Summary of SCRF Meeting

Fermilab, April 21-25, 2008

April 25, 2008

General Summary and Further Plan:

4/21: Cavity: Gradient R&D, performance, diagnostics (S0),

4/22: Cavity: Integration, Tuner, Coupler and String-Test (S1, S1-global)

4/23: Cryomodule: plug-compatible interface, high-pressure, 5K-shield

4/24: HLRF/LLRF and MLI: Modulator, distribution, Beam-handling

4/25: Summary, TDP R&D plan, and work-assignment

General Agenda for SCRF Fermilab Meeting, April 21-25

Day	Subject	Goal
4/21	Cavity: preparation High gradient R&D (S0)	Plan for 35 MV/m (S0)
4/22	Cavity: Integration and Test in cryomodule (S1)	Tuner, Coupler, and Plan for S1, S1-global
4/23	Cryomodule and Cryogenics	Plug-compatible IF, HPG, 5K shield,
4/24	HLRF and Main Linac Integration	Efficient RF powering Beam handling
4/25	Summary and TDP R&D, work assignment, further meeting plan	R&D organization, Interium review plan

Goals of SCRF Meeting

Fermilab, April 21-25, 2008

- Reach consensus on
  - SCRF functional design parameters
  - Plug-compatible interface parameters
- Update TDP R&D plan and milestone
  - Cavity:
    - Achieve 9-cell cavity performance of 35 MV/m (S0),
    - Achieve cavity-string performance of 31.5 MV/m in cryomodule (S1)
  - Cryomodule and Cryogenics
    - Establish plug-compatible design and optimum thermal balance,
  - HLRF/LLRF:
    - Establish efficient power source and distribution system,
  - MLI:
    - Establish beam-handling design and boundary conditions
  - System Engineering
    - Achieve Cryomodule-String Test in one RF unit and with beam (S2)

Cavity: Gradient R&D

Progress:

- Fundamental understanding with chemical analysis and physical observation,

Further R&D:

- Countermeasure (project oriented)
  - Test facility and instrumentation to be improved,
  - Feedback loops for fabrication and test to be reinforced
- Fundamental Research for high gradient
  - Encouraged in some fraction for high gradient

Consensus:

- R&D target in TDP2:
  - Improve physical inspections before chemical process and cold test
  - 35 MV/m with yield 50 % of chemical process, in TDP-1.

Cavity: Integration

Progress:

- Functional specification and interface better defined:
- Understanding on reliability
  - Tuner: Redundancy of “Piezo” helpful for minimum maintenance,
  - Coupler: tunability may help to maximize the operational efficiency
- Global effort for cavity-string test (S1, and S1-global),

Further R&D:

- Tuner: Lifetime test for tuner piezo and motors,
- Coupler windows reliability
- Metal transitions,
- Beam pipe flange

S1 and S1 Global

Consensus:

- It is very important to achieve the cavity-string test, redundantly planned:
- S1-global to be realize with international effort, within a time period of CY2009-2010

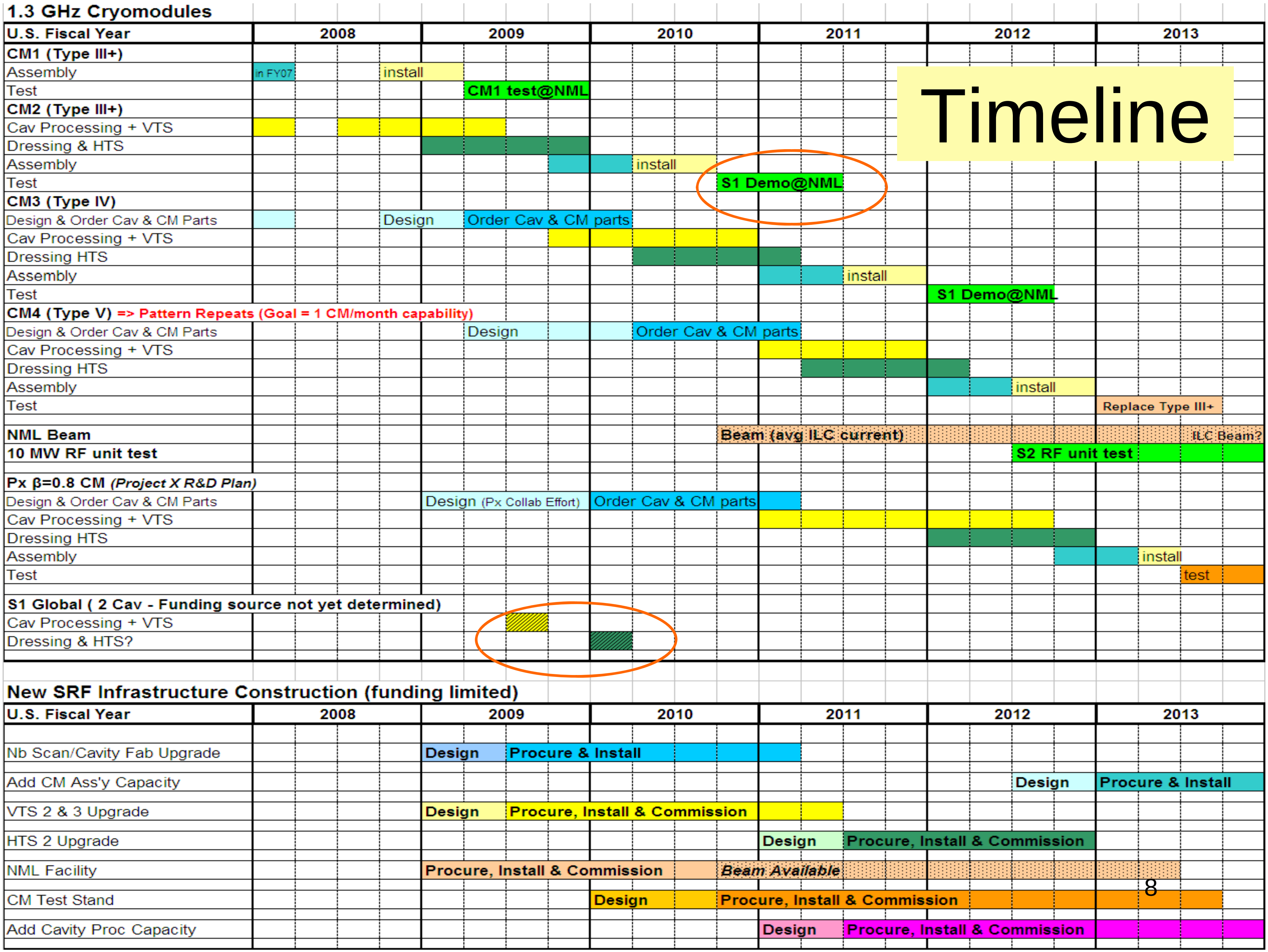
Further work:

- Cryomodule work to be optimized,

Global R&D Plan

Calender Year		2008	2009	2010	2011	2012
EDR	TDP1				TDP-II	
S0: Cavity Gradient (MV/m)	30	35 (> 50%)				35 (>90%)
KEK-STF-0.5a: 1 Tesla-like/LL						
KEK-STF1: 4 cavities						
S1-Global (AS-US-EU) 1 CM (4+2+2 cavities)			CM ($4_{AS}+2_{US}+2_{EU}$) <31.5 MV/m>			
S1(2) -ILC-NML-Fermilab CM1- 4 with beam			CM2	CM3	CM4	
S2:STF2/KEK: 1 RF-unit with beam			Fabrication in industries		STF2 (3 CMs) Assemble & test	

Timeline


1.3 GHz Cryomodules
U.S. Fiscal Year
2008
2009
2010
2011
2012
2013
CM1 (Type III+)
Assembly
in FY07
install
Test
CM1 test@NML
CM2 (Type III+)
Cav Processing + VTS
Dressing & HTS
Assembly
install
Test
S1 Demo@NML
CM3 (Type IV)
Design & Order Cav & CM Parts
Design
Order Cav & CM parts
Cav Processing + VTS
Dressing HTS
Assembly
install
Test
S1 Demo@NML
CM4 (Type V) => Pattern Repeats (Goal = 1 CM/month capability)
Design & Order Cav & CM Parts
Design
Order Cav & CM parts
Cav Processing + VTS
Dressing HTS
Assembly
install
Test
Replace Type III+
NML Beam
Beam (avg ILC current)
ILC Beam?
10 MW RF unit test
S2 RF unit test
Px β=0.8 CM (Project X R&D Plan)
Design & Order Cav & CM Parts
Design (Px Collab Effort)
Order Cav & CM parts
Cav Processing + VTS
Dressing HTS
Assembly
install
Test
test
S1 Global (2 Cav - Funding source not yet determined)
Cav Processing + VTS
Dressing & HTS?
New SRF Infrastructure Construction (funding limited)
U.S. Fiscal Year
2008
2009
2010
2011
2012
2013
Nb Scan/Cavity Fab Upgrade
Design
Procure & Install
Add CM Ass'y Capacity
Design
Procure & Install
VTS 2 & 3 Upgrade
Design
Procure, Install & Commission
HTS 2 Upgrade
Design
Procure, Install & Commission
NML Facility
Procure, Install & Commission
Beam Available
CM Test Stand
Design
Procure, Install & Commission
Add Cavity Proc Capacity
Design
Procure, Install & Commission

Cryomodule and Cryogenics

Progress:

- Functional specification and interface

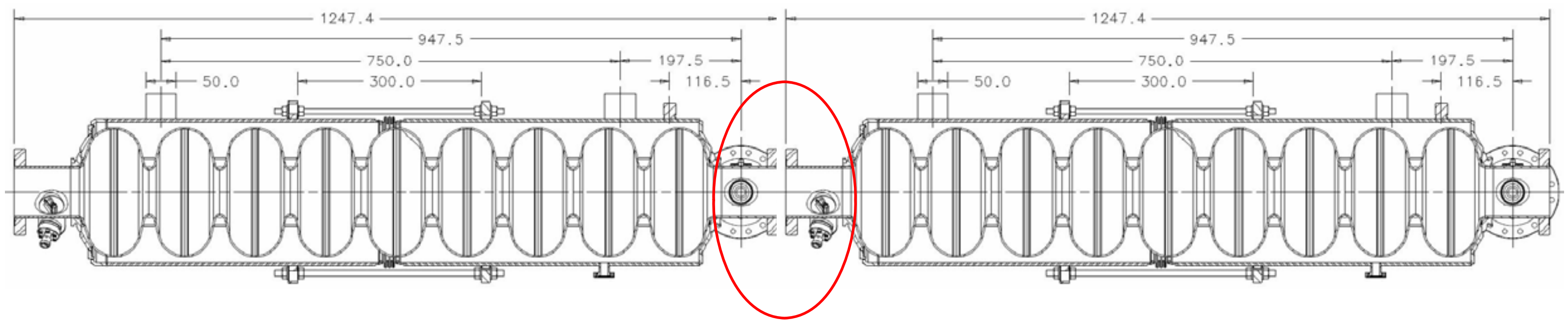
Consensus:

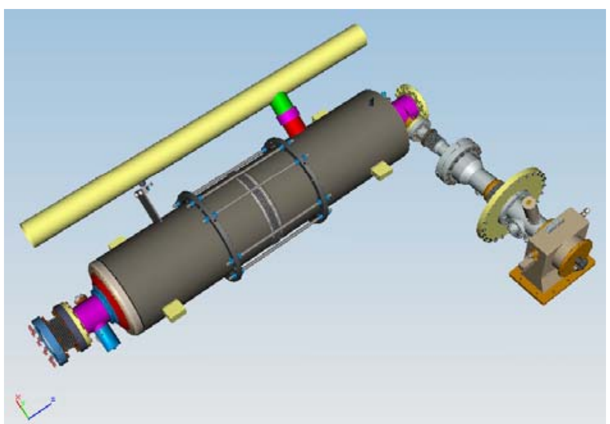
- Cryomodule diameter
- Cryogenics design pressure
- 5 K shield: to be simplified for cost saving with keeping reasonable thermal balance (radiation shield cooled w/ go-line)

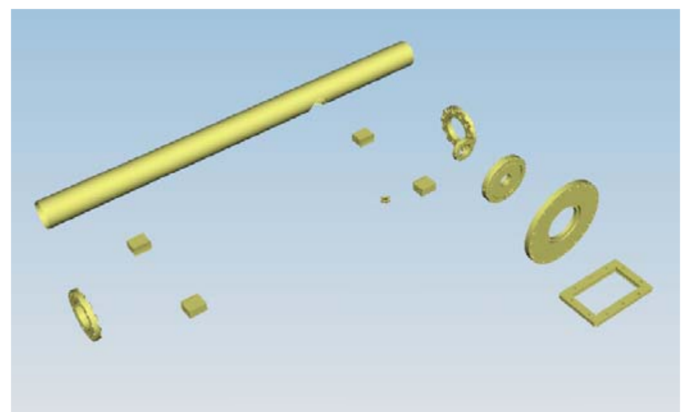
Further Work:

- As an example, beam pipe flange and seal; to be unified,
- Cryomodule: further design to be well plug compatible.

SCRF Cavities
to be plug-compatible



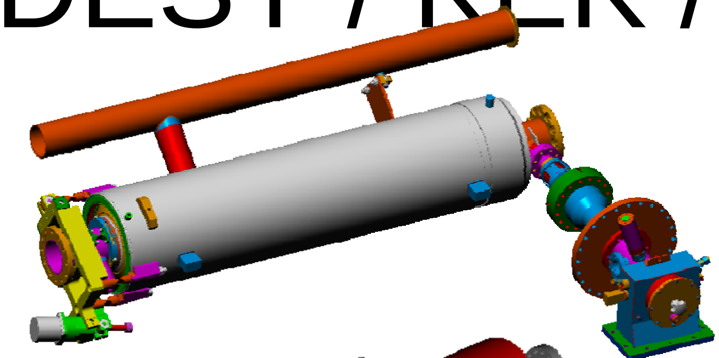


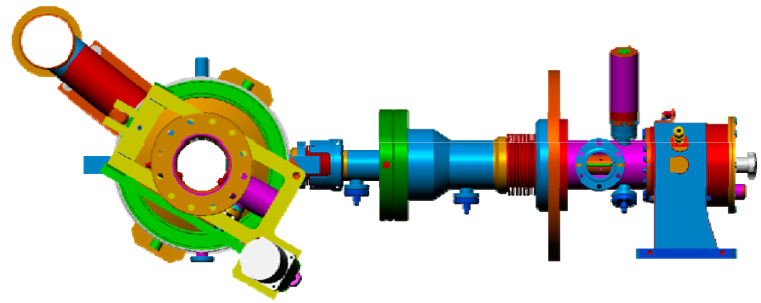


Many thanks for Don Mitchell and Lars Hagge for 3D-CAD and EDMS

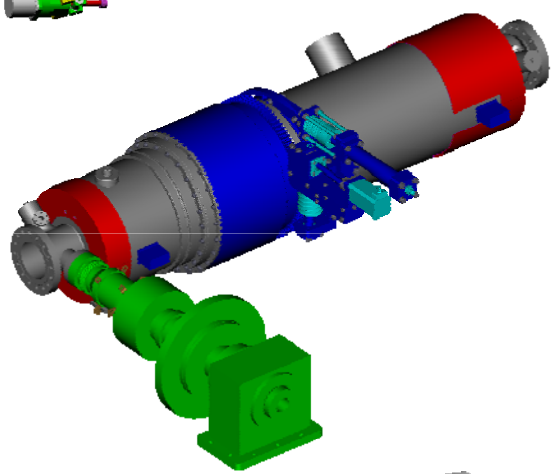
DESY / KEK / FNAL Cavities

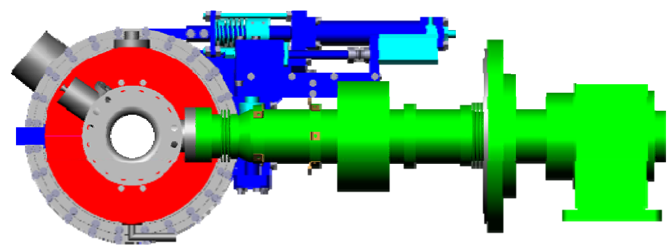
DE
SY



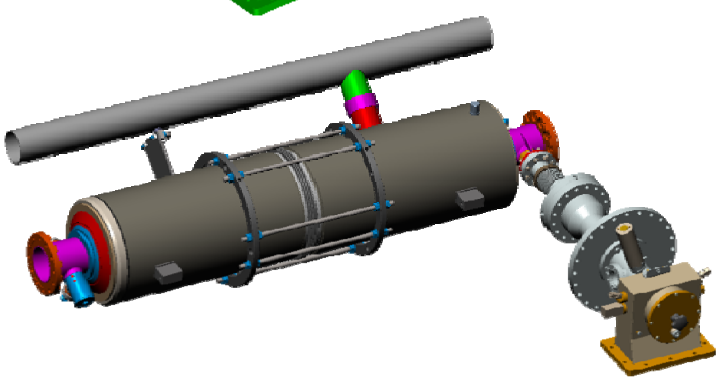


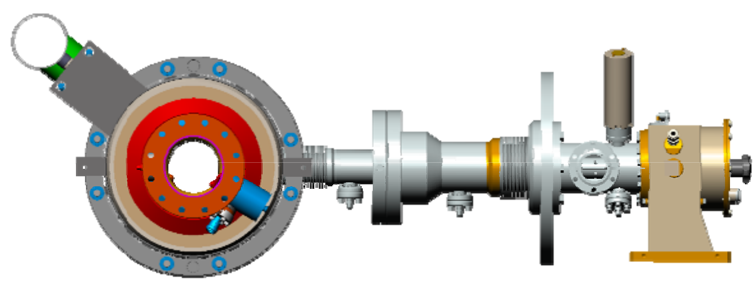
KE
K





FN
AL





HLRF/LLRF and MLI

- Progress:
  - Understanding "power distribution system design with gradient distribution", and with grouping
  - Operational overhead required more (LLRF)
  - Quadrupole R&D
- Further work and decision:
  - Optimization of operational margin,
  - Optimization of tunability,
  - Evaluation of elimination of circulator…

What will be next?

- Functional specification and interface to be settled soon,
- If the consensus may not be simply made, PM and GLs to discuss and to propose the design unification or plug-compatible conditions, Examples:
    - tuner-motor,
    - coupler-tunability,
    - beam-pipe flange,
- We need to re-organize WP activities

WP1.1. Cavity Processing

Table A.2: Cavity Processing Work Packages

ID	Title	Description
1.1.1.	Gradient Performance	Single-cell R&D - focus on final rinse after electropolishing before high pressure water rinse, 9-cell R&D with repeated processing and testing of cavities, including exchange of cavities between institutes and regions. Production-like effort, including fabrication, processing and testing of cavities. This includes monitoring XFEL production (Appendix A.5), and the development of new vendors)
1.1.2.	Fabrication Specification	Based on results from WP 1.1.1, specify material and fabrication. Includes analysis of Pressure Vessel regulation
1.1.3.	Process Specification	Process specification based on results from WP1.1.1.
1.1.4.	Cavity Design Specification	Interface, Shape, Flange Seal, Lorentz detuning, Beam dynamics.

WP1.2. Cavity Production

Table A.3: Cavity Production Work Packages

ID	Title	description
1.2.1.	Tuner	Development of slow tuner for resonance stabilization and fast tuner for Lorentz detuning compensation
1.2.2.	Input Coupler	Development of coupler designs, including evaluation of fixed/variable coupling, port diameter, heat load, etc.
1.2.3.	Magnetic Shield	Determination and test of magnetic shielding method, inside/outside He-vessel.
1.2.4.	He-Vessel	Vessel material, bi-metallic junctions, Pressure Vessel regulation, and alignment method.
1.2.5.	Integration/Test	system integration into cryomodule and performance test
1.2.6.	Cost & Industrialization	Cost estimate and pre-industrialization value engineering

WP1.3. Cryomodule

Table A.4: Cryomodule Work Packages

ID	title	description
1.3.1.	Standardization	Establish basic design parameters, plug compatible interface conditions, and high-pressure gas code (regulation) issues,
1.3.2.	Cooling pipe configuration	Calculation of pressure drops, definition of the maximum pressure, cooling procedure, new piping on the module transverse cross section.
1.3.3.	5-K shield	Calculation of thermal-balance with or w/o 5 K-shield Trade-off with cryogenics operation cost.
1.3.4.	Quadrupole Assembly	Quadrupole location, support, installation procedure, alignment, vibration, current leads,
1.3.5.	Assembly Process	Study of Assembly procedure, fixtures, facilities, Study of inter-connect procedure,
1.3.6.	Engineering design with CAD	Systematic engineering design using 2D/3D CAD, R&D for technically critical components such as Ti-SUS junction, vacuum components, etc.
1.3.7.	Systematic performance evaluation	Establish performance test contents, and procedure
1.3.8.	Transportation	Seek transportable cryomodule (region to region) Investigate transportation down to the tunnel through vertical shaft, with inclination (to save shaft size).
1.3.9.	Cost/Industrialization	Cost estimate based on BCD, and Industrialization effort (mass production and reducing the cost)

WP1.4. Cryogenics

Table A.5: Cryogenics Work Packages

ID	title	description
1.4.1.	Heat loads	The heat load to the entire cryogenics system is investigated under static and dynamic conditions. Static, dynamic, distribution system loads are considered, including tolerances and uncertainties.
1.4.2.	Cryoplant design	The cryogenics plant engineering is to be carried out in cooperation with industry and in close communication with CF&S technical area engineers to optimize interface with the CFS system.
1.4.3.	Reliability, repair	The long-term and stable operation is a critical requirement. Studies of segmentation, load-sharing, and maintenance scenario are to be made to keep the system redundancy in balance of the global cost.
1.4.4.	Venting, pressure limits	The high pressure gas design needs to fit to any regional codes and constraints. The peak pressure in the cryogenics system in various modes of pre-cooling, steady state operation, emergency modes such as SRF cavity quenches and vacuum failure modes should be carefully studied including the inspection pressure to be required.
1.4.5.	Surface impact	The location and distribution of surface equipments such as large compressors and associated utilities are optimized in balance of reliability /maintainability and cost.
1.4.6.	Oxygen deficiency hazard	Safety plan against oxygen deficiency hazard (ODH) in tunnel and surface building is investigated.
1.4.7.	Cryobox design	The cryogen distribution box capacity, location, and distribution in the tunnel, are designed and optimized in balance of the performance/redundancy and cost.

WP 1.4. Cryogenics (cont)

1.4.8.	Liquid control	The liquid helium level in the cavity and He vessel is an important design parameter to ensure safe and reliable operational condition. The static and dynamic operational conditions are studied and a level control operation is designed and optimized by using heaters.
1.4.9.	Optimization of cryogenics	Trade-off studies that compare cryomodule complexity and cost for cryogenic system loads
1.4.10.	2K heat exchanger	4K to 2K heat transfer to pumped vapor, pre-cool liquid supply
1.4.11.	Standards	The cryogenics system design needs to be consistently designed and standardized according to the industrial high-pressure gas regulation to be met. .Regional code, compliance, hardware transfer
1.4.12.	e+/- sources cryo.	Cryogenics for e+, e- source linac, undulators, DR, BDS, RTML, and associated distribution and special objects, as unique and separate from Main Linac. The cryogenic engineering should be similar to that of the main linac system, with a smaller scale. These systems must be properly integrated into the ML cryogenics system.
1.4.13.	Damping ring cryo.	
1.4.14.	BDS cryo.	
1.4.15.	RTML cryo.	
1.4.16.	Main Linac Vacuum.	The vacuum systems for thermal insulation in all cryogenics system in ML, e+/- sources, BDS, RTML are designed in close cooperation with cryogenics system design. The vacuum system for beam pipe is designed as separate system, in this work package.
1.4.17.	RTML vacuum.	

WP 1.5. HLRF

Table A.6: High Level RF Work Packages

ID	title	description
1.5.1.	Modulator	Develop; test alternate Marx Modulator & its industrialized design-for-manufacture version. Advance baseline 'Bouncer' modulator design and 50kV design. Develop selection criteria and select a baseline modulator for the ED Phase.
1.5.2.	Klystron	Baseline development of multi-beam klystrons with industry (DESY, KEK). Evaluate multi-beam klystrons in test facilities (DESY, SLAC). Develop sheet beam klystron prototype followed by 'design for manufacture version at SLAC. Develop 50 kV Mega-multi-beam klystron prototype at KEK in collaboration with industry. Accumulate test data and apply selection criteria for the ED Phase baseline
1.5.3.	RF power distribution	Complete development and optimization of components with industry. Participate in the selection process for XFEL. Complete SLAC alternate variable tap-off, circulator-less design and perform prototype testing. Complete testing on cryomodules at NML (FNAL) and KEK. Complete new cost estimate.
1.5.4.	HV charger system	Design, prototype, test alternates to the baseline power system (SLAC). Install system for operational testing at (SLAC). Collaborate and track design progress at XFEL.
1.5.5.	Interlock and Control	Develop a programmable fast/slow interlock card in VME and construct and test a complete RF station system at SLAC. Track and participate in the similar development for the XFEL (Europe).

W.P. 1.6. ML Integration

Table A.7: Main Linac Work Packages

ID	title	description
1.6.1.1.	Quadrupole package design	Specify complete quadrupole package design: a) Determine the cost/performance optimal quad/bpm aperture considering beam dynamics, cryo heat loads and beam interception issues. b) Describe likely backgrounds (Halo, SR, MP, dark currents) and the means of dealing with them and minimizing beam interception damage. c) Based on the linac optics and magnet field requirements (from other WPs), work with magnet experts to design a set of SC quads and correctors. d) Based on the linac bpm requirements (from other WPs), work with instrumentation experts to design the bpms and signal processing system. e) Based on above results and the HOM absorber requirements (from other WPs), work with cryomodule group to define layout of the quad package that achieves the required performance.

ML Integration (Cont.)

1.6.1.2.	Quadrupole prototypes	Demonstrate basic performance of quadrupole package components: a) Build prototype quads and correctors (combined and separate) to verify quad center stability and basic field requirements can be met b) Build prototype bpms to verify required resolution and stability in a 'cleanable' design c) Using prototype quads and bpms in a beamline, show that quad shunting will provide a stable, micron-level measure of the quad magnetic center d) Build prototype HOM absorbers to verify HOM attenuation in bench tests and in beam operation in one of more the test facilities
1.6.2.	Lattice optimization and Identification of emittance drivers	Optimized lattice and identification of emittance 'drivers': a) Do analytical estimates of the various emittance growth mechanisms in the linac to establish the relative sizes and scaling with energy and lattice strength. b) Use this info to optimize the linac lattice and identify the critical alignment, resolution and magnetic field requirements. c) Compare simulations to analytic results - understand any significant deviations and 'cross-term' effects. d) Identify those mechanisms that ultimately limit further emittance reductions and suggest possible mitigations.
1.6.3.	Initial alignment	Specify linac alignment requirements a) Develop realistic models of both short and long range spatial misalignments for the beamline components based on the likely methods of installation and global alignment. b) Incorporate these models into the beam simulation programs to determine if the misalignments will cause unacceptable emittance growth after beam-based steering c) Work with the installation/alignment groups to establish specs for the initial alignment of the components that can be easily interpreted by those who will do this work.

ML Integration (cont.)

1.6.4.	Energy errors	Specify allowable energy errors: a) Develop realistic models of how the bunch energy and energy spread may vary from ideal along the linac and along each bunch train. b) Incorporate these models into the beam simulation programs to determine the allowed energy errors. c) Work with the LLRF group to translate these errors to specs on their system to regulate the rf gradients and phases in each rf unit.
1.6.5.	Static tuning	Evaluation of effectiveness of the various tuning algorithms a) Evaluate the various proposed linac alignment methods, including quad shunting, in terms of performance, impact on operation, sensitivity to lattice errors and requirements on beam position resolution, accuracy and offset stability. b) Briefly describe how the tuning will be done in other parts of the machine c) Describe how various tuning bumps could be used to further reduce the emittance growth
1.6.6.	Dynamic tuning	Specify requirements to maintain small beam emittance during operation: a) Specify acceptable fast and slow quad motion in terms of amplitudes and correlations. For the latter, determine the implications for the 'static' tuning system. b) Specify a fast FB system to stabilize the beam orbits, including the requirements on the magnet response times.

ML Integration (Cont.)

		c) Specify methods for measuring the bunch/beam energy profile, matching the quad lattice and regulating the bunch energy at the end of the linacs. Work with Controls and LLRF to have these implemented d) Specify system and procedures to monitor the bunch/beam emittance including the instrumentation requirements. Work with the Instrumentation group to design bunch size monitors.
1.6.7.	Wake field and cavity topics	Examine relevant cavity design and wakefield issues for Main Linac: a) Examine relevant cavity design and wakefield issues for Main Linac. Compute wake offsets due to FPC/HOM antennae intrusions and propose methods to reduce it. b) Specify short and long range wakefields and cross (x-y) coupling effects. c) Evaluate the effectiveness of the HOM absorber to remove the wake energy before it is absorbed in the 2K cryo system. d) Simulate multi-cavity trapped modes to look for significant wakefield build up. e) Develop cavity distortion model to match first/second band dipole mode properties. f) Analyze dipole mode signals to provide info on cavity properties. g) Evaluate multipacting in power and HOM couplers.

Work-package Activities to be resumed

- Gradient R&D (S0): Lilje, Hayano, Champion
- Tuner, Coupler: Hayano, …
- S1-global: Hayano, Ohuchi, Champion, Pagani,

- Cryomodule/cryogenics: Ohuchi/Carter, Champion/Mitchell, Peterson

- HLRF, Tunability: Fukuda, Adolphsen,

  Cost saving vs. tunability
- MLI: Quadrupole alignment tolerance , Adolphsen,

TDP1 and 2 plan, rev. 2

- Need to be submitted due May 7.
  - Revision specially required on
    - Gradient (S0)
    - Cavity string test (S1, S1-global)
    - HLRF/LLRF

Next meetings

- SCRF Webex meetings:
  - 5/14, 6/11, 7/9, 8/6?, 9/3, 10/1,
- Work-package meeting:
  - Determined by WP cordinator,
- TTC meeting (at Dehli) :
  - Oct.
- GDE meeting (at Chicago)
  - November
- AAP review
  - January or February, 2009

Summary and Remark

- The SCRF meeting organized to discuss:
  - Cavity gradient R&D plan,
  - Functional specification and Plug compatible interface,
  - S1 and S1-global plan,
  - Cost effective power distribution and optimum tune-ability.
  - Static and dynamic tolerance in MLI and beam dynamic
- We reach:
  - Consensus for concept of plug compatible design,
  - TDP R&D direction,

- I would thank everyone's participation and cooperation