

Efficiency of ML Anomaly Detection Triggers for Emerging Jets

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Emerging Jets (EMJs)

- Astronomical observations (e.g. galaxy rotation curves) indicate the existence of dark matter.
- Hidden Valley models propose a dark QCD-like sector that couples to the SM through a mediator particle [1]
 - EMJ: Phenomenological model where long-lived dark mesons decay into SM quarks, producing sub-jets with displaced vertices.
- A recent analysis [2] investigated pair production of scalar bi-fundamental mediators.
 - No significant deviation from the SM was observed.
- In this work we focus on the s-channel and on how novel AD triggers could help find this signal.

Anomaly Detection (AD) Triggers

- Traditional triggers are based on prior knowledge of the signal, or on kinematic cuts.
- AD ML techniques find signals which are different from typical events, independent of a model.
- AD triggers are trained on typical events, so they fail to reconstruct rare or beyond SM signals.
- Two AD Triggers:
 - **CICADA**: Convolutional Autoencoder [3]
 - **AXOL1TL**: Variational Autoencoder [4]

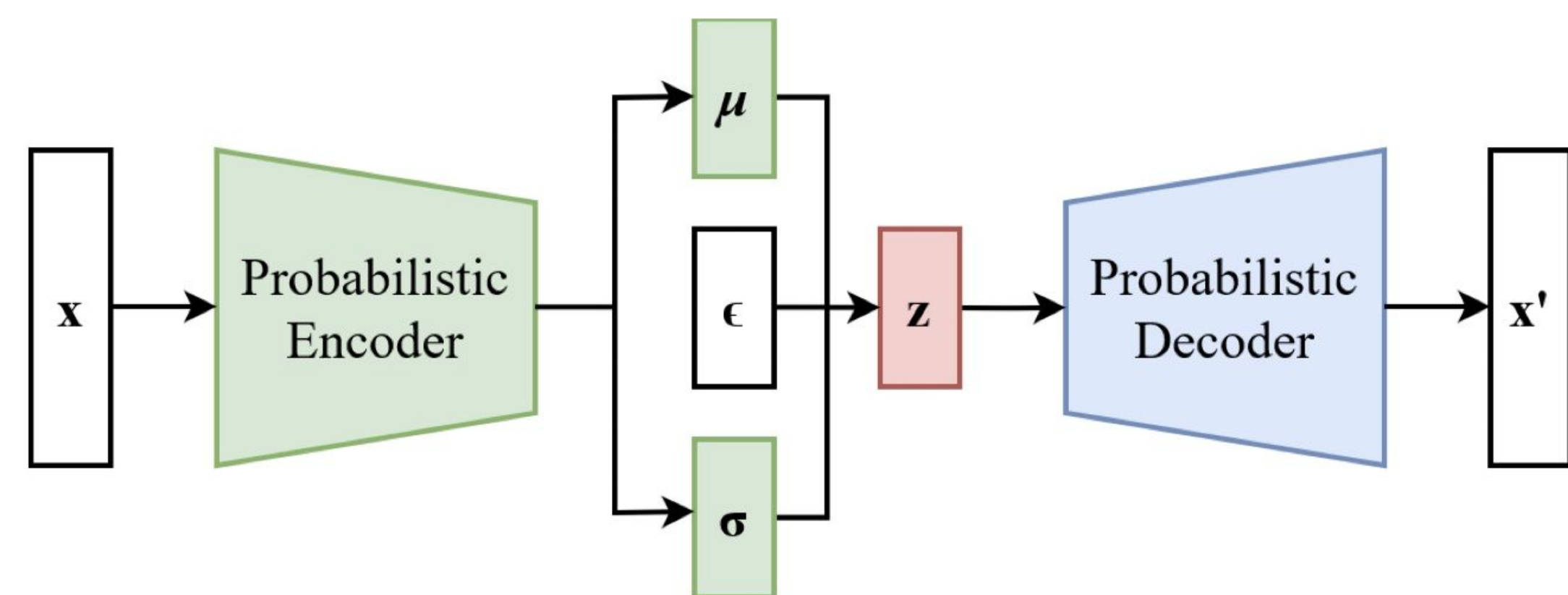
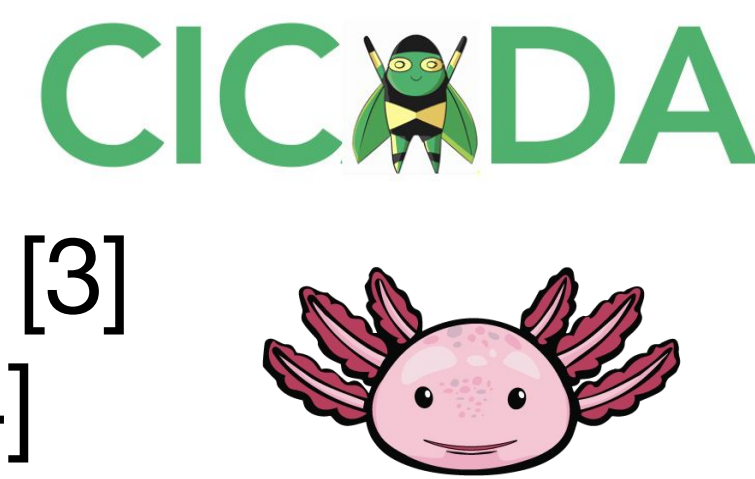


Figure 1: Structure of a Variational Autoencoder

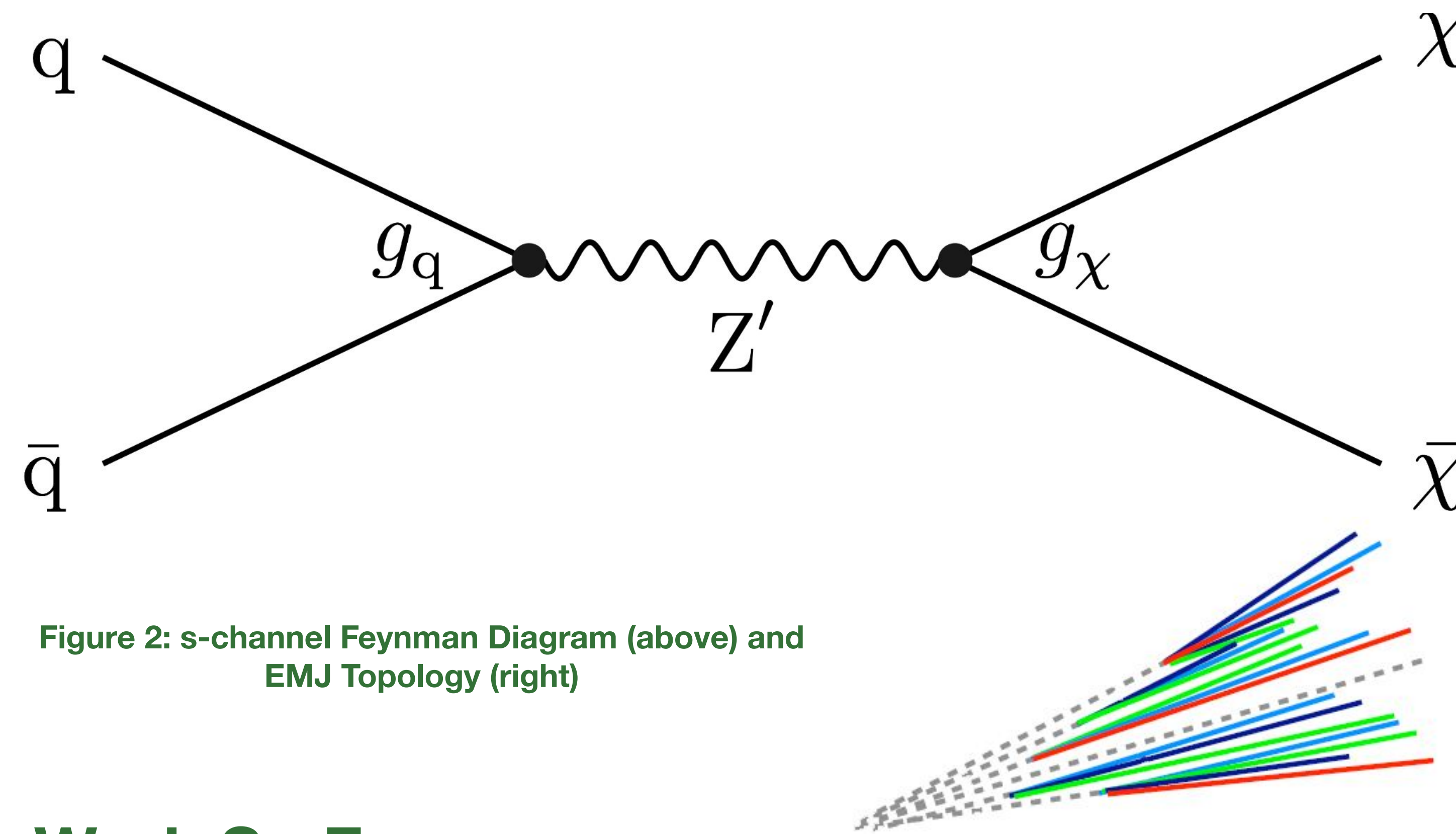


Figure 2: s-channel Feynman Diagram (above) and EMJ Topology (right)

Work So Far

- Development of s-channel Pythia MC production code.
- Production of s-channel samples for mass values ranging from 100 GeV to 2000 GeV.
- *Substantial improvement in trigger efficiency observed when including AD triggers for lower Z' mass, but negligible improvements for higher mass.*
- Study of how jet kinematic distributions are impacted by cuts on the AD scores.
- Derived ROC curves from AD scores and observed good discrimination of EMJ events against typical events.

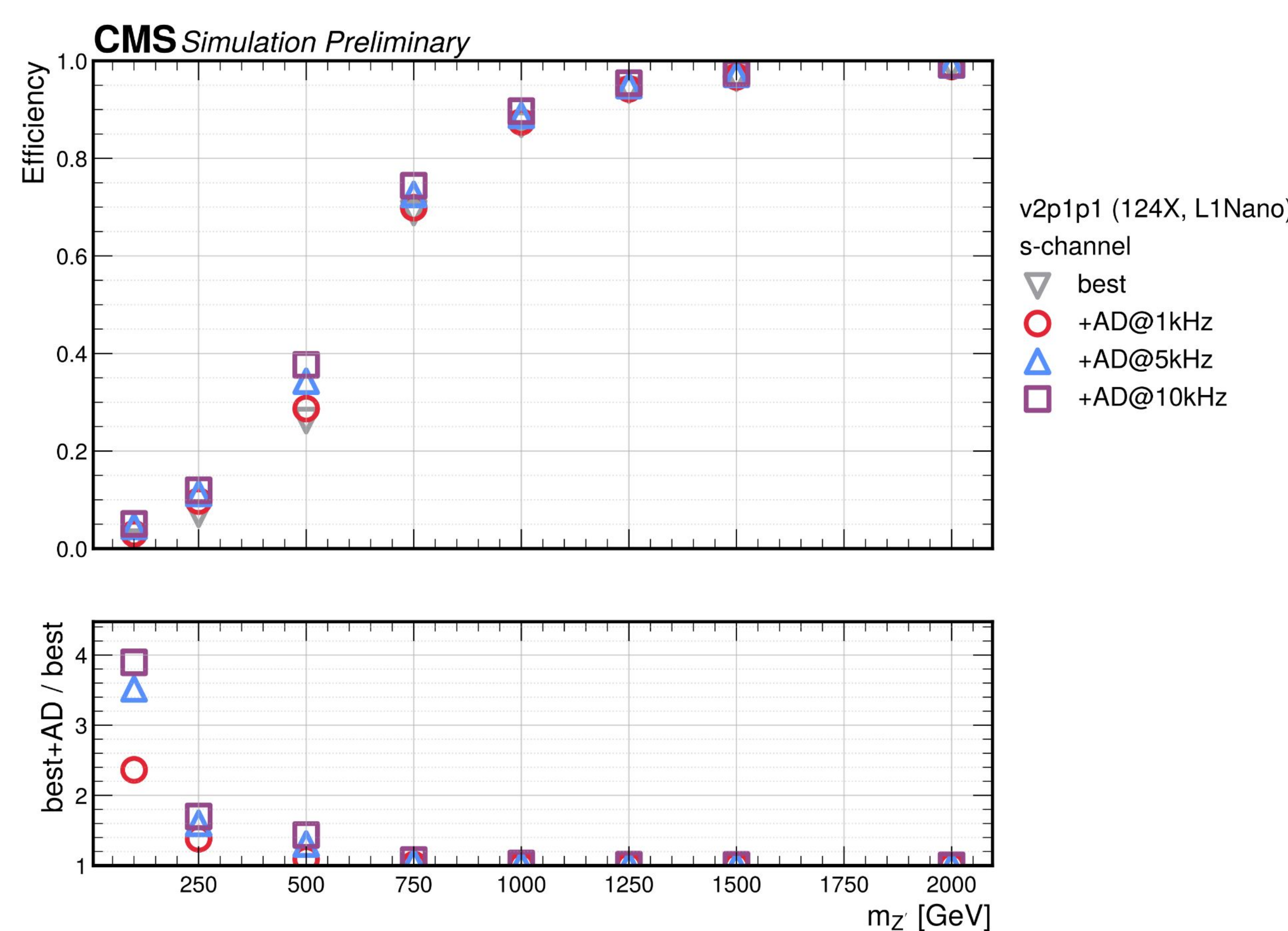


Figure 3: Efficiency of CICADA v2.1.1 as a Function of Z' Mass

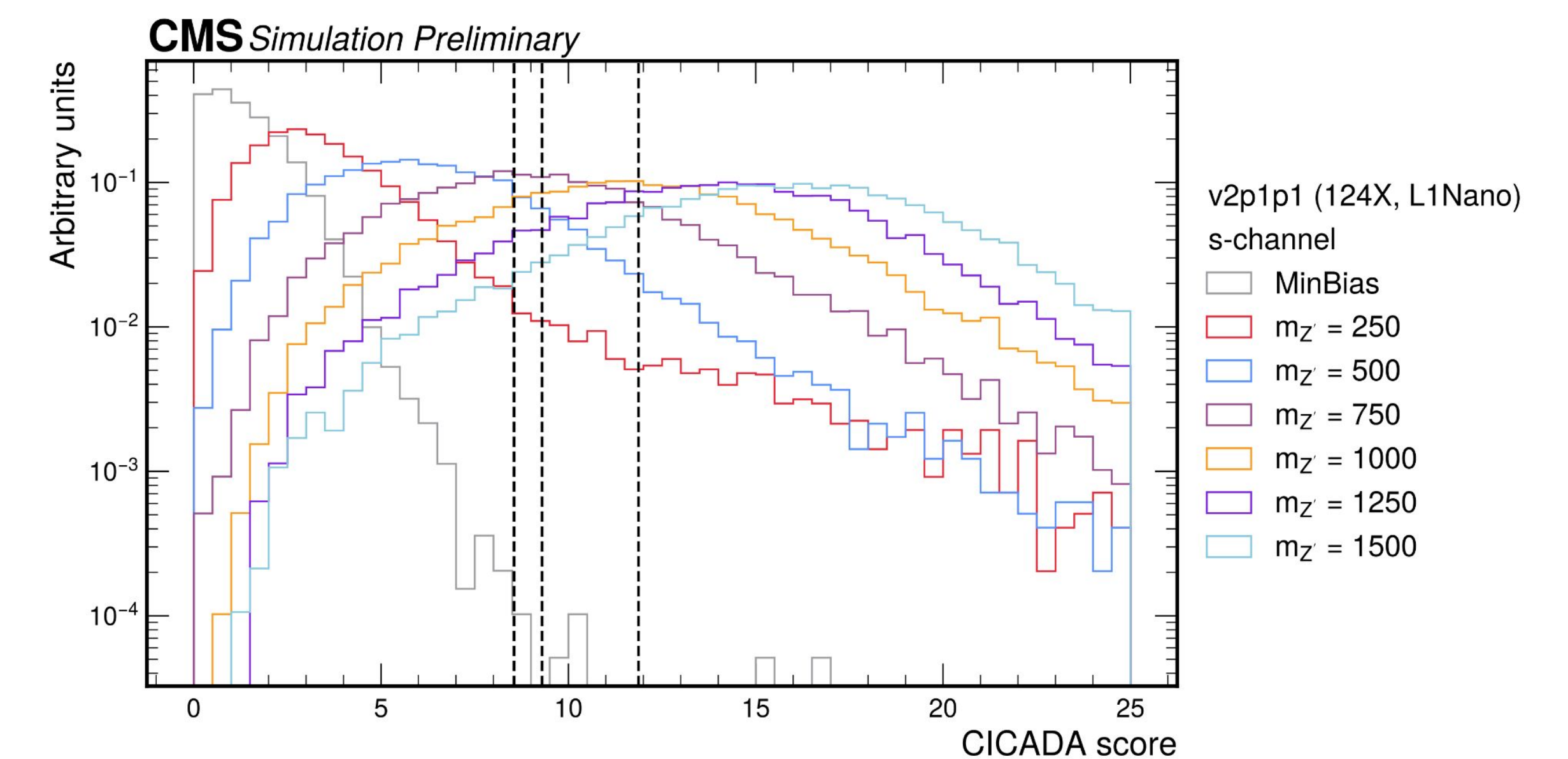


Figure 4: Distributions of CICADA v2.1.1 AD Scores for Various Z' Masses

Future Work

- Study background mass sculpting due to AD triggers.
- Include novel LLP triggers in trigger efficiency study.
- Study LLP and AD trigger efficiencies as a function of the lifetime of the long-lived dark mesons.

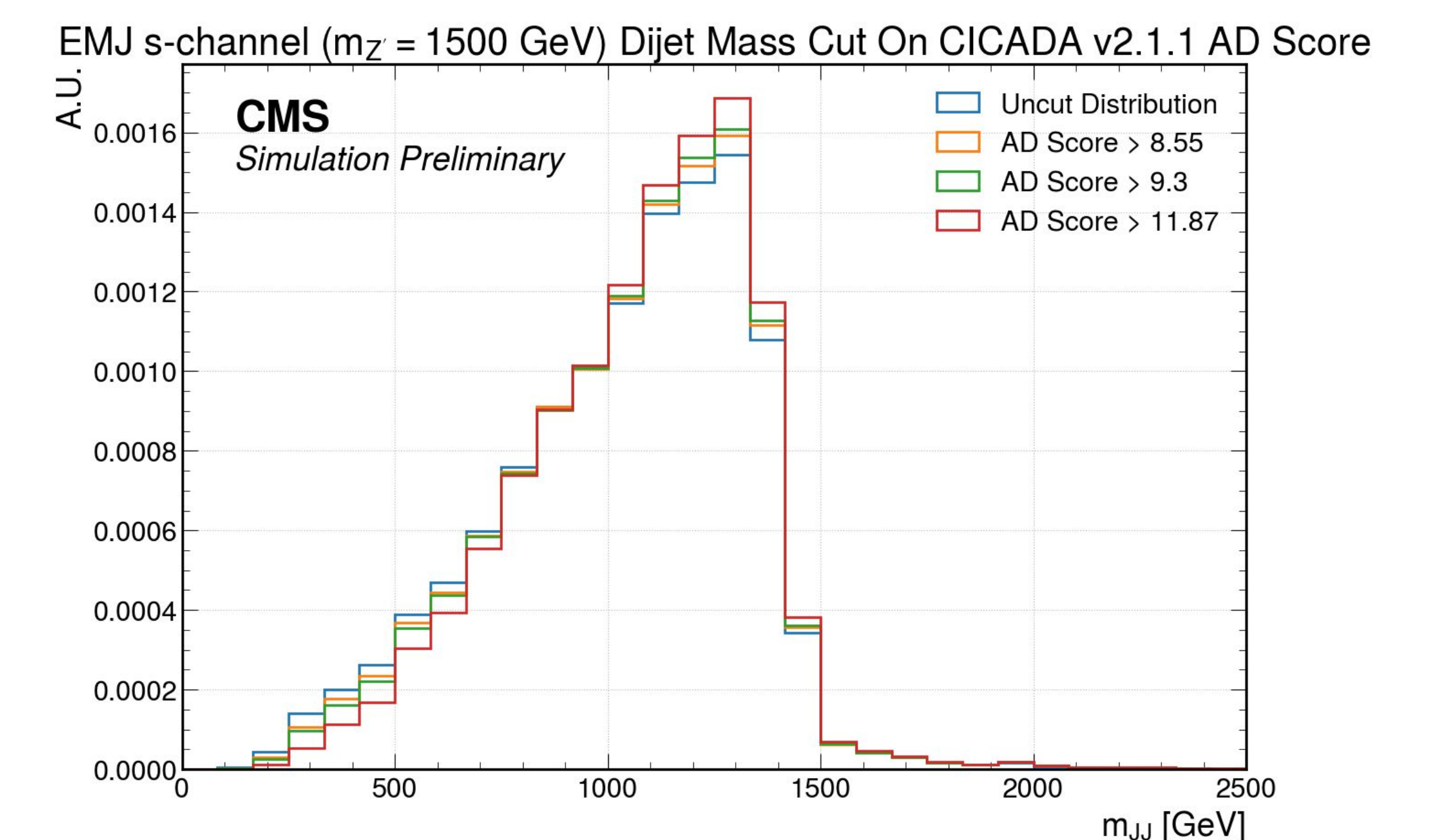


Figure 5: Dijet Mass Distributions for Z' Mass of 1500 GeV with Different AXOL1TL AD Score Thresholds

Acknowledgements Bibliography

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- [1] arXiv:1502.05409v3
- [2] arXiv:2403.01556v1
- [3] CERN-CMS-DP-2023-086
- [4] CERN-CMS-DP-2023-079

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