

Development and cooperation on γ -spectroscopy instruments



Li Guang-shun
for the
gamma instrumentation
collaboration

2022-02-18

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Chinese Academy of Sciences (CAS)*

Contents

目录 CONTENTS



1

Development & campaigns

2

Project under A3 program

3

Other cooperation

4

Outlook



γ -ray detector array as a cornerstone

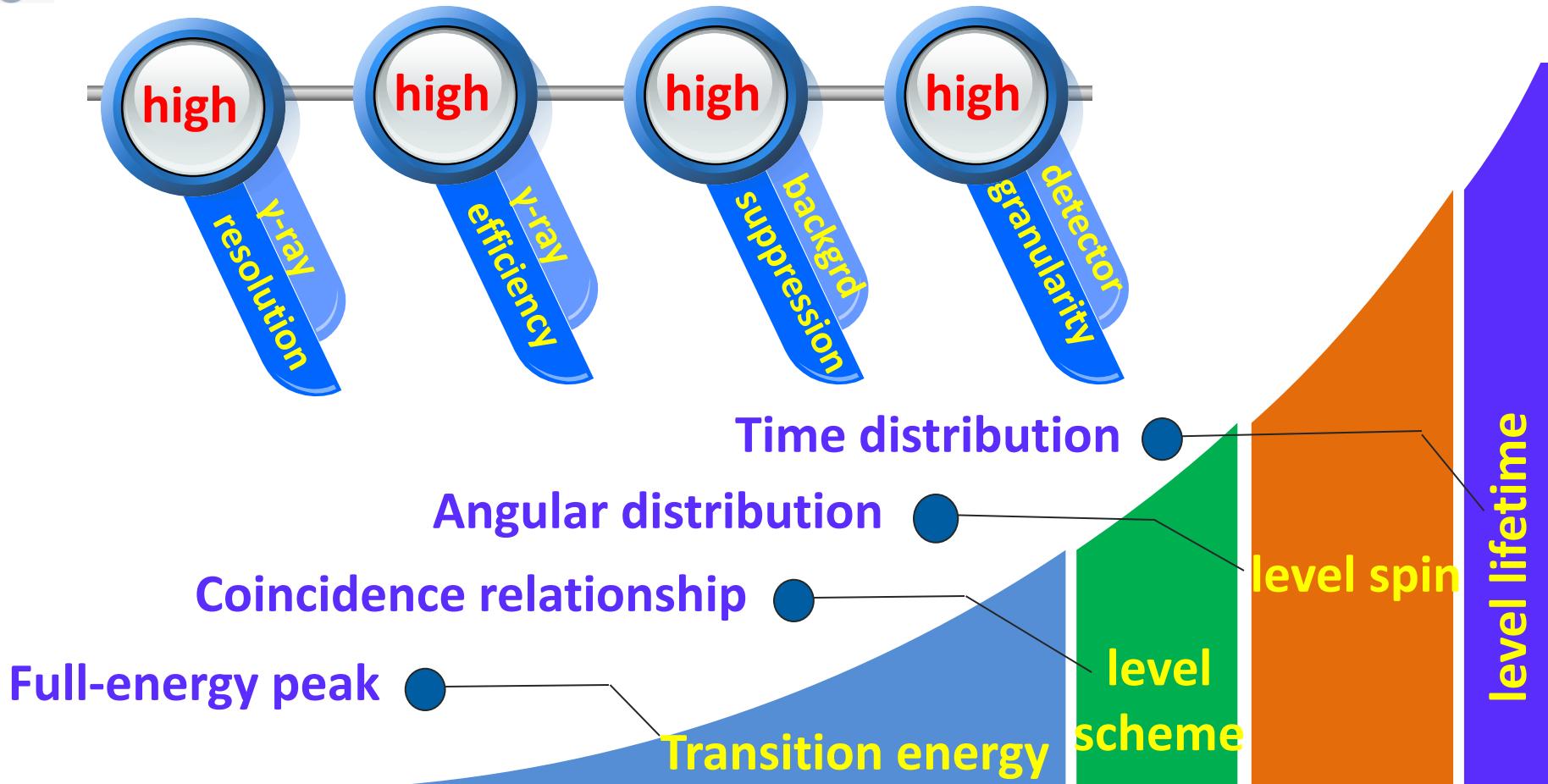


The basic information of nuclear excited states

➤ Large is still unknown, especially the exotic nuclei near drip line



Requirements:



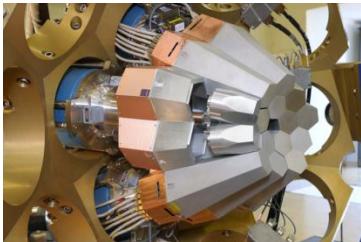
Examples of the γ detector arrays in the world



Partially covered ONLY ...

Europe

- AGATA
- FATIMA
- JUROGAM
- ROSPHERE
- ...



America

- GRETINA
- TIGRESS
- GAMMASPHERE
- GRIFFIN
- ...

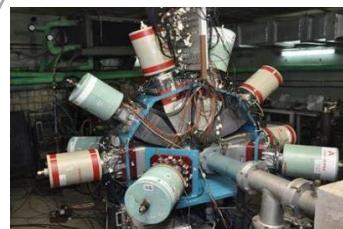


- AFRODITE
- ...



Africa

- INGA
- ...



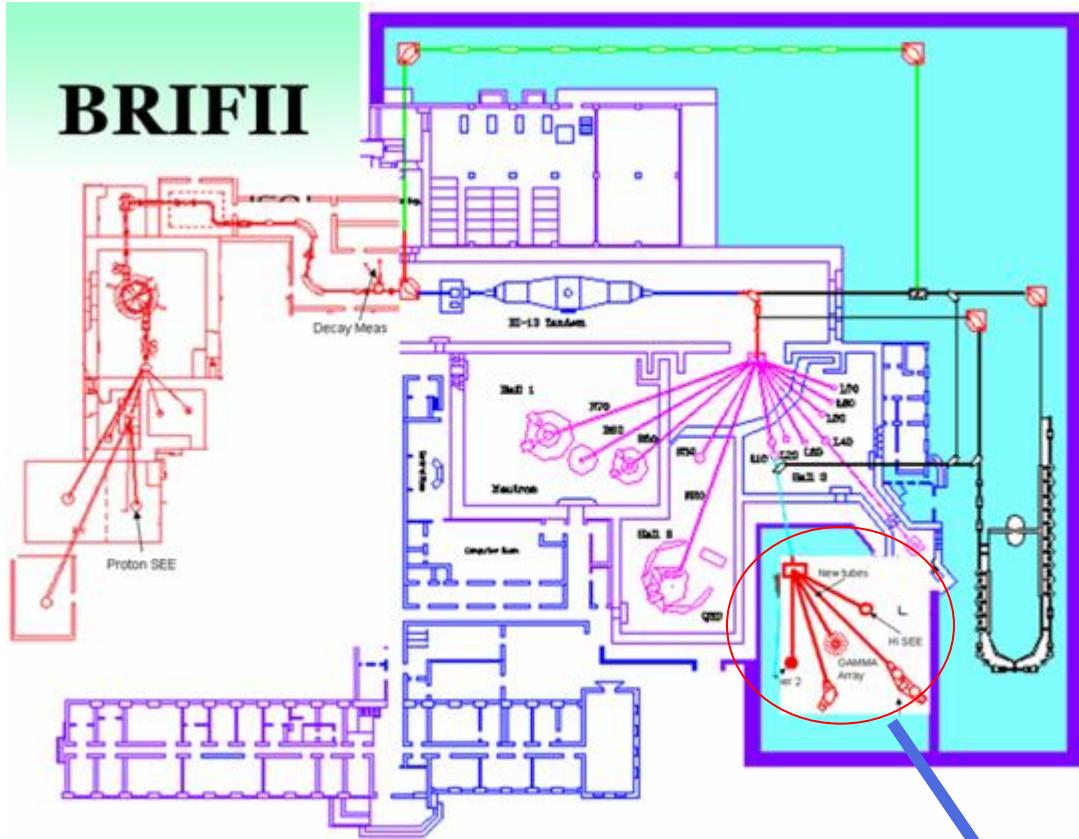
Asia



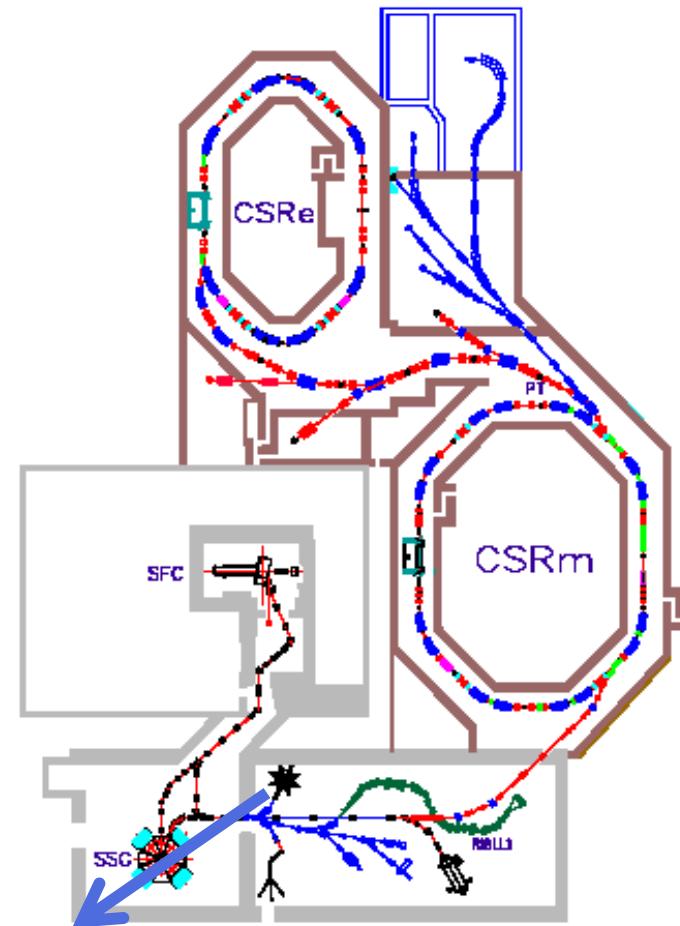
We would also like to contribute to the fundamental studies ...

Main facilities depend on ...

BRIFII



Beijing, HI-13 tandem



Lanzhou, HIRFL

γ-spectroscopy studies

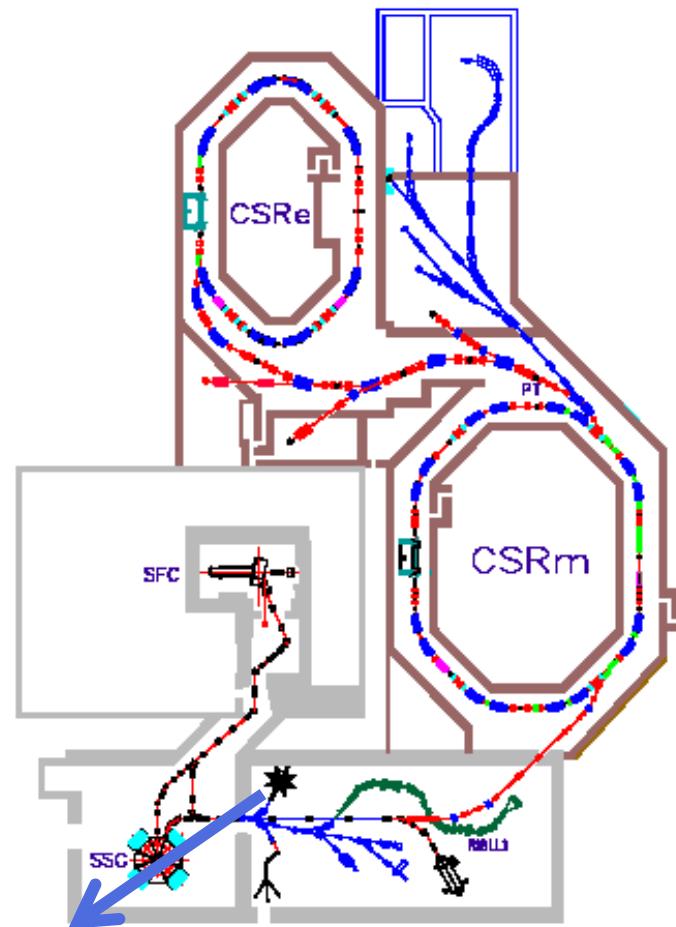
Facility @ IMP



HIRFL

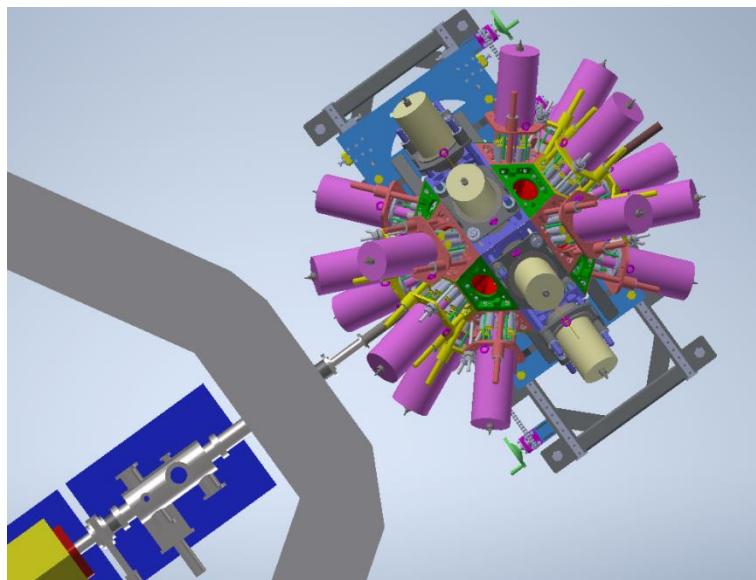


Picture of gate



Lanzhou, HIRFL

HPGe array @ IMP

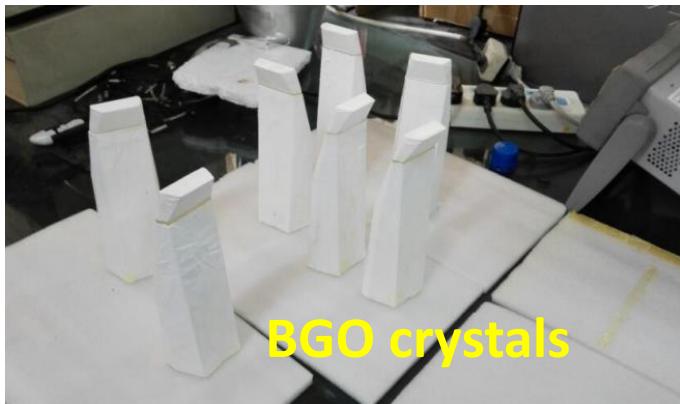


16 coaxial HPGes (70%)

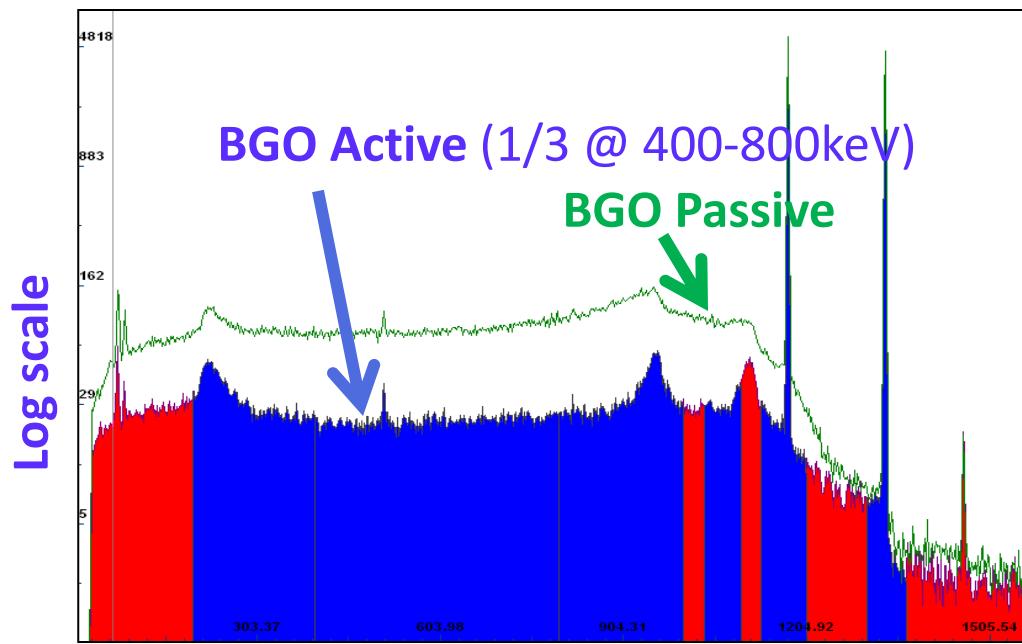
8 Clover HPGes (160%)

Dedicated supporting frame

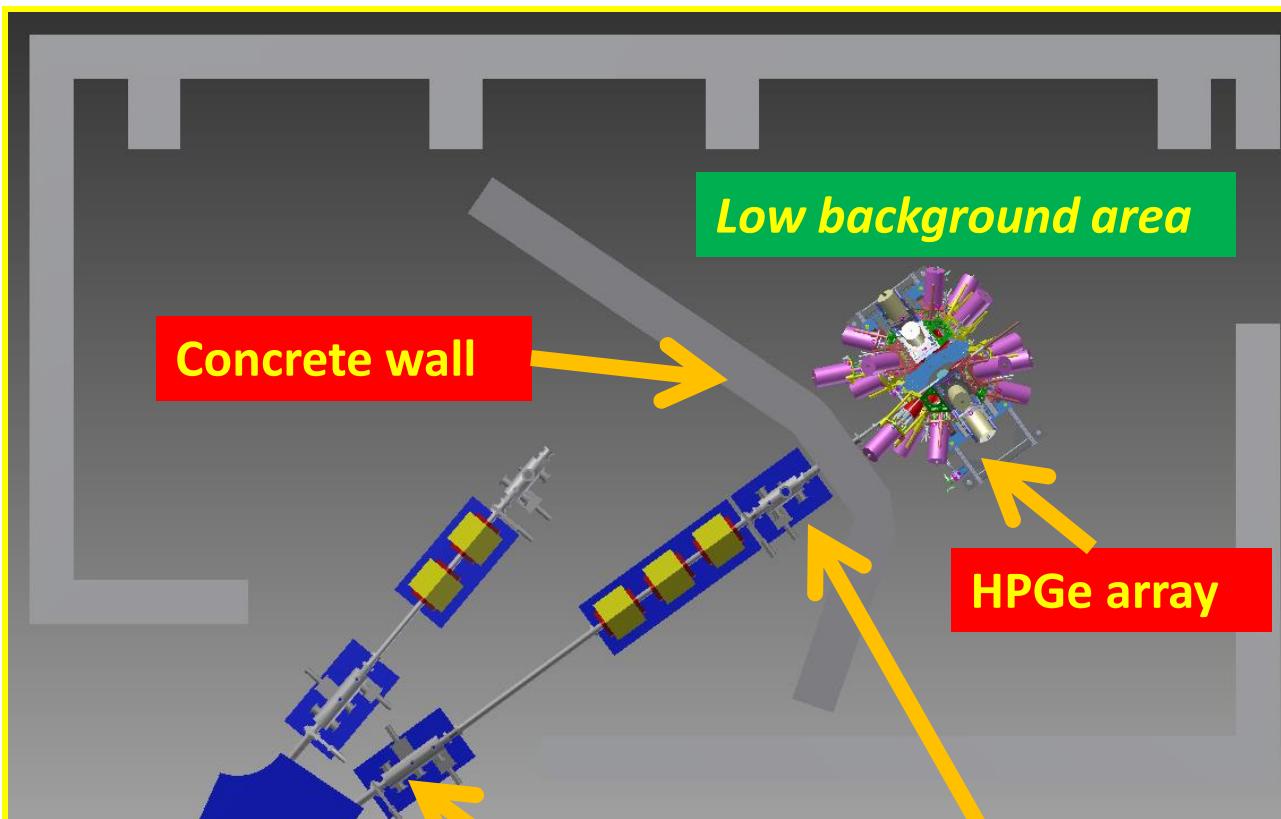
BGO Anti-Compton shields @ IMP



BGO crystals



Low energy beam line @ IMP



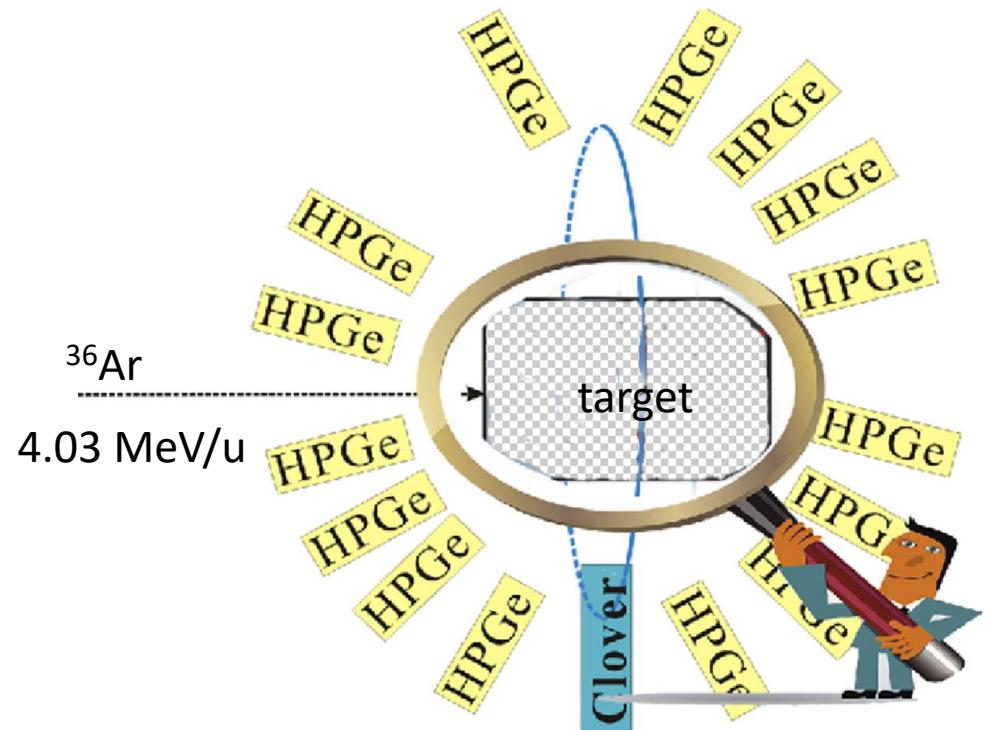
Aperture: phi 3, 5, 8 mm

Slit: X, Y direction

Beam spot:
< phi 5 mm

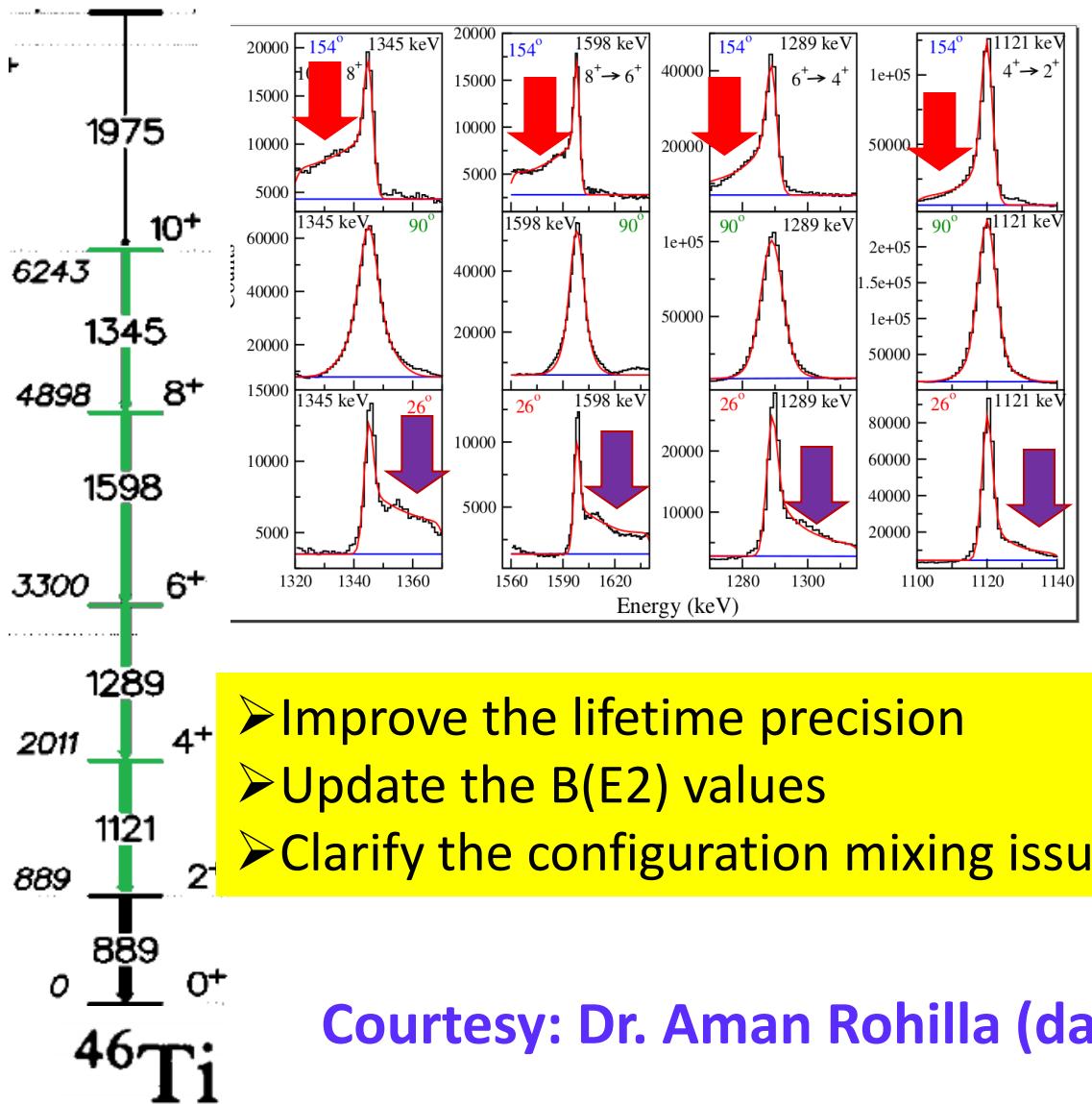
Commissioning run @ IMP

Lifetime measurement of nuclear excited state via DSAM method

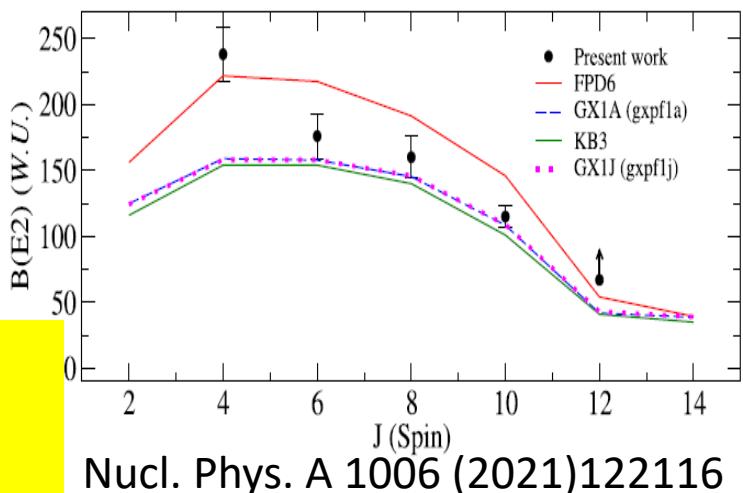


15 HPGe + 6Clover

Experimental data of ^{46}Ti



$^{36}\text{Ar} + ^{12}\text{C}$ → ^{46}Ti (46mb)
 → ^{45}Ti (358mb)
 → ^{45}Sc (115mb)



Nucl. Phys. A 1006 (2021) 122116

- Improve the lifetime precision
- Update the B(E2) values
- Clarify the configuration mixing issue

Courtesy: Dr. Aman Rohilla (data analysis)

Participants from domestic collaborations @2021



- IMP - Institute of Modern Physics, CAS
- PKU - Peking University
- SDU - Shandong University
- CIAE - China Institute of Atomic Energy
- etc.

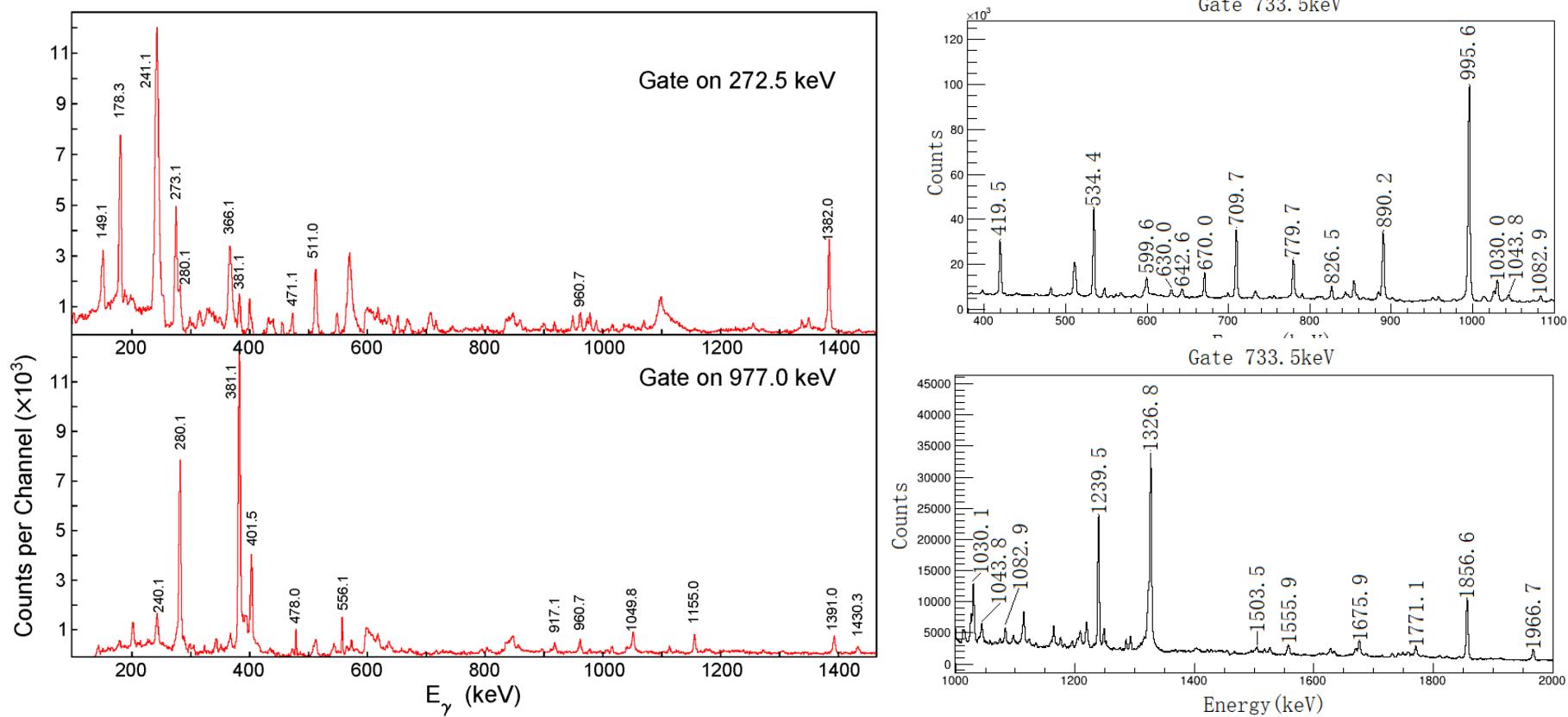
More than 600 hours beam time



First collaborative run within Chinese collaboration



Experimental data of 2021



Typical gated spectra from the HPGe array

Data is still in analysis ...

Cooperation of new era

➤ Available γ -ray detectors:

IMP (Lanzhou): HPGe > 16; Clover > 8; LaBr₃ > 4

CIAE (Beijing): HPGe > 10; LaBr₃ > 5

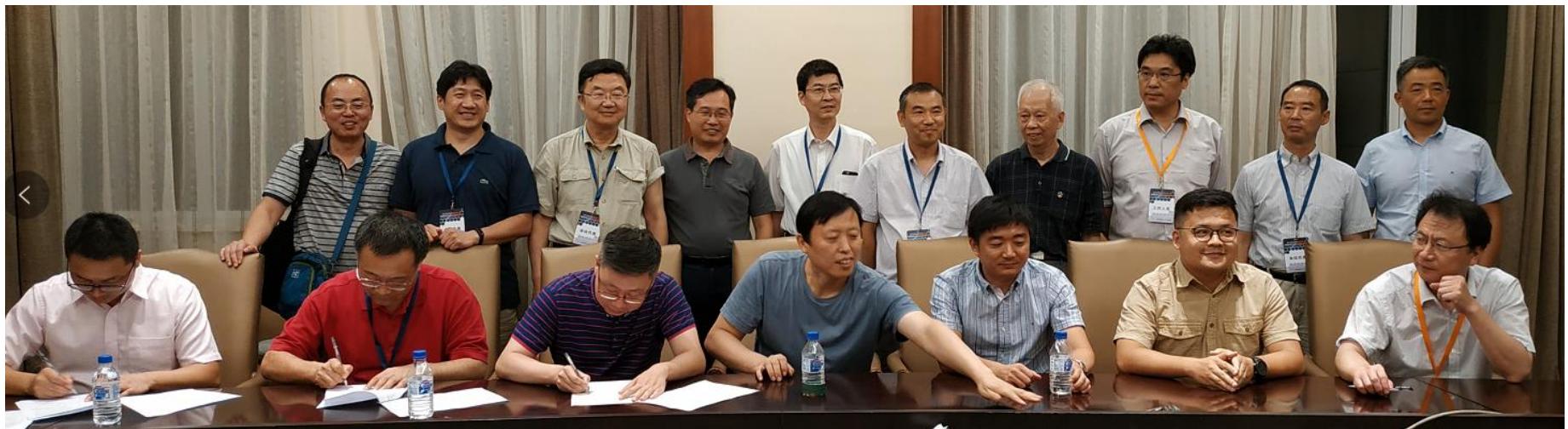
Shandong U. (Weihai): HPGe + LaBr₃ > 10

Beihang U. (Beijing): Clover + LaBr₃ > 6

... ...



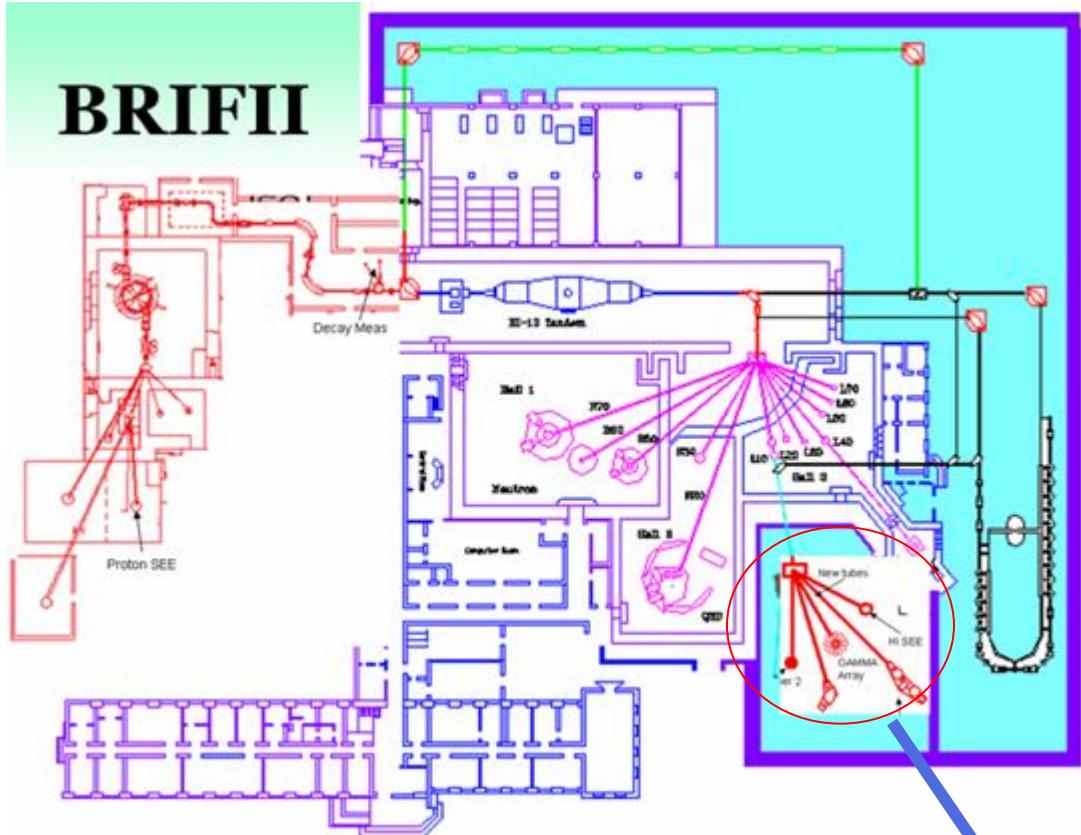
➤ New cooperative agreement (2019)



To form a gamma pool in China...

Main facilities depend on ...

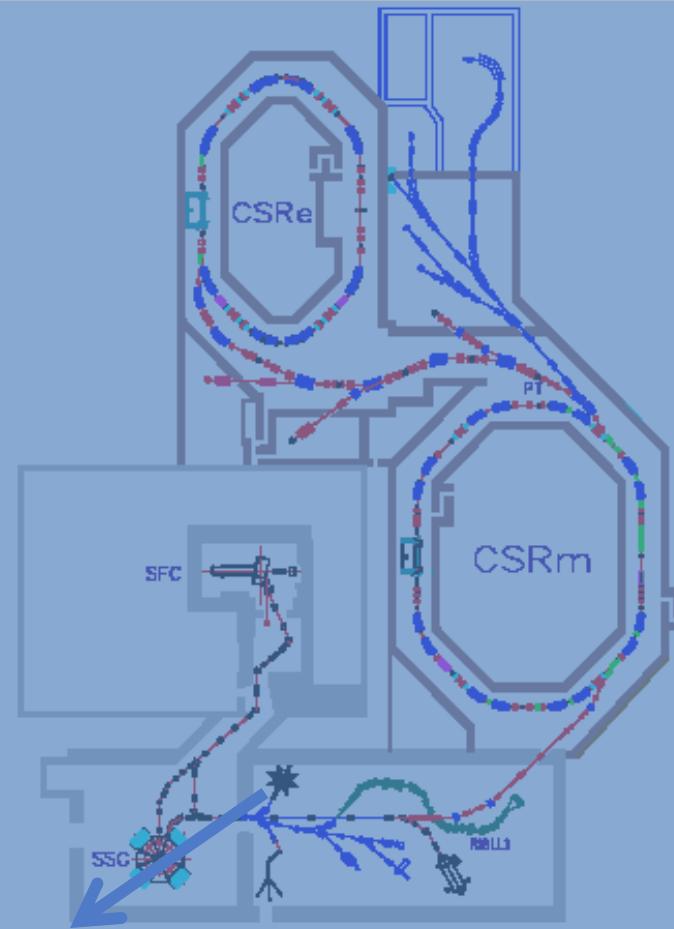
BRIFII



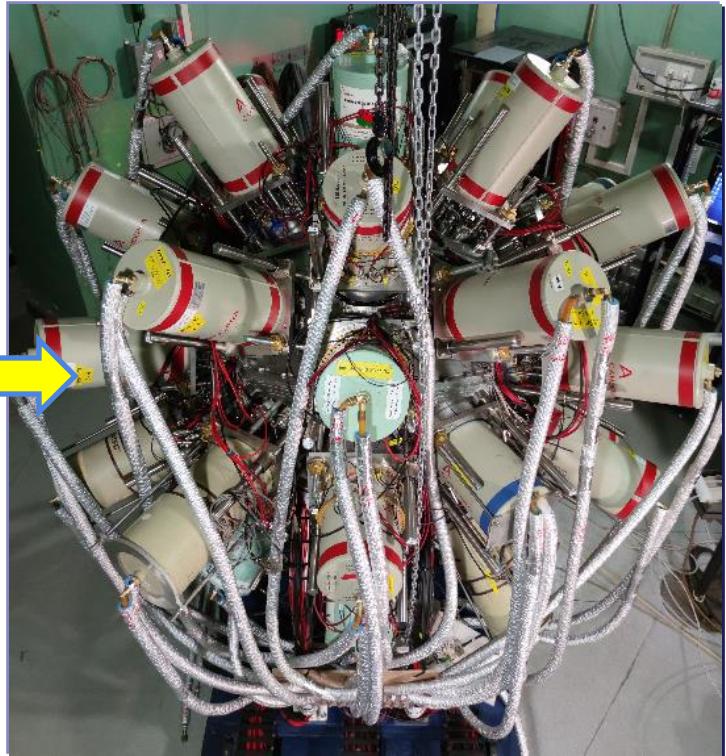
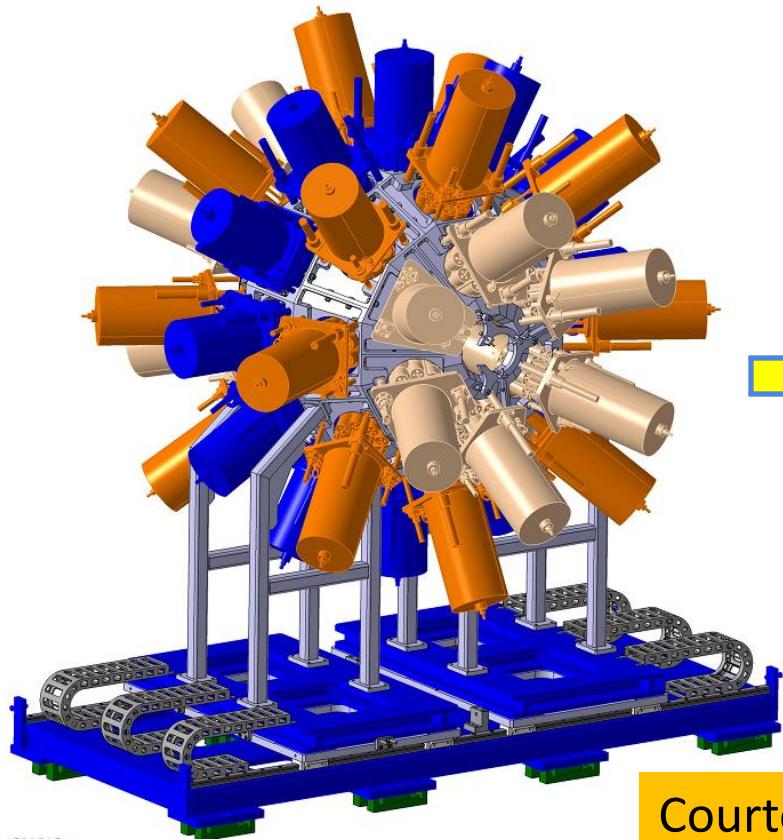
γ -spectroscopy studies

Beijing, HI-13 tandem

Lanzhou, HIRFL



China conjoint gamma array



Courtesy: Dr. Zheng Yun (CIAE)

16 coaxial HPGes (70%)-IMP

7 coaxial HPGes (35%)-CIAE

1 Clover HPGe (120%)-BUAA

8 Clover HPGes (160%)-IMP

2 coaxial HPGes (70%)-CIAE

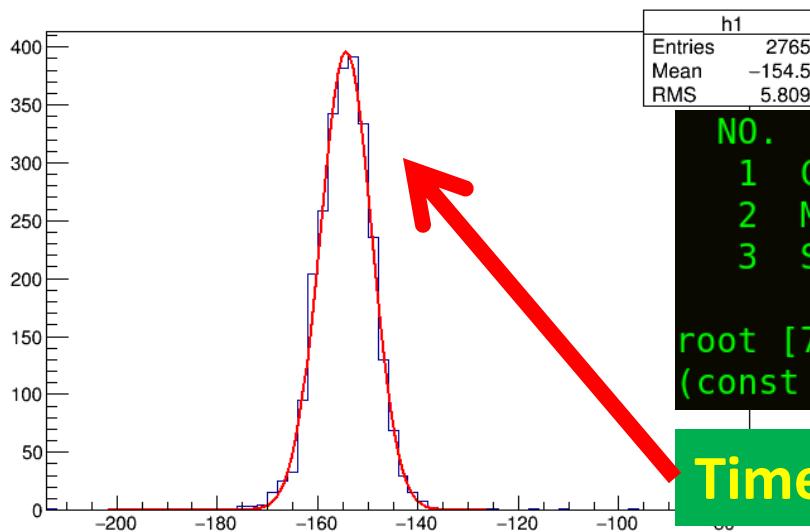
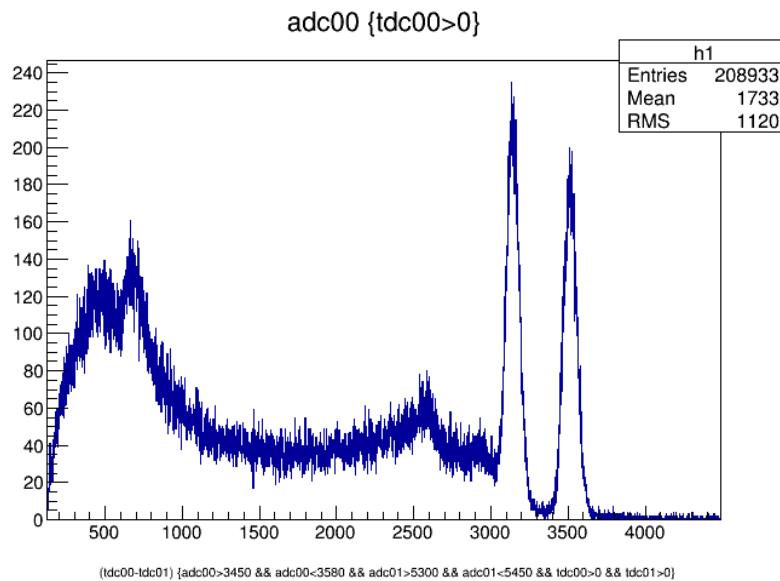
2 coaxial HPGes (30%)-SDU

Experimental campaign at 2021 - 2022



Courtesy: Dr. Zheng Yun (CIAE)

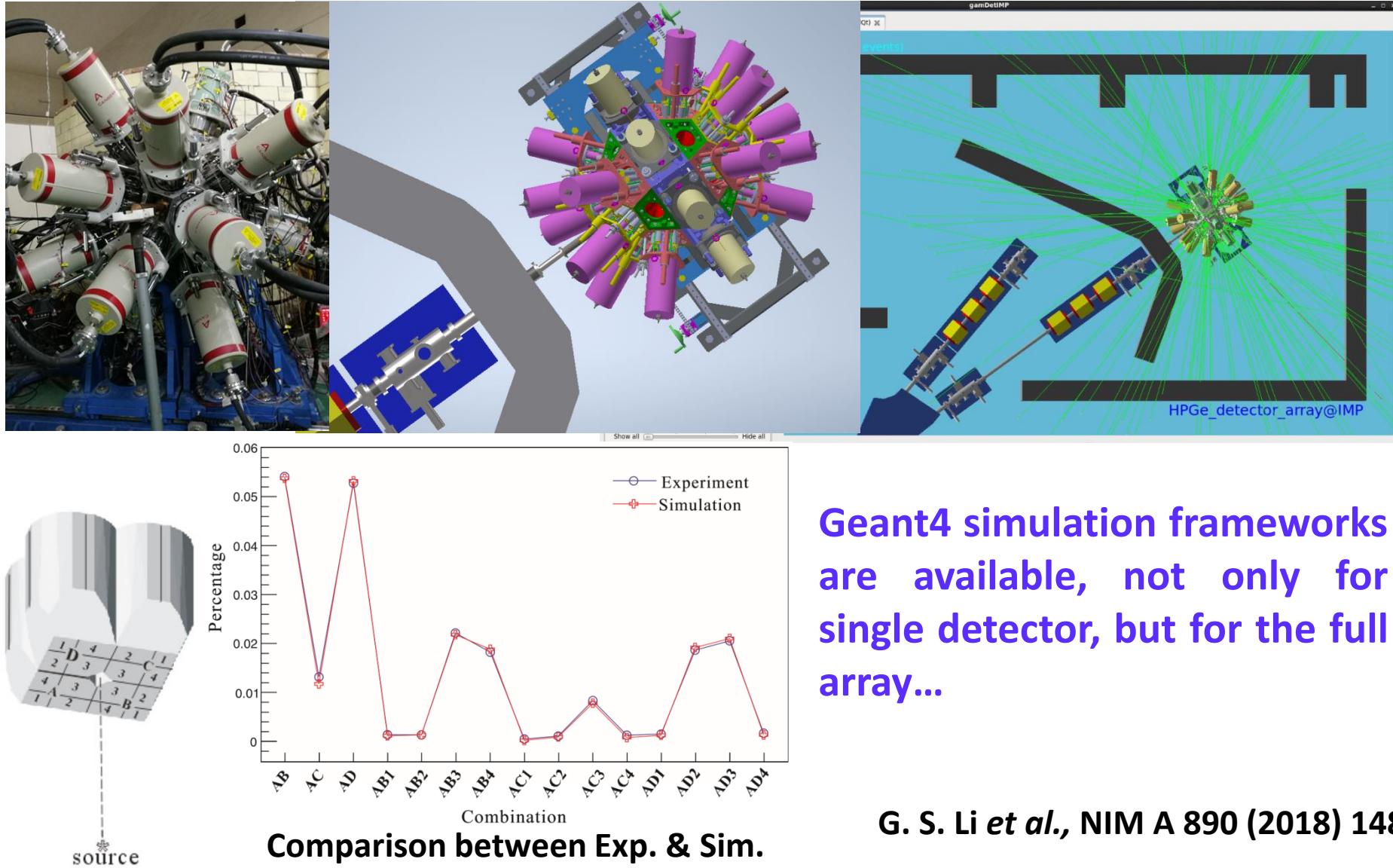
LaBr₃ detector development @ IMP



LaBr₃(Ce) detector

IMP

Simulation tools development @ IMP

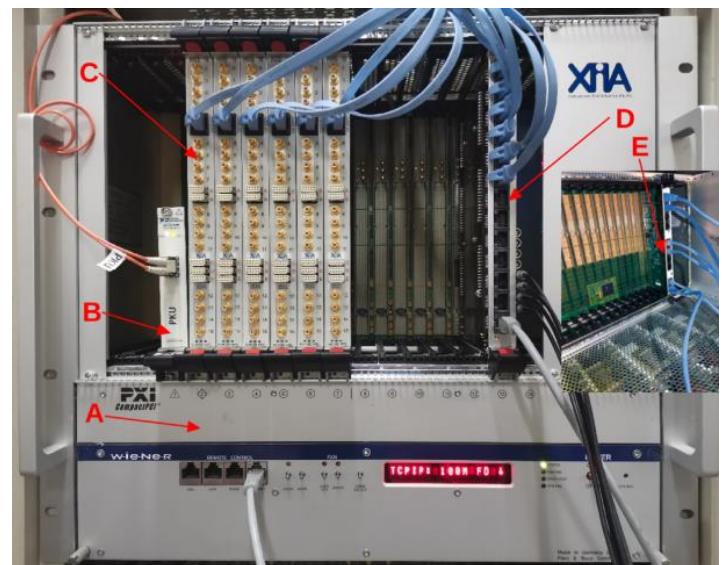


High speed/stable DAQ system @ IMP



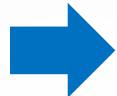
VME based & Digitizer based DAQ systems are also available from IMP

Courtesy: Dr. Wang Jianguo (IMP)



Contents

目录 CONTENTS



1

Development & campaigns

2

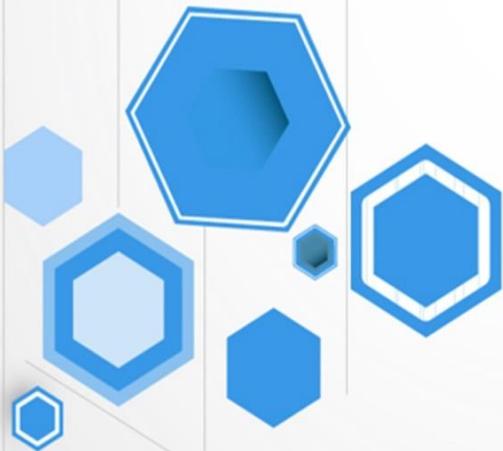
Project under A3 program

3

Other cooperation

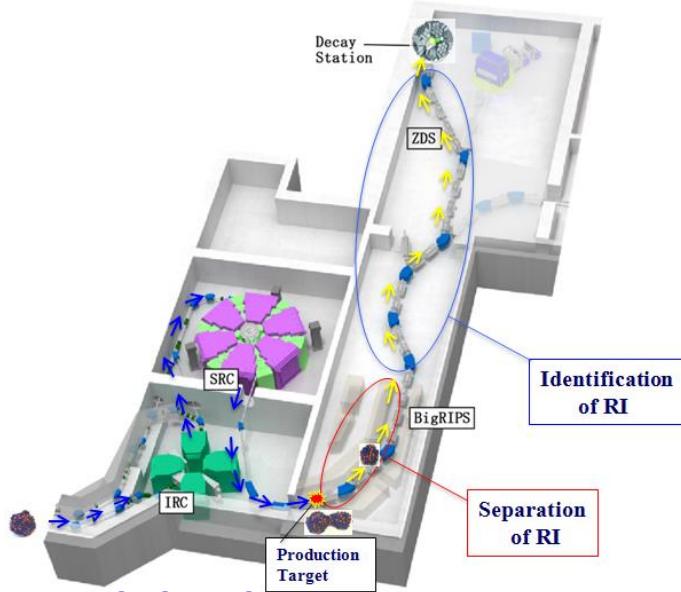
4

Outlook



Collaborators from the A3 countries

Conclusion: there is a variety of post-EURICA physical cases



Special thanks to:

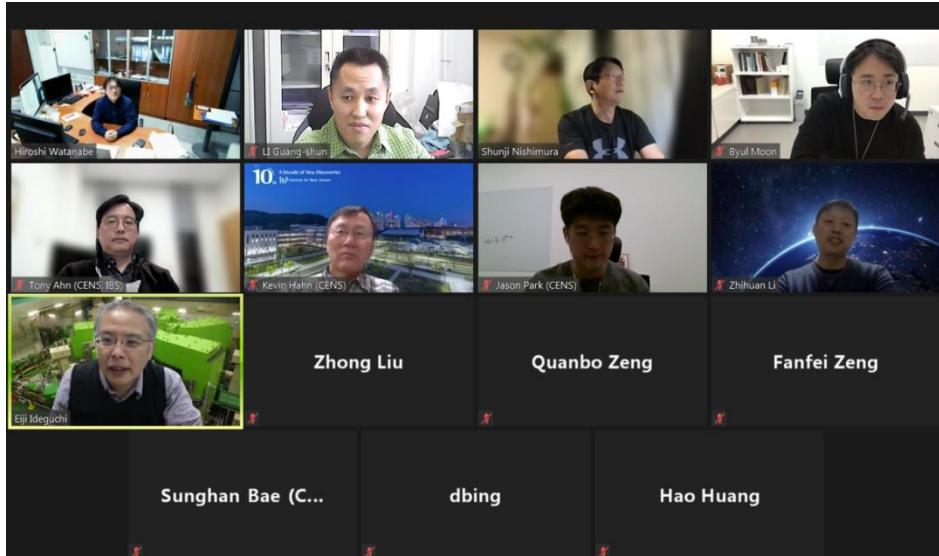
BAUU: H. Watanabe, B.H. Sun, et al.

RIKEN: S. Nishimura, et al.

IBS: T. Ahn, B. Moon, et al.

IMP: G.S. Li, Z. Liu, et al.

RCNP, CIAE, PKU, SDU ...

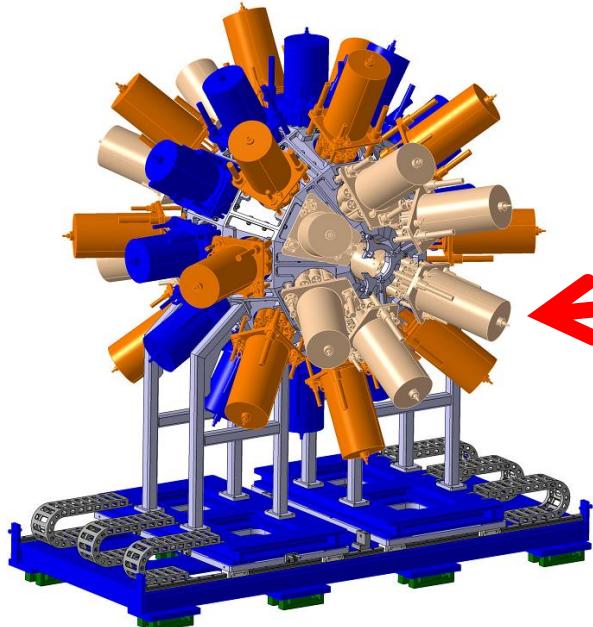


Online meeting at October, 2021

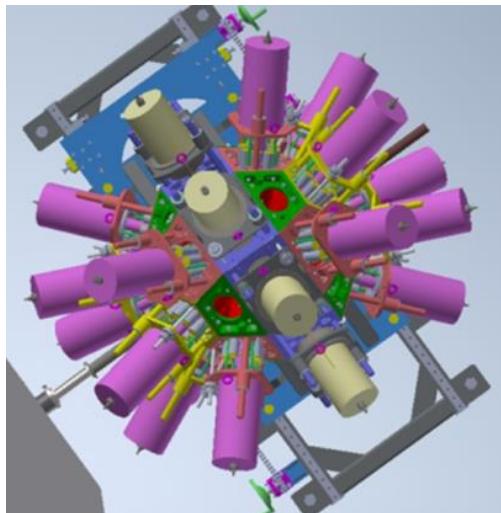


Online meeting at July, 2021

Two candidates to be employed at BigRIPS



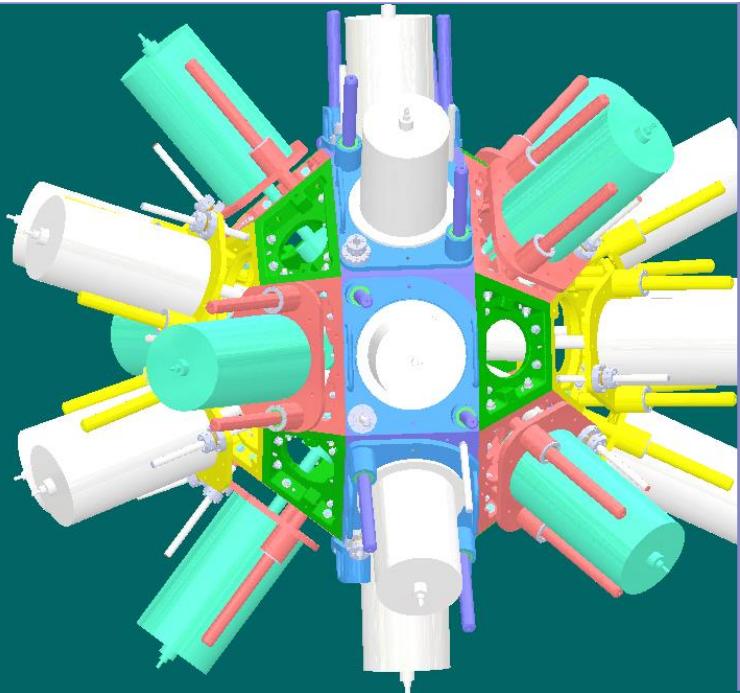
In the model of CIAE, the
**radius of the basic ball-
shell is around 600 mm**



In the model of IMP, the
**radius of the basic ball-shell
is around 490 mm**

Example of simulations with the IMP frame

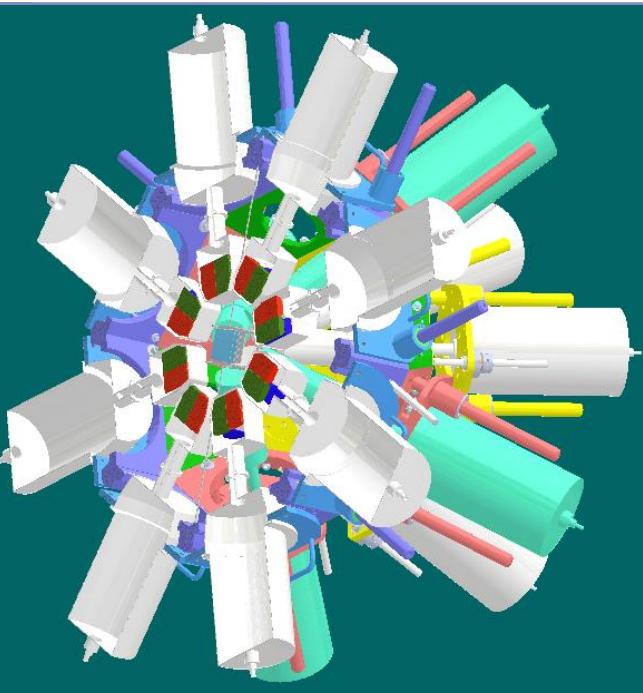
distance	Small angle (HPGes)	Middle angle (HPGes)	90 degree (Clovers)
IMP Closest model	140 mm	93 mm	129 mm



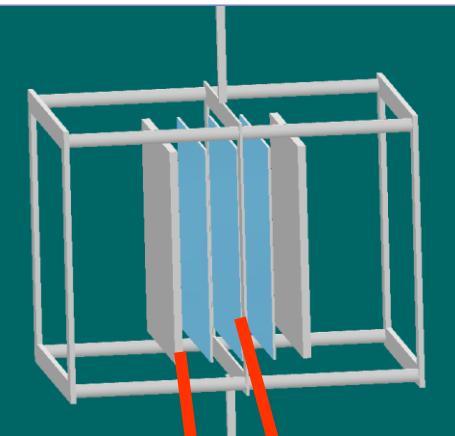
16 coaxial HPGes (70%)

8 Clover HPGes (160%)

4 of the 8 are from Korea



Half –view of the array

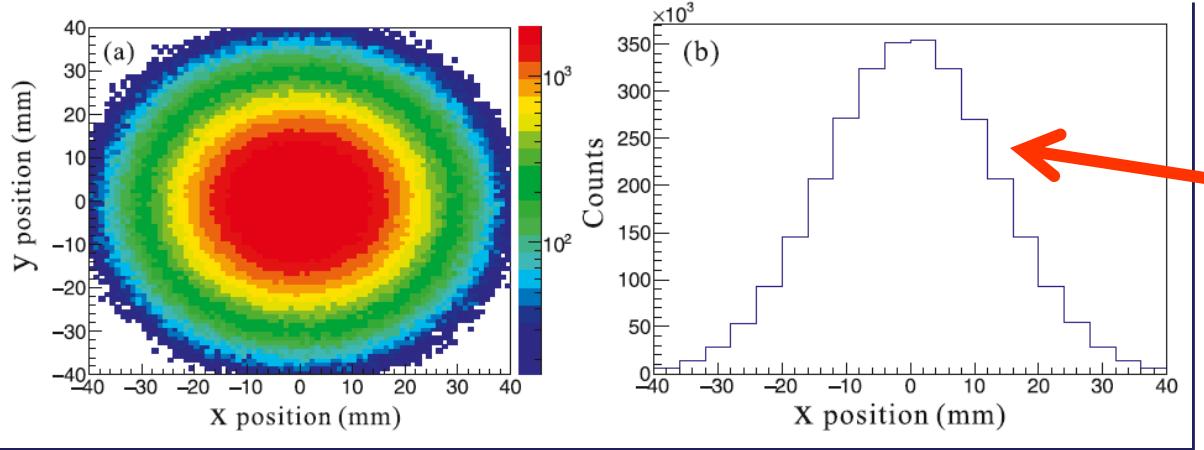


3 mm C9H10 of
2 layers

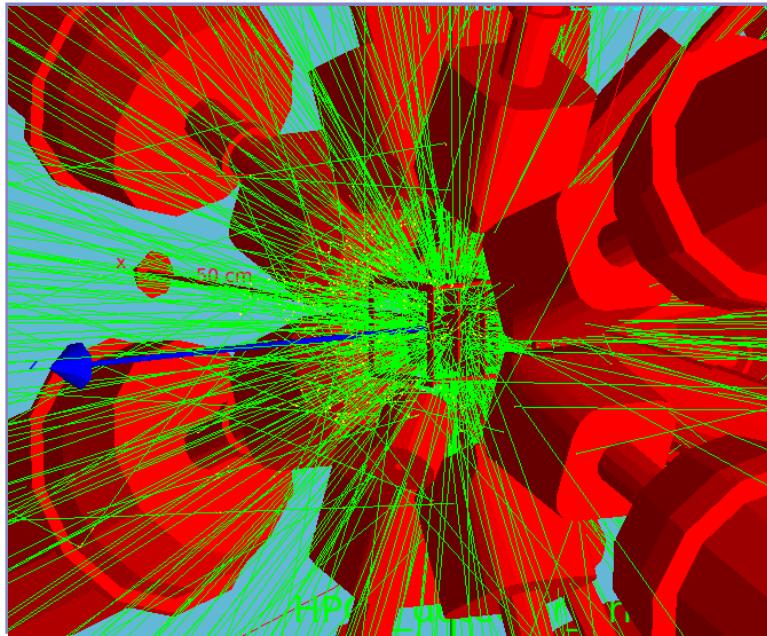
1 mm Si of 3
layers

Si: 78 mm x
78 mm

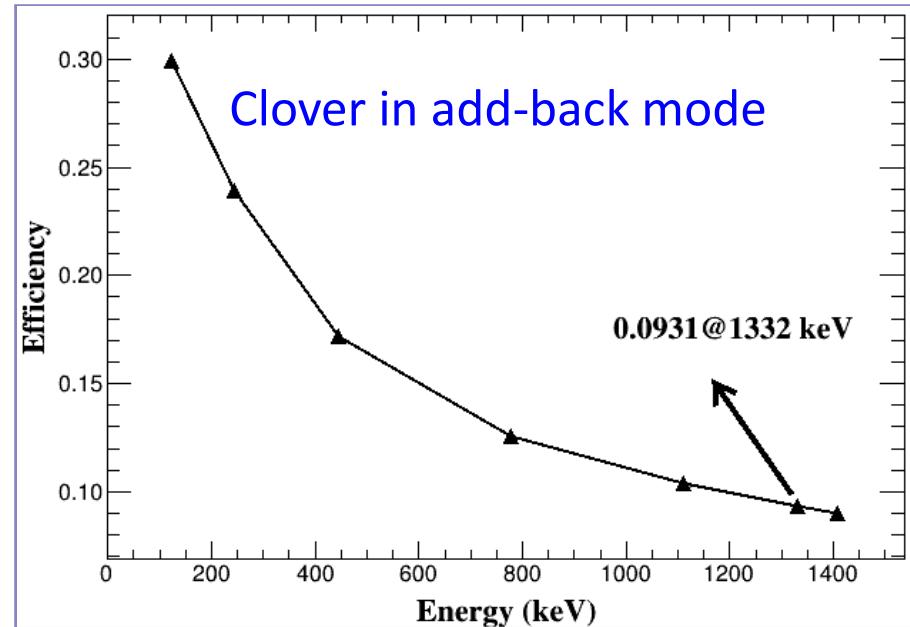
Example of simulations with the IMP frame



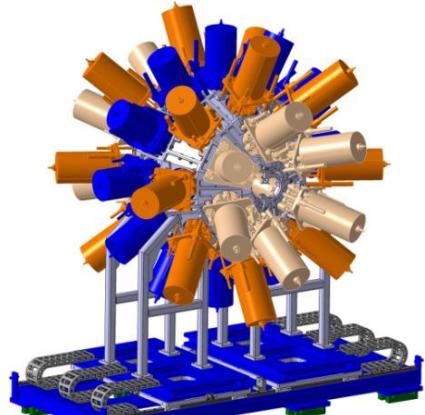
Gamma source
distribution at middle Si
detector



2 mm Al casings included
DSSDs
and bPlasts included



Comparison on the efficiencies



16 coaxial HPGes (70%)-IMP

4 Clover HPGe (Super) -Korea

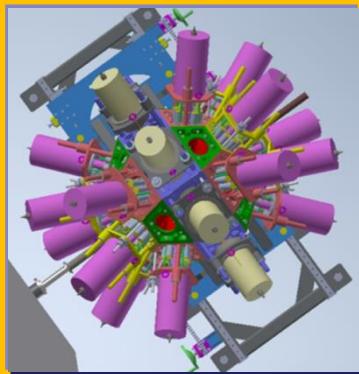
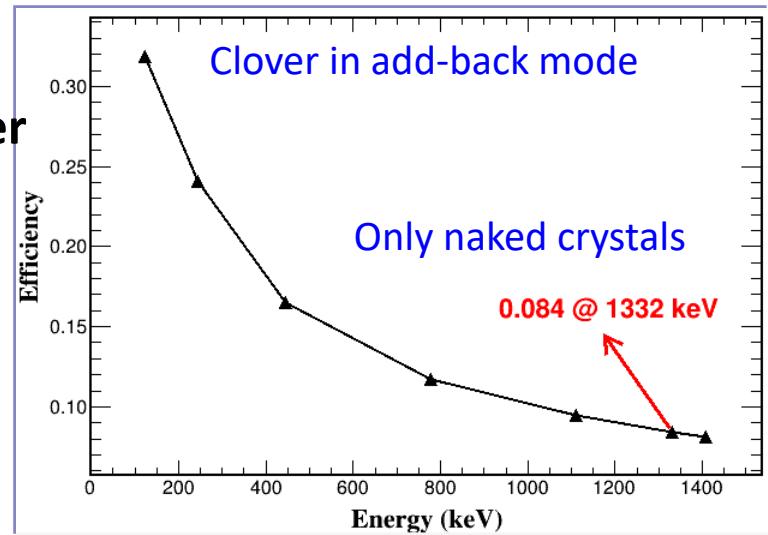
7 coaxial HPGes (35%)-CIAE

- 40 detectors considered
- Larger distance to the center
- Better granularity

8 Clover HPGes (160%)-IMP

2 coaxial HPGes (70%)-CIAE

3 coaxial HPGes (30%)-SDU



16 coaxial HPGes (70%)-IMP

4 Clover HPGe (Super) -Korea

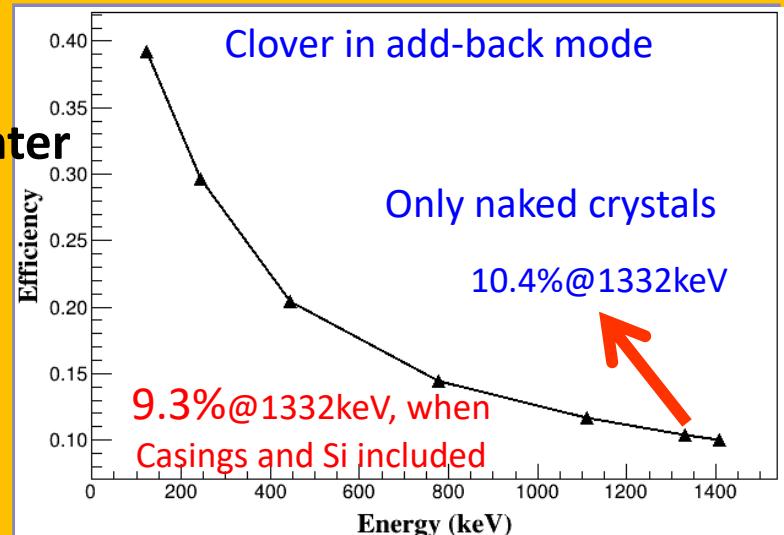
7 coaxial HPGes (35%)-CIAE

- 24 detectors considered
- Smaller distance to the center
- Worse granularity

4 Clover HPGes (160%)-IMP

2 coaxial HPGes (70%)-CIAE

3 coaxial HPGes (30%)-SDU



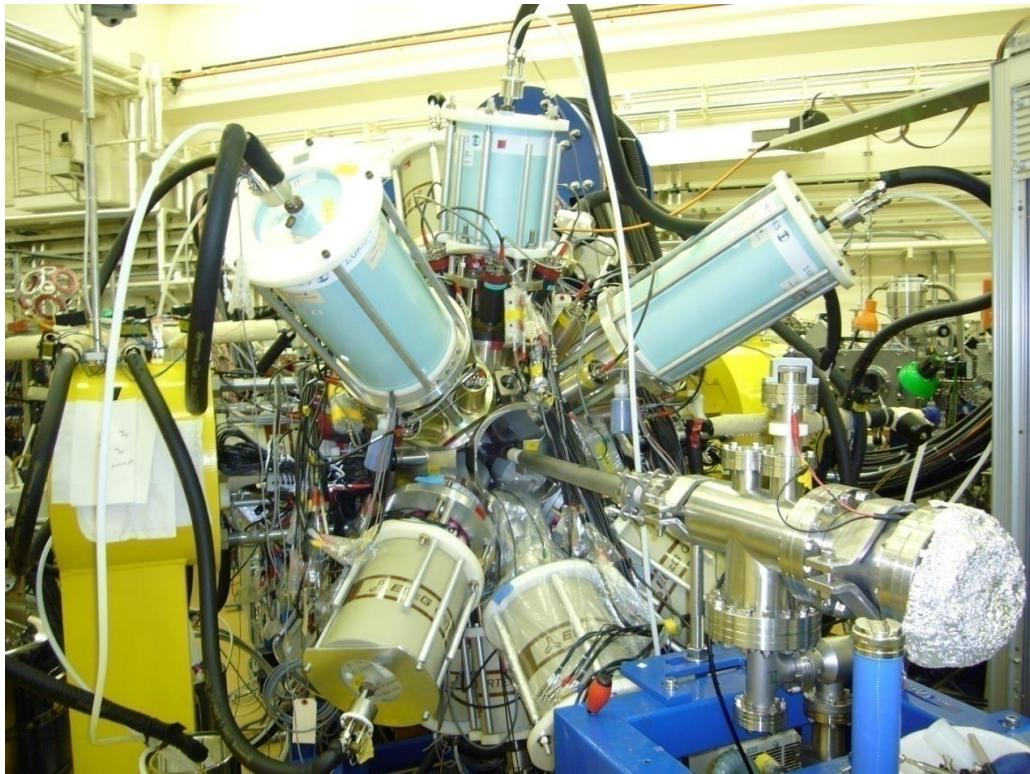
Contents

目录 CONTENTS



- 1 Development & campaigns**
- 2 Project under A3 program**
- 3 Other cooperation**
- 4 Outlook**

Successful collaboration with JAEA



Special thanks to:

JAEA: M. Oshima, Y. Toh, *et al.*

IMP: Zhang. Y. H, Zhou. X. H, *et al.*

GEMINI, Japan Atomic Energy Agency (JAEA)

14 HPGe's with AC shields

Many publications from this collaboration !!

Selected results ...

Selected research results

IOP PUBLISHING

JOURNAL OF PHYSICS G: NUCLEAR AND PARTICLE PHYSICS

J. Phys. G: Nucl. Part. Phys. 38 (2011) 095105 (9pp)

doi:10.1088/0954-3899/38/9/095105

Signature inversion in the $7/2^-$ [503] band of ^{155}Pt

PHYSICAL REVIEW C 75, 034314 (2007)

Band properties of the transitional nucleus ^{187}Pt

PHYSICAL REVIEW C 80, 034303 (2009)

Properties of the rotational bands in the transitional nucleus ^{189}Pt

PHYSICAL REVIEW C 89, 054303 (2014)

In-beam γ spectroscopy of the even-even nucleus ^{190}Pt

High spin states in the Pt isotopes are further systematically studied

Selected results ...

Selected research results

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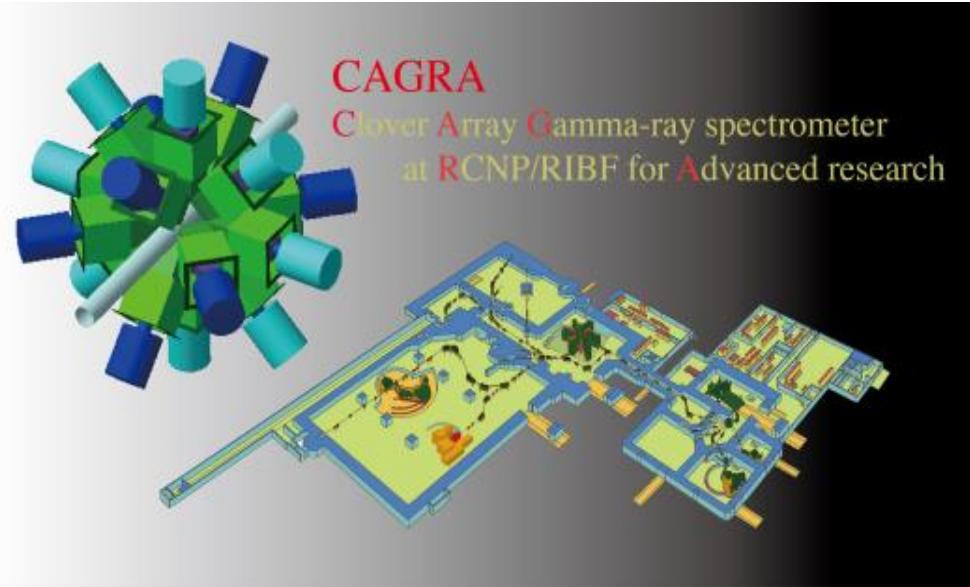
S. Guo, *et al.*, Phys.Rev. C 86, 014323 (2012)

H. X. Wang, *et al.*, Phys.Rev. C 86, 044305 (2012)

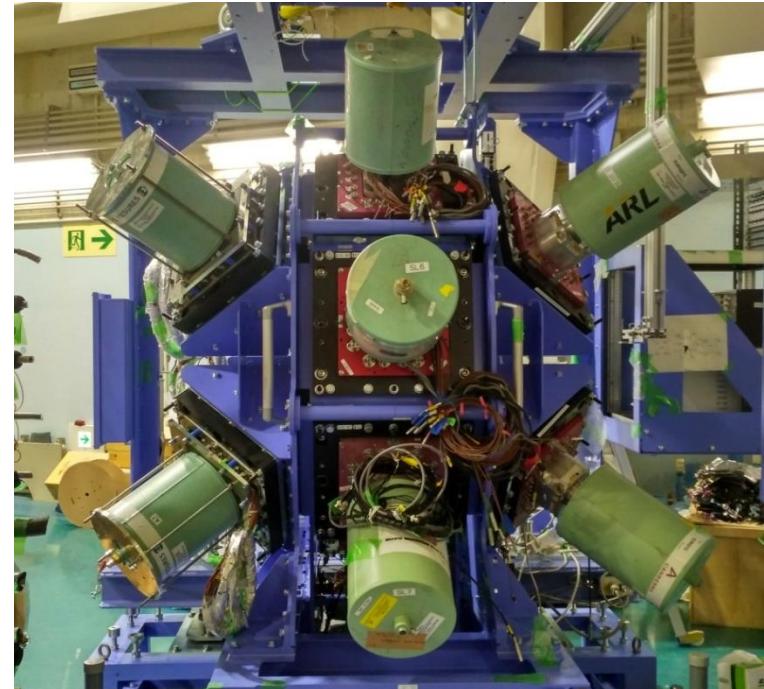
Y. D. Fang, *et al.*, Phys.Rev. C 82, 064303 (2010)

... ...

Successful collaboration with RCNP



Collaboration: USA, Japan, China



16 Clover detectors + Acs, 2 from IMP

Performed experiment (2017):

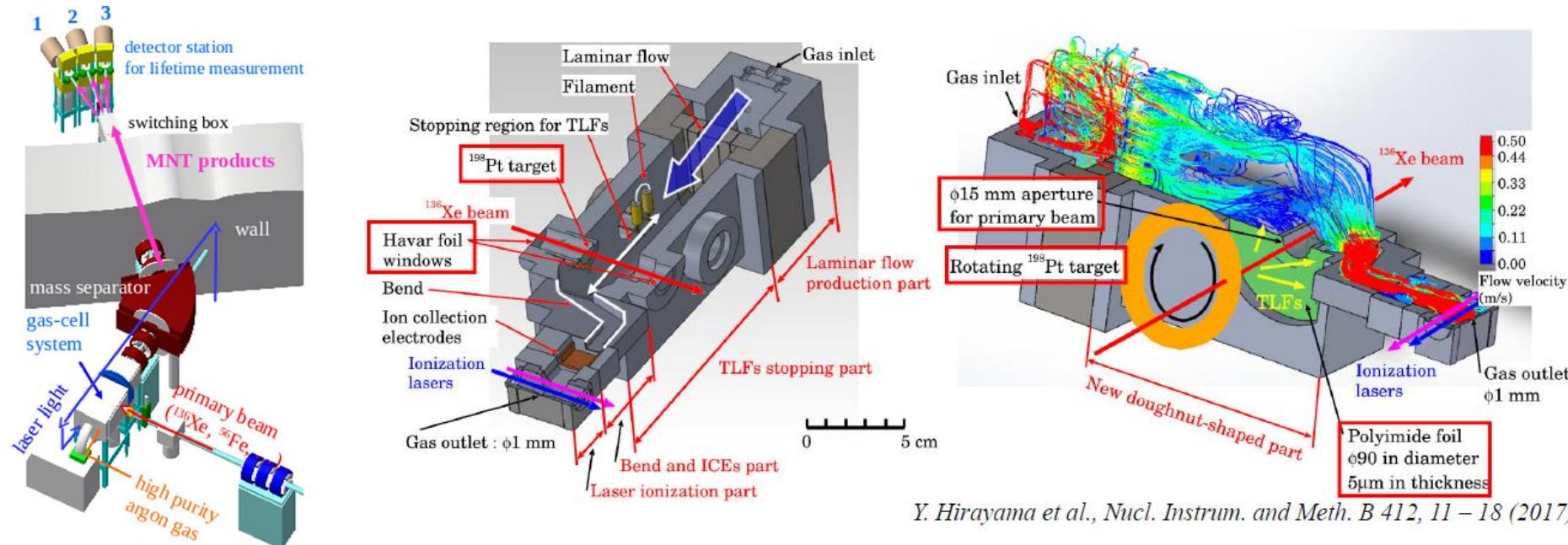
High-Spin States in ^{91}Y , $^{93,94}\text{Nb}$ and ^{94}Zr , by Dr. Liu. M. L *et al.*

Approved beam time:

Linear Polarization Measurement in Wobbling Bands, by Dr. Guo. S *et al.*

On going collaboration with KEK

The KISS project



Y. Hirayama et al., Nucl. Instrum. and Meth. B 412, 11 – 18 (2017).

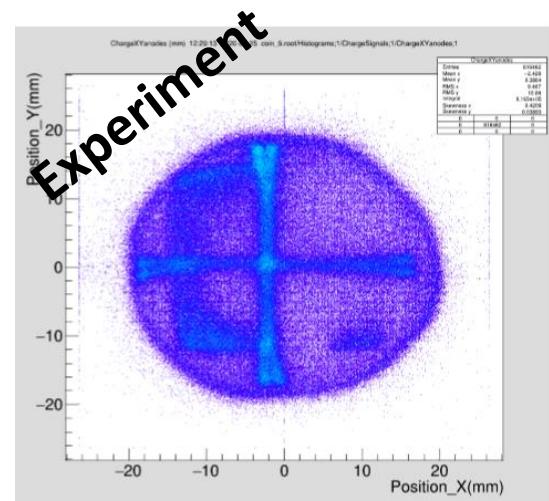
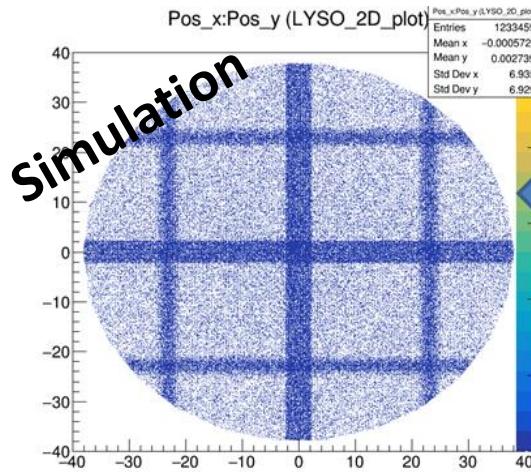
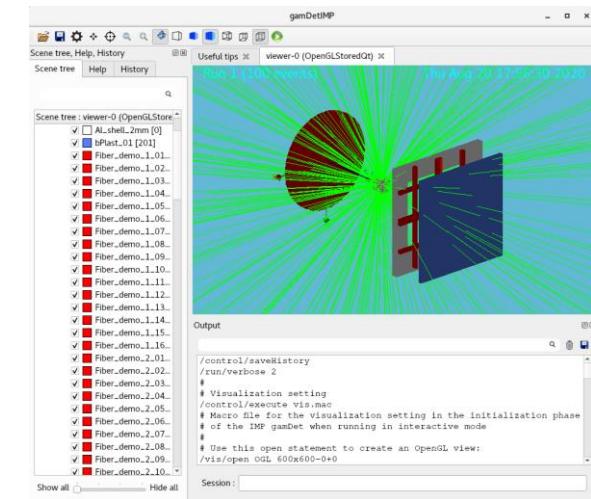
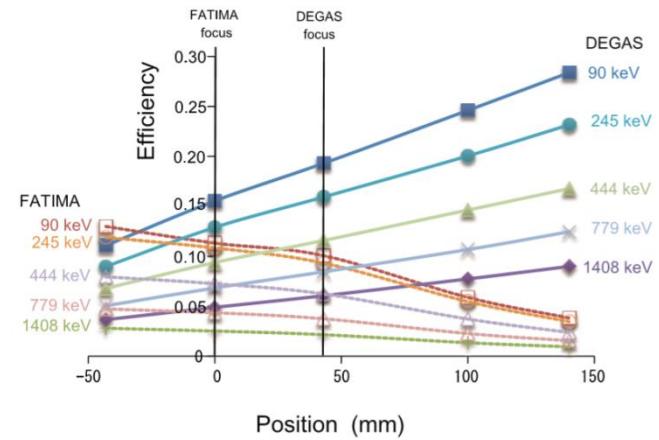
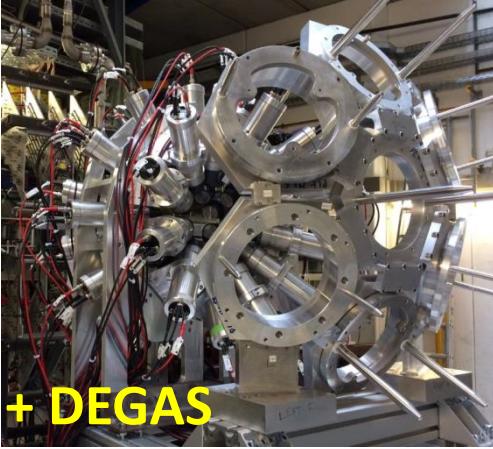
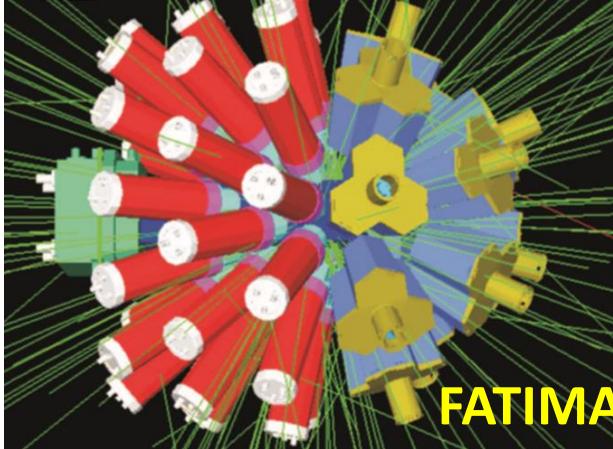
4 IMP Clover detectors were employed for the project at 2020

They will be employed again for the project at 2023

WNSC: Dr. Yutaka Watanabe, et al.

IMP: Dr. LI Guang-shun, et al.

On going collaboration with Germany/GSI



NUSTAR/DESPEC project

G. S. Li *et al.*, NIM A, 2020, to be published
IMP, Lanzhou

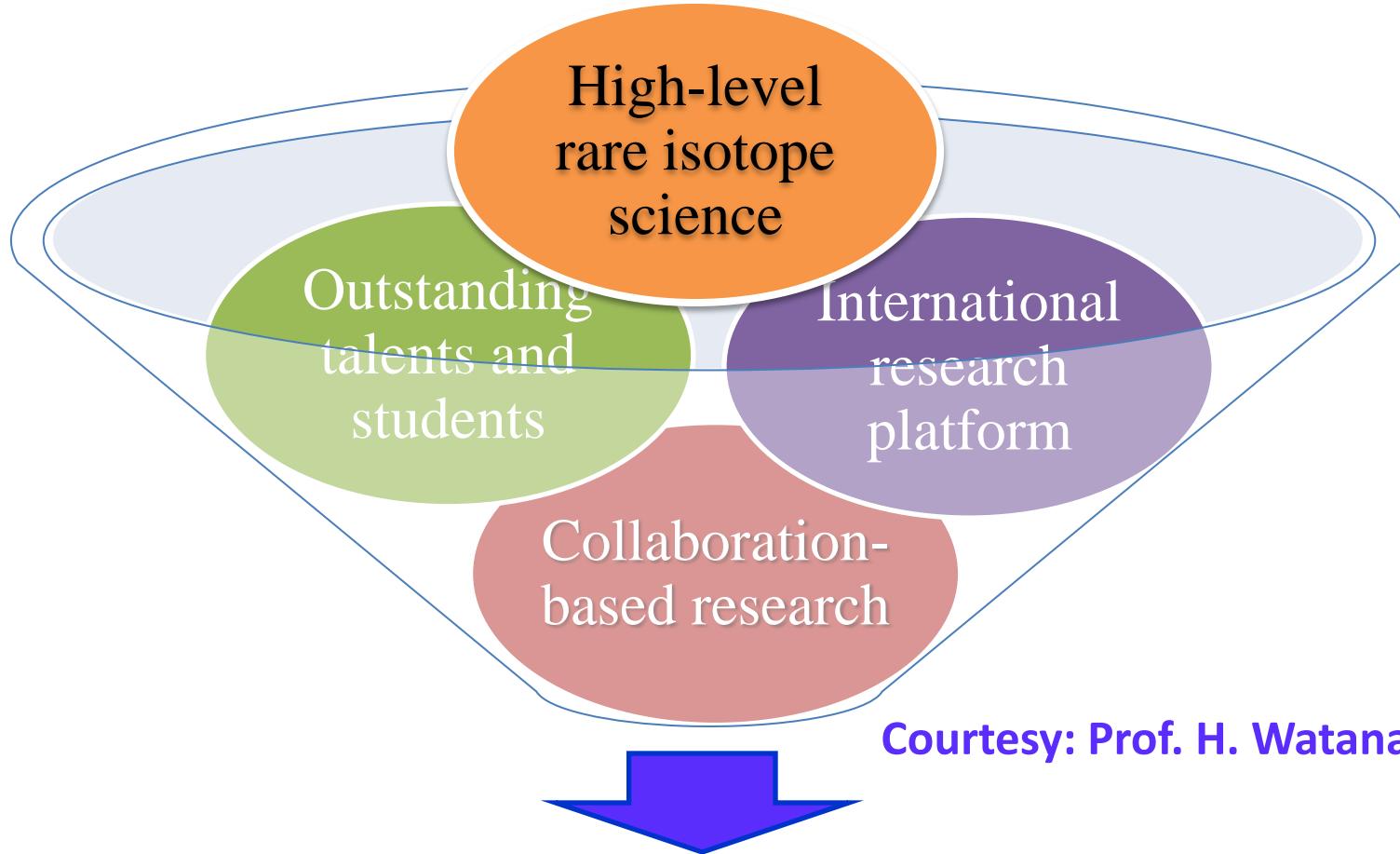
A tip of the iceberg



The sharing of the instrumentations are only
partially covered in this talk!

Outlook

Contribution to the (inter)national interest in East Asia



- Maximize scientific outputs and impact of RIBF/HIAF/RAON
- Foster researchers who will bare the future of Nuclear Physics in A3 countries

Outlook



- Strengthen the collaboration, share the instrumentations
- We will have more bright future

Thank you for your attention!

