

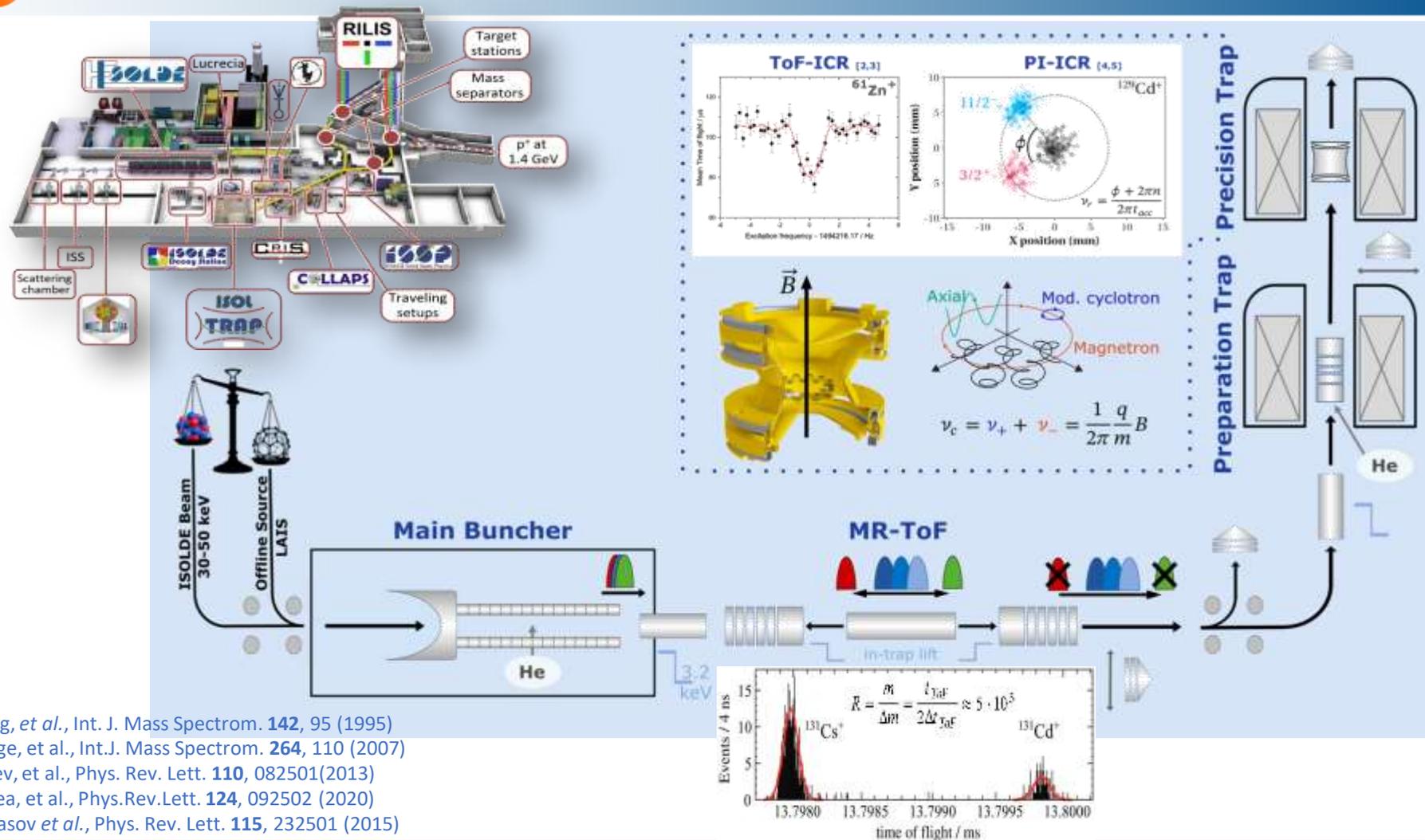
*Maroua Benhatchi*

# Recent results & developments at ISOLTRAP





# High-Precision Mass Spectrometer ISOLTRAP

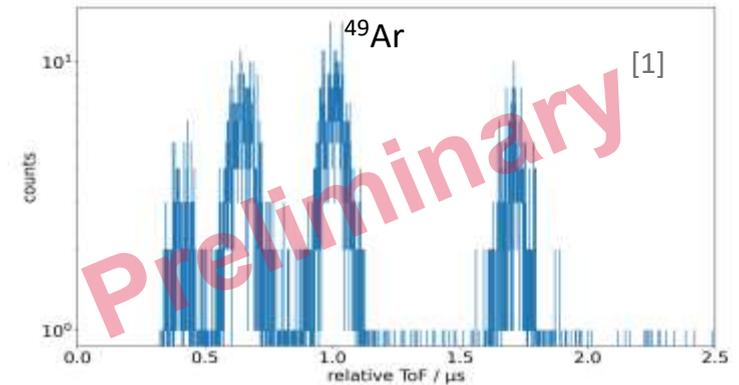
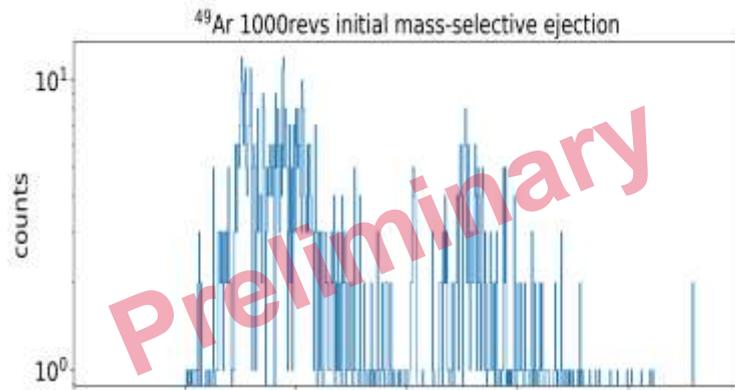
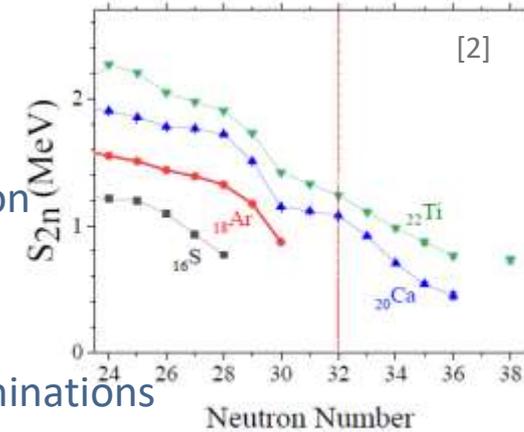


- [1] M. König, *et al.*, *Int. J. Mass Spectrom.* **142**, 95 (1995)
- [2] S. George, *et al.*, *Int. J. Mass Spectrom.* **264**, 110 (2007)
- [3] S. Eliseev, *et al.*, *Phys. Rev. Lett.* **110**, 082501(2013)
- [4] V. Manea, *et al.*, *Phys. Rev. Lett.* **124**, 092502 (2020)
- [5] D. Atanasov *et al.*, *Phys. Rev. Lett.* **115**, 232501 (2015)



# ISOLTRAP - Measurements

- Mass measurement of neutron rich  $^{49,50}\text{Ar}$ 
  - Motivations:
    - two neutron separation energy  $S_{2N}$  up to  $N = 32$  Sub-shell closure in Argon
  - Results:
    - first direct measurement of  $^{49}\text{Ar}$  mass !
    - no succes for  $^{50}\text{Ar}$  due to space-charge effects induced by massive contaminations
    - commissioning of Mini-RFQ for Mass-Selective Re-Trapping [1]



[1] D. Lange et al., in preparation  
[2] D. Lange et al., INTC-P-715 (2024)



# ISOLTRAP - Measurements

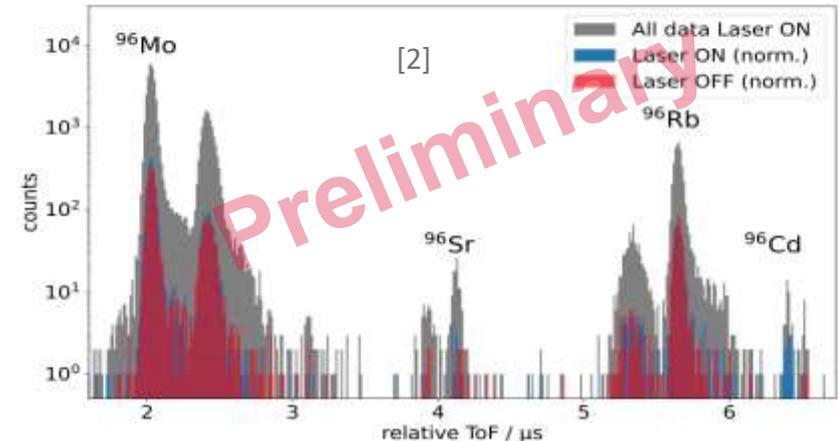
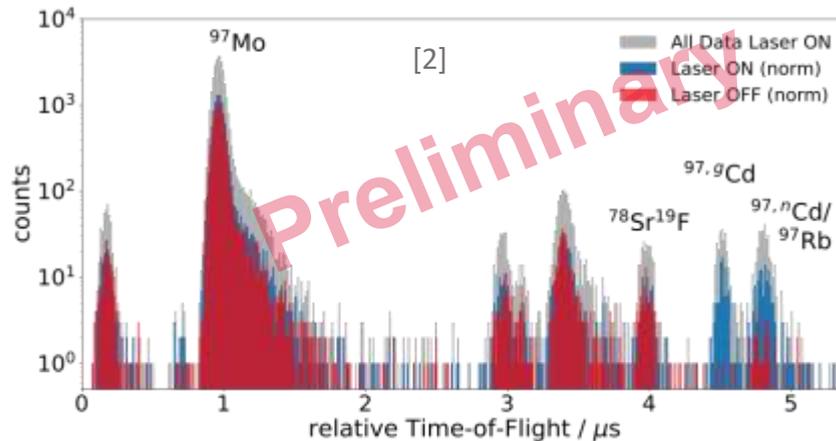
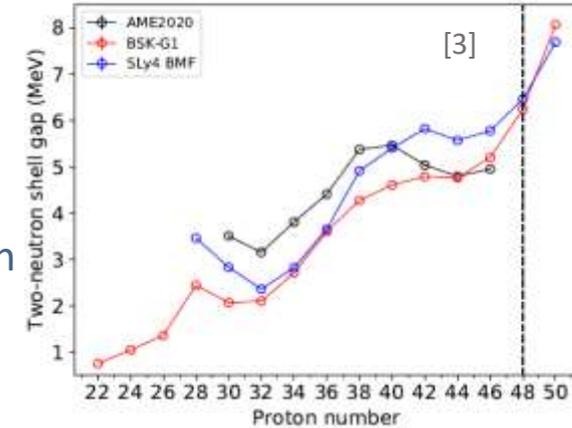
- Mass measurement of neutron deficient  $^{96,97,98}\text{Cd}$

- Motivations:

- evolution of nuclear structure around the doubly magic  $^{100}\text{Sn}$
- rp-process sensitivity to nuclear masses around the doubly magic  $^{100}\text{Sn}$

- Results:

- first direct measurement of  $^{96,97g,97n}\text{Cd}$  masses !
- improvement on  $^{98}\text{Cd}$  mass
- implementation of a new DAQ system for the MR-ToF MS in parallel to the standard one [1]

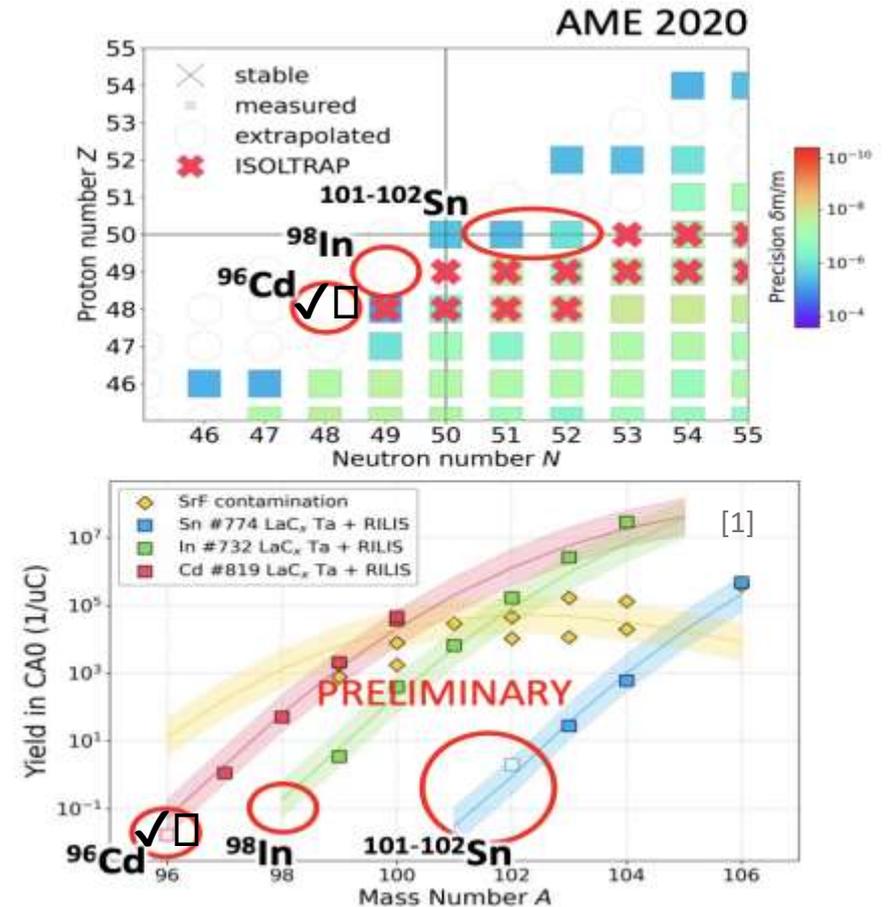
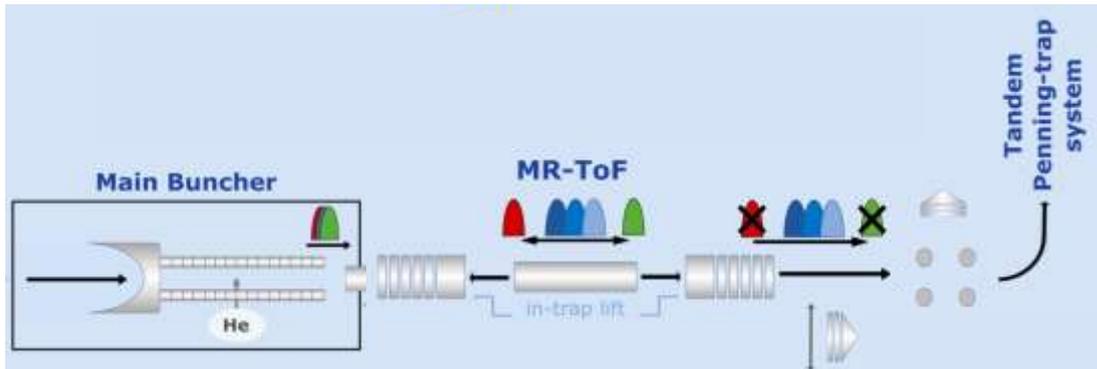


[1] M. Benhatchi et al., in preparation  
[2] D. Lange et al., in preparation  
[3] M. Mougeot et al., INTC-P-682 (2023)



# ISOLTRAP - Measurements

- Edge of sensitivity
  - Interest in more exotic nuclei !
  - Challenges:
    - low production yields



[1] M. Mougeot et al., INTC-P-682 (2023)



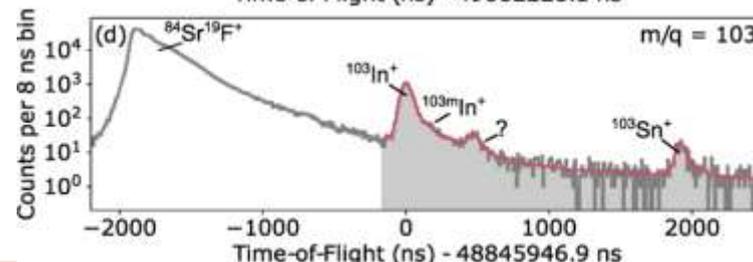
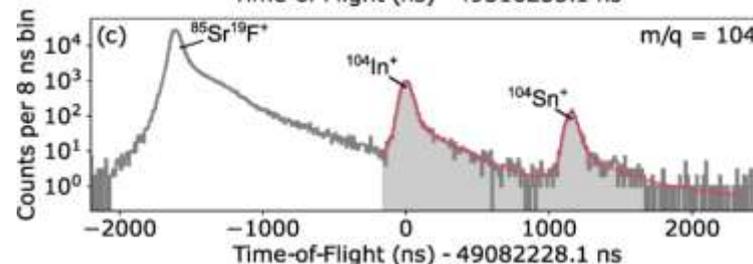
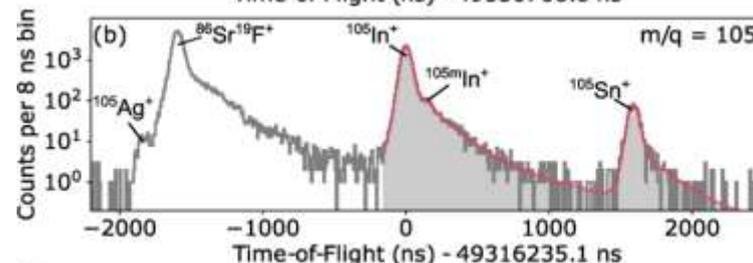
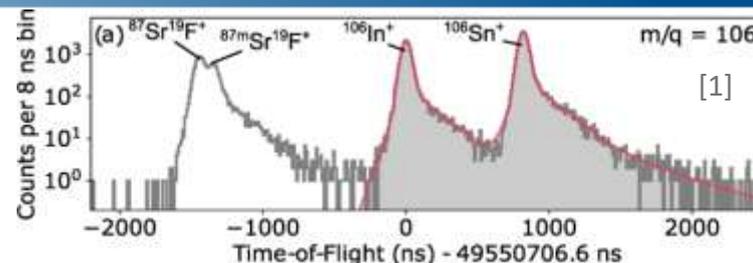
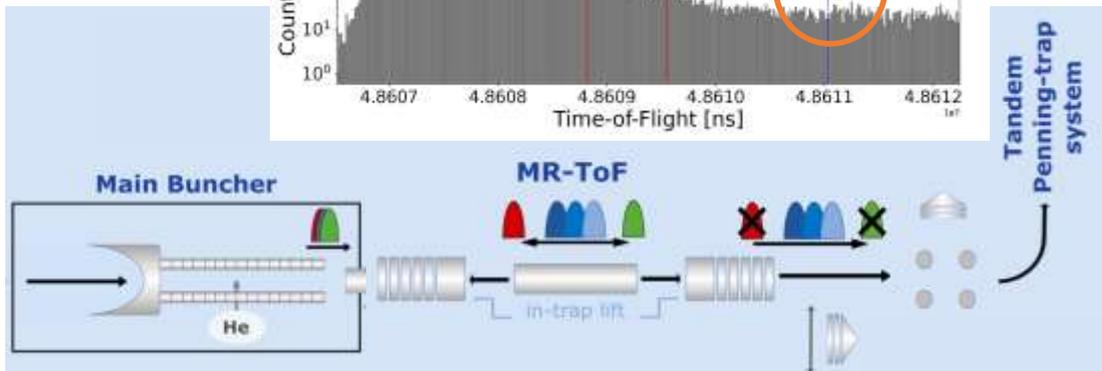
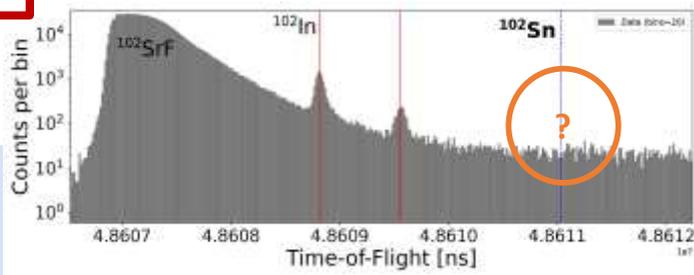
# ISOLTRAP - Measurements

- Edge of sensitivity

- Interest in more exotic nuclei !
- Challenges:
  - low production yields
  - isobaric and molecular contamination

**How to overcome these limitations?**

- ions of interest overlaid by tailing of contaminants
- ToF shift and peak deformation due to space charge effects

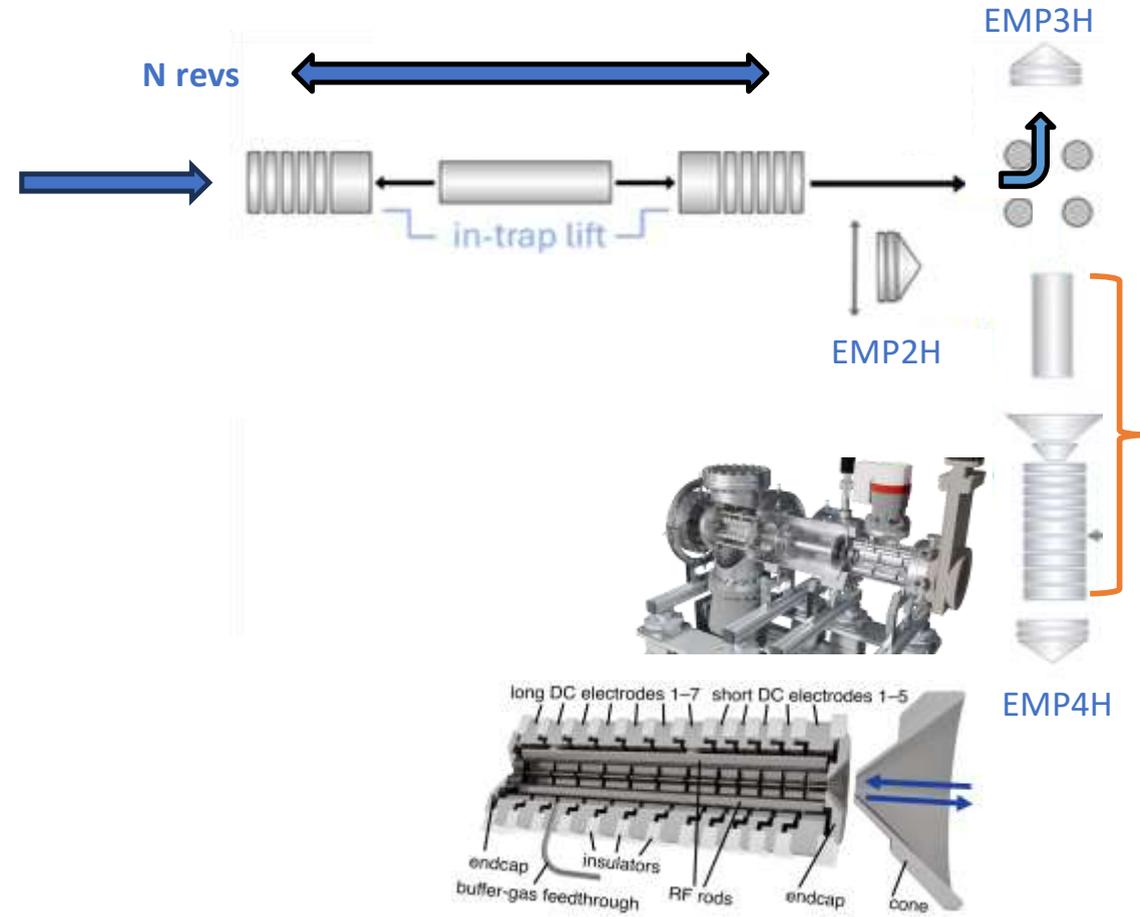


[1] L. Nies et al., PRC 111, 014315 (2025)



# ISOLTRAP - Technical development

- Mini-RFQ<sup>[1]</sup>
  - Mass-selective re-trapping <sup>[2]</sup> :
    - contamination suppression
    - collision-induced dissociation (CID)
  - Initial trapping in MR-ToF



Mini-Buncher designed by MIRACLS <sup>[3]</sup>

[1] D. Lange et al., in preparation

[2] T. Dickel, et al., J. Am. Soc. Mass Spectrom. **28**, 1079-1090 (2017)

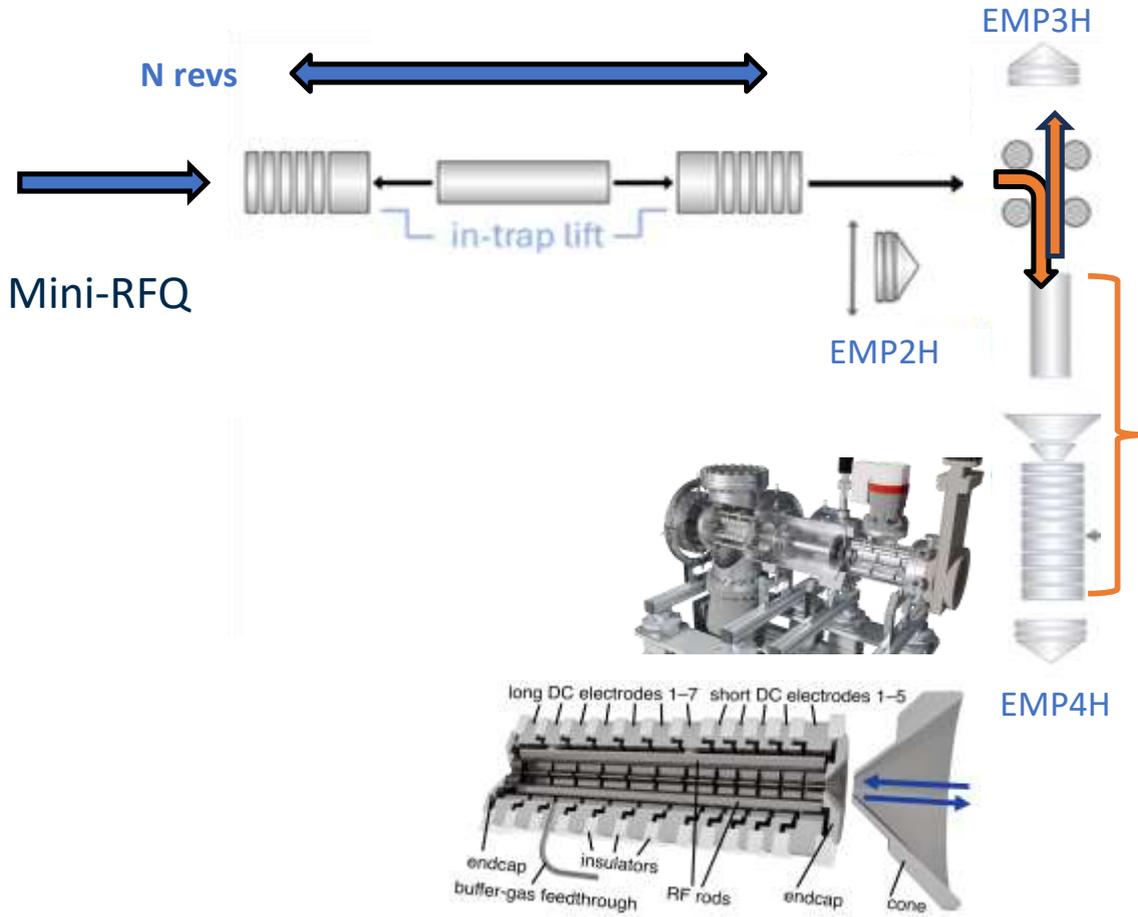
[3] C. Kanitz, Master-Thesis, Friedrich-Alexander- Universität Erlangen-Nürnberg (2021)



# ISOLTRAP - Technical development

- Mini-RFQ<sup>[1]</sup>

- Mass-selective re-trapping <sup>[2]</sup> :
  - contamination suppression
  - collision-induced dissociation (CID)
- Initial trapping in MR-ToF + **Re-bunching** in Mini-RFQ



Mini-Buncher designed by MIRACLS <sup>[3]</sup>

[1] D. Lange et al., in preparation

[2] T. Dickel, et al., J. Am. Soc. Mass Spectrom. **28**, 1079-1090 (2017)

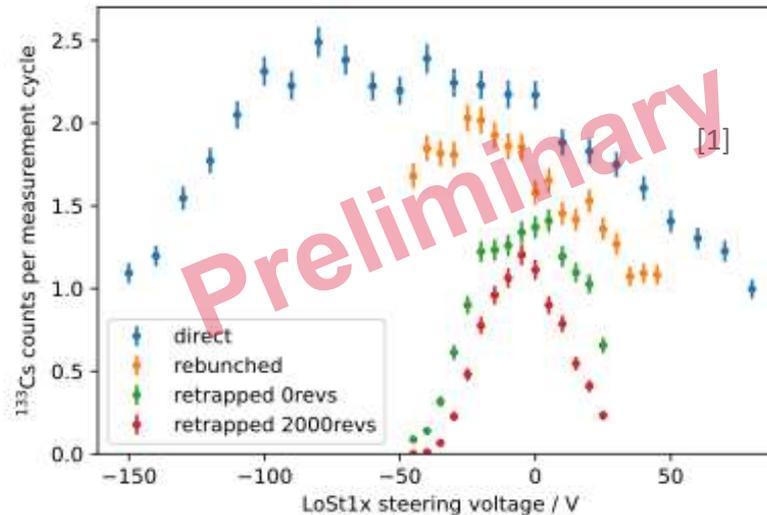
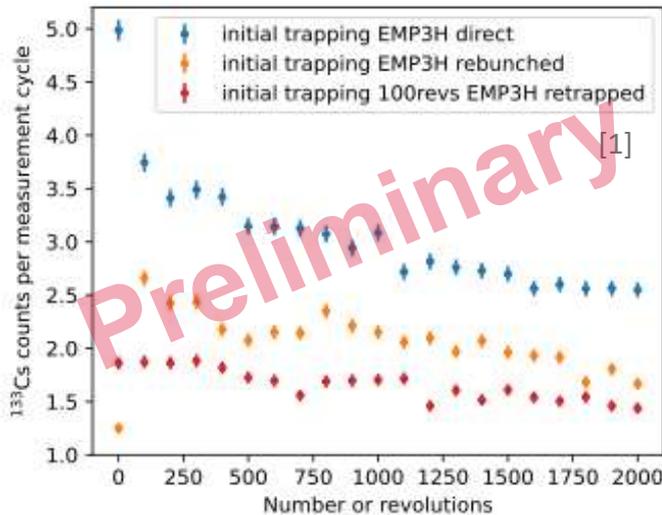
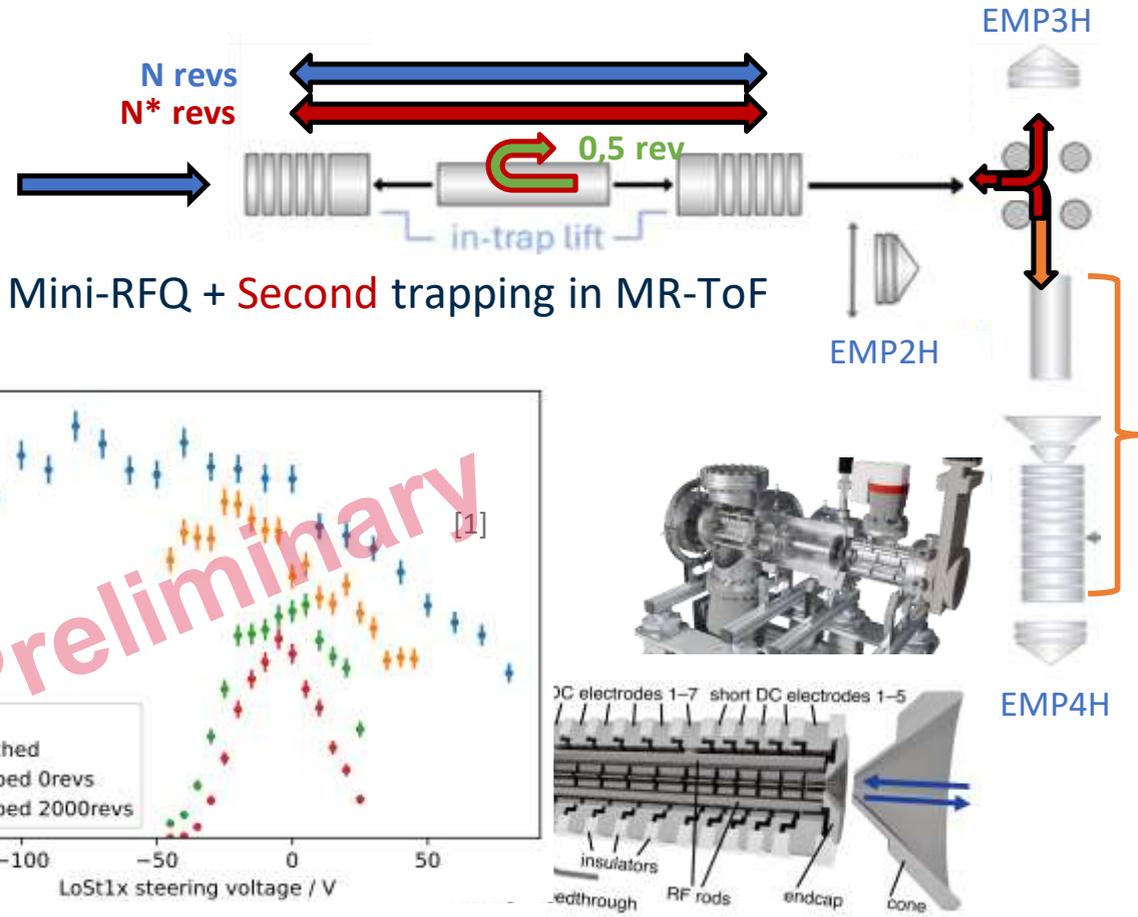
[3] C. Kanitz, Master-Thesis, Friedrich-Alexander- Universität Erlangen-Nürnberg (2021)



# ISOLTRAP - Technical development

## • Mini-RFQ<sup>[1]</sup>

- Mass-selective re-trapping <sup>[2]</sup> :
  - contamination suppression
  - collision-induced dissociation (CID)
- Initial trapping in MR-ToF + Re-bunching in Mini-RFQ + Second trapping in MR-ToF



Mini-Buncher designed by MIRACLS <sup>[3]</sup>

[1] D. Lange et al., in preparation

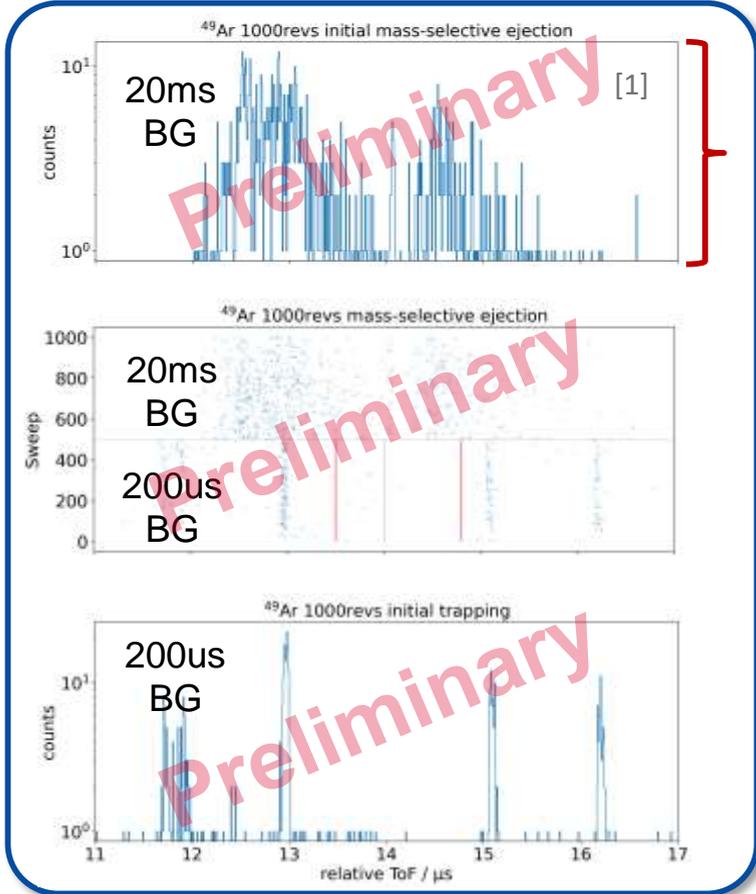
[2] T. Dickel, et al., J. Am. Soc. Mass Spectrom. **28**, 1079-1090 (2017)

[3] C. Kanitz, Master-Thesis, Friedrich-Alexander- Universität Erlangen-Nürnberg (2021)

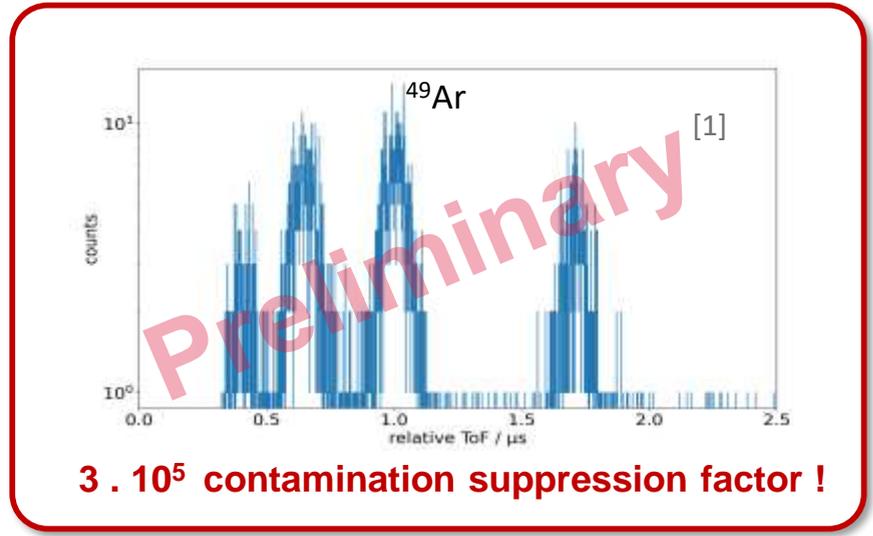
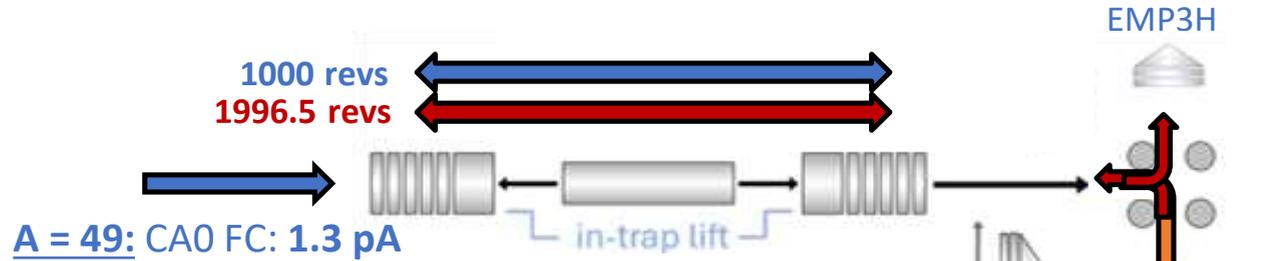


# ISOLTRAP - Technical development

## • Mini-RFQ<sup>[1]</sup>: Ar beamtime



x100



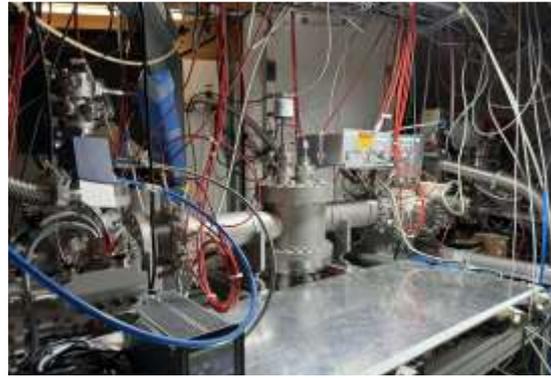
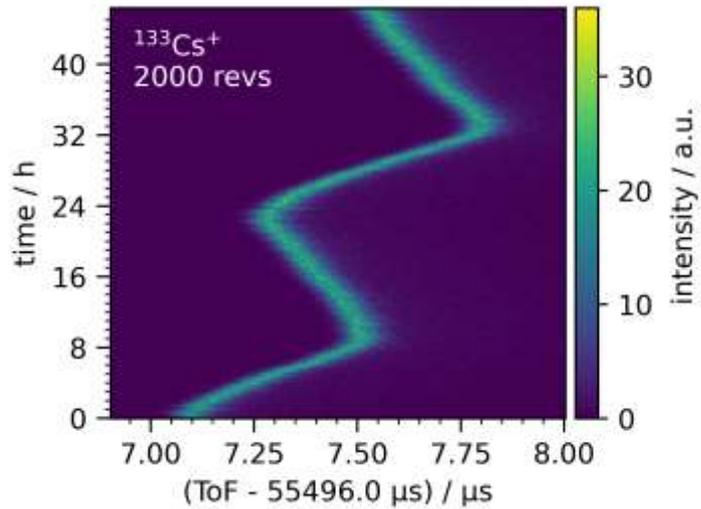
**3 . 10<sup>5</sup> contamination suppression factor !**

[1] D. Lange et al., in preparation

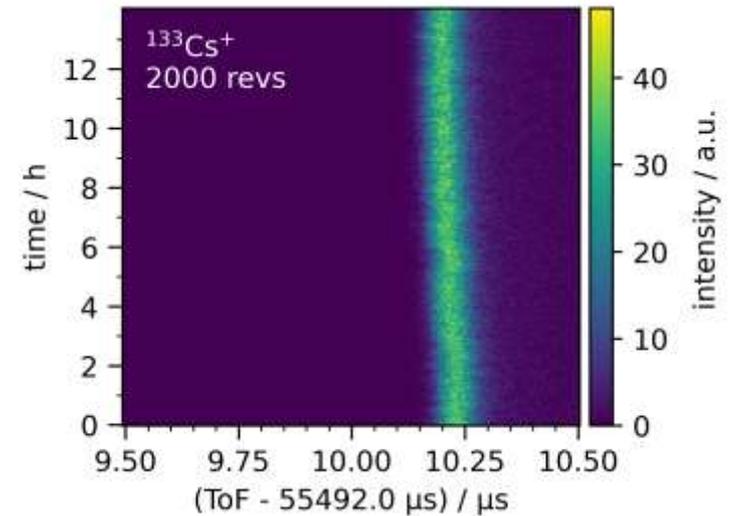


# ISOLTRAP - Technical development

- MR-ToF MS Temperature Stabilization



Temperature-Stabilization



- ToF drift correlated with temperature  $\sim 500 \text{ ns/K}$

- Active temperature stabilization system based on Peltier elements <sup>[1]</sup>
- MR-ToF MS enclosure

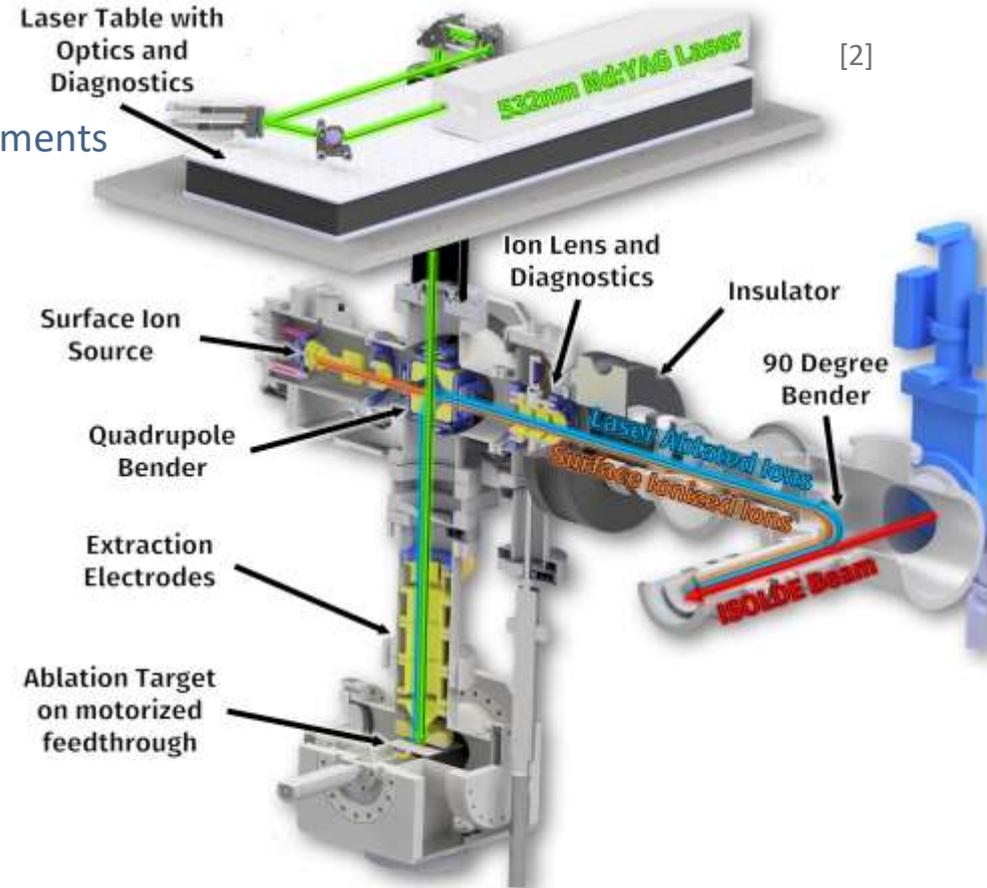
[1] F. Mehlhorn, BSc thesis, University Heidelberg



# ISOLTRAP - Technical development

- LAIS<sup>[1]</sup>

- Offline ion sources for:
  - optimizations, testing, reference for mass measurements
- Surface ion source:
  - alkali ions (K, Rb, Cs)
  - stable production of continuous ion beam
- Laser Ablation Ion source:
  - wide range of possible target materials
  - target holder on motorized feedthrough
  - laser pulses produce bunches of ablated ions



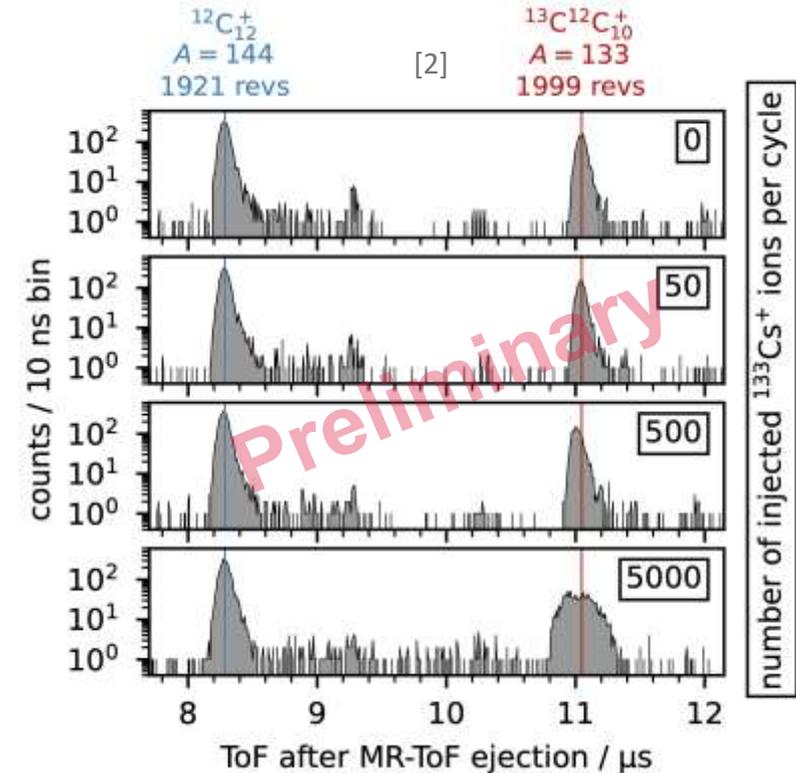
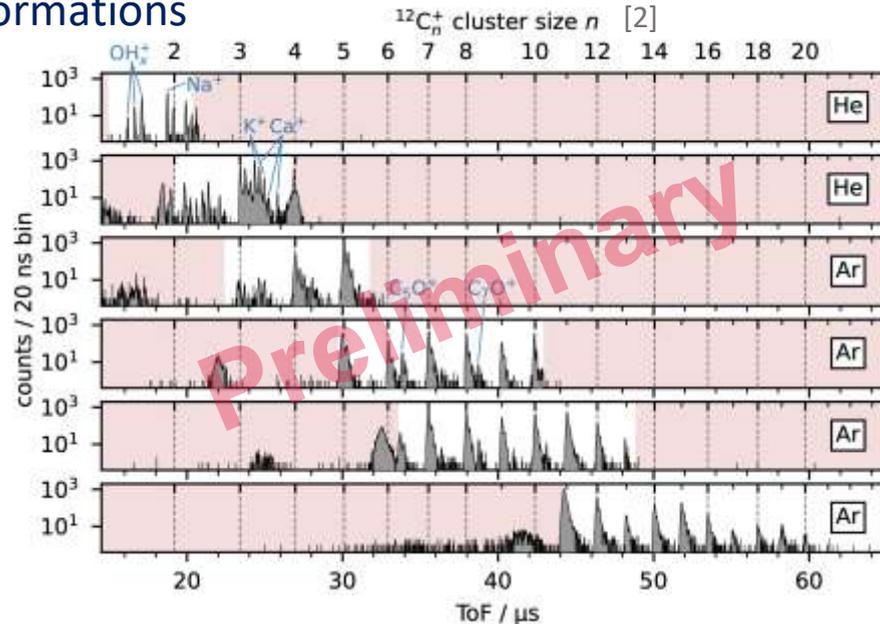
[1] P.F. Giesel et al., in preparation

[2] L. Nies, dissertation, [10.17181/CERN.RQYQ.2TJZ](https://cds.cern.ch/record/2712121/files/10.17181/CERN.RQYQ.2TJZ) (2023)



# ISOLTRAP - Technical development

- LAIS<sup>[1]</sup>
  - Production of different metals and carbon clusters available
    - RFQ-CB require heavier buffer gaz for heavier species
  - Load ions from both source possible
  - Possibility to investigate space charge effects, and molecular formations



[1] P.F. Giesel et al., in preparation



# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>

## Standard DAQ - MCS6A :

Scaler TDC type that convert raw data into histogram

- good for low intensity beams
- amount of data is reduced
- all raw data is lost
- can create bias



Time resolution of 0,1 ns

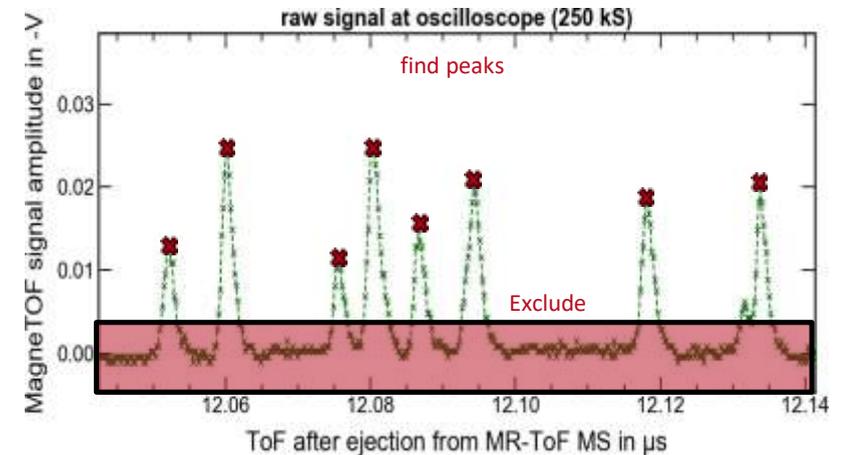
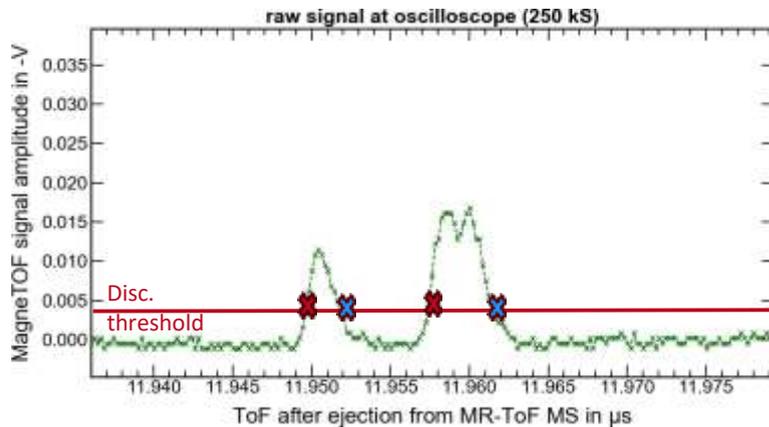
## New DAQ - Picoscope 6428A :

Oscilloscope + python programs [1]

- raw data  $\Rightarrow$  one spectrum saved for each ion shot
- python to control both the scope and the conversion to counts



Time resolution of 0,2 ns  
Amplitude resolution of 0,4 mV

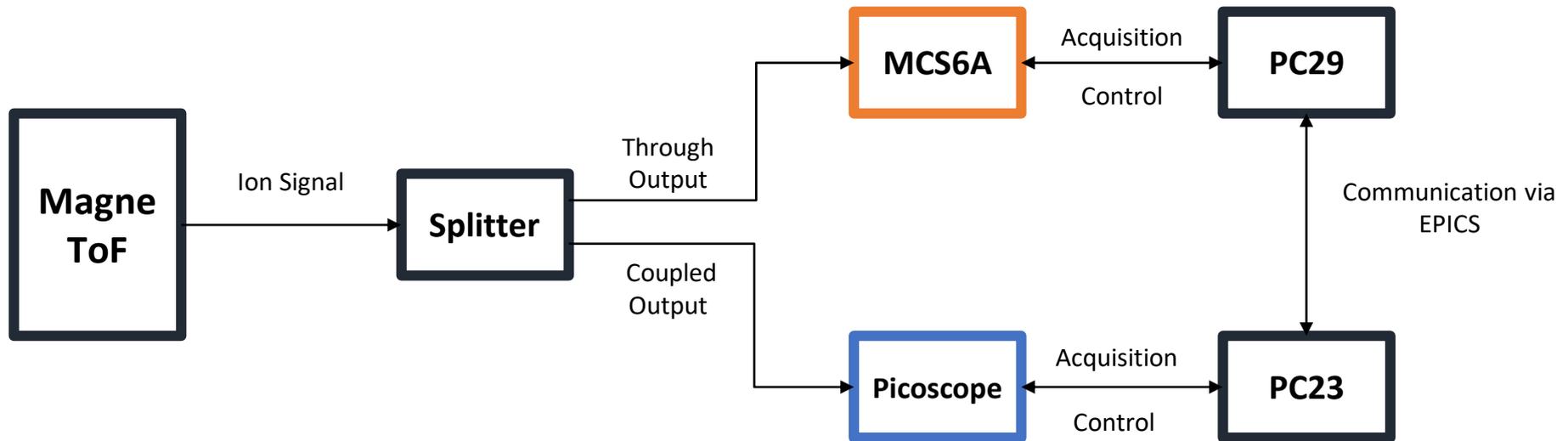


[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Detector signal divided with an active splitter
    - through output: no effect on MCS6A acquisition
    - coupled output: half of initial signal going to PicoDAQ
    - no reflections, nor noise increase on both outputs

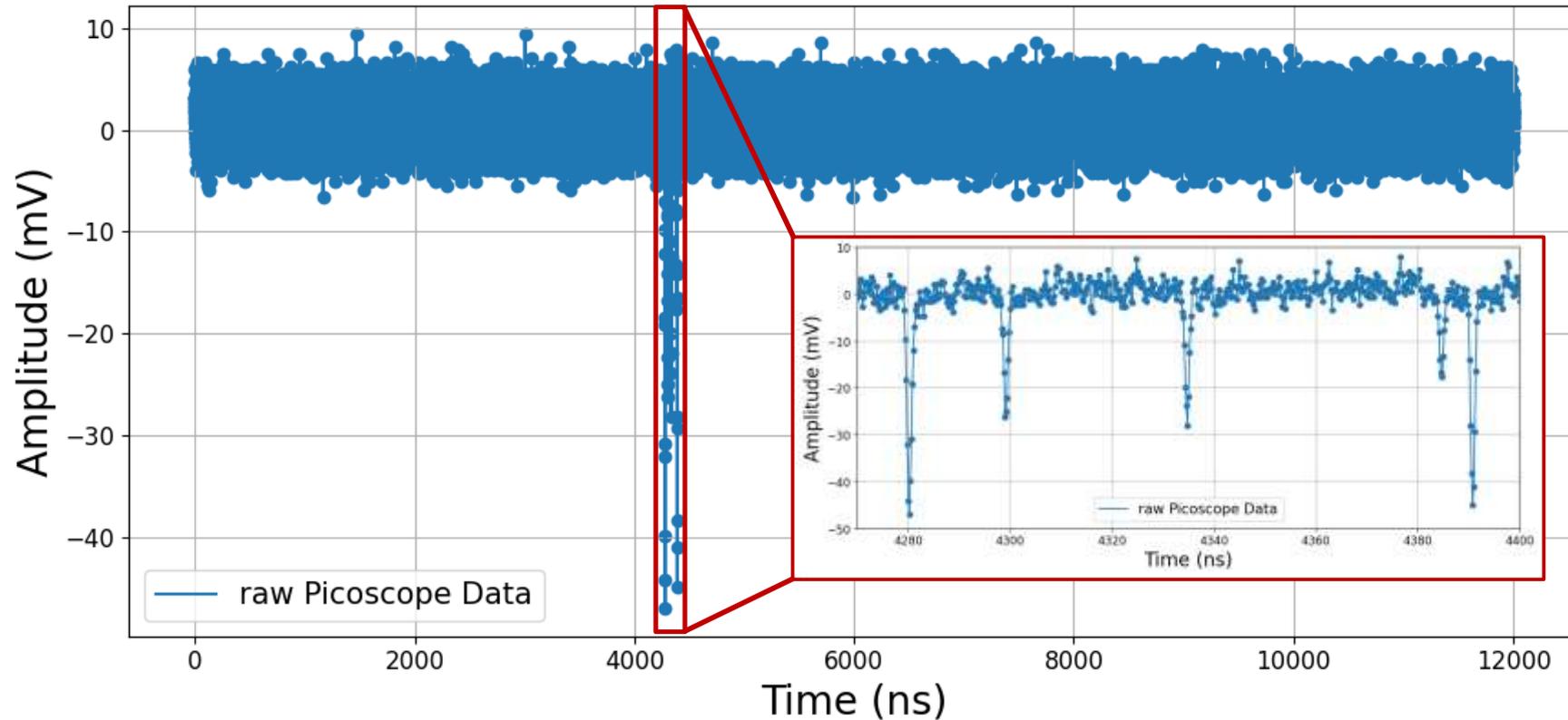


[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>

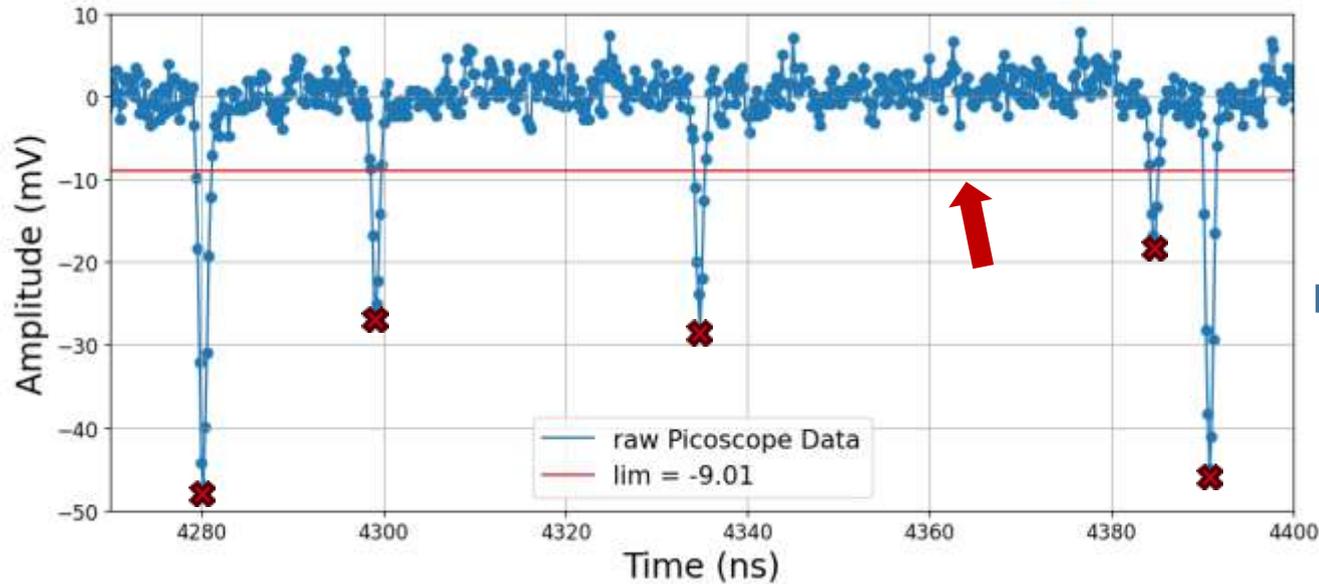


[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Selecting ions peaks: use « `find_peaks` » function from **SciPy**



Ion	ToF (ns)	Amp (mV)
1	t1	a1
2	t2	a2
3	t3	a3
4	t4	a4

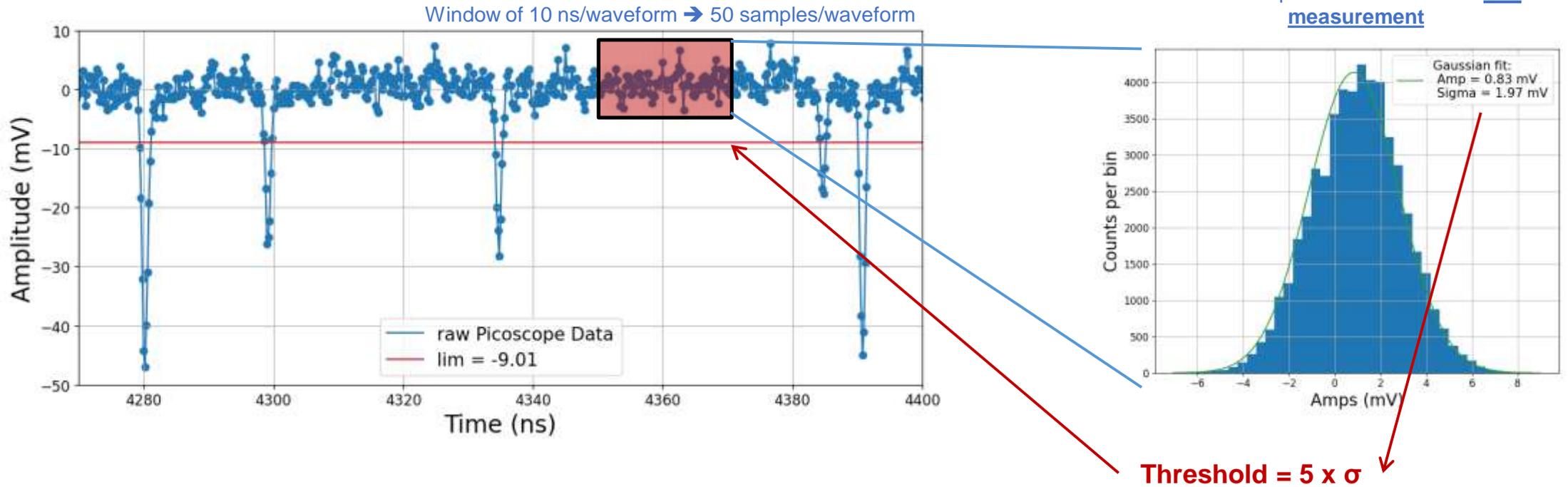
One file for one waveform  
(x N cycles for one measurement)

[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Define an ion amplitude threshold:
    - characterize noise amplitude



[1] M. Benhatchi et al., in preparation

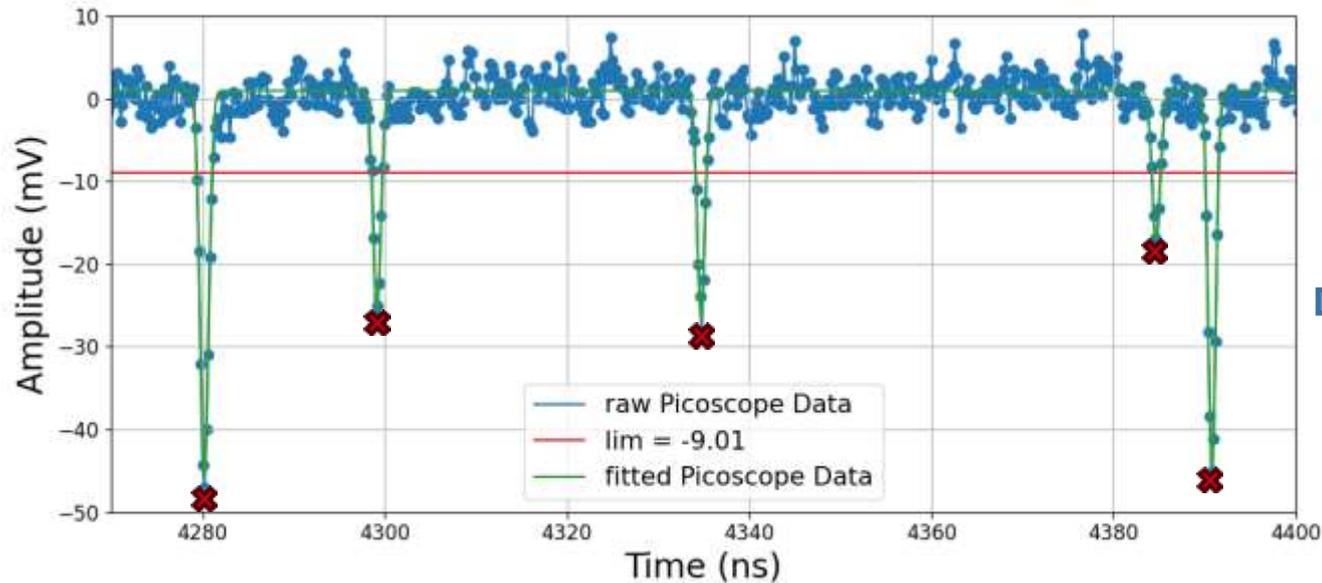


# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>

- Ions ToFs:

- from « **find\_peaks** »: the function return peaks indexes → Time of indexed sample
- from fitting the waveform with multi-gauss function



Ion	ToF (ns)	
	ToF_PF (ns)	ToF_Fit (ns)
1	t1	t'1
2	t2	t'2
3	t3	t'3
4	t4	t'4



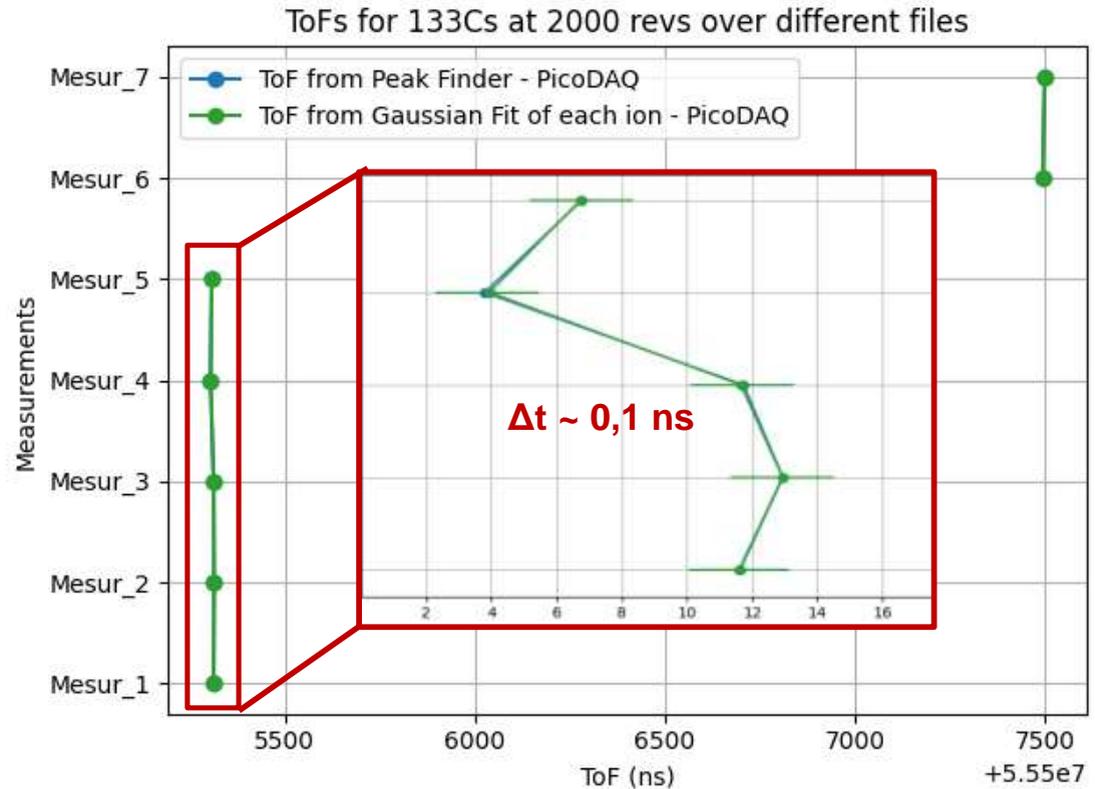
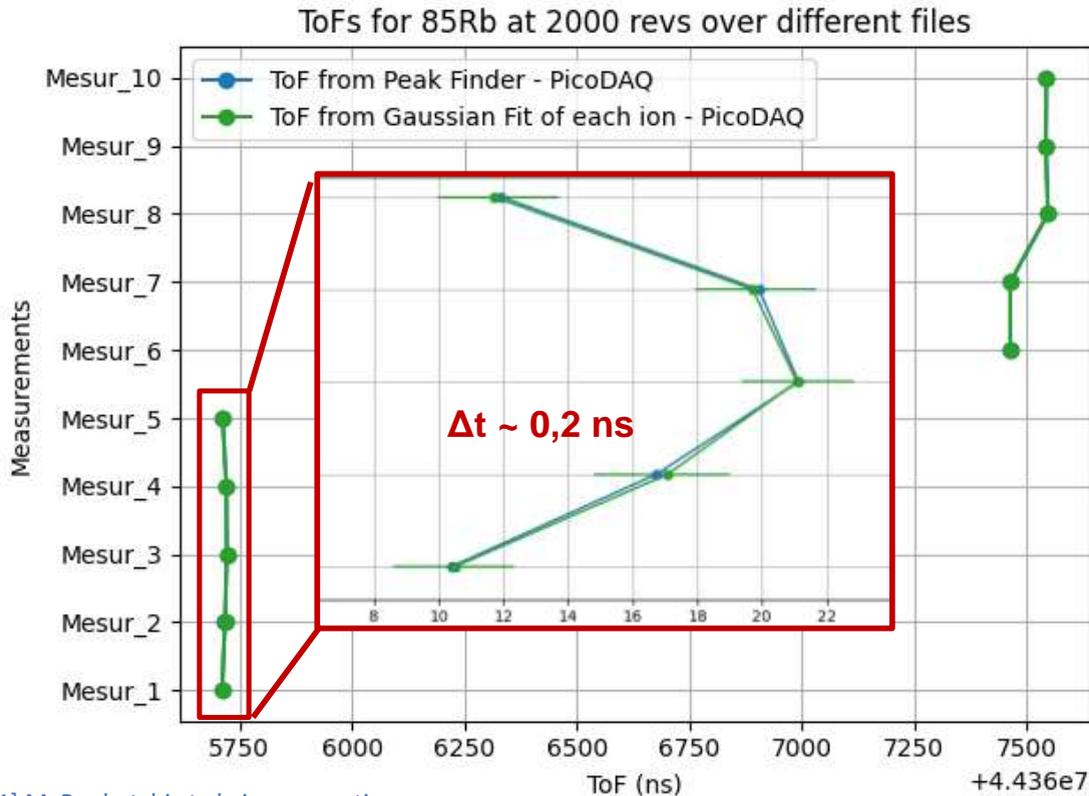
One file for one waveform  
(x N cycles for one measurement)

[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Ions ToFs: comparing ToFs results for PicoScope between two methods



[1] M. Benhatchi et al., in preparation

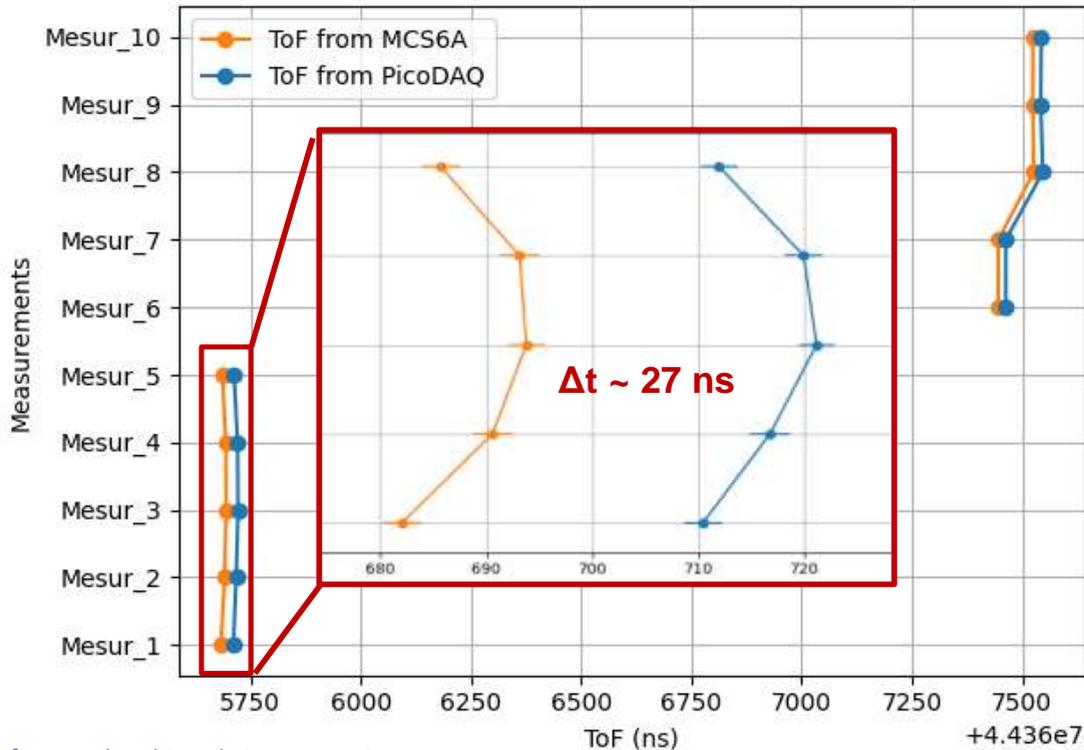


# ISOLTRAP - Technical development

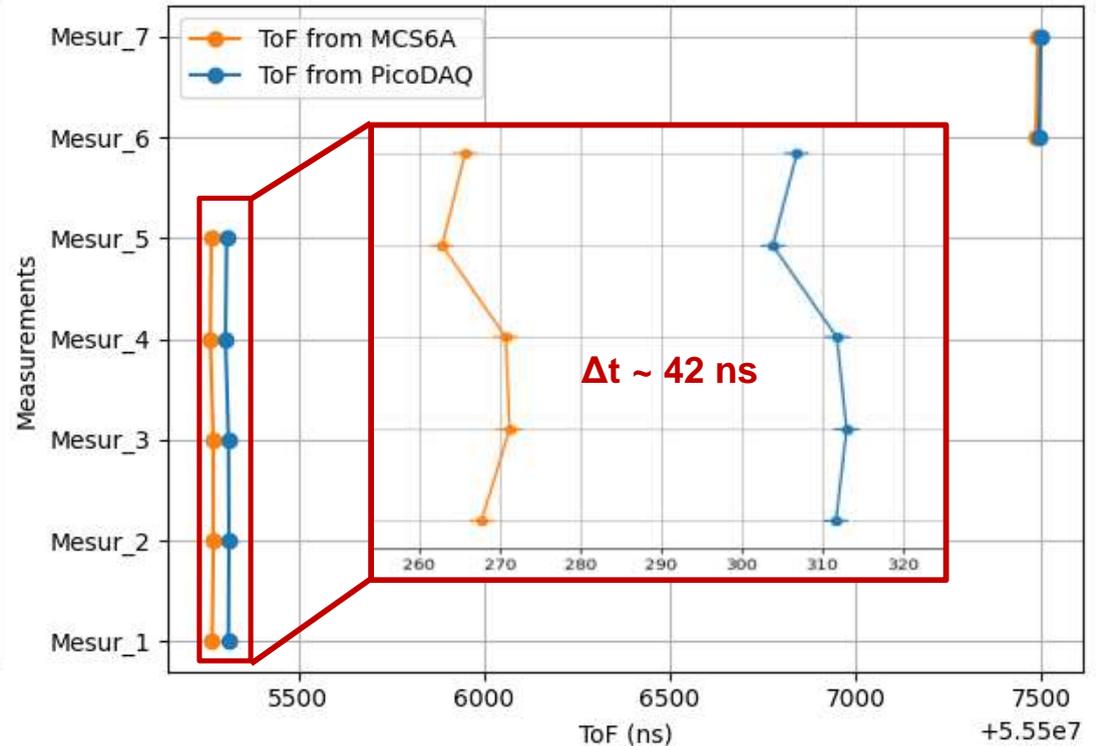
- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Ions ToFs: comparing ToFs results between two DAQs

Origin still unknown, but the ToF shift is constant for one spectra !

ToFs for 85Rb at 2000 revs over different files



ToFs for 133Cs at 2000 revs over different files

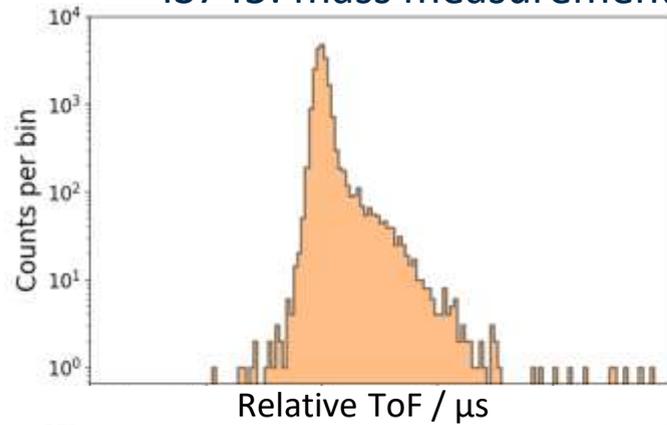


[1] M. Benhatchi et al., in preparation

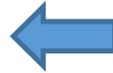


# ISOLTRAP - Technical development

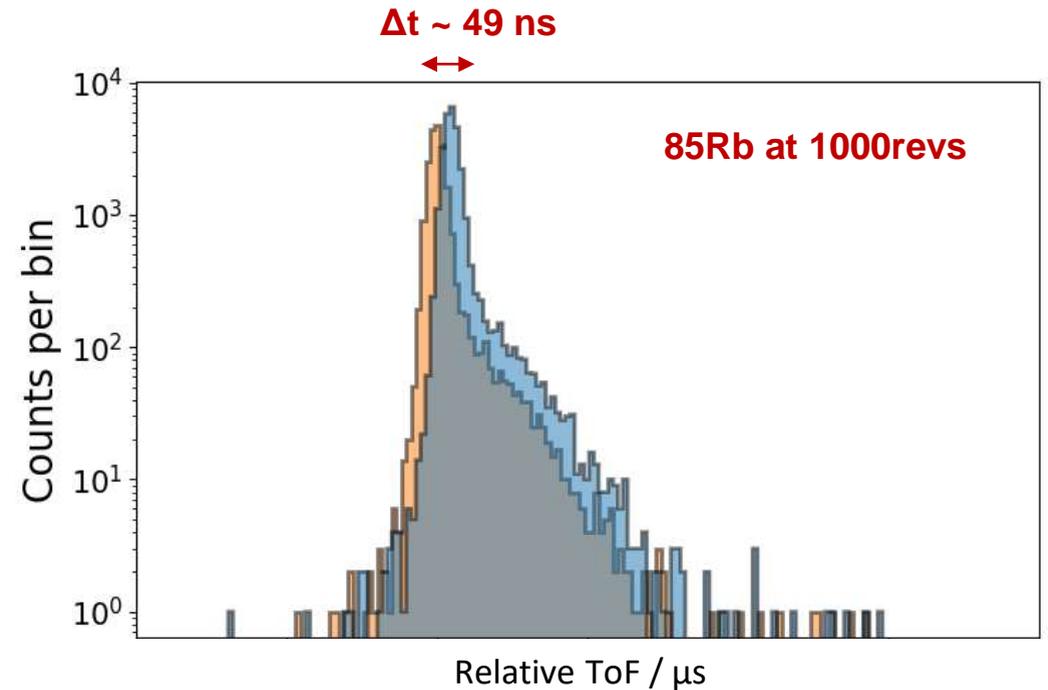
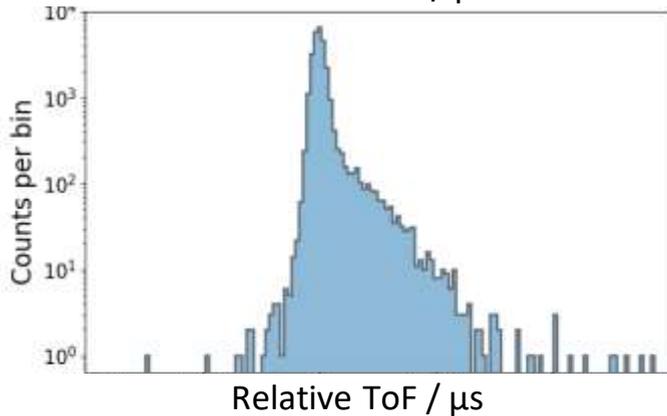
- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - IS745: mass measurement of neutron deficient Cd



MCS6A



PicoDAQ

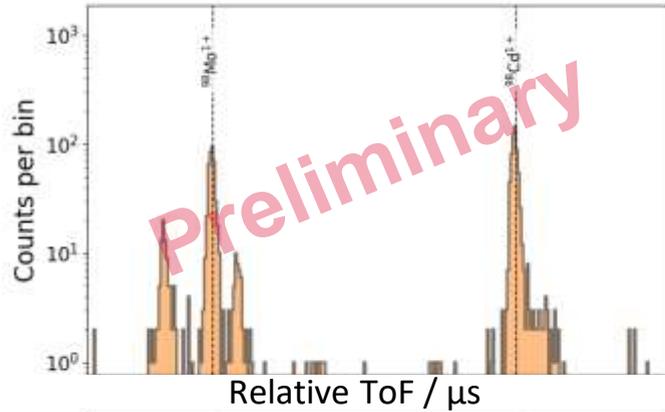


[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

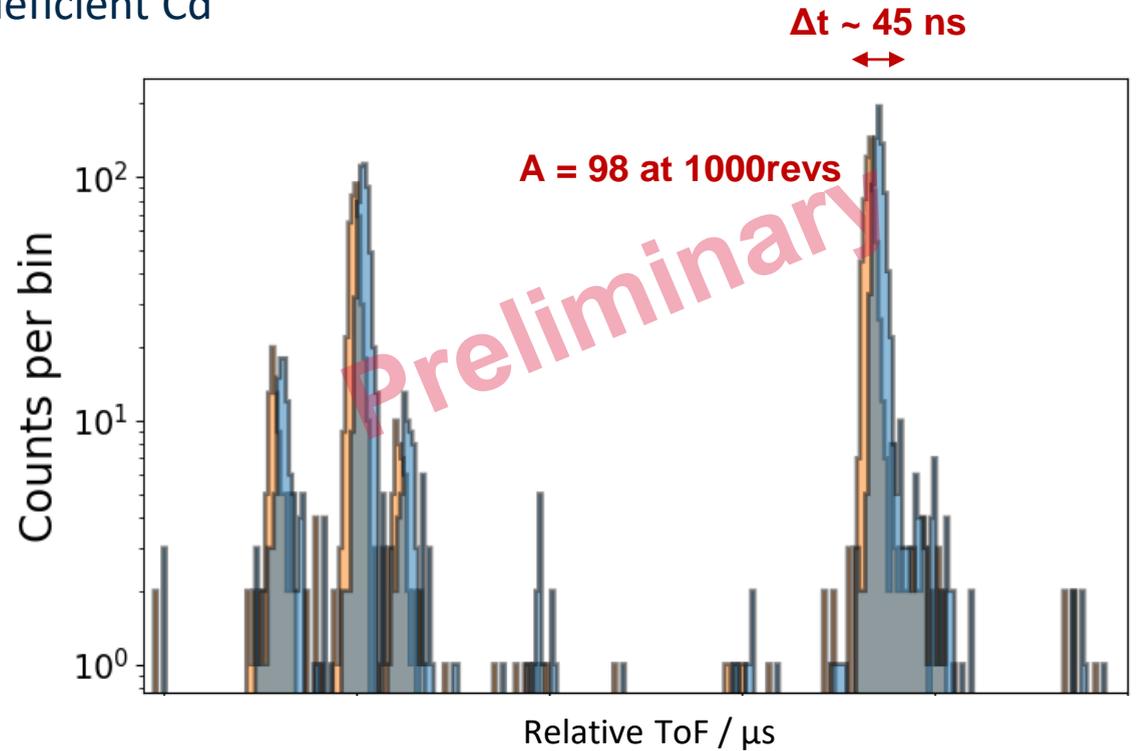
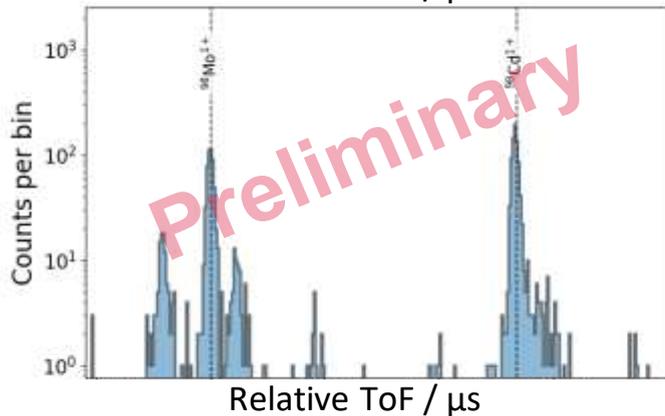
- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - IS745: mass measurement of neutron deficient Cd



MCS6A



PicoDAQ

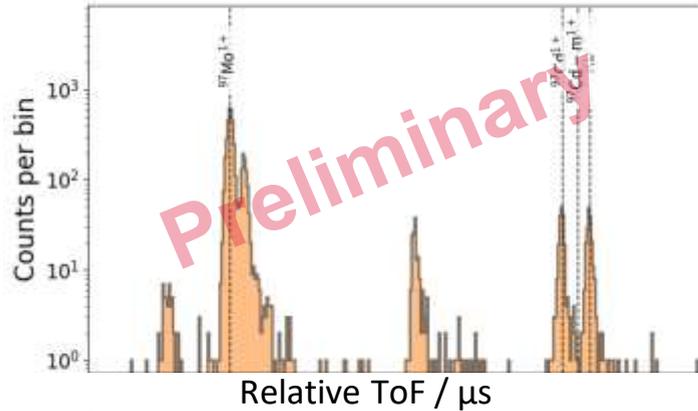


[1] M. Benhatchi et al., in preparation



# ISOLTRAP - Technical development

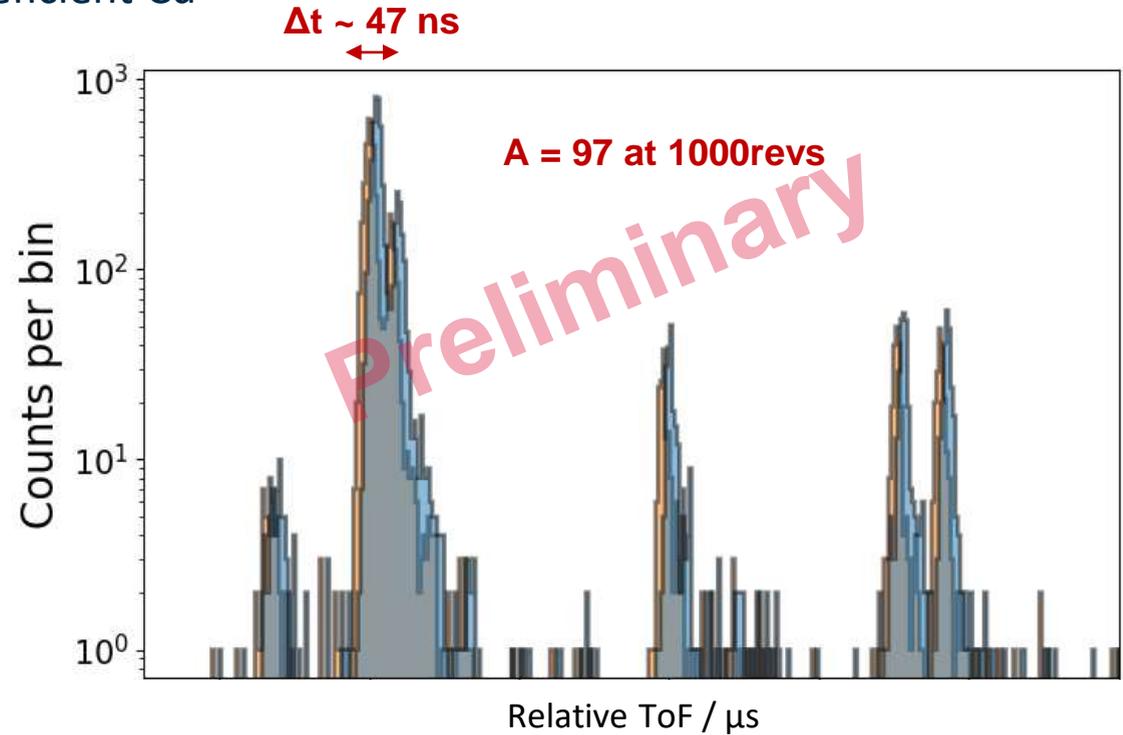
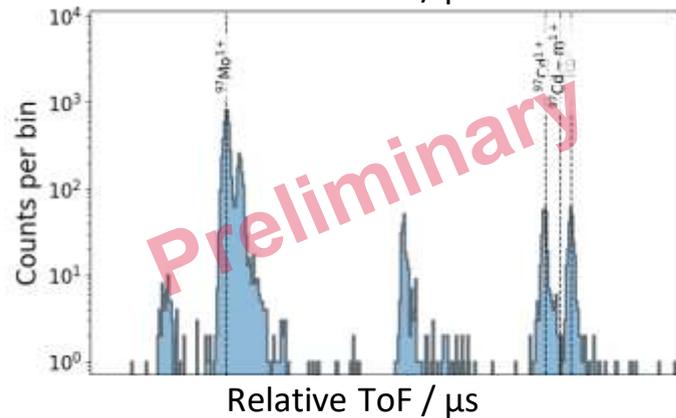
- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - IS745: mass measurement of neutron deficient Cd



MCS6A



PicoDAQ

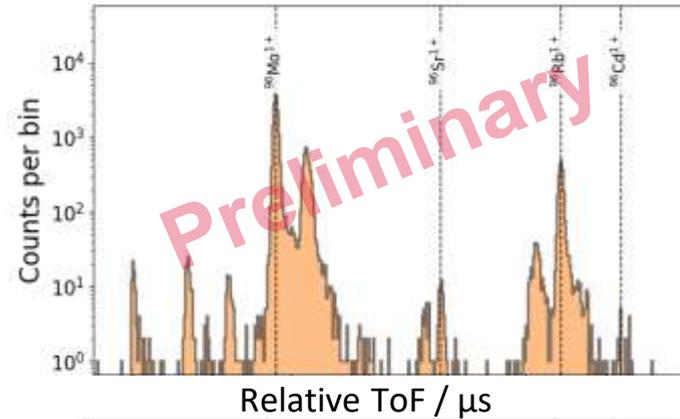


[1] M. Benhatchi et al., in preparation

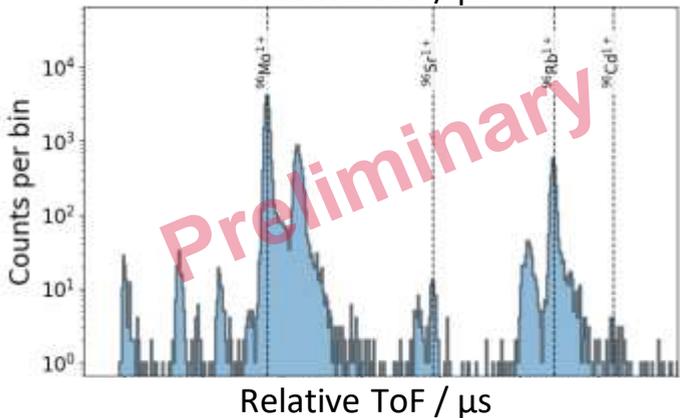


# ISOLTRAP - Technical development

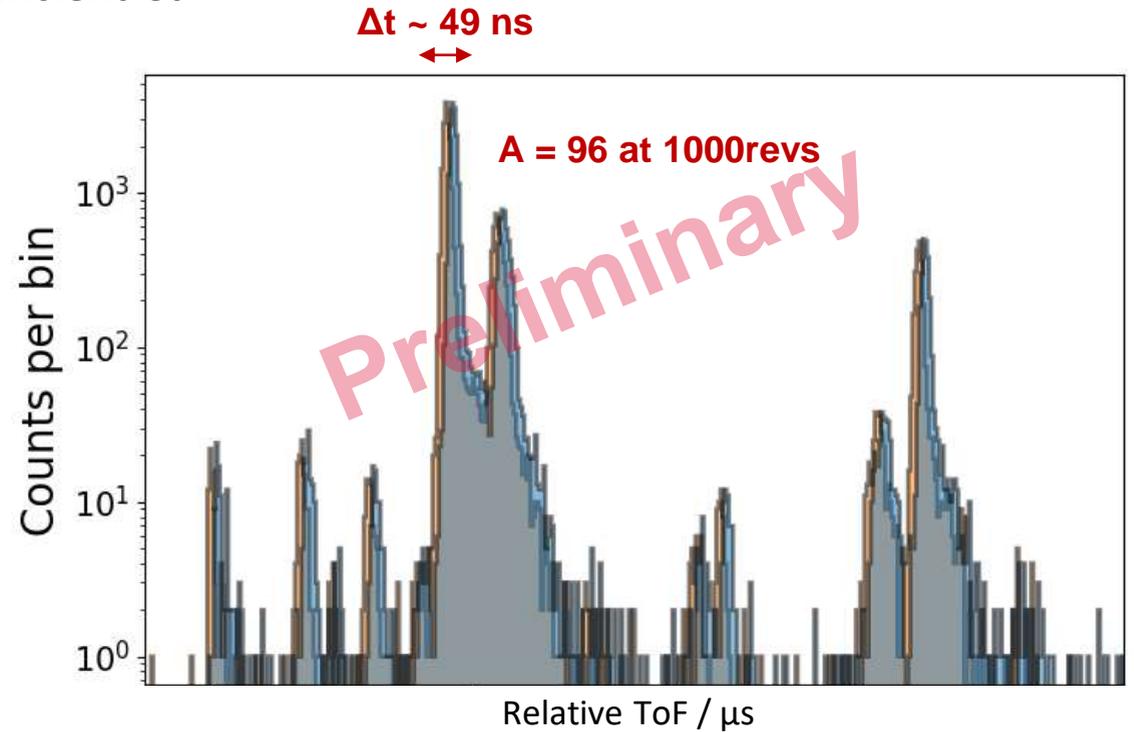
- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - IS745: mass measurement of neutron deficient Cd



MCS6A



PicoDAQ



[1] M. Benhatchi et al., in preparation

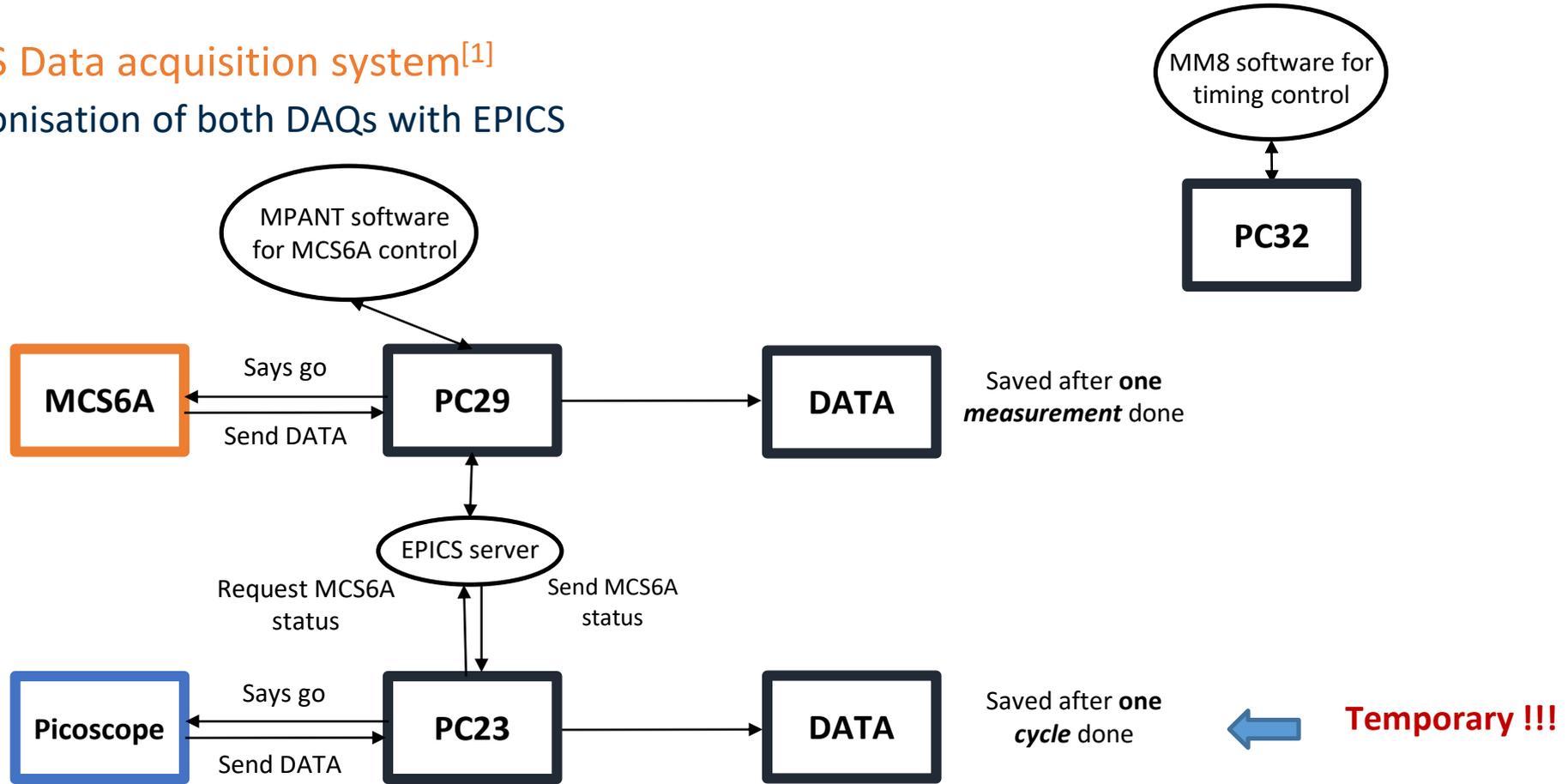


**Thank you for your  
attention !**



# EXTRA - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Synchronisation of both DAQs with EPICS

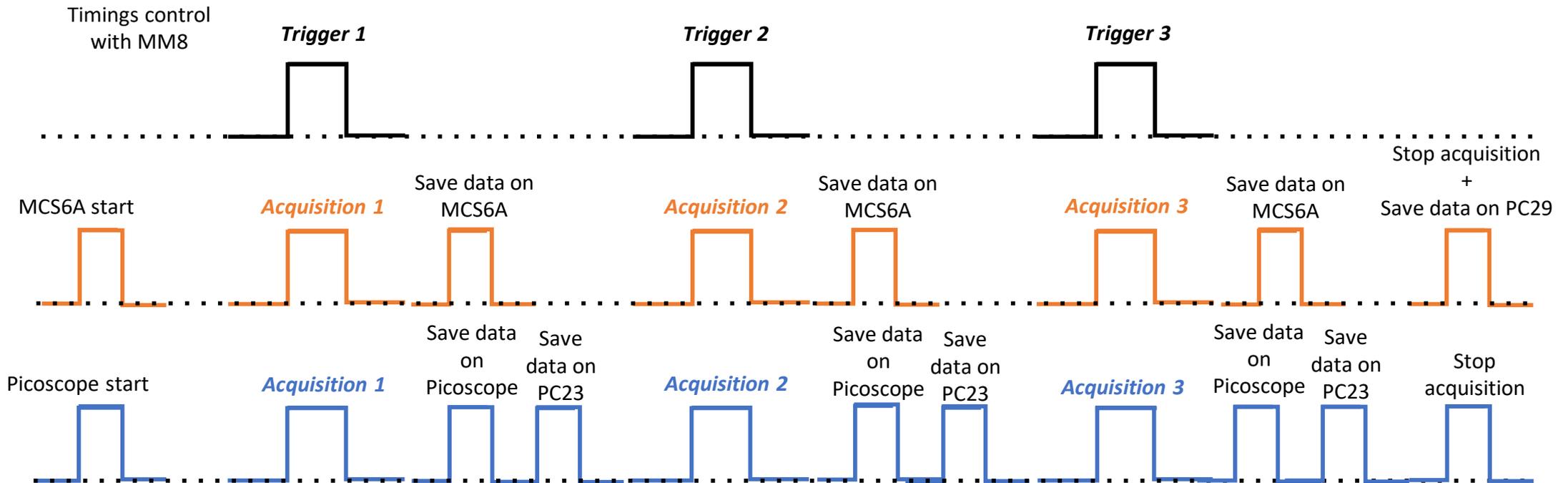


[1] M. Benhatchi et al., in preparation



# EXTRA - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Long cycles (> ~100ms) for one ion bunch

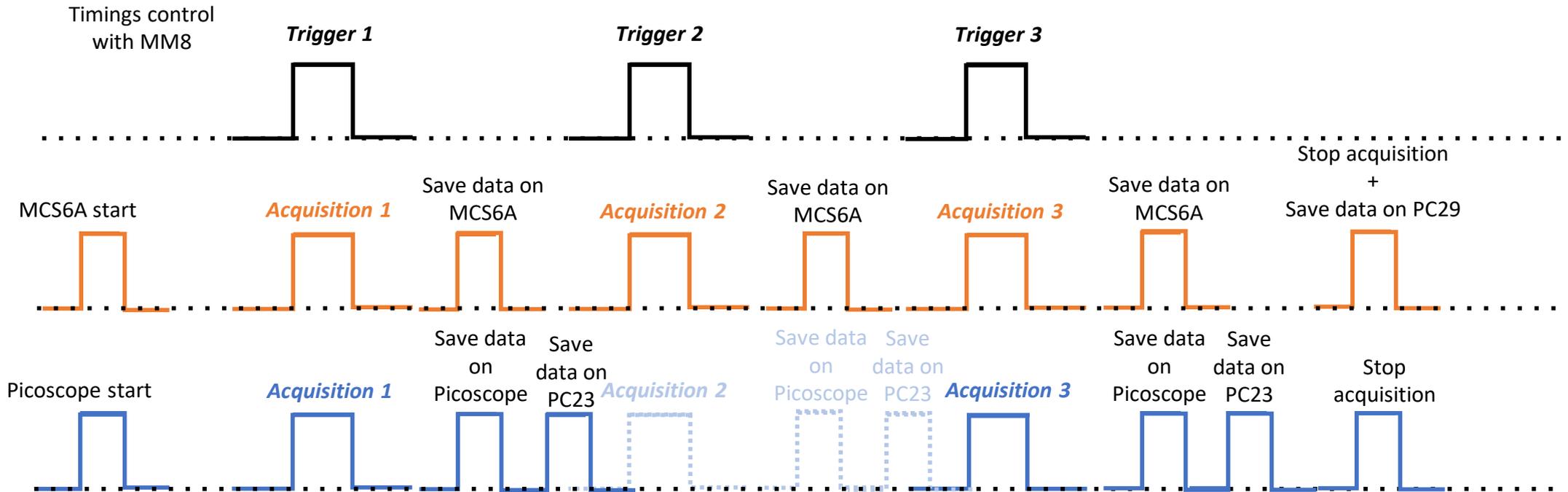


[1] M. Benhatchi et al., in preparation



# EXTRA - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Short cycles (< ~100ms) for one ion bunch

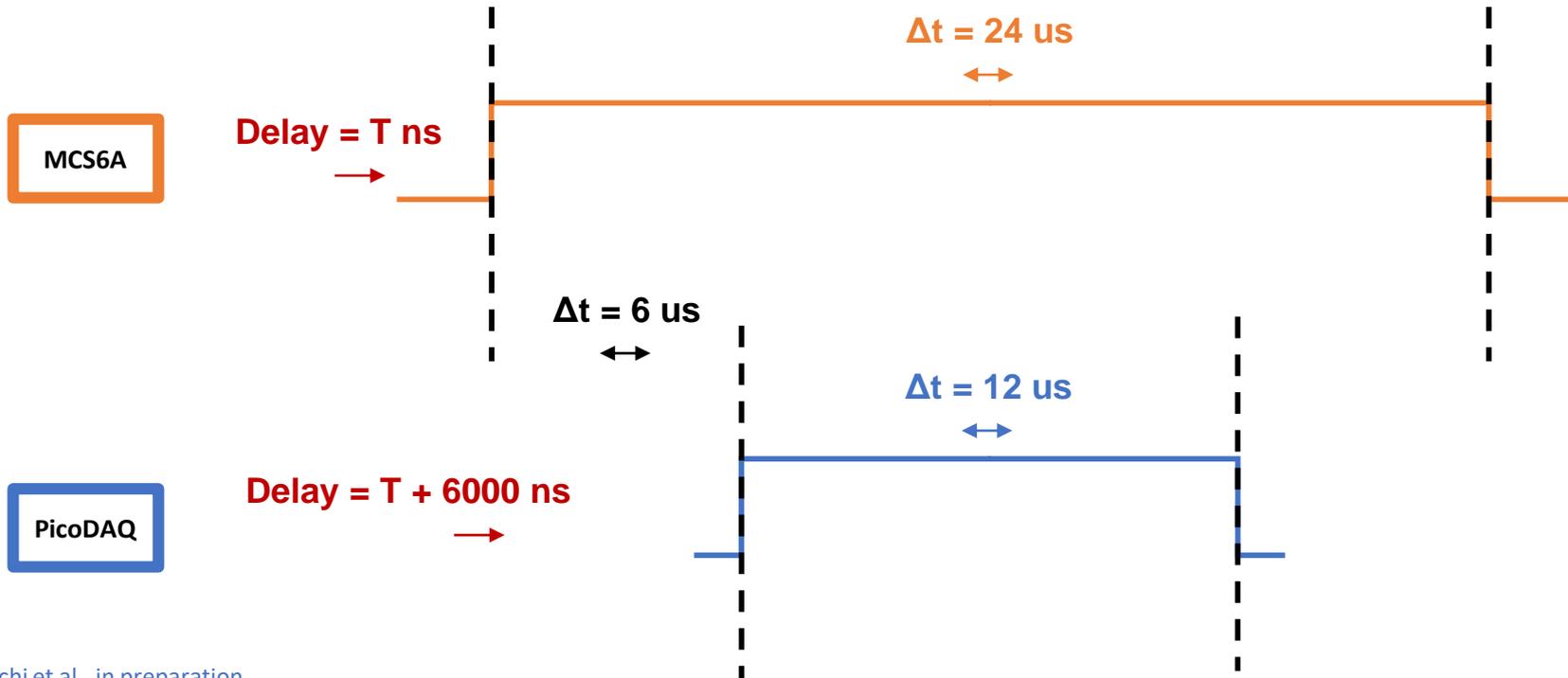


[1] M. Benhatchi et al., in preparation



# EXTRA - Technical development

- MR-ToF MS Data acquisition system<sup>[1]</sup>
  - Acquisition time window, with T defined by calibration ( for A and N revs → T )
  - Picoscope time window reduced due to memory space issue



[1] M. Benhatchi et al., in preparation