

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

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

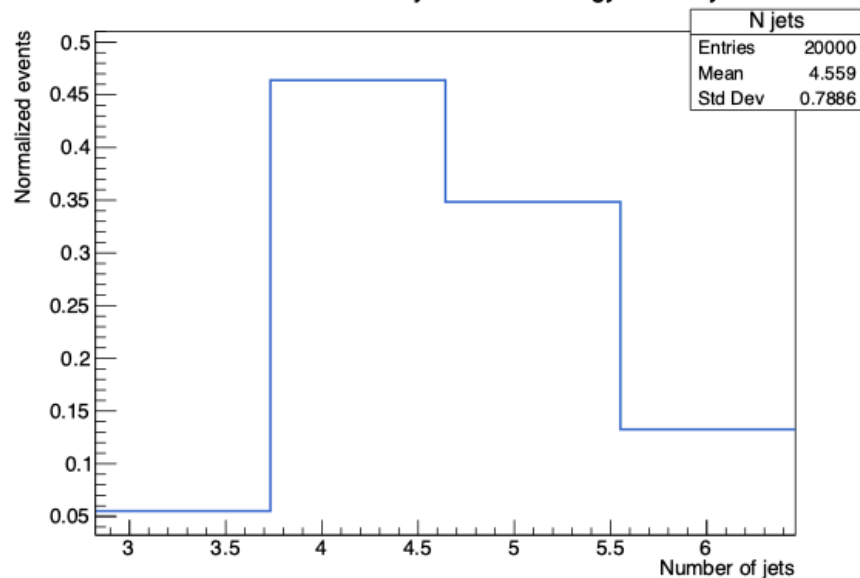
If d_{iB} is smallest i becomes a jet

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

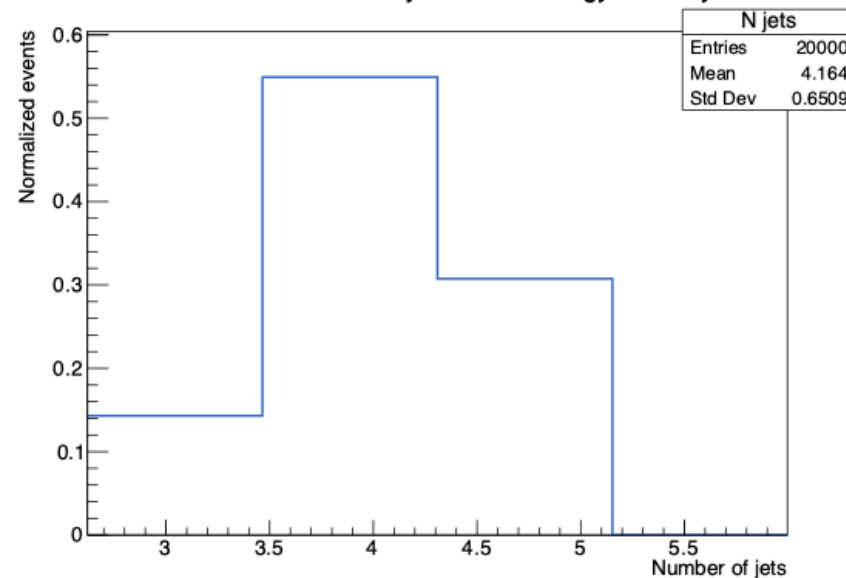
- *Basic guidance on jet algorithms (& FastJet) for FCC-ee FCC Physics Performance meeting, 27 June 2022, Cacciari, Salem, Soyez*
 - Their study looks at **H(bb)Z(vv)** example process
 - anti-kt algorithm with energy recovery shows indistinguishable results from Durham n-jet algorithm in their study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

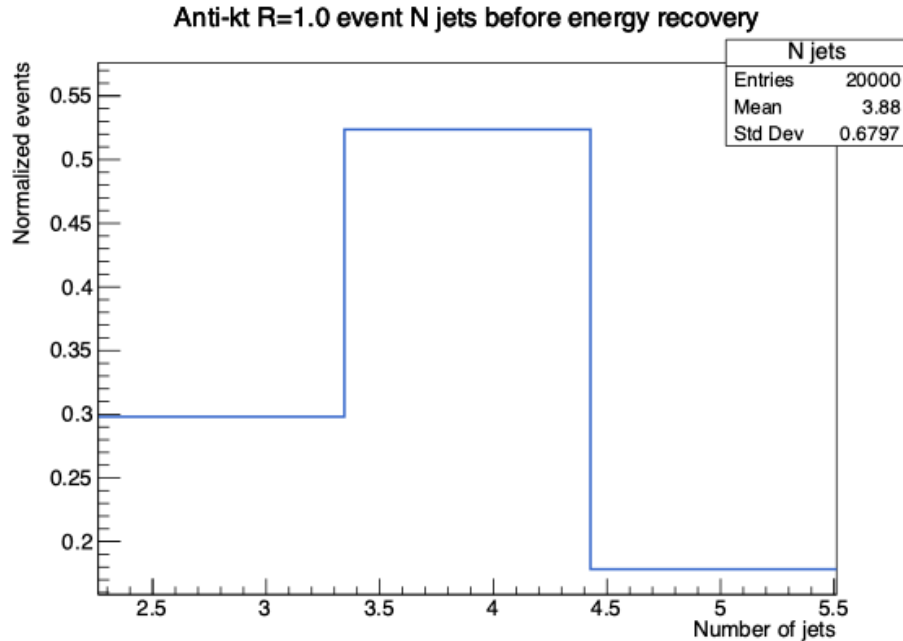
Anti-kt R=0.4 event N jets before energy recovery



Anti-kt R=0.7 event N jets before energy 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

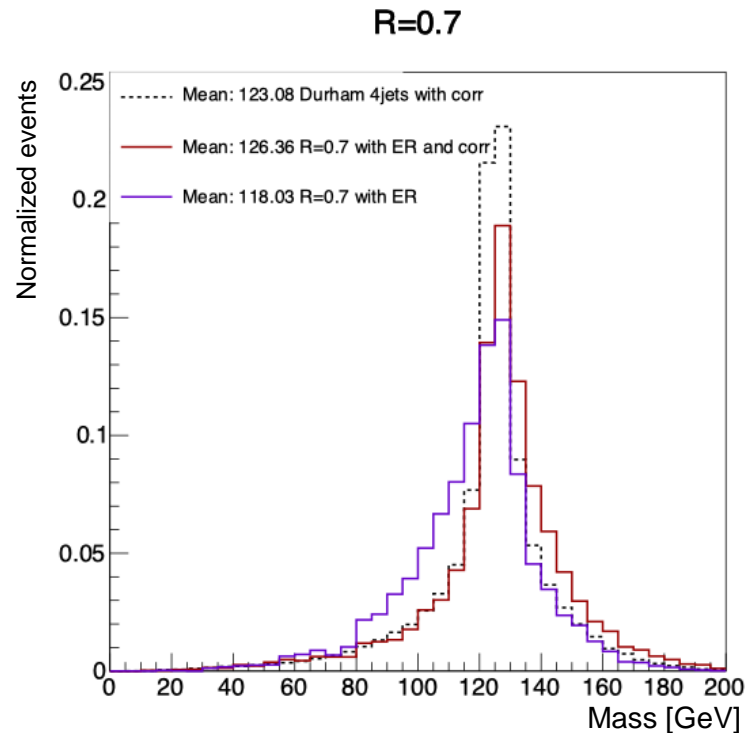
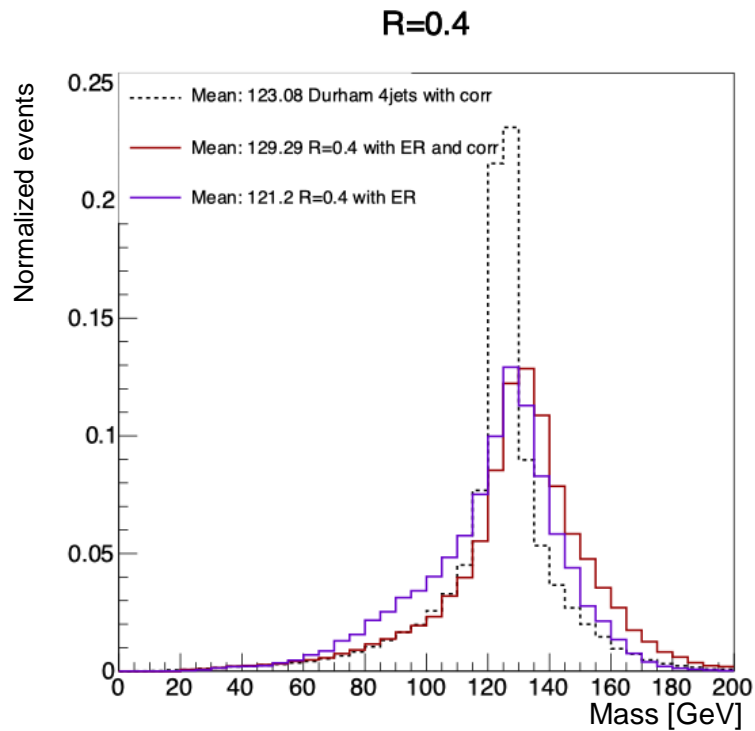
minimum energy 10 GeV – also applied to Durham-kt for consistency

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

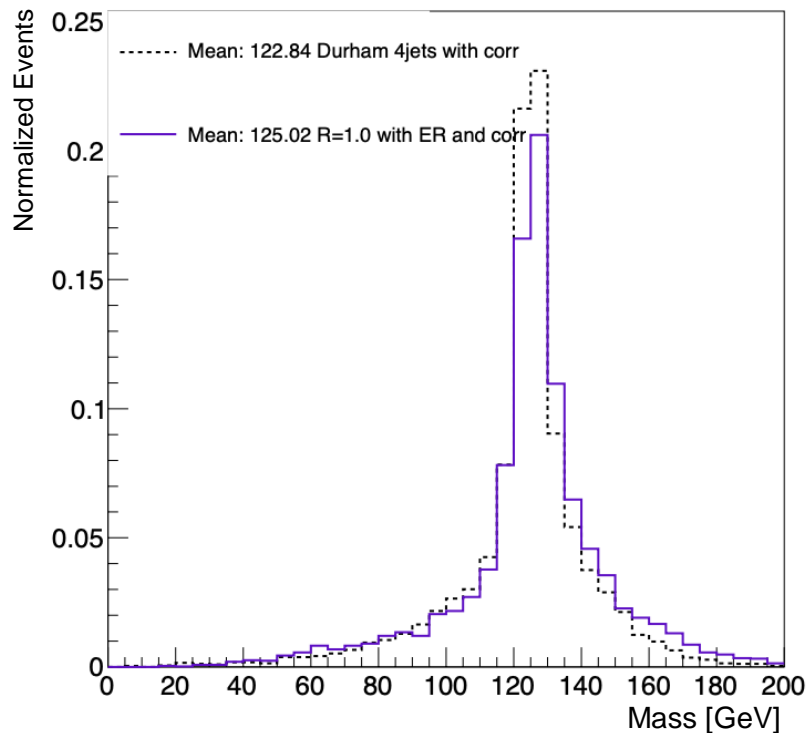


ER – Energy recovery

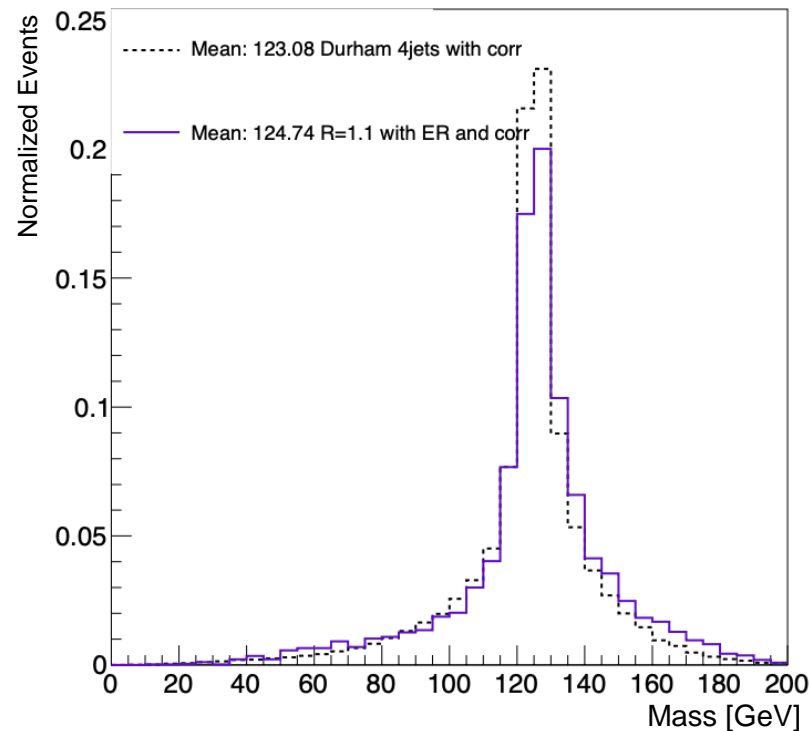
Choosing smaller R for the anti-kt algo results is worse mass resolution

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

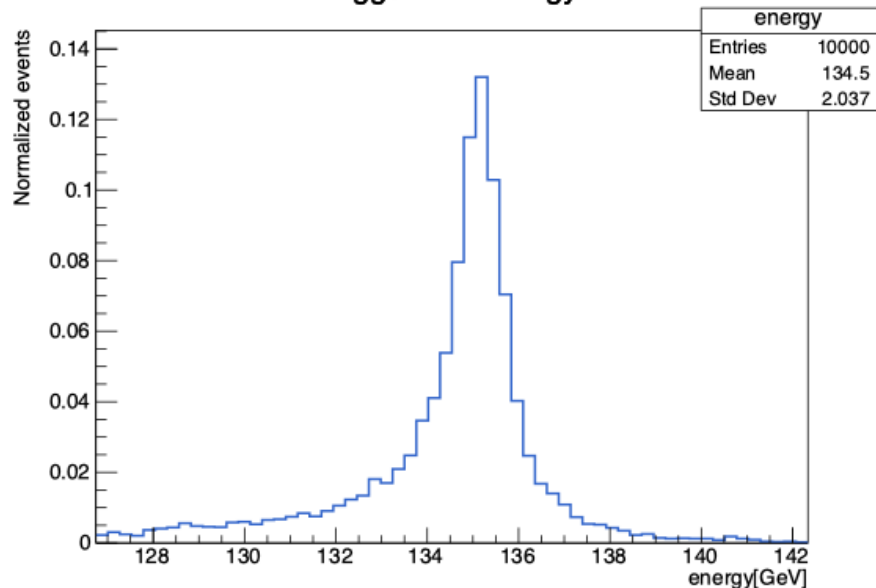
Comparing reconstructed Higgs masses

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

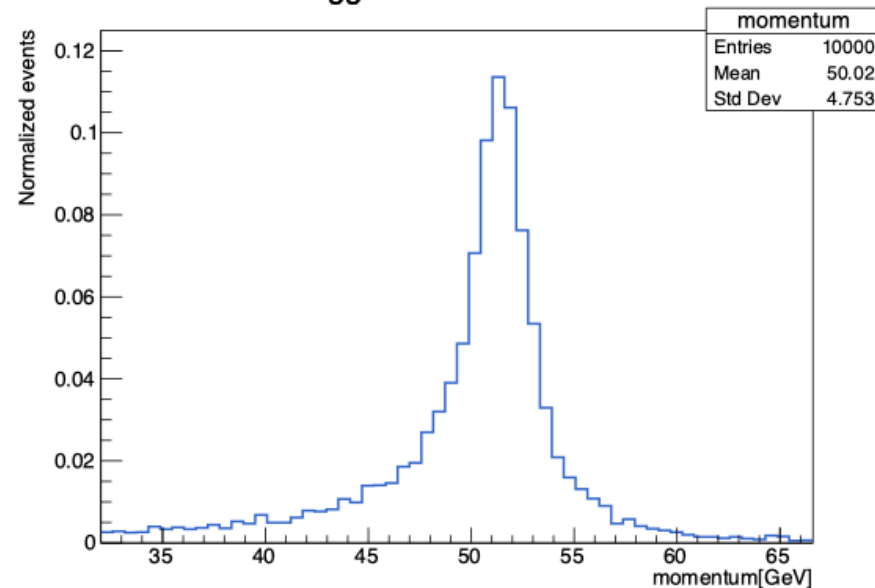
Jet Radius	Higgs mass [GeV]	Z mass [GeV]
0.4	129.29	91.39
0.7	126.36	92.53
1.0	125.02	92.06
1.1	124.74	91.82
Excl. Durham n-jet	123.08	92.22

Higgs truth energy and momentum

Higgs truth energy

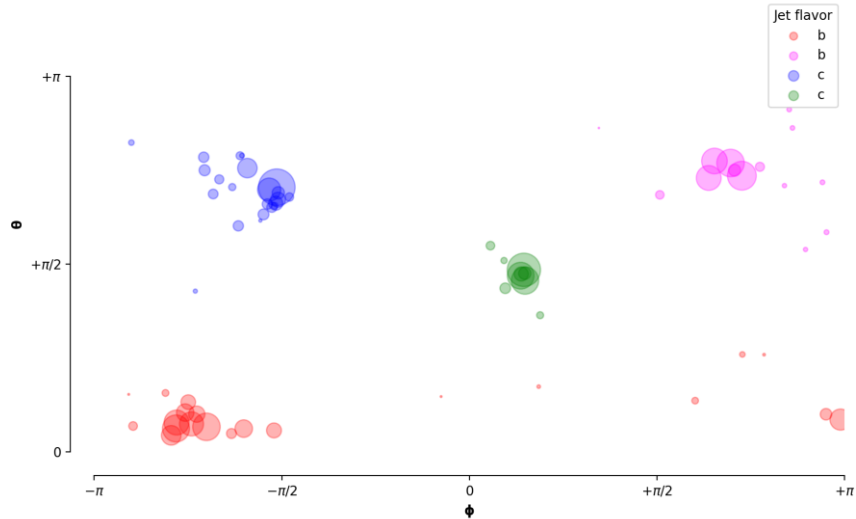


Higgs truth momentum

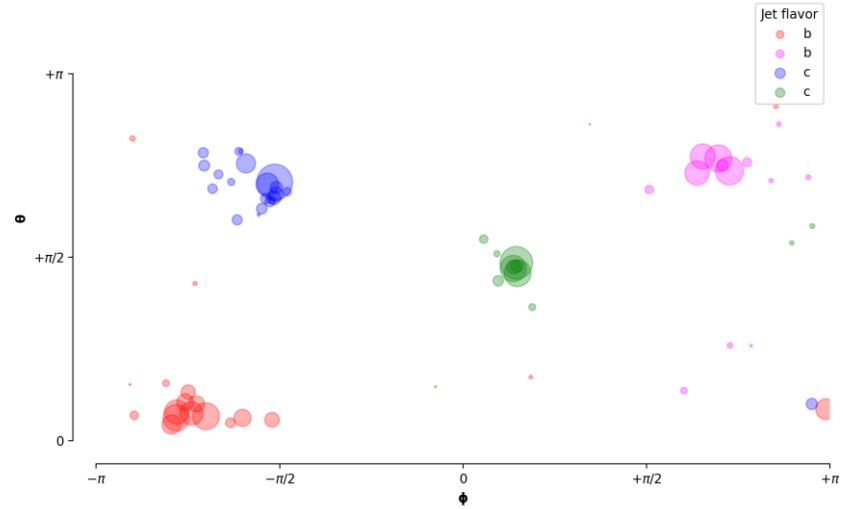


Durham-kt and anti-kt theta-phi event displays

Durham-kt 4-jets mode

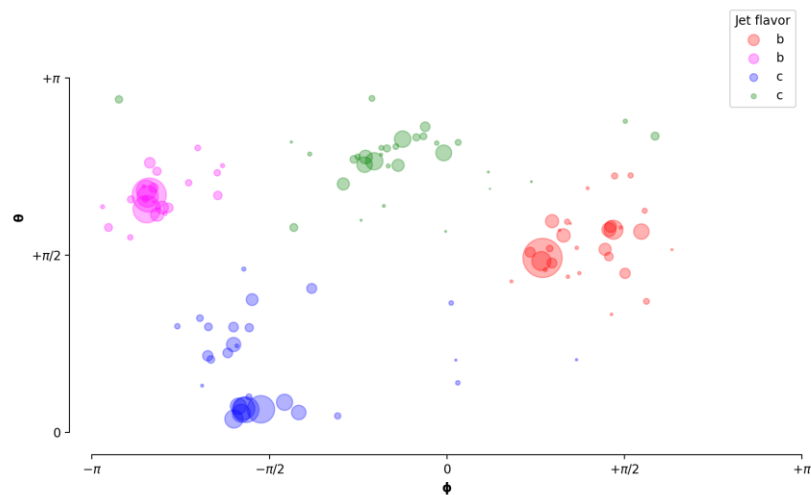


anti-kt R=1.0 with energy recovery

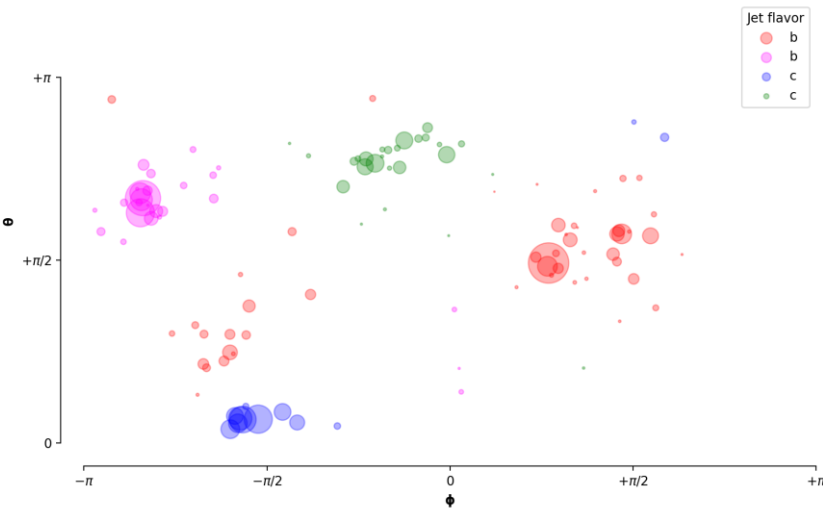


Durham-kt and anti-kt theta-phi event displays

Durham-kt 4-jets mode



anti-kt R=1.0 with energy recovery



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
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