Pulsed intense lithium beam acceleration test for neutron

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We are proposing inverse kinematic pulsed neutron production with linear accelerators and a laser ion source. The inverse kinematic scenario is to use a lithium driver beam instead of a conventional proton beam and is effective to mitigate undesired radiation emission and provide highly directed neutron flux. To demonstrate the capability of intense neutron flux, we build a new front end of the proposed neutron production system, which consists of a laser ion source, ablation plasma confinement solenoid, and radiofrequency quadrupole (RFQ) linac. We have succeeded to obtain more than 35 mA of Li^{3+} beam which was detected behind a bending magnet.

Why Inverse kinematic for neutron generation

$$\mathrm{D + d \rightarrow {}^{3}He + n + 3.28\ MeV}$$
$$\mathrm{T + d \rightarrow {}^{4}He + n + 17.6\ MeV}$$
$$\mathrm{{}^{7}Li + p \rightarrow {}^{7}Be + n - 1.64\ MeV}$$
$$\mathrm{{}^{7}Li + d \rightarrow 2\,{}^{4}He + n + 15.03\ MeV}$$
$$\mathrm{{}^{9}Be + p \rightarrow {}^{9}B + n - 1.85\ MeV}$$
$$\mathrm{{}^{9}Be + d \rightarrow {}^{10}B + n + 4.35\ MeV}$$

Endothermic reactions (negative energy emission)

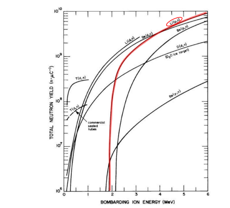

Fig. 1. The thick target neutron yield as a function of bombarding ion energy for various low energy nuclear reactions [1].

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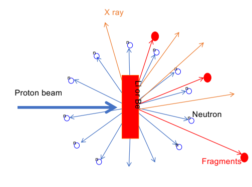
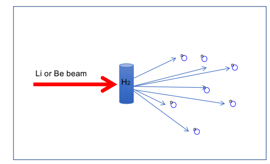


Isotropic neutron production



High directivity neutron

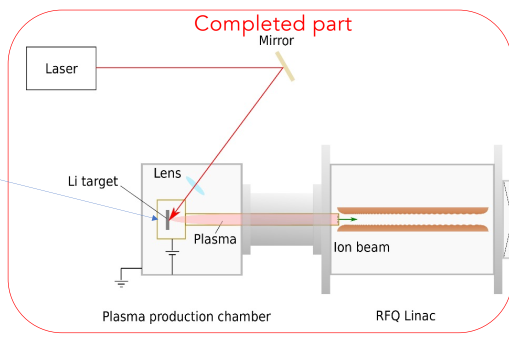
- When heavy ions are delivered, neutrons are directed to forward because of the high gravity center velocity.
- Neutron flux can be increased while beam energy is kept near the threshold.

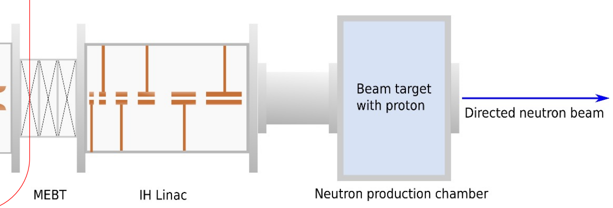
Lithium accelerator for pulsed fast neutron flux

Li beam energy	14-15 MeV
Beam pulse width	2 us
Repetition rate	1000 Hz
Peak ion beam current	35 mA
Average ion beam current	70 uA
Neutron energy	1 MeV -5 MeV
Average neutron flux	7×10^{9} n/s/sr

Feature
- Beam energy close to threshold
- Fast neutron
- High pulsed neutron flux

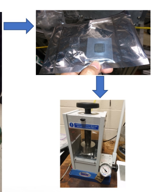
Li foil target



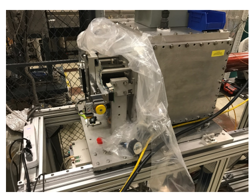


hydrogen-rich target such as plastic polymer, Hydride, or H_2 gas with plasma window

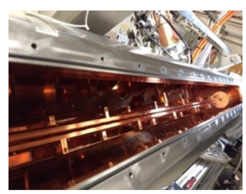
Preparation of Li target in Ar



Put in a pouch and then pressed

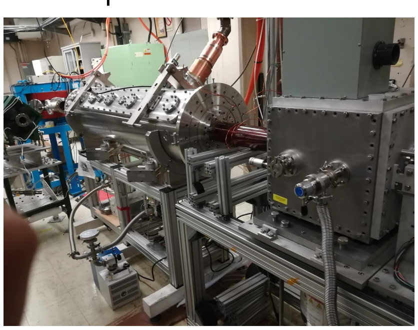


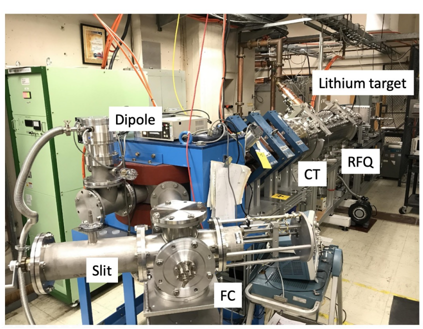
Loading Li target in laser ion source

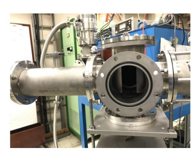


Dedicated RFQ for Li3+ beam

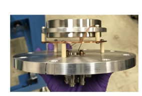
Beam performance





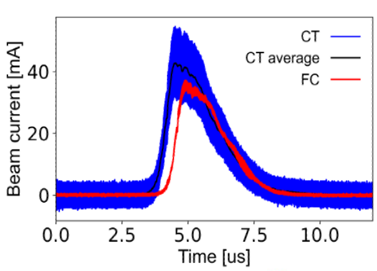


50 mm slit

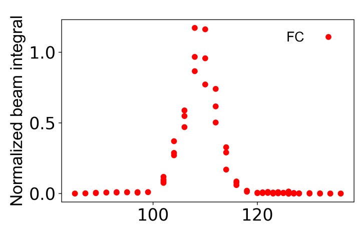


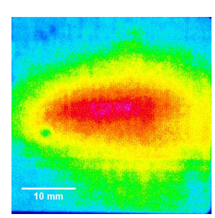
FC and ring

- Laser
  - Thales
  - QS220 us,
  - 1.6 J at laser exit (~0.8 J at target)
- Solenoid : 15 A (790 G)
- Extraction voltage : 52 kV
- RF power : ~ 100 kW
- Q1 : 8A
- Q2 : 13.2 A
- Q3 : 6.8 A
- Dipole : 110 A (2.7 kG)
- Ring bias : -400 V



CT peak : 43 mA, 95 nC
FC peak : 35 mA, 74 nC
FWHM : 2.0 us





Scintillator image

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