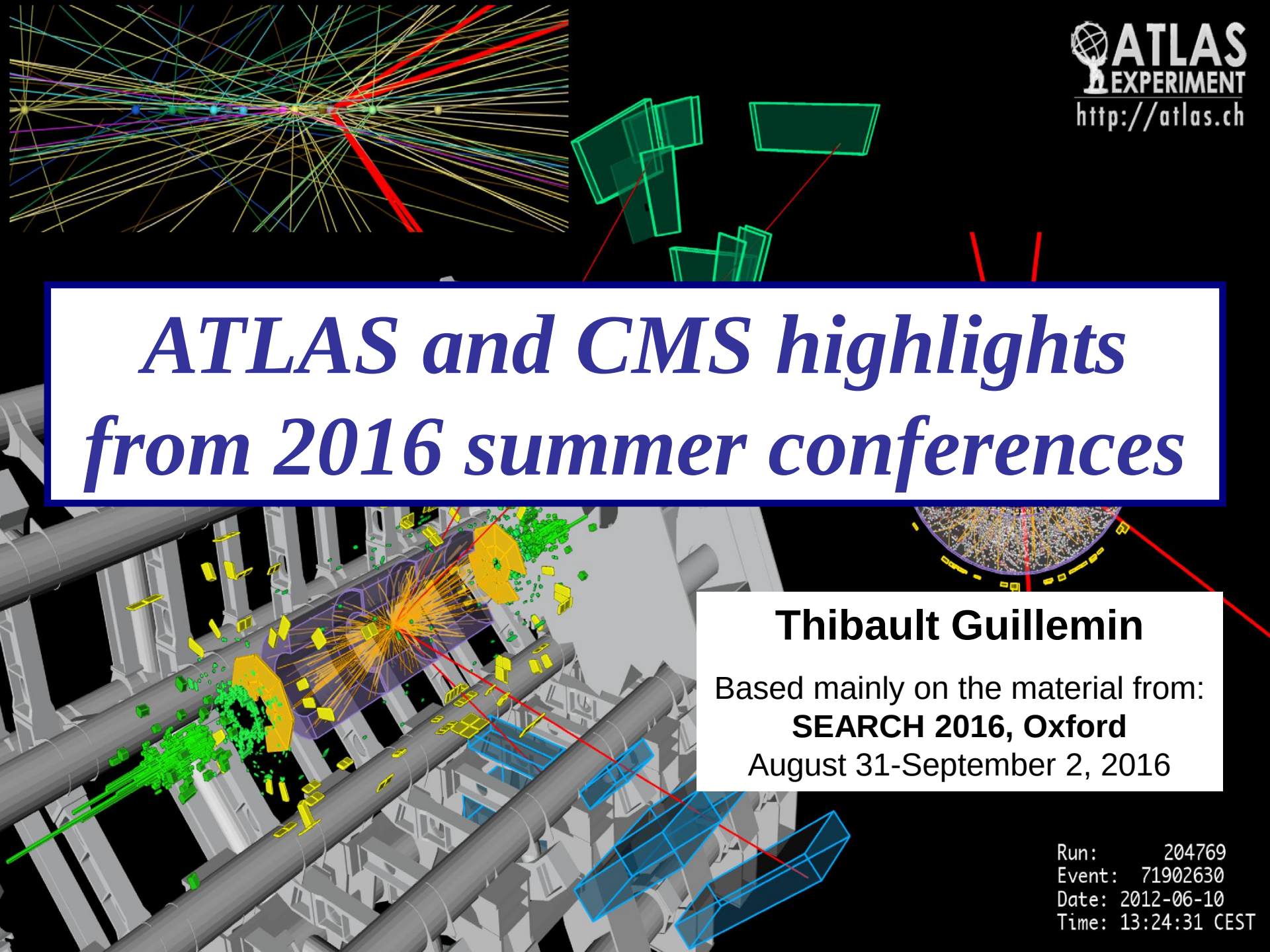


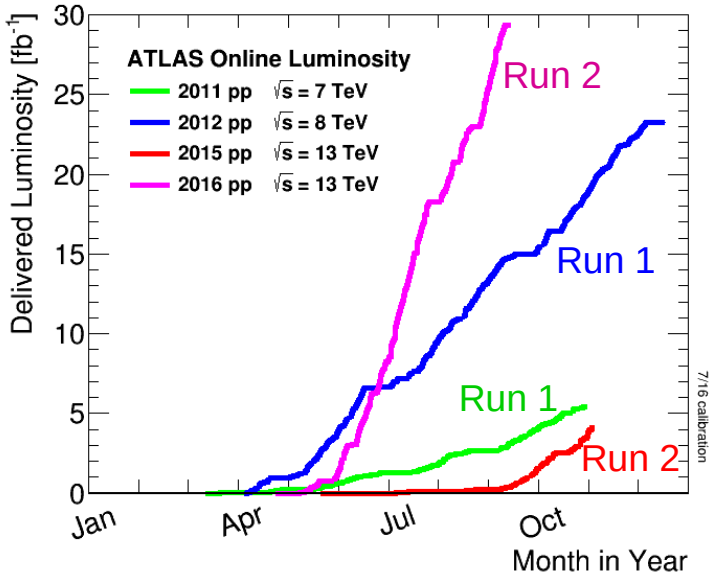
ATLAS and CMS highlights from 2016 summer conferences

Thibault Guillemin

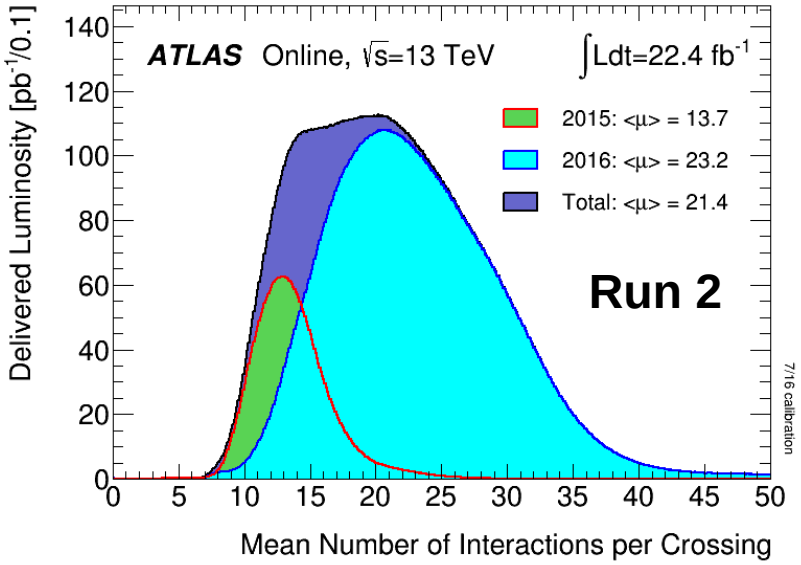
Based mainly on the material from:
SEARCH 2016, Oxford
August 31-September 2, 2016

The Run 1 and Run 2 LHC datasets

Outstanding performance of the LHC in 2016



- Pileup in 2016 higher than in Run 1
- Instantaneous luminosity at design level



Run 1

Run 2

Datasets analysed

2011: 5 fb^{-1}, 7 TeV

2012: 20 fb^{-1}, 8 TeV

2015: 3 fb^{-1}, 13 TeV

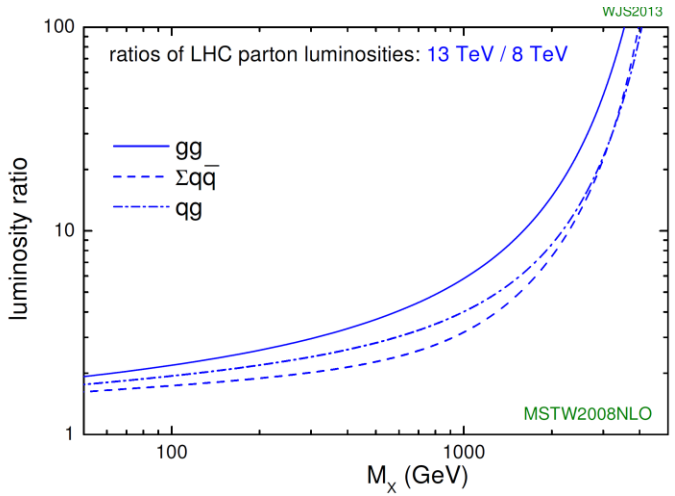
2016: 10-12 fb^{-1}, 13 TeV

- Main ATLAS detector upgrade: addition of an insertable B-layer (IBL)
  ➔ 4th pixel layer at 3.3 cm from the beam
- No major detector upgrade for CMS

What happens going from 8 to 13 TeV?

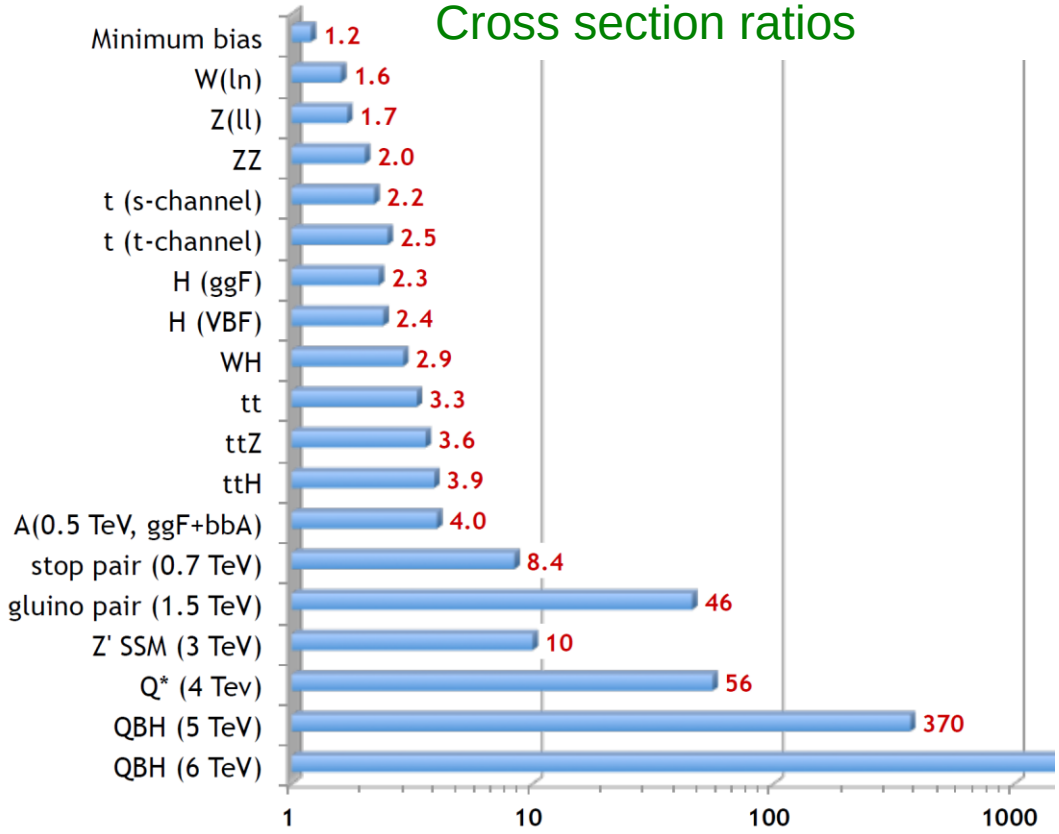
This is not ‘just’ an increase of 60% of the centre-of-mass energy…

Parton luminosity ratios



From J. W. Stirling

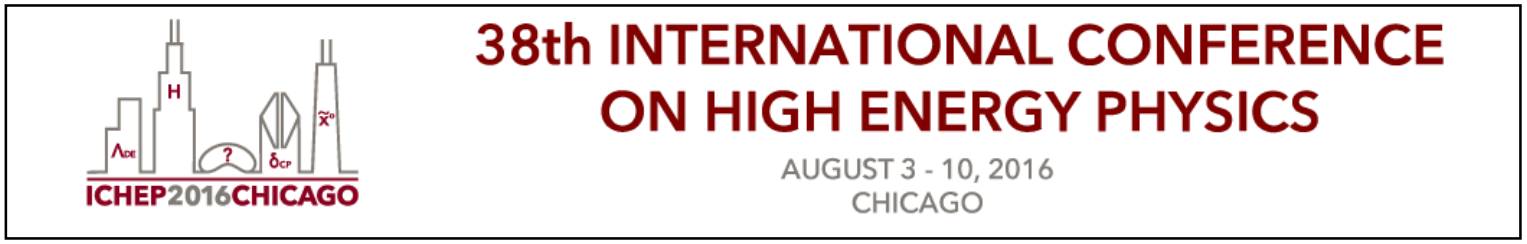
Cross section ratios



From A. Hoecker

The high mass discovery potential is exponentially increasing at Run 2.

The ICHEP physics harvest



- ICHEP: major conference this year
- ATLAS: 65 new results
- CMS: 70 new results

- In this summary: **drastic (but hopefully representative) selection of results**

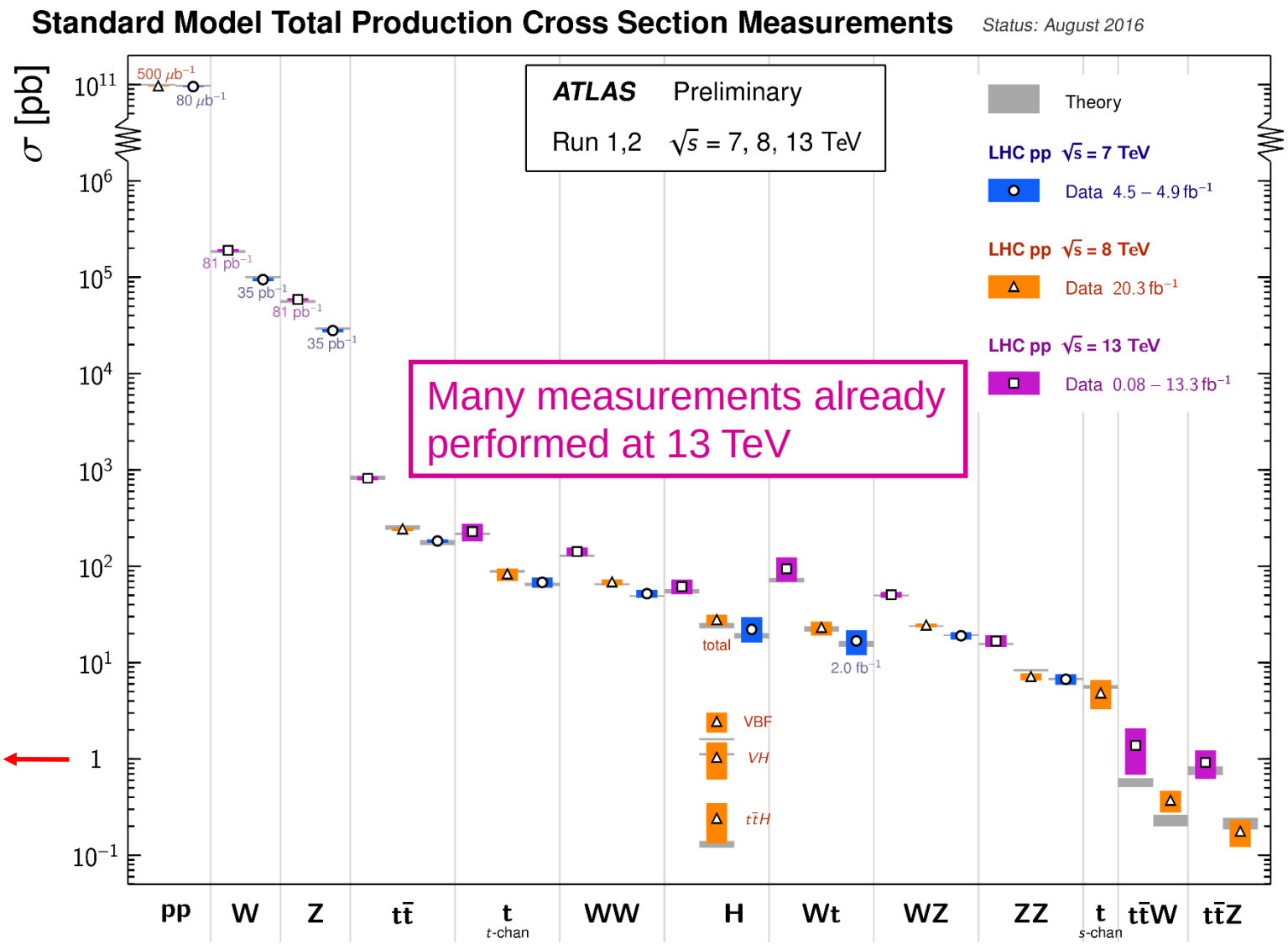
- Full list of results:

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/WebHome#NEW_All_ATLAS_13_TeV_results_pre
http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/ICHEP-2016.html

Outline

- Electroweak and top measurements
- Higgs boson sector
- Supersymmetry
- Exotic searches

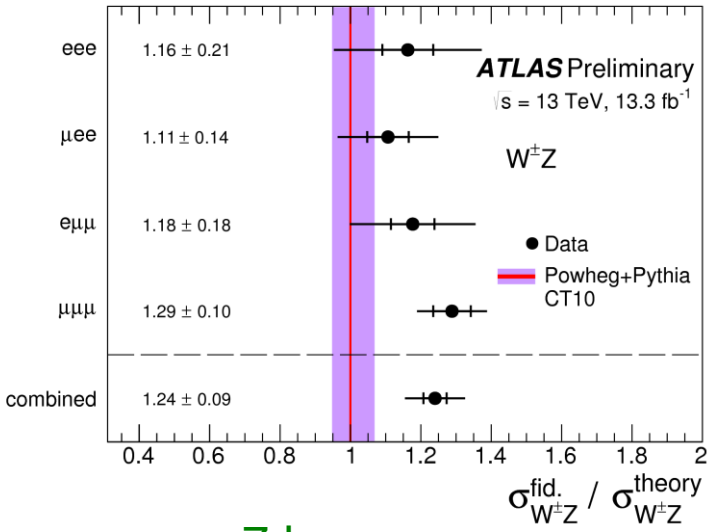
The cross section stairway plot

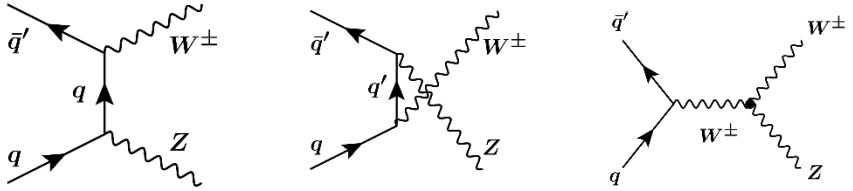


Diboson production: WZ (1/2)

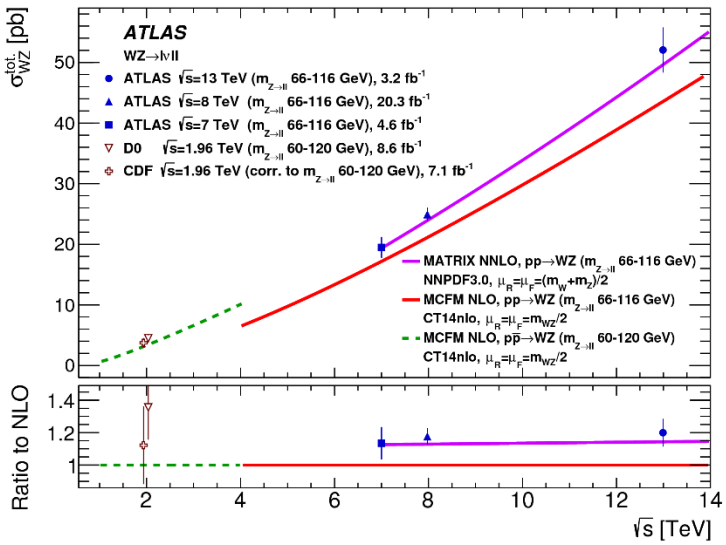
ATLAS-CONF-2016-043

σ_{fid} ratio per channel

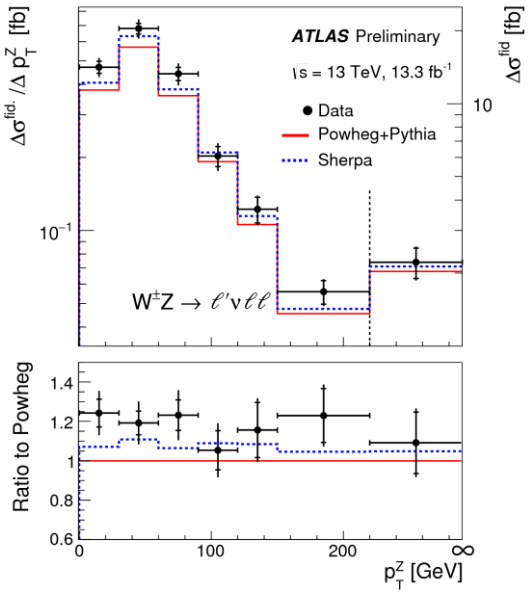




σ_{tot} vs E_{CM}



Z boson p_T



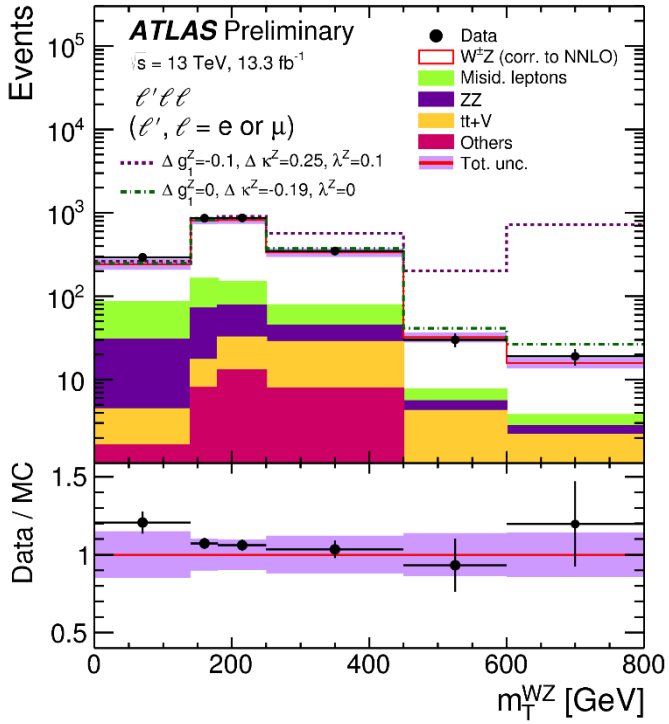
- ~7% precision (dominated by systematics)
- Consistent with NNLO
- Waiting for differential NNLO

Prediction accuracy crucial for all non-resonant searches!

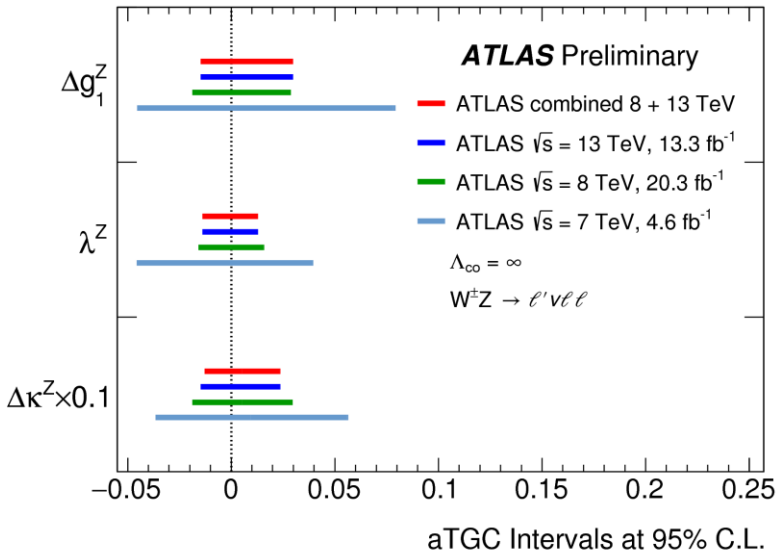
Diboson production: WZ (2/2)

- Channel sensitive to anomalous triple gauge boson couplings
- Deviations w.r.t. SM introduced as 3 dimensionless anomalous couplings: $\Delta\kappa^Z$, Δg_1^Z, and λ_Z

m_T^{WZ} distribution



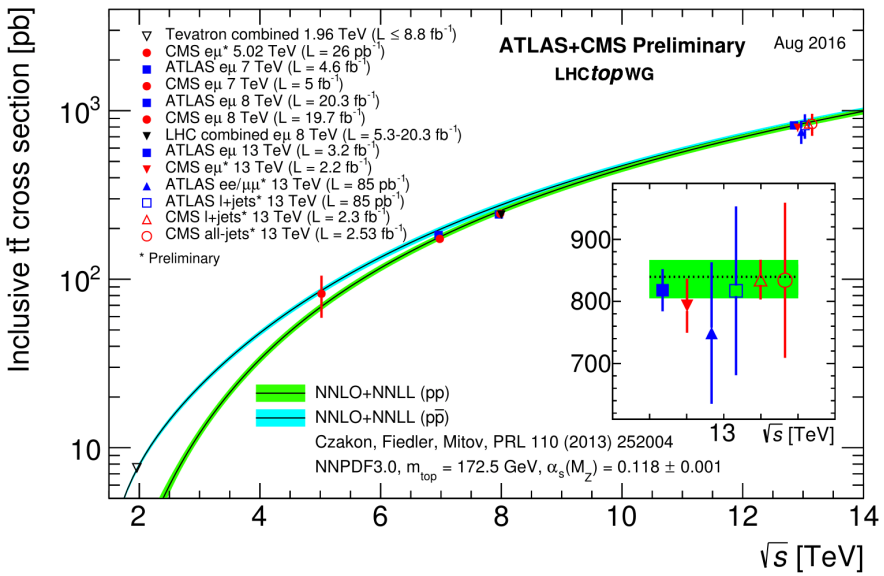
95% CL limits on aTGC



- First aTGC limits with 2016 data
- Run 1 and Run 2 combination

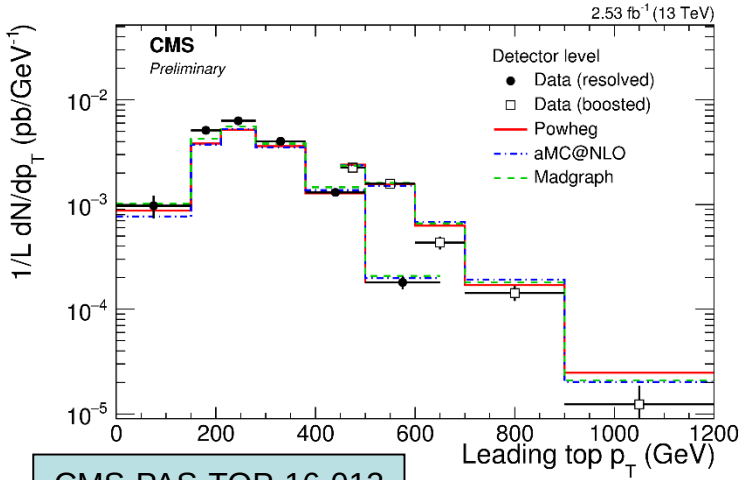
LHC: a top quark factory

Inclusive top pair cross section



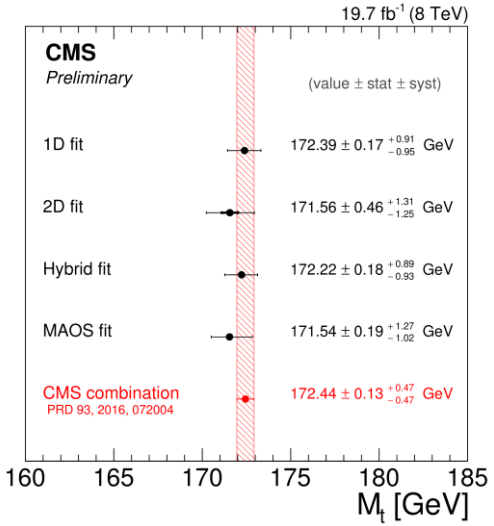
Results consistent and in agreement with NNLO+NNLL over a large range of centre-of-mass energies

Differential top p_T cross section



CMS-PAS-TOP-16-013

m_t measurement, dilepton channel

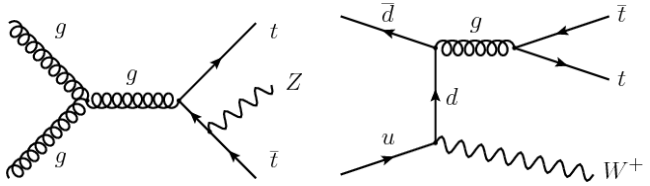


Single measurement at 0.5 GeV accuracy

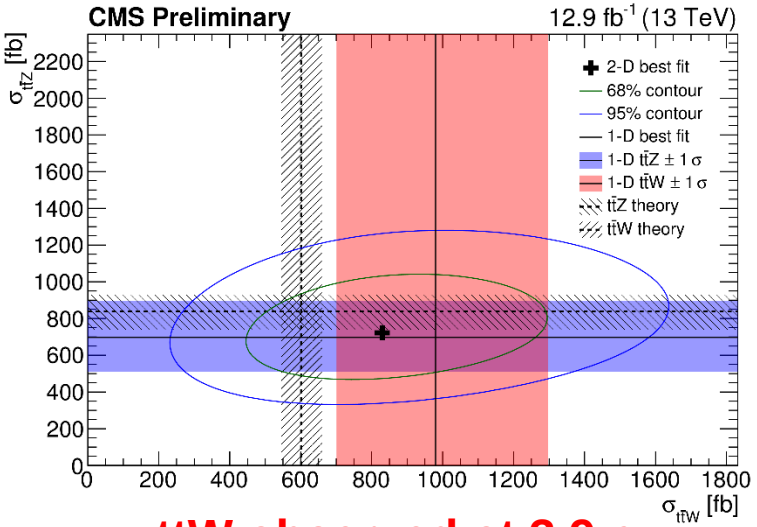
CMS-PAS-TOP-15-008

Rare processes with top quarks

CMS-PAS-TOP-16-017

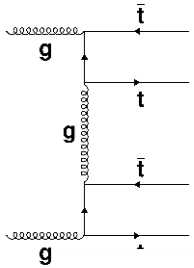


ttZ and ttW cross sections

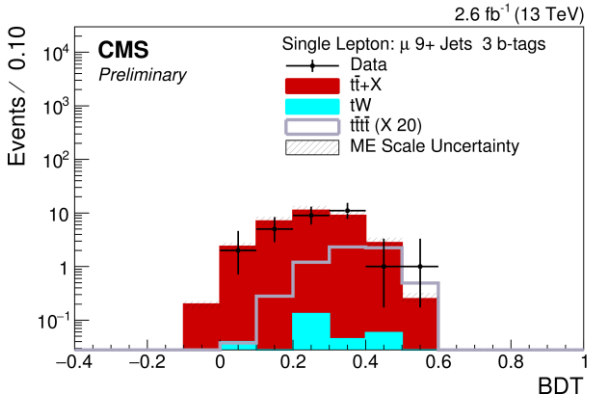


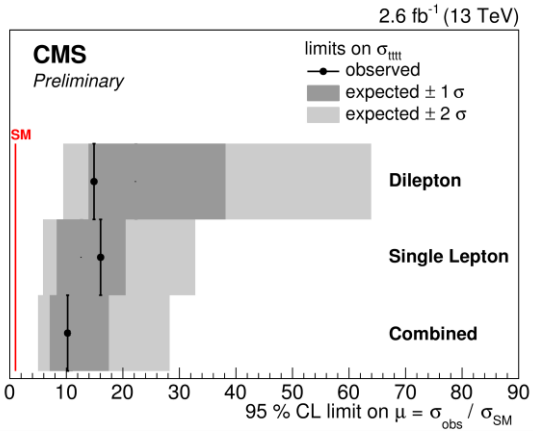
ttW observed at 3.9 σ
ttZ observed at 4.6 σ

CMS-PAS-TOP-16-016



Four top quark production





Limit ~10 σ_{SM}

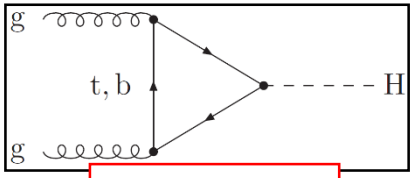
Outline

- Electroweak and top measurements
- Higgs boson sector
- Supersymmetry
- Exotic searches

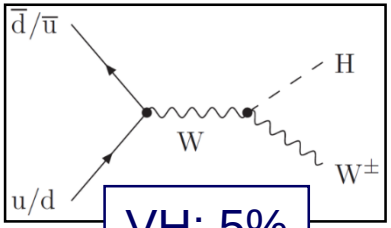
Higgs production and decay at LHC

125 GeV is a reallly unique and fantastic place to study Higgs couplings…

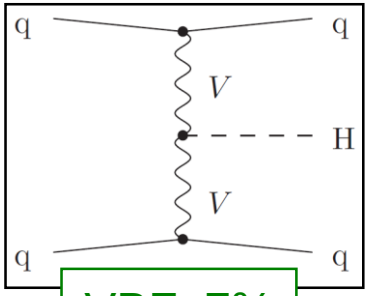
Four main production mechanisms



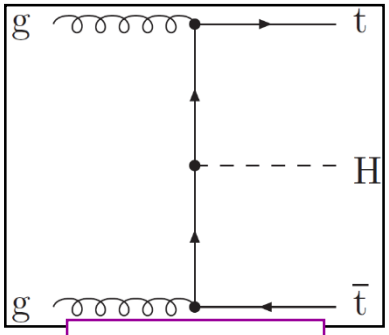
ggF: 87%



VH: 5%



VBF: 7%



ttH: 0.9%

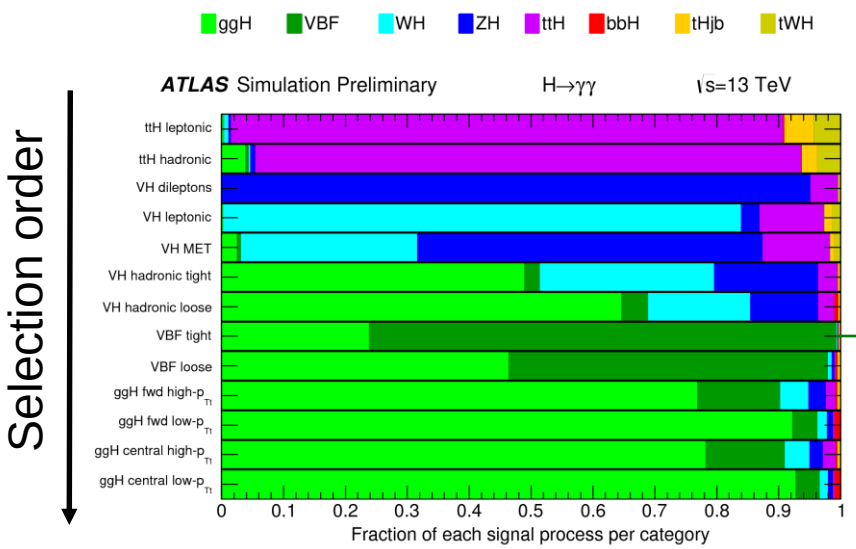
m_H = 125.09 GeV Run 2

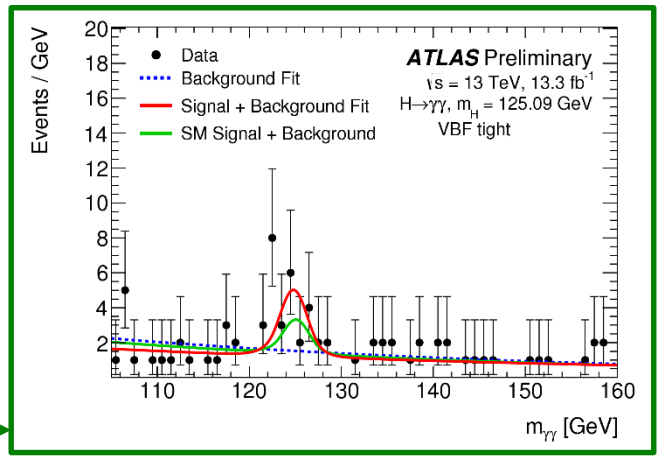
Channel	BR (%)	ATLAS	CMS
bb	58.1	✓	✓
WW*	21.5		✓
gg	8.18		
ττ	6.25		
cc	2.88		
ZZ*	2.64	✓	✓
γγ	0.23	✓	✓
Zγ	0.15		
μμ	0.022		

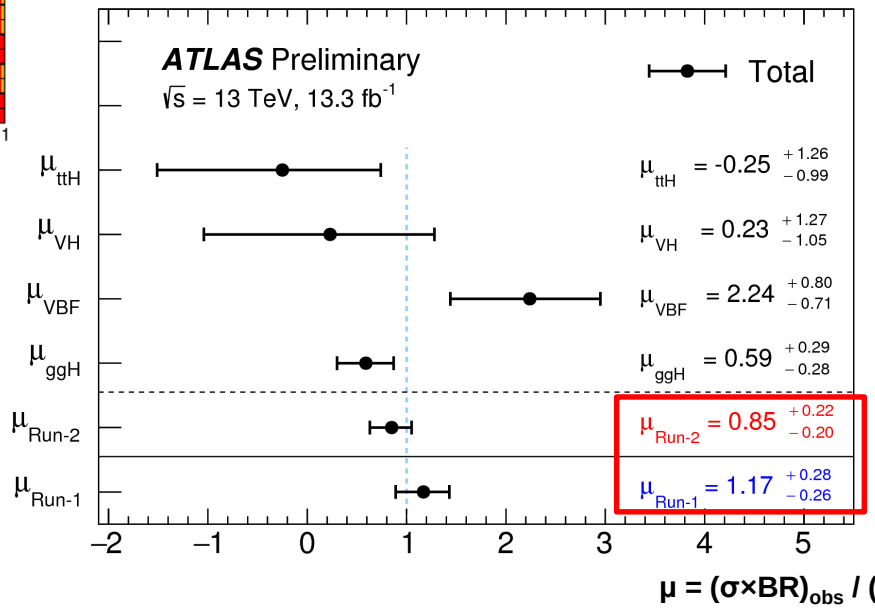
The ‘big 5’ channels currently accessible at LHC (only bb not observed at Run 1)

Coupling measurement in the H→γγ channel

Reconstruction categories optimized to probe production modes







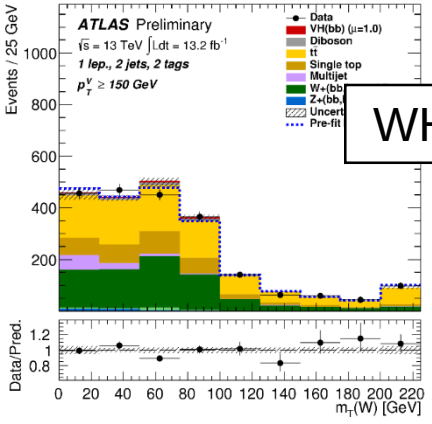
- 13 reconstruction categories
- Predicted purity of the targeted mode ~80%

ATLAS-CONF-2016-067

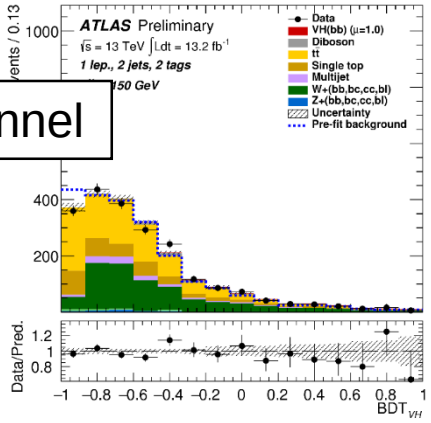
Coupling measurement in the (V)H→bb channel

Analysis performed in 3 channels: ZH→ννbb, WH→lνbb and ZH→llbb

W transverse mass

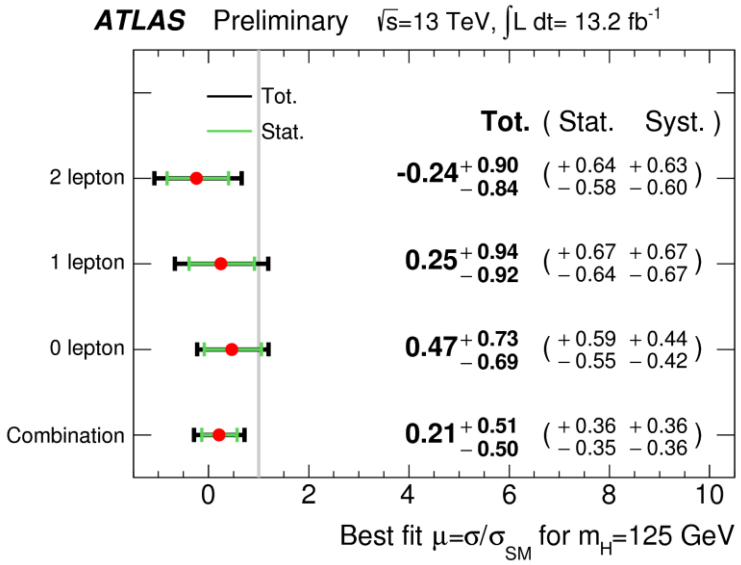


Final MVA discriminant



WH channel

ATLAS-CONF-2016-091



μ = 0.21 ±0.36(stat.) ±0.36(syst.)

Obs. (exp.) significance:
0.4 σ (1.9 σ)

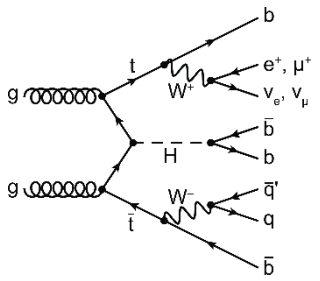
Run 1: μ = 0.52 ±0.32(stat.) ±0.24(syst.)

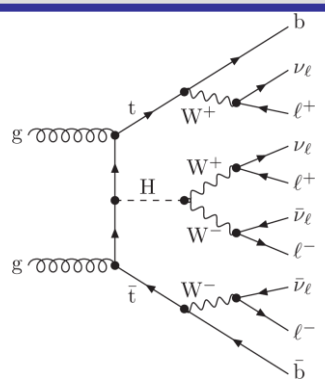
Obs. (exp.) significance: 1.4 σ (2.6 σ)

CMS Run 1: 2.1 σ (2.5 σ)

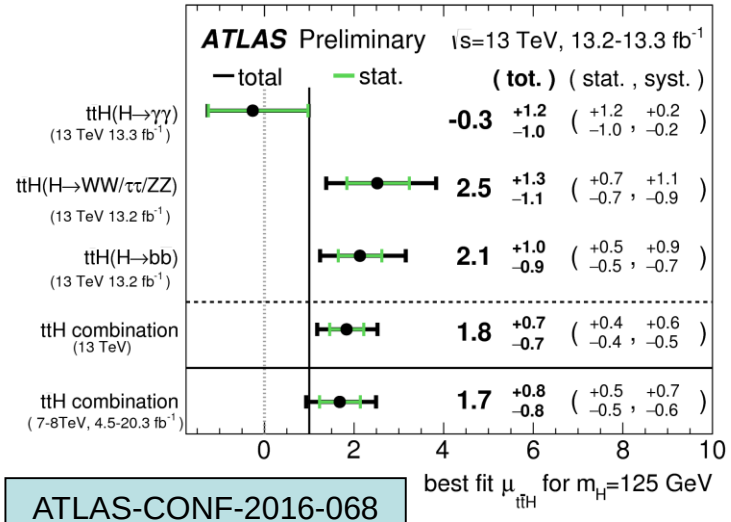
Coupling measurement in the ttH production mode

- Production mode probed in 3 channels: bb, ‘multilepton’ and γγ
- Cross section increased by 3.9 at 13 TeV





All channels

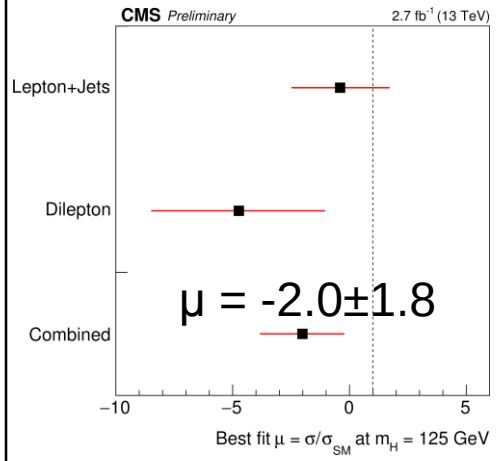


ATLAS-CONF-2016-068

Obs. (exp.) significance: 2.8 σ (1.8 σ)

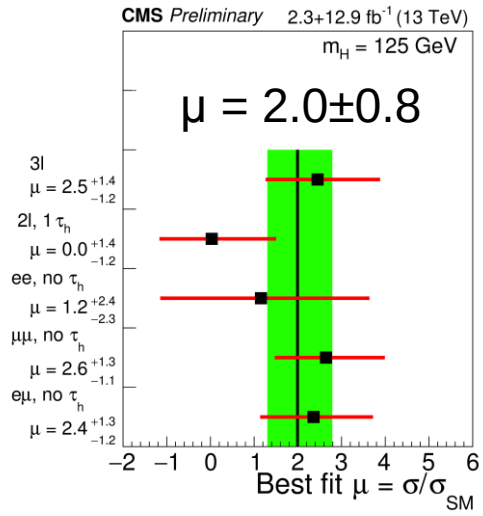
Run 1: μ = 1.7±0.8
2.3 σ (1.5 σ)

bb (2015 data)



CMS-PAS-HIG-16-004

Multilepton



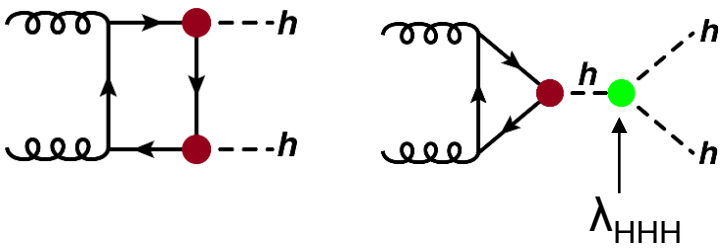
CMS-PAS-HIG-16-022

Run 1: μ = 2.8 ±1.0
3.4 σ (1.2 σ)

Di-Higgs production searches

Di-Higgs searches performed in the non-resonant (SM) and resonant (BSM) cases
The two most promising channels: HH→γγbb and HH→bbbb

SM

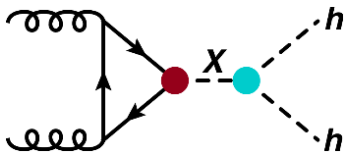


Higgs self coupling: a pillar of the EWSB mechanism, a key goal of the HL-LHC physics program

For H125:
$\sigma(pp\rightarrow hh)_{SM}$ = 34.2 fb

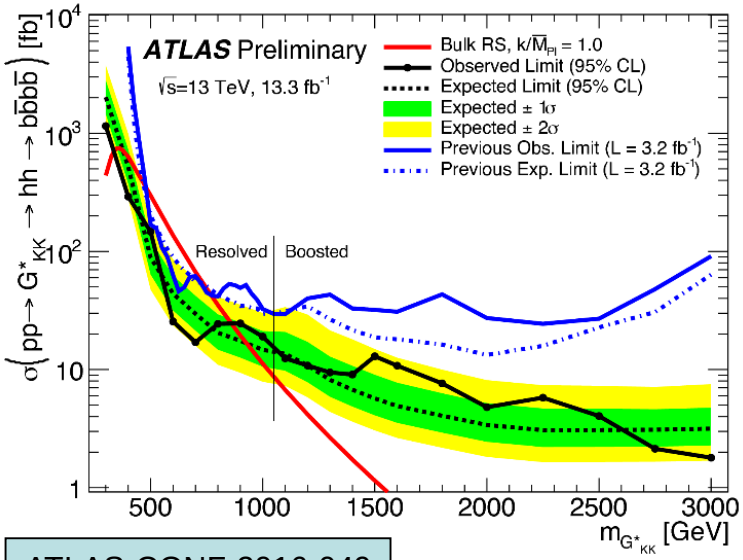
Current limit ~50 times σ_{SM}

BSM



Many BSM models predict enhanced cross sections.

Limits from the HH→bbbb channel



ATLAS-CONF-2016-049

Outline

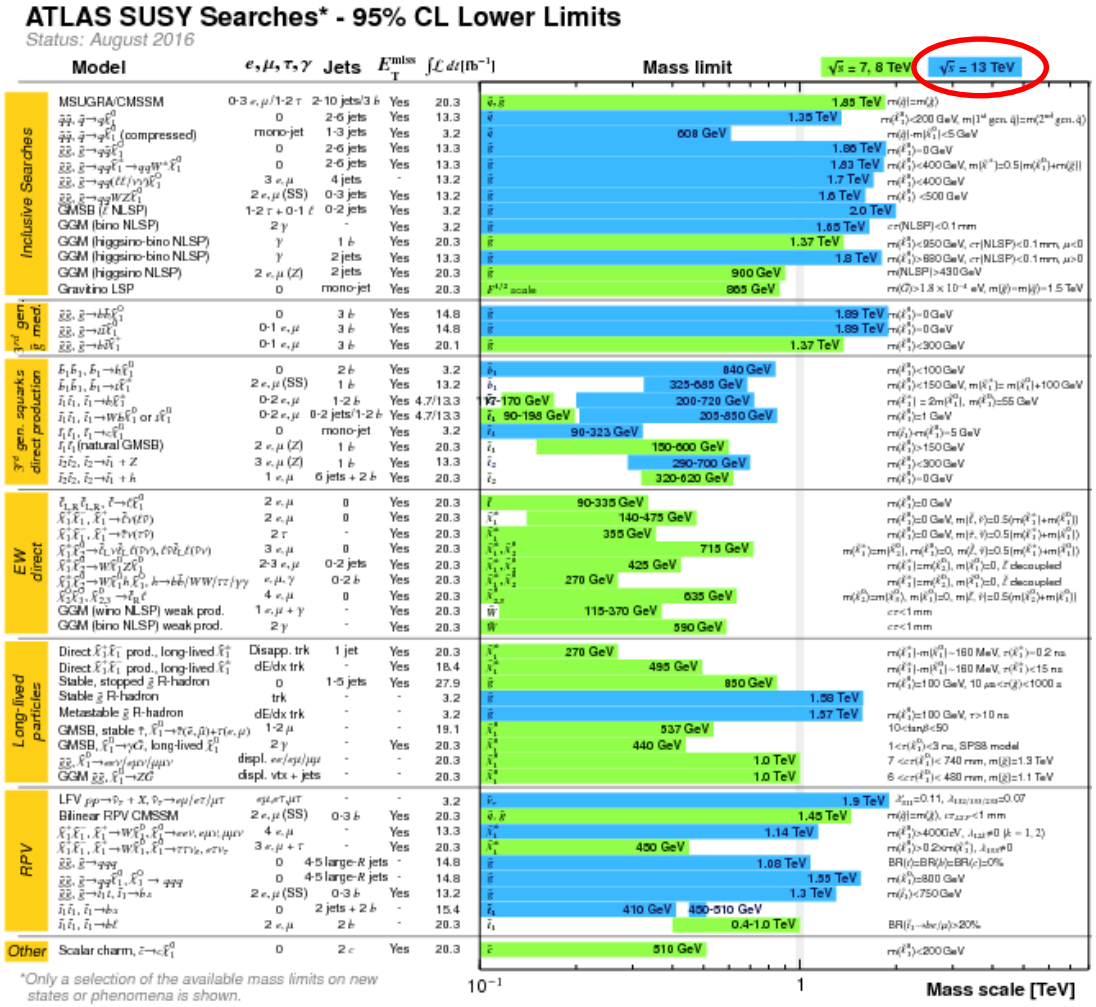
- Electroweak and top measurements
- Higgs boson sector
- Supersymmetry
- Exotic searches

Overview of SUSY searches

SUSY is a class of models, with many assumptions and parameters:

SUSY breaking mechanism, R-parity conservation, mass spectrum, extended Higgs sector,…

➔ Very simplified models used to set limits

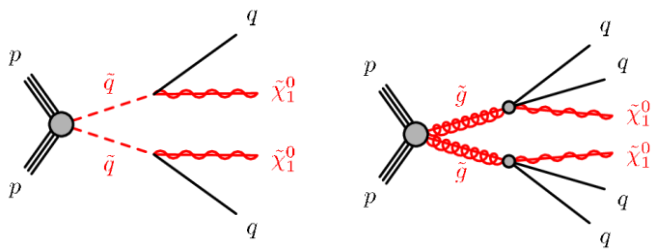


5 main types of searches:

- Inclusive squark/gluino
- 3rd generation squark
- EW production
- Long-lived particles
- R-parity violating scenarios

A wide variety of searches already performed at 13 TeV

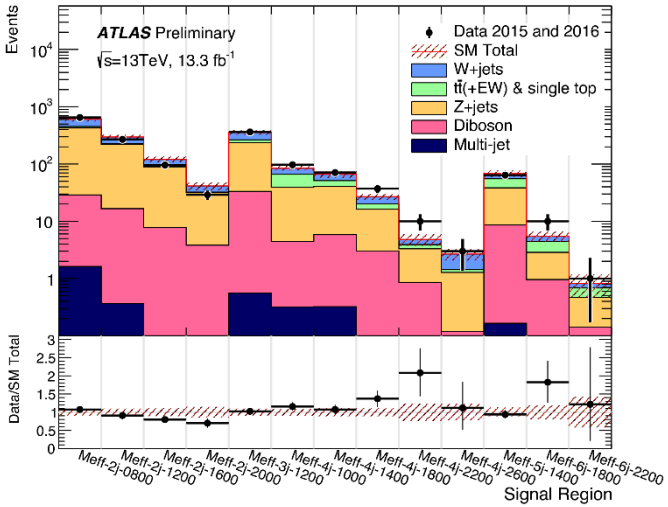
Inclusive squark/gluino production

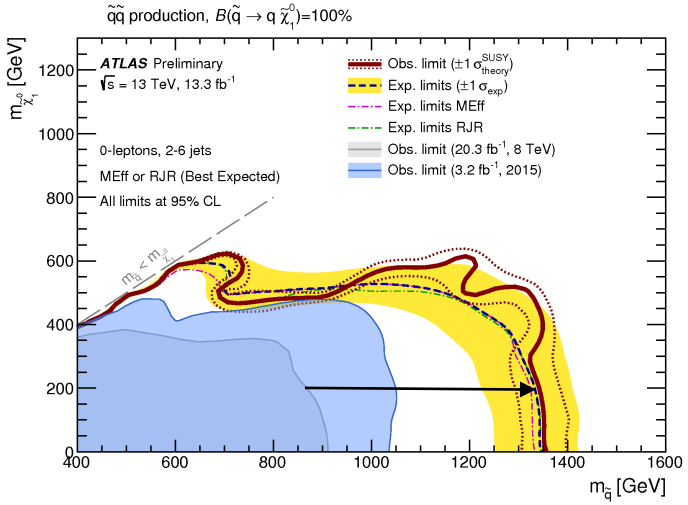


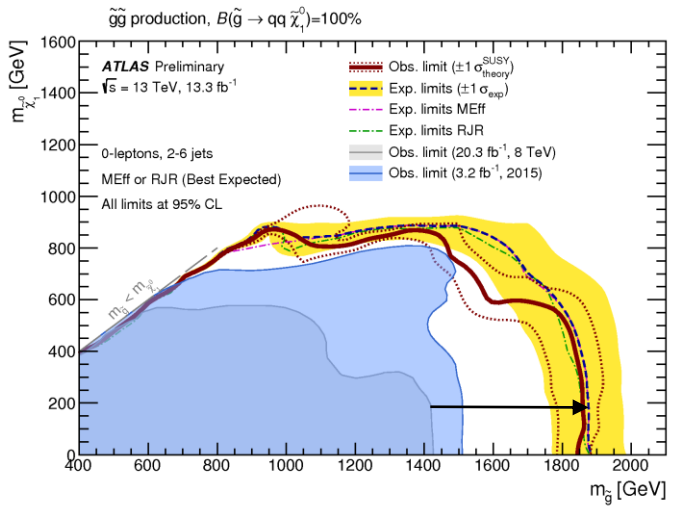
- Typical high E_T^{miss} and jet multiplicity signature
- 0-lepton channel

ATLAS-CONF-2016-078

Many signal regions (m_{eff})

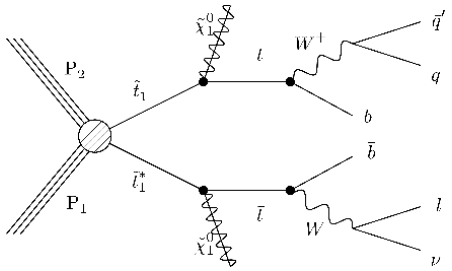




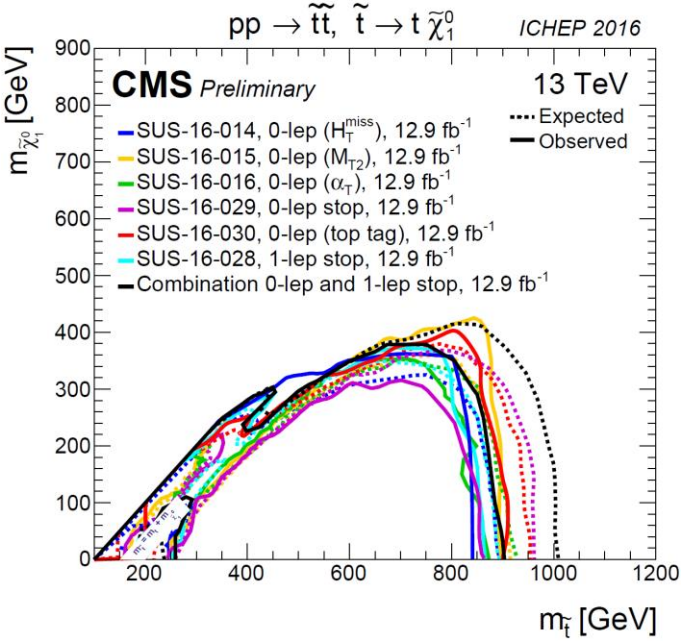


For $m_{\chi 1,0}$~200 GeV: **squark limit extended from 850 GeV to 1.3 TeV**
gluino limit extended from 1.4 TeV to 1.9 TeV

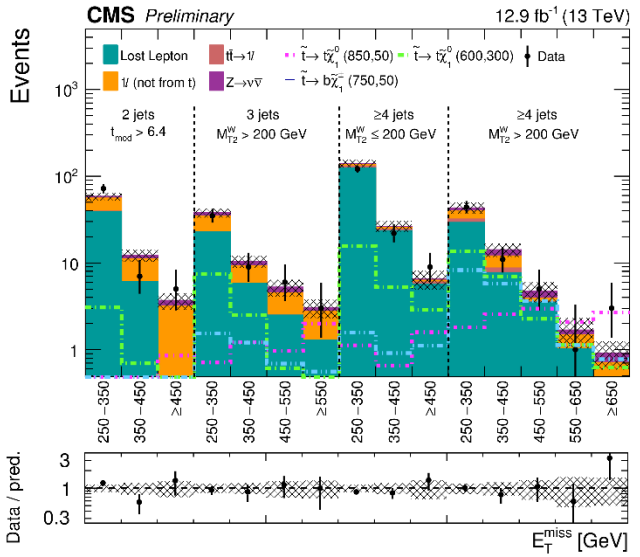
Third generation squark production



- Typical high E_T^{miss} and jet multiplicity signature
- In addition: one lepton and b-jets
- M_W^{T2} analysis



Many signal regions (E_T^{miss})



CMS-PAS-SUS-16-028

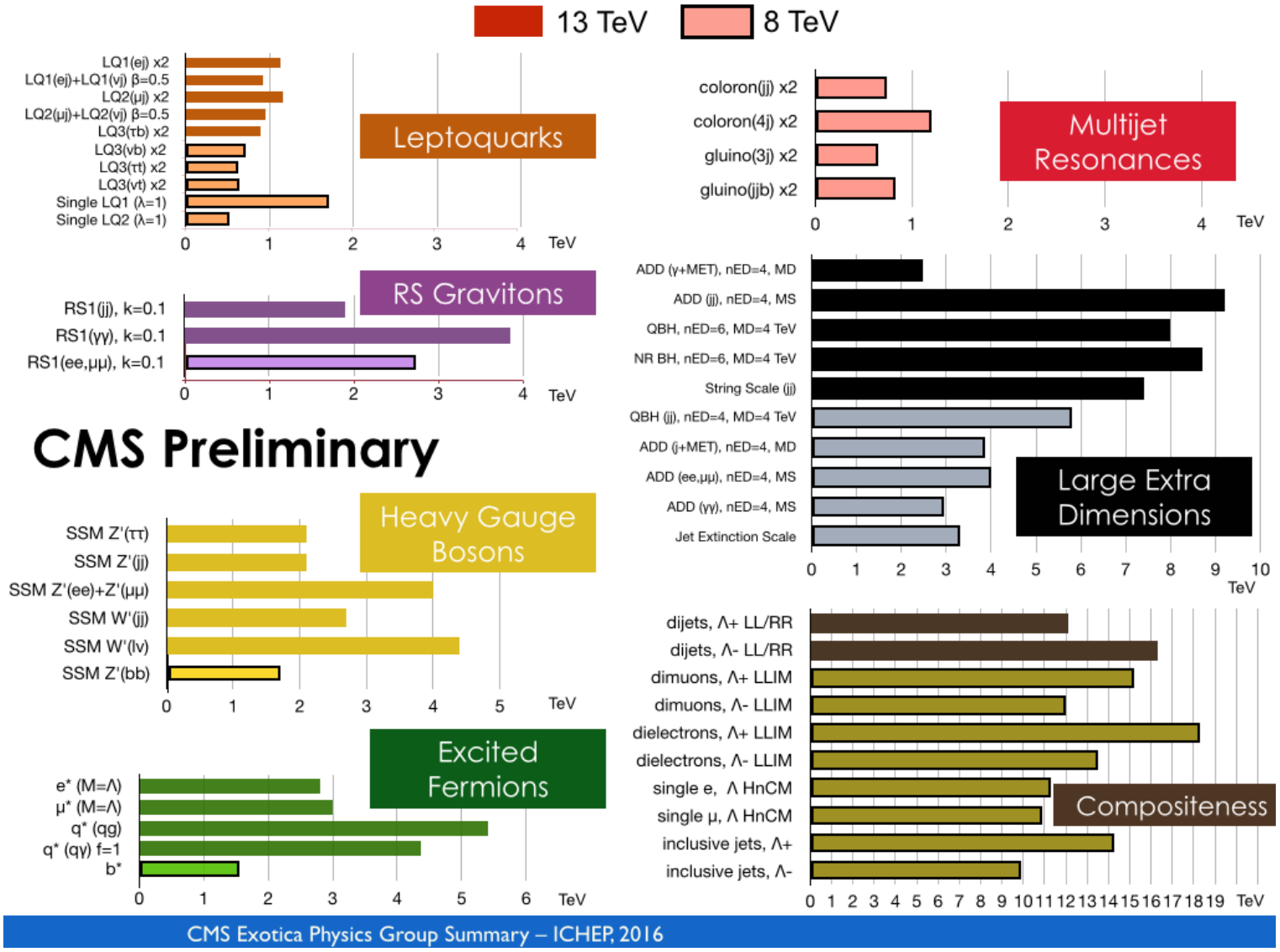
For $m_{\chi 1,0}$~200 GeV:
stop limit at 900 GeV

Outline

- Electroweak and top measurements
- Higgs boson sector
- Supersymmetry
- Exotic searches

Overview of exotic searches

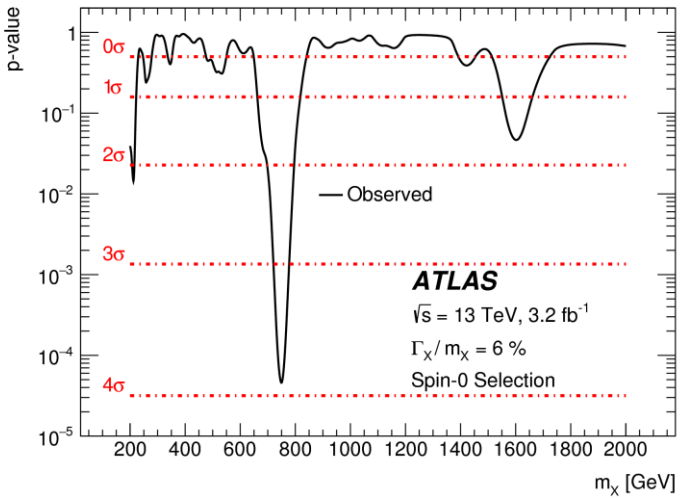
A wide variety of exotic searches already performed at 13 TeV…Nothing found!



The diphoton saga: episode 1

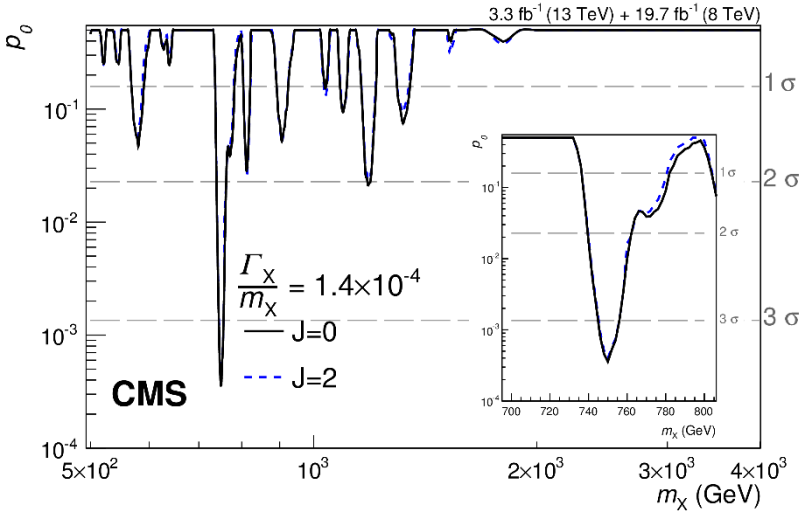
Large excess at ~750 GeV, observed by both ATLAS and CMS

JHEP08(2016)128



Maximum significance: 3.9 σ

Phys. Rev. Lett. 117 (2016) 051802

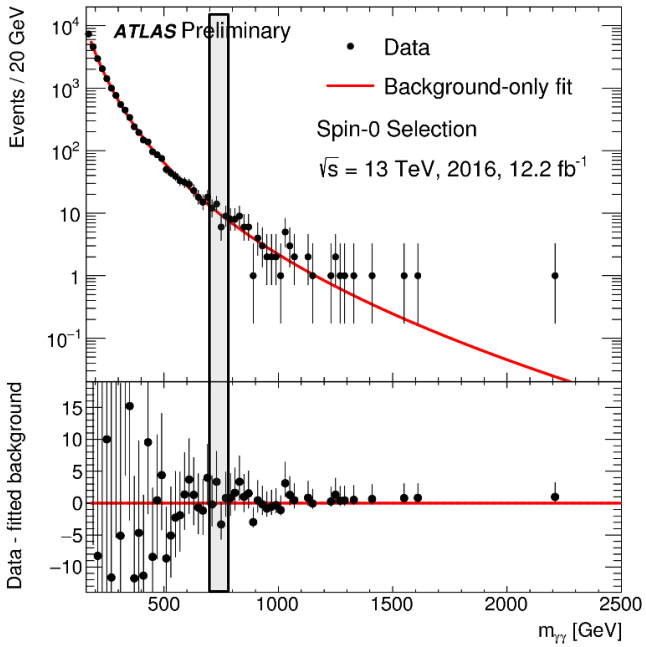


Maximum significance: 3.4 σ

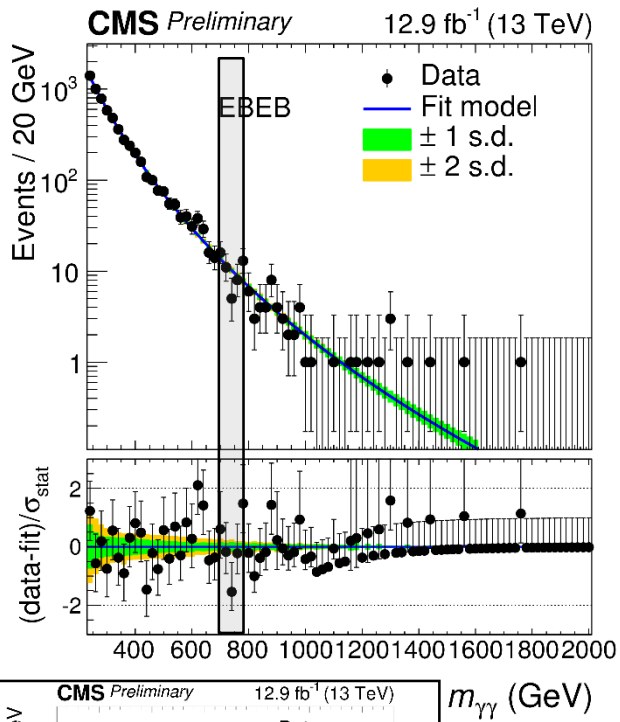
Six months of intense excitement, waiting eagerly for 2016 data…
More than 500 theory papers…

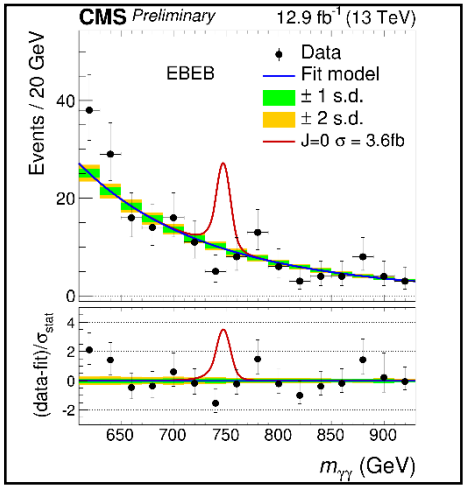
The diphoton saga: episode 2 (last one)

ATLAS-CONF-2016-059



CMS-PAS-EXO-16-027





No excess, with 4 times more statistics

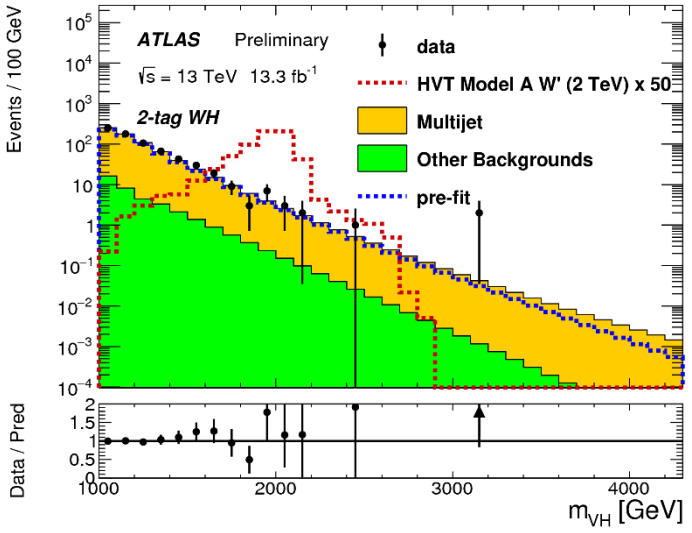
The 2015 excess would look like this in 2016 data.

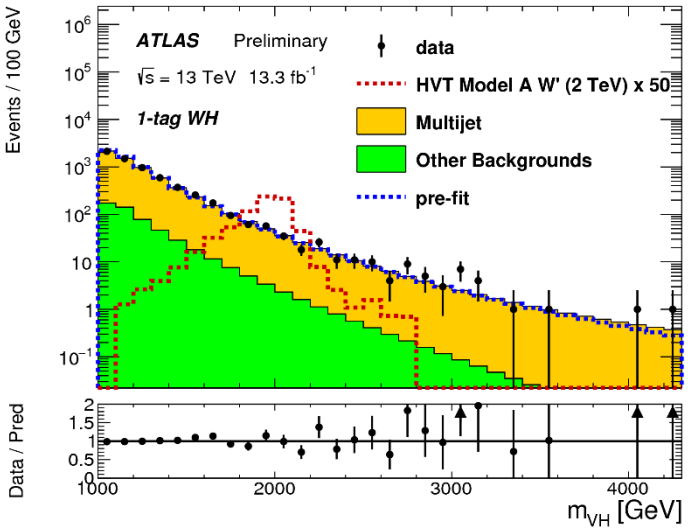
But real excesses may still be around the corner…

- Search for a high mass resonance decaying to VH
- Fully hadronic channel (qqbb)

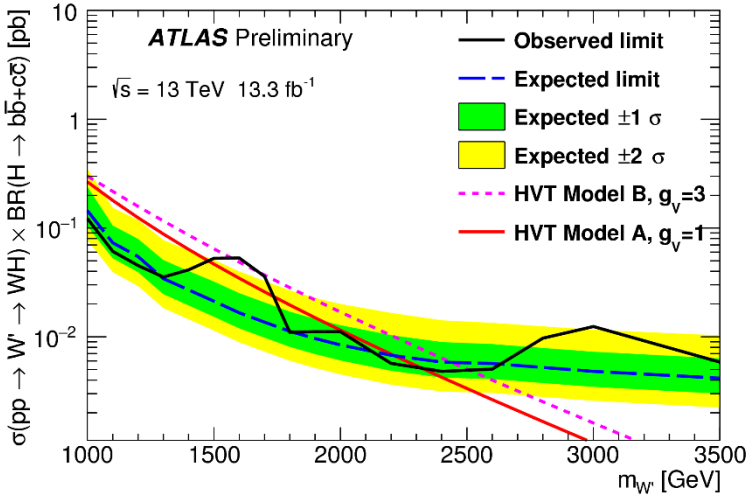
ATLAS-CONF-2016-083

m_{VH} distribution

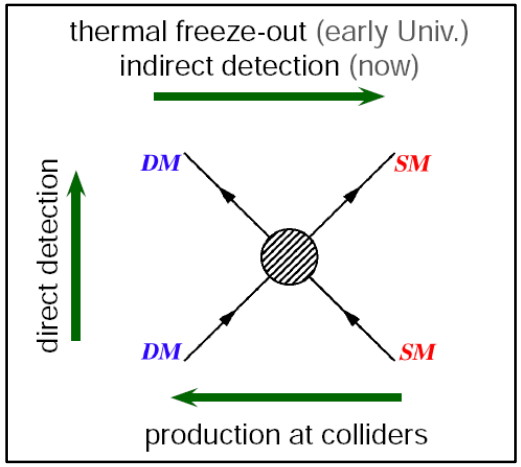




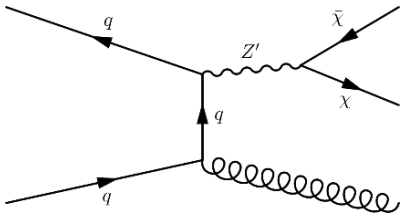
Small excess at 3 TeV:
3.5 σ local, 2.5 σ global



Dark matter



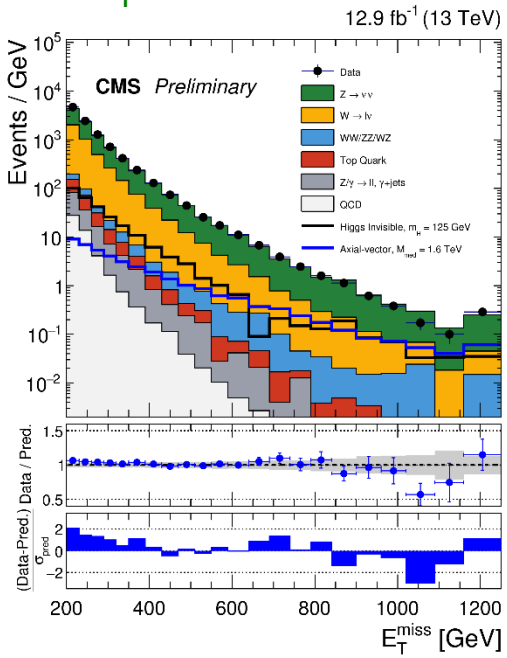
Analyses at colliders are of type mono-X + E_T^{miss}



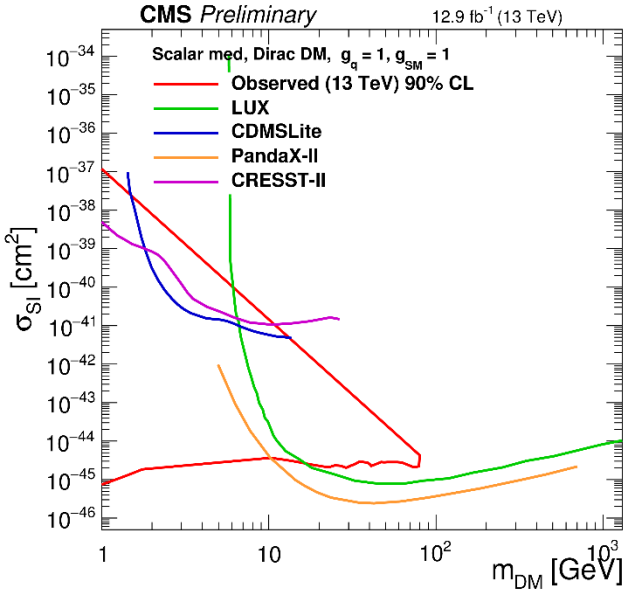
Mono-jet analysis (tagging the ISR jet)

CMS-PAS-EXO-16-037

E_T^{miss} distribution



DM-nucleon scattering σ



Complementarity of the approaches

Summary

- Thanks to the beam energy increase and the outstanding performance of the LHC, many Run 2 results are already pushing higher the Run 1 limits.

➔ **No sign of BSM physics yet**

➔ But we already have ~15 fb^{-1} of post-ICHEP data to analyse!

- The energy is not the only parameter: **the integrated lumisosity is key for rare processes and precision**.

- Huge and diverse program of physics (precision measurements and direct searches) for Run 2, Run 3 and beyond: the detailed exploration of the Higgs sector and of the TeV scale is only starting…