SiD PFA Development & Results

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Outline

- PerfectPFA studies
- The IowaPFA
- Optimizing SiD with PandoraPFA

SiD

Flux return/muon
R_{in}= 333 cm
R_{out}= 645 cm

Solenoid: 5 T; R_{in}= 250 cm

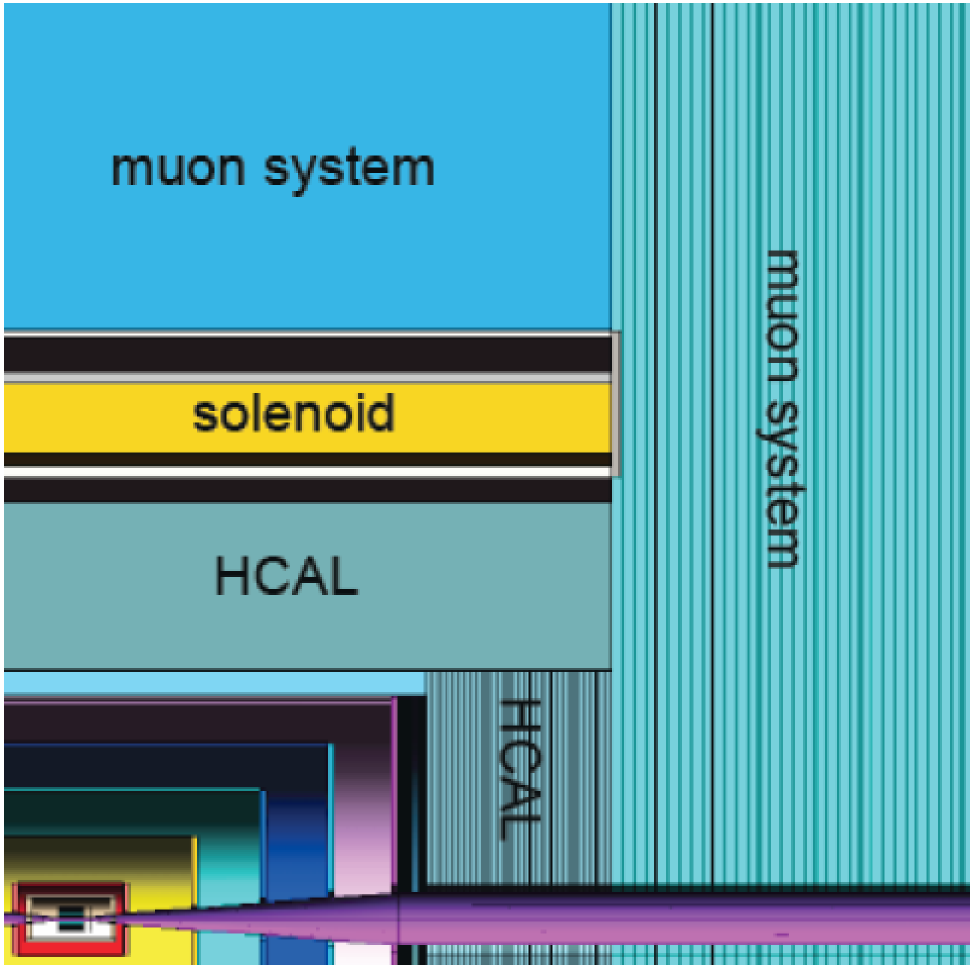
PFA

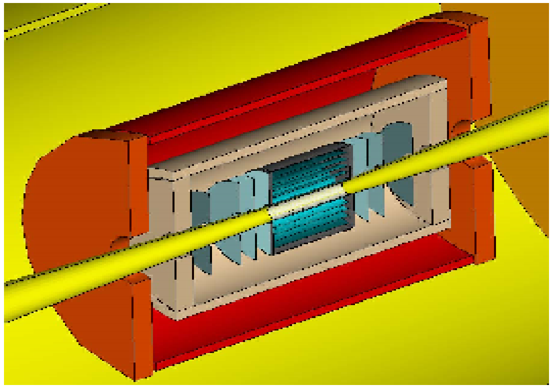
HCAL Fe: 34 layers; R_{in}= 138 cm

EMCAL Si/W: 30 layers R_{in}= 125 cm

Si

Si tracking: 5 layers; R_{in}= 18 cm



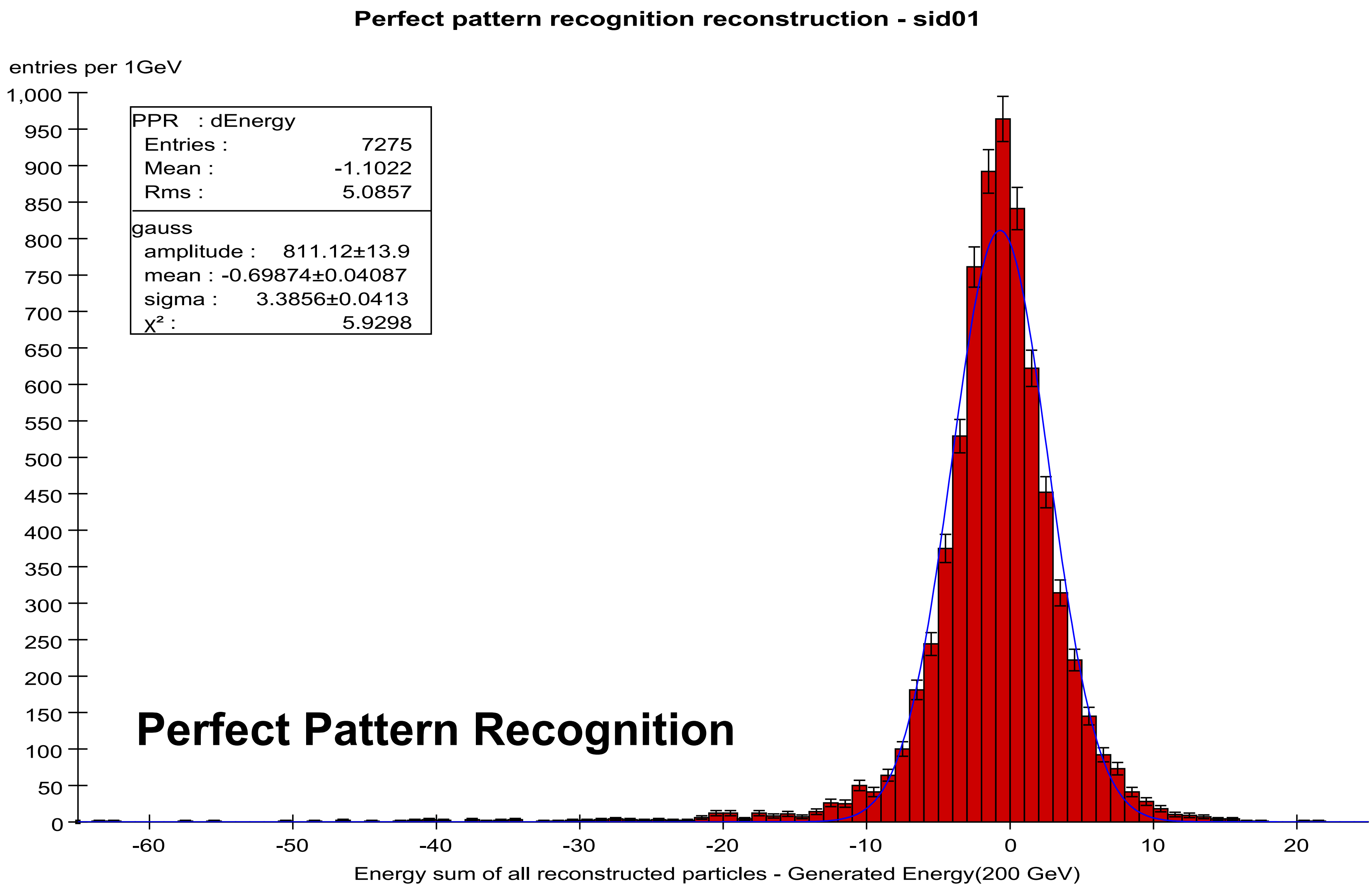


Vertex detector:
5 barrels, 4 disks; R_{in}= 1.4 cm

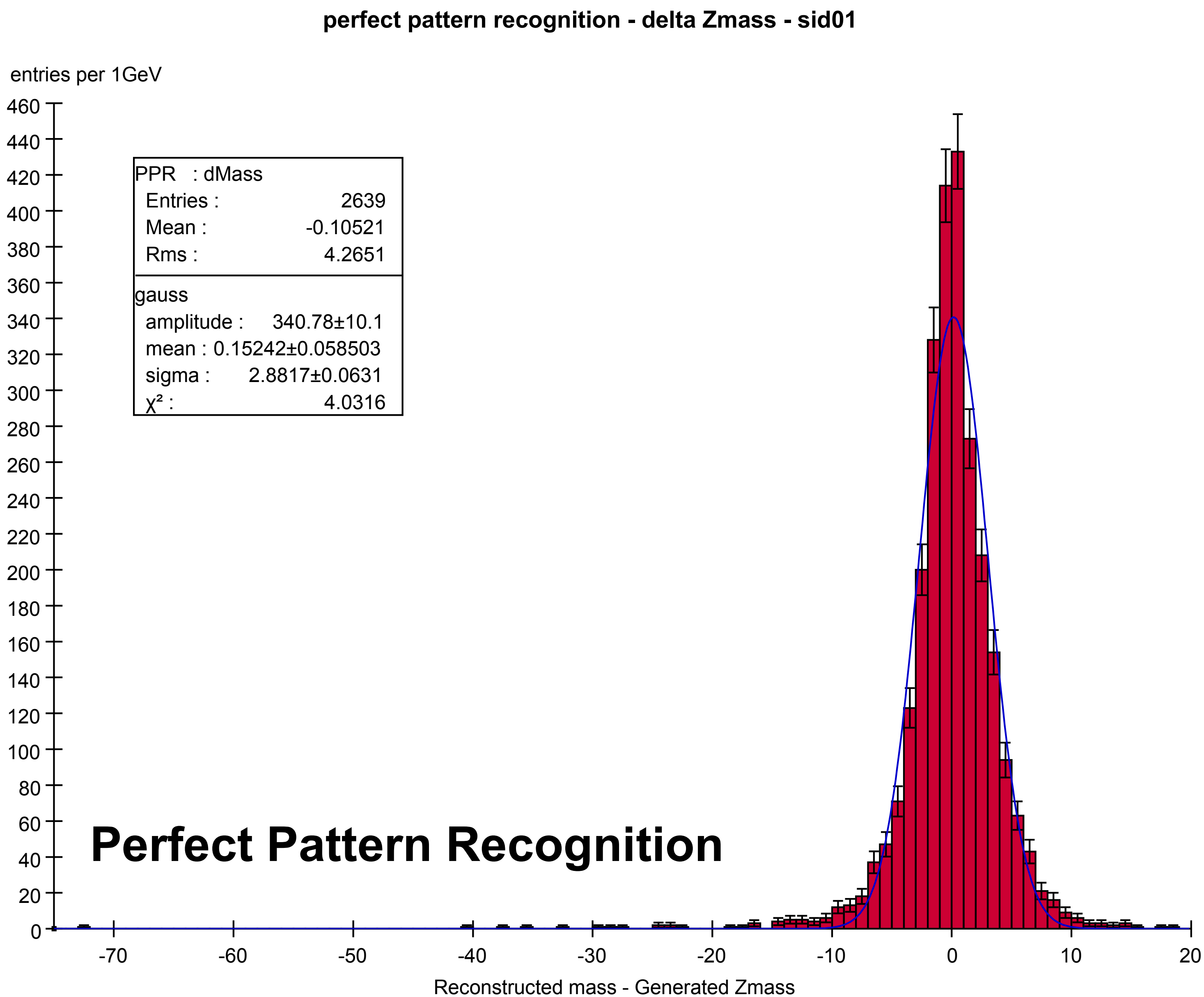
Perfect Pattern Recognition

- **Cheat on tracking:** correctly assign tracker hits, if sufficient number of hits smear parameters. If insufficient number of hits treat as neutral.
- **Correctly assign hits in the calorimeter:** If sufficient number of hits use them to reconstruct neutrals. (both energy and direction)

ΔE results for SID01



Mass resolution

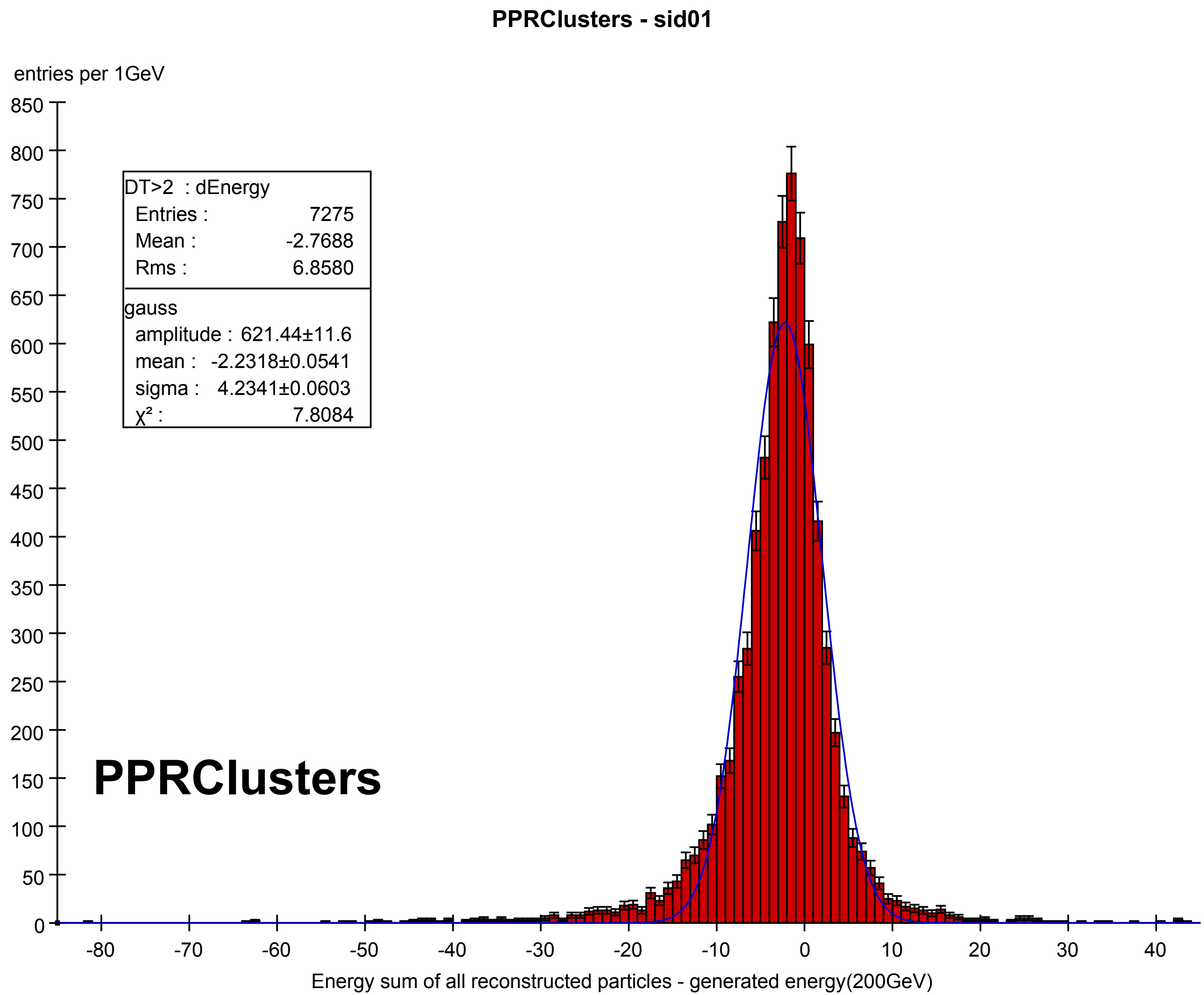


PPRClusters

- **PPRClusters:** Cluster hits in the calorimeters, discard clusters with < 3 hits, and assign clusters to the particle contributing the most energy to the cluster. Then proceed as above.
- This is though cheating on assignments a more realistic approach

ΔE results for SID01

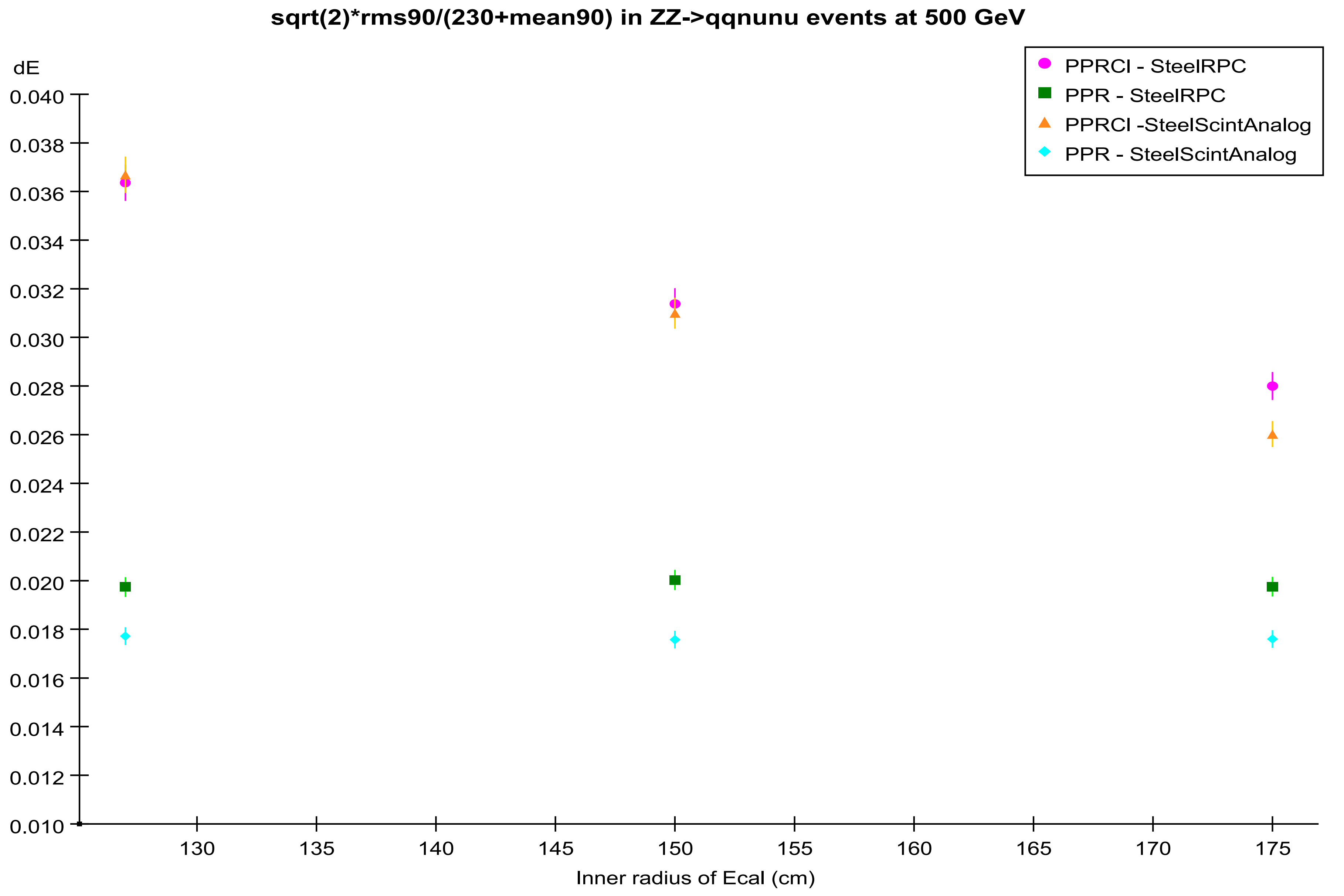
Using PPRClusters



Definitions

- For comparison purposes, define
  - $\Delta E=\sqrt{2}*rms_{90}/mean_{90}$+ <E> of the total reconstructed energy distribution in fixed cm energy events

Radial dependence



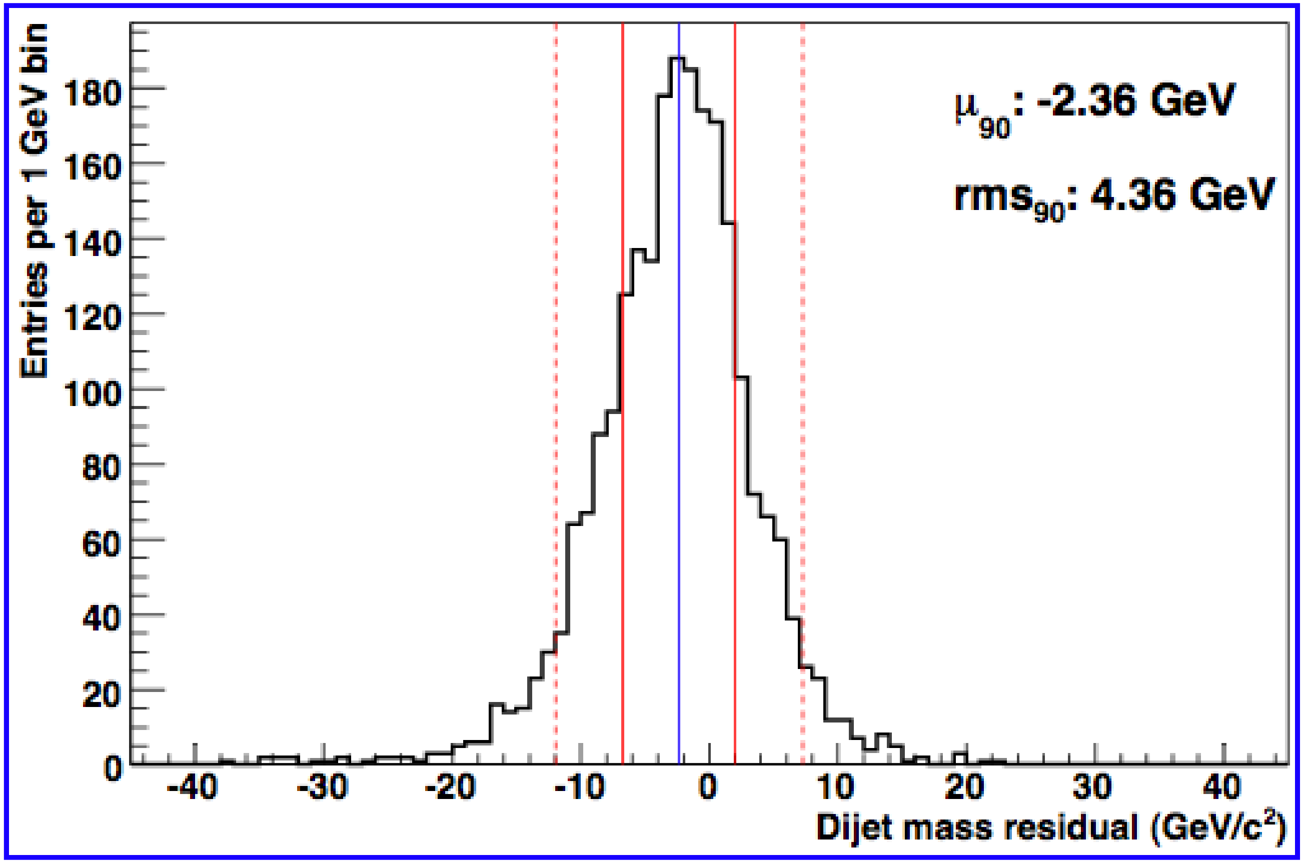
Conclusions

- The large difference in energy resolution for scintillator vs RPC translates into a small difference in jet energy resolution.
- Real clustering, even when cheating on assignments, has an impact on performance, and we start seeing a radial dependence.

IowaPFA

- using org.lcsim
- Supports both RPC and Scintillator readout in the HCAL
- Choice of
  - cluster algorithms
  - photon finders
- uses track cheating up to now

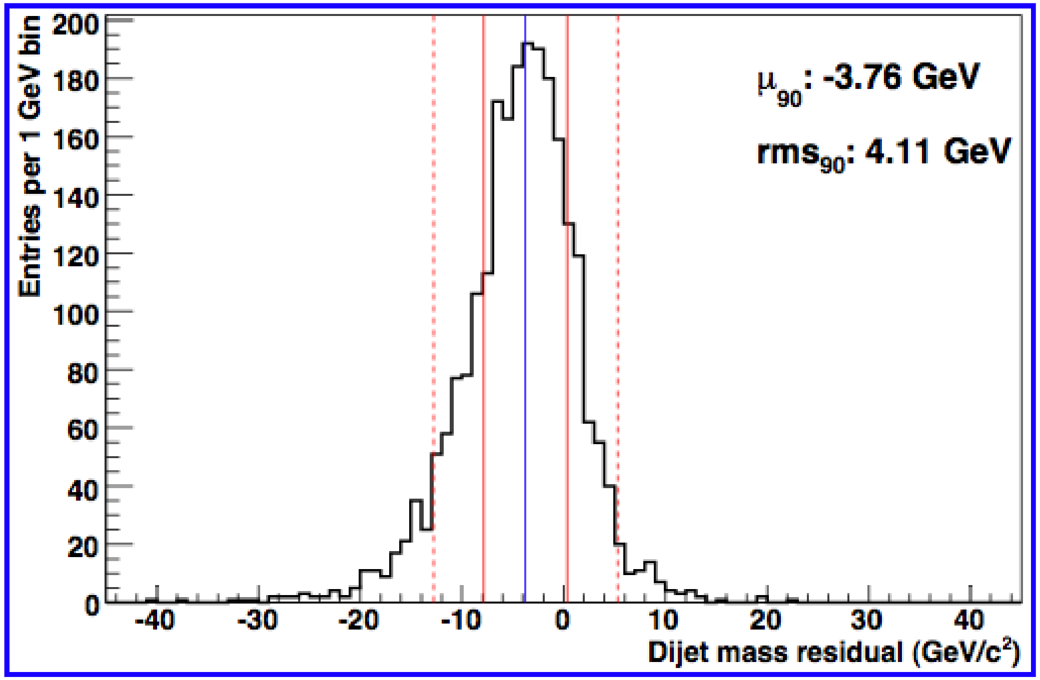
sid01



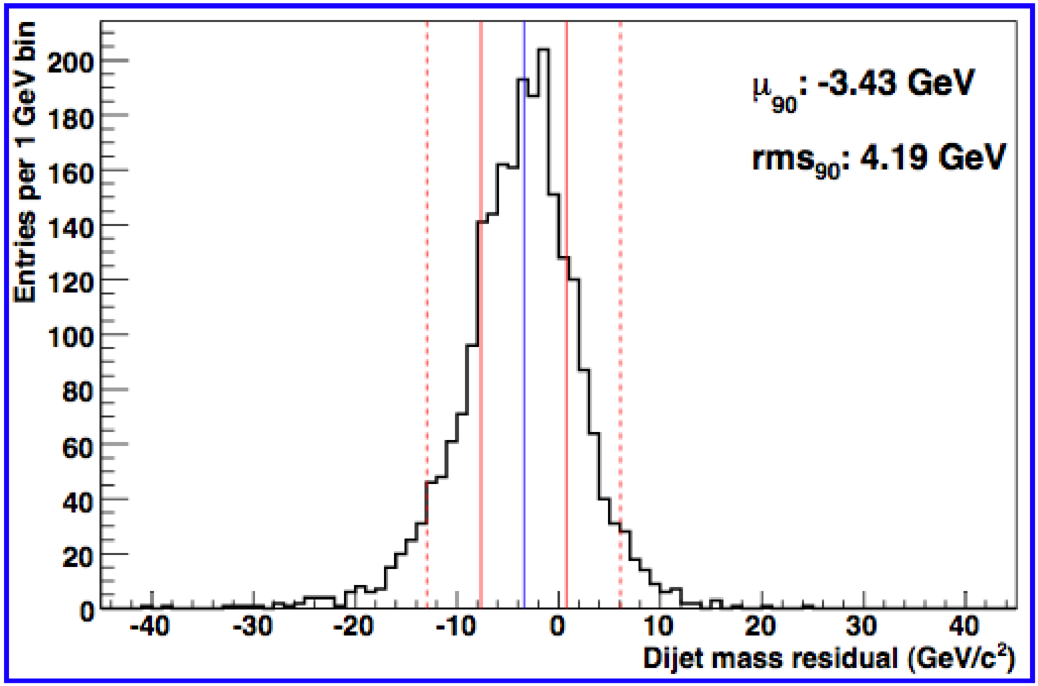
sid01

HCAL with RPC's

sid01_scint



sid01_scint
Scintillator HCAL
with digital readout



sid01_scint
Scintillator HCAL
with analog readout

Looking at ΔM/M

HCAL	ΔM/M
Steel/RPC	4.9-5.1%
Steel/Scintillator	4.7-4.8%
W/Scintillator	4.7-4.9 %
W/RPC	5.5%

- $\Delta M = rms_{90}$
- $M = m_Z - mean_{90}$

Optimizing SiD parameters

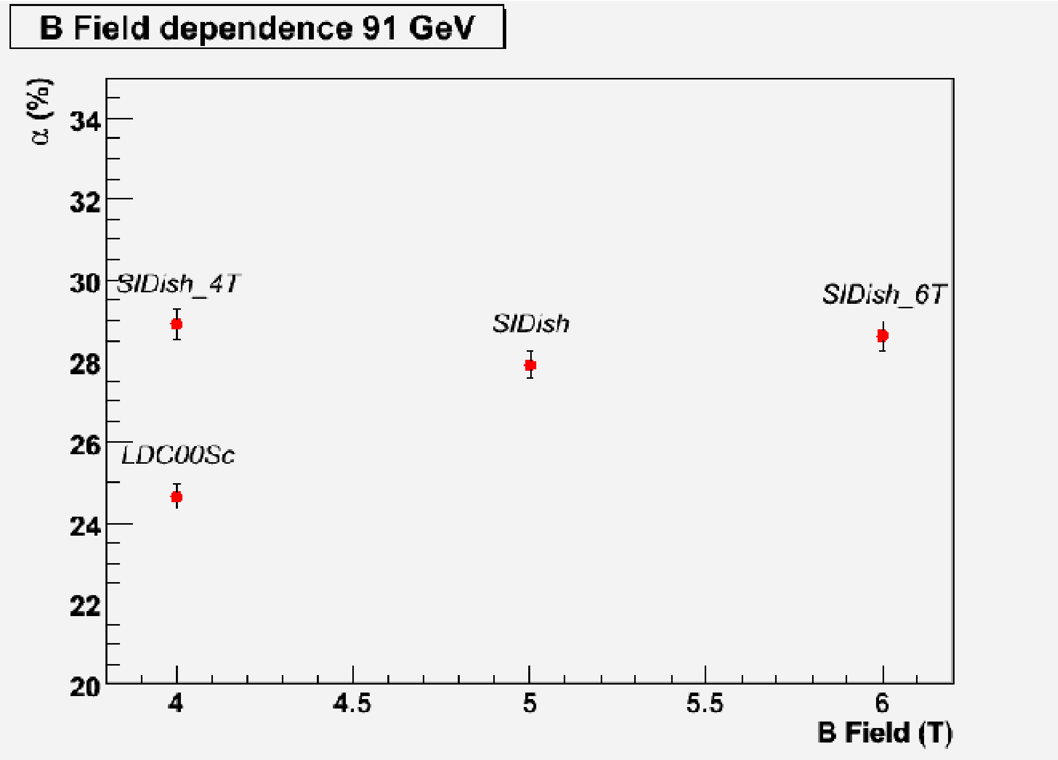
- Use the current best Particle Flow Algorithm
  - PandoraPFA by Mark Thomson
- Start optimizing SiD
  - ECAL radius and length
  - B field
  - HCAL depth segmentation
- Caveat : Only works well within Mokka/Marlin Framework
- No real SiD detector model available in this framework
- Have to use a SiD look-alike, the *SiDish*

The setup

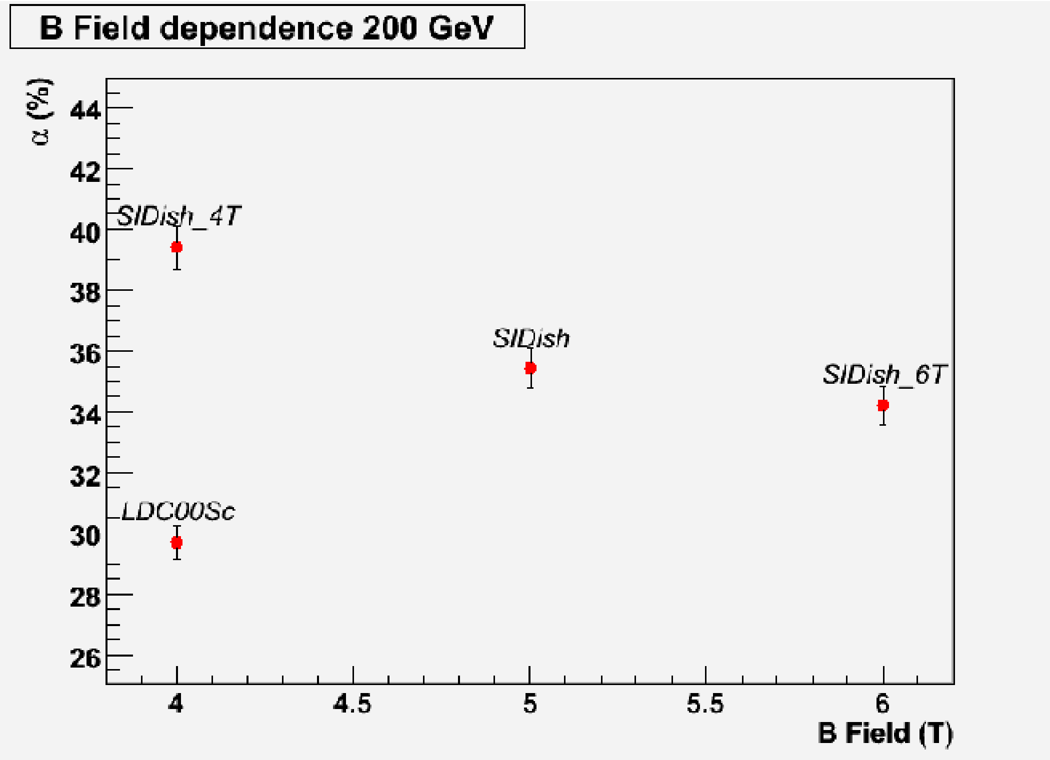
- Use PandoraPFA 2.01 & LCPHYS
- LDC00Sc Model
- Define SIDish
- Use track cheating
  - tracking shouldn't matter ... to first order
- Detector Summary:

	LDC00Sc	SIDish
ECAL inner radius	1.7 m	1.25m
ECAL length	2.7 m	1.7 m
ECAL layers	30+10	20+10
ECAL material	SiW	SiW
HCAL layers	40	40
HCAL material	Fe-Scint	Fe-Scint
Field	4 T	5 T

B Field

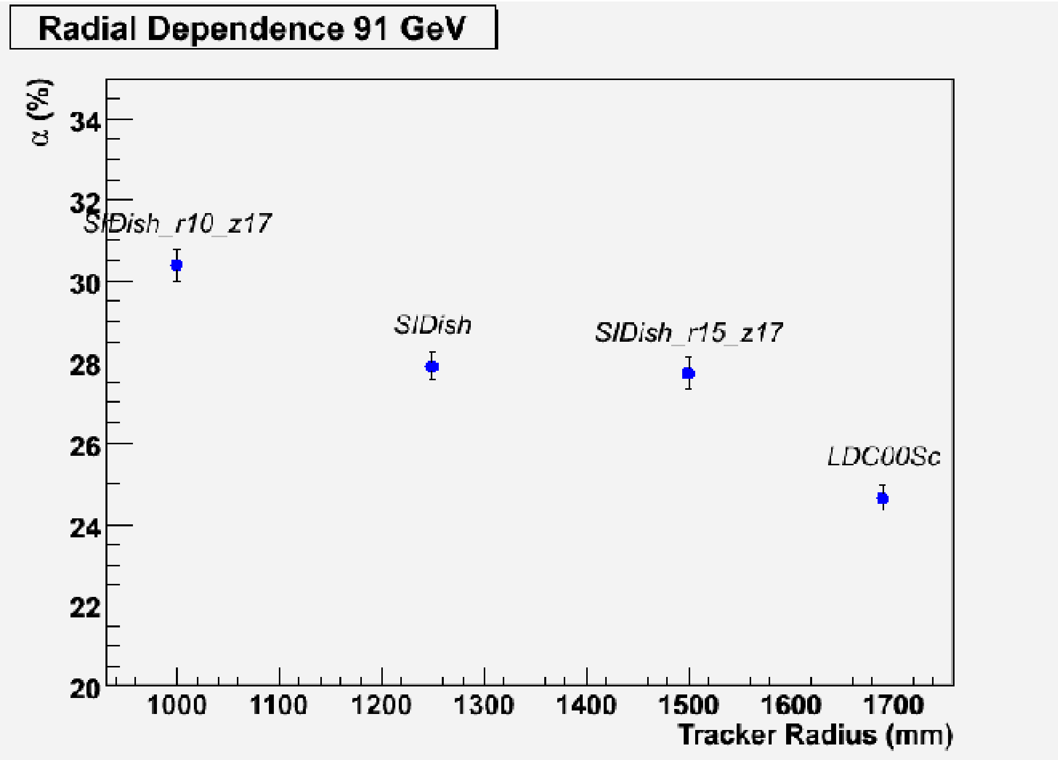


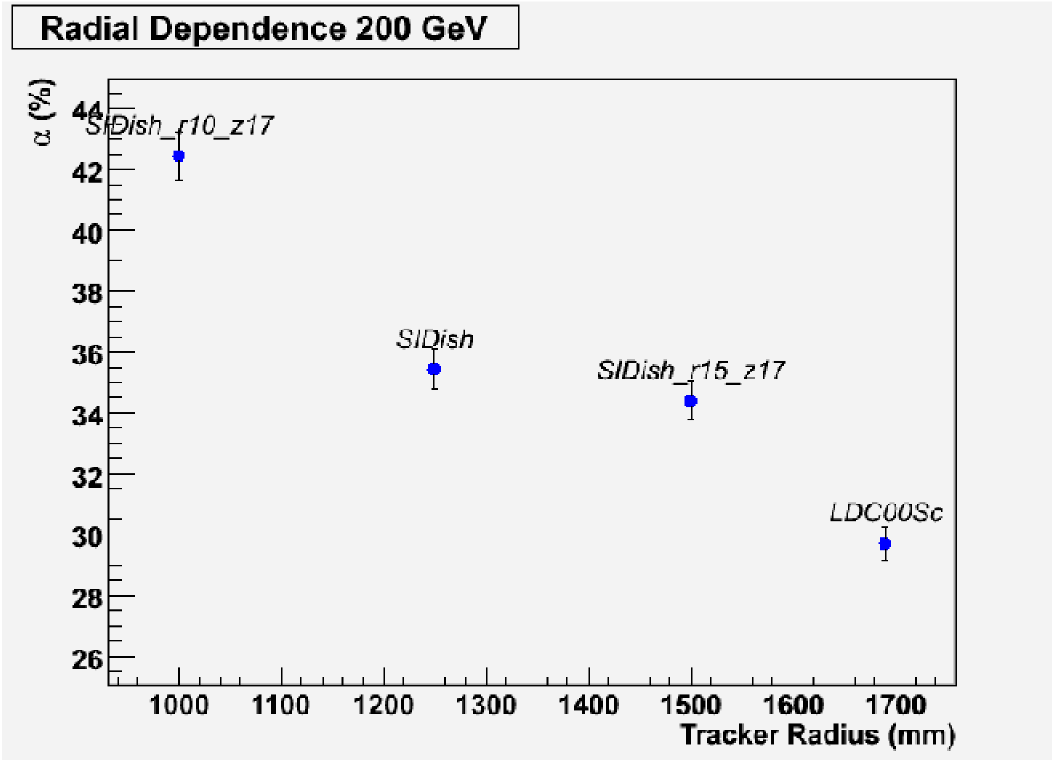
B Field dependence 91 GeV
α (%)
34
32
30
28
26
24
22
20
SIDish_4T
SIDish
SIDish_6T
LDC00Sc
4
4.5
5
5.5
6
B Field (T)



B Field dependence 200 GeV
α (%)
44
42
40
38
36
34
32
30
28
26
SIDish_4T
SIDish
SIDish_6T
LDC00Sc
4
4.5
5
5.5
6
B Field (T)

ECAL inner radius

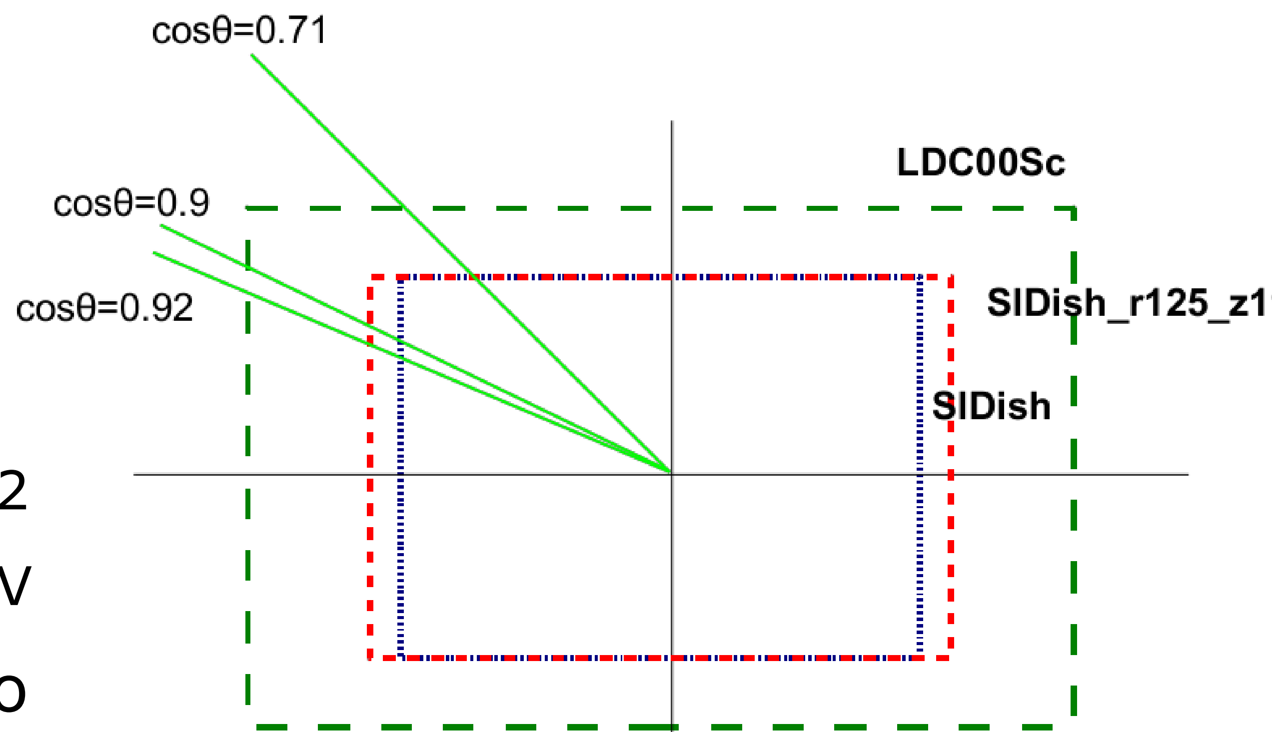




Detector TAG	rms90 (91 GeV)	rms90 (200 GeV)
LDC00Sc	24.6 ± 0.3	29.7 ± 0.5
SIDish	27.9 ± 0.4	35.4 ± 0.7
SIDish_r10_z17	30.4 ± 0.4	42.5 ± 0.8
SIDish_r15_z17	27.7 ± 0.4	34.4 ± 0.6

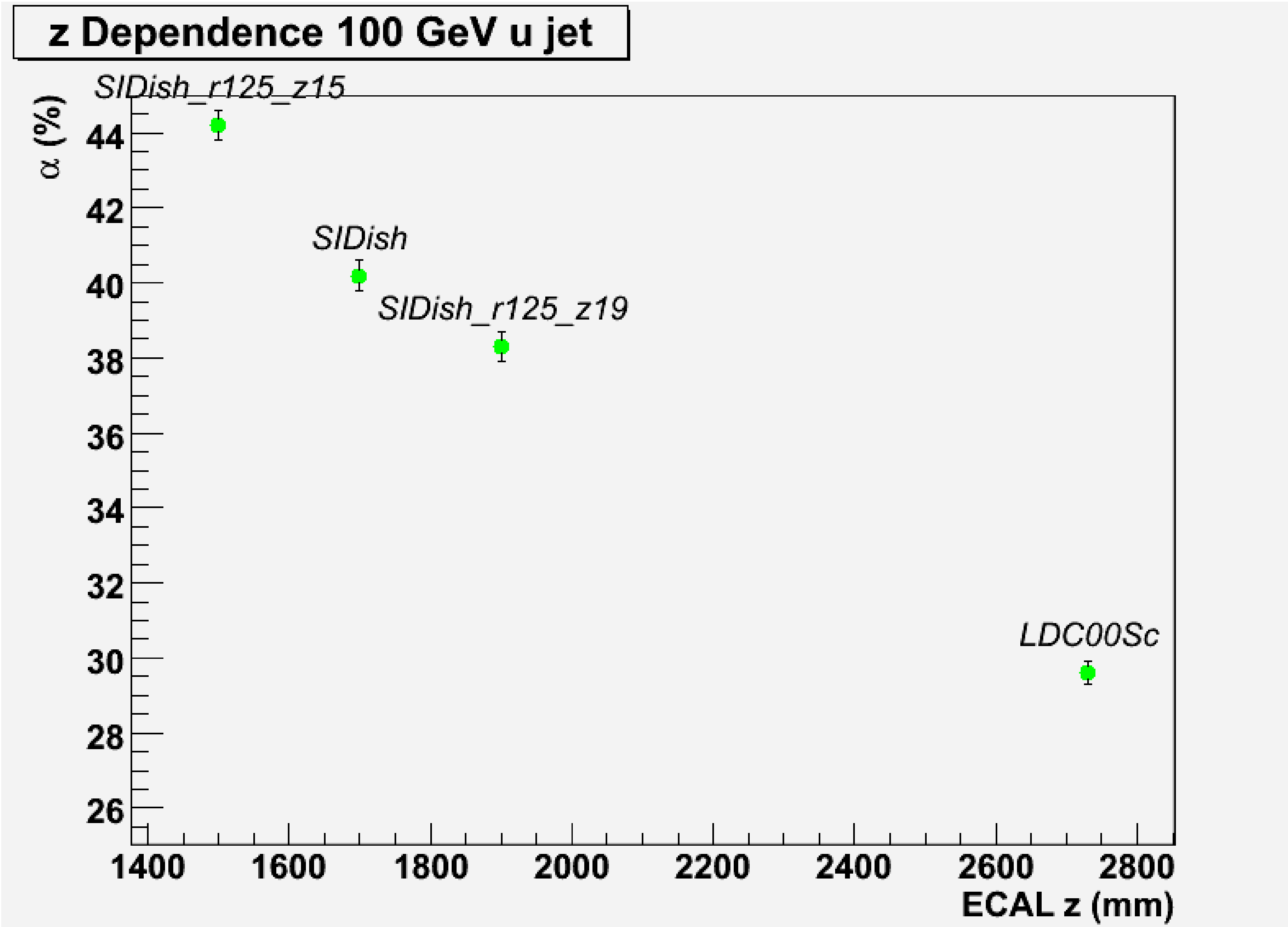
ECAL length

- Study forward performance
- Special Samples
  - 1 u jet at cosθ=0.92
  - available at 100 GeV
- Will extend study to higher energies



Detector Tag	u (100 GeV)	
	α %	Error
SIDish	40.2	0.4
LDC00Sc	29.6	0.3
SIDish_r125_z15	44.2	0.5
SIDish_r125_z19	38.3	0.4

ECAL length (II)



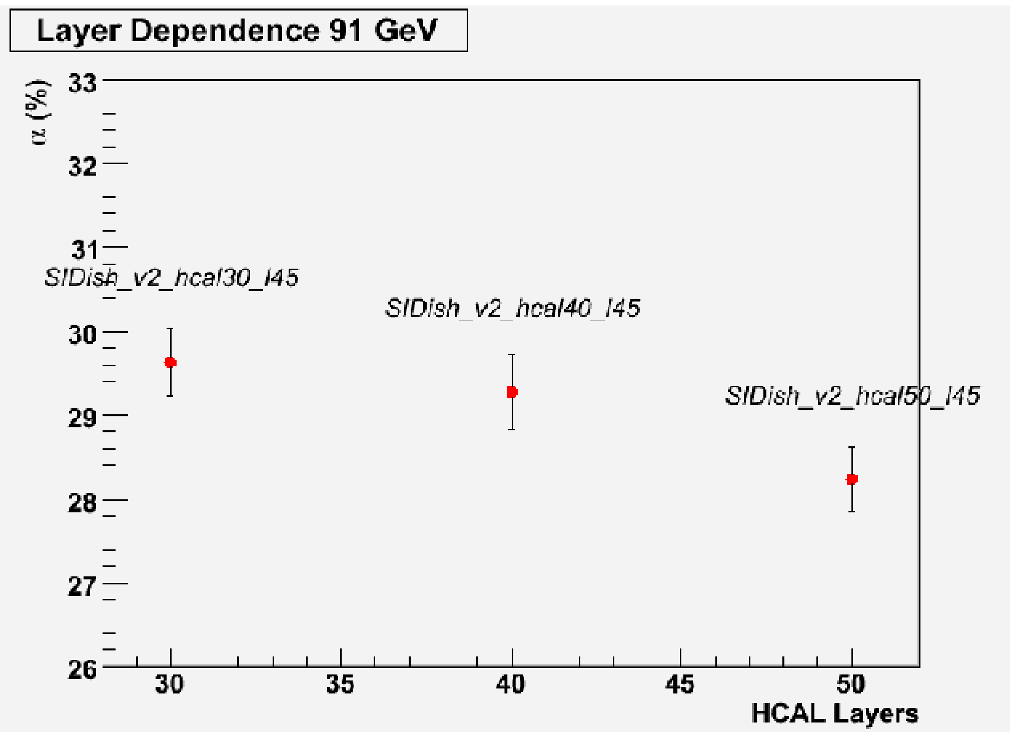
Forward performance depends linearly from detector length

HCAL segmentation

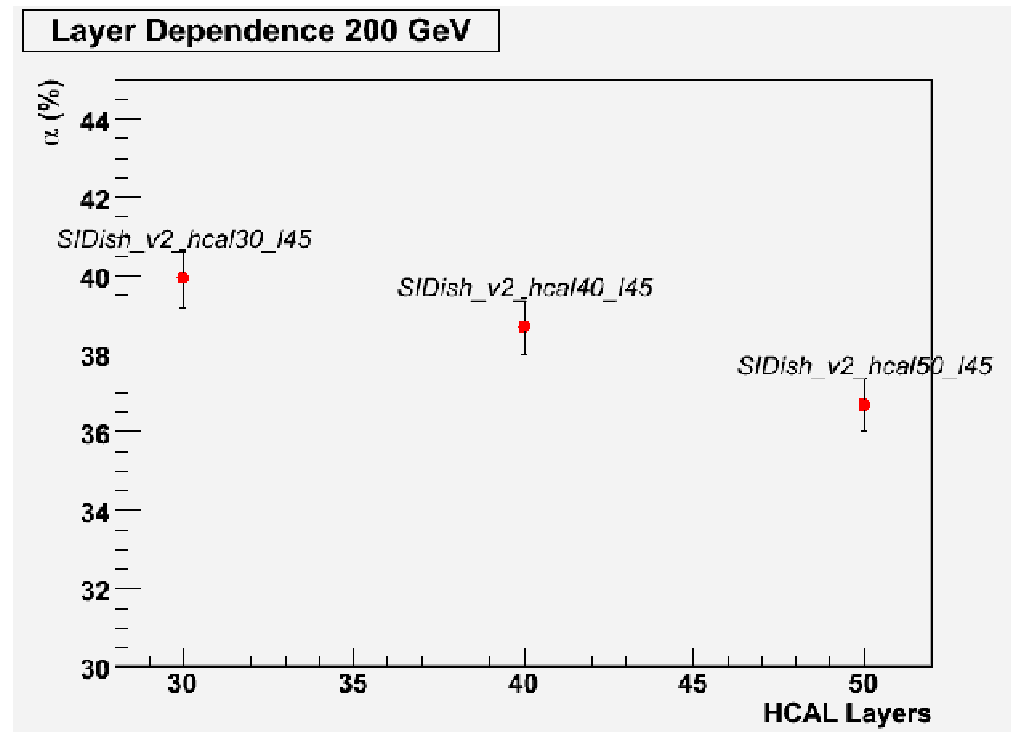
- Use SIDish
- HCAL as Fe-Scint
- Fix λ_{Iron} to 4.5
- vary number of layers
  - 30,40, 50

Detector Tag	Layers	uds (91 Gev)		uds (200 GeV)	
		α %	Error	α %	Error
SIDish_v2_hcal30_l45	30	29.6	0.4	39.9	0.7
SIDish_v2_hcal40_l45	40	29.3	0.4	38.7	0.7
SIDish_v2_hcal50_l45	50	28.2	0.7	36.7	0.7

Results



Layer Dependence 91 GeV
α (%)
33
32
31
30
29
28
27
26
SIDish_v2_hcal30_l45
SIDish_v2_hcal40_l45
SIDish_v2_hcal50_l45
30
35
40
45
50
HCAL Layers

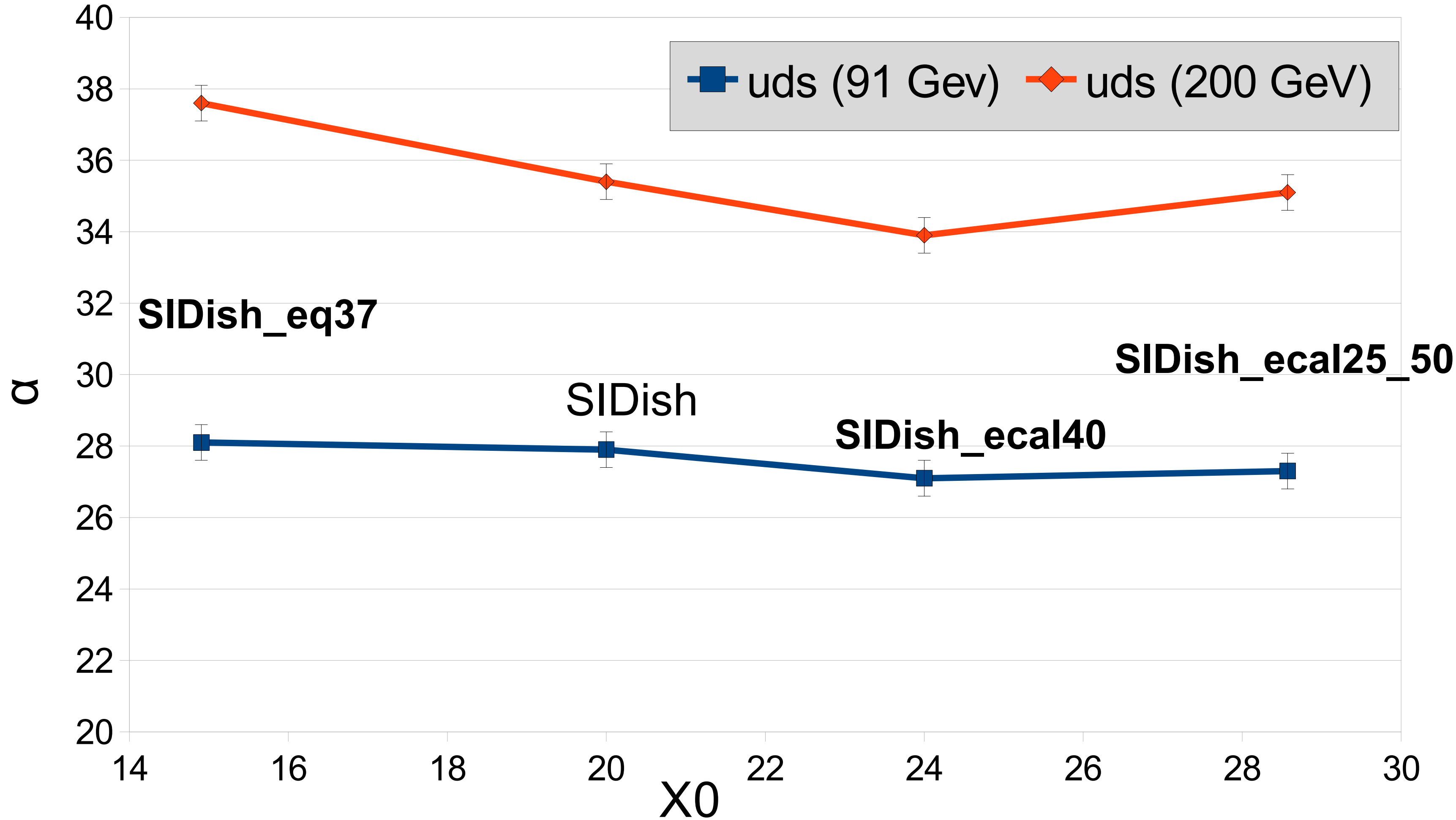


Layer Dependence 200 GeV
α (%)
44
42
40
38
36
34
32
30
SIDish_v2_hcal30_l45
SIDish_v2_hcal40_l45
SIDish_v2_hcal50_l45
30
35
40
45
50
HCAL Layers

ECAL segmentation

- Is the ECAL optimal ?
  - we see a small benefit going from 20+10 to 30+10 layers
  - better segmentation helps ?
  - or just pure thickness ?
- Made a SiDish_ecal_q37
  - SiDish with 37 layers but same overall thickness
- Make a SIDish_ecal25_50
  - 20+10 layers
  - 2.5 mm /5.0 mm tungsten thickness and smaller gaps (1 mm)
  - will change global radius (very small effect)

Results



Detector Tag	Radiator Thickness	Layers	X_0	uds (91 Gev) α %	uds (91 Gev) Error	uds (200 GeV) α %	uds (200 GeV) Error
SIDish	1.4/4.2 mm	20+10	20	27.9	0.4	35.4	0.7
SIDish_ecal40	1.4/4.2mm	30+10	24	27.1	0.5	33.9	0.6
SIDish_ecal_eq37	1.41 mm	37	15	28.1	0.4	37.6	0.6
SIDish_ecal25_50	2.5/5.0 mm	20+10	29	27.3	0.4	35.1	0.6

Summary

- SiD is on its way to fix the general detector parameters
  - ECAL radius and length
  - B field
  - HCAL depth segmentation
- Tools are coming online
- We' ll have a detector frozen soon (~ month)
- Thanks to Ron Cassell, Matt Charles, Steve Magill, John Jaros, Norman Graf, Harry Weerts and Andy White for contributions to this talk.