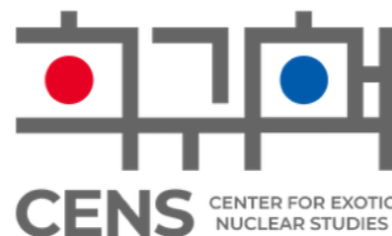


September 2-3, 2022  
CENuM Workshop

# Introduction to IDATEN

Byul Moon

Center for Exotic Nuclear Studies, Institute for Basic Science



# IDATEN project at RIBF

## NP2112-RIBF212

Title: **Fast-timing  $\gamma$ -ray spectroscopy of exotic nuclei at RIBF**

Spokesperson(s): **Hiroshi Watanabe**

Approved — Grade A  
1.5 days

1.5 days(including 0.5days for BigRIPS tuning)

A construction proposal of the fast-timing measurement at RIBF was approved.

Spokespersons: H. Watanabe, P. H. Regan, and B. Moon

In-house contact person: S. Nishimura

The world largest fast-timing array is coming...

# What is IDATEN?

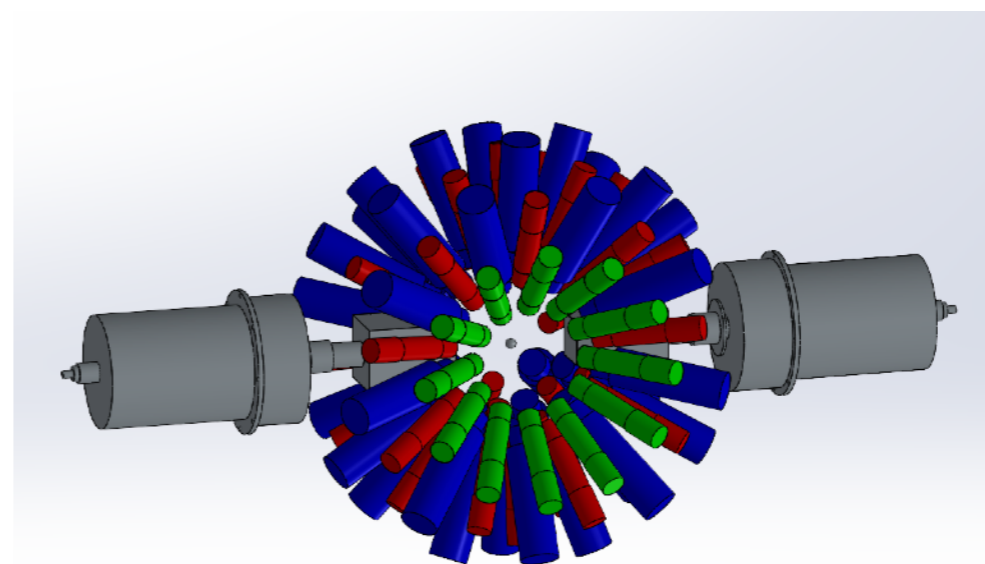
International Detector Assembly for fast-Timing measurements of Exotic Nuclei



IDATEN is a Japanese word of the god of speed from Buddhism and Hinduism.

韋馱天 / 위타천 / स्कन्द / Iskandar / Alexander the Great

In Japanese baseball pro games, a speedy player is called as Idaten.



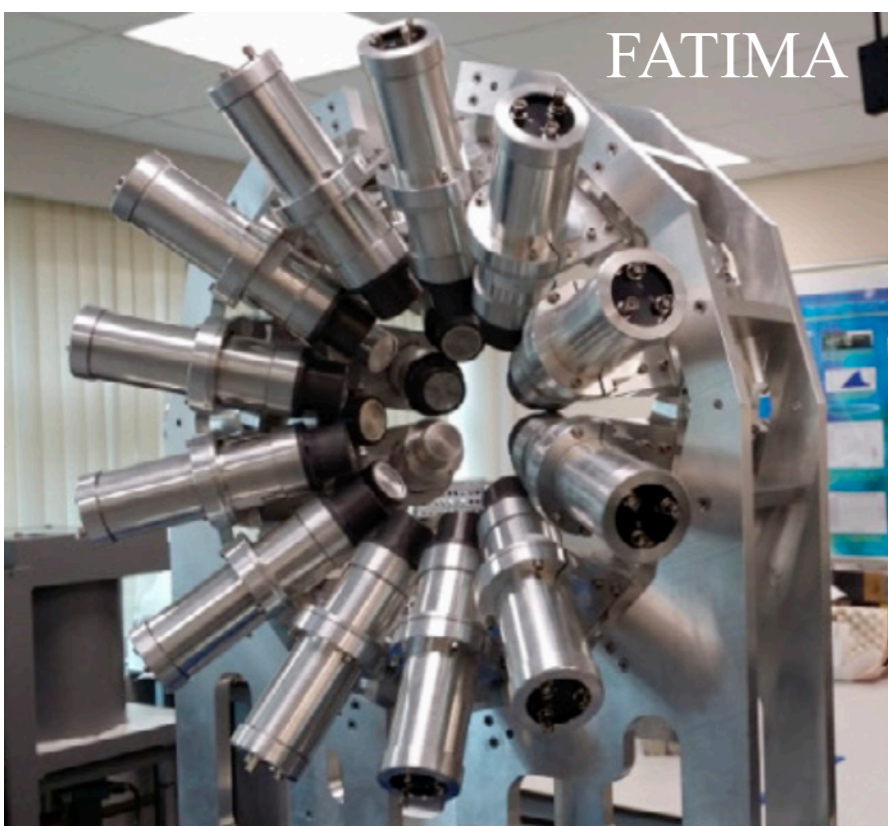
A large array of 84 (?)  $\text{LaBr}_3(\text{Ce})$  detectors

36 FATIMA (FAst-TIMing Array)

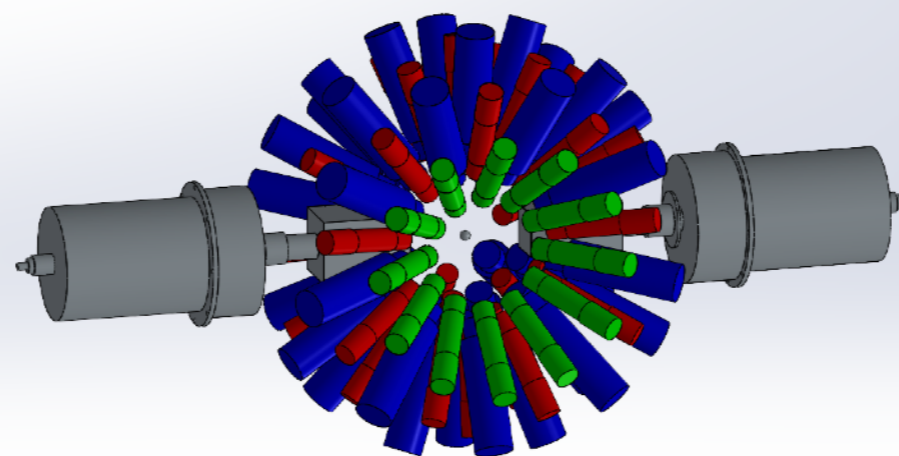
36+12 KHALA (Korea High-resolution Array of  $\text{LaBr}_3$ )

... and two clover detectors

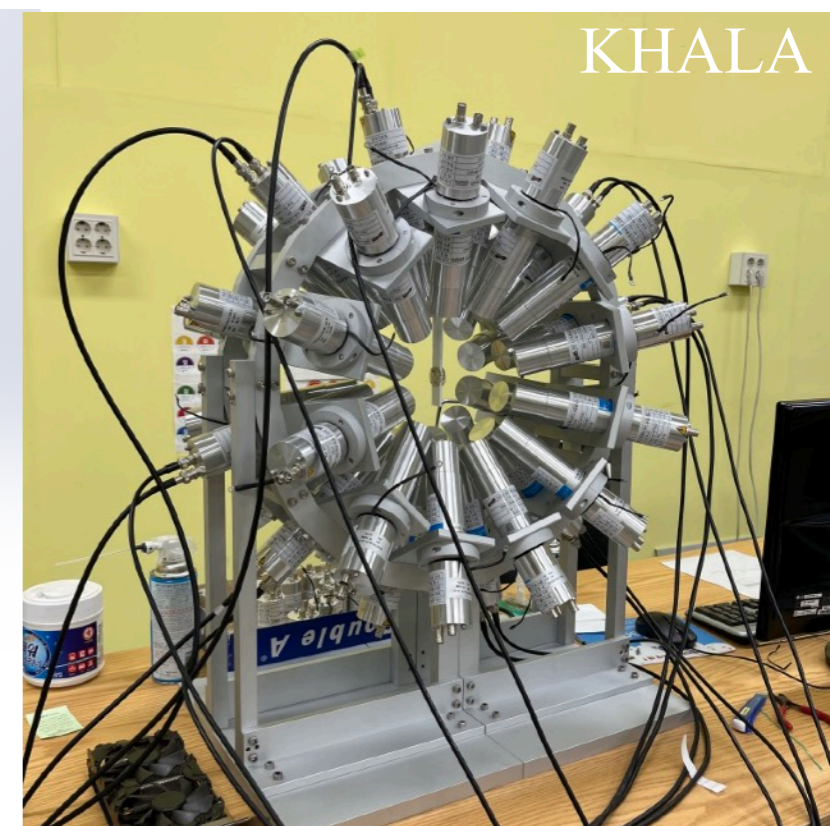
# Summary of IDATEN specification



FATIMA



IDATEN-84 array



KHALA

FATIMA

KHALA

Number of detectors

36

36+12

LaBr<sub>3</sub>(Ce) crystal size $\phi 1.5'' \times 2''$ -length $\phi 1.5'' \times 1.5''$ -length

Energy resolution

3.4% @ 779 keV

3.3% @ 662 keV

Time resolution

334.3(4) ps @ 1332-1173 keV

335(1) ps @ 511-511 keV

Passive Pb shield

Optional

No

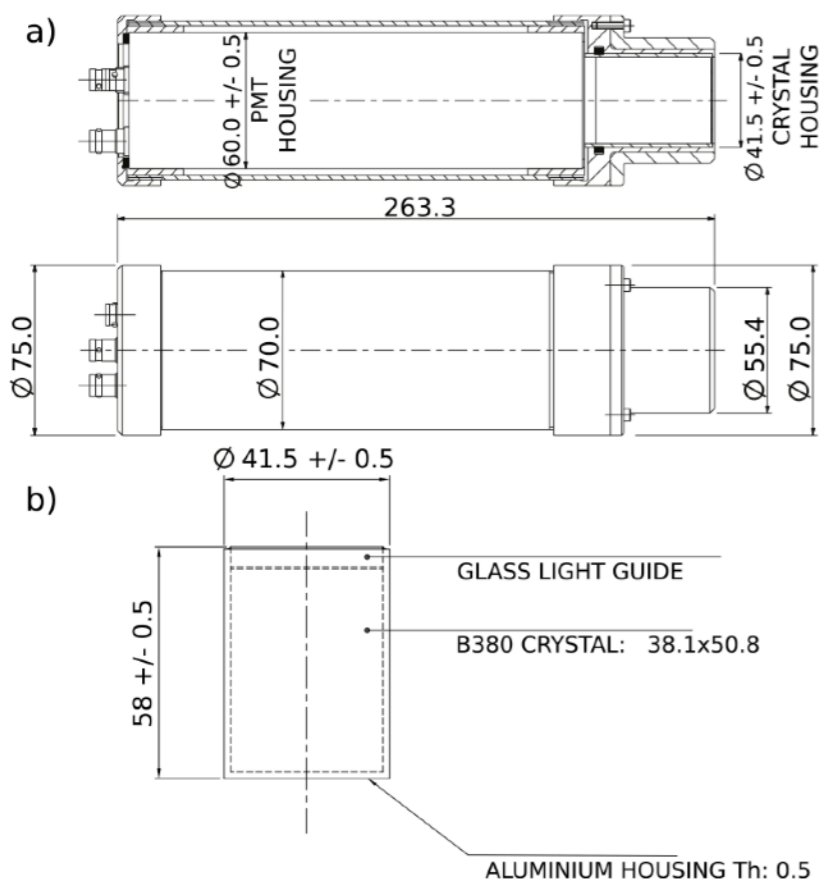
Owners

U. of Surry, U. of Brighton

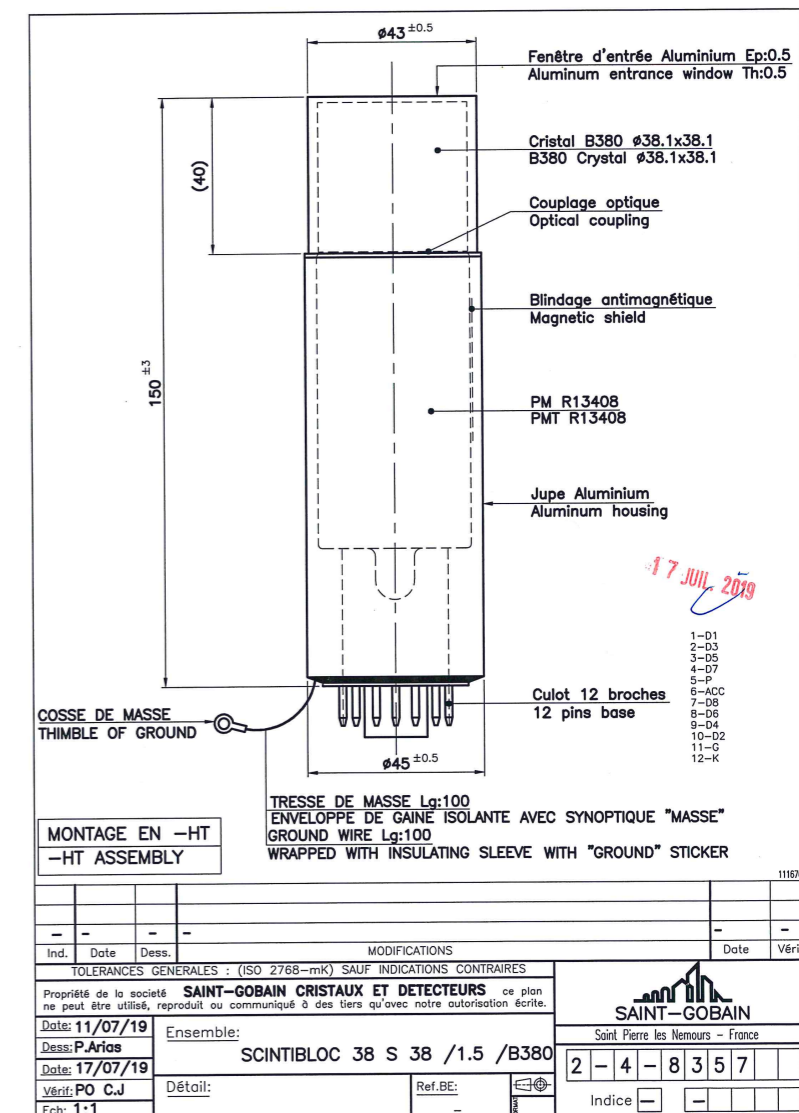
Korea U., SNU

# Detector module

## FATIMA



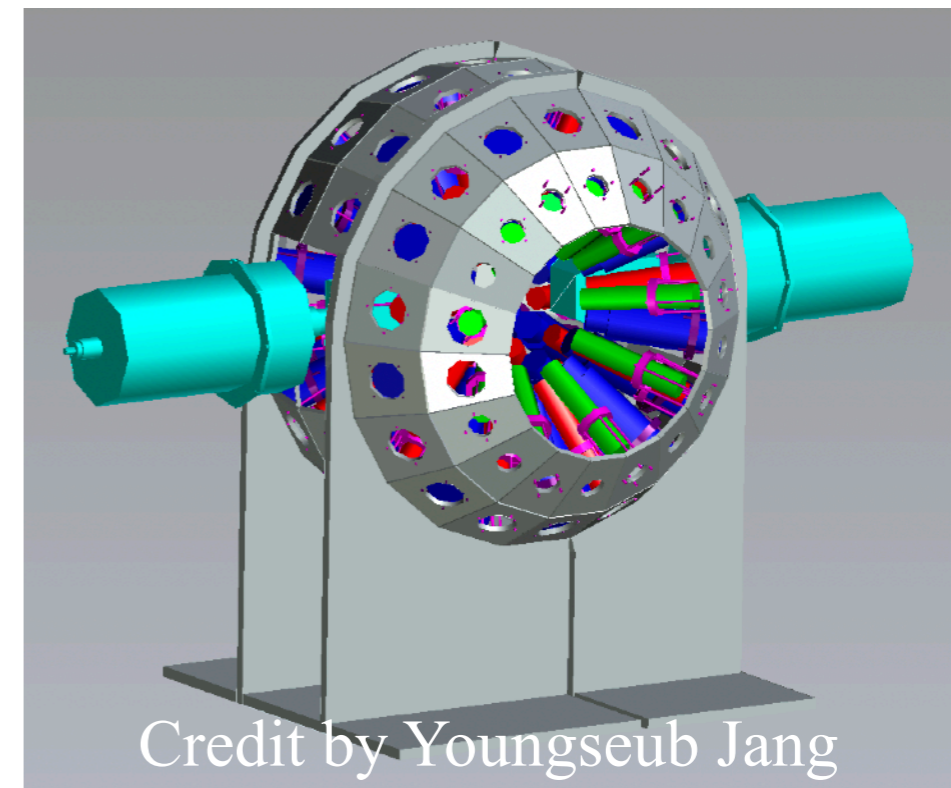
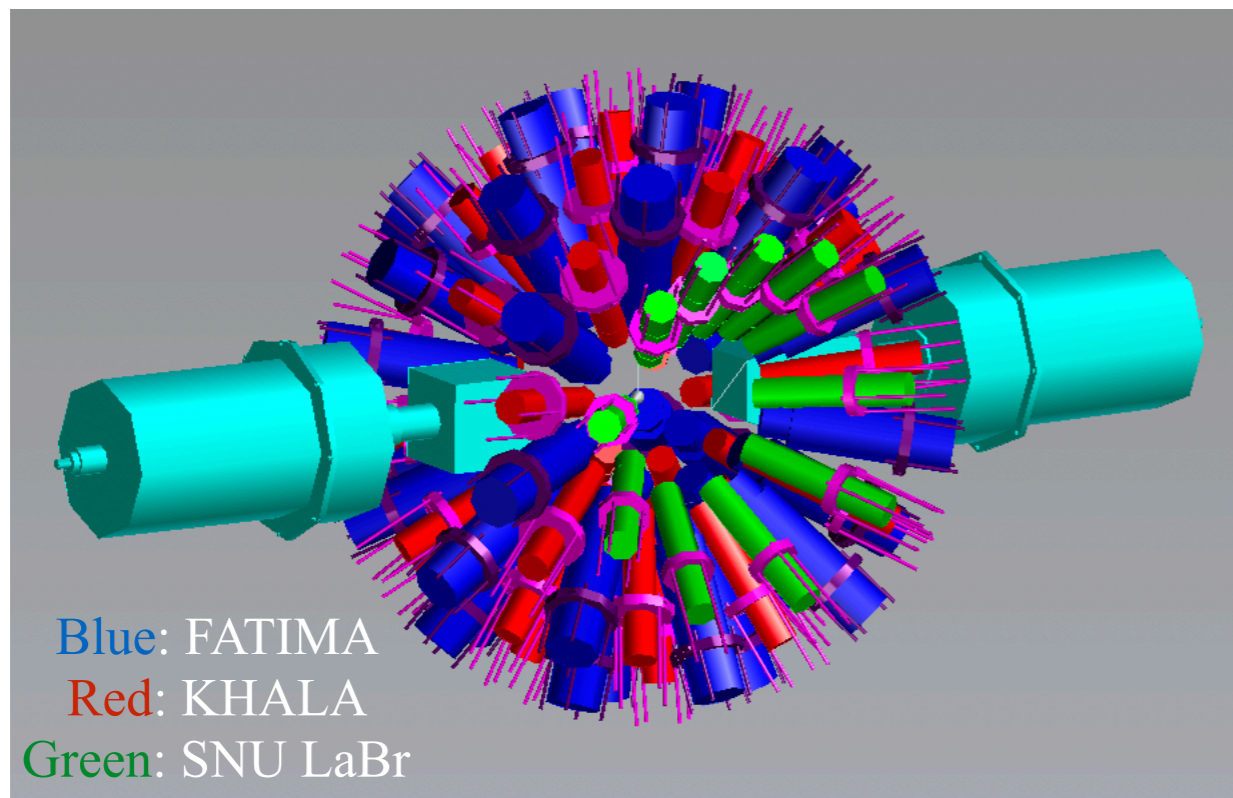
## KHALA



- Both crystals are procured from Saint-Gobain. (B380)
- PMTs are from Hamamatsu, but different models and diameters.
- FATIMA is composed of individual crystal and PMT while they are combined in KHALA.

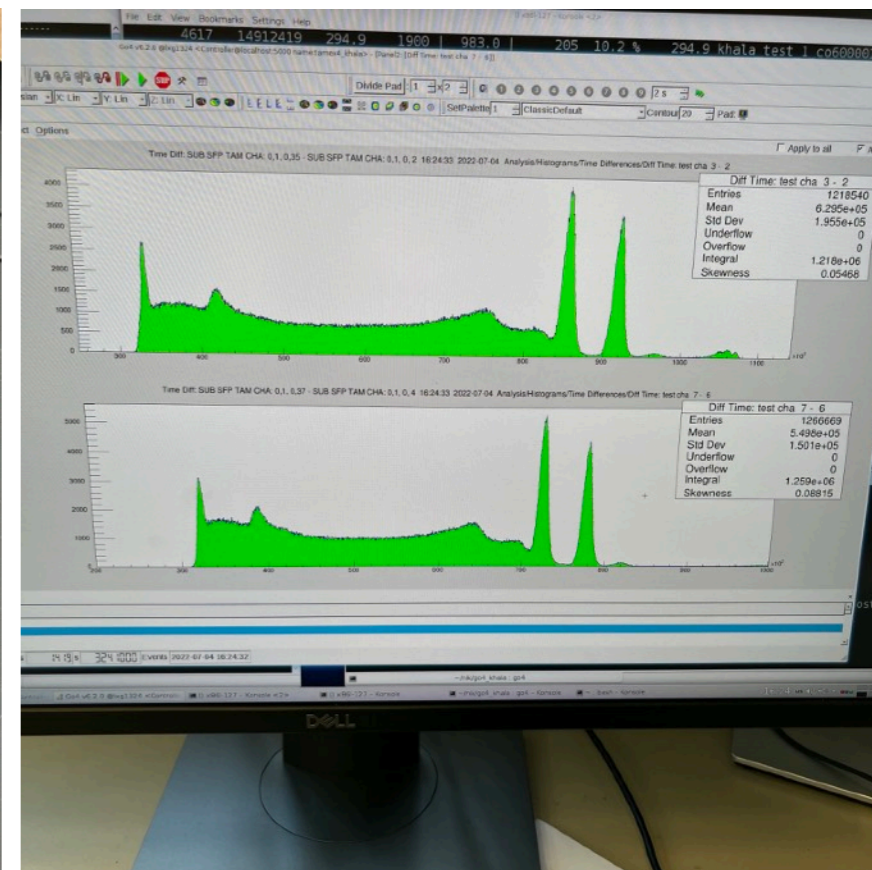
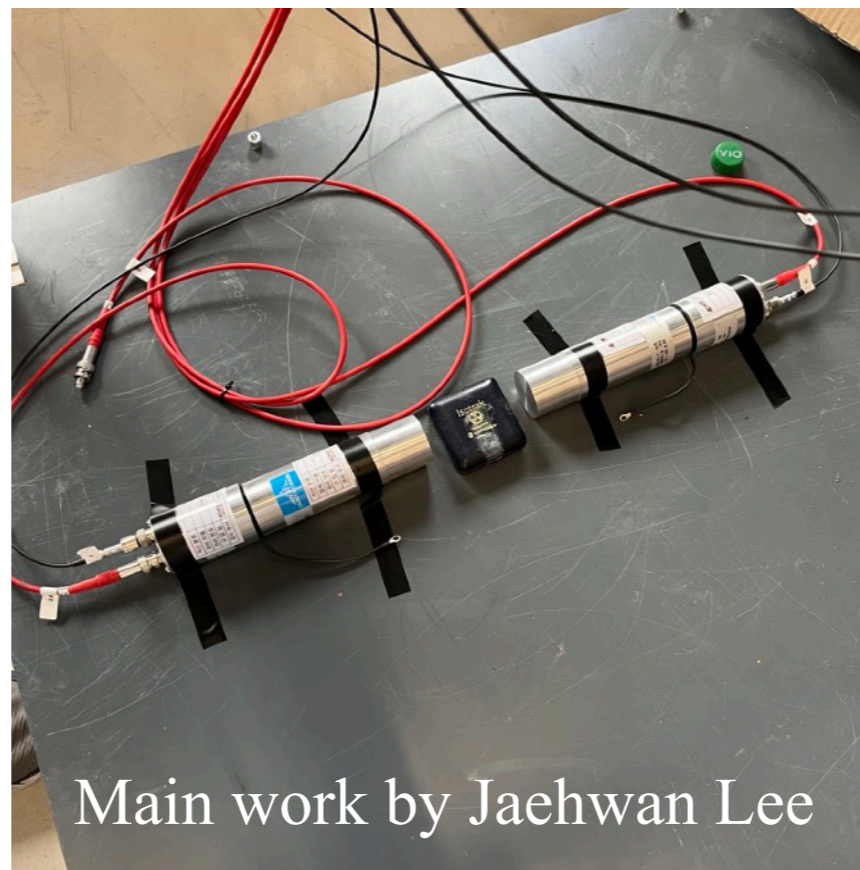
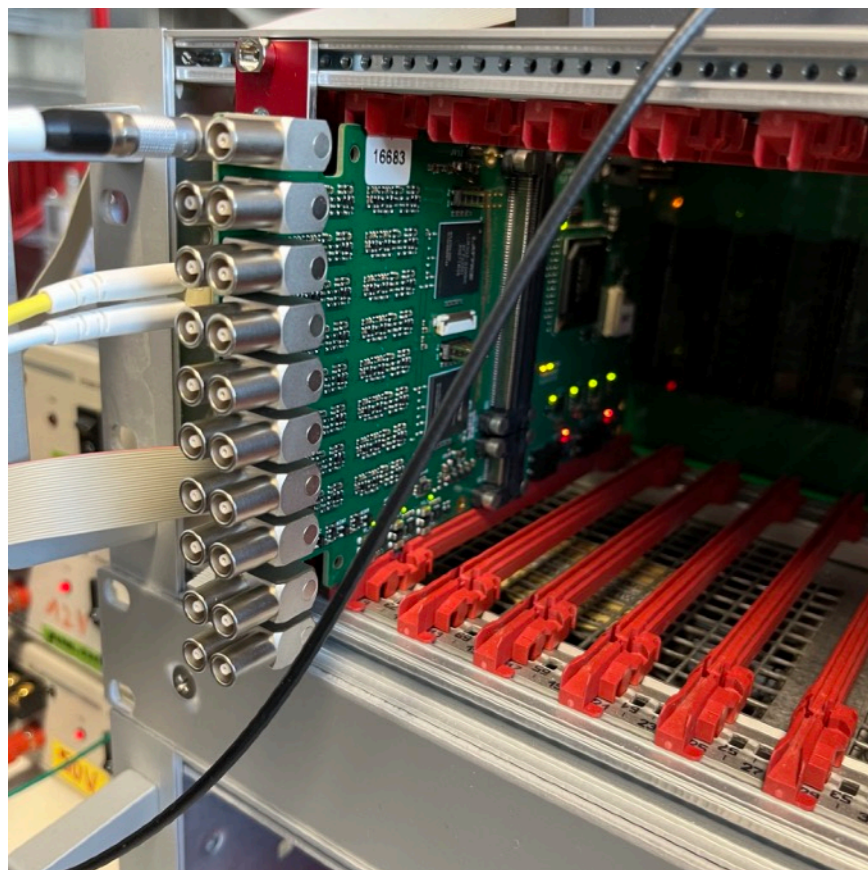
M. Rudigier *et al.*, NIMA **969**, 163967 (2020)

# IDATEN geometry & supporting frame



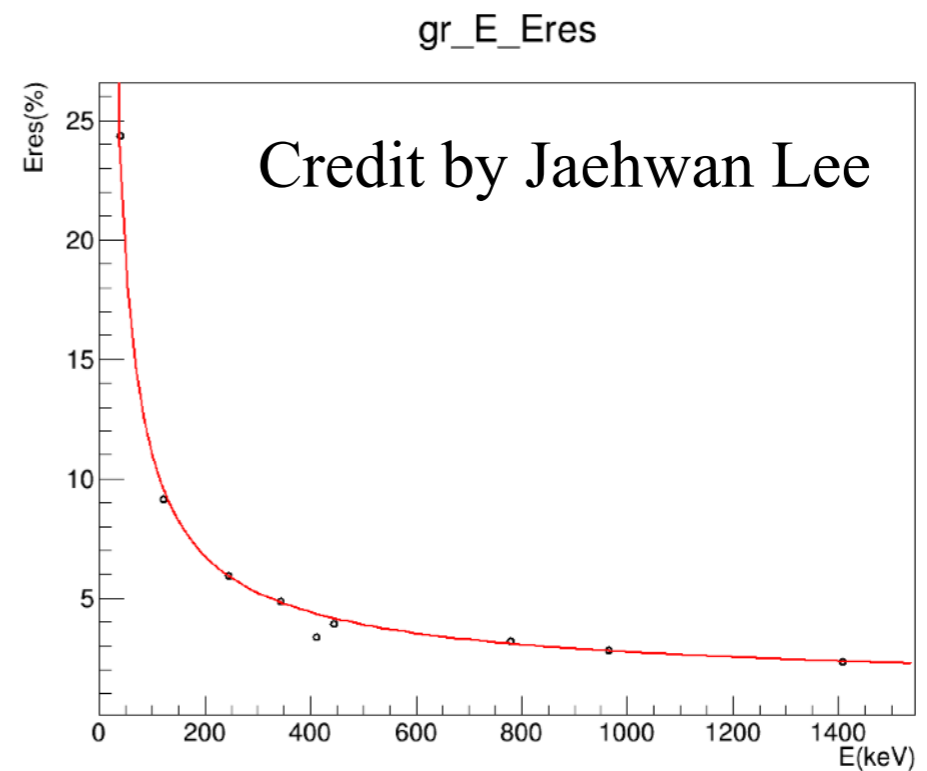
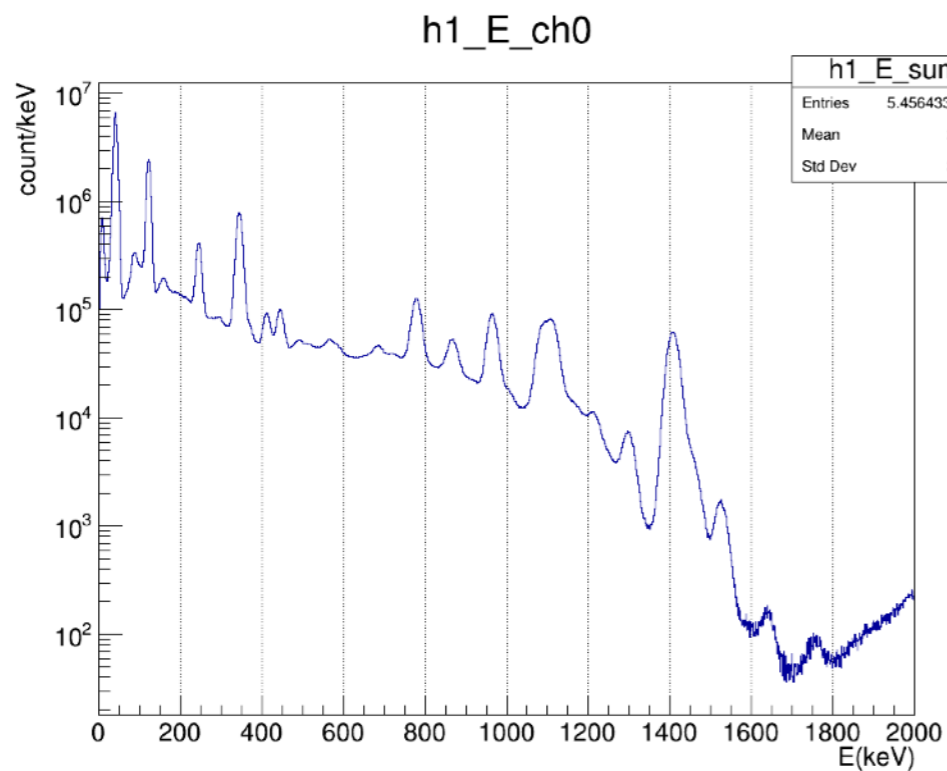
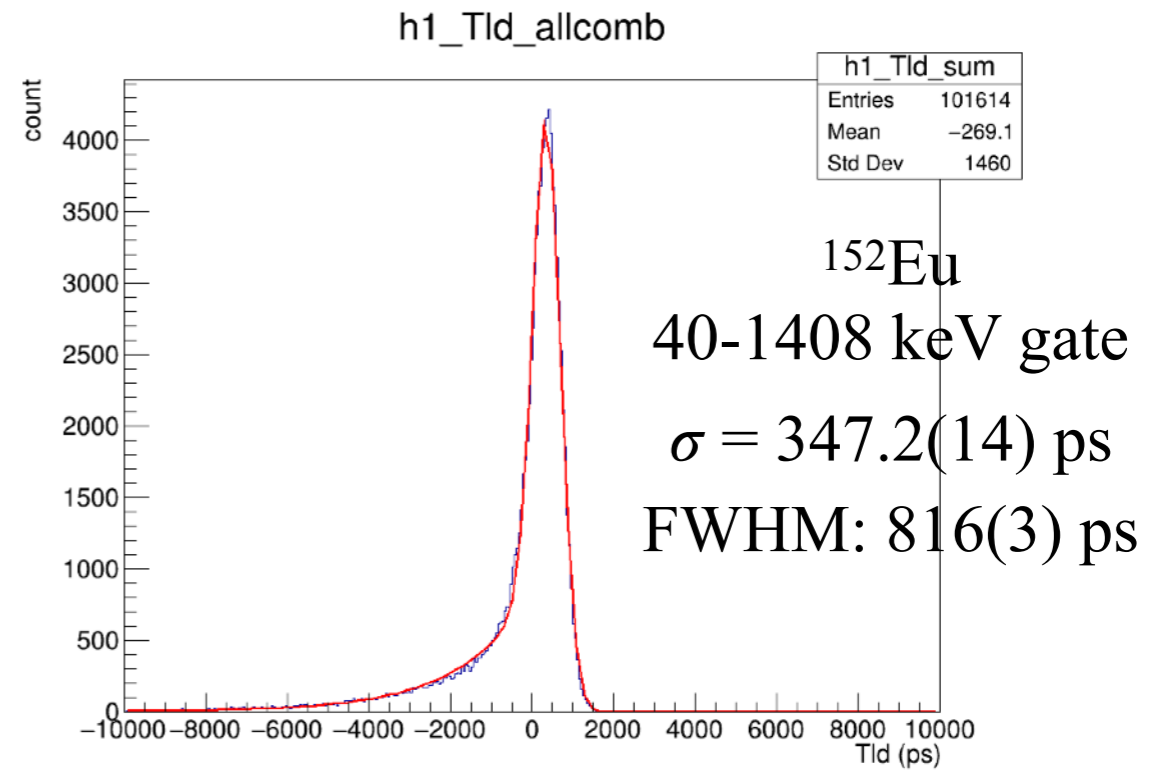
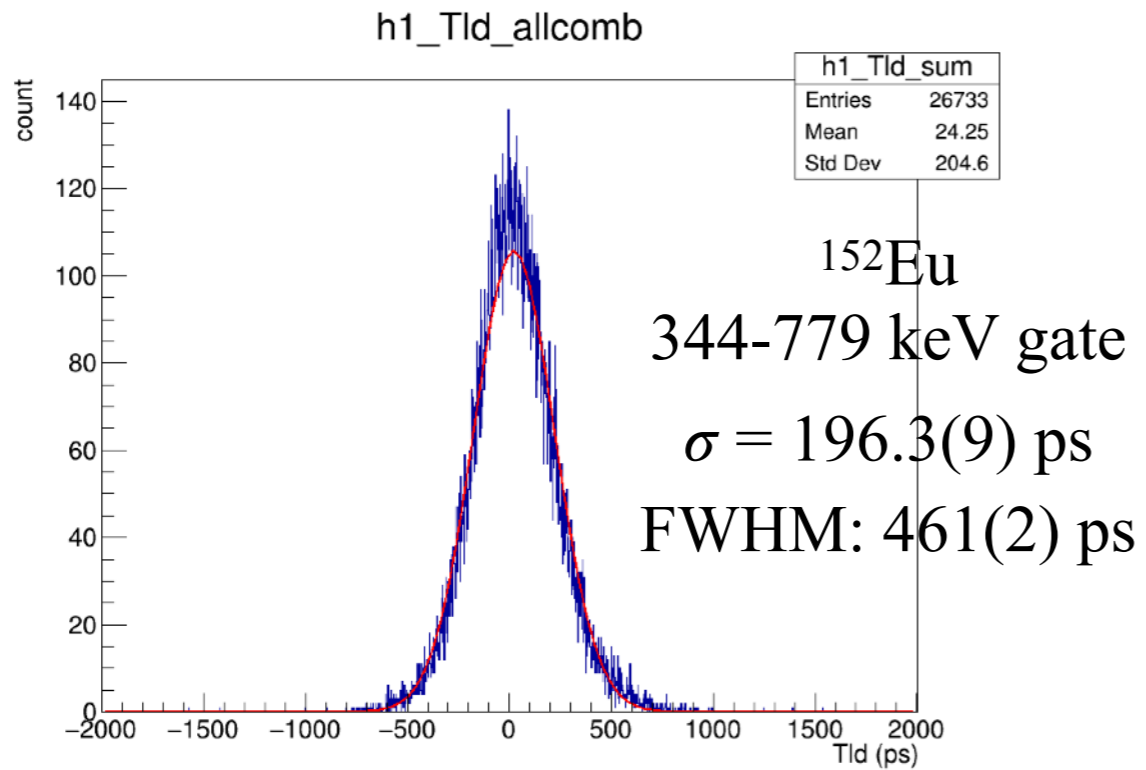
- 84  $\text{LaBr}_3(\text{Ce})$  detectors (36 FATIMA + 48 KHALA)
- Located at 17 cm from the center and two clover detectors at 15 cm
- 100 slots available, but the distance may increase for the full occupancy
- The design of the frame is finished and some parts will be tested in Korea.

# IDATEN DAQ



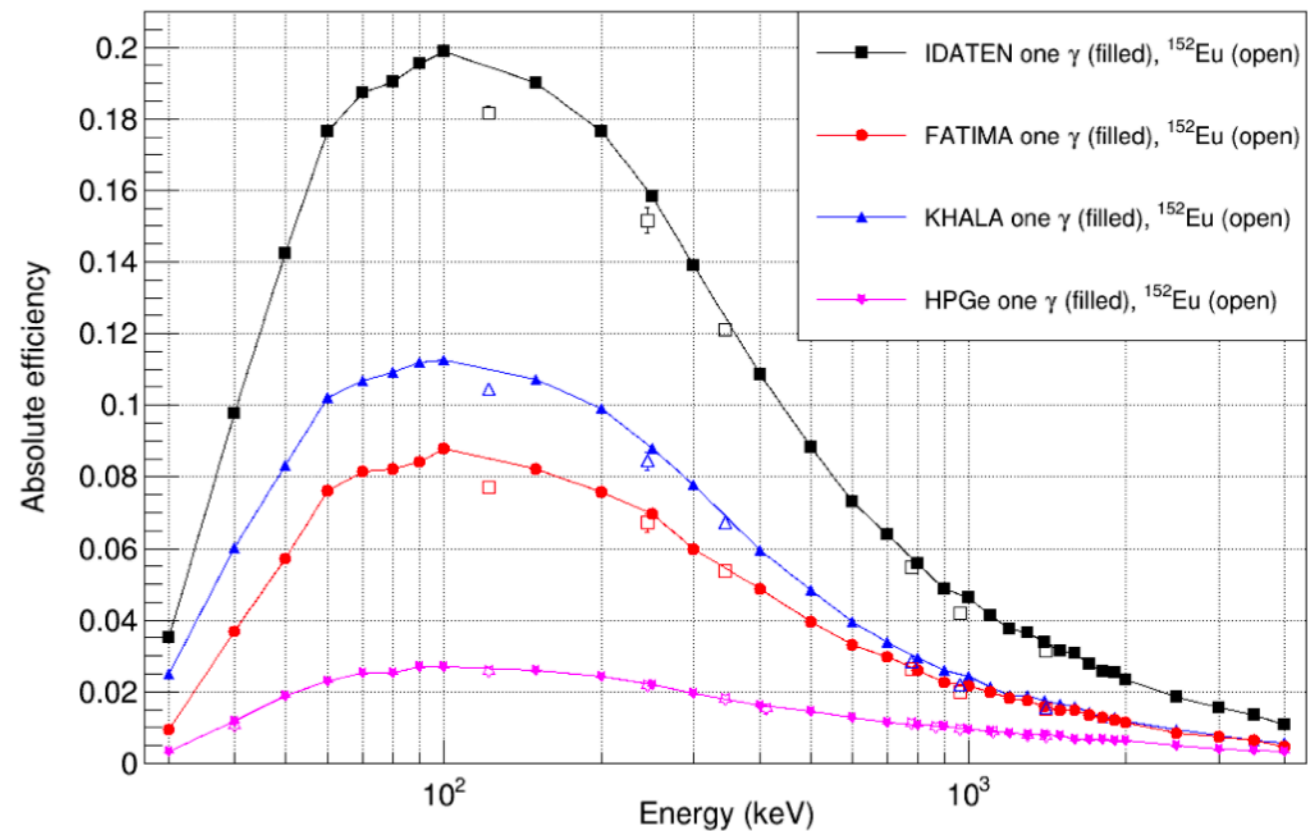
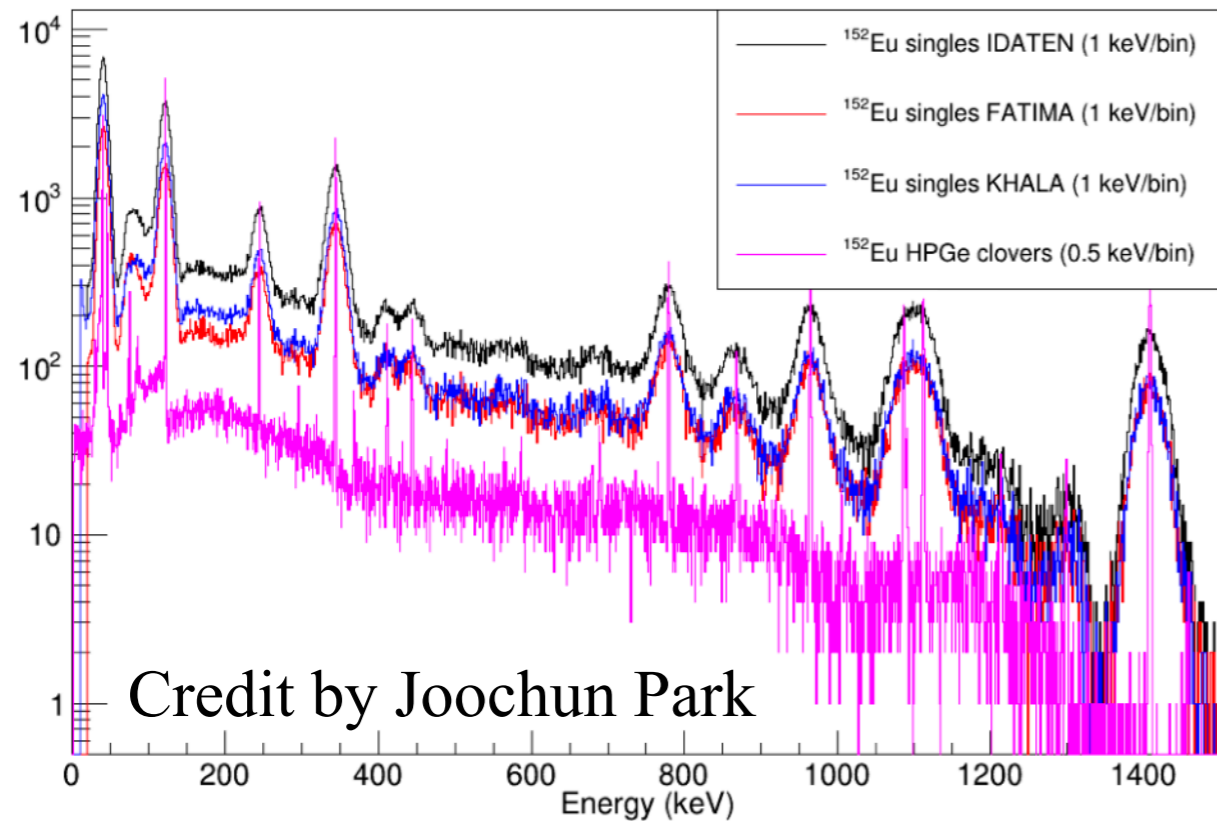
- Candidate: Twinpeaks FEE + TAMEX TDC modules developed by GSI
- Capability of applying a long gate width (able to measure long-lived isomers)
- Advantage of the compact system, cheap price, and short dead time.
- 16 input channels per a card with two amp types
- Used for FATIMA-DESPEC experiments and currently testing with KHALA detectors

# Performances





# IDATEN simulation



- Simulation based on NPTool
- Source data simulated with IDATEN-82 array
- Atomic and self-radioactive backgrounds are planned to be implemented.
- All proponents are strongly recommended to do the simulations for the PAC proposal.

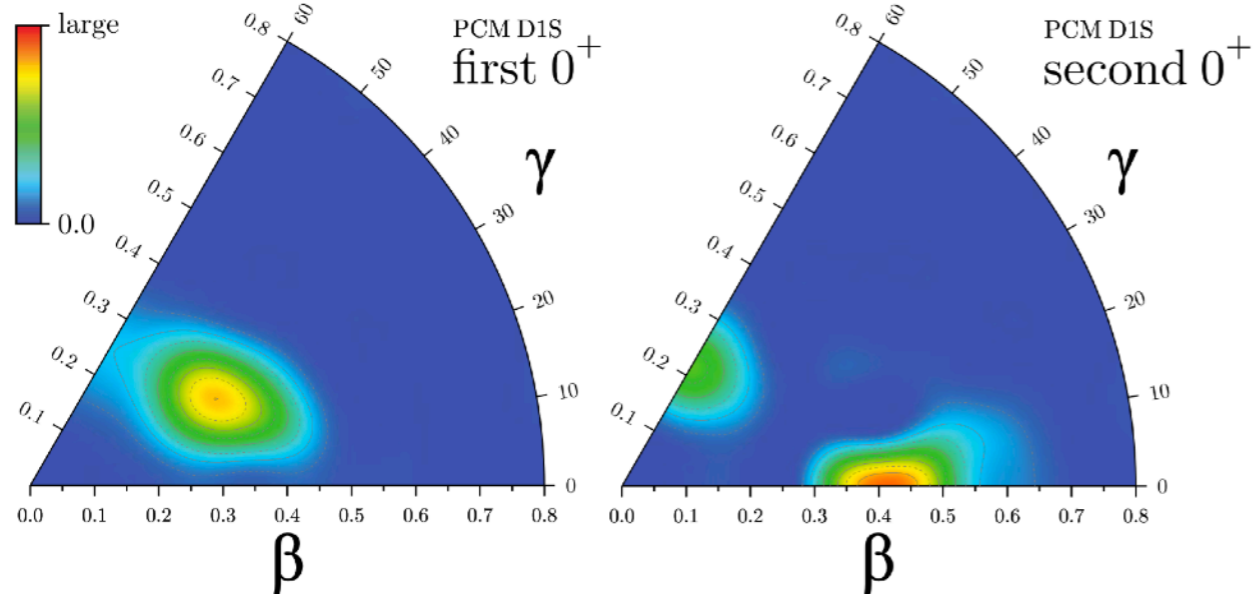
# Proposals to be submitted

1	Title of proposal	Expected beamtime	Contact person	E-mail address
2	Shape coexistence at the center of the N=40 island of inversion	5 days	Bruno Olaizola	<a href="mailto:bruno.olaizola@cern.ch">bruno.olaizola@cern.ch</a>
3	Shape coexistence and collectivity in the doubly magic 78Ni region	7 days	Eda Sahin	<a href="mailto:eda.sahin@fys.uio.no">eda.sahin@fys.uio.no</a>
4	Shape Evolution and New Isomer in N~60 Neutron-Rich Selenium	4 days	Quanbo Zen	<a href="mailto:zengquanbo@impcas.ac.cn">zengquanbo@impcas.ac.cn</a>
5	Exploring quantum shape phase transition around Z = 40 and N = 60 with gamma-gamma fast timing	5 days	Tumpa Bhattacharjee	<a href="mailto:btumpa@vecc.gov.in">btumpa@vecc.gov.in</a>
6	Lifetime measurement of excited states in 108Zr	1.5 days	Byul Moon	<a href="mailto:mb0316@ibs.re.kr">mb0316@ibs.re.kr</a>
7	Nuclear structure study of Pd, Ag, and Cd isotopes towards N=82 with fast-timing lifetime measurement	7 days	Hiroshi Watanabe	<a href="mailto:hiroshi@ribf.riken.jp">hiroshi@ribf.riken.jp</a>
8	Seniority and collectivity in nuclei beyond doubly-magic 132Sn	4 days	Byul Moon	<a href="mailto:mb0316@ibs.re.kr">mb0316@ibs.re.kr</a>
9	Probing octupole collectivity and dipole polarizability in neutron-rich Ba, La, and Ce isotopes by lifetime measurement of excited states	4 days	Hiroshi Watanabe	<a href="mailto:hiroshi@ribf.riken.jp">hiroshi@ribf.riken.jp</a>
10	Study of the deformation pattern in the rare-earth region	5 days	Sorin Pascu	<a href="mailto:s.pascu@surrey.ac.uk">s.pascu@surrey.ac.uk</a>
11	First 2+ state lifetime measurement for the neutron-rich Yb and Er isotopes: a quest for strong deformation around N=110	4 days	Jeongsu Ha	<a href="mailto:jeongsu.ha@kuleuven.be">jeongsu.ha@kuleuven.be</a>
12	Exploring the structure of the neutron-rich heavy nuclei beyond	5-6 days	Andrea Gottardo (?)	<a href="mailto:Andrea.Gottardo@lnl.infn.it">Andrea.Gottardo@lnl.infn.it</a>
13	Fast-timing spectroscopy of excited states in N ~ Z nuclei below	5 days	Joochun Park	<a href="mailto:jcpark@ibs.re.kr">jcpark@ibs.re.kr</a>
14	Study of shell structure, core-breaking and seniority-breaking effects close to 100Sn with IDATEN	5-7 days	Andrey Blazhev	<a href="mailto:a.blazhev@ikp.uni-koeln.de">a.blazhev@ikp.uni-koeln.de</a>

Total beam time of ~65 days with interesting physics cases!

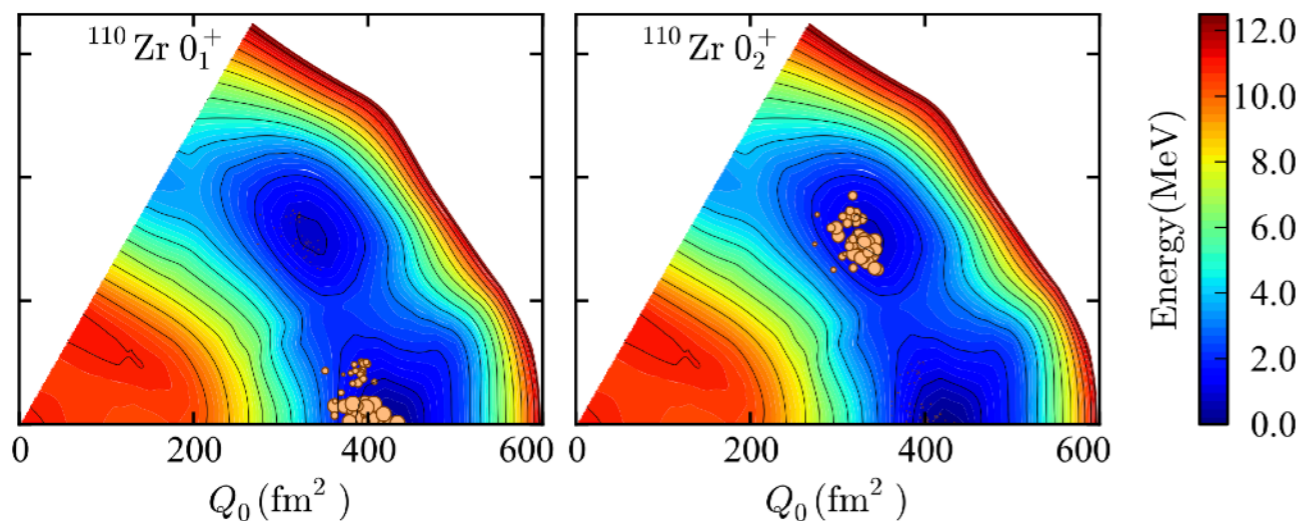
# Nuclear shape of $^{108}\text{Zr}$

- Predicted nuclear shape of  $^{110}\text{Zr}$



M. Borrajo *et al.*, PLB **746**, 341 (2015)

N. Paul *et al.*, PRL **118**, 032501 (2017)



T. Togashi *et al.*, PRL **117**, 172502 (2016)

- Two theoretical models showed similar level schemes, but with different structures.
- BMF calculations predict triaxial ground states with  $\gamma$ -softness.
- MCSM calculation predicts the prolate deformed ground state with triaxial excited state.
- Need the transition rate information to investigate the nuclear shape.
- Lifetime measurements are essential to discriminate between different theoretical predictions.

# Nuclear shape of $^{108}\text{Zr}$

- Shape evolution in Zr isotopes

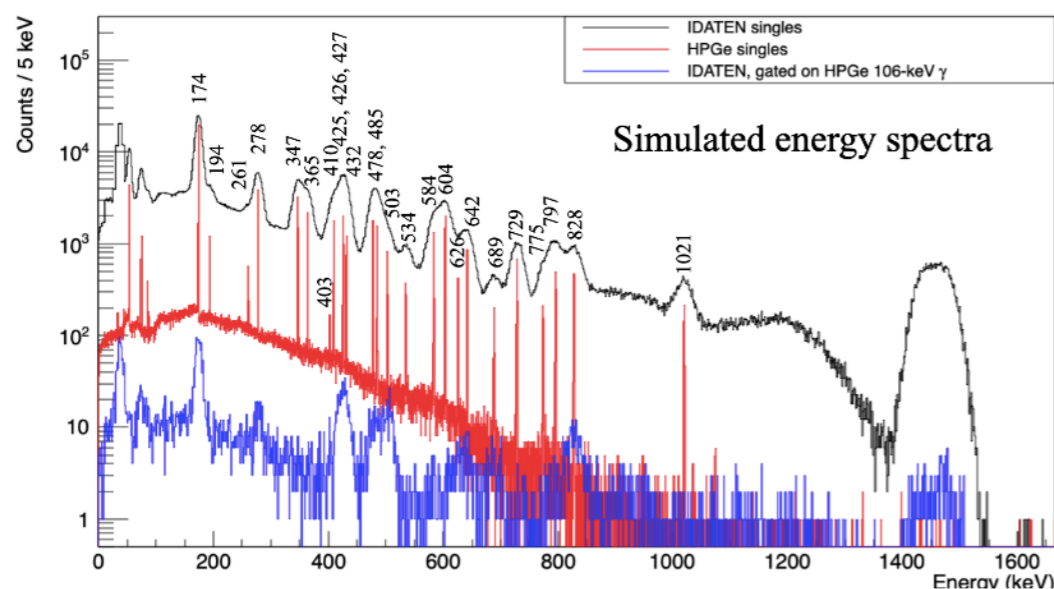
A. Bruce (U. Brighton) and B. Moon (CEN/IBS)

Preliminary

Credit by A. Bruce

Preliminary

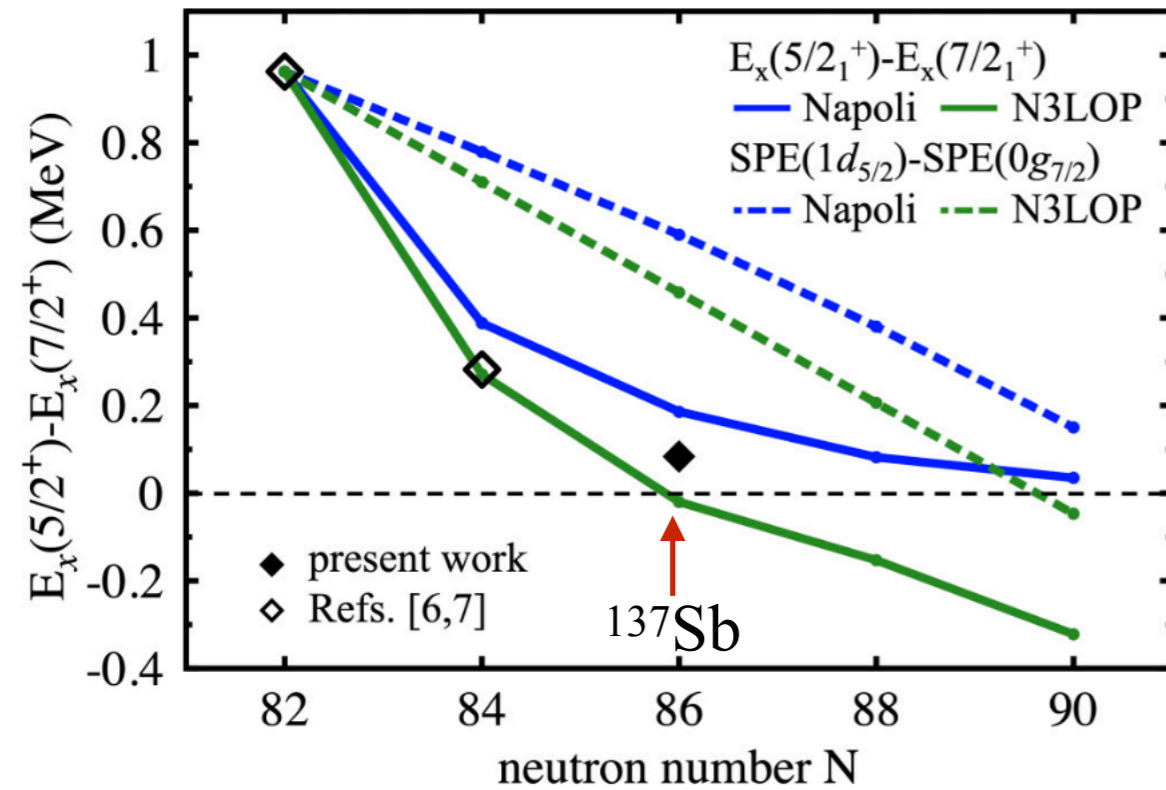
Credit by B. Moon



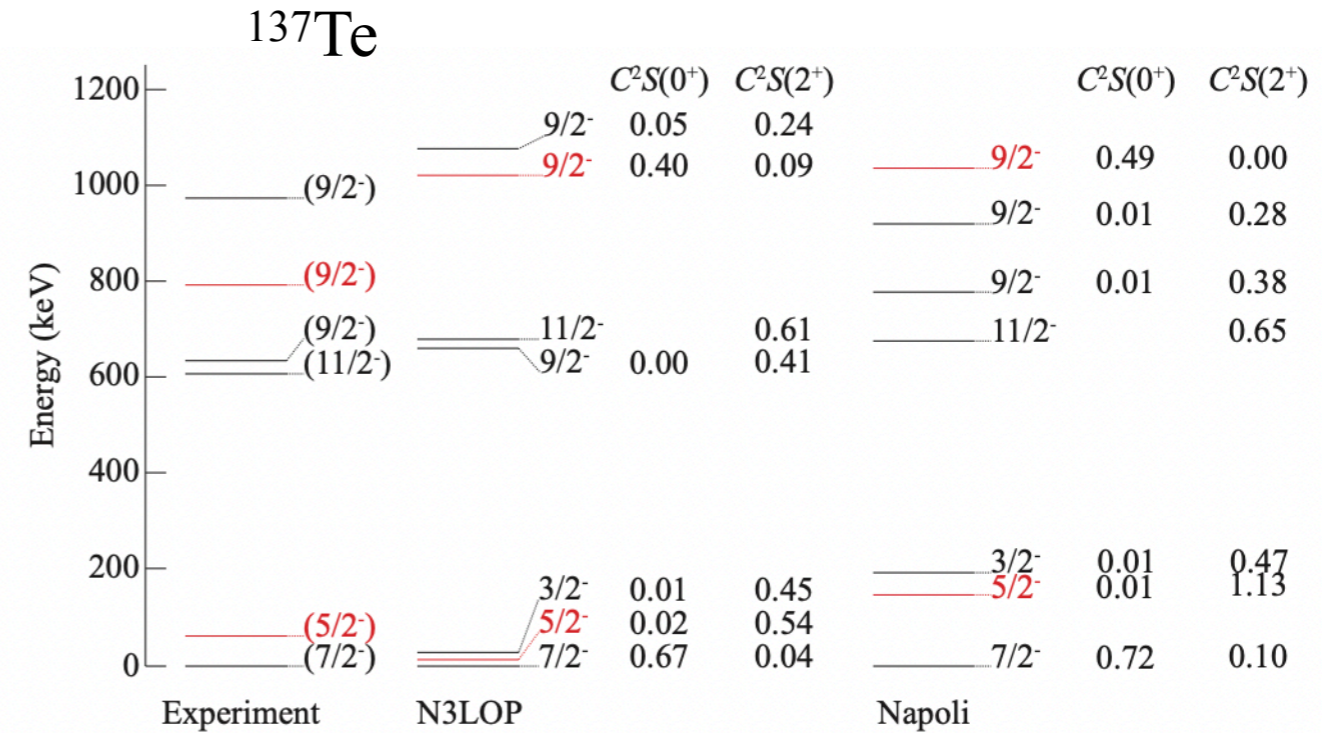
Credit by Youngseub Jang

- Need transition information to investigate the nuclear shape of  $^{108}\text{Zr}$  (prolate? triaxial?)
- New  $\gamma$ -band and  $K$ -band structures were observed.
- Nuclear shape in ground and excited states and  $K$ -hinderance

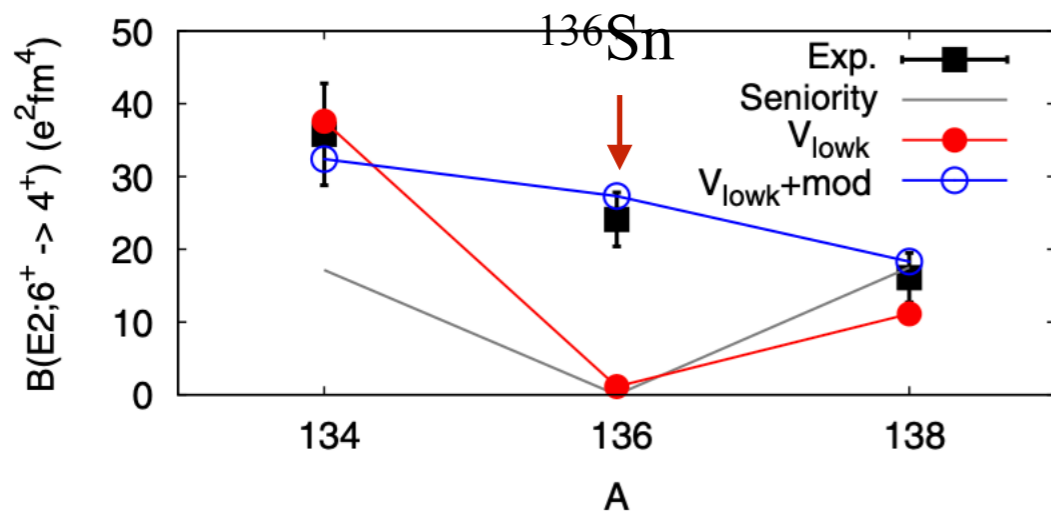
# Seniority schemes beyond $^{132}\text{Sn}$



A. Junclaus et al., PRC 102, 034324 (2020).



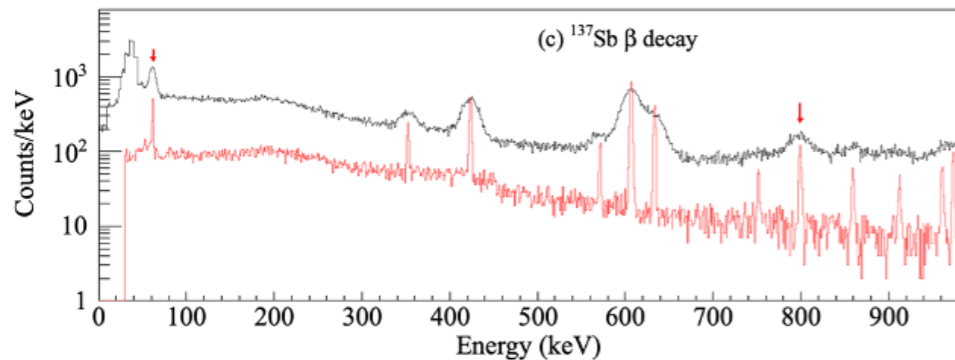
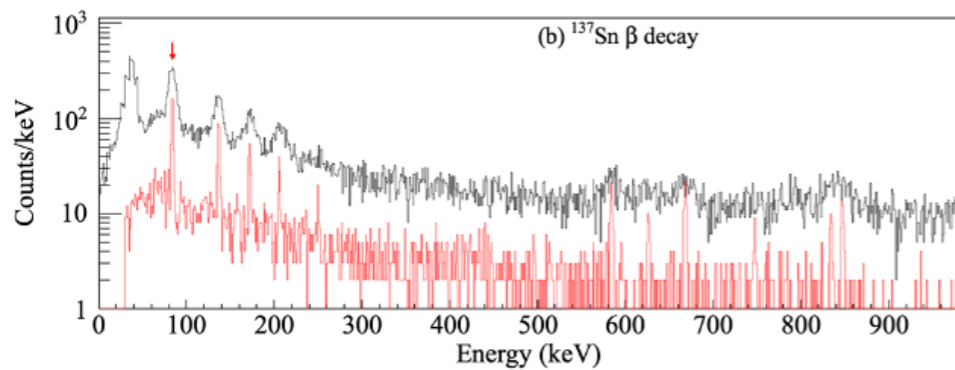
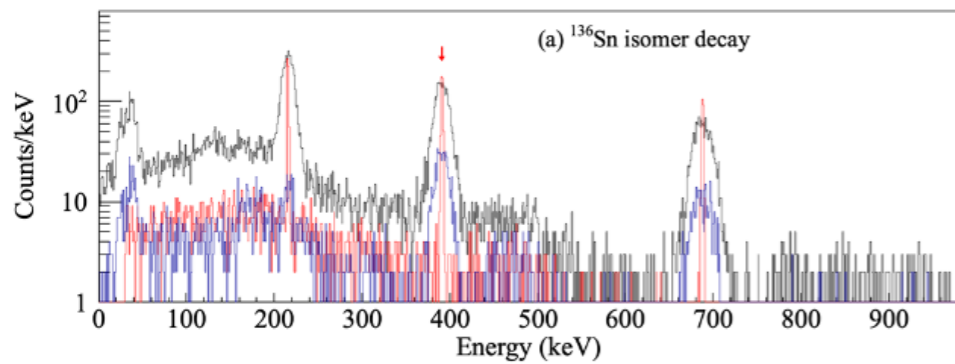
B. Moon et al., PRC 103, 034320 (2021).



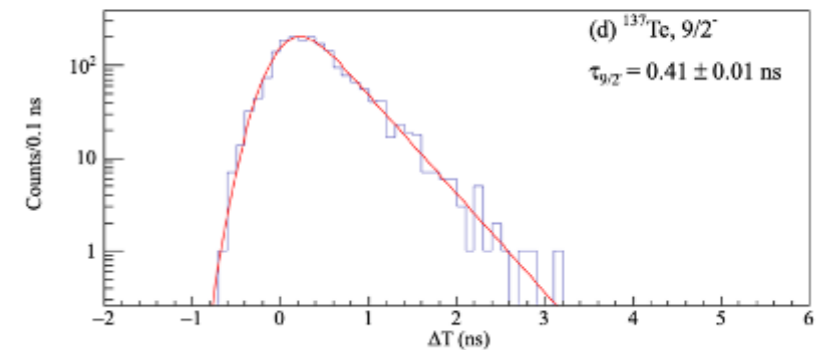
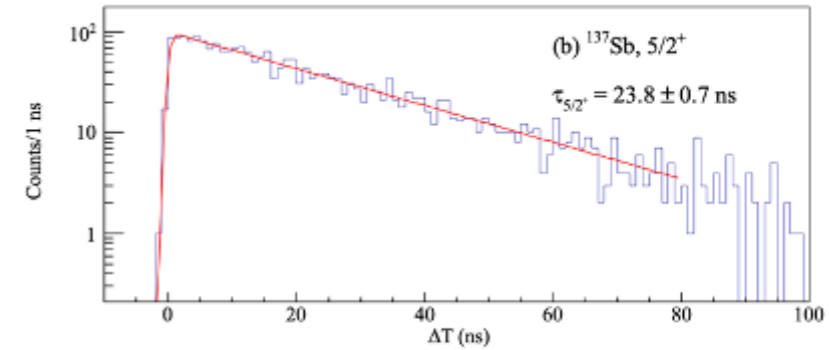
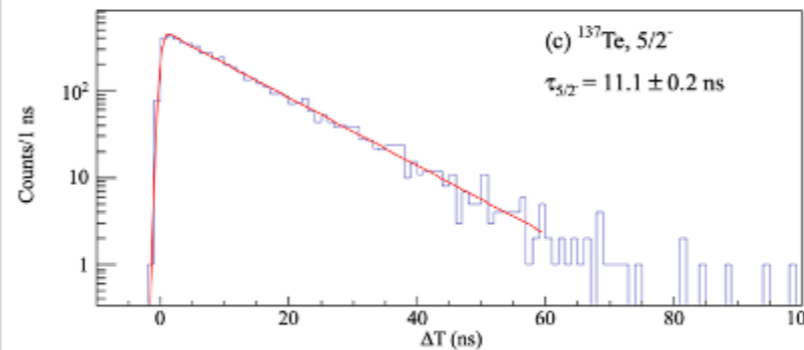
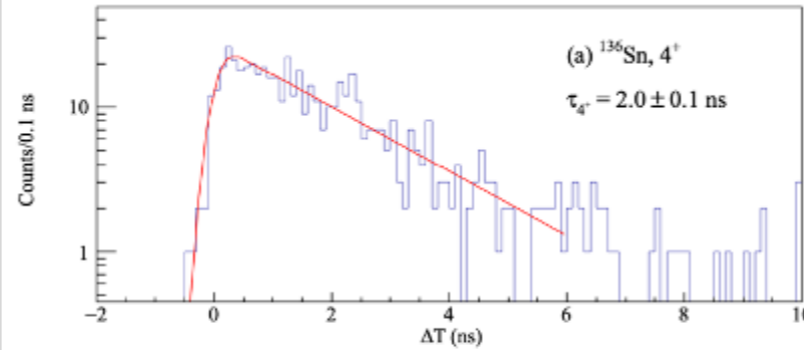
G. Simpson et al., PRL 113, 132502 (2014).

- $1f_{7/2}$  neutron orbital is being occupied after  $N = 82$ .
- Seniority-3 scheme in  $1f_{7/2}$  neutron orbit becomes dominant.
- In Sb, neutrons in  $1f_{7/2}$  neutron orbit reduce the  $1d_{5/2} - 0g_{7/2}$  proton gap.
- Key role of level lifetimes to investigate seniority scheme in this region

# Seniority schemes beyond $^{132}\text{Sn}$



Credit by Youngseub Jang

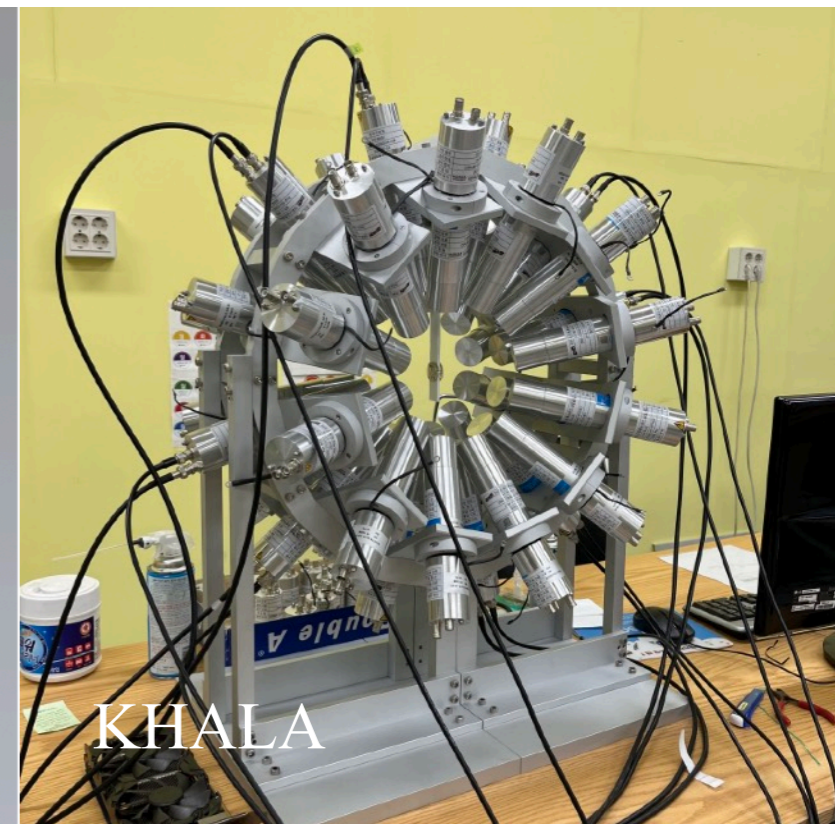
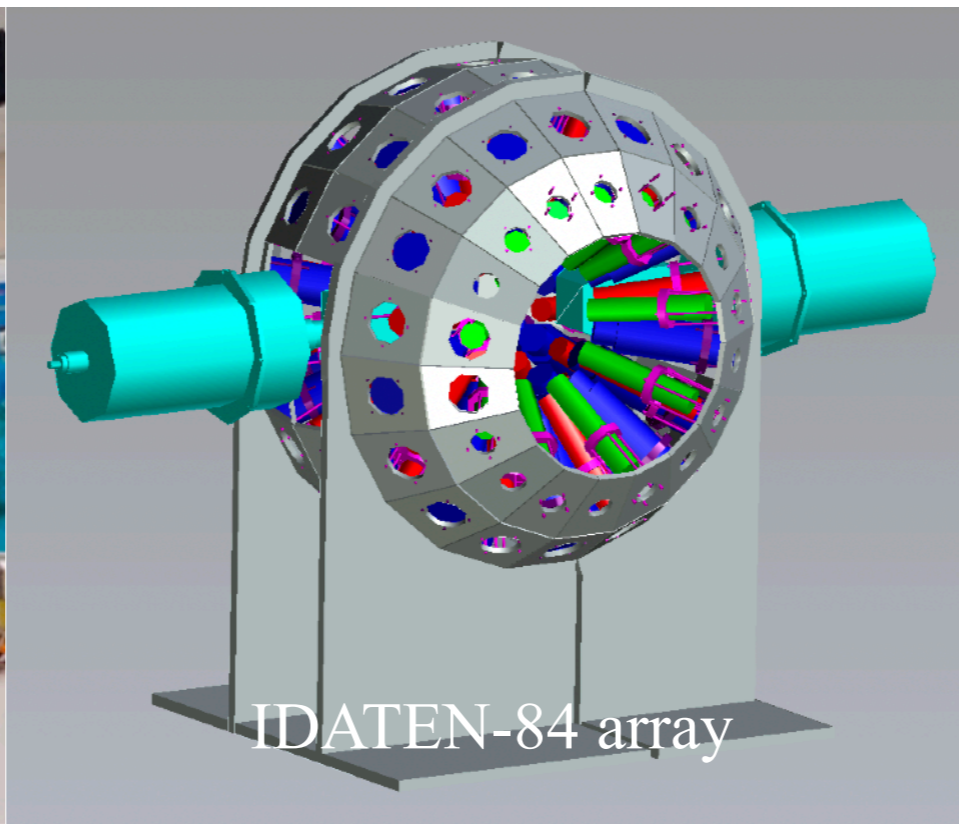
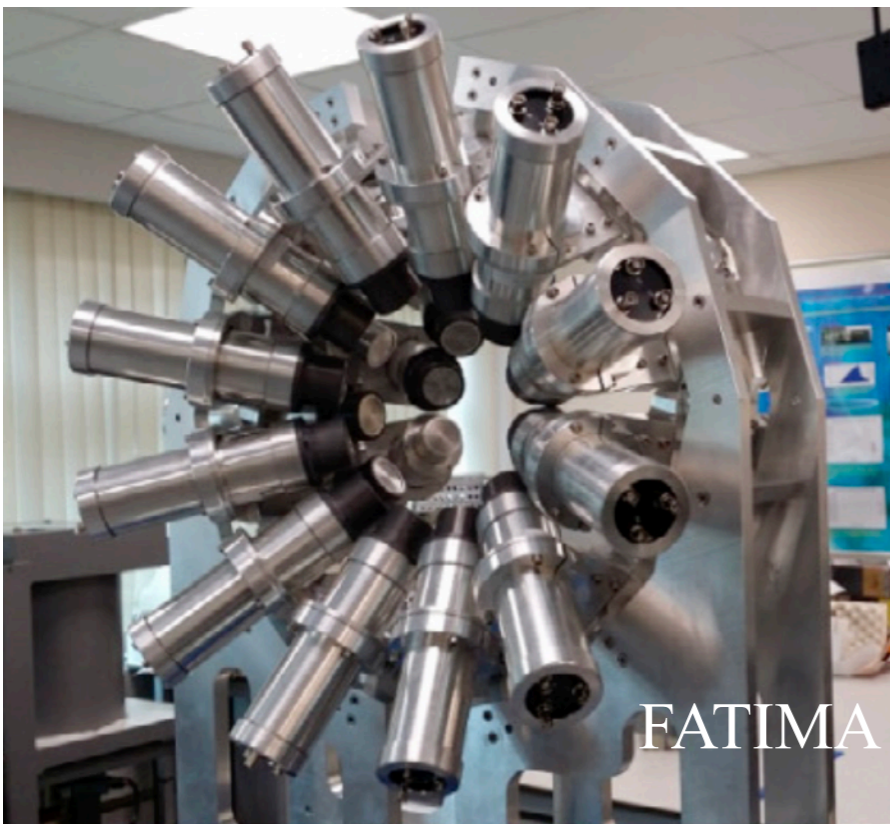


- Give perspectives on the seniority-3 schemes in odd-A Sb and Te isotopes
- Seniority-2 scheme and admixed seniority in  $^{136}\text{Sn}$
- $\pi g7/2$  and  $\pi d5/2$  shell evolution
- $\nu h9/2$  single-neutron or collectivity  $9/2^-$  states in  $^{137}\text{Te}$  and  $^{139}\text{Te}$

B. Moon (CEN/IBS) and R. Lozeva (IJCLab, CNRS/IN2P3)

# Summary

- A new large fast-timing array is coming in 2023/2024.
- Many proposals are being prepared with interesting physics cases.
- Korean scientists are leading the collaboration (CENuM / CENS).



# Collaborators

- IDATEN spokespersons  
Hiroshi Watanabe (Beihang U.)  
Patrick Regan (U. Surrey)  
Byul Moon (CENS/IBS)
- Core members  
Byungsik Hong, Youngseub Jang, Jaehwan Lee (KU, CENuM)  
Sunghoom Ahn, Sunghan Bae, Yung Hee Kim, Joochun Park (CENS/IBS)  
M. Gorska (GSI)  
S. Nishimura (RNC)  
S. Pascu, Zs. Podolyak (U. Surrey)  
A. Bruce (U. Brighton)

To be a great collaboration! Thank you!