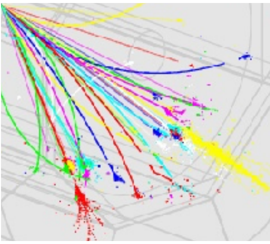
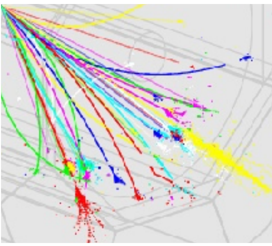


Detector Optimization

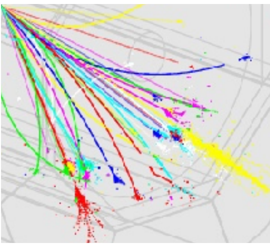
02.06.2008

M. Stanitzki



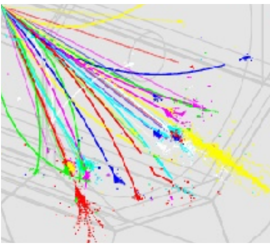
What are we trying to do …

- Use PFA algorithms to optimize general detector parameter for jet energy resolution
- The PFA algorithm of choice
  - Should work with all kind of detectors
  - Should be optimal for each specific design
  - Support all kind of readout technologies
  - Should work with all frameworks
  - be a *Eierlegende Wollmilchsau*
- A algorithm tailored to a specific detector will always be superior !



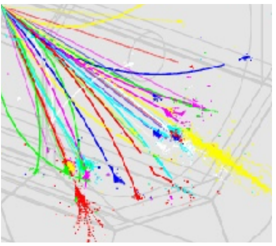
Where are we right now

- Want to use current PFAs to
  - make an informed choice
  - Acknowledge the caveats
  - back up design choices so far
  - Freeze a detector design to the best of our knowledge
- We always know more next week(month, year)



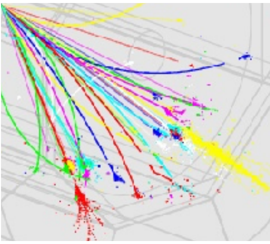
In this talk ...

- Summarize the global parameters studied
- Make some suggestions on parameter choices
  - Building a detector with the best energy resolution possible
  - keep in mind some mechanical constraints
  - Won't touch impacts on tracker/vertex design
- I'll ignore
  - Cost (Marty will cover that)
  - What resolution is good enough (Should we limit ourselves to that ...)
- I'll quote a lot of numbers from
  - RAL talk
  - talk at last Advisory meeting



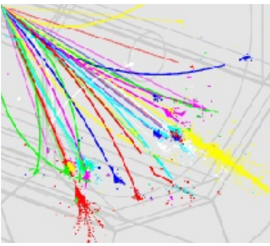
Short Summary

- PFA of choice is PandoraPFA
- Using an SID-lookalike , the SIDish
- Results for 45 GeV & 100 GeV jets
- Numbers quoted are (if not mentioned otherwise)
  - $\cos(\theta_{Thrust}) < 0.7$: Barrel Events
  - using α in % $\frac{\sigma_E}{E} = \frac{\alpha}{\sqrt{E}}$
- There are a set of caveats
  - Calibrate Response for different detector variations
  - not optimal
  - Using track cheaters



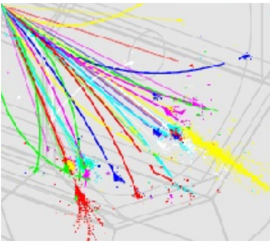
Global Parameters

- B Field (B)
- Tracker radius (r)
- Tracker length (z)
- HCAL depth (λ)
- HCAL segmentation (n_{Layers})
- Some other calorimetry questions



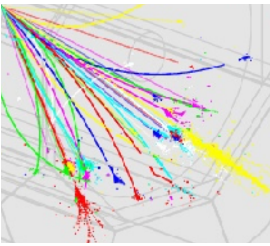
B field

- Choice for a compact detector with 5 T field
  - good for tracking, vertexing
  - good for beam background suppressions
- Impact on PFA performance
  - Small at the Z pole (<1 %)
  - 4 % gain going from 4 to 5 T at 200 GeV
  - tracker radius and B field strongly connected
  - not always gaining by raising B field -> loopers
  - there are sweet spots for B and r



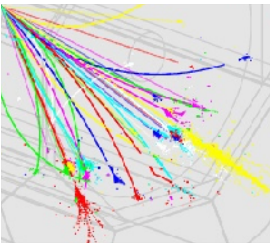
Impact of B field choice

- Choice of B field of 5 T severely constrains parameter phase space
- Maximal $r_{Tracker}$ ~ 1.5 m (limited by maximum coil size)
- from current SiD design have additional 25 cm available
  - to vary tracker radius
  - vary calorimeter depth and segmentation
  - that is not a lot ... (λ_{Iron}=168 mm ..)



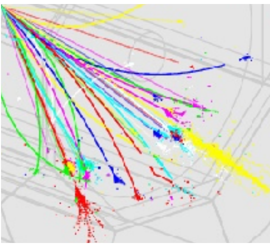
Tracker radius

- Radius has a certain impact on performance
- increasing $r_{Tracker}$ from 1.25 to 1.5 m
  - about 1% gain at 200 GeV
- Going to smaller $r_{Tracker}$
  - Not a good idea
  - 7 % worse at 200 GeV
- If we keep B fixed at 5 T
  - ~ 1.25 m is probably not a bad choice
  - could argue for moving to 1.5 m



Tracker length

- New study (triggered by John)
- Two approaches
  - use existing data sets and look in the forward region defined as $0.9 < \cos(\theta_{Thrust}) < 1.0$
  - use specially generated samples with one u jet at exactly $\cos(\theta)=0.92$
- Caveats
  - for first approach we already have a lot of samples but not a lot of stats in forward
  - for the second we are simulating things right now

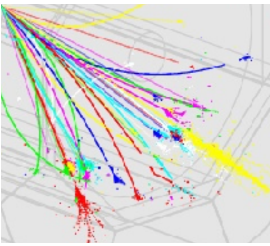


First results from study I

Taking the standard samples and looking in the forward region...
$0.9 < \cos(\theta_{Thrust}) < 1.0$

Detector Tag	B	Z	uds (91 GeV)		uds (200 GeV)	
			α %	Error	α %	Error
SIDish	5	1.7	70.4	1.8	105.0	4.0
SIDish_r125_z15	5	1.5	76.1	2.1	110.5	4.2
SIDish_r125_z19	5	1.9	67.8	1.7	92.4	3.5
SIDish_4T	4	1.7	71.8	1.8	106.2	4.0
SIDish_6T	6	1.7	69.5	1.7	99.9	3.8
LDC00Sc	4	2.7	49.5	1.3	66.6	2.5

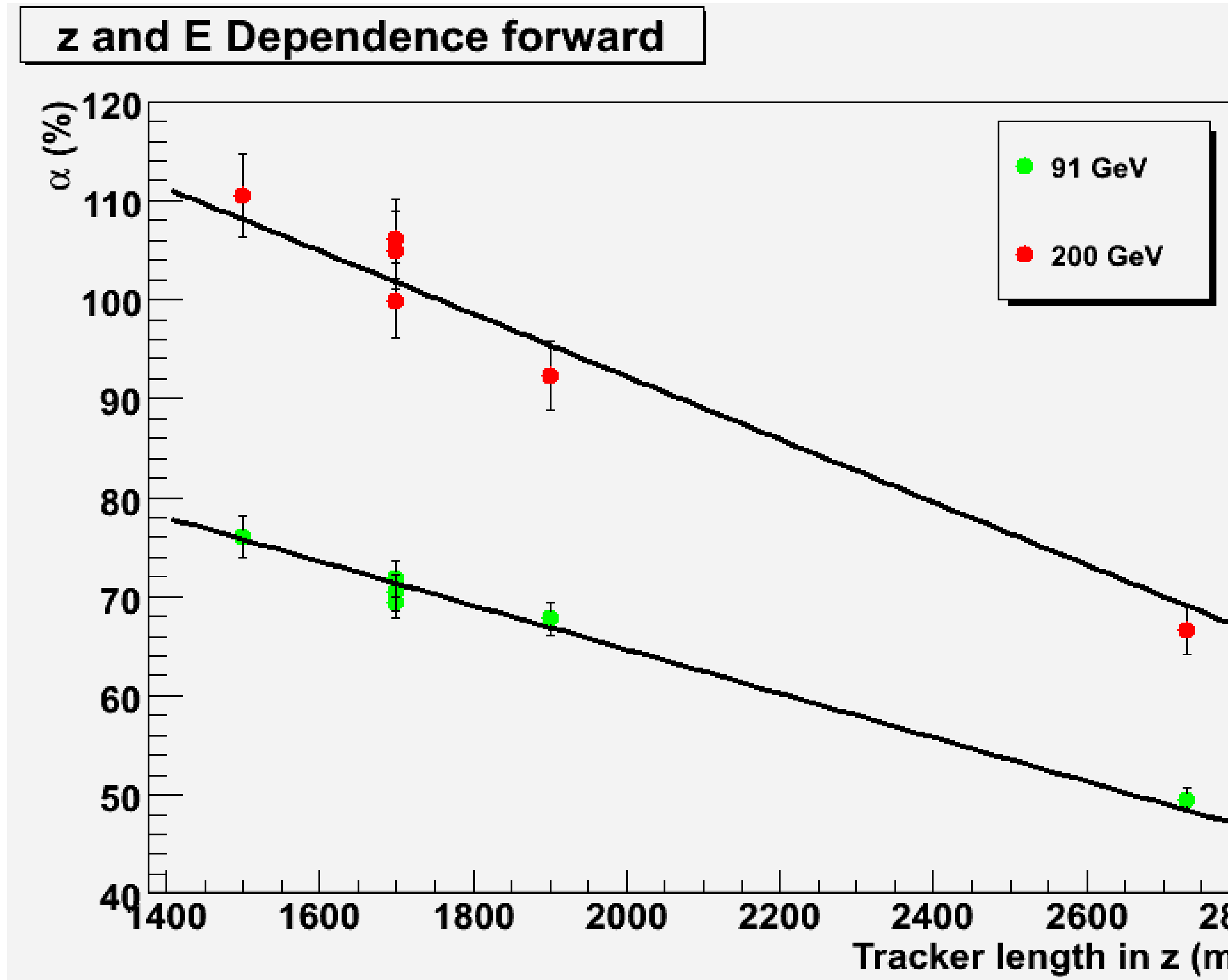
This is way less statistics plus there are two jets and not one well defined u-quark !

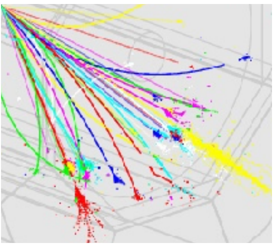


z dependence for study I

Large Error bars !

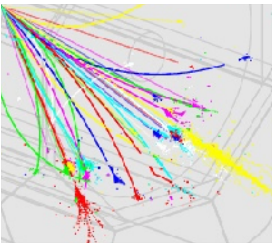
- α linear in Z
- small impact of B field
- Can't really say a lot on calorimetry impact



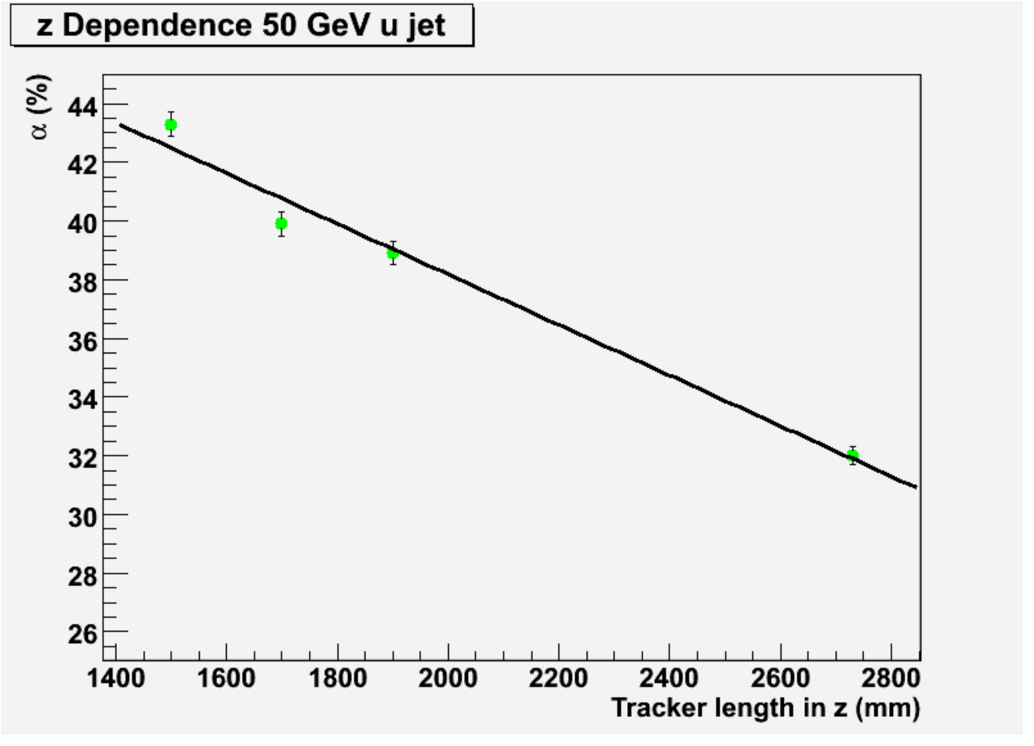


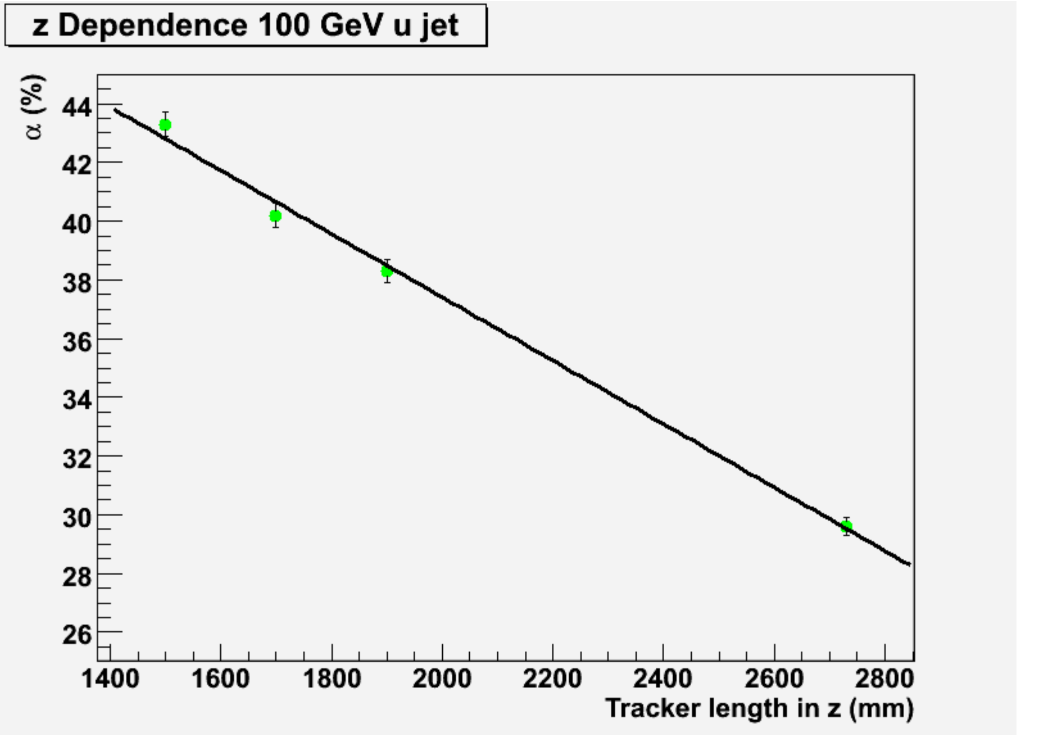
Tracker length study II

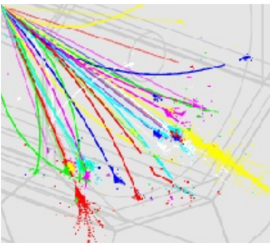
Detector Tag	u (50 GeV)		u (100 GeV)		u (250 GeV)	
	α %	Error	α %	Error	α %	Error
SIDish	39.9	0.4	40.2	0.4	78.8	2.0
LDC00Sc	32.0	0.3	29.6	0.3	71.5	4.1
SIDish_r125_z15	43.4	0.4	44.2	0.5		
SIDish_r125_z19	38.9	0.4	38.3	0.4		



z dependence for study II

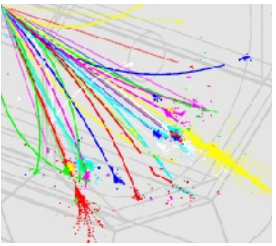






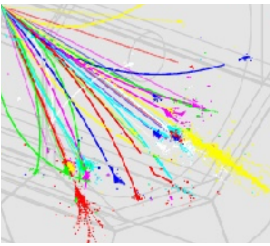
Tracker length conclusions

- If we care about forward performance
  - Need to make SiD longer
  - Study I indicates a lot longer (~ 1 m)
  - Study II also prefers longer detectors
- But fair to say right now ...
  - going from $z_{Tracker}$=1.7 to 1.9/2.0 m is not crazy at all
  - How much maneuvering space is available
  - How will this effect other systems ?
- I'll be able to say more soon



HCAL depth

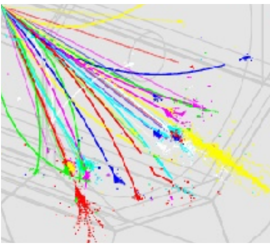
- Studies made by Mark Thomson favor a very deep HCAL
- We did two studies looking at segmentation and thickness
  - Keeping the total HCAL thickness constant
  - Keeping the λ_{Iron} constant
  - vary segmentation from 30 -50 layers



The setup

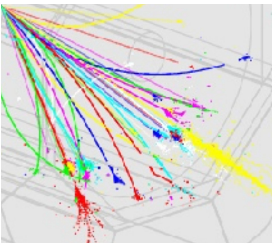
TAG	Layers	total thickness	Iron thickness	Absorber thickness	HCAL thickness	λ
SIDish_v2_hcal30	30	32.7	26.2	6.5	980	4.92
SIDish_v2_hcal40	40	24.5	18.0	6.5	980	4.61
SIDish_v2_hcal50	50	19.6	13.1	6.5	980	4.45
SIDish_v2_hcal30_l45	30	31.7	25.2	6.5	951	4.75
SIDish_v2_hcal40_l45	40	25.4	18.9	6.5	1016	4.83
SIDish_v2_hcal50_l45	50	21.6	15.1	6.5	1081	4.91

- Some Comment
  - different Mokka version compared to all other studies
  - SIDish_v2_hcal40 is the "standard" SiDish geometry!
  - λ done with λ_{Iron}=168 mm and λ_{Scint}=795 mm

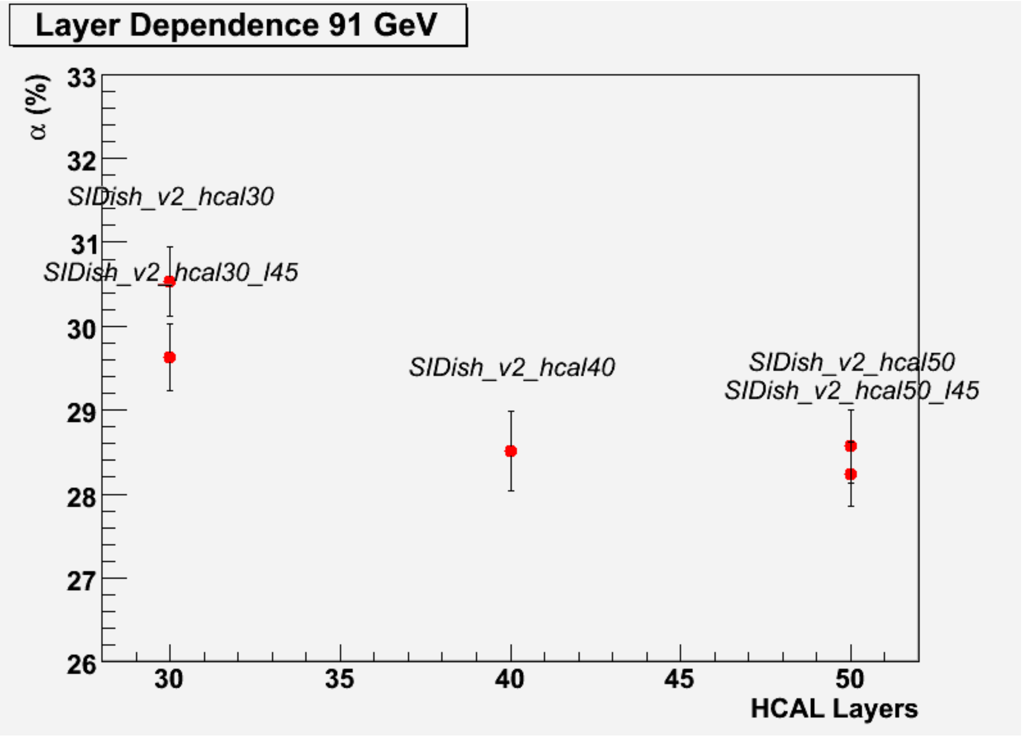


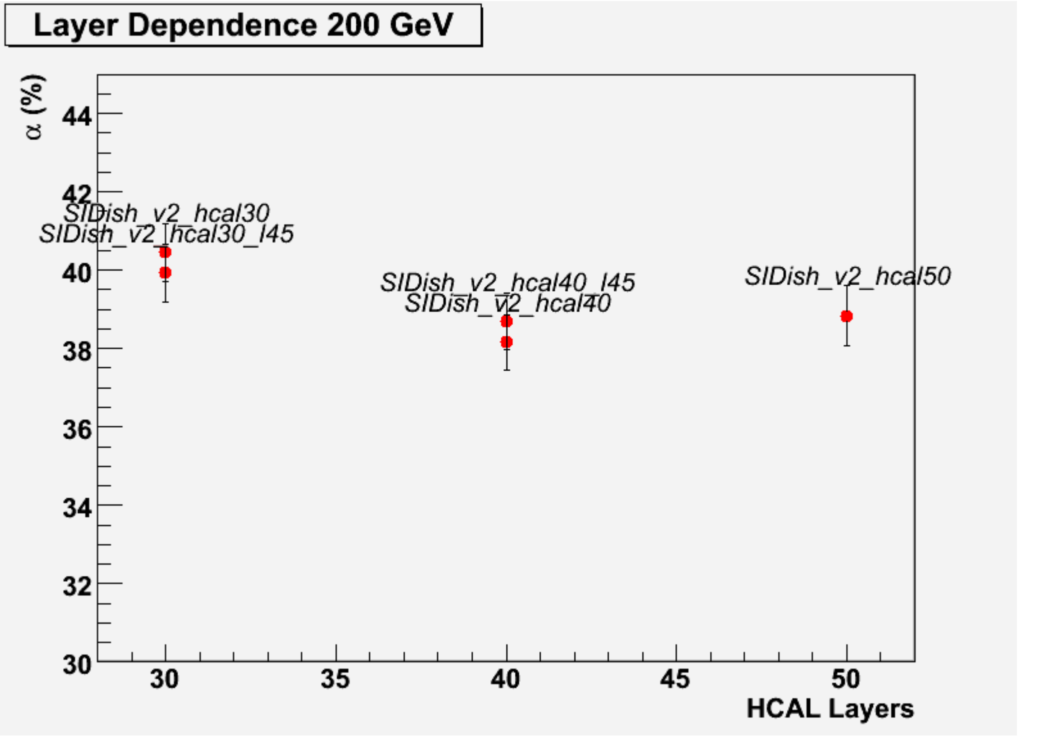
Results

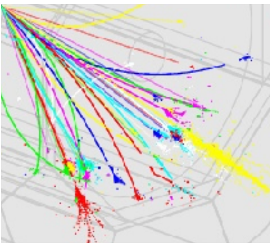
Detector Tag	Layers	uds (91 Gev)		uds (200 GeV)	
		α %	Error	α %	Error
SIDish_v2_hcal30	30	30.5	0.4	40.5	0.7
SIDish_v2_hcal40	40	28.5	0.5	38.2	0.7
SIDish_v2_hcal50	50	28.6	0.4	38.8	0.8
SIDish_v2_hcal30_l45	30	29.6	0.4	39.9	0.7
SIDish_v2_hcal40_l45	40			38.7	0.7
SIDish_v2_hcal50_l45	50	28.2	0.7		



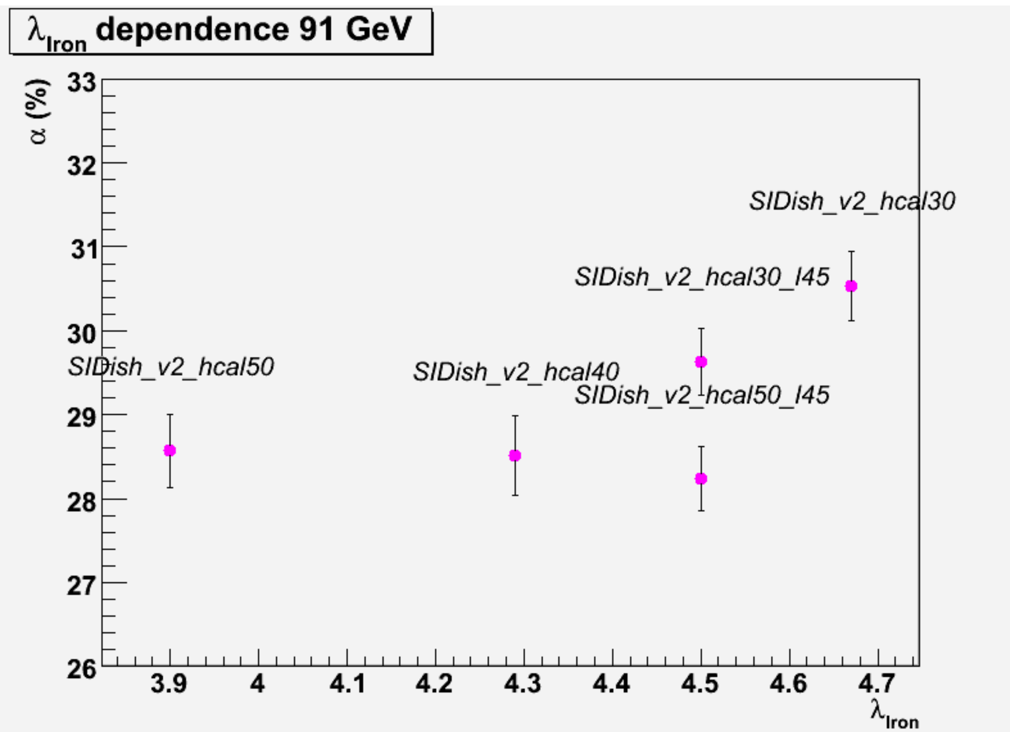
Number of layers



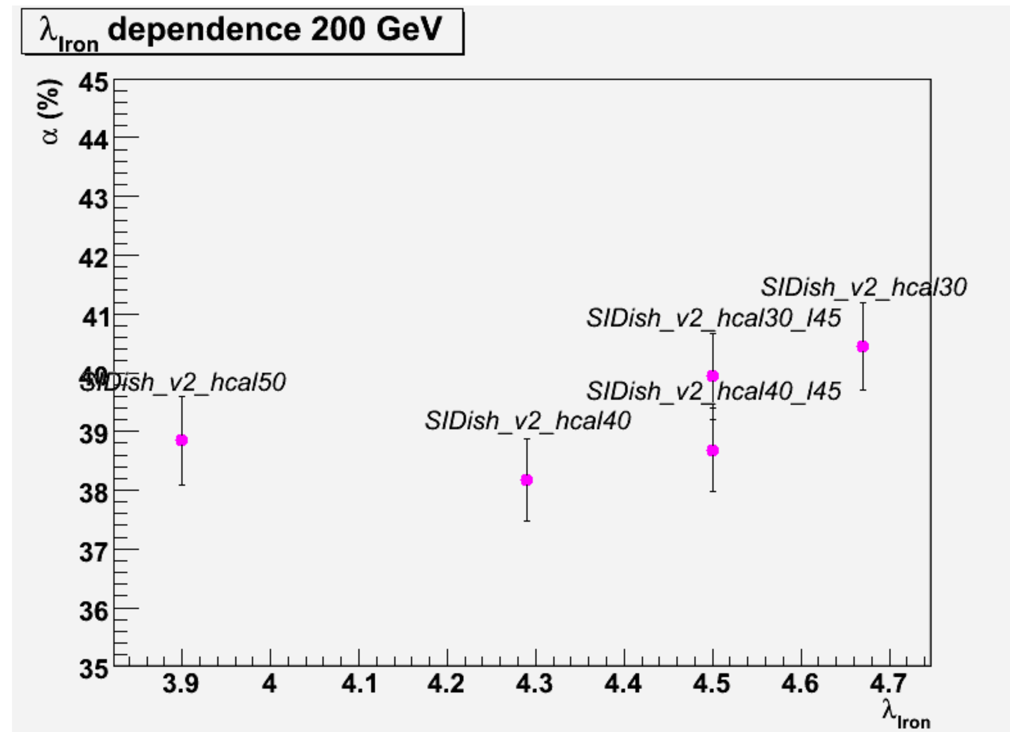




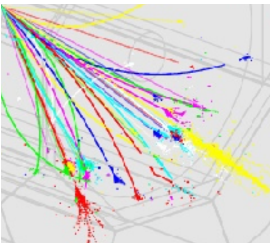
λ_{Iron}



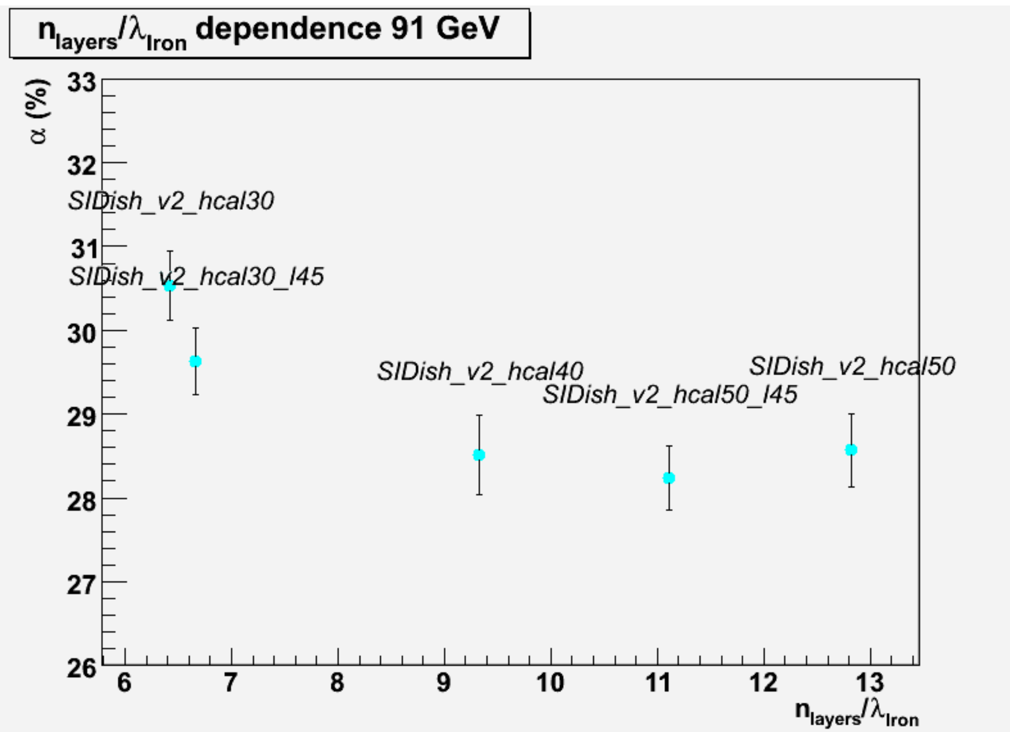
λIron dependence 91 GeV
α (%)
33
32
31
30
29
28
27
26
3.9
4
4.1
4.2
4.3
4.4
4.5
4.6
4.7
λIron
SIDish_v2_hcal30
SIDish_v2_hcal30_l45
SIDish_v2_hcal50
SIDish_v2_hcal40
SIDish_v2_hcal50_l45

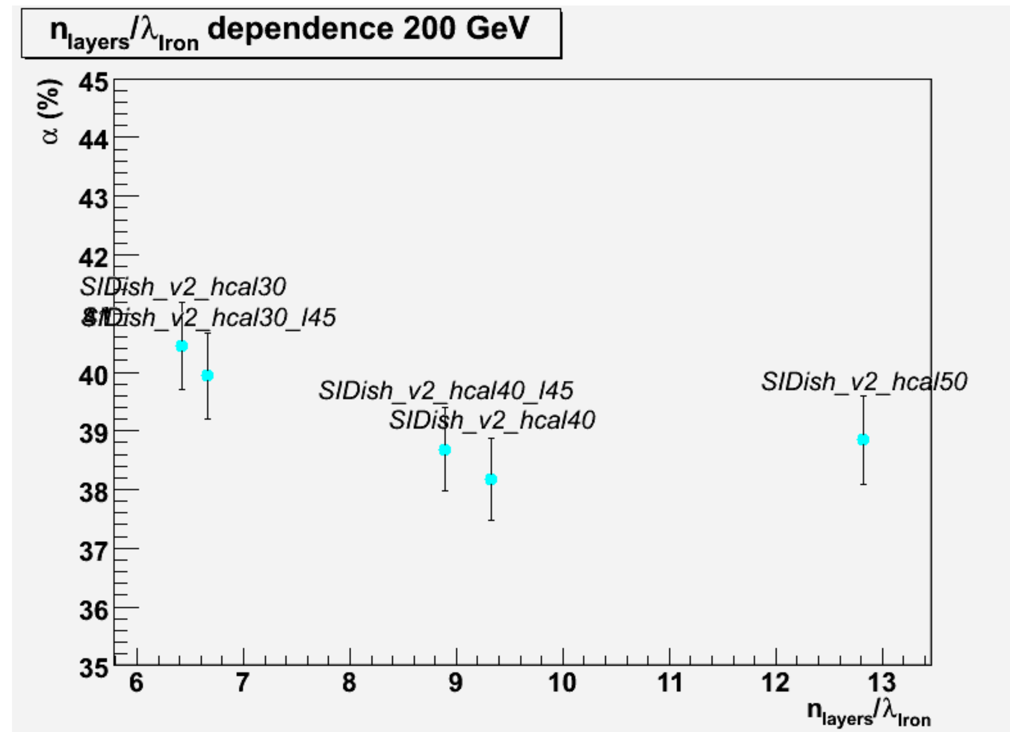


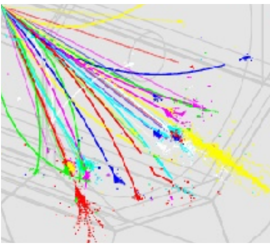
λIron dependence 200 GeV
α (%)
45
44
43
42
41
40
39
38
37
36
35
3.9
4
4.1
4.2
4.3
4.4
4.5
4.6
4.7
λIron
SIDish_v2_hcal30
SIDish_v2_hcal30_l45
SIDish_v2_hcal50
SIDish_v2_hcal40_l45
SIDish_v2_hcal40



$n_{Layers}/\lambda_{Iron}$

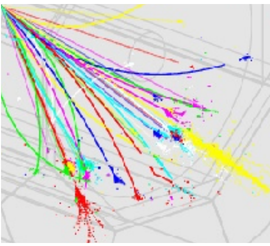






HCAL summary

- From what I can say right now
  - depth and segmentation are closely correlated
  - not just more steel or more scintillator
  - More like $n_{Layers}/\lambda_{Iron}$ as quantity to optimize
  - $n_{Layers}/\lambda_{Iron}$ ~10 a good rule of thumb ...
- Clearly need more points
  - But more HCAL is a good thing
- More results on Wednesday

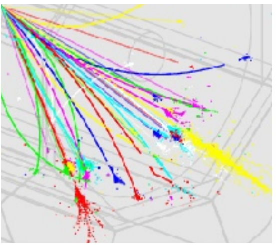


ECAL segmentation

- looked at different ECAL variants (Idea by Harry)

Detector Tag	Radiator Thickness	Layers	X_0	uds (91 Gev)		uds (200 GeV)	
				α %	Error	α %	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

- Results indicate
  - optimizing the ECAL design give you some benefits
  - Finer segmentation is 'favored"
  - 1- 2% improvements possible
- But this doesn't change the ECAL radius by more than a few cm



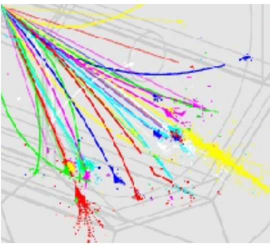
HCAL readout

- Run a version with the RPC's both for
  - LDC00
  - SIDish_RPC
- basically the same as LDC00Sc and SIDish
- Didn't change any of the cuts

Detector	91 GeV		200 GeV	
	α %	Error	α %	Error
LDC00Sc	24.6	0.3	29.7	0.5
LDC00	27.0	0.5	31.7	0.6
SIDish	27.9	0.4	35.4	0.7
SIDish_rpc	31.7	0.5	38.9	0.7

Scintillator (→ LDC00Sc, SIDish)

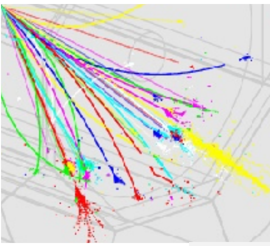
RPC (→ LDC00, SIDish_rpc)

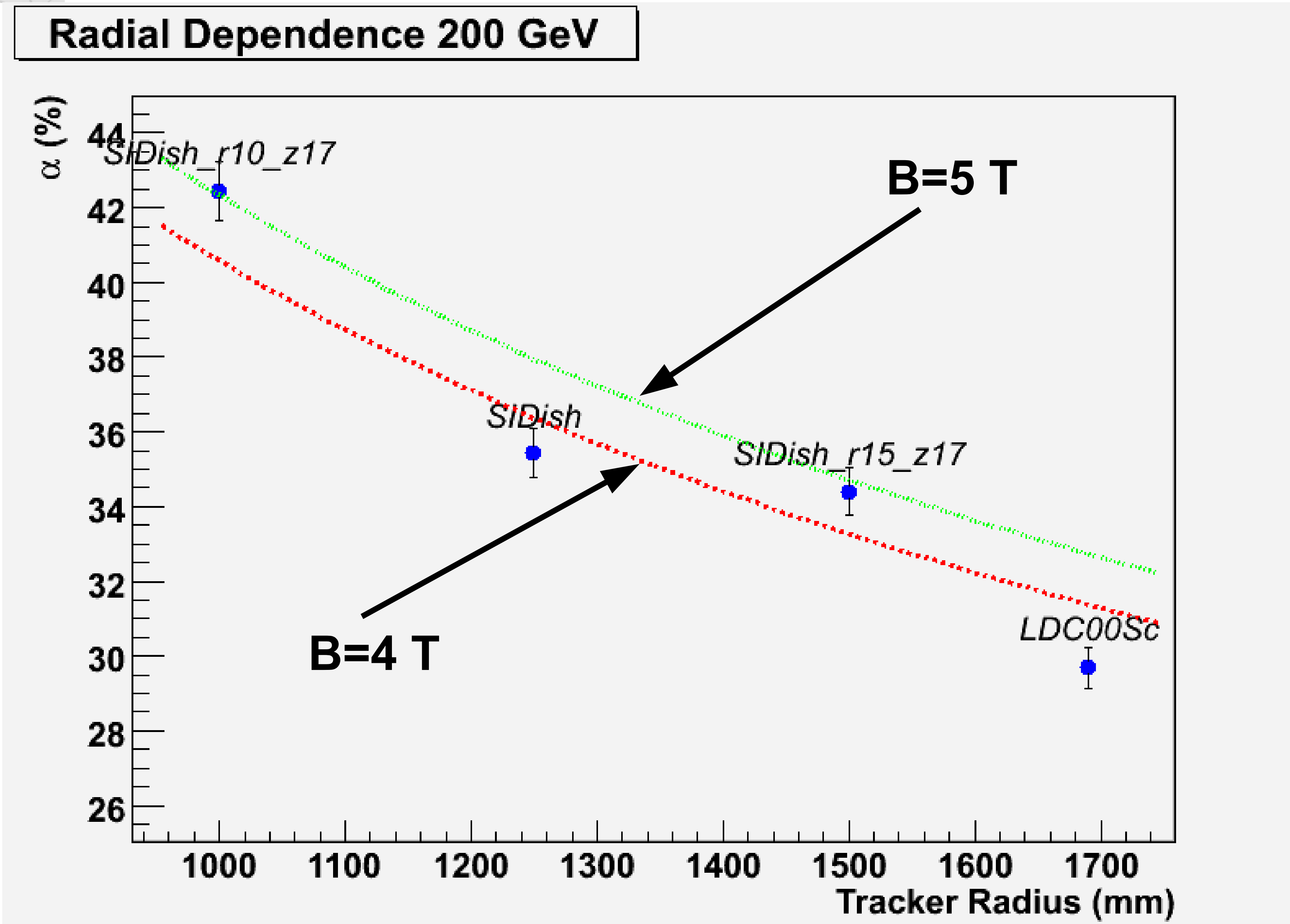


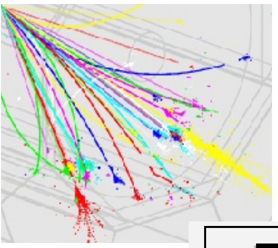
HCAL readout comments

- The RPC's have a worse performance so far
  - 2.5 -3 % worse for all detectors and energies studied
- Reasons
  - Algorithm not optimal for them ?
  - Some features in the simulation model ?
  - Do be understood (and help welcome)
- Does this effect the global parameters ?
  - yes in terms of readout gap size, etc
  - strong impact on engineering
  - but not a choice we need to make today ...

Parametrization
(from Mark Thomson)







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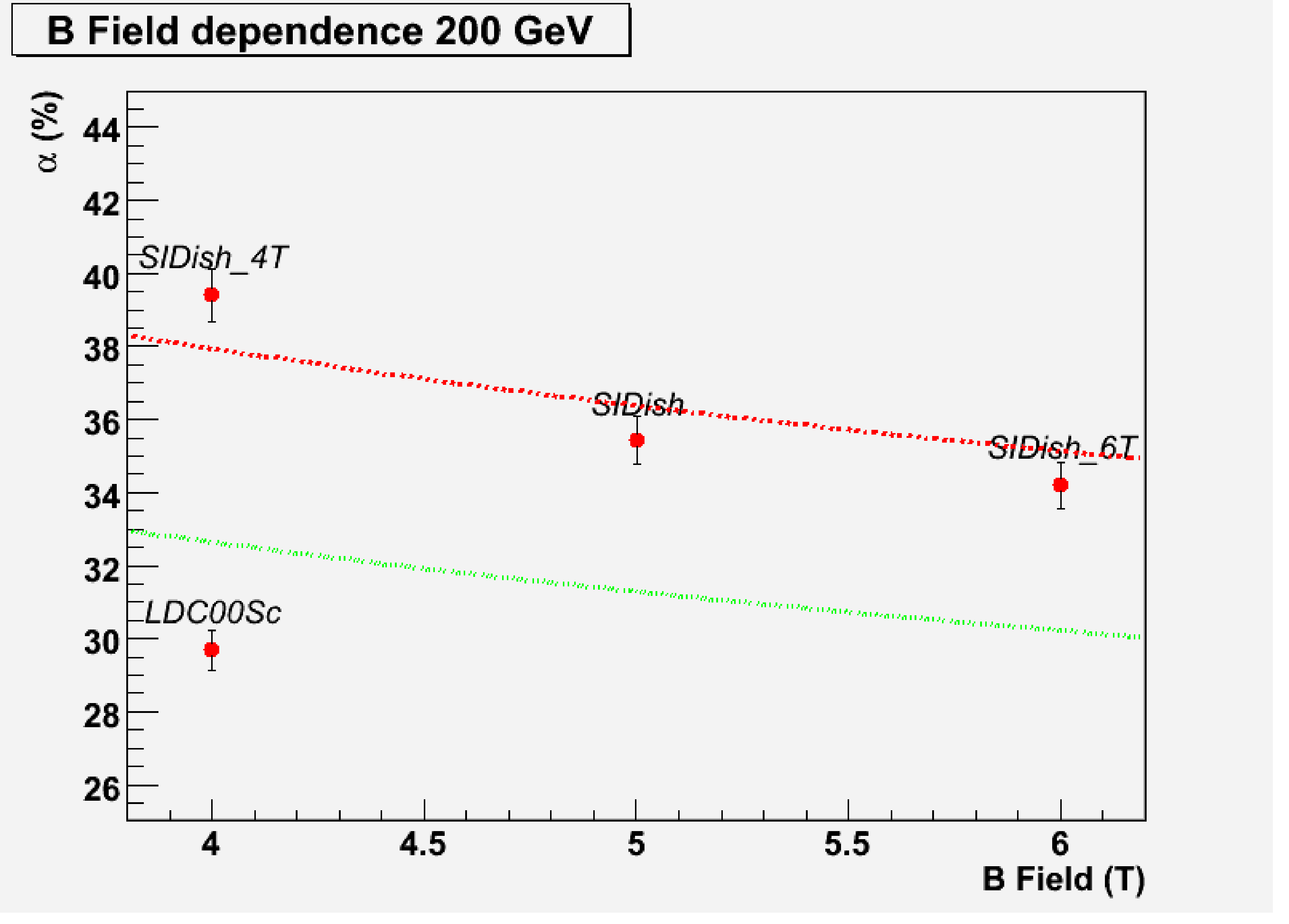
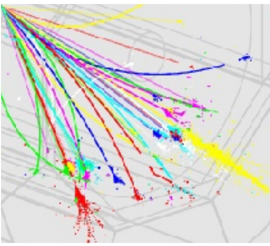
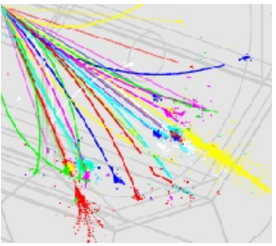


B Field dependence 200 GeV
α (%)
44
42
40
38
36
34
32
30
28
26
SIDish_4T
SIDish
SIDish_6T
LDC00Sc
4
4.5
5
5.5
6
B Field (T)



What needs to be done

- Where would I use the available 25 cm in $r_{Tracker}$?
- Invest them in the HCAL thickness !
  - maybe also 5 cm for the ECAL
- Make the detector longer
  - z=2.0 m sounds like a reasonable pick
- Segmentation is important ...
  - Hints for a optimal number of segments per λ_{Iron}



Plans

- Will explore a few more points
  - HCAL with 5.0 λ_{Iron}
  - SiDish with 2.1 m in z
  - I am sure John and Harry will add to the list
- But need also input from
  - Engineering constraints
  - Cost
  - Tracking/Vertexing