PULSED OPERATION OF THE 972MHz PROTOTYPE CRYOMODULE FOR ADS SUPERCONDUCTING LINAC

E. Kako, S. Noguchi, N. Ohuchi, T. Shishido and K. Tsuchiya
KEK, Tsukuba, Ibaraki, 305-0801, JAPAN

N. Akaoka, E. Chishiro, T. Hori, H. Kobayashi, M. Nakata, N. Ouchi and M. Yamazaki
JAERI, Tokai, Ibaraki, 319-1195, JAPAN

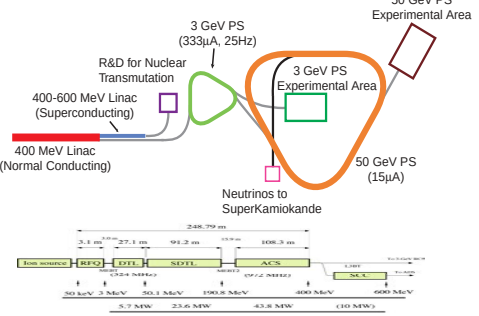
Abstract

A prototype cryomodule containing two 9-cell superconducting cavities of β=0.725 and fo=972MHz had been constructed under the collaboration of Japan Atomic Energy Research Institute (JAERI) and High Energy Accelerator Research Organization (KEK) on the development of superconducting LINAC for Accelerator Driven System (ADS). Cool-down tests to 2K of the cryomodule and high power rf tests with a 972MHz pulsed klystron have been carried out. Rf power of 350kW in pulsed operation of 3msec and 25Hz was transferred to a nine-cell cavity through an input coupler. Accelerating gradients of 14MV/m higher than the specification of 10MV/m have been achieved in both cavities. Compensation of Lorentz-force detuning by a piezo tuner was successfully demonstrated.

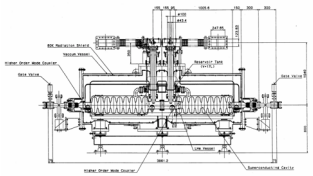
INTRODUCTION

Construction of the J-PARC (Japan Proton Accelerator Research Complex) is being carried out aiming at the commissioning in 2007. The 181MeV linac section, which consists of normal conducting accelerating structures, will be completed in 2006. A superconducting linac will be added in the second phase of the project, and the 600MeV H– beams will be delivered to the ADS experimental facility. The R&D work on superconducting linac for ADS is being continued in collaboration with JAERI and KEK. A prototype cryomodule with β=0.725 (424MeV) was designed and constructed. The first cool-down test of the cryomodule was successfully carried out last year, and the cryogenic performance at 2K and the rf property with low power were reported in EPAC'04. In the successive tests, high power rf system consisting of a 972MHz pulsed klystron, waveguides, circulators and dummy loads were prepared to study a high gradient operation in a pulsed mode. High field performance of the cavities and observation of mechanical vibration and Lorentz-force detuning in pulsed operation are described in this paper.

Superconducting LINAC in J-PARC



972MHz Prototype Cryomodule (β=0.725)

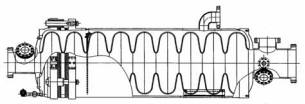


Design Parameters of the Prototype Cryomodule

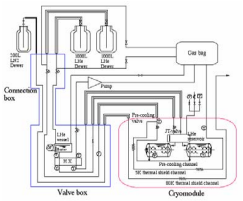
Pulsed Operation	3.0 ms
	25 Hz
Beam Current	30. mA
Temperature	2.0 K
Eacc	10. MV/m
Qo	> 1.x10^{10}
Input RF power	300. kW
Qext (Input)	5.x10^{5}

RF Parameters of 9-cell Cavity

Esp/Eacc	3.07
Hsp/Eacc	55.4 Oe/MV/m
R/Q	478. Ω
Geometrical factor	208. Ω
Cell-to-cell coupling	2.80 %

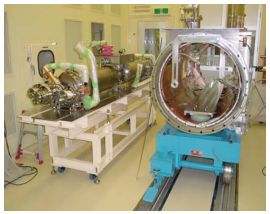


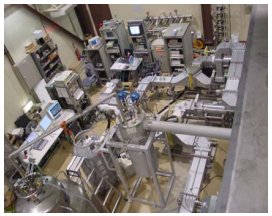
Cryogenic System

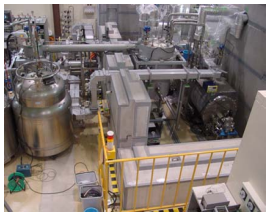


20W at 2K He, 30W at 5K He

Assembly of Cryomodule



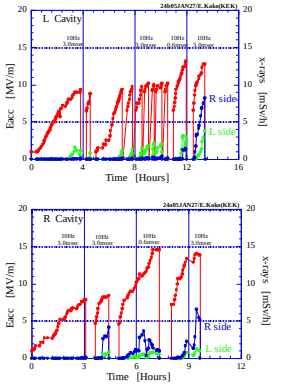




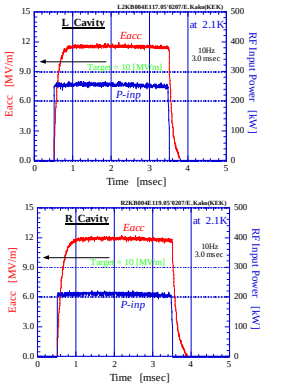
Experimental Set-up for High Power Test

Pulsed Mode Operation at High Gradient

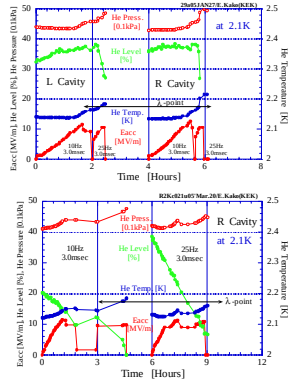
Initial High Power Test at 4.2K



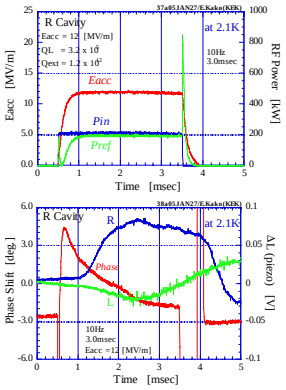
Achievement of Target Values



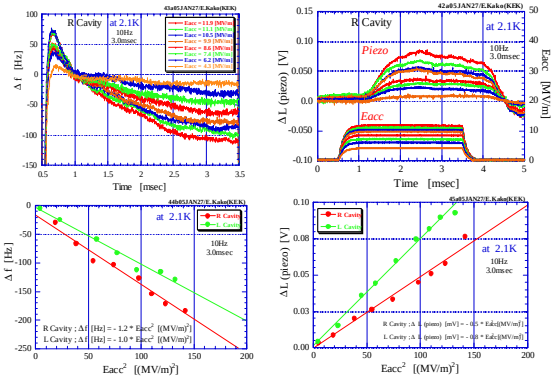
Cryogenic Performance at 2.1K



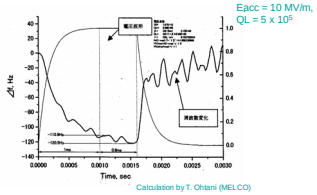
RF Pulse Signals



Frequency Shift (Δf) and Deformation (ΔL) of a Cavity Length due to Lorentz-force Detuning

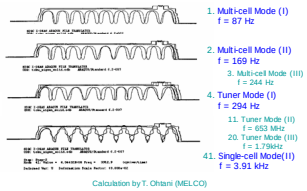


Calculation of Dynamic Lorentz-force Detuning



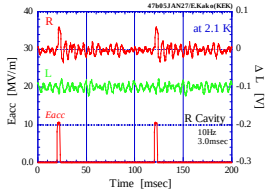
Calculation by T. Ohtani (MELCO)

Deformation Pattern of Mechanical Vibration Modes

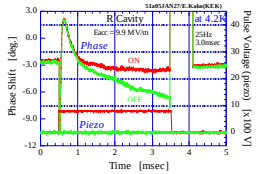


Calculation by T. Ohtani (MELCO)

Mechanical Vibrations due to RF Pulse



Compensation by a Piezo Tuner



SUMMARY

Accelerating gradients of 12MV/m higher than the specification had been stably achieved in pulsed operation at 2.1K.

Lorentz-force detuning in pulsed operation was systematically investigated, and mechanical vibration modes were measured.

Compensation of Lorentz-force detuning by a piezo tuner was demonstrated.

ACKNOWLEDGEMENTS

This work was supported by Ministry of Education, Culture, Sports, Science and Technology.