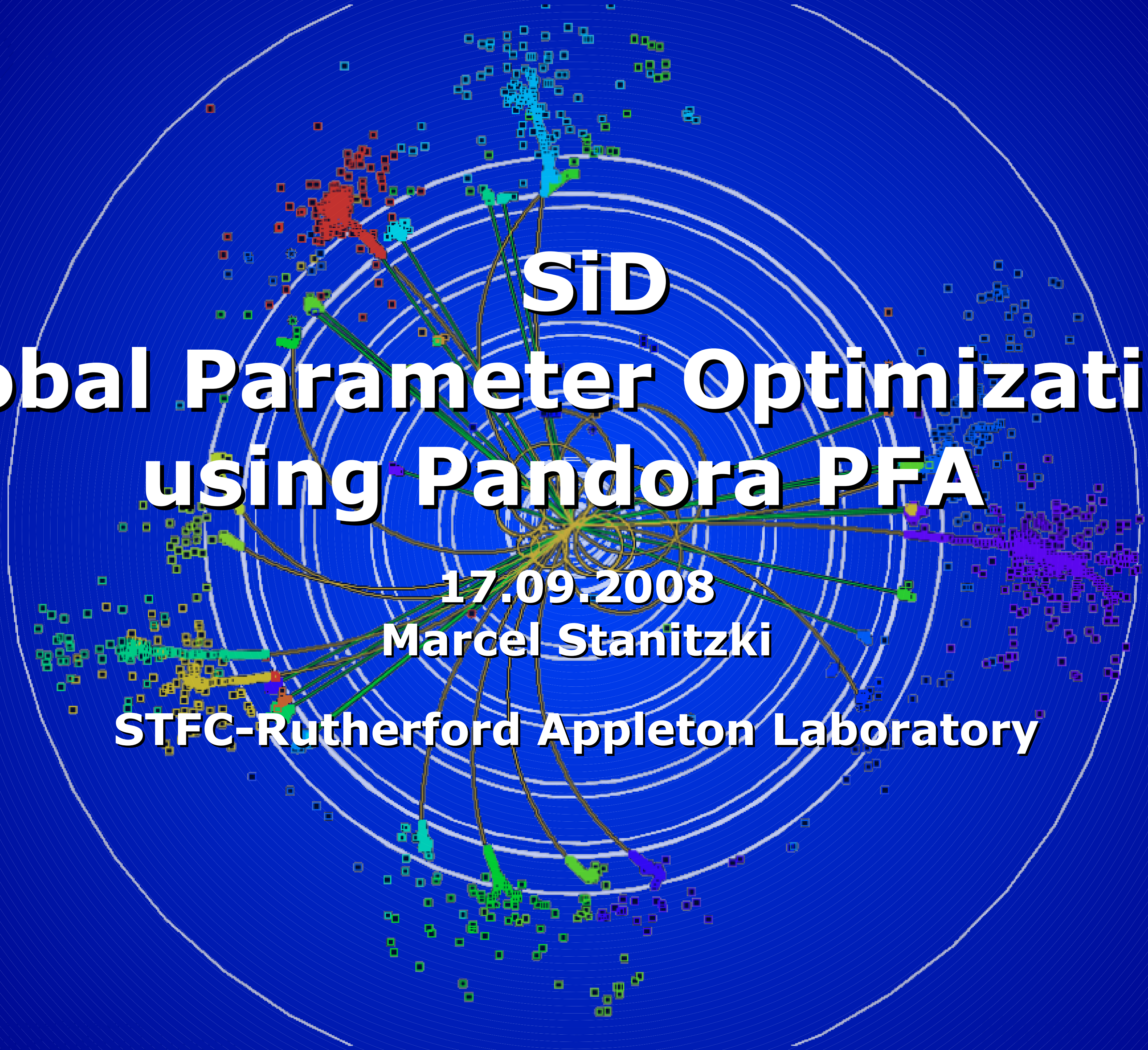
SiD
Global Parameter Optimization using Pandora PFA



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Detector Optimization

- Optimize the detector parameters
  - to maximize physics potential
- while keeping in mind
  - Engineering constraints
  - Costs
- In this talk
  - PFA is the driving force behind the detector design
  - So variable to optimize is **Jet Energy Resolution**
  - Use PFA algorithms to make choices
- Plenty of caveats
  - Covered extensively, by Marty, John, Mat, myself ...

The setup

- PFA of choice is PandoraPFA by Mark Thomson
  - only working algorithm at the beginning
- Using an SID-lookalike , the SIDish
- Results for 45 GeV & 100 GeV uds 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

Main parameters for PFA

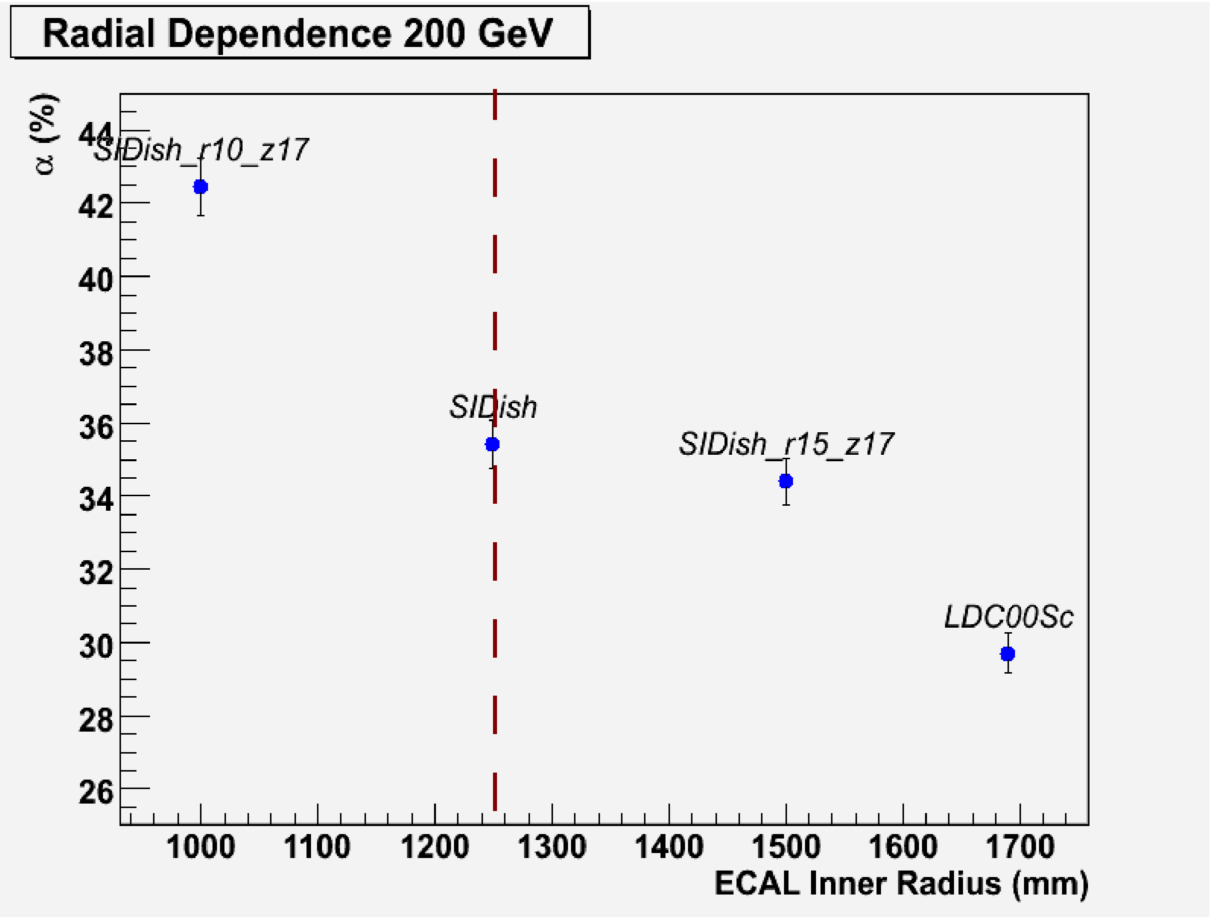
- B Field
- ECAL inner Radius
- ECAL inner z
- HCAL depth in λ_{iron}
- HCAL longitudinal segmentation

B field

- Choice for a compact detector with 5 T field
  - good for tracking, vertexing
  - important for beam background suppressions
  - PFA with sid01-style detectors require high B field
- Fixing the B field to 5 T severely constrains parameter phase space
- From *sid01* baseline we have <25 cm room to increase the radius

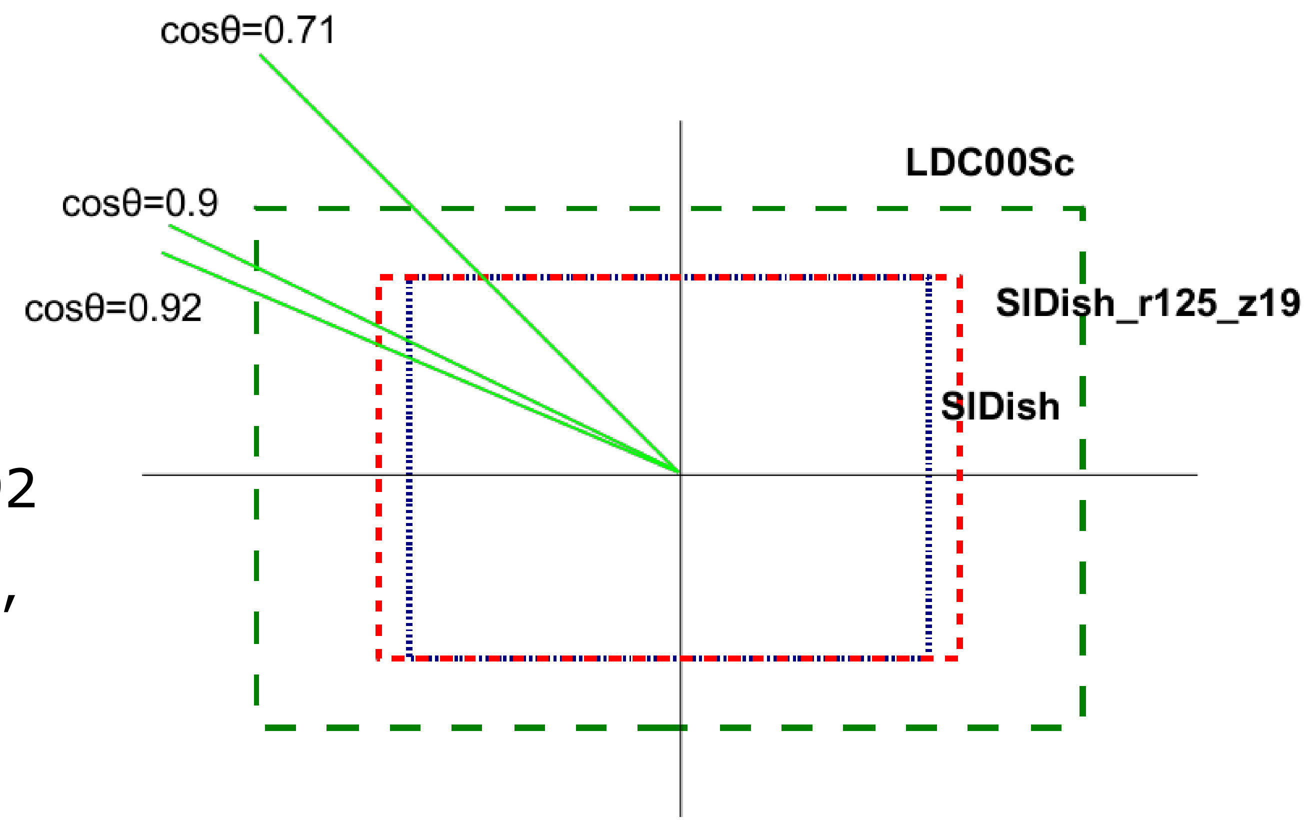
ECAL inner radius

- 1.25 m is alright for a SiD-style detector
- Good performance for PFA
- Larger Tracker brings small improvements
- Smaller Tracker is not such a good idea



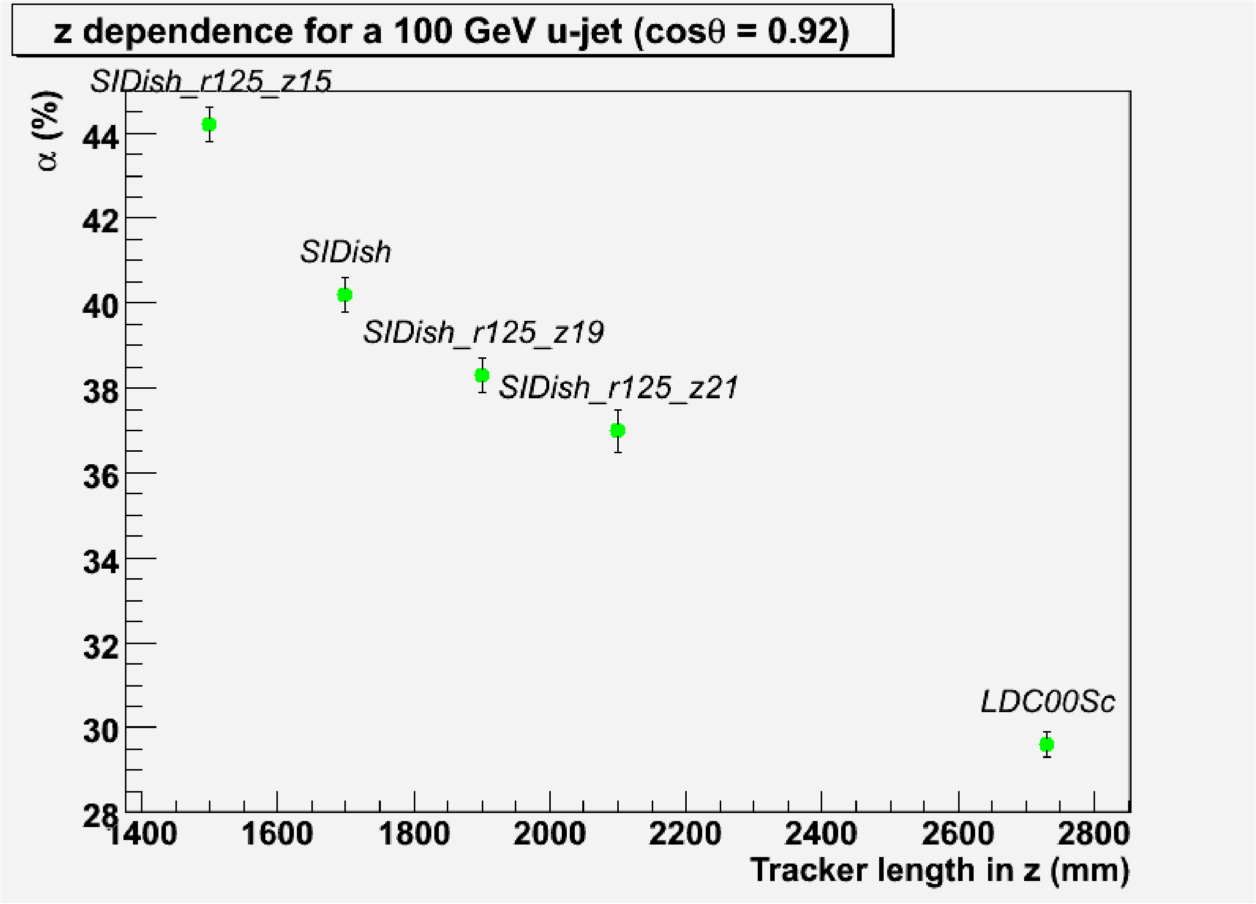
ECAL Inner z

- Study forward performance
- Special Samples
  - 1 u jet at cosθ=0.92
  - available at 50,100, 250 GeV
  - probing forward performance



Results

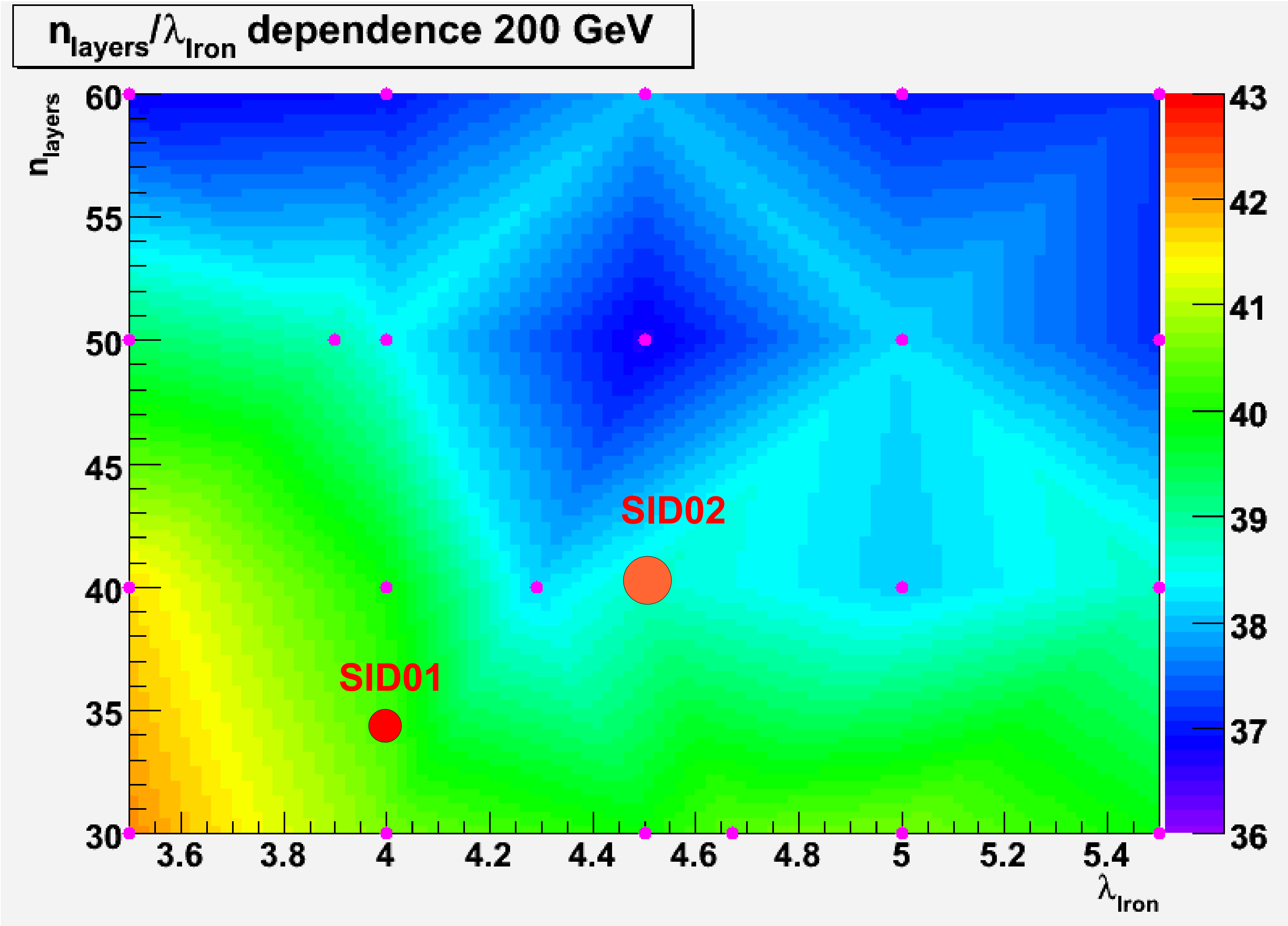
- Clear trend
- larger z is better
- Many reasons
  - done at fixed angle
  - better separation
  - less losses down the beampipe
- Physics impact … an open question



HCAL

- sid01 HCAL was only 4.0 λ_{iron} and 34 layers
- Agreement already before
  - Probably too shallow
- But how much more do we need ?
- Make scan over n_{Layers} and λ_{iron}
  - 30- 60 layers
  - 3.5-5.5 λ_{iron}
  - 20 detector configurations in total

Results



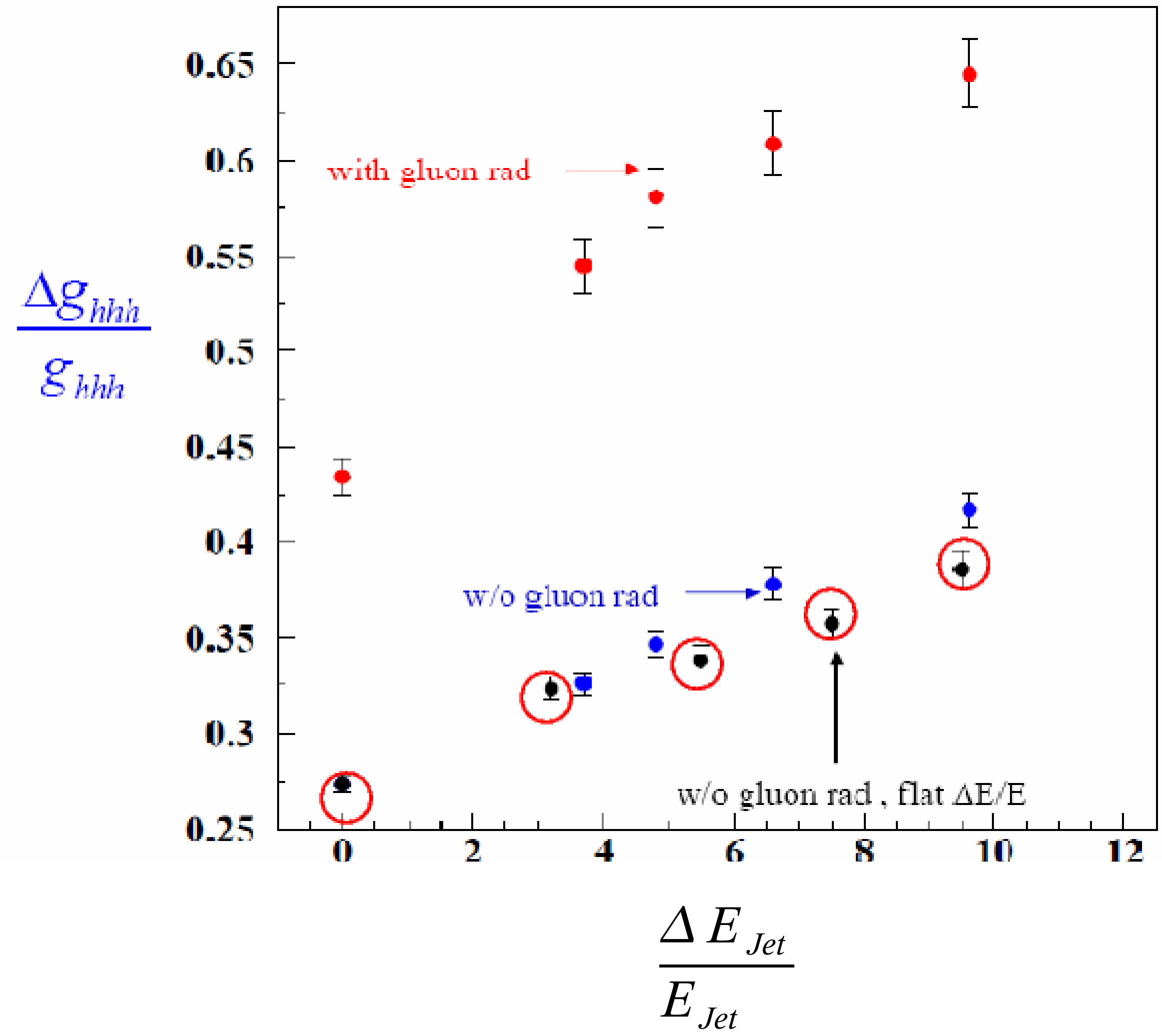
$n_{layers}/\lambda_{Iron}$ dependence 200 GeV
n_{layers}
60
55
50
45
40
35
30
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
λ_{Iron}
43
42
41
40
39
38
37
36
SID02
SID01

Using physics benchmarks

$$e^+ e^- \rightarrow ZHH \rightarrow q\bar{q}b\bar{b}b\bar{b}$$
$$\sqrt{s} = 500\ GeV$$
$$L = 2\ ab^{-1}$$
$$\frac{\Delta E_{Jet}}{E_{Jet}}\ 0.06 \rightarrow 0.03$$

~ 1.2 x Luminosity

Analysis now reflects current PFA status
Results are shown in black



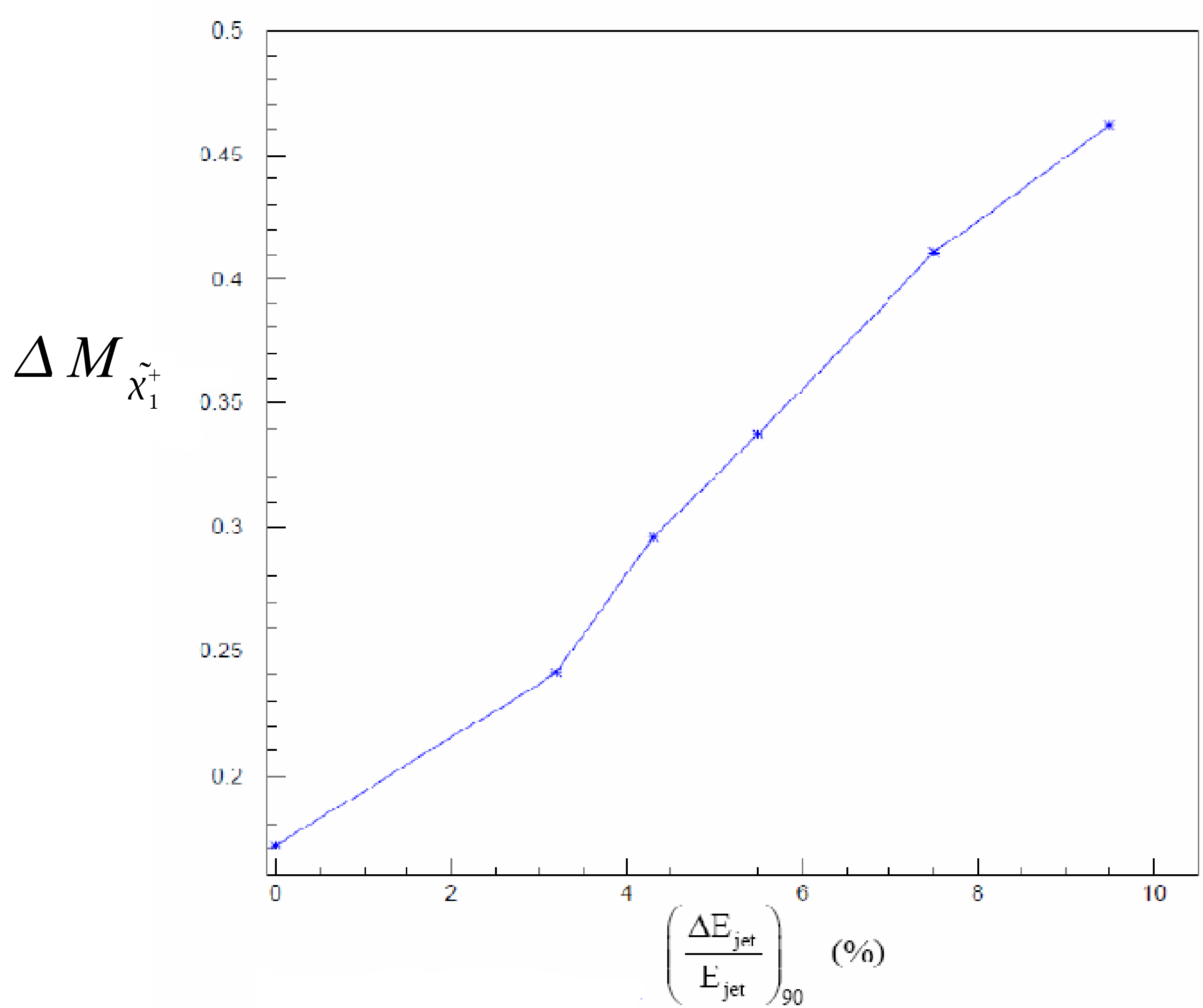
Chargino Mass error

$$e^+ e^- \rightarrow \tilde{\chi}_1^+ \tilde{\chi}_1^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 W^+ W^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 q \bar{q} q \bar{q}$$

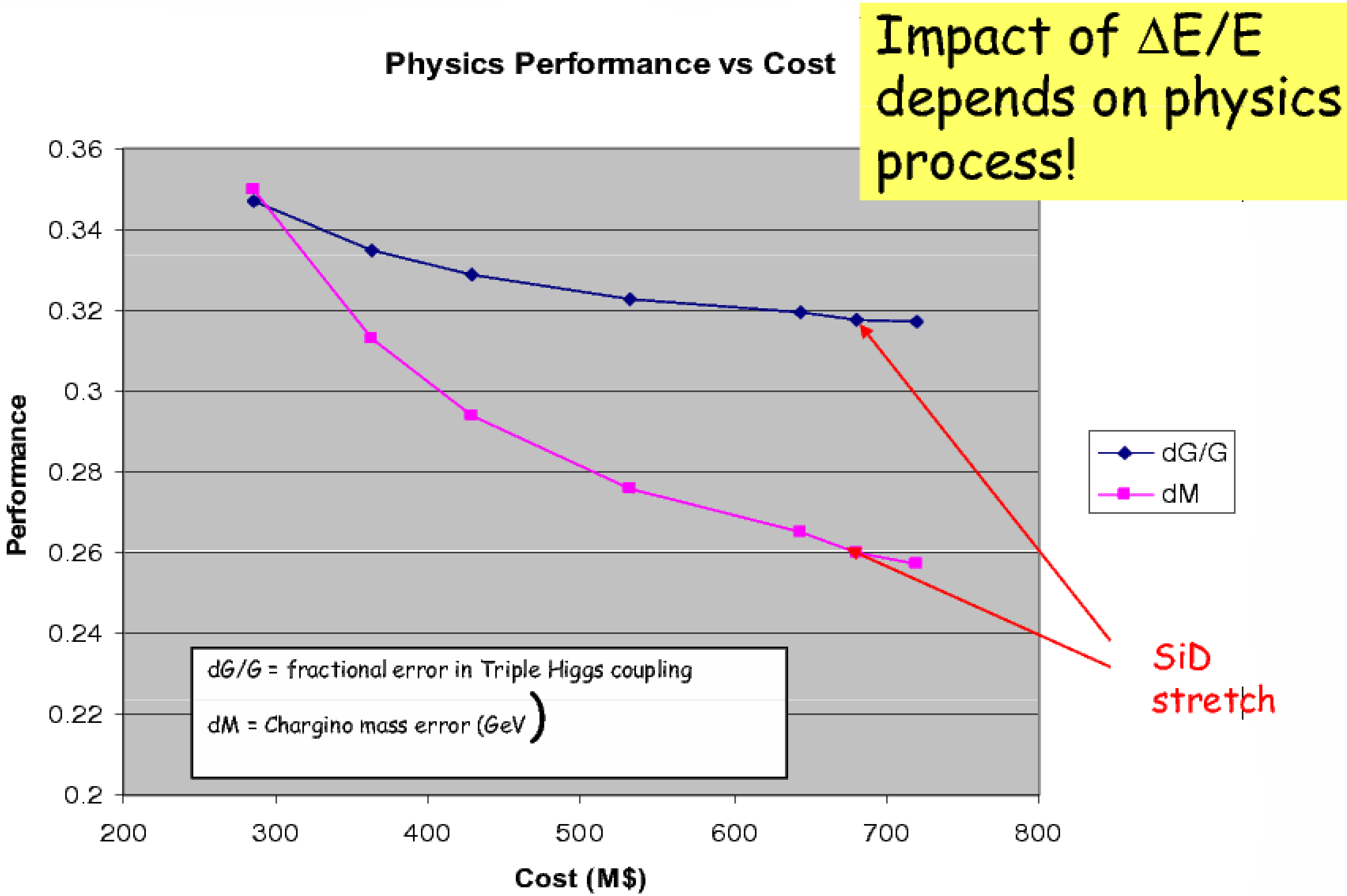
$$M_{\tilde{\chi}_1^+} = 200\ GeV$$
$$M_{\tilde{\chi}_1^0} = 106.1\ GeV$$
$$\sqrt{s} = 500\ GeV$$
$$L = 500\ fb\text{-}1$$

$$\frac{\Delta E_{Jet}}{E_{Jet}}\ 0.06 \rightarrow 0.03$$

~ 2.1 x Luminosity



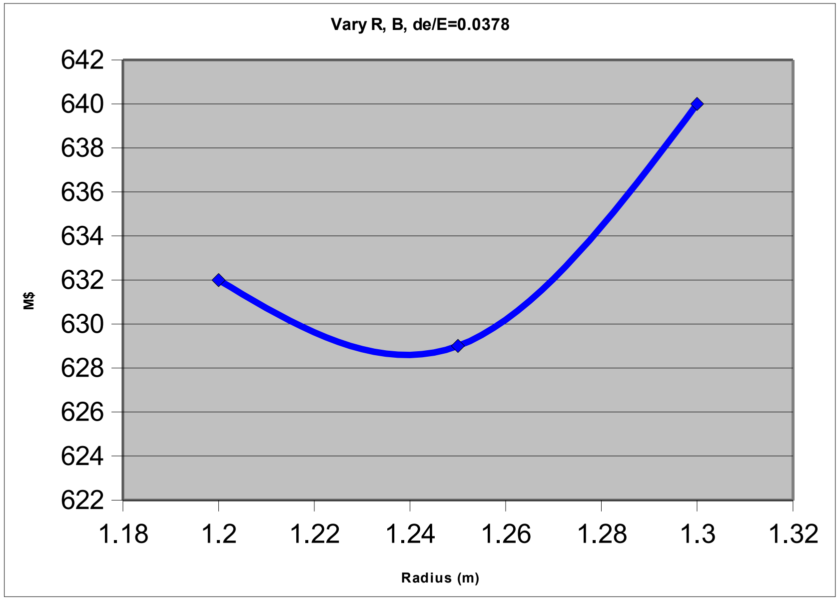
Physics and Cost

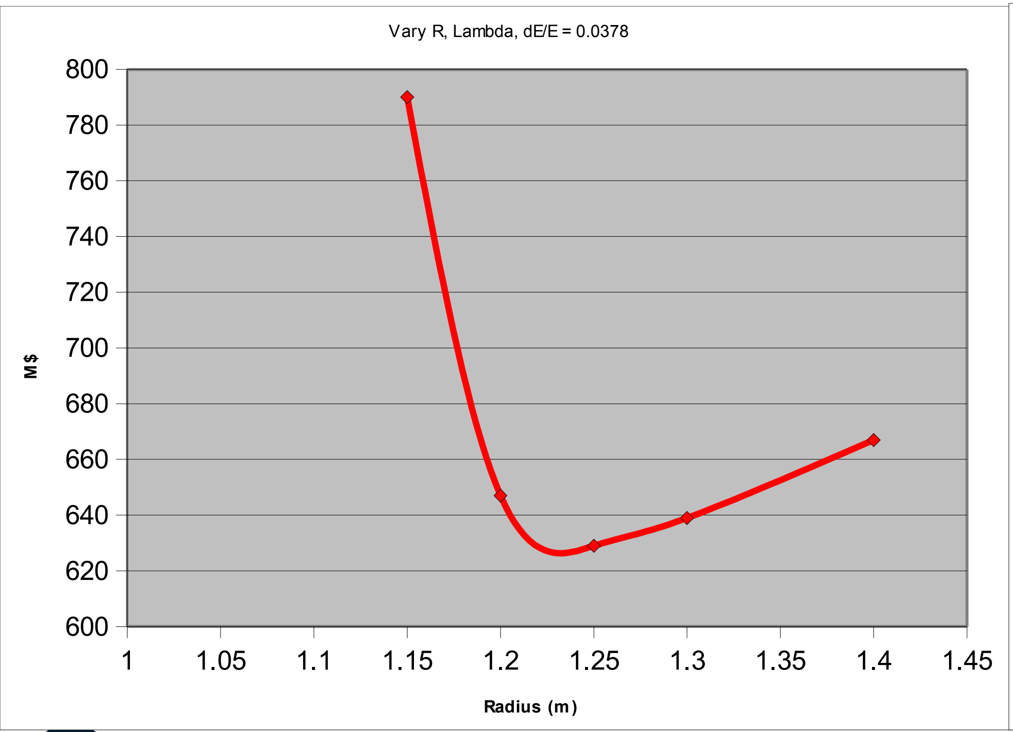


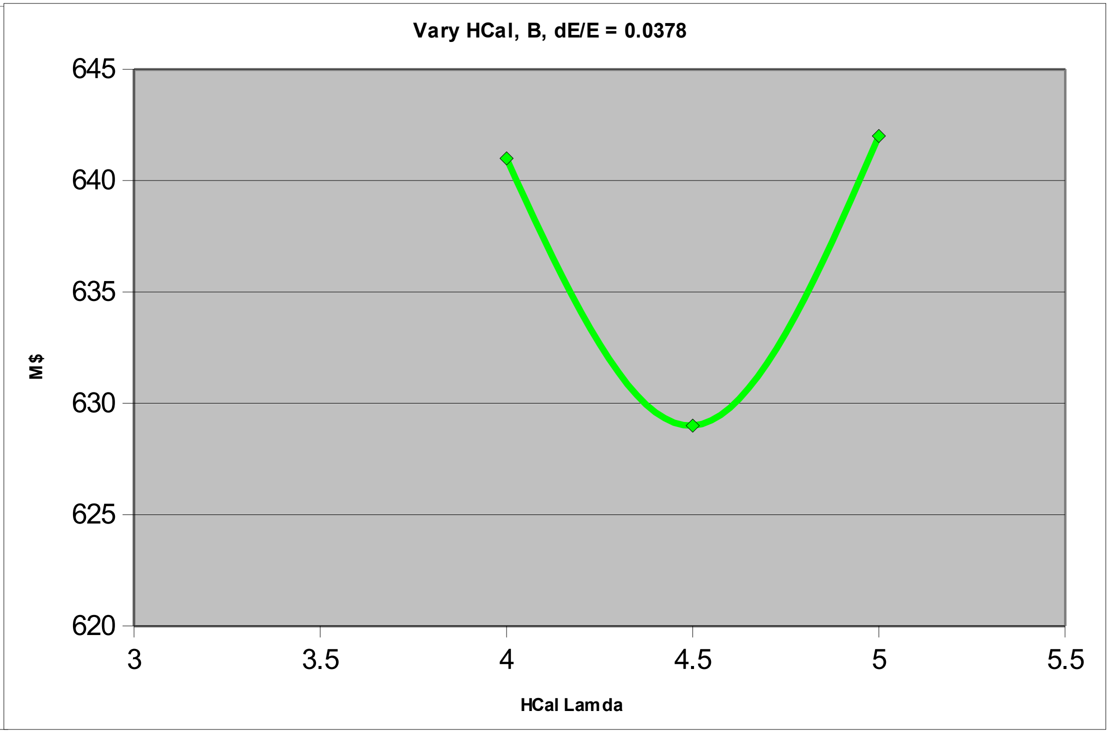
Done assuming same energy resolution in Barrel and Endcap

Optimizing Costs

- $R_{Tracker}$ = 1.25 m
- B = 5 T
- HCAL λ_{Iron} = 4.5
- $\Delta E/E$(180 GeV) = 0.0378







Making SiD02

	sid01	sid02-stretch	sid02
ECAL inner radius (m)	1.25	1.25	1.25
ECAL inner Z (m)	1.7	**2.1**	1.7
HCAL depth (λ_{iron})	4	**4.5**	**4.5**
HCAL layers	34	**40**	**40**
B Field	5	5	5

Two versions proposed for sid02

Finalizing SiD02

- Deeper HCAL was uncontroversial
- Impact of lengthening the tracker
- From engineering point of view
  - L* remains unchanged
  - significant (but possible) engineering/design change
- For reconstruction
  - significant (and impossible) software/reconstruction changes.
- Final sid02
  - Open process everyone was welcome to contribute
  - Decided to stay with z=1.7 meters
  - But will follow up on stretched design after LoI
- Simulation effort for sid02 has started

Quick checks on SiD02

- Updating SIDish to SIDish02
  - recent Mokka
  - HCAL with 4.5 λ_{iron} and 40 layers
  - ECAL in SiD Config (20 x 2.5mm +10 x 5 mm)
- Evaluated both versions
  - sid02
  - sid02 stretched

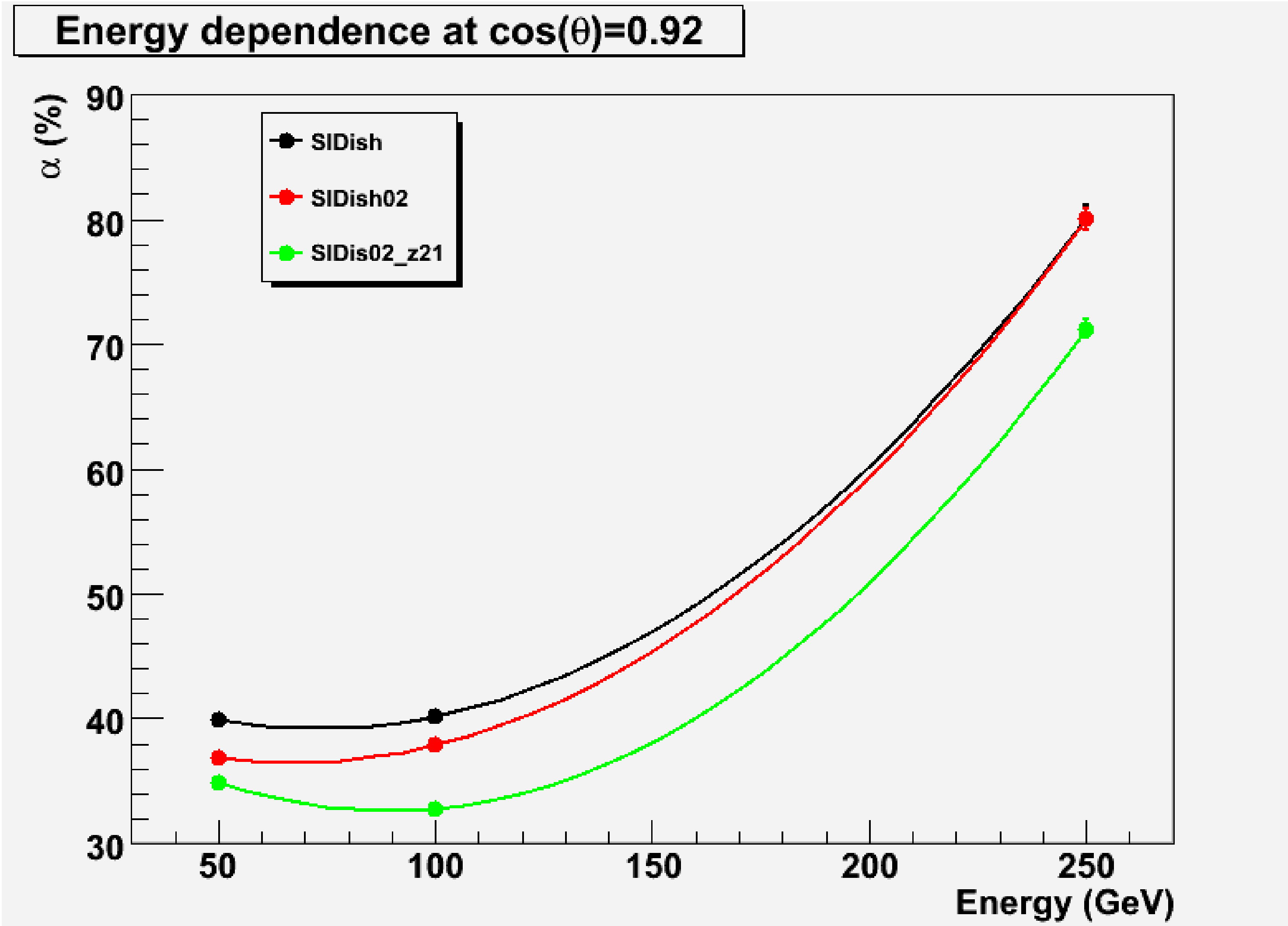
Results

Older Mokka version which
was quite different

Detector Tag	HCAL Layers	uds (91 Gev) α %	uds (91 Gev) Error	uds (200 GeV) α %	uds (200 GeV) Error
SIDish	*40*	*27.9*	*0.4*	*35.4*	*0.7*
SIDish02_v2	40	27.5	0.3	36.1	0.7
SIDish02_v2_z21	40	27.0	0.5	34.4	0.7

- No big surprises: results consistent
- Longer version slightly better (longer barrel), but that is expected

Z dependence



Forward performance at cos (θ)=0.92 using a single u jet at 50,100,250 GeV

Some open questions

- HCAL choice of absorber and readout
  - Steel, Tungsten, RPC,GEM, Scintillators, Micromegas
  - Baseline is Steel+RPC
- Performance at 1 TeV
  - not much effort put into this yet
  - how much needed for the LoI ?
- Physics performance
  - Gain in benchmarks processes by changing parameter x
- Lots of things to think about even after the LoI

Summary

- Have converged on sid02
  - Long process with lots of input from subgroups
- sid02 a good choice
  - physics performance
  - engineering constraints
  - cost
- Will be with us for the LoI
  - The detector we benchmark ...
- Redo the optimization exercise after the LoI
  - Once more ...
- Thanks to T. Barklow, M. Breidenbach, J. Jaros, H.Weerts and A.White for material and comments