Improvement of transmission efficiency for the rare-RI ring

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The injection and extraction efficiency of the rare-RI ring (R3) is one of the main factors used to determine the feasibility of experiments. Based on the triggered events for injection that are generated at the F3 focal plane of BigRIPS, the required extraction efficiency from R3 is 1% or more for the region where the production rate is 0.1 cps. However, the extraction efficiency in the third machine study,[1)] where unstable nuclei were successfully extracted for the first time, was less than 0.2% for the reference particle of ^{78}Ge. This is insufficient to conduct an experiment within a reasonable beamtime period using R3. This report describes the improvement of transmission efficiency obtained in the fourth machine study using new beam injection optics.

The particles produced and identified in the first stage of BigRIPS are transported to R3 through a long beam line including the SHARAQ spectrometer. Recently, the OEDO system[2)] was completed on the long beam line by installing new magnets and rearranging the existing magnets as shown in Fig. 1. Because the standard OEDO optics is not suited for our injection, we recalculated the injection optics from F3 of BigRIPS to R3. Achromatic (F-E9, S0) and momentum-dispersive (F4, F5, F6, and F-E7) focal planes were arranged in the long beam line to ensure that the transmission efficiency from F3 to S0 is close to 100%. The section from S0 is very important when considering the injection optics. It is necessary to consider dispersion matching in the horizontal direction while paying attention not to diverge in the vertical direction, because after the SHARAQ spectrometer, the apertures of the beam ducts are narrower compared with the former stage. In the fourth machine study, we carefully performed emittance matching between the injection beam emittance and the acceptance of R3. This is because, emittance mismatch was the main cause of the poor extraction efficiency of the third machine study.[3)] The matching point is the kicker center; however, there was no position detector there. Therefore, two PPACs at ILC2 were used to adjust the beam emittance.

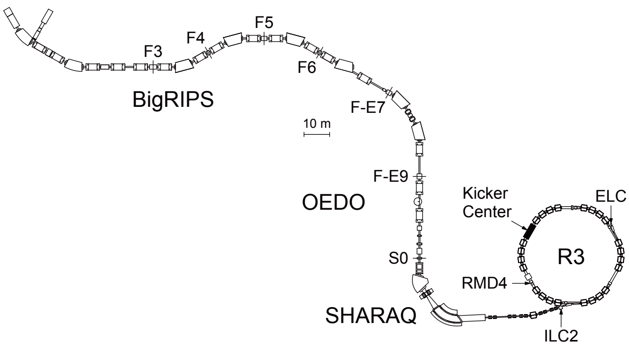

Fig. 1. Long beam transport line from BigRIPS to R3 with OEDO system.

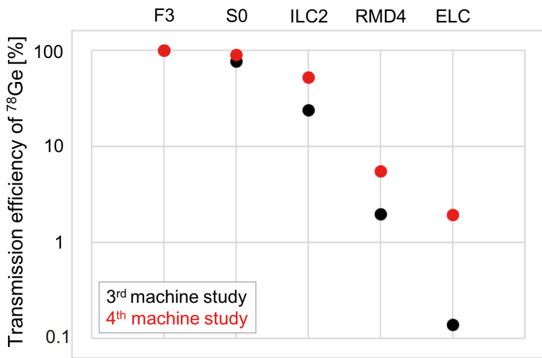

Fig. 2. Transmission efficiency of ^{78}Ge. The ILC2 is located just before the injection septa of R3. The RMD4 and ELC are located in the next straight section of the kicker and the region after extraction, respectively. The achieved extraction efficiency was larger than 1% as indicated by the red circle in the ELC column.

Figure 2 shows the result of the transmission efficiency of ^{78}Ge. There is no emittance gate at F3. The excitation timing and magnetic field strength of the kicker are optimized. The circulation time at R3 is about 700 μs. The injection efficiency is better than the previous one as indicated in the RMD4 column. The extraction efficiency is also improved by more than 10 times as indicated in the ELC column.

Experiments using R3 are now ready to be conducted for regions where sufficient statistics could be obtained. Because further improvement in transmission efficiency is very useful when conducting experiments at extremely rare-RI regions in the near future, we aim for a measurement efficiency of 20%.

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References

1) D. Nagae *et al.*, RIKEN Accel. Prog. Rep. **50**, 18 (2017).
2) S. Michimasa *et al.*, RIKEN Accel. Prog. Rep. **50**, 19 (2017).
3) S. Naimi *et al.*, in this report.