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FY2004 Progress Report
RIA 805 MHz β=0.47 Elliptical Accelerating Structure R&D
(R&D Category: Driver Linac)

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1. Elliptical Cavities for RIA

A five-year R&D plan for FY2001-FY2005 is underway to develop the β = 0.47 elliptical accelerating structure for the Rare Isotope Accelerator (RIA) driver linac. Michigan State University (MSU) will continue to take the lead on the development of a β = 0.47 six-cell structure in collaboration with Thomas Jefferson National Accelerator Facility (JLAB) as their priorities allow. In any case, information gained at JLAB on the β = 0.61 and β = 0.81 SNS cavities will be closely followed and incorporated.

The RIA driver linac design uses elliptical cavities to supply about 75% of the required accelerating voltage (heavy ions accelerated from about 85-400 MeV/u) [1]. A significant synergistic advantage was realized with the decision to utilize the 805 MHz elliptical, axisymmetric, 6-cell cavities with geometric β (=v/c) values of 0.61 and 0.81 developed for the Spallation Neutron Source (SNS) project [2]. In addition, the RIA R&D program substantially benefits from SNS activities for the associated elliptical cavity's cryomodule, power coupler, and tuner. To complete the RIA acceleration lattice, a β=0.47 cavity and cryomodule are being developed specifically for RIA and is the basis of this research [3-10].

Recently, Shepard et al [1,12] proposed an alternative design based on 345 MHz triple-spoke cavities claiming a number of advantages that support replacing the elliptical cavities with triple-spoke cavities in the RIA driver linac. A detailed comparison of elliptical and triple-spoke cavities for RIA is presented in [13]. The analysis finds that the promised advantages of the triple-spoke are based on questionable assumptions and that several disadvantages were neglected. Also, a comparison of the status of cavity and cryomodule developments shows a significant difference in demonstrated performance. Finally it is shown that overall, the triple-spoke does not offer any credible advantage compared to elliptical cavities for RIA.

2. β=0.47 Cavity R&D Program

The cavity development proceeded in three phases. The single-cell prototyping was the first hardware element of the R&D program. Two single-cell units were made in 2001 following the design of Barni et al [5] and tested in a vertical cryostat configuration with the Q vs. accelerating gradient performance significantly exceeding that specified for RIA (9.7 MV/m with Q = 7 x 10^9). There were no problems with multipacting. With these promising results the work proceeded to the multi-cell structures.

Next a six-cell prototype with no radial couplers, stiffeners, tuner or helium vessel was fabricated to test the electromagnetic performance, frequency, field flatness, and microphonic response. The cavity was mechanically tuned to ~10 % field flatness before processing and assembling in a Class 100 cleanroom. The six-cell prototype was tested in September 2002 and significantly exceeded the design peak fields of 32.5 MV/m and 64.2 mT, and design cavity quality factor of 7 x10^9.

3. β=0.47 Cryomodule R&D Program

A rectangular cryomodule design with cryogenic alignment rail that can accommodate all of the superconducting cavity and magnet types is proposed for RIA [7,8]. Beam dynamics simulations show that four β=0.47 cavities per module are acceptable. A prototype cryomodule with two cavities was completed in February 2004 and is shown in Figure 1. Preliminary tests were successfully completed and presented at the 2004 International Linac Conference [8-10]. All design specifications, such as static load, gradient and quality factor were met. The rf frequency was within the 1 MHz tuner bandwidth at 2 K. Techniques to measure and control the microphonics showed vibrations that can be controlled with modest rf power levels.

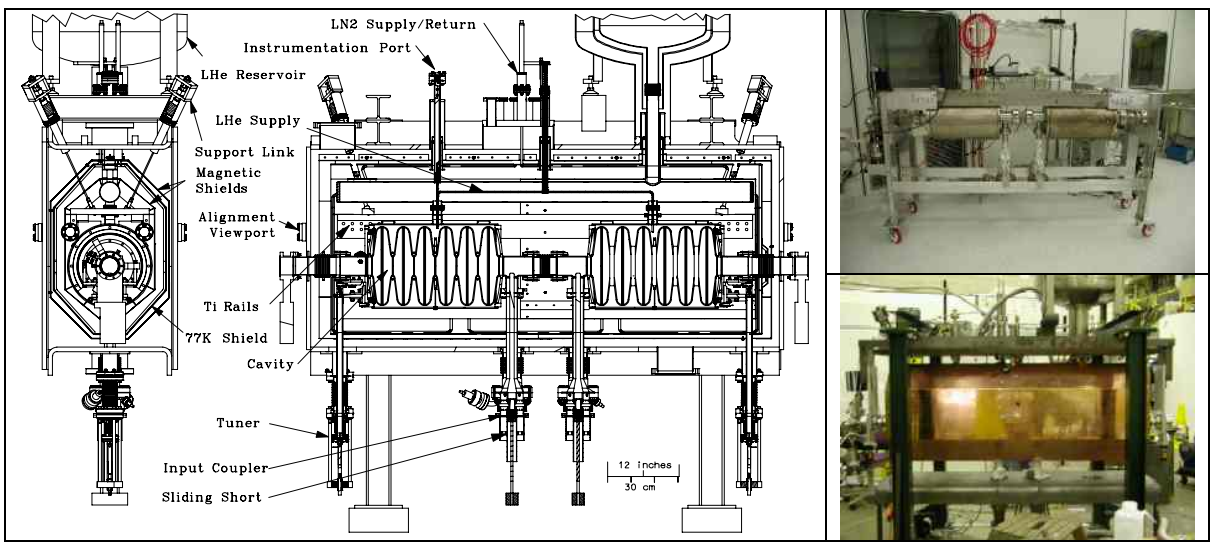

Figure 1. Left: end view and section view of the β=0.47 prototype cryomodule. Top right: cavities inside the helium vessels after attachment of the Ti rails and input couplers. Bottom right: cold mass after installation of the thermal shield.

Additional testing will continue through 2005 to demonstrate stable operation at full field under realistic operating conditions. Critical issues such as control of microphonics and LLRF control with acceptable amplitude and phase jitter will be studied. The microphonics work is in collaboration with DESY (Simrock) and the LLRF control work is in collaboration with LBNL (Ratti, Doolittle). This testing will require 3.5 FTEs in FY2005, but no new equipment. By the end of 2005 elliptical cavity R&D will be complete. At that time, RIA linac design, costing and production plans, which are critical long-lead items, can be finalized.

4. Summary of the R&D expenditures and schedule

Funding for the β = 0.47 R&D program from DOE to MSU and JLAB is listed in Table 1. The FY2004 funds were received in the summer 2004 and will be spent by early 2005. Provided that FY2005 funding of $350k is received (see Table 1), then elliptical cavity R&D for RIA will be complete in 2005, and driver linac designs and production plans can be finalized.

Table 1. β = 0.47 R&D funding from DOE to MSU and JLAB.
*Requested funding to complete elliptical structure R&D.

FY2001	**$400k**
FY2002	**$690k**
FY2003	**$500k**
FY2004	**$200k**
FY2005	**$350k***

5. References

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