Global Design Effort

Director's Report

Barry Barish
PAC Review
Fermilab
15-May-12

GDE Status & Plans

- Update on ILC accelerator R&D
- The Technical Design Report
  - Top level changes
  - Baseline Technical Reviews ; PM level changes
  - TDR Scope and Plans
  - Cost Estimate
  - Project Implementation Planning
- ILC Systems Tests
- Japanese candidate sites
- Post-TDR planning

Major R&D Goals for Technical Design

SCRF *(Yamamoto)*

- **High Gradient R&D - globally coordinated program to demonstrate gradient by 2010 with 50%yield; improve yield to 90% by TDR (end 2012)**
- **Manufacturing: plug compatible design; industrialization, etc.**
- **Systems tests: FLASH; plus NML (FNAL), STF2 (KEK) post-TDR**

Test Facilities

- **ATF2 - Fast Kicker tests and Final Focus design/performance EARTHQUAKE RECOVERY *(Tauchi)***
- **CesrTA - Electron Cloud tests to establish electron cloud mitigation strategy *(Palmer)***
- **FLASH – Study performance using ILC-like beam and cryomodule (systems test) *(Cowardine)***

The ILC SCRF Cavity

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

- ~ 70 parts electron-beam welded at high vacuum

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

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

Kerby, Carwardine

Global Plan for ILC Gradient R&D

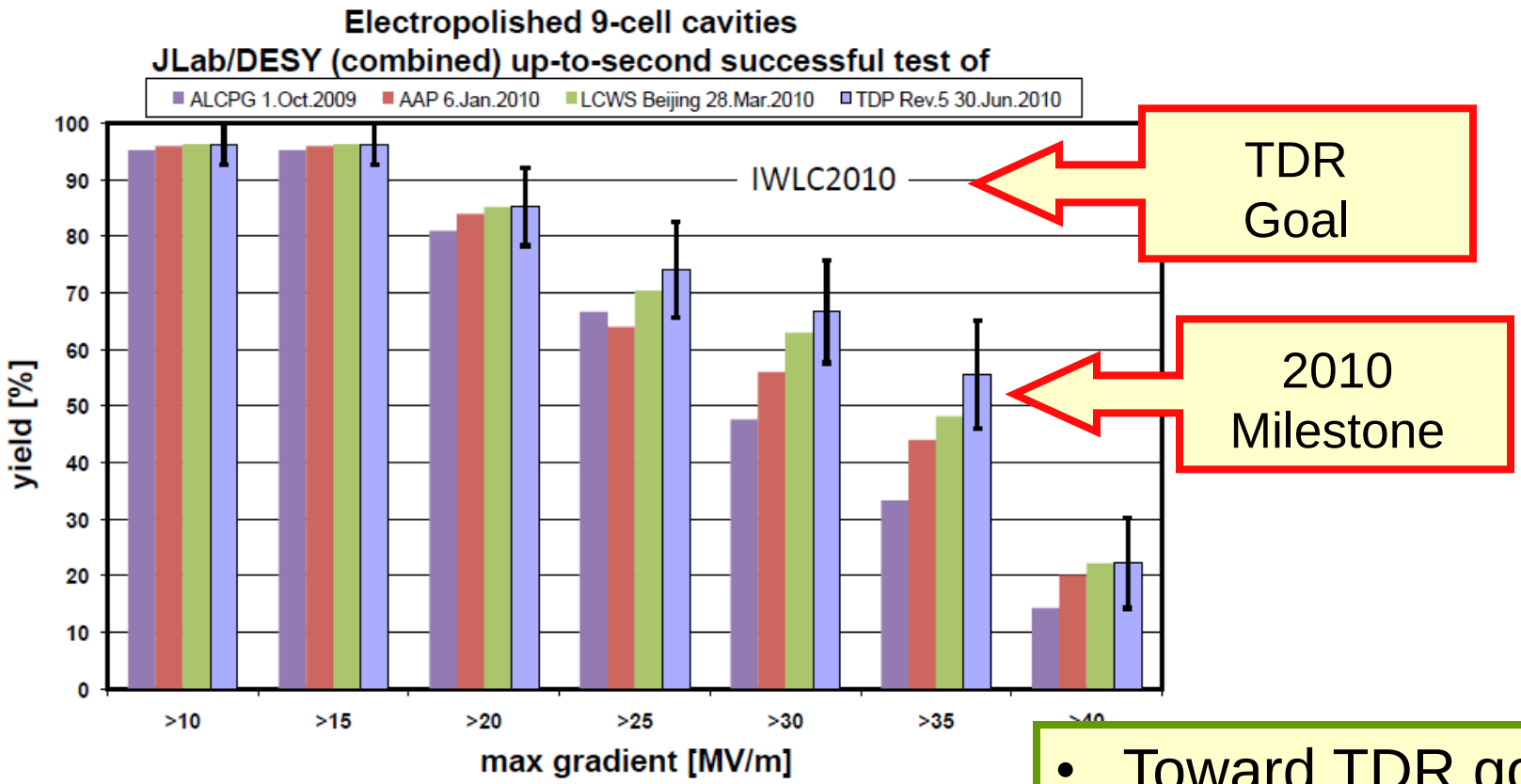
Year	07	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2		
Cavity Gradient in v. test to reach 35 MV/m	→ Yield 50%			→ Yield 90%		
Cavity-string to reach 31.5 MV/m, with one-cryomodule		Global effort for string assembly and test (DESY, FNAL, INFN, KEK)				
System Test with beam acceleration			FLASH (DESY) , NML (FNAL) STF2 (KEK, test start in 2013)			
Preparation for Industrialization				Production Technology R&D		

New baseline gradient:

Vertical acceptance: 35 MV/m average, allowing ±20% spread (28-42 MV/m)

Operational: 31.5 MV/m average, allowing ±20% spread (25-38 MV/m)

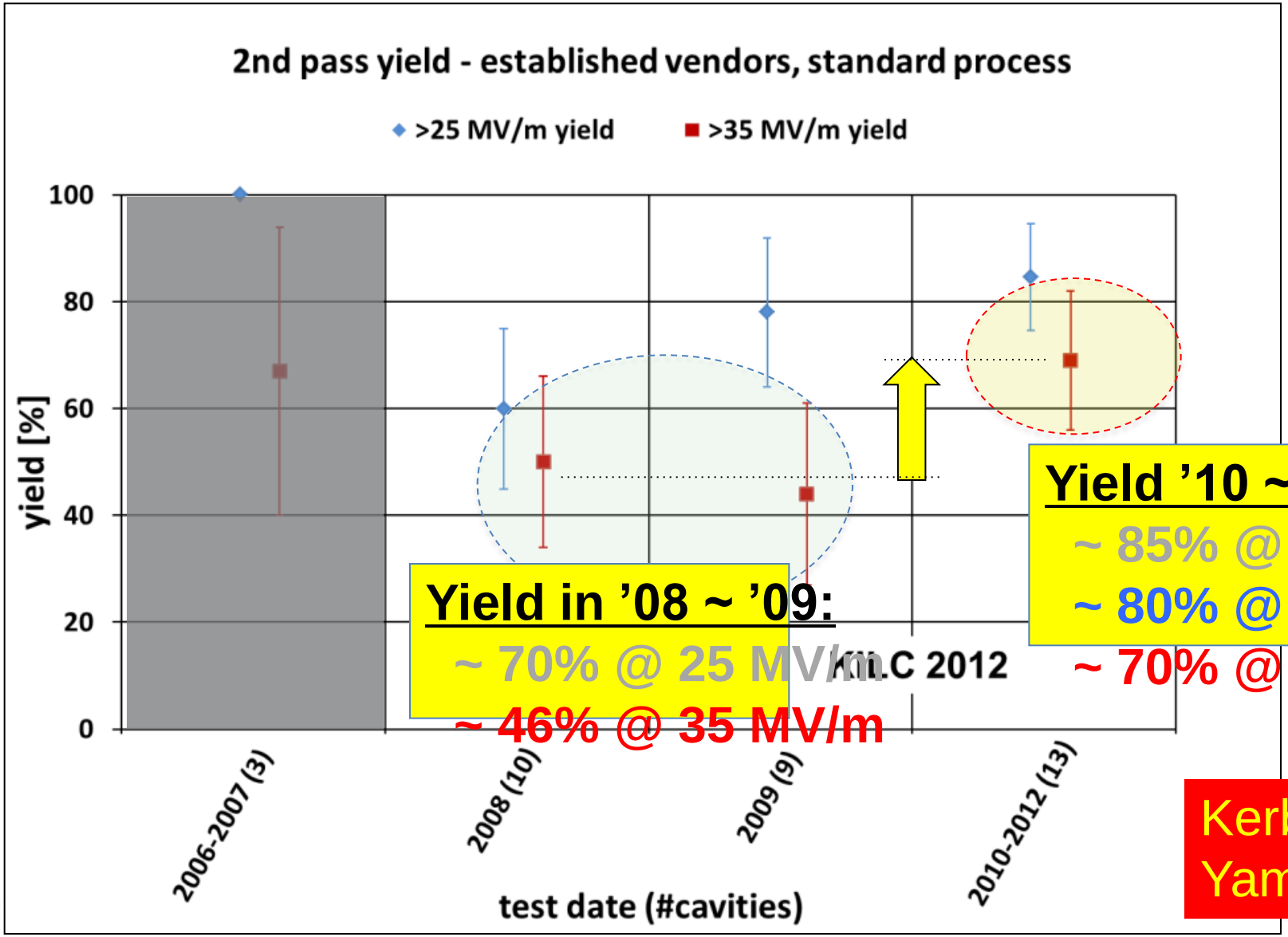
Cavity Gradient Progress



- Toward TDR goal
- Field emission; mechanical polishing
- Other progress

Yearly Progress in Cavity Gradient Yield

as of April 24, 2012



Yield in '08 ~ '09:

~ 70% @ 25 MV/m

~ 46% @ 35 MV/m

Yield '10 ~ '12:

~ 85% @ 25 MV/

~ 80% @ 28 MV/

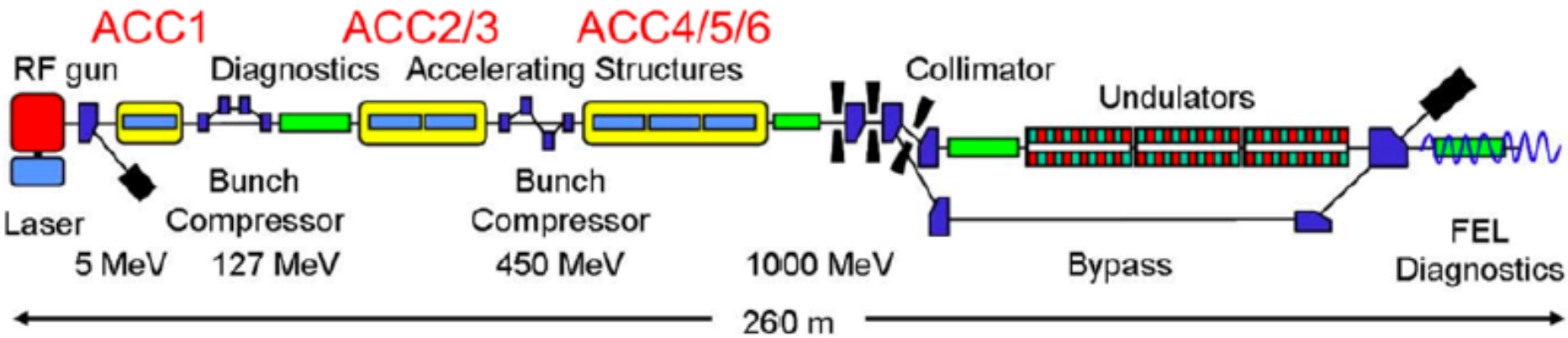
~ 70% @ 35 MV/

Kerby Yamamoto

TTF/FLASH 9mA Experiment

Carwardine

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

FLASH 9mA Expt achievements: 2009-mid 2012

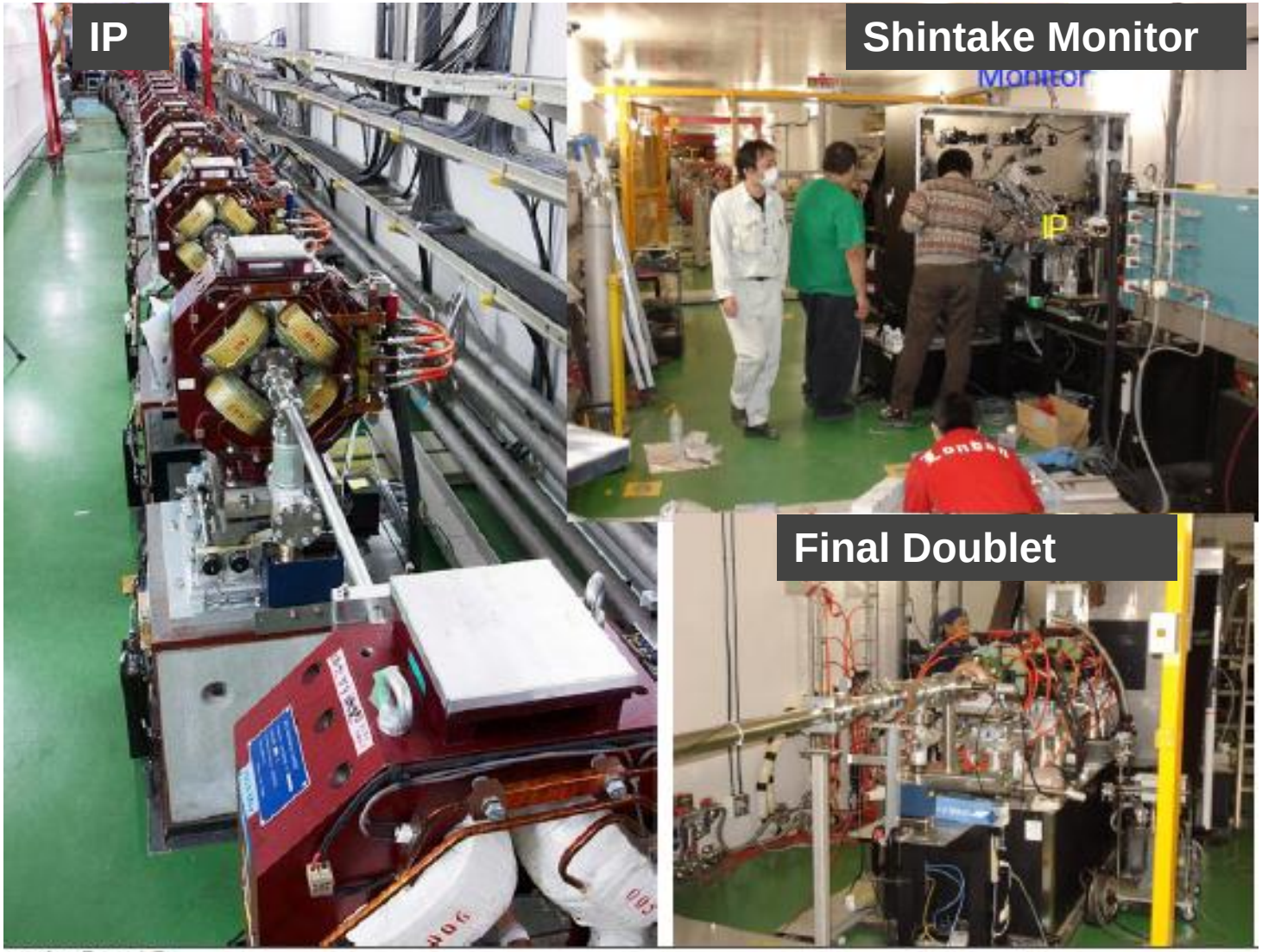
High beam power and long bunch-trains *(Sept 2009)*

Metric	ILC Goal	Achieved
Macro-pulse current	9mA	9mA
Bunches per pulse	2400 x 3nC (3MHz)	1800 x 3nC 2400 x 2nC
Cavities operating at high gradients, close to quench	31.5MV/m +/-20%	4 cavities > 30MV/m

Gradient operating margins *(Feb 2012)*

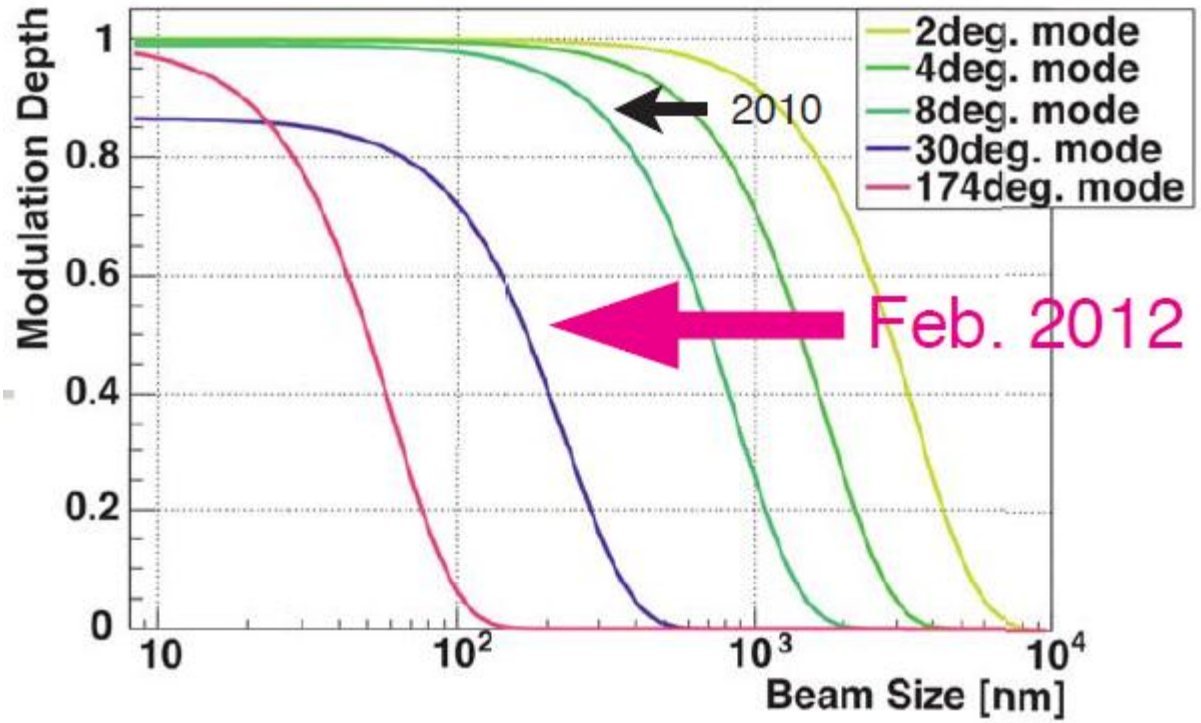
Metric	ILC Goal	Achieved
Cavity gradient flatness (all cavities in vector sum)	2% $\Delta V/V$ (800μs, 5.8mA) (800μs, 9mA)	<0.3% $\Delta V/V$ (800μs, 4.5mA) *First tests of automation for Pk/Ql control*
Gradient operating margin	All cavities operating within 3% of quench limits	Some cavities within ~5% of quench (800us, 4.5mA) *First tests of operations strategies for gradients close to quench*
Energy Stability	0.1% rms at 250GeV	<0.15% p-p (0.4ms) <0.02% rms (5Hz)

ATF2 – Beam size/stability and kicker tests



2010年 10月 19日 火曜日

ATF earthquake recovery

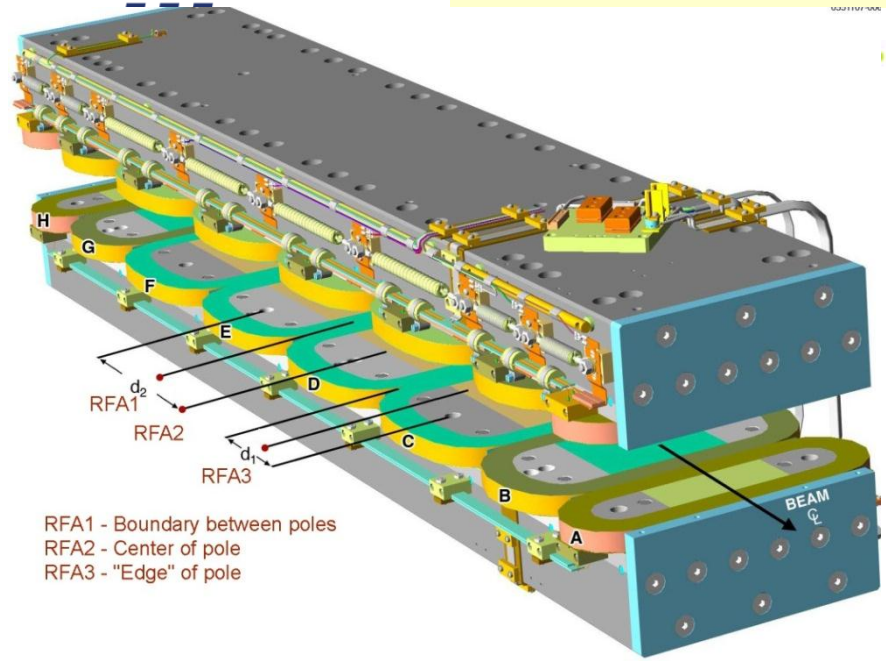


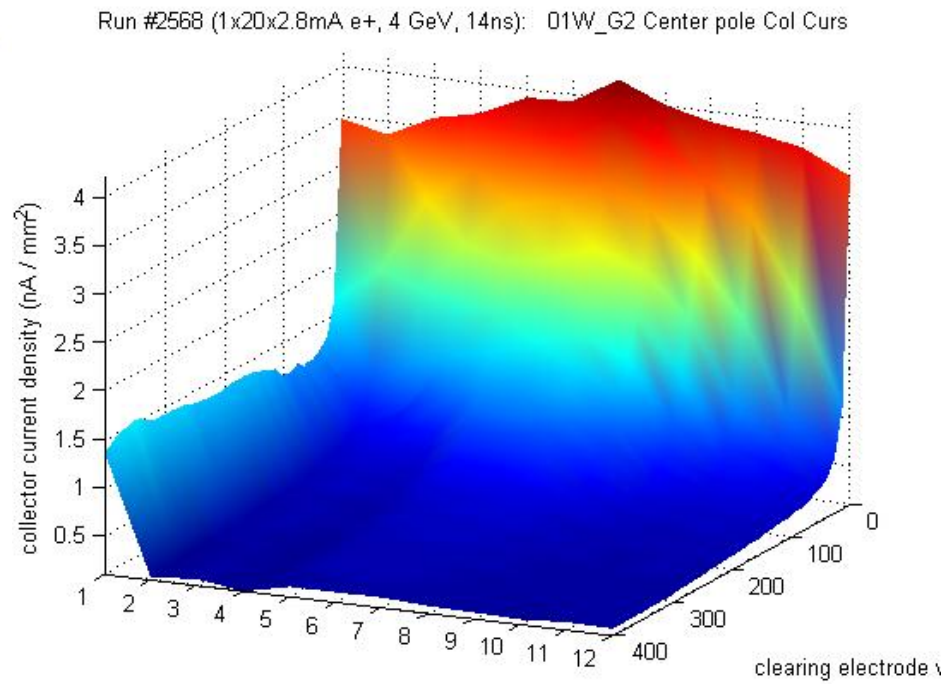
$$M = 0.52 \pm 0.010 \text{ (stat)}$$

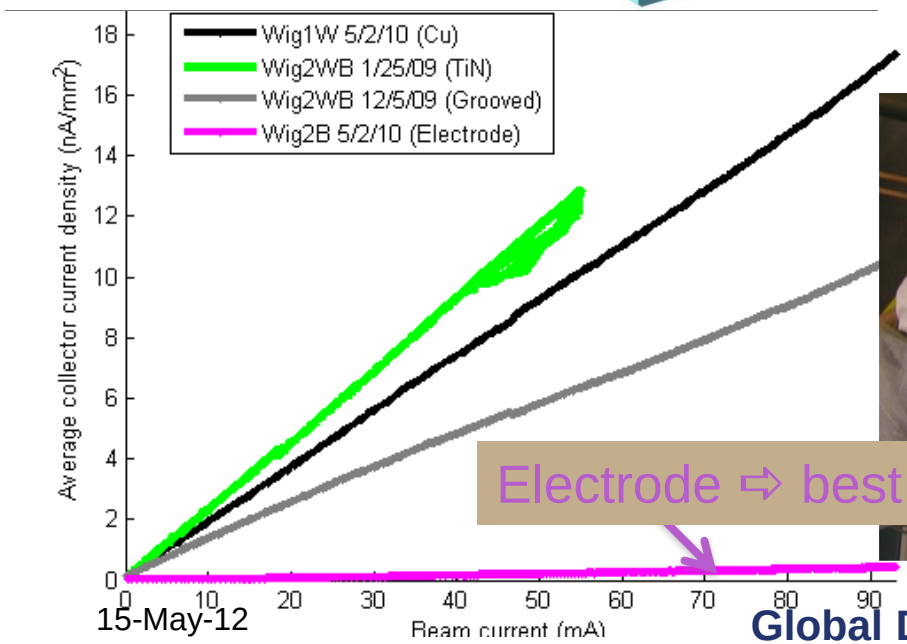
$$\sigma_y^* = 167.9 \pm 1.8 \text{ (stat) [nm]}$$

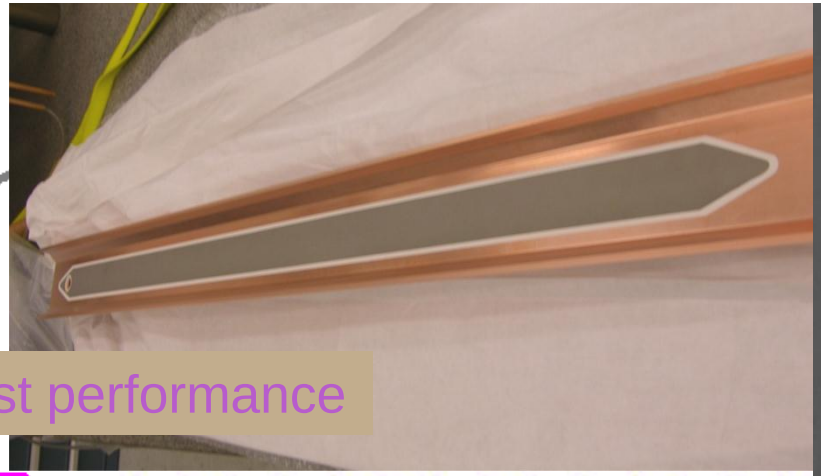
Tauchi

CesrTA - Wiggler Observations









Electrode ⇨ best performance

EC Working Group Baseline Mitigation Plan

EC Working Group Baseline Mitigation Recommendation				
	Drift*	Dipole	Wiggler	Quadrupole*
Baseline Mitigation I	**TiN Coating**	**Grooves with TiN coating**	**Clearing Electrodes**	**TiN Coating**
Baseline Mitigation II	**Solenoid Windings**	**Antechamber**	**Antechamber**	
Alternate Mitigation	**NEG Coating**	**TiN Coating**	**Grooves with TiN Coating**	**Clearing Electrodes or Grooves**

*Drift and Quadrupole chambers in arc and wiggler regions will incorporate antechambers

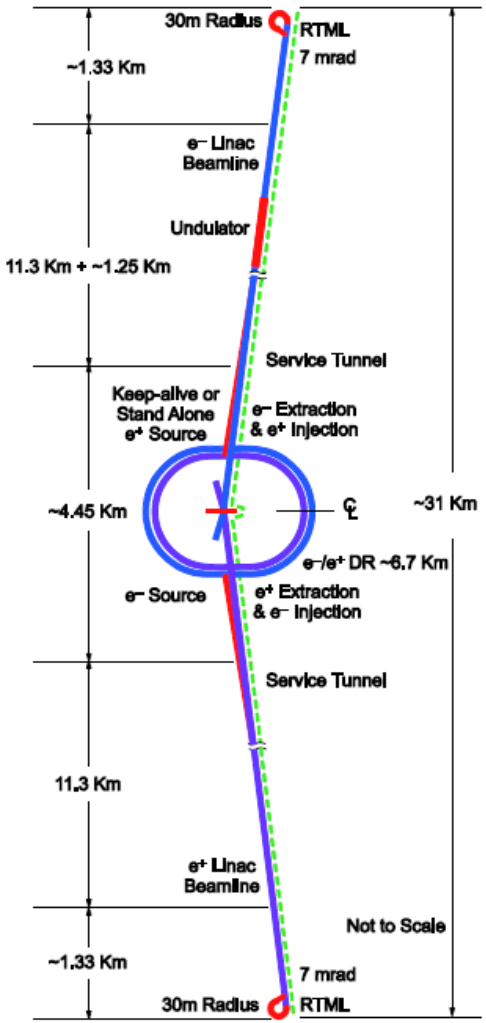
- Preliminary CESRTA results and simulations suggest the presence of *sub-threshold emittance growth*
  - Further investigation required
  - May require reduction in acceptable cloud density ⇨ reduction in safety margin
- An aggressive mitigation plan is required to obtain optimum performance from the 3.2km positron damping ring and to pursue the high current option

Palmer

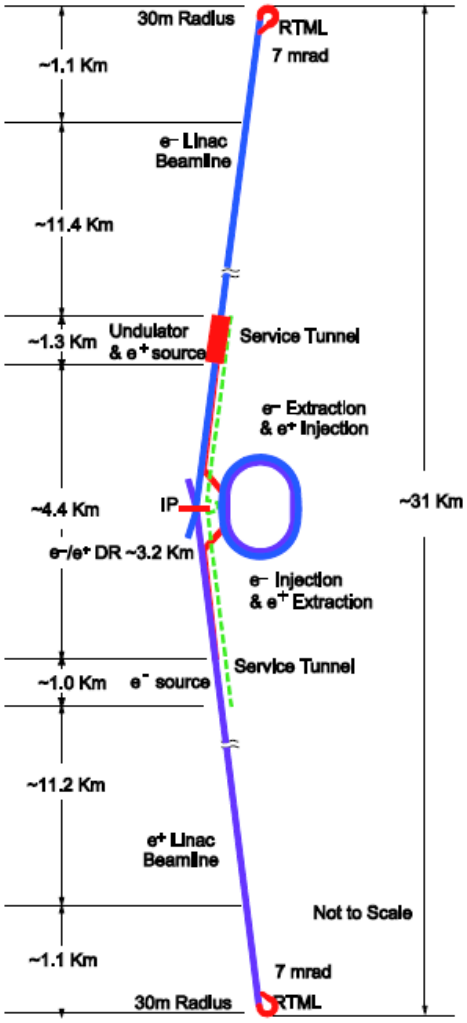
S. Guiducci, M. Palmer, M. Pivi, J. Urakawa on behalf of the ILC DR Electron Cloud Working Group

Proposed Design changes for TDR

RDR



SB2009



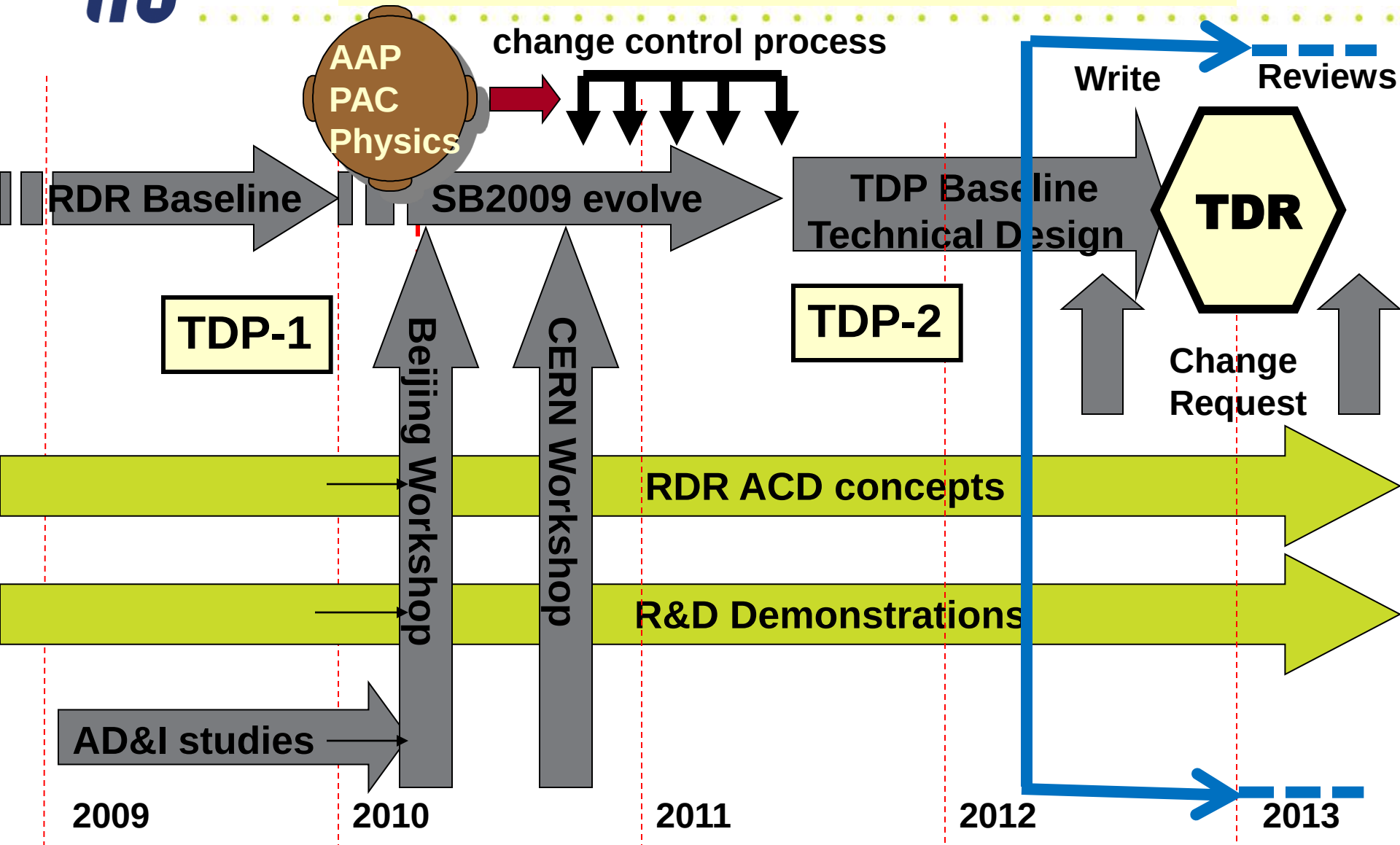
- **Single Tunnel for main linac**
- **Move positron source to end of linac *****
- **Reduce number of bunches factor of two (lower power) ****
- **Reduce size of damping rings (3.2km)**
- **Integrate central region**

Walker

Technical Change Guideline Re-Proposed

Tech. Area	Main Subjects	Description
ML Integration	Parameters and beam dynamics Single tunnel-layout CM and Q periodicity: ML tunnel length Possible tilting of the tunnel	Low-Power design as TDR baseline (SB2009), and alignment tolerance Circular tunnel in flat-land, and Kamaboko tunnel in mountain CM and Q periodicity: >> Stay at 9+4Q4+9 Reserved tunnel-extension of 400 m w/o or w/ utility ? >> More precise discussions for purpose required New request from CFS: < 0.5 % tunnel tilting
RF power	HLRF Configuration LLRF operational overhead	KCS in flat-land site RDR-RF unit in mountain site (DRFS to be withdrawn) ≥ 12% at G=31.5 MV/m +/-20% and RF power in RDR-unit <33.3 MV/m>
Cryomodule	Envelope/interface String Unit 5 K radiation shield	Piping interface with flange?, inter-connect condition, etc, Stay at 9 +4Q4+9 (no change to 8+4Q4+8) Simplification and accessibility for active components such as tuners
Cryogenics	Unit capacity	Stay at 5 units per linac Limit of tilting angle in ML tunnel
Cavity integration and Cavity/CM test	Envelope, baseline, compatibility Test conditions	Tuner type, coupler warm-flange, beam pipe flange, magnetic shield (inside/outside), LHe tank etc. Test plan and fraction of CM to be tested
Cavity performance	Yield Gradient spread Degradation in CM module	New recipe and cost-base scope: 1st pass: 60% and 2nd pass: 70% ? G = 31.5 +/- 20 % confirmed (Assume ~ 1/10 cavities to degrade dG = ~ 20 % or more, and) >> Adopt a statistical approach to cavity degradation; <> and rms
Cost	Cost containment Exchange rate and conversion	Technical design base on SB2009 (updated) compared with RDR cost PPP

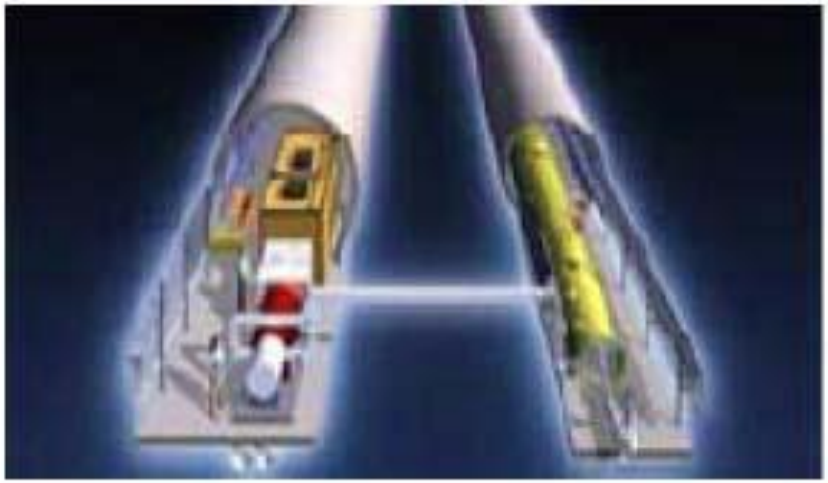
Technical Design Phase



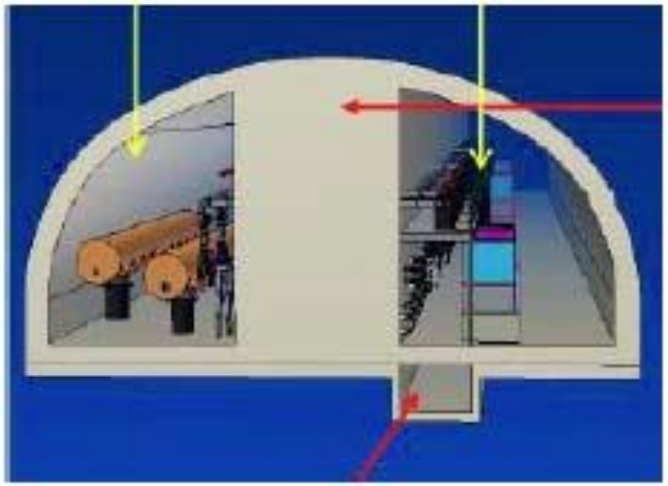
Conventional Facilities

Japan -- New Tunnel Shape

RDR two tunnel design (2007)



TDR mountain sites



Ross

Two Candidate Sites in Asia/Japan

Kuchler

Underground Power Station

Geological Samples

Impact of Top Level Changes

• RDR estimate = starting point	6,618	Δ
• Caverns, DR & cool Value Eng.	-86	-1.3%
• 1 stage B.C. (not yet considered)	-33	-0.5%
• Alternative RF (1 tunnel for ML, ½ bunches)		
Klystron Cluster/DRFS	-400/-419	-6.2%
• DR (6.4 => 3.2 km, ½ bunches)	-191	-2.9%
• Central Injector Complex	-104	-1.6%
• Sub-total of SB2009 changes estimated		-10.7%

- Did not consider range of cavity gradients nor details of alternating e+ production at 150 GeV

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Starting Point is the RDR Costs

- ***6.6 Billion ILC Units*** (2007 US $) ***+ 24 Million hours*** of Institutional Labor (which includes laboratories and universities, but not vendors or contractors)
- TDR will quote estimate in 2012 US $, need consider:
- Difference in Exchange Rates

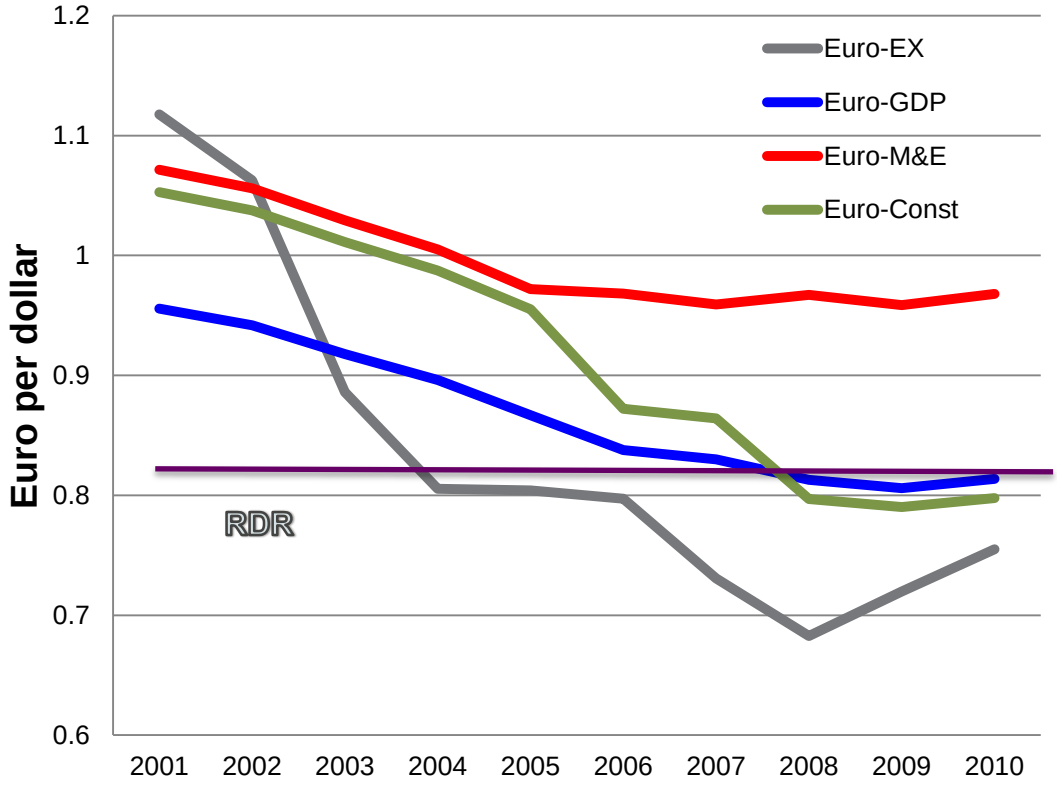
In 2006-07:	1 $ = 117 ¥	1 € = $ 1.20
1/1/2011:	1 $ = 81.5 ¥	1 € = $ 1.334
now 5/10/2011:	1$ = 80.6 ¥	1 € = $ 1.43

- 4 yr – escalation from 1/1/2007 => 1/1/2011 Index Links
  - US construction, technical goods -2.1%, 8.6%
  - Germany construct., indust. products 10.5%, 5.7%
  - Japan construction, industrial products 3.4%, 1.1%

5

OECD PPP (Yen/USD)-annual average by year

PPP = Purchasing Power Parity



EX-exchange rate
GDP: PPP based on all goods/services in GDP of each region
M&E: PPP based on machinery and equipment
Const: PPP based on civil construction

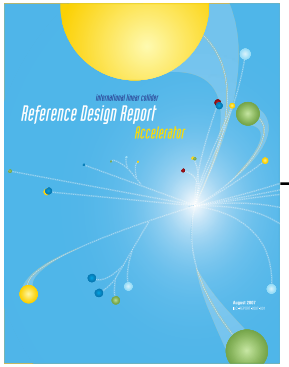
Full PPP determinations were done for 2005 and 2008; other year points based on GDP inflation rates

TDR Technical Volumes

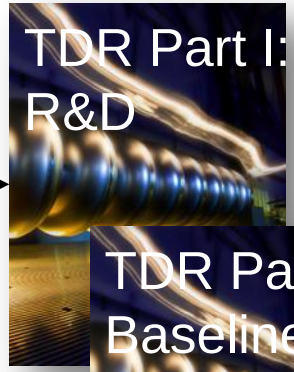
2007 2011 2013*

ILC Technical Progress Report (“*interim report*”)

AD&I



Reference Design Report



TDR Part I: R&D

~250 pages
Deliverable 2

TDR Part II: Baseline Reference Report

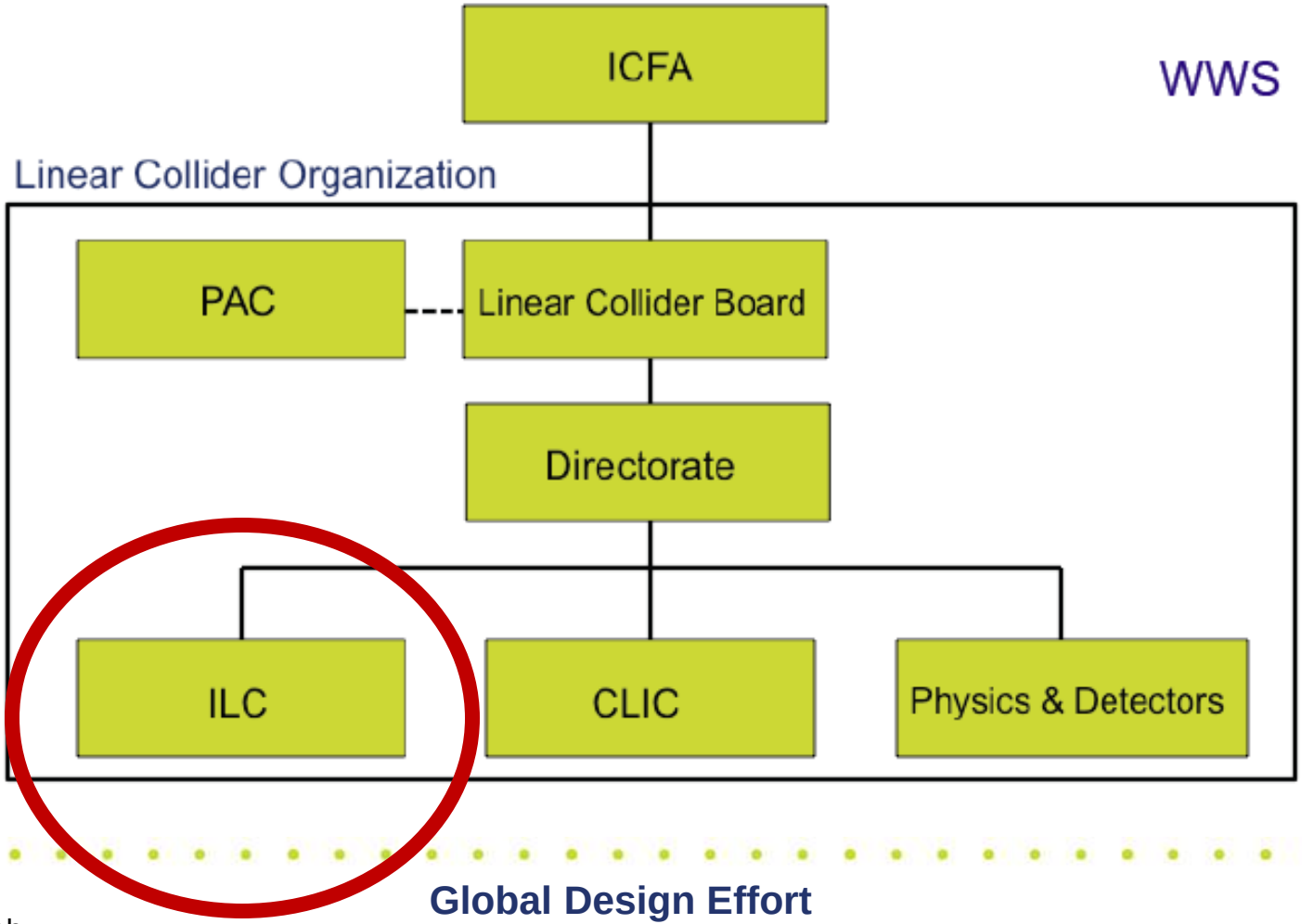
~300 pages
Deliverables 1,3 and 4

Technical Design Report

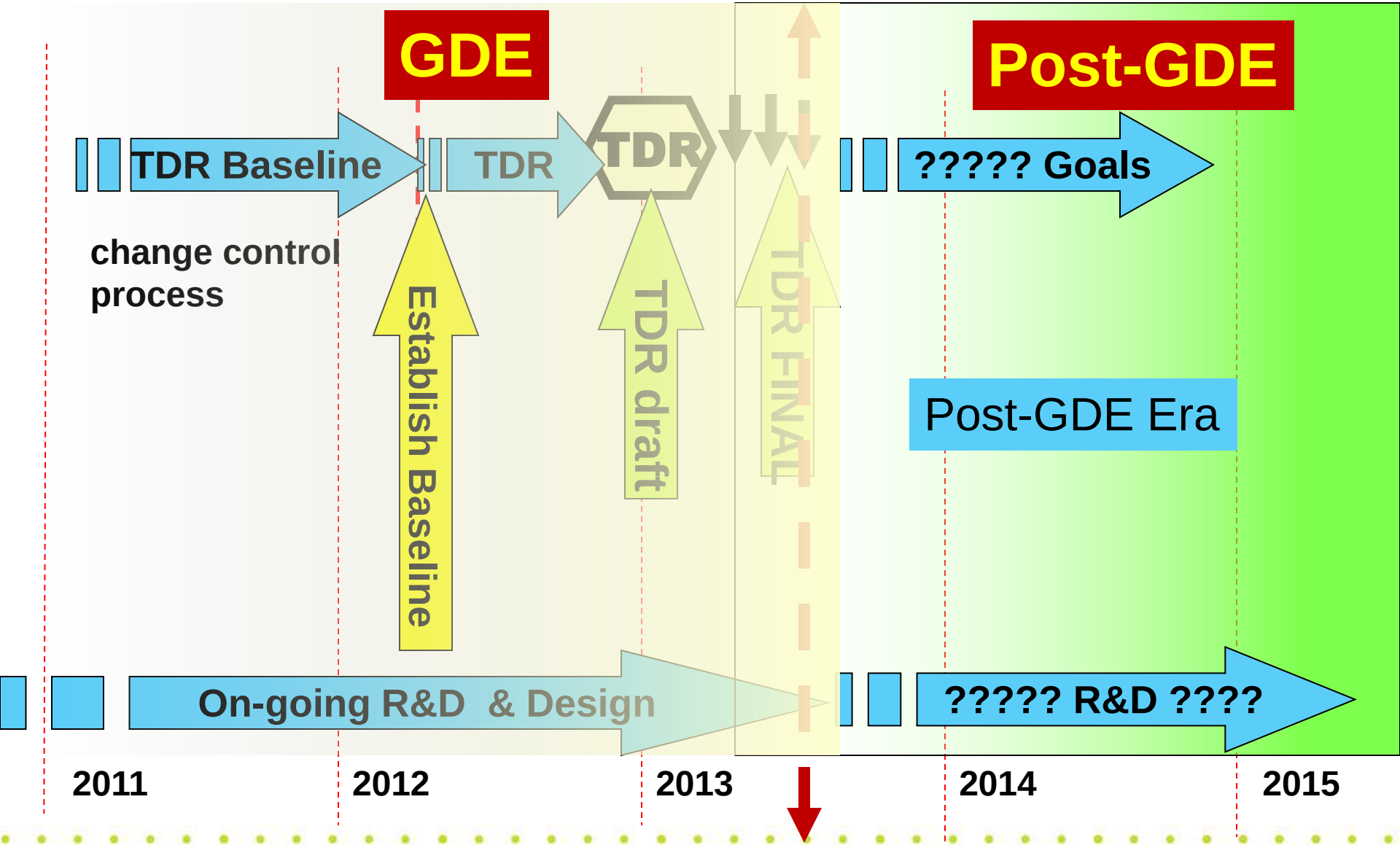
* end of 2012 – formal publication early 2013

Post – TDR (ILCSC)

Possible Organization



ILC Timeline – Post-GDE Transition



Post TDR

- Extending the energy of the ILC
- Continued R&D – especially SCRF
- Systems Tests
- Organization? (ILCSC)

Extending the reach of the ILC

- **ICFA LC Parameters subcommittee (2003 and 2006)**

The strong likelihood that there will be new physics in the 500 – 1000 GeV range means that the upgradeability of the LC to about 1 TeV is the highest priority step beyond the baseline.

- The energy of the machine should be upgradeable to approximately 1 TeV.
- The luminosity and reliability of the machine should allow the collection of order of 1 ab^{-1} (equivalent at 1 TeV) in about 3 to 4 years.
- The machine should have the capability for running at any energy value for continuum measurements and for threshold scans up to the maximum energy with the design luminosity ($\sqrt{s}$ scaling assumed).
- Beam energy stability and accuracy should be as stated for the baseline machine.

GDE Conclusions

- The major R&D milestones for TDR are in-hand
- The TDR will be a self-contained comprehensive R&D report; with a design based on new baseline; a new value costing; and a section on project implementation planning
- Submit: Dec 2012; Reviews of technical design & costs; rewrite as needed; submit to ICFA at LP2013 in June 2013 **(GDE mandate complete)**
- Envisioned post–TDR ILC program: 1) extend energy reach; 2) systems tests; 3) evolve design based on technology development and LHC results