COMPARING THE PERFORMANCE OF THE ANTI-KT AND DURHAM-KT JET CLUSTERING ALGORITHMS IN ZH FULLY HADRONIC FINAL STATE EVENTS

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Motivation

Investigating fully hadronic final state events

- **Durham-kt** algorithm in n-jets mode is not infrared safe
- Want to test if another algorithm can improve jet clustering accuracy

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Durham-kt n-jets–

$d_{ij} = 2\min(E_i^2, E_j^2)(1-\cos\theta_{ij})$

Recombine smallest d_{ij}

Algorithm stops when there are *n*-jets

Anti-kt–

$d_{ij} = 2\min(E_i^{-2}, E_j^{-2})(1-\cos\theta_{ij})(1-\cos R)$

$d_{iB} = E_i^{-2}$

If d_{ij} is smallest combine i and j

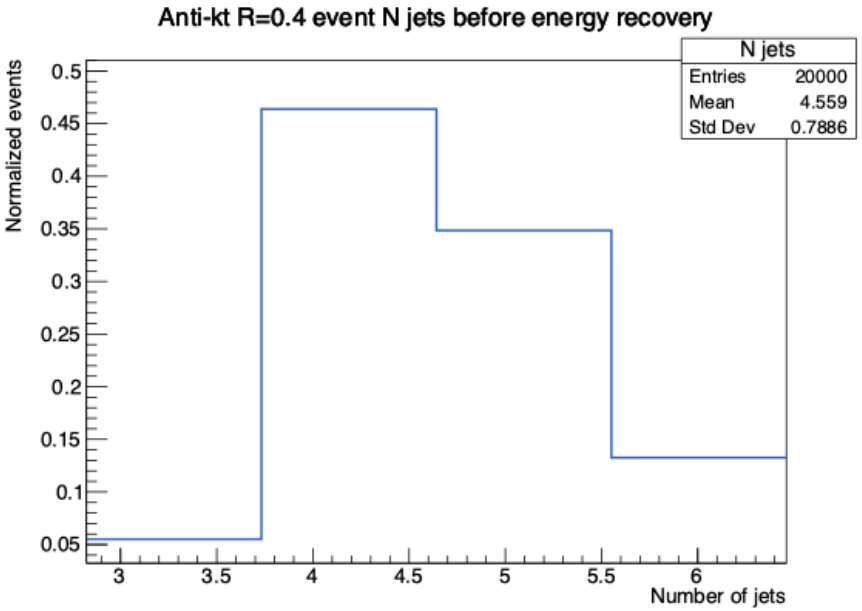
If d_{iB} is smallest i becomes a jet

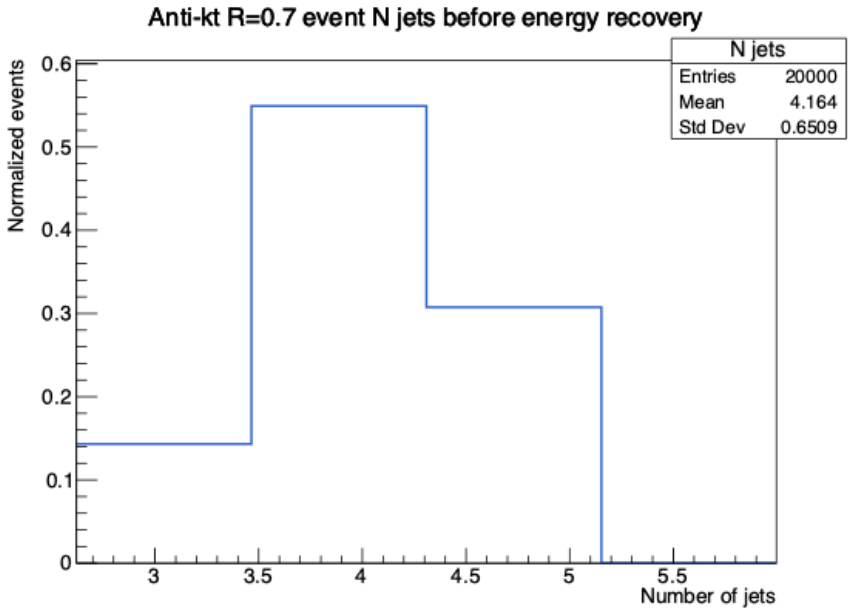
Comparing **anti-kt** and durham-kt algorithms

- *Basic guidance on jet algorithms (& FastJet) for FCC-ee FCC Physics Performance meeting*, 27 June 2022, Cacciari, Salem, Soyez
  - Their study looks at **H(bb)Z(vv)** example process
  - anti-kt algorithm with energy recovery shows indistinguishable results from Durham n-jet algorithm in their study

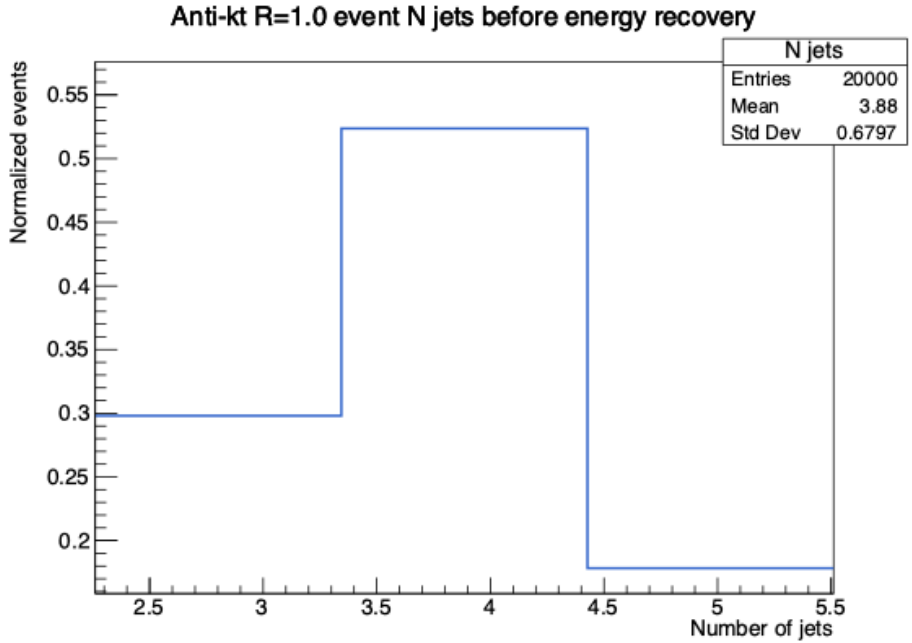
  - apply this method to fully hadronic final state events
    - using **H(bb)Z(cc)** as a sample process

Anti-kt R=0.4 and 0.7 N jets before recovery





Anti-kt R=1.0 N jets before recovery



Energy recovery algorithm for anti-kt

1. Jets are sorted by energy

2. Four highest energy jets are selected

3. Each extra jet recombines with high energy jet closest in angle

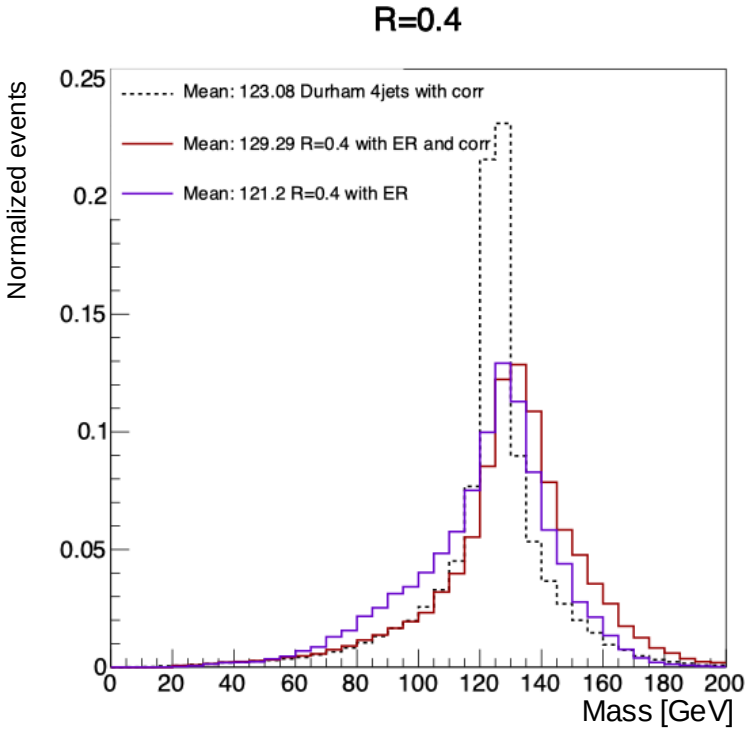
minimum energy 10 GeV – also applied to Durham-kt for consistency

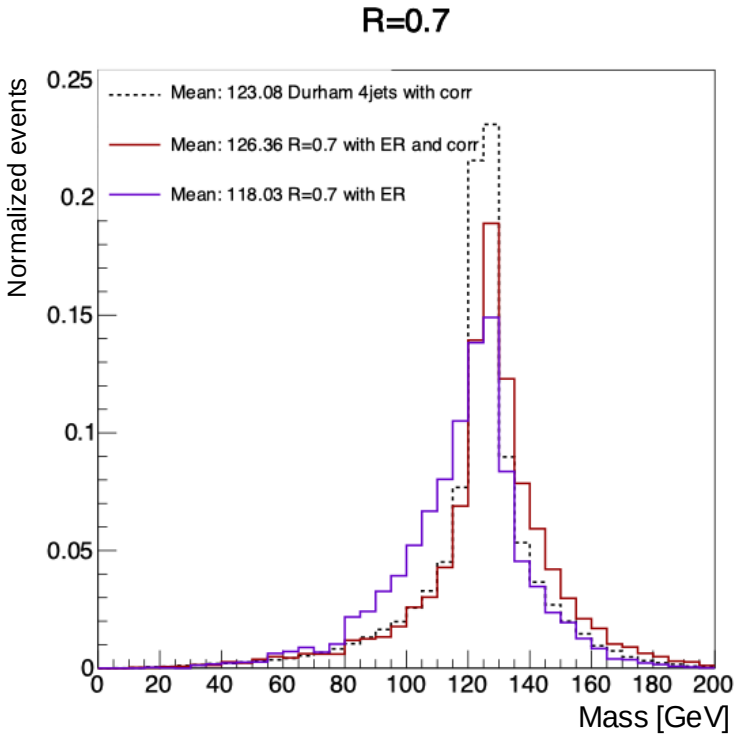
Once there are four jets – correction applied assuming 240 GeV C.O.M. energy (same correction is applied to Durham-kt jets)

Comparing reconstructed Higgs mass

- Comparing Durham-kt with anti-kt masses at R=0.4, 0.7, 1.0, and 1.1
- **H(bb)Z(cc)** sample process
- Events selected to plot have exactly 2 b and 2 c quarks
    - Truth flavor of the jet determined by closest truth quark

Anti-kt and Excl. Durham-kt Higgs mean mass



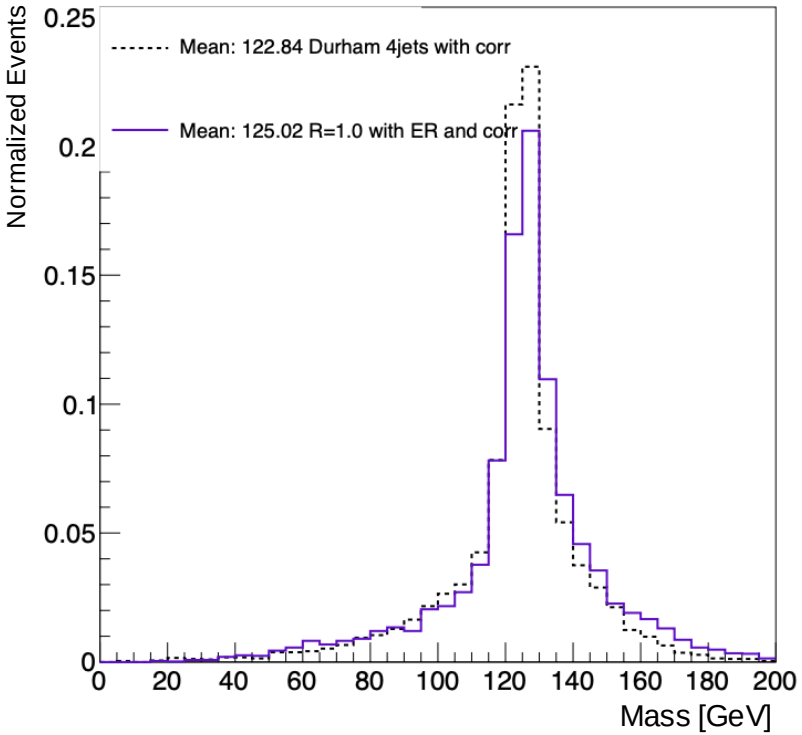


ER – Energy recovery

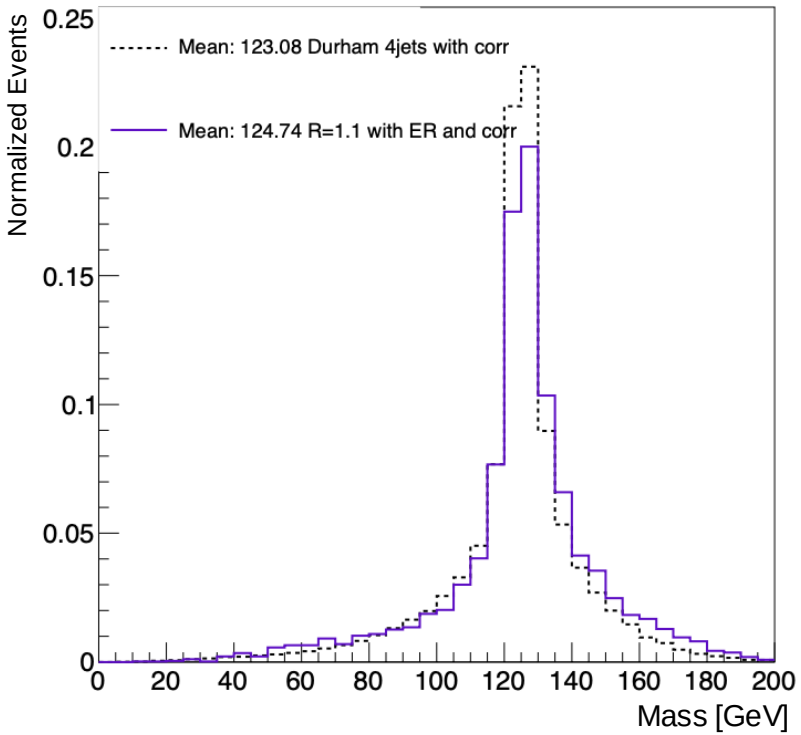
Choosing smaller R for the anti-kt algo results is worse mass resolution

Anti-kt and Excl. Durham-kt Higgs mean mass

1.0



1.1



At jet radius 1.0-1.1 anti-kt algorithm performs comparably to Durham-kt

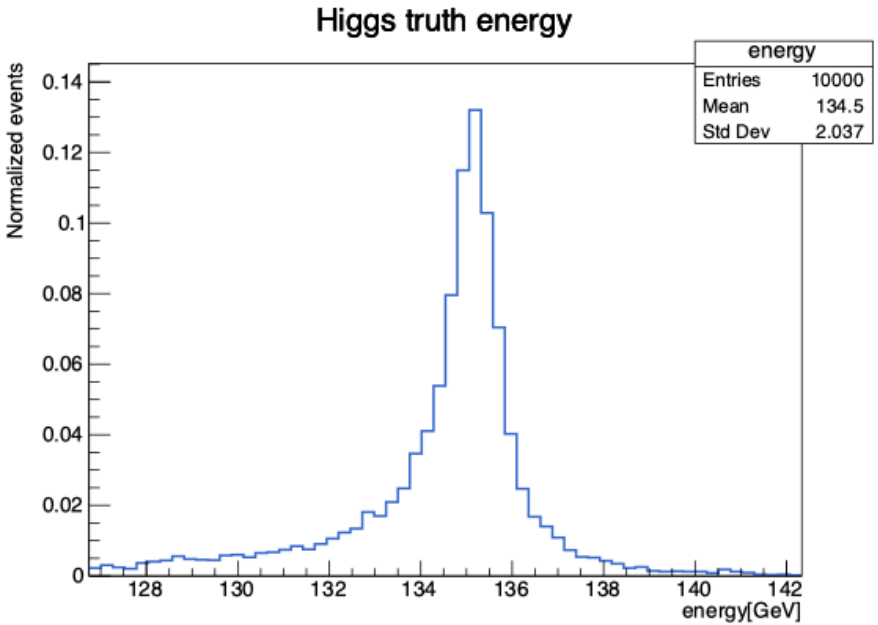
Comparing reconstructed Higgs masses

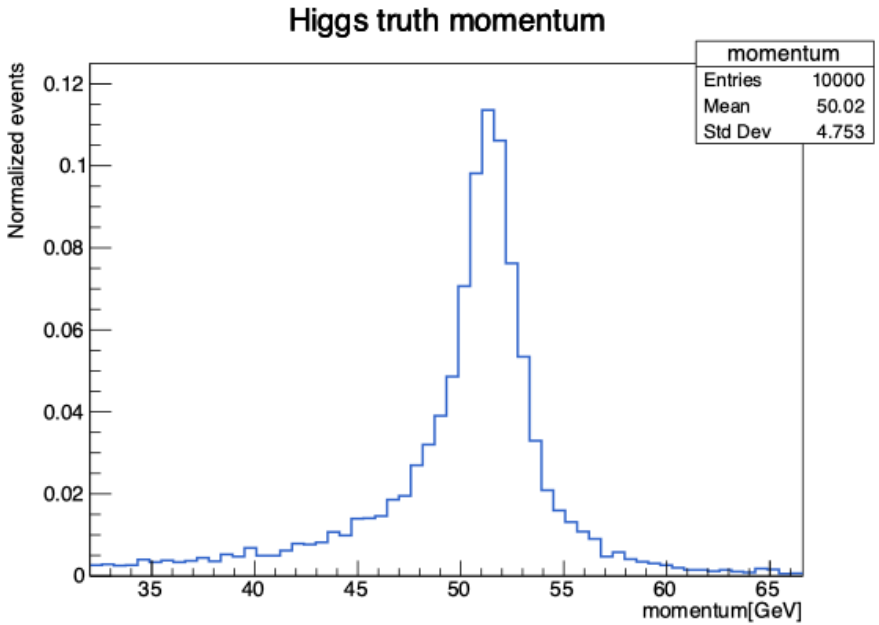
Mean Higgs mass with anti-kt algorithm and **energy recovery** and **energy correction**

Jet Radius	Higgs mass [GeV]	Z mass [GeV]
0.4	129.29	91.39
0.7	126.36	92.53
1.0	125.02	92.06
1.1	124.74	91.82

Excl. Durham n-jet	**123.08**	**92.22**

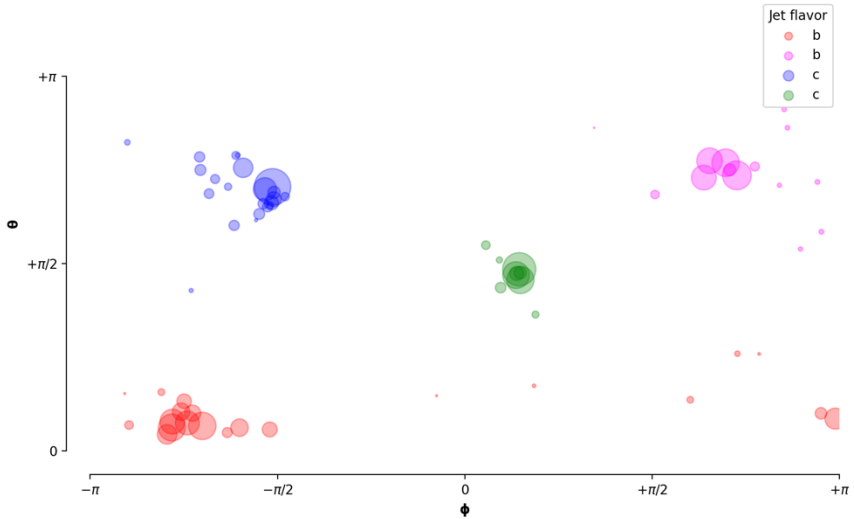
Higgs truth energy and momentum



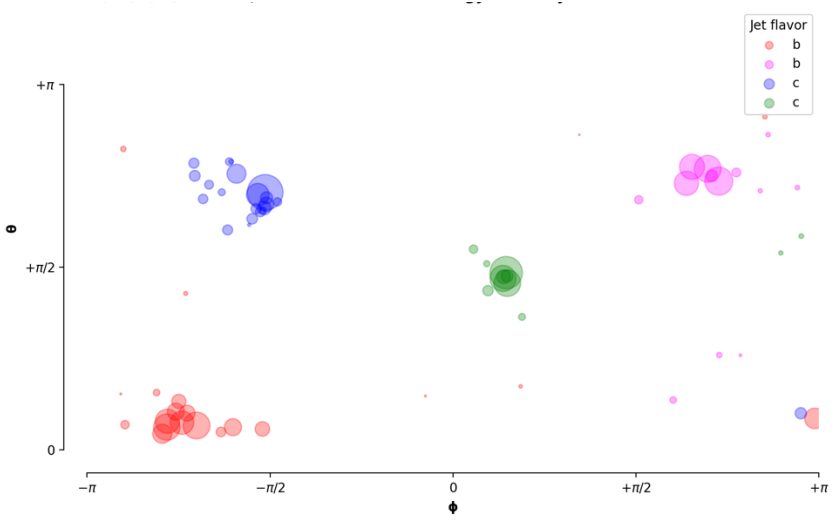


Durham-kt and anti-kt theta-phi **event displays**

Durham-kt 4-jets mode



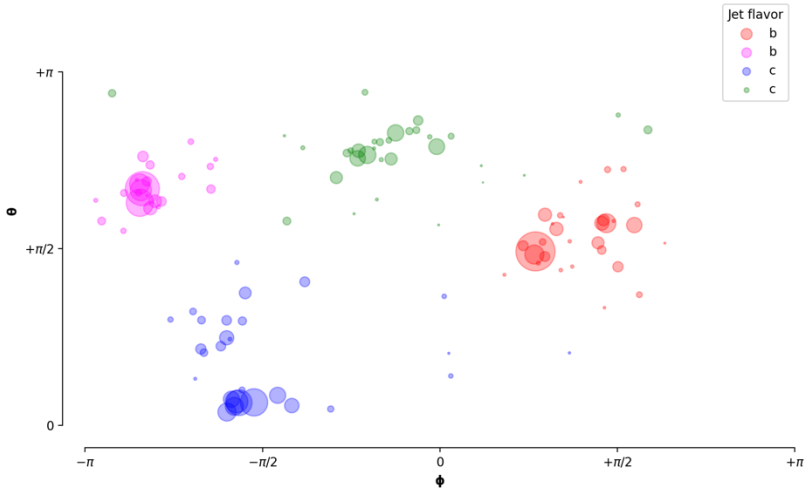
anti-kt R=1.0 with energy recovery



Thank you to N. Morange for the initial event display code from *Measurement of the Higgs width* presented at 7th FCC Physics Week

Durham-kt and anti-kt theta-phi **event displays**

Durham-kt 4-jets mode



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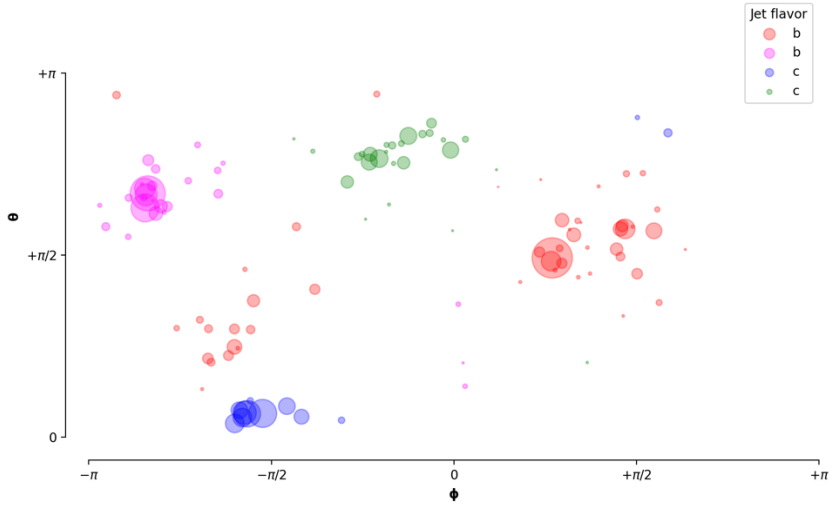

Conclusions

- The Durham-kt in n-jet mode performs comparably to the anti-kt when jet radius is set to **1.0-1.1**

- Follow up:
  - investigating the edge cases
  - performing a full analysis chain with anti-kt algorithm to see if there is an impact on the limit of the Higgs coupling

Thank you for your attention.

Thank you again to the Bard College Office of Undergraduate Research.