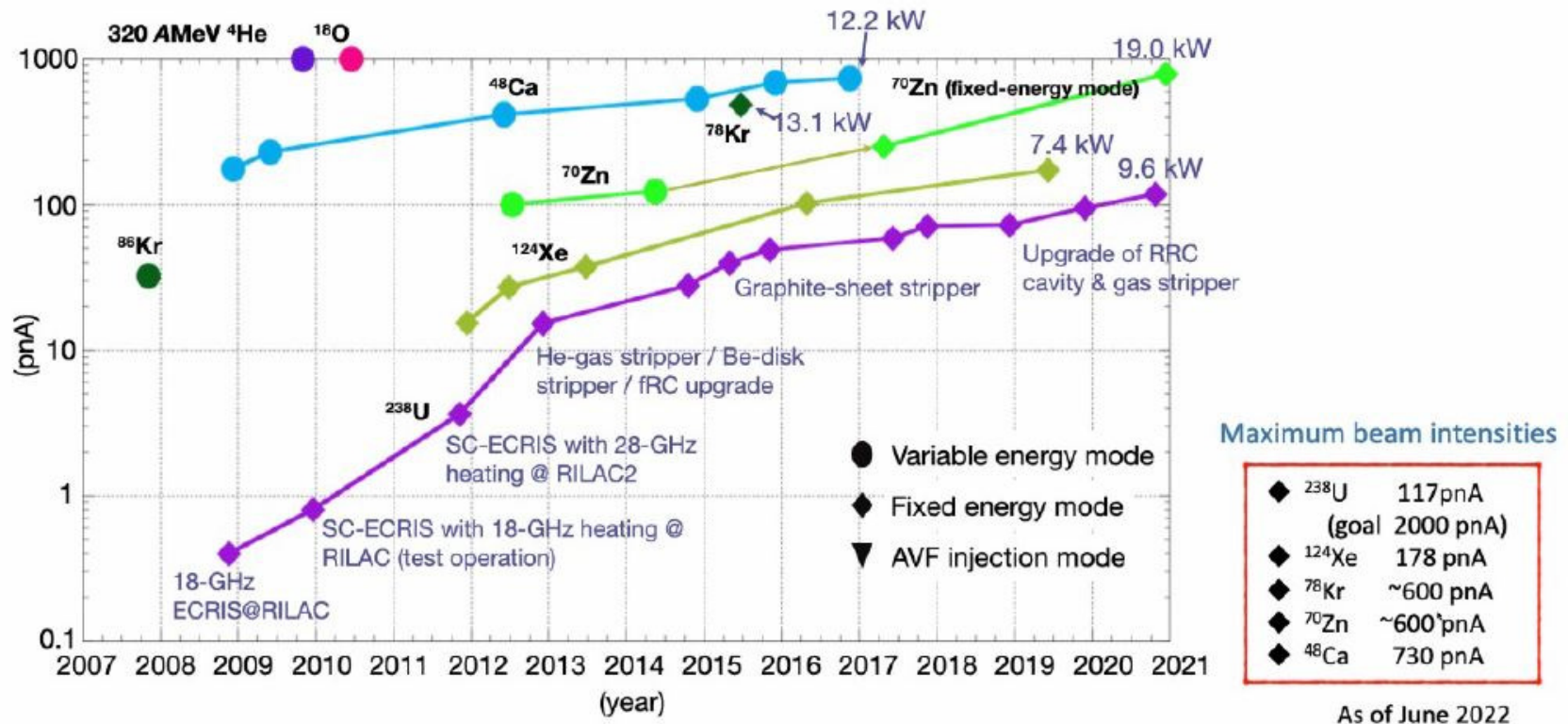


Demandes RIKEN + RCNP Osaka



- **Transfer with slowed-down beam
(shape evolution, shell structure, ...)**
- **Clustering away from stability**
- **Lifetime measurements : iDATEN**
- **Nuclear moments**
- **Mass measurements**
- **Study of the Wobbling mode**

Primary beam intensity at RIBF



Beam energies of the beams without explicitly indicated are 345 AMeV.

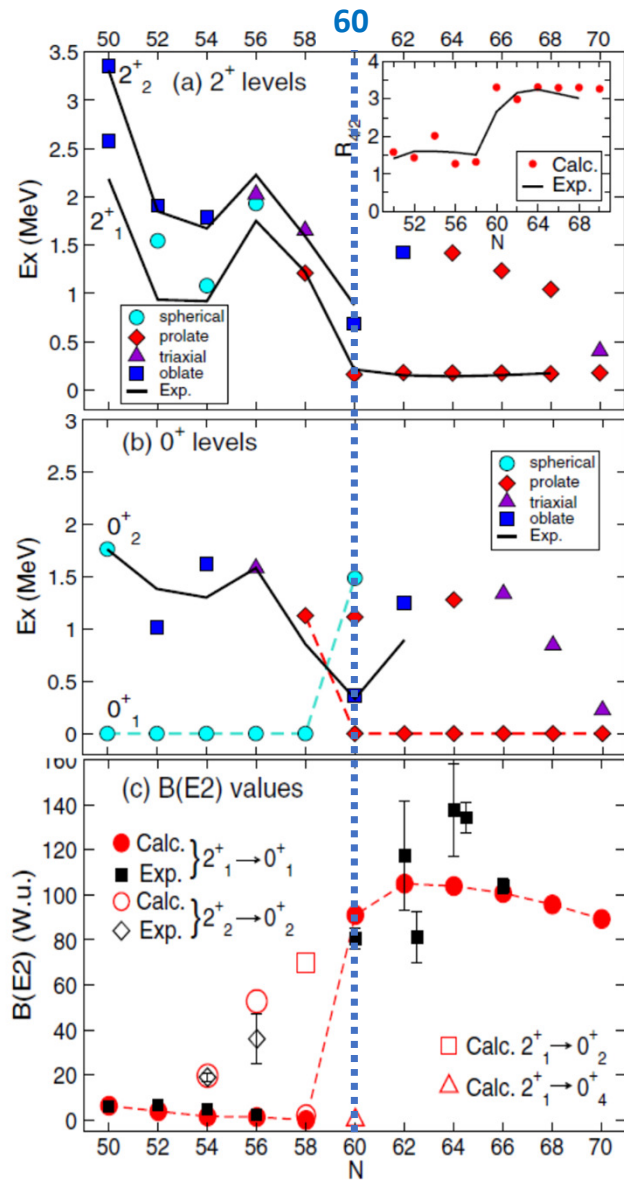
Courtesy of N. Fukunishi (RIBF Acc. gr.)

- Ever increasing intensities
- Limited beam time (3-4 months)

**Context in 2023: issues with the machine
Campaigns postponed twice**

From: S.Franchoo

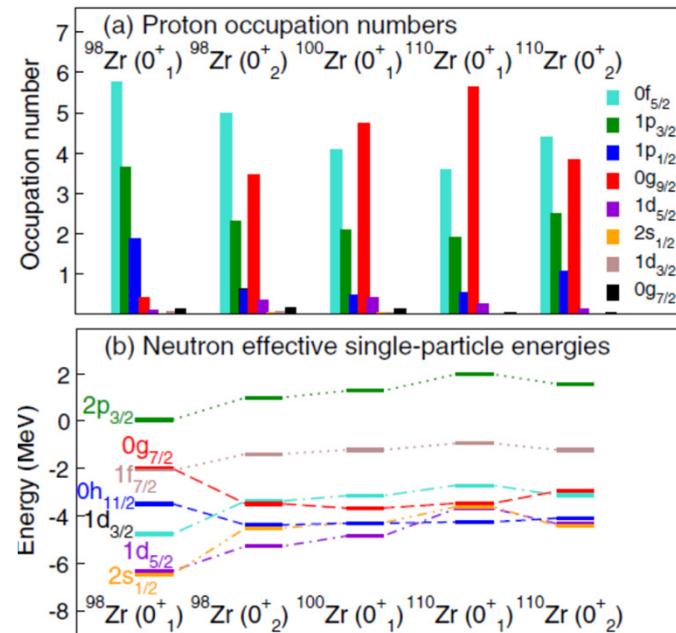
Physics case at OEDO: shape evolution in Zr isotopes



➤ **Drastic changes at N=60 !**

$E(2^+)$, $B(E2)$, ...

Such abrupt change can be identified to a **Quantum Phase Transition**



Strong occupation of the $\pi g_{9/2}$ -

⇒ Lower neutron $\nu g_{7/2}$ and $\nu h_{11/2}$

Type II shell evolution

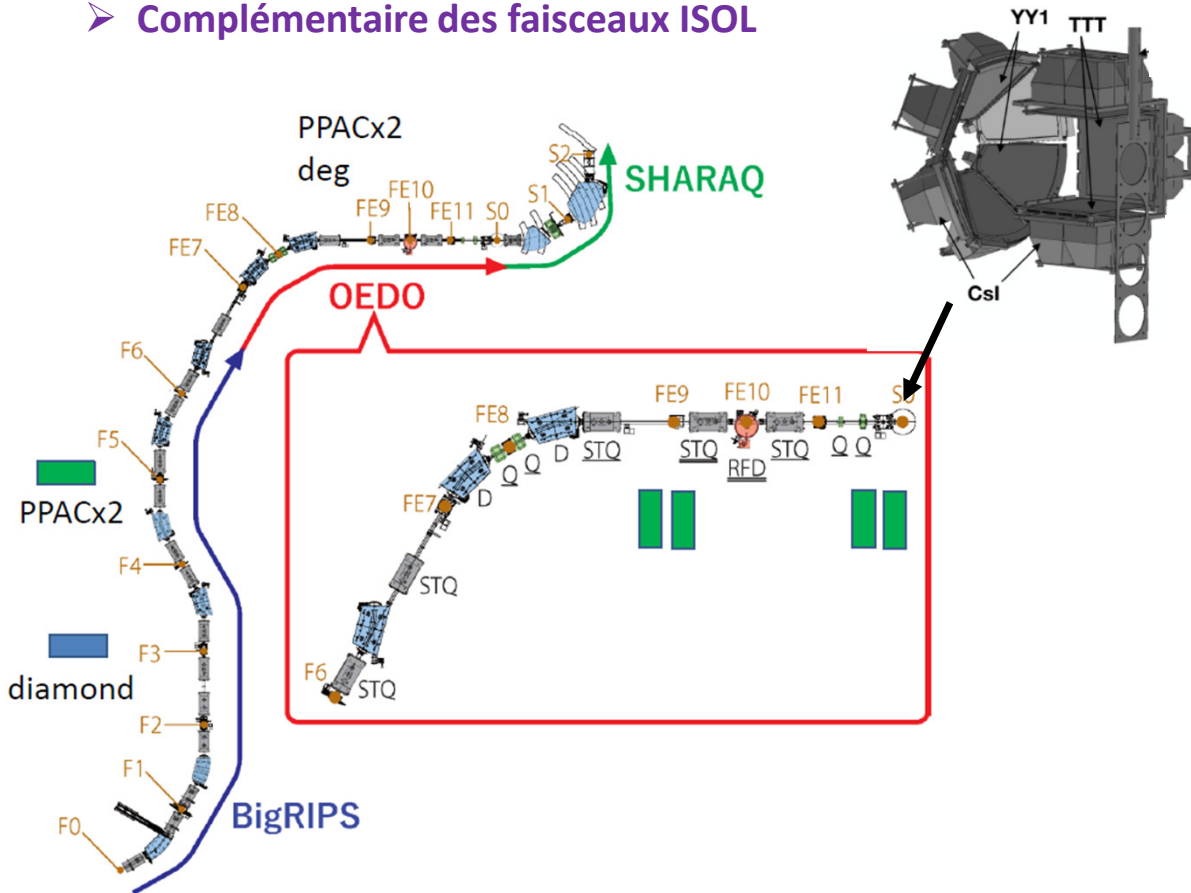
T.Togashi et al., PRL 117 (2017)

Plan : use pair transfer reaction

RIKEN – OEDO

Réactions de transfert avec des faisceaux ralentis

➤ Complémentaire des faisceaux ISOL



- Particle detection (Si) : TiNA
- Issue of gamma detection (under discussion)
option: 2 Quads (Gretina) + 18 GRAPE
NB: thick Si of GRIT may help

First experiments in 2022

$^{56}\text{Ni}(d,p)$ and $^{130}\text{Sn}(d,p)$ for astrophysics

2024

- Participation to $^{82}\text{Zr}(p,t)^{80}\text{Zr}$ (shape coexistence)
Spokesperson: J.Hwang (Daejeon)
- Proposition $^{102}\text{Zr}(p,t)$ Transition de phase

AP request 2024:

- Mission exp (2p/10j) 5k€

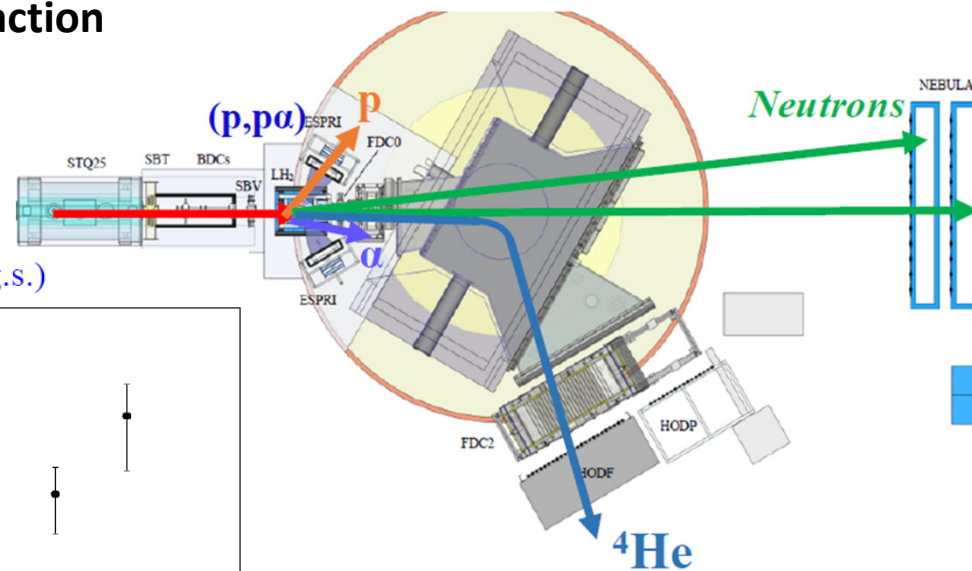
Physiciens IJCLab: M.Assié, D.Beaumel, V.Girard-Alcindor N.de Séréville, S.Franchoo, F.Hammache, I Stefan
Collaboration: CNS Tokyo, RIKEN, IJCLab, Tohoku, Madrid, Sevilla, Catania, IMP, CIAE

Clustering in n-rich isotopes and multineutrons using cluster KO reaction

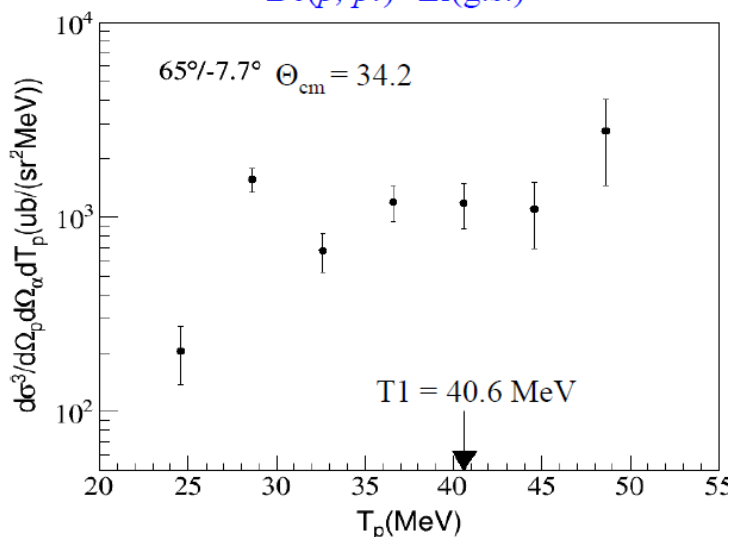
SAMURAI12 Experiment (Spokesperson: DB)

$^{10,12,14}\text{Be}(p,p\alpha)$ at 150 MeV/u

- **Cluster structure of neutron-rich Be isotopes**
- **First spectrum of the 6-neutron system**



$^{14}\text{Be}(p, pt)^{11}\text{Li(g.s.)}$

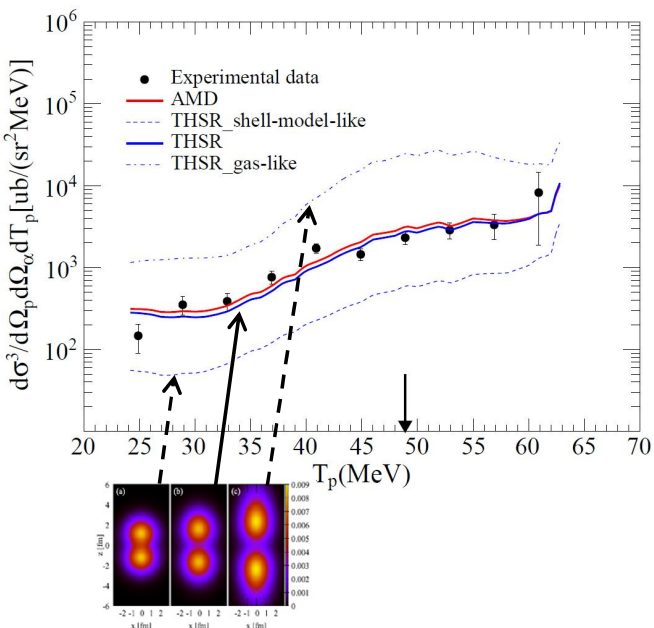


Large triton production from the surface of ^{14}Be

2024

➤ Follow-up expt on C isotopes using TOGAXSI ?
Spokes: Z.H. Yang (Peking U)

2024 request:
Mission exp (3p/10j) 7.5k€



Direct evidence of molecular structure of ^{10}Be

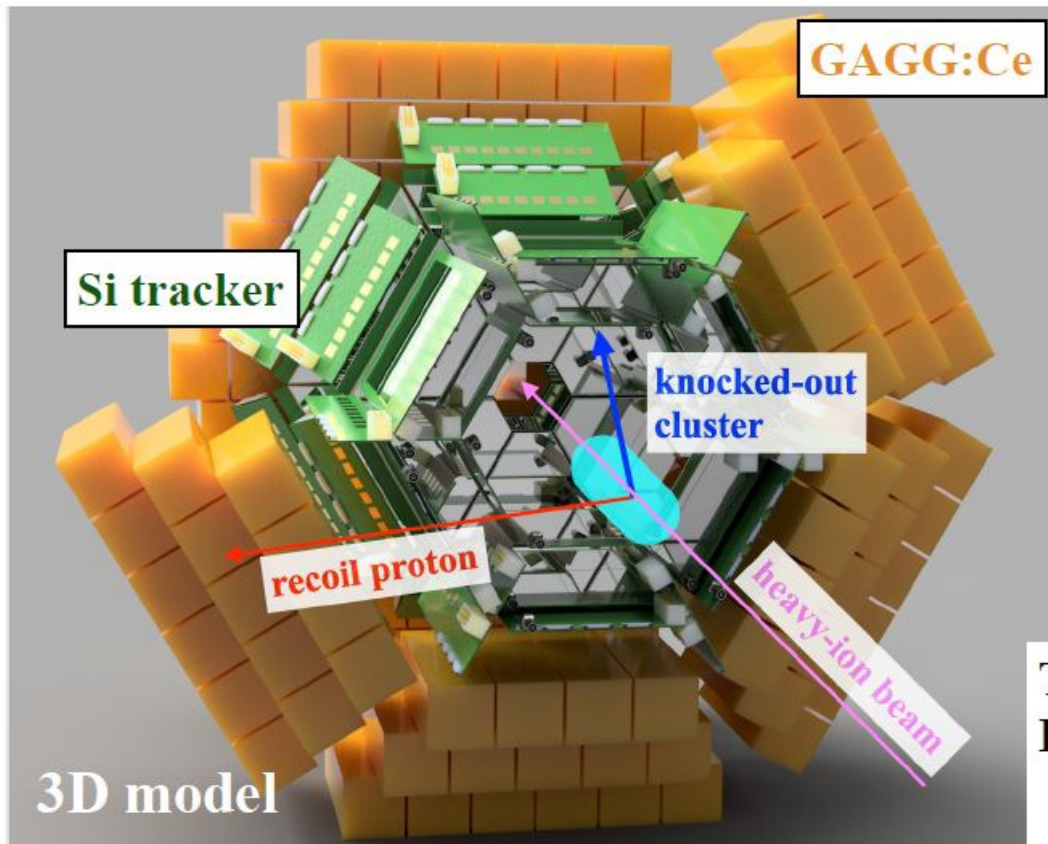
Submitted for publication

IJCLab: M.Assie, D.Beaumel, S.Franchoo, V.Girard-Alcindor F.Hammache, I.Stefan

Collaboration: **IJCLab, RIKEN, Hong Kong U., RCNP Osaka, TI Tech, LPC Caen, Tohoku U. CEA Saclay, Kyoto U., TU Darmstadt, NIPNE Bucharest, Kyushu U.**

TOGAXSI (戸隠) telescope

A new detector array for *inverse-kinematics* cluster and nucleon knock-out reaction experiments under construction.



From: T.Uesaka ~ 500 mm

All the detectors are placed in a vacuum to avoid multiple-scattering in materials

ONOKORO Program
For medium/heavy nuclei
(T.Uesaka, J.Zenihiro)

- RCNP & HIMAC
(Stable isotopes)
- RIKEN
(Unstable nuclei)

To be completed by 2023 summer.

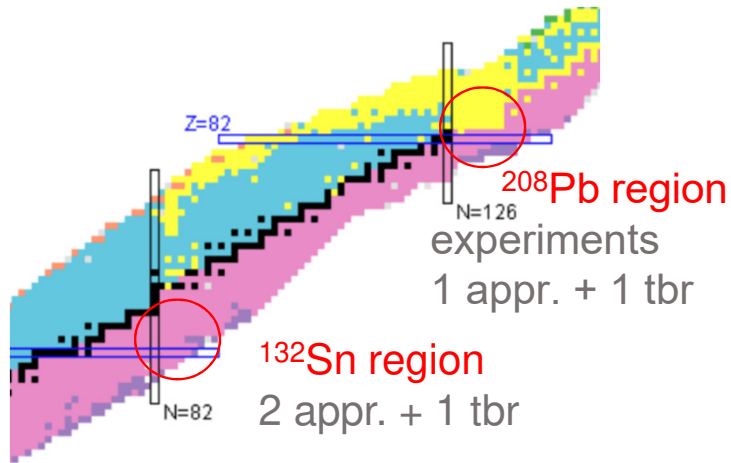
Experiments are planed:

Ca, Ar isotopes in 2023—

Sn, Xe isotopes in 2024—

Pb, Th isotopes in 2025—

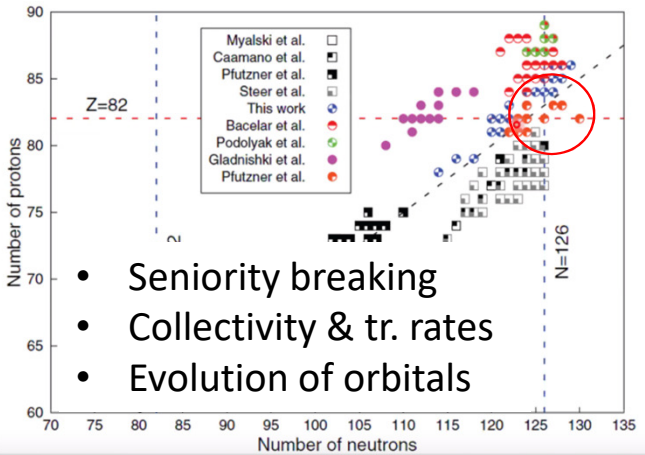
Isomer, lifetime and decay measurements around ^{132}Sn and ^{208}Pb with IDATEN



Bowry et al., Phys. Rev. C 88, 024611 (2013)

Caballero et al., Phys. Rev. C 95, 064322 (2017)

Phong et al., Phys. Rev. Lett. 129, 172701 (2022)

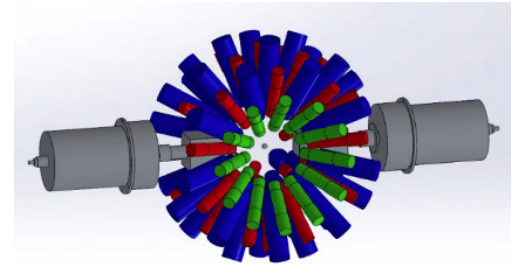


- Seniority breaking
- Collectivity & tr. rates
- Evolution of orbitals

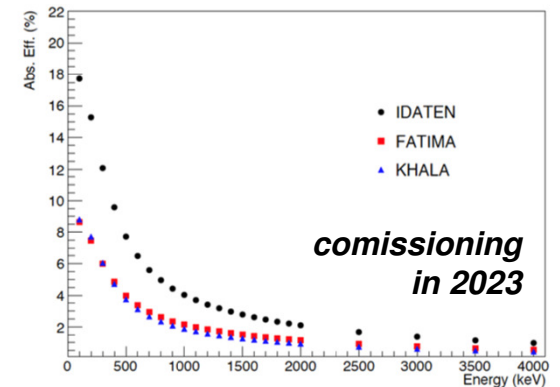
- 84 $\text{LaBr}_3(\text{Ce})$ scintillator detectors
- Two Clovers HpGe
- WASABI DSSSD for $\beta\gamma$ -correlation

- **New studies of lifetimes on short-lived states in the ^{208}Pb region within the IDATEN to be requested to PAC**
- **New studies of lifetimes on short-lived states in the ^{132}Sn region within the IDATEN to be requested to PAC**

- *Cd-Ag-Pd lifetime meas. $N\sim 82$ (appr. 7.5 d)*
- *^{132}Sn decay & lifetime & masses $N>82$ (5 d)*
 β -decay station + MRTOF
- *Isomers beyond $N=126$ ^{208}Pb region (5 d)*



with IDATEN in 2024



2 travels /2 pers. /2x7 days

AP request 2024:

$A>132, A>208$ experiments: 8.5 k€

IJCLab: R.Lozeva, V.Piau, NEXT (2/3 pers.)

Nuclear moments of isomeric states @ RIKEN

➤ Long-standing fruitful collaboration with the group of H. Ueno – since 2008

Y. Ichikawa, ..., G.Georgiev, et al. Nature Phys. 15,321 (2019)

F.Boulay, ..., G.Georgiev, ..., R.Lozeva, et al. PRL 124, 112501(2020)

• Double fragmentation:
Nature Physics 8, 918 (2012)

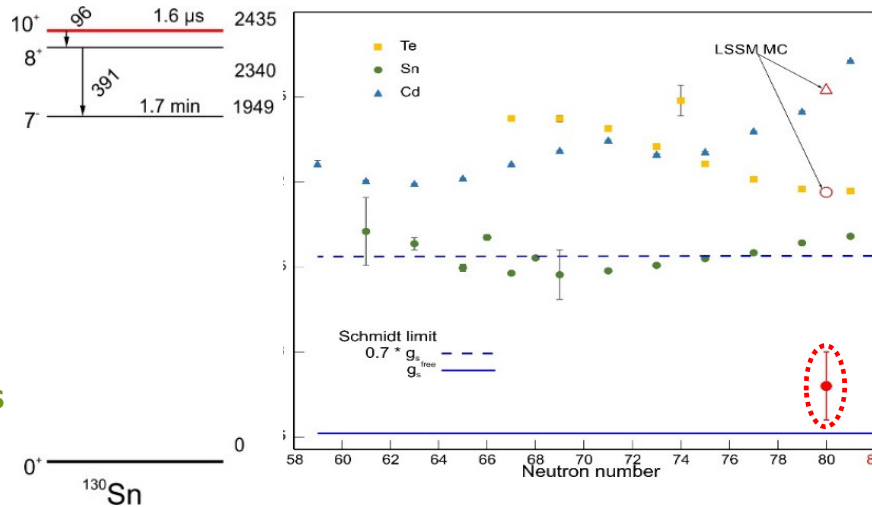
➤ Accepted proposal on 10^+ isomer in ^{130}Sn (2019, spokesperson: G.Georgiev)

December 2018 - TDPAD study of the 10^+ isomer in ^{130}Sn



TDPAD setup:

- plastic scintillator (t=0)
- 4 Ge (LE) + 2 LaBr₃ detectors
- magnetic field B=150 mT



• Unexpected experimental value obtained with very poor statistics.

• Requires a confirmation beyond any doubt.

⇒ New proposal accepted by the RIKEN PAC in December 2019 (G.Georgiev)

➤ Newly accepted proposal ^{132}Sn (2022, spokesperson: G.Georgiev)

TDPAC technique for short-lived isomers (few ns ~ usec) – similar setup

Request for 2024

- Missions: 4p (PhD student + SDF researchers) = 8 weeks → 15 k€
- furnitures: transport of 4 Ge detectors to RIKEN and back → 6 k€

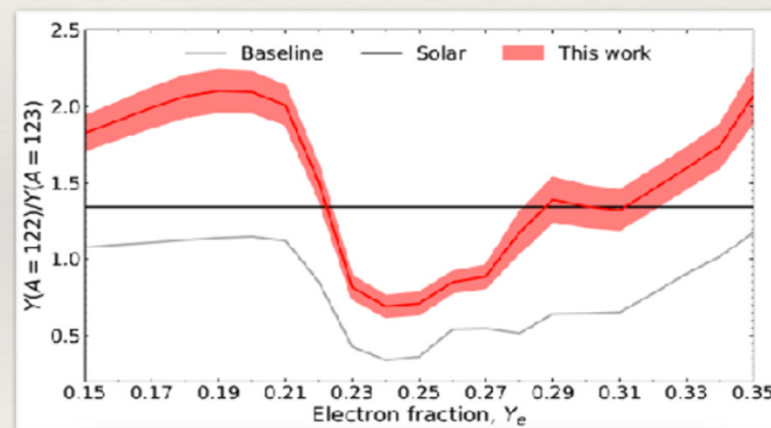
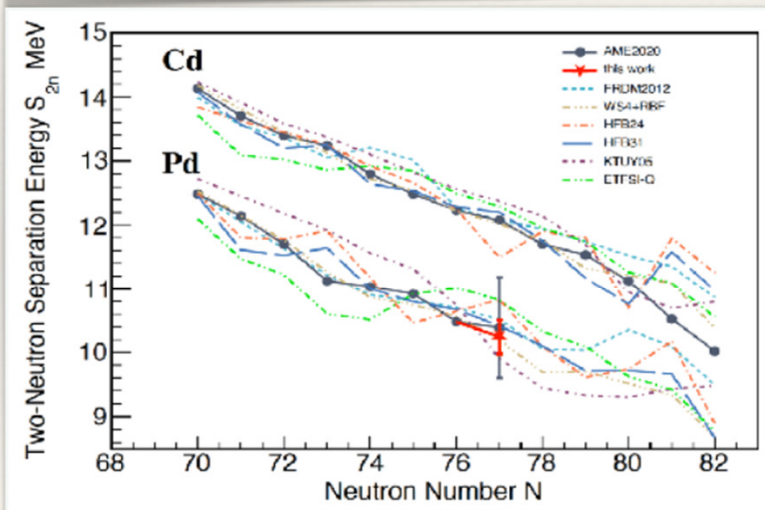
TOTAL : 21k€

Mass measurements at R3 - RIKEN

PHYSICAL REVIEW LETTERS 128, 152701 (2022)

First Application of Mass Measurements with the Rare-RI Ring Reveals the Solar r -Process Abundance Trend at $A = 122$ and $A = 123$

H. F. Li,^{1,2,3,4} S. Naimi,^{3,*} T. M. Sprouse,⁵ M. R. Mumpower,⁵ Y. Abe,³ Y. Yamaguchi,³ D. Nagae,^{3,†} F. Suzuki,^{3,‡} M. Wakasugi,³ H. Arakawa,⁶ W. B. Dou,⁶ D. Hamakawa,⁶ S. Hosoi,⁶ Y. Inada,⁶ D. Kajiki,⁶ T. Kobayashi,⁶ M. Sakaue,⁶ Y. Yokoda,⁶ T. Yamaguchi,⁶ R. Kagesawa,⁷ D. Kamioka,⁷ T. Moriguchi,⁷ M. Mukai,^{7,8} A. Ozawa,⁷ S. Ota,^{8,||} N. Kitamura,⁸ S. Masuoka,⁸ S. Michimasa,⁸ H. Baba,³ N. Fukuda,³ Y. Shimizu,³ H. Suzuki,³ H. Takeda,³ D. S. Ahn,^{3,9} M. Wang,¹ C. Y. Fu,¹ Q. Wang,¹ S. Suzuki,¹ Z. Ge,^{1,¶} Yu. A. Litvinov,¹⁰ G. Lorusso,^{11,12} P. M. Walker,¹² Zs. Podolyak,¹² and T. Uesaka³



The abundance ratio of mass $A=122$ and 123 can be better reproduced with new mass of 123Pd measured at RIBF with the Rare-RI Ring.

Mass measurements at R3 - RIKEN

New type of Schottky detector is being developed in collaboration with GSI and RIKEN. The aim is to improve the current precision of the mass measurement at the rare-RI ring.

- Detector will be installed at RIKEN early 2024
- First test experiment planned for spring 2024

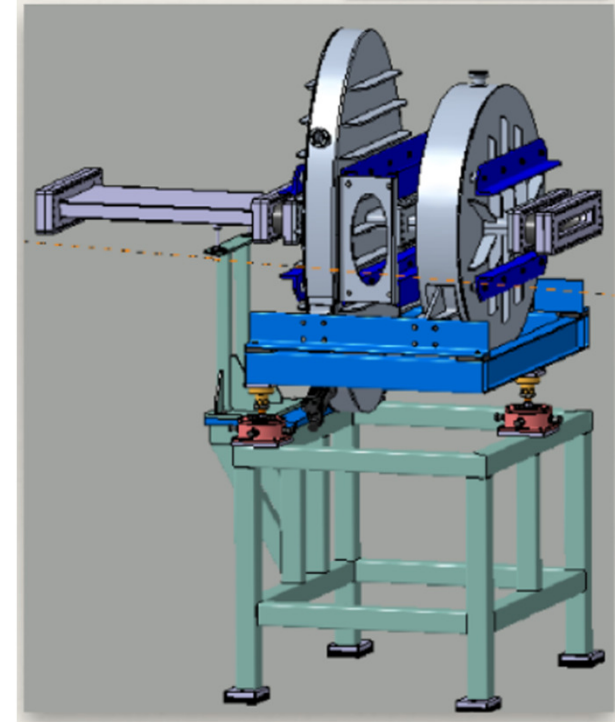
Mass Measurements with the Rare-RI Ring and using the new detector is planned in the fall of 2024

The experiment will focus on mass measurements of $N=Z$ nuclei for the rp-process

2024 request:

▪ Test of the new detector	1p/7j
▪ Experiment	1p/14j
Total	5k€

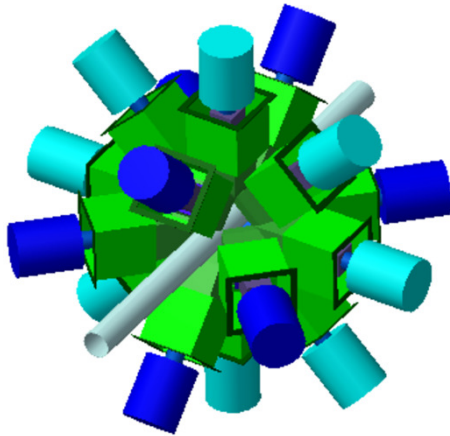
PhD project of
my student
George
Hudson-Chang



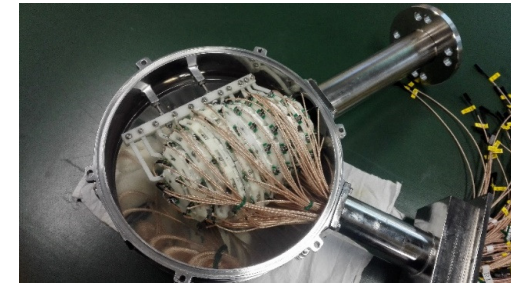
Linear Polarization Measurement in ^{137}Sm , ^{137}Pm : search new Wobbling Bands at RCNP - Osaka

Spokespersons: *S. Guo (IMP Lanzhou) and C. M. Petrache (IJCLab Orsay)*

In-beam gamma spectroscopy via the reaction $^{36}\text{Ar}+^{105}\text{Pd}$



CAGRA : 16 Clovers:
High efficiency ~ 5%
8 Clovers @ 90°:
Perfect sensitivity for
Linear pol. measurements
Fast digital DAQ system:
High triggering rate for
3-fold coincidence events ~20k/s



IMP Lanzhou CsI ball:
To select diff. emission channels

Participants IJCLab: A.Astier, C.Petrache, PhD student
Pluri-annual program on Lanthanides region
Related program at iThemba Labs on the Wobbling mode (in Ce and Ba)

AP request for 2024:

- | | | |
|--------------------|-------|-----|
| ➤ Furniture/Equip. | | 1k€ |
| ➤ Mission exp | 3p/7j | 7k€ |
| ➤ informatique | | 1k€ |

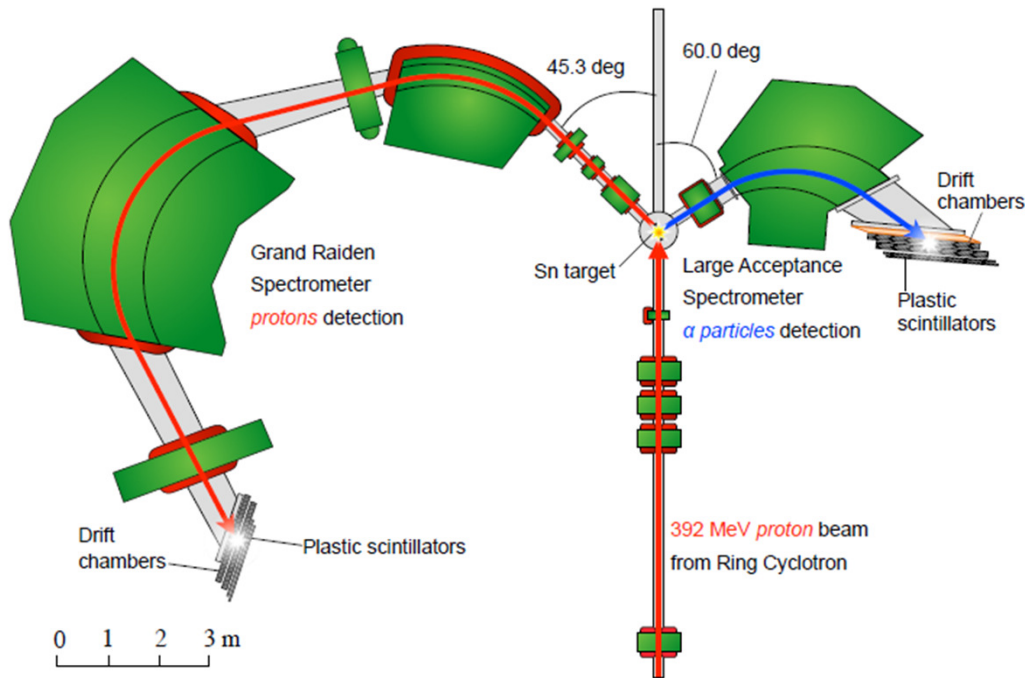
Collaboration: IJCLab, IMP Lanzhou, RCNP Osaka

Program	Installation	Request (k€)
OEDO	RIKEN	5.0
Clustering	RIKEN	7.5
iDATEN	RIKEN	8.5
Nuclear moments	RIKEN	21.0
Mass measurements at R3	RIKEN	5.0
Wobbling Mode	RCNP	9.0
	TOTAL	56.0

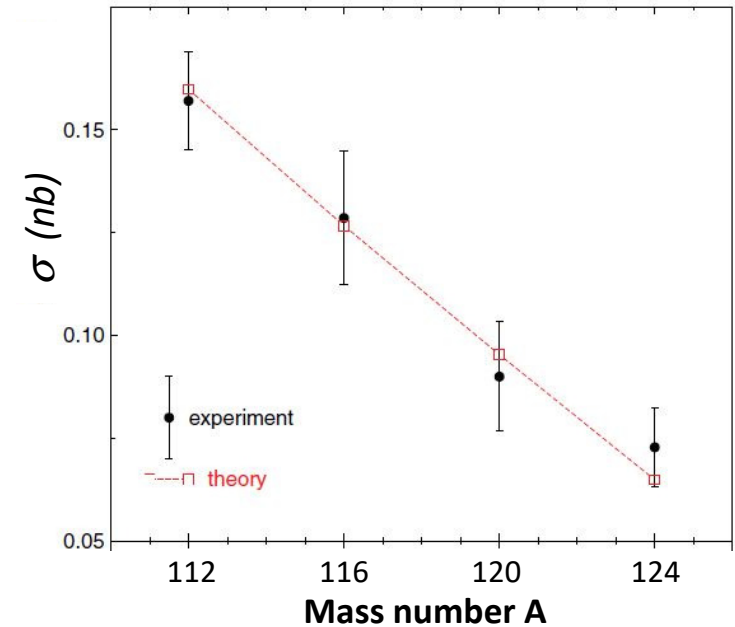
contribution IRP France-Japon (env.10-15%?)

α -clustering at the surface of medium-mass nuclei

$^A\text{Sn} (p,p\alpha)$ reaction in direct kinematics



2018 (p,p α) experiment on stable Sn



DWIA analysis with gEDF densities
J.Tanaka et al., *Science* 371, 260(2021)

2022: accepted experiments on Nd and Sm isotopes

- To clarify the systematic Q_α dependence of α -clustering strength
- Effect of deformation

Collaboration: TU Darmstad, RIKEN, RCNP, IJCLab, Kyoto U., Tohoku, Peking U.