

Boosted object tagging in ATLAS

Yicong Huang

On behalf of the ATLAS collaboration

BOOST 2021

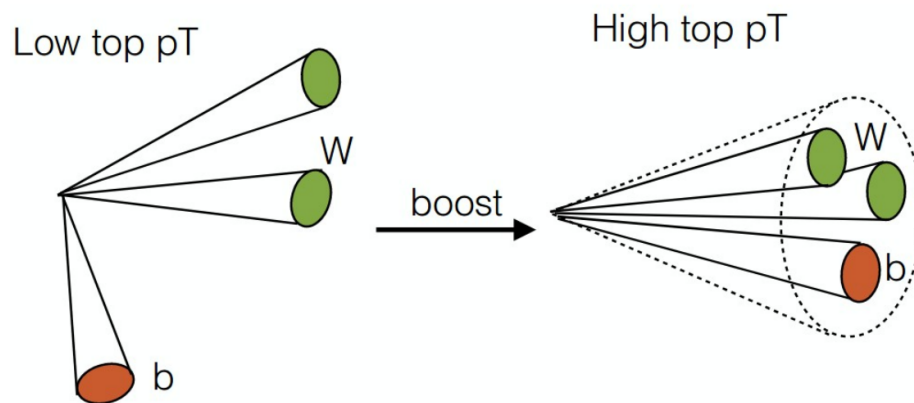
August 2nd ~ 5th, 2021



Introduction

- High-energy particle collisions such as those produced at the Large Hadron Collider (LHC) can result in the production of massive particles.
- The high p_T , massive particles such as Higgs bosons, top quarks, and W or Z bosons often decay hadronically.
- Decay products of boosted objects could be reconstructed as jets.
- Identification of boosted objects decaying hadronically is very important.
 - boosted $H \rightarrow bb$ in VH channel [Phys. Lett. B 816 \(2021\) 136204](#)
 - Measurement of $t\bar{t}$ differential cross section [Phys. Rev. D 98, 012003](#)
- Study the inner structure of the jets to distinguish between signal-like and background jets would be useful.

**All the results presented
are new for 2021!**



Overview of the taggers

- **Previous large- R jet definition (LCTopo jets):** anti- k_t $R = 1.0$ jets, reconstructed from calorimeter topo-cluster, groomed with the trimming algorithm.
- **New large- R jet definition (UFO jets):** anti- k_t $R = 1.0$ jets reconstructed from UFO, CS+SK soft-drop ($z_{\text{cut}} = 0.1$, $\beta = 1.0$) grooming algorithm applied.

Eur. Phys. J. C 81 (2021) 334

New Taggers developed in 2021

- W/Z taggers optimized for UFO CSSK soft drop jets. *ATL-PHYS-PUB-2021-029*
- Top taggers optimized for UFO CSSK soft drop jets. *ATL-PHYS-PUB-2021-028*
- Digluon tagger for identifying process like $H \rightarrow aa \rightarrow gggg$. *ATL-PHYS-PUB-2021-027*

Common steps to derive the taggers

- **Jet reconstruction**
reconstruct decay products of the interested objects using suitable jet definitions.
- **Truth labeling**
know the origin (signal or background) of the reconstructed jets in MC samples by matching reconstructed jet to truth jet, labeled with truth particle info.
- **Tagging**
design algorithms to identify jets from the decay of interested objects.

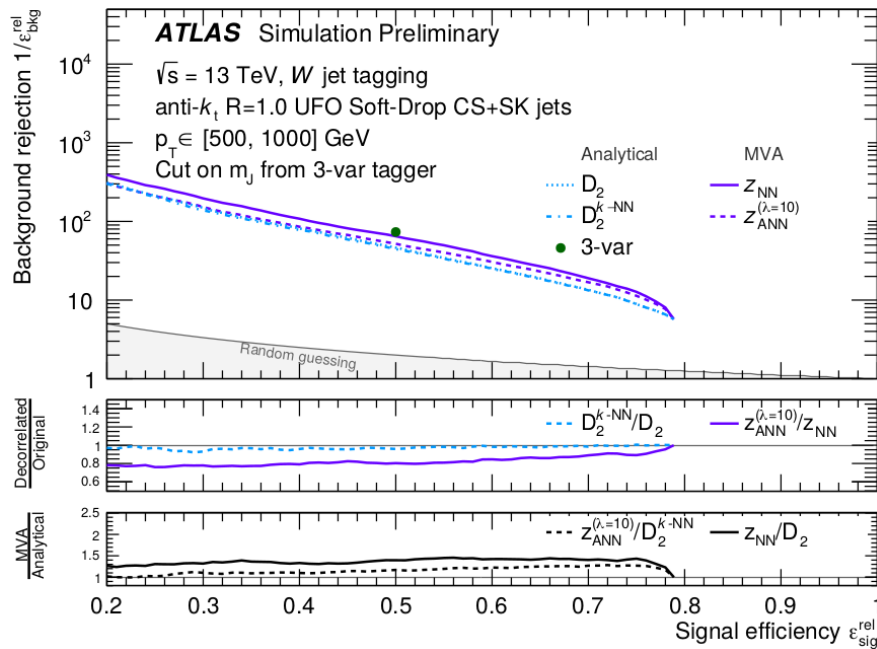
W/Z tagger

W/Z tagger: algorithm to identify boosted W/Z bosons using large- R jets.

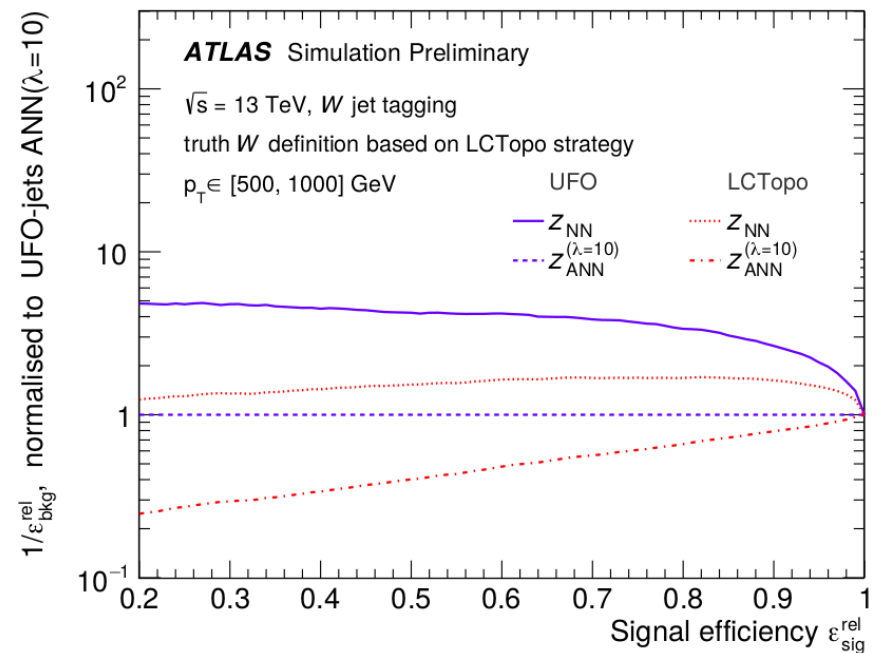
- Cut-based tagger, using cuts on variable m_j , D_2 or $D_2^{k\text{-NN}}$, n_{trk} .
- Tagger based on machine learning discriminant, DNN, ANN.

The W/Z tagger background rejection improved by a factor of 2-4 compared to LCTopo jets.

ATL-PHYS-PUB-2021-029



W/Z tagger performance comparison



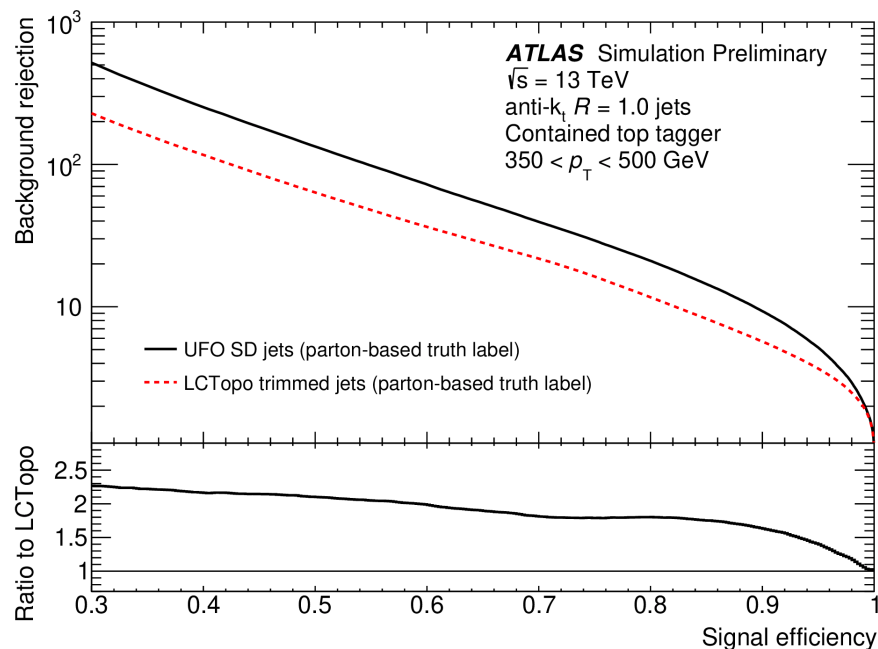
W/Z tagger UFO vs LCTopo

Top tagger

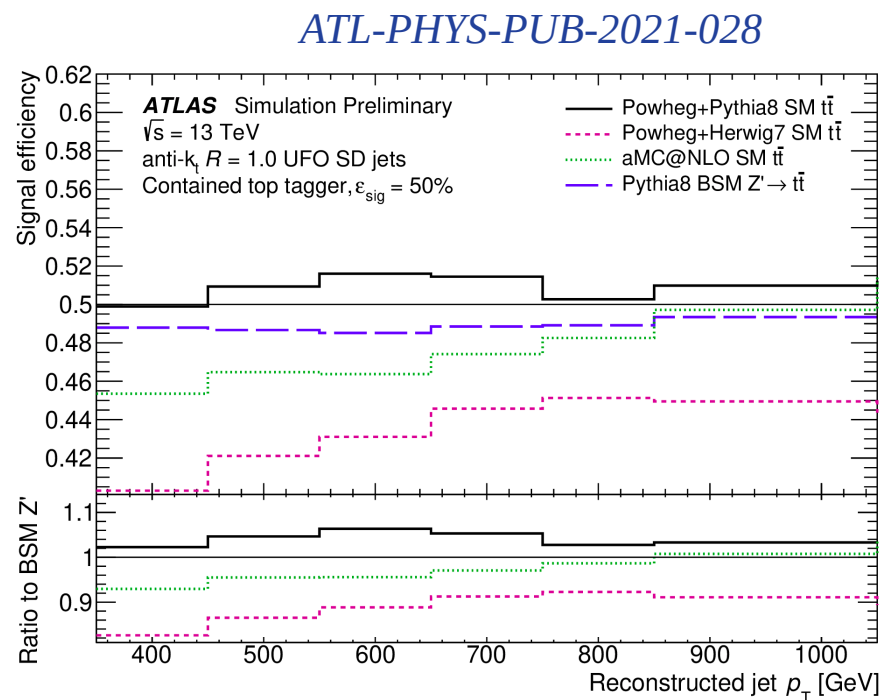
Top tagger: two DNN trained to identify jets from the decay of a top quark, with substructure variables and m , p_T as inputs.

- inclusive top tagger: jet contains some of the decay products of the top quark.
- Contained top tagger: jet contains “all” decay products of the top quark.

The top tagger performance improved significantly compared to LCTopo jets, especially for 50% signal efficiency.



Top tagger UFO vs LCTopo



Top tagger modeling dependence

Digluon tagger

Digluon tagger: identifying massive scalar particles decaying into gluons, $a \rightarrow gg$

- For process like $H \rightarrow aa \rightarrow gggg$, when $m_a > 1$ GeV and smaller than $m_h/2$, the decay products of a can be reconstructed as a small- R jet.

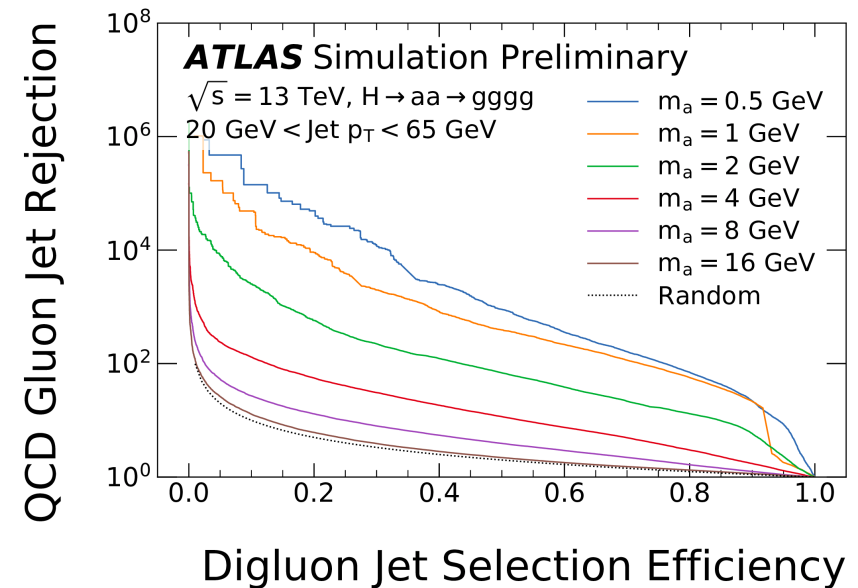
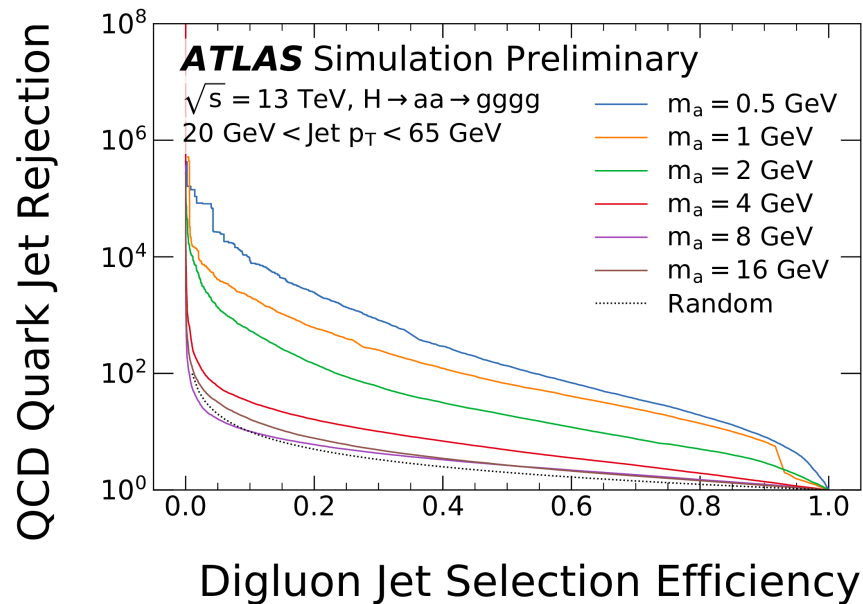
Jet level tagger

ATL-PHYS-PUB-2021-027

- DNN trained using all tracks within 0.6 of the jet axis.

Event level tagger

- Global info, combined with jet level tagger, return a single score per event.



Summary

- The new large- R UFO jet groomed with soft drop algorithm has better pile-up stability and resolution, W/Z tagger and top tagger are optimized for UFO jets.
- W/Z taggers using UFO jet
 - DNN based tagger shows the best performance, and the background rejection improved by a factor of 2-4 compared to LCTopo jets.
 - k -NN 3-var tagger and ANN tagger are studied to make the tagger less dependent on the jet mass.
- Top taggers using UFO jets
 - The top tagger performance improved compared to LCTopo jets, especially for 50% signal efficiency.
- Digluon tagger
 - Technique to tag $a \rightarrow gg$ jets from the prompt decay of light BSM scalars, which can couple to the SM Higgs boson.

[Link to longer talk](#)