SiD Cost Estimating

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Issues

Numbers

*Included suggestions on some unit prices and contingency. Added estimated indirects. Effect on bottom line ~7%

Issues

- Accounting Rules:
  - US versus European accounting:
    - US convention is to cost all technical labor –
      - Engineering
      - Technicians
      - Trades
      - But not faculty, physicists, students
    - European convention (appears to) cost none of the labor.
    - European system makes sense if adequate labor is permanently employed by the participating universities and labs – and conversely!!
    - Both systems cost full M&S.
  - Japanese accounting seems similar to European, except that there is relatively little “in-house” labor. Consequently labor appears to be costed M&S.

Other Costs

- Preliminary Engineering - is it a cost?
  - Conceptual design stage may well be considered R&D – as is generic detector R&D. The R&D is usually not included…
  - But there are substantial costs in all stages of development of complex systems:
  - Preliminary Engineering (???)
    - R&D
    - Design & Prototype
  - Final Engineering (Yes)
    - Production Engineering
    - Installation & Commissioning
  - Production (Yes)

Base and Contingency

- US convention is to generate base cost at ~66% confidence level, with explicit contingency that should take estimate to ~high 90's% confidence. (Confidence that project can be completed satisfactorily for the cost)
- European "style" appears to be less overt contingency, with more "hidden" in the base.

Escalation

- We all like to estimate in this year's $$.
- But inflation is real – and we will be judged by the sum of then year $$ that we spend.
- Particularly important because there will be a noticeable Δt between now and construction start.
- Assuming inflation at 3%/year (optimistic?) and construction start in 2011 (optimistic?), escalation is the second largest cost!

Indirects

- Indirects pay for services at the host institutions. Services include purchasing, legal, accounting, etc.
- We have used SLAC rates for large projects:
  - 6% on M&S
  - 20% on labor
- These rates may be optimistic. FNAL appears to be:
  - ~16% on M&S
  - ~30% on labor
- Assume that GDE will negotiate rational low rates (e.g. 6%, 20%) with participants.

Working Assumptions

- All technical labor included
- Contingency is explicit
- All engineering is included
- Indirects are included
- Escalation is included

- Comparison among detectors requires agreement on the accounting issues!

Uniform Unit Costs

- The detectors have significant technology overlap-
  - Superconducting solenoids
  - Si detectors
  - Fe flux returns
  - W calorimeter radiator
  - Large area detectors for HCal and muon systems
  - Etc

- We need a mechanism to develop a uniform (although not necessarily correct) basis for estimating unit costs for significant technologies…if inter-detector comparisons are to mean anything.
- Snowmass???

SiD Methodology

- A Work Breakdown Structure (WBS) has been developed:
  - 1.1 SiD
  - 1.1.1 VXD
  - 1.1.2 Tracking
  - 1.1.3 Calorimetry
  - 1.1.3.1 EMCal
  - 1.1.3.2 HCal
  - 1.1.4 Muon System
  - 1.1.5 Electronics
  - 1.1.6 Magnet
  - 1.1.7 Installation
  - 1.1.8 Management

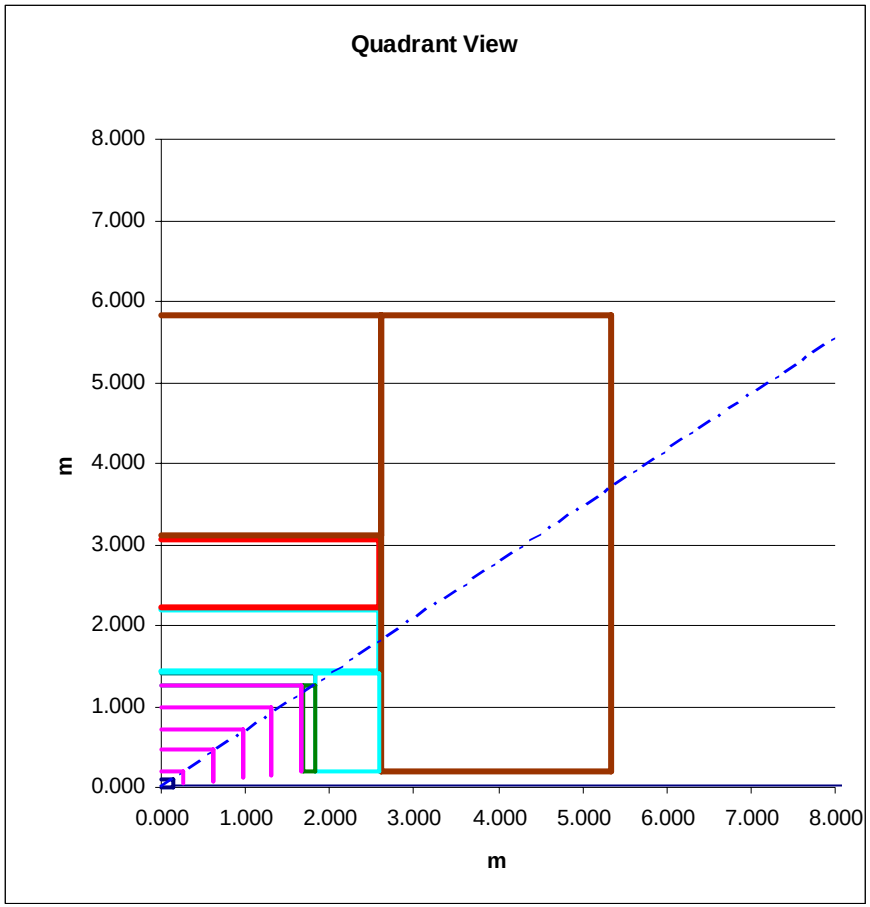
Fixed & Differential Costs

- In general, each subsystem has:
  - Fixed costs, such as engineering, assembly tooling, etc which scale weakly (or not at all) with reasonable variation of the detector parameters.
    - The fixed costs have been tabulated in the SLAC program WBS.
    - Labor is based on real SLAC costs with benefits.
    - Contingencies are estimated for each item.
  - Differential costs are those that scale with detector parameters, such as Tracker radius, HCal gap thickness, B, etc.
    - A self consistent SiD model is generated by the EXCEL program Parametric_Detectors_Test (MB).
    - Quantities of various materials and associated labor are estimated and multiplied by unit costs. Labor estimates are crude.
    - Contingency is applied as fixed fraction.

Caveats

- The estimates have ***not*** been reviewed.
- Every time the estimates have been re-visited, errors have been found. There is ***no*** reason to believe the errors are gone.
- The unit costs have ***no*** documented basis – there are no catalogs, bids, etc. – (but there is some experience).

SiD Cost baseline



Rtracker = 1.25 m

$Cos(\theta_{barrel}) = 0.8$

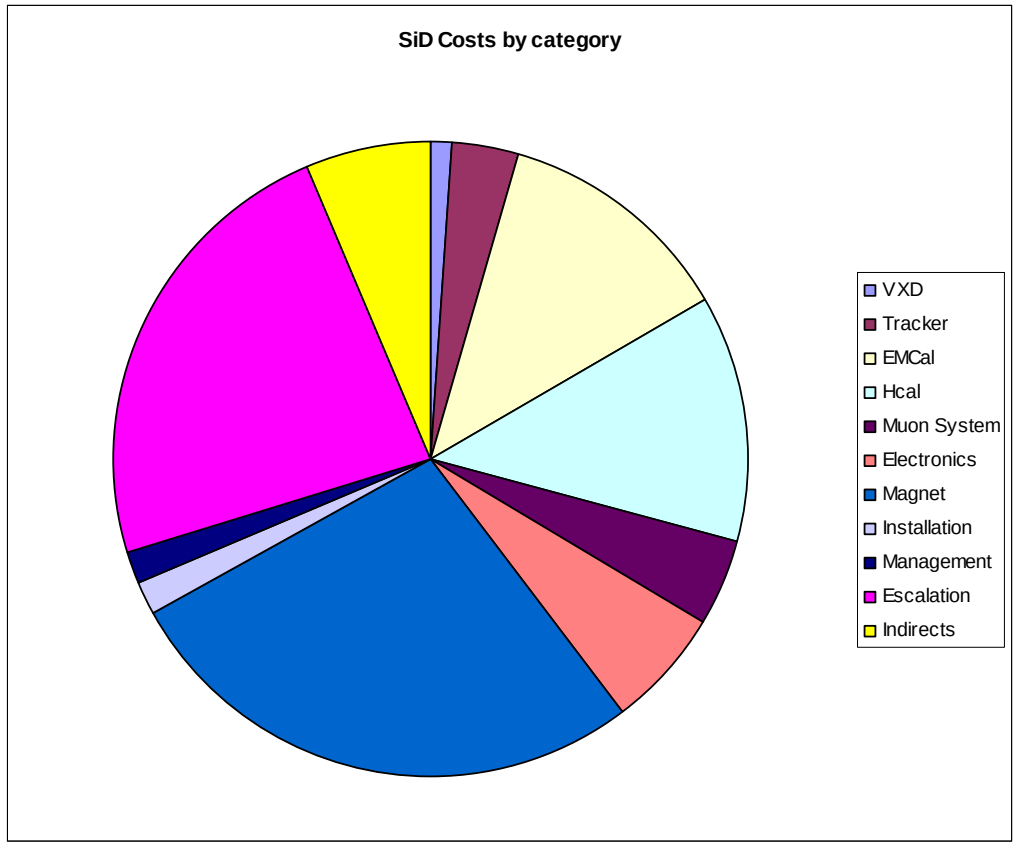
B = 5 T

Cal radiators are W

Hcal 4λ, 2X_0 (7mm)

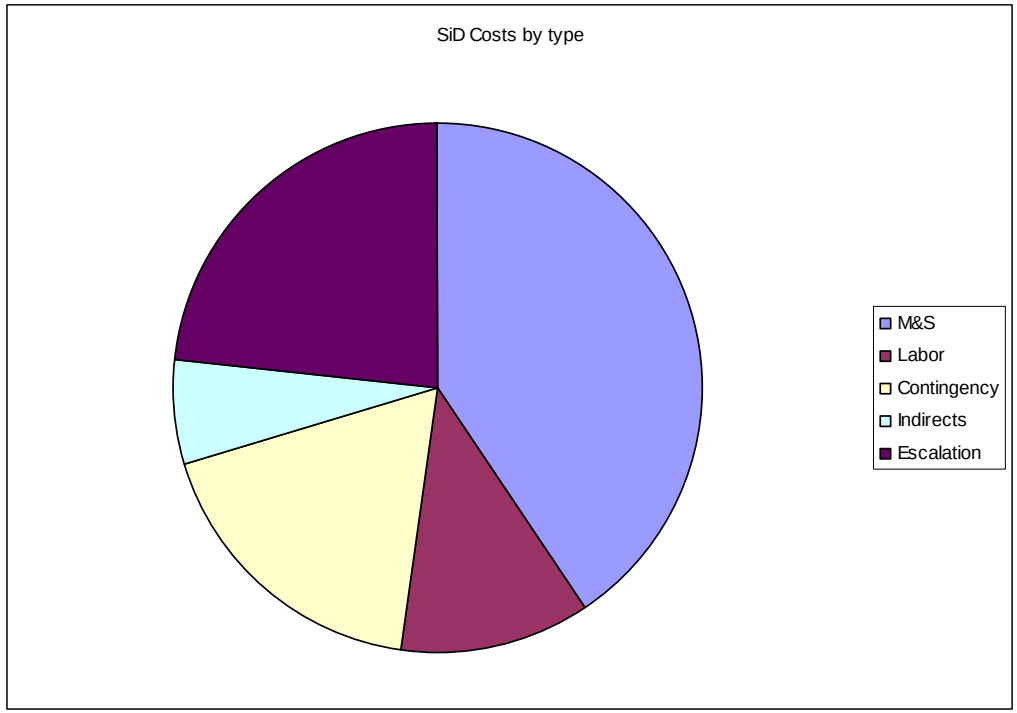
The Answer

Summary	
VXD	6.0
Tracker	19.9
EMCal	74.7
Hcal	74.2
Muon System	26.0
Electronics	37.5
Magnet	164.1
Installation	9.6
Management	9.4
Escalation	140.2
Indirects	38.5
Total	600.2



SiD Costs by type

SiD Costs by type	
M&S	$244
Labor	$70
Contingency	$107
Indirects	$39
Escalation	140.2
Total	$600



Some Analysis

	M&S	Labor	Totals
Base	$263	$73	$336
Contingency	$90	$25	$115
Total	$353	$97	$451
Indirect rates	0.06	0.20	
Indirects	$21	$19	$41
Totals w indirects	$375	$117	$491

Total Contingency		$115
Fraction of base=		0.25
Total Labor (inc contingency)		$97
Fraction of base =		0.22
base defined as M&S+Labor+contingency; no escalation, no indirects		

Total in FYXXXX M$	2005		***491.2***
Start Year	2011		
Construction Duration	6	years	
Inflation	1.03	per year.	
Factor	1.305		
Total Escalation			149.7
Total, TYM$			***641.0***

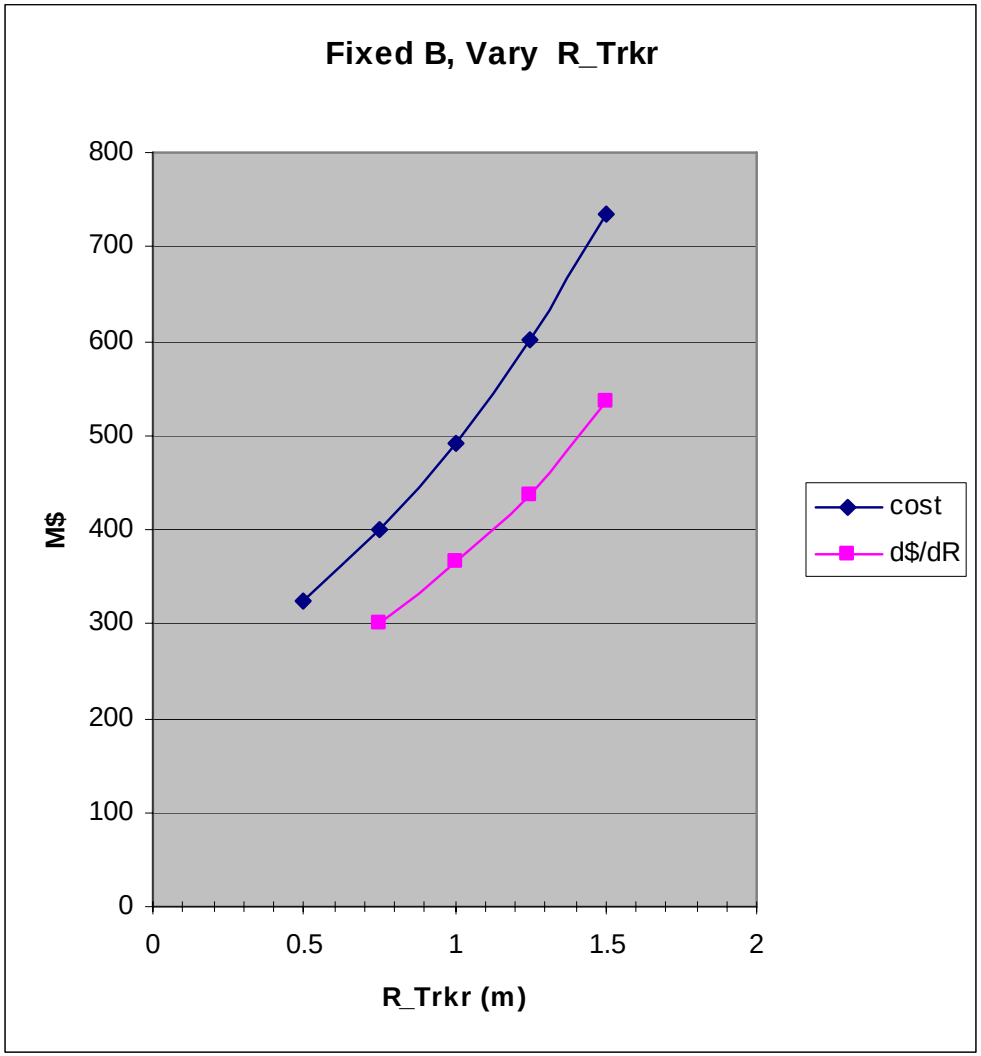
Cost Estimation

	Differential Costs								Fixed Costs		
item	*n*	*unit*	*unit cost*	*total m&s*	*subsystem total*	*associated unit labor*	*labor cost*	*total labor*	*M&S*	*M&S Contingency*	*Labor*
VXD									$4,000,000	$2,000,000	
Tracker					$2,965,290			834400	$3,940,000	$1,485,000	$6,624,400
Trkr Si	55.6	m^2	20000	$1,111,600							
Trkr ROC's	5788.0	ea	100	$578,800		100	$578,800				
Trkr Electronic Clusters	455.5	ea	580	$264,208							
Trkr Si EC	24.5	m^2	20000	$490,874							
Trkr EC ROC's	2556.0	ea	100	$255,600		100	$255,600				
Trkr Electronics Clusters EC	455.5	ea	580	$264,208							
EMCal					$40,086,252			$8,917,609	$1,000,000	$100,000	$5,224,400
EM Cal si	912.6	m^2	20000	$18,252,562							
Em Cal si endcap	294.1	m^2	20000	$5,881,910							
EMCal ROC's	89176.1	ea	100	$8,917,609		100	$8,917,609				
EM Cal W	0.0	kg	0	$5,250,650							
EMCal Electronic Clusters	891.8		2000	$1,783,522							
Hcal					$47,634,918			$981,556	$1,000,000	$100,000	$5,222,400
Hcal Detectors	3926.2	m^2	2000	$7,852,449		250	$981,556				
HCAL Rad	4.38E+05	kg	75.0	$32,837,142							
HCAL Rad endcap	9.26E+04	kg	75.0	$6,945,328							
Muon System					$14,340,404			$1,792,550	$1,000,000	$500,000	$1,970,060
Muon Chambers	7170	m^2	2000	$14,340,404		250	$1,792,550				
Electronics									$7,758,400	$1,654,600	$21,639,330
Magnet					$108,892,440				$7,687,500	$1,860,250	$5,642,201
Coil				$86,309,358							
Fe	2.34E+06	kg	3.48	$8,127,598							
Fe endcap	3.3E+06	kg	3.48	$11,509,864							
Fe additional (1)	8.46E+05	kg	3.48	$2,945,619							
Installation									$2,617,800	$522,320	$4,746,050
Management									$921,000	$171,700	$6,780,700
Total Costs(M$) by category					**$214**			**$12.53**	**$29.9**		**$57.8**
Contingencies by category	35	%			**$75**			**$4.38**		**$8.4**	

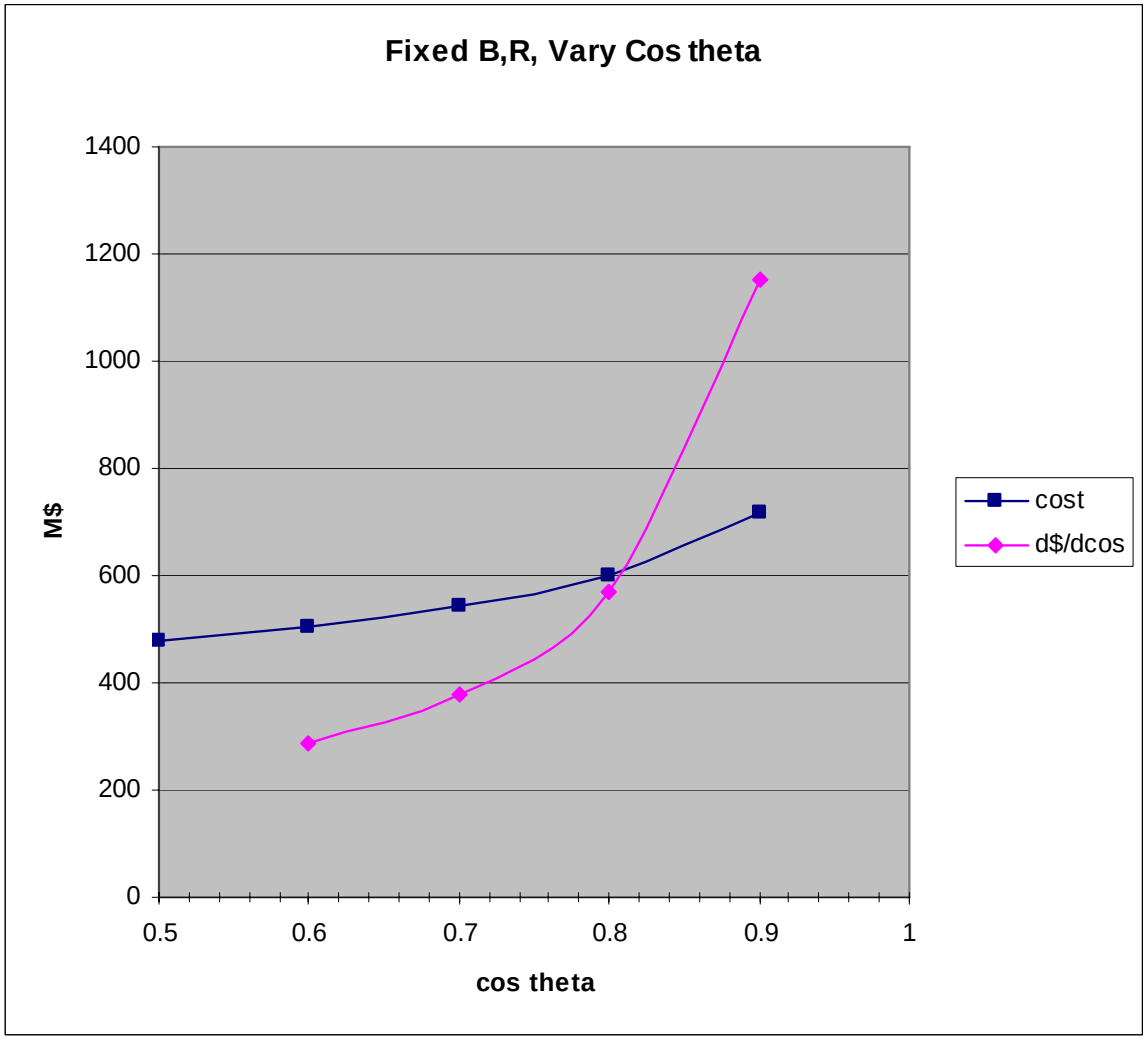
Some Critical Unit Costs

• Solenoid	$0.81E(MJ)^{0.662}M\$$	
• Si Detector	$\$2/cm^2$	Hamamatsu hint
• Tracker & EMCal		
Read Out Chips (ROC)	$100 each	TSMC fab should be <$40
• HCal W (7mm)	$75/Kg	extrapolation from quote on thinner material.
• HCal Detector	$\$2000/m^2$	Babar RPC + square pixel readout
• Magnet iron	$3.48/Kg	Babar Kawasaki experience. Note iron is a commodity with big fluctuations.

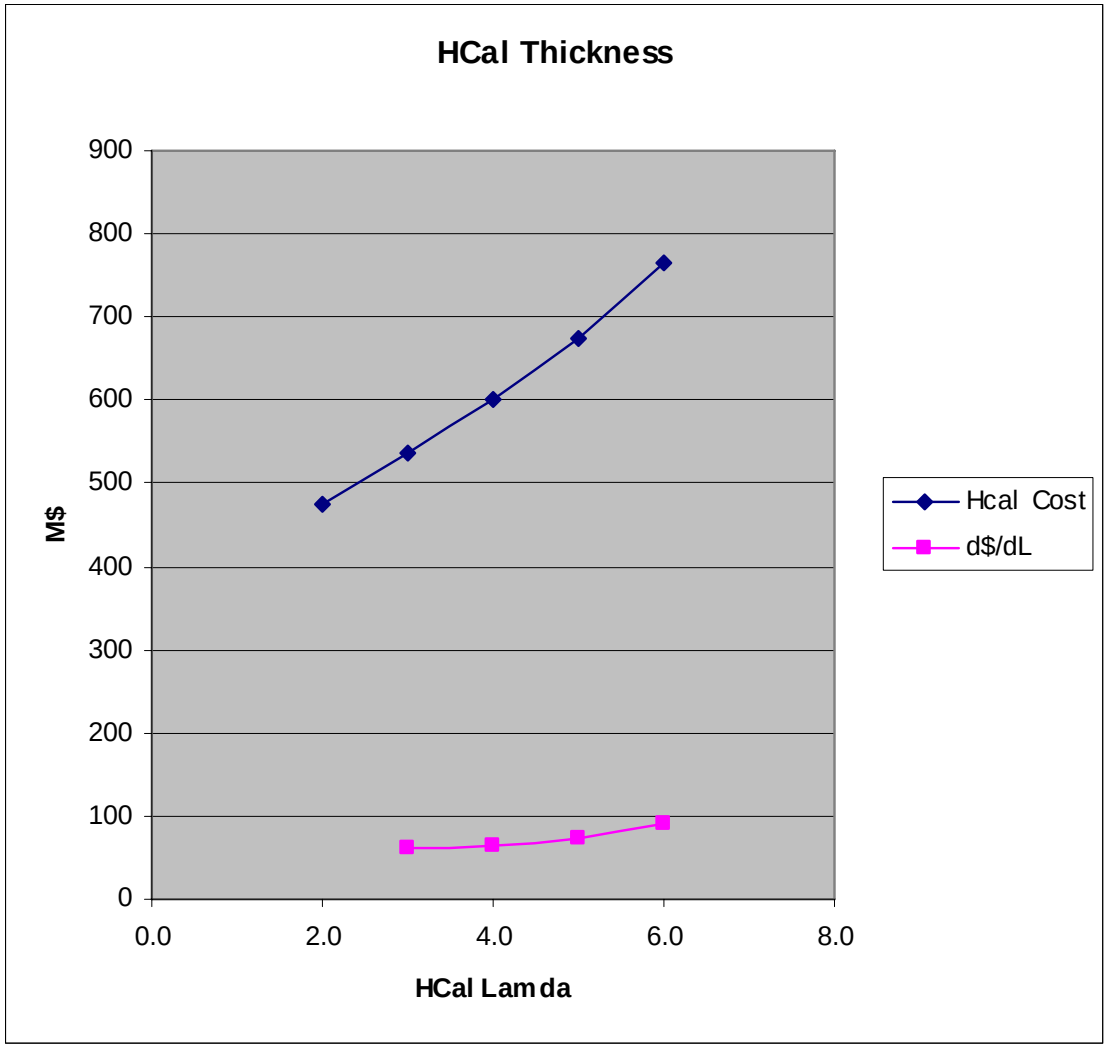
Variations – R_Trkr



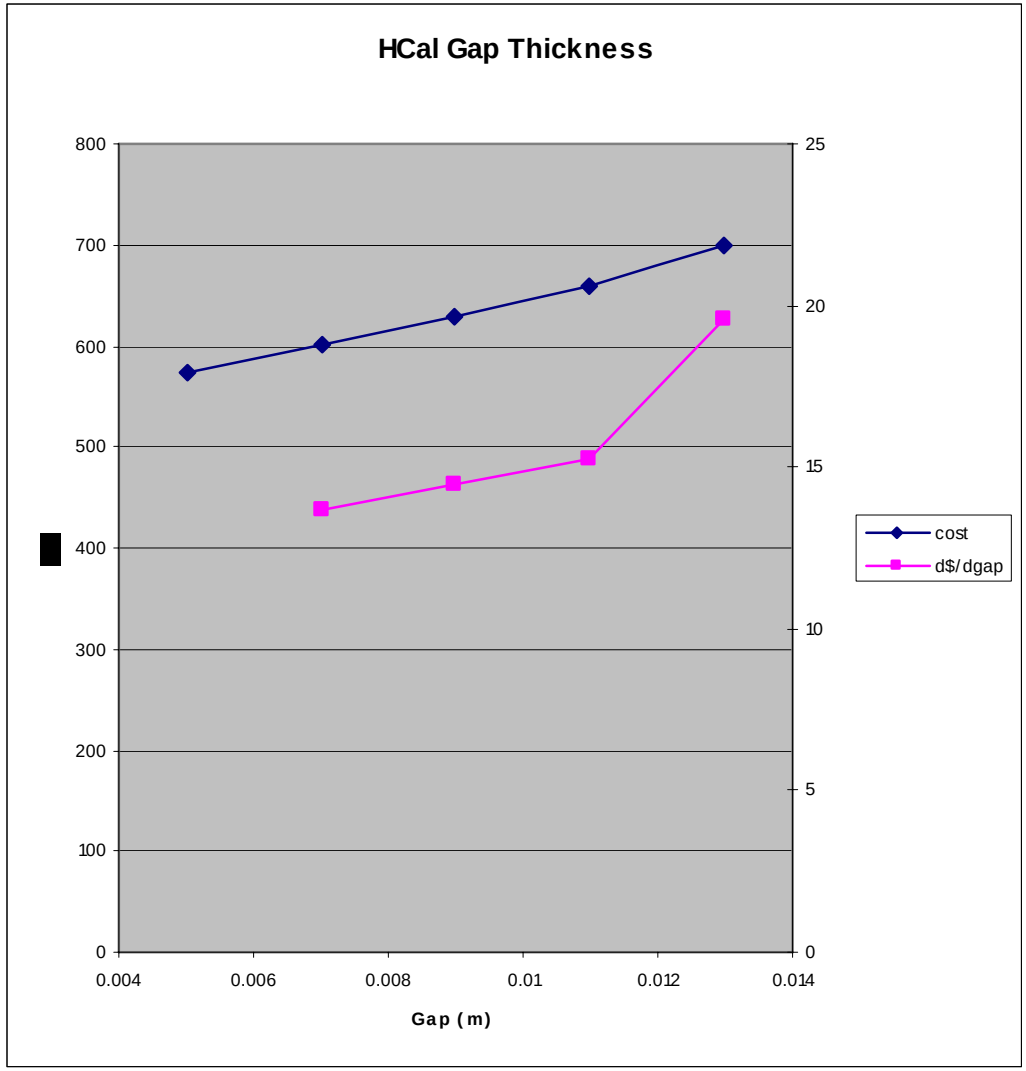
Variations – Cos(θ_{Barrel})



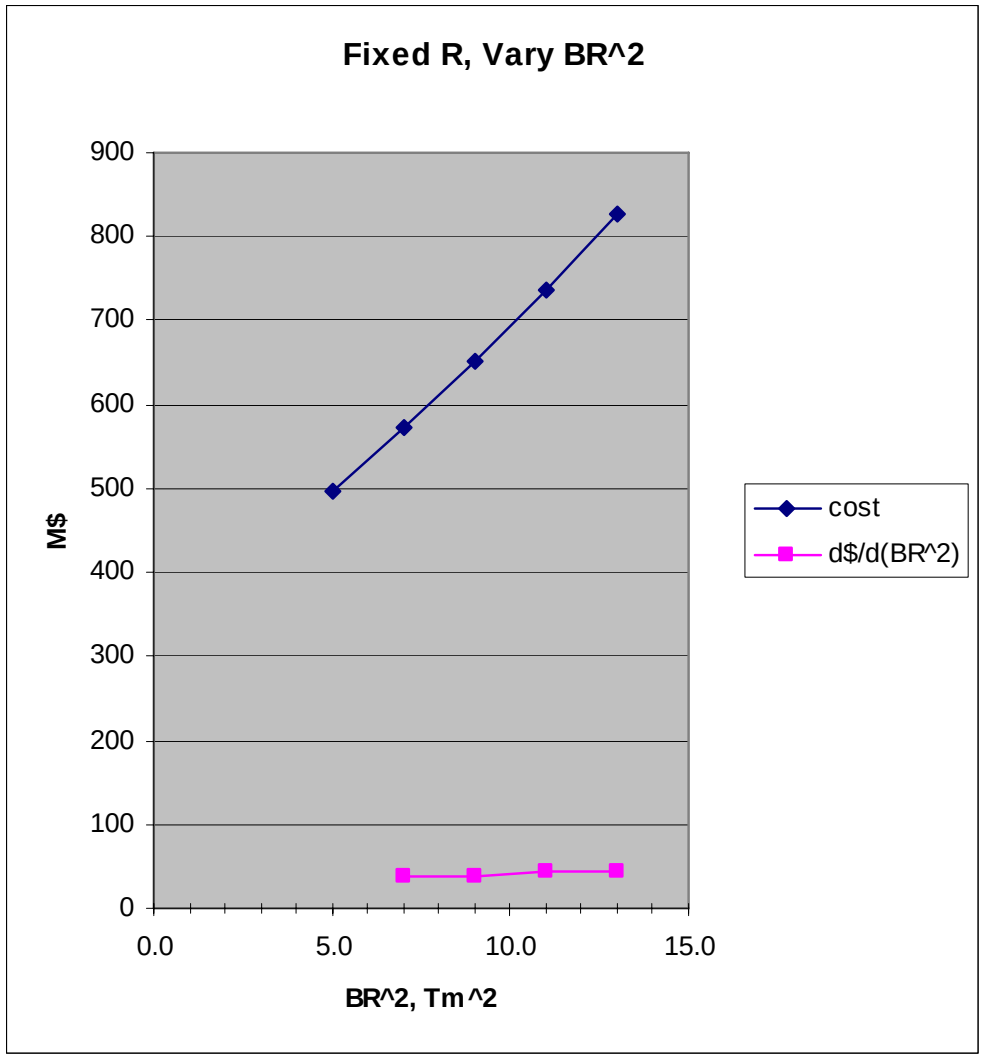
Variations – HCal Thickness (Interaction lengths)



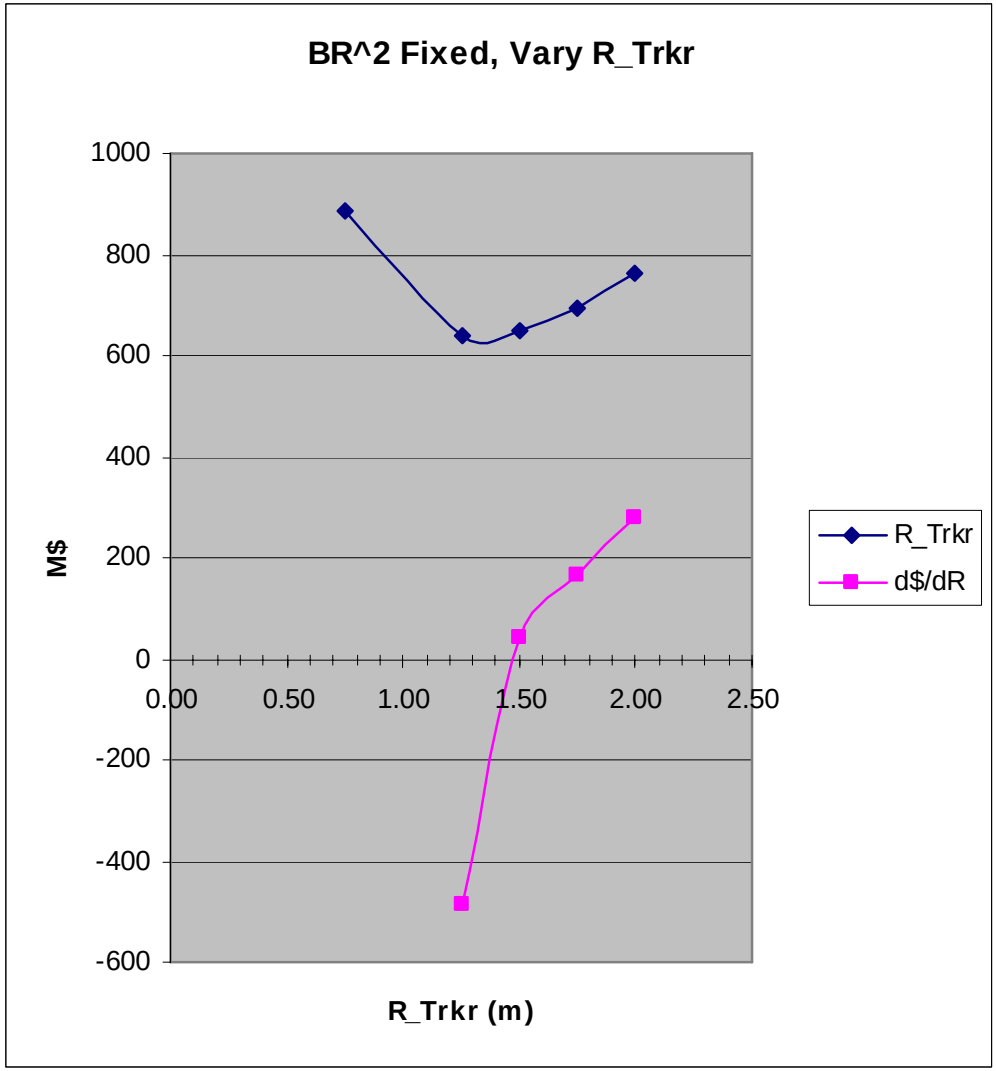
Variations – HCal Detector Gap



R_{Trkr} fixed, vary BR^2



BR^2 Fixed, Vary R_{Trkr}



Conclusions

- The “rules” matter.
- This estimate is not even version 0.
- The derivatives are probably not wildly wrong.
- Everything is sensitive to the important unit costs.
- A lot more work is needed.
- SiD may well cost ½ of 10% of the ILC!!!