STF Baseline Cavity and RF Components

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Abstract

Following the ITRP Recommendation to adopt superconducting cavity to the main LINAC of ILC, KEK has started the construction of STF. In the 2 years Phase-I starting in this year, a cryomodule containing 8-9cell 1.3GHz cavities is constructed, which will accelerate the beam by the end of the next year. 4 cavities are TTF type, aiming at 35MV/m operation. The other 4 are high gradient type, aiming at 45MV/m operation. In this paper, the design of TTF type STF baseline cavities and other components are reported.

Purpose of STF Baseline Cavity Development

- Improve design and demonstrate in the beam line for CDR / TDR.
- Establish industrial design and make the precise cost estimation in the close cooperation with industries.
- Offer the reliable system to the Asian regional facility STF.

Main Differences in TTF and STF Baseline Design

Cavity System	TTF		STF Baseline	Comments
Operating Gradient	24MV/m XFEL,TESLA500	35MV/m TESLA800	35MV/m	
Cavity Geometry	Iris Aperture 70mm Beam Pipe Aperture 78mm Cell Taper Angle 13 deg.		Iris Aperture 70mm Beam Pipe Aperture 84mm Cell Taper Angle 10 deg.	Almost same RF and Beam Accelerating Performance
Stiffness of Cavity Fixing Support	~40 kN/mm		110 kN/mm	Stiffer Jacket Baseplate Stiffer Tuner
Mechanical Tuner	Lever Arm on Beam Pipe	Blade + Lever Arm on Jacket	Slide Jack on Jacket	Simple and Stiff Motor Outside Easy Piezo Replacement
Lorentz Detuning	- 450Hz	- 900Hz	- 600Hz	Resonance Half Band Width ~300Hz
Stroke for Compensation	1.5μm	3μm	1.3μm	Short Stroke Precise Compensation Small Klystron Margin
Input Coupler	TTF-III	? TTF-IV	TRISTAN Type	Simple
Size	Diameter of Outer Conductor 40mm 70Ω	Diameter of Outer Conductor 60mm 70 Ω	Diameter of Outer Conductor 60mm 50Ω	Higher Power Capacity Larger Static Heat Load
Operating Power	250kW	350kW	350kW	
Ceramic Window	Cylindrical	Cylindrical	Coaxial Disk	Many Experiences TRISTAN,KEKB,SNS,ADS

STF Baseline Cavity Specification

			Input Coupler		
Frequency	f	1.3 GHz	Double TRISTAN Type Coaxial Disk Window + Door knob		
Number of cells		9			
Shape		Elliptical	Over Coupling Factor		1.57
Effective Length	L_{eff}	1038 mm	Coupler Q-Value	Q_{in}	2.2×10^6 <±10 %
Iris Aperture		70 mm	Max. Beam Power	35 MV x 10 mA	350 kW
Beam Pipe Diameter		84 mm	Max. Input Power		368 kW
Geometrical Impeadance	R / Q	1016 Ω	Pulse Length	1 msec. Beam	1.51 msec.
Geometrical Factor	G	277 Ω	Repetition Rate		5 Hz
Cell to Cell Coupling	k	2.00%			
Surface Peak Electric Field Ratio	E_{sp} / E_{acc}	2.17			
Surface Peak Magnetic Field Ratio	H_{sp} / E_{acc}	4.10 mT / (MV/m)	Cold Coupler	Window Size	ϕ92 mm(22) x t6.2
				Coaxial Line Outer Diameter	60 mm --> 81 mm
Operating Voltage	V_{acc}	35 MV			
Q_O at Operating Gradient	Q_O	$> 5 \times 10^9$			
Matched Q		3.45×10^6	Warm Coupler	Window Size	ϕ116 mm(30) x t6.6
Coupler Q	Q_{in}	2.2×10^6		Coaxial Line Outer Diameter	81 mm --> 104 mm
Half Band Width		295 Hz			
Filling Time	T_f	0.538 msec.	Diagnostics	Electron x 3	
RF Loss per Pulse (1.51msec.)		0.357 J		Arc Senser x 1	
Frequency Tuning Sensitibity		445 kHz/mm	4k Load	Static 1.1 W	Dynamic 0.2 W
Stiffness		3400 N/mm	80k Load	Static 7 W	Dynamic 3 W
		131 Hz/N			

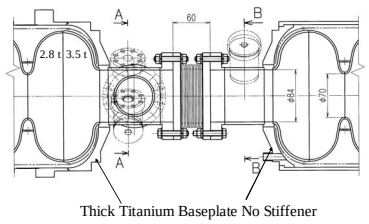
Tuner / Jacket

Place		Jacket Flange
Lorentz Force at 35 MV / m		42 N
Single Cell Mode Detuning		465 Hz
Stationary Detuning		695 Hz
Realistic Detuning	1.5msec. Pulse End	~ 600 Hz
Coarse Tuner	Sliding Wedge x 2	
	Stroke	3.5 mm
	Resolution	< 1 μm
	Drive	Stepping Motor x 1
Fine Tuner	Piezo Transducer x 1	
	Stroke	> 4 μm
	Resolution	< 0.05 μm
	Diameter	35 mm
	Length	60 mm
	Max. Load	3.5×10^4 N
	Stiffness	4.5×10^5 N/mm
Jacket (Titanium)	Stiffness	1.2×10^5 N/mm
	Base Plate Thickness	15 mm
	Cylinder Thickness	5 mm

HOM Coupler

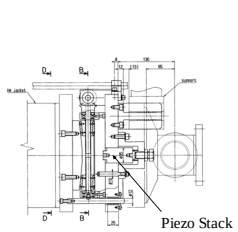
One TESLA Type on each Beam Pipe			
Filter			1.6 GHz
20 dB Frequency		40 dB	30 MHz
1.3 GHz Band Width		50 dB	10 MHz
	Frequency	R / Q	Q_{ext}
Acc. Mode	1300	1016 Ω	$> 2 \times 10^{10}$
TM_{011}			
1 / 9 – π	2395	97 Ω	$< 2 \times 10^4$
2 / 9 – π	2388	188 Ω	$< 1 \times 10^4$
3 / 9 – π	2378	38 Ω	$< 5 \times 10^4$
TM_{012}			
π	3764.6	40 Ω	$< 5 \times 10^4$
8 / 9 – π	3764.3	22 Ω	$< 1 \times 10^5$
TE_{111}			
6 / 9 – π	1688	549 Ω / m	$< 5 \times 10^4$
7 / 9 – π	1717	2100 Ω / m	$< 2 \times 10^4$
8 / 9 – π	1748	793 Ω / m	$< 5 \times 10^4$
TM_{110}			
6 / 9 – π	1864	864 Ω / m	$< 5 \times 10^4$
5 / 9 – π	1875	1270 Ω / m	$< 3 \times 10^4$
4 / 9 – π	1884	394 Ω / m	$< 5 \times 10^4$
TM_{111}			
1 / 9 – π	2536	2070 Ω / m	$< 2 \times 10^4$

Stiff Jacket Baseplate (Ti)

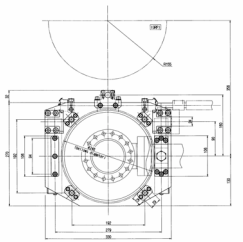


Thick Titanium Baseplate No Stiffener

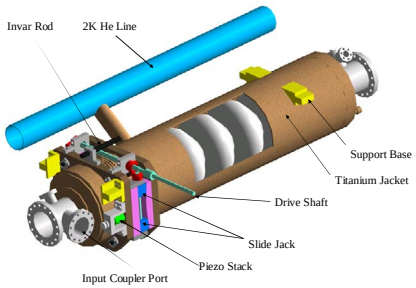
Slide Jack Tuner



Piezo Stack



Tuner and Jacket



Input Coupler