

Recent gamma-ray spectroscopy studies at the ROSPHERE array: The physics case of ^{32}Si

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Carpathian Summer School of Physics 2025

Exotic Nuclei and Nuclear/Particle Astrophysics (X)
Physics with small accelerators

22 June – 3 July 2025, Sinaia, Romania

Outline

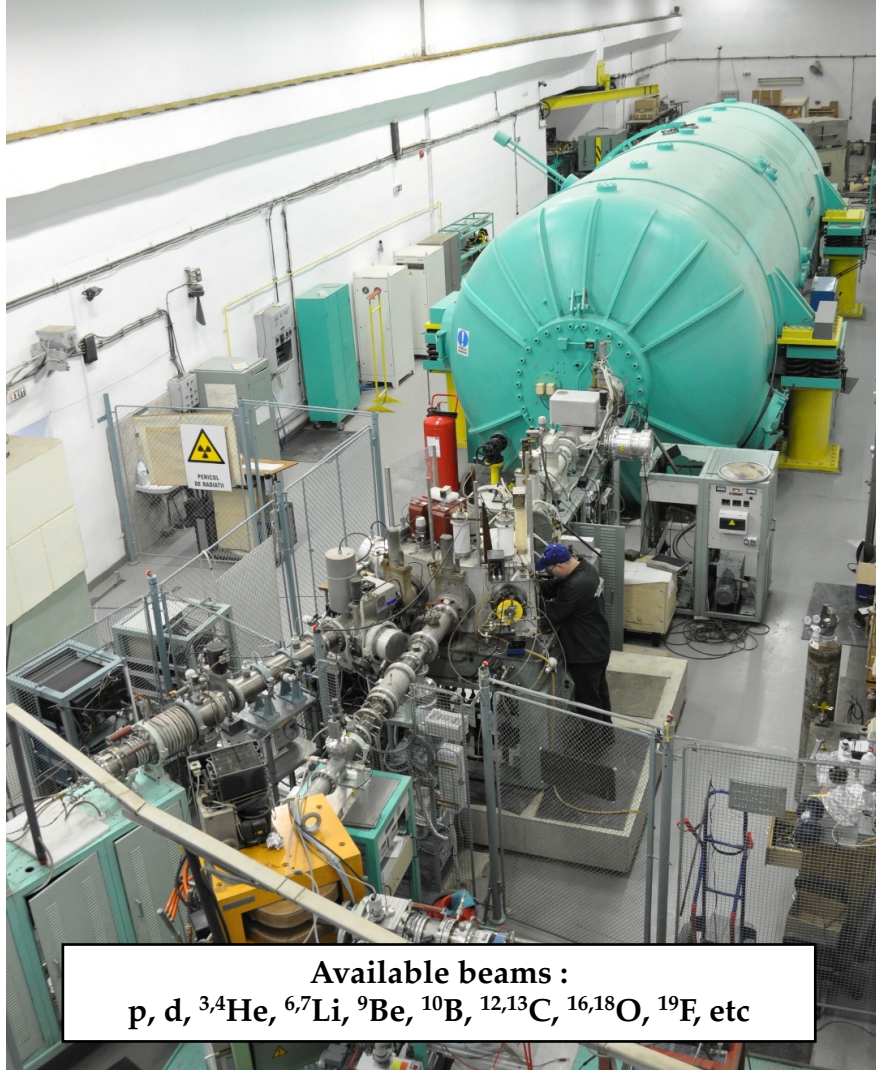
- ♦ The ROSPHERE array at the 9MV Tandem Accelerator of IFIN-HH
 - Overview of the 9MV Tandem Accelerator
 - Wide-range lifetime measurements with ROSPHERE
 - Heavy-ion transfer reactions with ROSPHERE and SORCERER
 - The new ROSPHERE-ELIGANT configuration
- ♦ The Physics Case of ^{32}Si
 - Shape coexistence and the N=20 “Island of Inversion”
 - Experimental study at the ROSPHERE array
 - Preliminary results

The HVEC FN Tandem 9MV Accelerator of IFIN-HH

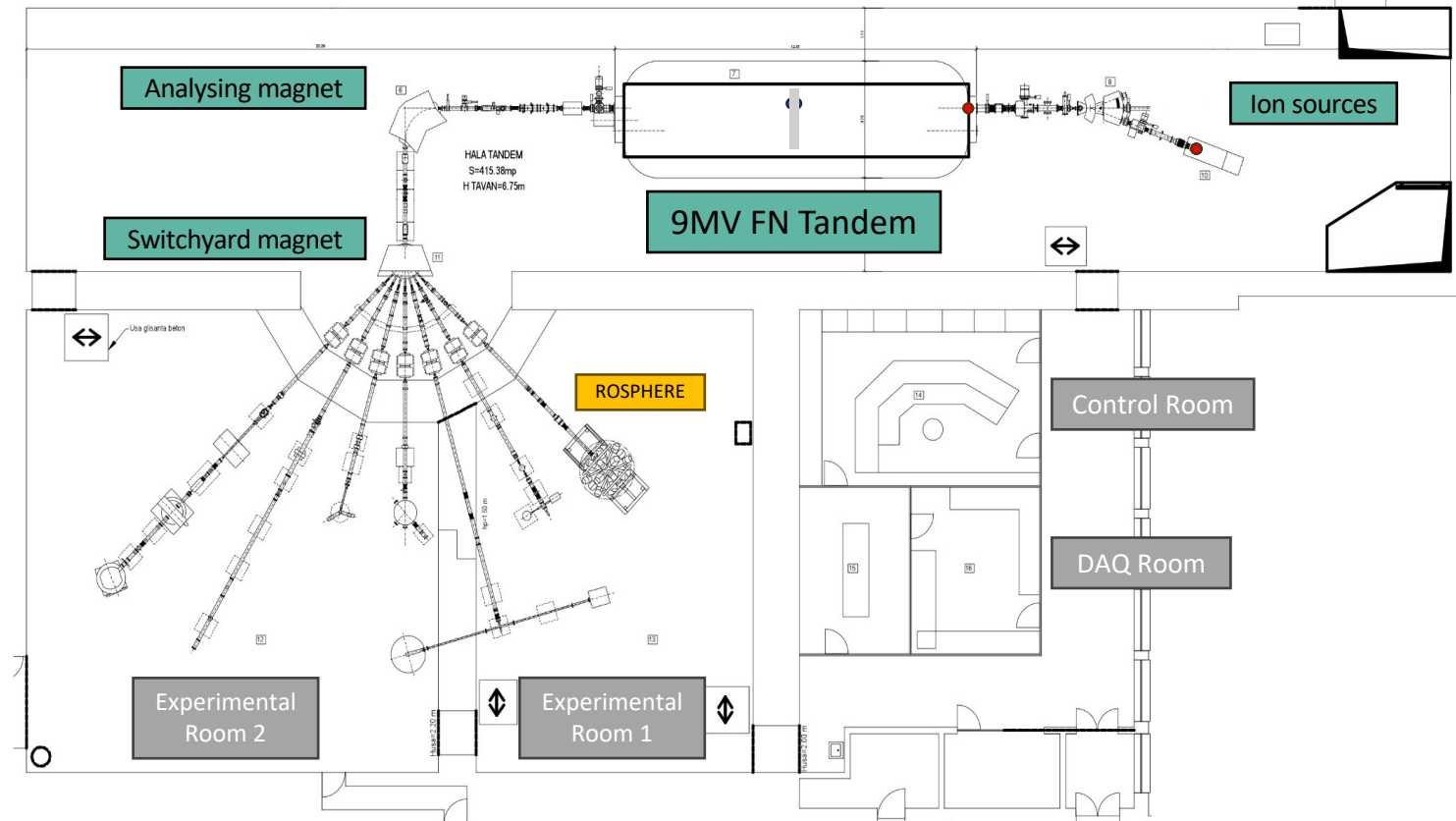


High Voltage Engineering Corporation

<https://www.highvolteng.com/>

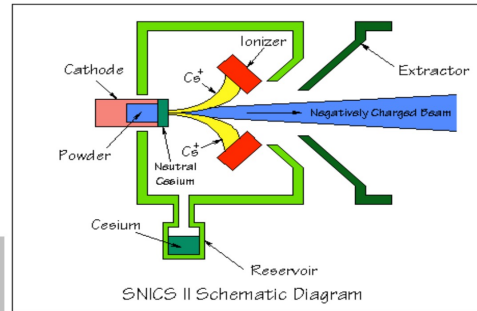


- ◆ 1973 – installation and reception of the 7.5 MV FN Tandem accelerator
- ◆ 1977 – 7.2 magnitude earthquake destroys the acceleration column
- ◆ 1983 – upgraded to 9MV
- ◆ 1986 – A second 6.2 magnitude earthquake affects the acceleration column
- ◆ 1990 – installation of a seismic protection system
- ◆ 2006 – 2012 The accelerator enters an extensive modernization process



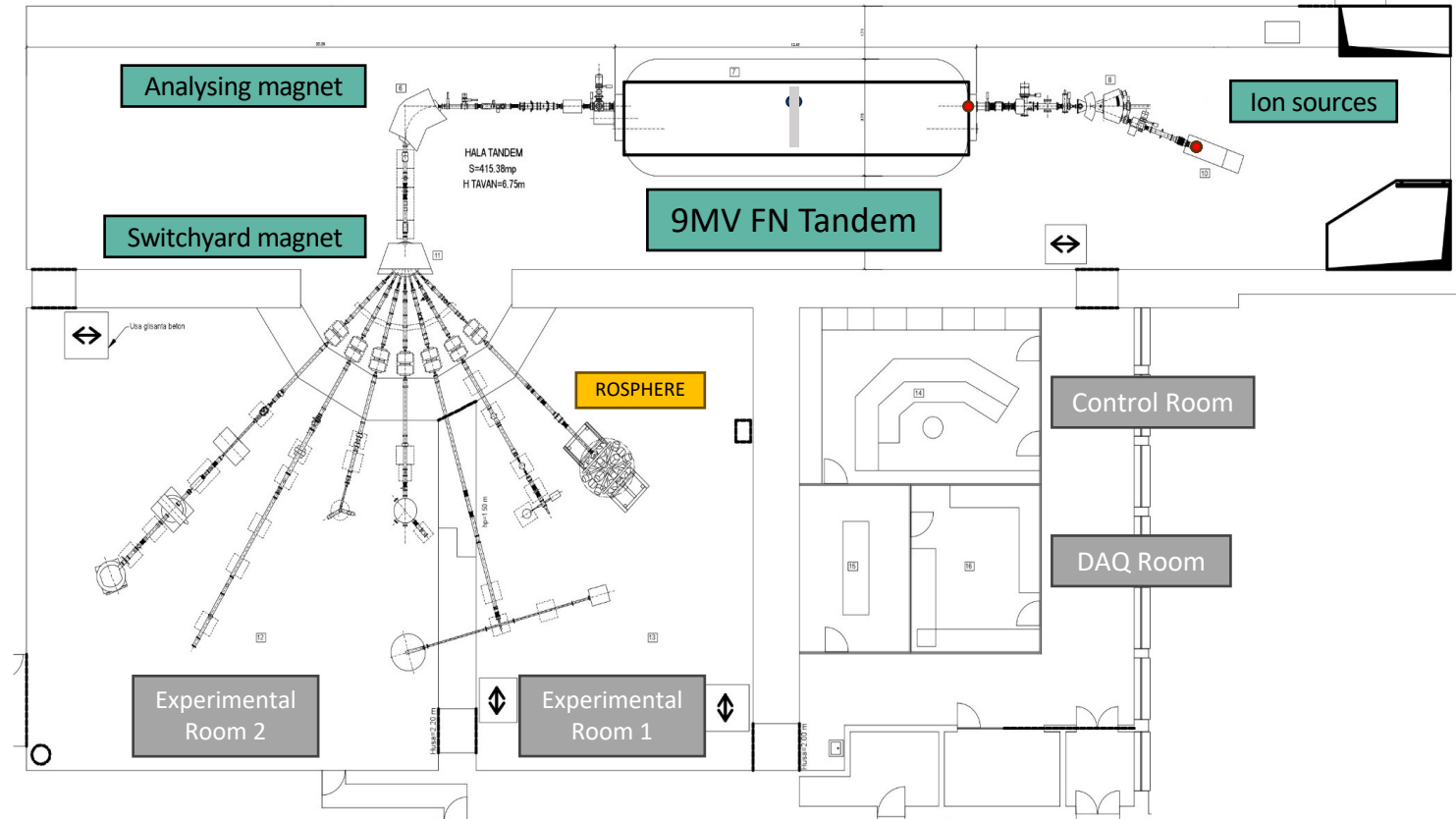
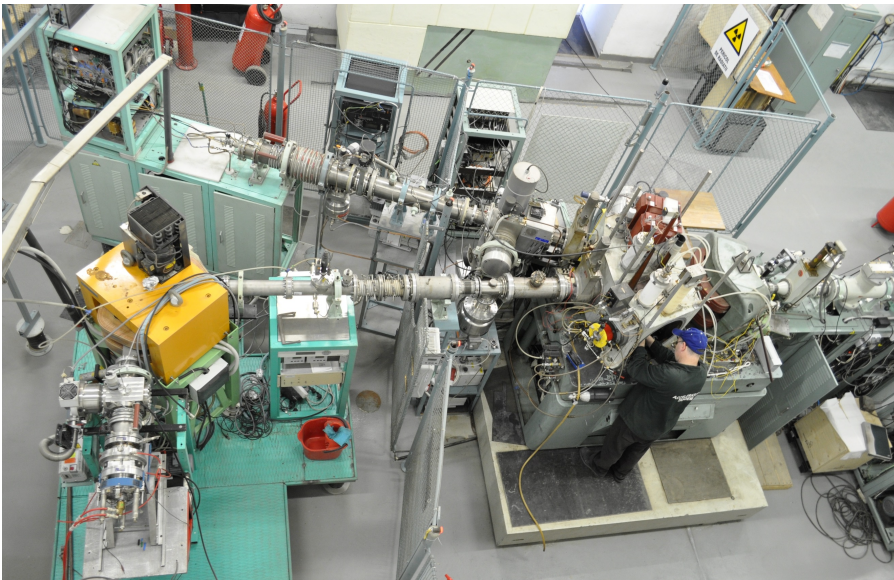
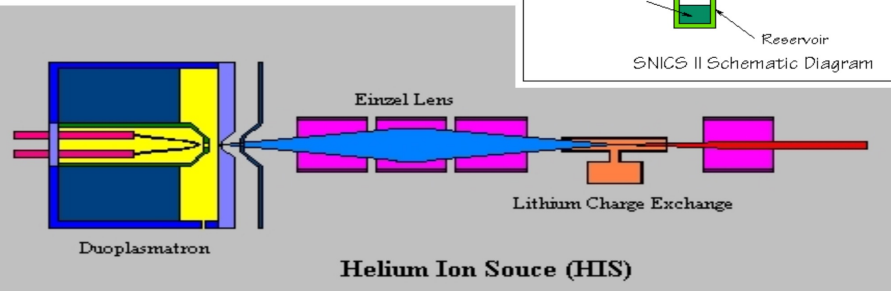
The HVEC FN Tandem 9MV Accelerator of IFIN-HH

Negatively charged beams for use in the Tandem are produced by ion sources outside the accelerator.



The Cs Sputter Ion Source: Cs vapors coming into contact with the ionizer is positively ionized and accelerated to 6 kV and sputters atoms from the cathode material. The sputtered atoms from the target material passing through the neutral Cs layer forms the negative ion beam which is pre-accelerated by the 50 kV voltage and injected in the accelerator, after filtering it through the injection bipolar magnet.

The Duoplasmatron Source: delivers positive ion beams from the gases injected into the duoplasmatron head. The ions are extracted from the source under a 20 kV potential and passes through a Li/Na charge exchange section, resulting in the negative ion beam. The duoplasmatron is mainly used for the delivery of the deuterium and $^3,4\text{He}^-$ beams.



The HVEC FN Tandem 9MV Accelerator of IFIN-HH

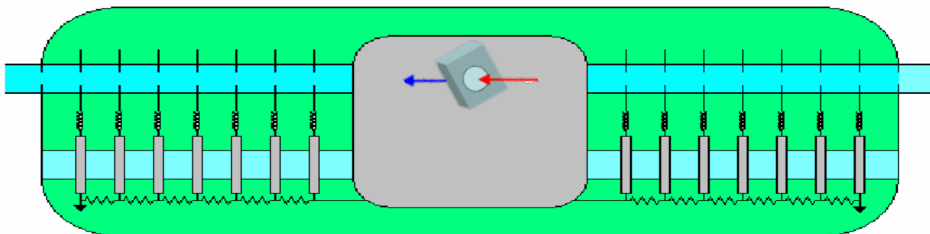


A thin carbon foil is placed in the beam tube at the center of the terminal. As the negatively charged beam strikes the foil (at fairly high energy), electrons are stripped from the ions, leaving them positively charged.

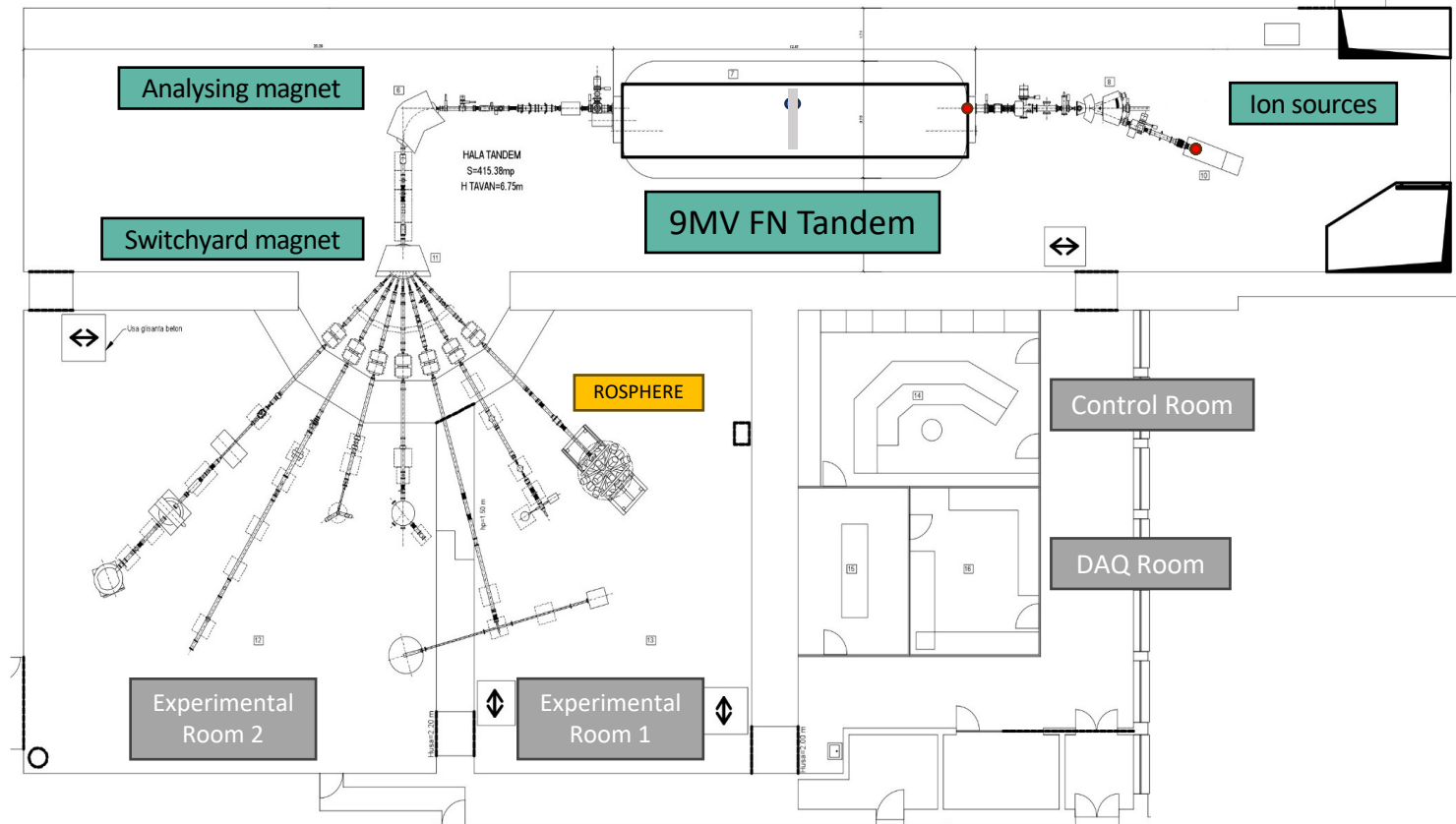
Positively Charged Beam Exits the Stripper Foil

$3 \mu\text{g}/\text{cm}^2$
Carbon
Stripper Foil

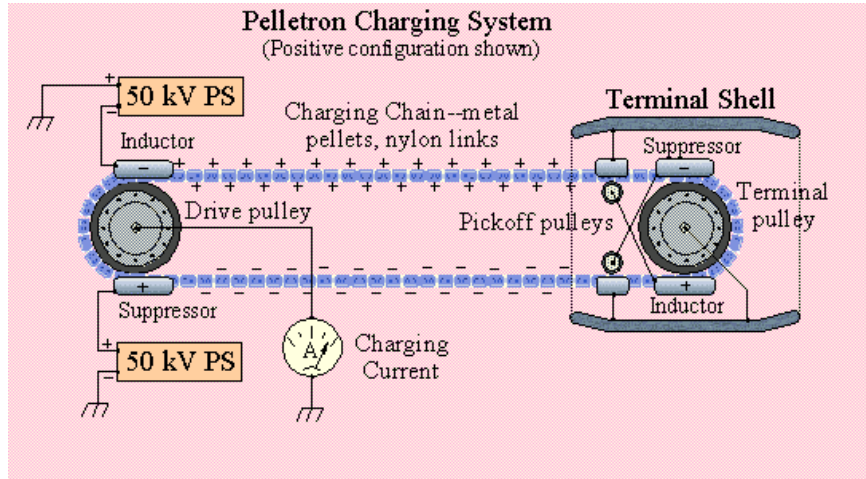
Negatively Charged Beam Enters the Stripper Foil



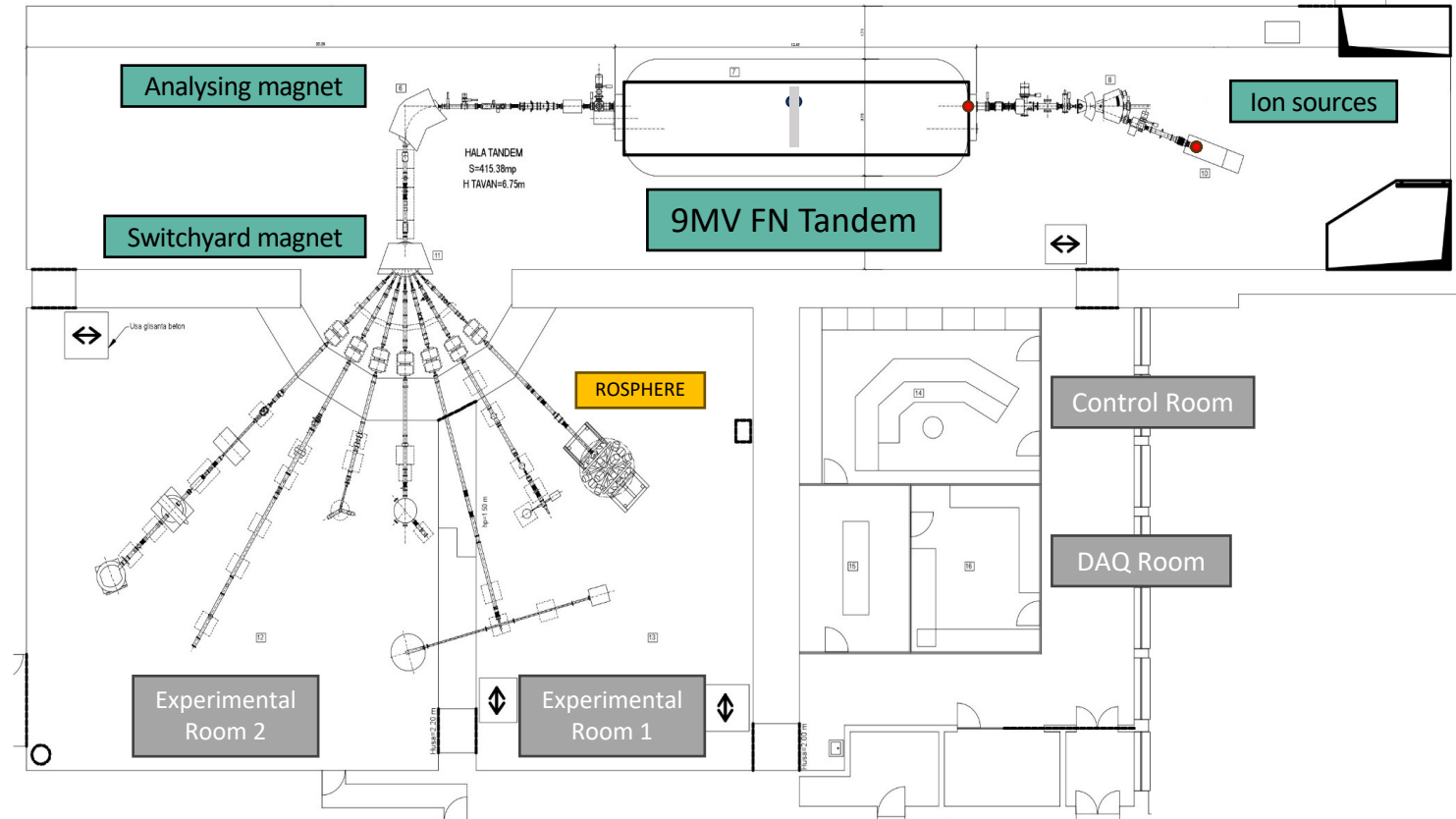
- The terminal is supported by a structure known as the column, which is a sandwich of glass blocks and metal planes. The column is held in place by compression supplied by a huge spring. The beam tubes are mounted along the side of the column.
- The steel pieces are linked with resistors (300 M Ω) and this represents a voltage divider from the maximum terminal potential to the ground potential (the ends of the tank).
- The entire accelerator is housed inside a large steel tank that is pressurized to approximately 11 bar with an insulating gas (SF_6 and N_2 mixture) to help prevent electrical discharges and to protect lab personnel.



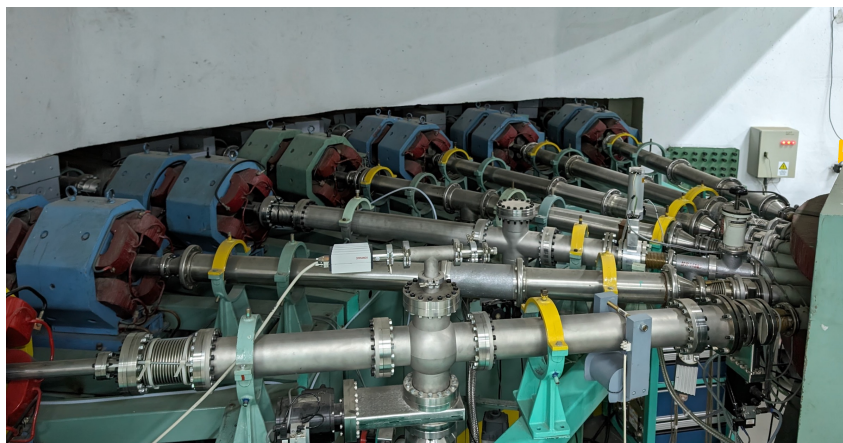
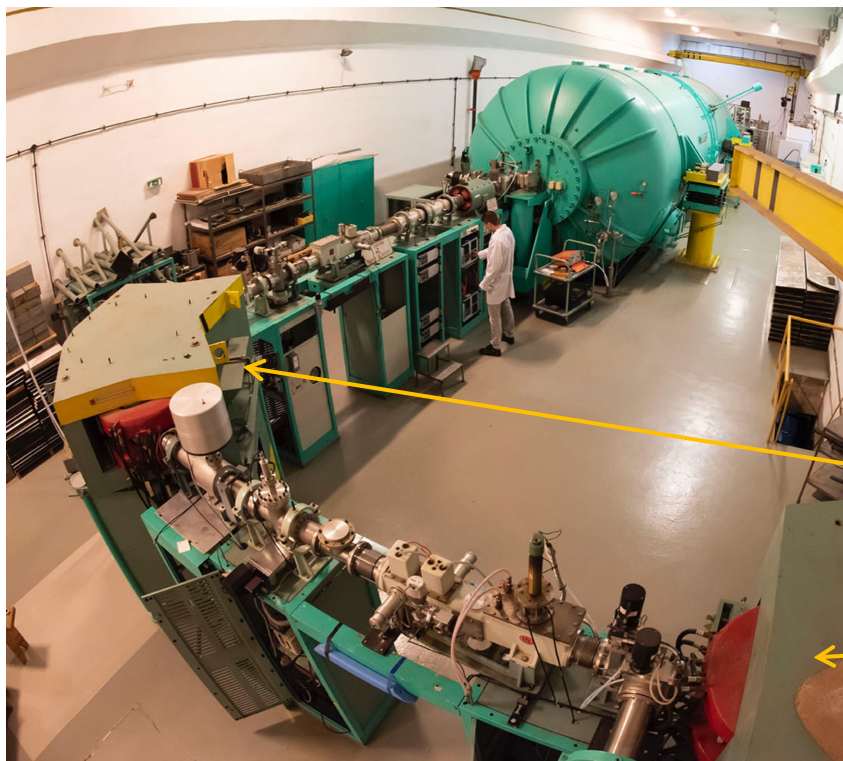
The HVEC FN Tandem 9MV Accelerator of IFIN-HH



The charging system known as a “pelletron” uses charged metal pellets connected by nylon links, rather than the traditional charging belt. Each link of the chain is slightly charged, and as the chain travels from the end of the accelerator to the terminal, charge is carried to the terminal.

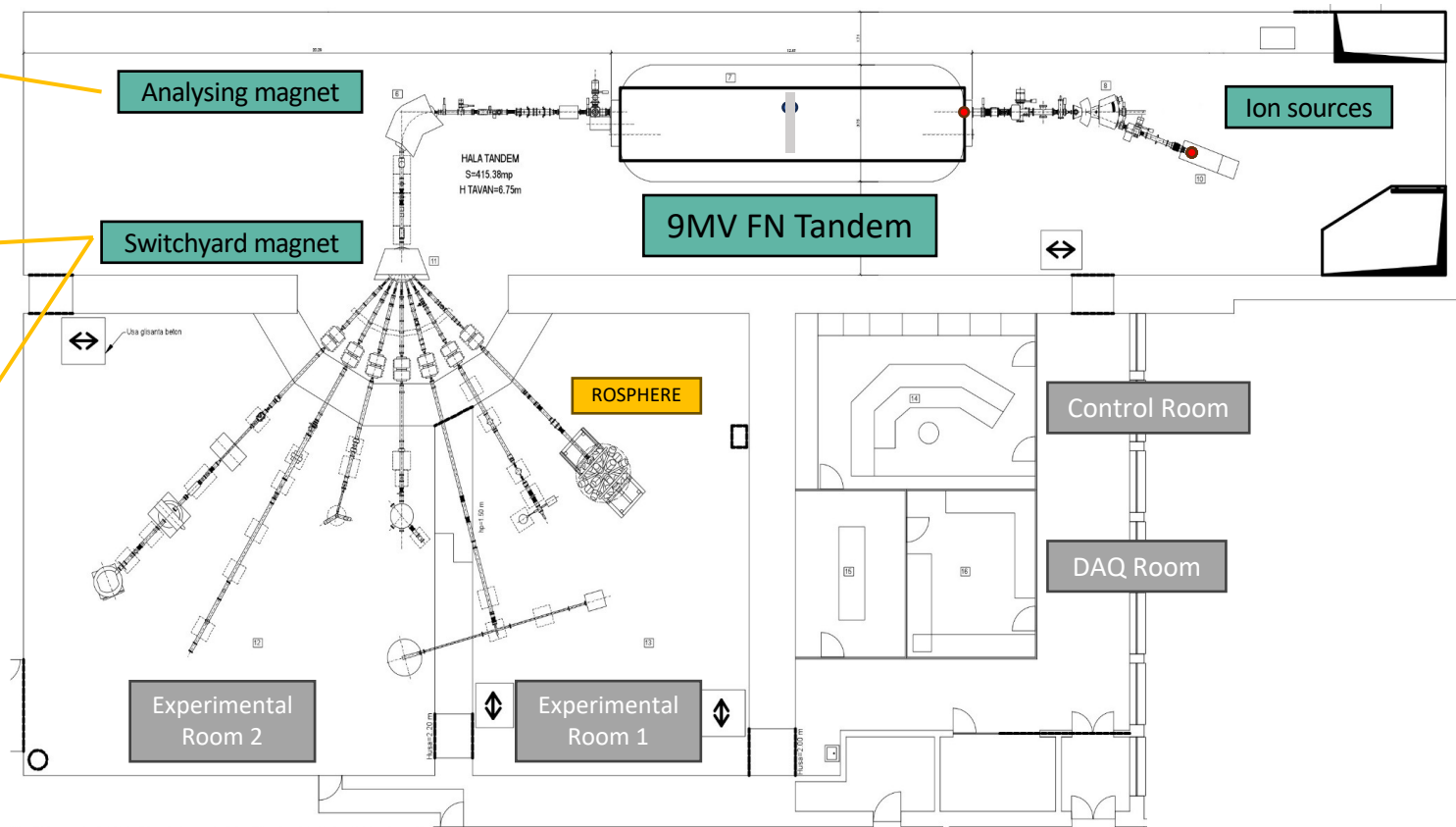
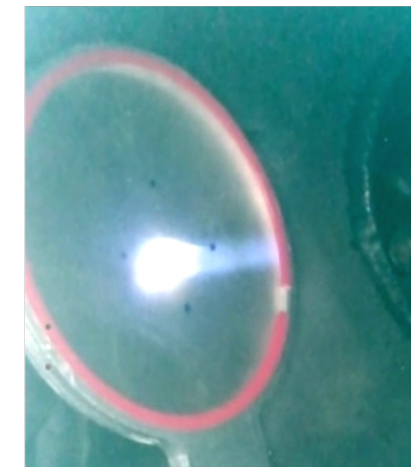


The HVEC FN Tandem 9MV Accelerator of IFIN-HH



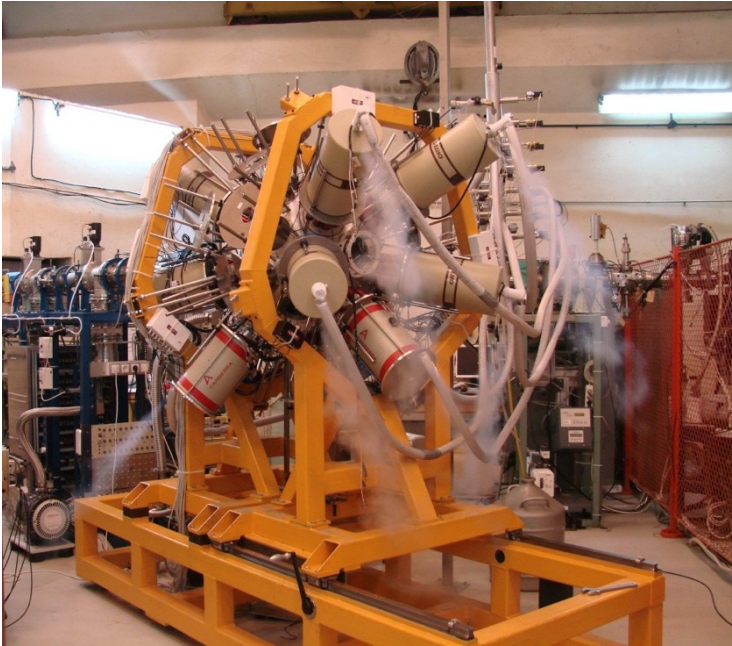
Beam transport and selection

- Einzel lens and Quadrupoles (focusing)
- Analysing dipole electromagnet (selection)
- Switchyard dipole electromagnet (sending beam to the desired beamline)
- Faraday cups (diagnosis)
- Slits (collimation and HV control)



The HVEC FN Tandem 9MV Accelerator of IFIN-HH

ROSPHERE - ROmanian array for SPectroscopy in HEavy ion REactions

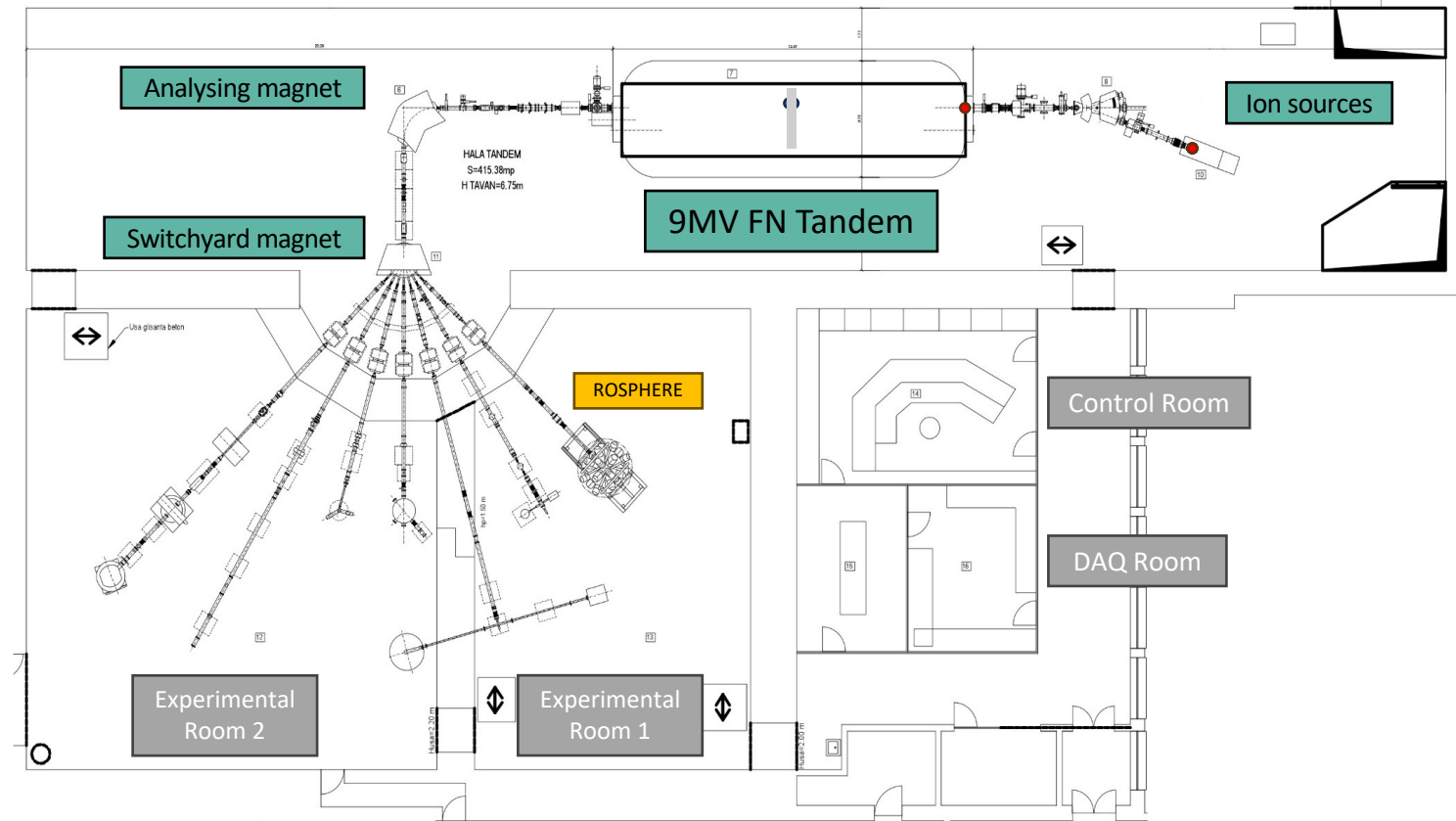
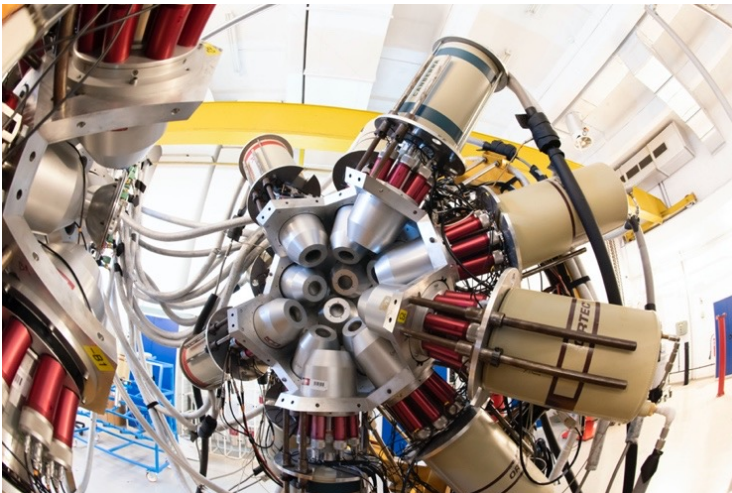


4 π array with three configurations:

- Full HPGe configuration (25 detectors)
- Mixed fast-timing configuration with $\text{LaBr}_3(\text{Ce})$
- High energy ELIGANT/ROSPHERE

Multidetector gamma-ray spectrometer dedicated to fundamental research in:

- Nuclear Structure
- Nuclear Reactions
- Nuclear Astrophysics
- Evaluation of Nuclear Data



IFIN-HH Target Preparation laboratory

http://tandem.nipne.ro/target_lab.php

Research services: Preparation and characterization of targets for nuclear structure experiments for IFIN-HH 9 MV Tandem Accelerator and international research facilities collaborators

Fully equipped target laboratory:



Methods:

- PVD - Physical Vapor Deposition
resistive heating
electron beam-based systems
- Cold rolling
- Tablet pressing

Characteristics of targets:

- material (natural/isotopically enriched)
- self-supported or backed
- thickness in units of $\mu\text{g}/\text{cm}^2$ - mg/cm^2
- backing characteristics

Elements featured in the nuclear targets

1 H																	2 He	
3 Li	4 Be	● Targets available at IFIN-HH (2025)																10 Ne
11 Na	12 Mg																	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og	

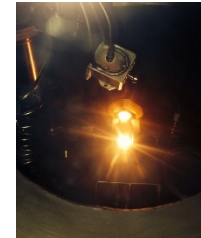
● Targets available at IFIN-HH (2025)

Examples of targets:

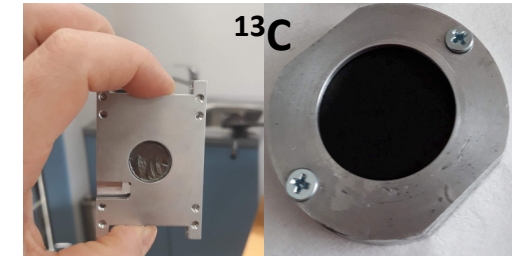
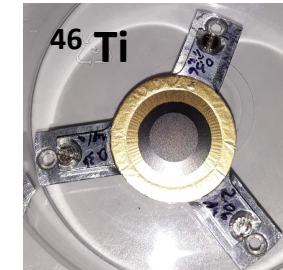
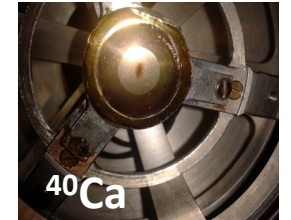
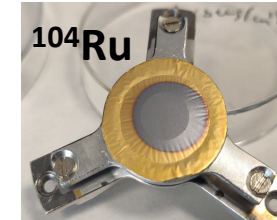
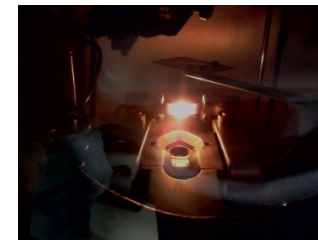
magnetron sputtering



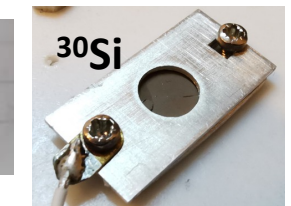
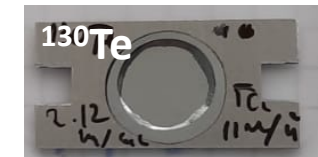
electron bombardment evaporation



resistive heating



Physics Letters B 834 (2022) 137398



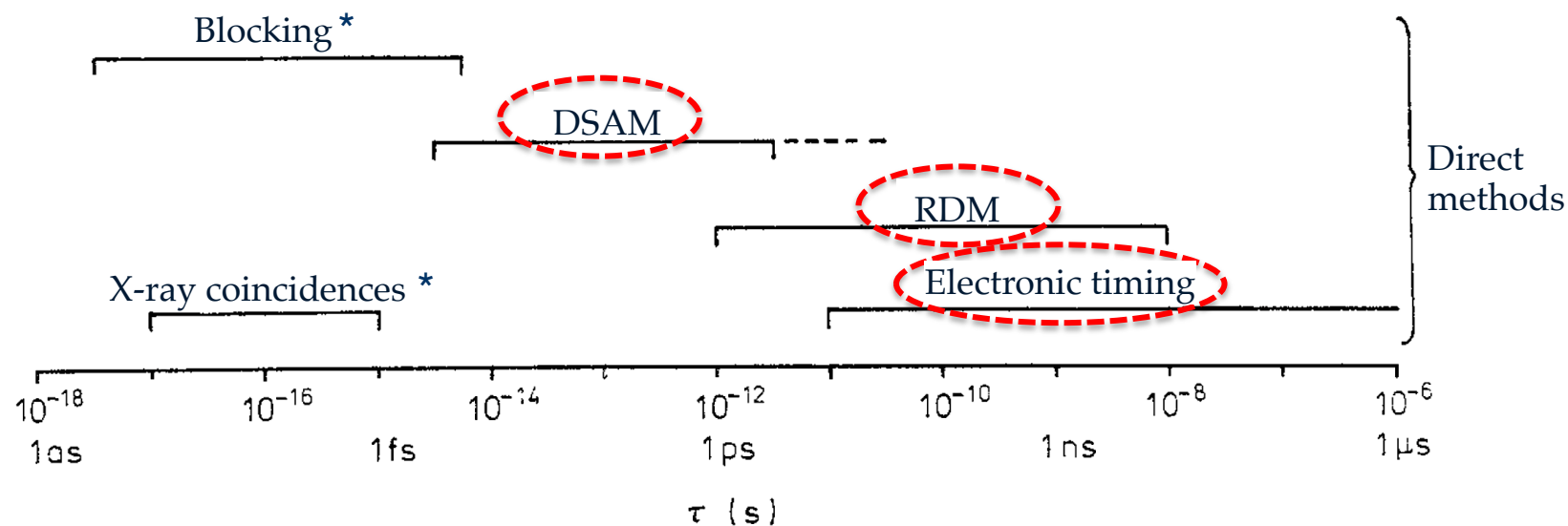
Journal of Radioanalytical Nuclear (2015) 305, 707
Journal of Radioanalytical Nuclear (2018), 316, 725
Vacuum (2019), 161, 162

EPJ Web of Conferences (2020) 229, 03001
Vacuum (2023) 215, 112250
INTDS Newsletter (2023)

Wide-range lifetime measurements with ROSPHERE

The transition matrix elements give fundamental information about the structure of the states involved and are benchmark tests for the predictions of nuclear models.

ROSPHERE can access a wide range of nuclear lifetimes through a combination of methods and configurations:



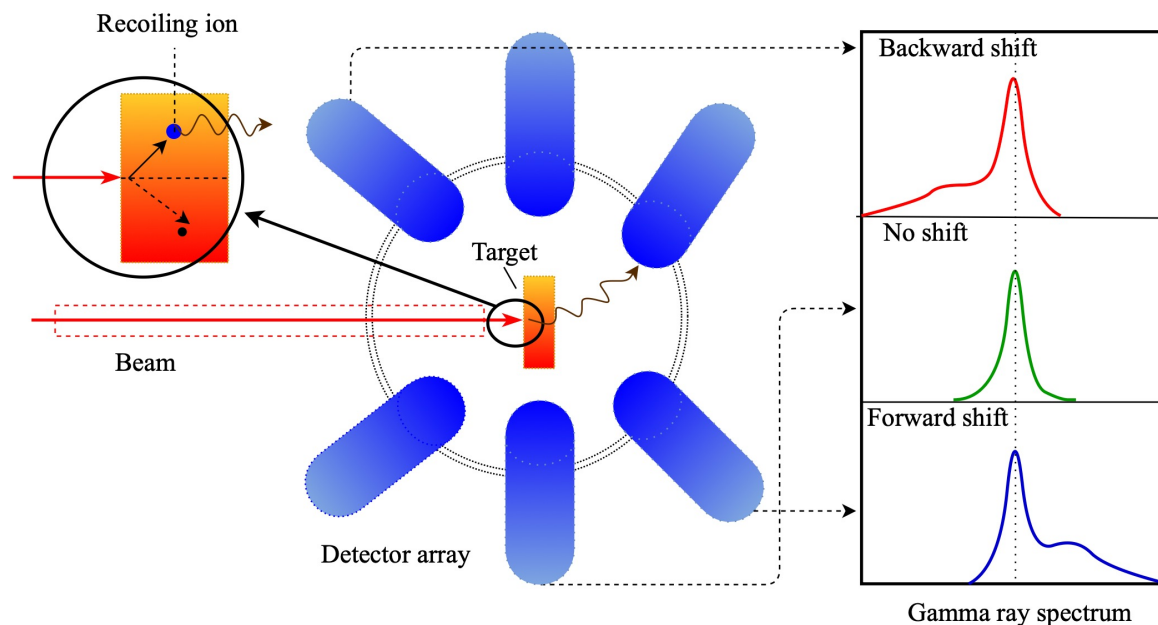
* Exotic techniques applicable to specific cases General techniques available at ROSPHERE

Wide-range lifetime measurements with ROSPHERE

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ROSPHERE can access a wide range of nuclear lifetimes through a combination of methods and configurations:

♦ 0.01-1 ps via **DSAM (Doppler Shift Attenuation Method)**



$$\overline{E}_s(\theta) \approx E_0 \left(1 + \frac{\overline{v}}{c} \cos\theta \right)$$

where:

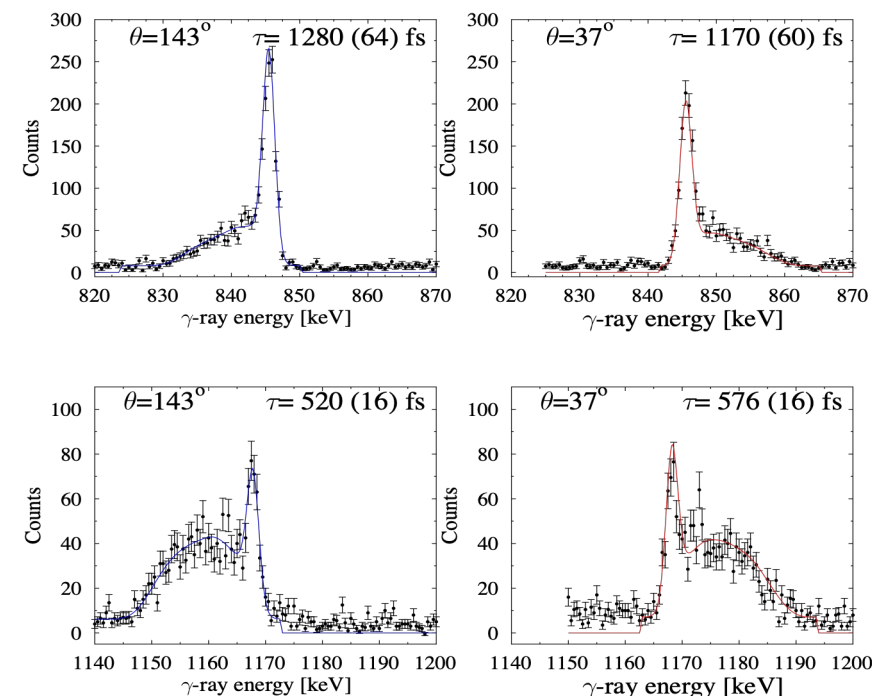
E_0 — photon energy emitted at rest

$\overline{E}_s$ — average photon energy emitted while stopping

$\overline{v}$ — average velocity of the recoil nucleus

θ — photon emission angle wrt the direction of the nucleus

$^{62}\text{Ni}(^{13}\text{C}, ^{12}\text{C})^{63}\text{Ni}$ at 28 MeV, $E_\gamma = 846$ and 1168 keV



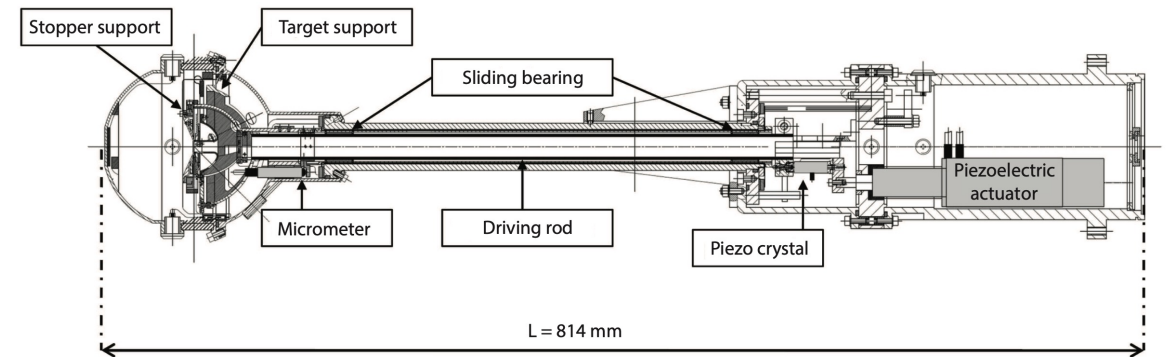
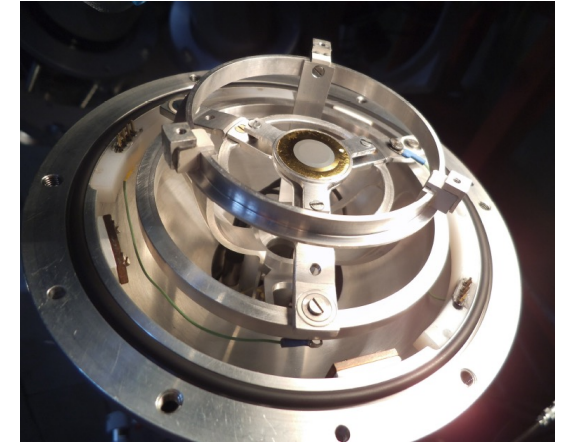
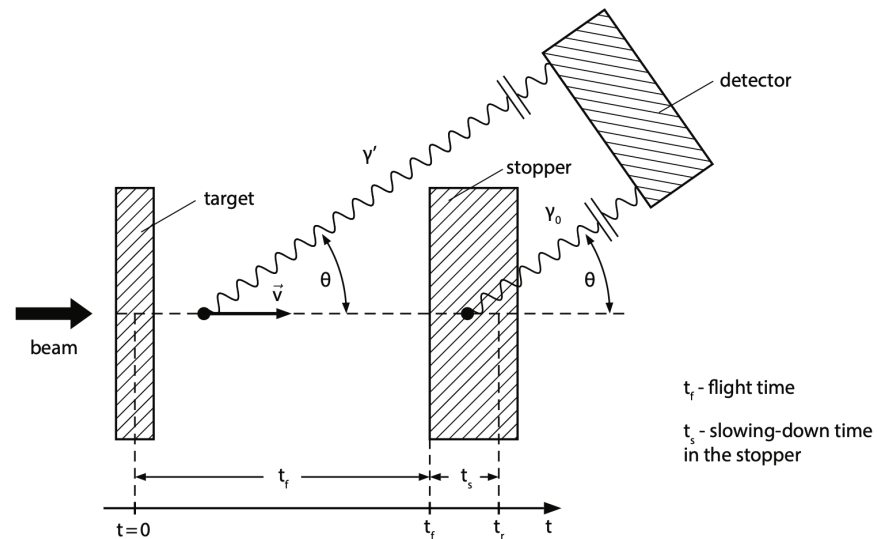
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- ♦ 1-100 ps via **RDM (Recoil Distance Method)**

In-flight decay of a nucleus:



The Bucharest plunger device:

- was developed based on a design developed at Institute for Nuclear Physics (IKP) of the University of Cologne
- a piezoelectric actuator and a piezoelectric crystal move the target. They are connected to a feed-back loop that maintains the target to stopper distance

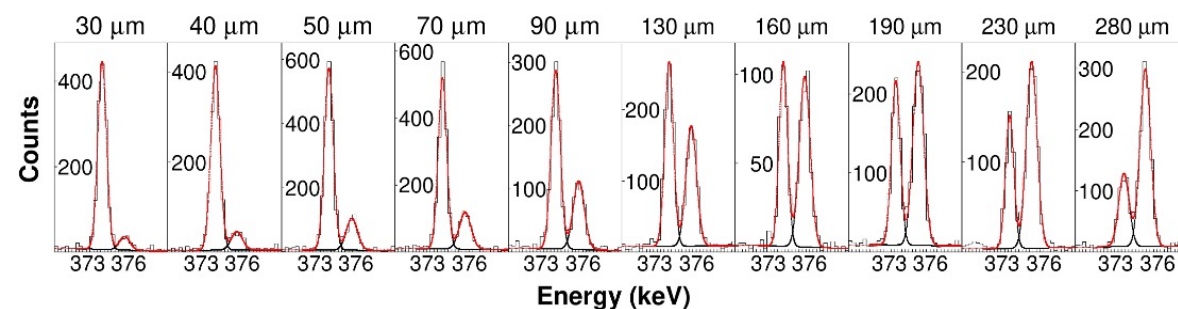
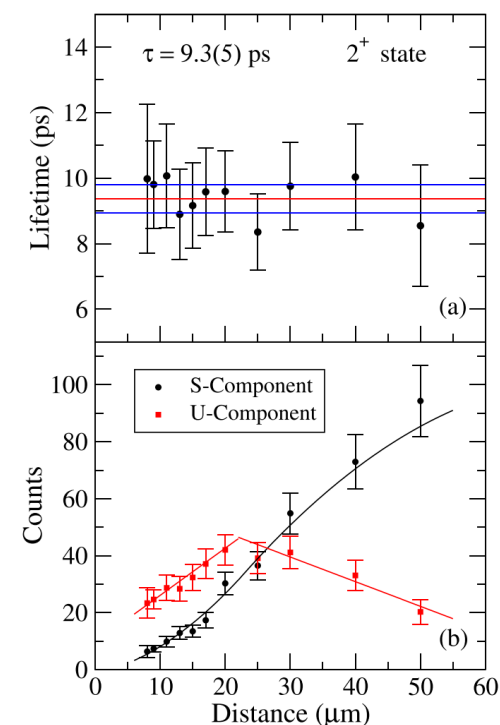
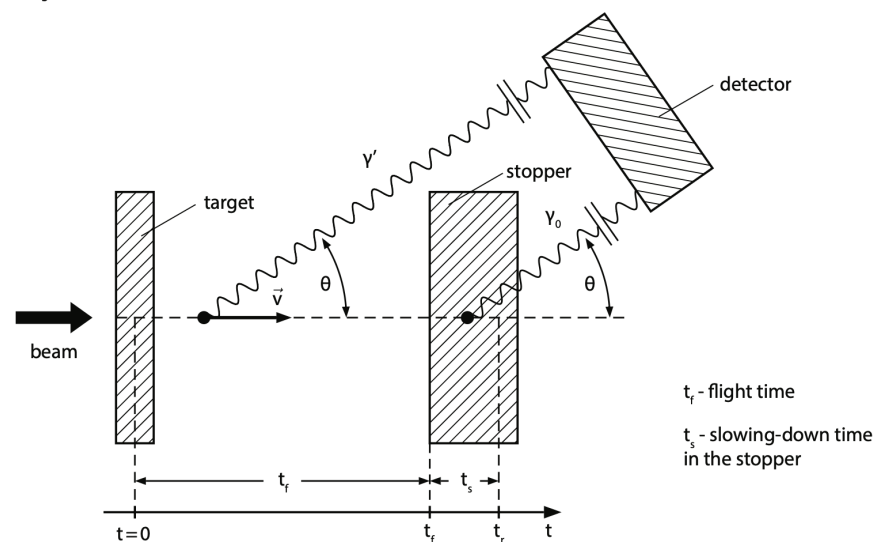
Wide-range lifetime measurements with ROSPHERE

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ROSPHERE can access a wide range of nuclear lifetimes through a combination of methods and configurations:

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In-flight decay of a nucleus:

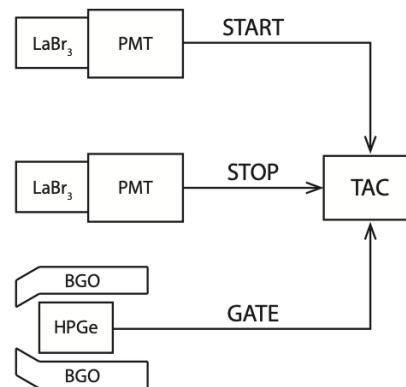
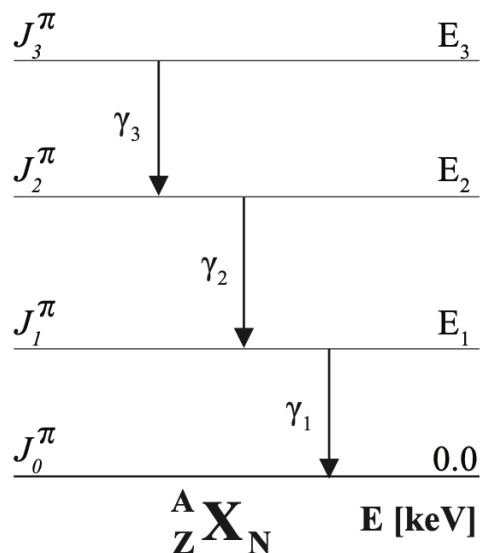


Wide-range lifetime measurements with ROSPHERE

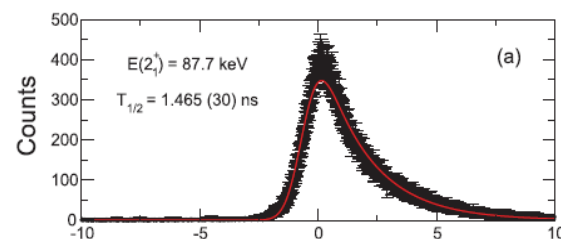
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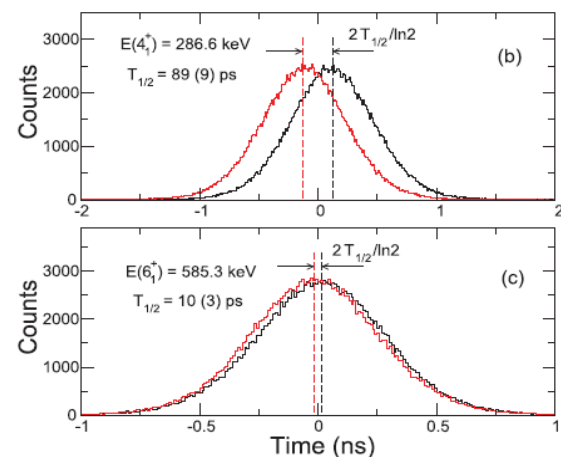
- ♦ 0.01-1 ps via DSAM (Doppler Shift Attenuation Method)
- ♦ 1-100 ps via RDM (Recoil Distance Method)
- ♦ 10 ps-10 ns via **fast-timing**



Slope method (> 100 ps)



Centroid shift method (10-100 ps)



Wide-range lifetime measurements with ROSPHERE

The transition matrix elements give fundamental information about the structure of the states involved and are benchmark tests for the predictions of nuclear models.

ROSPHERE can access a wide range of nuclear lifetimes through a combination of methods and configurations:

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- ♦ 1-100 ps via RDM (Recoil Distance Method)
- ♦ 10 ps-10 ns via fast-timing
- ♦ 10 ns- 10 μ s via **fast beam-pulsing**



Pulsing systems

1. Millisecond pulsing system.

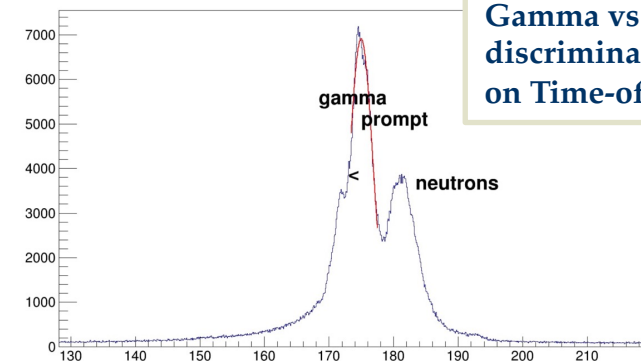
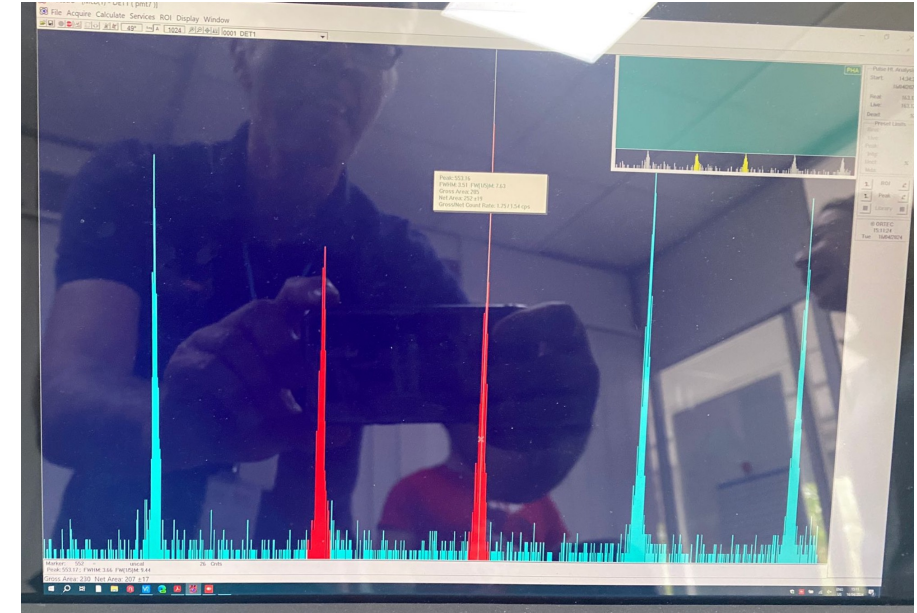
The millisecond pulsing system was built by Dr. Sorin Papureanu and Dorin Moisa and it is practically an electrostatic deflection unit used to chop the continuous beam from millisecond range to hundreds of seconds. The system was mainly used for activation measurements, when decay time of the studied nuclei was in the range of pulsing system. The control module made by Dorin Moisa was able to control the acquisition system in order to start writing the data between two pulses or during one pulse.



2. Nanosecond pulsing system.

The nanosecond pulsing system was installed in 2009. The system is manufactured by NEC and it uses a system for chopping the beam and a system to bunch the already chopped beam. The system uses a 5 MHz RF generator for making the bunches. Typically the bunches are 200 ns apart, but a system called sweeper allows to make this difference bigger to 400, 800 and so on. The efficiency of bunching is around 25% of the continuous beam.

Happy spokesperson* with ~ 2.5 ns wide beam pulses



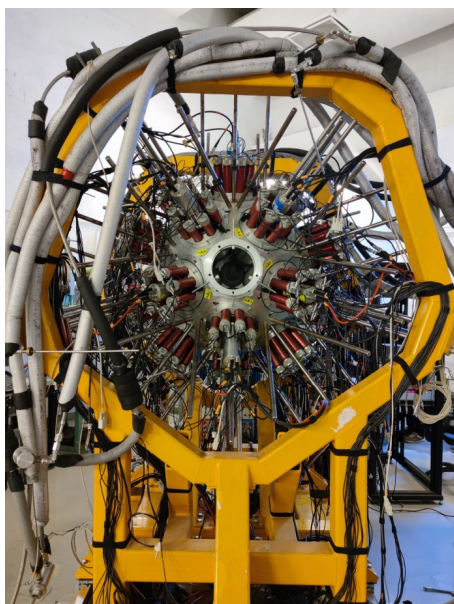
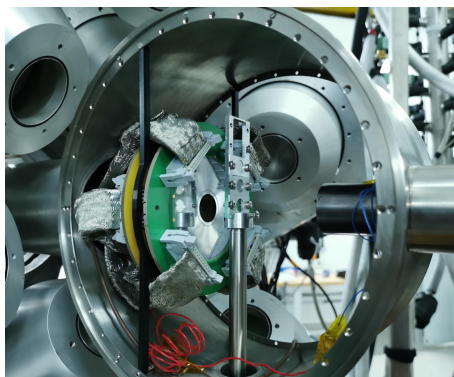
**Gamma vs Neutron
discrimination based
on Time-of-Flight**

* O. Wieland, "Search for HOT PDR in neutron rich ^{66}Ni at finite temperature", 2024

ELIGANT+ROSPHERE campaign

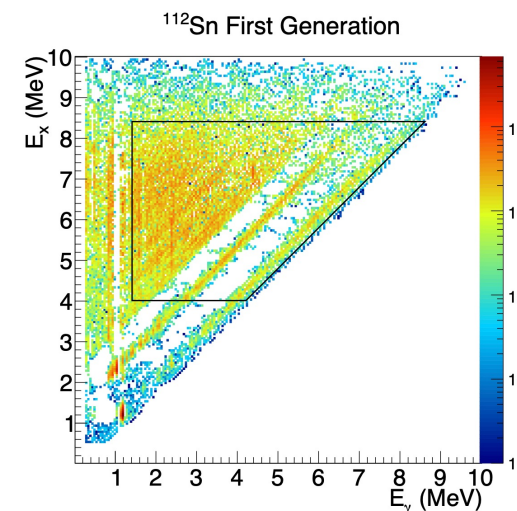
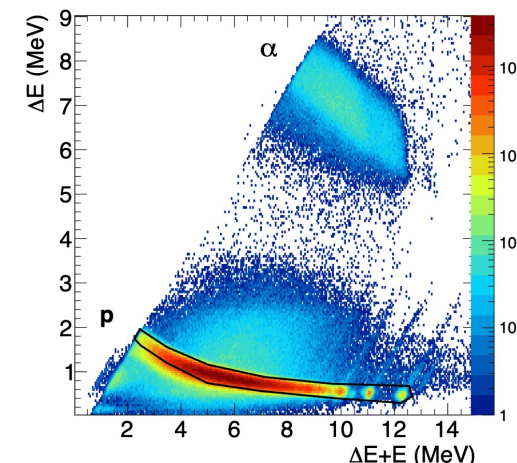
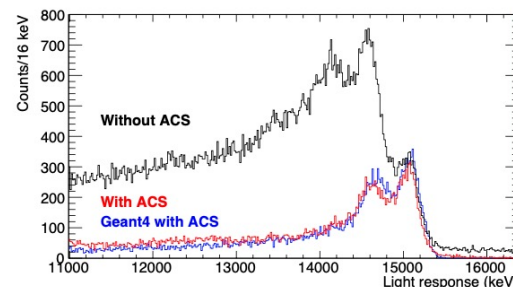
ELI-NP, IFIN-HH, and Tandem → ELIFANT

- ▶ Combining the large volume γ -ray detectors with the ROSPHERE anti-Compton shields
- ▶ In-beam experiments using the 9MV Tandem at IFIN-HH
- ▶ Collaboration between ELI-NP and Department of Nuclear Physics
- ▶ Clean measurements of high-energy γ -rays



ROSPHERE performance

- ▶ Two example configurations:
 - ▶ Camera+Wieland - 21 LaBr₃
 - ▶ Constantin - 23 LaBr₃, collimators
- ▶ Efficiency $\sim 1\%$ at 10 MeV
- ▶ ACS peak-to-total $\sim 10\%$ at 20 MeV (>1.5 MeV background)



Courtesy of P-A Soderstrom

Heavy Ion Transfer Reactions

Heavy ion equivalents of “classical” transfer reaction:

- $(d,p) \leftrightarrow ({}^{13}\text{C}, {}^{12}\text{C})$
- $(t,p) \leftrightarrow ({}^{18}\text{O}, {}^{16}\text{O})$
- $(t,\alpha) \leftrightarrow ({}^{11}\text{B}, {}^{12}\text{C})$

Advantages:

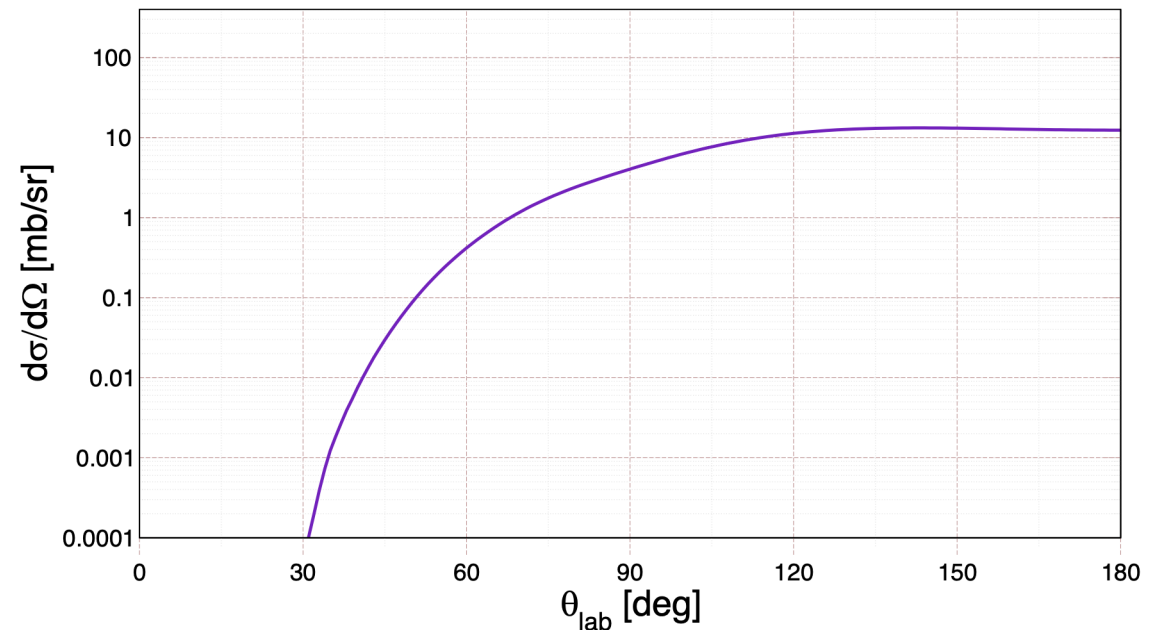
- Clean data if performed below the Coulomb barrier
- High recoil velocity
- Recoil velocity distribution is forward focused
- Selective population of states in the residual nucleus

Heavy ion transfer reactions can be used at ROSPHERE to measure the lifetime of 0^+ states

5% below Coulomb barrier

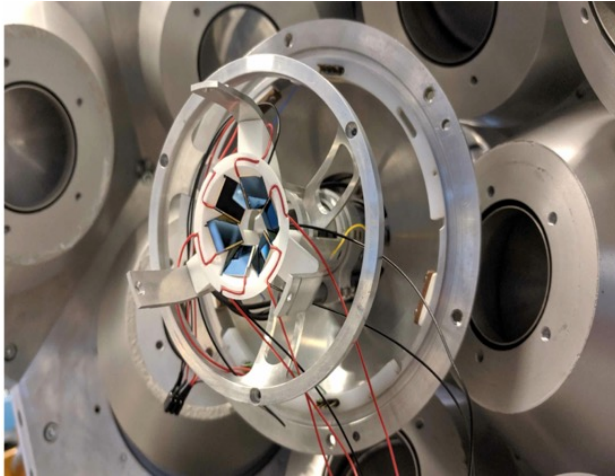
→ The heavy partner is going in the forward direction

${}^{12}\text{C}$ angular distribution for different ${}^{13}\text{C}$ incident energies
 ${}^{62}\text{Ni}({}^{13}\text{C}, {}^{12}\text{C}){}^{63}\text{Ni}$ 28 MeV 5% below Coulomb Barrier

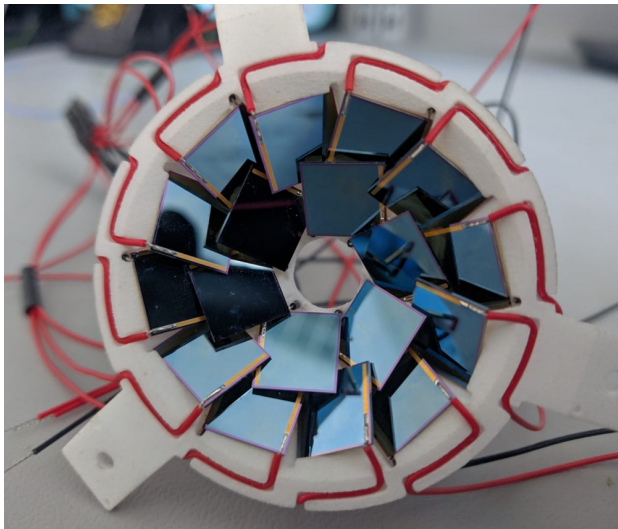


A dedicated detector for sub-barrier transfer

SORCERER v1 (6 cells)



SORCERER v2 (18 cells)



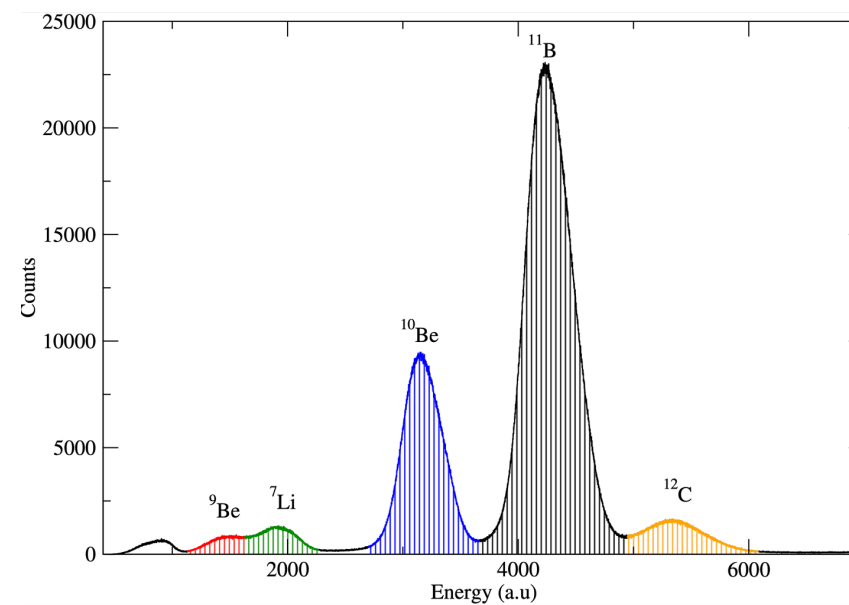
Nuclear Instruments and Methods in Physics
Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment

Volume 951, 21 January 2020, 163090

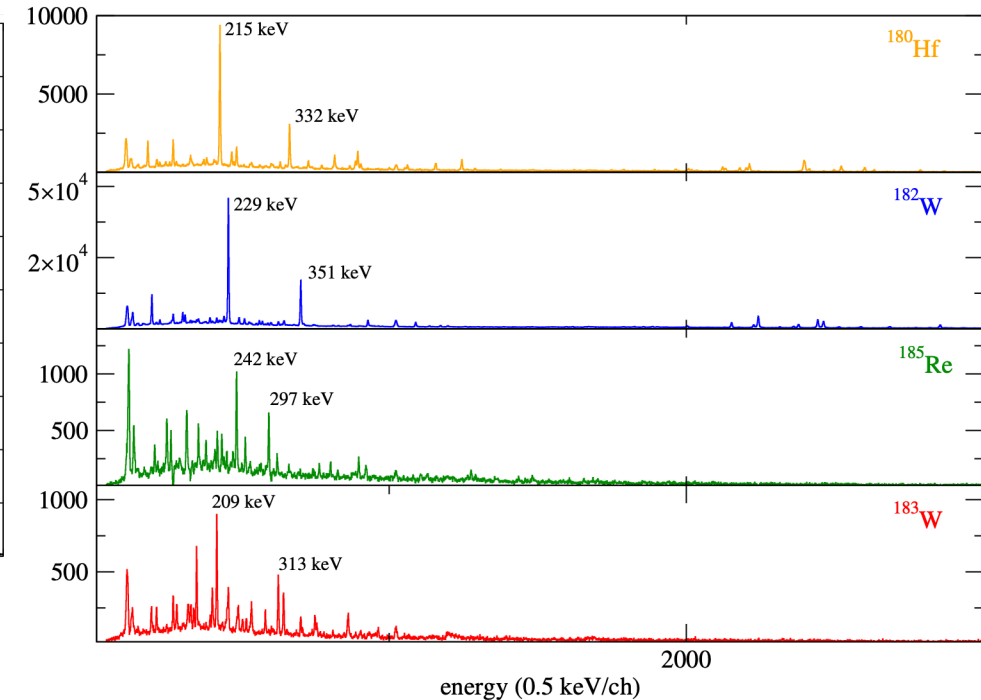


SORCERER: A novel particle-detection system for transfer-reaction experiments at ROSPHERE

T. Beck ^{a, ✉}, C. Costache ^b, R. Ličá ^b, N. Mărginean ^b, C. Mihai ^b, R.E. Mihai ^b, O. Papst ^a, S. Pascu ^b, N. Pietralla ^a, C. Sotby ^b, L. Stan ^b, A.E. Turturică ^b, V. Werner ^a, J. Wiederhold ^a, W. Witt ^a



$^{11}\text{B} + ^{181}\text{Ta} @ 49\text{MeV}$



Access policy

<https://useroffice.nipne.ro/>

- ♦ Open-access facility, proposals are evaluated by a Physics Advisory Committee (PAC) based on scientific merit.
- ♦ PAC members:
 - Primoz Pelicon (Jožef Stefan Institute, Slovenia)
 - Norbert Pietralla (IKP, Uni-Darmstadt, Germany)
 - Georgi Georgiev (IJC-Lab Orsay, France)
 - Silvia Leoni (Uni-Milano, Italy)
 - Timo Sajavaara (JYFL, Finland)
 - Anna Mackova (Nuclear physics Institute of the Czech Academy of Sciences, Czech Republic)
 - Zsolt Podolyak (University of Surrey, UK)



The 9MV Accelerator together with the 3 and 1 MV Tandetrans of IFIN-HH are part of the EURO-LABS project.



Access policy

<https://useroffice.nipne.ro/>

◆ Beamtime schedule for 2025 at the 9MV Tandem Accelerator

- ~ 4500 hours of beamtime (190 days)
- 19 experiments
- User community: 20% local, 80% international

IFIN-HH 9 MV Tandem Accelerator Schedule January - July 2025														IFIN-HH 9 MV Tandem Accelerator Schedule August - December 2025																					
L1 setup legend				L1 setup legend																															
Fast-timing				Fast-timing																															
HPGe+SC/DSSD				HPGe+SC/DSSD																															
Plunger				Plunger																															
EUGANT				EUGANT																															
January		February		March		April		May		June		July		August		September		October		November		December													
1 We	Winter Holidays	1 Sa	P. Vasileiou (L1) 12C + 176Yb 60 MeV	1 Sa	K. Gladnishki (L1) 13C + 122,124Sn 47 MeV	1 Tu	D. Kahl, A. Rotaru (L5 TPC)	1 Th	Holiday	1 Su	S. Bagchi (L1)	1 Tu	W. Korten (L1)	1 Fr		1 Mo		1 We	E. Stefanova (L1) 118 + 82Se 40 MeV	1 Sa	P. Koseoglou (L1) 180 + 170Er 69 MeV	1 Mo	Holiday												
2		2		2		2		2		2		2		2		2		2		2		2		2	2	2	2	2	2	2	2	2			
3		3 Mo		3 Mo		3		3		3		3		3		3		3		3		3		3	3	3	3	3	3	3	3	3	3		
4		4		4 Tu		4 Tu		4		4		4		4		4		4		4		4		4	4	4	4	4	4	4	4	4	4		
5		5		5		5		5		5 Mo		5		5		5		5		5		5		5	5	5	5	5	5	5	5	5	5		
6 Mo		6		6 Th		6 Th		6		6		6		6		6		6		6		6		6	6	6	6	6	6 Mo	6	6	6	6	6	
7		7		7		7		7 Mo		7		7		7		7		7		7		7		7 Mo	7	7	7	7	7	7	7	7	7	7	
8 We		8		8 Sa		8	T. Kröll (L1) 180 + 50Cr 42 MeV	8	W. Korten (L1) p+72Ge (test) 4.3-5.1 MeV	8	Holiday	8		8		8 Mo	Summer Vacation	8		8		8 Mo	J. Pandey (L1) d + 55Mn 16-18 MeV												
9		9 Su		9		9		9		9		9		9		9		9		9		9		9	9	9	9	9	9	9	9	9			
10		10 Mo		10 Mo		10		10		10		10		10		10		10		10		10		10	10	10	10	10	10	10	10	10	10		
11		11 Tu		11		11		11		11		11		11		11		11		11		11		11	11	11	11	11	11	11	11	11	11		
12		12		12		12		12		12		12		12		12		12		12		12		12	12	12	12	12	12	12	12	12	12		
13 Mo		13		13		13		13		13		13		13		13		13		13		13		13	13	13	13	13	13	13	13	13	13		
14		14		14		14 Mo		14		14		14		14		14		14		14		14		14 Mo	14	14	14	14	14	14	14	14	14		
15	Maintenance (tank open)	15	K. Gladnishki (L5) 7Li+206Pb 34 MeV (TDPAC)	15	M. Luciani (L1) 11B + 87Rb, 89Y 30 MeV	15		15	V. Werner (L1) 3He + 12C 18 MeV (pulsed) (partly run)	15	P.-A. Söderström (L1) p + 140Ce 14 MeV	15	R. Lica (L1) 36S + 18O 56-60 MeV	15	Summer Vacation	15 Mo		15		15	S. Pascu (L1) 6Li + 147Sm 33 MeV	15 Mo	L.-N. Cojocariu (L5) p + SiPM 10 MeV												
16		16		16		16		16		16		16		16		16		16		16		16		16	16	16	16	16	16	16	16	16			
17		17 Mo		17 Mo		17		17		17		17		17		17		17		17		17		17	17	17	17	17	17	17	17	17	17		
18		18		18		18		18		18		18		18		18		18		18		18		18	18	18	18	18	18	18	18	18	18		
19		19 We		19		19		19		19		19		19		19		19		19		19		19	19	19	19	19	19	19	19	19	19		
20 Mo		20		20		20		20		20		20		20		20		20		20		20		20	20	20	20	20	20	20	20	20	20	20	
21		21		21		21		21		21		21		21		21		21		21		21		21 Mo	21	21	21	21	21	21	21	21	21	21	
22	Holiday	22	K. Gladnishki (L1) 13C + 122,124Sn 47 MeV	22	M. Luciani (L1) 11B + 87Rb, 89Y 30 MeV	22	Orthodox Easter	22		22	P.-A. Söderström (L1) p + 140Ce 14 MeV	22	R. Lica (L1) 36S + 18O 56-60 MeV	22	Summer Vacation	22 Mo		22		22	S. Lalkovski (L1) 13C + 100Mo 59 MeV	22 Mo	Winter Holidays												
23		23		23		23		23		23		23		23		23		23		23		23		23	23	23	23	23	23	23	23	23			
24		24 Mo		24 Mo		24		24		24		24		24		24		24		24		24		24	24	24	24	24	24	24	24	24	24		
25		25		25		25		25		25		25		25		25		25		25		25		25	25	25	25	25	25	25	25	25	25		
26		26		26		26		26		26		26		26		26		26		26		26		26	26	26	26	26	26	26	26	26	26		
27 Mo		27		27		27		27		27		27		27		27		27		27		27		27	27	27	27	27	27	27	27	27	27	27	
28		P. Vasileiou (L1) 12C + 176Yb 60 MeV		28 Fr		D. Kahl, A. Rotaru (L5 TPC)		28		8-10 MeV		28		Maintenance		28		p + 91Zr 17 MeV		28		W. Korten (L1) p + 72Ge 4.3-5.1 MeV (pulsed)		28 Mo	Summer Vacation	28		28		28		28		28	
29	29		29	29	29		29	29	29		29	29	29		29	29	29		29	29	29		29	29		29		29		29					
30	30		30 We	30	30		30	30	30		30	30	30		30	30	30		30	30	30		30	30		30		30		30					
31 Fr	31 Mo		31 Mo	31 Sa	31		31	31 Th	31 Su		31	31 Fr	31		31 We	31	31		31	31	31		31	31		31		31		31		31			

Publication highlights

♦ 10 publications in 2024 and 2025 (July):

- Phys. Rev. C 4
- Phys. Rev. Lett. 2
- Phys. Scr. 2
- Nucl. Phys. A 1
- NIM A 1

IOP Publishing Phys. Scr. 100 (2025) 075301 <https://doi.org/10.1088/1402-4896/addaac>

Physica Scripta



PAPER

Nuclear level density of ^{128}Te from $(p, p'\gamma)$ scattering and complementary photonuclear data

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P-A Söderström¹, A Kuşoğlu^{1,2}, S Aogaki¹, D L Balabanski¹, S-R Ban¹, R Borcea³, M Brezeanu¹, S Calinescu³, C Costache³, R Corbu¹, M Cuciuc¹, A Dhal¹, I Dinescu³, N M Florea³, T Furuno⁴, A Gavrilescu¹, A Gupta⁵, Y Honda⁴, J Isaak⁵, N C Jerca¹, T Kawabata⁴, V Lelasseux¹, R Lica³, C Marin¹, C Mihai³, S Niculae¹, H Pai¹, I P Pârlea¹, T Petruse¹, A Spataru¹, D A Testov¹, D Tofan³, T Tozar¹, A Turturică³, G V Turturică¹ and S Ujeniuc³

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Keywords: nuclear level density, constant temperature model, fermi gas model, gamma-ray detectors

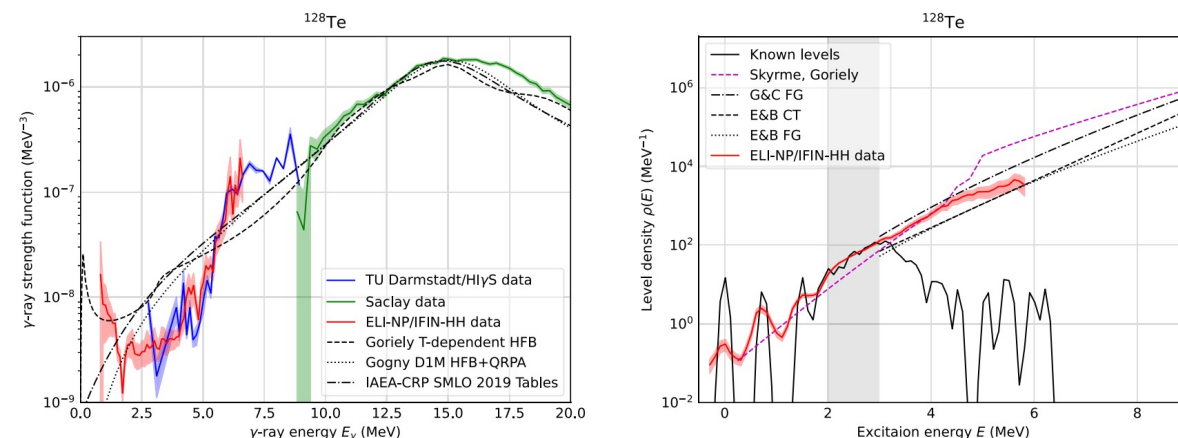


Figure 3. (Left) Experimental γ -ray strength functions of ^{128}Te obtained from this work (ELI-NP/IFIN-HH), the photoabsorption cross-section from Reference [43] (TU Darmstadt/HI γ S), and (γ, n) cross-section data from Reference [44] (Saclay). For comparison, three typical parametrisations, as implemented in the TALYS code, are shown as solid lines for electric dipole strength and dashed lines for magnetic dipole strength. (Right) Nuclear level density of ^{128}Te . The shaded region shows the range for fitting to known spectroscopic states. The transparent bands correspond to the statistical and systematic uncertainties. Three phenomenological parametrisations discussed in the text and one microscopic model implemented in TALYS are shown for comparison.

Publication highlights

PHYSICAL REVIEW LETTERS **134**, 092501 (2025)

Increasing Octupole Collectivity across the $Z = 64$ Isotopic Chain: $B(E3)$ Values in ^{150}Gd

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An enhanced electric octupole ($E3$) strength of $45(5)$ W.u. has been measured for the $3^- \rightarrow 0^+$ transition in ^{150}Gd , providing direct evidence for large octupole collectivity in this nucleus. The value was determined following two sensitive experiments, to measure the mean lifetime of the $J^\pi = 3^-$ level and the weak $E3$ decay branch direct to the ground state. The systematics of the $E3$ strength across the Gd isotopic chain reveals that enhanced octupole collectivity is obtained for ^{150}Gd . The increasing low-lying octupole strength in the Gd isotopes is analyzed with five state-of-the-art theoretical models. It is found to be best reproduced by quasiparticle random phase approximation calculations, providing a good understanding of octupole collectivity in the rare-earth region.

DOI: 10.1103/PhysRevLett.134.092501

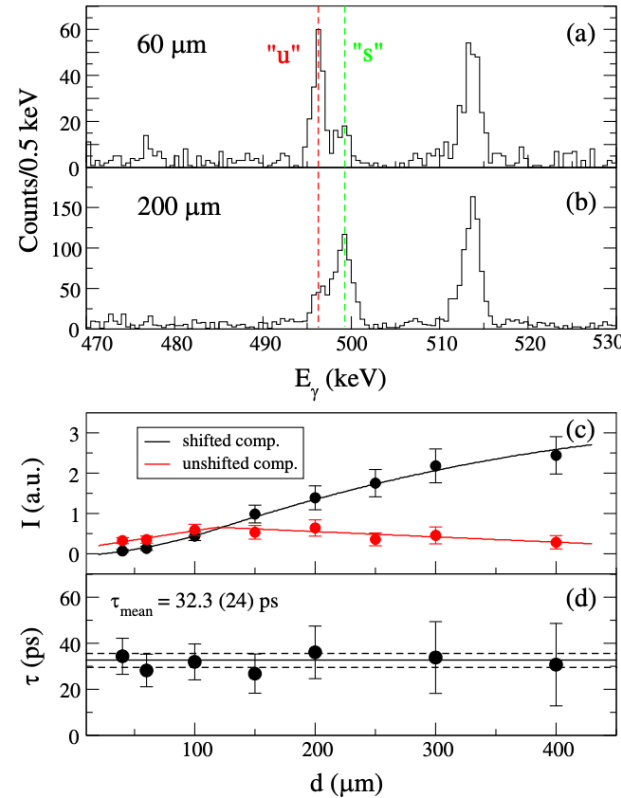


FIG. 1. Shifted ("s") and unshifted ("u") components of the 496 keV γ ray ($3^- \rightarrow 2^+$ transition), measured at 37° relative to the beam axis, at 60 μm [panel (a)] and 200 μm [panel (b)]; (c) Relative intensities of the shifted and unshifted components of the $3^- \rightarrow 2^+$ transition and their corresponding fit with second-degree polynomials; (d) Mean lifetime of the 3^- level as a function of the plunger distance.

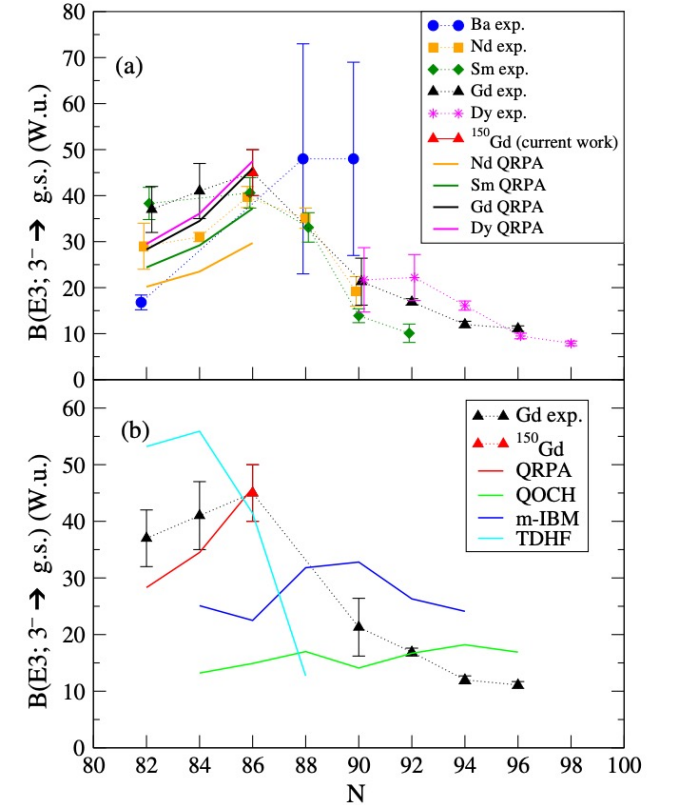


FIG. 3. (a) The systematics of measured (full symbols) $B(E3) \downarrow 3^- \rightarrow 0^+$ strength in the Ba-Dy region (red triangle is from the current work). In addition, the results of the QRPA model for the Nd, Sm, Gd, and Dy isotopic chains are presented (full lines) in the $N = 82-86$ region; (b) Experimental $B(E3) \downarrow 3^- \rightarrow 0^+$ for Gd isotopes are compared with state-of-the-art theoretical calculations.

Publication highlights

PHYSICAL REVIEW LETTERS **133**, 072502 (2024)

Direct Observation of Competing $M1$ and $M3$ Transitions in ^{10}B

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(Received 29 February 2024; revised 14 May 2024; accepted 21 June 2024; published 13 August 2024)

Excited states in ^{10}B were populated with the $^{10}\text{B}(p, p'\gamma)^{10}\text{B}^*$ reaction at 8.5 MeV and their γ decay was investigated via coincidence γ -ray spectroscopy. The emitted γ rays were measured using large-volume $\text{LaBr}_3:\text{Ce}$ and CeBr_3 detectors placed in anti-Compton shields. This allowed the observation of weak γ -ray transitions, such as the $M3$ transition between the $J^\pi, T = 0^+, 1$ isobaric analog state (IAS) and the $J^\pi, T = 3^+, 0$ ground state and the $E2$ transition between the $J^\pi, T = 2^+, 0$ state and the IAS, i.e., performing measurements of branching ratios at the level of $\lambda \geq 10^{-4}$. For the first time in ^{10}B , the competing $M1$ and $M3$ transitions from the decay of the IAS have been observed in a γ spectroscopy experiment. The experimental results are compared with *ab initio* no-core shell model calculation using the newest version of the local position-space chiral N^3LO nucleon-nucleon interaction. The calculations reproduce correctly the ordering of the bound states in ^{10}B , and are in reasonable agreement with the observed branching ratios and reduced transition probabilities.

DOI: 10.1103/PhysRevLett.133.072502

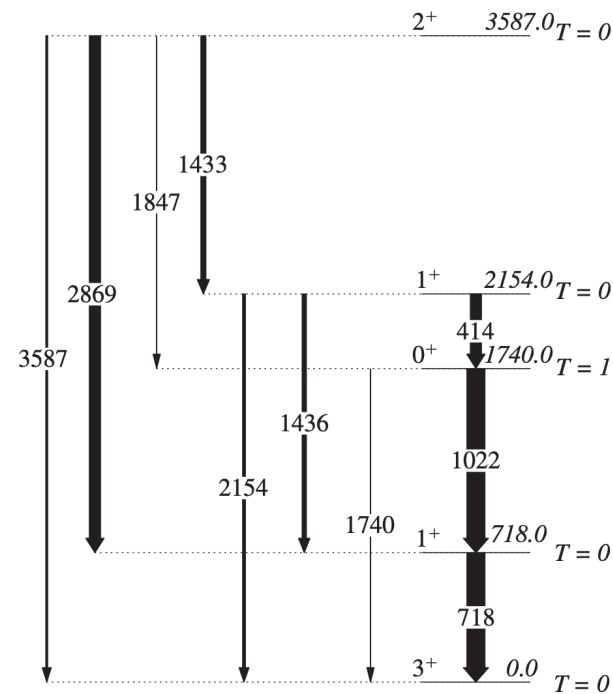


FIG. 1. A partial level scheme of the bound states of ^{10}B . Arrow widths are proportional to the branching ratios (in %) observed in the present experiment. Spin, isospin, and parities have been taken from Ref. [33].

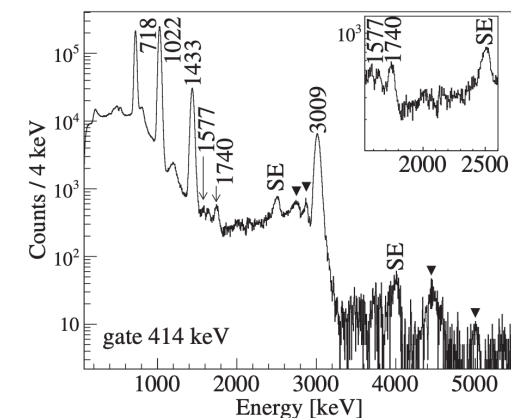


FIG. 2. The γ -ray spectrum observed in coincidence with the 414 keV γ -ray transition of ^{10}B . The ^{10}B γ rays are labeled with their energies. The peaks marked with the triangles indicate contamination.

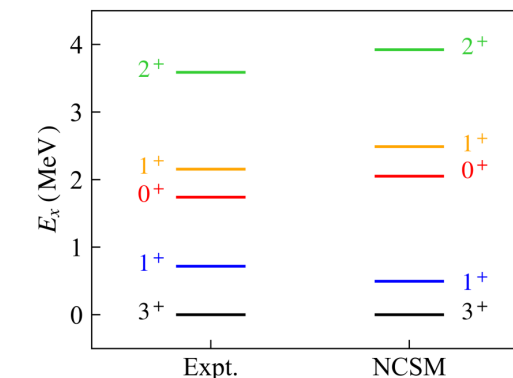


FIG. 4. Experimental bound excited states of ^{10}B compared with the NCSM calculation with the newest version of the local position-space chiral N^3LO NN force [49].

Publication highlights

Nuclear Instruments and Methods in Physics Research A 1065 (2024) 169495



Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima



Full Length Article

Development of a plastic scintillator based and SiPM readout detector for high-precision fast-timing measurements at rosphere array

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ARTICLE INFO

Keywords:
Nuclear instrumentation
Silicon photoMultiplier
SiPM
Beta detector
Low power
Vacuum
Fast-timing
Transfer reactions

ABSTRACT

We report on the development of a custom particle detection system that aims to improve the detection capabilities of the ROSPHERE array. The detector is designed specifically for lifetime measurements using the in-beam Fast-timing method for nuclear states in nuclides produced in nuclear transfer reactions. An 80 x 3.6 mm disc of BC400 plastic scintillator was coupled to a sparse SiPM array readout connected to a dedicated Front End Electronics board. The detector was tested versus a conical LaBr₃(Ce) coupled to a Hamamatsu PMT readout. The timing measurements resulted in a resolution of 896(5) ps. The detector design, characteristics, and performances are presented in this paper along with future improvements.

Table 1

Time resolutions obtained in the transfer reaction induced by a beam of ^{11}B on a ^{181}Ta target for the BC400 plastic coupled to a Sparse SiPM and a full SiPM respectively. Both sets of data were obtained versus a 1.5-inch conical LaBr₃(Ce) scintillator coupled to an R9779 Hamamatsu PMT readout with a tested time resolution of 130 ps. Is important to note that the in-beam time resolutions were obtained without an energy gate condition on the LaBr₃(Ce) peaks, while for the ^{60}Co data we used an energy gate.

Detector array	Charged particle resolution (ps)	γ photons (in-beam) resolution (ps)	γ photons (^{60}Co) resolution (ps)
Sparse SiPM	896(5)	480(4)	472(1)
Full SiPM	454(4)	390(2)	278(1)

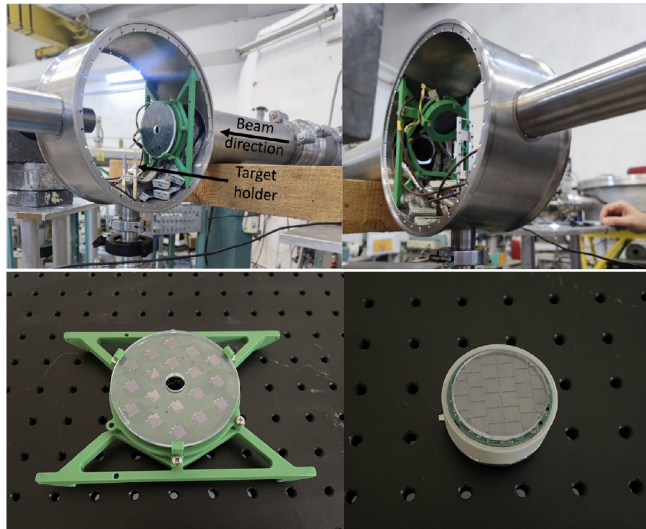


Fig. 4. Top panels: the setup used to test the detectors. Bottom panels: zoomed in picture of the detectors. On the left is the sparse SiPM array, and on the right is the full SiPM array placed off-beam at an angle of 45°.

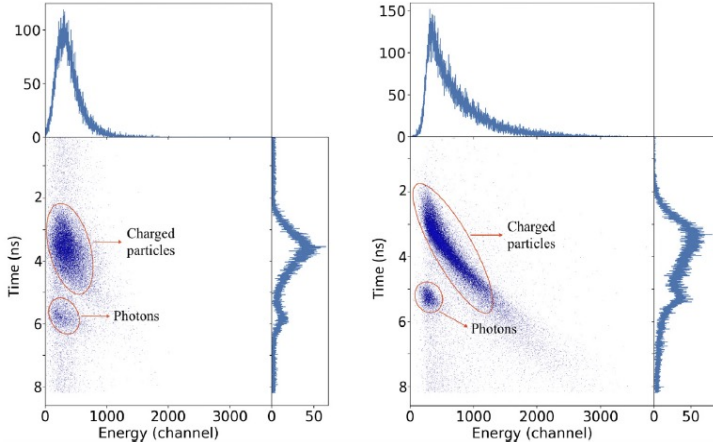
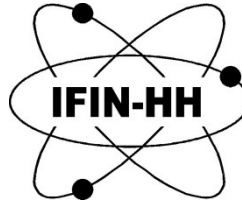


Fig. 6. The Particle — TAC coincidence matrix obtained in the transfer reaction induced by a beam of ^{11}B on a ^{181}Ta target, at incident energy (47 MeV) below the Coulomb barrier. In the left graph, we have the data obtained with the sparse SiPM array, and on the right, we have the data obtained with a full SiPM array.



Unveiling the intruder 0^+ state in ^{32}Si near the $N=20$ 'Island of inversion'

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Young Research Teams Grants (TE)
Project no. PN-IV-P2-2.1-TE-2023-0339

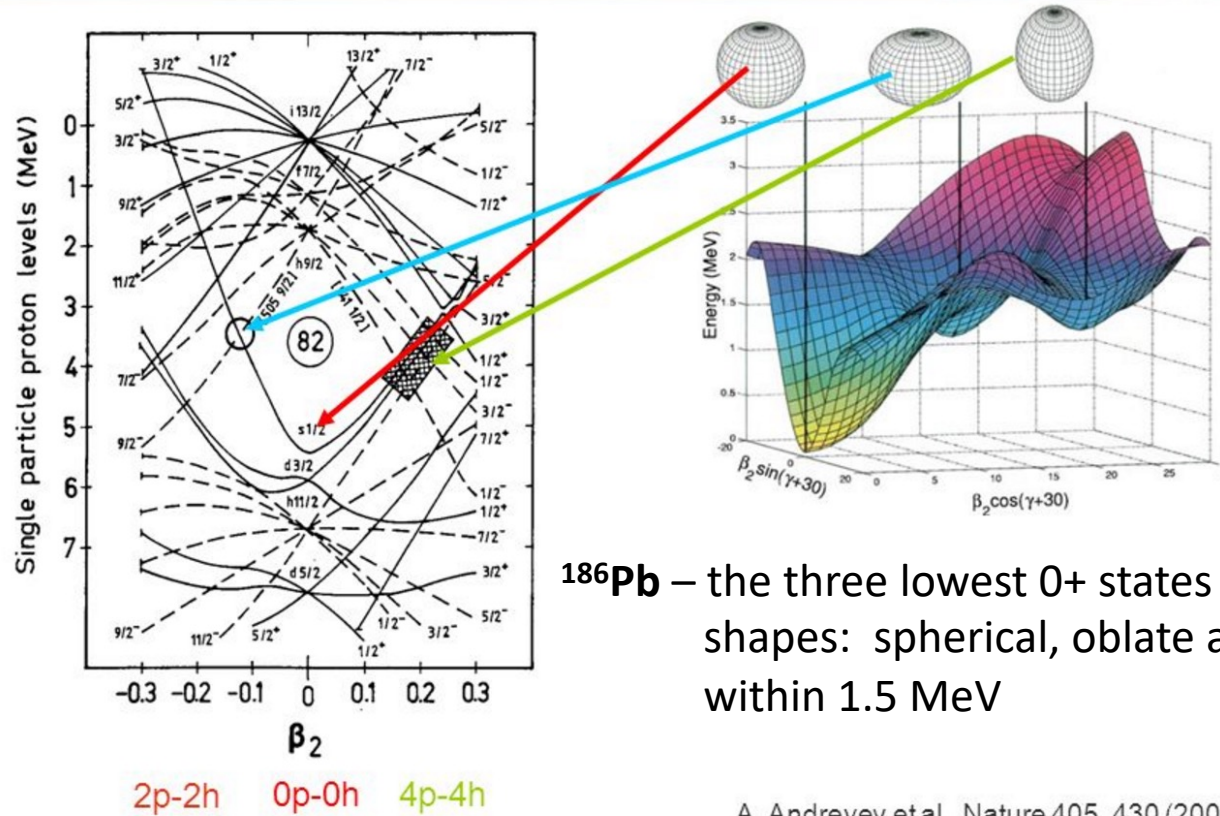


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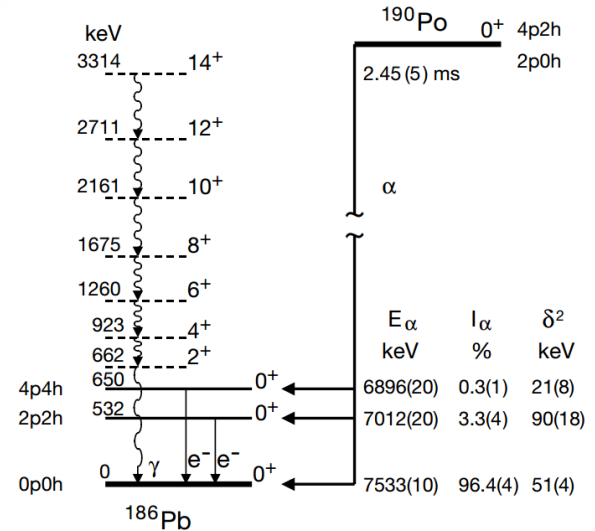


EXECUTIVE AGENCY FOR
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Shape coexistence



^{186}Pb – the three lowest 0^+ states of different shapes: spherical, oblate and prolate, within 1.5 MeV



A. Andreyev et al., Nature 405, 430 (2000)

Shape coexistence

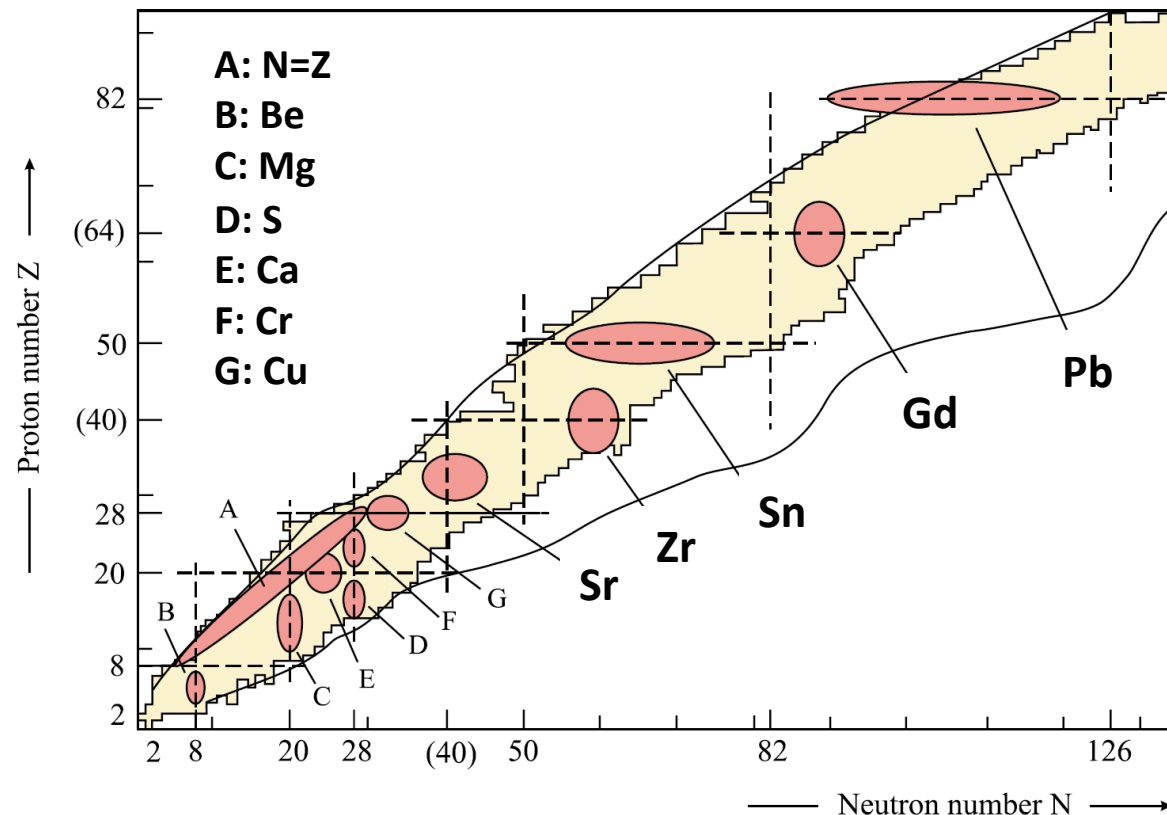
- Historical overview

Nuclear deformation and shape coexistence have been hot topics in nuclear structure for more than 60 years

- 1956: First case - 0_2^+ state in ^{16}O (*H. Moninaga, Phys. Rev. 101 (1956) 254.*)
- 1970: Regions of deformation start to be unveiled by the advance of experimental techniques and availability of RIB. (heavy odd-A nuclei near proton shells $Z=50$ and $Z=82$)

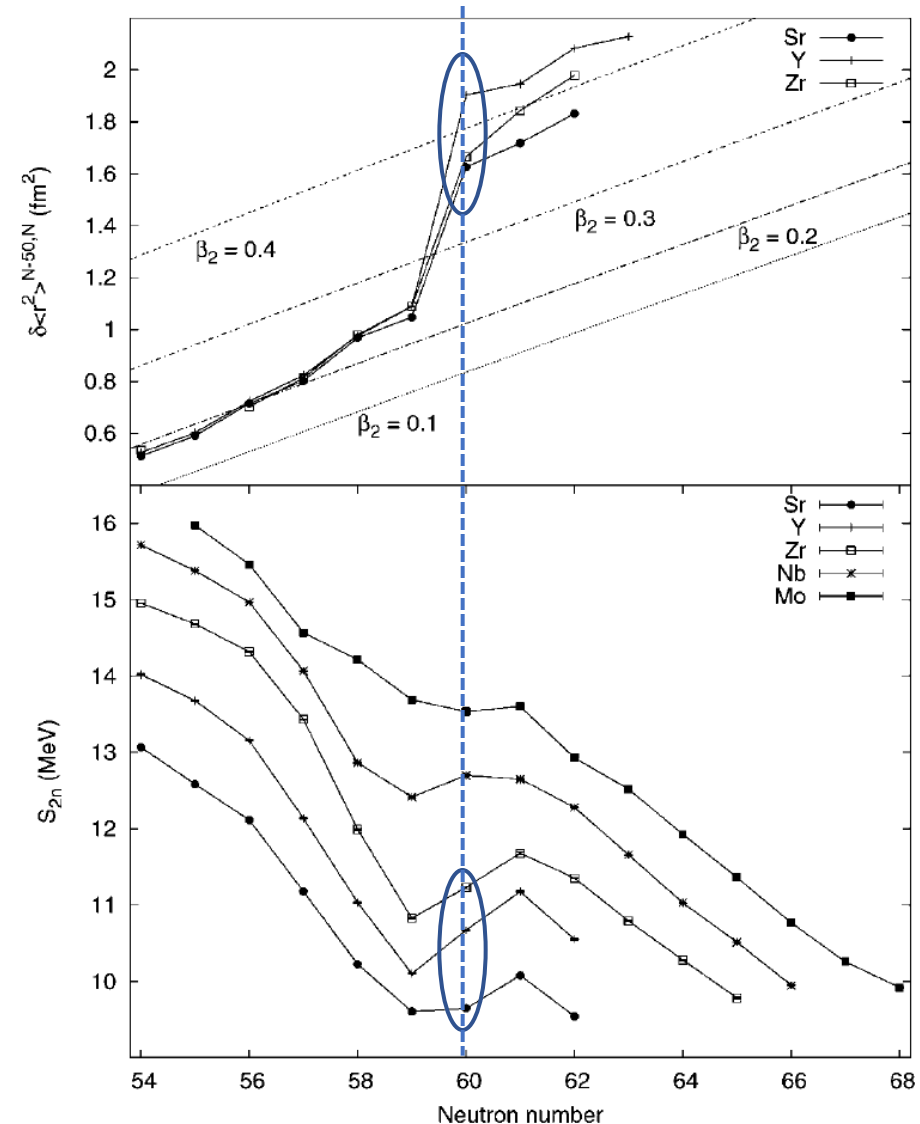
- Theoretical approaches:

- **Spherical shell model:** particle-hole excitations ($mp-nh$) across shell closures (Large Scale SM, Monte Carlo SM)
- **Mean-field model:** two-body nucleon-nucleon force as a starting point to obtain energy surfaces for different nuclear shapes using the Hartree-Fock theory (HF)



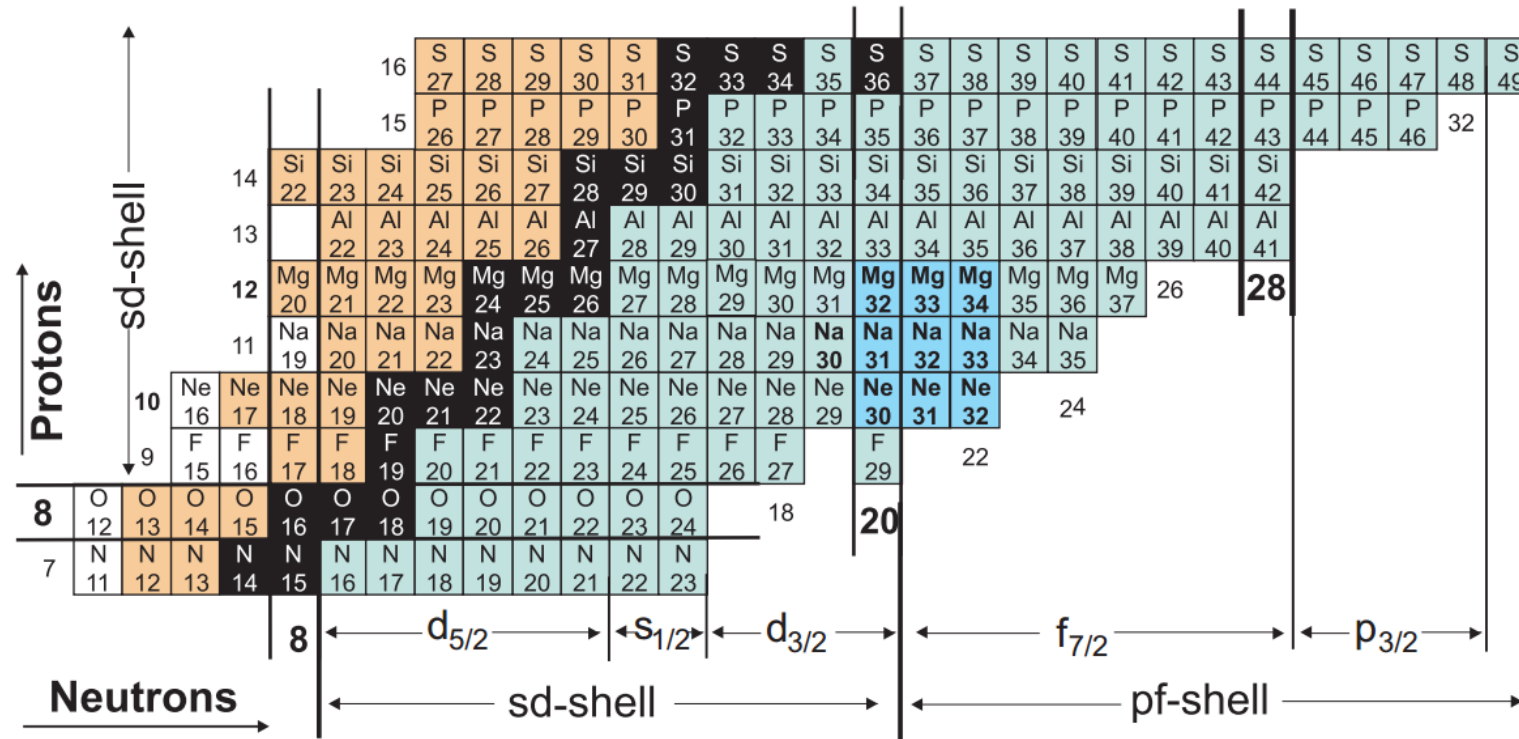
Spectroscopic fingerprints of shape coexistence

- **Direct:**
 - Diagonal $E2$ matrix elements - $\langle Ji || E2 || Jf \rangle$ (multistep Coulomb Excitation)
 - Transition Probabilities - $B(E2)$ (lifetime measurement, γ yield from Coulex)
- **Indirect:**
 - $E0$ strength - $\rho^2(E0)$ - (conversion electron spectroscopy)
 - Particle-core coupling (systematics of bands with coupled ($\Delta I=1$) or decoupled ($\Delta I=2$) spin sequences)
- **Hints:**
 - First 2^+ state excitation energy - E_{2^+}
 - Mean-square radii - $\delta \langle r^2 \rangle$ (isotope and isomer shifts using laser spectroscopy)
 - Changes in masses (S_{2n} - two-nucleon separation energies)

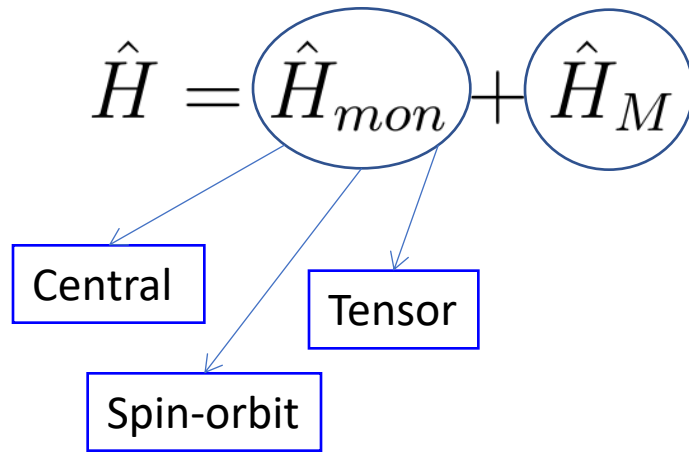


$N=20$ “Island of Inversion”

Name “Island of Inversion” given in Warburton et al. PRC, vol. 41, pp. 1147-1166 (1990)

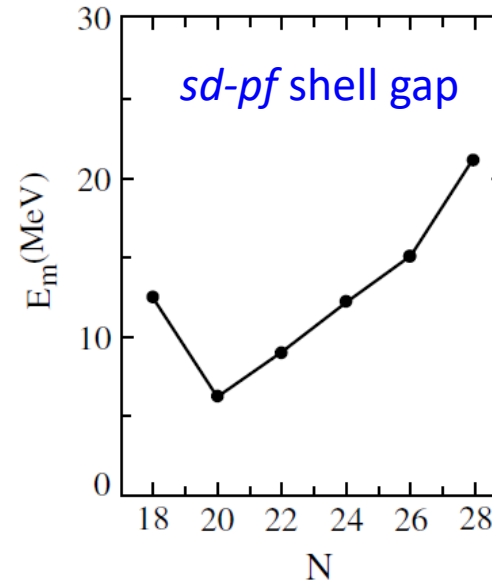
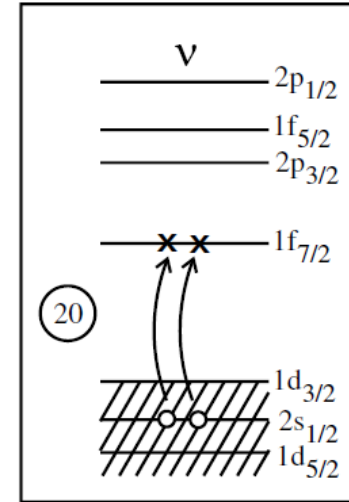


Shell model interpretation

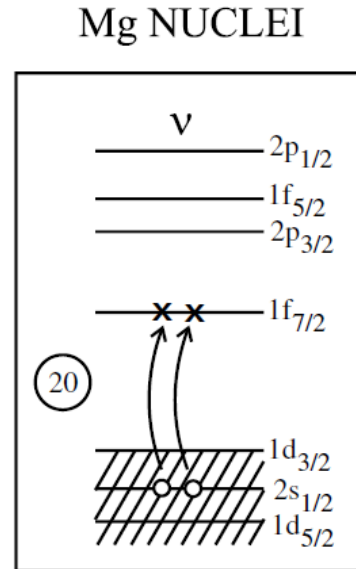
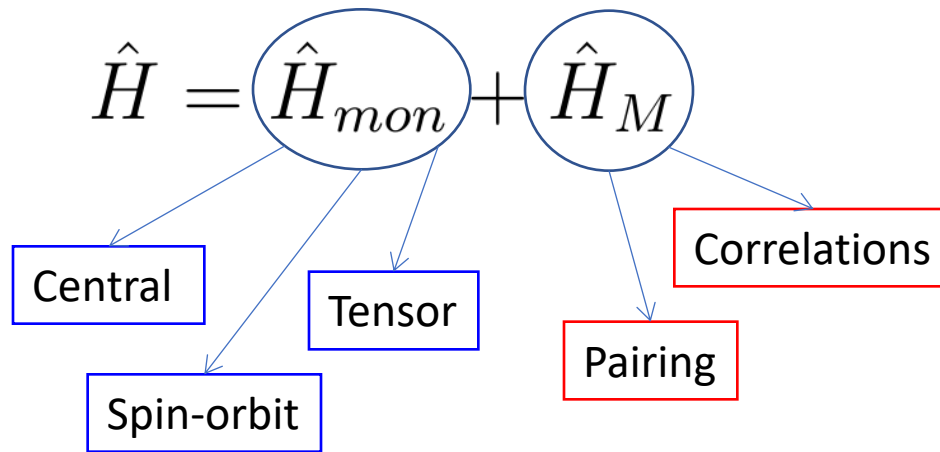


Monopole term — responsible for the spherical mean field and shell structure evolution. Influences the shell-gap

Mg NUCLEI

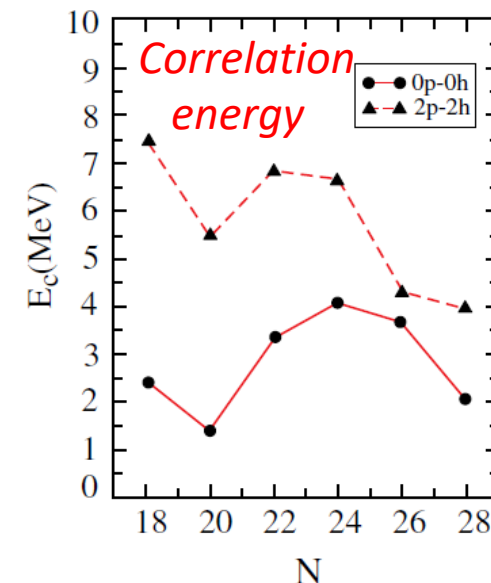
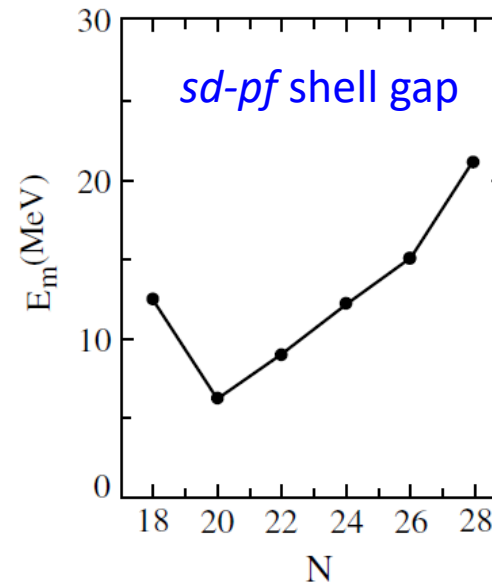


Shell model interpretation



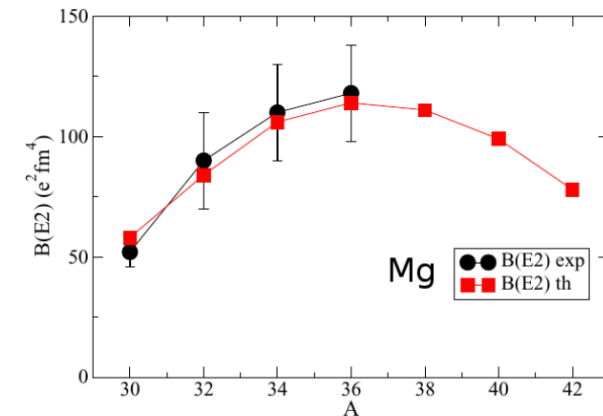
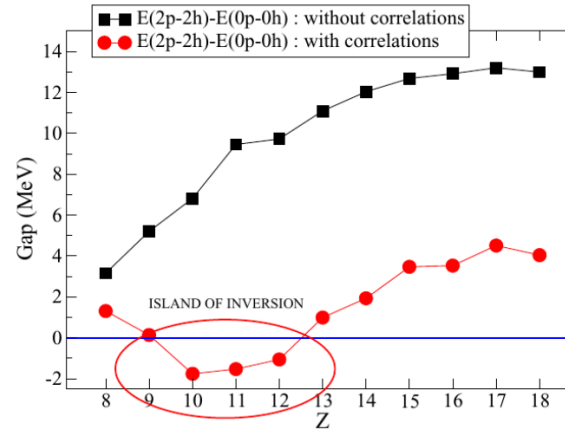
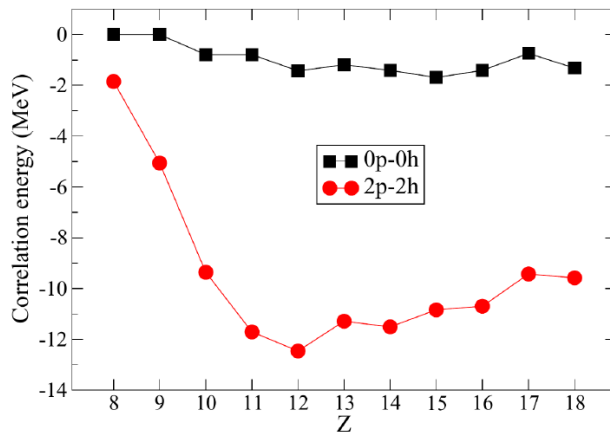
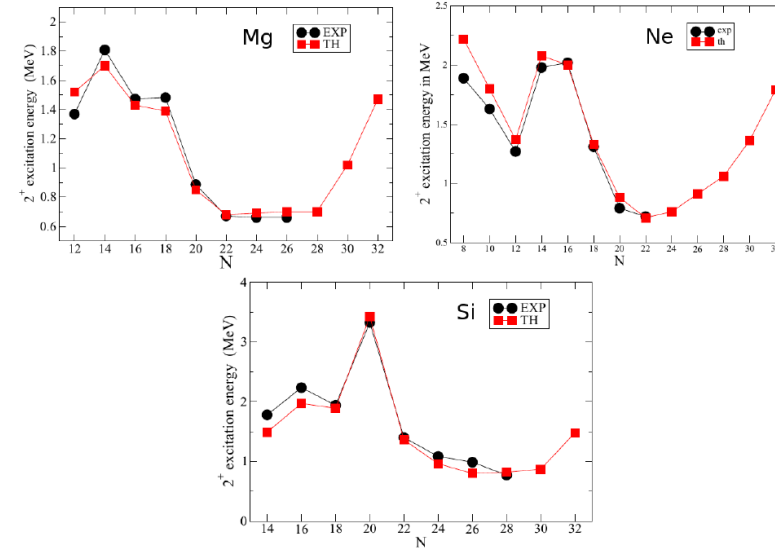
Monopole term — responsible for the spherical mean field and shell structure evolution. Influences the shell-gap

Multipole term — responsible for the onset of deformation and disappearance of magic numbers far from stability. Influences the correlation energy



The SDPF-U-MIX interaction

- Developed by the Strasbourg-Madrid collaboration
- It is based on the SDPF-U interaction [1] which was used to describe N=28 nuclei.
- The SDPF-U-MIX interaction [2] - using a core of ^{16}O allows the valence neutrons in the sd - pf shell and, most importantly, neutron excitations across the sd - pf shell gap. Describes N=20 nuclei together with N=28.
- Calculations performed using the ANTOINE code
- Good reproduction of signature observables:
 - disappearance of N=20 magic number in Mg and Ne
 - $np - nh$ configurations give rise to collective excitations with large values of $B(E2)$



[1] F. Nowacki and A. Poves, Phys. Rev. C **79**, 014310 (2009).

[2] E. Caurier et al., Phys. Rev. C **90**, 014302 (2014).

1999 vs 2014

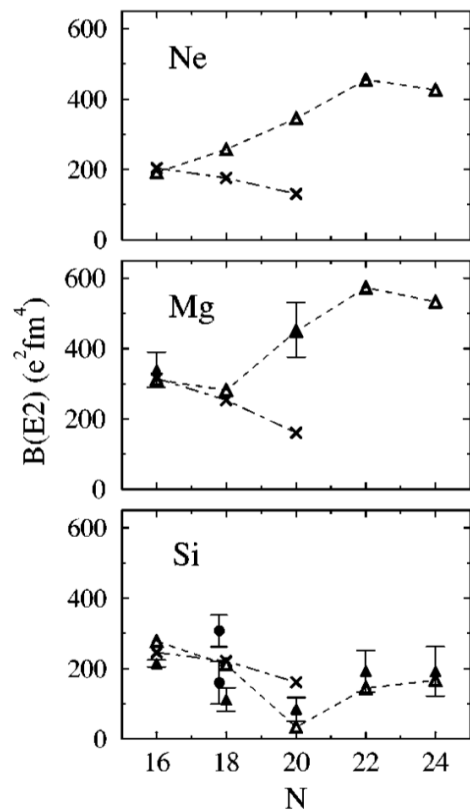
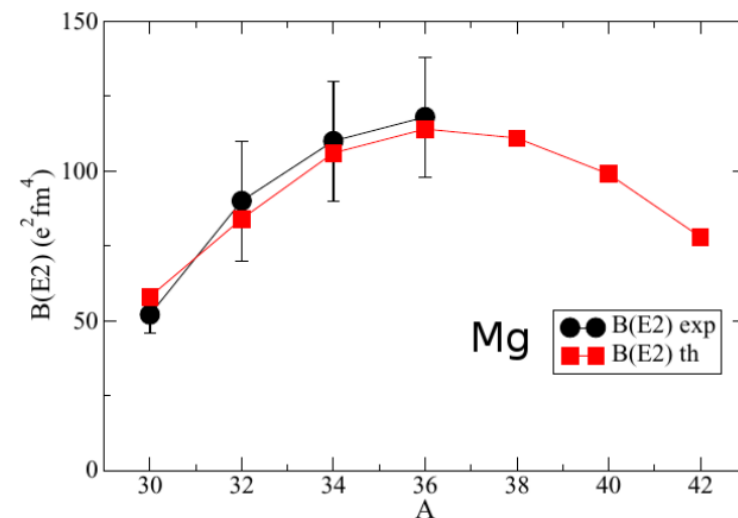


FIG. 7. $B(E2; 0_1^+ \rightarrow 2_1^+)$ values of Ne (top), Mg (center), and Si (bottom) isotopes. The filled (open) triangles mean experimental (calculated) values, while the crosses are those obtained by the sd -shell model. For ^{32}Si , previously measured quantities [37,38] are also shown by circles.

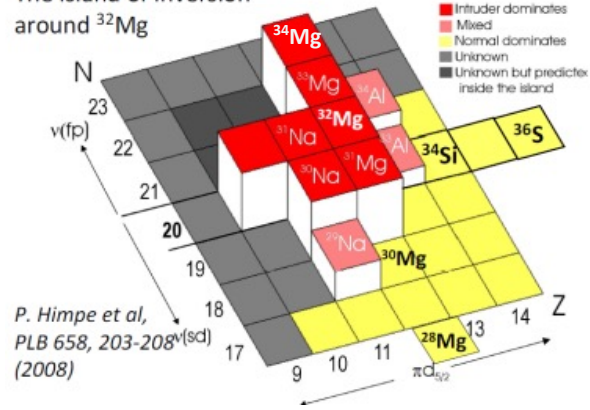


E. Caurier et al., Phys. Rev. C **90**, 014302 (2014).

IS530: ^{34}Mg β -decay at IDS

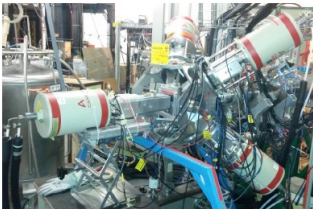
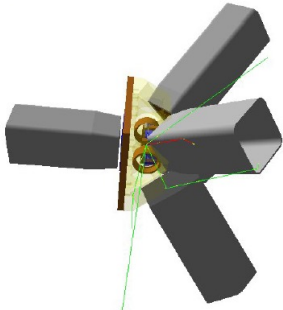
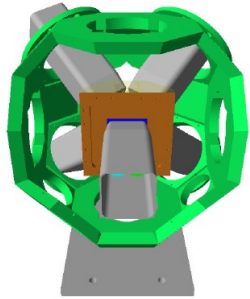
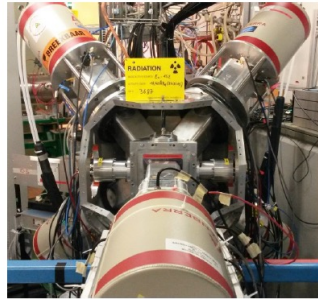
Nuclear structure at the border of the N=20 "Island of Inversion"

The island of inversion
around ^{32}Mg



Detection setup

- 5 Clover detectors
- Plastic scintillator around the implantation point



^{34}Al

PHYSICAL REVIEW C **95**, 021301(R) (2017)

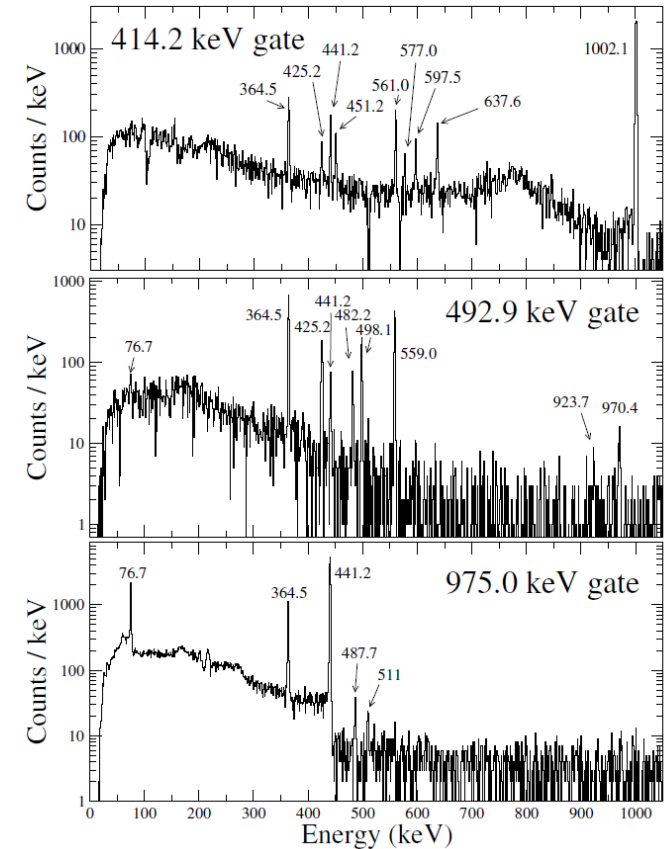
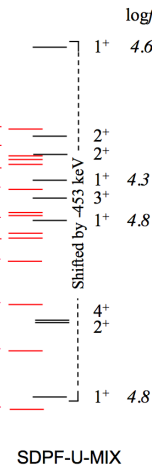
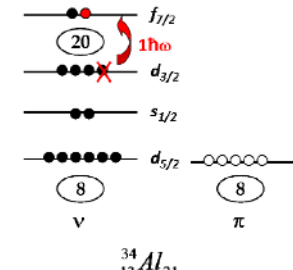
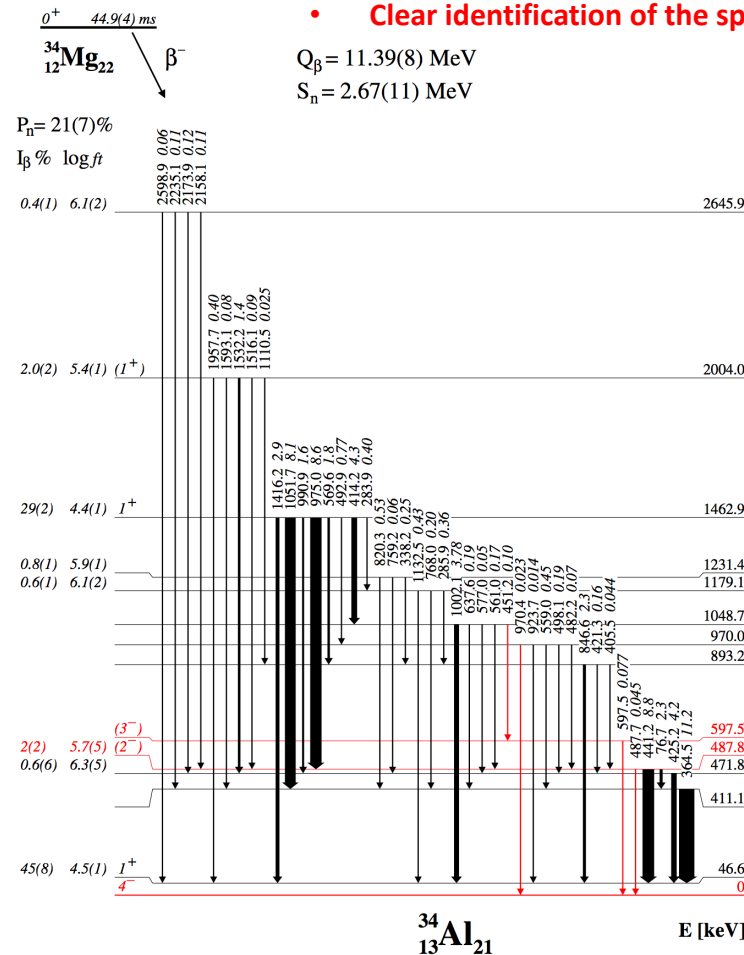
RAPID COMMUNICATIONS

Identification of the crossing point at $N = 21$ between normal and intruder configurations

R. Lică,^{1,2} F. Rotaru,² M. J. G. Borge,^{1,3} S. Grévy,^{4,5} F. Negoită,² A. Poves,^{6,7} O. Sorlin,⁴ A. N. Andreyev,⁸ R. Borcea,² C. Costache,² H. De Witte,⁹ L. M. Fraile,¹⁰ P. T. Greenlees,^{11,12} M. Huyse,⁹ A. Ionescu,² S. Kisyov,^{2,13} J. Konki,^{11,12} I. Lazarus,¹⁴ M. Madurga,¹ N. Mărginean,² R. Mărginean,² C. Mihai,² R. E. Mihai,² A. Negret,² R. D. Page,¹⁵ J. Pakarinen,^{11,12} S. Pascu,² V. Pucknell,¹⁴ P. Rahkila,^{11,12} E. Rapisarda,¹ A. Șerban,² C. O. Sotny,² L. Stan,² M. Stănoiu,² O. Tengblad,³ A. Turturică,² P. Van Duppen,⁹ R. Wadsworth,⁸ and N. Warr¹⁶
(IDS Collaboration)

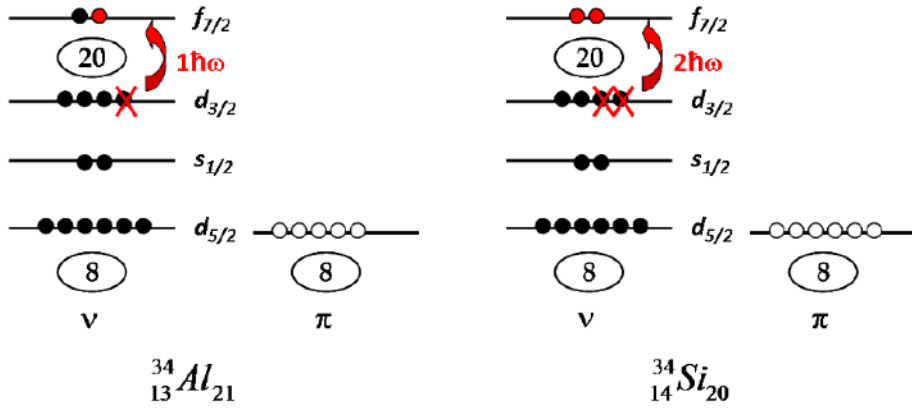
- 42 transitions placed in the ^{34}Al level scheme
- **Clear identification of the spherical 4^- ground state and deformed (intruder) 1^+ isomer at 46.6 keV**

$Q_\beta = 11.39(8)$ MeV
 $S_n = 2.67(11)$ MeV



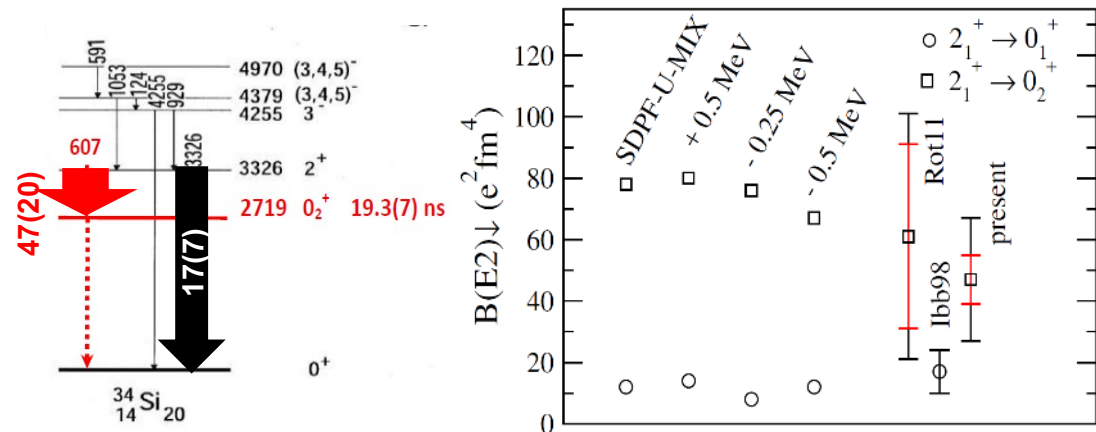
IS530: ^{34}Mg β -decay at IDS

Nuclear structure at the border of the N=20 "Island of Inversion"



^{34}Si populated from separately implanted $^{34}\text{Mg} \rightarrow ^{34}\text{Al}(1^+)$ and $^{34}\text{Al}(4^-, 1^+)$

- Deformed configurations ($2p-2h$) dominate the 0_2^+ and 2_1^+ states – 86 - 89%
- The 0_1^+ ground state is dominated by the spherical ($0p-0h$) configuration – 90%
- The 2_3^+ state corresponds to the $0p-0h$ nature (spherical), dominated by the $\pi(1d_{5/2})-(1s_{1/2})$ configuration with N = 20 closed



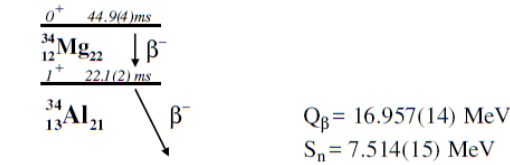
$$B(E2; 607\text{keV}; 2_1^- \rightarrow 0_2^+) \downarrow - \frac{4939 \cdot B(E2; 0_1^+ \rightarrow 2_1^+) \uparrow}{5 \cdot B_r} - 47(20)e^2 fm^4 - 7.2(31)W.u.$$

PHYSICAL REVIEW C **100**, 034306 (2019)

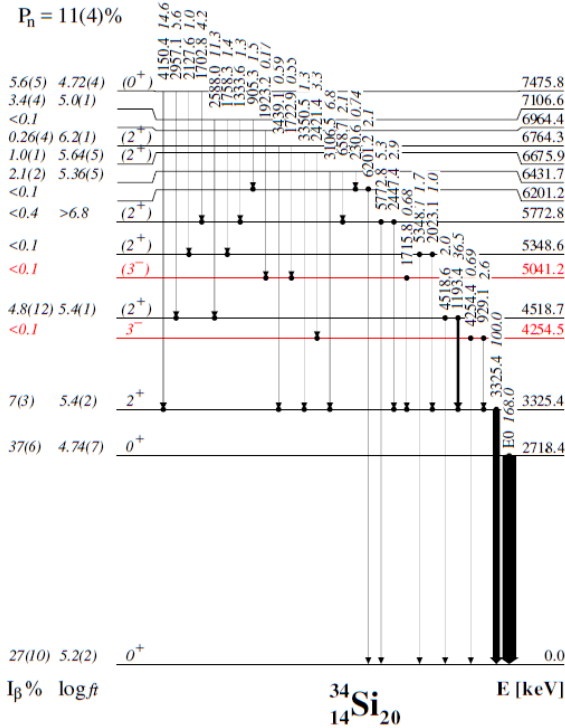
Normal and intruder configurations in ^{34}Si populated in the β^- decay of ^{34}Mg and ^{34}Al

R. Lică^{1,2}, F. Rotaru¹, M. J. G. Borge^{2,3}, S. Grévy^{4,5}, F. Negoită¹, A. Poves^{6,7}, O. Sorlin⁴, A. N. Andreyev⁸, R. Borcea¹, C. Costache¹, H. De Witte⁹, L. M. Fraile¹⁰, P. T. Greenlees^{11,12}, M. Huyse⁹, A. Ionescu^{1,13}, S. Kisiov^{14,15}, J. Konki^{11,12,2}, I. Lazarus¹⁵, M. Madurga², N. Mărginean¹, R. Mărginean¹, C. Mihai¹, R. E. Mihai¹, A. Negret¹, F. Nowacki^{16,17}, R. D. Page¹⁸, J. Pakarinen^{11,12}, V. Pucknell¹⁵, P. Rakhila^{11,12}, E. Rapisarda^{2,19}, A. Șerban¹, C. O. Sotby¹, L. Stan¹, M. Stănoiu¹, O. Tengblad³, A. Turturică¹, P. Van Duppen⁹, N. Warr²⁰, Ph. Dessagne²¹, T. Stora²², C. Borcea¹, S. Călinescu¹, J. M. Daugas²³, D. Filipescu¹, I. Kuti²⁴, S. Franchoo²⁵, I. Gheorghe¹, P. Morfouace^{25,23}, P. Morel²³, J. Mrazek²⁶, D. Pietreanu¹, D. Sohrler²⁷, I. Stefan²⁵, R. Șuvăilă¹, S. Toma¹ and C. A. Ur^{1,28}
(IDS Collaboration)

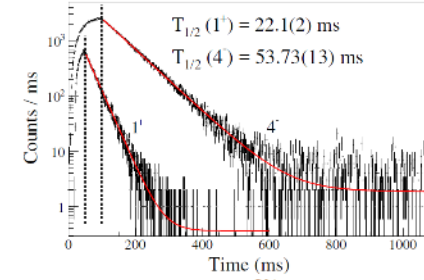
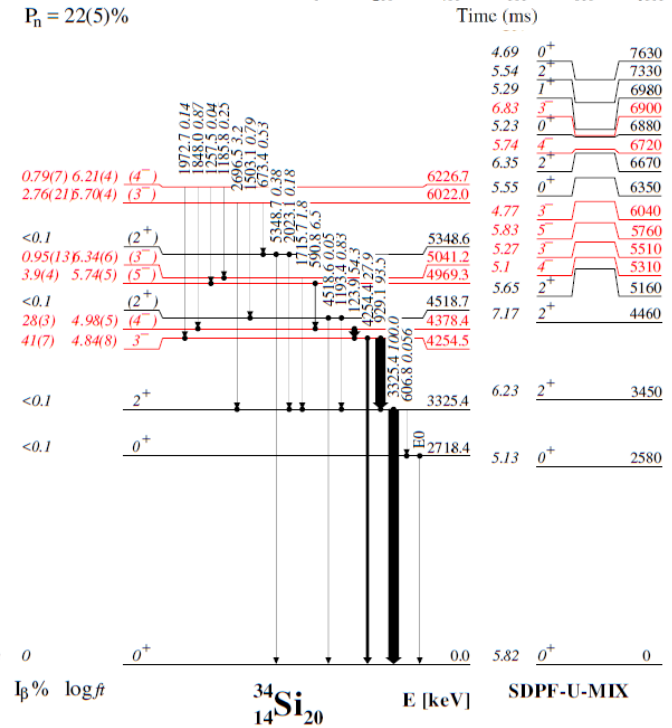
^{34}Si



$P_n = 11(4)\%$

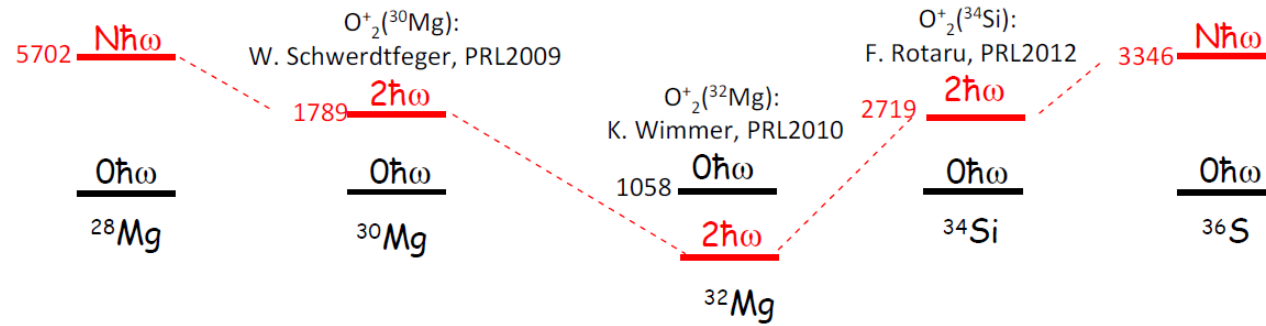


$P_n = 22(5)\%$

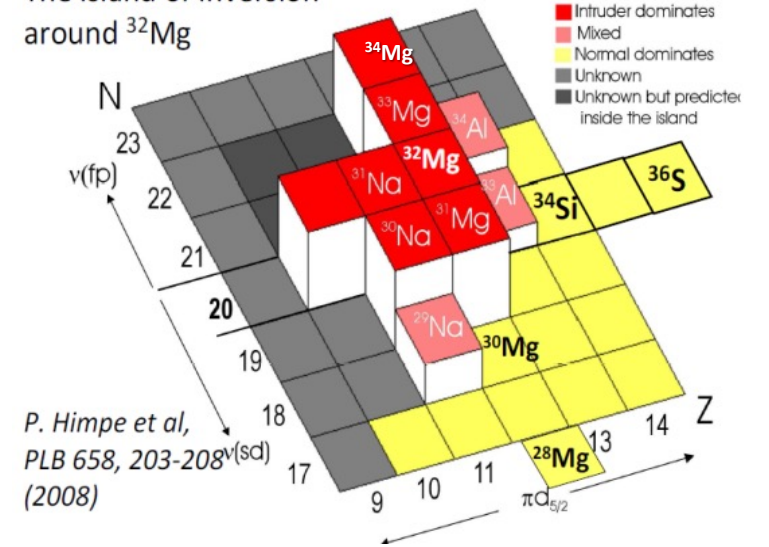


^{32}Si - Scientific motivation

Testing the Shell Model at the outskirts of the Iol

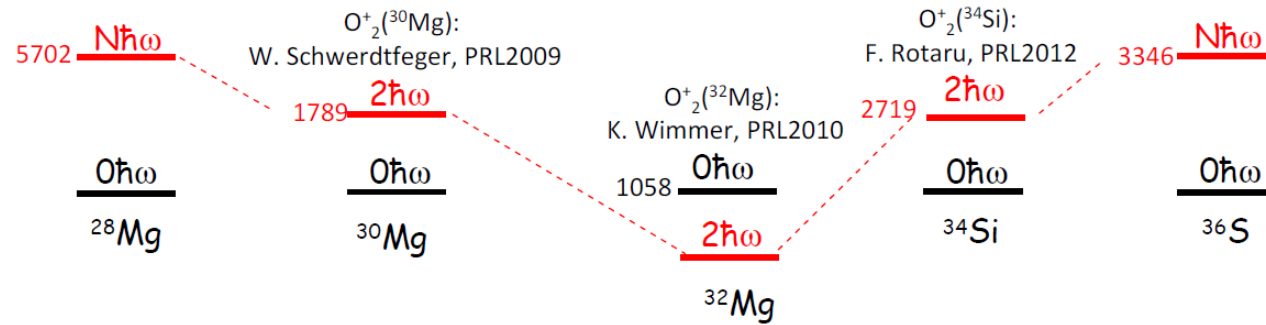


The island of inversion
around ^{32}Mg

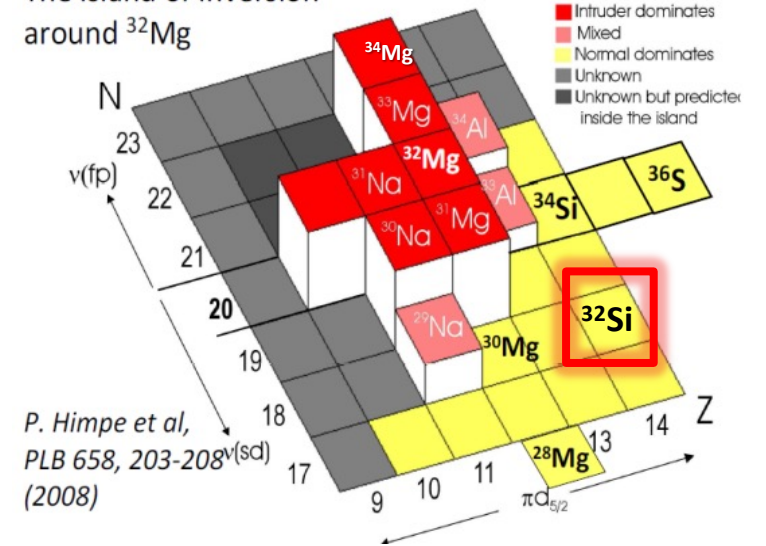


^{32}Si - Scientific motivation

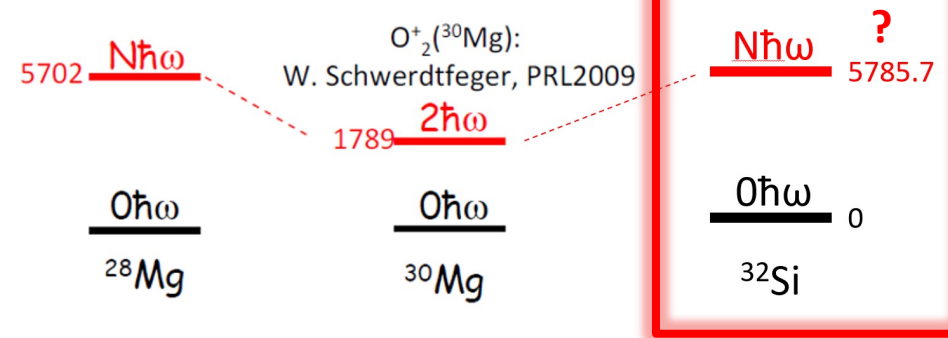
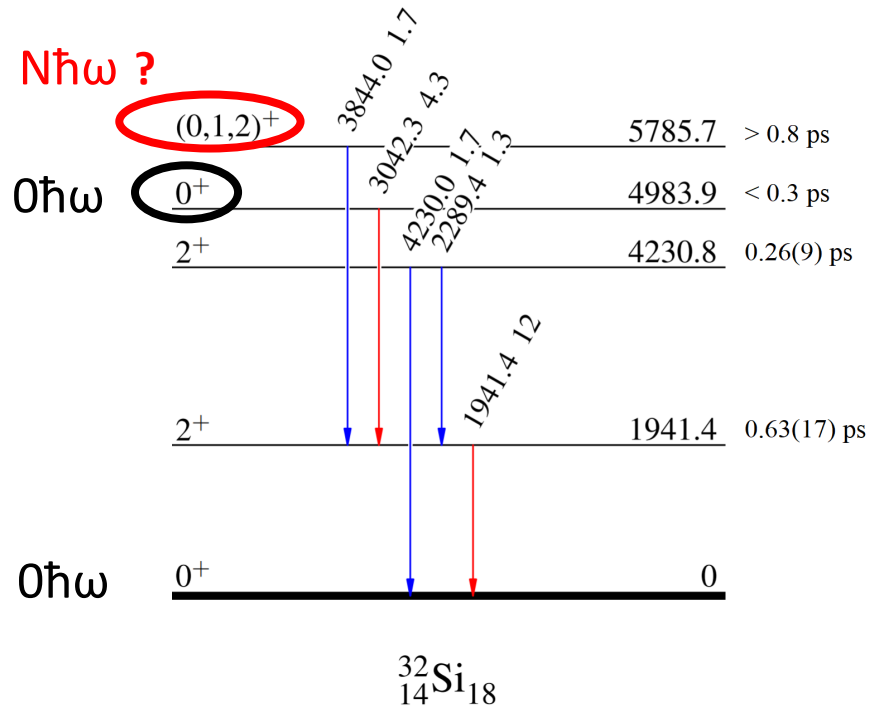
Testing the Shell Model at the outskirts of the Iol



The island of inversion around ^{32}Mg



P. Himpe et al, PLB 658, 203-208 (2008)

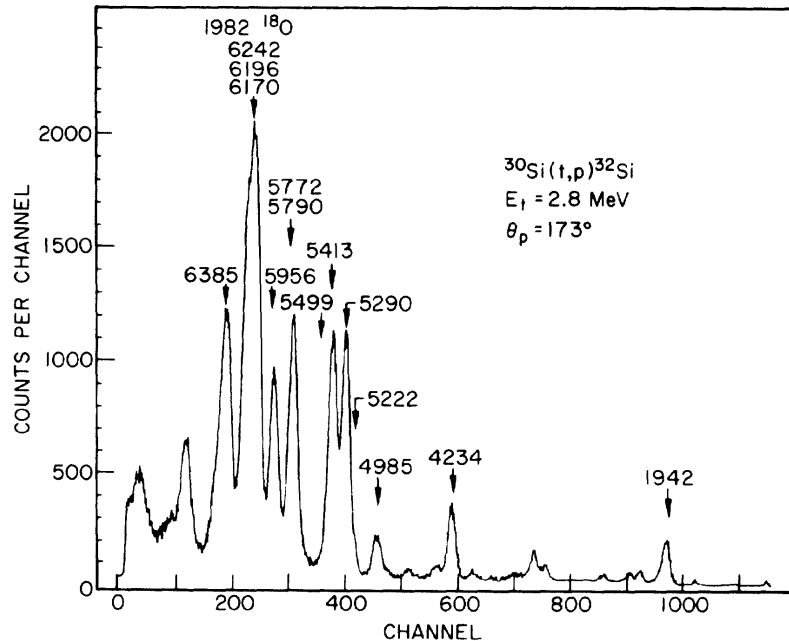


Intruder configurations should arise in ^{32}Si in a similar manner as it happens in ^{28}Mg

Previous experimental results

The $^{30}\text{Si}(t,p\gamma)$ DSAM [1] study reported:

- an upper limit, $T_{1/2} < 0.3$ ps, for the 4.98 MeV 0^+ state
- a lower limit, $T_{1/2} > 0.8$ ps, for the 5.78 MeV $(0,1,2)^+$ state,

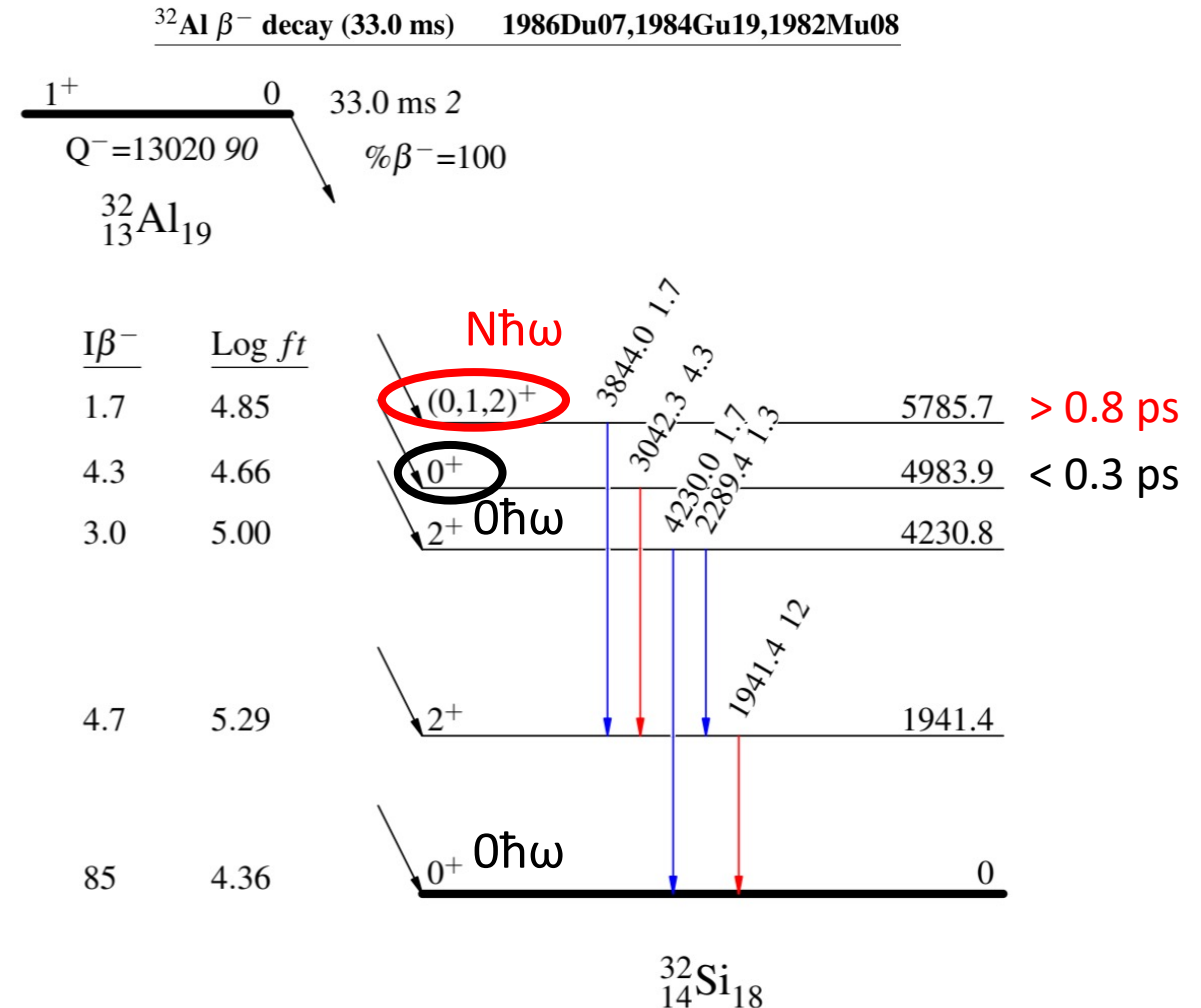


Proton spectrum measured in time coincidence with all rays observed by the Ge(Li) detector following the $^{30}\text{Si}(t,p)^{32}\text{Si}$.

[1] J.G. Pronko and R.E. McDonald, Phys. Rev. C6 No. 6 (1972).

ENSDF

$^{32}\text{Al} \beta^-$ decay (33.0 ms)
 $^{30}\text{Si}(t,p)$
 $^{30}\text{Si}(t,p\gamma)$
 Coulomb excitation
 $^{208}\text{Pb}(^{37}\text{Cl},X)$



Experiment at IFIN-HH 9MV Tandem (July 2019)

Spokespersons: Răzvan Lică (IFIN-HH), Maria Jose Garcia Borge (IEM-CSIC)

- **Reaction:** Sub-barrier 2-n transfer reaction
 $^{30}\text{Si}(^{18}\text{O}, ^{16}\text{O})^{32}\text{Si}$ @ $E_b = 26$ MeV
- **Detection:** RoSphere array of 25 HPGe with SORCERER (2% efficiency at 2 MeV)

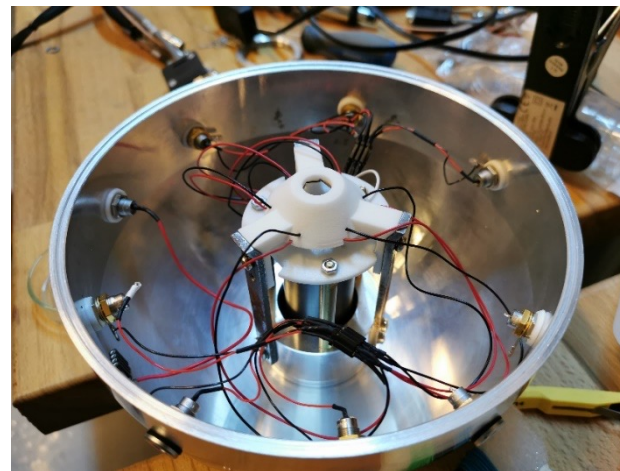
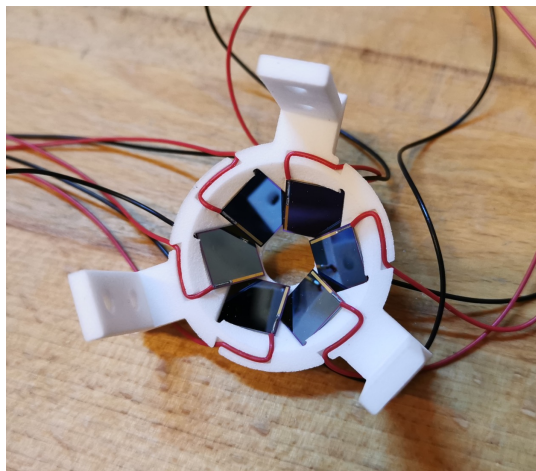


Nuclear Instruments and Methods in Physics
Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment

Volume 951, 21 January 2020, 163090

SORCERER: A novel particle-detection system for transfer-reaction experiments at ROSPHERE

T. Beck ^{a,*,}, C. Costache ^{b,}, R. Lică ^{b,}, N. Mărginean ^{b,}, C. Mihai ^{b,}, R.E. Mihai ^{b,}, O. Papst ^{a,}, S. Pascu ^{b,}, N. Pietralla ^{a,}, C. Sotby ^{b,}, L. Stan ^{b,}, A.E. Turturică ^{b,}, V. Werner ^{a,}, J. Wiederhold ^{a,}, W. Witt ^a



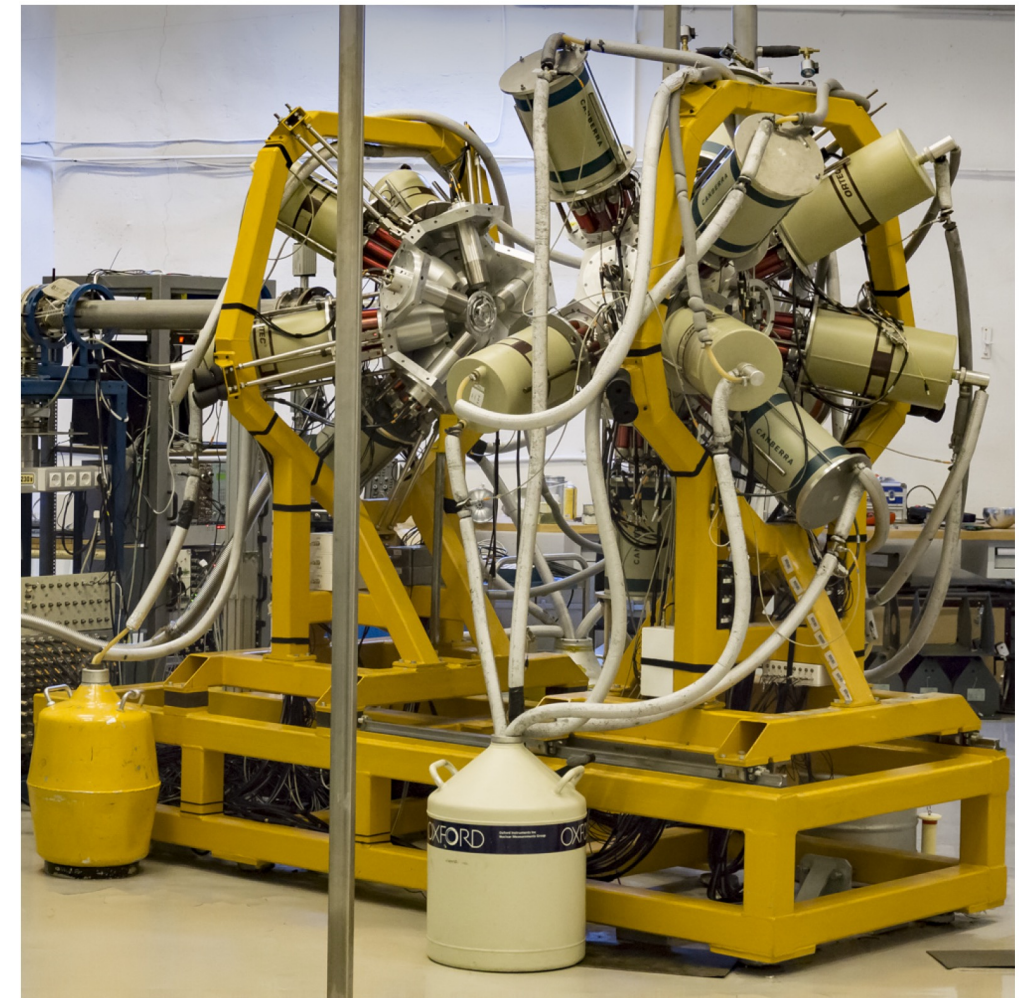
Nuclear Instruments and Methods in Physics
Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment

Volume 837, 21 November 2016, Pages 1-10



The ROSPHERE γ -ray spectroscopy array

D. Bucurescu ^{a,}, I. Căta-Danil ^{a,}, G. Ciocan ^{a,}, C. Costache ^{a,}, D. Deleanu ^{a,}, R. Dima ^{a,}, D. Filipescu ^{a,*,}, N. Florea ^{a,}, D.G. Ghiță ^{a,}, T. Glodariu ^{a,}, M. Ivașcu ^{a,}, R. Lică ^{a,}, N. Mărginean ^{a,}, R. Mărginean ^{a,}, C. Mihai ^{a,*,}, A. Negret ^{a,}, C.R. Niță ^{a,}, A. Olăcel ^{a,}, S. Pascu ^{a,}, T. Sava ^{a,}, L. Stroe ^{a,}, A. Șerban ^{a,*,}, R. Șuvăilă ^{a,}, S. Toma ^{a,}, N.V. Zamfir ^{a,*,}, G. Căta-Danil ^{b,}, I. Gheorghe ^{c,}, I.O. Mitu ^{c,}, G. Suliman ^{c,}, C.A. Ur ^{c,}, T. Braunroth ^{d,}, A. Dewald ^{d,}, C. Fransen ^{d,}, A.M. Bruce ^{e,}, Zs. Podolyák ^{f,}, P.H. Regan ^{f,*,}, O.J. Roberts ^h

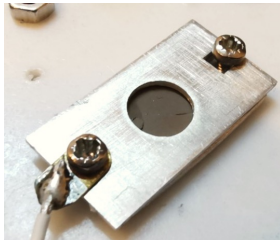


Experiment at IFIN-HH 9MV Tandem (July 2019)

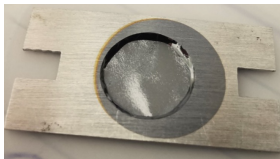
Spokespersons: Răzvan Lică (IFIN-HH), Maria Jose Garcia Borge (IEM-CSIC)

- **Reaction:** Sub-barrier 2-n transfer reaction
 $^{30}\text{Si}(^{18}\text{O}, ^{16}\text{O})^{32}\text{Si}$ @ $E_b = 26$ MeV
- **Detection:** RoSphere array of 25 HPGe with SORCERER
(2% efficiency at 2 MeV)
- **Targets:** produced in-house – ^{30}Si

^{30}Si (pressed powder)
117.4 mg/cm²



Ti backing (3 mg/cm²)
 $^{30}\text{Si} = 0.2$ mg/cm²



Ta backing (13 mg/cm²)
 $^{30}\text{Si} = 0.2$ mg/cm²



Fig. 2 A TE18-High Vacuum Deposition System produced by Intercovamex Company; **B** interior of the deposition chamber, showing: *a* rotating substrate holder; *b* thermal evaporation; *c* electron-beam evaporation system; *d* sputtering deposition system; *e* quartz crystal monitor; *f* shutter

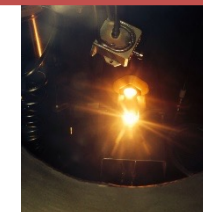
J Radioanal Nucl Chem
DOI 10.1007/s10967-014-3899-y

The status of the Target Preparation Laboratory at IFIN-HH Bucharest, Romania

N. M. Florea · L. Stroe · R. Mărginean · D. G. Ghiță ·
D. Bucureanu · M. Badea · C. Costache · R. Lică · N. Mărginean ·
C. Mihai · D. V. Moșu · C. R. Niță · S. Pascu · T. Sava



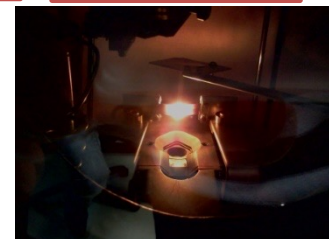
electron bombardment
evaporation



magnetron sputtering



resistive heating



$T_{1/2}$ measurement – stopping power

- **Technique:** variation of the RDDS technique – the ‘flight time’ is changed by using backing materials with different stopping times.

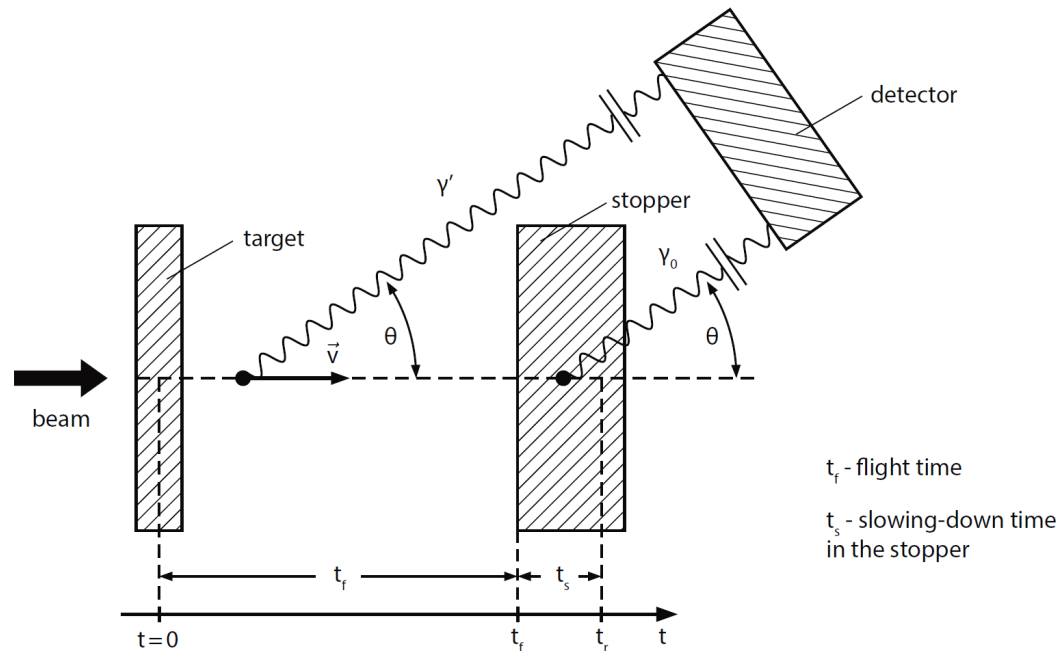
$$E_s(\theta) = E_0 \frac{\sqrt{1 - \beta^2}}{1 - \beta \cos \theta} \approx E_0 \left(1 + \frac{v}{c} \cos \theta \right),$$

where:

E_0 — photon energy emitted at rest
 E_s — photon energy emitted in-flight
 v — velocity of the recoil nucleus
 θ — photon emission angle wrt the direction of the nucleus

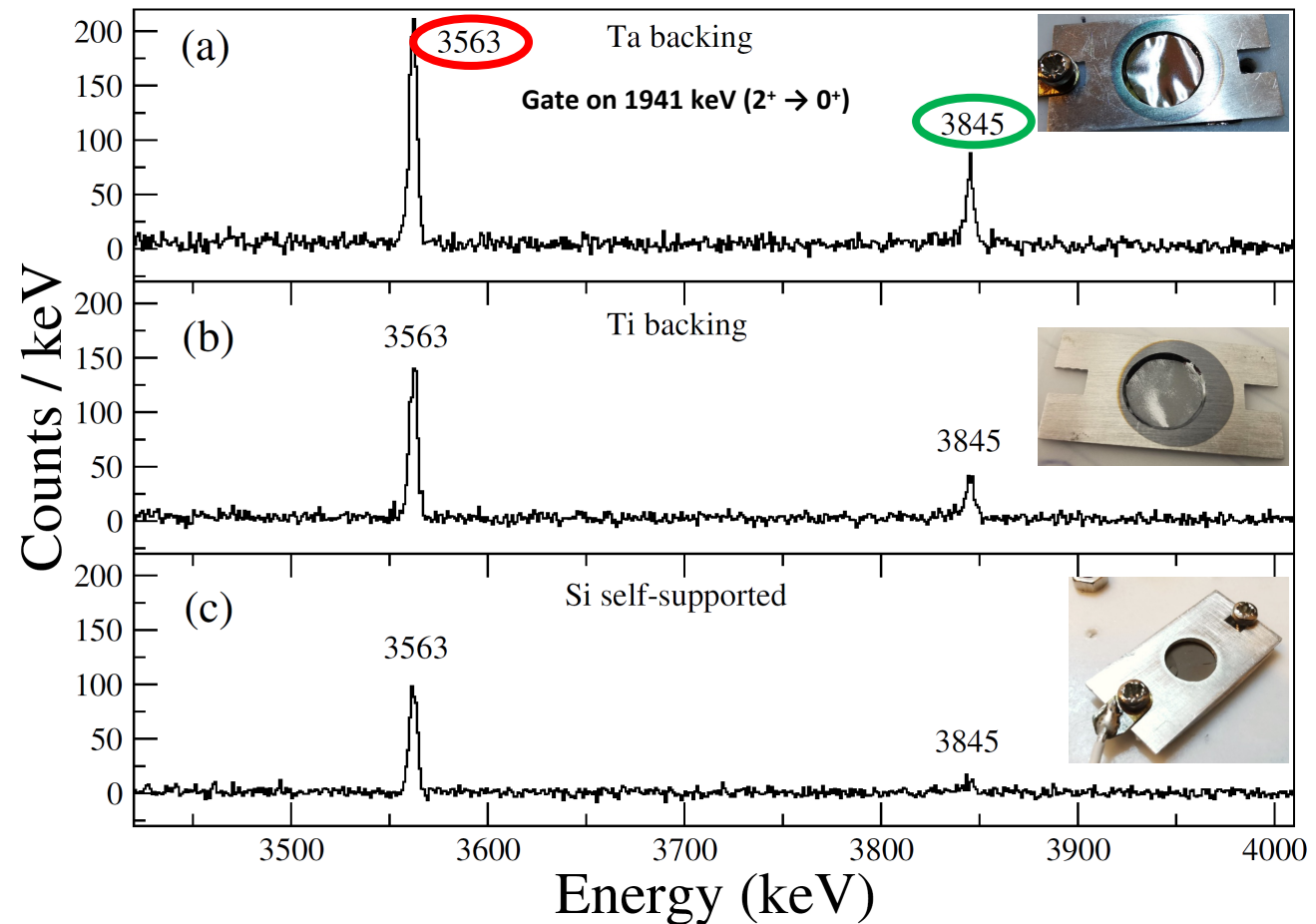
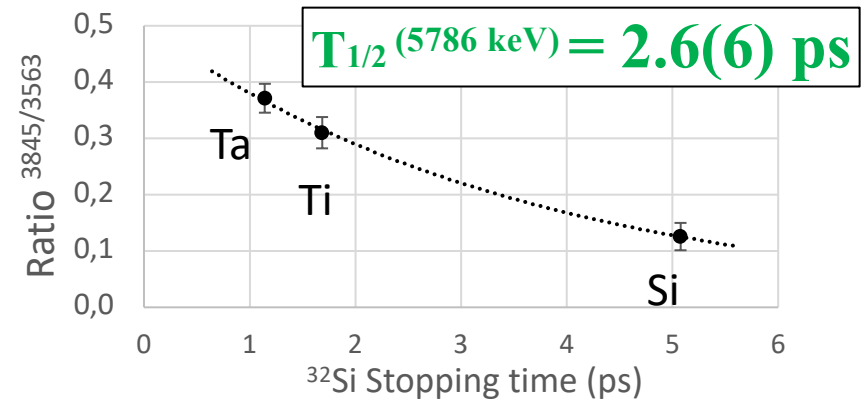
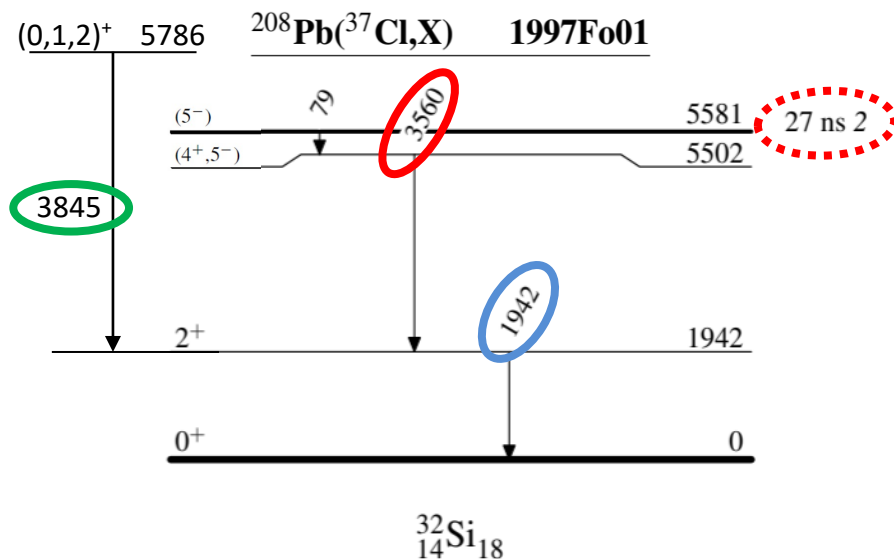
‘Standard’ RDDS or DSAM cannot be employed

$^{30}\text{Si}(^{18}\text{O}, ^{16}\text{O})^{32}\text{Si}$ @ $E_b = 26$ MeV $\rightarrow v/c(^{32}\text{Si}) = 3.5\%$
 $E_s(3.8 \text{ MeV}, \theta=57^\circ) > 60 \text{ keV} !!!$



$T_{1/2}$ measurement – stopping power

- **Technique:** variation of the RDDS technique – the ‘flight time’ is changed by using backing materials with different stopping times.
- **Analysis:** measure only stopped (unshifted) components. The 3563 keV transition populated from the long-lived ($T_{1/2} = 27(2)$ ns) 5581 keV level was used for the normalization.



J^π assignment – angular correlations

When an excited nucleus decays by emitting multiple γ rays, an anisotropy is generally found in the spatial distribution of the second γ ray with respect to the first.

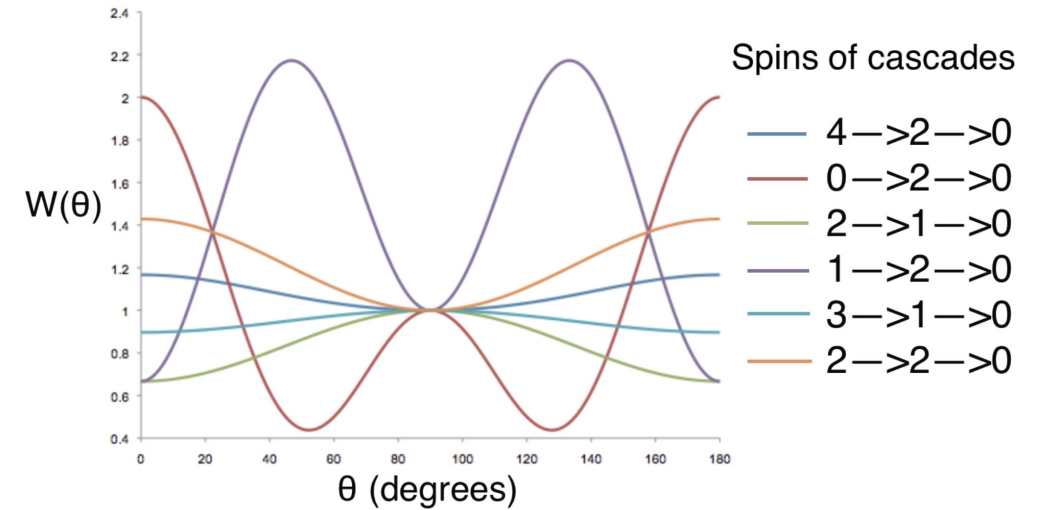
General formula:

$$W(\theta) = \sum_{k=0, k=\text{even}}^{2L} a_k P_k(\cos\theta),$$

Specific case $L=2$ (quadrupole transitions)

$$W(\theta) = a_0 P_0(\cos\theta) + a_2 P_2(\cos\theta) + a_4 P_4(\cos\theta)$$

G. Goertzel, Angular Correlation of Gamma-Rays, Phys. Rev. 70, 897 (1946).



MSc Thesis, Andrew Dale MacLean, March, 2016

J^π assignment – angular correlations

When an excited nucleus decays by emitting multiple γ rays, an anisotropy is generally found in the spatial distribution of the second γ ray with respect to the first.

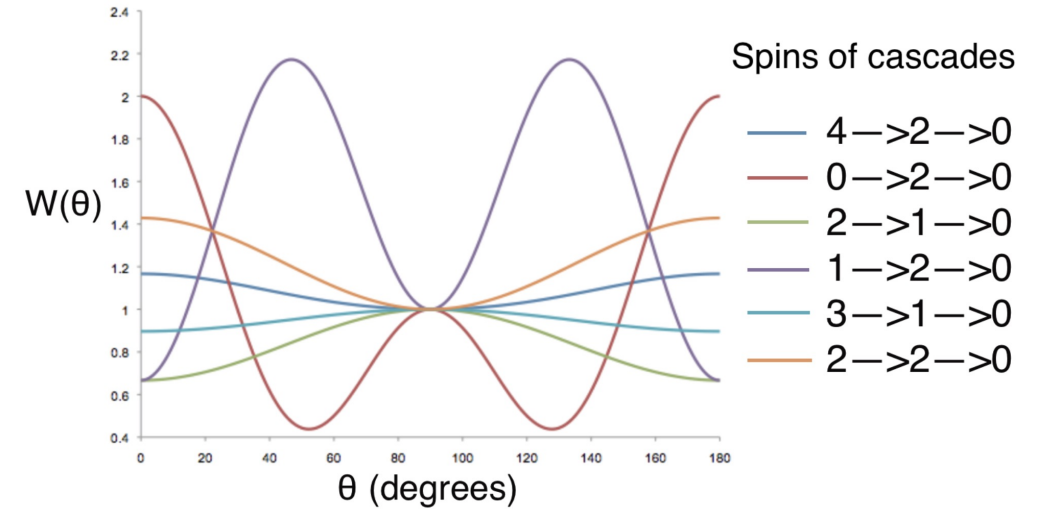
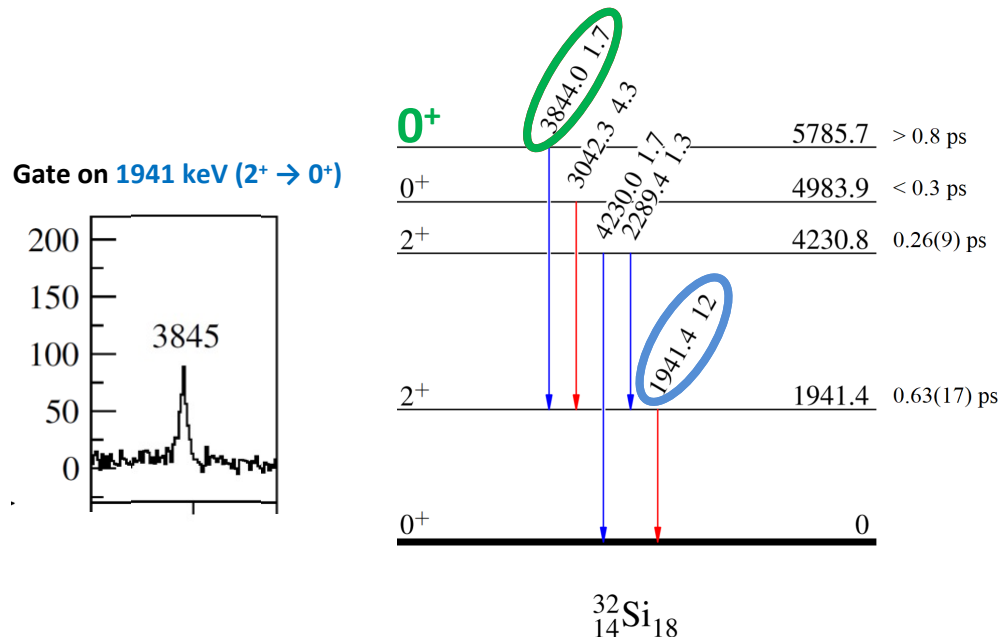
General formula:

$$W(\theta) = \sum_{k=0, k=\text{even}}^{2L} a_k P_k(\cos\theta),$$

Specific case L=2 (quadrupole transitions)

$$W(\theta) = a_0 P_0(\cos\theta) + a_2 P_2(\cos\theta) + a_4 P_4(\cos\theta)$$

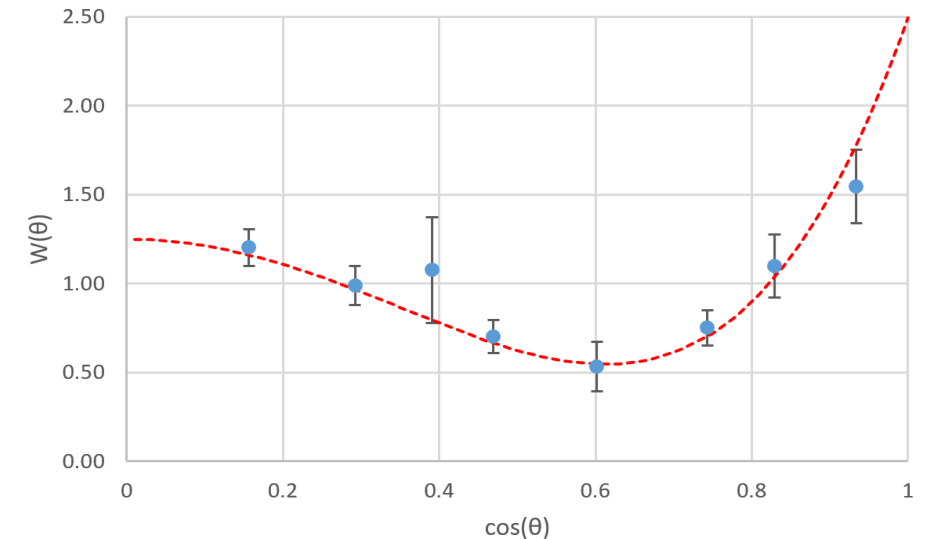
G. Goertzel, *Angular Correlation of Gamma-Rays*, Phys. Rev. 70, 897 (1946).



MSc Thesis, Andrew Dale MacLean, March, 2016

Angular correlations using ROSPHERE (25 HPGe)

^{32}Si 3844-1942 keV ($0^+ \rightarrow 2^+ \rightarrow 0^+$)



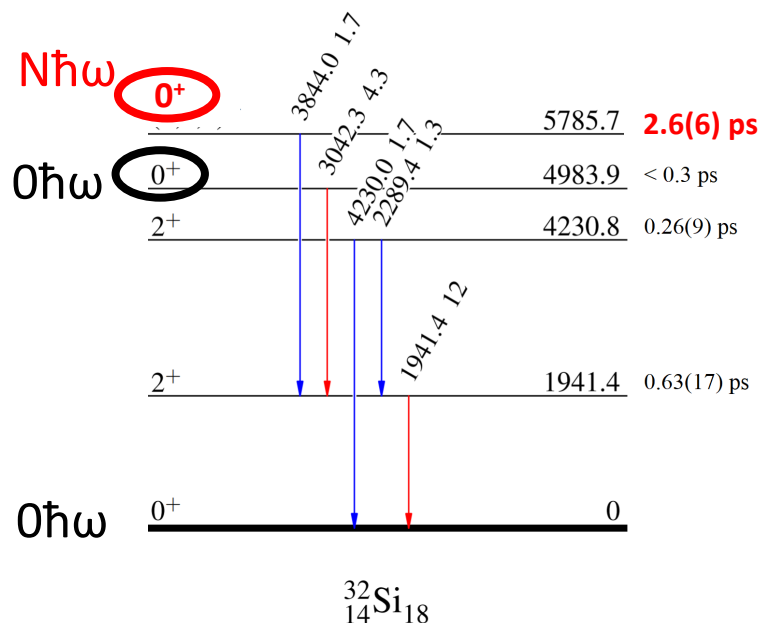
Experimental results

The 5786 keV level in ^{32}Si :

- Spin-parity assignment: $J^\pi = 0^+$
- Half-life measurement: $T_{1/2} = 2.6(6) \text{ ps}$

$B(E2; 3042.3 \text{ keV}; 0_2^+ \rightarrow 2_1^+) > 1.2 \text{ W.u.}$

$B(E2; 3844 \text{ keV}; 0_3^+ \rightarrow 2_1^+) = 0.043(10) \text{ W.u.}$



Theoretical calculations

- Preliminary USD-based Shell model calculations [A. Poves] predict:

$B(E2) \sim 4 \text{ W.u.}$ from the normal ($0\hbar\omega$) state

$\rightarrow$ expected $T_{1/2} \sim 140 \text{ fs}$

$B(E2) \sim 0.1 \text{ W.u.}$ from the intruder ($N\hbar\omega$) state

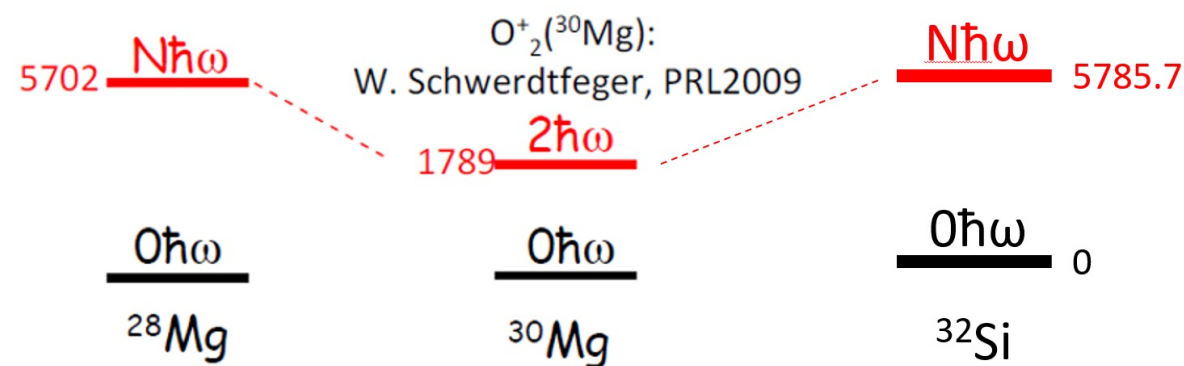
$\rightarrow$ expected $T_{1/2} \sim 1.5 \text{ ps}$



- These predictions are comparable to experimental data available for ^{28}Mg :

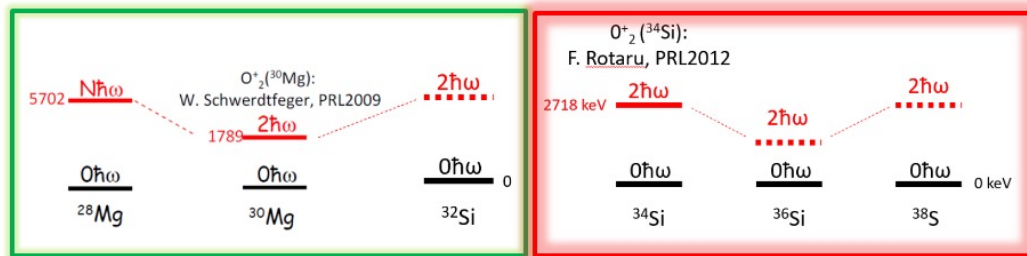
$B(E2)(0_2^+ \rightarrow 2_1^+) = 2.6(4) \text{ W.u.}$

$B(E2)(0_3^+ \rightarrow 2_1^+) = 0.077(12) \text{ W.u.}$



Outlook

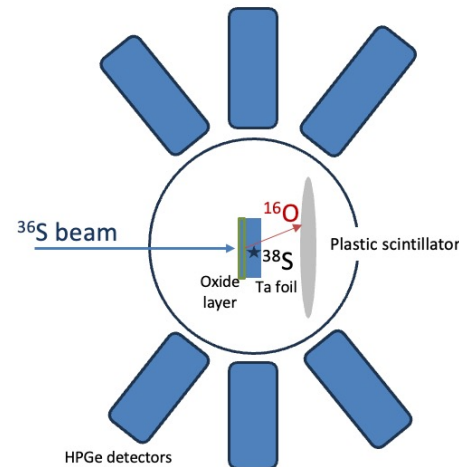
- Expand the study to other candidates near the N=20 "Island of Inversion" – ^{38}S (experiment scheduled between 7-19 July 2025)



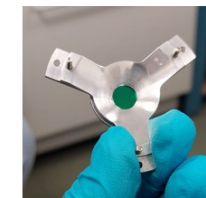
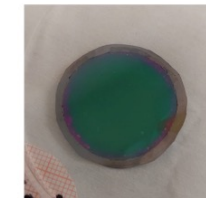
S	S	S	S	S	S	S
32	33	34	35	36	37	38
P	P	P	P	P	P	P
31	32	33	34	35	36	37
Si	Si	Si	Si	Si	Si	Si
30	31	32	33	34	35	36
Al	Al	Al	Al	Al	Al	Al
29	30	31	32	33	34	35
Mg	Mg	Mg	Mg	Mg	Mg	Mg
28	29	30	31	32	33	34

Proposed experiment

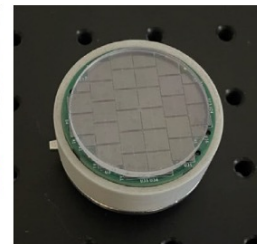
- Reaction:** Inverse kinematics sub-barrier 2-n transfer reaction $^{18}\text{O}(^{36}\text{S}, ^{38}\text{S})^{16}\text{O}$ @ $E_b = 56-60$ MeV
- Target:** $\text{Ta}_2^{18}\text{O}_5$ (0.8 μm oxide layer on 7 μm Ta foil)
- Detection:**
 - Angular correlations:** 24 HPGe + 1 LaBr + Plastic scint.
 - Fast-timing:** 10 HPGe + 15 ELIGANT $\text{LaBr}_3(\text{Ce})/\text{CeBr}$ + Plastic scint.



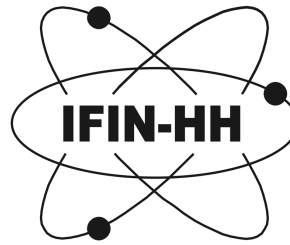
ELIGANT 3x3" $\text{LaBr}_3(\text{Ce})/\text{CeBr}$



$\text{Ta}_2^{18}\text{O}_5$ at ROSPHERE in 2022
Suitable for plunger measurements



In-beam plastic scintillator with SiPM readout
C. Neacsu et al., NIM A 1065, 169495 (2024).



Unveiling the intruder 0^+ state in ^{32}Si near the N=20 'Island of inversion'

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Thank you for your attention!