Introduction to the SB2009 Low-Power Studies

have lots of info already, but we still need some more from you!

with minor touch-ups from meeting

Peter H. Garbincius
Fermilab

July 15, 2009

Marc & Nick – 9july09 e-mail

- Primary point: make sure component <u>counts</u> and <u>specifications</u> are fixed to allow cost estimation to proceed – <u>for each of 3 sites</u>!
- Exercise is for Low-Power =
  half-number of bunches filled
  for <u>single tunnel</u> for <u>DRFS</u> & <u>Klystron Cluster</u>
- Consider and estimate two (three) scenarios:
  - Bare minimum to support Low-P 5 MW beams
  - Install only ½ RF power systems but make sure there is an "easy" upgrade path to full-P
  - And some intermediate scenario???

Some Working Assumptions

- Do not include any perceived constraint of an ~ 3 km circumference Damping Ring on path for upgrade. Assume DR solution can be found.
- Keep Dumps and Collimators at RDR power ratings (not a cost driver = $ 0.055/$ 6.617 B)
- Luminosity restored by Andrei's travelling focus which is also small relative cost ~ 1.5 * $ 0.022 B
- Need Impacts (including longer RF pulse) on:
  - HLRF Components, including overhead & upgrade
  - Electrical Power requirements
  - Cooling Requirements
  - Civil Construction – both surface and underground

Driven by some of PHG's Questions on June 9, 2009

- Don't have enough resources to address all options => only RDR (2 tunnel, full power) vs. Klystron Cluster (1 tunnel, ½ power) & DRFS (1 tunnel, ½ power) for each of 3 regions
  with upgrade path(s) to full power
- Config/Reg: Euro Americas Asia

<u>Config/Reg</u>:	<u>Euro</u>	<u>Americas</u>	<u>Asia</u>
DRFS	D-easy	D-easy	D-easy
Klystron Clust	KC-easy	KC-easy	KC-**???**

  Is Klystron Cluster approach even attainable
  in the mountainous Asian region?

RDR => same Power & Cooling est for all 3 regions

Some Low-P parameters

- For filling more cavities per klystron,
  RF pulse length increases 1.6 => 2.0-2.1 msec
  => 31% more avg power per klystron
  Fukuda-san: modulator/PS cost => 15% more
  these costs scale as sqrt(P)
- Klystron Cluster: each 10 MW klystron drives
  26 => 52 cavities
  Chris Adolphsen provided prelim estimates for full-P KlyClust in Aug08 & half-P RDR in Aug06
- DRFS: each 750 KW klystron drives
  2 => 4 cavities (2 configs)
  Shigeki Fukuda provided estimate 7july09

Comparison of klyCluster vs. RDR Estimates

SENSITIVE COST ESTIMATE INFORMATION

Peter H. Garbincius and Tom Lackowski

August 22 2008 revised September 4, 2008

for incorrect +/- sign – changes higlighted in yellow

filename: klyCluster_estimate_4sept08.doc

note: Adjusted RDR Estimate => The total CFS base number has been corrected to reflect the actual costs of the shaft base cavern spaces that were based on overestimated, incorrect cavern volumes (6 * 15,334 m^3 = 92,0006 m^3) in the RDR estimate. The Americas' ML RDR estimate ($ 1,160.9 M) was first adjusted to more correct (6 * 2,795 m^3 = 17,852 m^3) shaft base cavern volumes (=> $ 1,116.1 M), to which the estimates for the alternative klystron placement was compared. This was done so that the savings reflected for the new klystron scheme were not artificially inflated.

This is for Main Linac only for 560 RF units	adjusted RDR estimate	klyCluster estimate	2007 $ difference
Americas' only CFS Estimate (2006 unit costs)			(negative => savings)
reference spreadsheets: 30march07, 29aug08	$ 1,116.1 M	$ 821.8 M	- $ 294.3 M
escalate difference 2006 => 2007 @ 1.106			- $ 325.5 M
CF&S institutional labor	271 K man-hrs	195 K man-hrs	- 76 K man-hrs

Remove ~ 2*11 meters of WR 650 wg per RF unit
between klystron and cryomodules through penetration
and across beam and service tunnels
at $ 249 per meter (2006) = $ 5.48 K/RF unit * 560 RF units
= $ 3.1 M escalate difference 2006 => 2007 @ 1.0323 -$ 3.2 M
I assume all other RF hardware, plumbing, & accessories are needed
HLRF WBS SUM 121906 rsl-mn.xls
PHG: I don't understand Ray Larsen's spreadsheet line 44 so just use his base quote of $ 249/meter

Add ~ 1,370 meters of RFpipe per 30 RF units
at $ 1 K per meter * 560 RF units +$ 25.6 M
estimate from Chris Adolphsen (28july08)

Add $ 20 K per RF unit for coaxial RF couplers * 560 RF units +$ 11.2 M
estimate from Chris Adolphsen (28july08)

Add extra control and LLRF cables, alcoves, RTML services in ML tunnel,
radiation shielding of tunnel electronics, & needed other stuff not estimated

total change in 2007 $ (negative => savings) +$ 33.6 M - $ 325.5 M = -$ 291.9 M

Note: This difference estimate is only for Main Linac (560 RF units). There are another similar 32 RF units and service tunnel for RTML. This covers 2*BC2(15 RF units each) + 2*BC1(only take 1 RF unit each since the 100% backup can be provided by the other high power RF drivers on the same RF pipe). So, as a first order, average estimate of the savings for the combined Main Linac + RTML-BC1 + RTML-BC2 would be to multiply by (560+32)/560 = 1.057. Notice that this coupling of RF drivers could also remove two RF driver systems for the backups for RTML BC1's which is approximately $ 1.164 M (2006) * 1.0323 = $ 1.2 M (2007) each. This could be partially offset by needs of 2 additional RTML shafts for these Rfpipes. Similar savings by removing second tunnel for Electron Source, Positron Source, and Beam Delivery Systems have NOT been considered yet.

Peter

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9/4/08

RDR MAR 30 2007

A5
Main Linac

Denotes changed item

Denotes new item

KLY Power Cluster Scheme for Aug 29 2008

Main Linac

WBS	Description	QTY	Unit	RDR Unit Cost	RDR Extension	RDR Section Total	KLY QTY	KLY Unit	KLY Unit Cost	KLY Extension	KLY Section Total
				FINAL CONTRACT COST- in 2006 US$ (except where noted)					FINAL CONTRACT COST- in 2006 US$ (except where noted)		
				Man-Hours Total		$ Total			Man-Hours Total		$ Total
1.7	Conventional Facilities			271,161	Man-Hrs	$ 1,160,918,226			173,933	Man-Hrs	$ 821,758,793
				(still to be corrected RDR)		$ 1,116,055,056					
		QTY	Unit	Unit Cost	Extension	Section Total	QTY	Unit	Unit Cost	Extension	Section Total
1.7.1	CIVIL ENGINEERING			155,883	Man-Hrs	$ 737,794,472			111,674	Man-Hrs	$ 532,682,498
1.7.1.1	Engineering, study work and documentation					$ 38,581,023					$ 30,151,840
1.7.1.1.1	In-house Engineering	$90	/ man-hr	$14,029,463	155,883		$90	/ man-hr	$10,050,613	111,674	
	In-house Engineering	2%	%	$701,473,148	$ 14,029,463		2%	%	$502,530,659	$ 10,050,613	
1.7.1.1.2	Outsourced Consultancy Services					$ 38,581,023					$ 30,151,840
	Outsourced Engineering	6%	%	$701,473,148	$ 38,581,023		6%	%	$502,530,659	$ 30,151,840	
1.7.1.2	Underground Facilities					$ 593,008,308					$ 333,284,348
1.7.1.2.1	Shafts					$ 105,194,184					$ 112,024,494
	e- ML 14m dia. Shafts @ Points 5, 3 (2 x 425 vert ft)	259	vert m	$134,768	$ 34,904,783		259	vert m	$134,768	$ 34,904,783	
	e- ML 9m dia. Shaft @ Point 7 (1 x 425 vert ft)	130	vert m	$78,280	$ 10,137,260		130	vert m	$78,280	$ 10,137,260	
	e- ML 1500mm dia. Survey Shafts @ Points 3.1, 5.1 (2 x 425 vert ft)	259	vert m	$7,240	$ 1,875,160		259	vert m	$7,240	$ 1,875,160	
	e- ML 3 m dia shafts @ pts 14,15						259	vert m	$10,635	$ 2,754,465	
				$0					$0		
	e+ ML 14m dia. Shafts @ Points 2, 4 (2 x 425 vert ft)	259	vert m	$134,768	$ 34,904,783		259	vert m	$134,768	$ 34,904,783	
	e+ ML 9m dia. Shaft @ Point 6 (1 x 425 vert ft)	130	vert m	$78,280	$ 10,137,260		130	vert m	$78,280	$ 10,176,400	
	e+ ML 1500mm dia. Survey Shafts @ Points 2.1, 4.1 (2 x 425 vert ft)	259	vert m	$7,240	$ 1,875,160		259	vert m	$7,240	$ 1,875,160	
	e+ ML 3 m dia shafts @ pts 16,17						259	vert m	$10,635	$ 2,754,465	
				$0					$0		
	Surface Grouting of Points 2-5 14m dia. Shafts (4 x 425 vert ft)	4	ea.	$721,678	$ 2,886,710		4	ea.	$721,678	$ 2,886,710	
	Surface Grouting of Points 6-7 9m dia. Shafts (2 x 425 vert ft)	2	ea.	$541,258	$ 1,082,515		2	ea.	$541,258	$ 1,082,515	
	Surface Grouting of Points 2.1, 3.1, 4.1, 5.1 Survey Shafts (4 x 425 vert ft)	4	ea.	$270,629	$ 1,082,515		4	ea.	$270,629	$ 1,082,515	
	Points 2,3,4,5,6,7 - 14&9m dia. Shafts, finishing (stairs, conc. wall, elev.#2)	777	vert m	$7,254	$ 5,636,164		777	vert m	$7,254	$ 5,636,164	
	Surface Grouting of Points 14,15,16,17 Survey Shafts (4 x 425 vert ft)						4	ea.	$320,560	$ 1,282,240	
	ML Underground Potable Water (1/2 of Points 2 & 3)	1	ea.	$67,188	$ 67,188		1	ea.	$67,188	$ 67,188	
	ML Underground Potable Water (Points 4,5,6,7)	4	ea.	$67,188	$ 268,750		4	ea.	$67,188	$ 268,750	
	ML Underground Sanitary Sewer (1/2 of Points 2 & 3)	1	ea.	$67,188	$ 67,188		1	ea.	$67,188	$ 67,188	
	ML Underground Sanitary Sewer (Points 4,5,6,7)	4	ea.	$67,188	$ 268,750		4	ea.	$67,188	$ 268,750	
1.7.1.2.2	Tunnels					$ 389,191,025					$ 195,744,069
	e- ML 4.5m dia. Beam Tunnel, TBM Excavation (37,162 lin ft)	11,327	lin m	$7,171	$ 81,228,749		11,327	lin m	$7,171	$ 81,228,749	
	e- ML 4.5m dia. Service Tunnel, TBM Excavation (37,162 lin ft)	11,327	lin m	$7,171	$ 81,228,749		0	lin m	$0	$ -	
	e- ML 4.5m dia. Tunnels, Conc. Inv. (74,324 lin ft)	22,654	lin m	$1,351	$ 30,611,218		11,327	lin m	$1,351	$ 15,305,609	
				$0					$0		
	e+ ML 4.5m dia. Beam Tunnel, TBM Excavation (36,660 lin ft)	11,174	lin m	$7,171	$ 80,131,548		11,174	lin m	$7,171	$ 80,131,548	
	e+ ML 4.5m dia. Service Tunnel, TBM Excavation (36,660 lin ft)	11,174	lin m	$7,171	$ 80,131,548		0	lin m	$0	$ -	
	e+ ML 4.5m dia. Tunnels, Conc. Inv. (73,320 lin ft)	22,348	lin m	$1,351	$ 30,197,735		11,174	lin m	$1,351	$ 15,098,868	
				$0					$0		
	Provide Tunnel Construction Water Treatment Plant	4	ea.	$156,250	$ 625,000		4	ea.	$156,250	$ 625,000	
	Maintain and Operate Tunnel Construction Water Treatment Plant	4	ea.	$1,160,074	$ 4,640,295		4	ea.	$772,609	$ 3,090,436	
	Treatment of Tunnel Construction Water	4	ea.	$99,046	$ 396,185		4	ea.	$65,965	$ 263,859	
1.7.1.2.3	Halls										
1.7.1.2.4	Caverns					$ 66,214,274					$ 18,378,585
	e- ML Shaft Base Caverns D&B Excavation @ Points 3, 5, 7 (3 x 20,056 CY)	46,003	m^3	$605	$ 27,831,815						

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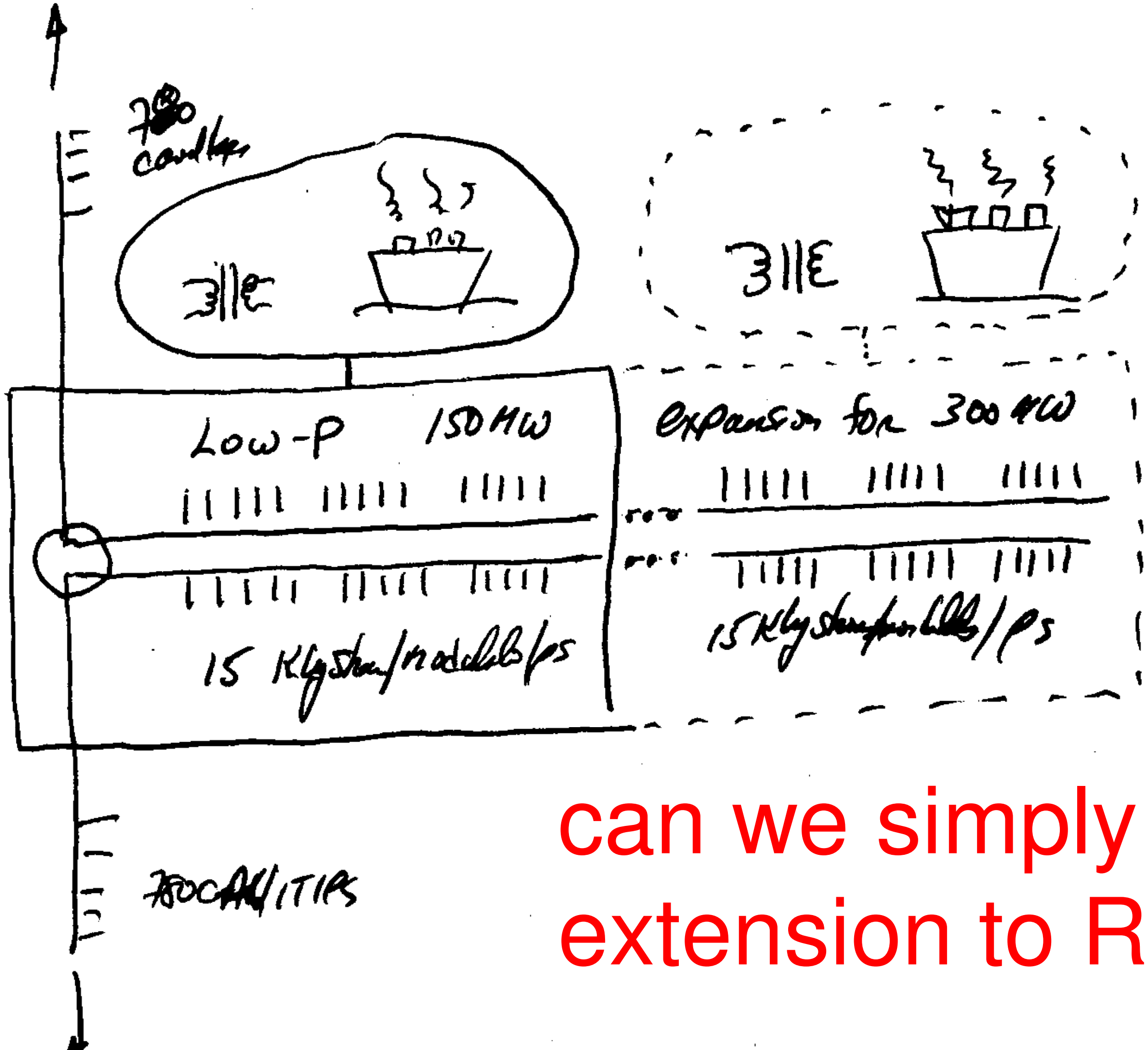
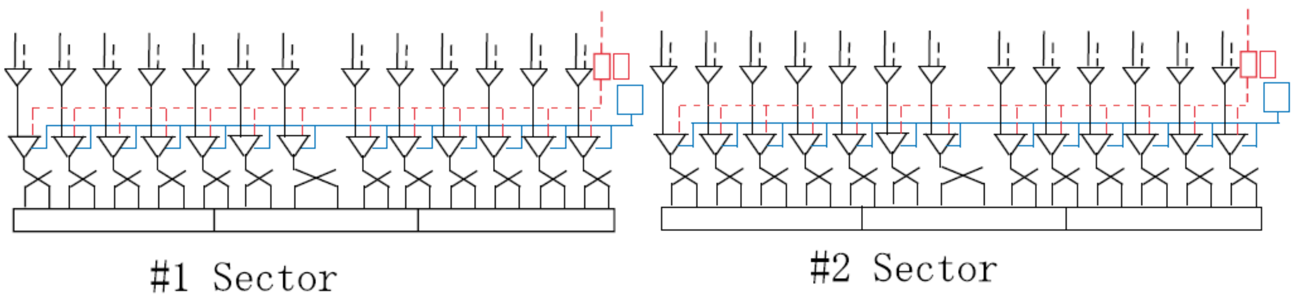
Upgrade path for Low-P Klystron Cluster

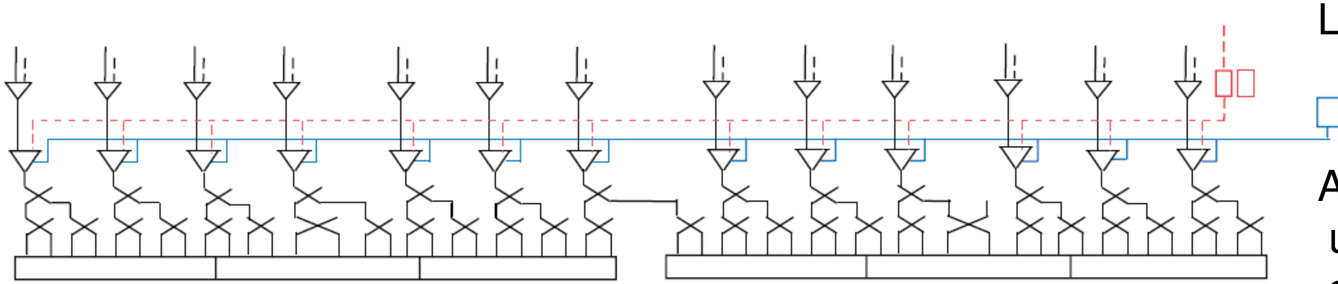


can we simply add an extension to RF pipe?

LowP Scheme for DRFS

DRFS Scheme A (1 klystron feeds 2 cavities)
= 1 DC P/S
1 MA Pulsers 1 Back-up
13 Klystrons
26 Cavities
13 Magic-tee(Hybrid)





Low Power Option@ Sectors (1 klystron feeds 4 cavities)
= 0.5 DC P/S
0.5 MA Pulsers 0.5 Back-up
6.5 Klystrons
26 Cavities
19.5 Magic-tee(Hybrid)

Standard Scheme

- High operability
- Maximum usage of SC cavity

Low Power Option

- Aiming for the easy upgradeability to standard scheme
- Low cost
- Partial sacrifice of DRFS operability

Cost Impact for LowP DRFS

Fukuda-san update 15july09, see his presentation

DRFS	Standard		Low P		Cost Impact
	No	Cost	No	Cost	%
DC PS w Backup	1	269 ~~288~~	1	186 ~~166~~	
MA Modulator	2	100	1	50	
MA Klystron	13	845	7	423	
Magic Tee	13	91	20	137	
		1305 ~~1324~~		795 ~~775~~	60.9% ~~58.6~~
BCD	Standard		Low P		
	No	Cost	No	Cost	
Mod	1	515	1	297	
Kly	1	300	1	150	
PDS	1	345	1	173	
		1160		620	53.4

Assume the PS's cost proportional to Square root of av. Power.

15july: Shigeki thinks > sqrt(P), asks Ray Larsen for better est.

What do we need?

- Updated estimate for over-moded waveguide and cylindrical couplers for Klystron Cluster
- Understand impact and possible cost reductions for Cryogenics:

  what about Cryogenics load?
-   how much is static (same)?
  how much is RF related (1/2 * 1.31 = 0.65)?
  how can you add capacity later?

  add second plants?
  what were the layout of our 10 plants?

  1 + 2 + 2 …IP… 2 + 2 + 1 – optimization?

To Do (continued)

- Can you add RF pipe & couplers upstairs?
- How can Klystron Cluster be done in mountains?
- Which of the two Low-P DRFS options to choose?
- Need better developed DRFS cost estimates
- We have Low-P electrical power & cooling ests. which are ½ * 1.31 = 0.65 RDR levels for ML. How does the CFS estimates scale for both low-P and for facilitating upgrade to full-Power later?
- Do we need to change single tunnel from 4.5 meter to something larger for KlyClus, DRFS? Layout?
- modified shafts, access tunnels, shaft base caverns?

References (they all work, but…)

SB2009 Definition and Working Assumptions:
http://ilcagenda.linearcollider.org/materialDisplay.py?materialId=0&confId=3526
1) With respect to the Reference Design, a reduced parameter set is to be adopted - number of bunches = 1312 and a 2ms RF pulse, 2) a Single-tunnel solution for the Main Linacs and RTML is to be adopted, with two possible variants for the HLRF - Klystron cluster scheme and DRFS scheme and 3) the CFS team will develop design solutions for each HLRF variant at each of the (3) sample sites.

The DESY meeting report: http://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=*879845 – SEE TABLE PAGE 18.

operationally from a PPT presentation, it is better to save, then open

August 2006 (Chris Adolphsen) presentation on low power operation:
http://ilcagenda.linearcollider.org/getFile.py/access?sessionId=3&resId=0&materialId=5&confId=3526

Availability Task Force - July 2009 (Shigeki Fukuda) presentation on DRFS availability, including low power option:
http://ilcagenda.linearcollider.org/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=3719 (see slides 17 and 18).

Backup Slides

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KLY Power Cluster Scheme for Aug 29 2008

Main Linac

WBS	Description	RDR Qty	Unit	RDR FINAL CONTRACT COST- in 2006 US$ (except where noted) Man-Hours Total		RDR $ Total	KLY Qty	Unit	KLY FINAL CONTRACT COST- in 2006 US$ (except where noted) Man-Hours Total		KLY $ Total
	(STILL TO BE CORRECTED IN RDR) e- ML Shaft Base Caverns D&B Excavation @ Points 2, 4, 6 (3 x 20,056 CY)	8,926	m^3	$605	$ 5,400,230		6,469	m^3	$605	$ 3,913,745	
	e- ML Points 3,5,7 D&B Exc. for Shield Doors (in Base Caverns) (3 x 959 CY)	2,199	m^3	$753	$ 1,654,522		2,199	m^3	$753	$ 1,654,748	
	e- ML Beam Dump Cavern D&B Excavation @ Point 3 (3,034 CY)	2,320	m^3	$753	$ 1,745,800		2,320	m^3	$753	$ 1,745,800	
	e+ ML Shaft Base Caverns D&B Excavation @ Points 2, 4, 6 (3 x 20,056 CY)	46,003	m^3	$605	$ 27,831,815						
	(STILL TO BE CORRECTED IN RDR) e+ ML Shaft Base Caverns D&B Excavation @ Points 2, 4, 6 (3 x 20,056 CY)	8,926	m^3	$605	$ 5,400,230		6,469	m^3	$605	$ 3,913,745	
	e+ ML Points 2,4,6 D&B Exc. for Shield Doors (in Base Caverns) (3 x 959 CY)	2,199	m^3	$753	$ 1,654,522		2,199	m^3	$753	$ 1,654,748	
	e+ ML Beam Dump Cavern D&B Excavation @ Point 2 (3,034 CY)	2,320	m^3	$753	$ 1,745,800		2,320	m^3	$753	$ 1,745,800	
				$0					$0		
	Shield Doors @ Base Caverns @ Points 2-7	6	ea.	$625,000	$ 3,750,000		6	ea.	$625,000	$ 3,750,000	
1.7.1.2.5	Miscellaneous works					$ 32,408,826					$ 7,137,201
	e- Refuge Areas (14 ea @ 10' x 20' x 10')						1,653	m^3	$2,158	$ 3,567,869	
	e+ Refuge Areas						1,654	m^3	$2,158	$ 3,569,332	
	e- ML Personnel Crossovers, D&B Excavation (23 X 295.5 CY)	5,196	m^3	$2,158	$ 11,213,163		0	m^3	$0	$ -	
	e- ML Waveguides, Drill Excavation (968)	968	ea.	$5,156	$ 4,991,250		0	ea.	$0	$ -	
	e+ ML Personnel Crossovers, D&B Excavation (23 X 295.5 CY)	5,196	m^3	$2,158	$ 11,213,163		0	m^3	$0	$ -	
	e+ ML Waveguides, Drill Excavation (968)	968	ea.	$5,156	$ 4,991,250		0	ea.	$0	$ -	
1.7.1.3	Surface Structures					$ 75,914,855					$ 122,001,510
1.7.1.3.1	Central Lab Buildings										
1.7.1.3.2	Detector Assembly Buildings										
1.7.1.3.3	Office Buildings					$ 5,057,150					$ 5,057,150
	Points 4-7 Office Buildings (4 x 3,750 sq ft)	1,396	sq m	$3,623	$ 5,057,150		1,396	sq m	$3,623	$ 5,057,150	
1.7.1.3.4	Service Buildings					$ 17,981,957					$ 25,799,102
	Points 2-7 Electrical Service Buildings (6 x 1,500 sq ft)	836	sq m	$2,805	$ 2,344,863		836	sq m	$2,805	$ 2,344,863	
	Points 2-7 Cooling Towers & Pump Stations Bldgs. (6 x 7,500 sq ft)	4,181	sq m	$2,805	$ 11,727,120		6,968	sq m	$2,805	$ 19,544,264	
	Points 2-7 Cooling Ventilation Buildings (6 x 2,500 sq ft)	1,394	sq m	$2,805	$ 3,909,975		1,394	sq m	$2,805	$ 3,909,975	
1.7.1.3.5	Cryo- Equipment Buildings					$ 24,612,619					$ 24,612,619
	Points 2-7 Cryo - Warm Compressor Building (6 x 4,500 sq ft)	2,508	sq m	$4,108	$ 10,301,811		2,508	sq m	$4,108	$ 10,301,811	
	Points 2-7 Cryo - Surface Cold Box Building (6 x 6,250 sq ft)	3,484	sq m	$4,108	$ 14,310,809		3,484	sq m	$4,108	$ 14,310,809	
1.7.1.3.6	Control Buildings										
1.7.1.3.7	Workshops					$ 12,822,374					$ 12,822,374
	Points 4-7 Workshop Bldg. - Machine & Detector (4 x 11,250 sq ft)	4,181	sq m	$3,067	$ 12,822,374		4,181	sq m	$3,067	$ 12,822,374	
1.7.1.3.8	Site Access Control Buildings					$ 782,556					$ 782,556
	Points 4-7 Site Access Buildings (4 x 750 sq ft)	279	sq m	$2,805	$ 782,556		279	sq m	$2,805	$ 782,556	
1.7.1.3.9	Shaft Access Buildings					$ 14,658,198					$ 14,658,198
	Points 2-7 Shaft Access Buildings (6 x 9,375 sq ft)	5,226	sq m	$2,805	$ 14,658,198		5,226	sq m	$2,805	$ 14,658,198	
1.7.1.3.10	Miscellaneous Buildings										
1.7.1.3.11	User Facilities										
	KLY Cluster Buildings (no of klystron in surface average 60 to 64)										$38,269,509.84
	Points ,16,4,17,6,7,14,5,15,						12,128	sq m	$2,805	$34,017,342	
	Points 2,3						1,516	sq m	$2,805	$4,252,168	
1.7.1.4	Site Development					$ 30,290,286					$ 47,244,801
1.7.1.4.1	Off-site Site work										
1.7.1.4.2	Network of Monuments										
1.7.1.4.3	Construction Support										
1.7.1.4.4	Site Preparation					$ 1,215,000					$ 2,025,000

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WBS	Item	Qty	Unit	RDR MAR 30 2007 — FINAL CONTRACT COST - in 2006 US$ (except where noted): Man-Hours Total		$ Total	KLY Qty	Unit	KLY Power Cluster Scheme for Aug 29 2008 — FINAL CONTRACT COST - in 2006 US$ (except where noted): Man-Hours Total		$ Total
	Points 2 - 7, Clearing, Grubbing, and Initial Site Preparation (6 sites)	6	ea.	$202,500	$ 1,215,000		10	ea.	$202,500	$ 2,025,000	
1.7.1.4.5	Utility Distribution					$ 21,046,500					$ 33,817,500
	Points 2 - 7, Utility Corridors (Gas, DWS, San., Storm, Elec., Comm.)	6	ea.	$3,037,500	$ 18,225,000		10	ea.	$3,037,500	$ 30,375,000	
	Points 2 - 7, Septic Field / Tank or Sanitary Sewer	6	ea.	$101,250	$ 607,500		10	ea.	$101,250	$ 1,012,500	
	Points 2 - 7, Wells or DWS	6	ea.	$54,000	$ 324,000		10	ea.	$54,000	$ 540,000	
	Points 4 - 7, Elevated Water Tank	4	ea.	$270,000	$ 1,080,000		4	ea.	$270,000	$ 1,080,000	
	Points 4 - 7, Water Pump House	4	ea.	$202,500	$ 810,000		4	ea.	$202,500	$ 810,000	
1.7.1.4.6	Road, Sidewalks & Parking Areas					$ 7,100,279					$ 9,940,391
	Points 2 - 7, Service Roads (6 sites x 1250 lin ft / site)	2,286	lin m	$1,107	$ 2,530,602		3,200	lin m	$1,107	$ 3,542,843	
	Points 2 - 7, Paved Areas (6 sites x 8750 sy / site)	43,896	sq m	$97	$ 4,266,691		61,454	sq m	$97	$ 5,973,368	
	Points 2 - 7, Flatwork (6 sites x 2,500 sq ft / site)	1,394	sq m	$217	$ 302,986		1,952	sq m	$217	$ 424,180	
1.7.1.4.7	Landscaping					$ 726,007					$ 1,124,410
	Points 2 - 7, Landscaping	6	ea.	$67,500	$ 405,000		10	ea.	$67,500	$ 675,000	
	Points 4 - 7, Security Fencing (4 sites x 5,000 lin ft / site)	6,097	lin m	$53	$ 321,007		8,536	lin m	$53	$ 449,410	
1.7.1.4.8	Environmental					$ 202,500					$ 337,500
	Points 2 - 7, Sediment & Erosion Control (6 sites)	6	ea.	$33,750	$ 202,500		10	ea.	$33,750	$ 337,500	
1.7.1.4.9	Miscellaneous Site Works										
1.7.2	ELECTRICAL			37,585	Man-Hrs	$ 169,134,000			28,189	Man-Hrs	$ 126,850,500
1.7.3	AIR TREATMENT EQUIPMENT			2,561	Man-Hrs	$ 12,328,035			4,283	Man-Hrs	$ 20,618,471
1.7.3.1	Engineering, study work and documentation					$ 806,507					$ 1,348,872
1.7.3.1.1	In-house Engineering	$90	/ man-hr	$230,431	2,561		$90	/ man-hr	$385,392	4,283	
	In-house Engineering	2%	%	$11,521,528	$ 230,431		2%	%	$19,269,599	$ 385,392	
1.7.3.1.2	Outsourced Consultancy Services					$ 806,507					$ 1,348,872
	Outsourced Engineering	7%	%	$11,521,528	$ 806,507		7%	%	$19,269,599	$ 1,348,872	
1.7.3.2	HVAC Equipment					$ 11,521,528					$ 19,269,599
1.7.3.2.1	OA & Exhaust Air Processing					$ 4,363,546					$7,272,576
	OA Supply/Exhaust Systems @ Points 2 - 7	6	ea.	$727,258	$ 4,363,546		10	ea.	$727,258	$ 7,272,576	
1.7.3.2.2	Air-conditioning for Tunnels					$ 7,157,983					$11,997,023
	Beamline Tunnel A/C, e- ML	11,895	lin m	$90	$ 1,065,756		11,895	lin m	$90	$ 1,065,756	
	Beamline Tunnel A/C, e+ ML	10,394	lin m	$90	$ 931,267		10,394	lin m	$90	$ 931,267	
	Fan Coil Units	1	ls	$5,160,960	$ 5,160,960		1	ls	$0	$ -	
	Chilled Water cooling for RF Racks in surface (placeholder)	1	ls				1	ls	$10,000,000	$ 10,000,000	
1.7.3.2.3	Air-conditioning for General Areas										
1.7.4	PIPED UTILITIES			266	Man-Hrs	$ 1,300,792			1,255	Man-Hrs	$ 6,153,112
1.7.4.1	Engineering, study work and documentation					$ 107,405					$ 508,055
1.7.4.1.1	In-house Engineering	$90	/ man-hr	$23,868	266		$90	/ man-hr	$112,901	1,255	
	In-house Engineering	2%	%	$1,193,388	$ 23,868		2%	%	$5,645,057	$ 112,901	
1.7.4.1.2	Outsourced Consultancy Services					$ 107,405					$ 508,055
	Outsourced Engineering	9%	%	$1,193,388	$ 107,405		9%	%	$5,645,057	$ 508,055	
1.7.4.2	Plumbing					$ 1,193,388					$ 1,988,979
1.7.4.2.1	Potable Water										
1.7.4.2.2	Sanitary Sewer										
1.7.4.2.3	Sump Systems					$ 1,193,388					$1,988,979
	Dewatering Sump Systems at Points 2, 3, 4, 5, 6, 7	6	ea.	$198,898	$ 1,193,388		6	ea.	$198,898	$ 1,193,388	
	Dewatering Sump Systems at Points 14, 15, 16, 17						4		$198,898	$ 795,592	
1.7.4.3	Fire Suppression										$3,656,078

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A5 Main Linac

Denotes changed item

Denotes new item

KLY Power Cluster Scheme for Aug 29 2008

Main Linac

WBS	Description	Qty / Rate	Unit	RDR: FINAL CONTRACT COST - in 2006 US$ (except where noted) — Man-Hours Total		RDR: $ Total	KLY Qty / Rate	Unit	KLY: FINAL CONTRACT COST - in 2006 US$ (except where noted) — Man-Hours Total		KLY: $ Total
	e- shafts						648	lin m	$128	$82,875	
	e-tunnels						11,327	lin m	$128	$1,448,950	
	e-caverns						1	ls	$306,000	$306,000	
	e+ shaft						648	lin m	$128	$82,875	
	e=tunnels						11,174	lin m	$128	$1,429,378	
	e+caverns						1		$306,000	$306,000	
1.7.4.4	Fuel System Distribution										
1.7.5	**PROCESS (COOLING) WATER**			*38,249*	*Man-Hrs*	$ 187,609,926			*17,433*	*Man-Hrs*	$ 85,507,211
1.7.5.1	Engineering, study work and documentation					$ 15,490,728					$ 7,060,228
1.7.5.1.1	In-house Engineering	$90	/man-hr	*$3,442,384*	*38,249*		$90	/man-hr	*$1,568,940*	*17,433*	
	In-house Engineering	2%	%	$172,119,198	$ 3,442,384		2%	%	$78,446,983	$ 1,568,940	
1.7.5.1.2	Outsourced Consultancy Services					$ 15,490,728					$ 7,060,228
	Outsourced Engineering	9%	%	$172,119,198	$ 15,490,728		9%	%	$78,446,983	$ 7,060,228	
1.7.5.2	Primary Stations					$ 29,863,815					$ 22,961,983
1.7.5.2.1	Cooling Towers & Pumping Stations					$ 19,875,852					$ 19,234,983
	Cooling Towers for Process Water	1	ls	$9,636,281	$ 9,636,281		1	ls	$12,081,000	$ 12,081,000	
	Cooling Towers for Chilled Water	1	ls	$5,200,237	$ 5,200,237		1	ls	$0	$ -	
	Tower Pump and Accessories for Process Water	1	ls	$1,842,963	$ 1,842,963		1	ls	$1,639,000	$ 1,639,000	
	Tower Pump and Accessories for Chilled Water	1	ls	$1,220,138	$ 1,220,138		1	ls	$0	$ -	
	Chilled Water Pump	1	ls	$1,191,250	$ 1,191,250		1	ls	$0	$ -	
	Controls	1	ls	$784,983	$ 784,983		1	ls	$784,983	$ 784,983	
	Pump for RF Surface water system (for 10 plants)	1	ls				1	ls	$2,416,000	$ 2,416,000	
	Heat Exchanger for RF Surface water system (for 10 plants)	1	ls				1	ls	$2,314,000	$ 2,314,000	
1.7.5.2.2	Primary Stations and Piping					$ 9,987,962					$ 3,727,000
	Chillers	1	ls	$5,347,115	$ 5,347,115		1	ls	$0	$ -	
	Tower Piping for Process Water (surface)	1	ls	$821,952	$ 821,952		1	ls	$650,000	$ 650,000	
	Tower Piping for Chilled Water (surface)	1	ls	$489,039	$ 489,039		1	ls	$0	$ -	
	Tower Piping for Process Water (shaft)	1	ls	$1,679,547	$ 1,679,547		1	ls	$951,000	$ 951,000	
	Chilled Water Piping (surface)	1	ls	$286,335	$ 286,335		1	ls	$0	$ -	
	Chilled Water Piping (shaft)	1	ls	$1,363,974	$ 1,363,974		1	ls	$0	$ -	
	Piping RF Surface Water System (for 10 plants)	1	ls				1	ls	$2,126,000	$ 2,126,000	
1.7.5.3	Secondary Stations					$ 142,255,383					$ 55,485,000
1.7.5.3.1	Demineralized Water Stations and Distribution Piping					$ 69,245,357					$ 34,882,000
	Demineralized Pump/Skid System w/ Materials & Installation	1	ls	$69,245,357	$ 69,245,357		1	ls	$34,882,000	$ 34,882,000	
1.7.5.3.2	Chilled Water Stations and Distribution Piping					$ 32,456,126					$ -
	Heat Exchangers (cavern)	1	ls	$1,726,838	$ 1,726,838		1	ls	$0	$ -	
	Distribution Pumps (cavern)	1	ls	$1,649,580	$ 1,649,580		1	ls	$0	$ -	
	Piping (cavern)	1	ls	$399,846	$ 399,846		1	ls	$0	$ -	
	Piping (tunnel)	1	ls	$19,274,532	$ 19,274,532		1	ls	$0	$ -	
	Piping Connections to End Equipment	1	ls	$9,405,330	$ 9,405,330		1	ls	$0	$ -	
1.7.5.3.3	Water Stations and Distribution Piping					$ 14,473,690					$ -
	Water Stations and Distribution Piping	1	ls	$14,473,690	$ 14,473,690		1	ls	$0	$ -	
1.7.5.3.4	Compressed Air					$ 2,404,000					$ 2,404,000
	Compressed Air	1	ls	$2,404,000	$ 2,404,000		1	ls	$2,404,000	$ 2,404,000	
1.7.5.3.5	Process Water Distribution					$ 23,676,210					$ 18,199,000
	Heat Exchangers (cavern)	1	ls	$2,772,791	$ 2,772,791		1	ls	$1,845,000	$ 1,845,000	
	Distribution Pumps (cavern)	1	ls	$1,879,121	$ 1,879,121		1	ls	$1,601,000	$ 1,601,000	
	Piping (cavern)	1	ls	$661,007	$ 661,007		1	ls	$316,000	$ 316,000	
	Piping (tunnel)	1	ls	$16,515,925	$ 16,515,925		1	ls	$14,437,000	$ 14,437,000	

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KLY Power Cluster Scheme for Aug 29 2008

				A5 Main Linac (RDR)					A5 Main Linac (KLY Power Cluster Scheme)		
				Denotes changed item							
				Denotes new item							
				FINAL CONTRACT COST- in 2006 US$ (except where noted)					FINAL CONTRACT COST- in 2006 US$ (except where noted)		
				Man-Hours Total		$ Total			Man-Hours Total		$ Total
	Piping Connections to End Equipment	1	ls	$1,847,365	$ 1,847,365		1	ls	$0	$ -	
1.7.6	HANDLING EQUIPMENT					$ 11,300,000			2,511	Man-Hrs	$ 11,300,000
1.7.7	SAFETY EQUIPMENT					$ 14,020,000			2,492	Man-Hrs	$ 11,216,000
1.7.8	SURVEY AND ALIGNMENT					$ 27,431,000			6,096	Man-Hrs	$ 27,431,000

LEGEND (AUG 21 2008)

- Changes in RDR $amount or quantities for the KLY cluster scheme
- New line item added for the KLY cluster scheme
- **Still to be corrected in RDR**

LEGEND (RDR Dec 2006)

- Main CFS WBS level (1.7)
- Second level of WBS (1.7.1 to 1.7.8)
- Third level of WBS
- Fourth level of WBS detail

CFS criteria for KlyCluster study

Criteria Comparison.xls [Compatibility Mode]

Draft - Started Jul 17 2008

DRAFT Sep 18 2008

Criteria Comparison - Main Linac RF (except where noted with *)

blue shade indicate numbers that are arbitrarily adjusted to increase water delta T in post RDR

notable differences ??

Row	Items shown per RF (except where noted with *)	units	ILC RDR	ILC POST-RDR (RF on & off) (from Shigeki, et. al.) [Use for VE Schemes]	ILC POST-RDR (from Wilhelm)	ILC RF Off?? (frm Adolphsen)	ILC KLY Cluster (frm Adolphsen)	ILC CFS Workshop Jun 08	TESLA RF On	TESLA RF Off	XFEL RF On	XFEL RF Off	CLIC	Proj X
8	*Tunnel Scheme		deep two-tunnel				single tunnel	??	near surface single-tunnel		near surface single-tunnel		???	near surface single-
20														
21	**Process Water Circuit** (RF watercooled components)													
22	Collector Heat Load to water	KW	45.8	Shigeki/Adolphsen et. al.	30? (wilhelm)	60	45.8		31.9	91.13		282		
23	Location		service tunnel				surface	surface	tunnel		tunnel			
24	Collector Water Flow given	l/min	not given	37		37	37		35			282		
25		gpm	not given	9.77		9.8	9.8		9.25			74		
26	Collector Water Delta T	C	not used	18		23	18					14		
27		F	not used	32		42	32					26		
28	Maximum allowable Temperature	C	not given	87		87	87							
29		F	not given	189		189	189							
30	Maximum allowable pressure	Bar	not given	15		15	15							
31		Psi	not given	59		59	59							
32	Pressure drop	Bar	2	0.3		0.3	0.3							
33		Psi	29	32		32	32							
34	Supply Temperature Stability		not given	none										
35	Circulator Heat Load to water (for 26 qty)	KW	not given	2.49										
36	Circulator quantity per RF		26						36		32			
37	Circulator Water Flow	l/min	not given	26.78					28.8					
38		gpm	not given	7.1					7.6					
39	Maximum allowable Temperature	C	not given											
40		F	not given											
41	Maximum allowable pressure	Bar	not given											
42		Psi	not given											
43	Pressure drop	Bar	not given											
44		Psi	not given											
45	Supply Temperature Stability		+ - 2.5 C											
46	RF Load Heat Load to water	KW	none	30.05										

KlyCluster est did not use Chilled Water!

Criteria Comparison.xls [Compatibility Mode]

Draft - Started Jul 17 2008 DRAFT Sep 18 2008

Criteria Comparison - Main Linac RF (except where noted with *)

blue shade indicate numbers that are arbitrarily adjusted to increase water delta T in post RDR

notable differences ??

Row	Items shown per RF (except where noted with *)	units	ILC RDR	ILC POST-RDR (RF on & off) (from Shigeki, et. al.)	ILC POST-RDR (from Wilhelm)	ILC RF Off?? (frm Adolphsen)	ILC KLY Cluster (frm Adolphsen)	ILC CFS Workshop Jun 08	TESLA RF On	TESLA RF Off	XFEL RF On	XFEL RF Off	CLIC	Proj X
				Use for VE Schemes										
8	*Tunnel Scheme		deep two-tunnel				single tunnel	??	near surface single-tunnel		near surface single-tunnel		???	near surface single-
166	**Chilled Water Circuit** (Watercooled Racks and other heat load to air)													
167	Tunnel Space Temperature	C	29	> 40		> 40								
168		F	85	> 104 ?		> 104 ?								
169	Tunnel temperature Stability	%	none	none		none	Negligible 'Heat load to air' in the tunnel in this scheme??							
170	Tunnel Space Humidity	%RH	non-condensing	none		none								
171	Heat Load to Air (waveguide) beam tunnel	KW	none given	5.9		5.9								
172	Heat Load to Air (RF component) svc tnl	KW	10.1		Ignored. (very warm tunnel space)??	Ignored. (very warm tunnel space)			assumed none (??) absorbed in tunnel wall		assumed none (??) absorbed in tunnel wall			
173	Heat Load to Air (non-rf component)	KW	16											
174	Heat Load to Air in w/m	w/m	687											
175	RACKS Total Heat Load per RF	KW	11.5	5.75			Only 1 KW remain in tunnel. (10 kw remain in surface							
176	RACKS Minimum supply temperature	C	non-condensing	reduced to 50%							18			
177		F	non-condensing								64.4			
178	*Conceptual Design Scheme		watercooled racks supplied with blended cold water (from chilled water)	self contained racks with chiller supplied with process water (rack w chiller cost not by cfs)			only 1 kw rack in tunnel(ignored). The other cluster in surface used underfloor data center aircooling						existing cold water, available at the center point of the accelerator	
179	*Total load to Chilled Water (RF+Rack+non-RF)	KW	37.6			none	0							
180	*Supply Temperature used in chilled water	C	6	Chilled Water distribution- not used.		Chilled Water distribution- not used.	Chilled Water distribution- not used.				6			
181		F	43								43			
182	*Delta T used in chilled water	C	10						12		6			
183		F	18						21.6		10.8			
184	*Total Load for a representative water plant	MW	3.9											
185	*Total Flow per representative plant	l/min	5614											
186		gpm	1483											
187	*Main Pipe Size in representative plant	mm	250											
188		in	10											

Introduction & Outline

- Now we need ***cost differentials***:
  How much could we save if we made this proposed change?
- Later in the Technical Design Phase – 2:
  we will need a ***complete new cost estimate*** (bottom-up)
- For Reference Design Report, we had
  estimate = $a + b + c$ new estimate => $a' + b + d$
  where d replaces c, but may have an ***updated estimate*** for a
  need to compare $a+b+c$ => $a+b+d$ or $a'+b+c$ => $a'+b+d$
  sometimes easy comparing b => d, sometimes b/d affects a/a'
  non-diagonal, coupled effects
- We need estimate comparison for ***same year*** => 2007 RDR
- What questions need to be asked for each AD&I study?
- Prior examples: Klystron Cluster & 230 GeV e-e+ studies

What information we need for each study?

- Descriptive text – what changes
- Configuration – number of new components, # and length of tunnel(s), sketches, 3D CAD, etc.
- Required utilities: power, cooling, cryogens
- Cost estimates for new components:
  e.g. overmoded waveguide and couplers
  for Klystron Cluster study,
  klystrons and modulators for DRFS
- Do old unit cost estimates change? Learn Curve?
- Use new ICET cost estimate template (enable macros)

http://www-ilcdcb.fnal.gov/example_26march09-Construction.xls

- Head to head comparison: old vs. new (CFS)