Studies of ECR plasma chamber contamination with accelerated beams and diamond detectors

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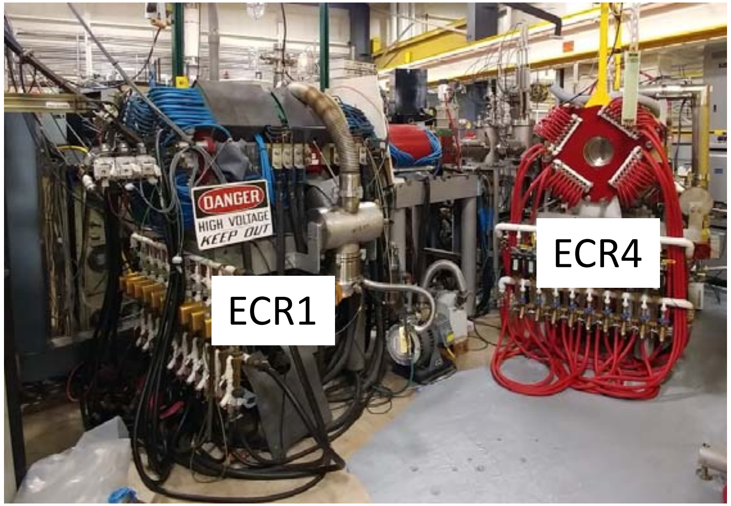
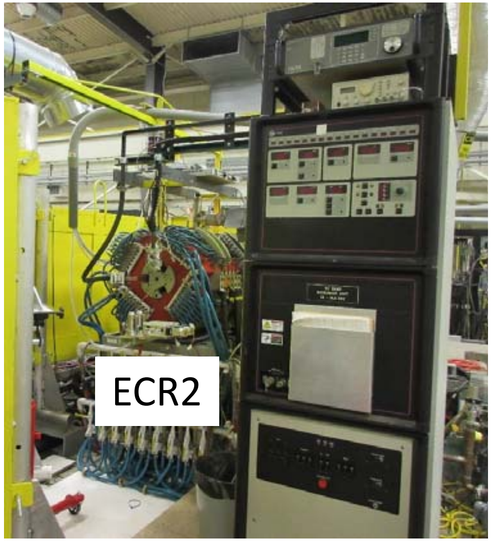
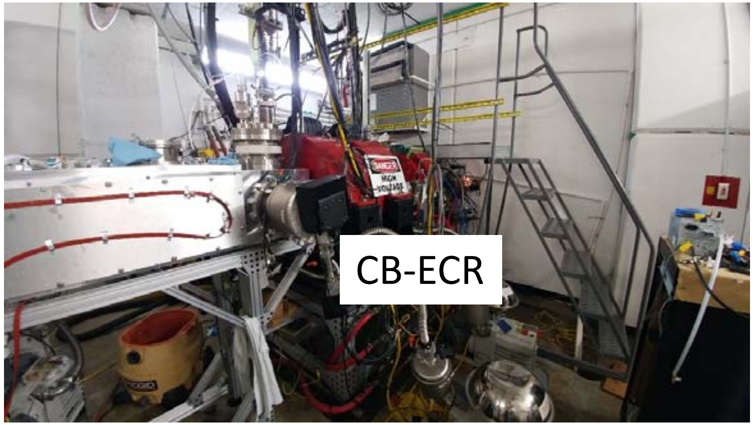
Introduction

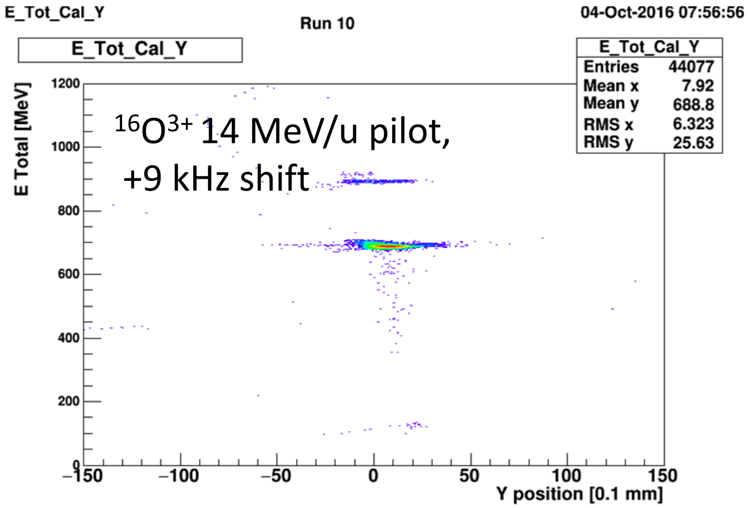


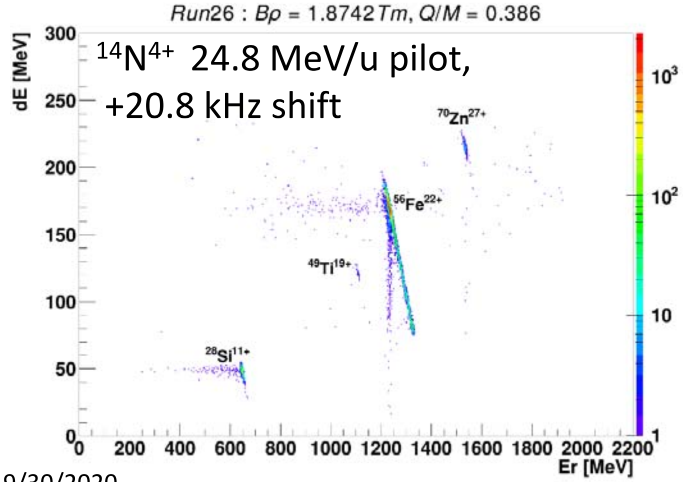




- We are currently operating 3 ECR Ion Sources. Provide beam to 2 cyclotrons.
- ECR1 has been operating for 25 years, has provided beams from H to ^{238}U.
- ECR2 (A-ECR) is dual frequency heated (14.5 GHz and 11.8 GHz).
- CB-ECR is providing charge-bred ion beams for our re-accelerated beams.
- ECR4 is an updated version of ECR1, operating at 6.4 GHz. Ready this year!

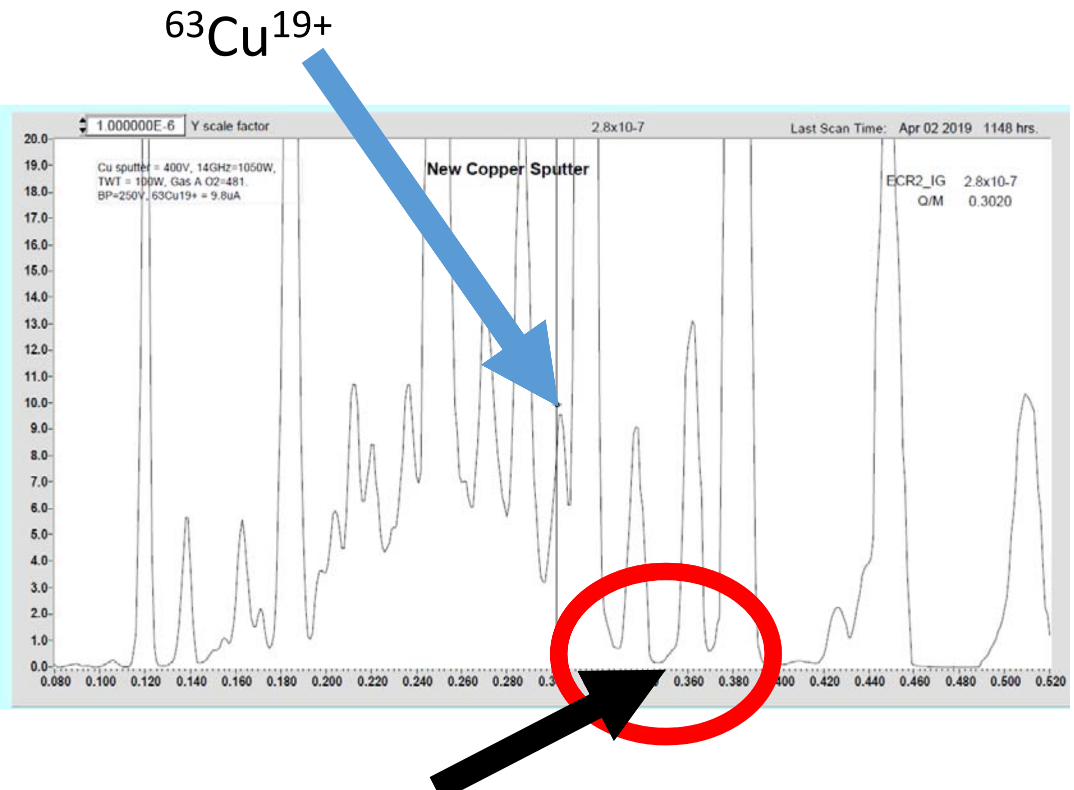
CB-ECR background problem





- CB-ECR is made of Al – 7075 alloy.
  - 6 % Zinc
  - 2.5% Mg
  - 1.5% Cu
  - < 0.5% Si, Fe, Mn, Ti, Cr, other metals
- Have observed ^{64}Zn background multiple times, including in RIBs test.
- ^{63}Cu observed in ^{63}Zn RIB tests.
- Most recent test with $^{14}N^{4+}$ pilot beam at 24.8 MeV/u observed ^{70}Zn, ^{63}Cu, ^{56}Fe, ^{49}Ti, ^{35}Cl and ^{28}Si.

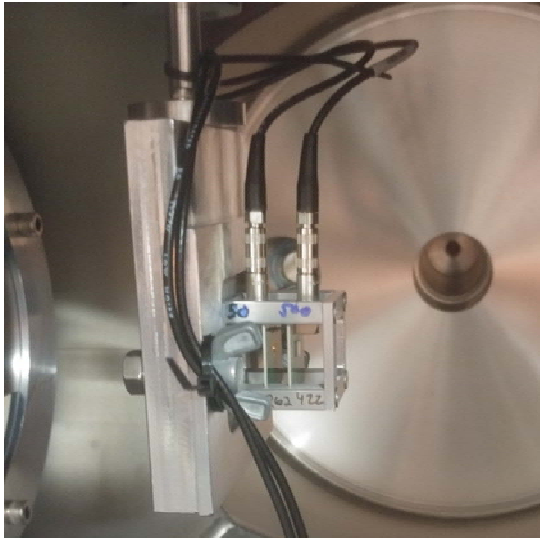
ECR2 beam background problem



Region of interest near Q/M ~ 0.35, many possible beams. Need to be tuning the right one!

- ECR2 has plasma chamber with Al-6061 alloy (cleaner)
  - 0.6 % Si
  - 1.0% Mg
  - 0.25% Cu
  - < 0.2 % Cr, and other metals
- However, ECR2 has run many metals for experimenters (Li, Mg, Cr, Fe, Zr, etc.)
- Developing high charge state beams such as $^{63}Cu^{22+}$, $^{78}Kr^{27+}$, $^{107}Ag^{29+}$ and $^{124}Xe^{34+}$.
- High charge state ions are low intensity, so background can be a problem.

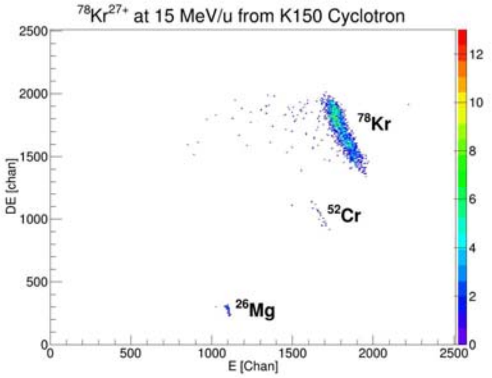
Measurement Setup

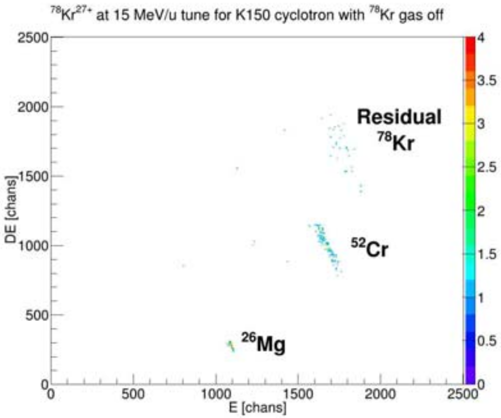


- Ortec Silicon Detector, 2mm thick (not shown).
- Diamond telescope detector (Applied Diamond Inc.) – ΔE - 50 µm + E - 500 µm, mounted on actuator
- DAQ - CAEN 1422A preamp and CAEN DT5780 Digitizer – Readout with CAEN CoMPASS software.
- Can measure K150 cyclotron accelerated ions from ^{4}He up to ^{129}Xe with a single setup.

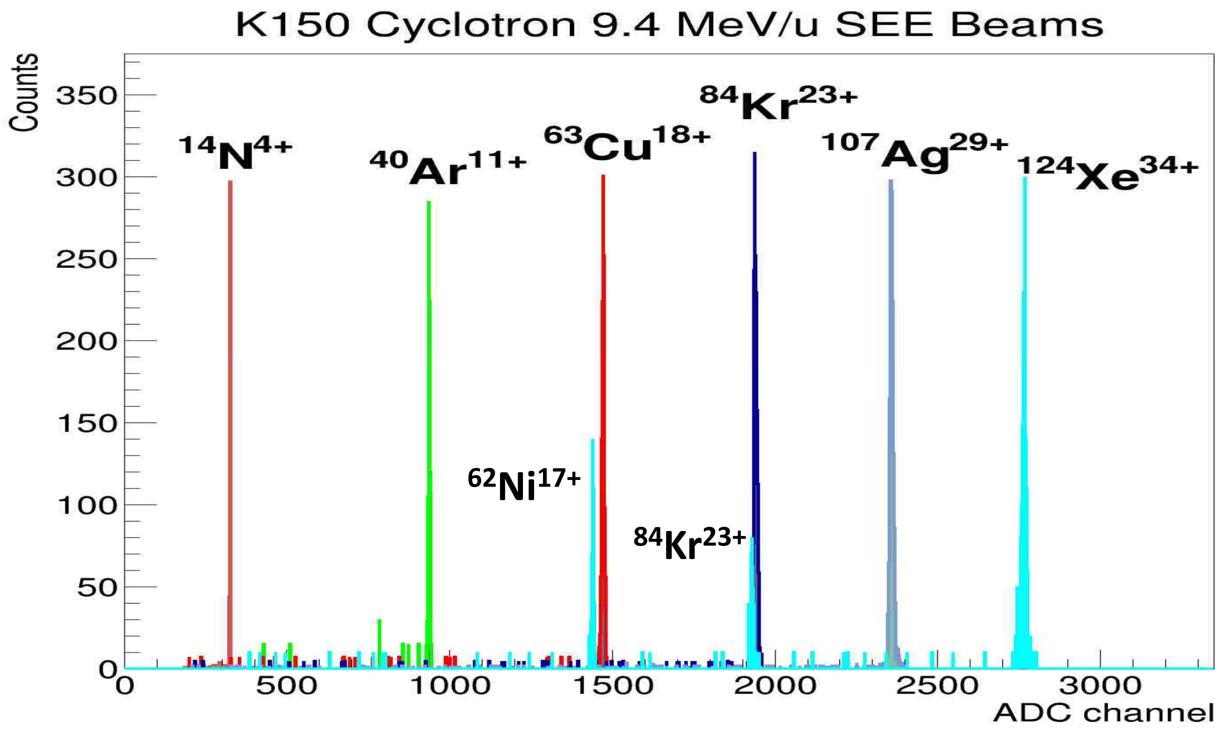
Some Results

- $^{78}Kr^{27+}$ beam, measured with diamond telescope





Beams measured with the Silicon Detector



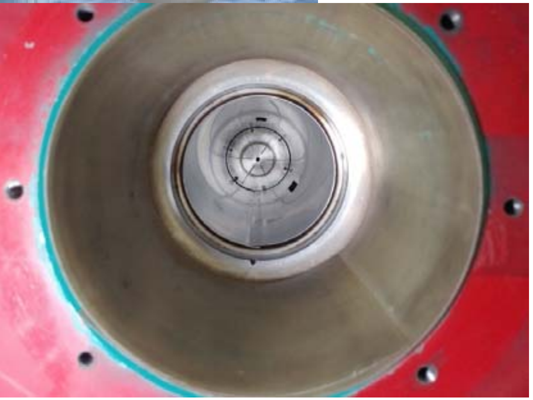
Using detectors, identified high charge state Ag and Xe from our ECR2 ion source.
Can use detector setup to improve the beam tunes!

Background Reduction Attempts

- Silane (SiH_4) coating
  - SiH_4 reacts in the source forming a SiO_2 layer.
  - Ran SiH_4 into CB-ECR for about 48 hours.
  - Measured ^{64}Zn background before treatment… Had about 10^5 p/s background.
  - No initial plasma after treatment, had to run O_2 for ~ 6 hours to restart source.
  - ^{64}Zn background still present at similar levels in post-accelerated beam.
  - ENTIRE SYSTEM WAS CONTAMINATED. Had to clean everything!
- Al liner with 1000 series "commercially pure" > 99% Aluminum.
  - Can not machine "pure" Aluminum (too soft).
  - 1050 series Aluminum is 99.5% pure Al, but still contains contamination.
  - Installed a liner into ECR1 (stable beam ECR source). Covered 75% of the surface area of the ion source.
  - NO REDUCTION OF BACKGROUND observed. Still getting background from extraction plate or even the small amount of contamination in the liner.

Conclusion

True Fact, Ion Sources have Memory!



- For weak, high charge state or charge-bred beams, background beams arising from materials or previously used metals can impact beam purity
- Post acceleration beam identification allows one to improve the ion source and cyclotron tuning to purify beam and maximize intensity.
- Diamond detectors have a provided radiation-hard beam measurement method.
- Testing of beam purification methods is ongoing.

Thank you for your attention!