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MECHANICAL TUNER FOR A 325MHZ BALLOON SINGLE SPOKE RESONATOR

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ABSTRACT

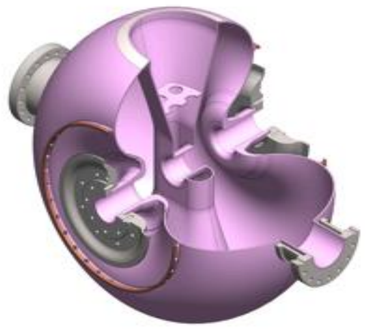
TRIUMF designed, fabricated and tested the first balloon variant of the single spoke resonator at 325 MHz and β=0.3. TRIUMF has also designed and built a mechanical tuner as part of the development. The tuner employs a nutcracker lever pressing at the beam ports driven by a scissor jack. The scissor is actuated through a tube coupling to a warm ball-screw and servo-motor located outside the cryostat. The design challenge is that the cavity is relatively stiff and the tuning sensitivity is relatively high so a strong tuner with high resolution is required.The design, fabrication and warm tests of the tuner will be presented.

Specification

Parameter	Value	Units
SSR1 rf frequency	325	MHz
Cavity bandwidth	60	Hz
Tuning sensitivity	467	Hz/μm
Tuning force	33	Hz/N
Spring constant	14	N/μm
Coarse tuning range	180	kHz
Displacement range	0.39	mm
Maximum Force	5500	N
Resolution	<1.5	Hz
Position resolution	<3.2	nm

Table 1: SSR1 and Tuner design parameters

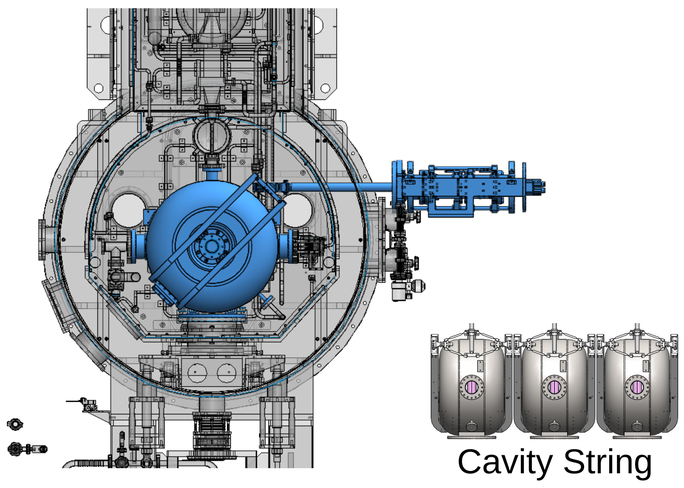
SSR1 Cavity



Parameters	Beam Tube	Value
df/dp (Hz/mbar)	free	-1.6
	fixed	+1.5
LFD (Hz/(MV/m)^2)	free	-8.7
	fixed	-1.4

Conceptual Design

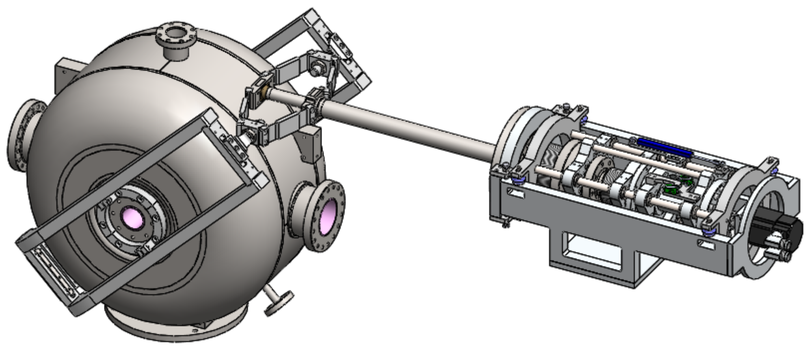
- Cryomodule design favours horizontal motor mount

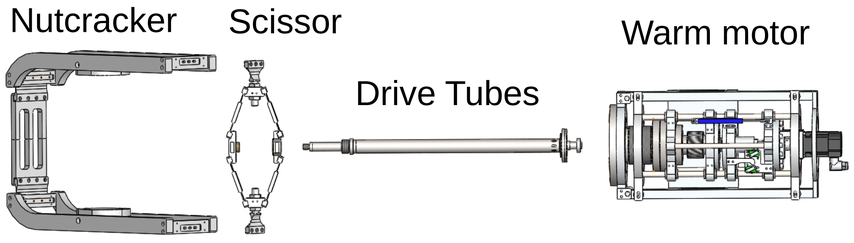


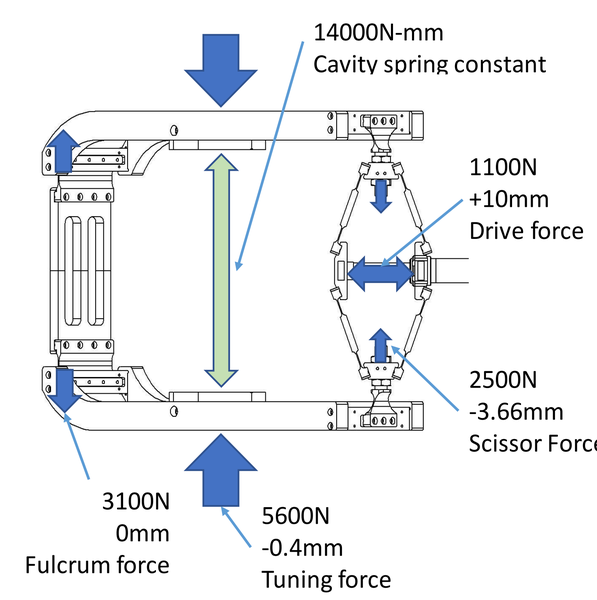
Cavity String

The SSR1 cavity and tuner installed in the SSR1 cryomodule.

- Warm motor and ball screw located outside cryostat
- Tube coupling drives scissor mechanism that squeezes a nutcracker lever pressing at the beam ports

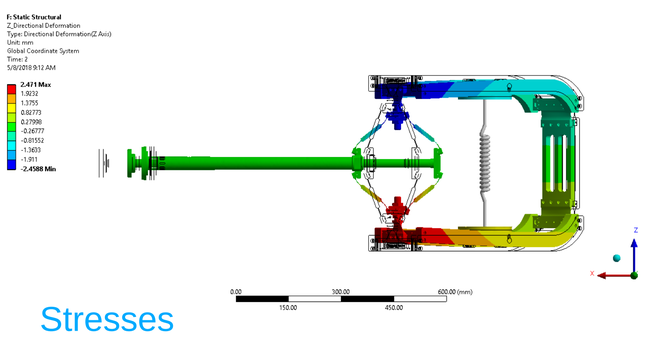






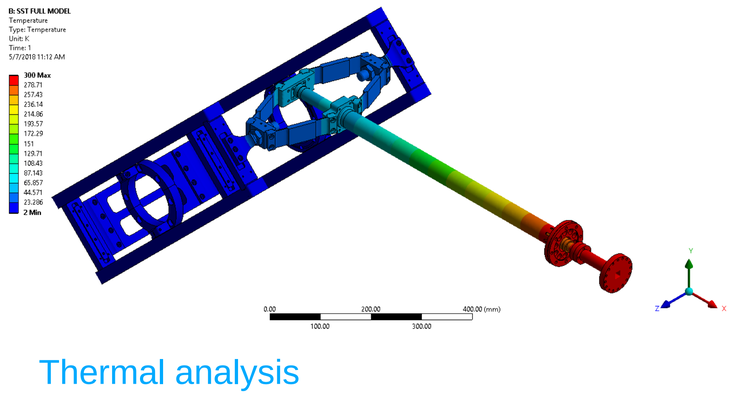
The forces and displacements on the SSR1 tuner components under maximum load. The mechanical advantage in force is 5:1 and the drive ratio is 25:1

Detail Design



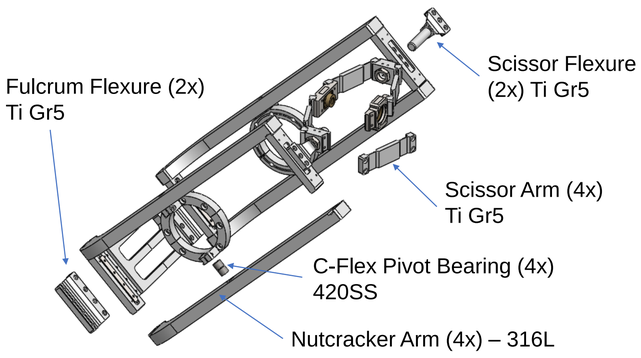
Stresses

All stresses comfortably below yield limits



Thermal analysis

Conductive heat load is 0.1 W to 2K and 1.3W to 50K



Material choice

Ti-Gr5 Flexures and C-Flex bearings produce zero backlash operation

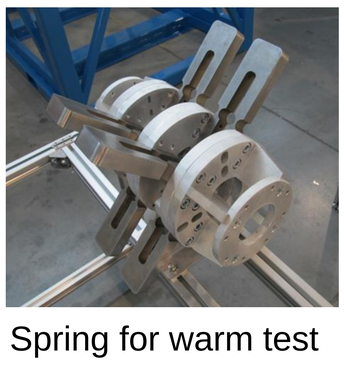
Motor and ball screw

Motor	
Manufacturer	Kollmorgen
Model	AKM31E-ANCNR-00
Rated Torque	1.2Nm
Resolution	2^{16} cts/rev
	1.2 nm/count
	0.56Hz/count

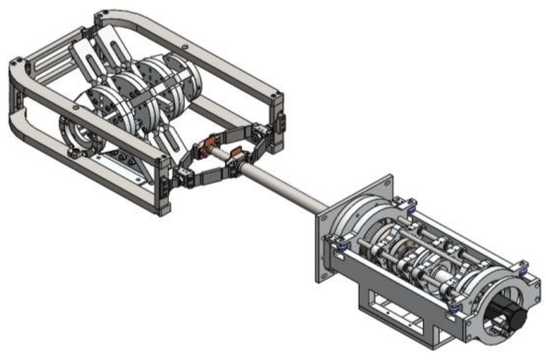
Ball screw	
Manufacturer	NSK
Model	W1601MA-1PY-C3Z2
Dynamic rating	3510 N
Static rating	8450 N
Pitch	2 mm
Diameter	16 mm

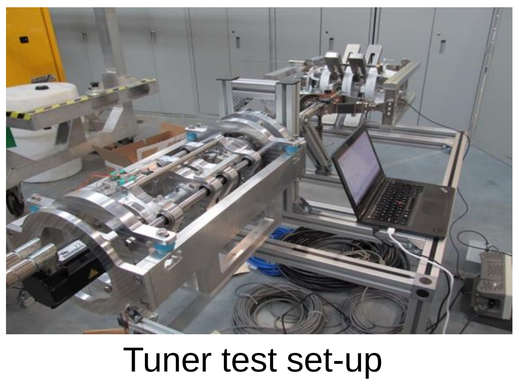
Warm Test

The tuner mechanism was warm tested using a Bosch frame and spring to replicate the cavity. A linear variable displacement transducer (LVDT) measures spring length.



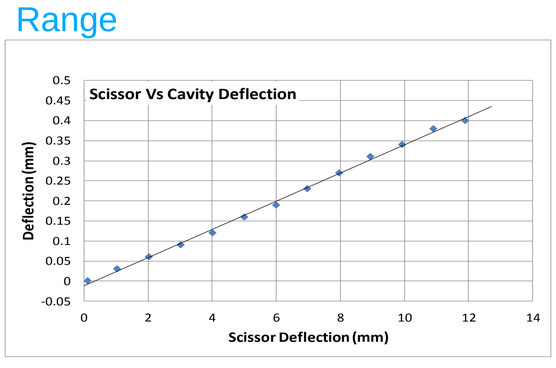
Spring for warm test





Tuner test set-up

Range



Response