INTC-P-702: Studying N=28 with argon isotopes

CRIS collaboration meeting 2025

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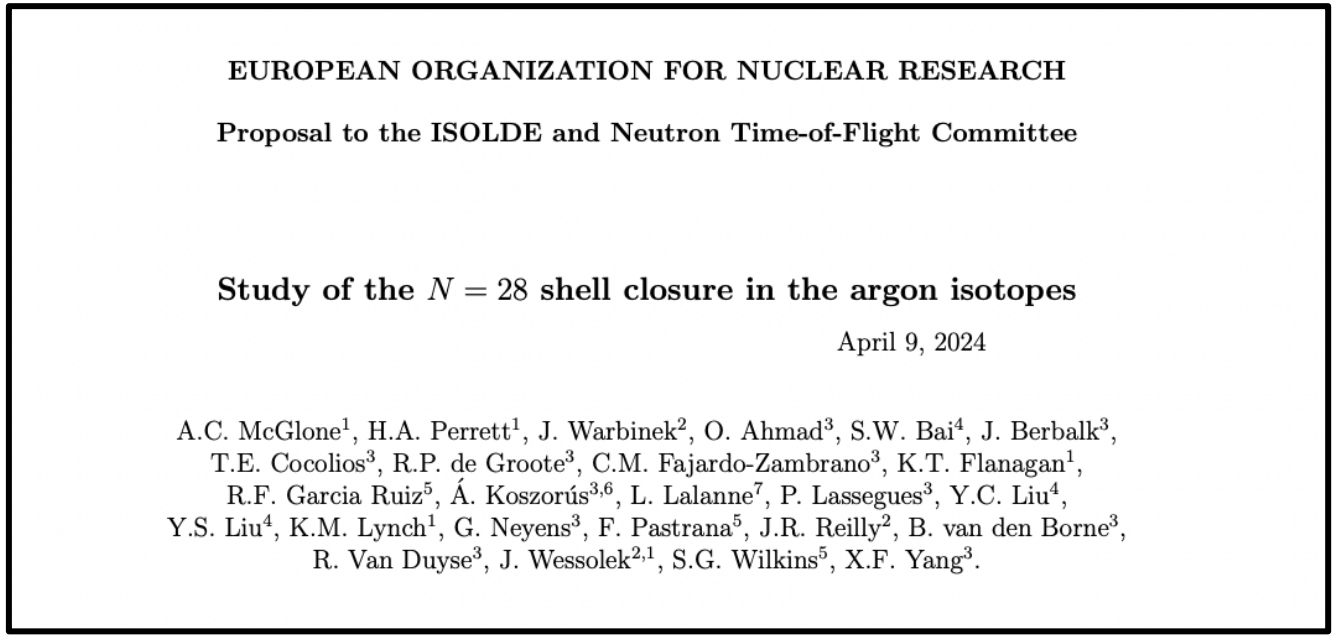
CRIS

Status

- Defended to INTC in May 2024. https://cds.cern.ch/record/2894938/files/INTC-P-702.pdf
- 21 total shifts approved (3 stable beam setup, 18 radioactive)
- Requested for scheduling April/May 2025



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

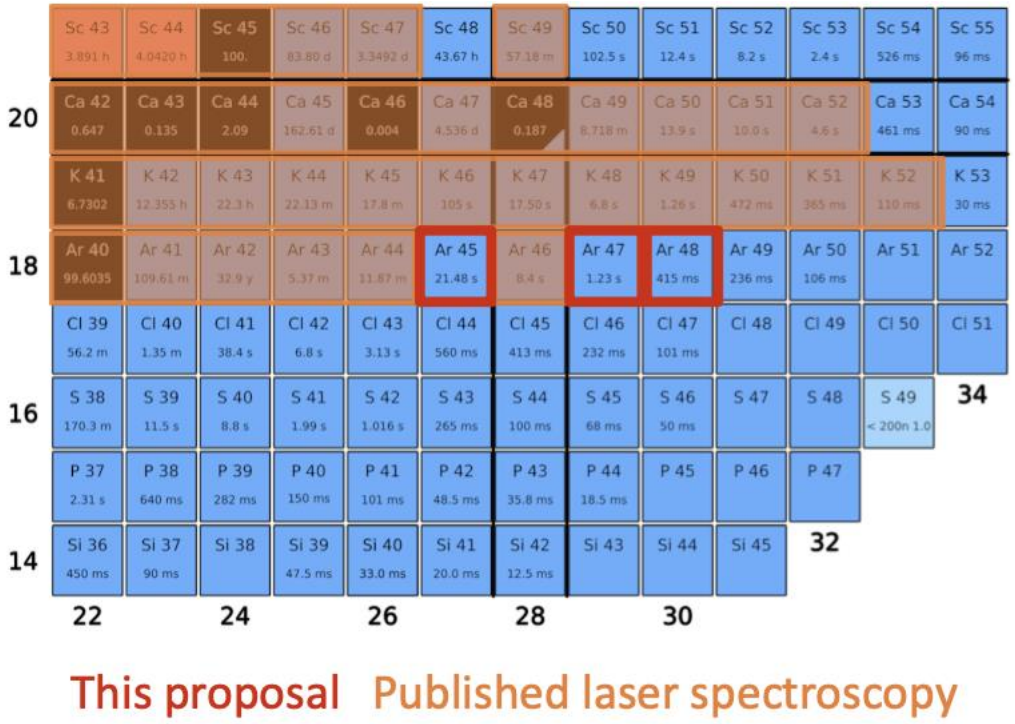
Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Study of the $N = 28$ shell closure in the argon isotopes

April 9, 2024

A.C. McGlone[1], H.A. Perrett[1], J. Warbinek[2], O. Ahmad[3], S.W. Bai[4], J. Berbalk[3], T.E. Cocolios[3], R.P. de Groote[3], C.M. Fajardo-Zambrano[3], K.T. Flanagan[1], R.F. Garcia Ruiz[5], Á. Koszorús[3,6], L. Lalanne[7], P. Lassegues[3], Y.C. Liu[4], Y.S. Liu[4], K.M. Lynch[1], G. Neyens[3], F. Pastrana[5], J.R. Reilly[2], B. van den Borne[3], R. Van Duyse[3], J. Wessolek[2,1], S.G. Wilkins[5], X.F. Yang[3].

Status

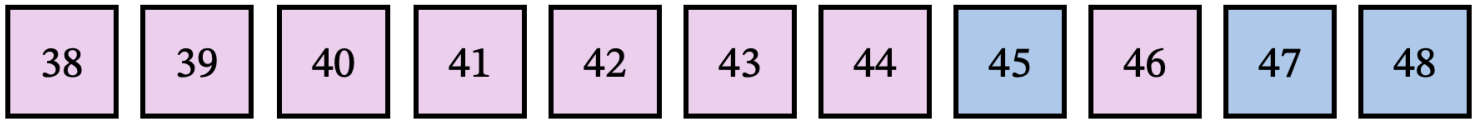


Persistence of N=28 shell closure below 48Ca

- Complete disappearance in 42Si
- Signatures of shape coexistence in 44S
- Study onset of collectivity

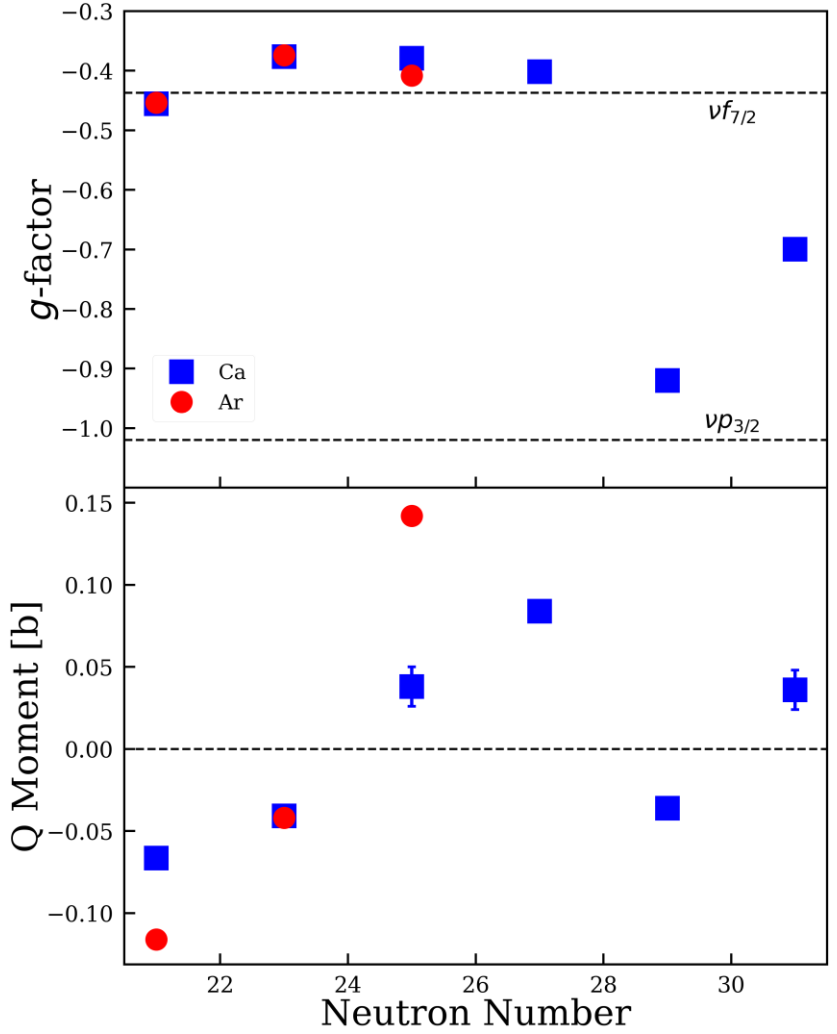
Physics goals

- Crossing N=28, want to complete the picture with complete moments
- Determine strength of closure in Ar
- Experimental g-factors and q moments for Ar follow the same trend as Ca
- Moments of ^{45,47}Ar will be sensitive to the presence of mixed configurations



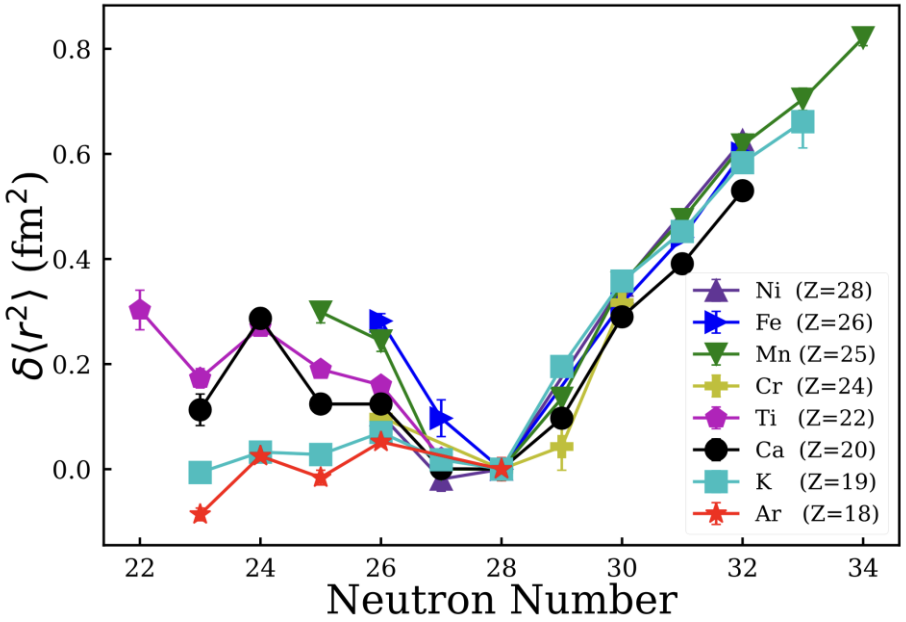
Previously measured

This Proposal



Physics goals

- Crossing N=28, want to complete the picture with complete moments
- Determine strength of closure in Ar
- Investigate charge radii crossing N=28 towards N=32
- Predicted bubble nuclei for ^{46}Ar



K. Blaum et al., Nucl. Phys. A 799, 30–45 (2008).
I. Angeli, K.P. Marinova. J. Phys. G, 42, 055108 (2015).
H. Heylen et al., Phys. Rev. C, 94, 054321 (2016).
K. Minamisono et al., Phys. Rev. Lett., 117, 252501 (2016).
F. Sommer et al., Phys. Rev. Lett., 129, 132501 (2022).
A. Koszorus, X. Yang, et al., Nature Phys., 17, 1–5 (2021).

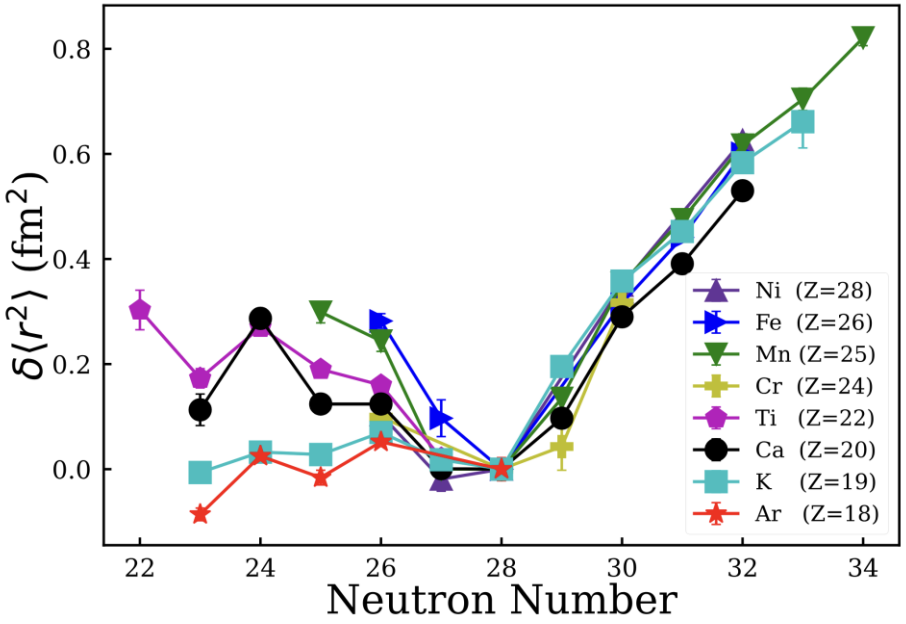
$5/2^-$, $7/2^-$ $(3/2)^-$

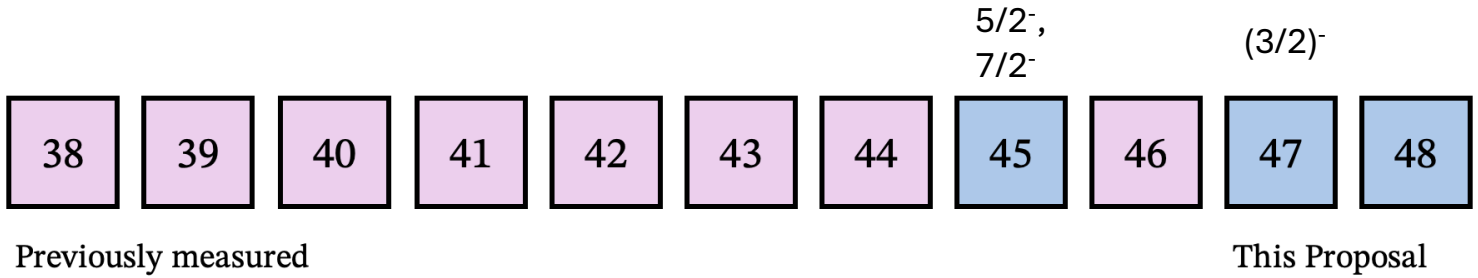
38	39	40	41	42	43	44	45	46	47	48

Previously measured — This Proposal

Physics goals

- Crossing N=28, want to complete the picture with complete moments
- Determine strength of closure in Ar
- Investigate charge radii crossing N=28 towards N=32
- Predicted bubble nuclei





Side quest: Kr and Xe from same target / ion source

Laser Schemes

Populate metastable state in CEC with K vapour.

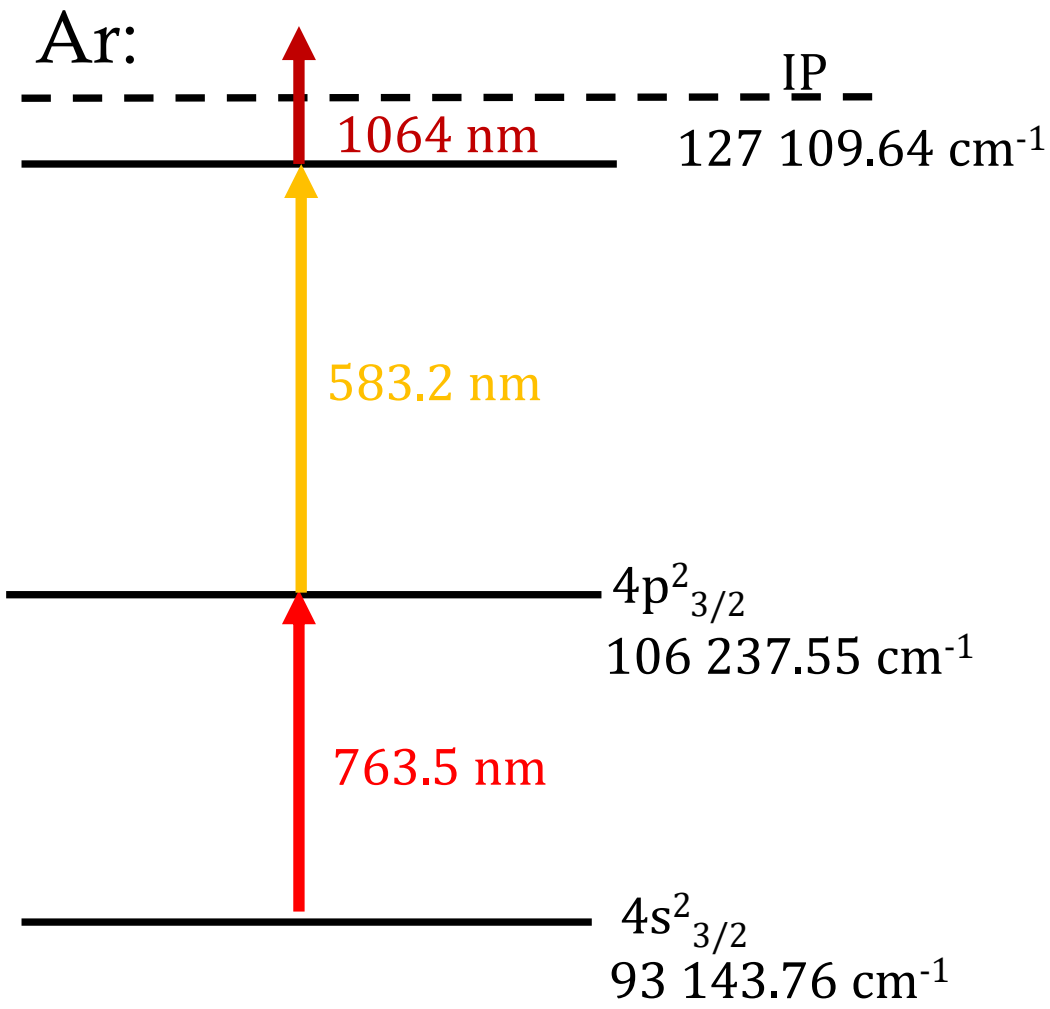
Typical TiSa + Dye + 1064 scheme

JyvIS

PDL

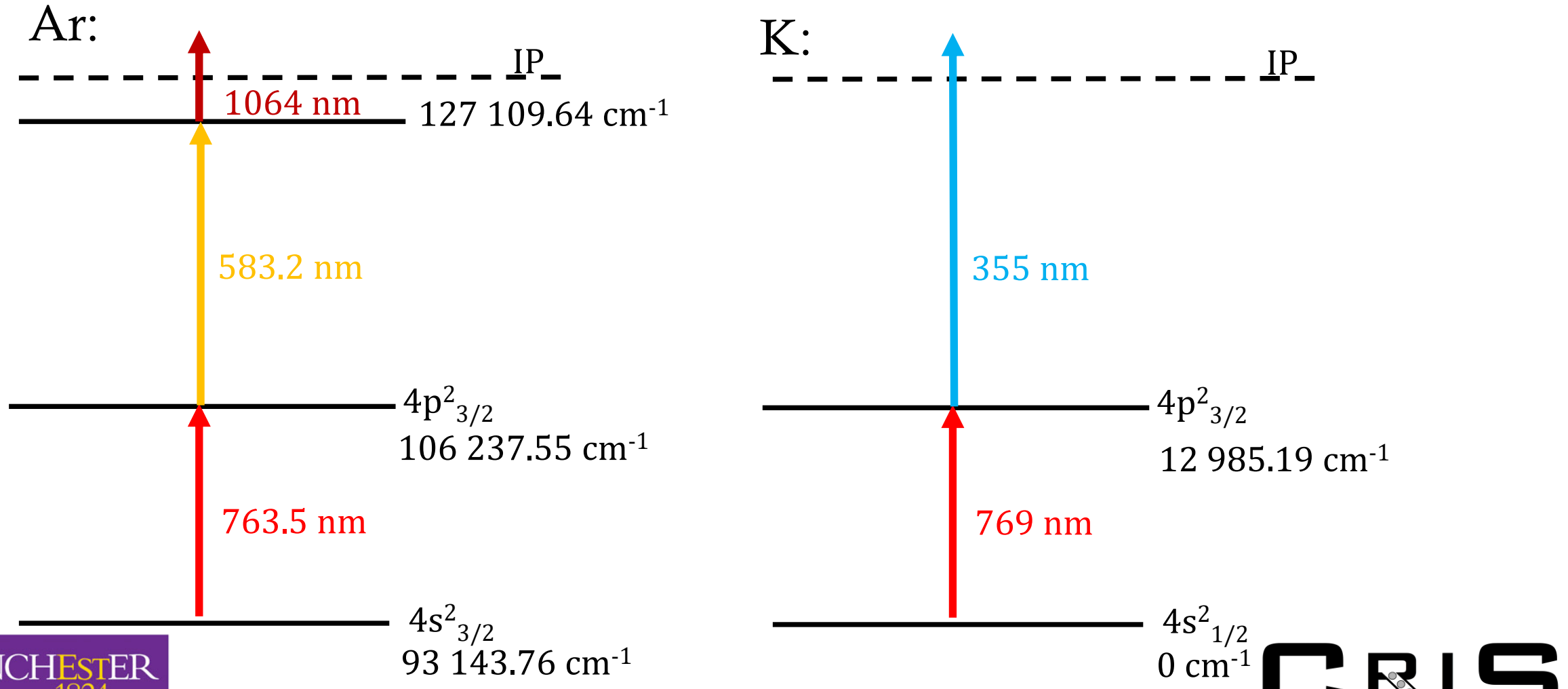
Rhodamine 6G

TriLi/
Innolas
OPO



Laser Schemes

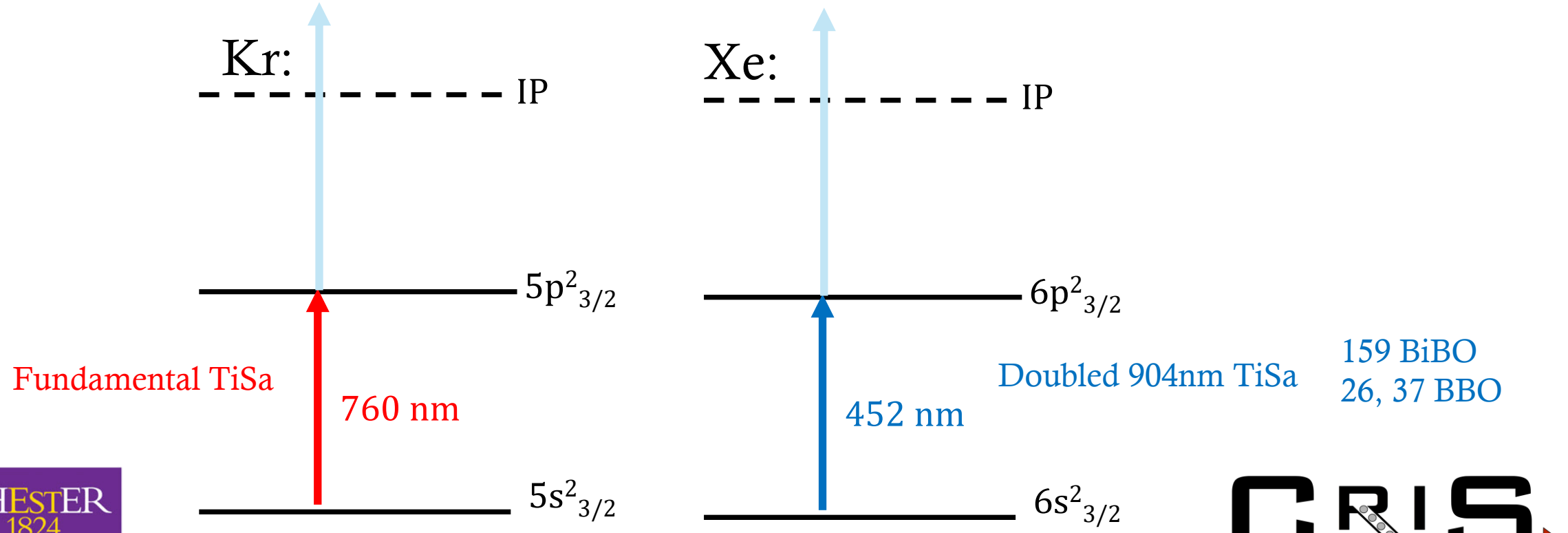
Similarity in Scheme with K means easy swap between commissioning and Ar experiment



Laser Schemes

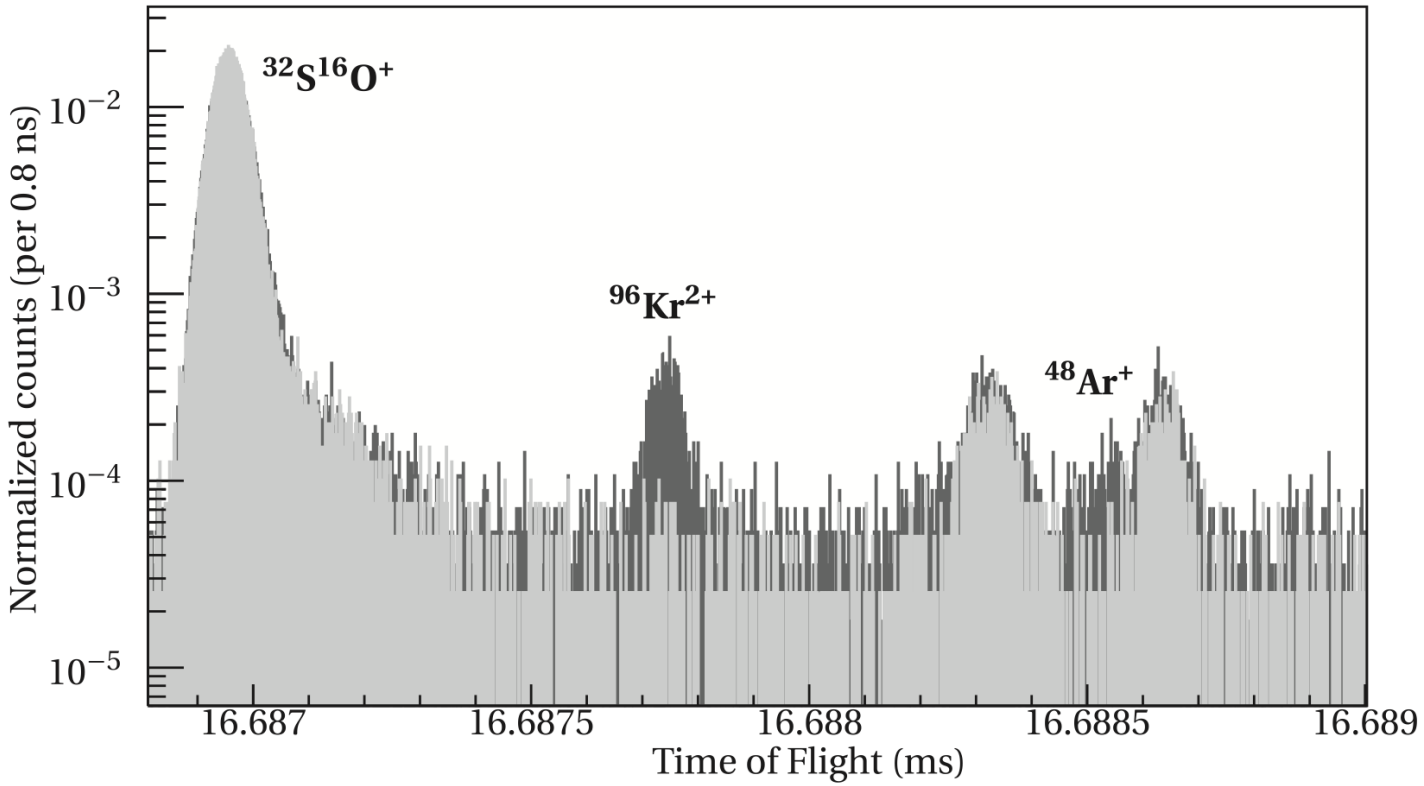
Other options:

- Produced by the same ion source: Kr and Xe



Contamination

- Expected contamination from Kr2+ and Xe3+.
- ISOLTRAP observed several stable molecular contaminants
  - $^{34}S^{12}C+$
  - $^{34}S^{12}C+$
- Narrow beam gate required for reduction of intensity

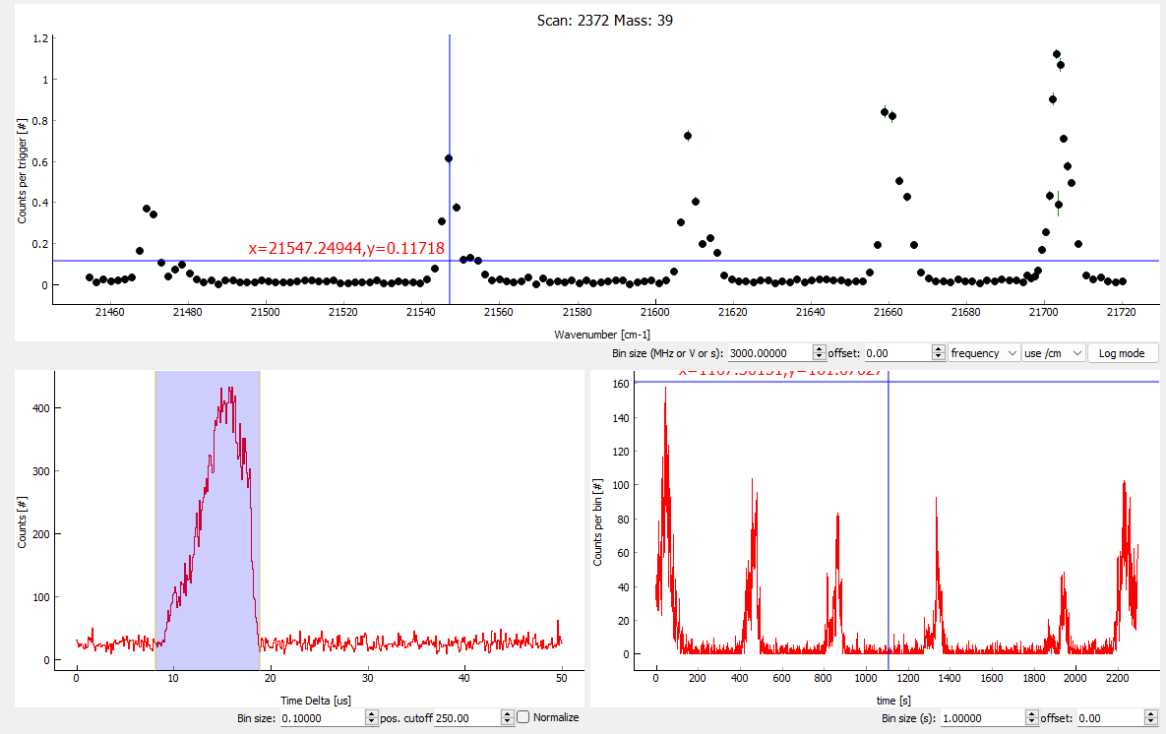


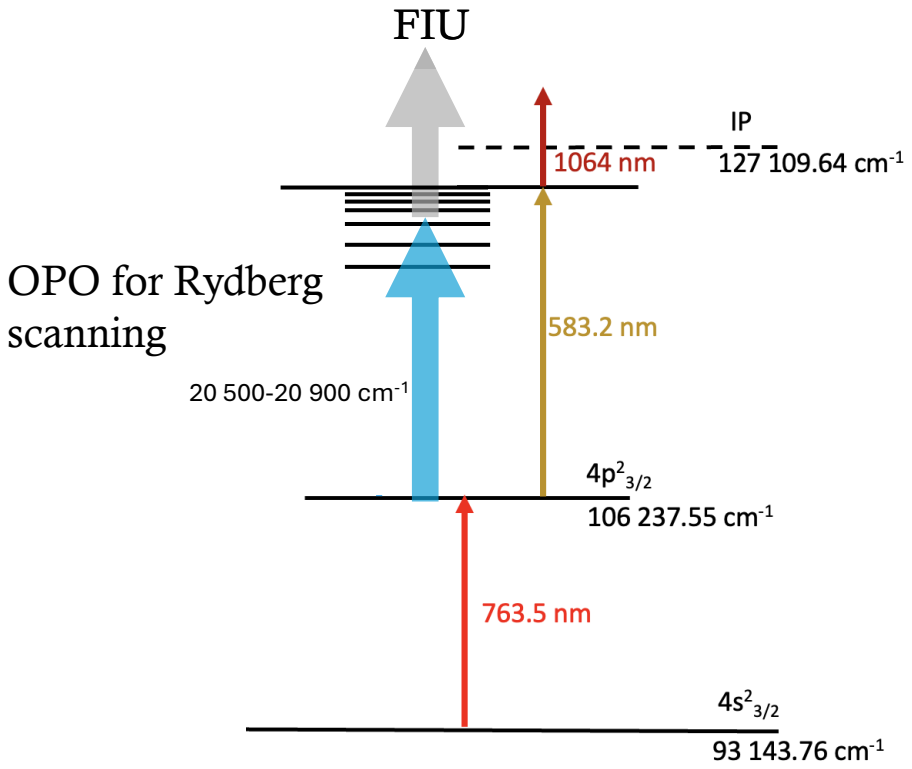
M. Mougeot Phys. Rev. C **102**, 014301

FIU

Using OPO to scan across the Rydberg scheme

Suppress laser related background, use deflectors





Thank You

KU LEUVEN

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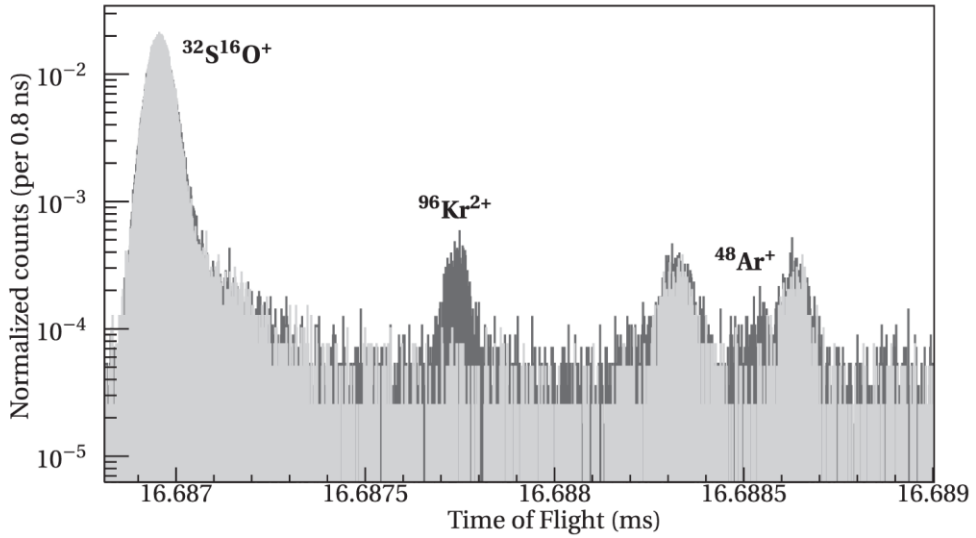
The University of Manchester

CRIS

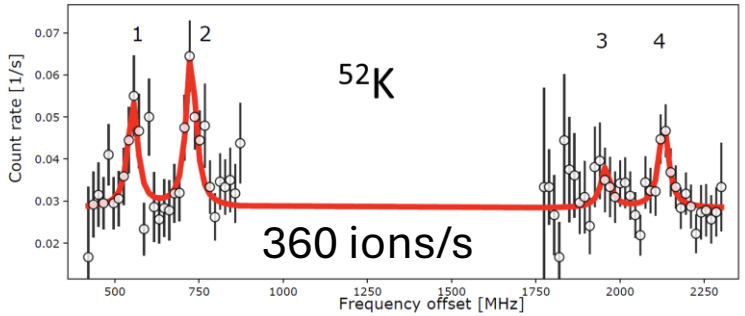
Yields and contaminations



M. Mougeot et al., Phys. Rev. C 102, 014301 (2020).

ISOLTRAP measurements on ^{48}Ar

- Expect similar level of contamination
- Mostly $^{32}S^{16}O^+$, $^{96}Kr^+$
- Narrow beam gate required to reduce contamination
- Shifts estimated from worst case of expected background in CR



A. Koszorus et al., Nature Phys. 17 439–443 (2021).

Contributions for shift estimate:

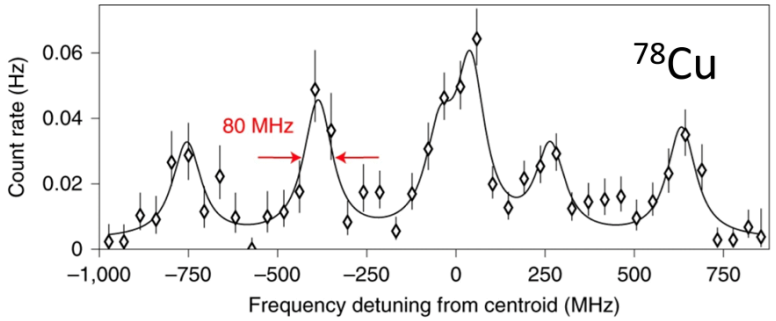
- Reduction of yield due to narrow beam gate
- CRIS efficiency
- Population of metastable state, hyperfine structure
- Time needed for multiple scans (strongly dependent on signal-to-background ratio)

Shift request

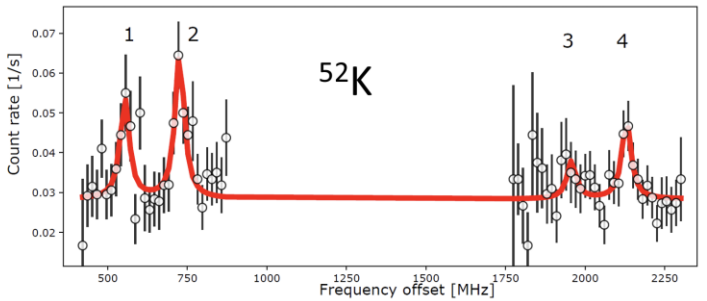
- UCx target + FEBIAD plasma ion source
- Yields (extrapolated) sufficient for CRIS
- Contamination known (ISOLTRAP)

Measurements feasible down to ^{48}Ar

	Half live	Yields (/μC)	Shifts	New results
$^{38\text{-}44}$Ar	> 8s	10^6-10^7*	3	-
^{46}Ar	8.4 s	1.11×10^5*	2	-
^{45}Ar	21.48(15) s	3.49×10^5*	2	I, μ, Q_s, $\delta\langle r^2\rangle$
^{47}Ar	1.23(3) s	7.72×10^3*	6	I, μ, Q_s, $\delta\langle r^2\rangle$
^{48}Ar	415(15) ms	1.58×10^3*	5	$\delta\langle r^2\rangle$
Stable		CRIS setup	3 (no protons)	



20 ions/s



360 ions/s

R.P. de Groote et al., Nature Phys. 16, 620–624 (2020).
A. Koszorus et al., Nature Phys. 17 439–443 (2021).

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- Stable beamtuning for **CRIS setup**: 3 shifts
- **Reference measurements** throughout experiment, calibration of voltage drifts and systematic effects: 5 shifts
- **Laser spectroscopy** of ^{45}Ar: 2 shifts, **Laser spectroscopy** of ^{47,48}Ar: 11 shifts
- Shifts requested account for expected contamination and reduction of yields by using a narrow beamgate

TAC comments: The TAC does not foresee any serious issues with this proposal.