1.1.3	Tracker	1 each	@CF=Tracker	15,446,950	5,869,383	11,473,252	4,015,638	36,805,223
1.1.3.1	Tracker ED&I	1 each		0	0	7,761,320	2,716,462	10,477,782
1.1.3.1.1	Mechanical Engineer	20 man year		0	0	140,000	49,000	3,780,000
1.1.3.1.2	Mechanical Designer	10 man year		0	0	91,520	32,032	1,235,520
1.1.3.1.3	Mechanical Tech	40 man year	WAG	0	0	101,153	35,404	5,462,262
1.1.3.2	Tracker Mechanics	1 each		2,900,000	1,375,000	1,200,325	420,114	5,895,439
1.1.3.2.1	Tracker Space Frame, Barrel	1 lot		1,250,000	625,000	0	0	1,875,000
1.1.3.2.2	Outer Endcap Frame[0]	2 lot		250,000	125,000	0	0	750,000
1.1.3.2.3	Tracker Cooling	1 lot		150,000	150,000	0	0	300,000
1.1.3.2.4	Tracker Alignment System	1 each		1,000,000	350,000	0	0	1,350,000
1.1.3.2.5	Mechanical Engineer	3 man year		0	0	140,000	49,000	567,000
1.1.3.2.6	Mechanical Designer	3 man year		0	0	91,520	32,032	370,656
1.1.3.2.7	Mechanical Tech	5 man year		0	0	101,153	35,404	682,783
1.1.3.3	Tracker Silicon Detectors	1 each		11,546,950	4,244,383	2,511,607	879,063	19,182,003
1.1.3.3.1	Barrel	1 each		6,340,450	2,341,108	1,531,015	535,855	10,748,428
1.1.3.3.1.1	Tracker Barrel Module	8,130 each	Parametric	665	248	188	66	9,487,528
1.1.3.3.1.1.1	Tracker Silicon	0.01 Sq.m.		30,000	10,500	0	0	405
1.1.3.3.1.1.2	Tracker Module Mechanics Barrel	1 each		65	23	0	0	88
1.1.3.3.1.1.3	Tracker KPiX	1 each		100	35	0	0	270
1.1.3.3.1.1.4	Tracker Cable	1 each		100	50	0	0	150
1.1.3.3.1.1.5	Mechanical Tech	2 man hour		0	0	54	19	145
1.1.3.3.1.1.6	Procurement Officer	1.5 man hour		0	0	54	19	109
1.1.3.3.1.2	Level 1 Concentrator, Tracker	467 each		2,000	700	0	0	1,260,900
1.1.3.3.1.3	Level 2 Concentrator, Tracker	1 each		0	0	0	0	0
1.1.3.3.2	Endcaps	2 each		2,603,250	951,638	490,296	171,604	8,433,575
1.1.3.4	Tracker Integration	1 lot		1,000,000	250,000	0	0	1,250,000

SiD LoI Costs

M. Breidenbach

Outline

- Parametric Model
- Work Breakdown Structure
- What is a cost?
- What is excluded?
- What is the answer (for now)?
- Effect of detector variations.
- Cost Sensitivity to selected "commodity" inputs.
- WBS examples
- Supercoil cost estimating

Parametric Model

- Self consistent Excel model of SiD
  - e.g. tracking layers and disks adjusted to fit allocated space
  - Calorimeters adjusted to nest properly with the tracker
  - Solenoid is adjusted for its radius and field
  - Iron is adjusted to return the flux.
- Fundamental parameters can be varied:
  - e.g Tracker radius and aspect ratio; N layers
  - Calorimeter N layers, thickness, materials, gaps
- Costs calculated for each system:
  - Cost driving component counts are calculated
    - e.g. tungsten plate area, silicon detectors, and KPiX for the EMCal
  - Model has cost tables for these M&S items and associated tech labor in hours
  - Costs that are ~fixed, e.g. engineering or fixturing, are imported from the Work Breakdown Structure.
- Macros allow easy variation of parameters to calculate cost derivatives.

Work Breakdown Structure

- Hierarchical structure breaking down SiD to "recognizable and understandable" units.
- Separate tables for purchased M&S and labor.
- Contingencies for each item, propagated through the WBS.
- Cost are estimated in 2008 US$.
- Labor both costed in $ and summed by man-years.
- Labor is estimated in ~50 different types, e.g. Project Engineer, plumber, iron worker – and condensed to the ILC categories Engineering, Technical, and Administrative.
- The "ILC" style cost is defined here as the base M&S cost without contingencies, plus the labor in man-years in the 3 categories.

U.S. DOE style costing

- Contingencies are assigned to M&S and labor
  - Allows extra funding to hold a schedule in the face of unforeseen problems.
  - Fund items that were missed in the estimate
  - Provide some relief from under-estimates
- Transform labor to $ value using SLAC salary numbers including benefits, but not overhead.
- Compute indirects as fraction pf M&S and Labor. SLAC large Project numbers are used.
- Escalation (inflation) calculated assuming a start date, a 6 year construction cycle, and an inflation rate.
  - Assume 2016 start, inflation = 3.5%/year
  - These assumptions are uncertain
  - The escalation is substantial

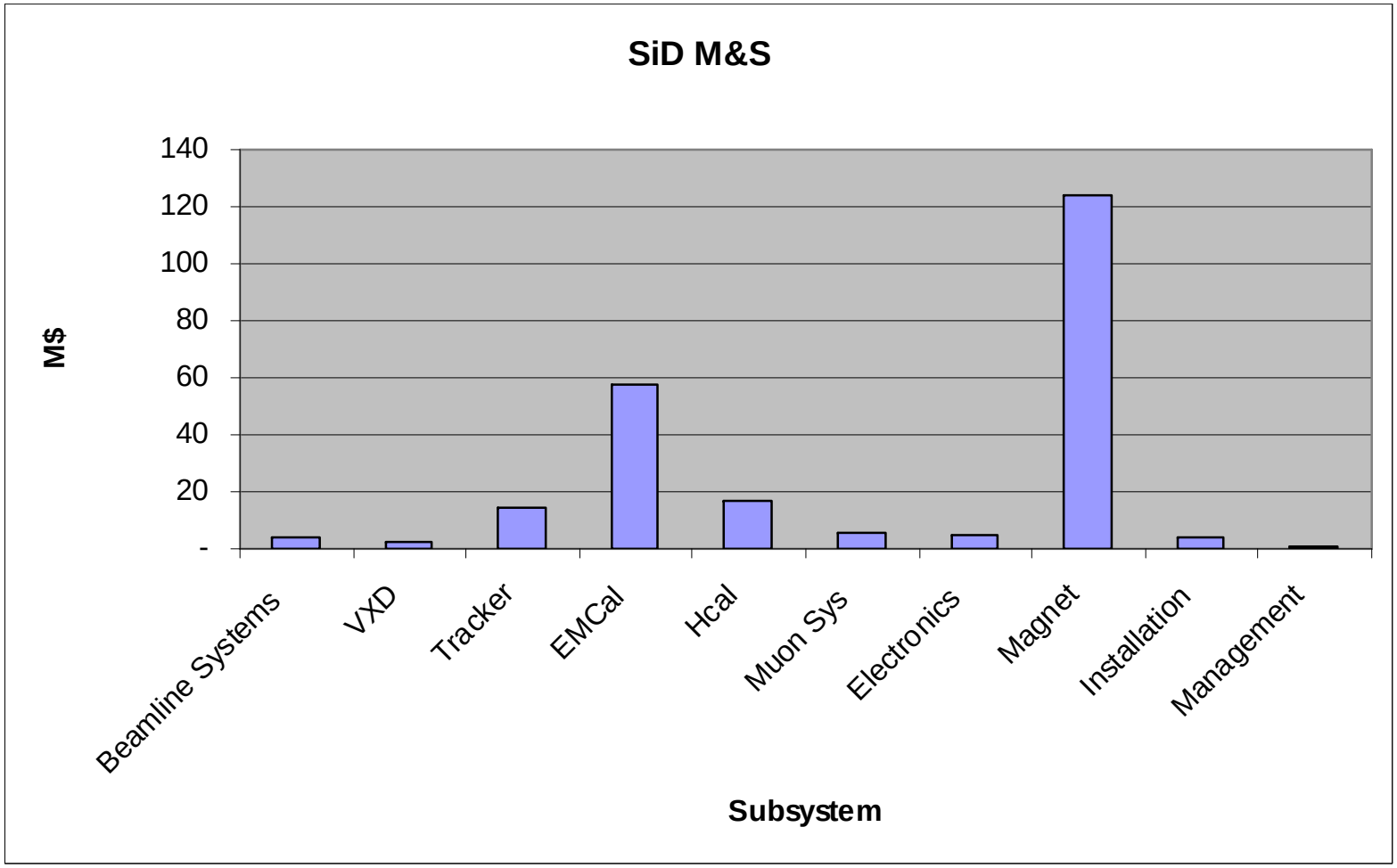
Interface Assumptions

- IR Hall, with finished floor & walls, lighting, and HVAC are provided by ILC.
- Utilities, including 480 VAC power, LCW, compressed air, and internet, are provided on the hall wall.
- External He compressor system with piping to the hall is provided. The refrigeration and associated piping is an SiD cost.
- Any surface buildings, gantry cranes, and hall cranes are provided by ILC.
- Data storage and offline computing are provided by others.
- Detector motion rails (both for push-pull and detector opening in beamline and garage positions) are installed by SiD in suitable channels provided by ILC.

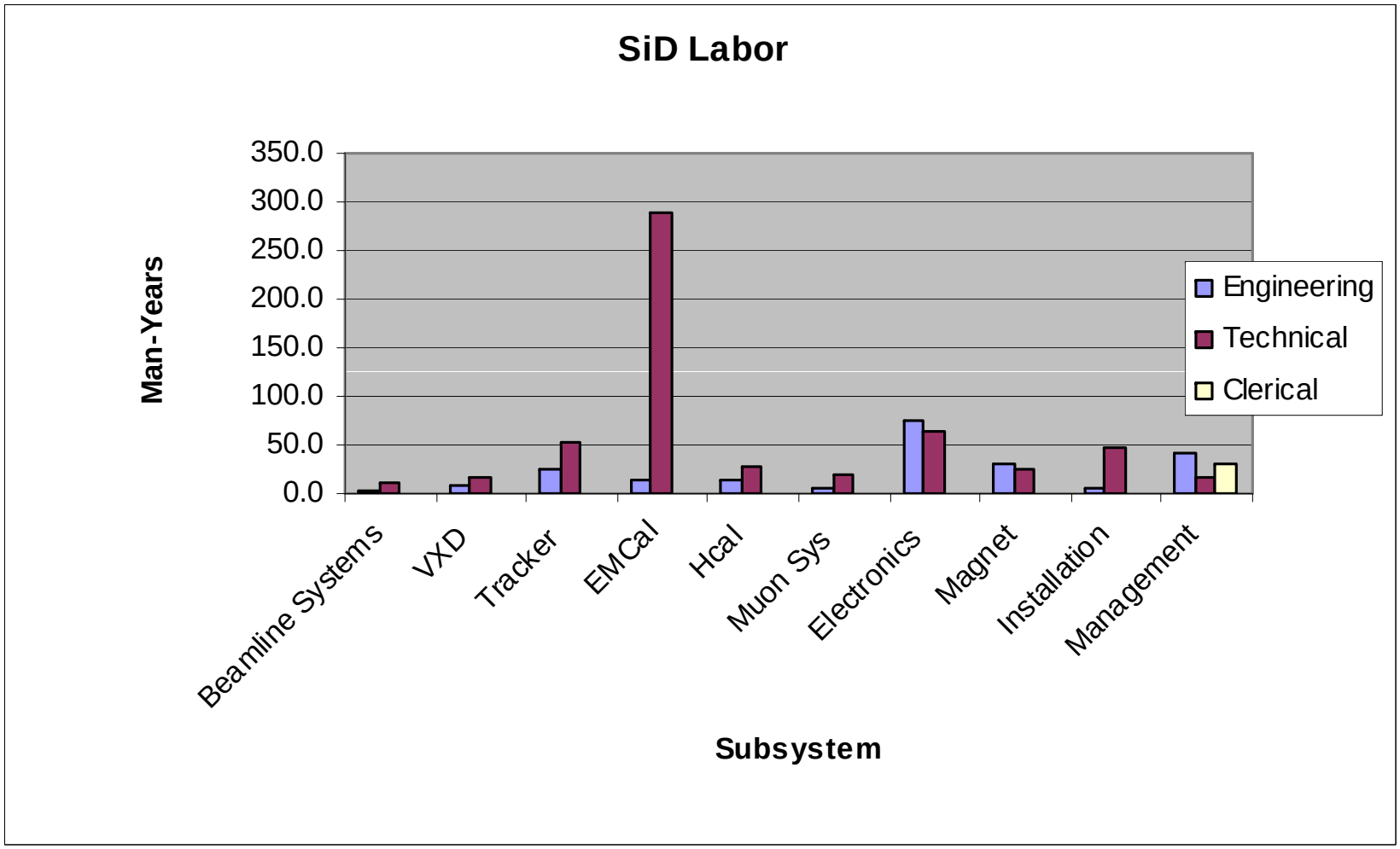
SiD Cost Summary

		M&S Base (M$)	M&S Contingency (M$)	Engineering (MY)	Technical (MY)	Administrative (MY)
1.1.1	Beamline Systems	$ 3.68	$ 1.42	4.0	10.0	0.0
1.1.2	VXD	$ 2.80	$ 2.04	8.0	17.7	0.0
1.1.3	Tracker	$ 14.45	$ 5.71	24.0	53.2	0.0
1.1.4	EMCal	$ 57.74	$ 23.02	13.0	287.8	0.0
1.1.5	Hcal	$ 16.72	$ 6.15	13.0	28.2	0.0
1.1.6	Muon Sys	$ 5.35	$ 1.65	5.0	20.1	0.0
1.1.7	Electronics	$ 4.90	$ 1.65	76.3	63.8	0.0
1.1.8	Magnet	$ 123.74	$ 42.58	29.2	25.0	0.0
1.1.9	Installation	$ 4.10	$ 1.08	4.5	46.0	0.0
1.1.10	Management	$ 0.92	$ 0.17	42.0	18.0	30.0
Totals		$ 234	$ 85	219	570	30

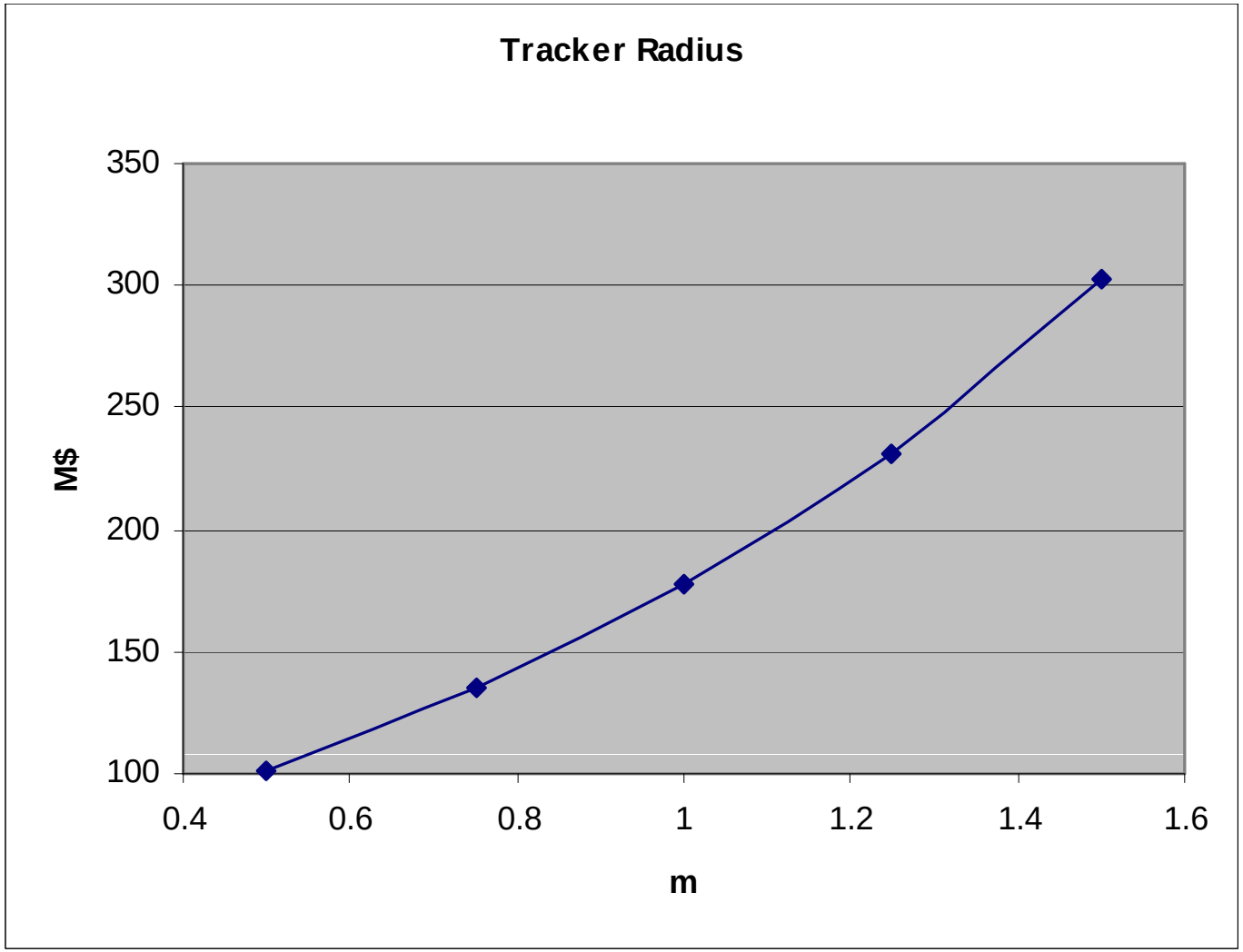
Subsystem M&S



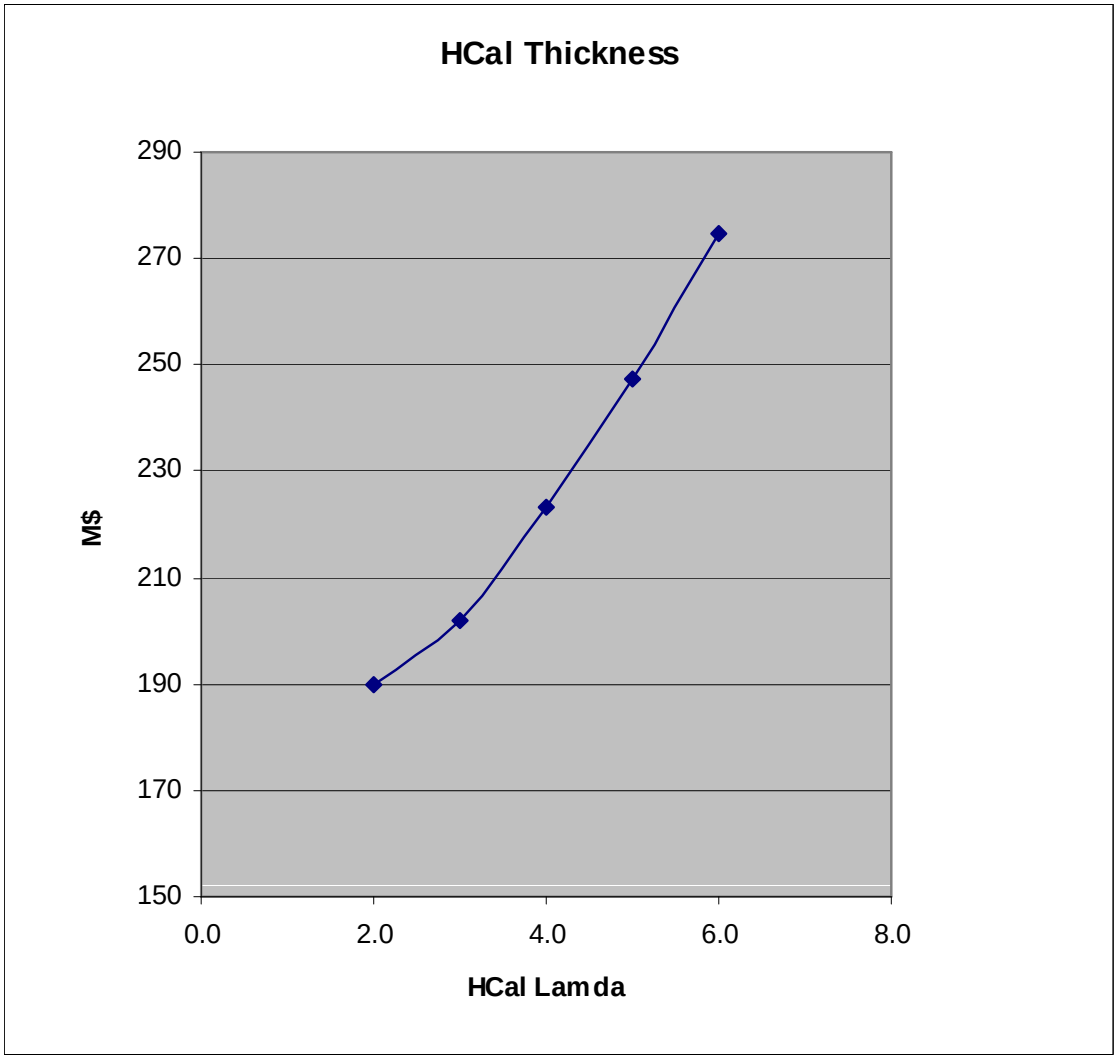
SiD Labor by Subsystem



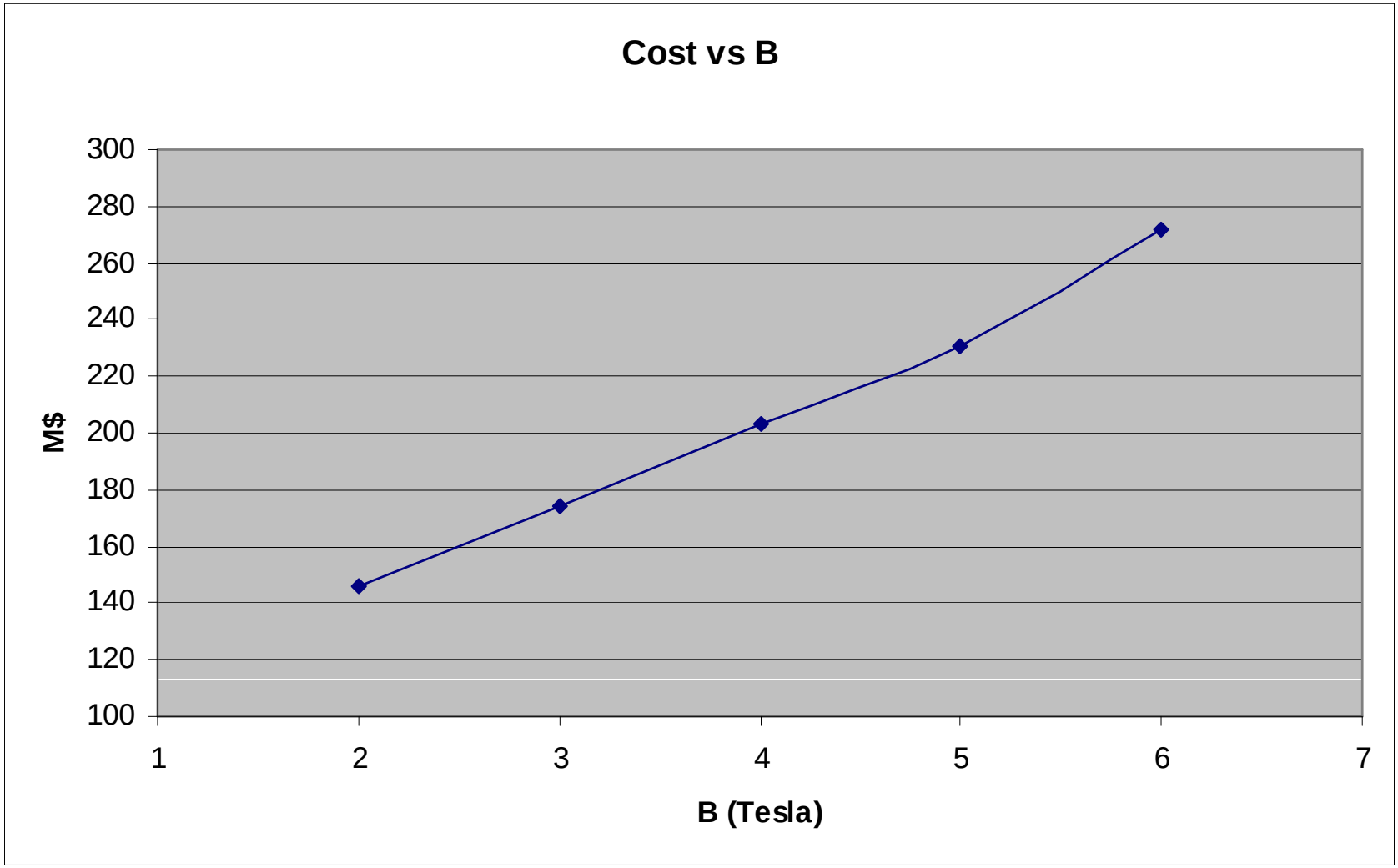
M&S Cost vs Tracker Radius



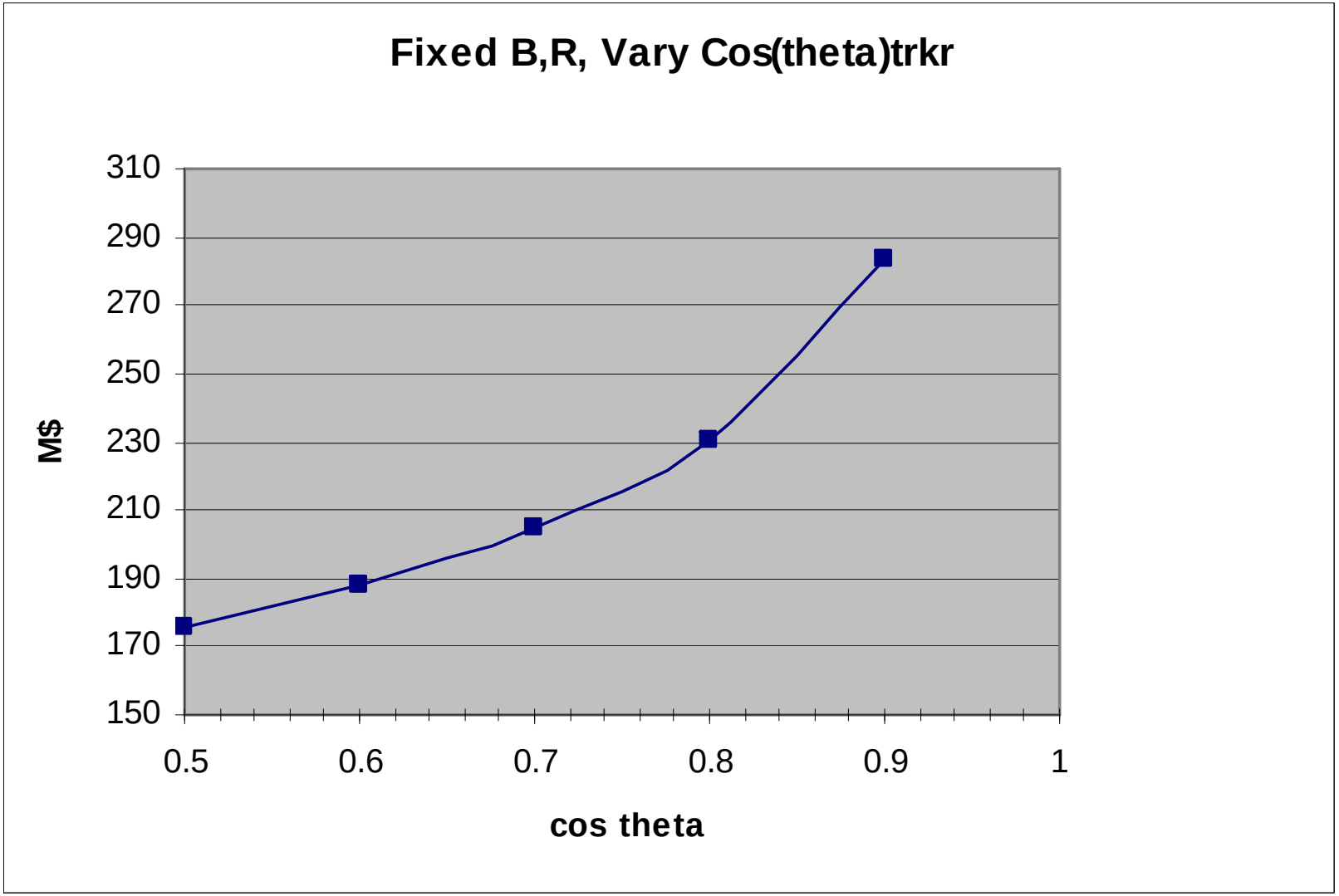
M&S Cost vs Hcal Thickness



M&S Cost vs B


Cost vs B
300
280
260
240
220
200
180
160
140
120
100
M$
1
2
3
4
5
6
7
B (Tesla)

M&S Cost vs Tracker Aspect Ratio



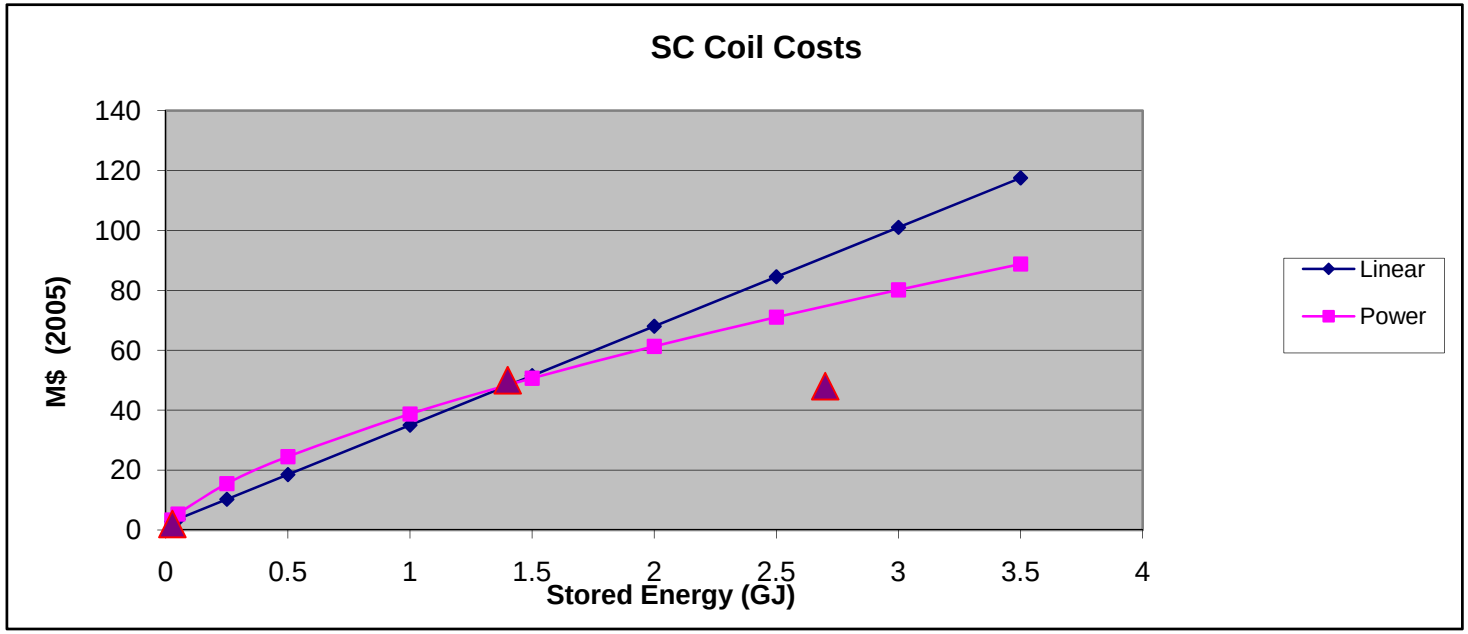
Cost Sensitivity

Effect of doubling the nominal unit cost

Item	Nominal Unit Cost	ΔSiD Base M&S Cost (M$)
Magnet Iron (finished and delivered)	$7/Kg	56
Tungsten (powder alloy) plate	$88/Kg	7
Si Detector	$3/cm^2	39
HCal Detector	$2000/m^2	7

Superconducting Solenoid

- Superconducting coils of this scale are difficult to estimate.
- Usual practice is to scale by stored energy, either a + bE or
- $cE^{0.66}$
- Attempt was made to extract the CMS cost for cold mass and cryostat - ~$48M.
- Obtained industrial estimate for SiD coil; ~same cost; but ½ the stored energy!



Superconducting Coil, continued

- We have chosen to be conservative, and are using the linear fit to Babar at the low end and the industrial estimate to get the slope.
- SiD is pursuing R&D on an advanced conductor that would be significantly simpler than the CMS conductor.

WBS

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1.1.3.4	Tracker Integration	1 lot		1,000,000	250,000	0	0	1,250,000

US Costs (if you are curious)

	M&S		Labor	Totals
Base	$231		$80	$311
Contingency	$84		$28	$112
Total	$315		$108	$423
Indirect rates	0.06		0.20	
Indirects	$19		$22	$40
Totals w indirects	$334		$129	$463
Total in FYXXXX M$		2008		**462.9**
Start Year	2016			
Construction Duration	6	years		
Inflation	1.035	per year.		
Factor	1.460			
Total Escalation				212.9
Total, TYM$				***675.9***

Conclusions

- This estimate is adequate for a Letter of Intent.
- It is not adequate for a DOE Project Review (Lehman)
- Adding contingency would be advised when thinking about these numbers.
- Many commodity costs remain unstable.