Status of PIPERADE

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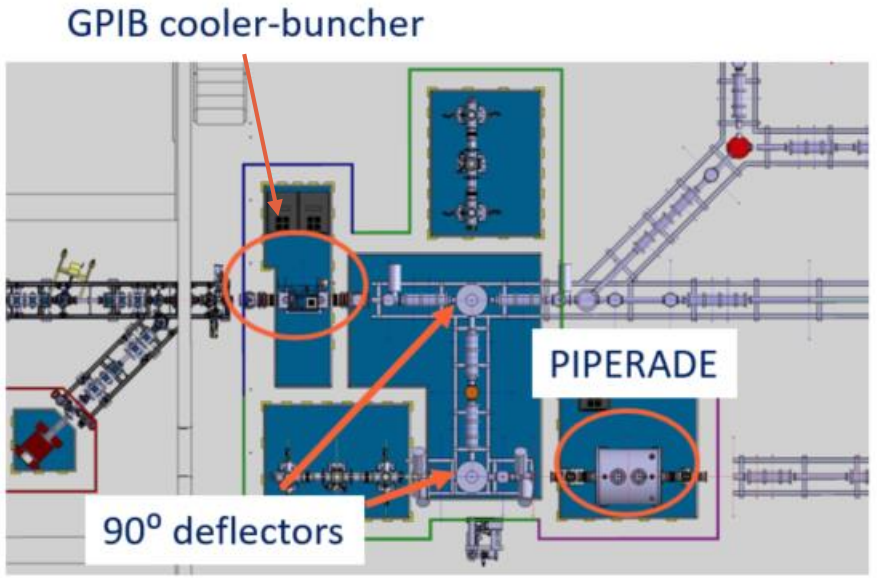
Outline

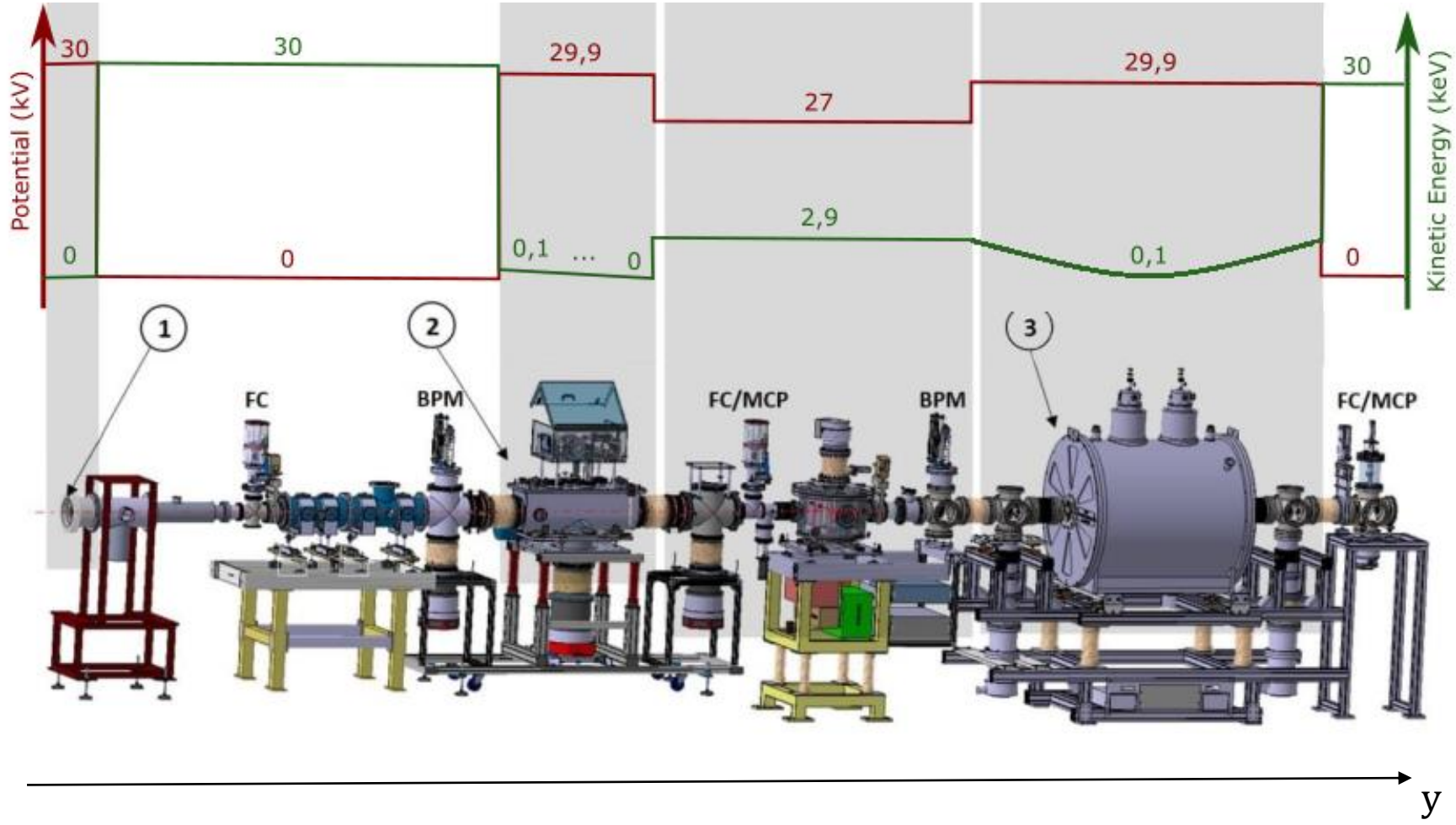
- Context of PIPERADE
- How to trap ions
- ToF-ICR improvements
- Diaphragm change
- New hexagonal MCP
- Conclusion

Why do we develop PIPERADE ?



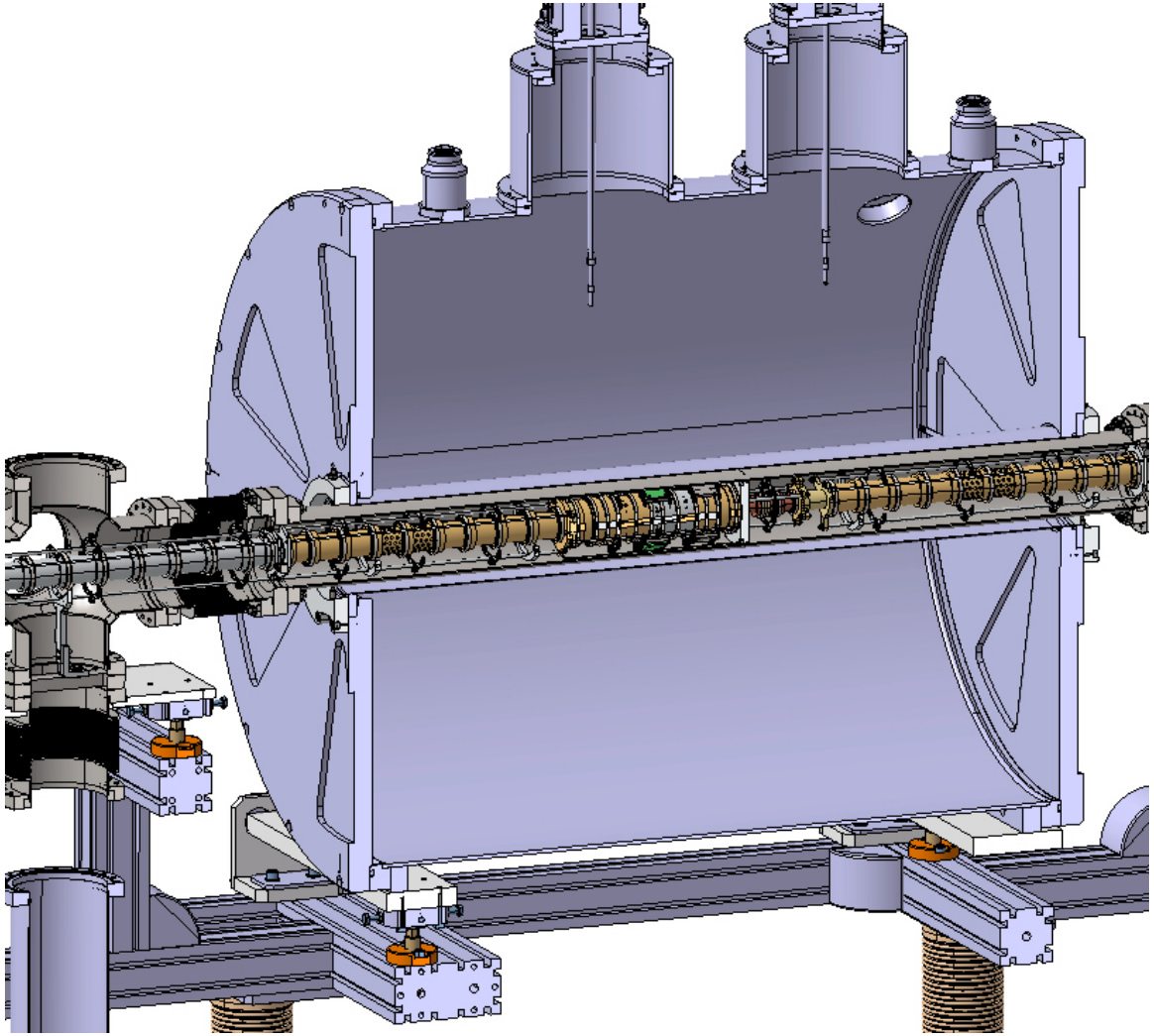
- High-resolution purification of isobars and isomers
- High-precision mass measurements of exotic nuclides

PIPERADE at LP2i Bordeaux

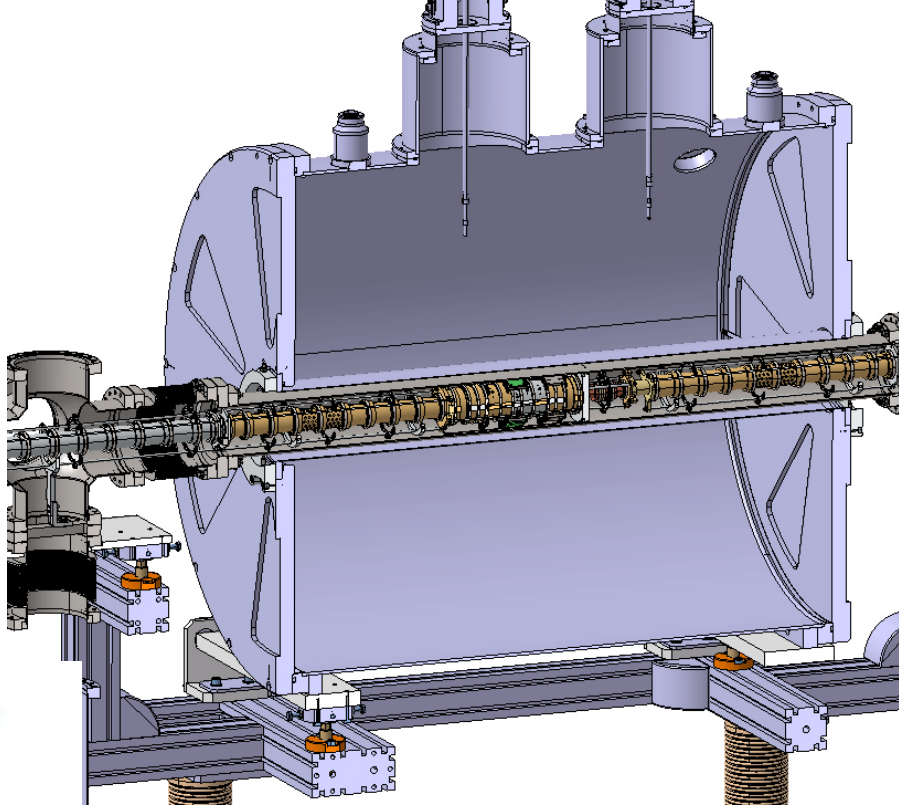


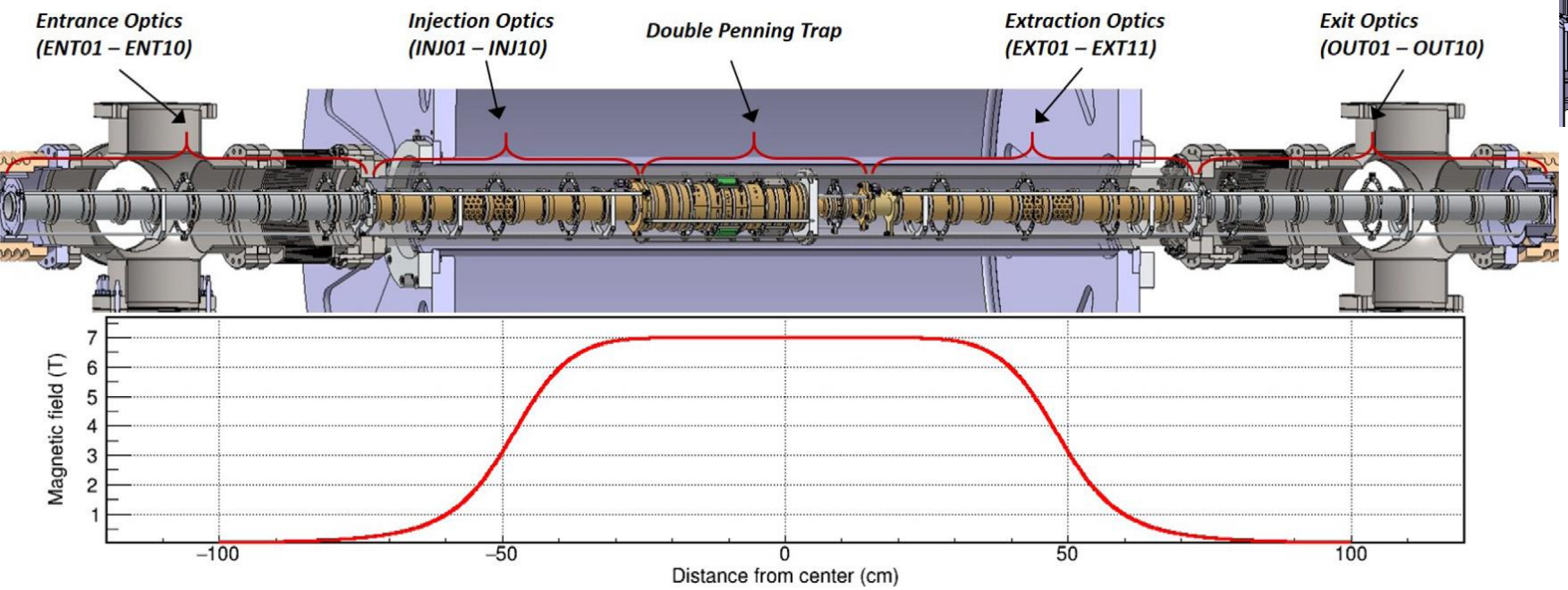
1. Surface ionisation source
2. General Purpose Ion Buncher(GPIB)
3. Penning traps (PIPERADE)

How do we trap Ions ?

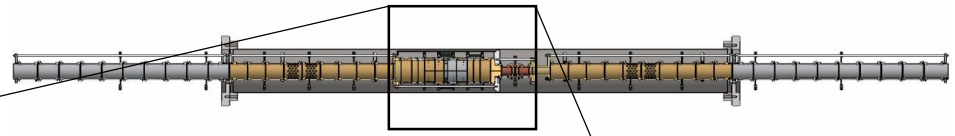


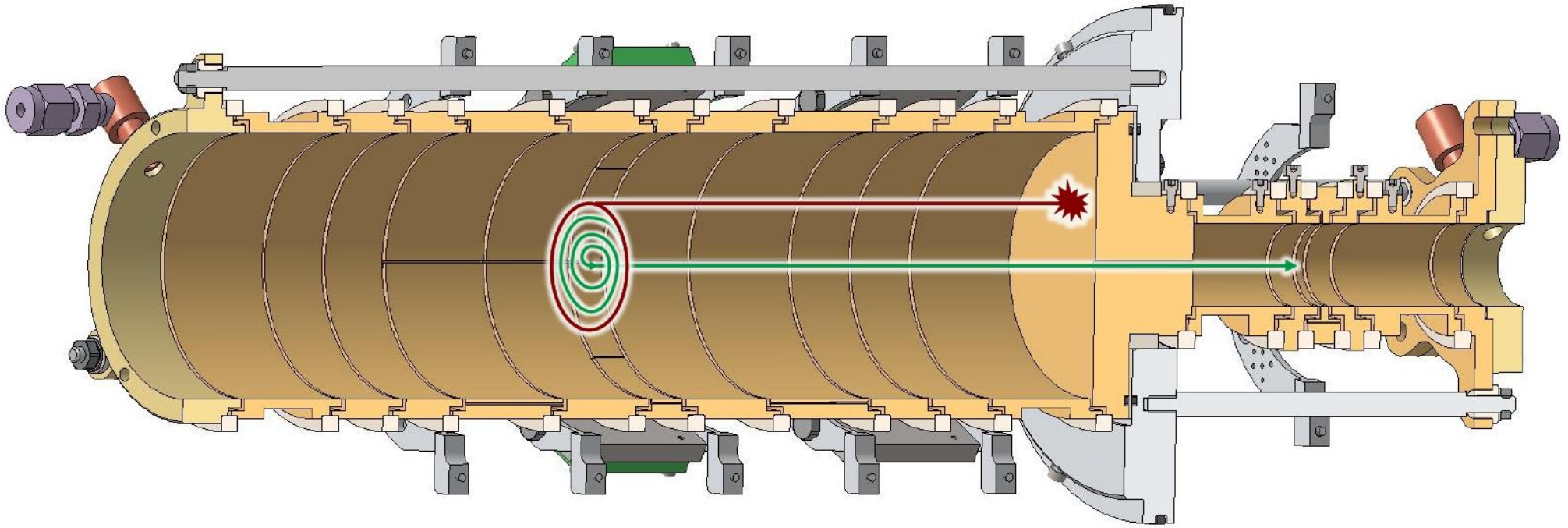
How do we trap Ions ?





Buffer Gas Cooling





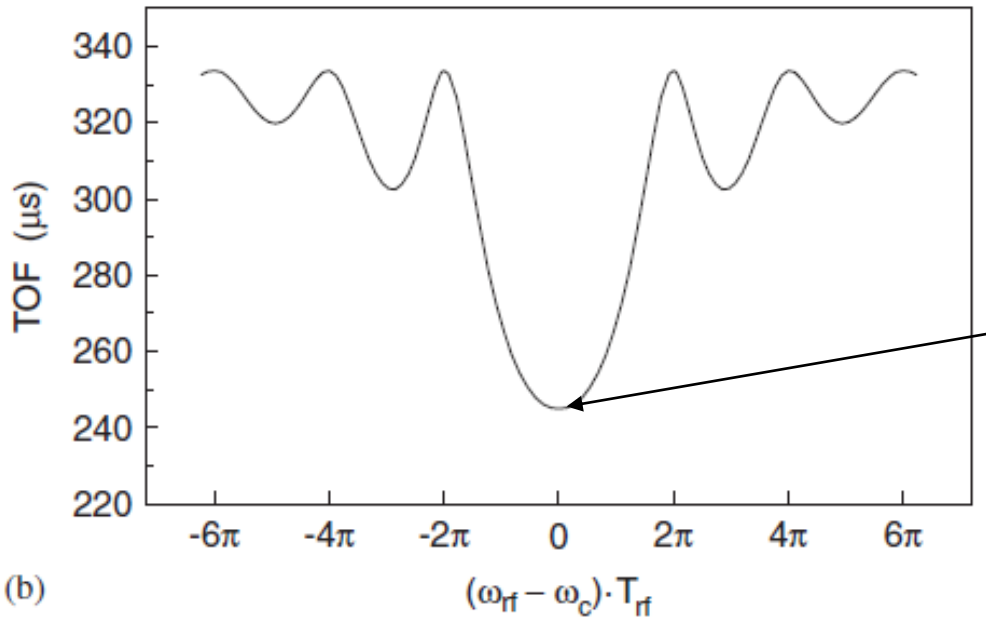
Implemented on PIPERADE with a resolution of 10^5

Time of Flight Ion Cyclotron Resonance

- Give radial energy to the ions
- Then convert it to axial energy
- Therefore ToF is shorter at the resonance

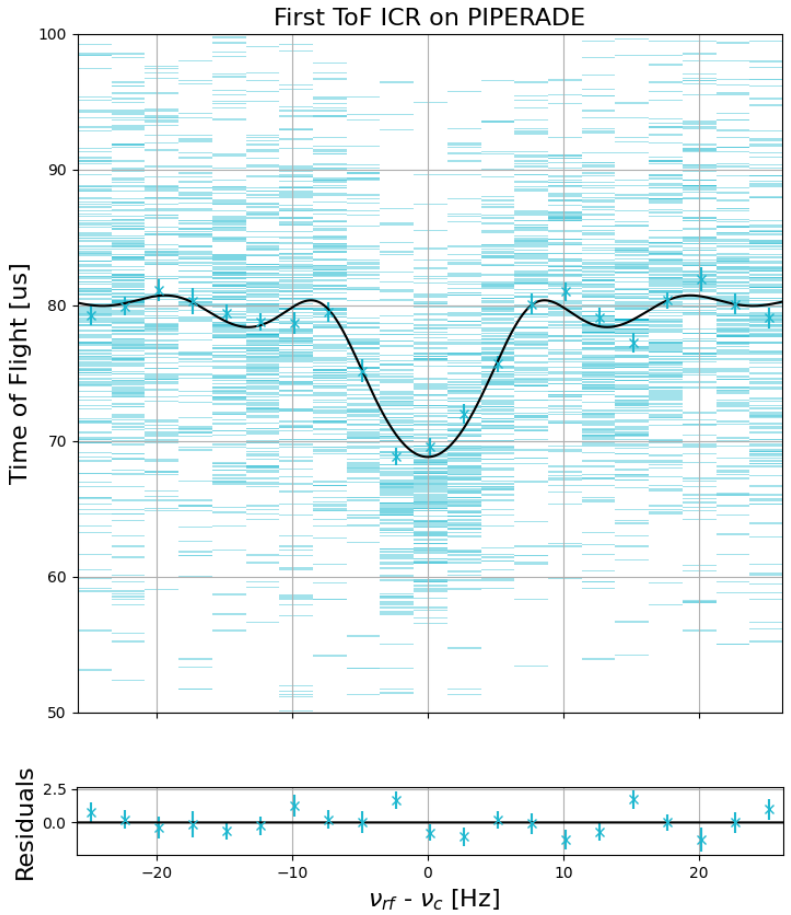
M. Koenig, et al., Quadrupole excitation of stored ion motion at the true cyclotron frequency, Int. J. Mass Spectrom. 31 (1995) 95, https://doi.org/10.1016/0168-1176(95)04146-C

Ideal ToF ICR



$$\nu_c = \frac{qB}{2\pi m}$$

First ToF-ICR on PIPERADE



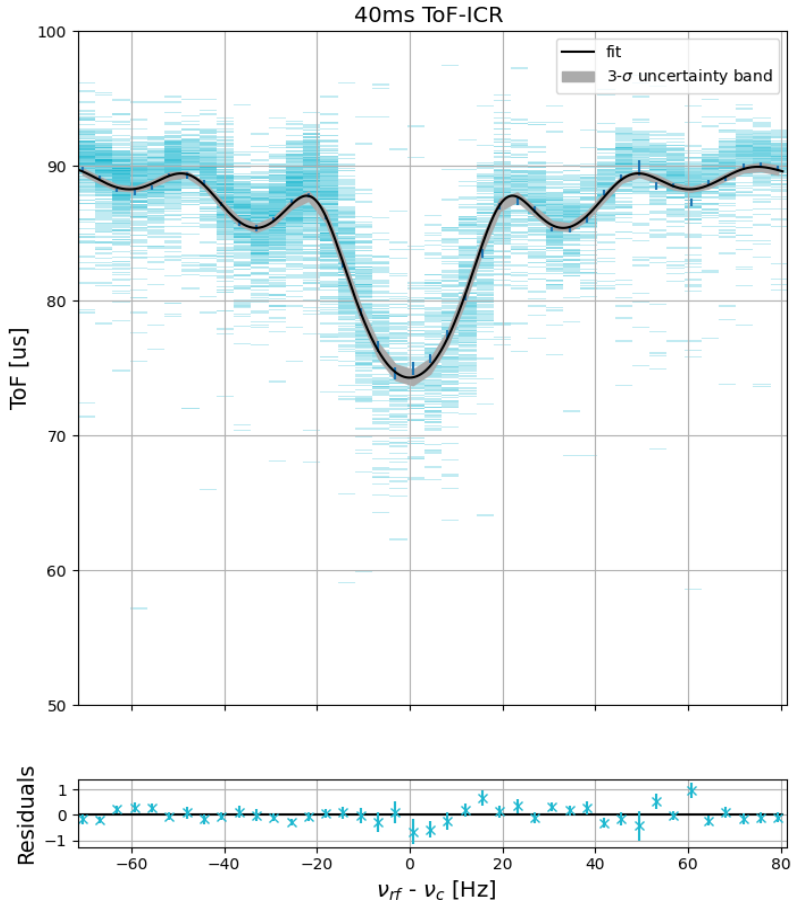
$$Excitation\ Time\ of\ 100\ ms$$

$$\nu_c = 2752475{,}72\ \pm 0{,}23\ Hz$$

The ion bunch is not well defined and really large

$$\boldsymbol{\nu_c = \frac{qB}{2\pi m}}$$

Improvements



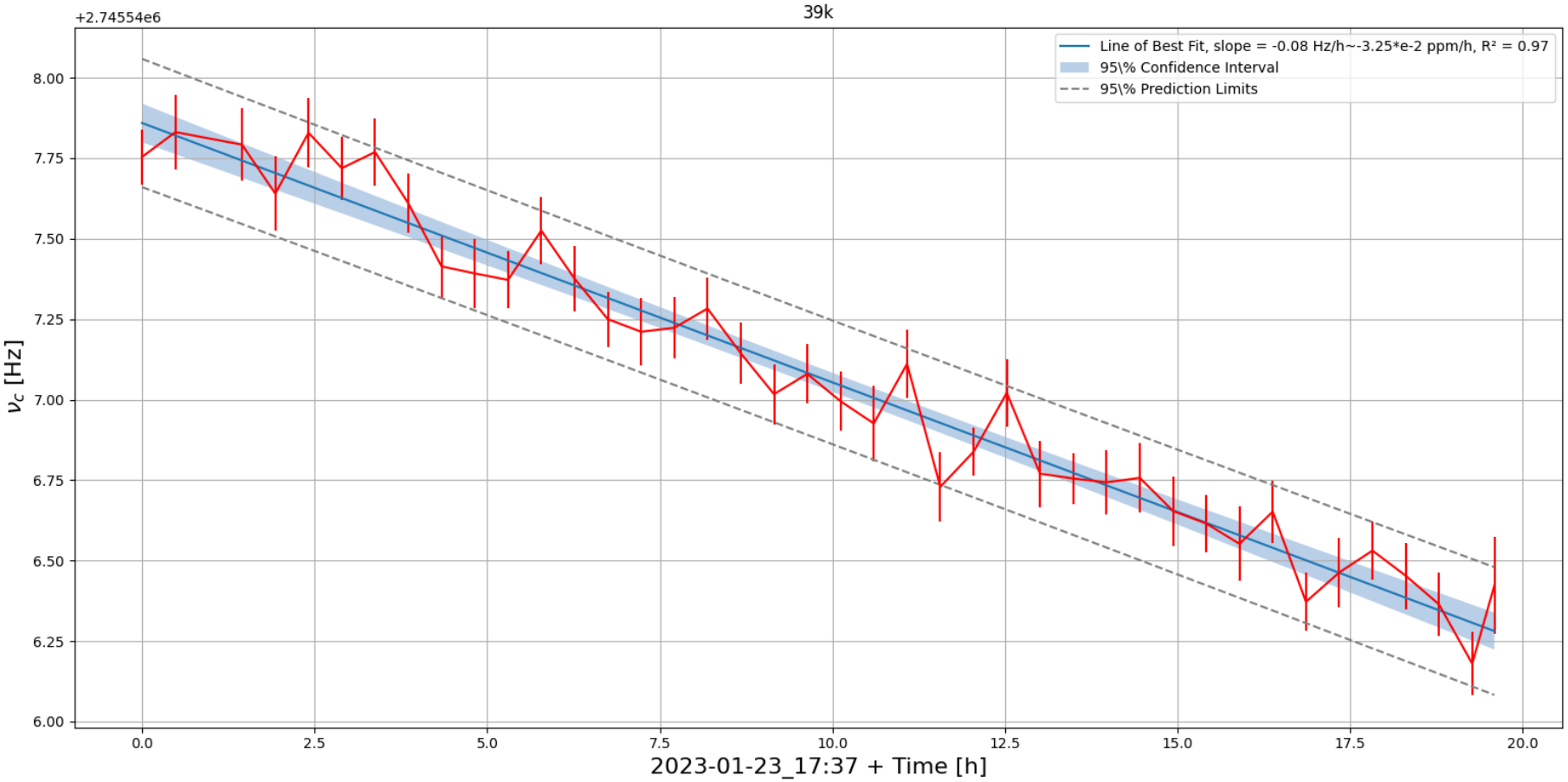
$$Excitation\ Time\ of\ 40\ ms$$

$$\nu_c = 2745830{,}56\ \pm 0{,}11\ Hz$$

Better defined bunch
Optimised extraction shape
Better preparation in the first trap

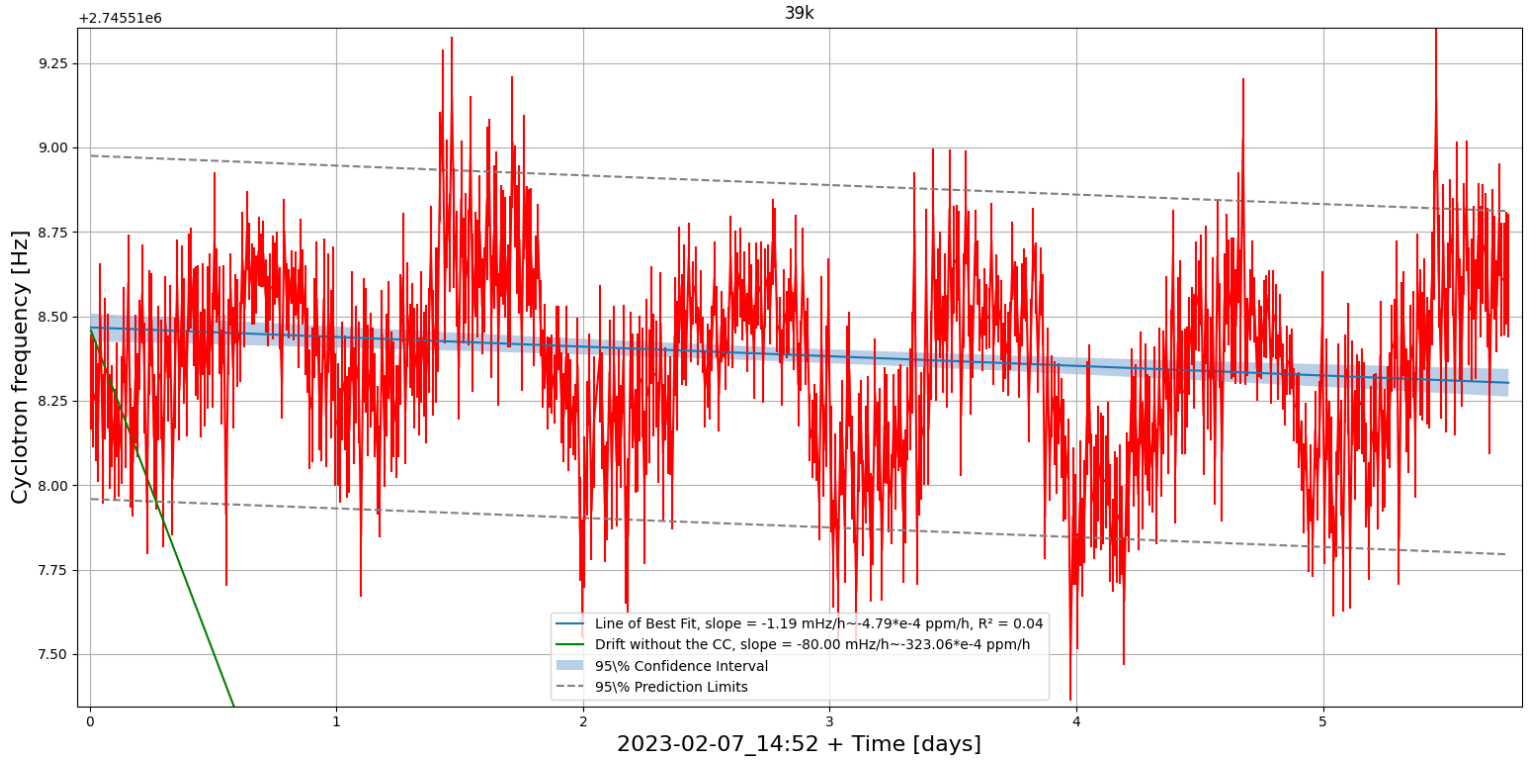
$$\boldsymbol{\nu_c = \frac{qB}{2\pi m}}$$

Drift of the magnetic field



$$\frac{\Delta B}{B} = -3{,}2 \pm 0{,}1\ 10^{-8}\ h^{-1}$$

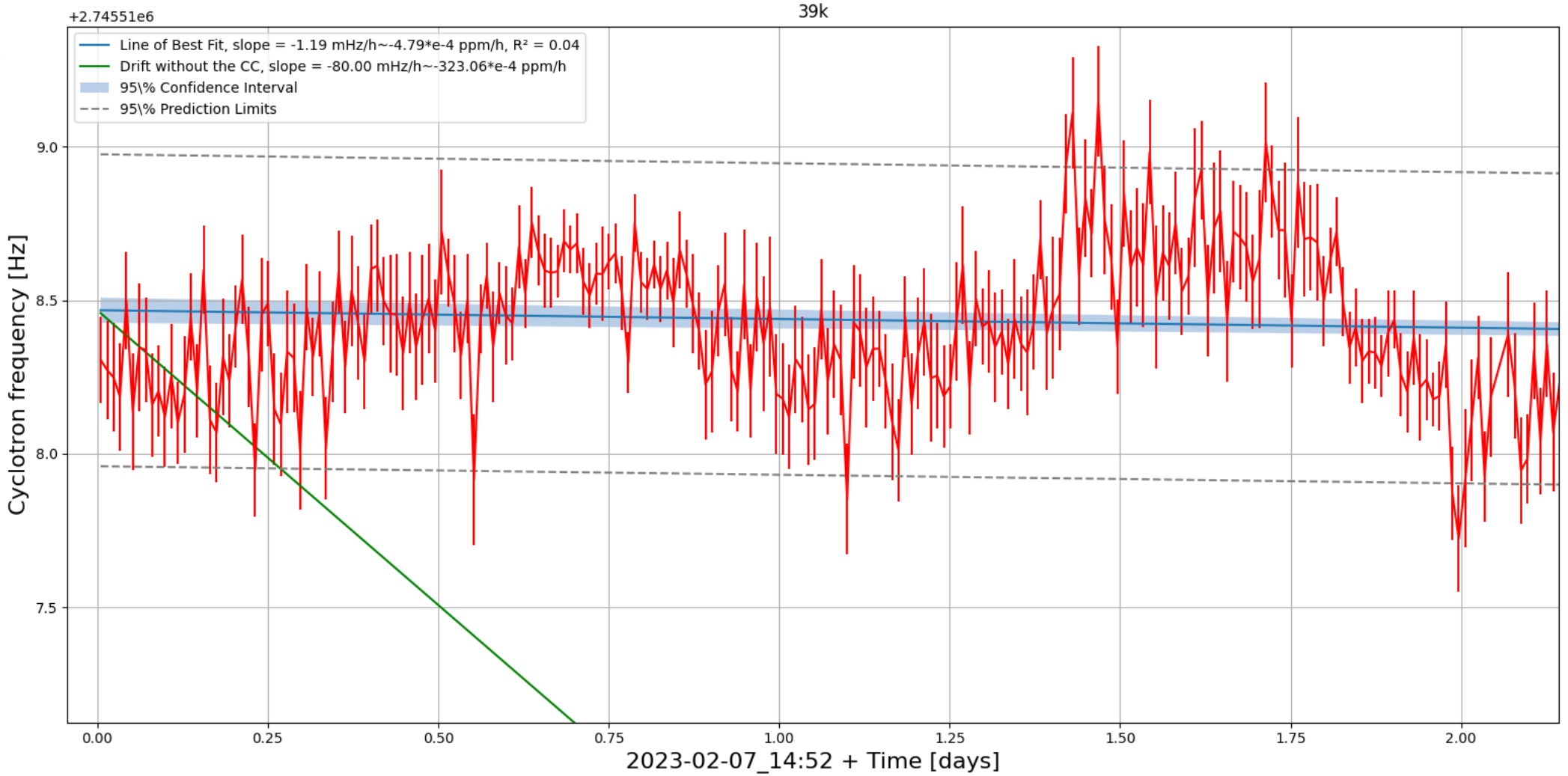
Compensating coil



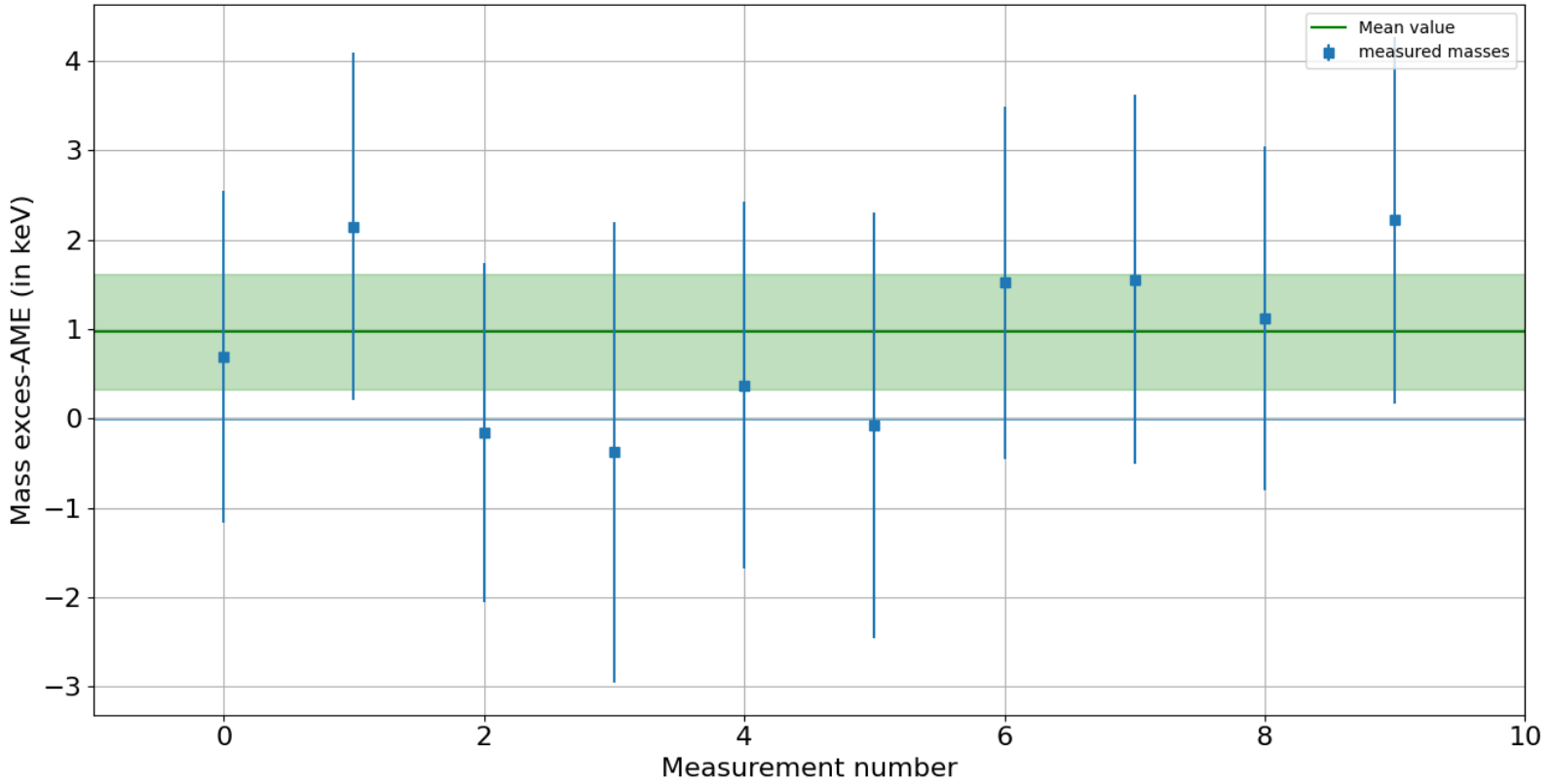
$$\frac{\Delta B}{B} = -3{,}2 \pm 0{,}1\ 10^{-8}\ \ h^{-1}$$

$$\frac{\Delta B_{cc}}{B_{cc}} = -4{,}79 \pm 0{,}97\ 10^{-10}\ \ h^{-1}$$

Compensating coil



Mass measurement of ^{41}K vs ^{39}K



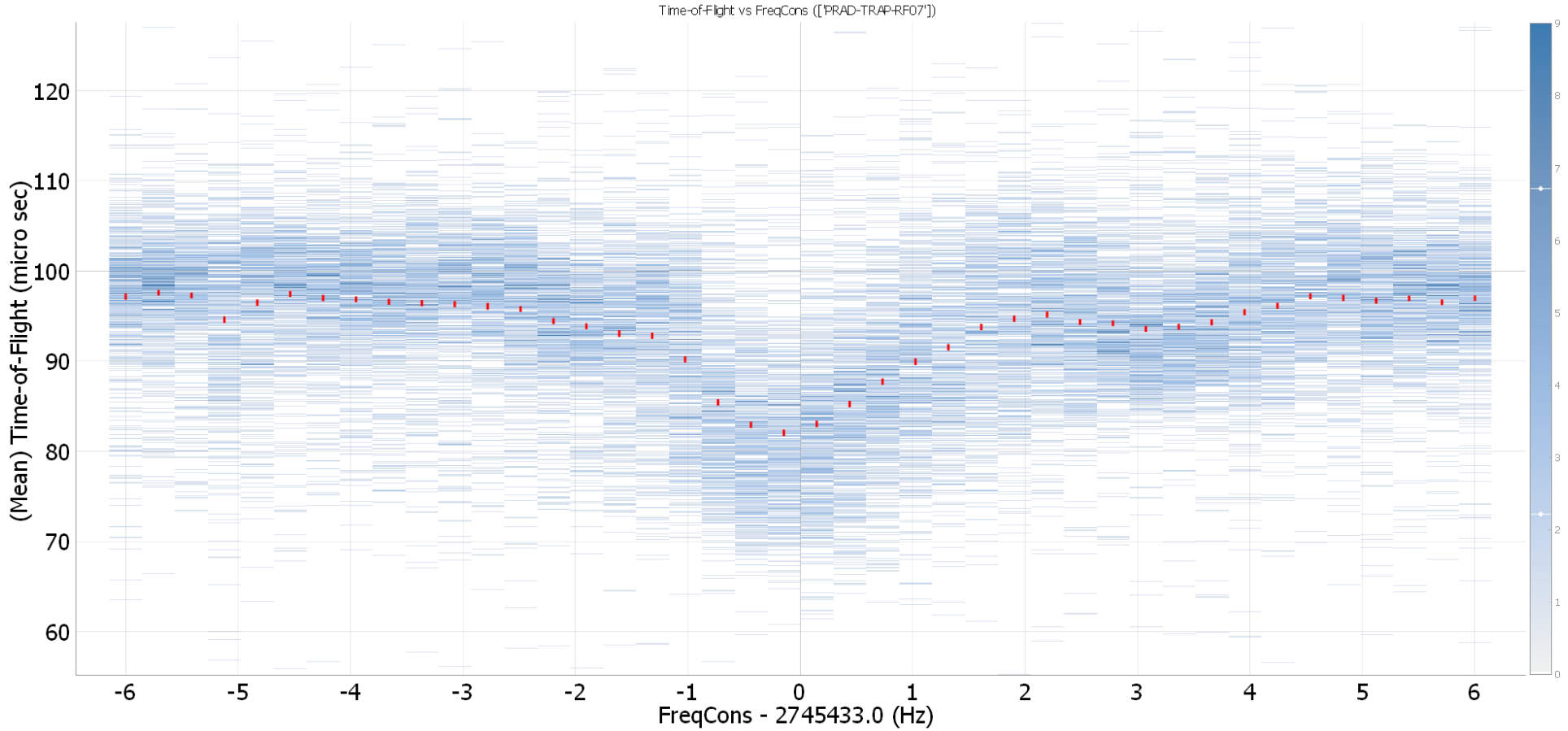
Measured with a well known reference (^{39}K)

$$\nu_c = \frac{qB}{2\pi m} \quad (+1)$$

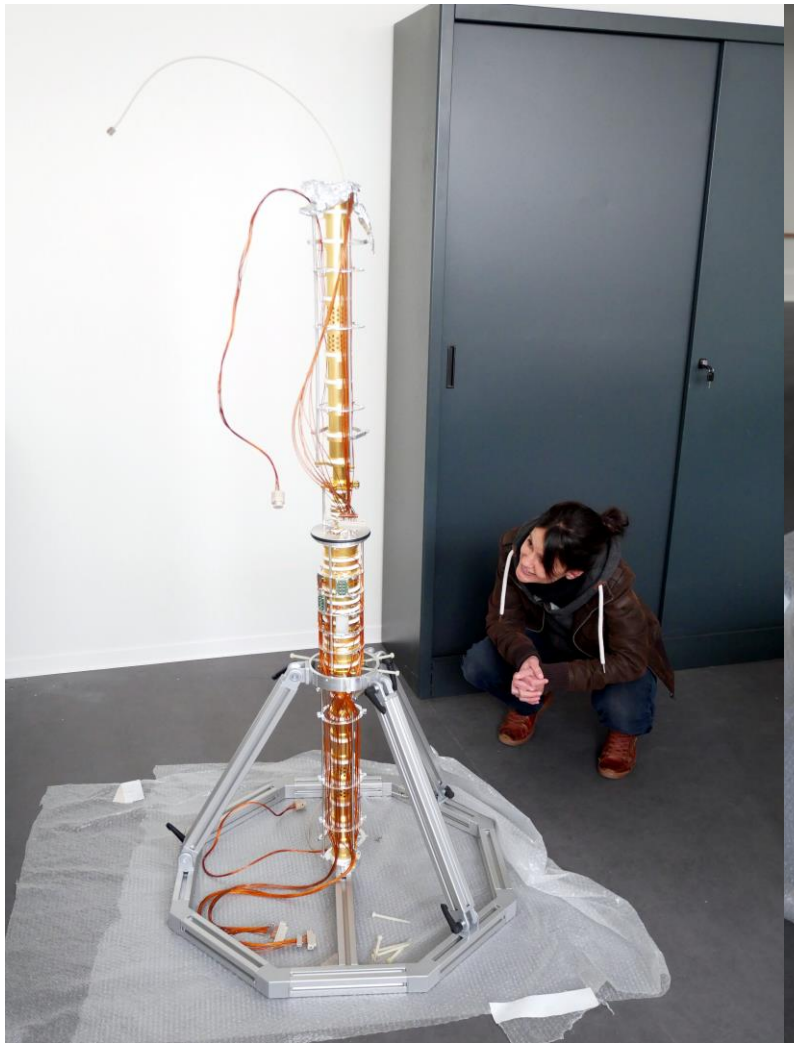
Done without the compensating coil

What are the limitations ?

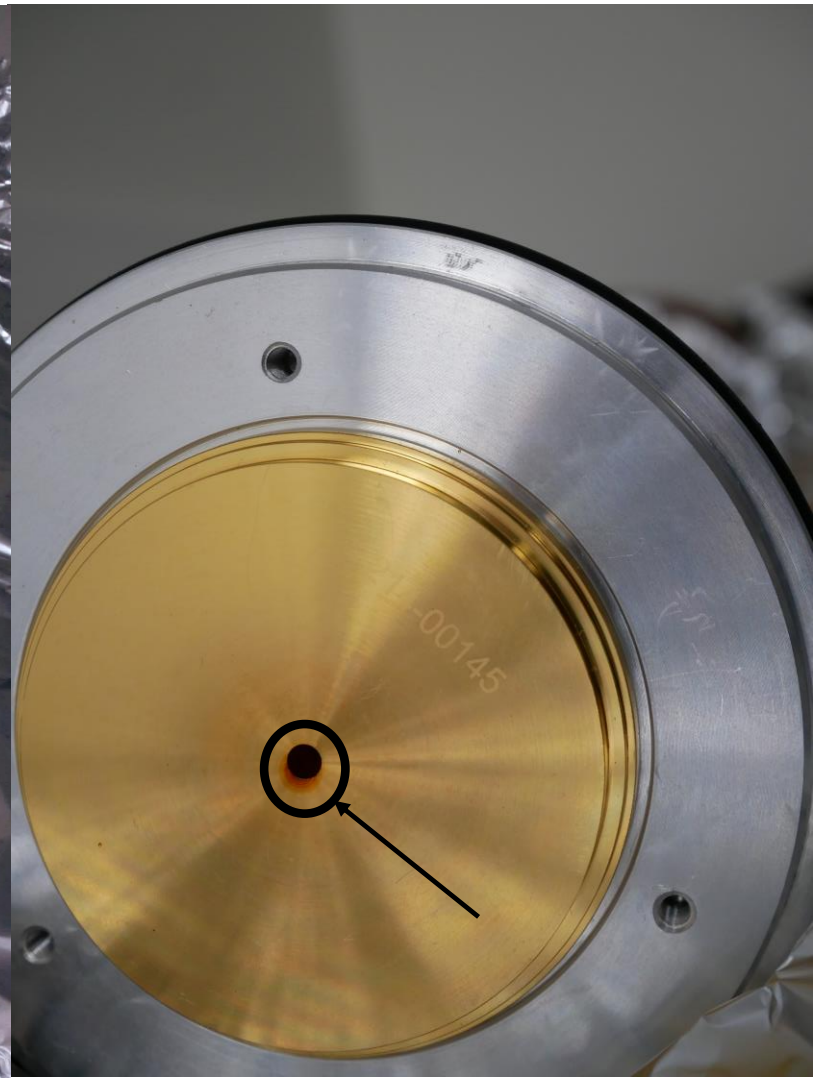
500 ms ToF-ICR



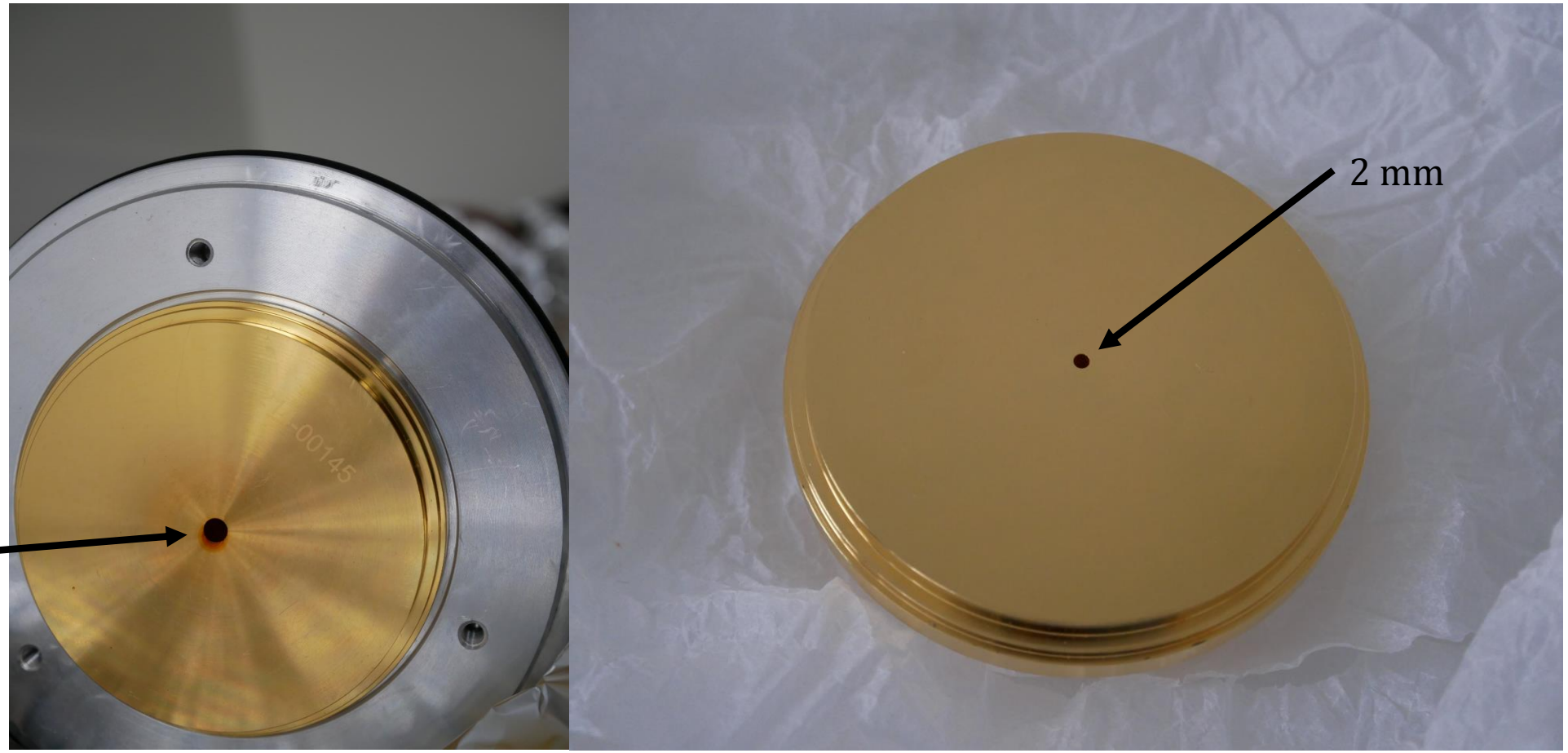
Diaphragm change



Old diaphragm



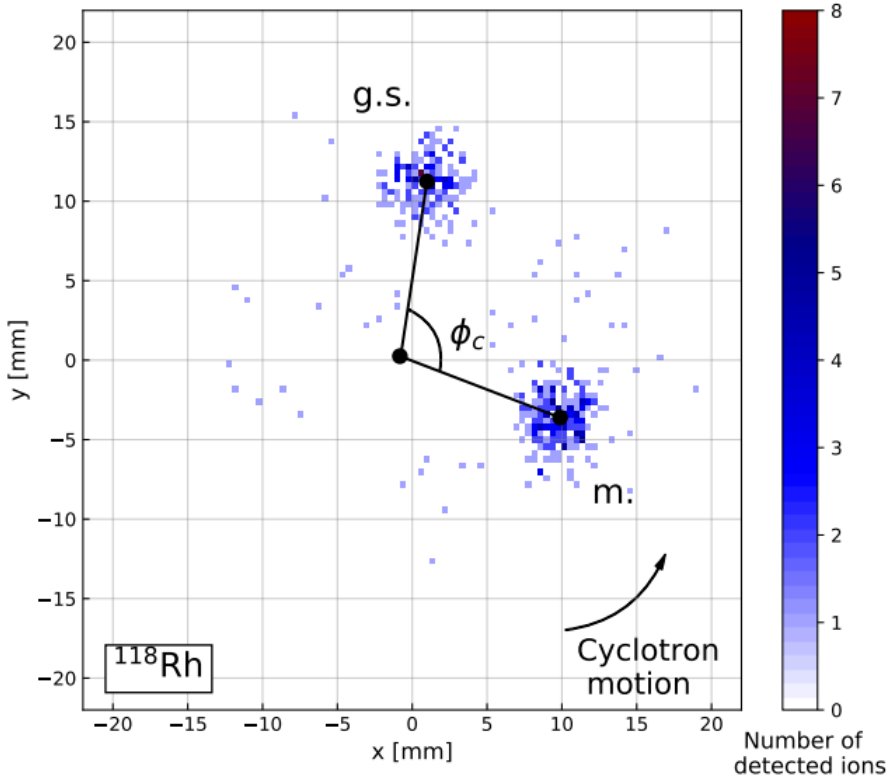
New diaphragm



Phase-Imaging Ion-Cyclotron-Resonance technique

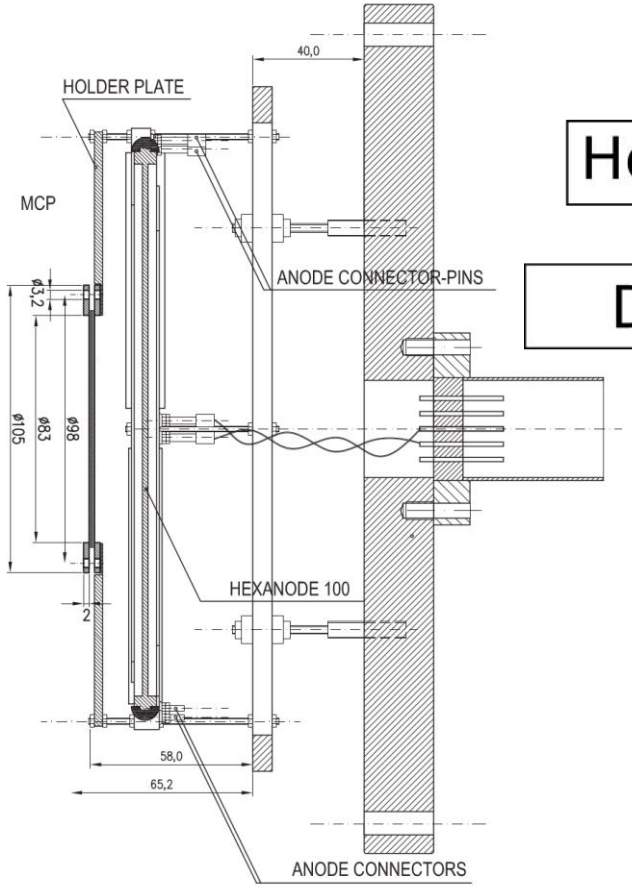
- PI-ICR powerful tool for high precision mass measurements and for phase dependant cleaning of ion beams
  - 40 times higher resolving power
  - 5 times increase in precision **compared to TOF-ICR**
  - Drawback: setting up time is long for each case, high sensitivity to fluctuations of trap-voltages

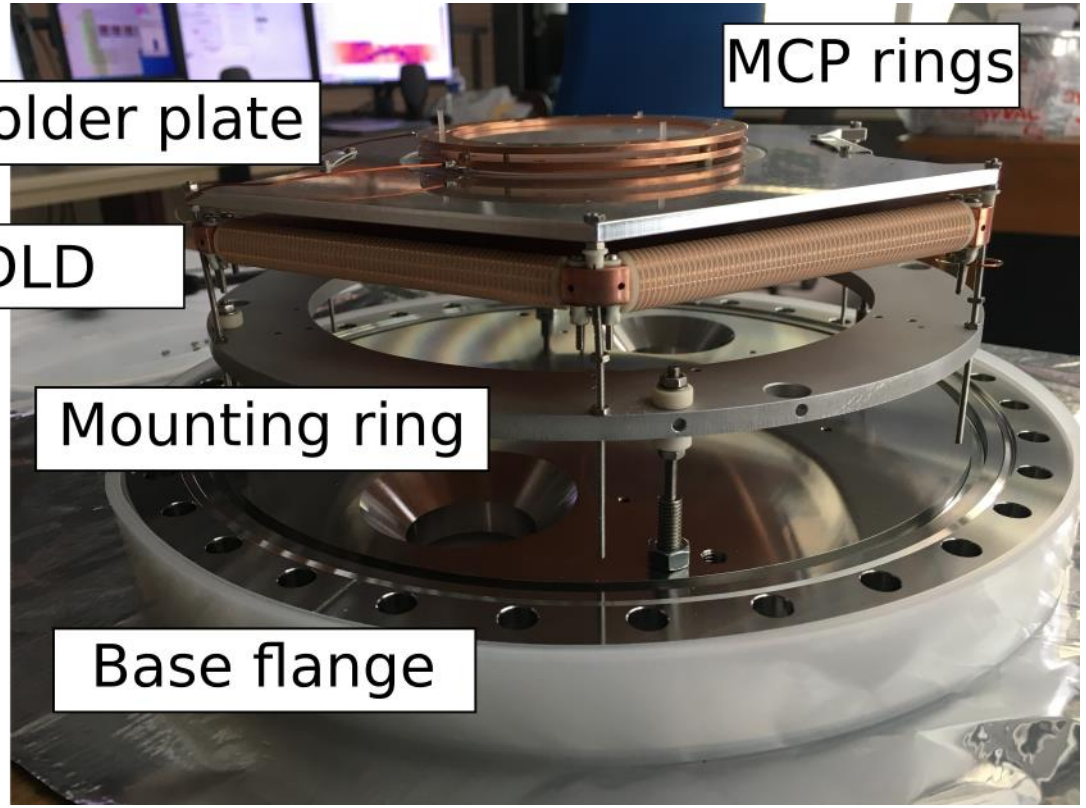
$$\nu = \frac{\phi_c + 2\pi n}{2\pi t}$$



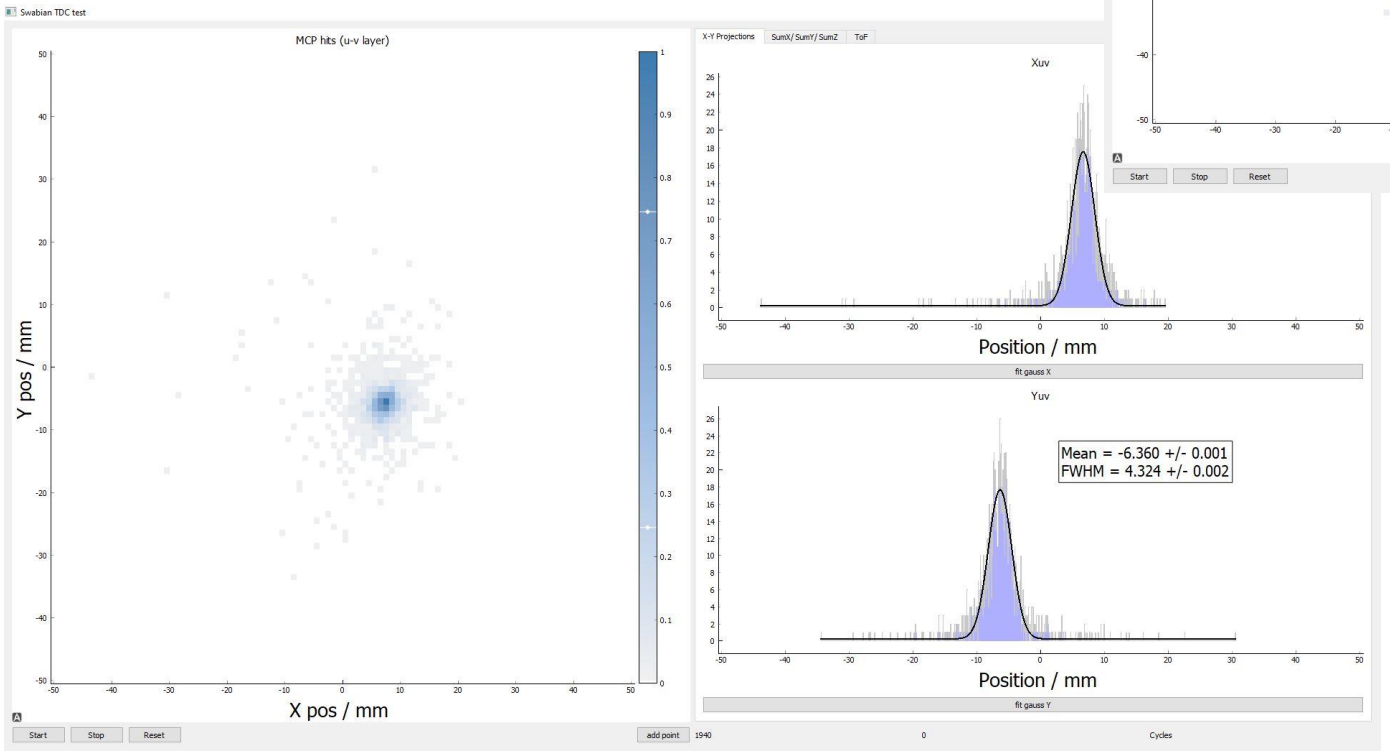
An example of the PI-ICR of ^{118}Rh from JYFLTRAP (by M.Hukkanen et al.,)

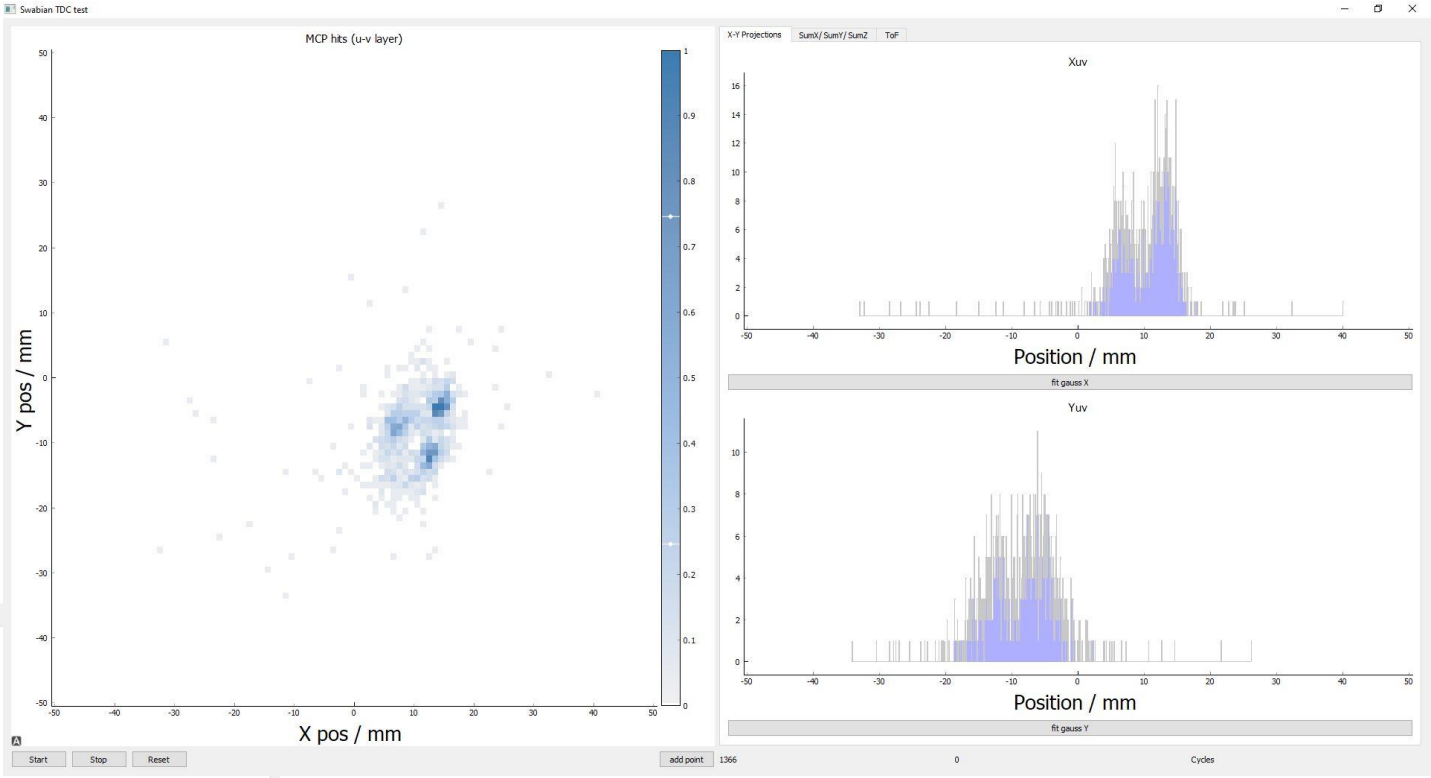
New Hexagonal MCP





First Images





Conclusion

- ToF-ICR has been improved (precision of 10^{-7} – 10^{-8}) and is reaching a final characterisation state
- Drift of the magnetic field has been studied
- The new hexagonal MCP has been installed
- The diaphragm has been changed
- New programs for the beamline control has been created

Perspectives

- Investigation in the number of ions that can be purified per seconds
- Investigation of systematic errors (E field anharmonicities, B-field inhomogeneities)
- Find the limits for the ToF-ICR (precision, excitation time, conversion radius)
- Find a working extraction for PI-ICR
- Do a first mass measurement with PI-ICR

Thank you!

The PIPERADE team:

P. Alfaurt, P. Ascher, D. Atanasov, L. Daudin, M. Flayol, M. Gerbaux, S. Grévy, M. Hukkanen, A. Husson, B. Lachacinski, Y. Langlois and A. de Roubin