Nuclear Structure and Decay Data Evaluations

S.Lalkovski
Sofia University ‘St.Kl.Ohridski’

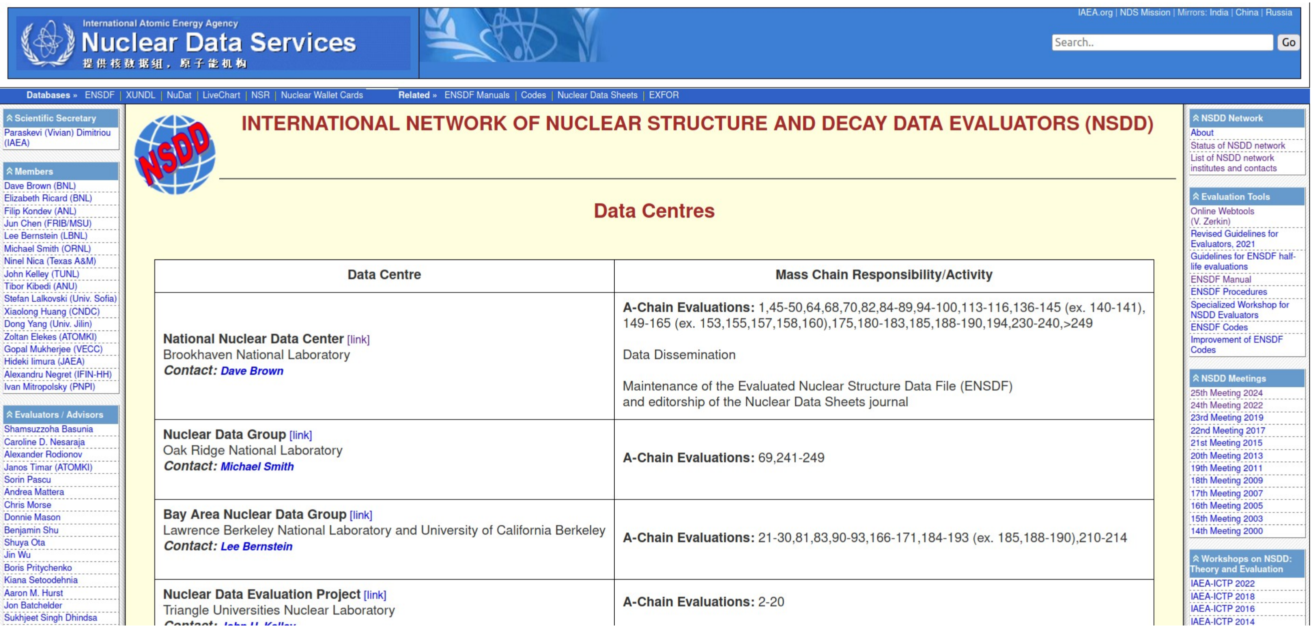
APRENDE Project

- Background
  - **NuPECC LRP’2024 observation:** The absence of a coordinated nuclear data effort in Europe, in conjunction with limited funding, has resulted in a shortage of expert data evaluators with serious repercussions for the international databases. Over the past two decades, **Europe’s contribution to ENSDF has dwindled to less than 20% of the overall**. **This figure is notably low considering the substantial volume of experimental data generated by the European nuclear physics facilities**. Combined with a global decline in the ENSDF effort worldwide, the cumulative ENSDF evaluation effort is no longer adequate to keep the database up to date within a 10-year cycle. **To maintain a regular 10-year update cycle**, **a minimum of 12 full-time evaluators is required**, whereas the current global effort amounts to just 5. What this situation implies is that the new, accurate, and precise experimental data generated by **state-of-the-art European nuclear physics facilities will not be promptly incorporated into the databases**, thus delaying their utilisation in various applications.
  - **NuPECC recommendation:** Dedicated efforts to train the next generation of nuclear data experts in data evaluation and the use of AI/ML methods and modern data-driven technologies are supported.
  - **Pre-APRENDE status:** 0.2 FTE dedicated to data evaluation in Sofia University is an NSDD member since 2017; Similar numbers in ATOMKI and IFIN-HH – the three EU NSDD centres

- APRENDE Scope (Task 4.1. Decay data evaluations and education)
  - To train a new a evaluator (Sofia Uni) – one scientist recruited to 0.5 FTE; Training on A=117 and XUNDL already started
  - To deliver two mass-chain evaluations (A=106, 111)
- APRENDE Effort
  - Sofia University: **24.4 PM**
  - IFIN-HH: **3.8 PM**
  - ATOMKI: **4.5 PM**

- APRENDE Context (**ATOMKI, IFIN-HH, SofiaUn**i are the EU members of the Nuclear Structure and Decay Data Network that maintains the ENSDF)
  - Effort to attract more people in Bulgaria (National Program *Enhancing the qualification in the fields of Nuclear Technology and Nuclear Engineering*) and Romania (post-doc)

Nuclear Structure and Decay Data Evaluation activities



IAEA.org | NDS Mission | Mirrors: India | China | Russia

International Atomic Energy Agency
Nuclear Data Services
提供核数据组，原子能机构

Search.. Go

Databases » ENSDF | XUNDL | NuDat | LiveChart | NSR | Nuclear Wallet Cards   Related » ENSDF Manuals | Codes | Nuclear Data Sheets | EXFOR

Scientific Secretary
Paraskevi (Vivian) Dimitriou (IAEA)

Members
Dave Brown (BNL)
Elizabeth Ricard (BNL)
Filip Kondev (ANL)
Jun Chen (FRIB/MSU)
Lee Bernstein (LBNL)
Michael Smith (ORNL)
Ninel Nica (Texas A&M)
John Kelley (TUNL)
Tibor Kibedi (ANU)
Stefan Lalkovski (Univ. Sofia)
Xiaolong Huang (CNDC)
Dong Yang (Univ. Jilin)
Zoltan Elekes (ATOMKI)
Gopal Mukherjee (VECC)
Hideki Iimura (JAEA)
Alexandru Negret (IFIN-HH)
Ivan Mitropolsky (PNPI)

Evaluators / Advisors
Shamsuzzoha Basunia
Caroline D. Nesaraja
Alexander Rodionov
Janos Timar (ATOMKI)
Sorin Pascu
Andrea Mattera
Chris Morse
Donnie Mason
Benjamin Shu
Shuya Ota
Jin Wu
Boris Pritychenko
Kiana Setoodehnia
Aaron M. Hurst
Jon Batchelder
Sukhjeet Singh Dhindsa

NSDD

INTERNATIONAL NETWORK OF NUCLEAR STRUCTURE AND DECAY DATA EVALUATORS (NSDD)

Data Centres

Data Centre	Mass Chain Responsibility/Activity
National Nuclear Data Center [link] Brookhaven National Laboratory ***Contact:*** *Dave Brown*	**A-Chain Evaluations:** 1,45-50,64,68,70,82,84-89,94-100,113-116,136-145 (ex. 140-141), 149-165 (ex. 153,155,157,158,160),175,180-183,185,188-190,194,230-240,>249 Data Dissemination Maintenance of the Evaluated Nuclear Structure Data File (ENSDF) and editorship of the Nuclear Data Sheets journal
Nuclear Data Group [link] Oak Ridge National Laboratory ***Contact:*** *Michael Smith*	**A-Chain Evaluations:** 69,241-249
Bay Area Nuclear Data Group [link] Lawrence Berkeley National Laboratory and University of California Berkeley ***Contact:*** *Lee Bernstein*	**A-Chain Evaluations:** 21-30,81,83,90-93,166-171,184-193 (ex. 185,188-190),210-214
Nuclear Data Evaluation Project [link] Triangle Universities Nuclear Laboratory	**A-Chain Evaluations:** 2-20

NSDD Network
About
Status of NSDD network
List of NSDD network institutes and contacts

Evaluation Tools
Online Webtools (V. Zerkin)
Revised Guidelines for Evaluators, 2021
Guidelines for ENSDF half-life evaluations
ENSDF Manual
ENSDF Procedures
Specialized Workshop for NSDD Evaluators
ENSDF Codes
Improvement of ENSDF Codes

NSDD Meetings
25th Meeting 2024
24th Meeting 2022
23rd Meeting 2019
22nd Meeting 2017
21st Meeting 2015
20th Meeting 2013
19th Meeting 2011
18th Meeting 2009
17th Meeting 2007
16th Meeting 2005
15th Meeting 2003
14th Meeting 2000

Workshops on NSDD: Theory and Evaluation
IAEA-ICTP 2022
IAEA-ICTP 2018
IAEA-ICTP 2016
IAEA-ICTP 2014

We evaluate:

- γ-ray energies ($E\gamma$), and intensities ($I\gamma$)
- γ-ray multipolarities (λL) and mixing ratios (δ)
- Levels J^{π}, $T_{1/2}$

We calculate:

- Level energies (E_{level})
- Intensity balances to each level
- Branching ratios
- Electromagnetic transition rates

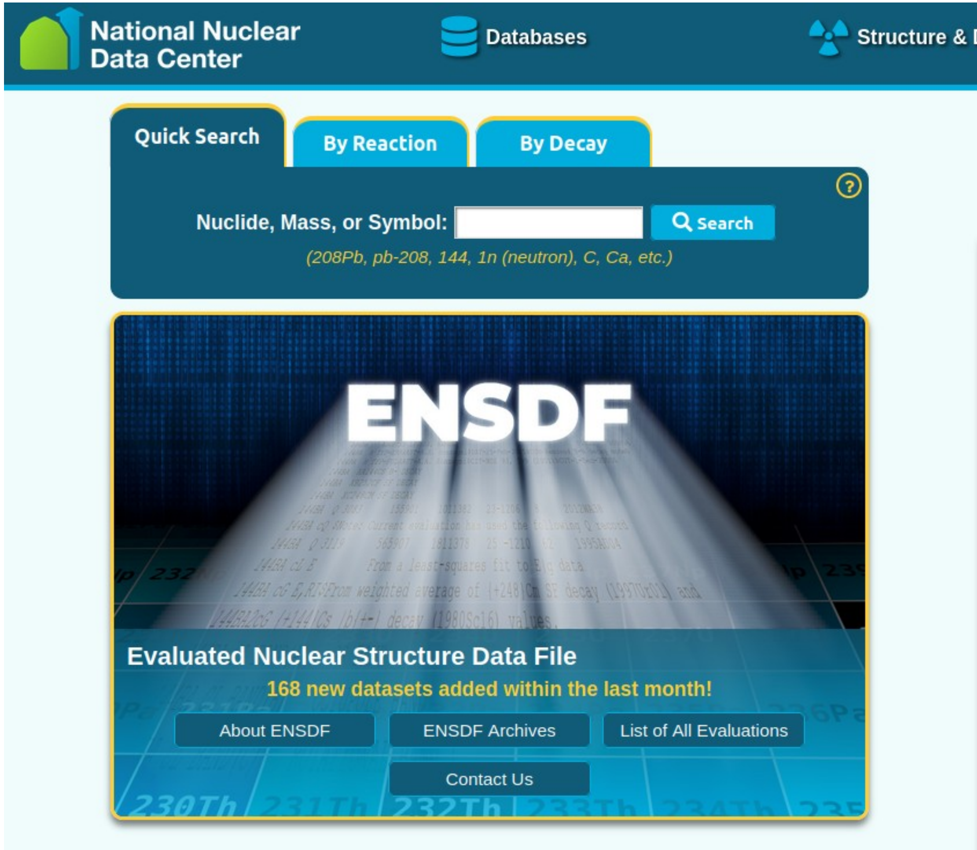
We use:

- AME2021 (2021Wa16)
- Static moments tables (N. Stone)

Process:

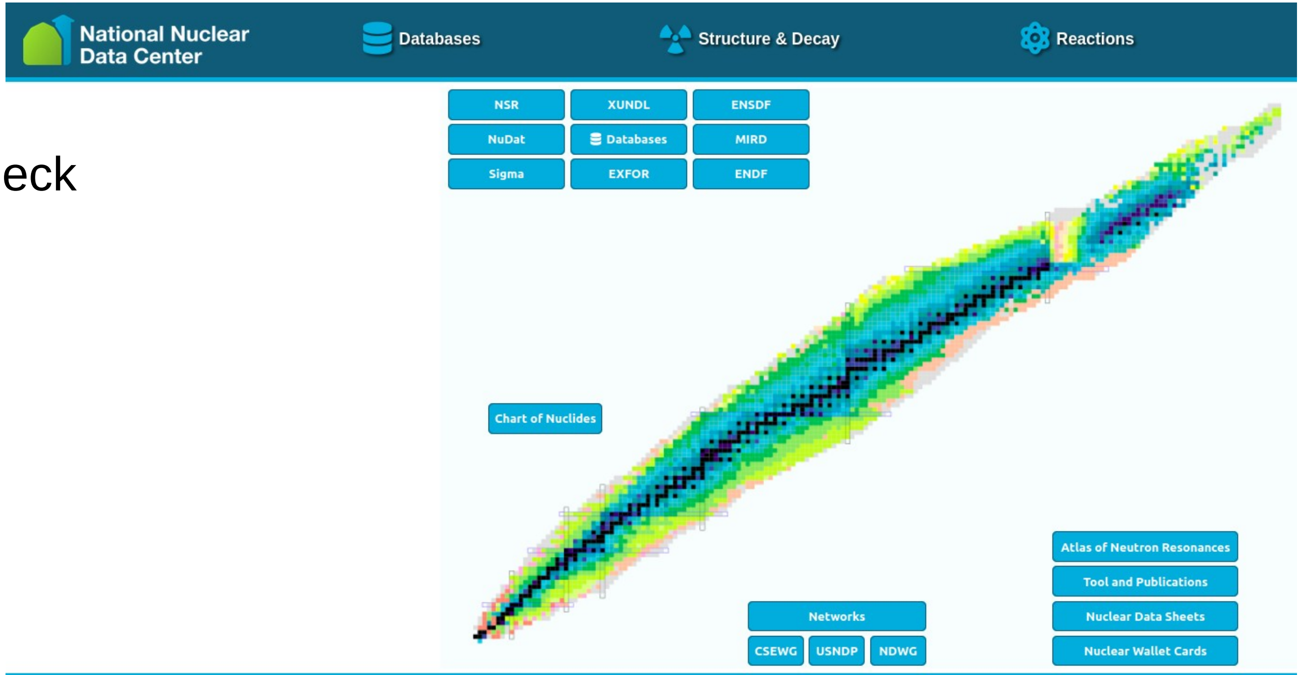
- Nucleus by nucleus approach – a critical compilation of published data (primary, secondary data)
- Data organized in data sets, each of which containing data from similar reactions, $\beta^{\pm}$, *EC* etc.
- Adopted levels and gammas data sets contain recommended numbers for all measured quantities
- The process is repeated for all nuclei in a given mass chain

- Submission to NNDC for review
- Reviewed data disseminated through the www.nndc.bnl.gov/ensdf site and published in Nucl.Data Sheets
- Each mass-chain should be re-evaluated once/decade
- Meanwhile
  - unevaluated data is critically compiled and uploaded to XUNDL data base
  - Correction still can be made and uploaded to ENSDF



Data Bases and Utilities

- **NSR** (Nuclear Science References)
- **XUNDL** (Unevaluated Nuclear Structure and Decay Data Library)
- **ENSDF** (Evaluated Nuclear Structure and Decay Data File)



Codes

- Fmtchk, pandora, consistencyCheck
- Gtol
- Bricc
- Logft
- Avetool
- JavaNDS

EXAMPLES

Example 1: the 1871 keV state in ^{112}Cd

1870.68[@] *4*	4^+	A DEF		J^π: 1253.31γ E2 to 2^+; 455.14γ M1+E2 to 4^+; band member.
1870.96 *5*	0^+	AB DEFGH J LM	QR T V	XREF: J(1869.7)Q(1873)R(1872)T(1876). J^π: 1253.49γ E2 to 2^+; L(pol d,t)=0.

^{112}Cd Levels

Cross Reference (XREF) Flags

A	^{112}Ag β^- decay (3.130 h)	I	^{112}Cd(γ,pol γ')	Q	^{110}Cd(t,p)
B	^{112}In ε decay (14.88 min)	J	^{112}Cd(γ,γ')	R	^{113}Cd(pol d,t)
C	Coulomb excitation	K	^{111}Cd(d,pγ)	S	^{112}Cd(α,α')
D	^{110}Pd(α,2nγ)	L	^{112}Cd(pol d,d$'$)	T	^{111}Cd(d,p)
E	^{112}Cd(n,n$'\gamma$)	M	^{112}Cd(d,d$'$)	U	^{112}Cd(pol p,p$'$)
F	^{112}Cd(p,p$'\gamma$)	N	^{112}Cd(π^-,X)	V	^{112}Cd(p,p$'$)
G	^{111}Cd(n,γ) E=th:primary	O	^{112}Cd(e,e$'$)	W	^{114}Cd(p,t)
H	^{111}Cd(n,γ) E=th:secondary	P	^{110}Pd(^{3}He,n)		

Example 1: the 1871 keV state in ^{112}Cd

1870.68[@] *4*	4^+	A DEF		Jπ: 1253.31γ E2 to 2^+; 455.14γ M1+E2 to 4^+; band member.
1870.96 *5*	0^+	AB DEFGH J LM	QR T V	XREF: J(1869.7)Q(1873)R(1872)T(1876). Jπ: 1253.49γ E2 to 2^+; L(pol d,t)=0.

^{112}Cd(n,n′γ) 2001Ga44,2007Ga22

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	S. Lalkovski, F. G. Kondev	NDS 124, 157 (2015)	1-Aug-2014

2007Ga22, 2001Ga44: Facility: University of Kentucky Van de Graaf accelerator; Beam: pulsed, E(n)= 1.8 to 4.2 MeV from ^{3}H(p,n)^{3}He reaction, FWHM = 1 ns, neutron flux = 5×10^7; Target: 52.5g CdO enriched to 98.18% in ^{112}Cd; Detectors: three Compton-suppressed HPGe; Measured: γ, γ(θ), γ-γ coinc., Iγ, Eγ, $T_{1/2}$; Deduced: γ-ray Mult., ^{112}Cd level scheme; From the same collaboration: 2009Gr10, 2000Ga22, 1999Ga20, 1999Ga15, 1999Mc03, 1997LeZZ, 1997YaZZ, 1996Ga26, 1996Le19, Others: 2010Sc13, 1990Ar20, 1976De23.

Example 1: the 1871 keV state in ^{112}Cd

										[illegible] 10 B(E2)(W.u.)=0.88 *17* Mult.: α(K)exp=0.00050 *7* in ^{111}Cd(n,γ) E=th (1997Dr03). Mult.: a_0=15.6 *2*; A_2=0.210 *13*; A_4=−0.036 *19* from γγ(θ) in ^{110}Pd(α,2nγ) (1993De09).
1870.68	4^+	401.88 *13*	58 *3*	1468.822	2^+	E2		0.01277		α(K)=0.01093 *16*; α(L)=0.001492 *21*; α(M)=0.000288 *4* α(N)=5.04×10^{-5} *7*; α(O)=2.44×10^{-6} *4* Mult.: A_2=+0.60 *2*, A_4=−0.10 *2* in ^{110}Pd(α,2nγ) (1997Dr03).
		455.26 *13*	32.0 *17*	1415.480	4^+	M1+E2	+2.7 *+4−3*	0.00871		α(K)=0.00750 *11*; α(L)=0.000987 *15*; α(M)=0.000190 *3* α(N)=3.35×10^{-5} *5*; α(O)=1.706×10^{-6} *24* Mult.: A_2=0.06 *23*, A_4=−0.41 *24* from γγ(θ) in ^{110}Pd(α,2nγ) (1997Dr03). δ: Other: 2.43 *15* or −0.45 *14* from γγ(θ) in ^{110}Pd(α,2nγ) (1997Dr03).
		558.39 *11*	100.0 *25*	1312.390	2^+	E2		0.00487		α(K)=0.00421 *6*; α(L)=0.000542 *8*; α(M)=0.0001042 *15* α(N)=1.84×10^{-5} *3*; α(O)=9.62×10^{-7} *14* Mult.: A_2=+0.64 *3*, A_4=−0.12 *4* from γγ(θ) in ^{110}Pd(α,2nγ) (1997Dr03).
		1253.16 *12*	89 *3*	617.518	2^+	E2		7.17×10^{-4}		α(K)=0.000612 *9*; α(L)=7.25×10^{-5} *11*; α(M)=1.387×10^{-5} *20* α(N)=2.47×10^{-6} *4*; α(O)=1.431×10^{-7} *20*; α(IPF)=1.510×10^{-5} *22* Mult.: A_2=+0.52 *4*, A_4=−0.15 *6* from γγ(θ) in ^{110}Pd(α,2nγ) (1997Dr03).

Adopted Levels, Gammas (continued)

γ(^{112}Cd) (continued)

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Mult.†	δ†f	α^e	Comments
1870.96	0^+	402.50 *16*	11.2 *12*	1468.822	2^+	E2		0.01271	α(K)=0.01088 *16*; α(L)=0.001485 *21*; α(M)=0.000287 *4* α(N)=5.02×10^{-5} *7*; α(O)=2.43×10^{-6} *4* Mult.: A_2=+0.60 *2*, A_4=−0.10 *2* from γγ(θ) in ^{110}Pd(α,2nγ) (1997Dr03).
		558.7	3.5@ *9*	1312.390	2^+	E2		0.00487	α(K)=0.00420 *6*; α(L)=0.000541 *8*; α(M)=0.0001041 *15* α(N)=1.83×10^{-5} *3*; α(O)=9.61×10^{-7} *14*
		1253.56 *12*	100.0 *12*	617.518	2^+	E2		7.16×10^{-4}	α(K)=0.000612 *9*; α(L)=7.25×10^{-5} *11*; α(M)=1.386×10^{-5} *20* α(N)=2.47×10^{-6} *4*; α(O)=1.430×10^{-7} *20*; α(IPF)=1.517×10^{-5} *22* Mult.: A_2=0.218 *42* and A_4=0.990 *51* in ^{112}In ε decay (14.88 min) (1972Ka34).

Example 2: ^{107}Sn beta-decay data

ИССЛЕДОВАНИЕ РАСПАДА ^{107}Sn

В.П.Бурминский, О.Д.Ковригин

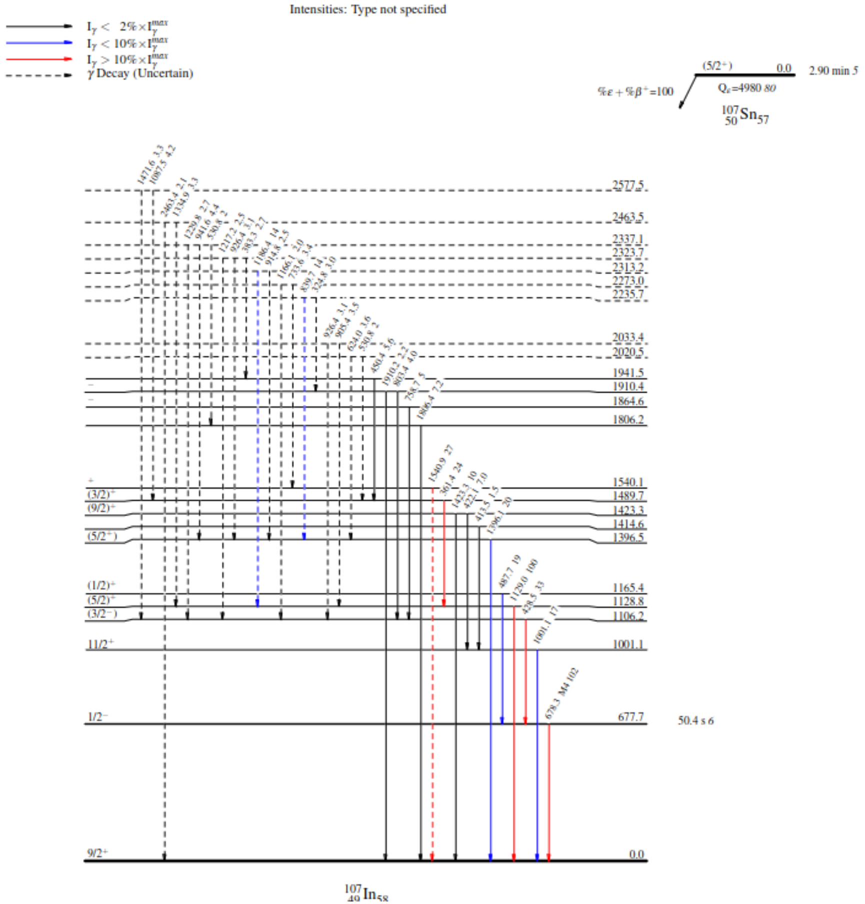
Наиболее полные данные о γ-лучах, сопровождающих β-распад ^{107}Sn известны из нашей работы /I/. В работе /2/ приводится нижняя часть схемы распада ^{107}Sn.

В настоящей работе обнаружен ряд новых γ-переходов и существенно уточнены значения энергий известных γ-линий, сопровождающих β-распад ^{107}Sn. Кроме того, определены коэффициенты подавления γ-лучей в измеренных спектрах интегральных антисовпадений. Результаты измерений приведены в таблице.

$E_\gamma(\Delta E_\gamma)$, кэВ	$I_\gamma(\Delta I_\gamma)$, отн.ед.	коэф. подавления	$E_\gamma(\Delta E_\gamma)$, кэВ	$I_\gamma(\Delta I_\gamma)$, отн.ед.	коэф. подавления
324,8(4)*	3,0(5)	-	I087,5(3)	4,2(II)	4,2(6)
36I,44(I3)	24(2)	7,5(I3)	II09,3(6)	I,4(6)	4,5(7)
374,I0(I7)*	3,8(6)	5,9(I0)	III9,0(6)*	3(I)	I,8(4)
383,3(7)	2,7(8)	6,5(II)	II29,04(II)	I00	2,8(4)
4I3,5(9)*	I,5(6)	2,5(5)	II66,I(7)	2,0(5)	3,6(6)
422,I(3)	7,0(I7)	8(2)	II73,7(5)	2,2(3)	I,7(3)
428,46(5)	33(3)	3,I(5)	II86,44(6)	I4(I)	3,9(5)
450,43(I9)	5,6(I4)	8(2)	I2I7,2(4)	2,5(6)	3,8(6)
487,67(I8)	I9(2)	3,I(5)	I222,2(5)*	2,4(6)	4,3(7)
530,8(7)*	2(I)	9(2)	I229,8(4)*	2,7(5)	2,9(5)
624,0(5)*	3,6(I4)	3,8(7)	I244,5(7)*	3(I)	2,9(6)
678,34(8)	I02(5)	I,0(I)	I254,2(8)*	2,4(3)	3(I)
733,55(25)	3,4(I2)	4,2(6)	I334,9(6)	3,3(6)	8(2)
758,7(3)	5(2)	~5	I359,65(I4)	7,6(II)	3,0(5)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EG	RI +- DRI		MULT	MR	CC	PARENT	SPIN	DAUGHTER		ID
514	100.00	0.00				514.0+X	(27/2+)	X	(23/2+)	54FE(59CO,A2PG)
514.5 7	100.00	9.86				514.5+X	(25/2+)	X	(21/2+)	78SE(32S,P2NG)
678.3 10	100.00	0.00	M4		0.060	677.3	1/2-	0.0	9/2+	ADOPTED LEVELS, GAMMAS
678.3 10	100.00	4.90	M4			677.7	1/2-	0.0	9/2+	107SN EC DECAY (2.90 M)
678.3 10	100.00	0.00	M4			678.2	1/2-	0	9/2+	106CD(3HE,PNG)
678.3 3	100.00	0.00	M4			678.3	1/2-	0.0	9/2+	106CD(D,NG)
678.34 6	100.00	0.00	M4			678.34	1/2-	0	9/2+	106CD(A,P2NG)
678.4 3	100.00	0.00	M4		0.0590 8	678.5	1/2-	0.0	9/2+	107IN IT DECAY (50.4 S)
679	100.00	0.00	M4			679	1/2-	0	9/2+	COULOMB EXCITATION
1000	100.00	0.00				1000.0	11/2+	0.0	9/2+	54FE(59CO,A2PG)
1000.4 5	100.00	7.69	M1			1000.5	11/2+	0.0	9/2+	58NI(52CR,3PG),54FE(56FE
1001	100.00	6.34				1001	11/2+	0	9/2+	COULOMB EXCITATION
1001.1 10	100.00	23.53				1001.1	11/2+	0.0	9/2+	107SN EC DECAY (2.90 M)
1001.3 3	100.00	10.00	E2(+M1)			1001.25	(11/2)+	0.0	9/2+	106CD(D,NG)
1001.4	100.00	0.00				1001.4	(11/2+)	0	(9/2+)	92MO(19F,2P2NG)
1001.5 10	100.00	0.00	M1			1001.4	11/2+	0.0	9/2+	ADOPTED LEVELS, GAMMAS
1001.46 8	100.00	0.51	M1			1001.48	11/2+	0	9/2+	106CD(A,P2NG)
1001.5 10	100.00	3.65	M1			1001.5	11/2+	0.0	9/2+	94MO(16O,P2NG)
1001.6 3	100.00	5.80				1001.51	11/2+	0.0	9/2+	78SE(32S,P2NG)
1001.5 10	100.00	9.70	M1			1001.6	11/2+	0	9/2+	106CD(3HE,PNG)
1001.6 1	100.00	1.30	M1			1001.61	11/2+	0	9/2+	54FE(58NI,5PG),
428.5 10	100.00	0.00	M1(+E2)			1105.6	(3/2)-	677.3	1/2-	ADOPTED LEVELS, GAMMAS
428.5 10	100.00	9.09				1106.2	(3/2-)	677.7	1/2-	107SN EC DECAY (2.90 M)
428.4 10	100.00	4.17				1106.6	3/2-	678.2	1/2-	106CD(3HE,PNG)
428.5 3	100.00	0.00	M1(+E2)			1106.8	(3/2)-	678.3	1/2-	106CD(D,NG)
429	100.00	LT				1107	3/2-	679	1/2-	COULOMB EXCITATION
1129.3 10	100.00	0.00	E2			1128.4	(5/2)+	0.0	9/2+	ADOPTED LEVELS, GAMMAS
1129.0 10	100.00	0.00				1128.8	(5/2)+	0.0	9/2+	107SN EC DECAY (2.90 M)
1129.2 4	100.00	5.00	E2			1129.2	(5/2)+	0.0	9/2+	106CD(D,NG)
1129.3 10	100.00	0.00	E2			1129.2	5/2+	0	9/2+	106CD(3HE,PNG)
487.6 10	100.00	0.00	E1			1164.7	(1/2)+	677.3	1/2-	ADOPTED LEVELS, GAMMAS
487.7 10	100.00	10.53				1165.4	(1/2)+	677.7	1/2-	107SN EC DECAY (2.90 M)
487.6 10	100.00	3.14				1165.8	(1/2,3/2	678.2	1/2-	106CD(3HE,PNG)
487.6 4	100.00	10.71	E1			1166.0	(1/2)+	678.3	1/2-	106CD(D,NG)
660	100.00	0.00				1174.0+X	(31/2+)	514.0+X	(27/2+)	54FE(59CO,A2PG)
660.0 3	100.00	9.52				X+1174.5	(29/2+)	514.5+X	(25/2+)	78SE(32S,P2NG)
1396.1 10	100.00	0.00	(E2)			1395.6	(5/2+)	0.0	9/2+	ADOPTED LEVELS, GAMMAS
1396.0 5	100.00	9.62	(E2)			1396.0	(5/2)+	0.0	9/2+	106CD(D,NG)
1396.1 10	100.00	3.44				1396.1		0	9/2+	106CD(3HE,PNG)
1396.1 10	100.00	20.00				1396.5	(5/2+)	0.0	9/2+	107SN EC DECAY (2.90 M)
413	0.00	0.00				1413.0	13/2+	1000.0	11/2+	54FE(59CO,A2PG)
1413	0.00	0.00				1413.0	13/2+	0.0	9/2+	54FE(59CO,A2PG)
413.2 5	41.88	3.19	M1			1413.9	13/2+	1000.5	11/2+	58NI(52CR,3PG),54FE(56FE

Example 2: ^{107}Sn beta-decay data



Example 3: ^{199}Tl SF

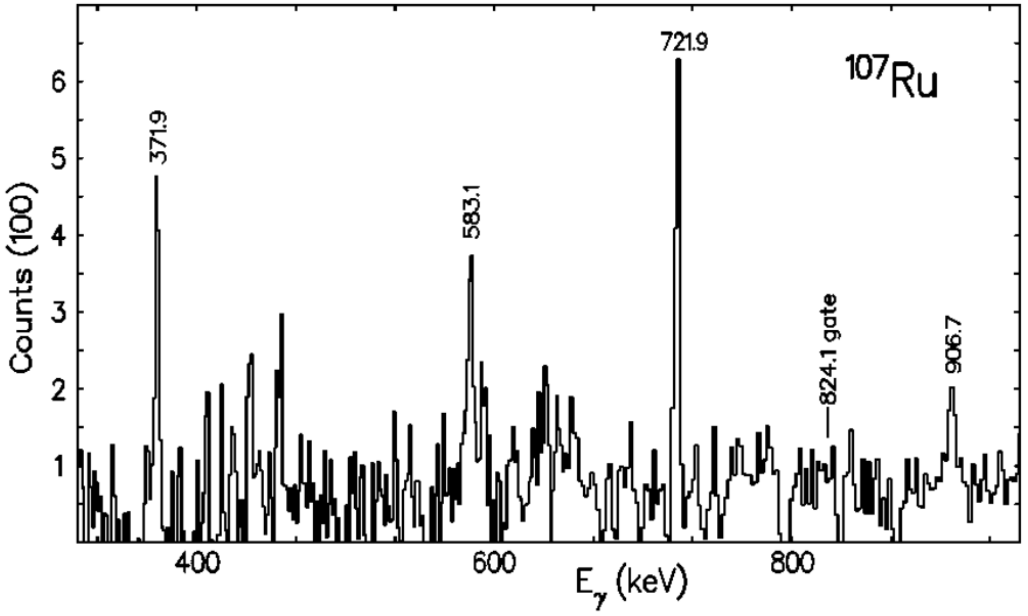
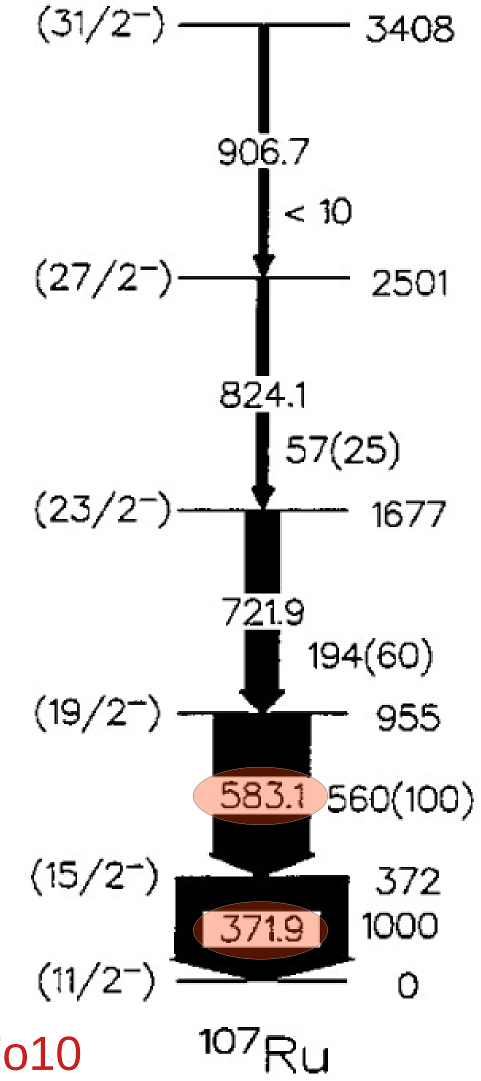


FIG. 4. Sum of spectra double-gated on (371.9 + 824.1 keV) and (583.1 + 824.1 keV) lines in ^{107}Ru from the ^{199}Tl(CN) experiment. The energies of the transitions are in keV.

Complementary: $^{87-92}$Rb



2000Fo10

Example 3: ^{252}Cf SF

Negative parity band

OBSERVATION OF ROTATIONAL BANDS IN THE . . . PHYSICAL REVIEW C **65** 014307

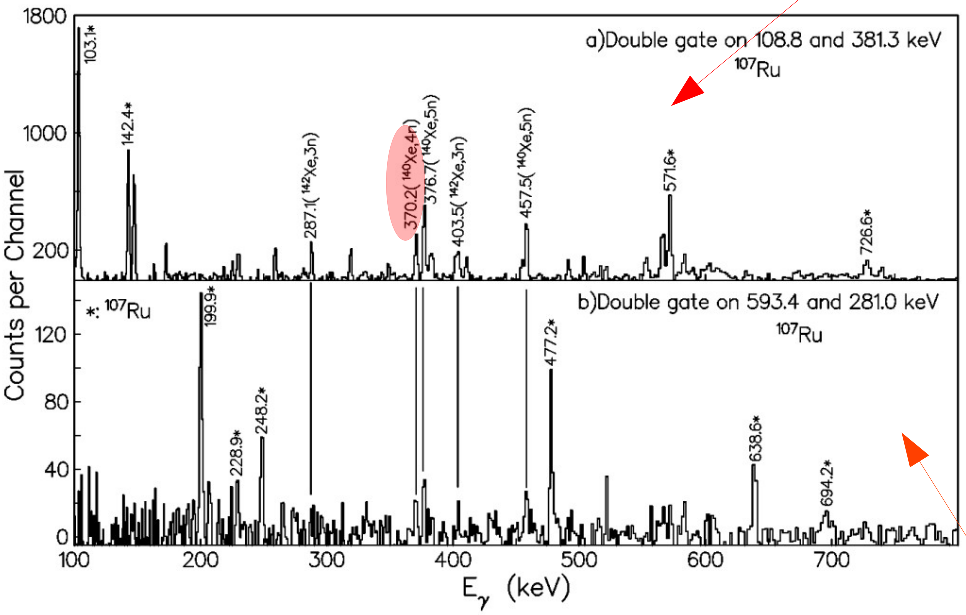
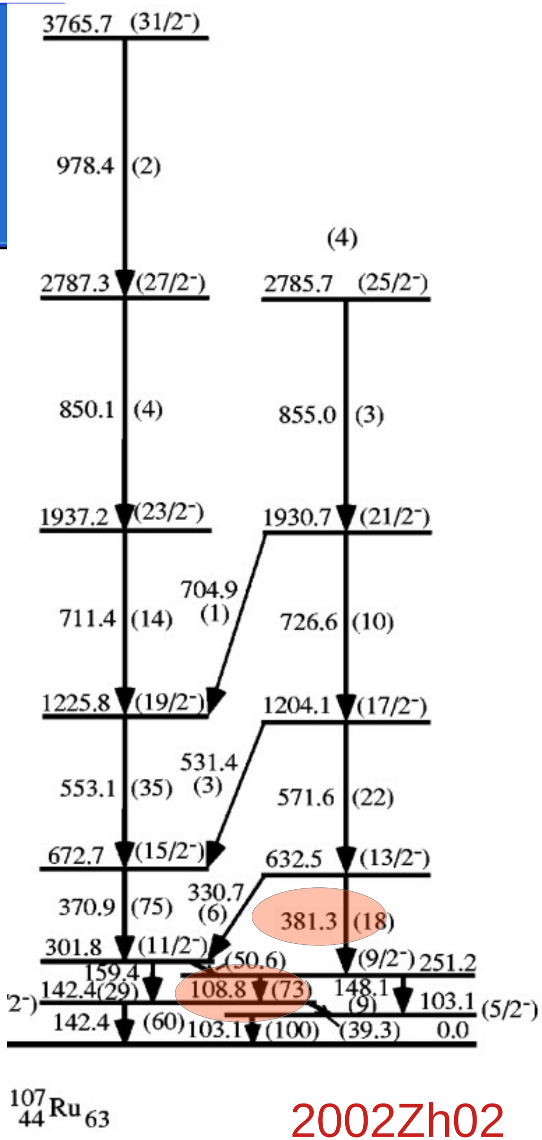


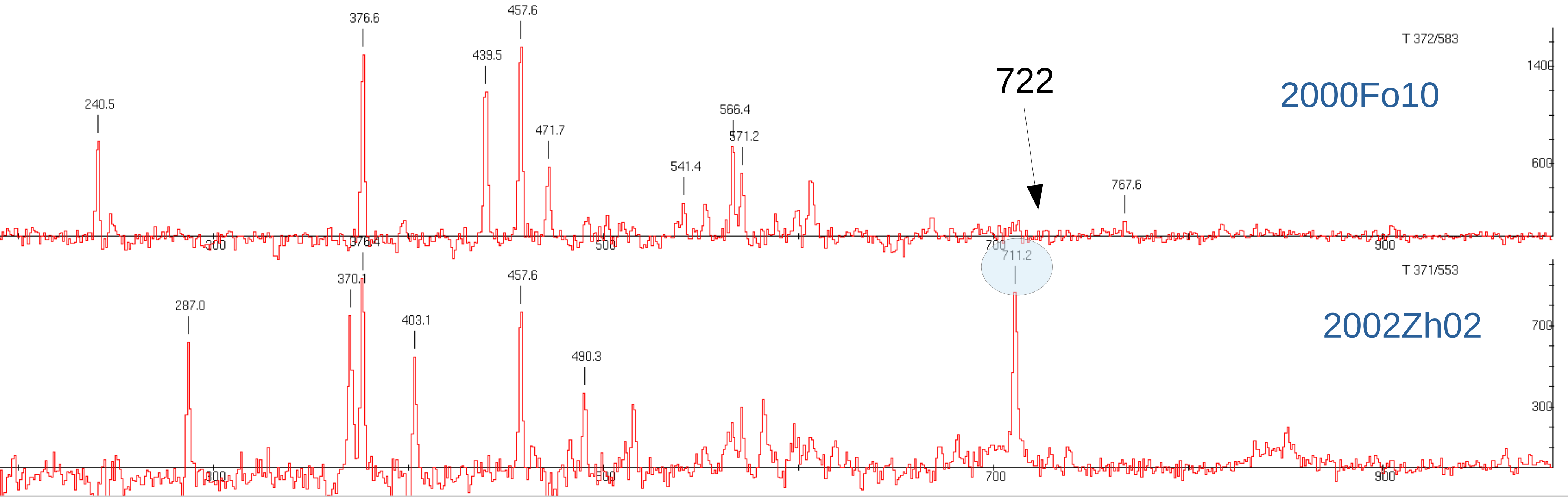
FIG. 2. (a) Upper panel: Coincidence spectrum obtained by double gates on the 108.8 and 381.3 keV transitions in ^{107}Ru. (b) Lower panel: Coincidence spectrum obtained by a double gate on the 593.4 and 281.0 keV transitions in ^{107}Ru.

Positive parity band



2002Zh02

Example 3: ^{252}Cf SF



Example 3: ^{252}Cf SF

Nuclear Inst. and Methods in Physics Research, A 969 (2020) 163967

Contents lists available at ScienceDirect

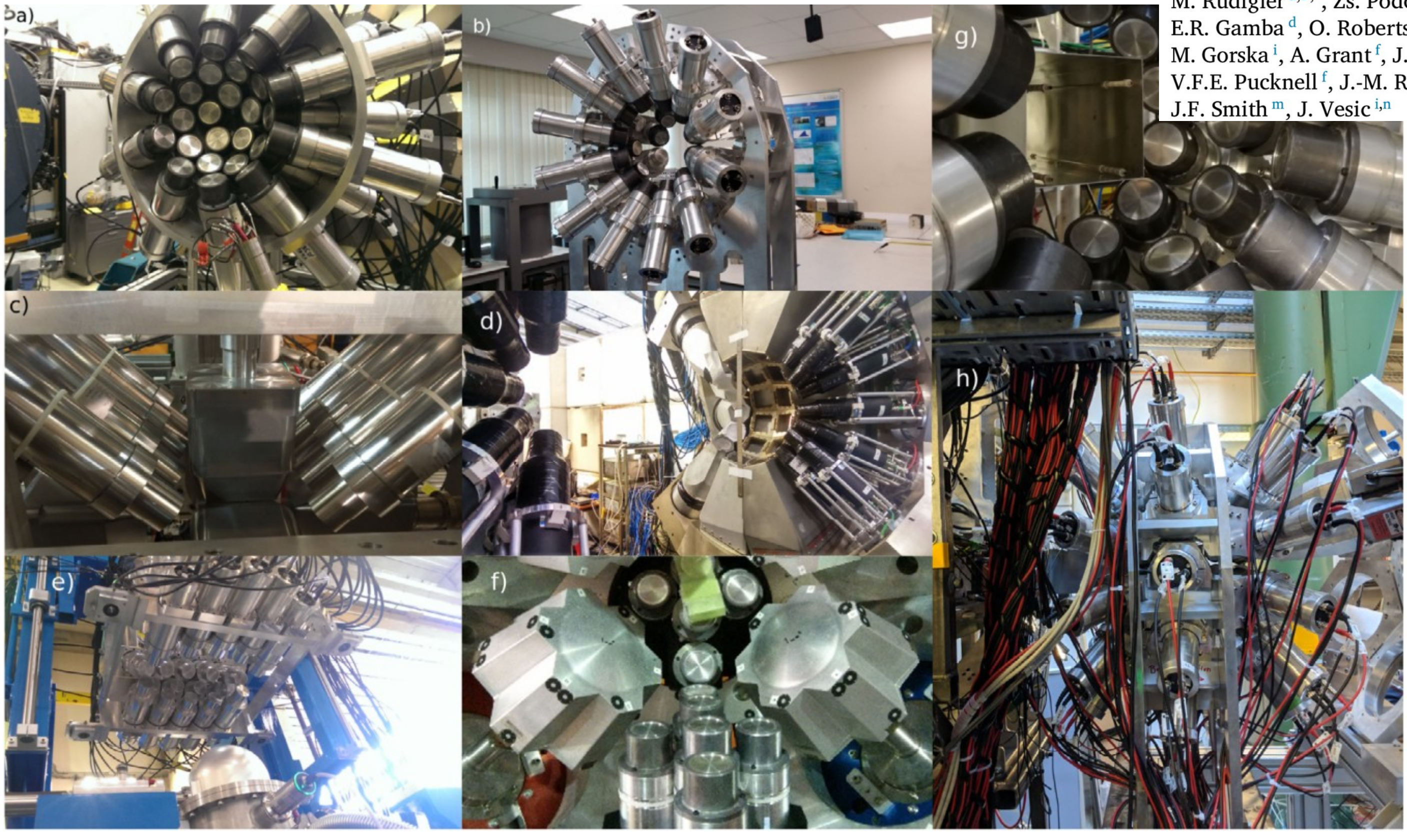
Nuclear Inst. and Methods in Physics Research, A

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

ELSEVIER

FATIMA — FAst TIMing Array for DESPEC at FAIR

M. Rudigier[a,b,*], Zs. Podolyák[a], P.H. Regan[a,c], A.M. Bruce[d], S. Lalkovski[a,e], R.L. Canavan[a,c], E.R. Gamba[d], O. Roberts[d], I. Burrows[f], D.M. Cullen[g], L.M. Fraile[h], L. Gerhard[j], J. Gerl[i], M. Gorska[i], A. Grant[f], J. Jolie[j], V. Karayonchev[j], N. Kurz[i], W. Korten[k], I.H. Lazarus[f], C.R. Nita[l], V.F.E. Pucknell[f], J.-M. Régis[j], H. Schaffner[i], J. Simpson[f], P. Singh[k], C.M. Townsley[a], J.F. Smith[m], J. Vesic[i,n]



^{252}Cf SF Decay data set

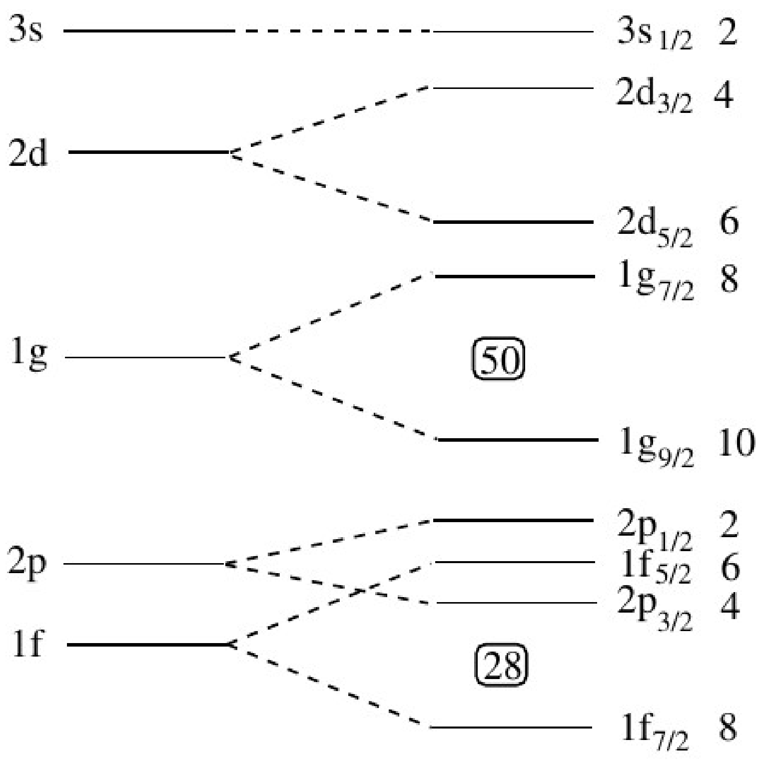
Detectors:
Gammasphere, comprising 55 HPGe
+
FATIMA, comprising .. $LaBr_3$:Ce

Measured: g-g-g, g-g-g-g, g-g-g(t), EG,RI

Deduced: level schemes, $T_{1/2}$

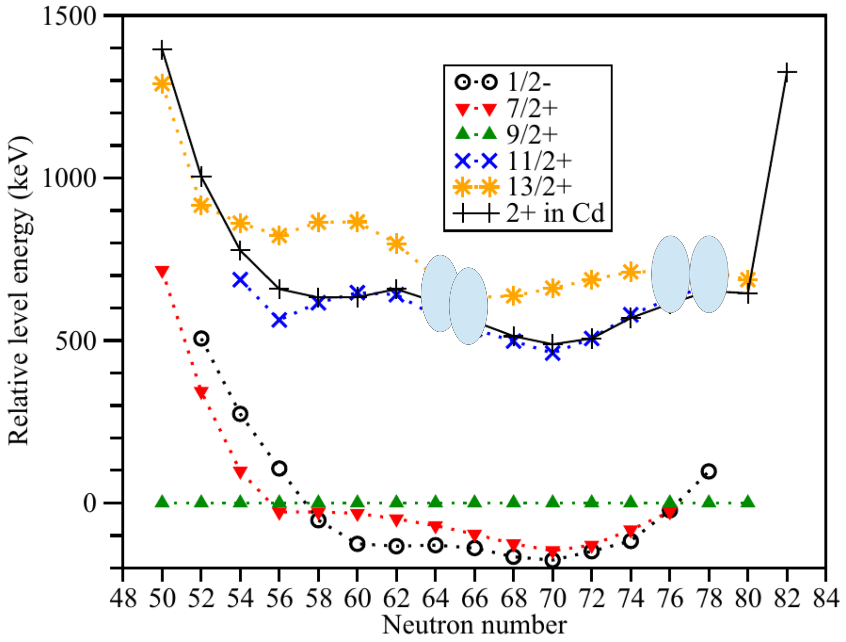
Example 4: j-1 anomaly in Ag

- Irregular ordering of the lowest-lying $7/2^+$ and $9/2^+$ states, prominent feature of the Ag isotopic chain.
- Expected significant $\pi g_{9/2}$ contribution for the Ag positive-parity excited states.
- The $\pi g_{9/2}^{-3}$ scheme generates a multiplet of states with spins up to $21/2^+$.
- Single particle transition across the shell gap is unlikely to be the reason for $7/2^+$.
- Extensive studies via large scale shell model calculations with effective Q·Q and surface delta (SDI) interactions, three-valence holes-vibrator coupling model calculations, IBFM, etc.

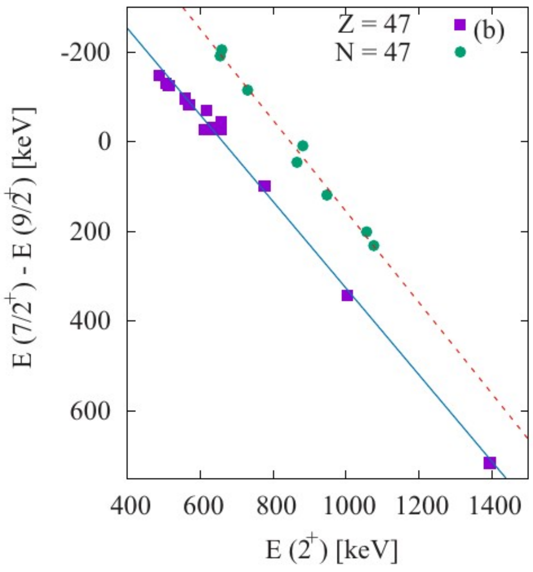


Example 4: j-1 anomaly in Ag

- Systematic studies on the Ag isotopic chain show that the *j, j-1* energy gap is strongly correlated with the energies of the 2+ states in the neighbouring even-A nuclei. Hence, the core excitations play an important role in the development of the low-energy part of the Ag spectrum.



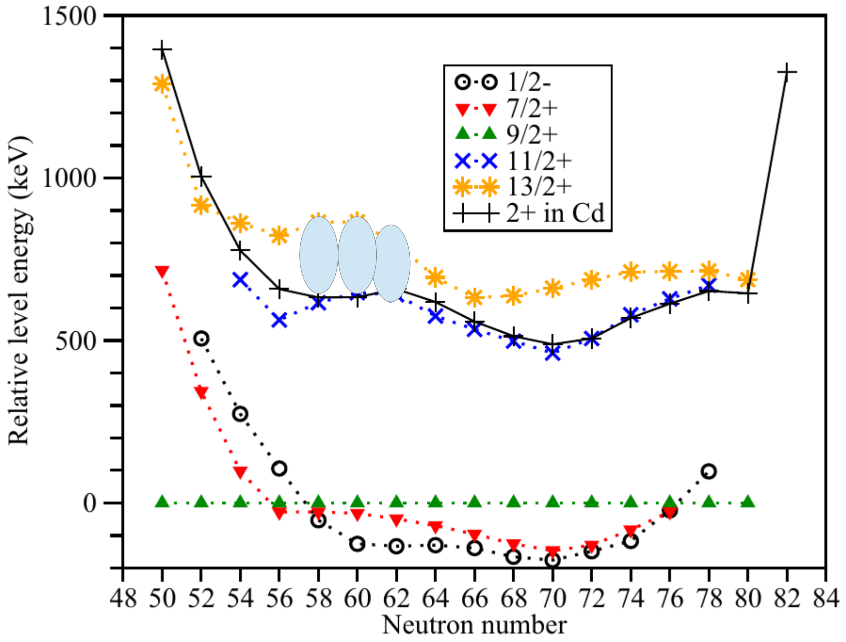
- The $11/2^+$, $13/2^+$ evolution with neutron number suggests that their wave functions are also dominated by the core excitation.



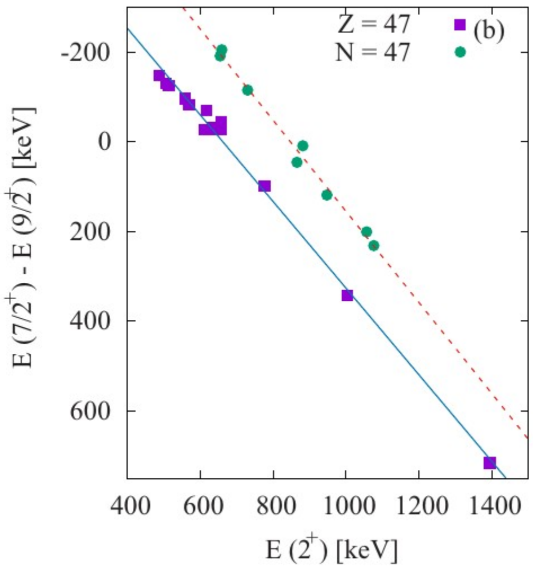
S.Lalkovski, S.Kisyov, Phys.Rev.**C106**, 064319 (2022)

Example 4: j-1 anomaly in Ag

- Systematic studies on the Ag isotopic chain show that the *j, j-1* energy gap is strongly correlated with the energies of the 2+ states in the neighbouring even-A nuclei. Hence, the core excitations play an important role in the development of the low-energy part of the Ag spectrum.



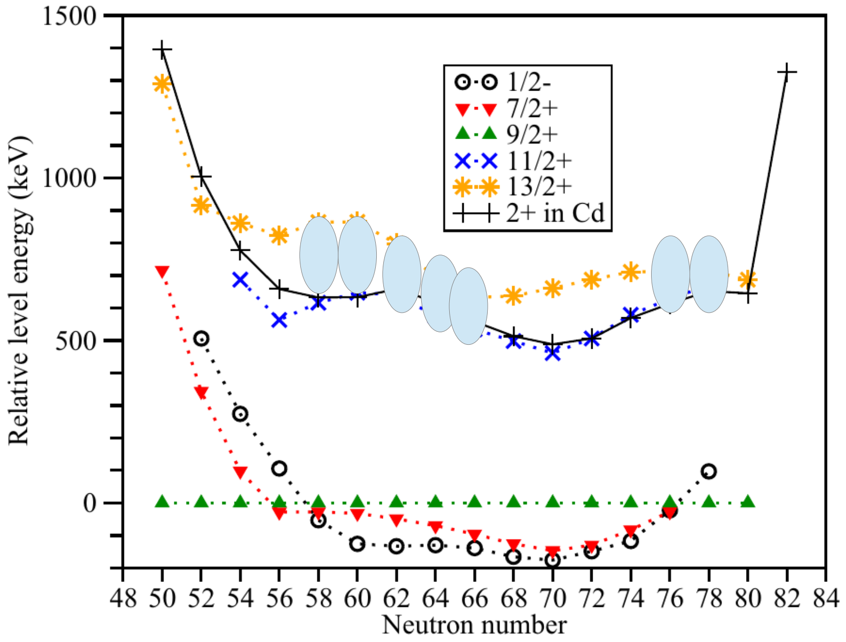
- The $11/2^+$, $13/2^+$ evolution with neutron number suggests that their wave functions are also dominated by the core excitation.



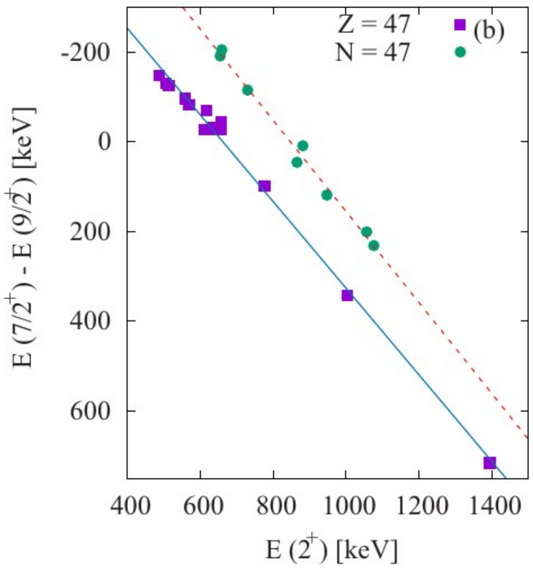
S.Lalkovski, S.Kisyov, Phys.Rev.**C106**, 064319 (2022)

Example 4: j-1 anomaly in Ag

- Systematic studies on the Ag isotopic chain show that the *j, j-1* energy gap is strongly correlated with the energies of the 2+ states in the neighbouring even-A nuclei. Hence, the core excitations play an important role in the development of the low-energy part of the Ag spectrum.



- The $11/2^{+}$, $13/2^{+}$ evolution with neutron number suggests that their wave functions are also dominated by the core excitation.



S.Lalkovski, S.Kisyov, Phys.Rev.**C106**, 064319 (2022)

CTBTO project – a different approach

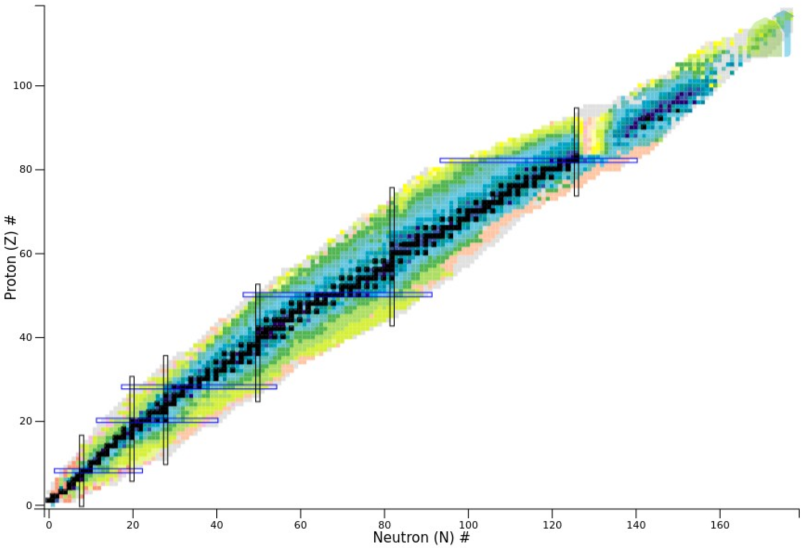
^{106}Rh β^- decay (28.6 s) 1982Ka10,1977Ok02,1977Ok03 (continued)

$\gamma(^{106}$Pd)

Iγ normalization: $I(512\gamma)_{abs}$=20.6% *6* (1969Od01); Other: $I(616+622\gamma)_{abs}$=10.6% *3* (1969Od01), $I(512\gamma)_{abs}$=21.0 20 %, $I(616+622)_{abs}$=10.0 10% (1966Ov01).
This table lists only data taken with semiconductor detectors.
α(K)exp=ce(K)/Iγ normalized to α(K)(512γ)=0.00484 *7* (E2 BRICC theory).

E_γ [†]	I_γ [‡@]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [&]	Comments
333.5 *4*	0.024 *10*	1562.259	2+	1229.19	4+	[E2]	0.02088 *30*	E_γ: 333.5 4 (1977Ok02). I_γ: 0.024 10 (1977Ok02).
428.31 *11*	0.322 *12*	1562.259	2+	1133.706	0+	[E2]	0.00948 *13*	E_γ: 428.4 2 (1982Ka10), 428.4 2 (1977Ok02), 428.39 22 (1975Hs02), 428.3 3 (1972Ma71), 428.19 25 (1972GeZG), 427.9 5 (1969St03), 427.7 10 (1968Ha35); Others: 428.20 (2017Da31), 427 (1971Az02). I_γ: 0.302 7 (2017Da31), 0.346 11 (1982Ka10), 0.36 4 (1977Ok02), 0.312 18 (1975Hs02), 0.35 18 (1972Ma71), 0.45 5 (1969St03); Others: 0.3 (1971Az02), 1.38 20 (1972GeZG), 0.014 5 (1968Ha35);
434.14 *14*	0.111 *6*	1562.259	2+	1128.062	2+	[M1+E2]	0.0085 *6*	E_γ: 434.25 21 (1982Ka10), 434.2 3 (1977Ok02), 434.3 5 (1975Hs02), 433.5 4 (1972GeZG), 434.1 5 (1972Ma71), 435.0 15 (1969St03). I_γ: 0.099 10 (1982Ka10), 0.09 2 (1977Ok02), 0.118 6 (1975Hs02), 0.077 39 (1972Ma71); Other: 0.23 6 (1969St03), 1.7 5 (1972GeZG),
439.24 *22*	0.054 *9*	2001.57	0+	1562.259	2+	[E2]	0.00878 *12*	E_γ: 439.17 27 (1982Ka10), 439.5 5 (1977Ok02), 439.0 7 (1972GeZG), 439.6 10 (1972Ma71). I_γ: 0.062 10 (1982Ka10), 0.046 20 (1977Ok02), 0.03 2 (1972Ma71); Other: 1.1 4 (1972GeZG),
511.8595 *30*	100	511.861	2+	0.0	0+	E2	0.00558 *8*	E_γ: 511.83 8 (1982Ka10), 511.85 1 (1977Ok02), 511.8605 31 (1976Sh25), 511.80 15 (1975Hs02), 511.85 8 (1972GeZG), 511.8 2 (1972Ma71), 511.8 2 (1969St03), 511.9 3 (1968Ha35), 512.0 5 (1967Fo09), 511.6 5 (1967Ra11); Others: 511.86 (2017Da31), 511.8605 31 relative to the 511 annihilation peak in 1976Sh25, 512 (1971Az02), 512 (1969Od01); I_γ: absolute $I\gamma(512\gamma)_{abs}$=20.6% *6* (1969Od01), 21% *2* (1966Ov01), 22.0% *11* (1975Ge06), 20.5% (1953Ka47). Mult.: A_2= −0.14 9, A_4= 0.44 11 (1975Hs02); Also, α(k)exp=0.0048 8 (1967Vr05), 0.0035 1 (1952Al06), 0.0054 15 (1950Me86); Other: 0.00480 (1975DzZU); K/LM=6.15 62 (1960Se05); K/L=7.1 1 (1958Gr07); Other:

Summary



Core ENSDF nuclear data evaluation activities

- **Mass chains data compilation, evaluations and dissemination;** For a given mass chain typically (A=107) there are
  - ***– 15 nuclei***
  - ***– 370 sources from 1939 to 2024***
  - ***– 88 data sets***
- **XUNDL evaluations** by article/nucleus

Data evaluations for monitoring applications

- **CTBTO –** *Recommended nuclear data and future data needs for 120 FP*
- **40 nuclei** *are under presently under evaluation (a team of NSDD evaluators)*

Evaluations on data for medical applications

- **^{117}Sn nucleus data evaluation**, *comprising 22 data sets (Done within SANDA. Now the whole A=117 under evaluation as part of the training process)*

Summary

Data analysis – some recent results

- **^{146}La beta-decay with Gammasphere** *(experiment, performed at Argonne National laboratory, USA)*
- **^{99}Rh fast-timing data from RoSphere** *(experiment, performed at IFIN-HH)*
- **^{115}Ag from ^{252}Cf spontaneous fission** *(experiment, performed at Argonne National laboratory, USA.)*

Experiments targeted on specific phenomena

- **Sub-nanosecond lifetimes of core-excited states in ^{105}Cd** *(experiment performed in July/August 2023 in IFIN-HH (Romania))*
- **Sub-nanosecond lifetimes lifetimes in ^{103,105}Ag** *(experiment performed in July/August 2023 in IFIN-HH (Romania))*
- **Sub-nanosecond lifetimes lifetimes in ^{107}Ag** *(experiment performed in Dec 2024 in IFIN-HH (Romania). Ongoing analysis.)*

Collaboration

- **Data Evaluation**
  - **IFIN-HH:** A.Negret, H.K.Singh (APRENDE Project)
  - **ATOMKI:** Z.Elekes, J.Timar (APRENDE Project)
  - **Sofia University:** O.Yordanov (APRENDE Project), N.Petrov
  - **NSDD:** F.Kondev (ANL), A.Nichols (Oxford Uni), J.Chen (MSU), T.Kibedi (ANU), S.Pascu (IFIN-HH) (CTBTO Project)

- **EXPERIMENTAL**
  - **Lawrence Berkeley National Lab:** S.Kisyov
  - **National Military Medical Academy:** D.Ivanova
  - **Sofia Medical University:** L.Atanasova
  - **IFIN-HH:** R.Lica, C.Mihai

Thank you!