RCNP EXPERIMENT E488

PROPOSAL FOR EXPERIMENT AT RCNP

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TITLE:
Measurement of displacement cross sections of aluminum, copper and tungsten under cryogenic proton irradiation at 400 MeV

SPOKESPERSON:

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EXPERIMENTAL GROUP:

Full Name	Institution	Title or Position
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Hiroki MATSUDA	J-PARC, JAEA	Post-doc
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Shin-ichiro MEIGO	J-PARC, JAEA	Group Leader
Tatsushi SHIMA	RCNP, Osaka Univ.	Associate Professor

RUNNING TIME: Installation time without beam 1 days
Beam tuning and beam profile measurements 0.5 days
Data runs 1.5 days

BEAM LINE: Ring: N0 course

BEAM REQUIREMENTS:

Type of particle	proton
Beam energy	400 MeV
Beam intensity	1-10 nA
Any other requirements	halo-free, large emittance, a broader beam as much as possible

BUDGET: 0 yen.
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SUMMARY OF THE PROPOSAL

We propose a new measurement of displacement cross sections related with electrical resistivity increase in metals (aluminum, copper and tungsten) due to radiation damage under proton irradiation at cryogenic temperature (around 10 K), where recombination of defects by thermal motion is well suppressed. Historically, displacement per atom (DPA) is used as unit of displacement damage intensity for the lifetime estimation of the materials in fission, fusion and accelerator facilities. DPA is defined by the integral of displacement cross section and irradiation fluence. The radiation damage model in the particle transport code PHITS can calculate displacement cross section for secondary particles produced by the spallation reactions and it will be used for the design of ADS Target Test Facility (TEF-T) in J-PARC (180 – 400 MeV protons). However, the accuracy of displacement cross section has not been investigated for the high-energy region (1 MeV - 1 GeV) due to lack of experimental data. The coordinated research project (CRP) in International Atomic Energy Agency (IAEA) titled with “Primary Radiation Damage Cross Sections” also requires the experimental data to validate the calculation method of radiation damage.

In our proposed experiments, electrical resistivity changes in metals (aluminum, copper, and tungsten) related with displacement cross section will be measured at 100 - 400 MeV using our new cryogenic irradiation device developed at the Fixed-Field Alternating Gradient (FFAG) accelerator facility at Kyoto University Research Reactor Institute (KURRI). In the first experiments, we will measure electrical resistivity and temperature on samples under cryogenic proton irradiation at 400 MeV with our device. We will also investigate measurement method of beam profile and current. In the next proposal, we will change the beam energies from 400 MeV to 200 MeV.

After the cryogenic proton irradiation, we will measure the thermal recovery of the radiation induced resistivity increase using an electrical heater. This data is required for design of the superconducting magnet used in accelerator facilities. We found that the behavior of the resistivity recovery for 125 MeV protons is similar to that for 0.54 MeV protons, while 20 % of the defects remain at an annealing temperature of 290 K. As there are no data of thermal recovery of radiation defects for the high-energy region, our experimental data are also valuable for the design of super conducting magnet in accelerator facilities.

The total required time will be 2 days of measurement time including beam tuning for 400 MeV protons.