Status of SiD/Iowa PFA

by

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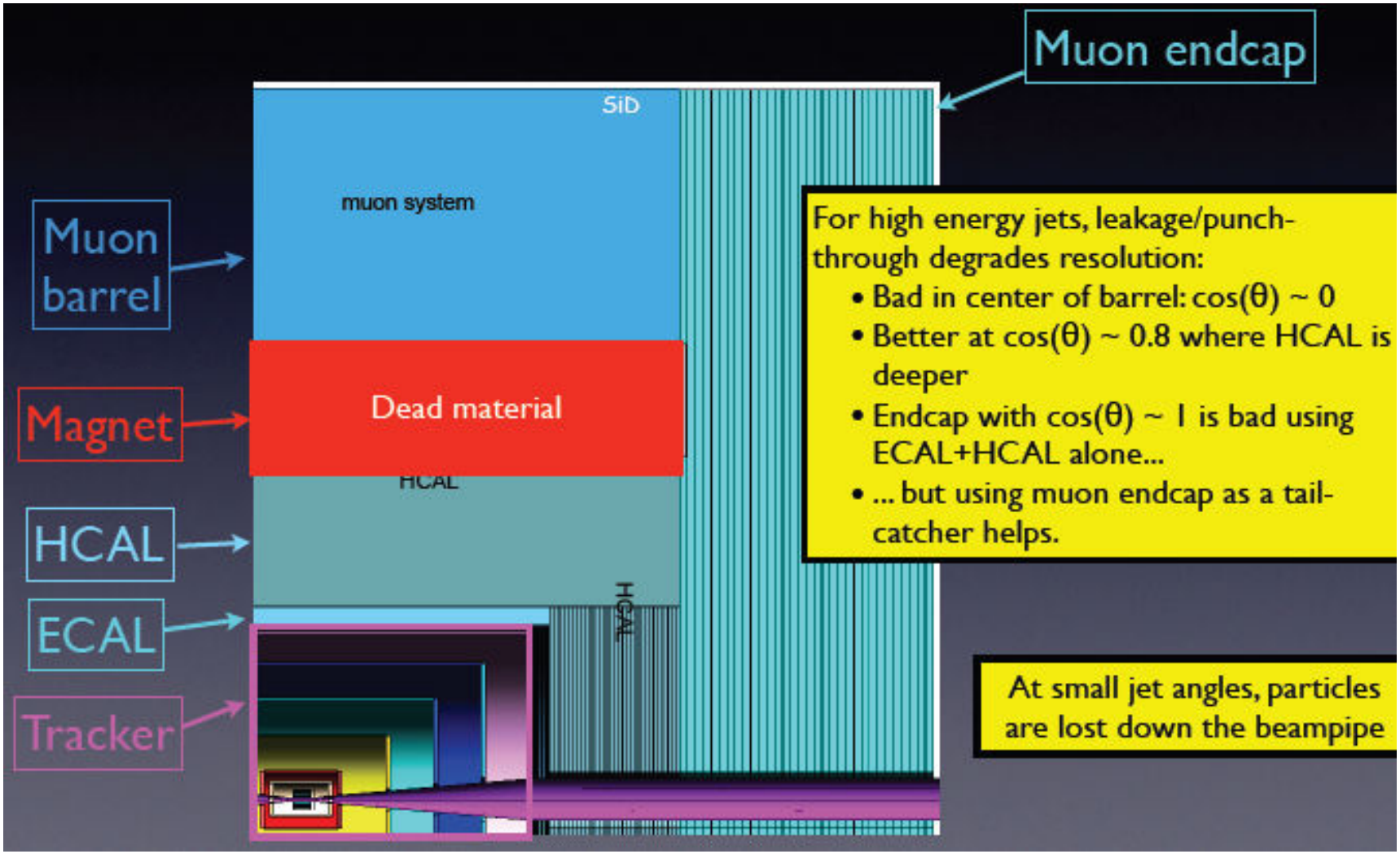
The Detector (SiD02)



The Particle Flow Algorithm

Goal: To obtain dijet mass resolution $\Delta M/M < 3\text{-}4\%$ (Z width)

➔ $\Delta E(cm)/E(cm) < 3\text{-}4\%$ for $e^+e^- \rightarrow qq$ (q=u,d,s)

Resolution for PFA :

$$\sigma = \sigma_{EM} \oplus \sigma_{neu.had} \oplus \sigma_{conf}$$

Attempt to minimize σ_{conf} in the PFA

In calorimetry $\sigma/E \propto 1/\sqrt{E}$…
… but in a PFA the confusion increases with E
At high energies leakage is also important

Generally σ_{PFA} ~ between $\sqrt{E}$ and E

Overview at LOI (April 2009)

$e^+e^- \rightarrow qq$ (q=u,d,s) at E_{cm} = 100 GeV → qq100

$e^+e^- \rightarrow Z(qq)\,Z(\nu\nu)$ at E_{cm} = 500 GeV → ZZ

rms_{90}

	Real tracking		Cheat tracking		
	barrel	forward	barrel	forward	
qq100	3.7%	3.8%	3.4%	3.5%	$\Delta E_{CM}/E_{CM}$
qq200	3.0%	3.2%	2.8%	3.0%	
qq360	2.7%	2.7%	2.6%	2.6%	
qq500	3.5%	3.3%	3.5%	3.4%	
ZZ	4.7%	3.9%	4.2%	3.7%	$\Delta M/M$

For qqbar events, $E_1 = E_2 = E_{cm}/2$ and $\Delta E_1 = \Delta E_2 = \Delta E_{cm} / \sqrt{2}$

$M^2_{12} = 2E_1E_2(1 - \cos\theta_{12})$ and $\Delta M_{12}/ M_{12} = \Delta E_{cm}/E_{cm}$

In December 2008

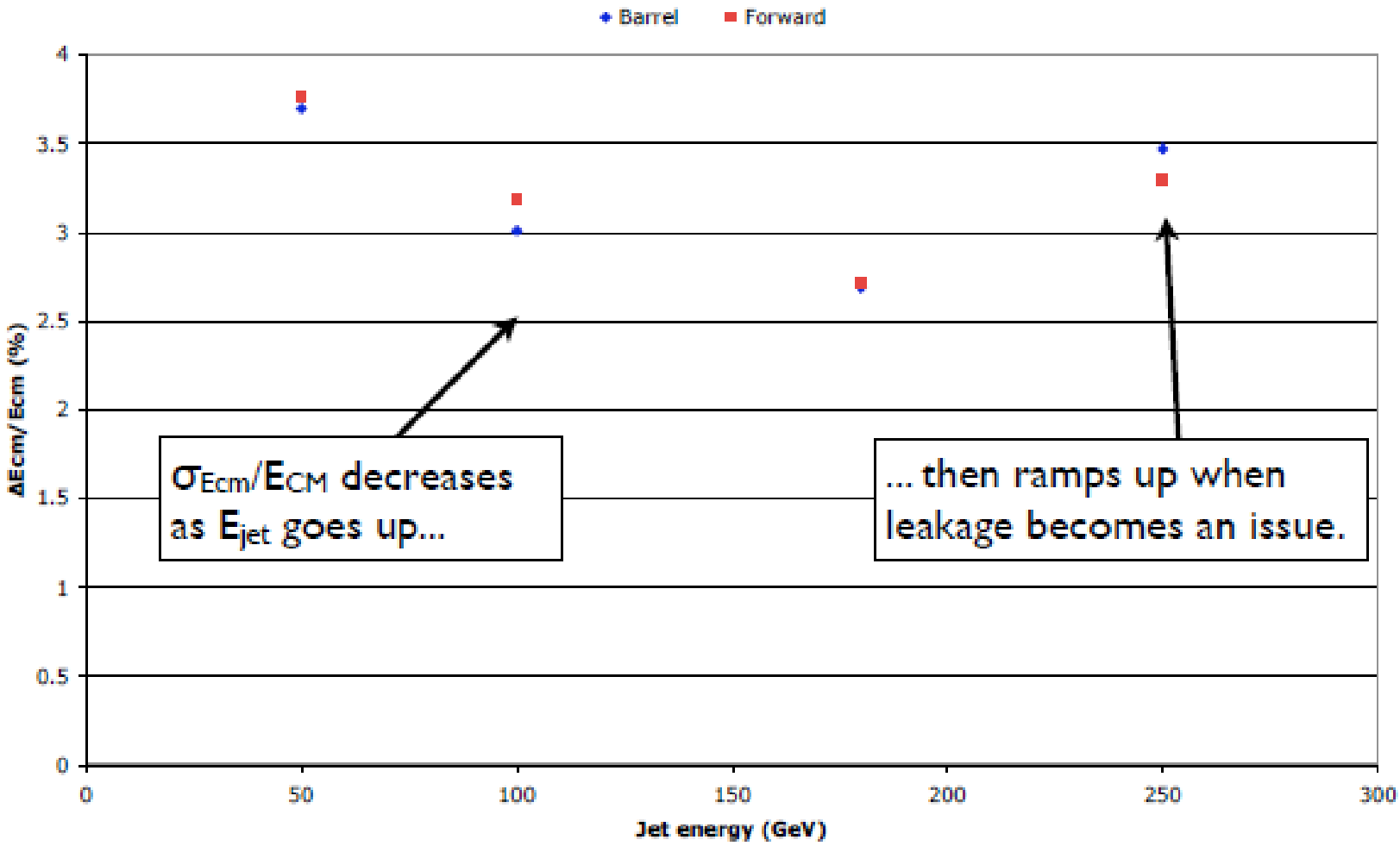
Barrel ($0<\cos(\theta)<0.8$)

	Before	After
qq100	3.7%	3.6%
qq200	3.0%	2.9%
qq500	3.5%	3.4%
ZZ	4.7%	4.7%

Endcap($0.8<\cos(\theta)<0.95$)

	Before	After
qq100	3.8%	3.6%
qq200	3.2%	3.1%
qq500	3.3%	3.2%
ZZ	3.9%	3.8%

Energy dependence



Leakage study at 500 GeV and 1 TeV

Marty Breidenbach helped produce a SiD02-like detector with 6 λ HCAL
Ron Cassell generated the events and produced the files for 1 TeV, 500 GeV, 200 GeV

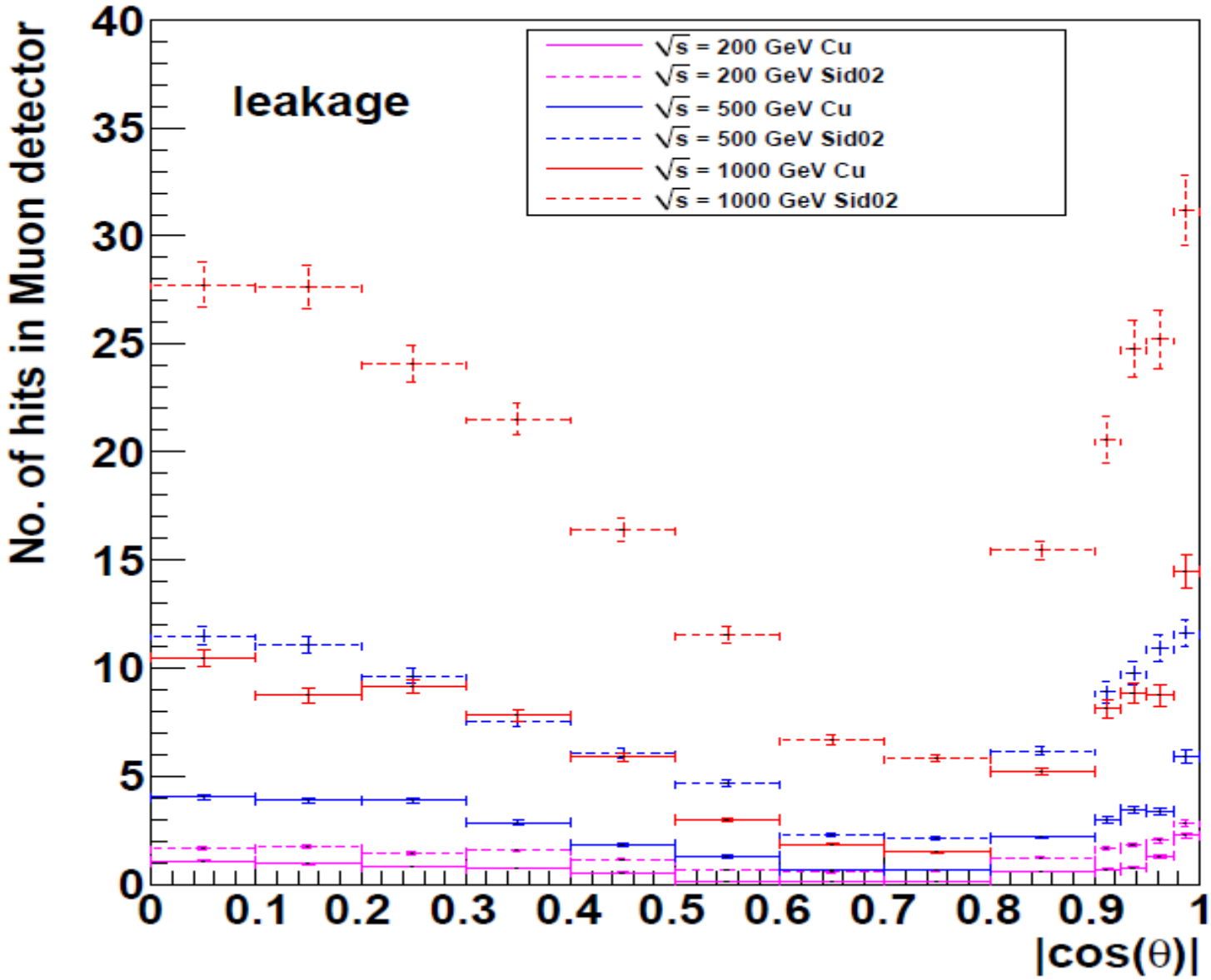
- Change Steel for Cu for absorber
- Increase to 54 layers from 40 layers in HCAL
- 1.7λ more material in HCAL
- No gap between HCAL and Muon endcap (instead of 10 cm)

Compare sid02 with sid02-Cu at various energies by looking at:

- # hits in Muon detector (indicates punch through, a measure of leakage)
- Energy resolution

Punch-through muon hits

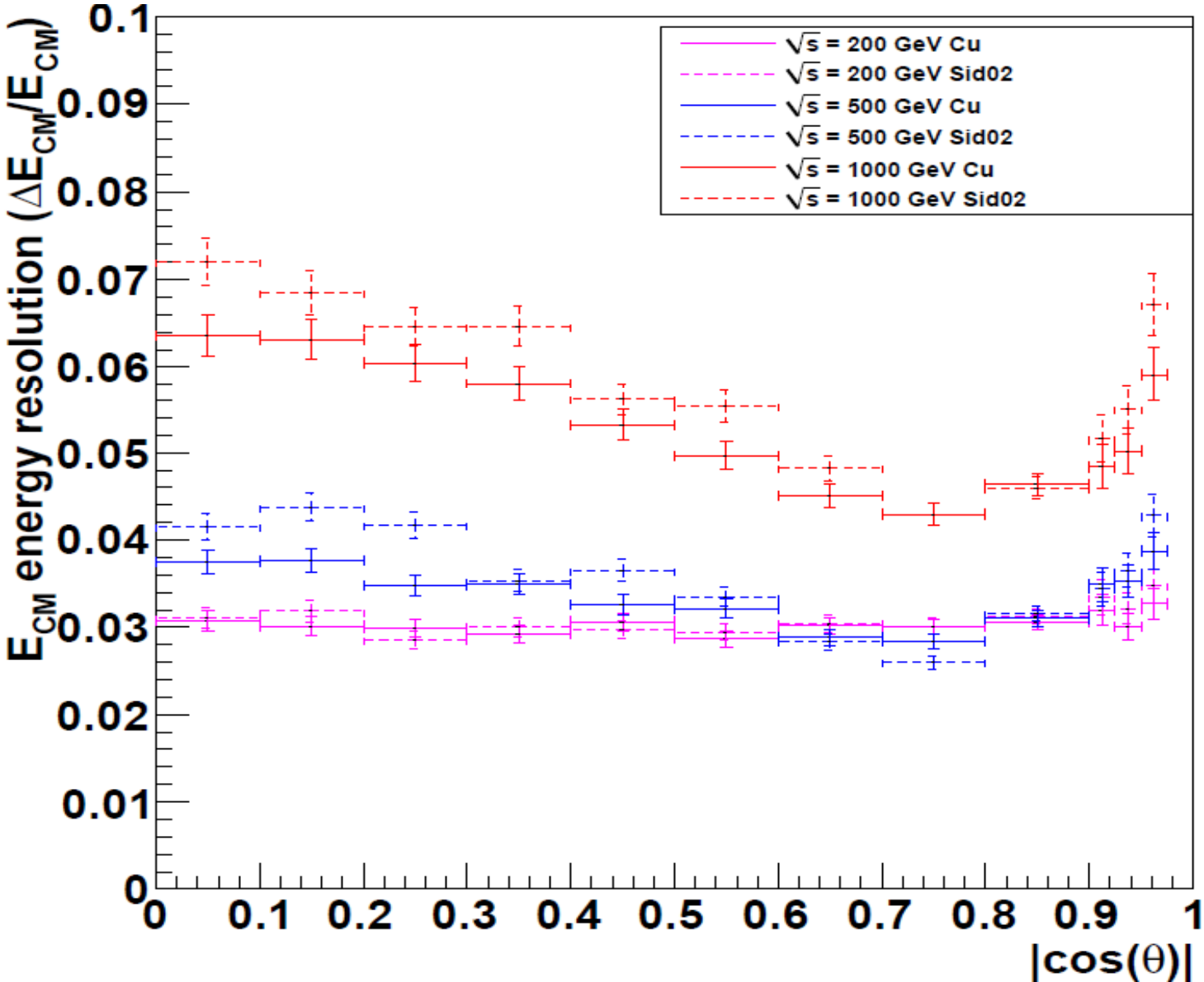
SiD02-Cu
SiD02



Resolution study (SiD02-Cu comparison)

real tracking

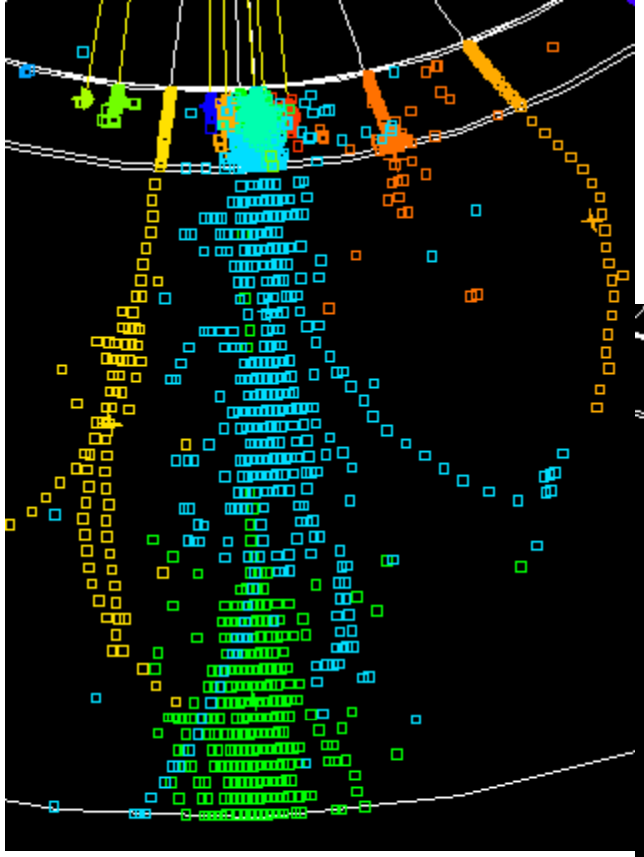
SiD02-Cu
SiD02



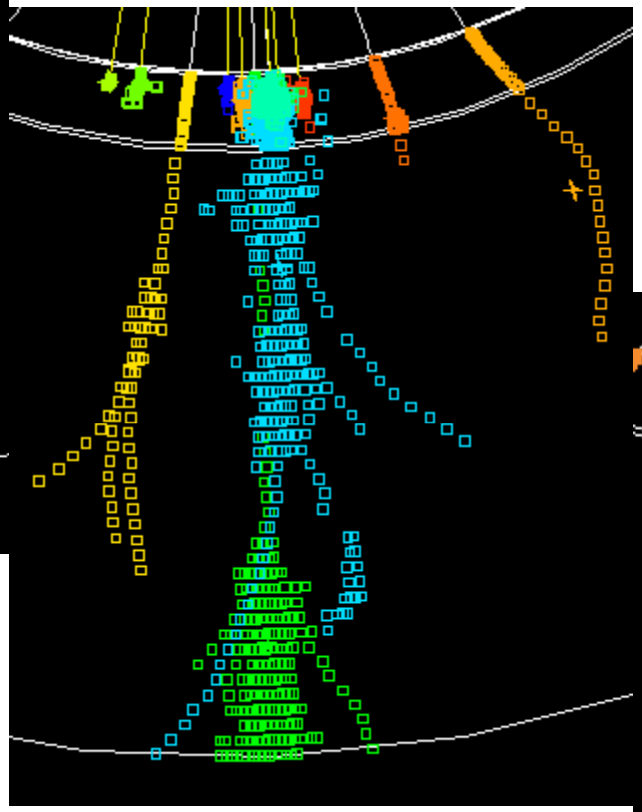
Lessons learned

- Leakage is present in substantial amount
- Not the whole story at all
- Confusion clearly important at 500 GeV, dominant at 1 TeV
- Back to the drawing board
- Anatomy of the events

p(left) = 105 GeV, p(right) = 97 GeV
Angle < 1 degree, connected `seeds'

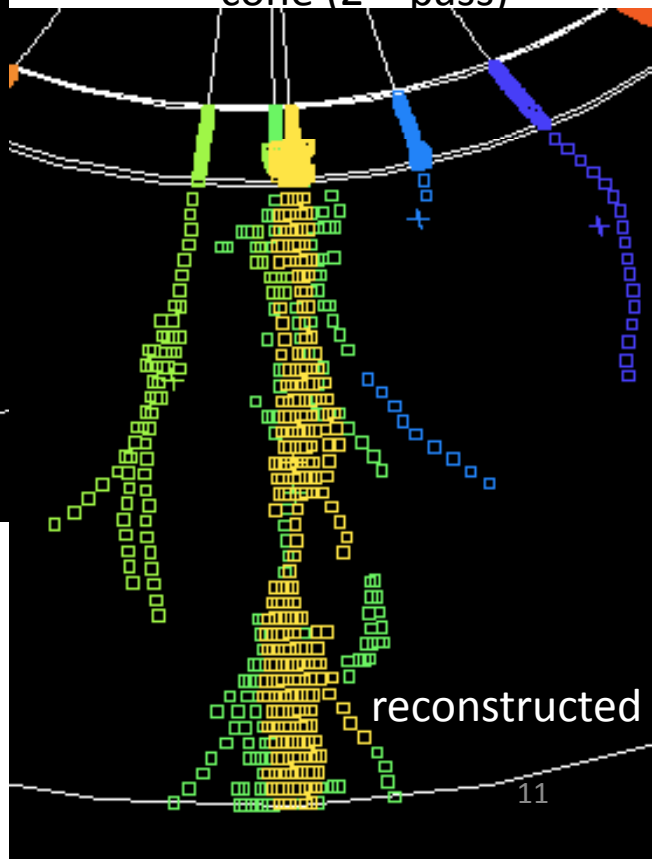


RefinedCheatCluster



RefinedCluster - sharedhits

p = 7.7 GeV, blue piece picked up by cone (2nd pass)

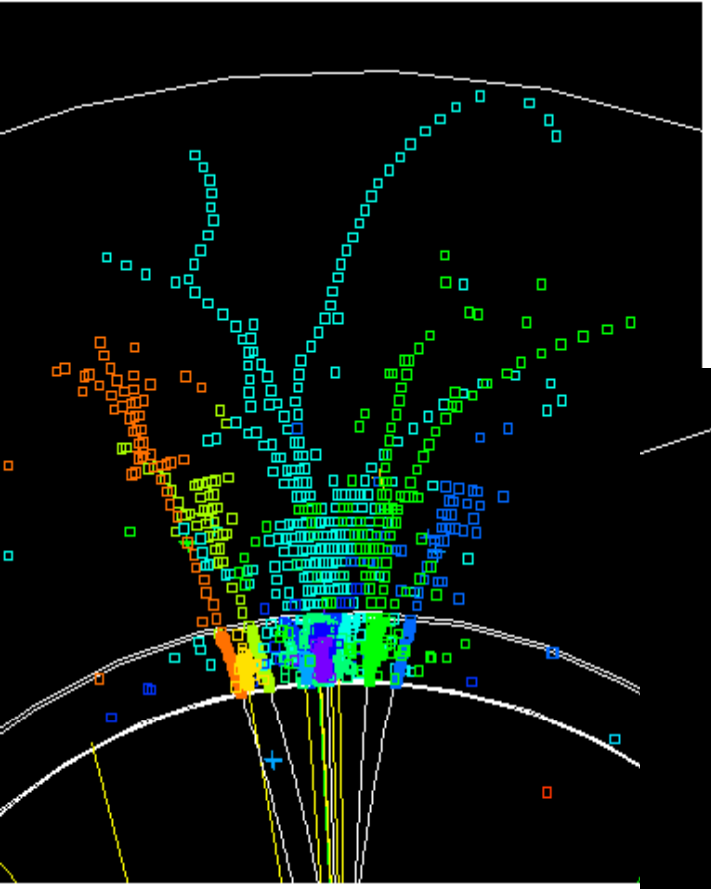


reconstructed

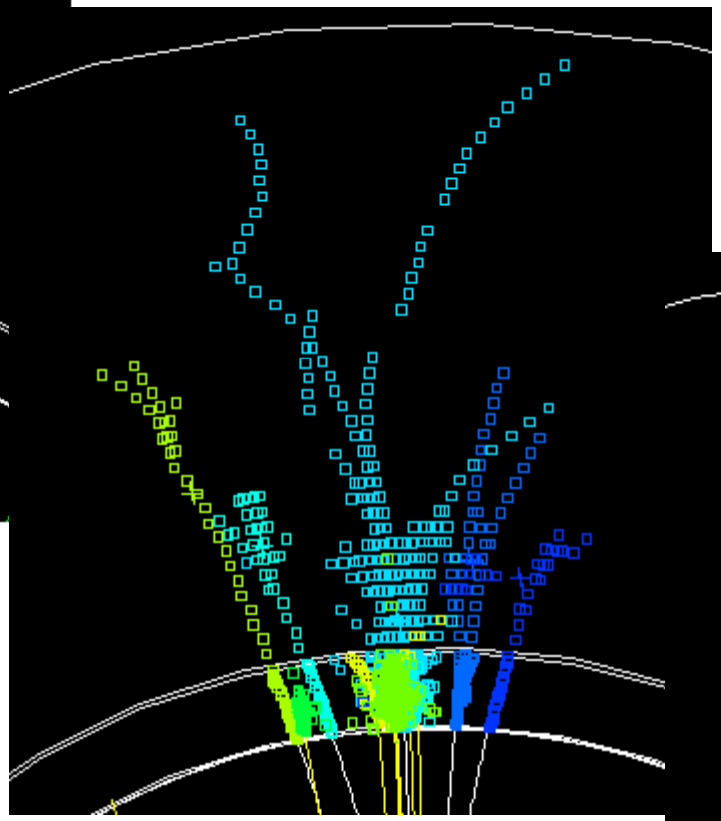
$e^+e^- \rightarrow qq$ at 500 GeV

has a low energy 12 GeV neutral hadron and several photons present in the ECAL; interaction of charged hadron

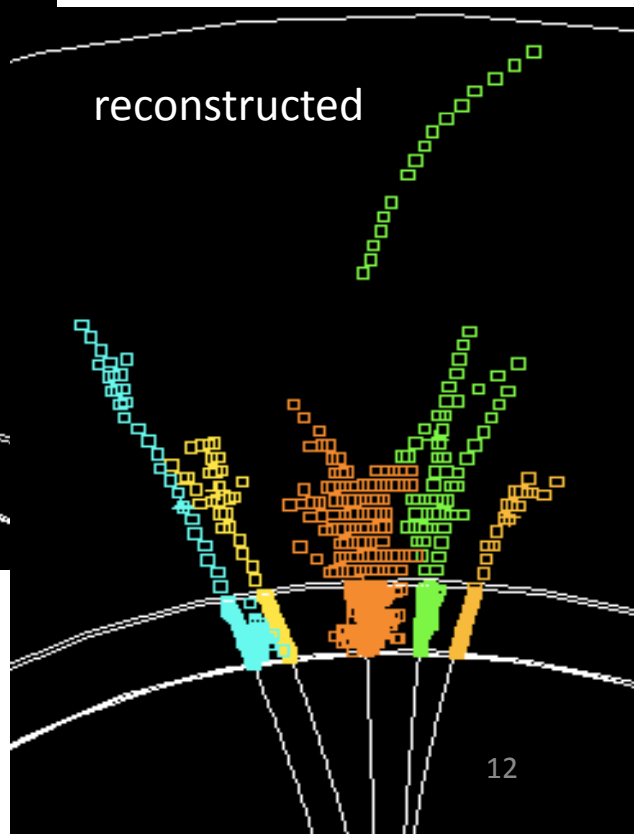
p (orange) = 119 GeV, E/p match, enough hits (green) = 17 GeV



RefinedCheatCluster



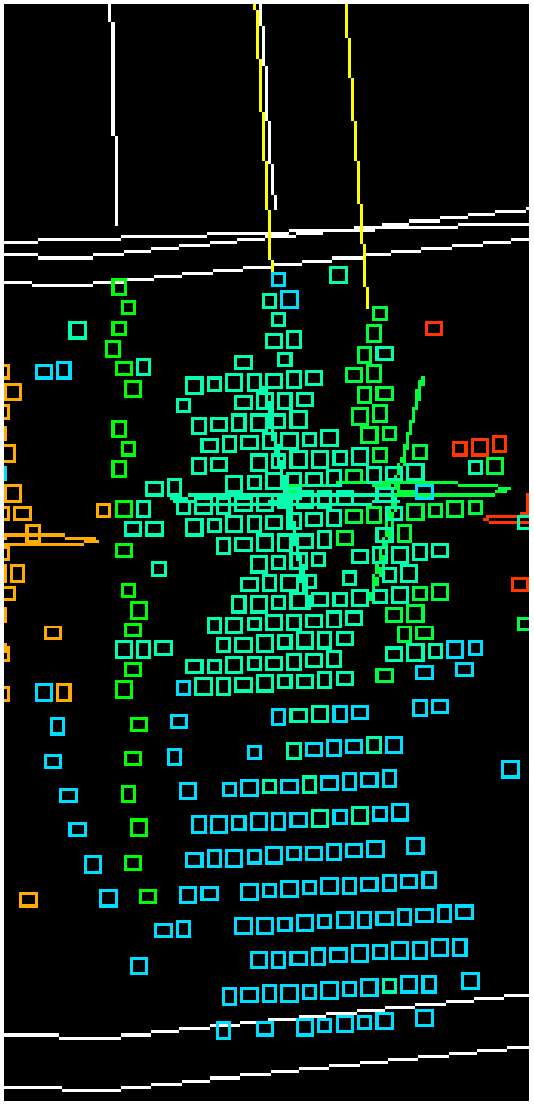
RefinedCluster - sharedhits



reconstructed

$e^+e^- \rightarrow qq$ at 500 GeV

RefinedCluster - sharedhits

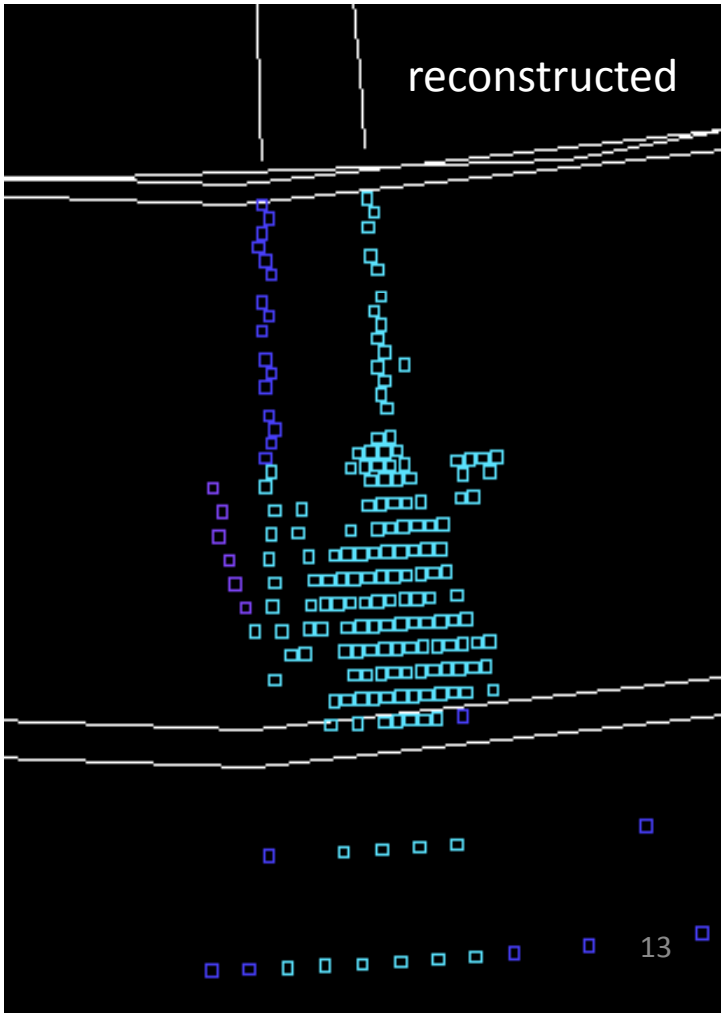


Backscatter
p(orange) = 97 GeV
p(blue) = 105 GeV

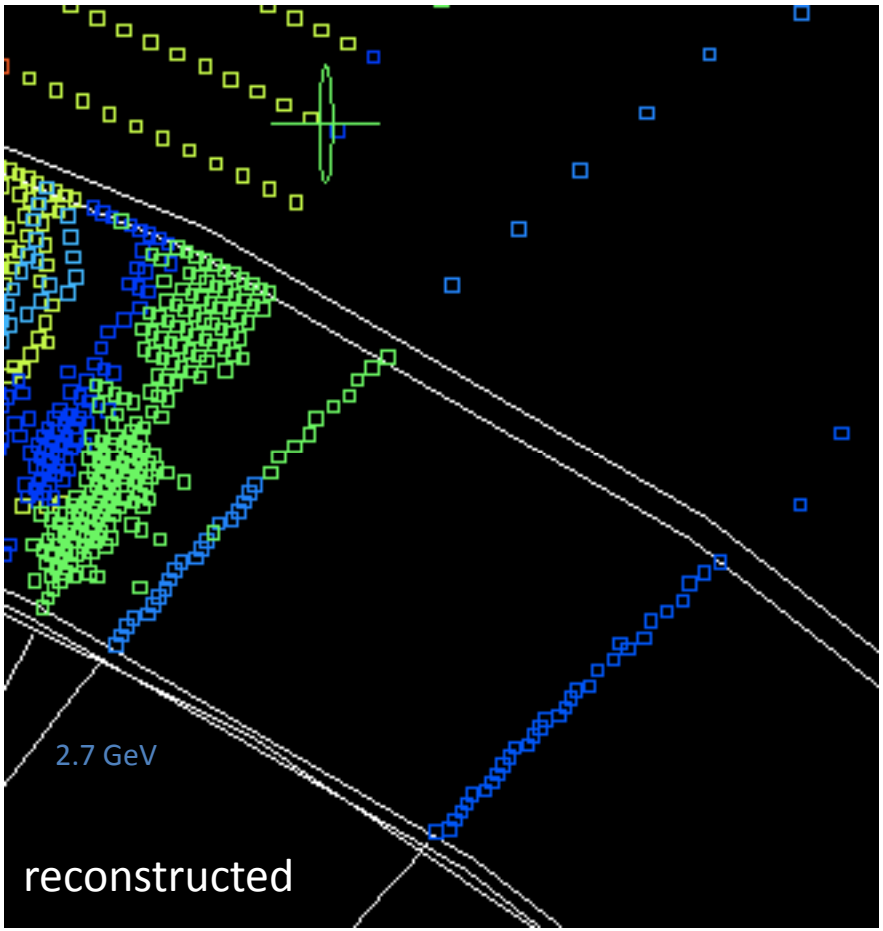
ECAL

$e^+e^- \rightarrow qq$ at 500 GeV

In 97 GeV track-cluster `cone' gives high score to the stub and is connected; 105 GeV can not access the stub



$e^+e^- \rightarrow qq$ at 500 GeV



ECAL

p (green) = 40.8 GeV,
p (blue) = 2.7 GeV
Higher score by cone to green cluster seed, blue has implied cluster connected to seed

Algorithm modifications/additions

- Cone algorithm is too aggressive!
  - Mostly the cone algorithm picks up MIP-like pieces
  - Use reconstructed shower information (not only stubs)
  - Use directional information

- Low-momentum tracks steal pieces from high-momentum showers
  - Iteration starts with lowest momentum track and assigns clusters
  - Keep clusters available for others tracks even if assigned
  - Use geometry information (proximity) to adjudicate cluster assignments between tracks

- Misc:
  - Can Barrel Muon be used as a backing calorimeter, for merged high p tracks ?
  - Backscattering ?

Conclusion

- Much better understanding of weak points of algorithm
- Hitting our stride in aftermath of LOI
- Christoph Pahl joined the effort, can now afford an FTE
- Clear path to improve pattern recognition
- Lots of work to do!

Leakage study (SiD02-Cu comparison)

cheat tracking