Measurements of Bremsstrahlung Radiation and X-ray Heat Load to Cryostat on SECRAL

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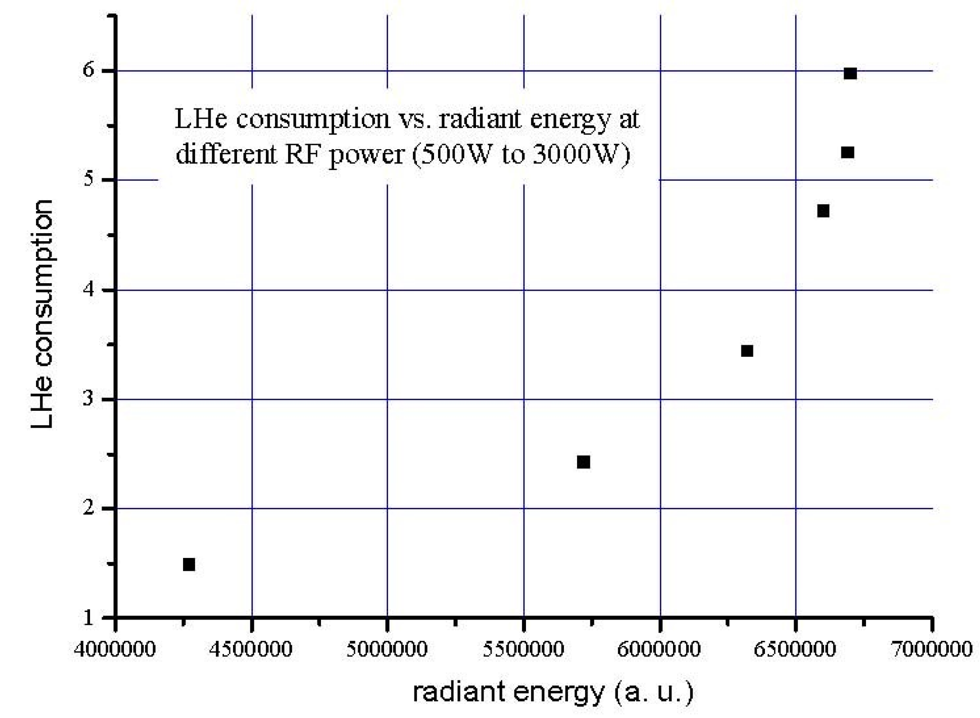
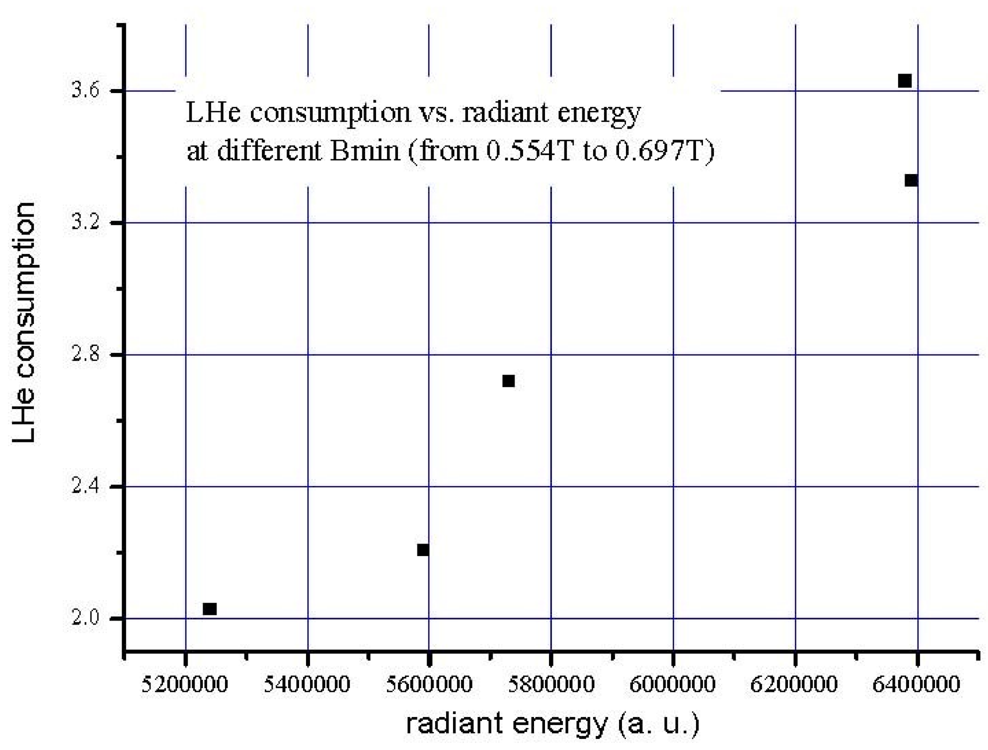
Abstract

Measurement of Bremsstrahlung radiation from ECR plasma can yield certain information about the ECR heating process and the plasma confinement, and more important a plausible estimate of the X-ray heat load to the cryostat of a superconducting ECR source which needs seriously addressed. To better understand the additional heat load to the cryostat due to Bremsstrahlung radiation, the axial Bremsstrahlung measurements have been conducted with different source parameters. In addition, the heat load induced by intense X-ray or ϒ-ray was estimated in terms of liquid helium consumption. And possible solutions to reduce the X-ray heat load induced by Bremsstrahlung radiation are proposed.

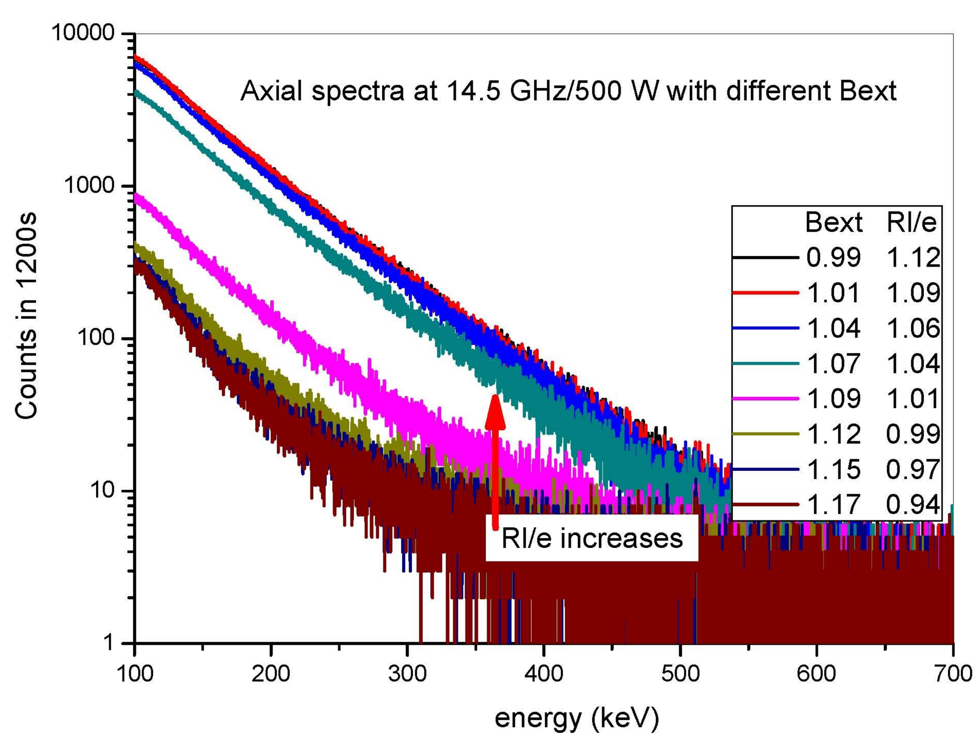
Heat load vs. Bremsstrahlung radiation at 24 GHz

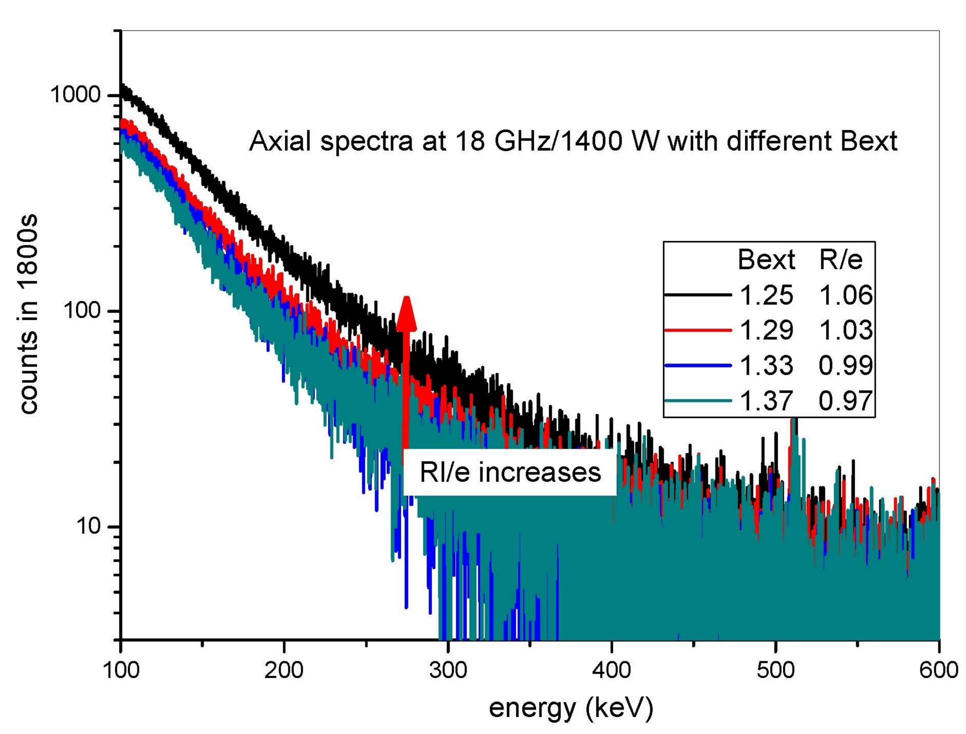


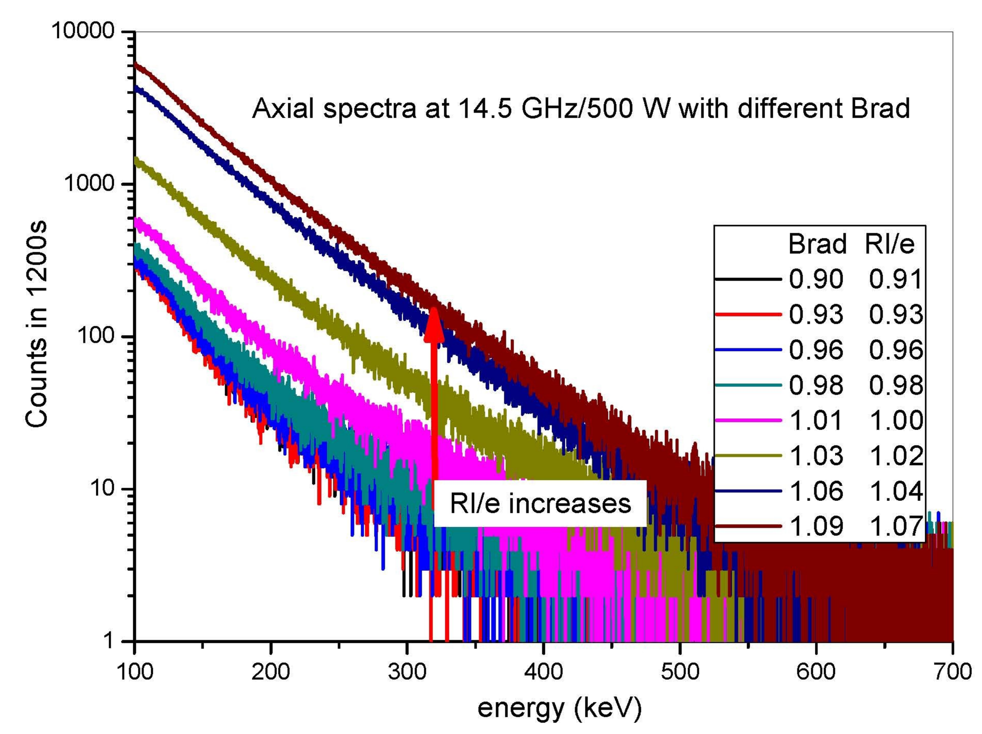


As expected, the heat load to the cryostat increases with the Bremstrahlung radiant energy when RF power or B_{min} increase, but not linearly. This may be explained that the higher RF power and B_{min} lead to intenser high energy Br radiation, which is difficult to shield and eventually absorbed by the cold mass of the SC magnet. That means that the additional heat load to the cryostat is much higher for high frequency and high power ECR ion sources.

Thick-target Bremsstrahlung vs. magnetic configuration (the ratio between B_{last} and B_{ext}-$R_{l/e}$)

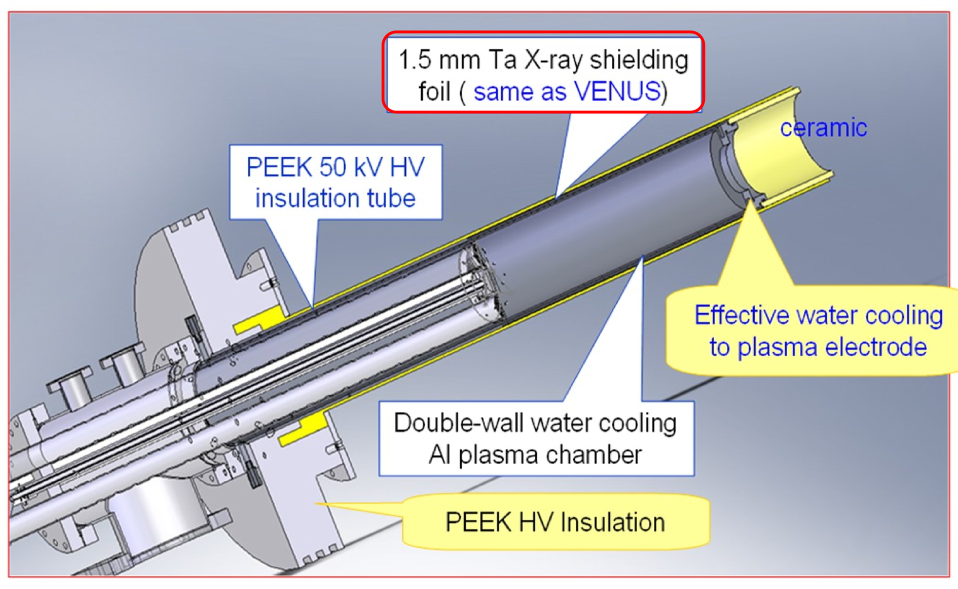


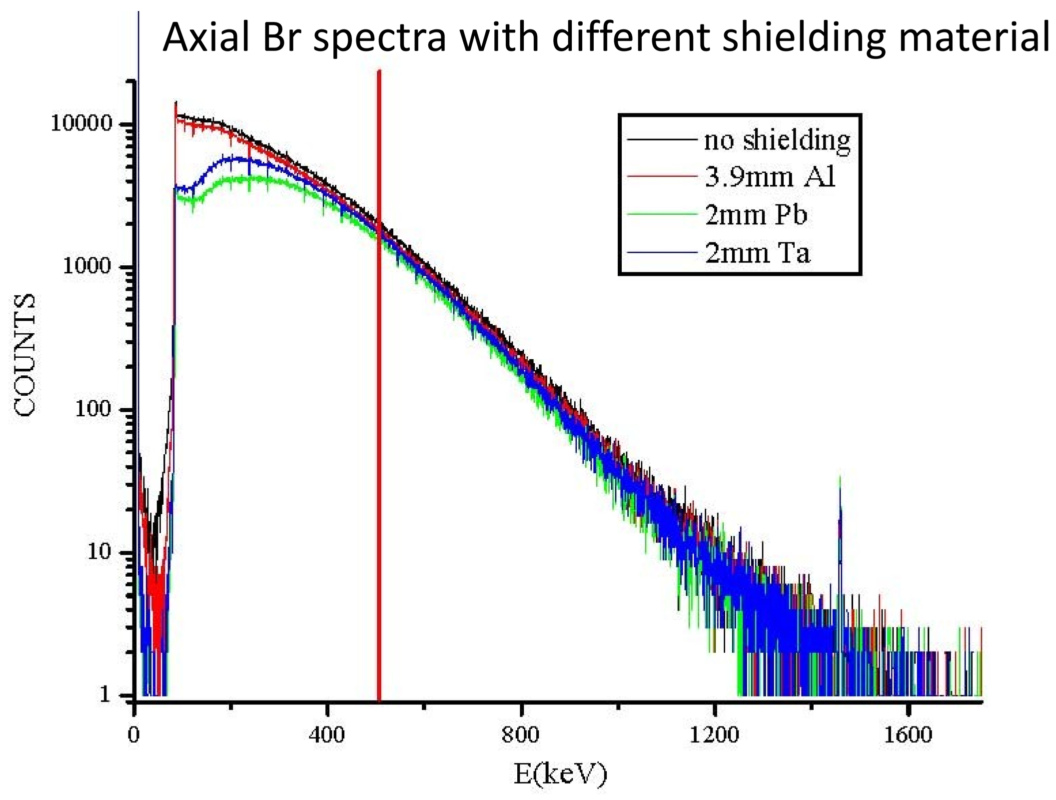




The systematic measurements of Br spectra showed that the axial spectra is not only influenced by RF power and B_{min}, but also sensitive to the ratio of B_{last} to B_{ext}-$R_{l/e}$. When $R_{l/e}$ is increased and close to 1 or even beyond 1, the axial spectra show apparent thick-target Br character, which means there are high energy electrons colliding on the electrode.

Shielding of X-ray





The heavy metal shield can reduce the Bremsstrahlung heating of the cryostat to some extent. But there is no efficient shielding for Br radiation above 500 keV.

Possible solutions to X-ray heating

- Shielding (only effective against radiation below 400 keV)
- Appropriate magnetic configuration (mainly the ratio of B_{last} to B_{ext}) to avoid thick-target Br

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- Aluminum chamber- to maintain the ambipolar diffusion in the plasma and prevent electrons from striking the wall?

This effect needs confirming by further experimental research.