Comparing resolved and boosted jet identification algorithms to search for beyond the Standard Model scalar bosons with the ATLAS detector

Aidan Gardner-O'Kearny, Abraham Tishelman-Charny, Elizabeth Brost

Introduction

- The Standard Model is a highly accurate description of the universe
- Despite this accuracy, there are a number of lines of experimental evidence and theoretical considerations that indicate that it is incomplete
- Many extensions to the Standard Model predict several more Higgs-like scalars to exist
- Our analysis is searching for the X→SH→bb$\gamma\gamma$ decay channel where the S mass is different than H mass

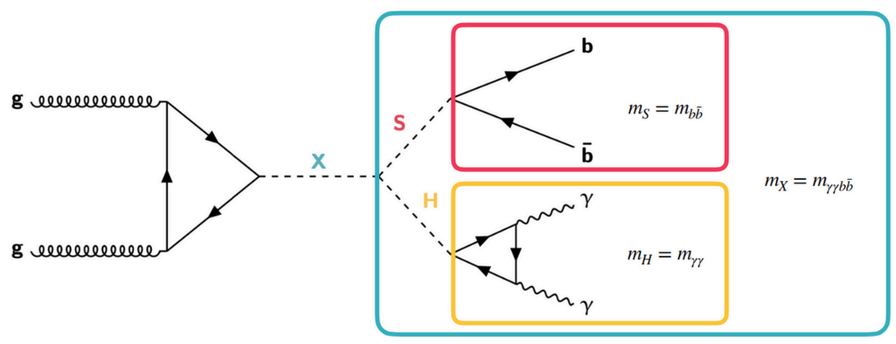

Figure 1: Signal X→SH→bb$\gamma\gamma$ process. Credit: SH→bb$\gamma\gamma$ Analysis Team, ATLAS https://indico.cern.ch/event/1380392/#8-run-2-recap-sh-bbyy

- Range of mass points for X, S
  - m_X: 0.2-1 TeV
  - m_S: 30-700 GeV
- Primary background of analysis is $\gamma\gamma$ + jets, a way to get bb$\gamma\gamma$ from scalars (non-resonant)

Truth Higgs Investigation

- How close are large-R jets to H→$\gamma\gamma$
- The distribution peaks at 70 GeV, 3.14 as well as at 125 GeV, 0
  - Indicates that the H→$\gamma\gamma$ decay is being reconstructed as jets

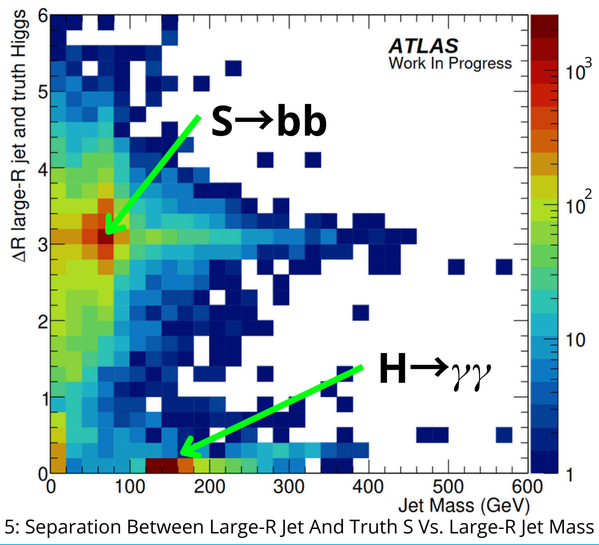

Figure 5: Separation Between Large-R Jet And Truth S Vs. Large-R Jet Mass

Tagger Score Distribution

- A score generated by the bb tagger that assigns a score to a jet that designates a jet as more or less bb-like
- The distribution of the tagger score of S→bb candidate in both signal and background tells us how well the tagger performs

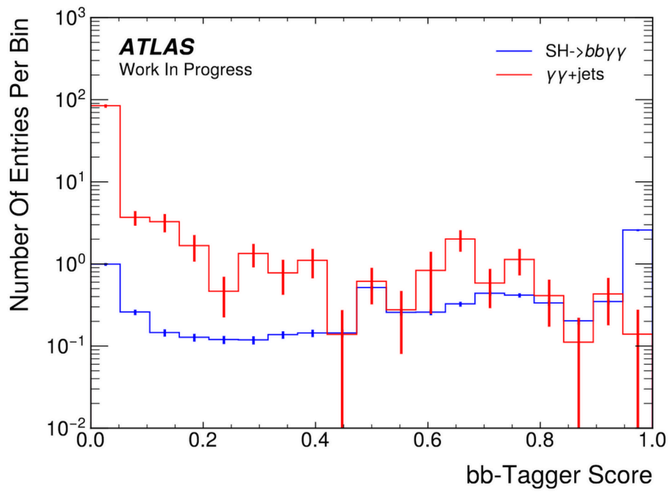

Figure 7: bb-Tagger Scores Of Candidate Large-R Jets

- Good separation between signal and background at high bb-tagger score
- Some features to understand
  - Rise in signal at ~0.7
  - Large fraction of signal at 0
- This is a result that indicates that bb-tagging could be used to identify S→bb in high m_X/m_S cases

Large Radius Jets

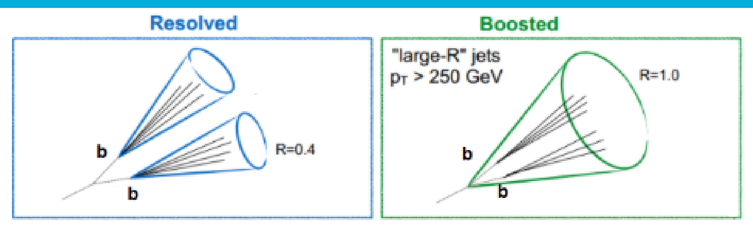

Figure 2: Resolved and boosted jets. Credit: Galetsky Vladlen For ATLAS https://espace.cern.ch/lip/pub/docs/LIP-STUDENTS-20-04.pdf

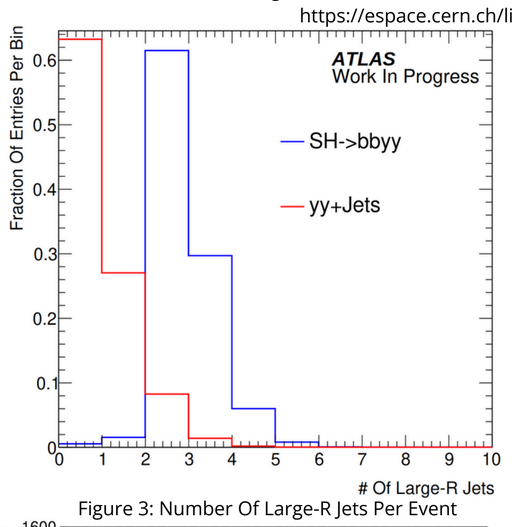

Figure 3: Number Of Large-R Jets Per Event

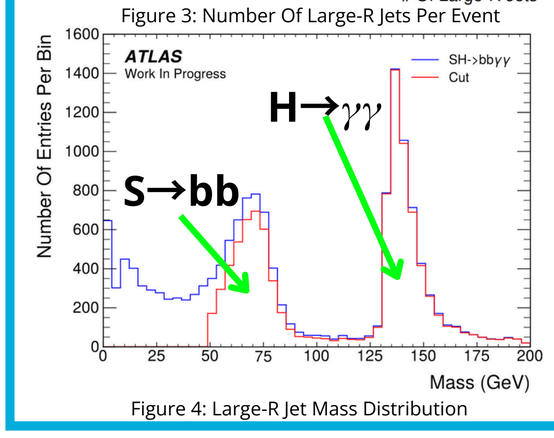

Figure 4: Large-R Jet Mass Distribution

- For this work
  - m_X : 1 TeV
  - m_S : 70 GeV
- After passing trigger, events required to have at least 2 quality photons, no leptons, and 2-6 b-jets
- When m_X/m_S is large, expect collinear b-jets
- Background: usually no large radius jets **expected**
- Signal: 2 large-R jets is **unexpected**
- Distribution of mass in large radius jets peaks at S mass (~70 GeV) and Higgs mass (~125 GeV)

Jet Candidate Selection

- When >1 large-R jet per event, need to select which large-R jet is from the S→bb decay
- Added separation between large-R jet and photons
- Tested two methods
  - Highest momentum jet
  - Jet with mass closest to S mass

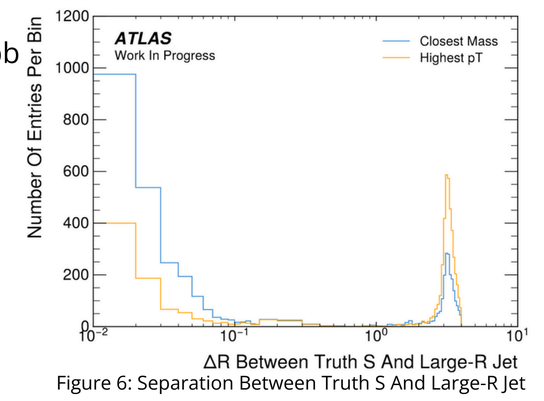

Figure 6: Separation Between Truth S And Large-R Jet

- Tested by calculating the separation of the selected jet against the truth S position
- Choosing the jet with the mass closest to the S mass performs better at choosing the S→bb candidate

Conclusions And Next Steps

- Identified the H→$\gamma\gamma$ being reconstructed as a large-R jet
- Found good separation between signal and background in bb tagger score
  - Major background of $\gamma\gamma$ + jets is highly suppressed after selections
- Need to check how many of the H→$\gamma\gamma$ jets are left after selection
- Add separation requirements between large-R jet and Higgs photons
- Add other backgrounds
- Calculate signal to sqrt background ratio to compare sensitivity to previous analysis

Aknowledgements

I would like to take this opportunity to thank my mentor, Dr. Abraham Tishelman-Charny for his support with this project and support with my continued professional development. I would also like to thank Dr. Elizabeth Brost for her feedback on numerous matters. This project was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI). Not Export Controlled.

Brookhaven National Laboratory · U.S. Department of Energy · ATLAS Experiment · University of Oregon Physics