ILC Accelerator Operational Gradient

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SCRF Webex Meeting, July 28, 2010

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.

Short and Long Term R&Ds

Priority	Subjects	R&D themes	Actions planned
Highest	Fabrication	Forming/machining EBW, Improve tools for QC in mass production	Cost effective fabrication R&D with Pilot Plant (KEK) Destructible bare 9-cell cavities, (FNAL/JLAB/Cornell/Industry) Bare 9-cell cavities w/ in-house welder (JLAB) XFEL and HighGrade Project (DESY)
High.	Mechanical polishing prior to heavy EP	Eliminates 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	Large-grain cavities and multi-wire slicing (KEK), Processing and evaluation of 8 existing 9-cell large grain cavities,
High	Seamless cavity	Eliminate weld prep machining and EBW	Hydroform and test muti-cell cavities, (DESY-JLab) Hydroform and test multi-cell cavities (FNAL/Ind.)
Mid.	Material improvement	Nb with low Ta concentration	Material characterization and 1-cell cavity testing (FNAL) Material characterization 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 horizonatal test FE as well as dark current in linac beam operation, Comparison across facilities world-wide,

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

A possible balance in ILC 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)

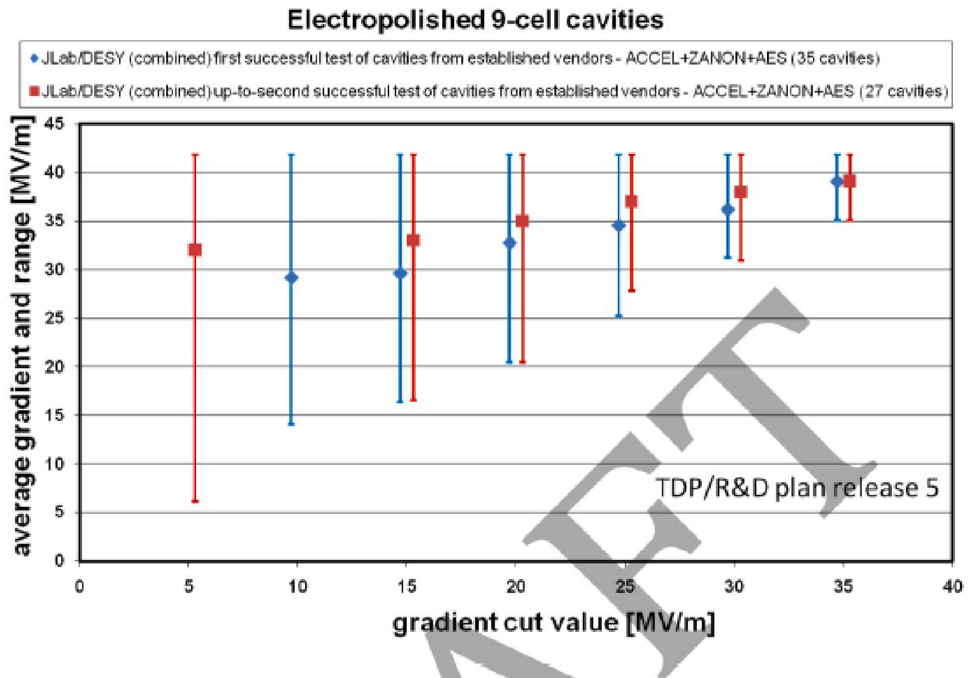

Figure 3.3: Average gradient (data points) and range (error bars) of the first-pass and second-pass data samples after excluding cavities which fail to meet the minimum gradient shown on the horizontal axis. The two data samples have been artificially offset from each other for clarity. [updated data by June 30.]

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 in cryomodule and accelerator operation?

backup

Discussion Topics: Single-tunnel HLRF system in the 1st BAW, Sept. 7-8, 2010

- KCS:
  - RF power margin required for cluster operation, including gradient spread, as consistent with cavity production strategy,
  - Tuning and control strategy, including impact on high gradient operation and required gradient operational margin
  - RF amplitude and phase performance tolerance within a cluster; allowed common-mode and normal-mode fluctuations,
  - R&D required, including demonstrations of component performance and demonstrations with small clusters
- DRFS:
  - Cavity and klystron sorting and resulting required RF power margins
  - Installation strategy; needed tunnel infrastructure and access
  - RF amplitude and phase performance tolerances, including gradient spread, as consistent with cavity production strategy,
  - R&D required in the remaining half of the TDP (and beyond) including radiation shielding, klystron lifetime, redundancy strategies
- Backups:
  - Original RF system in RDR, in single tunnel, just in case, as a backup,

Preparation for the 1st BAW

- May 7: SCRF webex meeting and homework assignment

- May 26: AD&I meeting
- June 2: SCRF webex meeting and progress report from each collaborator,

- June 23: AD&I meeting
- June 30: SCRF webex meeting and preliminary draft report to be distributed >>> in progress, assuming R&D plan draft can be partly used.

- July 21: AD&I meeting
- July 28: SCRF meeting and draft report to be distributed,

- Aug. 25: SCRF meeting and the final report (prior to the 1st BAW) to be distributed

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

- Gradient Improvement Studies: (Convener: Rongli Geng)
  - 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,
  - Cavity: Specifications of Gradient, Q0, and Emitted Radiation in *vertical test*, including the spread and yield,
  - Cryomodue: Specifications of Gradient, Cryogenic-load and Radiation, including the gradient spread and operational margin with nominal controls, in *cryomodule test*,
  - **ILC Accelerator:** 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.

Time-Table / Agenda (Plan: Sept. 10)

Day	Am/pm	Subject	Convener Session Chair/- presenter
9/10		ILC accelerator gradient and operational margin	A. Yamamoto and J. Kerby
	am-1	ILC Accelerator Gradient - Overview on ILC gradient specification - Observation on average and spread - Operational experience	C. Adolphsen - A. Yamamoto - J. Kerby - TBD
	am-2	Cryomodule operational margin - Operational experience - Requirements from cavity-string operation - Discussions	M. Ross - TBD - TBD
	pm-1	Accelerator/beam operational margin - Operational experience in accelerators - Requirements from accelerator tuning/op. - Discussions	N. Walker - TBD - TBD
	pm-2	Genearl Discussion and recommendation - General discussions - Summary and recommendations	A. Yamamoto - TBD - All

Cavity Gradient R&D Goals

	Consideration in RDR/SB2009	Re-optimization required in TD Phase 2
R&D goal: S0 - 9-cell cavity gradient	35 MV/m (≥ 90%)	35 MV/m (≥ 90 %): kept for forward looking
R&D goal: S1 - Cryomodule gradient w/o beam	31.5 MV/m in average	31.5 MV/m in average or higher to be optimized for reasonable cryomodule operational margin, inclusive
R&D goal: S2 - Cryomodules gradient with beam acceleration	Not specified	Likely to be the same as ILC operational gradient
ILC-ML design value: - Accelerating gradient	31.5 MV/m in average	31.5 MV/m in average or lower to be optimized for reasonable accelerator operational margin, inclusive