Status of International Electron-Positron Linear Collider

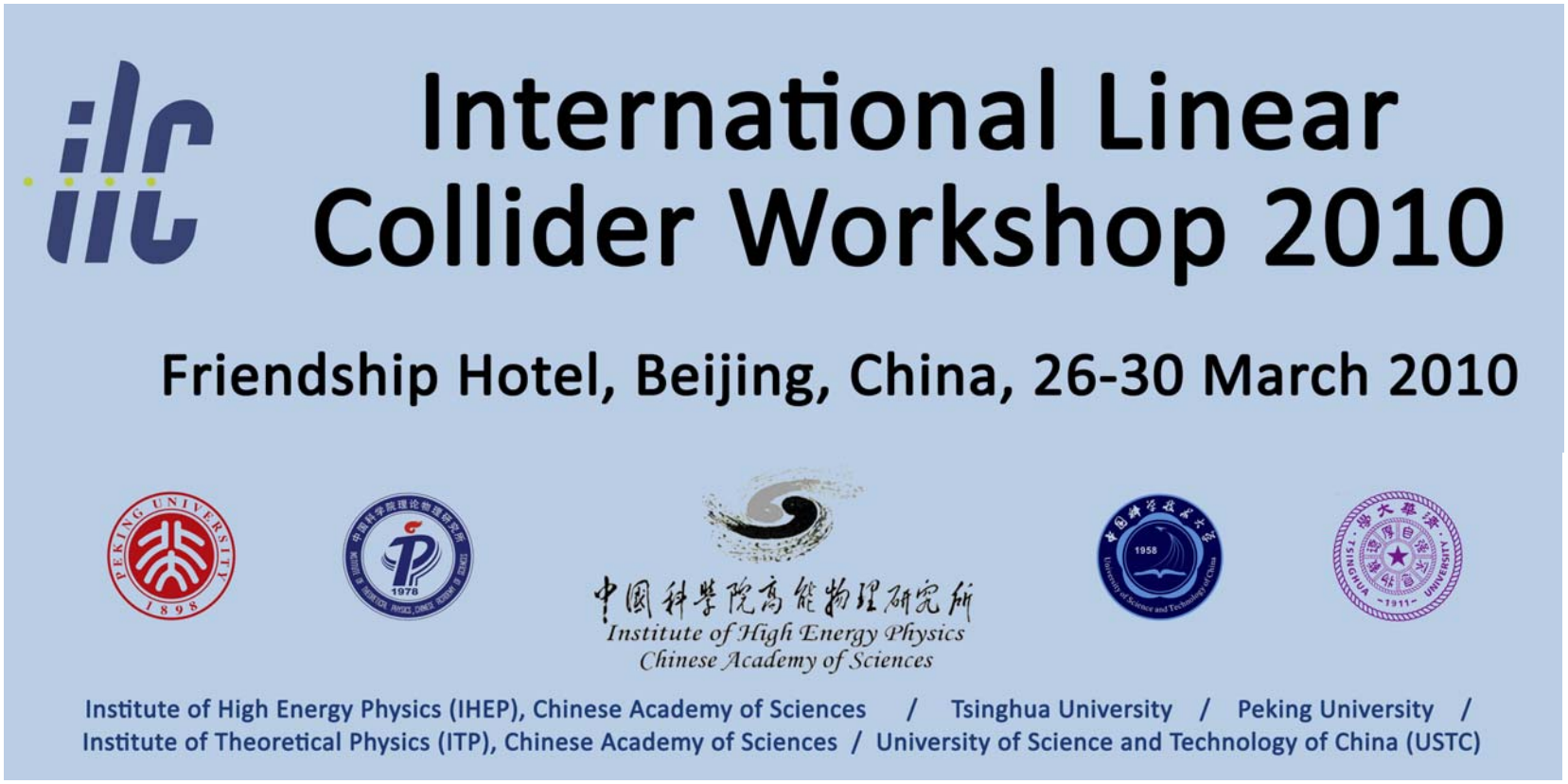
Jean-Eudes Augustin

LPNHE

08 April 2010

Transparencies stolen from: M.Peskin, B.Barish, Hesheng Chen,M.Ross, A.Yamamoto, M.Demarteau, S.Yamada, M.Davier,J-P.Delahaye, F.Richard…

Most recent information:



Presentations available on:

http://ilcagenda.linearcollider.org/conferenceOtherViews.py?view=standard&confId=4175

Michael Peskin in Albuquerque 2009

To begin, I would like to recall the elements of the ILC physics case as we made it in 2001.

We argued that,

Whatever would be found at the LHC, the next machine should be the ILC.

ILC

http://www.linearcollider.org

an **electron-positron collider**

at a **C.M energy of 500GeV upgradeable to 1 TeV**

with a luminosity of $2\ 10^{34}\ cm^{-2}s^{-1}$

to provide 500 events/femtobarn in 4 years

Michael Peskin in Albuquerque 2009

It is a truism in high-energy physics that

1. Higher energy is always better.
2. Technologies of the future will give us higher energy.

(CLIC, Muon Coll., Wakefields, New SC material, ?)

To advocate for the ILC,
we will need to argue that we cannot wait !

That is,

The specific phenomena found at the LHC urgently require new measurements that can only be made at an e+e- collider and are possible at 500 GeV.

The High Energy Physics community has since long set up an international cooperation body,

ICFA, the International Committee for Future Accelerators

It has a subcommittee:

the International Linear Collider Steering Committee **ILCSC**

ILCSC has set-up:

- the **Global Design Effort GDE** under Barry Barish in charge of the **accelerator and facility** design,

and

- the **physics and detector** management by the **Director of Research**, Sakue Yamada.

GDE produced the 2007 **ILC Reference Design** and is working on the 2012 Technical Design

the DR managed the **detector proposals and validation process** during 2009, and leads the detector work for the 2012 TD

Note: M Peskin reported in Albuquerque on the work of the Physics Group set-up by the Director of Research.

Plan of the talk:

GDE activities: Technical Design Phase

- **SupraConducting RF**
- **test facilities at DESY: FLASH**
  at KEK: ATF2
  at Cornell: CesrTA
- **Accelerator Design and Integration:rebaseline**
  Cost Containment, SB2009 proposal
- **Plans for the Project Implementation**

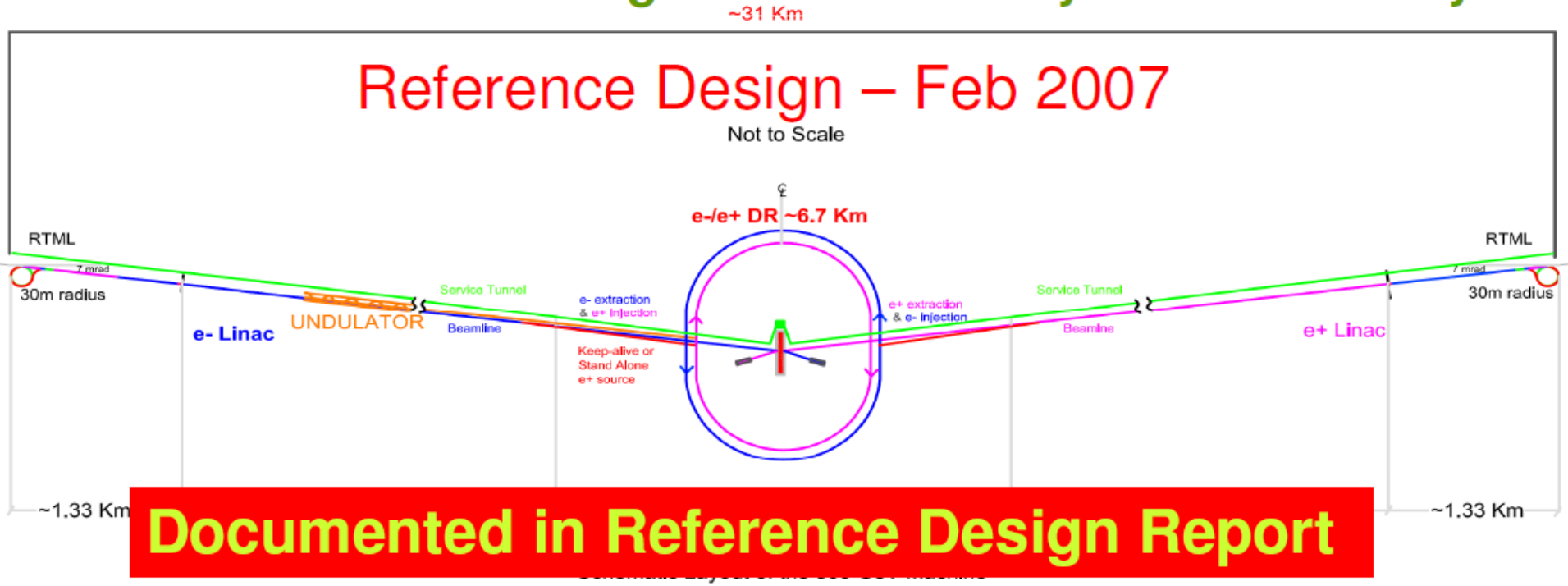
Physics and Detectors activities

- **Detectors Letters of Intent, and validation process**
- **Common tasks groups**
  Detector R&D

ILC – CLIC Collaboration

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



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

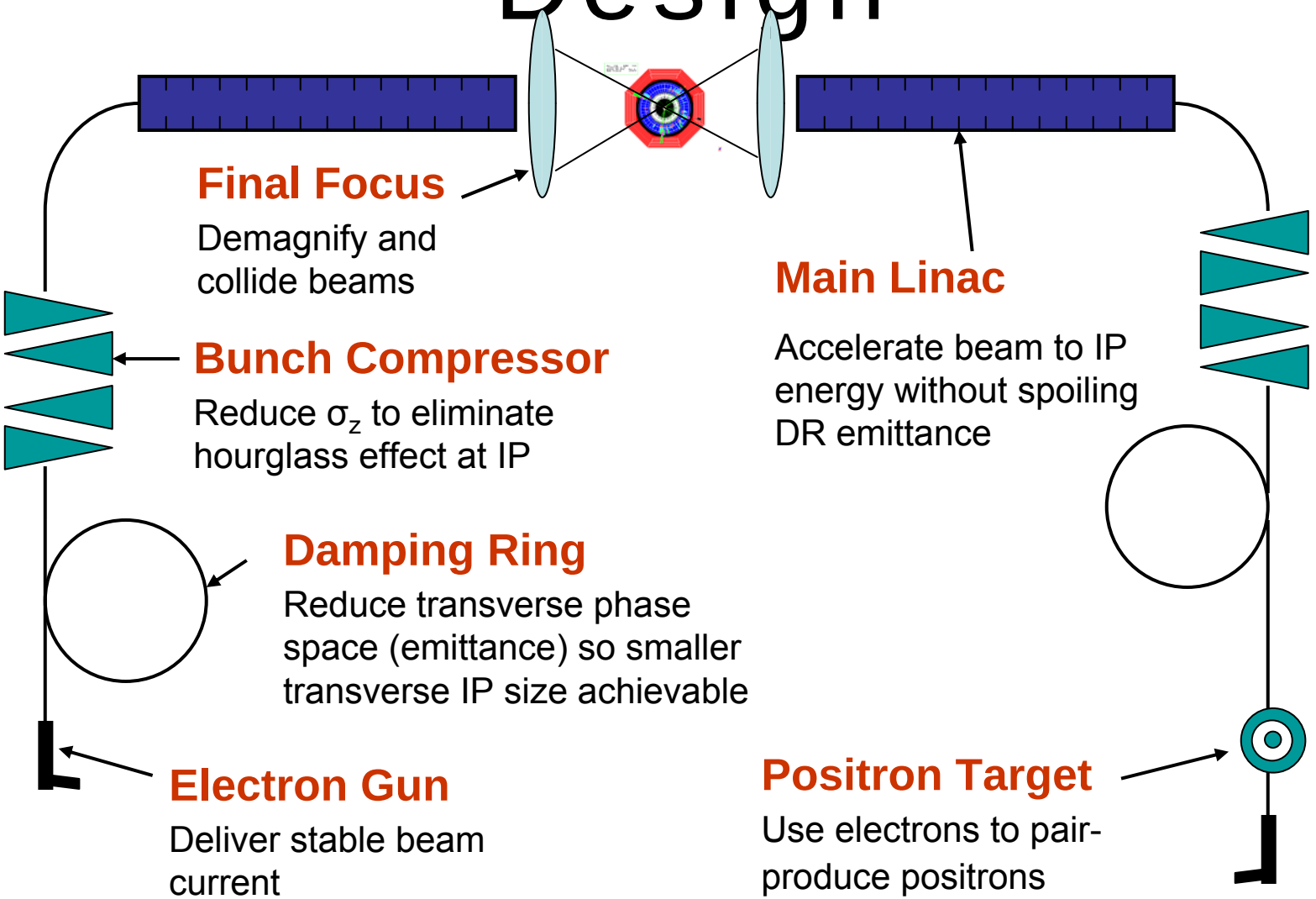
Major TDP Goals:

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

Updated every six months
A "living document"

ILC Accelerator Design

B.Barish



Final Focus

Demagnify and collide beams

Main Linac

Accelerate beam to IP energy without spoiling DR emittance

Bunch Compressor

Reduce σ_z to eliminate hourglass effect at IP

Damping Ring

Reduce transverse phase space (emittance) so smaller transverse IP size achievable

Electron Gun

Deliver stable beam current

Positron Target

Use electrons to pair-produce positrons

The ILC SCRF Cavity

B.Barish

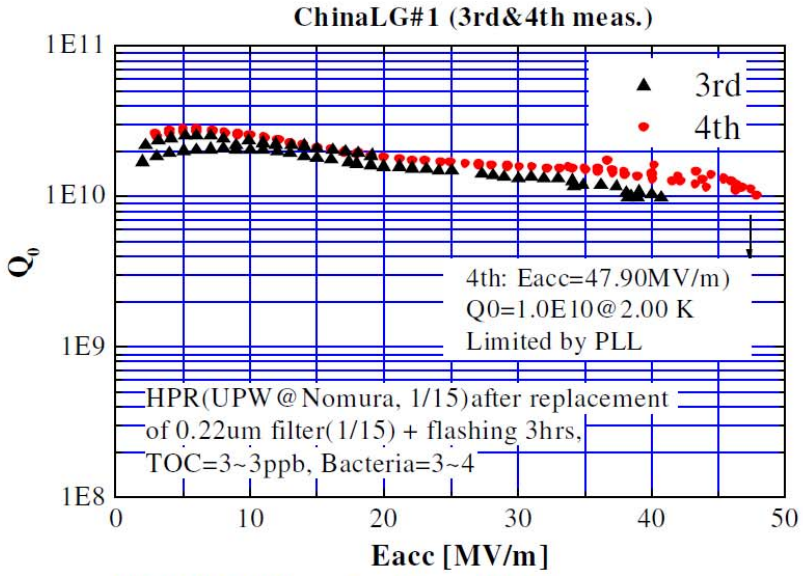
Figure 1.2-1: A TESLA nine-cell 1.3 GHz superconducting niobium cavity.

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

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

ILC cavity made by Chinese single crystal (collaborating with KEK Saito group)

Hesheng Chen



47.9 MV/m (after EP)

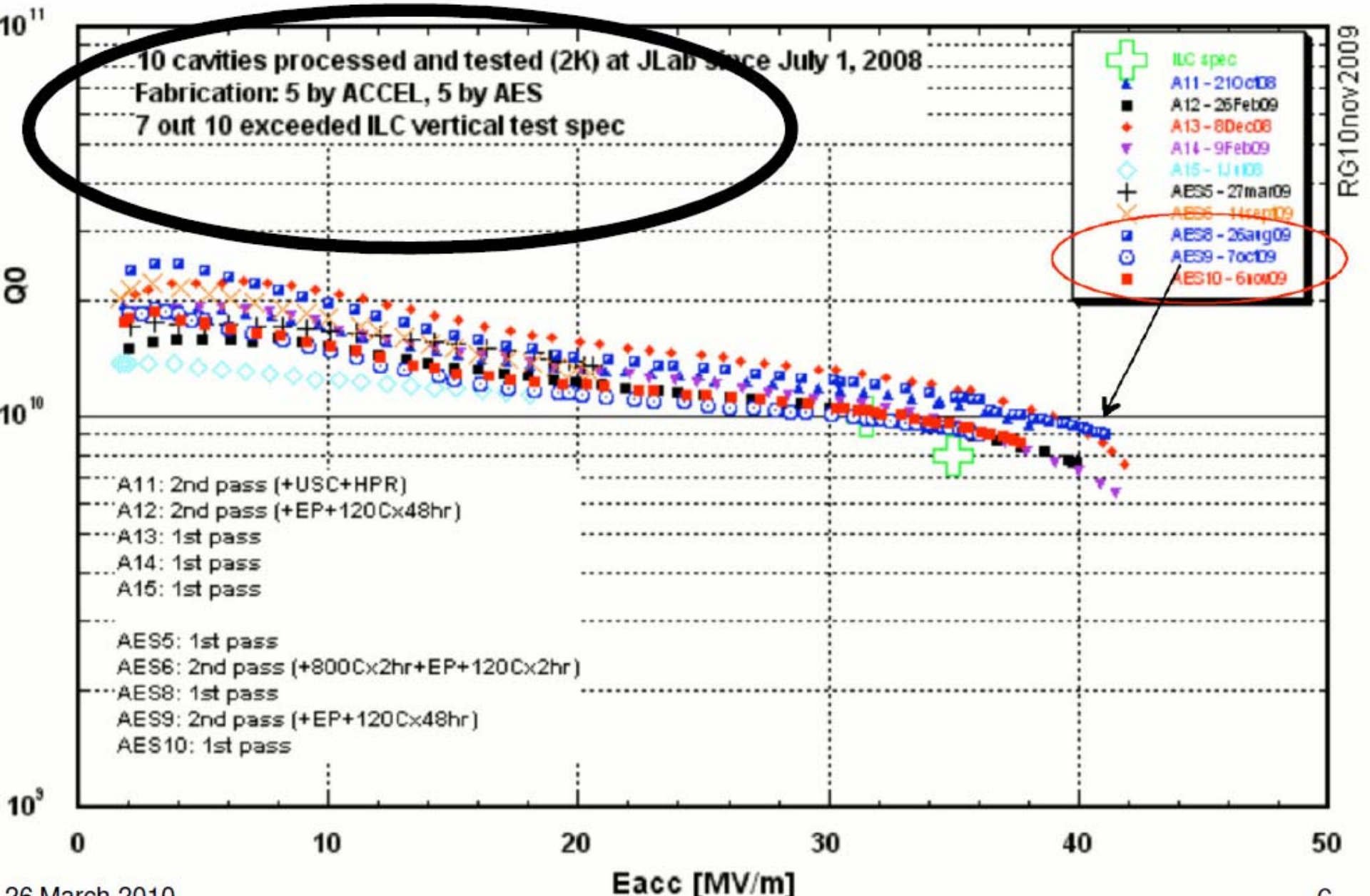
Global Plan for SCRF R&D

B.Barish

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		

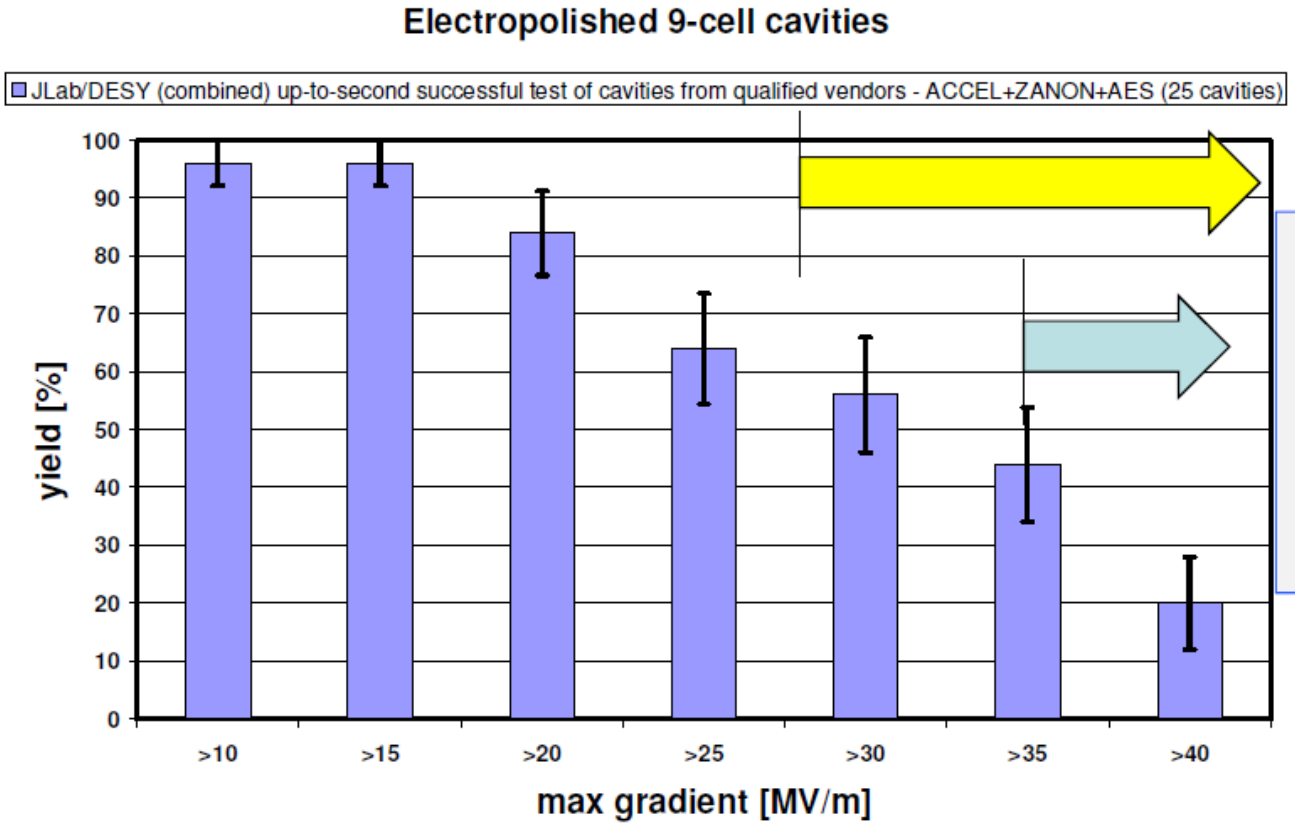
FY09 Results from JLab/FNAL

M.Ross



A.Yamamoto

‘Production Yield’ – 2009



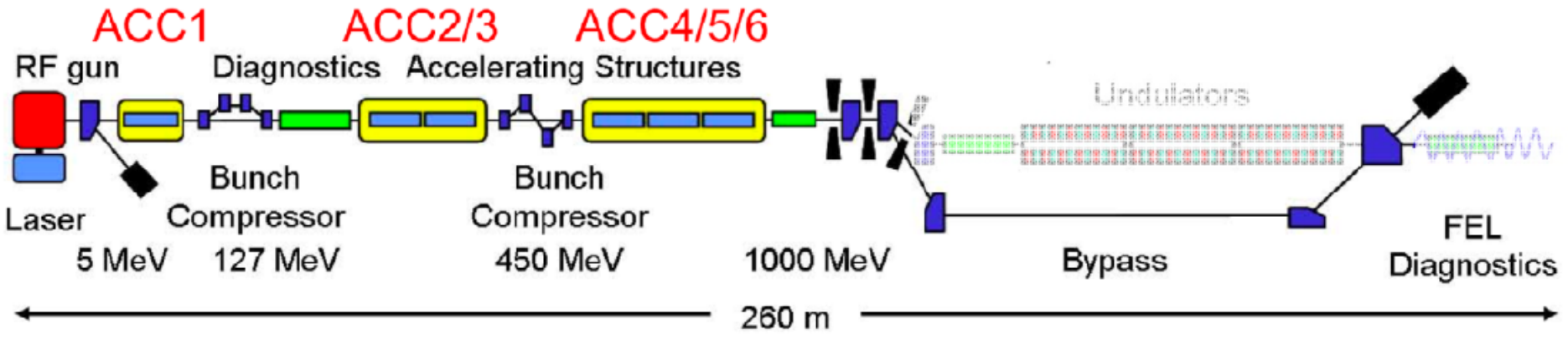
>35MV/m
35-41.8MV/m
44% yield
(RDR definition)

- 2009 proposal: high (> 35 MV/m) performance retained in system
- ‘Gradient spread’ – to ~20%

<36.5MV/m>
27.9-41.8MV/m
64% yield

High Power SCRF Linac Operation

DESY/FLASH 9mA – 36 kW



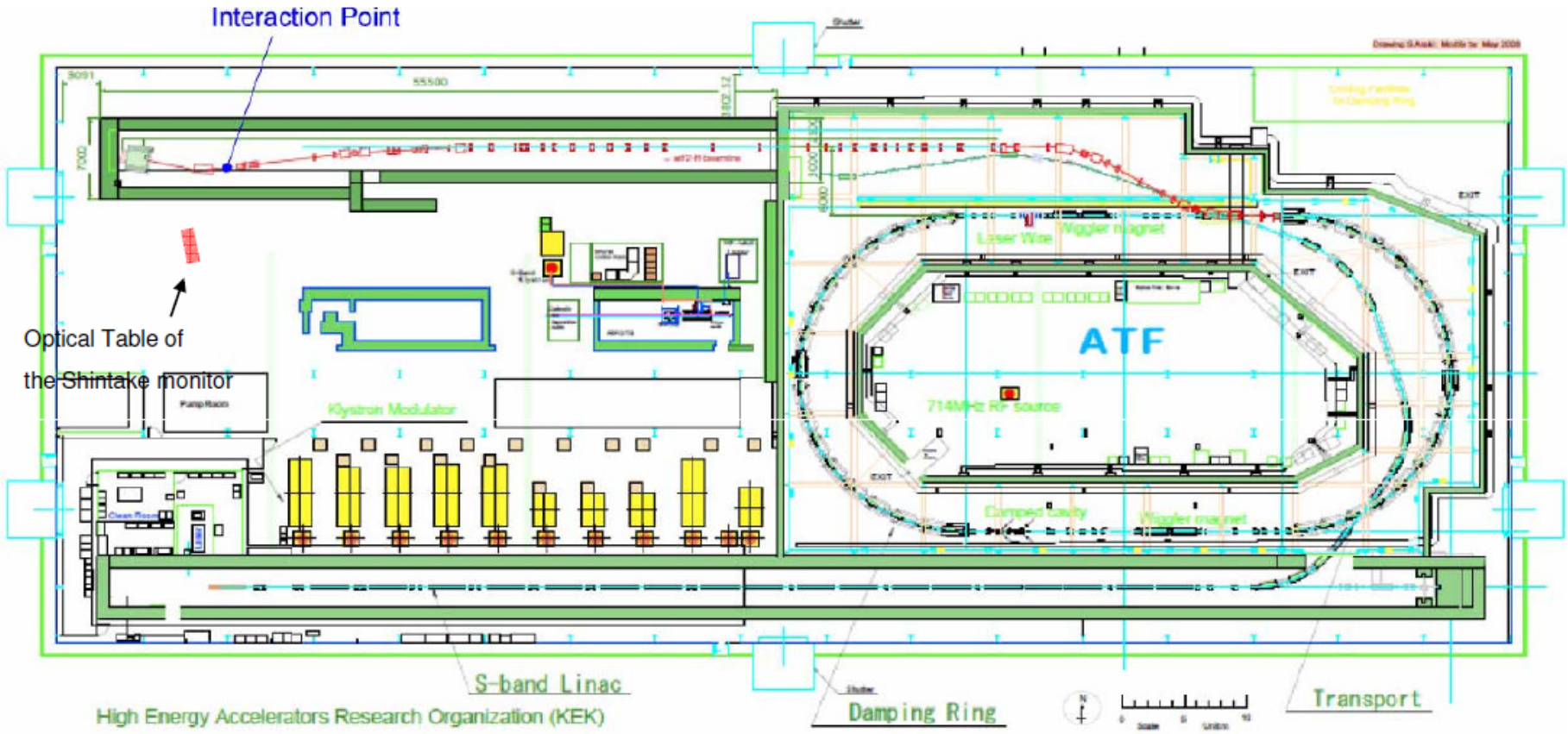
		XFEL X-Ray Free-Electron Laser	ILC	FLASH design	FLASH experiment
Bunch charge	nC	1	3.2	1	3
# bunches		3250*	2625	7200*	2400
Pulse length	μs	650	970	800	800
Current	mA	5	9	9	9

DESY, ANL, FNAL, SLAC, KEK

M.Ross

ATF/ATF2

B.Barish



ATF/ATF2 Layout

ATF2 Goals

- Test fast kicker magnet
- Focus the electron beam to 35 nm in vertical
- Stabilize the vertical beam position with 2 nm resolution

Rationale for Re-baseline

B.Barish

- Cost constraint in TDR
  - **Updated cost estimate in 2012 ≤6.7 BILCU**
  - **Need margin against possible increased component costs**

''Cost containment''

- Process forces critical review of RDR design
  - **Errors and design issues identified**
  - **Iteration and refinement of design**
  - **More critical attention on difficult issues**

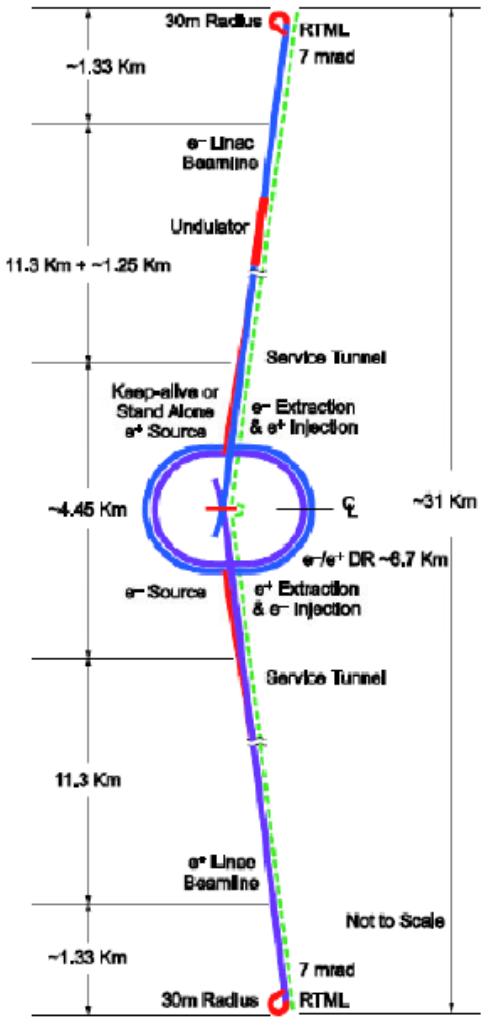
- Balance for risk mitigating R&D
  - **Majority of global resources focused in R&D**
  - **Important to prepare / re-focus project-orientated activities for TDP-2**

- Need for design options and flexibility
  - **Unknown site location**

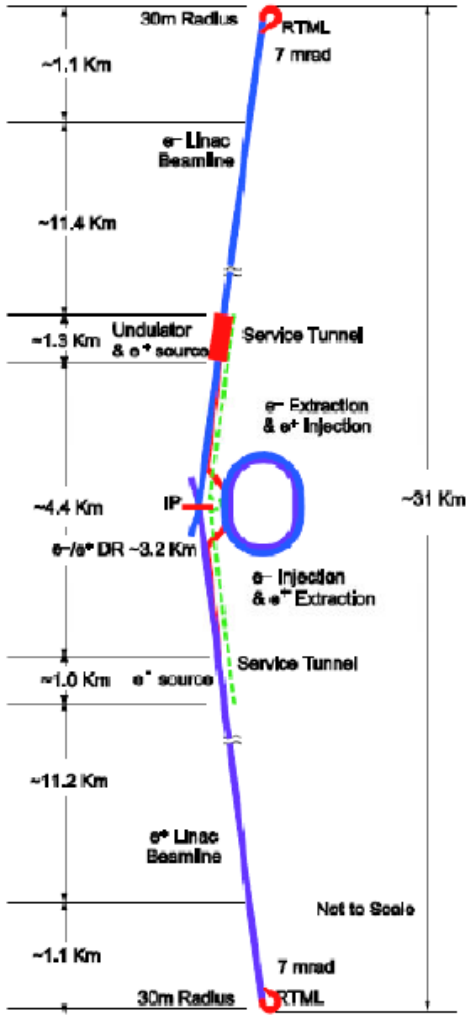
Proposed Design changes for TDR

B.Barish

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
- Single stage bunch compressor

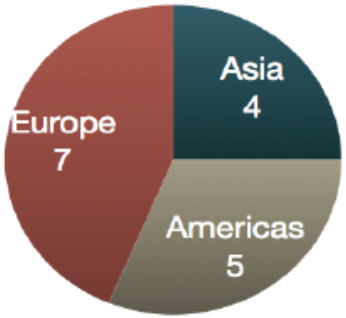
AAP Review

B.Barish

- **The Accelerator Advisory Panel review addressed the superconducting RF program, conventional facilities, electron cloud R&D, test facilities operation and project management.**

AAP Reviewers

- Regular Members
  - C Damereli
  - J Dorfan
  - E Elsen
  - T Himel
  - M Kuriki
  - O Napoly (*)
  - K Oide
  - H Padamsee
  - T Raubenheimer
  - D Schulte
  - W Willis



- External Members
  - N Hoitkamp (*)
  - L Rossi (*)
  - T Tajima
  - M Uesaka
  - F Zimmermann

(*) apologies received

- F Lehner served as the scientific secretary for this meeting

Conclusion (final)

B.Barish

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.***

A.Yamamoto

Summary of GDE meeting in Beijing last week

- **What to have been worked in ILC10?**
  - Key themes in SB2009, and
  - Communication with Physics/Detector Groups
- **Where we have reached?**
  - Cavity Gradient, Single Tunnel,
  - Low Power Parameters, e+ Source location
    - A solution to keep a higher luminosity
- **What we plan, further?**
  - Process for Consensus with Phycis/Detector,
  - Proposal for Top Level Change Control
- **Summary**

Next: proposals and discussions at the CERN-ECFA october meeting

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Physics and Detectors activities

- **Detectors Letters of Intent, and validation process**
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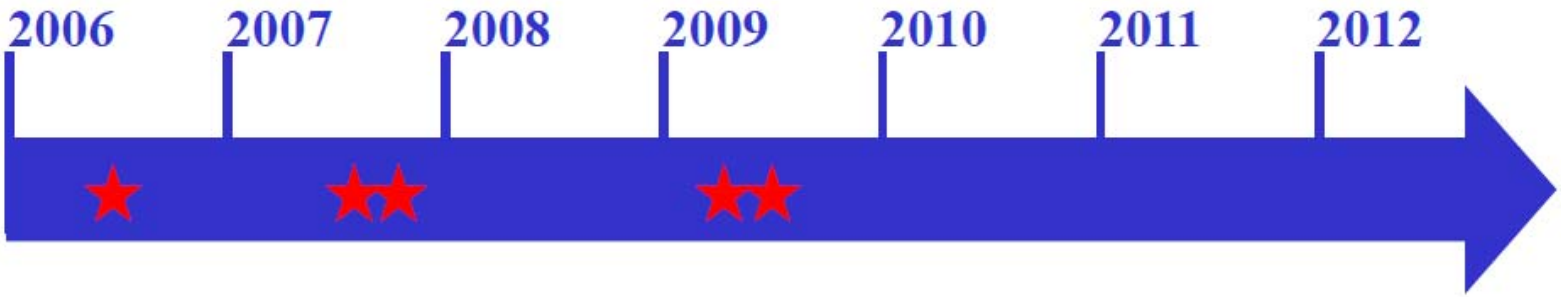
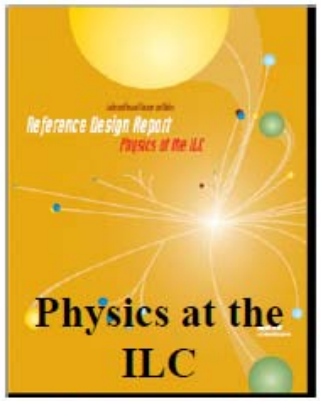
  Detector R&D

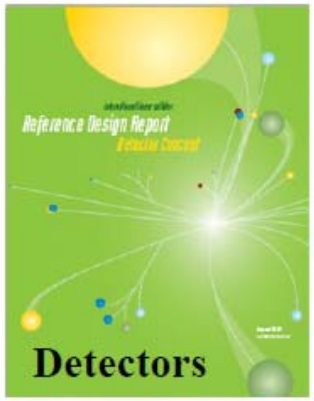
ILC – CLIC Collaboration

Recent Timeline

Physics & Detectors







- May 2006: Submission of Detector Outline Document by 4 concepts
- August 2007: Submission of Reference Design Report
- Fall 2007: Appointment of Research Director
- All of 2007: three independent WWS Detector R&D Reviews
- Spring 2008: IDAG formed
- ECFA WS June 2008: Start of IDAG validation process
- March 31, 2009: Submission of three LOIs

- Today: validation process complete

International Detector Advisory Group IDAG

Review Organization

- 'vertical' reviews by subject with one convener (all projects studied)
- 'horizontal' reviews by project with one referee (all aspects included)

	Benchmarking		Tracking	Calorimetry	MDI
ILD	Hewett	Li	Nickerson	Green	Himel
SiD	Grosjean	Palestini	Danilov	Karlen	Toge
4th	Godbole	Grannis	Elsen	Kobayashi	Kim

Davier

ILC Physics and Challenges

Precision on momentum, jet energy, and vertex; hermeticity; granularity

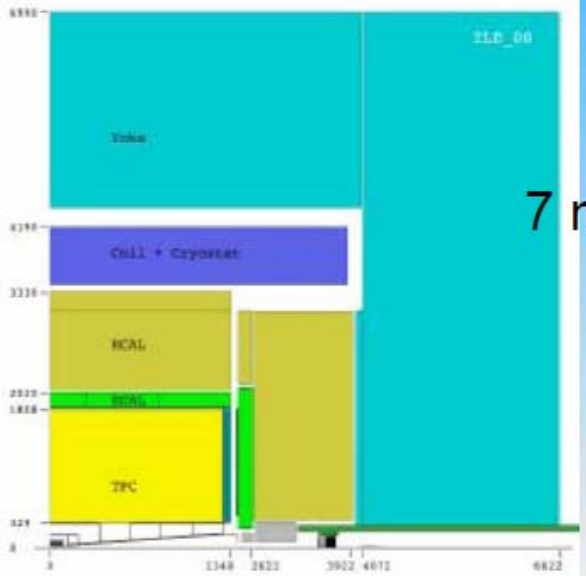
Benchmark processes

Reaction	Detector parameter tested	Measurements
$e^+e^- \to Z(\to l^+l^-)H$ $m_H = 120$ GeV, $\sqrt{s} = 250$ GeV	p resolution material distribution γ recovery	m_H σ
$e^+e^- \to ZH(H \to c\bar{c}, Z \to \nu\bar{\nu})$ $m_H = 120$ GeV, $\sqrt{s} = 250$ GeV	heavy flavor tagging secondary vertex reconstruction particle id.	$BR(H \to c\bar{c})$
$e^+e^- \to ZH(H \to c\bar{c}, Z \to q\bar{q})$ $m_H = 120$ GeV, $\sqrt{s} = 250$ GeV	same as for $e^+e^- \to ZH(H \to c\bar{c}, Z \to \nu\bar{\nu})$ confusion resolution capability	$BR(H \to c\bar{c})$
$e^+e^- \to Z \to \tau^+\tau^-$ $\sqrt{s} = 500$ GeV	τ reconstruction particle flow π^0 reconstruction tracking of close tracks	σ A_{FB} τ polarization
$e^+e^- \to t\bar{t}(t \to bqq')$ $m_t = 175$ GeV, $\sqrt{s} = 500$ GeV	multi jets particle flow b tagging lepton tagging tracking	σ A_{FB} m_t
$e^+e^- \to \chi^+\chi^-/\chi_2^0\chi_2^0$ $\sqrt{s} = 500$ GeV	particle flow WW, ZZ separation multi jets	σ masses

The 3 concepts: sizes

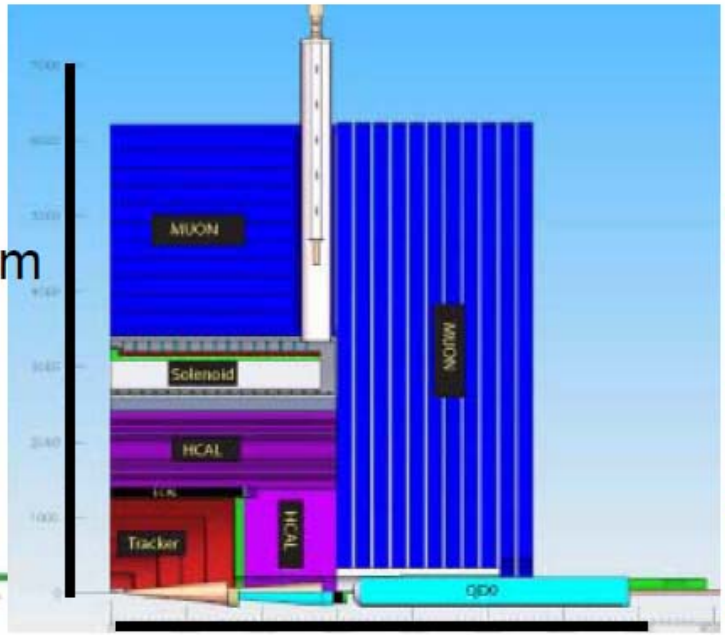
(¼ R-z view)

ILD



7 m

SiD



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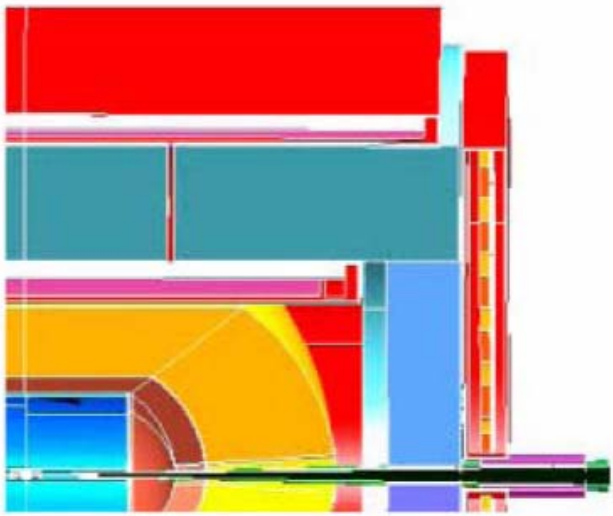
Fourth



IDAG Recommendations

a. **The ILD and SiD concepts are validated and should be considered for the next phase of detailed baseline studies together with GDE. They constitute a solid basis for the two-detector push-pull concept with a large amount of complementarity in their design and expected performances. Tracking options are very different, and even if their baseline choices for calorimetry are similar, their implementation and exploitation will ensure robustness in the ILC physics results. They should both demonstrate a feasible solution at the end of the TDR phase of the accelerator.**

b. **The Fourth concept is not validated. However R&D on dual readout calorimetry should be supported in view of its potential for higher energy colliders.**

Full IDAG report available in ILC web → Physics and Detectors → IDAG
http://ilcdoc.linearcollider.org/record/23970/files/IDAG_report_090816.pdf

Activity of the two validated detector groups

- **Purpose of the present work:**
- In 2012, when GDE provides a report which will be used to propose the project to governments,

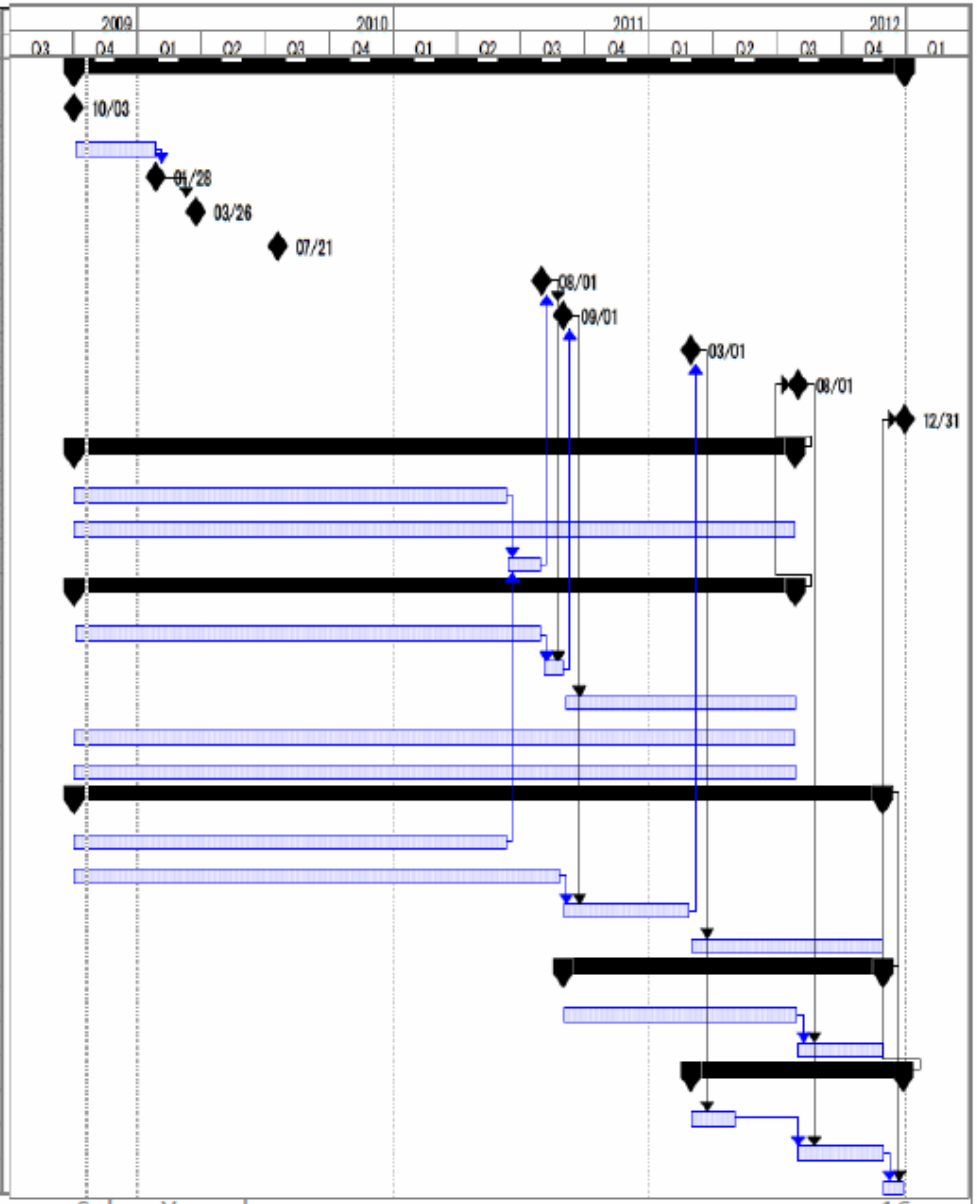
  we need ***to present that detectors can be built to pursue desired physics.***

- Each validated detector group intends to complete its **detailed baseline design**, *which is still* ***conceptual but detailed enough***

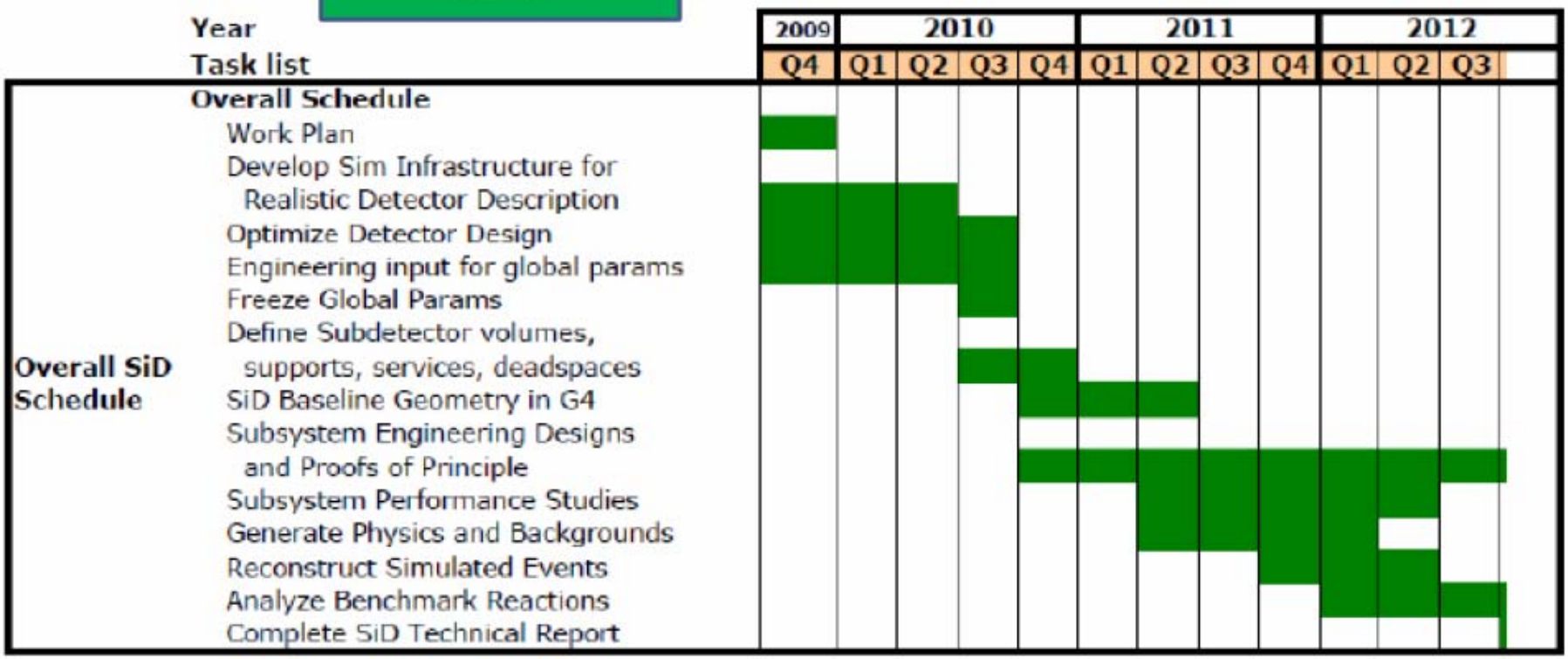
  to design MDI parameters and integration with the accelerator, and ***to allow realistic physics simulations***.

ILD

ID	Name	Duration
1	**Detailed baseline design**	**38.41mons**
2	LCWA2009	0mons
3	Detailed Work Plan	3.7mons
4	ILD Workshop	0mons
5	LCWS2010	0mons
6	ICHEP2010	0mons
7	Define a feasible baseline options (2)	0mons
8	Define a feasible baseline design (2)	0mons
9	Complete implimentation of design	0mons
10	Freeze design	0mons
11	Submit detailed baseline design report	0mons
12	**Detector R&D**	**33.4mons**
13	R&D for proof of principle of the baseline (1)	20mons
14	R&D for detailed design/industrialization (1,2)	33.4mons
15	R&D Review	1.5mons
16	**MDI/Integration**	**33.41mons**
17	R&D for integration/alignment	21.59mons
18	Complete baseline integration design (3)	0.91mons
19	Detailed design of integration/alignment (3)	10.68mons
20	R&D for push-pull mechanism (5)	33.4mons
21	Design of integration with accelerator (6)	33.41mons
22	**Simulation**	**37.45mons**
23	Simulation on det. performance/optimization	20mons
24	Improvement of framework/tools/analysis	22.5mons
25	Implimentation of baseline (4)	5.8mons
26	Simulation/Analysis (7,8)	8.9mons
27	**Cost estimate (9)**	**14.82mons**
28	Develop methodology	10.8mons
29	Estimate for the baseline design	3.95mons
30	**Writing the report**	**9.86mons**
31	Progress report	2mons
32	DBD report drafting	3.95mons
33	DBD report editing	0.95mons



SiD



The very long graph below shows the SiD schedule for individual susbsystems.

They also list required and available resources for each item.

Common Task Groups

- Physics Panel Convener: Michael Peskin
- Detector R&D Panel Convener: Marcel Demarteau ◀
- **Software Panel** Convener Akiya Miyamoto
- Machine Detector Interface MDI
  Convener: Karsten Büsser
- **Engineering Tools** Convener Catherine Clerc

\+ SB2009 Working Group Convener Jim Brau

R&D Collaborations

- CALICE Collaboration
- FCAL Collaboration
- LC-TPC Collaboration
- SILC Collaboration
- VERTEX Detector R&D groups
- SiD Tracking
- SiD ECal
- Dual Readout Studies
- EUDET
- …

- **Observation:**
  - The LOI and subsequent validation process had an element of competition; It is NOT a competition anymore! Our job is to prove that the ILC can do the job and that it's the only option when the LHC says 'go'!

Crucial Detector R&D Topics

- **Five areas have been identified as pillars of the detector concepts that need to be validated by 2012 to put a proposal for a concept detector on a firm scientific basis**

  1. **Areas of Particle Flow Calorimetry within CALICE**
  2. **Further development and understanding of two Particle Flow Algorithms**
  3. **Three areas of LC-TPC studies**
  4. **kPiX**
  5. **Test Beams**

- **For the first four topics, will state**
  - **Goal of R&D and status**
  - **Areas that have been identified as critical and in need of additional resources**

- **By elevating the importance of these R&D topics and providing in a timely manner limited additional resources, the experimental foundation for the detector concepts would be on a much stronger basis by 2012**

- **Please note that, given the fragility of the detector community, it is equally essential to keep the other R&D programs at the current level**

- **A report is being drafted with these recommendations to the RD; We're almost close to a consensus!**

M.Demarteau

ILC Research and Development Plan for the Concept Detectors

Version 0.1

October 2009

ILC Research Directorate

Director: Sakue Yamada

DRAFT

Prepared by the Common Task Group for Detector R&D:

Roberto Carosi, Dhiman Chakraborty, Marcel Demarteau (convenor), Franco Grancagnolo (deputy convenor), John Hauptman, Ron Lipton, Wolfgang Lohmann, Aurore Savoy-Navarro, Felix Sefkow, Tohru Takeshita, Yuri Tikhonov, Jan Timmermans, Andy White

Working group to study SB2009

- In order to study SB2009 and communicate with GDE in a systematic way, a working groups was formed after the Albuquerque meeting.

Members: Jim Brau (management, convener)

Mark Thomson(ILD), Tom Markiewicz(SiD)

Karsten Buesser(MDI),

Akiya Miyamoto (Software)

Keisuke Fujii (Physics)

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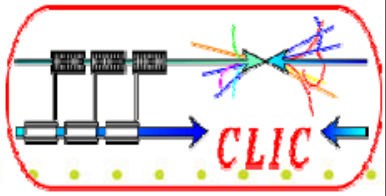
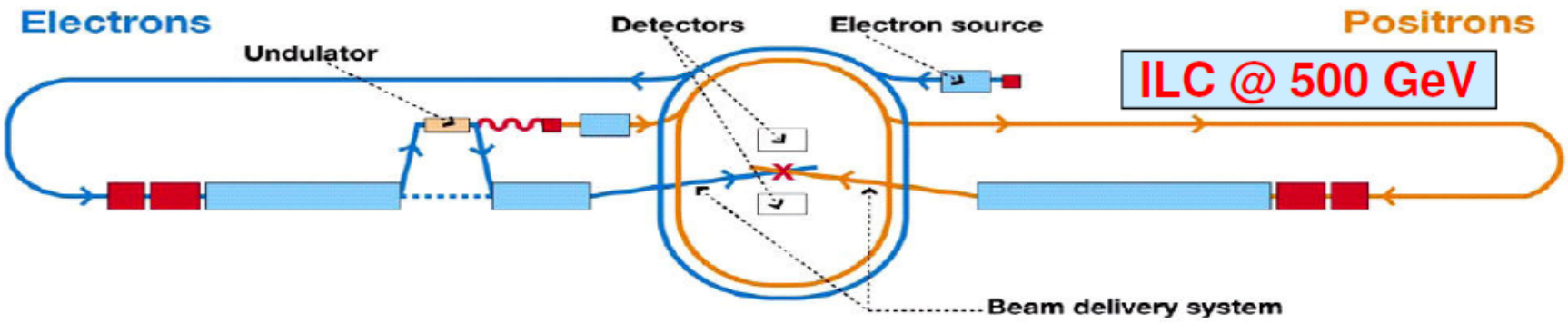
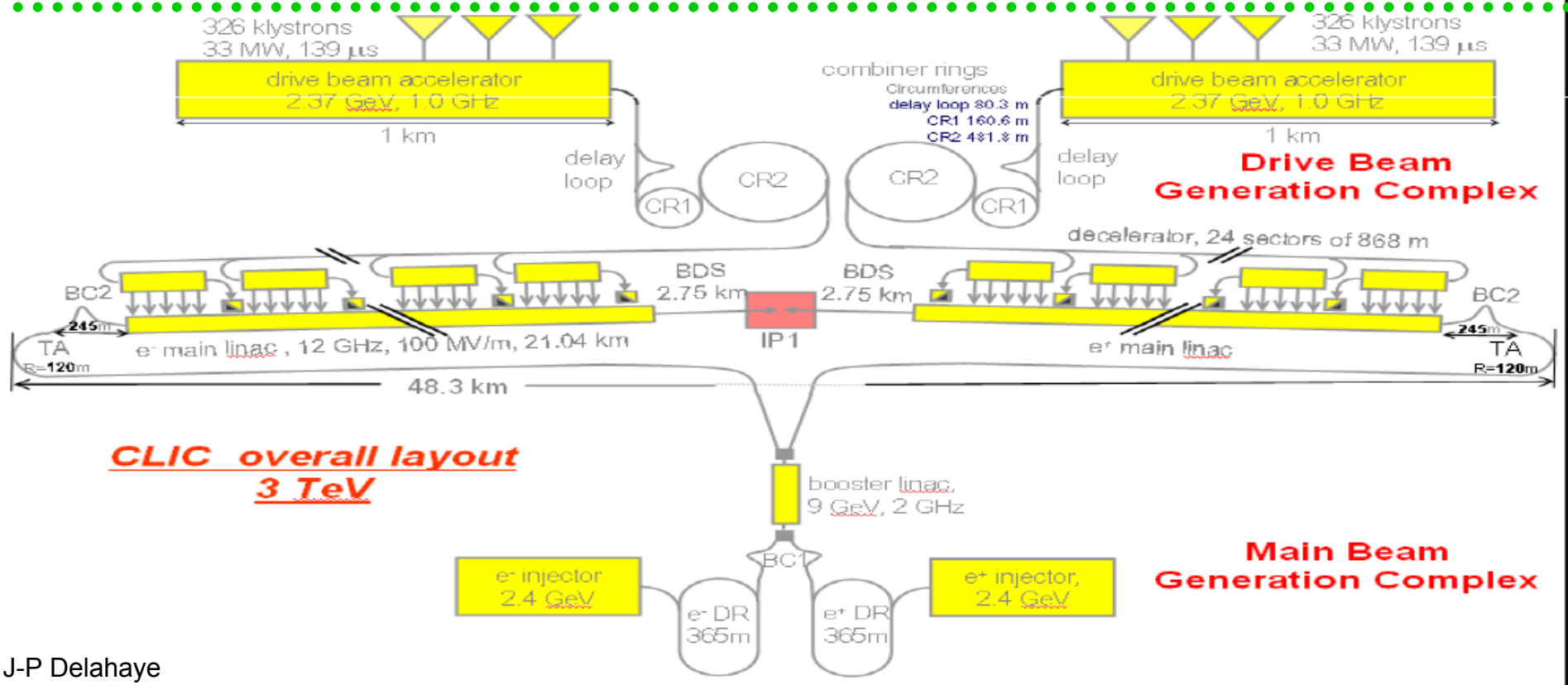
Detector R&D

ILC – CLIC Collaboration

CLIC and ILC layouts

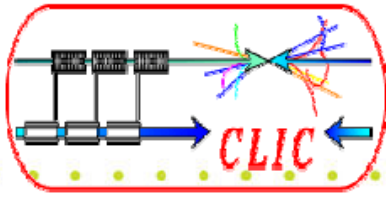






J-P Delahaye

CLIC/ILC technical collaboration on subjects with strong synergies



	CLIC	ILC
Physics & Detectors	L.Linssen, D.Schlatter	F.Richard, S.Yamada
Positron Generation	L.Rinolfi	J.Clarke
Damping Rings	Y.Papaphilipou	M.Palmer
Beam Dynamics	D.Schulte	A.Latina, K.Kubo, N.Walker
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
Cost & Schedule	P.Lebrun, K.Foraz, G.Riddone	J.Carwardine, P.Garbincius, T.Shidara

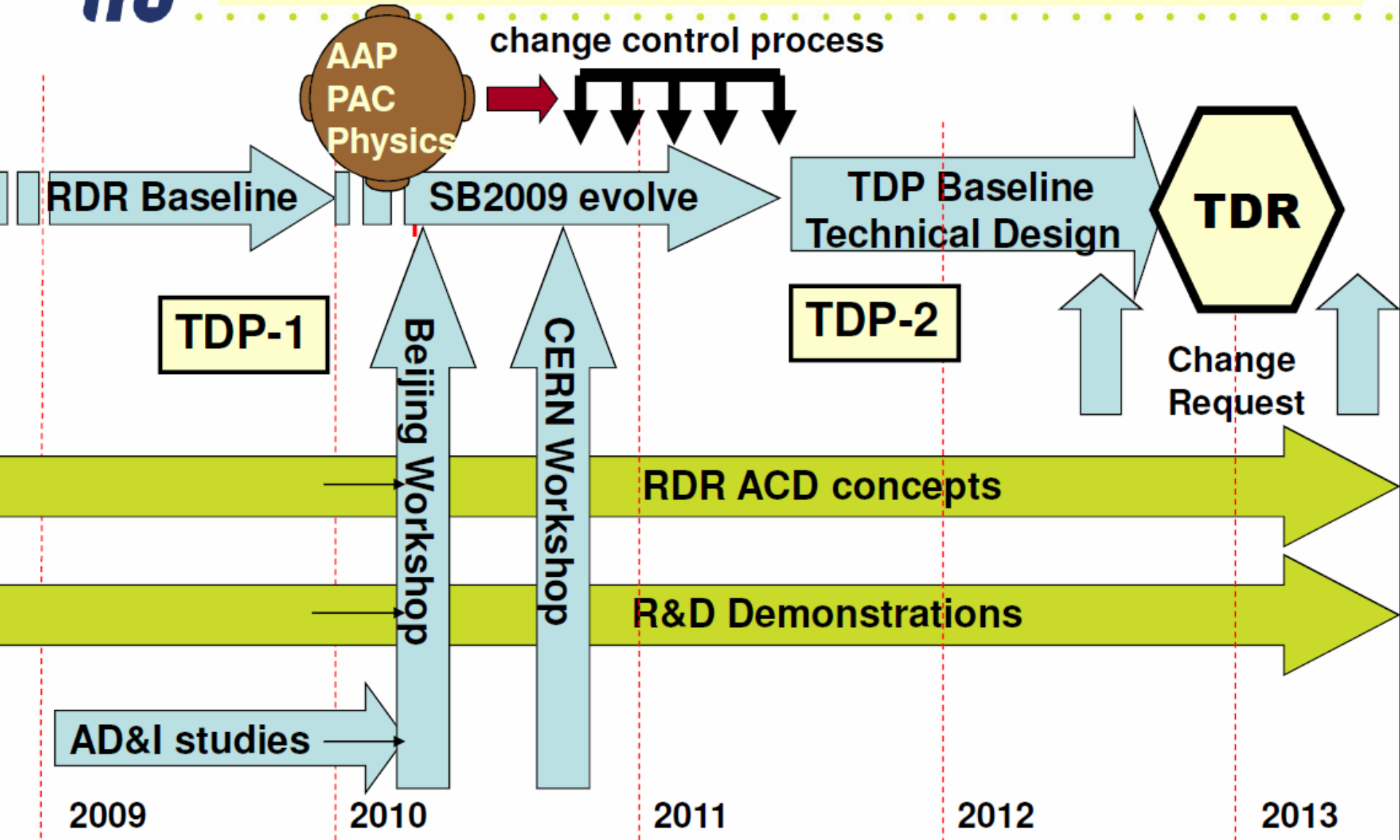
Next steps:

– **International Workshop on Linear Colliders 2010 (ECFA-CLIC-ILC Joint Meeting)** organized by the European Committee for Future Accelerators (ECFA) will study the physics, detectors and accelerator complex of a linear collider covering both CLIC and ILC options.
Dates : Monday 18 October - Friday 22 October 2010.
Venue: CERN and CICG (International Conference Centre Geneva, Switzerland)

and:

--- Interim report **Technical Design Phase 1** **end** 2010

Technical Design Phase and Beyond



Back_ups

Michael Peskin in Albuquerque 2009

If the LHC discovers that electroweak symmetry breaking results from a new spectroscopy such as supersymmetry,

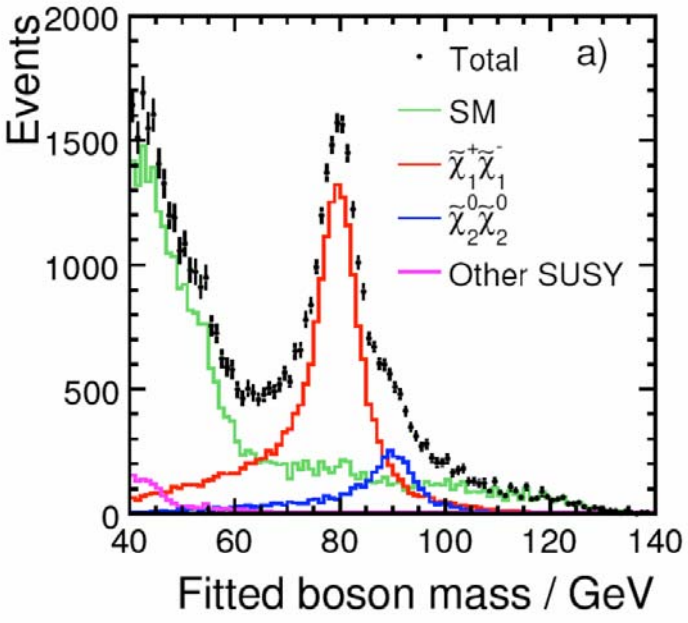
the ILC is needed to determine the model unambiguously by measuring the masses, couplings and spins of new particles.

If the LHC discovers that electroweak symmetry breaking results from strong interactions in the Higgs sector,

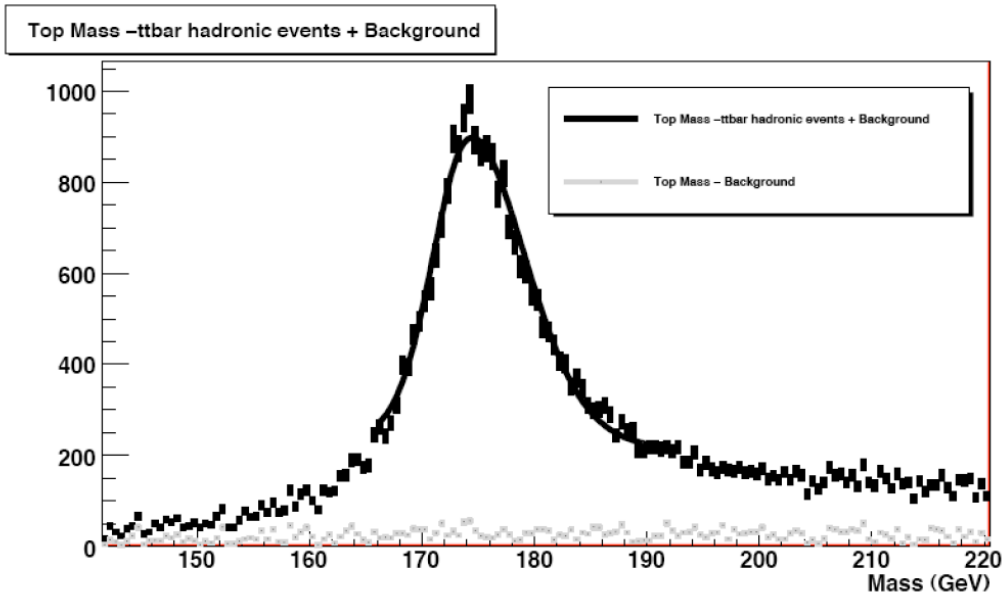
the ILC is needed to measure these strong interactions through W and top processes.

If the LHC discovers a minimal Higgs boson and nothing else,

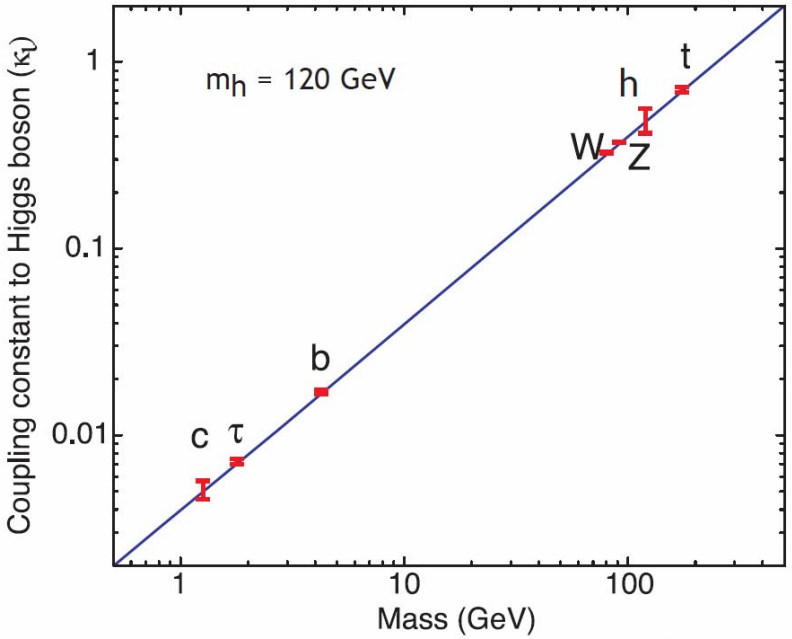
the ILC is needed to check precisely that this particle indeed generates all masses of quarks, leptons, and gauge bosons.



ILD LOI

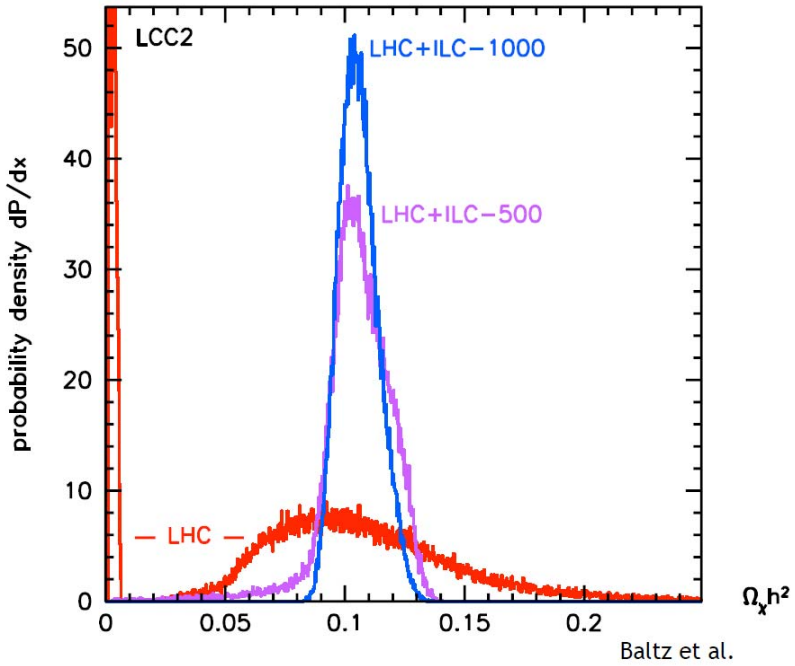


SiD LOI



ACFA LC study

and also dark matter if…



Baltz et al.

RDR Design & "Value" Costs

B.Barish

- 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$

The 3 concepts: choices and numbers

	ILD	SiD	Fourth
Vertex	Si pixels	Si pixels	same as SiD
Tracker	TPC + Si strips layers	Si strips 5 double layers	Small-cell He drift chamber (clusters)
Forward	Si strips disks	Si strips disks	not specified
EM calo	W+Si pix.(scint.strips) 23 X_0 0.25 cm^2	W +Si pix. 26 X_0 0.13 cm^2	BGO +? 25 X_0 4(1) cm^2
Had calo	Fe+scint. tiles (gas) 5.5 λ 9 cm^2	Fe+RPC pads 4.8 λ 1 cm^2	Cu+quartz/scint. fibers 7.3 λ 19 cm^2
Magnet	3.5 T 3.35 m	5 T 2.6 m	3.5 T 3 m (inner)
Flux return	Fe 7 m	Fe 6 m	Air 1.5T outer sol.
Muon	RPC (scint.strips)	RPC (scint.strips)	Al drift tubes

Validation of the LOIs and Reorganization

- IDAG examined the LOIs very intensively.
- Its report was made on August 17,

  earlier than formerly expected.
- **IDAG Conclusion:**

  ILD and SiD are recommended to be developed.

  The dual readout cal technology is recommended for R&D.
- **ILCSC in Hamburg on August 19 endorsed the IDAG conclusion.**
- We could go into the new phase.

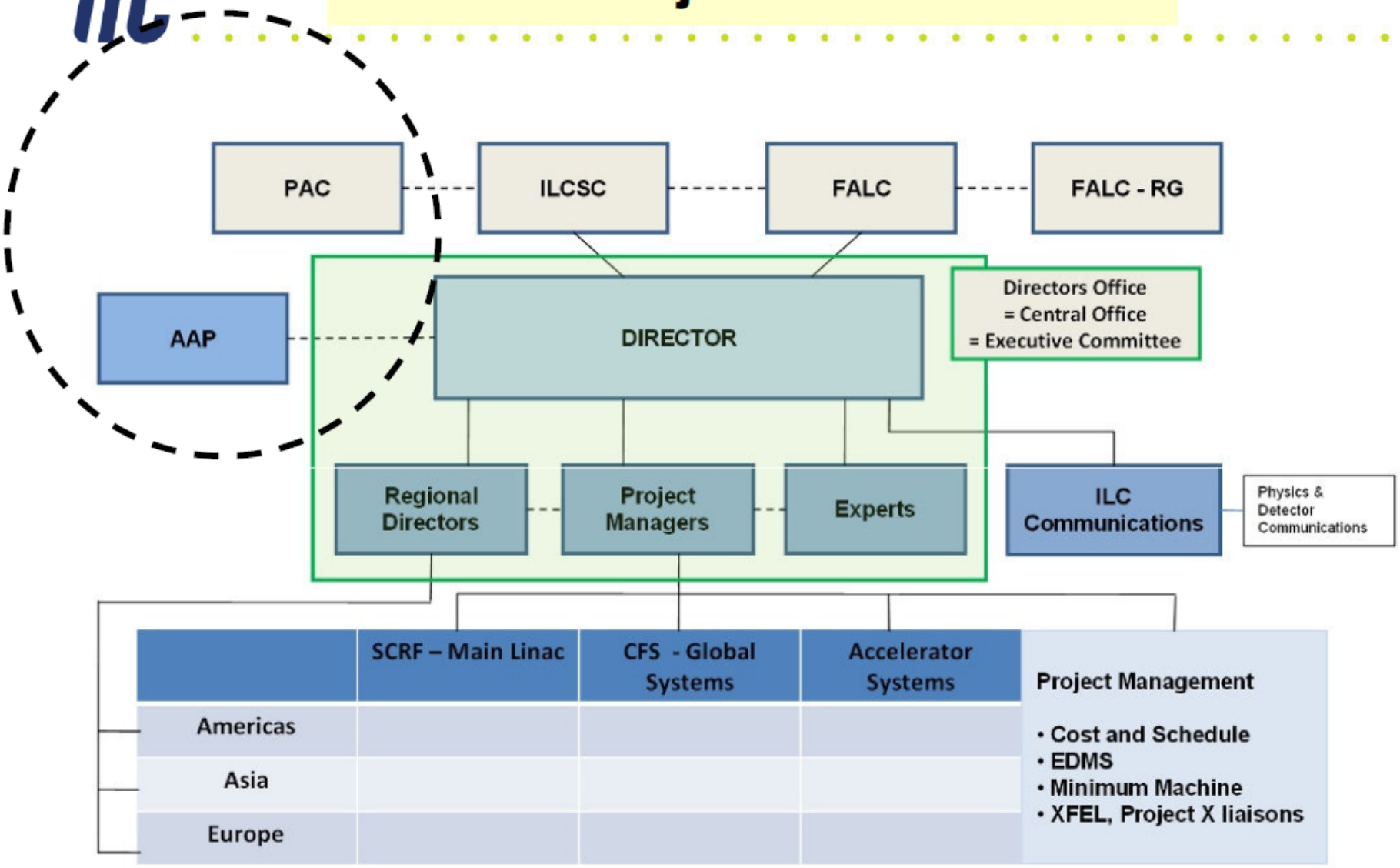
This is an important step ! Thanks to IDAG

- IDAG report was presented by the chair at ALCWS09 in Albuquerque

- The actual content of these various CLIC-ILC collaborations to be decided directly by the interested parties (mostly CERN and the ILC groups)
- For what concerns the participation of members of SiD and ILD to the CLIC CDR we feel that it should be done in agreement with these collaborations
- For what concerns the workshops we are already organizing the next European WS (**ECFA WS at CERN** in Sept 2010) with an OC comprising CLIC+ILC representatives
- These various initiatives should further improve the good relationships between the two communities

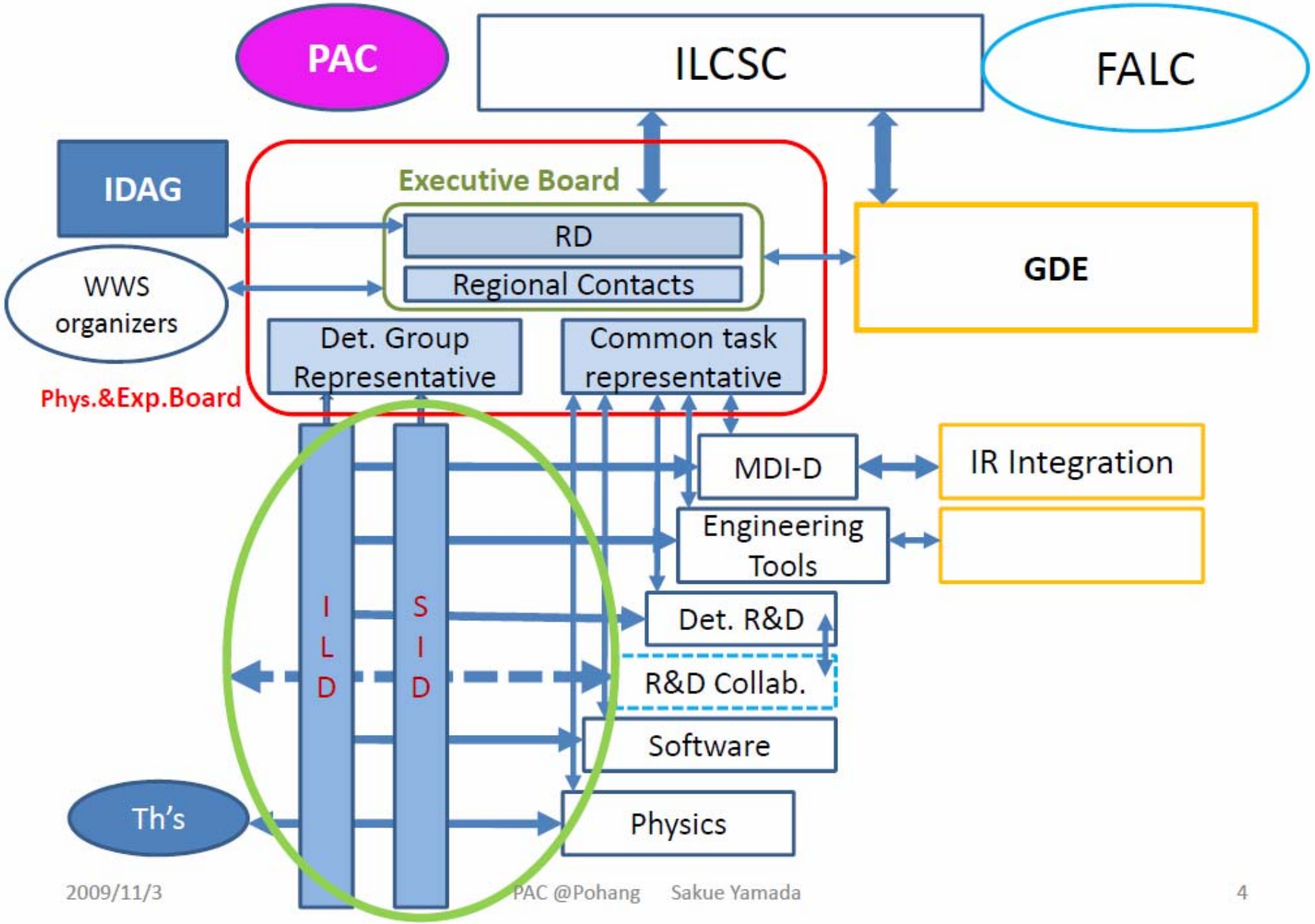
GDE Project Structure

B.Barish



Oct. 03, 2009

ILC Physics and Detectors organization



IDAG will monitor the two groups, to help them accomplish their goal.

IDAG monitors also the common task groups.

IDAG will meet during LC workshops twice a year, will meet with detector groups and CTGs.

IDAG will look into some written reports, too.

Major R&D Goals for TDP 1

B.Barish

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

CLIC / ILC Joint Working Group on General Issues

B.Barish

- ILCSC has approved formation of a CLIC/ILC General Issues working group by the two parties with the following mandate:
  - **Promoting the Linear Collider**
  - **Identifying synergies to enable the design concepts of ILC and CLIC to be prepared efficiently**
  - **Discussing detailed plans for the ILC and CLIC efforts, in order to identify common issues regarding siting, technical issues and project planning.**
  - **Discussing issues that will be part of each project implementation plan**
  - **Identifying points of comparison between the two approaches .**
- The conclusions of the working group will be reported to the ILCSC and CLIC Collaboration Board with a goal to producing a joint document.

- The committee has been appointed:
  - **P.LeBrun (co-chair), D.Schulte, K.Peach [CLIC]**
  - **M.Harrison (co-chair); E.Elsen; K.Yokaya [ILC]**