10252007 GDE meeting @ FNAL

Summary of ‘Cavity Production and Integration’

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Definition of work area

- **Cavity preparation & process**

  Gradient (S0 task), Surface Treatment procedure,
  Shape (TESLA shape, LL, re-entrant, others),
  Input coupler port diameter, HOM performance,
  Wake of HOM antenna and Input coupler antenna,
  Flange seal method, Cavity Fabrication method,
  Materials and thickness (High Pressure Vessel regulation),
  Pre-tuning procedure (method, target, specifications),
  Vertical test, Cavity fixture (support), …

- **Cavity package**

  Tuner, Piezo maintenability, Lorentz detuning compensation,
  Tuner motor maintenability (motor inside/outside),
  Coupler (variable coupling/fixed coupling),
  Magnetic shielding method (inside or outside vessel),
  High Pressure Vessel regulation,
  Helium vessel material and thickness (Ti or SUS, …),
  Alignment method, Assembly procedure in clean room,
  HOM probe, monitor antenna, Coupler peripherals(arc sensor, temp sensor, pumping, coupling adjuster,etc), …

Cavity Kick-off-meeting

Sep.19-21, 2007 at DESY

- Review of BCD R&D activity during RDR
  - RDR cavities, S0 task, US activities, KEK activities
- Review of Alternatives
  - shape, vertical EP and High Peak Power Process, cavity materials
- Recent research activities
  - surface process, HF free EP
- Industrialization plan of XFEL
- Discussion of plug compatible concept
- Discussion of work package
- Evaluation of Survey

Strategy of cavity package design

1. Baseline Engineering Design

decision of Unified Parameters (gradient, HOMs, detuning compensation ...).
down-selection of technologies (cavity shape, tuners, couplers, ...).
decision/selection of detailed engineering.

2. Baseline Fabrication & Qualification Procedure

decision on fabrication method, qualification/test procedure.

3. Cost Evaluation of Baseline Engineering Design

re-evaluation of cost if the design is changed from RDR.
The evaluated cost will be the reference for plug-in's cost.

4. Plug-in specification if candidates are there

Pick-up possible plug-in compatible components(parts),
decision of plug-in performance spec., dimension spec.,
interface spec., material spec., qualification/test spec.,
installation spec., transportation spec., ...

Technology down-selection

1. Identify the down-selection item.

2. Identify the proposal & proposer of the technology.

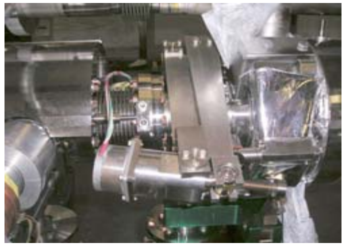
3. Make comparison tables for advantages & disadvantages from each proposer.

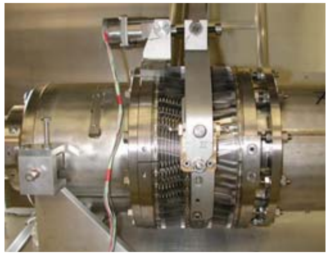
4. PM Make fair-minded comparison table to be filled in by each proposer.

5. PM decide the technology according to the table.

Example of comparison table

Slow Tuner					
		TTF		STF	STF
		Saclay -1	**Blade**	**Slide Jack**	**Ball Screw**
		Lifetime Test (~ 0.1mm x 10000 Times) is necessary.			
Mechanism		Double Lever	Blade+Lever+Screw	Wedge+Screw+Gear	Screw+Worm Gear
			Blade has the potential Problem of Fatigue.		Life time of Coating?
Stiffens	N / µm	40	25	290	1000
		Not Stiff	Not Stiff. If used to TESLA Cavity DLD at Flat-Top becomes ~900Hz.		
Stroke	mm		< 2	3.5	Long enough
Location		Beam Pipe	Jacket Cylinder	Jacket Cylinder	Jacket Cylinder
		The room for tuner is small. Top Heavy. Alignment?			
Cost					





Cont.

Fast Tuner					
		TTF		STF	STF
		Saclay -1	**Blade**	**Slide Jack**	**Ball Screw**
		Piezo(200V)	Piezo(200V)	Piezo(150V)	Piezo+Blade
			Speed ?		Blade has the potential Problem of Fatigue. Speed ?
		NORIAC (1 Spare)	NORIAC (1 Spare)	Piezo Mechanic x 1	Piezo Mechanic x 1
Size	mm	10 x 10 x 26	10 x 10 x 38	φ20 x 18	
Stiffness	N / μm	105	70	500	
Max. Load	kN	4	4	14	
Stroke:RT	μm	40	60	20	
Stroke:2k	μm	4	6	2	
Compensation	μm	3.4	6	1	
Speed					
Delay		0.6 msec.			
Repairability					
Motor		need Disassemble	need Disassemble	Outside	Poor
Piezo		need Disassemble	need Disassemble	Repairable	need Disassemble
		US Study on this Subject exists.			
		How to check Piezos just we install. There are no experience for long term operation in Pulsed mode. Life time Test is necessary.			

Possible plug-compatible units

C1-level : Cryomodule

C2-level : Cryostat with GRP, He-pipes, and thermal shields.

C3-level: Cryostat vessel, GRP supports, Pipes, Thermal Shields, Invar fixture, Cavity support, Quad support, Cryostat Pumping system, Instruments(vacuum, temperature, etc) Installation fixture and method, Transportation fixture and method,

C2-level : Cavity package with He jacket, tuner and coupler,

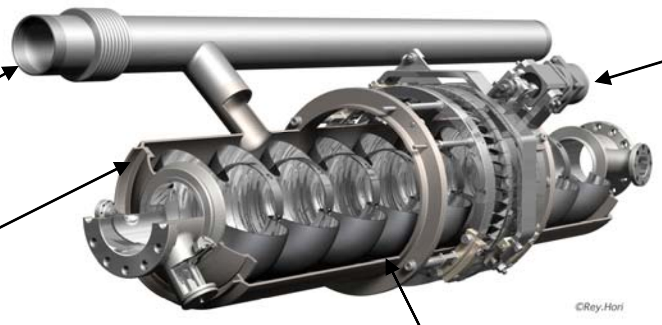
C3-level: Cavity, Jacket, Magnetic shield, Tuner, Coupler, Instruments (RF cable, temperature sensor, piezo drive, etc)

C2-level : Quad-steer-BPM package,

C3-level: Quad magnet, Steer dipole coils, Current feedthrough, BPM

C2-level : HOM absorber

C2-level : Beam line pumping



For example;

Cavity Cryomodule Cryogenic parallel session

Oct.23-24, 2007 at DESY

- Discussion of specification profile table which allow a plug compatible concept & boundary conditions

- EDR strategy (R. Stanek)

- Discussion of work package

Example of Specification tables which allow a plug-compatible concept (1)

Slow Tuner

tuner	specification item	Rough guess	unit and comments	
Slow tuner	Tuning range	>600	kHz	
	Hysteresis in Slow tuning	<10	μm	
	Motor requirement	step-motor use, Power-off Holding, magnetic shielding		
	Motor specification	ex) 5 phase, xxA/phase, É	match to driver unit, match to connector pin asignment,É	
	Motor location	insdie 4K? / outside 300K? / inside 300K accessible from outside?	need availability discussion, MTBF	
	Magnetic shielding	<20	mG at Cavity surface, average on equater	discuss later
	Heat Load by motor	<50	mW at 2K	discuss later
	Physical envelope	do not conflict with GRP, 2-phase line, vessel support, alignment references, Invar rod, flange connection,É		cable connection, Mag shield
	Survive Frequency Change in Lifetime of machine	~20 Mio. steps	could be total number of steps in 20 years,	

•Table is under developing

Example of Specification tables which allow a plug-compatible concept (2)

Fast Tuner

Fast tuner	Tuning range	>1	kHz over flat-top at 2K	
	Lorentz detuning compensation	<100	Hz at 31.5MV/m flat-top	
	Actuator specification	ex) low voltage piezo 0-1000V, É	match to driver unit, match to connector pin asignment, É	decide later
	Actuator location	insdie 4K?/inside 4K accessible/inside 100K? accesible / inside 300K accessible from outside?		decide later
	Magnetic shielding	<20	mG at Cavity surface average	
	Heat Load in operation	<50	mW	measure first, discuss later
	Physical envelope	do not conflict with GRP, 2-phase line, vessel support, alignment references, Invar rod, flange connection,É		
	Survive Frequency Change in Lifetime of machine	$>10^{10}$	number of pulses over 20 years, (2x109:operational number)	

•Under developing

Example of Specification tables which allow a plug-compatible concept (3)

Coupler

specification items	condition	Rough guess	unit and comments		
Power requirements	Operation	>400	kW for 1300 us		
	Proccessing	>1000	kW upto 400 us	need after vac break, cool-down	
		>600	kW larger than 400 us	need after vac break, cool-down	
	Processing with reflection mode	>600	kW for 1300us	in Test stand	
Processing time	warm	<50	hours	after installation	
	cold	<30	hours	after installation	
Heat loads /coupler	2K static	<0.1	W		should get Tom'snumber later
	5K static	<0.5	W	depend on tunability	should get Tom'snumber later
	80 K static	<3	W		should get Tom'snumber later
	5K dynamic	<0.3	W		should get Tom'snumber later
	80K dynamic	<3	W		should get Tom'snumber later
Cavity vacuum integrety		2	# of windows		
			bias capablity	decide later	
RF Properties	Qext	Yes/No	tunable	decide later	
	Tuning range	1-10	10^6 if tunable	decide later	
Physical envelope	Position		compatible to TTF-III	decide later	
	Flange		compatible to TTF-III	decide later	to cavity, to cryostat
	waveguide		compatible to TTF-III	decide later	
	support		compatible to TTF-III	decide later	
Instrumentation					
vacuum level		>1			
spark detection		0	at window		
electron current detection		>1	at coax		
temperature		>1	at window		

•Under developing

<u>EDR strategy discussion for cavities and cryomodules</u>

By R. Stanek

Summary:

- Cavity & cryomodule design effort would like to
  - Arrive at a consensus design for an ILC cryomodule
  - Build on the anticipated success of XFEL project
  - Utilize the components that give the best chance for success
- Due to uncertainty in project start date, current inability to meet ILC cavity requirements (gradient & yield) and a general influx of new ideas (cost reduction/reliability), **EDR phase will face multiple decision paths in its design process**
- Important to contain the design work within acceptable parameter space
- This process needs to be open and responsive to the requirements and plans of each Region
- **Need to decide, will we have a <u>unified design</u> or a <u>plug compatible design?</u>**
- Design changes must be validated
- Opportunities to test these changes (in cryomodules or with beam) will be limited in the EDR phase
- There is a general consensus on how extensive these validation tests need to be (survey results)
- Combination of feedback from test facilities, time to implement design changes, and validation testing requirements => results in a final ILC cryomodule design available after the EDR phase is complete
  - If the design is Region dependent, things change

Survey Results (abbreviated)

Validation Survey	NOTE: Vallidation tests occur after all R&D and prototype work is complete & design change is mature enough to be considered as change to baseline													
If you make a change in this →	Cavity Shape LL OR RE	Cavity Material Large Small Grain	Magnet Shield Location	Quad Design	Quad Position	BPM Design	He Vesssel SS vs. Ti	Tuner Design	Coupler Design	Pipe Size (dia)	Rad Shield Design	Support Design Transport fixture	Instrumentation	Align System
You validate the change by doing this ↓														
Can design change be made without testing? (Y/N)	N	N	N	N	N (few Y)	N	N	N	N	Y (few N)	Split	N	N	N
Number of components fabricated & tested?	24-30	30	10	1-3	3	3	24-30	10	24	1	1-3	1-3	1	1
Does design change require only component level testing? (Y/N) Component level testing equals Vert or Horiz testing or cycle test	N	Y (V&H)	N	N	N	N	Split (H)	N	N	N	Split	N	N	N
Hours of component level testing?		1000hrs		40hrs		500hrs	1000hrs	1000hrs	1000hrs			250 hrs	250 hrs	
Does design change require testing in cryomodules (without beam)? (Y/N)	Y	N	Y	Y	Y	Y	Y (few N)	Y	Y	Y	Y	Y	Y	Y
Number of cryomodules?	3		1	1	3	3	3	1-3	3	1	1	1-3	1-3	1
Does design change require testing in RF Unit/String test (with beam)? (Y/N)	Y	N	N	N	Split	Y	N	Split	Split	N	N	N	N (few y)	N
Hours of string testing?	1000hrs	0	0	0	1000hrs	1000hrs	0	1000hrs	500hrs	0	0	0	100hrs	0

Results from survey can be used to identify dependencies in design schedule

Proposed Work Package

Cavity package

WP-CP1. Cavity Tuner

Tuner Selection (Saclay tuner, Brade tuner, Slide-jack tuner, Ball-screw tuner,.. Fast tuner selection)
Lorentz detuning compensation (specification, method, required rigidities, fast tuning specification,…)
[Selection at end of 2008], then detail engineering design.

WP-CP2. Cavity coupler

Coupler selection (variable coupling, fixed coupling, port diameter, …)
[Selection of fixed/variable coupling at end of 2008], then detail engineering design.

WP-CP3. Cavity Magnetic shield

Magnetic shielding method (inside or outside vessel)
[Selection of magnetic shield inside/outside at end of 2008], then detail engineering design.

WP-CP4. Cavity vessel

Vessel material (material selection, metal junctions, HPV regulation) including alignment method.
[Engineering design detail at end of 2009]

WP-CP5. Cryomodule Operation (S1 task)

Demonstration of 31.5MV/m operation by at least one cryomodule.
[demonstration by end of 2009]

Plan for developing WPs and Spec. tables

- Call of EOI for proposed WP, ~next week.
- Develop WP, with interested Institute, with resource(?), ~end of November.
- Revise specification profile table, ~end of November.
- Finalize WP & spec. tables, Feb.2008

3 - 7 March, ILC-GDE meeting at Sendai

end