

SiD Cost Estimating

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Issues

Numbers

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- 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.

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.

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)

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 ~the single largest cost!

Working Conclusions

- All technical labor included
- Contingency is explicit
- All engineering is 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

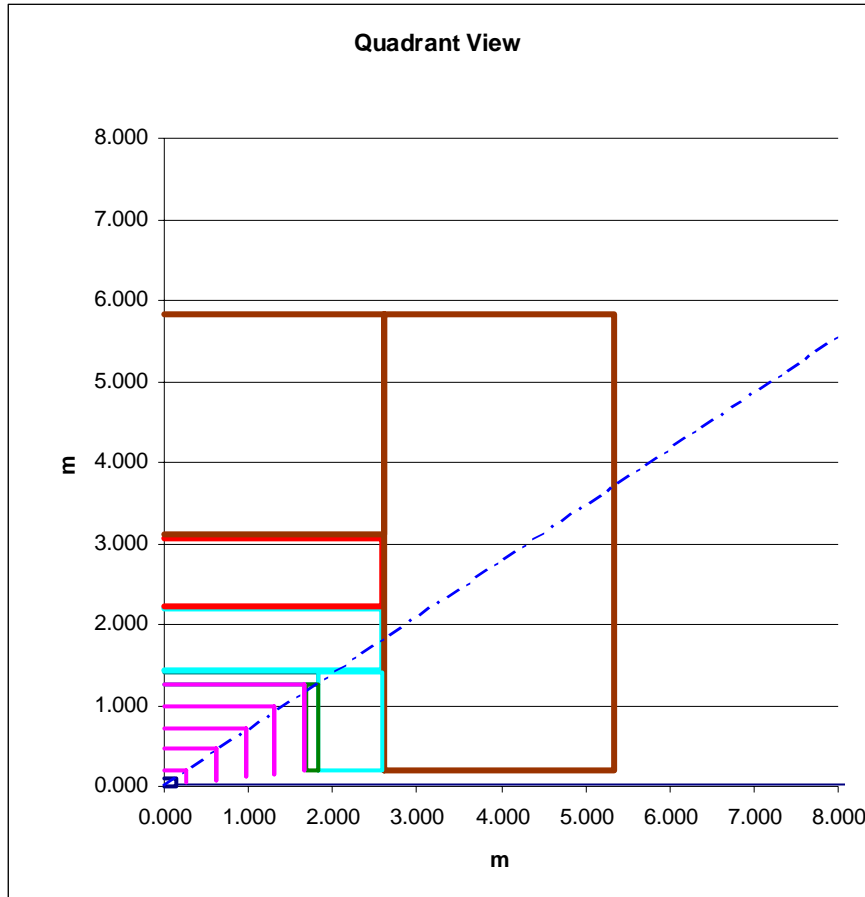
Fixed & Differential Costs

- 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, but no indirects.
 - 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.
 - 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



$R_{\text{tracker}} = 1.25 \text{ m}$

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

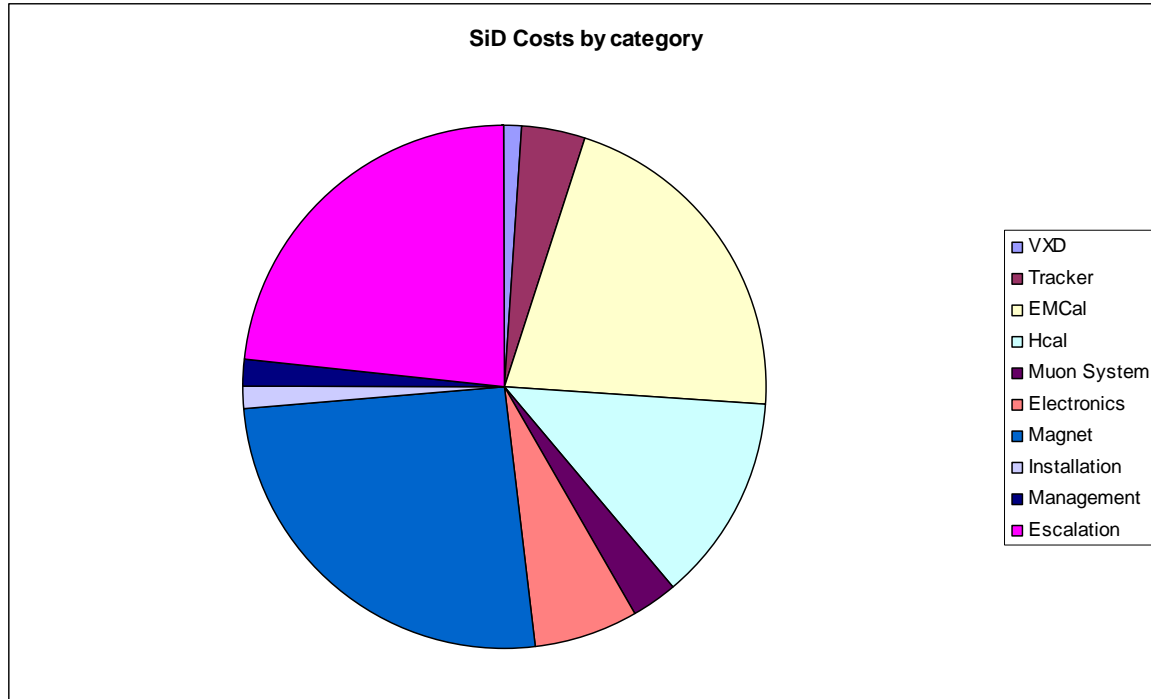
$B = 5 \text{ T}$

Cal radiators are W

$H_{\text{cal}} 4\lambda, 2X_0 (7\text{mm})$

The Answer

Summary	
VXD	\$6,000,000
Tracker	\$24,321,293
EMCal	\$127,950,922
Hcal	\$78,326,882
Muon System	\$18,042,628
Electronics	\$37,510,256
Magnet	\$155,790,165
Installation	\$9,563,553
Management	\$9,368,695
Escalation	\$142,290,795.3
Total	\$609,165,188



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
1.1.1	VXD								\$4,000,000	\$2,000,000	
1.1.2	Tracker				\$6,779,178			834400	\$3,940,000	\$1,485,000	\$6,624,400
	Trkr Si	55.6 m^2	67600	\$3,757,209							
	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	67600	\$1,659,154							
	Trkr EC ROC's	2556.0 ea	100	\$255,600		100	\$255,600				
	Trkr Electronics Clusters EC	455.5 ea	580	\$264,208							
1.1.3.1	EMCal				\$86,571,673			\$8,917,609	\$1,000,000	\$100,000	\$5,224,400
	EM Cal si	912.6 m^2	60000	\$54,757,685							
	Em Cal si endcap	294.1 m^2	60000	\$17,645,729							
	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									
1.1.3.2	Hcal				\$54,810,094			\$981,556	\$1,000,000	\$100,000	\$5,222,400
	Hcal Detectors	3926.2 m^2	450	\$1,766,801		250	\$981,556				
	HCAL Rad	4.38E+05 kg	100.0	\$43,782,856							
	HCAL Rad endcap	9.26E+04 kg	100.0	\$9,260,437							
1.1.4	Muon System				\$7,091,640			\$3,939,800	\$1,000,000	\$500,000	\$1,970,060
	Muon Chambers	15759 m^2	450	\$7,091,640		250	\$3,939,800				
1.1.5	Electronics								\$7,758,400	\$1,654,600	\$21,639,330
1.1.6	Magnet				\$110,943,950				\$7,687,500	\$1,860,250	\$5,642,201
	Coil			\$86,126,568							
	Fe	2.42E+06 kg	3.48	\$8,424,604							
	Fe endcap	3.8E+06 kg	3.48	\$13,155,728							
	Fe additional (1)	9.30E+05 kg	3.48	\$3,237,050							
1.1.7	Installation								\$2,617,800	\$522,320	\$4,746,050
1.1.8	Management								\$921,000	\$171,700	\$6,780,700
	Total Costs(M\$) by category				\$266			\$14.67	\$29.9		\$57.8
	Contingencies by category	25 %			\$67			\$3.67		\$8.4	
	Total Base, no contingency	WBS SiD May 05		368.6							
	Total Contingency			98.2							
	Total in FYXXXX M\$	2005		466.9							

Totals:

Some analysis

Total Contingency \$98

Fraction of base= 0.27

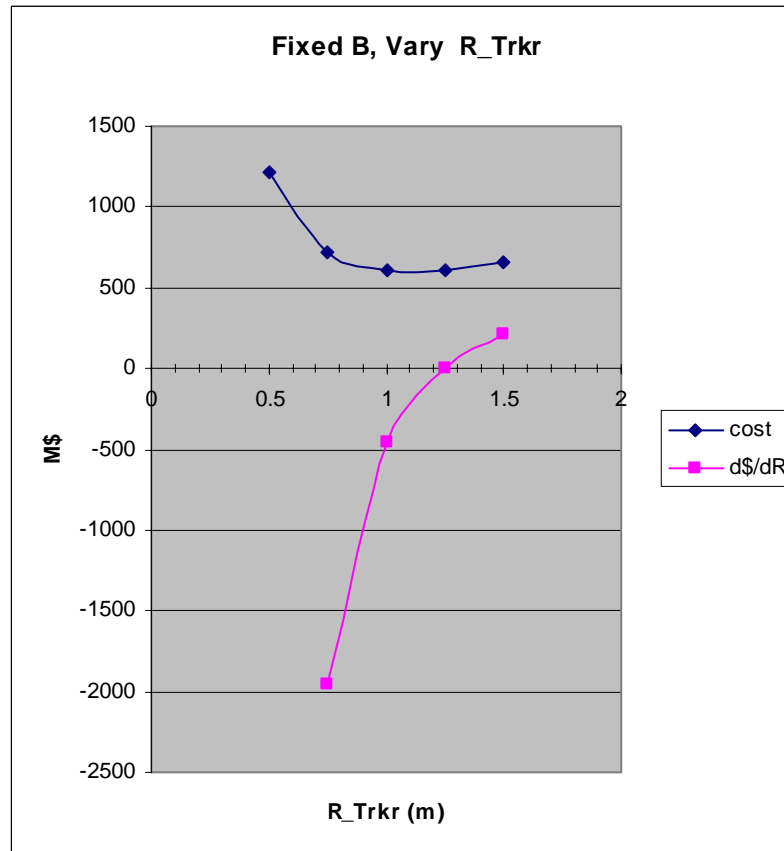
Total Labor (contingency) \$96

Fraction of base = 0.21

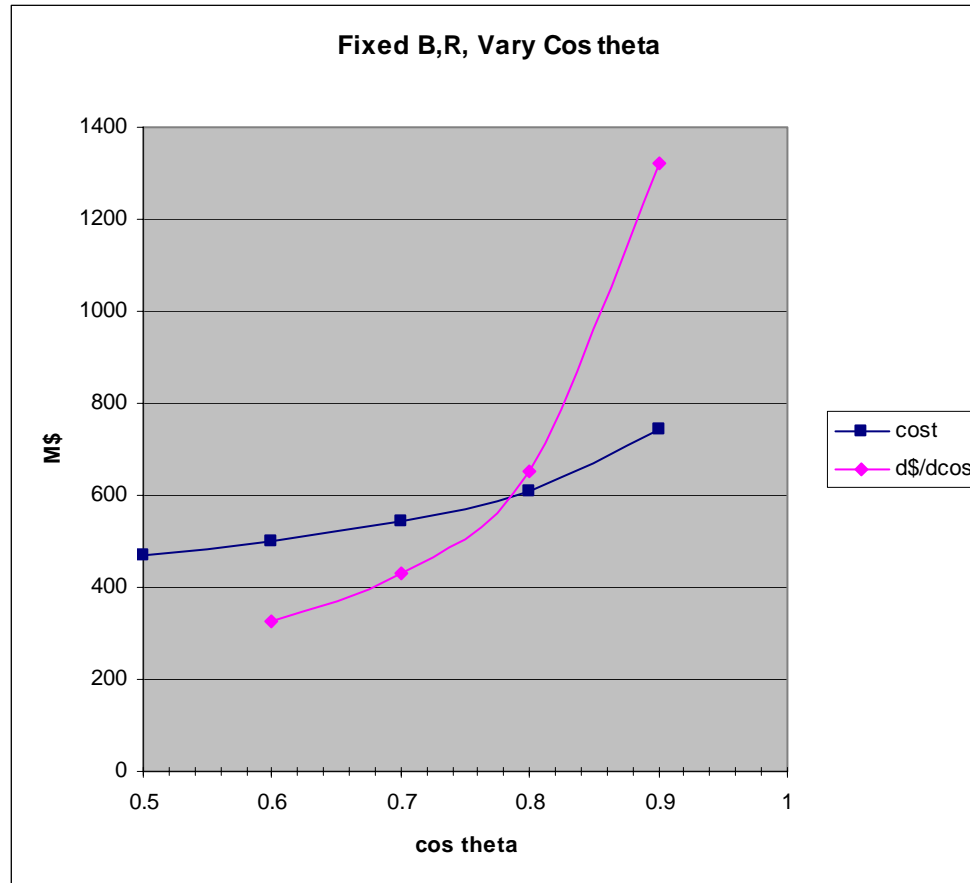
Some Critical Unit Costs

- Si Tracker Detector \$6.76/cm²
- Si EMCal Detector \$6.00/cm²
- Electronics ROC \$100 + \$100 install
- HCal W \$100/kG
- Solenoid $0.81E(MJ)^{0.662}M\$$
- HCal, Muon Detectors \$450/m²
- Magnet Fe \$3.48/kG

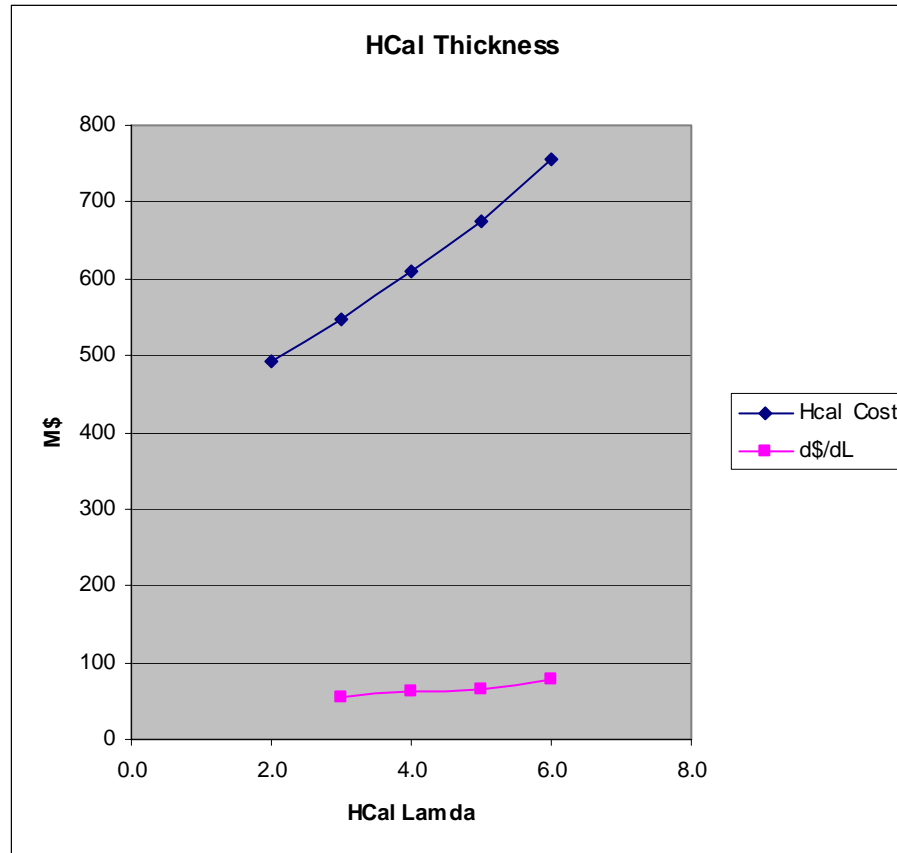
Variations - R_Trkr



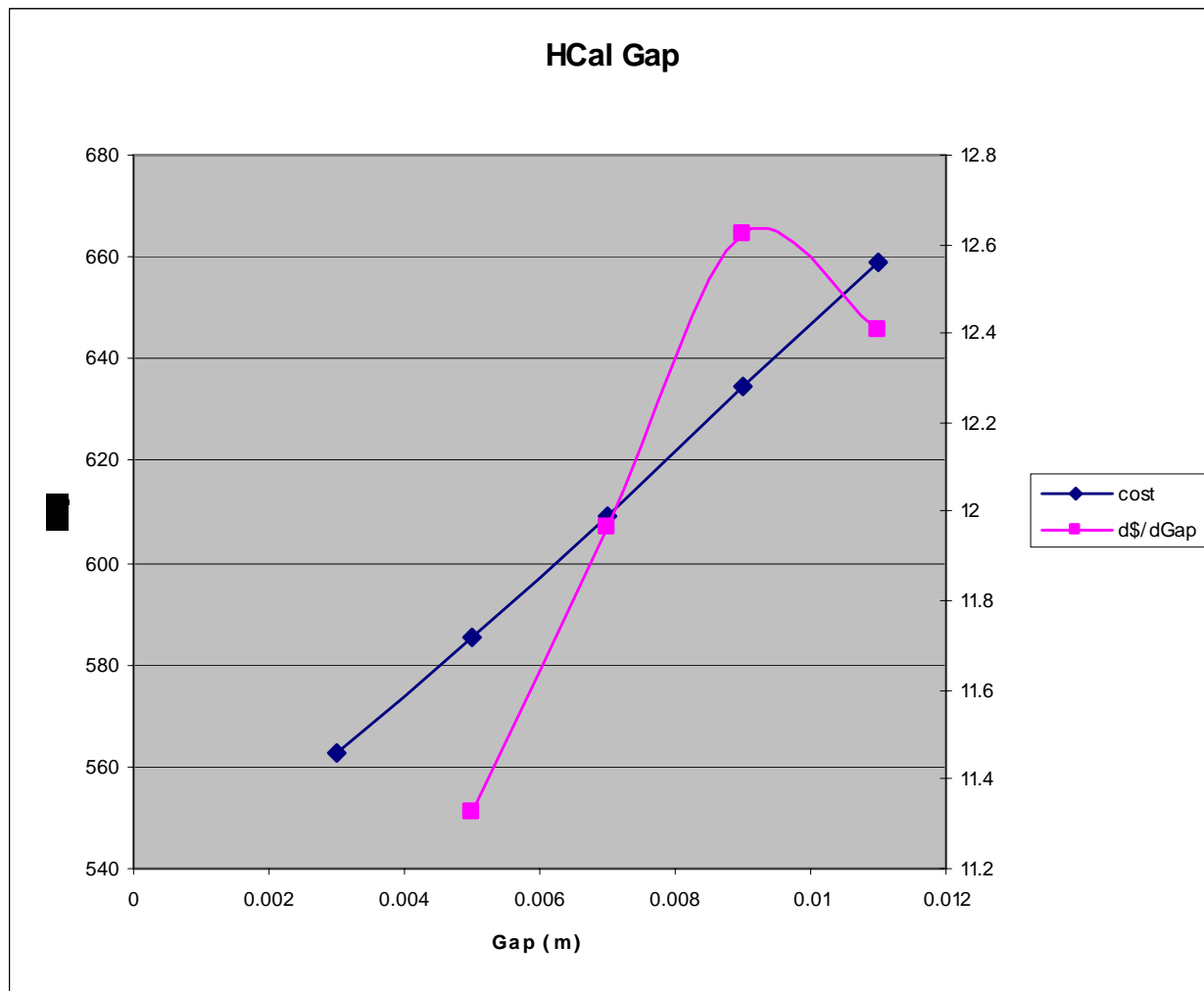
Variations - $\text{Cos}(\theta_{\text{Barrel}})$



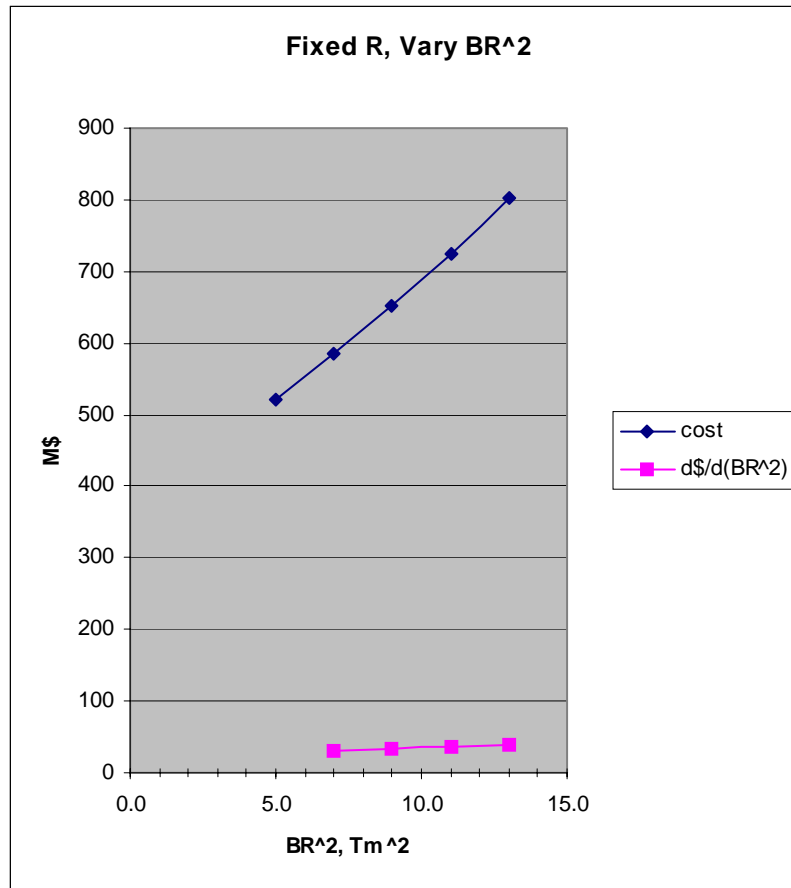
Variations - HCal Thickness (Interaction lengths)



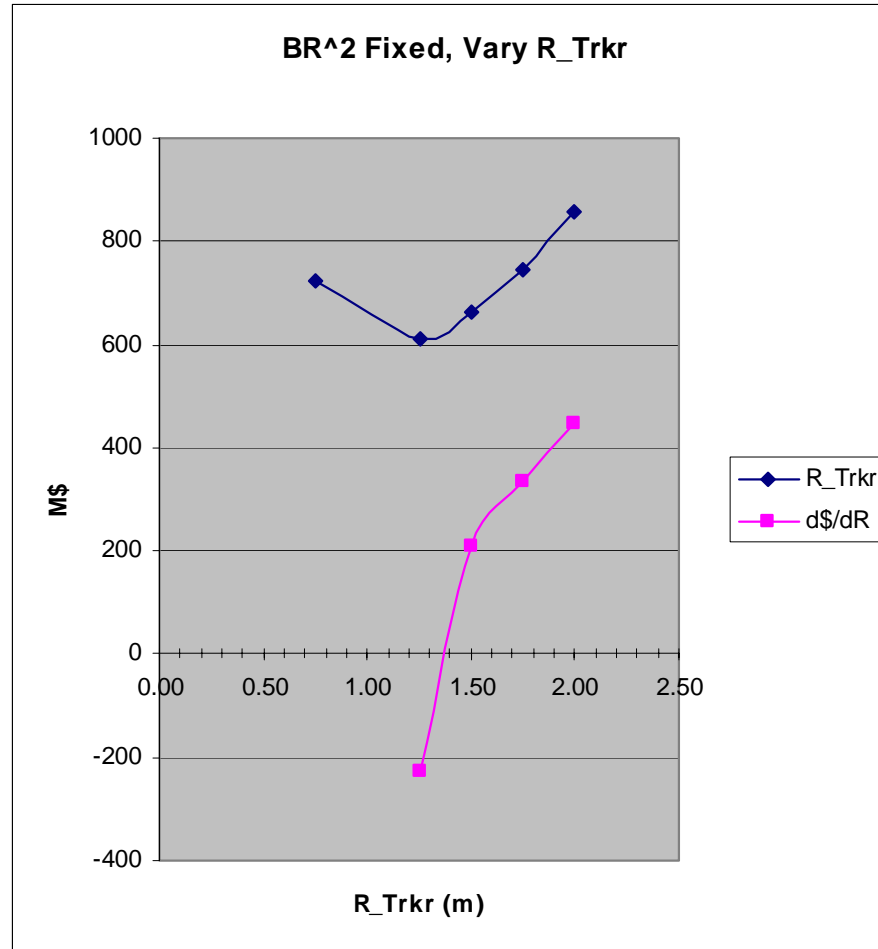
Variations - HCal Detector Gap



R_{Trkr} fixed, vary BR^2



BR² Fixed, Vary R_{Trkr}



Conclusions

- 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 $\frac{1}{2}$ of 10% of the ILC!!!