Cost Reduction Strategies

TILC08 · GDE Meeting on International Linear Collider · Tohoku University

Sendai · Japan · March 3 to 6, 2008

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Outline

- Introduction
- ILC RDR Value Estimate and Methodology
- Cost Reduction since VLCW06 Vancouver
  - RDR Mgmt at CalTech, October 2006
  - ILCW Valencia, November 2006
- Cost Reduction Policy
- Cost Reduction Strategies
  - Reduction of the 500 GeV or 1 TeV Capital cost
  - Reduction of the total Lifetime cost
  - Value Engineering (Performance over cost)

Outline (cont'd)

- Cost Reduction Classes and Categories
  - Fixed Parameters but perhaps higher risk
    - Single Item in the order of several percent (i.e. Single Tunnel, Dog-Bone Damping Ring, Process Water, …)
    - In the order of one percent (i.e. Service shafts, galleries and caverns, …)
    - Large number of items (i.e. Reduction of the number of Magnet families, number of BPMs etc)
  - Change of Scope
    - Lower Energy
    - Less Luminosity

Outline (cont'd)

- Comparison with different Designs
  - Comparison between TESLA and ILC Cost
  - Comparison between USLCTOS and ILC Cost
- Organization of WG 1: Cost Reduction
  - N. Walker, Possible Cost Reduction Strategies
  - T. Raubenheimer, The Cost of Performance
  - T. Himmel, Quantifying the Trade-Offs
  - P. Garbincius, RDR Value Breakdown
- Cost Reduction Example: Single Tunnel
- Summary

Introduction

Why are we discussing cost?

- Strong Support from Executive Committee
- Ray Orbach: "In making our plans for the future, it is important to be conservative and to learn from our experiences. Even assuming a positive decision to build an ILC, the schedules will almost certainly be lengthier than the optimistic projections. Completing the R&D and engineering design, negotiating an international structure, selecting a site, **obtaining firm financial commitments**, and building the machine could take us well into the mid-2020s, if not later."

Introduction

- Reference Design Report is not a minimum cost Linear Collider
- American Association for the Advancement of Science (AAAS) Annual Meeting in Boston, February 14 to 18, 2008
  - Basic Science: An expensive fun?
- Cost is one of the big concerns for the ILC approval.

Costing Rules (partial)

2. Cost estimate on the basis of a world wide call for tender, i.e. the value of an item is the world market price if it exists.
3. The selection criterion is the best price for the best quality.
4. One vender supplies the total number of deliverables …
5. If necessary parametric cost estimate is used for scaling of the cost, i.e. for cost improvement. The cost improvement is defined by the following equation:

$$P = P_1\ N^a$$

(Three vendor would increase the cost by 25 %.)

Total ILC Value and Explicit Manpower

- Total ILC Value Cost **ILCU* 6.62 B**

ILCU 4.79 B shared + **ILCU 1.83 B** <site specific>#

plus **14.2 k person-years** Explicit Manpower

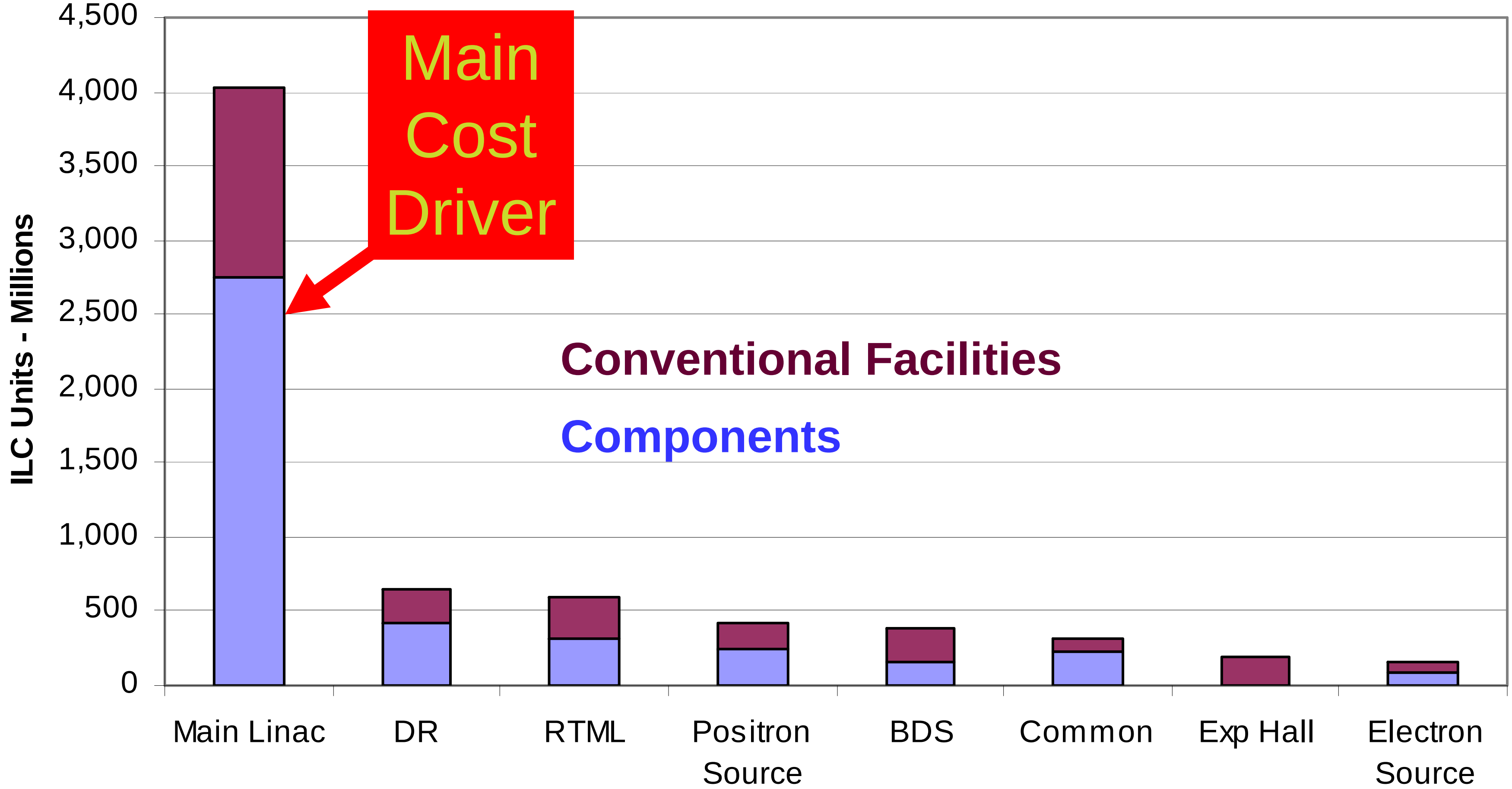
= 24.2 M person-hours

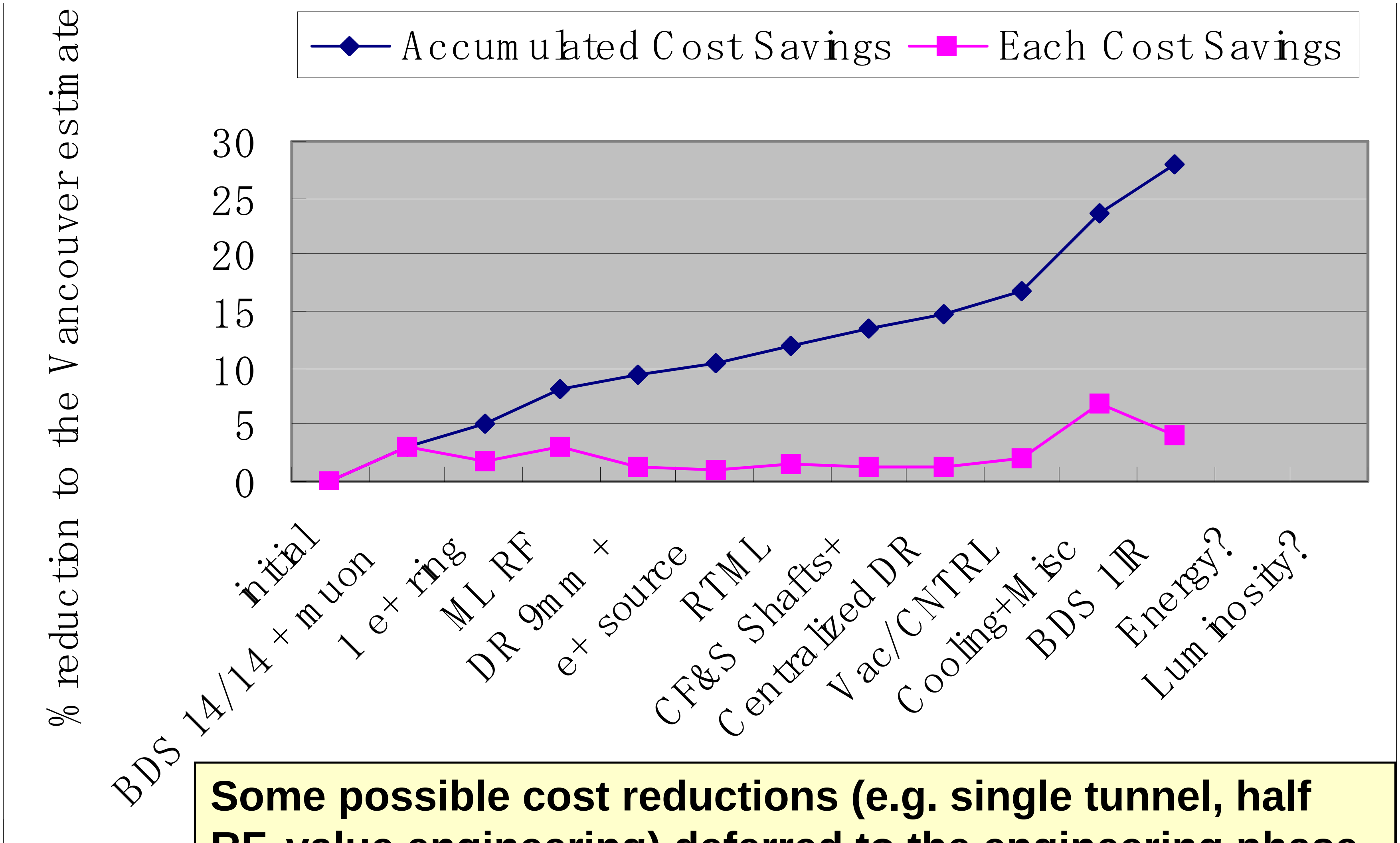
@ 1,700 person-hr/person-yr

*ILCU(nit) = $ (January 2, 2007)

#<site specific> = average of the three site specific costs

ILC Value – by Area Systems





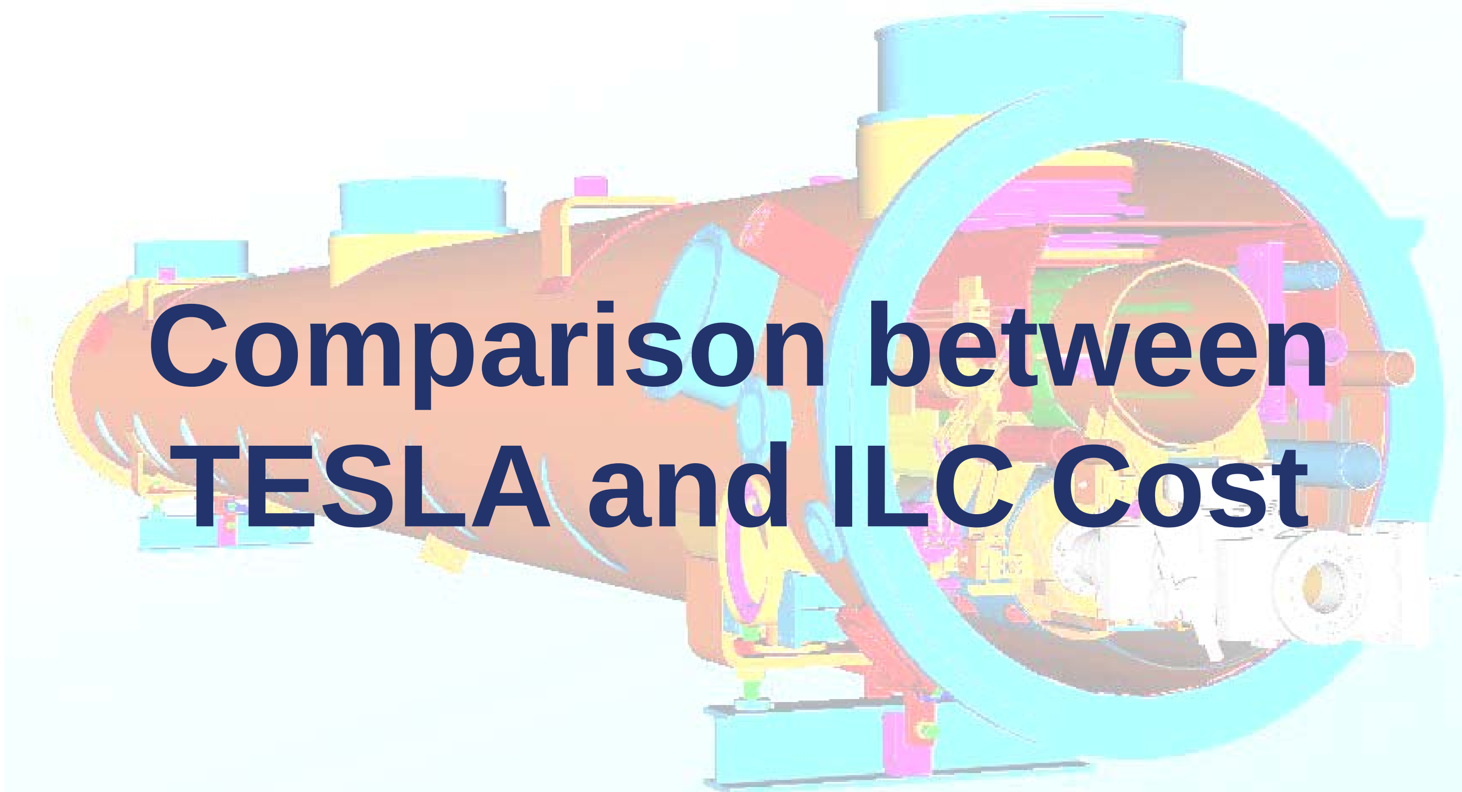
Some possible cost reductions (e.g. single tunnel, half RF, value engineering) deferred to the engineering phase

Cost Reduction Policy

- Cost reduction does not mean the reduction of unit costs
- Definition of the lowest reasonable cost:
  - "The lowest reasonable cost represent the minimum cost for that a project at given parameter and given time could be constructed. For lower cost the project would fail."
- This definition is a weak upper limit. But if one asks for each item the question, is this really necessary for the success of project, or is it only more convenient or safer then it is easy to justify the cost to all funding agencies and committees.

Cost Reduction Policy (cont'd)

- Model for the highest cost the project will be most likely approved as an international project.
- The design of the project to this cost
- Disadvantages
  – Hard to find the limit
  – Even hard to justify it



Comparison between TESLA and ILC Cost

Scale of ILC and TESLA

16,088 SC Cavities: 9 cell, 1.3 GHz (TESLA: ~36/26)

1848 CryoModules: 2/3 containing 9 cavities,
    1/3 with 8 cavities + Quad/Correctors/BPM

613 RF Units: 10 MW klystron, modulator, RF distribution

ML: 562 RF Units (15 to 250 GeV); TESLA 572 (5 to 250 GeV)

72.5 km tunnels ~ 100-150 meters underground (TESLA 37 km)

13 major shafts $\geq$ 9 meter diameter (TESLA 19 shafts)

443 K cu. m. underground excavation: caverns, alcoves, halls

10 Cryogenic plants, 20 KW @ 4.5^{o} K each (TESLA 12 x 15 kW)
  plus smaller cryo plants for e-/e+ (1 each), DR (2), BDS (1)

92 surface "buildings", 52.7 k sq. meters (TESLA ~30 k m^2)

240 MW connected power, 345 MW installed capacity (145/180)

13,200 magnets – 18% superconducting

Comparison between TESLA & ILC

	TESLA TDR / M€	Scaled TESLA TDR / M$	ILC RDR / M$	Difference / M$
Total Cost	**3136** (1.6 M$/M€)	**5018**	**6620**	**1600**
Conventional Facilities	676 (CE+PW etc.)	1082	2472	1390
Underground Buildings		100 %	175 %	
Surface Buildings		100 %	240 %	
Consultant Engineering		100 %	1000 %	
Power Distribution		100 %	510 %	
Water Cooling		100 %	333 %	
Cryogenic System	162	260	567	300
Cryo Plant*		12 x 100 %	10 x 200 %	

*TESLA: 12 x 2.2 kW @ 2 K

ILC: 10 x 3.5 kW @ 2 K

XFEL: 2.45 kW @ 2 K; M€ 34.35 for Cryogenic System

Schedule for Working Group 1

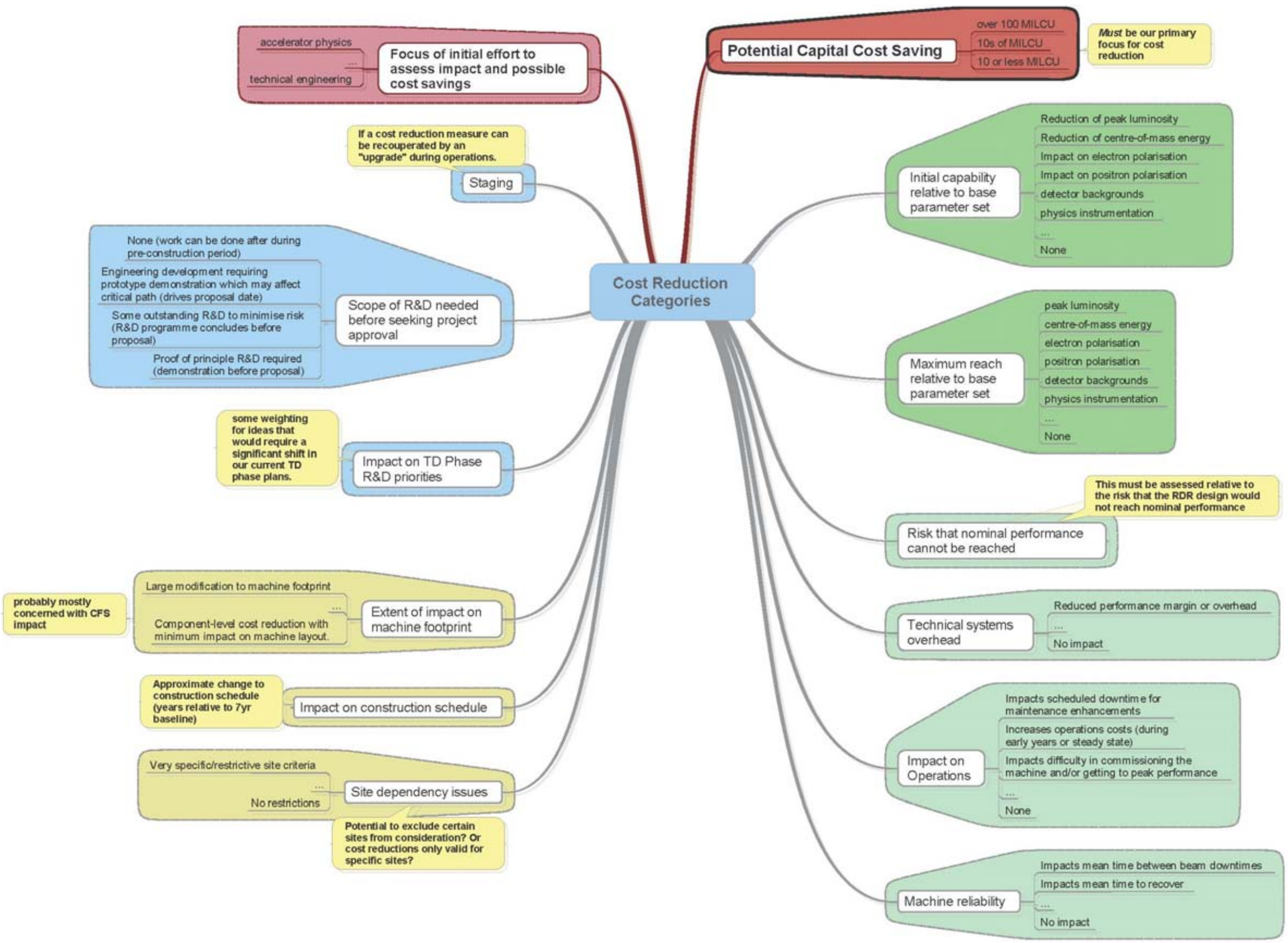
Tuesday 4/3/2008

	coveners: Walker, Carwardine, Shidara			
Introduction	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*	
Study Groups	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)		
ILC-CLIC	09:00	90	Discussion on joint studies with CLIC (sources/DR?)
	10:30	*30*	*coffee*
	CFS cost reduction: convener: Marc Ross		
CFS Cost Red.	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)		
	14:00	120	presentations from SGs
	16:00	*30*	*coffee*
	16:30	30	present consolidated list
	17:00	30	discussion of furthrer work

Cost Reduction Categories by Nick Walker



Cost Reduction List by J. Carwardine (part.)

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								

Cost Reduction Rules by T. Himel (part.)

There is more to cost reduction than thinking of ideas to reduce the cost. In deciding whether to accept a cost reduction idea, one must account for possible negative impacts of the change. While reducing construction costs, the proposed change might:

1. Increase the first year's operating cost. (deferring costing of an item from the construction budget to the operating budget is an example of this.)
2. Increase annual operation cost. (Letting Linde build and pay for the cryoplants in return for us paying them for their use is an example of this.)
3. Introduce a risk of lower average luminosity, either permanently or until an upgrade can be performed. (Going to 1 tunnel without compensating by improving availability of other components is an example of this.)
4. Implementing the change forces design changes in the accelerator, so the cost of the design changes must be accounted for. For the present stage of the project, this is negligible for the big savings we are considering and will be ignored.

Cost Reduction Rules by T. Himel (part.)

$$<\Delta C> = -C_c + K_{ops}\, C_{ops1} + K_{ops}\, N_{year}\, C_{opsN} + K_{lum}\, \Delta L\, R_L$$

Where

$<\Delta C>$ = The expected (average) value of the cost change. Negative is a saving.

C_c = The reduction in the construction cost

C_{ops1} = The increase in the first year's operating cost to pay for an item deferred.

C_{opsN} = The increase in all years' operating costs

ΔL = The percent decrease in luminosity that may be caused by the change

R_L = The probability that the above luminosity reduction will occur

The items above are different for each cost reduction idea while those below have a single value for the whole project.

K_{ops} = The conversion constant from operating to construction costs

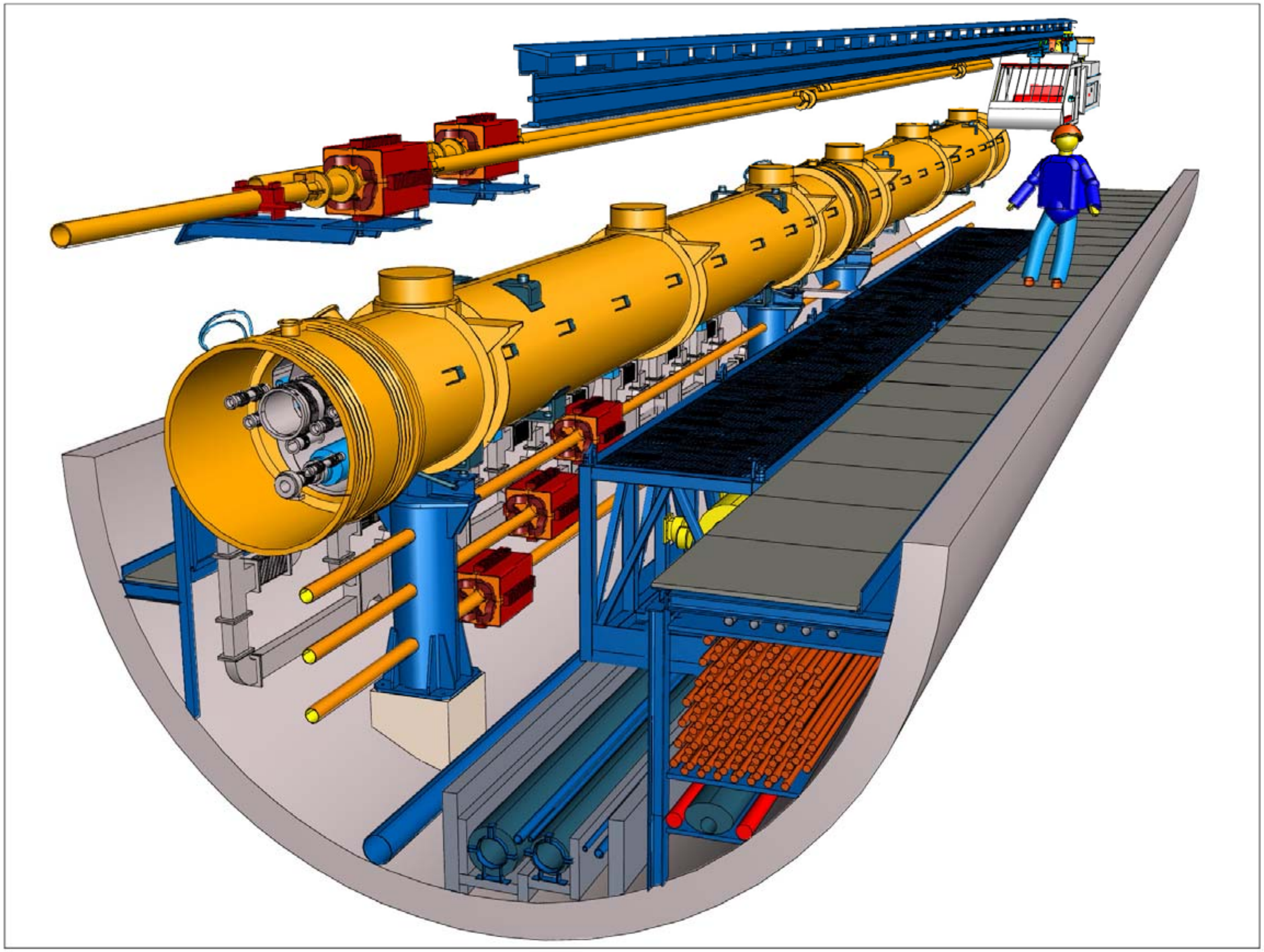
N_{year} = The number of years for which to add up the increased operating cost

K_{lum} = The conversion constant from percent luminosity reduction to construction cost

Cost Reduction Example: Single Tunnel

- Single tunnel designs exist (TESLA & XFEL)
- In Europe Safety issues are solved (HERA, XFEL, LHC and CLIC)
- A Mock Up was built in the extension Tunnel of TTF and for XFEL Installation
- A “4 % Prototype” will be built (XFEL Linac)
- Absolute a twin tunnel is site independent roughly twice as expensive as a single tunnel
- The relative cost saving are about 5 % and depends on geology, diameter, footprint etc.
- Advantages and disadvantages were discussed several times: i.e. GDE White Paper Number of Tunnels, Answer to ITRP question 22

Sketch of the TESLA Tunnel (TDR)



Summary

- Cost Reduction is possible
- Cost Reduction is necessary
- Success of Sendai depends on a Consensus of the whole community that Cost Reduction is essential
- Please join the Working Group 1 if you have other (new) Ideas or different opinion
- Everyone should support the Cost Reduction effort