SiD HCAL: Gas or Scintillator

Vishnu Zutshi
NIU/NICADD

Conclusion

I Don't Know

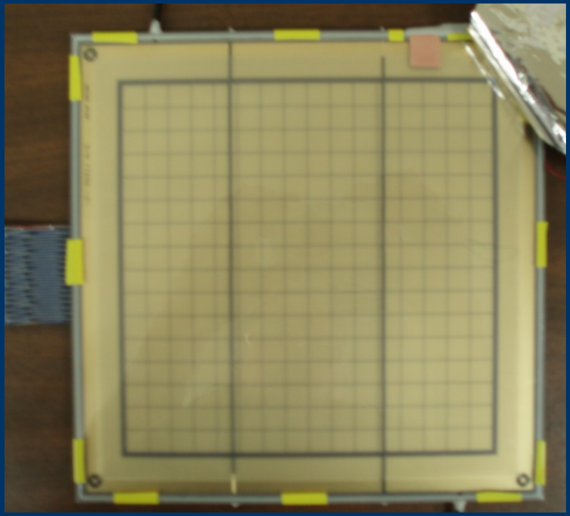
And here is why……

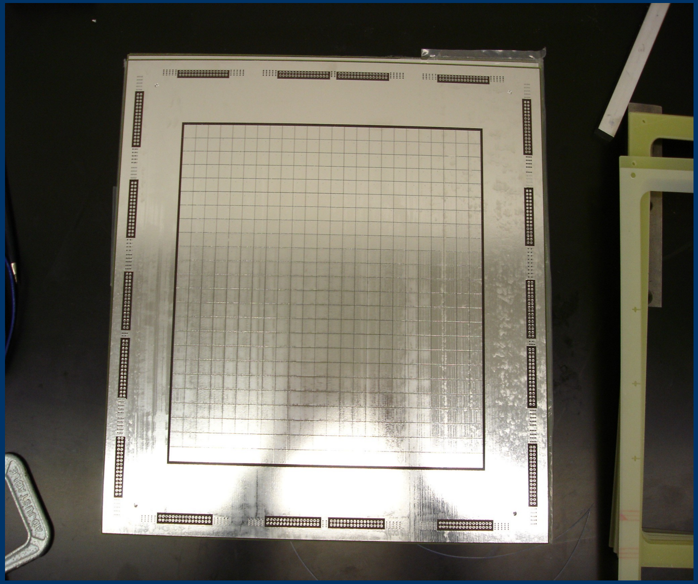
Cost

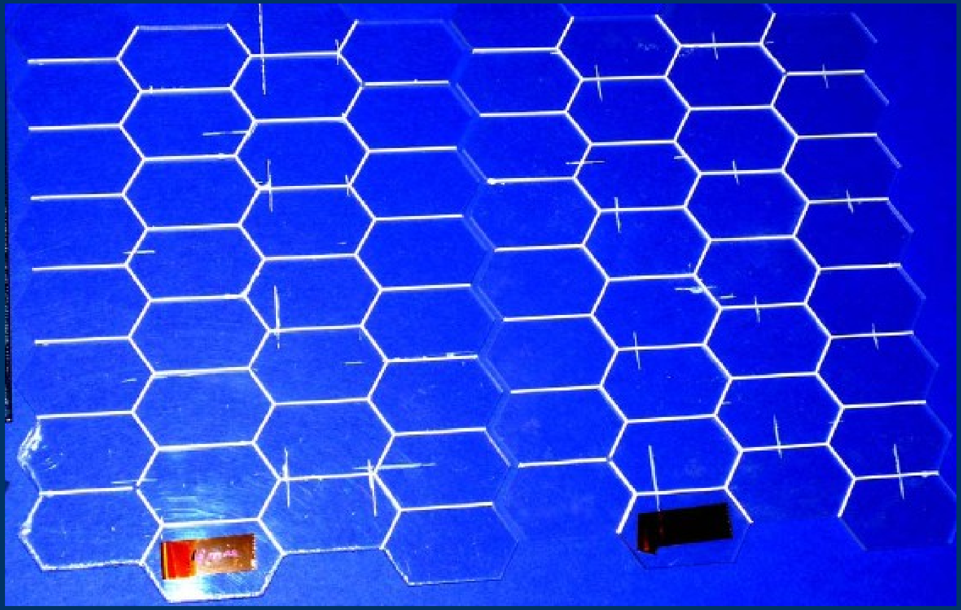
- Cannot beat RPC's in per channel cost
- ~$2/channel including electronics and readout
- Costing for the scintillator option more uncertain
- Significant fraction of the cost expected in SiPMs
- Best guess would be a total per channel cost that is approximately 3 times higher
- Costing estimates for GEM difficult to do since production costs for large GEM layers is unknown
- Operational costs.....

Granularity

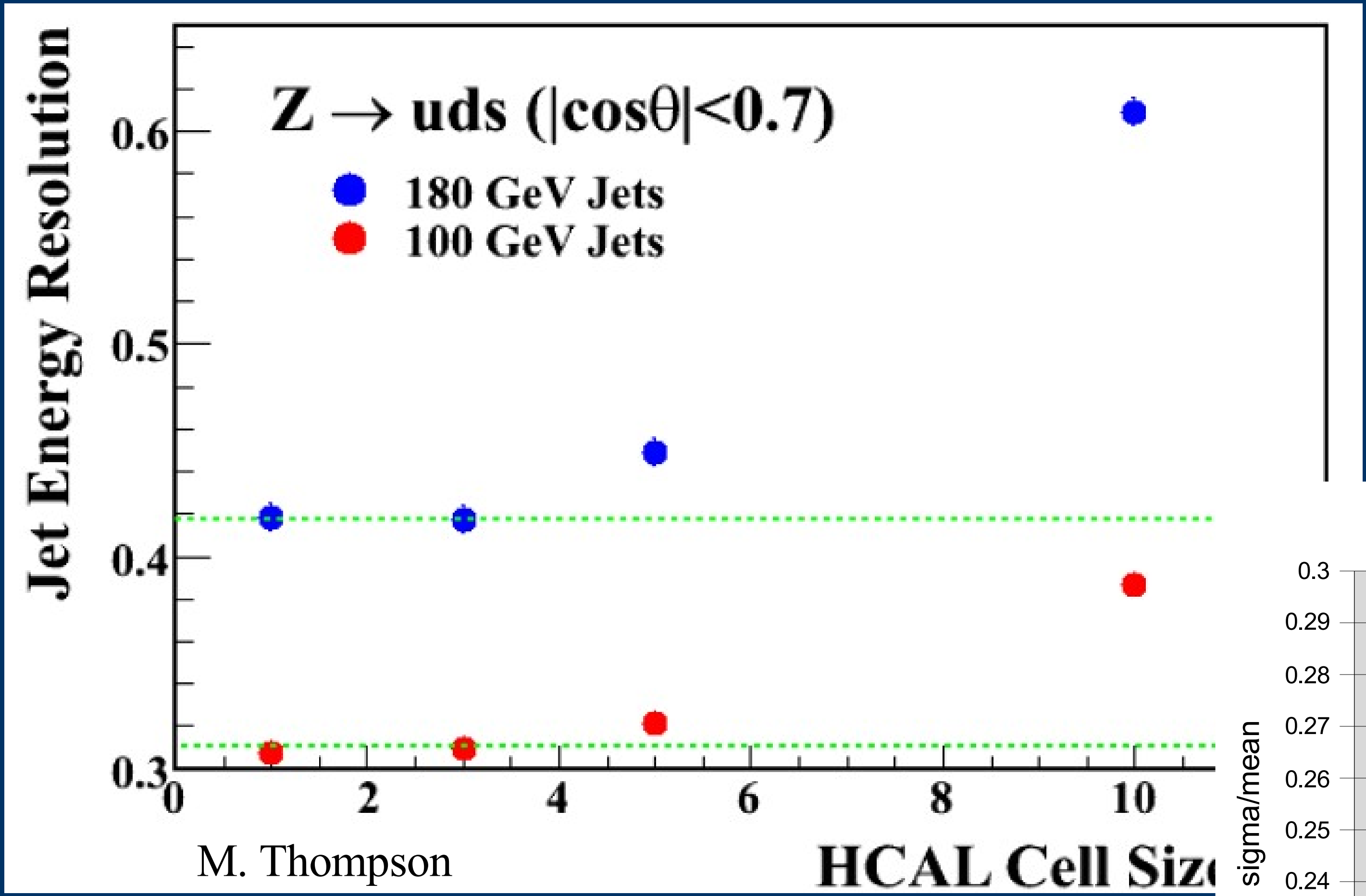
- Fine granularity straightforward with RPCs and GEMs
- First with SiPMs, and now with direct coupling this looks feasible for the scint. option too.



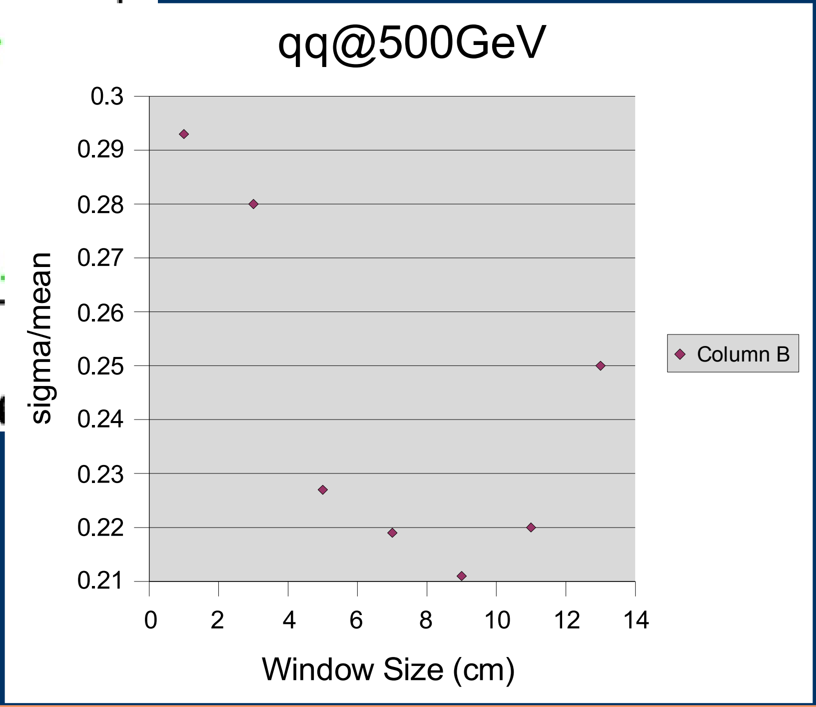




Granularity



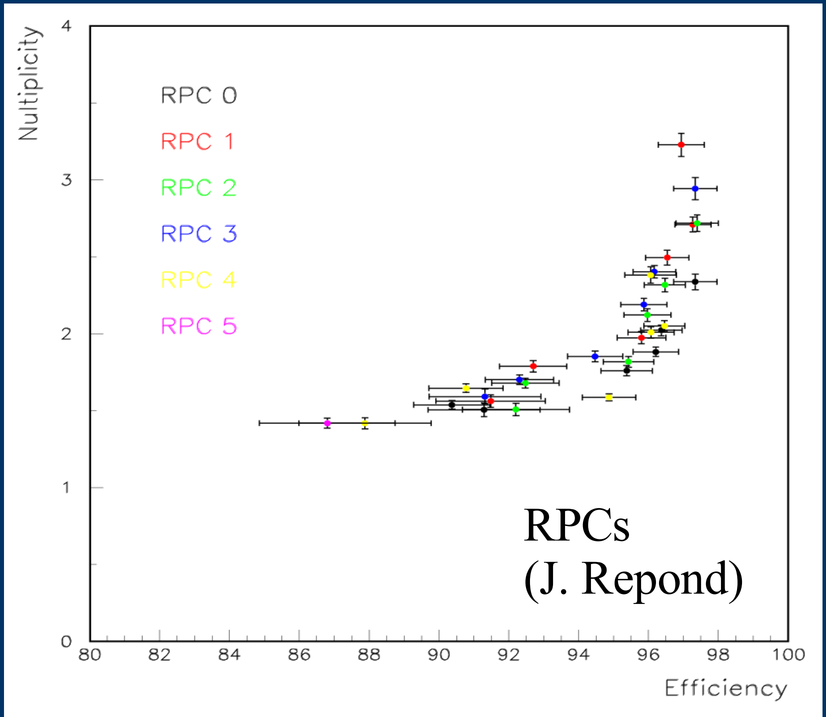
M. Thompson

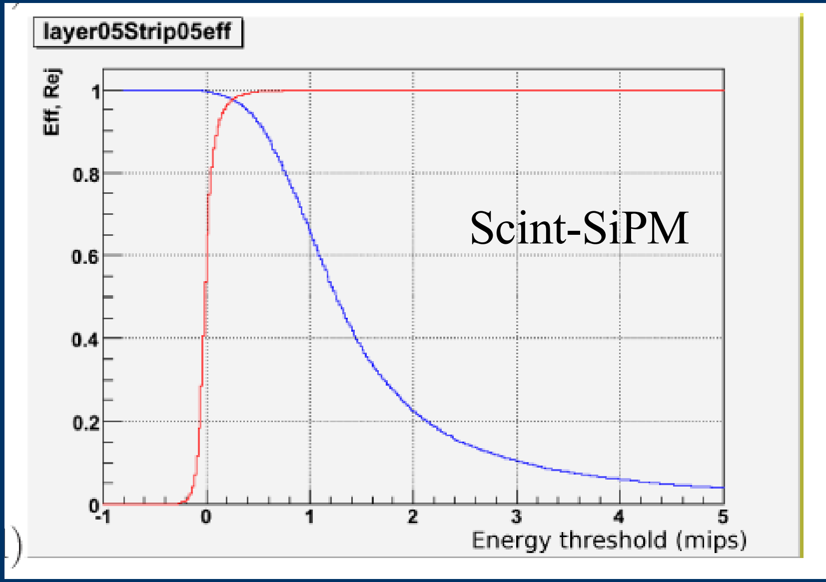


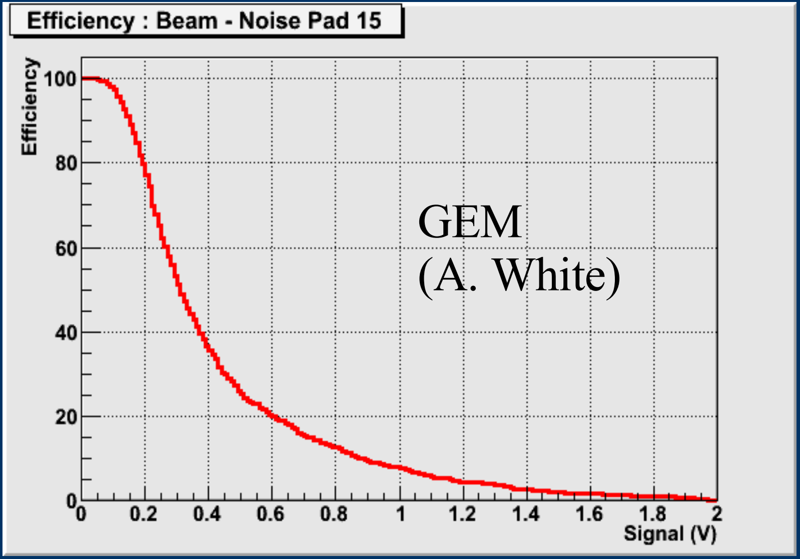
- 1cm x 1cm granularity not demanded by simulations

Efficiency

- All options give high MIP eff. with required noise suppression.
- SiPMs have high dark rate which is under control with ~ 0.5 MIP cut
- Avg. multiplicity of ~1.7 (1.3) for RPC (GEM) (Coarser effective granularity?)
- Inter-chamber gap inefficiency

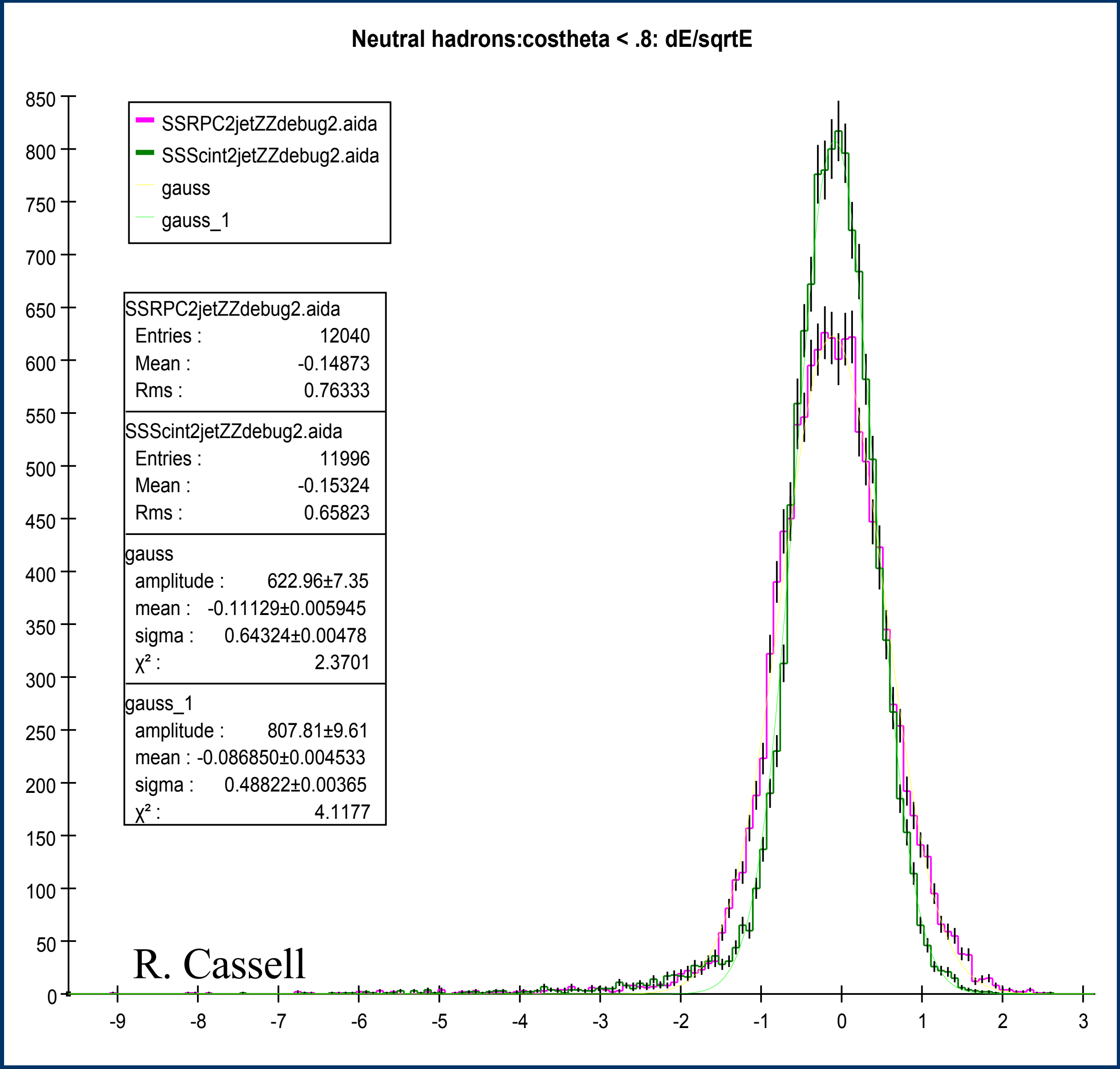






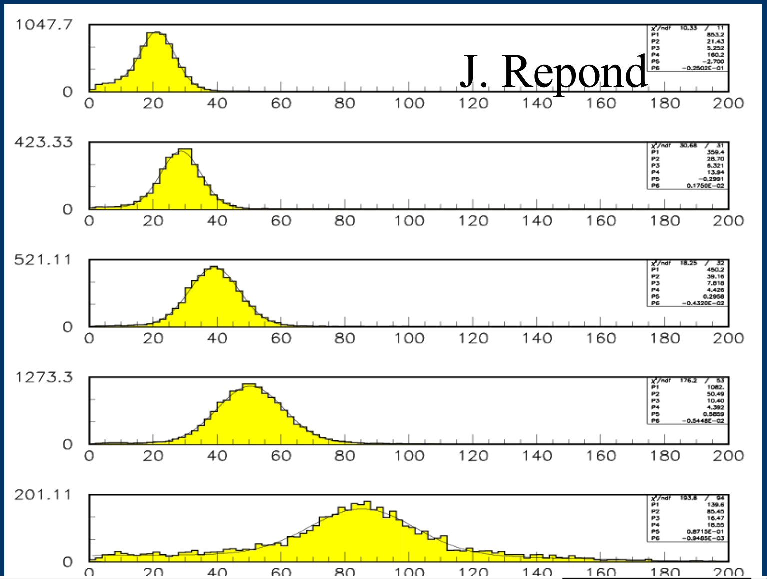
Energy Resolution

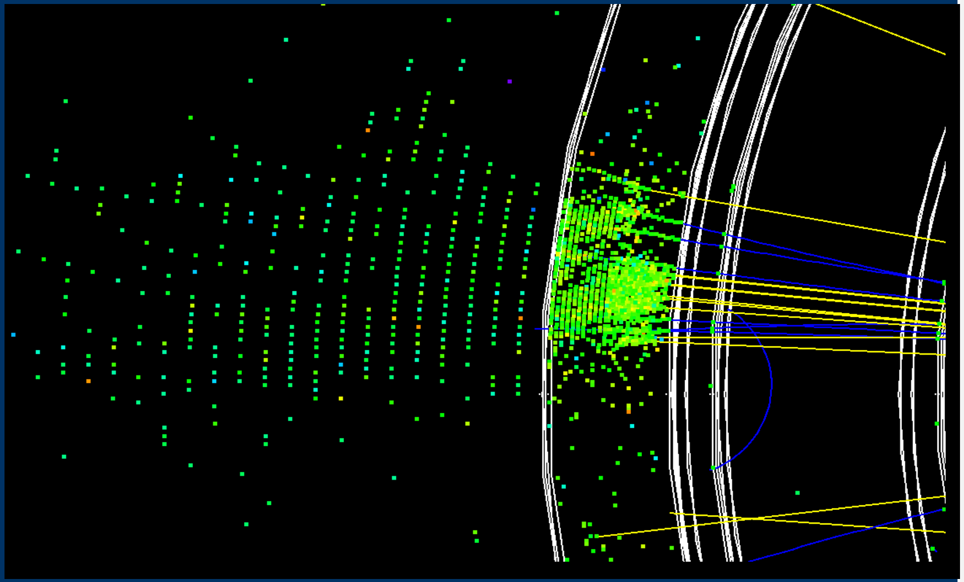
- Single hadron resolution significantly better for scint.
- However on average only 10% of energy in neutral hadron clusters.
- On the other hand you are going to have coalesced showers...

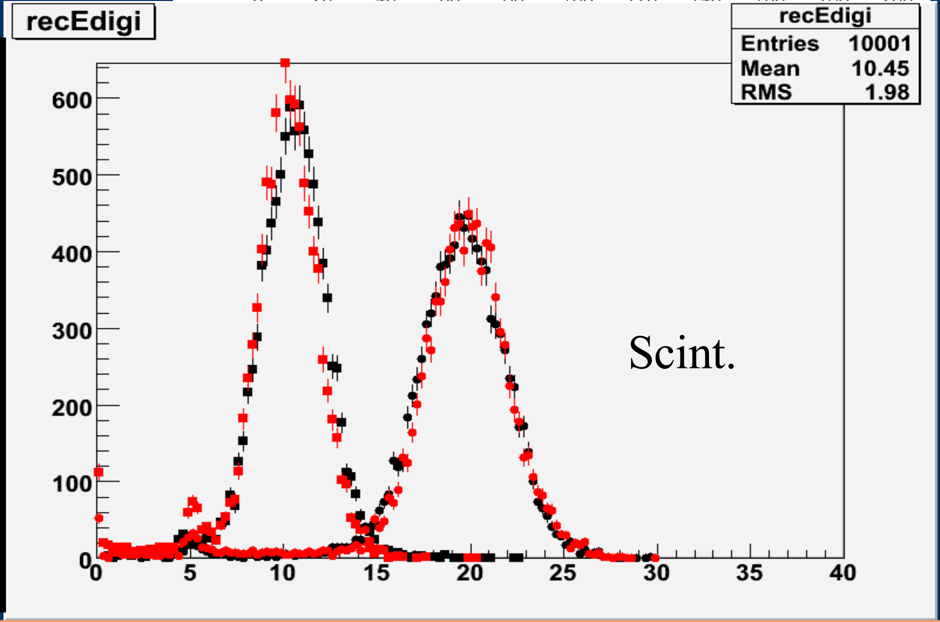


Digital vs Analog

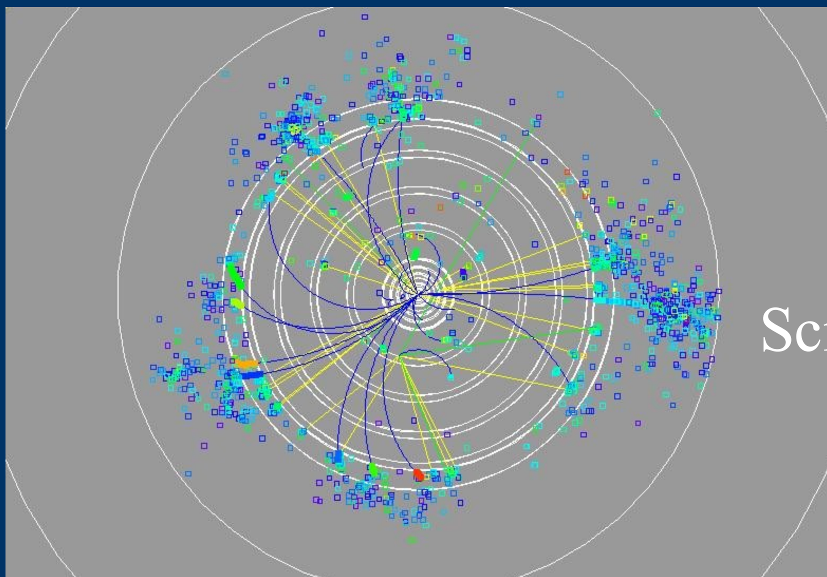
- Data seems to confirm that hit counting is a legitimate method of single hadron energy estimation.
- But does it work in full events with overlapping showers?
- Worse E/p x-check



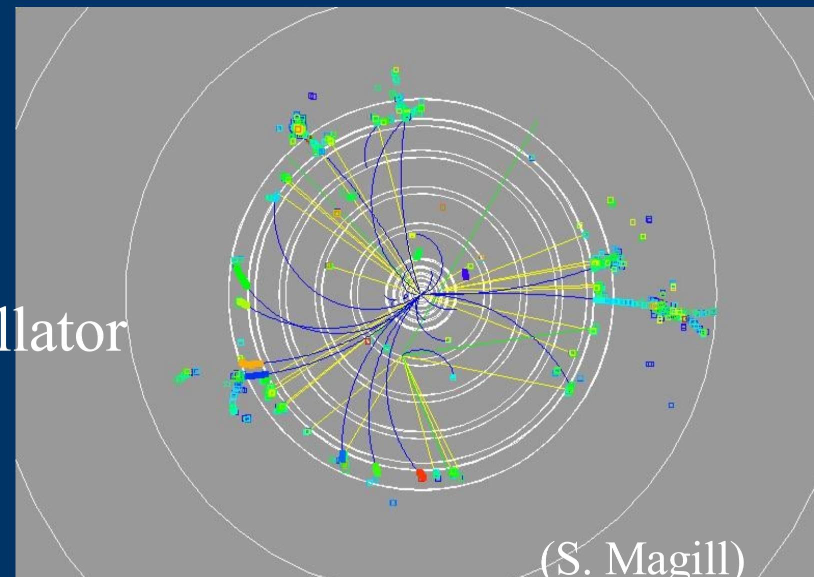


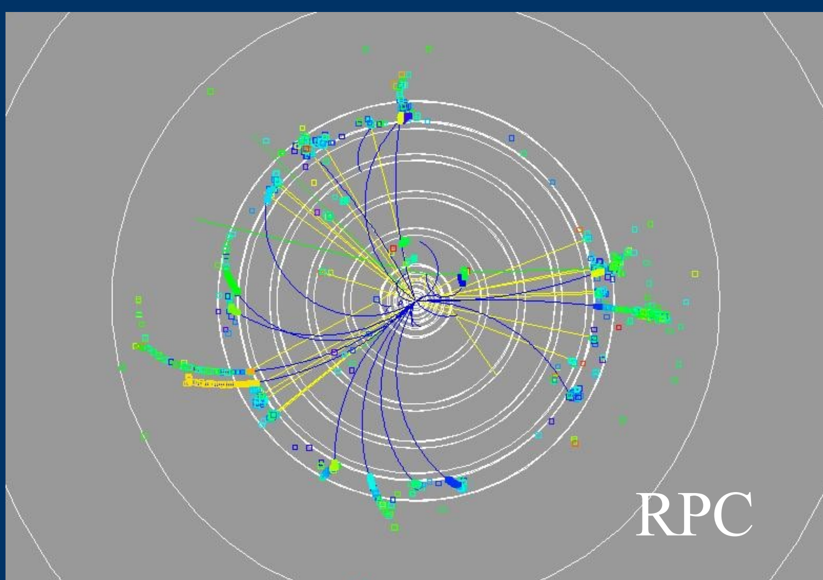


Pattern Recognition



Scintillator

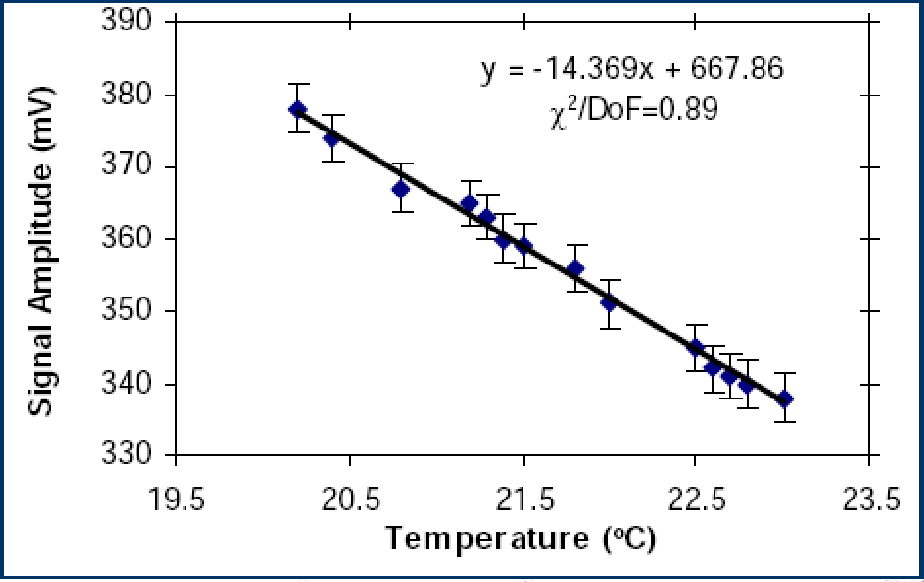


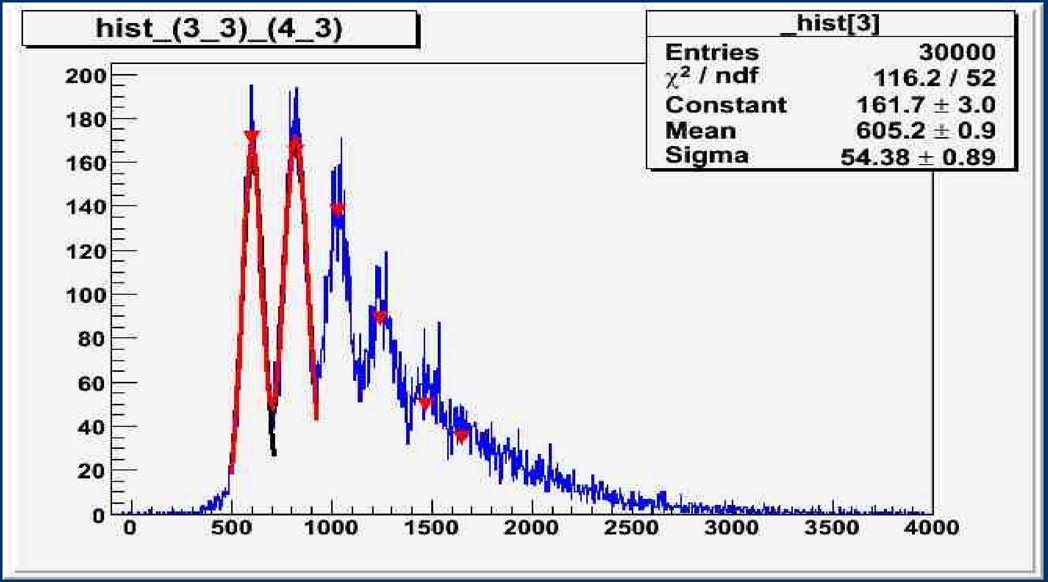


- Many more isolated hits in Scint.
- However most of these can be thrown away (proximity or density cuts) without sacrificing performance

Calibration & Monitoring

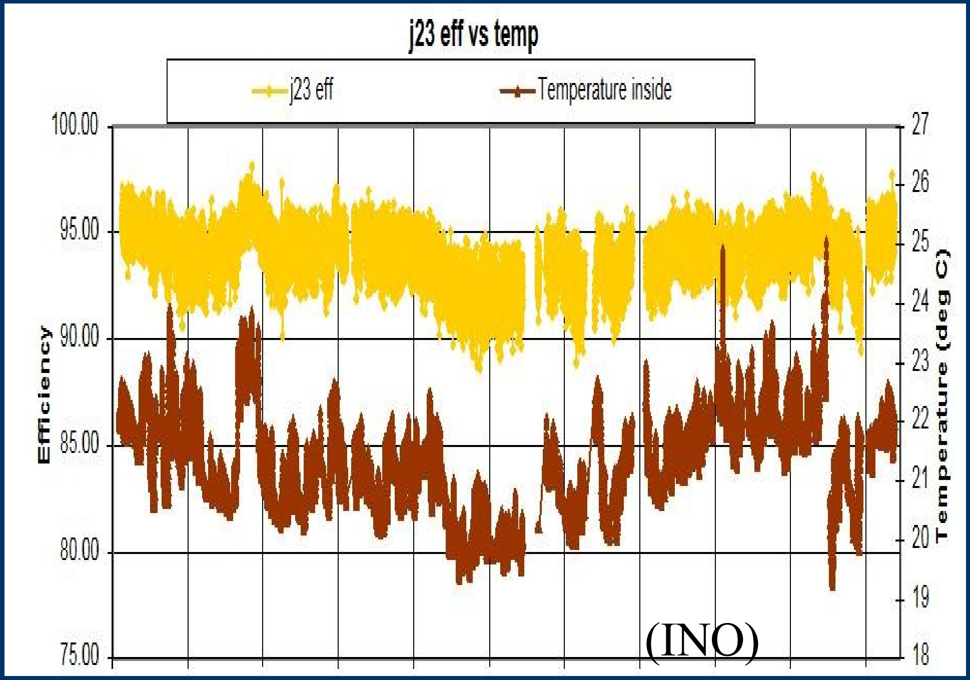
- SiPM response sensitive to temp. variations and will need to be monitored.
- Most direct way is by flashing LEDs and monitoring the gain.
- Distribute electrical signal instead of the optical one.
- Temp. monitoring alone ??
- While the system can be made scalable, monitoring on individual or groups of channel required.
- Not so in the case of gas cals..



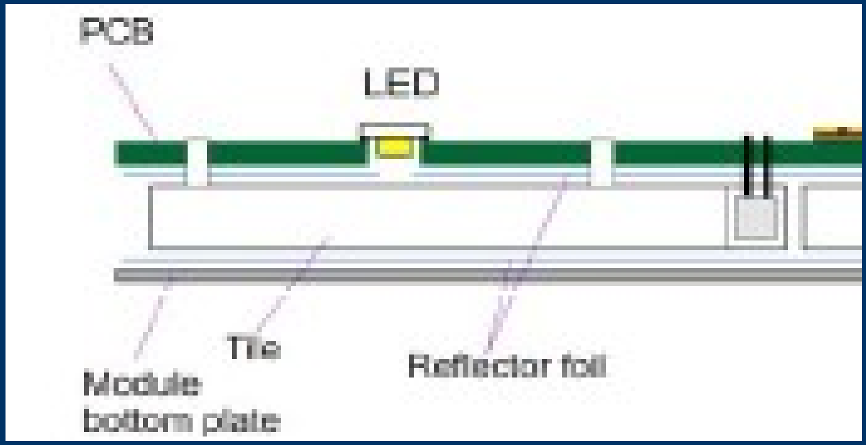


Calibration and Monitoring

- Ambient condition monitoring will be needed for gas-based calorimeters (inside-outside temperature, humidity, pressure etc.).
- Gas contamination is an important issue and will need to be stringently monitored (chromatography?)



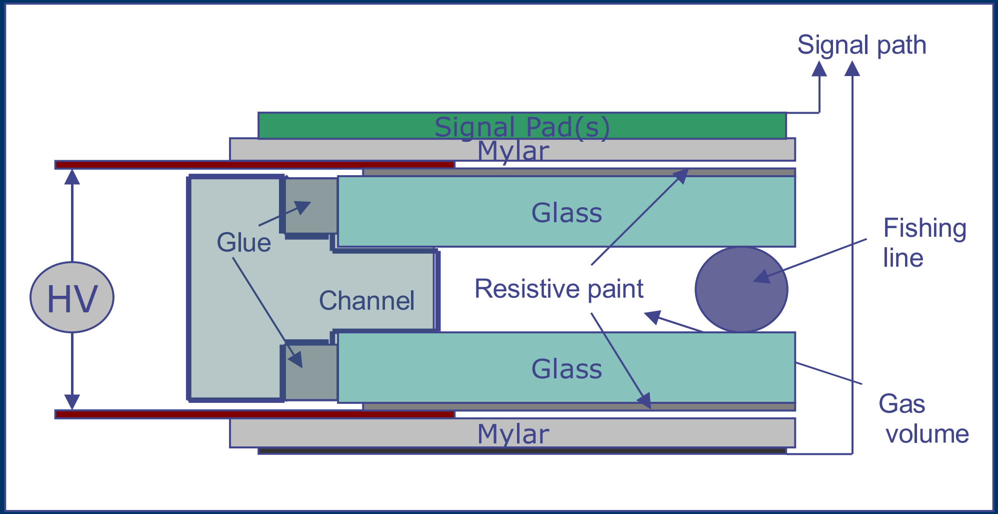
Layer Thickness



(M. Reinecke)

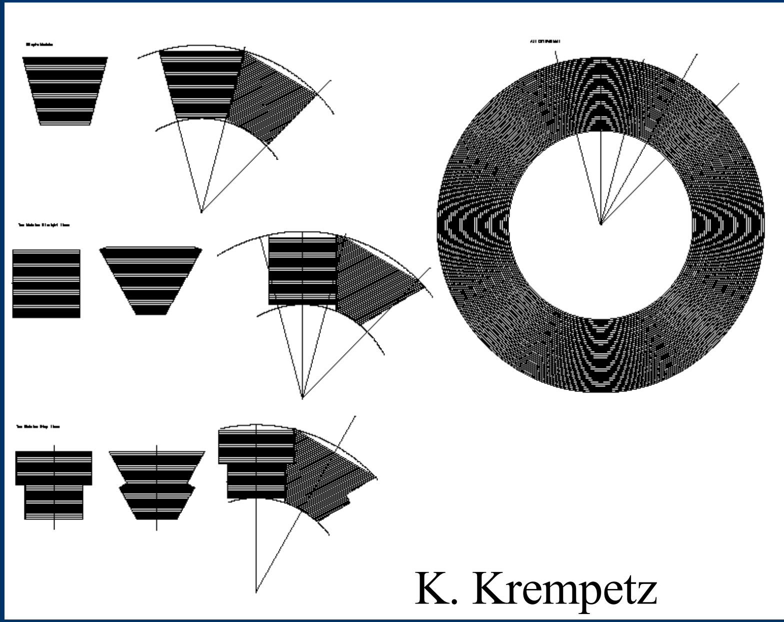
- Significant impact on the cost
- Both Scintillator and RPC active layers can be squeezed in ~ 6-6.5 mm.

- This includes both the media and the readout but not the tolerance required by the absorber plates.
- GEM's would need ~ 8mm



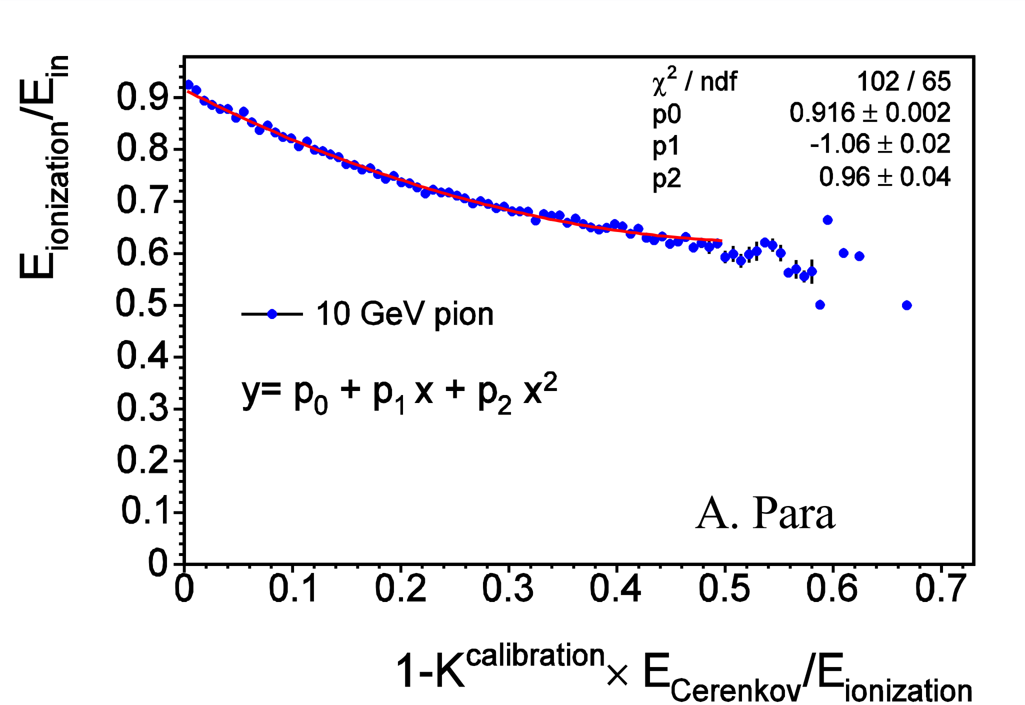
Overall Mechanical Design

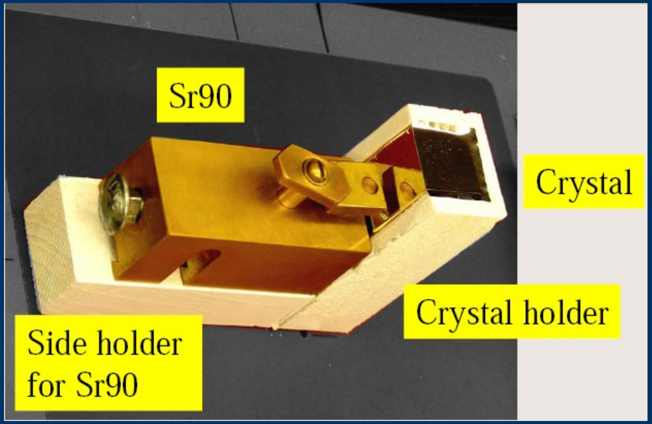
- Scint. may offer some simplicity in terms of flexibility for module design, integration and hermiticity etc.
- Essentially power and control in and digital signal out
- For gas HCALs a fairly robust gas delivery system would be needed
- Inlet and outlet pipes (steel?)
- Inter-chamber tubing inside a layer....



Non-PFA Calorimetry

- Not clear if PFA alone is enough in the 0.8-1.0 TeV region
- Segmented dual readout calorimetry an option for SiD?
- Light collection and signal generation very close to scint. option
- PbG-Scint. almost an extension





Configuration	Current (nA)
Crystal + Tedlar	2.8 – 2.9
Crystal + Tedlar + Sr90	2.9 – 3.0
Crystal + Sr90	7.2 - 7.3

Miscellaneous

- Rate capability (different media in forward region?)
- Magnetic field
- Availability of components in large quantity
- Long term aging
- Cooling

Summary

- Based on the information available so far either of the technology options could serve as the SiD HCAL
- Need to know more....
- R&D needs to continue on both gas and scintillator options
- Guidance from PFA(s) critical