TECHNISCHE UNIVERSITÄT DARMSTADT

PUMA
SPSC MEETING 2024

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In collaboration with: D. Calvet, D. Neidherr, K. Kormann, Y. Kubota, Y. Ono, E. C. Pollacco, L. Schweikhard


Alexander von Humboldt
Stiftung/Foundation


NEUTRON SKINS

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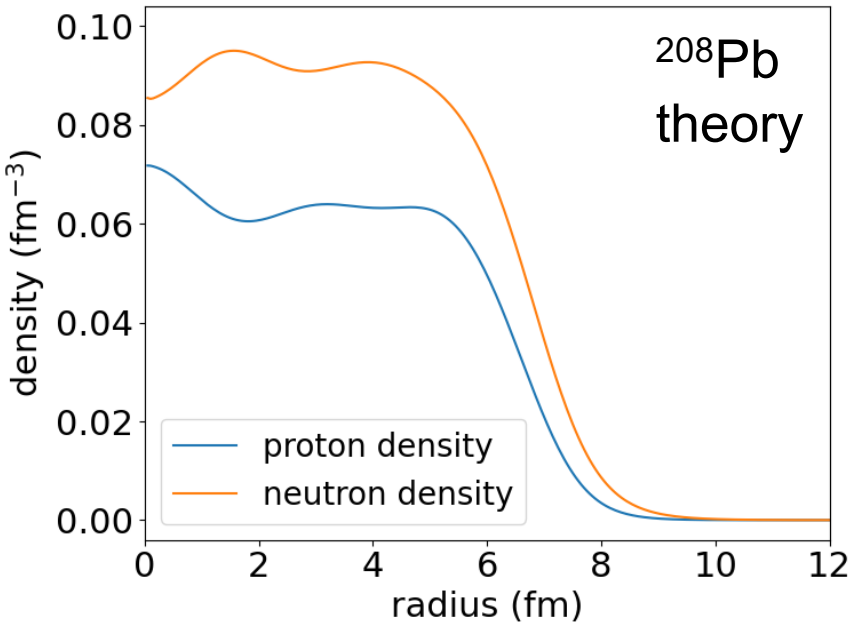
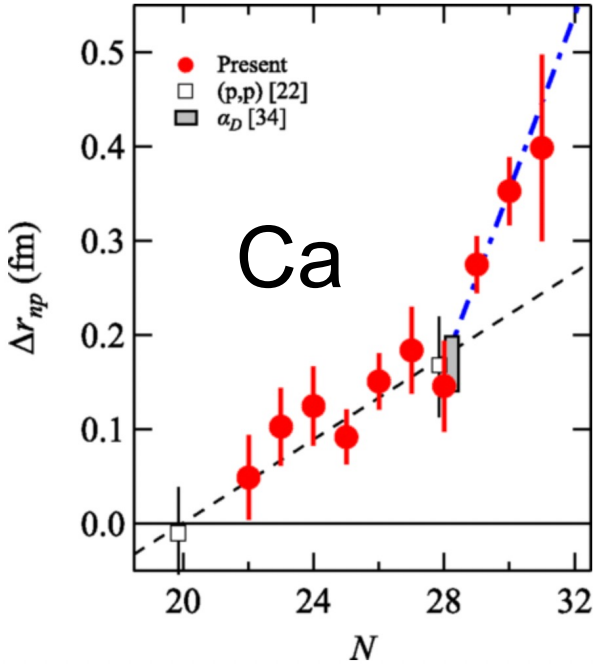
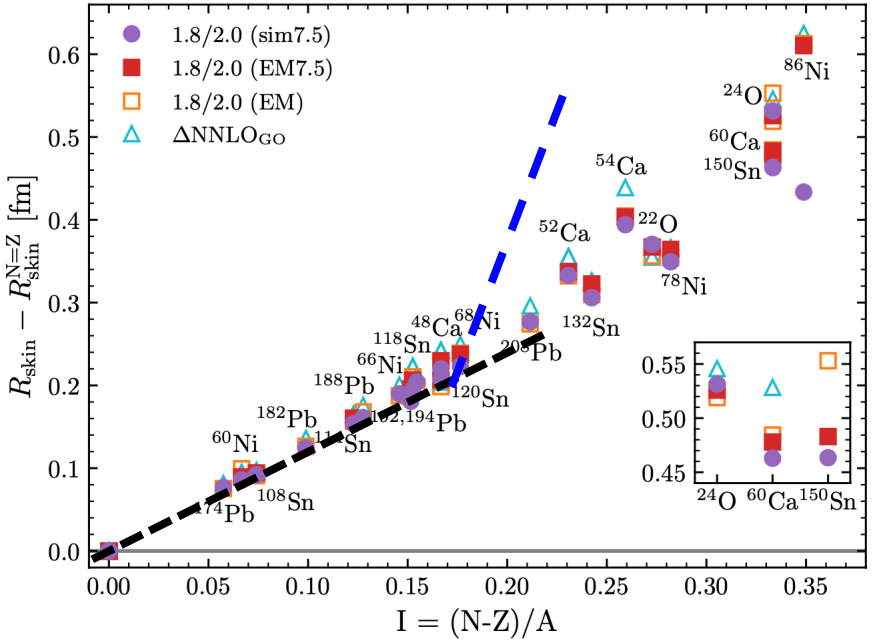


Interaction cross sections



Tanaka et al., PRL (2020)

$R_{skin} = \sqrt{\langle r_n^2 \rangle} - \sqrt{\langle r_p^2 \rangle}$ (fm)



Arthuis, Hebeler, Schwenk, arXiv (2024)

- Matter or neutron radius experimentally difficult to access
- Neutron skin thickness linked to nuclear equation of state (EOS) around saturation
- Modern theory based on chiral Effective Field theory challenged

PUMA

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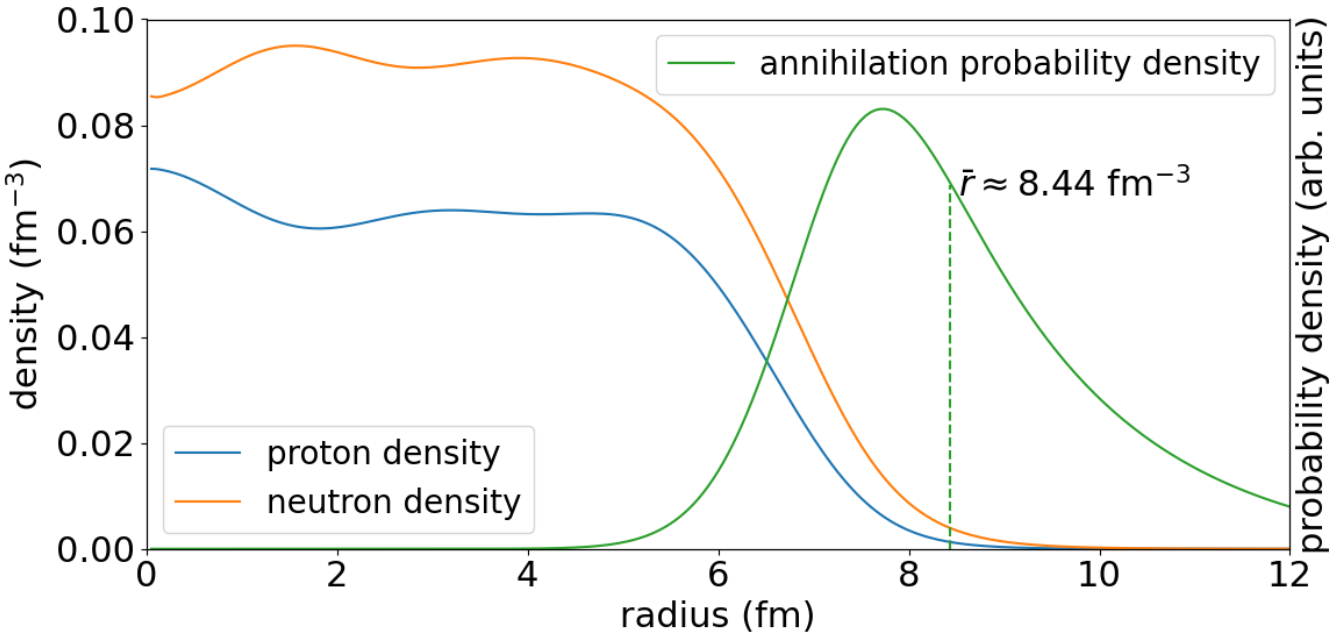

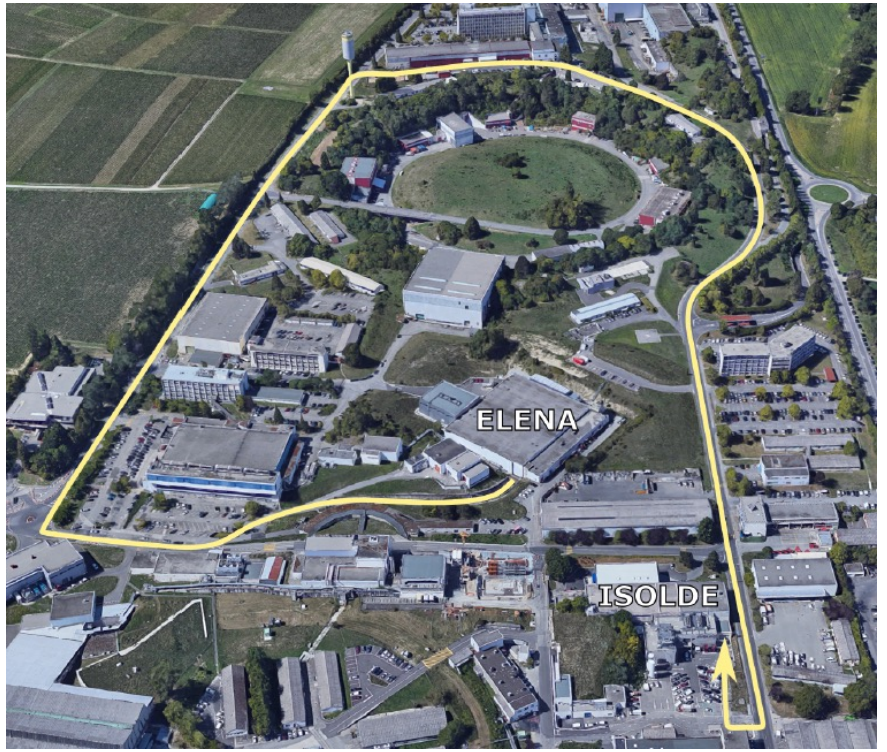

PUMA aims at the neutron-to-proton content of the density tail of stable and unstable nuclei from $\bar{p}$-nucleus annihilations.

T. Aumann *et al.* (PUMA collaboration), EPJA 58, 88 (2022)

PUMA @ ELENA

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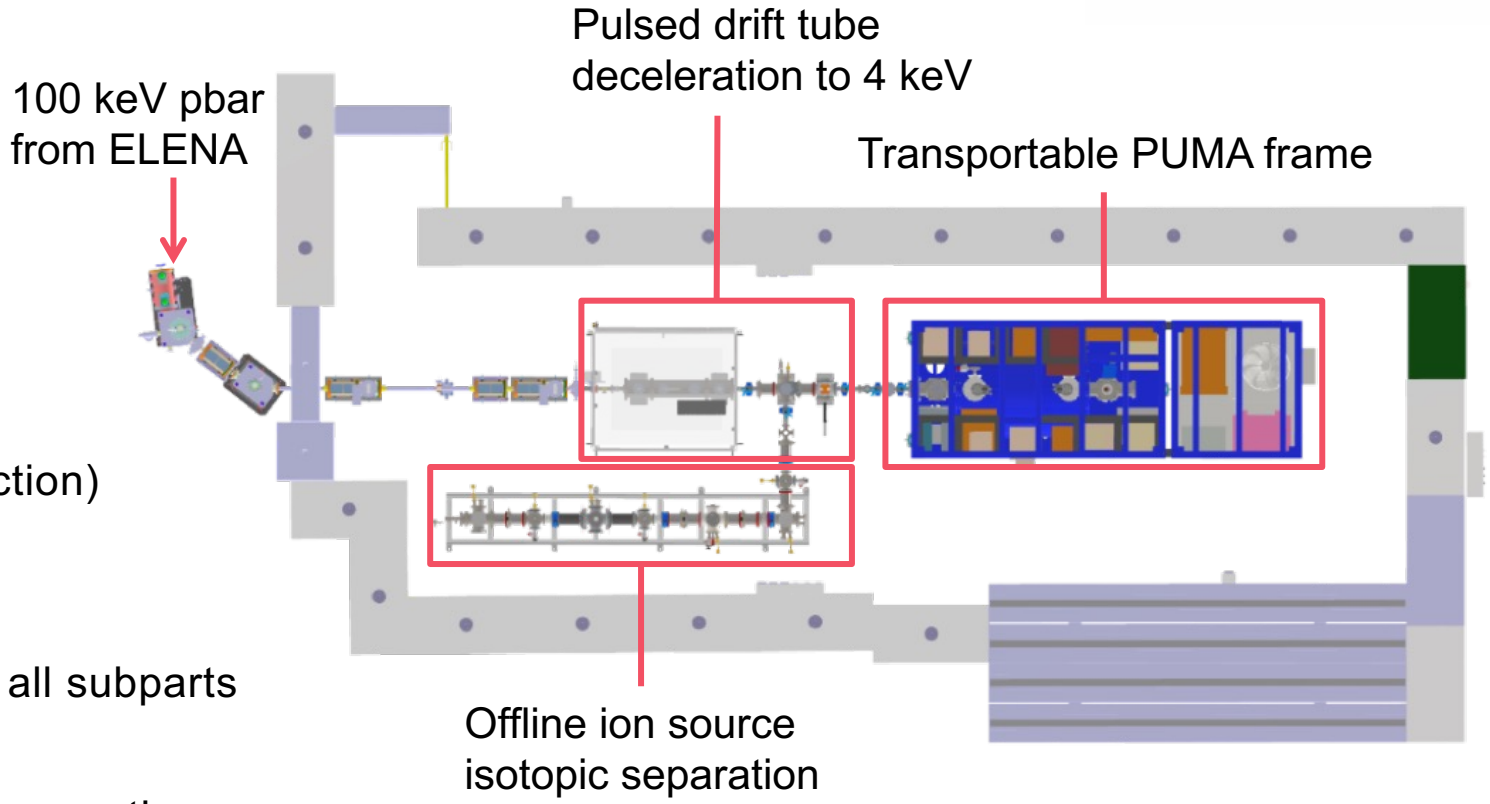

Three main sections at ELENA:

- The 4 keV antiproton beam line
- The transportable apparatus (trap and detection)
- The offline ion source

Main work performed in 2023: completion of all subparts

Main goal for 2024: on-site assembly and first operation

OUTLINE

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TRAP& CRYOSTAT

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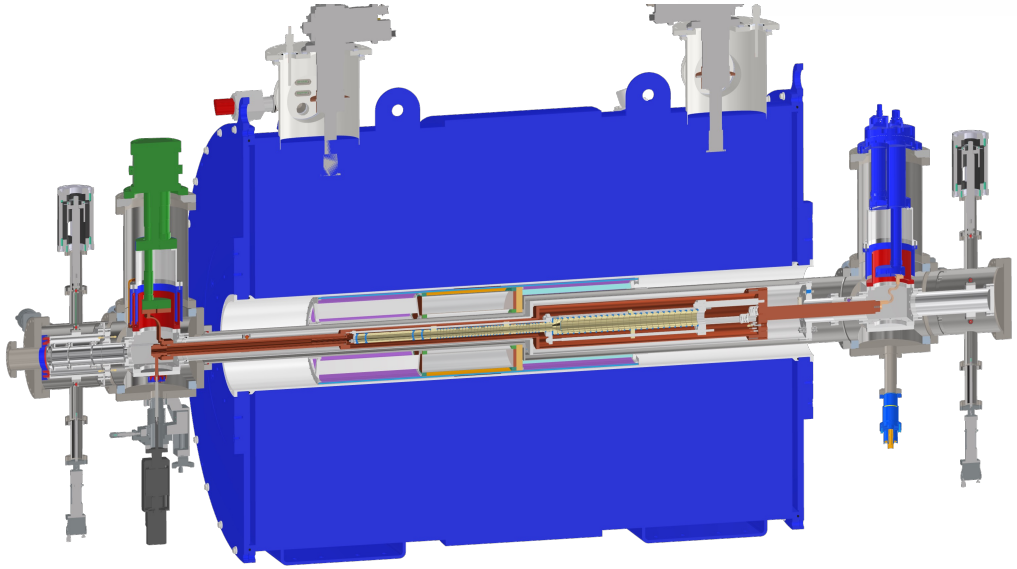
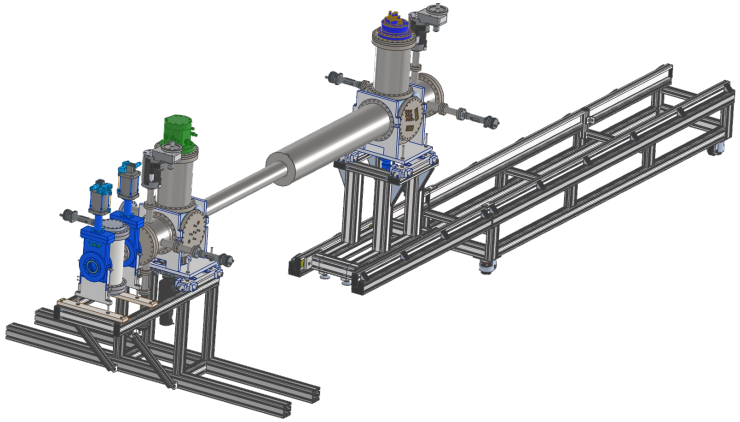
Work performed in 2023

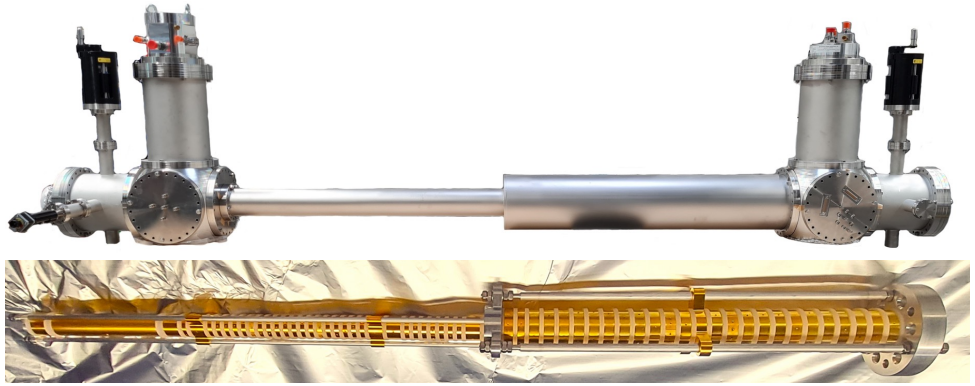
- Construction of all subparts completed
- Full mechanical assembly validated
- Completion of the trap setup for plasma manipulation at TUDa



Goals for 2024

- Installation at ELENA
- First trapping of antiprotons
- Vacuum validation (20 cm^{-3} residual gas) from annihilation rate





PION TRACKER

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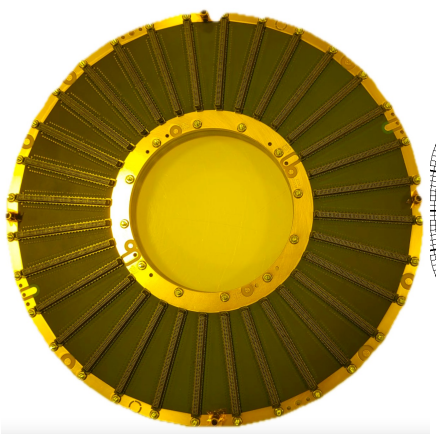
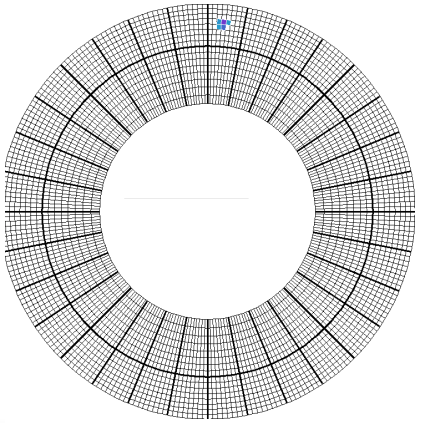
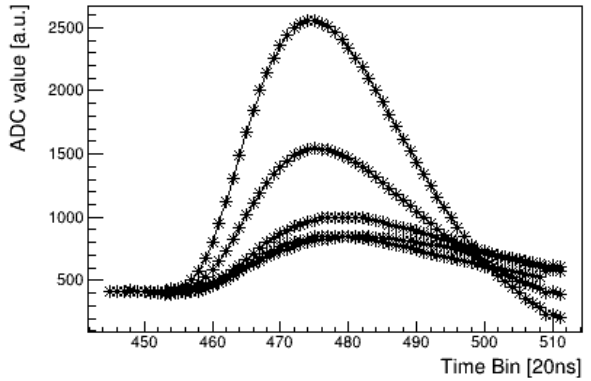
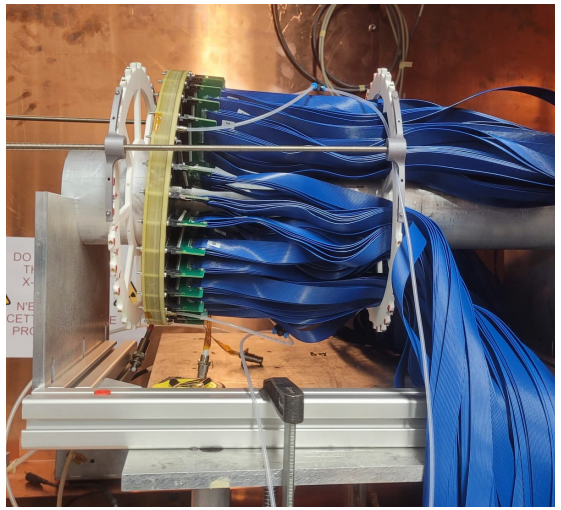
Work performed in 2023

- Construction of amplification stage at CERN
- Gain validation
- X-ray validation at GDD laboratory, CERN
- Energy resolution: 14 % (Ar-CO2)
- ARC FEE, DAQ; analysis software (clustering)
- Construction of field cage

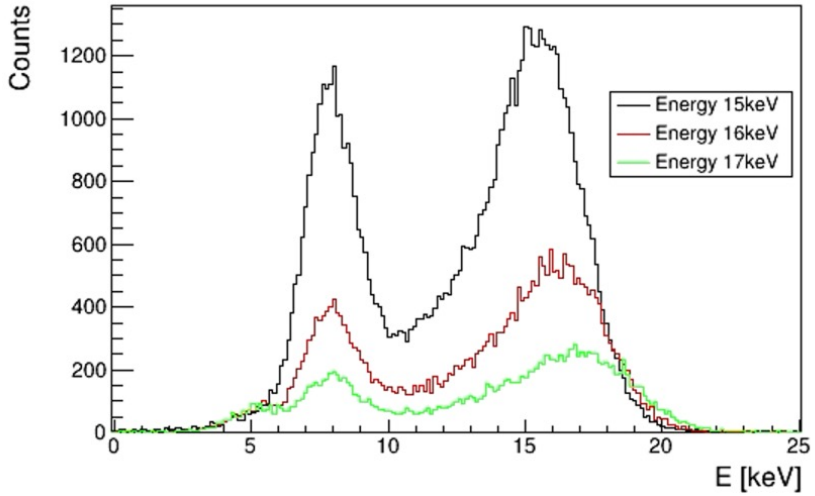








X-ray measurement



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Goals for 2024

- Full assembly at CERN (Feb. 2024)
- Cosmic-ray validation
- Operation in PUMA
- Characterisation, optimization of tracking

PION TRACKER

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Description

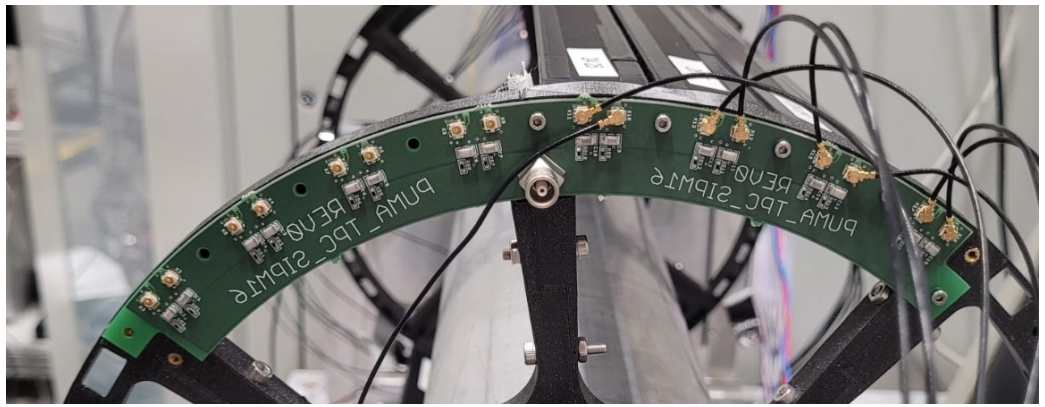
- 32 scintillator bars equipped with 4 SiPM each
- PADIWA conversion / power supply boards
- TRB3 electronics from GSI

Work performed in 2023

- Mechanical support
- Final assembly with short scintillator bars
- Operation with full electronics

Goals for 2024

- Full assembly with TPC (short bars) for validation
- Full assembly (long bars) inside PUMA



ANTIPROTON BEAM LINE

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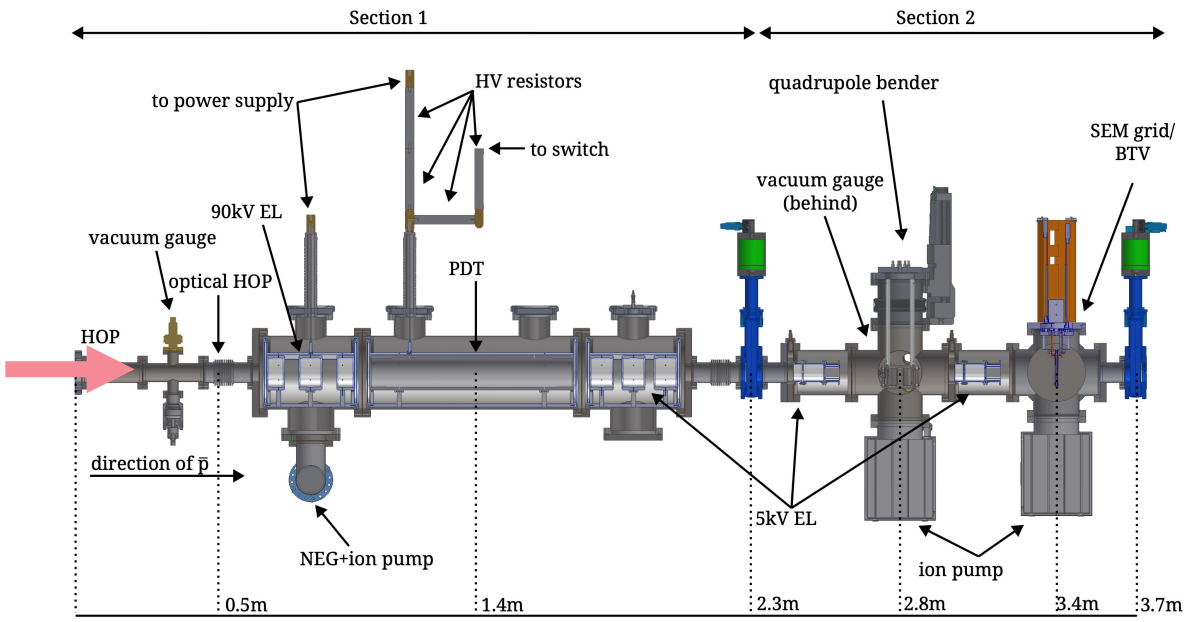

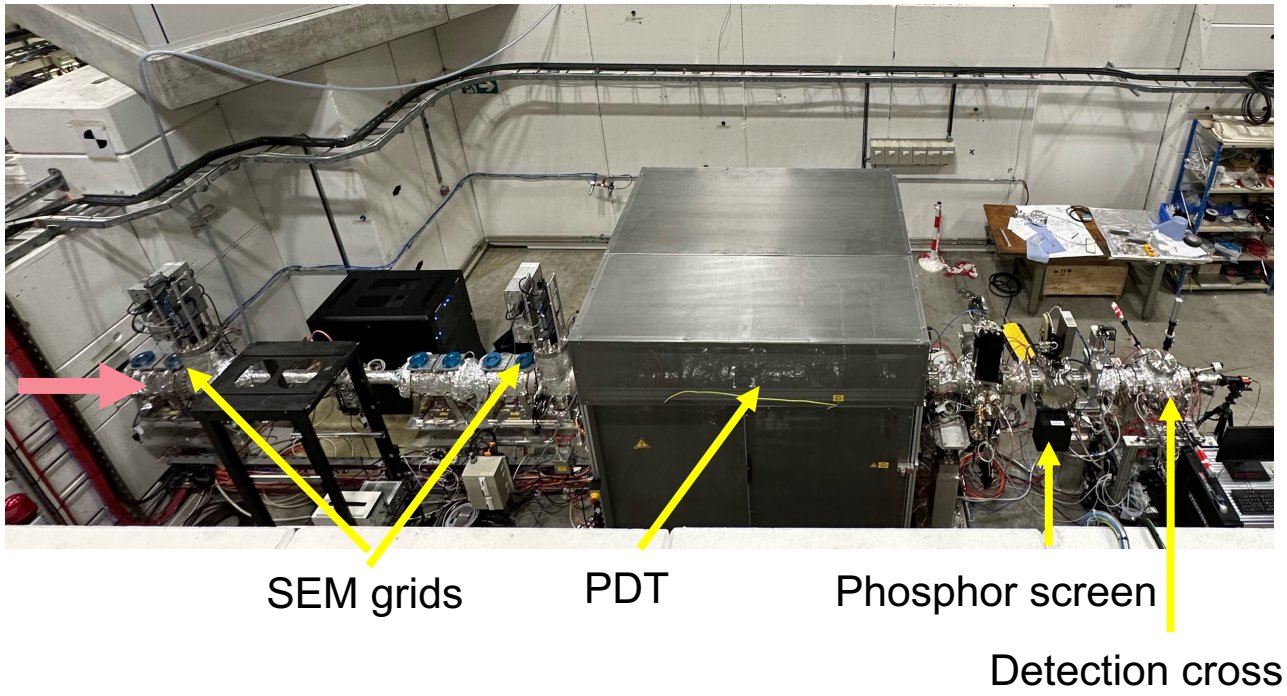

Work performed in 2023

- Reduction of leakage current on PDT power supply to 10 μA (100 μA in 2022)
- New HV Einzel lens with modified design
- In-beam validation of beam line (operation, resolution, efficiency, focusing)

ANTIPROTON BEAM LINE

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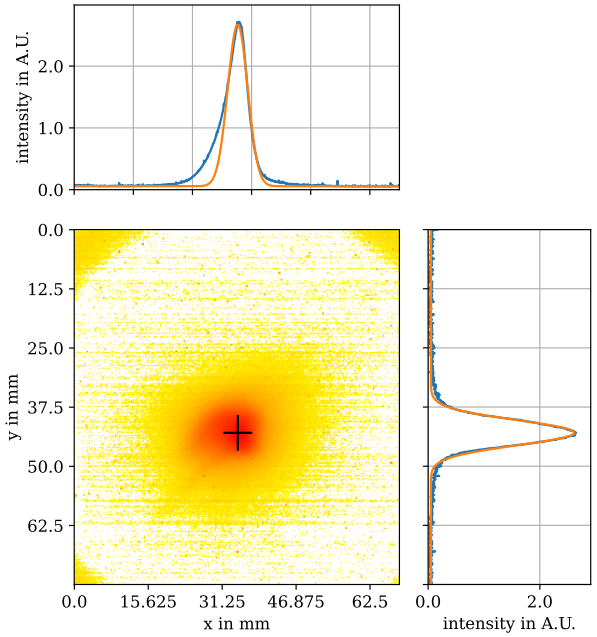
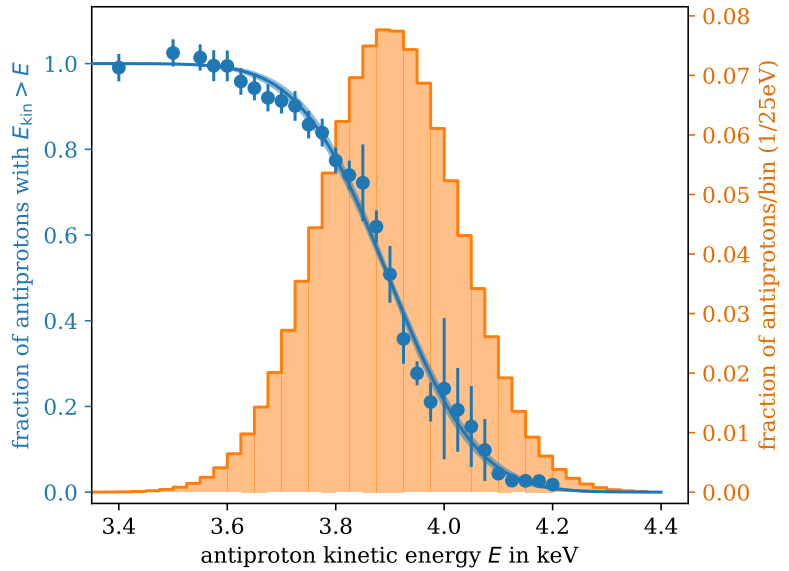
Measured / simulated properties:

- bunch length **93(3) ns** / 89 ns
- energy width **127(4) eV** / 101 ns
- beam profile **3 mm**
- transmission **55(3) %** / 100 %
- vacuum **6. 10^{-11} mbar in PDT** (wo NEG)





J. Fischer et al., arXiv:2401.11875, submitted for publication (2023)

OFFLINE ION SOURCE

TECHNISCHE UNIVERSITÄT DARMSTADT

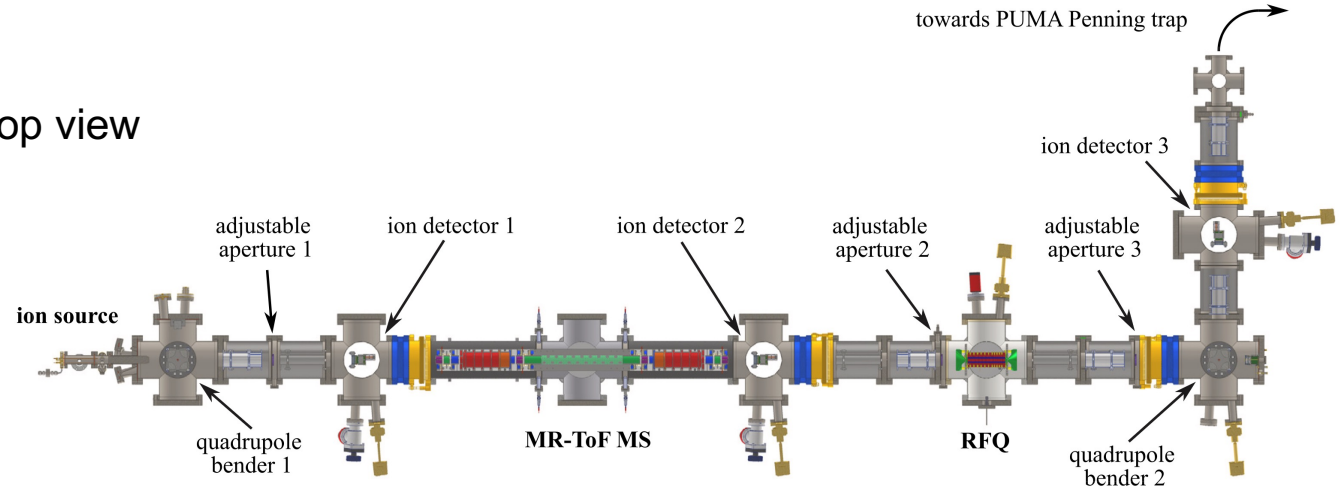
Work performed in 2023

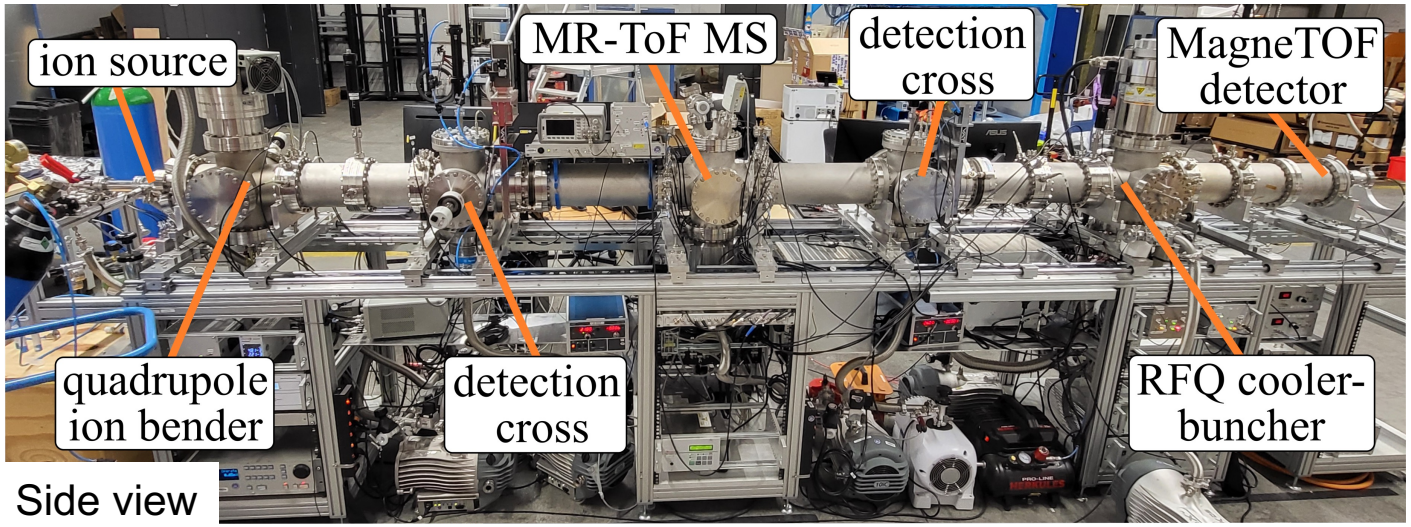
- Operation of main sections at TU Darmstadt
- Mass separation and stacking demonstrated

Goals of 2024

- Optimization of full assembly
- Vacuum validation at TU Darmstadt
- Installation at ELENA
- Ion transfer and trapping in PUMA

Top view





Side view

M. Schlaich et al., Int. Jour. Mass Spectr. 495, 117166 (2024)

OFFLINE ION SOURCE

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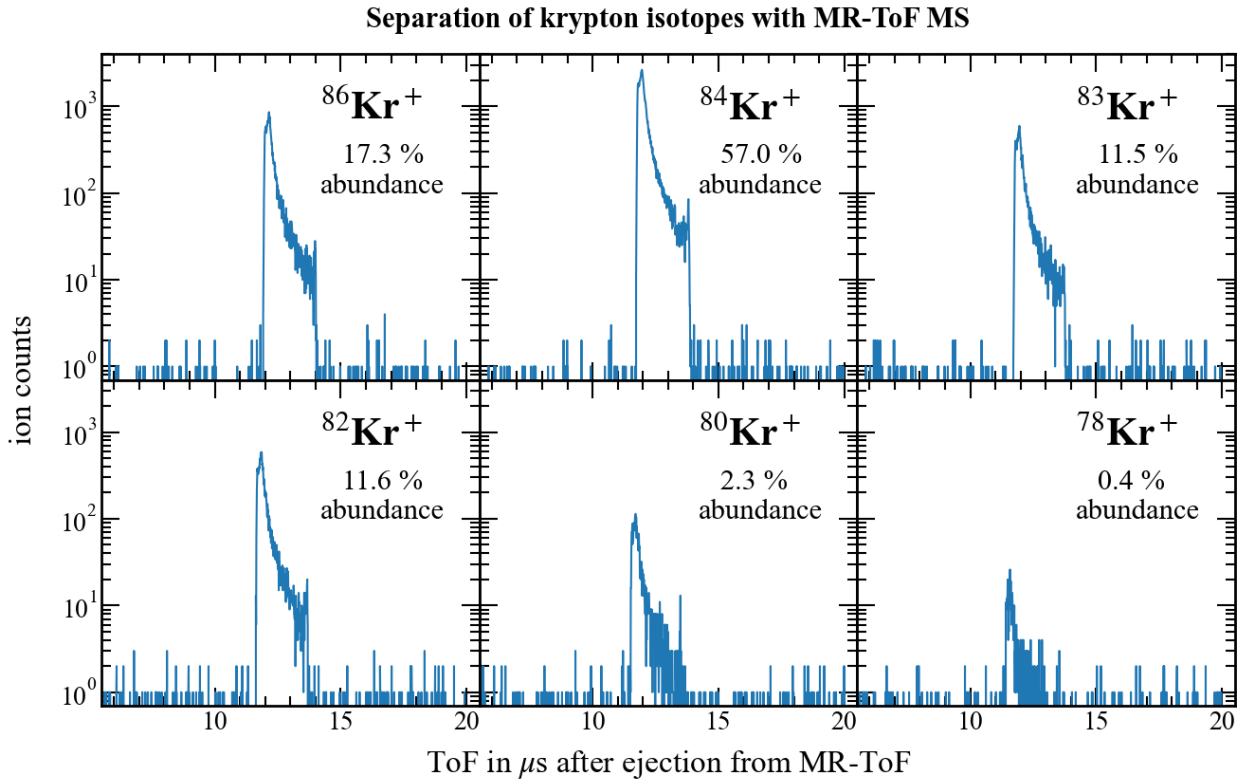

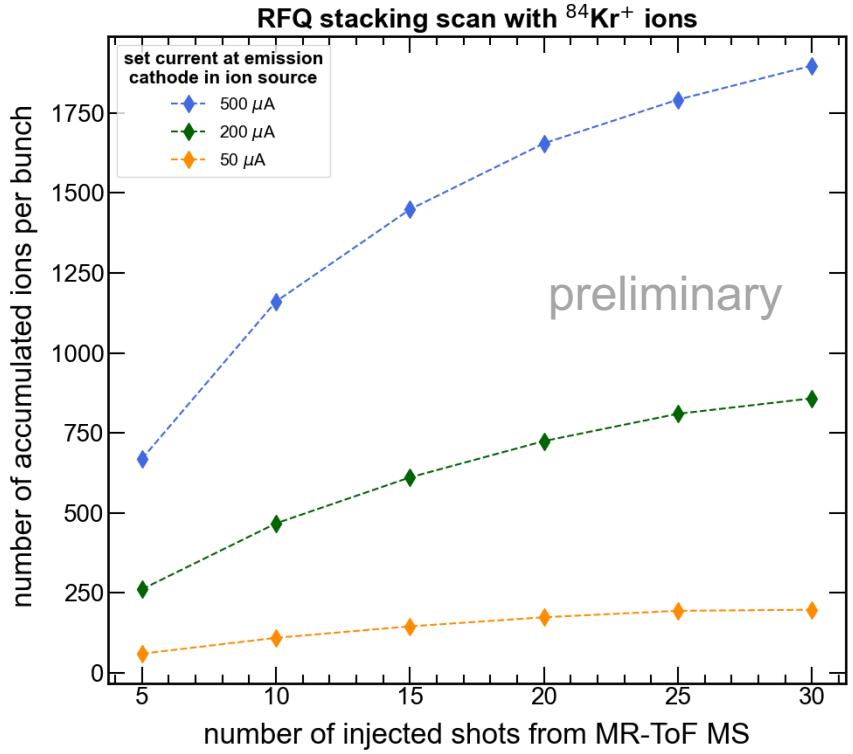

- H, N and noble gases produced by electron impact ionisation
- Isotope purification < 1 ms
- Accumulation and cooling > 10^4 ions in RFQ demonstrated

RC6 BEAM LINE @ ISOLDE

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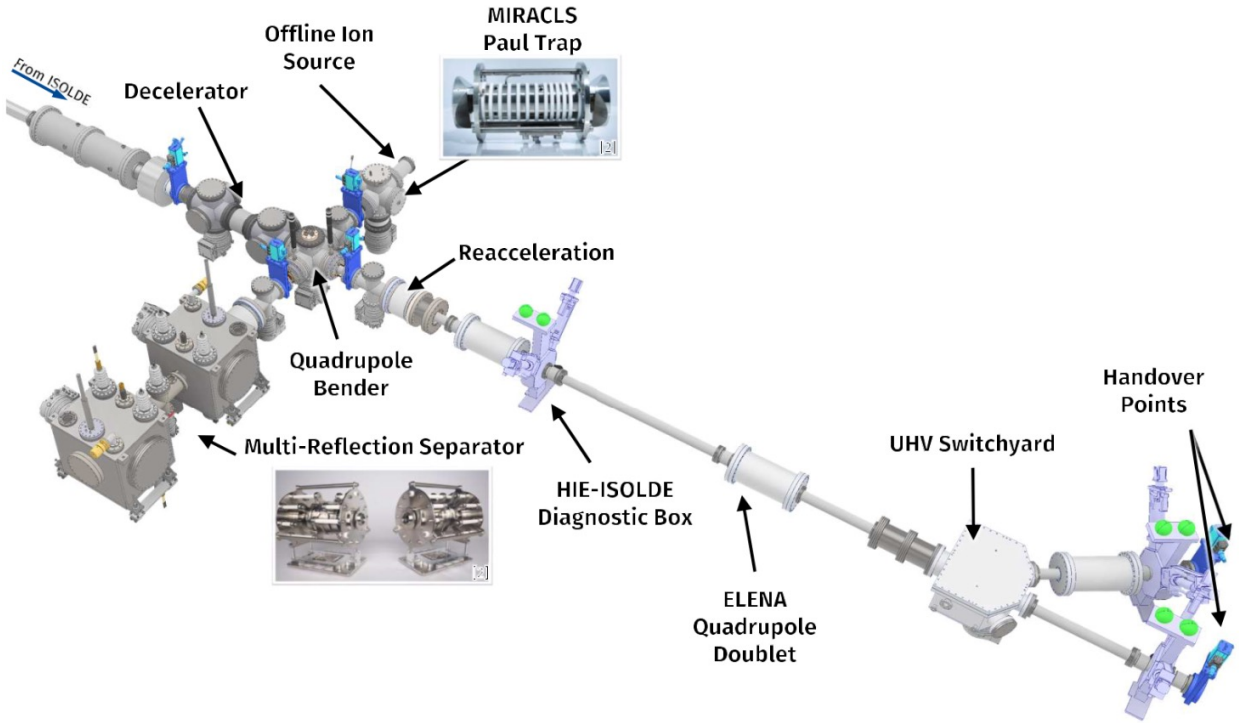
Description

- Accumulation and cooling (Paul trap)
- Isobar separation

  F. A. Maier et al., NIM A 1048, 167927 (2023)
  - 10^4 to 10^5 separation power
  - high ion flux of 10^5 to 10^7 s^{-1}
- Transfer beam line to HOP with differential pumping from 10^{-6} mbar to $<10^{-10}$ mbar



Work performed in 2023

- Design and simulations finalised
- Procurement started

Goals for 2024

- Construction and validation of RC6 beam line
- Design, procurement and construction of PUMA beam line

AGENDA FOR 2024

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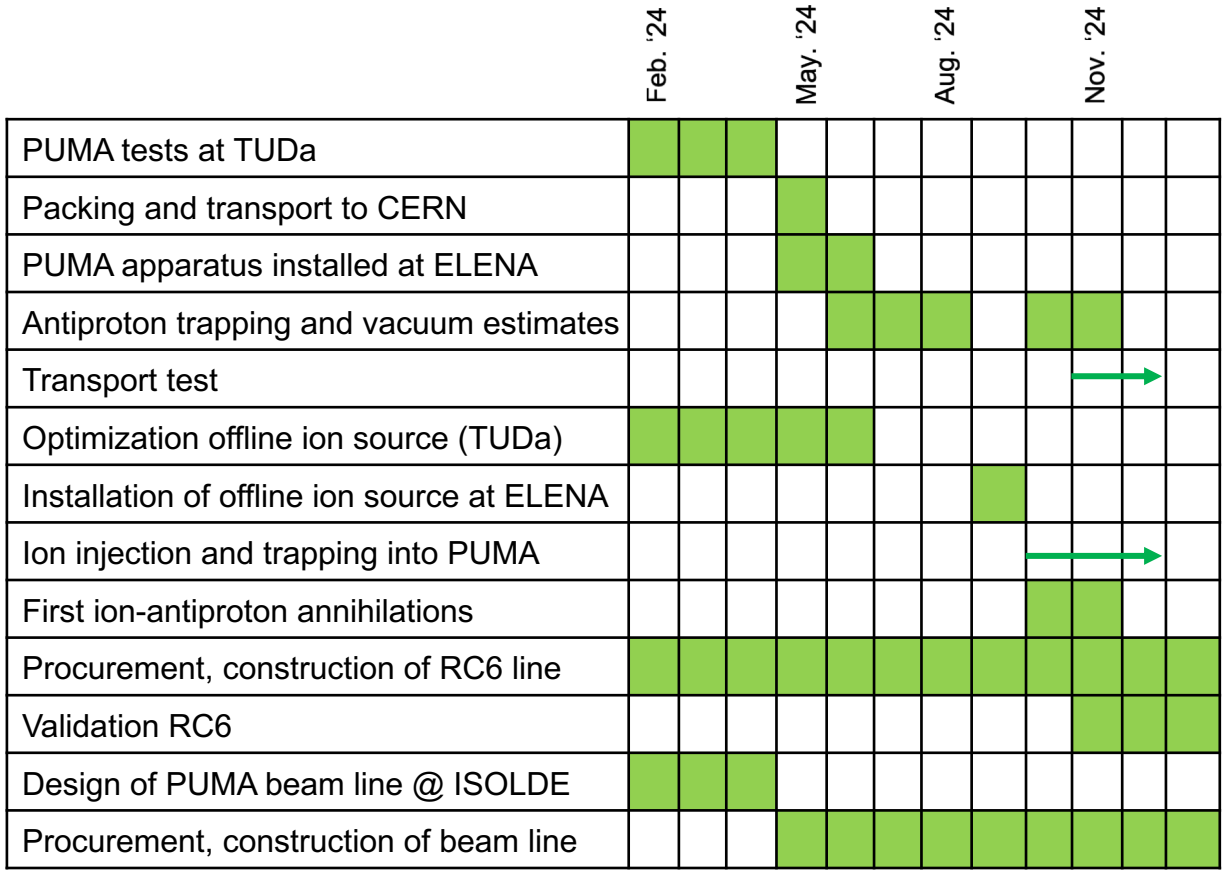
ELENA

- Full assembly of PUMA at ELENA (June 24)
- First antiproton trapping and vacuum estimate (Aug. 24)
- Installation of offline ion source (Sep. 24)

Test of transport and first ion-antiproton annihilations will follow

ISOLDE

- Construction of RC6 and transfer lines (Oct. 24)
- Construction of PUMA beam line (Q1 25)



PLANS 2025-2030+

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Until LS3

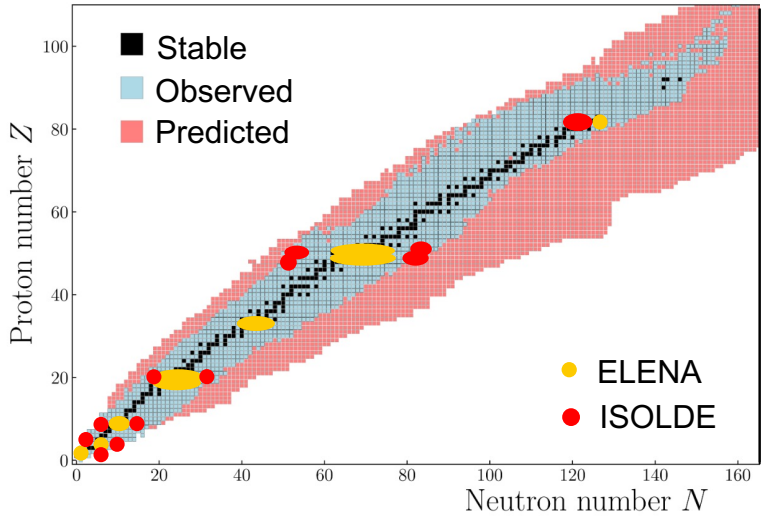
- Physics measurements at ELENA with stable nuclei
- Development of laser-ablation source for production of metals
- First measurement at ISOLDE

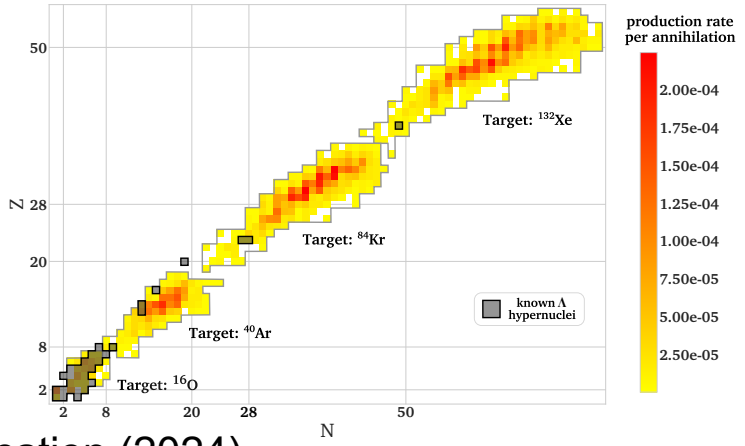
During LS3

- Optimization of PUMA at ELENA
- Installation laser-ablation source and validation
- R&D for future programs

After LS3

- PUMA physics program at ELENA and ISOLDE (2030+)
- Hypernuclei (Letter of Intent to be submitted at SPSC call)





A. Schmidt et al., arXiv:2402.01351, submitted for publication (2024)