Studies of the CB-ECRIS beam background

B.T. Roeder, F. Abegglen, J. Ärje, G.J. Kim, D.P. May, A. Saastamoinen, and G. Tabacaru

Re-accelerated Rare Isotope Beams (RIBs) prepared with the Light Ion Guide (LIG), charge-bred with the Charge Breeding Electron Cyclotron Resonance Ion Source (CB-ECR), and re-accelerated with the K500 cyclotron are becoming feasible at the Cyclotron Institute at Texas A&M. The desired characteristics of these beams are energies of 10 AMeV to 30 AMeV, low momentum and energy spreads of ~0.1%, and beam purities approaching 100%.

The following RIBs have been developed with the LIG and CB-ECRIS for attempts at Re-acceleration: ^{64}Ga [1], ^{63}Zn, ^{114}In [2], ^{112}In[3]. Of these beams, so far only the ^{112}In has been successfully observed after acceleration by the K500. The other three species, in particular the ^{64}Ga, have been obscured by stable beams with the same mass, so-called mass isobars. This stable beam background has intensities of orders of magnitude higher than the expected rates for the RIBs.

Following the attempt to observe re-accelerated ^{64}Ga, which was lost amongst 10^4 p/s of ^{64}Zn background, it was discovered that the plasma chamber of the CB-ECR was constructed with aluminum alloy, series 7075 [4]. This alloy contains the following impurities, which increase its strength: Zn (~6%), Mg (~2%), Cu (~1.5%) and Si, Fe, Mn, Ti, Cr (total < 0.5%) amongst other metals. The plasma in the CB-ECRIS sputters these metals, in particular the Zn and the Cu, from the surface of the plasma chamber and ionizes them, making them part of the beam that is injected into the K500 cyclotron.

In the past year, a few attempts have been made to observe the beam background arising from the impurities in the aluminum alloys of both the CB-ECRIS and ECR1, the stable beam ion source normally used with the K500 cyclotron. In May 2018, a pilot beam of $^{15}N^{4+}$ at 22 AMeV was used to provide the initial tune of the K500 cyclotron and of the beamline optics to MARS [5]. In that case, the goals were to observe $^{64}Ga^{17+}$ and/or $^{63}Zn^{17+}$ by making the appropriate K500 frequency changes. The beam mixture is stripped to higher charge states by a thin carbon foil at the entrance of MARS and the resulting charge states are tuned to the MARS focal for particle identification. The ^{64}Ga was not observed under the intense ^{64}Zn background from the CB-ECRIS. In the worst case, $^{64}Zn^{28+}$ was measured at the MARS focal plane with a rate of about $9*10^3$ p/s, while the expected rate of $^{64}Ga^{28+}$ was around 10 p/s. Similarly, the ^{63}Zn was not observed due to background from ^{63}Cu, although the K500 frequency change was much larger in that case. This made the observation difficult and ^{63}Zn was also not observed.

In December 2018, a pilot beam of $^{14}N^{4+}$ at 24.8 MeV/u was tuned to investigate if the different possible contaminant beams from the CB-ECRIS could be observed with MARS. By tuning the K500 frequency 20.8 kHz higher than the frequency for the $^{14}N^{4+}$, several contaminant beams were measured with MARS including ^{70}Zn, ^{56}Fe, ^{49}Ti and ^{28}Si. A spectrum showing these contaminants is shown in Fig. 1. In addition, a relatively intense ^{35}Cl contaminant beam was also seen with a different MARS spectrometer tune.

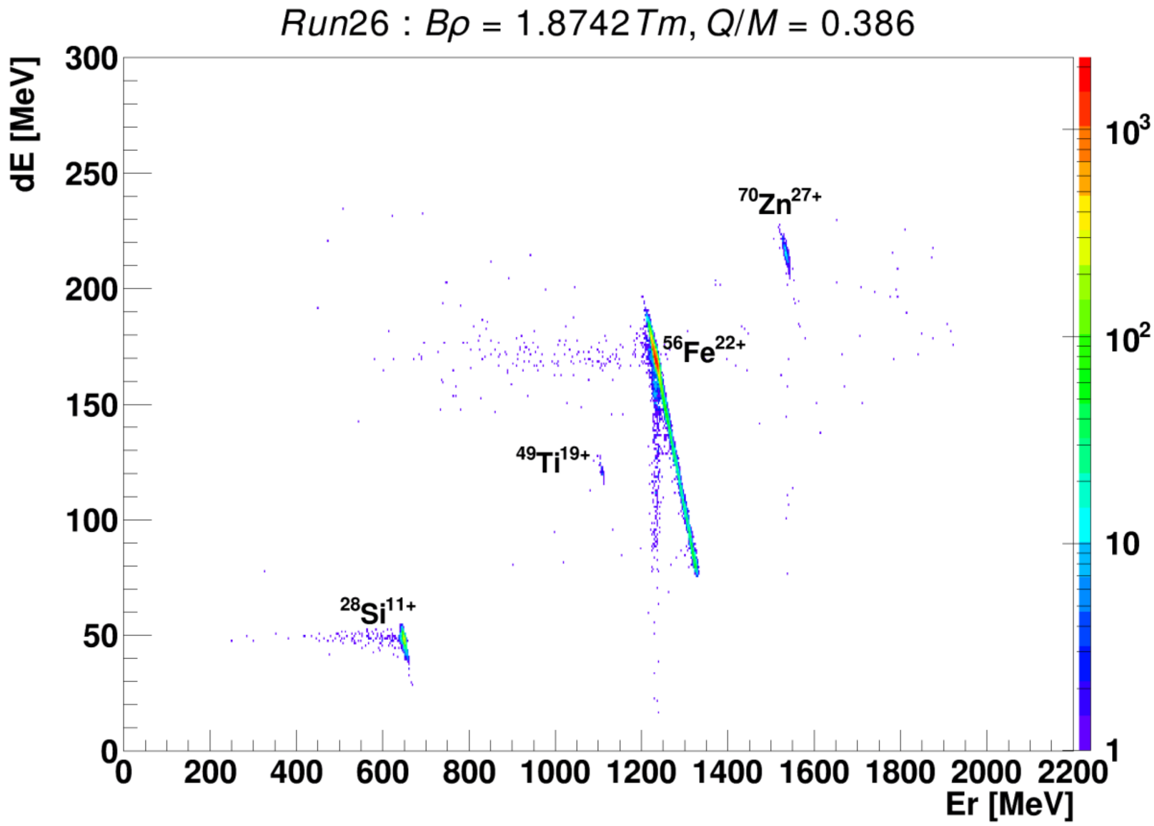

FIG. 1. Measurement of beam contaminants from the CB-ECR with $^{14}N^{4+}$ pilot beam at 14 MeV/u as observed at the MARS focal plane. See text for further explanation.

To combat this problem, we plan to try using pure aluminum liners or redesigning some components of the ECR plasma chambers to attempt to remove some of this contamination. The results of these efforts will be reported in next year's progress report.

[1] B.T. Roeder *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2016-2017), p. IV-17; http://cyclotron.tamu.edu/progress-reports/2016-2017/SECTION IV.html.

[2] B.T. Roeder *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018), p. IV-63; http://cyclotron.tamu.edu/progress-reports/2017-2018/SECTION IV.html.

[3] B.T. Roeder *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2018-2019), P. IV-17;http://cyclotron.tamu.edu/progress-reports/2018-2019/SECTION IV.html.

[4] https://en.wikipedia.org/wiki/Aluminium_alloy

[5] R.E. Tribble, R.H. Burch, and C.A. Gagliardi, Nucl. Instrum. Methods Phys. Res. **A285**, 441 (1989).