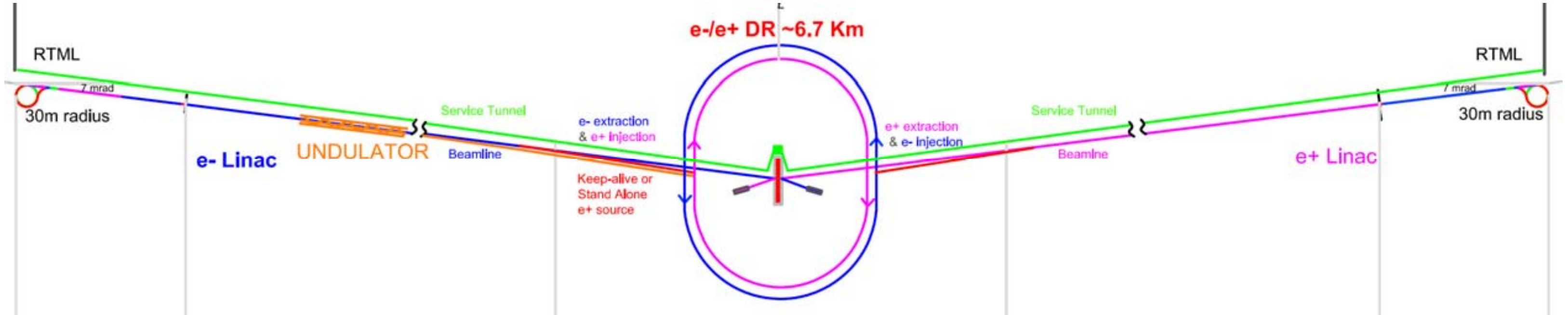
Summary of GDE Meeting and Future Actions



Barry Barish

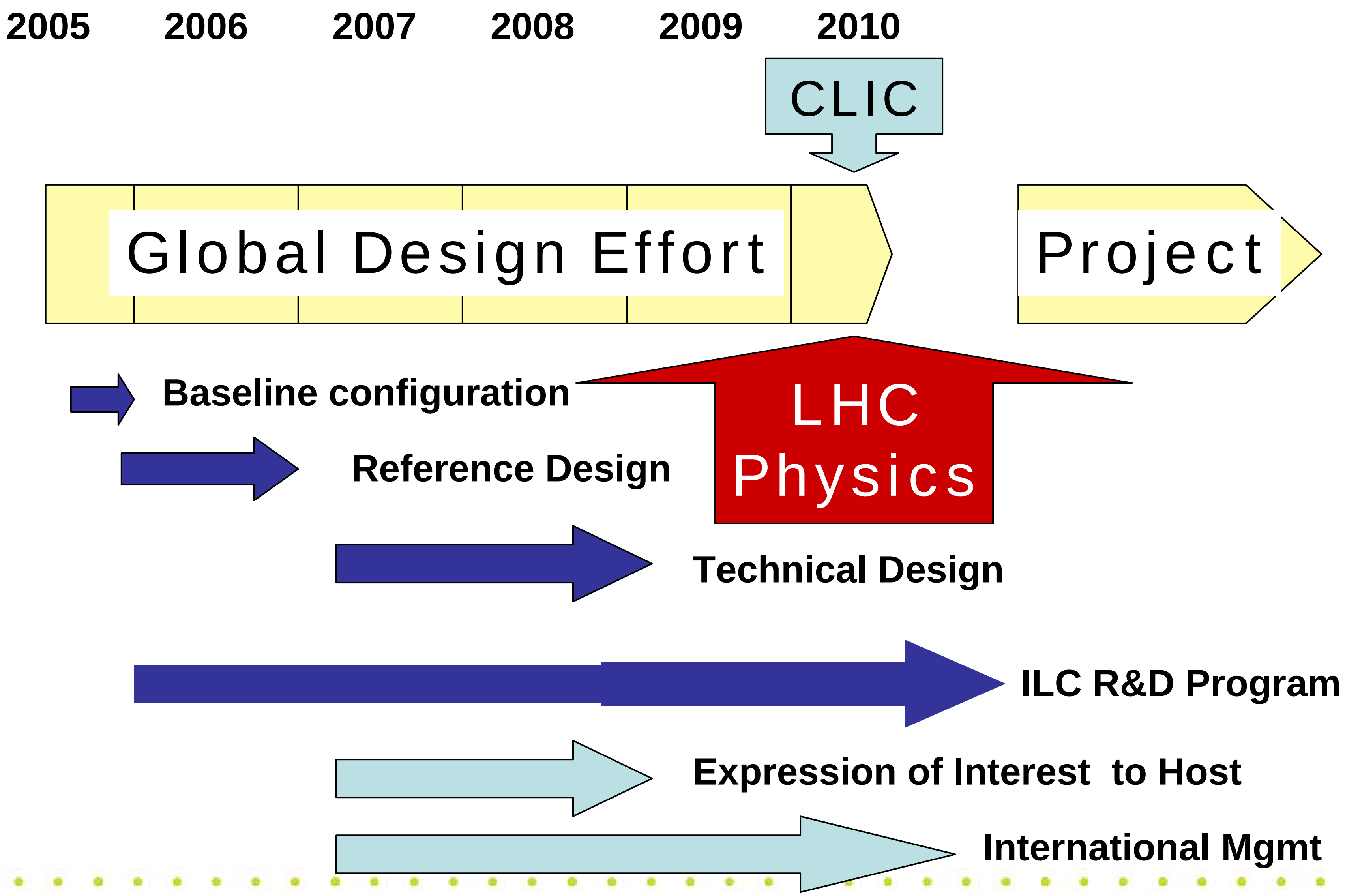
7-Feb-07

Confidentiality Issue

As of tomorrow noon, GDE "value estimates" will be released. You will then be able to share information that is in the RDR.

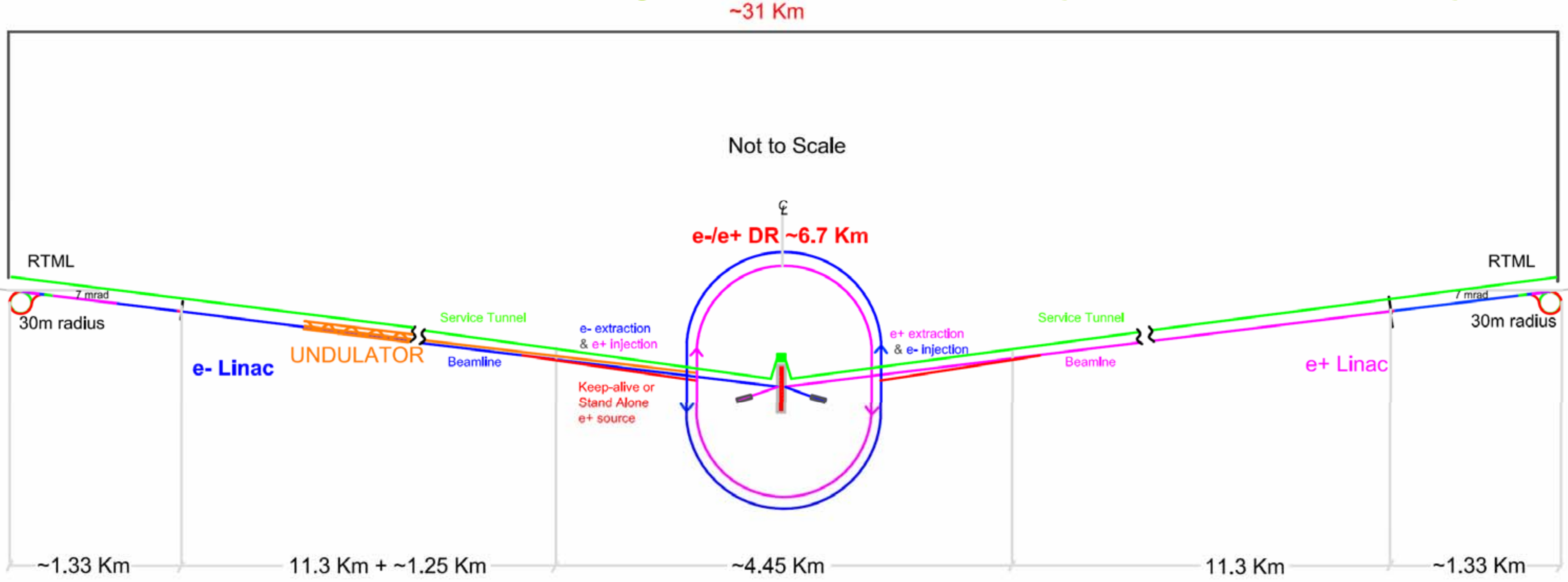
Value information beyond the RDR can only be shown with permission of GDE cost engineers (or myself)

The GDE Plan and Schedule



RDR ILC Schematic

- 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



RDR Design

Max. Center-of-mass energy	500	GeV
Peek Luminosity	~$2x10^{34}$	$1/cm^2s$
Beam Current	9.0	mA
Repetition rate	5	Hz
Average accelerating gradient	31.5	MV/m
Beam pulse length	0.95	ms
Total Site Length	31	km
Total AC Power Consumption	~230	MW

RDR vs ILC Physics Goals

- 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

The RDR Design meets these “requirements,” including the recent update and clarifications of the reconvened ILCSC Parameters group!

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 ILC Units - Shared

+

1.78B ILC Units - Site Specific

+

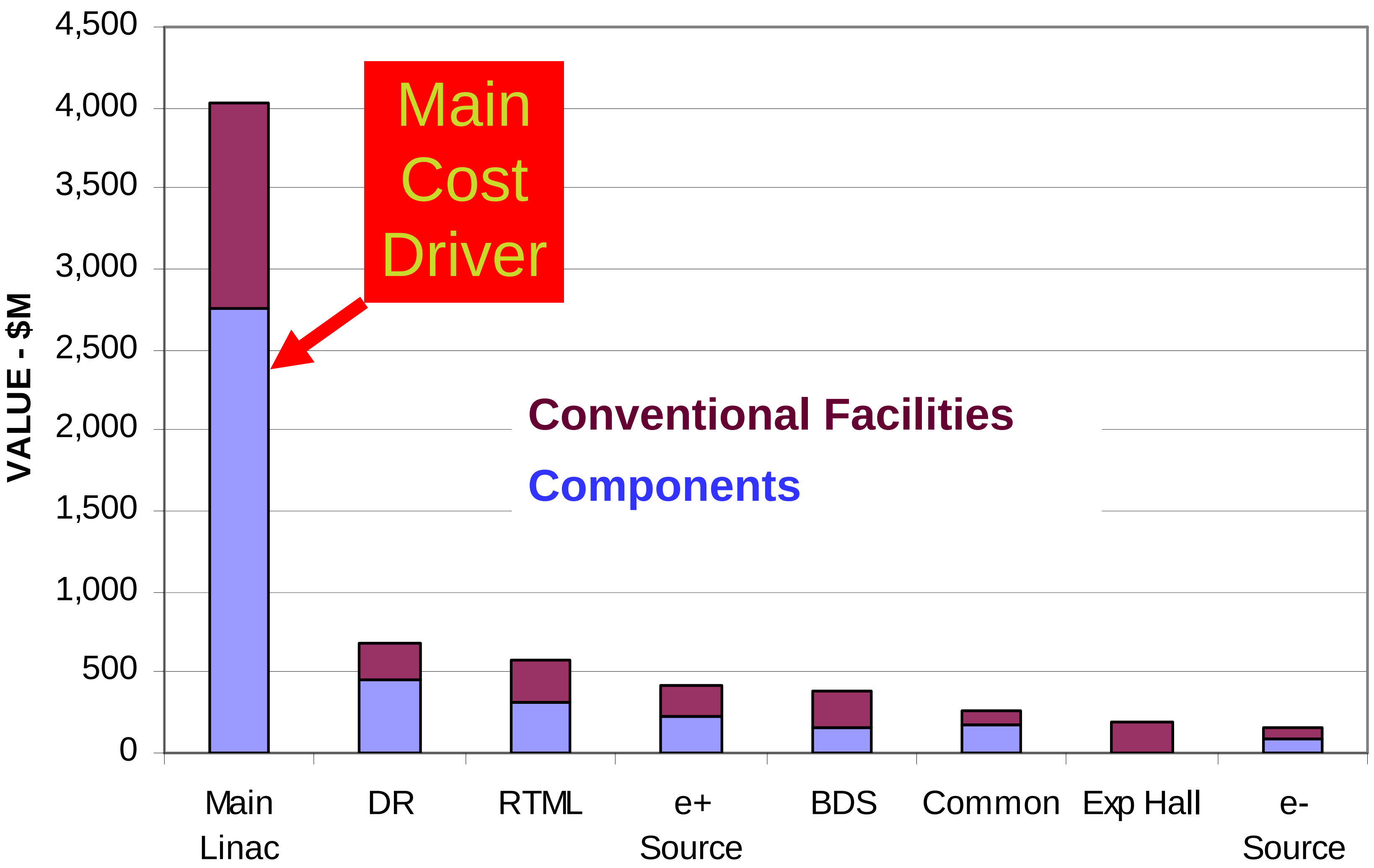
13.0K person-years

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

For this estimate

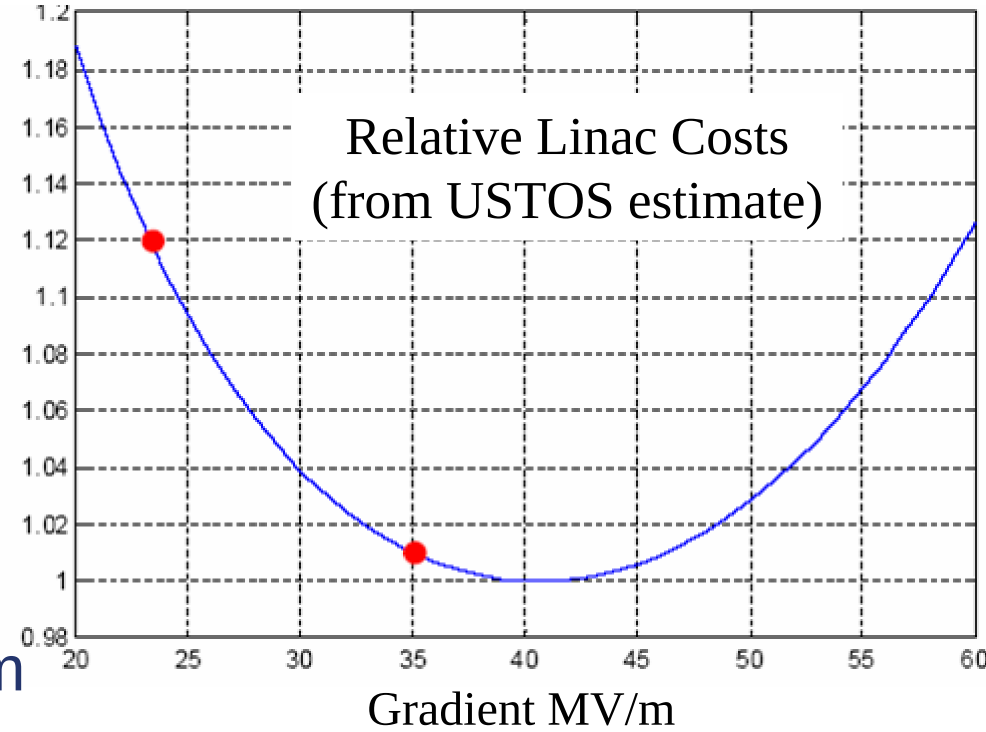
1 ILC Unit = 1 US 2007$ (= 0.83 Euro = 117 Yen)

ILC Value – by Area Systems



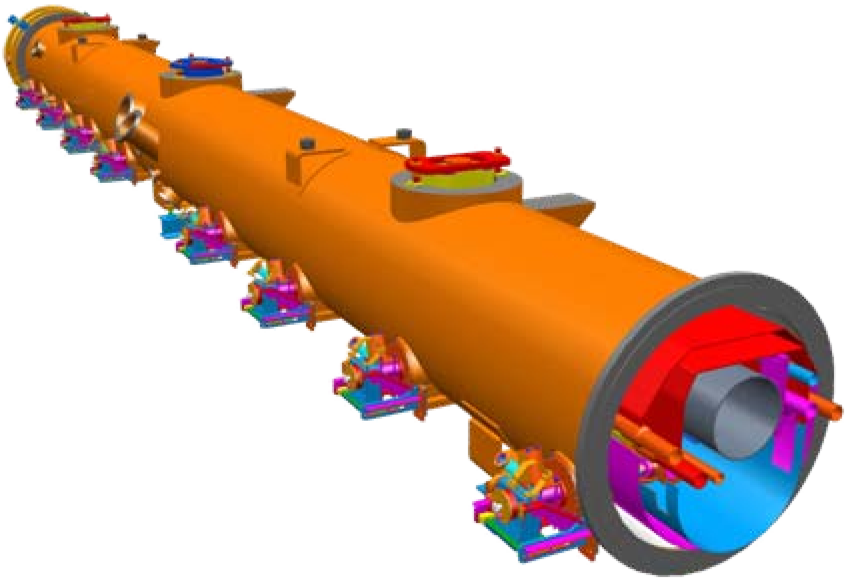
Main Linac Gradient Choice

- 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

Cryomodule Value Estimates



TESLA cryomodule

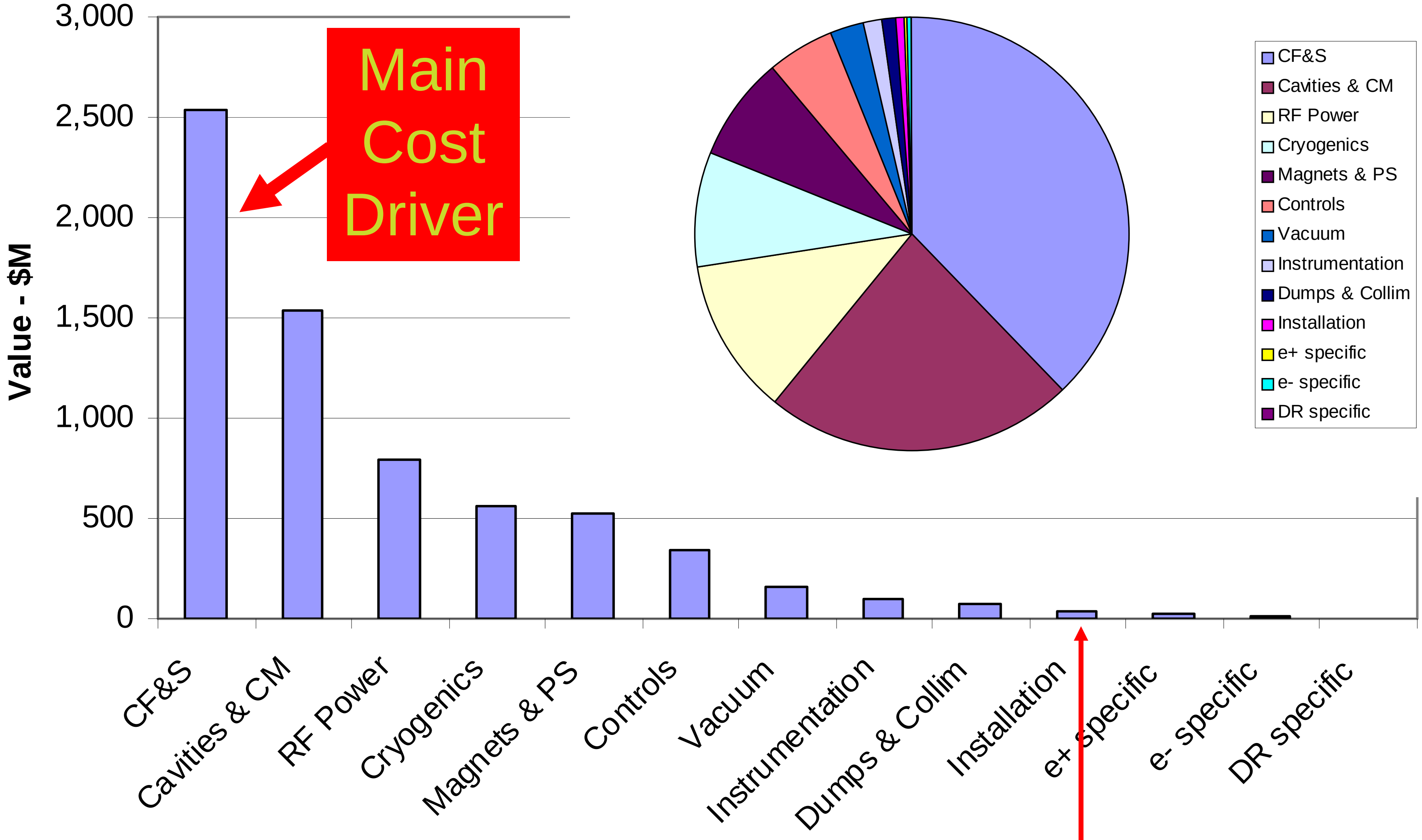
4th generation prototype ILC cryomodule

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)

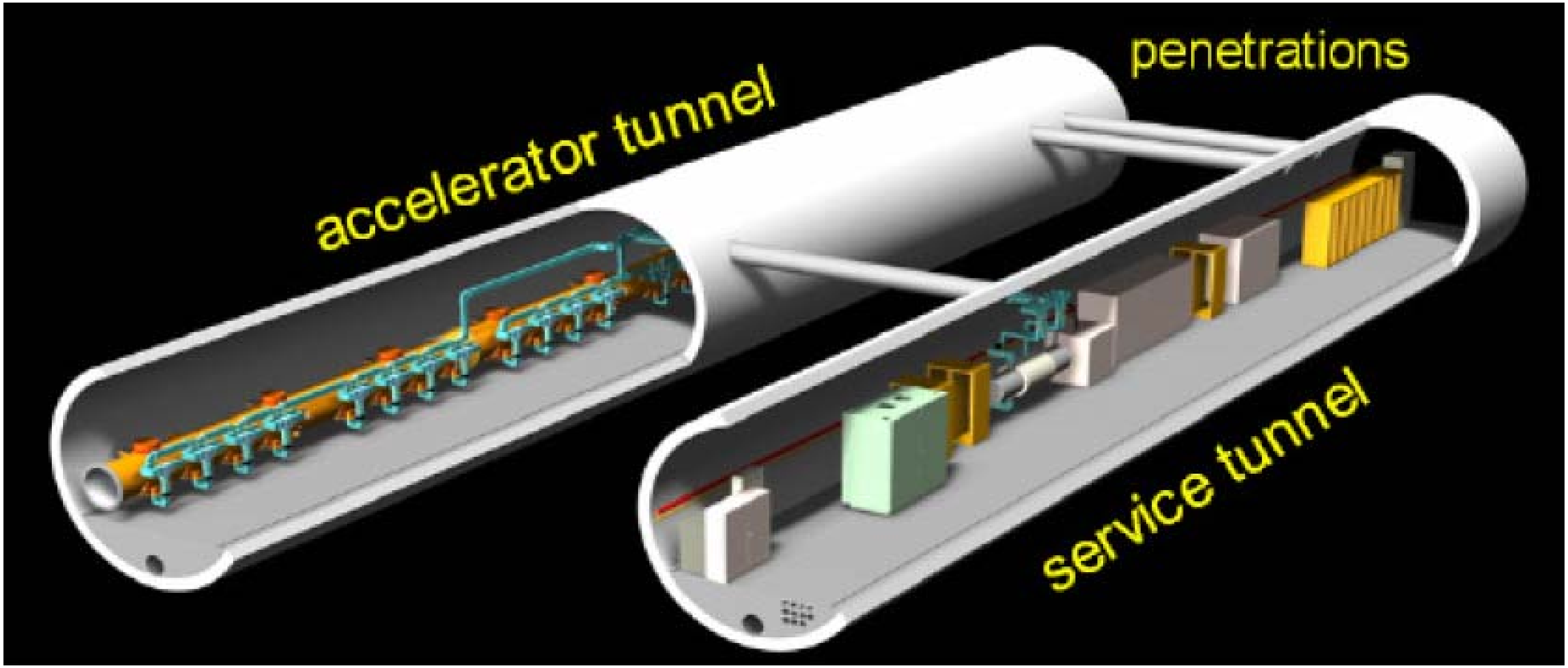
- Costs have been estimated regionally and can be compared.
  - **Understanding differences require detail comparisons – industrial experience, differencdes in design or technical specifications, labor rates, assumptions regarding quantity discounts, etc.**

ILC Value –Global & Technical Systems



Installation counted mostly as explicit labor

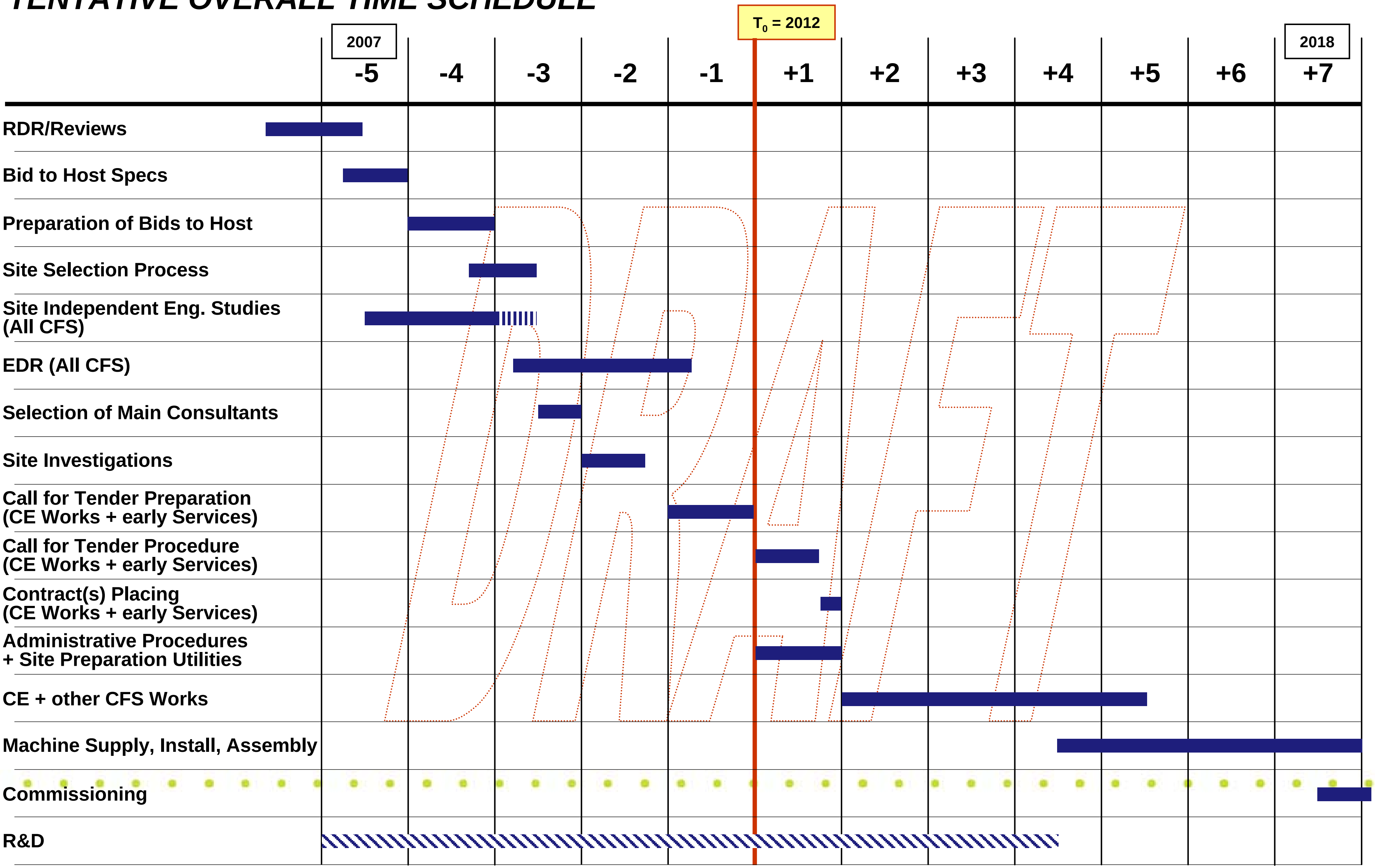
Main Linac Double Tunnel



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

CF&S Project Schedule

TENTATIVE OVERALL TIME SCHEDULE



RDR Report

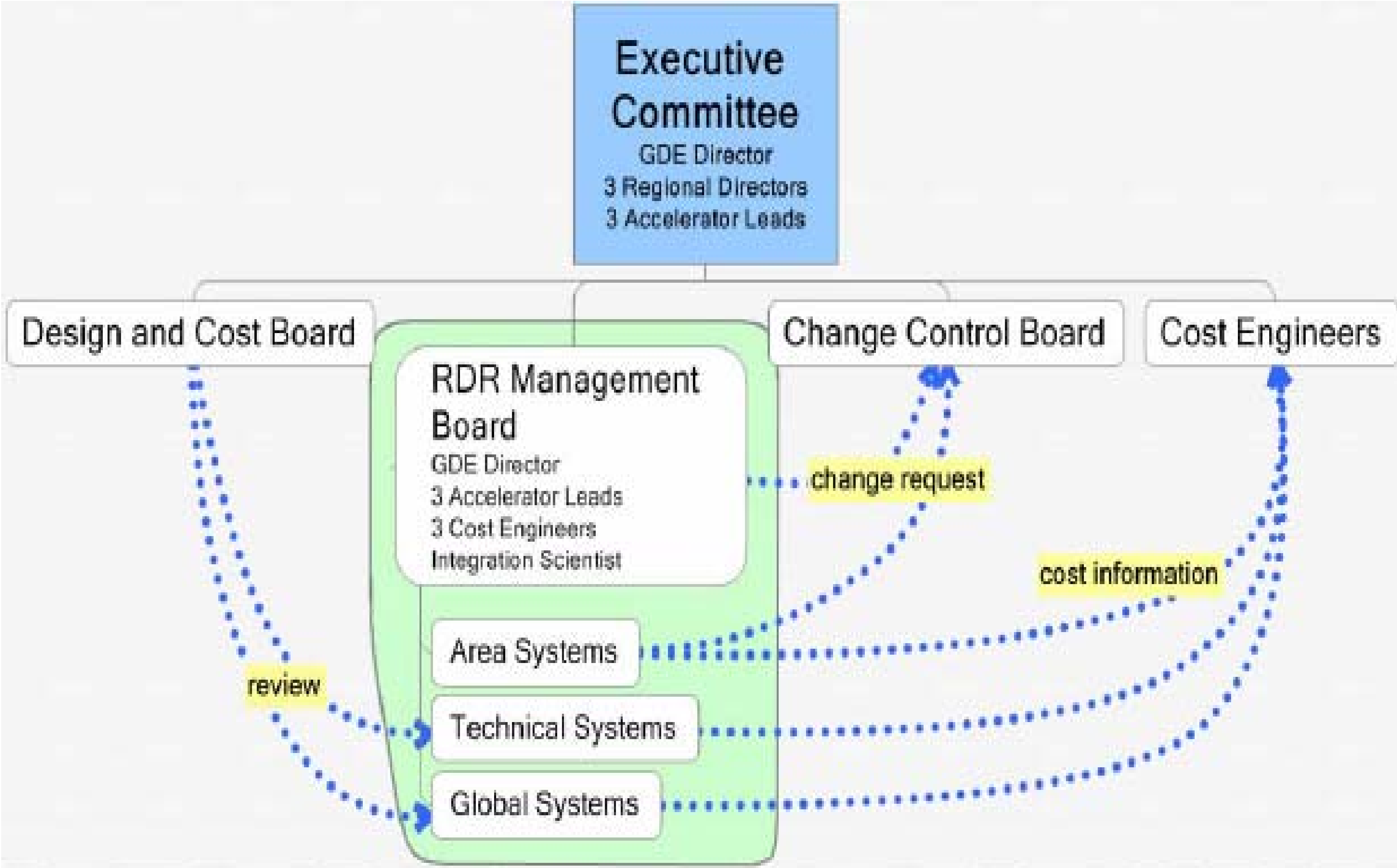
- Three Documents will be presented to the joint ICFA – ILCSC meeting tomorrow, then will be posted

  http://www.linearcollider.org/

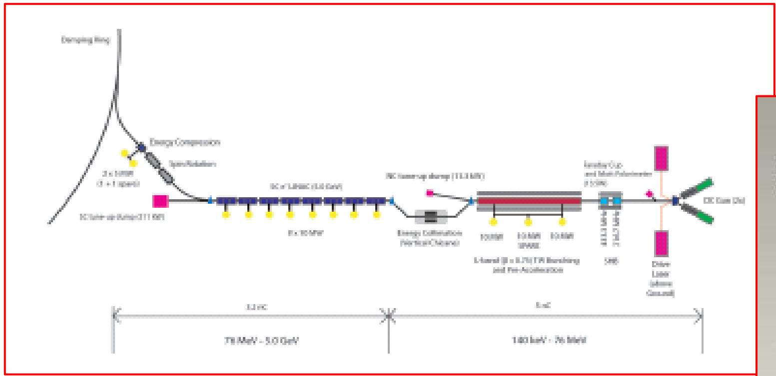
  - **RDR Overview – (Stand alone and Chapter 1)**
  - **Draft Reference Design Report**
  - **The International Linear Collider - *"Gateway to the Quantum Universe"***

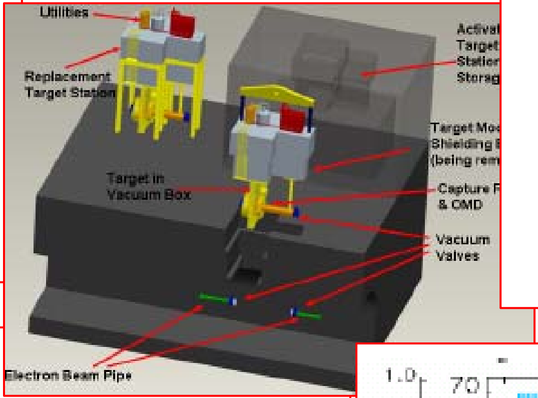
- **Thanks to all that have contributed! A fantastic accomplishment**

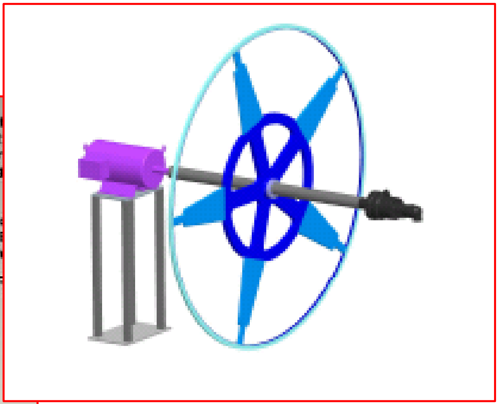
RDR Overview – Chapter 1

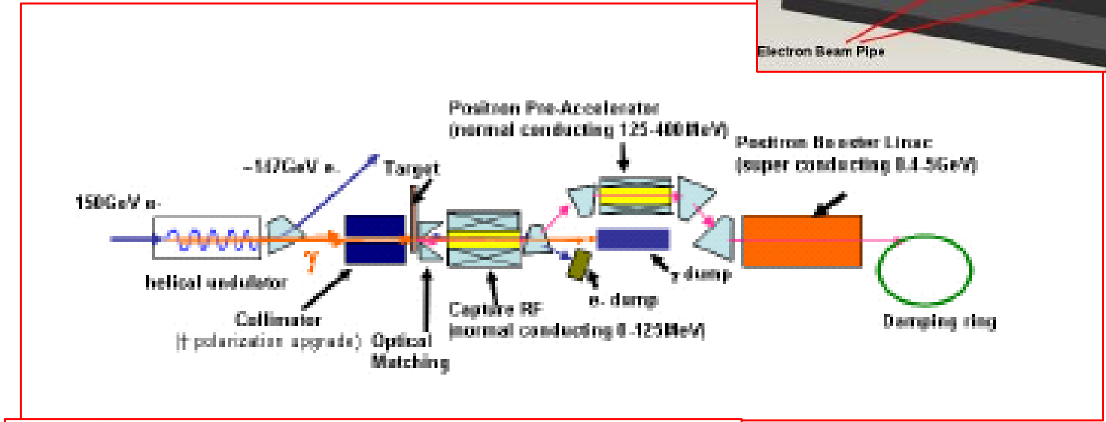


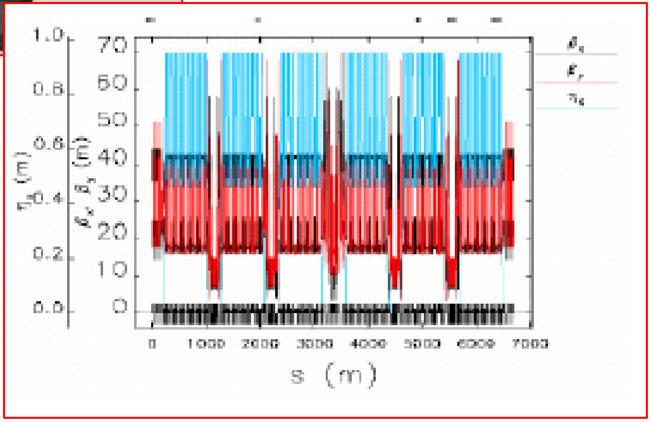
RDR Report – Accelerator Description

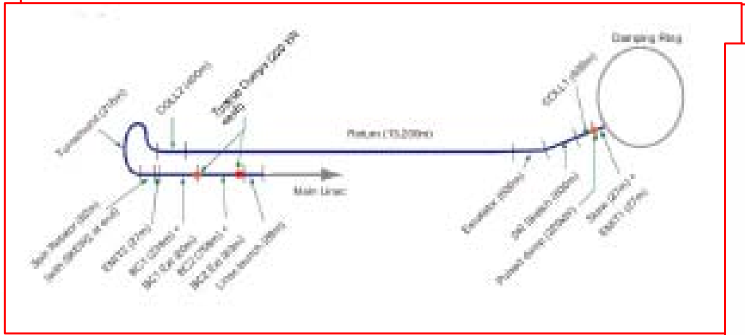


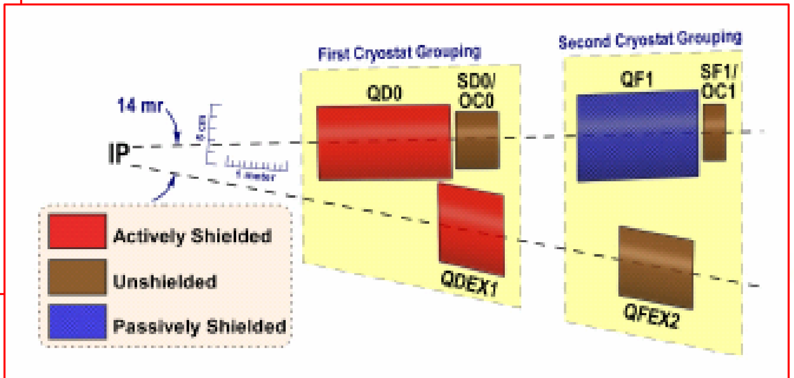












+ Main Linac

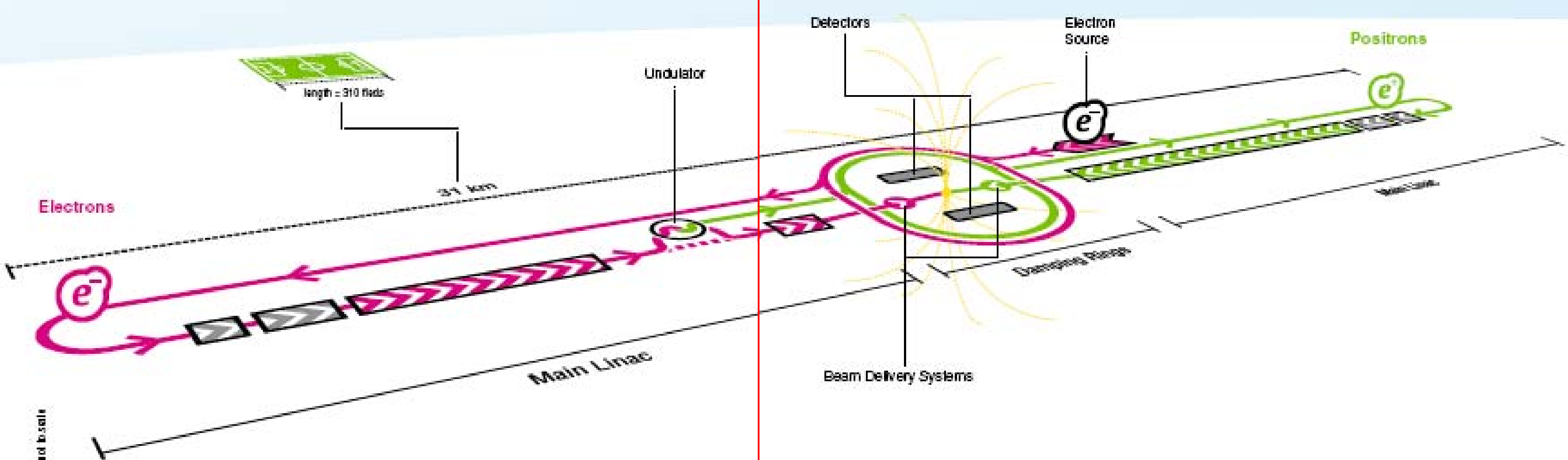
Schedule Post-Beijing

1. During the Beijing meeting, the EC will sign-off on all sections to be released.
2. A PDF of the Beijing report will be submitted to the ILCSC and after approval, posted on ILC main web. (with Cost numbers and any improvements made this week)
3. April 1st, 2007 is the date for a final draft, including *all* sections, edited, reviewed and signed-off by the EC
4. Supporting tech notes and CCRs should be in by Apr1
5. The final document will be published in summer, 2007, after external review.

RDR Report

Nan Phinney

RDR Companion Document



The ILC – a step-by-step guide

Electrons

To produce electrons we will fire high-intensity, two-nanosecond light pulses from a laser at a target and knock out billions of electrons per pulse. We will gather the electrons using electric and magnetic fields to create bunches of particles and launch them into a 250-metre linear accelerator that boosts their energy to 5 GeV.

Positrons

Positrons, the antimatter partners of electrons, do not exist naturally on earth. To produce them we will send the high-energy electron beam through an undulator, a special arrangement of magnets in which electrons are sent on a "roller-coaster" course. This turbulent motion will cause the electrons to emit a stream of X-ray photons. Just beyond the undulator the electrons will return to the main accelerator, while the photons will hit a titanium-alloy target and produce pairs of electrons and positrons. The positrons will be collected and launched into their own 250-metre 5-GeV accelerator.

The damping rings

When created, neither the electron nor the positron bunches are compact enough to yield the high density needed to produce copious collisions inside the detectors. We will solve this problem by using seven-kilometre-circumference damping rings, one for electrons and one for positrons. In each ring, the bunches will repeatedly traverse a series of wigglers, devices that causes the beam trajectories to "wiggle" and emit photons. This process makes the bunches more compact. Each bunch will spend approximately two tenths of a second in its damping ring, circling roughly 10,000 times before being kicked out. Magnets will keep the particles on track and focussed in their circular orbits around the ring. Upon exiting the damping rings the bunches will be a few millimetres long and thinner than a human hair.

The linacs

We will use two main linear accelerators ("linacs"), one for electrons and one for positrons, each 12 kilometres long, to accelerate the bunches of particles toward the collision point. Each accelerator consists of superconducting cavities nestled within a series of cooled vessels to form cryomodules. The modules use liquid helium to cool the cavities to -271°C, only slightly above absolute zero, to make them superconducting. We will launch travelling electromagnetic waves into the cavities to "push" the particles through, and accelerate them to energies up to 250 GeV. Each electron and positron beam will then contain an energy of about 1 kilojoule, which corresponds to an average beam power of roughly 10 megawatts.
The whole process of production of electrons and positrons, damping, and acceleration will repeat five times every second.

The beam delivery systems

In order to maximise the luminosity we will then focus the bunches to extremely small sizes. We will use a series of magnets, arranged along two 2-kilometre beam delivery systems on each side of the collision point, to focus the beams to a few nanometres in height and a few hundred nanometres in width. The beam delivery systems will scrape off stray particles in the beams and protect the sensitive magnets and detectors. Magnets will steer the electrons and positrons into head-on collisions.

The detectors

Travelling towards each other at nearly the speed of light, the electron and positron bunches will collide with a total energy of up to 500 GeV. We will record the spectacular collisions in two giant particle detectors. These work like gigantic cameras, taking snapshots of the fleeting particles produced by the electron-positron annihilations. The two detectors will incorporate different but complementary state-of-the-art technologies to capture this precious information about every particle produced in each collision. Having these two detectors will allow vital cross-checking of the potentially-subtle physics discovery signatures.

How Good is the RDR Concept?

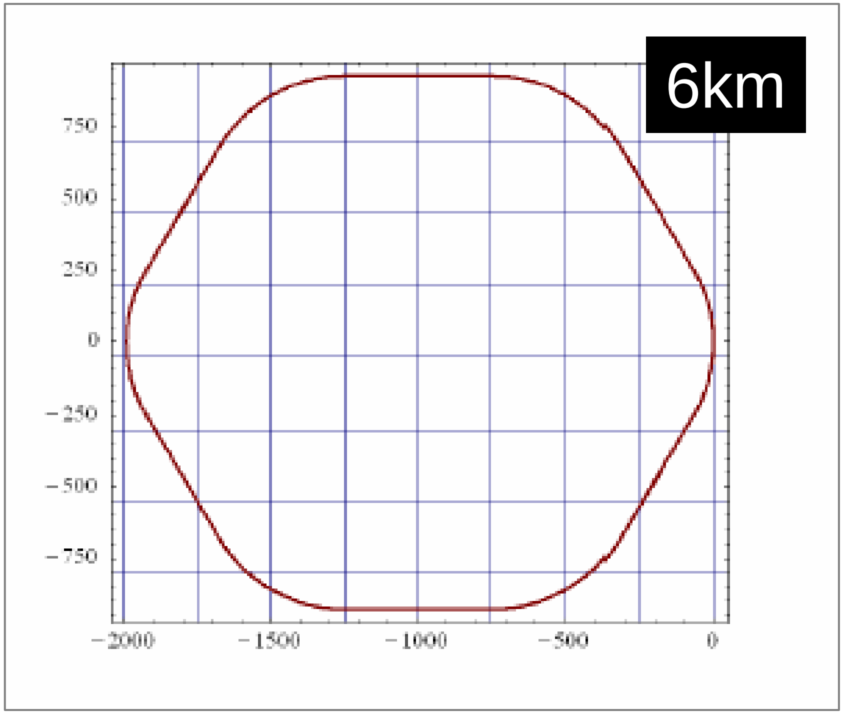
- The design has been carried out by Area Systems that have been built up into an overall design.
  - **We have advanced in integrating that design and even in being able to evaluate proposed changes that cross several area systems (e.g. central injector – E Paterson)**
  - **A more integrated design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

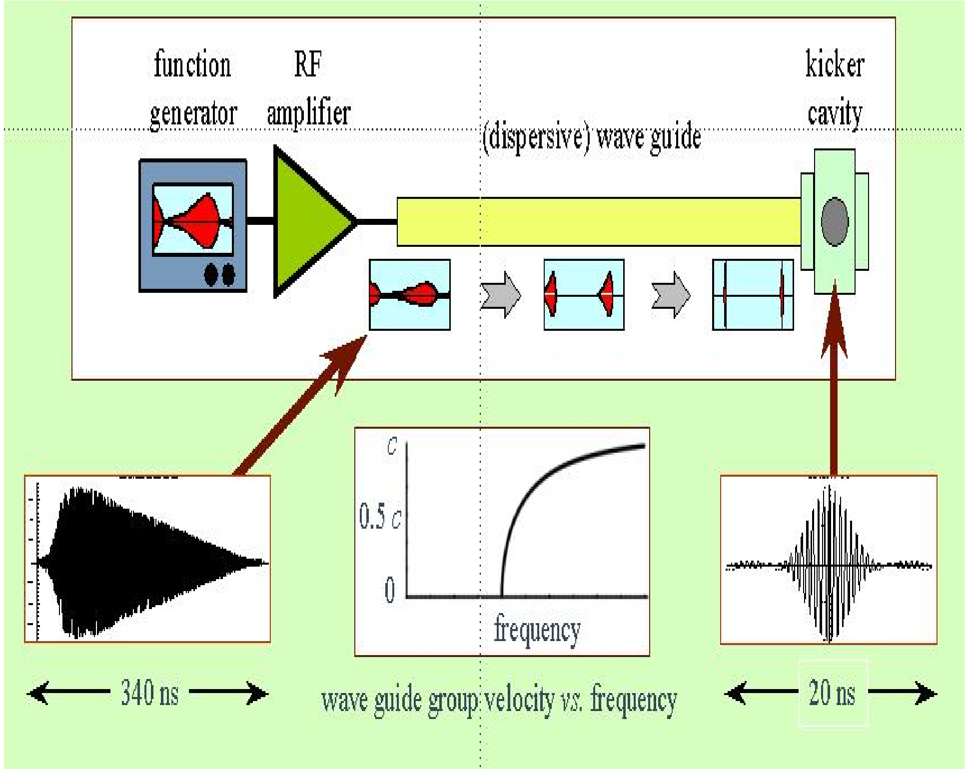
Design Challenges - *Availability*

- 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**
  - **Reduncancy – 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*

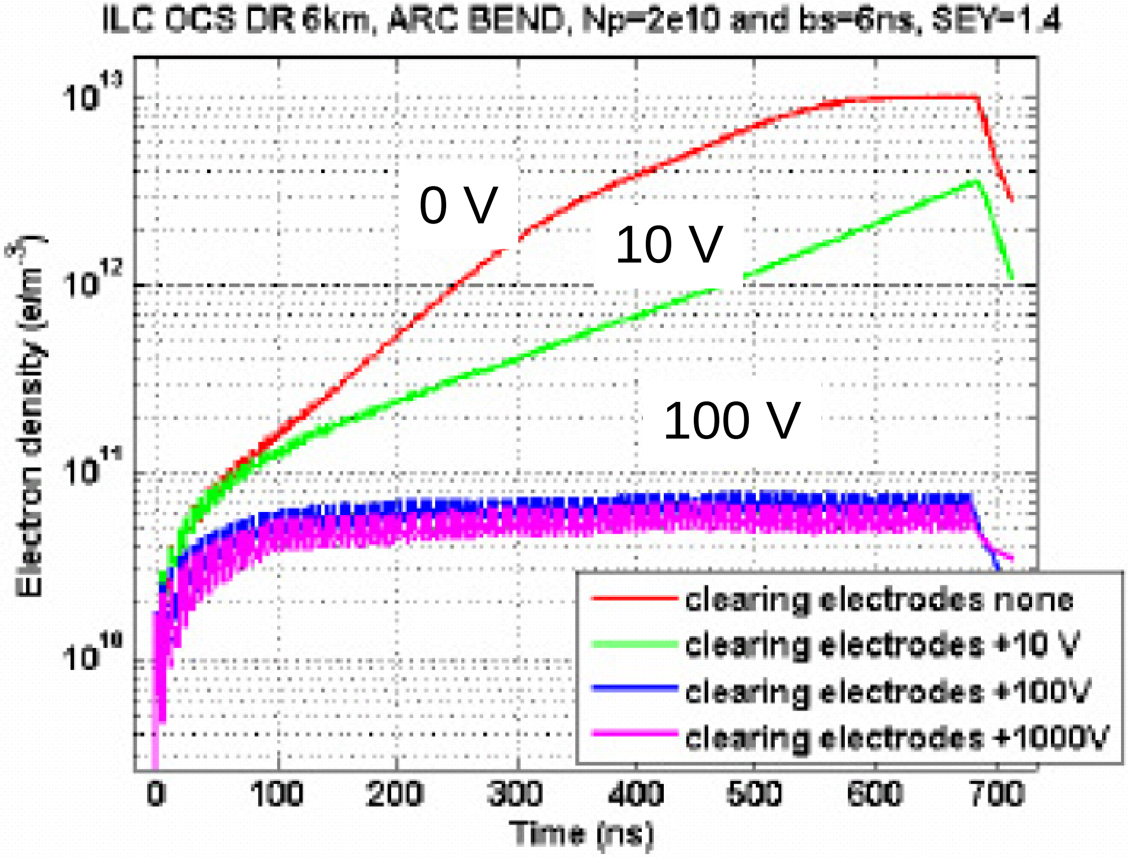


Requires Fast Kicker 5 nsec rise and 30 nsec fall time



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

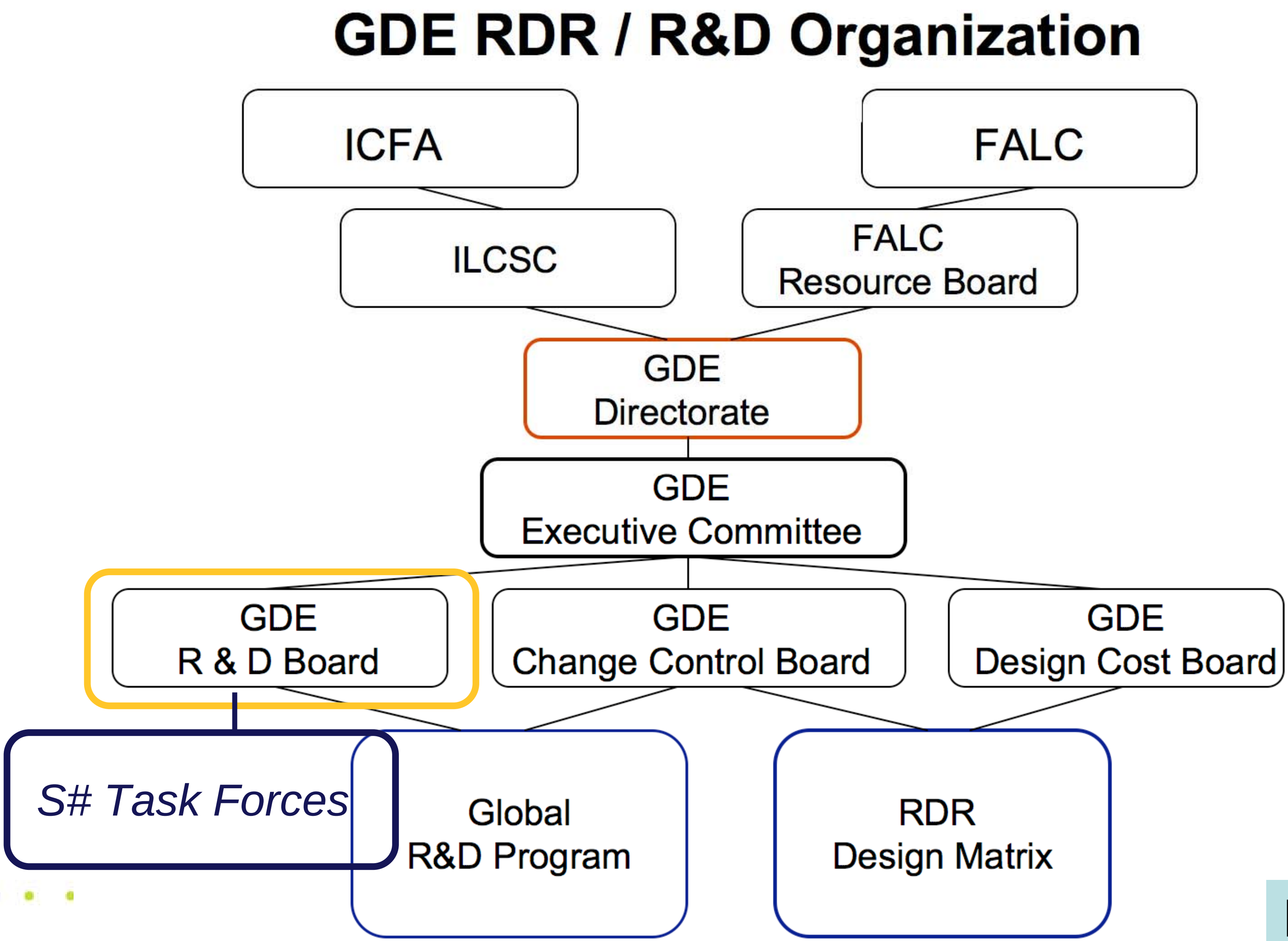
Electron Cloud in Damping Rings



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

GDE R&D Board (RDB)



Hayano

S-series Task Forces

For producing R&D plans

- S0 : Cavity Gradient R&D
- S1 : Cryomodule operating gradient R&D
- S2 : Planning of Linac Test Facility Scale
- S3 : Damping Ring R&D
- S4 : Beam Delivery System R&D
- S5 : Positron Source R&D
- S6 : Control system R&D
- S7 : RF Power Source R&D

Hayano

S2 Task Forces

Leader : T. Himel (SLAC) & H. Padamsee(Cornel)
member : H. Weise, B. Kephart, C. Adolphsen
N. Toge, H. Hayano
(S.Nagaitsev, N.Solyak, L.Lilje, M.Ross, D. Shulte, K.Kubo)

Mission :make a report of required Linac Test Facility

meeting : Tele-conference every week,
face-to-face in Vancouver, KEK, Valencia.

document :
S2charge_workplan5.doc
S2_report_v5.doc
http://www.linearcollider.org/wiki/doku.php?id=rdb:rdb_external:rdb_s2_home

Concise S2 report

Lessons learned from SRF acc. operation:

CEBAF, LEP-II, Cornel, TRISTAN, KEKB, TTF(FLASH)

Reasons of system tests:

28 items of possible reason are listed, and examined.

such as; component reliability test, beam base feedback test, ...

for minimum number of RF unit, for beam required, for being in string required, test possibility at TTF, etc.

phase 1: 1 RF unit system test

phase 2: continuation of test for performance improvement
and industry produced modules (5 RF unit one year operation)

Milestones and timeline for system tests:

2009~2011: phase 1 1 RF unit test (type 3,4 -> DFM cryomodules)

~2013: phase 2 several RF unit test (final ILC unit, multiple manufacturers)

Cost estimation of system tests:

total sum for phase 1 (9 cryomodules + 2 RF system)
with non-beam facility and beam facility

Hayano

Incredibly rough Phase 1 cost estimate per system test

Phase	n_{CM}	n_{RF}	CM cost (M$)	RF cost (M$)	Basic Infrastruc. cost (M$)	Cost Sum (M$)
1	1	1	2	3	12	17
1.1	2	0	4	0	0	4
1.2	3	0	6	0	0	6
1.3	3	1	6	3	0	9
Subtotal	9	2	18	6	12	36
Non-beam related facilities						15
Beam related facilities						35
Total	9	2	18	6	12	86

S3 Task Forces

Leader : A. Wolski (Cockcroft Inst.)

member : E. Elsen, J. Gao, S. Guiducci, T. Mattison,
M. Palmer, M. Pivi, J. Urakawa, M. Venturini,
M. Zisman

Mission : Develop coordinated plan for Damping Ring R&D

meeting : Tele-conference every week,
face-to-face in Cornel in Sep.'06,
will be in Frascati Mar. '07.

document :

https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/
https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/S3TaskForce/WebHome

Prioritized list of R&D objectives, Summaries of R&D activities, Summaries of resources,
Drafts of two Damping Ring R&D Plan Work Packages

Damping Rings R&D Issues

- The RDB S3 group has reviewed 76 R&D objectives for the damping rings, and identified 11 as "Very High Priority". These fall into the categories of:
  - **injection/extraction kickers;**
  - **electron cloud effects;**
  - **impedance and impedance-driven instabilities;**
  - **lattice design (for good dynamic aperture, etc.);**
  - **tuning and maintaining low vertical emittance;**
  - **ion effects.**
- Development of a detailed R&D plan is in progress, detailing objectives, resources, milestones and timescales.
  - **So far, draft work packages have been produced for the fast injection/extraction kickers; electron cloud studies; studies of impedance and impedance-driven instabilities.**
- The R&D program at present test facilities (notably, KEK-ATF) could be strengthened by future test facilities (e.g. CESR-ta and HERA-DR).
- With over 25 institutions and 150 people interested or already involved, coordination of R&D efforts is a significant issue.

Urakawa

Electron Cloud

- A draft of a detailed R&D plan has been prepared, specifying goals and milestones for a range of activities, including:
  - **Improved modelling of electron cloud build-up.**
  - **Improved modelling of beam instabilities driven by electron cloud.**
  - **Continued laboratory investigations of a range of mitigation techniques.**
  - **Tests of mitigation techniques in operating machines.**
- The R&D plan takes account of resources that are, or are likely to be, available.
- The present draft is still being discussed by S3: a public version should be available soon.
- Many R&D activities are already in progress…

On to the EDR …

- What is the EDR?
  - **We will write down a definition, after more dialogue with the GDE and ILC communities**
  - **The general goal is to bring ourselves to the point where we are "construction ready" and can make a construction proposal. Clearly, the minimum requirement is that we have done "much of" the engineering and R&D needed before construction**

On the the EDR …

- How do we organize work?
  - **We propose to organize the work toward the EDR by a Project Management and through formal work packages.**
  - **A work package = a commitment for accomplishing tasks defined in our WBS**
  - **Reporting will be to GDE Project Management office**
  - **Work will be organized through MOUs + attachments having formal “statements of work” for defined time periods with defined deliverables, milestones, reporting, required resources, etc.**

On to the EDR …

- Restructuring the GDE (see Brian Foster)
  - **General features of present GDE organization will continues, but it will be strengthened for the EDR effort**
- New Features
  - **Integrate a Project Management Office and function into the GDE**
  - **Strengthen system engineering and integration function –top level integration + continuity of technical systems**
  - **Enlarge effort, mostly in engineering areas**
  - **Develop a project WBS (in EDMS system) that defines both the breakdown of tasks or EDR work packages, and required resources for design and construction.**
  - **R&D program will be integrated with the EDR effort. Priorities, milestones, ACDs, resource allocations will be consistent with the EDR goals (also through R&D Work Packages)**

On to the EDR …

- Timeframe for implementing new EDR structures
  - **We have given the preliminary report (at their request) to ILCSC. (Discussion tomorrow)**
  - **The GDE dialogue we are having will continue at least until Hamburg meeting. We will appoint a task force to develop some models.**
  - **A search for a Project Manager is underway (suggestions welcome). The final plans for EDR phase will need to be "owned" by the Project Manager**

Summary & Final Remarks

- **We have produced the ILC RDR as planned!**
- **The design is completely consistent with the ILCSC physics goals and parameters**
- **We have produced a first version of the draft RDR that will be presented to ICFA / ILCSC tomorrow**
- **On to the EDR !!!!**