The Path Towards the TDR

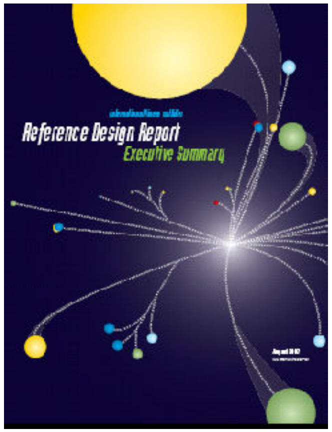
Barry Barish

LCWS10 - Beijing

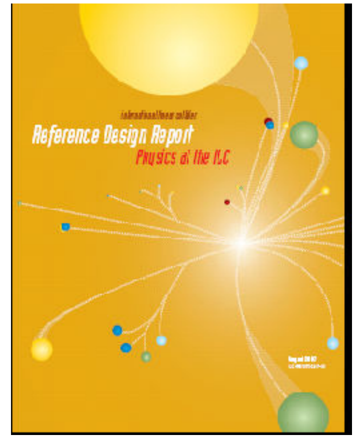
26-March-10

RDR Complete

- Reference Design Report (4 volumes)

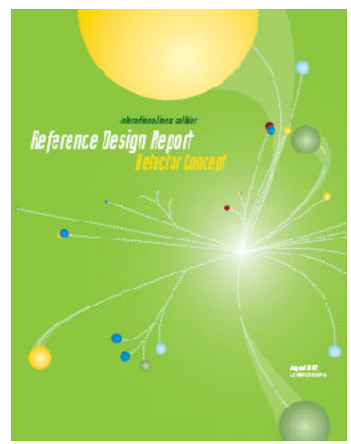


Executive Summary



Physics at the ILC

Accelerator



Detectors

RDR Design Parameters

Max. Center-of-mass energy	500	GeV
Peak Luminosity	$\sim 2 \times 10^{34}$	$1/cm^2 s$
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 ICFA Parameters

- 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!

Updated ILC R&D / Design Plan

ILC Research and Development Plan for the Technical Design Phase

Release 4

July 2009

ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

Major TDP Goals:

- **ILC design evolved for cost / performance optimization**
- **Complete crucial demonstration and risk-mitigating R&D**
- **Updated VALUE estimate and schedule**
- **Project Implementation Plan**

R & D Plan Resource Table

- Resource total: 2009-2012

FTE	SCRF	CFS & Global	AS	Total
Americas	243	28	121	392
Asia	82	9	51	142
Europe	108	17	64	189
	433	55	236	724
MS (K$)	SCRF	CFS & Global	AS	Total
Americas	18080	2993	6053	27126
Asia	23260	171	5260	28691
Europe	9890	921	530	11341
Total	51231	4085	11843	67158

- Not directly included:
  - **There are other Project-specific and general infrastructure resources that overlap with ILC TDP**

2009 – 2012: Resource Outlook

- Flat year-to-year resource basis
  - **Focus on technical enabling R & D**
  - **Limited flexibility to manage needed ILC design and engineering development**
- Well matched between ILC technical and institutional priorities with some exceptions:
  - **Positron system beam demonstrations**
  - **CF & S criteria optimization and site development**

Major R&D Goals for TDP 1

Ross

SCRF

- High Gradient R&D - globally coordinated program to demonstrate gradient by 2010 with 50%yield;

ATF-2 at KEK

- Demonstrate Fast Kicker performance and Final Focus Design

Electron Cloud Mitigation – (CesrTA)

- Electron Cloud tests at Cornell to establish mitigation and verify one damping ring is sufficient.

Accelerator Design and Integration (AD&I)

- Studies of possible cost reduction designs and strategies for consideration in a re-baseline in 2010

The ILC SCRF Cavity

Figure 1.2-1: A TESLA nine-cell 1.3 GHz superconducting niobium cavity.

- Achieve high gradient (35MV/m); develop multiple vendors; make cost effective, etc

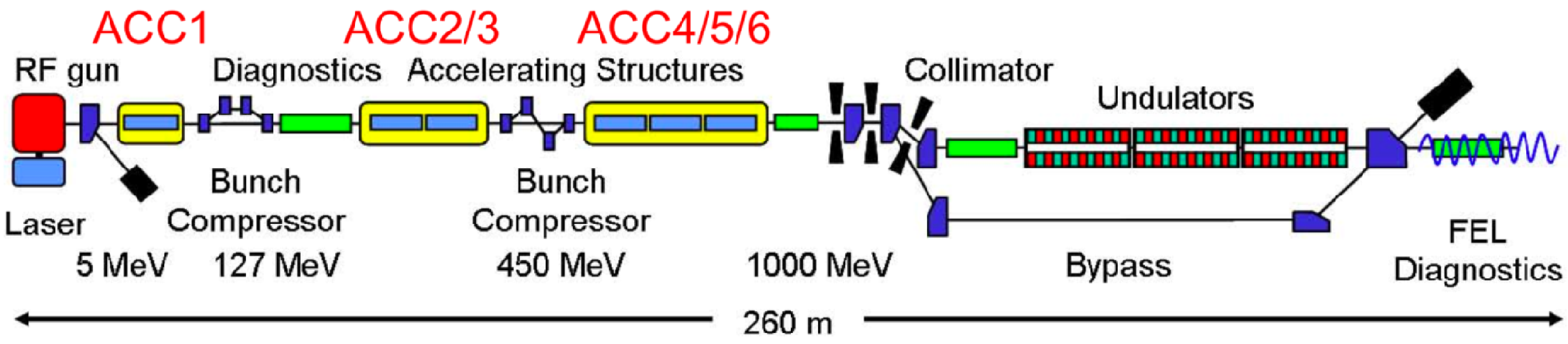
- Focus is on high gradient; production yields; cryogenic losses; radiation; system performance

Global Plan for SCRF R&D

Year	07	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2		
Cavity Gradient in v. test to reach 35 MV/m	→ **Process** Yield 50%			→ **Production** Yield 90%		
Cavity-string to reach 31.5 MV/m, with one-cryomodule		**Global effort for string assembly and test** (DESY, FNAL, INFN, KEK)				
System Test with beam acceleration		**FLASH (DESY) , NML (FNAL) STF2 (KEK, extend beyond 2012)**				
Preparation for Industrialization			**Production Technology R&D**			

TTF/FLASH 9mA Experiment

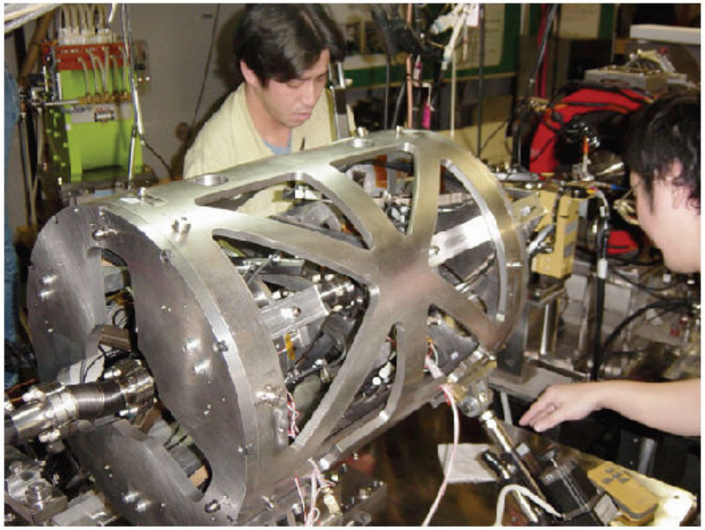
Full beam-loading long pulse operation → "S2"

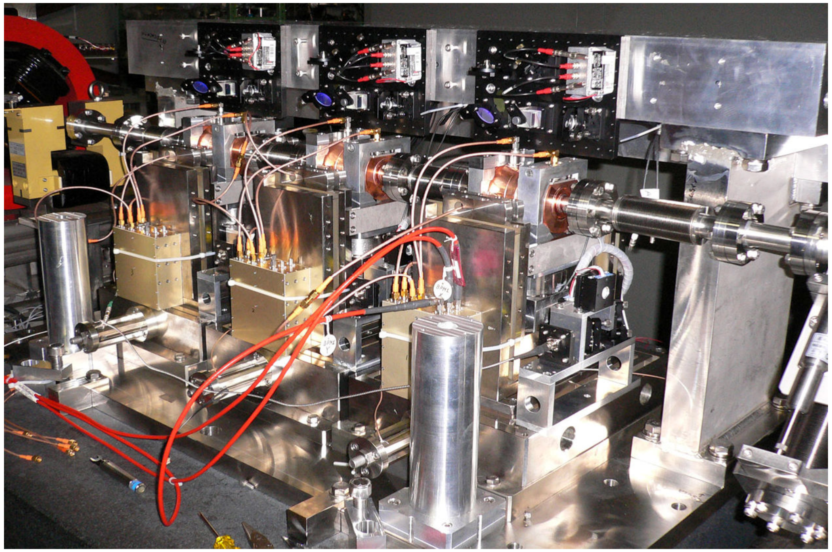


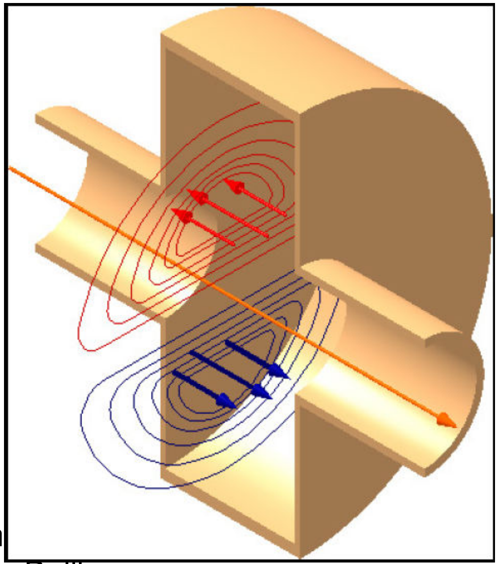
		XFEL	ILC	FLASH design	9mA studies
Bunch charge	nC	1	3.2	1	3
# bunches		3250	2625	7200*	2400
Pulse length	μs	650	970	800	800
Current	mA	5	9	9	9

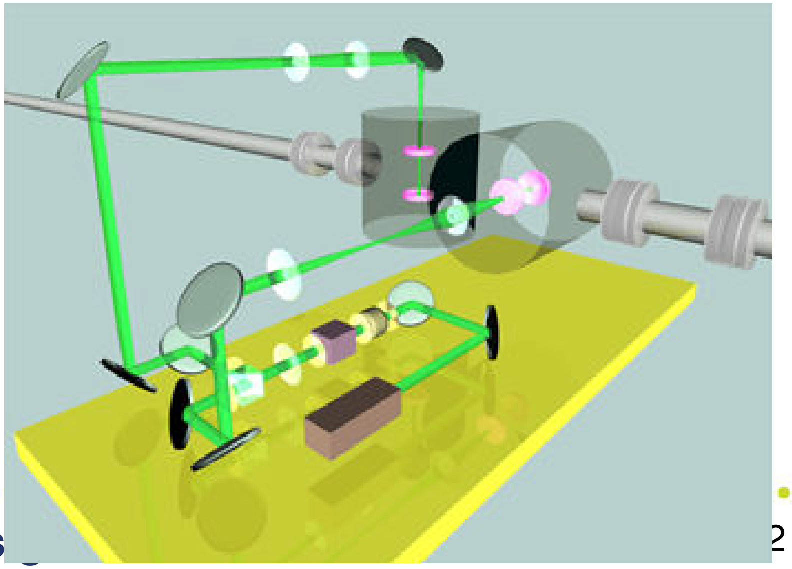
- Stable 800 bunches, 3 nC at 1MHz (800 μs pulse) for over 15 hours (uninterrupted)
- Several hours ~1600 bunches, ~2.5 nC at 3MHz (530 μs pulse)
- >2200 bunches @ 3nC (3MHz) for short periods

Making Very Small Emittance
(Beam Sizes at Collision)









Major R&D Goals for TDP 1

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- **High Gradient R&D - globally coordinated program to demonstrate gradient by 2010 with 50%yield;**

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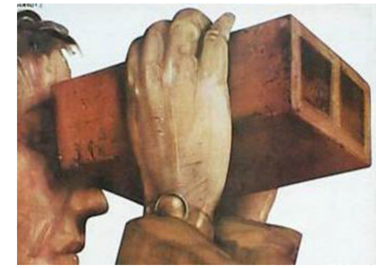
Why change from RDR design?

- Timescale of ILC demands we continually update the technologies and evolve the design to be prepared to build the most forward looking machine at the time of construction.



- Our next big milestone – the technical design (TDR) at end of 2012 should be as much as possible a "construction project ready" design with crucial R&D demonstrations complete and design optimised for performance to cost to risk.

- Cost containment vs RDR costs is a crucial element. (Must identify costs savings that will compensate cost growth)

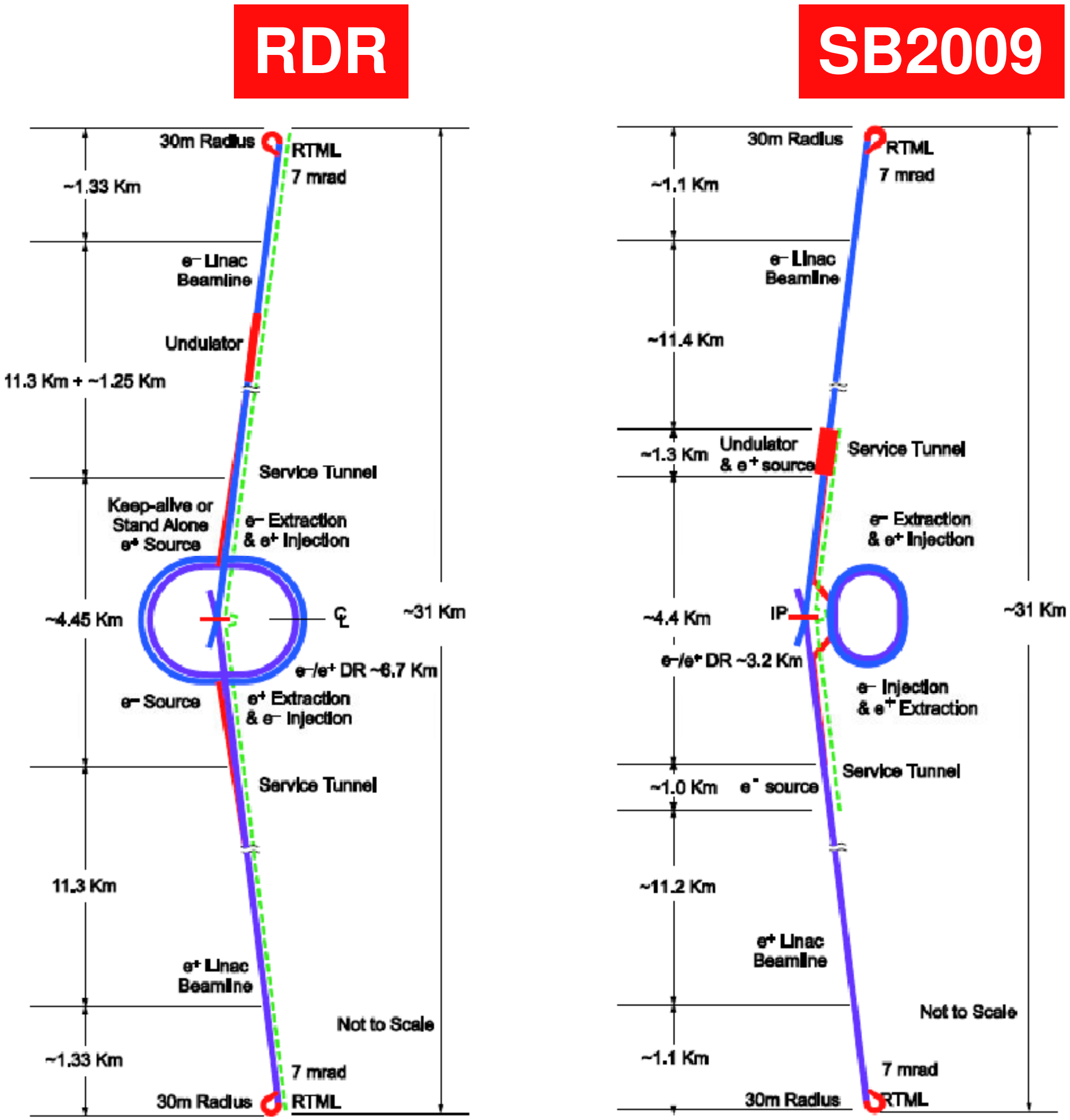
From Technical Design Report to ILC
(or beyond 2012)

- Steps to a Project – Technical (2-3 years)
  - **R&D for Risk Reduction and Technology Improvement**
  - **Engineering Design**
  - **Industrialization**
- Project Implementation
  - **Government Agreements for International Partnership**
  - **Siting and site dependent design**
  - **Governance**
- Time to Construct
  - **5-6 years construction**
  - **2 years commissioning**
- Project Proposal / Decision keyed to LHC results
- ILC Could be doing physics by early to mid- 2020s

ILC R&D Beyond 2012 ?

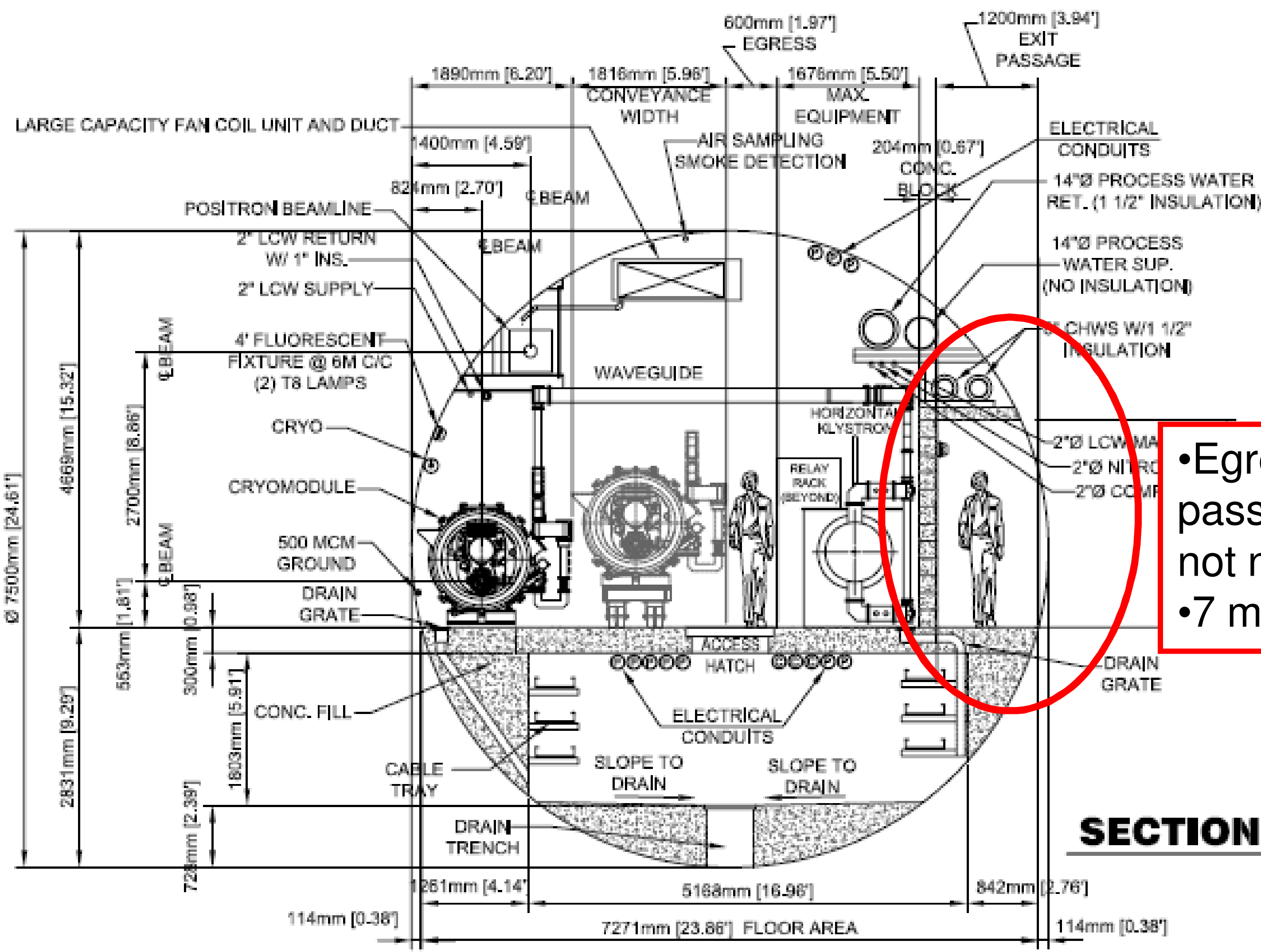
- The AAP points to uncertainties beyond 2012 in their conclusions:
  - **"Some aspects of the R&D for the ILC will have to continue beyond 2012."**
  - **"The milestone 2012 is however timely placed. The LHC will be providing operating experience of a large facility and with some luck the first physics discoveries will emerge."**
  - **"The HEP community is thus well prepared for the decision for the next facility. In a sense the construction of the ILC seems the natural evolution of that process, in which case the efforts for the ILC have to be ramped up without delay."**
  - **"Nature may be less kind or science policy makers not ready for a decision on the next big HEP project. In this case the large community must be engaged to facilitate the decision for the construction of the next HEP project."**
- We need to prepare for uncertainties in the path to the ILC after 2012, including what LHC tells us.

Proposed Design changes for TDR



- Single Tunnel for main linac
- Move positron source to end of linac ***
- Reduce number of bunches factor of two (lower power) **
- Reduce size of damping rings (3.2km)
- Integrate central region
- Single stage bunch compressor

7.5 m Diameter Single Tunnel



- Egress passageway not needed;
- 7 m Ø ok

7.5 m Diameter Single Tunnel
High-Level RF Solution

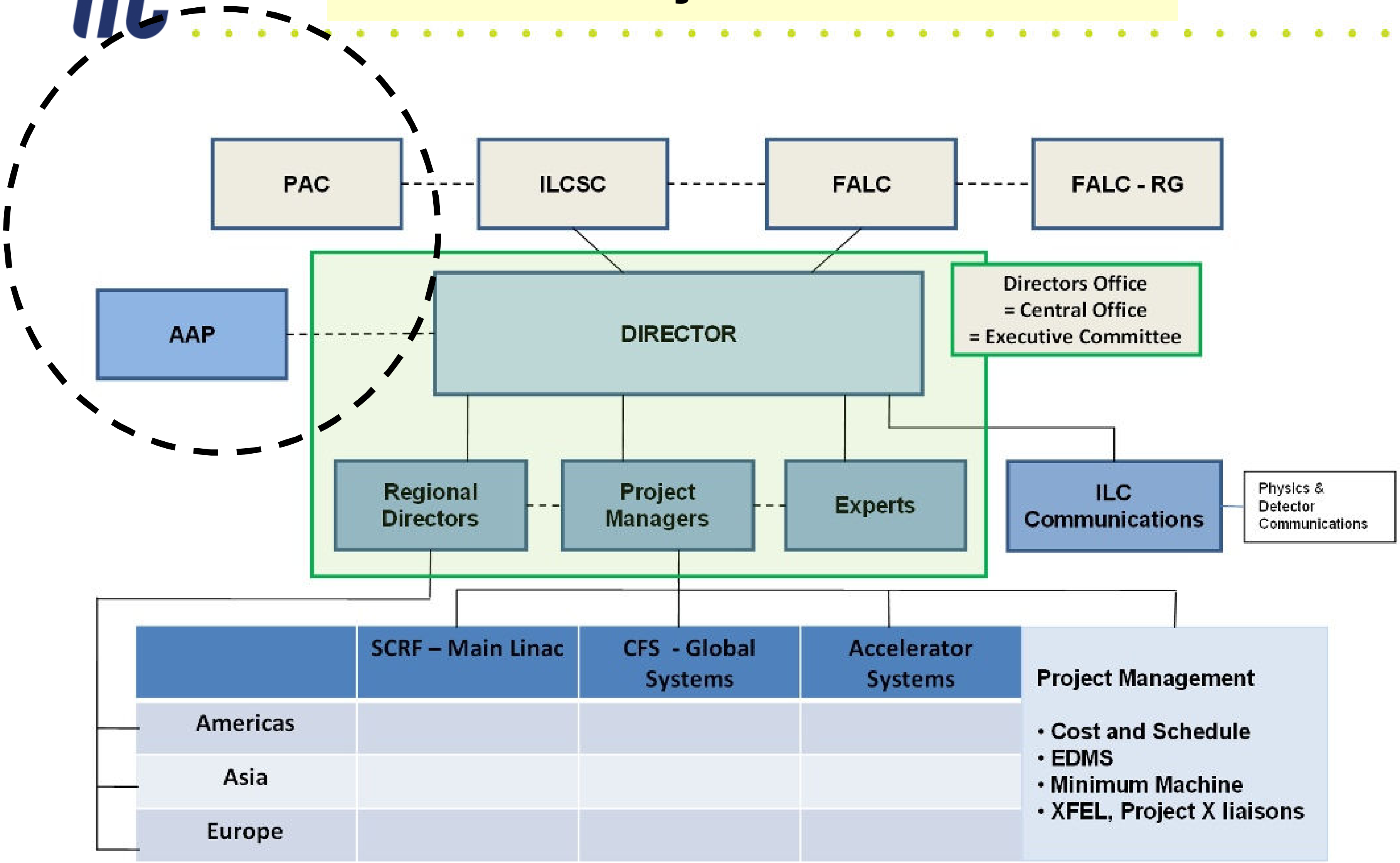
- **Critical technical challenge for one-tunnel option is the high level RF distribution.**

- **Two proposed solutions :**

  – **Distributed RF Source (DRFS)**
    - **Small 750kW klystrons/modulators in tunnel**
    - **One klystron per four cavities**
    - **~1880 klystrons per linac**
    - **Challenge is cost and reliability**

  – **Klystron Cluster Scheme (KCS)**
    - **RDR-like 10 MW Klystrons/modulators on surface**
    - **Surface building & shafts every ~2 km**
    - **Challenge is novel high-powered RF components (needs R&D)**

GDE Project Structure



PAC Questions on SB2009

1. Why are the cost savings only ~ 3% in going from 2 tunnels to 1? Do such seemingly small savings justify the increased reliability risks inherent in a single tunnel scheme? Also, Why are the cost savings only ~ 3% in going from ~6 Km damping rings to ~ 3 Km ones?
2. How feasible are each of the two rf distribution systems proposed for the single tunnel option?
3. What is the effect on the electron beam emittance of having the positron source at the end of the electron linac? What is the effect of this positron source location on the experiments when they run at cm energies below ~ 250 GeV?
4. How is the lack of significant R&D on the undulator positron source affecting confidence in this source design?
5. How practical is the traveling focus concept, and what experimental studies give confidence in its use in the ILC?
6. Are there any concerns about the apparent complexity of the proposed tunnel layout in the BDS/DR/IR region?

AAP Review - Conclusion (1)

The AAP welcomes the thorough study and the many new ideas contained in SB2009. The Project Managers are to be commended for carrying out this project in a short amount of time and with the solid engagement of the respective experts.

The SB2009 exercise was carried out to save cost and consolidate the design. The cost savings in SB2009 amount to 12.6% and are composed of several savings at the few per cent level. The AAP recognizes that a cushion of savings at this level will have to be identified to contain the cost of the project which is likely to change because of both a better understanding of the cost composition, of progress in optimization and of external influences such as the variations in cost of raw material and external services until the end of Technical Phase II.

Conclusion (final)

The AAP hence recommended:

For the *Single Tunnel*

- ***The AAP supports the transition to a single tunnel provided that at least one of the RF distribution schemes can be demonstrated to work;***

For the *Low Power Option*

- ***The AAP does not recommend the adoption of the Low Power Option;***

For the *Central Campus Integration*

- ***The AAP recommends staying with 6 ns bunch distance and the full number of bunches for the ILC Damping Ring until experimental research and simulation tools demonstrate the viability of a short bunch distance.***
- ***The AAP recommends finding a solution for the source that matches the requirements of the "Parameters for the Linear Collider" Document for positron production for all beam energies. – The AAP encourages further R&D on the positron source.***

Questions from Physics/Detectors

Questions from the Detector's SB2009 Working Group:

1) To assess the physics impact, we need beam parameters at several key energies:
   - a. 250 GeV (to compare with LoI),
   - b. 350 GeV (a likely operating energy for SB2009),
   - c. 500 GeV (again to compare with the LoI).
2) Beam parameters should include electron/positron beam energy spread.
3) We would like to understand the effect on backgrounds/luminosity spectrum for SB2009 with vs without traveling focus.

Questions from Physics/Detectors (2)

Questions from the Detector's SB2009 Working Group:

4) Despite the questions of feasibility, the conventional positron source remains very interesting in order to maximize yield and therefore luminosity. Please provide estimates of the expected luminosity and beam energy spread that would be possible with either a conventional positron source, or an undulator source, at cms energies between 200 and 300 GeV. Will the conventional source possibility remain an option in the re-baselined design? What R&D will be pursued either within the GDE or by other groups to ensure its development?

5) How stable would the Luminosity, Energy spread, and positron polarization be during a threshold scan, for example for ttbar or susy?

6) Can you provide a rough sketch of L(Ecm), Energy spread(Ecm), and Pol e+(Ecm) showing how they might be expected to vary between Ecm=91 and 500 GeV?

GDE Physics Questions Committee

- Jim Clarke, Brian Foster, Mike Harrison, Daniel Schulte, Andrei Seryi, Toshiaki Tauchi

- Question (1) To assess the physics impact, we need beam parameters at several key energies:
  - a. 250 GeV (to compare with LoI),
  - b. 350 GeV (a likely operating energy for SB2009),
  - c. 500 GeV (again to compare with the LoI).

GDE Physics Questions Committee

Response --- Parameter Table

	RDR			SB2009 w/o TF				SB2009 w TF			
CM Energy (GeV)	250	350	500	250.a	250.b	350	500	250.a	250.b	350	500
Ne- (*10^{10})	2.05	2.05	2.05	2	2	2	2.05	2	2	2	2.05
Ne+ (*10^{10})	2.05	2.05	2.05	1	2	2	2.05	1	2	2	2.05
nb	2625	2625	2625	1312	1312	1312	1312	1312	1312	1312	1312
Tsep (nsecs)	370	370	370	740	740	740	740	740	740	740	740
F (Hz)	5	5	5	5	2.5	5	5	5	2.5	5	5
γex (*10^{-6})	10	10	10	10	10	10	10	10	10	10	10
γey (*10^{-6})	4	4	4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
βx	22	22	20	21	21	15	11	21	21	15	11
βy	0.5	0.5	0.4	0.48	0.48	0.48	0.48	0.2	0.2	0.2	0.2
σz (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
σx eff (*10^{-9} m)	948	802	639	927	927	662	474	927	927	662	474
σy eff (*10^{-9} m)	10	8.1	5.7	9.5	9.5	7.4	5.8	6.4	6.4	5.0	3.8
L (10^{34} $cm^{-2}s^{-1}$)	0.75	1.2	2.0	0.2	0.22	0.7	1.5	0.25	0.27	1.0	2.0

Table 1: Beam parameter sets for RDR, SB2009 without travelling focus, and SB2009 with travelling focus, at four energy points. The set labeled “250a” corresponds to operating the undulator in the standard 5 Hz mode (F), “250b” to the “low-energy” mode operating at 2.5 Hz.

Status/plan for SB2009

- AAP recommends caution in adopting SB2009 until physics studies complete and technical feasibility is confirmed
  - **Example: Develop confidence that single tunnel HLRF technical solution before adopting change.**
  - **Example: Understand physics impact of moving the positron source to the end of the linac.**
  - **etc**
- PAC comments last November overlap AAP and physics studies/concerns. PAC meets May in Valencia
- First results of physics studies --- Saturday morning session
- What then ???

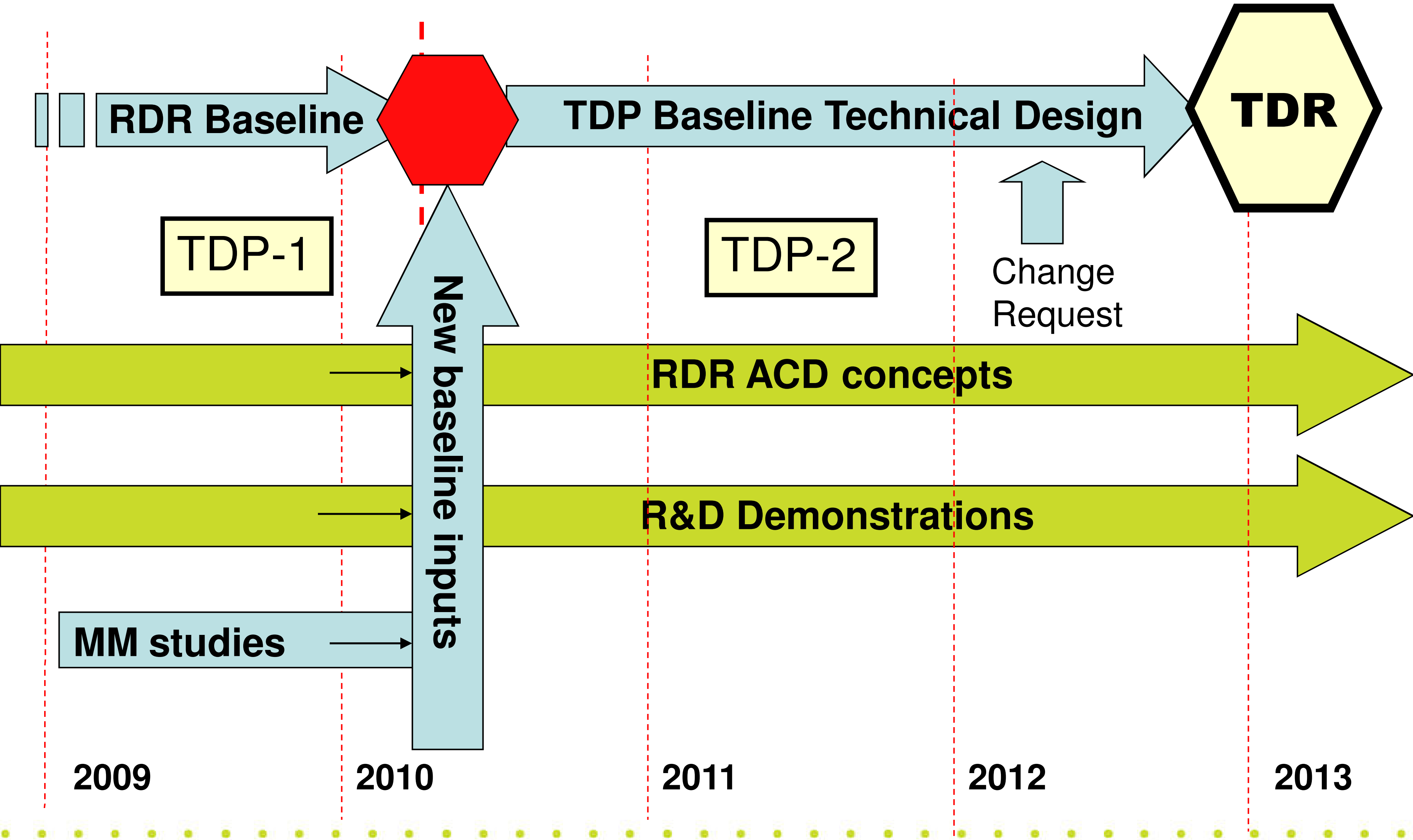
Recommendations of GDE EC (1)

- After review and subsequent discussion of the AAP SB2009 Review Report, the GDE EC agreed and confirmed:
  - **That containment of the capital cost (VALUE) estimate at the RDR level is a primary TD Phase 2 goal. Our design activity is now aimed at making the project more robust against possible (expected) unit cost increases.**
  - **To move forward with studies aimed at the possible adoption of the themes in SB2009 proposal, but not necessarily the exact details.**
  - **To establish a formal process to make these changes to the baseline in an open and transparent fashion, and where necessary after due process and consultation with all stakeholders.**

Recommendations of GDE EC (2)

- To pursue and introduce the baseline modifications in a stepwise fashion, as individual and independent change requests, via the above mentioned process (point 3).
- To present a schedule for the phased changes to the baseline via the formal change control process, beginning in October 2010 and to be completed no later than mid 2011.
- The GDE EC believes the above are consistent with the recommendations of the AAP. The GDE EC also believes that the time scale for controlled change to the baseline is consistent with the published goals for the TDR due to be complete at the end of 2012.

Technical Design Phase and Beyond



Technical Design Phase and Beyond