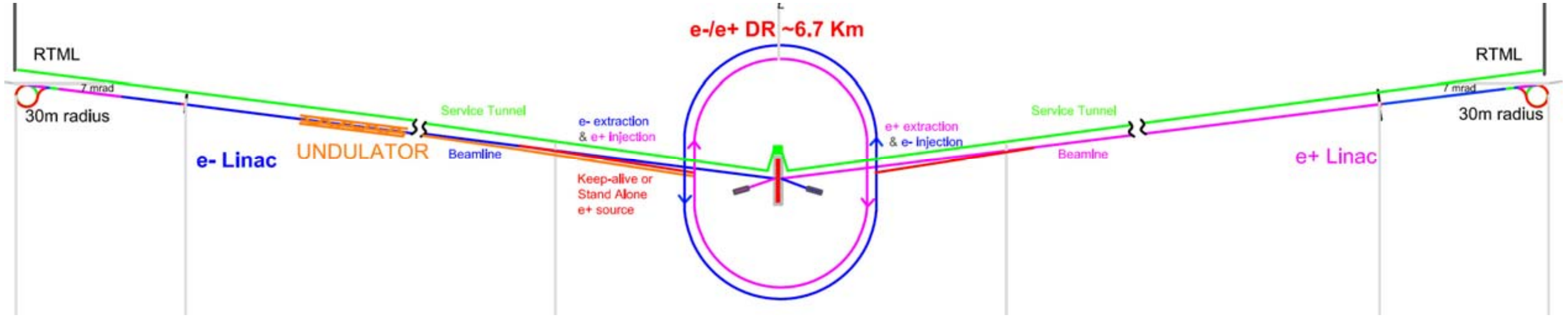
GDE Status



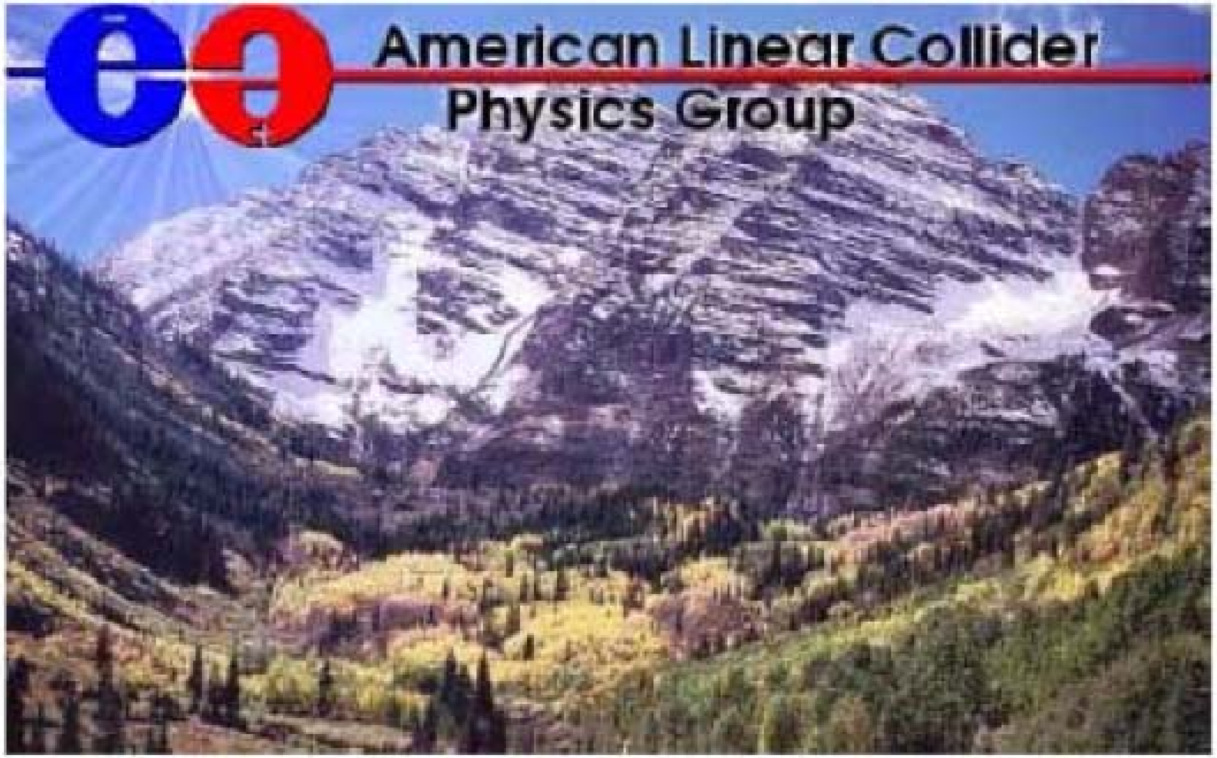
Barry Barish

4-Feb-07

Confidentiality Issue

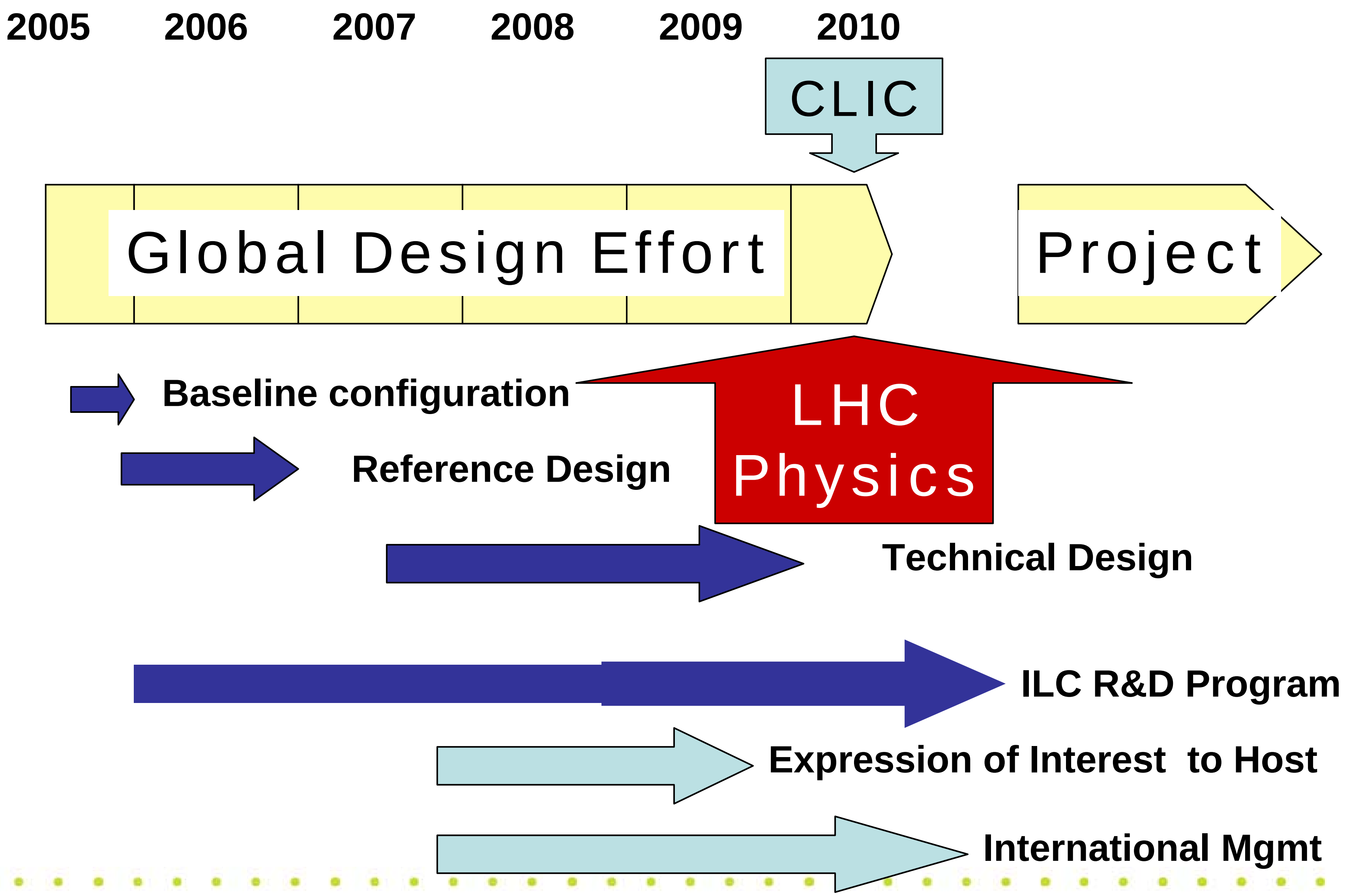
- No restrictions in the presentations at ACFA / GDE Beijing, but …..
- RDR and Costing will not be officially released to public until presented to ICFA/ILCSC - Thursday
  - **Joint meeting of ICFA/ILCSC followed by press release and press conference**
  - **Therefore, presentations at ACFA/ILCSC will be posted on Indico site, but only available by password until Thursday.**
  - **Password = dontaskmax**
- **Please defer communications outside and to the press until Thursday**.

GDE Began at Snowmass Aug 05



2005 International Linear Collider Physics and Detector Workshop
and Second ILC Accelerator Workshop
Snowmass, Colorado, August 14-27, 2005

The GDE Plan and Schedule



Snowmass to a Baseline

2005

Snowmass

August | September | October | November | December

WW/GG summaries

Response to list of 40+ decisions

All documented 'recommendations available on ILC Website (request community feedback)

Review by BCD EC

BCD EC publishes 'strawman' BCD

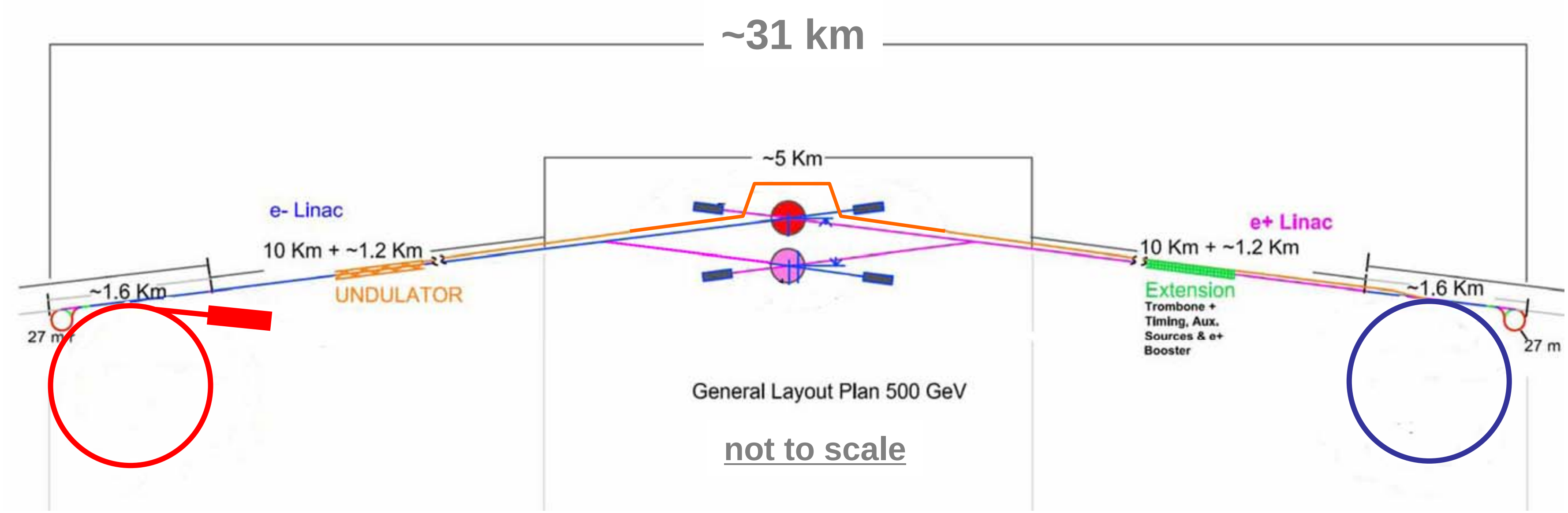
Public Review

Frascati GDE meeting

BCD Executive Committee:
Barish
Dugan, Foster, Takasaki
Raubenheimer, Yokoya, Walker

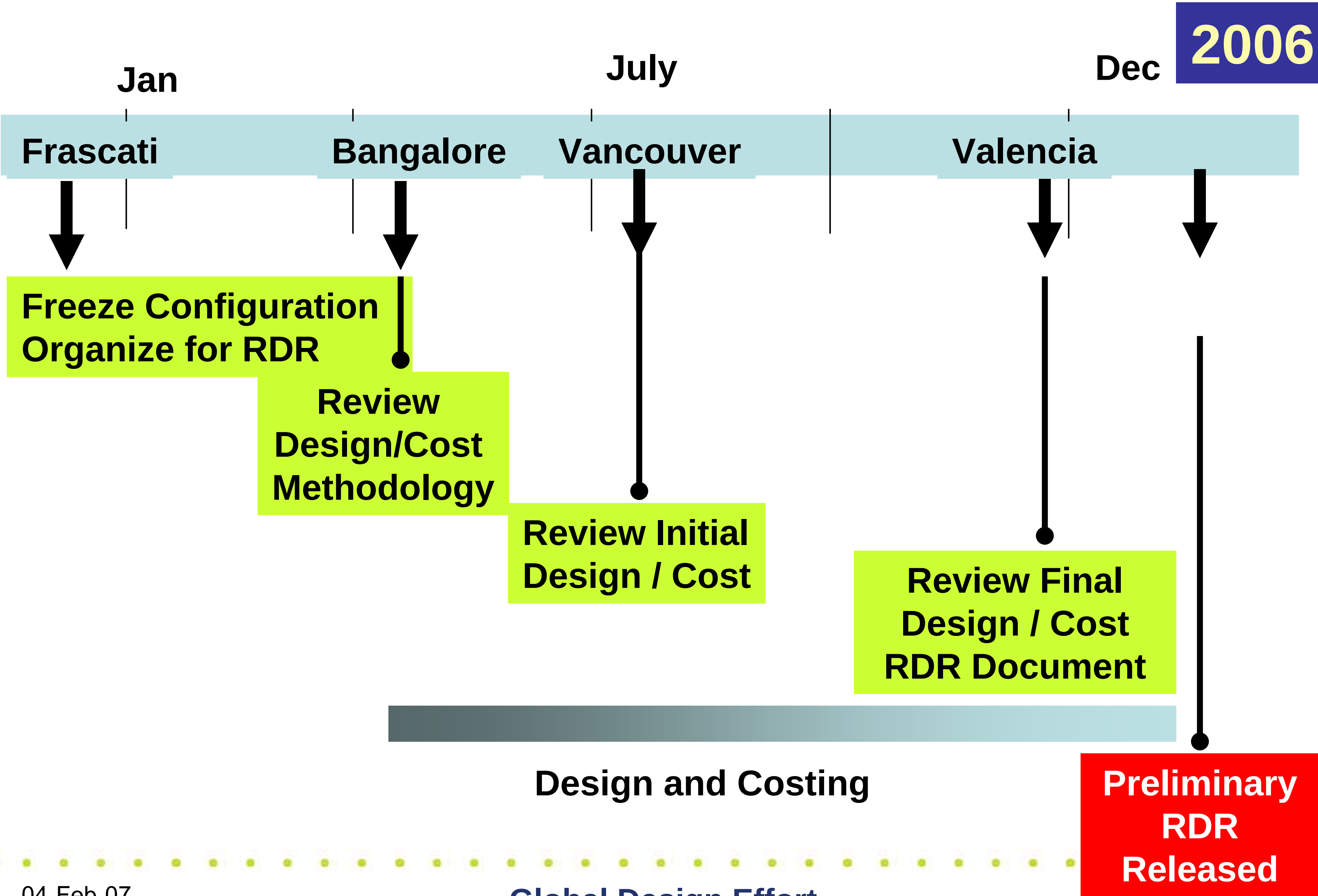
1st Milestone - ILC Baseline

Baseline Configuration -- Dec 2006

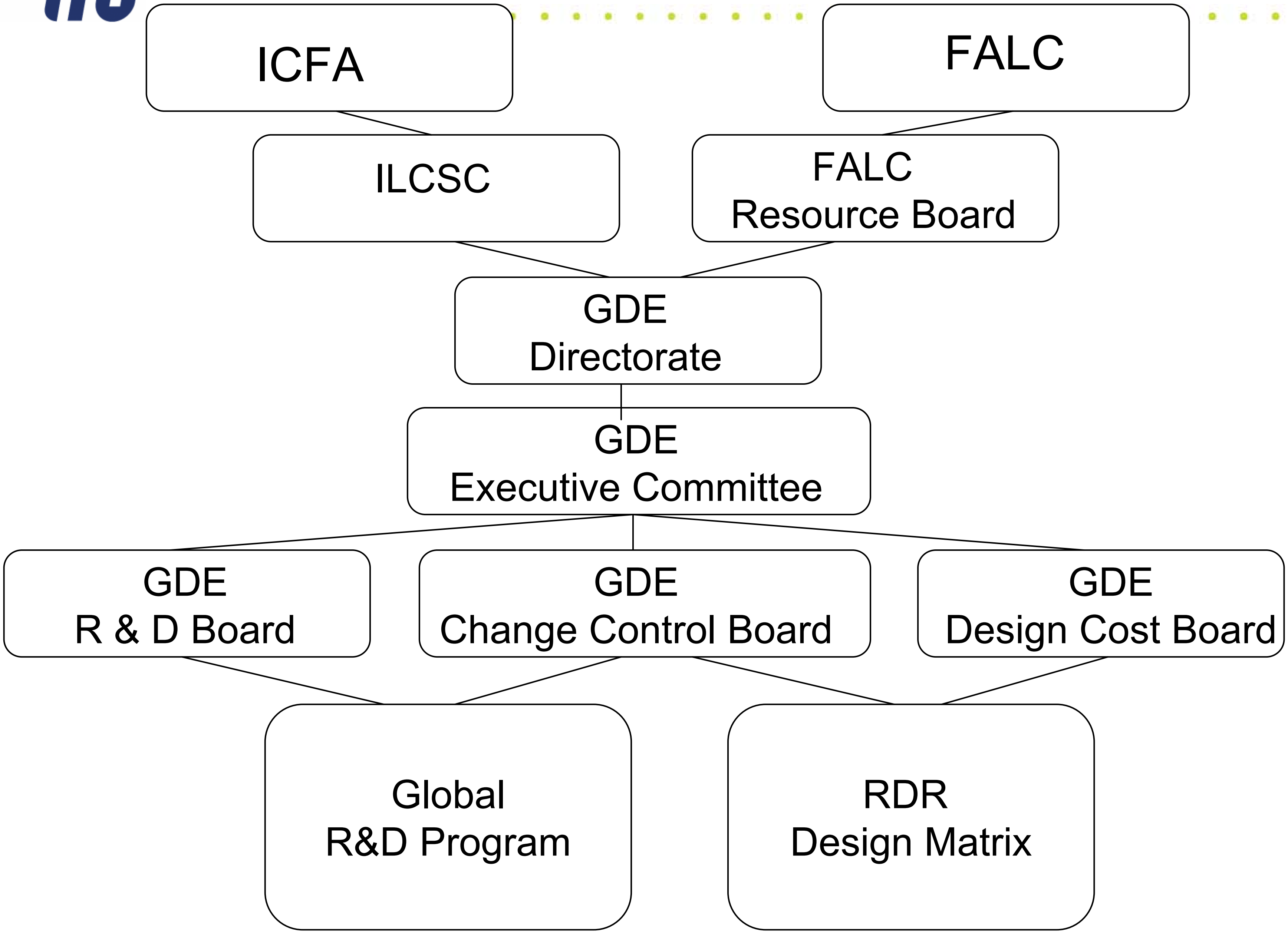


Documented in Baseline Configuration Document

Baseline to a RDR



GDE -- RDR Organization



RDR Management Board

- To carry out the RDR, we found we needed a stronger direct management.
- We created the RDR Management Group
  - Director
  - Executive Committee
  - Cost Engineers
  - Integration Scientist
- Met weekly to coordinate, review and guide the process and direct the writing the RDR (with RDR editors)
- Chair: Nick Walker

ILCSC Parameters Report

- E_{cm} adjustable from 200 – 500 GeV
- Luminosity → $\int L dt$ = 500 fb^{-1} in 4 years
- Ability to scan between 200 and 500 GeV
- Energy stability and precision below 0.1%
- Electron polarization of at least 80%

- The machine must be upgradeable to 1 TeV

- This report has served as our "requirements" document
- This group was reconvened to update and clarify
- Reconvened in Sept 06 and reported in Valencia Nov 06

Parameters Report Revisited

- **The ILCSC Parameters Group has given updated selected clarification on accelerator requirements, based on achieving ILC science goals:**
  - **Removing safety margins in the energy reach is acceptable but should be recoverable without extra construction. The max luminosity is not needed at the top energy (500 GeV), however …..**
  - **The interaction region (IR) should allow for two experiments ….. the two experiments could share a common IR, provided that the detector changeover can be accomplished in approximately 1 week.**

RDR Cost Estimating

- “Value” Costing System: International costing for International Project
  - **Provides basic agreed to “value” costs**
  - **Provides estimate of “explicit” labor (man-hr)]**
- Based on a call for world-wide tender:
  lowest reasonable price for required quality
- Classes of items in cost estimate:
  - **Site-Specific: separate estimate for each sample site**
  - **Conventional: global capability (single world est.)**
  - **High Tech: cavities, cryomodules (regional estimates)**

Vancouver Cost Data

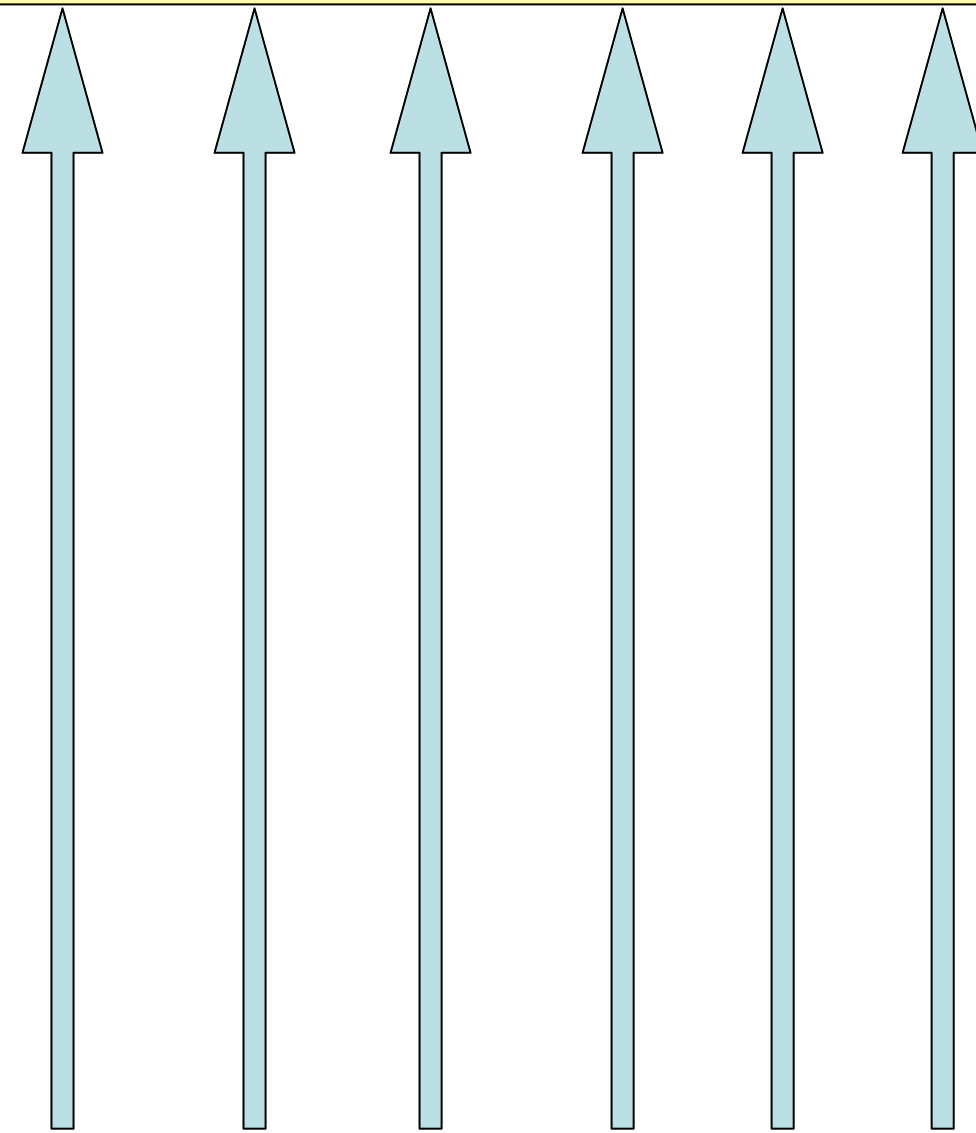
System description	July 18, 2006 - Cost Estimates received for								Regional		
	common	e-	e+	DR	RTML	ML	BDS	Exp	Am	Asia	Eur
e- Source		√									
e+ Source			√								
DR				√							
RTML					√						
Main Linac											
BDS							√				
Com, Op, Reliab											
Control System	√	√	√	√	√	√	√				
Cryogenics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

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

Cost Roll-ups

Area Systems

e- source	e+ source	damping rings	RTML	main linac	BDS



Technical Systems

Vacuum systems

Magnet systems

Cryomodule

Cavity Package

RF Power

Instrumentation

Dumps and Collimators

Accelerator Physics

Global Systems

Commissioning, Operations & Reliability

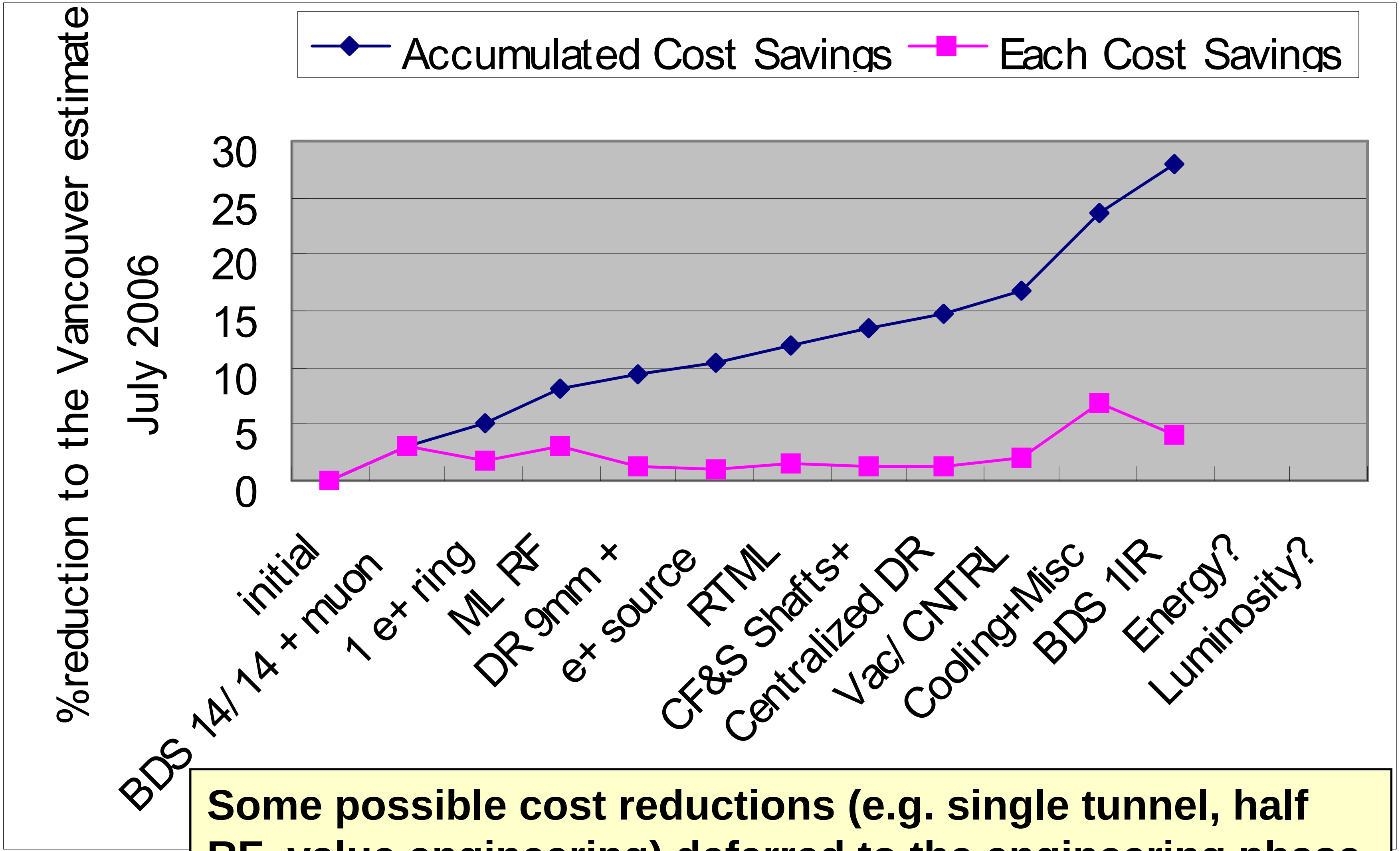
Control System

Cryogenics

Cost-Driven Design Changes

Area		RDR MB	CCR	CCB	approx. Δ$
BDS	2´14mr IRs	supported	14	YES	~170 M$
	Single IR with push-pull detector	supported	23	YES	~200 M$
	Removal of 2nd muon wall	supported	16	YES	~40 M$
ML	Removal of service tunnel	**rejected**			~150 M$
	RF unit modifications (24 ® 26 cav/klys)	supported			~50 M$
	Reduced static cryo overhead	supported	20	YES	~150 M$
	Removal linac RF overhead	supported			~20 M$
	Adoption of Marx modulator (alternate)	**rejected**			~180 M$
RTML	Single-stage bunch compressor	**rejected**			~80 M$
	Miscellaneous cost reduction modifications	supported	19	YES	~150 M$
Sources	Conventional e+ source	**rejected**			<100M$
	Single e+ target	supported	*in prep*		~30 M$
	e- source common pre-accelerator	supported	22	YES	~50 M$
DR	Single e+ ring	supported	15	YES	~160 M$
	Reduced RF in DR (6 ® 9mm σz)	supported	*in prep*		~40 M$
	DR consolidated lattice (CFS)	supported	*in prep*		~50 M$
General	Central injector complex	supported	18(19)	YES	~180 M$

Evolving Design → Cost Reductions



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

RDR Design & "Value" Costs

The reference design was "frozen" as of 1-Dec-06 for the purpose of producing the RDR, including costs.

It is important to recognize this is a snapshot and the design will continue to evolve, due to results of the R&D, accelerator studies and value engineering

The value costs have already been reviewed twice

- 3 day "internal review" in Dec
- ILCSC MAC review in Jan

Summary

RDR "Value" Costs

Total Value Cost (FY07)

$4.87B Shared

+

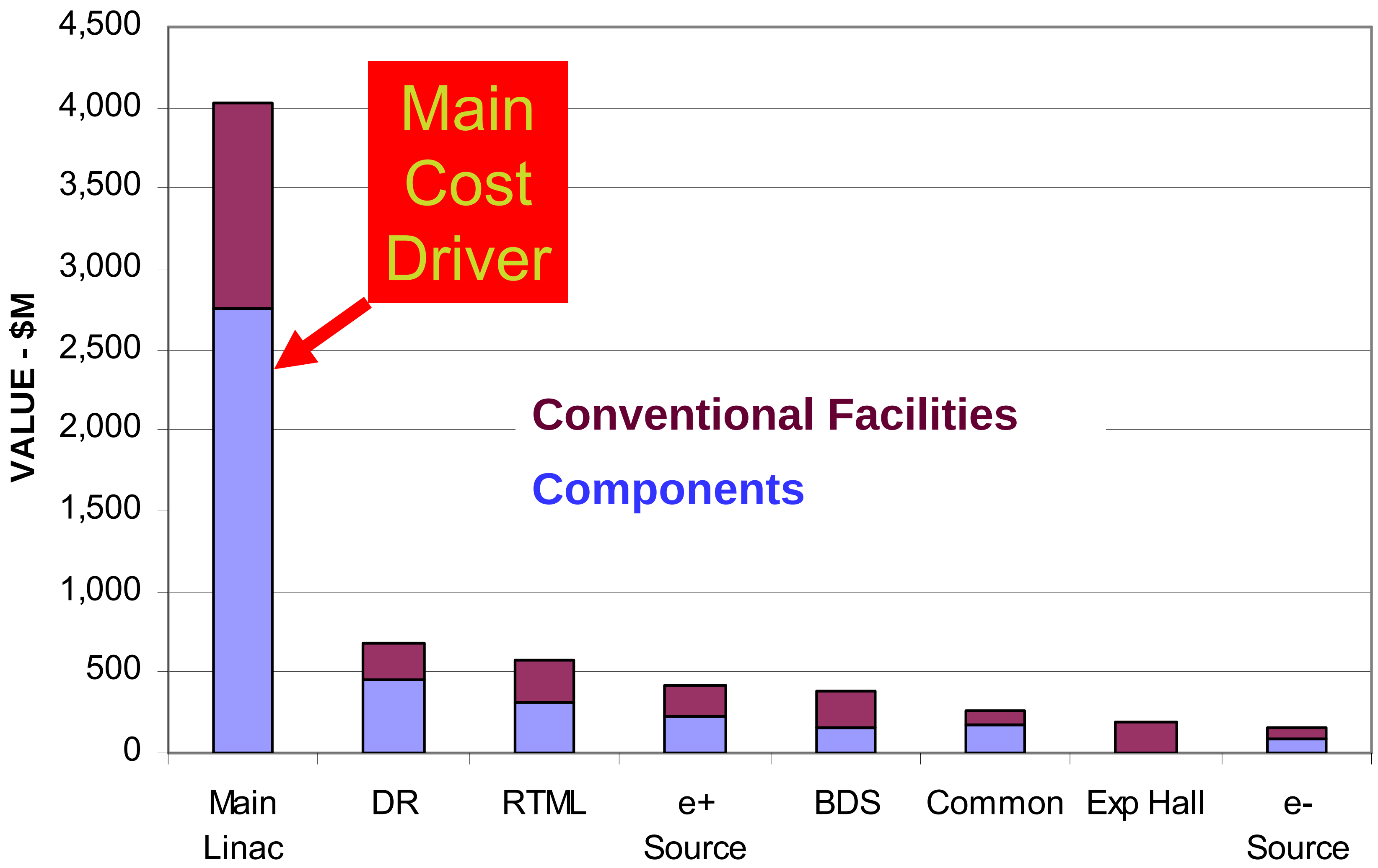
$1.78B Site Specific

+

13.0K person-years

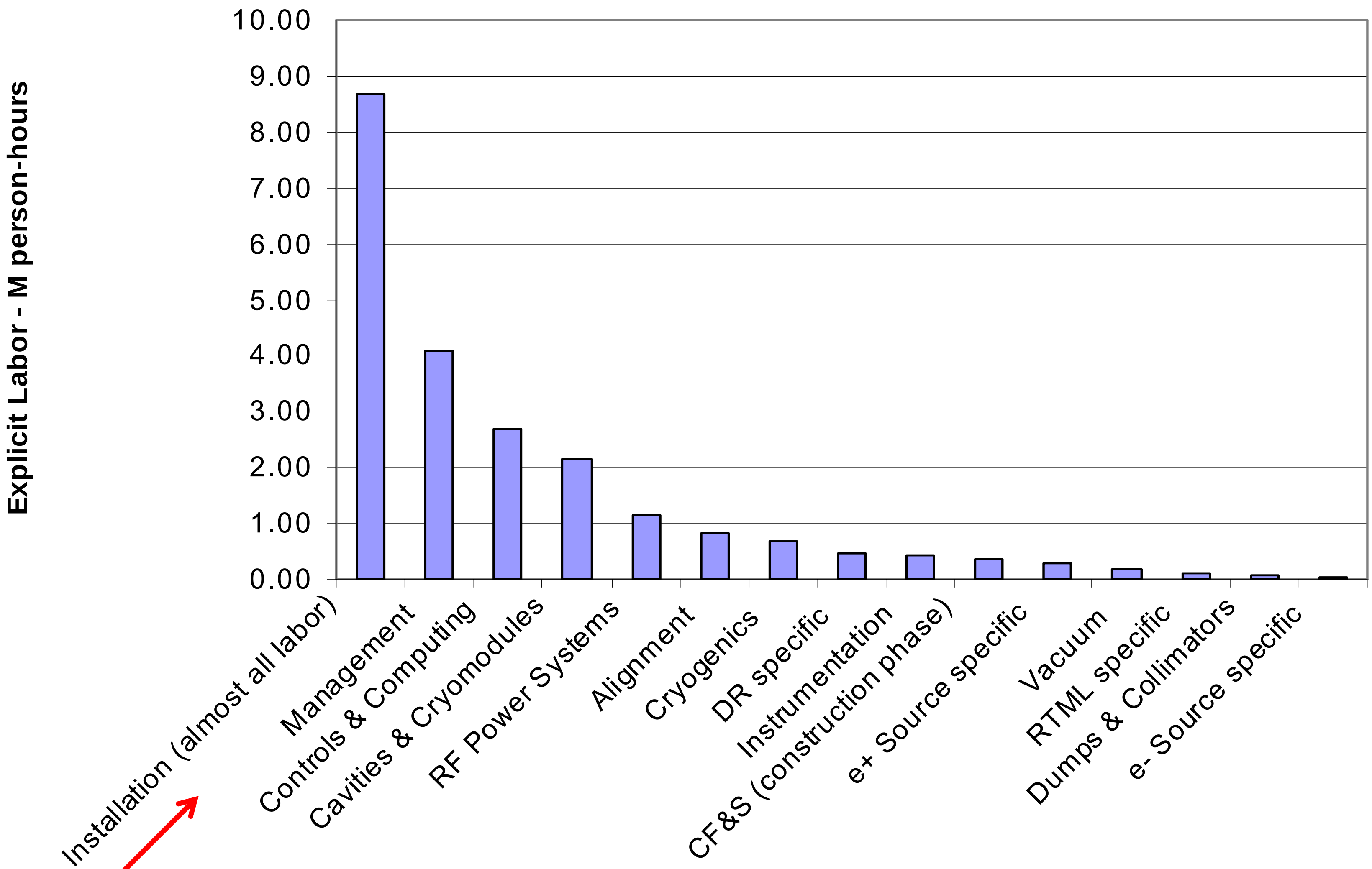
("explicit" labor = 22.2 M person-hrs @ 1,700 hrs/yr)

ILC Value – by Area Systems



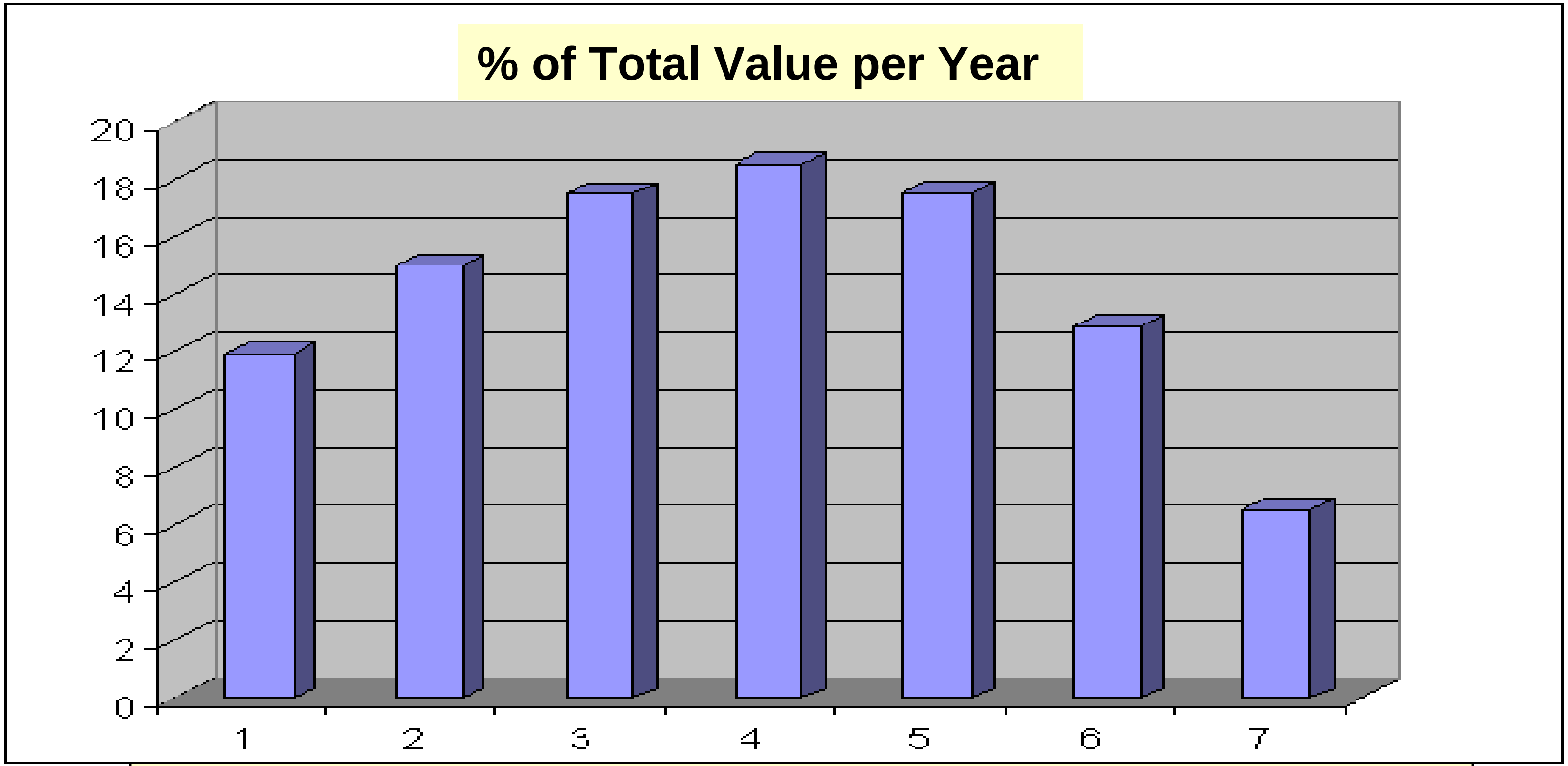
Explicit Manpower

13 K person-yrs = 22 M person-hrs



"management" includes overhead

Value Funding Profile



We are not using integrated cost/schedule tools yet; but it appears feasible to develop a realistic funding profile

How Good is our Cost Estimate?

- Methodology (value costing) is a practical way of developing agreed to “international” costing.
  - **Strength: Good scheme for evaluating value of work packages to divide the project internationally**
  - **Weakness: Difficult to sort out real regional difference from differences due to different specifications, etc**

- We have spent ½ year, developing methodology, good WBS dictionary, technical requirements and costing data requested. We spent another ½ year doing cost vetting and cost / performance optimization. VERY COMPLETE COST ANALYSIS FOR THIS STAGE IN THE DESIGN

Sanity Checks

Comparison with TESLA costs

	TESLA TDR / M€	Scaled TESLA TDR / M$	ILC RDR / M$	Difference / M$
Total Cost	**3136**	**5018**	**~6500**	**~1500**
Civil Facilities	676	1082	2437	1355
Underground Buildings	383	613	1070	457
Surface Buildings	44	70	168	98
Consultant Engineering	10	16	160	144
Power Distribution	34	54	275	221
Water Cooling	70	112	374	262
Cryogenic System	162	260	567	307
Cryo Plant*	12 x 11	12 x 17	10 x 34.3	139

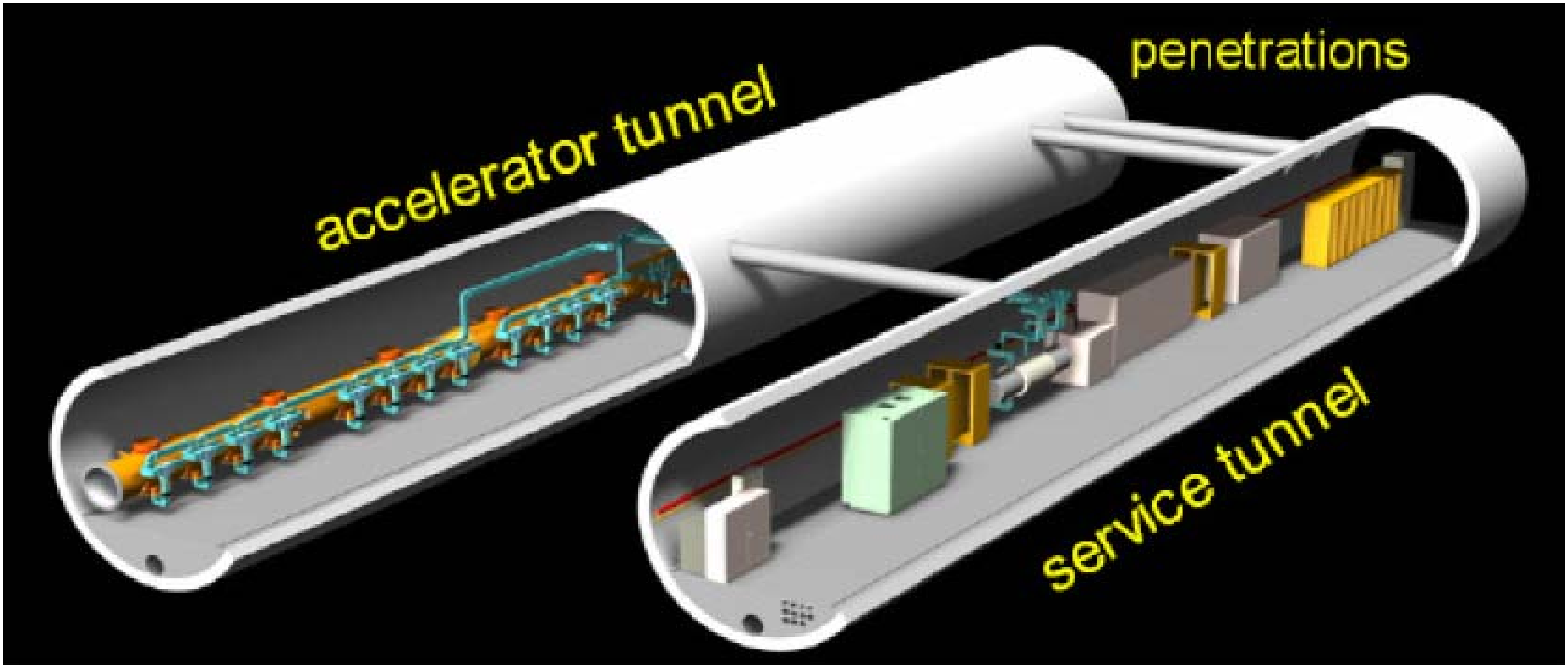
*TESLA: 6 x 4.3 kW @ 2 K

ILC: 10 x 3.5 kW @ 2 K

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

The difference is primarily in conventional facilities

Main Linac Double Tunnel



– **Three RF/cable penetrations every rf unit**
– **Safety crossovers every 500 m**
– **34 kV power distribution**

Cost Driver – Conventional Facilities

72.5 km tunnels ~ 100-150 meters underground

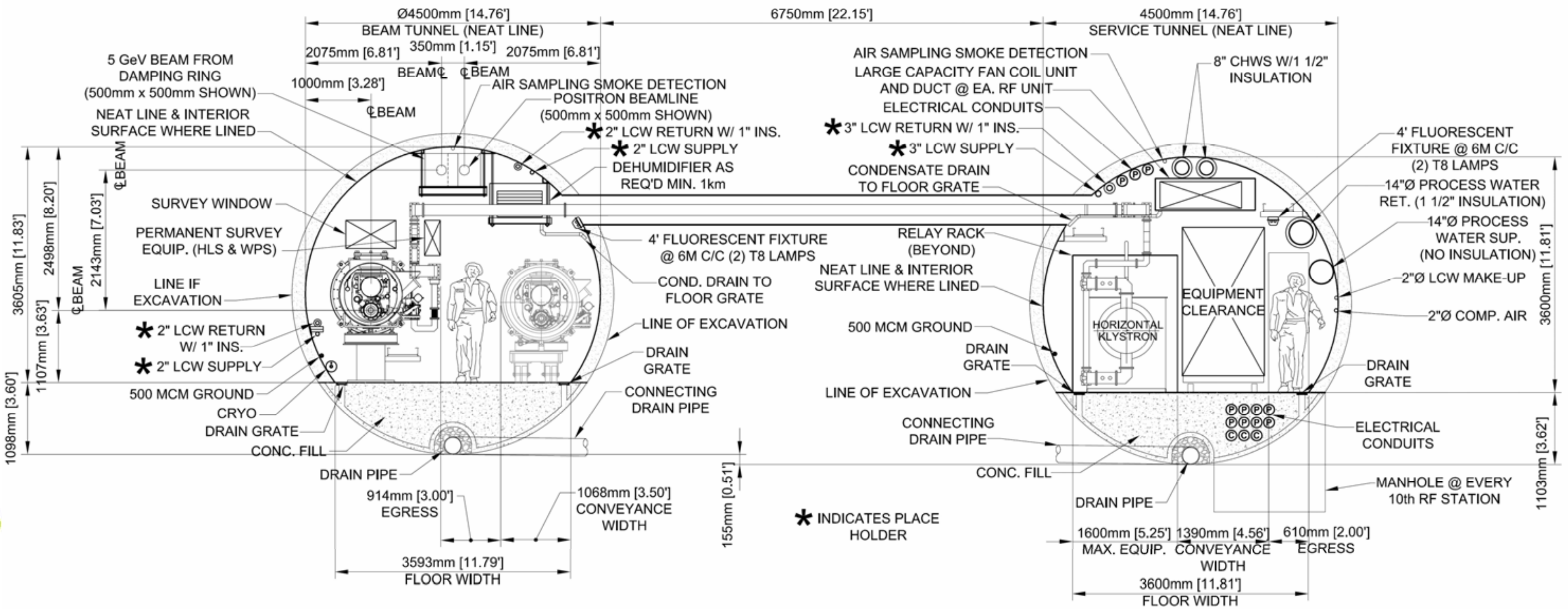
13 major shafts $\geq$ 9 meter diameter

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

92 surface "buildings", 52.7 K sq. meters = 567 K sq-ft total

Main Linac Tunnels

- Design based on two 4.5m tunnels
  - **Active components in service tunnel for access**
  - **Includes return lines for BC and sources**
  - **Sized to allow for passage during installation**
  - **Personnel cross-over every 500 meters**



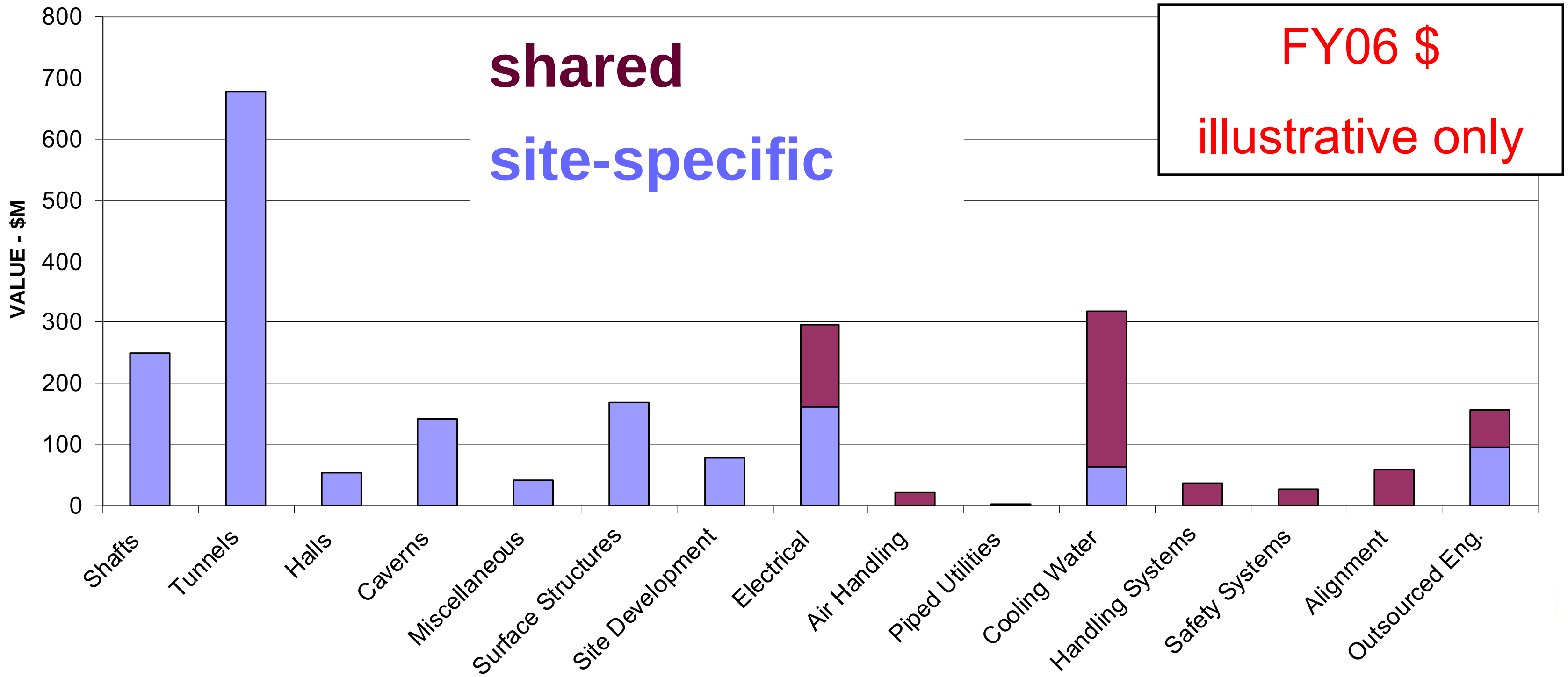
Conventional Facilities

Regional Comparisons :

Quote 2007$ – Escalate 2006$ by 10.6% U.S (Turner); 2-3 % other regions

ASIA	TOTAL COST=	$2,247,562	CIVIL ONLY=	$1,377,765
AMERICA	TOTAL COST=	$2,540,439	CIVIL ONLY=	$1,648,052
EUROPE	TOTAL COST=	$2,493,066	CIVIL ONLY=	$1,608,407

Yen to US $	0.0085714
Euro to US $	1.2
Euro to Yen	140
US to Yen	116.7



How Good is our Cost Estimate?

- Cost Estimate is ~ 30% level over the RDR concept. However, there are some important limitations:
  - **The estimate is for a concept or reference design, not an engineering design.**
  - **The design will evolve, giving concerns of future cost growth. We believe this can be compensated for by deferred potential gains from value engineering**
  - **Major Cost Drivers: Conventional facilities need actual site(s) for better estimates (e.g. safety, one tunnel, shallow sites, etc)**
  - **Major Cost Drivers: Main Linac limited because of proprietary information, regional differences, gradient, uncertainties regarding quantity discounts, etc**

- Risk analysis will be undertaken following this meeting

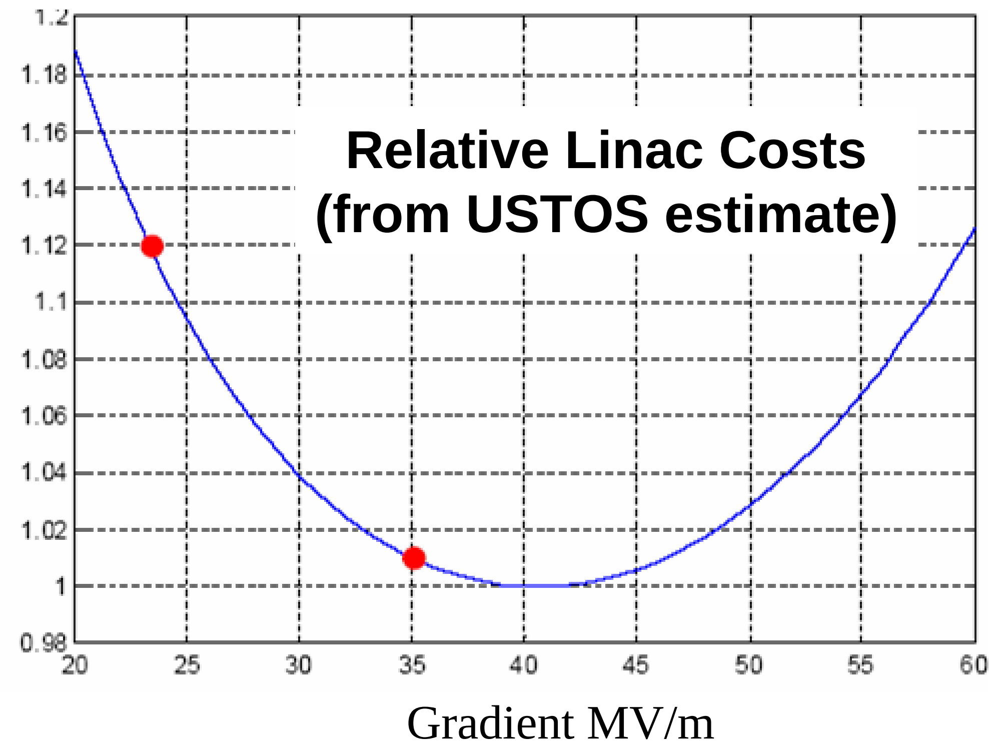
Cost Driver - The Main Linac

Subdivision	Length (m)	Number
Cavities (9 cells + ends)	1.326	14,560
Cryomodule (9 cavities or 8 cavities + quad)	12.652	1,680
RF unit (3 cryomodules)	37.956	560
Cryo-string of 4 RF units (3 RF units)	154.3 (116.4)	71 (6)
Cryogenic unit with 10 to 16 strings	1,546 to 2,472	10
Electron (positron) linac	10,917 (10,770)	1 (1)

- Costs have been estimated regionally and can be compared.
  - Understanding differences require detail comparisons – industrial experience, differences in design or technical specifications, labor rates, assumptions regarding quantity discounts, etc.

Main Linac Gradient Choice

- Balance between cost per unit length of linac, the available technology, and the cryogenic costs
- Optimum is fairly flat and depends on details of technology
- Current cavities have optimum around 25 MV/m



	Cavity type	Qualified gradient MV/m	Operational gradient MV/m	Length Km	Energy GeV
initial	TESLA	35	31.5	10.6	250
upgrade	LL	40	36.0	+9.3	500

Cost Impact of Lower Gradient

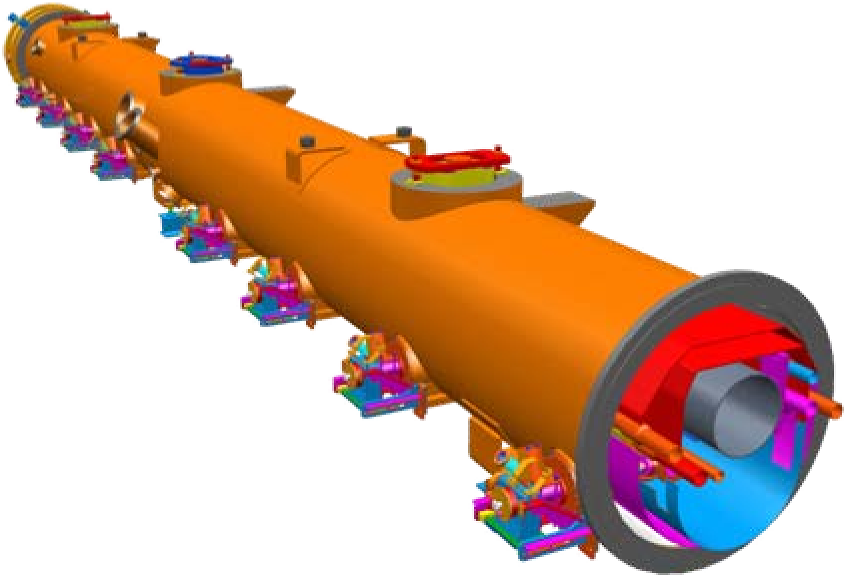
- We have given high priority to S0 Cavity R&D program to demonstrate baseline 31.5 MV/m

- Cost impact of running the ILC linacs with a range of gradients (22-34 MV/m with an average of 28 MV/m)
  - **assumes the power to the cavities is adjustable (one time only)**

- The Main Linac cost increases by 11.1% and the ILC cost increases by 6.7% assuming Main Linacs are 60% of the ILC cost.

From Chris Adolphsen

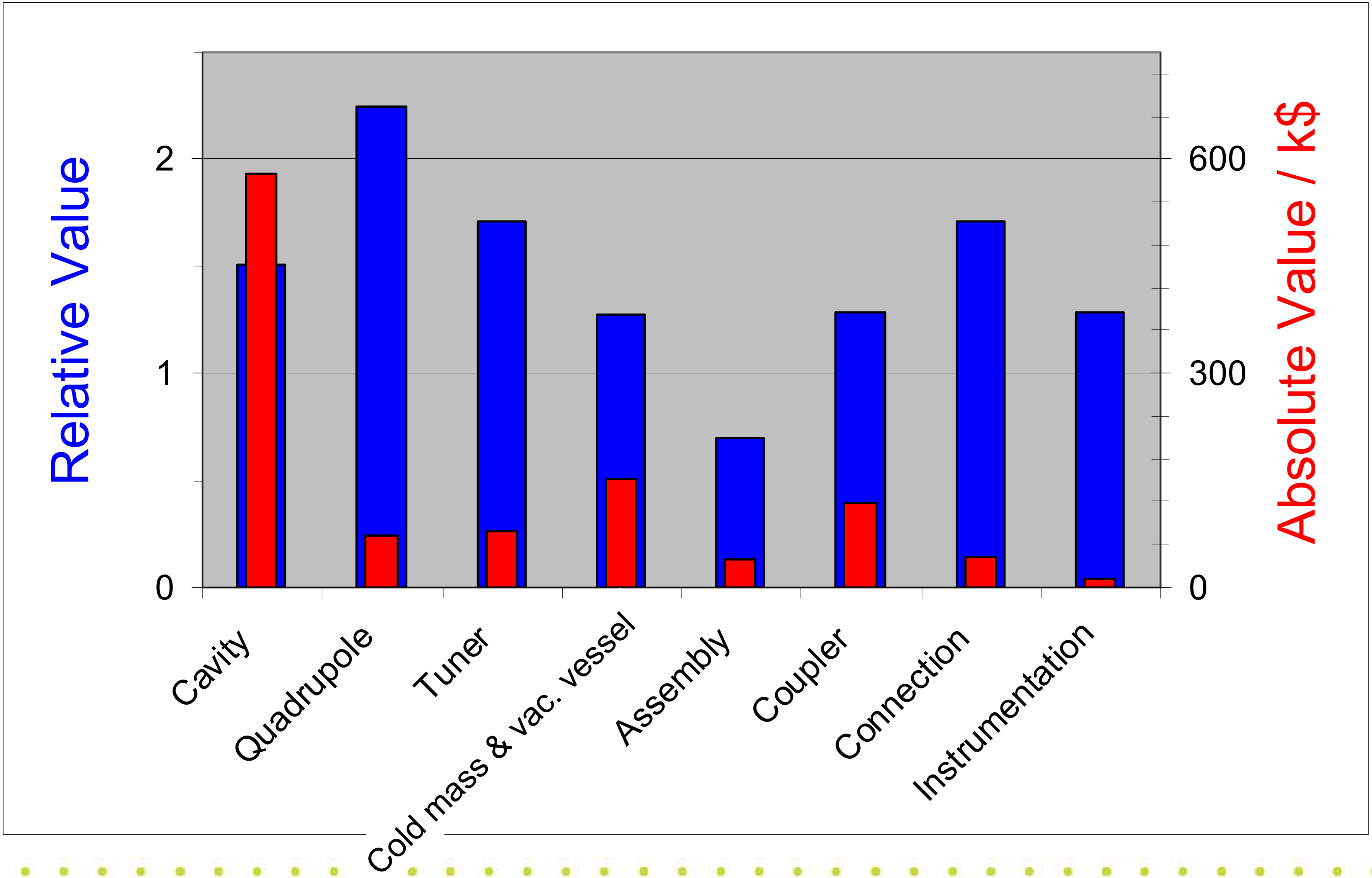
Cryomodule Value Estimates



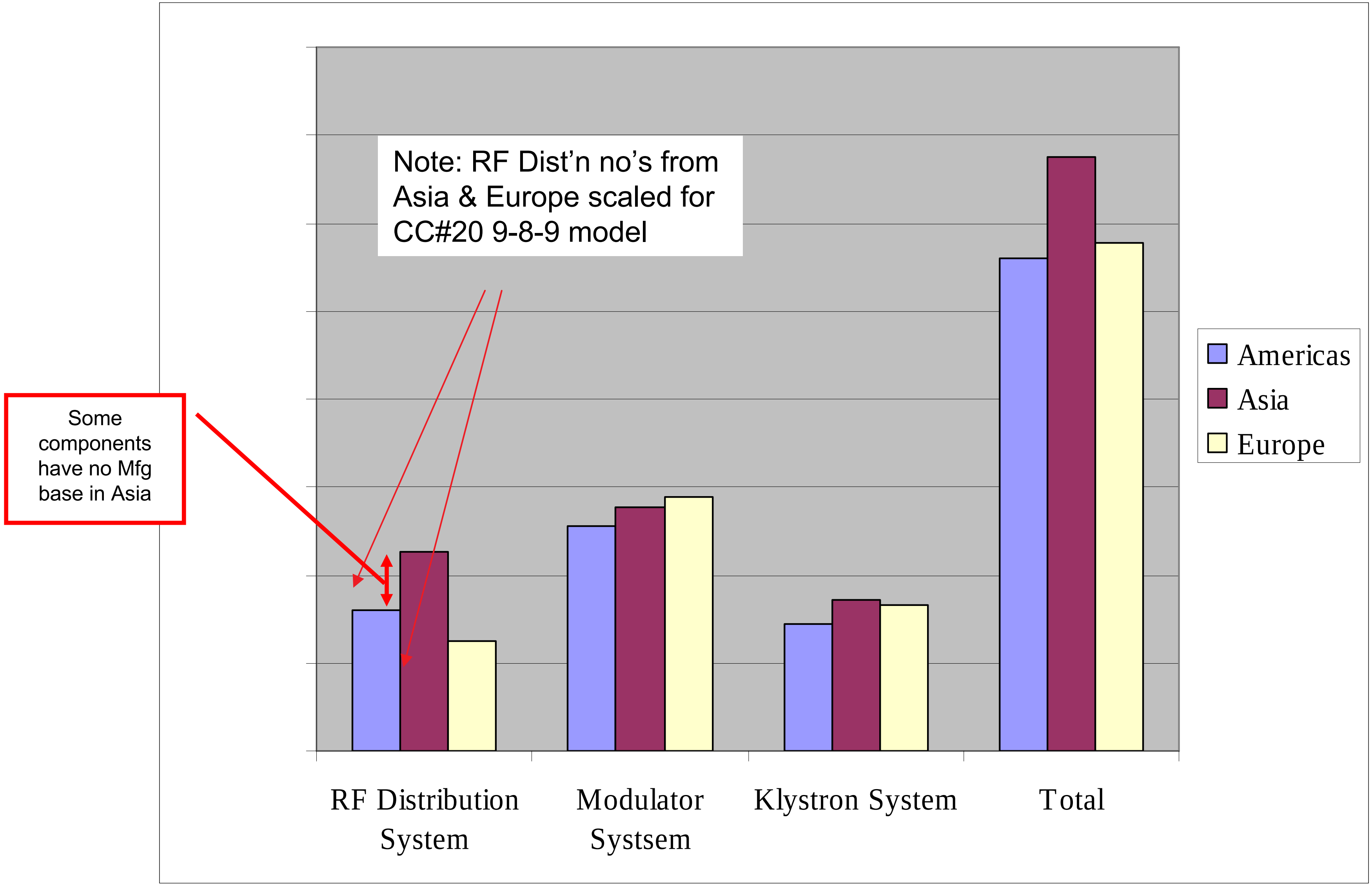
TESLA cryomodule

4th generation prototype ILC cryomodule

American vs European Estimate

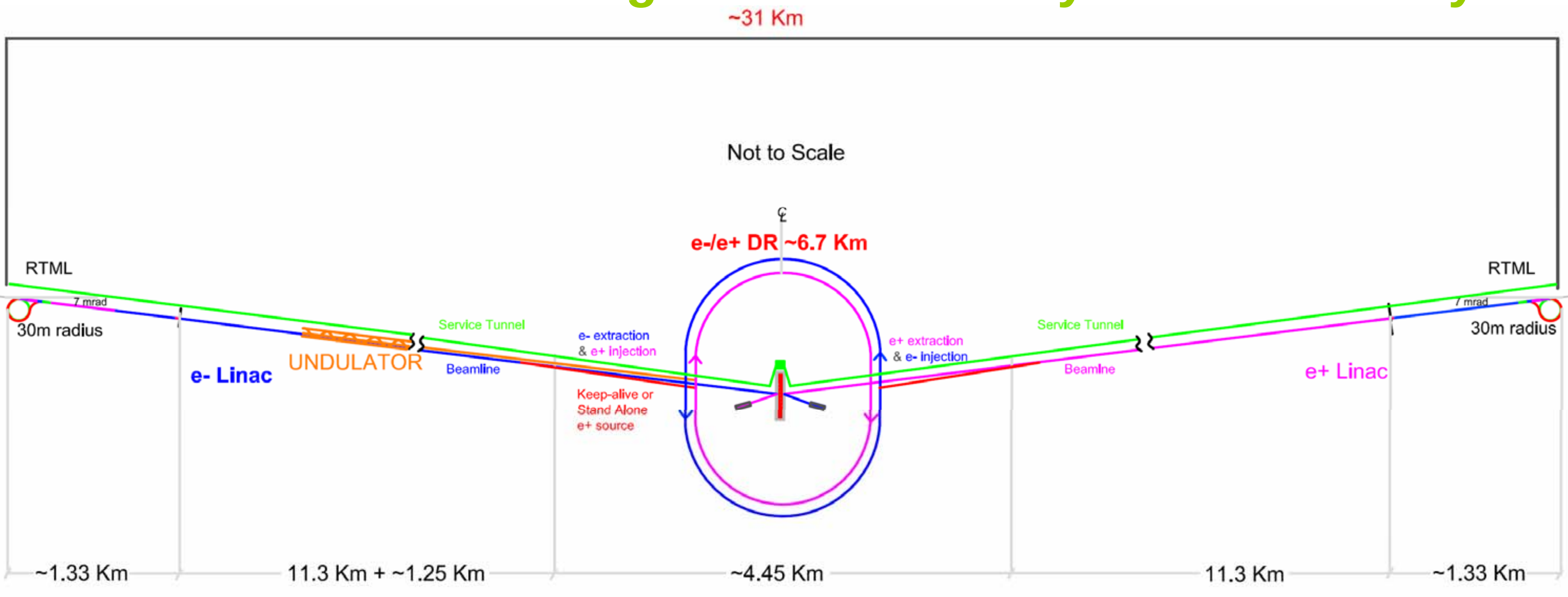


Cost of High Level RF by Region



2nd Milestone – ILC Reference Design

– **11km SC linacs operating at 31.5 MV/m for 500 GeV**
– **Centralized injector**
  - Circular damping rings for electrons and positrons
  - Undulator-based positron source
– **Single IR with 14 mrad crossing angle**
– **Dual tunnel configuration for safety and availability**



How Good is the RDR Concept?

- The design has been carried out by Area Systems that have been built up into an overall design.
  - **We have advanced in integrating that design and even in being able to evaluate proposed changes that cross several area systems (e.g. central injector – E Paterson)**
  - **A more integrated design approach is envisioned for the engineering design stage.**

- Technical system designs still immature, resulting in lack of detailed specifications, requirements and value engineering has been deferred

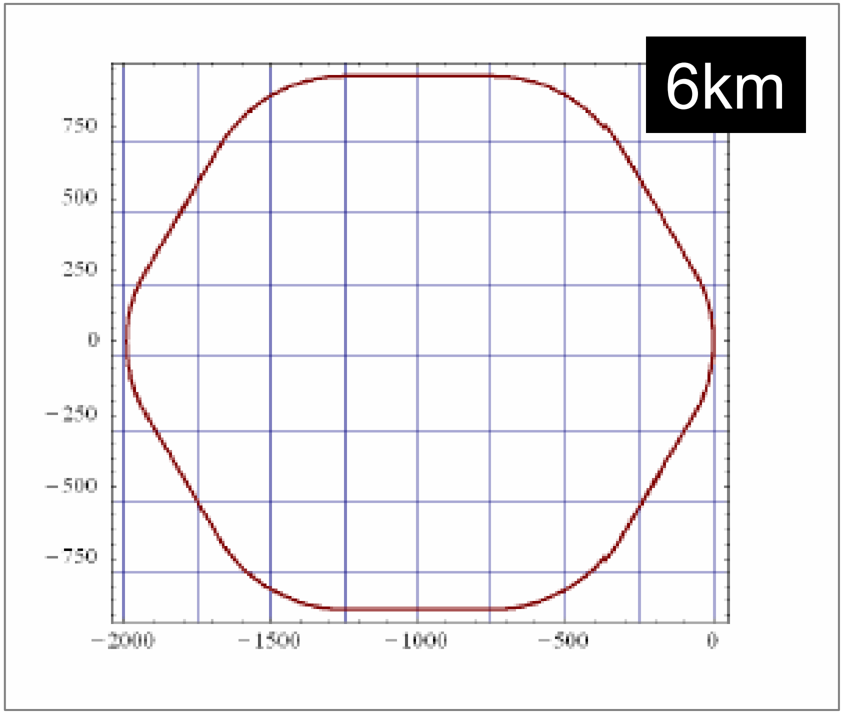
Design Parameters

Center-of-mass energy	500 GeV
Peak luminosity	2×10^{34} $cm^{-2}s^{-1}$
Availability	75%
Repetition rate	5 Hz
Duty cycle	0.005%
Main linacs	
Average accelerating gradient in cavities	31.5 MV/m
Length of each main linac	11 km
Beam pulse length	1 ms
Average beam current in pulse	9.0 mA
Damping rings	
Beam energy	5 GeV
Circumference	6.7 km
Length of beam delivery section (2 beams)	4.5 km
Total site length	31 km
Total site power consumption	230 MW
Total installed power	~300 MW

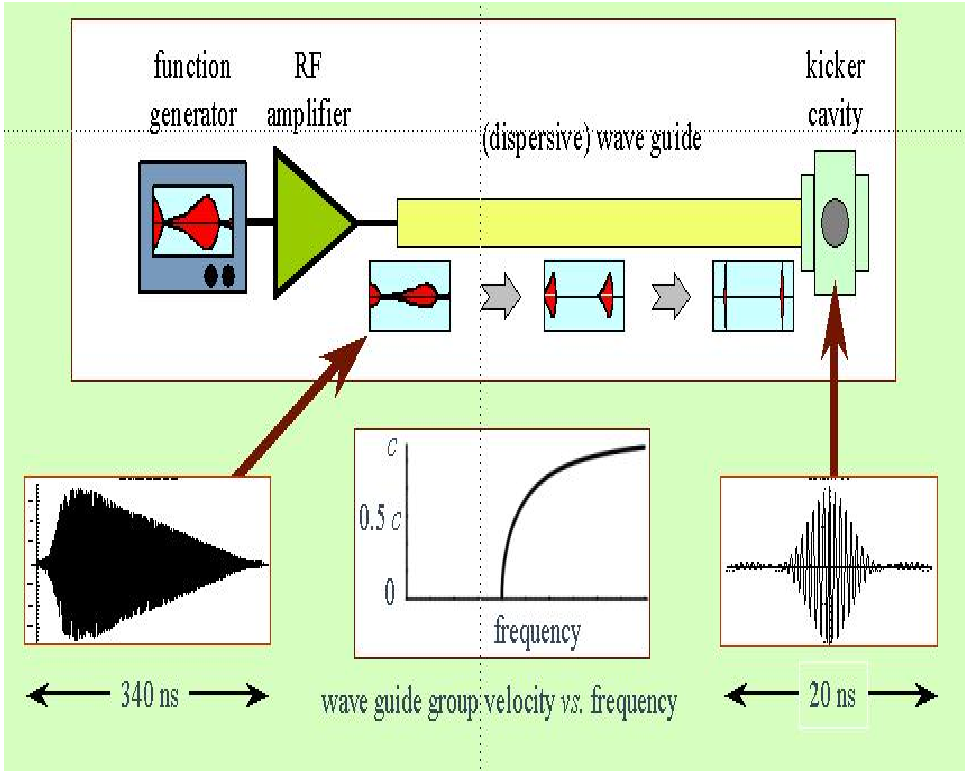
Design Challenges - *Availability*

- ILC is has about 10x the number of operating units compared to previous accelerators with similar availabilty goal (~ 85%)
- This will require significant improvements in:
  - **Failure rates on component and sub-systems - magnets, PS, kickers, etc**
  - **Redundancy – power, particle sources, etc**
  - **Access for maintenance and servicing – double tunnel concept**
- The availability issue will need much attention during engineering design phase.

Design Challenges – *Damping Rings*

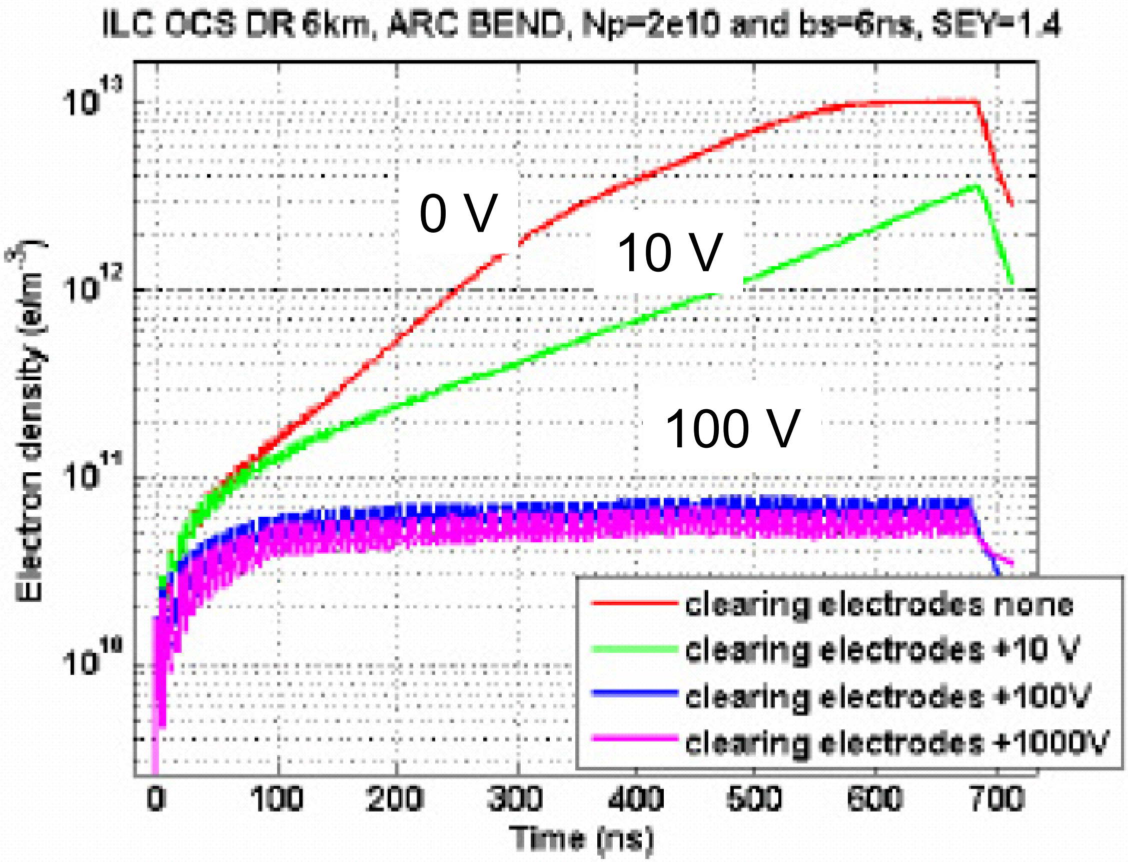


Requires Fast Kicker 5 nsec rise and 30 nsec fall time



The damping rings have more accelerator physics than the rest of the collider

Electron Cloud in Damping Rings



Electron cloud buildup in an arc bend of the 6.7 km ring and suppression effect of clearing electrodes biased at the indicated voltages.

Simulations show ~ 100 V is sufficient to suppress the average (and central) cloud density by two orders of magnitude. NEEDS EXPERIMENTAL DEMONSTRATION

Summary & Final Remarks

- We are releasing a “draft” Reference Design Report to ICFA/ILCSC on Thursday
  - The reference design presents a complete (but not engineered design) that can achieve the physics design parameters with acceptable risk.
  - Vetted and cost / performance optimized “value costing” has been obtained yielding the scope of the project, identified areas needing R&D, industrial study and value engineering.
- The Reference Design will provide an excellent basis and guidance for the undertaking an Engineering Design to bring us to construction readiness
- In Beijing, we will thoroughly expose the Reference Design, emphasize the R&D program, discuss plans for carrying out the Engineering Design to get to readiness for construction