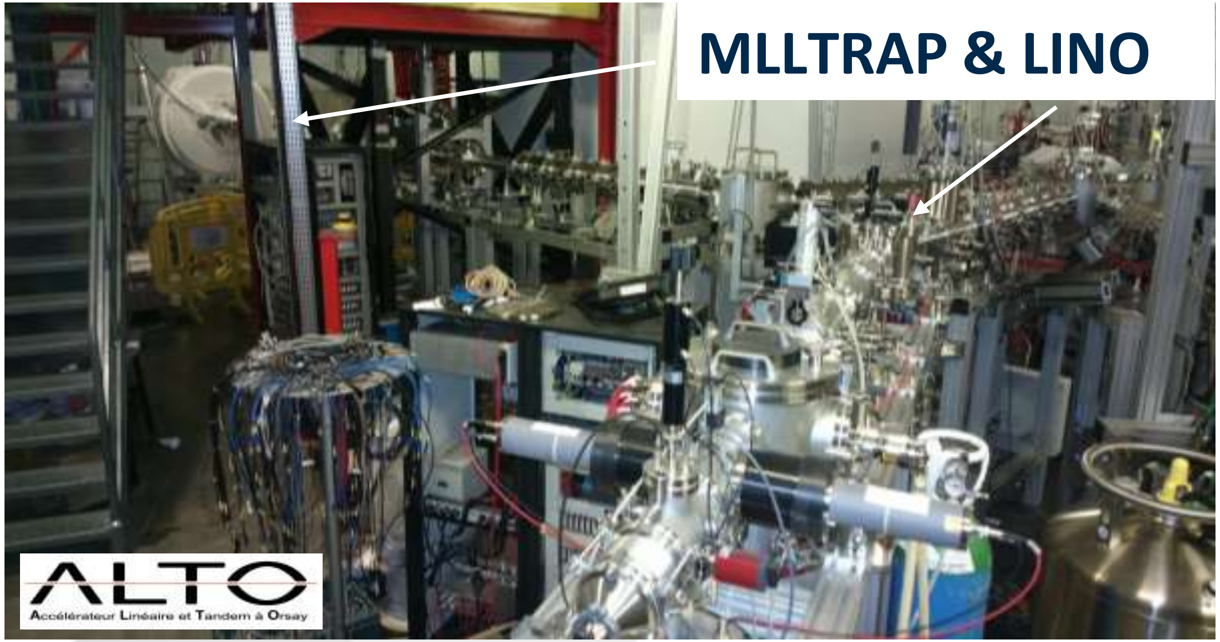


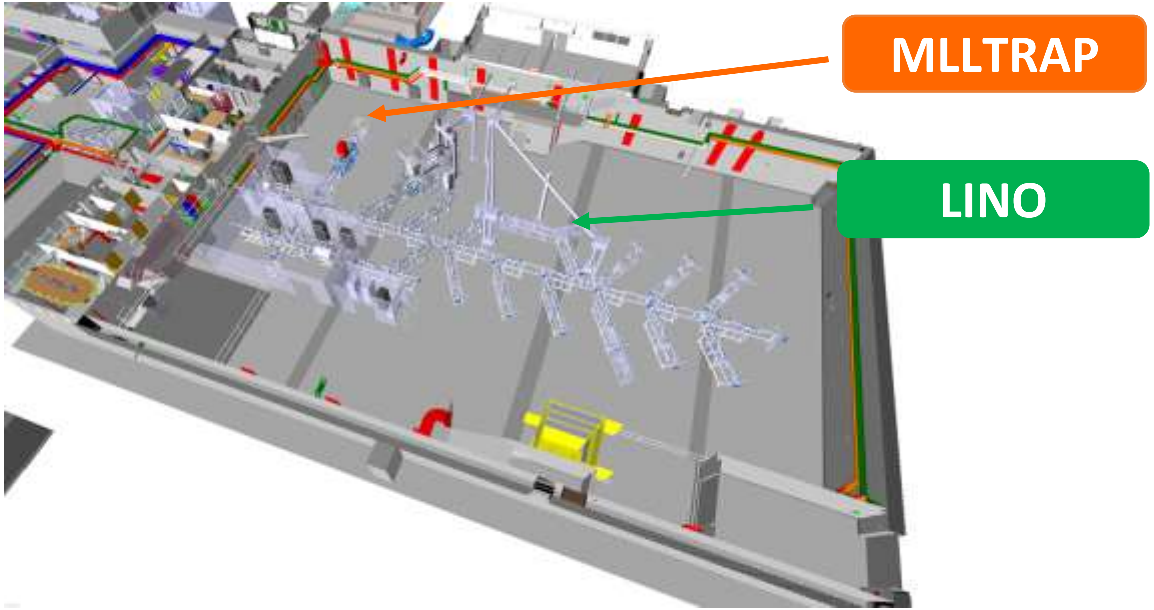
Enrique Minaya Ramirez

IJCLab

LINO

MLLTRAP

Framework : "adaptation of experimental devices for their use with DESIR"



MLLTRAP & LINO projects in France

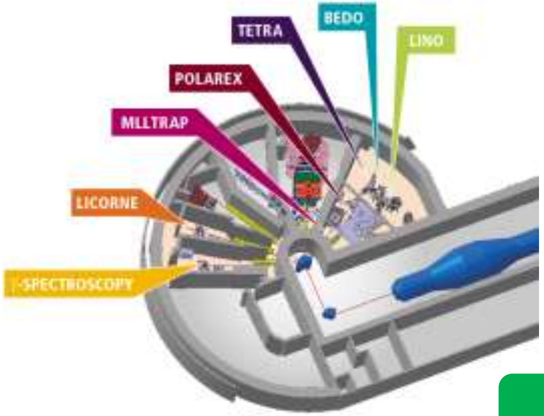
LINO

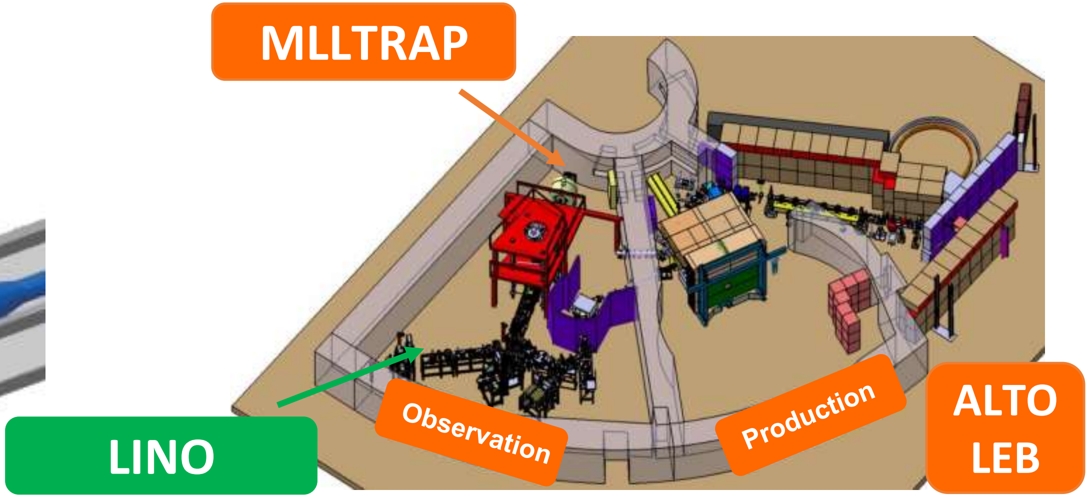
MLLTRAP

Framework : "adaptation of experimental devices for their use with DESIR"

2014 – 2022→2023 : Commissioning of LINO and measurement campaign @ ALTO
DESIR Laser workshop 14/11/2019

2016 – 2025→2026 : Commissioning and upgrade of MLLTRAP + mass measurement campaign @ ALTO
DETRAP workshop 16/06/2020





MLLTRAP & LINO projects in France

LINO

MLLTRAP

Spiral2 DESIR

Framework : "adaptation of experimental devices for their use with DESIR"

2014 – 2022→2023 : Commissioning of LINO and measurement campaign @ ALTO
DESIR Laser workshop 14/11/2019

2016 – 2025→2026 : Commissioning and upgrade of MLLTRAP + mass measurement campaign @ ALTO
DETRAP workshop 16/06/2020

2016 P2IO Investissements d'Avenir

"Charting Terra Incognita of Exotic Nuclei"

2017 Région îledeFrance SESAME

"Reaching Terra Incognita of Exotic Nuclei"

People involved at IJCLab

Scientific poles : Accelerator and Nuclear Physics :
E. Minaya Ramirez, A. Leite, L. Perrot, D. Lunney, K. Hauschild, A.Lopez-Martens, V. Manea, S. Franchoo, D. Yordanov

+ strong support Mechanical engineering from Engineering pole and ALTO platform

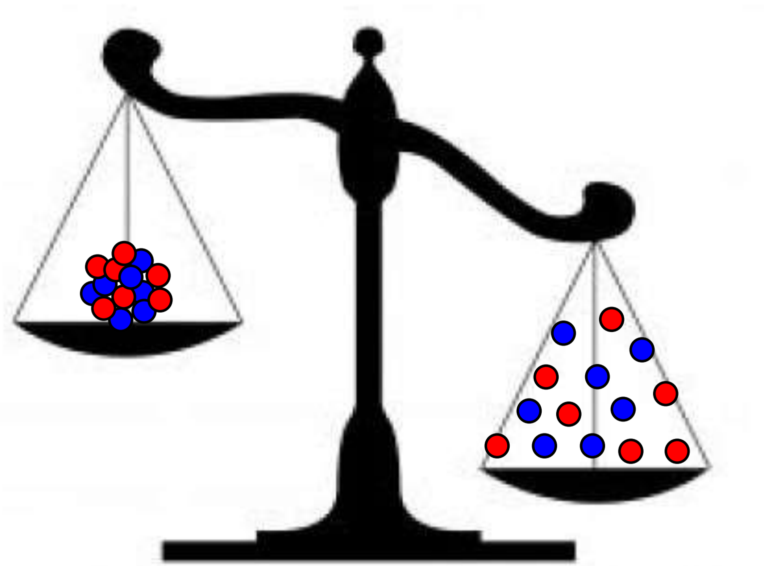
PhD students : L. Vazquez Rodriguez (2015 – 2018)

Postdocs : P. Chauveau (2017-2019)
PhD students : E. Morin (2019 – 2022) / S. Morard (2022 – 2025)

MLLTRAP

Fundamental observables to test state-of-the art nuclear theories

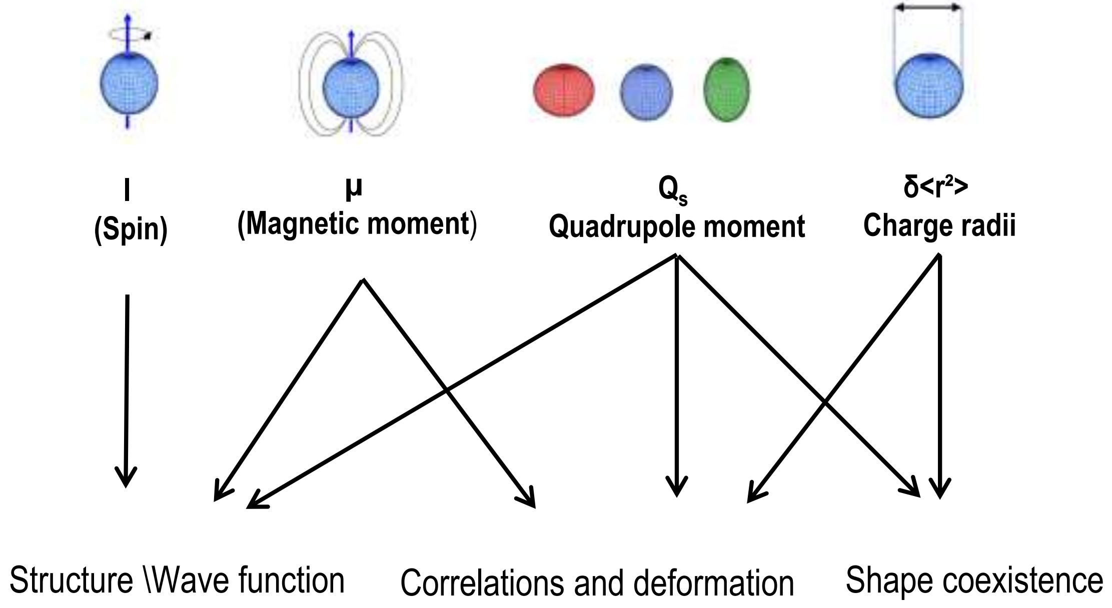
LINO



B(N,Z) : Nuclear binding energy

$$M_{atom}\ (N,Z) = M_{nucl}(N,Z) + Z^*\mathbf{M_e} - B_{el}(Z)$$

$$M_{nucl} = Z^*M_p + N^*M_n - B(N,Z)$$



Collinear (high-resolution) laser spectroscopy (I, μ, Q_s, δ<r²>)

β-NMR and β-γ asymmetry (I, parity)

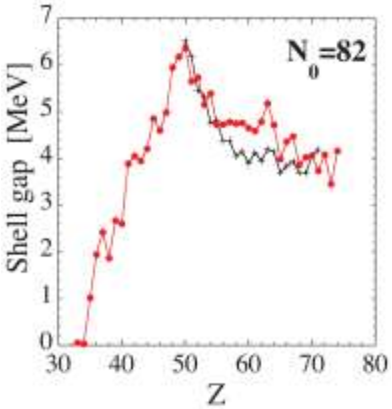
MLLTRAP

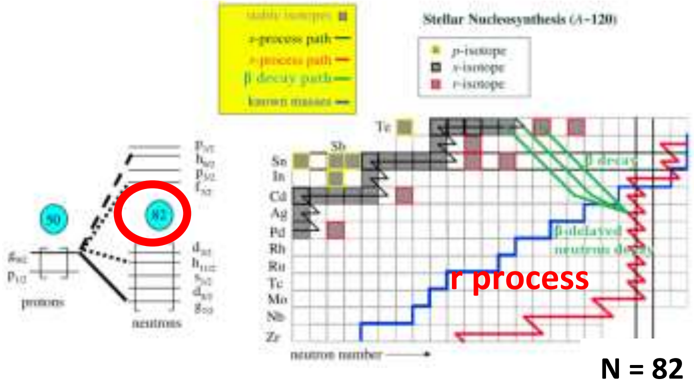
PAC ALTO March 2017

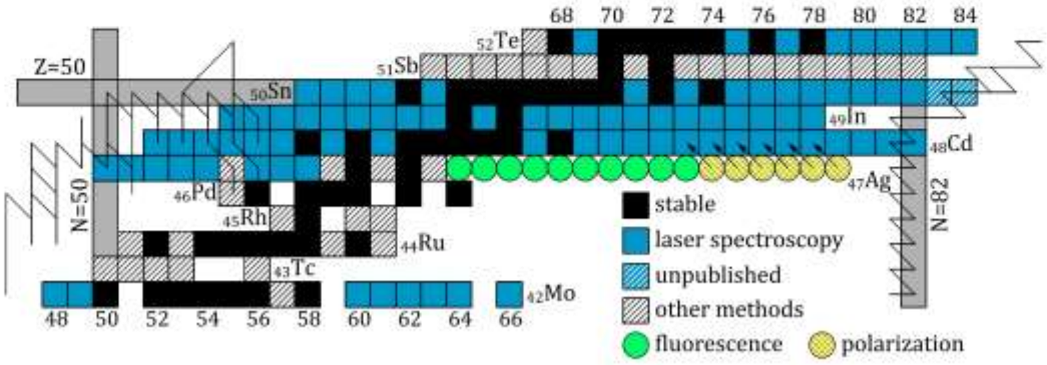
LINO

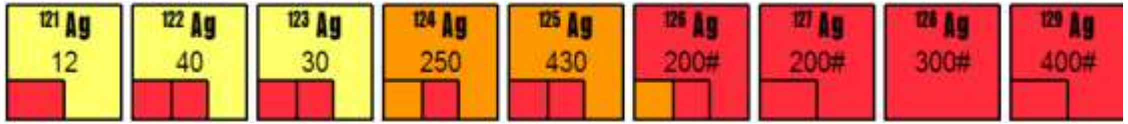
High-precision mass measurement of silver isotopes (A=113 – 129) towards the N=82 shell closure

Laser spectroscopy of $^{111\text{-}120}$Ag
Ground-state electromagnetic moments and rms charge radii measurements.





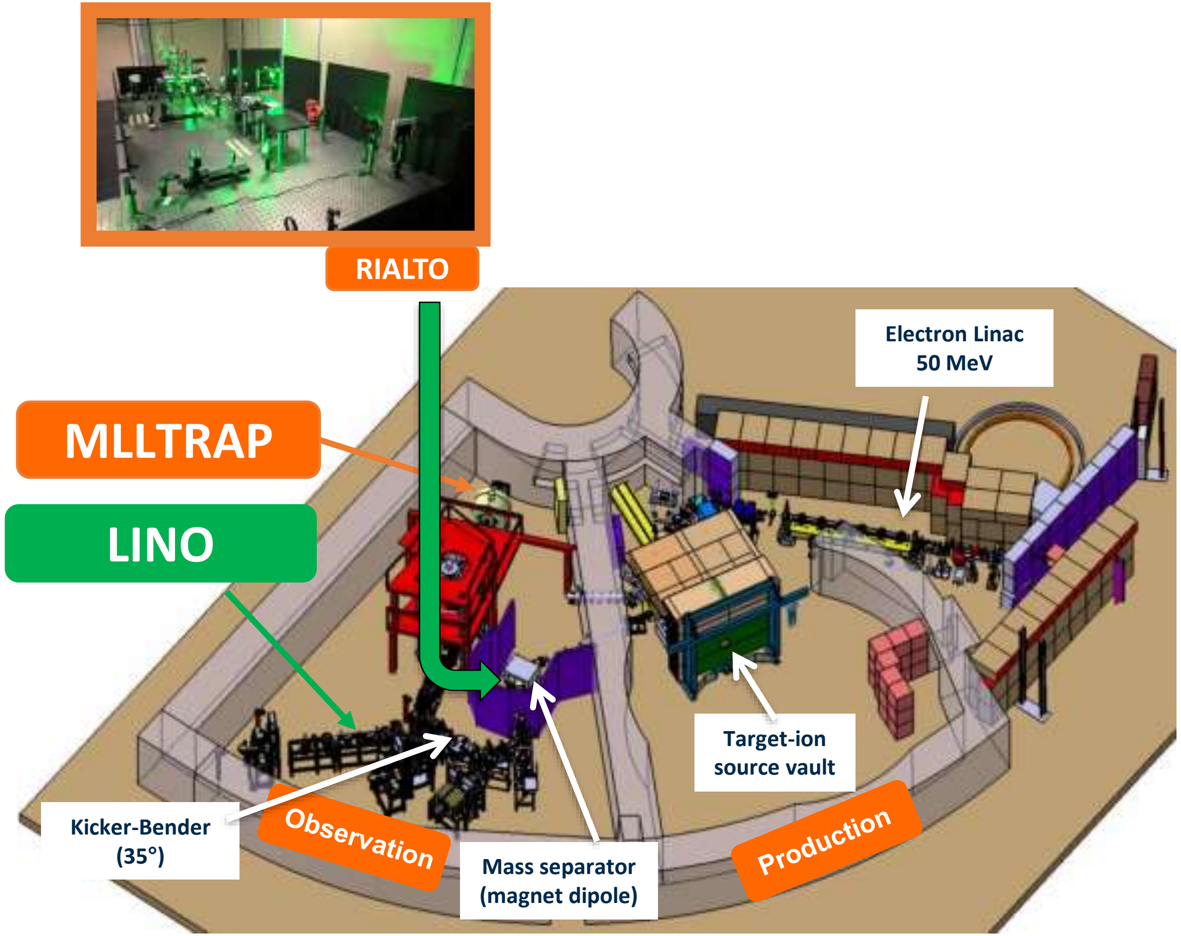




→ First request of silver isotopes at ALTO

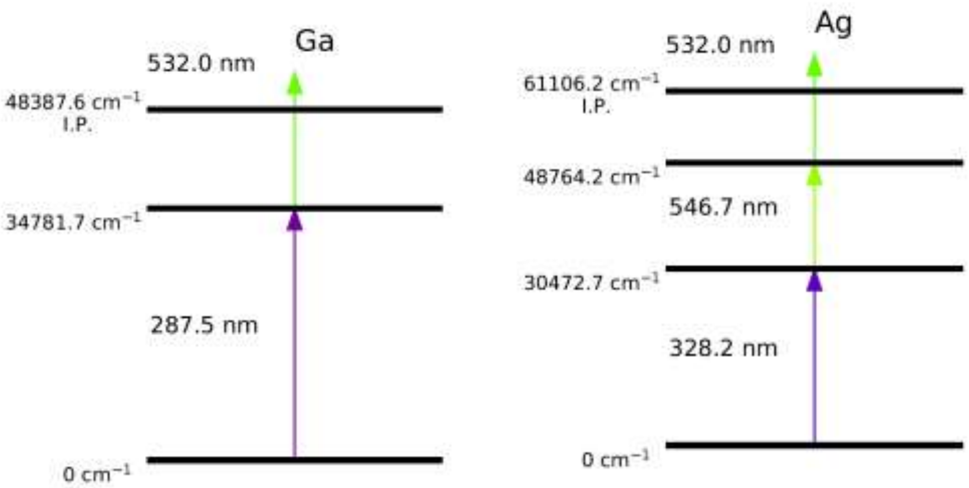
2019 Jyväskylä : masses measured up to ^{125}Ag **laser spectroscopy ^{96}Ag to ^{121}Ag**

MLLTRAP& LINO @ ALTO-LEB



First operational RIB facility based on photo-fission → populating the GDR of ^{238}U(~10^{11} f/s)

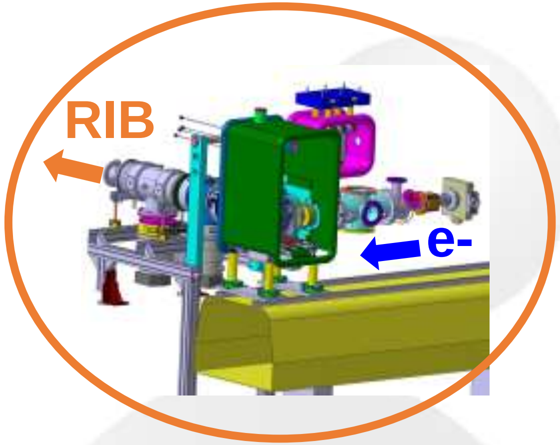
- **50 MeV** & **10 μA** e$^-$ beam
- UCx target (~70g, ~140 pellets)
- Magnetic dipole PARRNe → **A** selection (M/ΔM = 1500)
- **RIALTO : laser source** → **Z** selection of elements



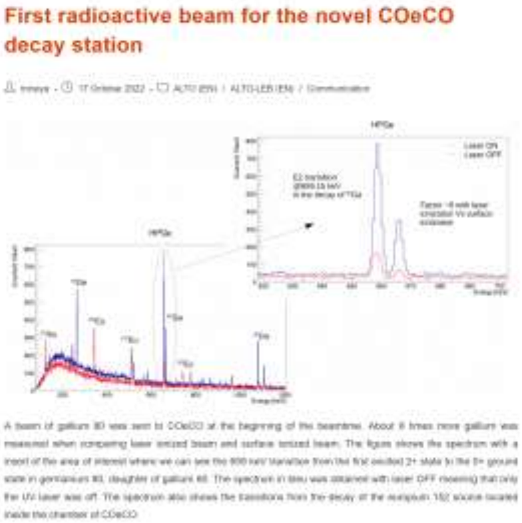
Switch between both laser schemes successfully validated during offline commissioning (09/2022)

ALTO-LEB : Robotic Frontend (FRISAL)

2019



October 2022

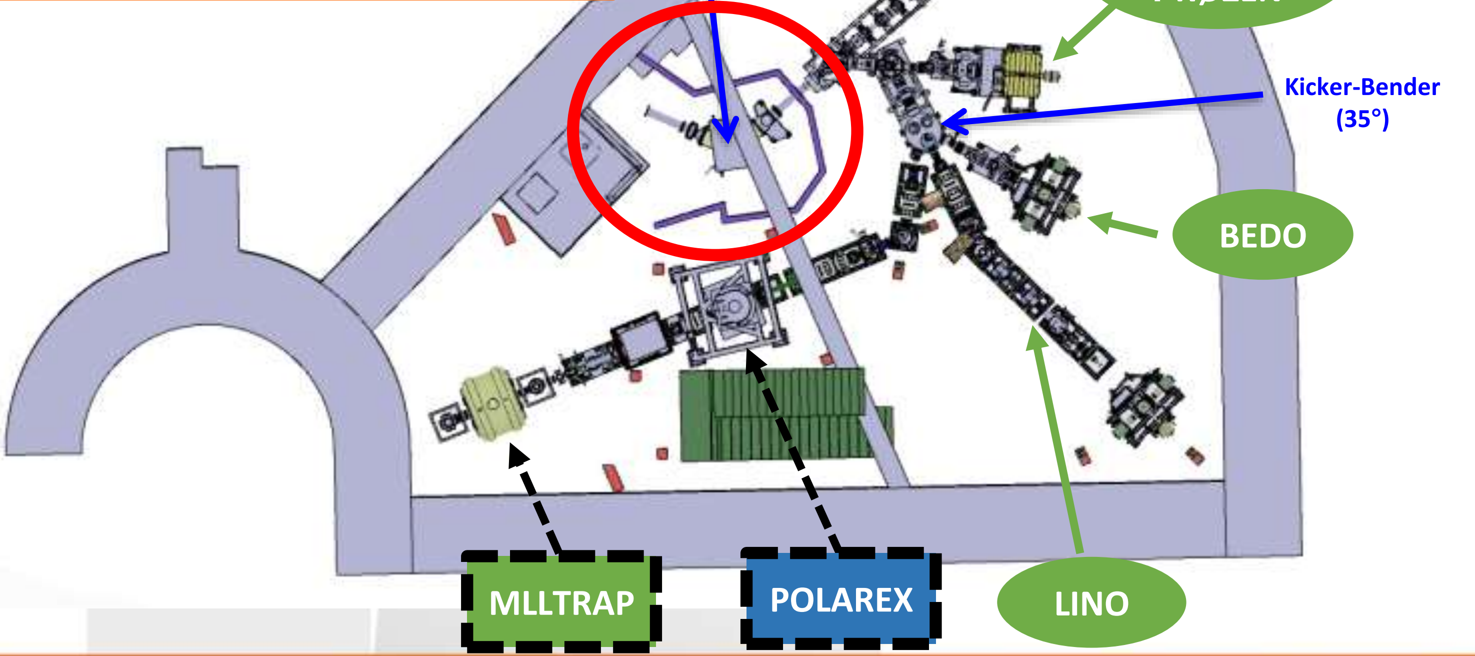


https://alto.ijclab.in2p3.fr/

ALTO-LEB : reliability and sustainability

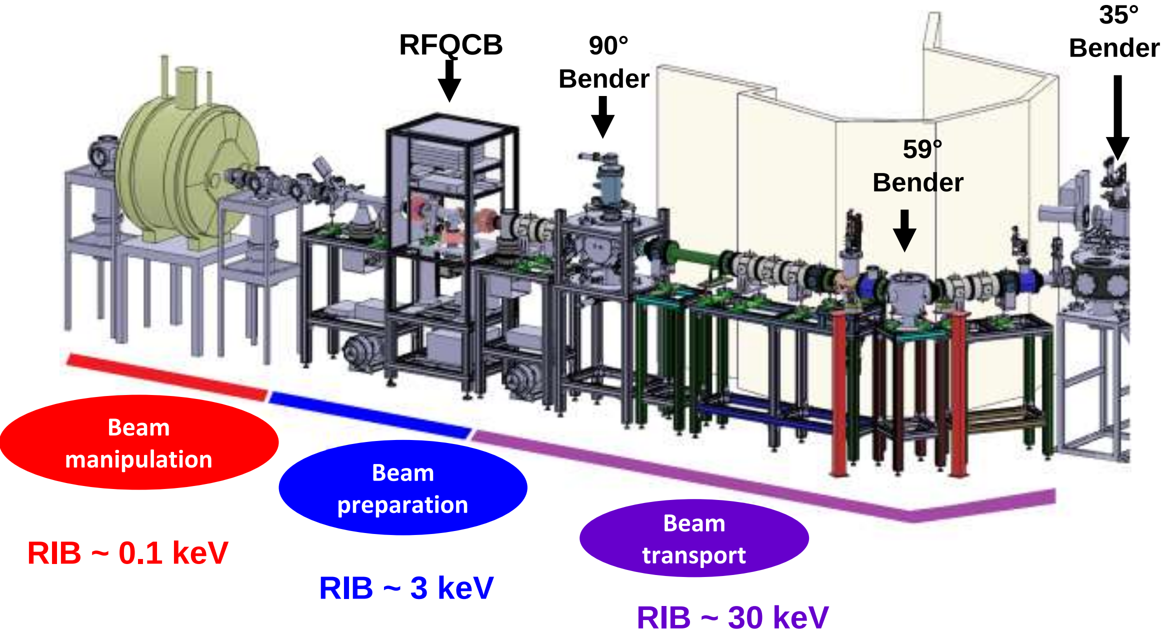
Emittance meter from iPHC

F. Osswald, Int. Beam. Instrum. Conf (2019) tupp007 293

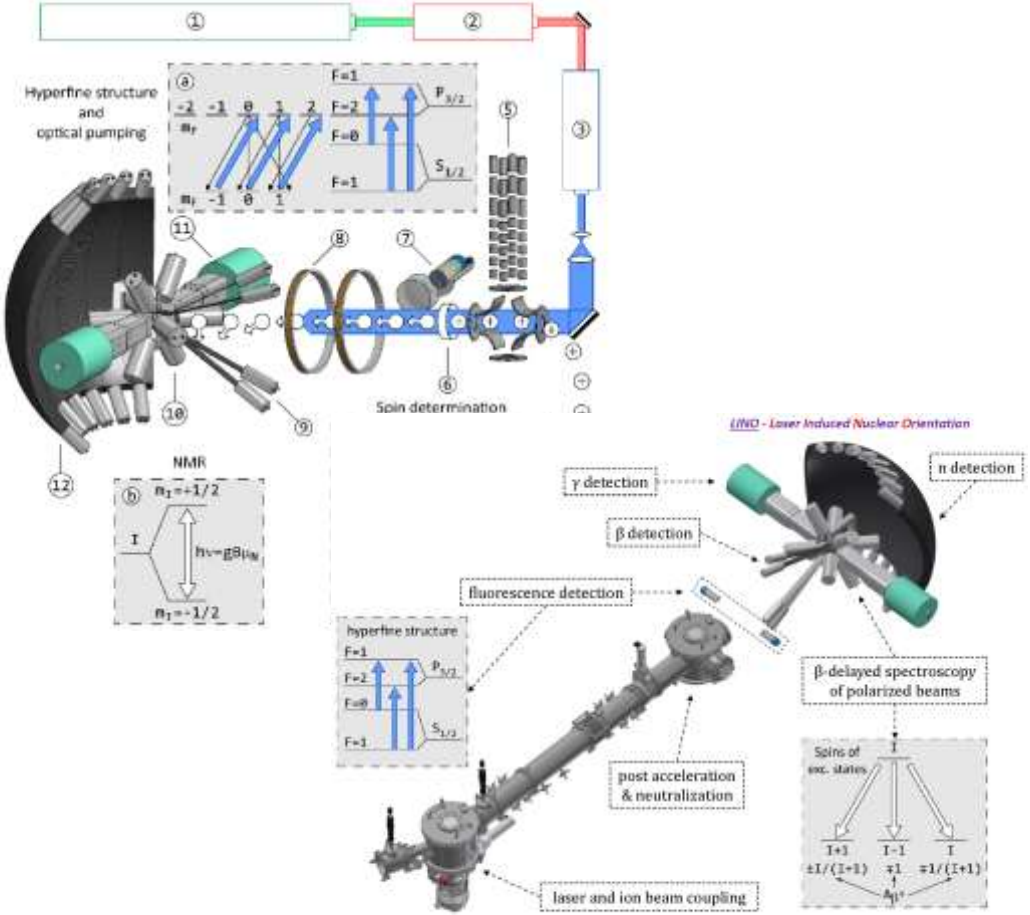


MLLTRAP & LINO @ ALTO : setups

MLLTRAP

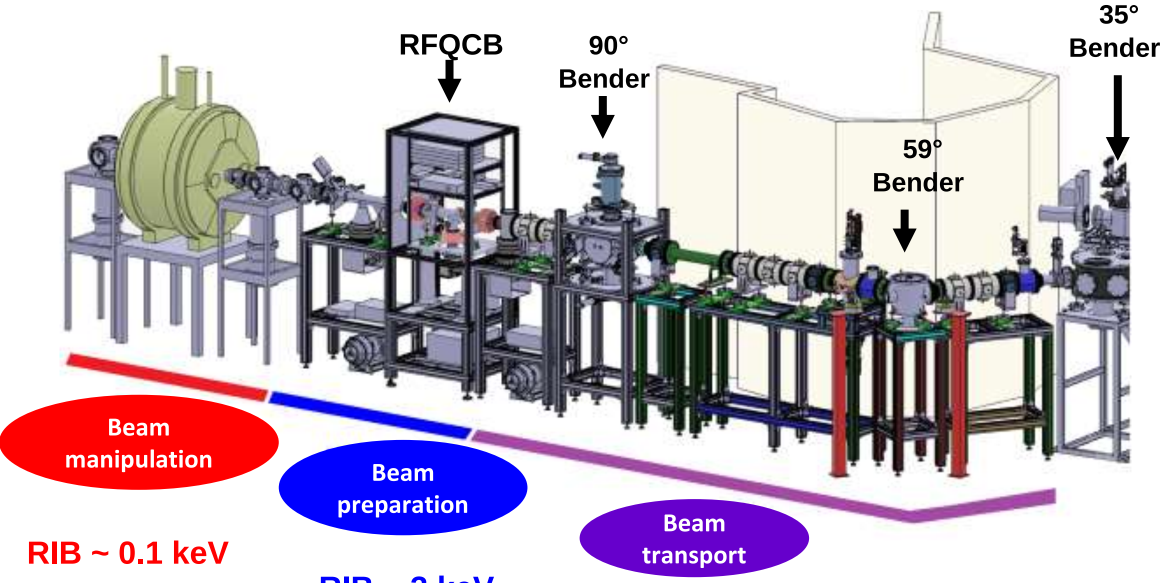


LINO



MLLTRAP

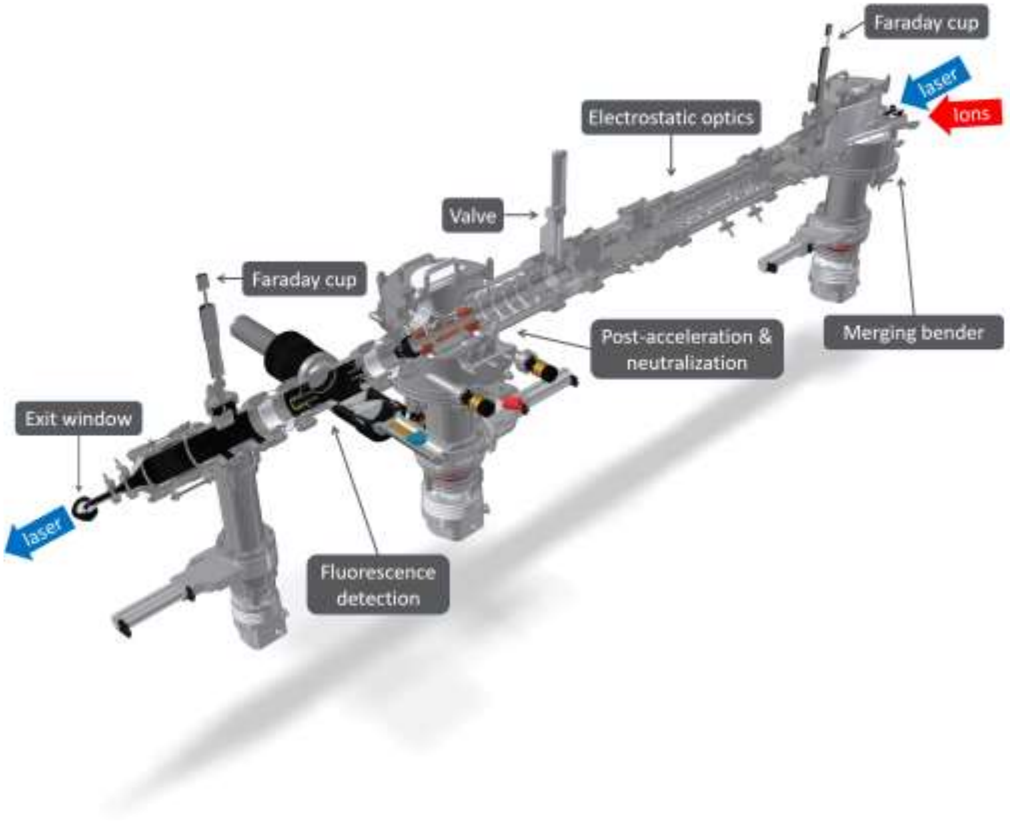
LINO



RIB ~ 0.1 keV

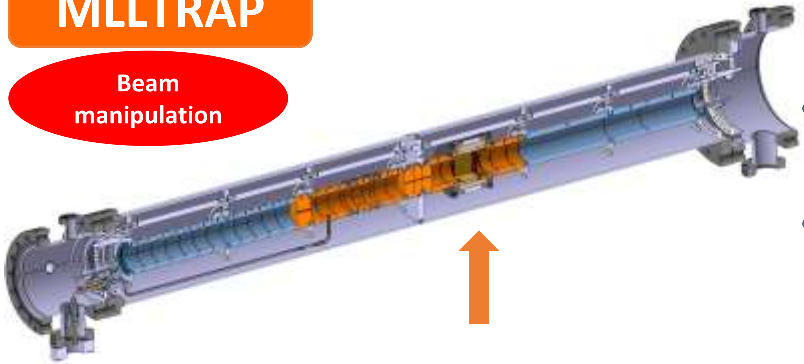
RIB ~ 3 keV

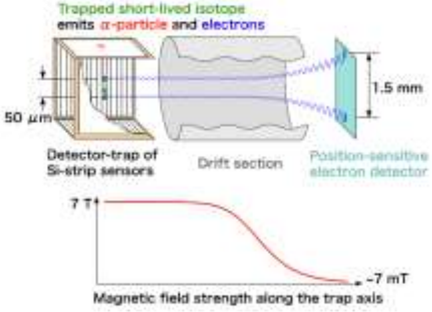
RIB ~ 30 keV

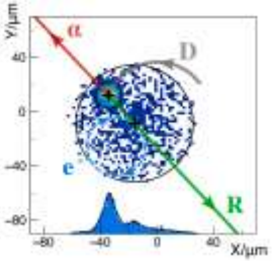


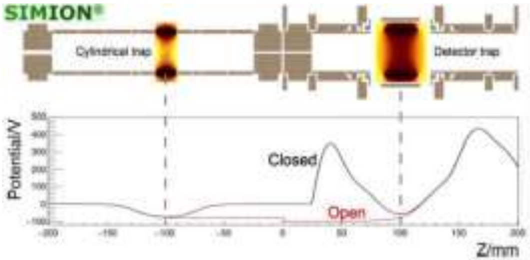
MLLTRAP

Beam manipulation









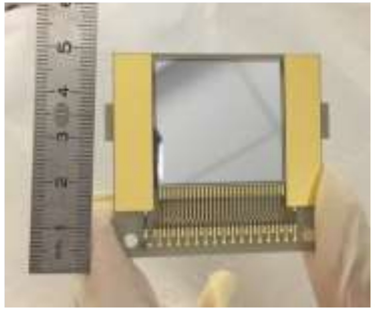
In-trap decay spectroscopy for MLLTRAP

- Decay experiments with carrier-free particles stored in a Penning trap enable studies on ideal ion samples.
- The improved energy resolution can be exploited for high-resolution α- and electron-decay spectroscopy.

→ Design fixed, all mechanical parts and insulators received in 2020.

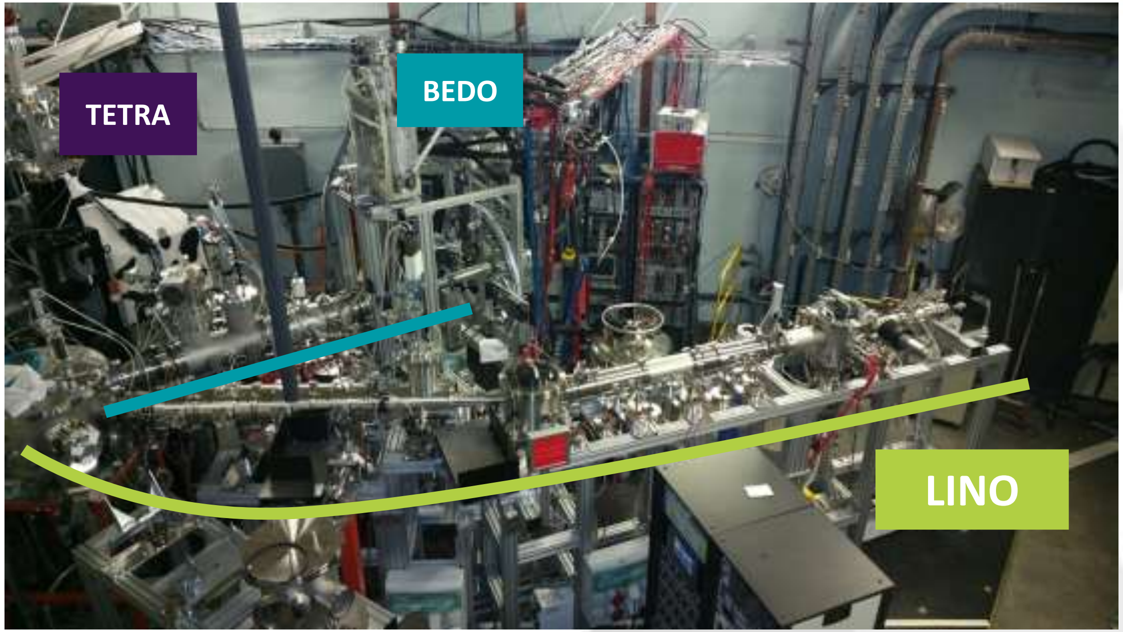
→ Gold plating of all the electrodes performed in October 2022

→ The next step is the mechanical assembly



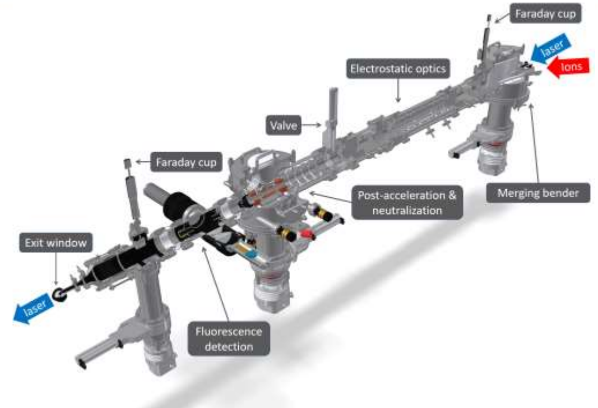
P. Chauveau et al., NIMB 982 (2020) 164508
P. Chauveau et al., NIMB 463 (2020) 371

LINO @ ALTO-LEB



LINO (Laser-induced nuclear orientation (μ,Q, J^p)

Offline commissioning of LINO → October 2019



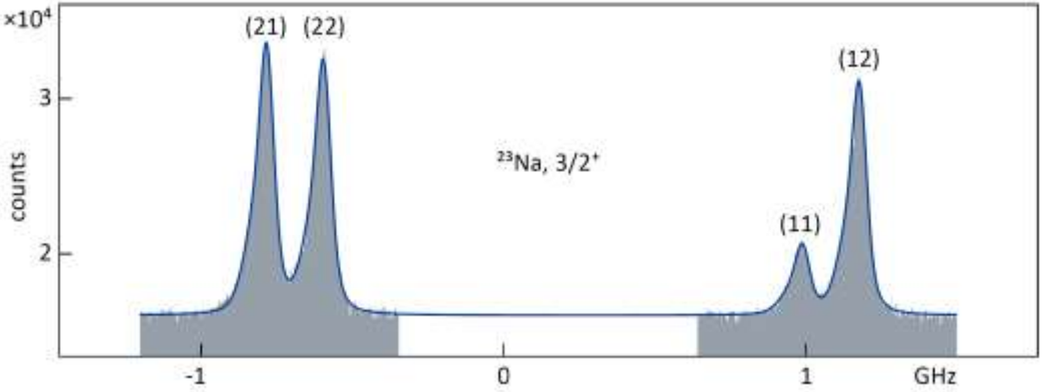
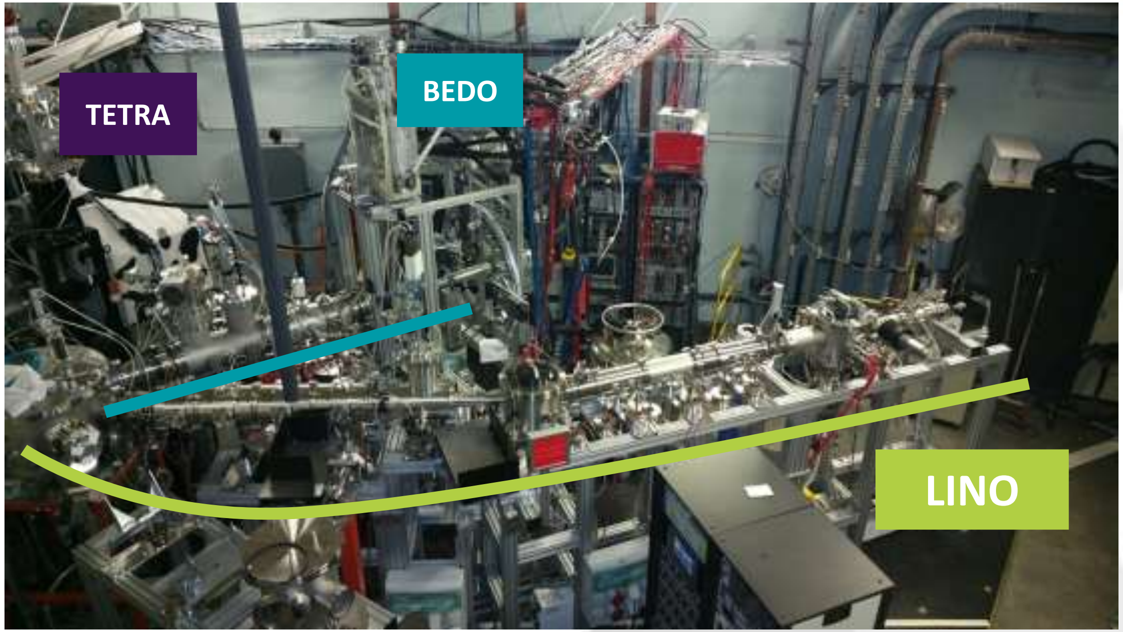


Figure 2. *Fluorescence spectrum of the D_1 line in ^{23}Na ($I^{\pi} = 3/2^{+}$).* Each transition is denoted in parentheses by the total angular-momentum quantum numbers of the lower and the higher state, respectively. The frequency scale is relative to the fine-structure splitting.

D.T. Yordanov et al., Journal of Instrumentation, 15 06004 (2020)



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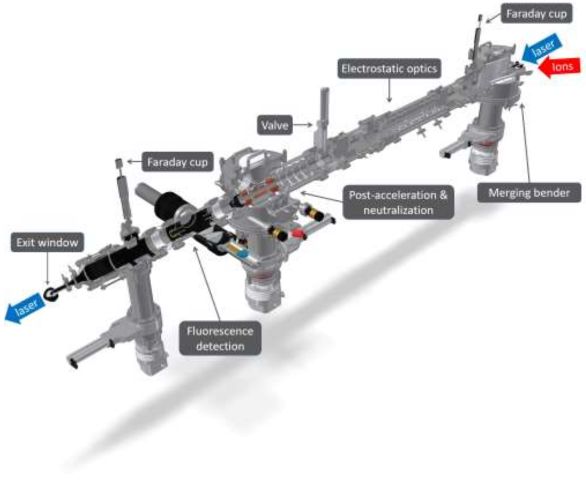


New Millennia eV, 532 nm pump laser bought to replace the old Ar-ion laser in order to be ready for on-line experiments.

LINO @ ALTO-LEB

1/2 journée discussion IJCLAb- LAC

mardi 14 juin 2022 à 09:00 → 12:05 Europe/Paris

100/0-MXX - Salle des Conseils (IJCLab)

09:00 – 09:15 Bienvenue direction IJCLAb

09:15 – 09:35 Préparation du faisceau de basse énergie d'Alto avec RFQ-cooler/buncher
Orateur: Enrique Minaya Ramirez

09:35 – 09:55 Faisceaux moléculaires à Alto
Orateur: Brigitte ROUSSIERE

09:55 – 10:15 Spectoscopie laser à Alto & au Ganil
Orateur: Serge Franchoo

10:15 – 10:45 PAUSE

10:45 – 11:05 Resonant ionization spectroscopy of radioactive molecules at Isolde
Orateur: Michail Athanasakis

11:05 – 11:25 Cavités Fabry Pérot pour la génération de rayons X-gamma par diffusion Compton
Orateur: Daniele Nutarelli

11:25 – 11:45 Réduction du bruit quantique pour les détecteurs d'ondes gravitationnelles
Orateur: Manuel Andia

11:45 – 12:05 Discussion

Laboratoire Aimé Cotton - Salle Balmer - bâtiment 505
Jeudi 13 Octobre 2022

PROGRAMME :

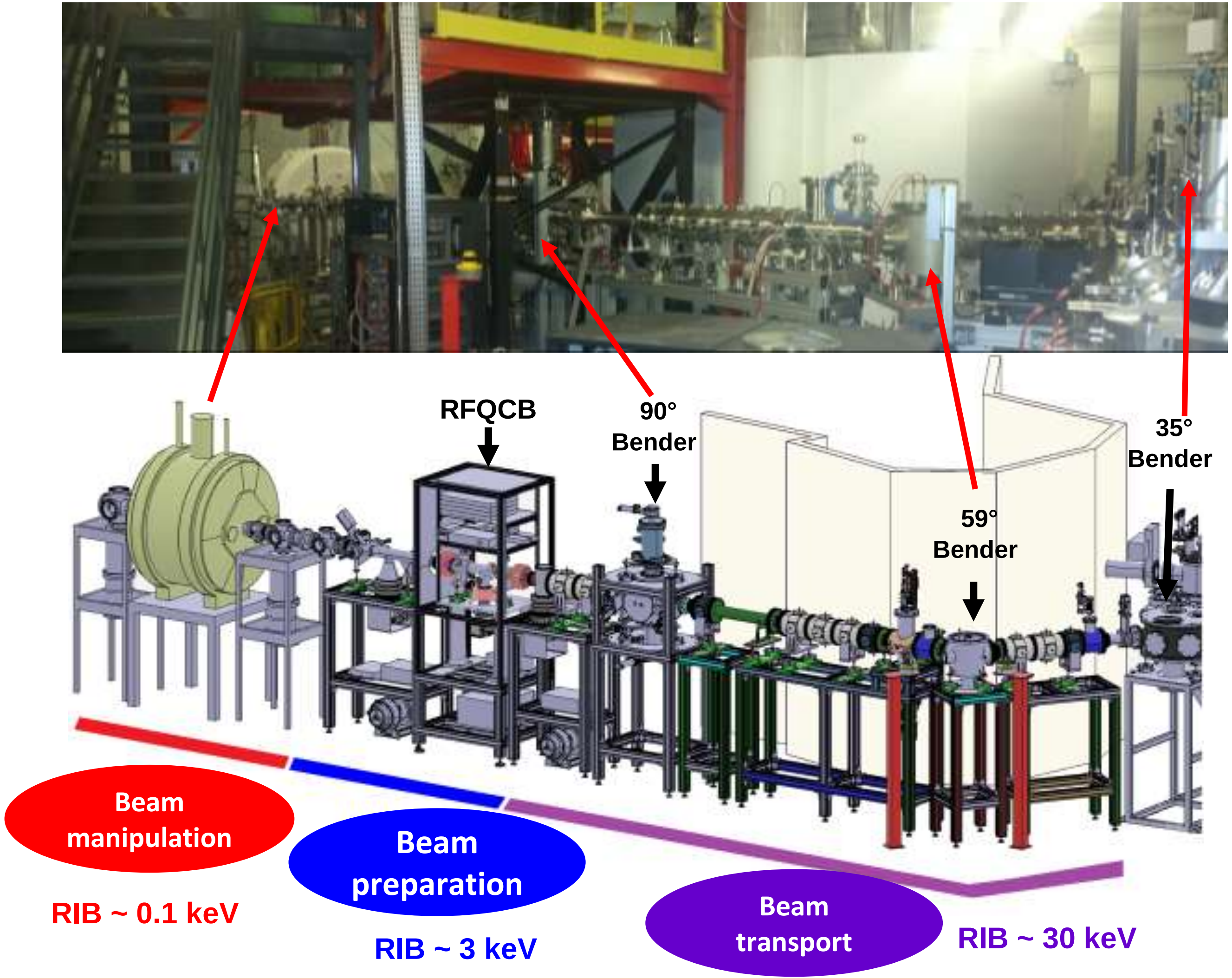
9.00-9.15	Accueil
9.15-9.30	Direction LAC (Olivier Dulieu)
9.30-9.45	Collision moléculaires pour l'astrophysique (Laurent Wiesenfeld)
9.45-10.00	Physique atomique dans les plasmas (Djamel Benredjem)
10.00-10.15	Théorie des molécules froides (Nadia Bouloufa)
10.30-10.45	PAUSE CAFE
10.45-11.00	Atomes de Rydberg (Patrick Cheinet / Steven Lepoutre)
11.00-11.15	Molécules froides (BaF) (Hans Lignier / Bruno Viaris)
11.15-11.30	Electron EDM/HBeam (Daniel Comparat)
11.30-11.50	Sources d'ions/électrons (Yan Picard / Daniel Comparat)
11.50-12.15	Prospectives et discussion (Daniel Comparat / Olivier Dulieu, /Jean-Paul Cromières)
12.15-13.00	BUFFET
13.00 +	Visites d'expériences (avec posters)

Organized by S. Franchoo

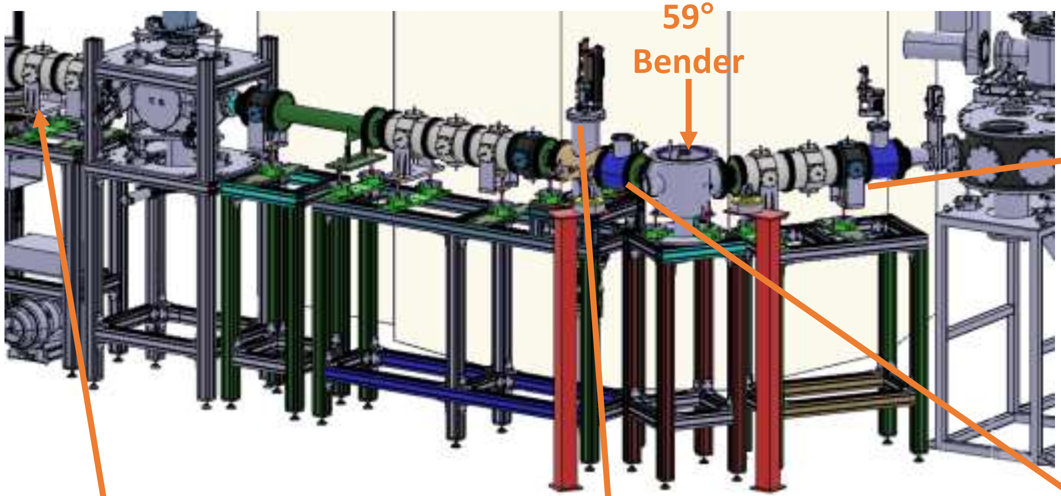
Organized by O. Dulieu

- **Possibility of using LINO through a new collaboration around molecular beams.**
- **Measurement of Emittance required to estimate the beam temperature.**

MLLTRAP @ ALTO-LEB



MLLTRAP @ ALTO-LEB : Beam transport

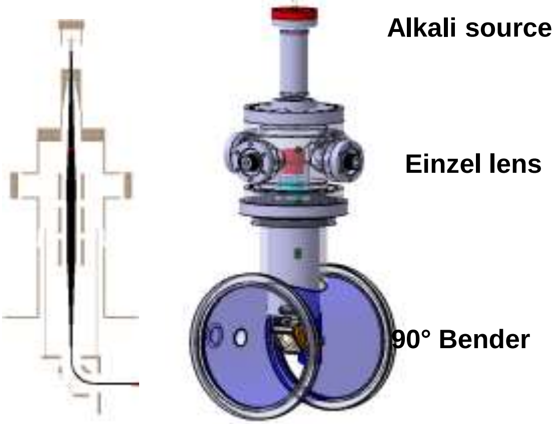


Beam transport

→Ready to be commissioned

delivery expected
11/2022 → 05/2023

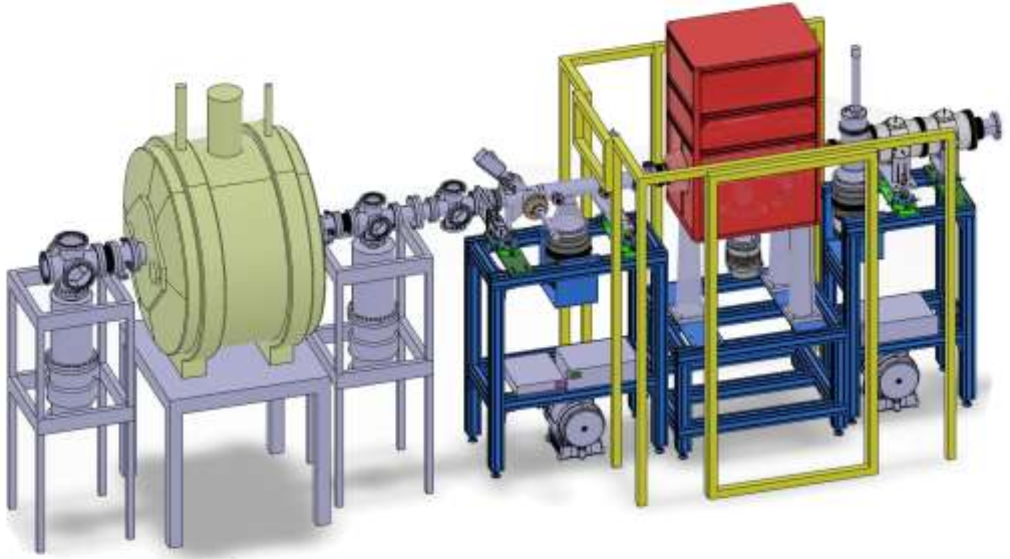
Beam profile monitor from

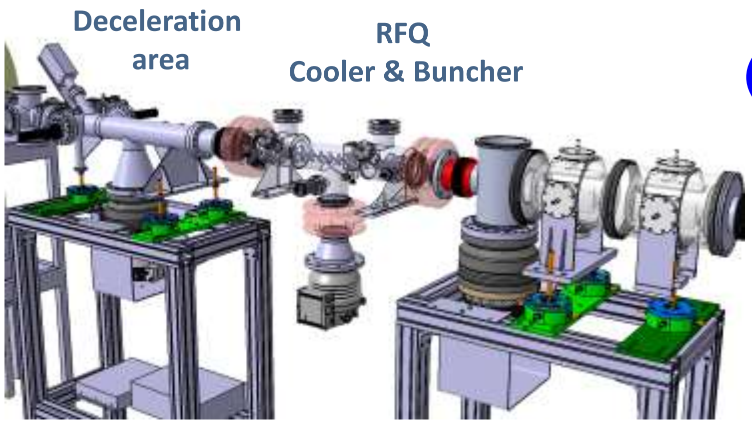


High voltage ion source

Simulation covered a large energy range : 1, 10, 30 and 50 kV were validated

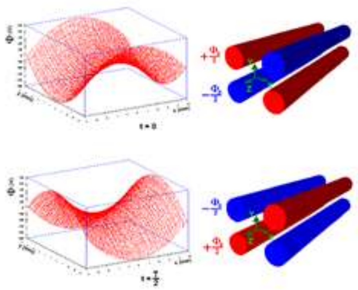
MLLTRAP @ ALTO-LEB : Beam preparation



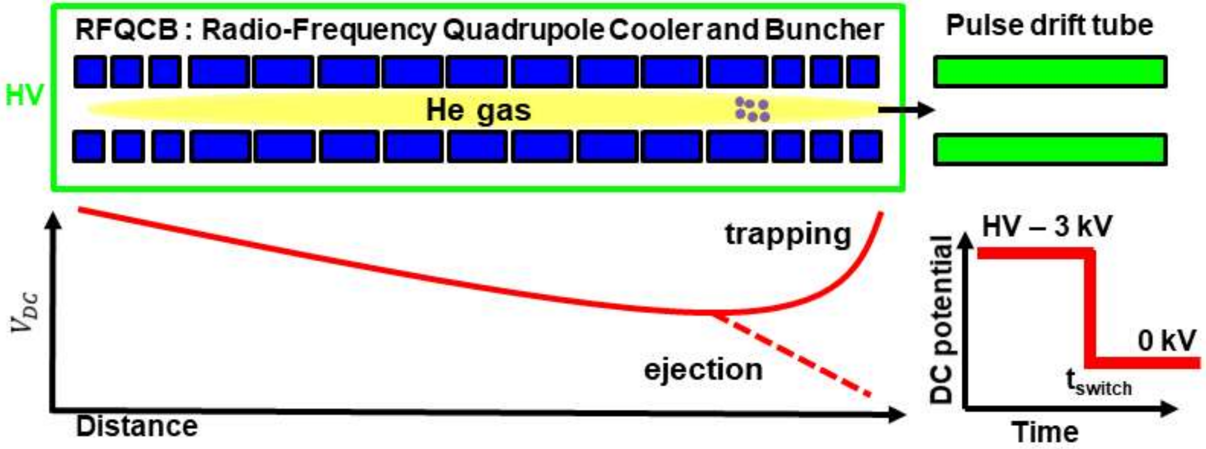


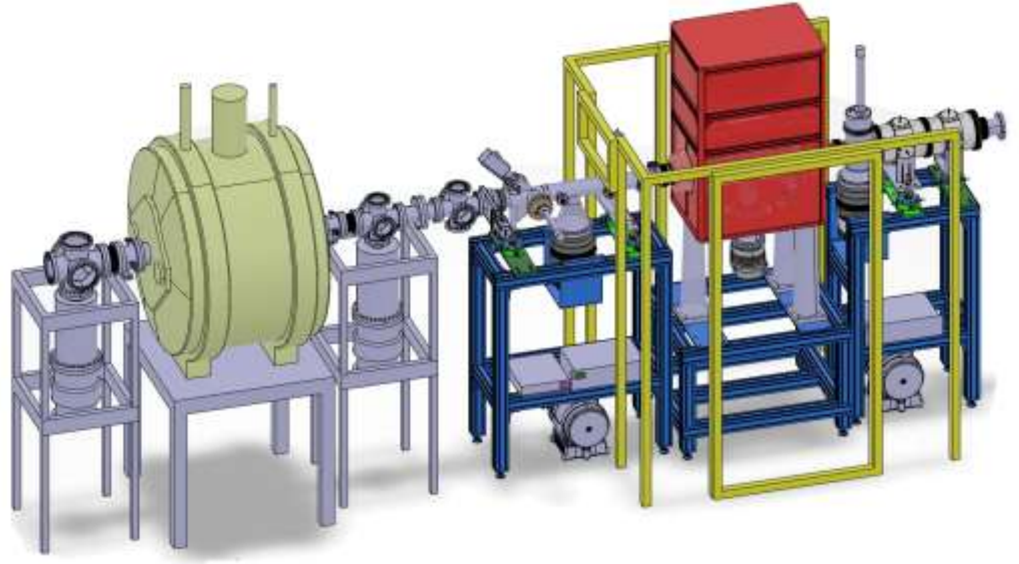
Beam preparation

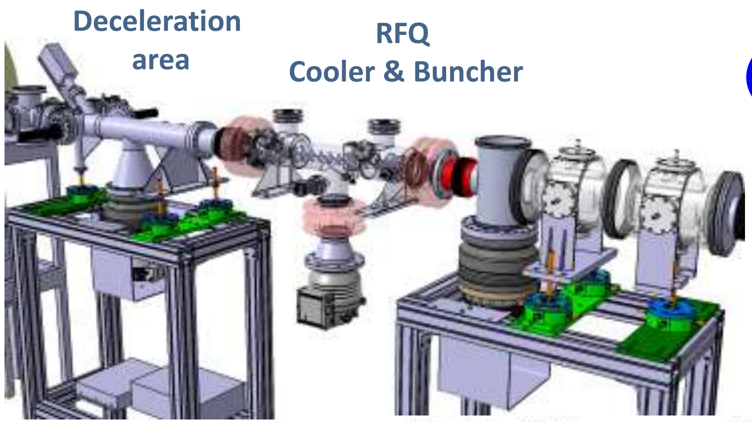
Paul trap



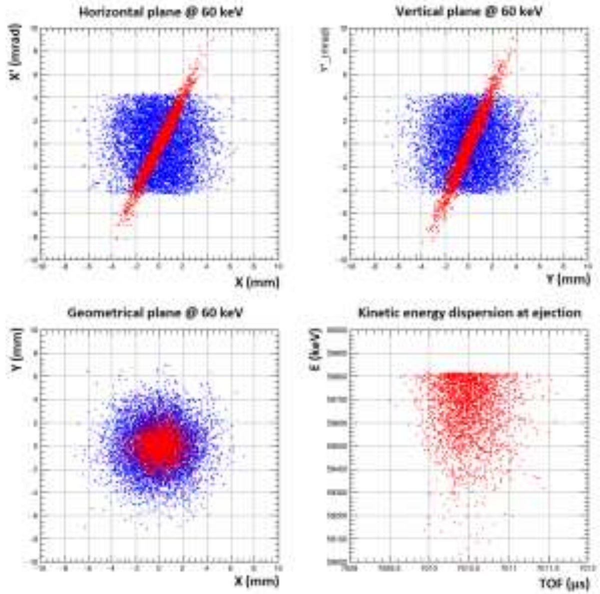
$$\Phi_0(t) = V_{DC} - V_{RF} \cos \Omega t$$







Beam preparation

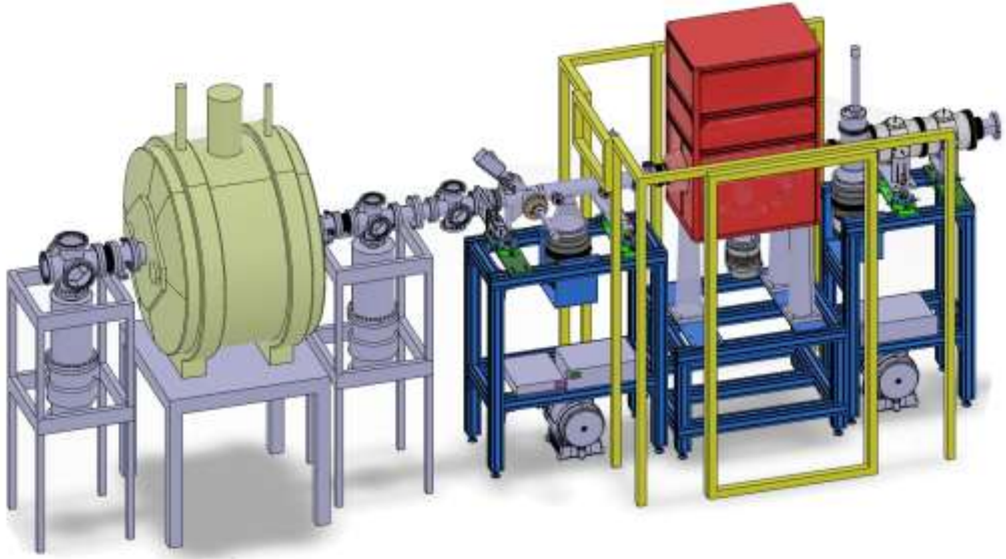


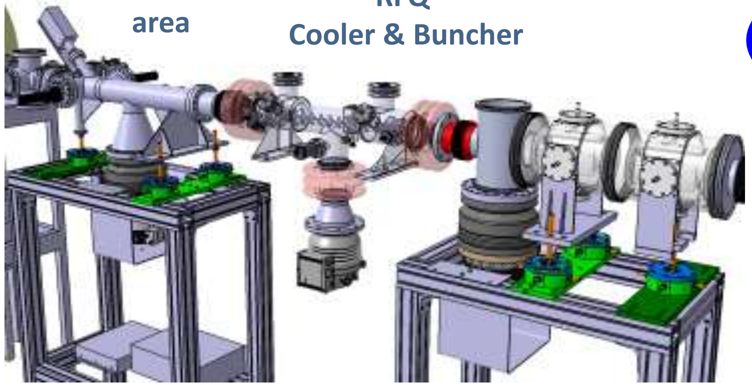
SIMION simulations at the injection point (blue color) and after having been cooled and bunched (in red).

Emittance at injection ~ 20 π.mm.mrad and ~ 3 π.mm.mrad at ejection, both at 60keV.

E. Minaya Ramirez et al., Nucl. Instr. Meth. B 463 (2020) 315

MLLTRAP @ ALTO-LEB : Beam preparation



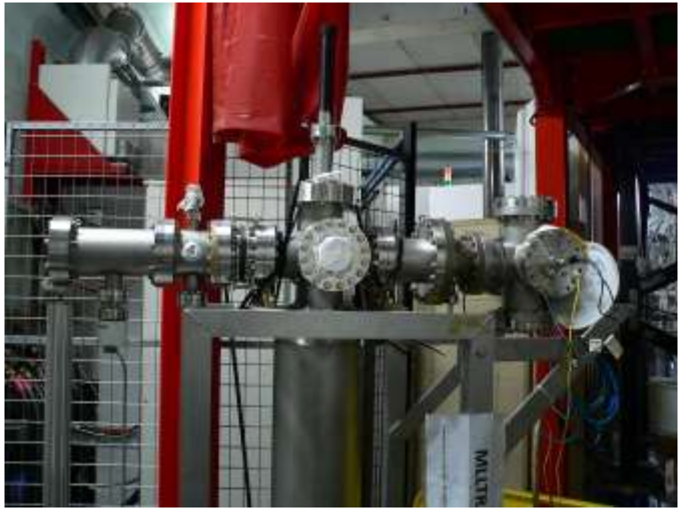


Beam preparation

- Electronics and pumping material received with a large delay.
- All the mechanical parts have been delivered. The assembly of the different parts are in progress.
- The alignment of the supports are currently in progress at ALTO

MLLTRAP @ ALTO-LEB : Beam manipulation

- Alignment of the vacuum tube axis with magnetic field lines was impacted by the installation and validation of the magnetic probe. The alignment is now finished (misalignment angle : 1.1 ± 0.1 mrad)
- Bender, injection electrodes and diagnostic system (faraday cup and microchannel plate) operational (tested with an alkali ion source).
- Upgrade of the control system in progress. Coupled with the installation of the MCP delay line (for PI-ICR).
- Installation of Penning traps in progress.

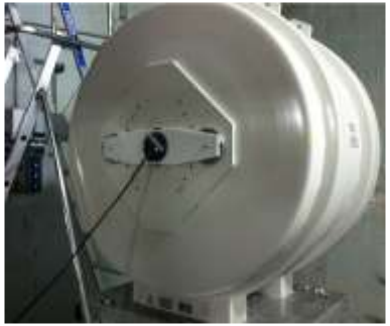


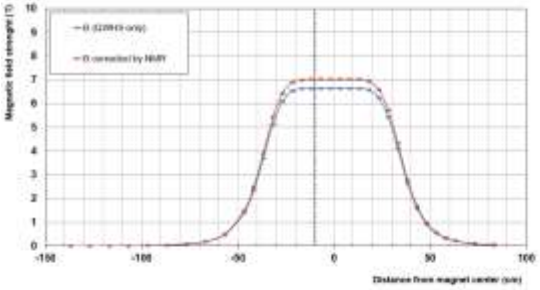
MLLTRAP @ ALTO – Beam manipulation

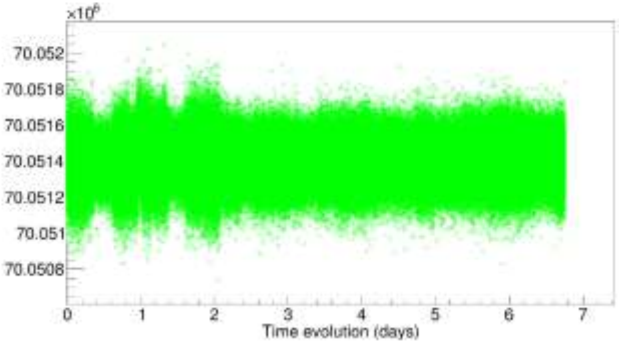
Beam manipulation

- **Probe developed by Caylar to track magnetic field evolution in real time.**
- **Probe located in the gap between bore's magnet and the vacuum tube.**

  → non-linear field drifts during long measurements

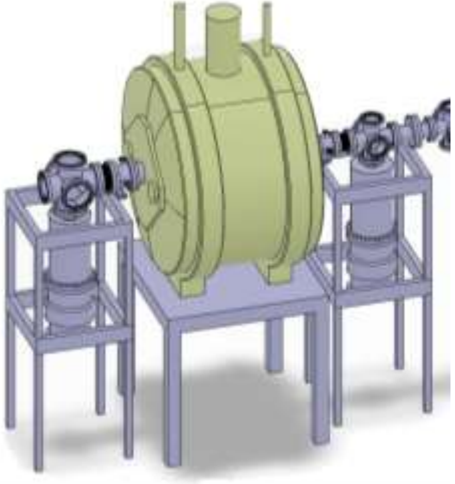


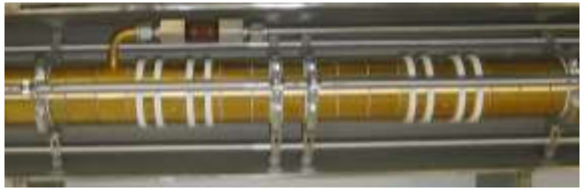


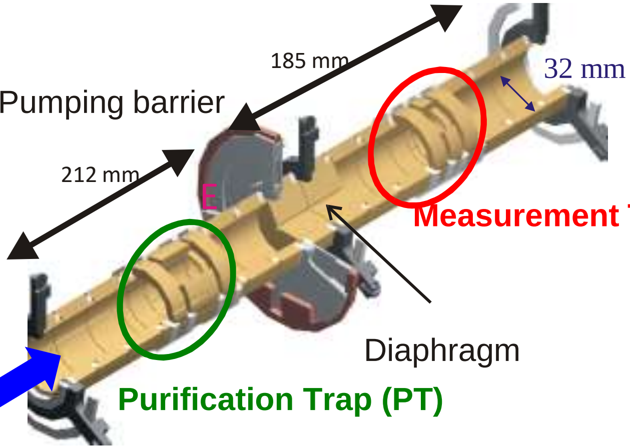


- First probe developed between (2018-2019) → miniaturized probe validated in September 2020.
- Coupled to the bore temperature. Currently 10^{-7} precision.

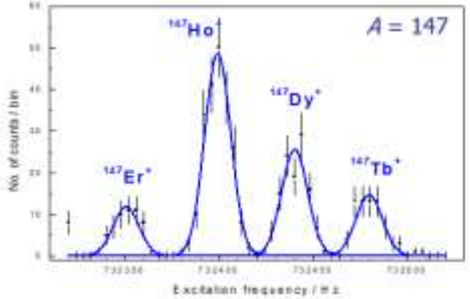
MLLTRAP @ ALTO-LEB : Beam manipulation



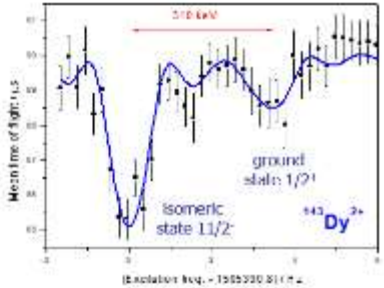




Beam manipulation



Mass resolving power of 100 000
→ separation of isobars

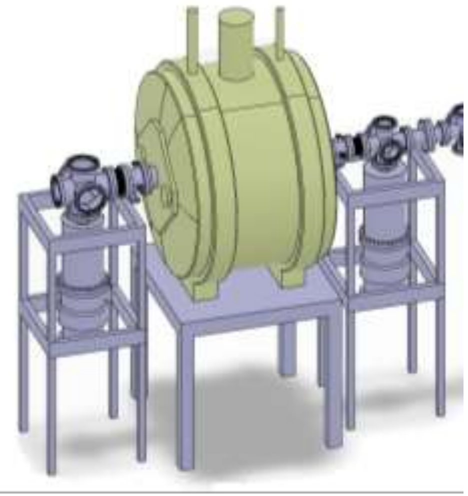


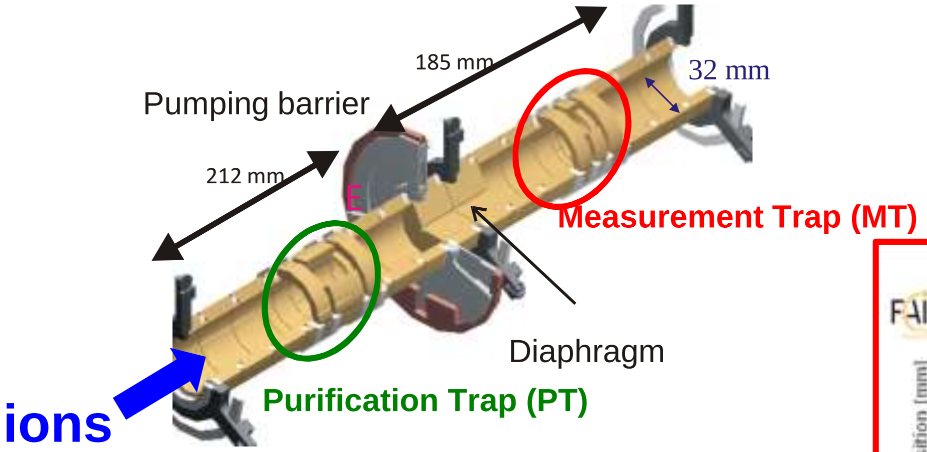
Mass resolving power of 1 000 000
→ separation of isomers

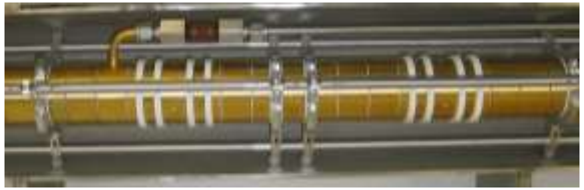
Time of Flight
Ion-Cyclotron-Resonance (TOF-ICR)

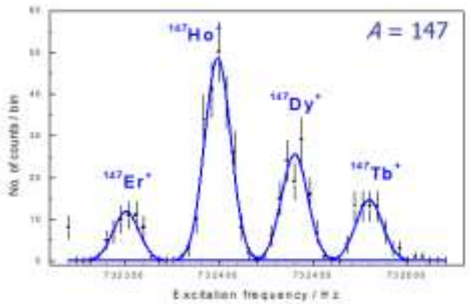
MLLTRAP @ ALTO-LEB : Beam manipulation

Beam manipulation

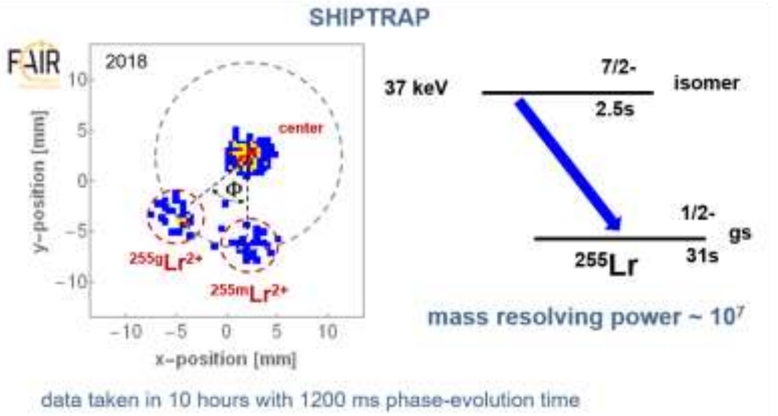








Mass resolving power of 100 000
→ separation of isobars



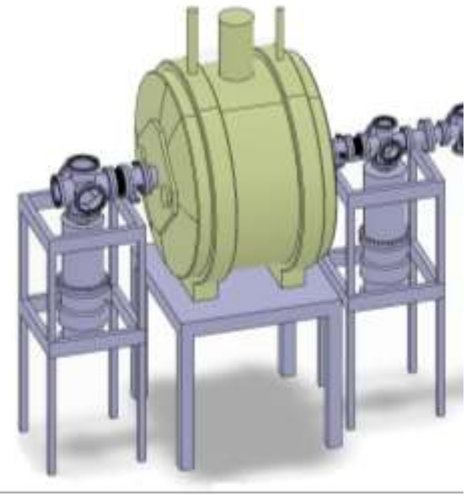
GSI-IN2P3 collaboration n°19-81

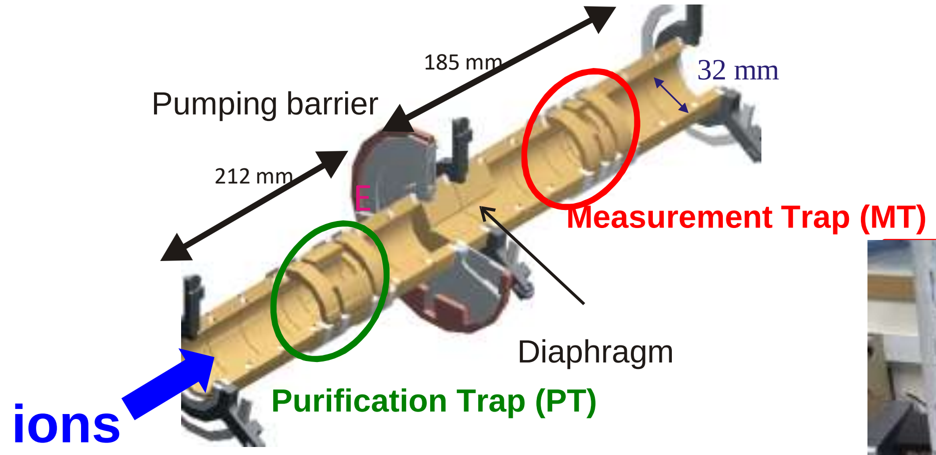
Phase Imaging
Ion-Cyclotron-Resonance (PI-ICR)

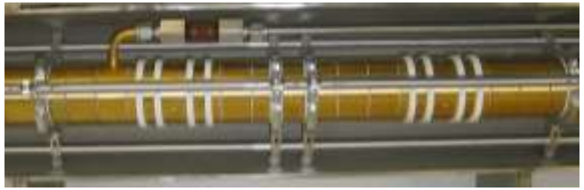
$$\varphi + 2\pi n = 2\pi\nu t \qquad \Delta\nu = \frac{\Delta\varphi}{2\pi t} = \frac{\Delta R}{\pi t R}$$

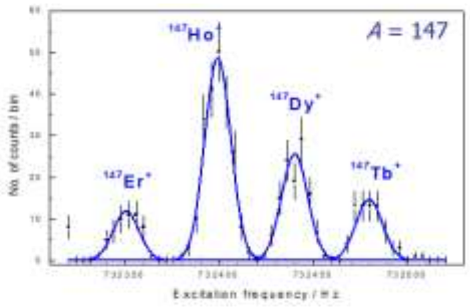
MLLTRAP @ ALTO-LEB : Beam manipulation

Beam manipulation



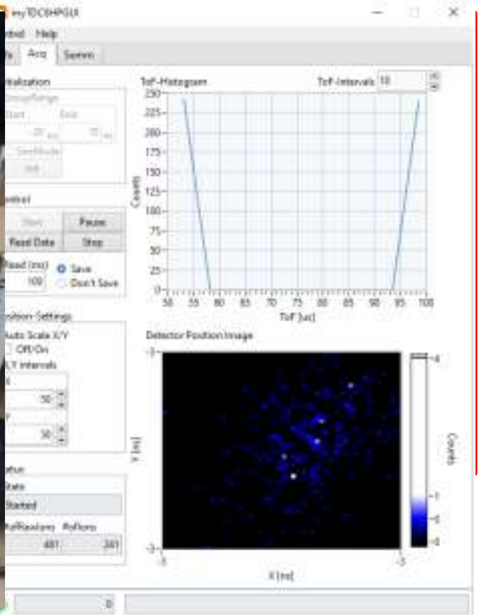






Mass resolving power of 100 000

→ separation of isobars



$$\varphi + 2\pi n = 2\pi \nu t$$

$$\Delta\nu = \frac{\Delta\varphi}{2\pi t} = \frac{\Delta R}{\pi t R}$$

MLLTRAP and LINO : Perspectives

- LINO was commissioned off-line in October 2019.
- Preparation and manipulation sections of MLLTRAP are under progress.
- The Offline commissioning of MLLTRAP will be performed with a high voltage source.
- Both experiments could benefit of the future radioactive beams produced at ALTO.

Thank you for your attention !