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Proposal of Compact Accelerator-based Neutron Source (CANS) by using ^{7}Li-d Nuclear Interactions

Sangbeen Lee+1), Seunghyun Lee1), Kihyun Lee1), Dae-Sik Chang1), Sunghwan Yun1), Young-Sub Cho1) and Dong won Lee1)

1)*Korea Atomic Energy Research Institute, Daejeon, Republic of Korea*

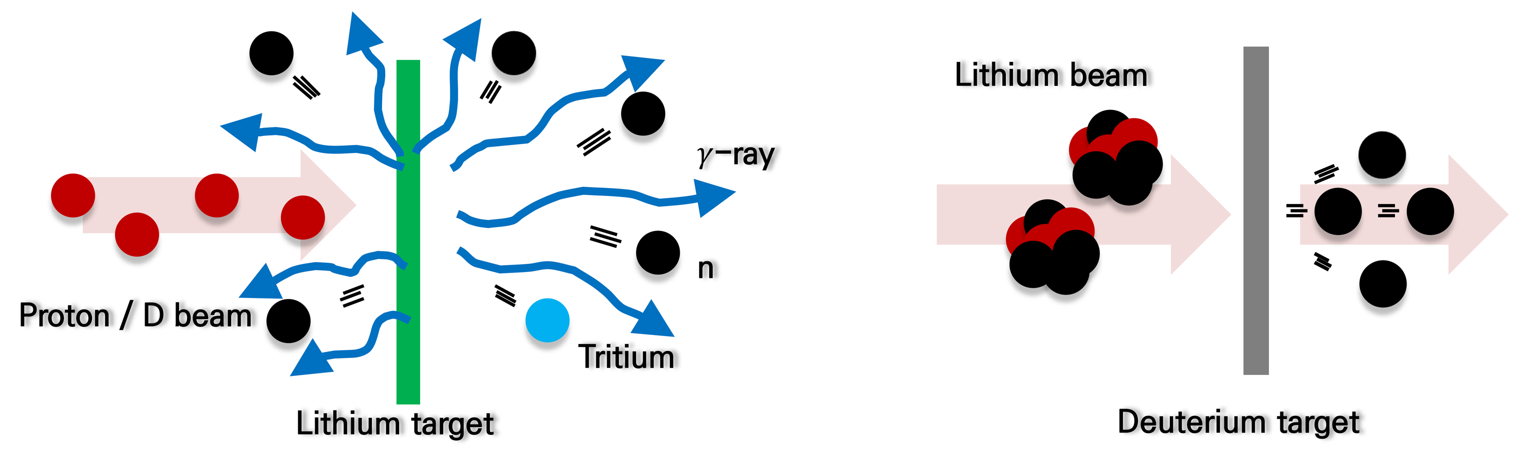
+*slee6306@kaeri.re.kr*

Abstract: High flux neutrons are demanded to research the fusion material, medical fields and other applications. With the neutron beam, irradiation tests of fusion reactor materials or the study of transmutation of long-lived radioactive nuclear waste or non-destructive testing are possible. The efforts to increase the neutron flux are reached to utilize the accelerator-based system. The most used in this system is proton-based accelerator. As an alternative to generate the high flux neutrons, a lithium ion colliding to deuterium target which is the inverse kinematic reaction is suggested in this paper. Utilizing the existing ion irradiation facility in KAERI, the neutrons of 14 MeV could be generated in forward direction.

KAHIF (Korea Atomic Energy Research Institute Heavy Ion Irradiation Facility) is providing He and Ar ion beams for research fusion material since it is transferred from KEK. This ion irradiation facility could transport the lithium ion up to 1.09 MeV/u with split-coaxial radio frequency quadrupole (SC-RFQ) and interdigital H-mode drift tube linac (IH-DTL). In order to generate forward directed neutron beam, additional Li ion source, deuterium target, and extra shielding around the target area will be required.

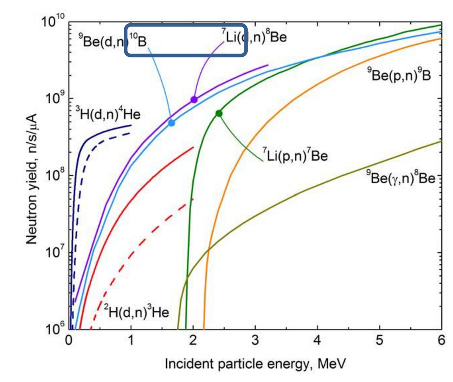
Neutron Sources

□ ^{7}Li(d,n)^{8}Be Inverse Kinematic Reaction

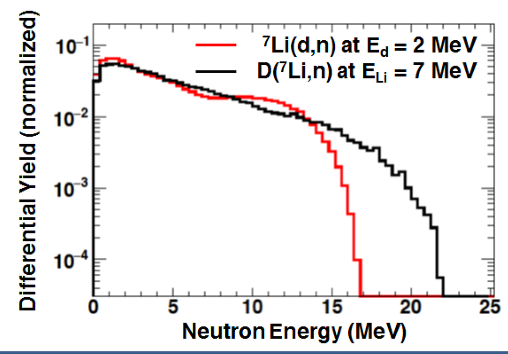


	Proton beam	Deuterium beam	Lithium beam
Target	Lithium	Lithium	Deuterium
Threshold energy	13 MeV	-	7 MeV
Products	Gamma ray, n	Tritium, n	n
Produced energy(n)	1.44	2.45 MeV	〉14 MeV
Directivity of flux	Isotope	Isotope	Forward direction

□ Neutron yield Reactions



□ Simulation by Geant4 code



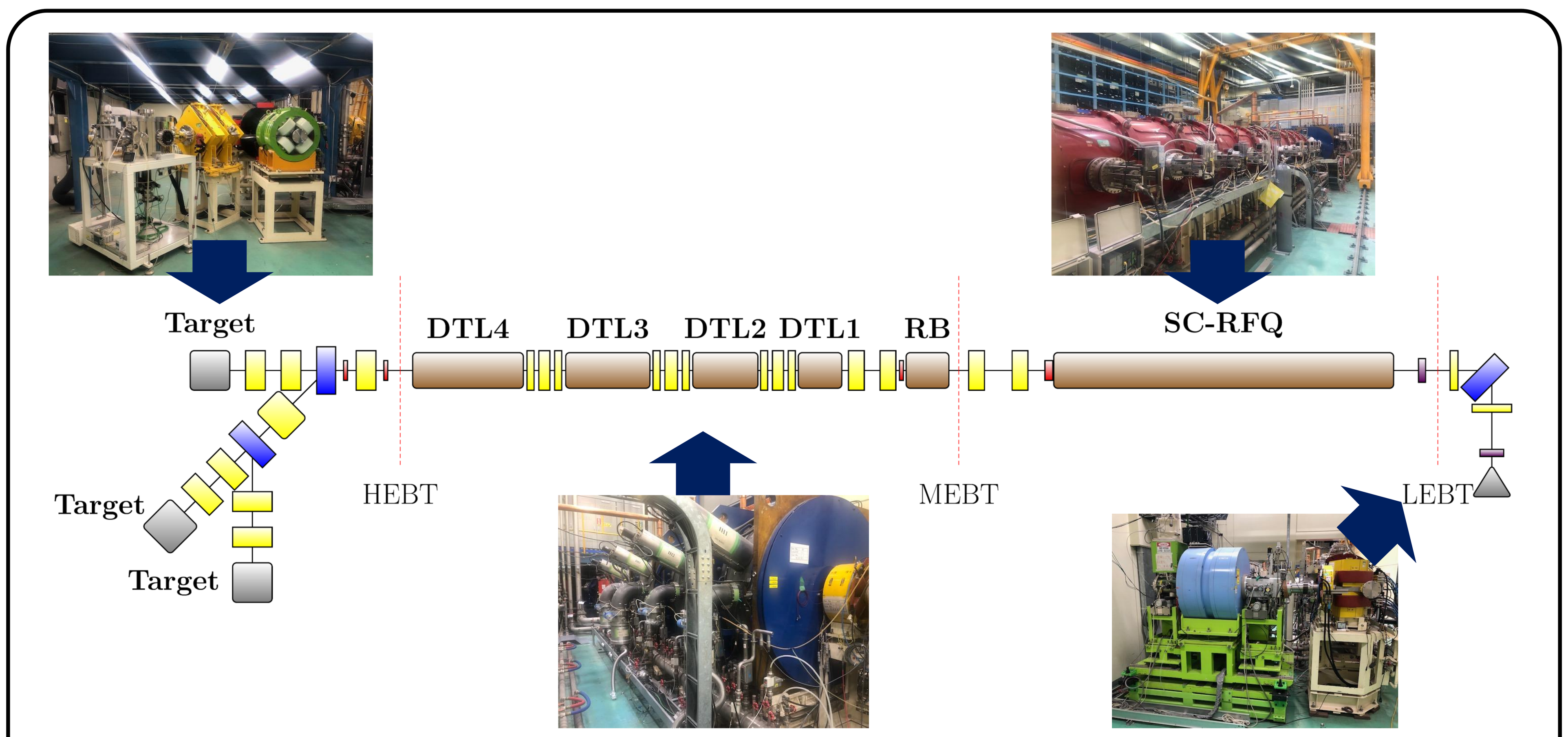
□ Design Requirements for 14 MeV Neutron

Parameter	Value	Unit
Acceleration ion	$^{7}Li^{3+}$	-
Beam energy	7	MeV
Beam current	〉1	mA
# of neutron	〉10^{10}	n/s (average)

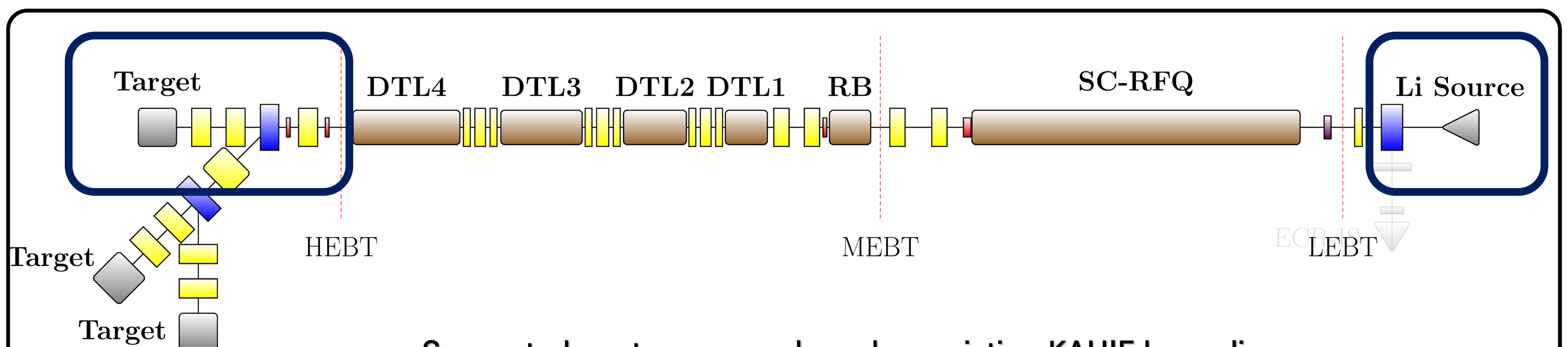
□ Features

- High flux due the forward focused emission
- Product neutron energy could be achieved up to 14 MeV
- Usage of the inverse kinematic reaction will help clean operation of linac from the contamination by neutron and tritium

Plans for Compact Accelerator-based Neutron Source



- Schematic view of KAERI Heavy ion Irradiation Facility at Daejeon



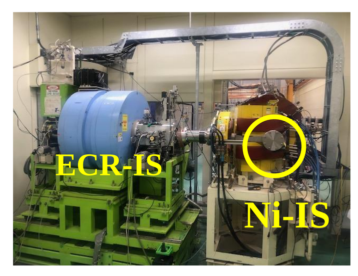
- Suggested neutron source based on existing KAHIF beam line

□ Accelerator components of KAHIF

- 18 GHz Electron Cyclotron Resonance Ion Source
- 25.96 MHz Split-Coaxial Radio Frequency Quadrupole
- 51.92 MHz Re-buncher
- 51.92 MHz Interdigital H-mode drift tune linac

□ Neutron Source based on KAHIF beam line

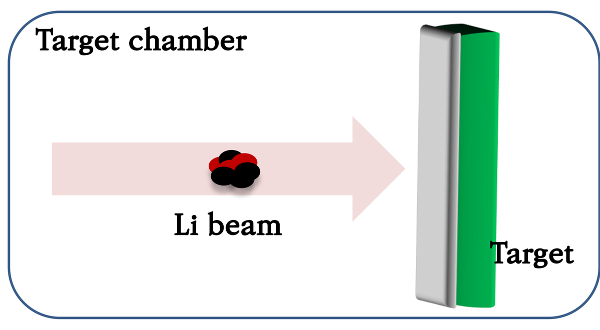
1. Lithium Ion Source



- The extra port at bending magnet is available for an additional ion source
- Thermionic emission from solid lithium
- AC heating and extraction HVPS are required

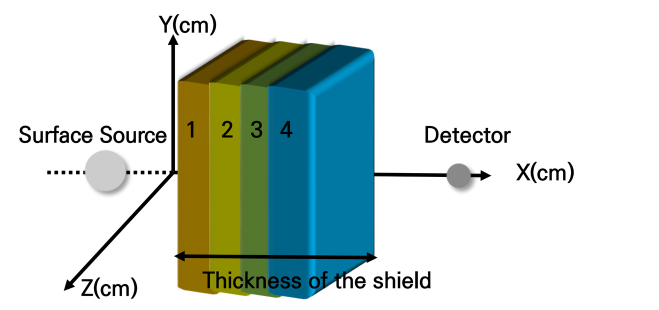
2. Target & Shielding

□ Deuterium-loaded titanium



- Titanium coated Cu target with water cooling
- For target regeneration, deuterium gas and target heating system

□ MCNP model and results



Shielding performance

	Different arrangement				Neutron (Sv)	Gamma ray (Sv)	N-γ all (Sv)
1	Fe	PE	B4C	Pb	1.0679×10^{-15}	12.454×10^{-18}	1.0803×10^{-15}
2	PE	Fe	Pb	B4C	1.3934×10^{-15}	8.0663×10^{-18}	1.4015×10^{-15}
3	PE	B4C	Pb	Fe	1.5036×10^{-15}	7.2572×10^{-18}	1.5109×10^{-15}
4	B4C	PE	Fe	Pb	1.3584×10^{-15}	6.1700×10^{-18}	1.3645×10^{-15}
5	B4C	Pb	Fe	PE	1.2002×10^{-15}	19.354×10^{-18}	1.2195×10^{-15}
6	Pb	B4C	PE	Fe	1.3494×10^{-15}	9.8543×10^{-18}	1.3592×10^{-15}

Summary

- □ Utilizing of the operating ion irradiation facility in KAERI, the compact accelerator-based neutron source is proposed to generate 14 MeV neutrons.
- □ The ion irradiation facility could accelerate ion beams from 0.178 MeV/u up to 1.06 MeV/u.
- □ A 7 MeV Li beam colliding deuterium target could produce the total neutron yield about 10^{9} n/s/uA.
- □ Li-IS, deuterium target, and neutron shielding are need to be optimized to requirements of the reaction.
- □ The specifications of these considerations will be studied.

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