1. Soft drop mass in future collider performance

In this section, we use the specific method, soft-drop, to study the performance of the detector with the different detector cell sizes and center-of-mass(c.m.) energy.

2. The technic of Soft-drop

Soft-drop(SD), taking literally, is the technique that reserves the soft P_T of jets which is greater than the set threshold. The formula and the technique are as following:

$$\frac{min(P_{T1}, P_{T2})}{P_{T1} + P_{T2}} > Z_{cut}(\frac{\Delta R_{12}}{R_0})^{\beta} \tag{1}$$

P_{T1},P_{T2} are P_T of the two jets. Z_{cut} is soft drop threshold. ΔR_{12} are the two jets distance on the η-ϕ plane. β is the angular exponent. R_0 is the characteristic radius in clustering.

1. First, Anti-kt(AK) algorithm is used to reconstruct jets.
2. Second, after reconstructing the AK4 jets, Cambridge-Aachen (C/A) algorithm is used to decluster the jets into two (C/A) jets.
3. Third, these two jets are compared with the formula 1. Two jets will be reserved when they pass the formula, otherwise, the softer jet of two jets will be removed.
4. Finally, loop the procedure from 1.to 3.until the jet can not be declusteded into two jets.

In our study, we compare $\beta = 0$ with $\beta = 2$ and observe their performance in the future detector. For $\beta = 0$, the selection only depends on the Z_{cut}. For $\beta = 2$, the selection depends on the angle of two declustering jets and Z_{cut}, and it can remove both "soft" and "wide angle" jets.

3. Analysis method

First, start at the central value of the signal median bin's right boundary. Then, add the left and right bins to extend the width and draw the Receiver Operating Characteristic(ROC) curves.

4. The results and conclusions

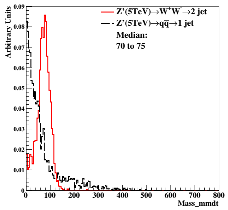
In the Figure[1][3][5][7], distributions of mass under SD at $\beta = 0$ and $\beta = 2$ with different c.m. energy and detector cell sizes are presented. Because different β and signal contain the different ranges of mass, we choose the different range in the histograms.

In the Figure [2][4][6][8], ROC curves are used to perform the study of comparing different parameters. The figures want to show which detector cell size has the best "background rejection" with different c.m. energies. In other words, which cell size has the best separation power to distinguish signal from background with different c.m. energies.

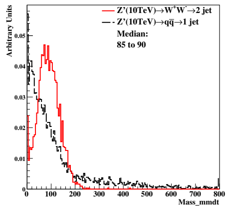
In the Figure [2], they show the ROC curves for WW signal at SD with $\beta = 0$ with different detector cell sizes and c.m. energies. These performances show that 5,10, 20 TeV have the best distinguish power with the smallest (1×1) detector cell sizes. Similar to the tt signal at same β in Figure[4], they have the best distinguish power at 10, 20 TeV with the smallest (1×1) detector cell sizes.

Oppositely, in the figure [6] and figure [8], these show the ROC curves for WW and tt signal at SD with $\beta = 2$. They show the same conclusions that all c.m. energies don't have any improvements with the smallest (1×1) detector cell sizes. Some of the ROC curves with the different detector cell sizes almost overlap, that means the performances of this three sizes are very similar. In addition, some of them have the best distinguish power with the bigger detector (5×5 or 20×20) cell size.

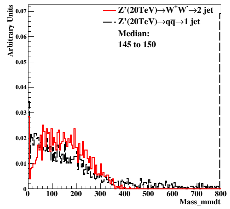
After this study, we found that SD with $\beta = 0$ has the better performance for distinguishing signal from background than $\beta = 2$. so we choose SD at $\beta = 0$ to be our mass cut and apply it in the jet substructure variables for the next step.



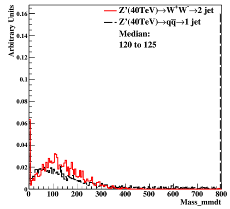
(a) 5TeV at 20×20(cm$\times$cm) in cluster



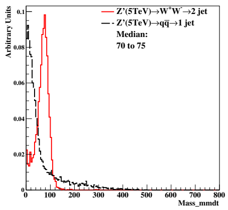
(b) 10TeV at 20×20(cm$\times$cm) in cluster



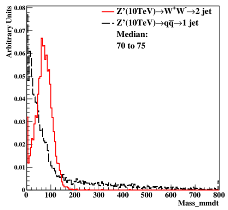
(c) 20TeV at 20×20(cm$\times$cm) in cluster



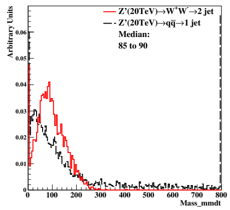
(d) 40TeV at 20×20(cm$\times$cm) in cluster



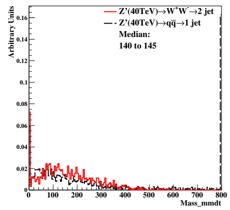
(e) 5TeV at 5×5(cm$\times$cm) in cluster



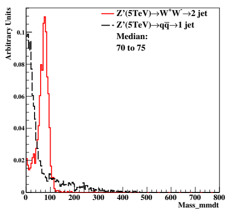
(f) 10TeV at 5×5(cm$\times$cm) in cluster



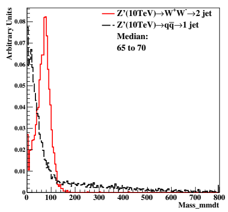
(g) 20TeV at 5×5(cm$\times$cm) in cluster



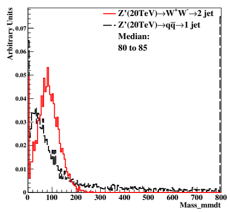
(h) 40TeV at 5×5(cm$\times$cm) in cluster



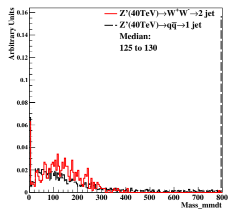
(i) 5TeV at 1×1(cm$\times$cm) in cluster



(j) 10TeV at 1×1(cm$\times$cm) in cluster

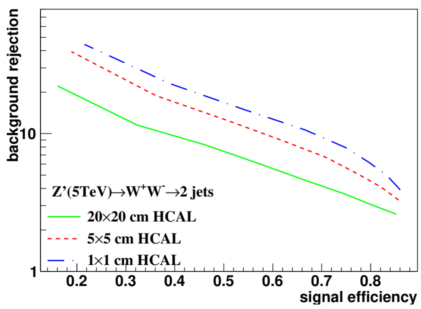


(k) 20TeV at 1×1(cm$\times$cm) in cluster

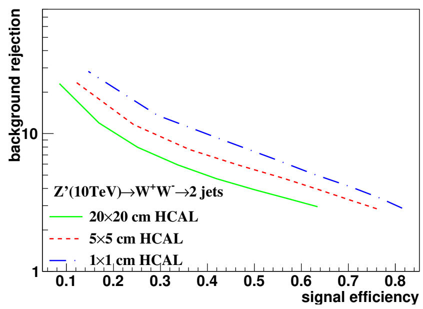


(l) 40TeV at 1×1(cm$\times$cm) in cluster

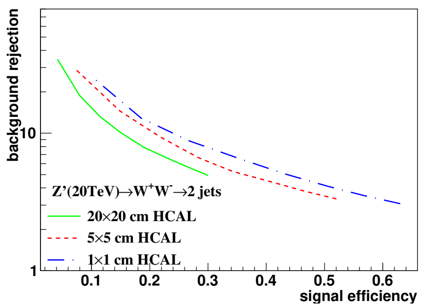
Figure 1: Distributions of mass soft drop at β=0, signal=ww, in 5,10,20,40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm$\times$cm) are shown here.



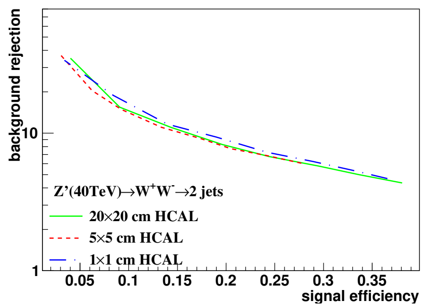
(a) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 5TeV



(b) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 10TeV

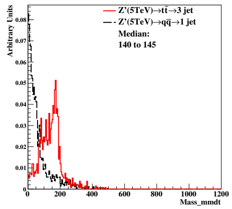


(c) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 20TeV

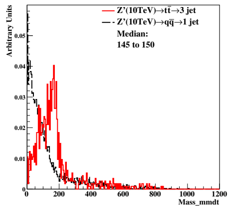


(d) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 40TeV

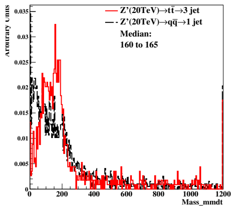
Figure 2: study of "fix central and change width" in mass soft drop at β=0, signal=ww, in 5, 10, 20, 40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown in each picture.



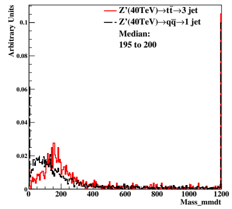
(a) 5TeV at 20×20(cm×cm) in cluster



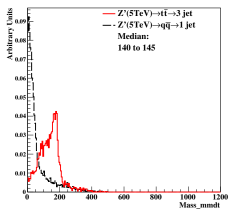
(b) 10TeV at 20×20(cm×cm) in cluster



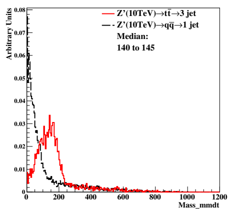
(c) 20TeV at 5×5(cm×cm) in cluster



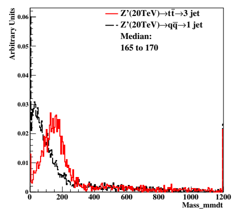
(d) 40TeV at 5×5(cm×cm) in cluster



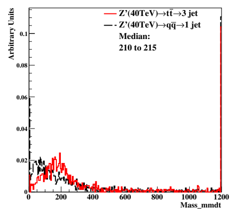
(e) 5TeV at 1×1(cm×cm) in cluster



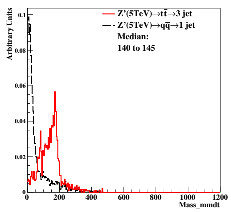
(f) 10TeV at 1×1(cm×cm) in cluster



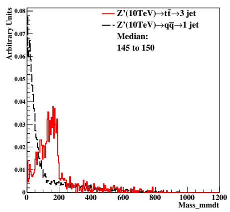
(g) 20TeV at 20×20(cm×cm) in cluster



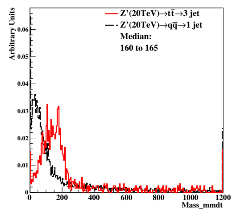
(h) 40TeV at 20×20(cm×cm) in cluster



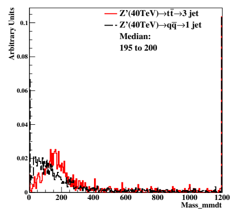
(i) 5TeV at 5×5(cm×cm) in cluster



(j) 10TeV at 5×5(cm×cm) in cluster

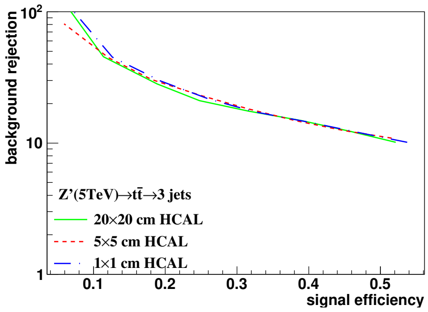


(k) 20TeV at 1×1(cm×cm) in cluster

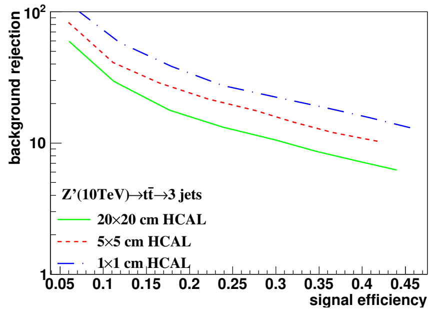


(l) 40TeV at 1×1(cm×cm) in cluster

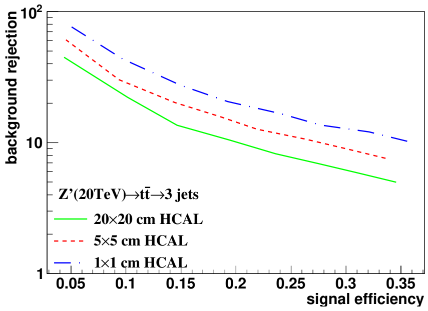
Figure 3: Distributions of mass soft drop at β=0, signal=tt, in 5,10,20,40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown here.



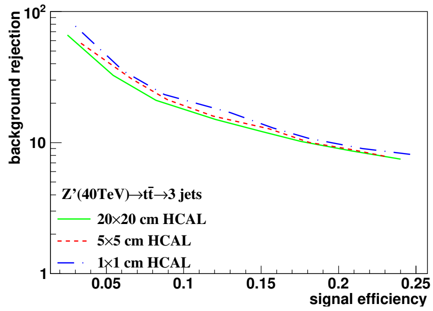
(a) Central at Median(20×20=,5×5=,1×1=) change width in cluster at 5TeV



(b) Central at Median(20×20=,5×5=,1×1=) change width in cluster at 10TeV

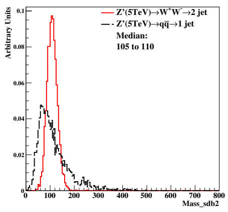


(c) Central at Median(20×20=,5×5=,1×1=) change width in cluster at 20TeV

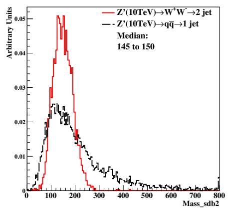


(d) Central at Median(20×20=,5×5=,1×1=) change width in cluster at 40TeV

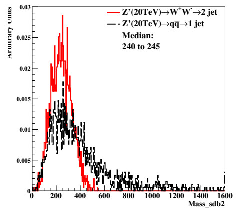
Figure 4: study of "fix central and change width" in mass soft drop at β=0, signal=tt, in 5, 10, 20, 40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown in each picture.



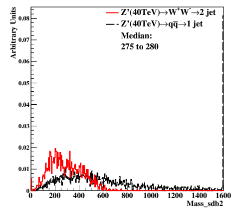
(a) 5TeV at 20×20(cm×cm) in cluster



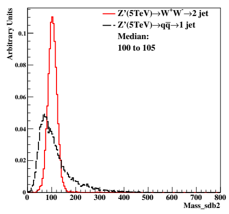
(b) 10TeV at 20×20(cm×cm) in cluster



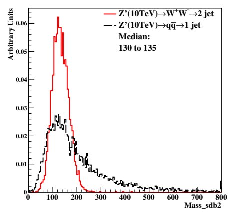
(c) 20TeV at 20×20(cm×cm) in cluster



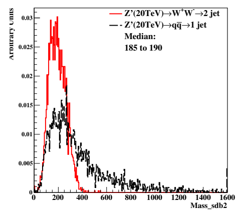
(d) 40TeV at 20×20(cm×cm) in cluster



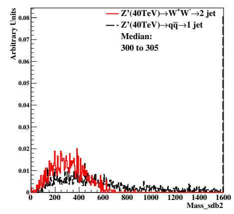
(e) 5TeV at 5×5(cm×cm) in cluster



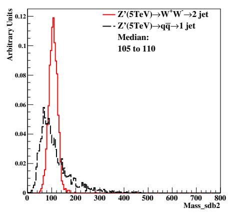
(f) 10TeV at 5×5(cm×cm) in cluster



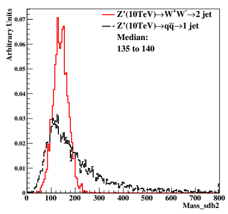
(g) 20TeV at 5×5(cm×cm) in cluster



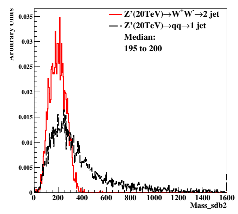
(h) 40TeV at 5×5(cm×cm) in cluster



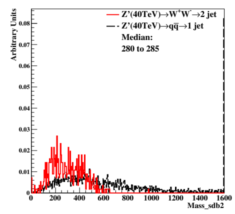
(i) 5TeV at 1×1(cm×cm) in cluster



(j) 10TeV at 1×1(cm×cm) in cluster

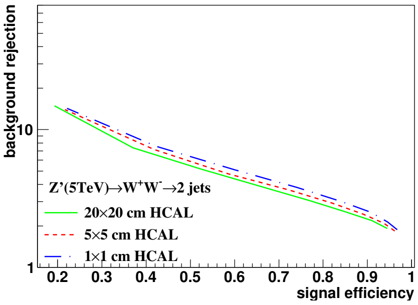


(k) 20TeV at 1×1(cm×cm) in cluster

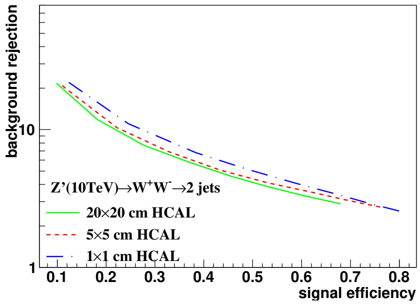


(l) 40TeV at 1×1(cm×cm) in cluster

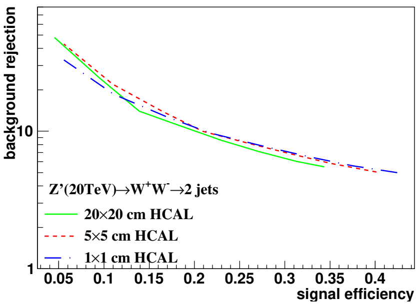
Figure 5: Distributions of mass soft drop at β=2, signal=ww, in 5,10,20,40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown here.



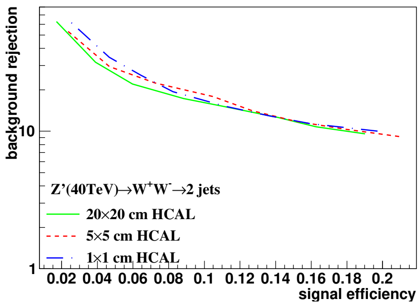
(a) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 5TeV



(b) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 10TeV

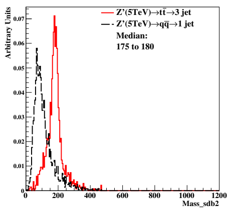


(c) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 20TeV

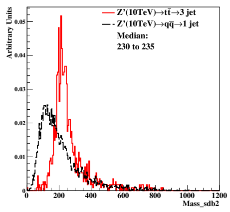


(d) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 40TeV

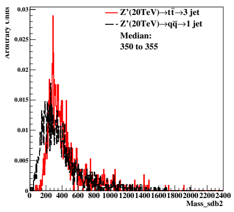
Figure 6: study of "fix central and change width" in mass soft drop at β=2, signal=ww, in 5, 10, 20, 40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown in each picture.



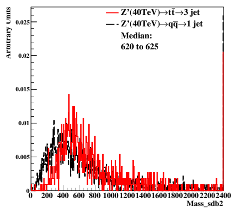
(a) 5TeV at in 20×20(cm×cm) cluster



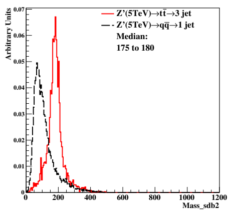
(b) 10TeV at in 20×20(cm×cm) cluster



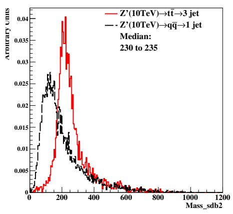
(c) 20TeV at in 20×20(cm×cm) cluster



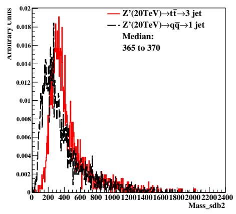
(d) 40TeV at in 20×20(cm×cm) cluster



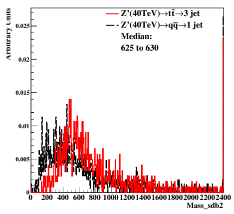
(e) 5TeV at in 5×5(cm×cm) cluster



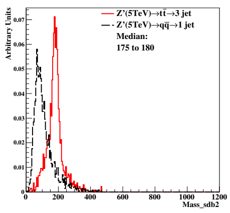
(f) 10TeV at in 5×5(cm×cm) cluster



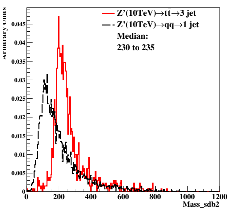
(g) 20TeV at in 5×5(cm×cm) cluster



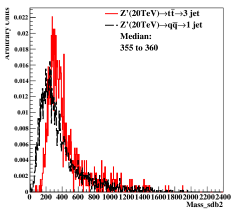
(h) 40TeV at in 5×5(cm×cm) cluster



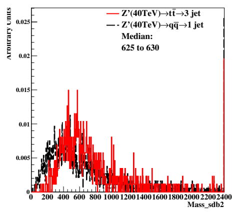
(i) 5TeV at in 1×1(cm×cm) cluster



(j) 10TeV at in 1×1(cm×cm) cluster

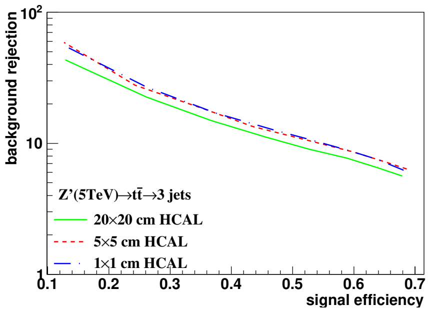


(k) 20TeV at in 1×1(cm×cm) cluster

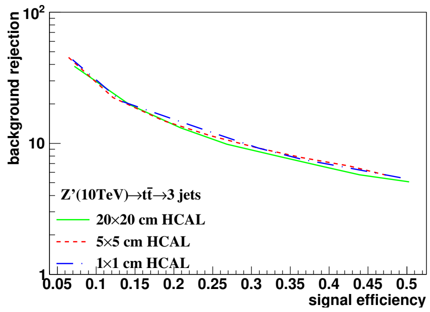


(l) 40TeV at in 1×1(cm×cm) cluster

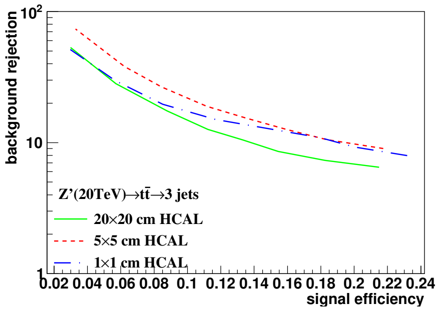
Figure 7: Distributions of mass soft drop at β=2, signal=tt, in 5,10,20,40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown here.



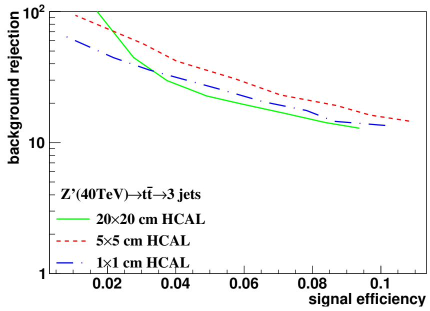
(a) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 5TeV



(b) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 10TeV



(c) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 20TeV



(d) Central at Median(20 × 20=,5 × 5=,1 × 1=) change width in cluster at 40TeV

Figure 8: study of "fix central and change width" in mass soft drop at β=2, signal=tt, in 5, 10, 20, 40TeV energy of collision in different detector sizes. Cell Size in 20×20, 5×5, and 1×1(cm×cm) are shown in each picture.