Superconducting RF activities at JAERI

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(Tandem-Booster)

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(Free Electron Laser)

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At Japan Atomic Energy Research Institute(JAERI), Tokai, an activity related to rf superconductivity started in 1984 with the developement of superconducting quarter wave resonators for the tandem booster linac. At present, three groups are working on the application of rf superconductivity to particle accelerators. A superconducting tandem booster and a superconducting linac driven free electron laser are in operation[1,2] and a superconducting proton linac project is being proposed[3].

1. Superconducting Tandem Booster

The superconducting tandem booster is an independently phased heavy ion linac composed of 40 129.8MHz superconducting quarter wave resonator(QWR)s which are made of solid niobium(RRR=150-200) and copper, which are housed in ten cryostats. It is preceded by a buncher comprising two 129.8MHz QWRs and two 259.6MHz QWRs and is succeeded by a de-buncher consisting of two 129.8 MHz QWRs. The booster was completed in 1993, commissioned after a cryostat opening and acceleration tests with various heavy ions in 1994 and has been operational for experiments in heavy ion nulear physics since 1995[1]. In the cryostat opening, a stiffening support was put to to the top end plate for every 129.8MHz QWR in order to improve frequency stability against a turbulant pressure instability and to reduce frequency tuning errors which increased after the first several thermal cycles. All the QWRs have been working well without opening their cryostats since 1994. With respect to the on-line resonator performances, several resonators were infected with a severe Q-disease [4]. There is no effective method of curing the Q-disease other than a heat treatment or a fast precooling, for the present. To the resonators made of composite materials, only a fast precooling is applicable. A fast precooling was carried out for our sick resonators, taking a sequential gas handling process over the hydrogen precipitation zone which is approximately from130K to 90K[4]. The resonator Q factors were recovered a great deal. The average of the accelerating field gradients measured in July1997 for the 40 linac resonators is 5.4 MV/m at an rf input of 4 W. Although there is some degradation due to electron field emission, the resonator performances have been well preserved. More details are reported on a poster(W12) .

2. Superconducting Linac Driven Free Electron Laser

A 500MHz-15 MeV superconducting electron linac was built and has been used to drive a free electron laser producing far infra-red light at JAERI. The linac is composed of two single-cell-cavity modules for pre-acceleration and two five-cell-cavity modules for main acceleration. The cavities and radiation shields are each separately cooled with compact closed cycle refrigerators(posters W14, Th49). The linac part started running stably in1995. The accelerating field gradients are between 4 and 7 MV/m. The cavities are operated in a pulse mode with a repetition of 10 Hz. Lasing experiments and improvements to the laser system have been repeated to obtain stronger amplified emission of light. In relation to the cavities, the rf control was improved to sustain flat top macro-pulses over 0.6 ms by adding a feed forward control. Up to now, 30 ms infra-red light pulses have been intermittently observed. For a sufficient intensity, the group still needs to carry out more improvements to the system.

3. Superconducting Proton Linac Project

JAERI is proposing a 1.5 GeV intense proton linac project for studies of nuclear transmutation technology and basic science with intense spallation neutrons, radioactive ions and muons/mesons. The maximum proton beam power is 8 MW and the linac is to be applicable to both pulse and CW operations for various kinds of applications. The high energy part of the linac from 100 MeV is to be composed of 600 MHz elliptical superconducting cavities because of the advantages; a short linac length benefited from high accelerating gradients, low beam loss owing to the large bore radius, suitability for high duty and CW operations, and a reduction in operating cost. Conceptional design of the superconducting linac and superconducting cavity developement have been proceeding in collaboration with KEK since 1995.

Figure 1 summarizes the preliminary conceptual design under the conditions of 5 cells per cavity, 2 cavities per module, doublet focusing between modules and maximum E_{peak} of 16 MV/m. The cavities are to be divided into eight groups with different betas in order to match up them to the proton beam velocity. The number of cavities is 308 and the linac length is about 733 m.

As for cavity developments, a vertical test facility was built and a single cell cavity of beta=0.5 was fabricated and tested. The test facitlity includes a class 10 clean room for cavity assembling, a high pressure water rinsing system with an ultra-pure water refining system and a vertical cryostat capable of measurements at 2 to 4.2 K. Cavity fabrication was done mainly in the KEK workshop. As a result of tests, obtained were E_{peak} =30 MV/m and Q_0 = 2x 10^{10} at low fields at 2 K. The proposed linac structure and the cavity development work are described in detail by N. Ouchi et al elsewhere in the proceedings of this workshop(oral Fri. 10-10, poster W56).

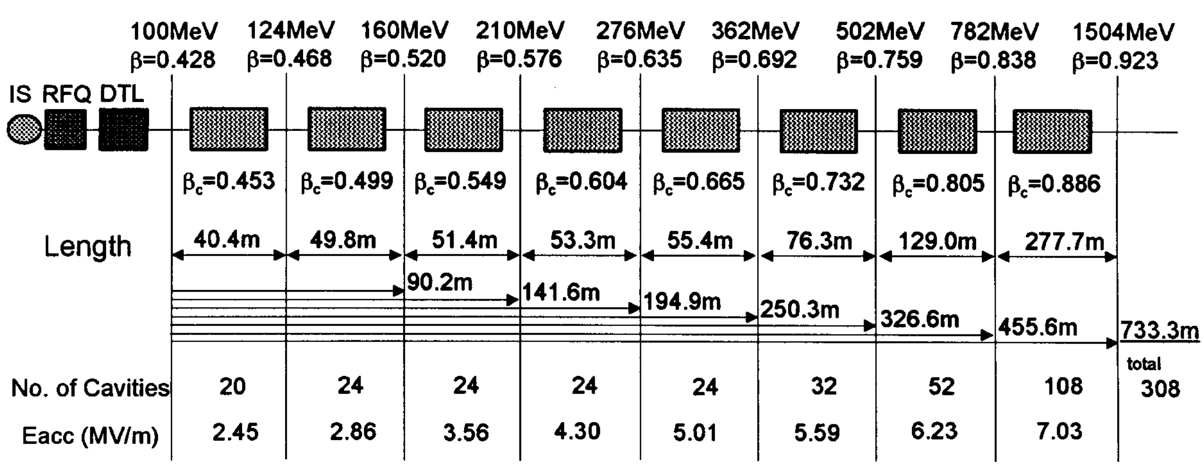

Fig.1 Preliminary conceptual design of the superconducting linac.

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