

Nuclear structure studies with Penning traps collaboration n°19-81



IN2P3 – GSI Collaboration

Identification of the laboratories

Partner	GSI
IN2P3 laboratories	IJCLab
Partner laboratories	SHIPTRAP (Division : SHE-Physik)

Identification of the collaboration

Title of the collaboration	Nuclear structure studies with Penning traps
Number of the collaboration	19-81
IN2P3 spokesperson	E. MINAYA RAMIREZ
GSI spokesperson	M. BLOCK
Scientific Domain	Nuclear Physics
Beginning of Collaboration	2019



Scientific and strategic goals



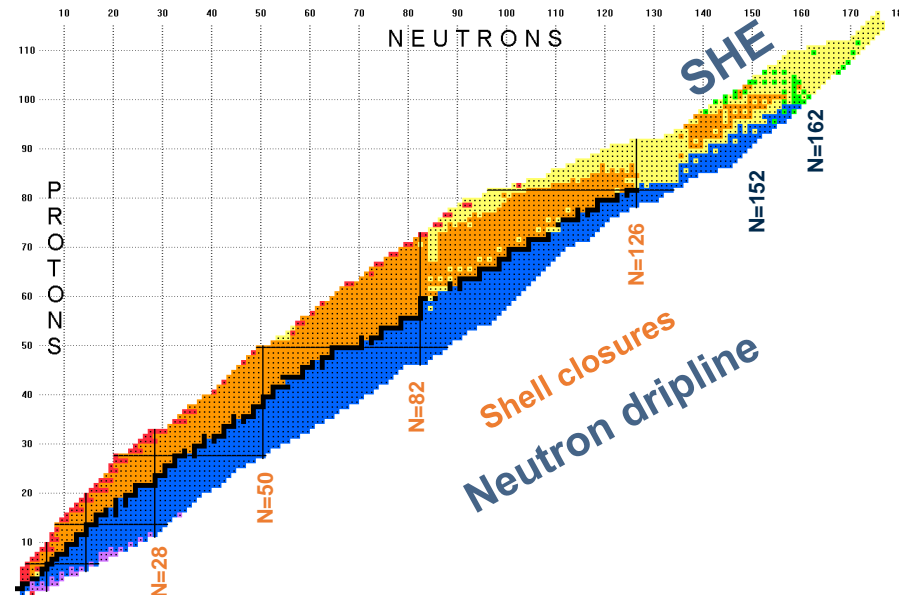
MLLTRAP

Perform high-precision mass measurements of very exotic nuclides



SHIPTRAP

- reveal nuclear shell structure
- provide anchor points to pinpoint α -decay chains
- identify (long-lived) nuclear isomers
- Impact in nuclear astrophysics





Scientific and strategic goals



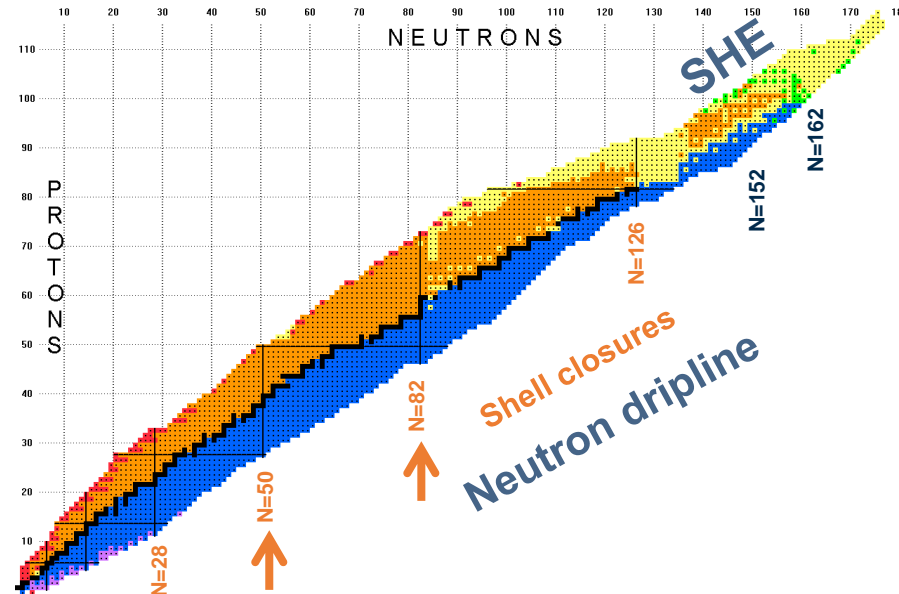
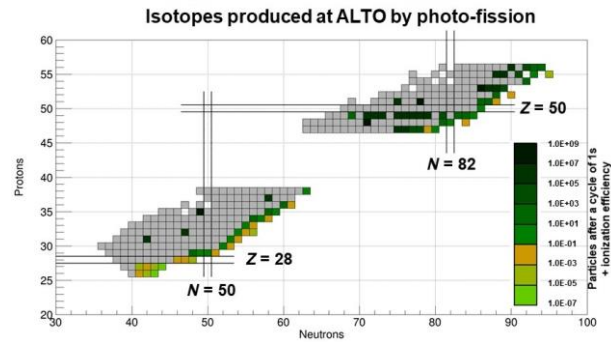
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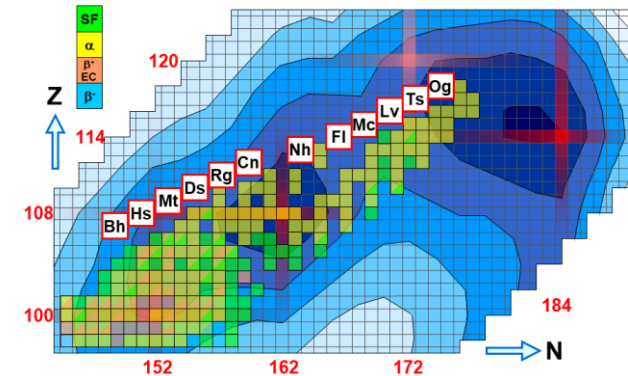
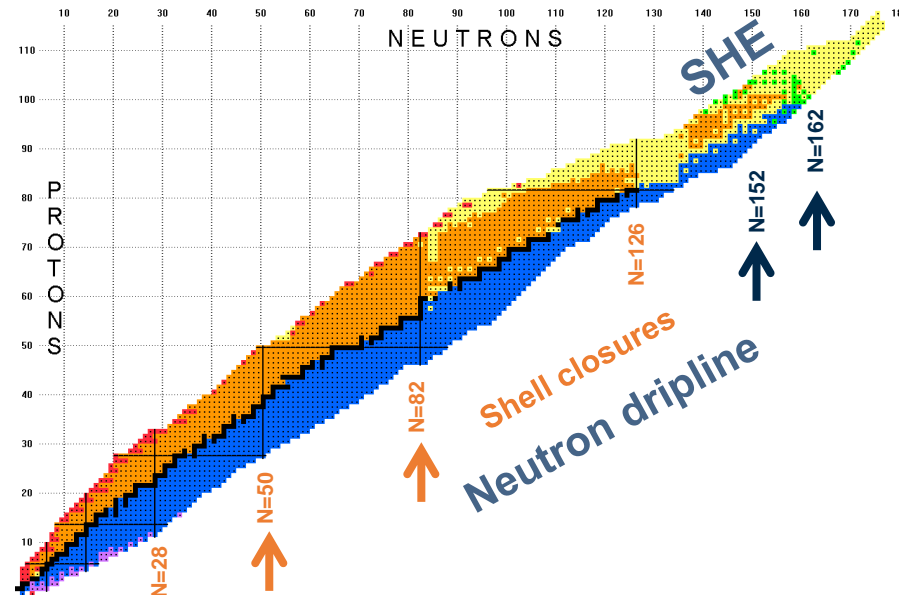
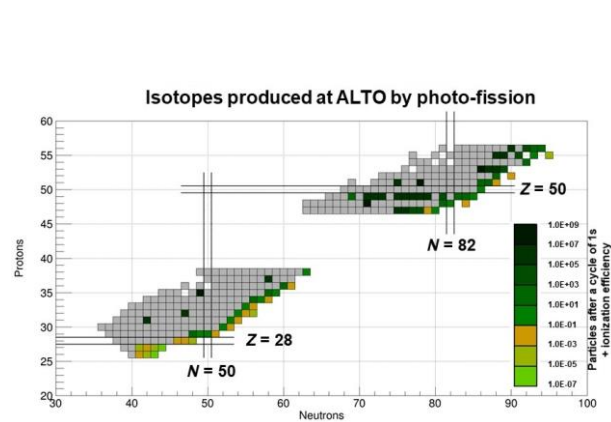


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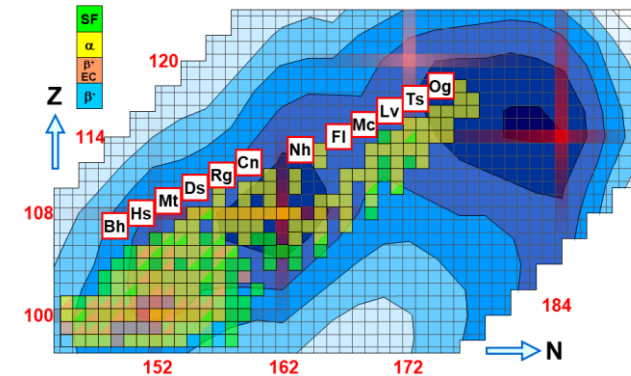
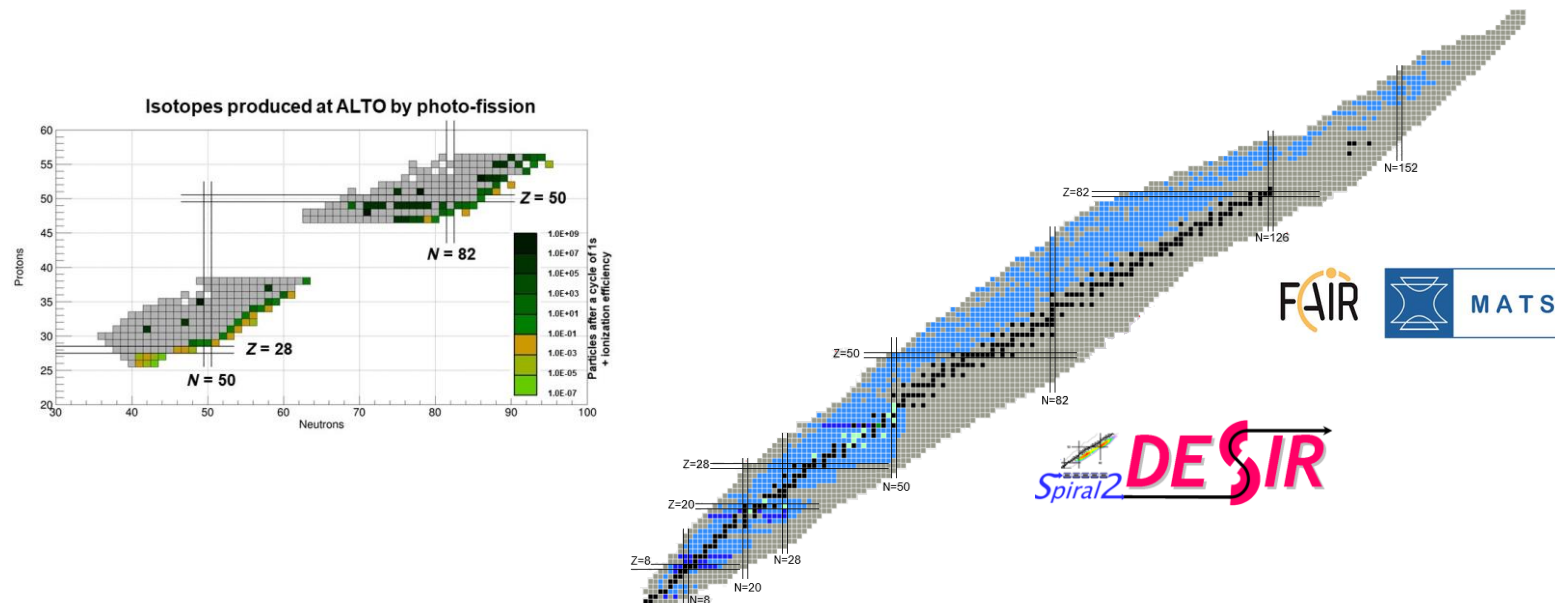


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MLLTRAP

Double Penning trap mass spectrometers



$$\nu_c = \frac{1}{2\pi} \frac{q}{m} B$$

SHIPTRAP

Double Penning trap mass spectrometers

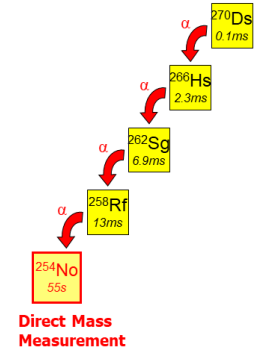
$$\nu_c = \frac{1}{2\pi} \frac{q}{m} B$$

$$M_{\text{atom}}(N, Z) = M_{\text{nucl}}(N, Z) + Z \cdot M_e - B_{\text{el}}(Z)$$

↓

$$Z \cdot M_p + N \cdot M_n - B(N, Z)$$

- absolute nuclear binding energy
- shell structure evolution
- benchmark nuclear models
- anchor points to fix decay chains



Double Penning trap mass spectrometers

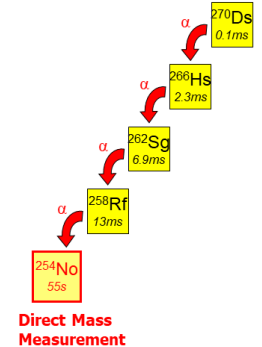
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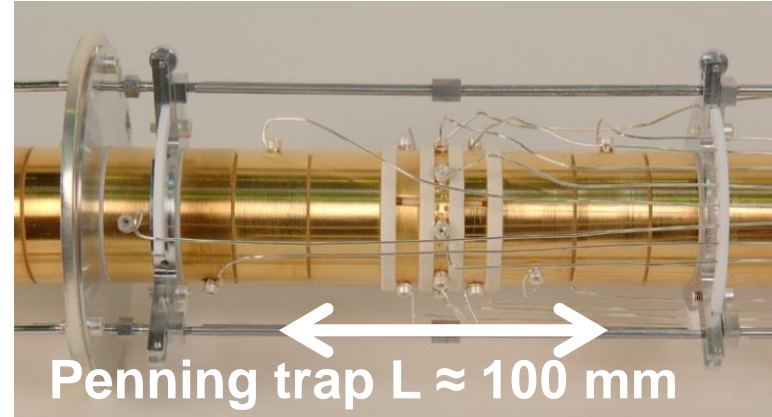
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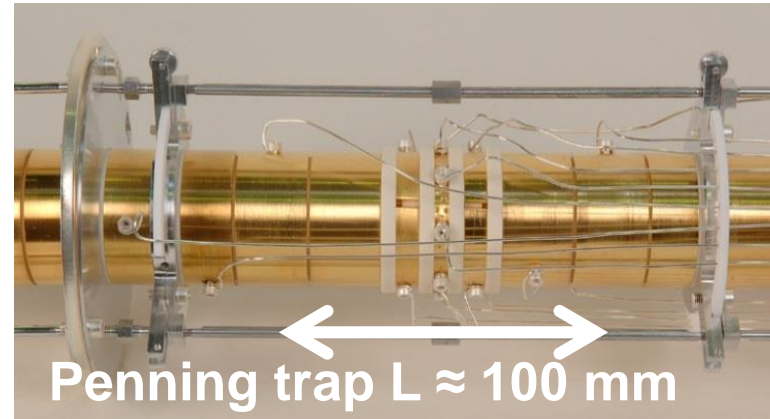
High precision measurements

$$\frac{\delta m}{m} \sim 10^{-6} \quad S_{2n}, \text{ shell gaps, pairing, single particles}$$

$$\frac{\delta m}{m} \sim 10^{-8} - 10^{-7} \quad Q_\beta, \text{ isomers, deformation, halos}$$



- Superconducting magnet of 7 T with 2 homogeneous areas
- Control system
- Diagnostic systems
- Cryogenic systems
- Ion traps R&D (FT-ICR / in-trap decay)
- Data analysis



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increasing efficiency, sensitivity, and resolving power
→ Required for very exotic nuclei

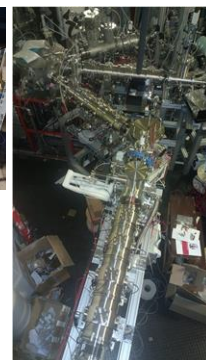
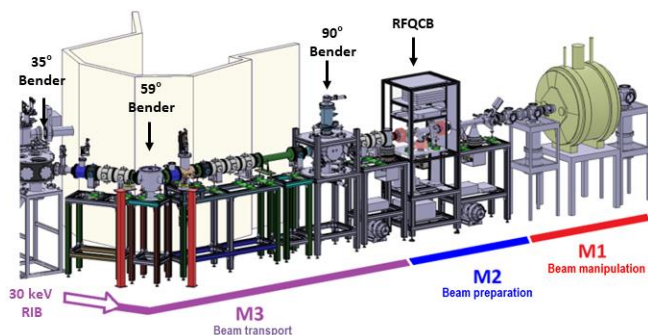


Current Status

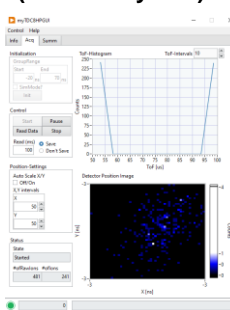


IN2P3

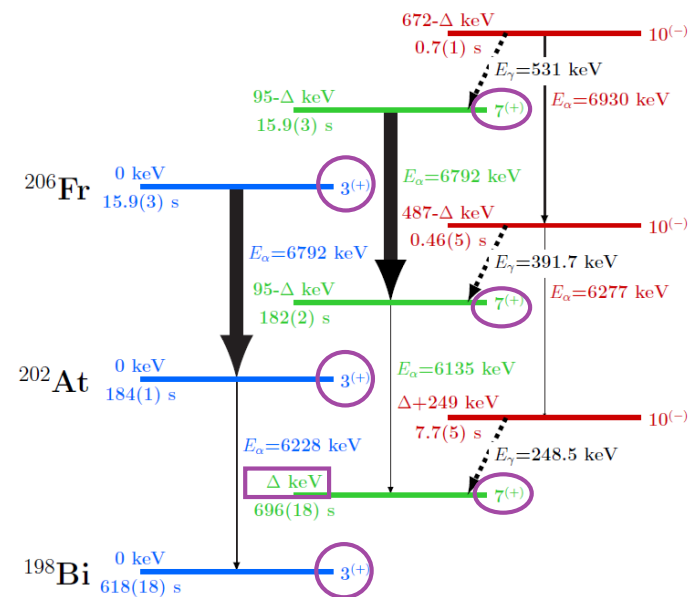
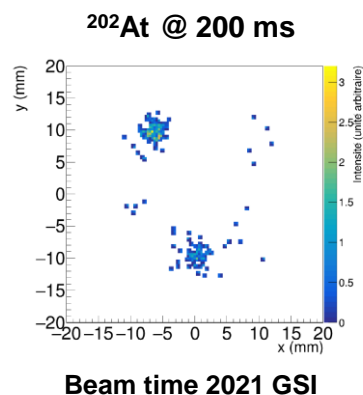
MLLTRAP



CS++
(MCP Delay line)



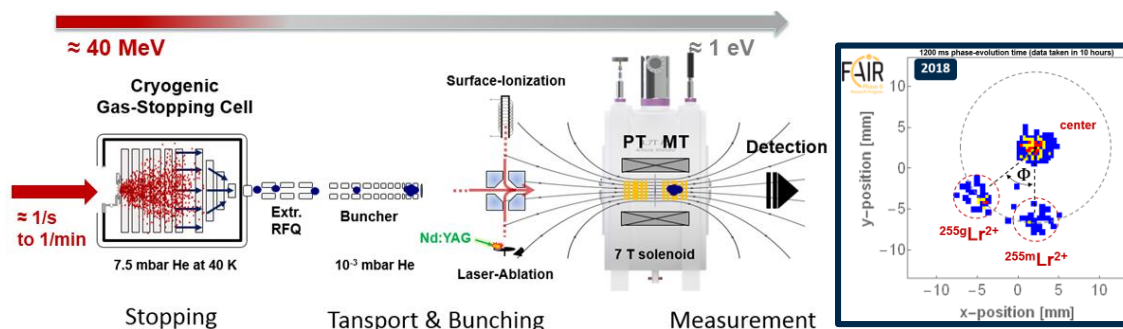
- Section M3 ready to be commissioned.
- Section M1 and M2 : installation in progress.
- CS++ in progress → full implementation of PI-ICR.
- ALTO-LEB : new front-end commissioned in October
→ laser scheme validated for silver
- Data analysis of the Fr-At-Bi decay chain well advanced
→ article in preparation (E. Morin et al.)
- PhD thesis defense of E. Morin the 9th of December.
- New PhD student (S. Morard) started in October.
- New permanent joined the project in April (A. Leite ~40%).
- R&D in-trap : last mechanical parts arrived to start the full assembly.



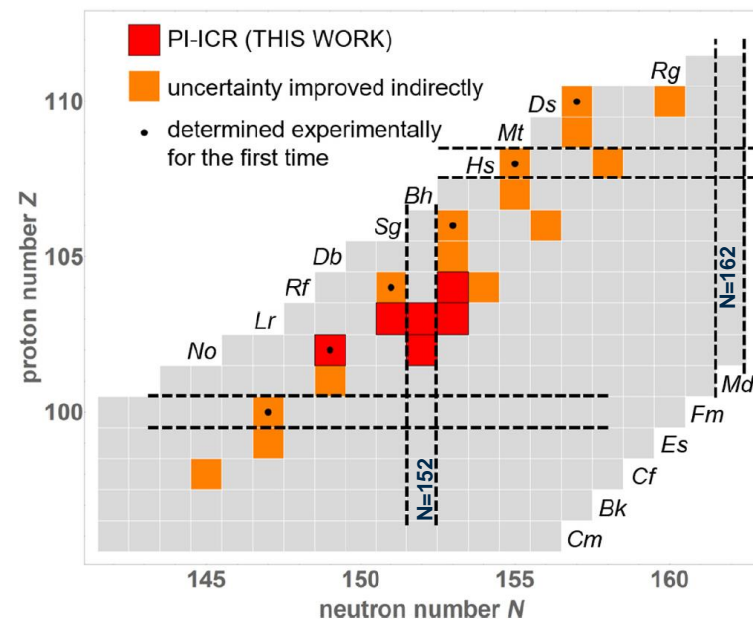
K.M. Lynch et al., PRC 93 (2016) 014319



Current Status



- O. Kaleja et al., accepted in Physical Review C, October 2022, Mass measurement of ground state of ^{251}No , ^{254}No , ^{254}Lr , ^{256}Lr , ^{257}Rf .
- The second paper on the data from 2018's beamtime, connected to the isomeric cases, is expected to be submitted beginning of 2023.
- The data analysis of the additional data of ^{257}Rf from 2020's beamtime is in progress.
- Systematic studies connected to the latest data analysis is in progress (2021's beamtime).
- G-PAC 2022 \rightarrow beam time approved for the study of ^{258}Db (in 2024)
- A new PhD student should join the project in 2023.



O. Kaleja et al., PRC (2020)



Days attributed



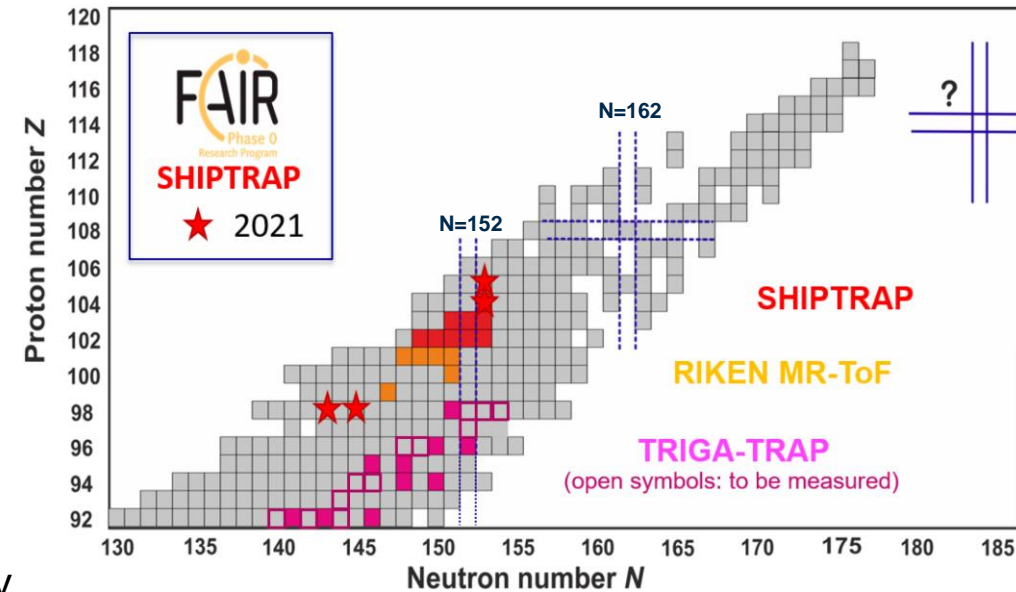
	Days attributed	Days spent	Days attributed	Days spent
2019	5	5	10	10
2020	20	10	30	Lockdown
2021	15	15 (+30 for PhD student)	15	Lockdown
2022	20 (requested)	15	20 (requested)	0 (only 1 person available)
2023	20 (requested)	--	20 (requested)	--

→ R&D tests / Beam preparation / Beam time / Data analysis



Scientific program for the future years

- Unique GSI-IN2P3 collaboration based on high precision mass measurements with double penning trap mass spectrometers (PTMS)
- Both experiments have been developed to perform direct high-precision mass measurements of radioactive nuclei.
- Complementary physics programs on the nuclear structure evolution far away from stability.
- Both experiments could benefit from their time invested on technical developments to increase the efficiency, sensitivity and resolving power of PTMS.
- Both experiments are connected to others frameworks : MATS and DESIR. Common abstract submitted at the “Physics with SPIRAL2 Heavy Ion Beams” to perform precision mass measurements of nuclei in the superheavy region with MLLTRAP (in-trap) at DESIR.





Thank you for your attention