Overview of ISOLTRAP's mass measurements (the 2017 edition)

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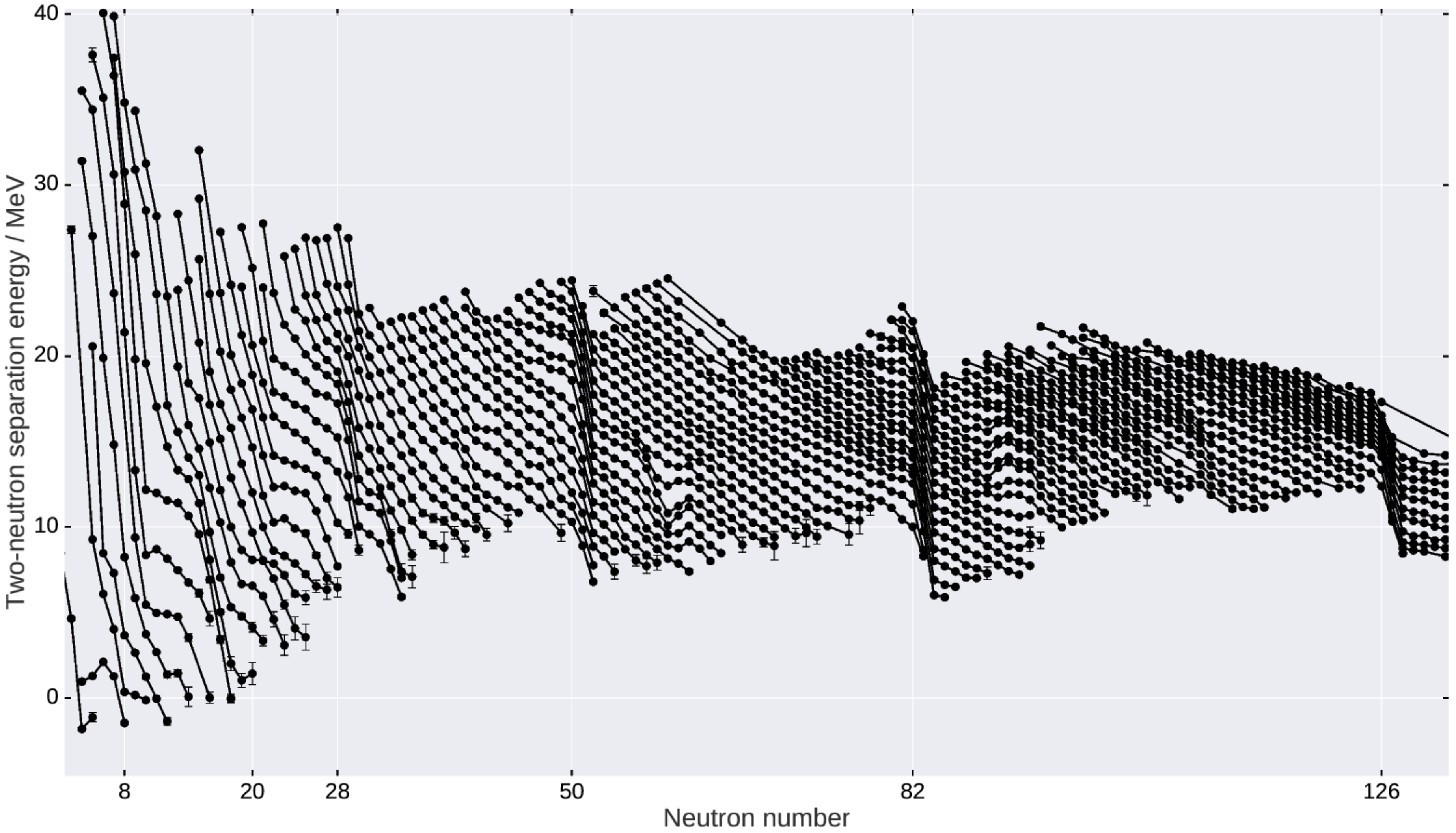
Contents

ISOLTRAP beam times throughout 2017:

- *Precision Mass Measurements at N = 82 (IS574) and N = 28 (IS490)*
- *Nuclear deformation in the A≈100 region (IS490)*
- *Q(β-) value for isotopes with A = 88*
- *TISD with MR-TOF MS*

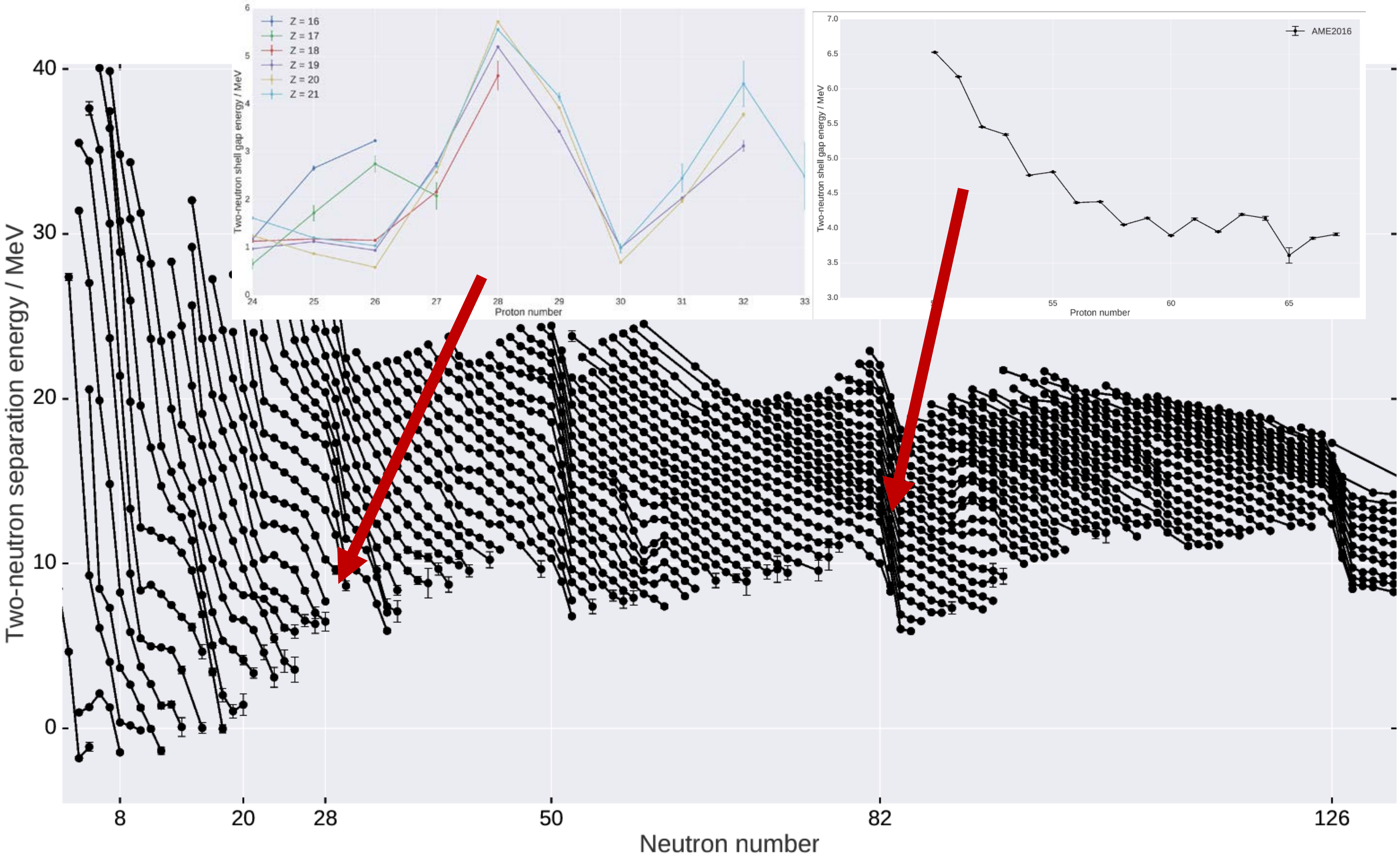
Introduction



S_{2n}(Z,N) = B(Z,N+2) – B(Z, N)

M. Audi *et al.*, Chinese Phys. C **41**, 030003 (2017).

Introduction



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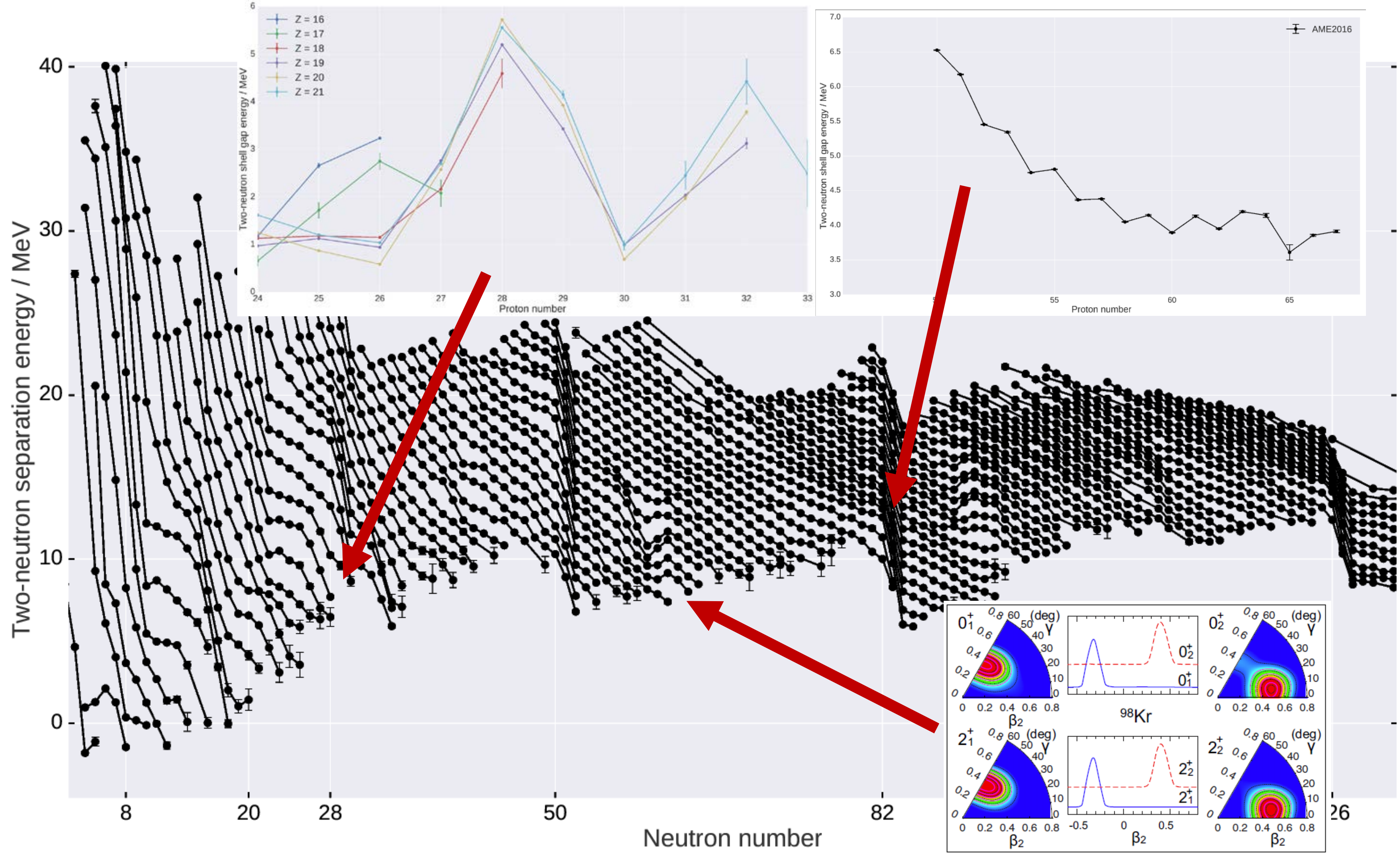
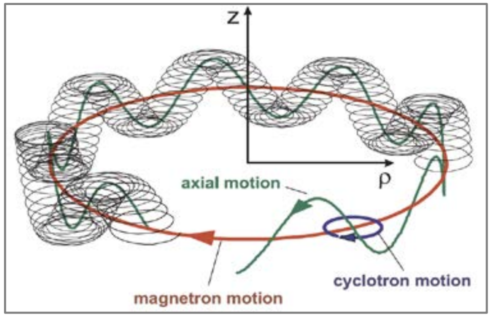
Introduction



$S_{2n}(Z,N) = B(Z,N+2) - B(Z,N)$

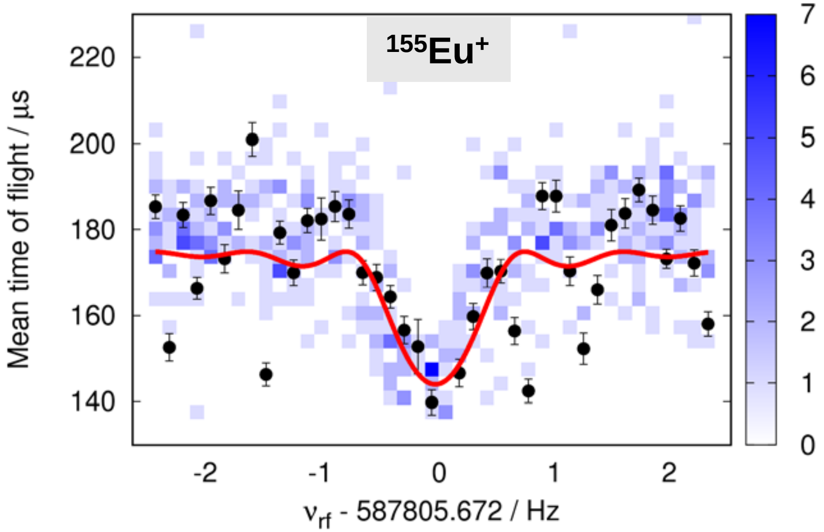
M. Audi *et al.*, Chinese Phys. C **41**, 030003 (2017); T. R. Rodriguez, Phys. Rev. C 90, 034306 (2014)

$$\nu_c = \frac{qB}{2\pi m}$$



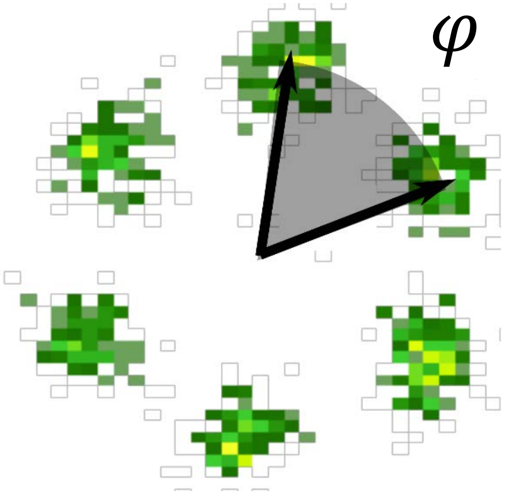
Time-Of-Flight Ion-Cyclotron Resonance

$$\nu_+ + \nu_- = \nu_c$$



Phase-Imaging Ion-Cycotron Resonance

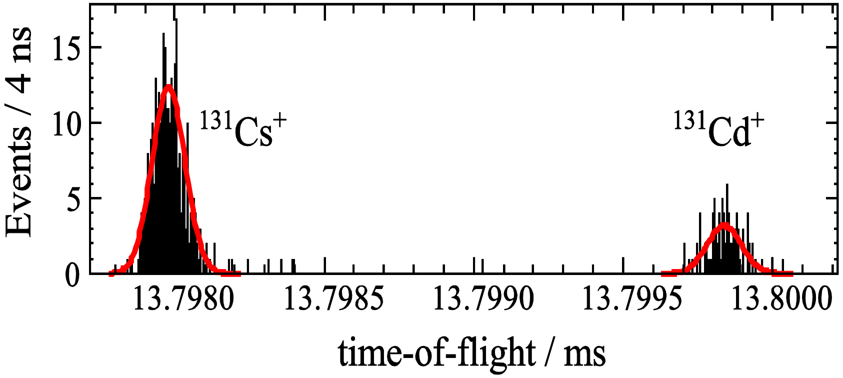
$$\omega = \frac{2\pi n + \varphi}{\Delta t}$$



M. König *et al.*, IJMS. **142**, 95 (1995); S. Eliseev, Phys. Rev. Lett. **110**, 082501

Multi-Reflection Time-Of-Flight Mass Spectrometry (MR-TOF MS)

$$t = a.\sqrt{m/q} + \mathbf{b}$$



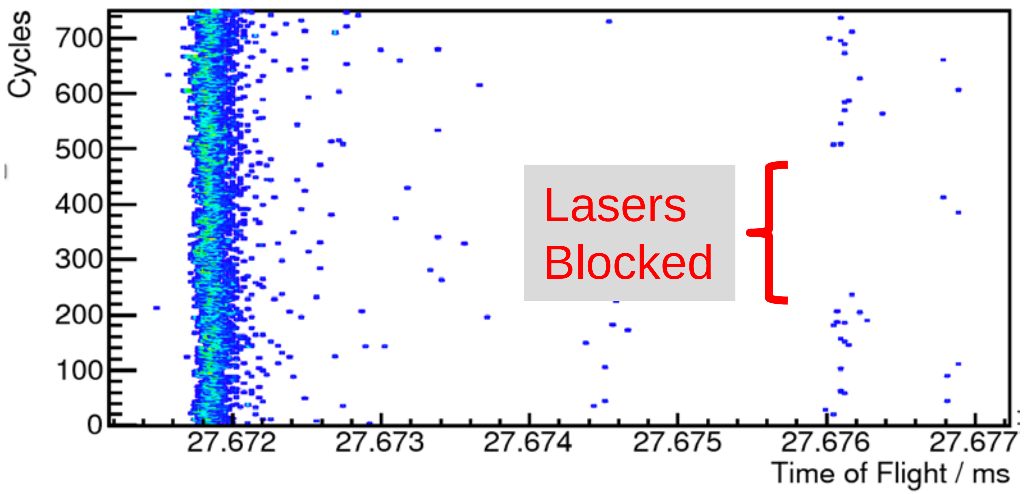
R. N. Wolf *et al.*, IJMS **313**, 8 (2012); F.Wienholtz *et al.*, Nature **489**, 346 (2013)

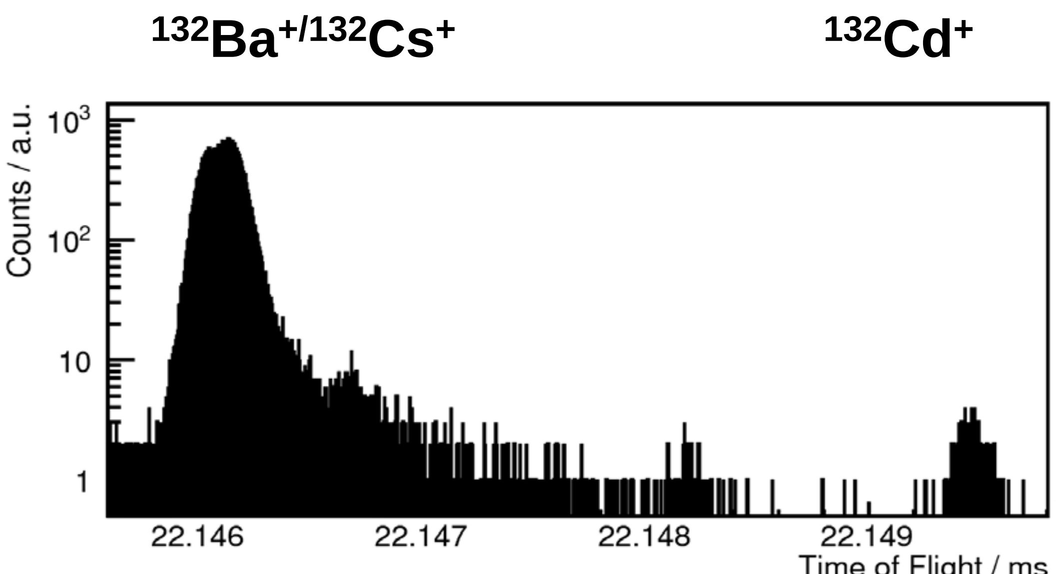
Precision mass measurements at *N*=82 and *N*=28

Precision mass spectrometry of $^{131,132}Cd$

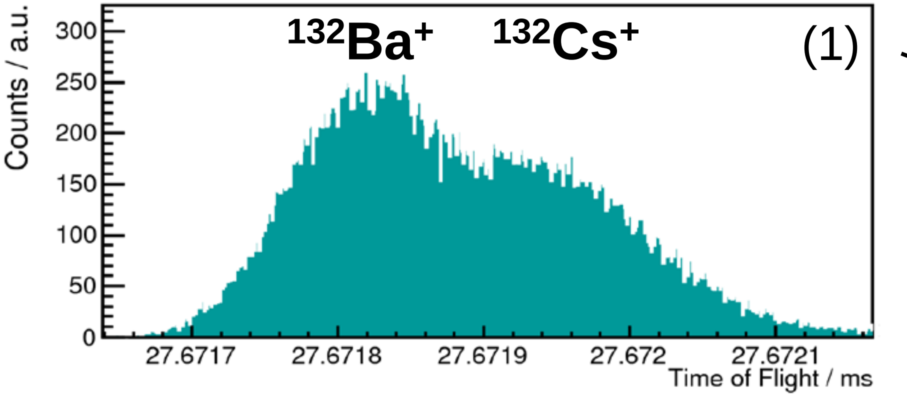
MR-TOF MS allows first mass measurement of ^{132}Cd.

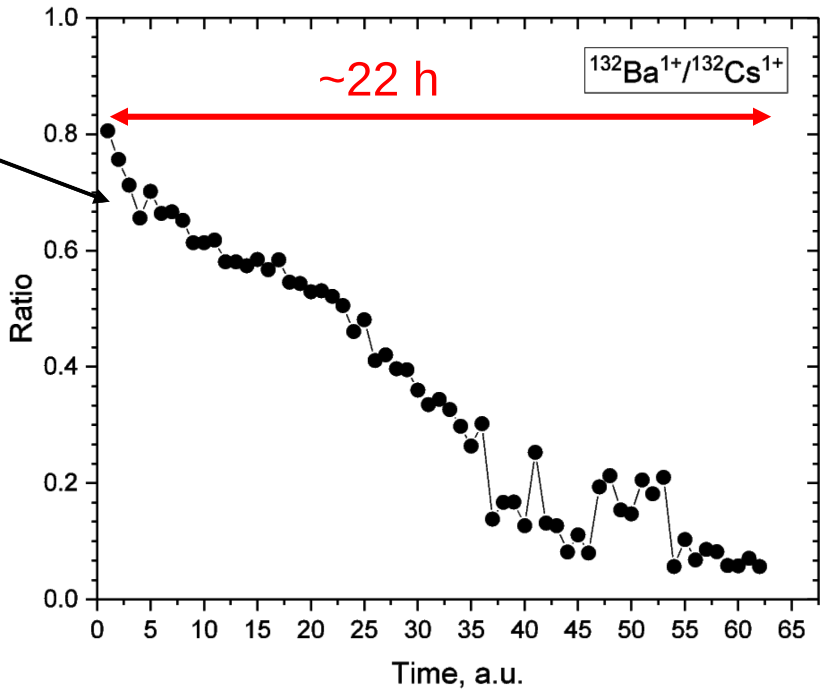
1. High-quality cadmium beams:
   - UC_x target
   - neutron converter
   - quartz insert
   - RILIS ion source
2. Low background
3. Clear Identification



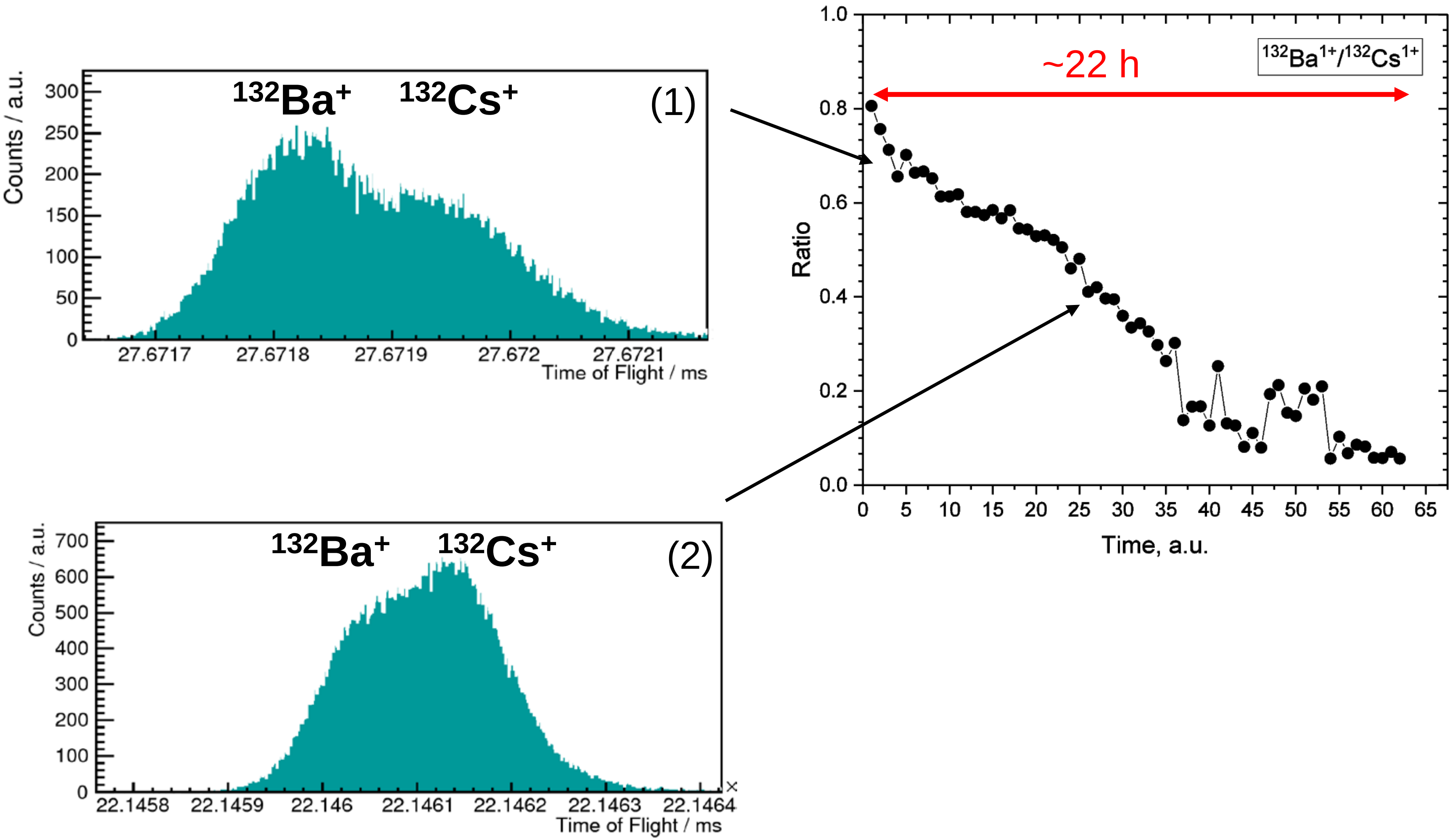


Precision mass spectrometry of $^{131,132}Cd$

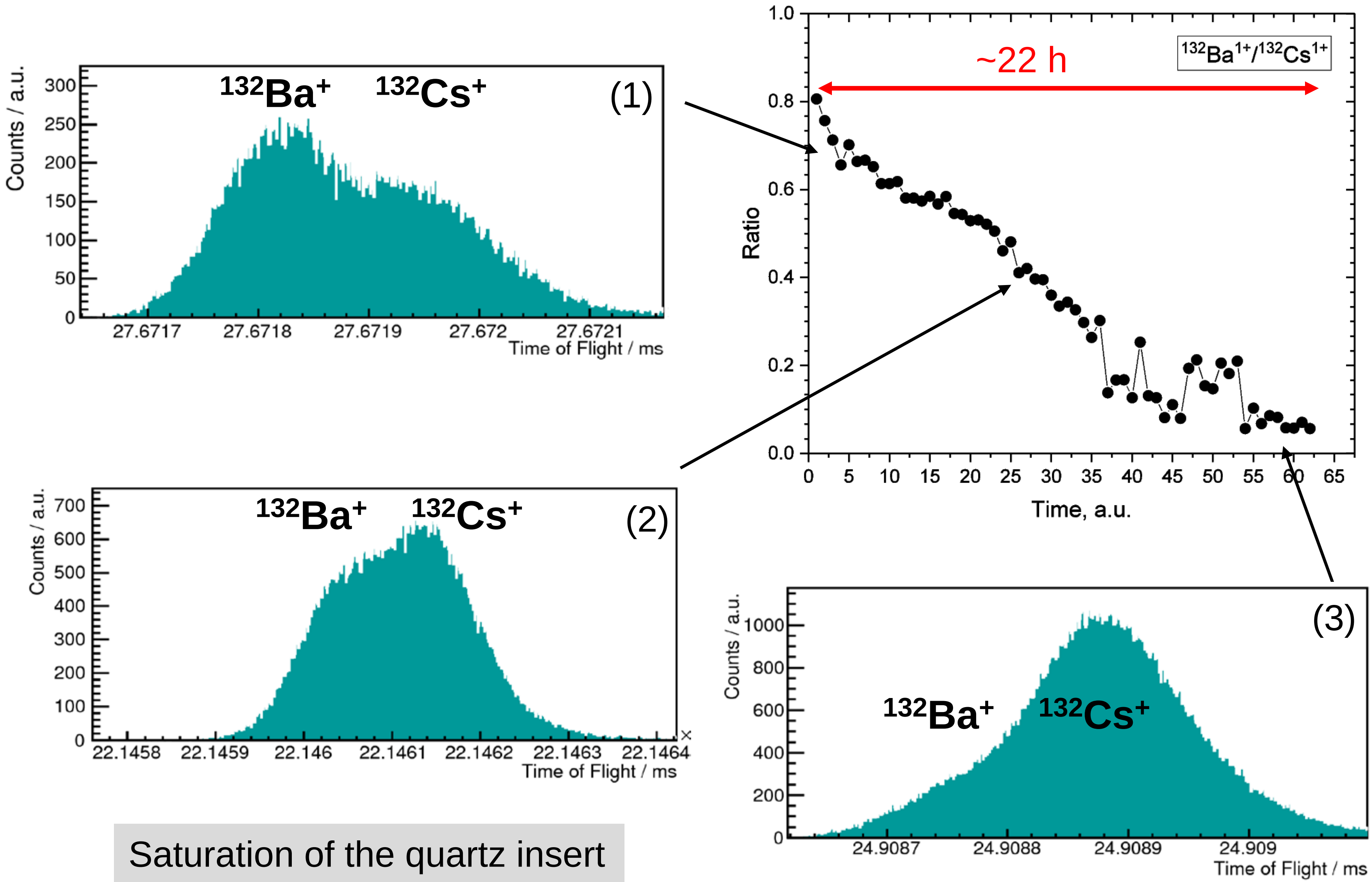




Precision mass spectrometry of $^{131,132}Cd$

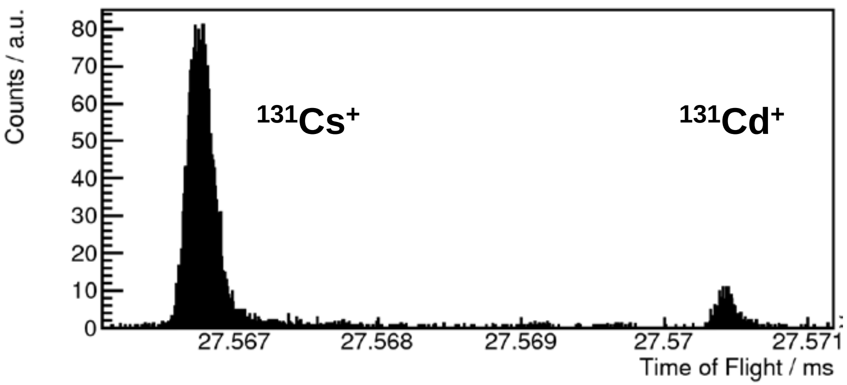


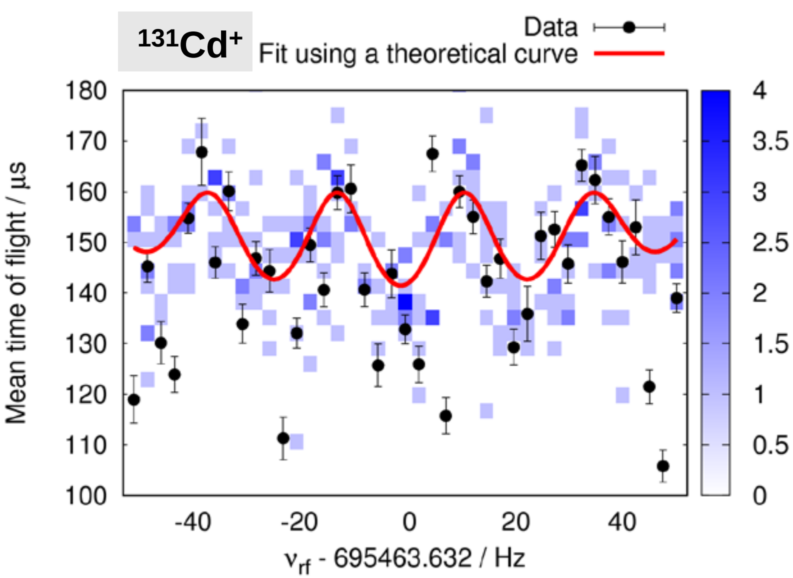
Precision mass spectrometry of $^{131,132}Cd$

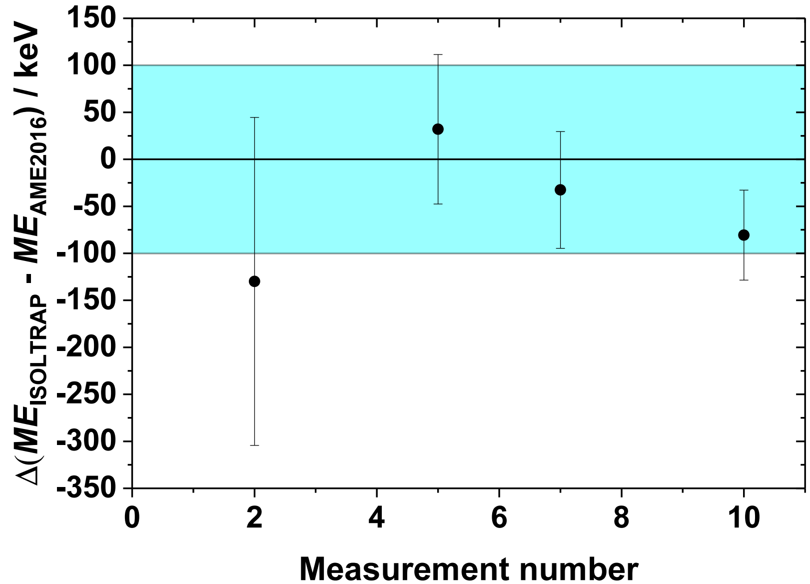


Saturation of the quartz insert

Precision mass spectrometry of $^{131,132}Cd$







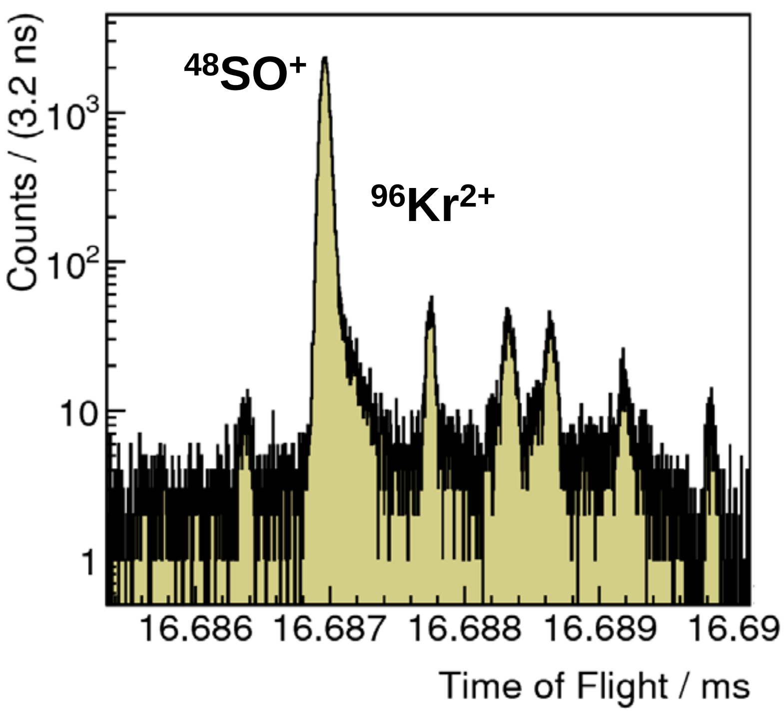
Penning trap confirms and improves the MR-TOF mass of ^{131}Cd from 2014.

S. George *et al.*, Phys. Rev. Lett. **98**, 162501 (2007); D. Atanasov *et al.*, PRL **115**, 232501 (2015);

Precision mass spectrometry of ^{48}Ar

UC$_x$ target with cold plasma: a challenge for the MR-TOF MS sensitivity.

Rich spectrum of masses with $^{32}S^{16}O^{+}$ being the most abundant peak at A = 48 identified by TOF-ICR



Precision mass spectrometry of ^{48}Ar

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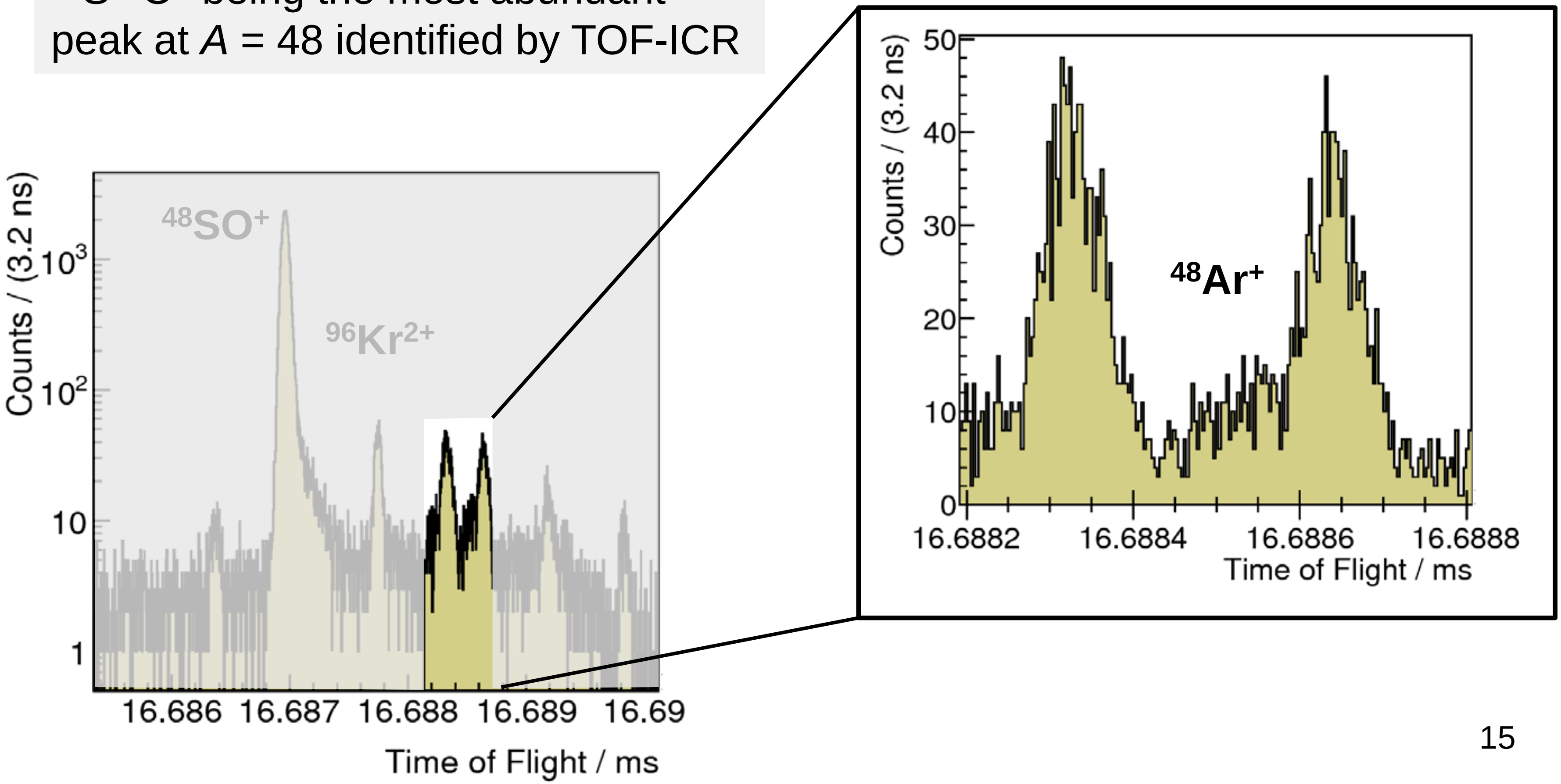
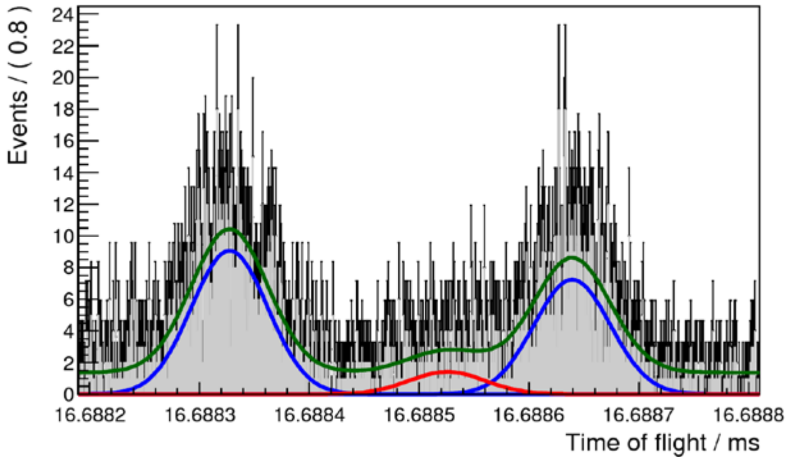
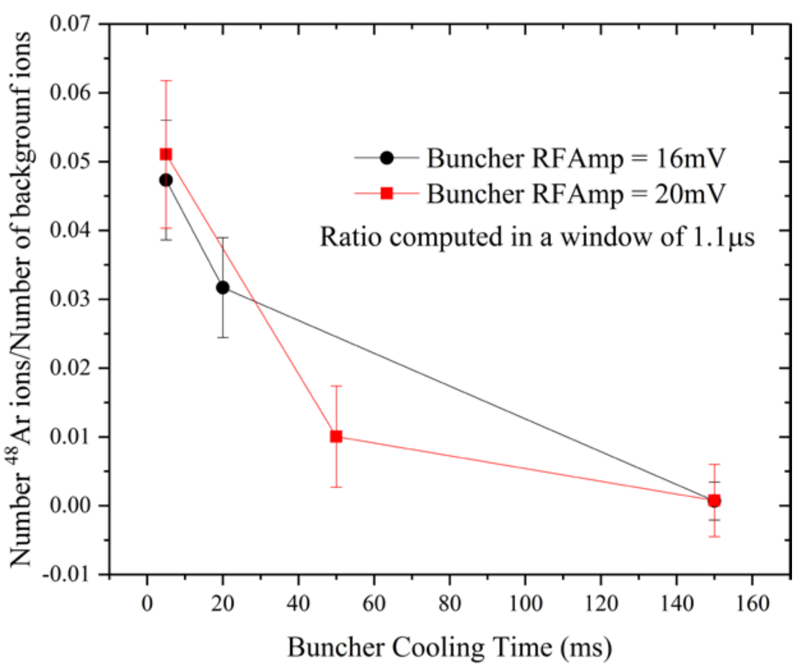


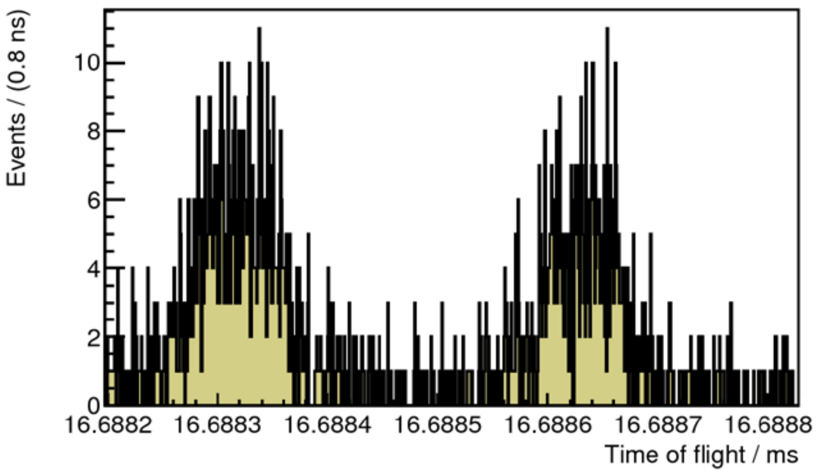
Precision mass spectrometry of ^{48}Ar

<u>Analysis ongoing</u>:

- Construct a combined model taking into account background and three Gaussian peaks
- Investigate possible TOF shifts due to contamination
- Observed signal does evolve with the cooling time in the Buncher trap

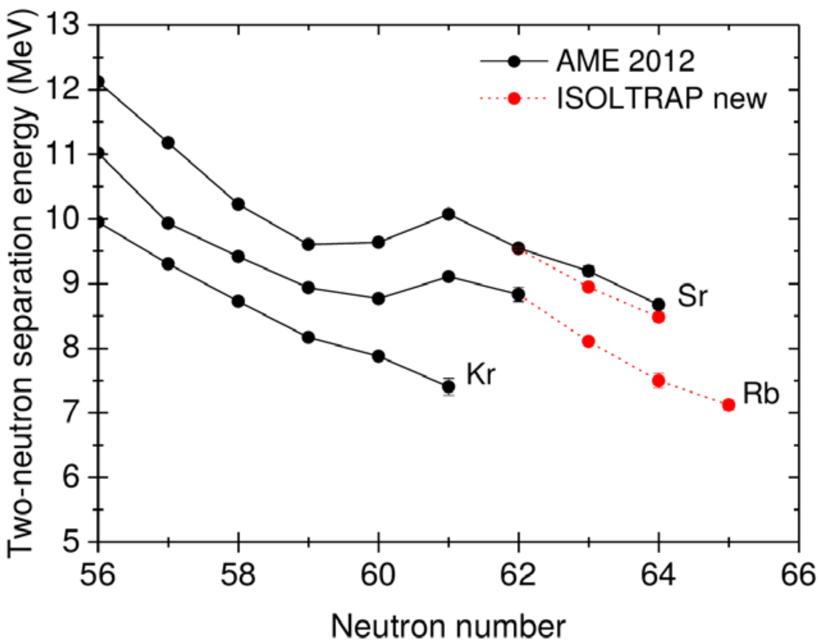


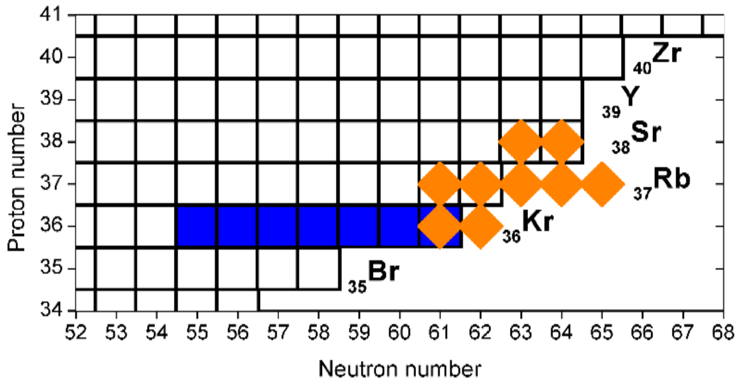




Background measurement

Precision mass measurements at *A*=100

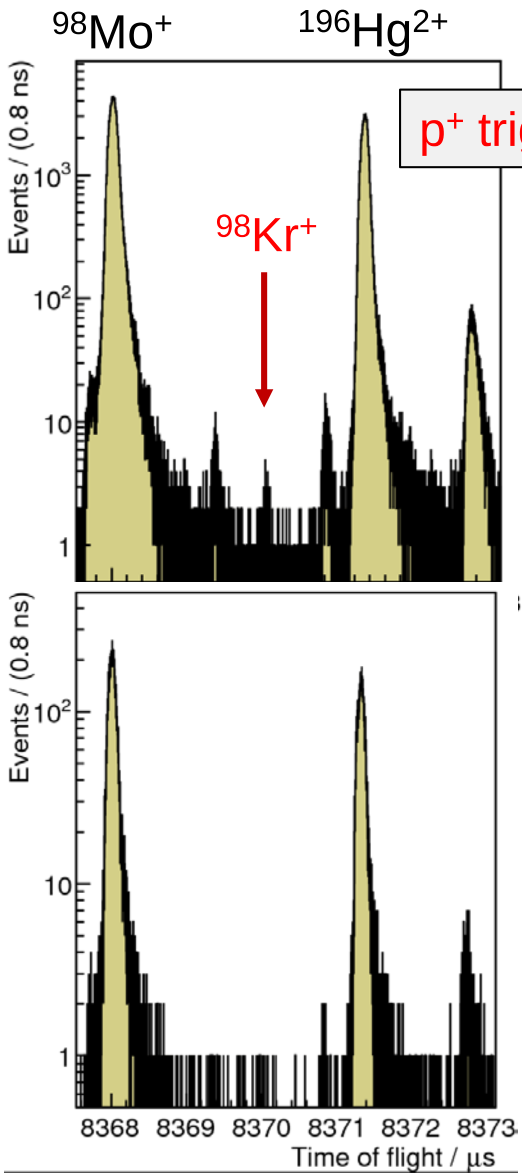




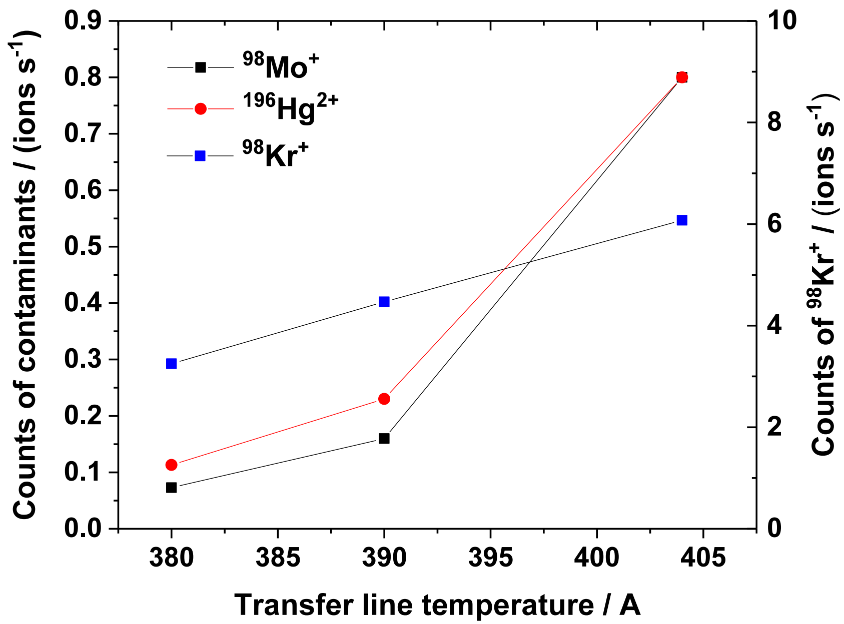
- Fourth campaign at ISOLTRAP in the *A* ≈ 100 region during the last 5 years.

M. Wang *et al.*, Chinese Physics C **36**, 1603 (2012). V. Manea, PhD thesis (2014). A. de Roubin, Phys. Rev. C **96**, 014310 (2017)
TITAN: R. Klawitter et al., Phys. Rev. C ***93****, 045807 (2016).*

Precision measurements of ^{98}Kr



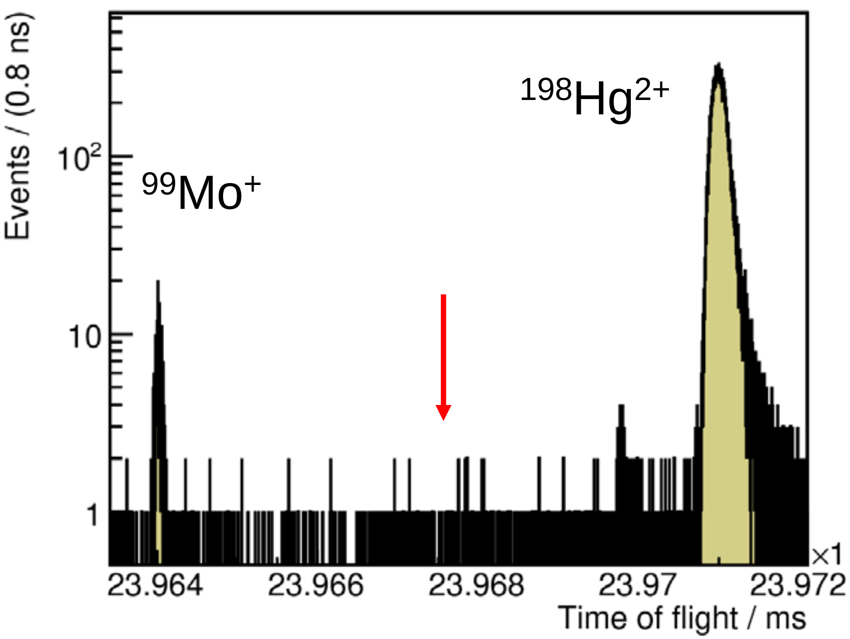
1. Uniformly distributed background
2. Main contamination being $^{196}Hg^{2+}$ and $^{98}Mo^{+}$
3. Target and Ion-source optimisations:
   - Ion-source anode current and voltage
   - Temperature of the transfer line
4. However $^{196}Hg^{2+}$ increased at a rate of 230 ions/h



Precision measurements of ^{99}Kr

- ^{99}Kr expected yield was in the order of the observed background
- Switching to doubly-charged ions →reduction of contamination
- Tune HRS separator for doubly-charge ions
- Check yields with $^{95}Kr^{2+}$ and $^{97}Kr^{2+}$ isotopes

Singly-charge A = 99



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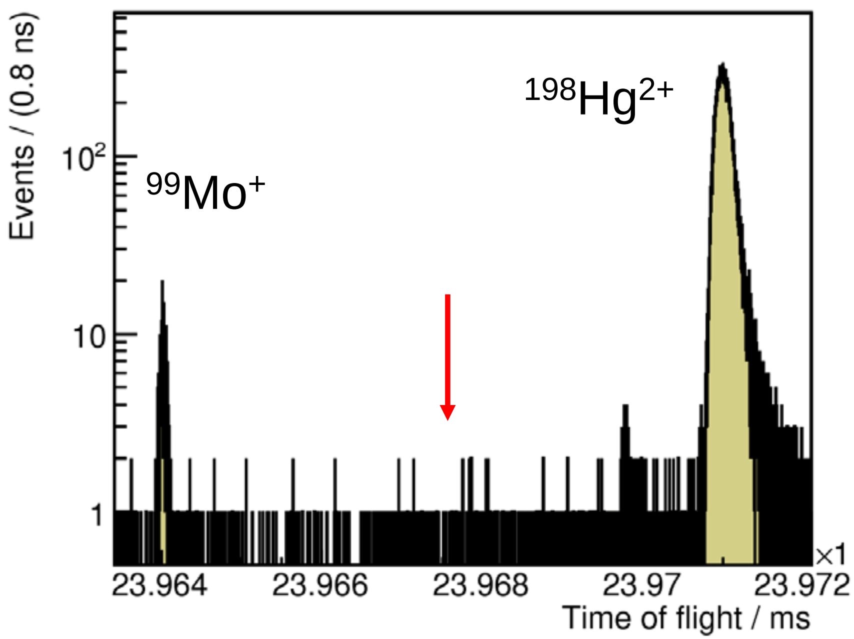
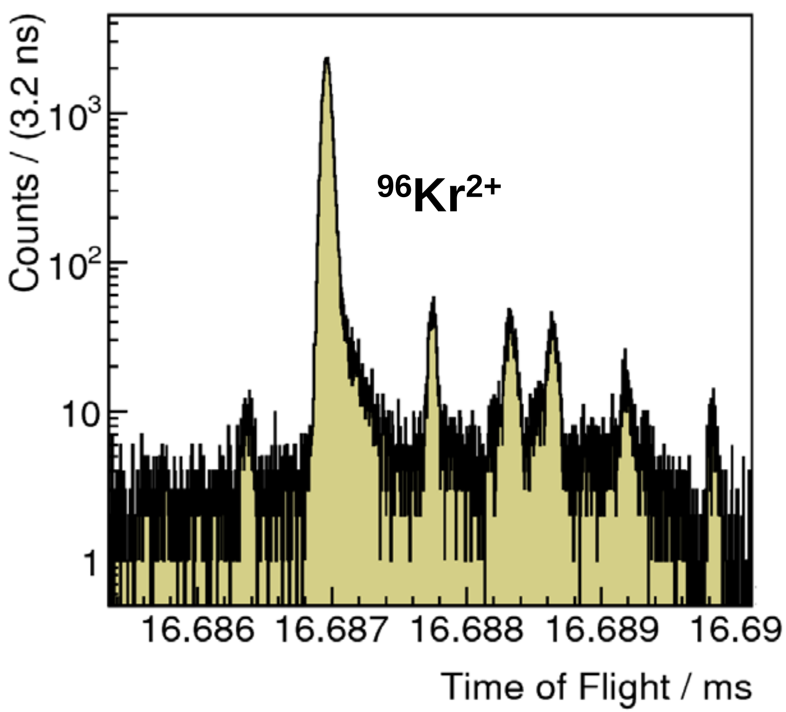
Singly-charge *A* = 99



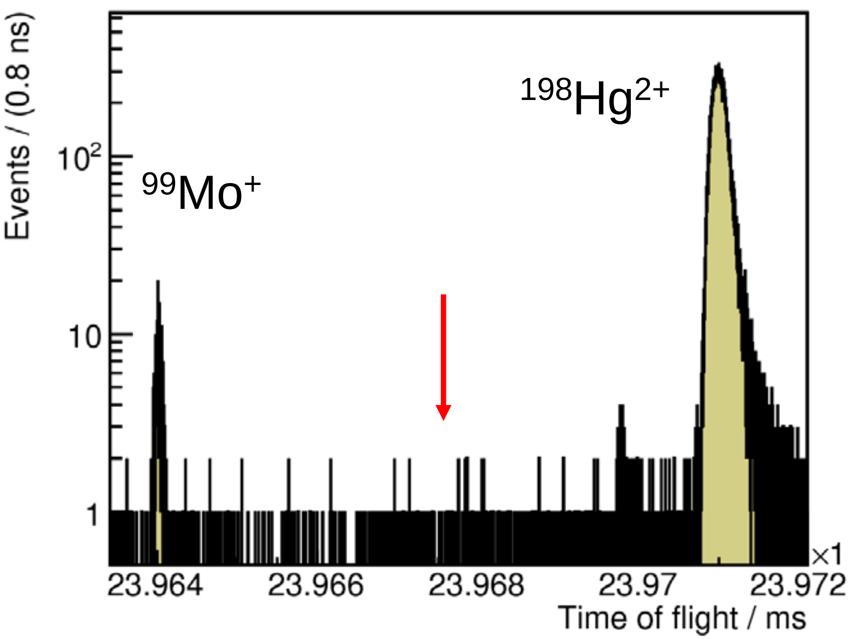
Singly-charge *A* = 48



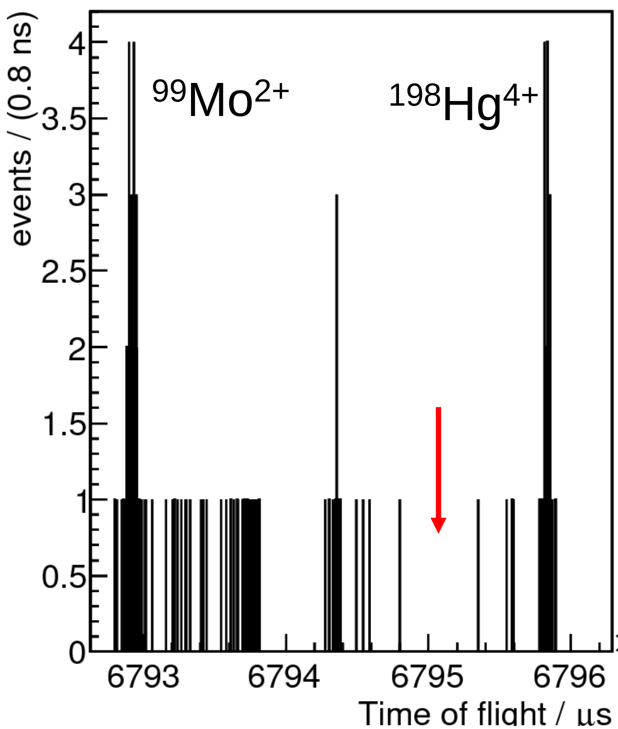
Precision measurements of ^{99}Kr

- Reduction in contamination when switching to doubly-charged ions
- Tune HRS separator for doubly-charge ions
- Check yields with $^{95}Kr^{2+}$ and $^{97}Kr^{2+}$ isotopes
- Observed $^{198}Hg^{4+}$

Singly-charge A = 99



Doubly-charge A = 99

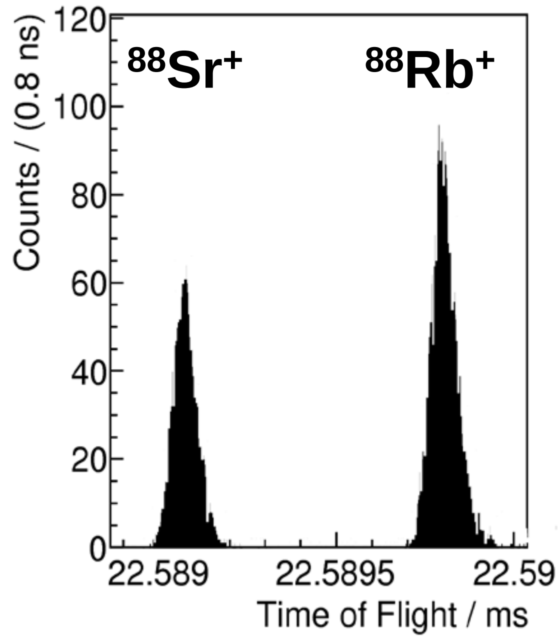


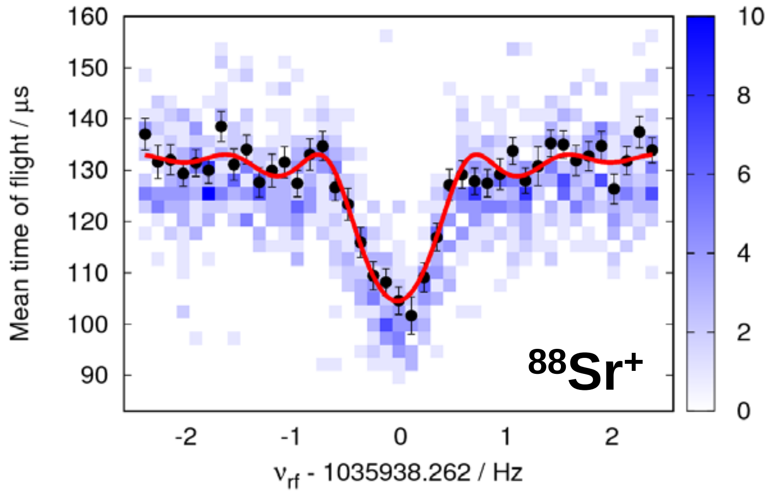
High-precision mass measurements by using PI-ICR

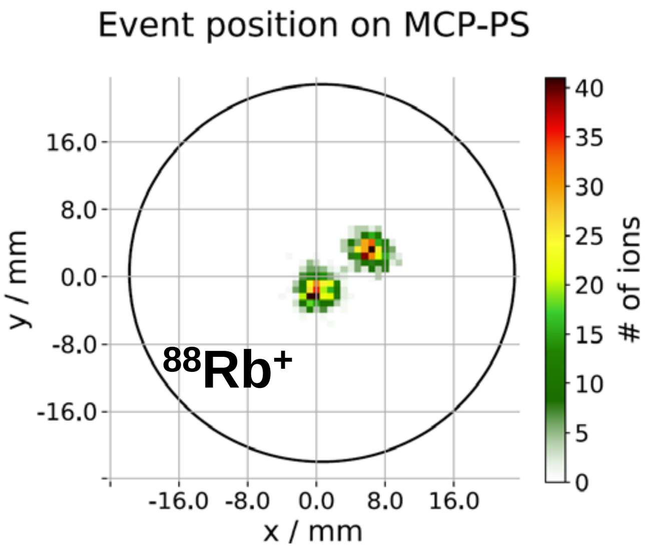
^{88}Rb – ^{88}Sr *Q*-value measurements

- Understand and control the systematic uncertainty of the PI-ICR technique

- Determine a well-known *Q*-value by using PI-ICR and compare to already established techniques (TOF-ICR and/or MR-TOF MS)



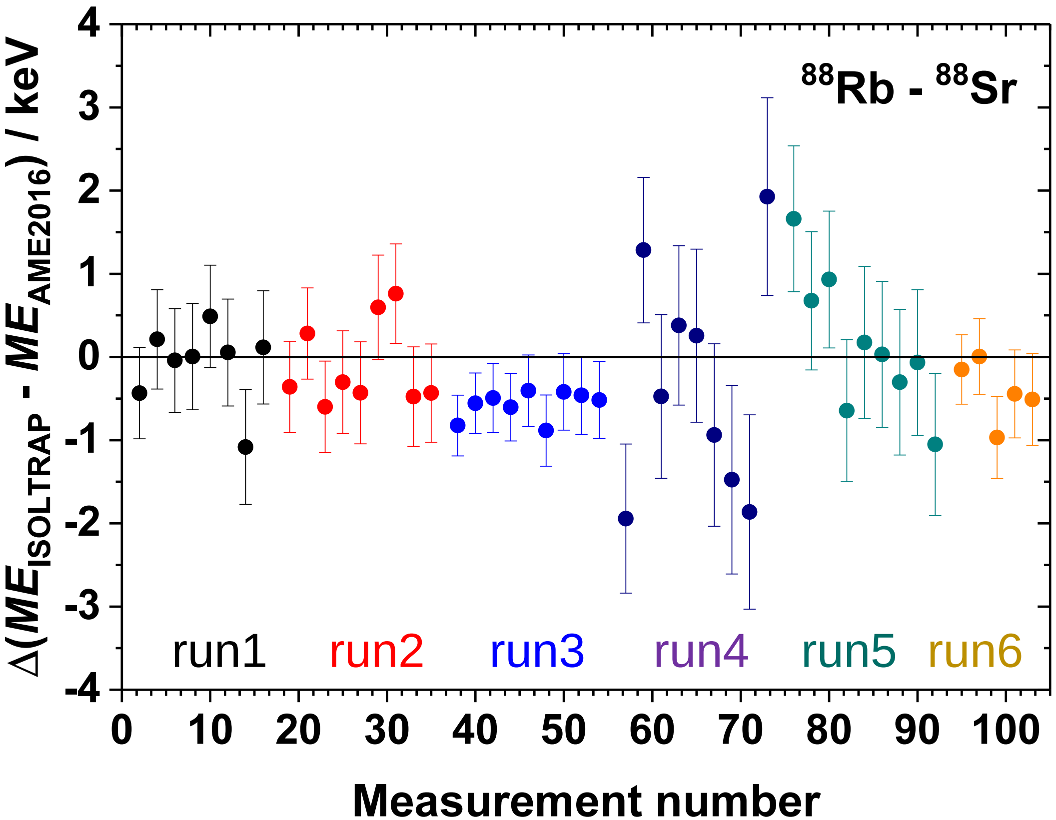




^{88}Rb – ^{88}Sr *Q*-value measurements

Systematic study of PI-ICR parameters :

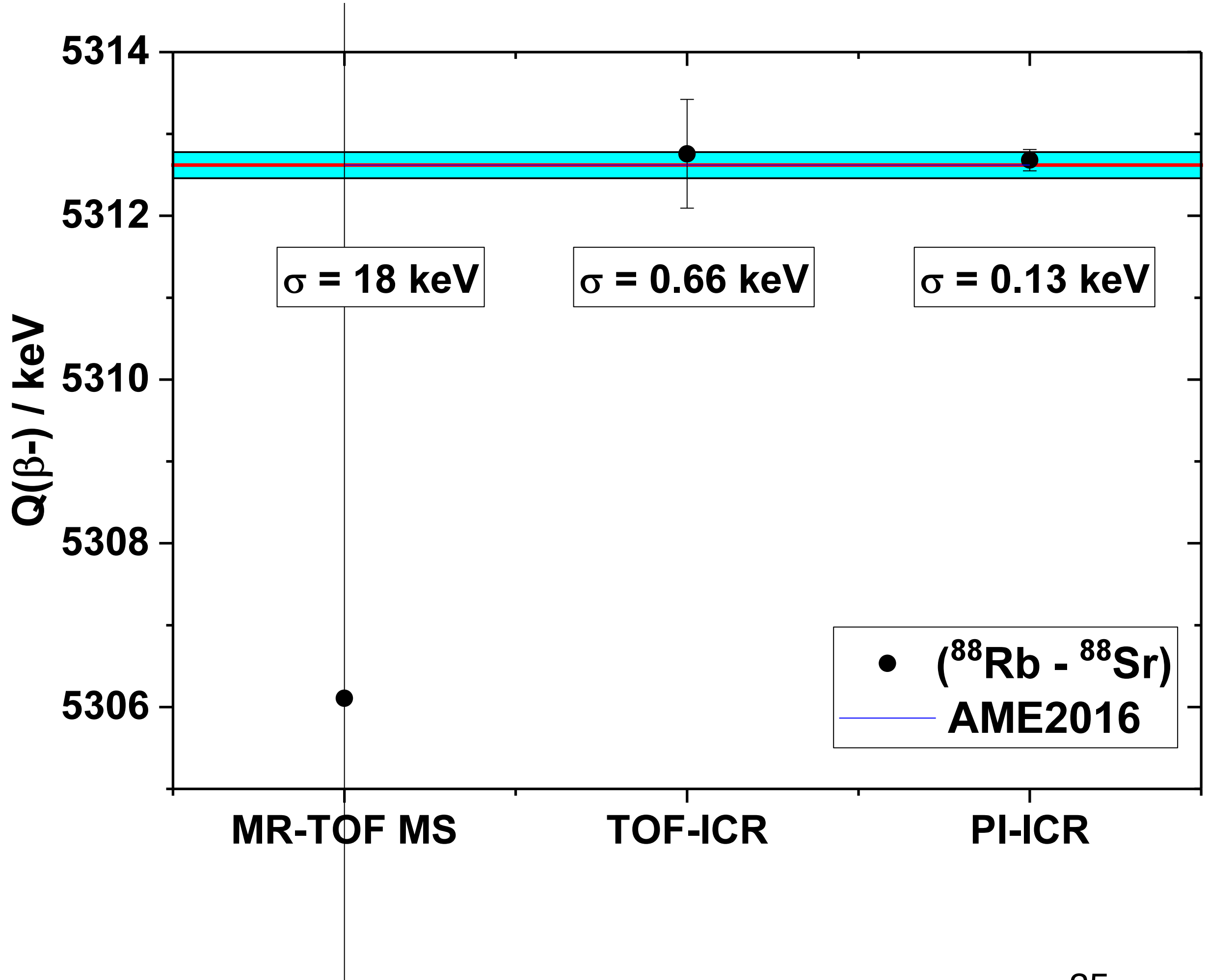
- Image quality
- **Accumulation time**: 600ms (run1-run3), 300 ms (run4-run5), 1000ms (run6)
- **None-overlapping spots**: (run2)
- **Variation of the dipole excitation**: (run3), (run5)
- **Phase variation to conversion pulse**: (run3), (run6)
- Saturation



^{88}Rb – ^{88}Sr *Q*-value measurements

$$Q = (R - 1) * (m_{daughter} - m_e)$$

- Consistent results between each measurement techniques
- The uncertainty reached by PI-ICR improves the accepted values in the literature

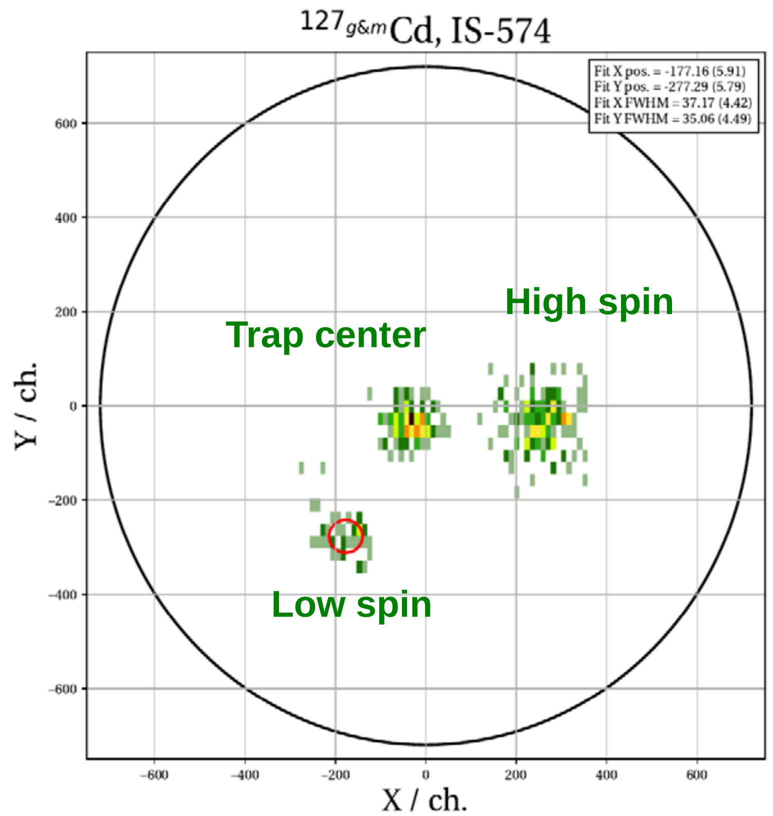


M. Audi *et al.*, Chinese Phys. C **41**, 030003 (2017); J. Karthein, master thesis 2017; J. Karthein et al. in prep.

Isomer separation in ^{127,129}Cd with PI-ICR

- The PI-ICR technique allowed fast and optimal separation of the isomeric states in the odd-*A* cadmium isotopes.
- Preliminary results confirm the values obtained at TITAN/TRIUMF

$$R = \frac{\nu_c}{\Delta\nu_c} \sim \frac{\nu_+ t r_+}{\Delta r_+} \sim 10^6$$



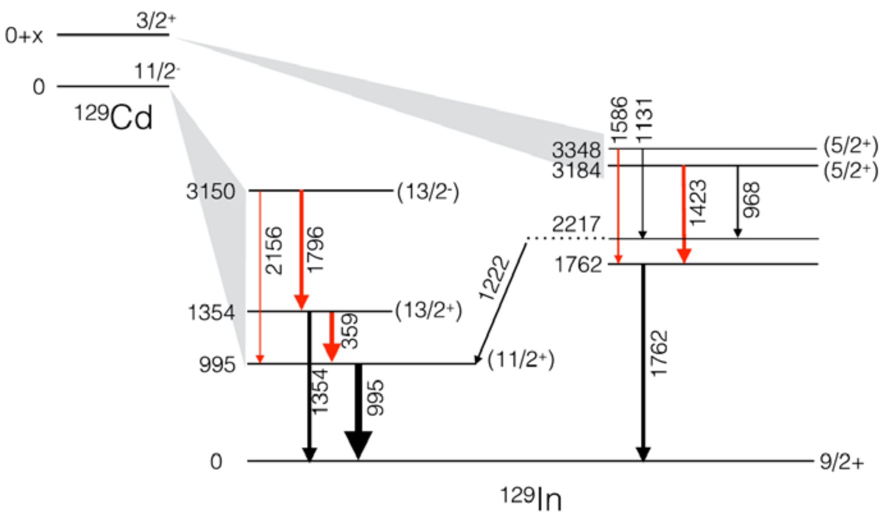
Measurement time: 209 ms

Further details at Poster #10 of J. Karthein

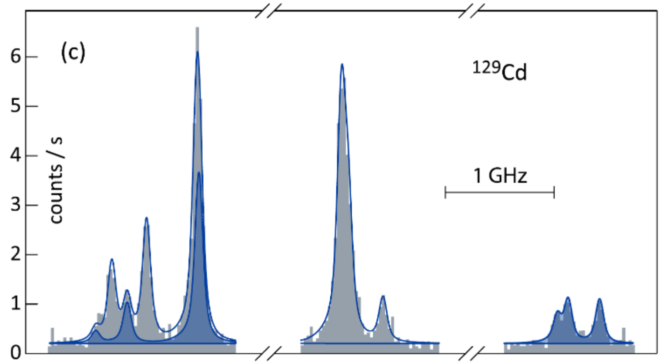
J. Karthein, master thesis 2017; J. Karthein et al. in prep.

Isomer separation in ^{127,129}Cd with PI-ICR

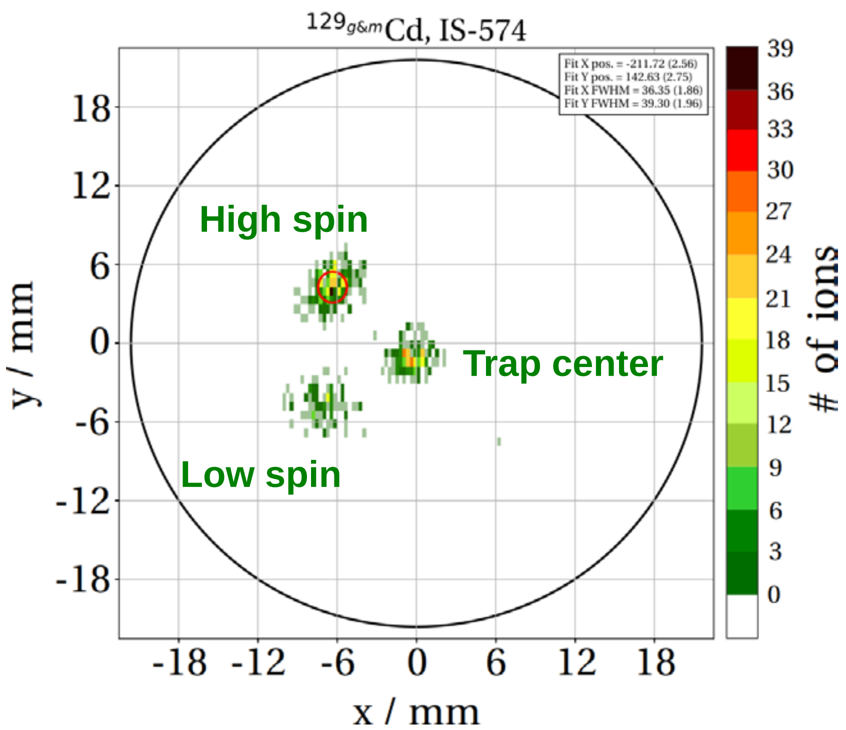
R. Dunlop et al. PRC 93 062801(R) (2016)



D. Yordanov et al. PRL 110 192501 (2013)



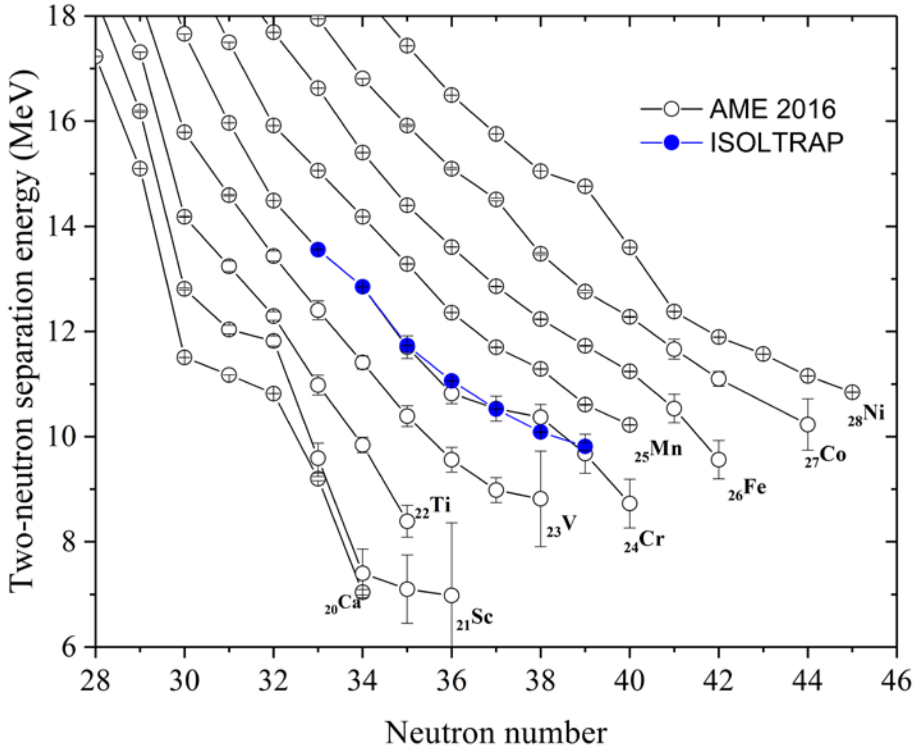
- Spins 3/2$^+$ and 11/2$^-$

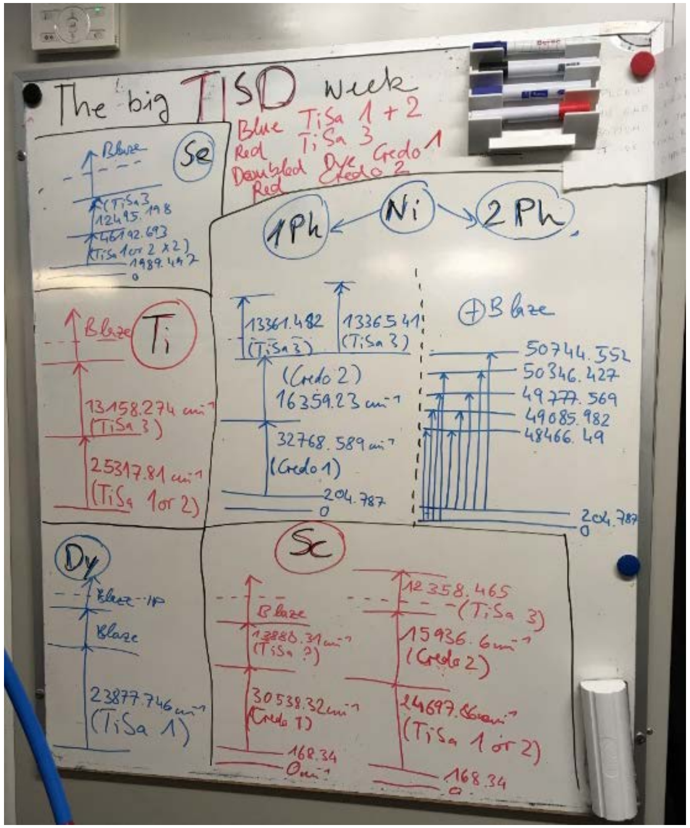


Measurement time
106 ms

J. Karthein, master thesis 2017; J. Karthein et al. in prep.

Yield studies of neutron-rich titanium and scandium

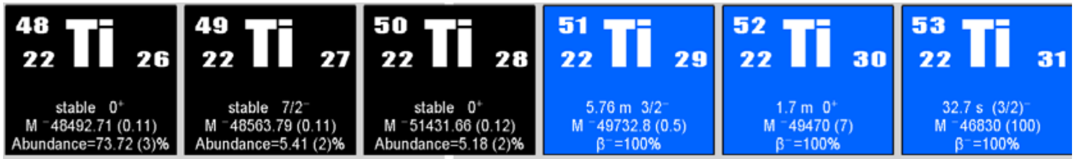




Credits: K. Chrysalidis

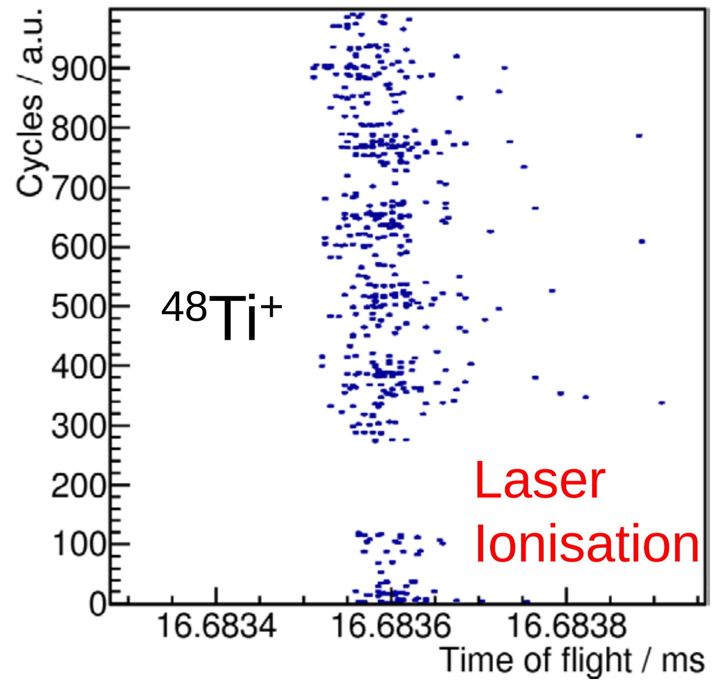
Z. Meisel *et al.,* Phys. Rev. C **93**, 035805 (2015). G. Audi *et al.*, Chinese Phys. C **41**, No. 3 (2017).
M.Mougeot *et al.,* article submitted.

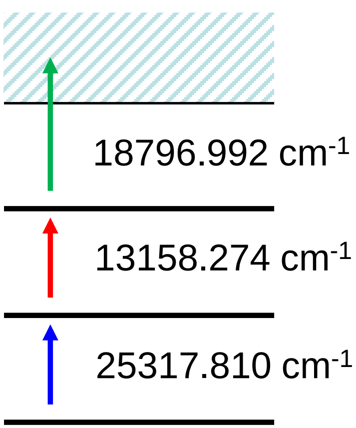
Titanium isotopes



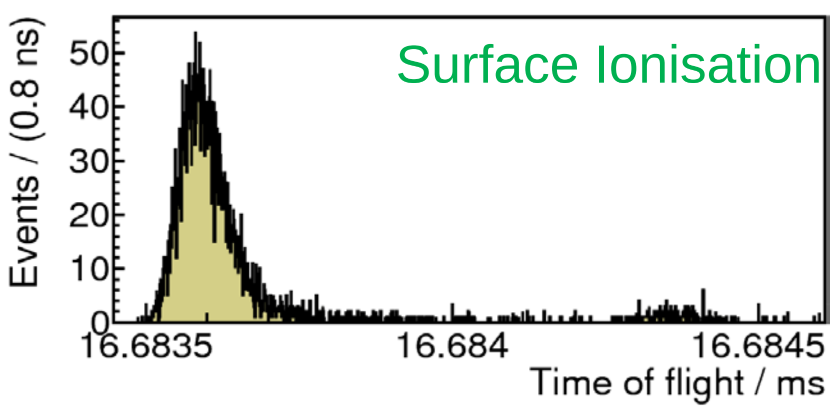
- Target material: tantalum foil
- Observed laser On-Off effects
- Enhancement factor determined to be in the order of 120 on ^{48}Ti
- Other masses of titanium were not observed

Beam gate opened for 5 μs



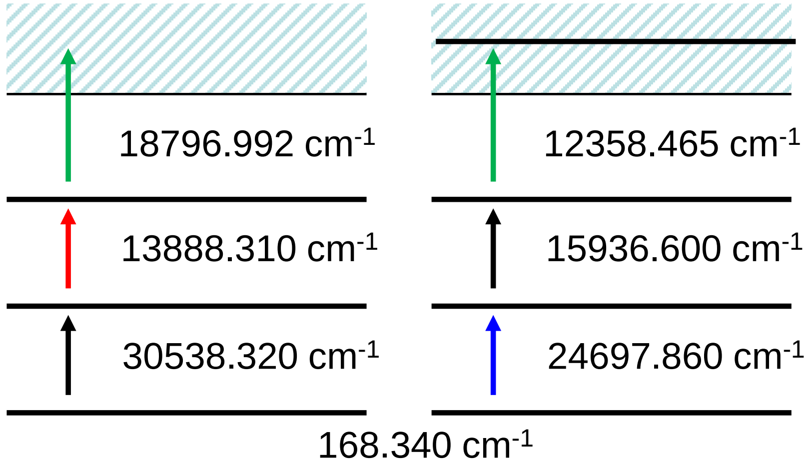


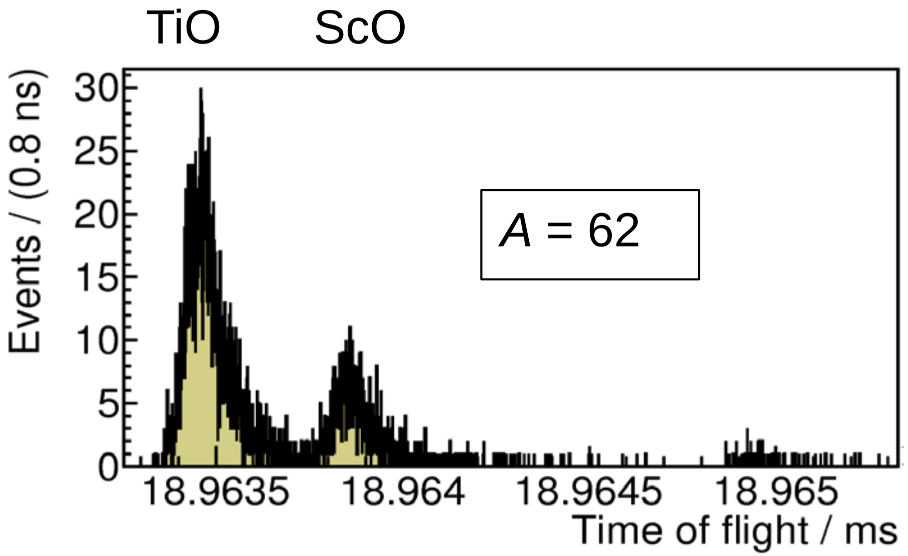
Beam gate opened for 1 ms



Scandium isotopes

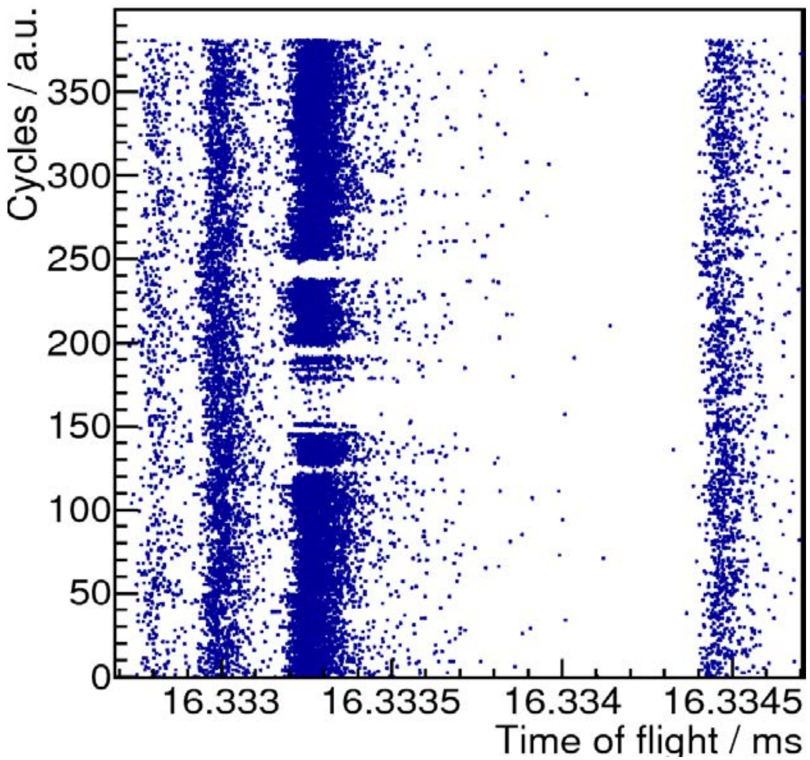
- Surface ionised stable scandium was observed
- Oxide sideband showed factor 3 higher yield compared to atomic scandium
- Two laser scheme to test

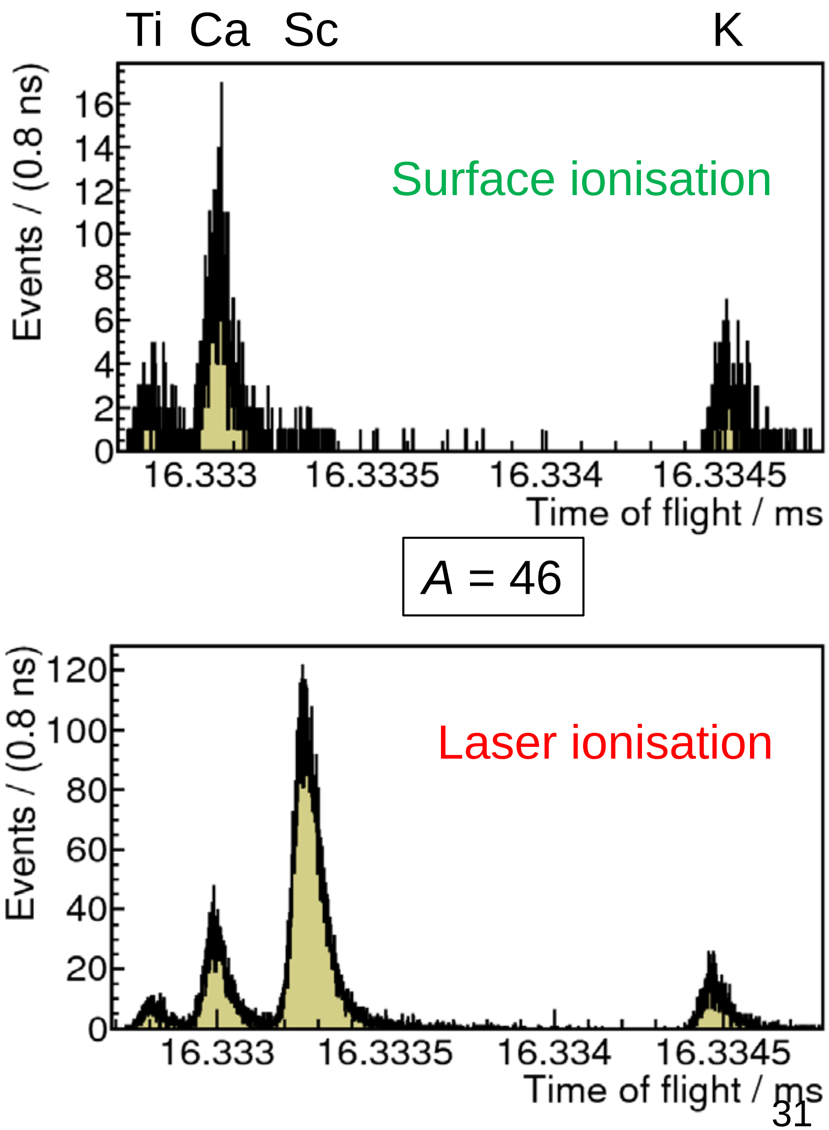




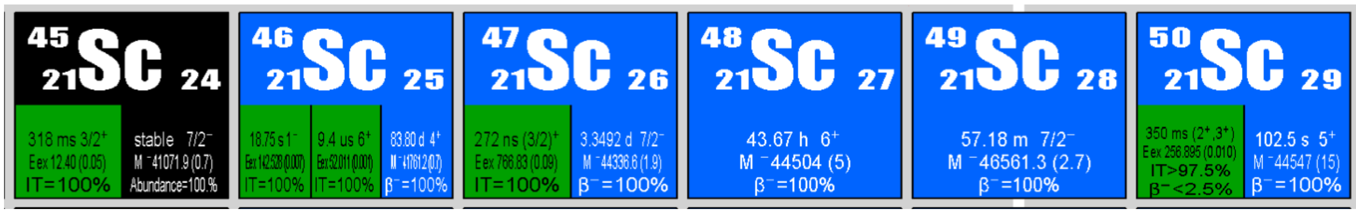
Scandium isotopes

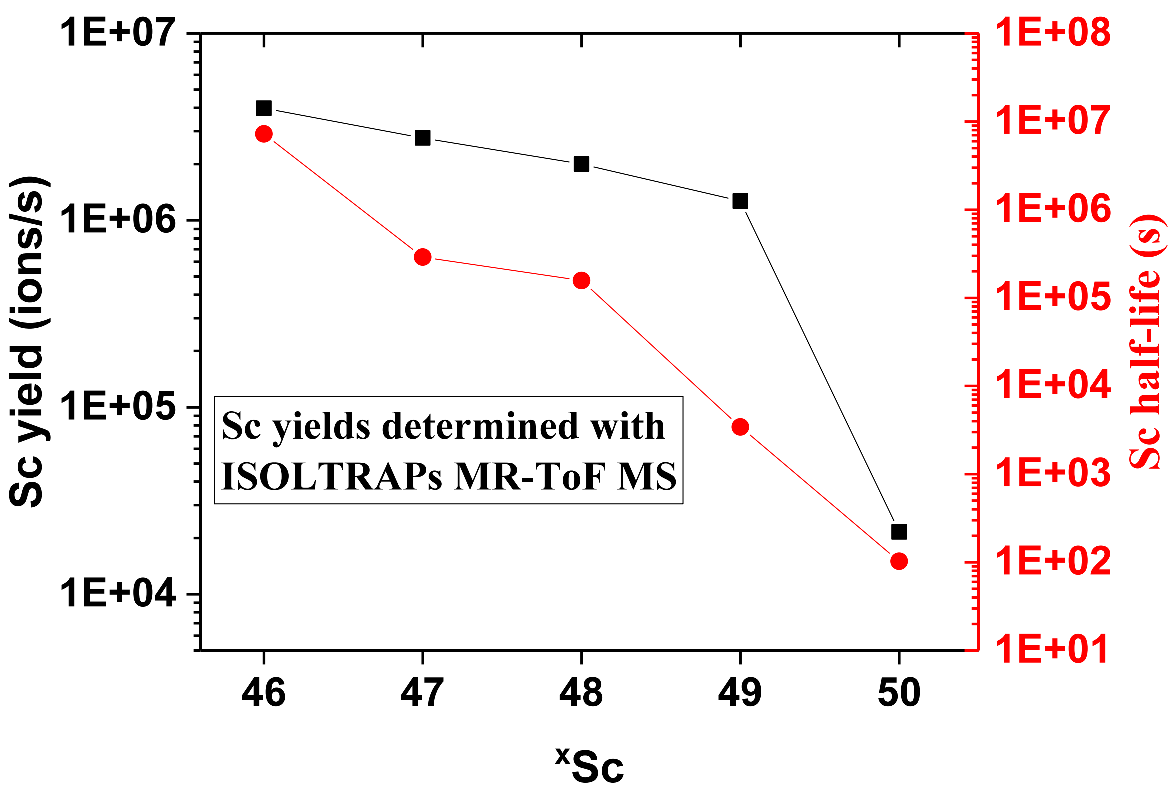
- Laser enhancement by a factor 50-60
- No effect from lasers seen on oxide scandium





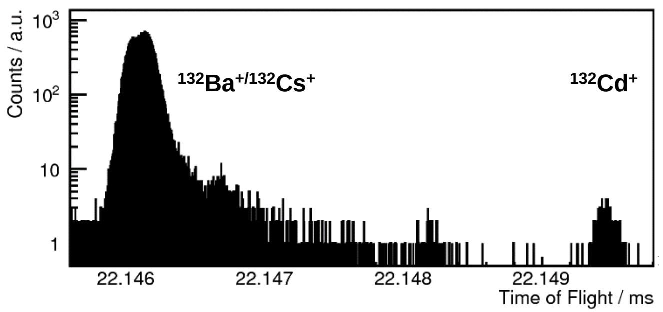
Yields of scandium

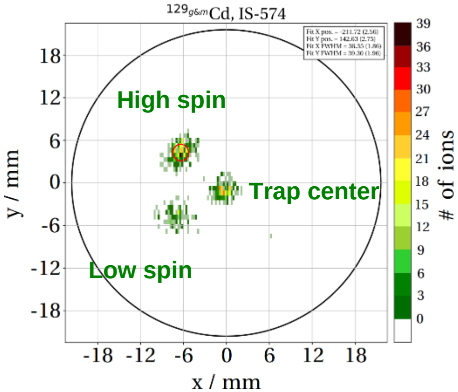


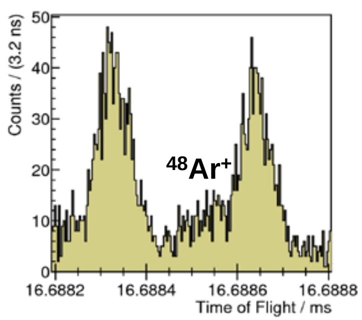


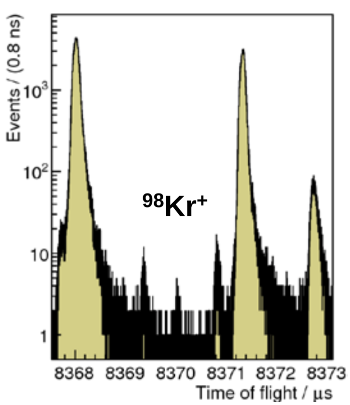
2017 in short

- First time measurements of ^{132}Cd, ^{48}Ar and ^{98}Kr completed by using MR-TOF MS
- TOF-ICR measurements of ^{131}Cd confirm the MR-TOF MS value
- Precise determination of the excitation energy of the isomers in $^{127,129}Cd$
- Successful determination $Q(^{88}Rb-^{88}Sr)$ with uncertainty of 0.13 keV
- First yield measurements of Scandium isotopes at ISOLDE









Acknowledgements

N. Althubiti, P. Ascher, G. Audi, **D. Atanasov**, D. Beck, K. Blaum, G. Bollen, M. Breitenfeldt, R. B. Cakirli, T. Cocolios, S. Eliseev, S. George, F. Herfurth, A. Herlert, **J. Karthein**, J. Kluge, M. Kowalska, S. Kreim, Yu. A. Litvinov, D. Lunney, **V. Manea**, E. Minaya-Ramirez, **M. Mougeot**, D. Neidherr, Ryan Ringle, M. Rosenbusch, A. de Roubin, L. Schweikhard, M. Wang, **A. Welker**, **F. Wienholtz**, R. Wolf, K. Zuber

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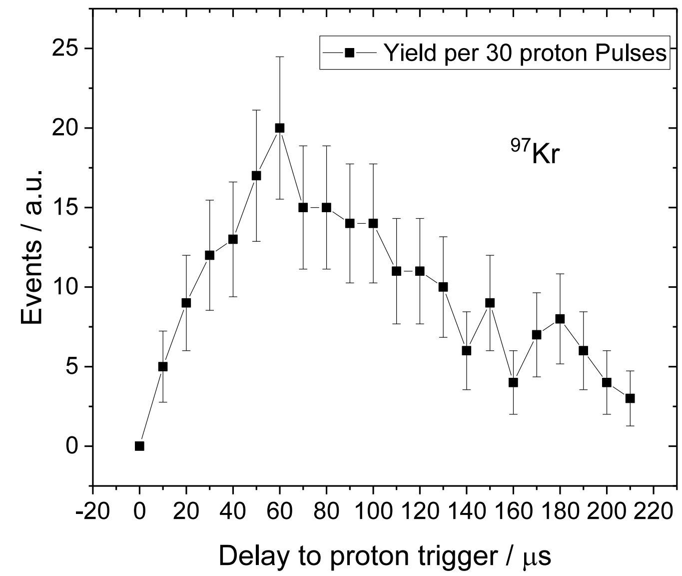
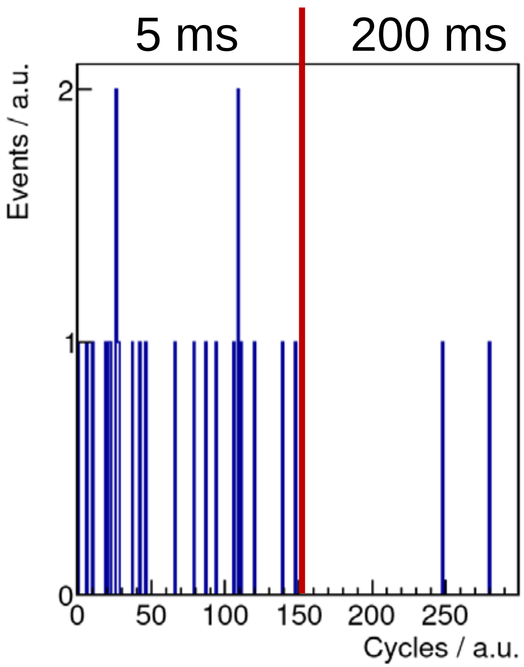
MR-TOF MS measurements of ^{98}Kr

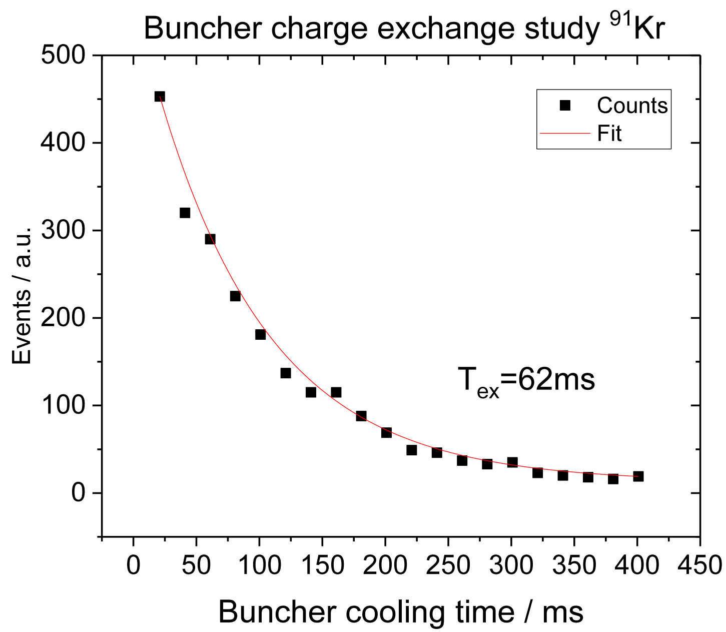
Additional tests to confirm ^{98}Kr observation

- Release curve $^{97}Kr^+$
- Charge exchange in the Cooler-Buncher trap for $^{91}Kr^+$



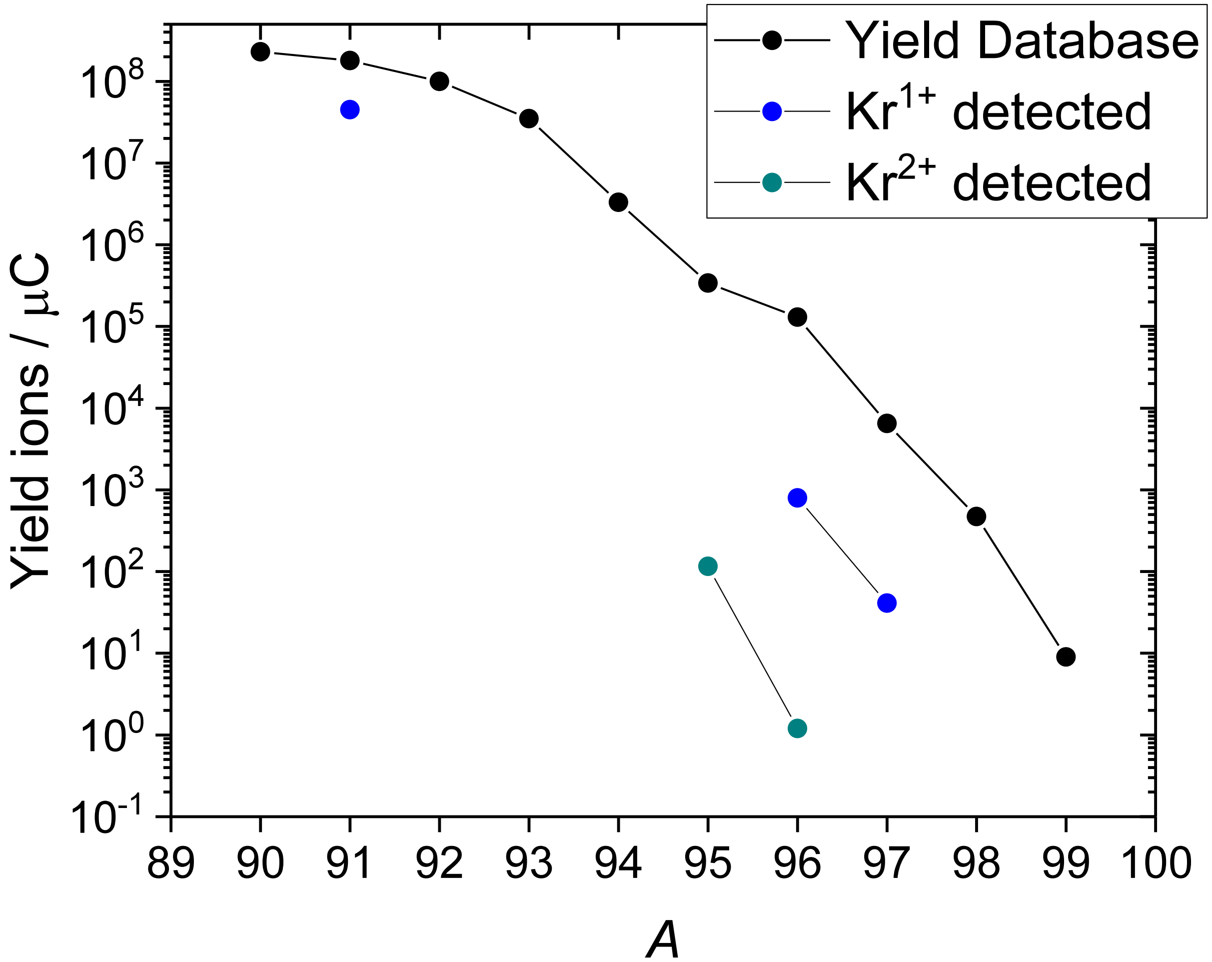
Buncher Cooling Time





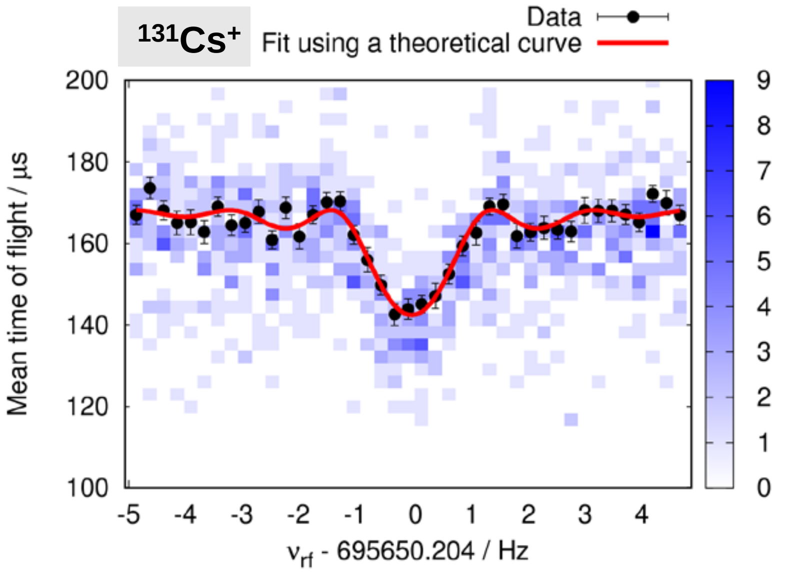
Precision measurements of ^{99}Kr

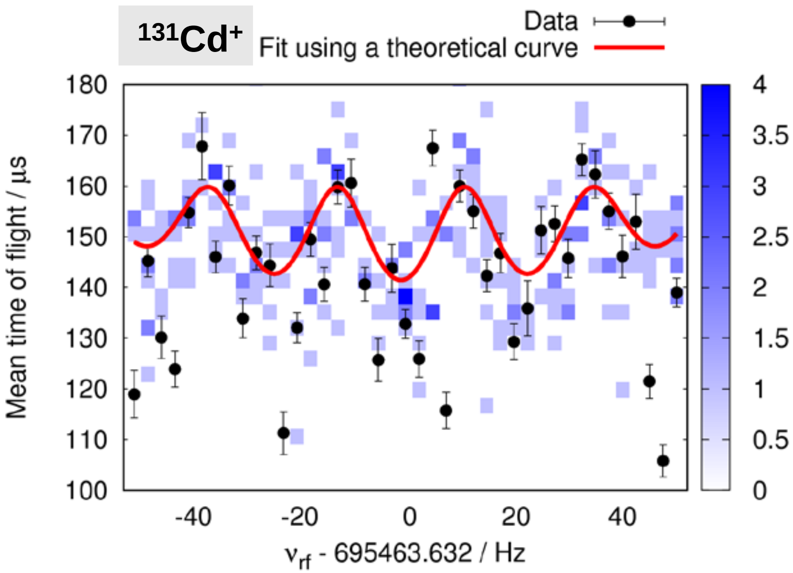
Comparison of yield for singly- and doubly-charged ions as detected after the MR-TOF

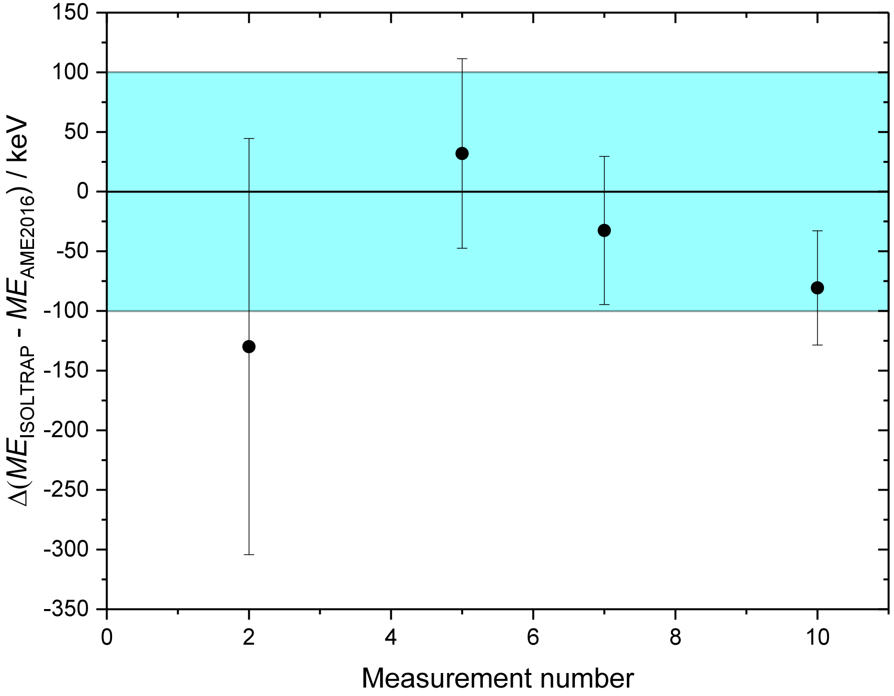


Values not corrected for efficiency losses

Precision mass spectrometry of $^{131,132}Cd$



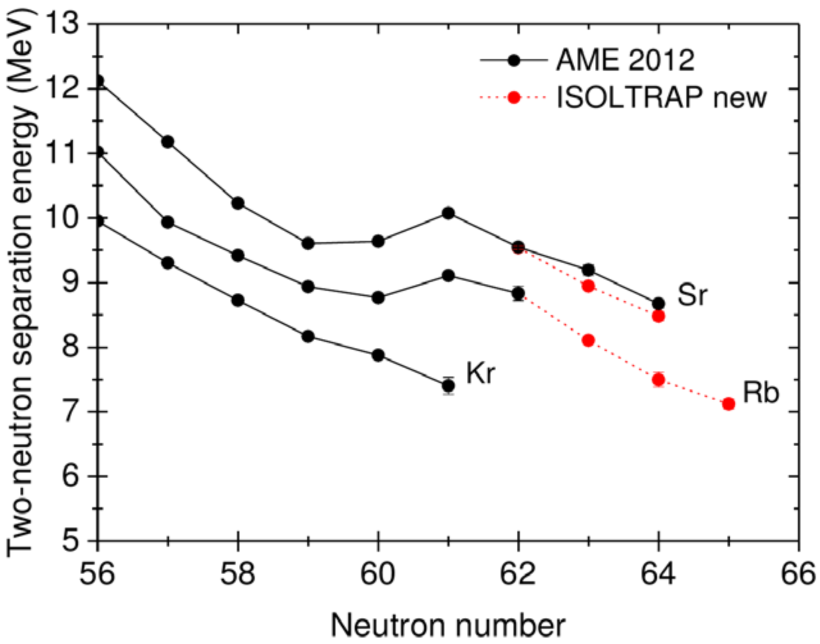


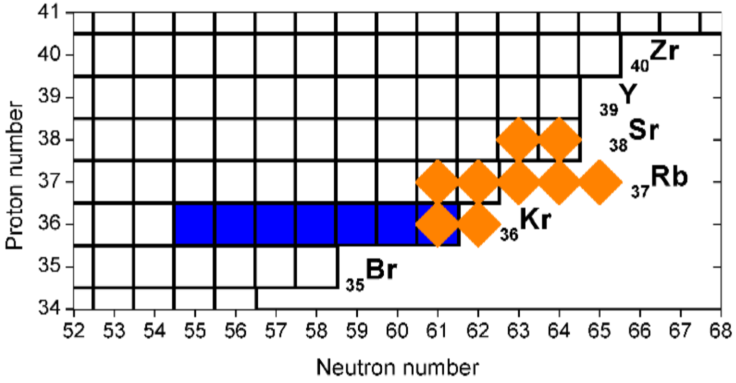


Penning trap confirms and improves the MR-TOF mass of ^{131}Cd from 2014.

M. König *et al.*, Int. J. Mass Spectrom. **142**, 95 (1995); S. George *et al.*, Phys. Rev. Lett. **98**, 162501 (2007);

Onset of deformation at N = 60

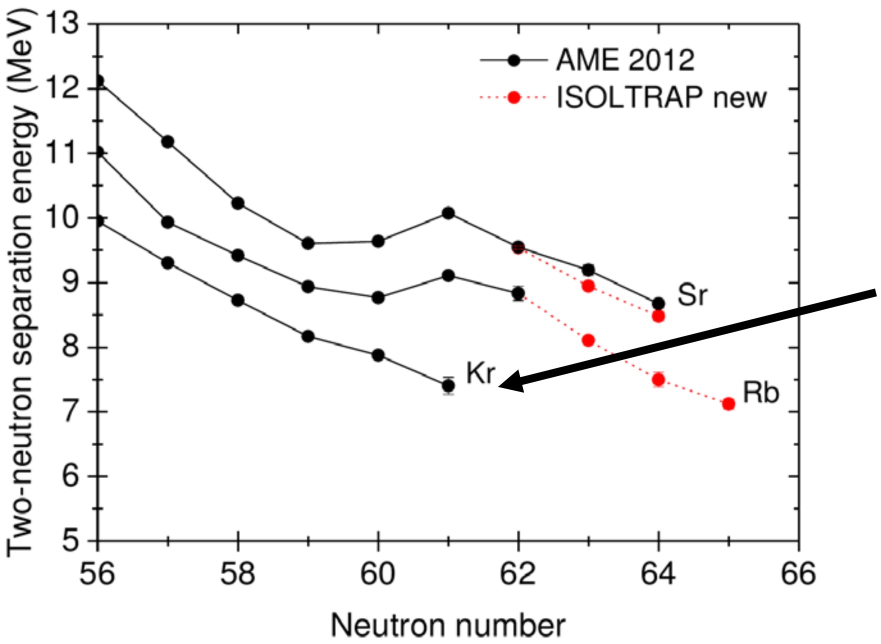


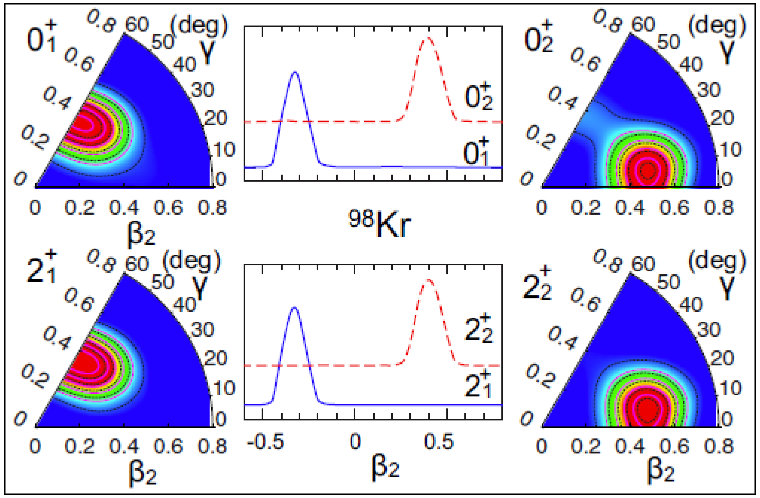


- Fourth campaign at ISOLTRAP in the A ≈ 100 region during the last 5 years.

M. Wang *et al.*, Chinese Physics C **36**, 1603 (2012). V. Manea, PhD thesis (2014). A. de Roubin, Phys. Rev. C **96**, 014310 (2017)
*TITAN: R. Klawitter et al., Phys. Rev. C **93**, 045807 (2016).* T. R. Rodriguez, Phys. Rev. C **90**, 034306 (2014)

Onset of deformation at N = 60





- Fourth campaign at ISOLTRAP in the $A \approx 100$ region during the last 5 years.

- Beyond-mean-field calculations show that the Kr configurations don't mix strongly in the ground state.

M. Wang *et al.*, Chinese Physics C **36**, 1603 (2012). V. Manea, PhD thesis (2014). A. de Roubin, Phys. Rev. C **96**, 014310 (2017)
TITAN: R. Klawitter et al., Phys. Rev. C ***93****, 045807 (2016).* T. R. Rodriguez, Phys. Rev. C **90**, 034306 (2014)