

# Optimizing the W resonance in dijet mass

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**Pennsylvania State University**  
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Andreas Hinzmann**

PENNSSTATE

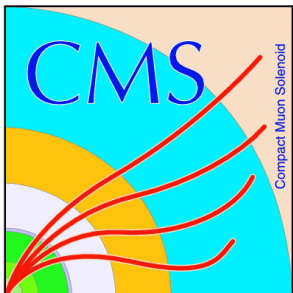


University of Michigan

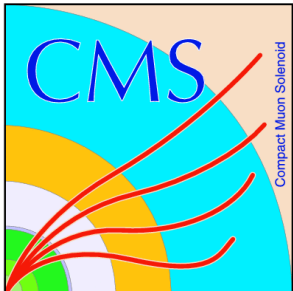
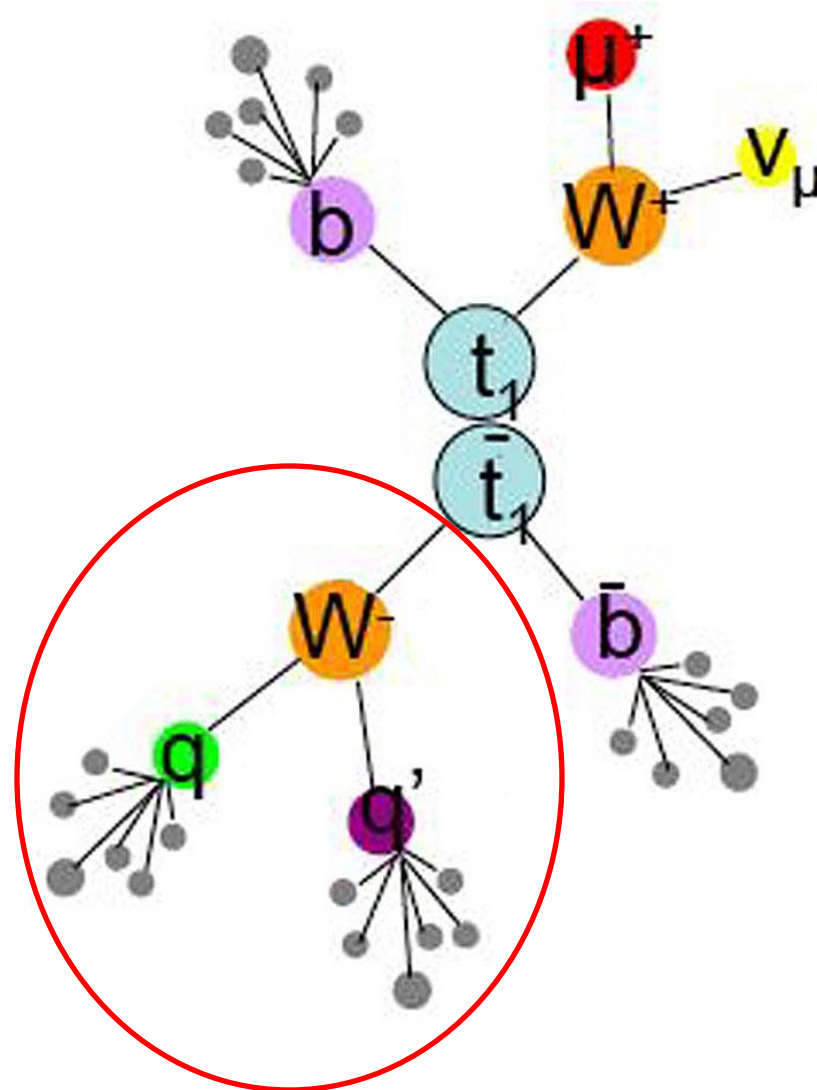


# The Goal of the Project

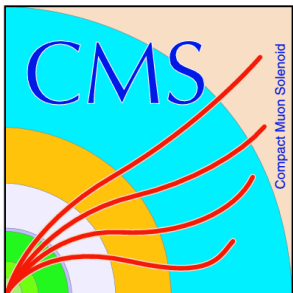
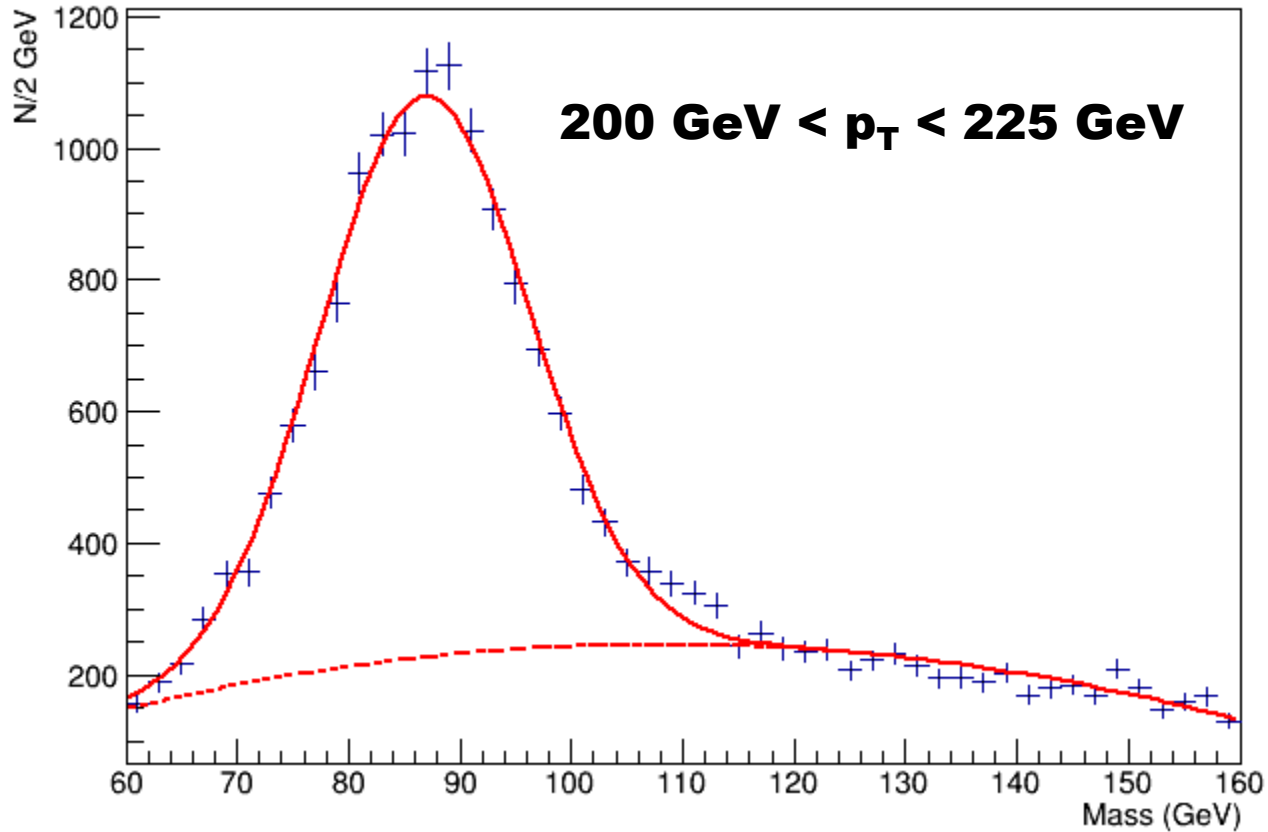
- Compare jet cone sizes and algorithms
- Identify the algorithm and parameters that gives a stable  $W$  mass and narrowest resonance
- Results will be used in talks with ATLAS to determine a common set of parameters for jet reconstruction between the experiments



# The Event



# Characterizing the W peak

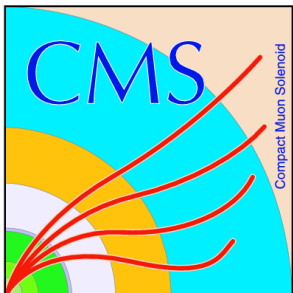


Searching for stable mean and smallest fractional width

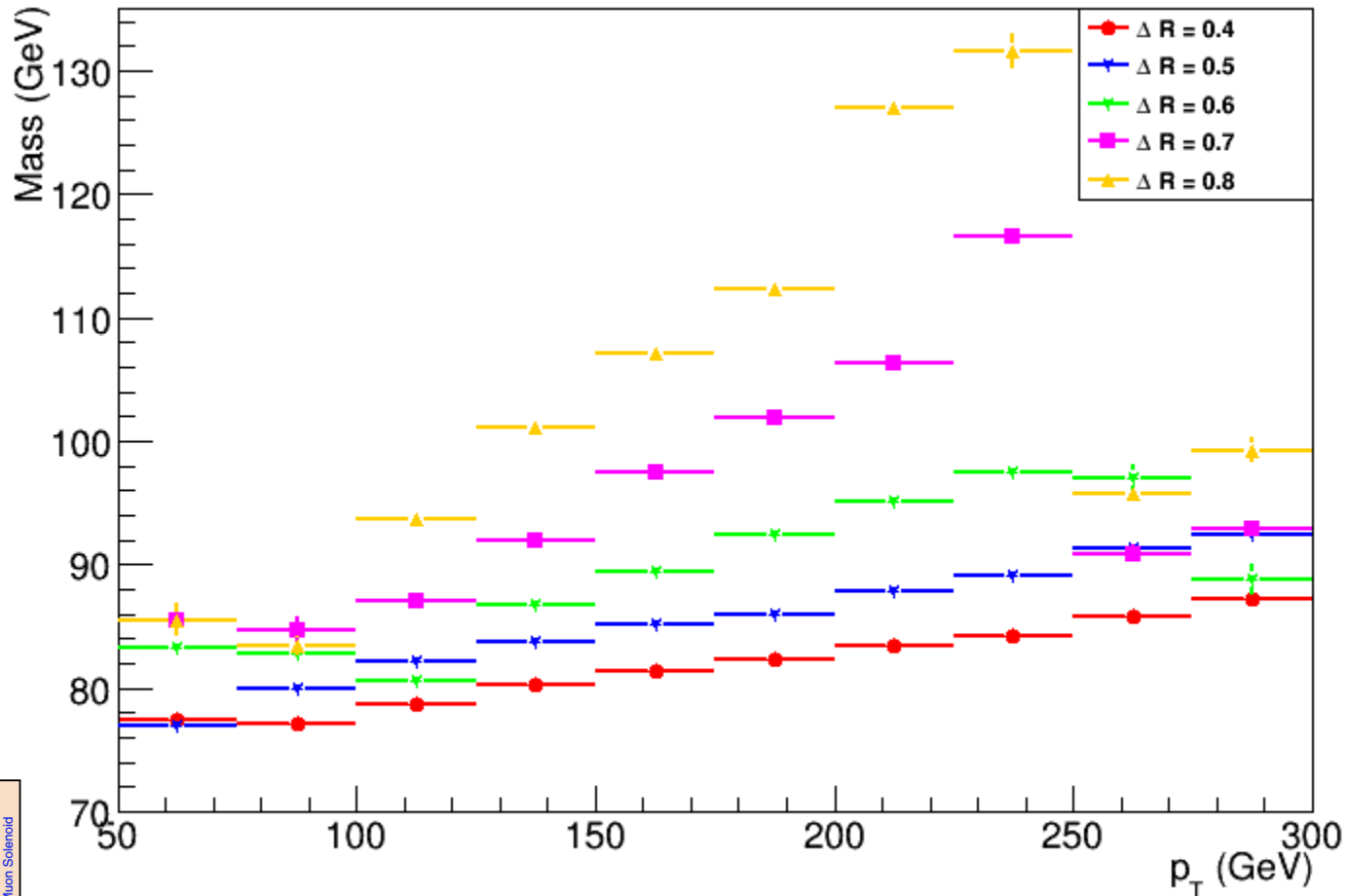
# Comparing cone sizes

- Using the anti- $k_T$  algorithm gives the most conic shape and is resistant to soft radiation
- Scanned through cone sizes from  $\Delta R = 0.4$  to  $\Delta R = 0.8$  with a resolution of 0.1

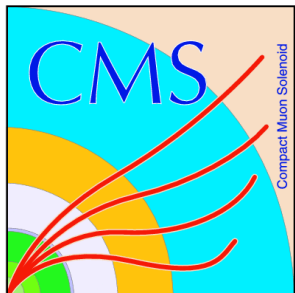
$$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$



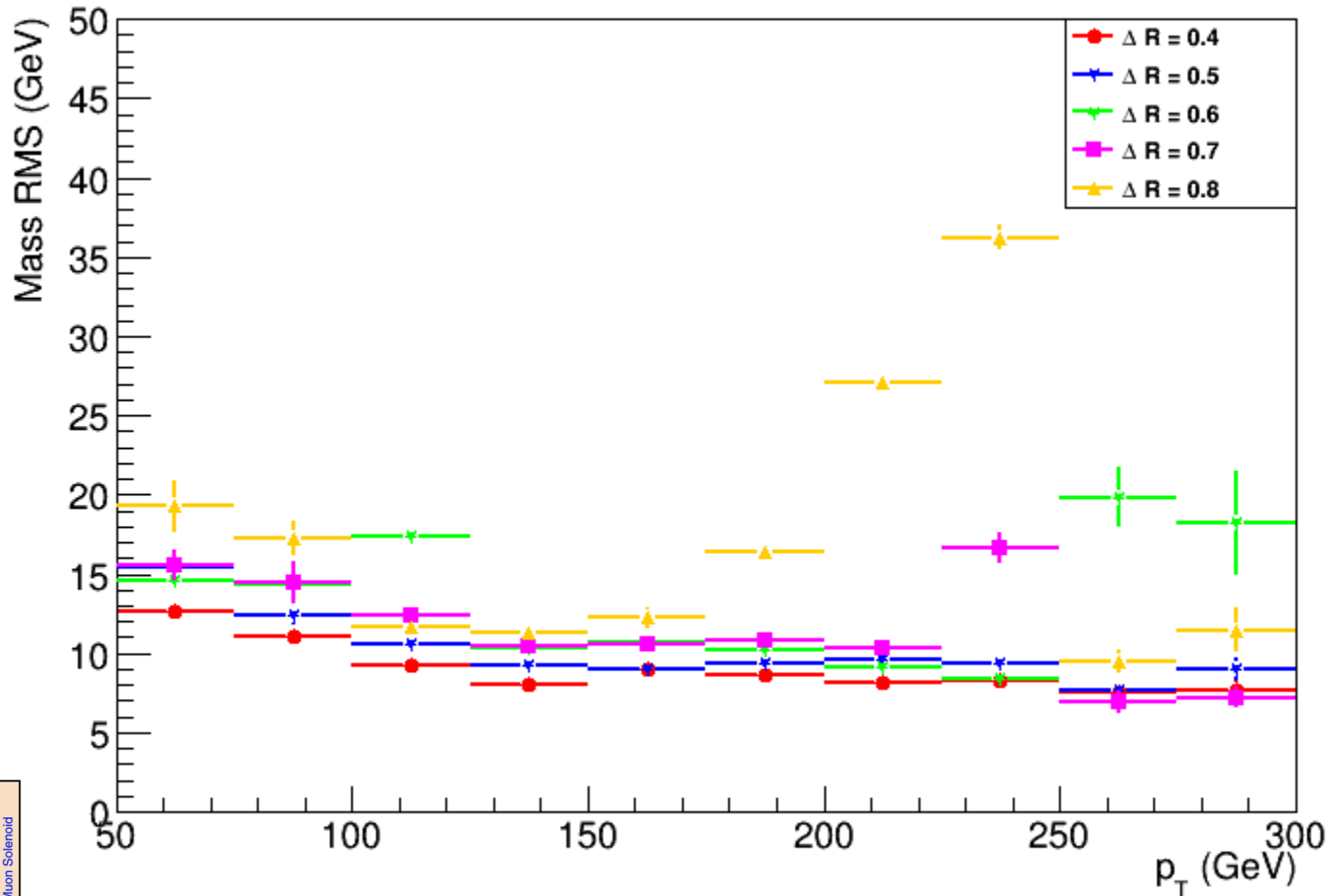
# Comparing cone sizes



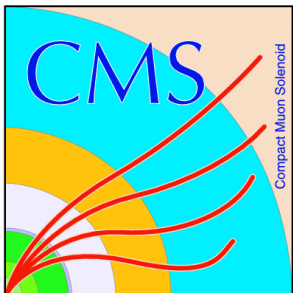
- Jump in larger cones probably due  $p_T$  cut for single jets



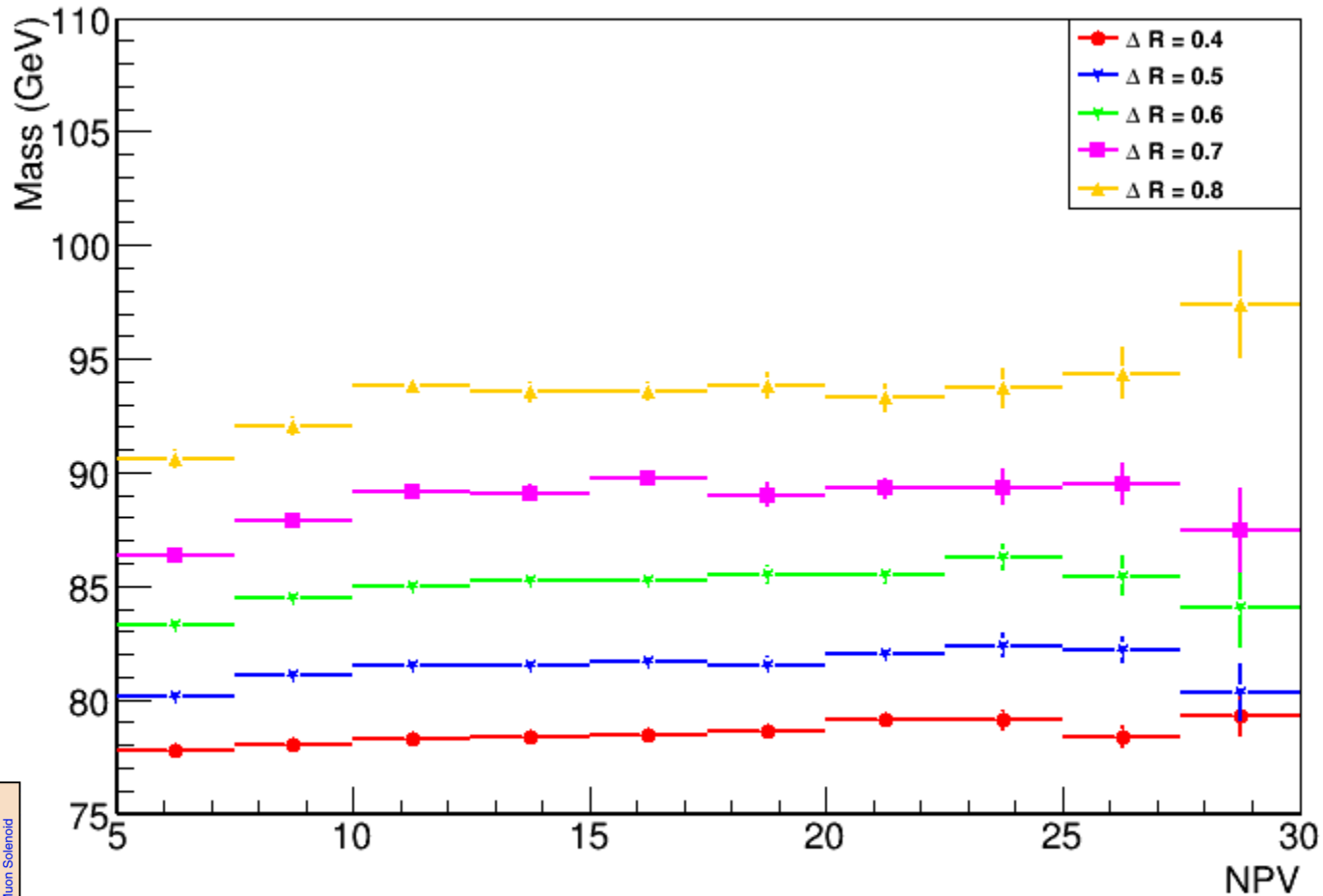
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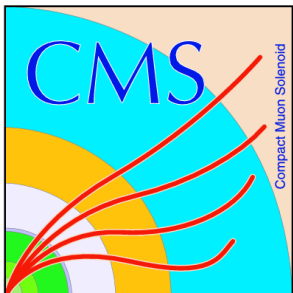
- $\Delta R = 0.4$  gives narrowest width



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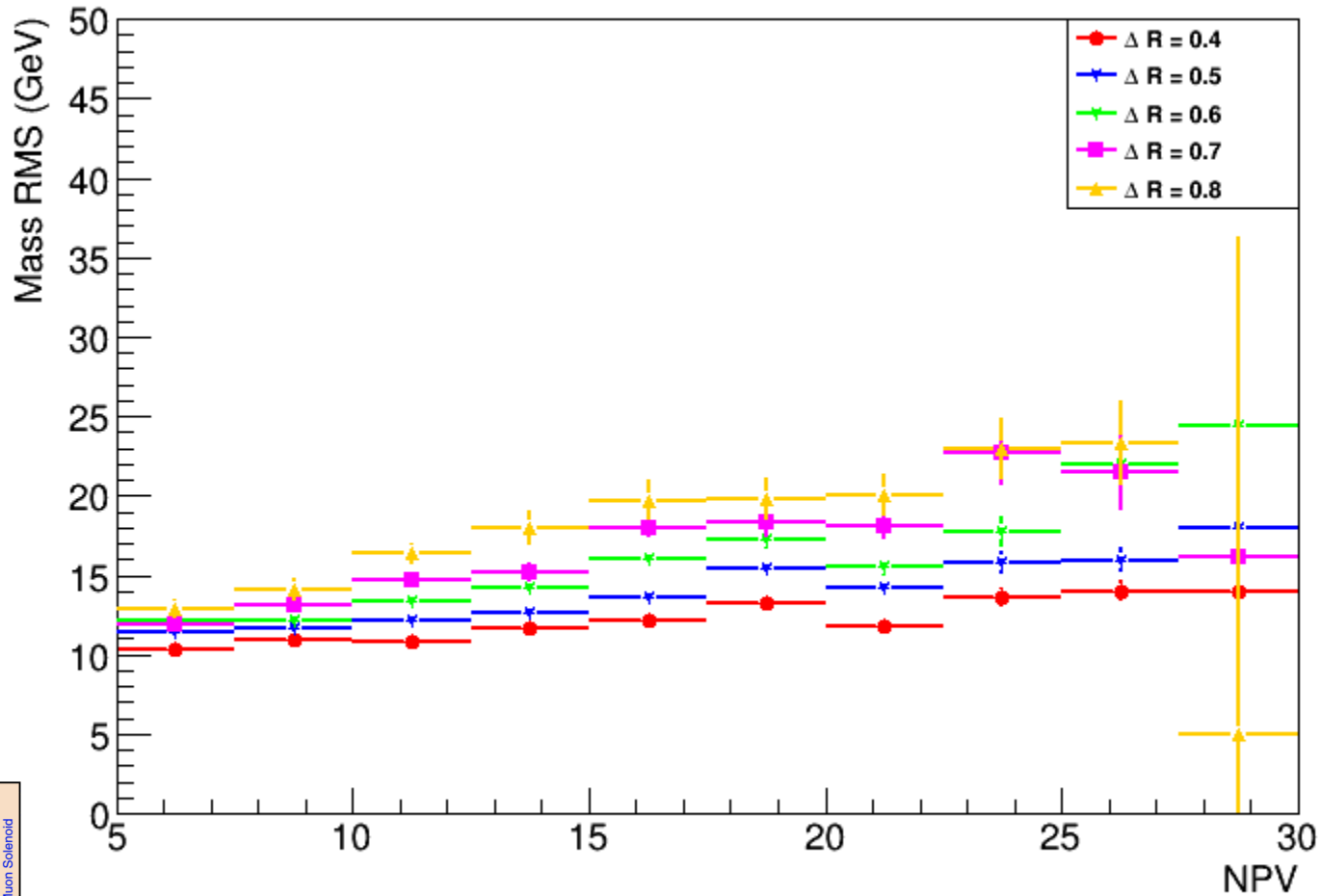


- Reasonably constant responses from each cone size

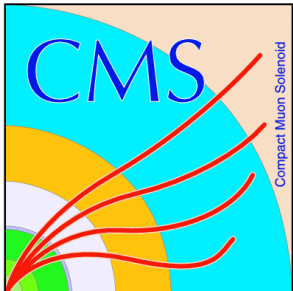




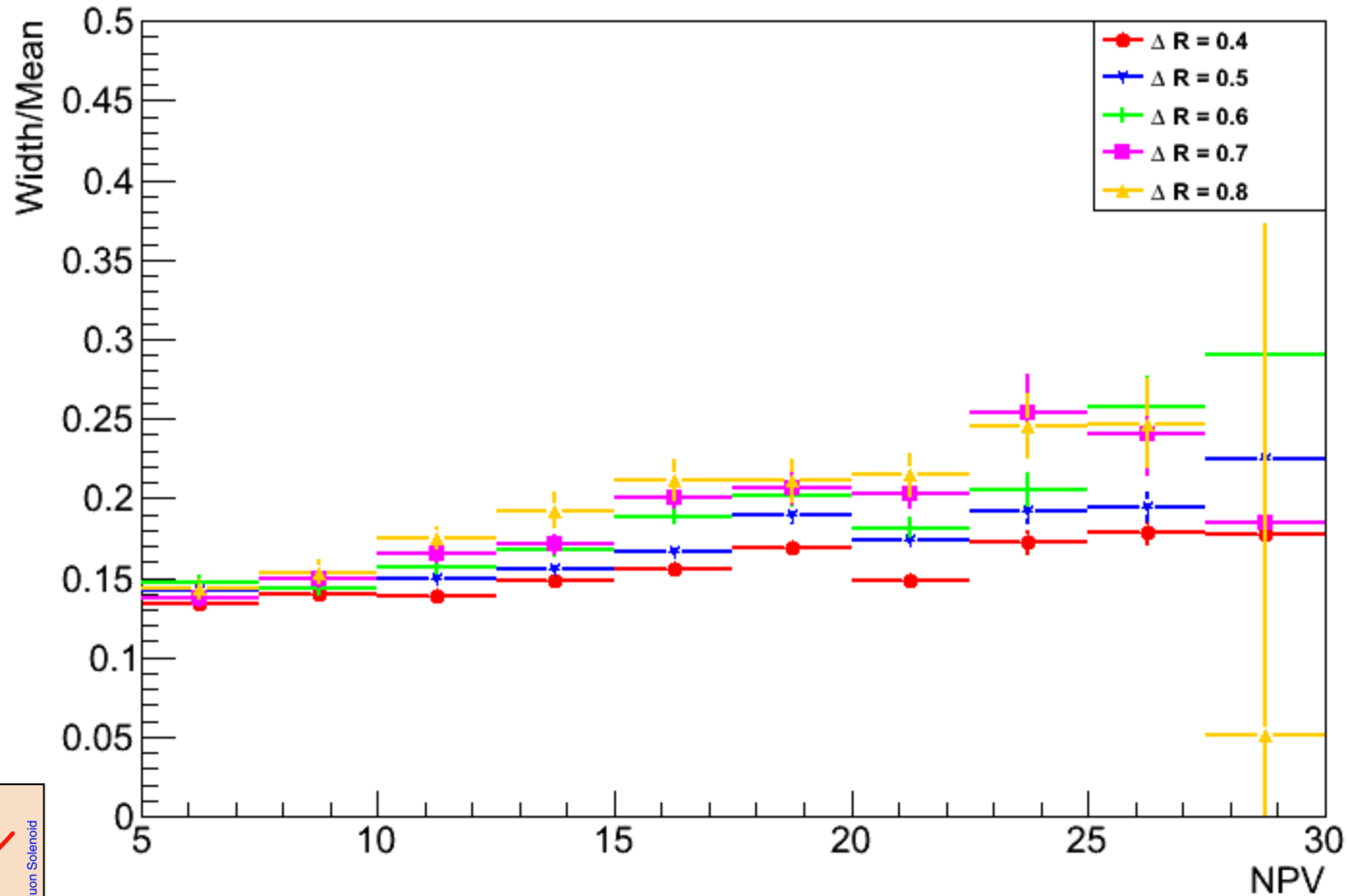
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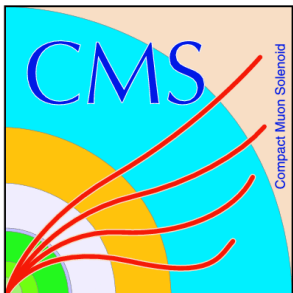
- Again,  $\Delta R = 0.4$  gives the narrowest width



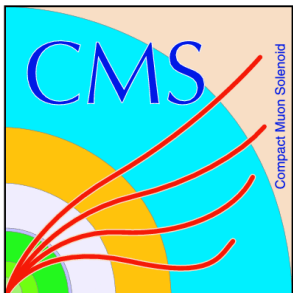
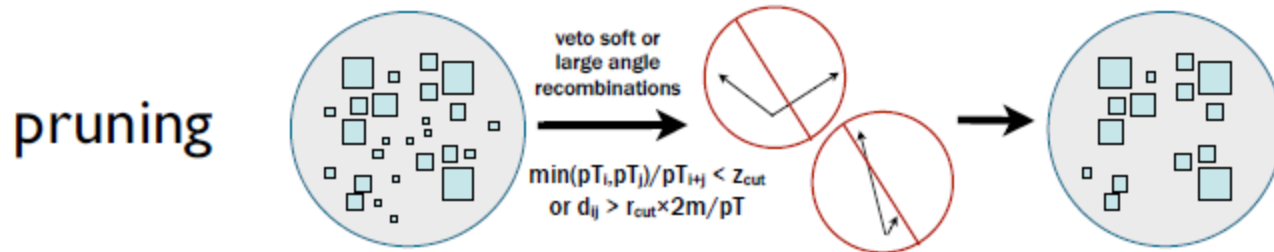
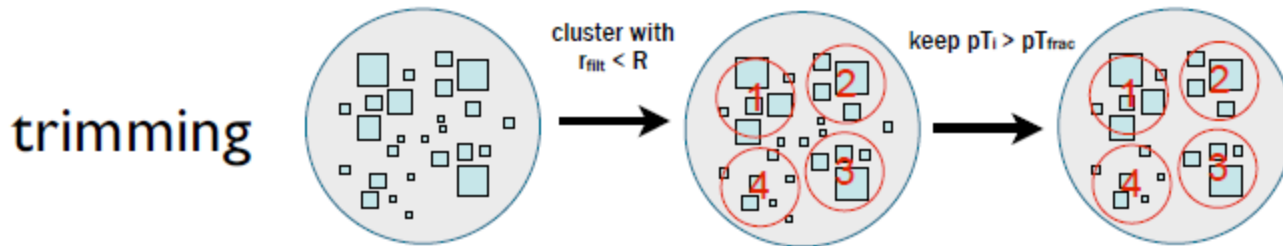
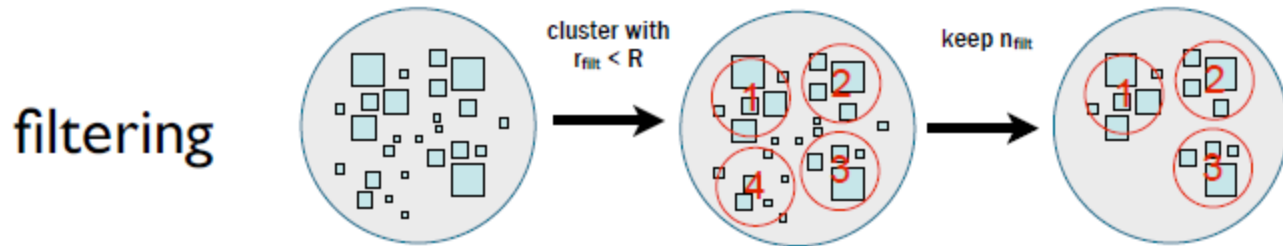
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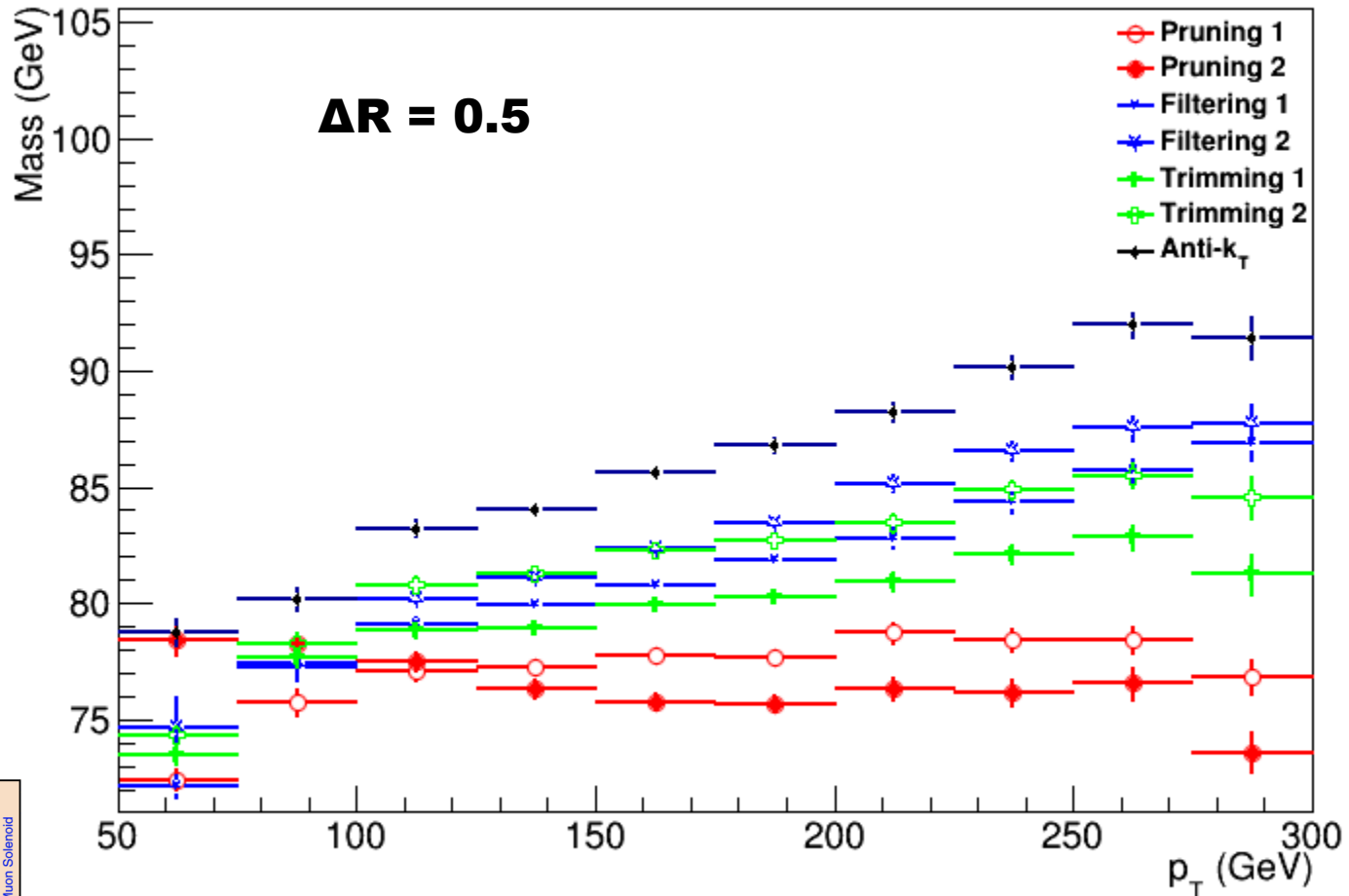
- Again,  $\Delta R = 0.4$  gives the narrowest width



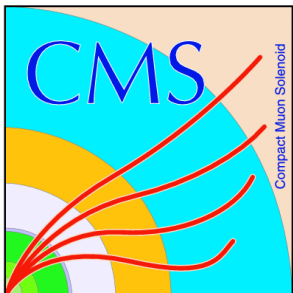
# Comparing algorithms



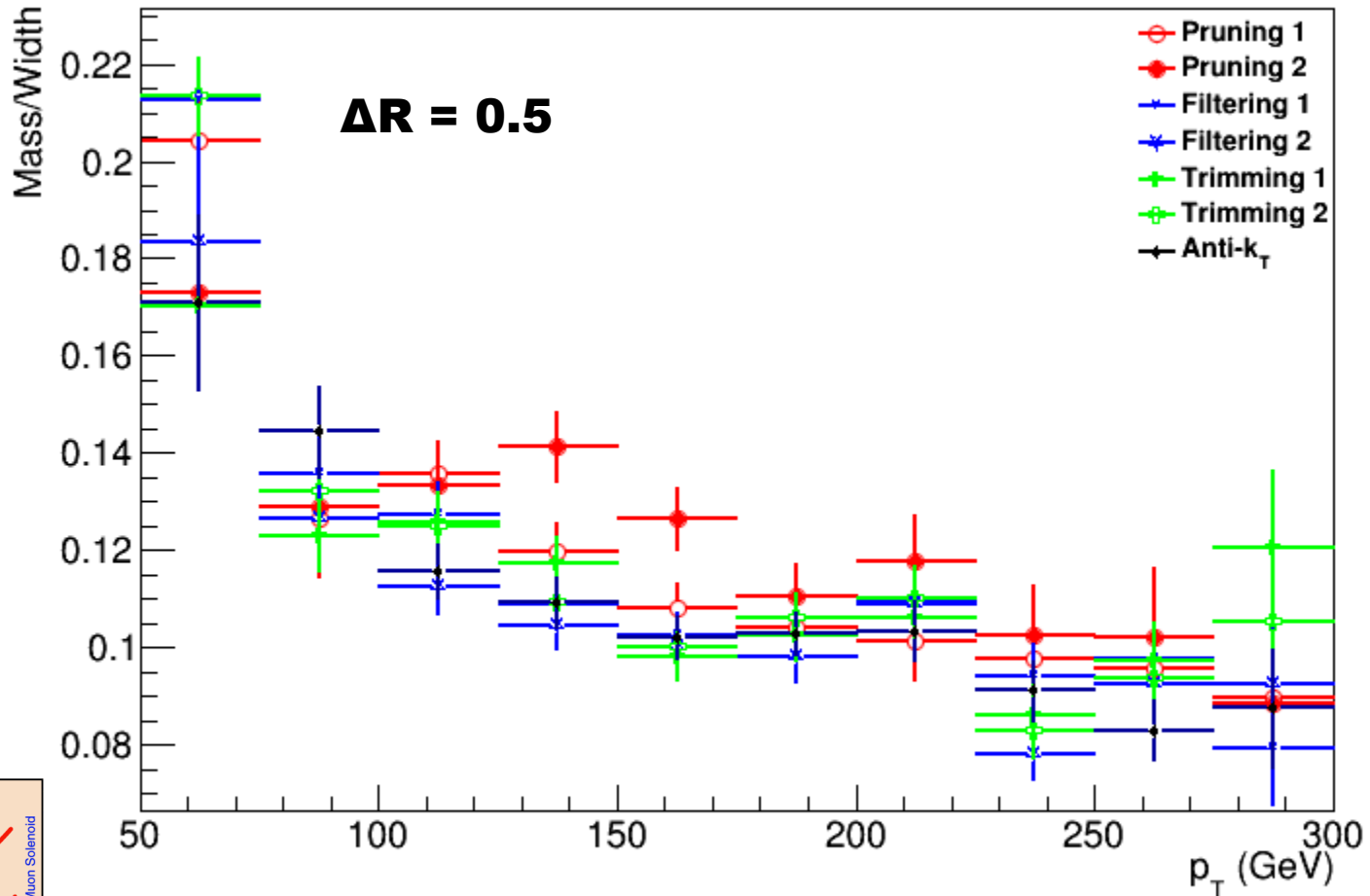
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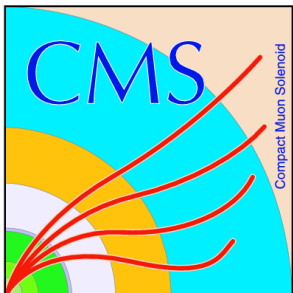
- Grooming keeps mass relatively constant compared to anti- $k_T$



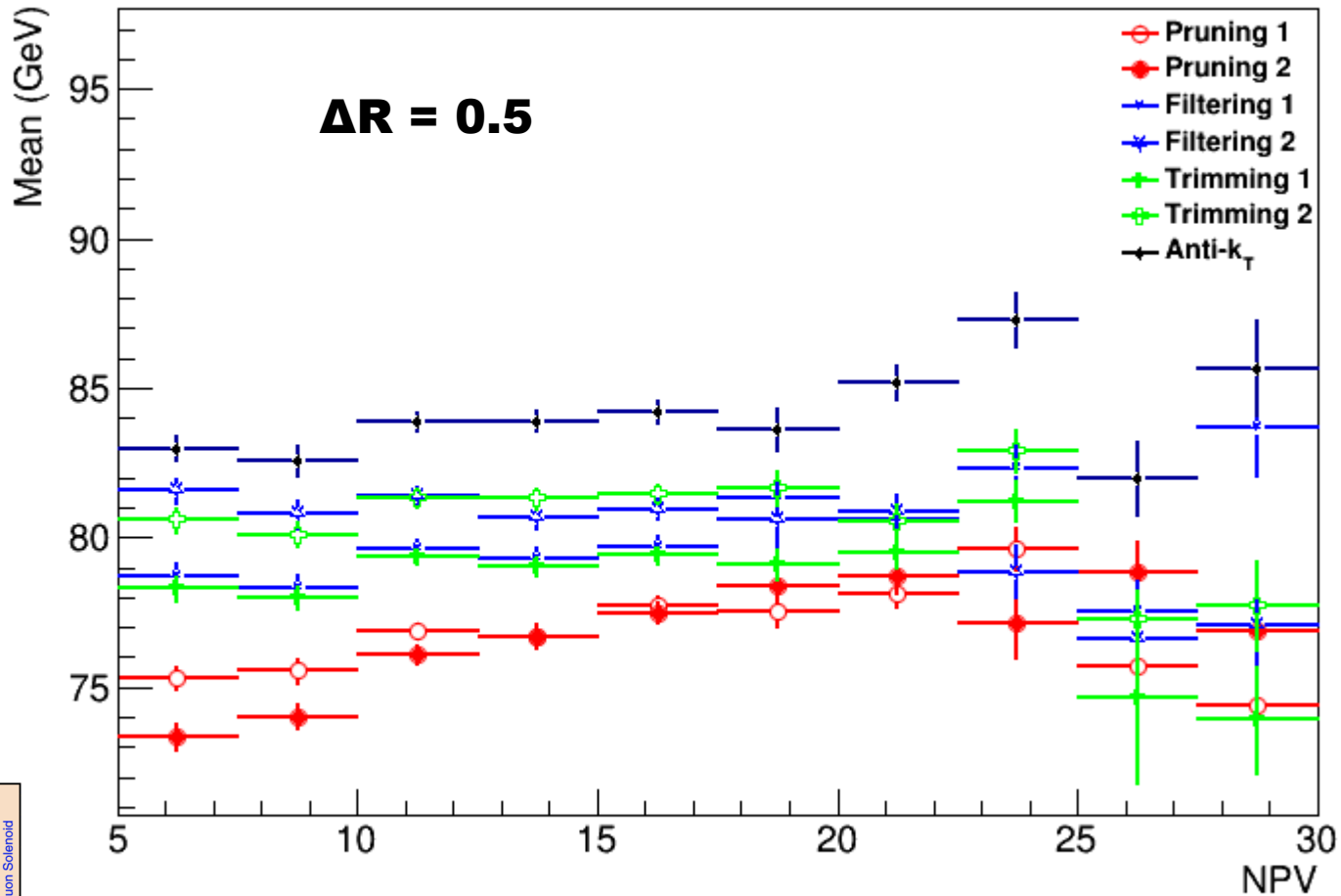
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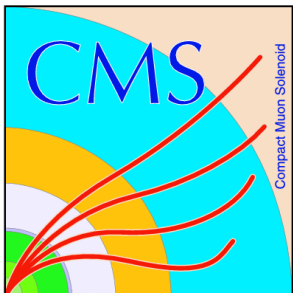
- Trimming and filtering compete for best resolution



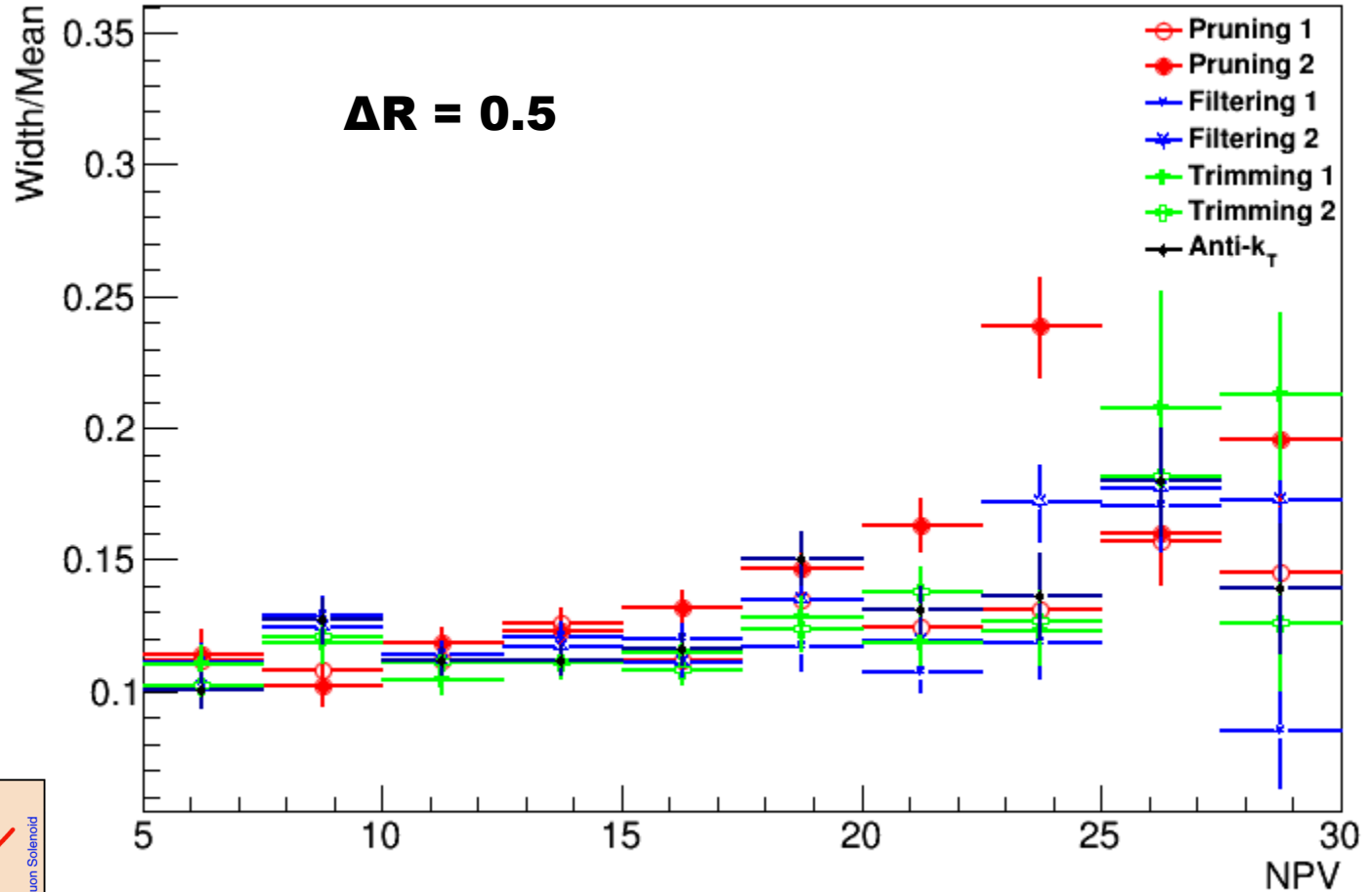
# Comparing algorithms



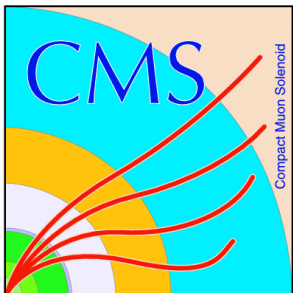
- Pruning may be too aggressive at low pileup



# Comparing algorithms

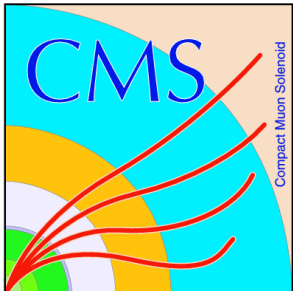


- Trimming and filtering compete for best resolution



# Conclusions

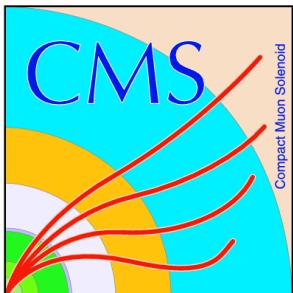
- Smaller cone sizes give the best mass resolution with a reasonably small response
- Pruning looks like it might be too aggressive
- Current plots should be improved by finding ways to increase the efficiency of picking the correct jets



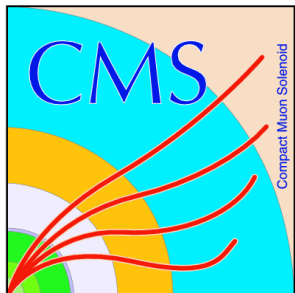


# Future work

- Explore additional parameter space of the algorithms
- Look at the effects of jet reconstruction on the top quark mass
- Work on selection cuts and parameters to increase the efficiency of selecting the correct jet

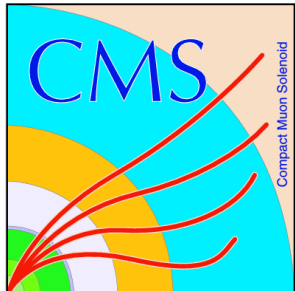
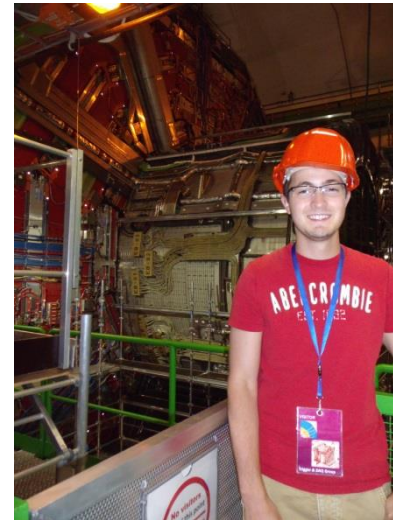
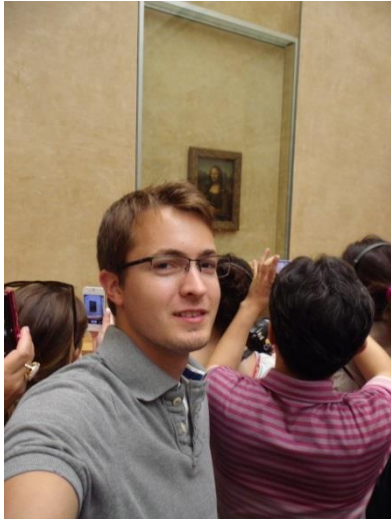


# Thank you!



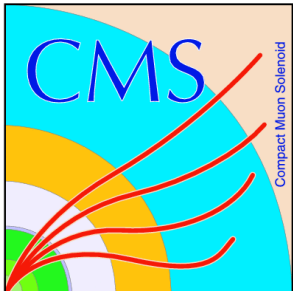
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# Thank you!



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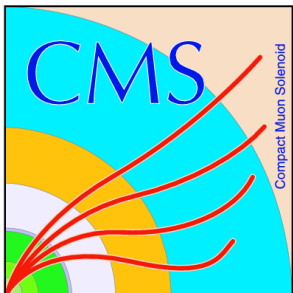
# Backup Slides



# Selection criteria jets

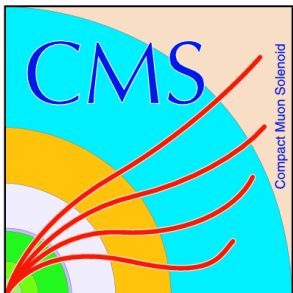
- Events must have at least two b tagged jets and one isolated muon with  $p_T > 10$  GeV and  $|\eta| < 2.4$
- Two jets with  $p_T > 20$  GeV and the highest combined secondary vertex values were selected as the b jets
- Other jets were in the opposite hemisphere from the muon, MET, and b tagged jet closer to the muon

$$\text{i.e. } \vec{p}_{jet} \cdot (\vec{p}_{\mu} + \vec{p}_{MET} + \vec{p}_b) < 0$$



# Selection criteria jets (cont.)

- Single jets were picked with the following cuts:  
 $p > 200 \text{ GeV}$ ;  $\text{mass} > 60 \text{ GeV}$ ;  $\text{MET} > 30 \text{ GeV}$ 
  - MET cut helps ensure boosted tops
- If there were no single jets, the dijet system with the highest  $p_T$  jets with a invariant mass of  $30 \text{ GeV} < m < 250 \text{ GeV}$  is picked



# Comparing algorithms

- Pruning

tight:  $n_{\text{subjets}}=2$ ,  $z_{\text{cut}}=0.1$ ,  $d_{\text{cut factor}}=0.5$ , algo = CA

loose:  $n_{\text{subjets}}=2$ ,  $z_{\text{cut}}=0.1$ ,  $d_{\text{cut factor}}=0.2$ , algo = CA

- Filtering

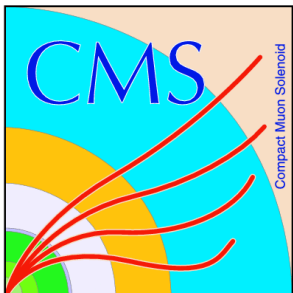
tight:  $r_{\text{filt}}=0.2$ ,  $n_{\text{filt}}=3$ , algo = CA

loose:  $r_{\text{filt}}=0.3$ ,  $n_{\text{filt}}=3$ , algo = CA

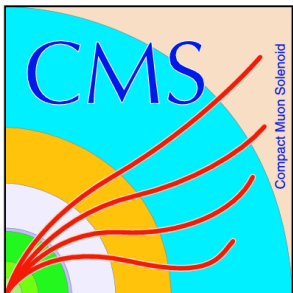
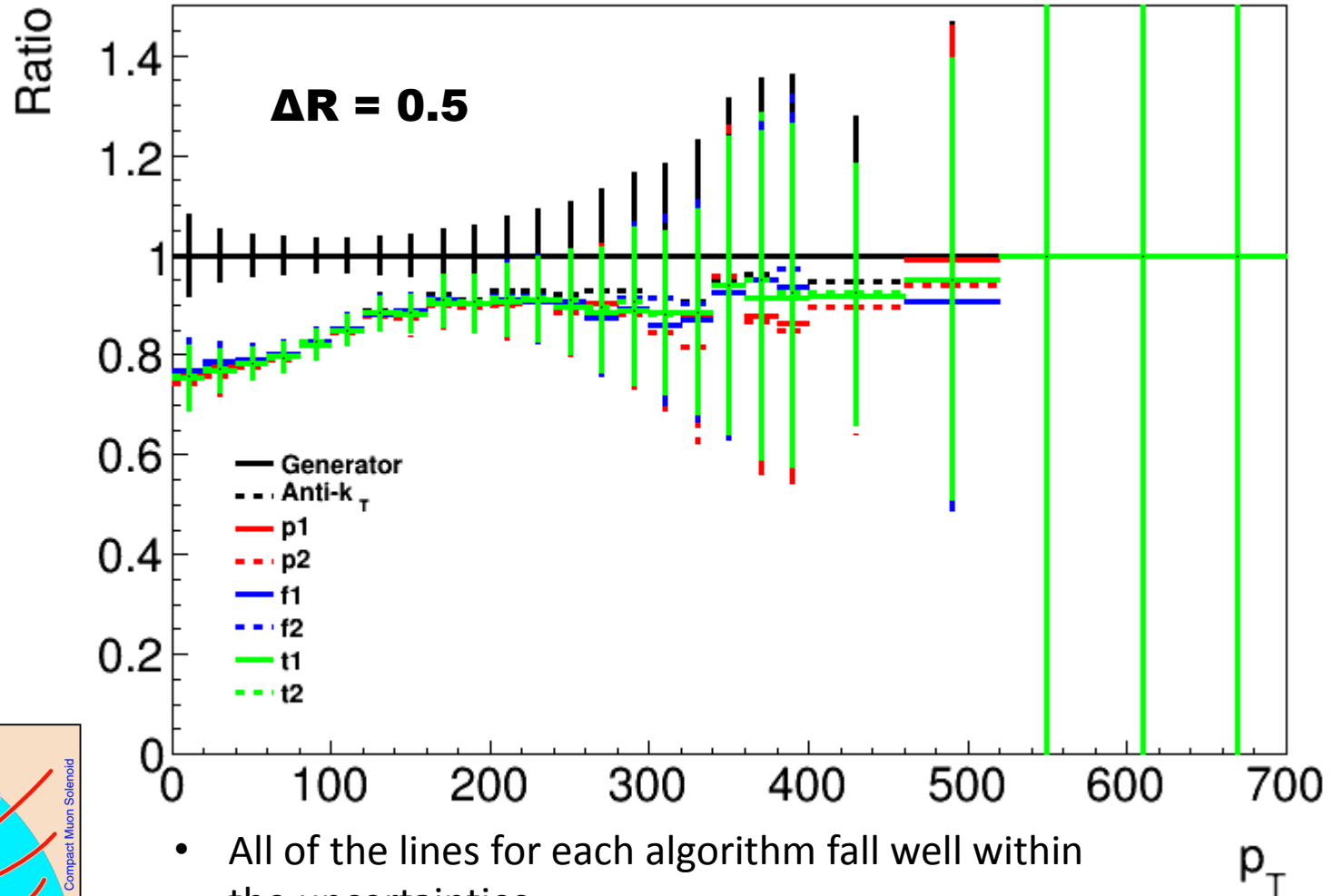
- Trimming

tight:  $r_{\text{trim}}=0.2$ ,  $pT_{\text{frac}}=0.05$ , algo = CA

loose:  $r_{\text{trim}}=0.2$ ,  $pT_{\text{frac}}=0.03$ , algo = CA

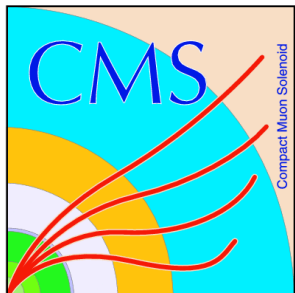
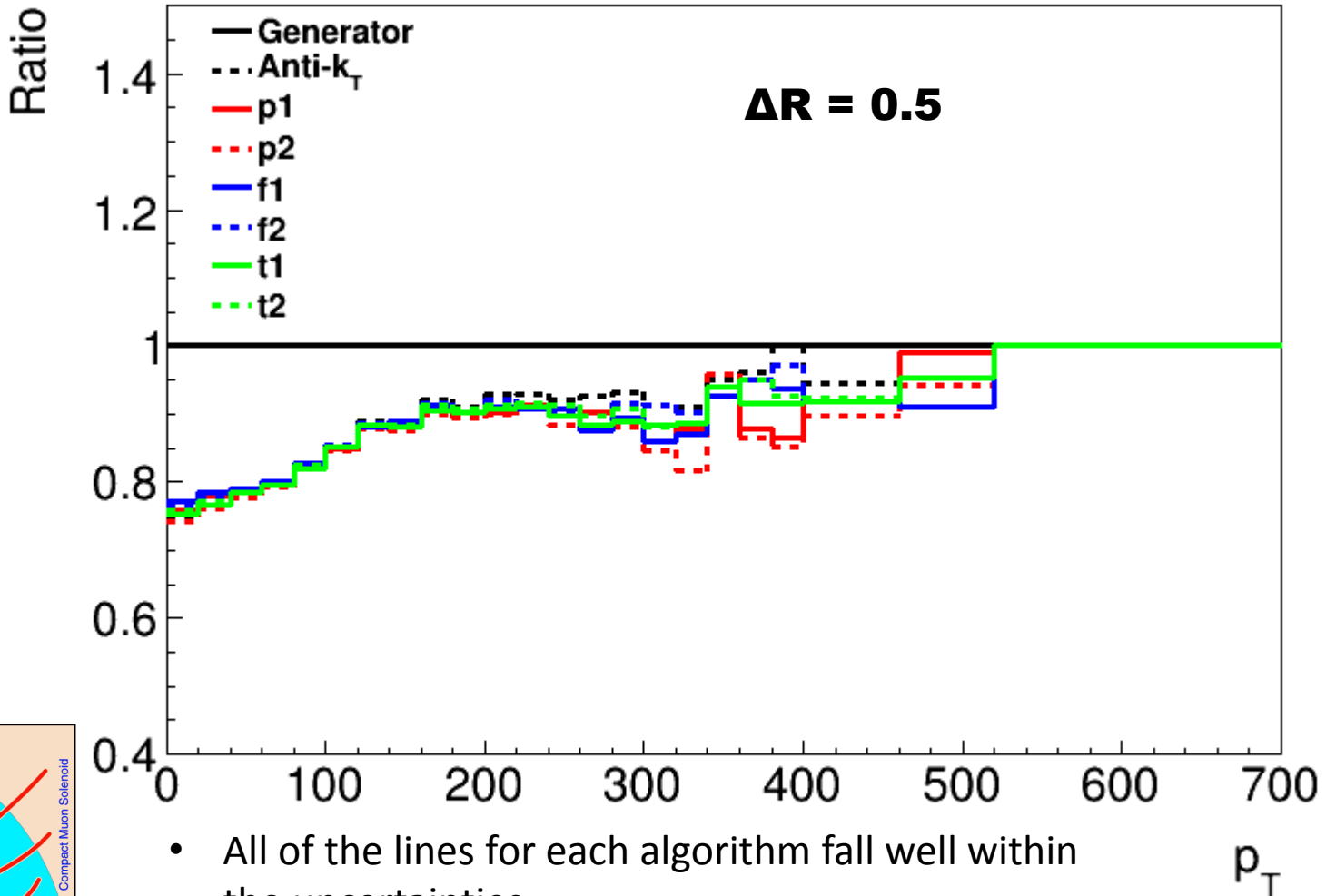


# Other measures of efficiency

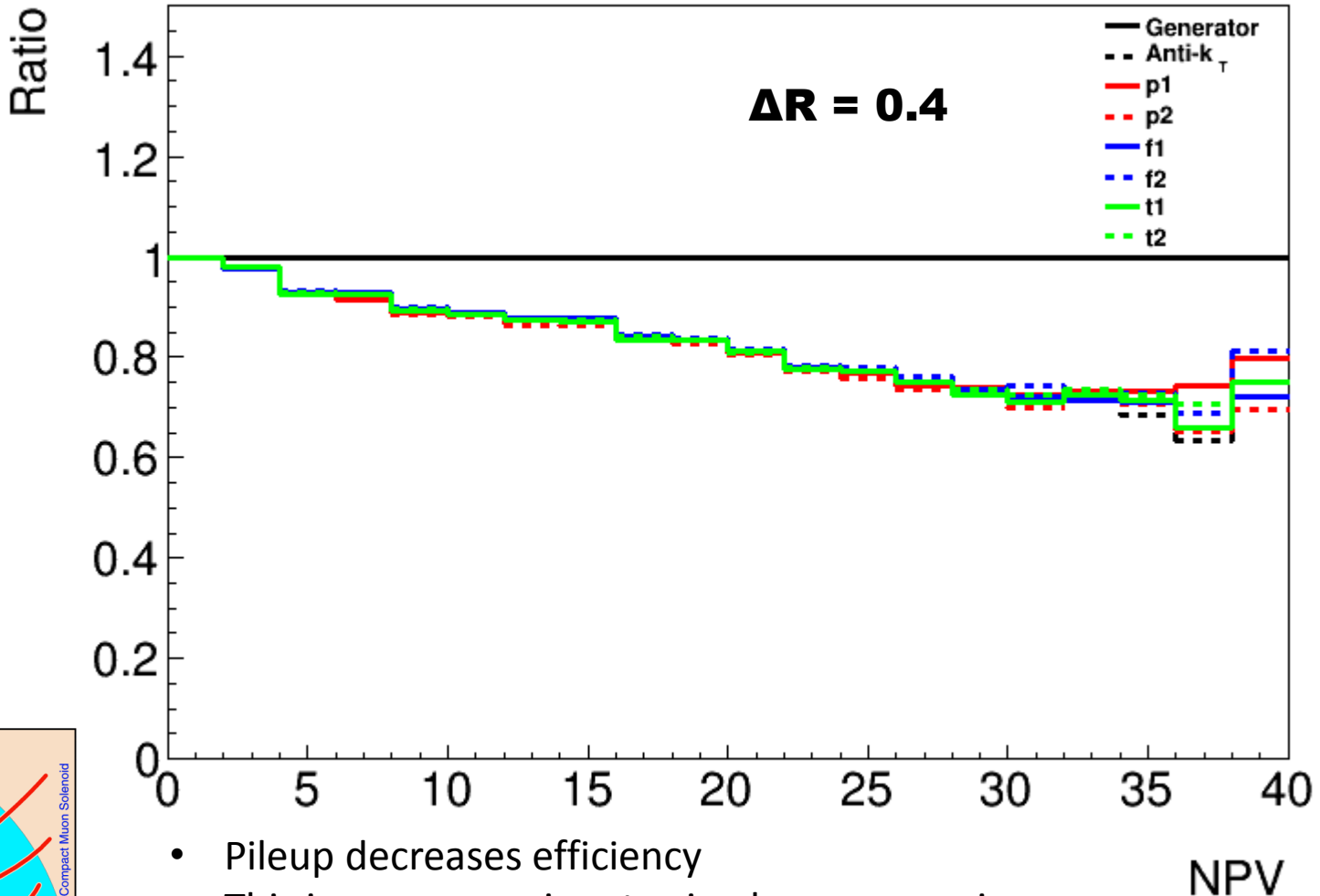




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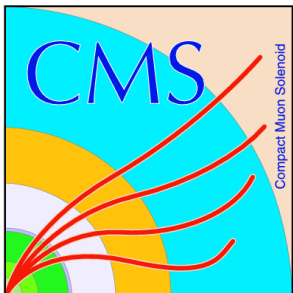


# Effects of PU

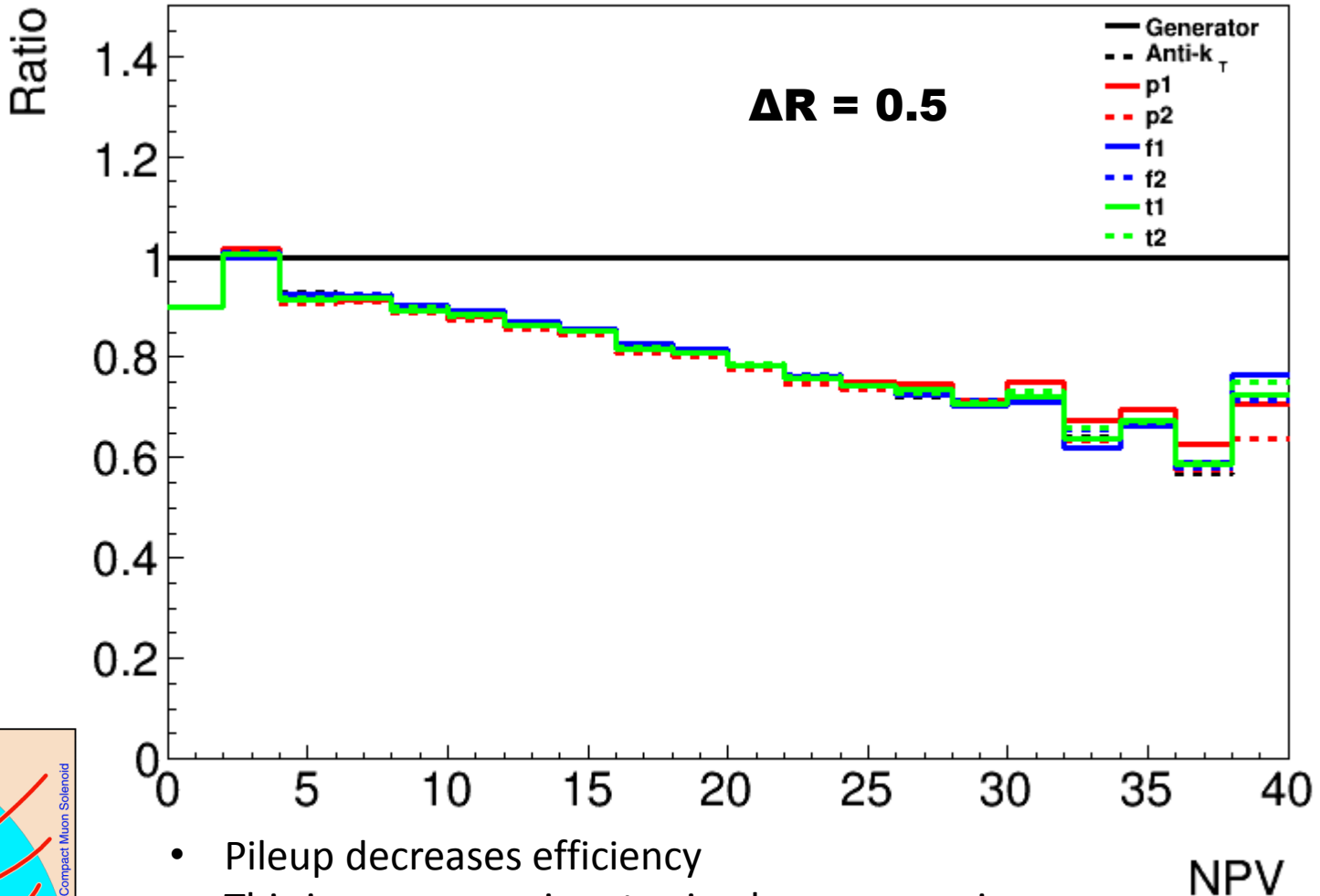


- Pileup decreases efficiency
- This is more prominent using larger cone sizes

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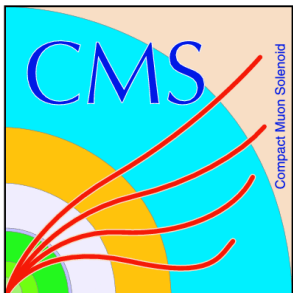


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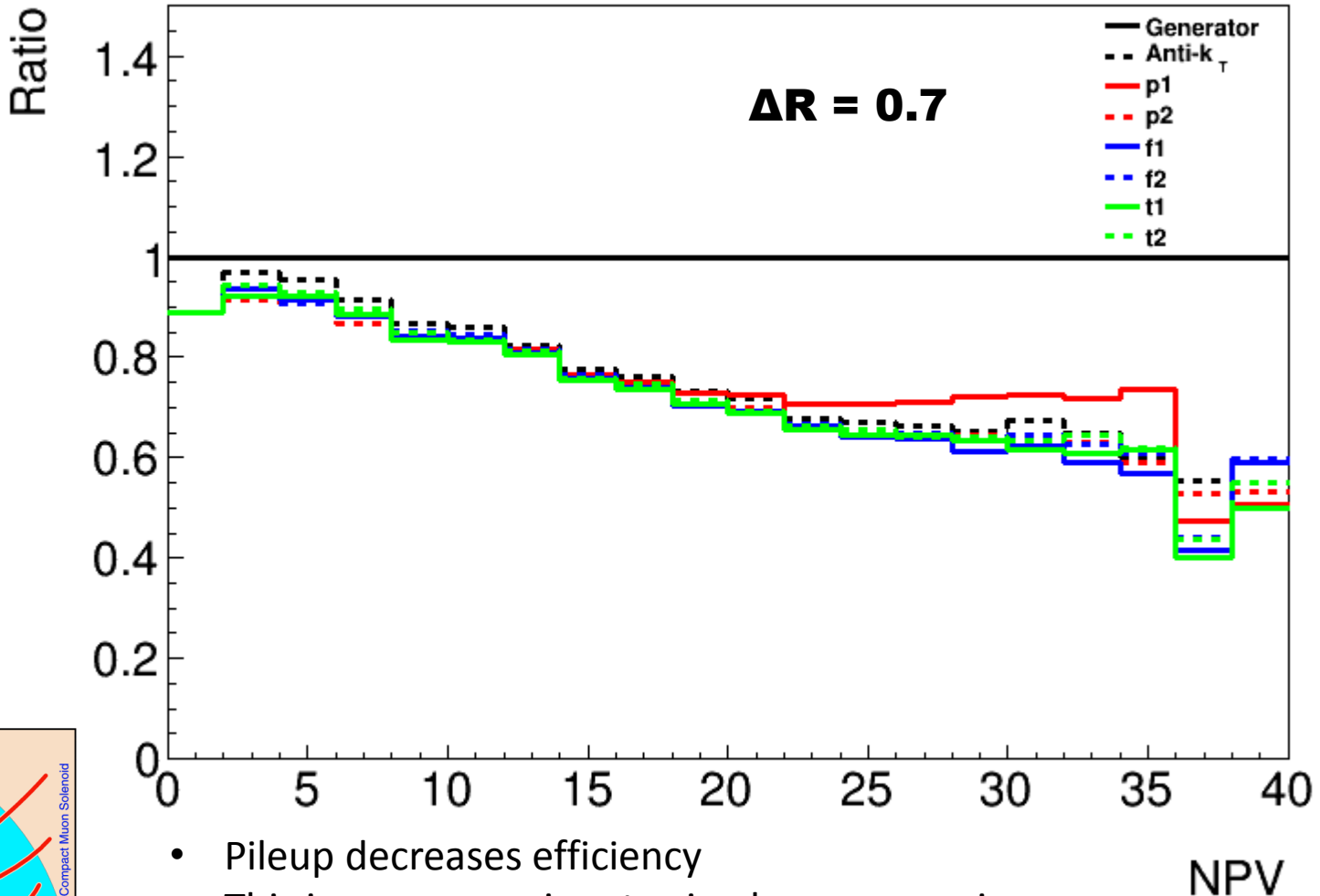


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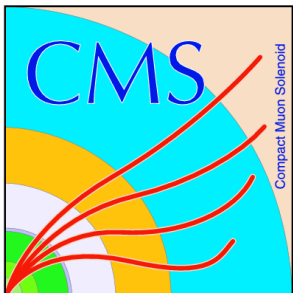


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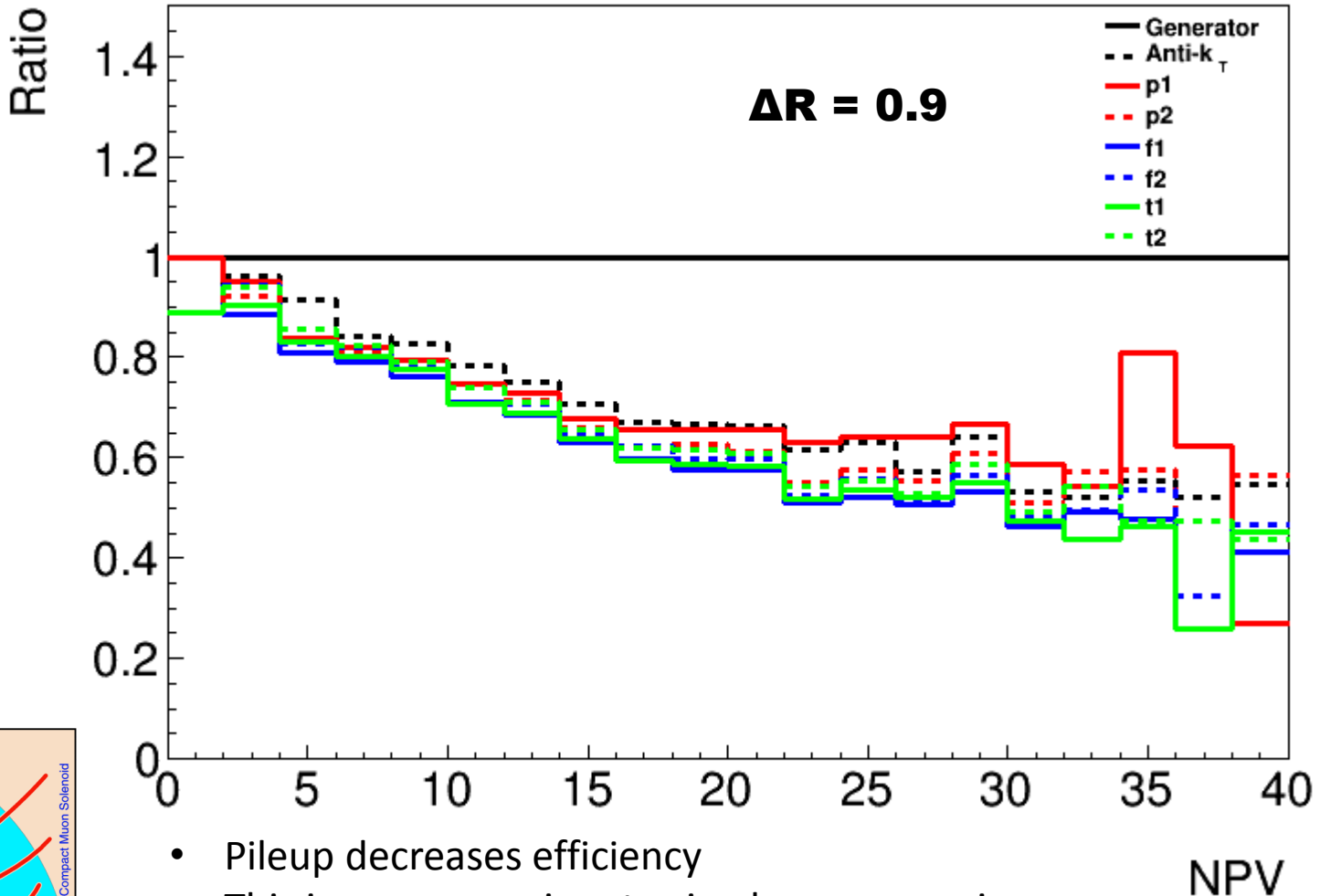


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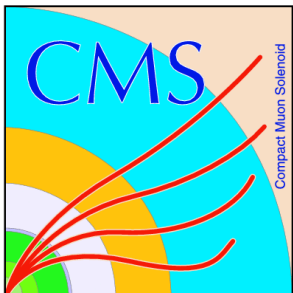


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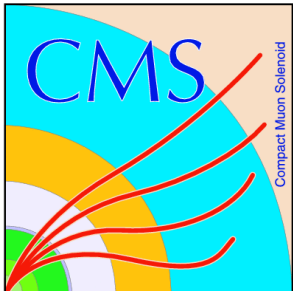
# PU jets simulation

$$\frac{d\sigma}{dp_T} \propto p_T^{-5}; p_T > 3 \text{ GeV}$$

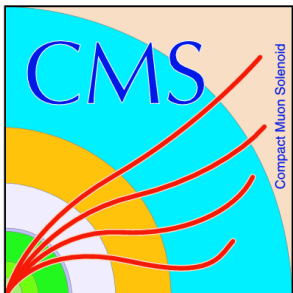
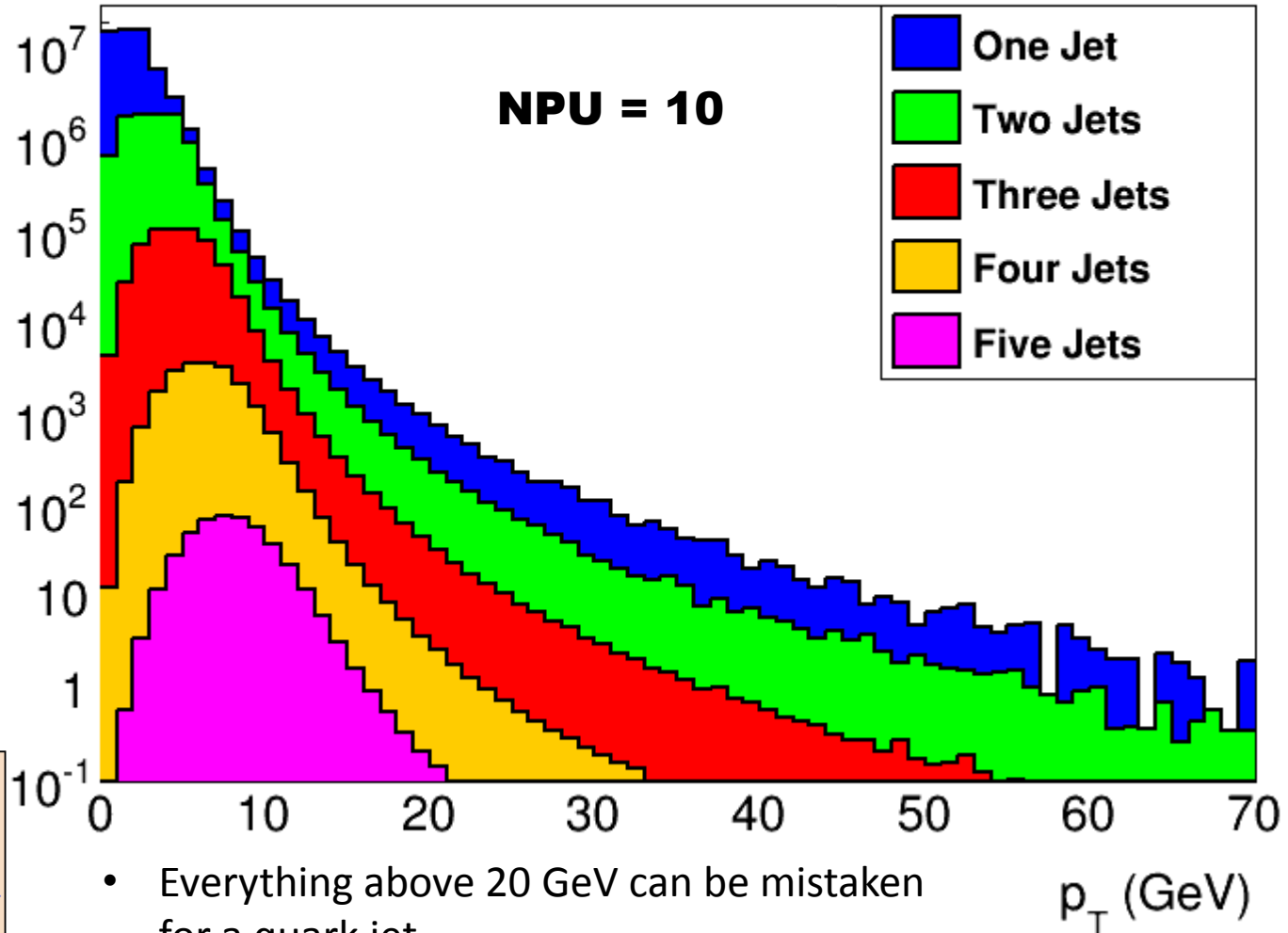
$$\frac{d\sigma}{dp_T} = mp_T + b; 0 \text{ GeV} < p_T < 3 \text{ GeV}$$

**Weighting:**  $\frac{A_{jet}}{A_{CMS}} \approx 0.0125$

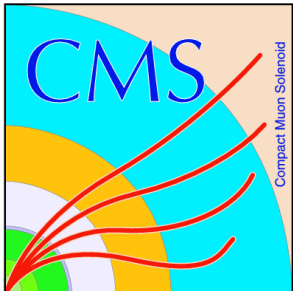
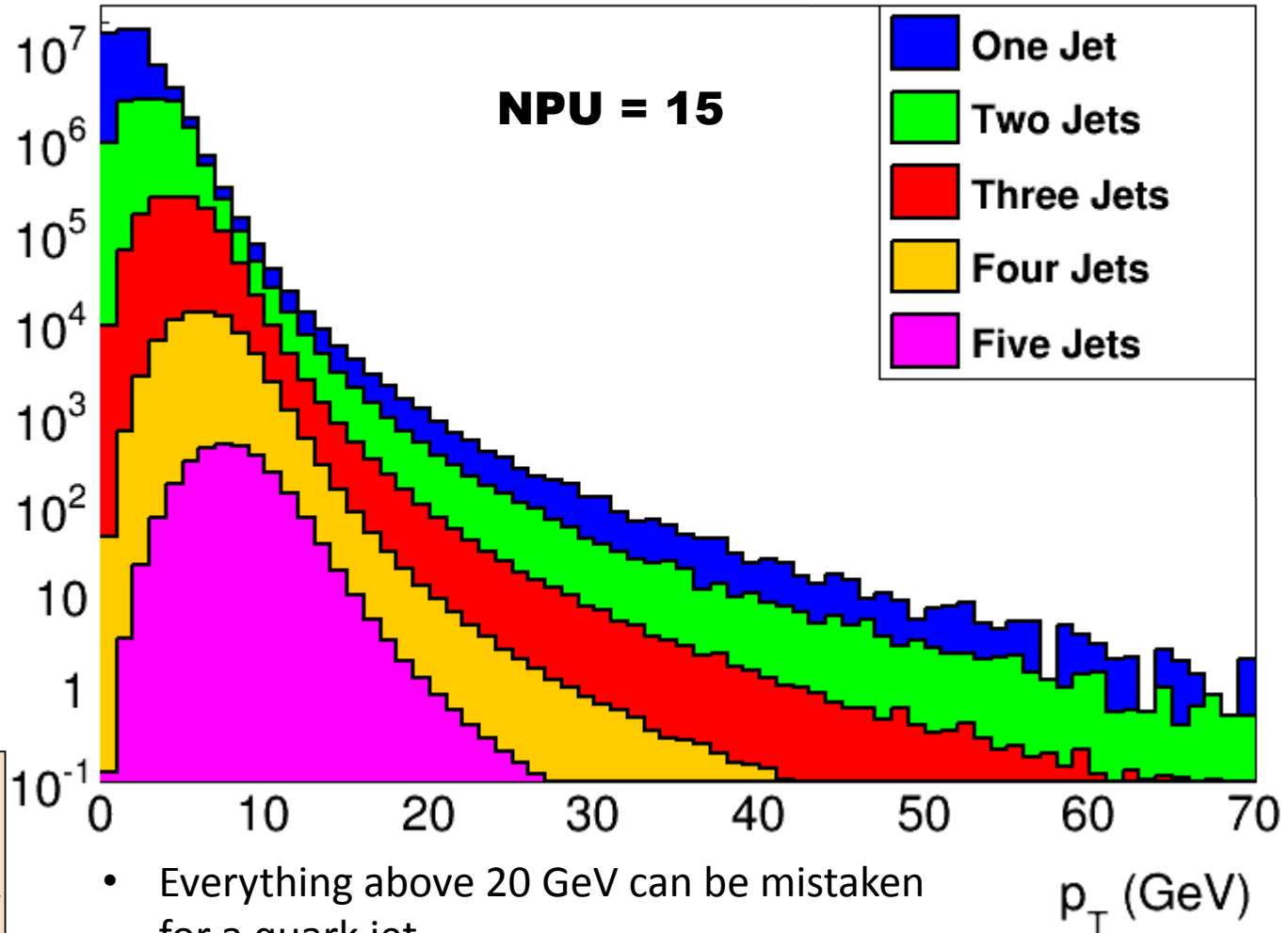
$$w(NPU, n_{jets}) = \frac{NPU!}{(NPU - n_{jets})! n_{jets}!} (0.0125)^{n_{jets}} (0.9875)^{NPU - n_{jets}}$$



# PU jets simulation

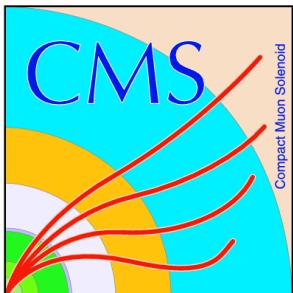
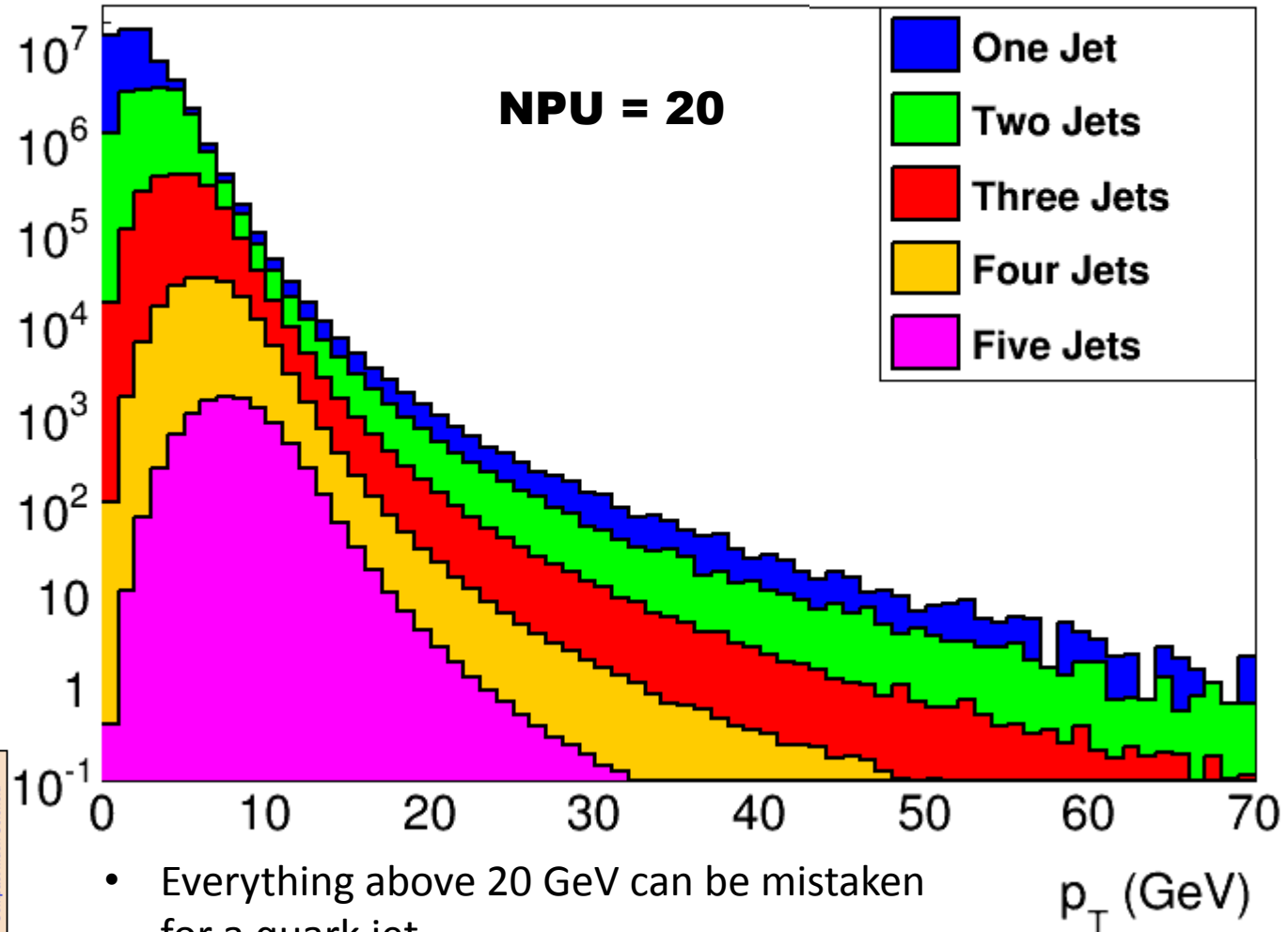


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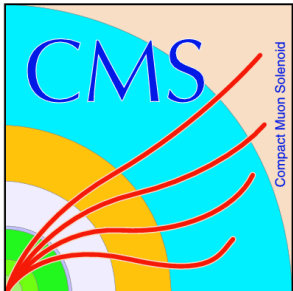
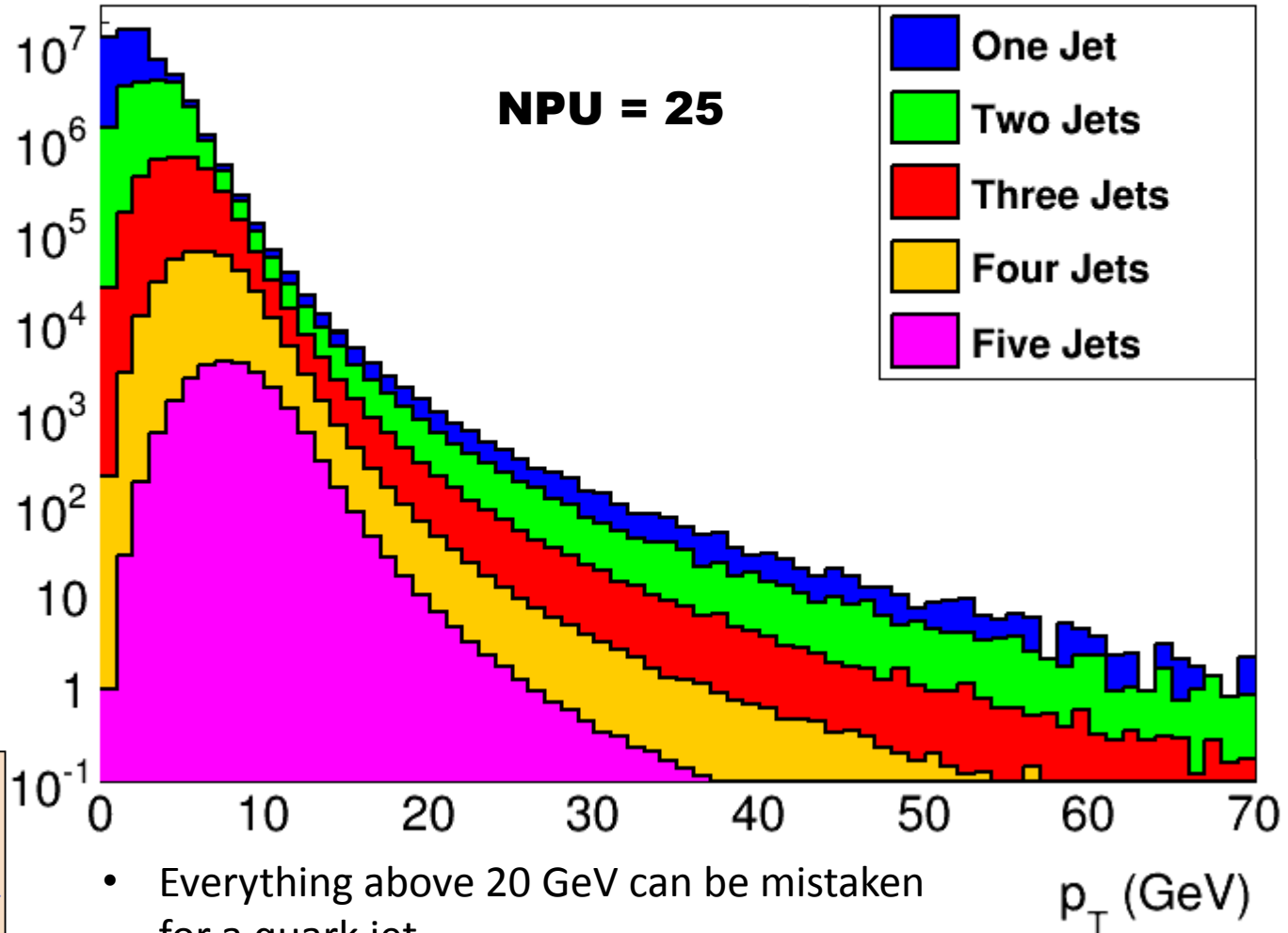




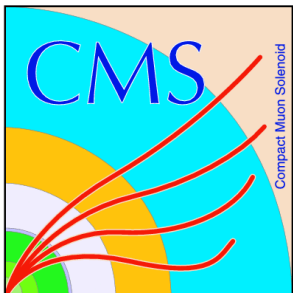
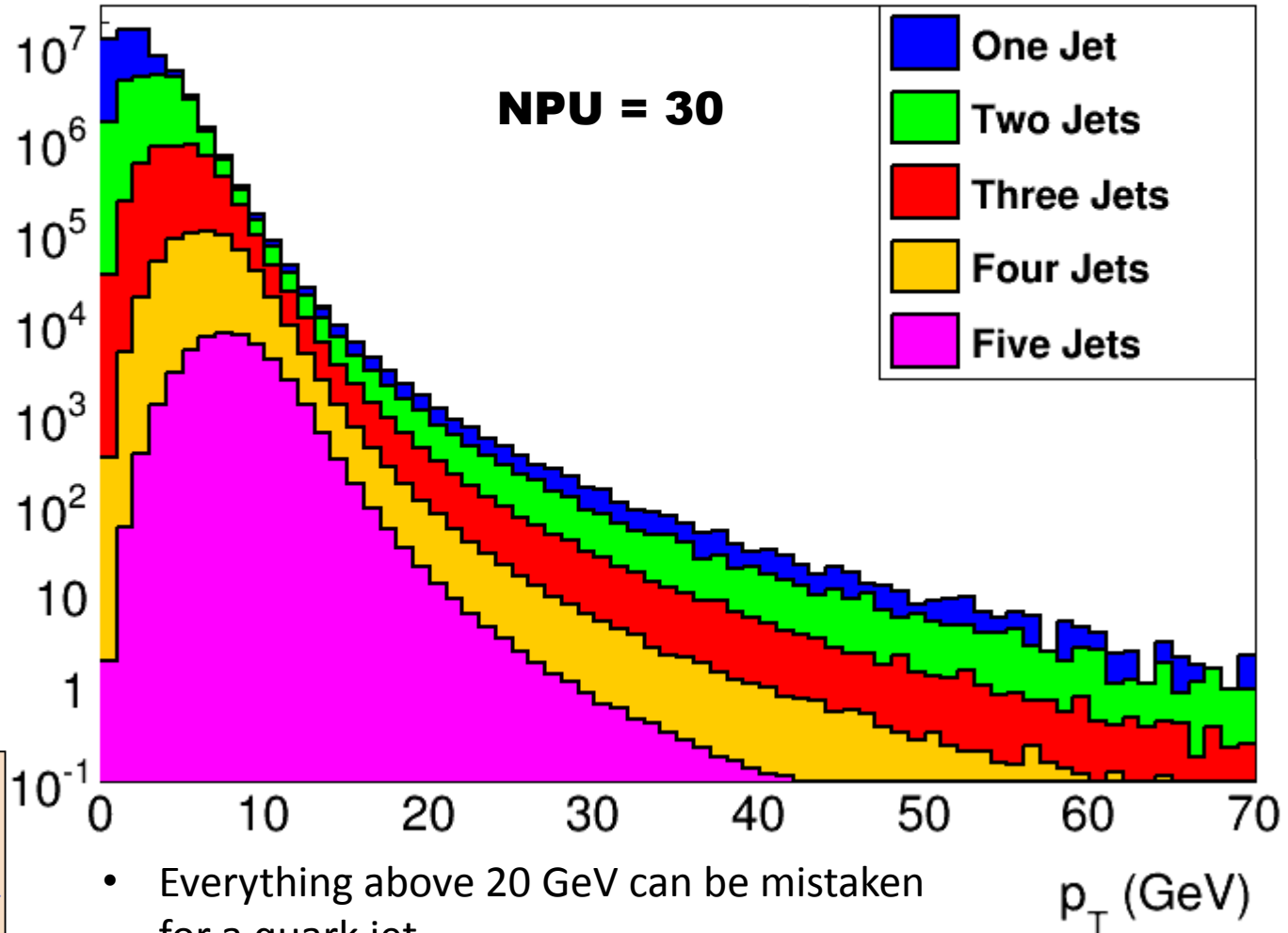
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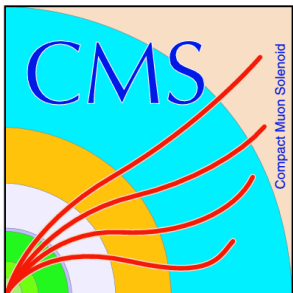
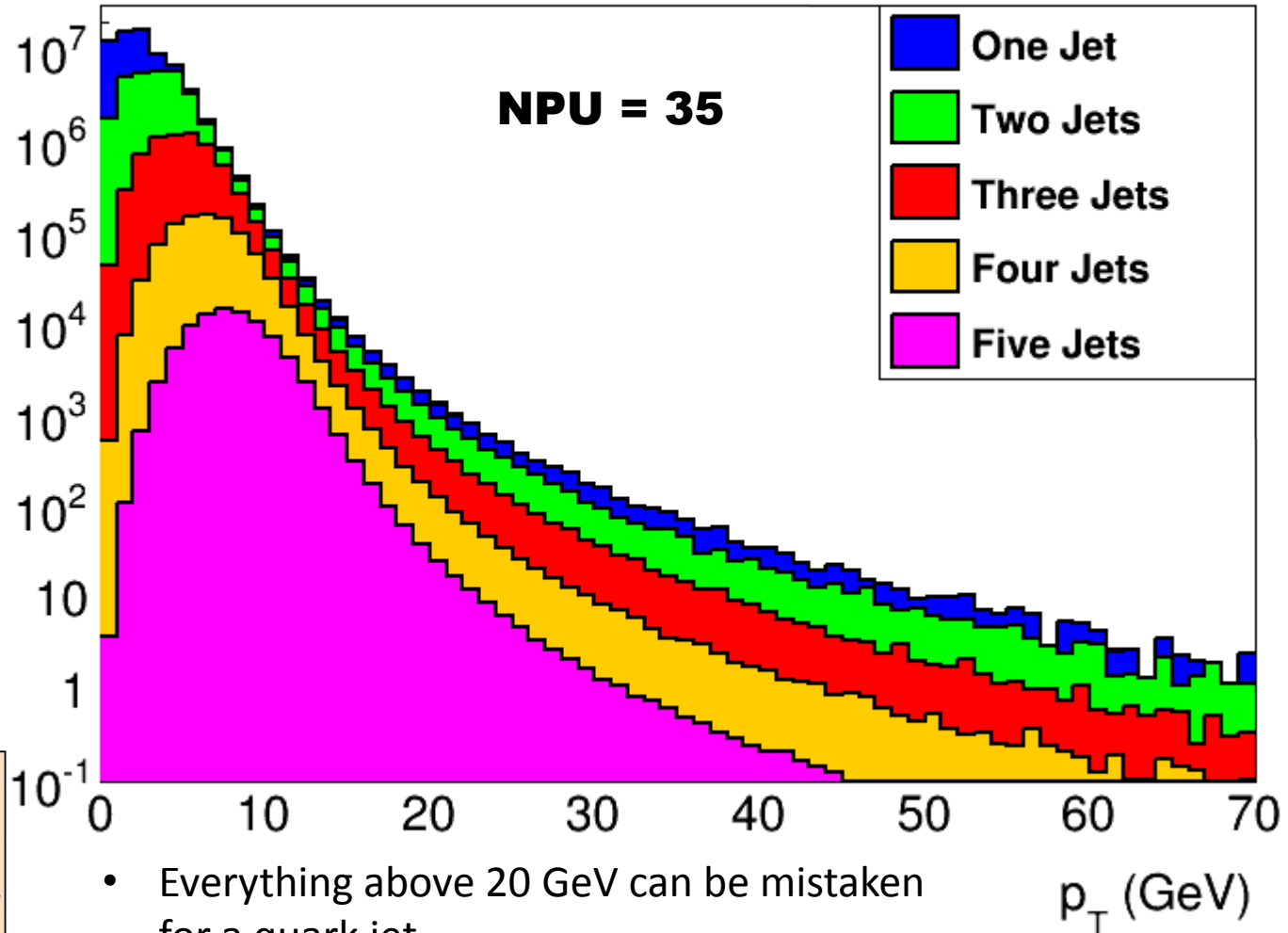
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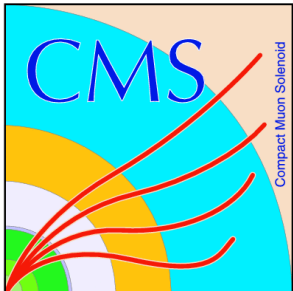
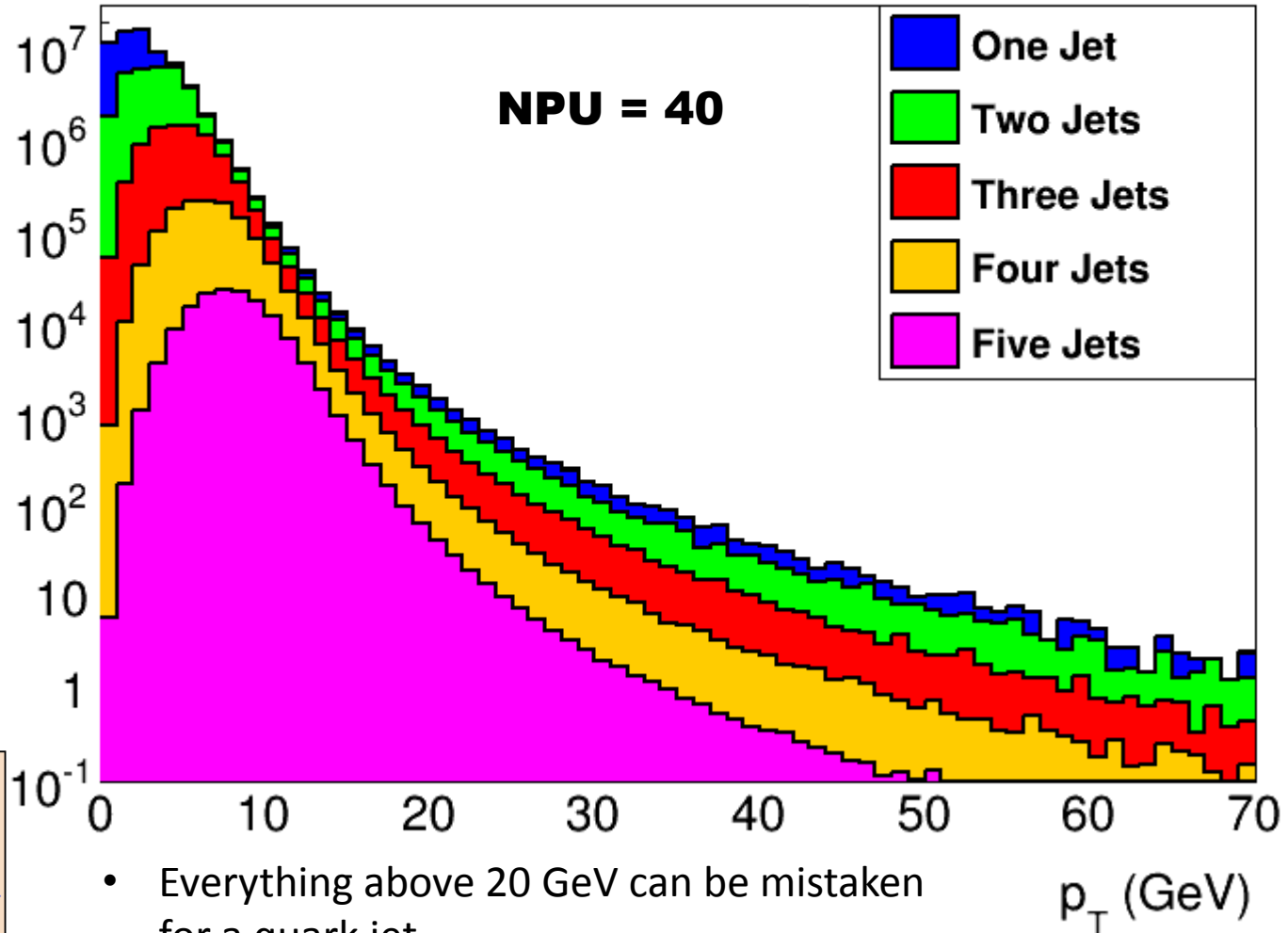
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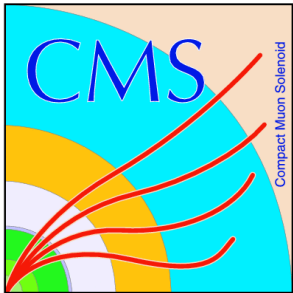
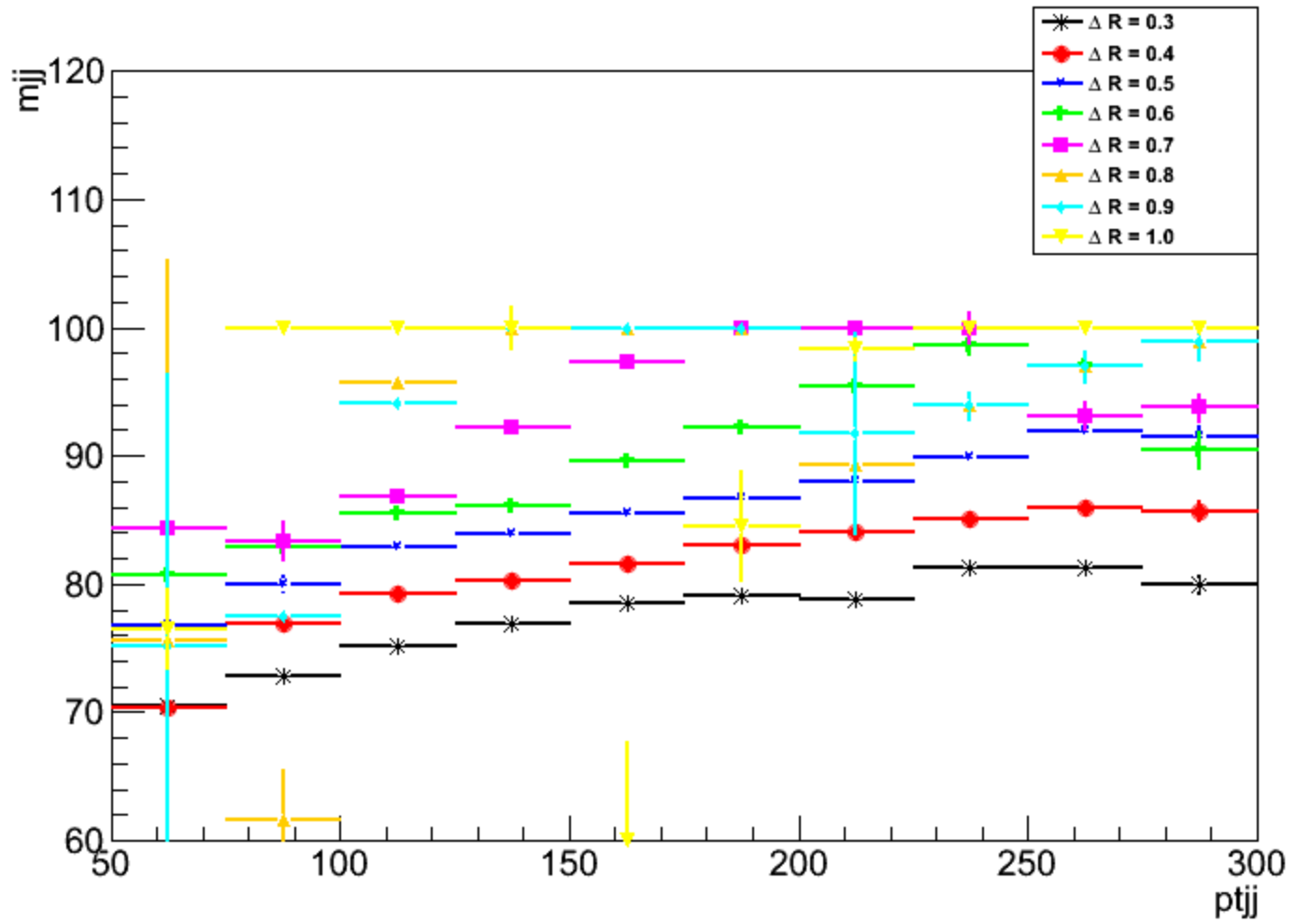


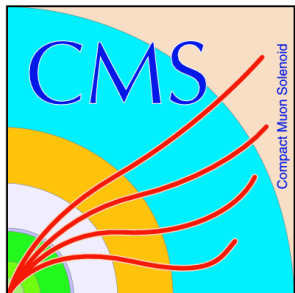
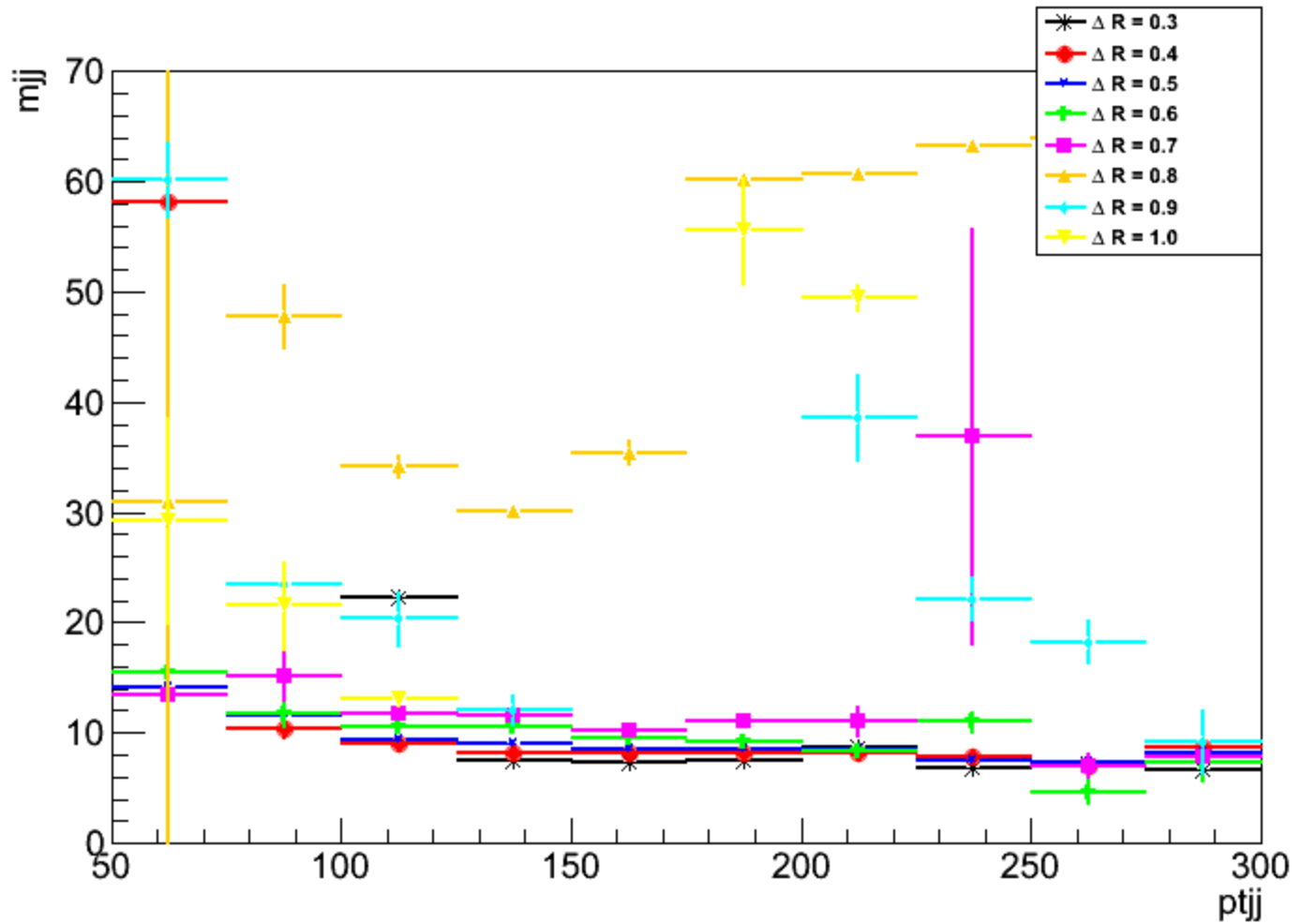
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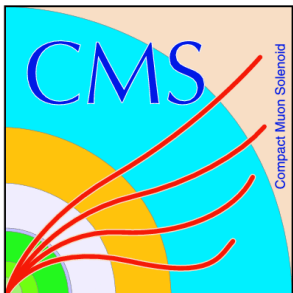
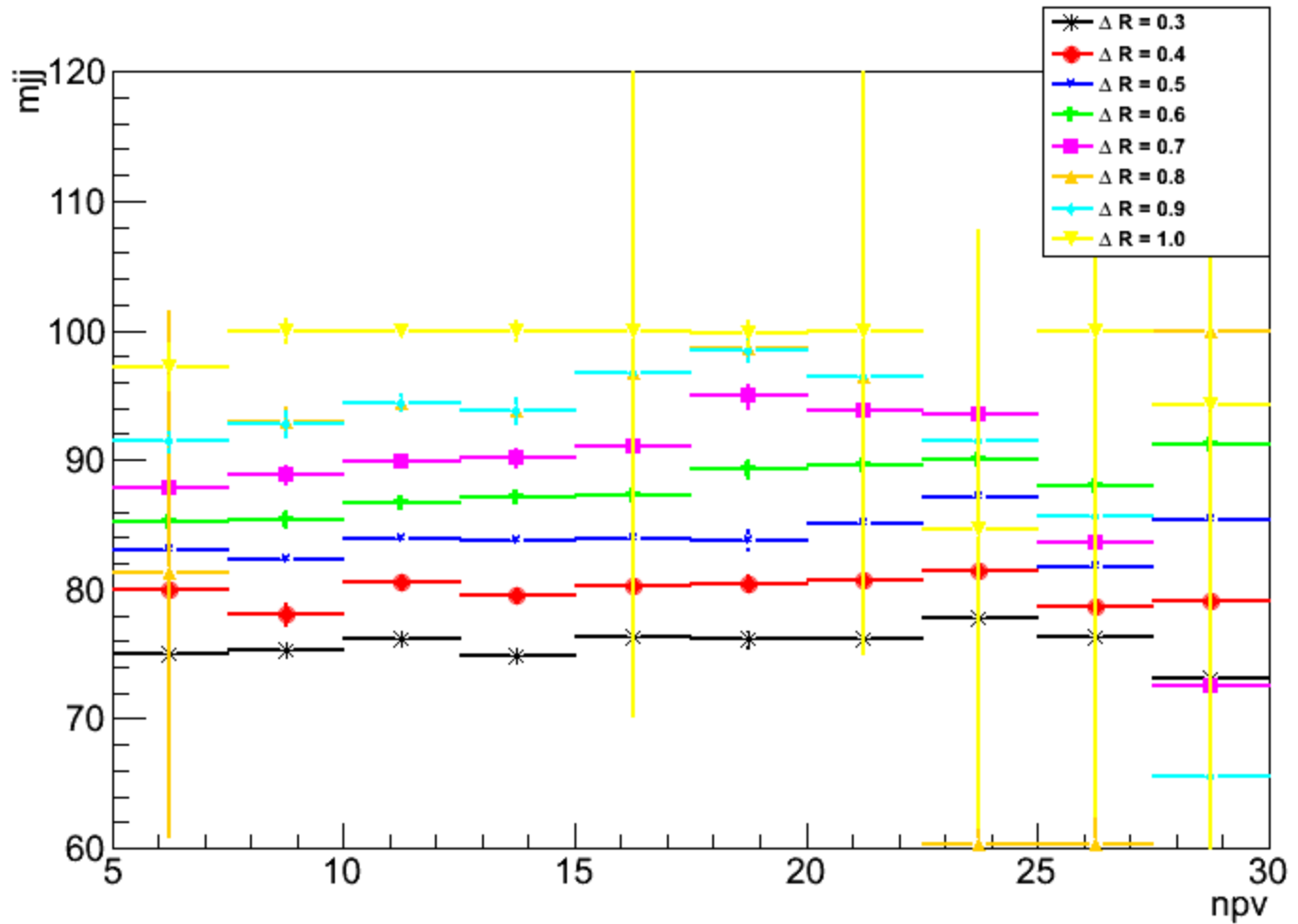


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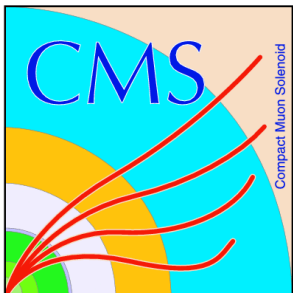
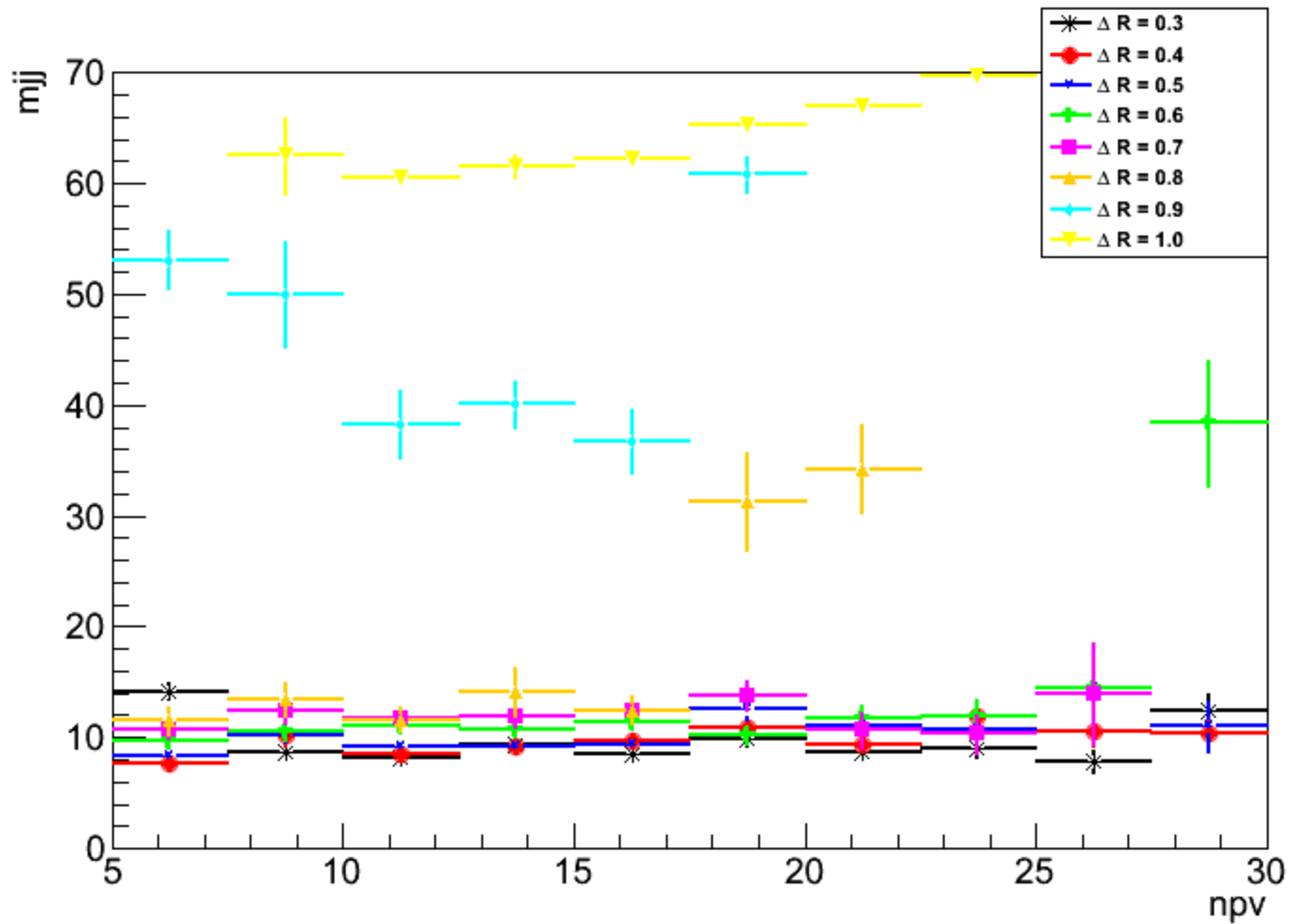


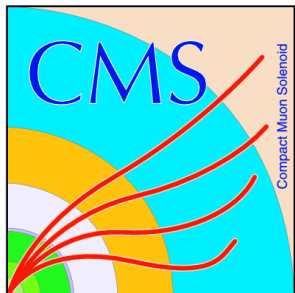
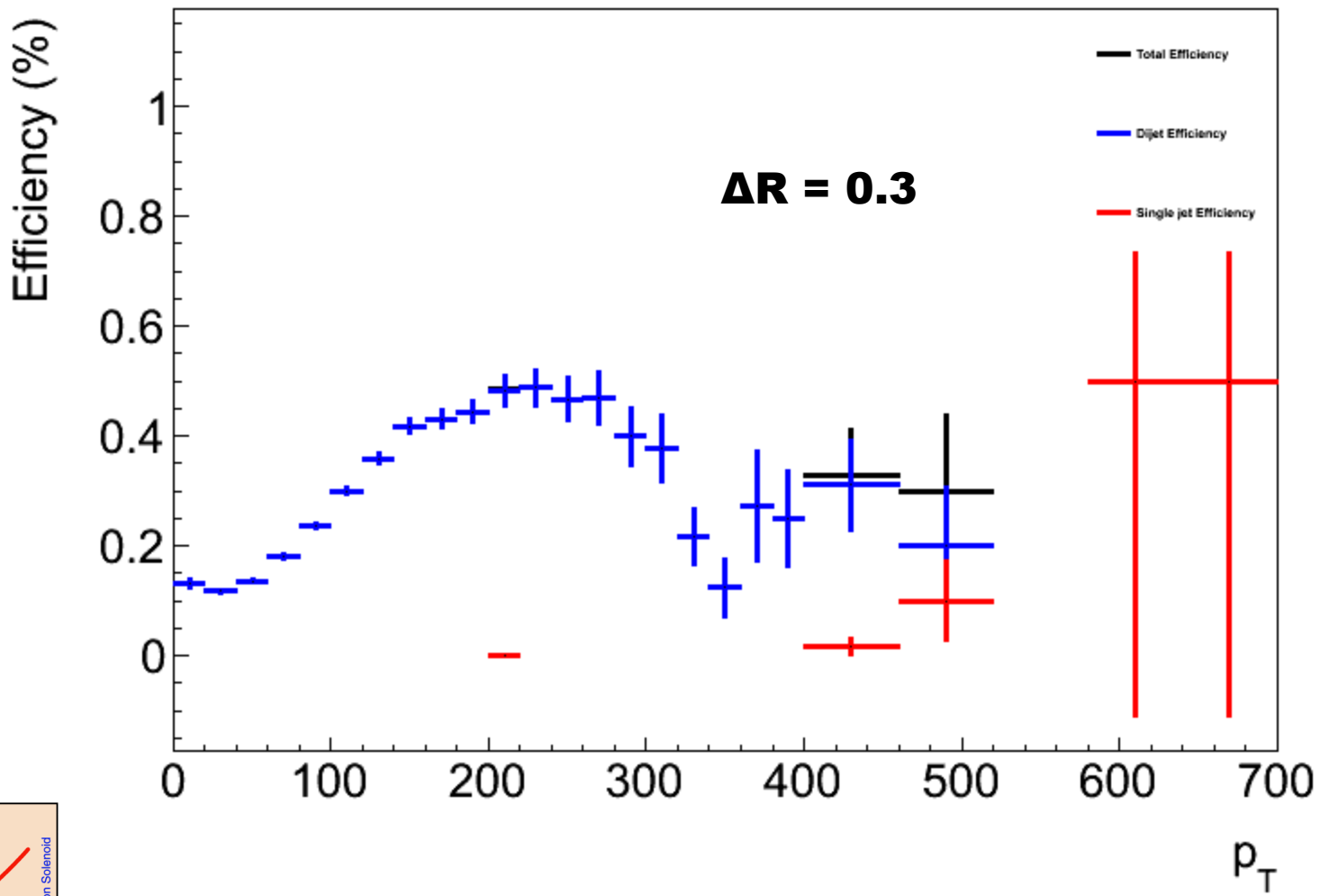


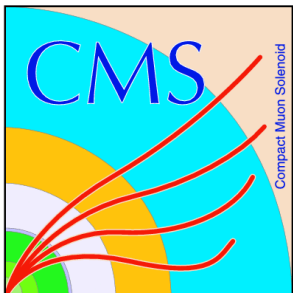
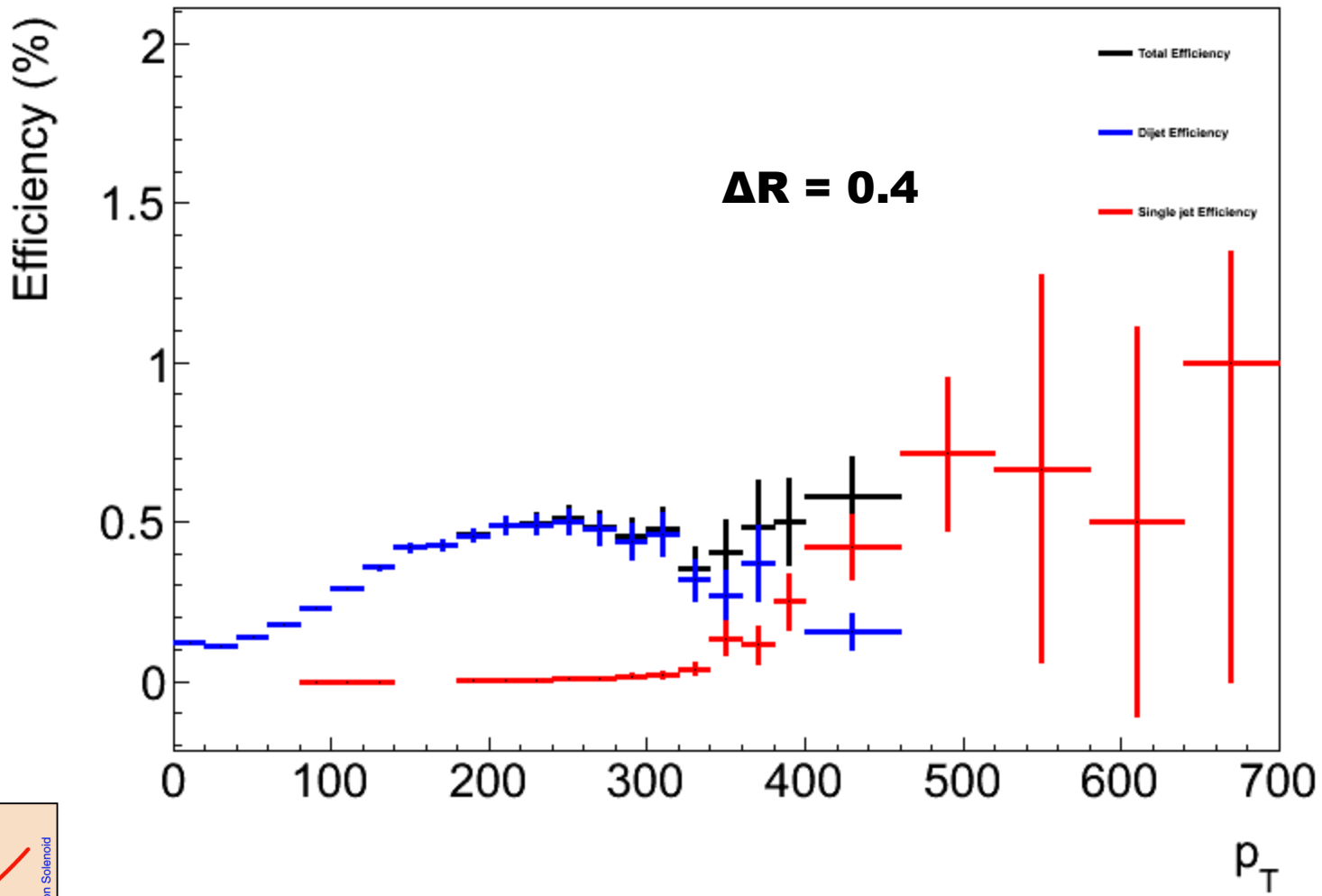


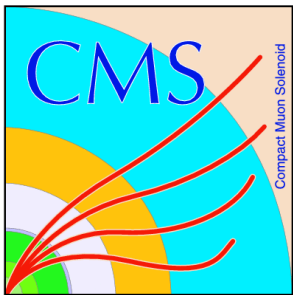
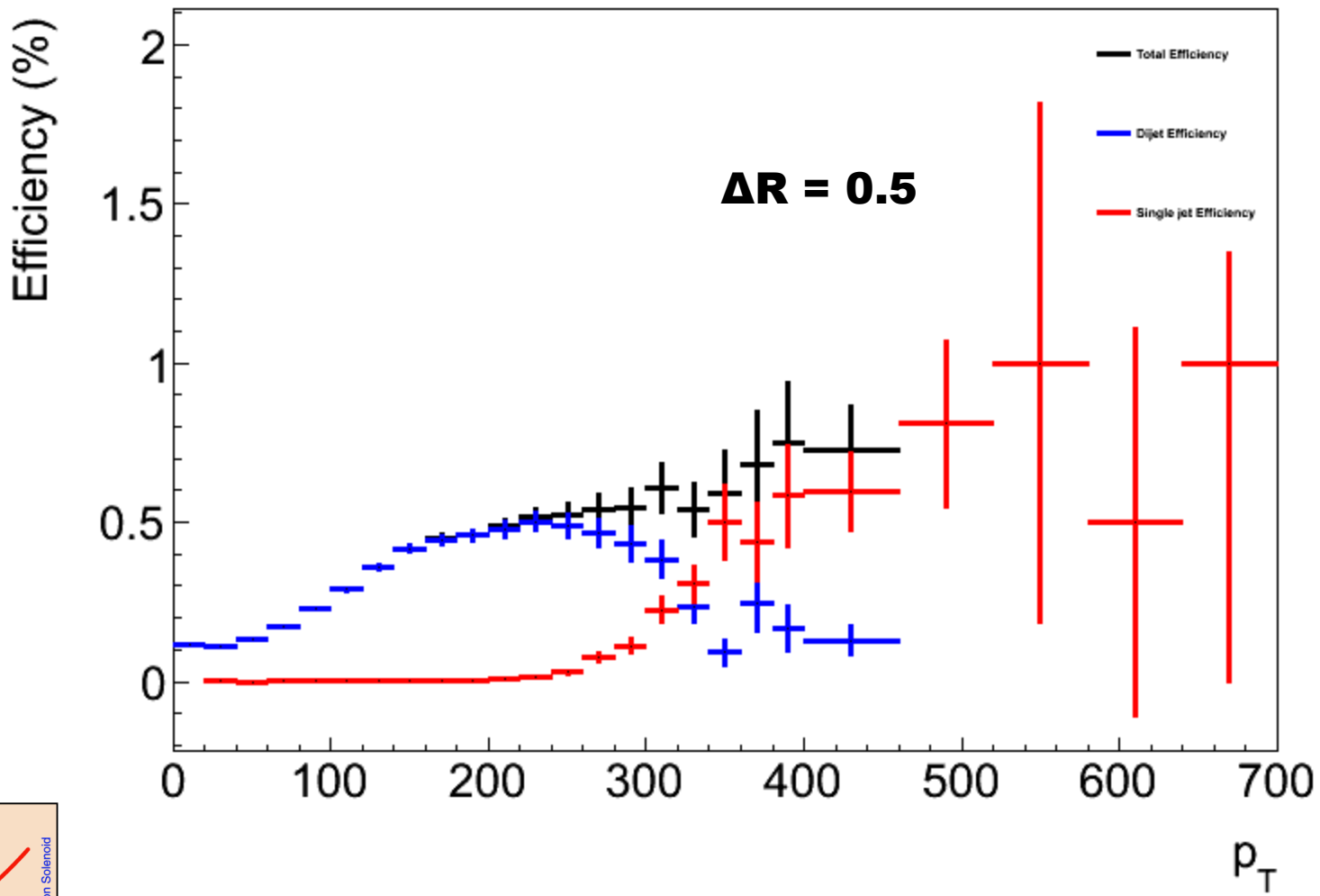


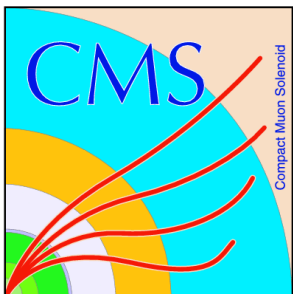
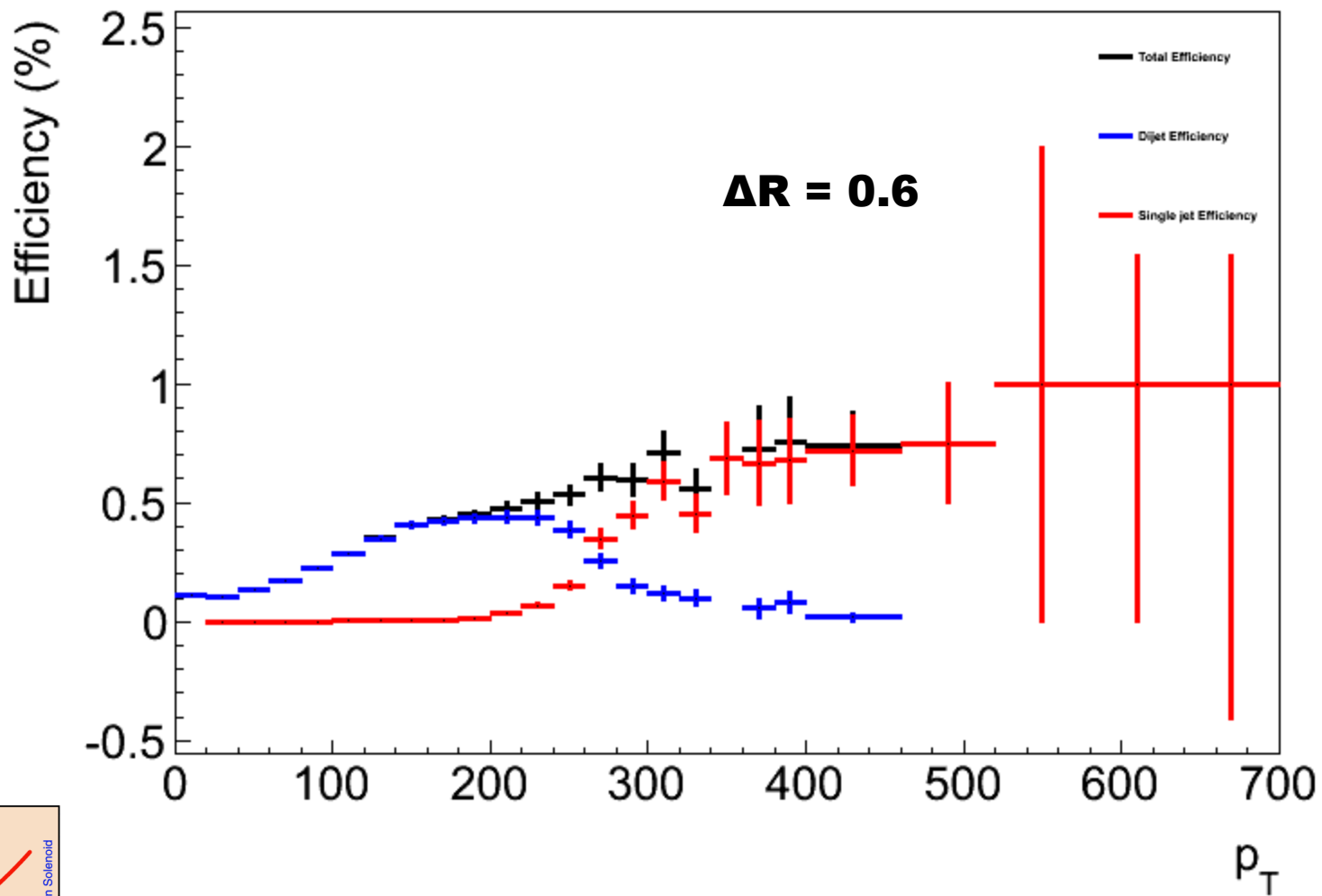


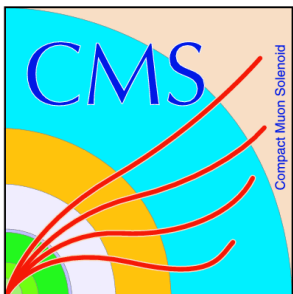
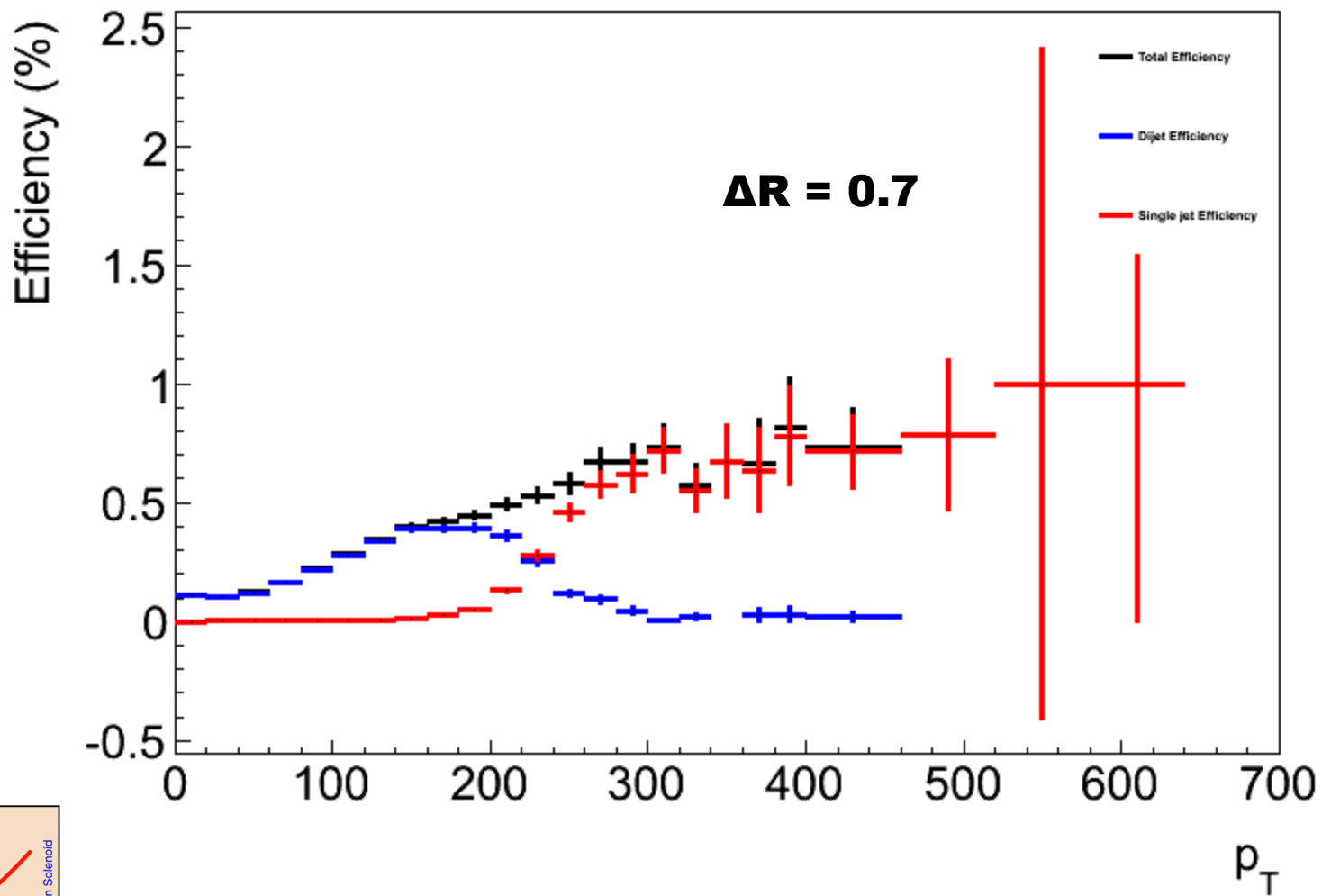


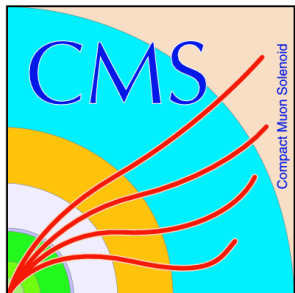
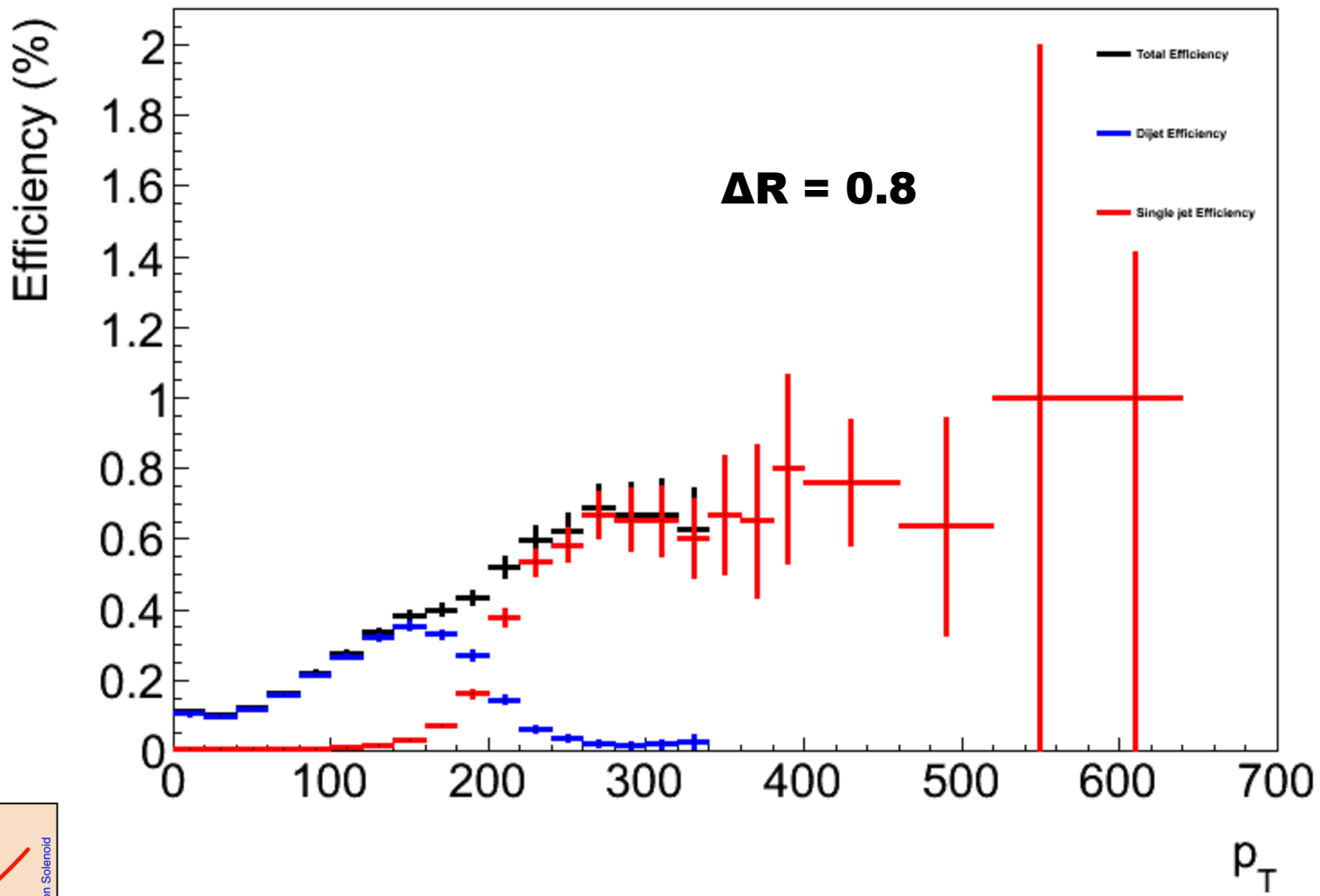


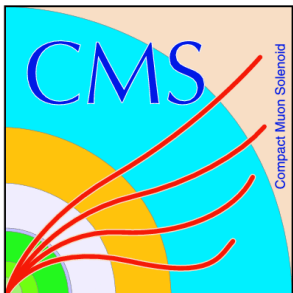
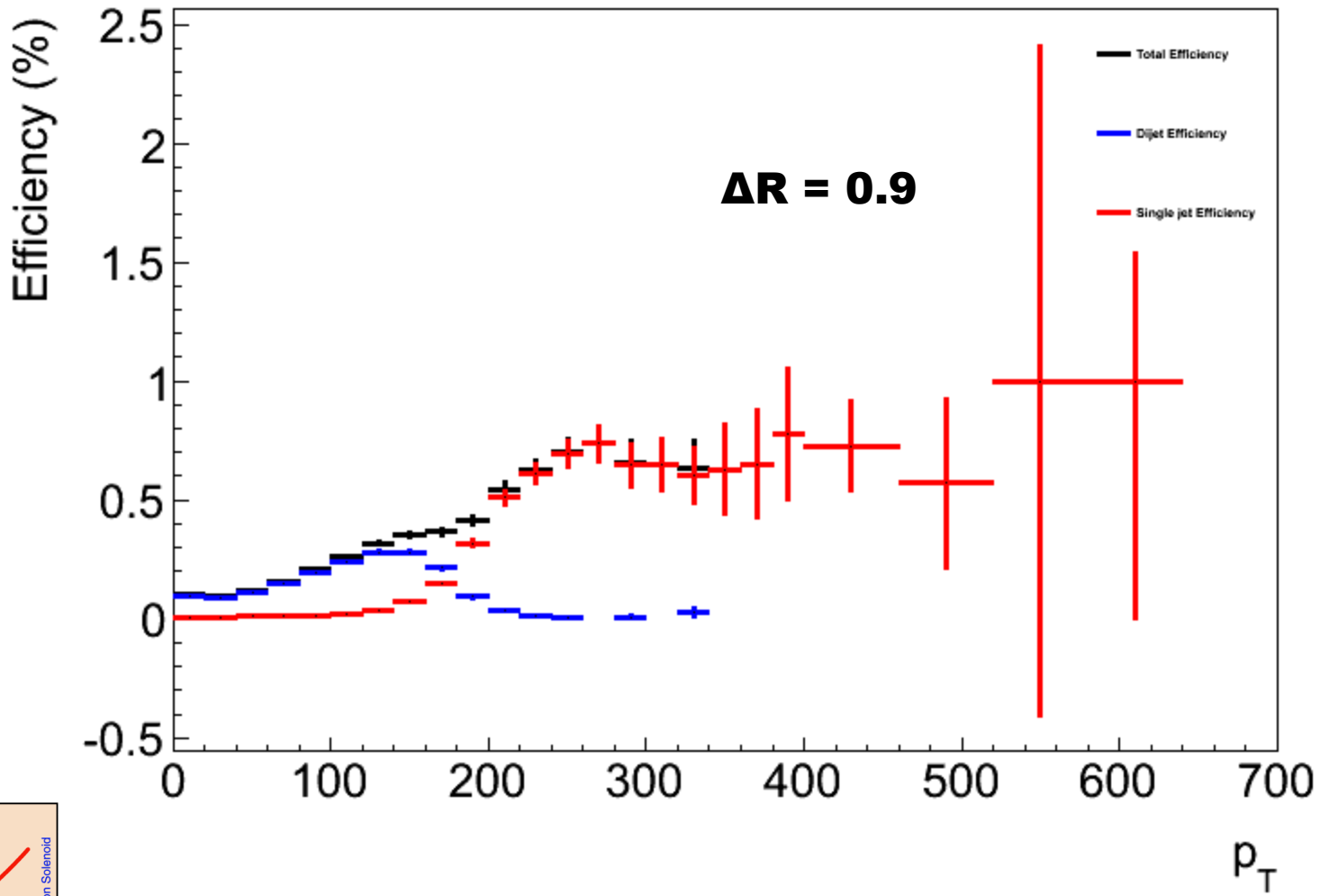




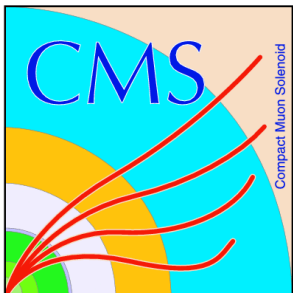
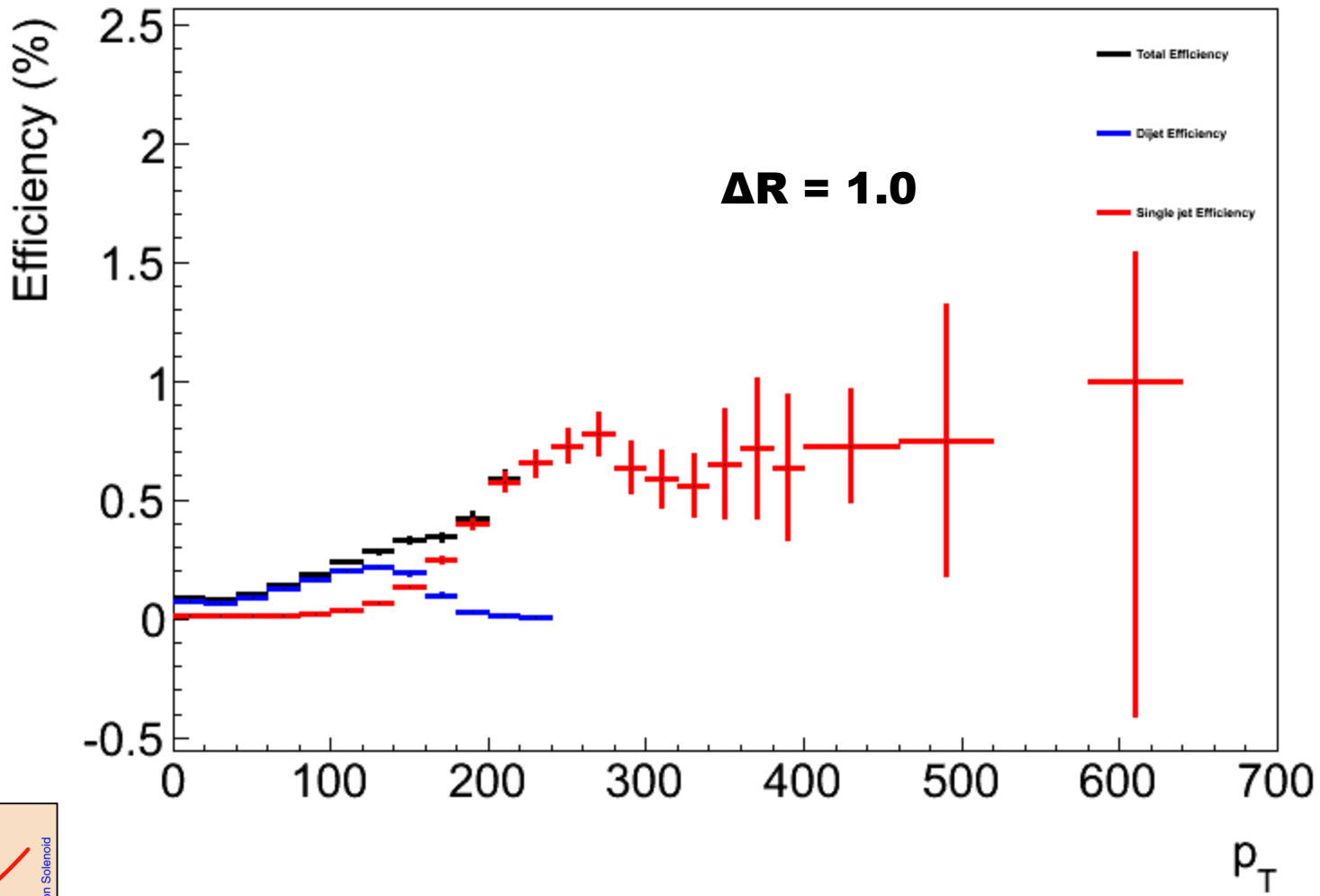






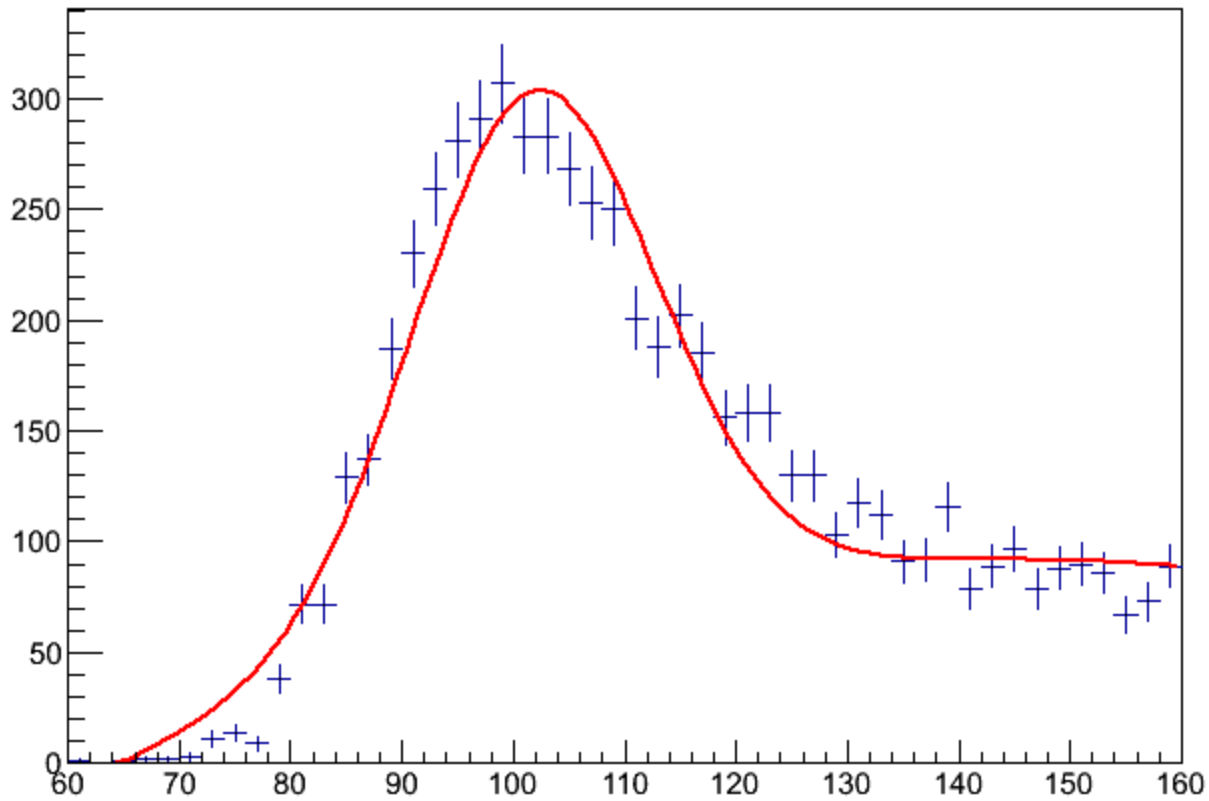




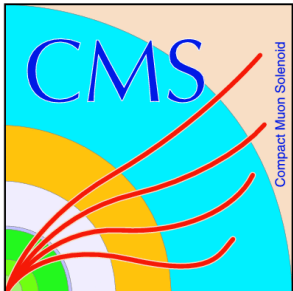


m<sub>jj</sub>

$\Delta R = 0.7$

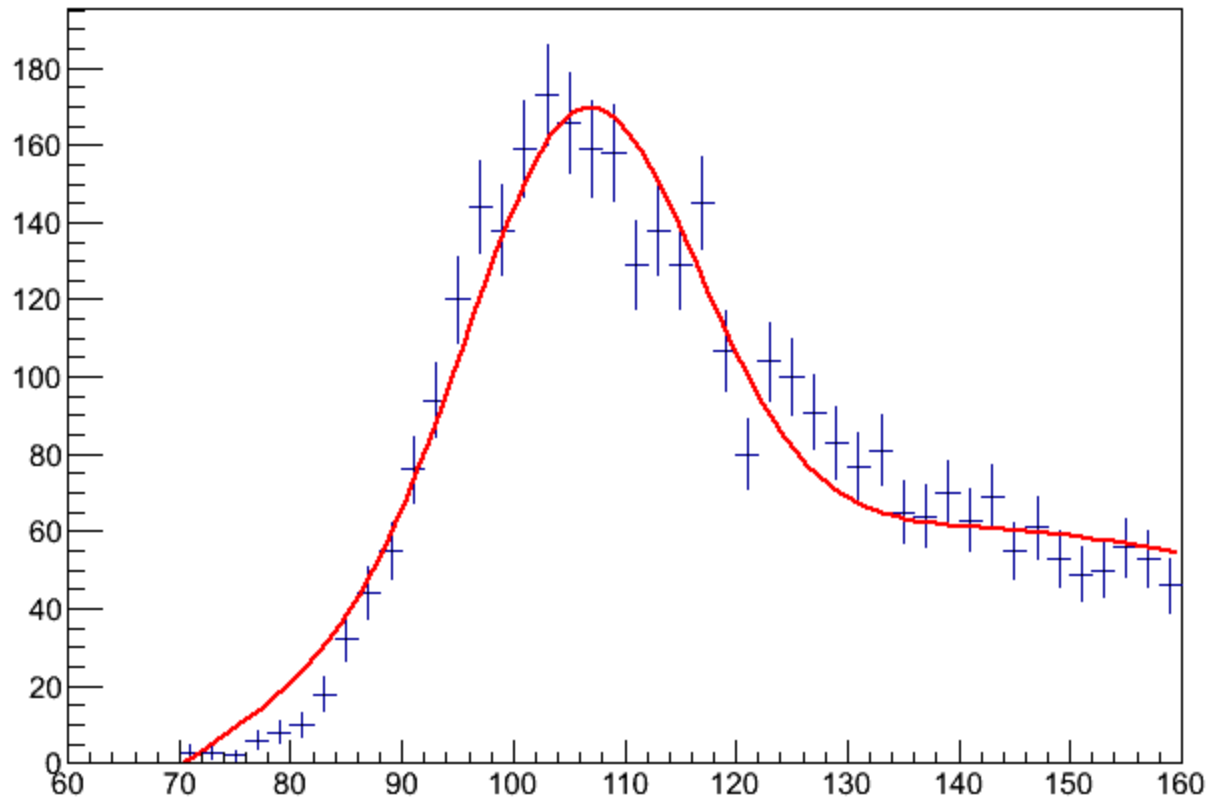


**175 GeV < p<sub>T</sub> < 200 GeV**

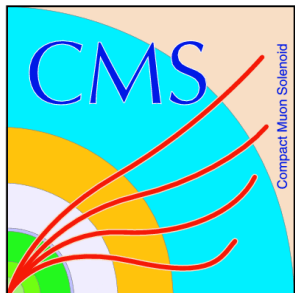


m<sub>jj</sub>

$\Delta R = 0.7$

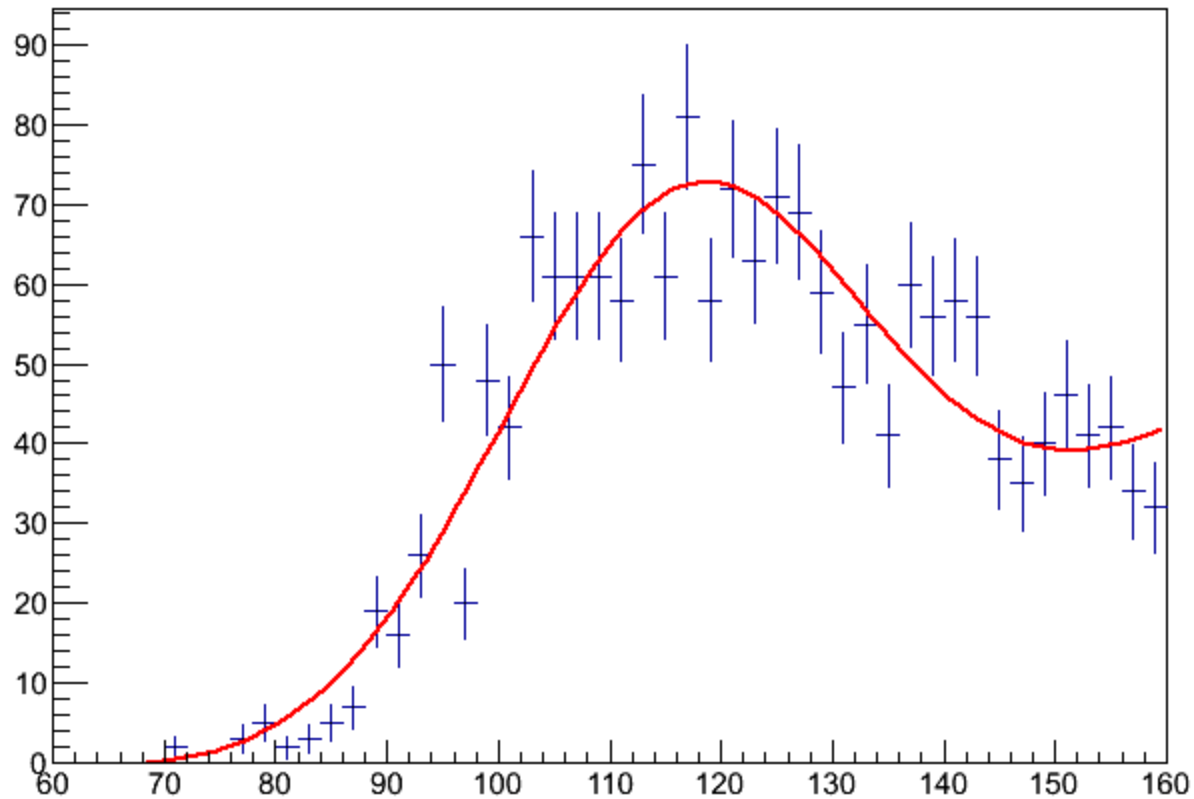


$200 \text{ GeV} < p_T < 225 \text{ GeV}$

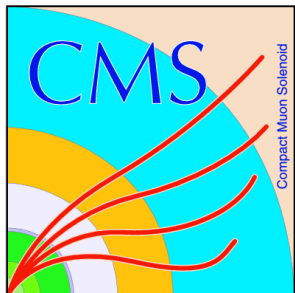


mjj

$\Delta R = 0.7$

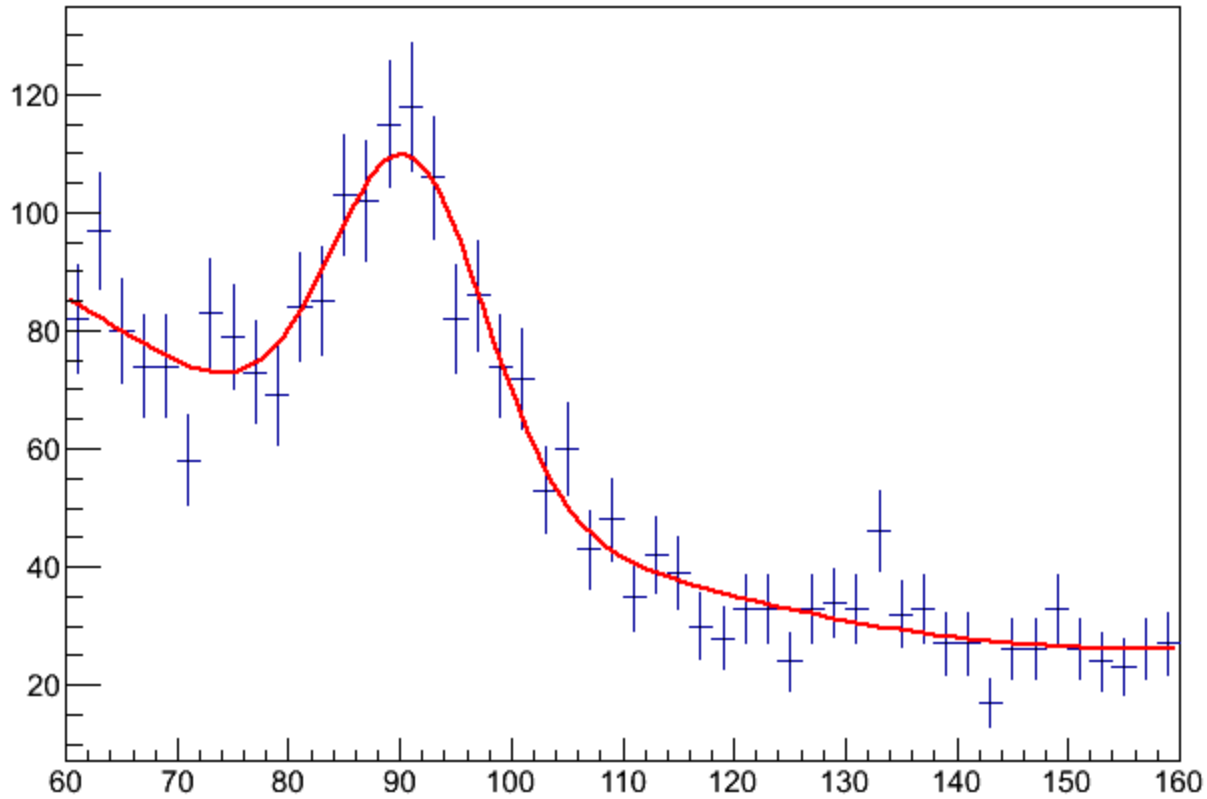


**$225 \text{ GeV} < p_T < 250 \text{ GeV}$**

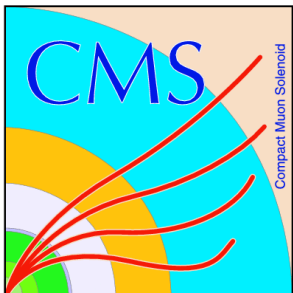


mjj

$\Delta R = 0.7$

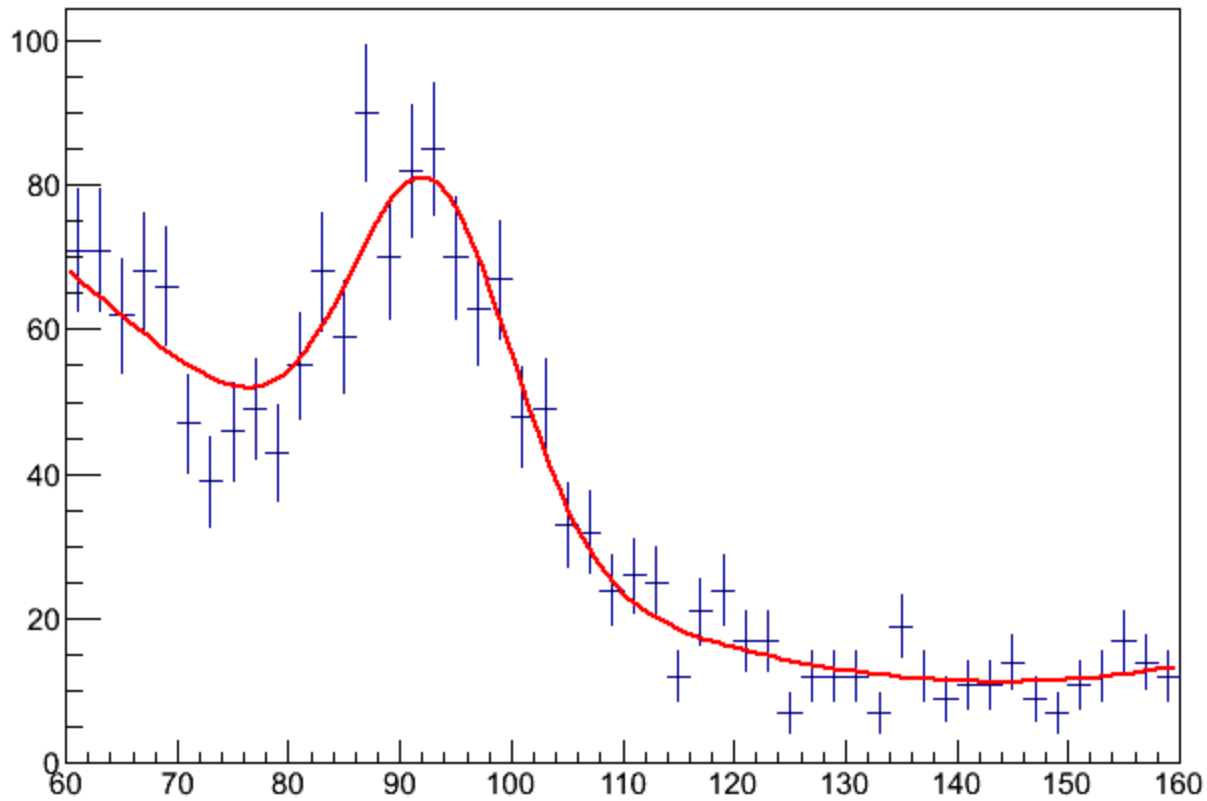


$250 \text{ GeV} < p_T < 275 \text{ GeV}$

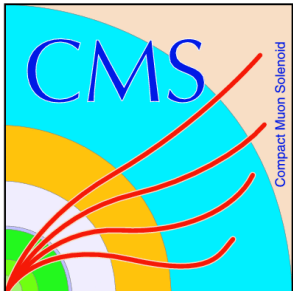


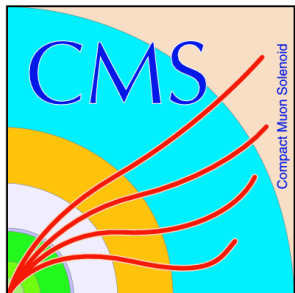
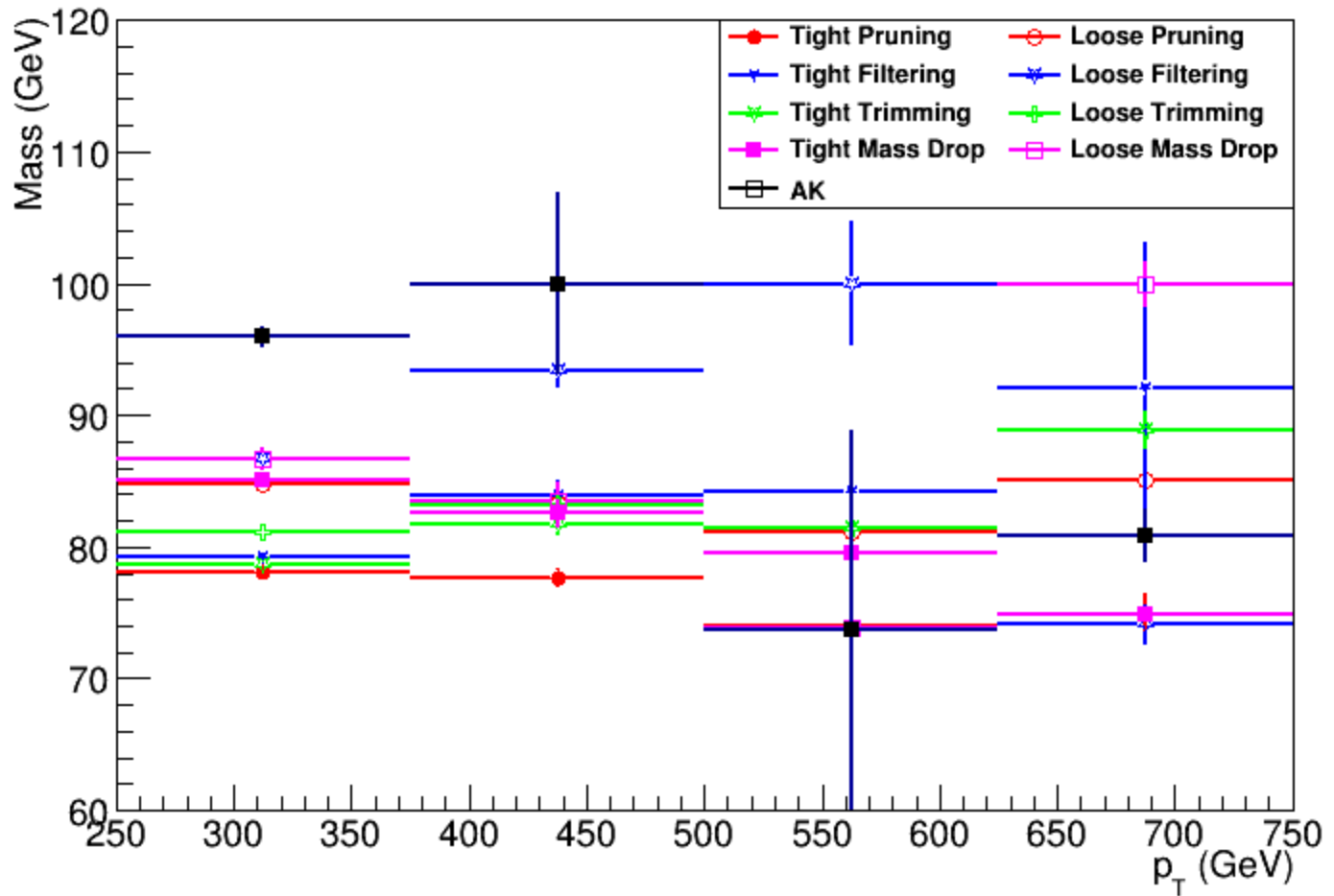
mjj

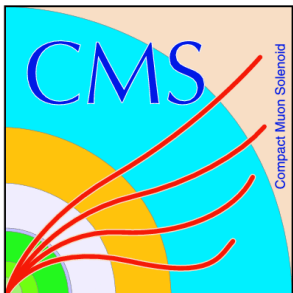
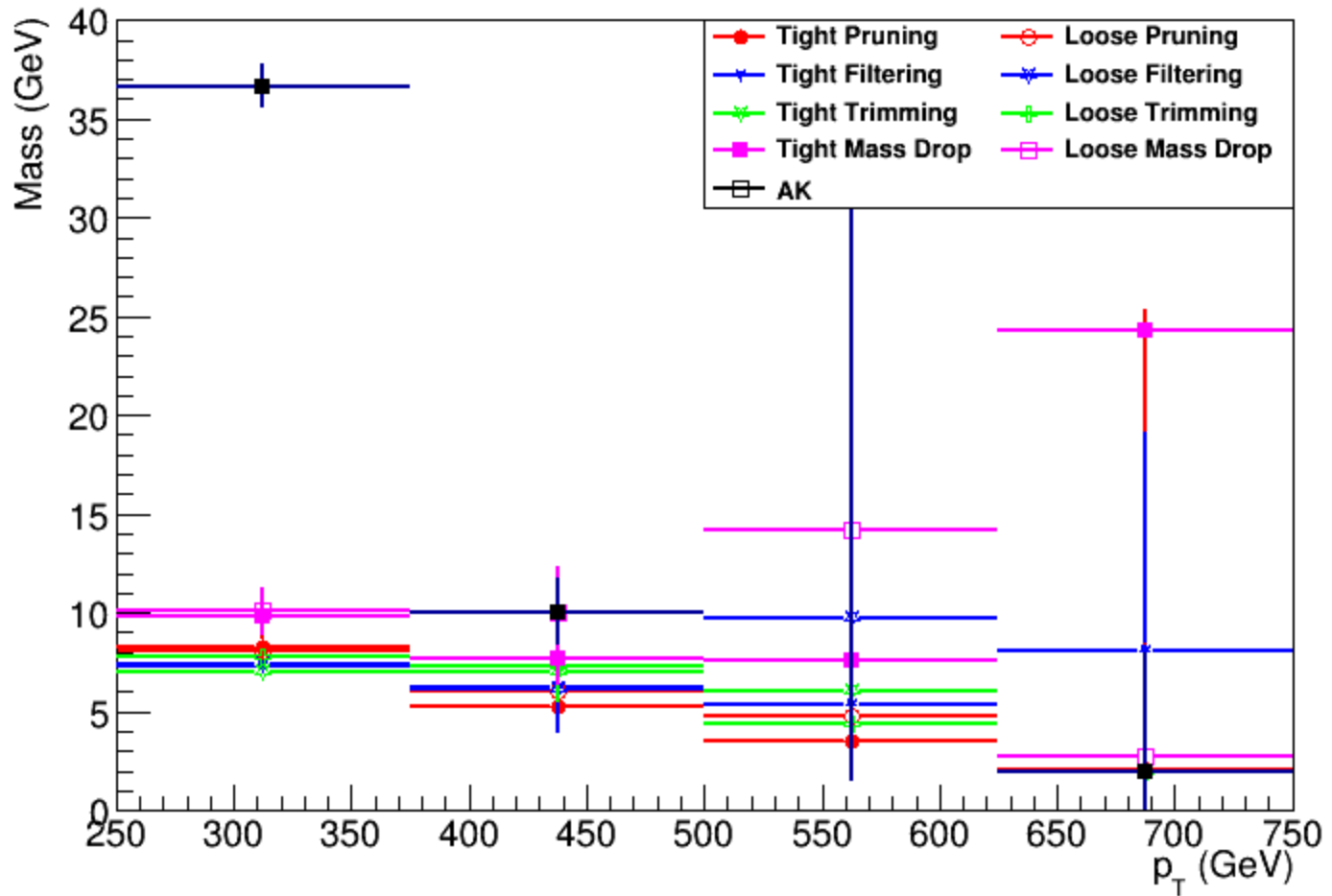
$\Delta R = 0.7$



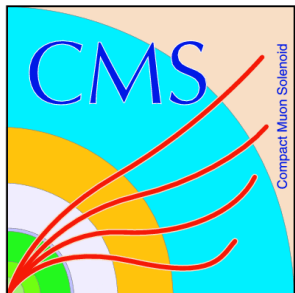
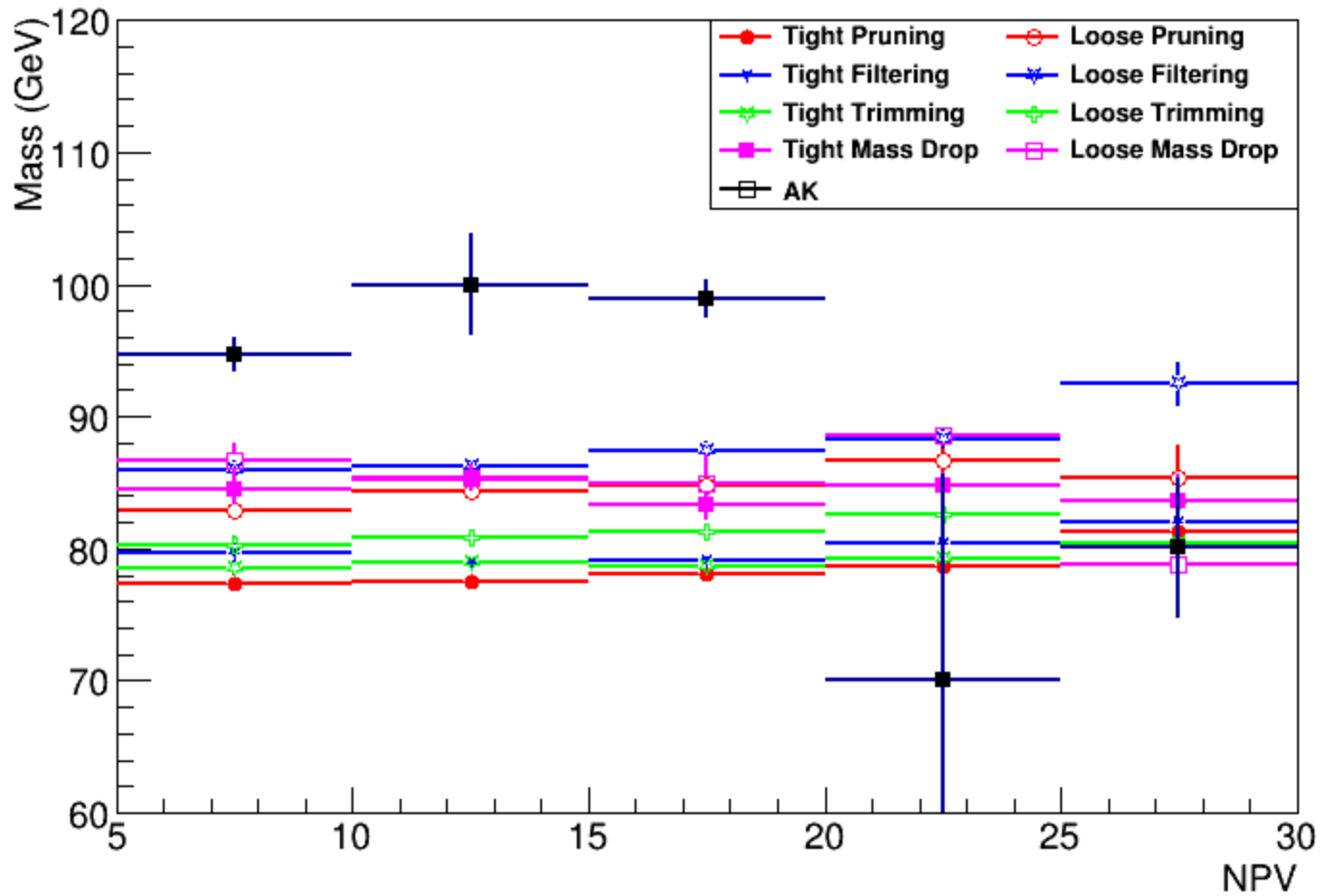
**$275 \text{ GeV} < p_T < 300 \text{ GeV}$**

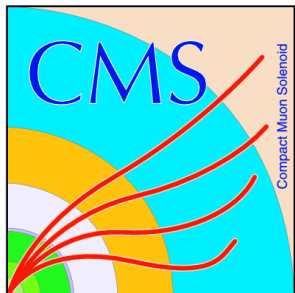
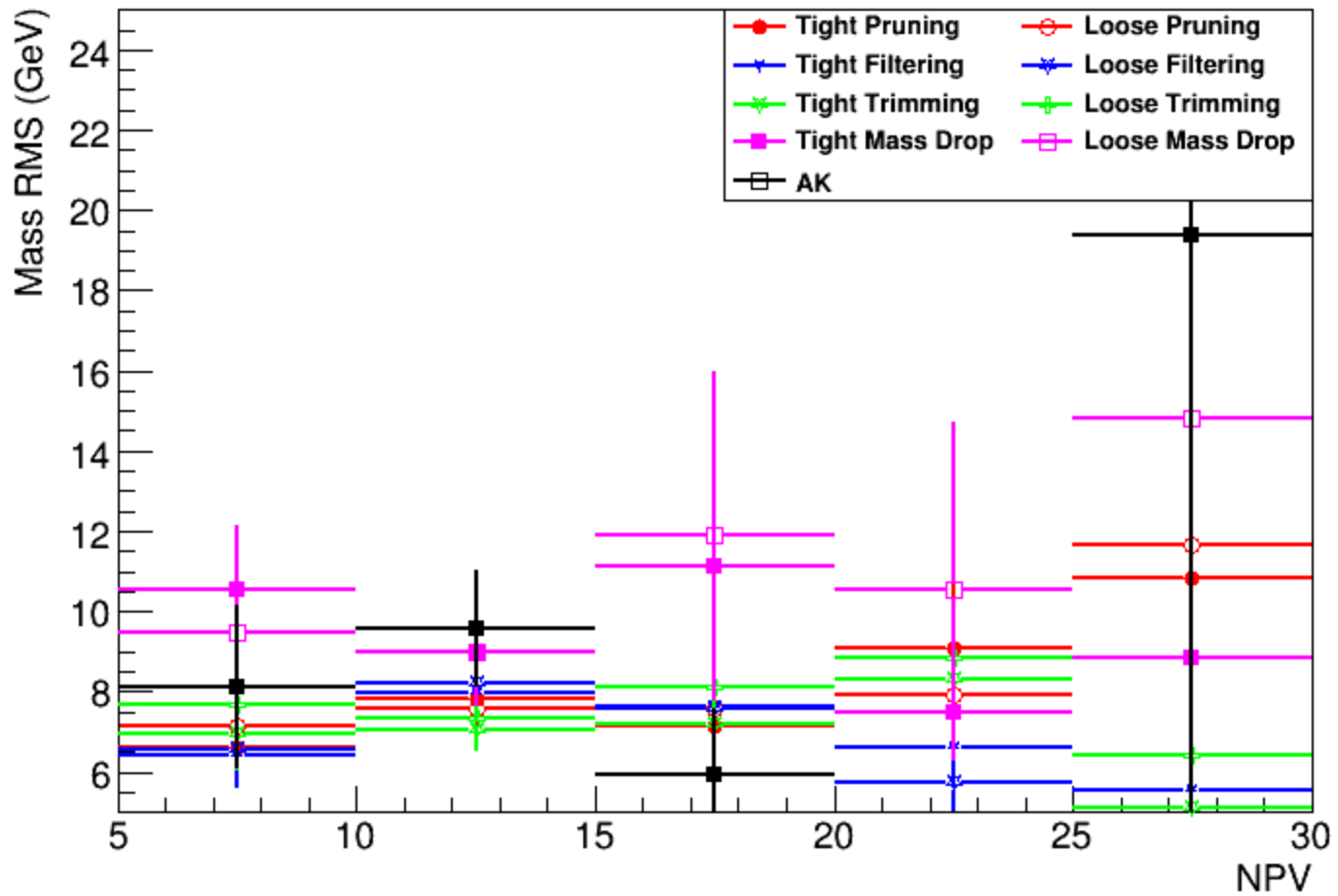


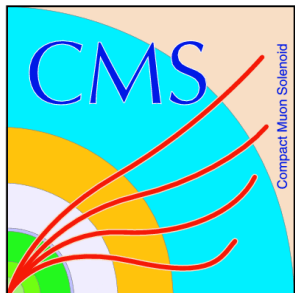
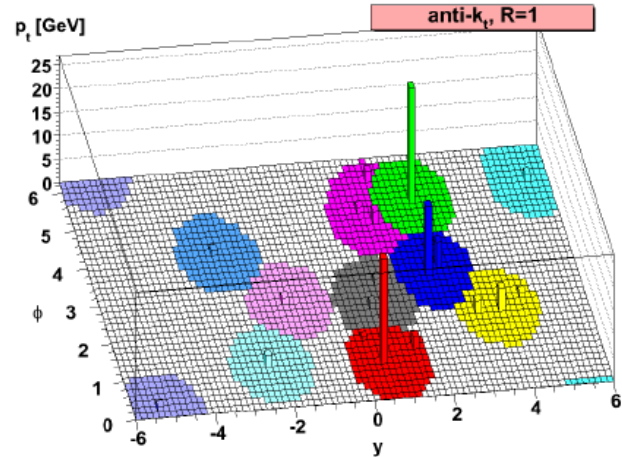
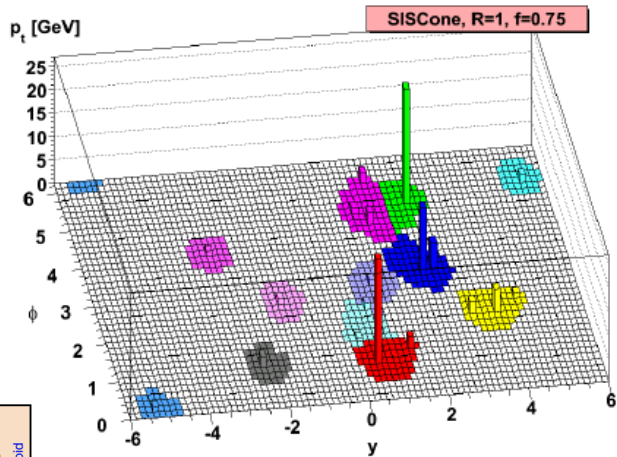
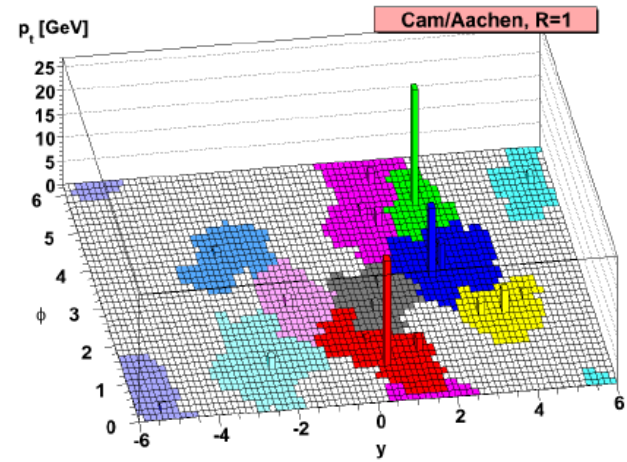
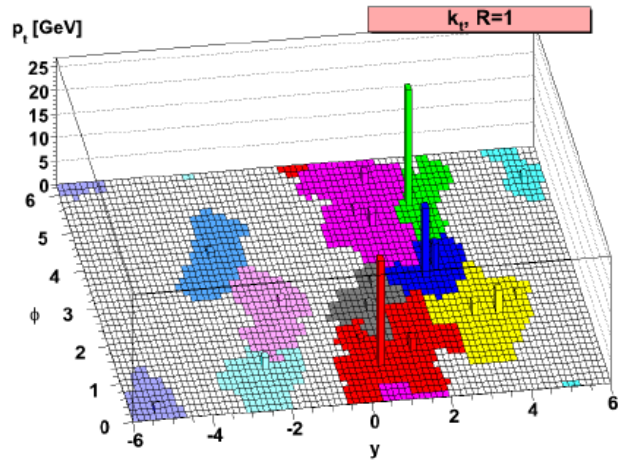






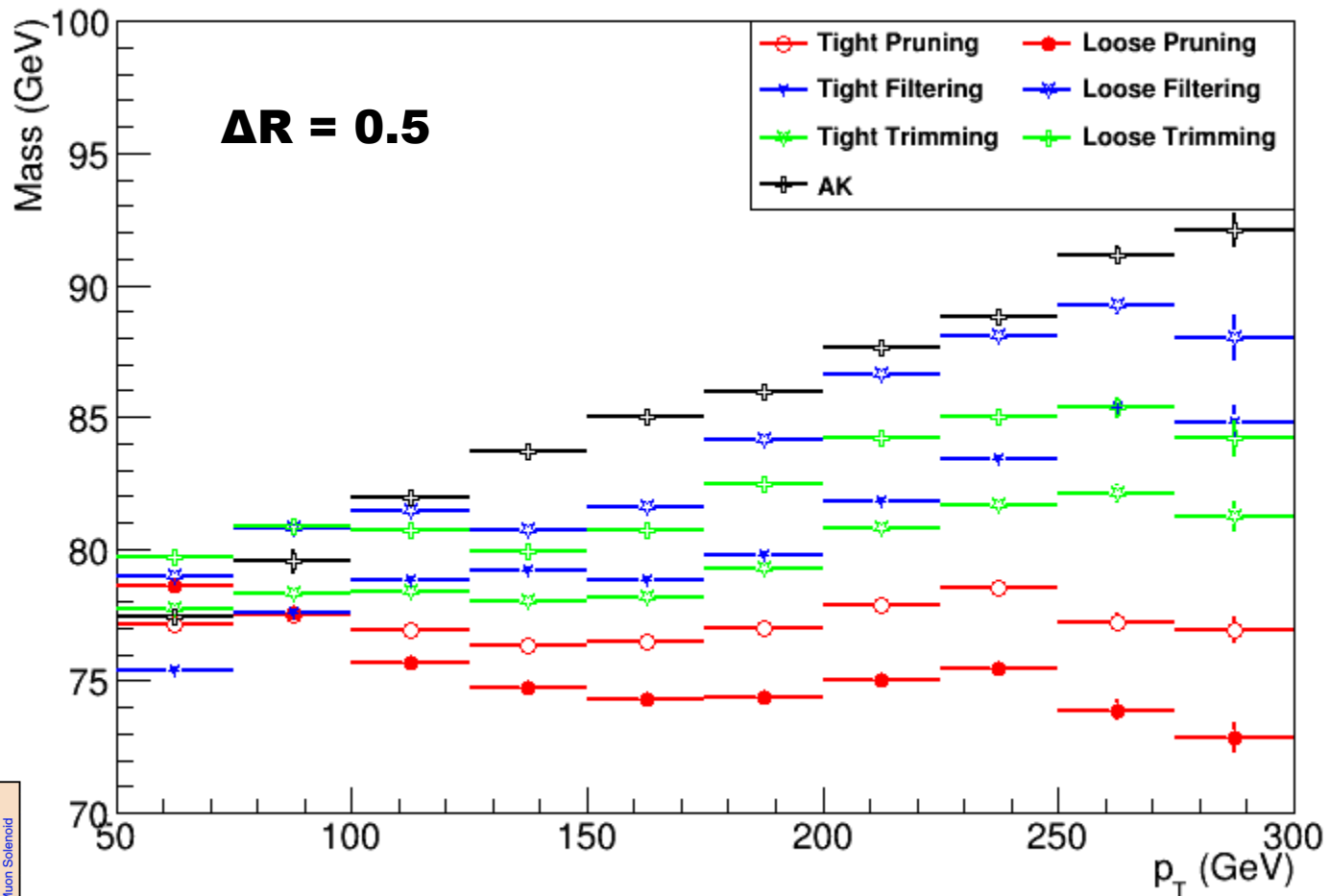




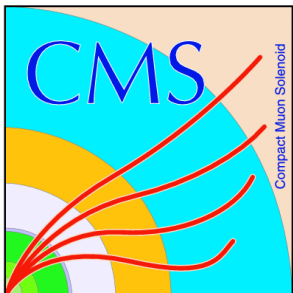


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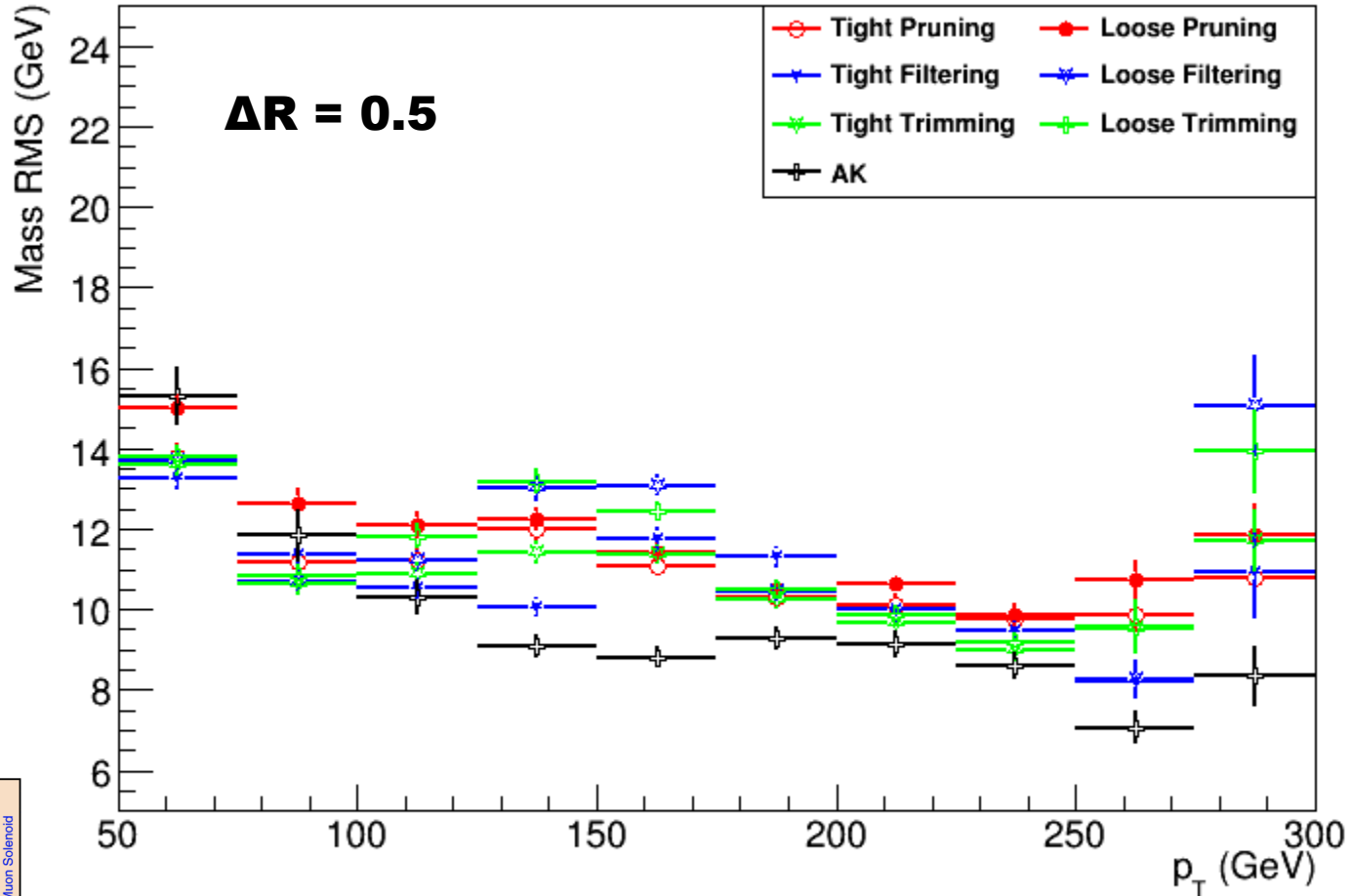
# Comparing algorithms



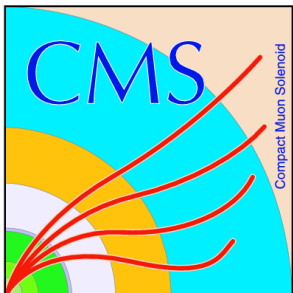
- Grooming keeps mass relatively constant compared to anti- $k_T$



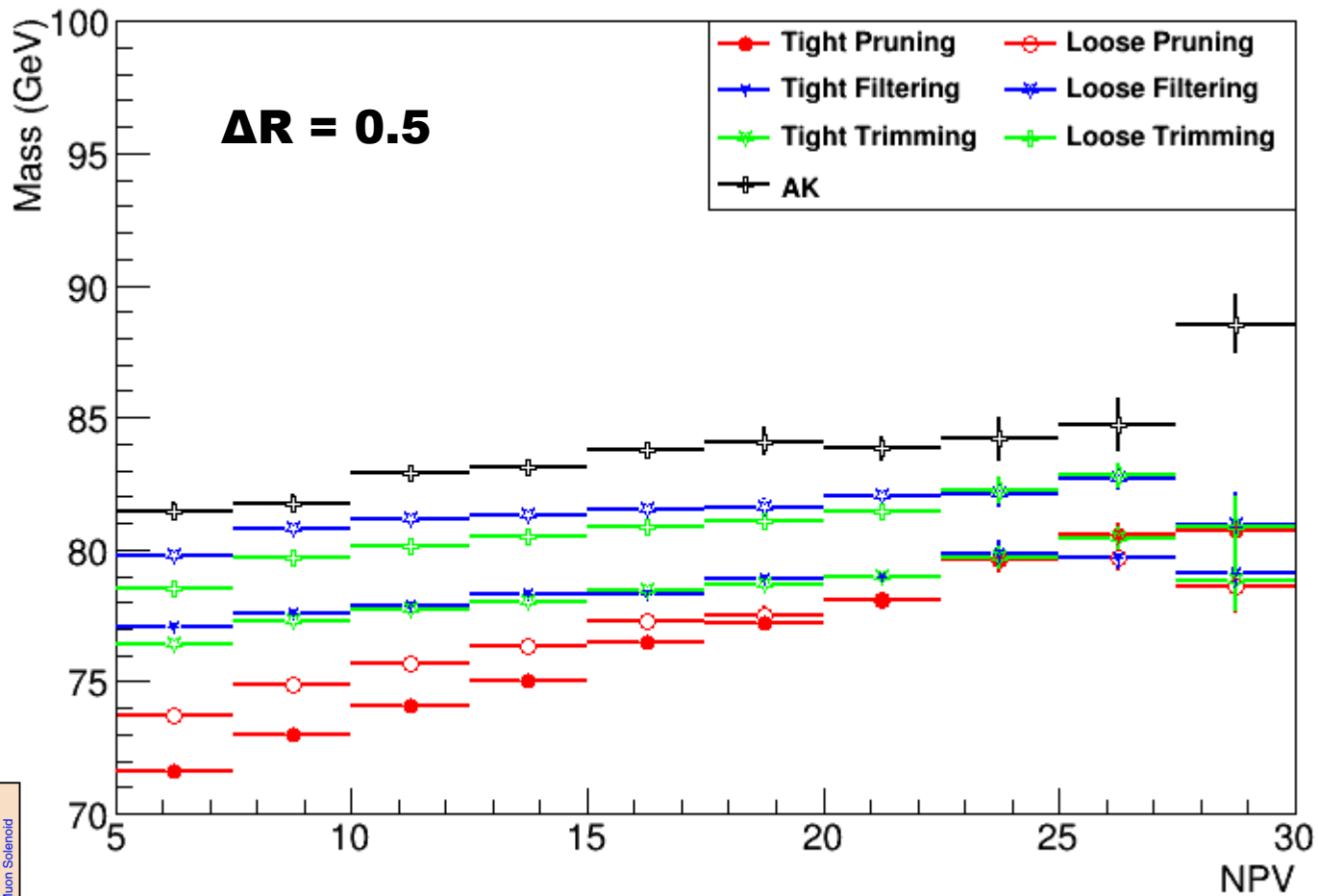
# Comparing algorithms



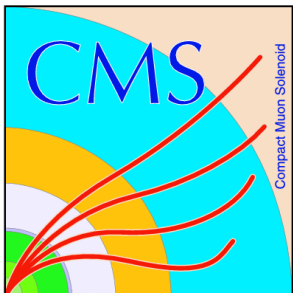
- Anti- $k_T$  seems to have the smallest width



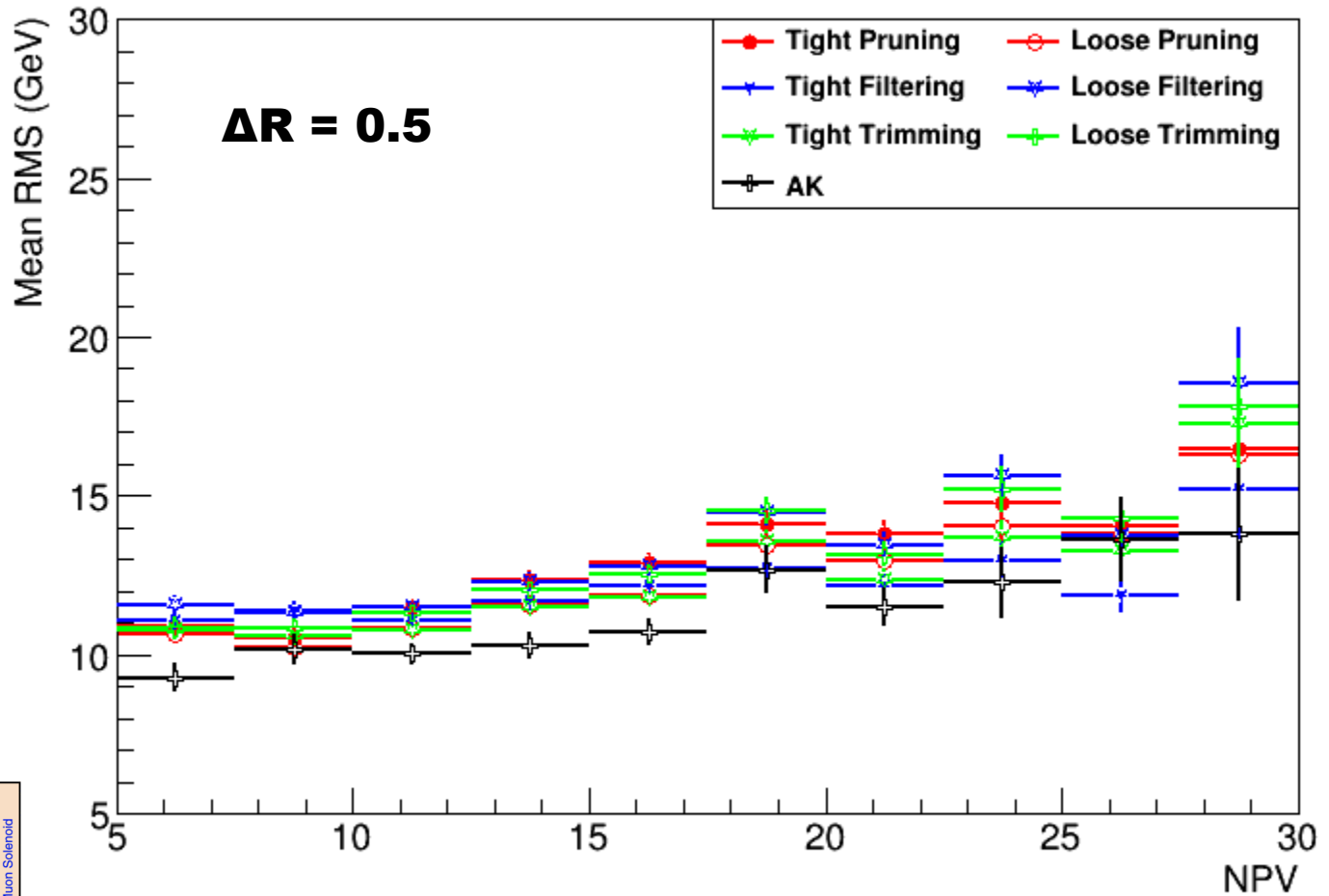
# Comparing algorithms



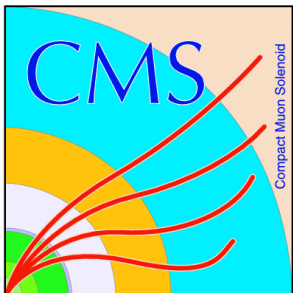
- Pruning may be too aggressive at low pileup



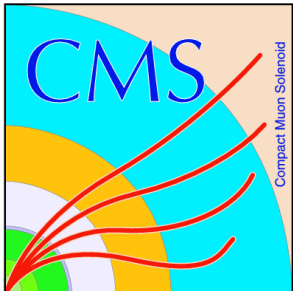
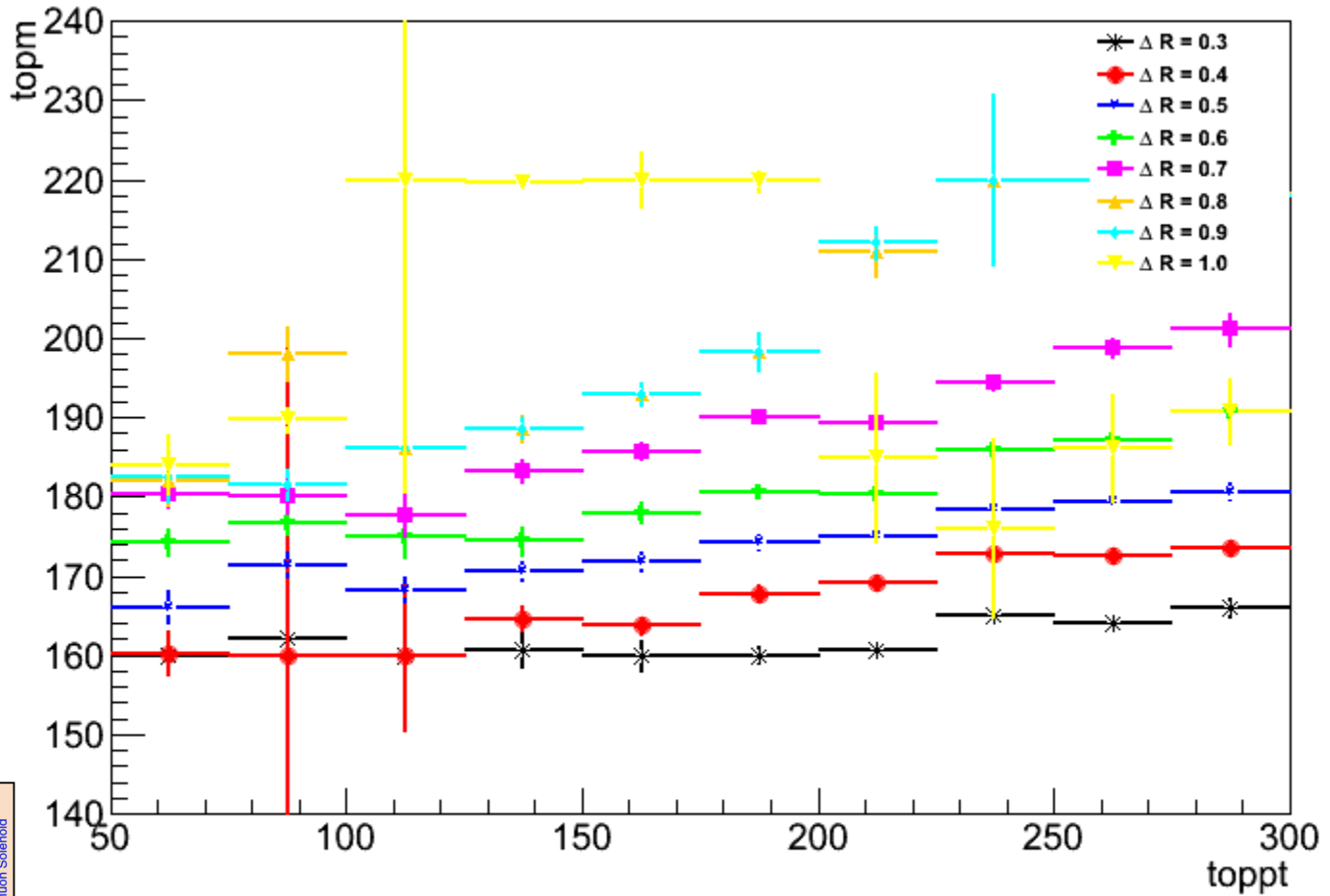
# Comparing algorithms



- Again, anti- $k_T$  has narrowest width



# Top Mass





# Top Mass Width

