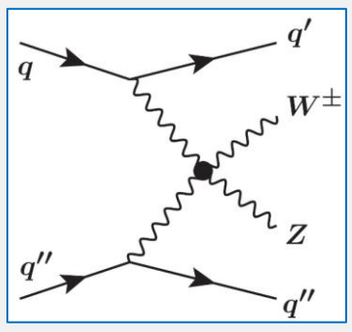
Event and object selection optimization for the measurement of vector boson scattering in WZ+2jets events with ATLAS Run3 data

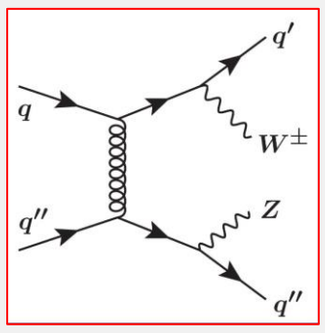
Motivation

Vector Boson Scattering (VBS) is an important test:
- ★ couplings (gauge / between Higgs and bosons)
- ★ probe the electroweak symmetry breaking mechanism

Our goal is to **measure the boson polarisaion in VBS events**
→ Maximize the sensitivity of the analysis towards the VBS signal

VBS signal WZjj-EW ($O(\alpha_{EW})=6$, $O(\alpha_s)=0$) ("WZjj-EW")





Dominant background WZjj-QCD ($O(\alpha_{EW})=4$) ("WZjj-QCD")

The data we will be using : Run-2(2015-2018)
and Run-3 ATLAS data(2022-2024)

Selection

Signal region selection:

$N_{lep} == 3$ (e/μ)
At least one lepton pair w/ SFOC, $\lvert m(l_1,l_2) - m_Z \rvert < 10\text{GeV}$ –> Z-boson
Reconstruct W-boson using 3rd lepton (l_3)
$m_T^W > 30\text{GeV}^*$
Njets>= 2
$p_{T,jet}^{lead} > 40$ GeV ("jet1")
remaining jet with largest p_T with $\eta_{jet1} \cdot \eta_{jet2} < 0$
$m(\text{jet1},\text{jet1}) > 500\text{GeV}$
$N_{jet,b-tag} == 0$

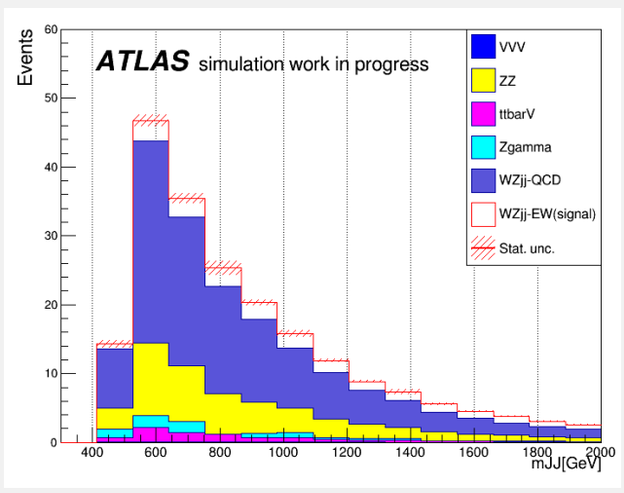
$*m_T^W = \sqrt{2 \cdot p_T^\nu \cdot p_T^l \cdot [1 - \cos\Delta\phi(l,\nu)]}$

Run-3 simulation

Run-3 simulated data in the signal region

(note: ttbar,Z+jets,tZ still missing, expected signal region contribution ~10%)

Main background processes from WZjj-QCD, ZZ, ttV

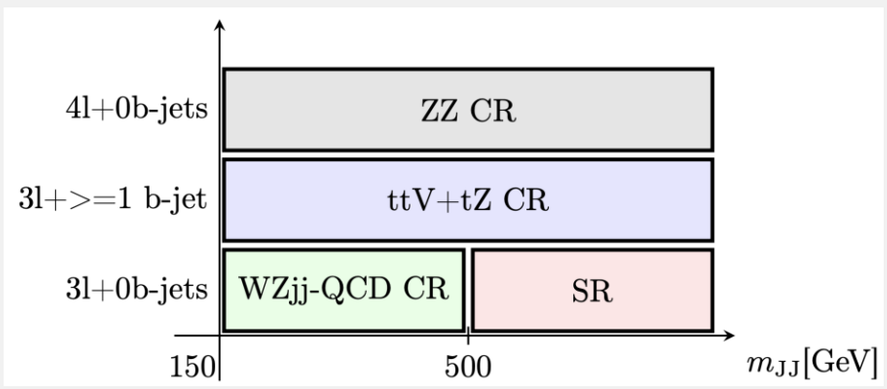


We need to know how well simulations model the data, derive corrections if necessary

Background modeling

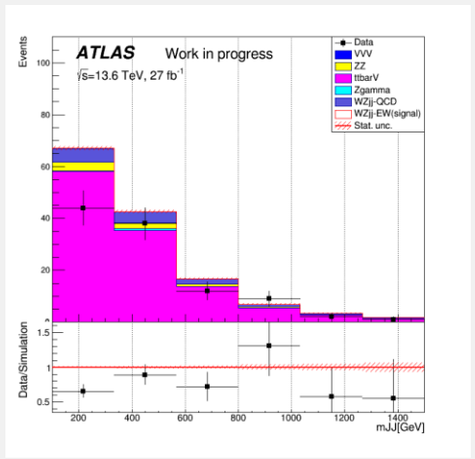
Define **control regions** enriched with dominant background processes to check the modeling of the backgrounds.

Larger confidence on background modeling
⇨ smaller uncertainties on the background estimation!

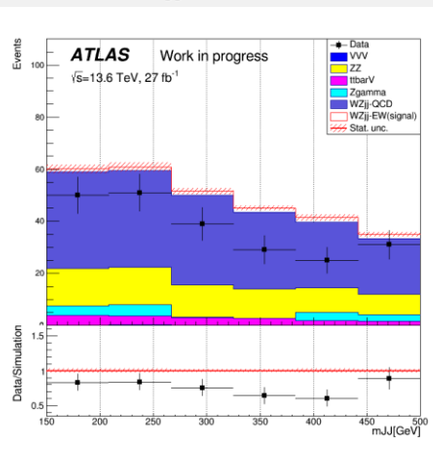


We are looking only at 2022 data here.

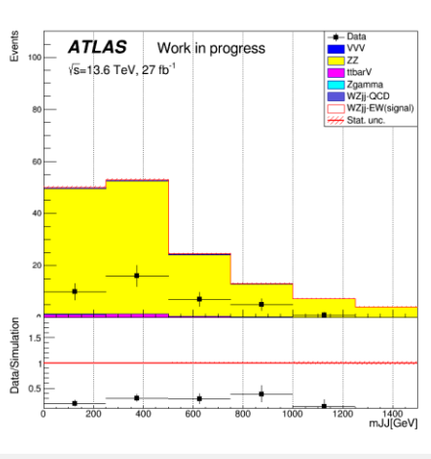
b-jet CR



WZjj-QCD CR



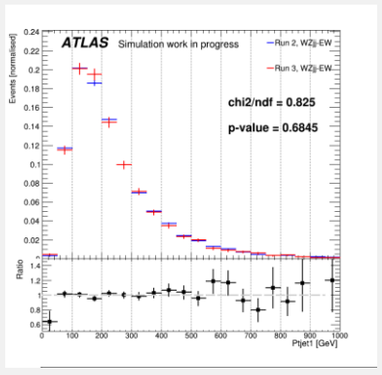
ZZ CR

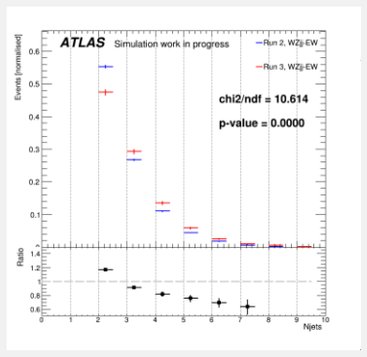


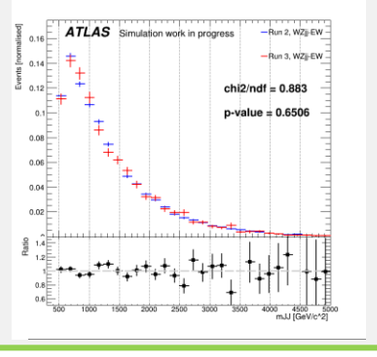
Mismodeling observed, dedicated corrections driven by data-simulation agreement in the control regions will be derived, ZZ simulation normalisation under investigation.

Compare WZjj-EW signal modeling Run-2 vs. Run-3

Run-2 : Sherpa 2.2.12
Run-3 : Sherpa 2.2.14
Different version of simulation, different center-of-mass energy between Run-2 and Run-3





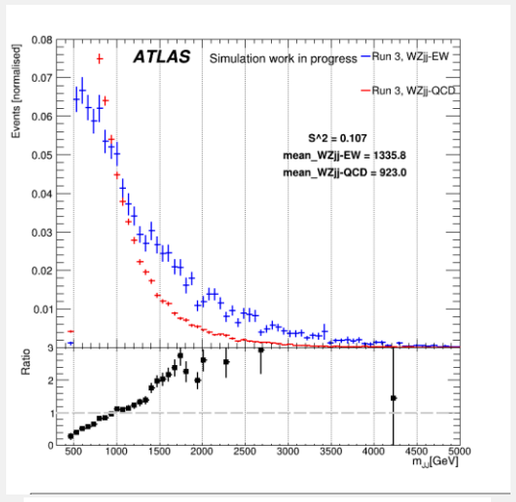


Generally, good agreement, but not in variables related to jet multiplicity (under investigation)

Discriminate WZjj-EW from background

WZjj-EW rare process and difficult to distinguish from background
⇨ find variables which discriminate best the WZjj-EW signal from the dominant WZjj-QCD background to define bins with larger signal-to-background ratio

- use Deep Neural Networks to define good discriminator
- Another way to increase sensitivity: reduce background contamination in signal region by optimising selection



$$\langle S^2 \rangle = \frac{1}{2} \int \frac{(y_S(y) - y_B(y))^2}{y_S(y) + y_B(y)} dy$$

Summary

- ☑ check the current modelings
- ☑ investigate difference in jet multiplicity between Run-2 and Run-3 WZjj-EW simulation
- ☑ find discriminating variables

Next Step:
- ☐ optimize the selection to reduce bkgs
- ☐ correct the modeling

⇨ using significance estimators like $S/\sqrt{(S+B)}$
→ confidence in bkg modeling reduces uncertainties and reduced bkg contamination reduces the bkg uncertainty impact!

Risako TAGAMI (CERN Summer Student, UTokyo)
Supervisor : Angela Burger, Valentina Cairo

ATLAS EXPERIMENT