Copper Neutron Target Design and Installation in KOMAC

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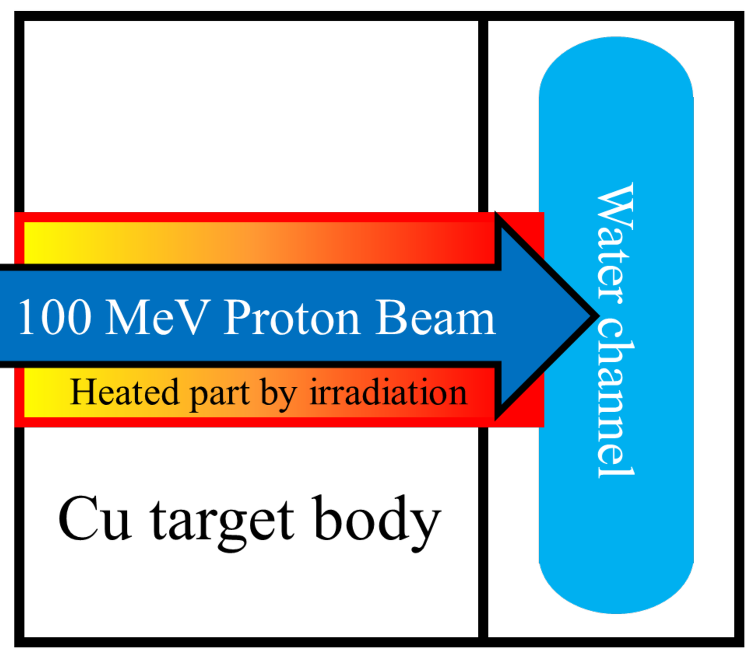
A copper target to provide fast neutron utilizing 100 MeV proton beam is designed and installed in this research. Simulation with Geant4 using QGSP_BIC physics model is conducted to evaluate target material candidates in respect to similarity of generated neutron with the cosmic-ray induced atmospheric neutron. Target geometry and thermal analysis is determined subsequently so that the target is able to stop 100 MeV proton inside its water-cooling channel for prevention of hydrogen blistering inside the target body. Target thermal analysis is conducted with the same geometry to verify that the configuration is able to afford proton beam energy deposition up to 2 kW. Finally, the designed target is manufactured and installed at the end of beam line in 100 MeV proton accelerator in KOMAC, preparing for its neutron characterization in near future.

Introduction

Copper target for production of near-atmospheric neutron for soft-error assessment for semiconductor devices is designed and manufactured. There had been a continuous demand on neutron production services from both industries and scientific areas. Proton accelerator in KOMAC is able to produce 100 MeV proton with 2 kW power at maximum, so the dedicated design for a target to meet the beam condition and demand of atmospheric neutron production, Copper-based target design had been studied and implemented.

Target Conceptual Design

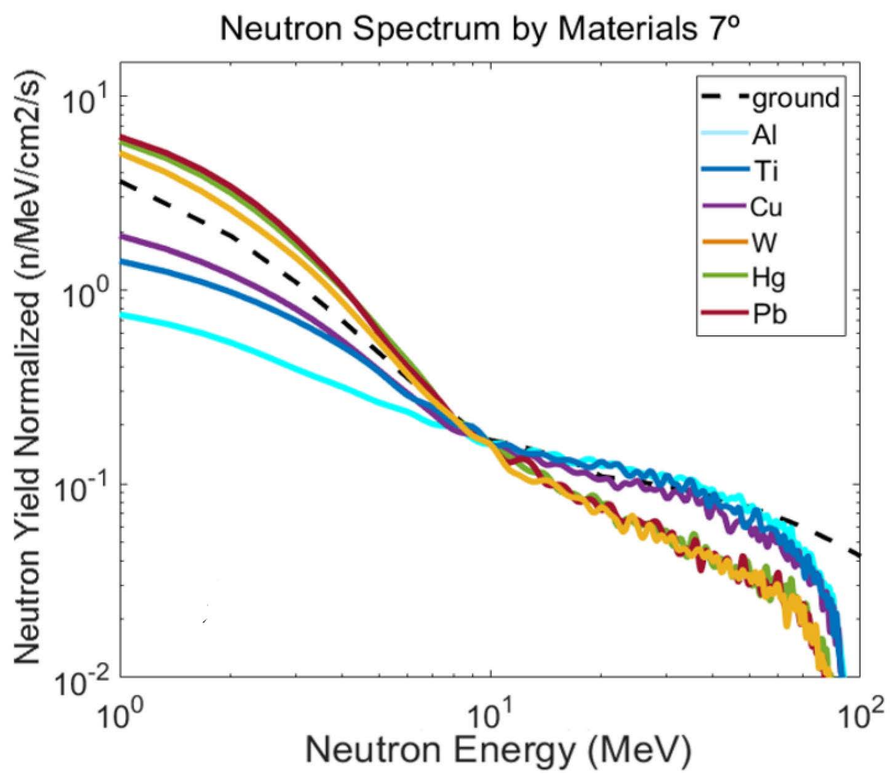


- Cylindrical body
  - -Generates Neutron
  - -Proton penetrate through
- Water channel backside
  - -Proton Stops at the water
  - -Cools 2 kW beam power

- Material Selection
  - -Al, Cu, Pb, Ti, W Tested
  - -Spectrum shape diagnosed

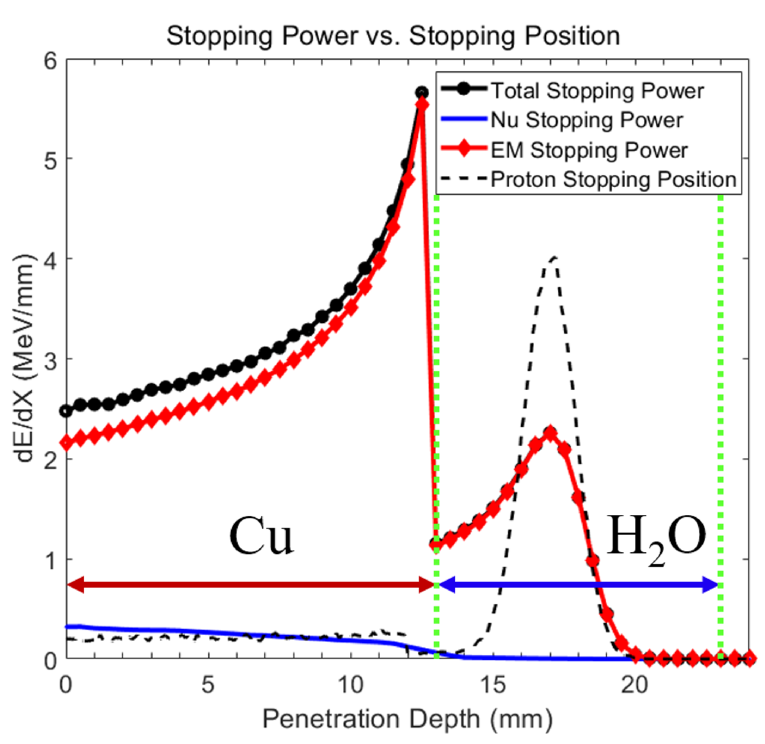
$$\sigma = \sqrt{a\sum_{i=1}^{10}(x_i-\bar{x}_i)^2 + b\sum_{i=10}^{100}(x_i-\bar{x}_i)^2}\ ,(1)$$

Materials	Deviation 1–10 MeV	Deviation 10–100 MeV	Effective overall deviation
Al	3.31	0.191	1.061
Ti	2.46	0.204	0.801
Cu	1.91	0.221	0.638
W	1.65	0.405	0.649
Hg	2.64	0.386	0.911
Pb	3.05	0.395	1.035



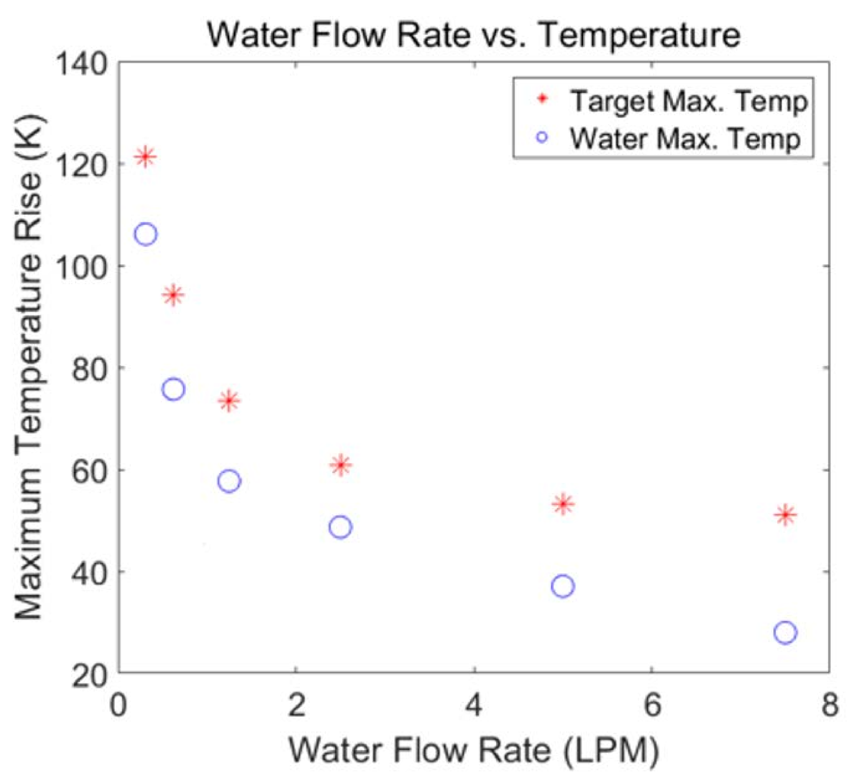
Cu chosen for most atmospheric-like spectrum

Thermal Analysis

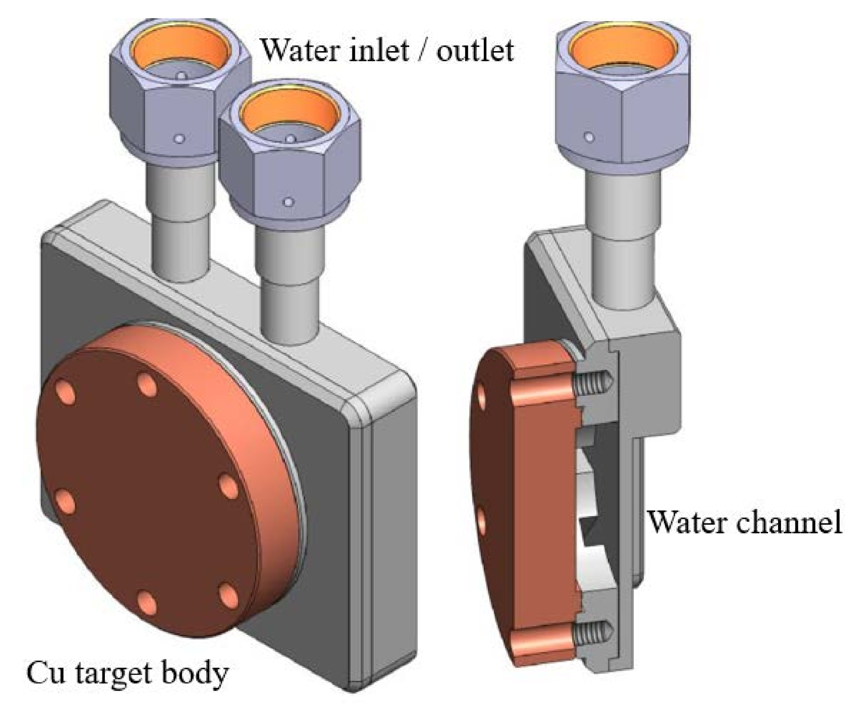


- Simulation on Geant4
- Cu body & water channel determined
  - -minimize H_2O & maximize Cu
- Stopping power simulation
  - -Geant4 simulation
- Cu 13 mm & H_2O 10 mm

- Simulation on ANSYS
- Water flow rate vs. global maximum temp. rise
  - starting from 300 °K.
- Temp. below 100 °C @ 1LPM
  - KOMAC provides 7.5 LPM
  - Expected temp. rise: 40 °K

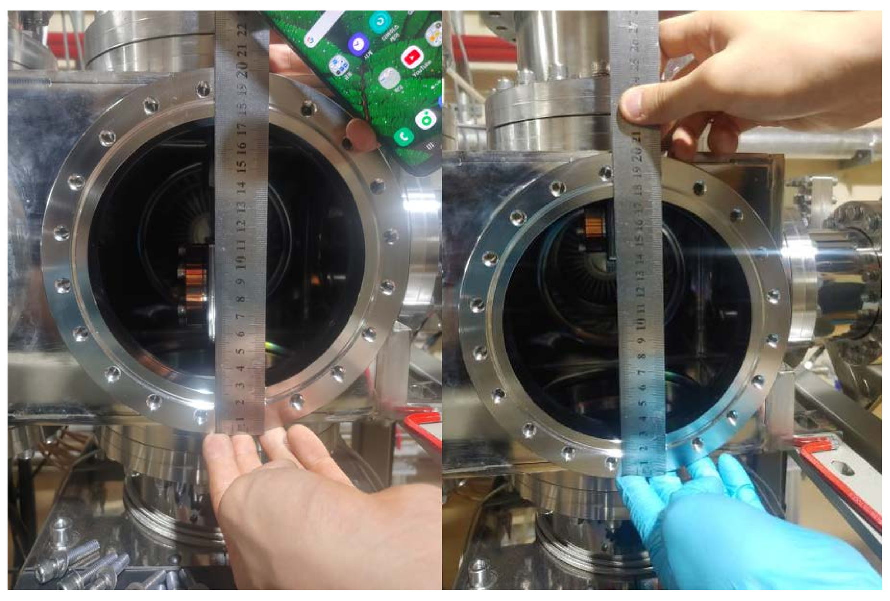


Target Assembly and Installation

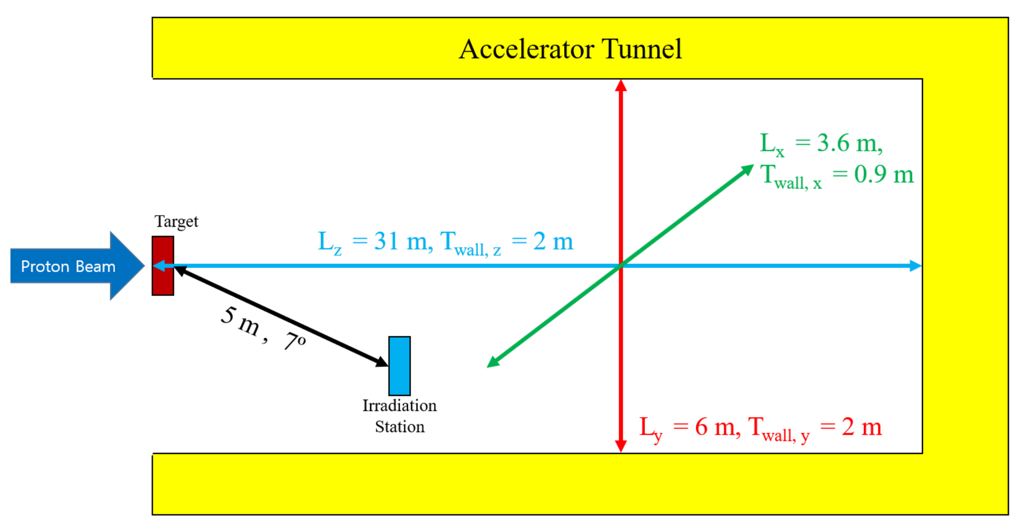


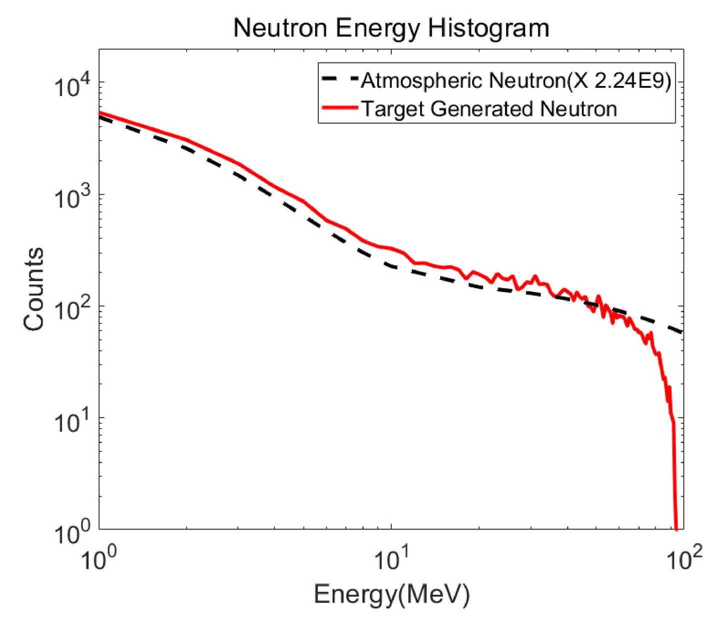
- Cu target body
  - -2.75 CF Flange type
  - -13 mm thickness
  - -Direct contact with water flow
- Water cooling channel
  - attached to a linear guide
  - 3/8" water channel

- Installation on beam line
  - located before beam dump
- Armed/retracted by remote controller
  - Controlled by air pressure
  - can take 2kW heat deposition



Target Transport Simulation





- Neutron generation & transport simulation to irradiation station
  - Tunnel geometry & irradiation station implemented
  - 5 m & 7° away from the target
  - Geant4 QGST_BIC physics model
- Expected neutron flux & acceleration factor calculation
  - Acceleration factor A = 2.2 x 10^9
  - Expected neutron flux = 1.07 x 10^7 n/cm² at 2 kW operation

$$A = \int_{E_{min}}^{\infty} \frac{\emptyset_{acc}(E)dE}{\emptyset_{atm}(E)dE}$$

Conclusion & Further Works

- Cu target for atmospheric-like neutron is designed and installed
- Test operation will be conducted in near future
- Generated neutron spectrum will be measured
  - TOF spectrometer
  - Neutron activation analysis
- More optimized spectrum with different material will be installed
  - Optimization with ML implemented

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