GDE Program for the ILC Technical Design Phase

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Presentation to the 'ILCDR08' Workshop, Cornell

Risk Reduction (Cost, schedule, technical)
and
Cost Reduction through R&D and design work

GDE TDP Overall Goal or Mission:

- **Develop an ‘ILC Project Proposal’ by mid-2012**
  - A complete and updated technical description
  - Results from critical R&D programs
  - One or more models for a Project Implementation Plan that include in-kind contribution schemes
  - An updated and robust VALUE estimate and construction schedule

This talk:

- **Our purpose**
- **Goals for:**
  - Accelerator Systems
  - CF / S
  - Project Implementation Plan
- **Schedule**
- **Organization**
- **Reviews and Meetings**
- **2008 R & D highlights - SCRF**

TD Phases

Phase 1 (July 2010)

- Critical R & D
- Evaluate the potential for cost reduction
- Re-baseline to prepare for technical design

Phase 2 (late 2012)

- consolidate the new baseline reference design
- detailed technical design studies
- updated VALUE estimate and construction schedule.
- critical R&D and technology demonstration milestones will be concluded.
- detailed development of the Project Implementation Plan.

RDR baseline and Risk

- **In most cases the RDR baseline choices were forward-looking and dependent on successful R&D during the TDP**
  - (remember Snowmass questions and RDR 'white papers'?)
  - EC, gradient, beam delivery precision control etc demonstrations are expected during TDP
- **In some cases, RDR baseline choices were more conservative and should be revisited during TDP1**
  - single tunnel, Marx modulator etc
  - 'alternate concepts' → which, if promising, may have significant impact on design, risk, cost and R&D
- **(<u>All choices</u> are to be revisited as part of the TDP1 re-baselining process)**
  - focus on those connected with ongoing R&D
- **Our goal is to define the R&D effort to achieve greatest impact on risk-reduction**
  - guided by RDR; baseline and Value estimate

ILC DR08 Workshop

Themes:

- **CesrTA Kick-off and Low Emittance tuning:**
  - EC Growth and Instability Studies
  - Development of low emittance tuning techniques (target $\varepsilon_y < 20$pm)
  - Development of x-ray beam size monitor to characterize ultra low emittance beams (1-D camera array)

- **Technical R & D and design effort**
  - aimed at risk reduction (technical) and cost reduction (design)
  - Assess state-of-the-art EC modeling, mitigation, understanding

- **(previous DR meeting at KEK 12.2007)**

Accelerator Test Facilities

- **CesrTA - Control and mitigation of electron cloud effects**
  - Global collaboration led by Cornell:
    - KEK: support for wiggler vacuum chamber, implementation of beam size monitors
    - UK (Cockroft): coordination and simulation
    - CERN: integration with proton accelerator electron cloud R & D
  - Strategy → action on a broad front
    - Test: vacuum chamber coatings, design, instrumentation and surface modeling
    - Test: beam dynamics simulations

- **ATF / ATF2 – control and monitoring of precision beams**
  - Global Collaboration led by KEK and SLAC:
    - Based loosely on the ATF collaboration MOU
    - Strong participation from all regions; a rough model of an in-kind ILC-like project
  - Strategy:
    - Test demagnification optics, tuning process and instrumentation with the ultra-low emittance ATF beam
      - (2 pm-rad vertical normalized emittance)

Test Facility Milestones

Test Facility	Deliverable	Date
Optics and stabilisation demonstrations:		
ATF	Generation of 1 pm-rad low emittance beam	2009
ATF-2	Demonstration of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demonstration of prototype SC and PM final doublet magnets	2012
	Stabilisation of 35 nm beam over various time scales.	2012
Linac high-gradient operation and system demonstrations:		
TTF/FLASH	Full 9 mA, 1 GeV, high-repetition rate operation	2009
STF & ILCTA-NML	Cavity-string test within one cryomodule (S1 and S1-global)	2010
	Cryomodule-string test with one RF Unit with beam (S2)	2012
Electron cloud mitigation studies:		
CESR-TA	Re-configuration (re-build) of CESR as low-emittance e-cloud test facility. First measurements of e-cloud build-up using instrumented sections in dipoles and drifts sections (large emittance).	2008
	Achieve lower emittance beams. Measurements of e-cloud build up in wiggler chambers.	2009
	Characterisation of e-cloud build-up and instability thresholds as a function of low vertical emittance (≤20 pm)	2010

GDE CF/S Workshop (Dubna June 2008)

- **The RDR represents a consensus design, which reconciled inputs from our constituent accelerator designers / engineers**
- **We believe a more cost-effective design, based on the RDR, is possible and mandated by a need to 'optimize' the ILC design**
  - *sacrifices* may be necessary - Value Engineering

PM Assumptions:

- There exists a 'minimal design' that satisfies all scope requirements and facilitates cost comparisons for 'optional' features
  - Not a trivial concept due to design optimization and consolidation already in RDR
- The shallow machine is more cost-effective because of reduced underground volume – (XFEL, Dubna site…) but:
  - Effective reliability strategy for single tunnel layout NOT done for RDR – due to time / resource limitations
- The process can be done within the 'consensus – building' context established for RDR
  - Our community must buy-in and participate

Integrated Central Campus Proposals.

- Dubna group C/D report

(A) 6.4 km damping rings rotated by 90 degrees from ‘standard’ orientation. DR are located in the same horizontal plane as the BDS but displaced laterally by ~200 m. It is assumed this is sufficient to be clear of IR facilities. In this configuration, injection and extraction from both rings is in the same long straight section.

(B) BDS layout in RDR shows horizontal offset of ~2 m in straight tunnel and location of (high powered) tune-up dump. Total length of 2×2.2 km is compatible with (D) through (I), i.e. injector systems sharing the same tunnel. Energy upgrade to 1 TeV does not require injector systems to be moved.

(C) Shorter (‘minimum’) 500 GeV version of the BDS showing offset and beam dump line location. On the e- linac (e+ injector) side this does not shorten the distance to the end of the linac as the e+ injector beamline components requires the same length as in (B). On the e+ linac, e- injector side the linac could be moved closer to the IR by 600 m. Upgrading to 1TeV is more complex than in (B)

(D) The iron walls in the BDS should be downstream of the injector systems and part of the PPS zone shielding that allows their operation while there is access to the IR. The booster to DR transport is shown as a 200 m long S shape. This contains the energy compressors and spin rotators and RTML systems, some older studies showed possible lattices for this geometry.

(E) 5 GeV SC linacs on both sides.

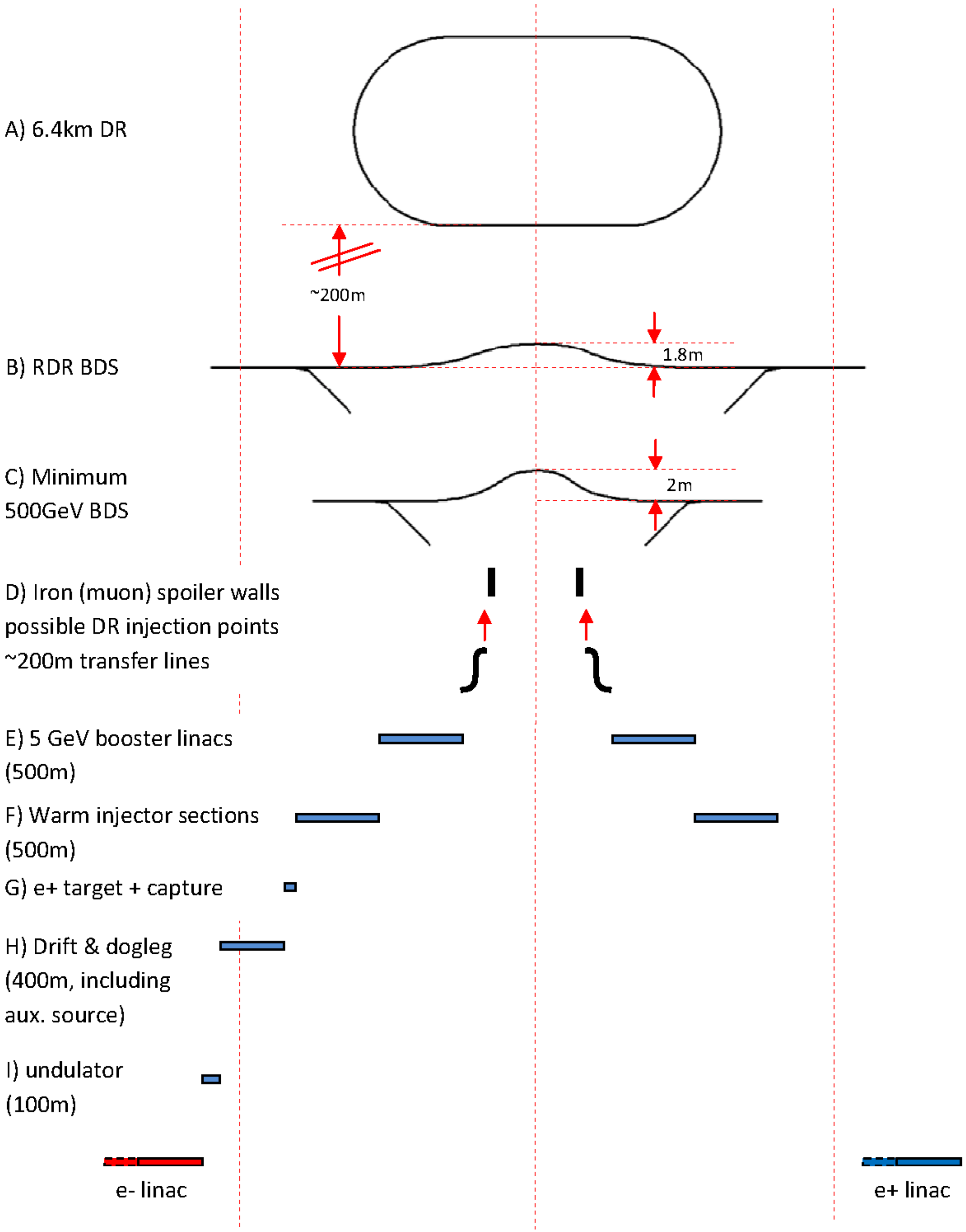
(F) ~400 or 500 MeV pre-injectors for e+ and full injector for e-.

(G) e+ Target and capture systems. Shared with possible single or few bunch ‘auxiliary source’. Nothing on other side.

(H) Drift for gamma beam and dogleg for e- main beam. The dogleg should match up with later dogleg in the BDS. This is the region where one might insert a compact S-band e- injector for the auxiliary source (KAS replacement).

(I) Location of 100 m long undulator at the end of the e- .

Integrated Central Campus Proposals.



Minimum Machine Definition

- **Physics scope (WWS document)**
  - 200-500 GeV centre-of-mass energy range
  - $2x10^{34}$ $cm^{-2}s^{-1}$
  - polarized electrons
- **Identify cost-driving requirements and criteria**
  - Push back on them to acceptable minimum
  - CFS will be primary target
    - Underground volume and construction
    - Process cooling water
- **Definition document due late 2008**
  - Led by Project Manager Nick Walker (DESY) and ILC Integration Scientist Ewan Paterson (SLAC)

Minimum Machine Design Plan

- This document will represent one of the primary deliverables for TD Phase 1 in 2008, as described in the TD Phase R&D Plan Release 2.
- The specification document will form the basis of the 'minimum machine studies' in 2009, which are intended to provide quantitative input into the planned review and re-baseline of the machine at the end of TD Phase 1.

Minimum Machine Design

1. General layout considerations ("Integration") whereby the goal is to reduce overall underground volume by more integrated use of tunnels, shafts and vaults.
2. Technical component specifications, for example water cooling parameters which should be less conservatively defined for individual sub-systems.
3. Accelerator performance specifications, for example reducing the number of individually powered magnets ("stringing"), relaxing alignment stability requirements and environmental specifications (temperature stability).

CF / S Strategy

- **RDR: Deep Rock, twin tunnel configuration**
  - strong similarities → each region developed the same design
- **Value Engineering:**
  - understand the cost drivers; review and evaluate the technical criteria that define them
    - underground volume
    - tunnel dimensions; second tunnel
    - stability and etc

Goal:

- Devise practical, 'minimum', technical criteria
- Strategy (must be site-independent):
  - Develop contrasting machine configurations
    - *for example: shallow site (Dubna); single tunnel (XFEL), etc*
- Implement comparison and analysis process between these and the RDR baseline
- Update site specifications; recommend further technical development and R & D
  - **for example: Use of long HV cables to power linac RF sources**

Project Implementation Plan (PIP)

- **The PIP will be developed in several stages during the TD Phases:**
  - Review existing examples of PIPs and develop and define the elements of the ILC PIP (2009)
  - Begin to develop the models for globally distributed mass-production of the SCRF (and other where suitable) components as part of an ‘in-kind’ project implementation scenario (2010)
  - Develop cost models for the SCRF based on the above, which will provide the framework for the SCRF technical groups when estimating their costs during TD Phase 2 (2012)
  - Develop the other identified elements of the PIP (2012)
- **The PIP will be published as part of the primary deliverables of the TD Phase in 2012.**
  - May be the most-read part of the TD report

Project Implementation

- **The suggestion of 'how' the work should be done**
  - (RDR / TDR rebaseline describes what and how much)
  - may include: Governance, CF / S siting process, and procurement models
- **How will the plan be linked to present activities?**
  - R&D must promote workable project plans
    - example: Plug-compatibility of cryomodule components
  - CF / S design work should support development of cost-effective designs in various site configurations to strongly encourage all interested parties
    - example activity: adapt single tunnel linac design to deep and shallow sites → without accepting large performance or cost penalty
    - (now planning – of course we cannot prepare for *any* and all possible sites in parallel)
  - should consider seam-less transition models following TDP completion and proposal submission
    - example: updated Value estimate format must smoothly re-map onto a real project plan

Connection between Plan and updated Value estimate

- **the Plan includes a schedule**
- **It also includes labor/procurement and management models**
- **the Value estimate will depend on these models**
- **Plan will be developed in concert with oversight groups**
  - funding agencies (FALC)
  - ICFA (ILCSC)
  - institutional managers

TD Phase 1 Schedule

Published in:
ILC Research and Development Plan for the Technical Design Phase

Release 2, June 2008
(next release 6 months)

Near term effort on these activities

Value engineering

Value engineering

Global Project Plan

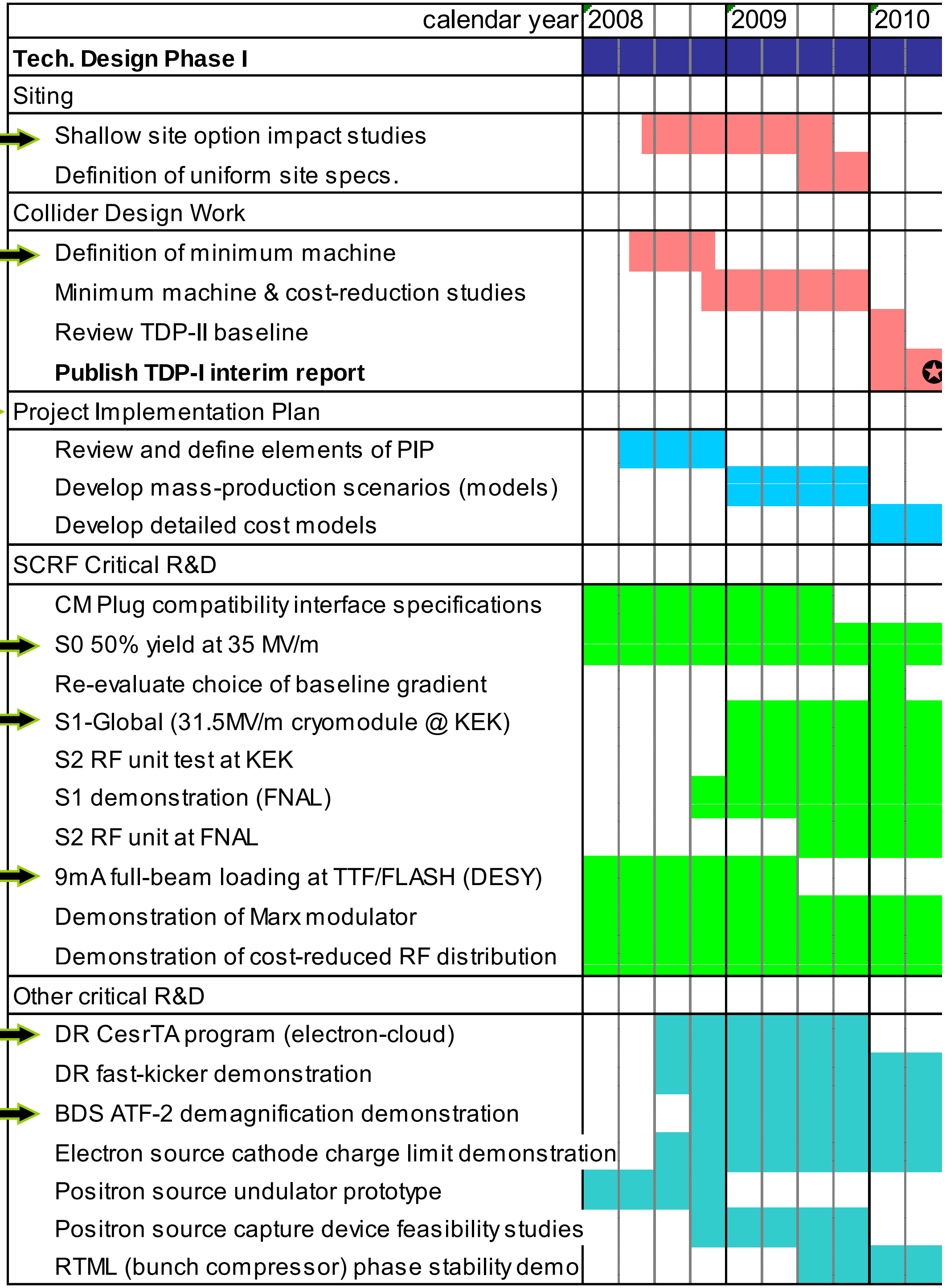
High Gradient

Cryomodule test

Systems Test

Electron Cloud

Precision beam control



TDP Organization supports this goal

- **Technical Area Groups to communicate, coordinate and monitor global R&D**
  - R&D emphasis strengthened following early 08 replan – longer TD Phase
- **Individuals, Institutions, National and Regional groups support 'in-kind' R&D because of overlap with existing or planned projects and infrastructure development goals**
- **TDP Cost Management and Tech. Area Leaders to propose strategic 'baseline choices'**
  - 2009 activity
  - consensus development required

Release of the ILC Technical Design Phase R & D Plan

- June 6, 2008

- **The plan includes an outline of our**
  - strategy
  - work plan
  - schedule
  - deliverables
  - resources
  - constituency
- **very useful for management, reviews, funding agencies, …**
- **Next review and release: December 08**

ILC Research and Development Plan for the Technical Design Phase

Release 2

June 2008

ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

R & D Plan Contents

TD Phase Work Packages

- **Initial 2007 concept:**
  - a management compendium of all required activities for EDR preparation
  - would have been workable; but required effective prioritization process
- **2008 practicality:**
  - a workable, supportable structure reflecting established programs and priorities
  - amendments to be made as needed
    - for example with the 09 re-baselining
- **See R & D plan**

Global Resource base 2007-2010: SRF

		FTE-Years						total M&S						
		Cavities	Cryomodule	HLRF	Cryogenics	ML Integ.	**total FTE-Years**	Cavities	Cryomodule	HLRF	Cryogenics	ML Integ.	**total M&S**	
Americas	**Canada**	18					**18**	1050					**1050**	k$
	USA	73	24	68	5	14	**183**	9169	3960	5909	134	362	**19535**	k$
Asia	**China**	12	8	8	4	1	**33**	1371	1371	1371	686	137	**4936**	k$
	India	24	12				**36**	1560	900				**2460**	k$
	Japan	45	6	11	4	5	**72**	19867	4125	4036	1607	9992	**39627**	K$
	Korea	13		5			**18**	1619		264			**1883**	K$
Europe	**EU (CERN)**				1	4	**5**					190	**190**	k$
	France	94					**94**	14785					**14785**	k$
	Germany	51	10	7	7	9	**83**	2506	531			35	**3071**	k$
	Italy	38	8		1	1	**48**	1738	235				**1973**	k$
	Russia	2	20				**22**	20					**20**	k$
	Spain		3				**3**		13				**13**	k$
		370	**90**	**99**	**21**	**34**	**615**	**53685**	**11136**	**11581**	**2427**	**10715**	**89542**	

plan lists contribution in native currency

- **Notes:**
  - XFEL project specifically excluded where possible
    - → Estimate 65% of France FTE / 80% France M&S is XFEL project-related
    - Other EU does not include XFEL
    - DESY XFEL R&D ~ 155 FTE 2007-2009
  - EU funding includes: CERN, European Commission Research Framework Programme 7/ 6 (5 contracts), National funding agencies (IN2P3, STFC, INFN, BMBF,…)
    - ILC project-specific and Generic R&D
  - Japanese effort is labeled ‘generic’; but largely supports ILC
    - Japanese FTE includes scientific and top-level engineering staff only
  - Currency conversion based on 01.01.2008

Global Resource base 2007-2010: Accelerator Systems

Region	Country	FTE-Years: Elec. Source	Posi. Source	Damping Rings	RTML	Beam Delivery	Simulations	total FTE-years	total M&S: Elec. Source	Posi. Source	Damping Rings	RTML	Beam Delivery	Simulations	total M&S	
Americas	Canada			5				**5**			20				**20**	k$
	USA	11	8	28	1	48	16	**113**	617	144	7174	3	3847	190	**11975**	k$
Asia	China			12	4	20	2	**38**		69	686	14	27	14	**809**	k$
	Japan	2	7	16		23	4	**52**			6447		3348		**9795**	k$
	Korea			2	2	4	3	**12**			28	28	217	28	**301**	k$
Europe	EU (CERN)			2		1	4	**7**			10		3	13	**26**	k$
	France		11		5	12		**27**		573			9		**582**	k$
	Germany		22	3		4	4	**33**		47	10		53	20	**129**	k$
	Italy			17				**17**			441				**441**	k$
	Spain					2		**2**								k$
	Sweden				2	2		**3**								k$
	UK		10	11		85		**106**		70	124		3069		**3263**	k$
		13	**57**	**97**	**14**	**201**	**33**	**415**	**617**	**903**	**14939**	**44**	**10574**	**264**	**27342**	

- **Notes:**
  - Test facilities account for ~80%
    - ATF2 effort regionally balanced
  - UK effort greatly reduced
    - 2009 and 2010 ~ 20% of total
    - Non ILC-specific 09 and 10 R&D (instrumentation etc) not included
  - Positron Source includes R&D on Compton ‘alternate’
  - Currency conversion based on 01.01.2008

The GDE TDP Program:

- **Has a broad inter-regional basis**
- **US ‘ART’ contribution is consistent with plan and significant**
  - But not dominant, overall
- **Is based on a multi-lateral collaboration →**
  - Not centralized
- **Relies on ‘in-kind’ R & D contributions from partner labs and regions**
  - ILC project-specific
  - Other project-specific
  - Generic R & D
- **Has adequate resources for TDP1**
- **Will require increased project-specific design resources for TDP2**

TDP External / Internal Reviews

Reviews by:

- **Project Advisory Committee**
  - J. – E. Augustin, Chair
  - reports to ILCSC
  - October 19-20, 2008
  - includes detector group review (50 / 50?)
  - will involve project managers (tbc)
- **Accelerator Advisory Panel**
  - Bill Willis, Chair
  - reports to Project Director, Barry Barish
  - April 2009 (tbc);
  - facilitated through ongoing, ‘embedded’, interaction between Panel and TDP Managers
  - 10 to 15 reviewers (?)
  - will involve Group Leaders and their support

GDE Meetings

- **4 AAP reviews:**
    - Interim TDP1 (April 2009)
    - Final TDP1 (in preparation for the July TDP1 result)
    - Interim TDP2
    - Final TDP2
  - Integrated with GDE plenary meetings semi-annually
- **One GDE / LCWS collaboration-wide meeting / year**
  - DESY 2007
  - Chicago 2008
  - request broad attendance
- **Additional thematic meetings**
  - of course.

GDE Communication

- **Accelerator Advisory Panel process is presented in the ‘ILC Newsline Director’s Corner’**
- ***Please watch this column* – key policy is described in it: for example**
  - Project Advisory Committee – the other review body
  - Dubna meeting
  - Minimum machine

- **Monthly communication:**
  - a summary of monthly meetings →
  - Accelerator Systems, SRF, CF / S and Global, Cost Management Group and others
  - Notification through GDE-wide (400 member) mailing list
- **The mailing list is important, and only Maxine Hronek uses it**
  - please help keep it updated.

ILC 2008 R&D: High Gradient:

Motivation:

- large potential impact on the cost of the ILC.
- RDR gradient choice is 35 MV/m in vertical test
- *present average: <u>31.5 MV/m</u>*

Strategy:

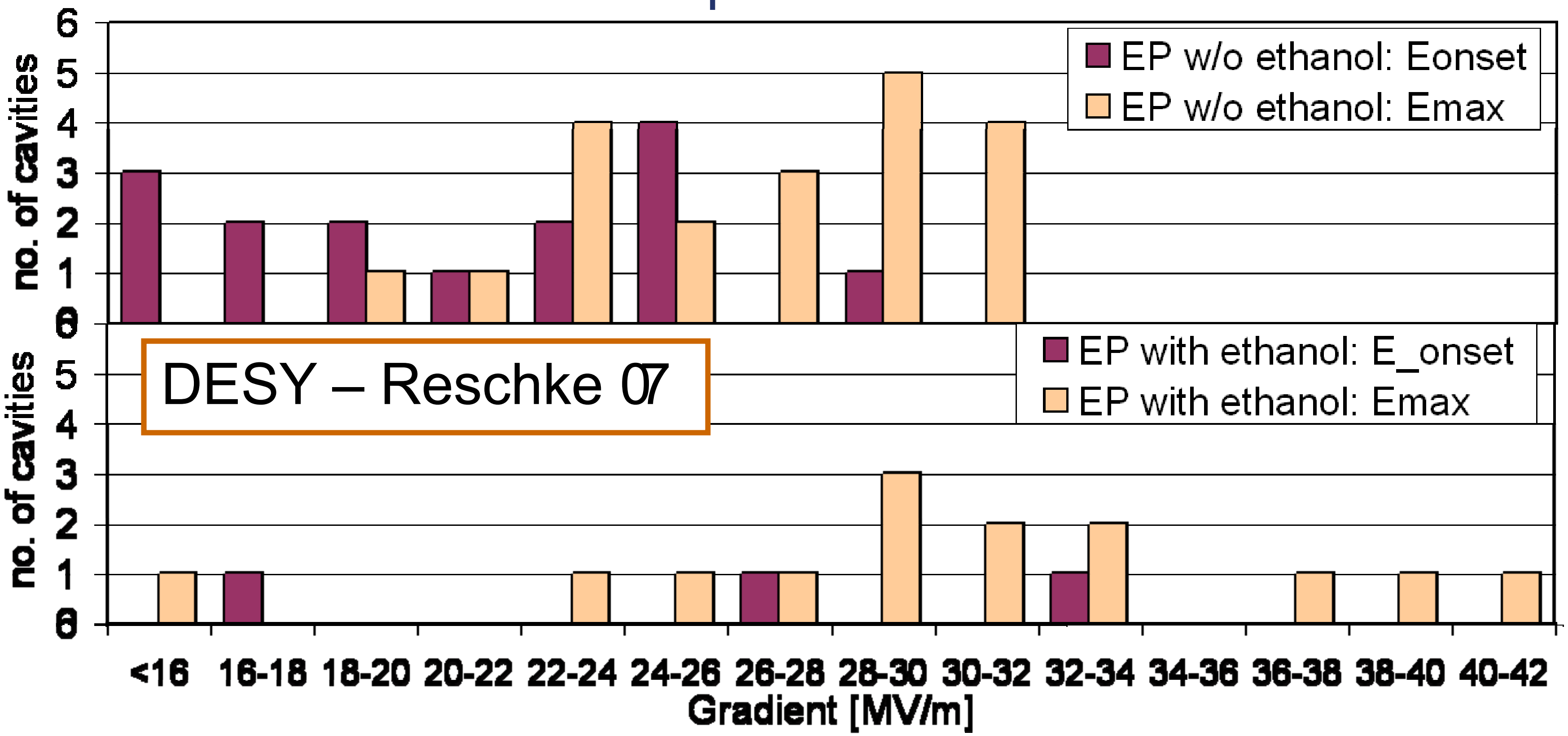
1: research cause of gradient limits
   a) field emission, b) localized quench, c) high cryo losses

2: develop countermeasures (JLab, KEK, DESY, Saclay)
   a) final rinses b) precision imaging/repair c) baking

3: verify counter measures

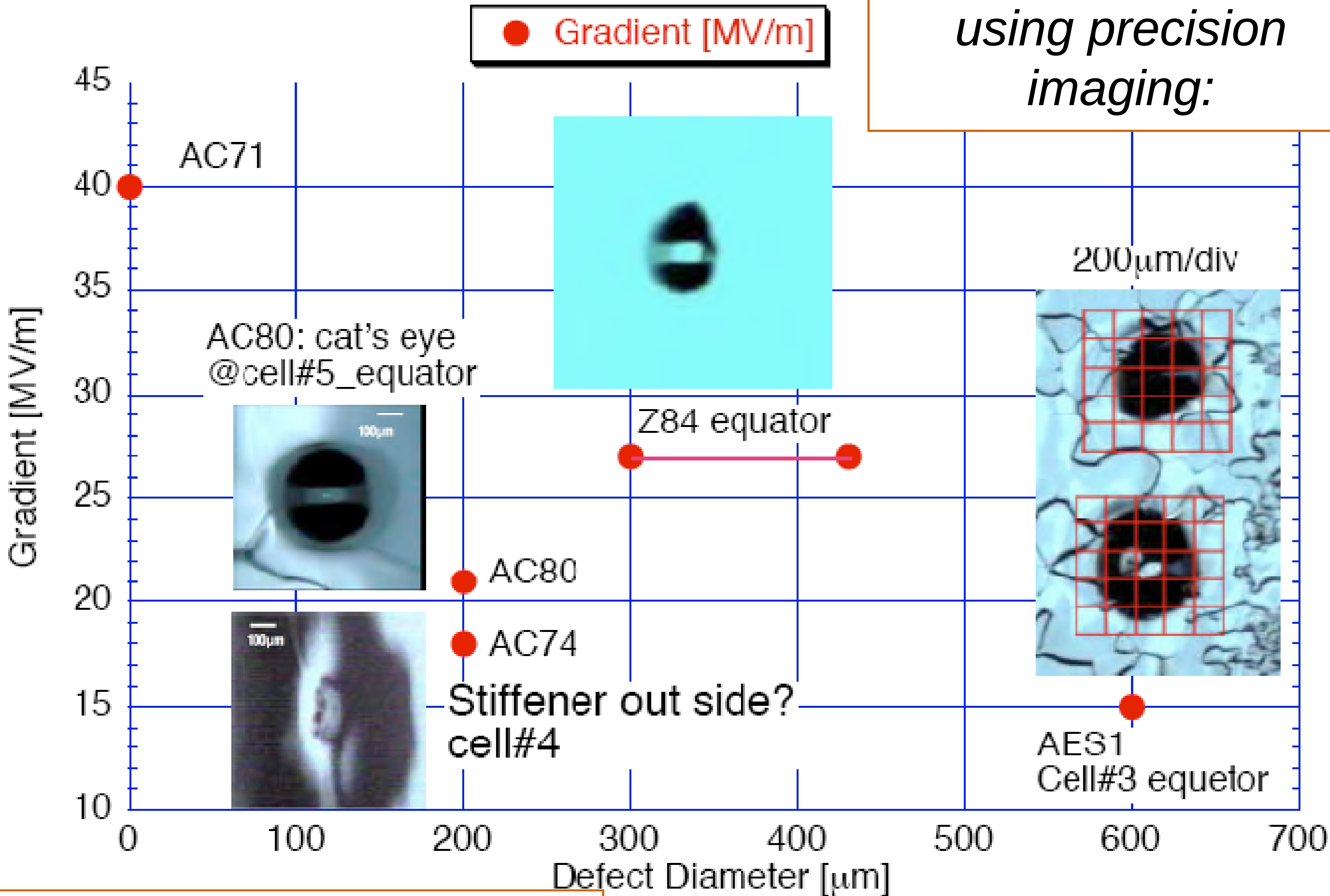
4: integrate statistics

Field Emission (reduced w/final ethanol rinse) → Localized quench



- *Note reduced number of field emission 'Eonset' entries in lower plot*
  - results from 15 cavities (DESY - Zanon)
  - some cavities tested many times
- *Gradient limits now dominated by localized quench →*
  - Thermal (DESY/FNAL/JLAB) / imaging (KEK) diagnostics very promising
  - *May be able to identify flaws after electro-polishing - <u>before vertical test</u>*

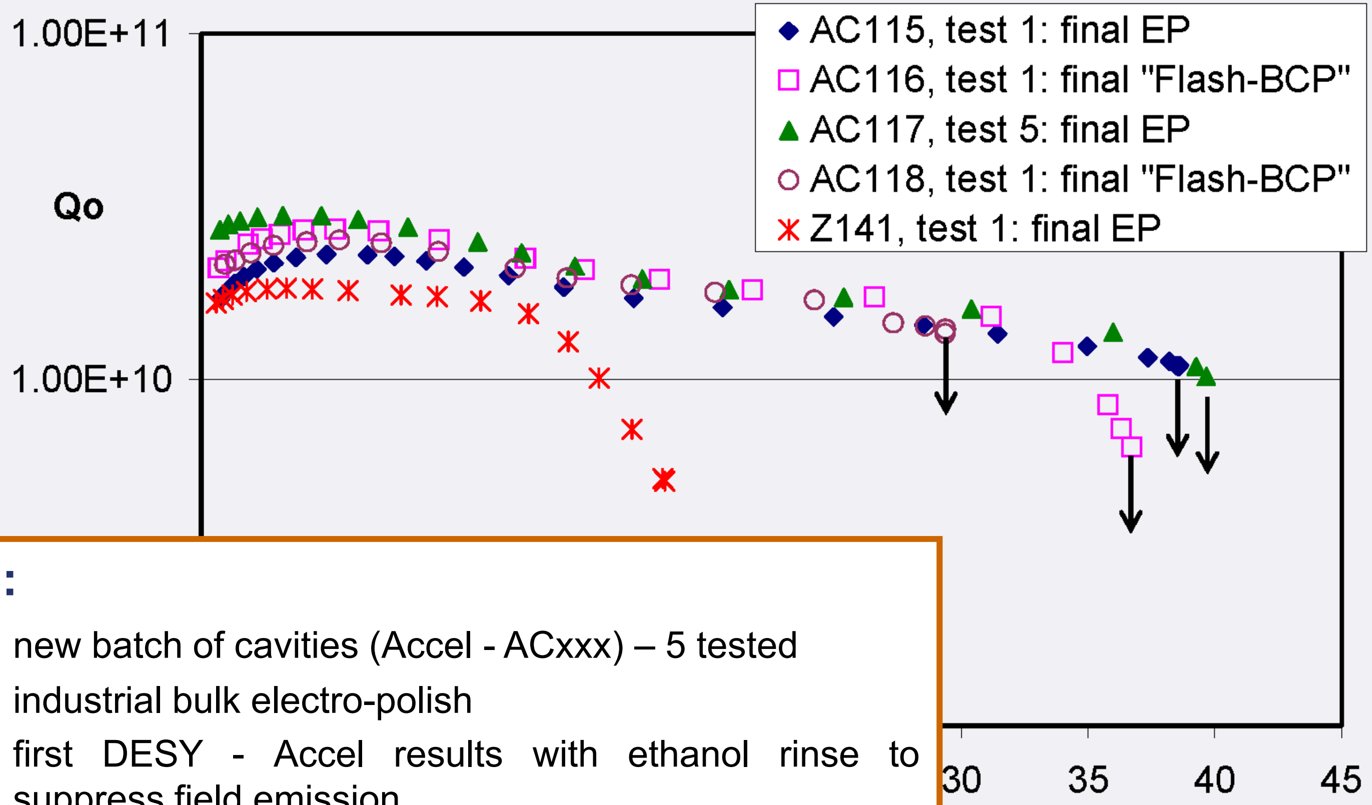
Identification of flaws using precision imaging:



- ***validate with thermal mapping***
- ***28 MV/m threshold may be possible?***

6th cavity production – rf results

- excellent + promising first results including first Plansee nine-cell (AC115)
- Z141 as first cavity with surfaces damages after fabrication under investigation



•06.2008 :

- new batch of cavities (Accel - ACxxx) – 5 tested
- industrial bulk electro-polish
- first DESY - Accel results with ethanol rinse to suppress field emission
- *Accel Average: 36.2 MV/m*

Americas	US FY06 (actual)	US FY07 (actual)	US FY08	US FY09	US FY10	TDP-1 Totals (to June 2010)	US FY11	US FY12
Cavity orders	22	12		10	10	**52**	10	10
Total 'process and test' cycles		40	5	45	30	**113**	30	30
Asia	**JFY06 (actual)**	**JFY07 (actual)**	**JFY08**	**JFY09**	**JFY10**		**JFY11**	**JFY12**
Cavity orders	8	7	8	25	15	**44**	39	39
Total 'process and test' cycles		21	40	75	45	**147**	117	117
Europe	**CY06 (actual)**	**CY07 (actual)**	**CY08**	**CY09**	**CY10**		**CY11**	**CY12**
Cavity orders	60	8		834		**902**		
Total 'process and test' cycles		14	18	26	30	**73**	380	406
Global totals								
Global totals - cavity fabricatio	90	27	8	869	25	997	49	49
Global totals - cavity tests		75	65	135	175	333	501	501

Cavities and Cavity testing: 2006 – 2012

- Results from Europe (DESY) - with strong expertise, mature infrastructure and mature industrial suppliers - dominate
- Americas (FNAL/ANL) and Asia infrastructure coming online now (many 07 tests < 20 MV/m)
- Global plan has reduced emphasis on blind, cyclic processing; more emphasis on developing diagnostics and countermeasures

Cryomodule Test – checking global ‘plug compatibility’

Goal:

- R&D on the Cryomodule facilitates the development of a detailed ILC Project Implementation Plan
  - including an achievable project schedule and plan for competitive industrialization in all regions.
- assume ILC will require a flexible design *based on modular sub-components*.

Strategy:

- provide framework for technical and industrial development
  - Specify engineering interfaces between Cryomodule sub-components
    - and if possible within them

Plan:

- Assemble and test a high-performance (31.5 MV/m average) cryomodule at KEK using components from each region (TDP 1)
  - 2 cavities from US, 2 from EU, 4 from Asia

SCRF Linac Systems Test – DESY/FLASH

Goal:

- Demonstrate precision accelerator control in nominal ILC conditions
  - high gradient, full beam loading: 31MV/m, 9 mA, 5Hz
  - Achieve nominal performance specifications in realistic conditions → energy spread, stability etc
- Test higher order mode absorbers, cryo system, instrumentation…

Strategy:

- DESY – FLASH/TTF is the *only* suitable test facility available during TDP1
  - scale, beam parameters, instrumentation etc
  - testing also supports ongoing DESY projects / programs

Status:

- DESY – led, KEK, FNAL are part of the team started March 2008
- To be complete by March 2009.
- Systems development in all 3 regions in TDP2 (DESY, FNAL, KEK)