

## 8 - 20 Annual Operation Status Report of LEAF

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Beam commissioning with several individual ion beams, such as  $\text{H}_2^+$ ,  $^4\text{He}^+$ ,  $^{129}\text{Xe}^{25+}$ ,  $^{15}\text{N}^{5+}$ , and cocktail beams, such as  $^{56}\text{Fe}^{14+}$  &  $^4\text{He}^+$ ,  $^{58}\text{Ni}^{15+}$  &  $^4\text{He}^+$  and so on, was implemented at the LEAF in 2022. The layout of LEAF is shown in Fig. 1. Thanks to the exceptional performance of the SECARL-I ion source, the temporary substitute for the FEER ion source, and the meticulous design of the RFQ accelerator, the LEAF platform has achieved stable operation of continuous-wave (CW) mode hundreds microampere level heavy ion beams with a transmission efficiency over 90%. Simultaneously, to address the requirements of nuclear astrophysics and nuclear material irradiation research, a beam energy adjustment system has been constructed and put into operation at the MEFT. This system enables the originally fixed beam energy of 0.5 MeV/u to be adjusted continuously in the range of 0.3~0.7 MeV/u, while maintaining a beam energy dispersion better than 0.11% with  $1\sigma$ .

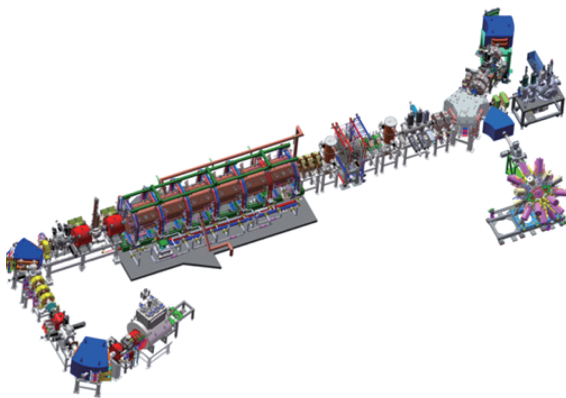


Fig. 1 (color online) Layout of LEAF.

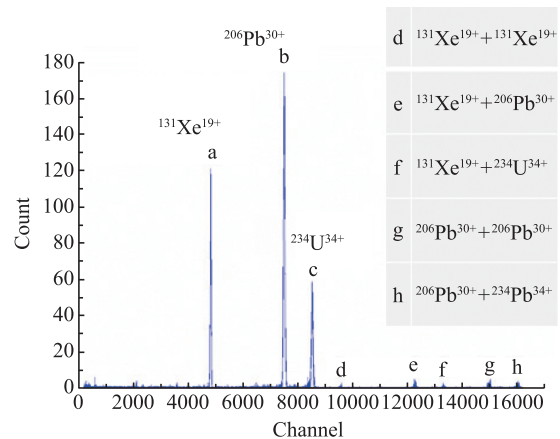


Fig. 2 (color online) Energy spectrum of uranium and other elements (Measured by the frisch-grid ionization chamber).

In addition to machine-oriented investigations, the LEAF delivered ion beams to the nuclear physics experimental terminal for more than 3 500 h. Moreover, the technique for high charge state positive ion mass spectrometry based on the LEAF has been developed. The isotopes and impurity elements of uranium could be discriminated effectively, as demonstrated in Fig. 2. To fulfill the demands of nuclear astrophysics research, the beamline is planned to be upgraded and a permanent-magnet ECR ion source dedicated to produce carbon ion beams will be integrated to LEAF. The implementation of these upgrades is anticipated to be finalized by the middle of 2023. Then, the beam intensity of  $\text{C}^{2+}$  delivered to the terminal will reach to 100  $\mu\text{A}$ , with an energy dispersion better than 0.1%, exclusively for the purpose of measuring the fusion reaction cross-sections of heavy ions within the Gamow energy region.