JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

laboratoire commun CEA/DSM CNRS/IN2P3

Status Update

JYFL Ion Source Group

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

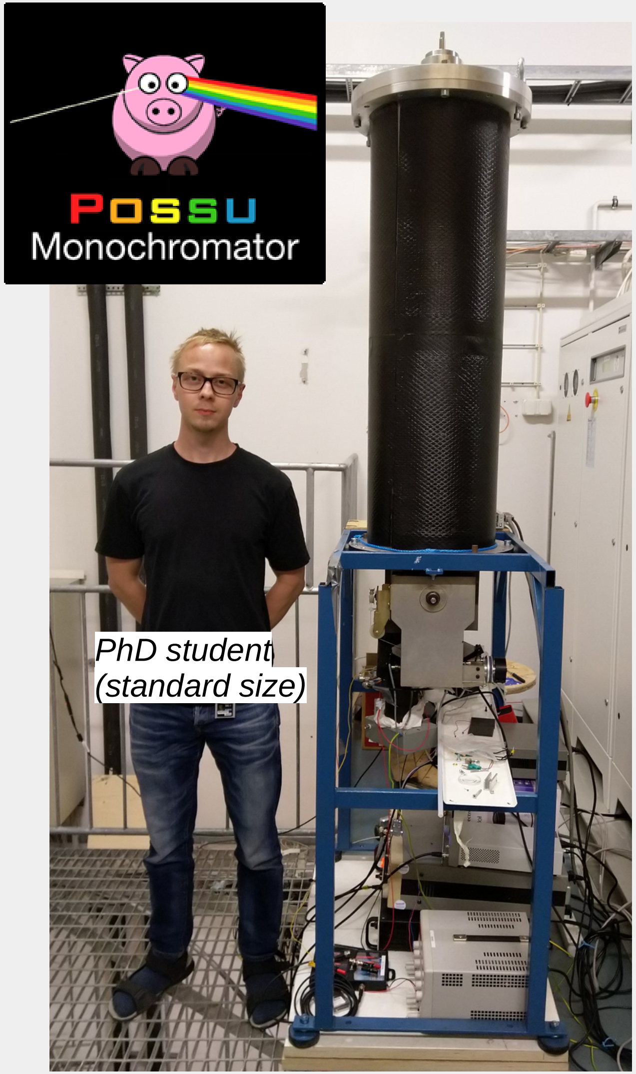
Plasma Investigations

- POSSU monochromator
- Ion confinement times
- Plasma instabilities

POSSU monochromator

- High resolution optical spectrometer (Fastie-Ebert type)
- Resolution is sufficient to determine Doppler broadening of ion emission lines →

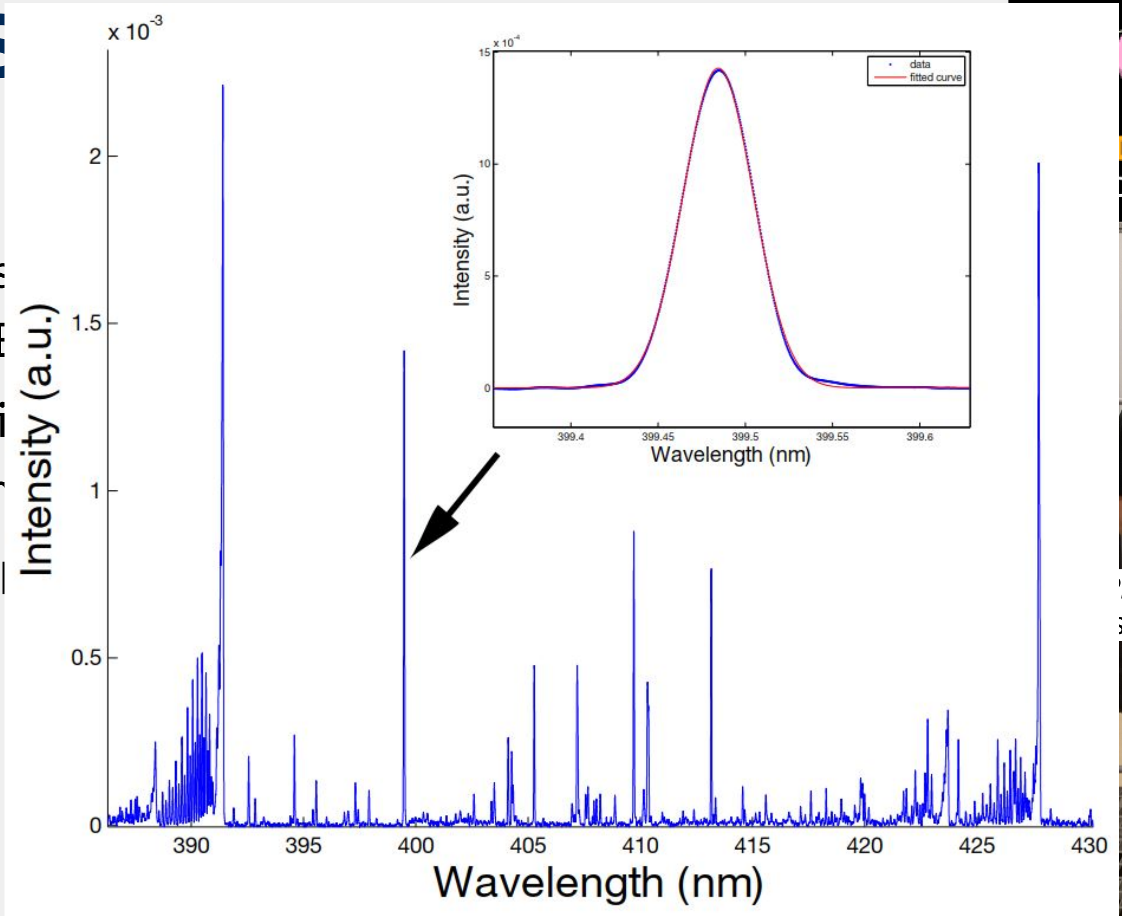
  Ion temperatures (~5 eV – 28 eV)



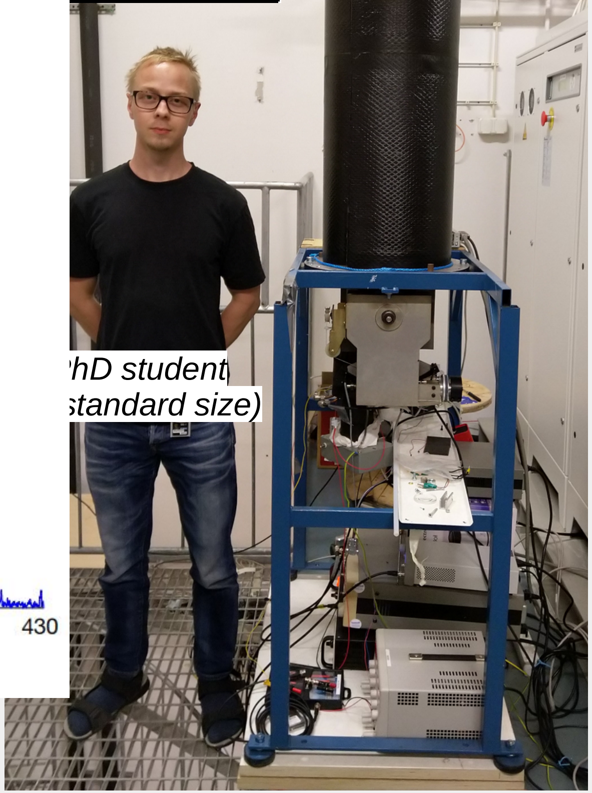
POS

- High res
  (Fastie-E
- Resoluti
  broader

  Ion temp



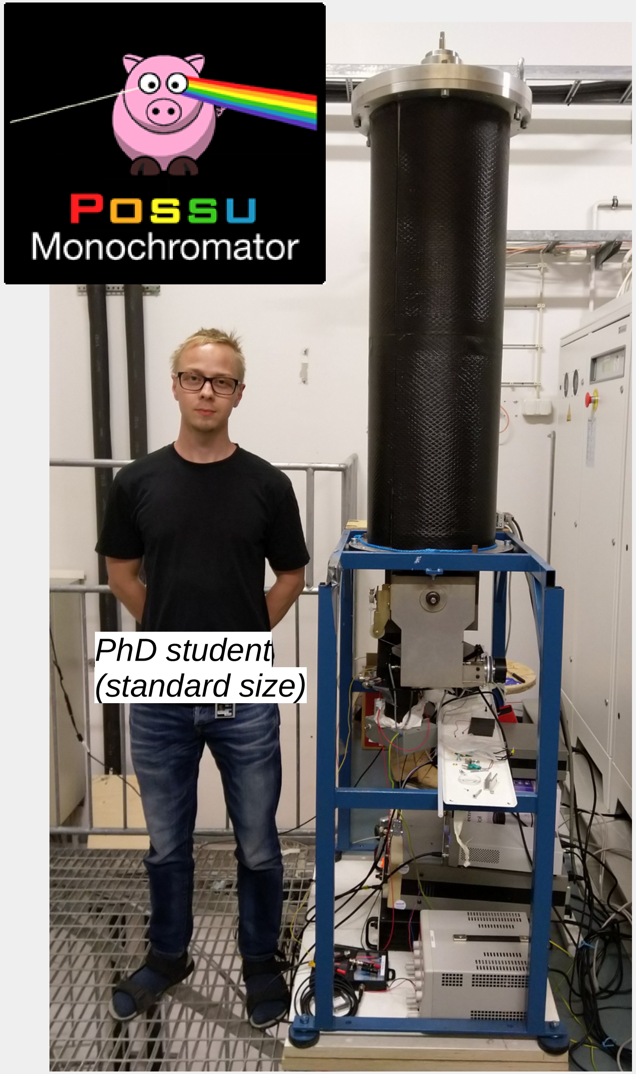
10 pm @ 632 nm



POSSU monochromator

- High resolution optical spectrometer (Fastie-Ebert type)
- Resolution is sufficient to determine Doppler broadening of ion emission lines →

  Ion temperatures (~5 eV – 28 eV)
- Also:
  - ion / neutral densities
  - cold e⁻ temperature



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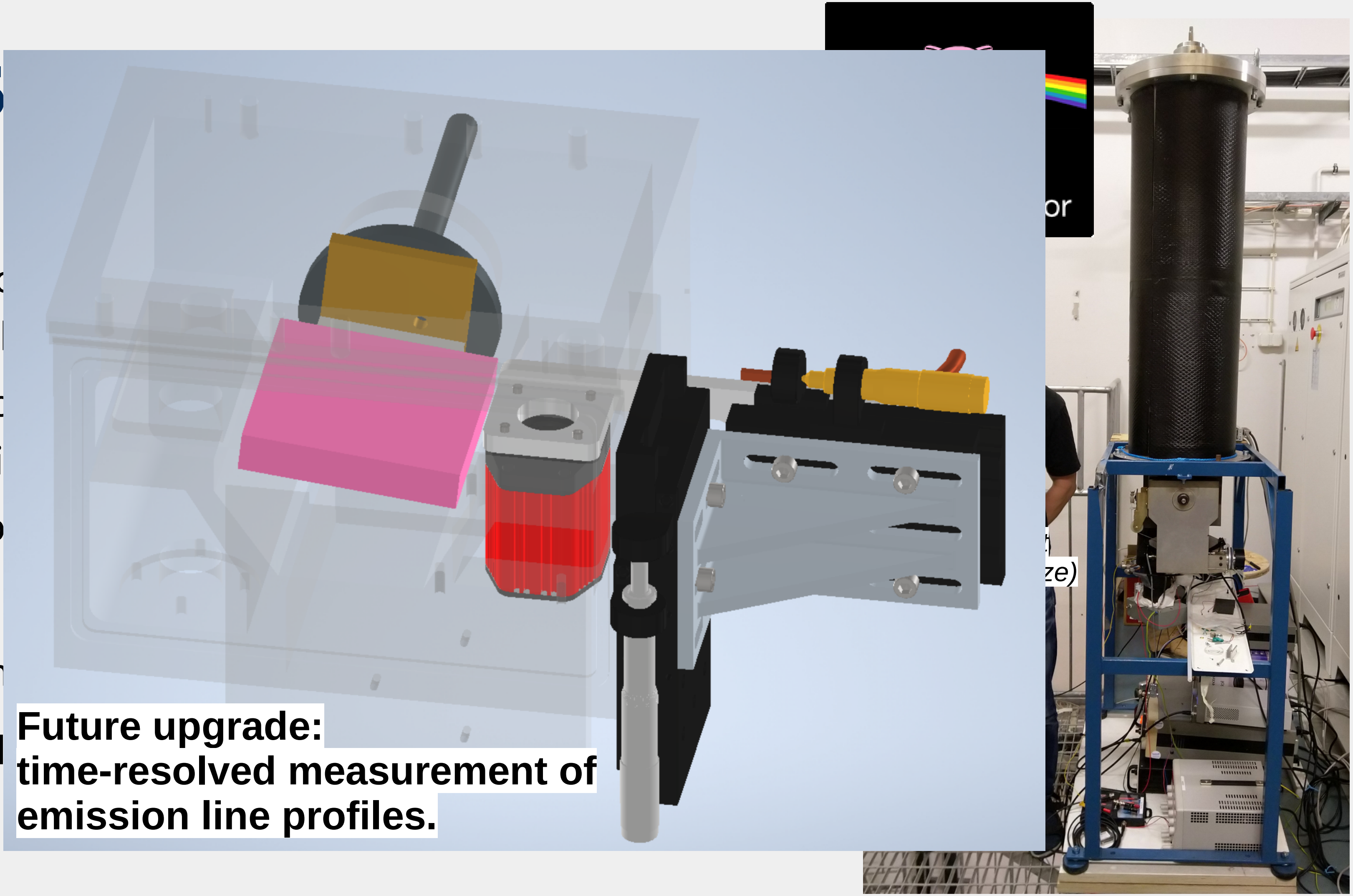
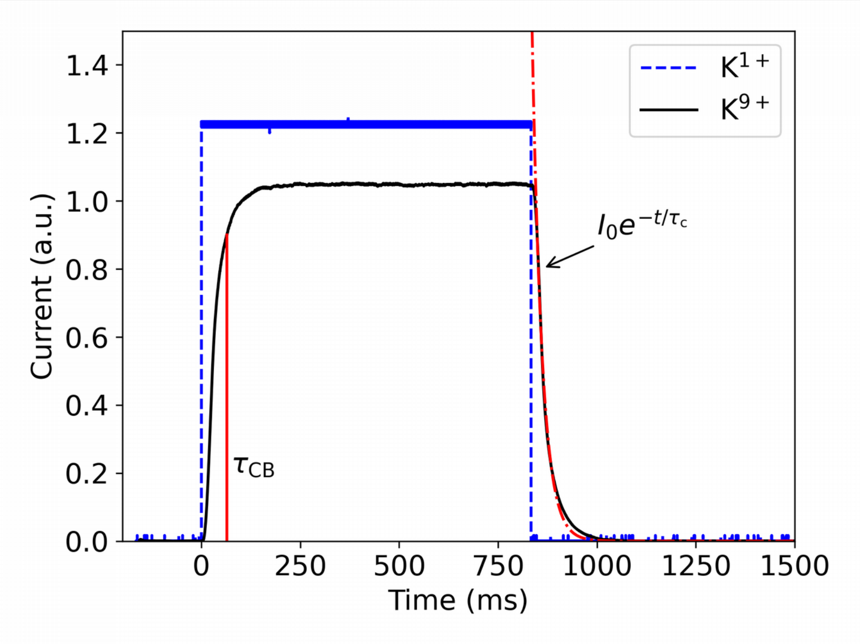


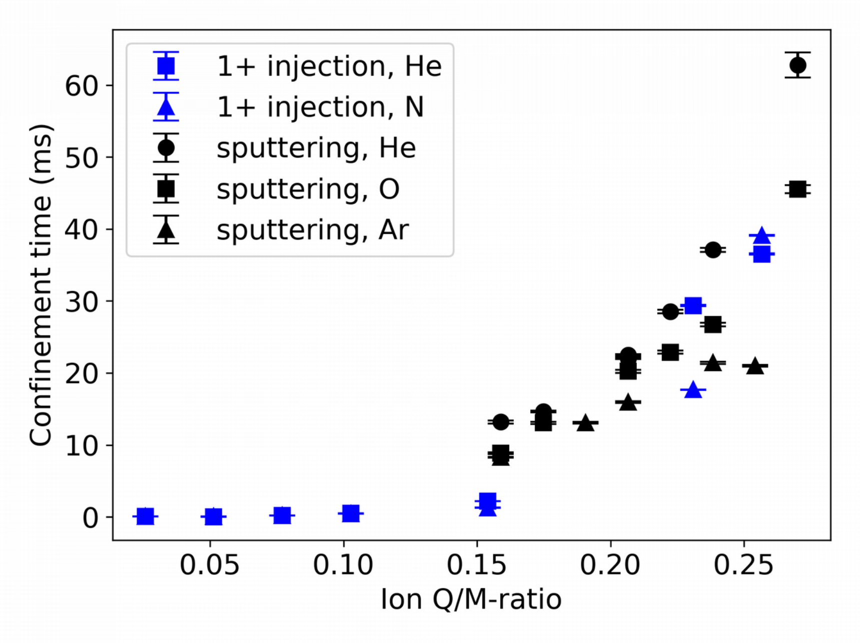
Ion confinement times

- <u>Very important</u> **for RIB production!**
- Focus on transient methods
  - Pulse material injection
  - Study extraction current time structure



Ion confinement times

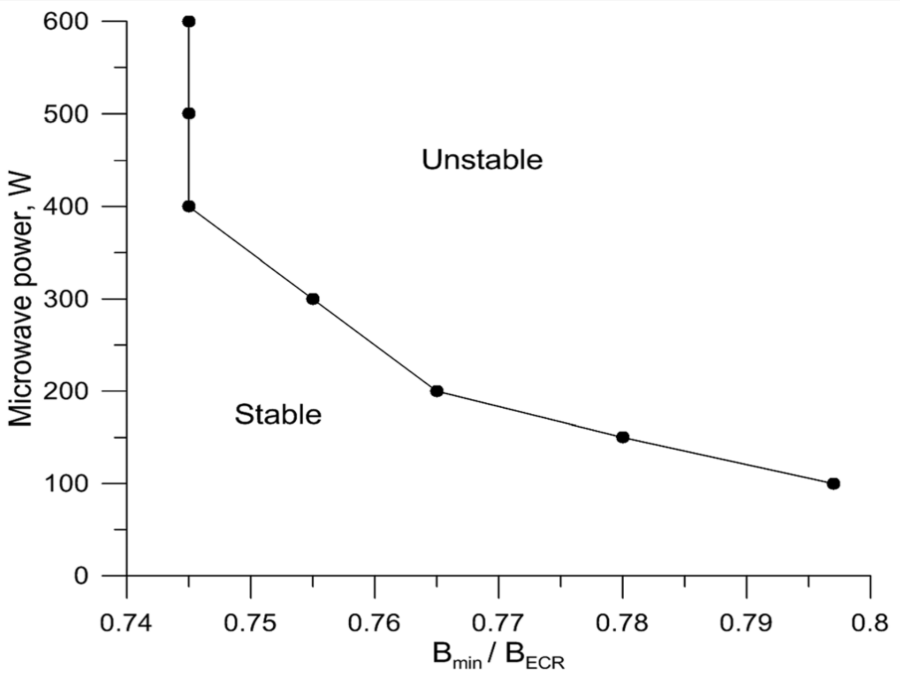
- <u>Very important</u> **for RIB production!**
- Focus on transient methods
  - Pulse material injection
  - Study extraction current time structure
- Mutual agreement in results from conventional and CB-ECRIS
- Long confinement times = partial explanation for high ion temperatures?



Data replotted from M. Marttinen *et al.*, Rev. Sci. Instrum., vol. 91, issue 1, (2020)

Plasma instabilities

- Cross instability threshold →
  - Pulse periodic emission of μW, X-ray and e^-
  - Periodic decline / total collapse of beam



Suppression of cyclotron instability in Electron Cyclotron Resonance ion sources by two-frequency heating

V. Skalyga, I. Izotov, T. Kalvas, H. Koivisto, J. Komppula, R. Kronholm, J. Laulainen, D. Mansfeld, and O. Tarvainen

Citation: Physics of Plasmas **22**, 083509 (2015); doi: 10.1063/1.4928428

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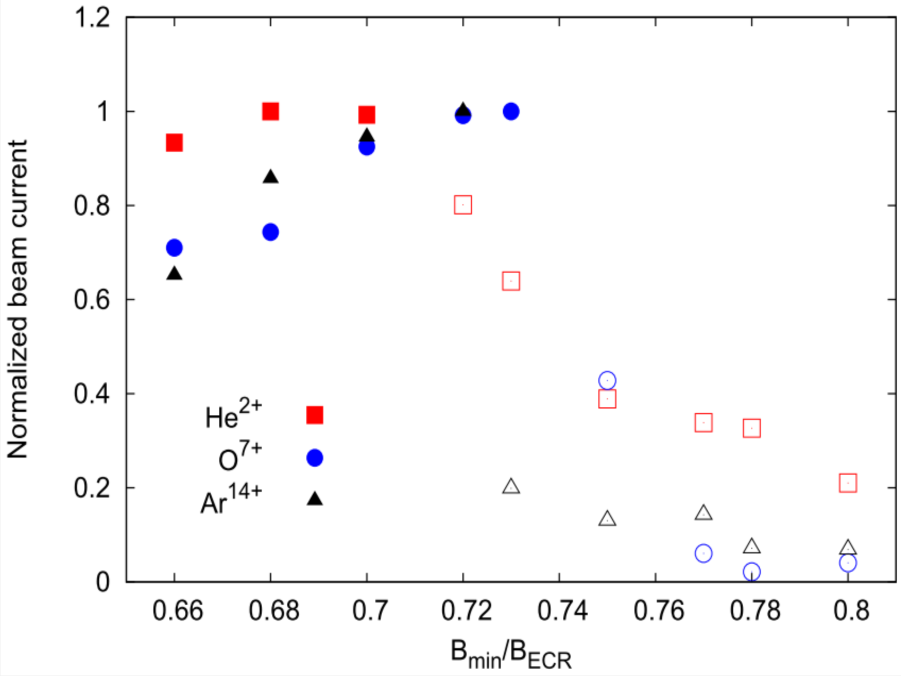

Plasma instabilities

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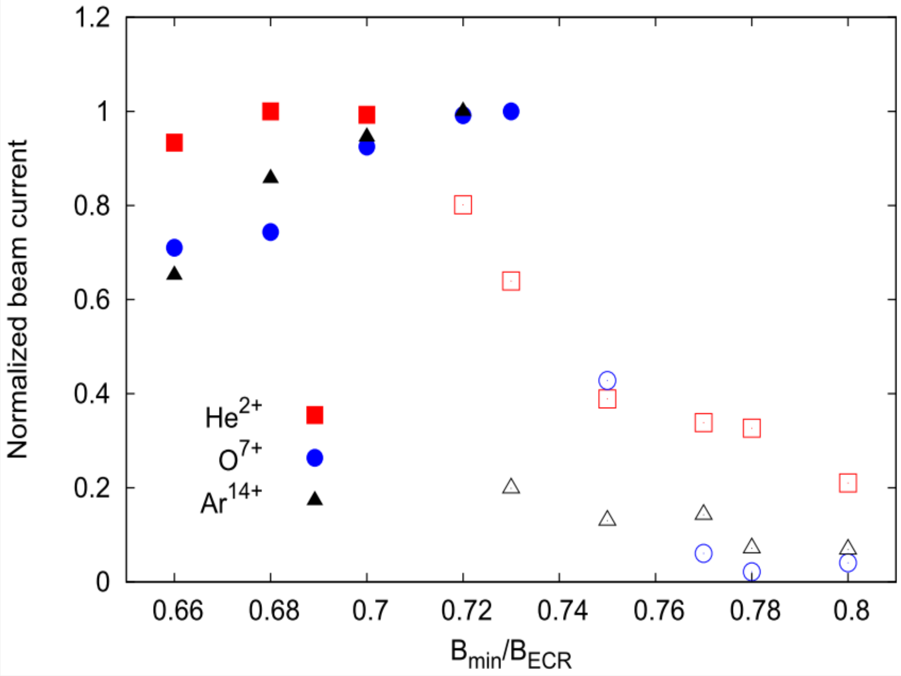
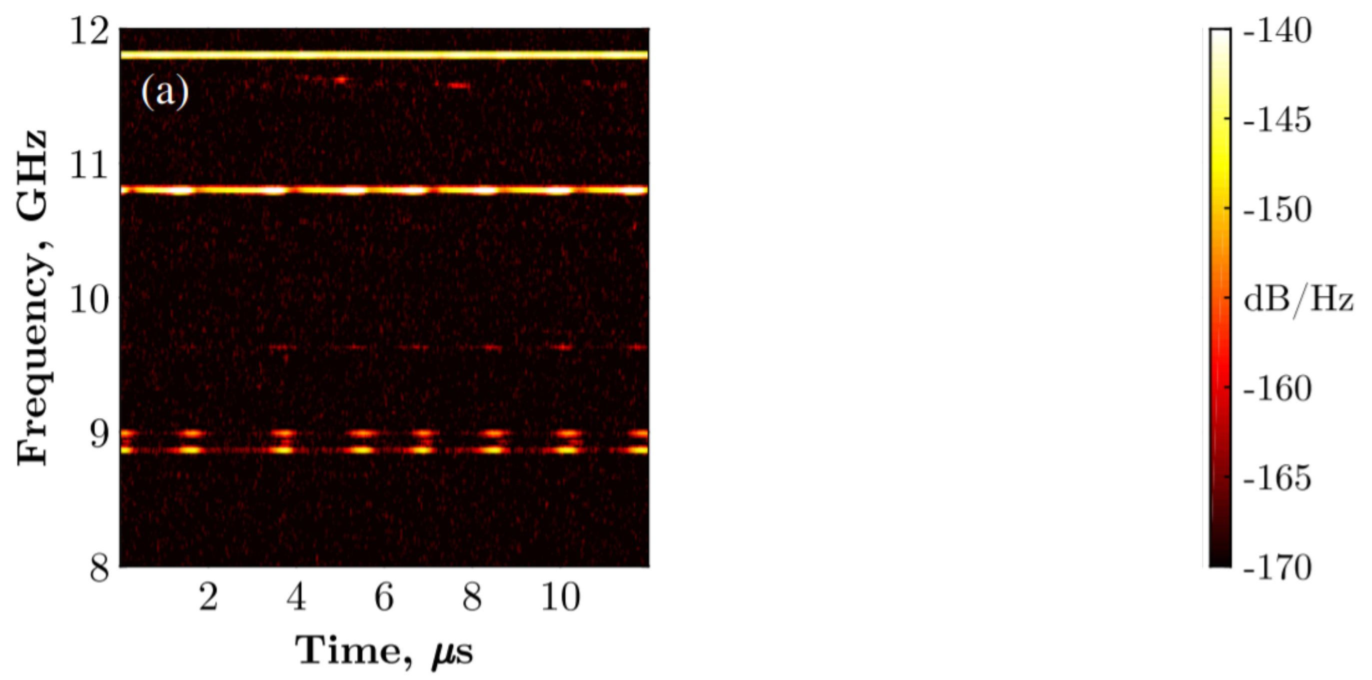
Increase B_{min}/B_{ECR} further?



Plasma instabilities

Increase B_{min}/B_{ECR} →

- Transition into “CW emission” / maser regime:



PHYSICAL REVIEW LETTERS **120,** 155001 (2018)

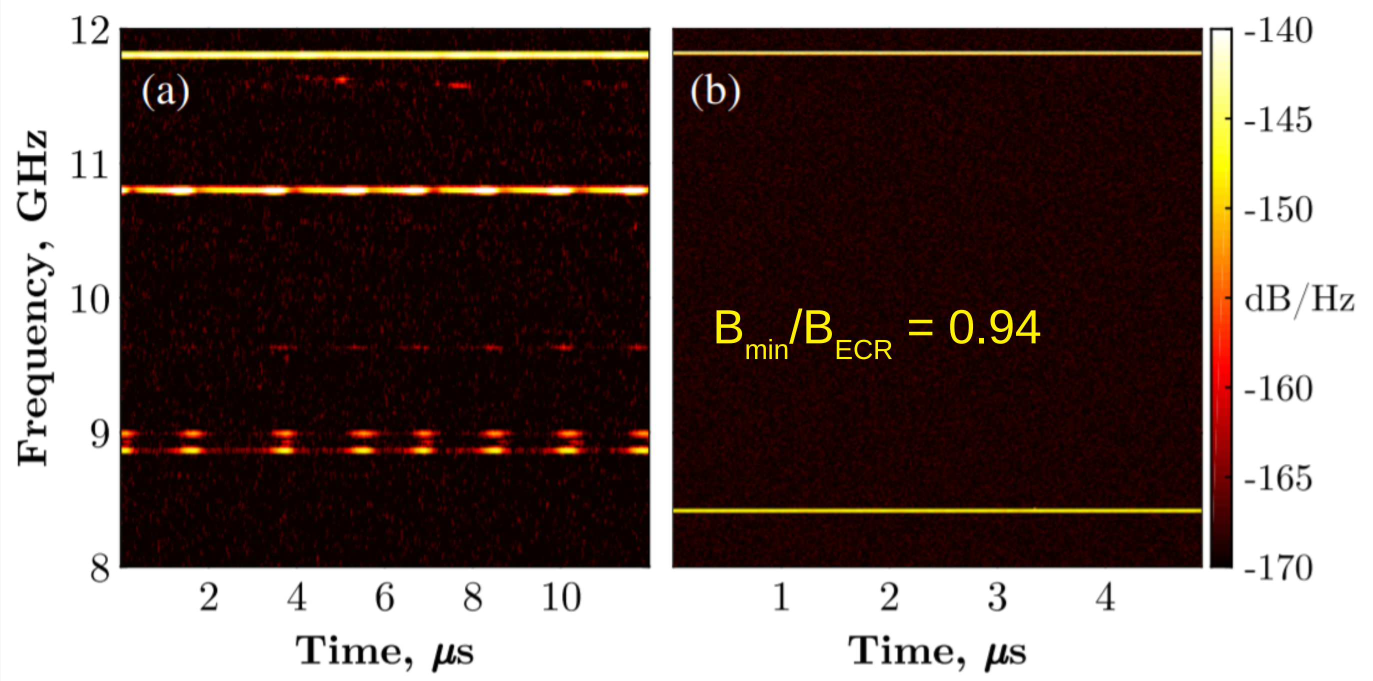
Observation of Poincaré-Andronov-Hopf Bifurcation in Cyclotron Maser Emission from a Magnetic Plasma Trap

A. G. Shalashov,[1,*] E. D. Gospodchikov,[1] I. V. Izotov,[1] D. A. Mansfeld,[1] V. A. Skalyga,[1] and O. Tarvainen[2]
[1]*Institute of Applied Physics, Russian Academy of Sciences (IAP RAS), 46 Ulyanova st., 603950 Nizhny Novgorod, Russia*
[2]*Department of Physics, University of Jyvaskyla, PO Box 35 (YFL), 40500 Jyvaskyla, Finland*

Plasma instabilities

Increase B_{min}/B_{ECR} →

- Transition into "CW emission" / maser regime:
  - Continuous µW emission



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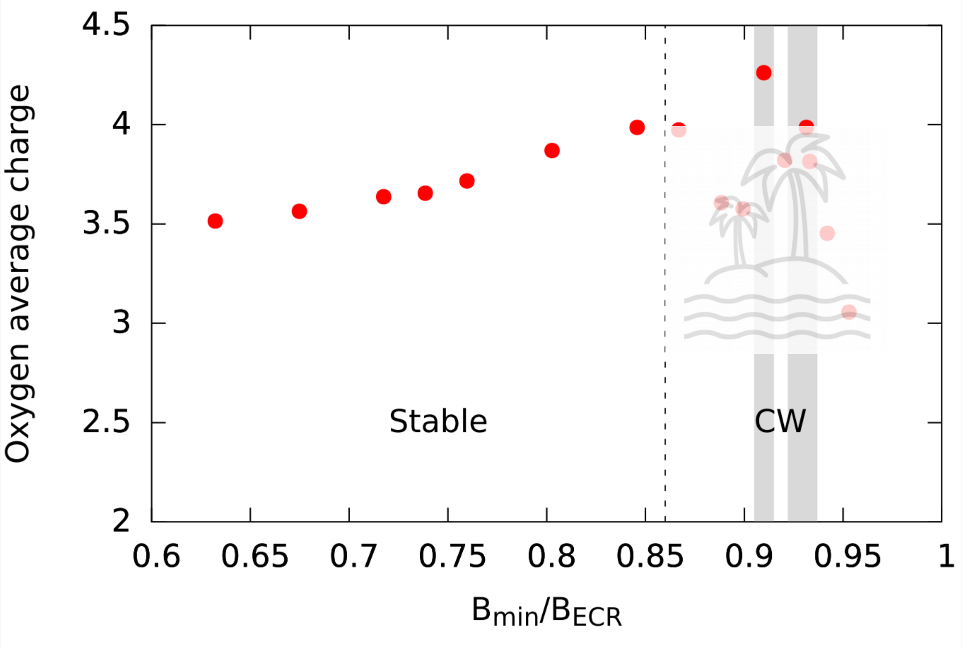
Plasma instabilities

Increase B_{min}/B_{ECR} →

- Transition into "CW emission" / maser regime:
  - Continuous µW emission
  - Average charge of extracted oxygen sometimes higher than in stable regime!



Data replotted from V. Skalyga et al., submitted to PRL (2020).

'Tuning an ECR ion source is searching for an island of stability in a sea of turbulence'

- R. Geller

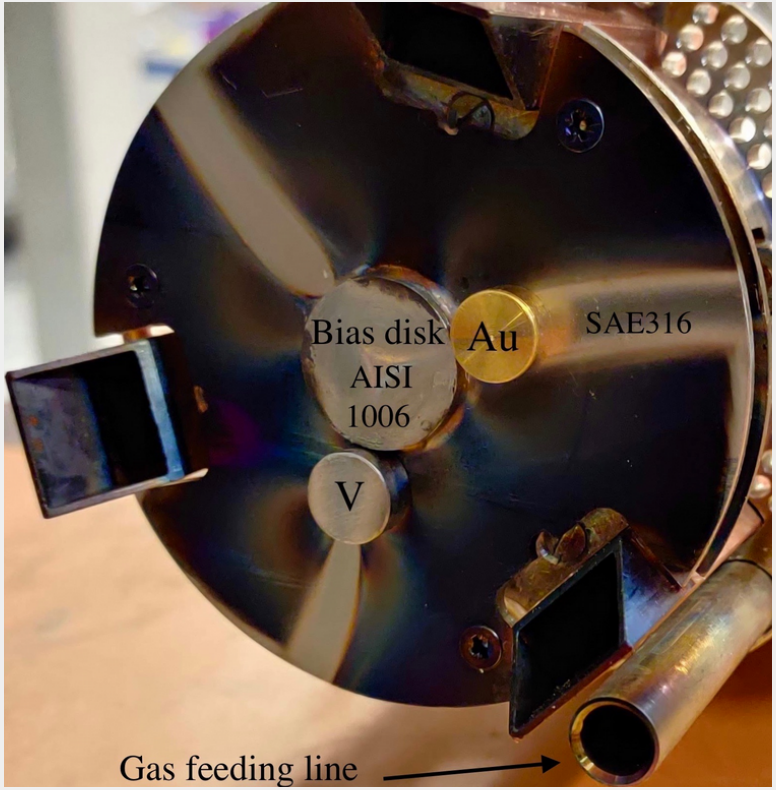
Source Development

- HIISI experiences
- CUBE-ECRIS

HIISI 18 GHz ECRIS

- One year running since commissioning.
- In active use at the K130 cyclotron.
- Produces high intensities and high charge states.

- Problems during 1st year of operation:
  - one hardened O-ring



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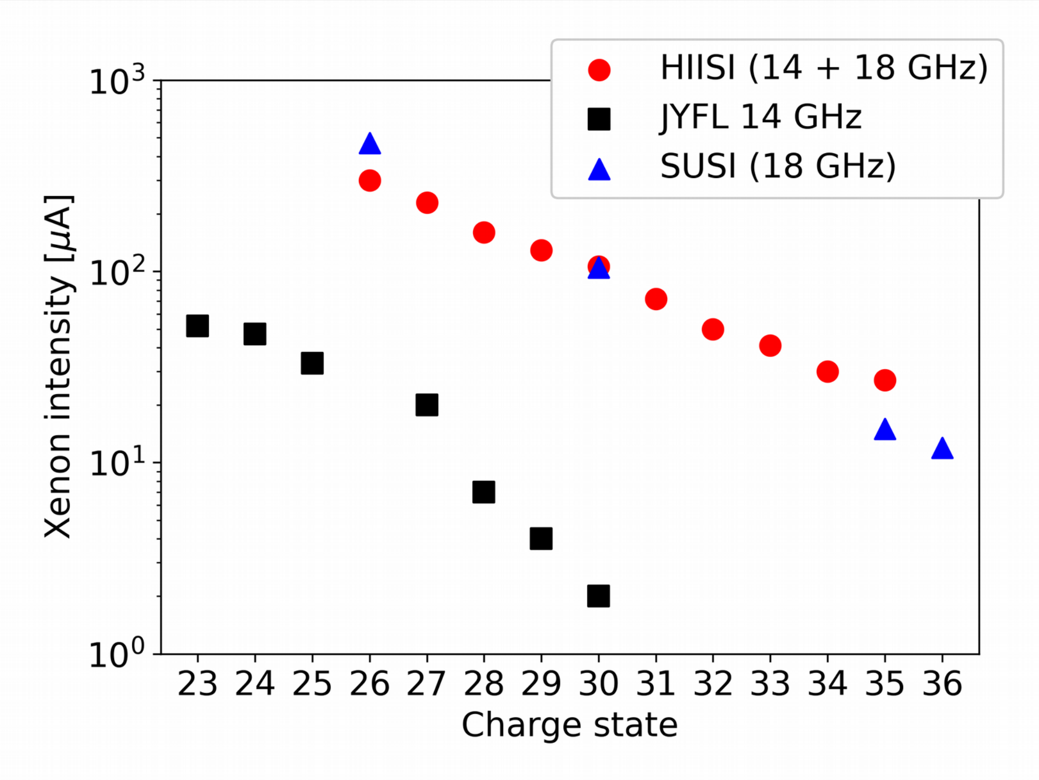
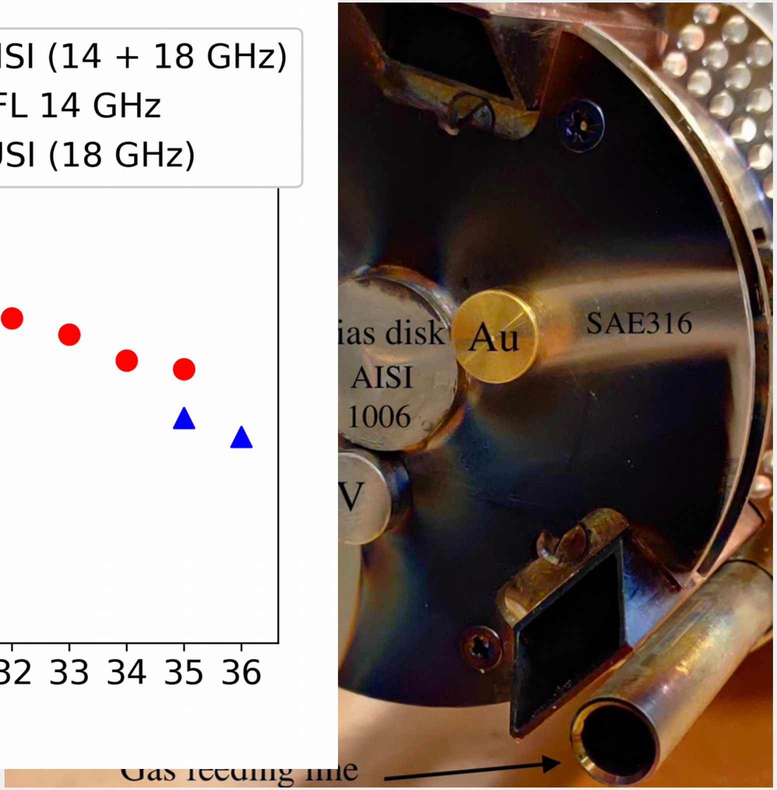
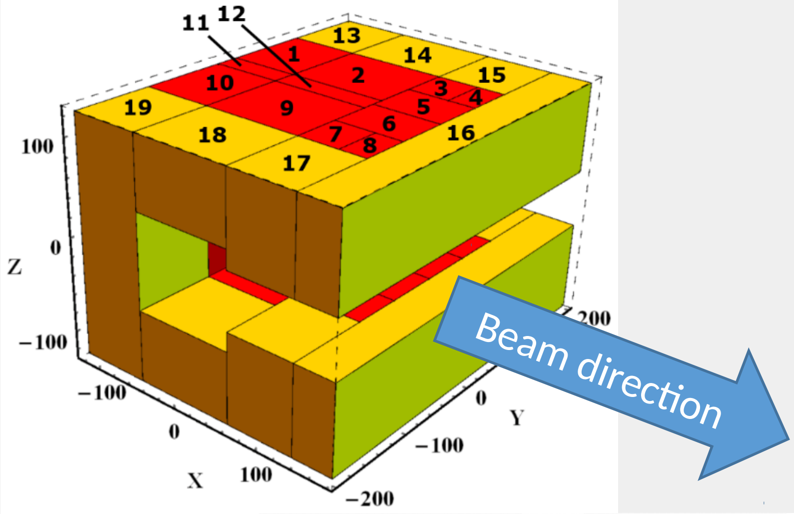


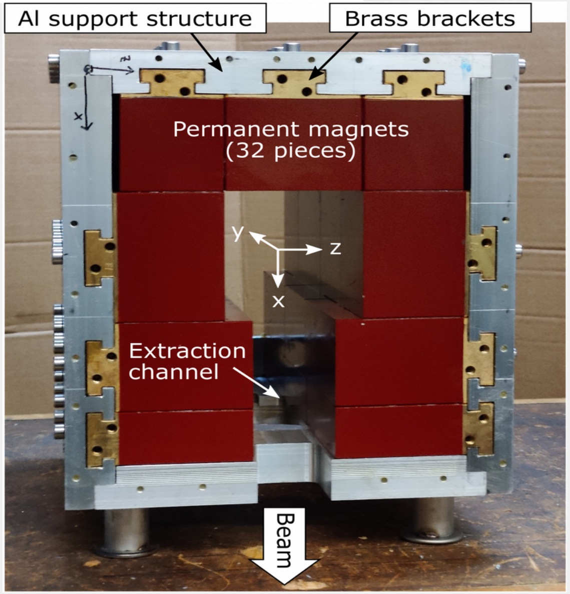


CUBE-ECRIS

- Unconventional min-B quadrupole field topology based on the ARC-ECRIS design, but with permanent magnets.
- **Scalable to 100 GHz** using existing superconductor tech.

- Goals:
  - study HCI production
  - demonstrate slit beam extraction
- Magnet assembly is finished and the resulting field is verified
- First plasma expected in Q1/2021





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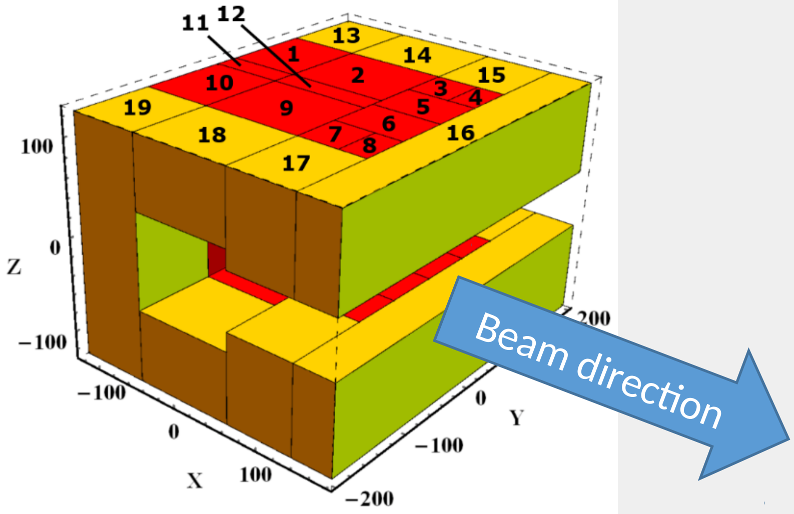

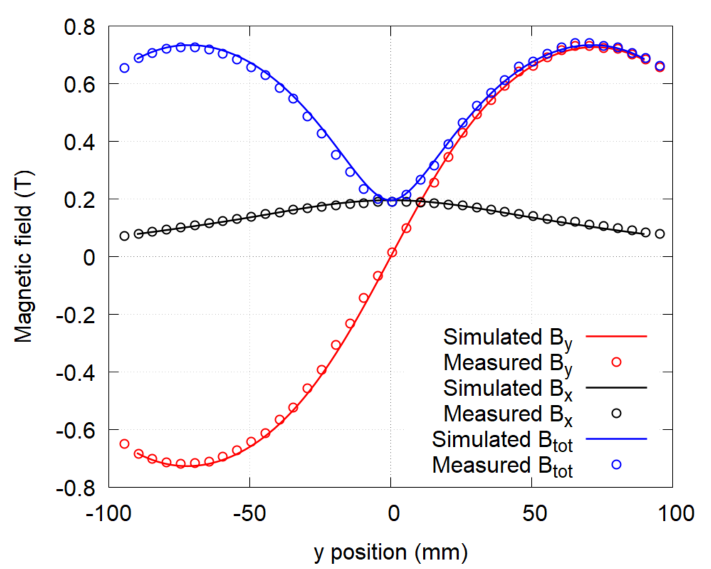

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