Summary of Physics results from the ATLAS experiment

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on behalf of the LAPP and LPSC ATLAS groups

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Outline

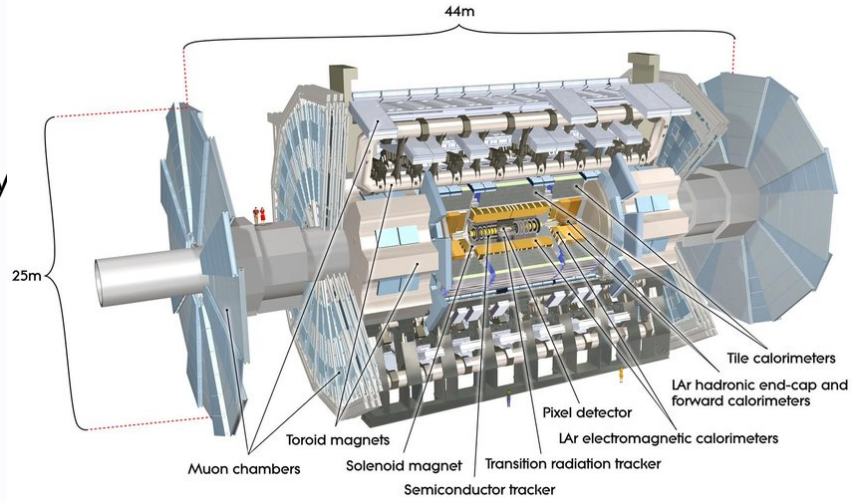
- **ATLAS Postdocs/PhD funded by ENIGMASS:**
  - **Postdocs:** Oleh Kivernyk (LAPP), Paolo Mastrandrea (LAPP), Nathan Readioff (LPSC)
  - **PhD:** Olympia Dartsi, Peter Falke, Angela Burger

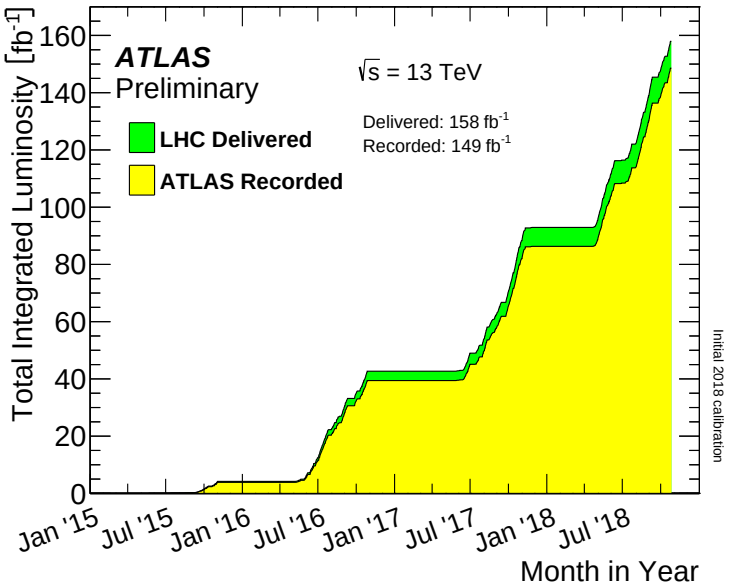
- **Performance**
  - Electron and photon calibration 2015-2016 (in preparation) ▸ Link
  - Photon identification 2015-2016 ▸ Link
  - Electron identification 2015-2016 ▸ Link

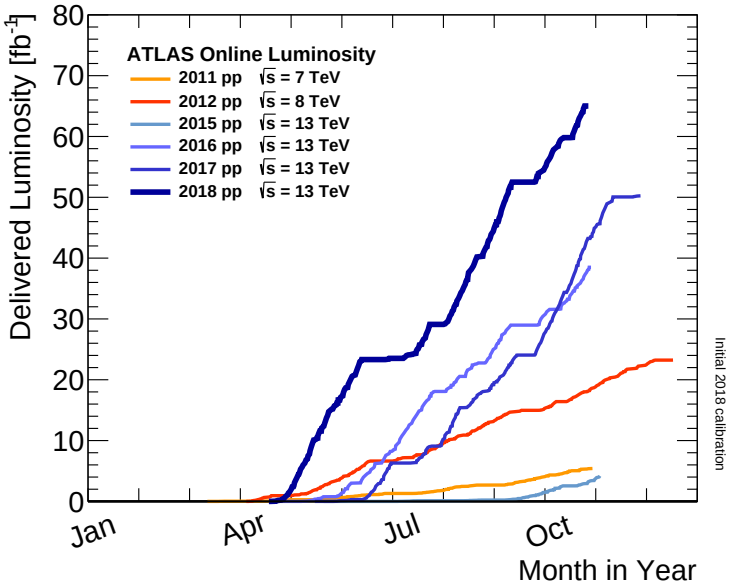
- **Physics analyses**
  - WZ cross sections and boson polarization ▸ Link
  - Observation of EWK WZjj production ▸ Link
  - $H \to \gamma\gamma$ fiducial, differential cross-sections, STXS, couplings ▸ Link
  - Observation of ttH production ▸ Link
  - Combination of searches for heavy resonances decaying into bosonic and leptonic final states ▸ Link

ATLAS experiment

- LHCs Run-II came to an end with an excellent result of **158fb^{-1} delivered pp data** since 2015.
- **ATLAS recorded** about **149fb^{-1}** of data (efficiency 94.3%).
- Important contribution of the LAPP and LPSC groups to detector operation.
- Plan to start Run-III in 2021 $\rightarrow$ now is the time to focus on analysing of Run-II data.

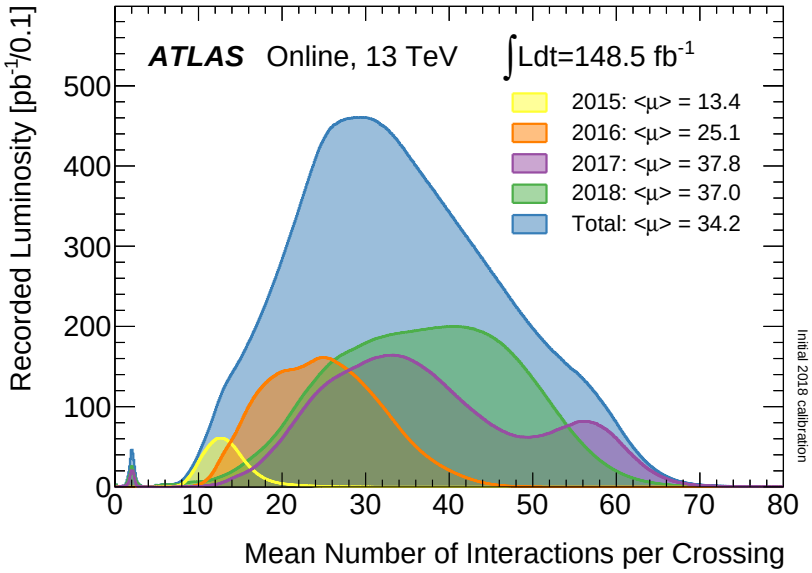




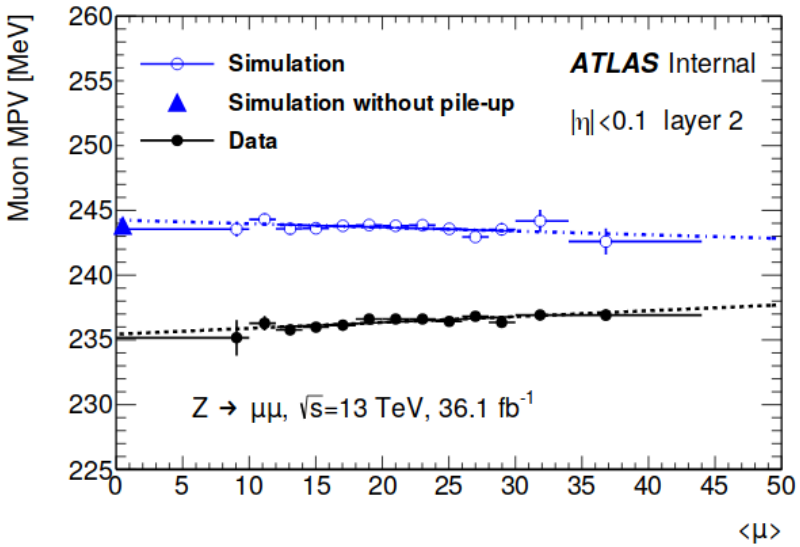


Performance: electron and photon energy calibration

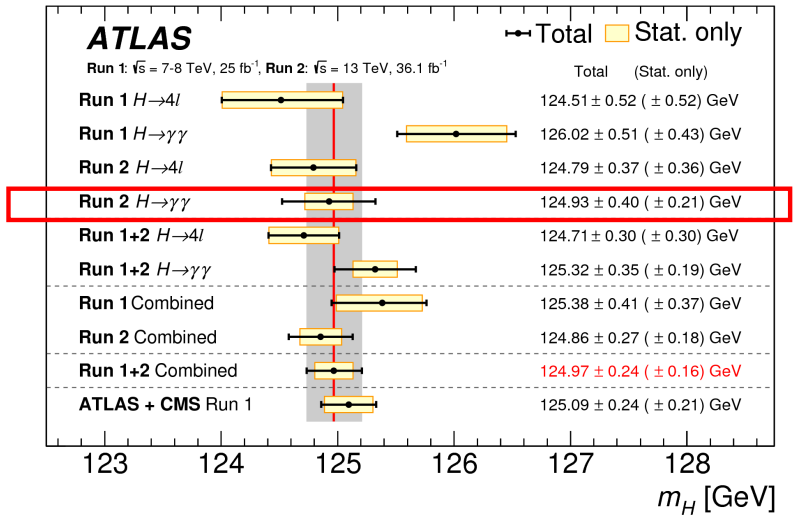
- Input to all Run-2 analyses using electrons/photons
- Active role of LAPP and LPSC groups in e/γ performance studies
- Detector calibration at harsh pile-up conditions is challenging
- Understanding of pile-up effects in calorimeter calibration significantly improved the measurement precision of Higgs mass in Run-II



Layer calibration



Higgs mass combination



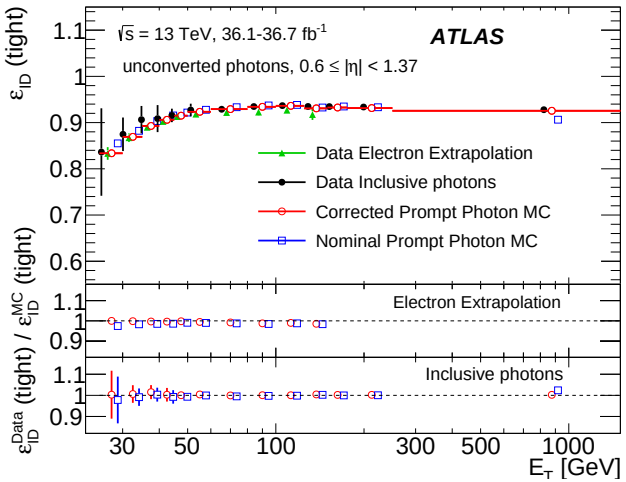
Performance: electron and photon identification

- Photon ID: cuts have been optimized to account for E_T-dependence.
- Electron ID: optimized to be robust against pile-up.

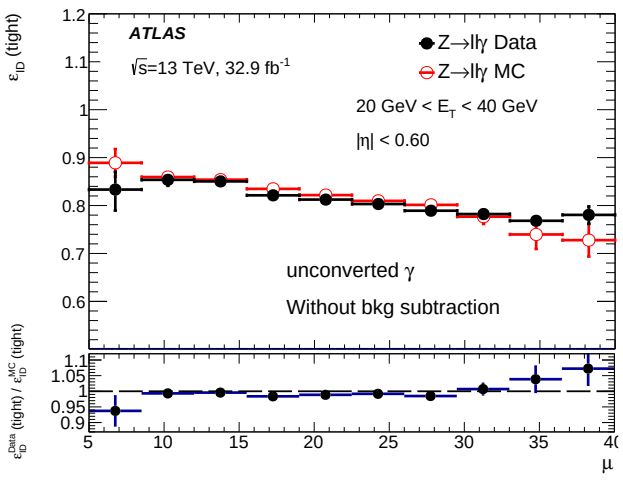
Identification	Photons	Electrons
Discriminating variables	EM shower	EM shower + track
Selection	Cuts	MVA likelihood
Efficiency measurements	$Z \to \ell\ell\gamma$, $e \to \gamma$, single photons	Tag and Probe using $Z \to ee$ and $Z \to \ell\ell\gamma$

- Efficiencies in data are measured using different methods covering different E_T-ranges. **Difficulties:** background subtraction, Data/MC differences.
- **Electron and photon triggers** updated in 2018 to keep up with the offline ID changes and pile-up
- Efficiency in MC corrected to match data.

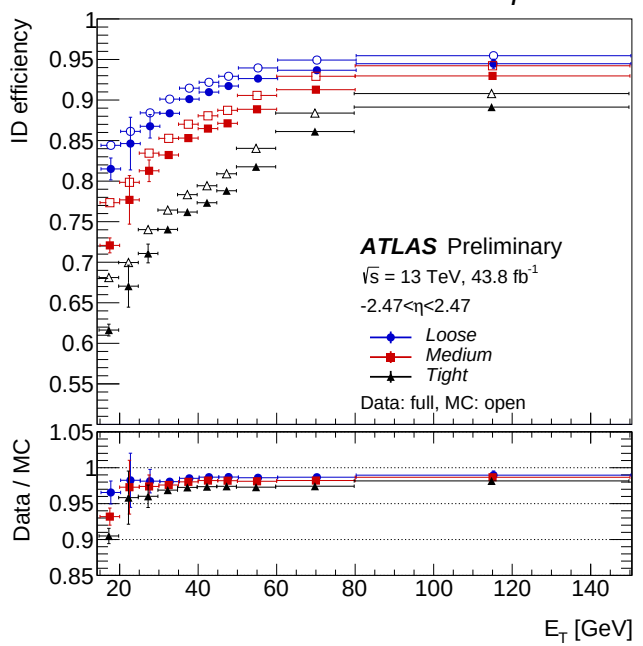
Photon ID versus E_T



Photon ID versus $< \mu >$

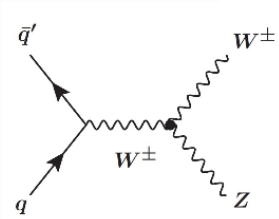


Electron ID versus E_T

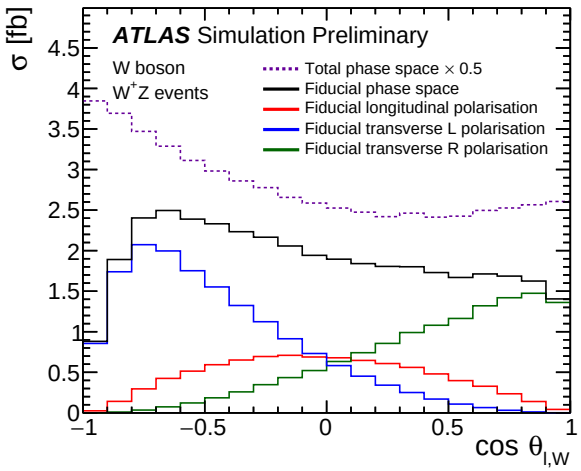


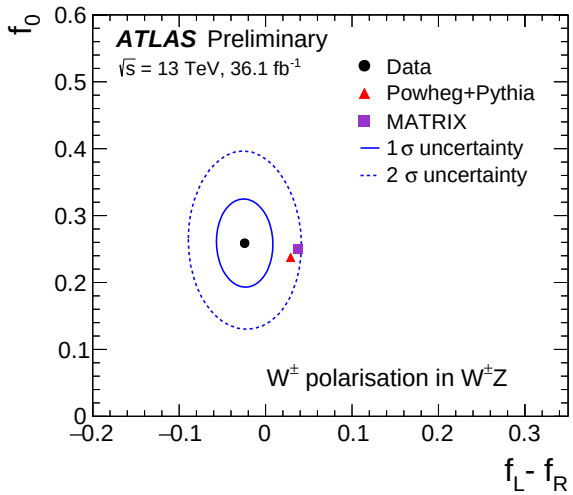
WZ cross sections and boson polarization

- **Precise measurements of total and differential** (p_T^Z, M_T^{WZ}, N_{jets}, etc) **cross sections**
  - Separate and combined measurements for 4 lepton flavour channels
- **First measurement of boson polarization in dibosons WZ** produced in hadrons collisions
  - analysis 100% done by LAPP
  - Uses lepton angular distributions
  - Template fits to $q_\ell \times \cos\theta_{l,W(Z)}$ distributions
- Observed (expected) significance of $4.2\sigma(3.8\sigma)$ for longitudinally polarized Ws
- Probes **anomalous triple gauge couplings** which is senstitive to new physics
- Previous such measurements done only at LEP

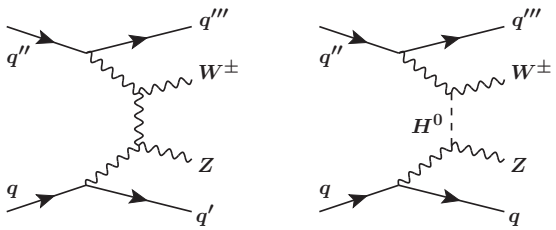


$$\frac{1}{\sigma_{W^\pm Z}}\frac{d\sigma_{W^\pm Z}}{d\cos\theta_{\ell,W}} = \frac{3}{8}f_L(1\mp\cos\theta_{\ell,W})^2 + \frac{3}{8}f_R(1\pm\cos\theta_{\ell,W})^2 + \frac{3}{4}f_0\sin^2\theta_{\ell,W}$$



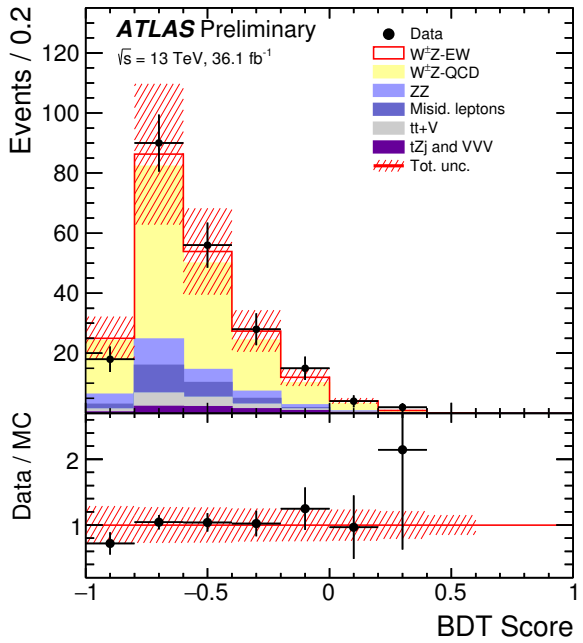


Observation of EWK WZjj processes

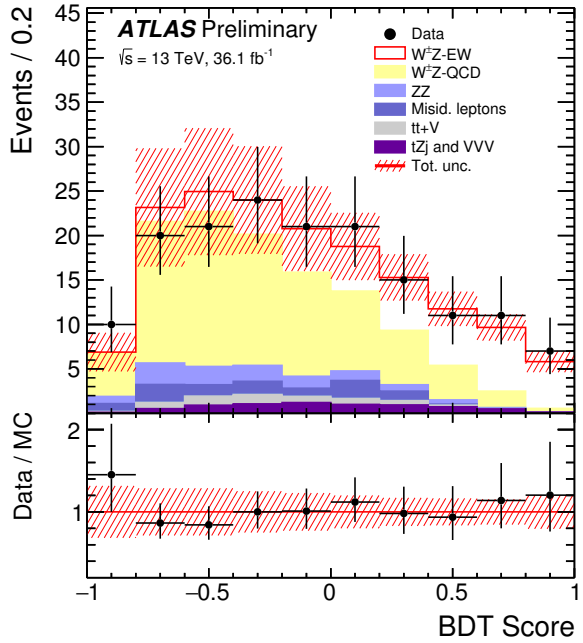


Dominant BKG: WZjj QCD

WZjj QCD CR ($250 < m_{jj} < 500$GeV)

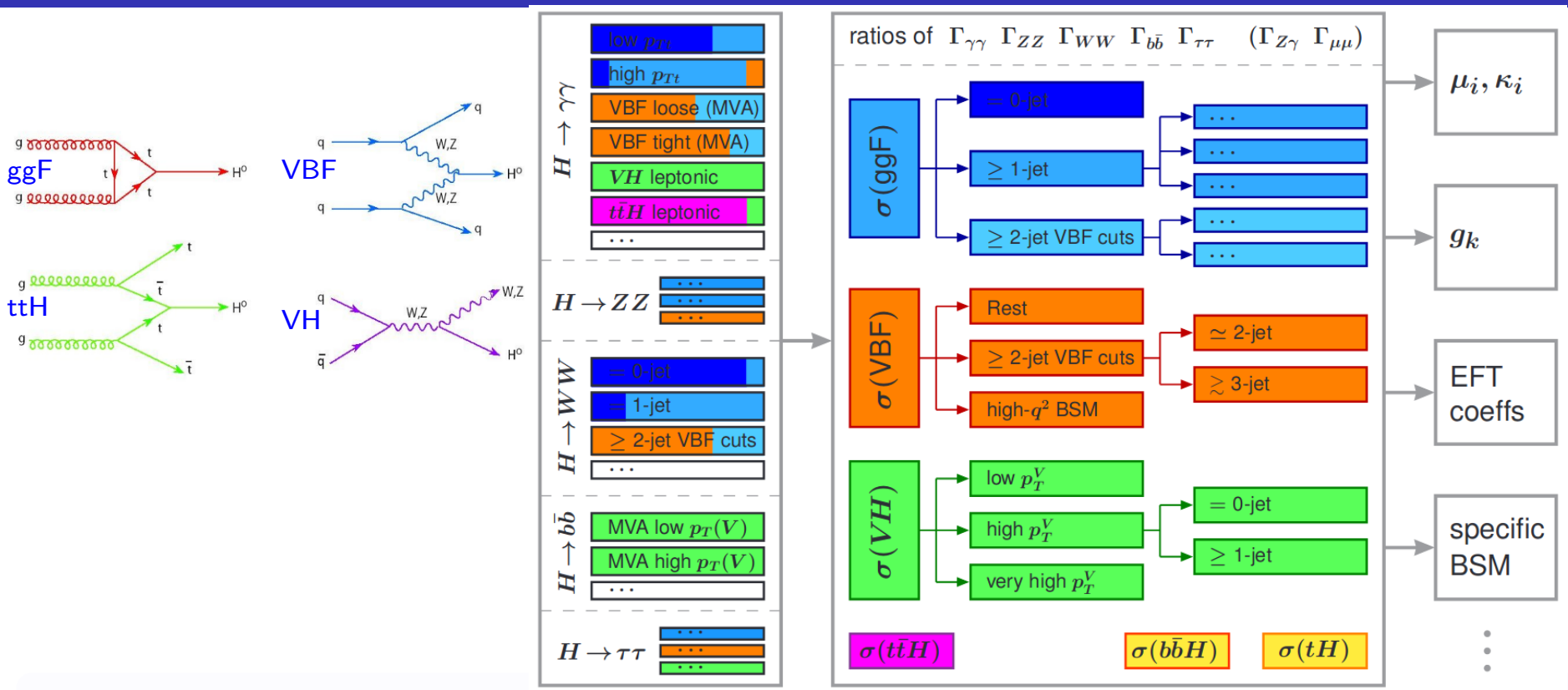


WZjj SR ($m_{jj} > 500$GeV + BDT)



- First observation (5.6σ) of **EWK WZjj production** using 2015-2016 data
  - very rare process (44 events observed)
  - analysis 100% done by LAPP
- Probes **anomalous quartic gauge couplings** which is senstitive to new physics
- BDT is trained to separate EWK WZjj signal from other processes
- Good modeling of BDT shape in WZjj QCD region
- Signal region: EWK WZjj dominates at high score of BDT
- **Same-sign EWK WWjj production** has been also recently reported by ATLAS

Simplified Template Cross Section (STXS)

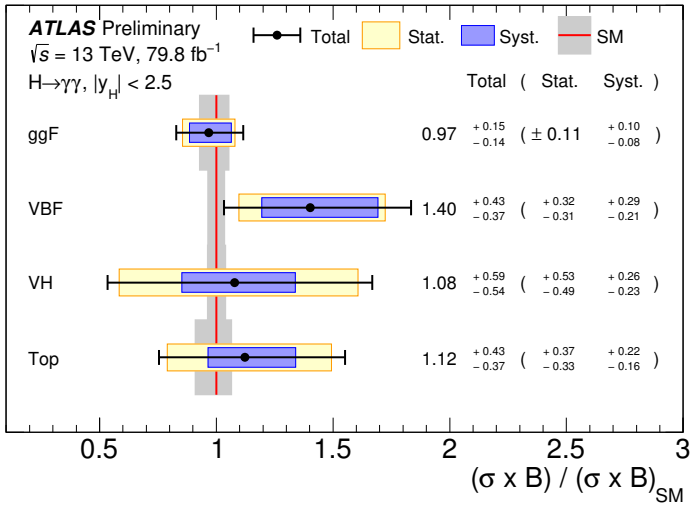


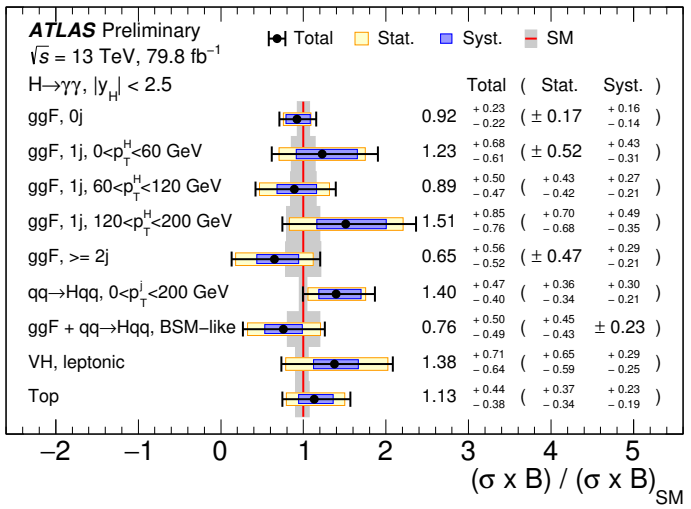
- Exp. categories are designed to enrich events of a given Higgs production mode (dependent on decay channel, MVA allowed)
- STXS bins are optimized for maximal sensitivity while reducing theory dependence (inclusive in Higgs decays)
- STXS are determined from the experimental categories by a global fit
- Measured STXS can be then used as input for interpretations (κ-factors, EFT interpratation)

Recent STXS measurements in Run-II

Full 2015-2017 dataset

- Active role in **optimization of HTXS bins**
- Active role in **H** $\rightarrow \gamma\gamma$ analyses
  - clean signal despite small branching ratio (0.2%)
  - large signal yields due to high ID efficiency
  - narrow $m_{\gamma\gamma}$ peak due to excellent photon energy resolution
- Enough events to measure
  - Stage 0: production XSs
  - Stage 1: STXS with strong merging (31$\rightarrow$9 bins)
  - Fiducial and differential XSs: $p_T^{\gamma\gamma}, y^{\gamma\gamma}, p_T^{j1}, N(b-jets)$
- Still limited by statistics
- **No significant deviation from the SM**
- Currently working on EFT interpretation of measured STXS

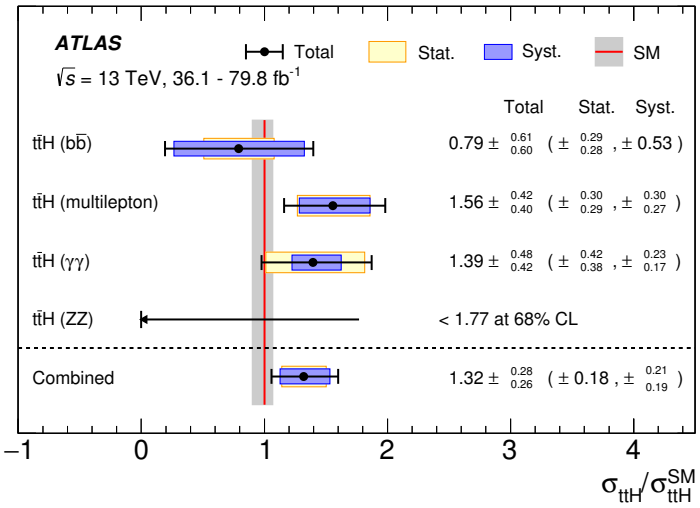


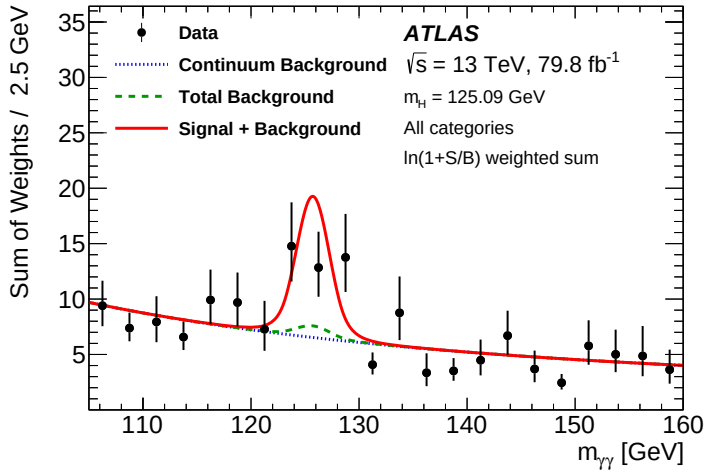


Observation of ttH in Run-II

- ttH cross section measurement allows direct constraint on top Yukawa coupling
- ATLAS observed ttH production (with a significance of 6.3σ) combining different decay channels
- LAPP contributed to diphoton decay channel
- LPSC contributed to multilepton decay channel

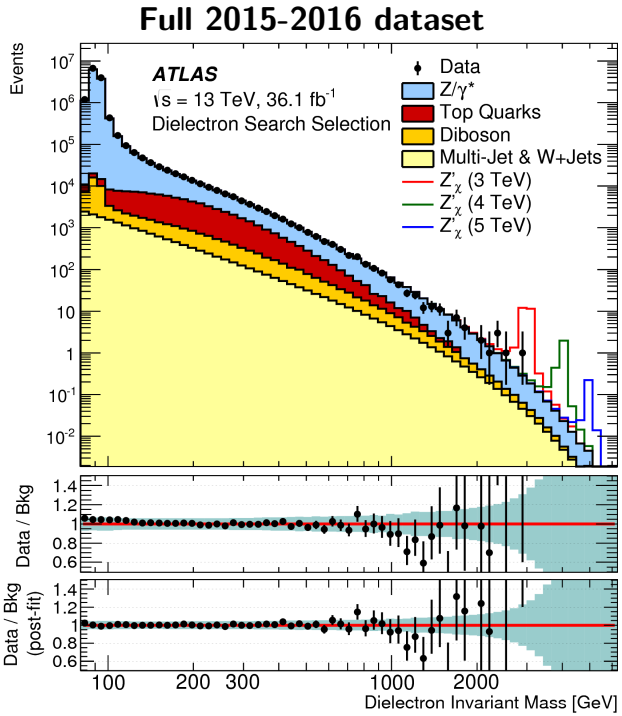
Full 2015-2017 dataset

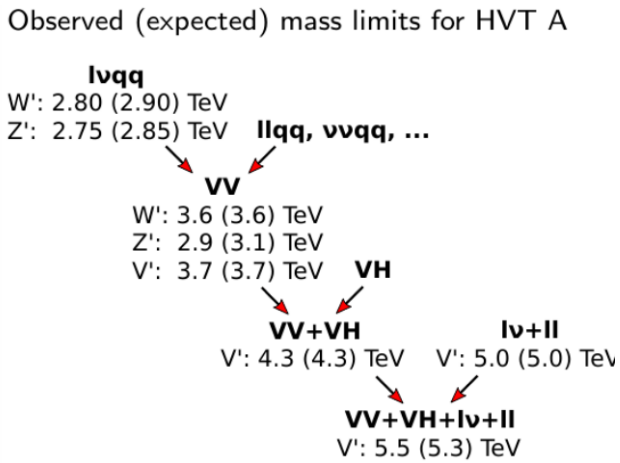


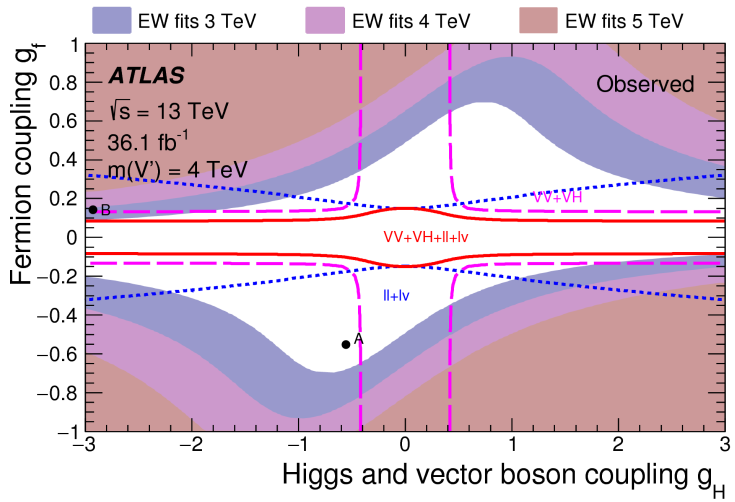


Searches beyond SM

- Leading role of LAPP in $Z' \to \ell\ell$ searches
- This result is used in the first ever combined search in VV, VH, $\ell\nu$ and $\ell\ell$ channels
- Constraints on new heavy W/Z bosons (based on Heavy Vector Triplet (HVT) model)
- No significant deviation from the SM predictions.
- Constraints obtained by the combination are improved significantly over individual channels.







Summary

- Significant contribution of LAPP and LPSC groups to e/γ performance
- Involvement in a wide range of ATLAS physics analyses
  - Standard Model (EW, Higgs, top) measurements
  - Beyond the SM searches