Toward a Cost Estimate for the ILC

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GDE – Cost Engineers

Outline

- here's what we told you at Fermilab in April
  http://ilcagenda.cern.ch/conferenceDisplay.py?confId=290
- progress since then
- first round cost estimates – Vancouver – July06
  - **characterization**
  - **what the data is telling us**
- cost reduction studies and decisions
  - **brief summary of each study**
  - **a detailed example by Andrei Seryi will follow**

The ILC-GDE Organization is

- Matrix of Machine Areas
  vs. Technical & Global Systems
- Executive Committee:
  Barry + 3 Regional Directors
  + 3 Accelerator Leaders
- RDR Management Team:
  EC + 3CE + Integration Physicist
- Cost Engineers (Tetsuo, Wilhelm, Peter)
- Design Cost Board (PHG, chairman)
- Change Control Board (Nobu Toge, chairman)
- R&D Board (Bill Willis, chairman)

Organizational Matrix

Cost Roll-ups

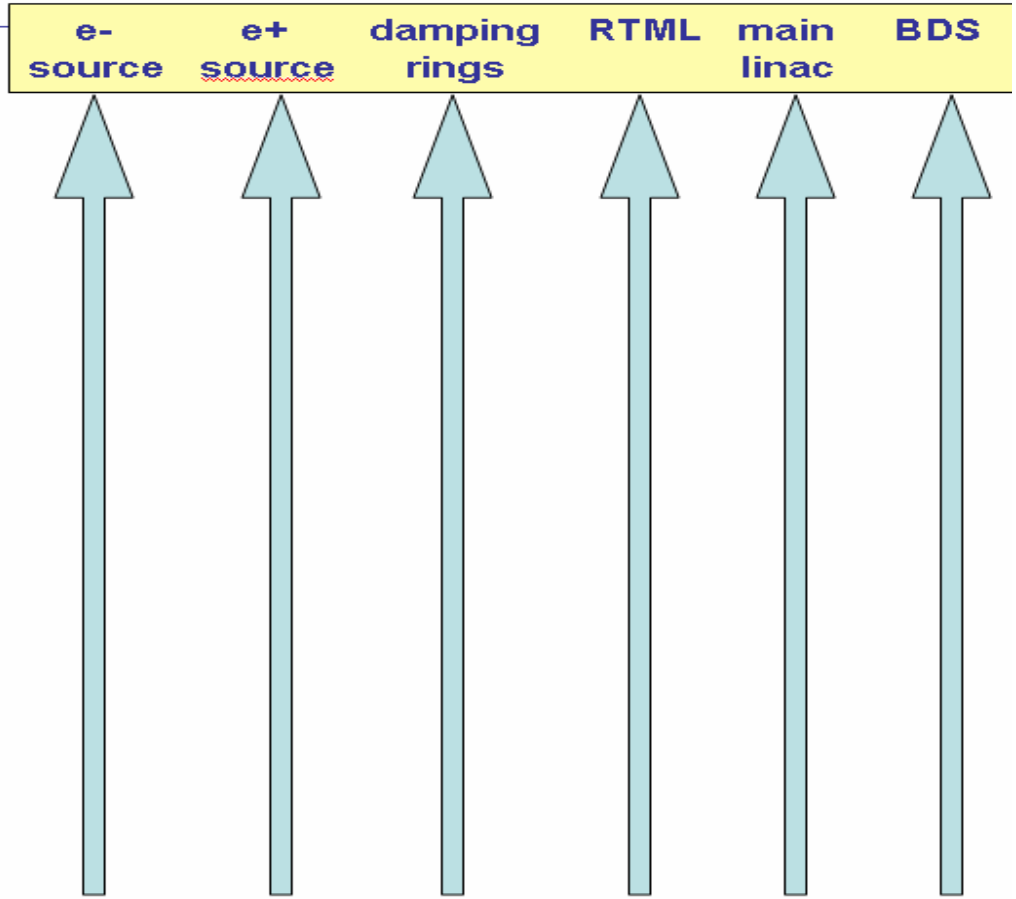
Area Systems

Technical Systems

- Vacuum systems
- Magnet systems
- Cryomodule
- Cavity Package
- RF Power
- Instrumentation
- Dumps and Collimators
- Accelerator Physics

Global Systems

- Commissioning, Operations & Reliability
- Control System
- Cryogenics
- CF&S
- Installation



Progress

- RDR Cost Estimating Guidelines and ***Instructions***

  http://www-ilcdcb.fnal.gov/RDR_costing_guidelines.pdf

  http://www-ilcdcb.fnal.gov/RDR_Cost_Estimating_Instructions_23may06.pdf

- ***Confidentiality Rules***

  http://www-ilcdcb.fnal.gov/cost-confidentiality-official-njw.pdf

  http://www-ilcdcb.fnal.gov/vancouver_cost_discussion_guidelines.pdf

- ***First cost estimates*** were obtained in early July
  for consideration at Vancouver meeting
  estimates are preliminary, need completion,
  checking, iterations, & review of requirements.

- They are in the spirit of an ITER-like VALUE estimate
  e.g. no labor, no contingency, no overheads

Confidentiality of Cost Estimates

- to protect Industrial Estimates
- to prevent biasing bidding process
- to insure independent estimates from 3 regions

- All cost estimates must be treated as
  confidential within the GDE
  not to be publicly presented
  or posted on a public web site

- Makes it more difficult to study and review the estimates,
  both internally and externally.
  Executive Committee has granted need-to-know
  "review access" = see, but don't take away
  to CCB, for example

Major Components of Estimate

- 4 Site Dependent Civil Construction Estimates
  - **CERN, DESY, Japan, Fermilab (estimate for each site)**
- Other conventional facilities estimates
  - **site-independent**
  - **power, HVAC, cooling, fire protect., hoisting, safety**
  - **each estimated by single region – need cross-checks**
- Technical Cost Drivers: Cavities, Cryomodules, RF
  - **independent estimates from each of 3 regions**
  - **based on Industrial Studies (not yet US for Cavities/CM, US Cavities/CM estimate is an engineering model)**
  - **comparisons are on-going – at KEK this weekend**
- Other items have **single** engineering level estimates
  - **based on world-market (lowest cost) estimates**
  - **often based on prior purchasing experiences**

Have > 90% of cost estimates

adequate for rough assessment and starting studies

System description	Cost Ests July 18, 2006 √ since √ Sept 20, 2006								Regional		
	common	e-	e+	DR	RTML	ML	BDS	Exp	Am	Asia	Eur
e- Source		√									
e+ Source			√								
DR				√							
RTML					√						
Main Linac											
BDS							√				
Com, Op, Reliab											
Control System	√	√	√	√	√	√	√				
Cryogenics		√	√	√	√	√	√ *				
Convent. Facilities	√	√	√	√	√	√	√ *	√	√	√	√
Installation	√	√	√	√	√	√	√				
Instrumentation	√	√	√	√	√	√	√				
Cavities				√					√		√
Cryomodules		√	√		√	√			√	√	√
RF	√	√	√	√	√	√			√	√	√
Magnets & PS		√	√	√ *	√		√ *				
Dumps & Collim		√	√	√	√		√				
Vacuum		√	√	√	√	√	√				
Accel Phys											

√ = complete, √ * = almost complete, missing something minor, = need

Let's look at ESTIMATES

- **Don't ask what it costs!**
- **Too premature to answer, but due to confidentiality, I couldn't tell you**
- **Will show comparative, but not absolute costs, in pie charts and bar graphs; can learn a lot about cost drivers and where we need to spend effort at cost reduction**
- **Show, but not give (via website or hard copy) these sensitive plots**
- **For concreteness, will use Civil Engineering from the Americas in these plots**

site-dependent civil engineering

ILC Cost Estimate – 16sept06 – by Areas

ILC Cost Estimate – 16sept06 – by TS &GS

These are US site-dependent costs for civil eng. (just pick one of 4 sites for concreteness)

RF Unit to power 3 CryoModules

Cost Ests. for CryoModule w/Cavity
based on different methods

- Europe – scaled TESLA with 80% cavity yield
  - most mature & value-based estimate
  - will learn soon from XFEL experience
- Asia – industrial studies
- Americas – in-house engineering
  - industrial study in process
- Asian & American estimates
  - represent a "reality check"
- Main Linac, Cavities, & CM groups are meeting this weekend at KEK
  - to compare details of estimates
  - and try to resolve differences

value

~ big cost swing!

Cost Consciousness

initially: Snowmass 05, Frascati, and the BCD baseline design was to meet the ***technically challenging*** goals

we must scrub and justify all cost estimates costs vs. goals and reliability

understand differences wrt TESLA & USLCTOS

beginning cost/performance optimization and tradeoff studies

Initiated(ing)Technical, Scope, Cost Reviews

- Power (≥ 320 MW) and Water Cooling!?!: specifications, requirements, implementation: chilled water, ΔT, temperature stability, etc.

  Marc Ross *et al.*

- Magnets and Power Supplies: help Technical Systems Group check requirements, design optimization, cost model

  Tom Markiewicz

- Conventional Facilities – just setting up study with experts from Fermilab, SLAC, SACLAY. Are designs and estimates logical, technically sound, complete, correct, and optimized?

Cost Reduction ***Studies*** commissioned by RDR_MGMT at Vancouver

- 2 vs. 1 tunnel for Main Linac, RTML, BDS
- Conventional Positron Source (not Undulator)
- Centralized Damping Rings in single tunnel
- Single Bunch Compressor for RTML
- Half # bunches => half # klystrons for ML & RTML
- Change BDS from 20+**2** mrad => 14+14 mrad
- Shallow (cut and cover) single tunnel w/gallery
  longer timescale than for Valencia

Cost Reduction Ideas from AS Leaders

- Remove 2 mrad crossing angle configuration
  change from 20 mrad + 2 mrad => 14 mrad + 14 mrad
  - **Approved by CCB – sent to Executive Committee**
  - **See Andrei Seryi's next presentation/discussion**
- Remove Second Positron Damping Ring
  - **Good progress on ion/electron cloud clearing – continue R&D**
  - **Approved by CCB – sent to Executive Committee**
  - **Saves ~ 1.9 % of total ILC estimate**
- Change from 18 meter long + 9 meter long muon spoilers in Beam Delivery System to single 5 meter long spoilers
  - **Now before CCB**
  - **Would reduce total ILC cost by ~ 0.4 %**

Other ideas needing study and R&D

- Surface Assembly of Detectors (BDS)
  - **as for CMS – less expensive than underground**
- Replace BDS Service Tunnels with Alcoves
  - **radiation and reliability issues**
- Optimize Experimental Halls (BDS)
  - **just big enough to cover each detectors needs**
- Decrease TESLA cavity iris to 60 mm, and also ½ apertures of quads and BPMs
- Marx modulator & sheet beam klystron
- Reduce energy and cryogenics margins

Summary of RDR_MGMT Decisions at KEK meeting Aug 31 – Sept 1

- Centralized Damping Rings
  - **electron and positron DRs in a single tunnel**
  - **make plan and cost estimate to submit to CCB**
  - **optimize BDS and e- and e+ Source geometries**
  - **would save ~ 1.7 % of total ILC cost**
- Conventional Positron Source
  - **Would reduce total cost by ~ 1.1 % wrt Undulator**
  - **Decide: Maintain Undulator & polarized e+ option**
  - **Encourage cost reduction studies for both undulator & conventional positron sources**

RDR_MGMT Decisions @ KEK (2)

- Half-current (half-# bunches) in Main Linac & DR
  - **Propose install ½ of Linac RF drivers (upgradeable later)**
  - **Reduce cost by ~ 4.1 % but reduce Luminosity by up to ½**
  - **Defer consideration of smaller DRs at this time**
  - **ML Leaders to prepare proposal which would be passed by WWS Leaders and Parameters Committee for reaction and comments before sending to CCB**
  - **Retain 2nd Bunch Compressor in RTML for max Luminosity**
- 2 vs. 1 tunnel
  - **reliability/availability (extra cost for increased energy margin), radiation damage shielding, & personnel egress balance decreased tunnel costs**
  - **decided to stay with 2 tunnels**
  - **try to optimize to smaller diameter tunnels CF&S to report on this study over this weekend**

RDR_MGMT Decisions @ KEK (3)

- BDS change from 20+2 mrad => 14+14 mrad
  - **RDR_MGMT reviewed status of change reques**
  - **approved by CCB – sent to Executive Committee**
  - **corresponds to ~ 2.0% of total ILC cost**
  - **Andrei Seryi will next present a detailed "case study"**

- **Still lots of hard work to do to produce a**

credible **cost estimate**

end of this presentation!

Backup Slides

RDR Cost Estimating Instructions and Standards

Table of Contents

Instructions (continued)

5. Cost Estimating Instructions
   - 5.a. Project Schedule
   - 5.b. System Boundaries
   - 5.c. Graded Approach
   - 5.d. Scaling from Other Projects
   - 5.e. Learning Curves
   - 5.f. Cost Estimates (50% point and uncertainties)
   - 5.g. Include NO contingency
   - 5.h. Spares
   - 5.i. The 5 Horsemen (additional costs beyond acquisition)
   - 5.j. Cost Sensitivities
   - 5.k. Watch out for duplication
   - 5.l Transportation costs
   - 5.m Optimization – Construction Costs vs. Long Term Operations

These RDR Cost Estimating Instructions and Standards contain lots of URL links to further details and examples

Largest Cost Risks

- Complete checks of designs and estimates
- Uncertainties and cost probability distributions
  - **risk budget, 95% limits, contingencies**
  - **market factors - as for LCLS construction**
- Production quantity cost reductions
  - **De-rate gain to ½ as per XFEL?**
- Gradient distribution for Cavity performance
  - **Included 80% yield, continue R&D, but what it…**
- Klystron performance and reliability
  - **Need more experience to understand risk**
- Underground construction risks

notes on Civil Engineering

- underground construction includes:

  tunnels, shafts halls, caverns, and

  misc = personnel passages and penetrations between tunnels for waveguides, power, and instrumentation

- Note: common design optimized for deep site was used, putting DESY at competitive cost comparison disadvantage – requested an additional (2 tunnel) study optimized for DESY site geology.

Cost Correlations: AS vs. TS/GS

Extrapolating to Large Quantities

- Industrial Studies such as TESLA
  give estimate for full quantities
- Engineering Studies (e.g. US CM/Cavities)
  assumes a typical "learning curve"
- Some items, e.g. magnets and PS estimates
  were "one-of" costs scaled by quantity
- Optimism ⇔ ? Reality ? ⇔ Conservatism
- XFEL's "risk" budget included provision for
  only getting ½ of the cost reduction
  due to production of large quantities
- Big issue – really have to understand this!

Slide Title

- Main
  - **Subpoint**
    - Sub, sub point