MAGNETIC FIELD INVESTIGATIONS OF THE ATLAS ECR ION SOURCES

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ABSTRACT

A complete redesign of the ATLAS ECR2 ion source permanent magnet hexapole was completed to support 18 GHz operation, allowing for increased intensities and beam energies. This permanent magnet hexapole has unfortunately not yet been manufactured and received. Additionally, the ATLAS ECR3 has struggled with instabilities without a known cause. These beam instabilities can be tuned out but often require significant effort. A recent plasma chamber cooling water leak has given rise to an opportunity for deeper investigation of the fully permanent magnet ion source. A magnetic field mapping of the ECR3 axial and radial magnetic fields was also completed, leading to further understanding of the ion source's cause for instabilities. Updated plans for ECR3 are described while we wait on the ECR2 hexapole to be manufactured.

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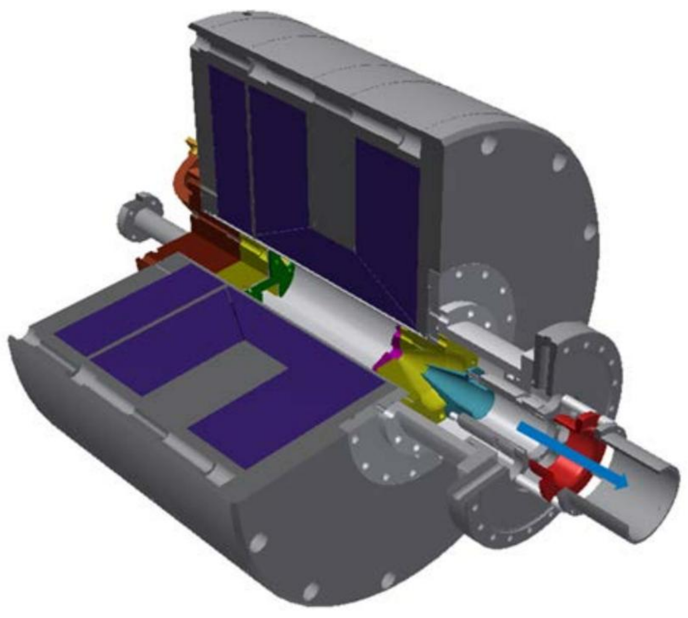
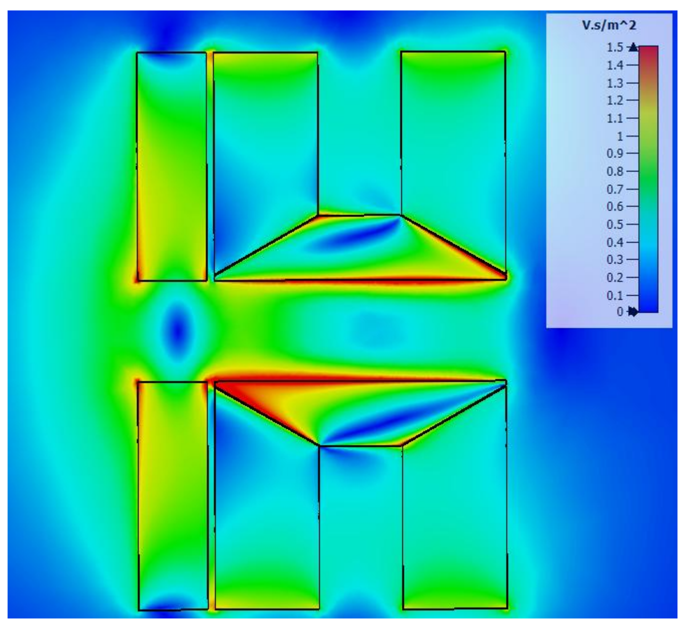
THE ATLAS ECR3

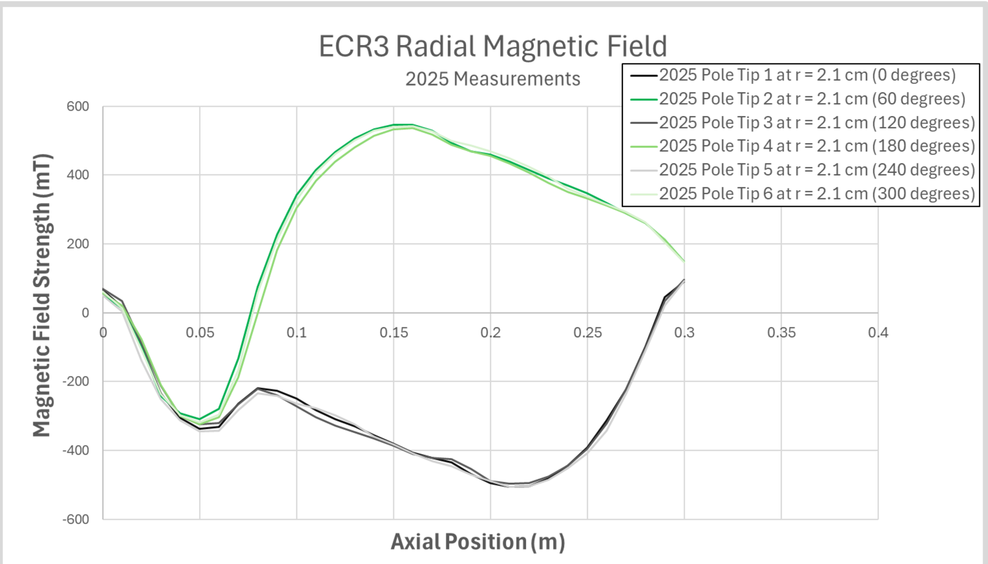
- Originally the BIE100 [1], ECR3 is an all-permanent magnet ECRIS that produces ion beams for the ATLAS facility [2]. This ion source was added to ATLAS to allow for a radioactive beams dedicated source and to give flexibility to scheduling with a two-source operational mechanism [3].

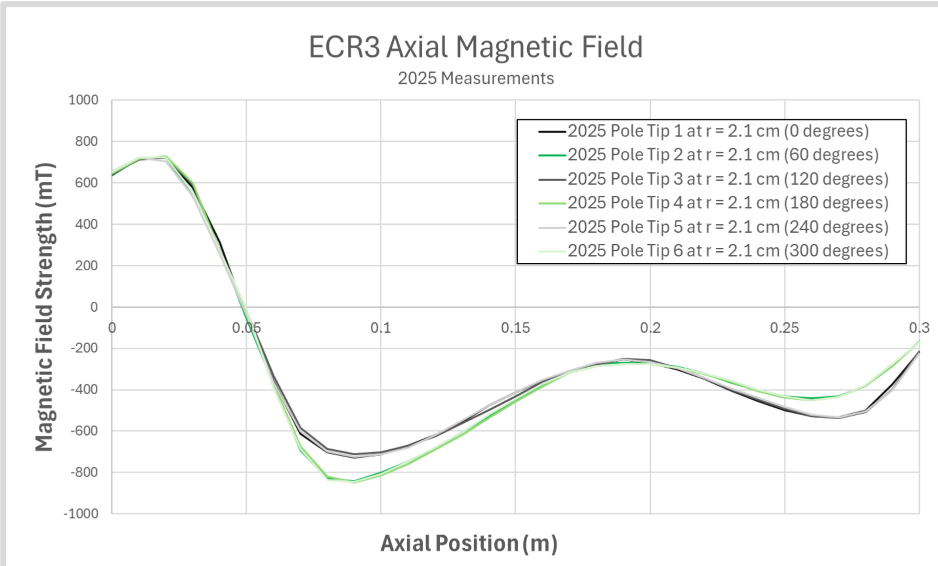


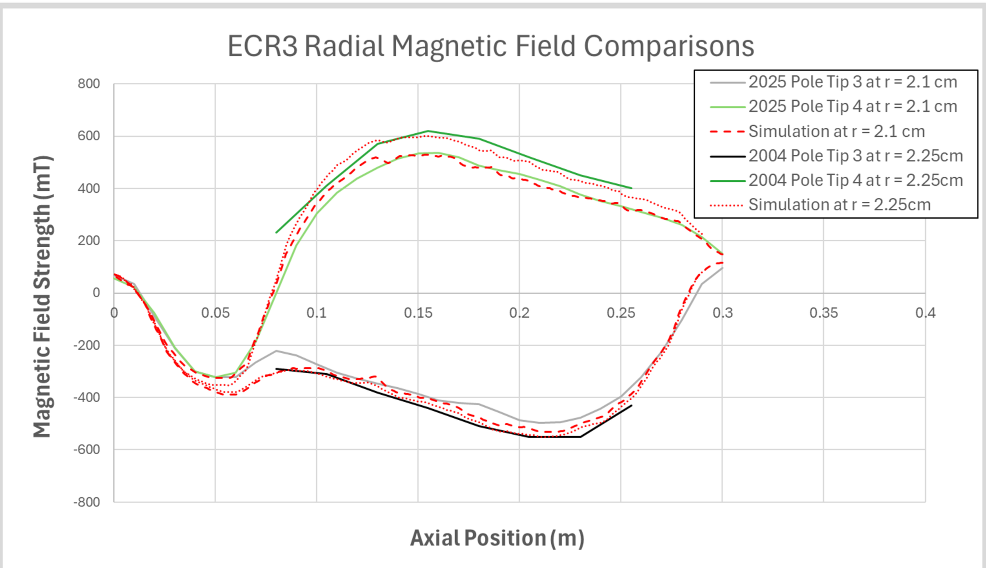


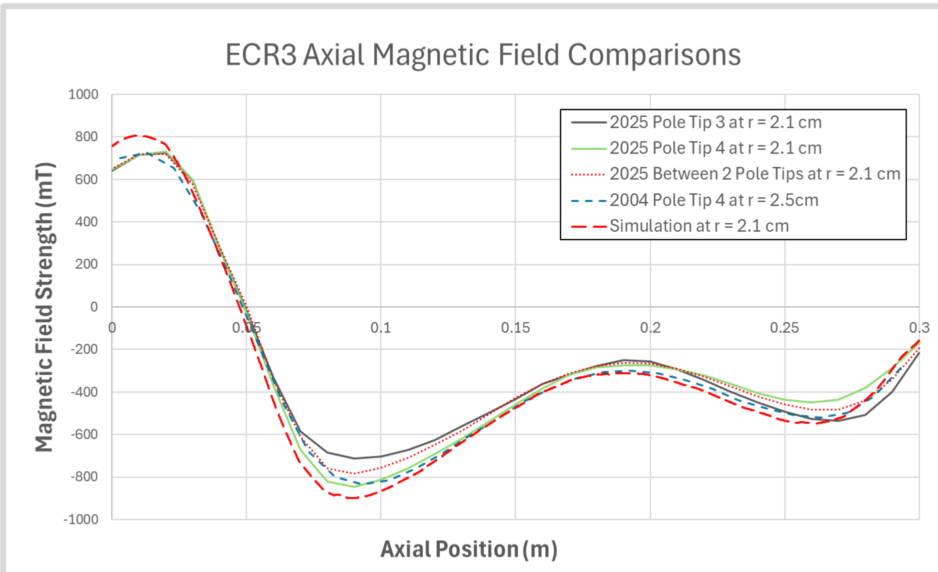
RADIAL FIELD PROFILE

AXIAL FIELD PROFILE





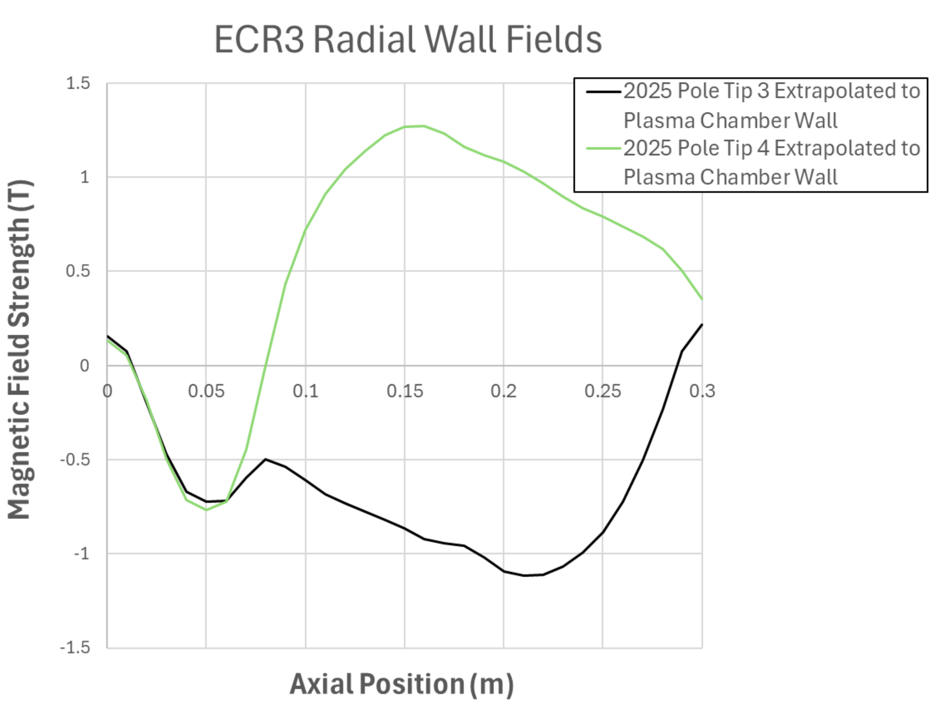




- The plasma chamber is about 17cm long and extends from 0.09m to 0.26m in the measured field profile plots.
- The magnetic field profiles and strengths agree with simulations and overlap nicely between pole tips.

RADIAL WALL FIELDS

- The plasma chamber wall is at r = 3.2cm.
- The measured magnetic fields at r = 2.1cm can be used to estimate the wall field profile based on simulations.
  - $B_{wall} = B_{r=2.1cm} \frac{B_{wall\_sim}}{B_{r=2.1cm\_sim}}$
- The BIE100 was designed with a wall field of 1.1T at the pole tip [1].
- The extrapolated wall fields are still roughly to the design spec of the BIE100.

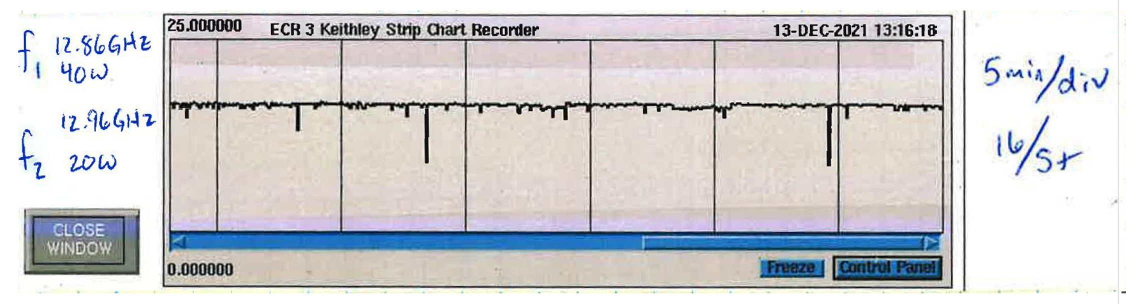


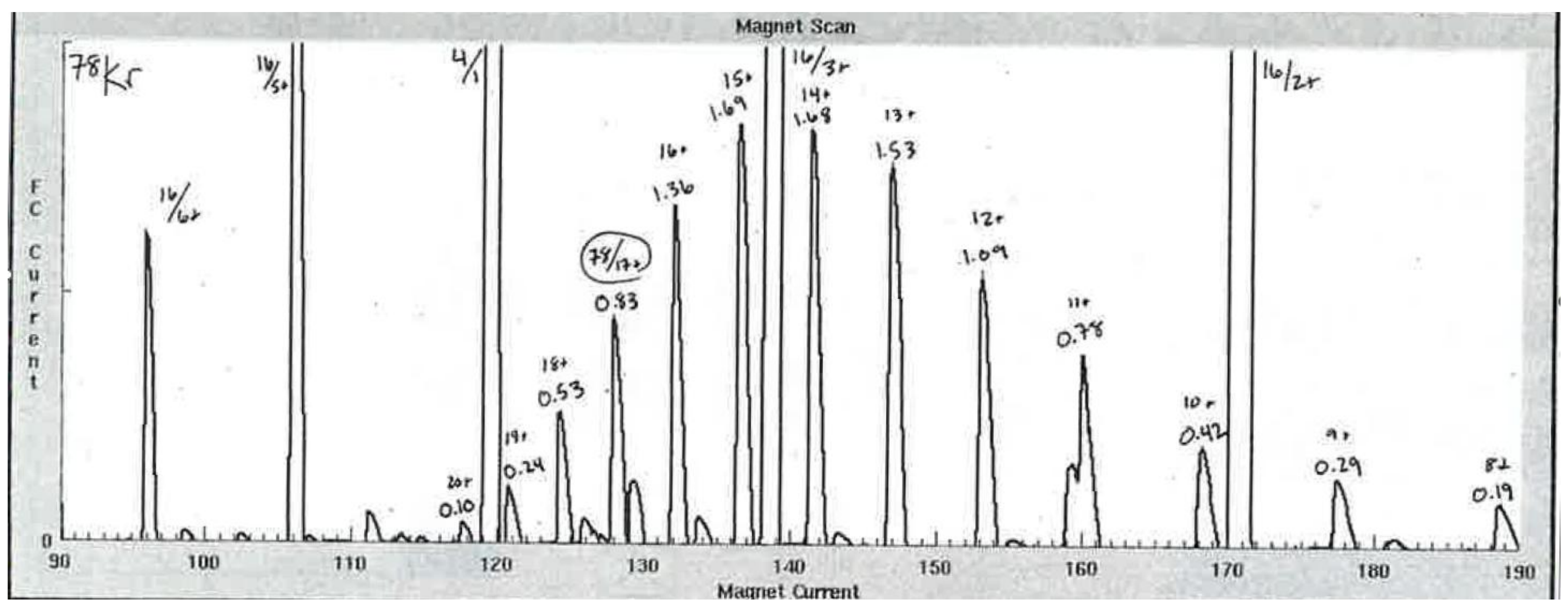
ECR3 STABILITY CHALLENGES

- ECR3 has successfully delivered many ion beams, including both stable and radioactive ion beams, such as carbon-14 [4].
- Although ECR3 has been successful from a beam delivery perspective, it has consistently proven difficult to find settings that would produce stable ion beams. Some devices would help, but there is not a single device that would always yield stability.

The parameters swept for stability included:

- RF power
- RF frequency
- Bias disk voltage
- Pumping speed
- Support gases
- Potential on electrostatic lenses
- Plasma chamber cooling water temperature





- These stability challenges gave us justification to map the magnetic fields of ECR3 during repair of a water leak to the plasma chamber from the cooling channels.
- Ideally, this field mapping would ensure there has not been damage or degradation to the magnets yielding poor performance.

KEY TAKEAWAYS

- The radial and axial magnetic fields do not suggest magnet damage.
- Both the radial and axial comparisons between simulation and reality agree within 10% and additionally agree with measured fields in 2004.
- The stability issues may be from additional magnetic materials that shape the overall magnetic fields, electrostatic devices discharging, or transport devices.

REFERENCES

[1] Xie D Z 2002 Rev. Sci. Instrum. 73 pp 531-533

[2] Scott R H, Dickerson C, Pardo R C and Vondrasek R, 2021 Proc. of the 24th Int. Workshop on ECR Ion Sources, East Lansing, MI, pp 157-159

[3] R H Scott et al 2024 J. Phys.: Conf. Ser. 2743 012093

[4] R H Scott et al 2022 J. Phys.: Conf. Ser. 2244 012068

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