Summary of physics results from ATLAS experiment at LAPP and LPSC

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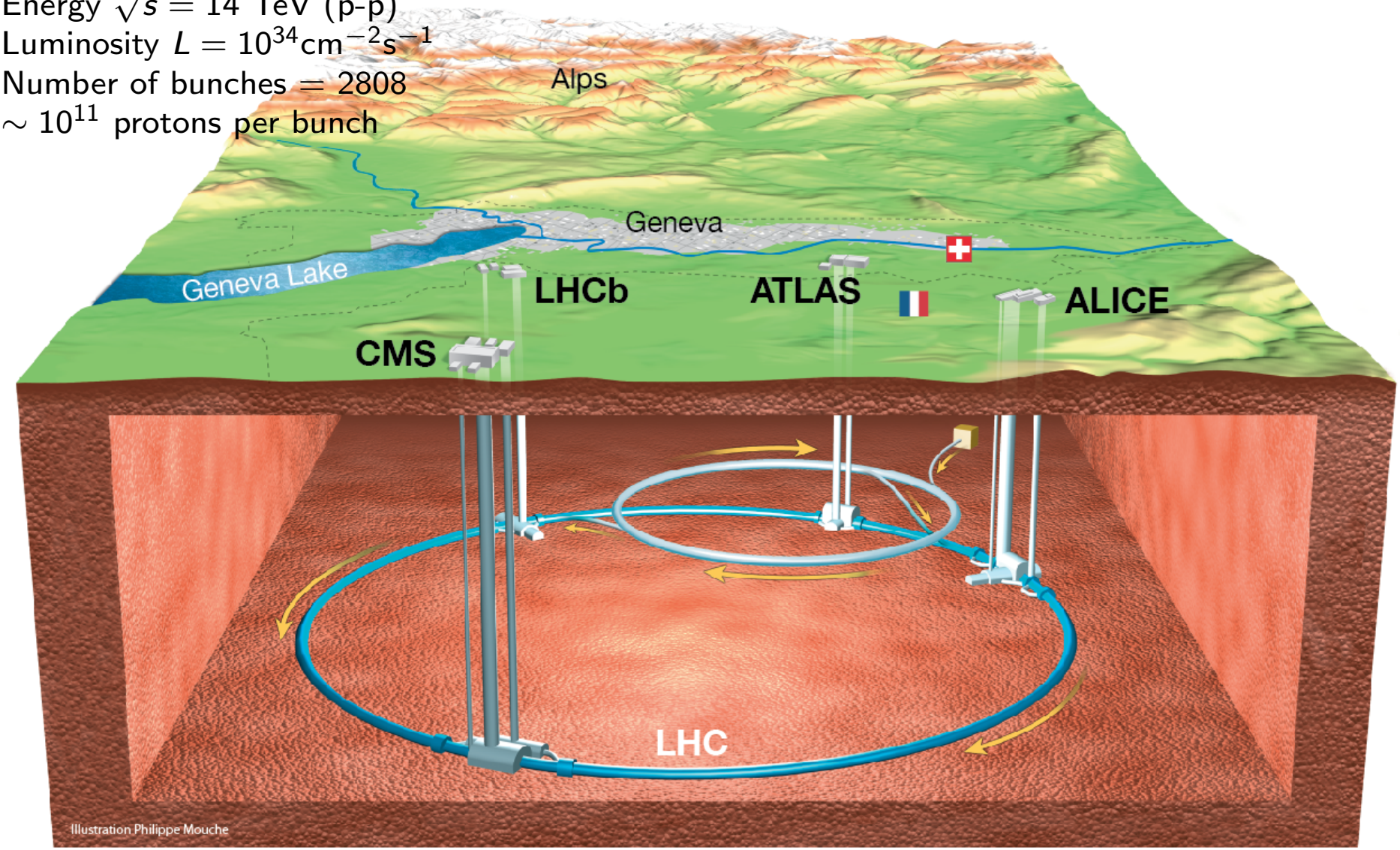
Annual Plenary Meeting ENIGMASS, Annecy

December 9, 2016

The Large Hadron Collider

The Large Hadron Collider
27 km ring. Design parameters:
Energy $\sqrt{s} = 14$ TeV (p-p)
Luminosity $L = 10^{34}\text{cm}^{-2}\text{s}^{-1}$
Number of bunches $= 2808$
$\sim 10^{11}$ protons per bunch

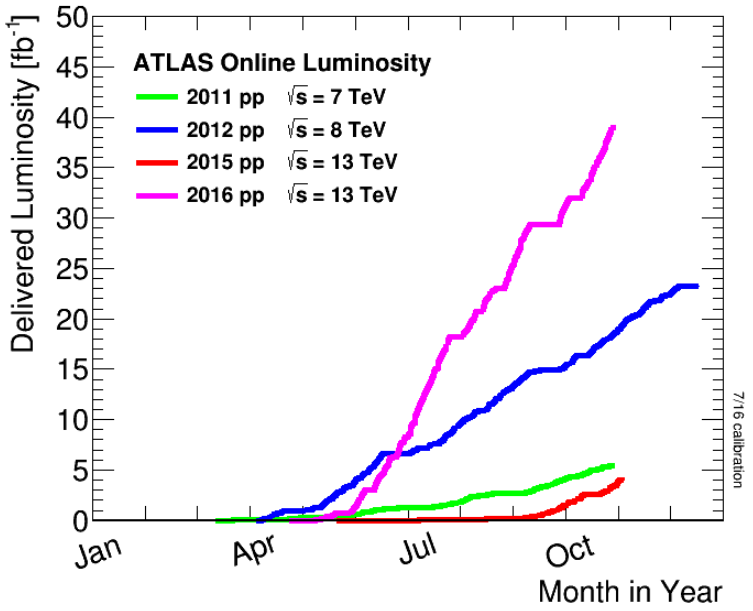
Two general purpose detectors:
ATLAS and CMS

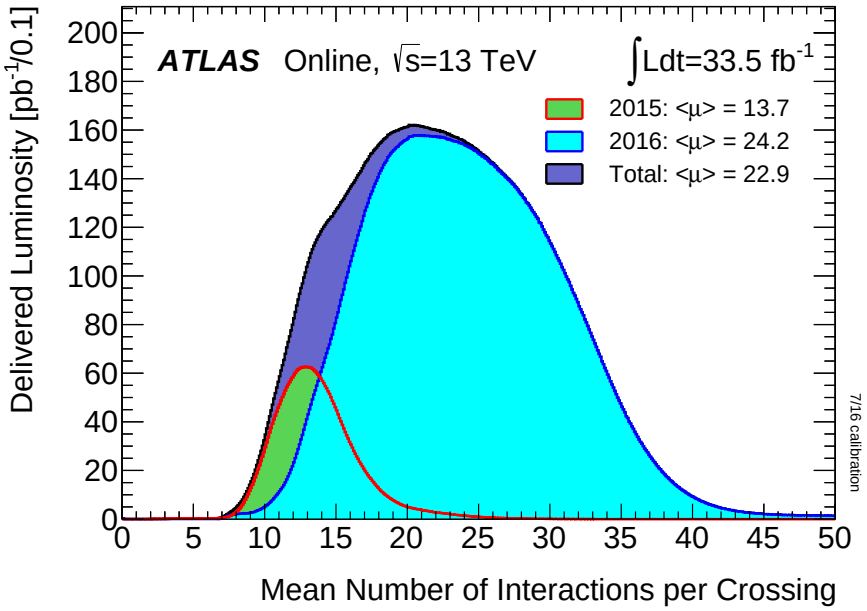


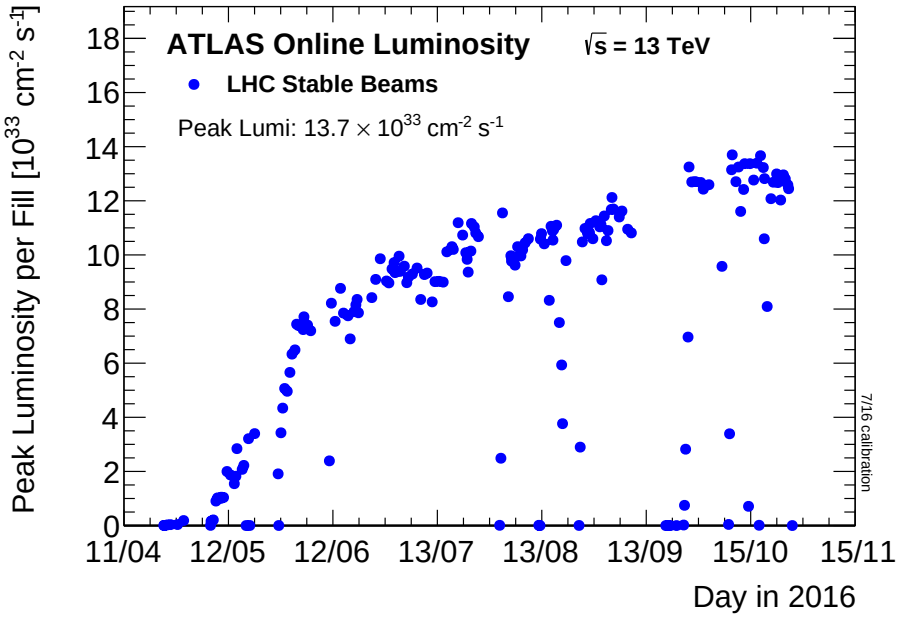
LHC performance in Run2

- Run2 of the LHC: 2015 - 2018
- Center-of-mass energy $\sqrt{s} = 13$ TeV (p-p)
- Proton bunch spacing 25 ns (compared to 50 ns in Run1)
- The LHC in 2016 processed well beyond expectations!

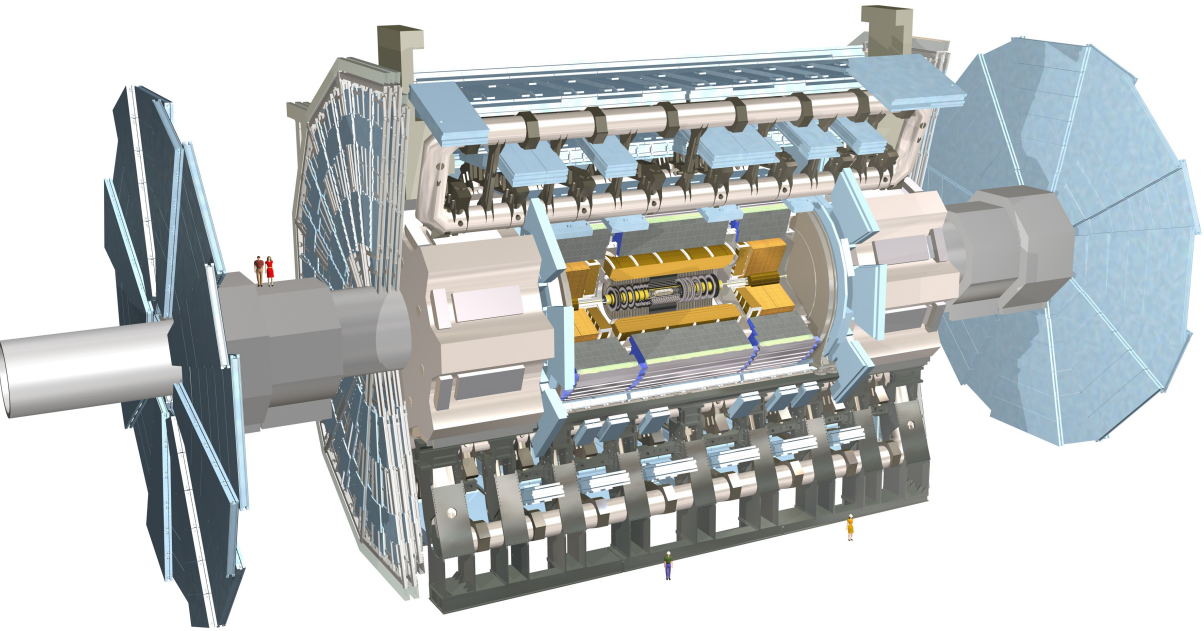
- $< \mu >$: mean number of interactions per crossing
- 2015: $< \mu > \approx 14$
- 2016: $< \mu > \approx 24$





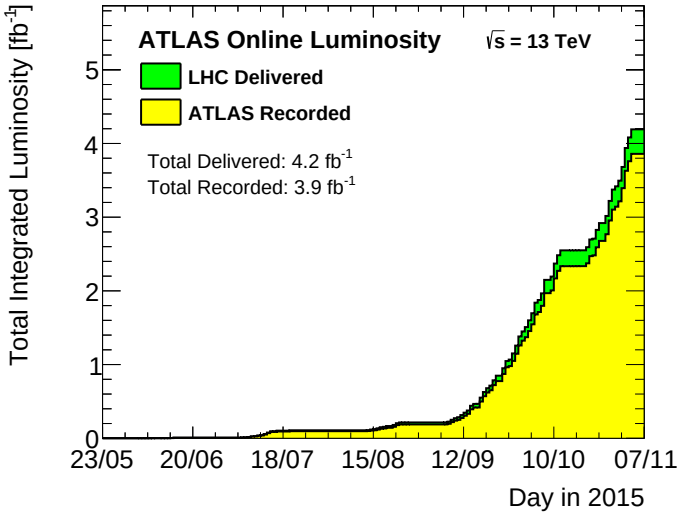


ATLAS in Run2

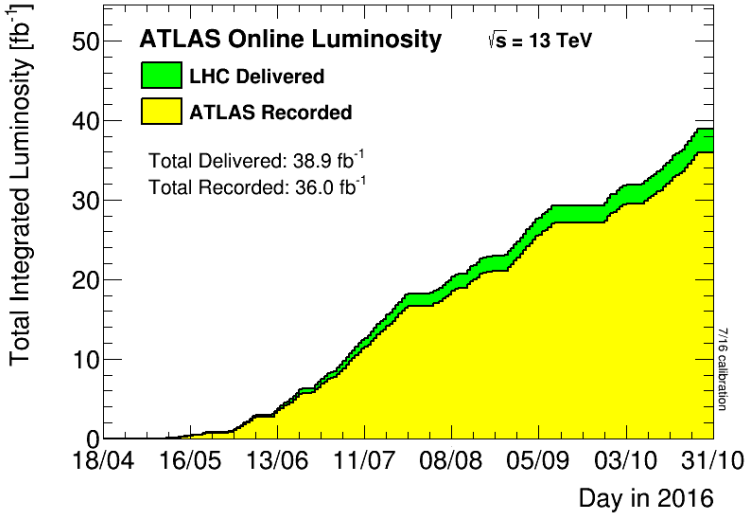


- Delivered luminosity: 43.1 fb^{-1}
- Recorded luminosity: 39.9 fb^{-1}
- Luminosity peak $1.4 \times 10^{34} cm^{-2} s^{-1}$ is above designed LHC value.

2015

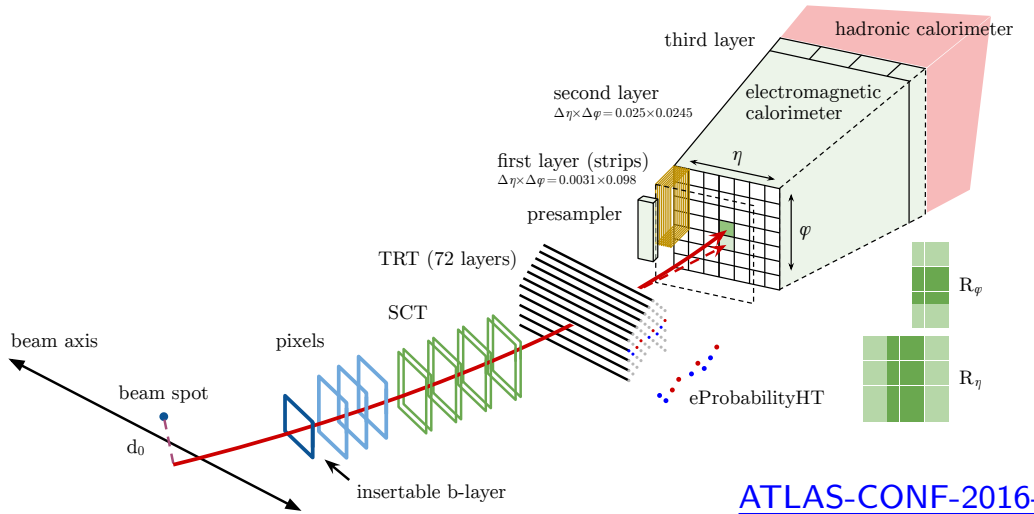


2016



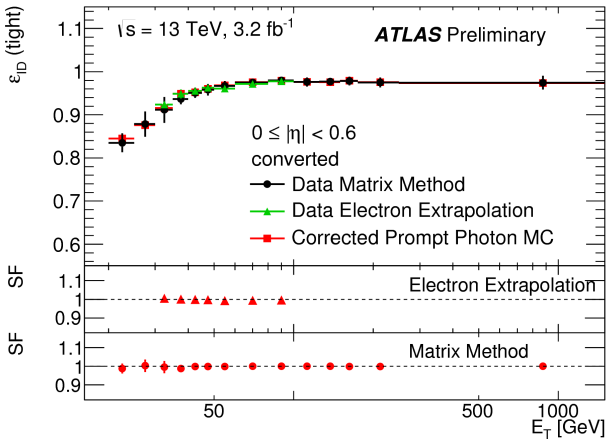
Object performance

- Strong contribution of the LAPP and LPSC groups to the efficiency measurements of **electron** and **photon** identification.
- Presice measurement of the **electron** energy scale and resolution.



[ATL-PHYS-PUB-2016-014](#)

Photon identification efficiencies and scale factors



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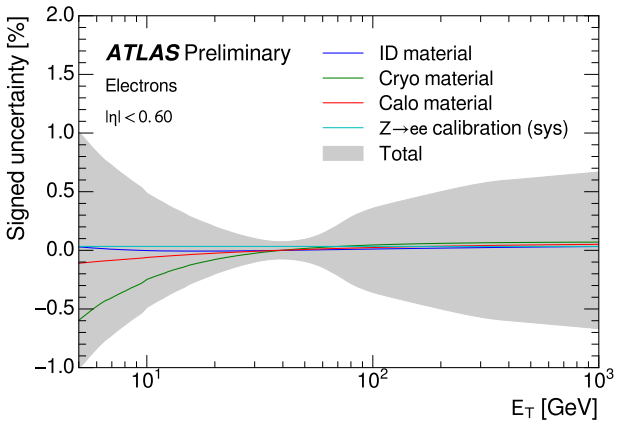
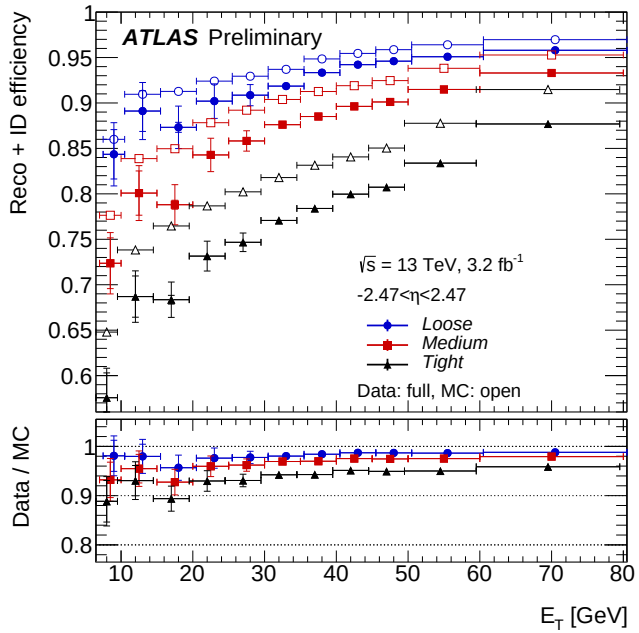
Uncertainty on the electron energy scale

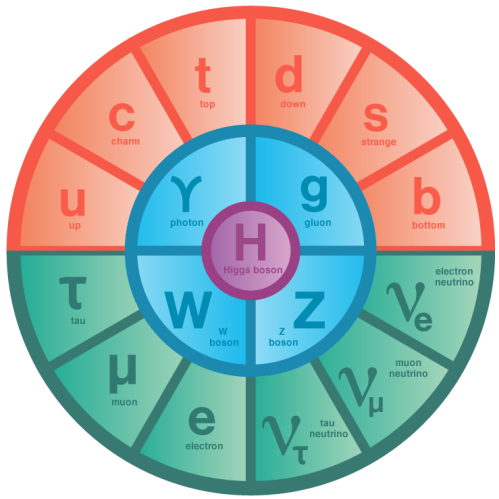


[ATLAS-CONF-2016-024](#)

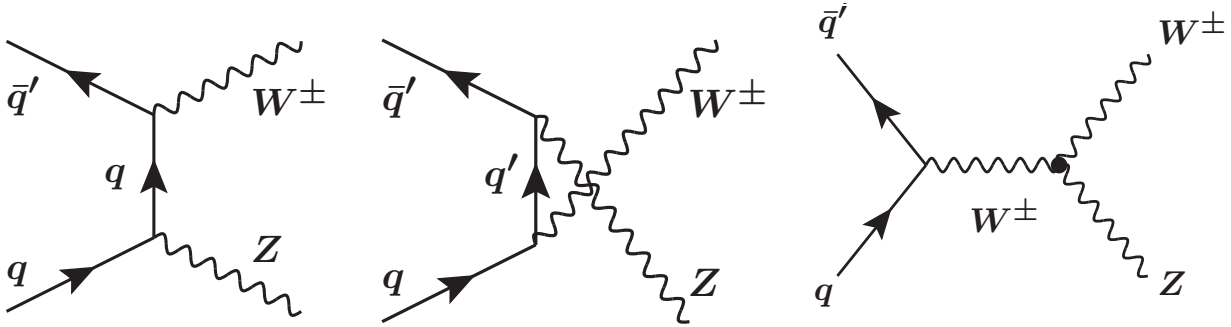
Electron identification efficiencies



Standard Model measurements

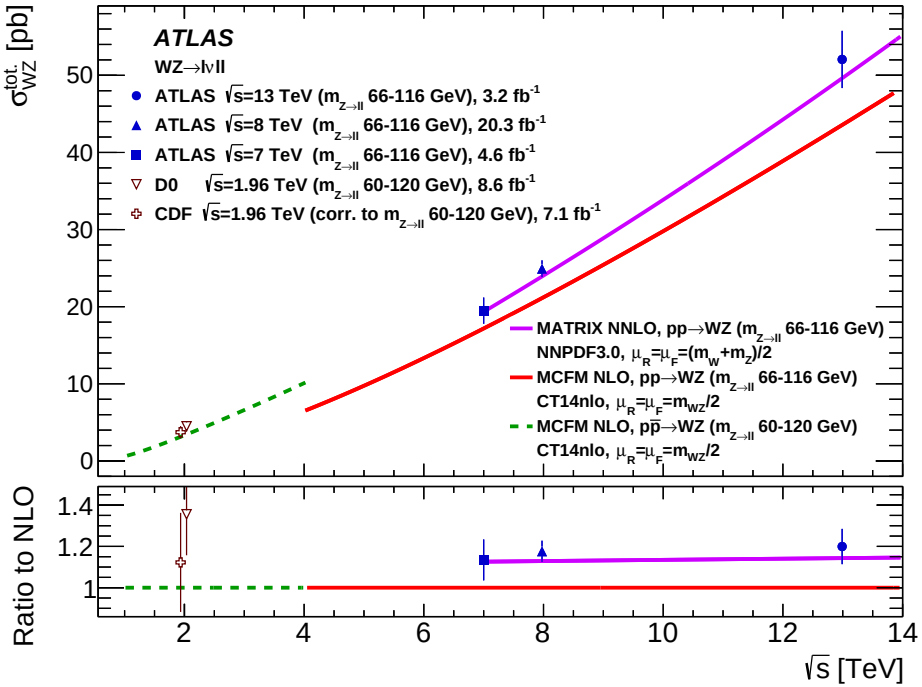


Electroweak sector: $W^{\pm}Z$ production

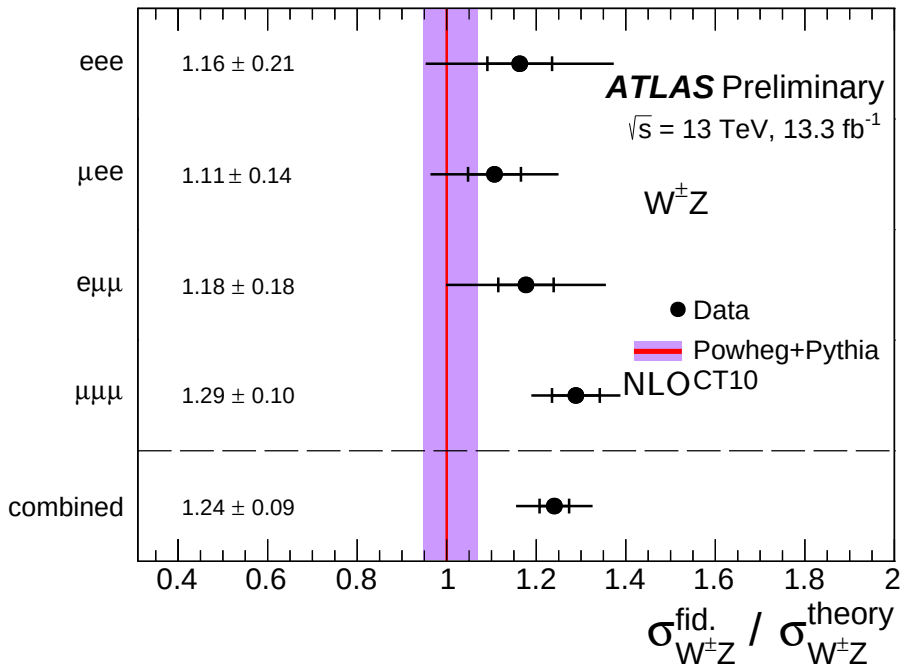


- Production of $W^{\pm}Z$ pairs in hadron collisions is an important test of the electroweak sector of the Standard Model.
- Direct test of gauge bosons self interactions.

[Phys. Lett. B 762 (2016) 1]

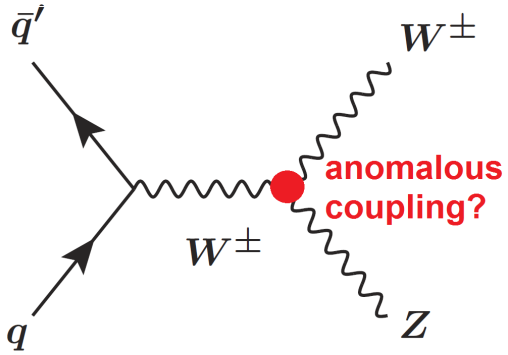


[ATLAS-CONF-2016-043]



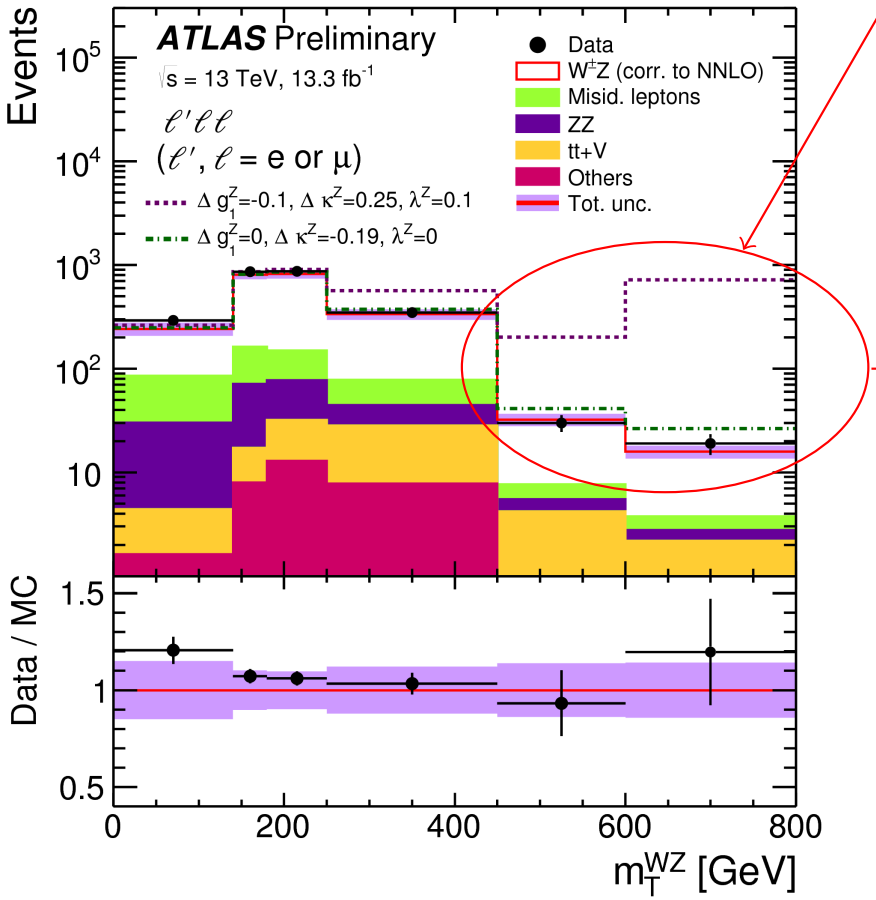
- Measurement of total, fiducial and differential $W^{\pm}Z$ production cross-section.

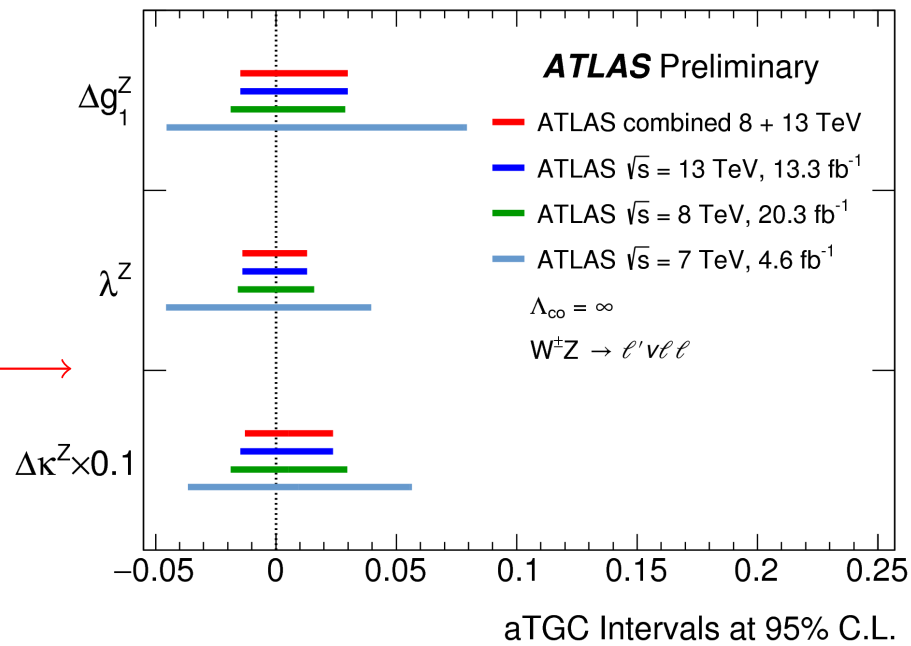
Searches of new physics in $W^{\pm}Z$ production



ATLAS-CONF-2016-043

- Probe of W and Z bosons self-interactions via WWZ triple gauge couplings provides a model independent way to access **physics beyond the Standard Model**.
- Presence of **anomalous** triple gauge couplings would manifest itself as an *increased yield of events* at high values of m_T^{WZ}.



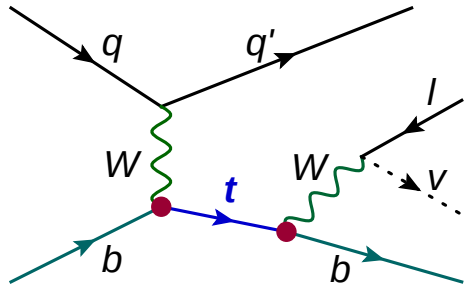


- Improve existing confidence intervals by up to 20%
  => new best model-independent limits for WWZ anomalous couplings.

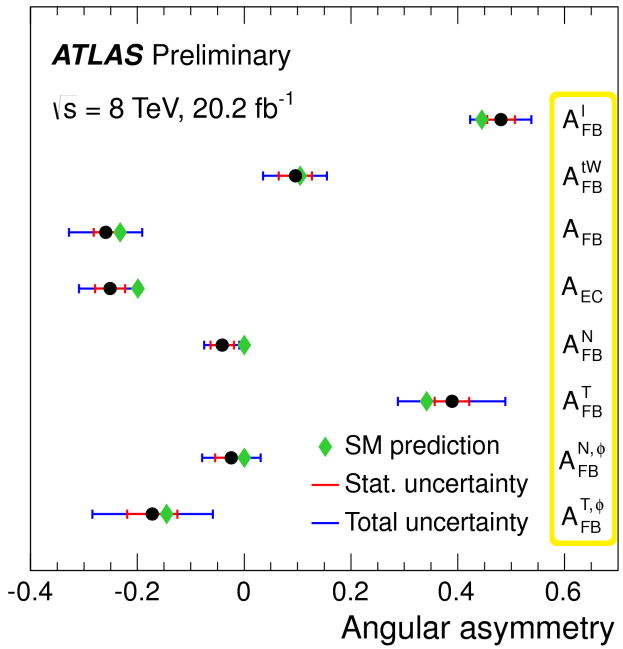
Top-quark physics: probing *Wtb* vertex structure

ATLAS-CONF-2016-097

- Single-top final state is sensitive to new contributions (= anomalous coupling) to the *Wtb* vertex.
- Produced top quark is highly polarized => W boson from t-quark decay also possesses polarization.
- Top-quark and W polarization observables can be extracted from asymmetries in angular distributions of final-state leptons.



Asymmetry	Angular observable	Polarisation observable	SM prediction
A_{FB}^{ℓ}	$\cos\theta_{\ell}$	$\frac{1}{2}\alpha_{\ell}P$	0.45
A_{FB}^{tW}	$\cos\theta_W \cos\theta_{\ell}^*$	$\frac{3}{8}P\,(F_R + F_L)$	0.10
A_{FB}	$\cos\theta_{\ell}^*$	$\frac{3}{4}\langle S_3\rangle = \frac{3}{4}\,(F_R - F_L)$	−0.23
A_{EC}	$\cos\theta_{\ell}^*$	$\frac{3}{8}\sqrt{\frac{3}{2}}\langle T_0\rangle = \frac{3}{16}\,(1 - 3F_0)$	−0.20
A_{FB}^{T}	$\cos\theta_{\ell}^{T}$	$\frac{3}{4}\langle S_1\rangle$	0.34
A_{FB}^{N}	$\cos\theta_{\ell}^{N}$	$-\frac{3}{4}\langle S_2\rangle$	0
$A_{FB}^{T,\phi}$	$\cos\theta_{\ell}^* \cos\phi_T^*$	$-\frac{2}{\pi}\langle A_1\rangle$	−0.14
$A_{FB}^{N,\phi}$	$\cos\theta_{\ell}^* \cos\phi_N^*$	$\frac{2}{\pi}\langle A_2\rangle$	0

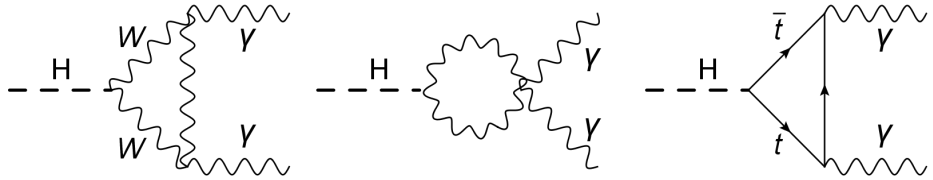


- Through the polarization observables imaginary part of g_R anomalous coupling can be probed with the best precision.
- *Extraction of limits* on Im g_R to probe CP-violation: Im $g_R \in$ [-0.17, 0.06] => best published limits

Higgs boson: $H \to \gamma\gamma$

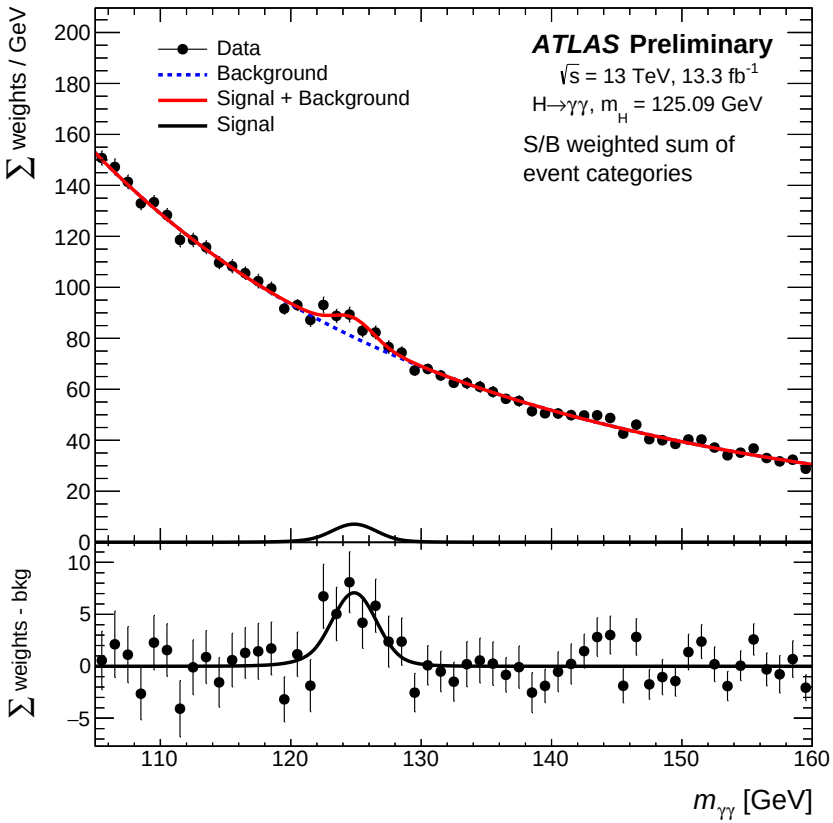
ATLAS-CONF-2016-067

- Since the discovery of the Higgs boson in 2012, focus has shifted to measuring its properties and testing the consistency of the Standard Model with data.

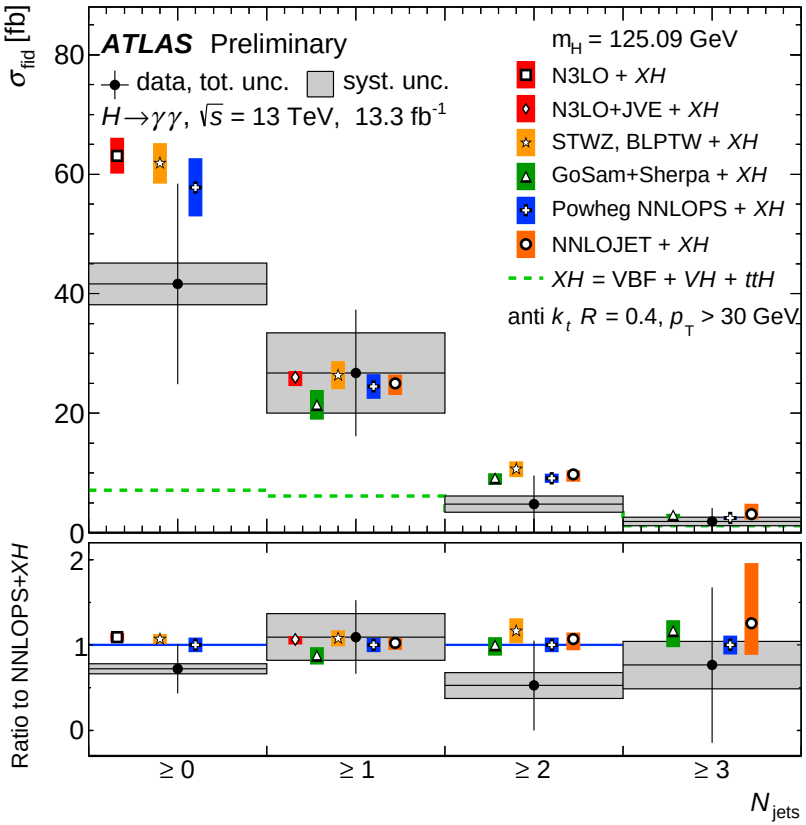


- First fiducial, differential and total production cross section measurements of Higgs boson production in $H \to \gamma\gamma$ at 13 TeV.

Diphoton invariant mass spectrum:



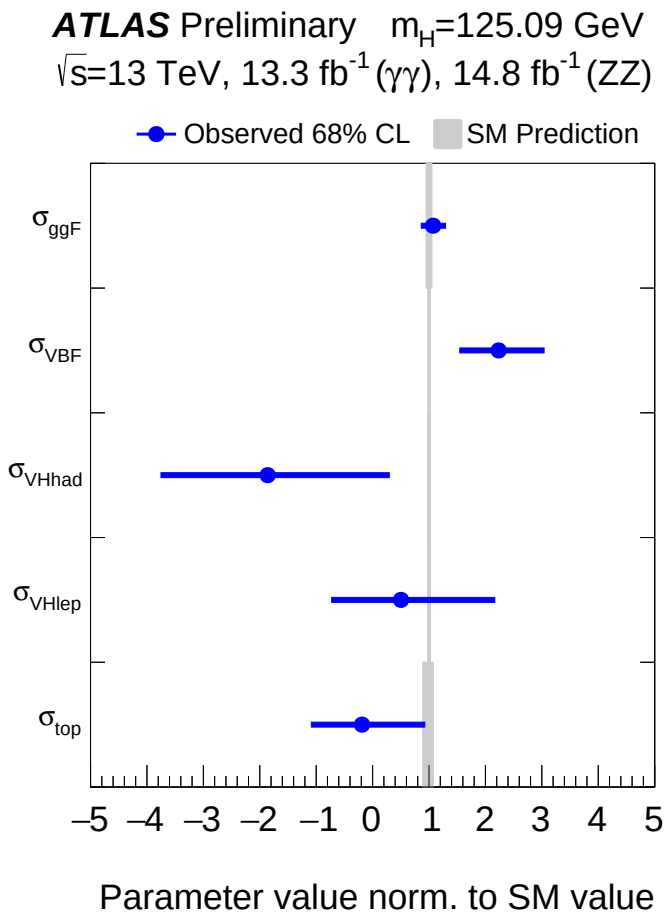
Differential cross-section for $H \to \gamma\gamma$ as a function of the jet multiplicity:



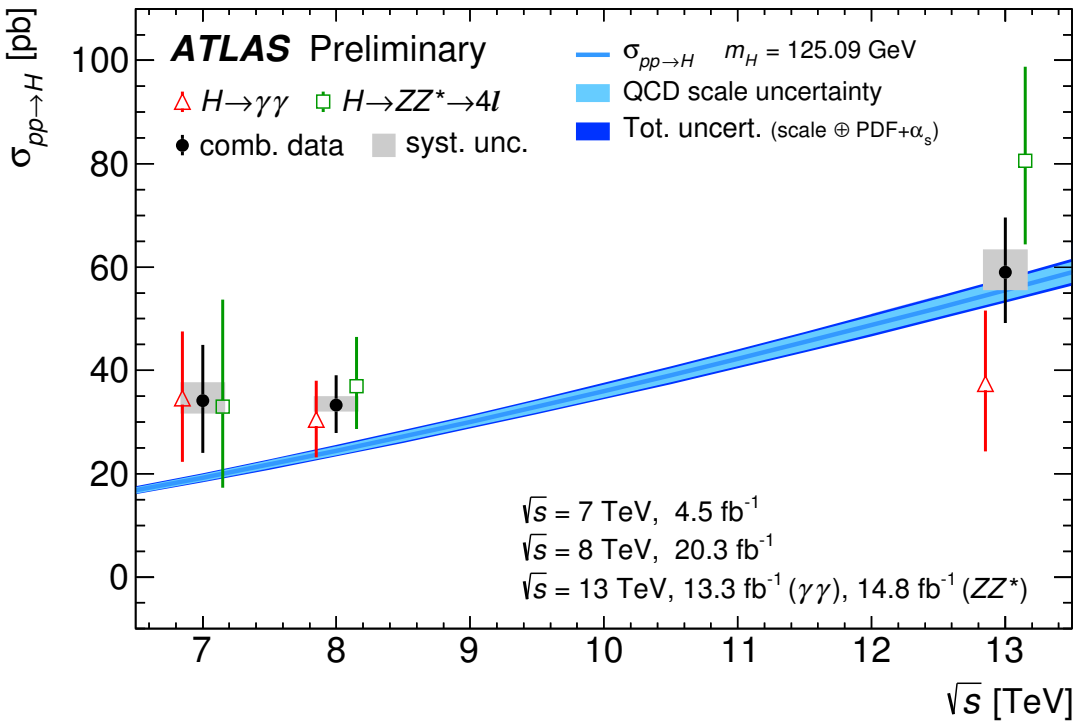
Higgs boson: combined $H \to \gamma\gamma$ and $H \to 4\ell$

ATLAS-CONF-2016-081

- Higgs production is seen with local significance 10σ (8.6σ expected).
- $\sigma(pp \to H + X) = 59.0^{+9.7}_{-9.2}(\text{stat.})^{+4.4}_{-3.5}(\text{syst.})\text{pb}$ is determined from fiducial measurements of $H \to \gamma\gamma$ and $H \to 4\ell$.
- No deviation from Standard Model is found.



Total $pp \to H + X$ cross sections

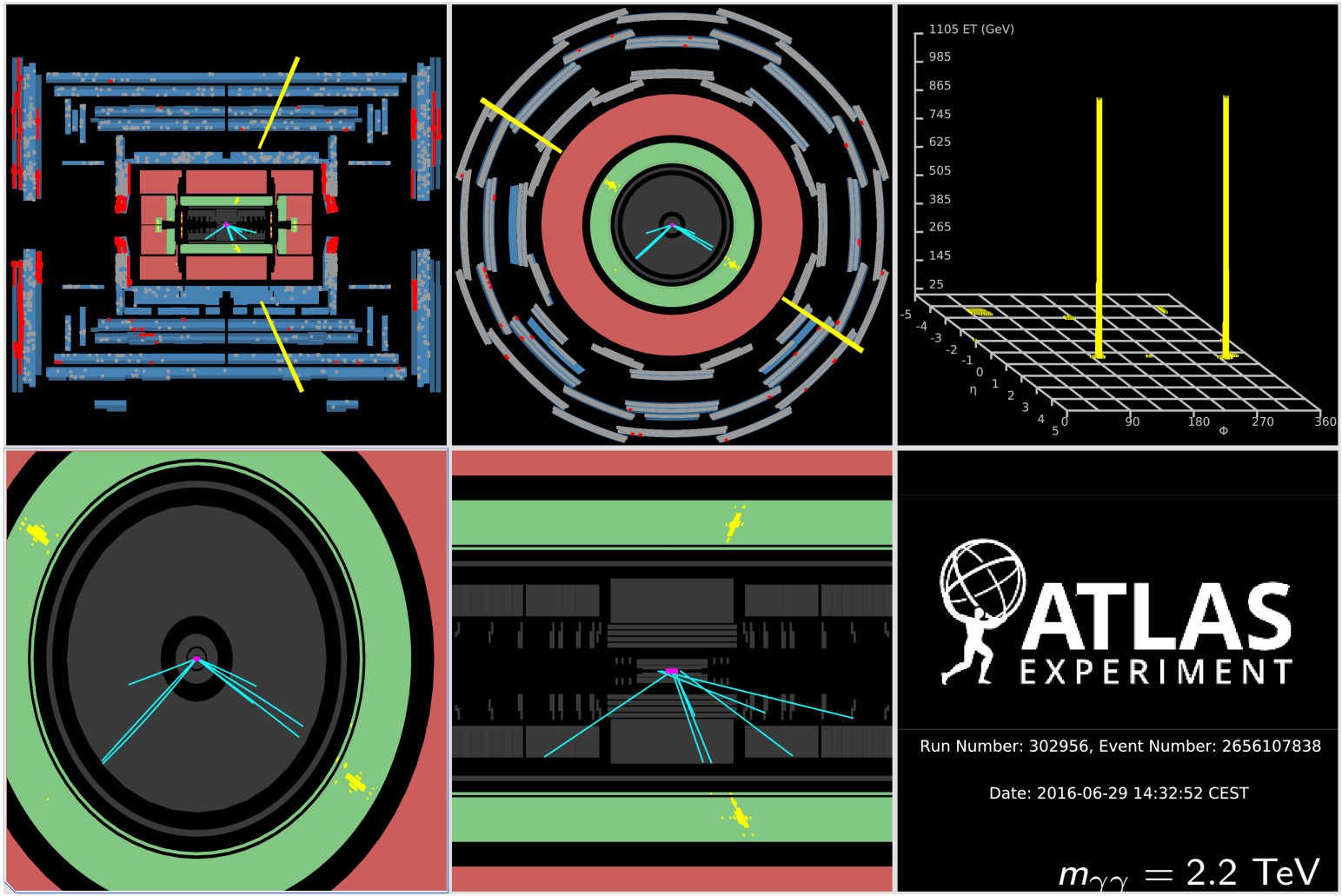


Searches for physics beyond the Standard Model

Searches for high-mass diphoton resonances

- Resonances decaying to diphotons predicted by several models beyond the Standard Model.

Analysis	Benchmark model	Search mass range
Spin-2	Graviton predicted by Randall-Sundrum model	500 GeV - 5 TeV
Spin-0	Higgs-like	200 GeV - 2.4 TeV

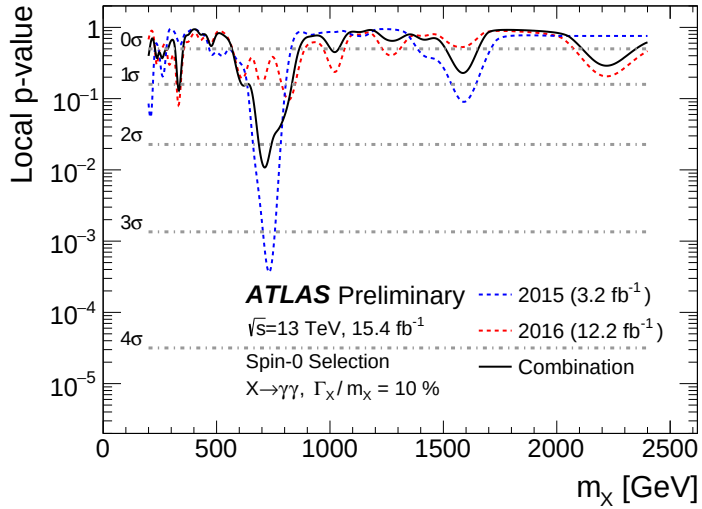


Searches for high-mass diphoton resonances

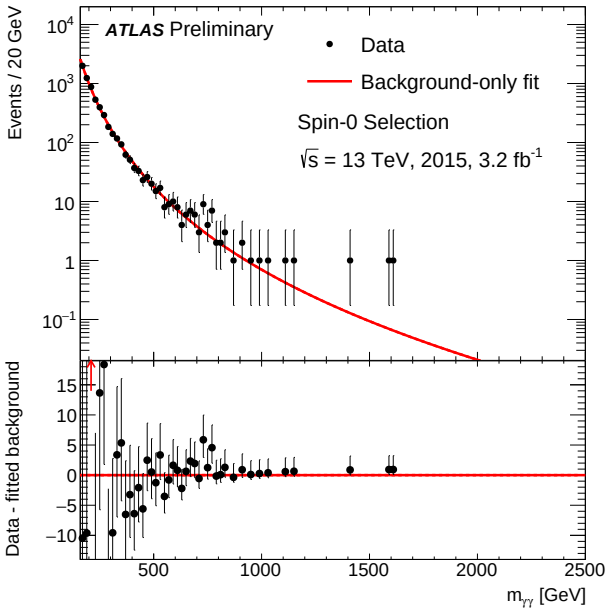
ATLAS-CONF-2016-059

- Limit setting based on fiducial cross section to minimize model dependence.
- Data consistent with background-only hypothesis over the full mass range.
- Excess around 750 GeV observed in 2015 data is not seen in 2016 data for spin-0 analysis.

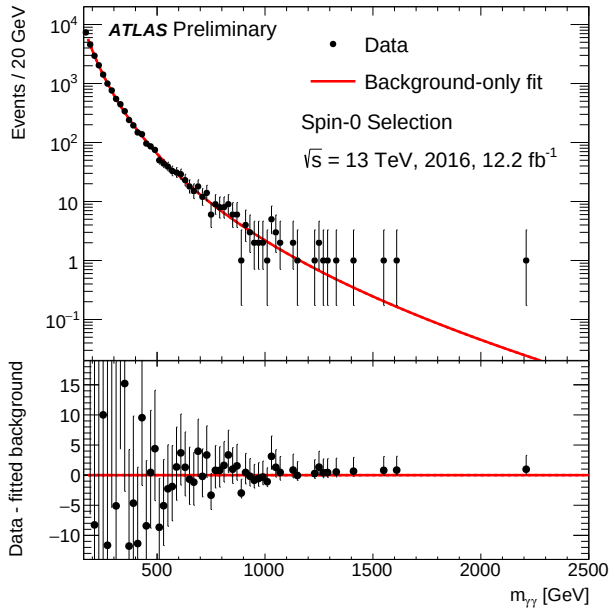
Significance for wide signal (10%)



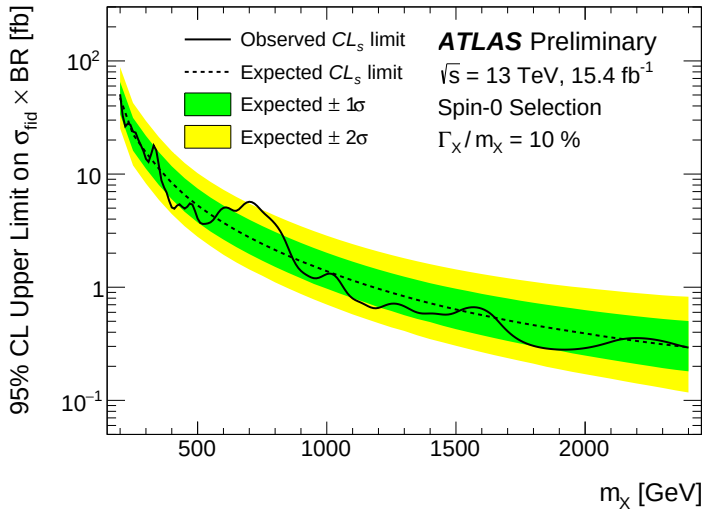
2015



2016

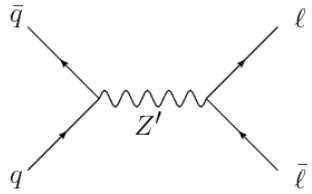


Limit on cross section

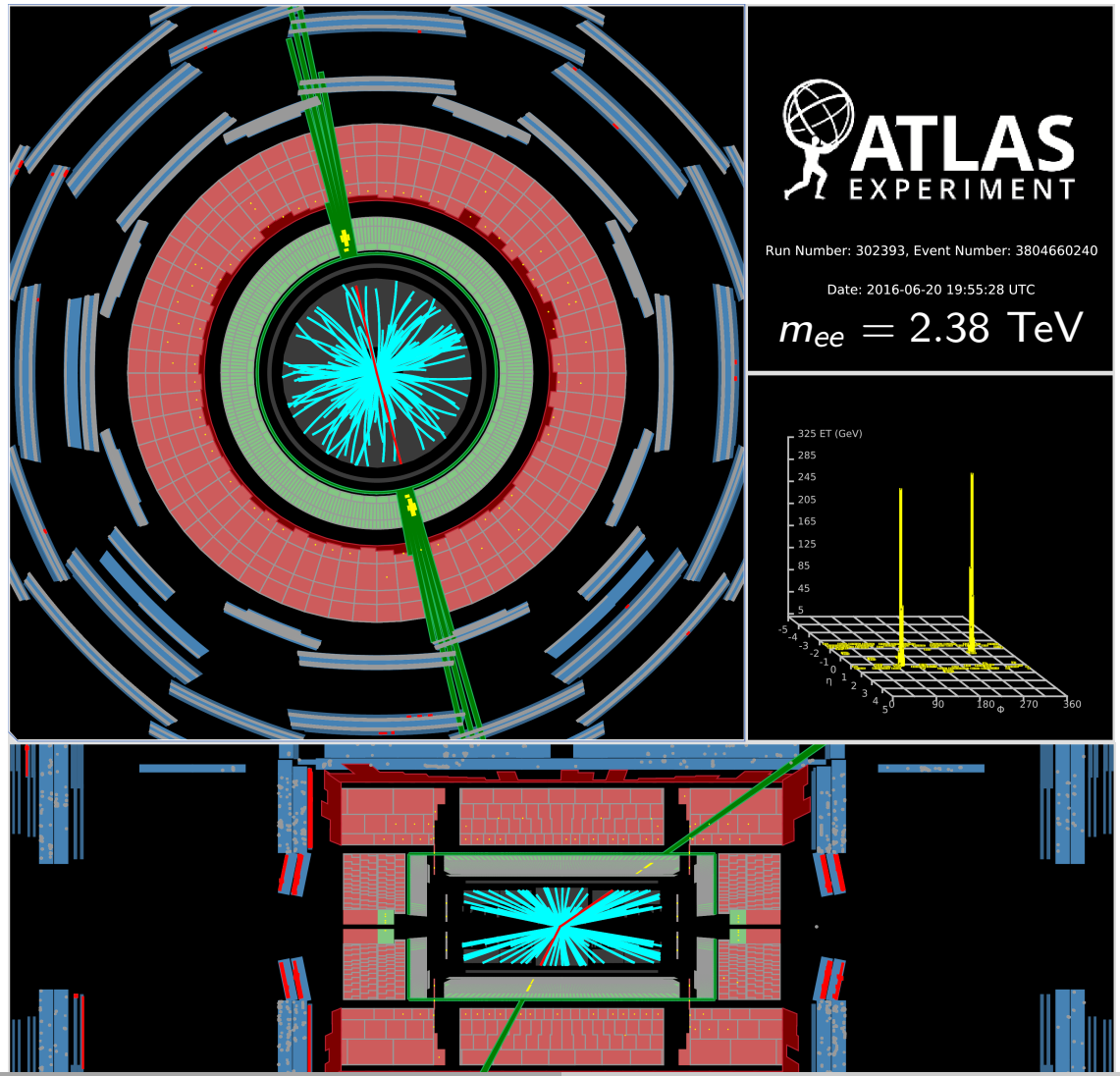


Searches for dilepton resonances

- Narrow resonances decaying to dileptons predicted by several models beyond the Standard Model.

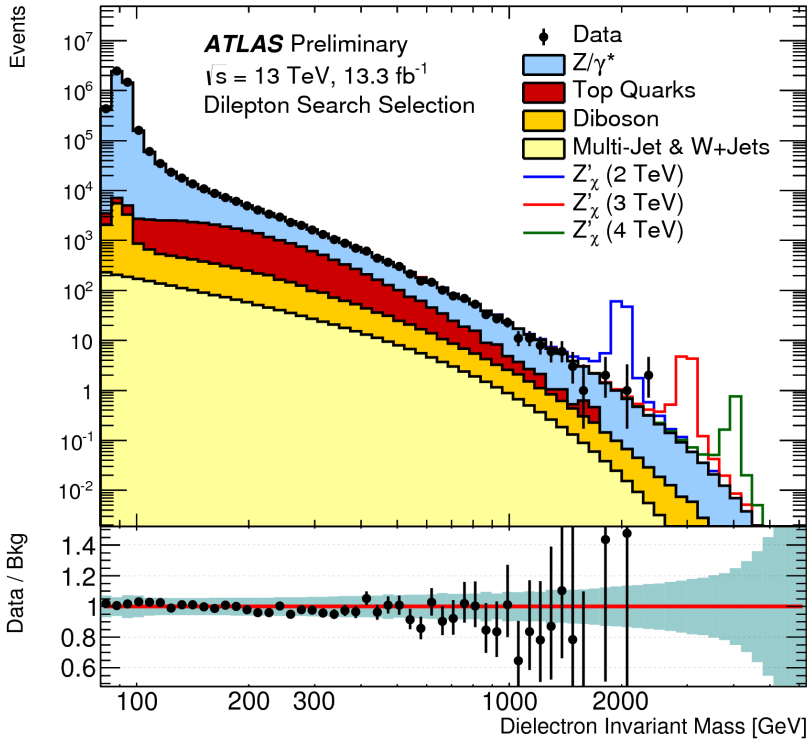


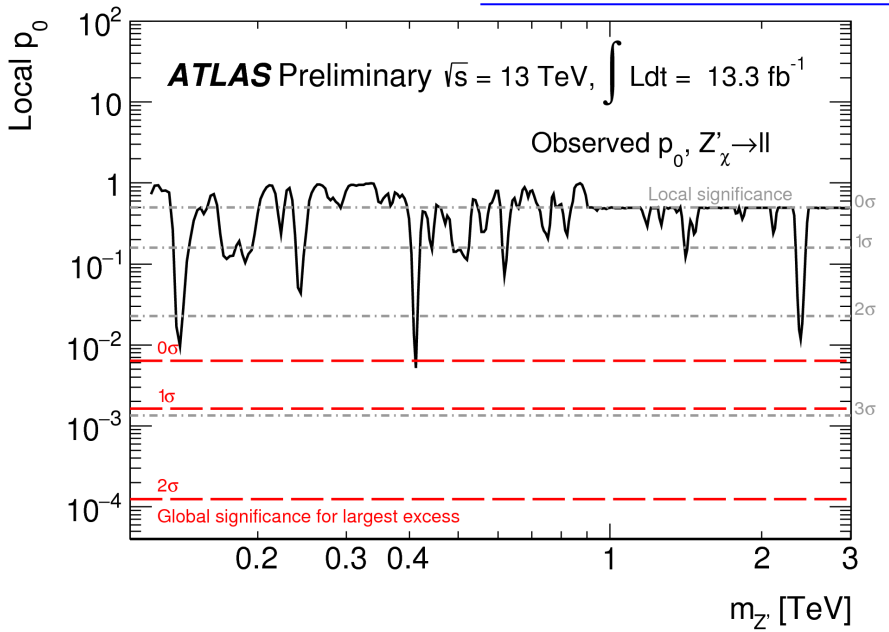
- Various models predict different kinds of Z' bosons.

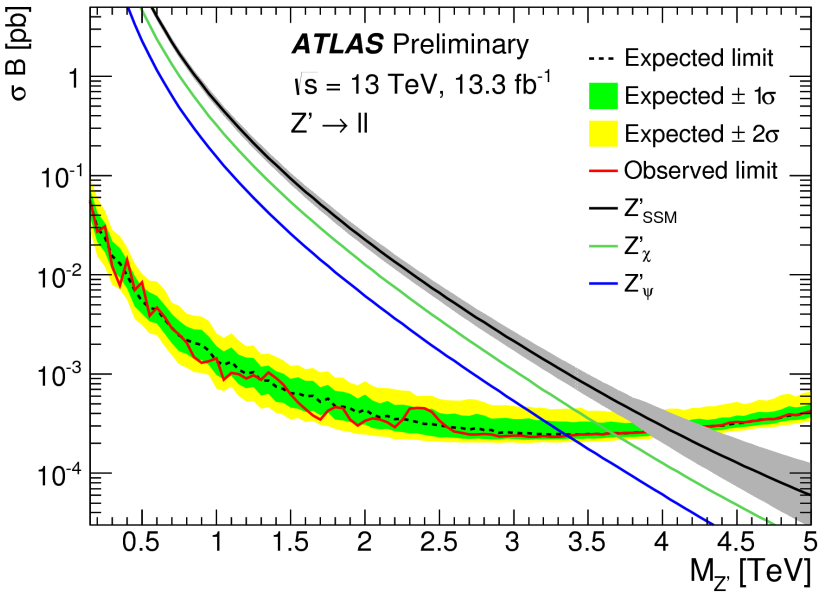


Searches for dilepton resonances: results

ATLAS-CONF-2016-045



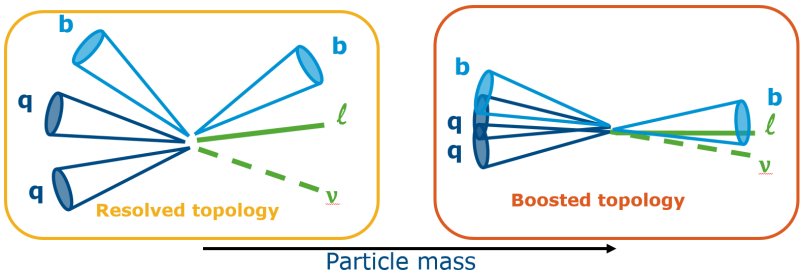




- The highest invariant mass event is found at 2.38 TeV in the dielectron channel, and 1.98 TeV in the dimuon channel.
- The observed dilepton invariant mass spectrum is **consistent with the Standard Model** prediction, within systematic and statistical uncertainties.

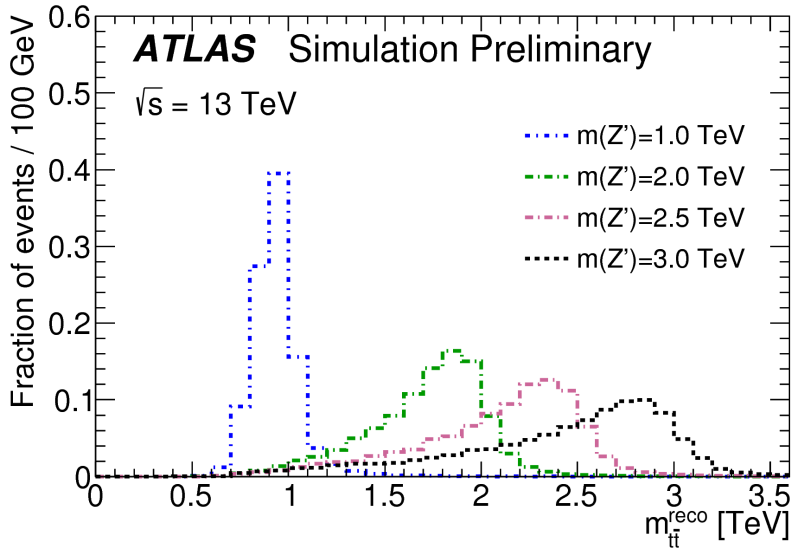
Searches for boosted $t\bar{t}$ resonances

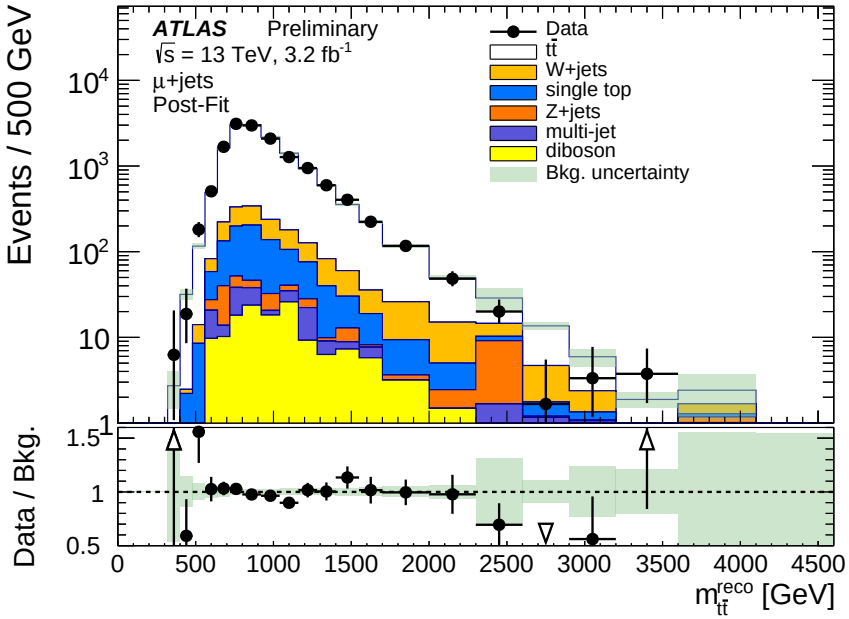
- Search of a *new heavy particle* that decays into $t\bar{t}$ pairs.

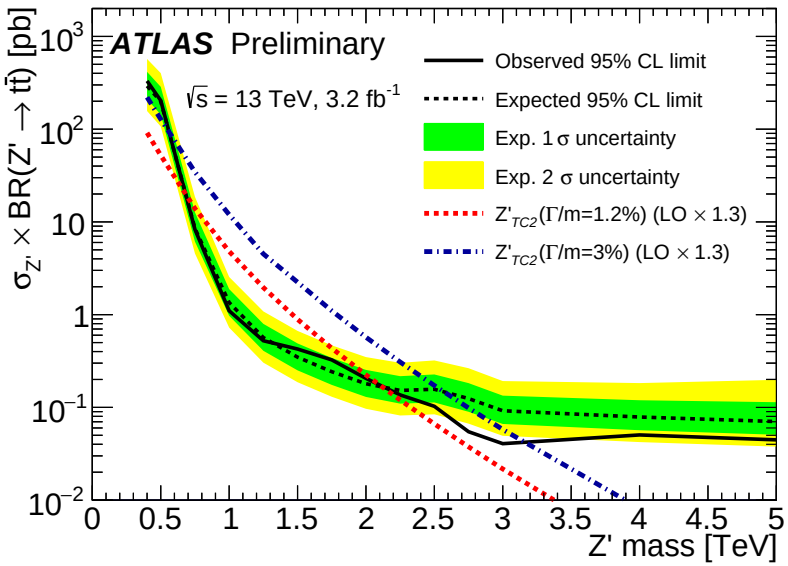


- Exclusion limits are set on the production cross section times branching ratio for hypothetical Z' bosons decaying into $t\bar{t}$.
- No significant deviations from the Standard Model predictions.

ATLAS-CONF-2016-014





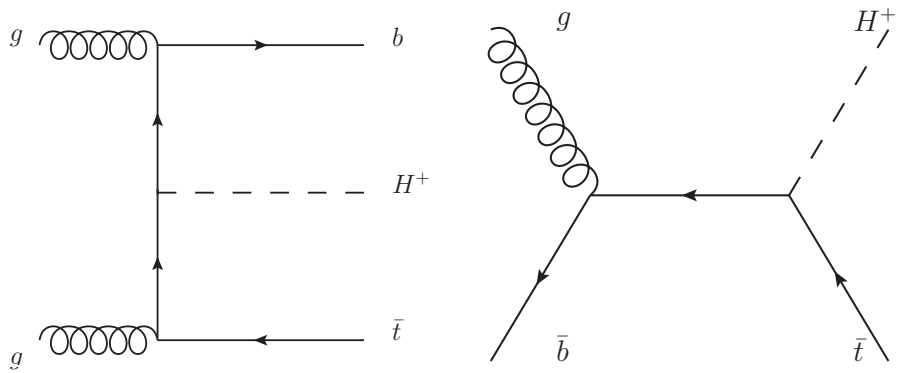


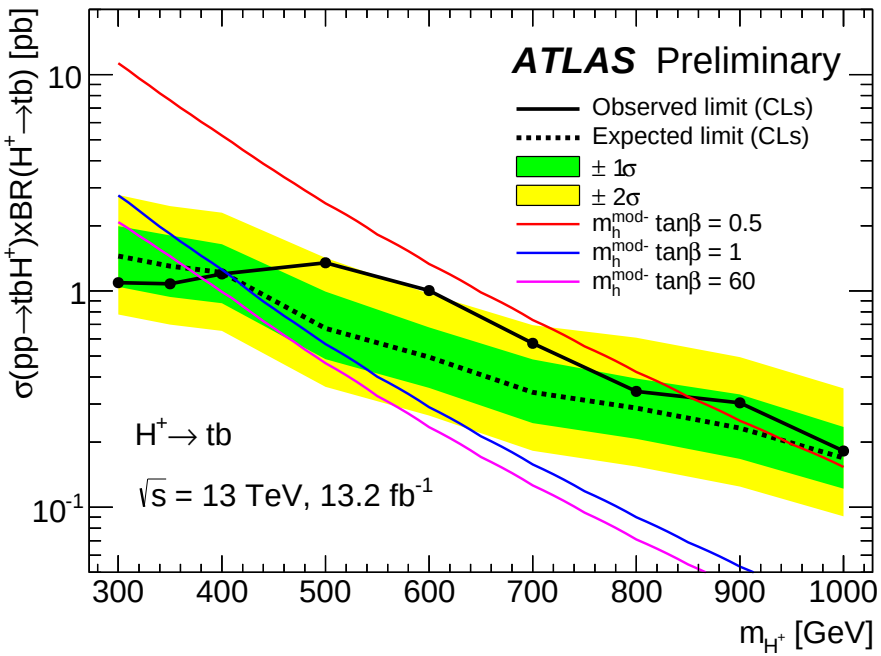
Searches for charged Higgs bosons: $H^{\pm} \to tb$

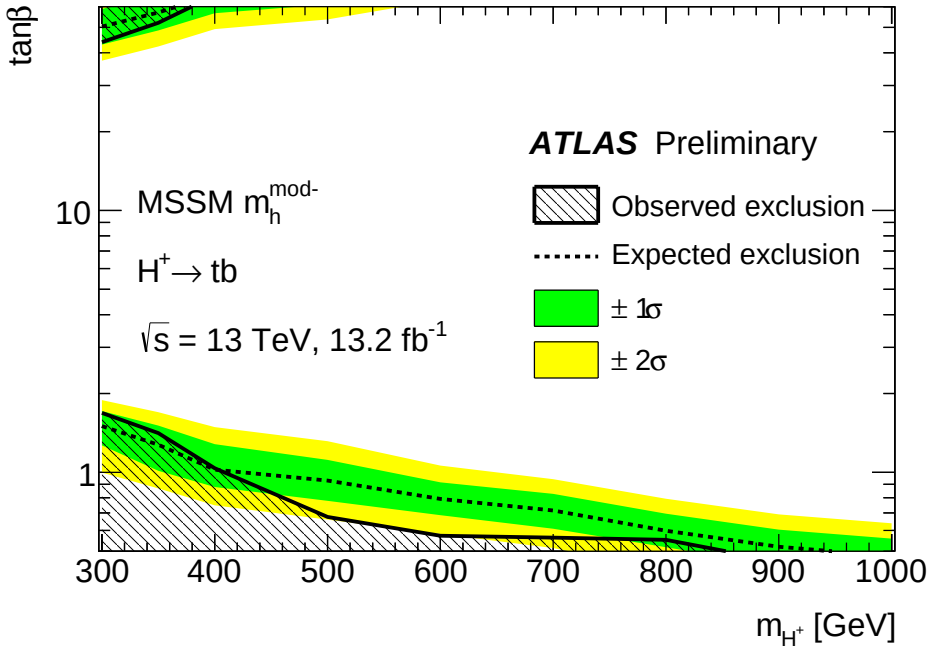
ATLAS-CONF-2016-089

- Charged Higgs boson is predicted by many models beyond the Standard Model
- Search for charged Higgs bosons heavier than the top quark and decaying via $H^+ \to t\bar{b}$
- Search mass range: **300-1000 GeV**
- Interpretation within benchmark scenarios of Minimal Supersymmetric extension of the Standard Model

Diagrams for H^+ production





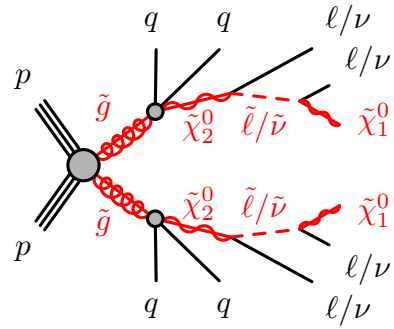


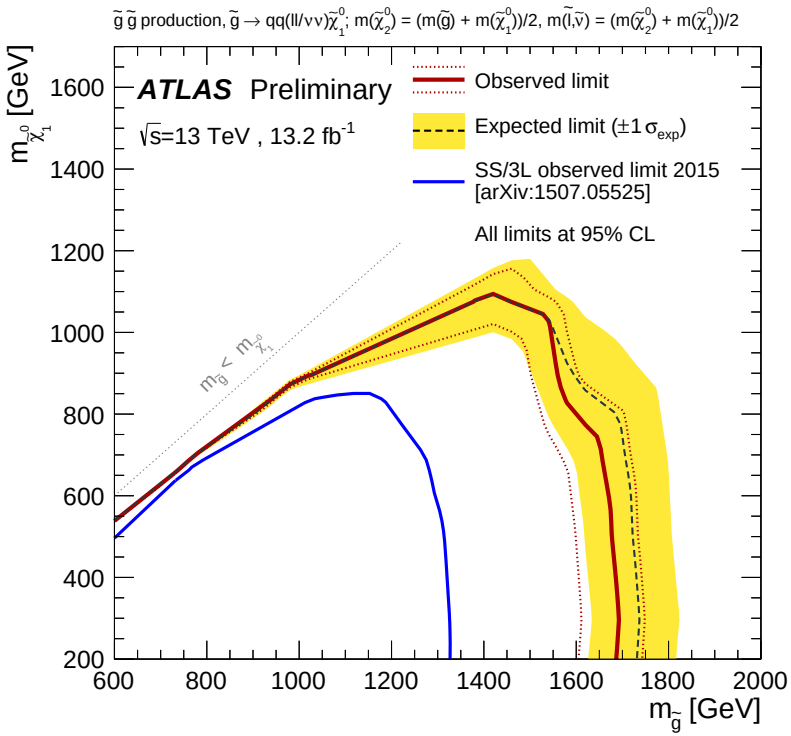
No significant excess above the expected Standard Model background.

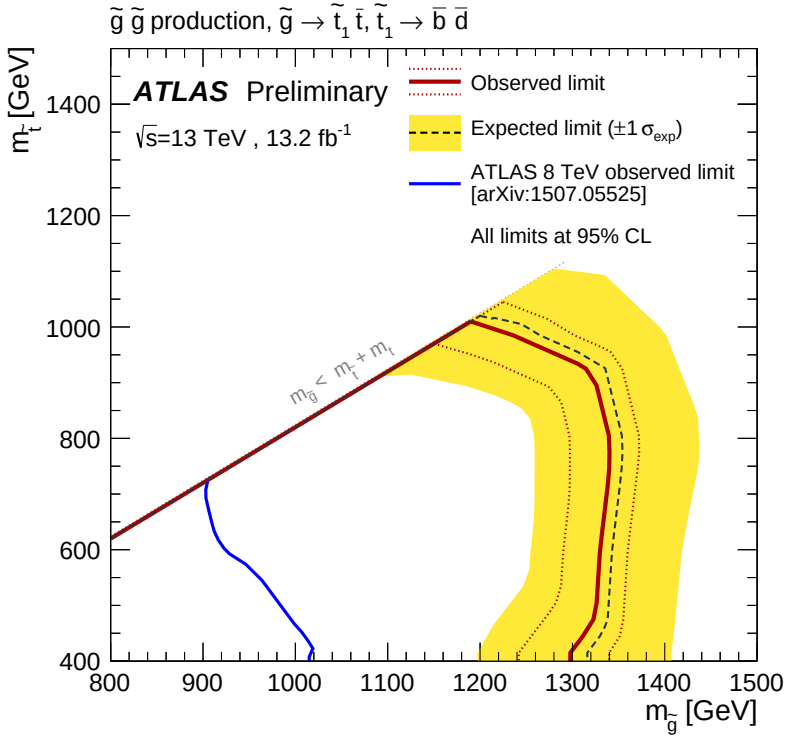
SUSY with two same-sign leptons or three leptons

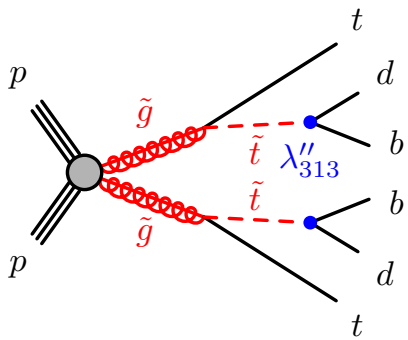
ATLAS-CONF-2016-037

- Search for SUperSYmmetry (SUSY) in final states containing jets and
  - two leptons with same charge → signature is present in many scenarios of physics beyond the SM.
  - three leptons of any charge combination
- Interpretation of results in the context of several simplified supersymmetric models featuring R-parity conservation and R-parity violation.







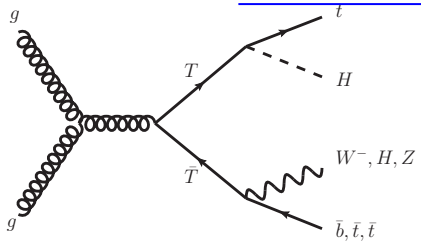


No significant excess above the Standard Model expectation.

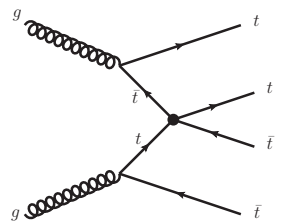
Events with b-jets and a pair of same-charge leptons

- Search for beyond the Standard Model processes resulting in pairs of isolated high transverse momentum same-sign leptons, *missing transverse momentum*, and b-jets.
- Rare experimental signature among Standard Model processes, while several beyond the Standard Model processes *predict* enhanced yield of such events.

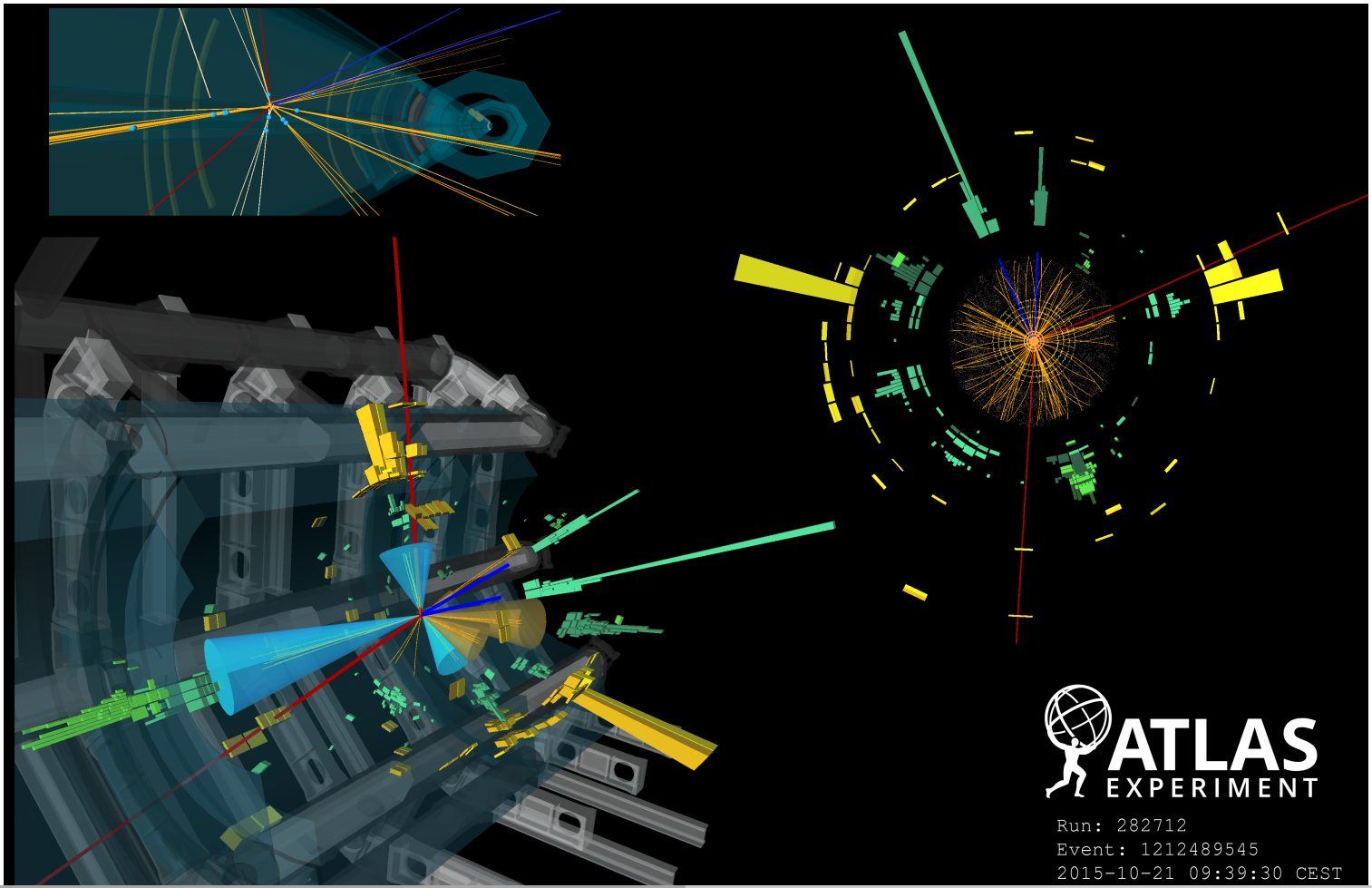
ATLAS-CONF-2016-032



Vector-like top quarks



Contact interaction

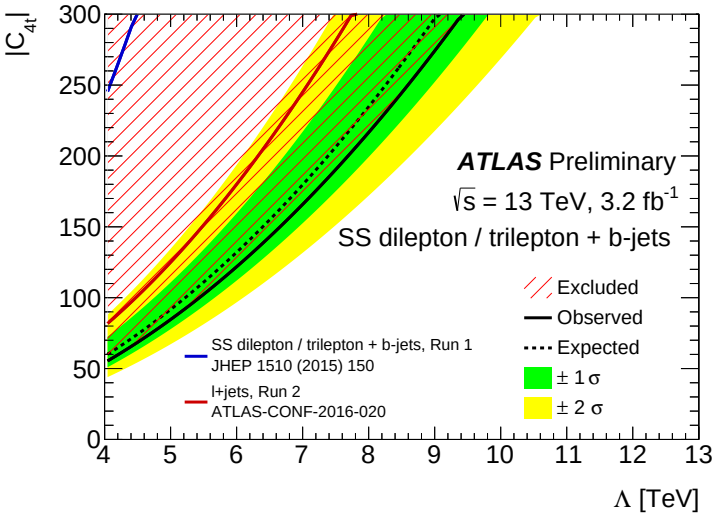


Events with b-jets and a pair of same-charge leptons

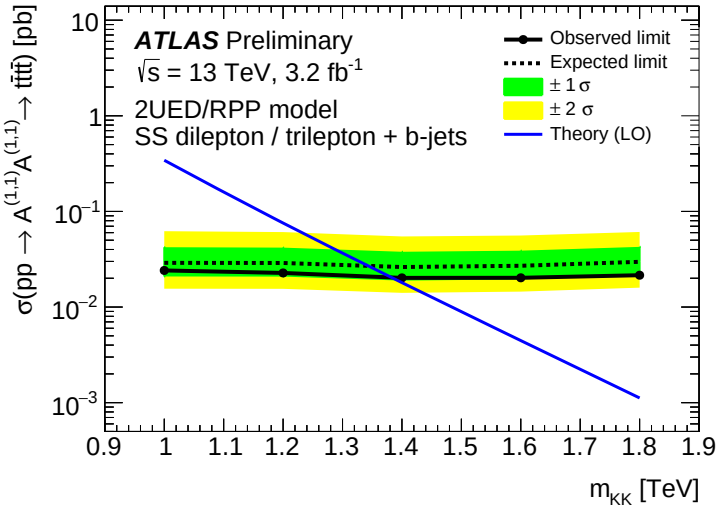
- The search is performed in the context of several beyond the Standard Model scenarios, with a set of eight signal regions defined for different models. ATLAS-CONF-2016-032

Search for four-quark production

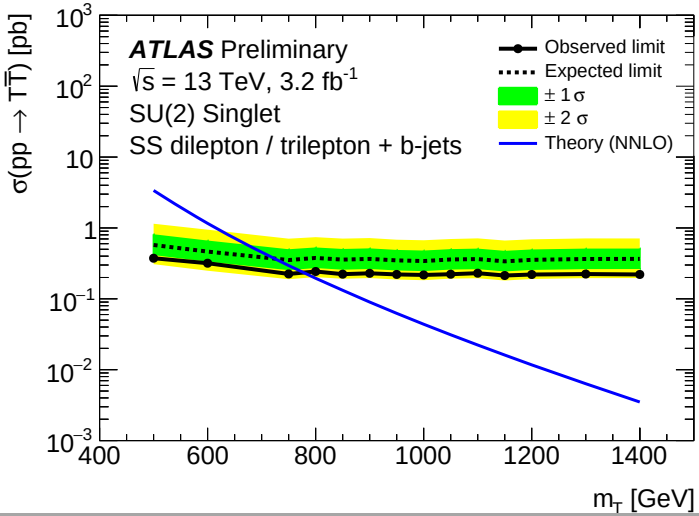
Limit on coupling constant in the contact interaction model:



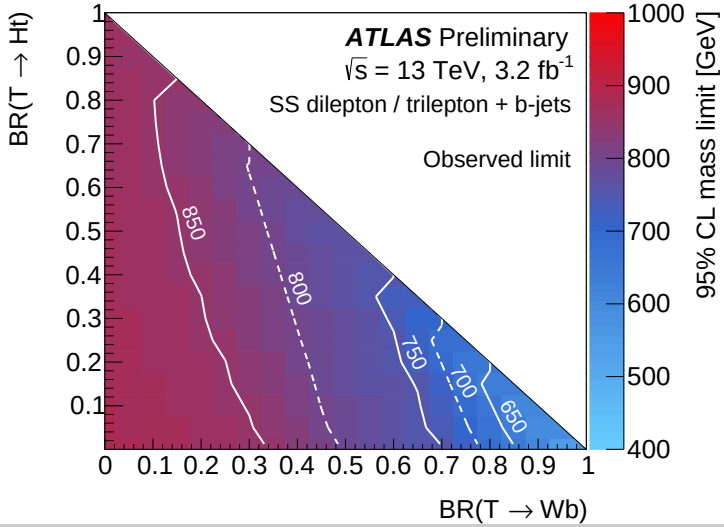
Limit on the 4-quark production rate: in model with extra dimensions:



Model with vector-like quarks:

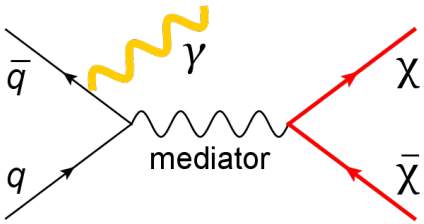


Limit on the mass of the T quark:

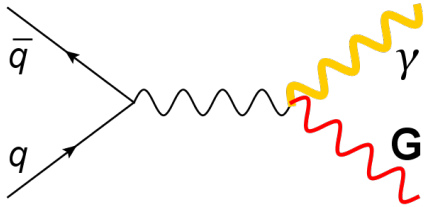


Events with a photon and missing transversy energy

- Theories of **dark matter** or **large extra spatial dimensions** predict the production of events with
  -*high transverse momentum* photon
  -*large* missing transverse momentum
- Low contribution of Standard Model processes provides powerful sensitivity to models of new phenomena.

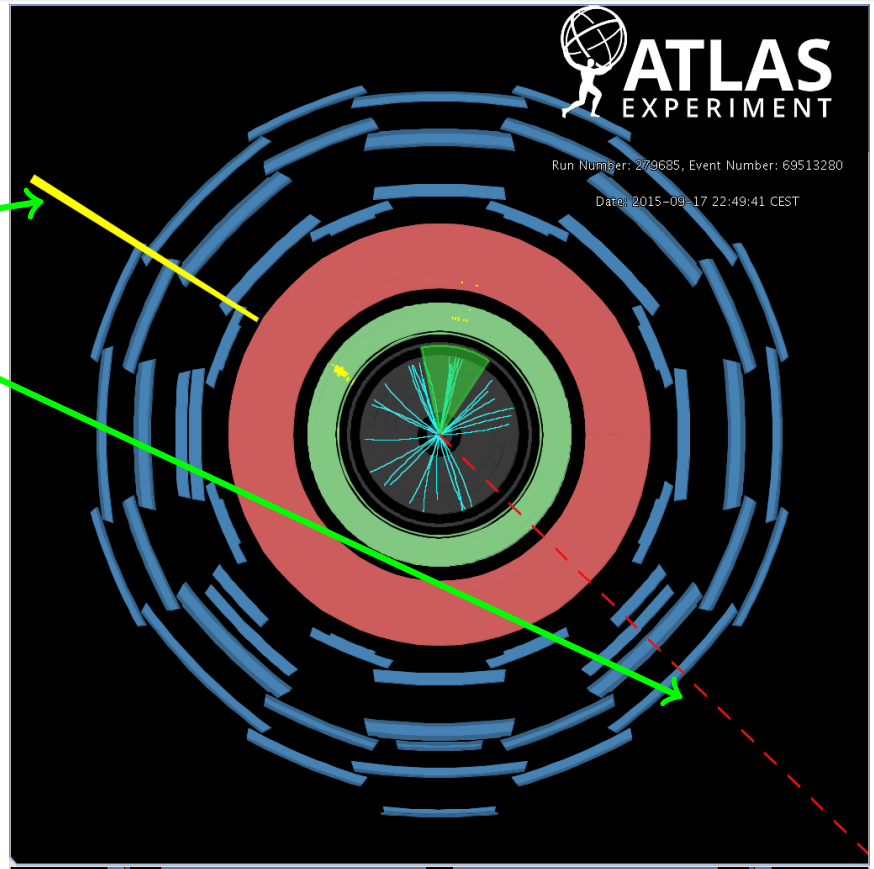


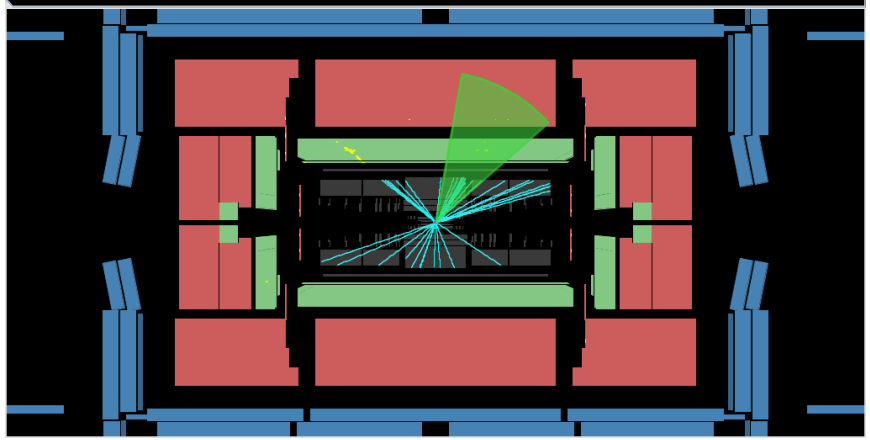
Production of pair of dark matter particles



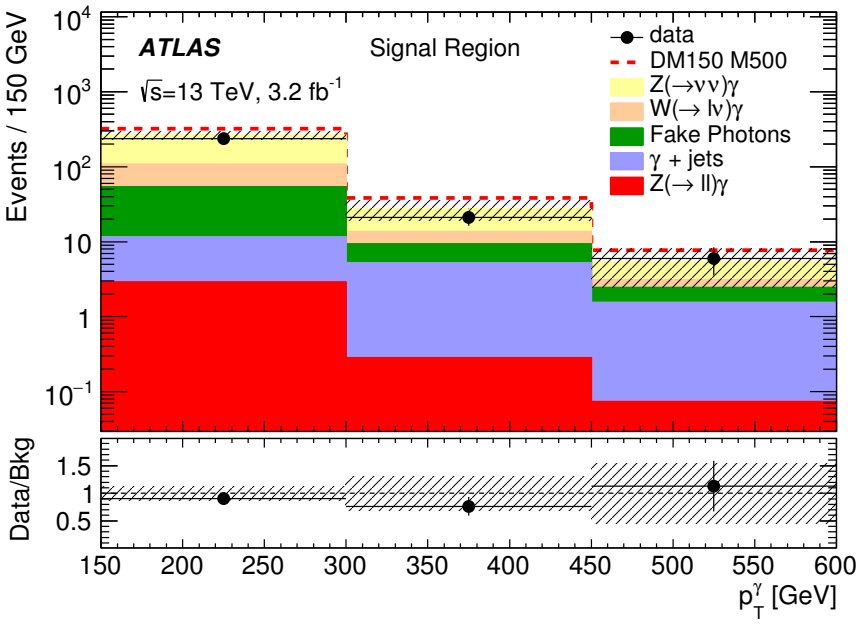
Graviton production in models of large extra dimensions

- Probing possible couplings of dark matter to photons through an effective operator.





Searches for new phenomena in $\gamma + E_T^{miss}$ events



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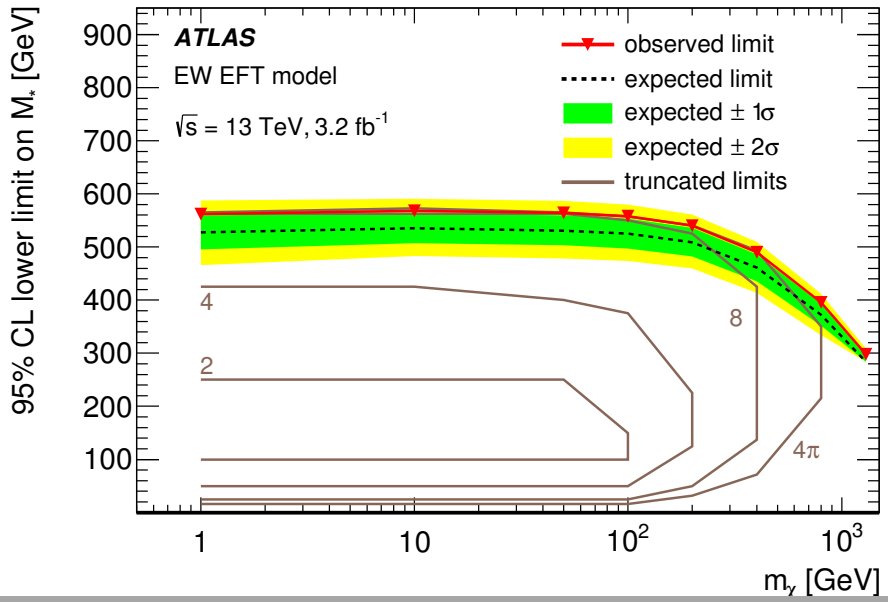
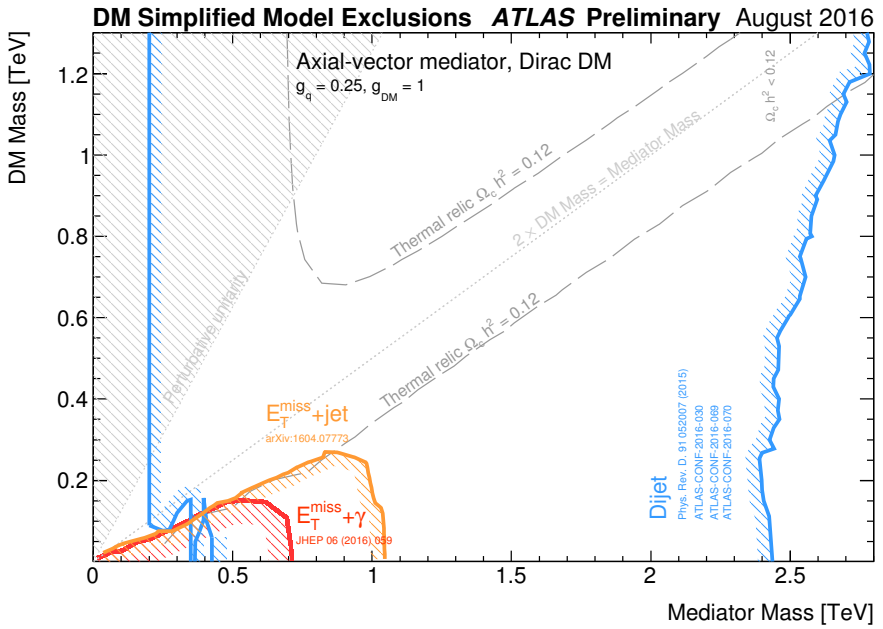
- Good agreement in the signal region: limits set on the visible cross section and on various models.
- The search excludes mediator masses below 710 GeV for χ masses below 150 GeV.
- The observed data are consistent with the Standard Model expectations.

Limit on effective mass scale for $\gamma\gamma\chi\chi$ model





Summary

- Strong contribution of the LPSC and LAPP groups to ATLAS physics.
- Significant contribution to the object performance.
- Involvement in wide range of physics measurements:
  - Standard Model (EW, Higgs, top measurements)
  - Beyond the Standard Model (SUSY, Dark matter, etc)
- Many public results with the Run2 data:
  https://twiki.cern.ch/twiki/bin/view/AtlasPublic
- ATLAS Beyond the Standard Model Higgs and Exotics Joint Workshop organized by the LPSC members.