

# EW uncertainties

Notes from a discussion with  
Doreen Wackerroth, David Kosower,  
Stefan Prestel, and Dieter Zeppenfeld

# The issue: EW backgrounds to mono-X analyses

Main background to mono-jet-like searches is Z+jets

Normalization estimated via W+jet and photon+jet CRs to complement poorer statistics for Z+jet CR

Relies on the ratio V/Z as a function of pT

Limiting factor: theory systematic uncertainties, especially for medium-high MET region where statistics is not an issue (e.g. invisible Higgs signals)

EW corrections are order 10–20%

Expect maximal variations in scale uncertainties  $\mathcal{O}$  7–15%

Photon/Z ratio working only at 15–20% level

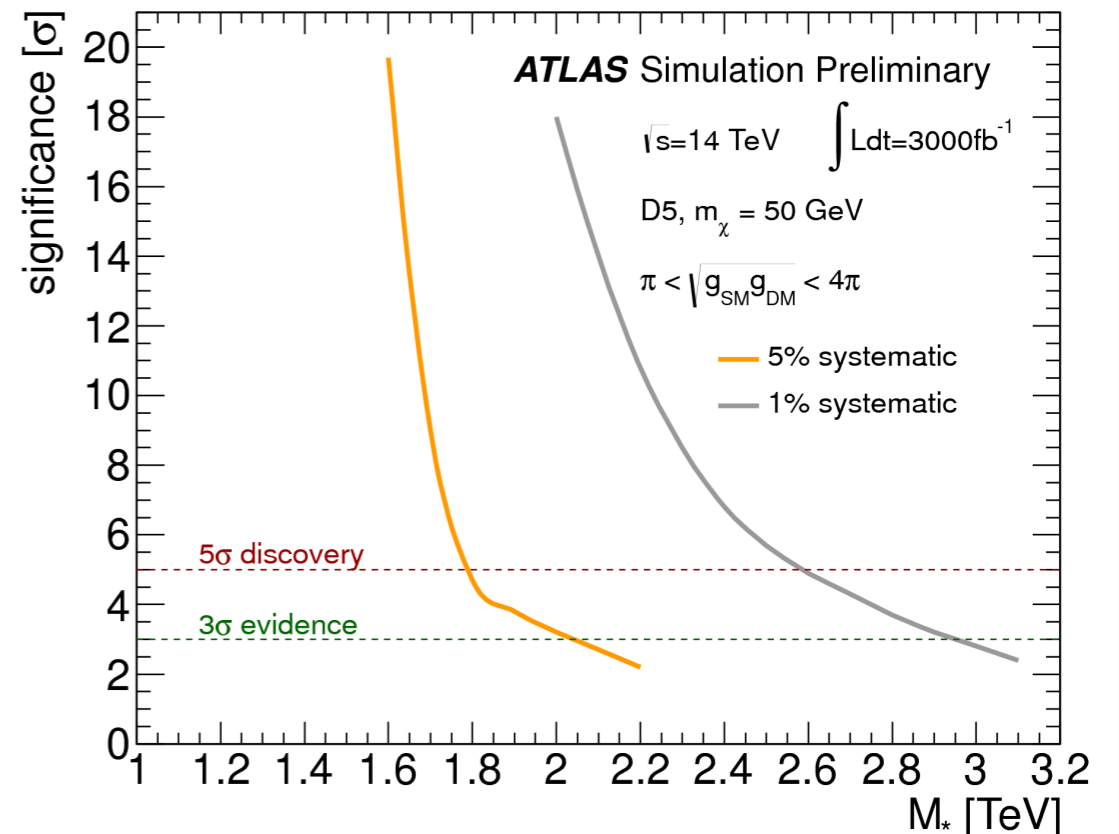
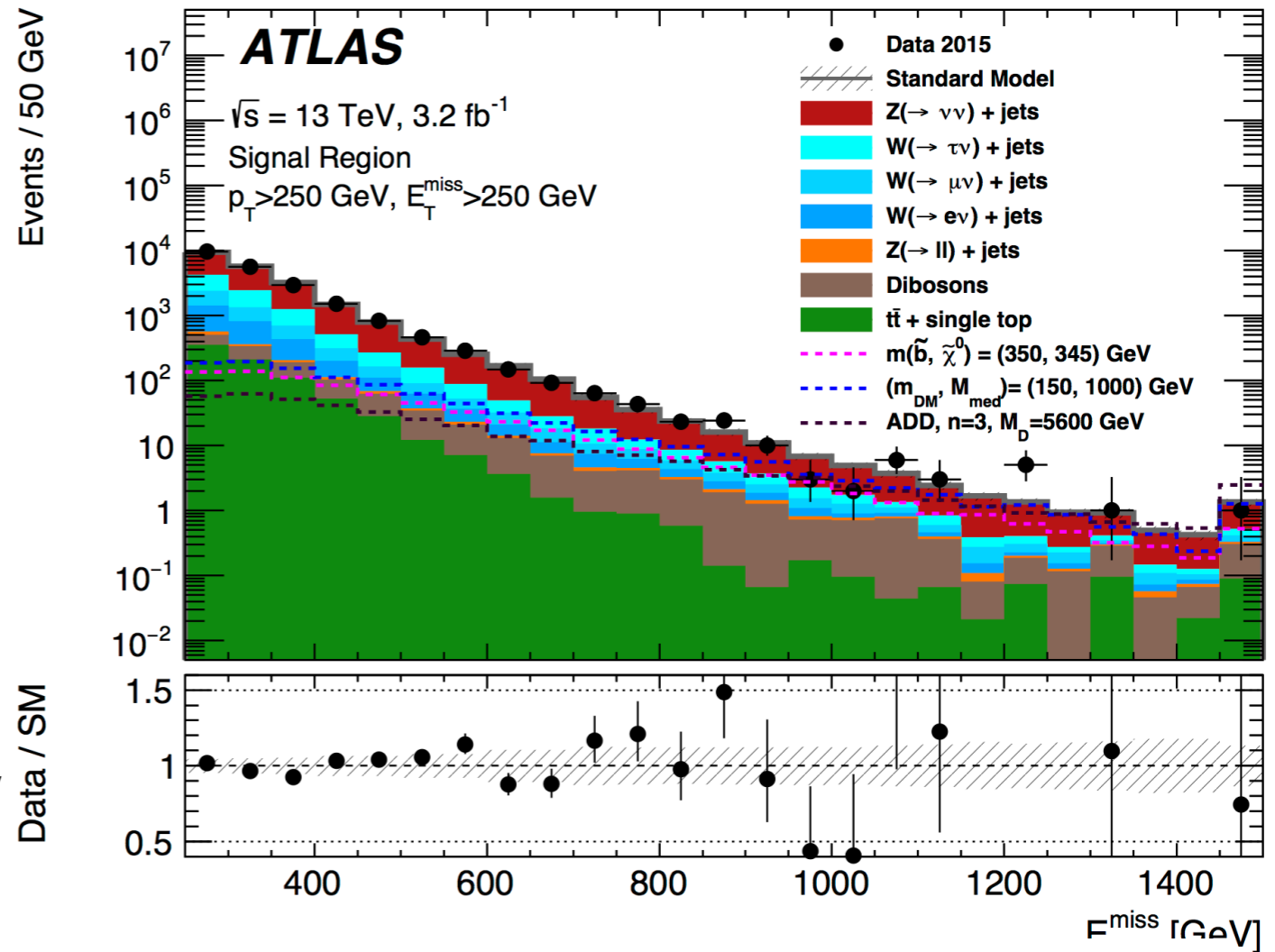
ATLAS uses parton-matched Sherpa MC ([arXiv:1604.07773](https://arxiv.org/abs/1604.07773) 13 TeV, [arXiv:1502.01518](https://arxiv.org/abs/1502.01518) 8 TeV) with electroweak corrections, and data in W and Z control regions.

Systematic uncertainties on the ratio of W/Z derived with commonly used procedures (fixed choice of scales varied by factors of  $\frac{1}{2}$  or 2, etc.)

ATLAS and CMS quote a 2-3% total uncertainty on the  $Z \rightarrow \nu\nu$  prediction at 250 GeV in Z pT, increasing to order 20% at higher MET.

Are these uncertainties realistic?

Are there ways to do better?



# Are uncertainties realistic?

- Electroweak corrections starting from 20% and getting larger at higher boson  $p_T$  - well understood
  - Cancellations between W and Z may not happen because of EW Sudakov factors
- Choice of scale and scale uncertainties encapsulating higher order corrections are ad-hoc (as in other measurements and searches)
  - Choice of central value for renormalization and factorisation scale matters
    - Discuss with QCD theorists on case-by-case basis
    - MC generation requires special attention on dynamic vs fixed scale choice
- Should the scale variations be correlated in numerator and denominator of  $V/Z$  ratio? Maximal conservative approach increases uncertainties

# Improvements ahead

*How can the estimate be improved?*

- Better calculations are available for small numbers of additional partons ( $\leq 3$ , which fits well with the usual veto after 2-3 additional jets). Request a ratio calculation for the mono-jet signal cuts?
- The next generation of precision is at least several years away. Sub 1% precision without experimental constraints seems very difficult at present.
- One should further explore the use of photon+jets. While this provides higher statistics, it is not obvious whether additional uncertainties (such as on photon fragmentation) negate this gain. The present Z/photon predictions do not describe the data as well as hoped, only to 15–20%.
- One could also explore absolute predictions of Z+jets, normalizing the prediction in control regions (for example, away from the Jacobian peak of t-channel signals)
- Once a better picture of the true uncertainties is available, one could also explore changing the analysis selection to reduce the sensitivity to them. For example, “Z $\rightarrow$ vv with  $p_T=1$  TeV plus no more than a few jets” may sample an unusual corner of phase space.

Improving the central uncertainty on many DM searches seems a very fruitful area for collaboration between DM searches and precision QCD theorists like those present for the neighboring workshop.

Discussion in the LHC DM WG could be one way to advance this.

# How we could proceed with this topic

- For each of the sub-topics (correction/scale choices):
  - Review talks of how ATLAS/CMS analyses treat V+jets uncertainties
    - Invite experts from these analyses in the Standard Model, SUSY, Exotics groups
    - Invite precision QCD experts
- Write a DM WG recommendation together:
  - best-available guidelines for theory literature and calculations
  - generator-level studies in the phase space of the analyses
  - better QCD calculations for the analysis cuts
- Public instructions and code on how to reproduce calculations