Update on the Global ILC Status and Plans

One shift Operation 2100:0600 20-21.09.2009

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Today

- Global Context
- ILC Reference Design
- ILC Cost Estimate Revisited
- Key R&D Plans and Milestones
- Evolving the ILC “Baseline”
- ILC / CLIC Collaboration
- Technical Design Report (2012) and after
- Final Remarks

ILC Global Context

- Advancing the energy frontier has been and will continue to be our most important tool for probing the central scientific questions in our field
  - **Worldwide consensus through long range planning studies that LHC followed by a complementary lepton collider (ILC is the leading candidate) is the highest priority for the future of particle physics (eg. EPP2010)**
  - **Cost of a future investment will be about the same scale as LHC or ITER.**
  - **The U.S. should have a significant role**

ILC Global Context (ILC)

- Large R&D and Design Effort Worldwide on Accelerator and Detectors for the ILC
  - **Total program is ~ $100M / year worldwide to be compared with a total world HEP program of ~$2500M / year.**
  - **The underlying technology – Superconducting RF acceleration is developing rapidly and is strong candidate for next generation particle accelerators (XFEL, ILC, Project X, etc). Also, broad applications beyond particle physics**
  - **SCRF accounts for about half the total ILC R&D program**

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**

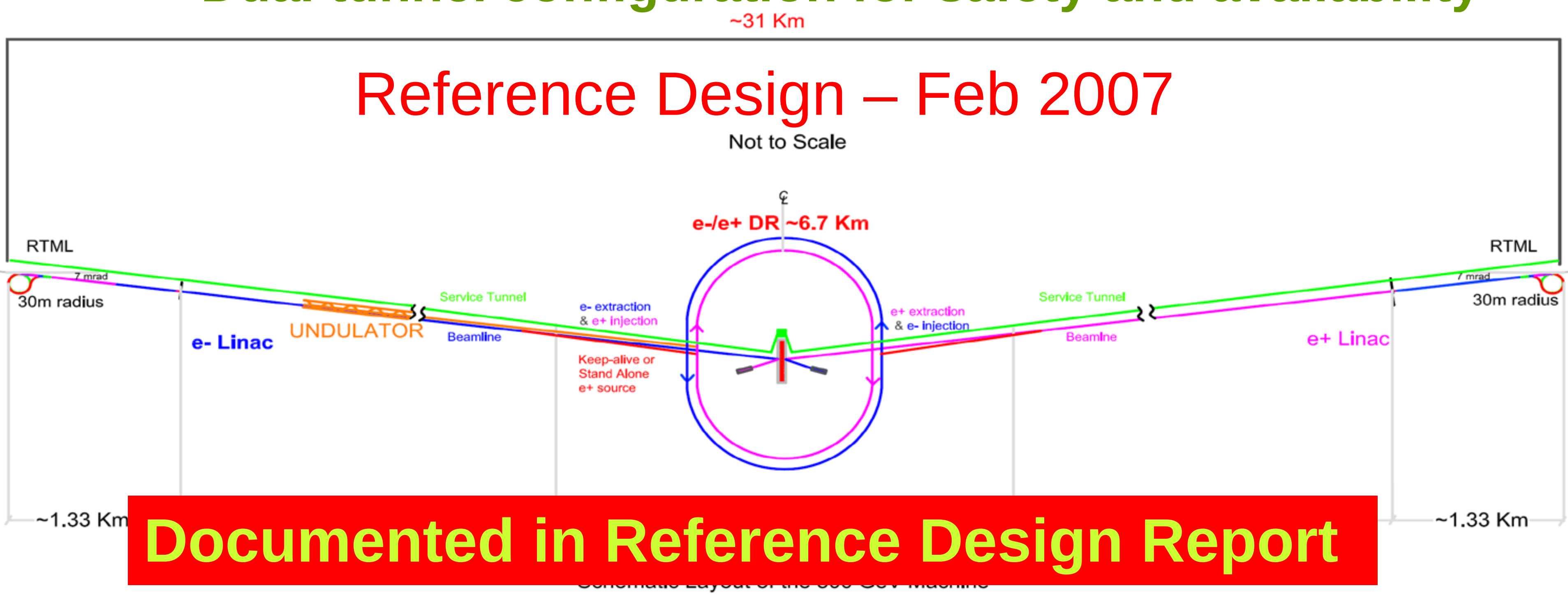
2009 – 2012: Resource Outlook

- Flat year-to-year resource basis
  - **Focused 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**
  - **Conventional facilities optimization and site development**

ILC Reference Design

- 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



Documented in Reference Design Report

International Costing

- "Value" Costing System: International costing for International Project
  - **Provides basic agreed to "value" costs**
  - **Provides estimate of "explicit" labor (man-hr)]**

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

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

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 three time

Total Value Estimate = 6.62 B$ (US 2007)

(+ 24M person-hours explicit labor ~ $1.4 B U.S.)

- ILCSC MAC review
- International Cost Review

Total ~ 8.0 B 2007$

RDR Design & “Value” Costs

Summary
RDR “Value” Costs

Total Value Cost (FY07)
4.80 B ILC Units Shared
+
1.82 B Units Site Specific
+
14.1 K person-years
(“explicit” labor = 24.0 M person-hrs
@ 1,700 hrs/yr)
1 ILC Unit = $ 1 (2007)

Host Cost

$1.82 B Site Specific
$0.70 B (~ 1/2 manpower)
$1.60 B (Shared Costs)

$4.1 B (approx 50% total)

Partners (off-shore cost)

$0.30 B (manpower)
$1.00 B (shared costs

$1.30 B (~ 15-20% total)

FY 07 $$

Translating to “U.S. Costs”

- **No official or detailed translation has been performed**

- **What are the factors?**
  - **Add some contingency (note GDE estimates include some, but not all (DoE) contingency. It needs to be done item by item. (conservatively + 20%) [$8B → ~$10B]**
  - **Escalation to “then year dollars.” This is the big factor that people use – escalating for ~ 15-20 years would be ~ 200%**
  - **For the total project, this gives ~$20B+ (then year $$)**

- **Comments:**
  - **US costs will only be a fraction of total project costs (off shore or on shore).**
  - **Thinking in “then year” $$ in the far future can be quite misleading. (Wages, GDP, etc also scale with inflation; Japan no inflation, etc)**

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**

Updated every six months
A “living document”

Major R&D Goals for TDP 1

SCRF

- **High Gradient R&D - globally coordinated program to demonstrate gradient by 2010 with 50%yield**
- **Preview of new results from FLASH**

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.

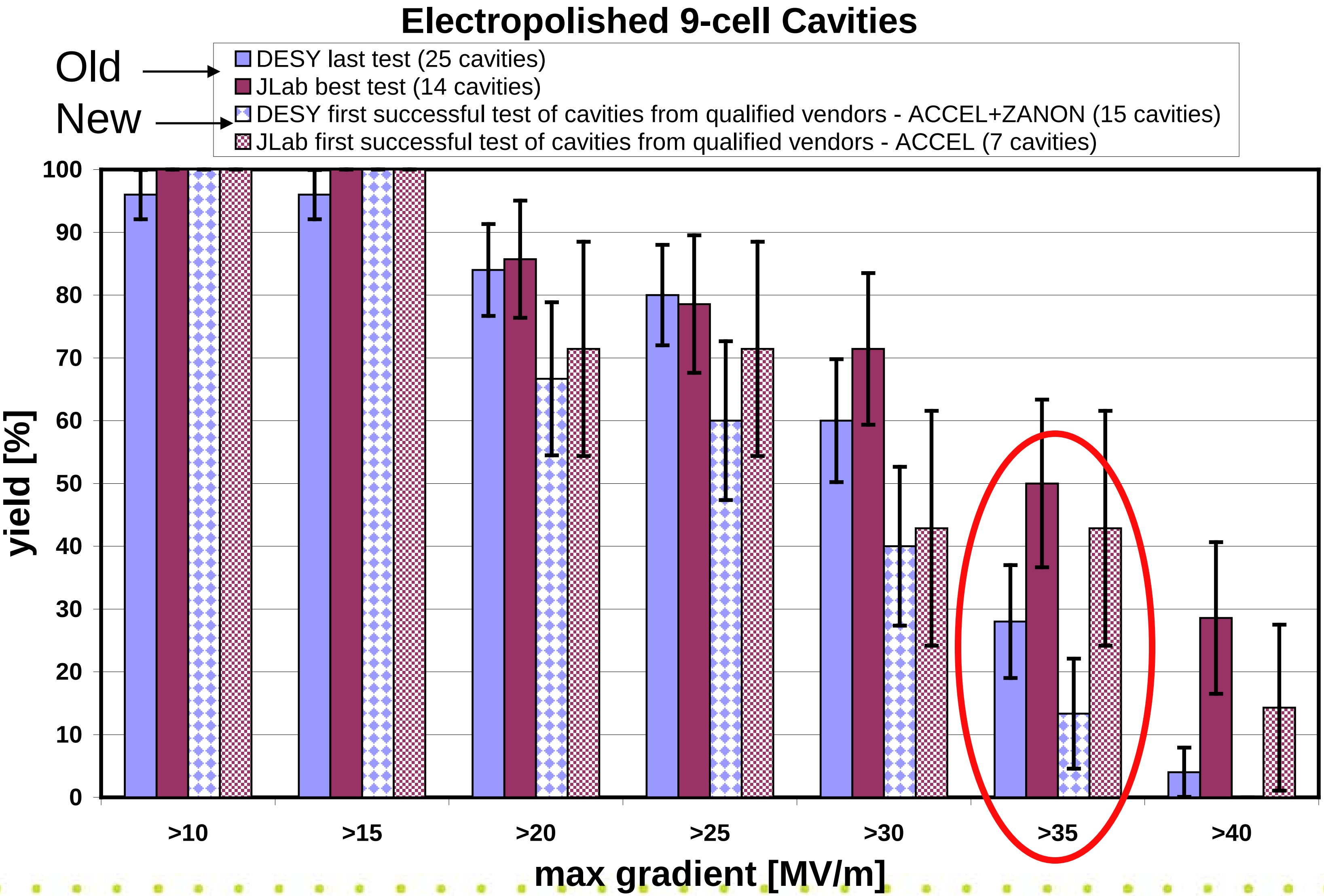
- Achieve high gradient (35MV/m); develop multiple vendors; make cost effective, etc

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

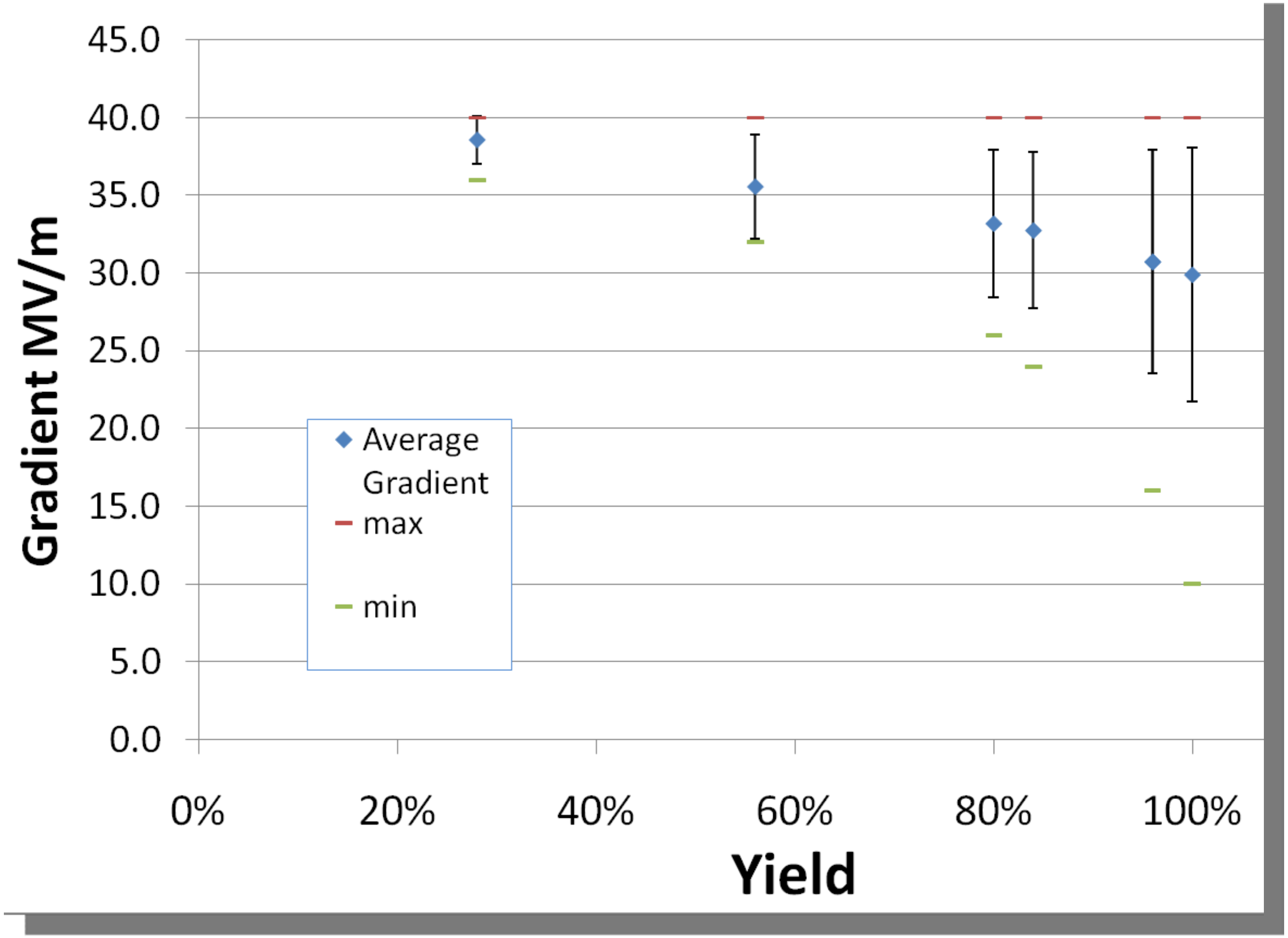
Standard Cavity Process/Recipe

	Standard Cavity Recipe
Fabrication	Nb-sheet purchasing
	Component preparation
	Cavity assembly with EBW
Process	Electro-polishing (~150um)
	Ultrasonic degreasing with detergent, or ethanol rinse
	High-pressure pure-water rinsing
	Hydrogen degassing at > 600 C
	Field flatness tuning
	Electro-polishing (~20um)
	Ultrasonic degreasing or ethanol
	High-pressure pure-water rinsing
	Antenna Assembly
	Baking at 120 C
Cold Test (vert. test)	Performance Test with temperature and mode measurement

Gradient Goal



Alternate Yield Definition



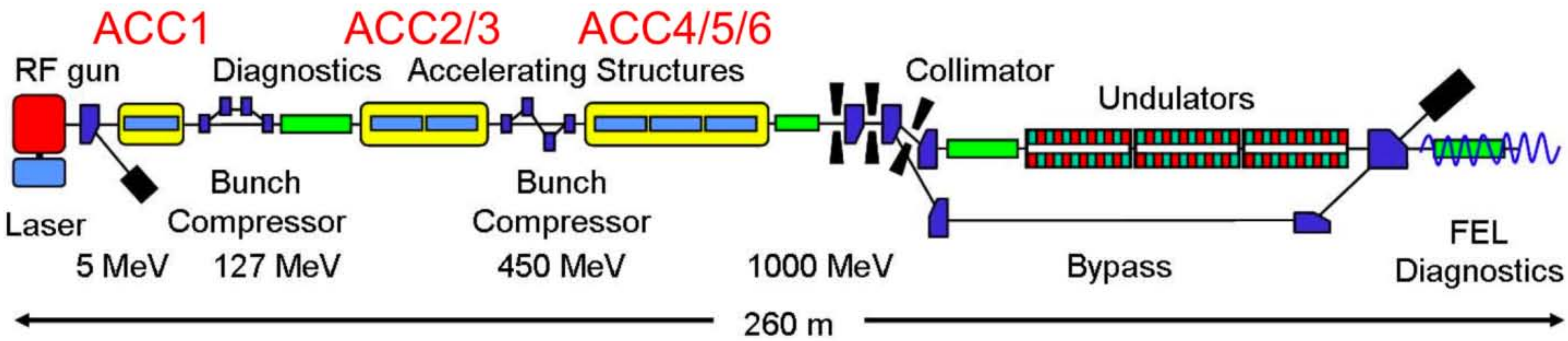
- Allowing for gradient spread
- Additional RF power needed to compensate
- 20% spread seems reasonable

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	→ 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, extend beyond 2012)				
Preparation for Industrialization			Mass-Production Technology R&D			

TTF/FLASH 9mA Experiment

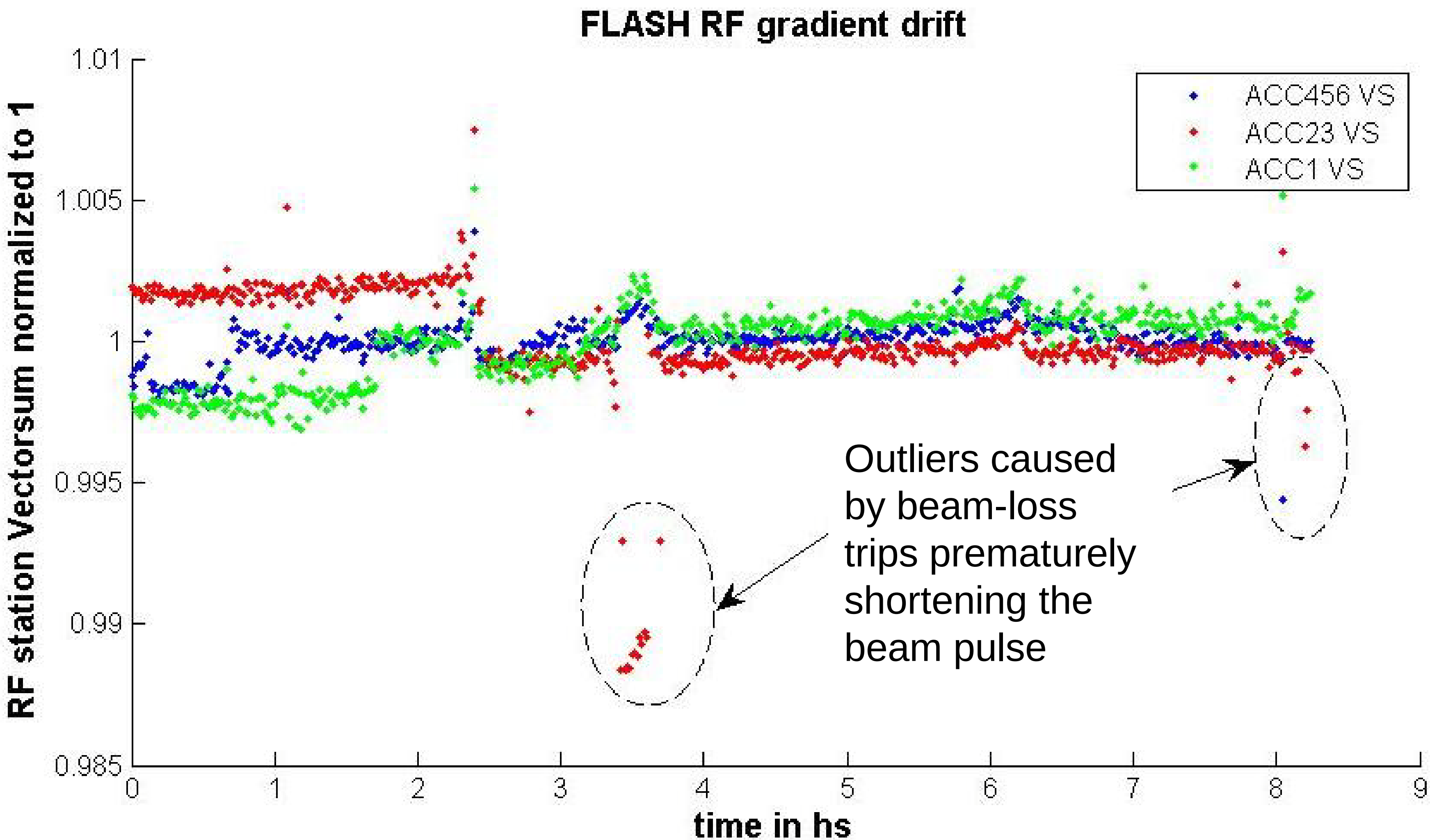
Full beam-loading long pulse operation → "S2"



		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

RF Gradient Long-Term Stability



Example Result

Major R&D Goals for TDP 1

SCRF

- High Gradient R&D - globally coordinated program to demonstrate gradient by 2010 with 50%yield
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Accelerator Design and Integration (AD&I)

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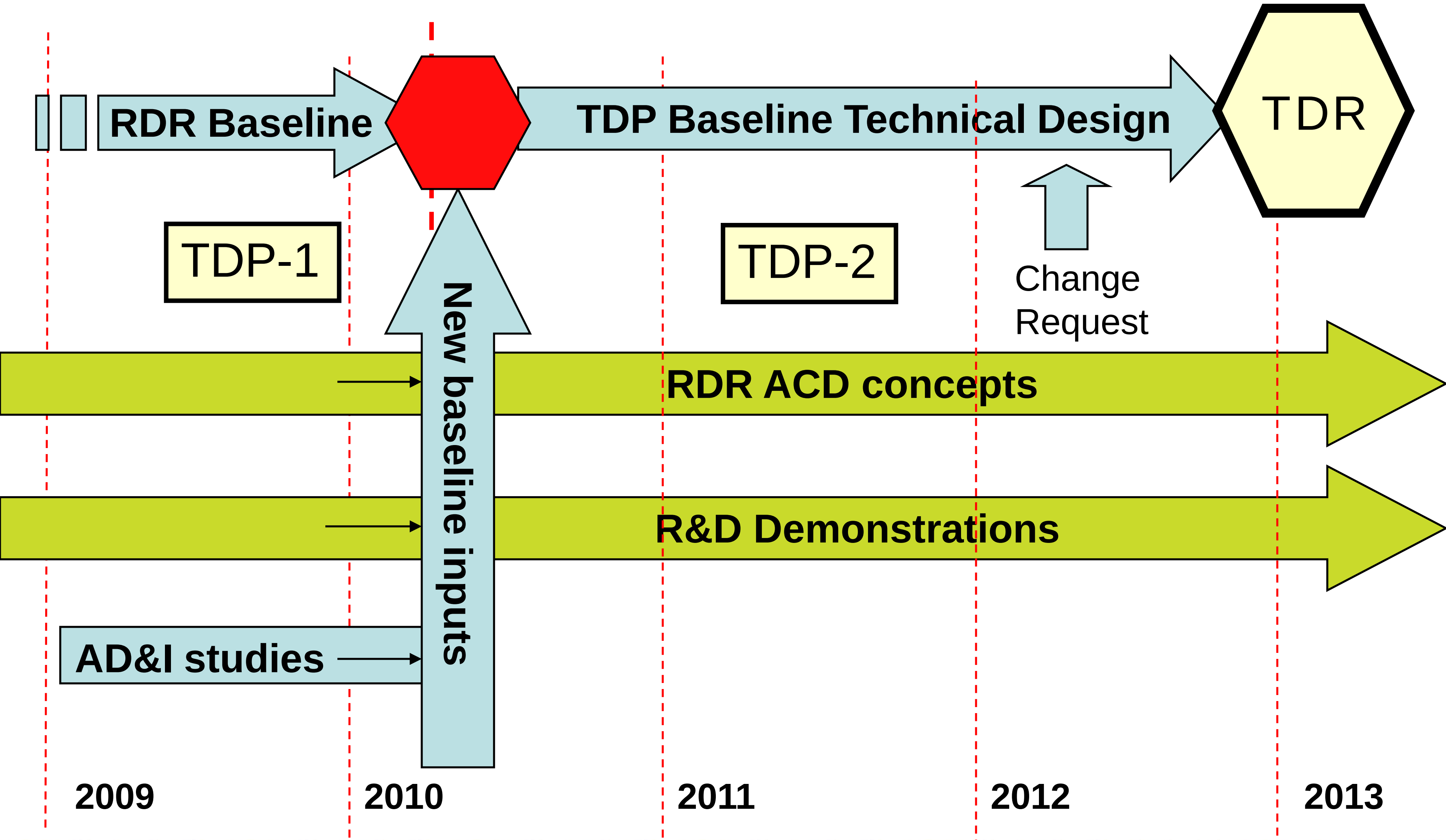
Technical Design Phase <u>and Beyond</u>



Rationale for Re-baseline

- Cost constraint in TDR
  - **Updated cost estimate in 2012 ≤6.7 BILCU**
  - **Need margin against possible increased component costs**
- Process forces critical review of RDR design
  - **Errors and design issues identified**
  - **Iteration and refinement of design**
  - **More critical attention on difficult issues**
- Balance for risk mitigating R&D
  - **Majority of global resources focused in R&D**
  - **Important to prepare / re-focus project-orientated activities for TDP-2**
- **Need for design options and flexibility**
  - **Unknown site location**

SB-2009 Proposal

1. **A Main Linac length consistent with an optimal choice of average accelerating gradient**
   – RDR: 31.5 MV/m, to be re-evaluated

2. **Single-tunnel solution for the Main Linacs and RTML, with two possible variants for the HLRF**
   – Klystron cluster scheme
   – DRFS scheme

3. **Undulator-based e+ source located at the end of the electron Main Linac (250 GeV)**
   – Capture device: Quarter-wave transformer

SB-2009 Proposal (cont)

4. Reduced parameter set (with respect to the RDR)
   - n_b = 1312 (so-called “Low Power”)

5. Approx. 3.2 km circumference damping rings at 5 GeV
   - 6 mm bunch length

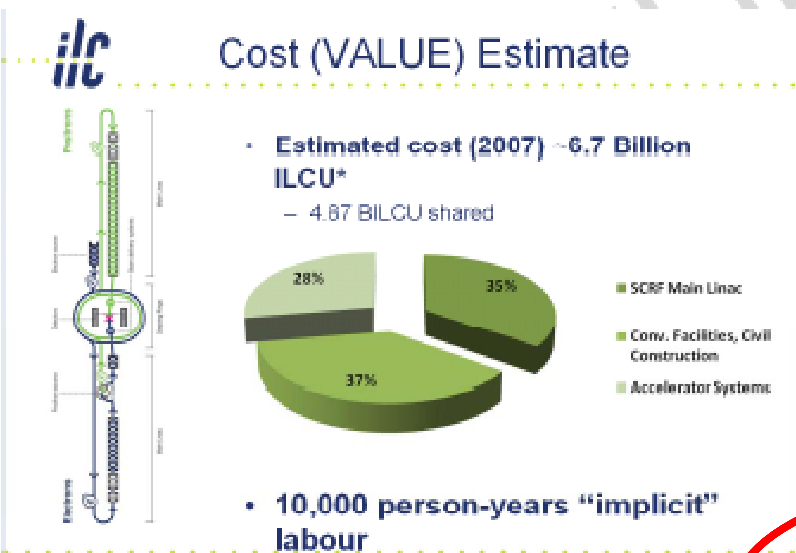
6. Single-stage bunch compressor
   - compression factor of 20

7. Integration of the e+ and e- sources into a common “central region beam tunnel”, together with the BDS.

New Baseline Cost Reductions

(Rough Estimates from 10.2008)

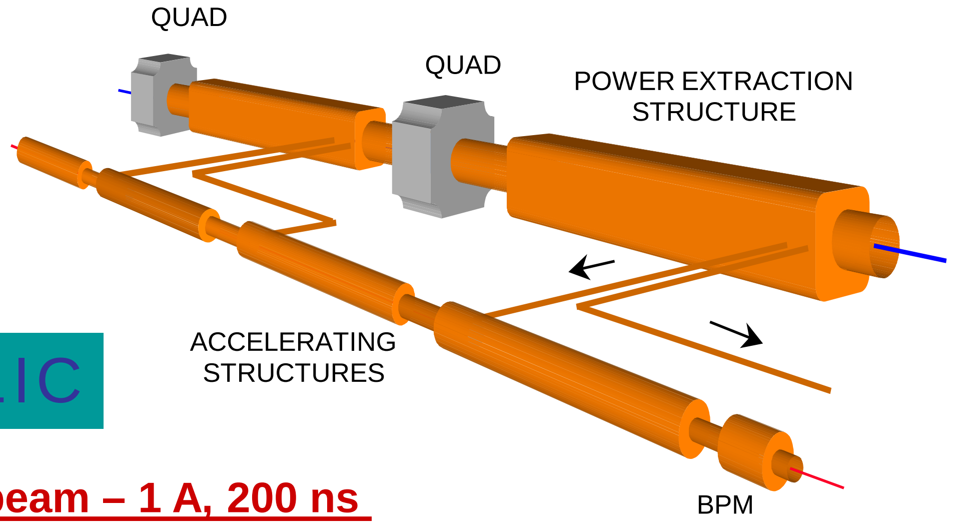
- Main Linac (total) ~ 300 MILCU
- Low-Power option ~ 400 MILCU
- Central injector Integration ~ 100 MILCU
- Single-stage compressor ~ 100 MILCU



- VERY preliminary: better estimates will be made (end 2009)
  - But still based/scaled from RDR value estimate
- Elements *not* independent! Careful of potential double counting!
- **Cost vs Performance vs Risk**: important information for making informed decisions in 2010

Compact Linear Collider

Two beam accelerator



Drive beam - 95 A, 300 ns from 2.4 GeV to 240 MeV

CLIC < 3 TeV

CLIC

Main beam – 1 A, 200 ns from 9 GeV to 1.5 TeV

Luminosity: $2 \cdot 10^{34} cm^{-2}s^{-1}$ @ 3 TeV
Normal conducting accelerator
Gradient 100 MV/m
RF frequency 12 GHz

ILC- CLIC Collaboration

- CLIC – ILC Collaboration has two basic purposes:
  1. **allow a more efficient use of resources, especially engineers**
     - **CFS / CES**
     - **Beamline components (magnets, instrumentation…)**
  2. **promote communication between the two project teams.**
     - **Comparative discussions and presentations will occur**
     - **Good understanding of each other's technical issues is necessary**
     - **Communication network – at several levels – supports it**
- Seven working groups which are led by conveners from both projects

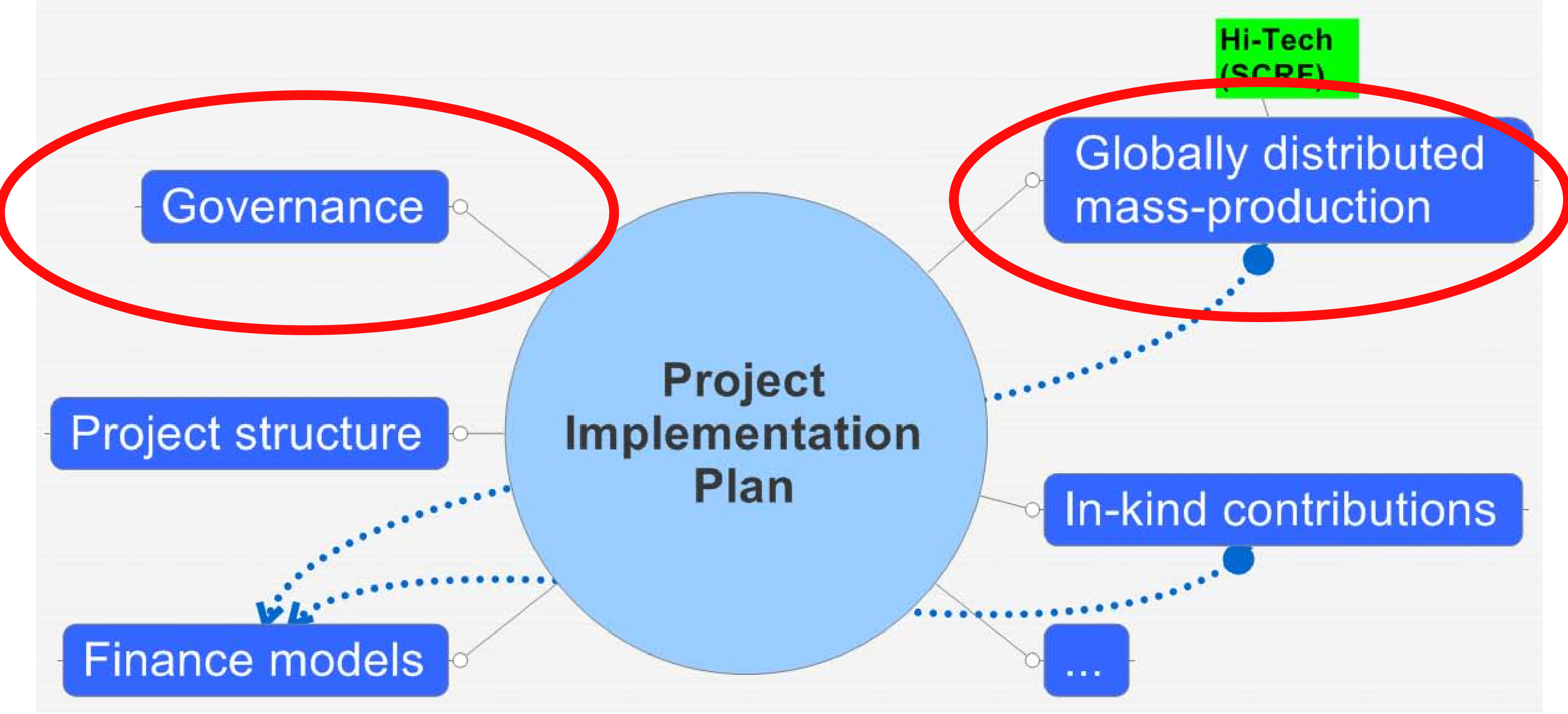
Collaboration Working Groups

	CLIC	ILC
Physics & Detectors	L.Linssen, D.Schlatter	F.Richard, S.Yamada
Beam Delivery System (BDS) & Machine Detector Interface (MDI)	L.Gatignon D.Schulte, R.Tomas Garcia	B.Parker, A.Seriy
Civil Engineering & Conventional Facilities	C.Hauviller, J.Osborne.	J.Osborne, V.Kuchler
Positron Generation	L.Rinolfi	J.Clarke
Damping Rings	Y.Papaphilipou	M.Palmer
Beam Dynamics	D.Schulte	A.Latina, K.Kubo, N.Walker
Cost & Schedule	P.Lebrun, K.Foraz, G.Riddone	J.Carwardine, P.Garbincius, T.Shidara

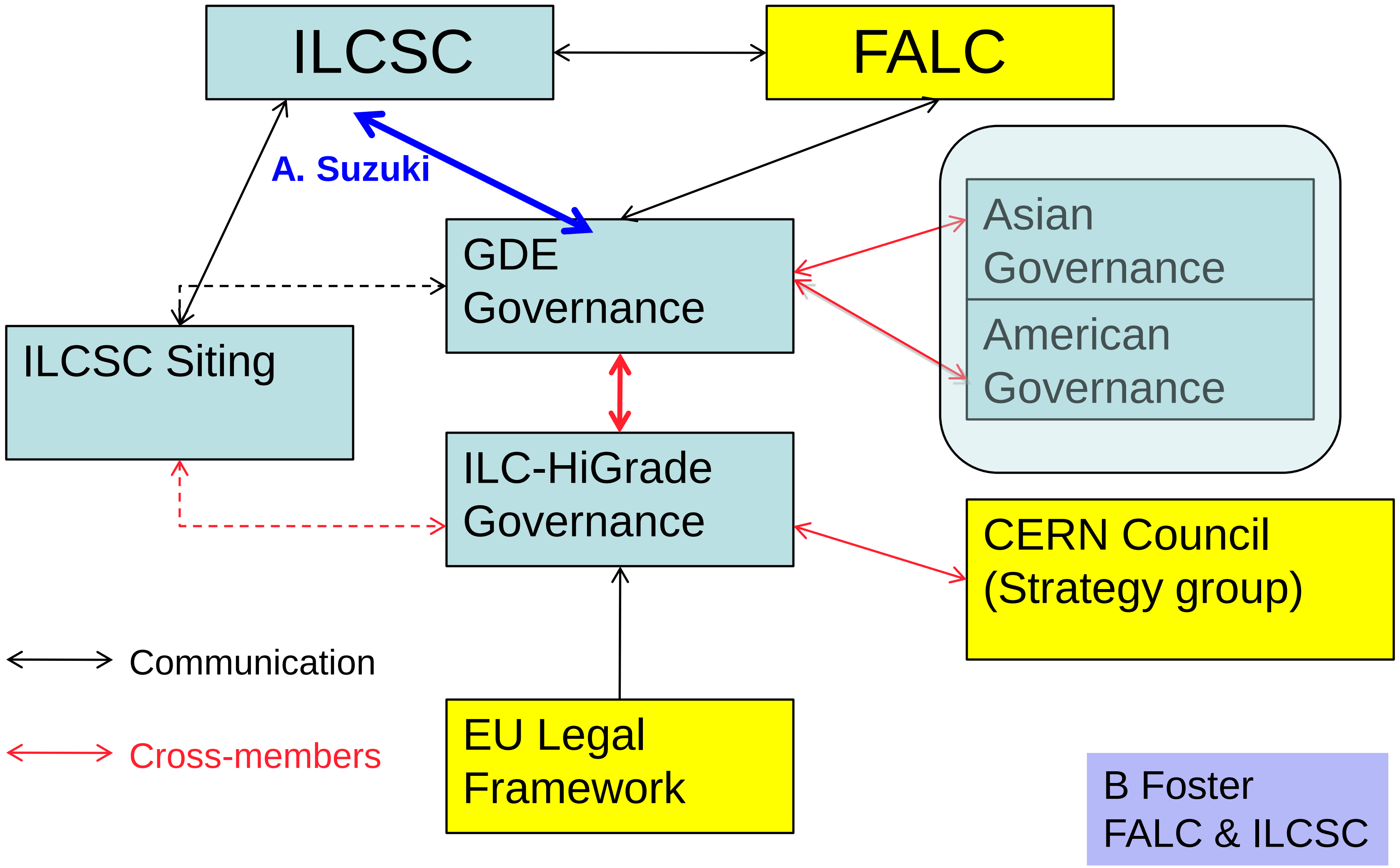
ILC / CLIC – Future Directions

- A recent management meeting at CERN reviewed collaborative status and looked at possible areas for additional co-operation.
- Conclusions from that meeting include:
  - **The existing working groups were deemed a success and we added two more (damping rings & positron production)**
  - **Jean Pierre Delahaye (CLIC Study Leader) has joined the GDE EC, and Brian Foster (European Regional Director) has joined the CLIC steering committee.**
  - **We plan to hold joint ILC/CLIC management meeting,**
  -
- There was discussion about creating a joint linear collider program general issues subgroup encompassing both the ILC and CLIC programs. A joint statement has been endorsed by ILCSC and the CLIC Collaboraton Board.

Project Implementation Plan



Governance



ILCSC
FALC
A. Suzuki
GDE Governance
Asian Governance
American Governance
ILCSC Siting
ILC-HiGrade Governance
CERN Council (Strategy group)
Communication
Cross-members
EU Legal Framework
B Foster
FALC & ILCSC

Timescale for ILC (Project Case)

- Technical Design and Costs (by end 2012)
  - **ILC Design optimized for cost / performance / risk**
  - **R&D program complete for major technical risk issues (SCRF gradient/yield, electron cloud mitigation, etc)**
  - **Industrialization advanced toward worldwide production**
  - **Value Costs well established**
  - **Safety, reliability and other project issues addressed.**

Timescale for ILC (Science Case)

	July	LHC	
8 TeV	2010	3 pb^{-1}	min bias, QCD
	2011	300 pb^{-1}	$\tilde{q}$ at 600 GeV, MET at 2σ, l+l+ at 3σ Z' at 1.5 TeV stable $\tilde{l}^-$ at 200 GeV
14 TeV	2012	1 fb^{-1}	$\tilde{q}$,$\tilde{g}$ at 1 TeV, MET, ll, lll at 5σ Higgs at 300 GeV in ZZ
	2013	10 fb^{-1}	Higgs at 140 GeV in ZZ*
	2014	30 fb^{-1}	Higgs at 120 GeV in $\gamma\gamma$ $t\bar{t}$ resonance at 3 TeV
	2015	100 fb^{-1}	strong WW scattering unexpected Q at 2 TeV
	2016	200 fb^{-1}	strong ZZ scattering unexpected Q at 3 TeV

M Peskin

What happens after 2012?

- Technical Design and Costs (by end 2012)
  - **ILC Design optimized for cost / performance / risk**
  - **R&D program completed for major technical risk issues (SCRF gradient/yield, electron cloud mitigation, etc)**
  - **Value Costs well established**
  - **Safety, reliability and other project issues addressed.**
- After 2012 ?
  - **Global plans are being developed.**
  - **Main elements – Continuing SCRF R&D, especially systems tests and industrialization; Selective design efforts (e.g. positrons); siting; etc**

Final Remarks

- **We will be well positioned to propose a robust well-developed project on a 2012-2013 timescale**

- **Earliest start for a construction project is ~ 2015, assuming science case, funding, siting, etc are in place**

- **CERN (see Sept *Physics World*) has stated its intent (or desire) to host a linear collider (either ILC or CLIC). This must be considered the most serious possibility, because of CERN 'stable' funding (earliest start ~ 2018)**

- **Japan or US are possible alternatives for hosting (Russia?). Japan is actively working toward the possibility (strong support group, siting efforts, industrialization, etc). Hosting efforts in the US are presently dormant, but the option remains viable, since we are developing key US technical infrastructures, etc.**