Design of the CW Cornell ERL Injector Cryomodule

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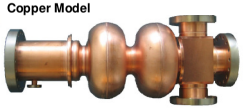
Abstract:
The Cornell ERL Prototype injector RF system will accelerate bunches of a 100 mA beam to an energy of several MeV, while preserving the ultra-low emittance of the beam. The injector linac will be based on superconducting RF technology with five 2-cell RF cavities operated in CW mode. Beside the five RF cavities, the injector cryomodule houses six broadband RF ring-absorbers located at 80 K for HOM damping, ten input couplers, LHe vessels with cavity frequency tuners, a cavity support structure and the cryogenic piping. The axial symmetry of the HOM absorbers, together with a twin-coupler design, avoids transverse on-axis fields, which would cause emittance growth. The design of the cryomodule is nearly finished, and prototyping of subcomponents has started. We expect first beam through the injector RF system late 2008. In this paper we give an update on the ERL injector cryomodule work.

Beam

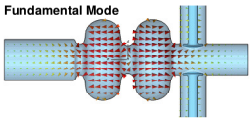
Max. current ($Q_{bunch} = 77$ pC)	100 mA
Max. current ($Q_{bunch} \approx 1$ nC)	1 mA
Max. bunch rep. rate	1.3 GHz
Emittance ($Q_{bunch} = 77$ pC)	< 0.5 μm rad
Max. emittance growth ($Q_b = 77$ pC)	< 0.1 μm rad
Bunch length	< 1 mm
Max. beam energy at end (100 mA)	5.5 MeV
Max. beam energy at end (33 mA)	15.5 MeV

2-cell cavity

Copper Model

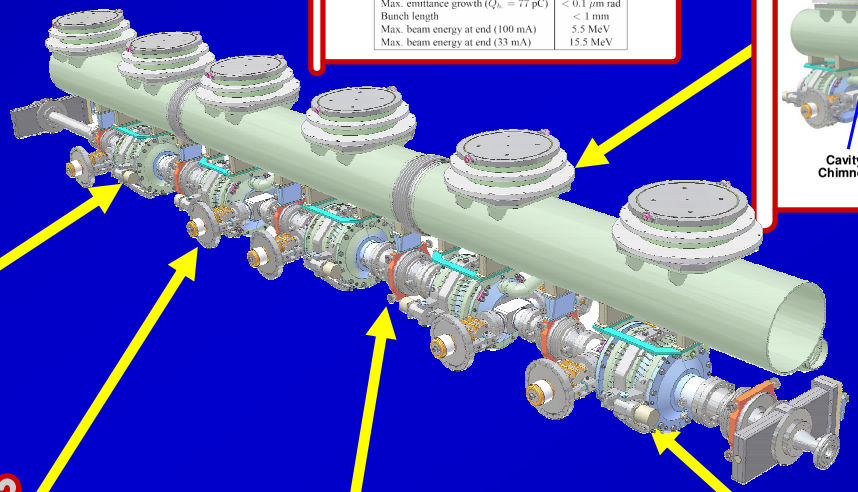


Fundamental Mode

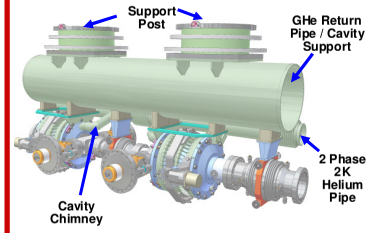


- Enlarged beam pipe to propagate all monopole and dipole higher-order modes.
- Two copper models have been built and studied; first Nb version this fall.
- Twin coaxial coupler to avoid transverse on-axis kick-fields (cause emittance growth).

Frequency	1.3 GHz
Number of cells	2
R/Q	218 Ω
E_{pk}/E_{acc}	1.94
H_{pk}/E_{acc}	42.8 Oe/(MV/m)
Cell to cell coupling	0.7 %
Max. transverse offset	0.5 mm
Max. cavity tilt	1 mrad
Q_0 at 2 K	$> 10^{10}$
Q_L	$4.6 \cdot 10^4$ to $4.1 \cdot 10^7$
Accelerating voltage	1 to 3 MV
Max. power transfered to beam	100 kW



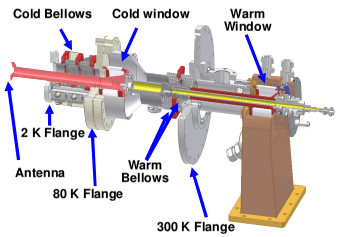
Cryostat / Cold Mass



- Based on TTF cryostat design.
- Modified for high CW 2 K loads.
- 80 K thermal shield.
- Simplified 5 K shield.
- Modified cavity / HOM absorber support.

Number of cavities	5
Number of HOM loads	6
Overall length	≈ 5.4 m
Total max. 2 K load	≈ 25 W
Total max. 5 K load	≈ 70 W
Total max. 80 K load	≈ 700 W

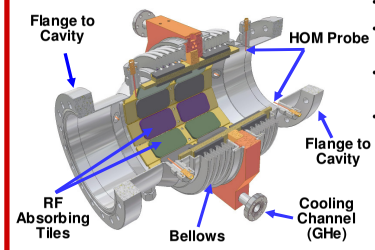
Input Coupler



- High power handling.
- Design optimized for small emittance growth.
- RF heating and required cooling has been studied in detail.
- Air cooled inner conductor.
- First prototypes early 2006.

Frequency	1.3 GHz
Bandwidth	±10 MHz
Max. cw traveling power	75 kW
Number of windows	2
Coaxial line OD	62 mm
Cold coax. line impedance	60 Ω
Q_{ext} range	$9.2 \cdot 10^4$ to $8.2 \cdot 10^5$

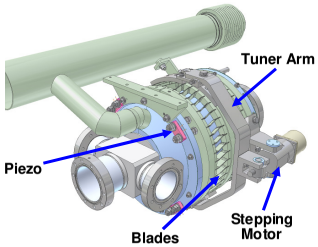
HOM Absorber



- Placed in beam line between cavities.
- Quality factors between some 100 and a few 1000 are required.
- Operated at 80 K to simplify thermal transitions to cavities at 2 K.
- Combination of three RF absorbing materials for effective damping from 1.4 GHz to > 50 GHz.

Average HOM loss /cavity	26 W
Max. power per absorber	200 W
HOM frequency range	1.4 to > 50 GHz
Operating temperature	80 K
Coolant	GHe
Absorber type	TT2-111R, HexMZ, ZRC10CB5

Frequency Tuner



- Based on TTF/INFN blade tuner.
- Integrated piezo-electric actuators for fast microphonics compensation.
- First prototype in 2006.

Tuning range (motor)	± 400 kHz
Resolution (motor)	≈1 Hz/step
Tuning range (piezo)	± 200 Hz

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