

## Recent developments of the GARIS facility for studies of superheavy elements

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From 2001 to 2017, a lot of studies on nuclear physics and chemistry of superheavy elements (SHEs) had been successfully performed by using gas-filled recoil ion separators GARIS [1] and GARIS-II [2] installed at RIKEN Heavy-Ion Linac (RILAC) facility. Since 2017, rearrangement of the GARIS-II and new development of accelerator and recoil separator in Radioactive Isotope Beam Factory (RIBF) has been done for further investigation of SHEs. Figure 1 shows general drawing of present GARIS facility for studies of SHEs.

The GARIS-II was moved from RILAC facility to RIKEN Ring Cyclotron (RRC) facility. High intensity heavy-ion beam provided by the 28 GHz superconducting ECR ion-source, heavy ion Linac RILAC-II, and the RRC is available. In addition to study on production and decay properties of SHEs, precise mass measurement of heavy elements by using a multi-reflection time-of-flight mass spectrograph (MRTOF-MS) [3] coupled with GARIS-II is also progressed. Recently, the direct mass measurement of  $^{257}\text{Db}$  produced via the  $^{51}\text{V}(^{208}\text{Pb}, 2n)$  reaction was succeeded [4]. The details of the experiment and result are separately given in this workshop [5].

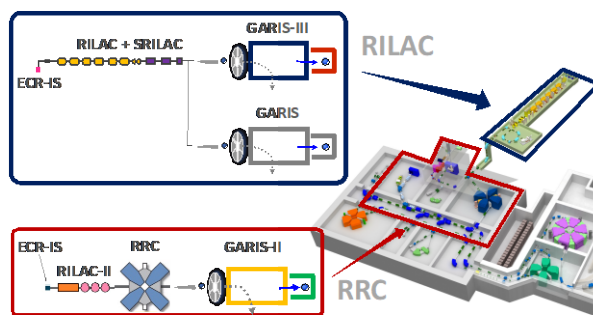


Fig.1 General drawing of the GARIS facility in RIBF.

The RILAC in RIBF upgraded to superconducting RIKEN linear accelerator (SRILAC) toward further investigation on SHEs. In addition to the GARIS, a new gas-filled recoil ion separator GARIS-III was also installed downstream of the SRILAC. The GARIS-III is same design, which consists of Q1-D1-Q2-Q3-D2, as the GARIS-II. Expanded chemistry room was also re-constructed next to irradiation room in the RILAC facility. In June 2020, the GARIS-III was operated and evaluated by using  $^{40}\text{Ar}$ -induced fusion reactions. The details of the experiment and result are given in this workshop.

### References

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- [4] P. Schury et al., arXiv:2006.02605.
- [5] T. Niwase, TASCA 2021 contribution.