GDE Program for the ILC Technical Design Phase (TDP)

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

Global Design Effort TDP Goal:

- **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

- **TD Phase 1 (July 2010)**
  - Critical R & D
  - Potential for cost reduction
  - Re-baseline to prepare for technical design

TD Phase 1 Schedule

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

Release 2, June 2008
(next release 6 months)

Describe the global context for these activities →

Show that the ART program supports and is consistent with GDE TDP1 plan

Value engineering →

Value engineering →

Global Project Plan →

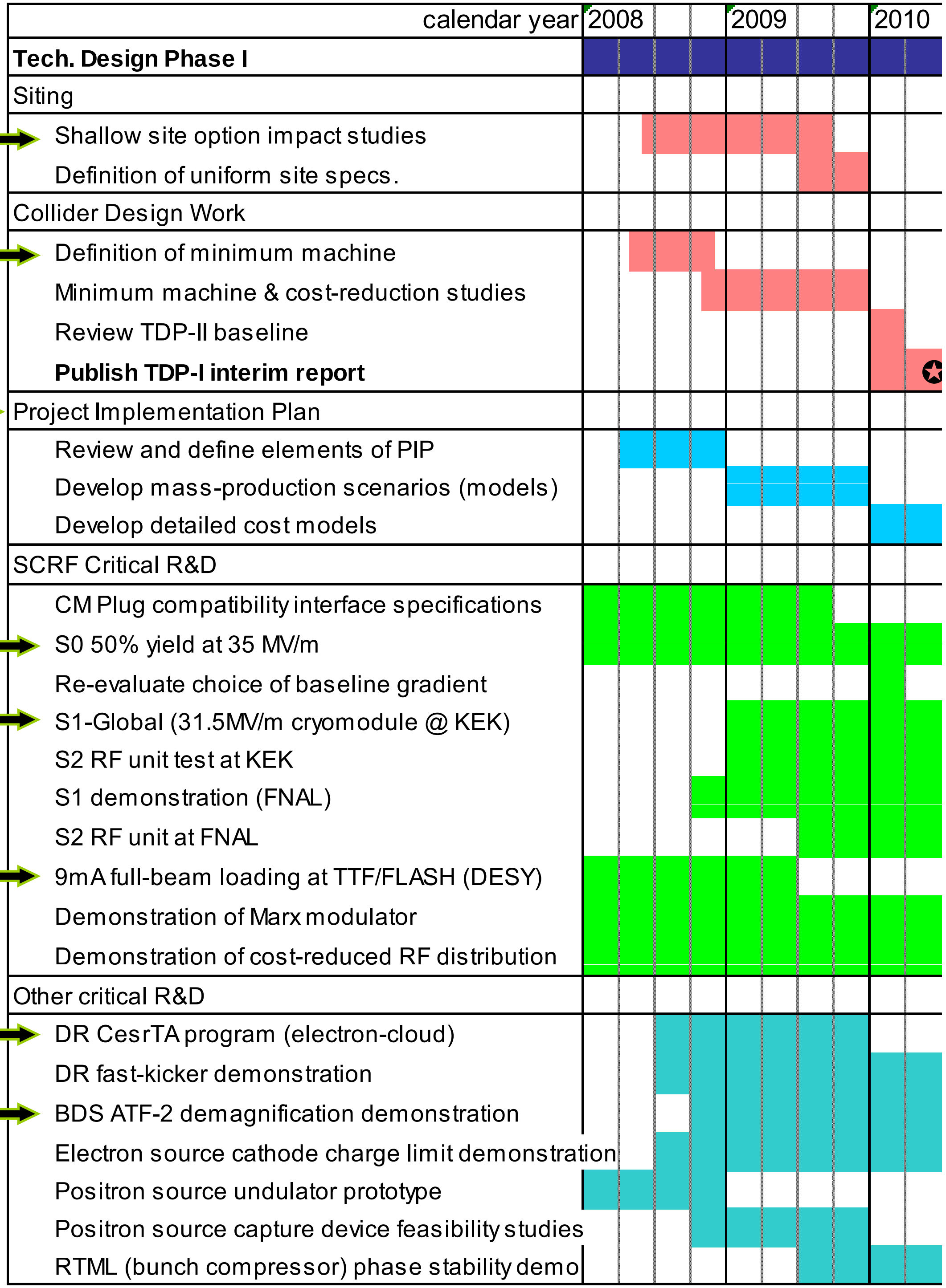
High Gradient →

Cryomodule test →

Systems Test →

Electron Cloud →

Precision beam control →



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:

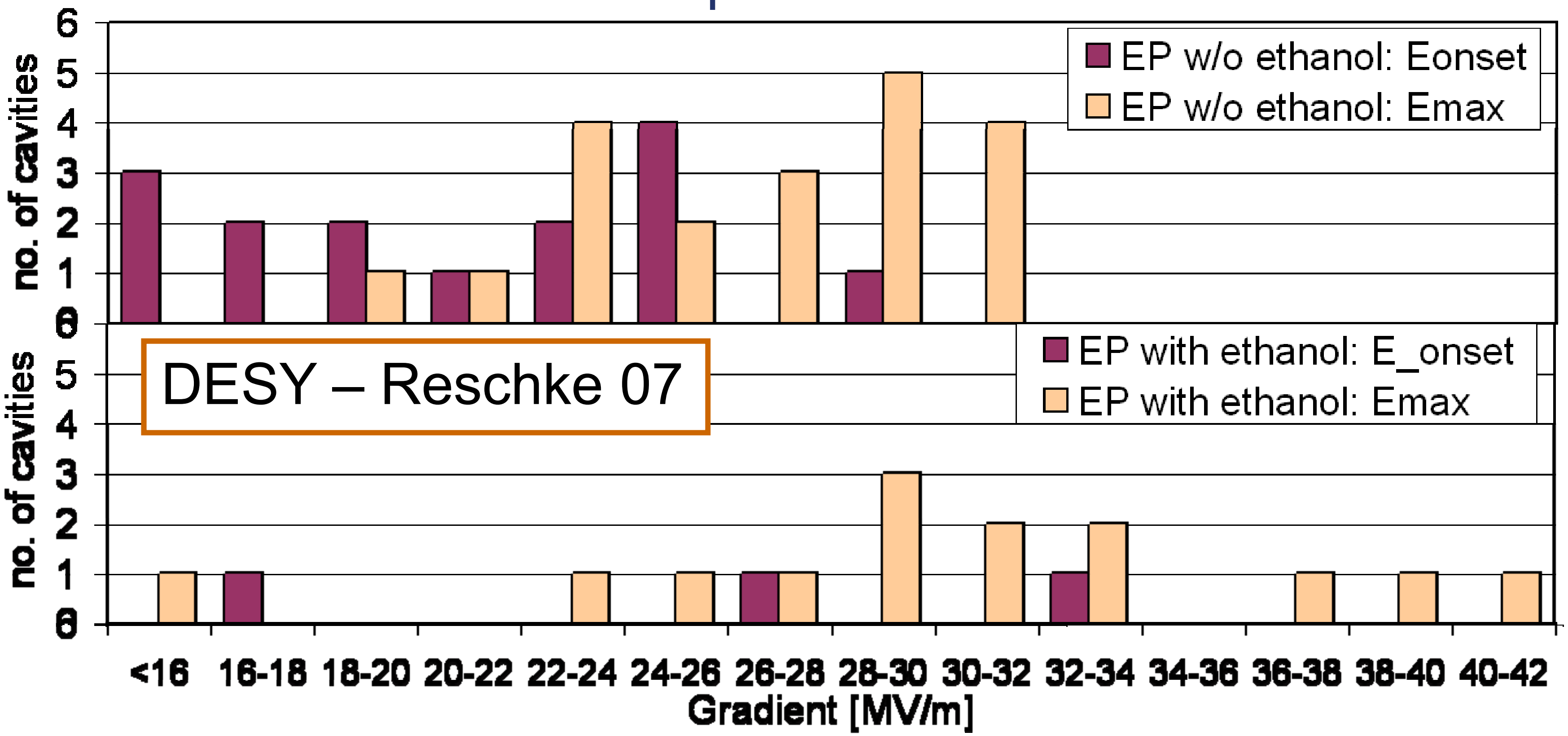
1: research cause of gradient limits
   a) field emission, b) localized quench, c) high cryo losses

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

3: verify counter measures

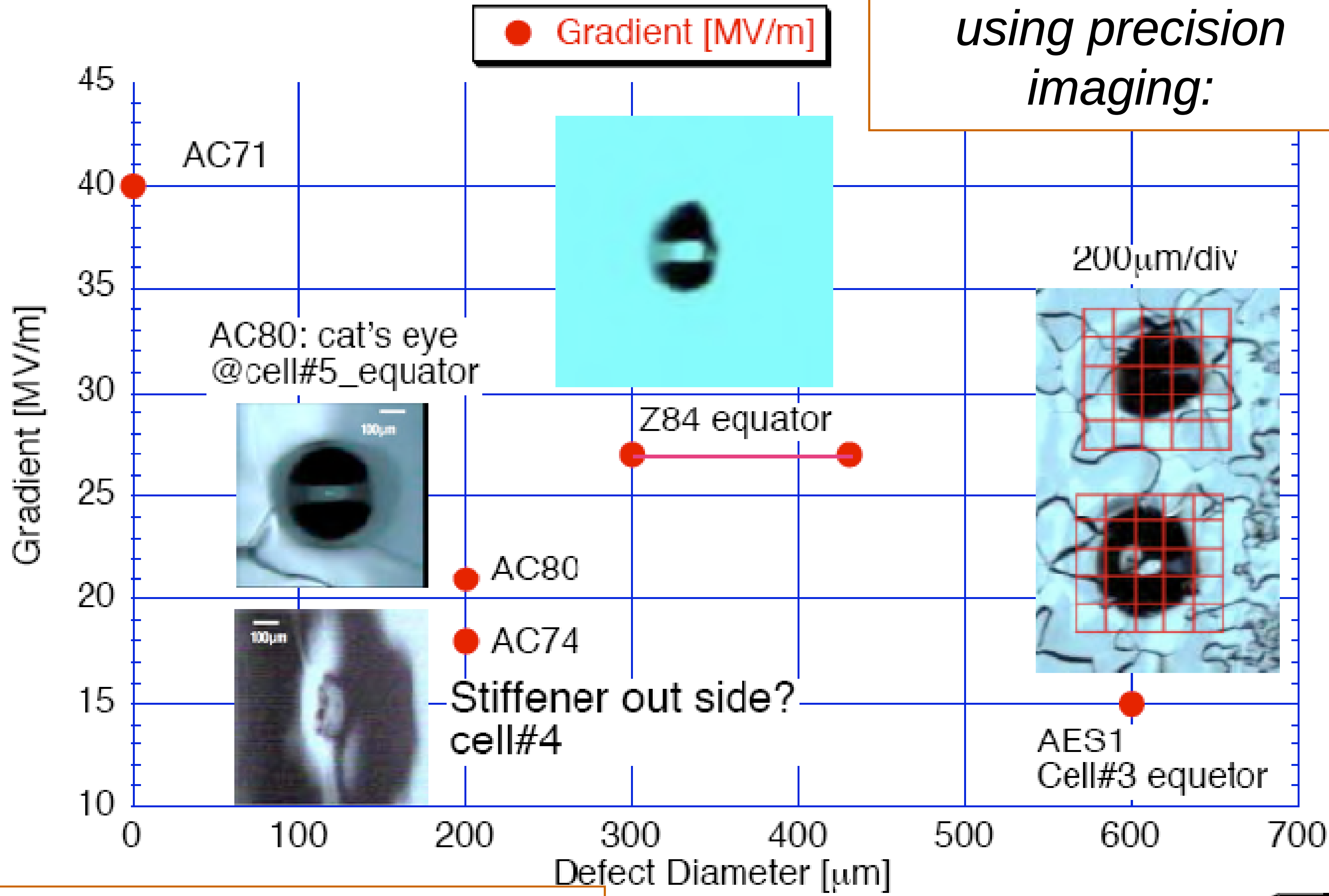
4: integrate statistics

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>*

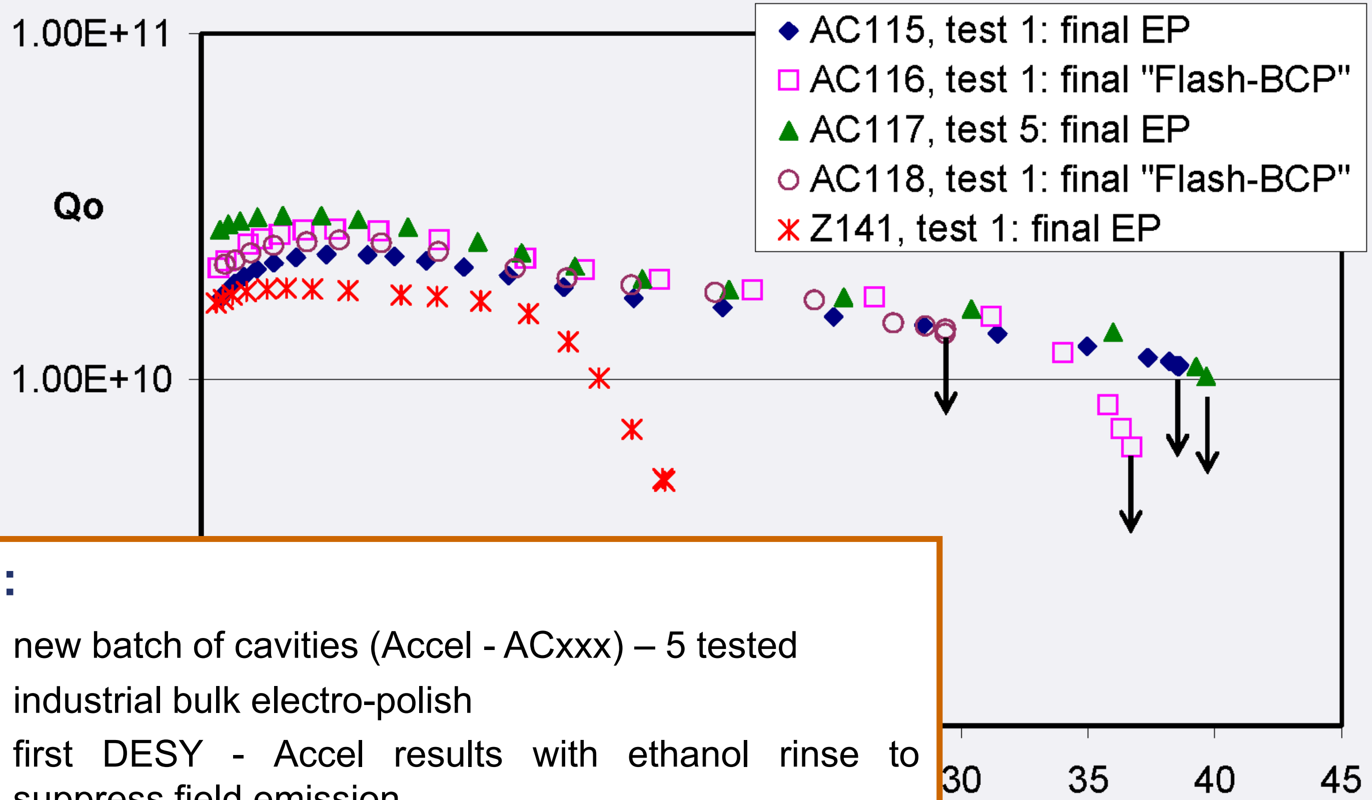
Identification of flaws using precision imaging:



- ***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)

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:
    - 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 Conventional Facilities and Siting (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 – (XFEL, Dubna site…)
  - 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

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)

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
- Define ‘uniform’ site specifications; recommend further development

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.**

Organization and Review Process

	Technical Area		
	1. Superconducting RF Technology	2. Conventional Facilities & Siting and Global Systems	3. Accelerator Systems
Technical Area Groups	1.1 Cavity 1.2 Cavity-Integration 1.3 Cryomodules 1.4 Cryogenics 1.5 High Level RF 1.6 Main Linac Integration	2.1 Civil Engineering and Services 2.2 Conventional Facilities Process Management 2.3 Controls	3.1 Electron Source 3.2 Positron Source 3.3 Damping Ring 3.4 Ring To Main Linac 3.5 Beam Delivery Systems 3.6 Simulations

- **Reviews by:**
  - Project Advisory Committee
    - J. – E. Augustin, Chair
    - reports to ILCSC
    - October 19-20, 2008
  - Accelerator Advisory Panel
    - Bill Willis, Chair
    - reports to Project Director, Barry Barish
    - Spring 2009; ongoing, ‘embedded’, interaction between Panel and TDP Managers

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**	

- **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	FTE-Years: Posi. Source	FTE-Years: Damping Rings	FTE-Years: RTML	FTE-Years: Beam Delivery	FTE-Years: Simulations	**total FTE-years**	total M&S: Elec. Source	total M&S: Posi. Source	total M&S: Damping Rings	total M&S: RTML	total M&S: Beam Delivery	total M&S: 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**
- **ART contribution is consistent 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**