SiD-Iowa PFA
Status and Plans

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Current Status at $\sqrt{s}$ = 500 GeV

$$e^+e^- \rightarrow q\bar{q}(q = u, d, s) \text{ at } \sqrt{s} = 500 \text{ GeV}$$

$\Delta E/E$ = 3.5% for rms90 at LOI 2009

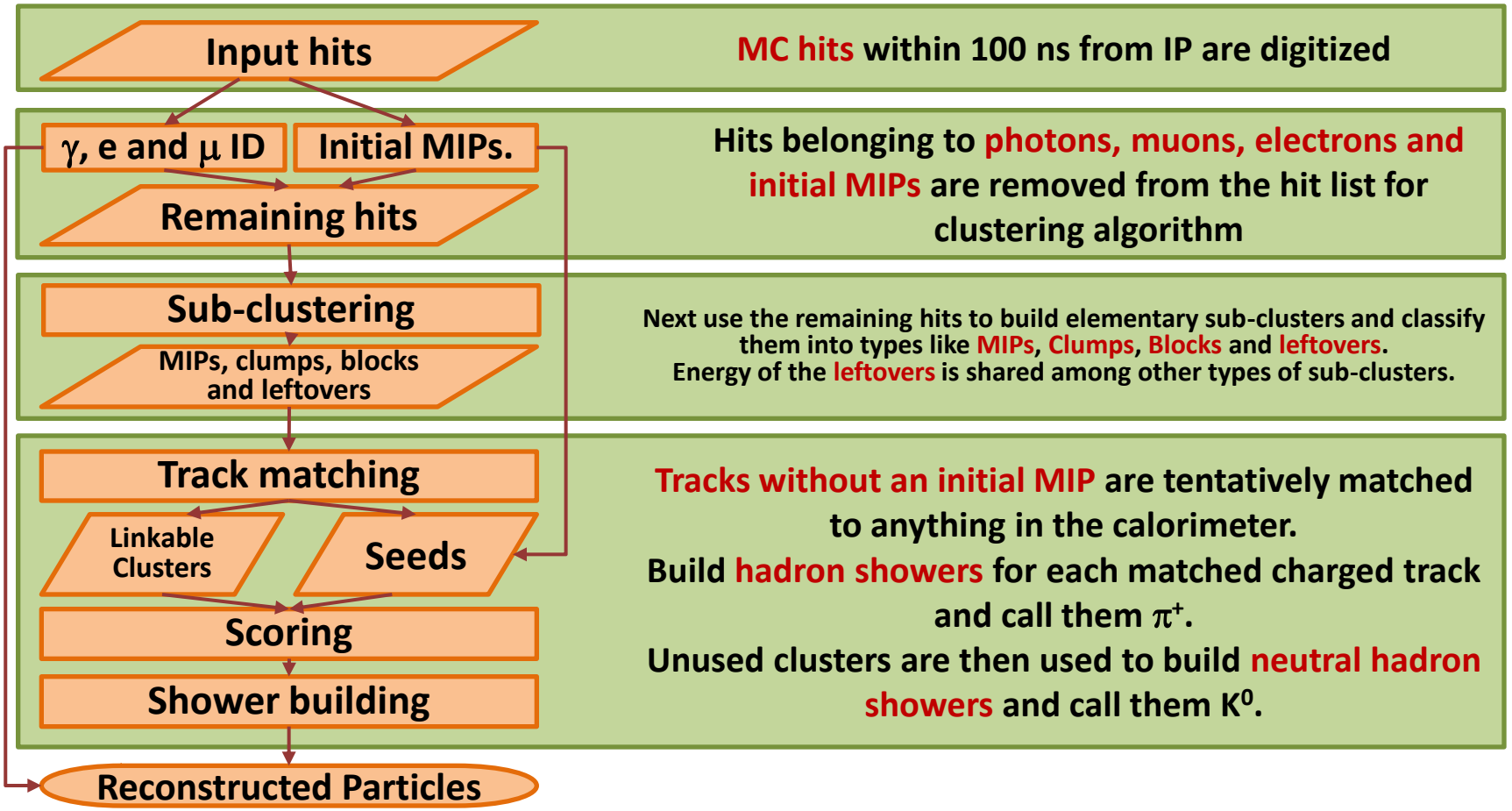
with **new improvements** using previous shower reconstruction algorithm, now

$\Delta E/E$ = 3.1% for rms90

which improves to

$\Delta E/E$ = 2.6%, with perfect photon reconstruction

An overview of the steps

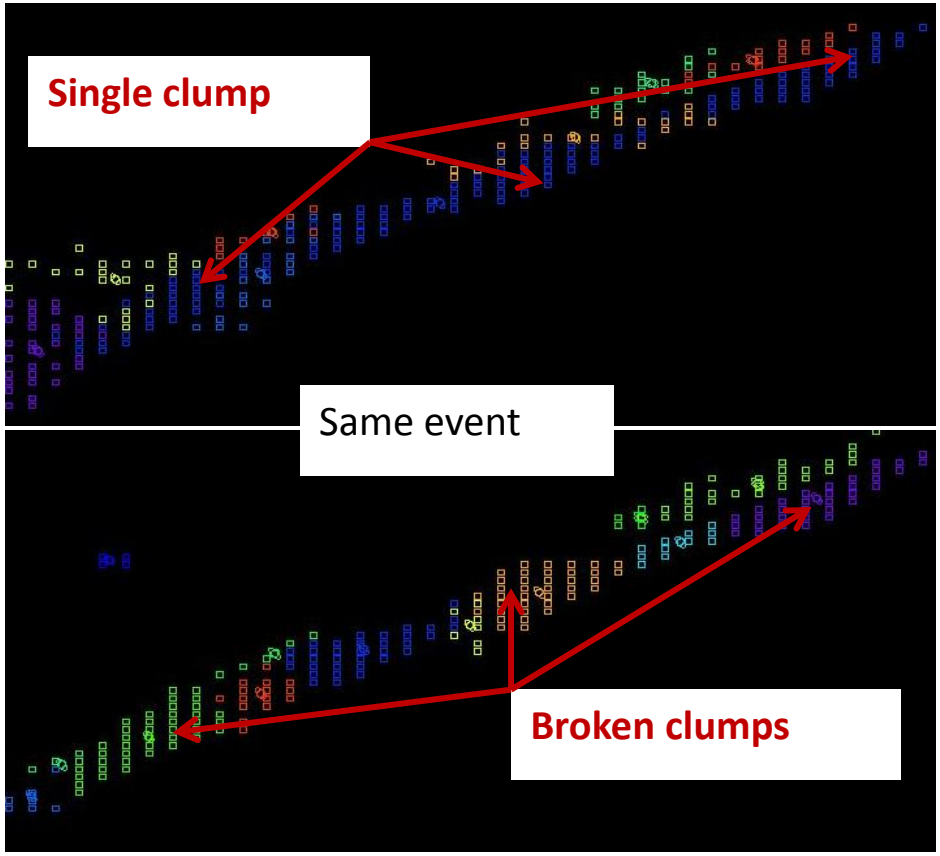


The Improvements

With the existing Shower Reconstruction Philosophy:
Improvement in MIP finding: made faster
Photon identification
Sub-cluster definition
Shower-seed finding by extrapolating tracks to ECAL
Linking sub-clusters to reconstruct showers
New Shower Reconstruction Philosophy:
Scalable for higher cm energies
Multi-pass iterative shower reconstruction:
Shower core reconstruction with high purity for charged tracks: first iteration
Neutral shower reconstruction and adding other pieces: second iteration
Adjustment of clusters in showers with overall event geometry, E/p: third iteration **(in progress)**

Subcluster improvements

Sub-cluster categories: Clumps, Blocks, leftovers, redefined

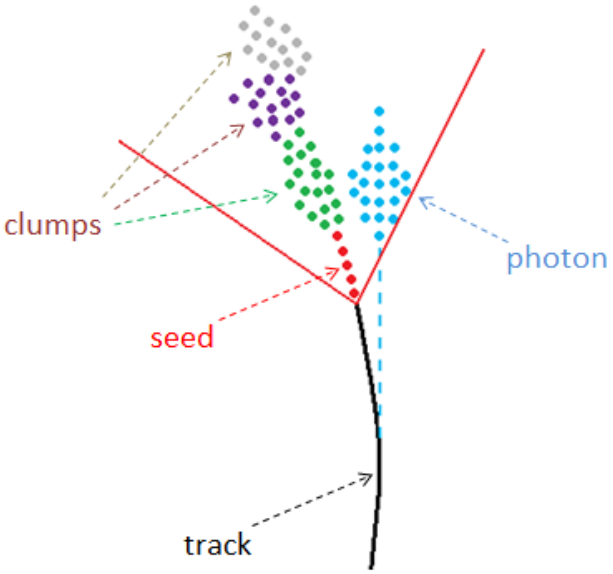


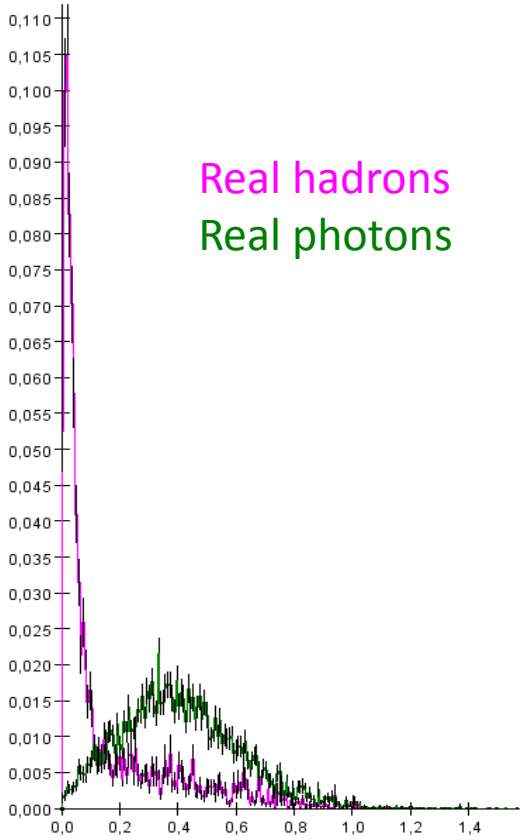
Energy weighted distribution:
Clumps ~46%
MIPs ~ 12%
Left-overs~ 23%
Photons~19%
Blocks ~ <1%

Improved clump purity
83% → 90%

Photon veto

- Improved photon purity:
  - Try to treat a reconstructed photon cluster as a hadronic clump if within 3 degrees of a track
  - Still have a 10% inefficiency and 10% contamination .

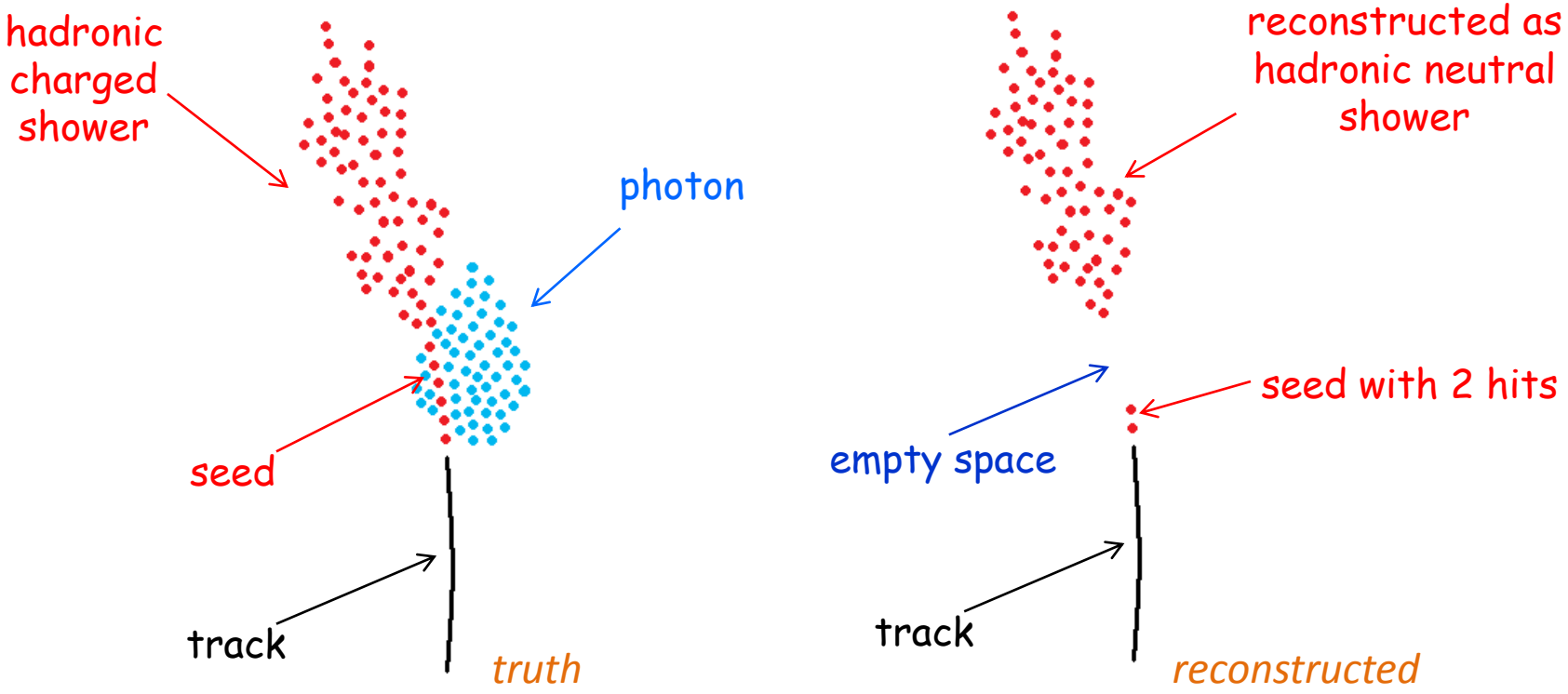




Energy weighted Purity:
83% → 90%
Energy weighted Efficiency:
92% → 90%

Track-seed matching, problems

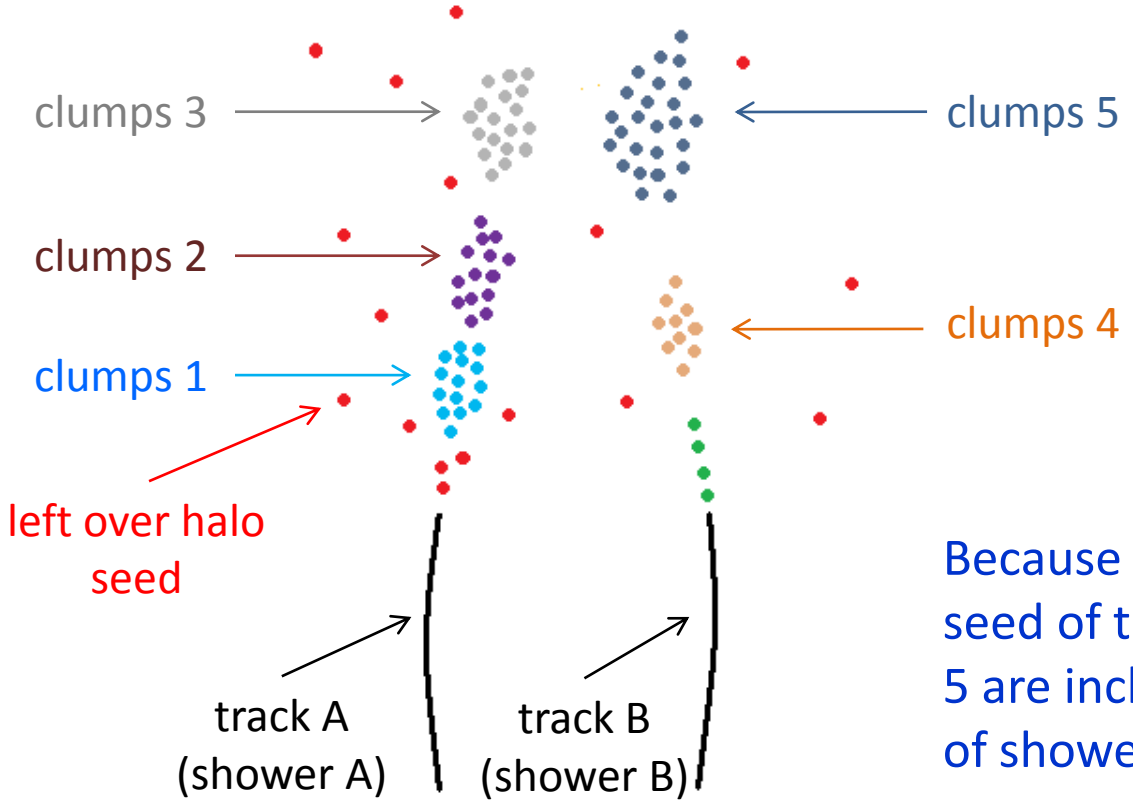
- Two problematic cases are identified:
  - Case 1: Photon close to a track



8% of tracks have this problem.

Track-seed matching, problems

- Two problematic cases are identified:
  - Case 2: Track seed is made from left-over hits.



Because of the leftover halo (the seed of the track A), the clumps 4 & 5 are included in shower A instead of shower B

7% of tracks have this problem.

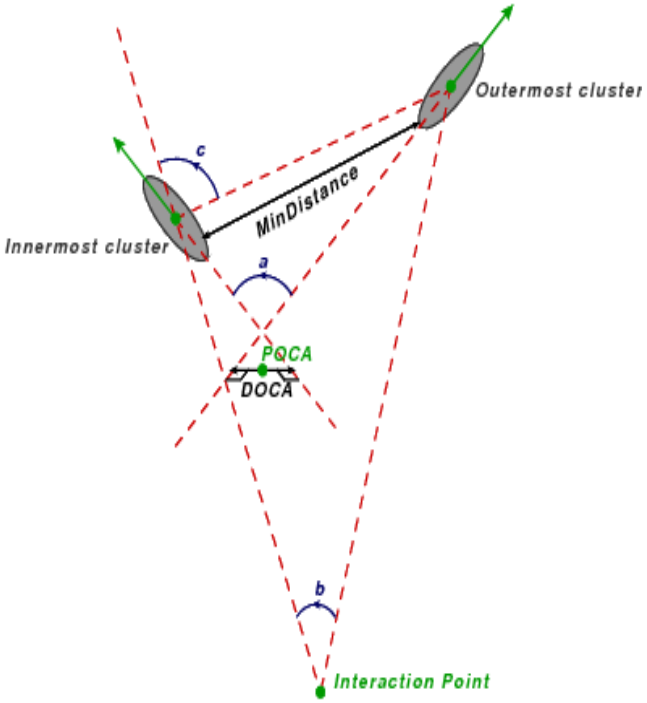
Track-seed matching, solutions

- Two problems shown on previous slides:
- 1) Photon steals most early hits, hard to extrapolate to main part of shower (8% of tracks)
  - Fix: helix extrapolation of the track to the closest sub-cluster
- 2) Seed is a sparse "leftover" cluster with poor geometrical information (7% of tracks)
  - Fix: helix extrapolation of the track to the closest sub-cluster

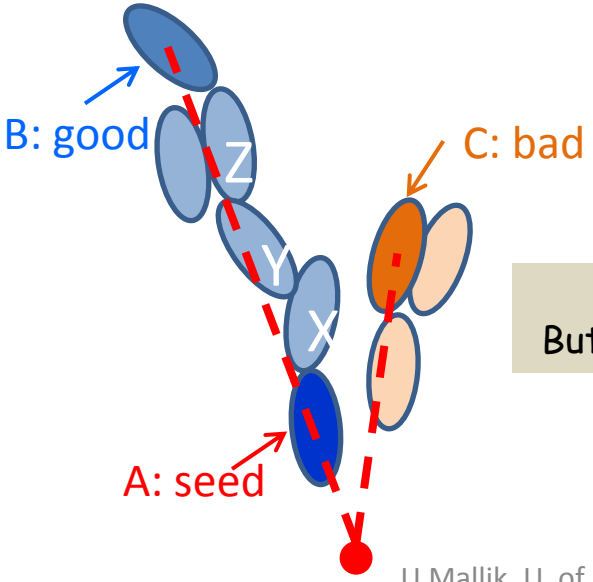
Performance : 80% of the 15% are fixed

Linking with Maximum Likelihood

- New and effective discriminating variables
- Correlations taken into account
- Individual likelihood for each sub-detector
  like ECAL, HCAL (different precision)



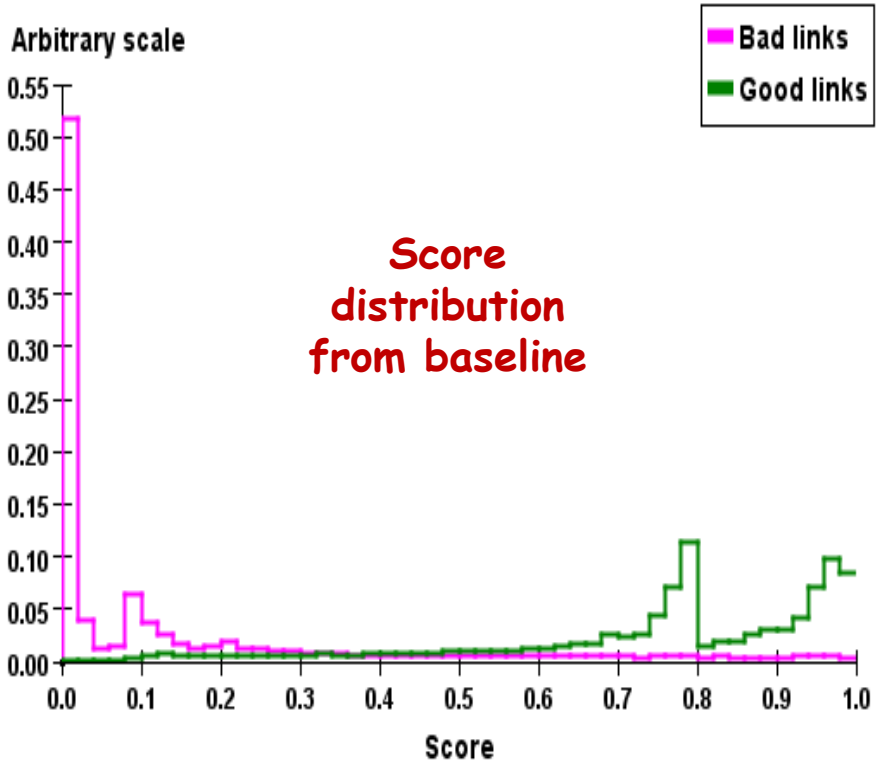
- **Train likelihood to link immediate neighbors**



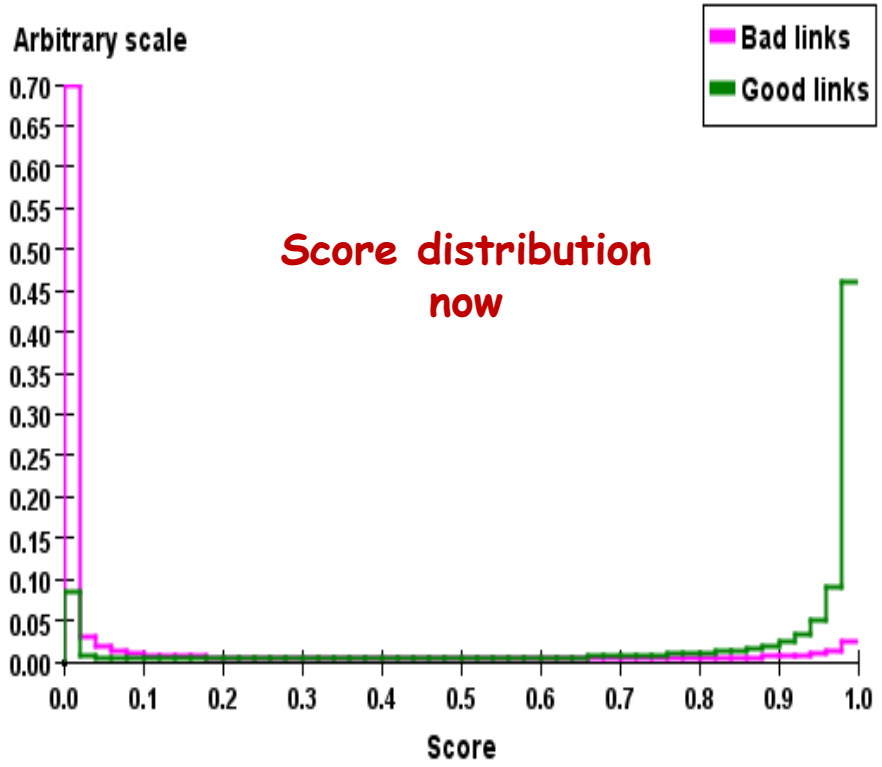
Link A to B via X,Y,Z
But no direct link from A to C

Likelihood, before and after

Score with likelihood of sub-cluster/sub-cluster links



Score distribution from baseline



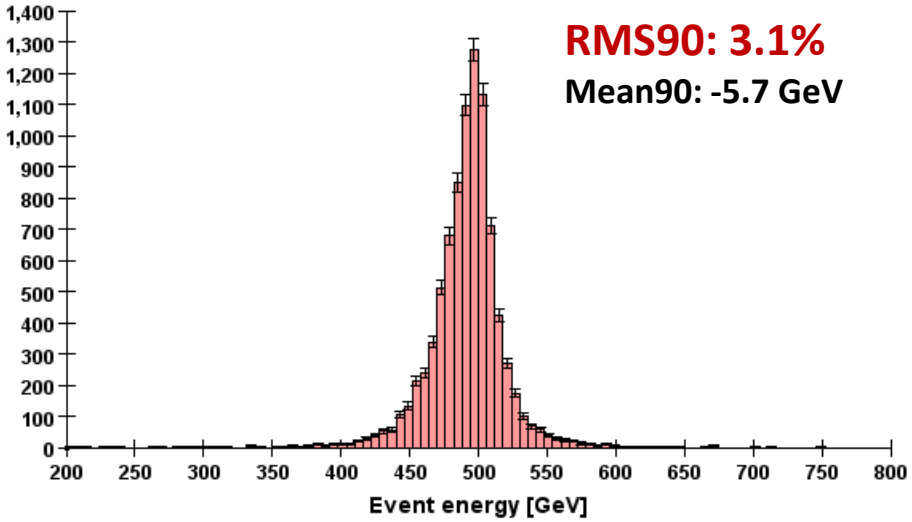
Score distribution now

Results

Total energy resolution

No cheating: 3.1%

- Not cheating with:
  - Photon finding
  - Electron finding
  - Muon finding
  - Pre-shower MIP finding
  - DTree clustering
  - Sub-structure finding
  - Photon veto
  - Track-seed matching
  - Sharing of the leftovers
  - Link scoring
  - Charged shower building
  - Neutral shower building
  - Particle making

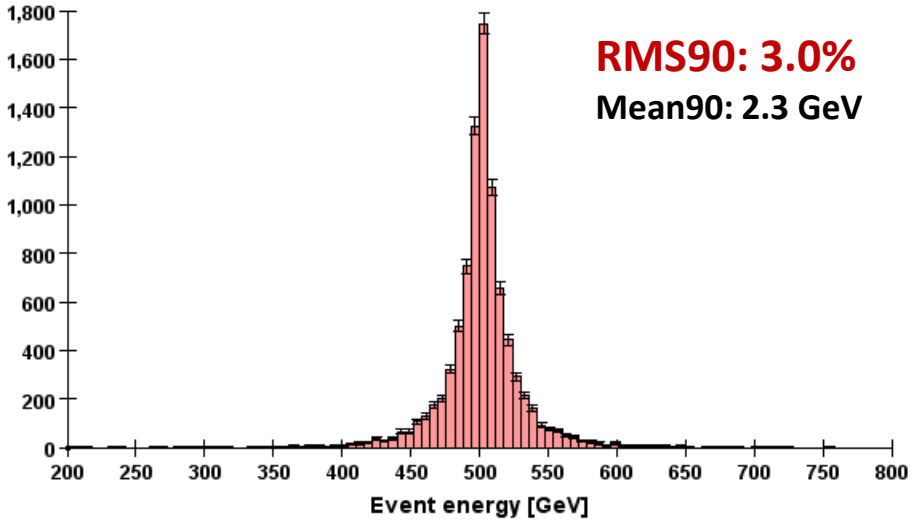


	Charged	Neutral	Photon	Purity
Reco as Charged	51.56	3.97	1.59	0.90
Reco as Neutral	6.69	7.81	1.55	0.49
Reco as Photons	3.12	0.79	22.91	0.85
Efficiency	0.84	0.62	0.88	

Total energy resolution

Perfect shower building: 3.0%

- Cheating with:
  - Charged shower building
  - Neutral shower building
- Not cheating with:
  - Photon finding
  - Electron finding
  - Muon finding
  - DTree clustering
  - Sub-structure finding
  - Photon veto
  - Sharing of the leftovers
  - Particle making
- Not affected by:
  - Pre-shower MIP finding
  - Track-seed matching
  - Link scoring



RMS90: 3.0%

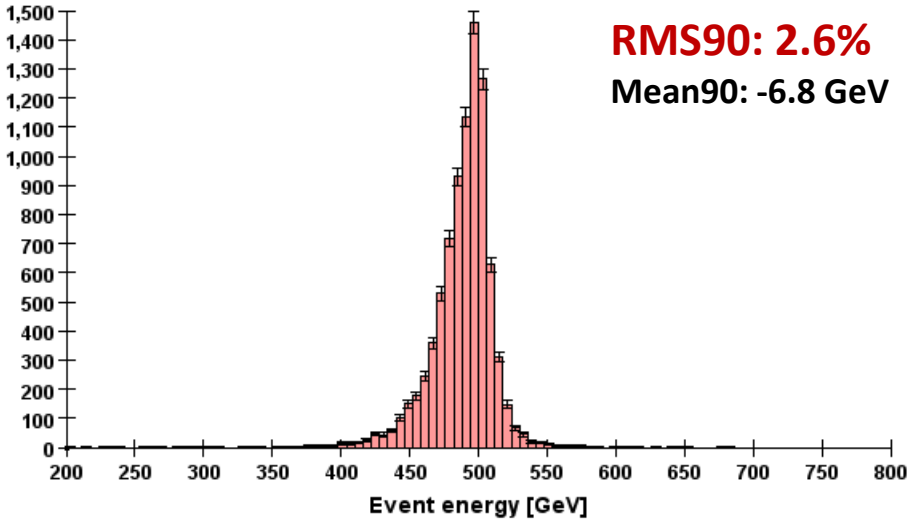
Mean90: 2.3 GeV

	Charged	Neutral	Photon	Purity
Reco as Charged	52.29	1.60	0.89	0.95
Reco as Neutral	5.94	10.27	2.17	0.56
Reco as Photons	3.06	0.80	23.00	0.86
Efficiency	0.85	0.81	0.88	

Total energy resolution

Perfect photon reconstruction: 2.6%

- Cheating with:
  - Photon finding
- Not cheating with:
  - Electron finding
  - Muon finding
  - Pre-shower MIP finding
  - DTree clustering
  - Sub-structure finding
  - Photon veto
  - Sharing of the leftovers
  - Particle making
  - Charged shower building
  - Neutral shower building
- Not affected by:
  - Track-seed matching
  - Link scoring

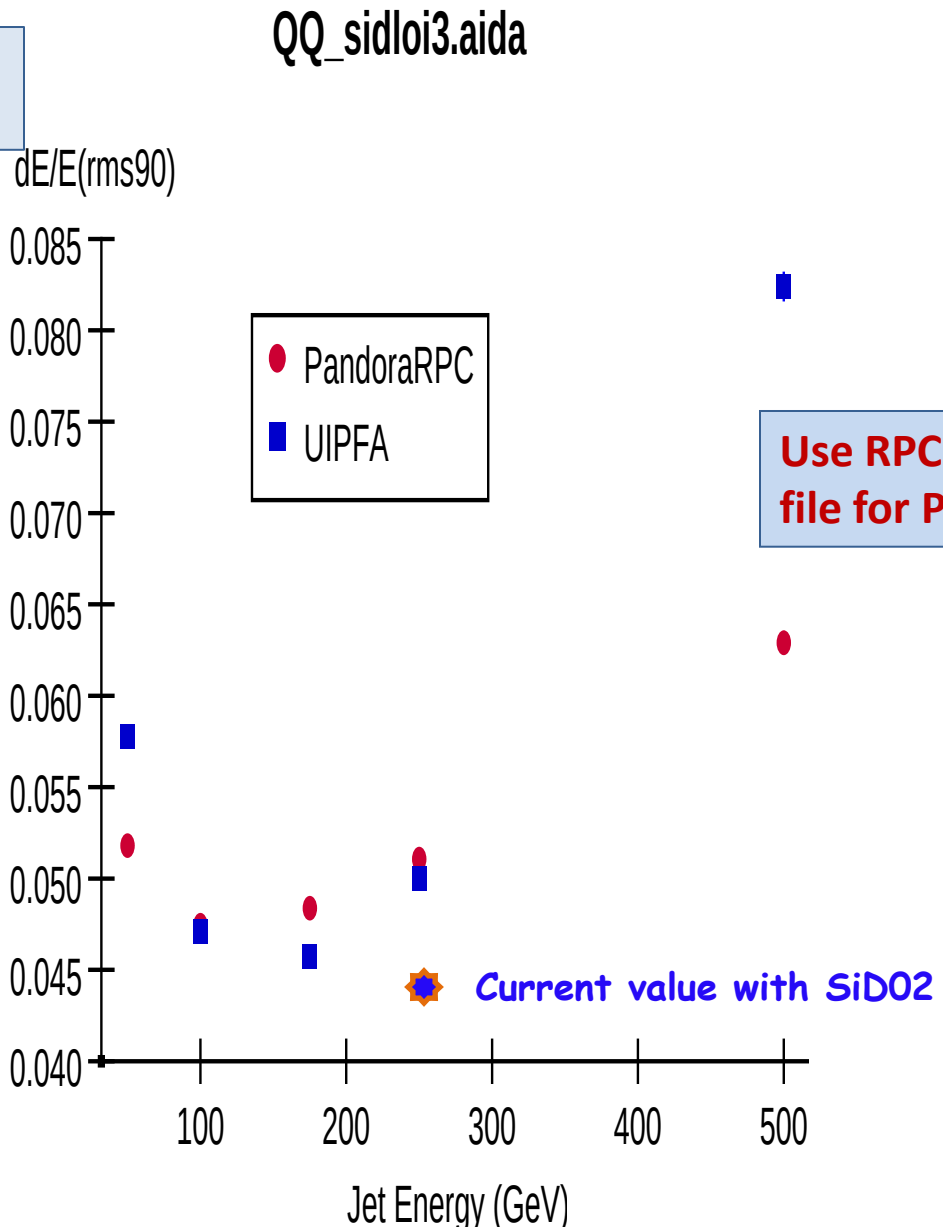


	Charged	Neutral	Photon	Purity
Reco as Charged	52.79	4.07	0.50	0.92
Reco as Neutral	6.56	8.44	0.12	0.56
Reco as Photons	1.88	0.00	25.65	0.93
Efficiency	0.86	0.67	0.98	

Taking Stock

From Ron Cassell's presentation at the PFA meeting of Mar 31 2011

- Cut events with q |cosθ|> 0.95.
- Plot sum of energy of all Reconstructed Particles.
- Use distribution **(rms90/mean90)*sqrt(2)**



Use RPC steering file for Pandora

Conlclusion and Next Steps

- Event energy resolution ΔE/E improved **from 3.5% to 3.1%**

$$e^+e^- \rightarrow q\bar{q}(q = u, d, s) \text{ at } \sqrt{s} = 500 \text{ GeV}$$

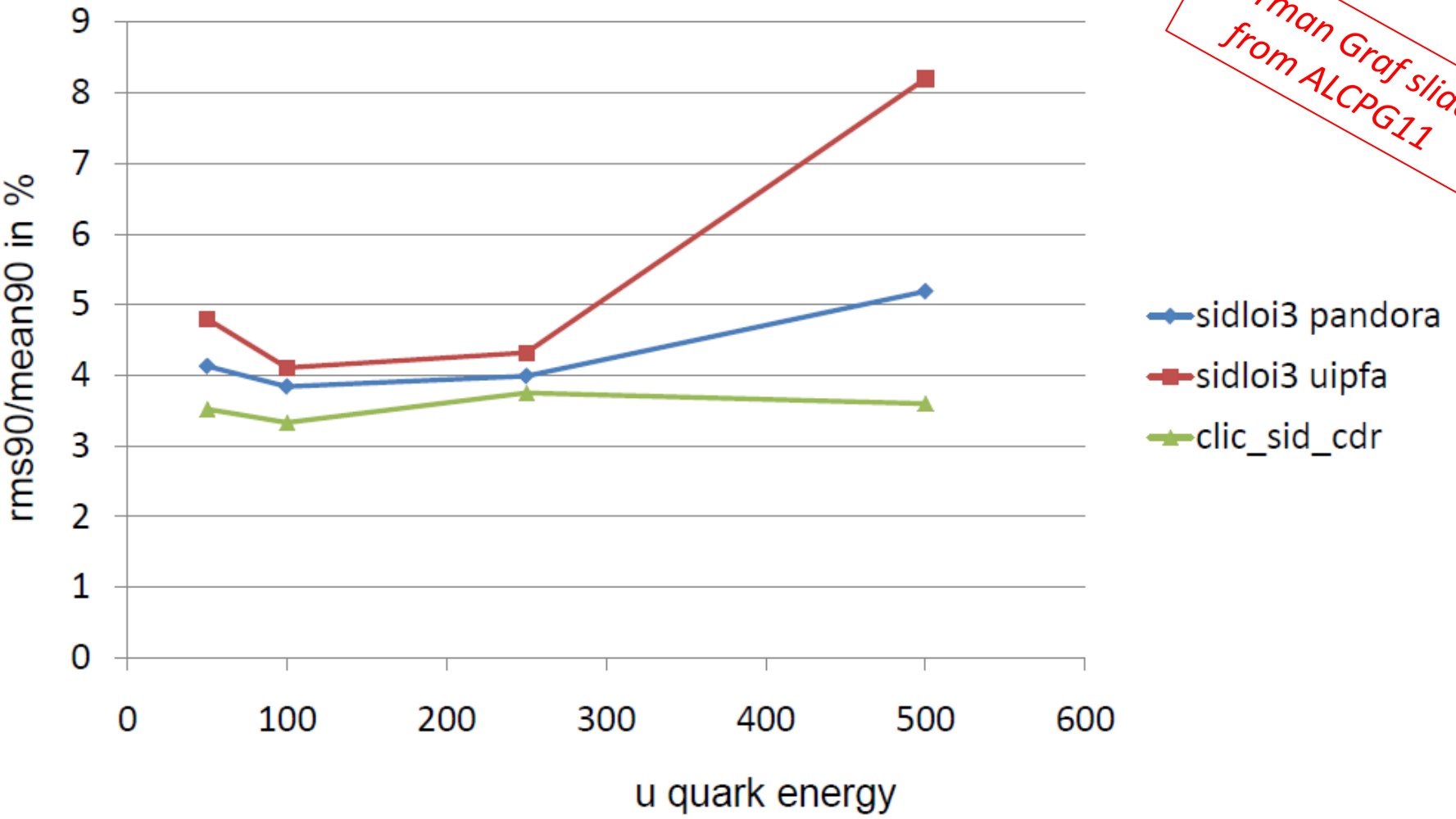
- For single jet energy this translates into an improvement from **(ΔE/E *√2) 4.9% to 4.4%**

- For higher energy scaling (√s of 1 TeV and further), a new shower reconstruction is in progress where
  - All tracks are treated simultaneously
  - First and second iterations with shower core building and adding on neutral showers and extra pieces of sub-clusters are completed
  - The third iteration where regional and overall event energy momentum balance is taken into account to achieve higher purity and efficiency is underway

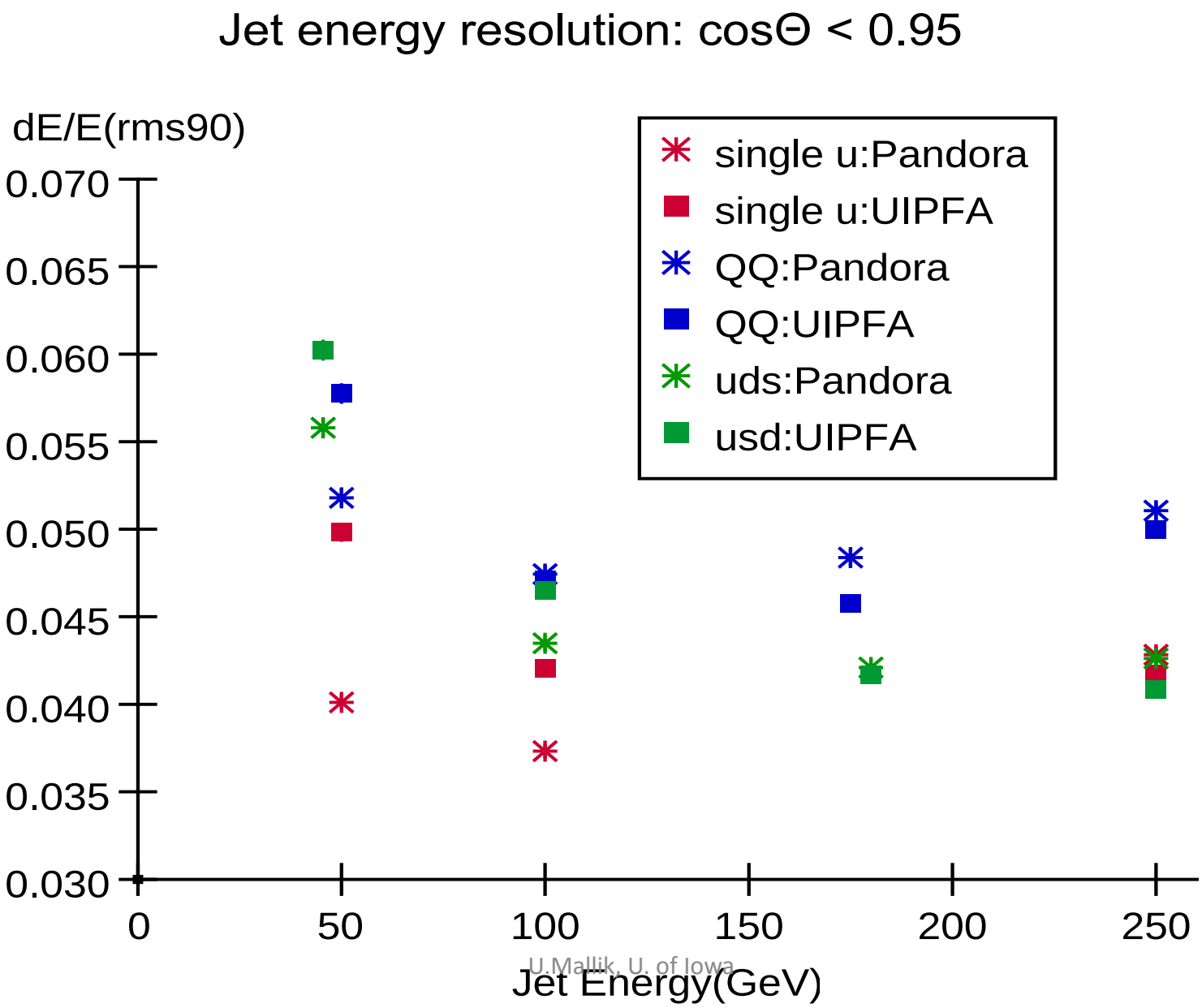
- More progress expected soon

Backup

single u quark rms90/mean90 in %



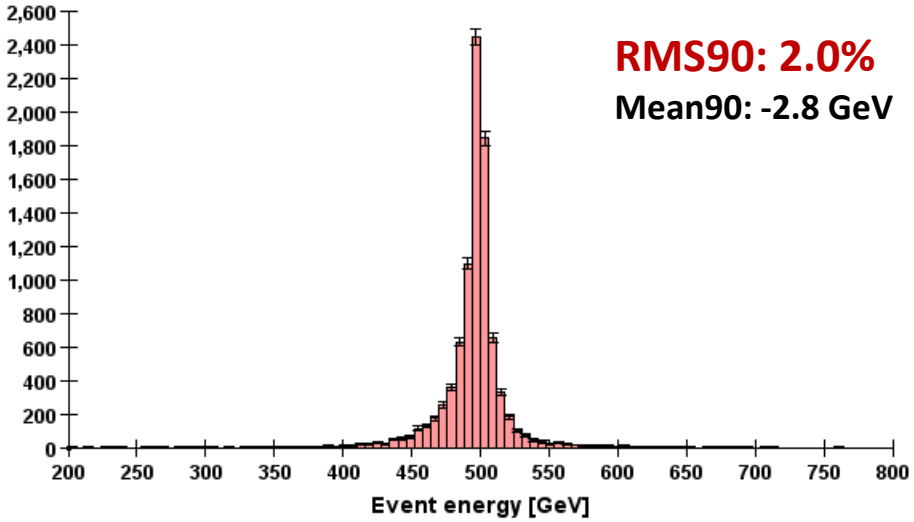
From Ron Cassell's presentation at the PFA meeting of Mar 31 2011



Jet-jet resolution

Perfect shower building and perfect photon reconstruction: 2.0%

- Cheating with:
  - Photon finding
  - Charged shower building
  - Neutral shower building
- Not cheating with:
  - Electron finding
  - Muon finding
  - DTree clustering
  - Sub-structure finding
  - Photon veto
  - Sharing of the leftovers
  - Particle making
- Not affected by:
  - Pre-shower MIP finding
  - Track-seed matching
  - Link scoring

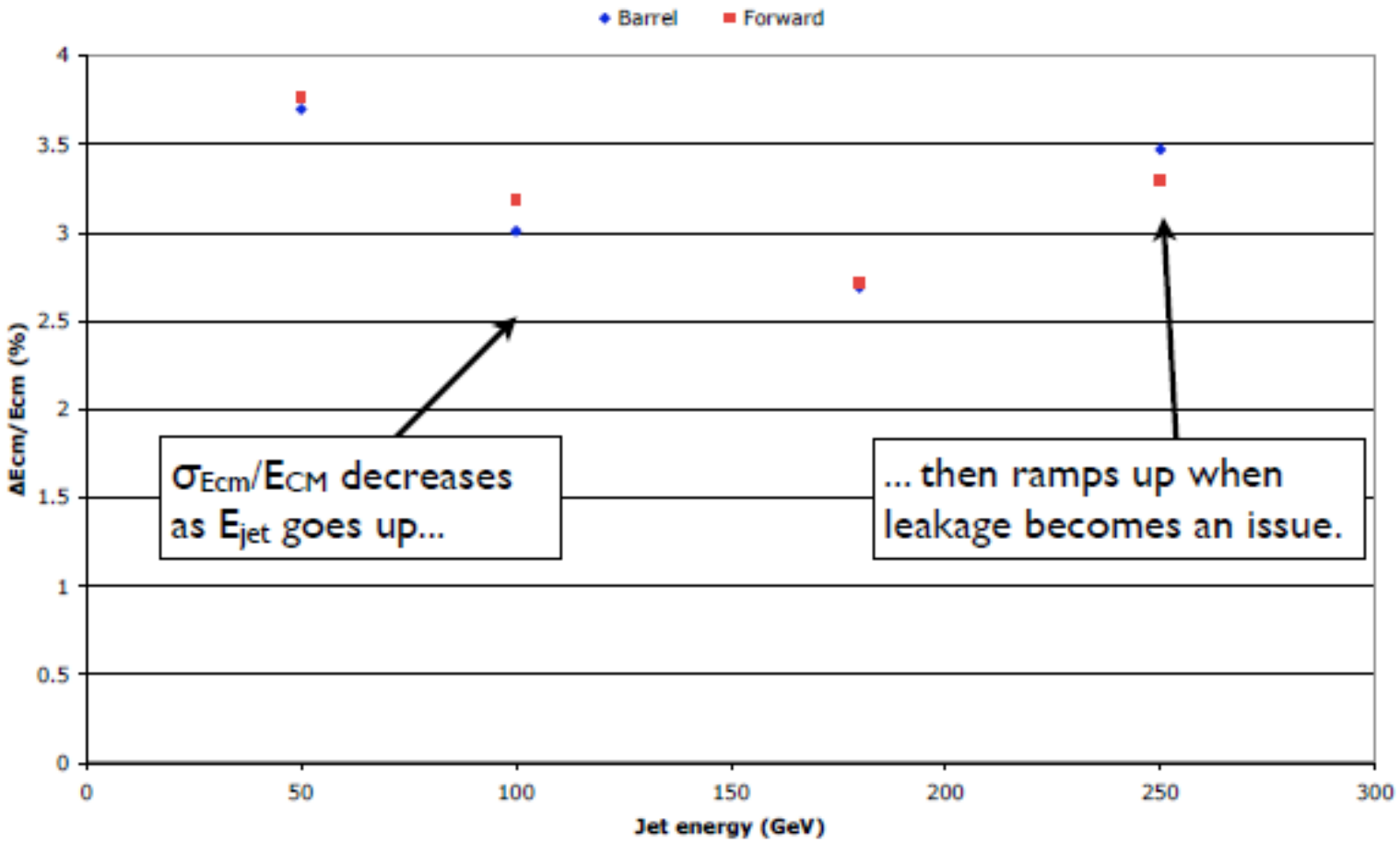


	Charged	Neutral	Photon	Purity
Reco as Charged	53.44	1.60	0.39	0.96
Reco as Neutral	5.86	11.03	0.13	0.65
Reco as Photons	1.86	0.00	25.67	0.93
Efficiency	0.87	0.87	0.98	

Performance at LOI

SiD02 geometry

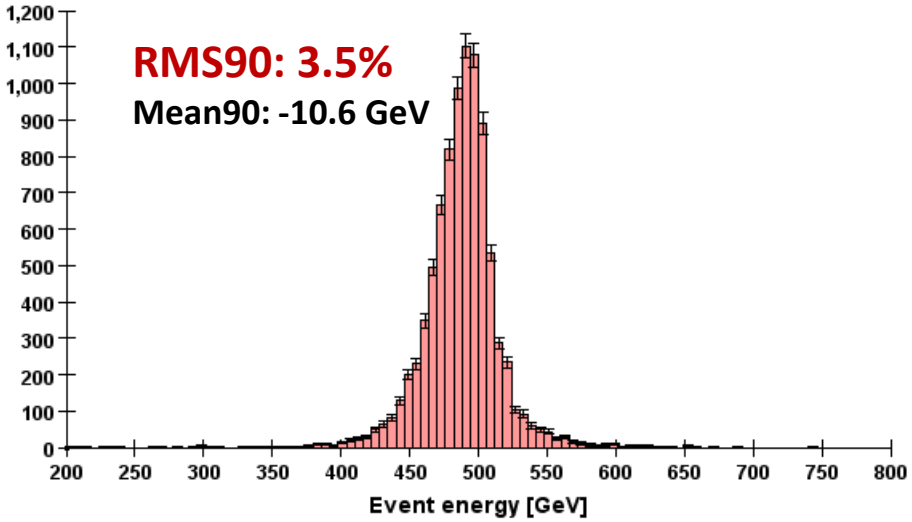
- Last significant resolution result used for the LOI
  - In 2009 for validation of the SiD concept (for all physics)



At higher energies resolution worsened partly due to leakage but also due to algorithm

Baseline LOI (2009)

- Baseline performance quoted in the LOI (2009):
  - Resolution: 3.5%



	Charged	Neutral	Photon	Purity
Reco as Charged	50.42	3.97	3.66	0.87
Reco as Neutral	8.35	7.94	1.73	0.44
Reco as Photons	2.59	0.73	20.61	0.86
Efficiency	0.82	0.63	0.79	

Properties of the problematic seeds

- 8% of matched tracks have problematic seeds:
  - On average 1/3 of events have one or more problematic seed.
- They have high momentum:
  - 60 GeV on average instead of 20 GeV for all tracks.
- They have low number of hits:
  - 90% of them have less than 4 hits.
- There is a big photon nearby