650 MHz Low Beta Dressed Cavity (Section 6.3,6.4,6.5)

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IIFC Joint Review Meeting
4-6 January, 2017
BARC, Mumbai

Scope of Work: 6.3: HB650 MHz Dressed Cavity
(Joint Project Document – R&D Phase)

Milestone	Major Milestone	Quantity	Delivery date As per signed Joint document
1	Fabricate 1-cell LB650 Cavity Process and test 1-cell LB650 Cavity at Fermilab	1	30 Sep 2015 30 Nov 2015
2	Finalize the design of 5-Cell LB650 Cavity		31 Dec 2015
3	Design review of 5-cell LB650 Cavity		31 Jan 2016
4	a) Fabrication of 1st 5-cell LB650 Cavity b) Processing and Vertical testing of 5-cell Cavity c) Dressing LB650 Cavity d) Testing of 1st 5-Cell Dressed LB650 at Fermilab	1	31 Dec 2016 30 Jun 2017 31 Dec 2017 31 Mar 2018
5	a) Fabrication of 2nd 5-cell LB650 Cavity b) Processing and Vertical testing of 5-cell Cavity c) Dressing LB650 Cavity d) Testing of 2nd 5-Cell Dressed LB650 at Fermilab	1	30 Sep 2017 31 Mar 2018 30 Sep 2018 31 Dec 2018

Scope of Work: 6.4 Helium Vessel and Cavity End group
(Joint Project Document – R&D Phase)

Miles tone	Major Milestone	Quantity	Delivery date As per Joint signed document	Remarks
1	a) Design of SSR1 He Vessel	Done	Done	
	b) Design of SSR2 He Vessel	1	30 Jun 2016	
	c) Design of LB650 He Vessel	1	31 Dec 2015	# 1
	d) Design of HB650 He Vessel	1	31 Dec 2015	
2	a) Design of 5-cell LB650 End Group	1	31 Dec 2015	# 1
	b) Design of 5-cell HB650 End Group	1	31 Dec 2015	
3	a) Fabrication of SSR1 He Vessel	2	31 Mar 2017	
	b) Fabrication of SSR2 He Vessel	2	31 Mar 2018	
	c) Fabrication of 5-cell LB650 He Vessel and its interface to the end group	2	30 Sep 2017	# 2
	d) Fabrication of 5-cell HB650 He Vessel and its interface to the end group DAE	4	30 Apr 2017	

1 Milestone at 1 and 2 are deliverables from Fermilab

2 Subjected to supply of design inputs from Fermilab by 31 Dec 2015

Scope of Work: 6.5: Slow and Fast Tuner (Joint Project Document – R&D Phase)

Milestone	Major Milestone	Quantity	Delivery date As per signed Joint Document	Remarks
1	a) Design of SSR1 Slow and Fast Tuner		Done	
	b) Design of SSR2 Slow and Fast Tuner		30 Jun 2016	
	c) Design of LB650 Slow and Fast Tuner		31 Mar 2016	# 3
	d) Design of HB650 Slow and Fast Tuner		31 Mar 2016	
2	a) Design of 5-cell LB650 Tuner interface		31 Mar 2016	# 3
	b) Design of 5-cell HB650 Tuner interface		31 Mar 2016	
3	a) Fabrication of SSR2 Tuner	2	30 Jun 2018	
	b) Fabrication of 5-cell LB650 Tuner, motor, readout and its interface to the end group at DAE Laboratories	2	30 Sep 2017	# 4
	c) Fabrication of 5-cell HB650 Tuner, motor, readout and its interface to the end group at DAE Laboratories	4	30 Sep 2017	

3 Milestone at 1 and 2 are deliverables from Fermilab

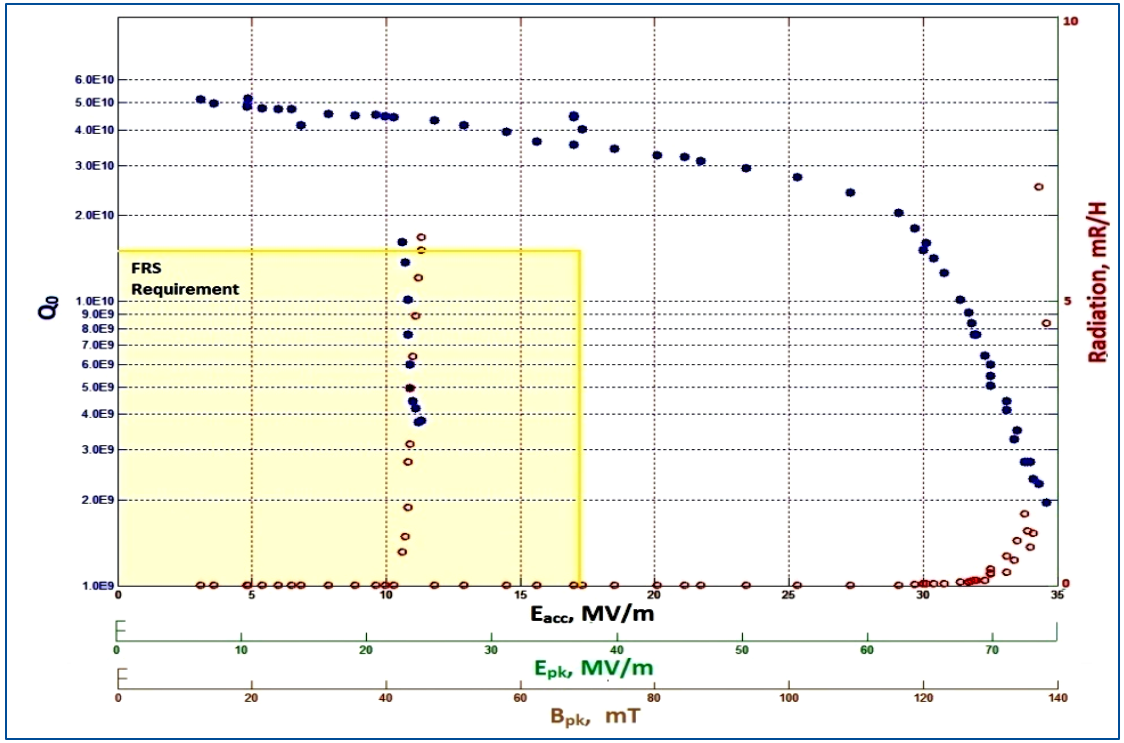
4 Subjected to supply of design inputs from Fermilab by 31 Mar 2016.

IIFC Technical Status: 1-cell LB650

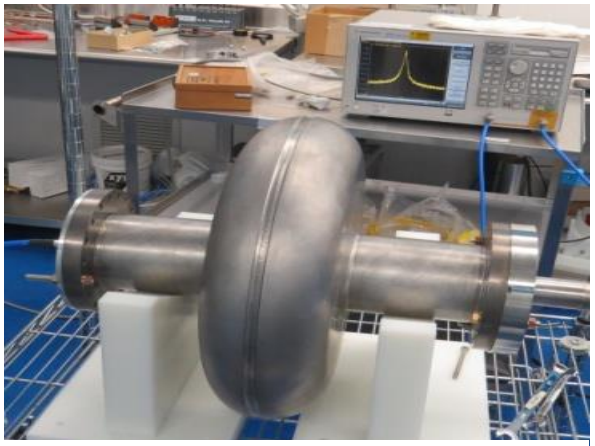
- Single-cell LB650 niobium cavity ,designed and developed by VECC, with the help of Electron Beam Welding (EBW) facility at IUAC, New Delhi
- Cavity was sent to Fermilab/ANL, USA for processing and subsequently testing in Vertical Test Stand at 2K temperature
- It achieved a very high accelerating gradient of 34.5 MV/m.
- Although, as per FRS, the operating accelerating gradient is 17 MV/m with Q0=1.5E+10, the above cavity reached up to 30 MV/m with Q0=1.5E+10.

IIFC Technical Status: 1-cell LB650

VTS Test Results of LB650 VECC Single cell cavity



Cavity could sustain 74MV/m Peak Electric Field (E_{pk}) and 137 mT Peak Magnetic Field (B_{pk}), with accelerating gradient of 34.5 MV/m @ 2K (-271^0 Celcius).



Single-cell LB650 niobium cavity

Maximum accelerating Gradient: 34.5 MV/m @2K

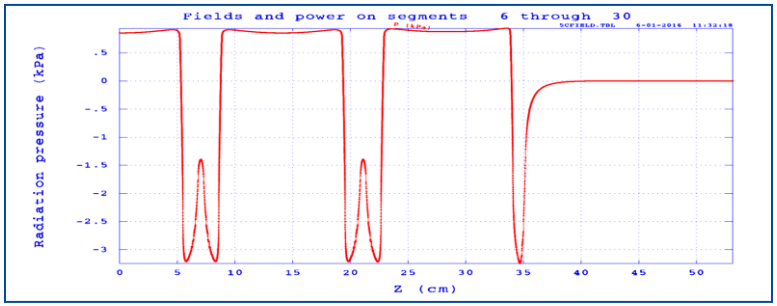
Accelerating Gradient of 30 MV/m @2K achieved with unloaded cavity quality factor Q_0 =1.5E+10.

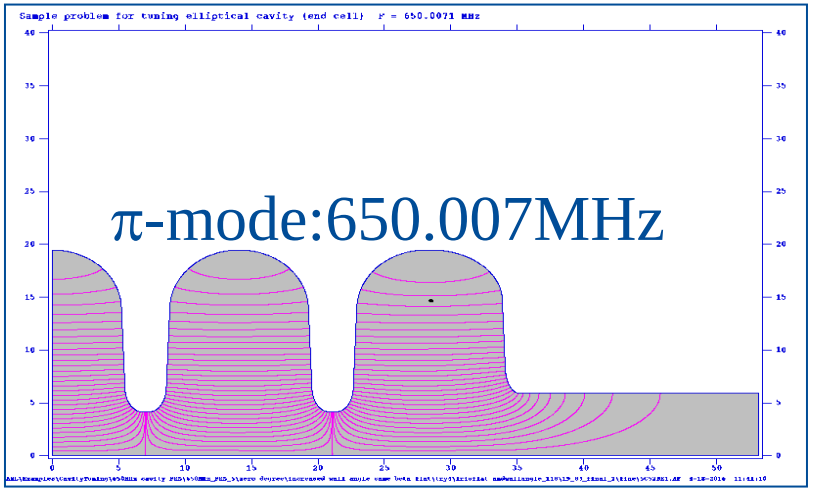
IIFC Technical Status: 5-cell LB650 Design

EM Design

- Cavity parameters optimization to meet FRS
- Design with 2° wall angle & equator and Iris flat considering processing and fabrication issues
- Calculation of Lorentz Force for mechanical analysis **(Maximum radiation pressure / Lorentz Force 3.24 kPa at iris region and 0.94 kPa at equator region, at specified energy gain 11.9MeV** in703 mm length of 5-cell **)**
- Field flatness (in Superfish) : > 99%
- HOM Analysis
- Multipacting Analysis

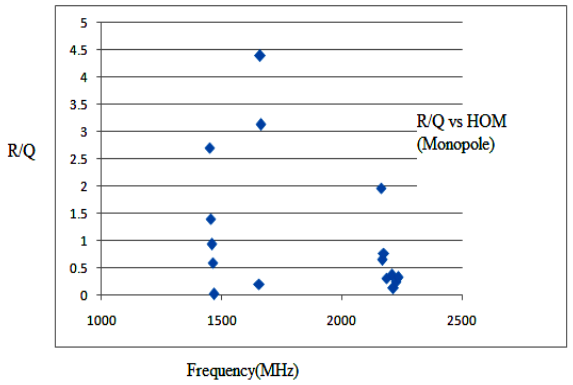
RF Parameters	Superfish simulation Result
E_p/E_a (at optimal β)	2.307 (39.04MV/m at specified energy gain at optimal β) FNAL FRS: ≤ 40 MV/m (at optimal β)
B_p/E_a (at optimal β)	4.383 mT/(MV/m) (74.157 mT at specified energy gain at optimal β) FNAL FRS: ≤ 75 mT (at optimal β)
R/Q (at optimal β)	346Ω
E_p/E_a (at Geometric β)	2.43
B_p/E_a (at Geometric β)	4.61
R/Q (at Geometric β)	329.3
G	164.3
Field flatness	99.95%





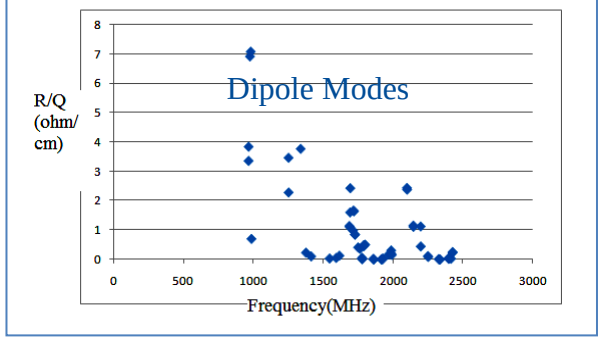
IIFC Technical Status: 5-cell LB650 Design

EM Design

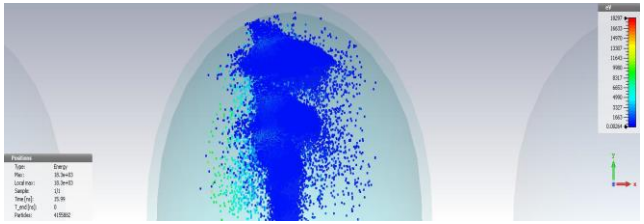


Monopole Modes

1st pass band-1450.85 to 1467.82MHz
2nd pass band-1656.68 to 1663 MHz
3rd pass band-2162.88 to 2185.91 MHz
4th pass band-2207.74 to 2234.5 MHz

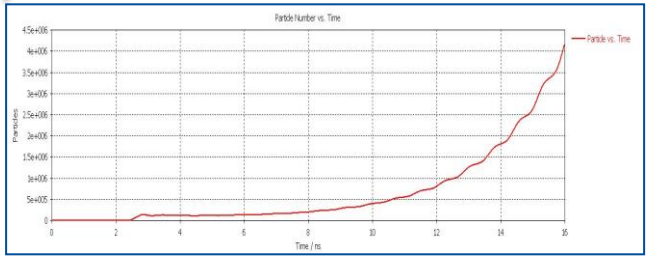


- Higher order mode analysis(up to 2.5 GHz) for both longitudinal and transverse modes of LB650 cavity .
- R/Q values for higher order monopole modes and higher order dipole modes are calculated
- R/Q values for higher order monopole modes is less than 5Ω for all the passbands



Particles after 16ns at Eacc=2.6MV/m (midcell)

- Multipacting has been found up to 4.8 MV/m.
- Multipacting rate is very high in the region of 2.5MV/m.
- At 4.8MV/m, increase in particle due to multipacting is very low.



Particles vs time at Eacc=2.6MV/m (midcell)

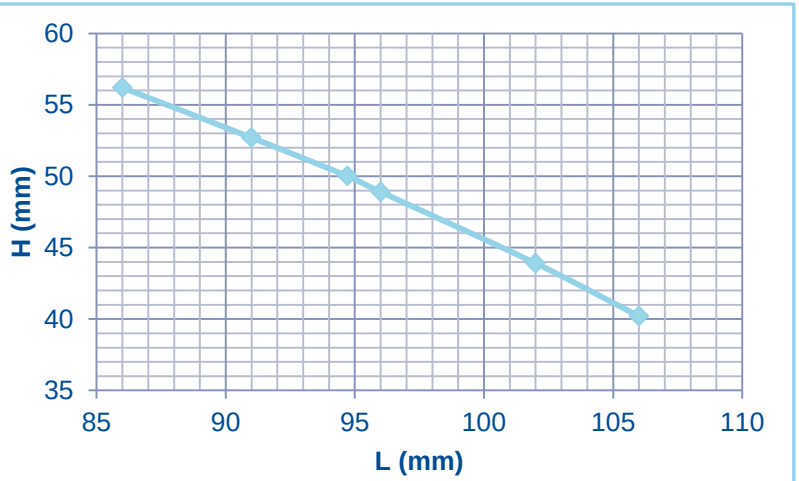
IIFC Technical Status: 5-cell LB650 Design

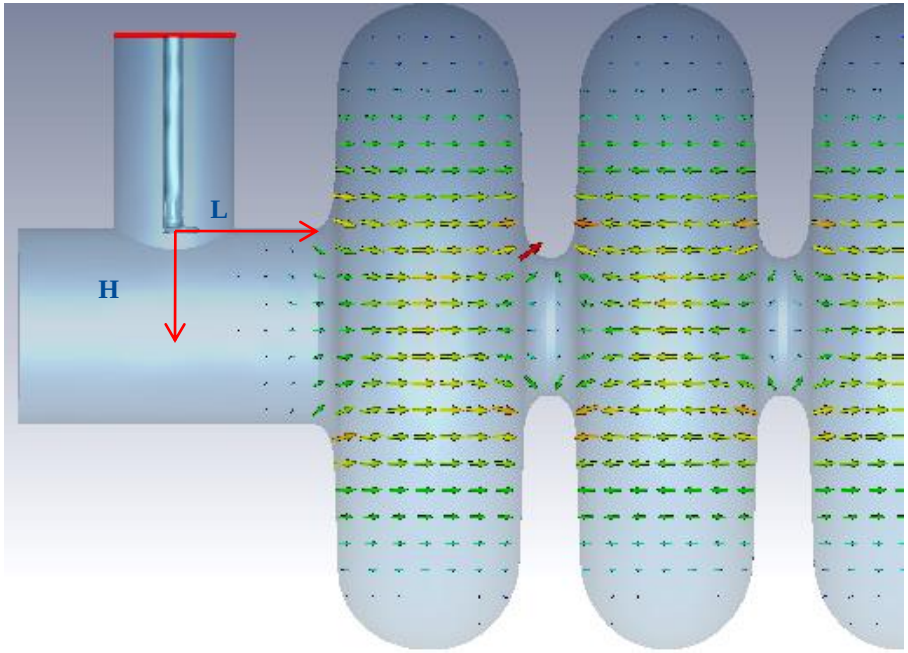
EM Design

- As per FRS , Bandwidth 65Hz (Q_L=1x10^7) and Q_0>1.5x10^{10}
- As per FRS, LB650 cavity has to fit the HB650 power coupler
- For calculating Q_{ext} for the coupler with LB650 cavity, Coupler dimensions have been taken from a Coupler model available in team center

- Outer Dia =72.9 mm , inner Dia=12.7 mm and antenna as per the model obtained from teamcenter.

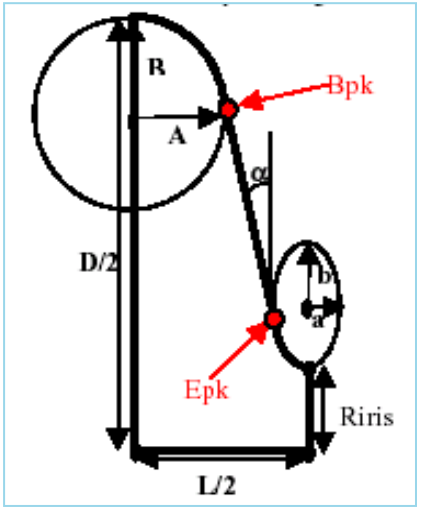
- Different values of L and H are shown for Q_L=1x10^7





IIFC Technical Status: 5-cell LB650 Design

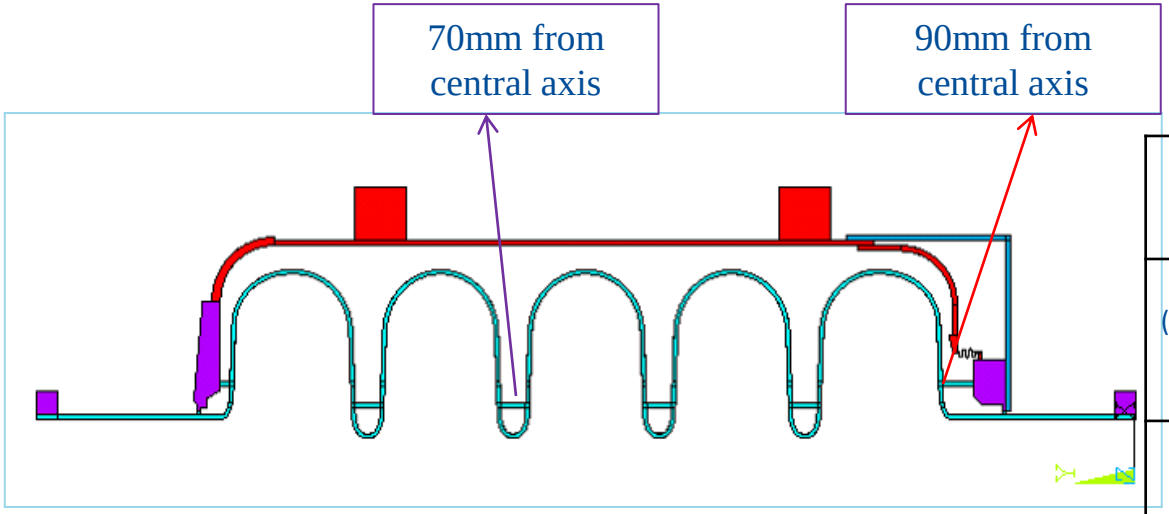
Dimensional Parameters	COLD Dimension (inside) (as designed) (mm.)	COLD Dimension Pre- BCP treatment of 250 µm (mm.)	WARM Dimension Inside (for fabrication) (mm.)
Equator radius	194.646	194.396	194.674
Iris radius	41.5	41.25	41.30899
A	52.14	51.89	51.9642
B	56	55.75	55.82972
a	12.95	13.2	13.21888
b	23.55	23.8	23.83403
Iris radius (for end cell)	59	58.75	58.83401
A (for end cell)	53.52	53.27	53.34618
B (for end cell)	48	47.75	47.81828
a (for end cell)	10.8	11.05	11.0658
b (for end cell)	25.7	25.95	25.98711
Equator flat (end cell)	3.79	3.79	3.79542
Iris flat (mid cell)	2.61	2.61	2.613732
Half cell length (L/2)	70.335	70.335	70.43488



IIFC Technical Status: 5-cell LB650 Design

LFD Analysis and df/dP analysis : Stiffener Ring Positioning

Design-A: Single stiffener ring for mid & end cells (R1-mid=70mm, R2-end= 90 mm)



Fabrication and cavity field flatness tuning are easy, but FRS criteria for both LFD and df/dP needs to be modified

	FRS Criteria (1st modified)	Tuner Stiffness **68kN/mm**
LFD (Hz/(MV/m)^2)	-1.0 (both for LB650 and HB650)	**-1.32 (does not Satisfy FRS)**
df/dP (Hz/mbar)	25	**30.3 (does not Satisfy FRS)**

- With increase in tuner stiffness, LFD value decreases from a high negative value to a lower negative value and saturates
- with increase in tuner stiffness, df/dP value decreases from a high positive value and saturates (within fraction of Hz) when tuner stiffness exceeds 50 kN/mm

Tuner Stiffness (kN/mm)	R-mid (mm)	R-end (mm)	LFD (Hz/(MV/m)^2) (at specified energy gain of 11.9MeV)	df/dP (Hz/mbar) at specified energy gain of 11.9MeV)
68	70	90	-1.32	**30.3**
80	70	90	-1.27	**30.0**
100	70	90	-1.21	**29.7**

IIFC Technical Status: 5-cell LB650 Design

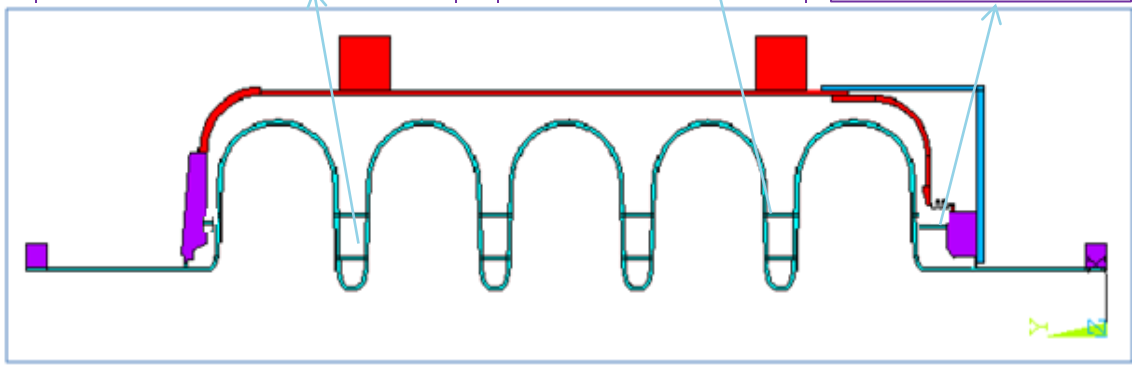
LFD Analysis and df/dP analysis : Stiffener Ring Positioning

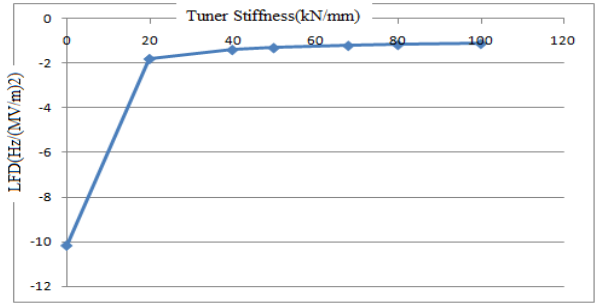
Design B:Two stiffener rings for mid cells & one for end cells (R-mid=70/109mm,R-end= 100mm)

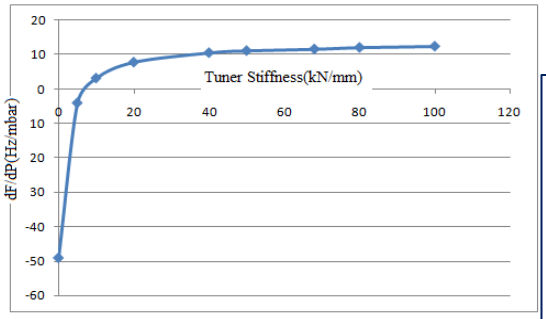
R_{1mid}=70mm from central axis

R_{2mid}=109mm from central axis

R_{end}=100mm from central axis







As tuner for LB650 has to be compatible to HB650 tuner and for HB650, tuner stiffness is chosen as 68kN/mm, **FRS criteria for LFD is again modified and increased to 1.25 Hz/(MV/m)^2.** So stiffener ring Rmid=70mm/109mm and Rend =100mm , satisfies both the FRS criteria at tuner stiffness=68kN/mm.

Fabrication and cavity field flatness tuning are complicated, but FRS criteria for only LFD needs to be modified

	1st modified FRS Criteria	Tuner Stiffnes 68kN/mm
LFD (Hz/(MV/m)^2)	1 (both for LB650 and HB650)	~1.21 (does not Satisfy FRS)
df/dP (Hz/mbar)	25	10.5 (satisfies FRS)

- With increase in tuner stiffness, LFD value decreases from a high negative value to a lower negative value and saturates
- Unlike design A, with increase in tuner stiffness, df/dP value decreases from a high negative value (at zero stiffness) to lower negative value, crosses zero before tuner stiffness increases to 10kN/mm and then df/dP starts increasing with the increase of tuner stiffness.

IIFC Technical Status: 5-cell LB650 Design

Cavity Stiffness : Stiffener Ring Positioning

Configuration	Stiffness of Bare cavity (kN/mm)	Stiffness of Bare cavity + Helium Vessel (kN/mm)
Single stiffener at 70 mm for mid-cells & 90 mm for end cells	0.72	1.66
Double stiffeners at 70 mm & 109 mm for mid-cells & single stiffener at 100 mm for end cells	2.353	3.264

Cavity stiffness value for both the Configuration, satisfy FRS criteria (< 5kN/mm)

Issues requiring management attention :Technical & Schedule (6.3: 650 MHz Dressed Cavity and Cryomodule)

Technical Issues:

1. VECC requested Fermilab to provide information regarding 5-cell cavity fabrication procedure, such as **acceptance criteria** at different stages of fabrication , drawings of different fixtures for frequency measurement of half-cells, and full cavity tuning .

2. Dressing of LB650 cavity is dependent on the design and engineering drawings of LB650 Helium vessel and LB650 slow fast tuner. Fermilab released drawing of Helium vessel and tuner for HB650 on 30th June 2016.

3. Information related to detail acceptance criteria for all the sub systems of dressed cavity is required from Fermilab.

4.Information for procedures, equipment, and infrastructure needed for cavity dressing are also required from Fermilab.

Issues requiring management attention :Technical & Schedule (6.4: Helium Vessel and Cavity End Group)

For LB650 helium vessel, HB650 helium vessel documentation is required. some documents of HB650 helium vessel are available and some will be available later. All those documents to be provided to DAE.(Team Centre Document # may be mentioned).

Delivery date for 'Fabrication of 5-cell LB650 He Vessel and its interface to the Endgroup (3c) depends on the actual date of availability of Engineering/Fabrication Drawings for LB650 Helium vessel.

Issues requiring management attention :Technical & Schedule (6.5: Slow and Fast Tuner)

Some documents of HB650 tuner are available and some will be available later. All the tuner documentation to be provided to DAE. (Team Centre Document # may be mentioned)

The LB650 cavity will use the same Tuner of HB650. HB650/LB650 tuner design documentation and Engineering/Fabrication Drawings should be provided .(Teamcentre Document # may be mentioned).

Delivery date for 'Fabrication of 5-cell LB650 Tuner, motor, readout and its interface to the end group at DAE Laboratories'(3b) depends on the actual date of the supply of complete Engineering/Fabrication Drawings from Fermilab.

Issues regarding **Addendum II to the Joint Project Document**

	A	C	E	F
50				
51	**EM design of LB650**	**Delivery Dates**		
52		***FNAL: Prototype Phase***	***FNAL: Final Design Phase***	***Remarks:***
53	Design specifications	***Apr. 2017***	***Apr. 2019***	***Teamcenter #ED0001834***
54	3D model in MWS or equivalent	Apr. 2017	***Apr. 2019***	Available at request
55	Details of sim. params. & results	***Apr. 2017***	***Apr. 2019***	Presented in CDR and references therein, draft is available
56	Detailed Design Report	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
57	Design Review docs. (prelim & final)	N/A	N/A	
58	Notes on design choices & reasons	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
59	Details of multipacting studies	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
60	Calculations of cavity cryogenic load	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
61	Calculations of cavity RF requirement	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
62				
63	**EM design of HB650**	**Delivery Dates**		
64		***FNAL: Prototype Phase***	***FNAL: Final Design Phase***	***Remarks:***
65	Design specifications	***Apr. 2017***	***Apr. 2019***	***Teamcenter #ED0001321***
66	3D model in MWS or equivalent	Apr. 2017	***Apr. 2019***	Available at re
67	Details of sim. params. & results	***Apr. 2017***	***Apr. 2019***	Presented in CD
68	Detailed Design Report	Apr. 2017	***Apr. 2019***	Presented in CD
69	Design Review docs. (prelim & final)	N/A	N/A	
70	Notes on design choices & reasons	Apr. 2017	***Apr. 2019***	Presented in CD
71	Details of multipacting studies	Apr. 2017	***Apr. 2019***	Presented in CD
72	Calculations of cavity cryogenic load	Apr. 2017	***Apr. 2019***	Presented in CD
73	Calculations of cavity RF requirement	Apr. 2017	***Apr. 2019***	Presented in CD
74				
75	**Design of Ring Magnets**	**Delivery Dates**		
76		***FNAL: Prototype Phase***	***FNAL: Final Design Phase***	***Remarks:***
77	Design specifications	N/A	N/A	
78	3D model in TOSCA or equivalent	N/A	N/A	
79	Details of sim. param. & results	N/A	N/A	
80	Detailed Design Report	N/A	N/A	
81	Design Review docs. (prelim & final)	N/A	N/A	
82				
83	**Beam dynamics design (linac+ring)**	**Delivery Dates**		
84		***FNAL: Prototype Phase***	***FNAL: Final Design Phase***	***Remarks:***
85	Design specifications	***Apr. 2017***	***Apr. 2019***	Presented in CDR and references therein, draft is available
86	Details of start-to-end sims.	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
87	Error analyses	***Apr. 2017***	***Apr. 2019***	Presented in CDR and references therein, draft is available
88	Detailed Design Report	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
89	Design Review docs. (prelim & final)	N/A	N/A	
90	Notes on design choices & reasons	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
91	Studies on beam halo & beam loss	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
92	Studies on injection into ring	Apr. 2017	***Apr. 2019***	Presented in CDR and references therein, draft is available
93	Optics files	Apr. 2017	***Apr. 2019***	http://pip2-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=119
94				

FNAL–Prototype phase ???

It is mentioned -- CDR and draft documents are available for LB650. Those documents to be provided to DAE. (Teamcentre Document # may be mentioned).

Table 1.2: Accelerator Physics Design (cont.)

Issues regarding **Addendum II to the Joint Project Document**

	A	B	C	D
1	**LB650 Bare Cavity**			
2		***FNAL: Prototype Phase***	***FNAL: Final Design Phase***	***Remarks:***
3	FRS			FRS for jacketed cavity only
4	Risk assessment	29-Jun-16	30-Jun-20	RA FNAL requirement only
5	TRS			TRS for jacketed cavity only
6	Preliminary Design Review Documentation			RF Design, prelim mech design, multipact sims, thermal/structural analysis, etc.
7	3D Models			
8	Engineering drawings			
9	Procurement Readiness Review Documentation			Production drawings, production plan incl schedule, etc.
10	Engineering Note(s)			
11	Final Design Review Documentation			Final RF Design, final mech design, final thermal/structural analysis,
12	Manufacturing Process Documents			Material and welding certs, code requirements, etc.
13	QA Documentation and Travelers			
14	Interface Specification			Required for CM only
15	Operational Readiness Clearance			Required for systems only
16				
17	**LB650 Jacketed Cavity**			
18		***FNAL: Prototype Phase***	***FNAL: Final Design Phase***	***Remarks:***
19	FRS	26-May-16	30-Jun-20	
20	Risk assessment	29-Jun-16	30-Jun-20	RA FNAL requirement only
21	TRS			
22	Preliminary Design Review Documentation			RF Design, prelim mech design, multipact sims, thermal/structural analysis, etc.
23	3D Models			
24	Engineering drawings			
25	Procurement Readiness Review Documentation			Production drawings, production plan incl schedule, etc.
26	Engineering Note(s)			
27	Final Design Review Documentation			Final RF Design, final mech design, final thermal/structural analysis, modal analysis, df/dP, LFD, etc.
28	Manufacturing Process Documents			Material and welding certs, code requirements, etc.
29	QA Documentation and Travelers			
30	Interface Specification			Required for CM only
31	Operational Readiness Clearance			Required for systems only

Table 4.1: LB650

RA for LB650 Bare/ Jacketed cavity to be provided to DAE.

Design review needs to be carried out by Fermilab also. So, preliminary design review done and final design review have to be made jointly.

Issues regarding **Addendum II to the Joint Project Document**

	A	B	C	D
33	**LB650 Helium Vessel**			
34		*FNAL: Prototype Phase*	*FNAL: Final Design Phase*	*Remarks:*
35	FRS			FRS for jacketed cavity only
36	Risk assessment			
37	TRS			TRS for jacketed cavity only
38	Preliminary Design Review Documentation			If separate from Jacketed cavity PDR
39	3D Models			
40	Engineering drawings			
41	Procurement Readiness Review Documentation			Production drawings, production plan incl schedule, etc.
42	Engineering Note(s)			Only if different than dressed cavity engineering note.
43	Final Design Review Documentation			If separate from Jacketed cavity FDR (one for Prototype, one for Production)
44	Manufacturing Process Documents			
45	QA Documentation and Travelers			
46	Interface Specification			Required for CM only
47	Operational Readiness Clearance			Required for systems only
48				
49	**LB650 Tuner**			
51	FRS	20-Apr-16	30-Jun-20	
52	Risk assessment	29-Jun-16	30-Jun-20	RA FNAL requirement only
53	TRS			
54	Preliminary Design Review Documentation	Pischalnikov - not documented		FEA, response analysis, electromechanical controls info, etc.
55	3D Models	30-Jun-16	30-Jun-20	Same design as HB 650 Tuner
56	Engineering drawings	30-Jun-16	30-Jun-20	Same design as HB 650 Tuner
57	Procurement Readiness Review Documentation			Production drawings, production plan incl schedule, etc.
58	Engineering Note(s)			
59	Final Design Review Documentation			Final FEA, response analysis, electromechanical controls info, etc. Final for the prototype and final for the production.
60	Manufacturing Process Documents			
61	QA Documentation and Travelers			No travelers
62	Interface Specification			Required for CM only
63	Operational Readiness Clearance			Required for systems only
64				
65	**LB650 Cryomodule**			
78	Interface Specification			preliminary design and at final design stages.
79	Operational Readiness Clearance			Required at CM operations level.

Table 4.2: LB650

	A	C	E	F
33	**HB650 Helium Vessel**	**Delivery Dates**		
34		*FNAL: Prototype Phase*	*FNAL: Final Design Phase*	*Remarks:*
35	FRS			FRS for jacketed cavity only
36	Risk assessment			
37	TRS			TRS for jacketed cavity only
38	Preliminary Design Review Documentation	13-Jun-16		If separate from Jacketed cavity PDR
39	3D Models	1-Jul-16	30-Jun-20	
40	Engineering drawings	1-Jul-16	30-Jun-20	
41	Procurement Readiness Review Documentation	31-Mar-17	30-Jun-20	Production drawings, production plan incl schedule, etc.
42	Engineering Note(s)	31-Mar-17	30-Jun-20	Only if different than dressed cavity engineering note.
43	Final Design Review Documentation	31-Mar-17	30-Jun-20	If separate from Jacketed cavity FDR (one for Prototype, one for Production)
44	Manufacturing Process Documents	31-Dec-17	30-Jun-20	
45	QA Documentation and Travelers	31-Dec-17	30-Jun-20	
46	Interface Specification			Required for CM only
47	Operational Readiness Clearance			Required for systems only
48				
49	**HB650 Tuner**	**Delivery Dates**		
50		*FNAL: Prototype Phase*	*FNAL: Final Design Phase*	*Remarks:*
51	FRS	20-Apr-16	20-Apr-16	
52	Risk assessment	29-Jun-16	29-Jun-16	
53	TRS		30-Jun-20	
54	Preliminary Design Review Documentation	Pischalnikov - not documented		FEA, response analysis, electromechanical controls info, etc.
55	3D Models	30-Jun-16	30-Jun-20	
56	Engineering drawings	30-Jun-16	30-Jun-20	
57	Procurement Readiness Review Documentation	31-Mar-17	30-Jun-20	Production drawings, production plan incl schedule, etc.
58	Engineering Note(s)	31-Mar-17	30-Jun-20	
59	Final Design Review Documentation	31-Mar-17	30-Jun-20	Final FEA, response analysis, electromechanical controls info, etc. Final for the prototype and final for the production.
60	Manufacturing Process Documents	31-Dec-17	30-Jun-20	
61	QA Documentation and Travelers	31-Dec-17	30-Jun-20	No travelers
62	Interface Specification			Required for CM only
63	Operational Readiness Clearance			Required for systems only
78	Interface Specification	30-Jun-18	30-Jun-20	design and at final design stages.
79	Operational Readiness Clearance	30-Jun-18	30-Jun-20	Required at CM operations level.

Table 5.2: HB650

LB650 helium vessel is classified as deliverable by DAE. But In JD, it was deliverable by Fermilab !!

For LB650 helium vessel design and fabrication, HB650 helium vessel documentation is required. some documents of HB650 helium vessel are available and some will be available later. All those documents to be provided to us.(Team Centre Document # may be mentioned).

For LB650 tuner, some parts of documentation is classified as deliverable by DAE. But it was deliverable by Fermilab (as mentioned in JD).

Some documents of HB650 /LB650 tuner are available and some will be available later. All the tuner documentation to be provided to us. (Team Centre Document # may be mentioned)

Summary: VECC

- EM design and optimization of stiffener ring position has been done to meet FRS criteria (E_{peak}, B_{peak}, LFD and df/dP)

- FRS criteria modified by Fermilab for peak magnetic field (from 72 mT to 75mT) and LFD (from 0.8Hz/(MV/m)^2 to 1.25 Hz/(MV/m)^2) on the basis of the design results from VECC.

- 3-D Modeling, Engineering Drawing , Structural analysis and modal analysis for LB650 cavity are in progress.

- 1st prototype 1-cell LB650 cavity has been successfully tested in VTS and achieved a record accelerating gradient of 34.5 MV/m.

- Various elements of bare and dressed cavity are developmental in nature requiring long lead time for procurement. Fermilab is requested to communicate information related to detail acceptance criteria, procedures, equipment, and infrastructure needed for cavity development.

- Delays in various design, documentation and drawings inputs for helium vessel, tuner etc. and lack of cavity fabrication information will correspondingly delay the schedule of bare cavity and dressed cavity.

- Revised schedule has to be discussed and agreed jointly.

Scope of Work: 6.3: HB650 MHz Dressed Cavity
(Joint Project Document – R&D Phase)

Milestone	Major Milestone	Quantity	Delivery date As per signed Joint document	New Delivery date (proposed by VECC)	New Delivery date (as per Fermilab's Proposal)
1	Fabricate 1-cell LB650 Cavity Process and test 1-cell LB650 Cavity at Fermilab	1	30 Sep 2015 30 Nov 2015	Completed (30.09.2015) Completed (06 Jul 2016)	
2	Finalize the design of 5-Cell LB650 Cavity		31 Dec 2015	31 Dec 2016 (as per Modified FRS)	
3	Design review of 5-cell LB650 Cavity		31 Jan 2016	31 Jan 2017 (as per Modified FRS)	
4	a) Fabrication of 1st 5-cell LB650 Cavity b) Processing and Vertical testing of 5-cell Cavity c) Dressing LB650 Cavity d) Testing of 1st 5-Cell Dressed LB650 at Fermilab	1	31 Dec 2016 30 Jun 2017 31 Dec 2017 31 Mar 2018	30 June 2018 30 Dec 2018 30 Jun 2019 30 Sep 2019	
5	a) Fabrication of 2nd 5-cell LB650 Cavity b) Processing and Vertical testing of 5-cell Cavity c) Dressing LB650 Cavity d) Testing of 2nd 5-Cell Dressed LB650 at Fermilab	1	30 Sep 2017 31 Mar 2018 30 Sep 2018 31 Dec 2018	31 Mar 2019** 30 Sep 2019** 31 Mar 2020** 30 Jun 2020**	31-Dec 2018 30 Jun 2019 31 Oct 2019 31 Dec 2019

** VECC will try hard to complete R&D phase by 31-Dec-2019, as requested by Fermilab. However, due to some eventualities, it may slip 6 more months as anticipated by VECC.

Thank You