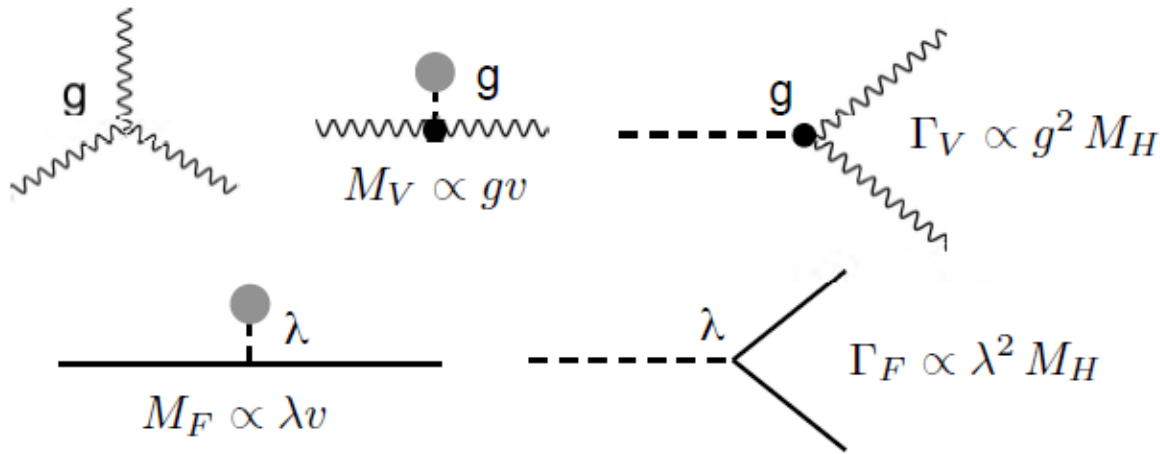


# Global Design Effort

## Update

### Higgs



**Barry Barish**  
SiD Workshop  
SLAC  
21-Aug-12

Any deviations are the result of new physics!



## GDE Status & Plans

- **Update on ILC accelerator R&D**
- **The Technical Design Report**
- **ILC Systems Tests**
- **Japanese candidate sites**
- **Post-TDR planning**
- **Staged approach? Higgs Factory → ILC**



# Major R&D Goals for Technical Design

## SCRF

- **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**
- **CesrTA** - Electron Cloud tests to establish electron cloud mitigation strategy
- **FLASH** – Study performance using ILC-like beam and cryomodule (systems test)

# 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 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			

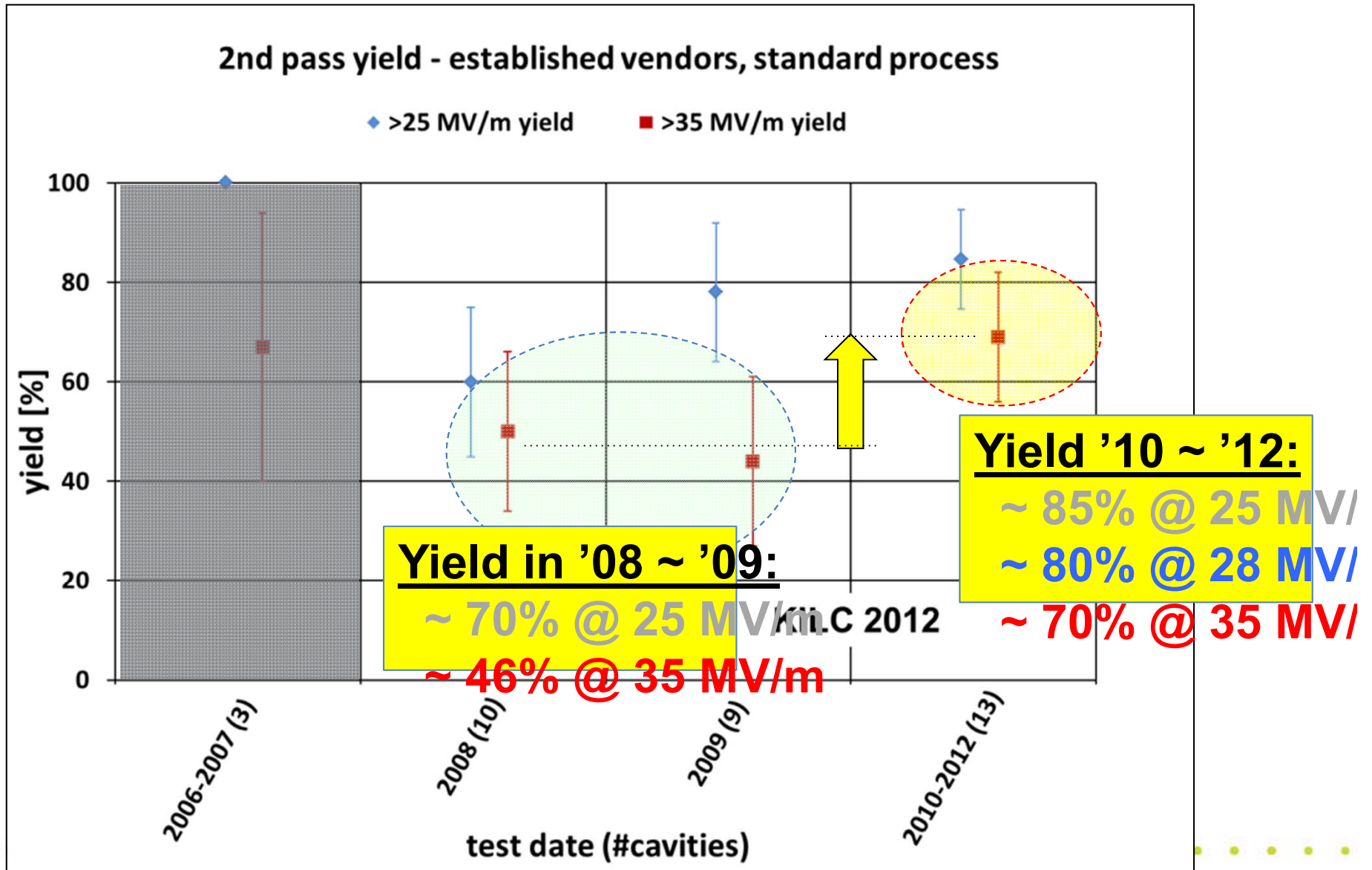
## New baseline gradient:

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

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



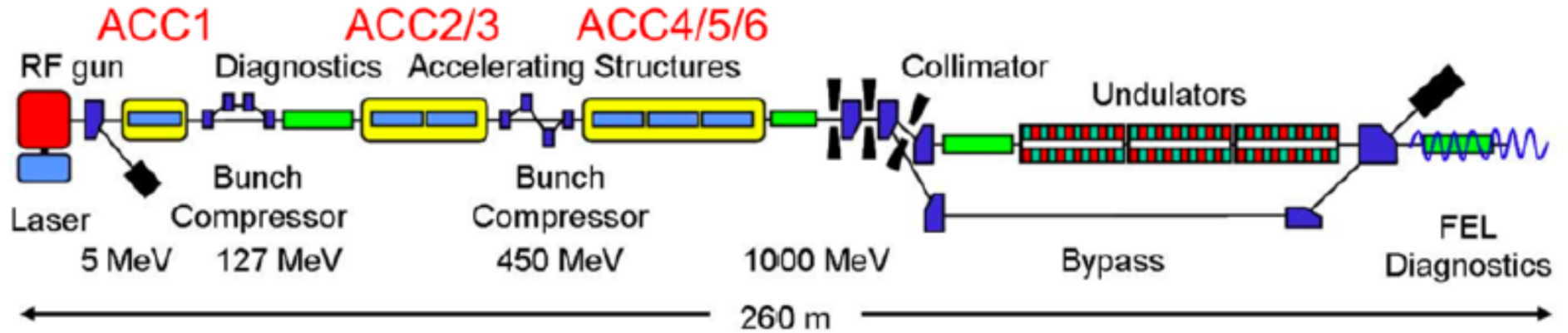
# Yearly Progress in Cavity Gradient Yield as of April 24, 2012





# 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	$\mu$ s	650	970	800	800
Current	mA	5	9	9	9

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



# FLASH 9mA Expt achievements: 2009-mid 2012

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

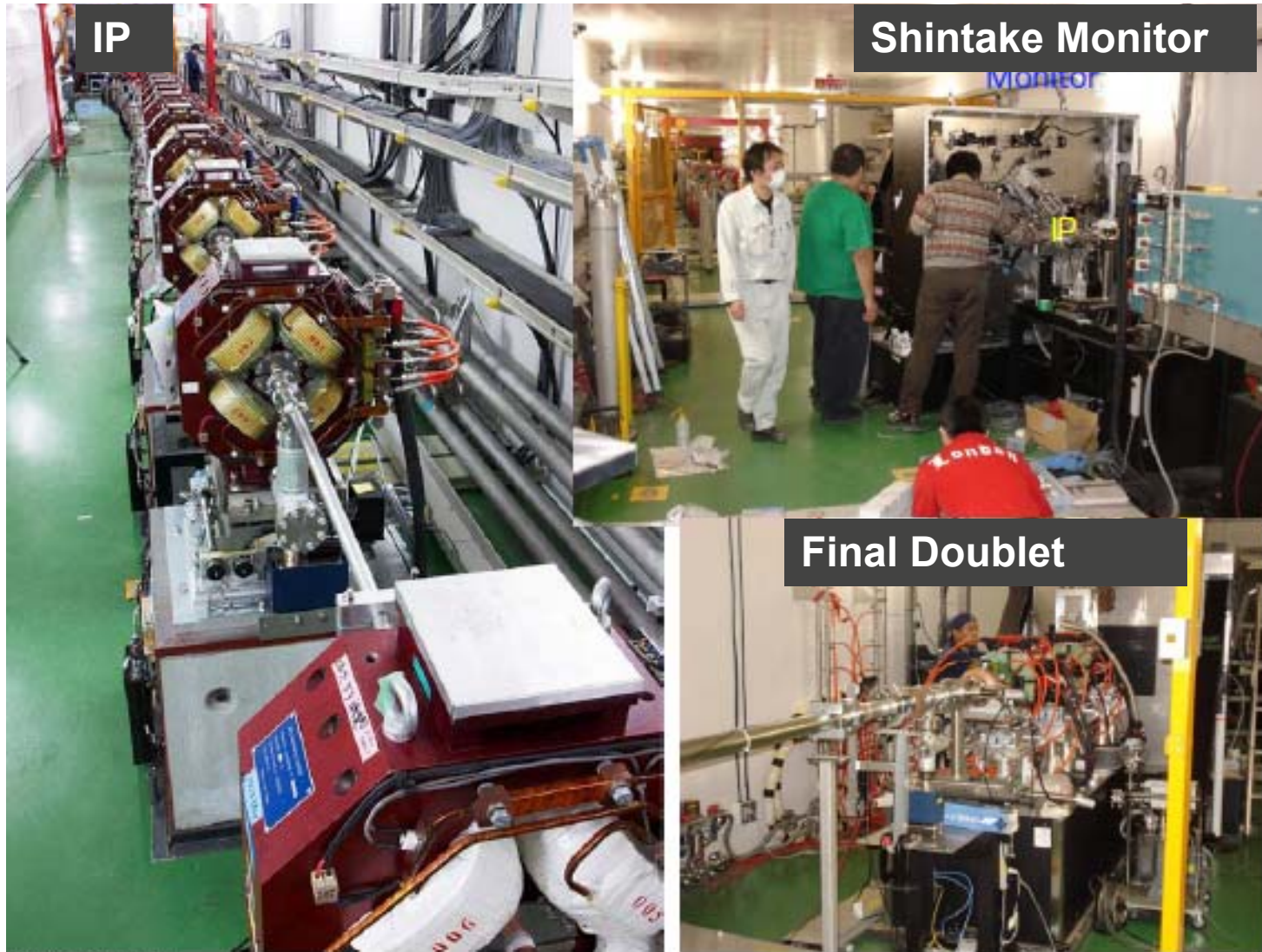
Metric	ILC Goal	Achieved
Macro-pulse current	9mA	9mA
Bunches per pulse	2400 x 3nC (3MHz)	1800 x 3nC 2400 x 2nC
Cavities operating at high gradients, close to quench	31.5MV/m +/-20%	4 cavities > 30MV/m

## Gradient operating margins (Feb 2012)

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



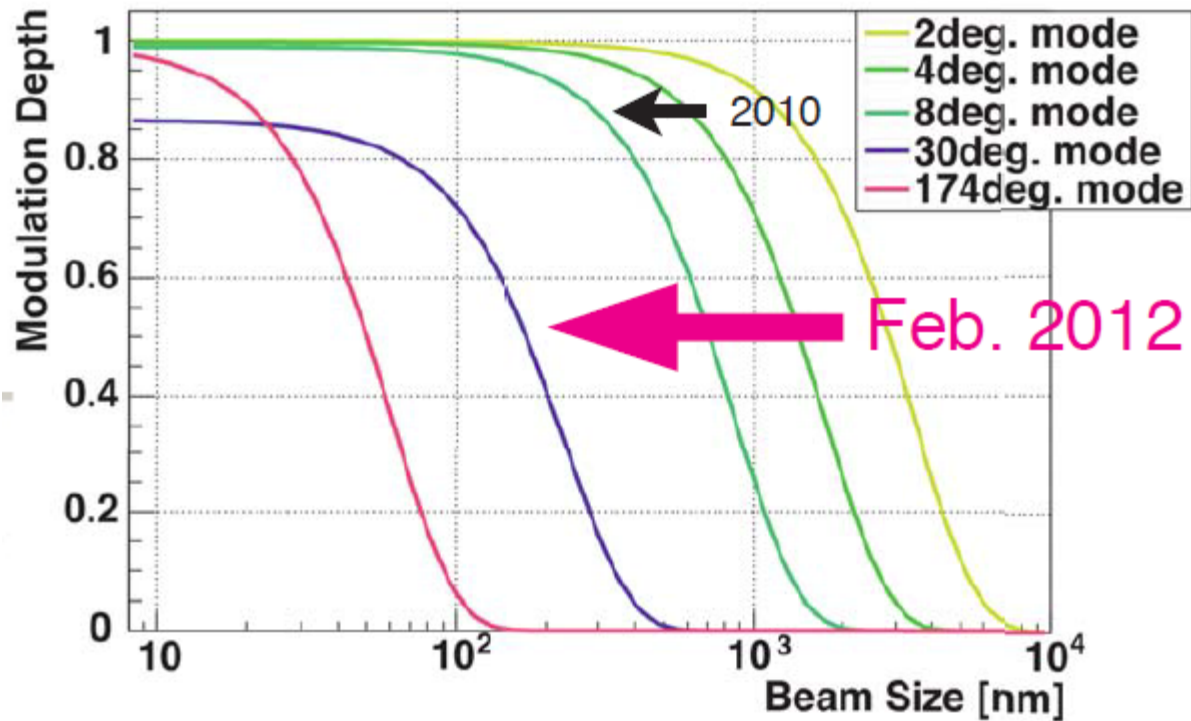
# ATF2 – Beam size/stability and kicker tests



2010年10月10日 火曜日



# ATF earthquake recovery



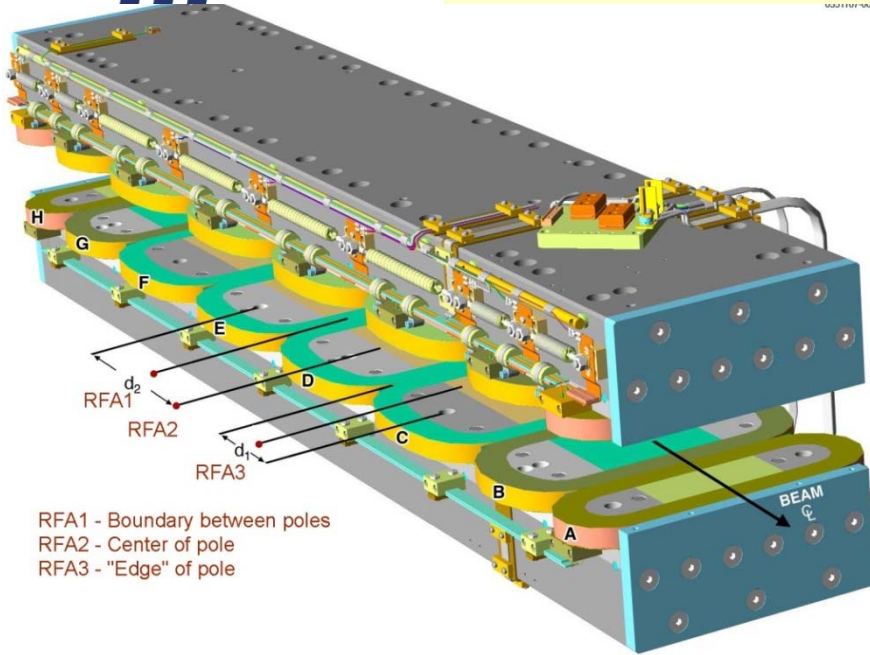
$$M = 0.52 \pm 0.010 \text{ (stat)}$$

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

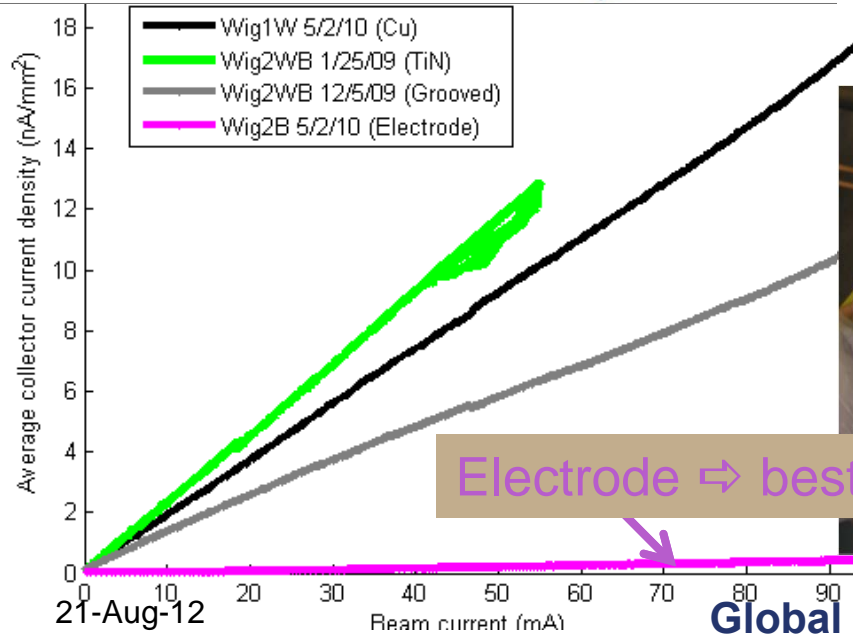
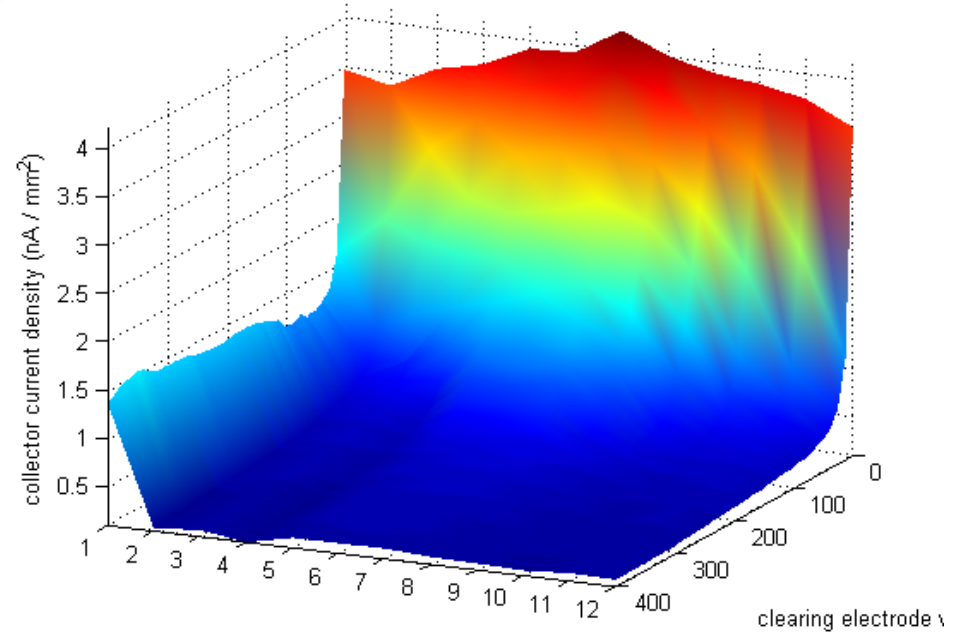


# CesrTA - Wiggler Observations

Run #2568 (1x20x2.8mA e+, 4 GeV, 14ns): 01W\_G2 Center pole Col Curs



RFA1 - Boundary between poles  
RFA2 - Center of pole  
RFA3 - "Edge" of pole



Legend:  
- Wig1W 5/2/10 (Cu)  
- Wig2WB 1/25/09 (TiN)  
- Wig2WB 12/5/09 (Grooved)  
- Wig2B 5/2/10 (Electrode)

Electrode ⇨ best performance



0.002" radius

21-Aug-12  
SiD Workshop - SLAC

Global Design Effort  
IWLC2010 - CERN, Geneva, Switzerland



# EC Working Group Baseline Mitigation Plan

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

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

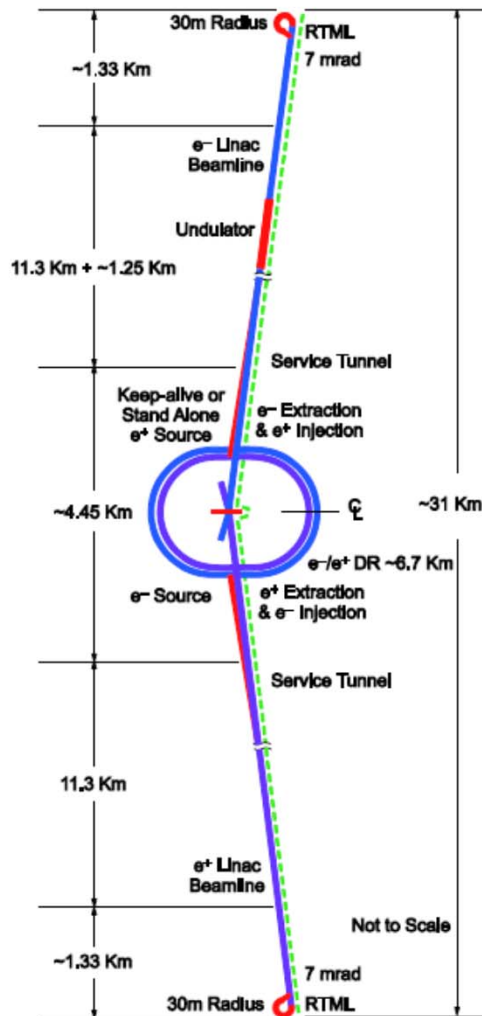
- Preliminary CESR-TA results and simulations suggest the presence of *sub-threshold emittance growth*
  - Further investigation required
  - May require reduction in acceptable cloud density  $\Rightarrow$  reduction in safety margin
- An aggressive mitigation plan is required to obtain optimum performance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

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

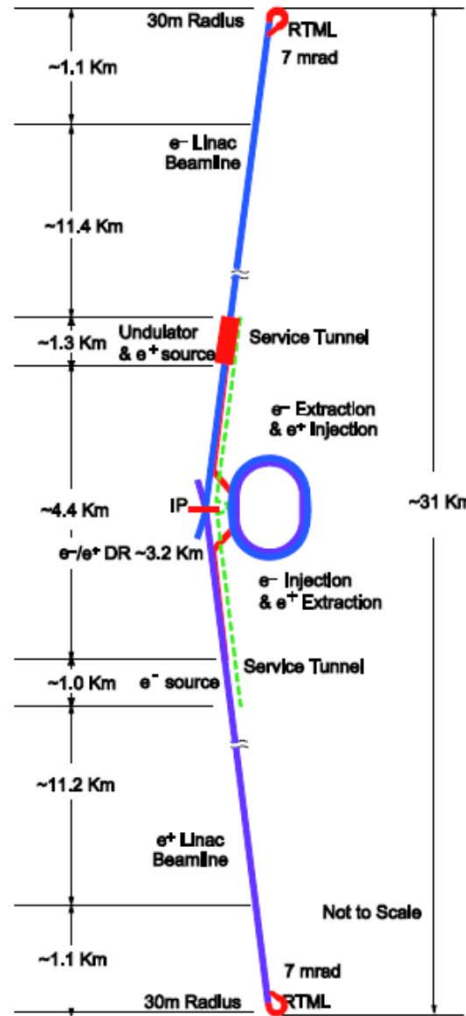


# Proposed Design changes for TDR

**RDR**



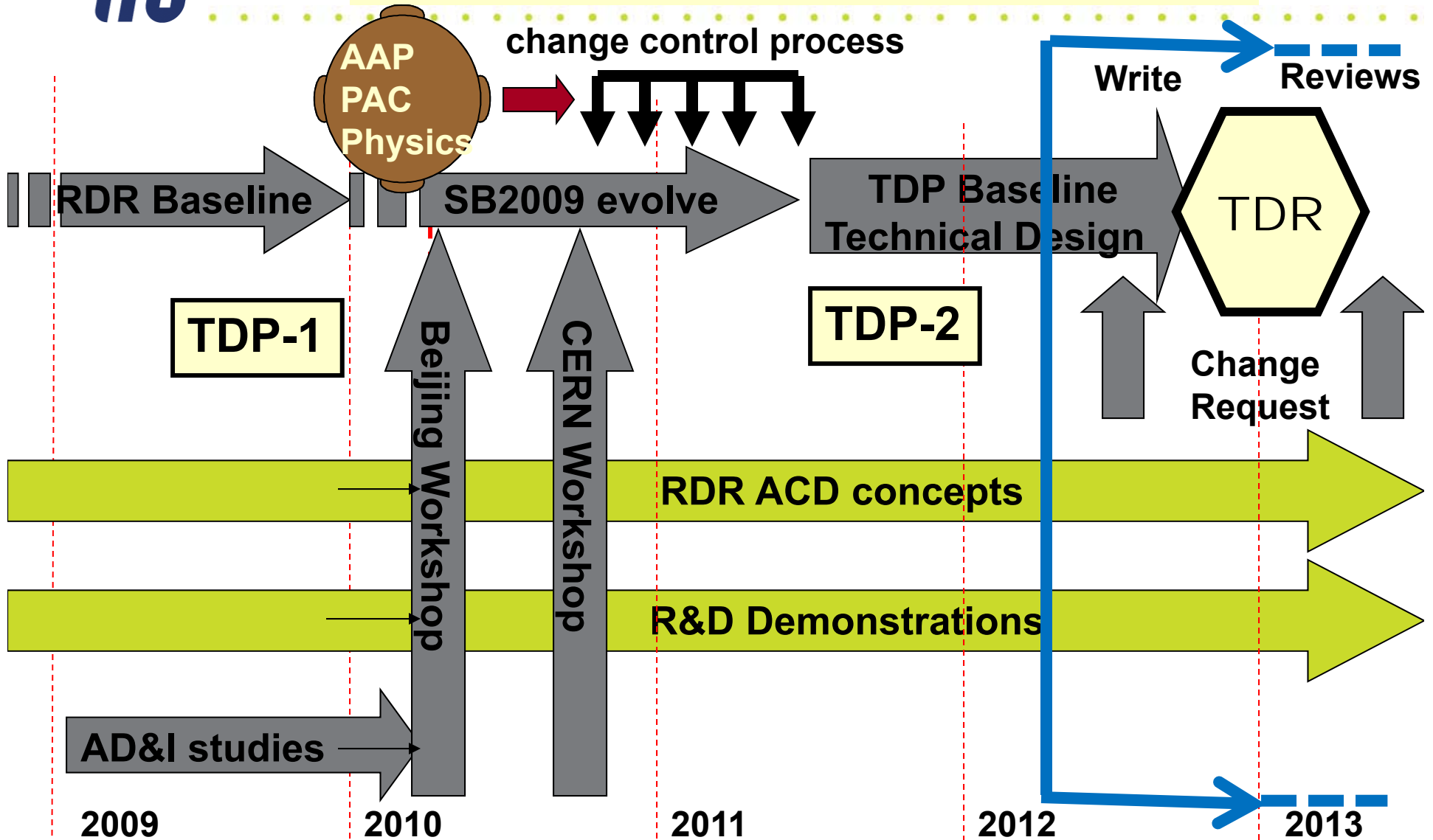
**SB2009**



- 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



# Technical Design Phase

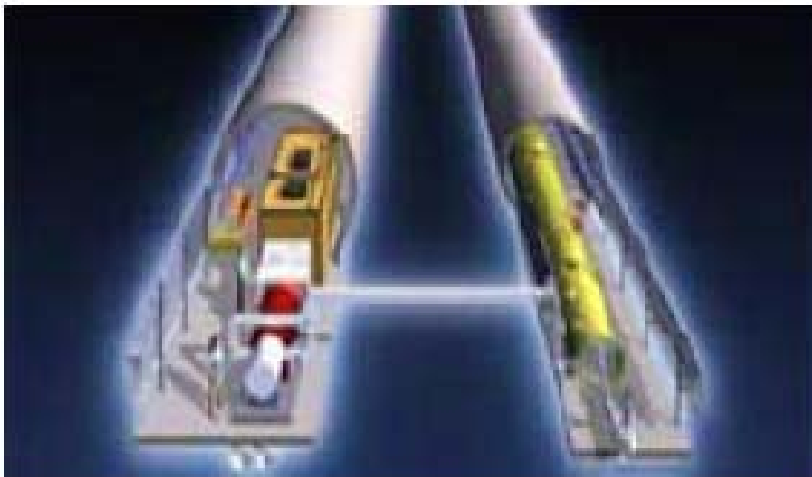




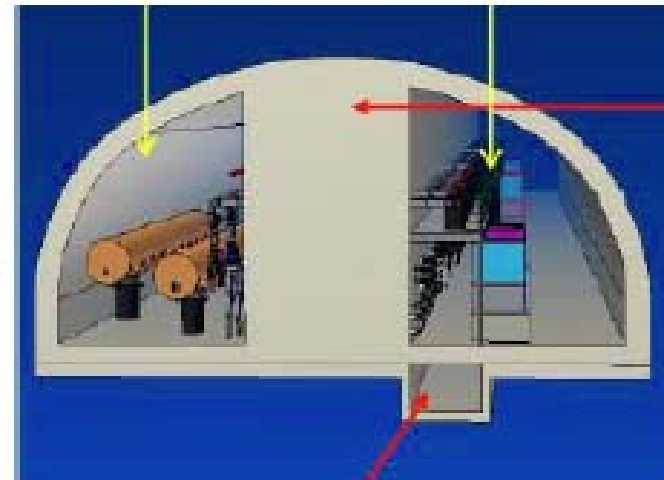
# Conventional Facilities

## *Japan -- New Tunnel Shape*

RDR two tunnel design (2007)



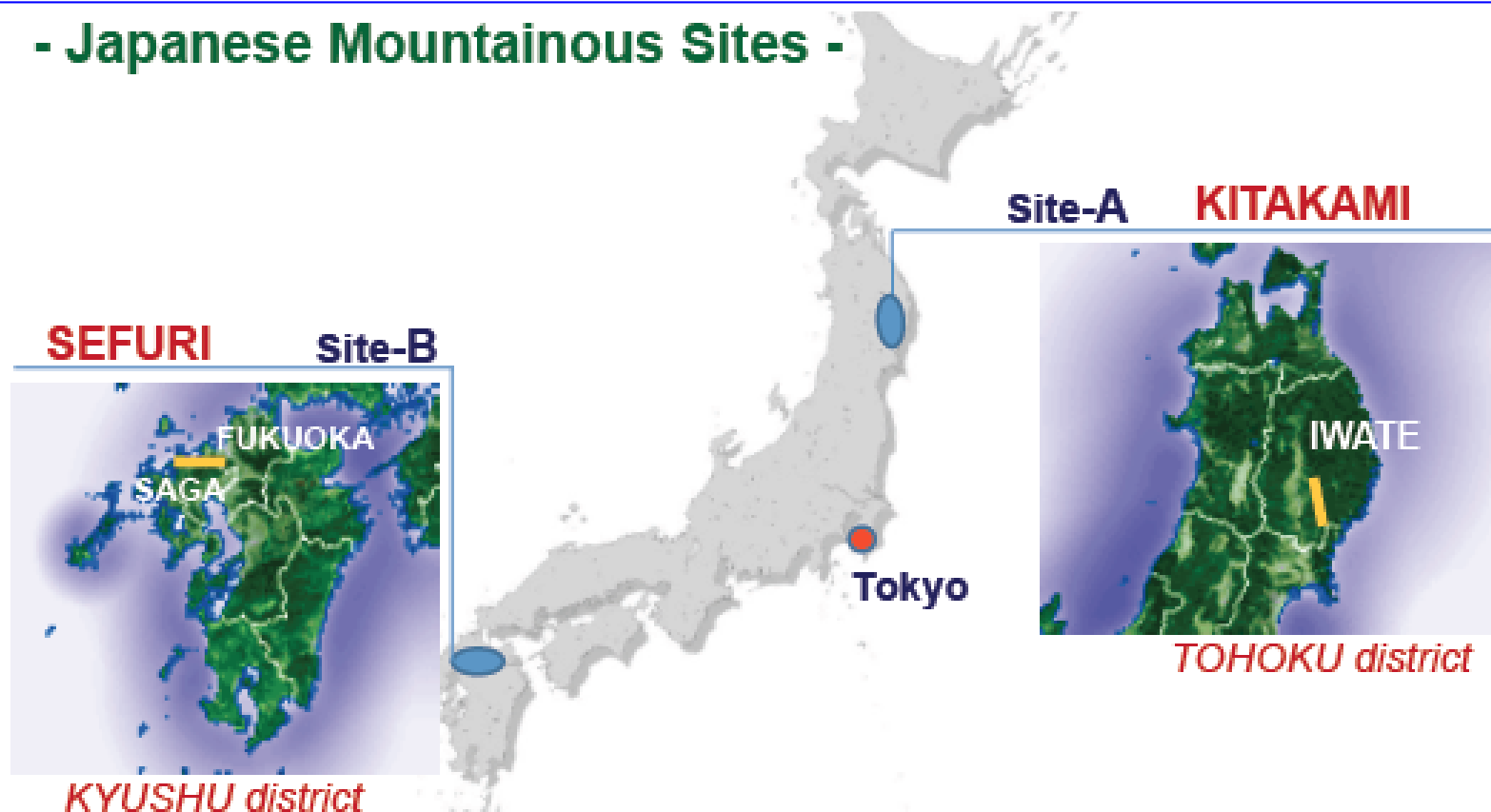
TDR mountain sites





# Two Candidate Sites in Asia/Japan

- Japanese Mountainous Sites -







# Underground Power Station





# Geological Samples





# Impact of Top Level Changes

- RDR estimate = starting point 6,618  $\Delta$
- 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<sup>+</sup> production at 150 GeV<sub>9</sub>



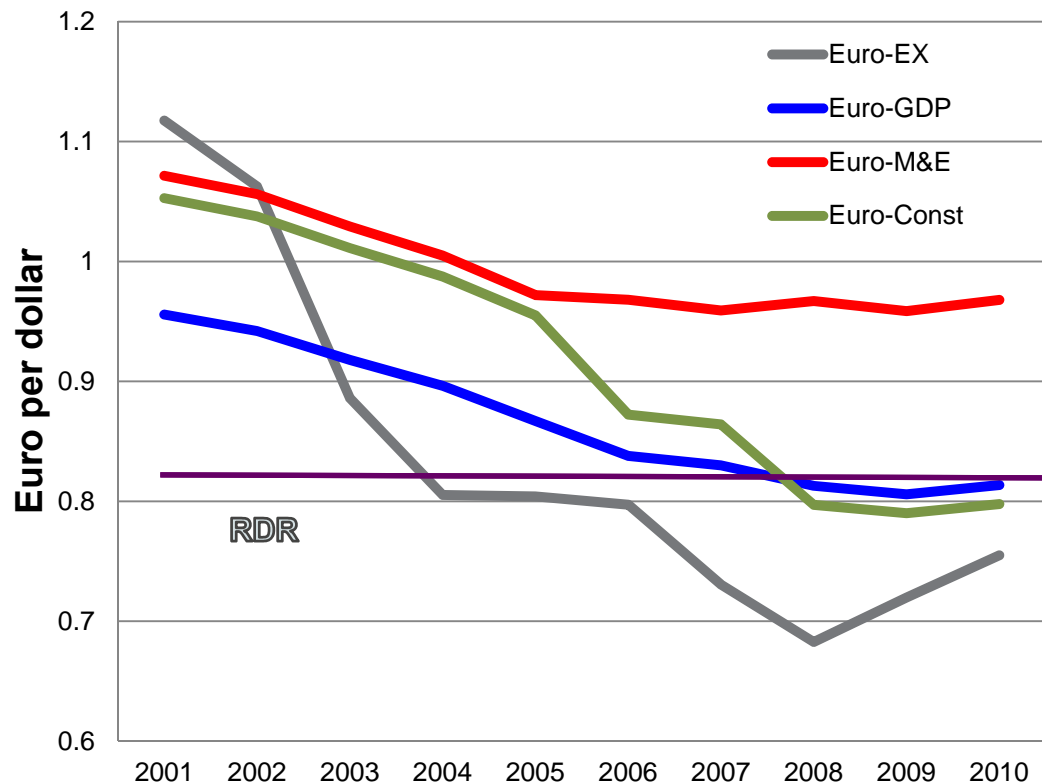
# Starting Point is the RDR Costs

- **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%



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

**PPP = Purchasing Power Parity**



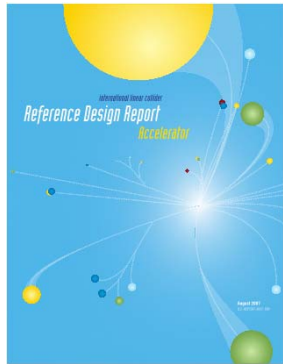
EX-exchange rate  
GDP: PPP based on all goods/services in GDP of each region  
M&E: PPP based on machinery and equipment  
Const: PPP based on civil construction

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



# TDR Technical Volumes

2007



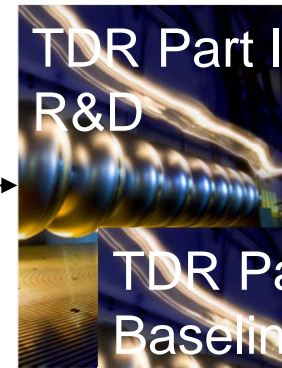
Reference Design Report

2011



ILC Technical Progress Report  
(*"interim report"*)

2013\*



TDR Part I:  
R&D

~250 pages  
Deliverable 2



TDR Part II:  
Baseline Reference Report

~300 pages  
Deliverables 1,3 and 4

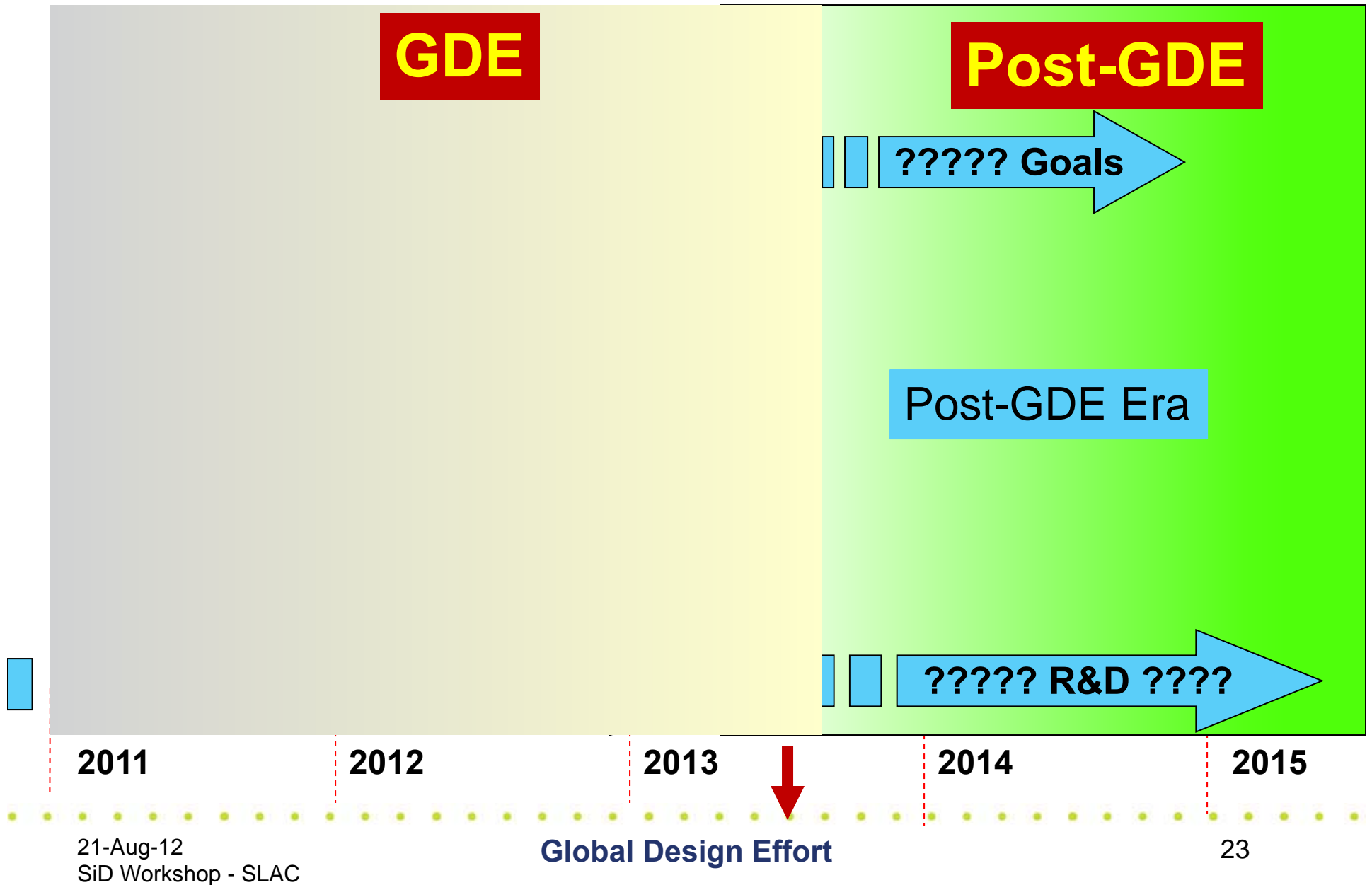
Technical Design Report

\* end of 2012 – formal publication early 2013

AD&I



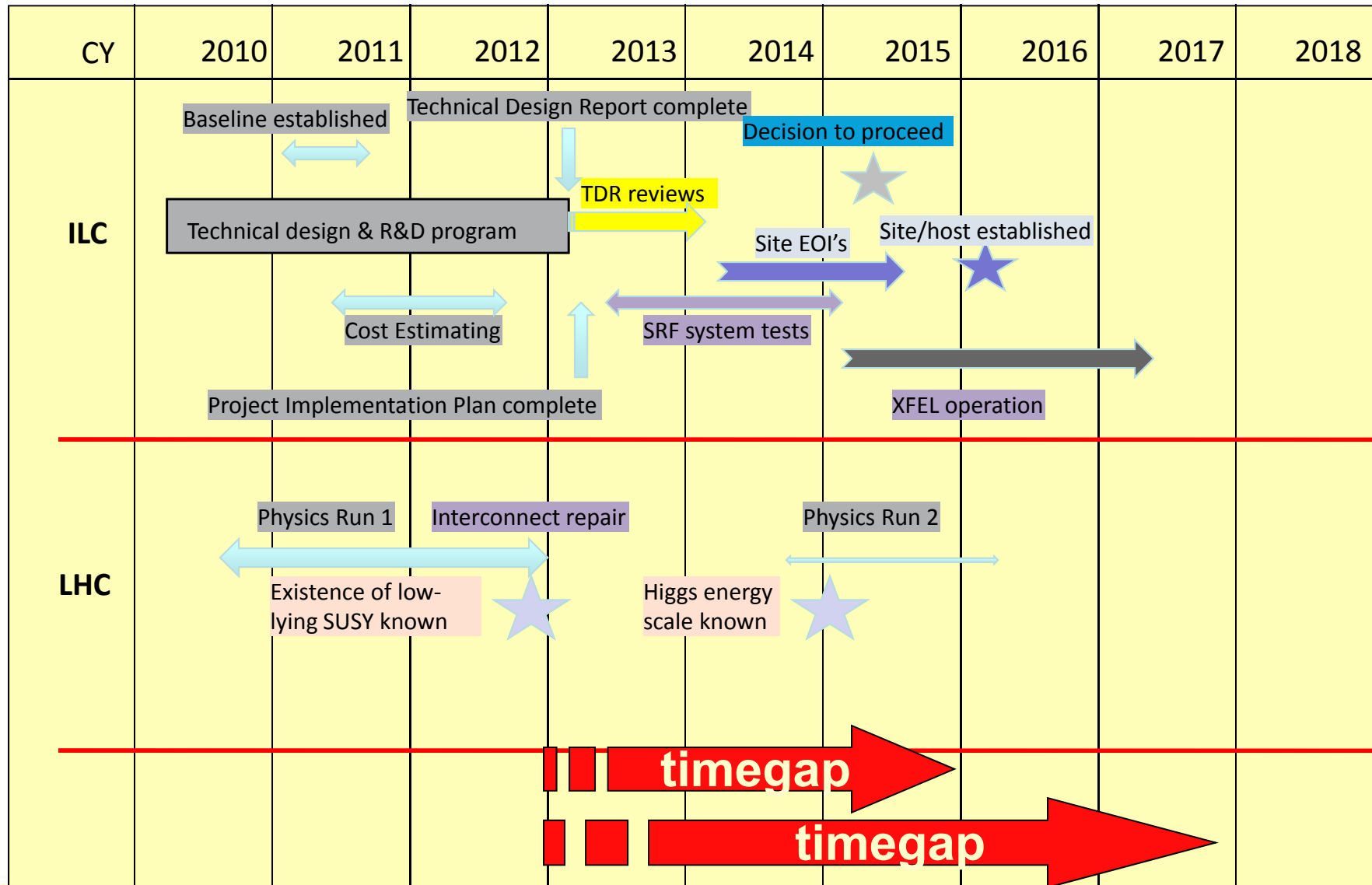
# ILC Timeline – Post-GDE Transition



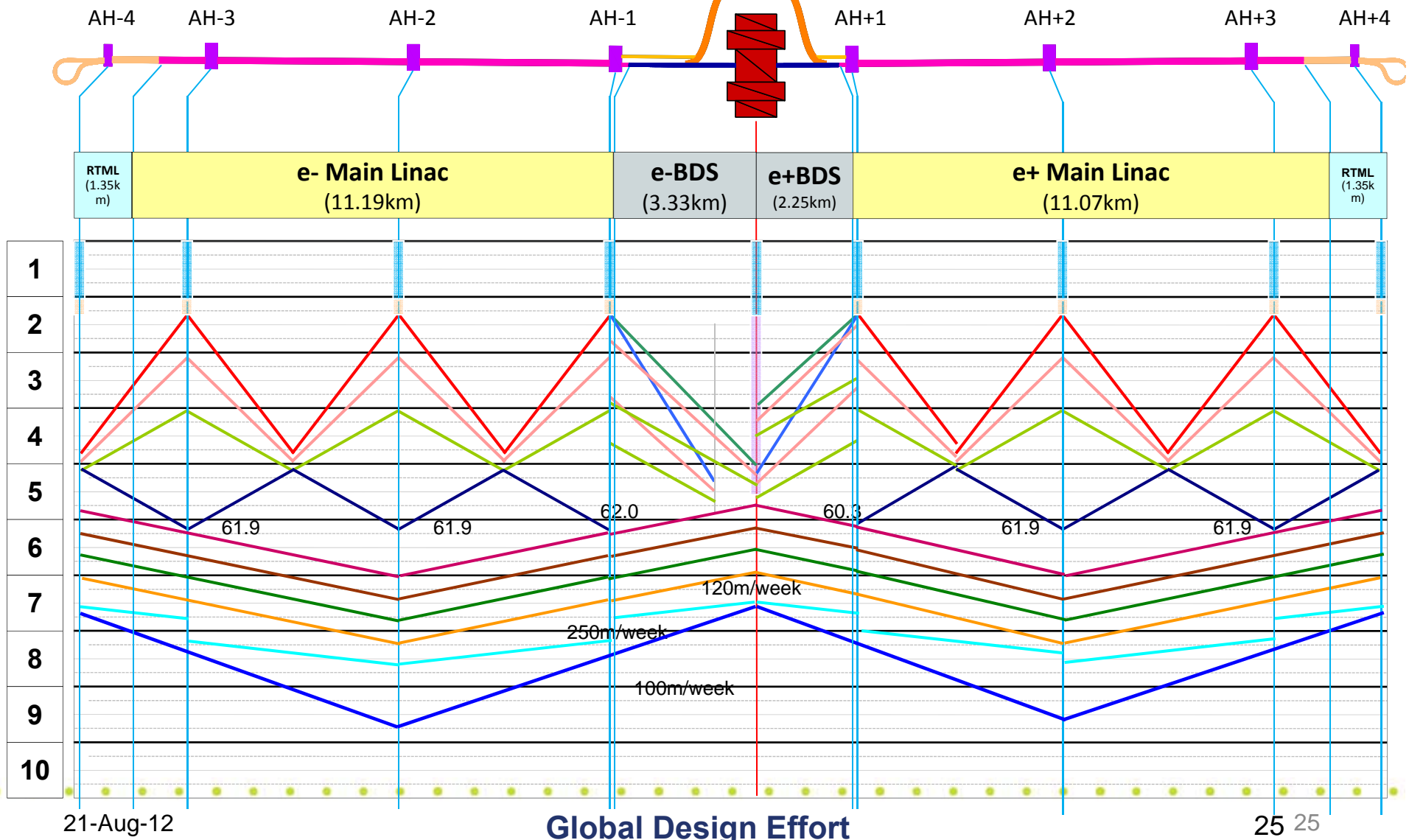
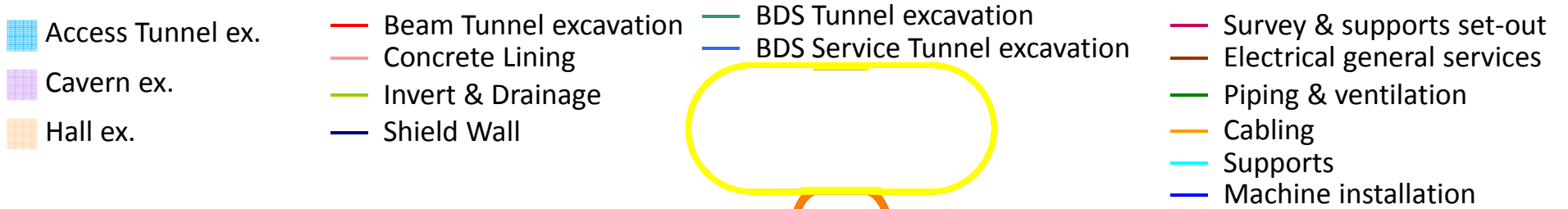


# ILC possible timeline

B. Barish, KILC12









# Higgs Factory – Energy

- ~125 GeV from LHC
  - $125+91=216$  GeV cm  $\rightarrow$  250 GeV
- 173 GeV Top quark
  - $2 \times 173 = 346$  GeV cm  $\rightarrow$  350-400 GeV
- Higgs self coupling (t-coupling) ???
  - $\geq 500$  CM (up to 650 ??)
- TeV and beyond....?

Staging / Upgrading





# 250 GeV CM (first stage)

*Relative to TDR 500 GeV baseline*

Two stage compressor (5-15 GeV)

Half linacs solution  
G = 31.5 MV/m

**POSITRON** linac straightforward  
~50% ML linac cost (cryomodules, klystrons, cryo etc.)  
~50% ML AC power

**ELECTRON** linac needs 10Hz mode for e+ production  
 $\Delta E = 135$  GeV instead of 110 GeV (+25 GeV)  
~57% ML linac cost (cryomodules, klystrons etc)

Main Linac infrastructure  
Linac components: 50%  
Cryogenics: 65%  
RF AC power: 80%

10Hz needs (1/2 linac  $\times$  10Hz/5Hz):  
100% ML AC power  
(1/2 linac  $\times$  10Hz/5Hz)  
80% cryo cost  
(50% static + 100% dynamic)



# Possible approaches

- **Build tunnel/shafts only for 250 GeV**
  - Cheapest option!
  - Energy extension now requires major civil construction (+cost)
    - Conceptually like TeV upgrade option
  - Shorten schedule ~2 years (guess) ~70% TDR \$
- **Build full 500 GeV machine tunnel**
  - Assume install low energy linac first
    - long 125/150 GeV transport line in 'empty tunnel.
  - Energy upgrade now just adds accelerator to tunnel
    - Options for 'adiabatic' upgrading
    - Implications for mass production scenarios (long term investment may now look attractive)
    - Additional upfront costs. May need to sell/cost entire project upfront
    - More expensive but over a longer time scale.
  - Shorten schedule < 2 years since all tunnels need to be constructed. ~77% TDR \$



# 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;
  - Technical Review by augmented PAC (Dec 2012 at KEK)
  - Cost Review by international committee (Jan 2013 at Orsay)
  - TDR Overall Review by ILCSC (Feb 2013 at Vancouver)
- Revise, rewrite as needed; finalize and submit to ICFA at LP2013 (June 2013)

## GDE Mandate Complete

- Post-TDR ILC program: 1) extend energy reach; 2) systems tests; 3) evolve design based on technology development and LHC results; consider staged design, beginning with Higgs Factory.