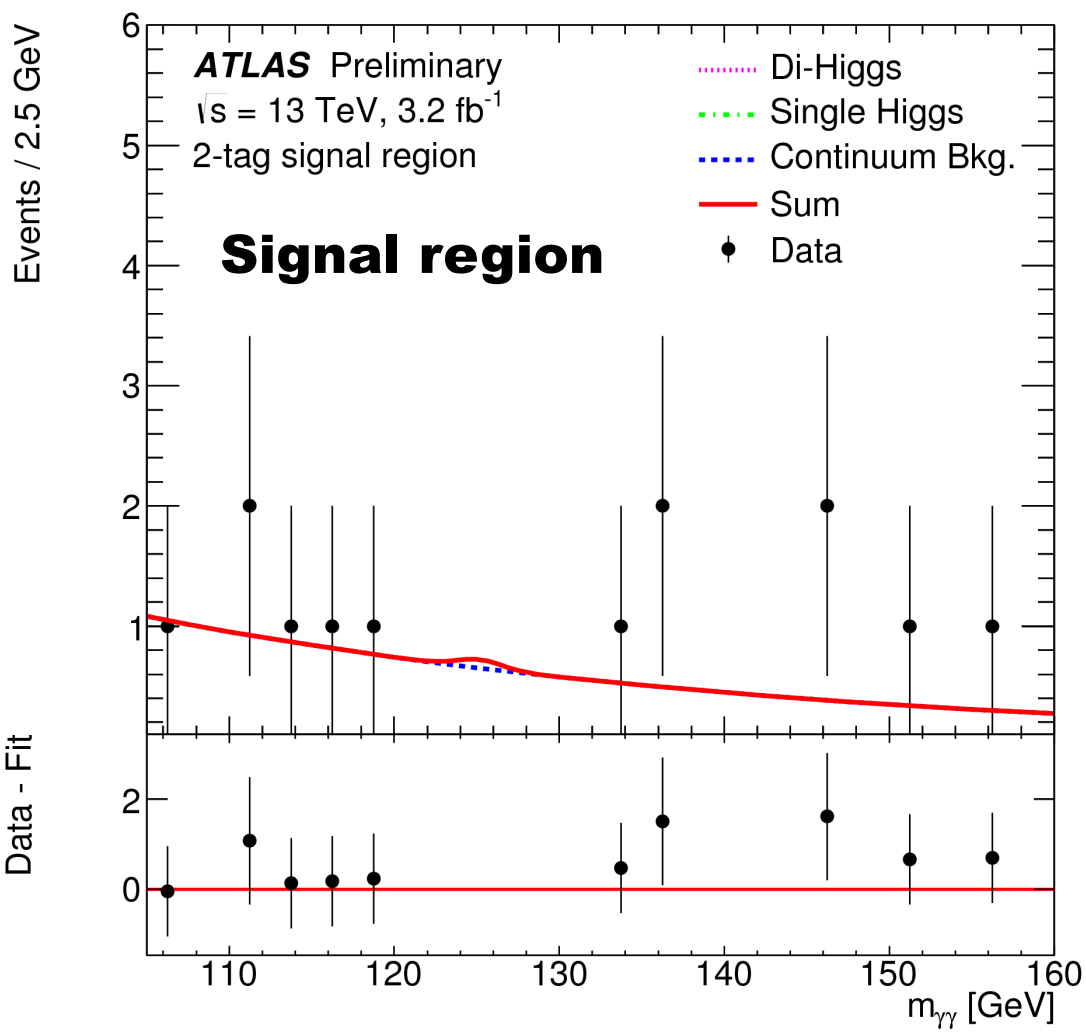


Sophisticated analysis based on a multivariate technique

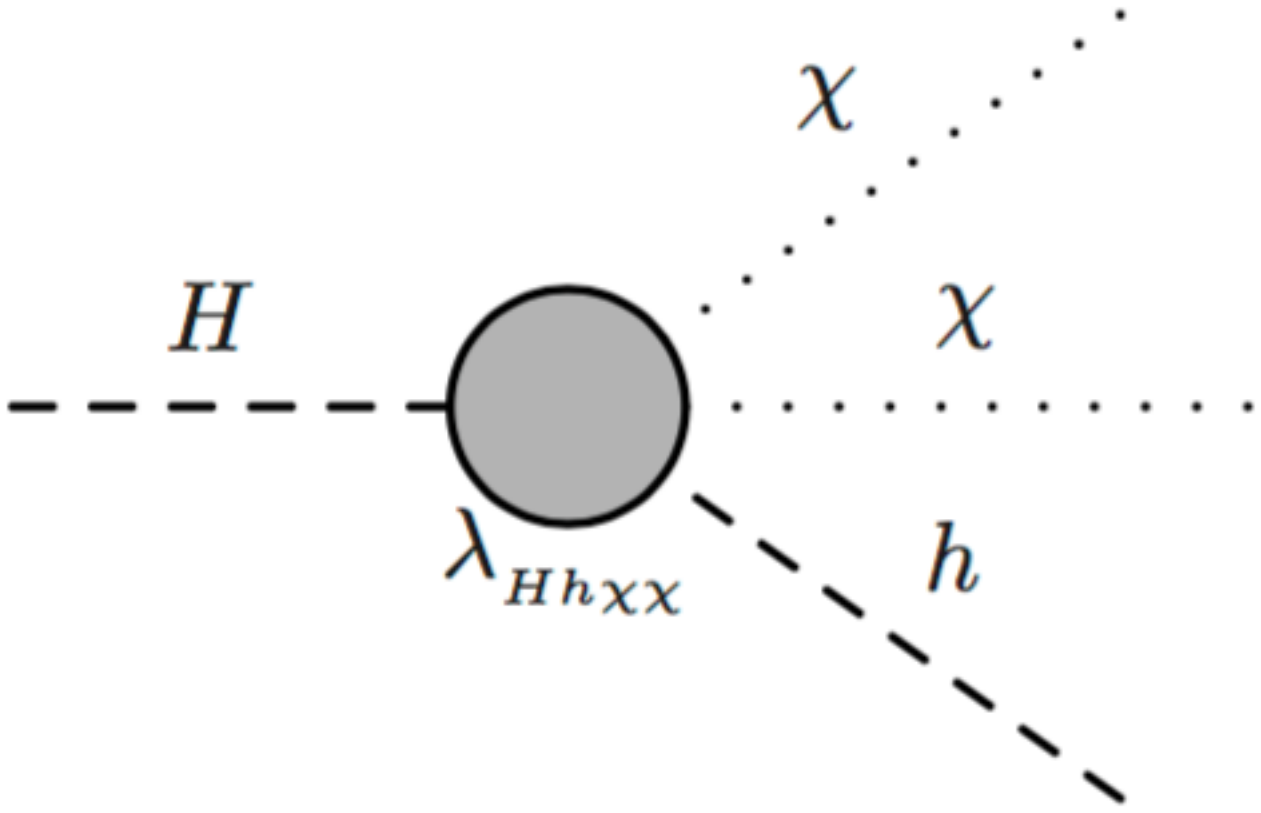
ATLAS-CONF-2016-004



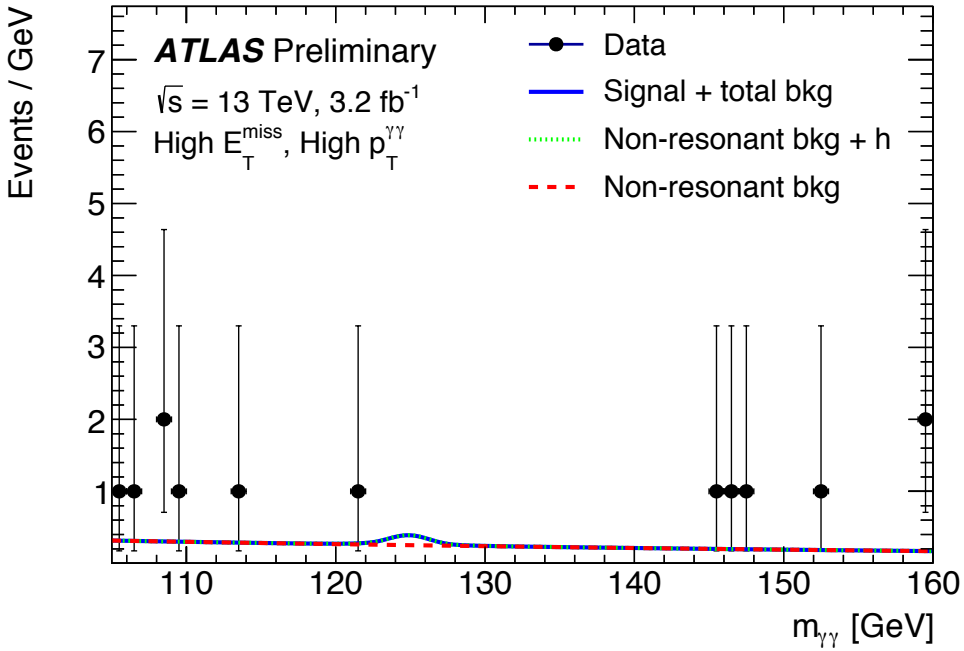


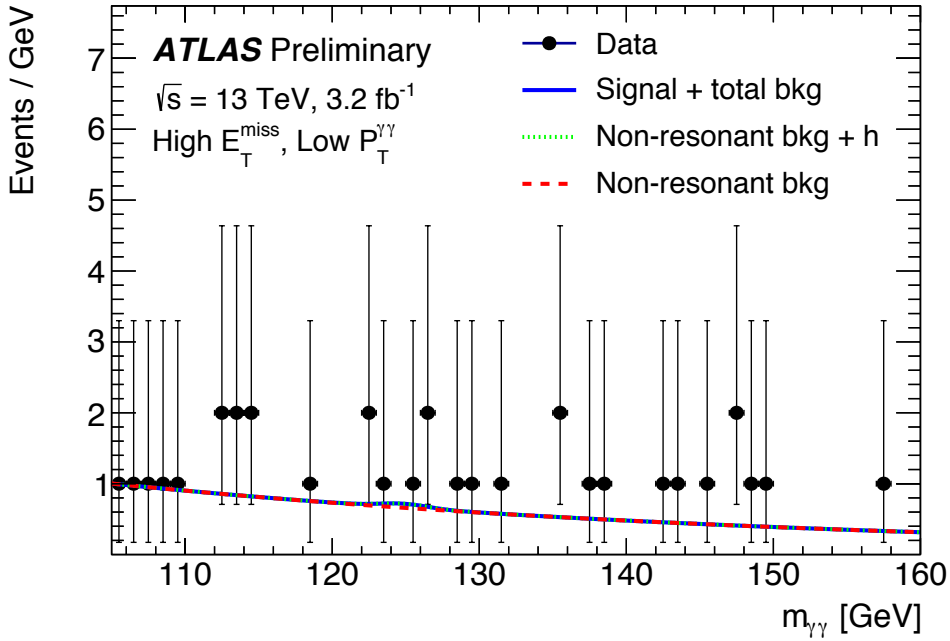


Analysis close to Run I paper strategy, including event counting and constrained mass.

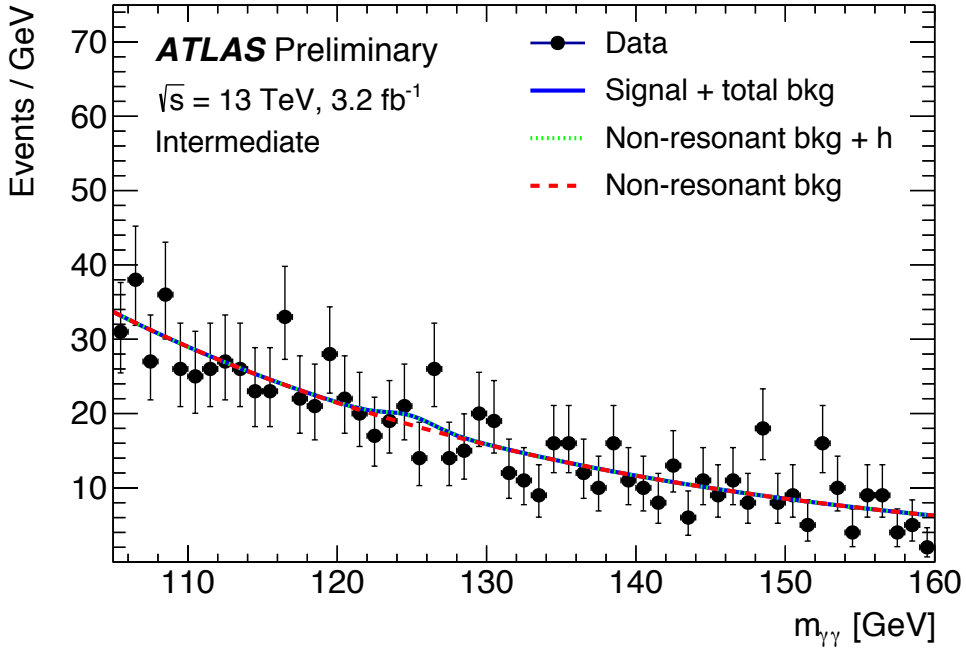


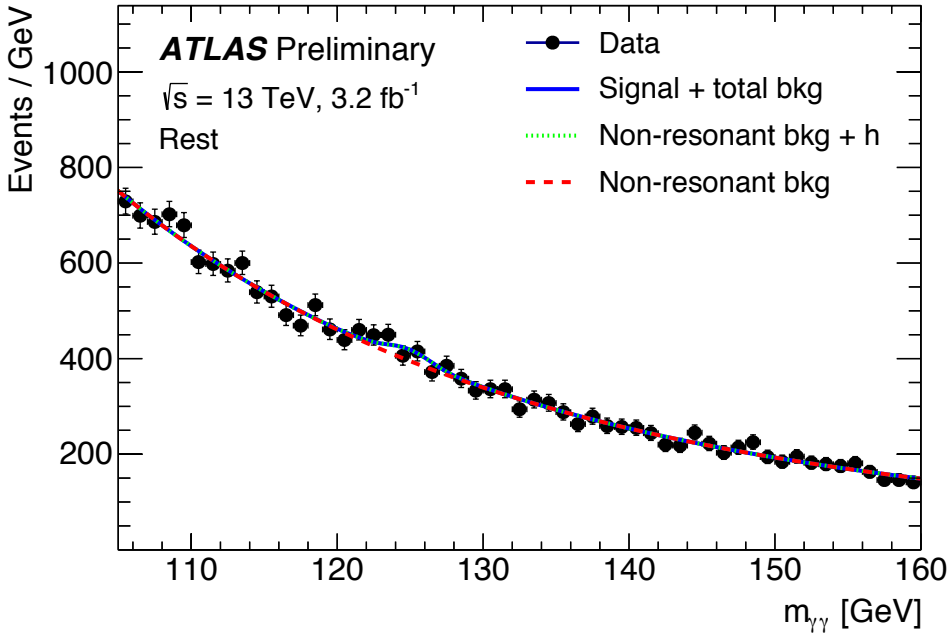
Heavy Scalar and Dark Matter



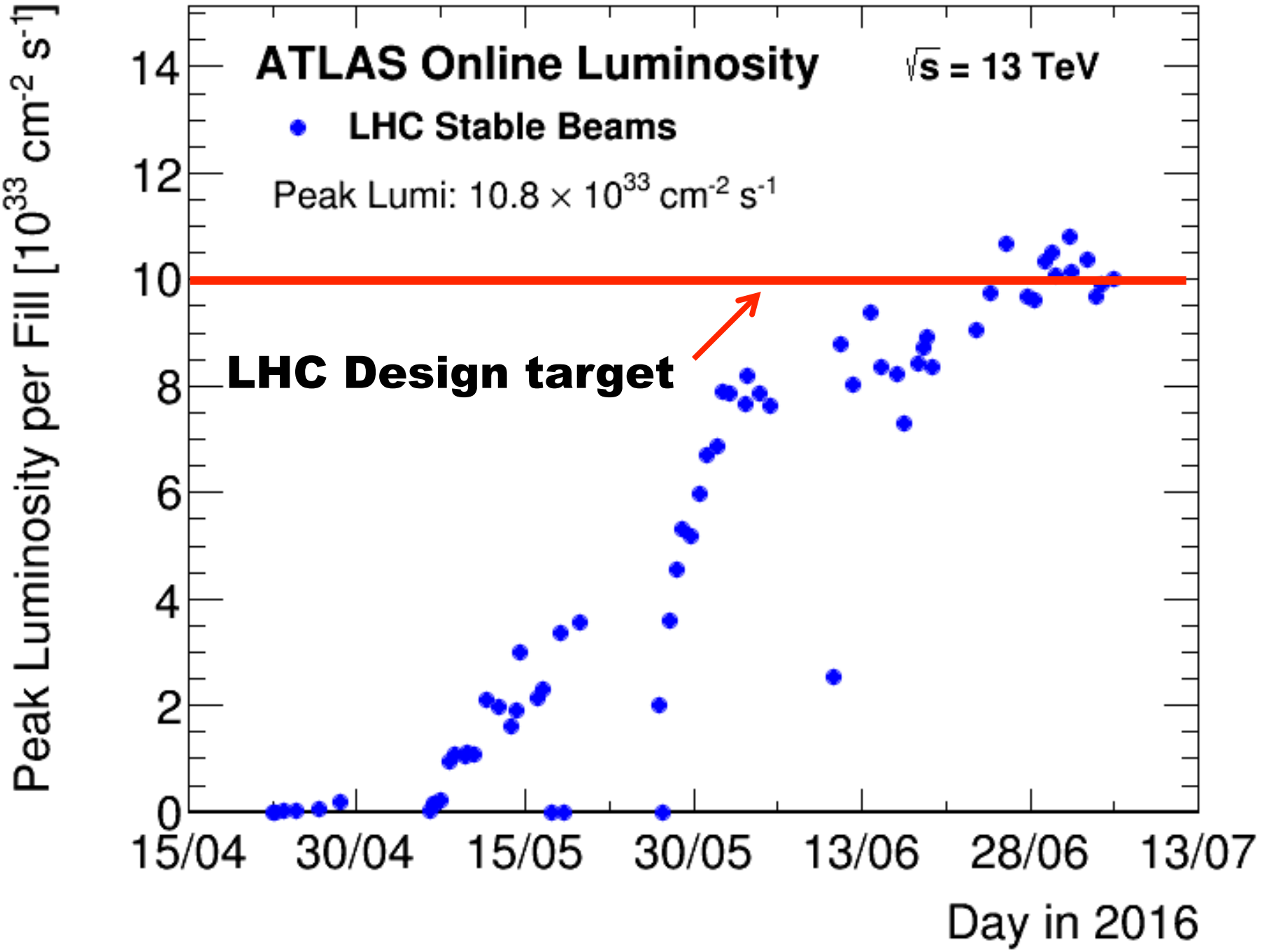


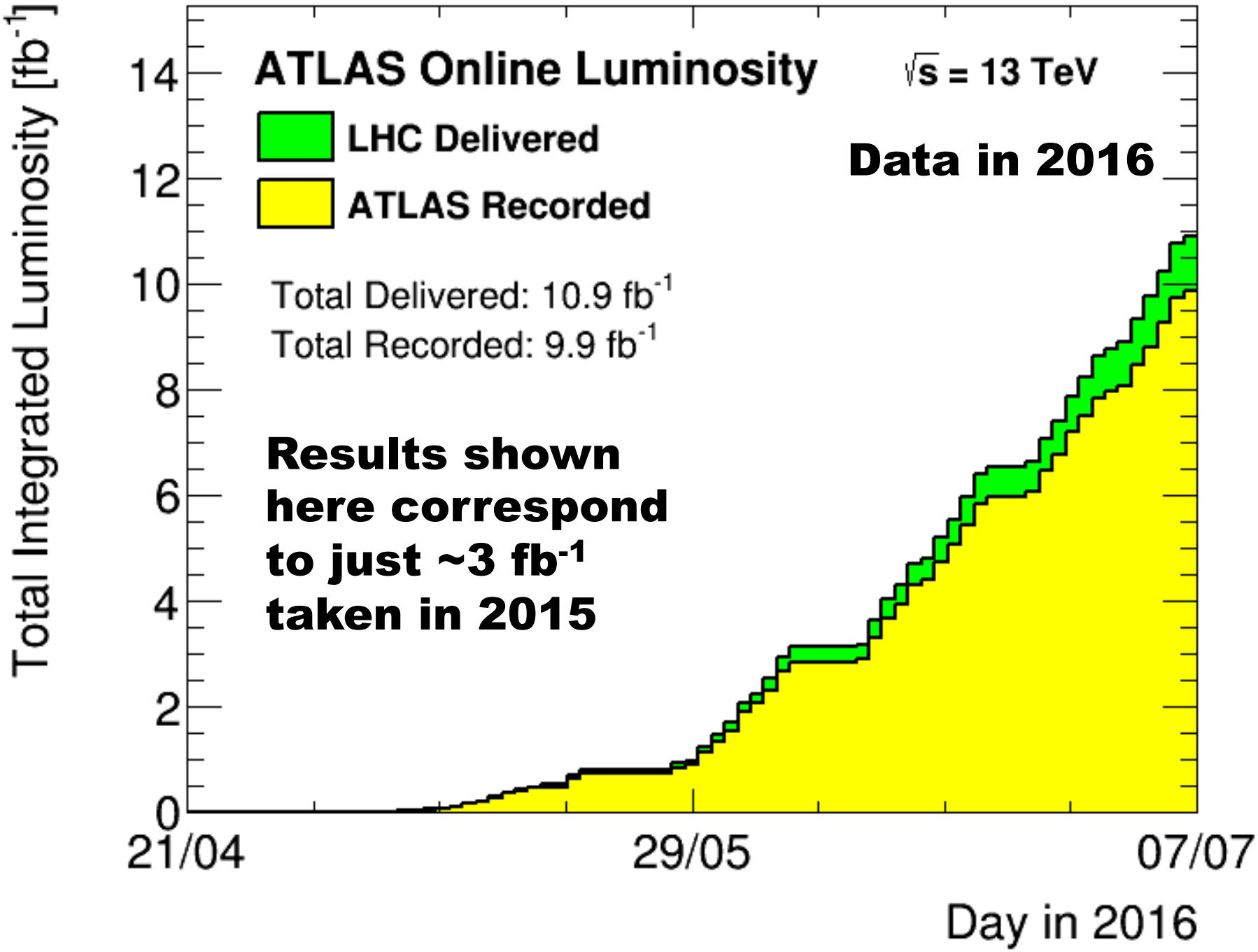
Di-photon candidates are classified according to presence of Missing energy

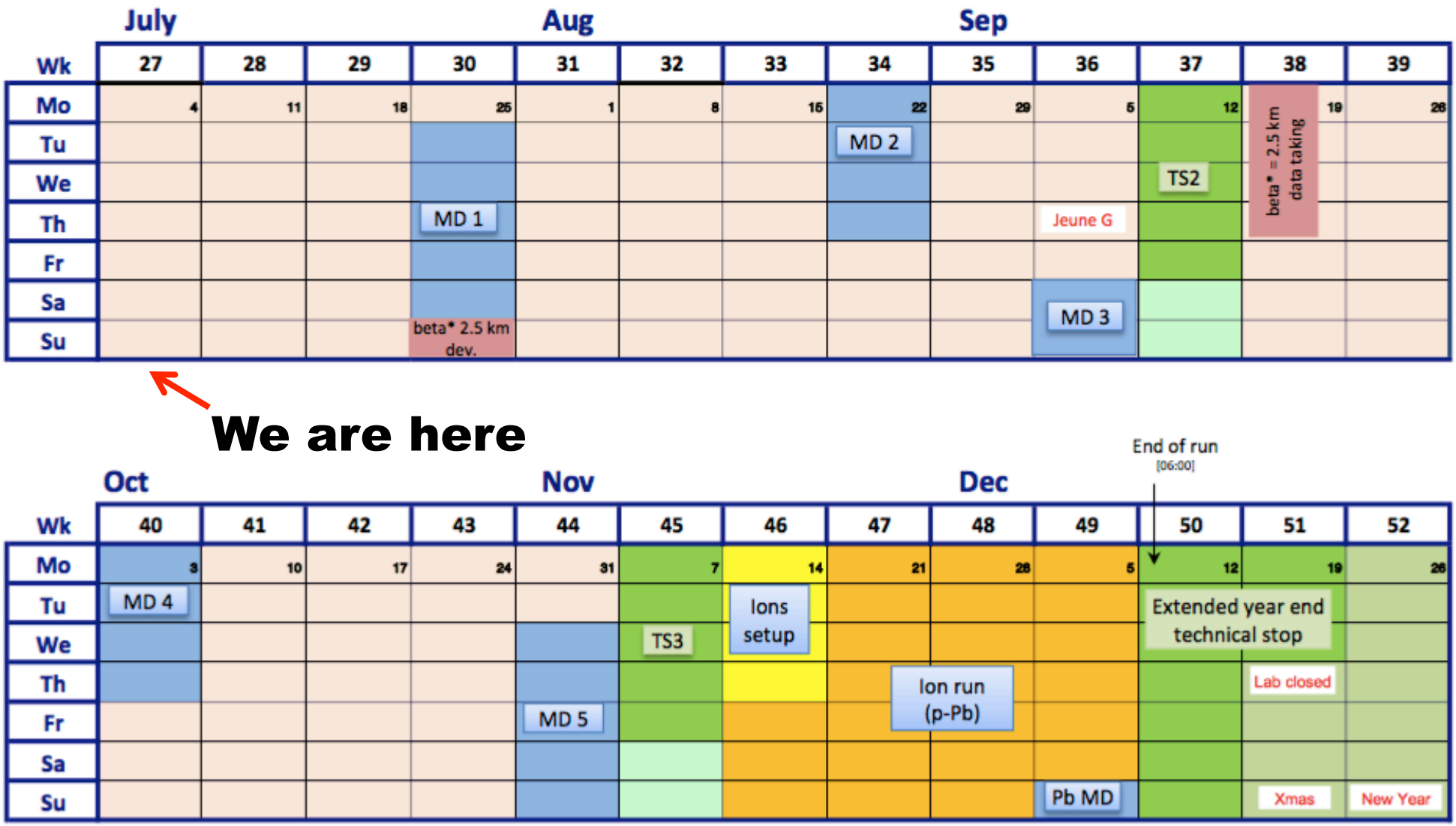




Prospects for 2016


ATLAS Online Luminosity
√s = 13 TeV
LHC Stable Beams
Peak Lumi: 10.8 × 10^33 cm^-2 s^-1
LHC Design target
Peak Luminosity per Fill [10^33 cm^-2 s^-1]
Day in 2016
0
2
4
6
8
10
12
14
15/04
30/04
15/05
30/05
13/06
28/06
13/07


ATLAS Online Luminosity
√s = 13 TeV
LHC Delivered
ATLAS Recorded
Data in 2016
Total Delivered: 10.9 fb-1
Total Recorded: 9.9 fb-1
Results shown here correspond to just ~3 fb-1 taken in 2015
Total Integrated Luminosity [fb-1]
0
2
4
6
8
10
12
14
21/04
29/05
07/07
Day in 2016



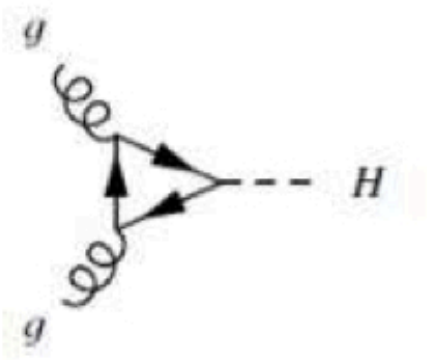
May get ~30 fb^{-1} this year alone

Stay tuned for massive updates

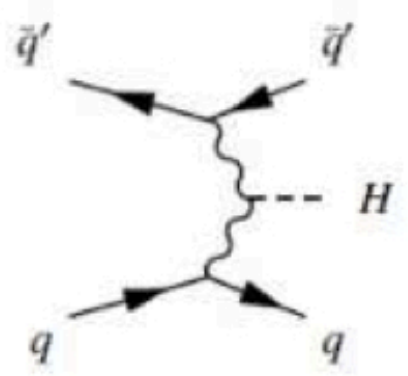
SA well represented with Z.Vilakazi in the IC, A.Muronga and BM as convenors

Additional Slides

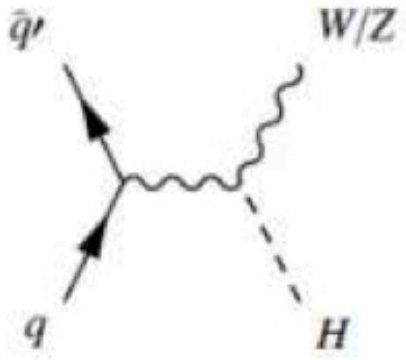
Higgs production at Hadron Colliders and decays

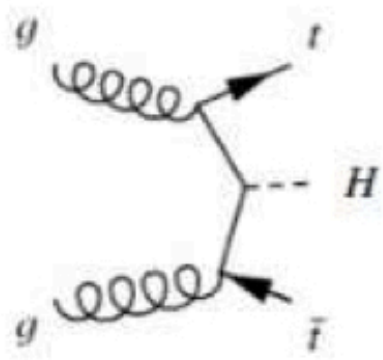


Gluon-gluon fusion



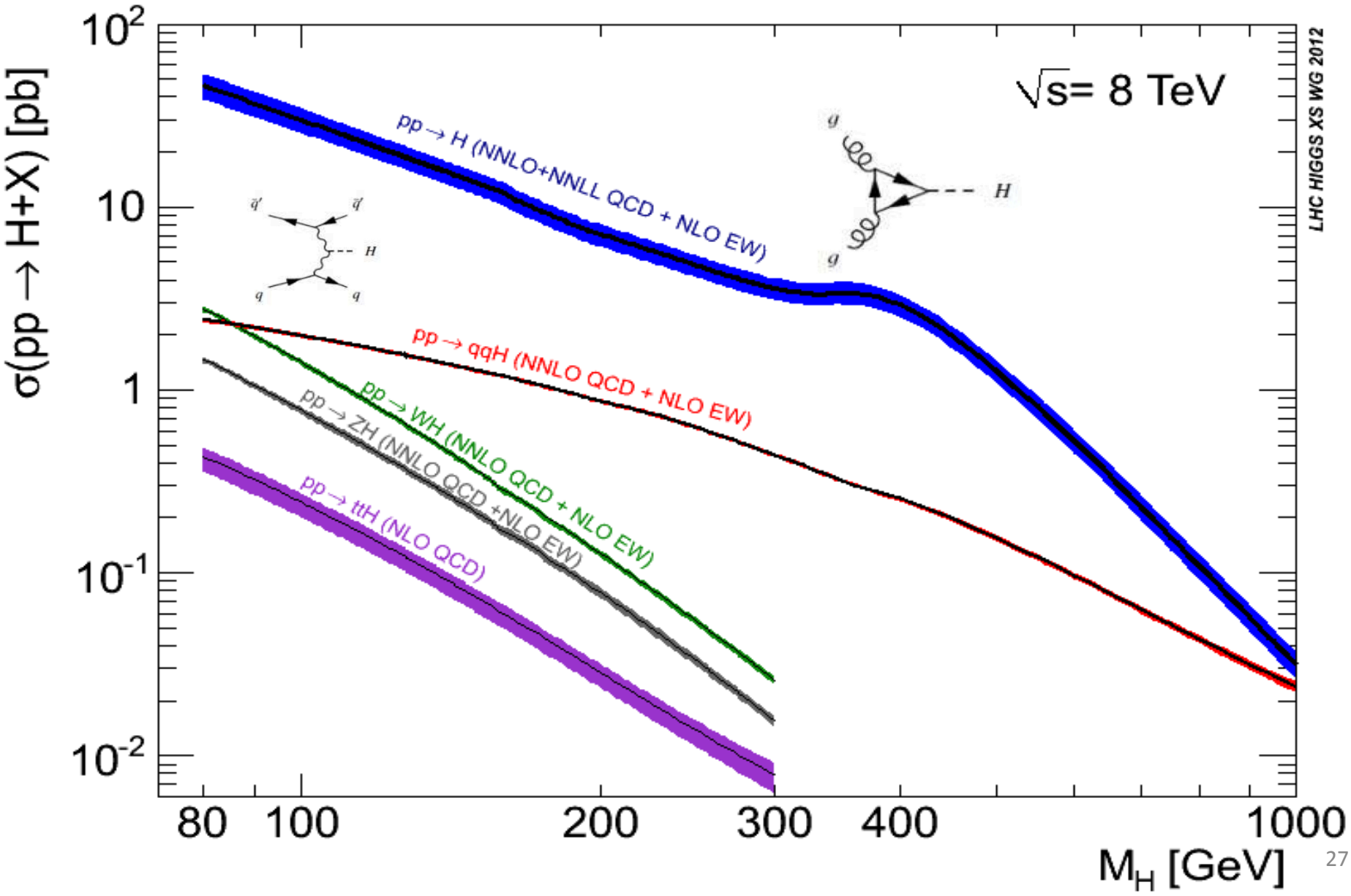
Vector Boson Fusion



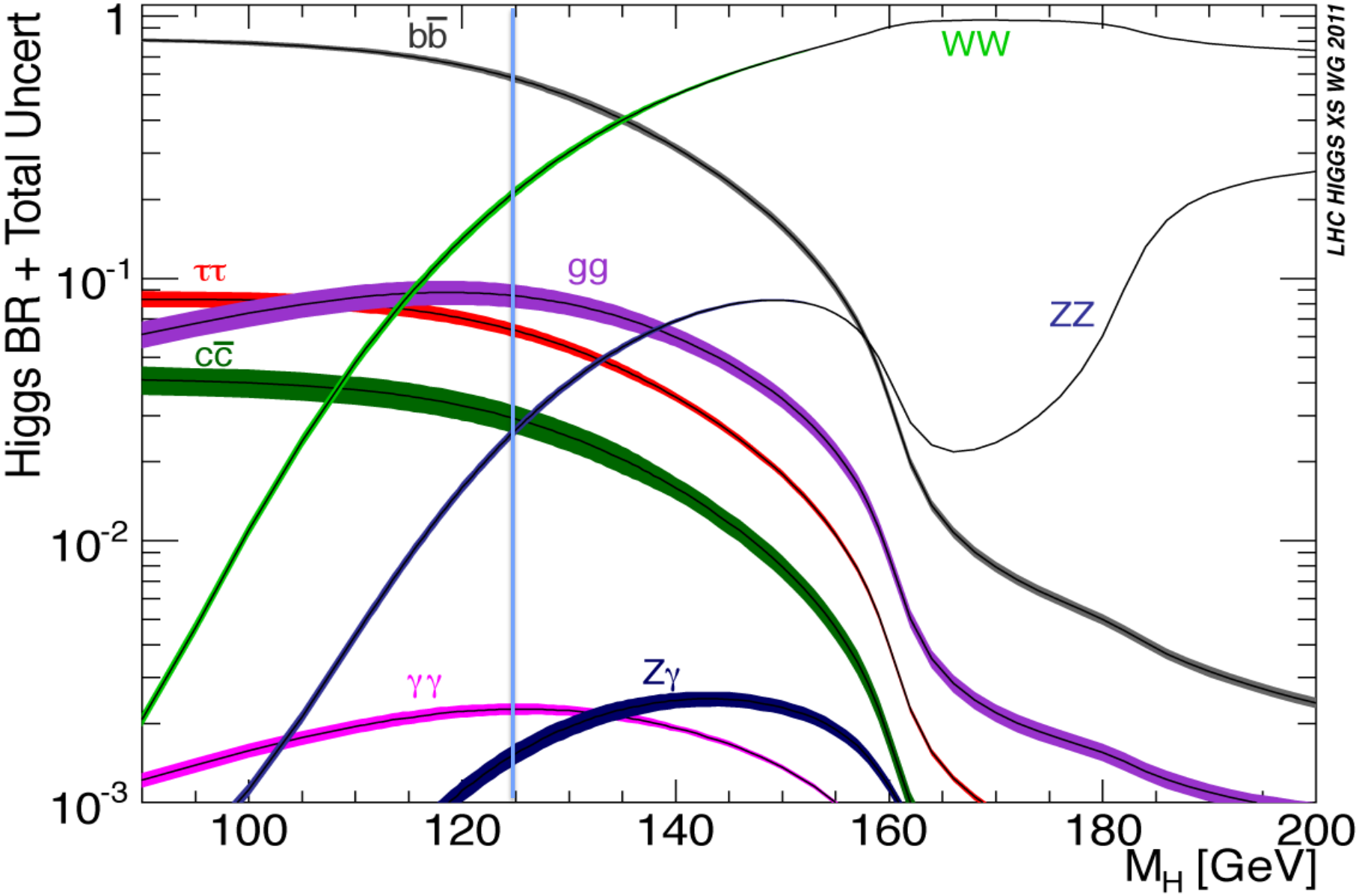


Associated Production

Higgs Cross-Sections at LHC



Main Decay Modes



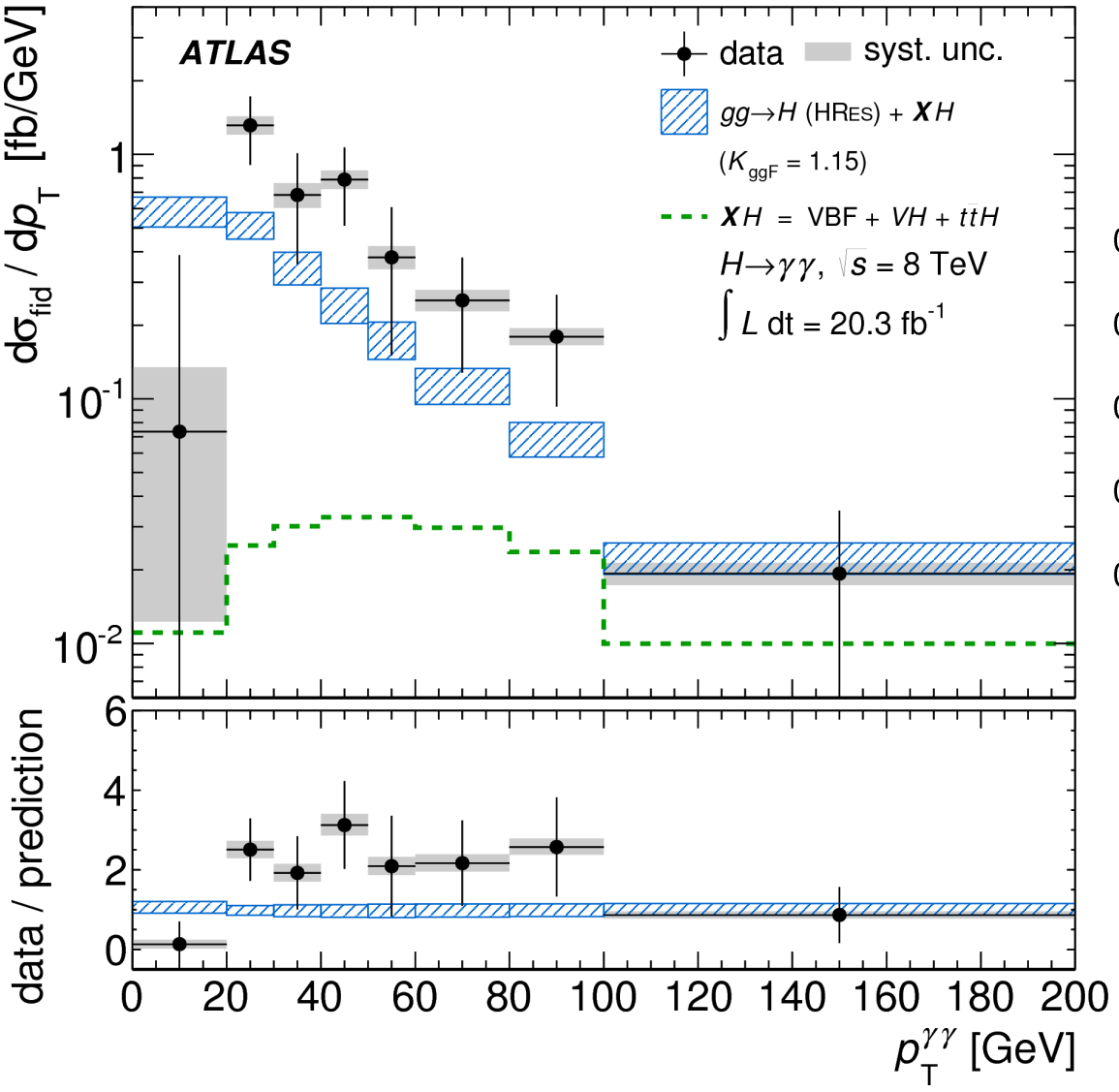
In the standard model there is a physical state, a Higgs boson with well defined couplings to weak bosons, fermions and self interactions

Gauge	Self-interaction	Fermion
$HW^+_\mu W^-_\nu : (-ig_{\mu\nu})2\frac{m^2_W}{\nu}$	$HHH : (i)3\frac{m^2_H}{\nu}$	$H\bar{f}f : (i)\frac{m_f}{\nu}$
$HZ_\mu Z_\nu : (-ig_{\mu\nu})2\frac{m^2_Z}{\nu}$	$HHHH : (i)3\frac{m^2_H}{\nu^2}$	
$HHW^+_\mu W^-_\nu : (-ig_{\mu\nu})2\frac{m^2_W}{\nu^2}$		
$HHZ_\mu Z_\nu : (-ig_{\mu\nu})2\frac{m^2_Z}{\nu^2}$		

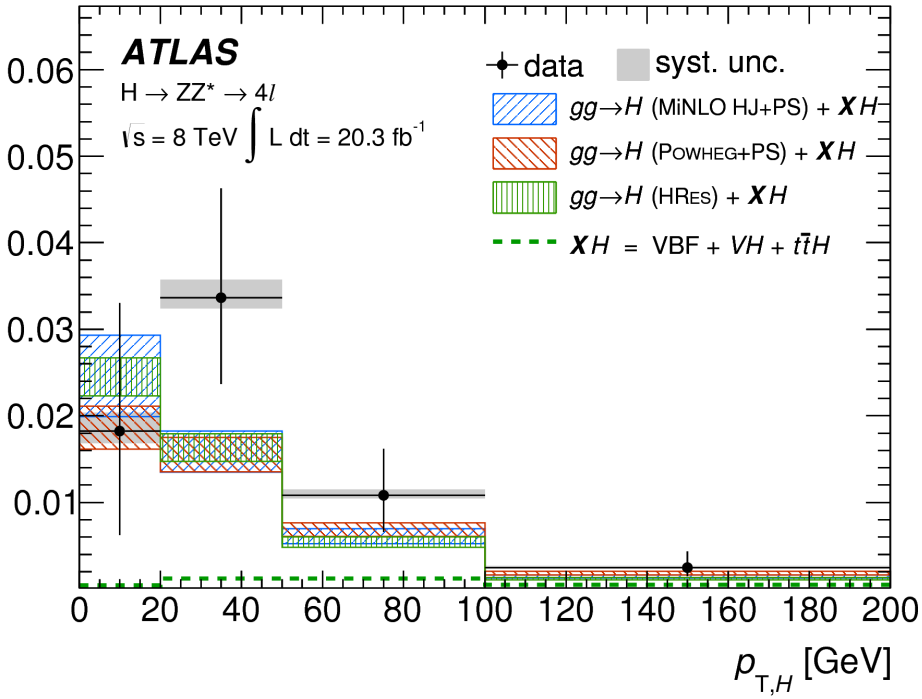
The exploration of the coupling to weak bosons plays now a pivotal role in understanding the nature of the scalar boson observed experimentally. New physics can be hidden in these couplings.

When measuring the Higgs boson transverse momentum certain discrepancies were found with the Standard Model

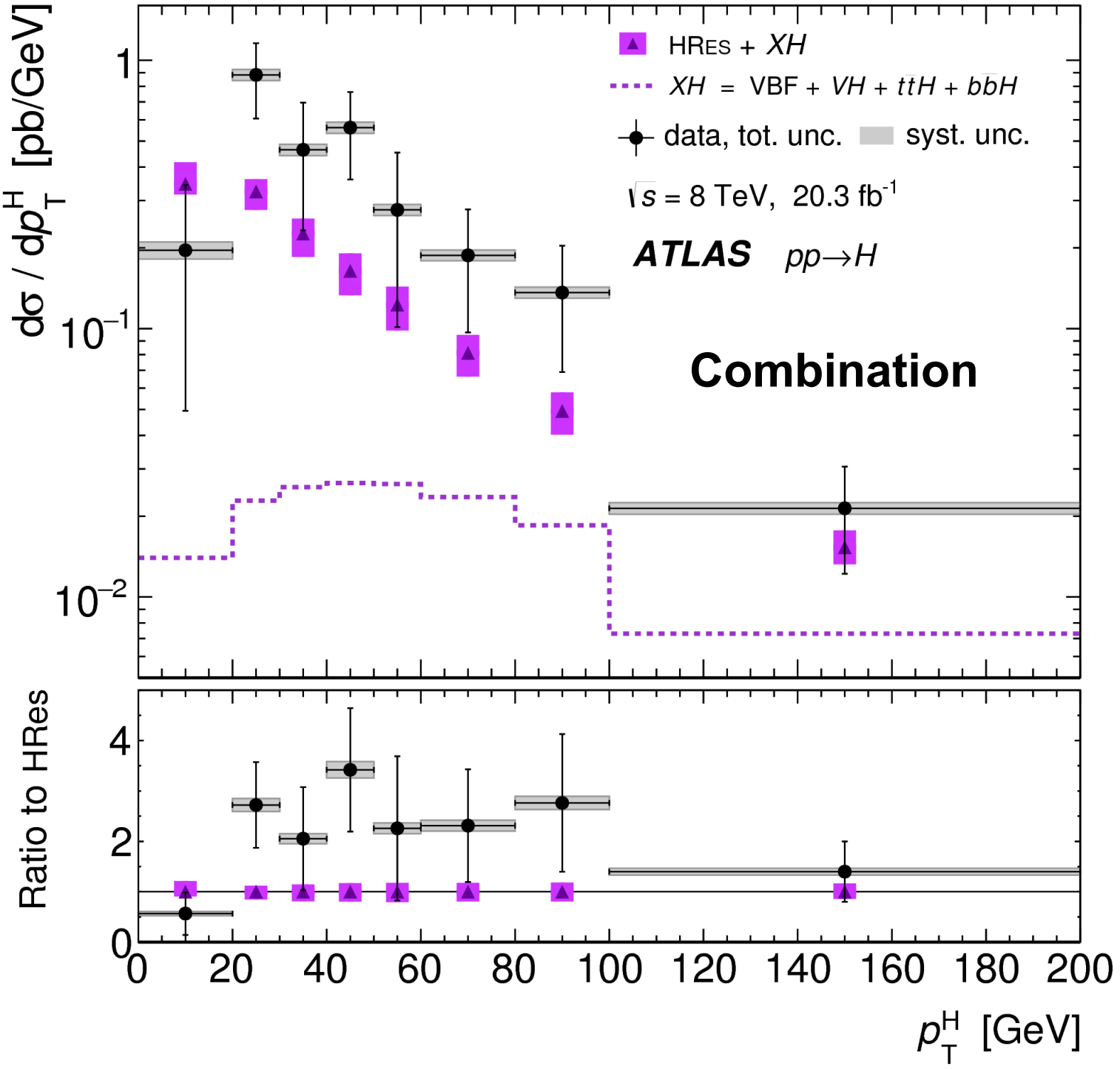
$H \to \gamma\gamma$



$H \to ZZ^* \to 4\ell$



Compatibility with the SM (HRes) is 2%



Look at other talks in this session for BSM interpretations of this plot

ATLAS-CONF-2016-012

Variables	Cut Values
Lepton p_{T} (leading, subleading)	>(30 GeV, 20 GeV)
$m_{\ell\ell}$	76–106 GeV
$E_{\mathrm{T}}^{\mathrm{miss}}$	>120 GeV
$\Delta R_{\ell\ell}$	<1.8
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\,\ell\ell}, \vec{E}_{\mathrm{T}}^{\mathrm{miss}})$	>2.7
Fractional p_{T} difference	<0.2
Number of b-jets	0
$\Delta\phi(\vec{E}_{\mathrm{T}}^{\mathrm{miss}}, \mathrm{jets})$	> 0.4
$p_{\mathrm{T}}^{\ell\ell}/m_{\mathrm{T}}^{ZZ}$	< 0.7