Measurement of differential cross-sections in the $H \to ZZ^* \to 4\ell$ decay channel with the ATLAS Run 3 data

Elena Cuppini

Max Planck Institute for Physics

The Higgs boson, ever since its discovery in 2012 by the ATLAS and CMS experiments, has remained a central object of study for testing the Standard Model (SM). Precision measurements of Higgs boson properties are key to probing electroweak symmetry breaking and investigating potential new physics. Among Higgs decay modes, the $H \to ZZ^* \to 4\ell$ channel is particularly powerful due to its excellent mass resolution, low background contamination, and clean final state of four light leptons.

Run 3 of the LHC, operating at a centre-of-mass energy of 13.6 TeV, provides new opportunities to study the production of Higgs bosons. ATLAS uses the four-lepton invariant mass spectrum to extract inclusive and differential cross-sections, while carefully constraining irreducible (ZZ^*) and reducible (Z+jets, $t\bar{t}$) backgrounds with a mixture of simulation and data-driven methods. A fiducial phase space is defined to minimise theoretical extrapolations, and unfolding procedures are applied to correct for detector effects. This allows differential measurements in variables such as the Higgs transverse momentum (see Abbildung 1), jet multiplicity, and four-lepton rapidity [1].

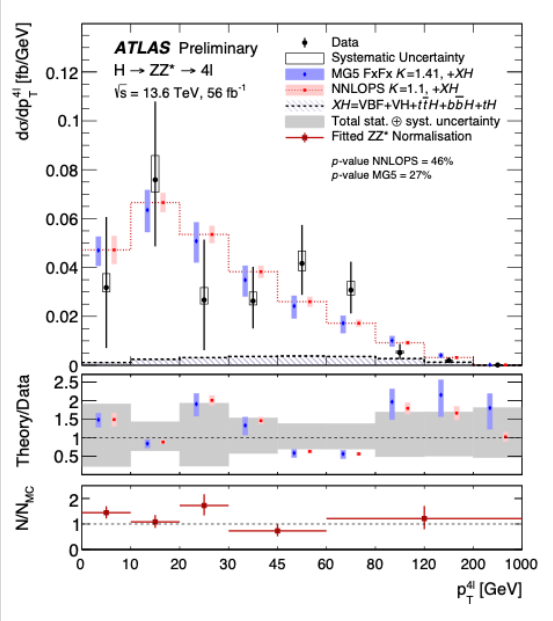

Abbildung 1: Differential fiducial cross-sections as a function of the Higgs boson transverse momentum [1].

Early Run 3 measurements confirm the robustness of the $H \to ZZ^* \to 4\ell$ channel as a precision probe of Higgs production. Beyond this, the analysis will be extended to include the entire Run 3 (2022–2026), with an expected integrated luminosity of about 300 fb^{-1}. With this sizeable dataset, ATLAS will be able to perform comprehensive measurements of all relevant physics quantities, comparable in scope to the Run 2 programme [2] but with higher precision. My immediate priority is to finalise a paper based on the 2022–2024 dataset. Afterwards, I plan to contribute further by developing and applying new unfolding techniques to improve the robustness of differential measurements, working on effective field theory (EFT) interpretations of the results, and expanding the set of observables sensitive to both production dynamics and possible new physics.

The $H \to ZZ^* \to 4\ell$ channel therefore continues to provide one of the most powerful windows into Higgs boson properties at the LHC. Run 3 measurements lay the foundation for upcoming precision studies, and the transition to the full dataset together with EFT frameworks will be essential steps toward a comprehensive characterisation of the Higgs sector.

Literatur

[1] ATLAS Collaboration, *Measurements and interpretation of the Higgs boson differential and production mode cross sections in the H→ZZ* → 4ℓ channel at $\sqrt{s}$ = 13.6 TeV with the ATLAS detector*, `http://cds.cern.ch/record/2929042`.

[2] ATLAS Collaboration, *Measurements of the Higgs boson inclusive and differential fiducial cross sections in the 4ℓ decay channel at $\sqrt{s}$ = 13 TeV* , `https://arxiv.org/abs/2004.03969`