Dear Reviewer,

there are still problems with the distributions in the plots on slides 7 and 8. Unfortunately I was not able to fix those issues by the deadline today. With your permission I would like to try and fix them until the talk. I would only be replacing those exact plots with updated versions (they would still be standalone Sherpa and Rivet and simulation only) and updating the conclusion.

If this is not acceptable please let me know and I will show the slides as they are.

I apologize for the inconvenience and thank you for your consideration!

Maren

Exploring the effects of a **boosted vector boson's polarisation** on the jet reconstructed from its **hadronic decay products**

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Collaborators: Max Lehmann, Amartya Rej, Donna Maria Mattern, Chris Delitzsch

04.04.25, DPG Spring Meeting

The V+jets Analysis

- Improves and expands upon the ATLAS Run-1 Analysis from 2014 (1407.0800)
- Production of a vector boson (W or Z) in association with additional jets
- Boosted $(= \mathrm{high}\ \mathrm{p}_t)$ bosons $\longrightarrow$ hadronic decay products are reconstructed as one "large R" jet

$\longrightarrow$ Additional aspect: polarization of the vector boson

Polarization: What and Why?

$$h = \vec{S}\,\frac{\vec{p}}{|\vec{p}|}$$

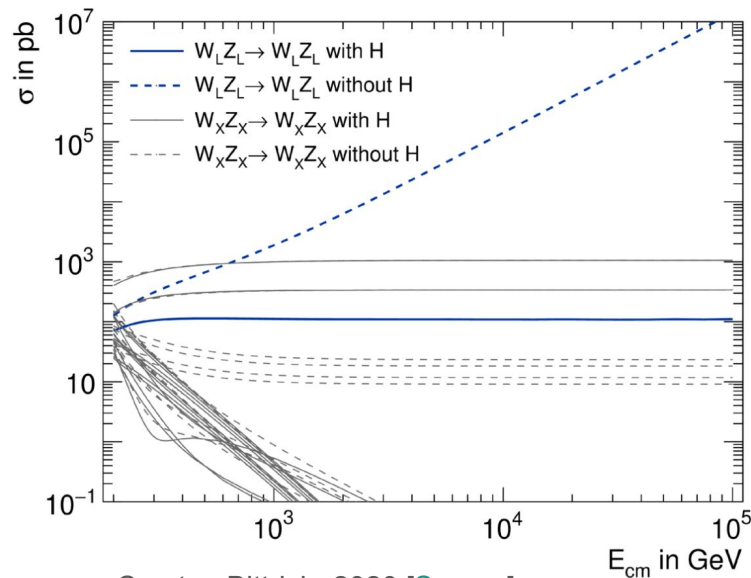$$h = -1 \qquad h = +1 \qquad h = 0$$

transversal   longitudinal

⟶ only for massive particles

Polarization of vector bosons

⇅

Higgs Mechanism

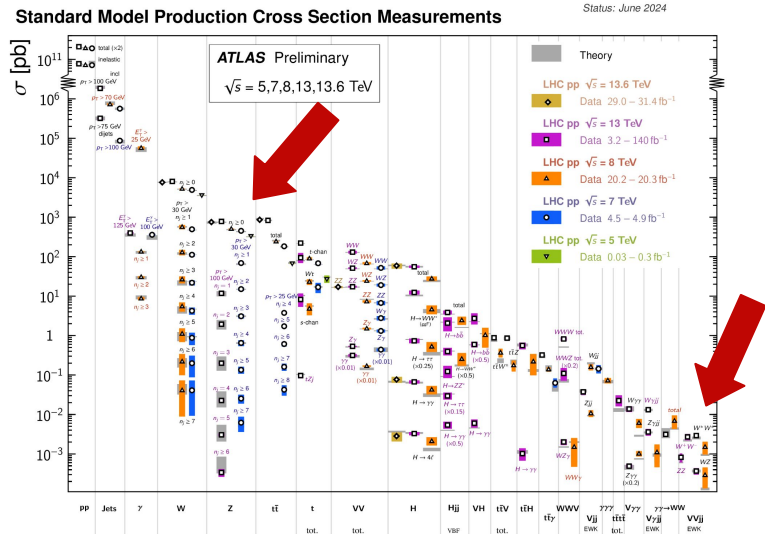Carsten Bittrich, 2020 [Source]

Why polarization in V+jets?

Advantages:

- (Comparatively) high cross section
- For W boson: no neutrino in the final state

⟶ V+jets as test bed for rarer processes?

Challenges:
- Decay products are reconstructed as jets
- Large background of QCD jets
- Taggers used to differentiate between QCD and vector boson jets are potentially biased

ATLAS summary plot, 2024 [Source]

Goal: Identify variables that differentiate QCD from vector boson jets, but do not depend on polarization

MC Study with simplified process

1. Simplify the process definition:

    $$p\ p \rightarrow W^+ j(j) \text{ with } W^+ \rightarrow qq' \text{ at Leading Order}$$

2. Create polarized events using Sherpa

    Polarised cross sections in Sherpa: 2310.14803

3. Analyse Events using Rivet
    - Identify W jet by directly accessing simulation information:
        - Retrieve intermediate vector boson from event record
        - Match one of the final state jets to that particle by minimizing ΔR
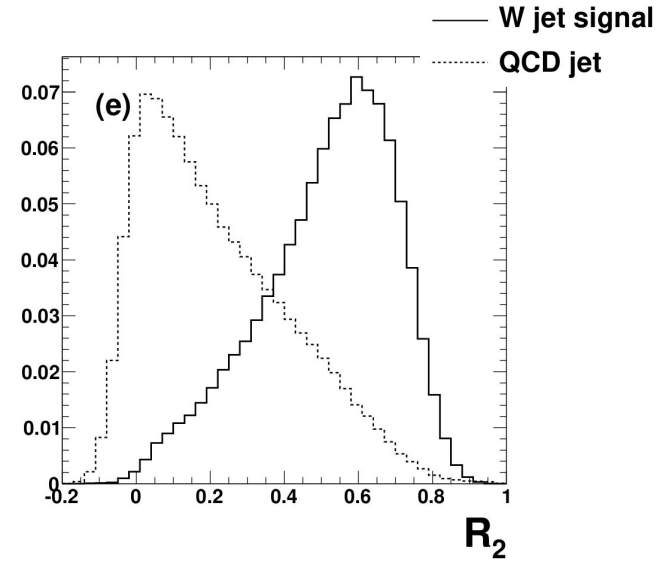
Characteristics of the W jet
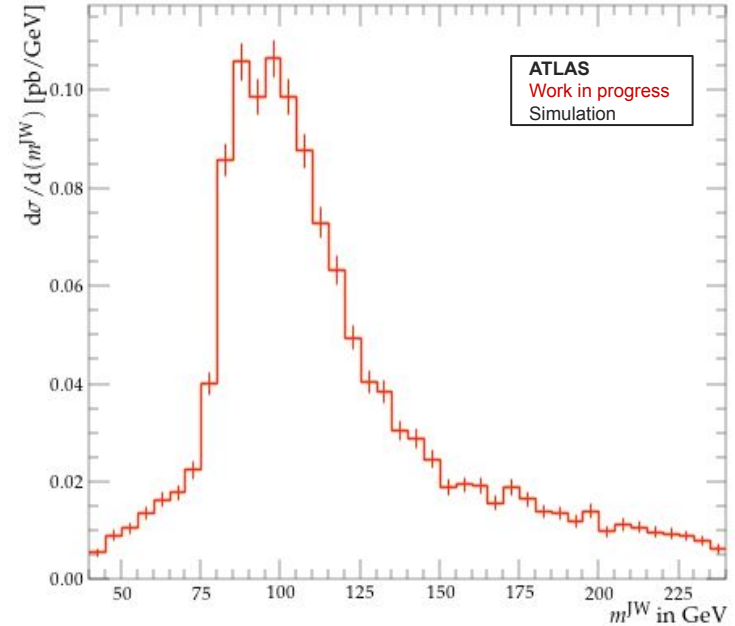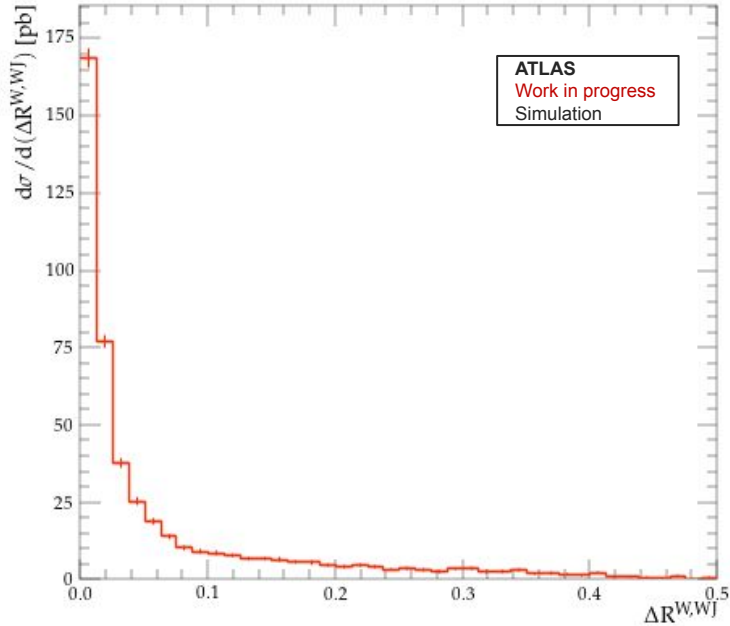
Example Variable: R_2

Idea:
- Boost to rest frame of jet
- Exploit differences in jet-substructure
- One possible Variable: Ratio of Fox-Wolfram moments H_0 and H_2
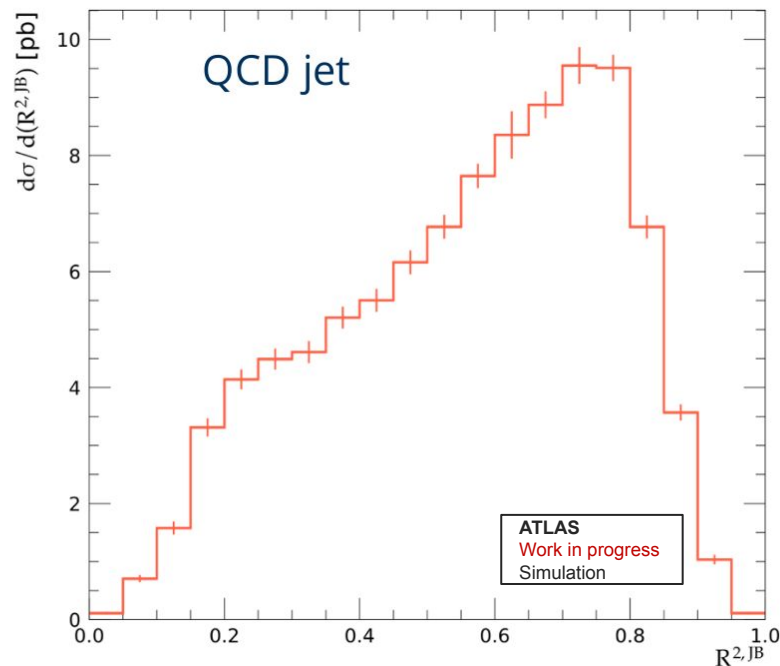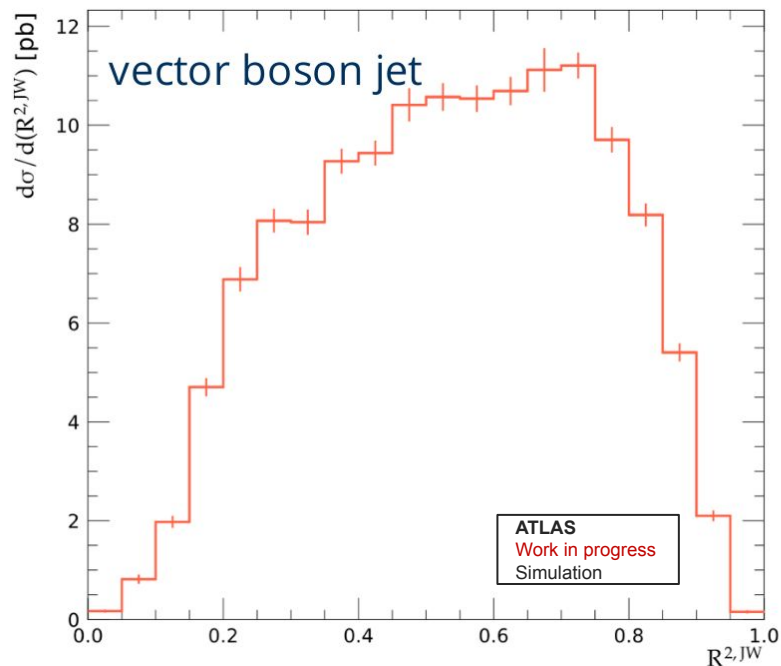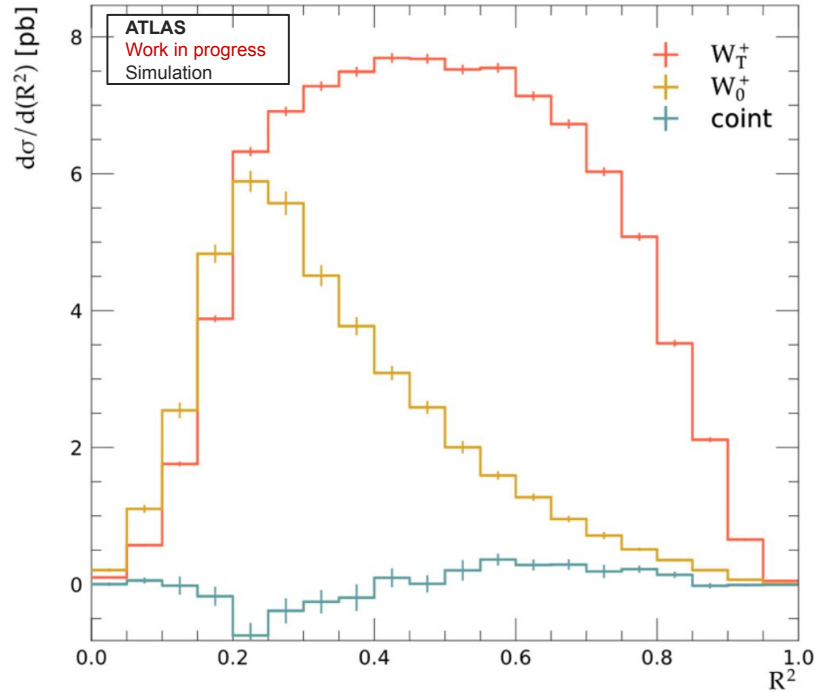

Adapted from Chunhui Chen, 2012 [Source]

$$R_2 = \frac{H_2}{H_0} = \frac{\sum_{i,j} |\vec{p_i}||\vec{p_j}| \frac{1}{2}\left(3\cos^2(\theta_{i,j}) - 1\right)}{\sum_{i,j} |\vec{p_i}||\vec{p_j}|}$$

Results: R_2 for W jets and QCD jets

Results: R_2 for different polarizations

Summary and Outlook

- Measuring the polarization of vector bosons using hadronic final states has
  - Advantages: higher cross-section
  - Challenges: background of QCD jet
- In order to tag the vector boson jets while avoiding a polarization bias, the impact of polarization on jet substructure variables needs to be understood
- First results: polarization does influence the distribution of R_2
- Next steps:
  - Why is the separation between W and QCD jets not as clear as we hoped?
  - Expand the study to other variables

Thank you for your attention!