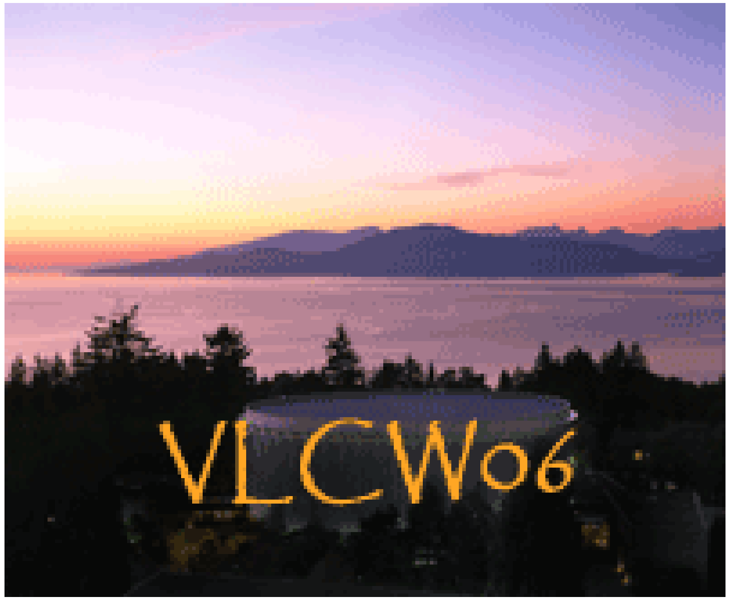
GDE Status Report



Barry Barish

GDE / Caltech

The Mission of the GDE

- Produce a design for the ILC that includes a detailed design concept, performance assessments, reliable international costing, an industrialization plan , siting analysis, as well as detector concepts and scope.

- Coordinate worldwide prioritized proposal driven R & D efforts (to demonstrate and improve the performance, reduce the costs, attain the required reliability, etc.)

Global Effort on Design / R&D

Snowmass
49 GDE members

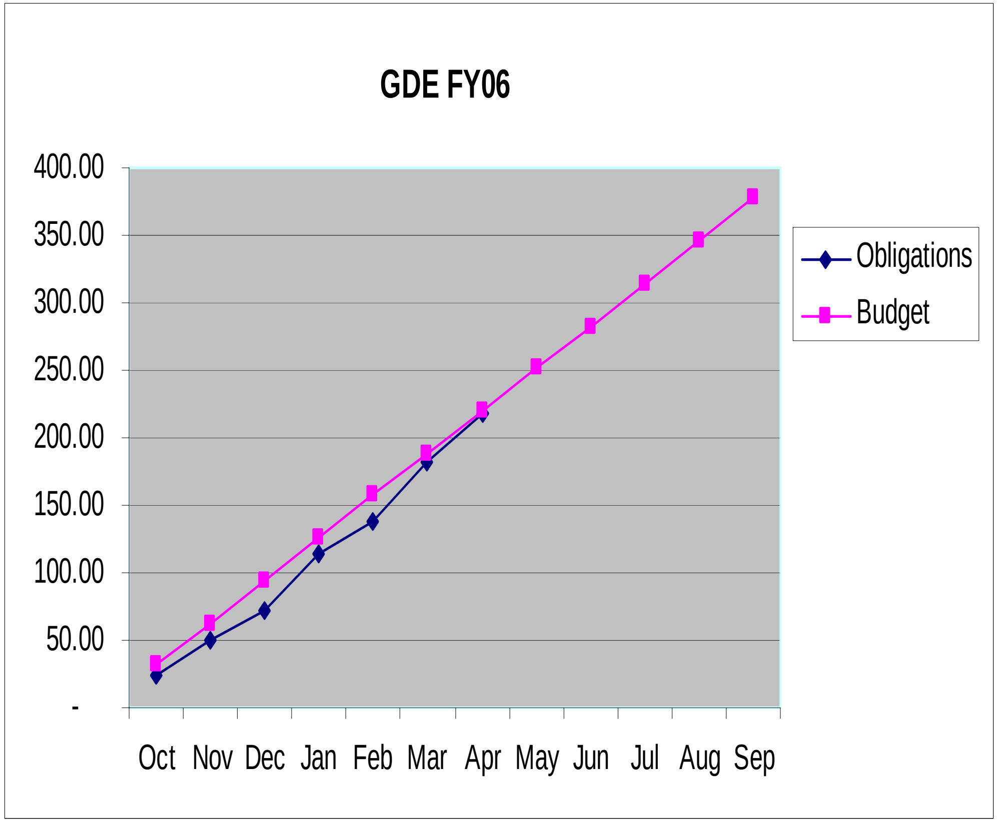
Present
GDE Membership
Americas 22
Europe 24
Asia 18

About 30 FTEs

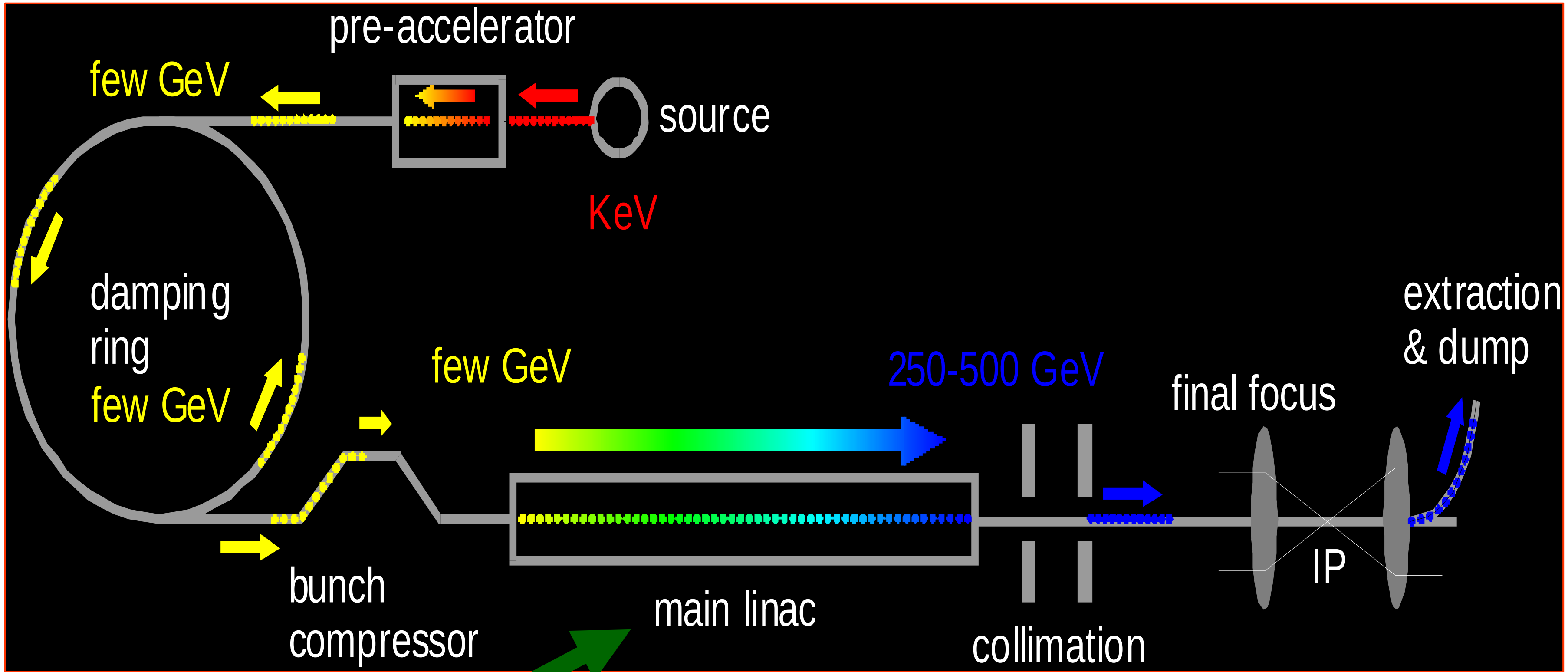
<u>Joint</u> Design, Implementation, Operations, Management
Host Country Provides Conventional Facilities

GDE Budget Status

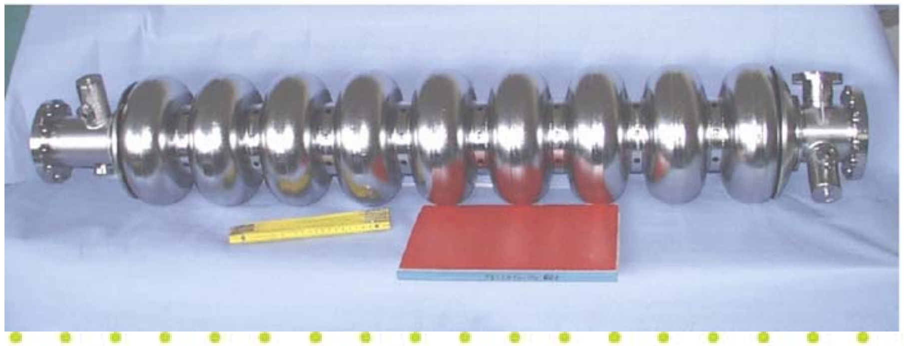
- **FY06** *as of 1-May-06*
  - **DOE budget for FY06**
    - **Total Budget - 377K**
    - **Carryover FY06 - 50K**
    - **M&S Cost - 85.8K**
    - **Personnel - 91.4K**
    - **Overhead - 39.9K**



Designing a Linear Collider



Superconducting RF Main Linac



Luminosity & Beam Size

$$L = \frac{n_b N^2 f_{rep}}{2\pi \Sigma_x \Sigma_y} H_D$$

- f_{rep} * n_b tends to be low in a linear collider

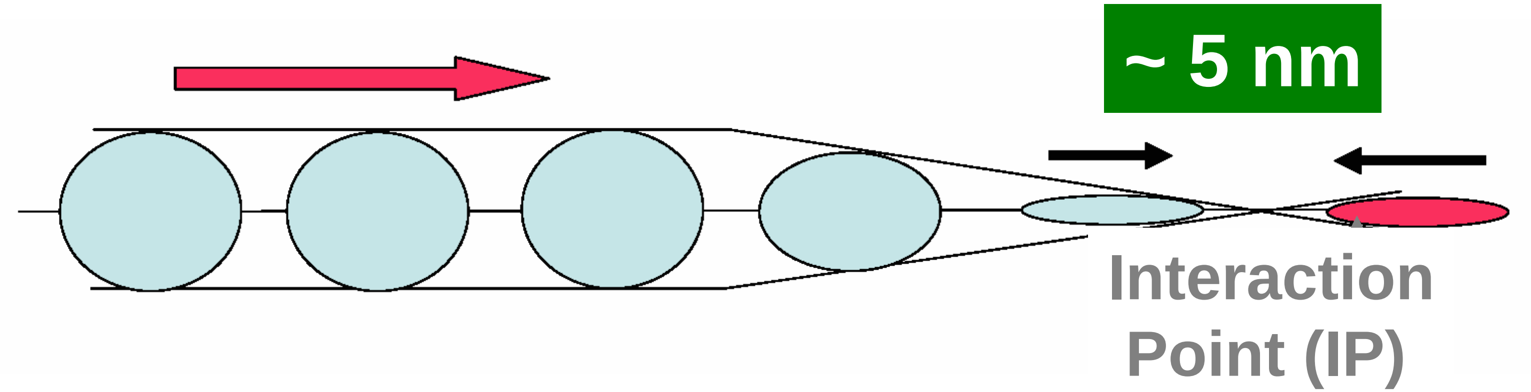
	L	f_{rep} [Hz]	n_b	N [10^{10}]	σ_x [μm]	σy [μm]
ILC	2×10^{34}	5	3000	2	0.5	0.005
SLC	2×10^{30}	120	1	4	1.5	0.5
LEP2	5×10^{31}	10,000	8	30	240	4
PEP-II	1×10^{34}	140,000	1700	6	155	4

- The beam-beam tune shift limit is much looser in a linear collider than a storage rings → achieve luminosity with spot size and bunch charge
  - **Small spots mean small emittances and small betas:**

σ_x = sqrt (β_x ε_x)

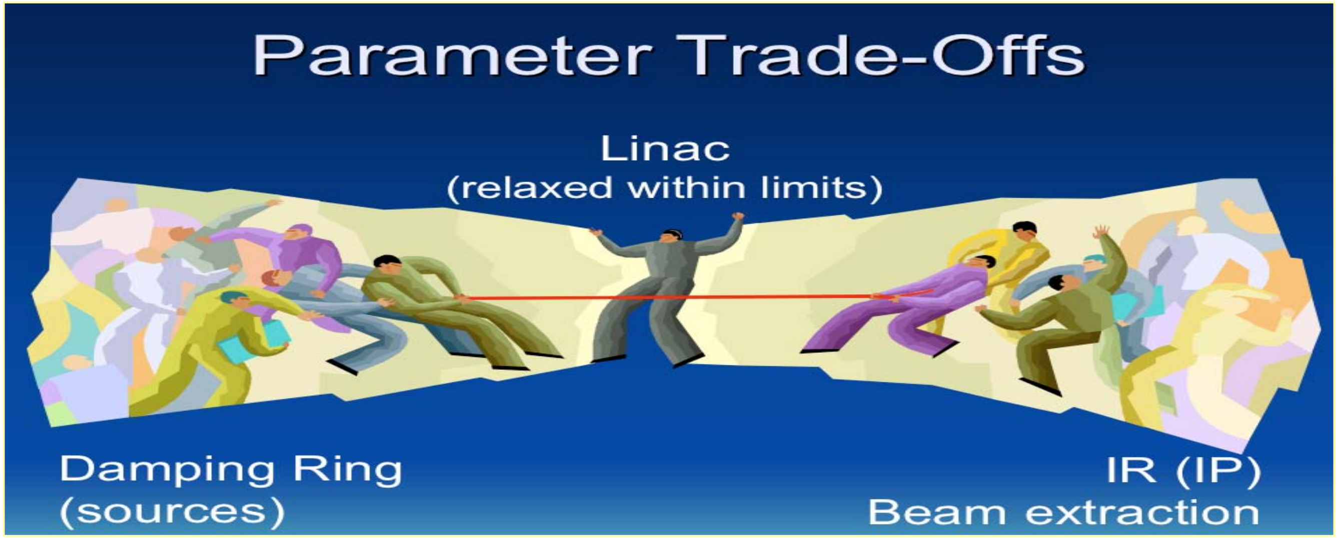
Achieving High Luminosity

- Low emittance machine optics
- Contain emittance growth
- Squeeze the beam as small as possible



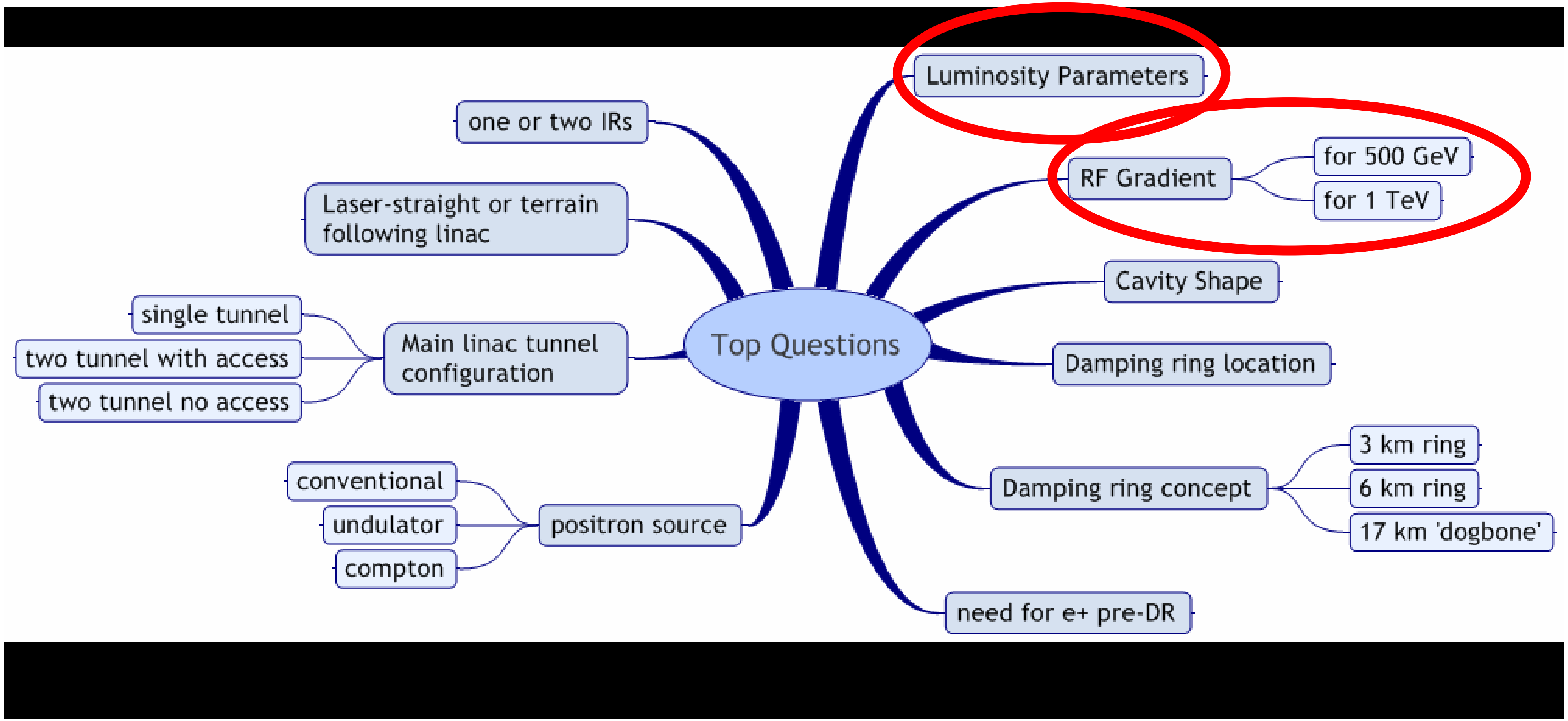
Parametric Approach

- A working space - optimize machine for cost/performance



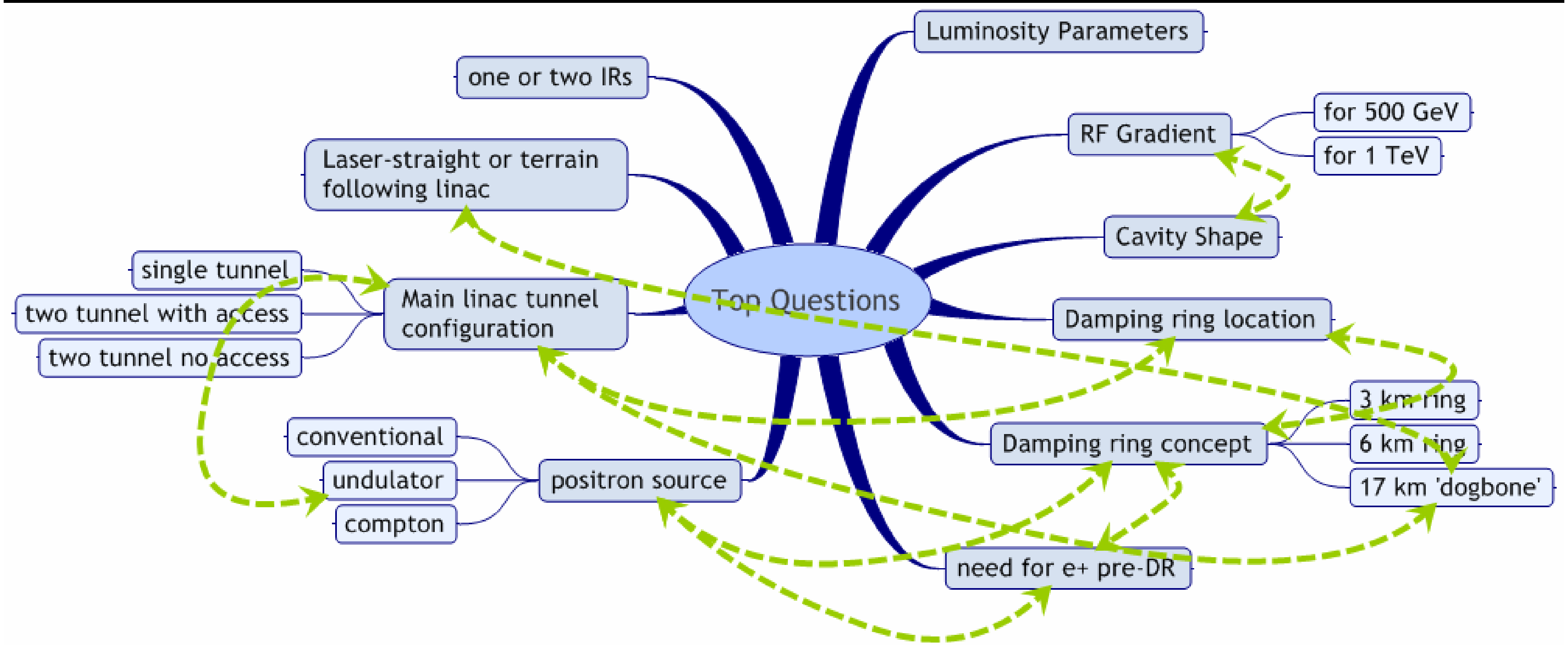
		min		nominal		max	
Bunch charge	N	1	-	2	-	2	$\times 10^{10}$
Number of bunches	n_b	1330	-	2820	-	5640	
Linac bunch interval	t_b	154	-	308	-	461	ns
Bunch length	σ_z	150	-	300	-	500	μm
Vert.emit.	$\gamma\epsilon_y^*$	0.03	-	0.04	-	0.08	mm·mrad
IP beta (500GeV)	β_x^*	10	-	21	-	21	mm
	β_y^*	0.2	-	0.4	-	0.4	mm
IP beta (1TeV)	β_x^*	10	-	30	-	30	mm
	β_y^*	0.2	-	0.3	-	0.6	mm

The Key Decisions



Critical choices: luminosity parameters & gradient

Making Choices – The Tradeoffs



Many decisions are interrelated and require input from several WG/GG groups

From 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

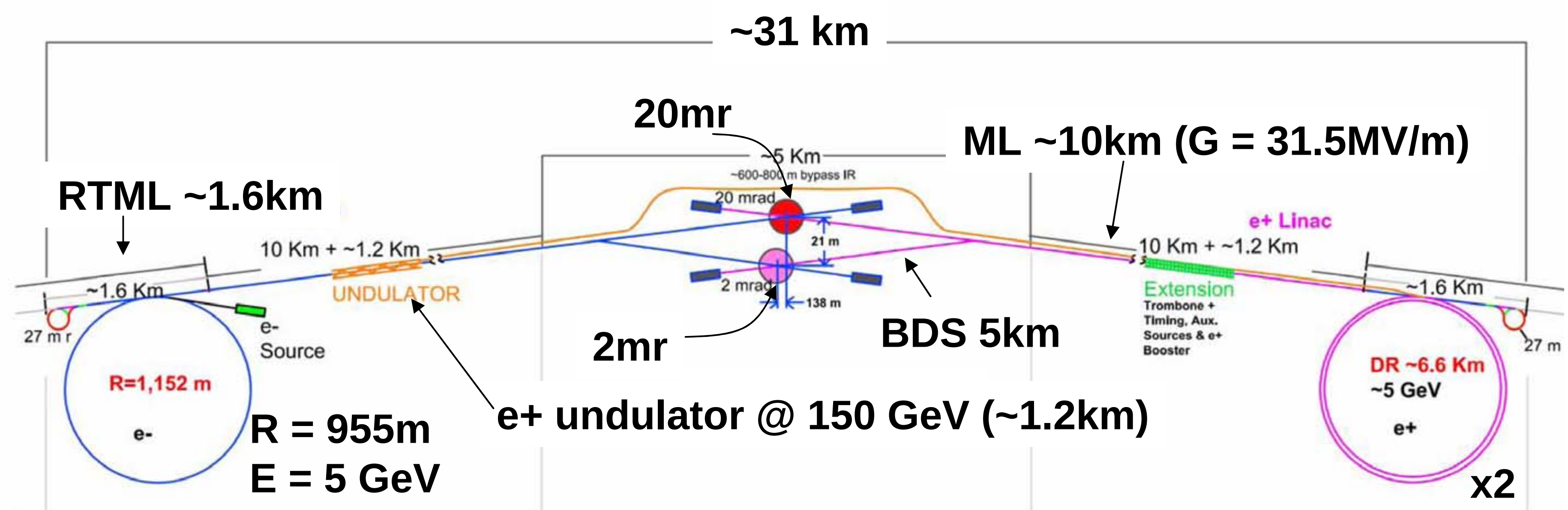
BCD EC publishes 'strawman' BCD

Public Review

Frascati GDE meeting

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

The Baseline Machine



not to scale

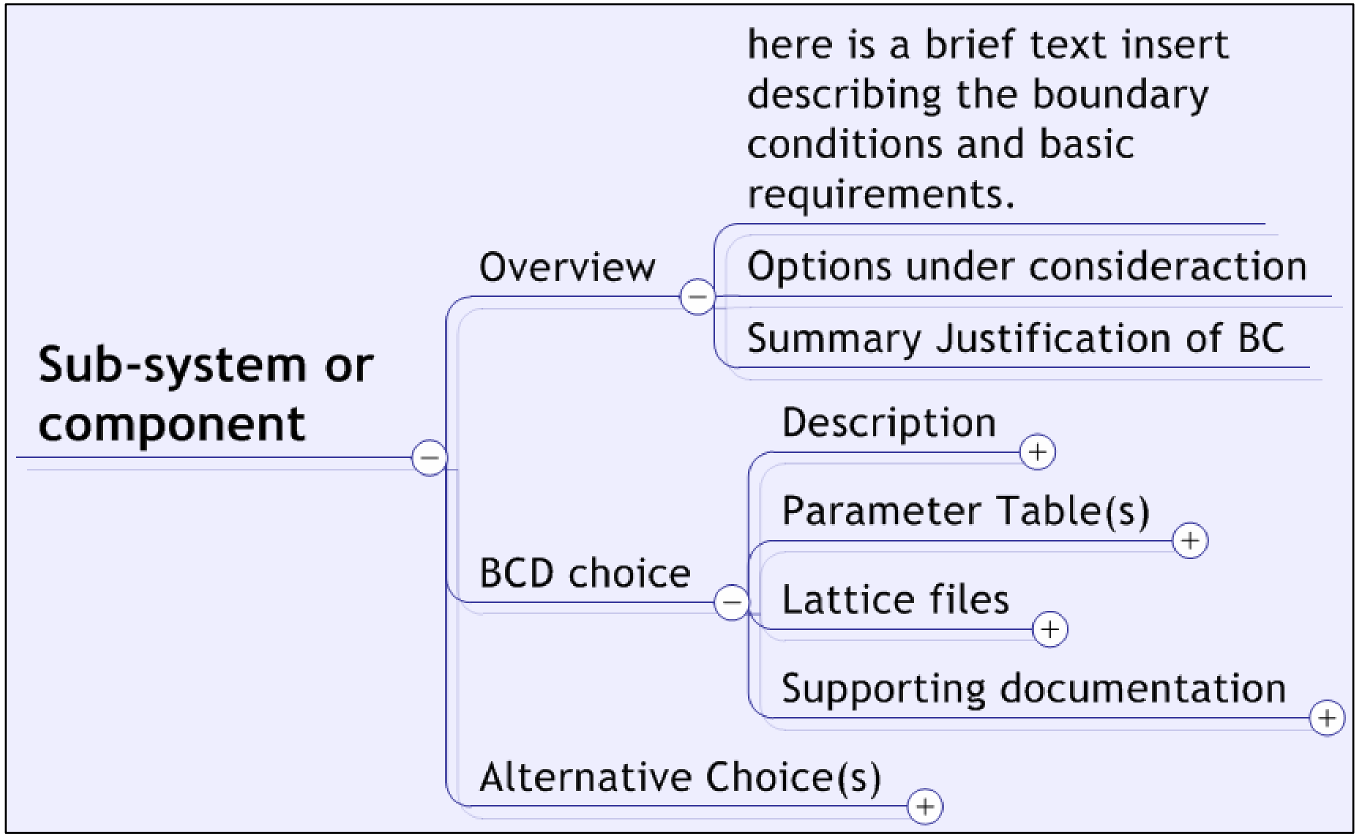
Baseline Configuration Document

- Our ‘Deliverable’ by the end of 2005

- A structured electronic document
  - **Documentation (reports, drawings etc)**
  - **Technical specs.**
  - **Parameter tables**

http://www.linearcollider.org/wiki/doku.php?id=bcd:bcd_home

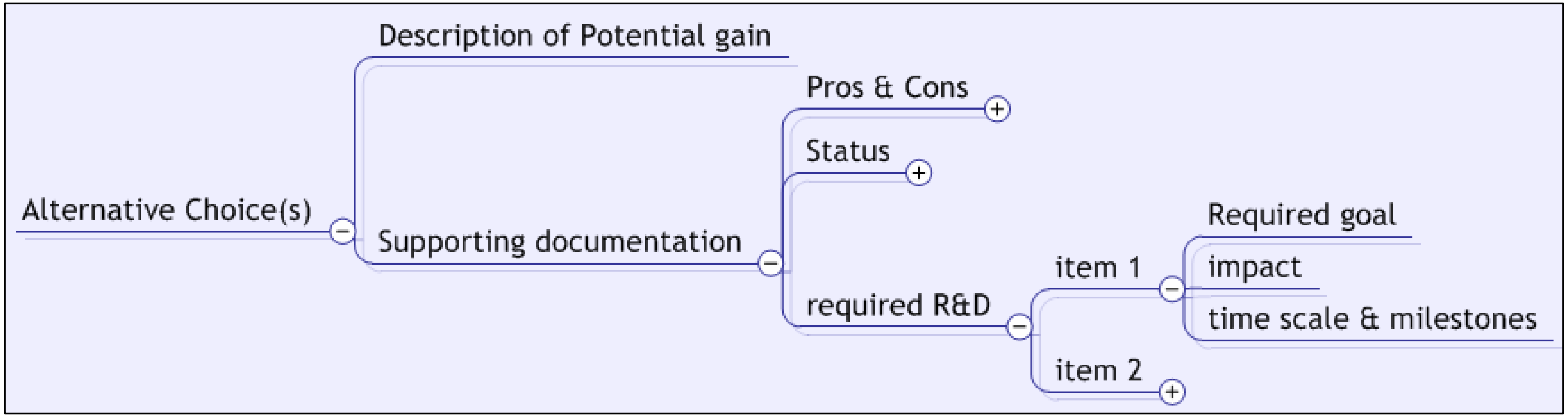
Structure of the BCD



Summary-like overview for those who want to understand the **choice** and the **why**

Technical documentation of the **baseline**, for engineers and acc. phys. making studies towards RDR

Alternatives Section(s)



Note ACD is part of the BCD

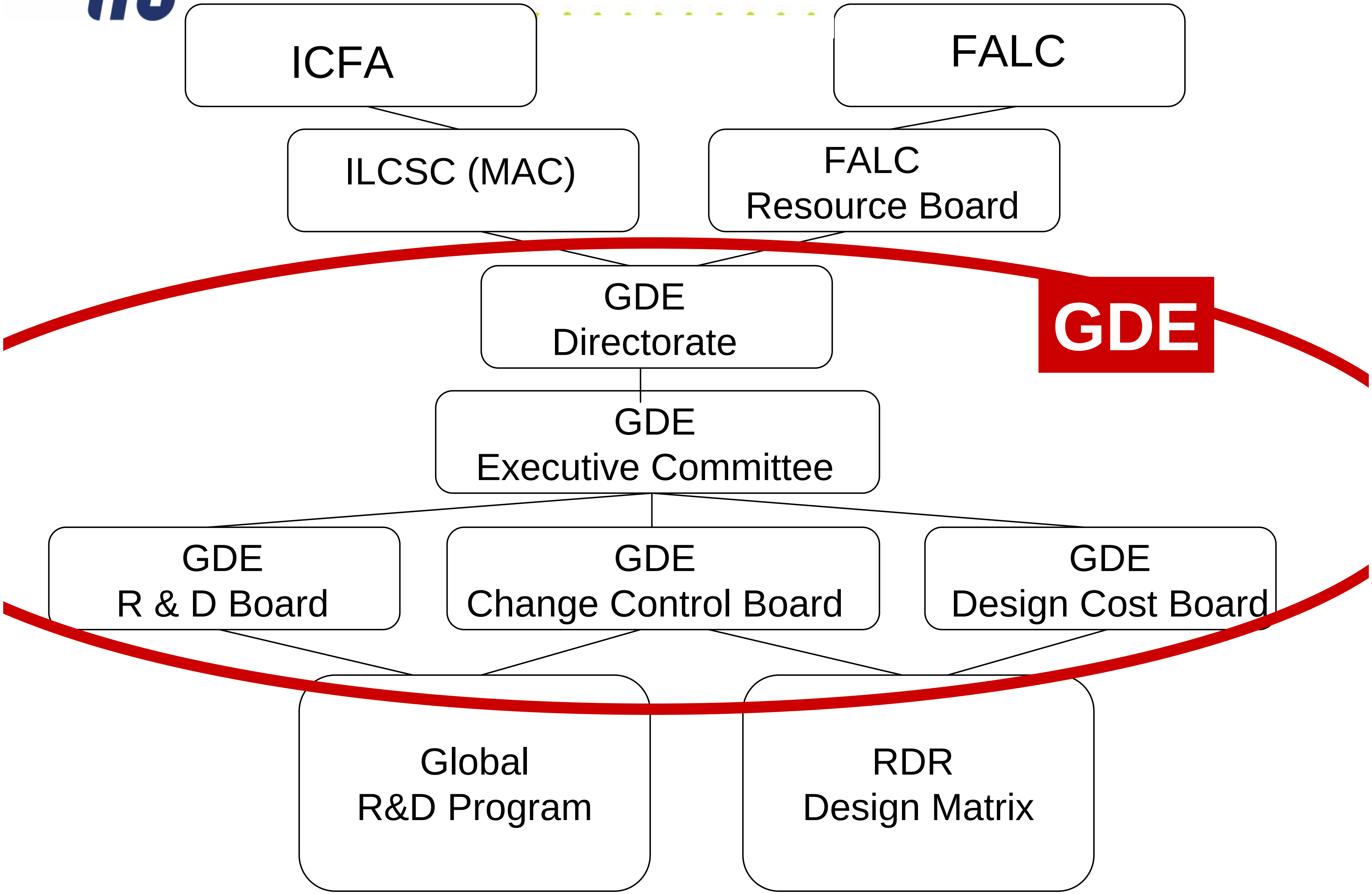
Creating a Reference Design

- The BCD is now being used as the basis for the reference design / cost effort this year.
- It is being evolved through a formalized change control process
- Our goal is to produce a consistent design for the ILC, capable of delivering design performance.
- We have been trying to contain costs for the basic machine, while determining costs on an “international basis.”
- The design will continue to evolve following the RDR, as the R&D provides more CCB actions.

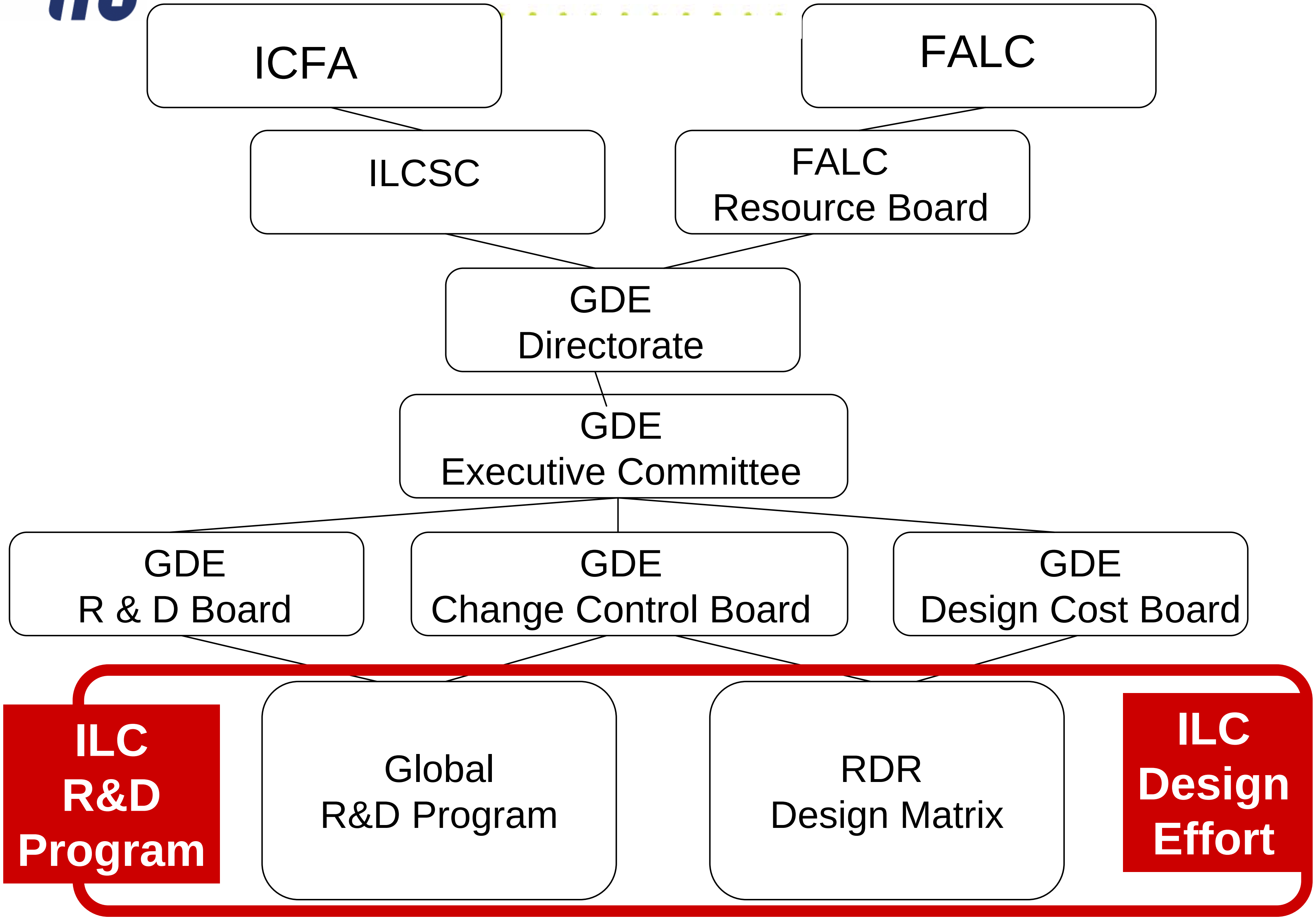
GDE Organization for RDR

- **Selected some selected new members for the GDE following the BCD completion who have needed skills in design, engineering, costing, etc**
- **Change Control Board**
  - **The baseline will be put under configuration control and a Board with a single chair will be created with needed expertise.**
- **Design / Cost Board**
  - **A GDE Board with single chair will be established to coordinate the reference design effort, including coordinating the overall model for implementing the baseline ILC, coordinating the design tasks, costing, etc.**
- **R&D Board**
  - **A GDE Board will be created to evaluate, prioritize and coordinate the R&D program in support of the baseline and alternatives with a single chair**

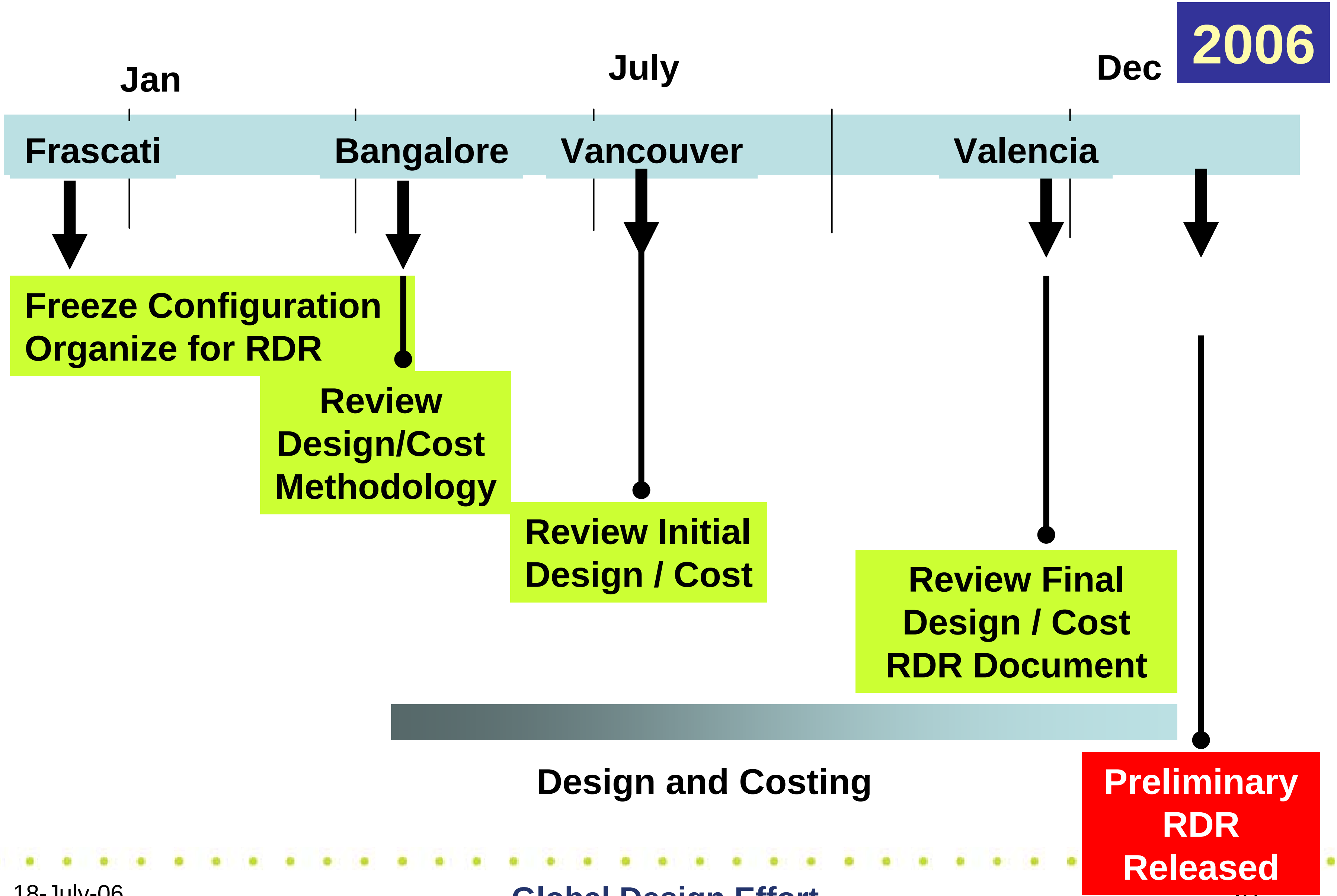
GDE RDR / R&D Organization



GDE RDR / R&D Organization



Baseline to a RDR



Memos on Cost Confidentiality

- **ILC-GDE Cost Disclosure Rules**
- **Guidelines for Area System, Technical and Global Group Leaders for discussing costs during parallel sessions at Vancouver**

Distributed to GDE members prior to VLCW06 to serve as guidance for discussions at this meeting and general policy as costing evolves

Managing the RDR Design Process

- **RDR Management Group (Walker, Chair)**
  - Guides the design/cost efforts on day by day basis
  - Composition - Accelerator Leaders (Walker, Raubenheimer, Yokoya); Cost Engineers (Shidara, Garbincius, Bialowons); Integration Scientist (Paterson)

- **Reviews conducted by Design Cost Board**

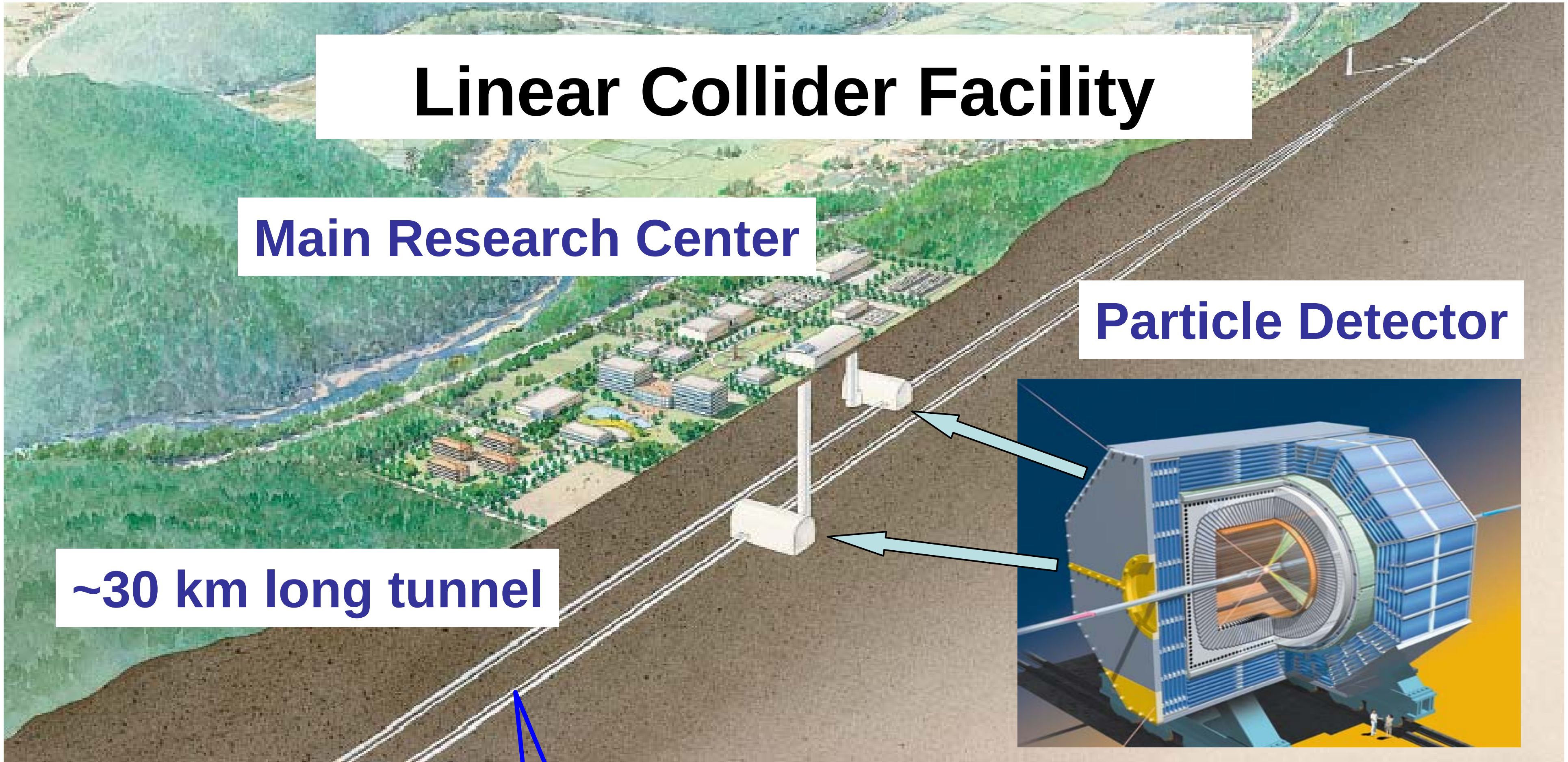
- **Changes in Baseline through CCB actions**
  - 13 change control requests, so far
    http://www.linearcollider.org/wiki/doku.php?id=bcd:bcd_history
  - RDR Configuration will the evolved BCD through CCB process !!

- **First Costing at VLCW06 – Starting point for costing validation, studies of alternatives for cost reductions, etc.**

RDR Matrix

	e- source	e+ source	Damping Rings	RTML	Main Linac	BDS
Vacuum systems	X	X	X	X	X	X
Warm magnet systems	X	X	X	X	(X)	X
Cryomodule	X	X	(X)	X	X	(X)
Cavity Package	X	X	(X)	X	X	(X)
RF Power	X	X	(X)	X	X	(X)
Cryogenics	X	X	X	X	X	X
Accelerator Physics	X	X	X	X	X	X
Operations & Reliability	X	X	X	X	X	X
Instrumentation	X	X	X	X	X	X
Controls	X	X	X	X	X	X
Systems integration	X	X	X	X	X	X
CF&S	X	X	X	X	X	X
Cost	X	X	X	X	X	X

Linear Collider Facility

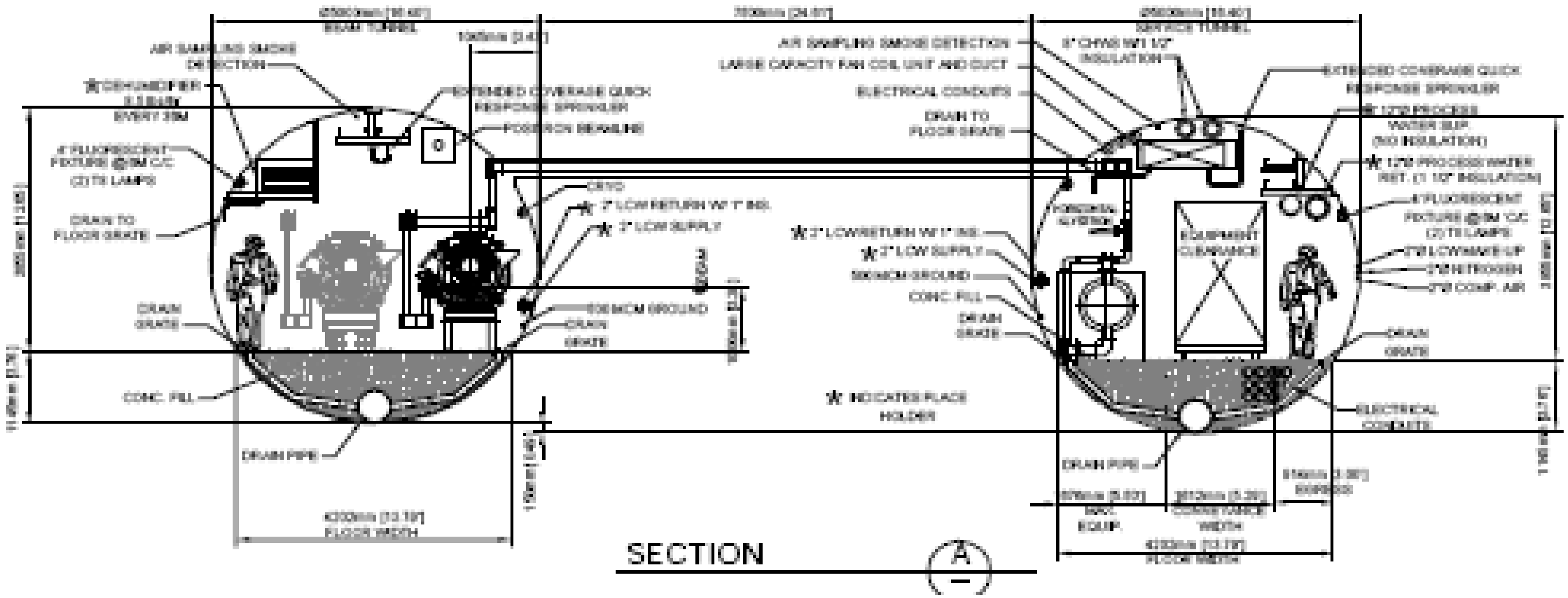


Two tunnels
- accelerator units
- other for services - RF power

Regional Differences

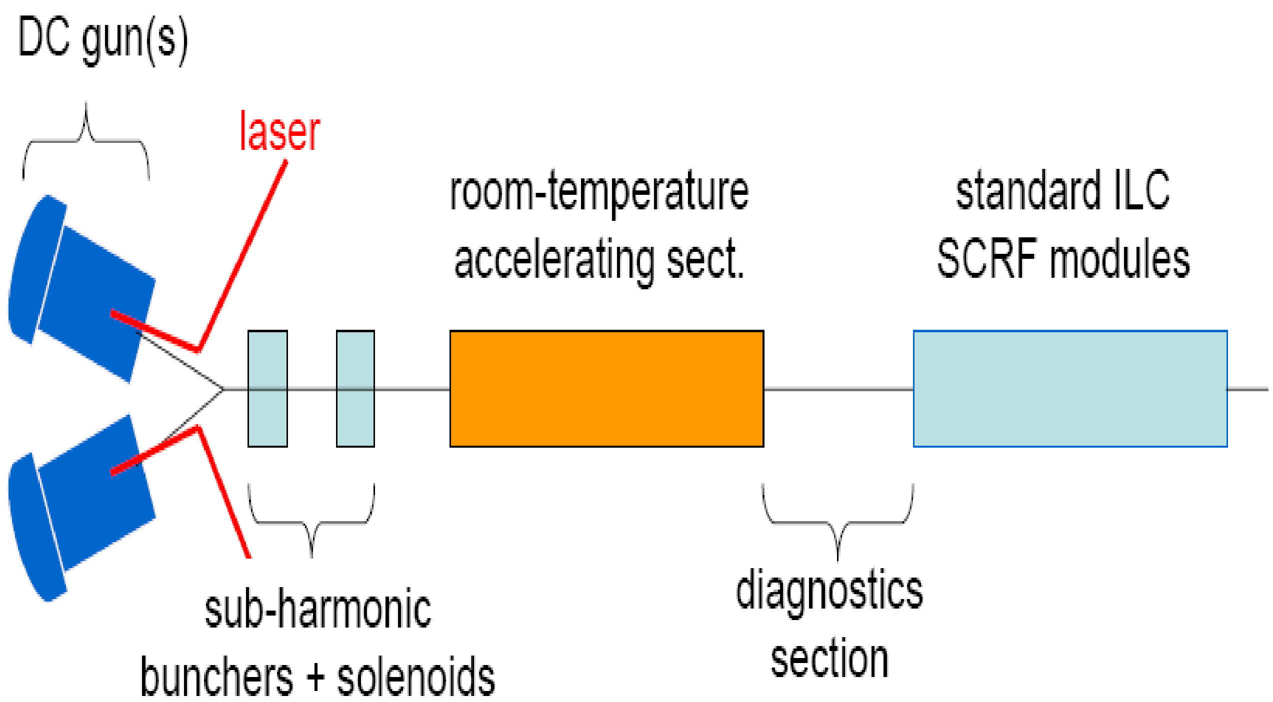
Tunnel Diameter

- **Both tunnels are 5 meter diameter (Fixed)**
- **5 meters in Asia & 7.5 meters elsewhere between tunnels (for structural reasons)**
- **5 meters between tunnels required for shielding**



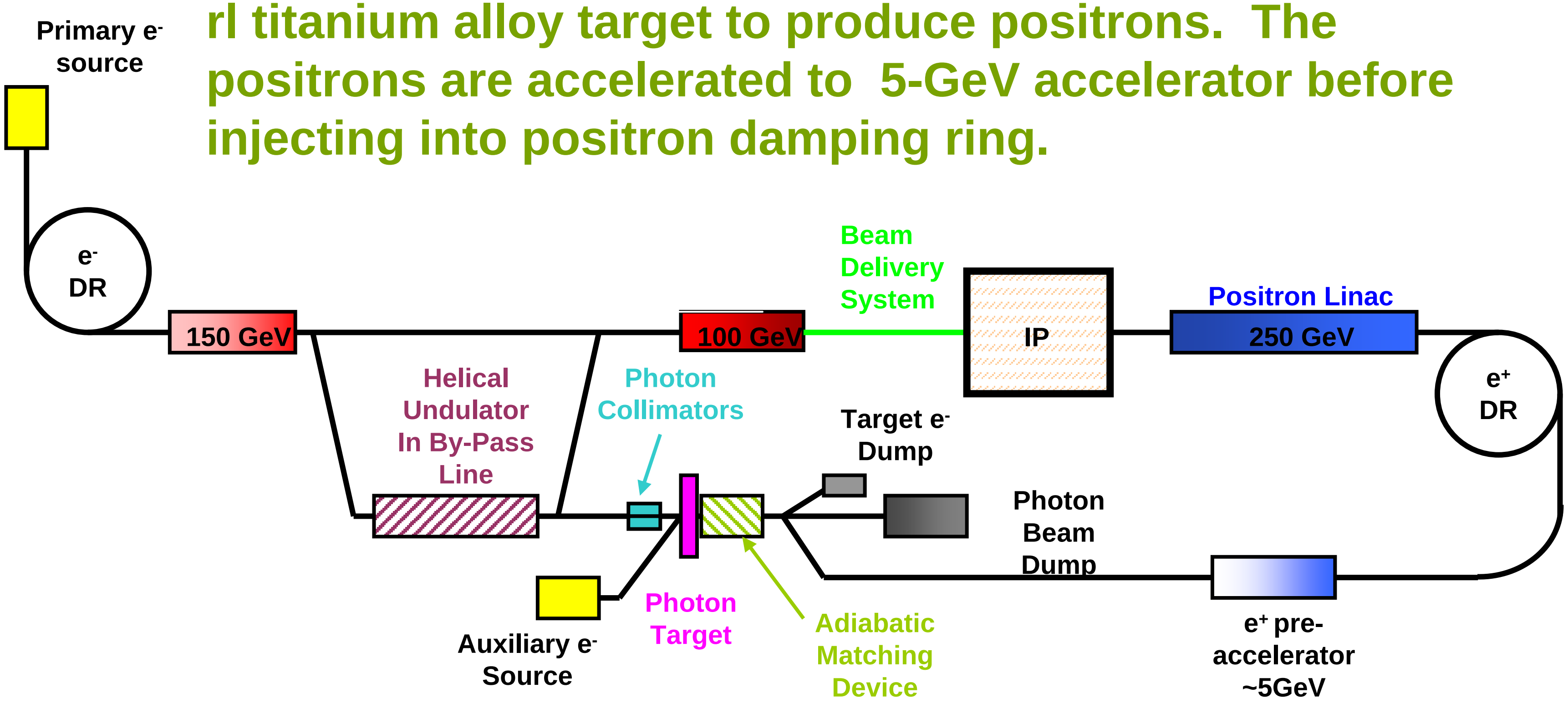
Baseline Features – Electron Source

- **Electron Source – Conventional Source using a DC ----- Titanium-sapphire laser emits 2-ns pulses that knock out electrons; electric field focuses each bunch into a 250-meter-long linear accelerator that accelerates up to 5 GeV**

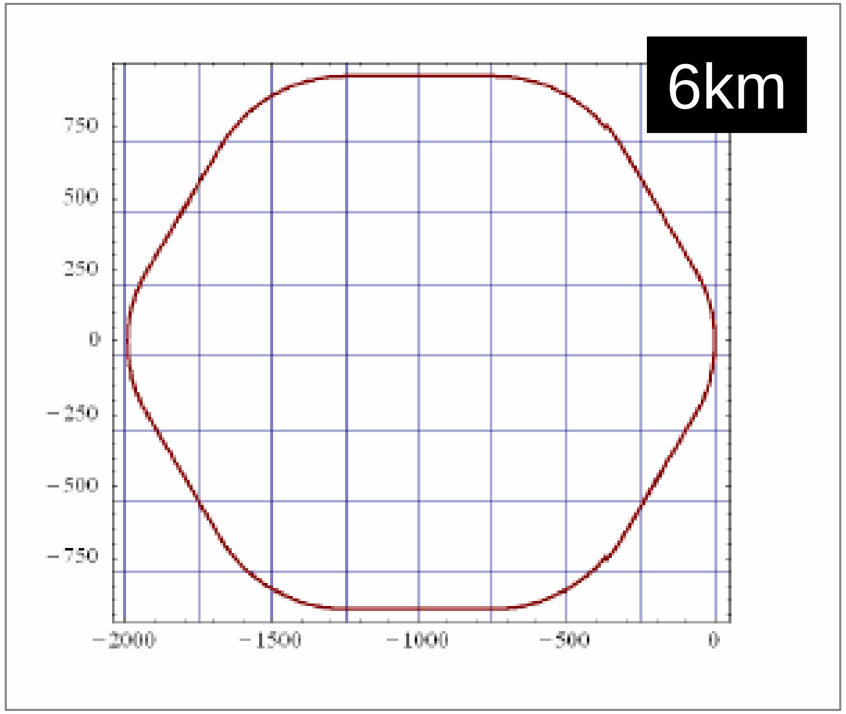


Baseline Features – Positron Source

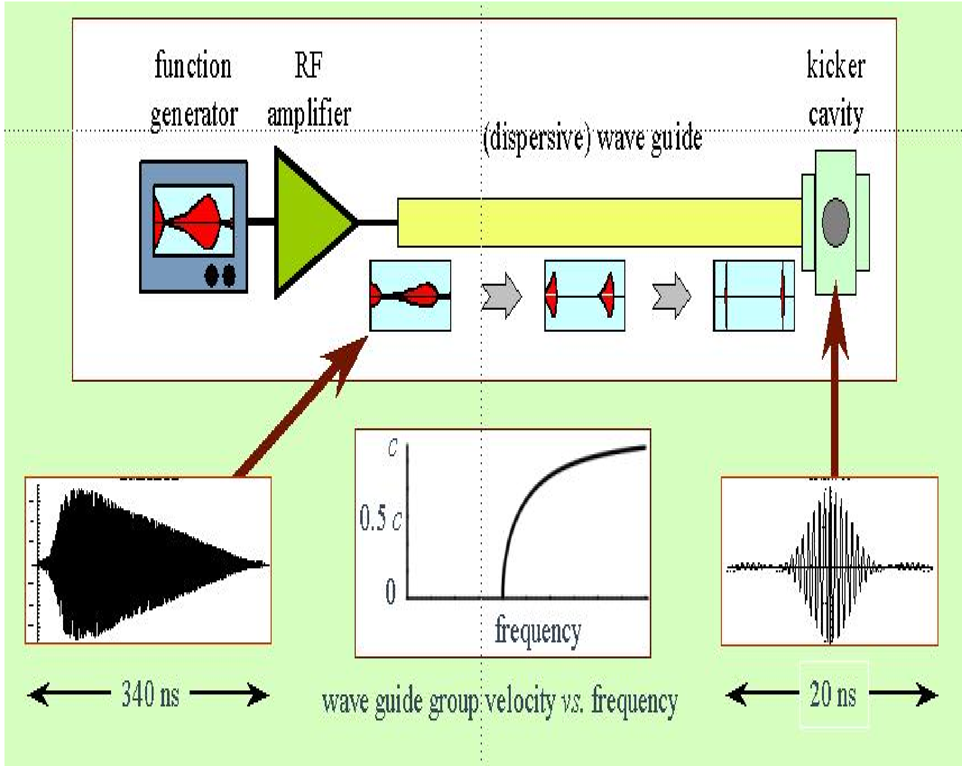
- **Positron Source – Helical Undulator with Polarized beams –** 150 Gev electron beam goes through a 200m undulator making photons that hit a 0.5 rl titanium alloy target to produce positrons. The positrons are accelerated to 5-GeV accelerator before injecting into positron damping ring.



6 Km Damping Ring



Requires Fast Kicker 5 nsec rise and 30 nsec fall time



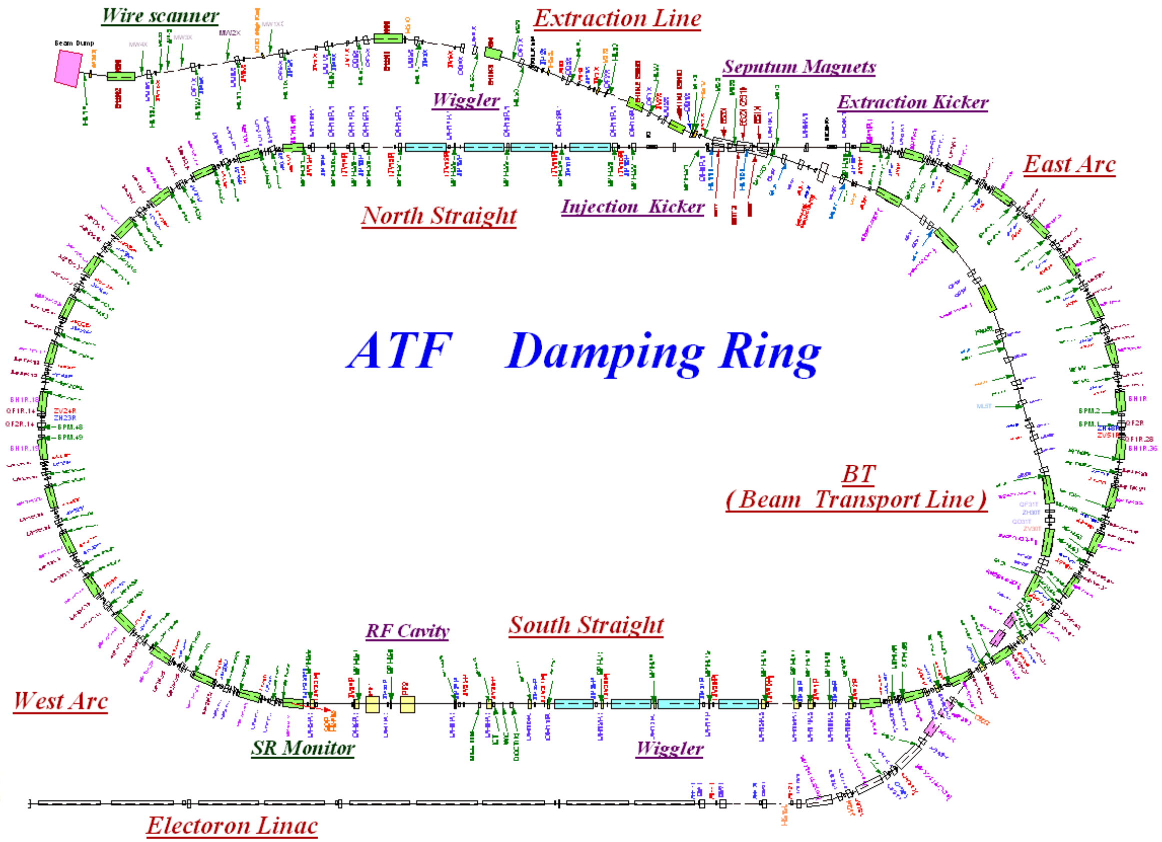
The damping rings have more accelerator physics than the rest of the collider

KEK ATF Damping Ring

- Probably world’s largest linear collider test facility

1.3 GeV Damping Ring and S-band linac
Commissioning started in 1997

Emittances of
$e_x/e_y = 8.0/.02\ \mu m$,
have been achieved



Damping Ring - Features

- **Damping Ring for electron beam**
  – Synchrotron radiation damping times ~ 10 - 100 ms.
  – Linac RF pulse length is of the order of 1 ms.
  – Damping rings must store (and damp) an entire bunch train in the (~ 200 ms) interval between machine pulses.

Particles per bunch	1×10^{10}
Particles per pulse	5.6×10^{13}
Number of bunches	5600
Average current in main linac	9.5 mA
Bunch separation in main linac	168 ns
Train length in main linac	0.94 ms = 283 km

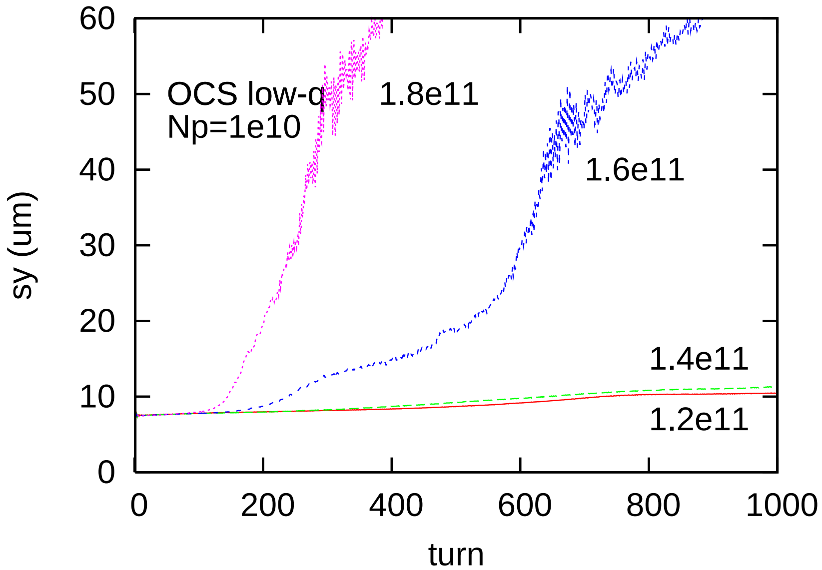
- **Damping Ring for positron beam**

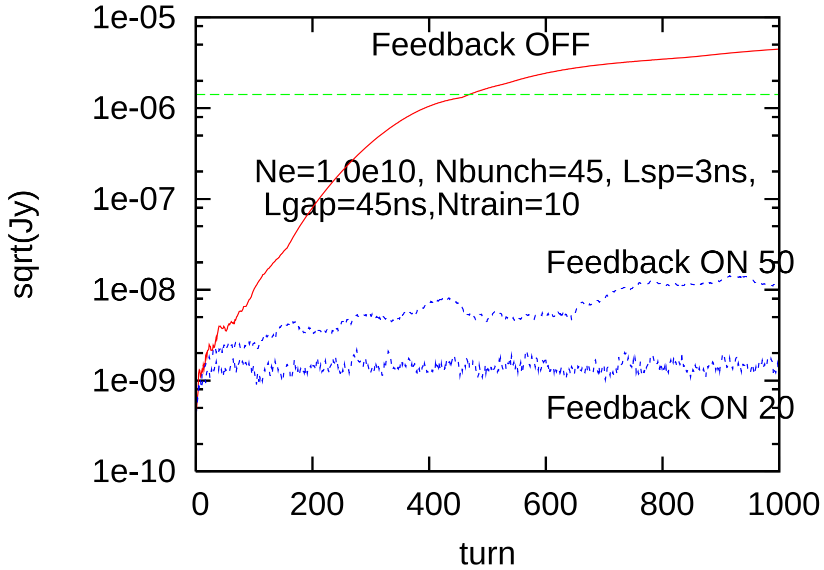
  In the present baseline, in order to minimize "electron cloud effects," positron bunches are injected alternately into either one of two identical positron damping rings with 6-kilometer circumference.

Damping Ring - Design Issues

Electron Cloud

- **Ecloud: Threshold of electron cloud, $1.4x10^{11}$ m^{-3}.**
- **Ion: Feedback system can suppress for 650 MHz (3ns spacing),**
- **Number of bunch in a train 45, and gap between trains 45ns.**



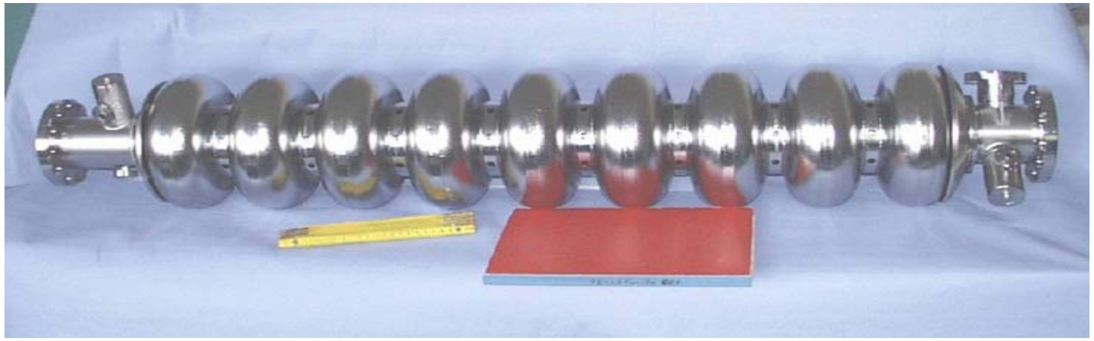


SRF Cavity Gradient

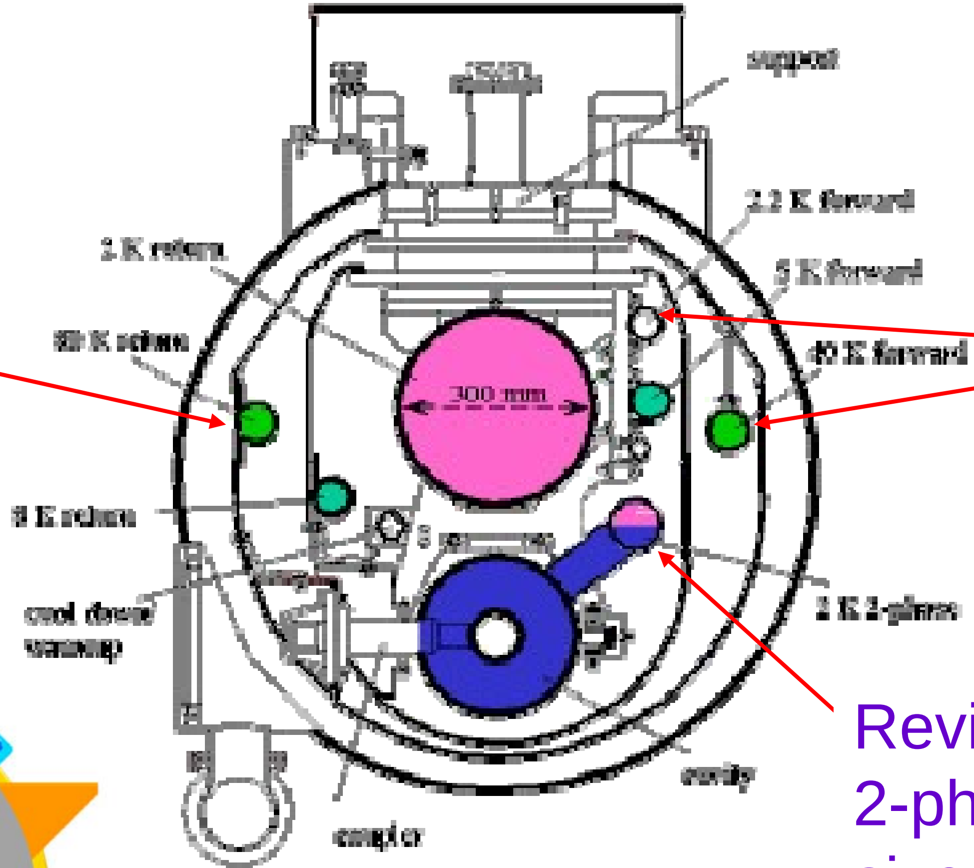
	Cavity type	Qualified gradient	Operational gradient	Length*	energy
		MV/m	MV/m	Km	GeV
initial	TESLA	35	**31.5**	**10.6**	**250**
upgrade	LL	40	**36.0**	**+9.3**	**500**

Total length of one 500 GeV linac ≈ 20km

* **assuming 75% fill factor**



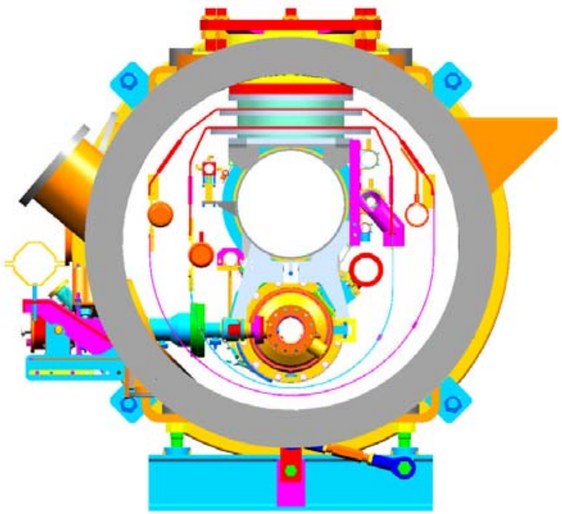
ILC Cryomodule



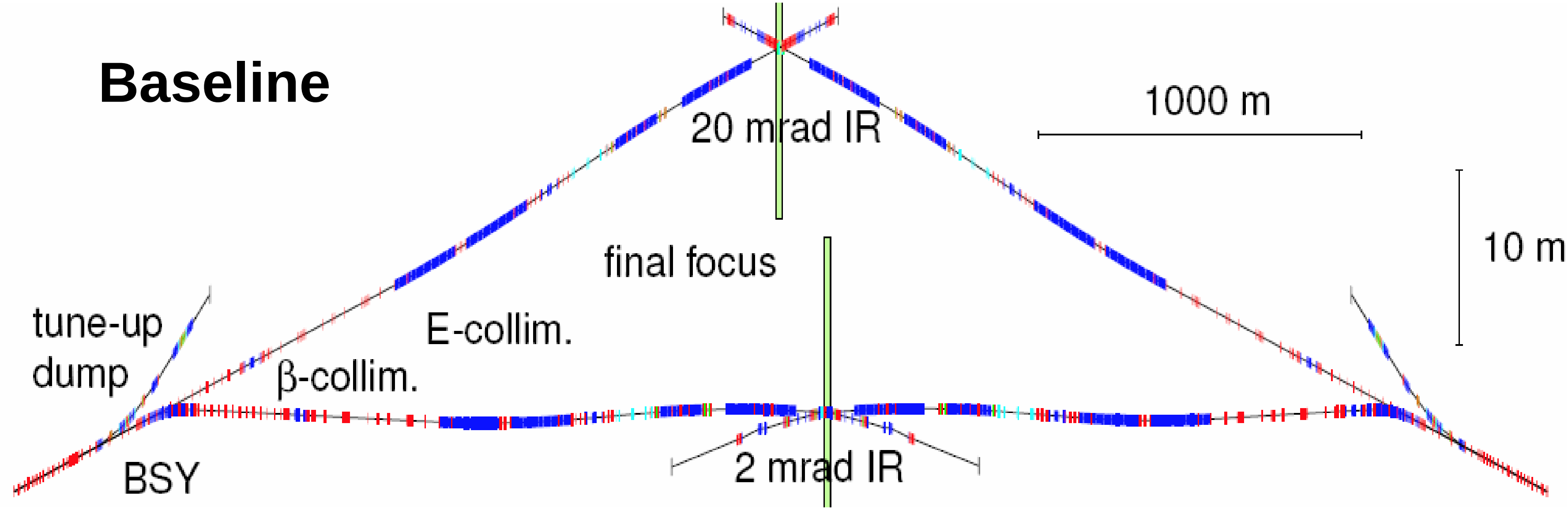
Increase diameter beyond X-FEL

Increase diameter beyond X-FEL

Review 2-phase pipe size and effect of slope

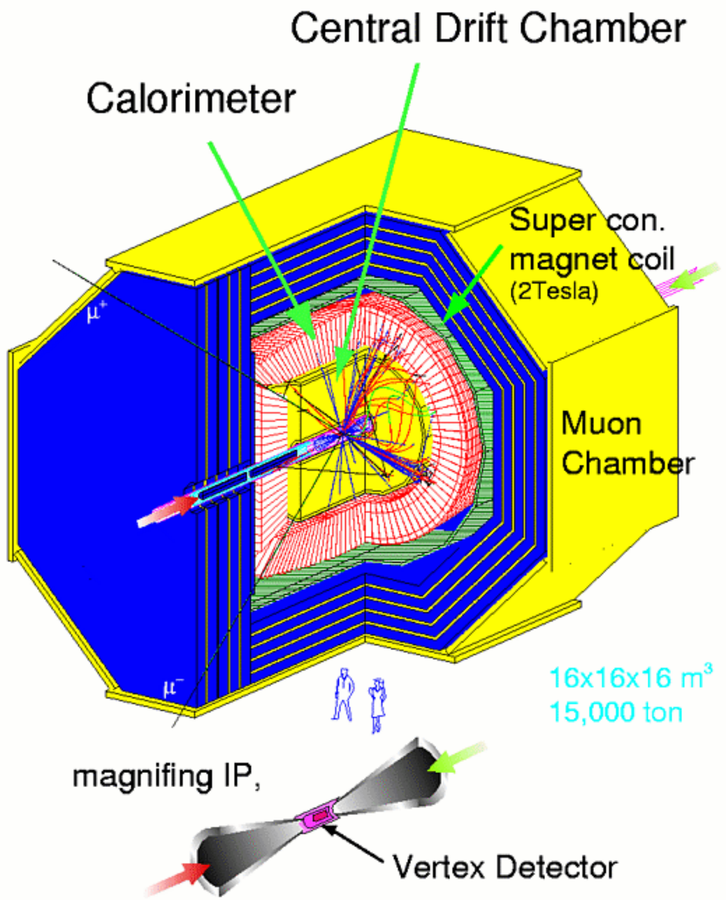


Beam Delivery System



- **Requirements:**
  - **Focus beams down to very small spot sizes**
  - **Collect out-going disrupted beam and transport to the dump**
  - **Collimate the incoming beams to limit beam halo**
  - **Provide diagnostics and optimize the system and determine the luminosity spectrum for the detector**
  - **Switch between IPs**

Detectors for the ILC



- **Large Scale 4π detectors with solenoidal magnetic fields.**
- **In order to take full advantage of the ILC ability to reconstruct, need to improve resolutions, tracking, etc by factor of two or three**
- **New techniques in calorimetry, granularity of readout etc being developed**

ILC Detector Concept Meetings

Wednesday 19 July 2006
12:30->*13:30* **GLD detector concept meeting** **(SUB 212)**

Saturday 22 July 2006
12:30->*13:30* **LDC detector concept meeting** **(SUB 212A)**

Sunday 23 July 2006
09:00->*13:00* **SiD detector concept meeting** **(SUB 205)**

RDR Cost Estimating

- **500 GeV BCD machine + “essentials” for 1 TeV**
- **Follow ITER “Value” & CERN “CORE” model for International Projects**
  - **Provides basic agreed to costs [common “value” + in-house labor (man-hr)]**
- **RDR will provide information for translation into any country’s cost estimating metric, e.g. Basis of Estimate => contingency estimate, in-house labor, G&A, escalation, R&D, pre-construction, commissioning, etc.**
- **Assumes a 7 year construction phase**

ILC Cost Estimate

- **Based on a call for world-wide tender:**
  lowest reasonable price for required quality

- **Classes of items in cost estimate:**
  - **Site-Specific (separate estimates for each site)**
  - **Conventional – global capability (single world est.)**
  - **High Tech – cavities, cryomodules, regional estimates**

- **Cost Engineers will determine how to combine and present multiple estimates**

- **WBS ; WBS Dictionary; Costing Guidelines are mature enough - cost estimating is underway**

WBS Level of Detail - Cryogenics

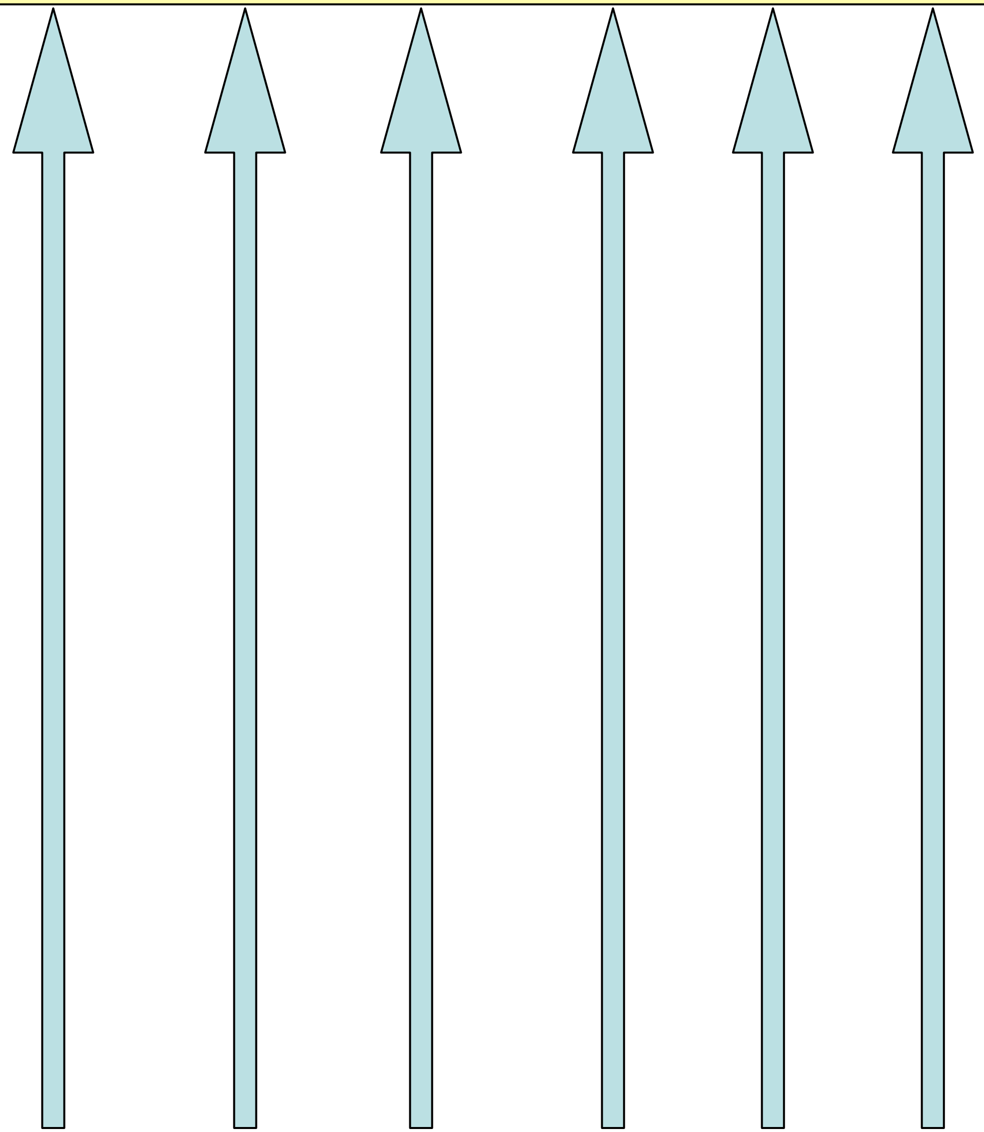
LHC refrig. single units

%	percentage of total materials cost for USLCTOS 500 GeV Cold option these percentages for USLCTOS are somewhat sensitive, they are listed just to give idea of level of detail that has been attained		
WB_6feb_PG_8feb (Follows USLCTOS)			This is what is on the web, the items 1.8.3.1.1.i
1.8.3 Cryogenic Plant and Distribution			were omitted. The green numbers on left are
4.08	1.8.3.1 Cryogenic Plants		percentage 4.08% of total USLCTOS 500 cold M&S
3.27	1.8.3.1.1 Cryo Refrigeration Unit (includes cryo distribution, but not civil utilities)		
This layer was not included - consider adding this layer to increase sensitivity			
	1.12	1.8.3.1.1.1 Cryo Cold Boxes	
	0.68	1.8.3.1.1.2 Cryo Warm Compressor System	
	0.12	1.8.3.1.1.3 Cryo Cold Compressor System	
	0.11	1.8.3.1.1.4 Cryo Purification System	
	0.13	1.8.3.1.1.5 Cryo Refrigeration System Controls	
	0.10	1.8.3.1.1.6 Cryo Liquid Helium Storage	
	0.17	1.8.3.1.1.7 Cryo Vertical Transfer Line	
	0.16	1.8.3.1.1.8 Cryo Distribution Boxes 1,2,8	
	0.11	1.8.3.1.1.9 Cryo Distribution Boxes 3,6,7	
	0.16	1.8.3.1.1.10 Cryo Warm He Gas Header	
	0.09	1.8.3.1.1.11 Cryo Vacuum Barriers	
	0.19	1.8.3.1.1.12 Cryo System Installation Contracts	
	0.04	1.8.3.1.1.13 Cryo Miscellaneous	
	0.05	1.8.3.1.1.14 Cryo Feed Boxes	
	0.04	1.8.3.1.1.15 Cryo End Boxes	
0.25	1.8.3.1.2	Cryo Cooling Towers	
0.04	1.8.3.1.3	Cryo Warm Helium Storage	
0.04	1.8.3.1.4	Cryo Helium Gas (initial charge) **- should this be operating, not construction?**	
0.00	1.8.3.1.5	Cryo Vacuum Barrier	
0.01	1.8.3.1.6	Cryo Feed Boxes	
0.01	1.8.3.1.7	Cryo End Boxes	
0.17	1.8.3.1.8	Cryo Load Controls	
0.30	1.8.3.1.9	Cryo Cold Bypass (1 kilometer) - what was this? fairly pricey!	
	1.8.3.2 Cryogenic Distribution **- actually included above 1.8.3.1.1.i - so can discard this element**		

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

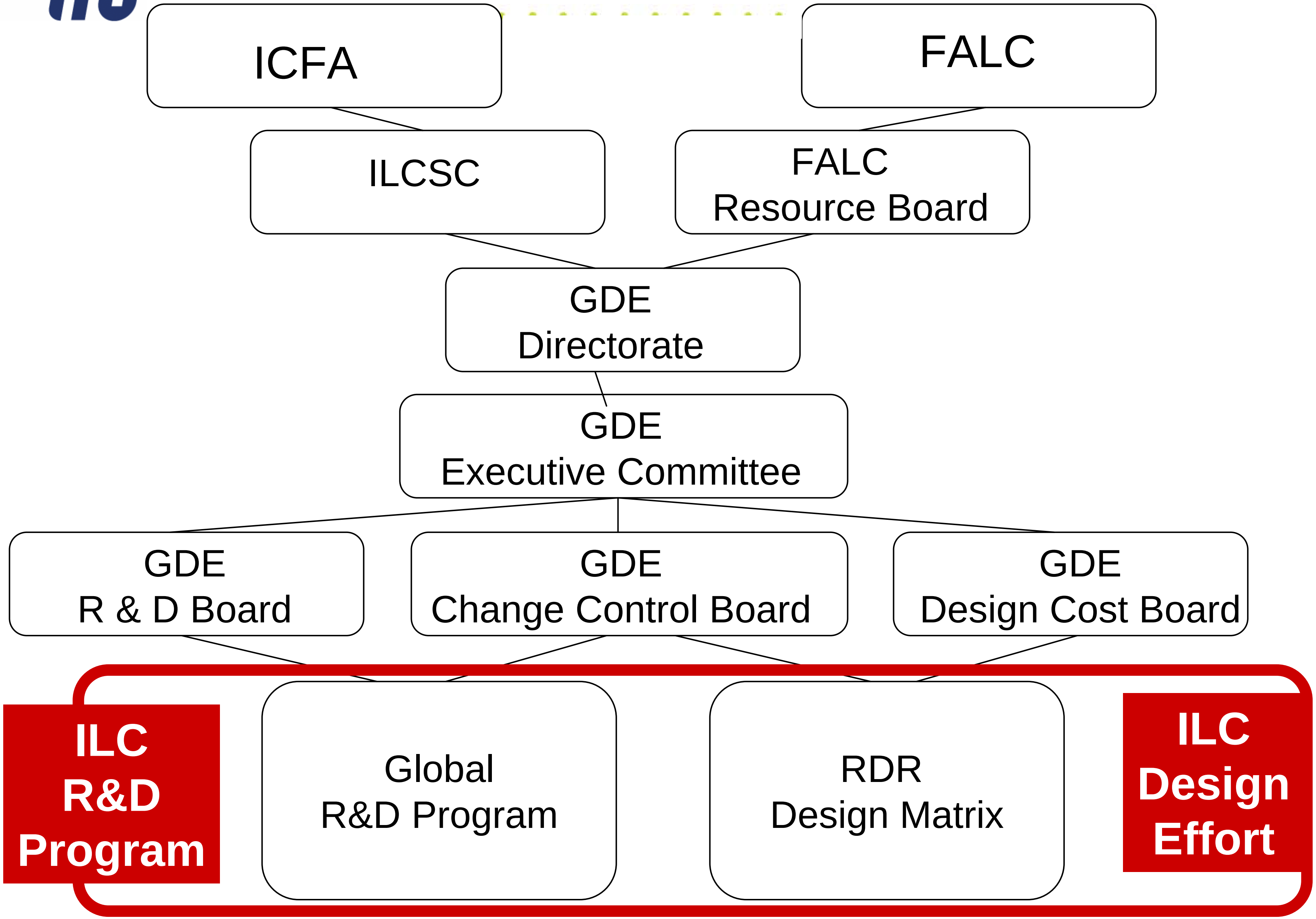
Global Systems

- Commissioning, Operations & Reliability
- Control System
- Cryogenics

Elements of the ILC R&D Program

- **R&D in support of the baseline**
  - **Technical developments, demonstration experiments, industrialization, etc.**
- **R&D in support of alternatives to the baseline**
  - **Proposals for potential improvements to the baseline, resources required, time scale, etc.**
  - **Guidance from Change Control Board**
- **DETECTOR R&D program aimed at technical developments needed to reach combined design performance goals**

GDE RDR / R&D Organization



Mission of the Global R&D Board

- **Coordinate worldwide, prioritized, proposal-driven, R & D efforts**

- **The goal is clear, the detailed means required resolution by the RDB of issues, for example:**
  - **Level of coordination**
  - **Parallel efforts coordination, Regional needs**
  - **“Reviewing” role: Ideal vs specific R&D Program**
  - **Balance ILC/ILC Detectors issues**
  - **Goals, Timelines**
  - **Interfaces, RDB/DCB, RDB/Industrialization…**

RDB Plan for Achieving its Mission

- First tackle work that leads to immediate benefits
  - **Project Tools to allow a Work Breakdown structure to put all Global R&D on a common basis, needs:**
    - **A Data Entry Tool**
    - **A Data Base with flexible features**
    - **A facility for generating needed Reports**
  - **CERN has kindly agreed to help us with the Data Base and Reports, and our Board member Eckhard Elsen agreed to be Data Integrator to make the system work**
- **Generate an Ideal ILC Research Program**

Ideal ILC R&D Program

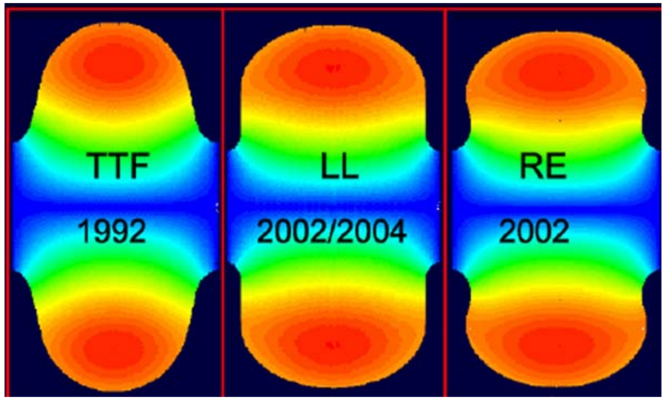
- Generate WBS for ten ILC Areas (no Cryogenics R&D identified for the Baseline), with about 400 items
- The structure will allow us to note links items in different Regions
- Assign Priorities 1 (very high), 2 (high), 3 (moderate), 4 (low)
  - **by team of two Board members per area, with justification**
  - **Reviewed anonymously by all members, with comments**
  - **Discussion of board to reach conclusion**
  - **Face to face meeting to consider uniformities among areas 8 March**
  - **"Last" iteration took place this week**
- Publication (RDB Public Wiki) took place this week

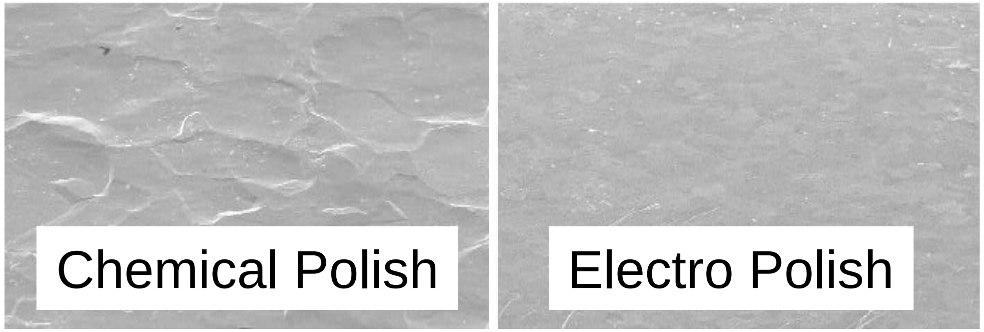
  http://www.linearcollider.org/wiki/doku.php
- Convenient Reports will be created from the data base at CERN soon, useful for example for Dugan 2007 meeting in May

Small Sample of Data Entry

SC_HOM_2K_Cryoload	SC_HOM	HOM induced cryoload at 2K	high	DESY		undefined	Measure cryogenic HOMs at 2K to be s as required to keep
SC_HOM_Improve_Existing	SC_HOM	Improve existing design	high	DESY	KEK	in progress	Slight modifications design for ease of f rejection, and therr
SC_HOM_Absorber_Material	SC_HOM	HOM absorber material	high	DESY	Cornell	in progress	Work on reproducib material.
SC_HOM_Feedthroughs	SC_HOM	Higher heat conductivity feedthroughs	moderate	TJNAF	DESY	in progress	Explore higher hea output lines
SC_HOM_Alternate	SC_HOM	Alternate HOM couplers	moderate	TJNAF	KEK	undefined	Explore alternate H
SC_HOM_Output_Parallel	SC_HOM	HOM output in F-piece plane	moderate	TJNAF	KEK	undefined	Radial positioning o plane of so called F
SC_HOM_Hidden_Capacity	SC_HOM	HOM: Hidden capacitor	moderate	TJNAF	KEK	undefined	Version of HOM cou
SC_HOM_No_Capacity	SC_HOM	HOM: No capacitor	moderate	TJNAF	KEK	undefined	Version of HOM cou
SC_Tuner	SC	Tuner					
SC_Tuner_Fast_Range	SC_Tuner	Increase fast tuning range	very high	Saclay	KEK	in progress	Design with increas
SC_Tuner_Fast_Actuator	SC_Tuner	Fast actuator R&D	very high	Orsay		in progress	Fast actuator R&D
SC_Tuner_35	SC_Tuner	Prototype tests at 35 MV/m	high				Prototype tests witl MV/m
SC_Tuner_MTBF	SC_Tuner	MTBF for cold motor	high			undefined	Verification of suffic
SC_Tuner_TJNAF	SC_Tuner	Renascence tuner	moderate	TJNAF		undefined	TJNAF Renascence
SC_Tuner_KEK	SC_Tuner	KEK screwball tuner	high	KEK		in progress	KEK coaxial ball scr for balls, Weight re
SC_Tuner_Redundancy	SC_Tuner	Tuner redundancy	high			undefined	Develop Redundant vessel
SC_Tuner_Warm_Motor	SC_Tuner	Warm tuner motor	low			undefined	Explore Warm motc
SC_Tuner_Magnetostrictive	SC_Tuner	Magnetostrictive tuner	moderate			in progress	Explore larger strok detailed characteriz
SC_Tuner_Reliability	SC_Tuner	Tuner reliability	high			undefined	Conduct Reliability piezo / magnetostri mechanisms and ir
CM	Accelerator	Cryo Module					
CM_4th_gen	CM	Development of a 4th generation cryomodule	high	FNAL	KEK	in progress	Type IV cryomodule from Type III+ : S cavity centerline loc cavity support deta rods) Same input c

Superconducting RF Cavities





Developing Global R&D Plan

- **High priority items first**
  - **Advice for US R&D Funding**
- **Initiating two SRF task forces**
  - **S0 / S1 to demonstrate gradient and yield**
  - **S2 to develop system tests**
- **Coordinate R&D on "alternatives" to the Baseline**
  - **CCB will define goals to replace the baseline**
  - **RDB will determine program – milestones, resources, etc**

Final Remarks

- **Design Status and Plans**
  - Baseline was determined and documented at end of 2005
  - Plan to complete reference design / cost by the end of 2006
  - Technical design by end of 2009

- **R & D Program**
  - Support baseline: demonstrations; optimize cost / perfomance; industrialization
  - Develop improvements to baseline – cavities; high power RF

- **Overall Strategy**
  - Be ready for an informed decision by 2010
  - Siting; International Management; LHC results; CLIC feasibility etc

My Final Plenary Talk

- **I will report on the status of the ILC costing !**
- **I will report on plans between Vancouver and Valencia**
- **I will report on other GDE decisions – for example the EDMS system we will adopt and our implementation plan.**