RCNP EXPERIMENT E

PROPOSAL FOR EXPERIMENT AT RCNP

28 Sep 2022

TITLE:

Towards constraining the neutrino interaction cross sections on ^{97,98}Mo and neutron capture cross section on ^{97}Tc using (^{3}He,t+γ) charge-exchange reactions

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EXPERIMENTAL GROUP:

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M.-K. Cheoun	Soongsil University	Professor
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RUNNING TIME:

Installation time without beam	~14 days
Development of device	0.5 days
Test running time for experiment	1.5 days
Data runs	4 days

NOTE: The installation time (~14 days) could be significantly reduced if scheduled together with E550 due to similar setups

BEAM LINE: Ring : WS course

BEAM REQUIREMENTS:

Type of particle	$^3He^{2+}$
Beam energy	420 MeV
Beam intensity	2~10 pnA (depending on target)
Other requirements	energy resolution $\leq$ 50 keV
	Dispersion-mathed beam transport

BUDGET: We request support for setting up the SGD array the target station of the Grand Raiden Spectrometer (Similar as the E550). We will provide the ^{97}Mo (1 mg/cm^2) and ^{98}Mo (4 mg/cm^2) targets.

SAFETY CONTROLLED ITEMS:

None

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SPOKESPERSON: Bingshui Gao

SUMMARY OF THE PROPOSAL

Core-collapse supernova (CCSN), which signals the death of a massive star, is among the key subjects of astrophysical studies. Large amount of neutrinos carrying important information on CCSN are emitted during the explosion. Those neutrinos have many observational consequences from which secrets on CCSN can be revealed. In this proposal, we focus on two appealing cases which are closely related to the CCSN neutrinos: the nucleosynthesis of ^{98}Tc in CCSN and geochemical neutrino detectors exploiting molybdenum ores.

The radioactive isotope ^{98}Tc ($T_{1/2} = 4.2 \times 10^6$ years) might have existed in the early solar system. It cannot be synthesised in stars via the rapid-neutron or slow-neutron capture processes due to the stable isobar ^{98}Mo. Theoretical calculations indicate that the neutrino-induced reaction ^{98}Mo(ν_e, e^-)^{98}Tc and neutron capture ^{97}Tc(n, γ)^{98}Tc are the main reactions responsible for the synthesis of ^{98}Tc in CCSN. We propose to determine their reaction cross sections *simultaneously* using the ^{98}Mo(^{3}He,t+γ) ^{98}Tc reaction. This can be achieved by measuring the Gamow-Teller strength $B(GT^-)$ from ^{98}Mo and extracting the level densities and γ strength functions in ^{98}Tc via Oslo analysis. Once the abundance of ^{98}Tc can be accurately determined in meteorites and combined with data from this proposal, important constraints on CCSN models can be obtained.

Geochemical neutrino detectors are natural long-term detectors that integrate neutrino fluxes from the Sun and CCSNe. Molybdenum ore is one such example where the number of ^{97}Tc atoms ($T_{1/2} = 4.2 \times 10^6$ years) have recorded information on the neutrino flux in the past millions year. The ^{97}Tc in molybdenum ore are produced mainly through the ^{97}Mo(ν_e,e^-)^{97}Tc (solar neutrino) and the ^{98}Mo(ν_e, e^-n)^{97}Tc (SN neutrino) reactions. Their cross sections, which are crucial to decipher information on neutrino flux from molybdenum ore, will be determined in this proposal. For this purpose, we will perform (^{3}He,t) charge-exchange reactions on ^{97}Mo target in addition to the ^{98}Mo target mentioned above to extract the $B(GT^-)$s. The neutron emission branching ratio will also be determined in the case of ^{98}Mo target.