Measurements of inclusive four-lepton production at ATLAS

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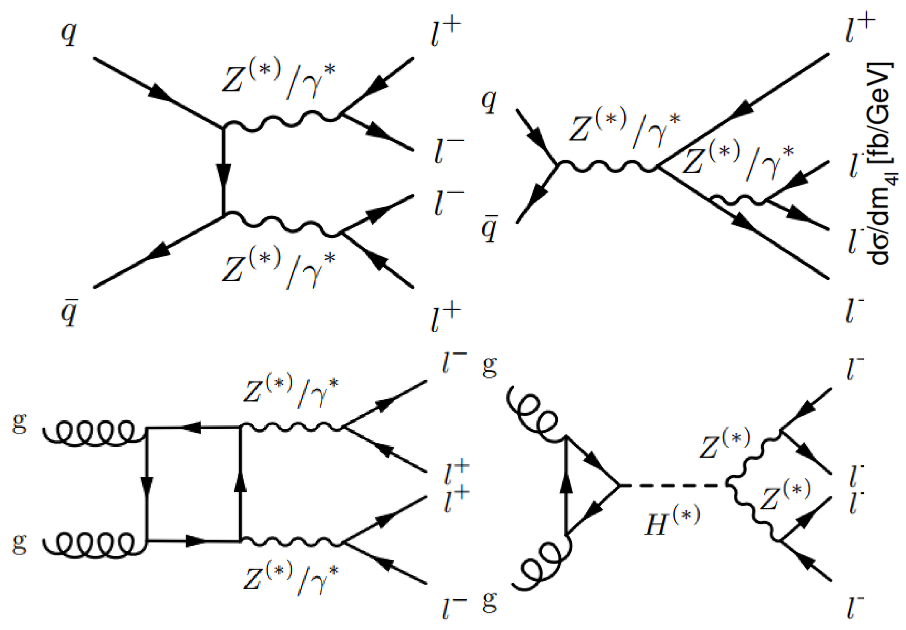
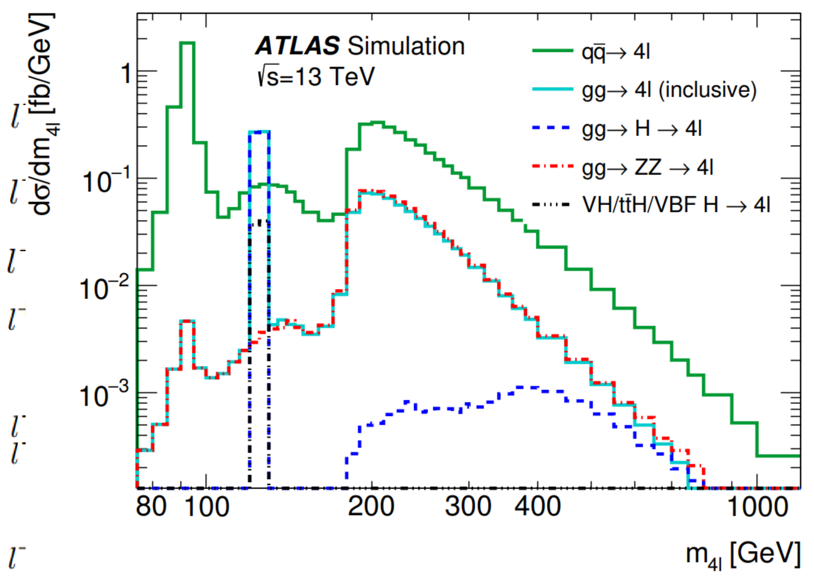
Motivation and Introduction

Motivation
- four-lepton(two same-flavor, opposite-sign lepton pairs, e or μ) final state is “clean” and has rich physics
- allow precision test on the SM (e.g. Higgs)
- sensitive to BSM



[1]



Fiducial definition
- no Z mass constraint in this analysis

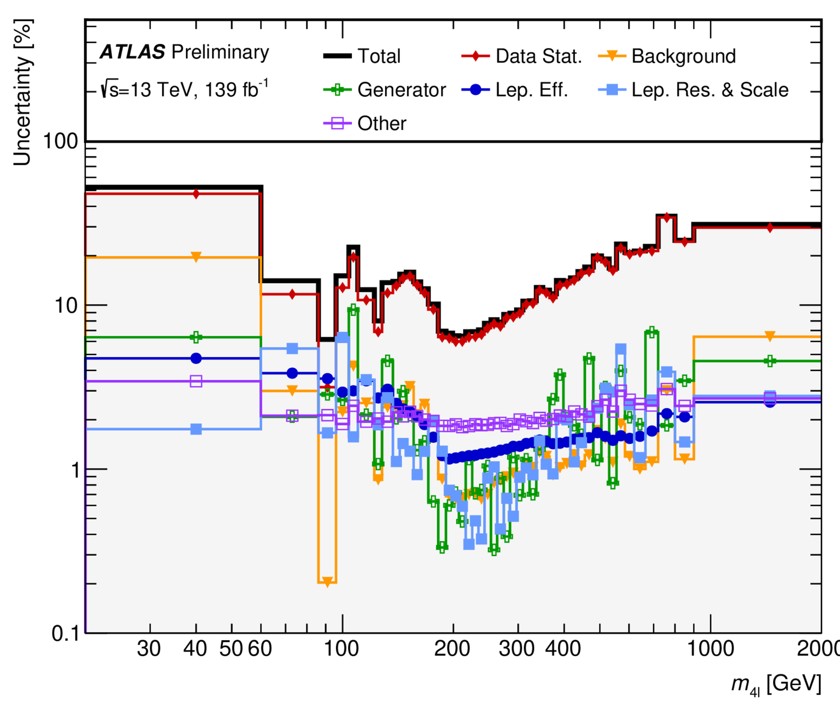
Lepton selection	
Muon selection	Bare, $p_T > 5$ GeV, $\lvert\eta\rvert < 2.7$
Electron selection	Dressed, $p_T > 7$ GeV, $\lvert\eta\rvert < 2.47$
Event selection	
Four-lepton signature	At least 4 leptons, with 2 Same-Flavour, Opposite-Sign pairs
Lepton kinematics	$p_T > 20/10$ GeV for leading two leptons
Lepton separation	$\Delta R_{ij} > 0.05$ for any leptons
J/ψ-Veto	$m_{ij} > 5$ GeVfor all SFOS pairs
Truth isolation	ptcone30/p_T < 0.16

Measured variables
- totally 10 variables measured in form of differential or double differential cross-sections
- invariant 4l mass (m_{4l}), invariant lepton-pair mass ($m_{12(34)}$), angular variable sensitive to polarization ($cos\theta^*_{12(34)}$[2]) etc.

Techniques
- unfolding method used to obtain particle-level data distributions
- binning determination considering the unfolding purity [3] as well as reconstruction-level statistics in each bin

Background and Uncertainties

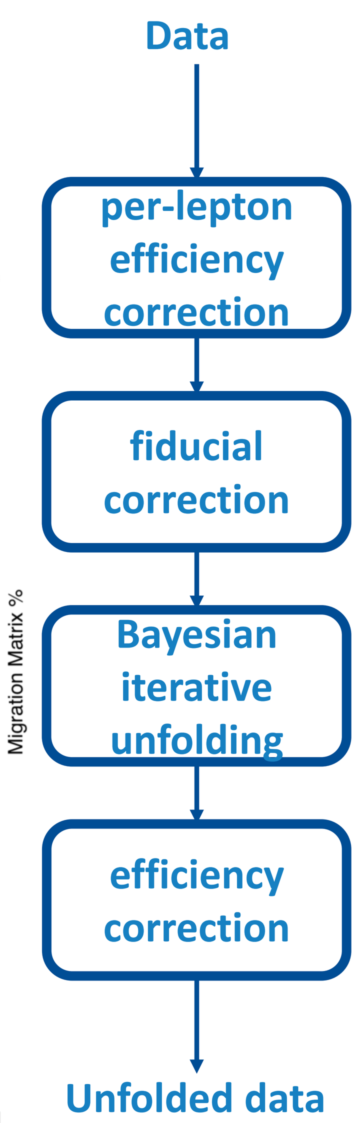
Background
- Non-prompt background:
  - estimate in data
  - amounts to 4.4%, inclusive m4l
  - largest background in off-shell ZZ region

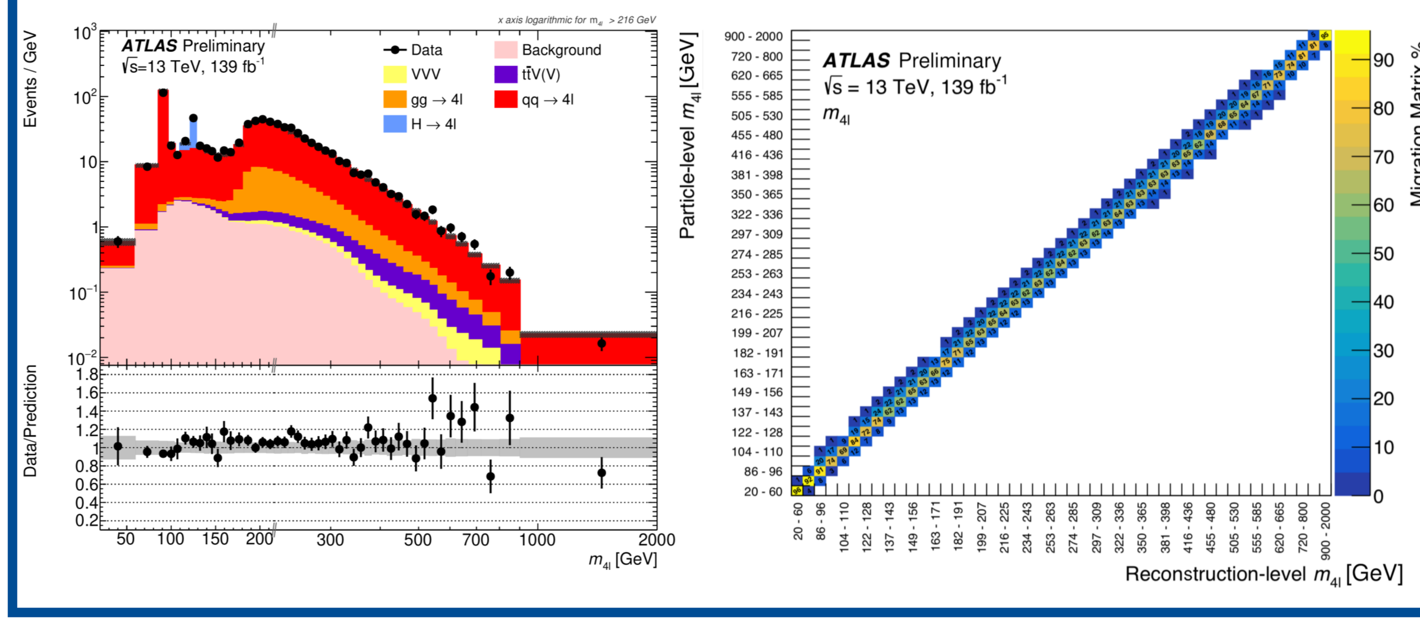


Uncertainties
- data statistical uncertainty dominant for most of the bins
- main systematic uncertainties:
  - 1.7% luminosity, inclusive m4l
  - 1.3% generator, inclusive m4l
- largest systematic uncertainty for very low and high m4l

Detector Correction

- detector effects: resolution of kinematic variables, inefficiency of reconstructing leptons and triggering of events
- corrections for inefficiencies and resolution effects at the fiducial phase space boundary
- Bayesian iterative unfolding to account for migrations within the fiducial phase space



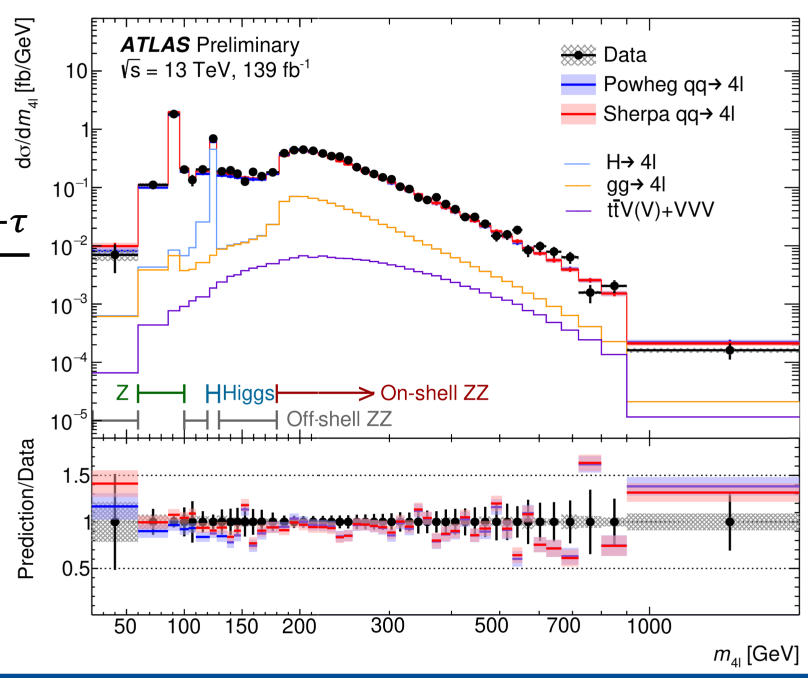


Measurement Results

Cross-sections
- fiducial cross-section inclusively and in slices of m_{4l}
- differential cross-section in m_{4l}
- the measurements extended the fiducial phase space and increased granularity compared to previous results[1]

	Region				
	Full	$Z \to 4\ell$	$H \to 4\ell$	Off-shell ZZ	On-shell ZZ
Measured fiducial cross-section [fb]	88.9 ±1.1 (stat.) ±2.3 (syst.) ±1.5 (lumi.) ±3.0 (total)	22.1 ±0.7 (stat.) ±1.1 (syst.) ±0.4 (lumi.) ±1.3 (total)	4.76 ±0.29 (stat.) ±0.18 (syst.) ±0.08 (lumi.) ±0.35 (total)	12.4 ±0.5 (stat.) ±0.6 (syst.) ±0.2 (lumi.) ±0.8 (total)	49.3 ±0.8 (stat.) ±0.8 (syst.) ±0.8 (lumi.) ±1.3 (total)
Sherpa	86±5	23.6±1.5	4.57±0.21	11.5±0.7	46.0±2.9
Powheg + Pythia8	83±5	21.2±1.3	4.38±0.20	10.7±0.7	46.4±3.0

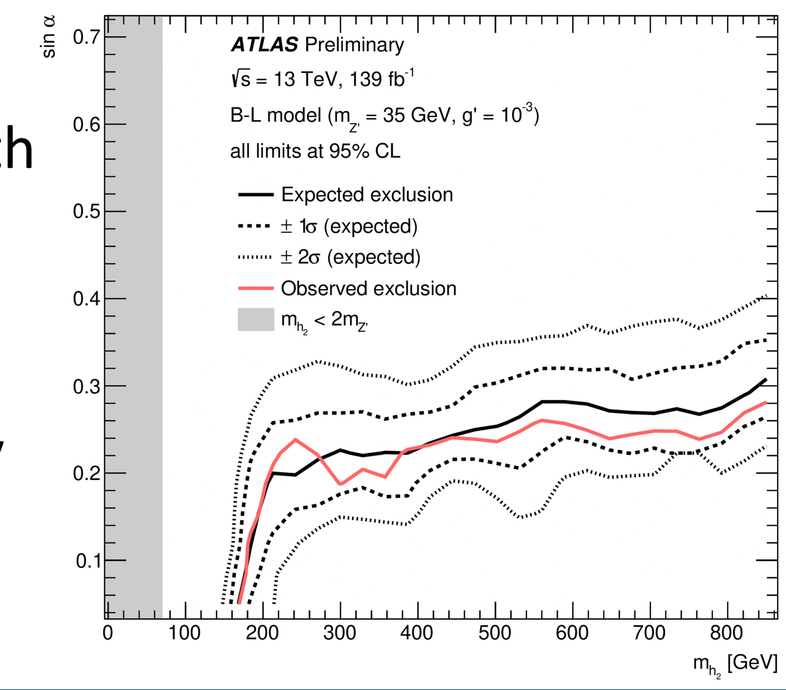
$Z \to 4l$ Branching ratio
- $\mathcal{B}_{Z\to 4l} = \frac{\left(\sigma^{\text{meas}} - \sigma^{\text{pred}}_{\text{non}-q\bar{q}\to 4l}\right)\times f_Z \times f_{non-\tau}}{\sigma_Z \times A_{\text{fid}}} = (4.41 \pm 0.30) \times 10^{-6}$
- most precise result and compatible with previous study[1]



BSM Interpretation

- using measured differential cross-sections to constrain BSM model, with all information needed in the HEPData

B-L Model
- $U(1)_{B-L}$ gauge symmetry broken introduced to solve neutrino mass problem
- multi-Gaussian based statistical likelihood function
- exclusion on m_{h_2}~sinα parameter-space @ 95% CL with fixed (mZ’ = 35GeV, g’ = 10^{-3})
- using the double differential distributions yields significantly stronger limits than the m4l distribution alone



CONF note: ATLAS-CONF-2020-042

[1] previous m4l analysis with ATLAS 2015-16 data: https://doi.org/10.1007/JHEP04(2019)048
[2] the angle between the negative lepton in the di-lepton rest frame and the di-lepton pair system in the laboratory frame
[3] purity here defined as the fraction of events in a reconstruction-level bin that originate from the same bin at particle-level

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