ILC-BAW1
ML Accelerator Operational Gradient
Introduction

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Reported at BAW1, held at KEK, Sept. 10, 2010

Baseline Assessment WorkShops

Baseline Assessment Workshops

- Face to face meetings
- Open to all stakeholders
- Plenary

	When	Where	What
WAB 1	Sept. 7-10, 2010	KEK	1. Accelerating Gradient 2. Single Tunnel (HLRF)
WAB 2	Jan 18-21, 2011	SLAC	3. Reduced RF power 4. e+ source location

Time-Table / Agenda (Sept. 9)

Day	Am/pm	Subject	Convener/presenter
9/9		Cavity: Gradient R&D and ML Cavity Gradient	R. Geng/A. Yamamoto
	9:00	Introduction and Current Status - Technical address for the 2nd part of WS - Overview from RDR to R&D Plan 5 - Progress of cavity gradient data-base/yield	Chair: M. Ross - A. Yamamoto - R. Geng - C. Ginsburg
	10:45	R&D Status and further R&D specification - Fabrication, testing, & acceptance for XFEL/HG - R&D expected in cooperation w/ vendors - R&D w/ a pilot plant w/ vendor participation	Chair: K. Yokoya - E. Elsen - M. Champion - H. Hayano
	13:30	Short-tem R&D and Specification - Field emission and R&D strategy - Gradient, Spread, Q0, Radiation: R&D specification, standardization	Chair: C. Pagani - H. Hayano - R. Geng
	15:45	Long-term R&D ACD subjects and goals - Seamless/hydro-forming, Large Grain, Cavity shape variation, VEP, Thin Film, - Further R&D toward TEV/ML - Discussions for Cavity R&D and Recommendations	Chair: A. Yamamoto - R. Rongli to lead discussions

Cavity Gradient Progress

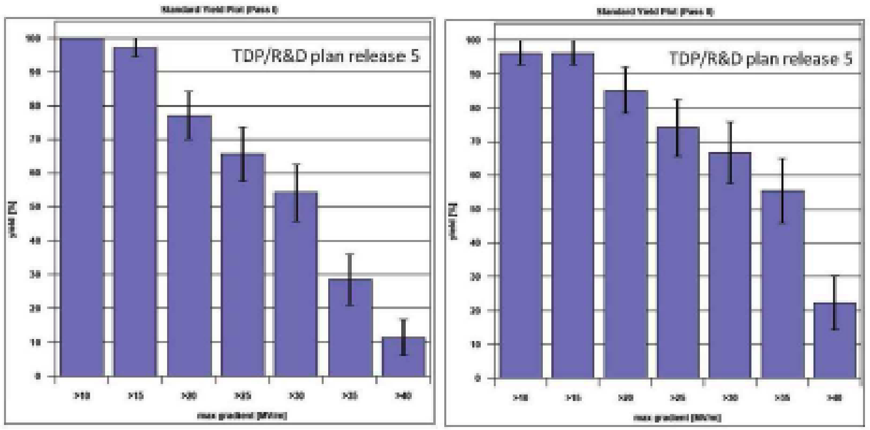


Figure 4.1: First-pass (left) and second-pass (right) yields as a function of maximum gradient. [updated data by June 30.]

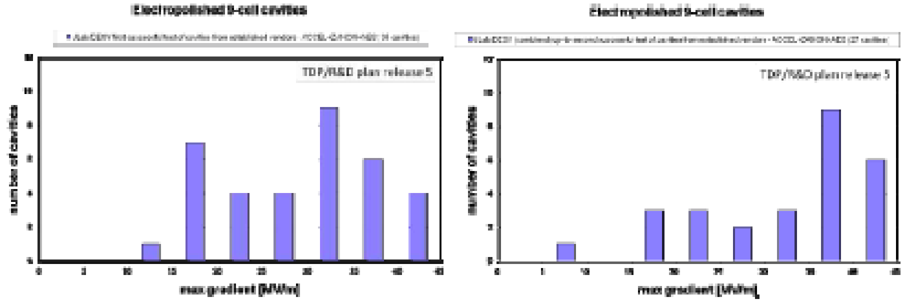
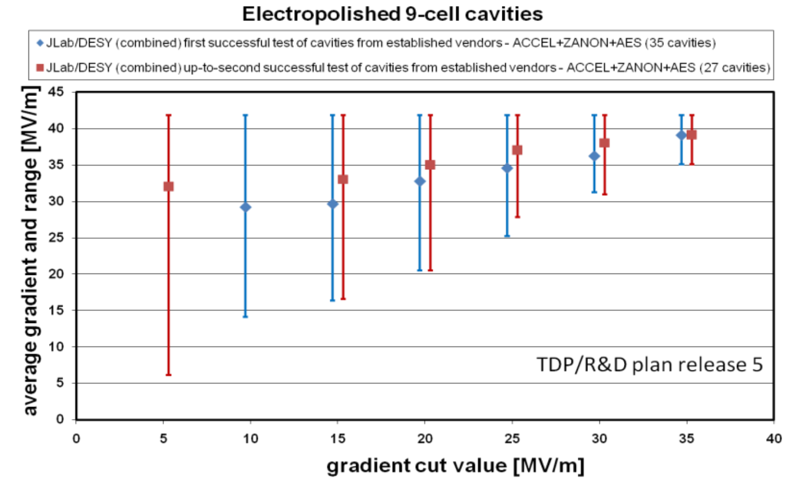


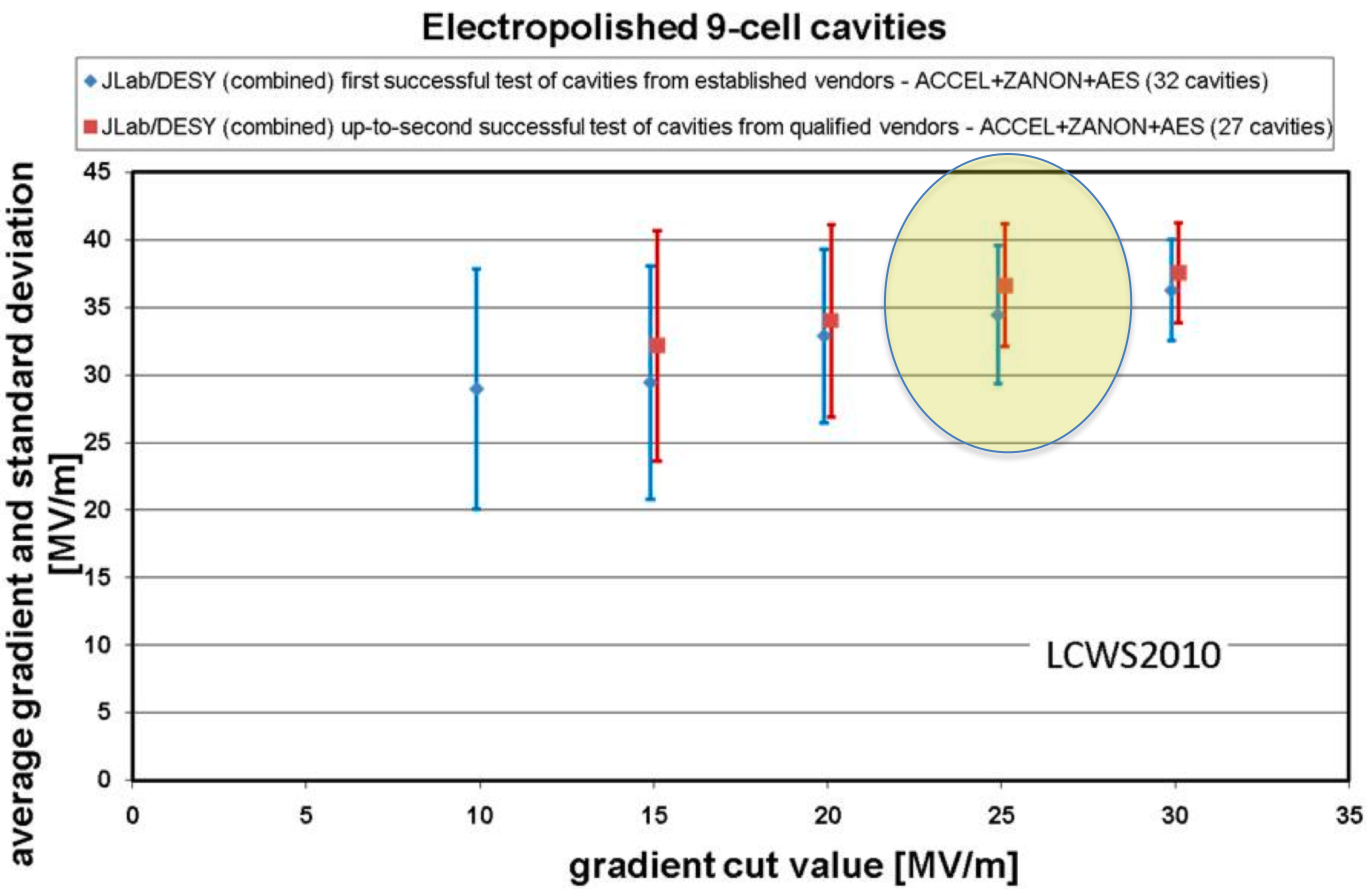
Figure 4.2: Number of cavities as a function of maximum gradient, for first-pass (left) and second-pass (right) data samples. [updated data by June 30.]

- ILC-GDE Cavity Database Team Progress report
  - C. Ginsburg et al.
  - as of June 30, 2010



Gradient Spread and Standard Deviation

- As of June 30, 2010
- Average: ~ 36 MV/m at gradient cut at 25 MV/m
- Standard deviation: ~ 5 MV/m gradient cut at 25 MV/m



Basic R&D Efforts in TDP-2


ILC Research and Development Plan for the Technical Design Phase

Release 5

August 2010

ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

Table 4-3: Basic R&D effort to improve field gradient with the cost effective cavity fabrication in TD Phase 2 (Categorised).

Priority	Subjects	R&D themes	Actions planned
Highest	Fabrication	Forming/machining EBW, improve tools for QC in mass production. VEP	Cost effective fabrication R&D with Pilot Plant (KEK) Destructible bare 9-cell cavities, (FNAL/JLAB/Cornell) Bare 9-cell cavities w/ in-house welder (JLAB) XFEL and ILC-HiGrade Project (DESY)
High.	Mechanical polishing prior to heavy EP	Eliminate weld irregularities, reduce surface removal by heavy EP.	Raw 9-cell mechanical polishing before chemistry (FNAL) 9-cell tumbling for cavity recover (Cornell)
Mid.	Large-grain and direct slicing	Eliminate rolling and contamination.	Large-grain cavities and multi-wire slicing (KEK), Processing and evaluation of existing 9-cell large grain cavities,
High	Seamless cavity	Eliminate/minimise weld preparation, machining and EBW.	Hydroform and test multi-cell cavities, (DESY-JLab, KEK) Hydroform and test multi-cell cavities (FNAL/Industry)
Mid.	Material improvement	Nb with low Ta concentration.	Material characterisation and 1-cell cavity testing (FNAL) Material characterisation and 1-cell testing (JLab)
High	Post vertical test local treatment	Rapid quench limit improvement with small incremental cost.	Local grinding (KEK) Local re-melting with laser beam (FNAL) Local treatment/re-melting with electron beam (JLab)
Highest	Field emission quantified	Additional information than unloaded quality factor.	Correlation of vertical test FE with horizontal test FE as well as dark current in linac beam operation, Comparison across facilities world-wide,

Time-Table / Agenda (Sept. 10)

Day	Am/pm	Subject	Convener/presenter
9/10		ILC accelerator gradient and operational margin	A. Yamamoto and J. Kerby
	9:00	Gradients from VTS to Operation - Introduction: Overview on ILC gradient specification at each testing / operation step - Terminology definition - Operational results from VT/HTS/CM tests in data base - Operational results from STF VT/CM tests at KEK	Chair: H. Hayano - A. Yamamoto - M. Ross - C. Ginsburg - E. Kako
	10:30	Operational margin - Lorentz Force Detuning and Effects on op. margin - Comments from LLRF and Beam Dynamics - Comments onAcceerator Operation gradient margin	Chair: N. Toge - E. Kako - (K. Kubo/C. Michizono) - N. Walker
	13:30	Cost Impacts - Reminder on cost effects - List of systems / technical components affected by gradient specification change - A plan to prepare for communication w/ industries	Chair: N. Walker - P. Garbincius - J. Kerby - A. Yamamoto
	15:15	General Discussion and recommendation - General discussions - Summary and recommendations	Chair: A. Yamamoto - All
	17:00	- End	

ILC ML Cavity Gradient

R&D Milestones and ML operational Specification

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Table 4-1: Milestones for the SCRF R&D Programme

Stage	Subjects	Milestones to be achieved	Year
S0	9-cell cavity	35 MV/m, max., at $Q_0 \geq 8\times10^9$, with a production yield of 50% in TD PHASE 1, and 90% in TD PHASE 2 [1), 2)]	2010/ 2012
S1	Cavity-string	31.5 MV/m, on average, at $Q_0 \geq 10^{10}$, in one cryomodule, including a global effort	2010
S2	Cryomodule-string	31.5 MV/m, on average, with full-beam loading and acceleration	2012

1. The process yield of 50 % in TDP-1, in the R&D Plan (release 2), has been revised to be the production yield of 50 % in the TDP-1.
2. A quantitative evaluation of radiation emission is to be included in the milestone list in near future.

Table 4-2: Key cost-relevant ILC design parameters and their relationship to the R&D programmes. A review of the proposed specifications remains a TD Phase 2 deliverable.

Cost-relevant design parameter(s) for TDR	Currently proposed specification	Relevant R&D programme	*Comment*
Mass production distribution (models)		S0	*cost optimisation will require a model for the yield curves based on the S0 R&D results*
Average gradient	35 MV/m	S0	*primary cost driver*
Gradient spread	±20% (28-42 MV/m)	S0/S1/S2	*cost-optimisation and performance balance*
Average performance in a cryomodule (margin)	5% (33 MV/m average)	S1	*total of 10% specified in RDR, but distribution not given (assumed equally split here)*
Allowed operational gradient overhead for RF control (full beam-loading)	5% (31.5 MV/m average)	S2 (S1*)	
Required RF power overhead for control	10%	S2 (S1*)	

**) important input will also be gained from S1 programme*

R&D Milestone in RDR revised in Rel-5

Stage	Subjects	Milestones to be achieved	Year
S0	9-cell cavity	35 MV/m, max., at Q0 ≥ 8E9, with a production yield of 50% in TDP1, and 90% in TDP2 [1), 2)]	2010/ 2012
S1	Cavity-string	31.5 MV/m, in average, at Q0 ≥ 1E10, in one cryomodule, including a global effort	2010
S2	Cryomodule-string	31.5 MV/m, in average, with full-beam loading and acceleration	2012

ILC Accelerator, Operational Gradient

- Strategy for Average Accelerating Gradient in the ILC operation:
  - Overview and scope of 'production yield' progress and expectations for TDP,
    - including acceptable spread of the gradient needed to achieve the specified average gradient,
  - Cavity
    - Gradient, Q0, and Emitted Radiation in *vertical test*, including the spread and yield,
  - Cryomodule
    - Gradient, Cryogenic-load and Radiation, including the gradient spread and operational margin with nominal controls,
  - ILC Accelerator
    - Gradient, Cryogenic-load and Radiation, including the gradient spread and the operational margin with nominal controls
  - Strategy for tuning and control,
    - including feedback, control of 'Lorentz force detuning', tolerances and availability margin,
  - Impact on other accelerator systems: CFS, HLRF, LLRF, Cryogenics, and overall costs.

A possible balance in ILC ML Accelerator Cavity Specification

A new guideline in TD Phase 2 may be proposed as follows (summarized in Table 3-4):

- R&D goal for the 9-cell gradient to be kept at 35 MV/m at a production yield of 90 % or more
- ILC project accelerating gradient specification specifying average gradient and spread of low-power test cavity gradients and a subsequent spread in cryomodule operational cavity gradient limits.

Table 3-4: A possible balance of gradients in various stages in the ILC ML cavity production stage (to be studied and established)

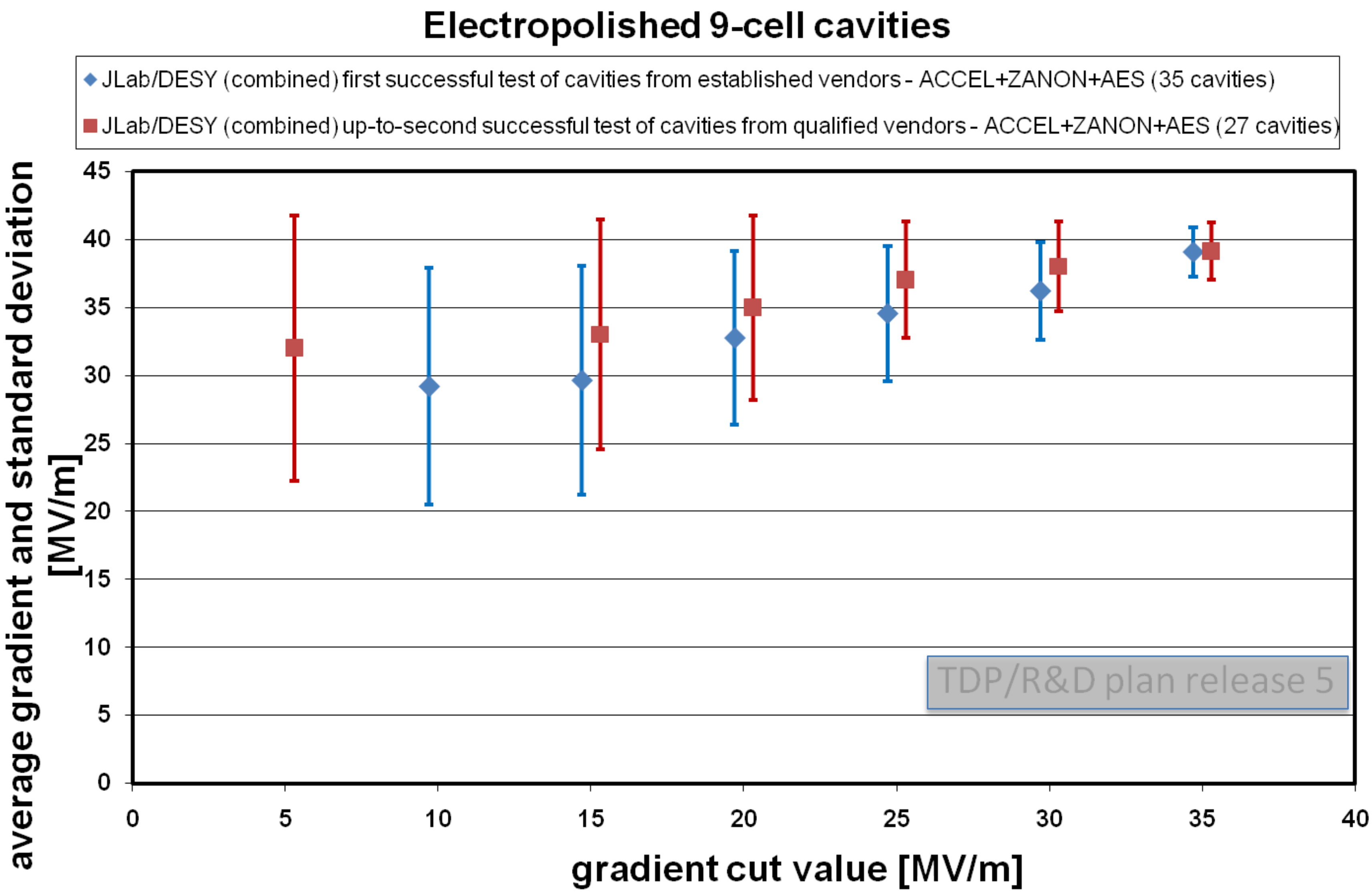
Single 9-cell cavity gradient	String Cavity gradient in cryomodule w/o beam	String cryomodule gradient in accelerator with beam
35 MV/m, on average w/ spread above a threshold	> 33 MV/m, on average (or to be further optimized)	31.5 MV/m, on average (or to be further optimized)

ILC-ML SCRF Cavity Gradient Specifications
proposed, based on R&D Effort and Milestone/Goals

Cost-relevant design parameter(s) for TDR	ML cavity gradient Specification	R&D Mile-stone	Relevant R&D Programme
Mass production distribution (models)			S0
9-cell Cavity Gradient in vertical test	35 MV/m, average - Spread: 28 – 42 MV/m (+/- 20 % or less)	35 MV/m at 90 % yield including 2nd pass, (eq. > 38 MV/m, average: TBD)	S0
Cryomodule Operational Gradient	> 33 MV/m, average	34 MV/m, average Oprational margin = 3 %**	S1
ML Operational Gradient	31.5 MV/m avg - Spread: 25 – 38 MV/m (+/- 20 % or less: TBD)	31.5 MV/m, average Op. G. limit = 1.5 MV/m** Control margin = 3 %**	S2 (S1*)
Required RF power overhead for control	10% (TBD)		S2 (S1*)

- Important input will also be gained from S1 program
- ** as starting points for the discussions

Gradient and Spread as of June, 2010



Subjects to be further studied in TDP-2

- Further Studied in TDP-2
  - How wide cavity gradient spread may be acceptable in balance of HLRF power source capacity and efficiency?
  - How large operational margin required and adequate in cryomodule and accelerator operation?

Discussions toward Common understanding/recommendation

- Observation
  - Challenging operational margin in accelerator operation to be reliable enough for sufficient availability for physics run.

- Our Strategy Proposed
  - Make our best effort with forward looking position to realize the accelerator operational gradient to be 31.5 MV/m, on average with reasonable gradient spread (> ~ 20 %),
  - Keep cost containment concept.
  - Prepare for the industrialization including cost and quality control.

  - Ask physics/detector groups to share our observation and forward looking strategy

Summary
Tasks in each day/session

Date	Main Theme	Tasks
Sept. 7	Introduction KCS: Design and R&D RDR: Technical	Make the workshop tasks clear Process for the reality including cost Feasibility as a backup solution
Sept. 8	DRFS: Design and R&D LLRF/Control Discussions	Process for the reality including cost R&F operation margin for cavity/accelerator Recommendation
Sept. 9	Cavity Gradient R&D Discussions	Strategy for cavity gradient improvement Short-term and long-term strategy to be clear
Sept. 10	ML Accelerator Gradient Discussions	Accelerator gradient including spread, Appropriate balance of gradient in cavity/cryomodule/accelerator, and Adequate margin in accelerator operation Recommendation

Back-up

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	→ Process Yield 50%			→ Production 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			Production Technology R&D			