SiD Optimization Status

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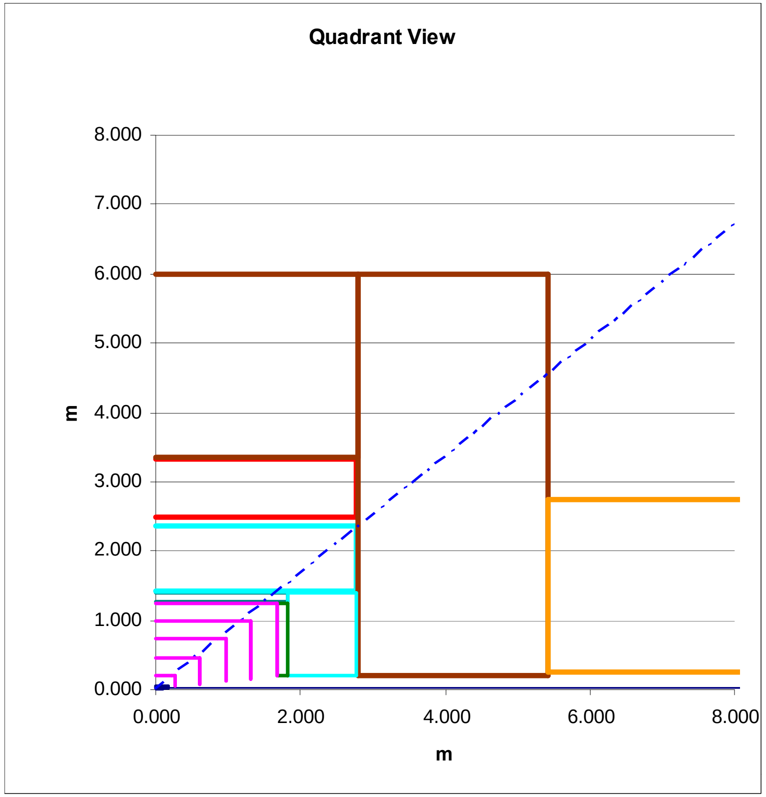
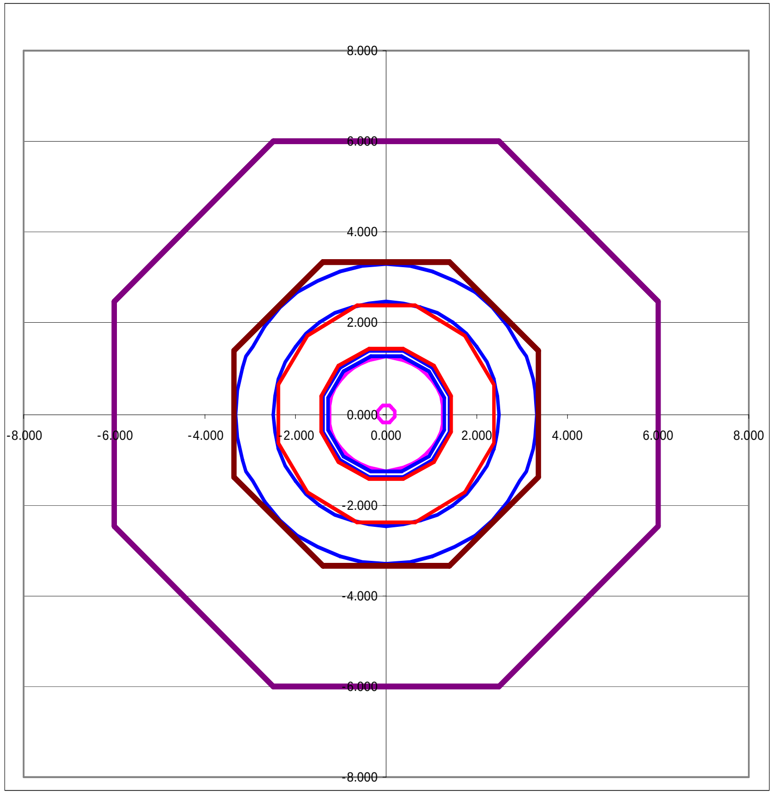




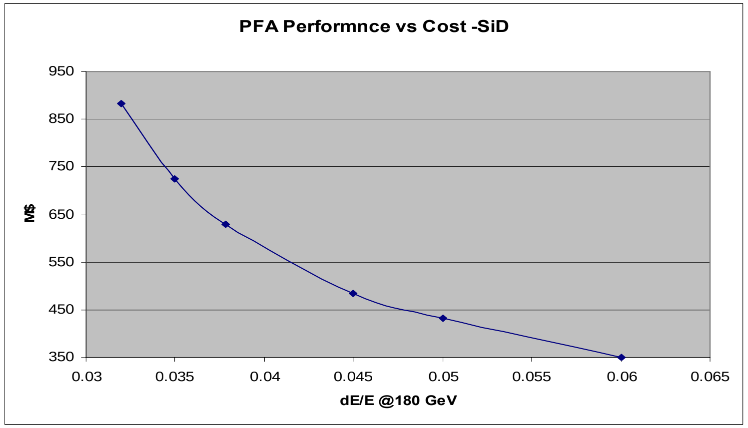
Review: Method proposed at SiD RAL Meeting

- Assume Mark Thomson's ILD Parameterization of $\Delta E_{jet}/E_{jet}$:

$$\alpha = 0.42\left(\frac{B}{4}\right)^{-0.31}\left(\frac{R}{1.78}\right)^{-0.61}\left(1+21.6e^{-\frac{N}{7.1}}\right)$$

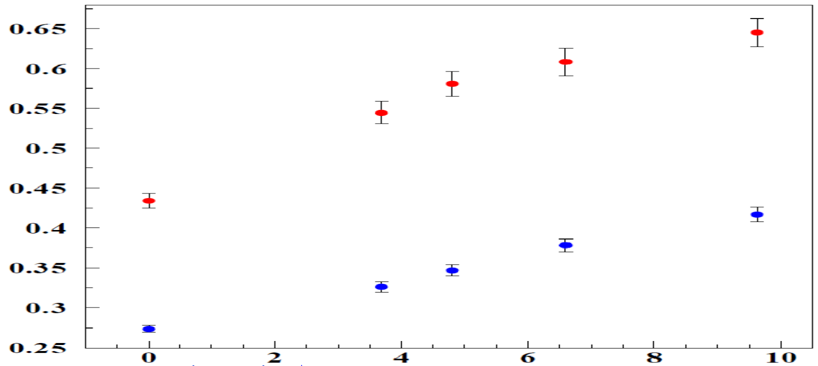
E_{jet}=180GeV

- Using SiD Cost Model, find R, B, and λ (= 4.3N/40) which minimize cost for a given $\Delta E_{jet}/E_{jet}$.



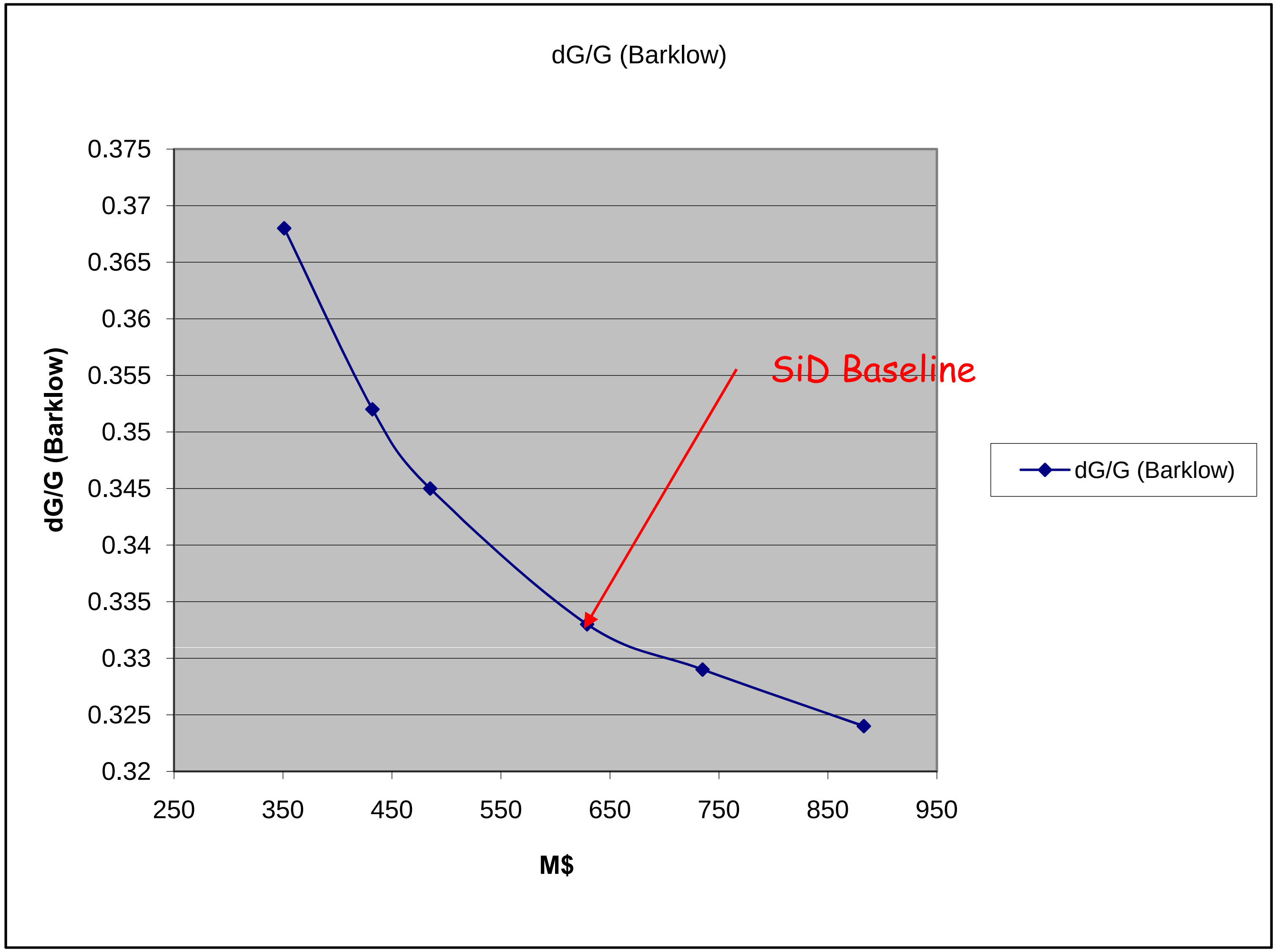
- Use Tim Barklow's study of ZHH, which gives Δg/g vs $\Delta E_{jet}/E_{jet}$.

$$\frac{\Delta g_{hhh}}{g_{hhh}}$$



$$\frac{\Delta E_{jet}}{E_{jet}} \equiv \frac{\alpha_{90}}{\sqrt{80}}\ (\%)$$

The Answer Last Time



What's Wrong with this Picture?

RAL talk listed many caveats:

- The cost model has not been reviewed/checked
- Mark's Parameterization is applicable to LDC. How applicable is it to SiD?
- Tim's input curve was derived assuming (in fast MC) a jet energy resolution $\Delta E/E = \alpha/\sqrt{E}$, not $\Delta E/E$ = constant, which more accurately describes a PFA calorimeter.

Cost Caveats

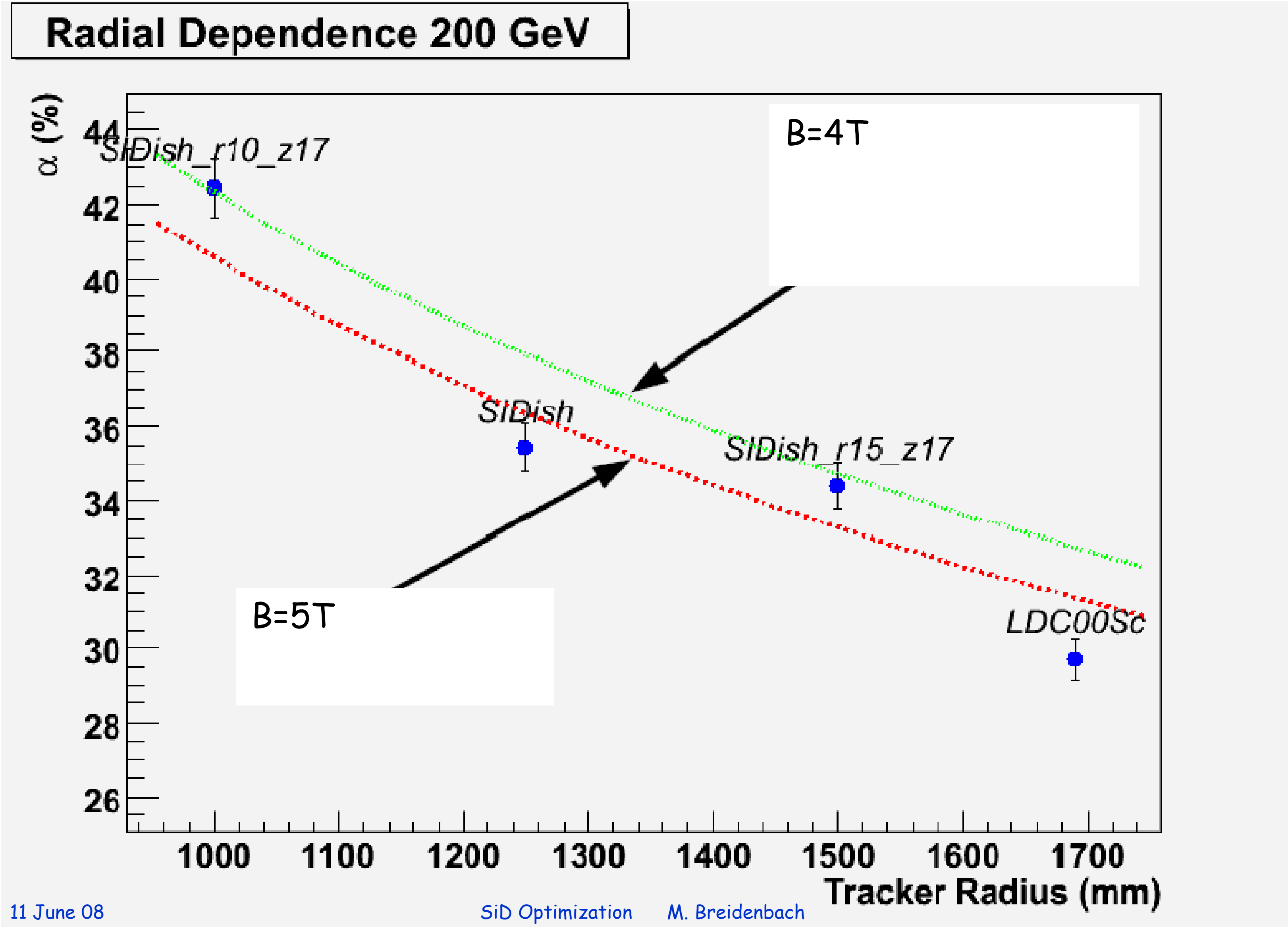
- Concerns regarding:
  - Fundamental estimates such as mechanical tech time/m^2 of calorimeter surface or electronics tech time/ tracker detector.
  - Conversion of tech time to $ (although it is available in hours)
  - Many important unit costs are very uncertain, e.g. tungsten (for the EMCal); Si detectors (for the tracker and EMCal), and Iron (for the magnet).
  - Several technology decisions are not made. In particular there is no serious baseline choice for the HCal detector technology. RPC's with KPiX readout is assumed.
  - The costs have not been adequately reviewed by the engineering team.
  - The costs have been developed in US dollars. The effects of the rapidly changing dollar/Euro ratio is not addressed.
  - There may still be errors!
- The cost numbers are U.S. style, with labor, contingency, indirects, and escalation. The inflation rate is taken as 3.5%, and the construction start date is 2012. These numbers may be optimistic!

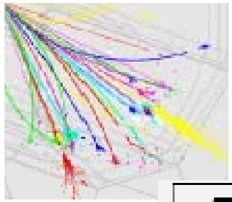
Is Mark's Parameterization valid for SiD?

- Marcel Stanitzky has studied a SiD-like detector, SiDish, using Mark's Pandora PFA program.

  SiDish has dimensions and aspect ratio appropriate for SiD, but still has TPC tracking, the LDC Ecal, and Scintillator/Fe Hcal.
  - Tracker radius=1.25m
  - Tracker Z=1.7 m
  - ECAL SiW 20+10 layers, 1x1 cm tiles
  - HCAL Fe-Scint 40 layers 3x3 cm tiles
  - Same Calorimeter layout as LDC00Sc (besides ECAL 30+10->20+10)
  - 5 T Field
- Does the performance of SiDish agree with Mark's parameterization?
- How well does the performance of SiDish reflect what the performance of SiD will be?

Using Mark's scaling Law





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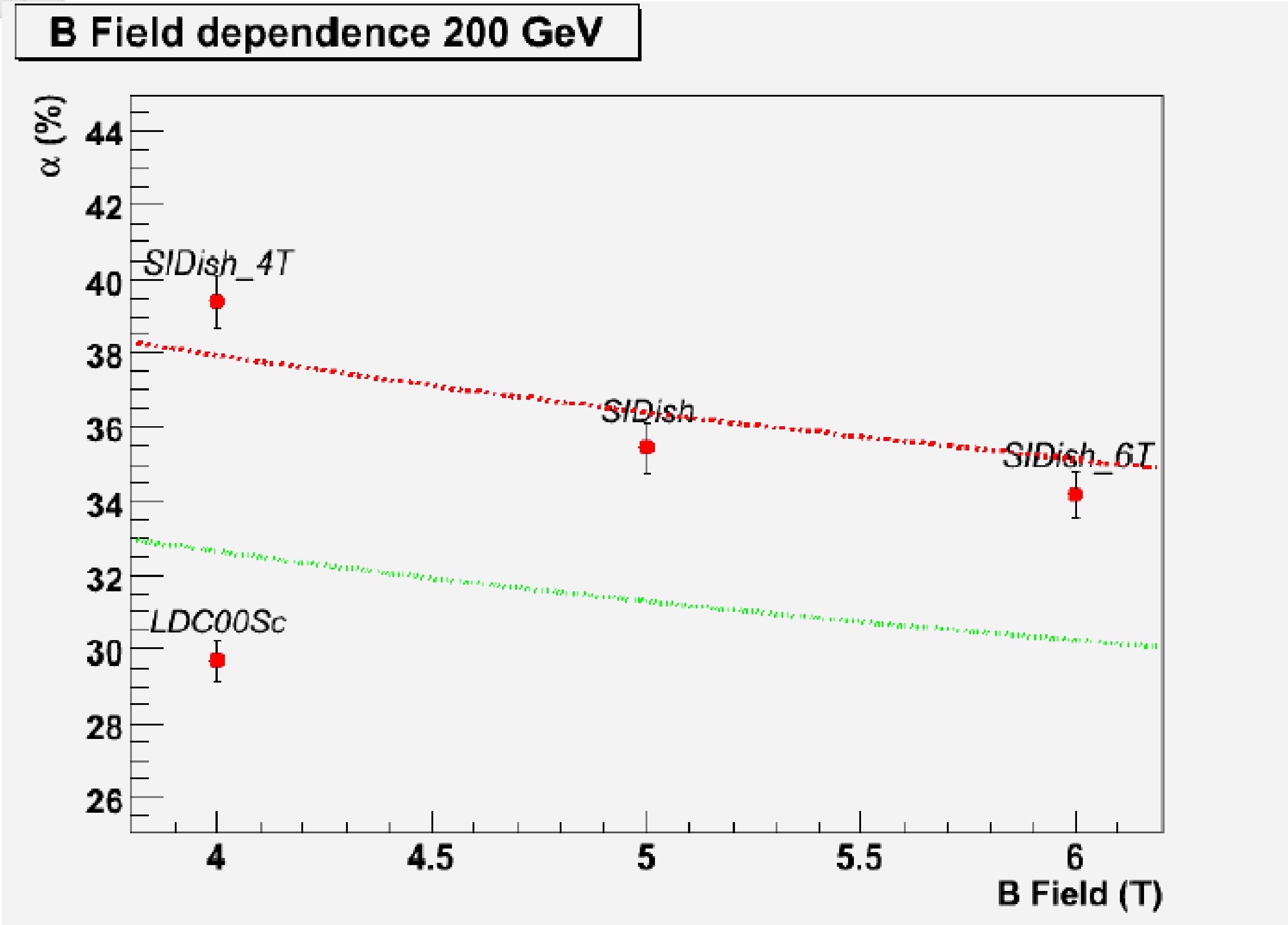

B Field dependence 200 GeV
α (%)
44
42
40
38
36
34
32
30
28
26
SIDish_4T
SIDish
SIDish_6T
LDC00Sc
4
4.5
5
5.5
6
B Field (T)

SiD = SiDish HCal issues?

No, but we can estimate how large the differences are.

- SiD's Fe/RPC's might under-perform SiDish's Fe/scintillator. The RPC response is not yet optimized, and the pixel sizes are different). Both Mark and Marcel see small effects in present Pandora:

Scintillator

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

RPC

ΔE/E might be as much as 10% worse
Or it might be better. Needs optimized PFA.

SiD = SiDish EMCal Issues?

- The SiDish ecal is a 20+10 version of the LDC ecal, total 20 X_0, with 1.4 mm and 4.2 mm W radiator thicknesses.
  SiD's EMcal is also 20 + 10, but with 2.5mm and 5.0mm radiator thicknesses, totaling 29 X_0.

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

SiDish and SiD Ecals roughly equivalent for PFA,
For the cases studied. No use was made of the smaller SiD pixels. SiDish and not SiDish_ecal_25_50 was used in subsequent studies..

SiD = SiDish Tracking Issues?

- Mark Thomson, in his talk at the SiD RAL meeting, stressed the importance of TPC pattern recognition to recognize V0's, decays, interactions, and loopers.
- He indicated ~ 3% (absolute) improvement in the jet energy resolution parameter α, corresponding to ~ 10% improvement in $\Delta E/E$ after a lot of homework.
- Two differences between LDC and SiD could be significant for Pandora:
  - Amount of material in the tracking volume (which needs more study)
  - Differences in pattern recognition capability.

$\Delta E/E$ could be worse by 10% (upper limit)

SiD = SiDish

- SiD could be better
  - There is a strong impression that PFA's (and Pandora) needs to be carefully tuned for a particular detector configuration. This has not yet been attempted.
  - Pandora does not use SiD's small EMCal pixels and probably does not take advantage of the small Moliere radius.
  - SiD probably has less material in the forward direction upstream of the endcap EMCal.

- And remember that there are several non PFA issues:
  - Background robustness
  - Background control
  - Superb momentum resolution

New Input for PFA Optimization

- Tim Barklow has redone his fast MC study of measuring the triple higgs coupling, assuming a more realistic jet energy resolution distribution, and assuming the jet energy resolution $\Delta E/E$ is constant vs energy, not ~ $\alpha/\sqrt{E}$. He's added an analysis of the error in the chargino mass vs $\Delta E/E$ too.

- Use Mark's parameterization for α appropriate for 100 GeV jets, to select R, Z, and lambda for a given resolution:.

$$\alpha = 0.315 \left(\frac{B}{4}\right)^{-0.19} \left(\frac{R}{1.68}\right)^{-0.49} (1 + 6.3e^{-\frac{N}{8.0}})$$

- Use Marcel's study of SiDish performance vs Z_{ecal} for forward jets, to select Z_{ecal} so as to match jet energy resolution in the endcap with that in the barrel (at 100 GeV)

New Input for $\Delta g/g$ vs $\Delta E/E$

T. Barklow

Analysis has now been redone with $\frac{\Delta E_{jet}}{E_{jet}}$ that reflects current PFA status

triple Higgs coupling error vs. genuine $\frac{\Delta E_{jet}}{E_{jet}}$ is plotted in BLACK

$BR(H \to b\bar{b})=0.678$

$e^+e^- \to ZHH$

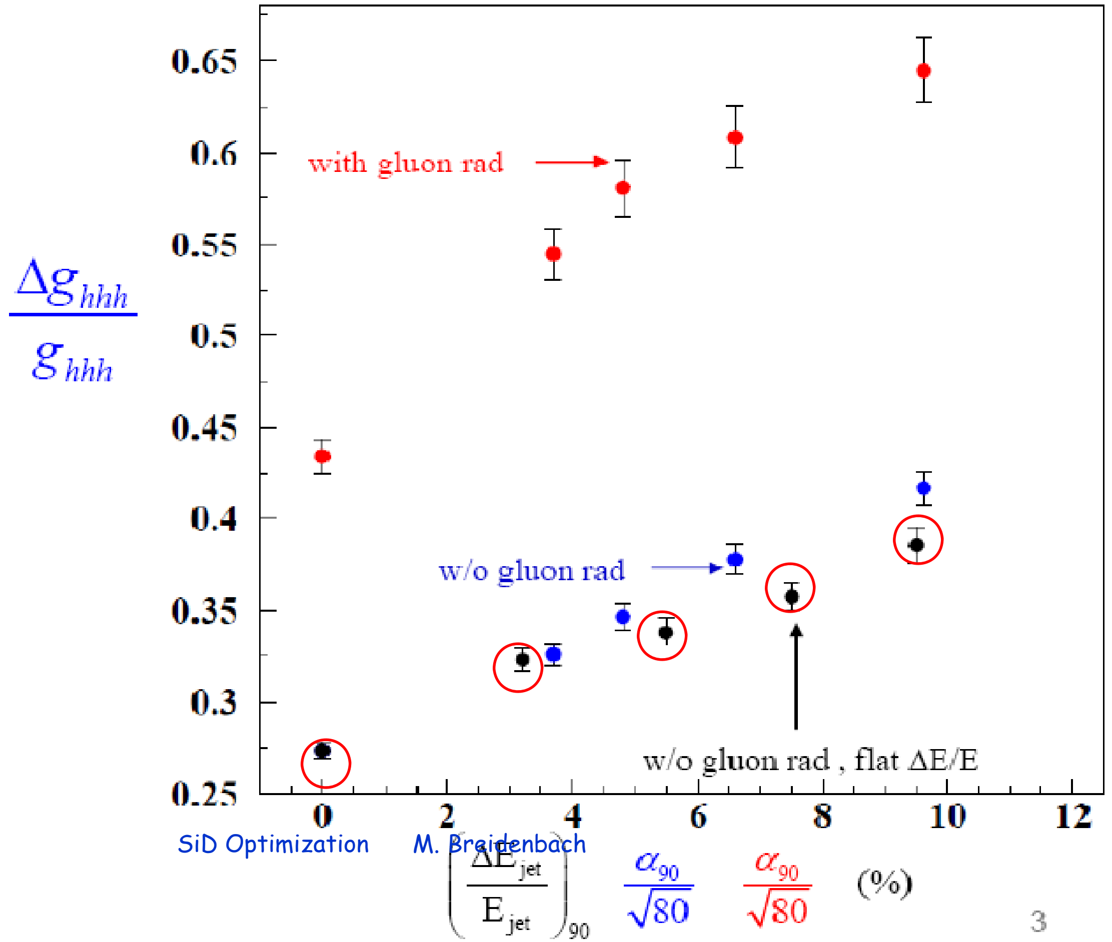
$\to qqb\bar{b}b\bar{b}$

$\sqrt{s} = 500\ GeV$

$L = 2000\ fb^{-1}$

$\Delta E_{jet}/E_{jet} = .06 \to .03$

equiv to $1.2 \times$ Lumi



T. Barklow

New Process: Chargino Mass vs ΔE/E

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

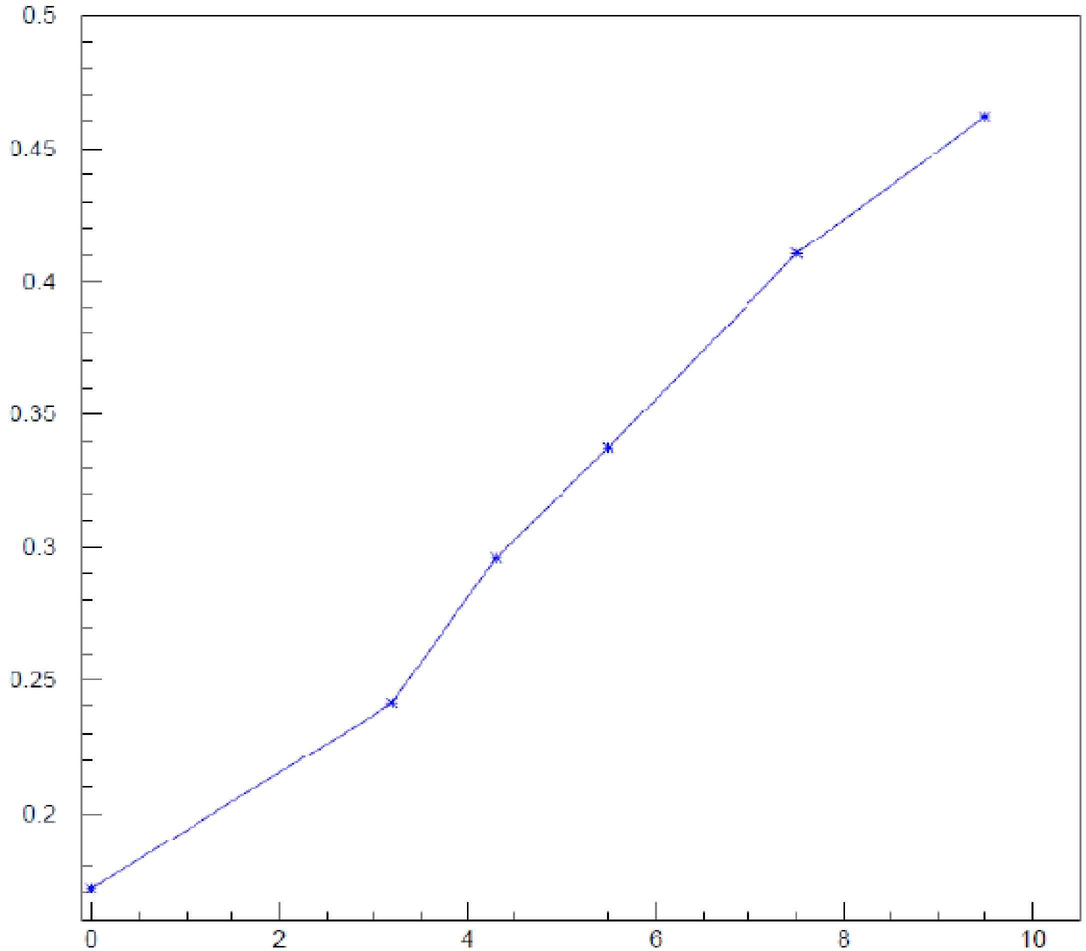
$M_{\tilde{\chi}_1^+} = 200.0$ GeV

$M_{\tilde{\chi}_1^0} = 106.2$ GeV

$\sqrt{s} = 500$ GeV

$L = 500\ fb^{-1}$

$\Delta M_{\tilde{\chi}_1^+}$ (GeV)



$\left(\frac{\Delta E_{jet}}{E_{jet}}\right)_{90}$ (%)

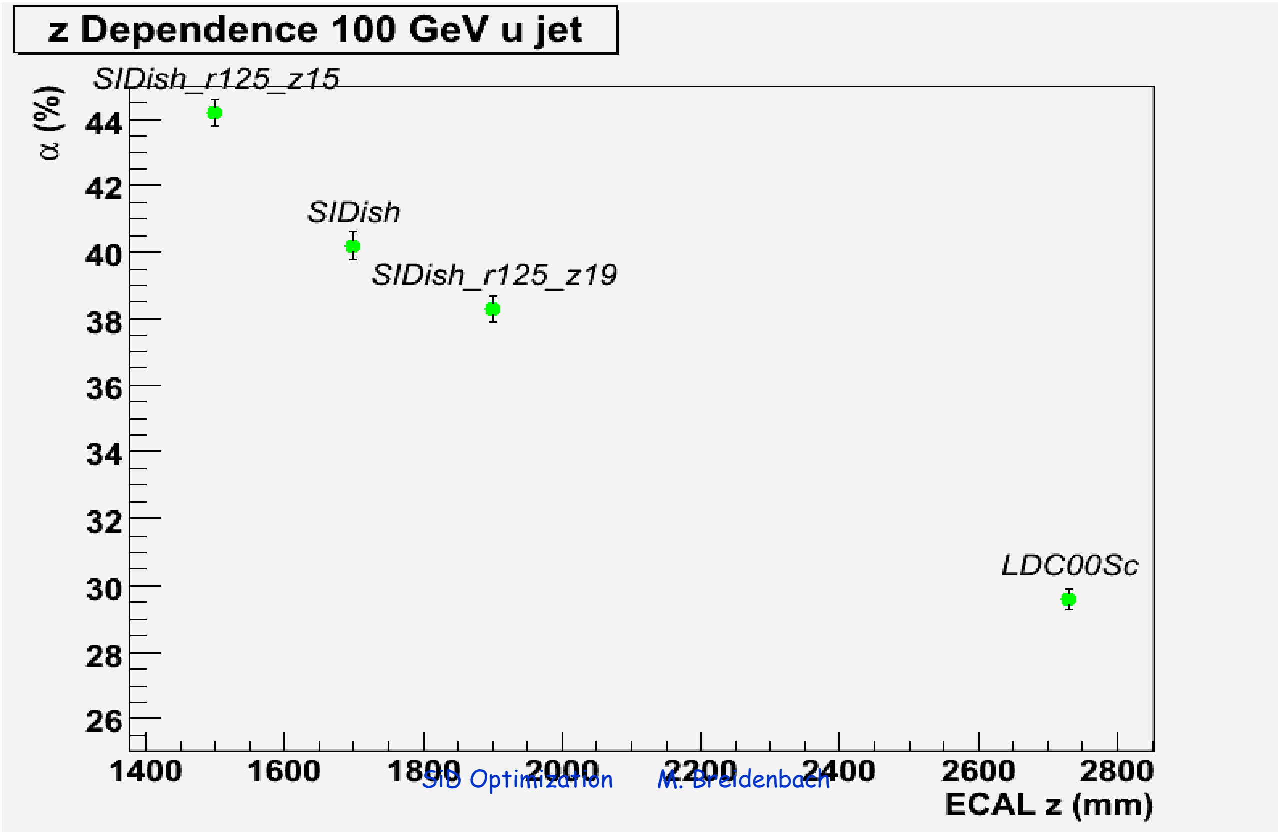
$\left(\frac{\Delta E_{jet}}{E_{jet}}\right)_{90} = .06 \rightarrow .03$

equiv to $2.1\times$ Lumi

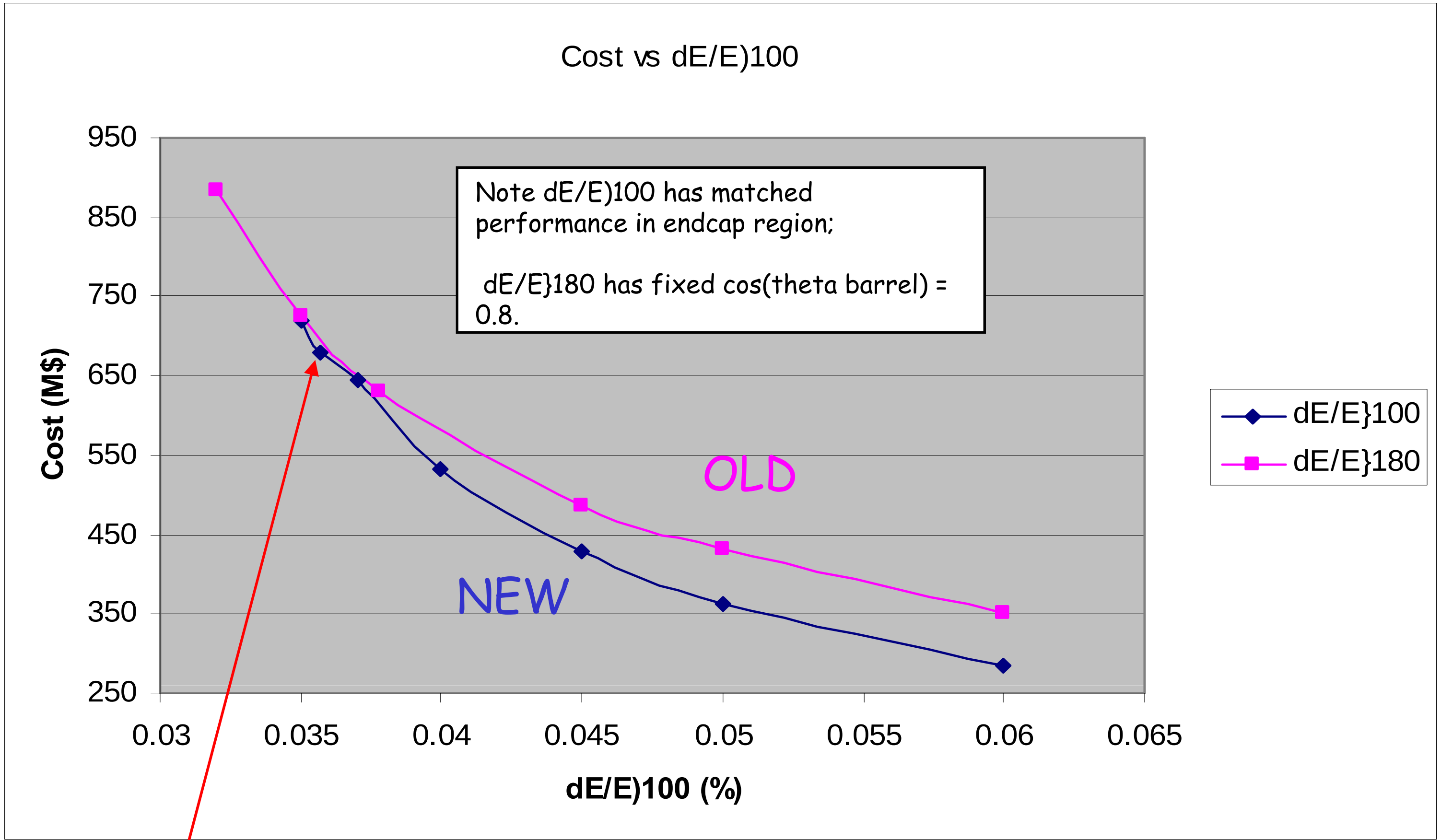
Jet Energy Resolution vs Z for Forward Jets (cos θ = 0.92)

M. Stanitzki

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	69.1	0.2
LDC00Sc	32.0	0.3	29.6	0.3	79.8	0.8
SIDish_r125_z15	43.4	0.4	44.2	0.5		
SIDish_r125_z19	38.9	0.4	38.3	0.4		

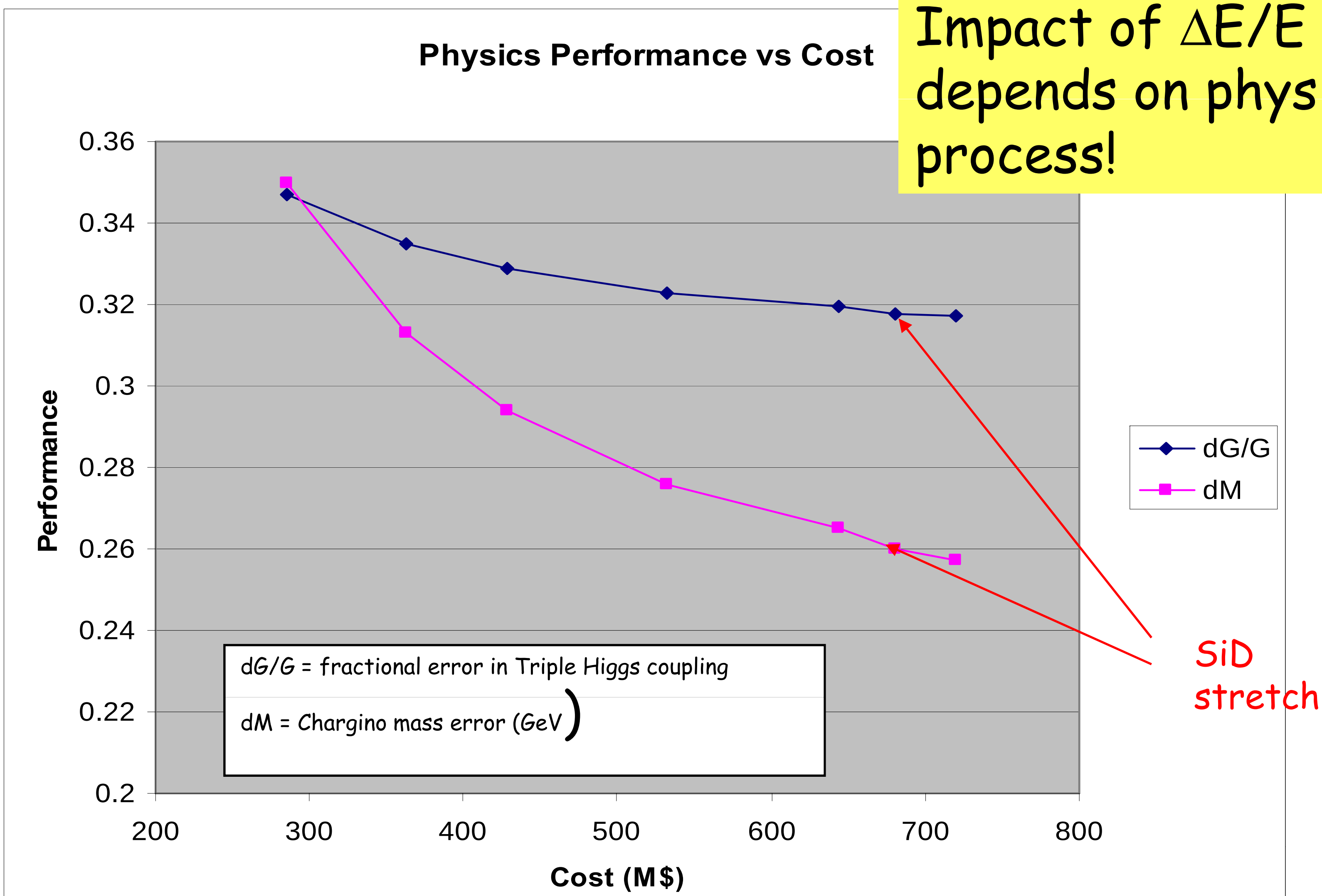


Cost vs ΔE/E Old and New



SiD stretch – R = 1.25, B = 5, HCal =4.5, Z = 2.05

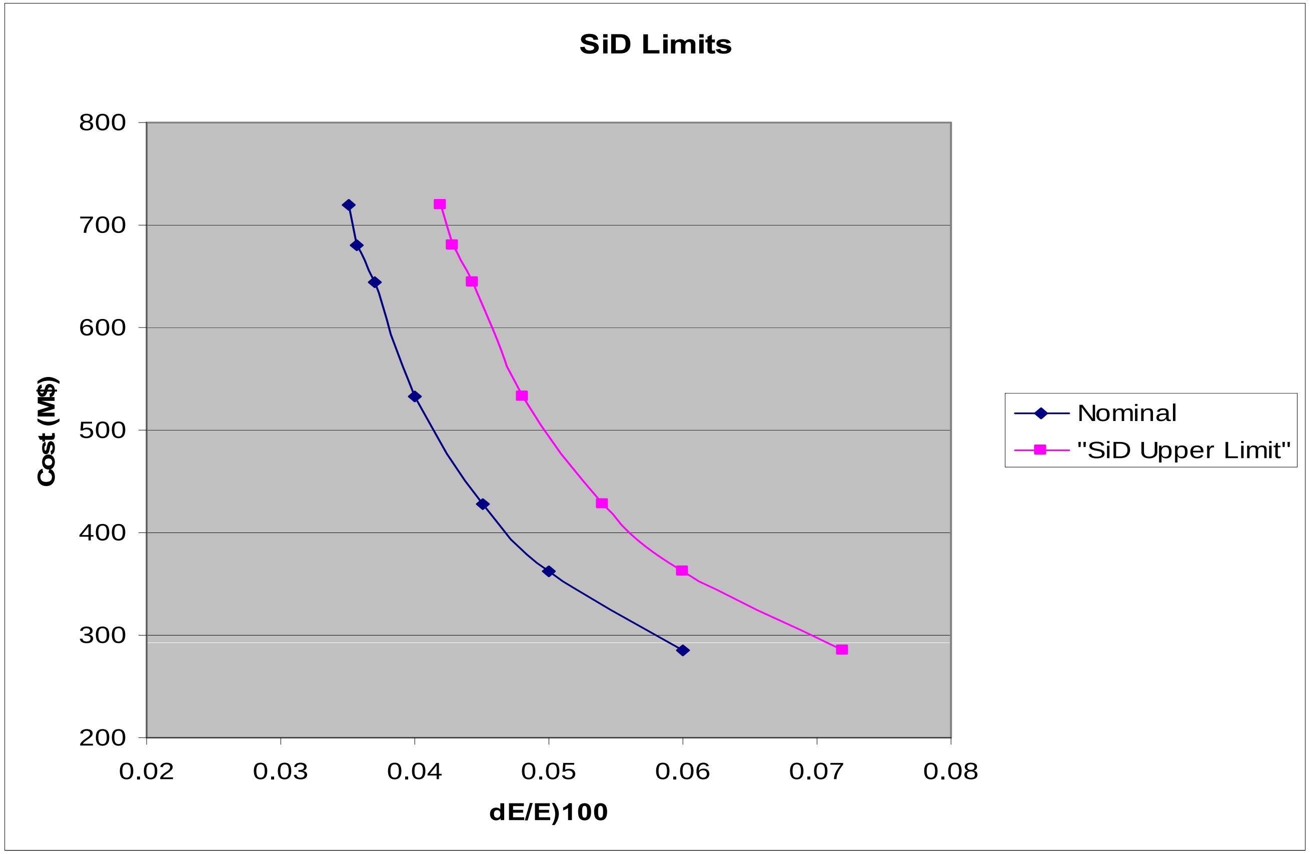
Bottom Line



Impact of ΔE/E depends on physics process!

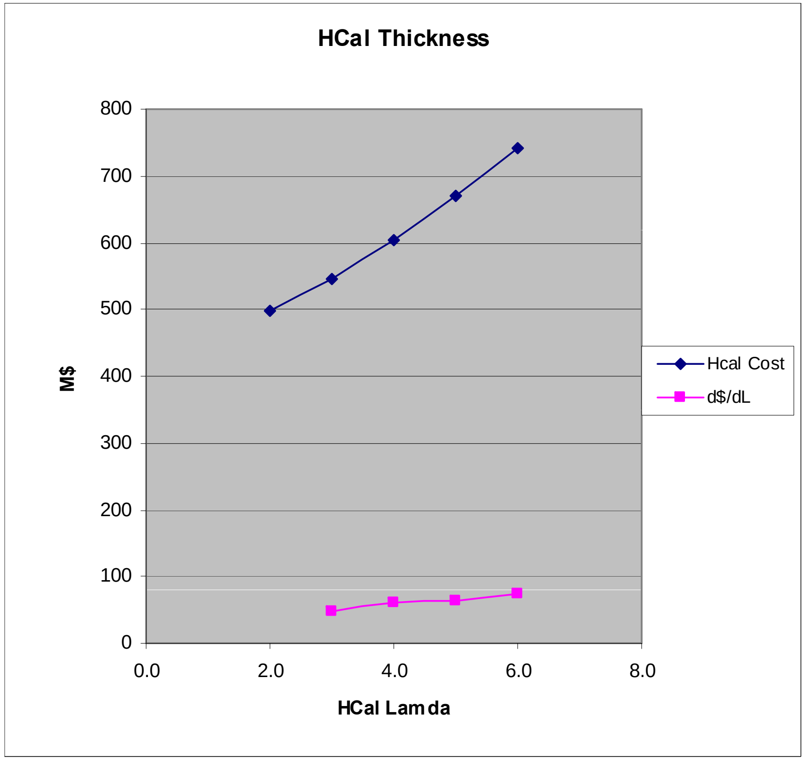
Accounting for SiD ≠ SiDish

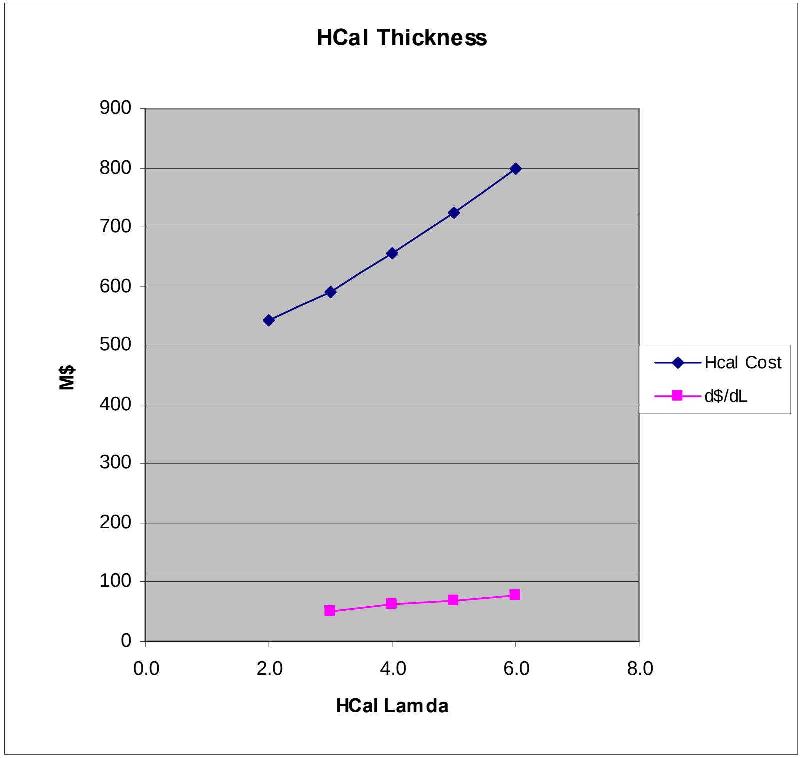
- We conservatively estimate that SiD's performance is 0%-20% worse than that of SiDish, to account for TPC/Si Tracker and Scint/RPC Hcal differences.



SiD Cost vs HCal Thickness

Rtrkr = 1.25, B=5 T





Ztrkr = 1.7

Ztrkr=2.05

EMCal Cost comments

- Baseline design + 2.05 m Ztrkr: 20 layers @ 2.5 mm
  10 layers @ 5.0 mm
  $679M
- Change to: 30 layers @ 1.4 mm
  10 layers @ 4.2 mm
  $732M

~$5M/layer (Si is not cheap!!!)

Status

- Still looks like SiD stretch – Rtrkr = 1.25 m, B = 5 T, λHcal = 4.5, Ztrkr 2.05 m - is on the high performance/high cost side of the performance vs cost "knee"
- Is the optimum different with a different PFA? Is there any case to push Ztrkr?
- Can we improve hcal segmentation information to refine the optimization?
- We have non PFA reasons to hold onto Rtrkr = 1.25 m and B = 5 T. Only the PFA (presumably not yet optimal for SiD) argues for thicker HCal and larger Ztrkr. Both are probably good for higher energy jets, but they are expensive:
  - Ztrkr = 1.7, λHcal = 4.0, cost = $605
  - Ztrkr = 1.7, λHcal = 4.5, cost = $628
  - Ztrkr = 2.05, λHcal = 4.5, cost = $680
- More work on higher jet energies is needed (ILC @ 1 TeV!)