ILC-BAW1
Interim Summary and Further Plan

Akira Yamamoto, Marc Ross and
Nick Walker
GDE Project Managers

Reported at BAW1, held at KEK, Sept. 9, 2010

The 1st BAW Announcement

http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=4593

The 1st Baseline Assessment Workshop (07-10 September 2010) http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=4593

LOCAL: Asia/Tokyo login

The 1st Baseline Assessment Workshop

Search

7-10 September 2010 KEK, Seminar hall, 1st floor, 4-goukan

- Overview
- General Plan and Focusing Discussions
- Timetable
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- Workshop Dinner
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Organized by ILC-GDE Project Managers:
Akira Yamamoto, Marc Ross, and Nick Walker
Hosted and locally organized by KEK LC office:
Chair: Seiya Yamaguchi
Scientific Secretary: Tetsuo Shidara
Administrative Secretary: Tomiko Shirakata

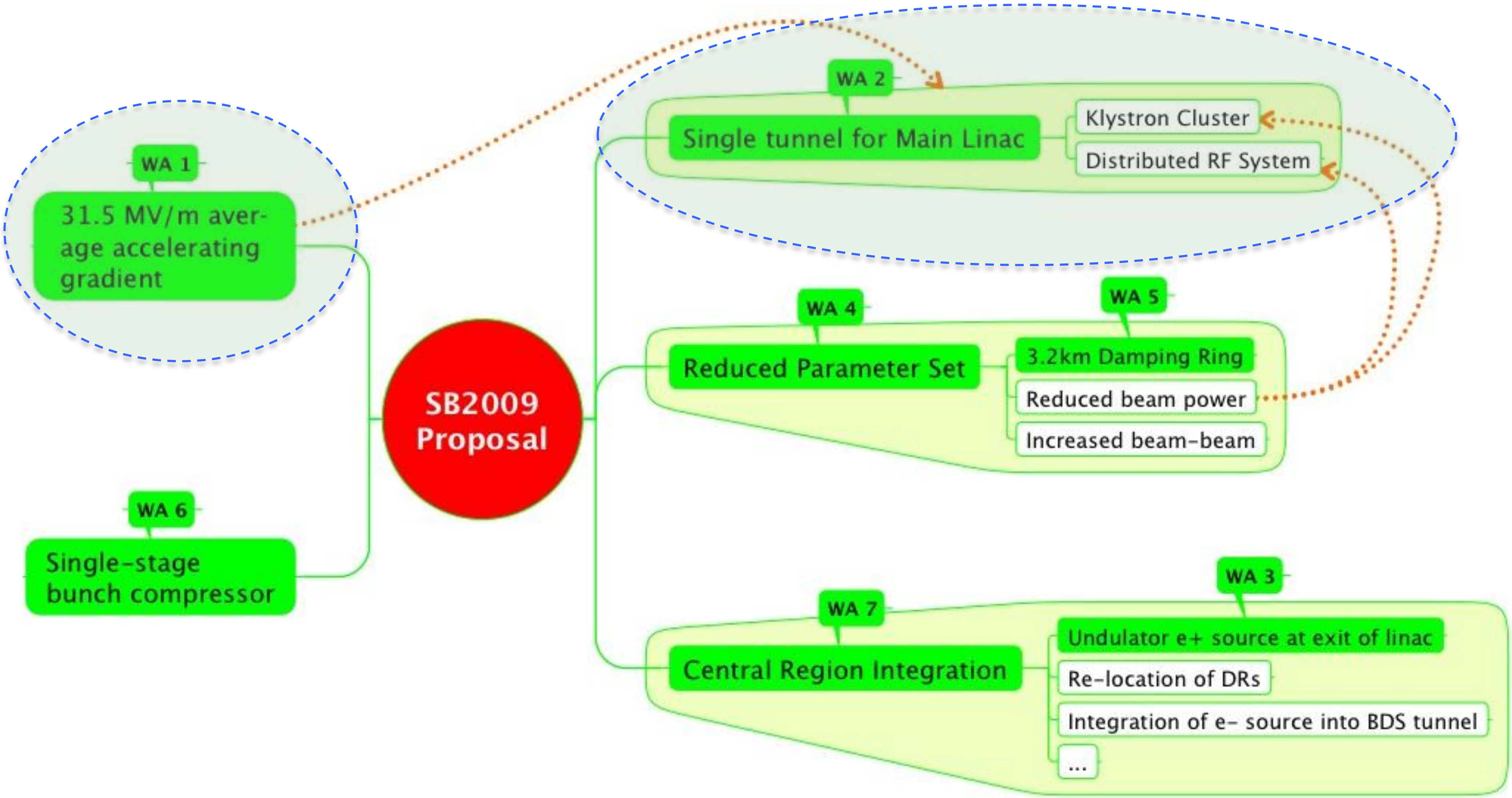
1. Main Subjects:
   1) Single-tunnel ML design and High Level RF System (Sept. 7 - 8)
   2) Accelerator Field Gradient for SCRF Cavity (Sept. 9 – 10)

2. Objectives and Goals:
- Assessment of technical proposal in SB2009
- R&D plan and goal in TDP-2
- Impact across system interfaces, cost and schedule
- Discussions toward consensus in GDE and Physics/Detector groups

Participants to the workshop (requested)
- GDE PMs/APMs
- GDE ADI team / TAG leaders
- Physics/Detector Representatives

Participants anticipated
- AAP and PAC members
- Internal and external experts

SB2009 Themes



N Walker

Updated ILC R&D / Design Plan

ILC Research and Development Plan
for the Technical Design Phase

Release 5
Aug. 2010

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**

TLCC Process

Baseline Assessment Workshops

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

- **Open plenary meeting**
- **Two-days per theme**
- **Two themes per workshop**
  - Two four-day workshops
- **Participation (mandatory)**
  - PM (chair)
  - ADI team / TAG leaders
    - Agenda organised by relevant TAG leaders
  - Physics & Detector Representatives
  - External experts
- **Achieve primary TLCC goals**
  - In an open discussion environment
- **Prepare recommendation**

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. 7)
updated: August 27

Day	Am/pm	Subject	Chair/presenter
9/7		Single Tunnel ML Design and HLRF -1	S. Fukuda / C. Nantista
	9:0 0 90 min	Opening and Introduction - Opening address - Report from AAP - BAW1 objectives and goals	Chair: S. Yamaguchi - A. Suzuki (KEK-DG) - E. Elsen - A. Yamamoto (GDE-PM)
	10:45 90 min	Single tunnel CF design and HLRF design - Single tunnel CF design status (1 hour) - General HLRF design in SB2009 (30 min)	Chair: T. Shidara - A. Enomoto - S. Fukuda
	13:30 120 min	HLRF KCS -KCS design and R&D status (45 min) -Demonstration of feasibility (45 min)	Chair: S. Fukuda - C. Nantista - C. Adolphsen
	15:45 105 min	HLRF – EU XFEL and RDR - Introduction (20 min) - Experience from XFEL (1 hour) - RDR configuration (as backup) (10 min) - Discussion (15 min)	Chair: N. Walker -M. Ross -W. Bialowons - S. Fukuda - ALL

Time-Table / Agenda (Sept. 8)

Day	Am/pm	Subject	Convener/presenter
9/8		Single Tunnel ML Design and HLRF -2	S. Fukuda / C. Nantista
	9:00	DRFS -DRFS design and R&D status -Installation strategy -(1 hour total)	Chair: C. Nantista - S. Fukuda - S. Fukuda
	10:45	HLRF and LLRF -LLRF requirements/issues for KCS 30 -LLRF requirements/issues for DRFS 30 -Requirements from Beam Dynamics 30	Chair: T. Shidara - C. Adolphsen - S. Michizono - K. Kubo
	13:30	Operational consideration - Sorting cavities in relation with HLRF 30 - Gradient and RF Power Overhead 30	Chair: C. Adolphsen - S. Noguchi - J. Cawardine
	15:45	Discussions and Recommendations - General discussions and questions - Summary and recommendations	Chair: A. Yamamoto - TBD - ALL

Single Tunnel Proposal: intro 1

- The proposal to go to a single tunnel solution for the Main Linac technical systems remains essential that outlined in the SB2009 report.
- The primary motivation was and remains a reduction in project cost due to the removal of the service tunnel for the Main Linac.

- The original proposal was based on the adoption of two novel schemes for the HLRF:
  - KCS
  - DRFS
- KCS has been identified as a preferred solutions for 'flat land' sites where surface access (buildings) is not restricted
- DRFS has been identified as being preferred solutions for mountainous region where surface access (buildings) is severely limited.

- Having both R&D programmes in parallel can be considered as risk-mitigation against one or other of them failiing.
- It is acknowledged that both these schemes require R&D
  - Programmes are detailed in the R&D Plan Release 5
- At the time of submission in December 2009, the two primary obstacles to adoption of a single tunnel were identified as
  - Safety egress
  - Operations & Availability

Single Tunnel Proposal: intro 2

- Both these issues were addressed during the 2009 and the successful results reported in the SB2009 proposal.
  - The conclusions of these studies were later accepted by both AAP and PAC
- The remaining identified issues were with the technical feasibility and cost of the HLRF solutions upon which the single-tunnel proposal was based.
- Two components to successful adoption were identified
  - Definition of acceptance criteria for TD Phase R&D for successful demonstration of one or more of the novel proposed schemes
  - Inclusion in the designs of a risk-mitigation strategy, whereby a fall-back to the RDR HLRF Technical Solution (in a single-tunnel) could be adopted, should the associated R&D not be considered successful.
- The remainder of these slides deals with these two additional points

RDR HLRF Tech. Solution 1

- Two scenarios have been cursorily studied for support of an RDR-like HLRF solution in a single-tunnel
  1. 10MW MBK + (Marx) Modulator in the tunnel
  2. XFEL-like solution with modulators (low-voltage) accessible in cryo refrigeration builds/caverns, with long pulsed cables feeding 10MW MBKs (via a pulse transformer) in the tunnel.
- Both are considered technically feasible.

- For 1, early investigations show the tunnel diameter would need to increase to 6.5m
  - This represents an estimated 10% increase in cost/unit tunnel length (~0.5% TPC) considered acceptable.
  - Current availability* simulations (cf SB2009 proposal) suggest an additional ~5% linac overhead (~2.5% TPC)
- For 2:
  - additional space for modulators in halls/caverns is required.
  - Cost of 3000 km of pulsed cable will be required.
  - Re-design of tunnel cross-section needed to accommodate cables.
  - Current availability* simulations (cf SB2009 proposal) suggest an additional ~2.5% linac overhead (~1.3% TPC)

* see later comments on availability

RDR HLRF Tech. Solution 2

- It is proposed that these RDR-like single-tunnel solutions be carried forward in parallel, to enough detail to support a cost estimate (incremental)
- This estimate – together with the scope of the necessary re-design work to adopt one of the scenarios, will be factored into the TDR Risk Assessment
- The main R&D and AD&I effort will continue to pursue the preferred baseline solutions for KCS and DRFS.
- In order to reduce the number of scenarios to be developed, we propose to phase out one of these RDR-like options within the next six-months

* see later comments on availability

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

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 - Acceerator 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
	15:30	General Discussion and recommendation - General discussions - Summary and recommendations	Chair: A. Yamamoto - All

Discussion Topics: Accelerating Gradient 1st BAW, KEK, Sept. 9-10, 2010

- Gradient Improvement Studies: (Convener: Rongli Geng/A. Yamamoto)
  - Material/fabrication, surface processing, instrumentation and repair
  - Strategy to overcome 'quench', and 'field emission' and to maintain moderate cryogenic load,
  - Strategy to define and specify 'Emitted Radiation', (Radiation that may result in increased cryogenic-load and usable gradient limitations),
  - Improvement of gradient and achievement of adequate yield,

- Strategy for Accelerating Gradient in the ILC: (Convener: Akira Yamamoto)
  - Overview and scope of 'production yield' progress and expectations for TDP, including acceptable spread of the gradient needed to achieve the specified average gradient,
  - Specifications of Gradient, Q0, and Emitted Radiation in *vertical test*, including the spread and yield,
  - Specifications of Gradient, Cryogenic-load and Radiation, including the gradient spread and operational margin with nominal controls, in *cryomodule test*,
  - Specifications of Gradient, Cryogenic-load and Radiation, including the gradient spread and the operational margin with nominal controls in *beam acceleration test*,
  - Impact on other accelerator systems: CFS, HLRF, LLRF, Cryogenics, and overall costs.

Global Plan for SCRF R&D

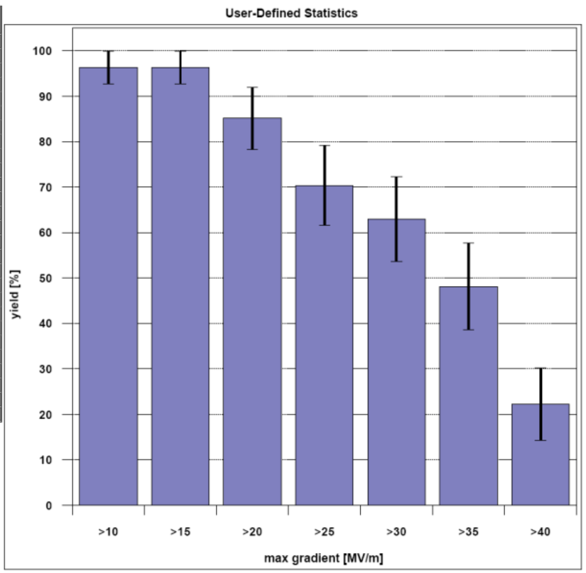
Year	07	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2		
Cavity Gradient in v. test to reach 35 MV/m	→ **Process** Yield 50%			→ **Production** Yield 90%		
Cavity-string to reach 31.5 MV/m, with one-cryomodule		Global effort for string assembly and test (DESY, FNAL, INFN, KEK)				
System Test with beam acceleration		FLASH (DESY) , NML (FNAL) STF2 (KEK, extend beyond 2012)				
Preparation for Industrialization			Production Technology R&D			

Cavity Gradient Yield as of June, 2010

2nd-pass cavity yield at >25 MV/m is (70 +- 9) %
improved to **(74 +- 8) %**
>35 MV/m is (48 +- 10) %
improved to **(56 +- 10) %**

LCWS2010

No.	Cavity	Test Date	Max. Eacc [MV/m]
1	TB9ACC013	01.Dec.08	41.80
2	TB9ACC014	09.Feb.09	41.50
3	ACCEL7	18.Jan.07	41.20
4	TB9AES008	26.Aug.09	41.10
5	Z143	12.Nov.08	41.00
6	TB9AES007	16.Mar.10	41.00
7	TB9ACC016	11.Feb.10	39.30
8	AC122	26.Aug.08	38.88
9	AC115	11.Dec.07	38.60
10	TB9AES010	06.Nov.09	37.70
11	TB9ACC011	21.Aug.08	37.00
12	TB9AES009	07.Oct.09	36.00
13	TB9ACC012	07.Jul.08	35.10
14	AC150	08.May.09	33.23
15	Z139	20.Oct.08	32.75
16	Z106	27.Feb.07	31.50
17	AC124	19.May.09	30.93
18	ACCEL6	23.Jan.07	29.00
19	AC127	11.Jun.09	27.85
20	AC149	05.May.09	23.27
21	TB9AES006	11.Sep.09	22.20
22	Z141	14.May.08	20.70
23	TB9AES005	09.Apr.09	20.50
24	TB9ACC015	14.Jul.08	19.00
25	Z131	25.Nov.08	17.96
26	Z130	15.Oct.08	16.60
27	AC126	21.Oct.08	6.14



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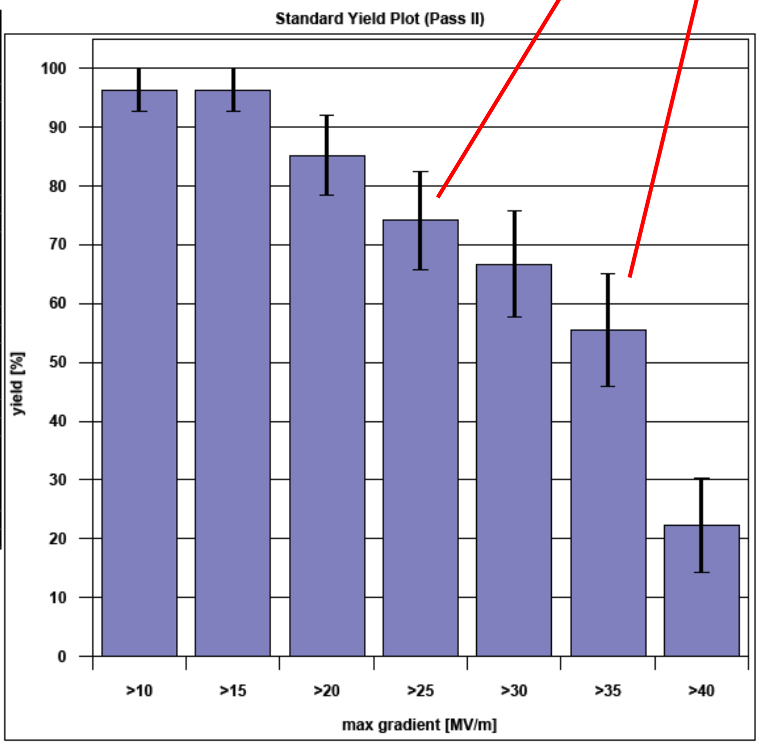
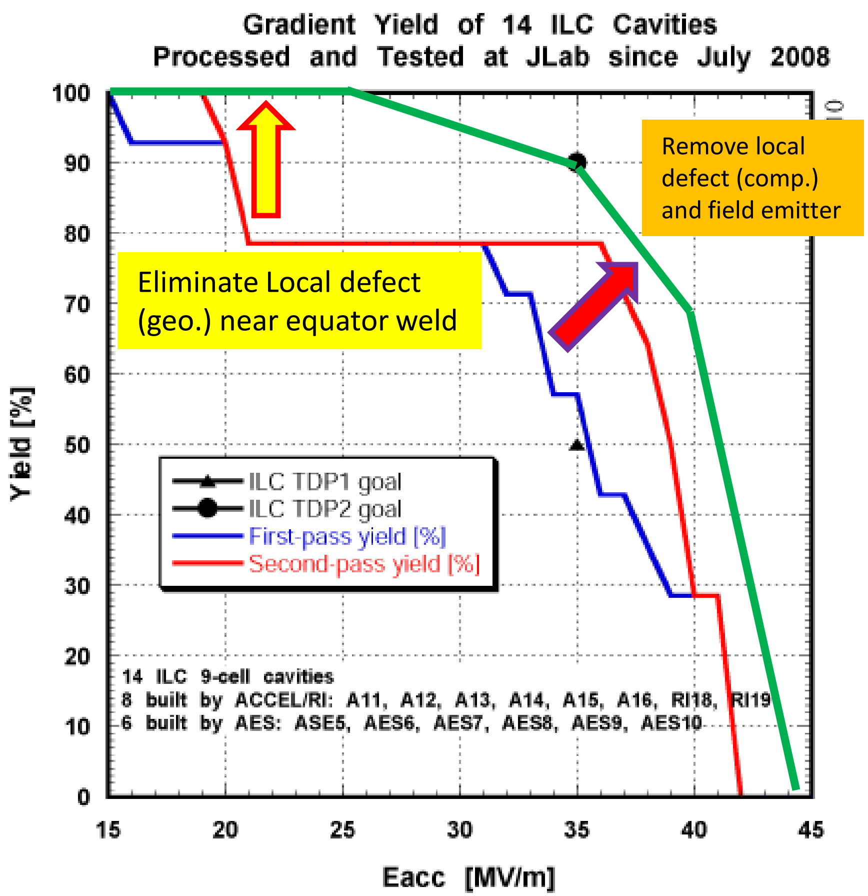


Gradient Improvement Plan

Based on Recent Understanding due to Globally Coordinated S0 Program



- Highest priority is to push yield up near 20 MV/m – the yield drop due to local (geometrical) defects near equator weld.
  - **Fab. QA/QC**
  - **Mechanical polish prior to heavy EP**
  - **Post-VT local targeted repair**
  - Seamless cavity
  - Large-grain mat. From ingot slicing
  - Fine grain mat. Optimization
- Also high priority is to suppress field emission at high gradient (up to 42 MV/m) – and quantify its effect on cryogenic loss and dark current.

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)

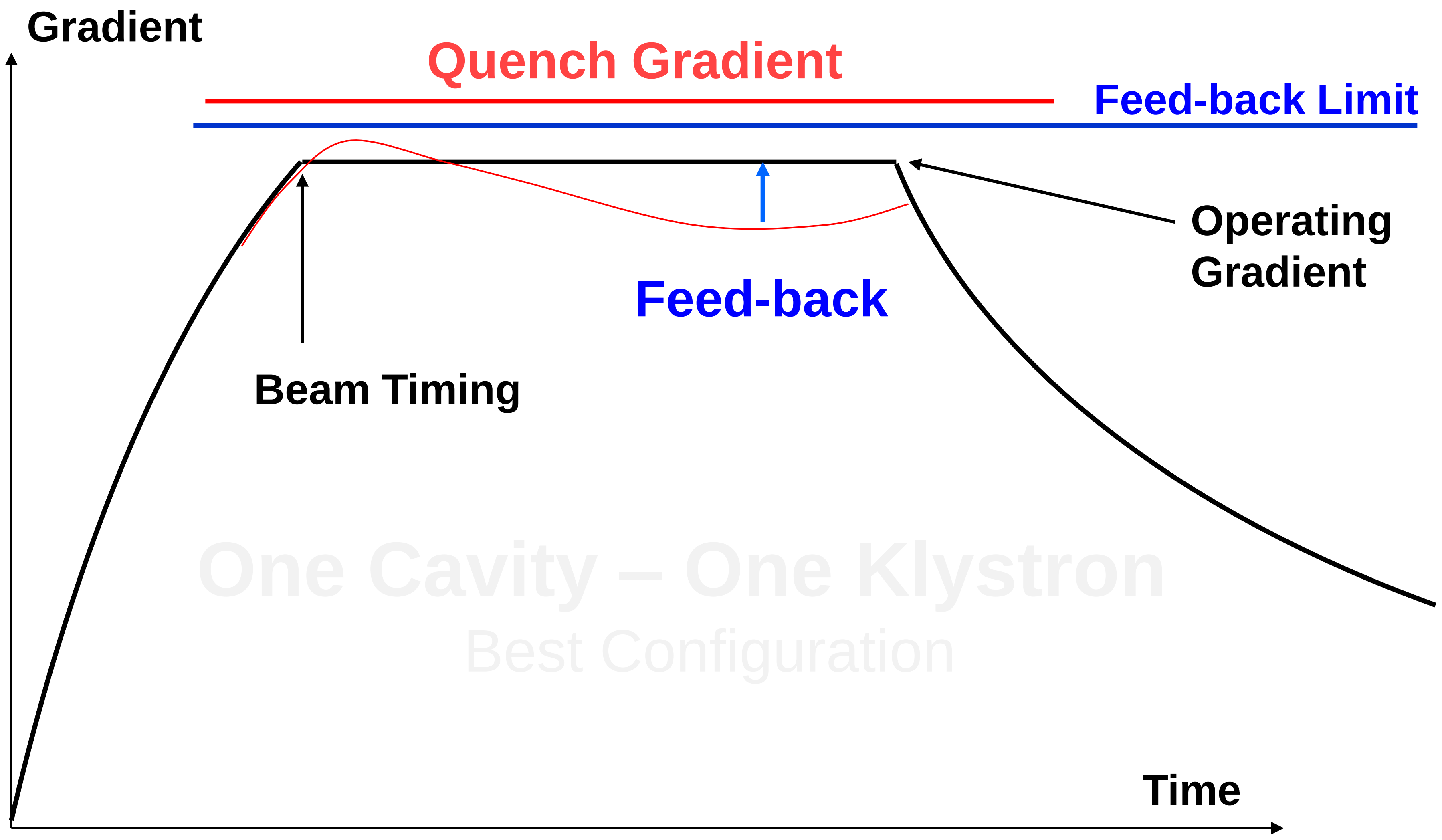
ILC SCRF Cavity Specification and relationship to the R&D Programs

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 program
- ** as a starting point for the discussions

Highest Gradient Operation

From S. Nogichi



Higher Gradient Operation with Better Electric Power Efficiency

Small Tuning Range

& Less DLD Effect

↓

Cavity Grouping with Over-Coupling

How should we do
for Degraded Cavity ?

To Save other Good Cavities,
We should have
Tunability for RF Power & Coupling.

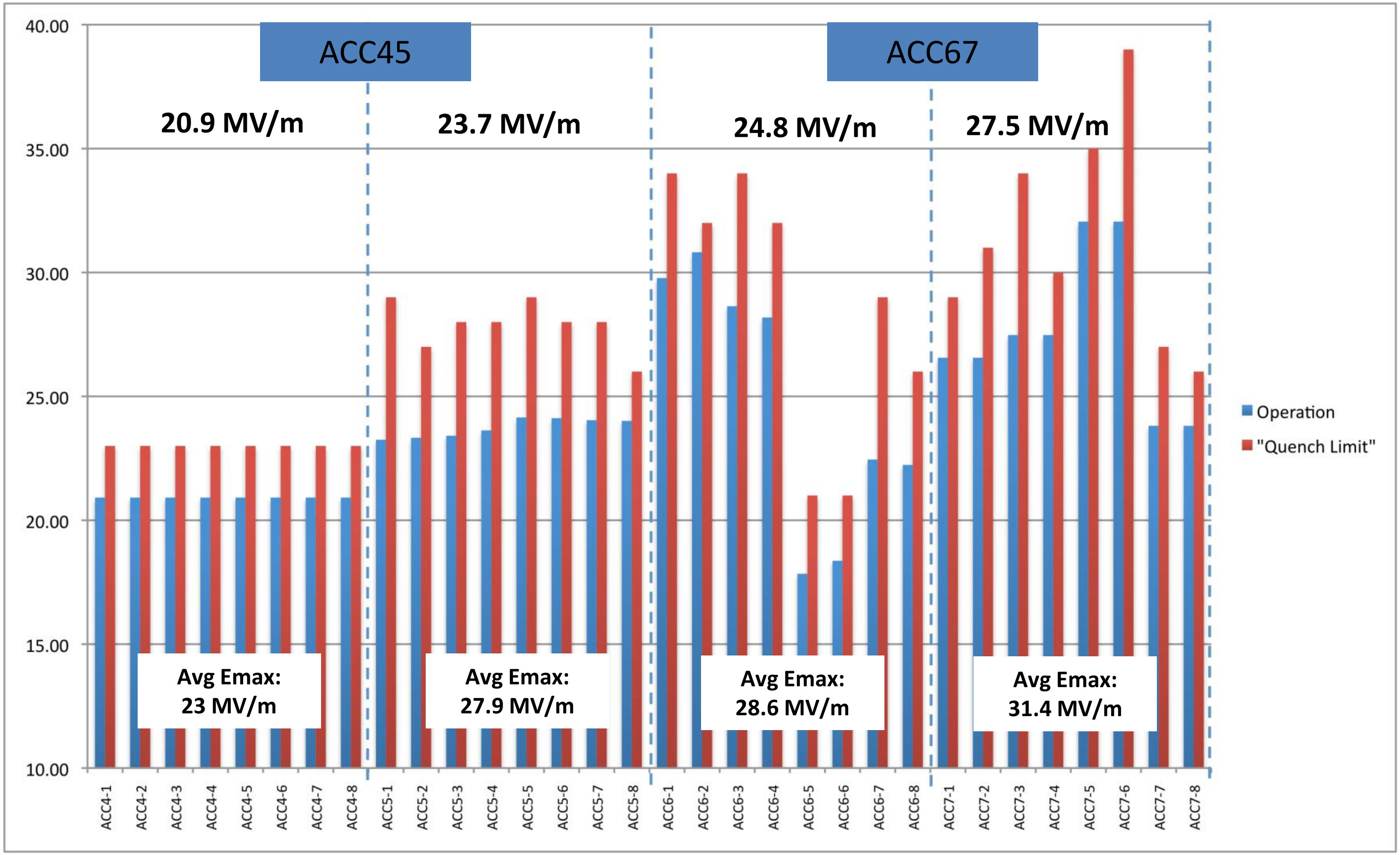
Summary from S. Michizono

		RDR	DRFS (PkQl)	DRFS(Cavity grouping)
RF power	Operation gradient	Max. 33 MV/m	Average 31.5 MV/m	Max. 38 MV/m
	RF source	10 MW		800 kW
	Waveguide loss	8% power	2% power	2% power
	Static loss (Ql, Pk)	2% power	2% power	2% power
	Kly Hv ripple	2.5% power	2.5% power	2.5% power
	Microphonics	2% power	2% power	2% power
	Reflection	0% power	14% power	0% power
	Other LLRF margin	10% power	10% power	5%~10% power
Tolerance	Ql tolerance		3% (2)	3% (2)
	Pk tolerance		0.2dB (2)	0.2dB (2)
	Detuning tolerance		15Hz rms(3)	20Hz rms (3)
	Beam current offset		2% rms (3)	

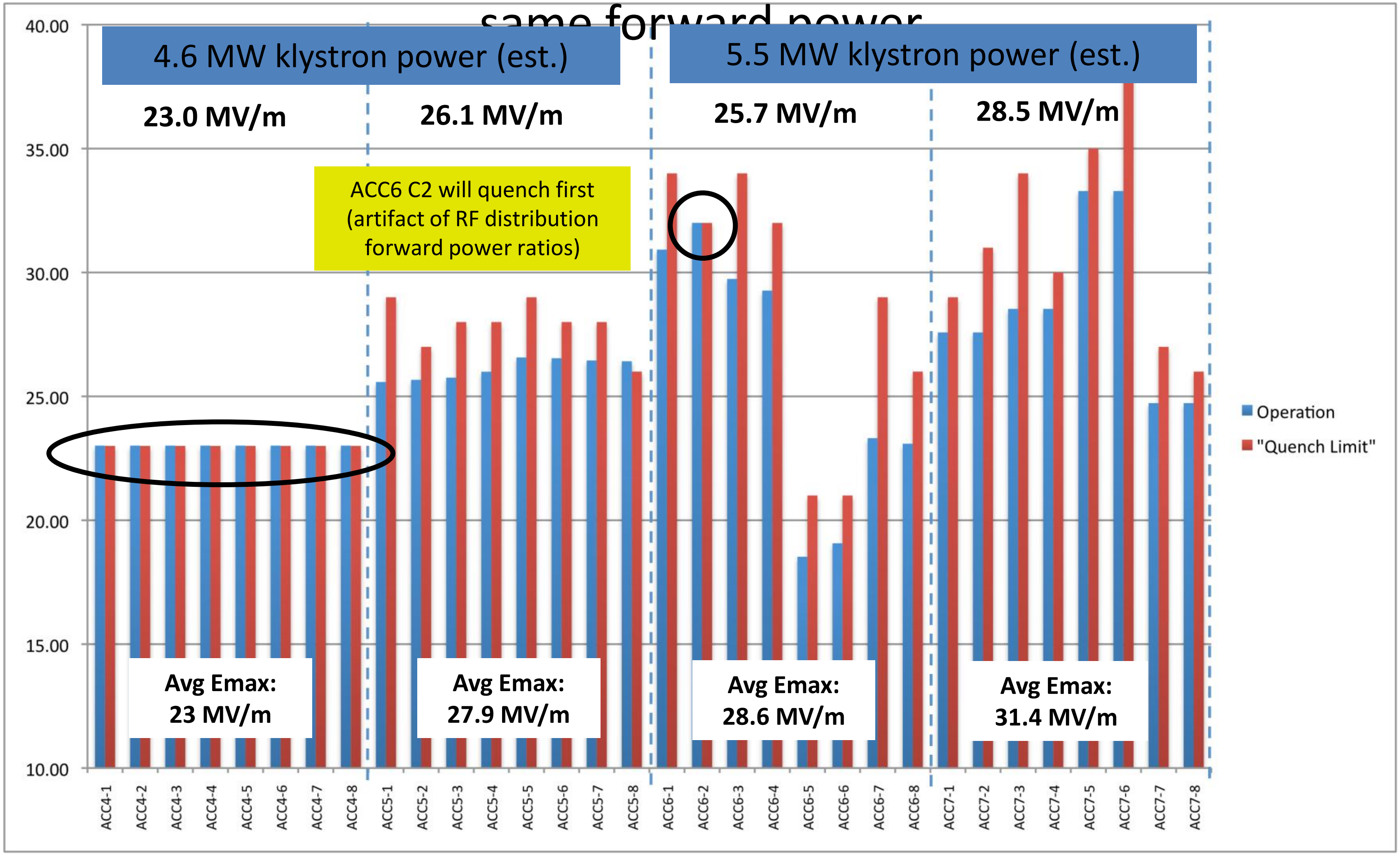
(1) LLRF overhead ~5%
(2) Cavity gradient tilt (repetitive) ~5%
(3) Pulse-to-pulse gradient fluctuation ~1%rms

- We have to examine these numbers experimentally.
- Tolerance should be discussed with cavity and HLRF group. If the tolerance is smaller, better gradient tilt would be possible.

Quench limits and operating gradients for 1.3GeV (FLASH ACC4-7) from J. Carwardine



Ideally, all cavities reach their respective quench limits at the same forward power



Reality: errors in power ratios due to manufacturing tolerances of rf attenuators
(In this case: tolerances are of the order +/-0.1dB)

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 consensus/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, as proposed in RDR, (and) on average with reasonable gradient spread,
  - Keep cost containment concept resulting in the ML tunnel length fixed and not to expand,
  - Prepare for the industrialization including cost and quality control.

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

Summary - 1
BAW1 Objectives and Goals

- Assess technical proposal in SB2009
- Confirm R&D Plan required and Goal in TDP-2
- Discuss Impact across system interfaces, cost, and schedule,
- Discuss toward consensus in GDE and Physics/Detector groups to prepare for TLCC.

Summary – 2
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 Gradien Discussions	Accelerator gradient including spread Appropriate balance of gradient in cavity/cryomodule/ML-accelerator, Adequate/required/acceptable gradient margin in accelerator operation Recommendation