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

UNIVERSITY of the WESTERN CAPE

Investigating shape coexistence in ^{80,82}Sr with β^{+}/EC decay spectroscopy

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78th Meeting of the INTC

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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

Investigating shape coexistence in ^{80,82}Sr with β^+/EC decay spectroscopy

September 24, 2020

N. Bernier[1,2], T. D. Bucher[1,2], J. N. Orce[1], L. J. Evitts[3], T. Kibédi[4], P. E. Garrett[5,1], T. R. Rodríguez[6], K. J. Abrahams[1], E. H. Akakpo[1], A. Algora[7], A. Andreyev[8], H. Bidaman[5], V. Bildstein[5], M. J. G. Borge[9], S. Buck[5], A. Briscoe[10], J. A. Briz[9], K. Chrysalidis[15], J. Cubiss[6], L. M. Fraile[11], J. Henderson[12], A. Illana[10,13], D. G. Jenkins[8,1], A. Korgul[14], R. Lica[15], C. V. Mehl[1], K. Miernik[14], A. I. Morales[5], E. Nácher[5], C. Ngwetsheni[1], S. S. Ntshangase[2], J. Ojala[10], B. Olaizola[15], S. Orrigo[5], R. Page[16], J. Pakarinen[10], M. Piersa[14], A. Radich[5], S. Rothe[15], B. Rubio[7], J. Smallcombe[16], M. Stryjczyk[17], S. Triambak[1], S. Valbuena[5], R. Wadsworth[8], and the IDS/ISOLDE Collaboration

The committee finds that there are interesting results which could be learned from this experiment especially with regard to the E0 state of ^{82}Sr to which the previously performed Coulomb Excitation measurements is insensitive.

This measurement would be important by itself but also to allow for a proper analysis of the Coulex work.

Regarding ^{80}Sr the committee feels that previous measurements did not indicate the presence of an E0 state and the study of this isotope is of less apparent interest.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Clarification for P-586 to the ISOLDE and Neutron Time-of-Flight Committee

Investigating shape coexistence in ^{80,82}Sr with β^+/EC decay spectroscopy

January 6, 2021

N. Bernier[1,2], T. D. Bucher[1,2], J. N. Orce[1], L. J. Evitts[3], T. Kibédi[4], P. E. Garrett[5,1], T. R. Rodríguez[6], K. J. Abrahams[1], E. H. Akakpo[1], A. Algora[7], A. Andreyev[8], H. Bidaman[5], V. Bildstein[5], M. J. G. Borge[9], S. Buck[5], A. Briscoe[10], J. A. Briz[9], K. Chrysalidis[15], J. Cubiss[6], L. M. Fraile[11], J. Henderson[12], A. Illana[10,13], D. G. Jenkins[8,1], A. Korgul[14], R. Lica[15], C. V. Mehl[1], K. Miernik[14], A. I. Morales[5], E. Nácher[5], C. Ngwetsheni[1], S. S. Ntshangase[2], J. Ojala[10], B. Olaizola[15], S. Orrigo[5], R. Page[16], J. Pakarinen[10], M. Piersa[14], A. Radich[5], S. Rothe[15], B. Rubio[7], J. Smallcombe[16], M. Stryjczyk[17], S. Triambak[1], S. Valbuena[5], R. Wadsworth[8], and the IDS/ISOLDE Collaboration

Could the advantage that ISOLDE presents over these facilities be clarified by the collaboration?

i) a uniquely versatile and superior array (betas, $LaBr_3$, clovers, SPEDE), ii) a dedicated experiment aimed at the study of 0^+ states,
iii) pure beams that result in cleaner spectra over fusion-evaporation reactions (^{32}Si + ^{nat}Ni)
iv) Large Q value

The production of Y beams has been observed at the booster but it is possible that the yields of ^{82,80}Y could be substantially lower. The committee recommends 3 shifts be awarded for beam development.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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

Investigating shape coexistence in ^{80,82}Sr with β^+/EC decay spectroscopy

January 14, 2025

J. N. Orce[1], L. Makhathini[1], M. Jaftha[1], N. Bernier[2], L. J. Evitts[3], T. Kibédi[4], E. Garrett[5,1], L. M. Fraile[2], U. Koester[6], T. R. Rodríguez[7], A. Algora[8], A. Andreyev[9], H. Bidaman[6], V. Bildstein[5], M. J. G. Borge[10], S. Buck[6], A. Briscoe[11], J. A. Briz[10], J. Fuller[9], J. Henderson[12], A. Illana[11,13], D. G. Jenkins[9,1], A. Korgul[14], R. Lica[15], E. Lawrie[16,1], D. Mavela[1], C. V. Mehl[1], K. Miernik[14], E. Nácher[8], J. Ojala[11], Olaizola[15], C. Page[9], R. Page[17], J. Sánchez[10], J. Pakarinen[11], M. Piersa[14], S. Rothe[15], B. Rubio[8], J. Smallcombe[16], M. Sokolowski[14], M. Stryjczyk[11], R. Wadsworth[9], J. Wilson[9], Z. Yue[9], J. Cubiss[19], and the IDS/ISOLDE Collaboration

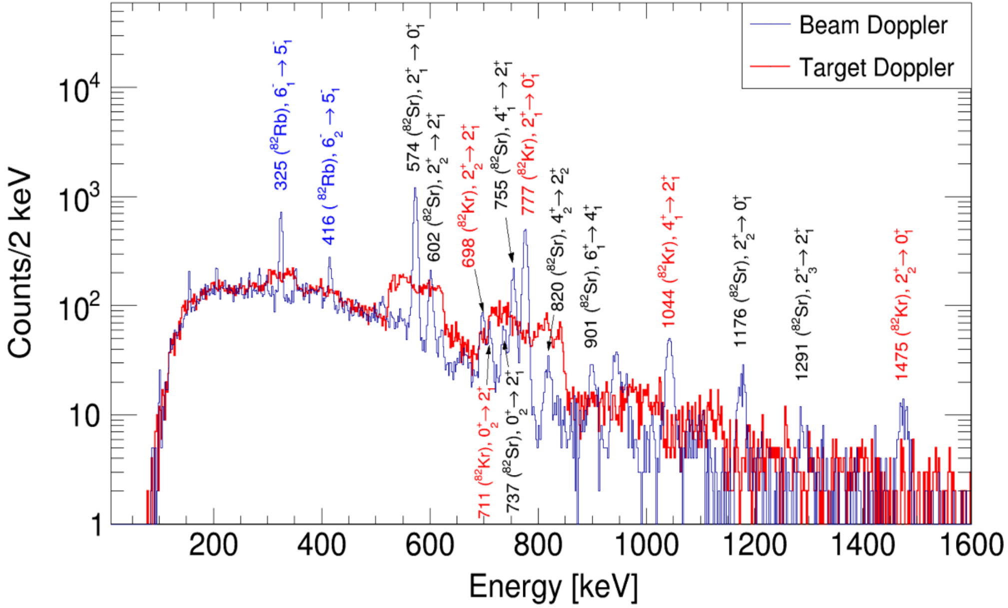
IS694 Yields Measurements 11-13 Nov 2024

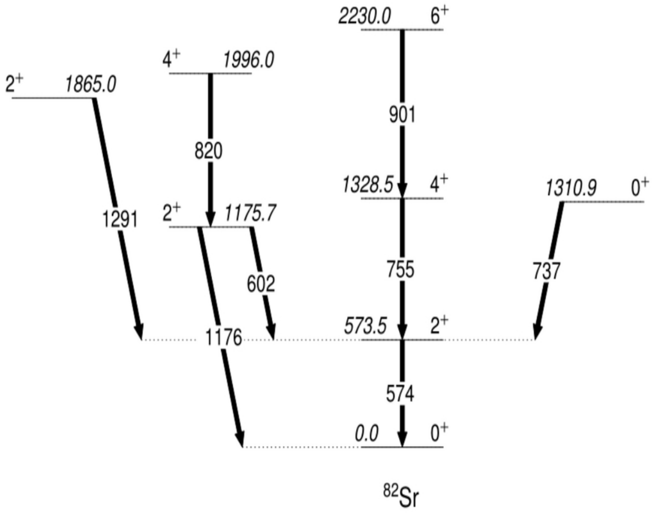
Summary of measured yields (molecular beams) with Nb foil target with CF_4 leak and hot plasma ion source

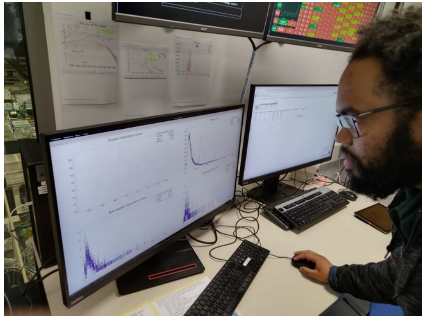
Isotope	Yield [ions/μC]	Expected Yield [ions/μC]
$^{78}YF_2$	—	—
$^{80}YF_2$	8.3×10^2	5×10^3
$^{82}YF_2$	2.2×10^4	5×10^4
$^{84}YF_2$	5.4×10^4	—
$^{89}YF_3$	7.7×10^1	—

^{82}Sr Coulomb excitation onto ^{208}Pb target using TIGRESS + S3 @ TRIUMF

- Second 0^+ state @ 1.311 MeV populated
- Excitations up to the 6^+ yrast state @ 2.23 MeV
- ^{82}Kr and ^{82}Rb contaminants





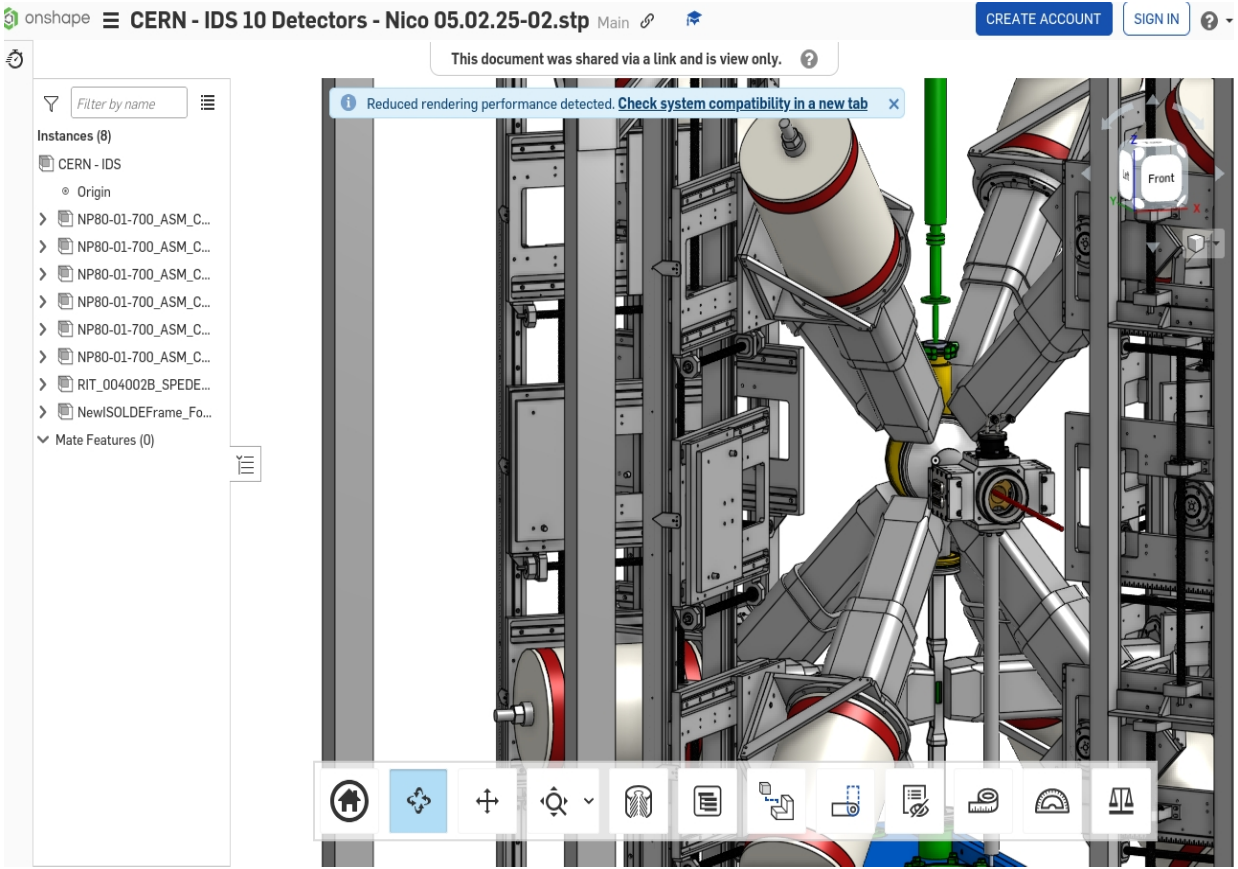


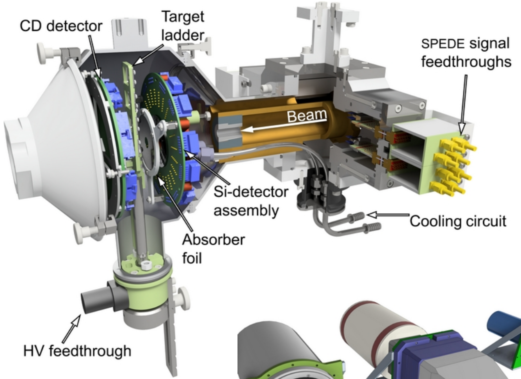
MSc thesis (Manfred Jaftha, UWC)

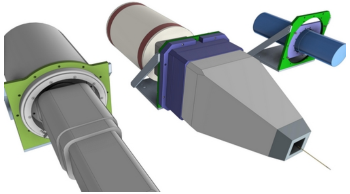
UWC involvement @ IDS

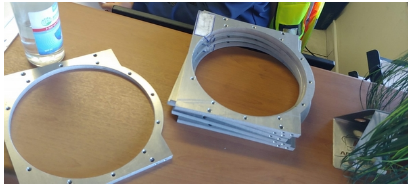
https://cad.onshape.com/documents/f05fcacbac1bf0e176ff4d7b/w/9dfc1f48a5bc190da444e5c6/e/d0f1218a9b5ec33b684627e6

Setup configuration for Nov 2024 Yields Measurements





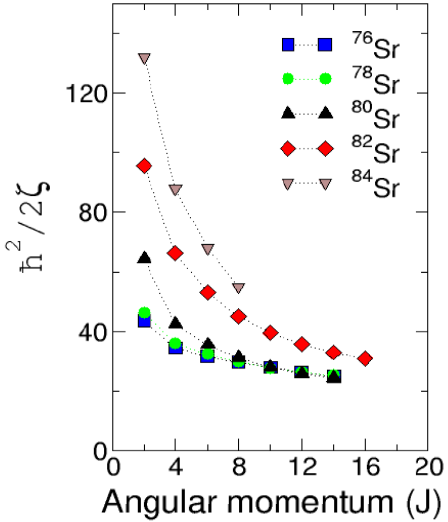


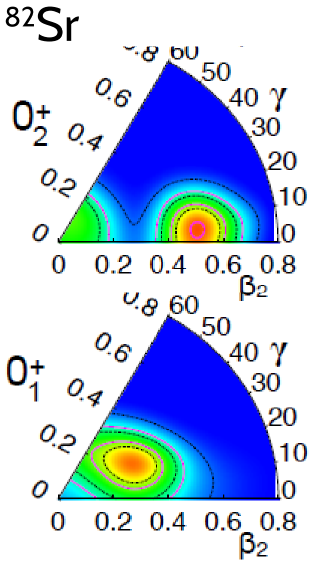


Credit: Shaun Hendricks & IDS Collaboration

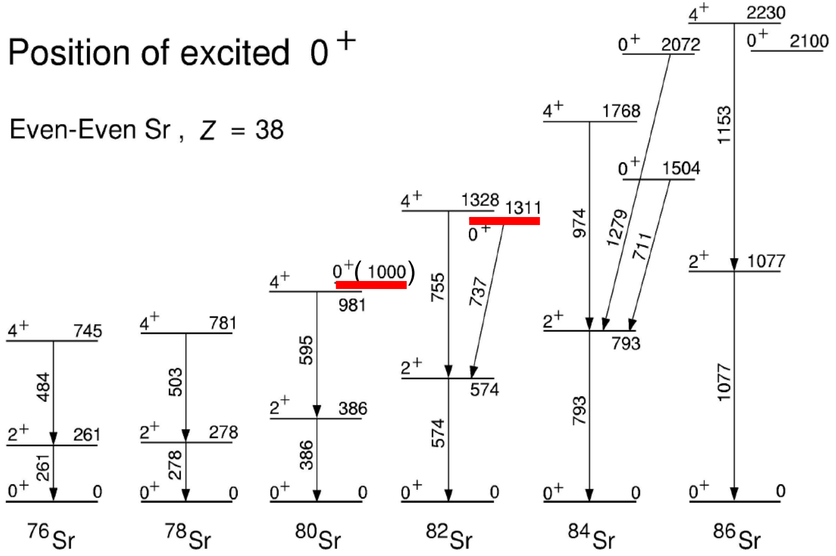
Shape coexistence in ^{82}Sr @ IDS

- The existence of low-lying excited 0^+ states has been associated with shape coexistence → anomalously high excitation energy of 2^+ states
- Triaxial ground state, but prolate first excitation predicted by collective wave functions
- The identification of these 0^+ states (together with $\rho^2(E0)$) and bands built on them will be used to investigate shape mixing at low spins.



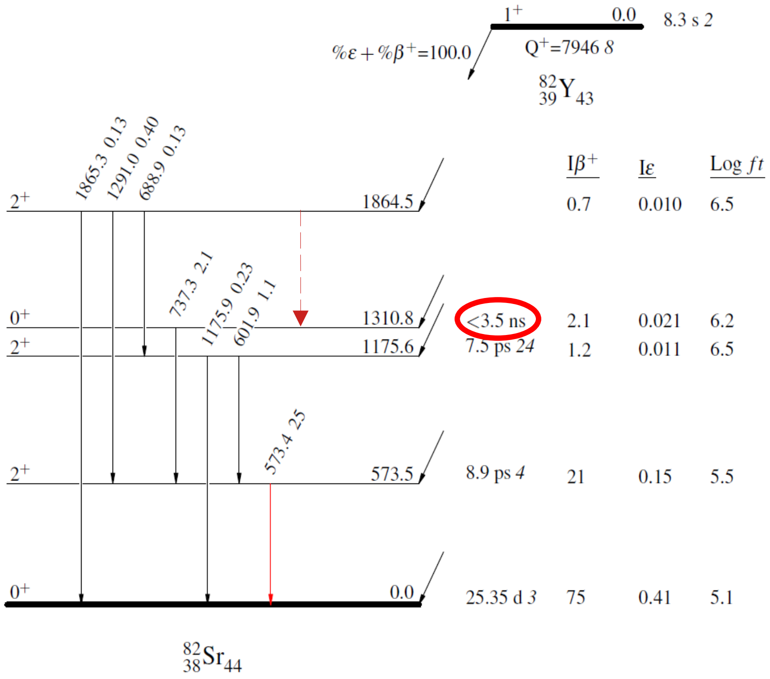


T. Rodriguez (2020)



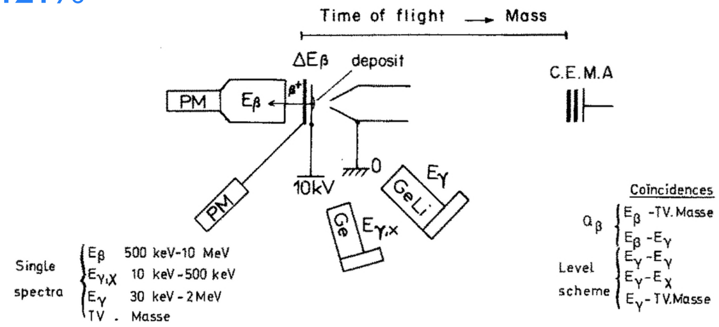
J. Döring *et. al.*, Res. Natl. Inst. Stand. Technol. **105**, 43 (2000)

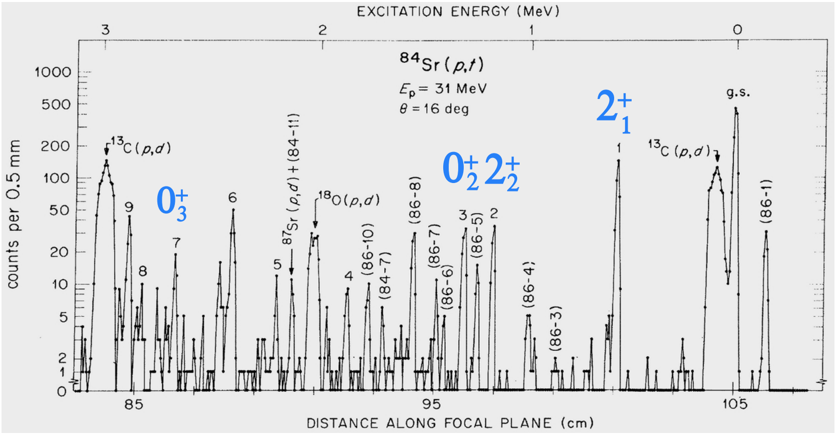
- In ^{82}Sr, the 0_2^+ state is populated by the 1^+ ground state of ^{82}Y (also observed in (p,t) reaction) with a combined β^+/EC feeding intenensity of 2.121%



M. Oinonen *et al.*, Nucl. Instr. Meth. **A416** 485 (1998)

Previous measurements using fusion-evaporation

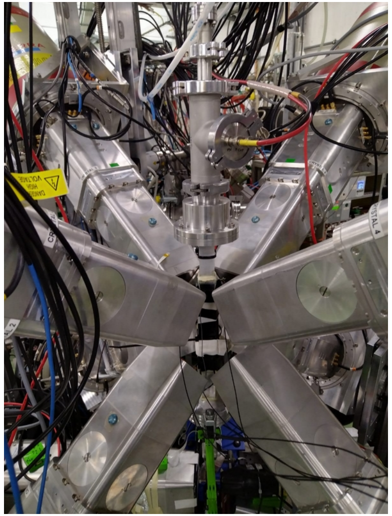


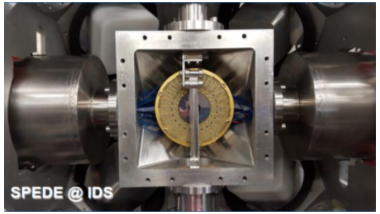


J. B. Ball *et al.*, Phys. Rev. C 8, 1438 (1973)

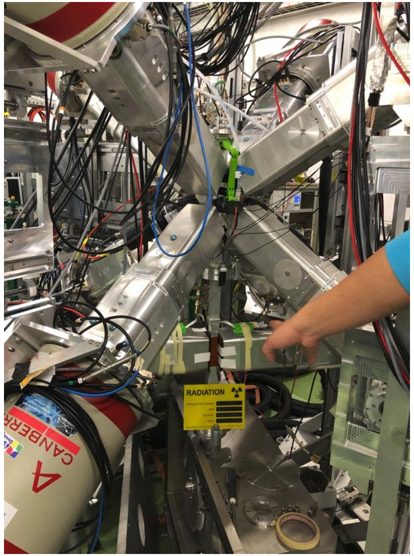
To populate low-lying states in ^{80,82}Sr via β^+/EC decay of ^{80,82}Y using IDS with two measurement positions

1. The **implantation** position with 8 clovers for γ-γ coincidences and angular correlations (next time: SPEDE, the conversion electron spectrometer, to measure the *E0* electrons and *E0* strengths)





2. The **decay** position with 2 clovers, 2 $LaBr_3$ and 1 beta detectors to measure lifetimes using β-γ_{Ge}-γ_{LaBr} coincidences



New count estimates and # of shifts with SPEDE

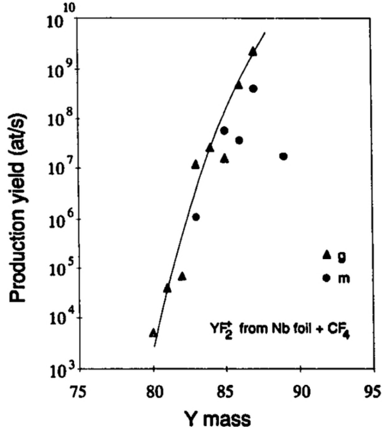
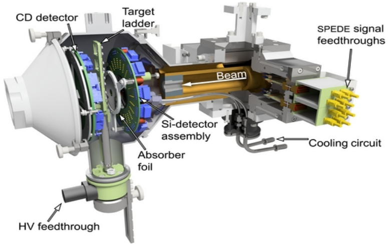


Fig. 3. Production yields of YF_2^+ ions from a 47 g/cm^2 Nb foil target equipped with a W surface ionizer and a CF_4 leak (g = ground state, m = isomer). Irradiation: 600 MeV protons.

Original Proposal (expected yields)

Isotope	Half-life	Yield [ions/s]	β-γ_{Ge}-γ_{Ge} [counts/shift]	β-γ_{Ge}-γ_{LaBr} [counts/shift]	$0_2^+ \rightarrow 0_1^+$ K $E0$ e$^-$ [counts/shift]	$2_\gamma^+ \rightarrow 2_1^+$ K $E0$ e$^-$ [counts/shift]	# of shifts
^{80}Y	4.8(3) s	1 x 10^4	~ 2 x 10^2	~ 1 x 10^2	40	3 x 10^3	9
^{82}Y	8.3(2) s	1 x 10^5	4 x 10^4	1 x 10^4	140	9 x 10^4	6



R. Eder *et al.*, Nucl. Instr. Meth. B **62** 535 (1992)

Summary of measured yields (molecular beams) with Nb foil target with CF_4 leak and hot plasma ion source

Isotope	Yield [ions/μC]	Expected Yield [ions/μC]
$^{78}YF_2$	—	—
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$^{84}YF_2$	5.4×10^4	—
$^{89}YF_3$	7.7×10^1	—

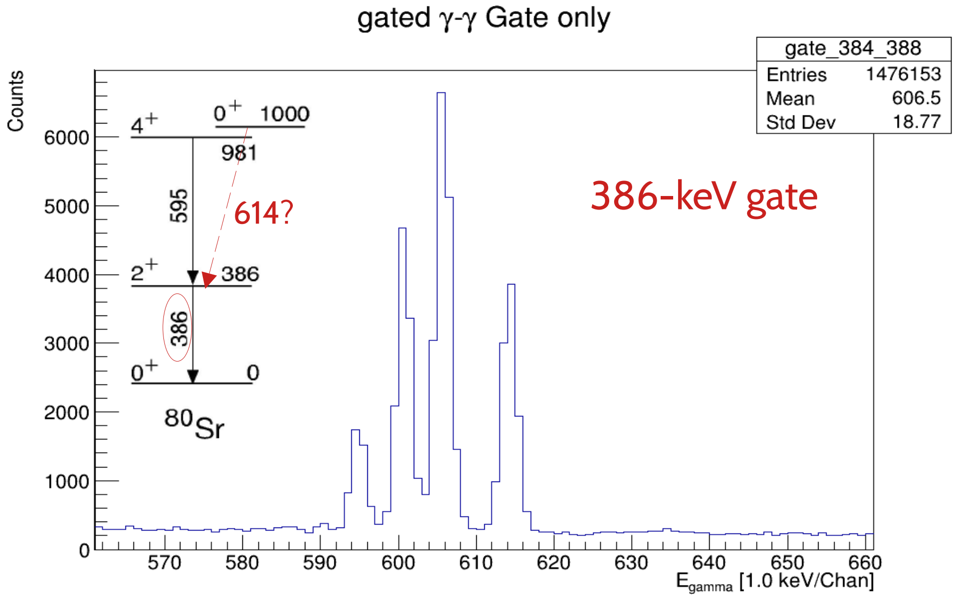
Final Estimates with SPEDE (measured yields)

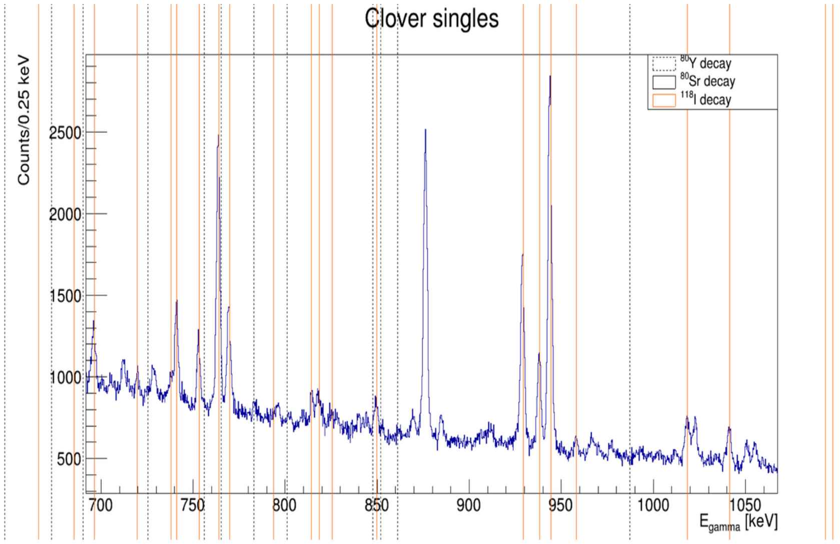
Table 2: New count estimates and number of shifts for 1.6 μA average proton current.

Isotope	Half-life	Yield [ions/s]	β-γ_{Ge}-γ_{Ge} [counts/shift]	β-γ_{Ge}-γ_{LaBr} [counts/shift]	$0_2^+ \rightarrow 0_1^+$ K $E0$ e$^-$ [counts/shift]	$2_\gamma^+ \rightarrow 2_1^+$ K $E0$ e$^-$ [counts/shift]	# of shifts
^{82}Y	8.3(2) s	3.5 x 10^4	2.8 x 10^4	7 x 10^3	50	3.2 x 10^4	15

Decay Spectroscopy of ^{80}Y @ IDS

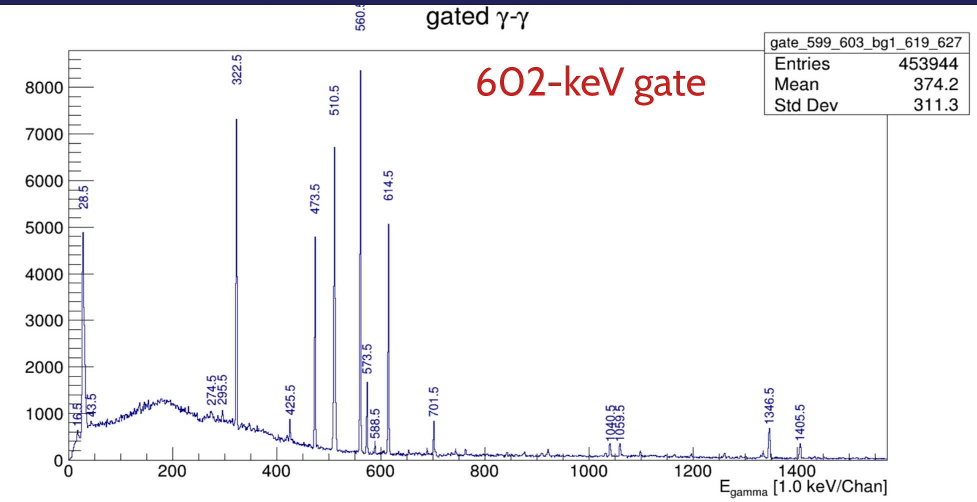
- 6x less ^{80}Y yields than expected. High yields for ^{84}Y -> new interesting case
- Plus A=118 contaminants in the region of interest possibly arising from spallation reaction in the Ta container. A Mo container could be considered (Ulli Koester).
- We shall focus on ^{82}Y

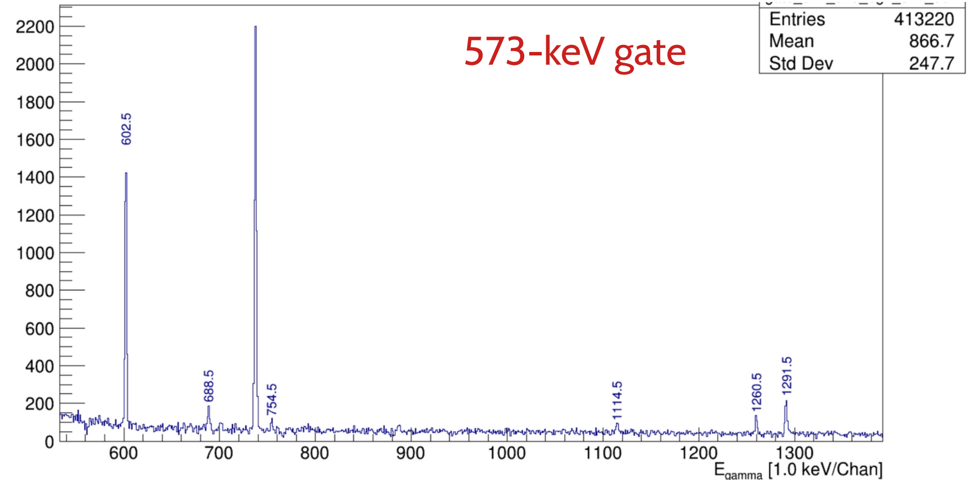


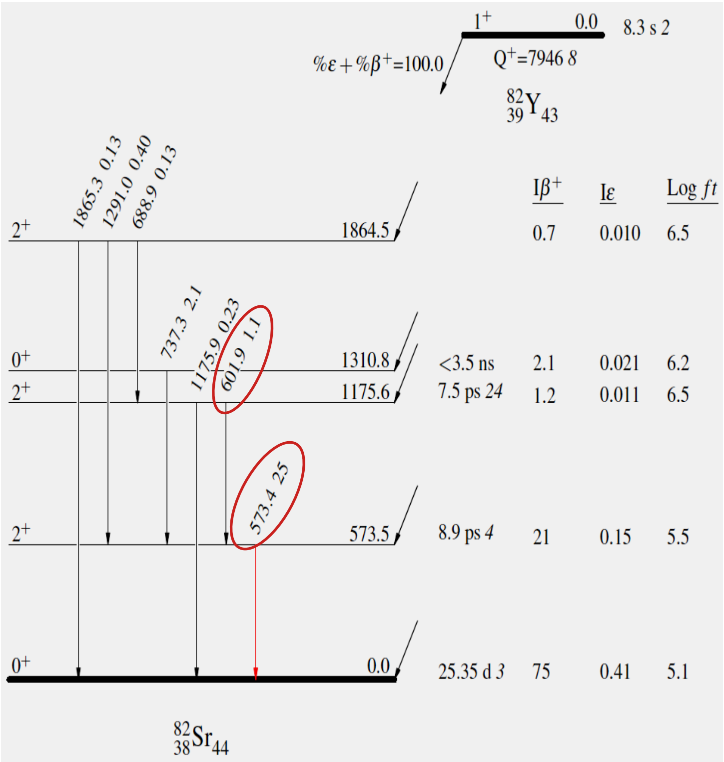


The orange lines are the ^{118}I gamma energies from NNDC

Decay Spectroscopy of ^{82}Y @ IDS





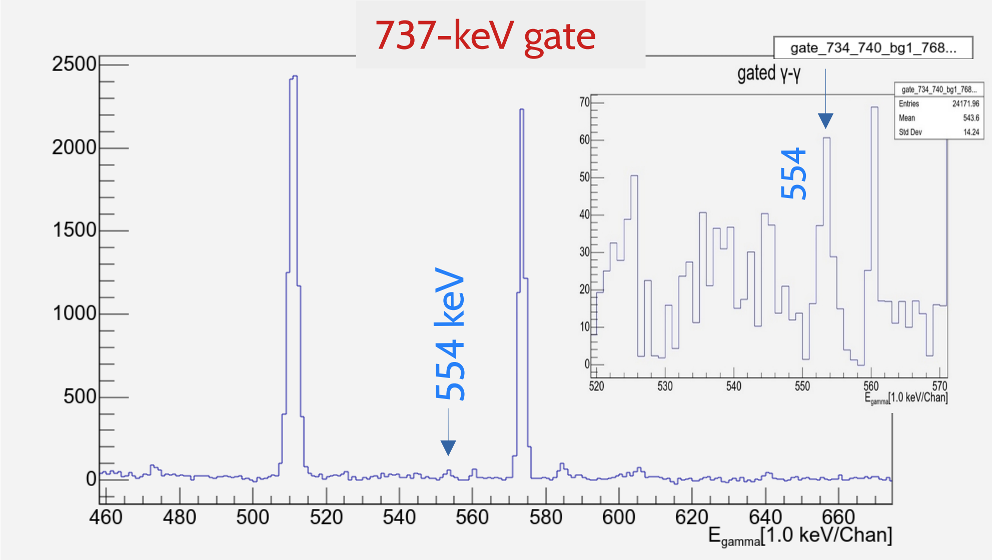


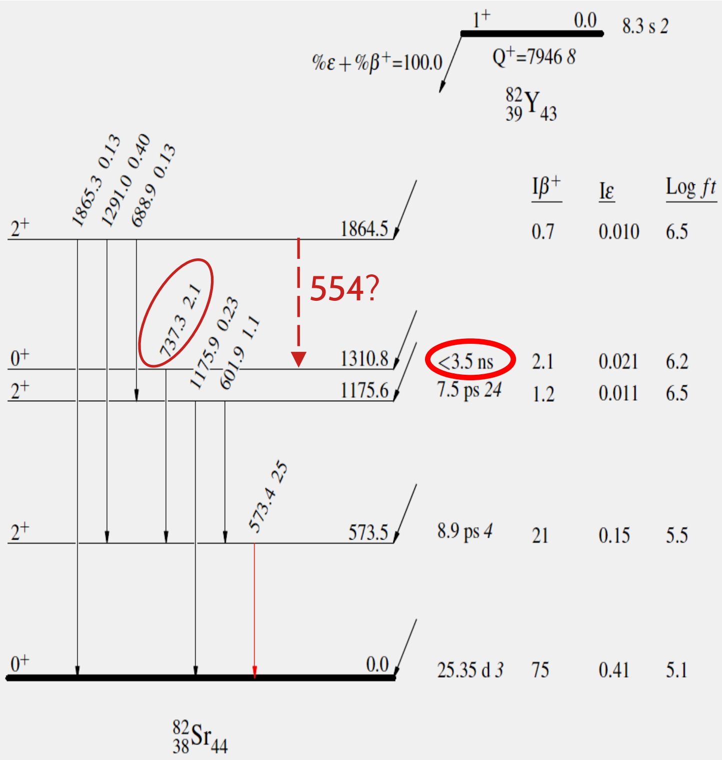
Estimated yield of 2.31E+04 ions/μC with 82YF2

Beam Time without SPEDE = 9 shifts

If SPEDE not available → 9 shifts aimed at angular correlations+lifetimes+new transitions (very large Q value!)

- Angular correlations of 737-573 keV cascade serve as demo for $0^+ \rightarrow 2^+ \rightarrow 0^+$ assignment
- Measure lifetime of 0_2^+ state via beta-LaBr(737)-Ge(573)
- Look for yet unknown 554 keV transition from $2_3^+ \rightarrow 0_2^+$
- Search for 0_3^+ band at ~2.665 MeV?





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Thanks to IDS collaboration, accelerator and target groups at ISOLDE

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