

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

S.V. Chekanov^a, M. Beydler^a, A.V. Kotwal^{b,c}, J. Proudfoot^a, S. Sen^b, N.V. Tran^c,
S.-S. Yu^e, Chih-Hsiang Yeh^e

^a *HEP Division, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439, USA.*

^b *Department of Physics, Duke University, USA*

^c *Fermi National Accelerator Laboratory*

^d *Department of Physics, Michigan State University, 220 Trowbridge Road, East Lansing, MI 48824*

^e *Department of Physics, National Central University, Chung-Li, Taoyuan City 32001, Taiwan*

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 [?].

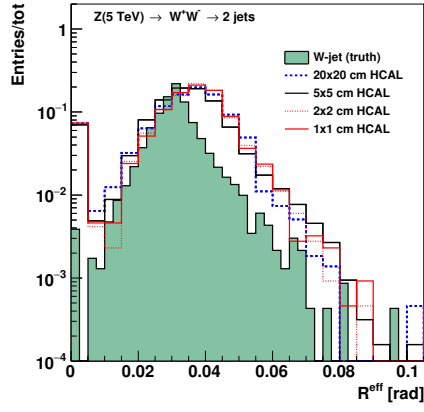
The studies of this paper are based on full Geant4 simulation and reconstruction as implemented in the detector described in [?]. This study included the discussion of the impact of the calorimeter granularity on the shape of hadronic showers in terms of the calorimeter hits for two particles separated 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

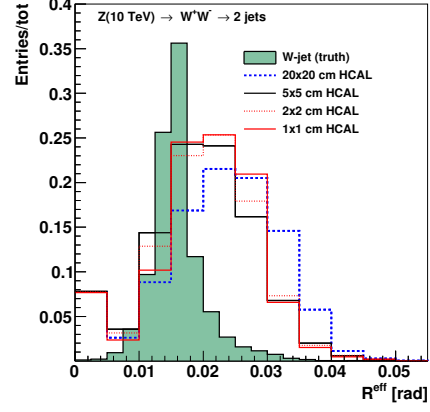
The effective radius is the average of the energy weighted radial distance in $\eta - \phi$ space of jet constituents. Recently, it has been studied for multi-TeV jets in Ref.[?].

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

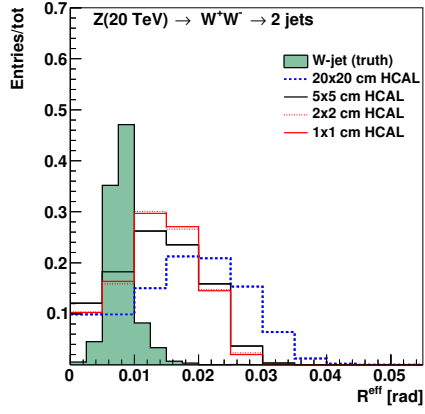
Email addresses: chekanov@anl.gov (S.V. Chekanov), mmbeydler@gmail.com (M. Beydler), ashutosh.kotwal@duke.edu (A.V. Kotwal), proudfoot@anl.gov (J. Proudfoot), sourav.sen@duke.edu (S. Sen), ntran@fnal.gov (N.V. Tran), syu@cern.ch (S.-S. Yu), jwzuzelski18@gmail.com (Chih-Hsiang Yeh)



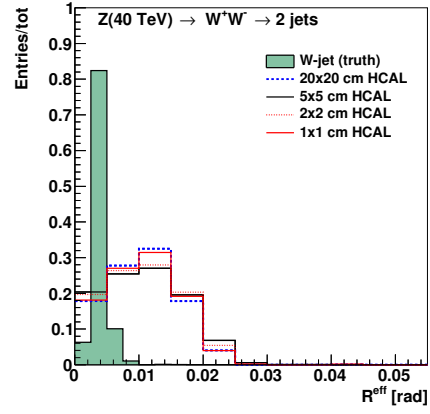
(a) 5 TeV



(b) 10 TeV



(c) 20 TeV



(d) 40 TeV

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

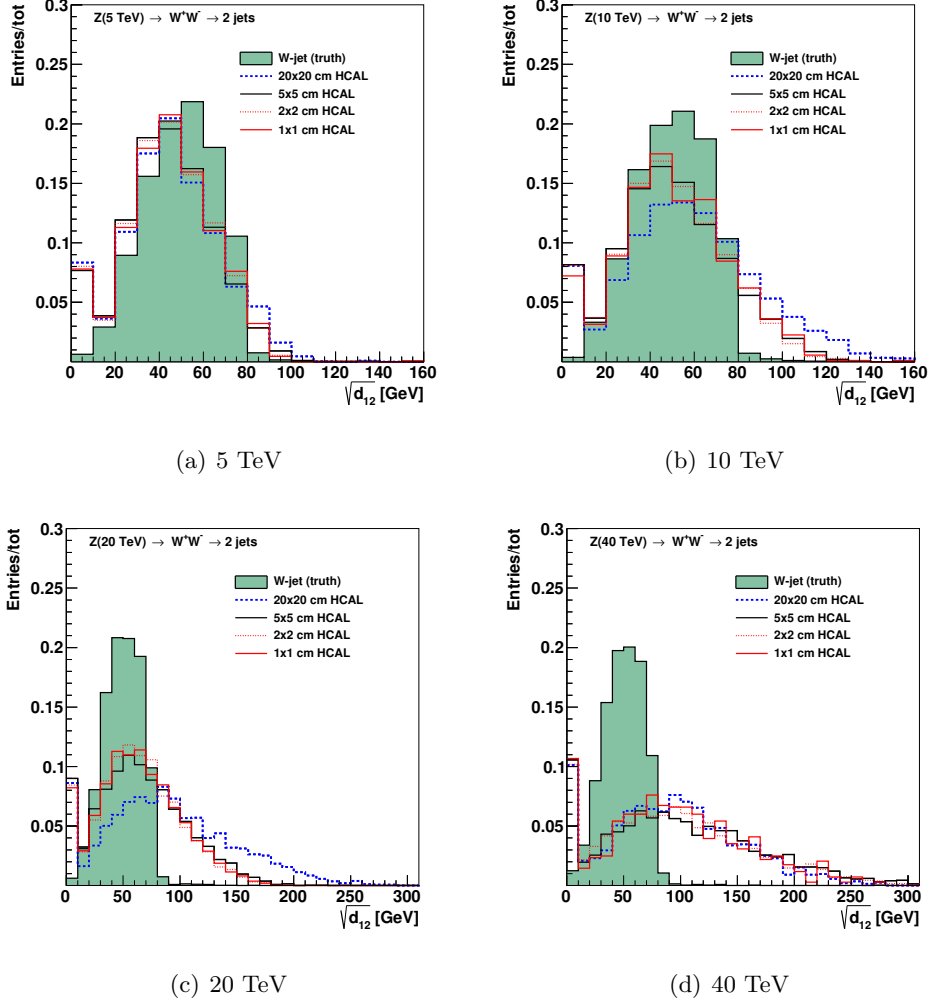


Figure 2: Jet splitting scale for different jet transverse moment and HCAL granularity.

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 cluster

In the Future detector ,when energy of collision is upper, pileup is bigger and bigger, and the most important thing is that can separate 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 cluster.

In the Figure 3 to 5, there are three variables about $c2b1$, τ_{21} , and τ_{32} signal efficiency versus background rejection rate plots. The criteria of separation efficiency is

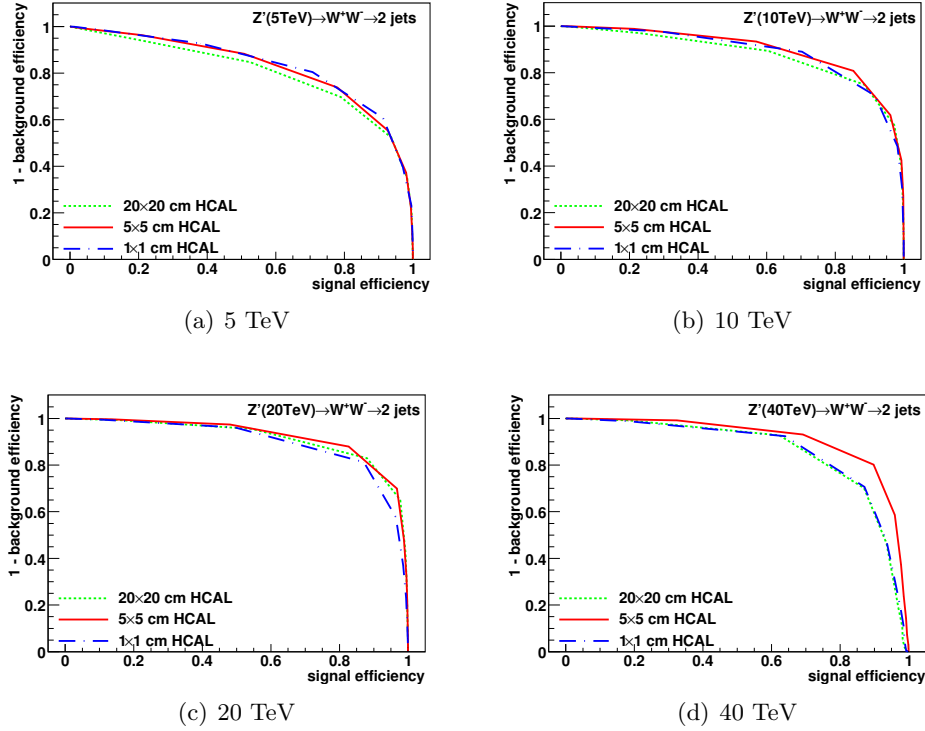


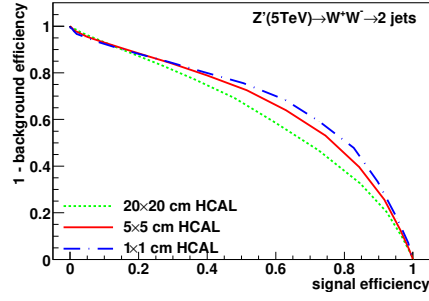
Figure 3: Signal efficiency versus background rejection rate using $c2b1$. We can see this variable is the best variable to separate the signal and background, because all lines are higher than other two variables. But in the different size of separation efficiency in this variable, we can't see more improvement in, as you can see, all lines nearly merge together in all energy.

that, if the point is higher, it means it can separate the signal and background more efficiently. Because at the same signal efficiency of different detector size, higher point means lower background efficiency, and that means it can separate well, and it will have the higher separation efficiency

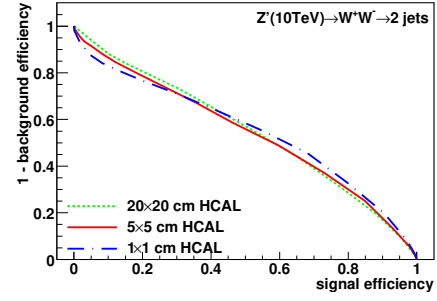
We can see $c2b1$ is the best way to separation, τ_{21} can't improve the separation in different detector size at higher energy, and τ_{32} has the good pattern to follow that the smaller detector size, the better the separation efficiency.

Acknowledgements

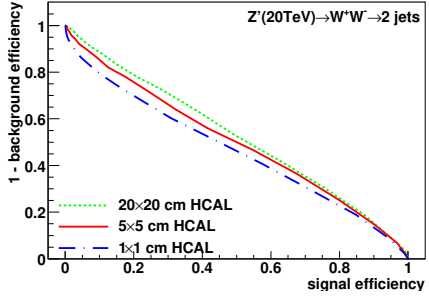
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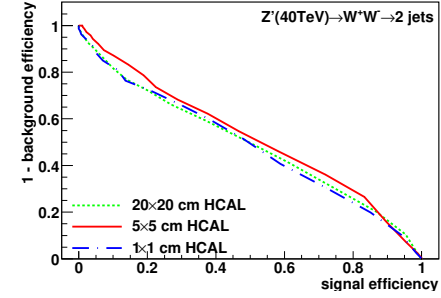
(a) 5 TeV



(b) 10 TeV

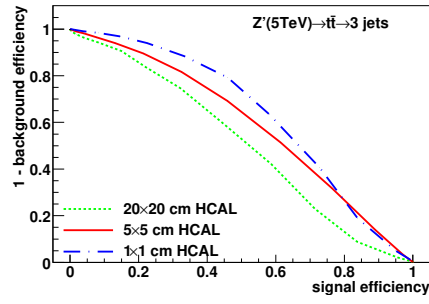


(c) 20 TeV

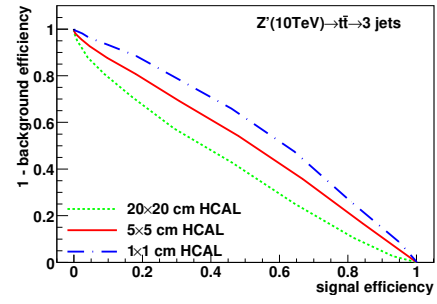


(d) 40 TeV

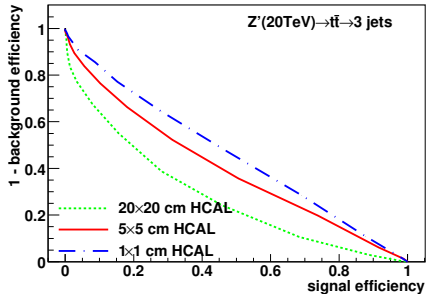
Figure 4: Signal efficiency versus background rejection rate using τ_{21} : we can see at 5 TeV in smallest detector size, it can separate signal and background well. But at 10 TeV, all lines nearly merge together. And in higher energy, we can see that it won't improve the separation efficiency, and bigger detector size even better than smaller size.



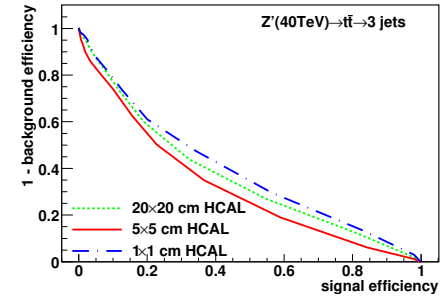
(a) 5 TeV



(b) 10 TeV



(c) 20 TeV



(d) 40 TeV

Figure 5: Signal efficiency versus background rejection rate using τ_{32} : we can see that it follows the role which smaller detector size have the bigger separation efficiency in all energy.

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References