

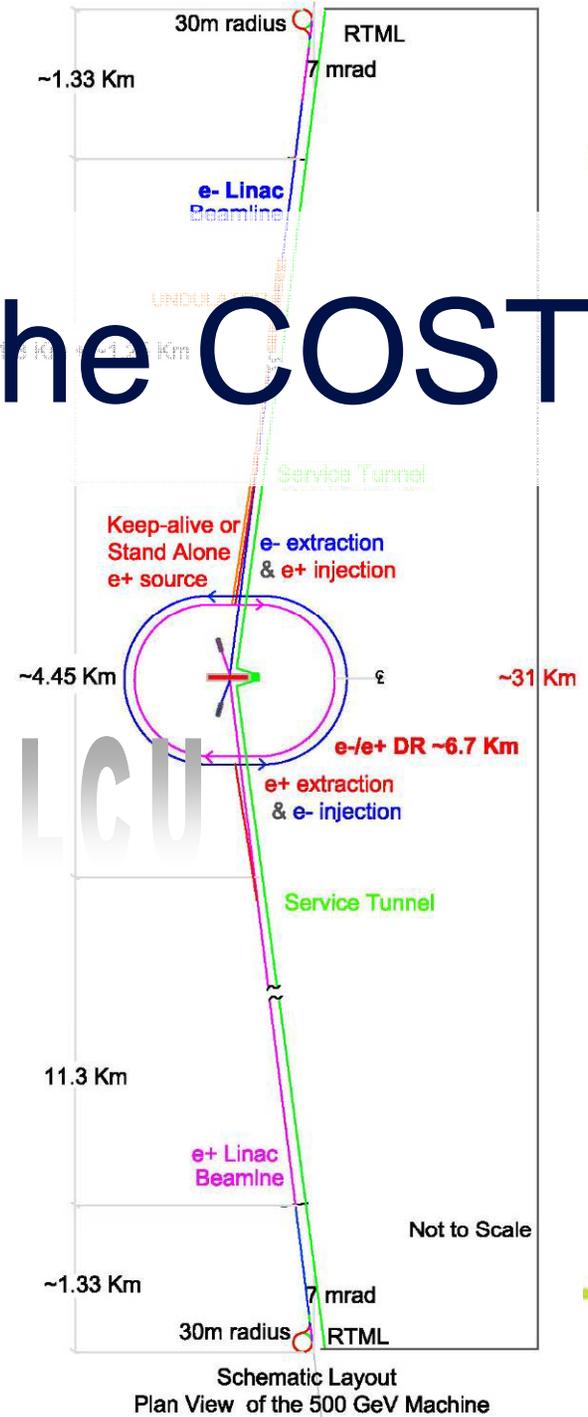
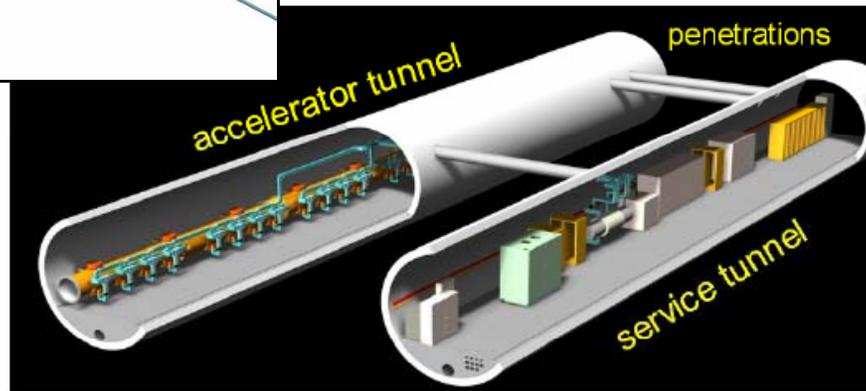
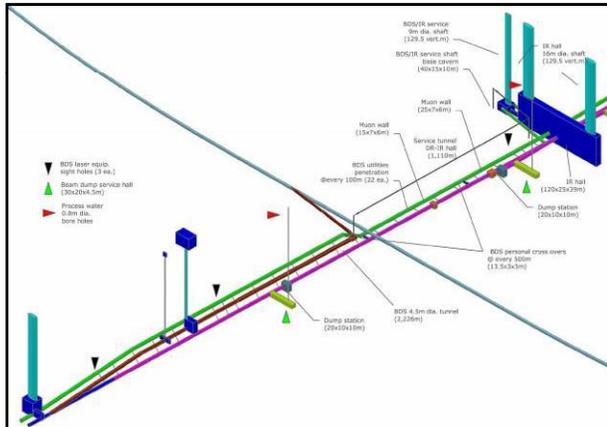


WG-1: Cost Reduction Studies

J. Carwardine, T. Shidara, N. Walker
(For WG-1 participants)



Reducing the COST



6.7 Billion ILCU



TILC – Working Groups

- WG-1 Cost Reduction Studies

APPROACH

- Review and evaluate RDR design
- Re-visit (Caltech) cost reduction lists
- Brainstorming

SPECIFIC TARGETS (Cost Drivers)

- Staging? / Scope?
- Main Linac Technology
- CDF -- Scope of halls, caverns, shafts, etc. Two vs One tunnel. Shallow vs Deep sites

GOALS

- Sendai – establish cost reduction goals

NOTE

- NO CHANGES OF PHYSICS SCOPE WITHOUT ENGAGING EXPERIMENTAL COMMUNITY

B. Barish



Cost Containment / Reduction

- Stated **Priority TD Phase Goal**
- Primary focus: CFS via
 - **Better-defined requirements**
 - From Accelerator Designers
 - From Technical System engineers
 - **VALUE ENGINEERING**
- Basic premise:
 - **RDR design is “sound”**
 - **CFS design is conservative**
- Premise for WG-1
 - **Invite new ideas, provide a forum for open discussion.**
 - **WG-1 is not a decision-making group.**
 - **No changes in scope without engaging the physics community.**

} Iteration
required



Cost Reduction is Not Easy!

- Goal: I want to reduce RDR value by 20%
 - **Approx: 1.3 BILCU**
- Easy way:
 - **Reduce length of main linacs by 40% and therefore the E_{cm} to 300 GeV**
- Hard way:
 - **Find 20×1% effects or 40×0.5% effects or 200×0.1% effects**
- The “Hard Way” is clearly more desirable
 - **Every %-level amount will count!**



WG-1 Schedule

Tuesday 4/3/2008

coveners: Walker, Carwardine, Shidara

09:00 30 Walker Possible cost reduction strategies
09:30 30 Raubenheimer The cost of performance: cost-performance derivatives
10:00 30 Himel Quantifying the trade-offs

10:30 30 *coffee*

11:00 30 Garbincius RDR value breakdown for cost reduction studies
11:30 30 *discussion on afternoon study groups*

12:00 *lunch*

14:00

through 18:00 study group 1,2,3,4. * **SG-1** Approaches to staging (E. Patterson)

Wednesday 5/3/2008

coveners: Walker, Carwardine, Shidara

ILC-CLIC collaboration: conveners Delahaye, Raubenheimer (WG-1a)

09:00 90 Discussion on joint studies with CLIC (sources/DR?)

10:30 30 *coffee*

CFS cost reduction: convener: Marc Ross

11:00 30 Processed water
11:30 30 Underground volume
12:00 30 Shallow site studies

12:30 30 *lunch*

Study group feedback and consolidation (Walker, Carwardine, Shidara)



Goal is to save 1.32 B out of 6.6 B = 20%
 where do we find it?

	Main Linac	DR	RTML	e+ source	BDS	common	EXP Hall	e- source	sum
Convent. Facil.	> 15 %								
Cavities & CM	> 15 %								
RF Power									
Cryogenics									
Magnets & PS									
Controls									
Vacuum									
Instrumentation									
Dumps & Collim									
Installation									
e+ specific									
e- specific									
DR specific									
total									

key:

> 15 %	> 15%
	5-15%
	1-5 %
	0.5-1%
	0.1-0.5%
	< 0.1%
	no entry

Installation is mostly accounted as in-house labor

note ordering as for rainbow

P. Garbincius



CF&S breakdown + electrical & cooling loads

Conventional Facilities average over 3 regions	Main Linac	Damping Rings	Rings to ML	Positron Source	BDS & Dumps	Common	Exp Hall	Electron Source	sum
Civil Engineering:									
Outsourced Engineering									
Underground Facilities:									
* Shafts									
* Tunnels									
* Caverns & Exp Hall									
* Crossovers & Penetrations									
Surface Structures									
Site Development									
Electrical									
RF power (MW)	75.7	14.0	7.1	4.1				1.1	102.0
Conventional power (MW)	13.5	1.7	3.8	7.3	4.9			1.2	32.5
Room Temperature Magnets	0.8	7.9	4.7	8.9	2.6			0.7	25.6
Water Systems power (MW)	9.9	0.7	1.3	1.3	3.5			1.3	17.9
Cryogenics power (MW)	33.9	1.8	0.0	0.5	0.3			0.5	36.9
Emergency power (MW)	0.4	0.2	0.2	0.2	0.3			0.1	1.4
Total Power (MW)	134.2	26.3	17.2	22.3	11.7			4.8	216.3
Air Treatment									
Piped Utilities									
Process Cooling Water									
LCW load (MW)	56.0	17.7	9.3	17.5	46.3			2.9	149.6
Chilled Water (MW)	21.1	1.8	1.3	5.3	1.0			1.4	32.0
** Cryo Air Towers (MW)	33.9	1.8	0.0	0.5	0.3			0.5	36.9
Handling Equipment									
Safety Equipment									
Survey & Alignment									
sum									

* scaling underground facilities components: $UF(i,j) = UF_{avg}(i) * UF_{americas}(i,j) / \sum UF_{americas}(i,k)$
 i = ML, DR, RTML, e+ source, BDS, common, Exp Hall, e- source
 j = shafts, tunnels, caverns & halls, crossovers & penetrations

** cooling systems are included in cost of cryogenics plants

key: > 5 % 1-5 % 0.5-1 % 0.1-0.5 % < 0.1 %

P. Garbincius



Process for WG-1

- Look for ways to reduce the cost
 - **More than walking through each line of the cost estimate.**
- Started with >100 suggestions from various sources
 - **Wide range of suggestions, topic areas, and scope.**
 - **Too many for this group to evaluate quantitatively.**
 - **Many ideas not new.**
- Different ways to group the ideas, eg:
 - **By technical area, technical system**
 - **By topic, eg engineering integration, lattices, staging, operating margins.**
- Four sub-groups individually considered the full list, identified their 'top 10' for further consideration



Cost Reduction List (partial)

Primary Impact	Short Description of the Proposal	Synopsis	Barry, EC	PMs	AP	Eng	SRFT	CFS	Potential cost savings
Technical System cost reduction proposals									
ALL	Remove the peak cooling (and cryo) capacity that's needed to operate on the hottest days	Reduces spare capacity that could be replaced during an upgrade, but spare capacity is high for peak load compared with normal requirements				X	X	X	
ML	Use re-entrant cavities and increase the design gradient to 40MV/m					X	X		
CFS/ML	Substantially increase the cooling water delta T (eg 60 degree C)					X	X	X	
CFS	Reduce diameter of largest shafts, lower the cryomodules into the tunnel vertically					X	X	X	
CFS/ML	Single tunnel solution					X		X	
CFS	Build equipment alcoves inside the tunnel envelope to avoid having to dig separate spaces					X		X	
CFS	Optimize locations of technical equipment to reduce overall tunnel volume					X		X	
PSRC	Replace the undulator positron source with a conventional source				X			X	
ALL	Shallow site solution							X	
BDS	Remove anything previously included for 1TeV				X	X	X	X	
ML	Use common charging supplies for multiple RF modulators					X	X		
ML	Flywheel generator for RF modulator					X	X		
PSRC	Remove the positron keep-alive sources				X	X			
PSRC	Shorten undulator-based positron source by 200-400m				X			X	
ML	Robotic "paint sprayer" concept for cavity processing for consistency and automation. Vacuum head could remove chemicals from enclosed spaces (eg re-entrant cavities)"	Reduce processing cost for cavities, increase consistency of processing to increase yield					X		
RTML/DR	Accept Short Bunch Design in DR and Single Stage Bunch Compressor				X		X	X	
ALL(?)	Give up on self reproducing bunch patterns				X			X	
ALL	Cut/cover solution							X	
ML	Reduce peak RF power by relaxing requirement for simultaneous peak energy and peak luminosity.	Reducing the power envelope would allow lower power klystrons, reduce electrical utility, cooling water, and cost of HLRF				X	X		
ML	Marx modulator instead of bouncer	Not clear what it takes to re-open the BCD/ACD decision				X	X		
ML	Sheet-beam klystron								



Different ways to assess benefit / impact

1. Estimate capitol cost saving
 - ***Is this a cost reduction at all?***
2. Direct physics parameter impact
 - ***Initial capability***
 - ***Maximum Reach***
3. Staging → SG-1
 - ***Can impact be later mitigated with an “upgrade”?***
4. Risk impact
 - ***on reaching nominal performance***
5. Scope of proposed modification
 - ***Major layout change to plug-compatible component change***
6. Technical systems overhead
7. Impact on operations
8. Machine reliability
9. Scope of necessary R&D programme
10. Impact on TD phase planning
11. Impact on construction schedule
12. Site dependency issues
13. Initial study effort (primary required resources)



Some themes from Top-10 lists

- Civil, siting:
 - **Single tunnel, shallow site,..**
 - **Underground space utilization**
- Accelerator
 - **Positron source**
 - **DR short-bunch design, eliminate BC2**
- Engineering
 - **HTRF: Marx, no circulators,..**
 - **Magnet stringing, power supply**
 - **Increase cooling water delta-T**



Site Studies

- (Also a cost-reduction study)
- Shallow site
 - **Cut and cover + klystron gallery**
 - **Shallow tunnel + klystron gallery**
- Single-tunnel (XFEL-like) options
 - **An engineered / construction solution**
 - **We get this (almost) for free.**
- Focus of JINR (Dubna) GDE Meeting (06.08)
 - **JINR shallow-site studies**
 - **CERN (CLIC-ILC) collaboration**

Formally part of ILC-
HIGRADE (European)
programme



CFS Session One - Processed Water

- **Review of Current RDR Design**
 - **Three Loop System for Process Water**
 - **Two Loop System for Chilled Water**
- **Description of Two Alternative Design Solutions**
 - **Use Process Water for All Cooling Requirements**
 - **Use Chilled Water for All Cooling Requirements**
 - **Several Other Ideas and Suggestions were Proposed for Continued Study as Resources Allow**
 - **Further Work is Needed to Develop an Accurate Cost Analysis of Various Alternatives**
- **Resources Available Include:**
 - **Minimal Engineering Support from FNAL**
 - **Possible Additional Support from KEK**
 - **Effort at CERN Based on Common ILC/CLIC Interest**

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CFS Session Two - Underground Volume

- **Currently Not Optimized for Equipment Size or Layout**
- **Primary Space Requirements Determined By:**
 - **Cryogenic Equipment**
 - **Process Water Equipment**
 - **HVAC Equipment**
 - **Installation and Material Handling Requirements**
- **Opportunities for Cost Reduction:**
 - **Revised Process Cooling Design May Result in a Reduction of Equipment Space Required**
 - **Revised HVAC Design May Result in a Reduction of Equipment Space Required**
 - **Overall Optimization of Equipment layout is Essential**
 - **Adjustment of Shaft Usage and Size will Affect Cavern Space Requirements**
- **CFS Will Try to Make Some Progress on this Effort in Spite of Resource Limitations**

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CFS Session Three - Shallow Site Studies

- **Several Variations Were Noted**
- **Near-Surface Solutions Include Actual Cut and Cover Excavation as well as Near Surface Tunnel Boring Techniques**
- **Other Aspects of General Tunnel Configuration Include:**
 - **Single Tunnel Solutions**
 - **Material Access and Life Safety Egress Impacted by Tunnel Configuration**
 - **Shaft Diameter Reduction or Further Shaft Elimination**
 - **Horizontal versus Vertical Cryomodule Installation**
- **Various Alternatives Noted May Preclude Construction in Certain Siting Locations**
- **Resources Will be Identified to Make Progress on this Topic Prior to the Dubna Meeting**

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Next steps

- Follow through on the 'Top-10' items from this meeting
 - **Several items need more thorough evaluation for feasibility, cost savings, risk, etc**
 - **Several items are already on the list and we need to get people working on them.**
- Continue to solicit and evaluate new proposals.
 - **Maintain an active list of possible cost reductions.**
 - **Distribute the outcomes from this meeting.**
- Specific items for further study
 - **Civil/siting: major theme of Dubna GDE meeting**
 - **Positron source integration study.**
 - **Technical systems impact of high cooling delta T.**
 - **Magnet power supply stringing and space utilization.**



Summary

- There is clearly benefit in having a forum for open discussion and evaluation of new cost reduction ideas.
- Open discussions with this ad hoc group were very positive.
- Formal engagement is also needed, eg from Technical Area Group Leaders.
- The real benefit will come from following through on the most interesting ideas (need people to work on them).