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# Jet Substructure Correction with Lund Jet Plane Reweighting

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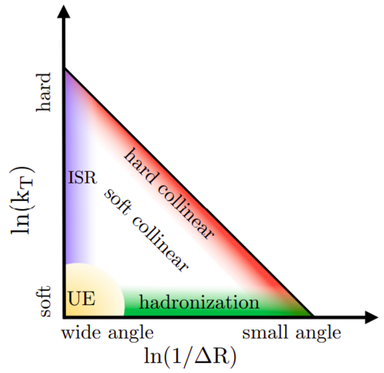
## Introduction

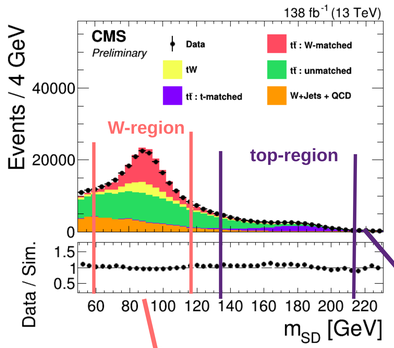
- You may want to search for (B)SM processes producing high prong (>3) jets, but there are no suitable SM proxies for calibrating jet tagging efficiency → what to do ?
- New method : a data-driven **per-prong calibration** → can scale to higher numbers of prongs!
- Derived from boosted W's (2 prongs), validate on boosted tops (3 prongs)
- Two stages to correction procedure :
  - **Recluster** jet so that each prong contained in a single subjet
  - Correct the modeling of each subjet through a data-driven correction to splittings based on the **Lund Jet Plane (LJP)**



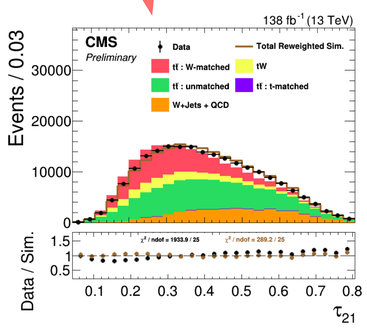

## The Lund Jet Plane

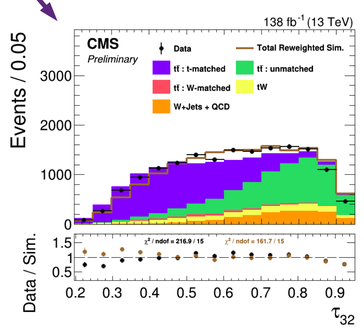
- A two dimension representation of the density of splittings inside the jet
- To construct a subjet Lund Jet Plane
  - Recluster fatjet into a desired # of subjets (= # prongs) using **exclusive kt** algorithm
  - Recluster each subjet using **Cambridge/Aachen** to get splitting history
  - Fill points based on splittings along hardest branch

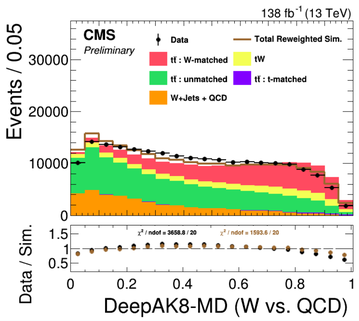
## Semi-leptonic $t\bar{t}$ Region

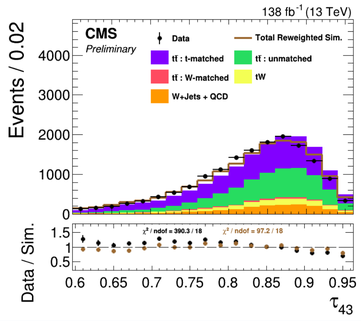



- Extract & test data-driven correction to LJP based on boosted W's from semi-leptonic $t\bar{t}$ events
- Using events from W-region, recluster into 2 subjets, construct LJP and take **data/sim. ratio**
- Test correction to sample of **boosted W jets** and **boosted top jets** → demonstrates **extrapolation** to higher number of prongs



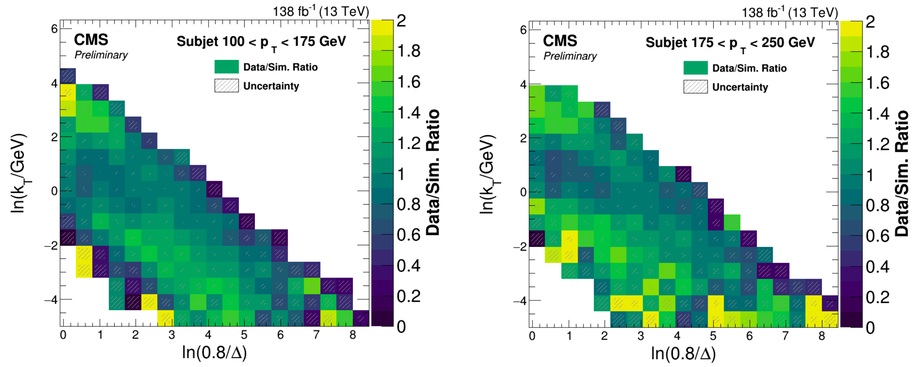




**Corrected simulation** has significantly better agreement with **data!**

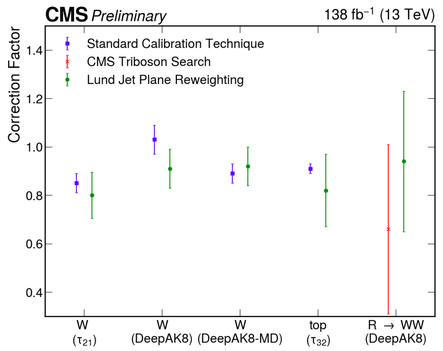
Non-perfect closure b/c bkg simulation not corrected

## Data/Sim Ratio




Ratio between data and simulated LJPs derived from sample of boosted W's, split into different bins of subjet $p_T$.
To apply the correction, jets are reclustered to obtain the per-subjet splittings, and then reweighted according to the multiplication of the data/sim ratio across all splittings in the subjet.

## Tagging Efficiency Calibration




- Compare **LJP calibrated efficiencies** to those from **standard methods** → good agreement
- Uncertainties on LJP method from stats, systematics, $p_T$ extrapolation, quark-flavor, and **subjet-quark matching**
- Matching uncertainty dominant → grows with number of prongs (up to 50% for 6-prong jets)

**This new calibration technique will enable future searches for high prong jets!**

Based on CMS DP-2023/046

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