



# PUMA SPSC MEETING 2025

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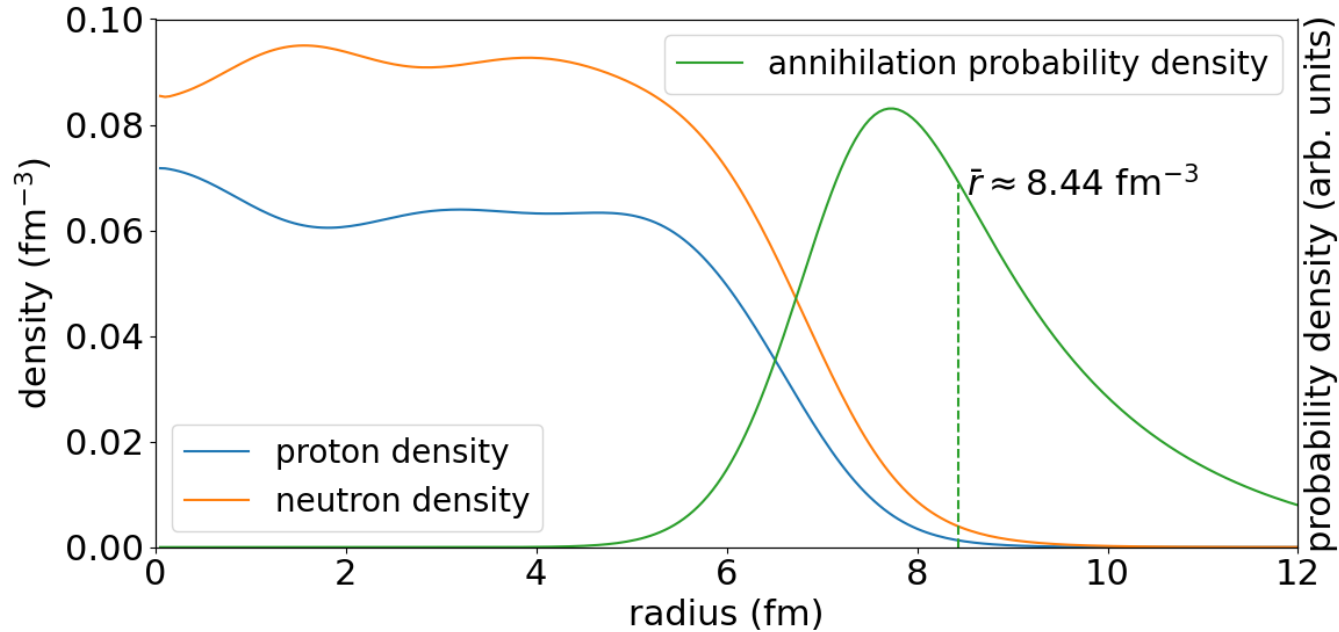
In collaboration with: D. Calvet, D. Neidherr, K. Kormann, Y. Kubota, Y. Ono, E. C. Pollacco, L. Schweikhard



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# OVERVIEW



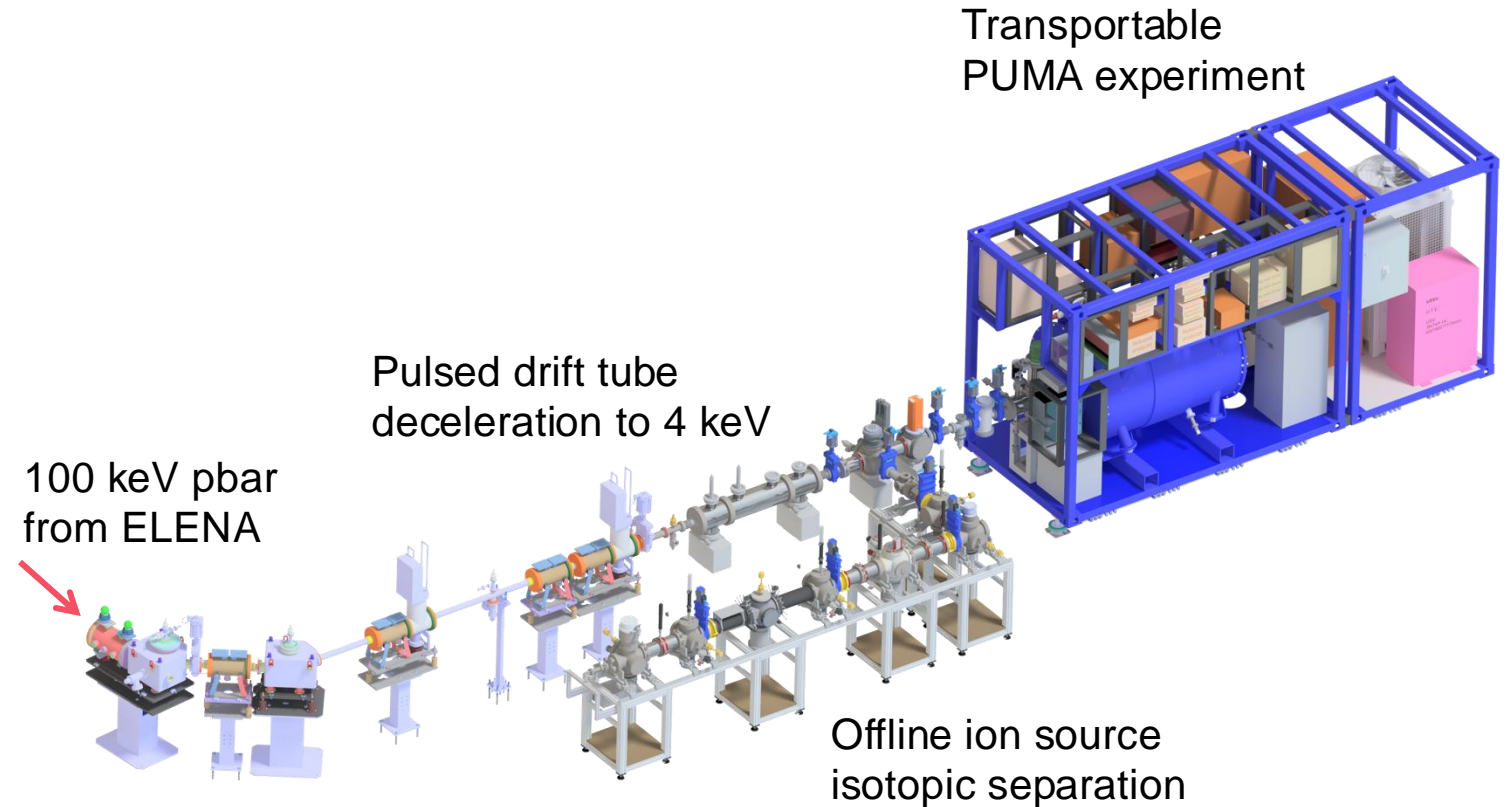
© Google maps

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)



# OVERVIEW

- Three main sections at ELENA:
  - The 4 keV antiproton beam line
  - The transportable experiment
  - The offline ion source
- **Main work in 2024**
  - construction and assembly
- **Main goals for 2025**
  - installation completed
  - vacuum estimate
  - first operations



# OUTLINE

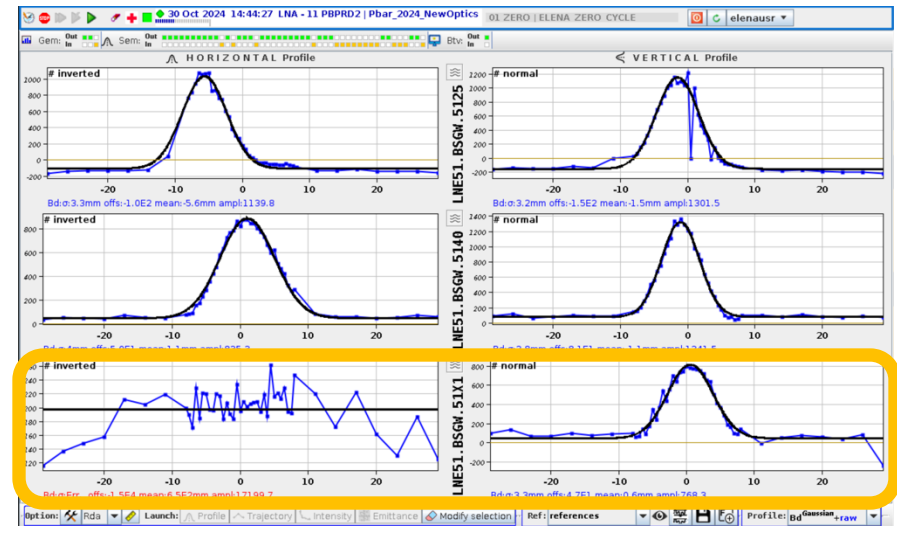
- 1** Status of PUMA beam line at AD
- 2** Solenoid and traps
- 3** Pion tracker
- 4** Offline ion source
- 5** The ISOLDE low-energy beam line
- 6** Agenda for 2025



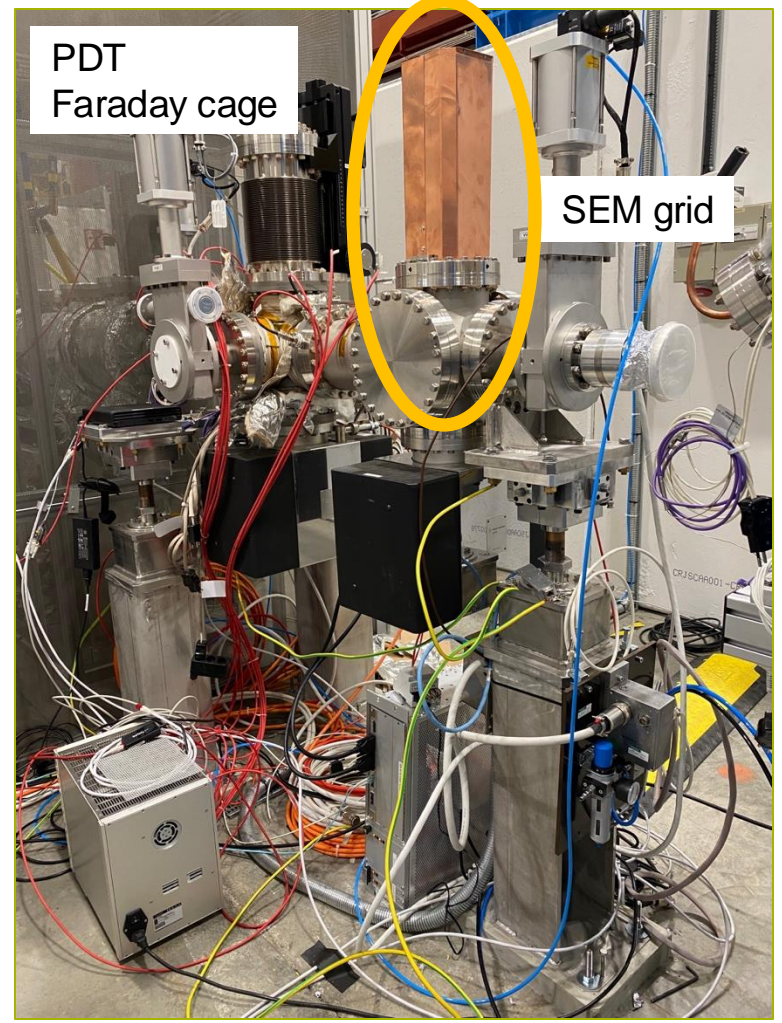
# ELENA BEAM LINE

- “PUMA” SEM grid installed, october 2024
- Tested with antiprotons on direct transmission through PDT

Broad horizontal distribution already observed with phosphore screen



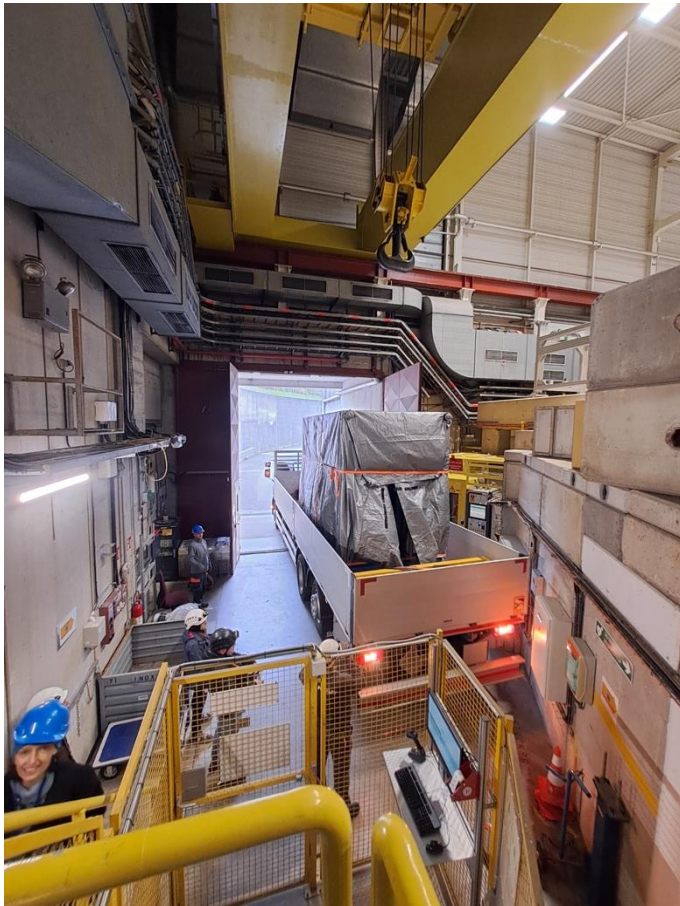
New SEM grid



- Beam-line characterization results from 2024 published  
J. Fischer et al., NIMB 550, 165318 (2024)



# MOVE TO ELENA



Arrival of PUMA frame on 04.12.2024



# MOVE TO ELENA



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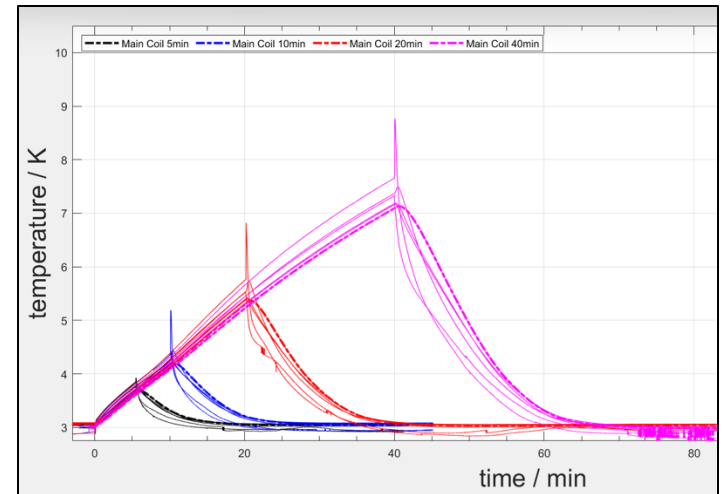
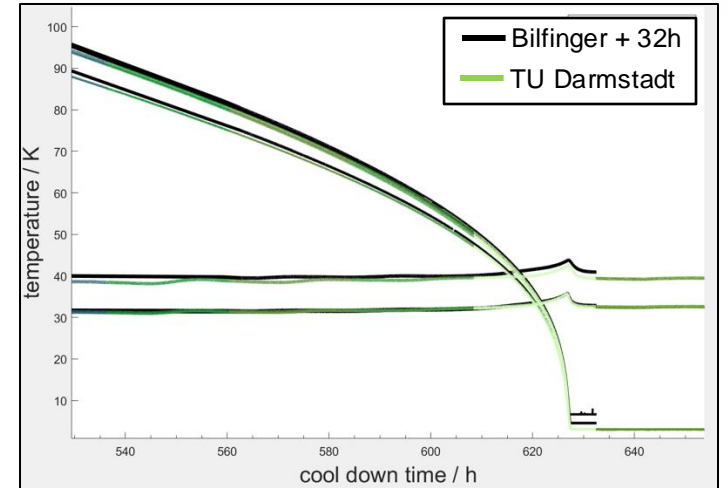


... latest status at the visit on site on 12.02.2025



# SOLENOID

- **Electrical modifications** to power scheme and control cabinet following requests from CERN safety group:
  - change of fuses and breakers
  - 125 A plugs changed to Marechal standard
  - automatic power switch implemented
  - signal lights added to visualize power on / off
- **Cooling test** with water chiller
- **Switching power source**
- **Charging up** to nominal magnetic field value (4T)  
No quench observed over several iterations
- **Moving** while energized  
 $\delta B/B \leq 10^{-8}$  at all times from NMR inside bore

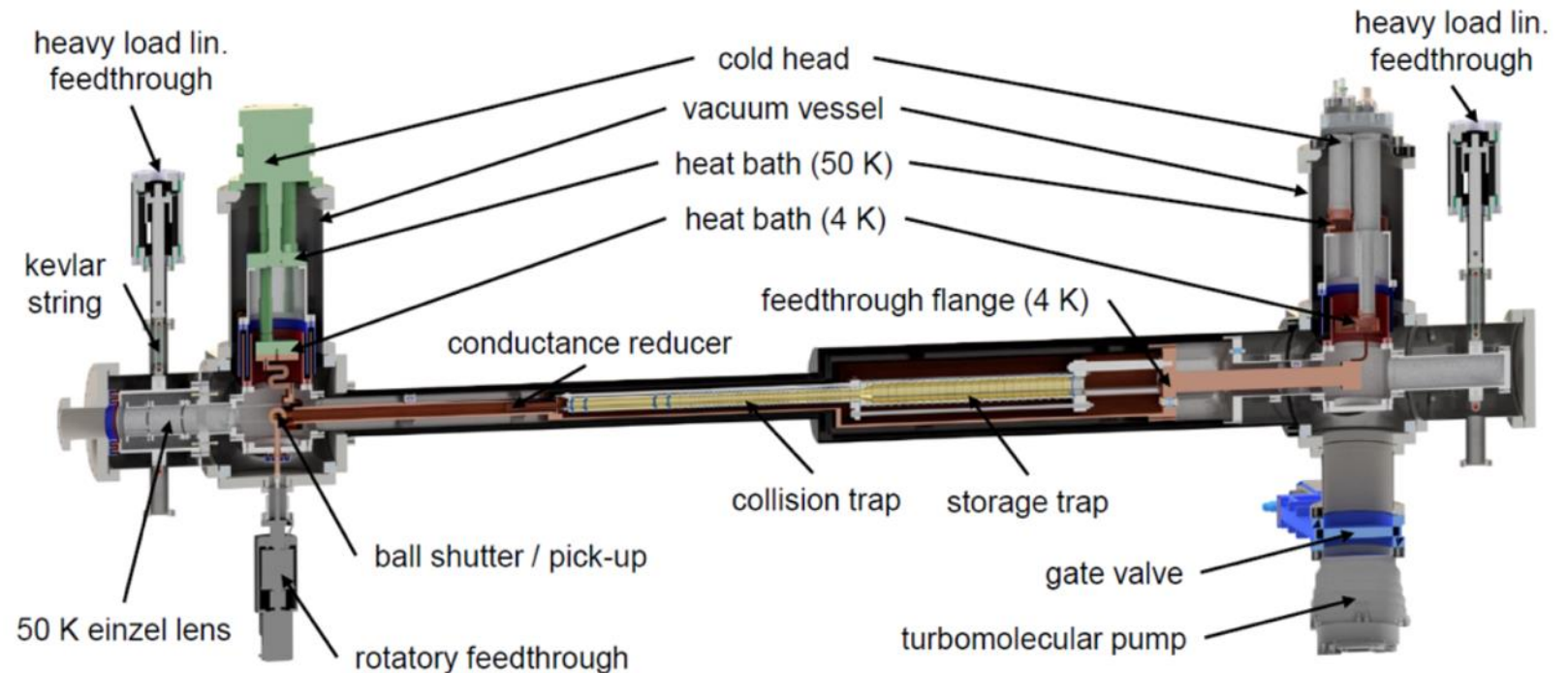




# TRAP ASSEMBLY



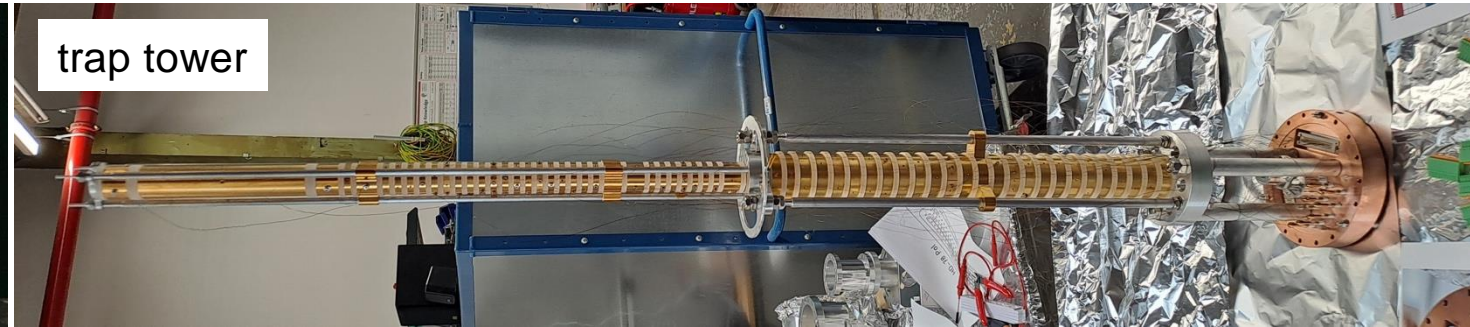
- **trap assembled and cabled**
  - 49 electrodes + 6 segmented
  - 1 drift tube
  - 2 cold-emission electron guns
  - 1 cylinder shutter
  - 1 steering x-y Einzel lens
  - 105 connections
- all parts **UHV cleaned**
- entrance tube **carbon coated**



# TRAP ASSEMBLY



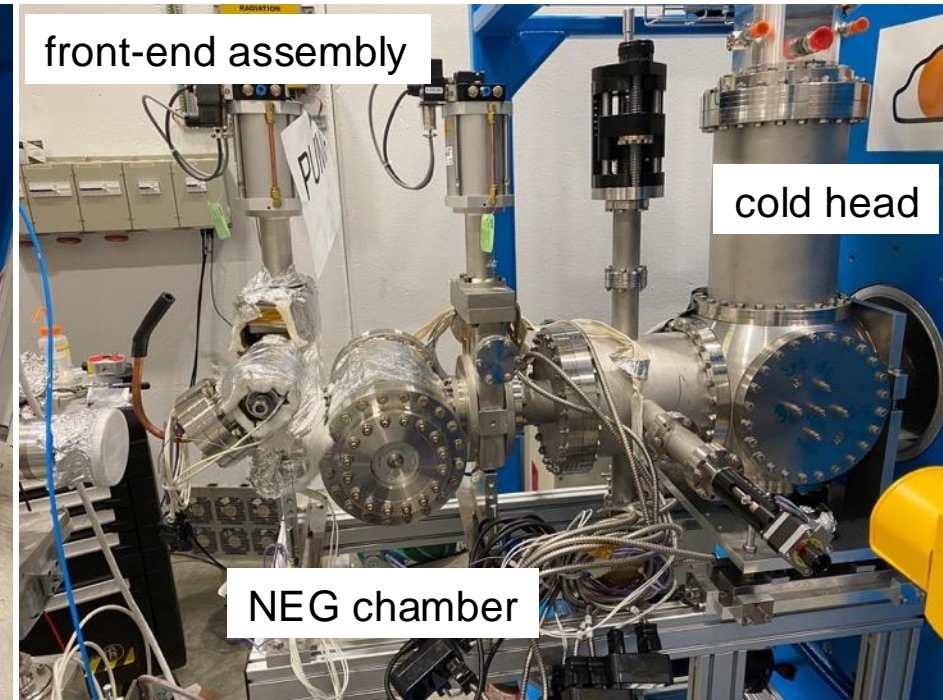
4K crostat



trap tower



300K chamber



front-end assembly

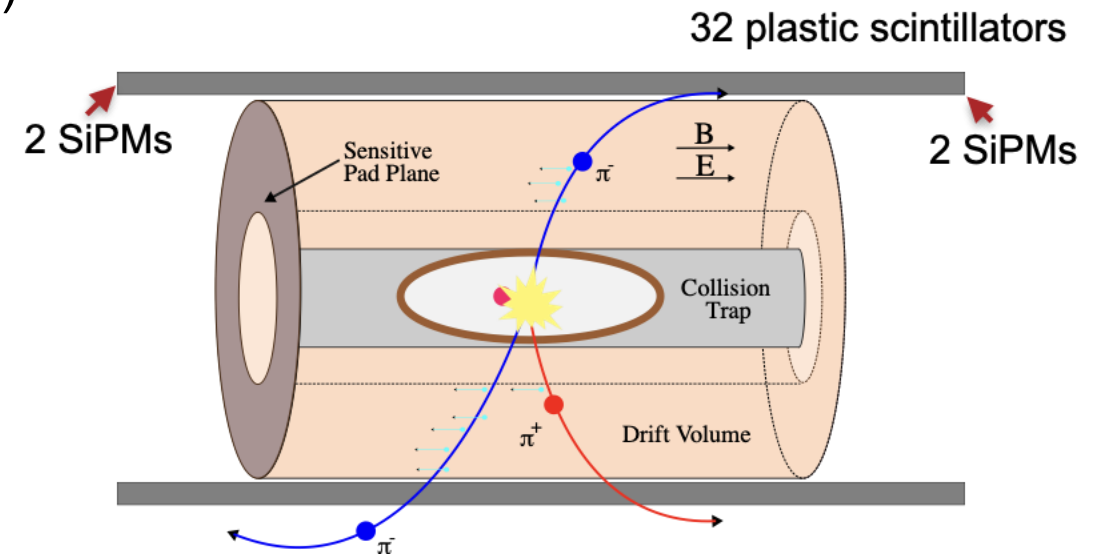
cold head

NEG chamber

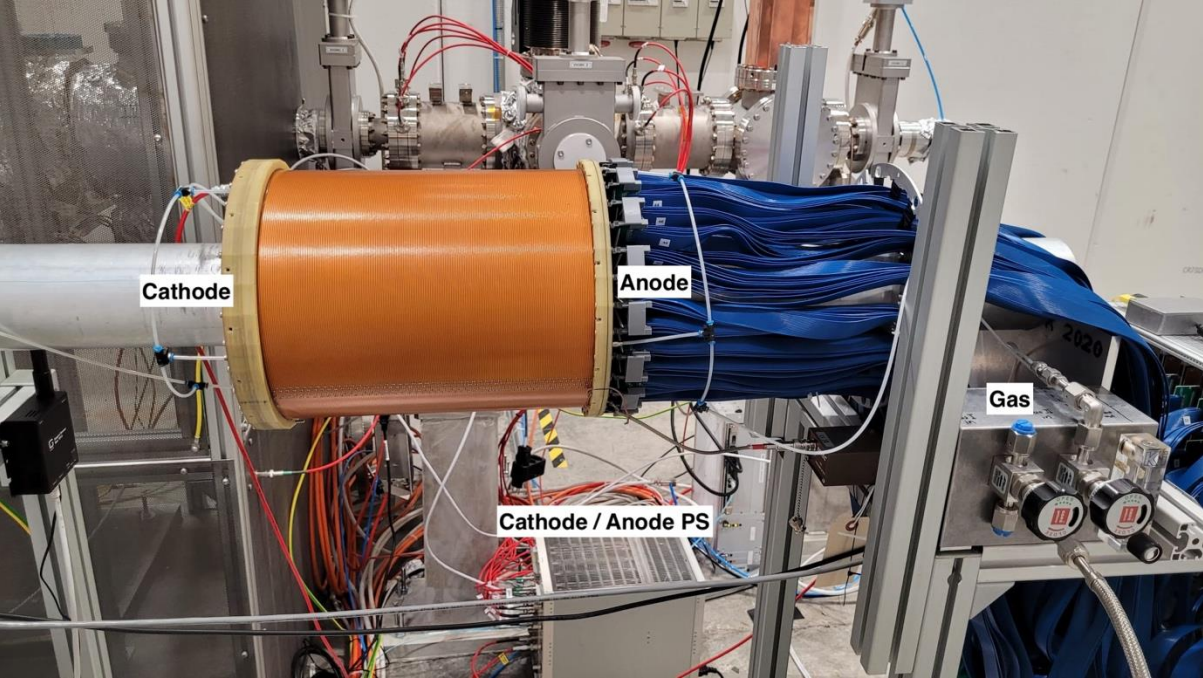


# PION TRACKER

- Assembly of amplification stage and field cage
- Minor modifications at MPGD-lab (ground connections)
- Investigation of sensitivity to ambient humidity
- DAQ, semi-online and event display
- Geant4 simulation and analysis software
- New design of plastic barrel holder
- New design of SiPM PCB
- First measurements with cosmic rays

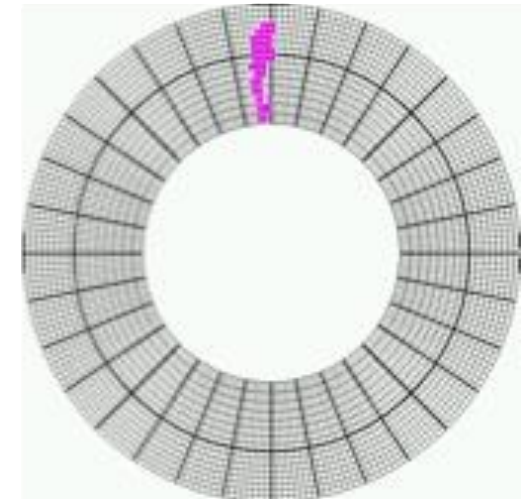
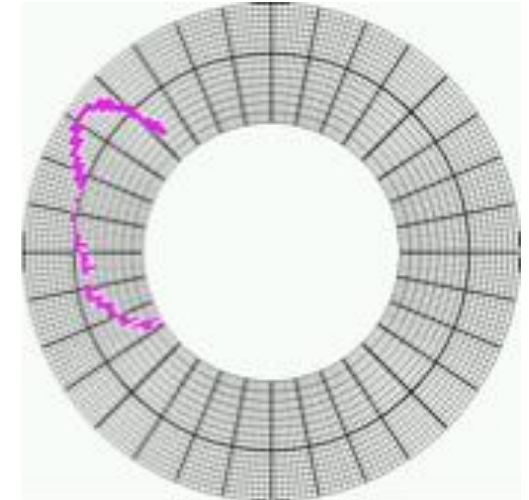


# PION TRACKER



# TIME PROJECTION CHAMBER

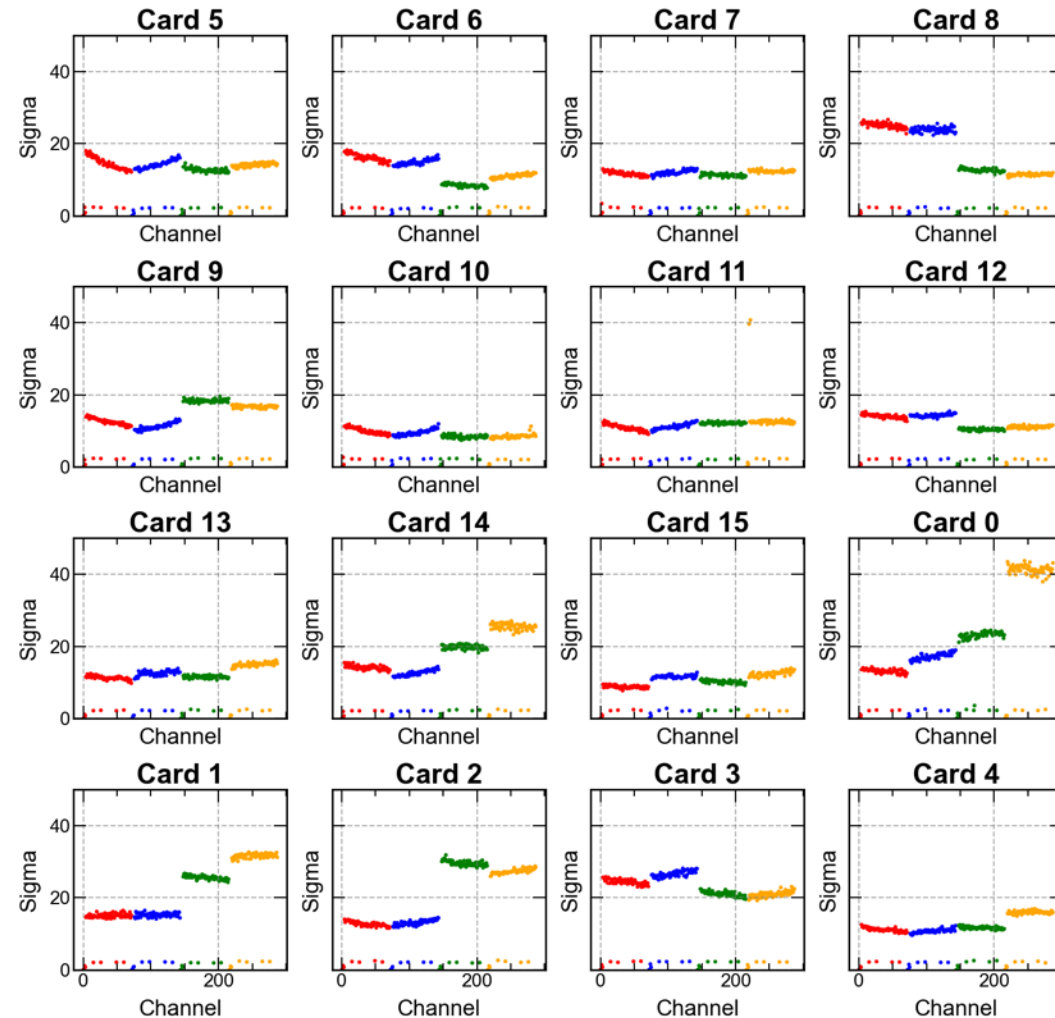
- Gas: Ar(93)-CO<sub>2</sub>(7) at atmospheric pressure
- Drift field: 200 V/cm
- Resistive Micromegas (500 V on DLC); gain ~ 10,000
- Front-end electronics: STAGE chip on ARC FEC
  - developed for T2K (D. Calvet, CEA/IRFU)
  - digitisation (up to 100 MHz), 12-bit ADC
  - 64 channels / chip, total of 4096 channels
  - 16 front-end boards + 1 Trigger Clock Module (TDCM)
- Validation on delta electrons with triggering by mesh  
[Amplification stage validated at RD51 with X-ray tube (2023)]



# TIME PROJECTION CHAMBER



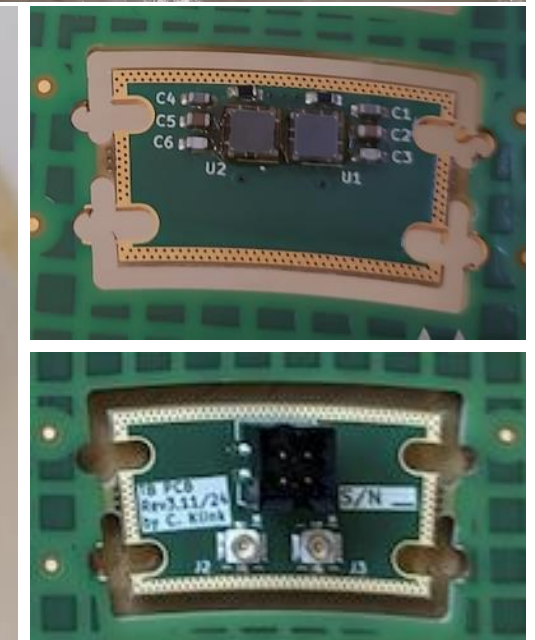
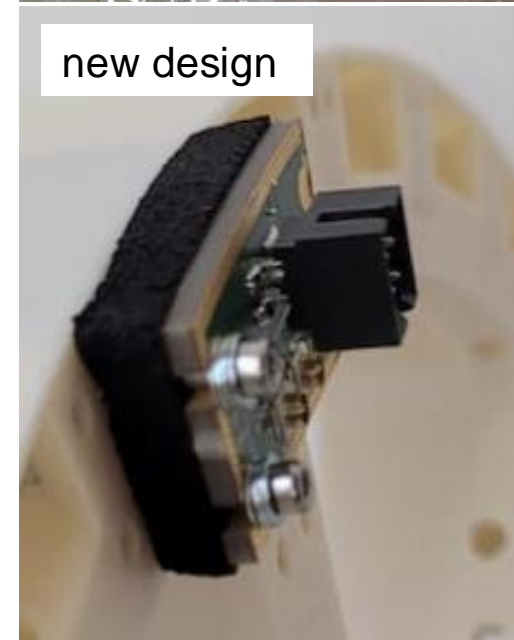
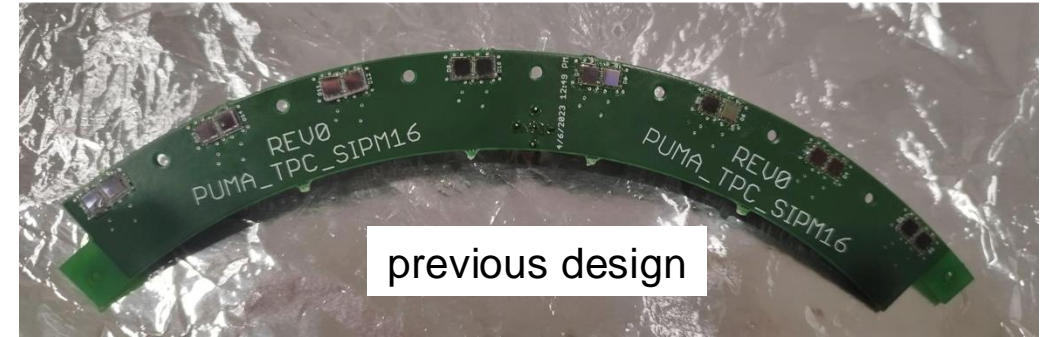
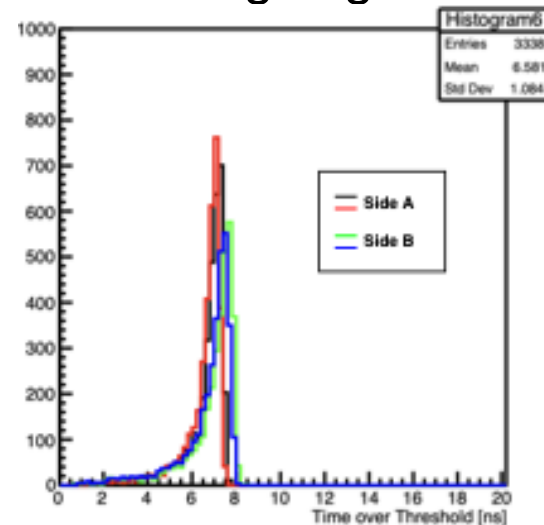
- ENC measurements
  - Range: 120 fC
  - Shaping time 385 ns
- Front-end electronics only:  
ENC ~ 0.1 fC
- FEE connected to TPC:
  - Measured: 0.3 – 0.6 fC for most
  - Some boards ENC > 0.6 fC
- Grounding optimization ongoing



# TRIGGER BARREL

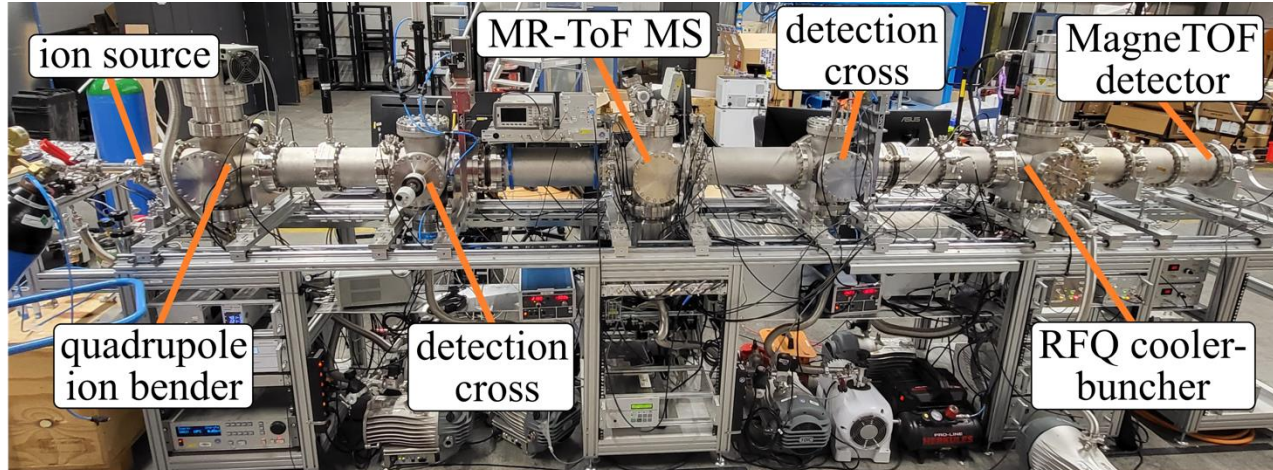
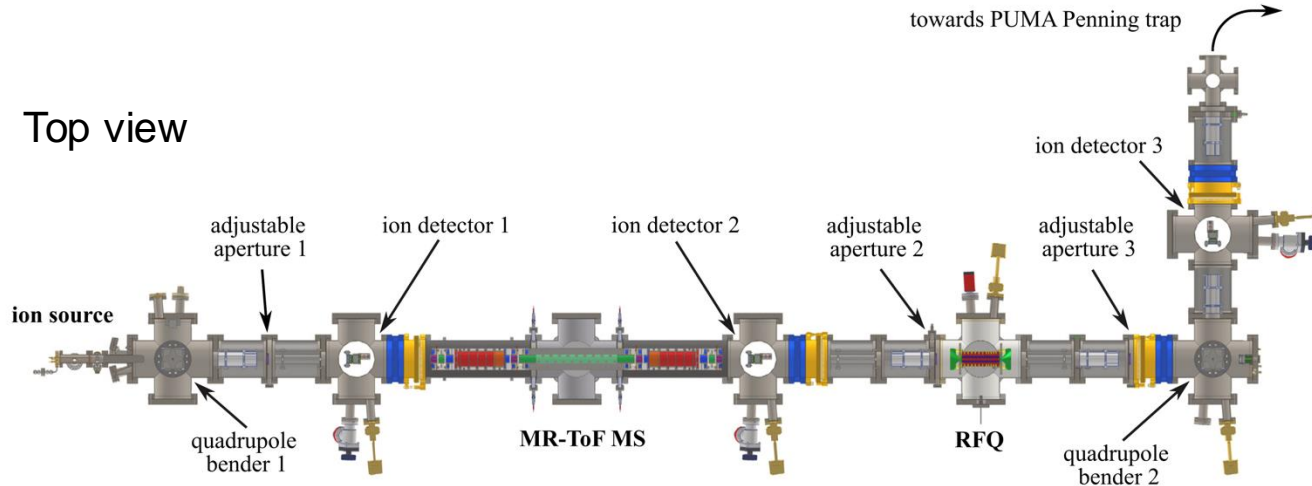
- Cosmic-ray validation of trigger barrel
- Silicon photomultiplier (SiPM) PCB re-designed:
  - individual PCB for each scintillator
  - reinforcement for light tightness
  - noise reduction
- Implementation and characterisation ongoing

Example of time-over-threshold of 4 SiPM connected to one plastic scintillator after triggering on a MIP



# OFFLINE ION SOURCE

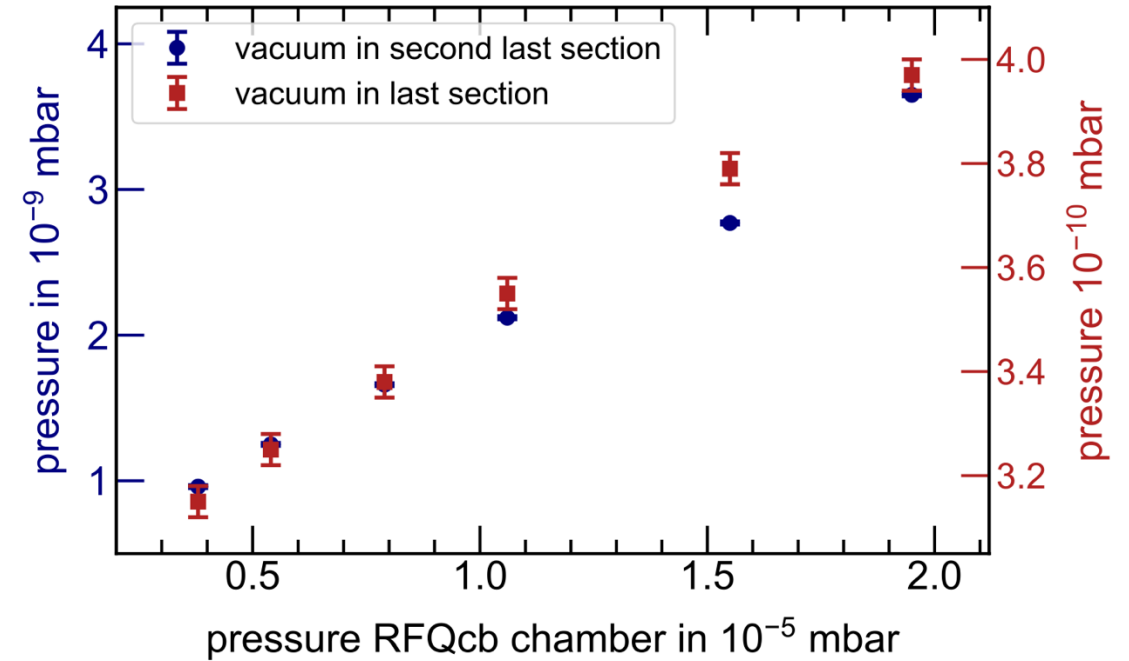
Top view



© Moritz Schlaich

Side view

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

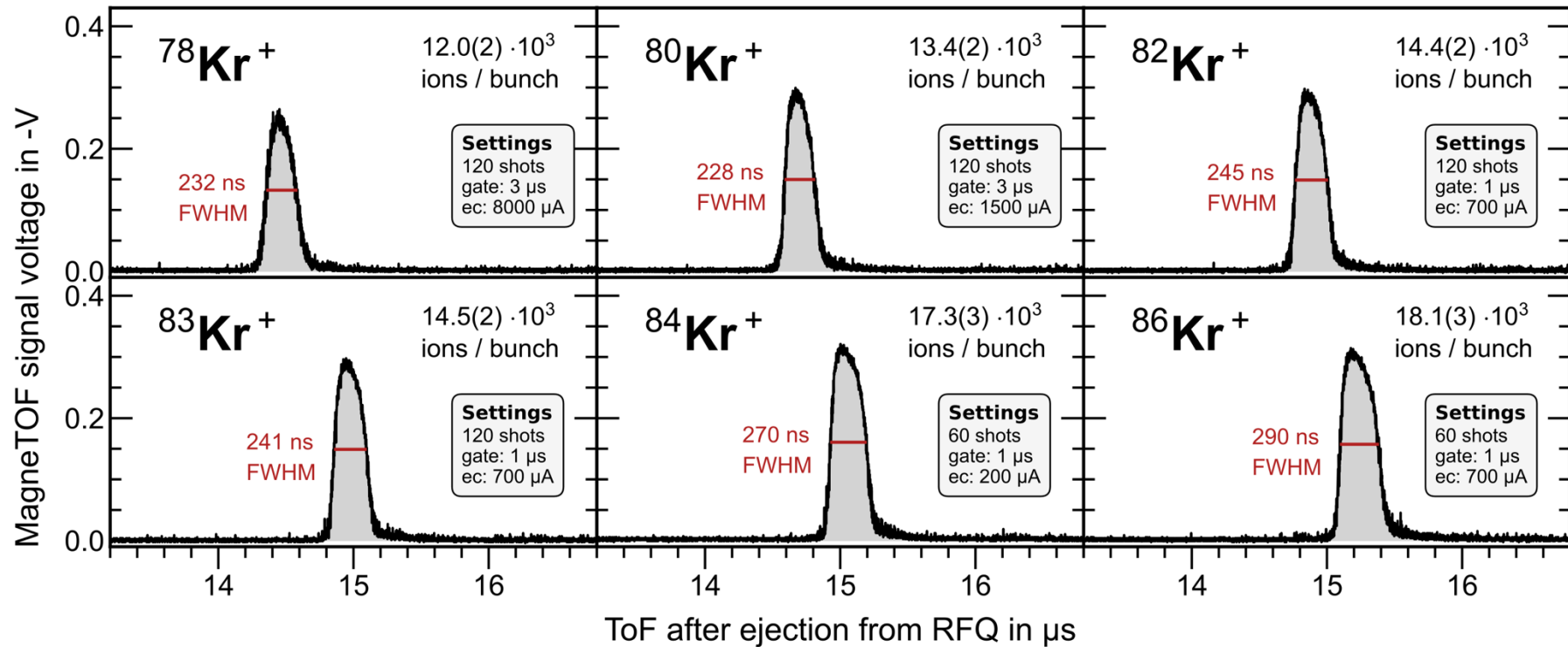


M. Schlaich et al., in preparation (2025)





# OFFLINE ION SOURCE



© Moritz Schlaich

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

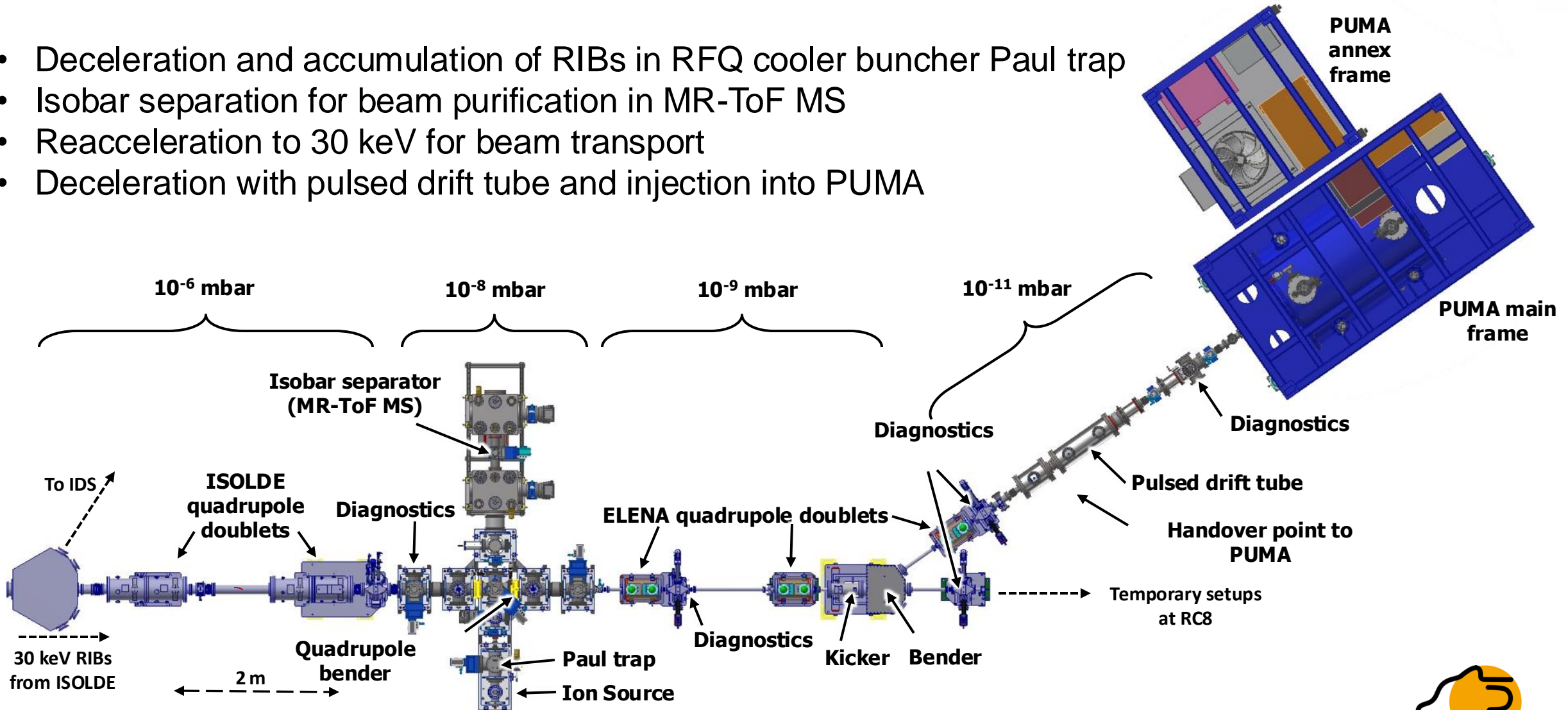


# RC6 BEAM LINE @ ISOLDE



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- Deceleration and accumulation of RIBs in RFQ cooler buncher Paul trap
- Isobar separation for beam purification in MR-ToF MS
- Reacceleration to 30 keV for beam transport
- Deceleration with pulsed drift tube and injection into PUMA

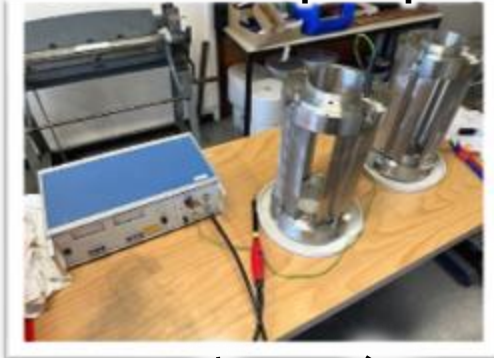


# RC6 BEAM LINE @ ISOLDE

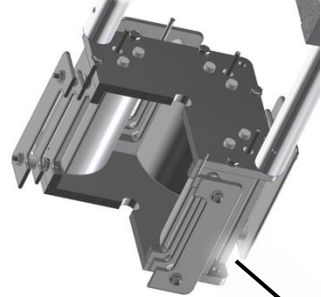


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ISOLDE standard quadrupole doublets



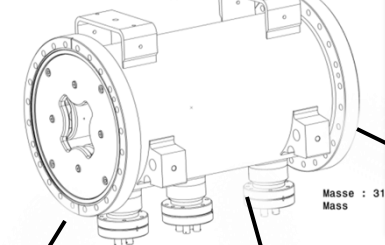
Quad. bender



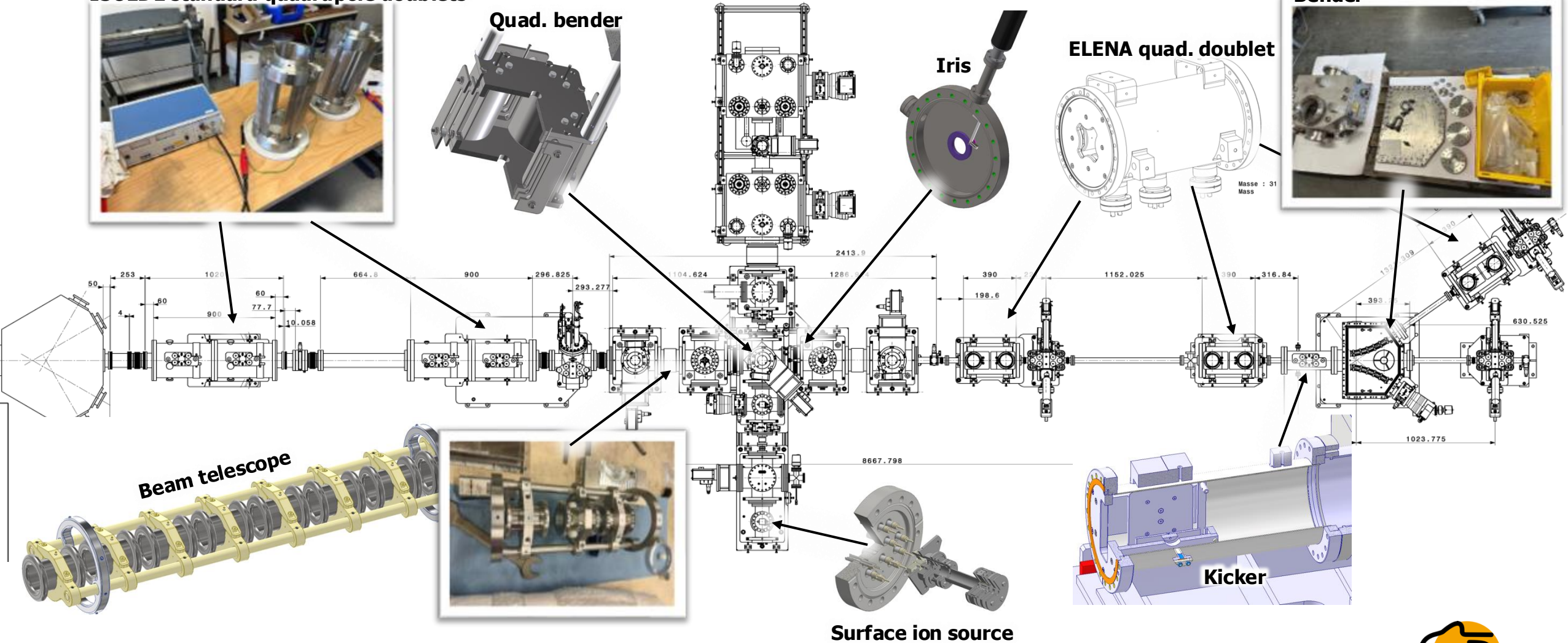
Iris



ELENA quad. doublet



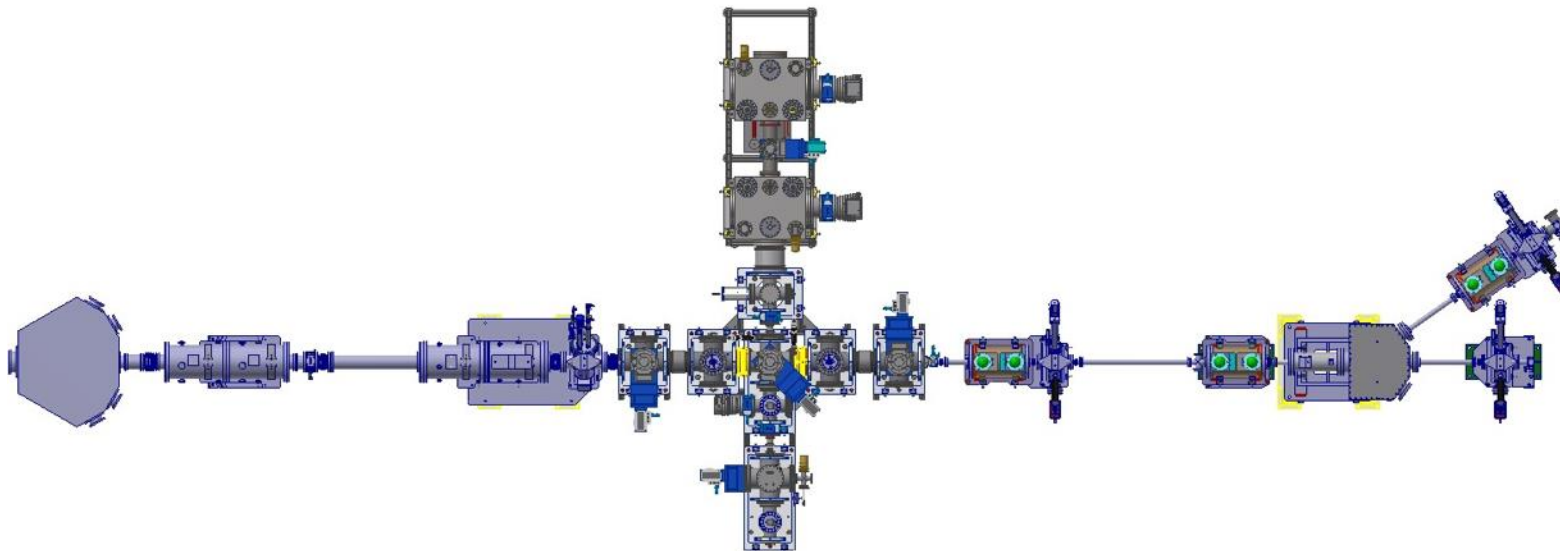
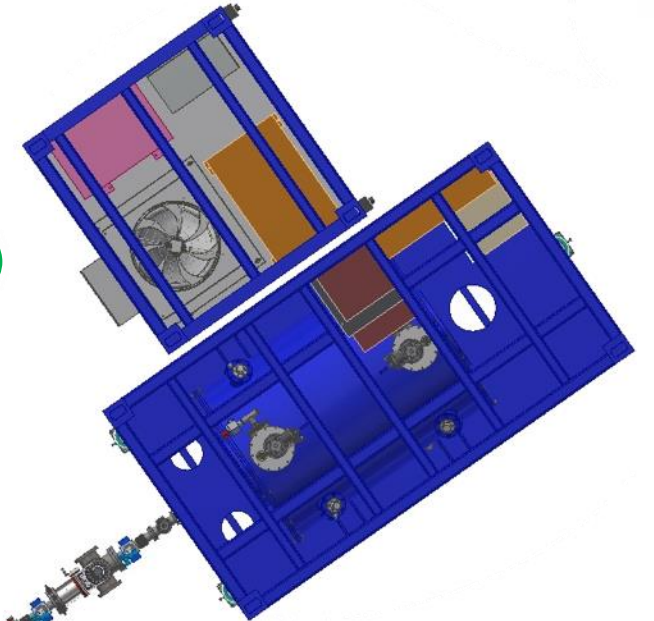
Bender



# RC6 BEAM LINE @ ISOLDE



- ✓ RC6 beamline design finalized, production of parts started
- ✓ ELENA quad. optics on shelf and available
- ✓ ISOLDE quad. optics and switchyard refurbished until YETS24
- ✓ Accepted experiment (Xe isotopes) for PUMA at ISOLDE (INTC 2024)
- MIRACLS hardware to be moved mid-2025
- Delivery of beam diagnostics slated for end-2025
- First ions through RC6 before YETS25
- Design and construction of transfer beam line to PUMA (2025)



# OBJECTIVES FOR 2025

## ELENA

- TPC installation April 25
- Installation of offline ion source (May 25)
- First antiproton trapping, vacuum estimate
- First ion-antiproton annihilations

## ISOLDE

- Construction of RC6 and transfer lines
- Construction of PUMA beam line
- Validation beam line

## Organisation:

- Settle a local PUMA team (~1 permanent + 1 PD + 2 PhD) + short / long term visits

