SiD@ILC

Refining Hadron Calorimeter Simulations

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July 2010

Project Overview

- The first aspect of the study is on the effect of dead areas - including gaps, regions without instrumentation, and dead material - in the calorimeters' performance. These gaps can affect pattern recognition, calibration, and uniformity of detector response, and unless corrected for, will degrade the accuracy of results. In my study, I focused on gaps between the modules in the hadron calorimeter.

- The cracks can either be projective or non-projective. Projective cracks will lie along a specific azimuthal angle (phi), while non-projective cracks will affect a range of phi.

- In order to determine the effects of the cracks, I use sid02 as a baseline: by looking at the effects of dead areas on a perfectly symmetrical detector, it is possible to separate the effects of added dead areas from the decreased resolution shown by the more realistic sidloi3 simulation.

Project Details

- In order to study these variants, I must first simulate appropriate events. I started with single neutral hadron events (K0L, n, nbar), and once I was sure of my simulation, progressed to qqbar events at 100, 200, 350 and 500 GeV events.
- I simulated two types of dead areas: gaps between the modules, and "skins" on the modules. Gaps are simulated by removing hits in the data; skins are simulated as uninstrumented steel.
- The size of the gaps will be determined by hardware limitations such as the amount of support structure needed. As they will probably between 10mm and 20mm, I simulated both extremes. The type of gap - projective or non-projective – will be decided upon based on the accuracy of the resolution and difficulty of construction.

Project Details

- Thus, I ran simulations of the following types of hadron calorimeter: cylindrical without cracks (for a baseline), cylindrical with 10mm non-projective cracks, cylindrical with 20mm non-projective cracks, cylindrical with 10mm projective cracks, cylindrical with 20mm projective cracks, realistic without cracks (for a baseline of the realistic detector), realistic with 5mm "skins", and realistic with 10mm "skins".

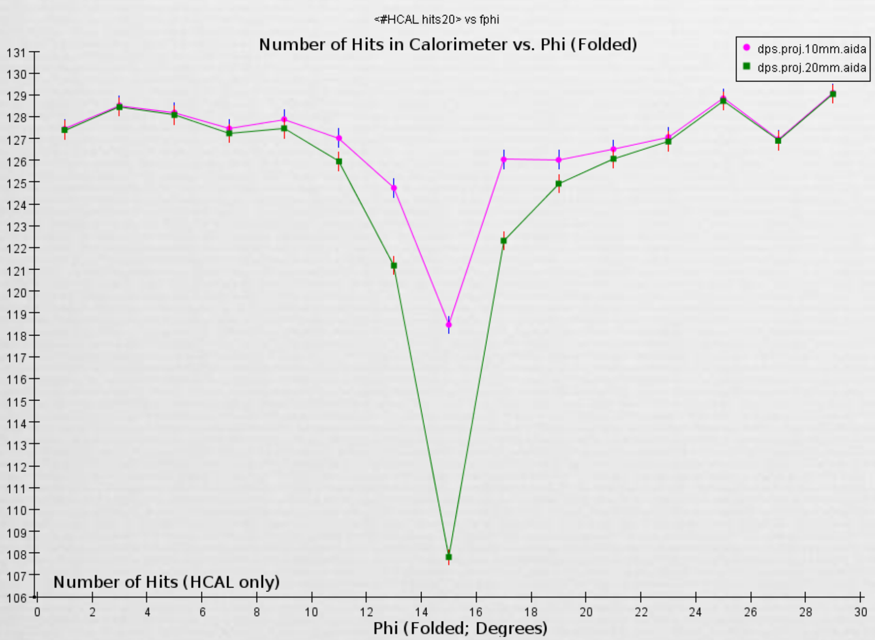
- As none of the already-simulated data sets had cracks, I simulated them by removing hits in the effective areas. The events I used were generated by Ron Cassell using SLIC; from there, I created xml files that used lcsim to reconstruct the events. This was done using a modified version of the existing ReconDriver; the code is my contrib area.

Project Details

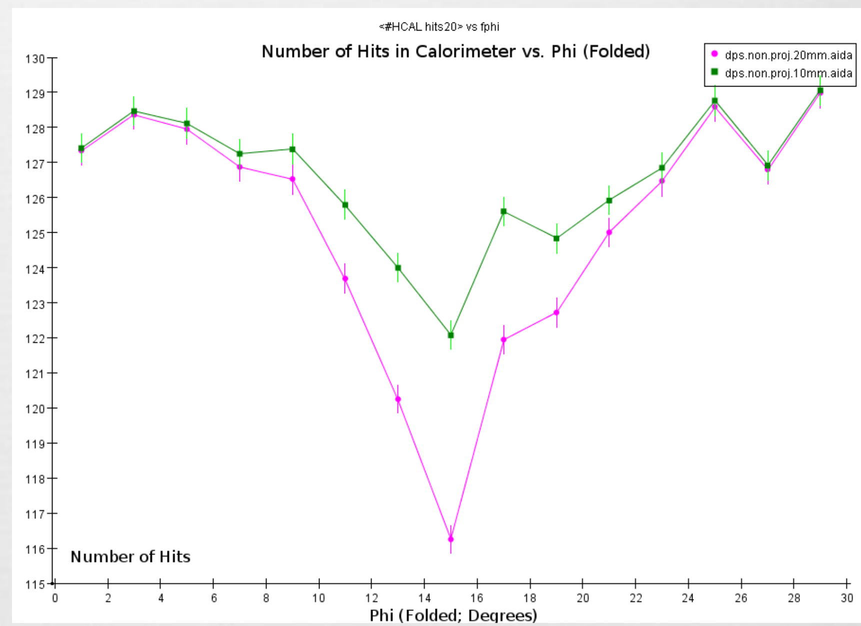
- I used 20 GeV neutral hadrons (K0_L, n, nbar) in order to make sure my hit-removal algorithm and reconstruction worked correctly. I then used qqbar events (uds only) at 100, 200, 350, and 500 GeV. I chose to use these as they are simplest to interpret and also generate – further study should be done with b & t quarks.
- Rather than plot the entire phi range, I took advantage of the twelve-folded symmetry in phi, and "folded" the results over a 30 degree area. Projective and non-projective results cannot be directly compared as the calculations vary slightly.
- Overall goals: study the event energy resolution, and overall physics effects of each type and size of crack. Determine if it is worth the extra time and cost to build a hadron calorimeter with non-projective cracks.

Data (Neutral Hadrons)

Projective Cracks (10 mm & 20 mm)



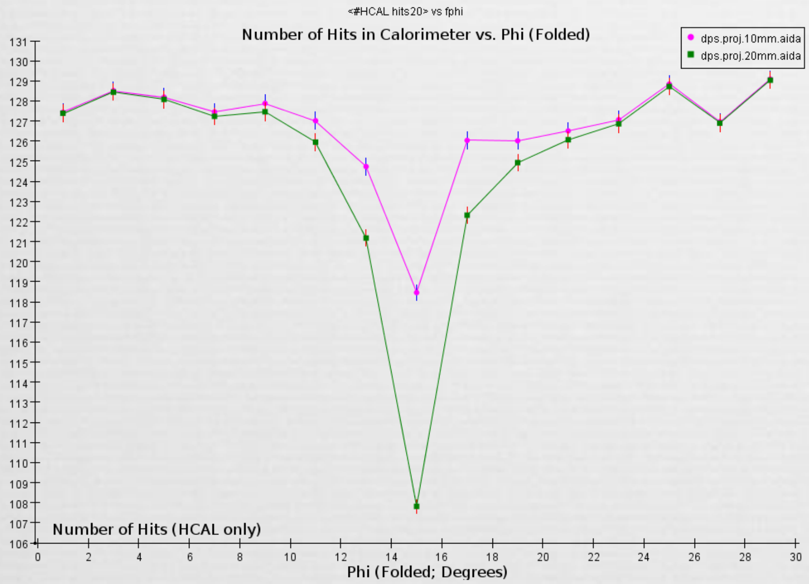
Non-Projective Cracks (10 mm & 20 mm)



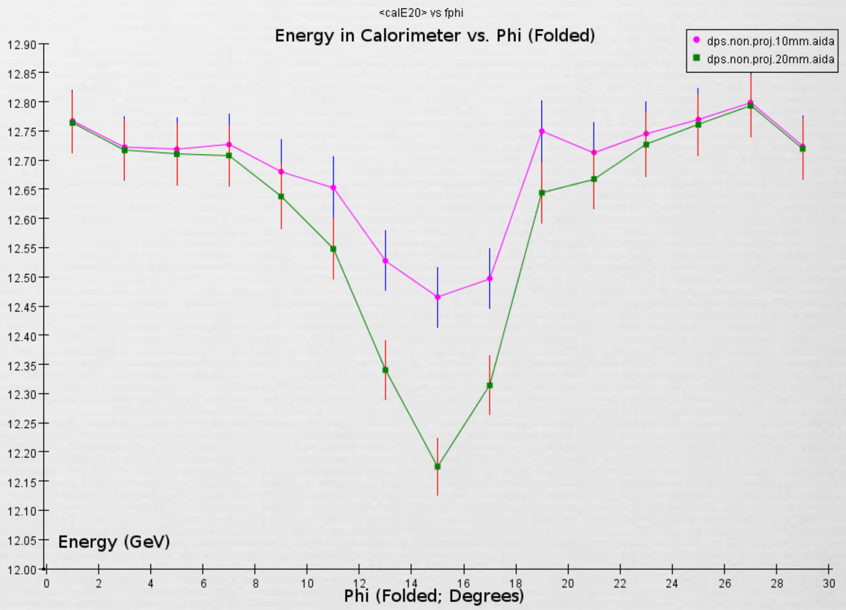
Both plots are of the number of hits in the hadron calorimeter vs. phi.
The data sets used were neutral hadrons at 20 GeV.

Data (Neutral Hadrons)

Energy in HCAL
(10mm and 20mm projective cracks)



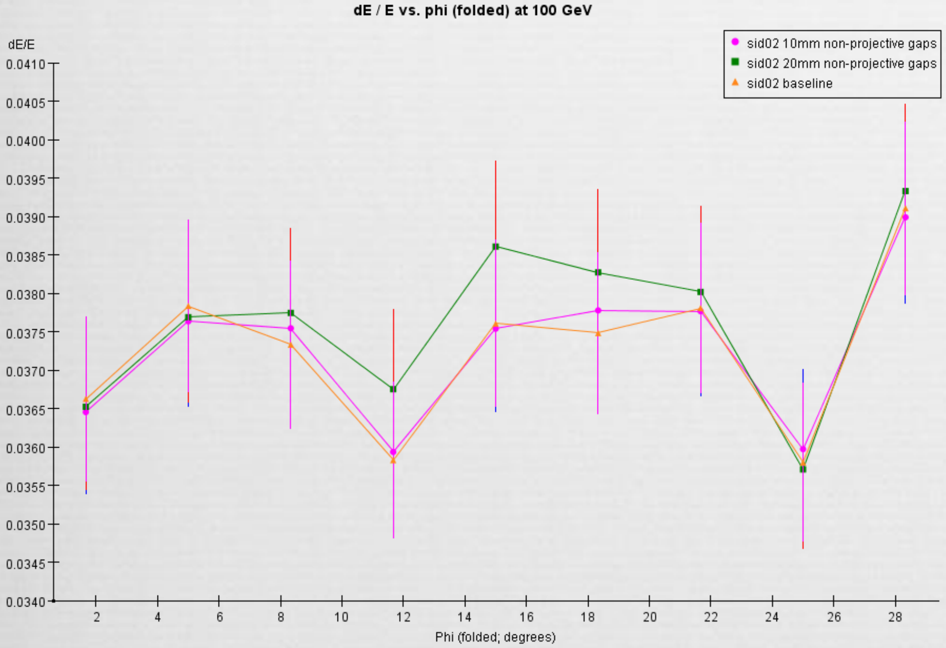
Energy in HCAL
(10mm and 20mm non-projective cracks)

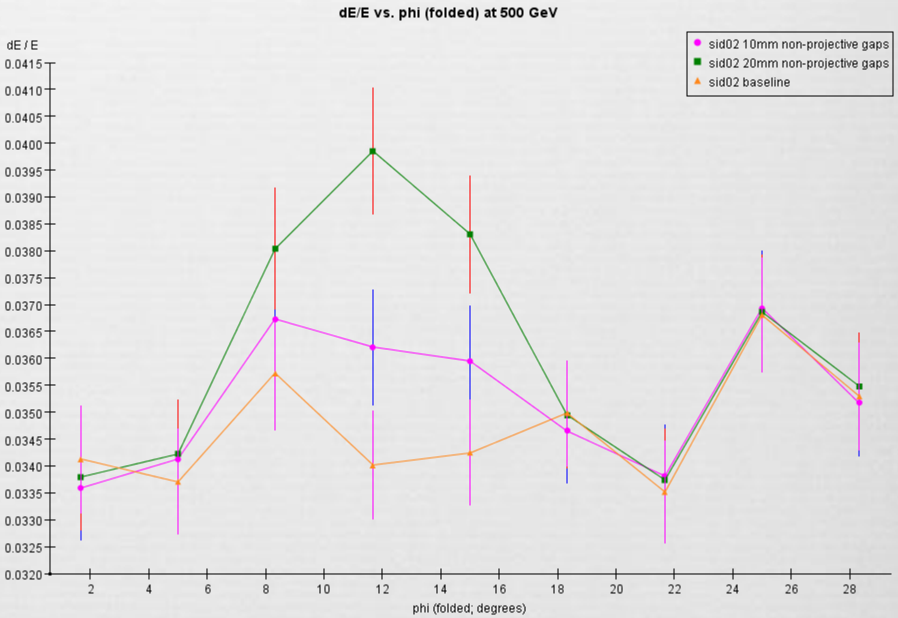


Both plots use 20 GeV neutral hadrons.

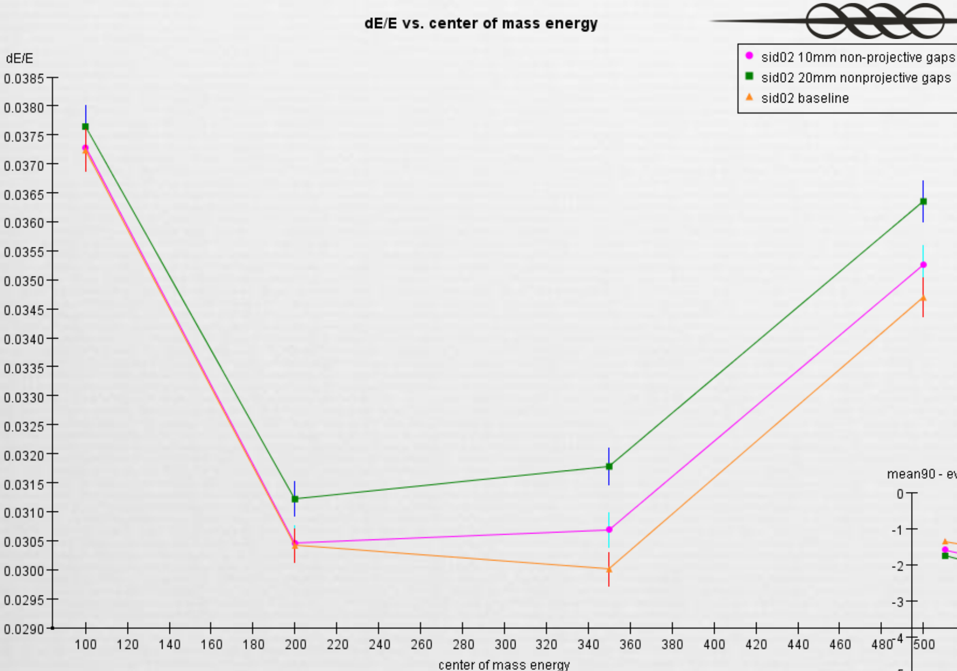
Data (non-proj sid02)

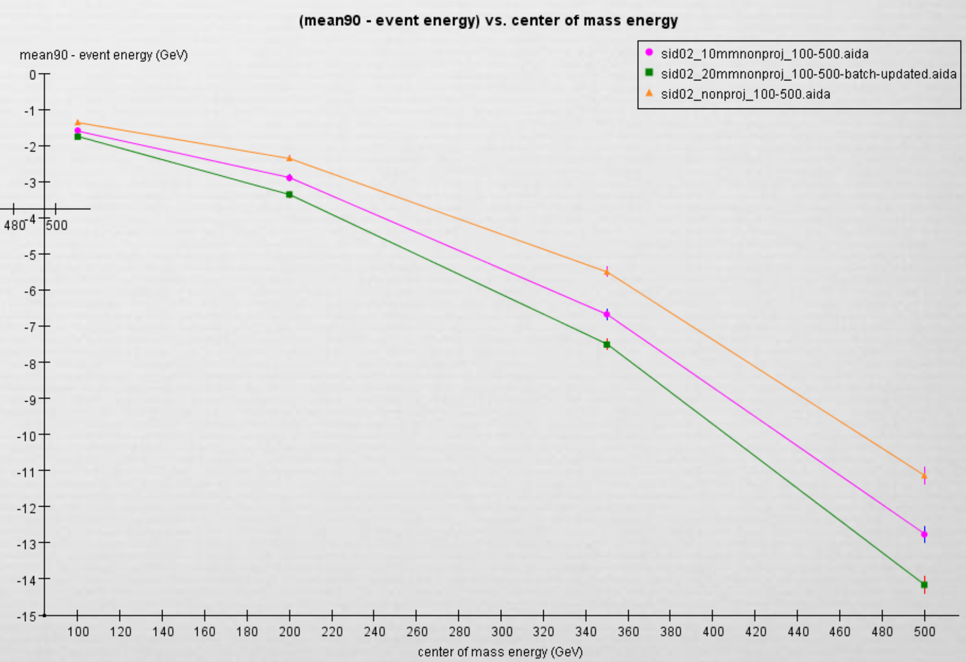
- Effects of the cracks are proportional to event energy.



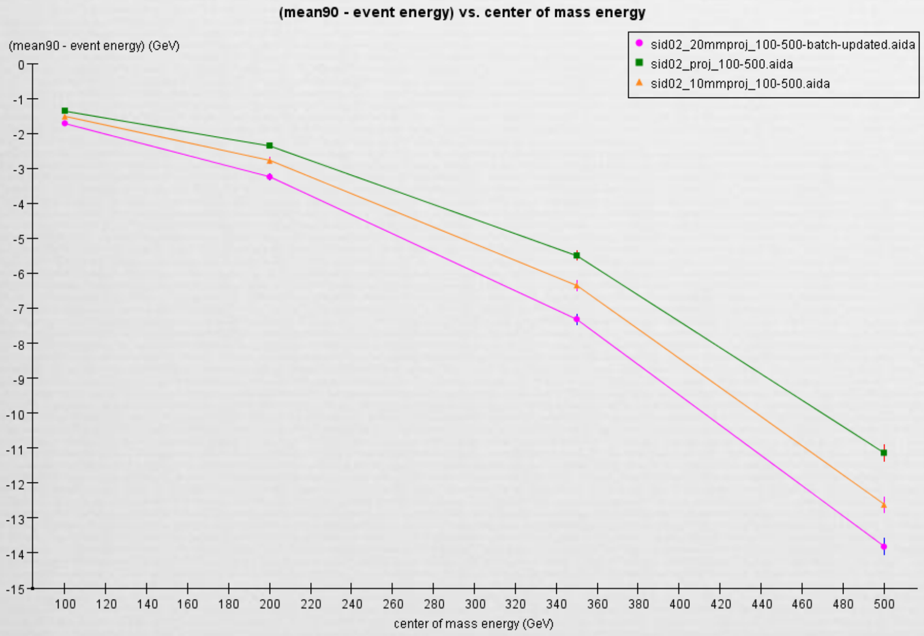


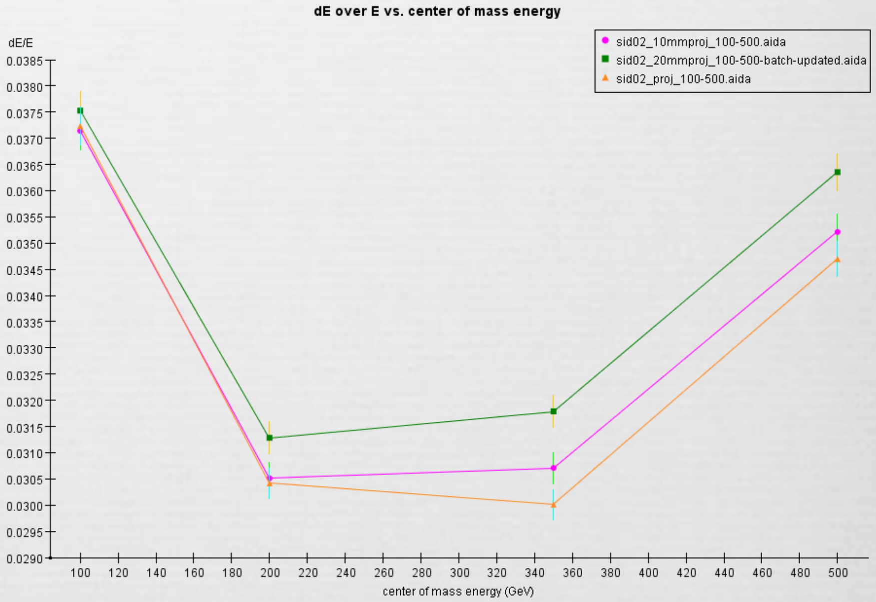
Data (non-proj sid02)



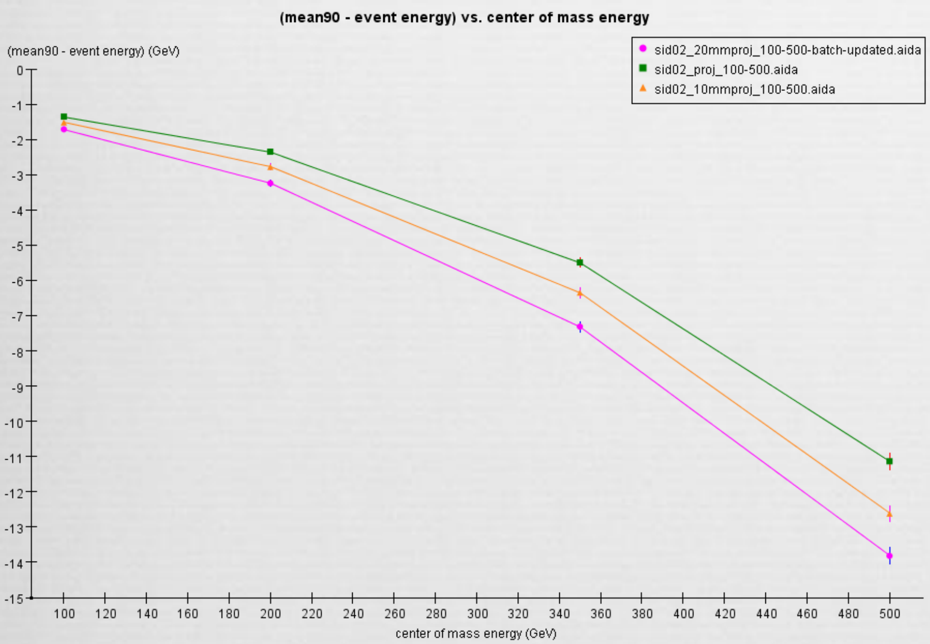


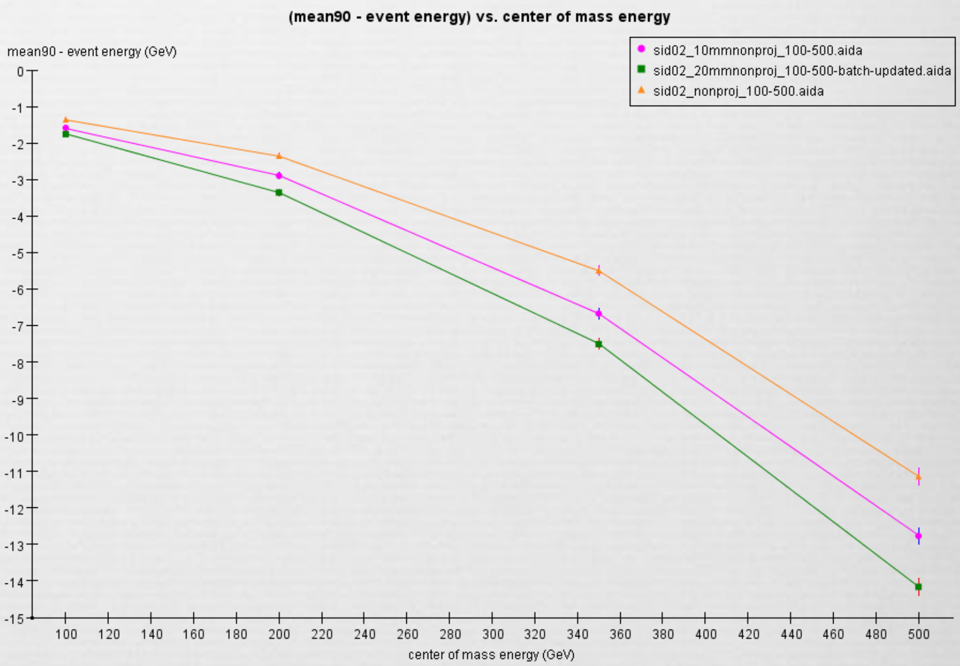
Data (proj sid02)



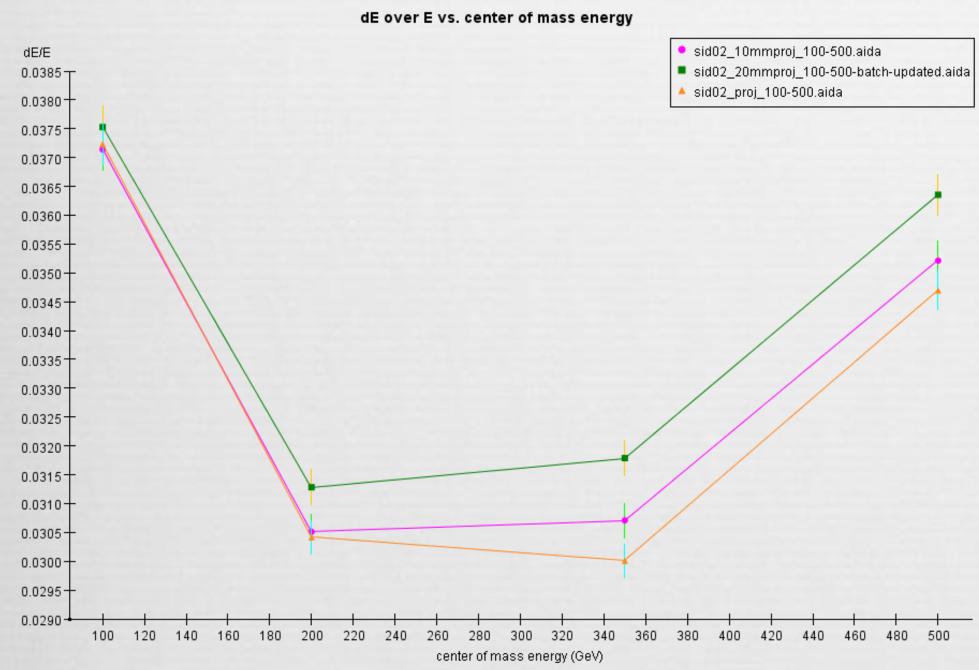


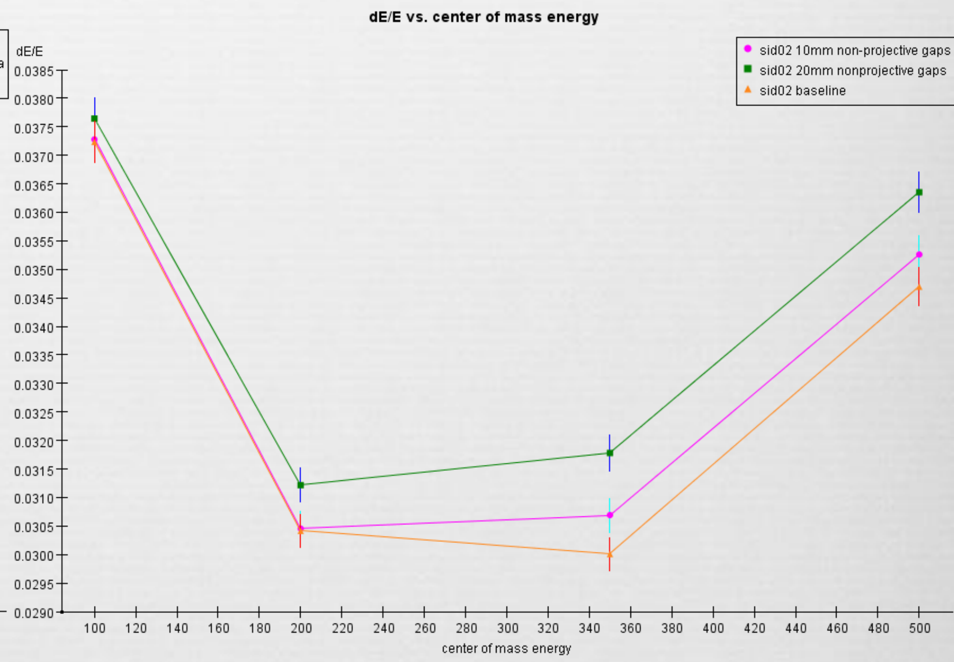
Data (Projective and Non-Projective Comparison)





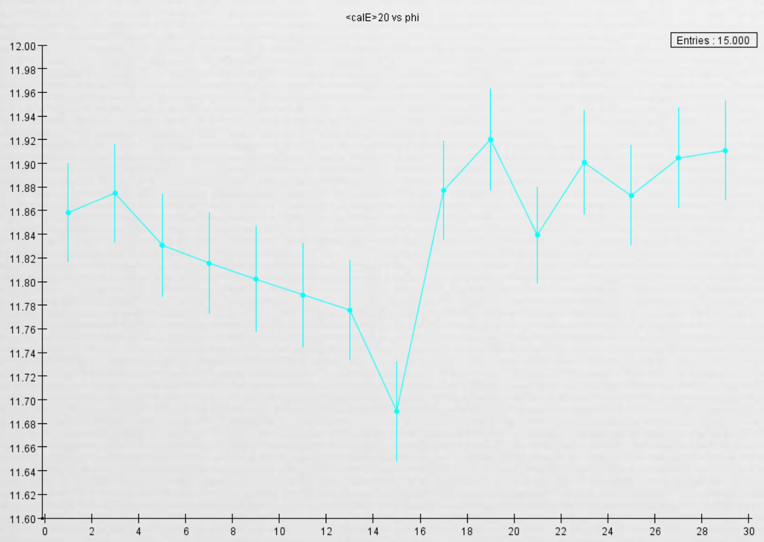
Data (Projective and Non-Projective sid02 qqbar events)



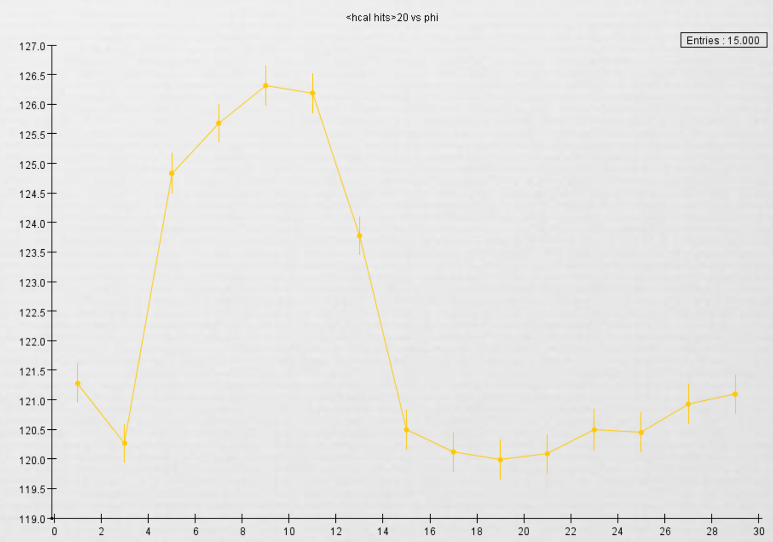


Data (neutral hadrons; sidloi3)

sidloi3 energy in the HCAL vs. phi

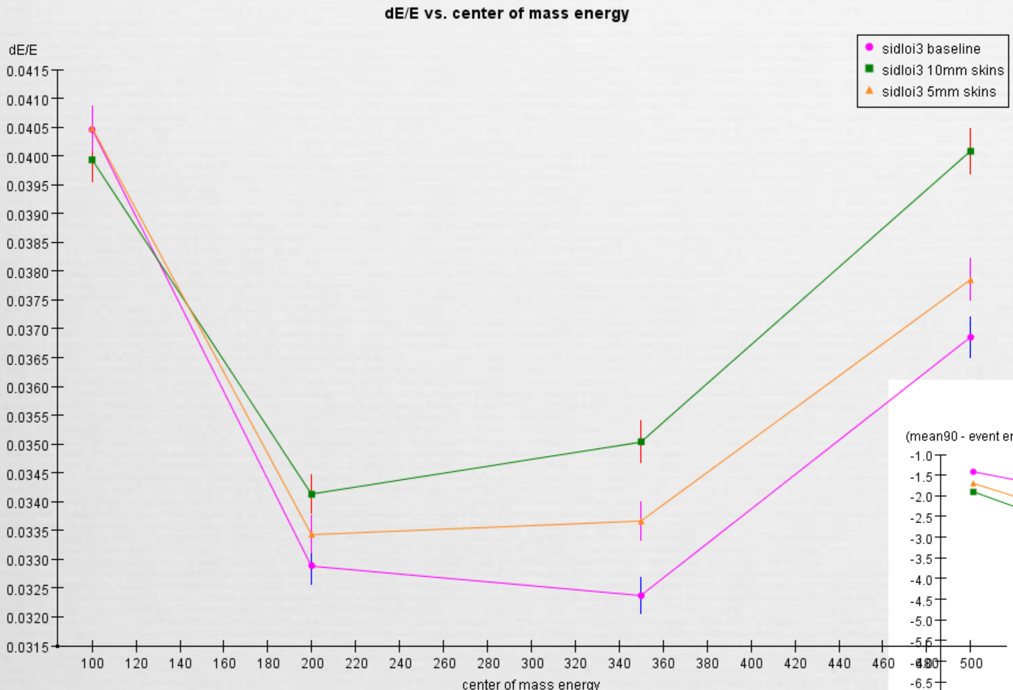


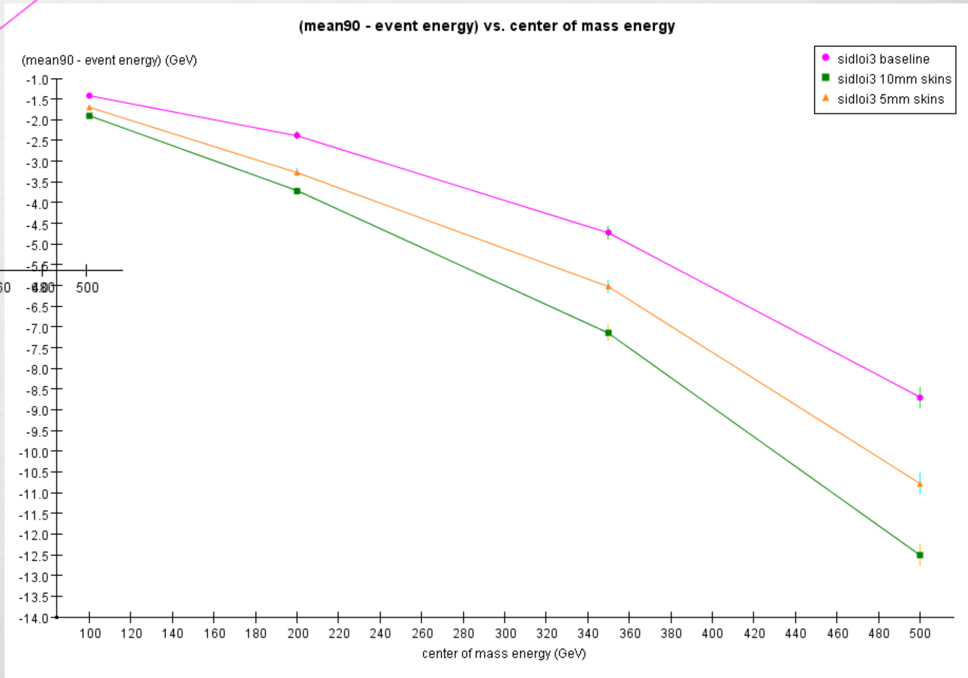
sidloi3 hits in the HCAL vs. phi



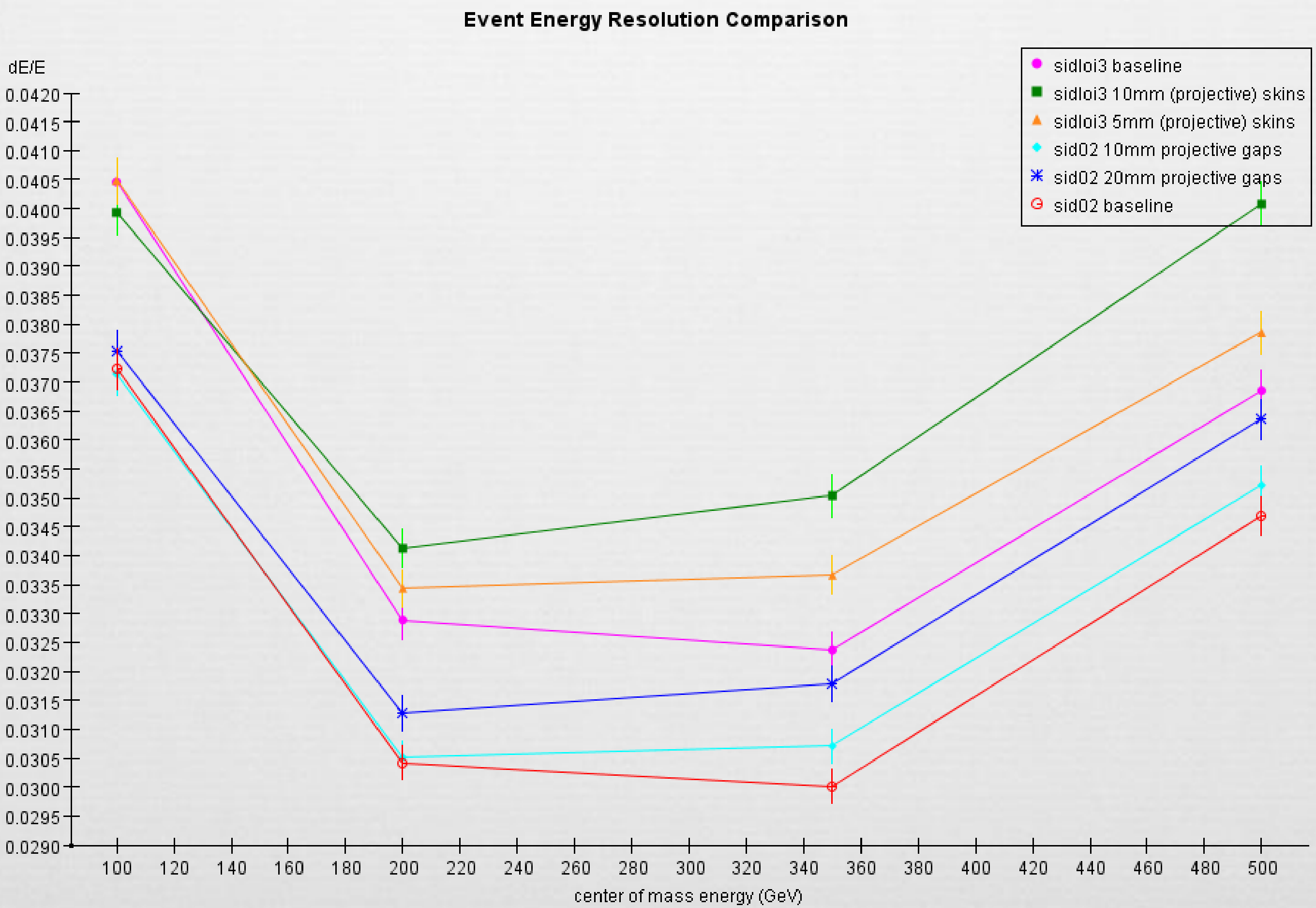
Note the asymmetry in phi using sidloi3, even without cracks.
Both plots use 20 GeV neutral hadrons.

Data (sidloi3)





Data



Event Energy Resolution Comparison
dE/E
0.0420
0.0415
0.0410
0.0405
0.0400
0.0395
0.0390
0.0385
0.0380
0.0375
0.0370
0.0365
0.0360
0.0355
0.0350
0.0345
0.0340
0.0335
0.0330
0.0325
0.0320
0.0315
0.0310
0.0305
0.0300
0.0295
0.0290
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
center of mass energy (GeV)
sidloi3 baseline
sidloi3 10mm (projective) skins
sidloi3 5mm (projective) skins
sid02 10mm projective gaps
sid02 20mm projective gaps
sid02 baseline

Conclusions

- Non-projective & projective cracks are nearly identical in terms of event energy resolution.
- The degradation suffered from the cracks in sidloi3 is approx. equal to the amount of degradation in resolution moving from sid02 to sidloi3. If the latter is possible to correct for, it seems likely the former should be as well.
- However, it is possible that the above is not the case. The next steps are obvious: work on corrections for non-projective cracks, and try to reduce the errors as much as possible. If it is not possible to reduce them to an acceptable accuracy level, work on corrections for projective cracks.