EAGLE*) – spektroskopia γ w ŚLCJ-UW

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Środowiskowe Laboratorium Ciężkich Jonów
Uniwersytet Warszawski

*) central **E**uropean **A**rray for **G**amma **L**evels **E**valuations

Plan seminarium

- Eksperymenty 2021–2024 (ogólnie)
- EAGLE
- Eksperymenty do lipca 2022
- Układ detektorów neutronów NEDA i jego instalacja w ŚLCJ
- Detektor cząstek naładowanych DIAMANT
- Eksperymenty EAGLE-NEDA-DIAMANT
- Przyszłość
- Podsumowanie

Eksperymenty EAGLE listopad 2021 – marzec 2024

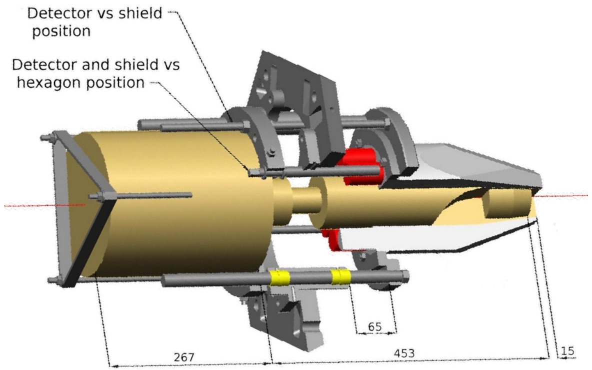
id	dates	spokeperson	title	beam	ancillary devices
HIL 088	29/11–8/12/2021 10 days	R. Zidarova, N. Pietralla	Collective isovector quadrupole excitation in ^{142}Sm — identification via a γγ correlation measurements after ε/β+-decay	^{32}S, 140 MeV	beam on-off device, 150 s/150 s
HIL 093	20/03–5/04/2022 14 days	P.E. Garret, M. Roccini K. Wrzosek-Lipska M. Zielińska	Probing shapes and structures in ^{100}Ru via Coulomb excitation.	^{32}S, 88 MeV	Coulex scattering chamber
HIL 094	5/04-13/04/2022 14/06-18/06/2021 12 days	K. Wrzosek-Lipska, P.E. Garrett, M. Zielińska	Electromagnetic structure of low-lying states in ^{110}Cd — complementary Coulomb excitation measurements with a ^{14}N beam	^{14}N, 34 MeV	Coulex scattering chamber
HIL 087	20/06–29/06/2022 10 days	C. Fransen	Lifetime studies in neutron-deficient ^{176}Pt using the RDDS technique EAGLE + Cologne Plunger	^{32}S, 170 MeV	Köln plunger
HIL 102	4/07–15/07/2022 11 days	A. Nałęcz-Jawecki	Search for chiral to not chiral transition by lifetime measurement of I=10+ state in ^{128}Cs with a plunger technique	^{10}B, 50–55 MeV	Köln plunger, LEPS
HIL 099	1/03–12/03/2023 11 days	B. Saygi	Lifetime measurement of excited states in ^{134}Sm	^{32}S , 150 MeV	NEDA, Köln plunger
HIL 097	20/03–4/04/2023 14 days	C. Petrache	Shape coexistence and octupole correlations in the light Xe, Cs and Ba nucle	^{16}O, 86 MeV	NEDA, Köln plunger
HIL 106	13/06–29/06/2023 14 days	C. Petrache	Shape coexistence and octupole correlations in the light Xe, Cs and Ba nuclei (continuation of HIL097)	^{32}S, 150 MeV	NEDA, Köln plunger
HIL 105	13–30/11/2023 16 days	M. Palacz	Single-proton states and N=Z=28 core excitations in ^{57}Cu	^{32}S, 82 MeV	NEDA, DIAMANT
HIL 115	5-20/12/2023 15 days	M. Matejska-Minda P. Bednarczyk	Study of the anomalous behavior of the Coulomb energy difference in the A = 70, T = 1 izobaric multiplet	^{32}S, 88 MeV	NEDA, DIAMANT
HIL 114	17–31/01/2024 14 days	B. Saygi, M. Palacz	Gamma-ray spectroscopy of ^{134}Sm	^{32}S, 145 MeV	NEDA, DIAMANT
HIL 117	18–26/03/2024 7 days	K. Miernik	^{144}Dy fission studies	^{32}S, 212 MeV	NEDA, DIAMANT

NEDA instalacja

12 eksperymentów, 148 (57+91) dni wiązki na tarczy, dodatkowo 3 pomiary uruchomieniowe – ok. 12 dni

EAGLE

A flexible gamma-ray spectroscopy array able to accommodate up to 30 HPGe detectors with ACS shields and ancillary devices.



Truncated icosahedron:

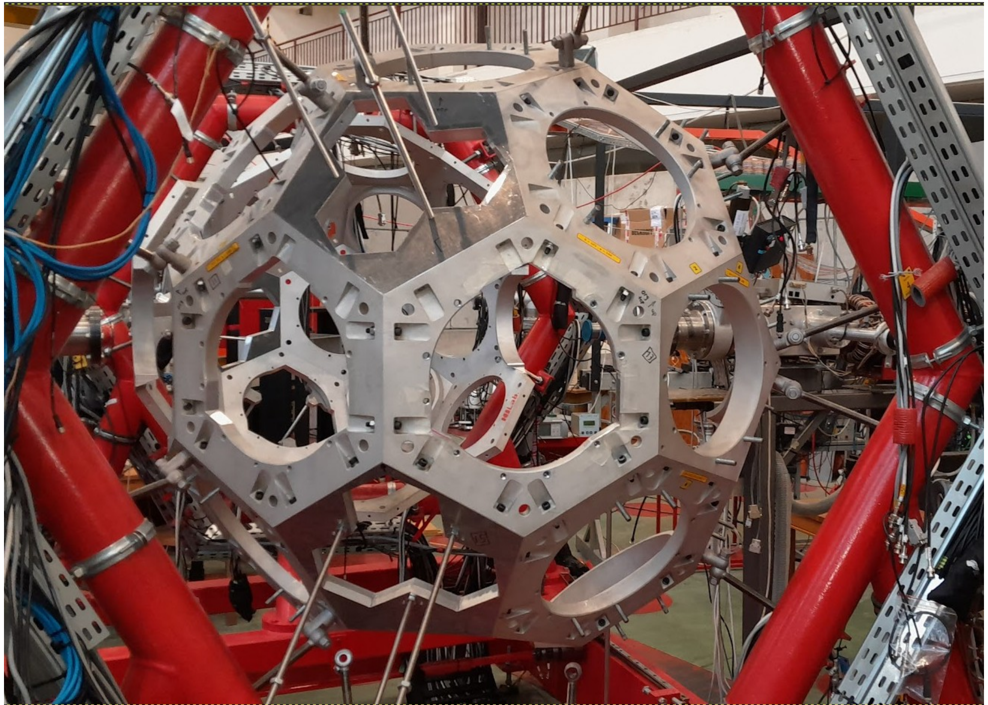
- 20 hexagonal faces, 4x5 theta angle rings: 37°, 79°, 101°, 143°
- 10 pentagonal faces   2x5 rings: 63°, 117°

Minimum distance target-detector (collimator):

- hexagon: ~ 11cm   eff=0.001 at 1.3 MeV
- pentagon: ~ 15 cm   eff=0.0008

Loan from GAMMAPOOL
of 16 HPGe detectors (~60%) and 15 ACS.
HIL owns 19 smaller HPGe's   (20 to 40%) with ACS's.
Typically ~15 detectors used in experiments, including ~14(+/- 1) GAMMAPOOL

total eff. ≈ 1.3 % at 1.3 MeV



J. Mierzejewski et al. NIM A659 (2011) 84

Pracownia detektorów HPGe w ŚLCJ

- Dwa stanowiska do pompowania (10^{-7} mbar) i wygrzewania detektorów
- Detektor helowy do sprawdzania szczelności próżniowej
- Niskoszumowe stanowisko do sprawdzania detektorów HPGe
- Wymiany FET
- Naprawy przedwzmacniaczy

M. Komorowska, (T. Abraham), M. Kisieliński et al.

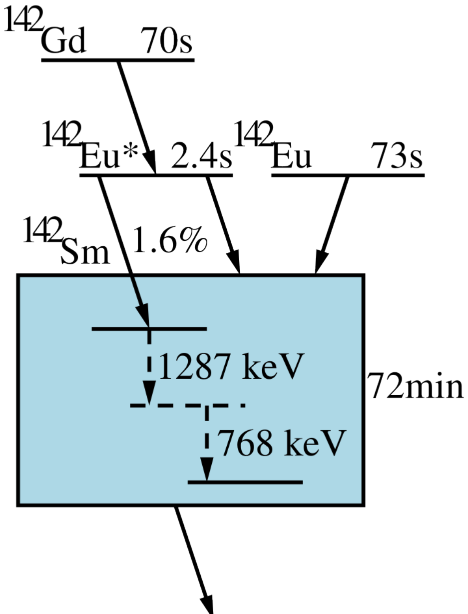
Eksperymenty listopad 2021 – lipiec 2022

Collective isovector quadrupole excitation in ^{142}Sm — identification via a γγ correlation measurements after ε/β+-decay

T. Stetz, N.Pietralla et al.

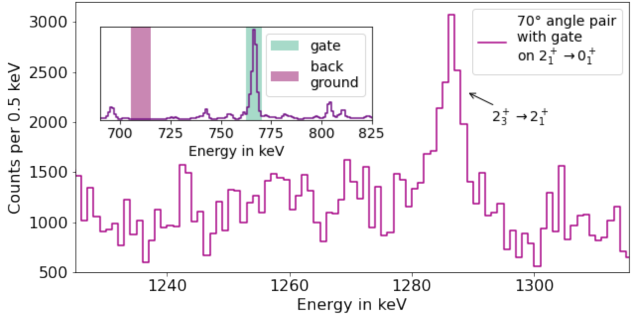
2^+_3 of ^{134}Sm – a candidate for a one-quadrupole mixed symmetry state(MSS).
Multipole mixing ratio needed to obtain the M1 strength of 2^+_3 –> 2^+_1 from a projectile Coulomb-excitation HIE-ISOLDE at CERN

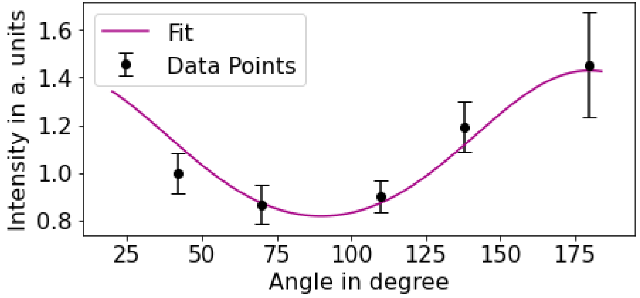
^{114}Cd(^{32}S, 4n)^{142}Gd
beam 150s on / 150s off



preliminary: >95% M1

γγ angular correlation measurement





Probing shapes and structures via Coulomb excitation

MSc thesis of I. Piętka, Faculty of Physics UW 2023

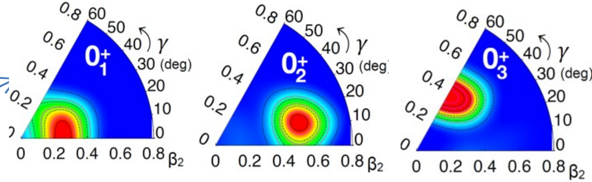
Courtesy of K. Wrzosek-Lipska

EAGLE@HIL

119°– 168° LAB

^{110}Cd

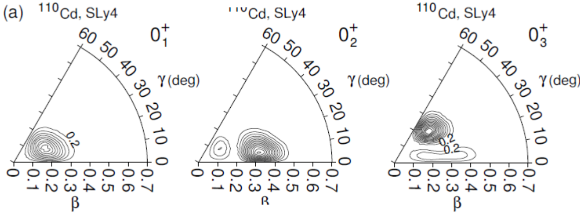
***T.R. Rodriguez*: BMF with SCCM + Gogny D1S [1,2]**



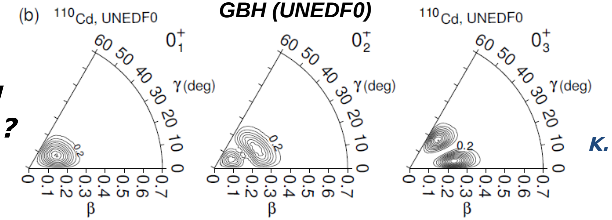
multiple shapes [1-3]

OR

GBH (SLy4)

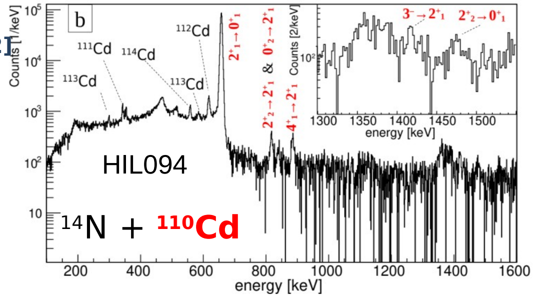


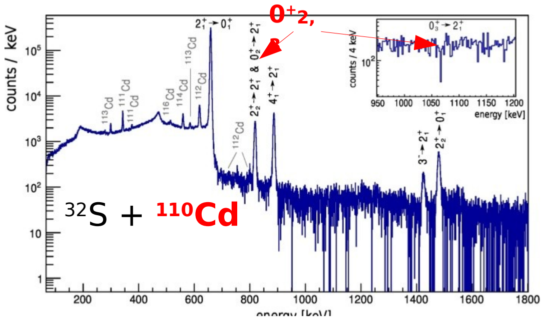
GBH (UNEDF0)



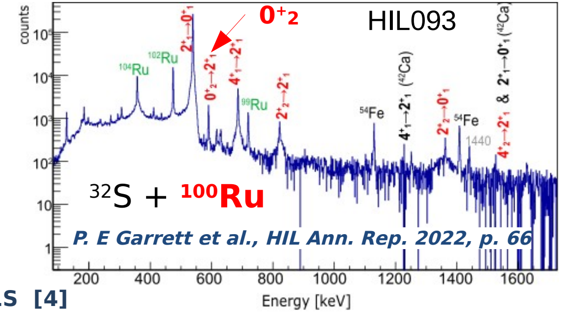
vibrational character ?

***L. Próchniak*: GBH + SLy4 (UNEDF0) [3]**





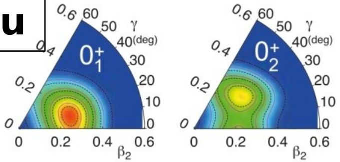
K. Wrzosek-Lipska et al., Acta Phys. Pol. B 51 (2020)



P. E Garrett et al., HIL Ann. Rep. 2022, p. 66

- Do the lighter Ru, N- mid-shell Cd behave as **spherical vibrators?**
- Do they display **shape coexistence?**
- Might there be multiple shape coexistence as suggested by the BMF calculations ?

^{100}Ru



Further studies of ^{110}Cd: CoulEx with heavier Z reaction partners:

→ **^{60}Ni** + **^{110}Cd** with **AGATA @ LNL** (*PhD thesis of I. Piętka*)

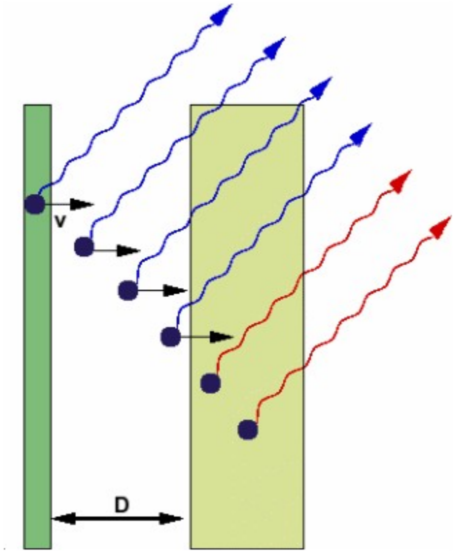
→ **^{110}Cd** + **^{208}Pb GRETINA @ ANL** (*PhD thesis at Univ.of Guelph*)

***T.R. Rodriguez*: BMF with SCCM + Gogny D1S [4]**

[1] P.E. Garrett et al., PRL 123 (2019) 142502, [2] P.E. Garrett et al., PRC 101 (2020) 044302
[3] K. Wrzosek-Lipska et al., Acta Phys. Pol. B 51 (2020),
[4] P. E. Garrett et al., PLB 809 (2020) 135762
[5] P.E. Garrett, M. Zielińska, E. Clément Progress in Part. and Nucl. Phys 124 (2022) 103931

Pomiary czasów życia z plungerem

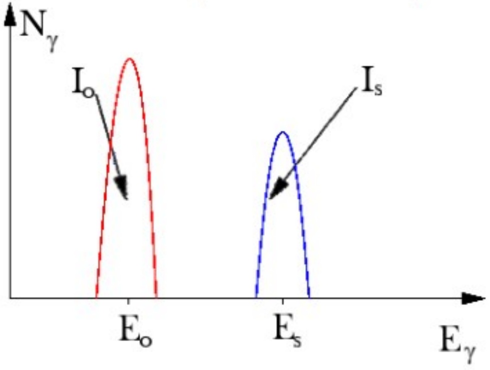
life time range: ~1 ns – 1 ps



time of flight: $t_D = \frac{D}{v}$

D = 10 to 500 μm

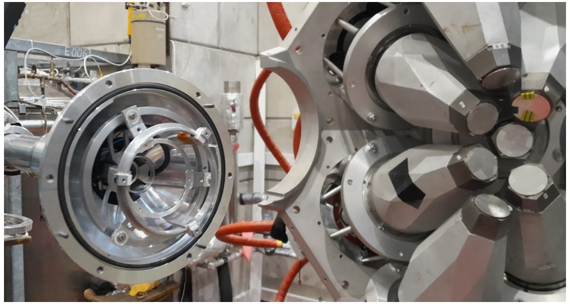
$$E_\gamma = E_0\left(1 + \frac{v}{c}\cos\theta\right)$$

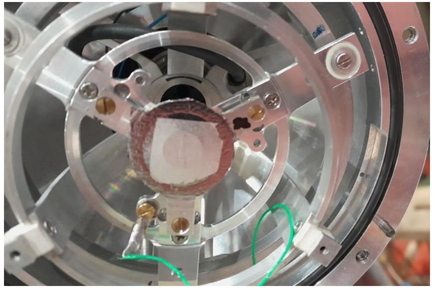


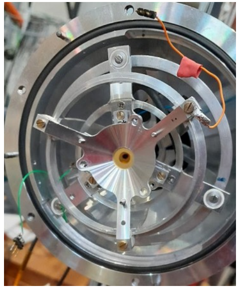
$$I_s = N_0 \exp\left(-\frac{t_D}{\tau}\right) = N_0 \exp\left(-\frac{D}{v\tau}\right)$$

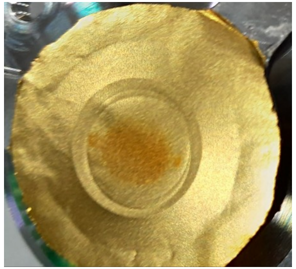
$$\frac{I_o}{I_o + I_s} = \exp\left(-\frac{D}{v\tau}\right) \qquad N_0 = I_0 + I_S$$

Köln plunger









Lifetime studies in yrast band of ^{176}Pt

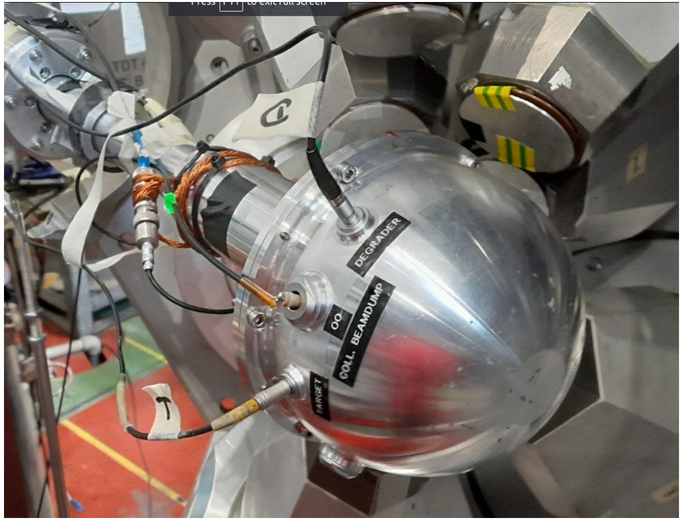
M. Novak, Ch. Fransen et al.

- Motivation:
  Evidence of shape coexistence in neutron-defficient A~180 nuclei. Different predictions for ^{176}Pt in IBM (spherical g.s.) and MF (prolate, as in heavier Pt nuclei). Existing data on transition strengths in ^{176}Pt not conclusive, and suffer from possible delayed feeding[1].

- ^{148}Sm(^{32}S, 4n)^{176}Pm,
  10 target-degrader distances, 15–600μm

- Lifetimes of 2^+, 4^+, 6^+ determined with „gating from above" (no delayed feeding),
  41(2) ps, 15(3) ps, 12(5) ps
  B(E2, $2^+ \rightarrow 0^+$), B(E2, $4^+ \rightarrow 2^+$) larger than in [1].

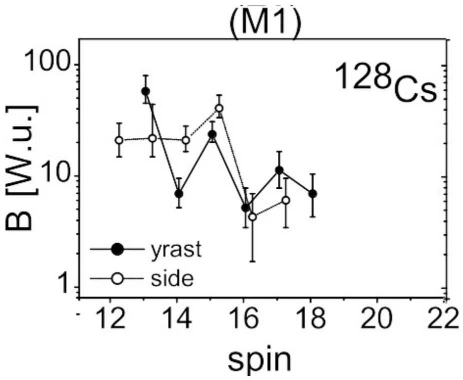
- Analysis of 8^+, 10^+ in progress, only „gating from below possible" due to limited statistics.

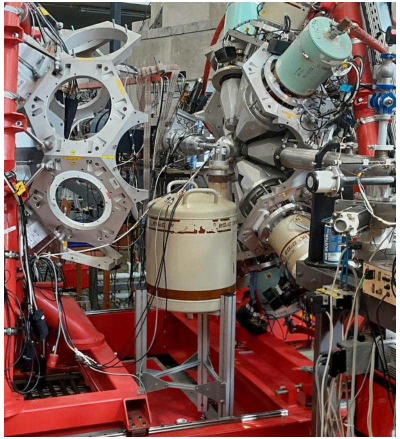


[1] G.D. Dracoulis et al. J.Phys: Nucl. Phys. 12 (1986) 283

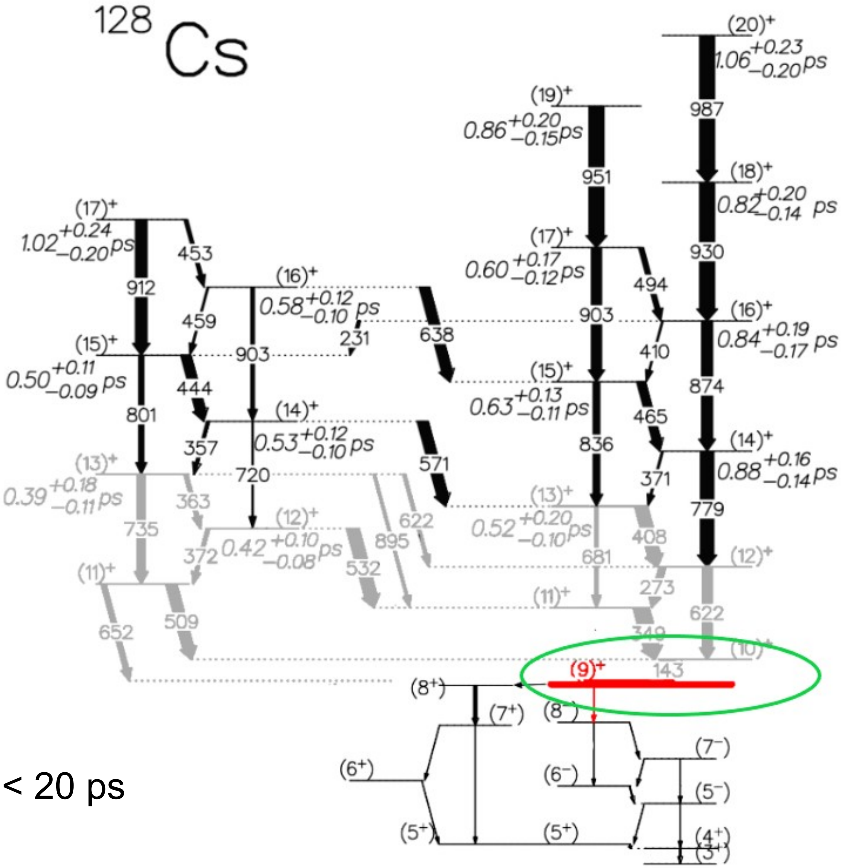
Search for chiral to not chiral transition by lifetime measurement of the I=10^{+} state in ^{128}Cs

A. Nałęcz–Jawecki, E. Grodner et al.





^{122}Sn (^{10}B,4n) ^{128}Cs
Köln plunger,
LEPS

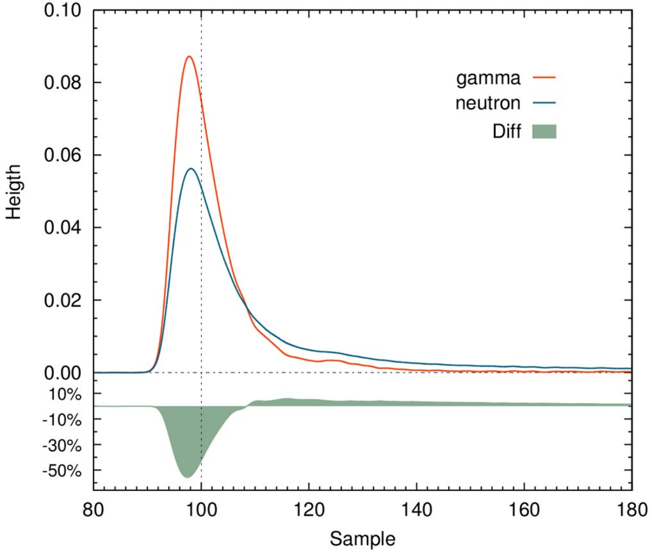


Preliminary result: $\tau_{10+} < 20$ ps
–> not chiral

Układ detektorów neutronów NEDA

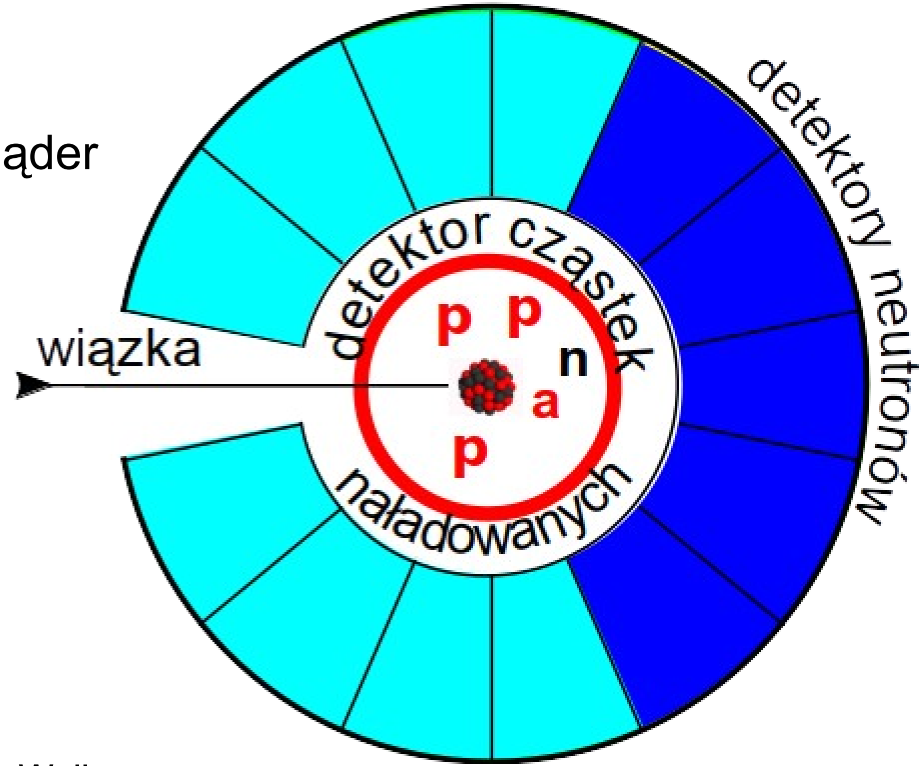
NEDA

- Układ detektorów neutronów skonstruowany w latach 2009–2018
- Główne zastosowanie: filtr krotności neutronów w reakcjach fuzji-ewaporacji, w których emisja neutronów jest rzadka (jądra bogate w protony, N~Z)
- Mechanizm detekcji neutronów:
  - rozpraszanie elastyczne – jedyny "dobry" proces: elastyczne rozpraszanie na protonach
  - rozpraszanie nieelastyczne $^{12}C(n,n'\gamma)^{12}C^*$
  - wychwyt neutronu $^{12}C(n,\alpha)^{9}Be$
- Scyntylator (ciekły): C_8H_{10}, ksylen, EJ301 (BC501) Oddziaływania z dużą gęstością jonizacji (neutrony) powodują zwiększone obsadzenie tripletowych stanów molekularnych (opóźniona emisji światła); czasy wyświecania: 3.16 ns, 32 ns, 270 ns; składowa wolna (270 ns) dla γ: 10%, dla n: 30%



NEDA: typowe zastosowanie

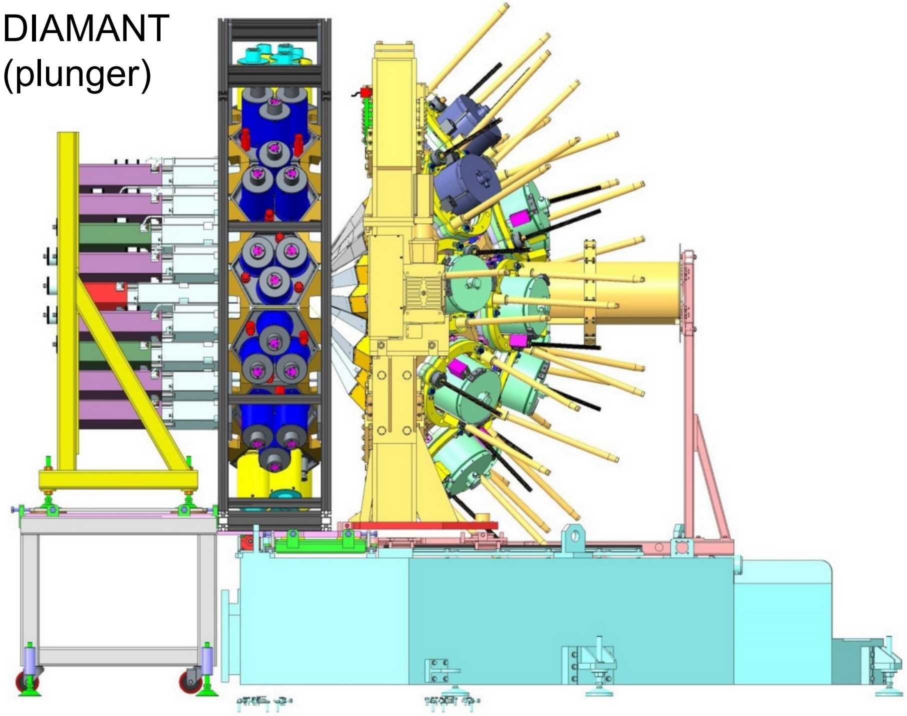
selekcja przypadków
spektroskopia ɣ bogatych w protony jąder
reakcje fuzji-ewaporacji



eksperymenty od lat 90-tych,
OSIRIS (Berlin), NORDBALL, GASP, EUROBALL, EXOGAM
różne układy detektorów neutronów → Neutron Wall → NEDA
różne detektory cząstek naładowanych

NEDA w GANIL 2018

12 AGATA TC
54 NEDA
42 NWall
DIAMANT
(plunger)



NEDA w GANIL 2018

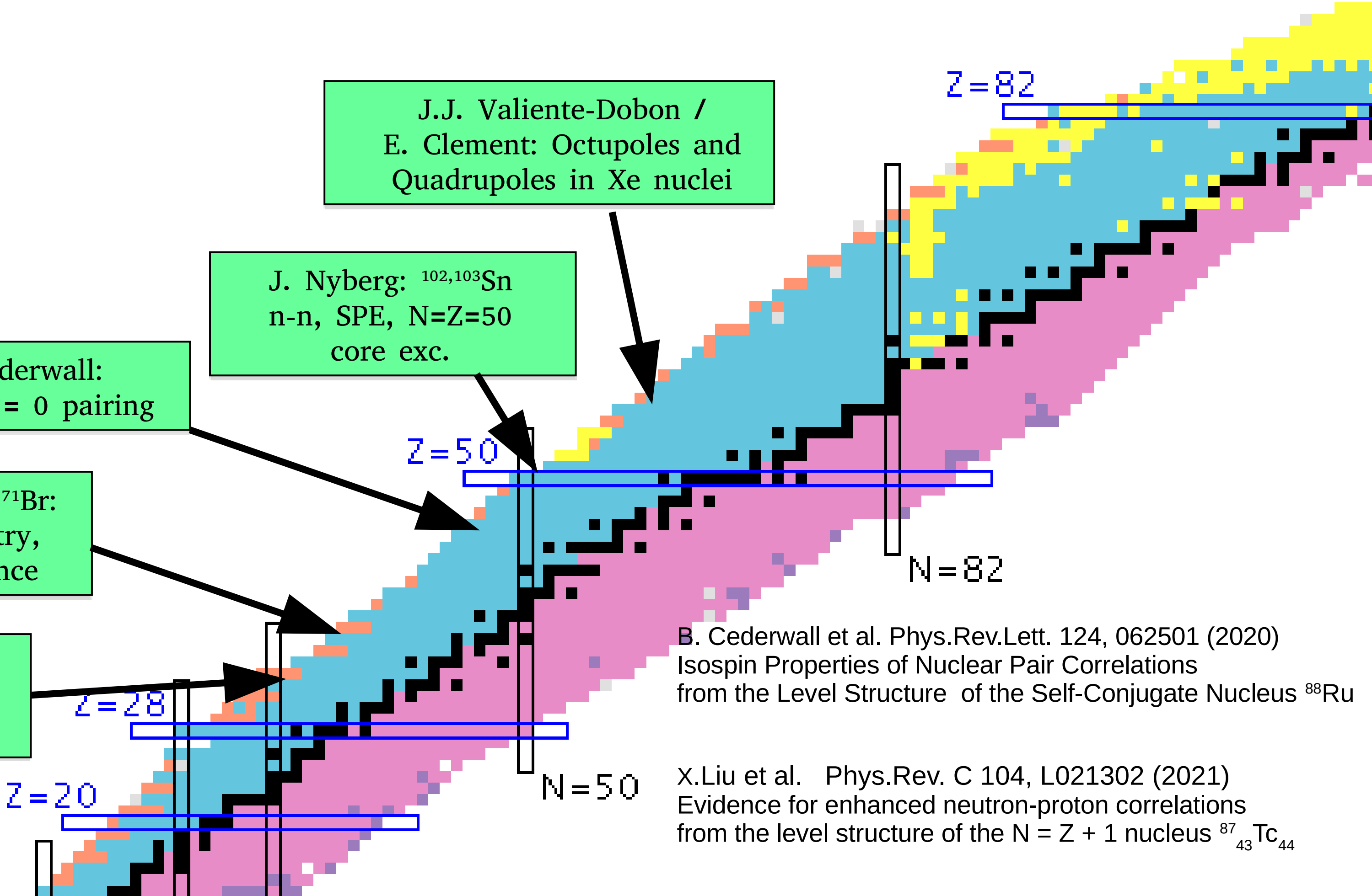
J.J. Valiente-Dobon /
E. Clement: Octupoles and
Quadrupoles in Xe nuclei

J. Nyberg: ^{102,103}Sn
n-n, SPE, N=Z=50
core exc.

B. Cederwall:
^{88}Ru – T = 0 pairing

A. Boso: ^{71}Kr – ^{71}Br:
isospin symmetry,
shape coexistence

S. Lenzi: A=63
isospin
symmetry



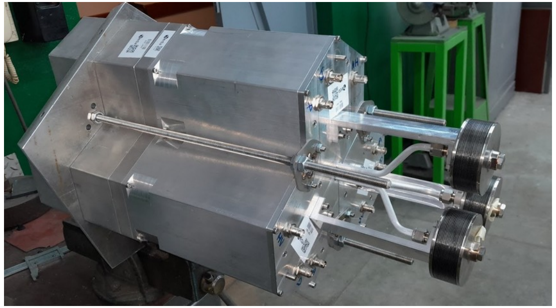
B. Cederwall et al. Phys.Rev.Lett. 124, 062501 (2020)
Isospin Properties of Nuclear Pair Correlations
from the Level Structure of the Self-Conjugate Nucleus ^{88}Ru

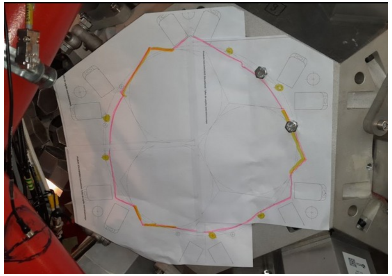
X.Liu et al. Phys.Rev. C 104, L021302 (2021)
Evidence for enhanced neutron-proton correlations
from the level structure of the N = Z + 1 nucleus $^{87}_{43}Tc_{44}$

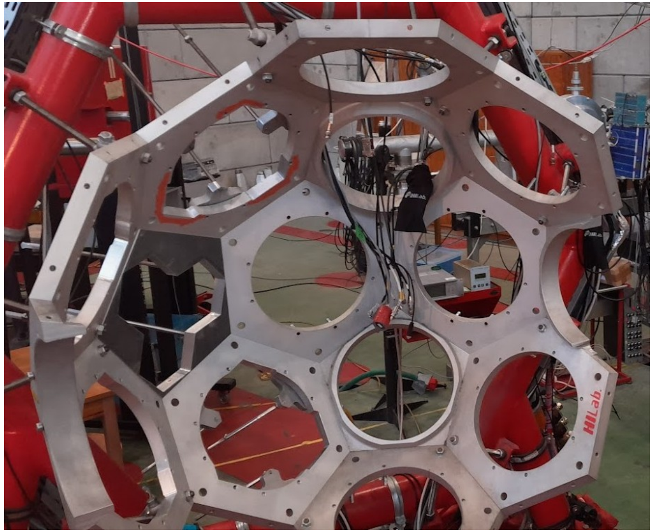
NEDA do ŚLCJ – historia (wniosków o finansowanie)

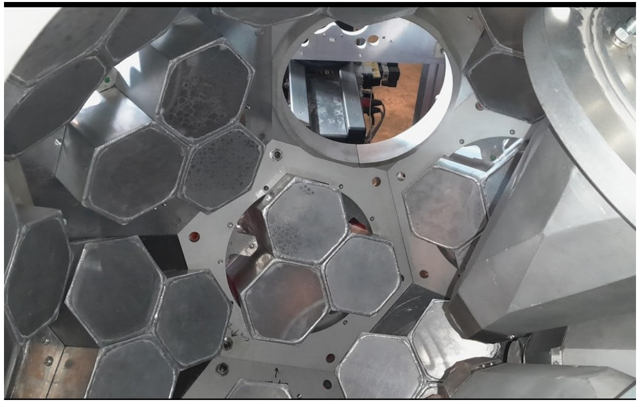
- OPUS grudzień 2014 ("około 50 detektorów neutronów" w ŚLCJ) 
- OPUS grudzień 2015 ("część NWall i kilka det. NEDA" w ŚLCJ) 
- OPUS grudzień 2016 (bez eksperymentów w W-wie) 
- OPUS czerwiec 2017 (bez eksperymentów w W-wie) 
- OPUS czerwiec 2020 (NEDA w ŚLCJ) – G.Jaworski 
- SONATA grudzień 2020 (NEDA ŚLCJ) – G.Jaworski 

Grudzień 2021

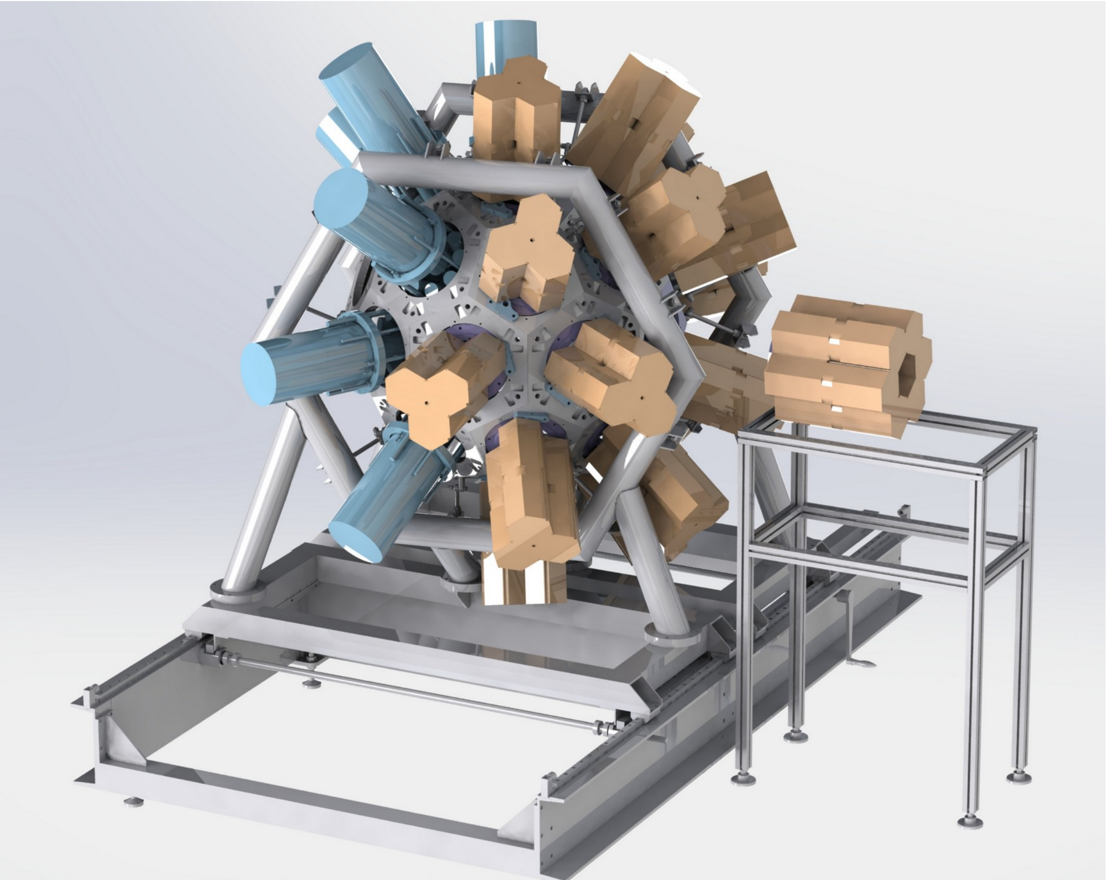


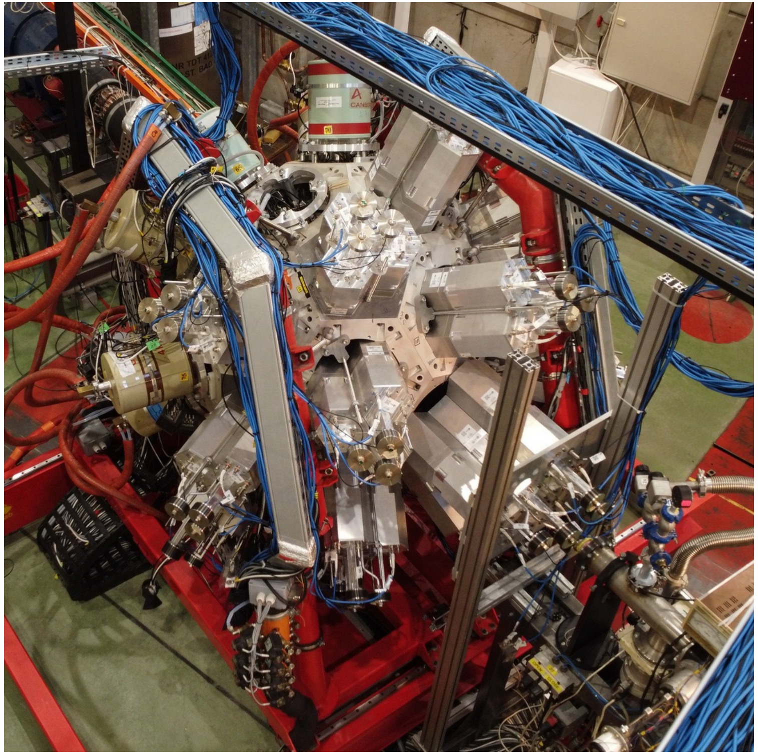






EAGLE-NEDA (NEEDLE)





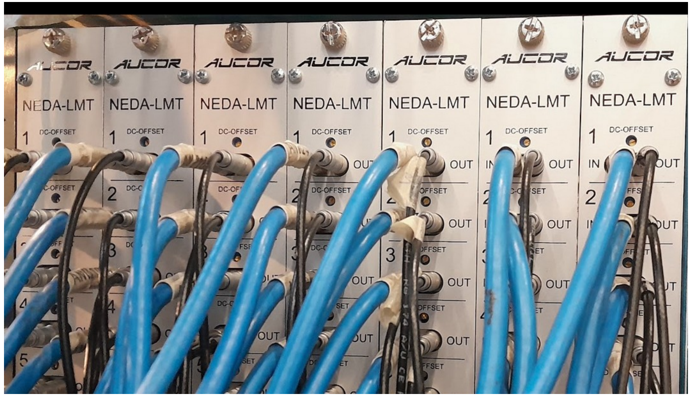
- 15x3 detektory NEDA na ramie w części przedniej
- 6(7) detektorów na oddzielnym stojaku – ściana przednia
- 15 HPGe w części tylnej

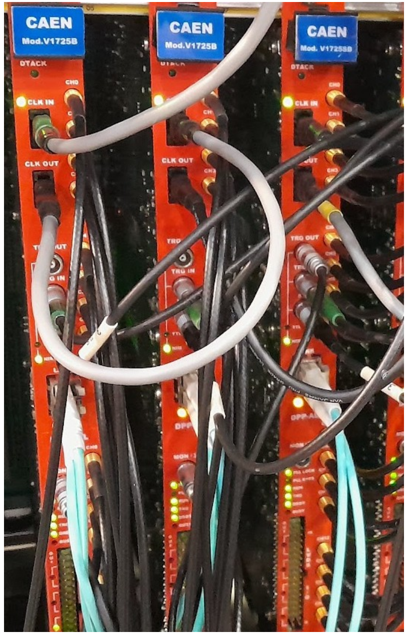
NEDA w ŚLCJ do ~ początku 2025

EAGLE-NEDA: elektronika, DAQ

Transformation from:
EAGLE: analog CAMAC based system, some digital elem.
NEDA: numexo2 (diff. input), GTS, Trigger Processor

- Custom made amplitude limiters restrict the NEDA signals to 2V (Aucor, Warsaw);
- 6 CAEN V1725(S)(B) digitizers (6x16 channels, 14-bit, 250 MHz sampling):
  - 2 units with PHA firmware for HPGe and ACS
  - 4 units with PSD firmware for NEDA („at least one PSD discriminated neutron" signal available for the trigger request)
- trigger validation logic implemented in external NIM units; for validated events: readout of all non-zero channels (NEDA: not only PSD discriminated neutrons – gamma-ray time ref. and multiplicity filtering possible);
- Software:
  - XDAQ (CERN) with LNL applications;
  - Spy and GreWare for on-line spectra;
  - GRAFANA for monitoring of rates;
  - ROOT selector for off-line (→ RadWare, TV, etc.).





DIAMANT

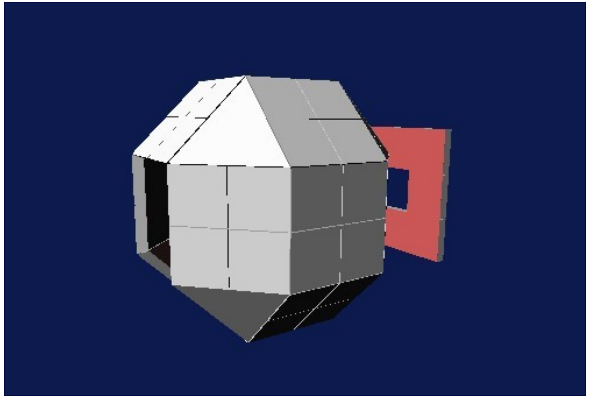
I. Kuti, J. Molnar et al. ATOMKI Debrecen

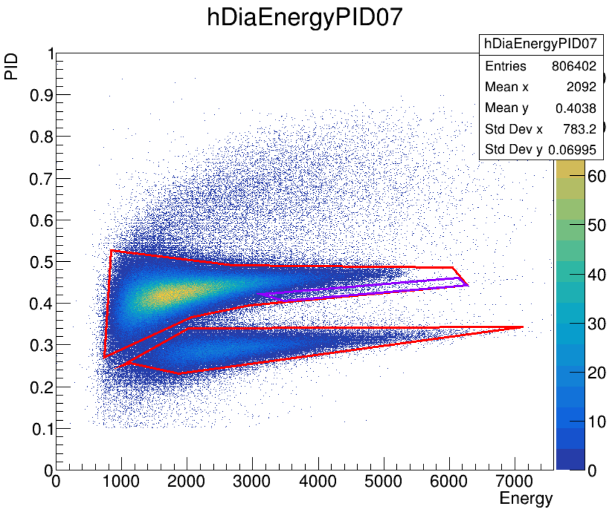
80 CsI detectors, rhombicuboctahedron, plus f.w.
able to register and distinguish
protons and alpha particles
emitted in a fusion-evaporation reaction

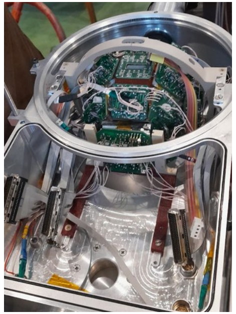
$\epsilon_p \approx 0.6$ $\epsilon_\alpha \approx 0.4$

DAQ:

- present: NUMEXO2 digitizers and GANIL software, AGAVA;
- in progress: new CAEN R5560 digitizer purchased by ATOMKI to replace NUMEXO2
  128 channels/125 MHz/14 bit
  (double trapezoid firmware
  development in progress)







Will be available at HIL also after NEDA leaves

Eksperymenty styczeń 2023 – marzec 2024

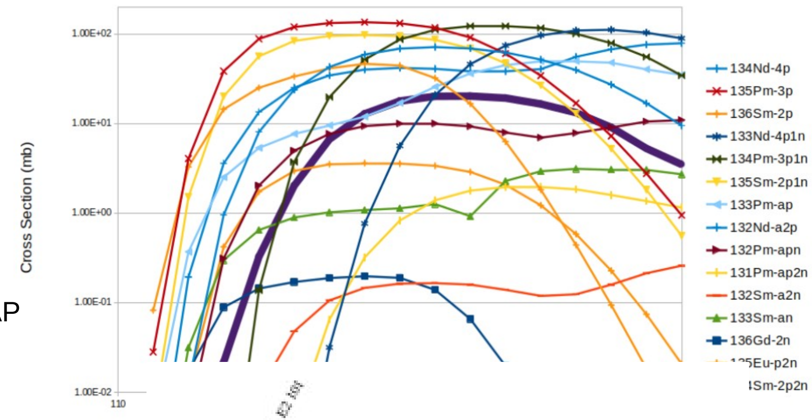
id	dates	spokeperson	title	beam	ancillary devices
HIL 099	1/03–12/03/2023 11 days	B. Saygi	Lifetime measurement of excited states in ^{134}Sm	^{32}S, 150 MeV	NEDA, Köln plunger
HIL 097	20/03–4/04/2023 14 days	C. Petrache	Shape coexistence and octupole correlations in the light Xe, Cs and Ba nuclei	^{16}O, 86 MeV	NEDA, Köln plunger
HIL 106	13/06–29/06/2023 14 days	C. Petrache	Shape coexistence and octupole correlations in the light Xe, Cs and Ba nuclei (continuation of HIL097)	^{32}S, 150 MeV	NEDA, Köln plunger
HIL 105	13–30/11/2023 16 days	M. Palacz	Single-proton states and N=Z=28 core excitations in ^{57}Cu	^{32}S, 82 MeV	NEDA, DIAMANT
HIL 115	5-20/12/2023 15 days	M. Matejska-Minda P. Bednarczyk	Study of the anomalous behavior of the Coulomb energy difference in the A = 70, T = 1 izobaric multiplet	^{32}S, 88 MeV	NEDA, DIAMANT
HIL 114	17–31/01/2024 14 days	B. Saygi, M. Palacz	Gamma-ray spectroscopy of ^{134}Sm	^{32}S, 145 MeV	NEDA, DIAMANT
HIL 117	18–26/03/2024 7 days	K. Miernik	^{144}Dy fission studies	^{32}S, 212 MeV	NEDA, DIAMANT

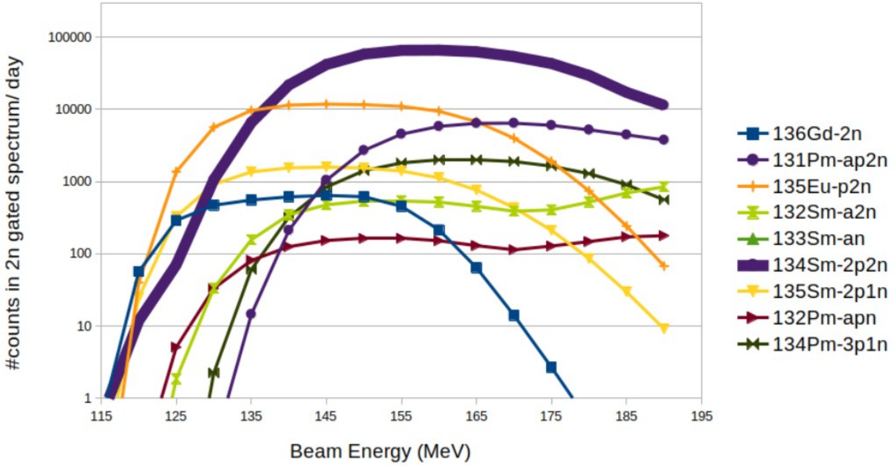
DIAMANT instalacja

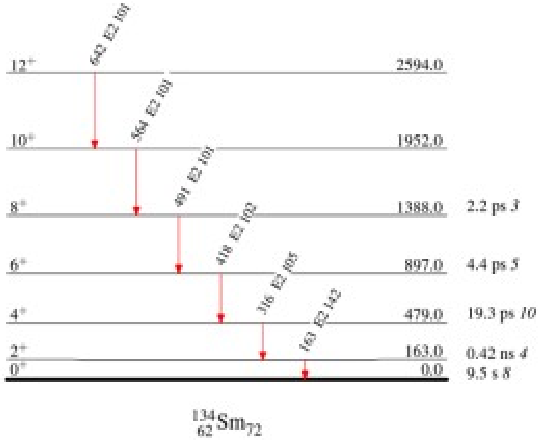
Spektroskopia ^{134}Sm (^{135}Eu ?)

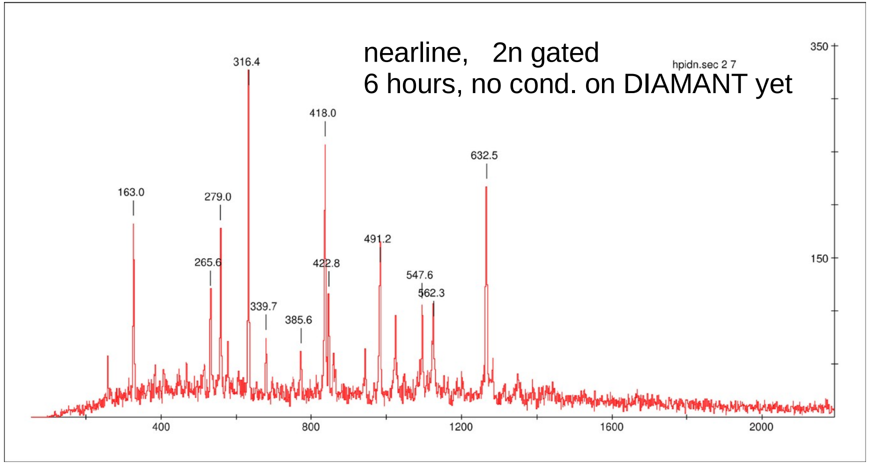
$^{32}S + ^{106}Cd \rightarrow ^{138}Gd \rightarrow 2p2n + ^{134}Sm$

HIVAP



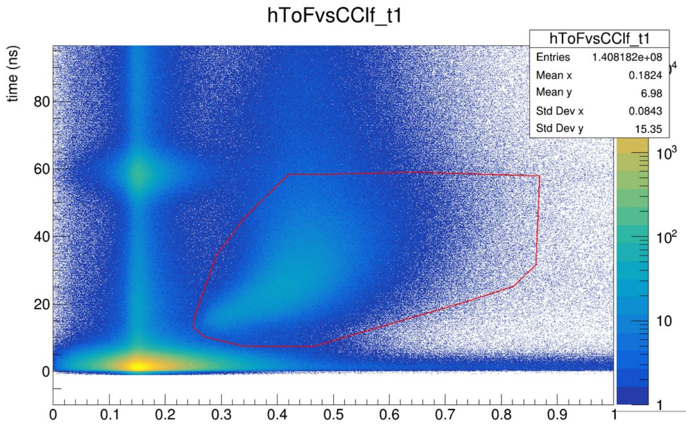


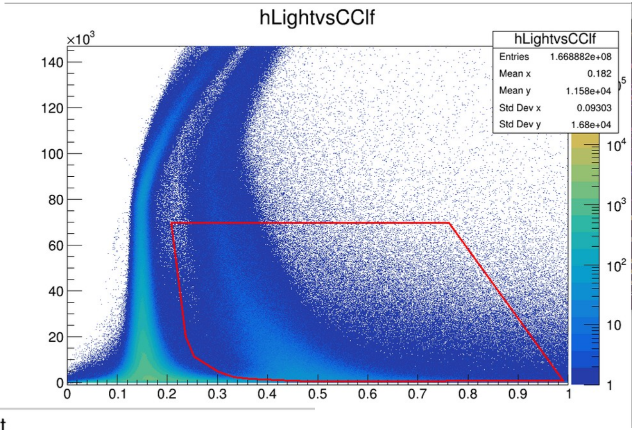


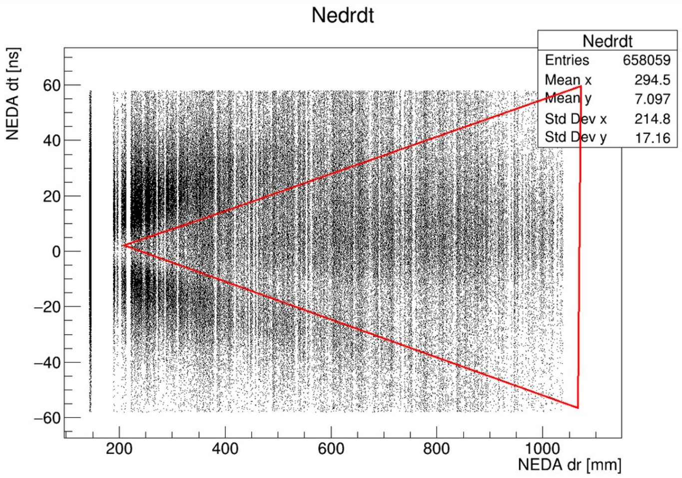


Analiza danych: P. Sekrecka, et al. (ŚLCJ)

Rozróżnienie neutron/γ oraz 2n/1n





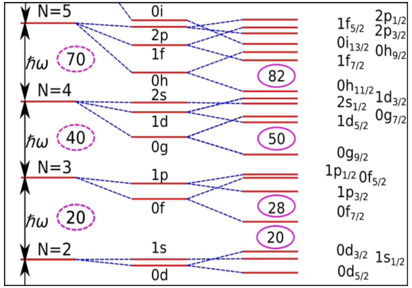


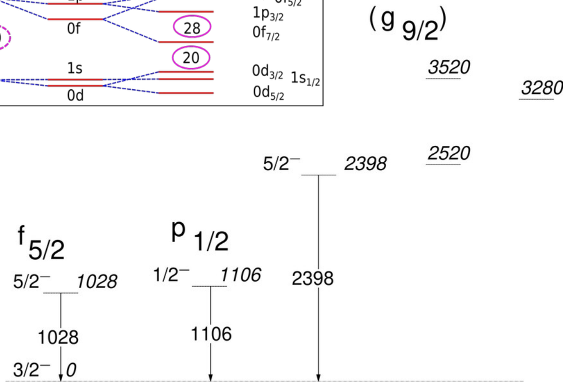
Single-proton states at N = Z = 28 and core excitations in ^{57}Cu

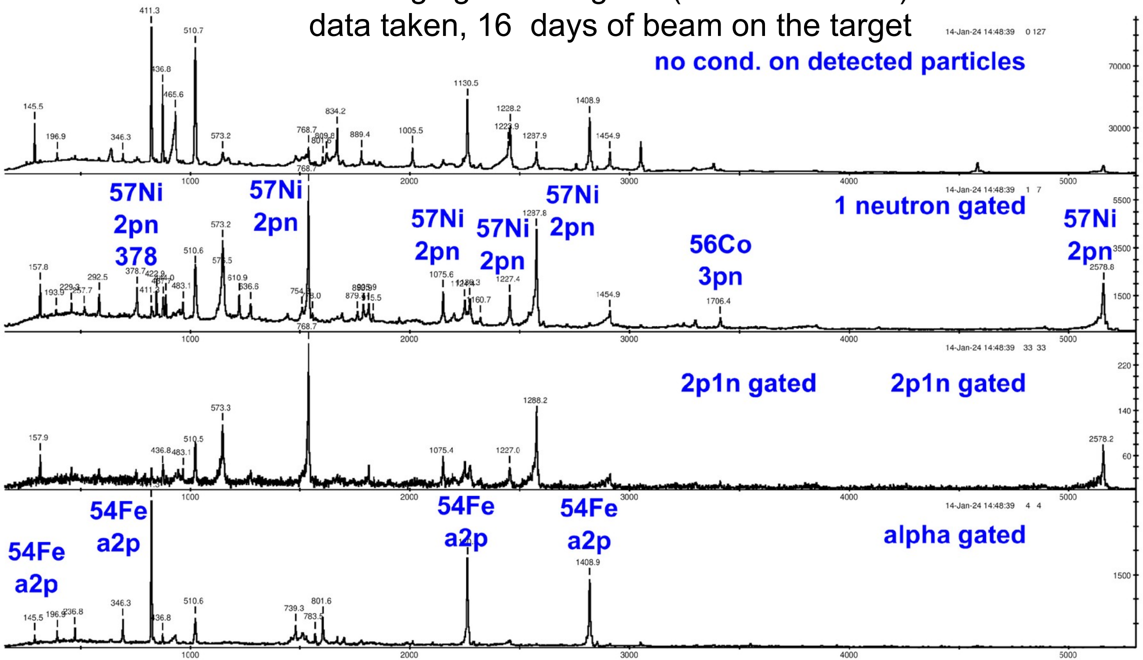
single-proton nucleus – softness of the ^{56}Ni core
rp-process: structure of ^{57}Cu essential for the rate of flow of material along the proton drip-line above ^{56}Ni

$^{32}S + {}^{28}Si \rightarrow {}^{60}Zn\ (CN) \rightarrow p2n + {}^{57}Cu$ ~ 0.1 mb
challenging 28Si target (A. Stolarz et al.)
data taken, 16 days of beam on the target

^{56}Zn 32.4 ms	^{57}Zn 45.7 ms	^{58}Zn 86 ms	^{59}Zn 178.7 ms	^{60}Zn 142.8 s	^{61}Zn 89.1 s
^{55}Cu 55.9 ms	^{56}Cu 80.8 ms	^{57}Cu 196.4 ms	^{58}Cu 3.204 s	^{59}Cu 81.5 s	^{60}Cu 23.7 m
^{54}Ni 114.1 ms	^{55}Ni 203.9 ms	^{56}Ni 6.075 d	^{57}Ni 35.6 h	^{58}Ni	^{59}Ni 81 ky
^{53}Co 244.6 ms	^{54}Co 193.27 ms	^{55}Co 17.53 h	^{56}Co 77.236 d	^{57}Co 271.811 d	^{58}Co 70.844 d
^{52}Fe 8.275 h	^{53}Fe 8.51 m	^{54}Fe	^{55}Fe 2.7562 y	^{56}Fe	^{57}Fe





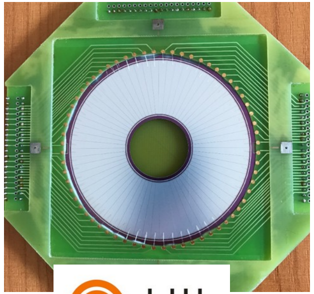


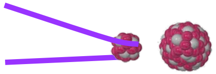
M. Regulska praca licencjacka
A. Malinowski praca magisterska

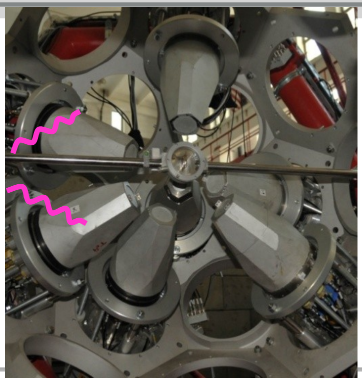
Zaakceptowane eksperymenty

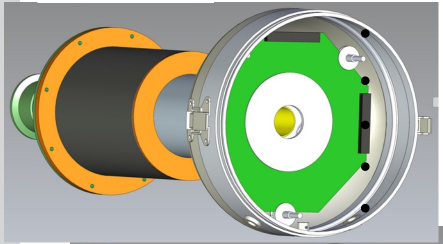
id	days	spokeperson	title	beam	anc. dev.
HIL 109	6	C. Fransen	Lifetime studies in neutron-deficient ^{172}Os using the RDDS technique	^{32}S, 170 MeV	Köln plunger
HIL 119	7	J. Heery, J. Henderson	Coulomb excitation of ^{34}S	^{34}S, 92, 129 MeV	SilCa
HIL 120	12	C. Liu, S. Y. Wang	Search for the new chiral nucleus in the 80 mass region: ^{72}As	^{11}B, 50 MeV	
HIL 121	3	J. Perkowski	Test of new magnetic selector and digital electronics system for ULESE spectrometer	^{14}N, 90 MeV	ULESE
HIL 124	12	A. Nałęcz–Jawecki	Search for transition between chiral and non-chiral configuration in ^{128}Cs by lifetime measurement of I=11^{+} ,12^{+} states with a plunger technique	^{22}Ne, 85 –90 MeV	Köln plunger
HIL 126	14	I. Kuti	Search for candidate wobbling bands in ^{103}Pd and in ^{101}Ru	^{12}C, 69 MeV	(NEDA), DIAMANT
HIL 127	15	A. Fijałkowska, G Jaworski	The discovery of excited states in very neutron defficient europium nuclei	^{40}Ca, 180–190 MeV	NEDA DIAMANT
HIL 129	15	G. Jaworski, A. Fijałkowska	The discovery of excited states in very neutron deficient ^{63}Ge nucleus	^{40}Ca, 100–110 MeV	NEDA, DIAMANT

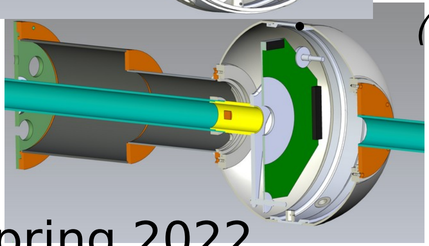
SilCA – Silicon Coulex Array







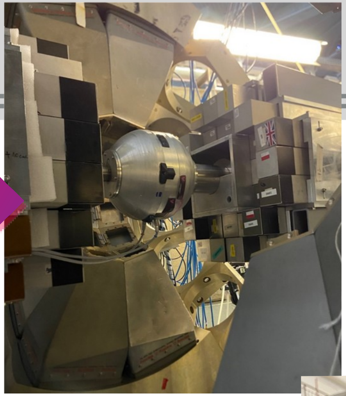




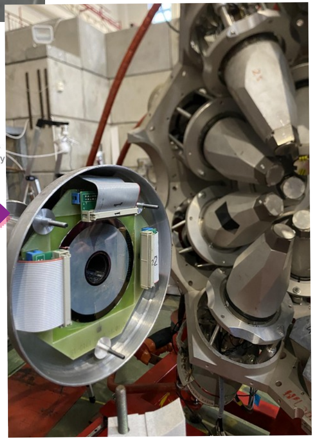
Spring 2022

r_{in} = 1.6 cm
r_{out} = 4.2 cm
64 sectors
(32 readout)
32 rings
(16 readout)

October 2022



Campaign
DSSD+NuBALL2
(+PARIS)
I-VI 2023
7 experiments
Full digital, FASTER

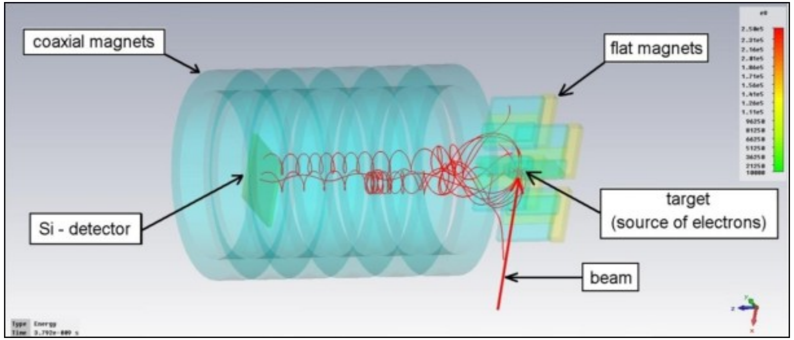


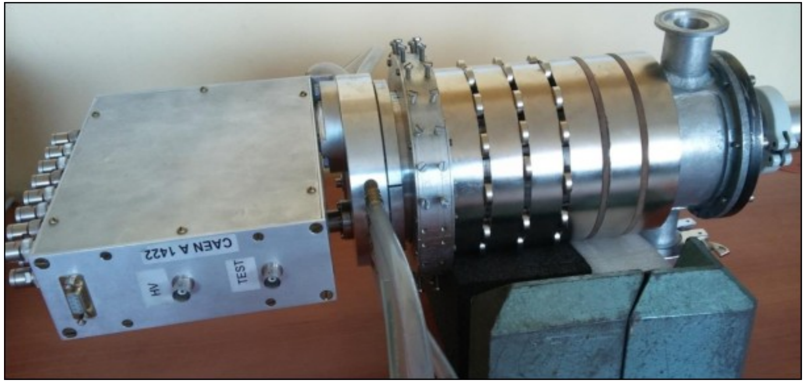
First tests (^{241}Am): February 2024
In-beam commissioning:
June 2024
DSSD+EAGLE (full digital, CAEN)

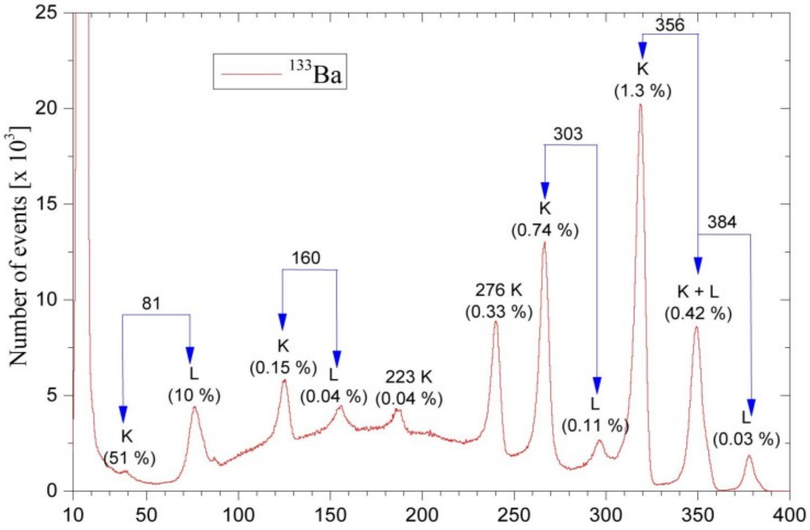
Project: P. Napiorkowski, J. Iwanicki, A. Iwanicki, J. Mierzejewski, KHK

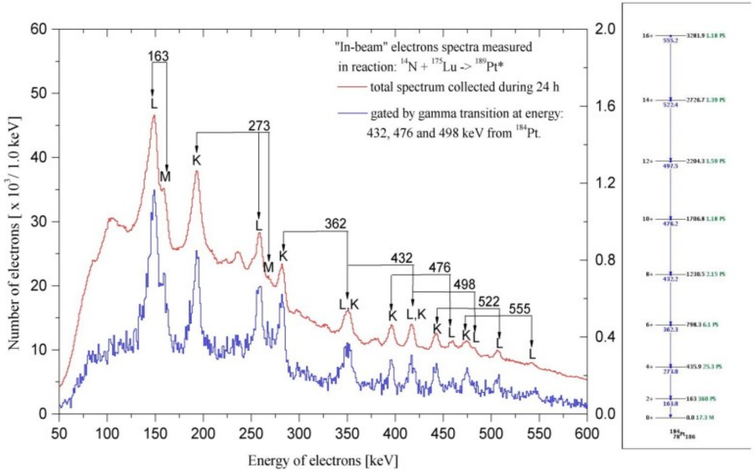
courtesy of K. Hadyńska-Klęk

ULESE – ICE spectrometer









Motivation:

$K^{\pi}=8^{-}$ isomers in nuclei with N=74 and N=106, E0 transitions.

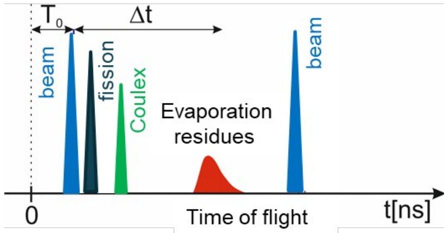
Used previously with EAGLE,

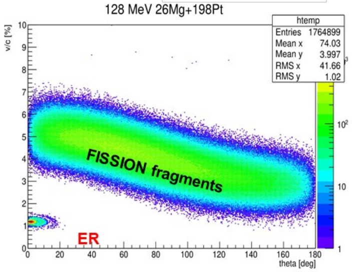
beam time allocated to test digital DAQ

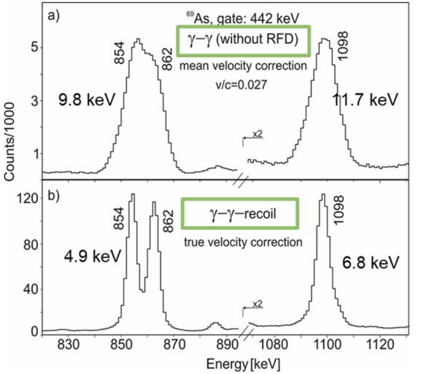
J. Perkowski et al. (Univ. of Łódź)

Coupling Recoil Filter Detector (RFD) with the EAGLE array

- RFD is a Kraków heavy ion detector which measures evaporation residues in coincidence with γ-rays
- ToF technique allows to reconstruct velocity of every recoil
- And to filter out unwanted reaction channels: scattered beam, Coulomb excitations, fission fragments, target impurities

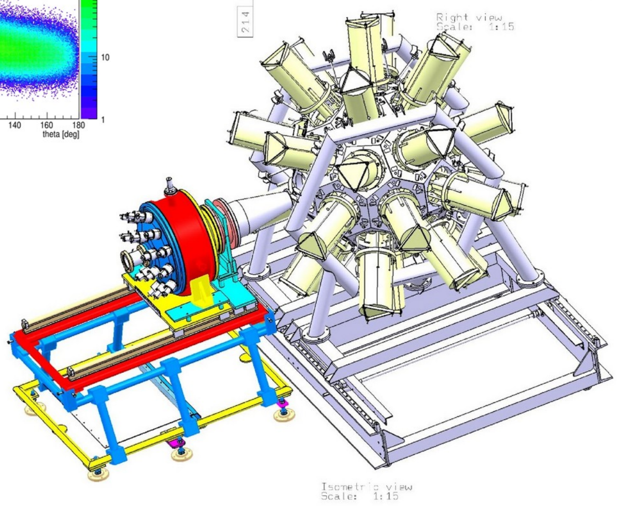






Plans for scientific program

- Investigation of a high spin structure in nuclei near ^{40}**Ca** and ^{56}**Ni** to **extend the known and unknown structures** up to or beyond the terminating states.
- Study collective bands in these regions, and **excited states lifetimes determination**.
- **Detailed γ-ray spectroscopy** in the **actinide region**, where γ-ray spectra are dominated by a large background from fission.



finansowanie SONATA BIS

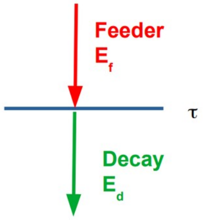
courtesy of M. Matejska-Minda

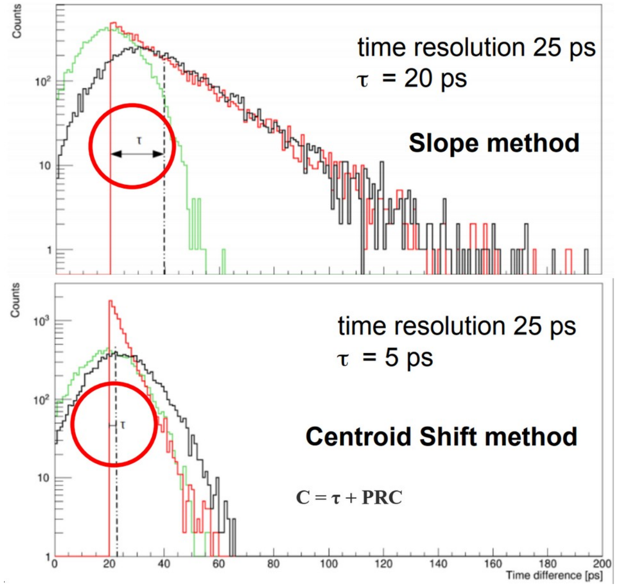
EAGLE + RFD

Pomiary czasów życia z użyciem szybkich scyntylatorów

A LoI was presented at the PAC meeting on 15 Jan 2024.
Installation of 15 $LaBr_3$ (ex. of FATIMA type) in anti-compton shields planned.
Physics:

- α-clustering along N=128
  lifetimes of the first 2^+, 4^+ and 6^+ states for even-even isotopes
- Test of seniority in neutron deficient $^{200,202}Po$
- Chiral to not chiral transition ^{126}Cs, ^{128}Cs
- Evolution of deformation in the rare-earth region





Th. Kröll, A Spaček et al.

Podsumowanie

- EAGLE intensywnie wykorzystywany w ciągu ostatnich 2+ lat,
  bogaty program eksperymentalny na najbliższy ~ rok.
- Instalacja układu NEDA → nowy, cyfrowy system akwizycji danych.
- EAGLE-NEDA-DIAMANT stwarza unikalne możliwości badania jąder bogatych w protony.
- Inne urządzenia dodatkowe   (obecnie i w planach):
  - RFD
  - spektrometr elektronów ULESE
  - Silicon Coulex Array
  - plunger
- Następne posiedzenie PAC: grudzień 2024.

Podziękowania:

- EURO-LABS za wsparcie eksperymentów.
- GAMMAPOOL za udostępnienie detektorów HPGe.
- Instalacja oraz użytkowanie NEDA w ŚLCJ są finansowane w ramach grantu NCN no. 2020/39/D/ST2/00466.

Ludzie (2021 – obecnie)

- G. Jaworski (NEDA, DAQ)
- A. Goasduff, N.Toniollo ((X)DAQ)
- I. Kuti, J. Molnar (DIAMANT, DAQ)
- M. Kowalczyk, P. Kulessa, M. Ciemała (DAQ, near-line)
- J. Grębosz (spy, GreWare – widma on-line)
- M. Komorowska, M. Kisieliński, A. Špaček, T. Abraham, W. Okliński (detektory HPGe, EAGLE front-end hardware)
- C. Fransen, C. Lakenbrink, M. Beckers, F. v. Spee, C. Müller-Gatermann, A. Nałęcz-Jawecki (plunger)
- K. Hadyńska-Klęk, K. Wrzosek-Lipska, I. Piętka, P.J. Napiorkowski, G. Colucci, J. Samorajczyk-Pyśk, P. Sekrecka, A. Tucholski, A. Fijałkowska, A. Korgul, S. Panasenko (wsparcie rozmaite)
- B. Radomyski, M. Matuszewski (mechanika – projekty, druk 3D)
- R. Kopik, P. Jasiński, M. Antczak (mechanika warsztat)
- A. Stolarz, J. Kowalska (tarcze)
- studenci: A. Malinowski, A. Otręba, W. Poklepa, M. Regulska, K. Solak, K. Szlęzak, K. Zdunek
- kierownicy i uczestnicy eksperymentów
- personel ŚLCJ-UW, **w tym ekipa cyklotronu**: https://www.slcj.uw.edu.pl/en/staff/

Instytucje

- ŚLCJ-UW,
- LNL Legnaro
- IFJ Kraków
- WF UW
- IKP Köln
- NCBJ Świerk

Zapasowe slajdy

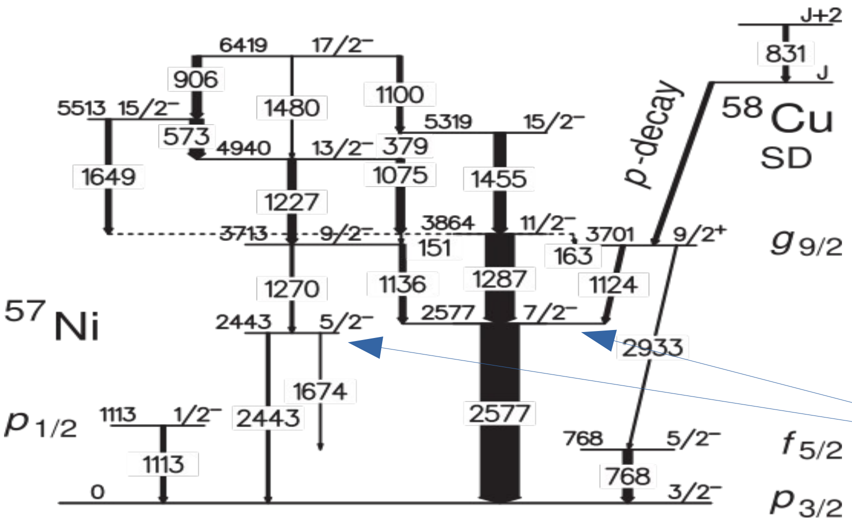
NEDA w ŚLCJ – harmonogram

- 12/2021 transport GANIL → ŚLCJ
- 12/2021 – 07/2022 testy detektorów, mechanika (równolegle eksperymenty EAGLE)
- 07/2022 – 01/2023 instalacja (mechanika, elektronika, DAQ)
- 30/01/2023 – 4/02/2023 pomiar uruchomieniowy EAGLE-NEDA
- 03/2023 – 06/20223 3 eksperymenty EAGLE-NEDA-Plunger
- 07/2023 – pomiar uruchomieniowy EAGLE-NEDA-DIAMANT
- od 11/2023 – eksperymenty EAGLE-NEDA-DIAMANT
- I poł. 2025 – transport ŚLCJ → LNL

Beams

Ion	Energy min [MeV]	Energy max [MeV]	Energy max [MeV/nukl]
$^{10}B^{+2}$	51	55	5.5
$^{11}B^{+2}$	40	50	4.5
$^{12}C^{+2}$	38	50	4.2
$^{12}C^{+3}$	53	92	7.7
$^{13}C^{+3}$		90	6.9
$^{14}N^{+2}$	32	50	3.6
$^{14}N^{+3}$	57	91	6.5
$^{15}N^{+3}$		43	2.9
$^{16}O^{+3}$	46	80	5.9
$^{16}O^{+4}$	80	120	7.5
$^{18}O^{+4}$	100	120	6.7
$^{19}F^{+3}$	50	66	3.5
$^{20}Ne^{+3}$	45	68	3.4
$^{20}Ne^{+4}$	68	115	5.8
$^{20}Ne^{+5}$	130	160	8.0
$^{22}Ne^{+3}$	44	55	2.5
$^{24}Mg^{+4}$		77	3.2
$^{32}S^{+5}$	79	110	3.4
$^{32}S^{+6}$	*120*(*)	150	4.7
$^{32}S^{+7}$	*120*(*)	225	7.0
$^{40}Ar^{+6}$	*90*(*)	132	3.7
$^{40}Ar^{+7}$	*130*(*)	164	4.1
$^{40}Ar^{+8}$	*180*(*)	200	5.0

^{57}Ni – the A=57 mirror of ^{57}Cu



In ^{57}Cu comparing to ^{57}Ni:

- $p_{3/2}$ and $p_{1/2}$ states should have similar relative Coulomb shifts
  → similar exc. energies of $1/2^-$, $5/2_2^-$, $7/2^-$
- $f_{5/2}$ expected at higher energy, close to $p_{1/2}$
  → $5/2^-$ close to $1/2^-$, i.e. $E_x \approx 1$ MeV

coupling of a $p_{3/2}$ nucleon to 2^+ in ^{56}Ni

^{28}Si(^{32}S,2pnγ)^{57}Ni

D. Rudolph et al. EPJ A6 (1999) 377

$S_p(^{57}Ni)$=7559 keV