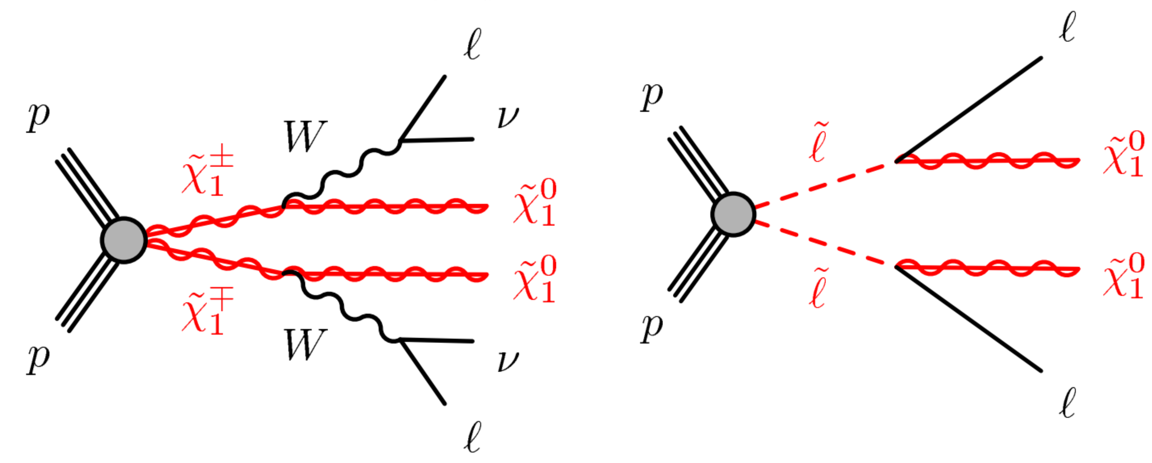
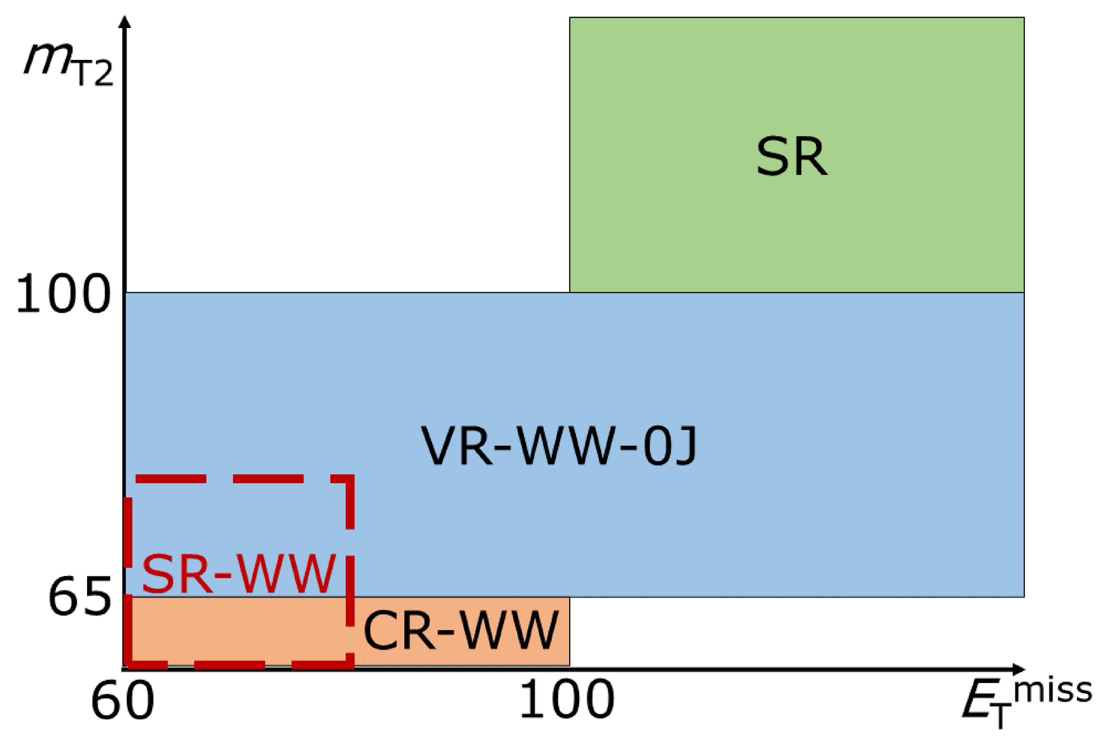
Sebastian Rutherford, Sarah Williams, April 2022

SUSY-Inspired Unfolded W^+W^- Measurement

Motivation

0-jet signal regions in the EWK 2l+0-jets search [1] are dominated by WW normalisation and diboson theory uncertainties. Unfolding a detector-level measurement has the potential to help improve the modelling and reduce theory uncertainties in further searches. Additionally, it may be possible to put further constraints on BSM physics.



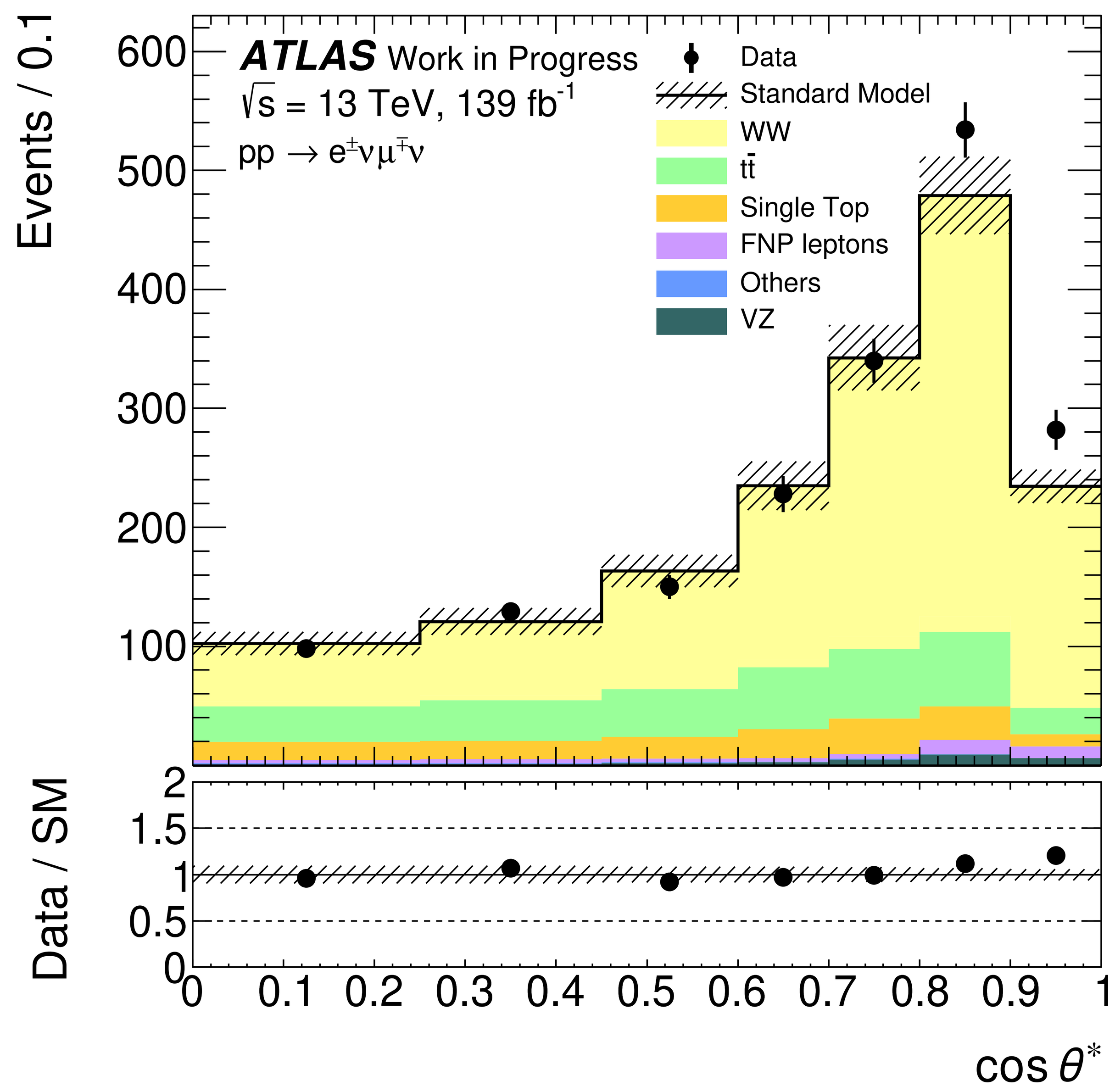


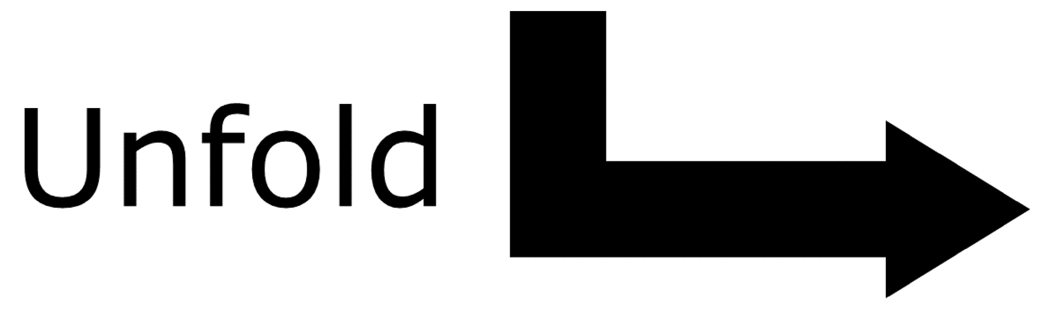
▲ Figure 1: 2D representation of phase space. Signal region for unfolding (SR-WW) is shown compared to regions used in search.
◀ Figure 2: Diagrams of two supersymmetric models considered in search [1]

Signal Region

The signal region is chosen to be similar to the WW control region (CR-WW) of the EWK 2l+0-jets search.

The E_T^{miss} significance cut is removed to simplify the definition of the fiducial region at particle-level. The m_{T2} range is increased to widen the phase space in which to measure angular distributions, since m_{T2} is sensitive to the angular separation of the lepton pair, but the E_T^{miss} cut is tightened to improve WW purity, and reduce top contamination.



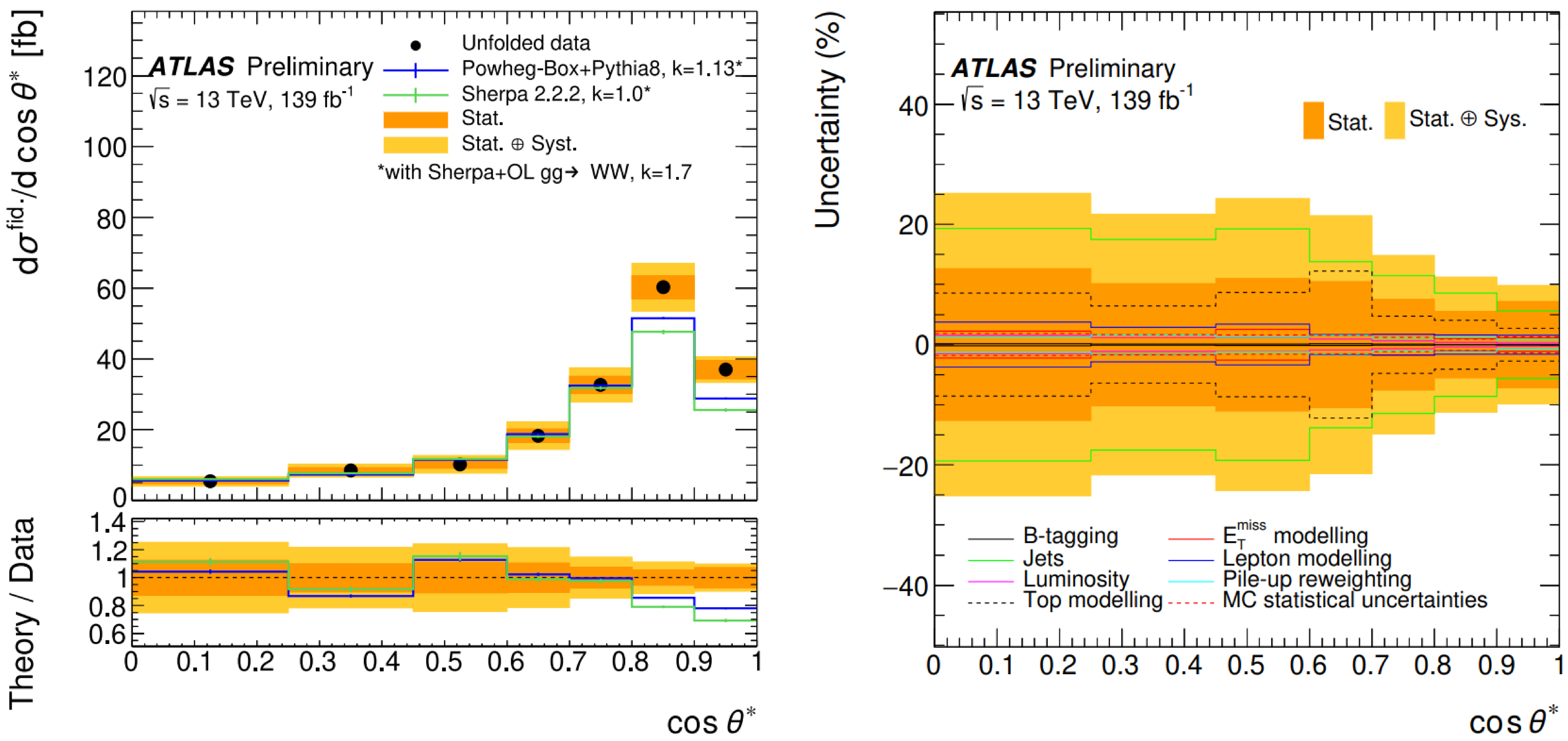


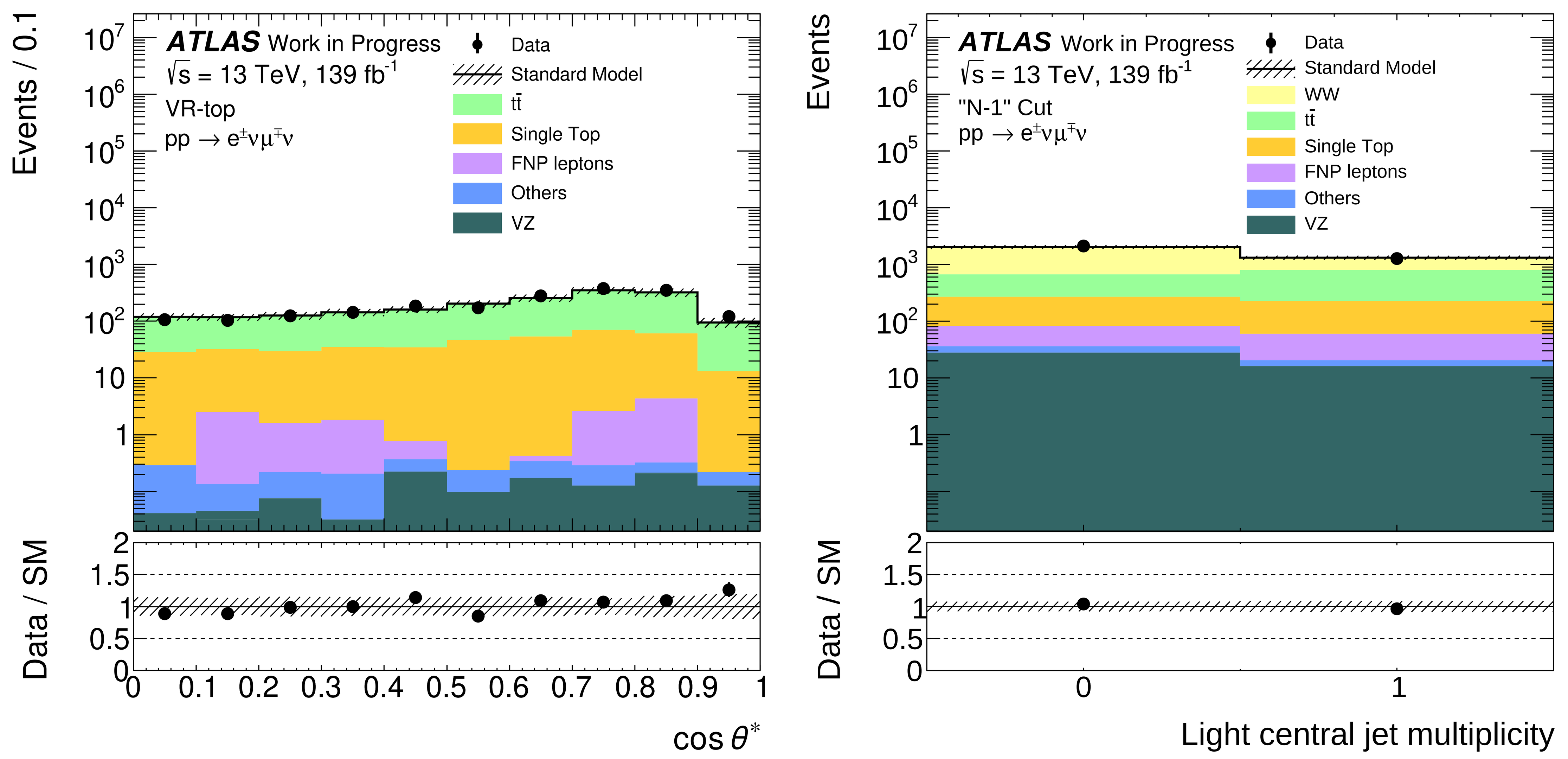
Unfolding

Detector-level distributions of six kinematic variables are input into an unfolding calculation to obtain particle-level differential distributions.

The process of Iterative Bayesian Unfolding (IBU) is employed, to better handle bin migration of events. The bins chosen for the differential measurements were optimised to reduce the migration of events between particle-level and detector-level bins, whilst achieving a desired statistical uncertainty.

◀ Figure 3: Signal-region detector-level distribution of $\cos\theta^*$
▼ Figure 4: Measured fiducial differential cross-section of WW production for $\cos\theta^*$ and contributions to the uncertainties [2]



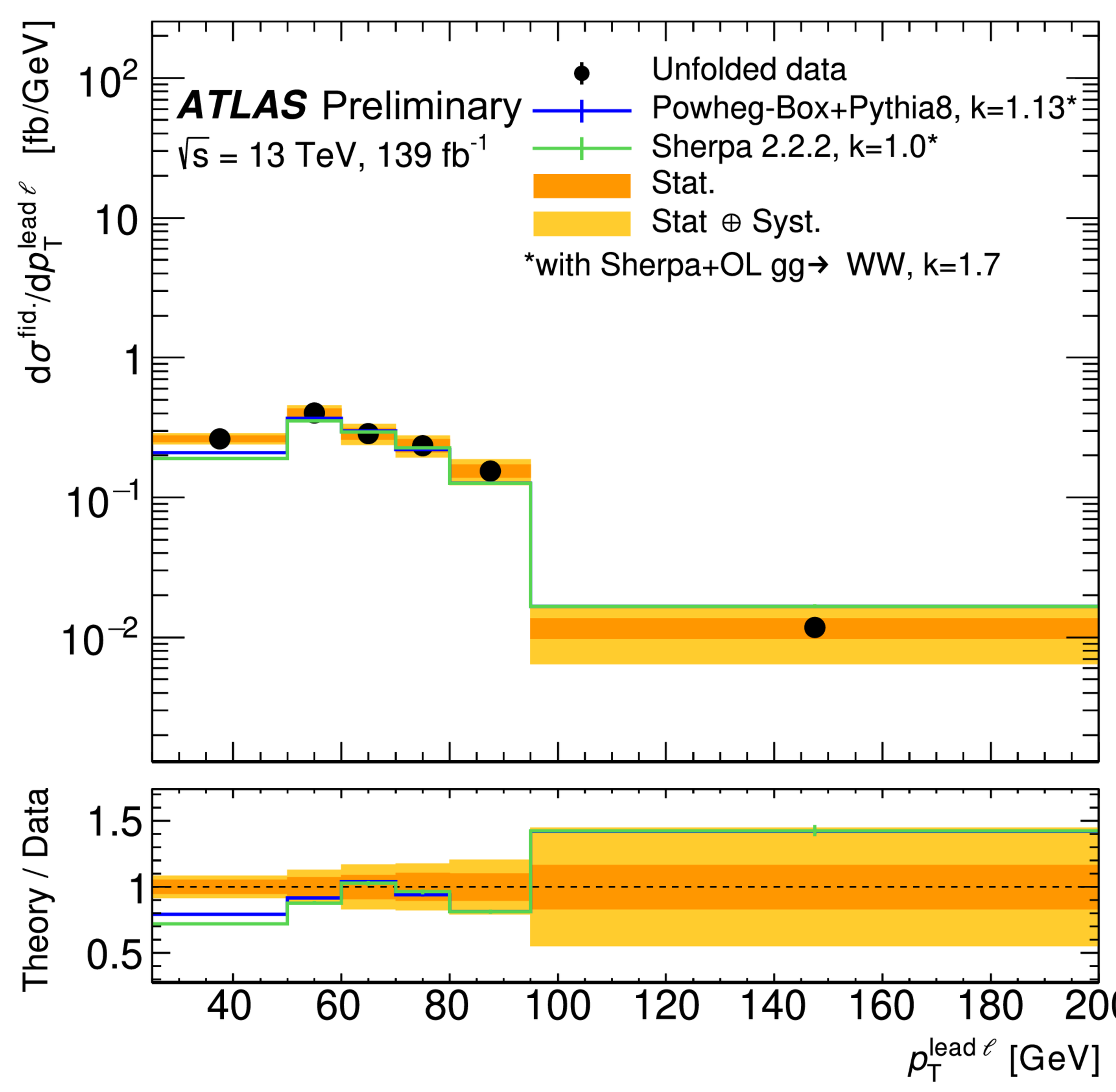


▲ Figure 5: Detector-level distribution of $\cos\theta^*$ in top validation region and jet multiplicity without the non-b-jet veto.
► Figure 6: Measured fiducial differential cross-section of WW production for leading lepton p_T [2].

Background Modelling studies

A top validation region was considered with an additional requirement of one b-tagged jet, where good agreement was observed between the observed and MC events, within uncertainties.

Additional insights into top related backgrounds were gained by dropping one of the cuts and looking at the jet multiplicity of non-b-tagged jets. The b-jet veto is still applied, but the non-b-jet veto is removed.



Results and Conclusion

The measured fiducial cross-section for WW production for this phase space is:

$$\sigma_{WW\to e^{\pm}\nu\mu^{\mp}\nu} = 19.2 \pm 2.6\,\mathrm{fb}$$

The strongest chi-squared disagreement for a comparison of unfolded distributions with different theory predictions was found for the $q\bar{q} \to WW$ (Sherpa 2.2.2) + $gg \to WW$ (Sherpa 2.2.2+OL) prediction and the leading lepton p_T distribution, shown in Figure 6.

The study validated the SM in a new, SUSY-motivated region, complimenting existing results [3]. The benchmark measurements can help improve future SM predictions and constrain BSM models.

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ATLAS EXPERIMENT

[1] ATLAS Collaboration, Search for electroweak production of charginos and sleptons decaying into final states with two leptons and missing transverse momentum in $\sqrt{s} = 13$ TeV pp collisions using the ATLAS detector, *Eur.Phys.J.C* 80 (2020) 2, 123

[2] ATLAS Collaboration, Fiducial and differential measurements of W^+W^- production in decay topologies inspired by searches for electroweak supersymmetry in two-lepton final states, ATLAS-CONF-2022-011

[3] ATLAS Collaboration, Measurement of fiducial and differential W^+W^- production cross-sections at $\sqrt{s} = 13$ TeV with the ATLAS detector, *Eur.Phys.J.C* 79 (2019) 10, 884