Status of MLLTRAP experiment at ALTO

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Supervised by
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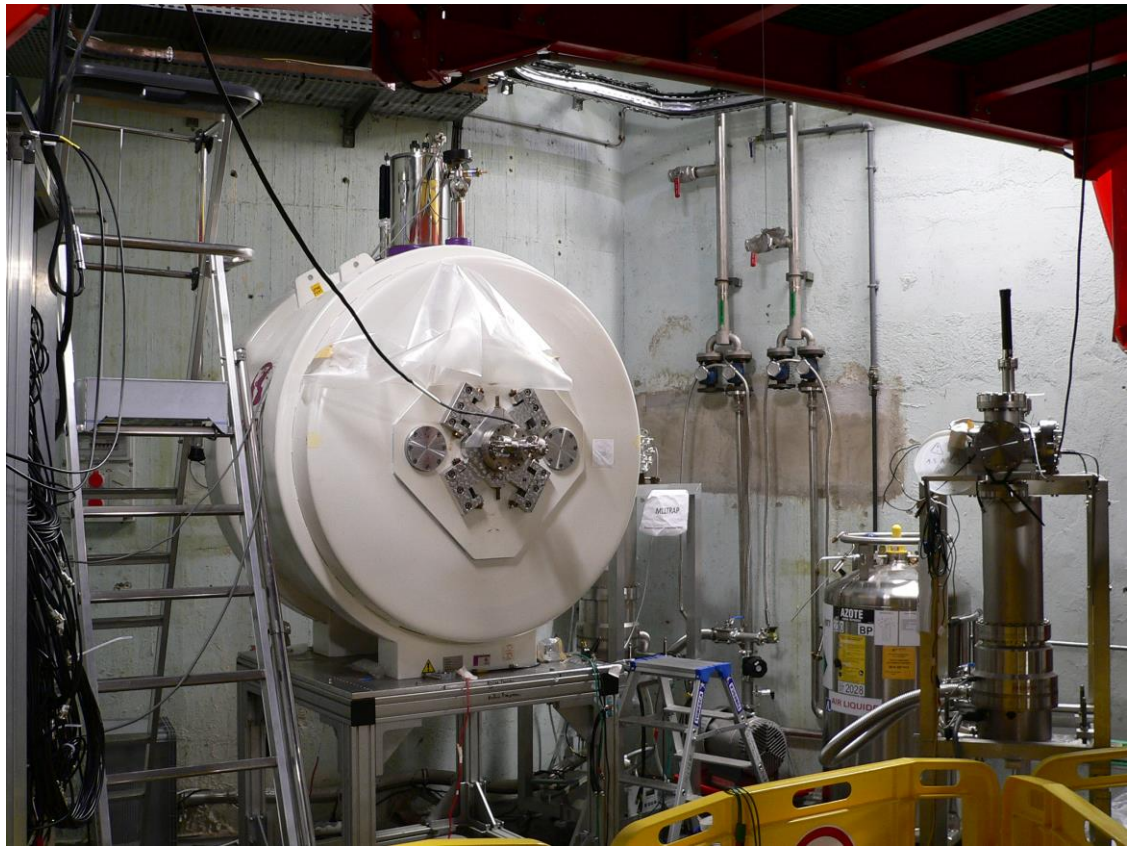


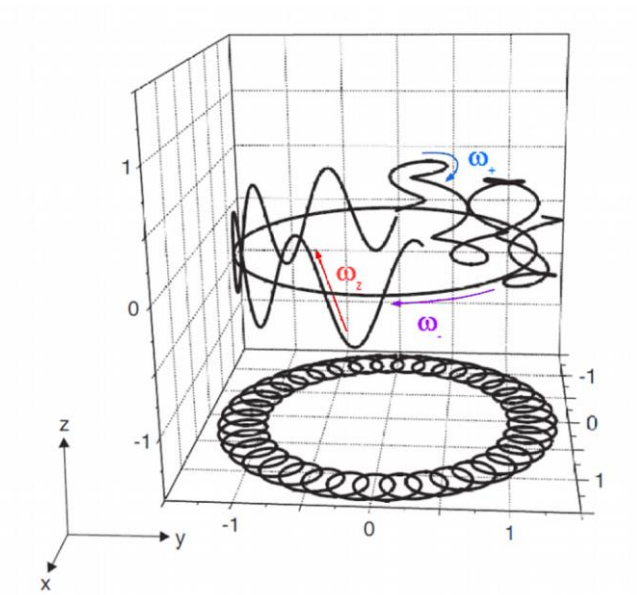
10/03/2022

Double Penning trap mass spectrometer

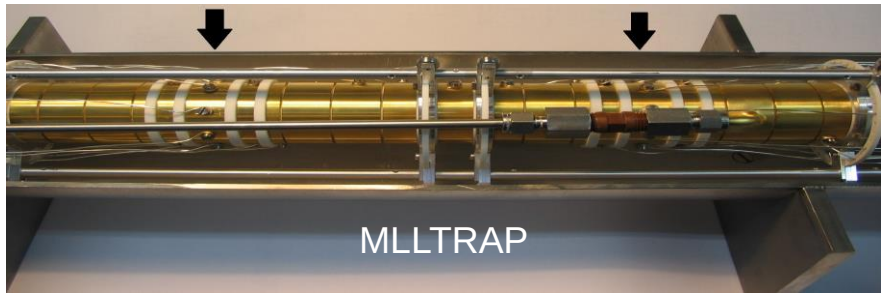
- Penning trap : superposition of high intensity magnetic field with low electrostatic field
- Application of quadrupolar field : 3 eigenmotions appear
  - An axial motion : ω_z
  - A slow radial motion, magnetron motion : ω_-
  - A fast radial motion, reduced cyclotron motion : ω_+

  –> $\omega_c^2 = \omega_z^2 + \omega_+^2 + \omega_-^2$
- Ion manipulation by exciting ions eigenmotions :
  - Isobaric separation with buffer gas cooling in preparation trap
  - Cyclotron frequency measurements in measurement trap :

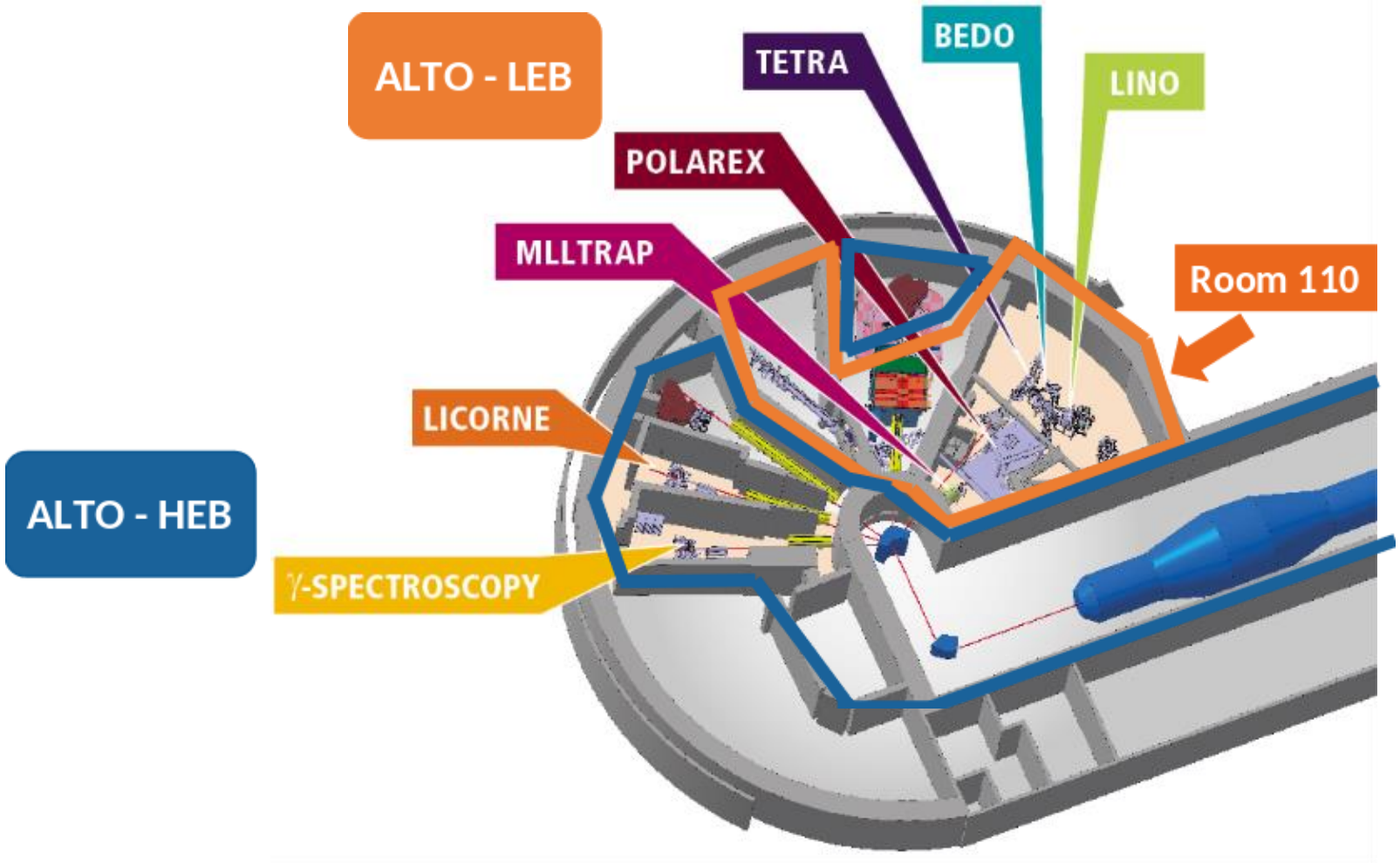
$$\omega_c = 2\pi\nu_c = \frac{qB}{m}$$



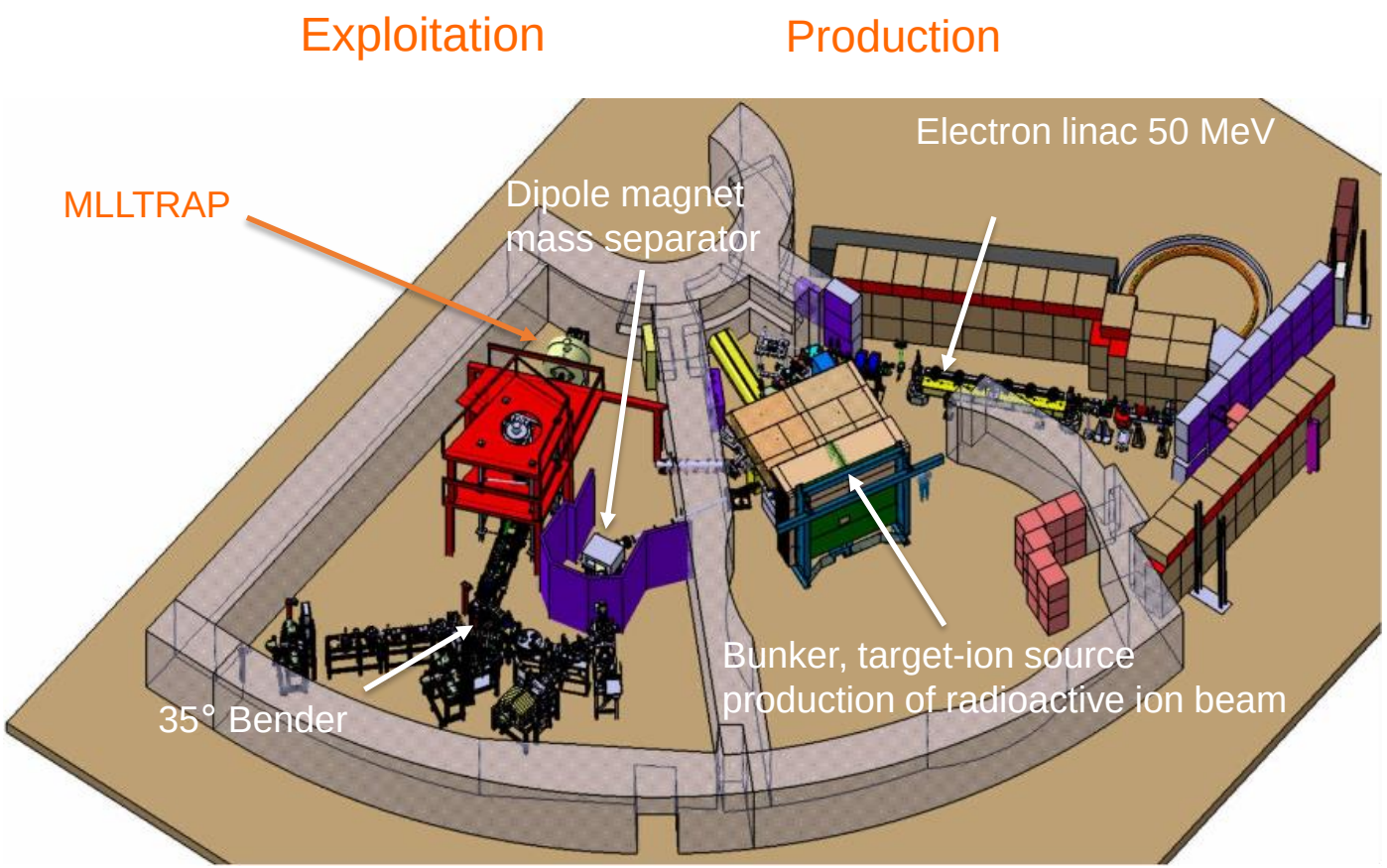
Measurement trap Preparation trap



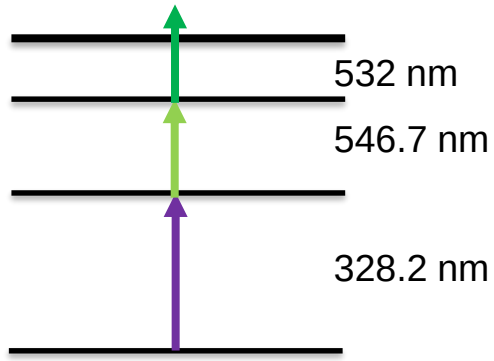
ALTO (Accélérateur Linéaire et Tandem à Orsay)



Radioactive silver ion beam production at ALTO

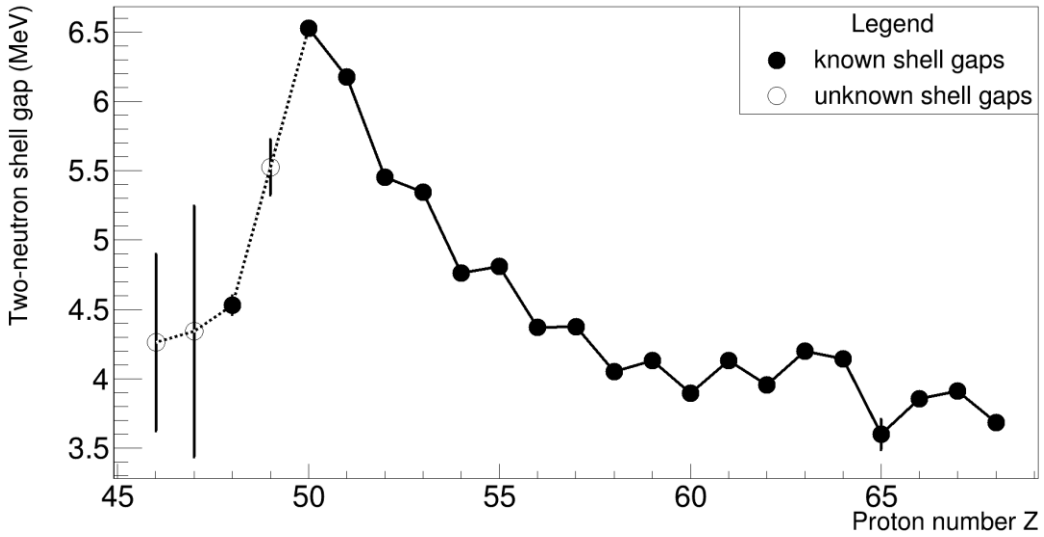


- Production by photofission
  - For $^{124\text{-}129}$Ag
- Selection with laser ion source
  - Ionization scheme tested at ALTO with RIALTO lasers and atomic beam unit



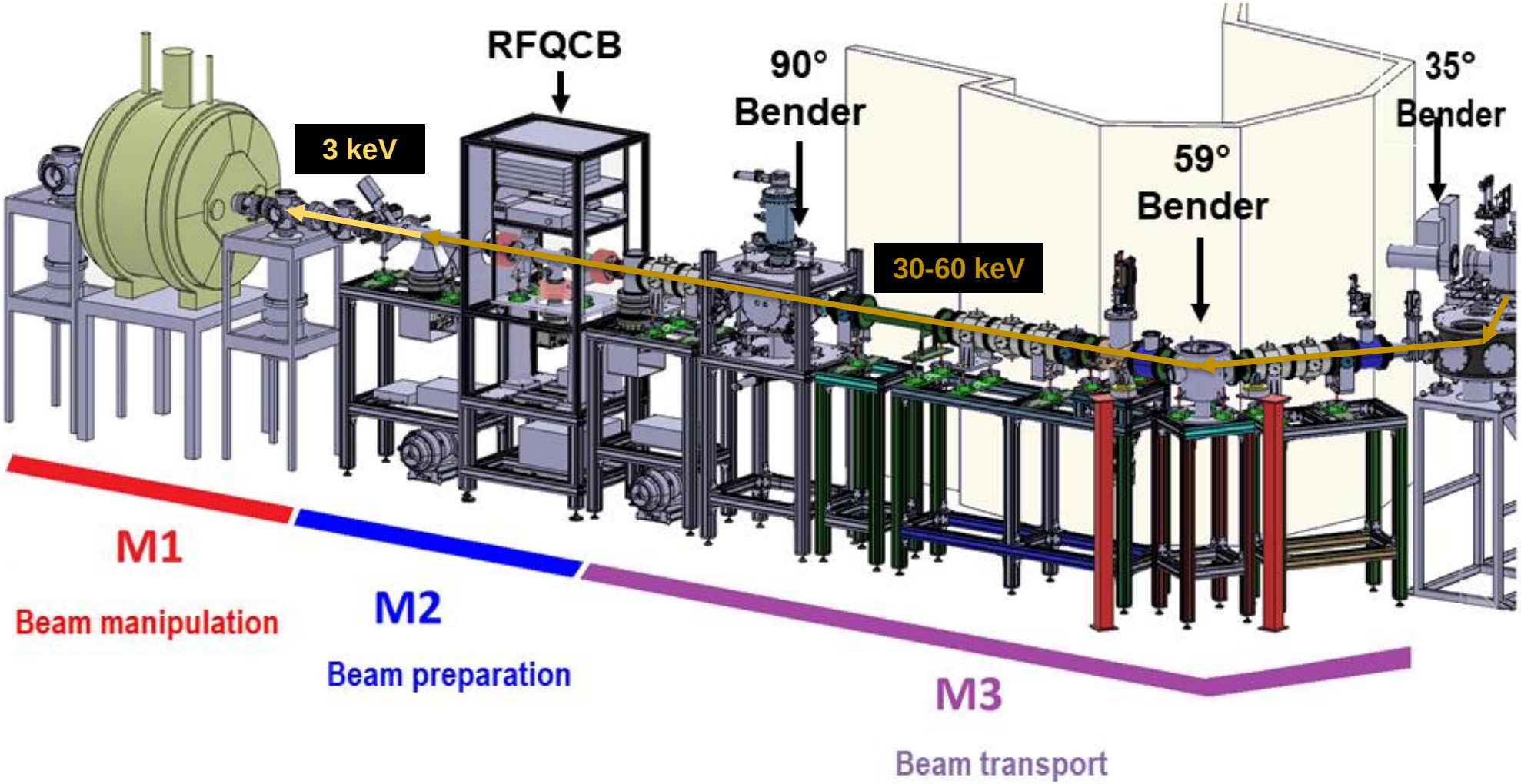
Study of N = 82 shell closure with silver isotopes high precision mass measurements (A = 124-129)

- Nuclear structure :
  - Access to binding energies -> interactions inside the nucleus
  - Neutron separation energy and shell gaps
  - -> Shell quenching for N = 82 ?
- Nuclear astrophysics
  - Nuclear informations (including nuclear masses) are important inputs for r-process path evolution models
  - N = 82 could be linked to A = 130 r-process solar abundance peak
  - Non-negligible impact of silver isotopes masses close to N = 82 on r-process simulations for at least 4 different scenarios (Mumpower et al, Progress in particle and nuclear physics 86, 2016)



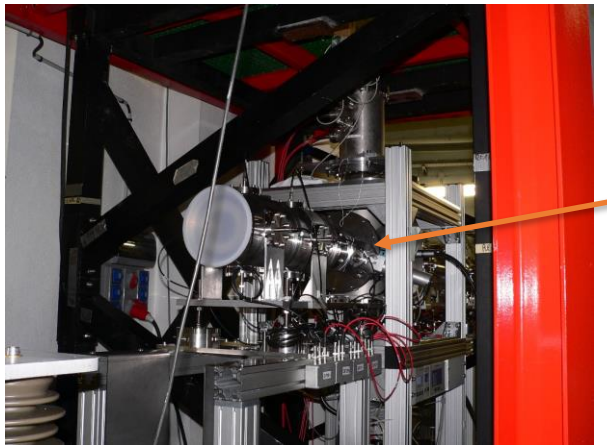
Data from AME 2020 M. Wang et al Chinese Physics C 45 (2021)

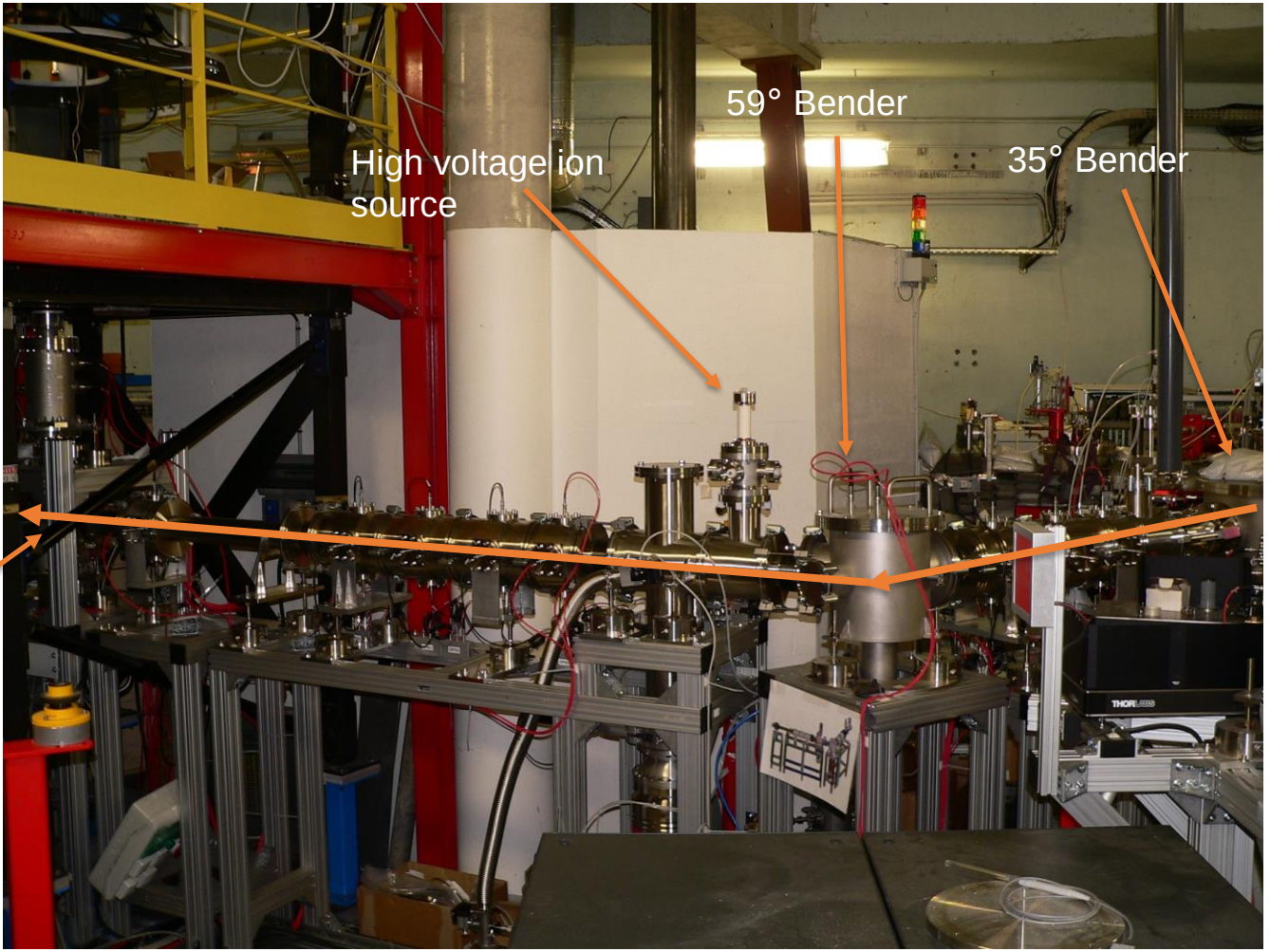
MLLTRAP at ALTO



M3 Section

- Alignement finished
- Vacuum tests done (december 2021-January 2022)
- High voltage ion source (Rb and Cs) designed to characterize the traps
  - Under vacuum : currently < 10^{-6} mbar
  - External high voltage cabling under installation

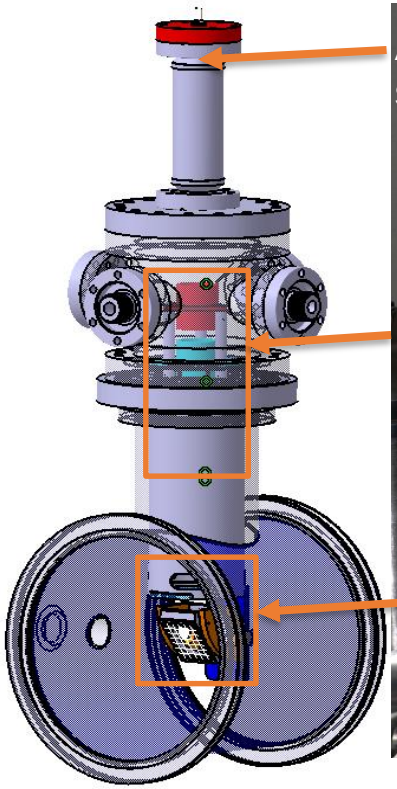


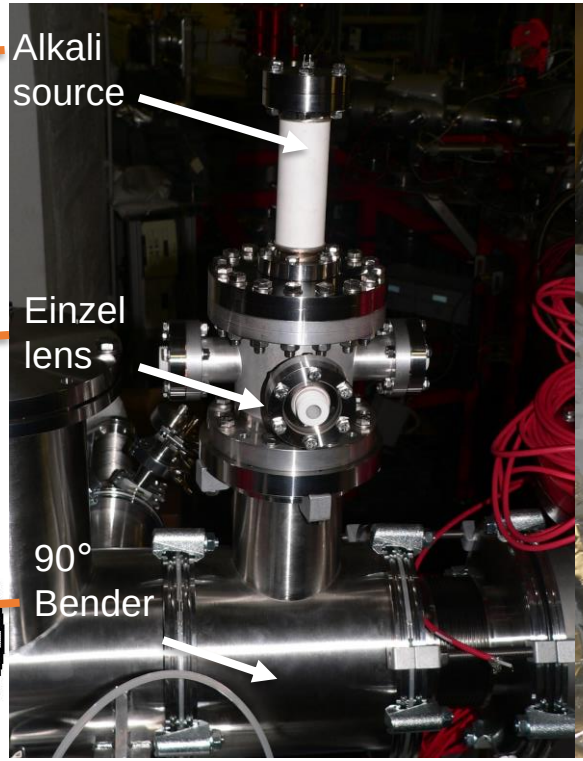


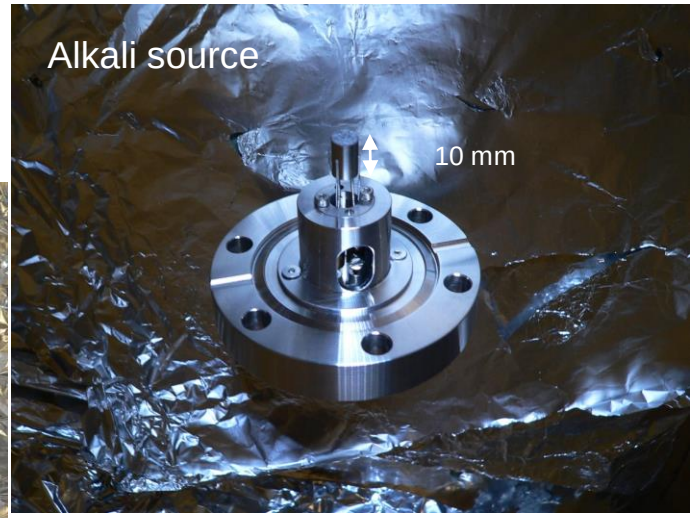
M3 Section – High voltage ion source

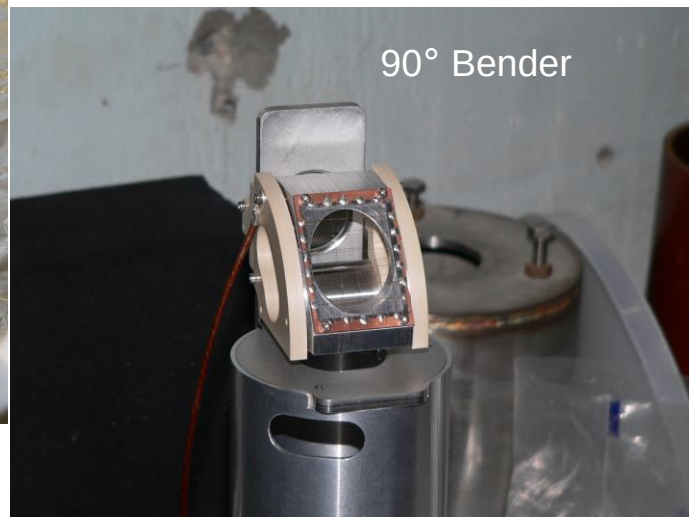
Installed in January 2022

Tests during spring 2022

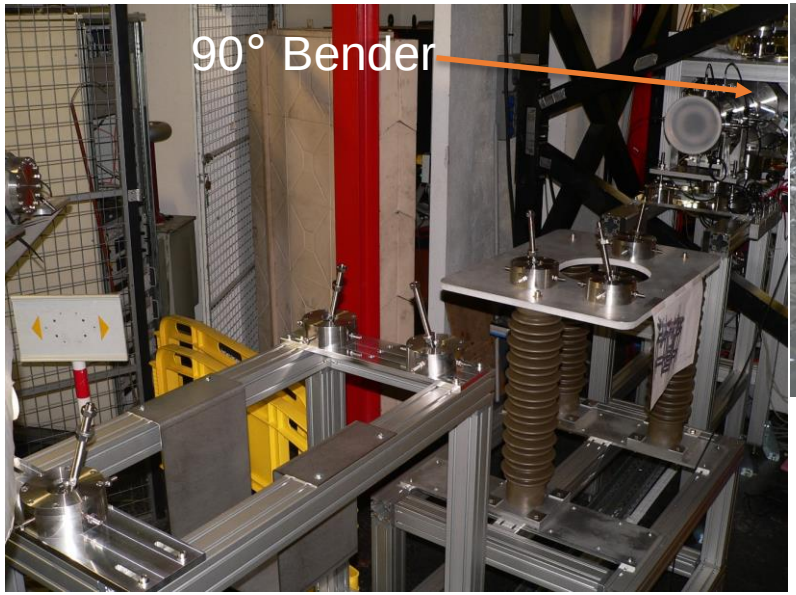


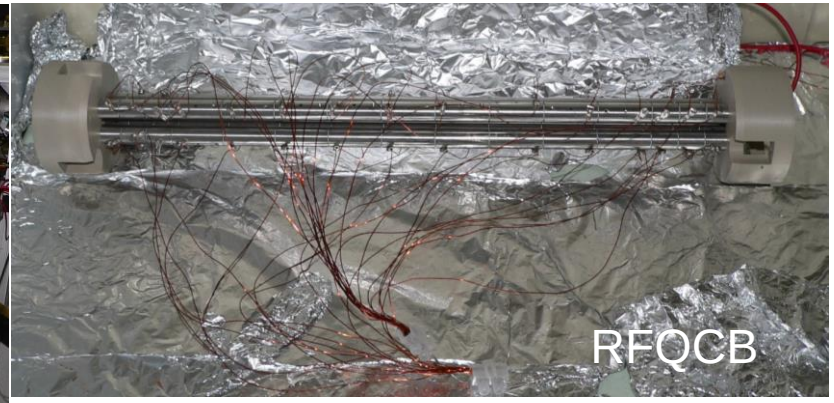


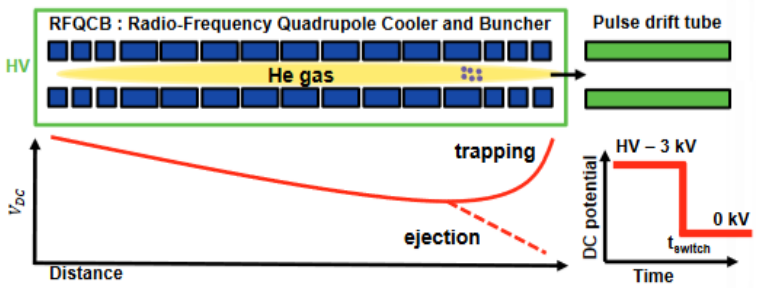


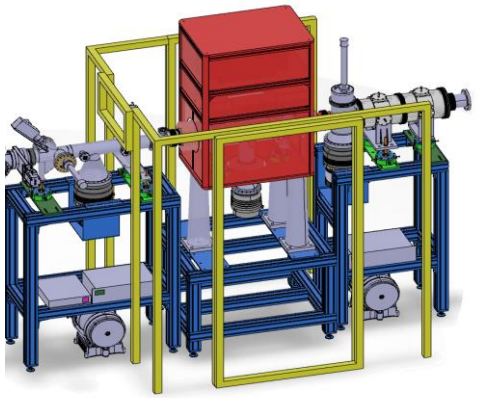


M2 section





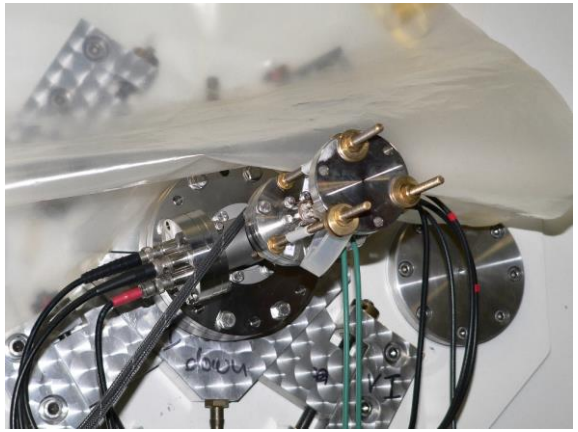




- Frames delivered in May 2021 and installed at ALTO
- All mechanical parts and electronics delivered
- RFQCB and deceleration area delivered in July 2021
- RFQCB built, RF supply in construction
- Deceleration area building in progress
- Tests offline planned in spring 2022

Vacuum tube alignement

- Alignement of the vacuum tube axis with magnetic field lines
- Alignment almost finished
- Preliminary result for misalignment angle : 1.1 ± 0.1 mrad
- Penning traps insertion delayed



Tests of the probe

- Coupled to the bore temperature
- 10^{-7} precision reached
- Tests of the probe at different position along the tube, around magnet's center

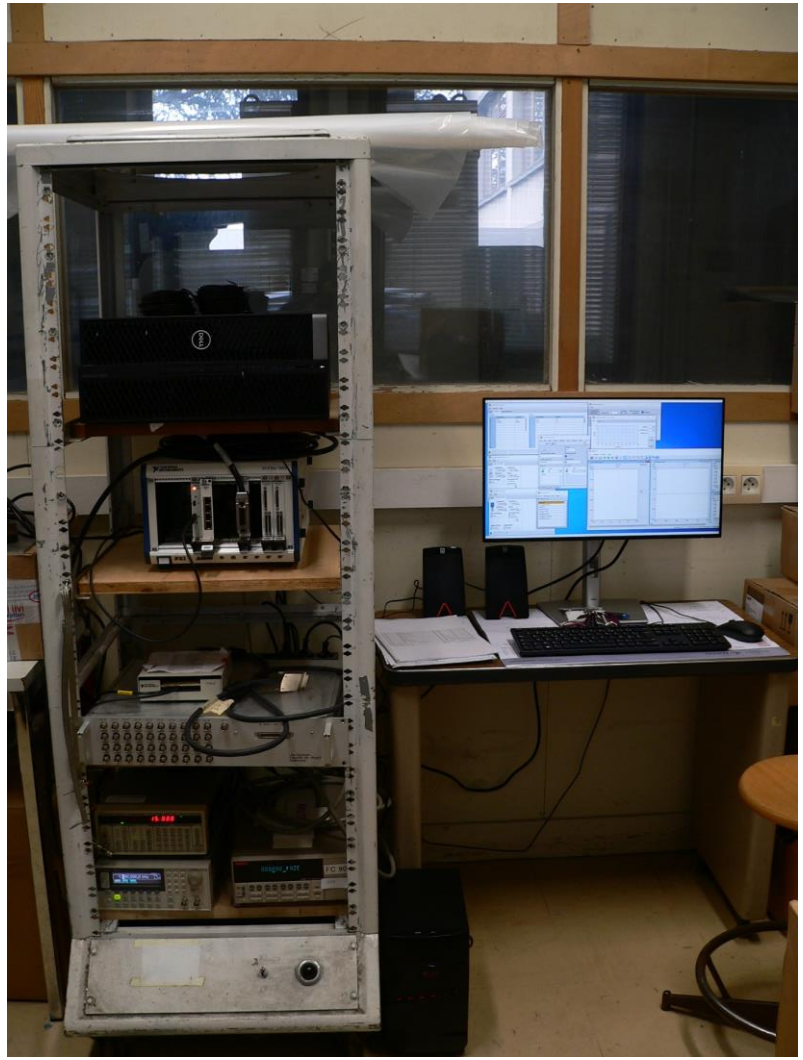
	~ 1cm from center	10 cm from center	5 cm from center	Magnet center
Relative uncertainties on Temperature (30 min periods)	10^{-4}	10^{-4}	10^{-4}	10^{-4}
Relative uncertainties on magnetic field (30 min periods)	10^{-6}	10^{-5}	10^{-6}	10^{-7}

- Next step : look at temperature stabilization influence

Control system for MLLTRAP

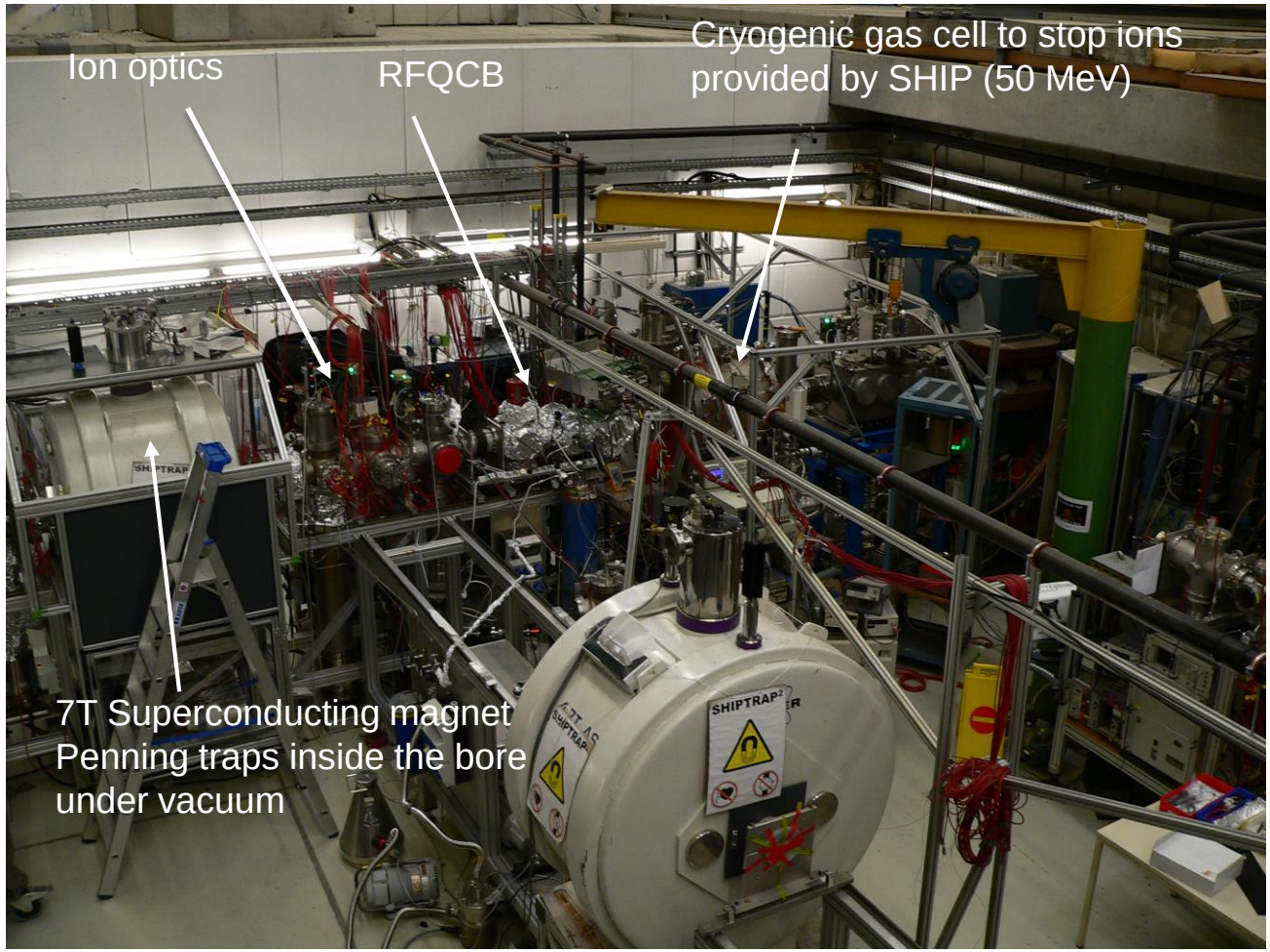
June 2021: Upgrade of control system

- Upgrade with the most recent version, working with Labview 2020
  - New C++ control system (CS++) developped by the Control System Framework from GSI (https://wiki.gsi.de/CSframework/WebHome)
  - Only one (new) computer to centralize the control of all MLLTRAP equipment + PXIe-1082 chassis
  - PI-ICR method compatible with the new CS++
  - For section M1 and M2
- Some devices already controled by the CS++



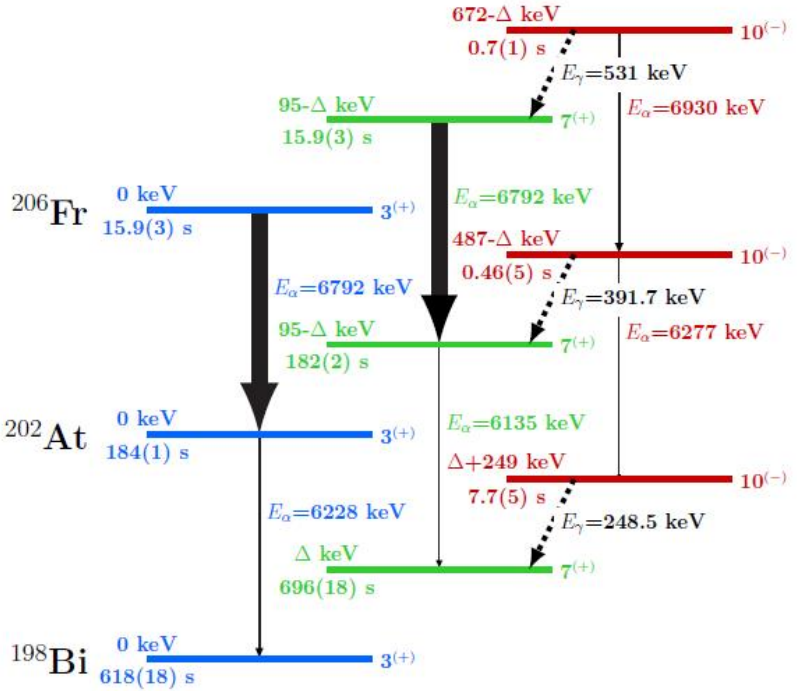
April-May 2021 : Mass measurement campaign of superheavy nuclei at GSI

- SHIPTRAP experiment : double penning trap mass spectrometer (similar to MLLTRAP)
- Studies of ground and isomeric states on heavy and superheavy isotopes (N = 152-162)
- Parasitic beamtime for preparation and optimisation of the experimental setup (study of nuclei around N = 115)



Study of ^{206}Fr-^{202}At-^{198}Bi and ^{204}Fr-^{200}At-^{196}Bi alpha decay chains

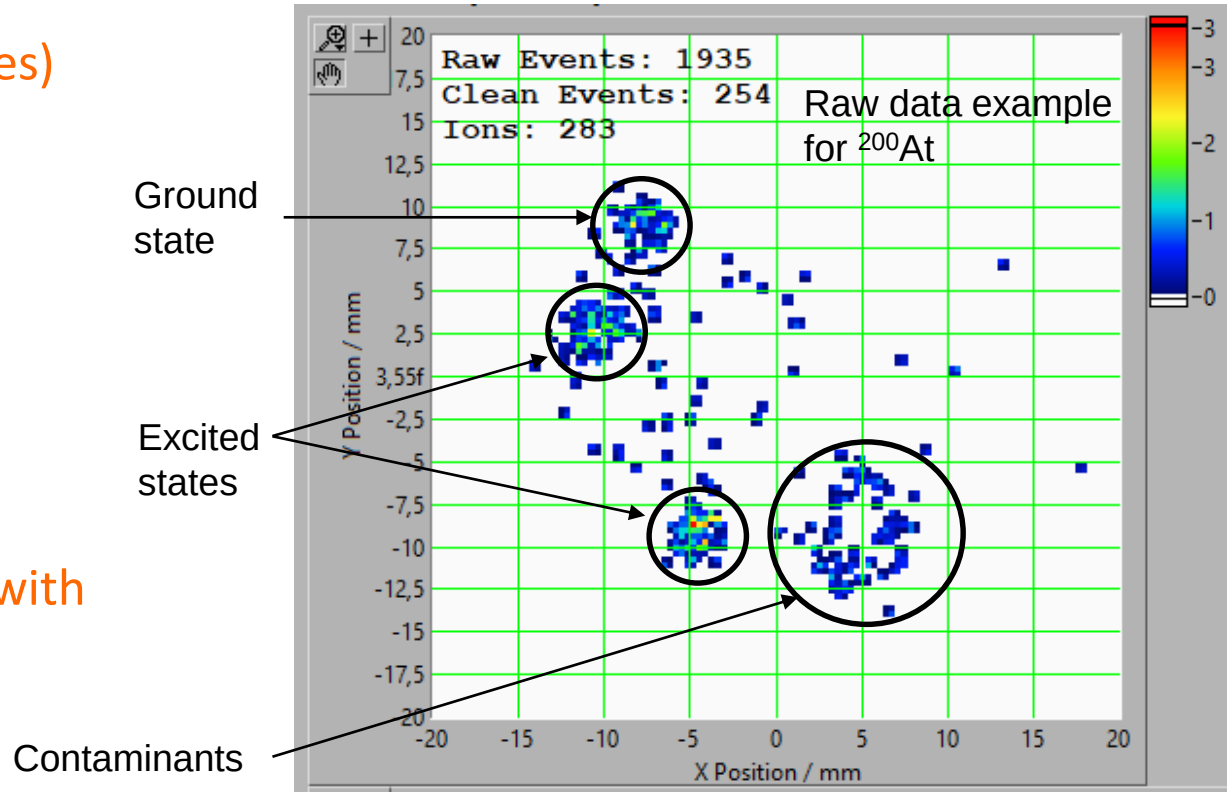
- Odd-Z and odd-N, Z > 82 neutron-deficient nuclei
- Main motivation in this region of nuclear chart : shape coexistence, need of excitation energies for calculations
- For ^{206}Fr-^{202}At-^{198}Bi :
  - Hyperfine structure and isotopic shift determined for ground and excited states
  - But excitation energies not directly accessed so far



Lynch et al. / Physics Review C 93 (2016)

Measurements using PI-ICR technique

- Absolute measurement of nuclei excited states masses (access to excitation energies)
- Informations on their relative populations
- Needed resolving power for isomer discrimination in ^{200}At case : 1.65x10^{6}
- Data analysis in progress in collaboration with SHIPTRAP members



Thanks you for your attention !