Status of DHCAL in the simulation

Jan Strube
Tohoku University

Current Status

DHCAL (in simulation) is gas between 2 glass plates, and some PCB: http://www.lcsim.org/detectors/sidloi3.html

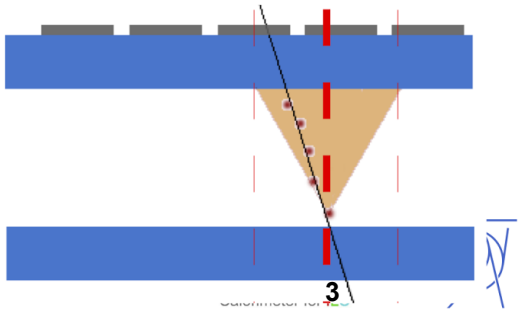
18.9 mm	Steel235
1.1 mm	PyrexGlass
1.2 mm	RPCGasDefault sensor
1.1 mm	PyrexGlass
3 mm	G10
1.6 mm	Air

In simulation, charge is deposited for the midpoint of the G4 step. Thresholds applied in digitization. No charge spreading across pads.

The following two slides are from Christian Grefe's talk at AWLC14

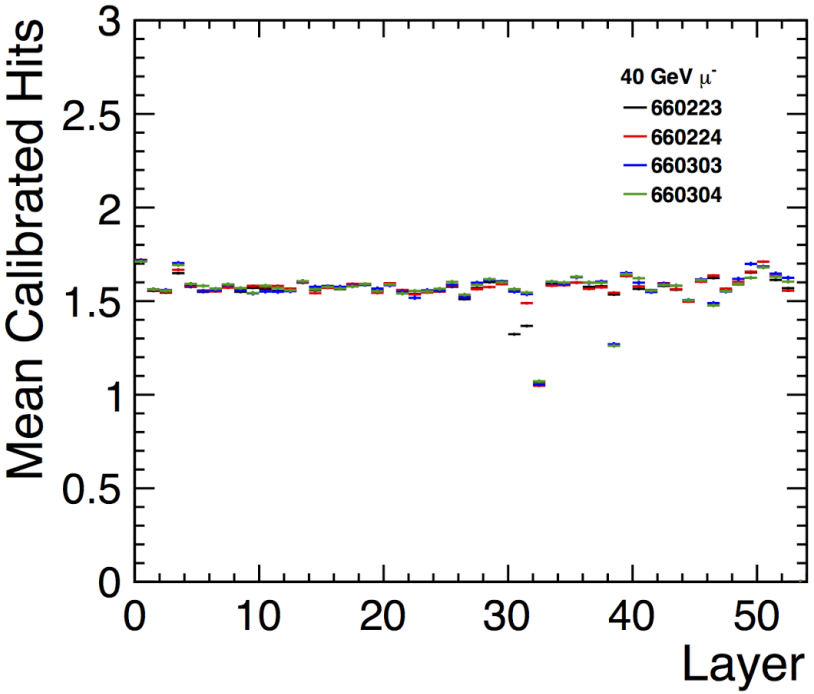
RPCSim (Marlin Version)

- Use all charge deposits generated by GEANT4 stored in SimCalorimeterHits
- Only allow one avalanche within distance cut d_{cut}, ignore other charge deposits
- Randomly generate total charge for each remaining deposit
  $\Rightarrow$ based on data from RPC with analog readout
- Correct generated charge by offset Q_0
- Lower effective total charge depending on distance to module boundary
- Spread charge according to model and collect charge on pads
  $\Rightarrow$ uses lookup from pre-calculated Monte Carlo integration
  - RPCSim3 (double exponential): $f(r) = Re^{-r/s_1} + (1-R)e^{-r/s_2}$
  - RPCSim4 (exponential): $f(r) = Re^{-r/s}$
  - RPCSim5 (double Gaussian): $f(r) = Re^{-r^2/(2{\sigma_1}^2)} + (1-R)e^{-r^2/(2{\sigma_2}^2)}$
  - RPCSim6: $f(r) = \left(A + r^2\right)^{-3/2}$
- Create CalorimeterHit for each pad over threshold t

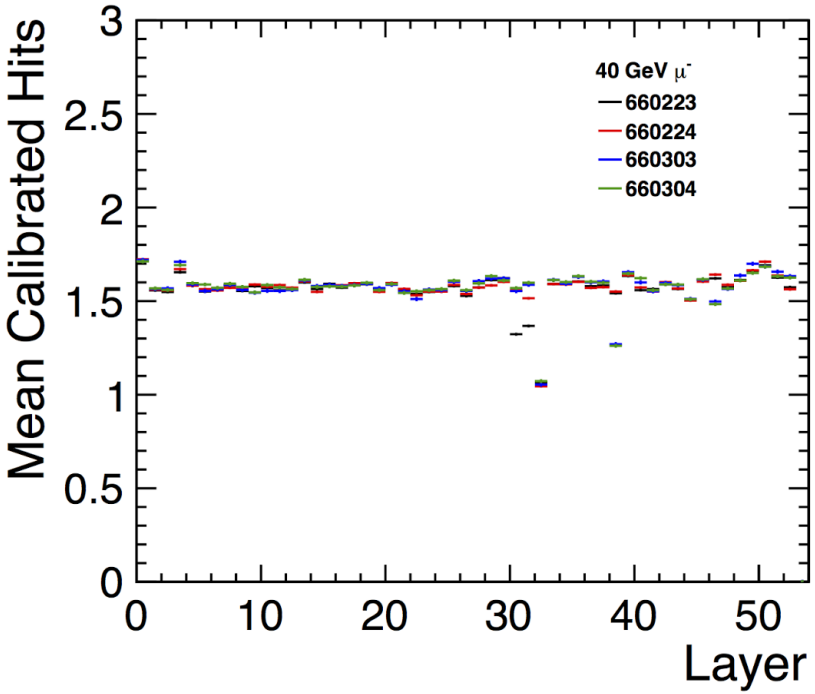


Longitudinal Profiles (40 GeV Muons)

Cleaned Calibration



Local Calibration



- Almost indistinguishable performance in correcting layer-to-layer fluctuations

Implementing in Simulation

Current chain:

1. SLIC
2. (event overlay)
3. org.lcsim tracking and digi
4. slicPandora reco

With RPCSim:

1. SLIC (mod'ed)
2. (event overlay - now also with intermediates)
3. marlinreco RPCsim
4. org.lcsim tracking and digi
5. slicPandora reco

What's needed to put current digi into our existing chain?

1. Charge deposition of intermediate particles to be stored in SimCalorimeterHit (including position). Currently sum of contributions put in center of cell.
   → no technical problem, 1 day to turn on and test
2. Modify the existing RPCSimProcessor to work on sidloi3 or similar, rather than a test stack.
   → requires some expertise on geometry / segmentation, ~5-7 days

   Christian Grefe offered to give guidance

What's needed? - cont'd

3. Adding a MarlinReco step to the chain
   → no technical problem, 1 day to test setup on the grid
4. Writing small analysis script, finding appropriate physics events, running them through the chain and validate the output
   → < 1 week
5. Selecting which of the rpcsim 3,4,5,6 should be used and which parameters?
   → should come from beam test validation

What do we gain?

At the end of this >2 week (summer student: 1 month+) process, we will have a proof of principle RPC digi in the simulation

- results in much(!) larger event files
- results in longer processing times (seconds per pion)
- results in a more complex reco chain that might be limited to different sites
- allows us to investigate the impact of a multiplicity different from 1 in the DHCAL

What's needed for production quality?

Ideally, the RPCsim is implemented in SLIC, where the intermediate particles are available at runtime, without the need to write them out.

Expert operation. Needs dedicated support to implement and multiple people to test.

Summary

Current DHCAL simulation is simplistic.

Studies needed:

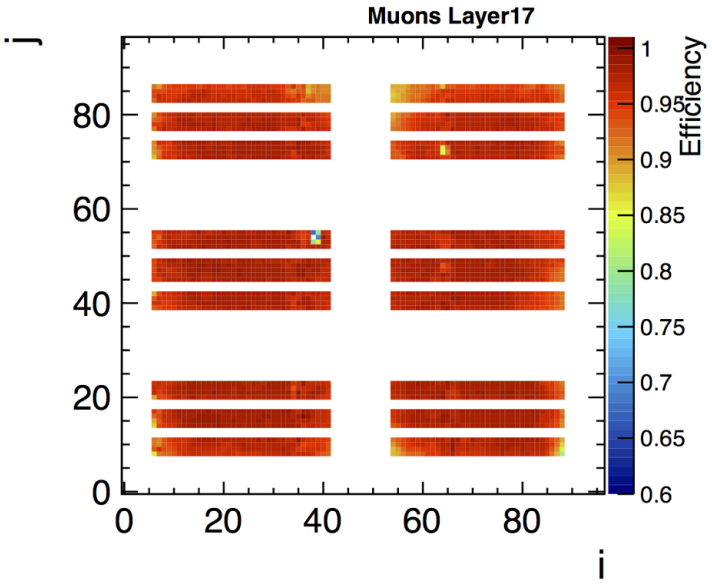
1. Impact of higher multiplicity on muon finding
2. Impact of higher multiplicity on shower shapes / clustering / calibration / energy resolution. Multiplicity most likely different from MIP track. Detailed studies needed.
3. Impact of finite efficiency (~ 95%)
4. Effect of different RPCSim variants. A single one must be chosen.

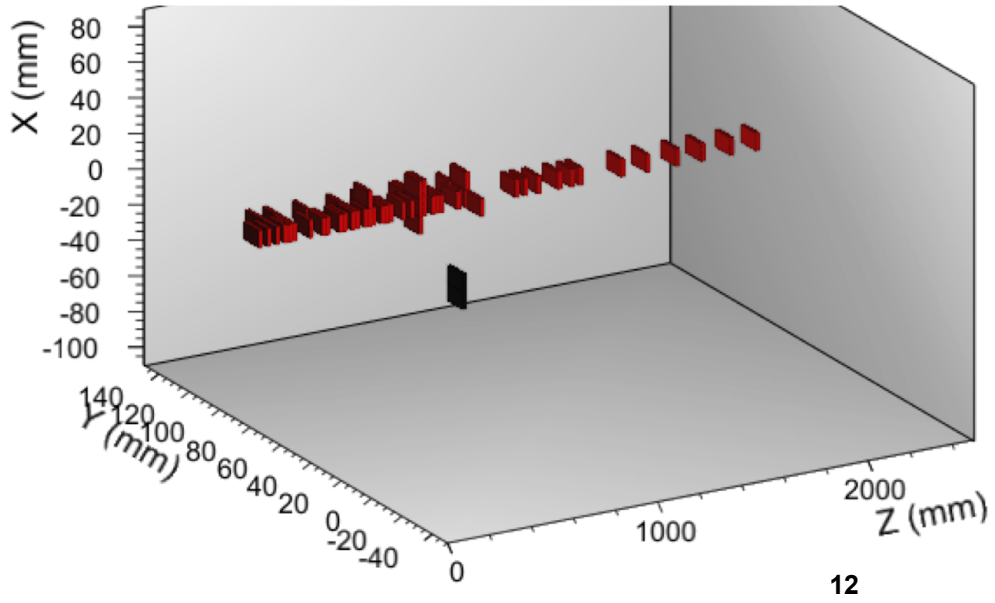
1-3 can be studied by implementing RPCsim, as laid out, or by tuning existing digisim parameters.

That’s all

Tuning of the Digitization with Muons

- Use fully cleaned regions from muon run (660357) as target
- Muon Monte Carlo with a Gaussian spread similar to angular spread in data
- Remove cells from both data sets which have been identified as dead in data
- Pre-select clean muon events using Hough transform $\Rightarrow$ remove other hits
- Digitize data with varying Q_0, t and charge spread parameters
- Response from MiPs not sensitive to d_{cut}
- Compare hits / layer distributions for Monte Carlo and data and minimize χ^2





12