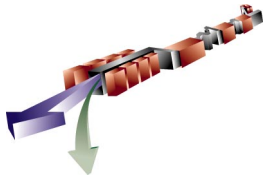


LCLS Cost Estimate

Vinod Bharadwaj

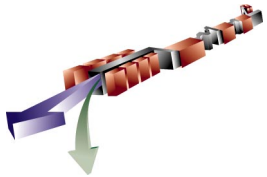
Stanford Linear Accelerator Center

- Methodology
- Timeline
- Some Costs

with help from ……

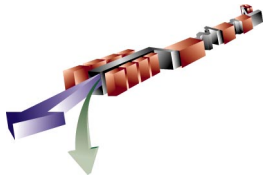
Ron Akre-RF
Jim Allen-Radiation Safety
Wesley Asher-Power Conversion
Lynn Bentson-Mechanical Hardware
Eric Bong- Mechanical Hardware
Patrick Bong-PPS
Tony Donaldson-Power Conversion
Alan Fisher-Gun Laser
Robert Fuller-Controls
Leo Giannini-MFD Tech
Tony King-Alignment
William Kroutil-Controls
Wayne Linebarger – Power Conversion
Bobbie McKee – Mechanical Hardware
Morrison Munro-Gun
Mario Ortega-Controls
Tom Porter-Controls
Ponciano Rodriguez-SEM
Bernie Romero-Plumbing
David Saenz-SEM
Patrick Smith-Injector Vault
Cherrill Spencer-Magnets
Rich Torres-Riggers
Dieter Waltz-FFTB beam dump

And others …….



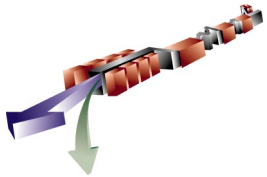
Methodology

- Start with the TDR Cost Estimate
  - Cost Estimate for linac systems
  - Used Excel spread sheet
- Work Breakdown Structure
  - 6 levels, the 6th level is not “nuts and bolts”
  - It is assumed that there will be costing information in more detail below the 6th level in additional documents
- Improved spread sheet for flexibility
  - Allow for different labor rate for different labs
  - Allow for hours for personnel costs
  - Allow for risk factors for contingency
- Added WBS sections for undulator, X-ray optics and conventional construction (and experiments)



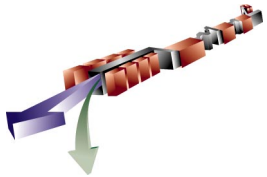
Methodology (cont.)

- Costs for everything we can think of, including
  - Necessary equipment, buildings etc.
  - Equipment that may be needed
  - Extras such as management, physicists, computers, travel, warehousing …..
- Parts list “flow chart”
  - Needed devices put into the optical deck
  - Deck used to make parts list table
  - Additional items added
  - Parts list document generated
  - Parts list table then added to cost estimate SS
- ESD “Task Force” help in cost estimates



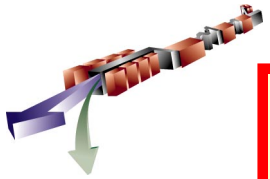
Methodology (cont.)

- Need to add features
  - Parts list table needs to be included in cost estimate, so that changes in parts counts are transparent
    - Point to parts list table for # of units in cost estimate SS
  - Costs, manpower as a function of time
- Using the complete list
  - Review costs and justifications
  - Decide on which costs are project related and which are general SLAC cost
  - Review scope of LCLS as additional tool to adjust the total project cost



Timeline

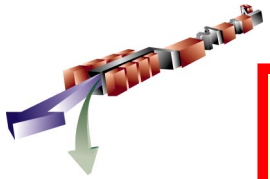
- Ensure that the cost estimate spread sheet has a complete set of costs
  - Essentially done except for x-ray optics, experiments
- Review individual costs with the engineering staff
- Review items that can be attributed to the lab with TD and SSRL management
  - These items should be done by the end of February
- Review project scope with the LCLS management
- Add budgeting schedule for project construction
  - These items will be complete before the Lehman review
- Move cost estimate from spread sheet to a database
  - After Lehman review



Level 2 WBS

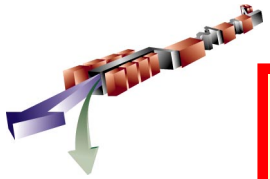
WBS	
1	LCLS TEC
1.1	PROJECT MANAGEMENT
1.2	BEAM GENERATION
1.3	X-RAY OPTICS
1.4	CONVENTIONAL FACILITIES

2	*LCLS SCIENTIFIC EXPERIMENT*



Level 3 WBS

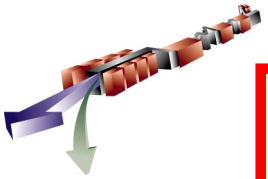
1	LCLS TEC
1.1	PROJECT MANAGEMENT
1.1.1	Construction Project Management
1.2	BEAM GENERATION
1.2.1	INJECTOR
1.2.2	ACCELERATOR
1.2.3	UNDULATOR
1.2.4	INSTRUMENTATION, CONTROLS AND P
1.2.5	Power Conversion
1.2.6	Vacuum Systems
1.2.7	INSTALLATION AND ALIGNMENT
1.3	X-RAY OPTICS
1.4	CONVENTIONAL FACILITIES
1.4.1	System Integration
1.4.2	New Buildings
1.4.3	Building Upgrades
1.4.4	Utilities, Power and Water



Labor Rate Table

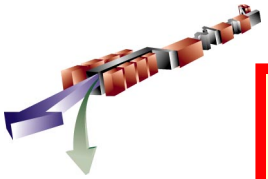
Labor Rate Table

Labor Type Code	Skill Description		ED&I or B&H	Labor Cost Type	ANL	BNL	LANL	LLNL	SLAC	UCLA	Spare
CDC	Controls: Coordinator Assoc.		ED&I	DL	50	50	50	50	50	50	0
CDE	Controls: Engineer		ED&I	DL	62	62	62	62	62	62	0
CDP	Controls: Programmer		ED&I	DL	61	61	61	61	61	61	0
CDT	Controls: Technician		B&H	DL	40	40	40	40	40	40	0
KLYC	Klystron: Coordinator Assoc.		ED&I	DL	48	48	48	48	48	48	0
KLYE	Klystron: Engineer		ED&I	DL	63	63	63	63	63	63	0
KLYT	Klystron: Technician		B&H	DL	41	41	41	41	41	41	0
MFPAS	Mech. Fab: Assembly Tech		B&H	SS	56	56	56	56	56	56	0
MFPC	Mech. Fab: Plating&Cleaning		B&H	SS	118	118	118	118	118	118	0
MFS	Mech. Fab: Machine Shop		B&H	SS	74	74	74	74	74	74	0
MALGN	Metrology:Eng.& Surveyors		B&H	DL	53	53	53	53	53	53	0
MEVE	AD: Mech/Vacuum Engineer		ED&I	DL	57	57	57	57	57	57	0
MDSN	Mech Drafting/Design		ED&I	SS	54	54	54	54	54	54	0
PCDC	PCD:Coordinator Associate		ED&I	DL	48	48	48	48	48	48	0
PCDE	PCD:Engineer		ED&I	DL	62	62	62	62	62	62	0
PCDT	PCD:Technician		B&H	DL	38	38	38	38	38	38	0
PCDW	PCD:Inst-Cabling-Elec Fab		B&H	SS	50	50	50	50	50	50	0
SEME	Site Engineering: Engineer		ED&I	DL	60	60	60	60	60	60	0
SEMLS	Site Engineering: Labor		B&H	SS	32	32	32	32	32	32	0
SEMPM	Site Engineering: Plant Maint.		B&H	DL	40	40	40	40	40	40	0
T&MCP	T&M Crafts - Union Carpenter		B&H	NSCL	50	50	50	50	50	50	0
T&MEL	T&M Crafts - Union Electrician		B&H	NSCL	60	60	60	60	60	60	0
T&MIW	T&M Crafts - Union Ironw ork.		B&H	NSCL	50	50	50	50	50	50	0
T&MPL	T&M Crafts - Union Pipefitter		B&H	NSCL	61	61	61	61	61	61	0
T&MEO	T&M Crafts - Union Equip. Op.		B&H	NSCL	57	57	57	57	57	57	0



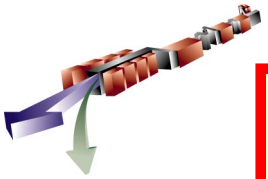
Overhead & Risk/Contigency

Overhead Table													
Type	**Description**				**ANL**	**BNL**	**LANL**	**LLNL**	**SLAC**	**UCLA**	**Spare**		
M&S	Overhead rate for M&S (%)				10	10	10	10	10	10	0		
Labor	Overhead rate for labor (%)				40	40	40	40	40	40	0		
ED&I	Overhead rate for ED&I (%)				40	40	40	40	40	40	0		
Spare1					0	0	0	0	0	0	0		
Spare2					0	0	0	0	0	0	0		
Spare3					0	0	0	0	0	0	0		
Risk/Contingency Table													
Risk level	Technical Risk Level	RL1	RL2	RL3	RL4	RL5	RL6	RL7	RL8	RL9	spare1	spare2	spare3
Contingency	Risk Level Contingency (%)	5	10	15	20	25	33.3	50	100	200	0	0	0



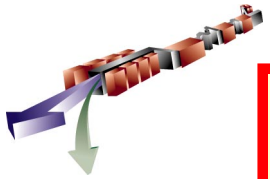
Cost Estimate Example BC2 Dipoles

WBS				<< M&	S >>	<<<	Labor	>>>	<<<	ED&I	>>>	Sub-totals			Direct	Dir+Cont.	D+C+Ind.
			# units	O-T-C	C-P-U	O-T-H	H-P-U	Rate	O-T-H	H-P-U	Rate	M&S	Labor	ED&I	Cost	Cost	Cost
1.2.2.3	***Bend Magnet 1D30.5 (BC2 magnets)***											135	61	66	263	308	371
1.2.2.3.1	*Materials*	RL1										135	0	0	135	142	156
1.2.2.3.1.1	Magnet Materials	SLAC	8	0.0	15.0			n/a			n/a	120	0	0	120		
1.2.2.3.1.2	Support Materials	SLAC	8	0.0	1.5			n/a			n/a	12	0	0	12		
1.2.2.3.1.3	Chicane Mover Materials	SLAC	2	0.0	1.5			n/a			n/a	3	0	0	3		
1.2.2.3.2	*Design*	RL4										0	0	62	62	75	105
1.2.2.3.2.1	Magnet Design	SLAC	1	0.0	0.0			n/a	120		MEVE	0	0	7	7		
1.2.2.3.2.2	Magnet Drafting	SLAC	1	0.0	0.0			n/a	450		MDSN	0	0	24	24		
1.2.2.3.2.3	Magnet Support & Mover Design	SLAC	1	0.0	0.0			n/a	120		MEVE	0	0	7	7		
1.2.2.3.2.4	Magnet Support and Mover Drafting	SLAC	1	0.0	0.0			n/a	450		MDSN	0	0	24	24		
1.2.2.3.3	*Assembly*	RL4										0	61	4	65	92	110
1.2.2.3.3.1	Magnet Assembly	SLAC	8	0.0	0.0	0	100	MFPAS			MEVE	0	45	0	45	63	
1.2.2.3.3.2	Magnet Support Assembly	SLAC	8	0.0	0.0	0	16	MFPAS			MEVE	0	7	0	7	10	
1.2.2.3.3.3	Magnet Mover Assembly	SLAC	2	0.0	0.0	0	16	MFPAS			MEVE	0	2	0	2	3	
1.2.2.3.3.4	Procurment, manufacture and assembly supe	SLAC	1	0.0	0.0	0	8	MFPAS		8	MEVE	0	0	0	1	1	
1.2.2.3.3.5	Magnet Tests in Lab	SLAC	8	0.0	0.0	0	16	MFPAS	0	8	MEVE	0	7	4	11	15	



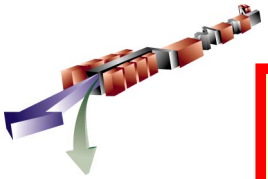
Cost Estimate Example – Gun Laser

WBS				<< M&	S >>	<<<	Labor	>>>	<<<	ED&I	>>>	Sub-totals			Direct	Dir+Cont.	D+C+Ind.
			# units	O-T-C	C-P-U	O-T-H	H-P-U	Rate	O-T-H	H-P-U	Rate	M&S	Labor	ED&I	Cost	Cost	Cost
	Instruments											2,850	410	299	3,559	3,877	4,519
1.2.1.10	***Gun Laser***											2,550	238	299	3,087	3,355	3,883
1.2.1.10.1	*Oscillator Laser & Pump*	RL1										402	0	0	402	422	464
1.2.1.10.1.1	CW diode-pumped doubled Nd:YVO4	SLAC	2	0.0	89.9			n/a			n/a	180	0	0	180		
1.2.1.10.1.2	CW mode locked Ti:Saf Oscillator,1.4W	SLAC	2	0.0	85.9			n/a			n/a	172	0	0	172		
1.2.1.10.1.3	Lock-t-clock Synchronization Option	SLAC	2	0.0	25.2			n/a			n/a	50	0	0	50		
1.2.1.10.2	*Oscillator Diagnostics*	RL1										116	0	0	116	122	134
1.2.1.10.2.1	Autocorrelators	SLAC	2	0.0	18.5			n/a			n/a	37	0	0	37		
1.2.1.10.2.2	IR w avelength monitors	SLAC	2	0.0	5.0			n/a			n/a	10	0	0	10		
1.2.1.10.2.3	Pow er meters (2 channel)	SLAC	2	0.0	3.8			n/a			n/a	8	0	0	8		
1.2.1.10.2.4	Pow er probes , 10W	SLAC	2	0.0	0.7			n/a			n/a	1	0	0	1		
1.2.1.10.2.5	Pow er probes , 2W	SLAC	2	0.0	0.8			n/a			n/a	2	0	0	2		
1.2.1.10.2.6	12 GHz photodiodes	SLAC	2	0.0	5.3			n/a			n/a	11	0	0	11		
1.2.1.10.2.7	3GHz,10GS/s, 4 channel scope	SLAC	1	0.0	43.2			n/a			n/a	43	0	0	43		
1.2.1.10.2.8	1-ns risetime diodes	SLAC	2	0.0	0.5			n/a			n/a	1	0	0	1		
1.2.1.10.2.9	Beam splitter & steering mirror	SLAC	4	0.0	0.3			n/a			n/a	1	0	0	1		
1.2.1.10.2.10	Mounts	SLAC	4	0.0	0.2			n/a			n/a	1	0	0	1		
1.2.1.10.2.11	Fiber-coupled spectrometer	SLAC	1	0.0	2.2			n/a			n/a	2	0	0	2		
1.2.1.10.3	*Temporal Pulse Shaper*	RL1										55	0	0	55	58	63
1.2.1.10.3.1	Gratings, 1x2 in, 1700 li/mm, 780 nm	SLAC	4	0.0	1.0			n/a			n/a	4	0	0	4		
1.2.1.10.3.2	Grating mounts, tip,tilt,azim knobs	SLAC	4	0.0	1.0			n/a			n/a	4	0	0	4		
1.2.1.10.3.3	Lenses,D=2 in f=0.5m,coated, 780nm	SLAC	4	0.0	0.5			n/a			n/a	2	0	0	2		
1.2.1.10.3.4	2 inch lens mounts	SLAC	4	0.0	0.5			n/a			n/a	2	0	0	2		
1.2.1.10.3.5	Mask mounts	SLAC	4	0.0	0.5			n/a			n/a	2	0	0	2		
1.2.1.10.3.6	Spatial light modulators for amplitude	SLAC	2	0.0	6.2			n/a			n/a	12	0	0	12		
1.2.1.10.3.7	Spatial light modulators for phase	SLAC	2	0.0	6.2			n/a			n/a	12	0	0	12		
1.2.1.10.3.8	Spatial modulator controllers	SLAC	2	0.0	6.0			n/a			n/a	12	0	0	12		
1.2.1.10.3.9	PC w ith GPIB and interface to SCP	SLAC	2	0.0	2.0			n/a			n/a	4	0	0	4		



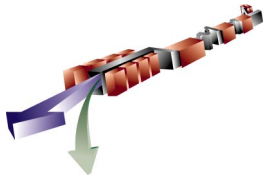
Level 4 Summary Data

1.2.2	**ACCELERATOR**	2,651	2,083	1,508	697	1,915	6,242	6,939	8,854
1.2.2(a)	**ACCELERATOR/Management**	52	0	1,269	89	541	1,321	1,410	1,951
1.2.2(b)	**ACCELERATOR/Devices**	1,050	970	240	308	678	2,259	2,567	3,245
1.2.2(c)	**ACCELERATOR/Instruments**	1,549	1,113	0	300	697	2,662	2,962	3,658
1.2.2.1	**System Integration**	52	0	1,269	89	541	1,321	1,410	1,951
1.2.2.2	**Bend Magnets - 5D7.1 (BC1 magnets)**	135	61	66	32	75	263	295	371
1.2.2.3	**Bend Magnet 1D30.5 (BC2 magnets)**	135	61	66	45	62	263	308	371
1.2.2.4	**Bend Magnet 4D102.36T (DL2)**	66	30	41	18	41	137	155	196
1.2.2.5	**Bend Magnet (VB)**	33	15	40	13	30	88	100	130
1.2.2.6	**Quadrupoles - 1Q5.6**	126	75	5	22	52	207	229	281
1.2.2.7	**Quadrupoles - QA**	42	25	2	7	17	69	76	94
1.2.2.8	**Quadrupoles - QE**	189	113	8	34	78	310	344	422
1.2.2.9	**Quadrupoles - 0.91Q17.72**	116	69	5	21	48	190	210	258
1.2.2.10	**Correctors**	200	506	5	112	266	711	823	1,089
1.2.2.11	**Accelerator Structures - X-band**	4	7	0	2	4	12	13	17
1.2.2.12	**Accelerator Structures - Transverse**	4	7	0	2	4	12	13	17
1.2.2.13	**Tune-up Dumps**	170	134	0	35	82	304	340	422
1.2.2.14	**Wire Scanners**	721	91	0	54	119	812	866	986
1.2.2.15	**BPMs**	224	314	0	74	174	538	612	786
1.2.2.16	**Toroids**	33	40	0	10	23	73	83	106
1.2.2.17	**Faraday Cup**	7	19	0	4	10	26	30	40
1.2.2.18	**BLM (X-Band Cavity)**	129	181	0	43	101	310	353	454
1.2.2.19	**Profile Monitor**	108	202	0	46	108	310	355	463
1.2.2.20	**Collimators**	158	131	0	34	79	289	323	402



Level 2 & 3 Summary Data

	SUMMARY OF LEVEL 2 & HIGHER COSTS								
WBS		M&S	Labor	ED&I	Contigency	Indirect	Direct Cost	DC+Contigency	DC+C+Indirects
1	LCLS TEC	63,793	14,099	14,813	13,578	32,879	92,705	106,283	139,162
1.1	PROJECT MANAGEMENT	230	0	2,446	1,001	298	2,676	3,678	3,975
1.2	BEAM GENERATION	28,857	14,099	11,614	7,846	13,314	54,570	62,416	75,730
1.3	X-RAY OPTICS	4000	2000	4000	2,500	2,500	10000	12500	15000
1.4	CONVENTIONAL FACILITIES	34,707	0	753	4,730	4,267	35,459	40,189	44,457
	SUMMARY OF LEVEL 3 & HIGHER COSTS								
1	LCLS TEC	63,793	14,099	14,813	13,578	32,879	92,705	106,283	139,162
1.1	PROJECT MANAGEMENT	230	0	2,446	1,001	298	2,676	3,678	3,975
1.1.1	Construction Project Management	230	0	2,446	1,001	298	2,676	3,678	3,975
1.2	BEAM GENERATION	28,857	14,099	11,614	7,846	13,314	54,570	62,416	75,730
1.2.1	INJECTOR	3,128	705	1,936	551	1,525	5,768	6,320	7,845
1.2.2	ACCELERATOR	2,651	2,083	1,508	697	1,915	6,242	6,939	8,854
1.2.3	UNDULATOR	18,361	1,265	4,557	2,897	4,747	24,183	27,080	31,826
1.2.4	INSTRUMENTATION, CONTROLS AND P	2,772	1,271	1,817	791	1,777	5,860	6,651	8,428
1.2.5	Power Conversion	406	229	319	191	312	953	1,144	1,456
1.2.6	Vacuum Systems	540	547	477	219	539	1,564	1,783	2,321
1.2.7	INSTALLATION AND ALIGNMENT	1,000	8,000	1,000	2,500	2,500	10,000	12,500	15,000
1.3	X-RAY OPTICS	4000	2000	4000	2,500	2,500	10000	12500	15000
1.4	CONVENTIONAL FACILITIES	34,707	0	753	4,730	4,267	35,459	40,189	44,457
1.4.1	System Integration	1,569	0	753	232	504	2,322	2,554	3,058
1.4.2	New Buildings	28,749	0	0	3,813	3,256	28,749	32,562	35,819
1.4.3	Building Upgrades	3,389	0	0	584	397	3,389	3,973	4,370
1.4.4	Utilities, Power and Water	1,000	0	0	100	110	1,000	1,100	1,210



Summary

- Cost Estimate in reasonable shape
  - Can go from design -> parts list -> to cost estimate
  - Lines exist in the spread sheet for almost all of the item
- Need to add some features
  - Parts list needs to be directly integrated into cost estimate
  - Time distribution of costs and manpower
- Need to review and fine tune cost estimate
  - Justification from the engineers
  - Decision on what belongs in the project
  - LCLS scope changes for acceptable overall cost
- Need eventually to move to a database that will allow project management