Studies of granularity of a hadronic calorimeter for tens-of-TeV jets at a 100 TeV pp collider

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Abstract

Texts

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1. Introduction

Particle collisions at energies beyond those attained at the LHC will lead to many challenges for detector technologies. Future experiments, such as high-energy LHC (HE-LHC), future circular pp colliders of the European initiative, FCC-hh [?] and the Chinese initiative, SppC [?].

The studies of this paper are based on full Geant4 simulation and reconstruction as implemented in the detector described in [?]. This study included the discussion of the impact of the calorimeter granularity on the shape of hadronic showers in terms of the calorimeter hits for two particles separated by some angle. It was concluded that HCAL granularity is essential in resolving two close-by particles for energies above 100 GeV. This paper makes a new step towards understanding of this problem using high-level physics quantities used in physics studies.

2. Studies of effective jet radius

The effective radius is the average of the energy weighted radial distance in $\eta - \phi$ space of jet constituents. Recently, it has been studied for multi-TeV jets in Ref.[?].

New we sill study jet splitting the effect of granularity on jet splitting scales. A jet k_T splitting scale [?] is defined as a distance measure used to form jets by the k_T recombination algorithm [? ?]. This has been studied by ATLAS [?], and more

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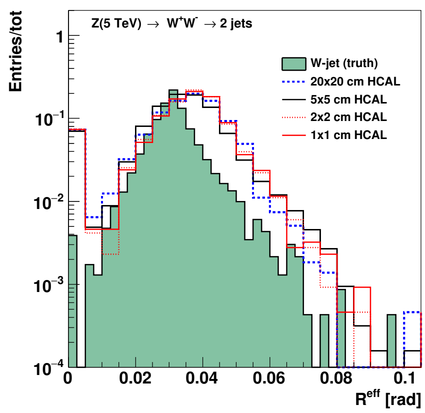
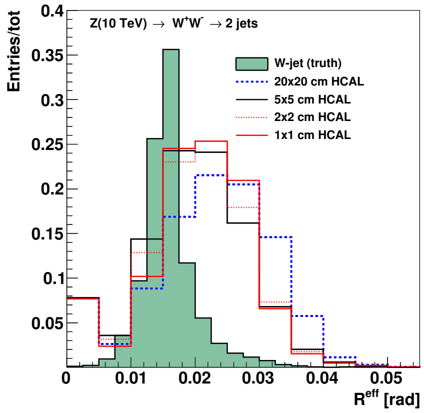
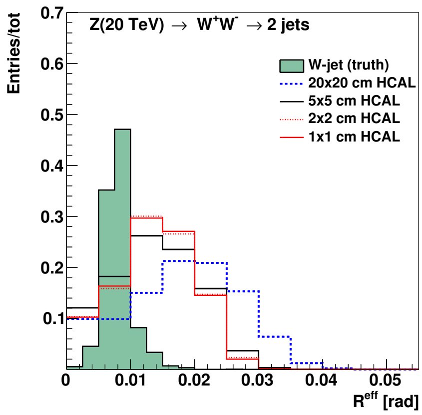


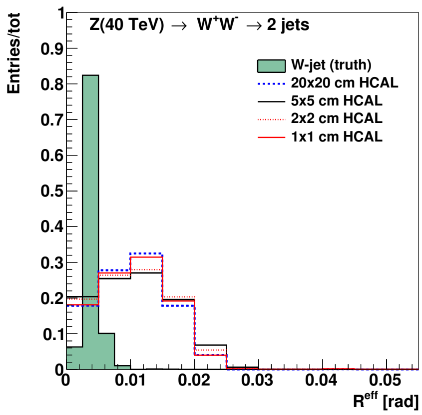
(a) 5 TeV



(b) 10 TeV

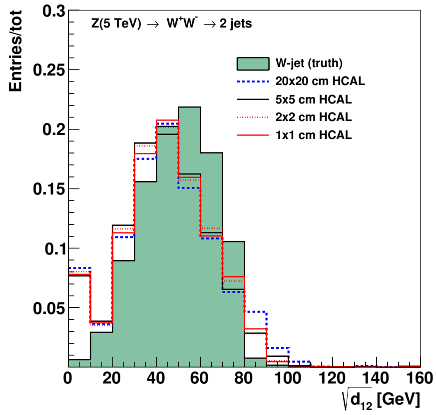


(c) 20 TeV

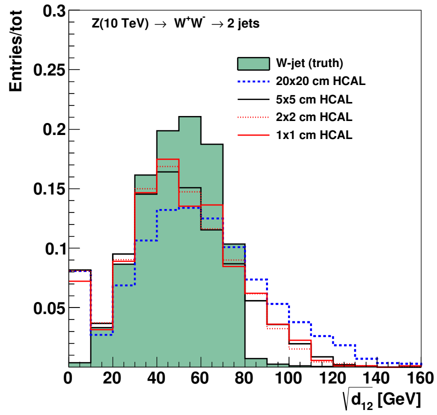


(d) 40 TeV

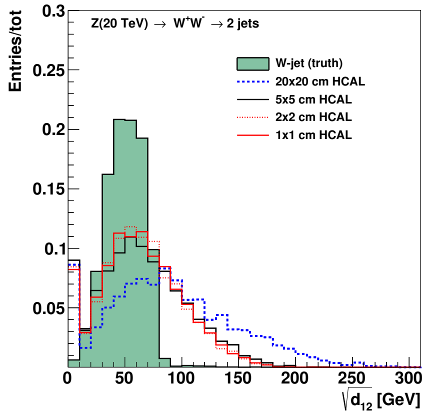
Figure 1: Jet effective radius for different jet transverse moment and HCAL granularity.



(a) 5 TeV



(b) 10 TeV



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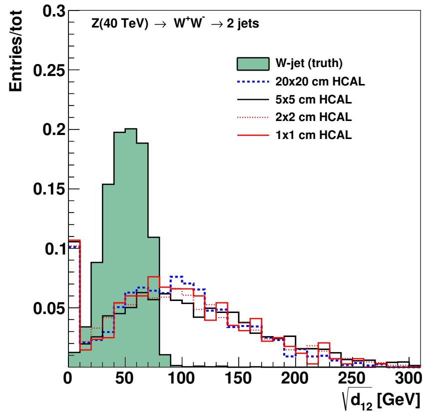

(d) 40 TeV

Figure 2: Jet splitting scale for different jet transverse moment and HCAL granularity.

recently in the context of 100 TeV physics [**?**]. The distribution of the splitting scale $\sqrt{d_{12}} = \min(p_T^1, p_T^2) \times \delta R_{12}$ [**?**] at the final stage of the k_T clustering, where two subjets are merged into the final one, is shown in Fig. 2.

3. Studies of signal and background separation in detector-level of cluster

In the Future detector ,when energy of collision is increased, pileup is bigger. The most important thing is separating signal and background efficiently. In this section, we want to study in different variables and see wether those can efficiently separate the signal and background in different detector size in detector-level of cluster.

Figure 3 to 5 show three variables about $c2b1$, τ_{21}, and τ_{32} in different energy of collision, the ROC curve of the different HCAL detector sizes. The criteria of separation efficiency is that in the different sizes of the detector, if the certain one of the detector size has the highest value of (1-background efficiency) at same signal efficiency of different detector sizes, it means its background efficiency is the lowest one among all(because value of [1-background efficiency] is limited between zero to one), and we can say it has the highest separation efficiency compare with other detector sizes.

In Figure 3 we can see that $c2b1$ is the best variable to separate the signal and background, because all lines have the highest separation efficiency compare with other two variables(Figure 4 and Figure 5) in same energy. But in the different detector size of separation efficiency in this variable, we can't see more improvement in, as you can see, all lines nearly merge together in all individual energy, it means all detector sizes has the similar separation efficiency in same energy.

Figure 4 performs that τ_{21} at 5 TeV in smallest detector size(1×1) can separate signal and background well. But higher than 5TeV, all lines nearly merge together, it means they have similar separation efficiency. In 20TeV and 40TeV, specially, bigger detector size has the higher separation efficiency than smaller detector size in this two energy.

Figure 5 shows τ_{32} follows the role that smaller detector size have the bigger separation efficiency in all energy. This one is what we want to see, because we want to use the smaller detector size to enhance the separation efficiency of the detector.

In summary, the purpose of this study is to see which variable can separate the signal and background efficiently. We can see that $c2b1$ have the high separation efficiency in any energy of collision in all size of detector, and τ_{32} have the higher separation efficiency when the detector size is smaller in all energy of collision. We think this two variables can help the future high energy collider analysis.

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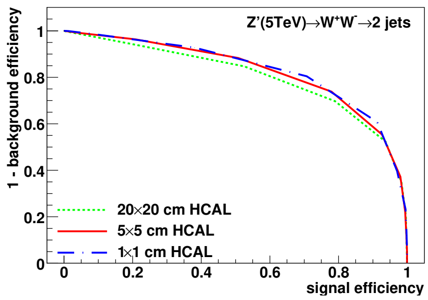
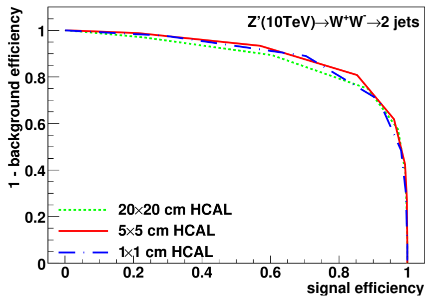
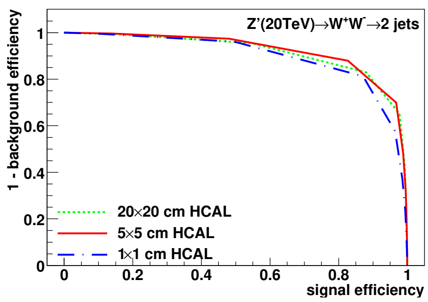


(a) 5 TeV



(b) 10 TeV



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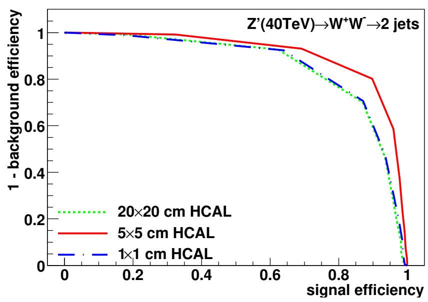
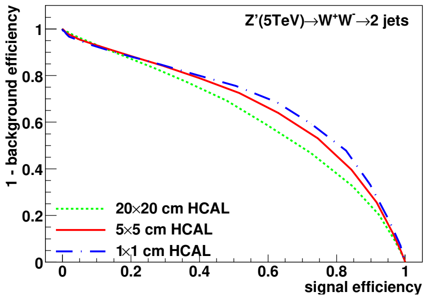
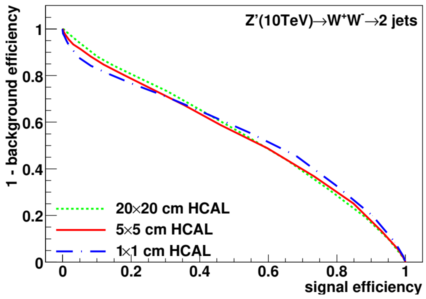


(d) 40 TeV

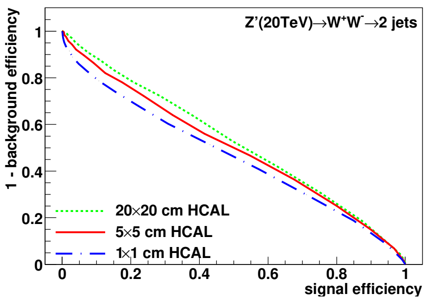
Figure 3: Signal efficiency versus background rejection rate using $c2b1$.In the pictures, there are three ROC curve of the different detector sizes in different energy of collision.



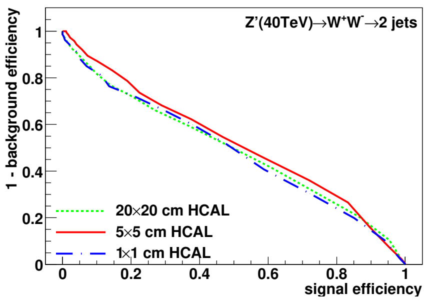
(a) 5 TeV



(b) 10 TeV

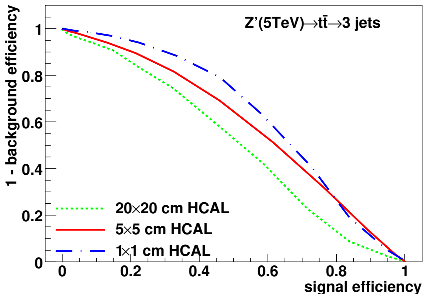


(c) 20 TeV

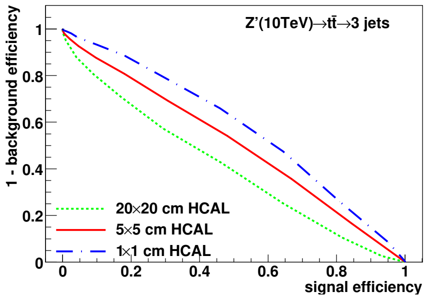


(d) 40 TeV

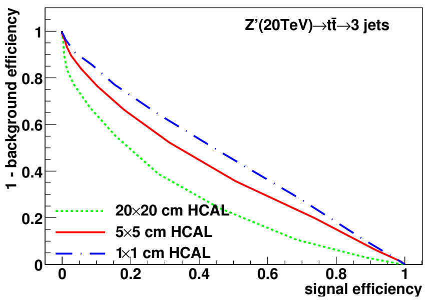
Figure 4: Signal efficiency versus background rejection rate using τ_{21}.In the pictures, there are three ROC curve of the different detector sizes in different energy of collision.



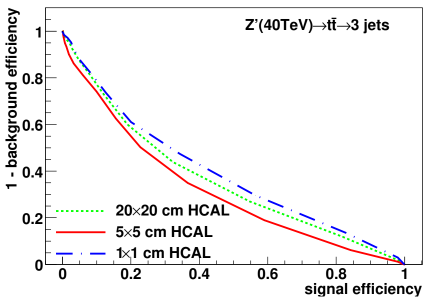
(a) 5 TeV



(b) 10 TeV



(c) 20 TeV



(d) 40 TeV

Figure 5: Signal efficiency versus background rejection rate using τ_{32}.In the pictures, there are three ROC curve of the different detector sizes in different energy of collision

References