Observation of Electron Cyclotron Instabilities in SECRAL-II Ion Source

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Outline

I. Research aim

II. Experimental setup

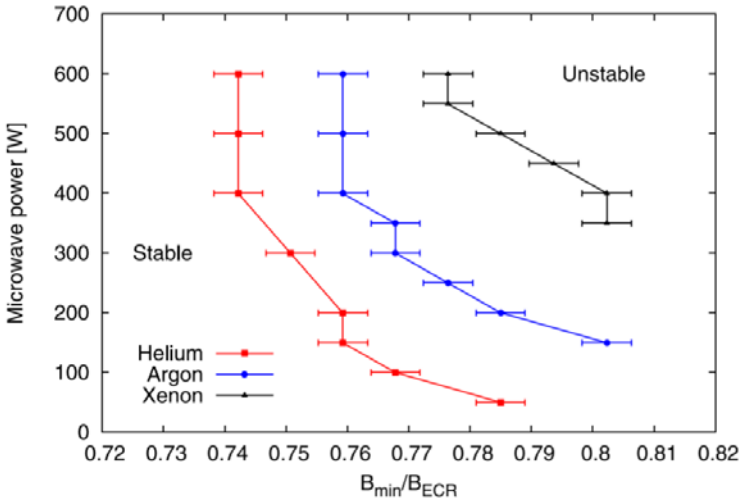
III. Results

IV. Discussion

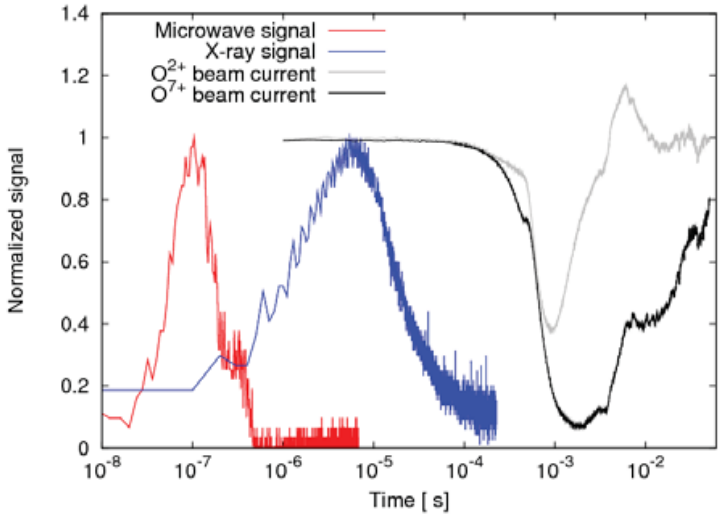
Research aim

☐Electron cyclotron instabilities threshold

➢Threshold between stable and unstable regimes



➢Diagnostic Signals



O. Tarvainen, et al., Rev. Sci. Instrum. 87 (2016)

☐Research aim of this study

Effects of other magnetic field parameters (mirror ratio、 radial field ..) on electron cyclotron instabilities

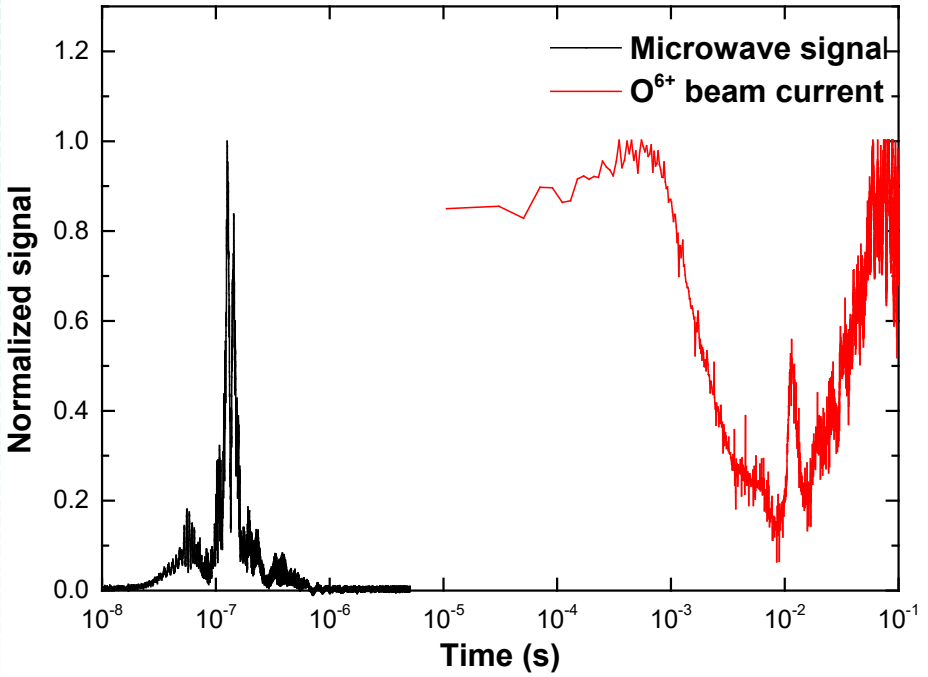
Experimental setup

Source parameters

Beam	Oxygen
Frequency (GHz)	18
Power (W)	1000
Extraction Voltage (kV)	15
Biased Disk Voltage (-V)	10~60
Injection Pressure (mbar)	$1\sim2\times10^{-7}$

Note: we do not optimize beam current at each data point, just tuning the gas injection and biased disk voltage to make ion source stable (long-term)

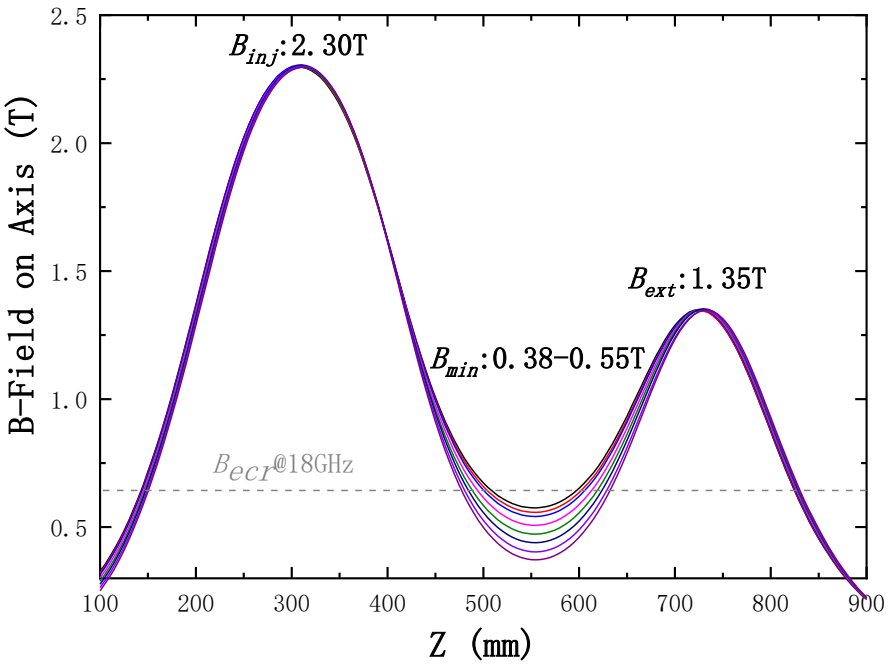
Typical microwave emission and beam current signals on SECRAL-II when electron cyclotron instability is triggered

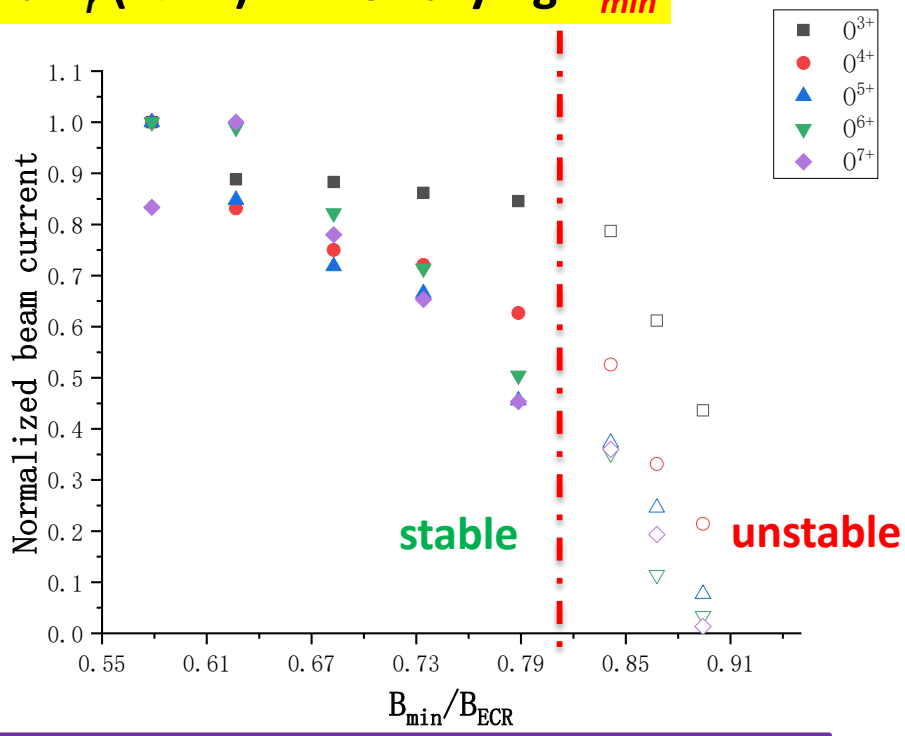


The microwave detection setup can been found in J. Li's presentation (1122)

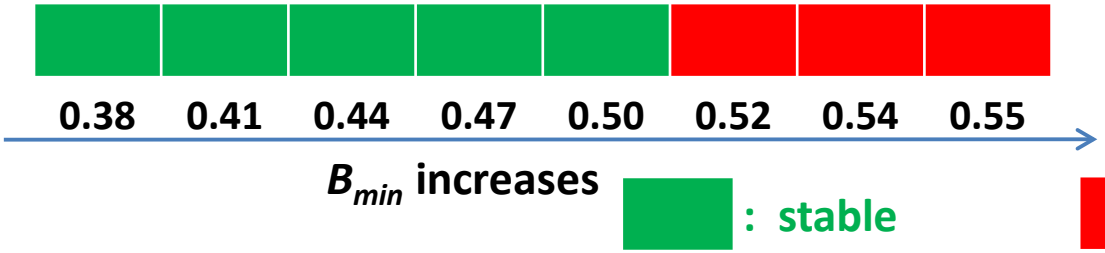
Experimental results

Part 1- constant B_{inj} , B_{ext} and B_r (1.1 T) while varying B_{min}



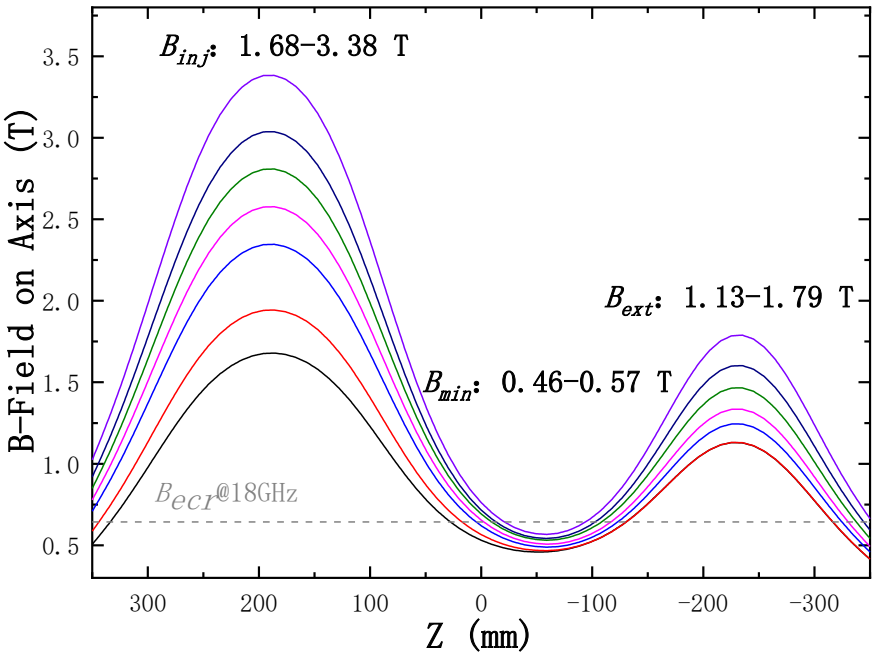


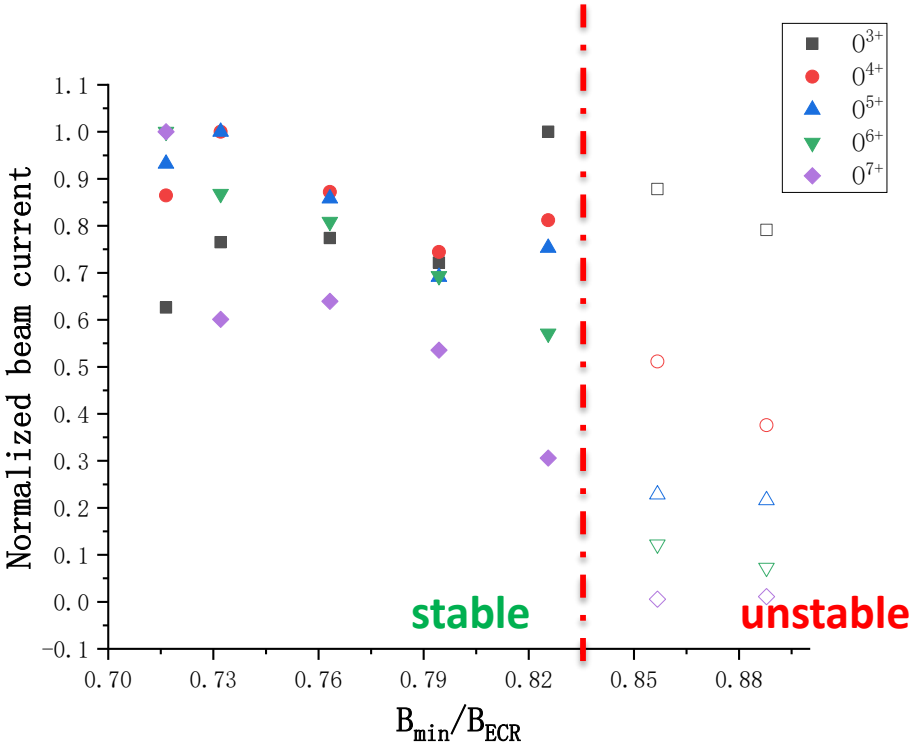
Note: beam normalization is carried out independently for each charge state and open symbols correspond to instability regime

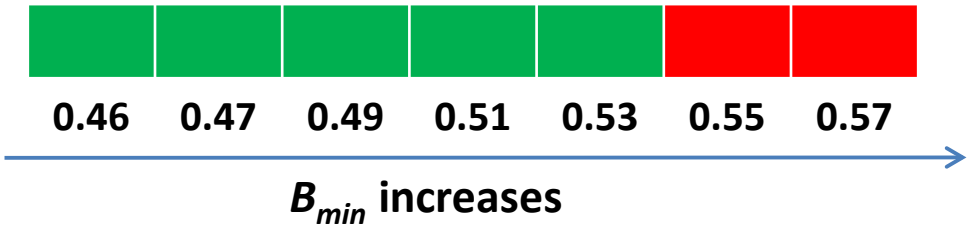


Experimental results

Part 2- constant on axis gradient (~4.5 T/m) and B_r (1.1 T) while varying B_{min}

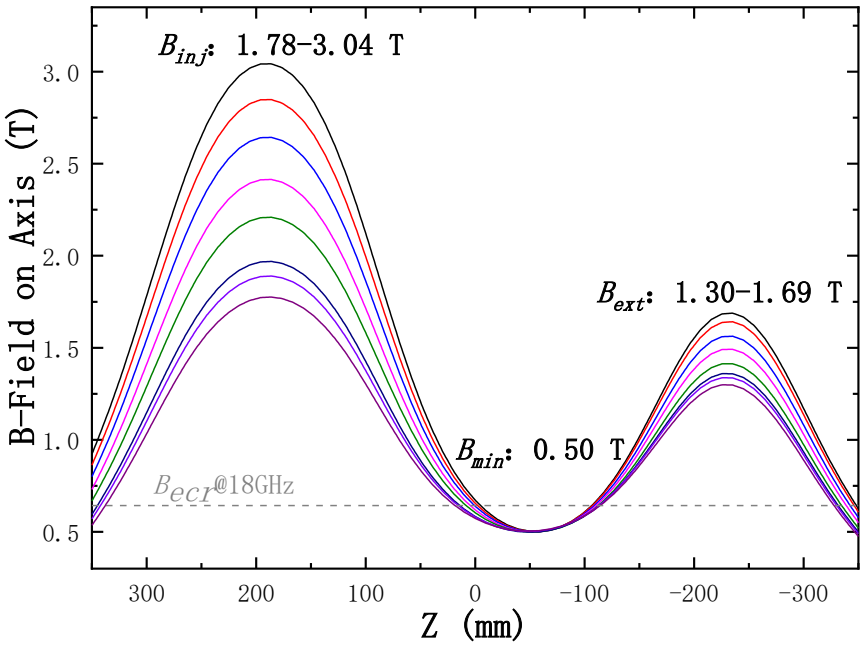


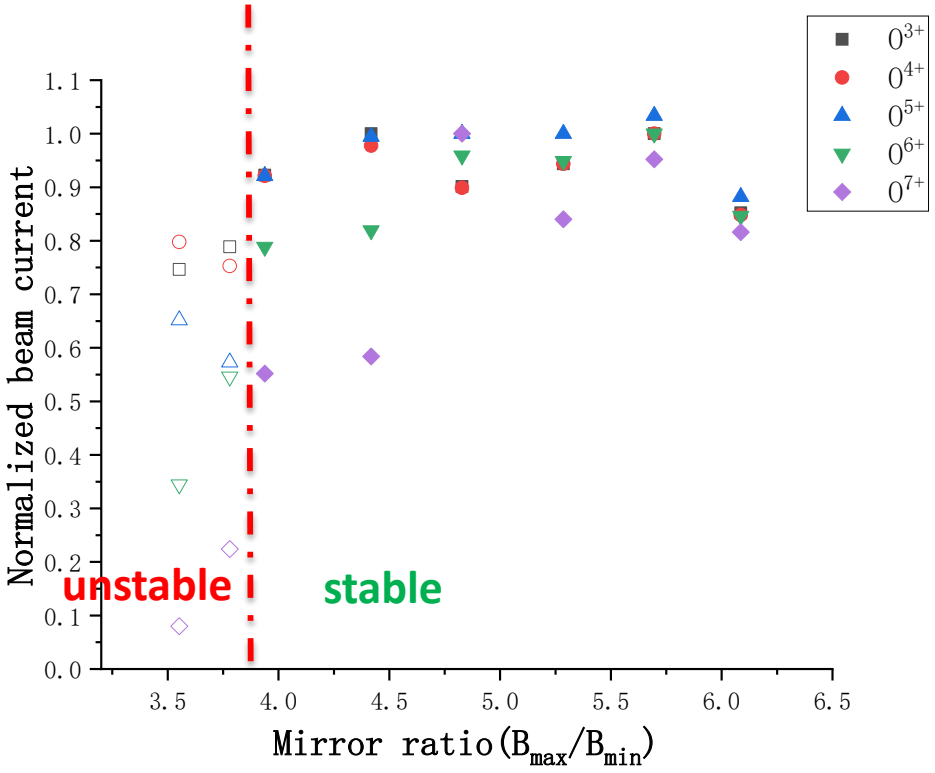


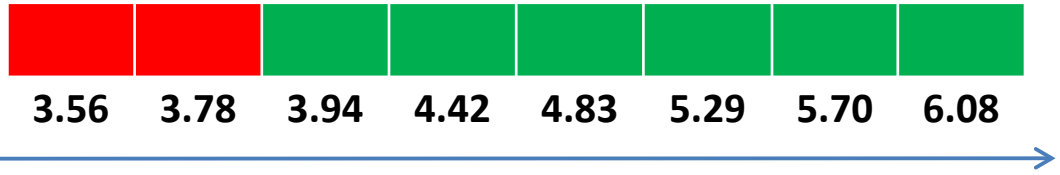


Experimental results

Part 3- constant B_{min} (0.50 T) and B_r (1.1 T) while varying mirror ratio (i.e. B_{inj} and B_{ext})



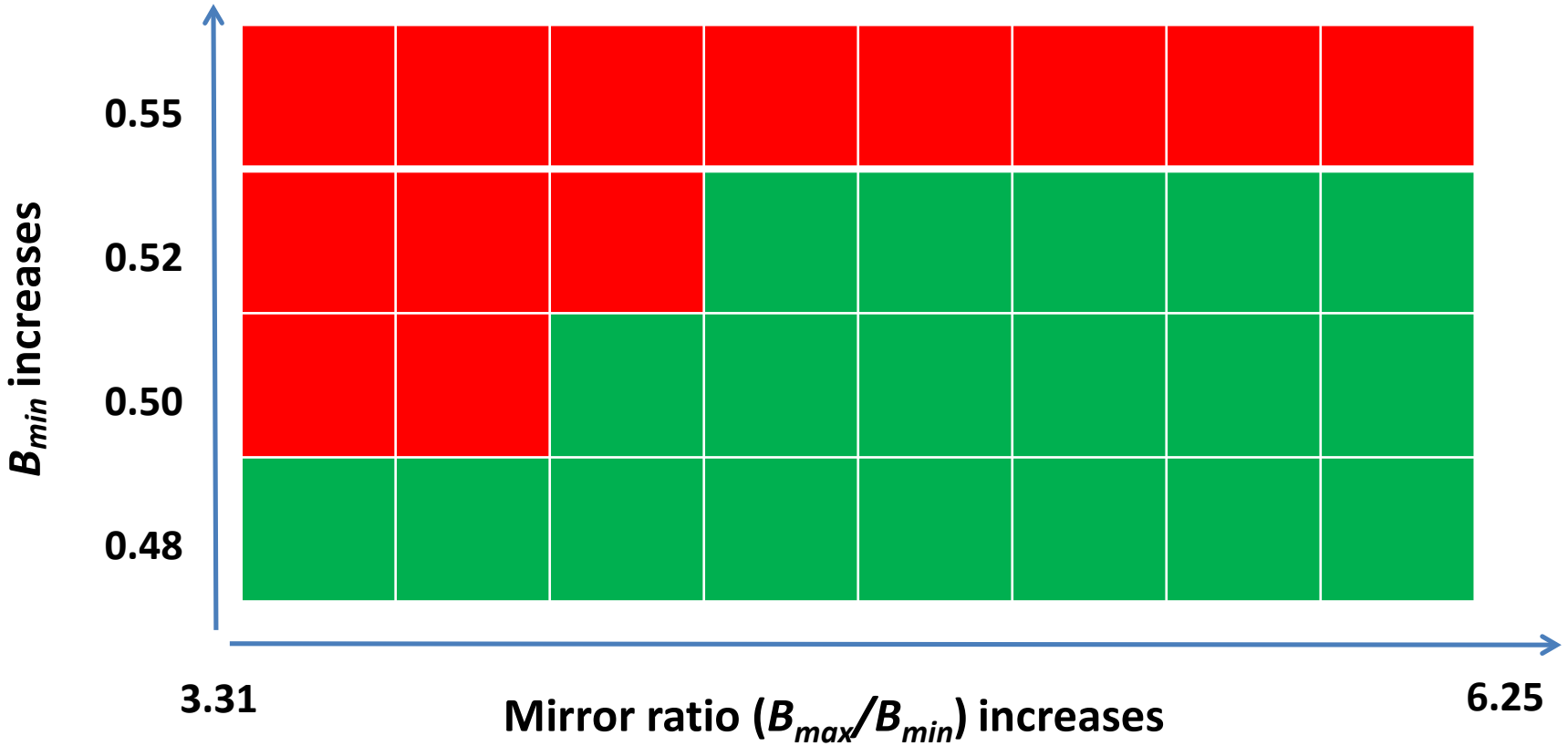




Mirror ratio (B_{max}/B_{min}) increases

Experimental results

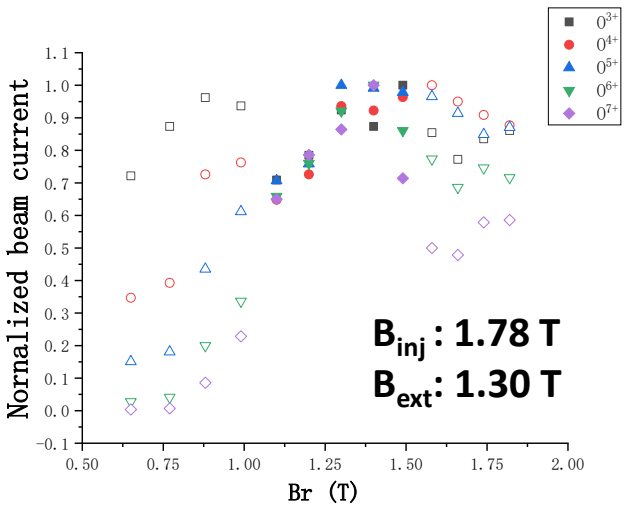
Summary: constant B_{min} and B_r while varying mirror ratio (i.e. B_{inj} *and* B_{ext})



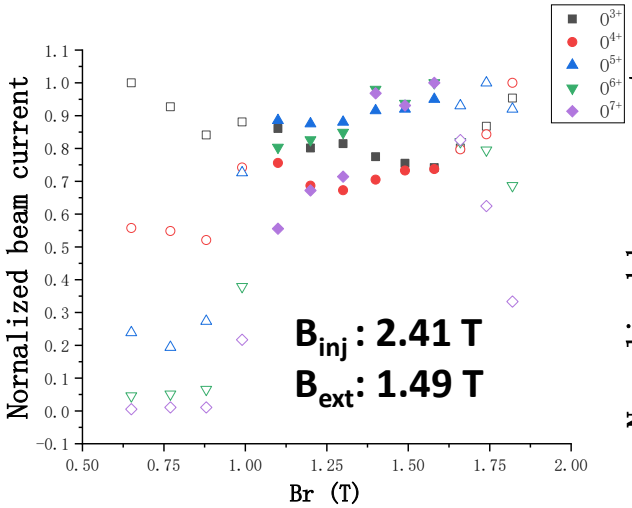
Experimental results

Part 4 - constant axial magnetic fields while varying B_r

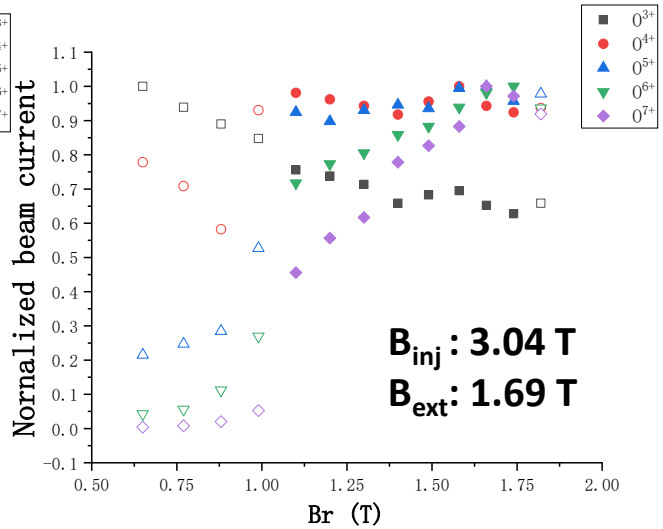
B_{min}: 0.50 T



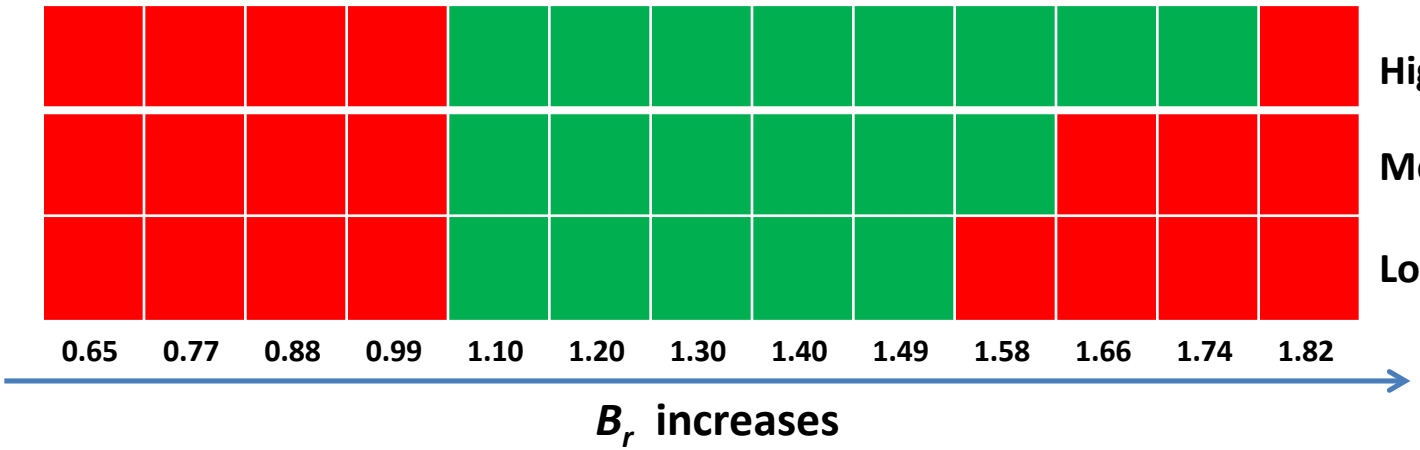
a. Low mirror ratio



b. Medial mirror ratio

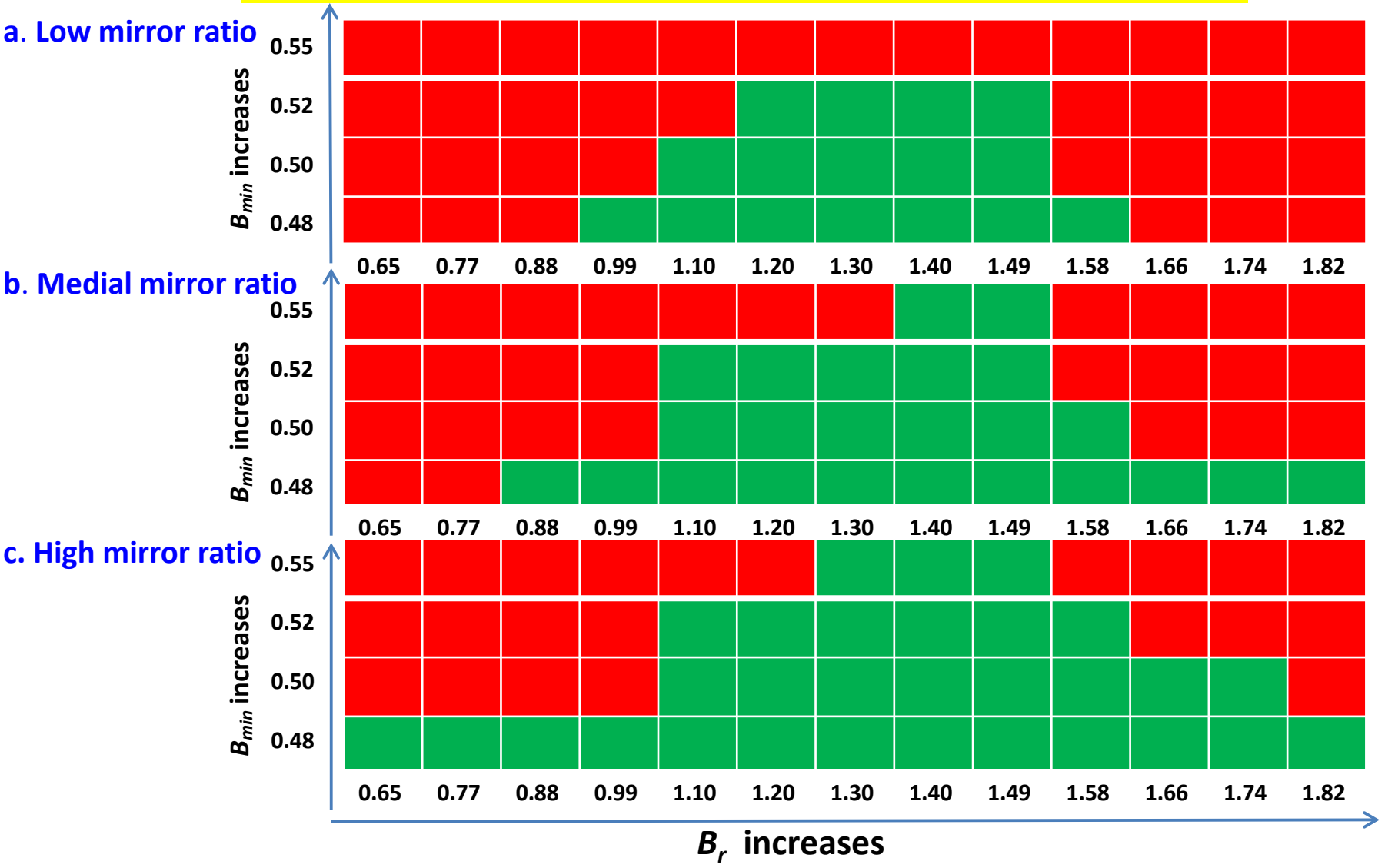


c. High mirror ratio



Experimental results

Summary: constant axial magnetic fields while varying B_r

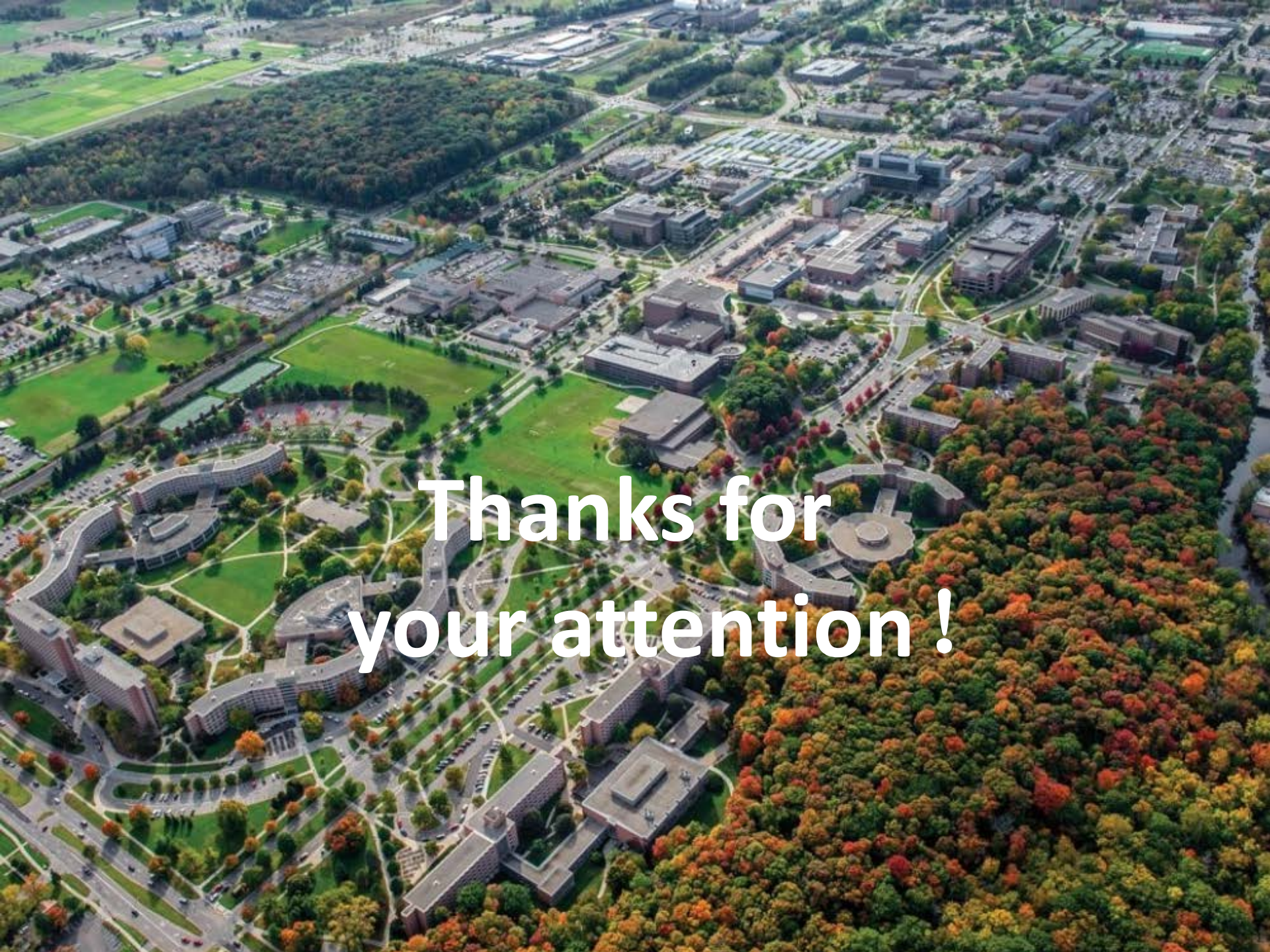


Discussion

- B_{min} is the primary magnetic field parameter affecting the appearance of cyclotron instability, but not the only one; mirror ratio and radial field also affect the appearance of cyclotron instability;

- Effects of magnetic configuration on electron cyclotron instability may provide a physical explanation for the semiempirical magnetic field scaling laws of ECRIS;

- The trigger of cyclotron instability maybe a combined effect of many magnetic field parameters, further analyses are needed to reveal the inherent link between these parameters and plasma heating ($< \nabla B_{ecr} >$) as well as confinement.


Thanks for
your attention !