Probing the atomic nucleus with the IMP-DRAGON

LI Guang-shun
for the
gamma instrumentation
team @ IMP

2025-09-05

Institute of Modern Physics (IMP),
Chinese Academy of Sciences (CAS)

Contents

目录
CONTENTS

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:

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**

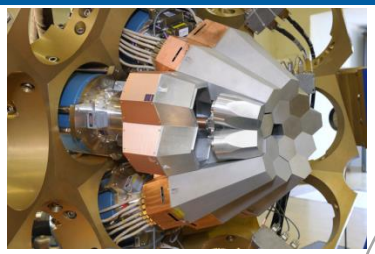
Requirements:

Examples of the γ detector arrays in the world

Partially covered ONLY …

Europe

- AGATA
- JUROGAM
- ROSPHERE
- DEGAS
- …

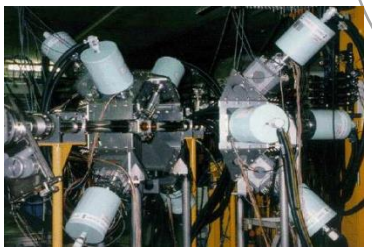


America

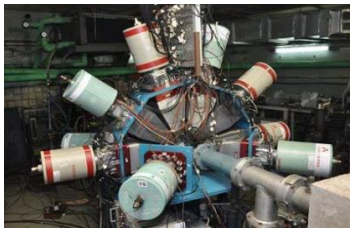
- GRETINA
- TIGRESS
- GAMMASPHERE
- GRIFFIN
- …

Africa

- AFRODITE
- …



Asia



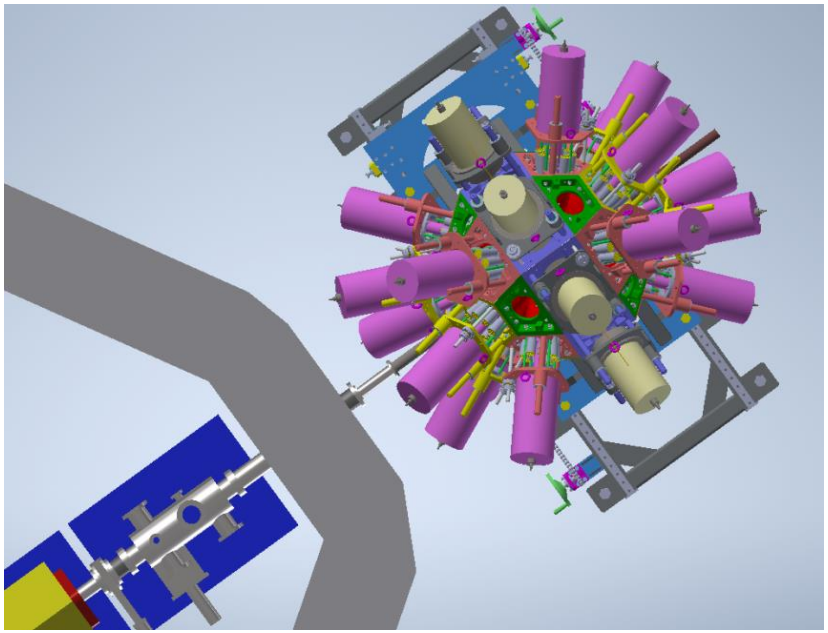
- INGA
- …

We would also like to contribute to the fundamental studies …

IMP - DRAGON

IMP-Detectors for Research by Analyzing Gamma-ray Observation in Nuclei

NIM A 1080 (2025) 170804

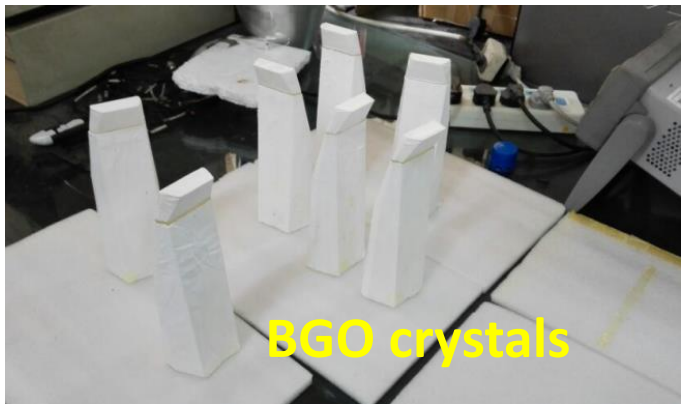


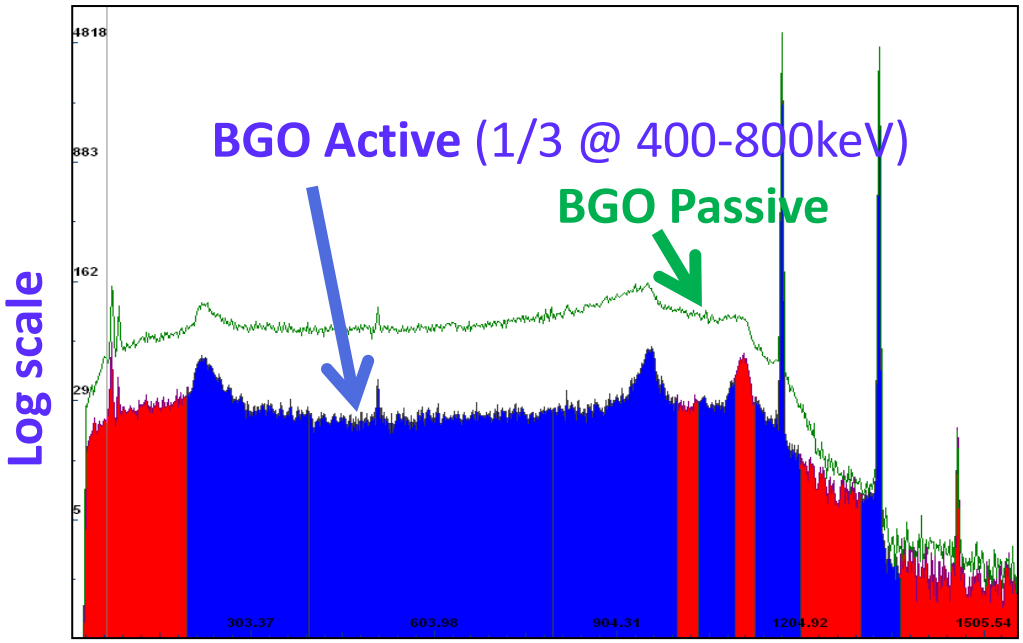
Up to 16 coaxial HPGes (70%)

Up to 8 Clover HPGes (160%)

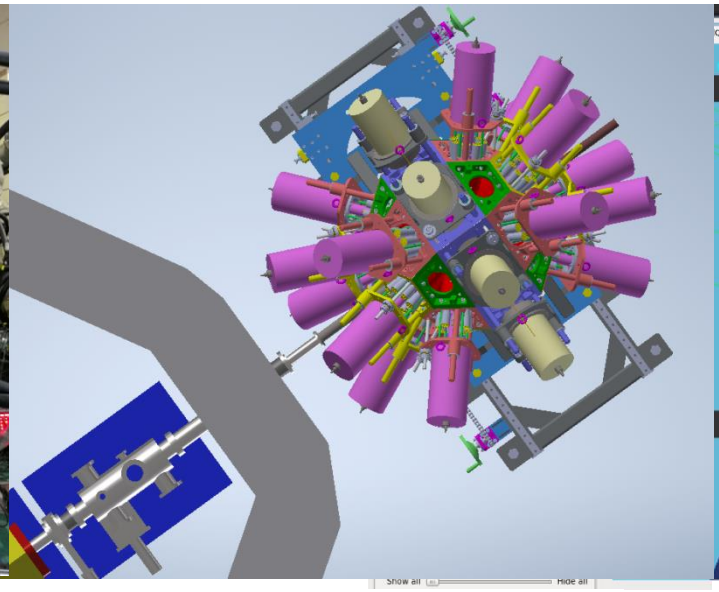
Dedicated sub systems

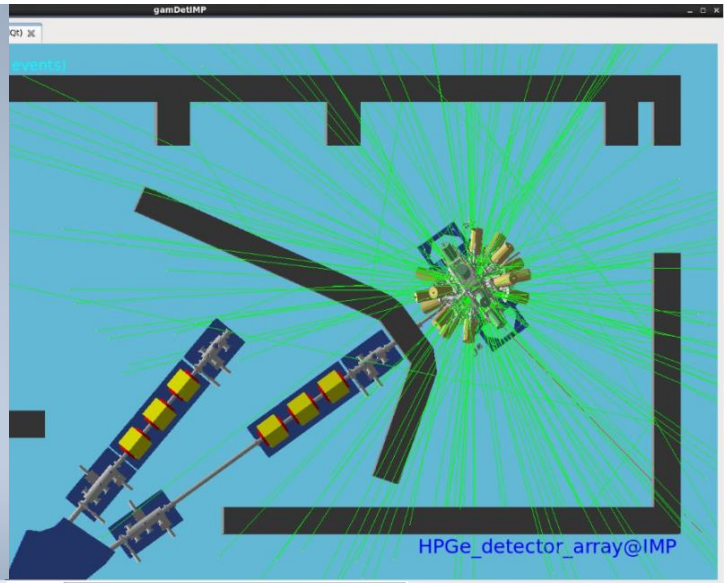
BGO Anti-Compton shields @ IMP - DRAGON

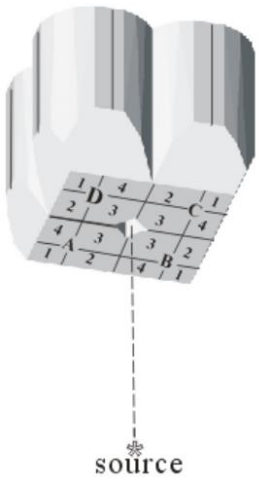


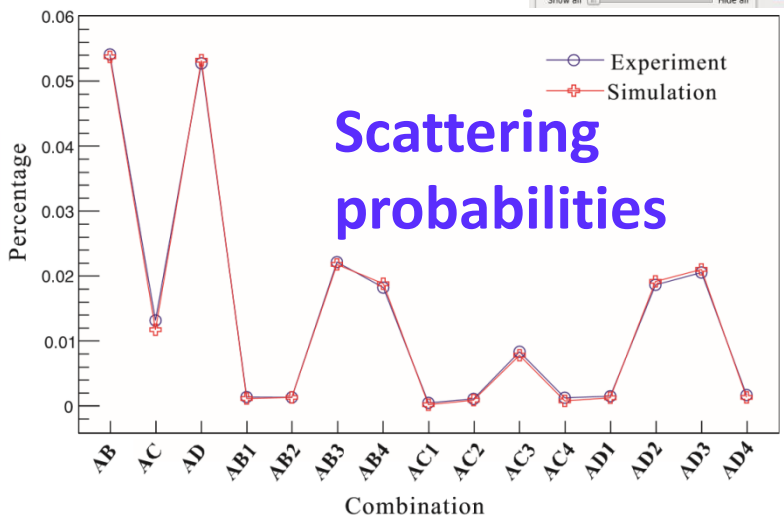


Simulation tools development for IMP - DRAGON



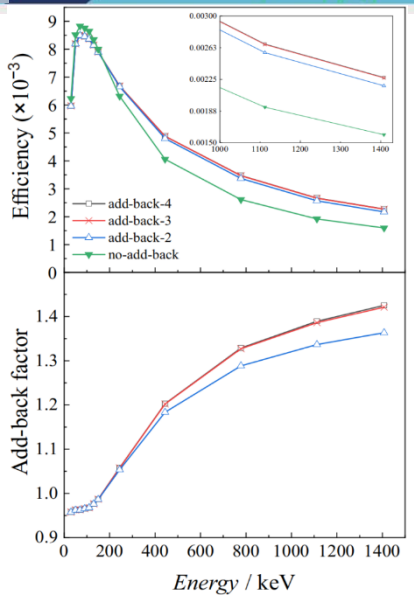






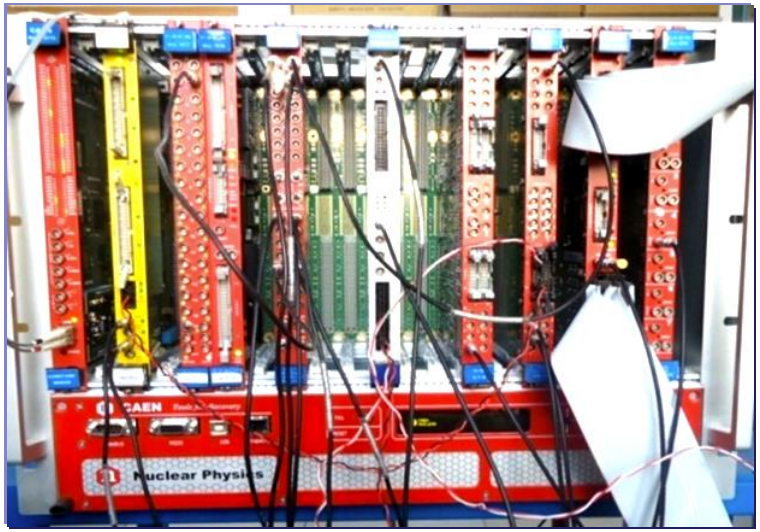
Scattering probabilities

Comparison between Exp. & Sim.



Add-back factors

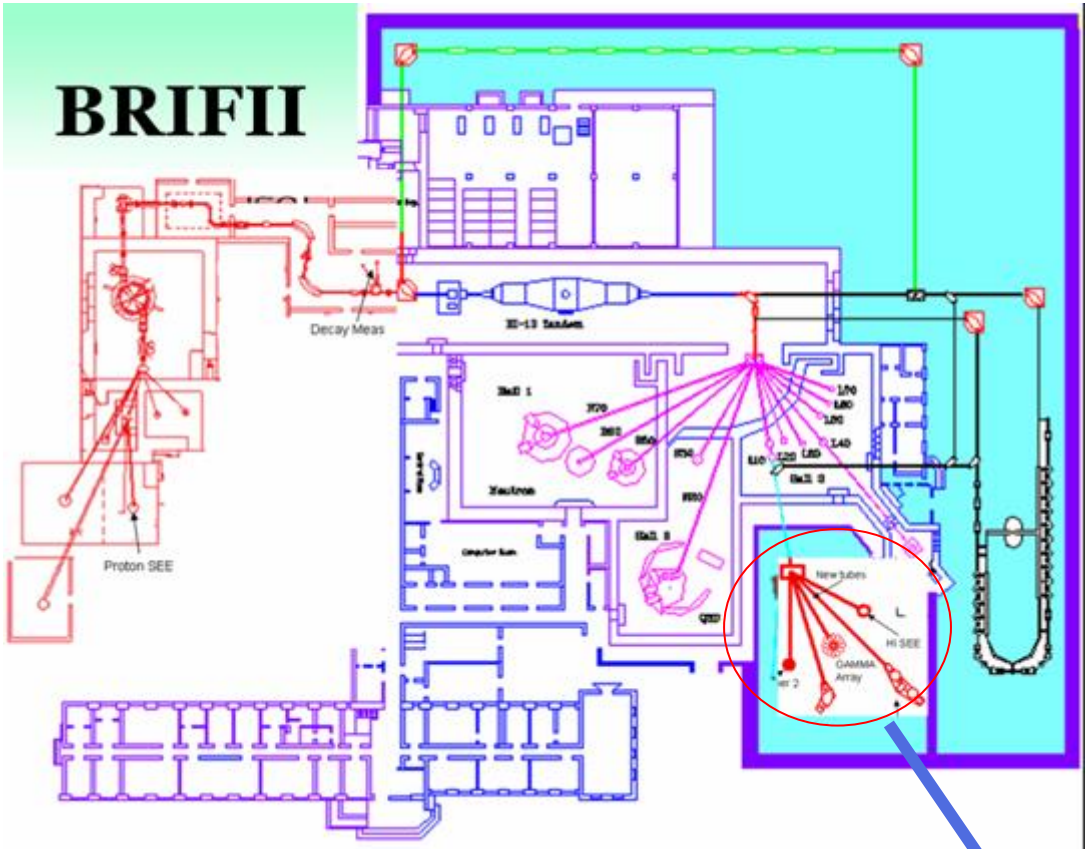
High speed/stable DAQ system @ IMP

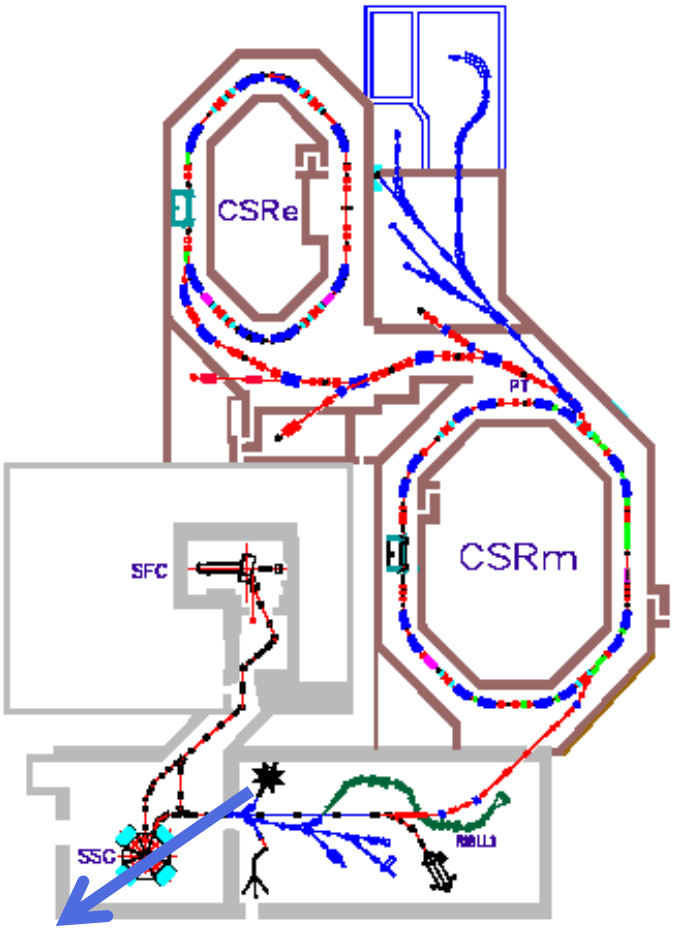


VME based & Digitizer based DAQ systems

Courtesy: Dr. Wang Jianguo(IMP)

Main facilities depend on …



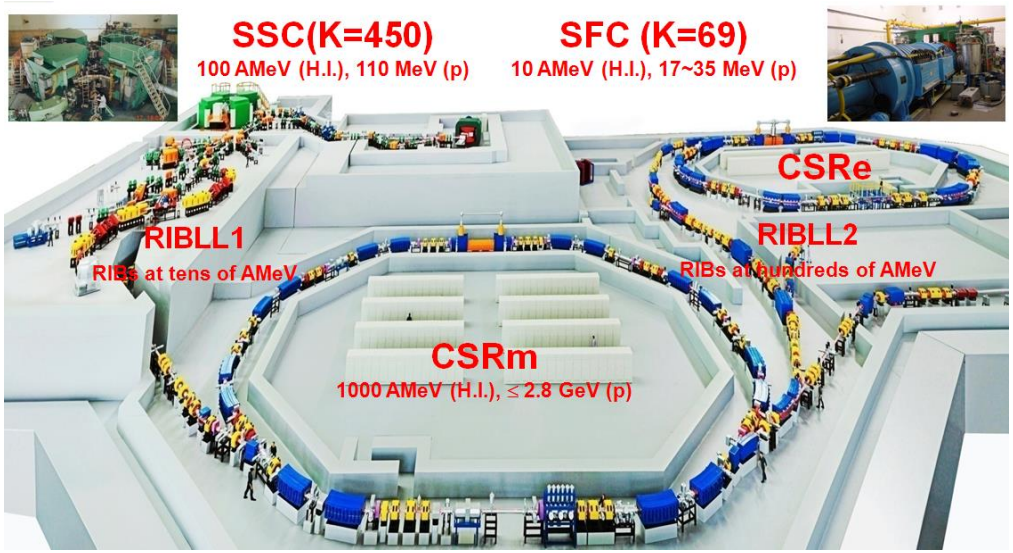


γ-spectroscopy studies

Beijing, HI-13 tandem

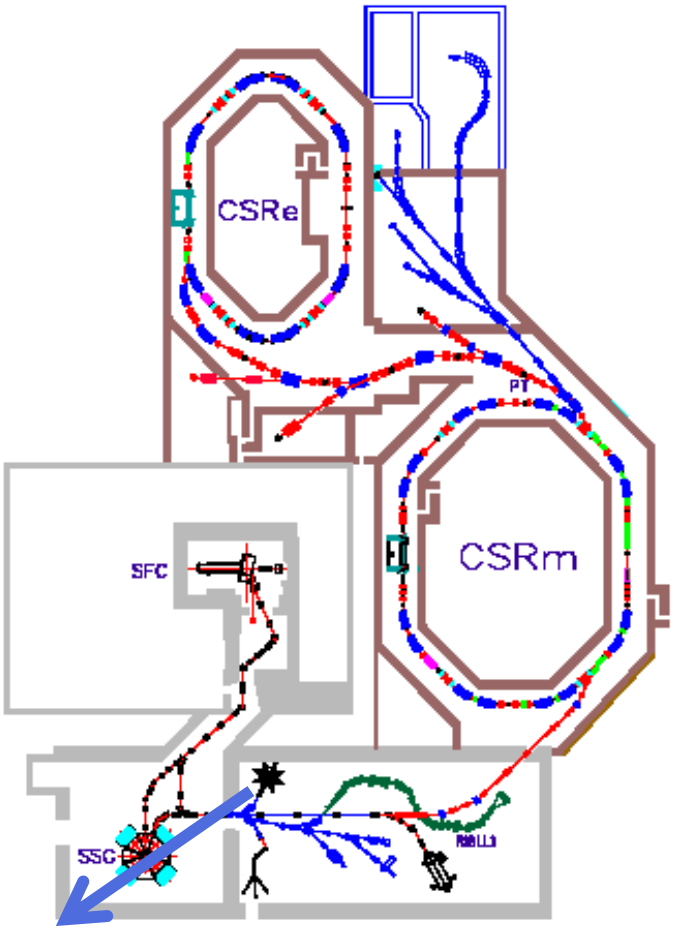
Lanzhou, HIRFL

Facility @ IMP



HIRFL

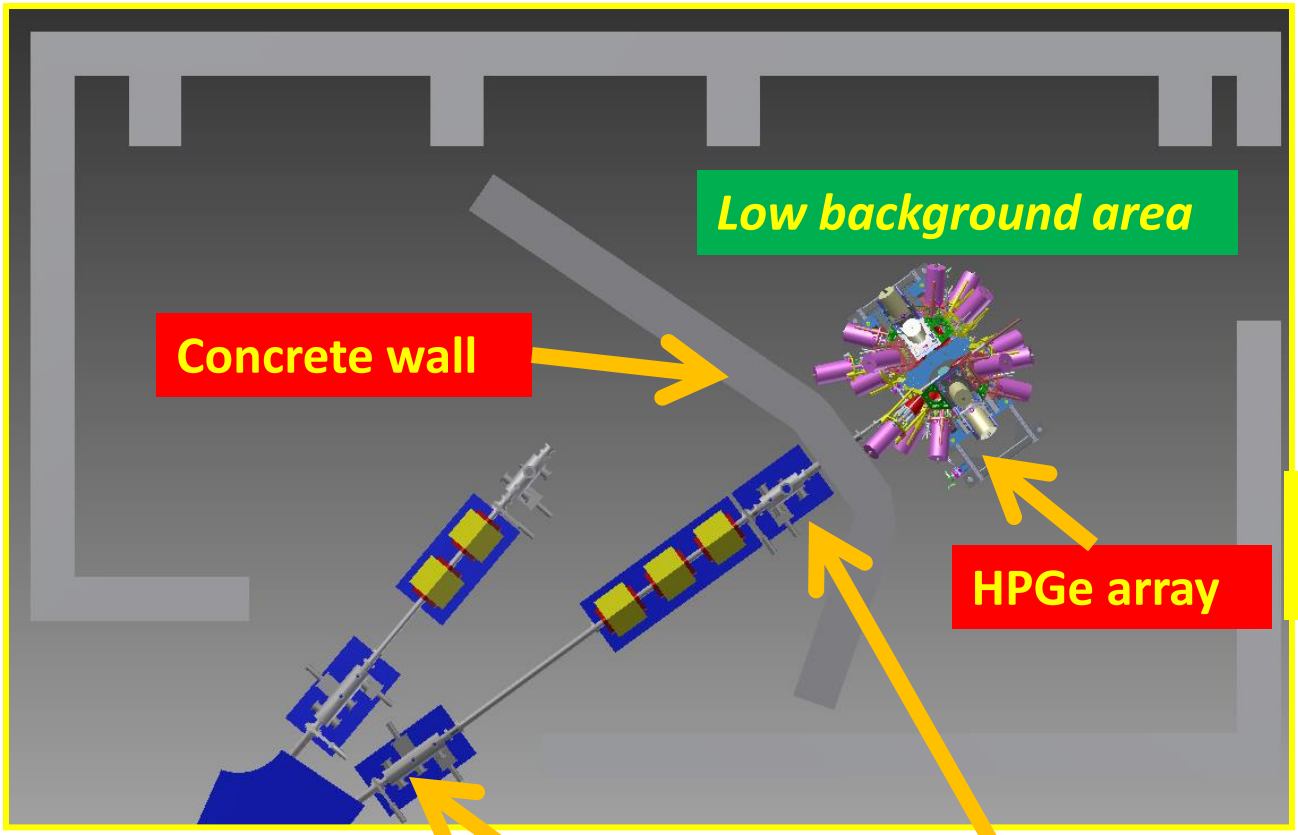
Picture of gate



γ-spectroscopy studies

Lanzhou, HIRFL

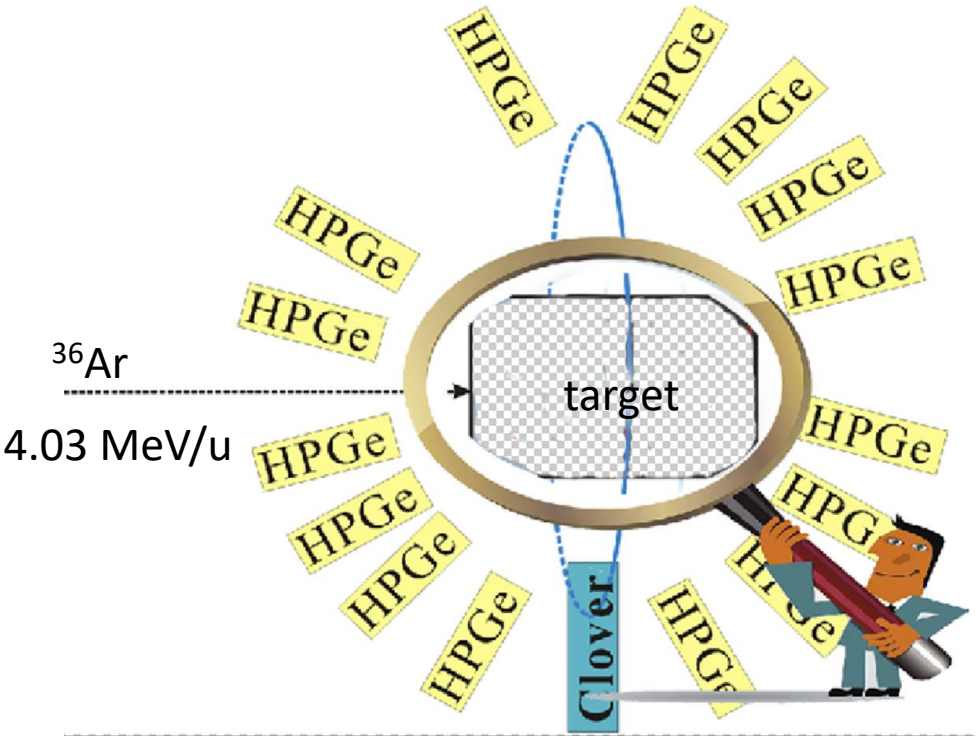
Low energy beam line @ IMP



Beam spot:
< phi 3 mm

Commissioning run @ IMP

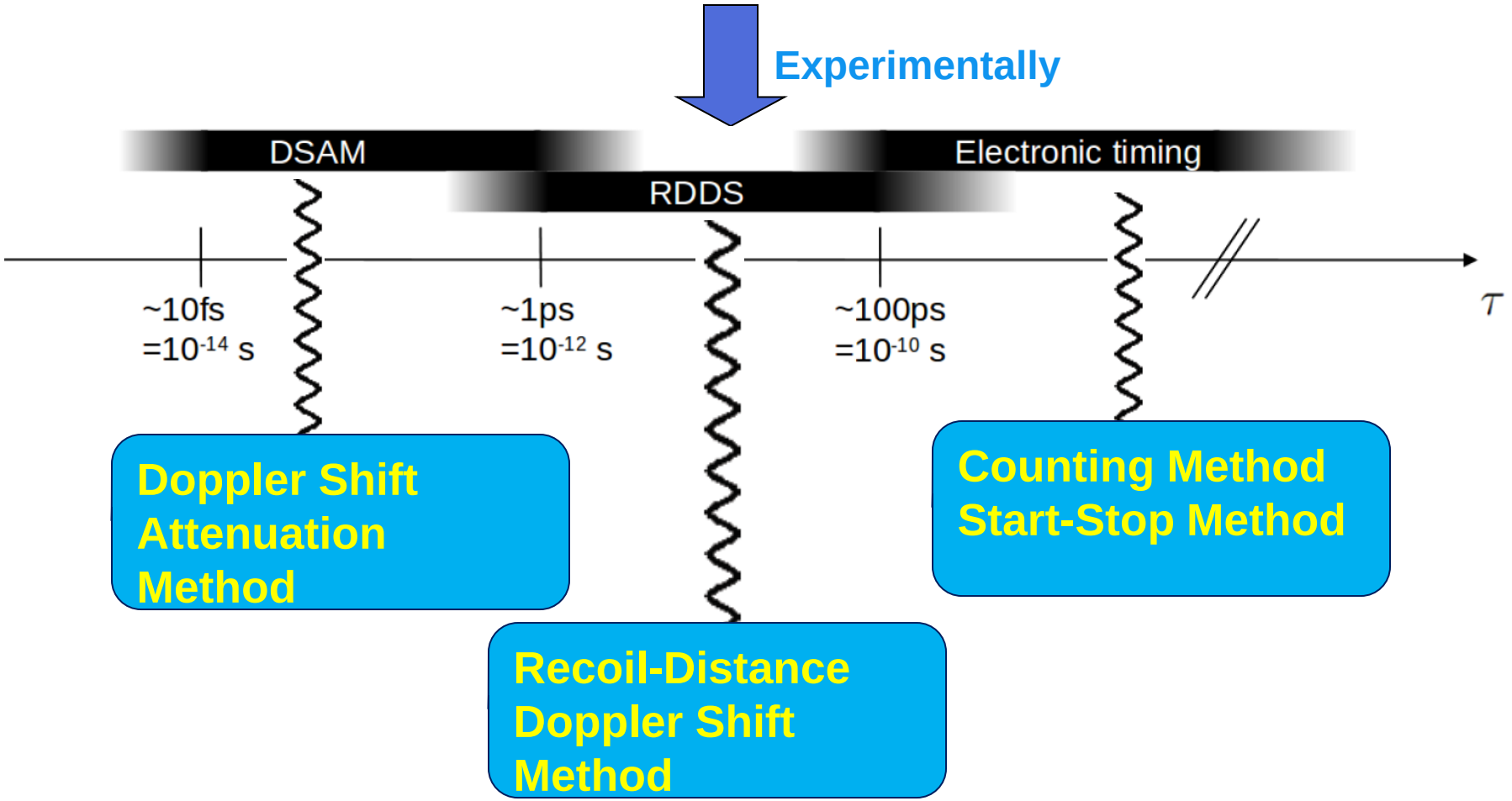
Lifetime measurement of nuclear excited state via DSAM method



15 HPGe + 6Clover

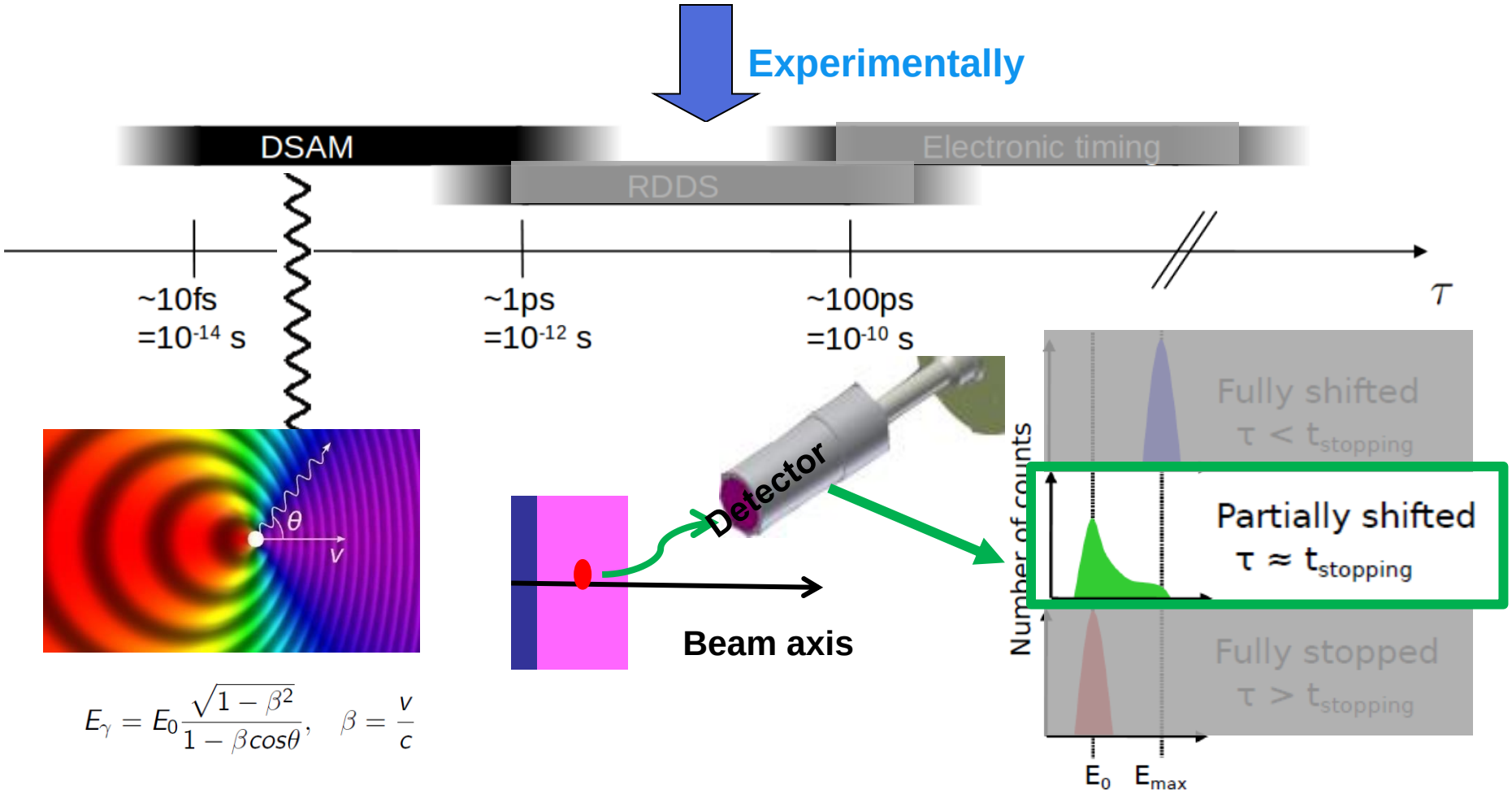
The lifetime of nuclear excited state

Determines the reduced electromagnetic transition probability, can be used to test nuclear structure models



DSAM -- details

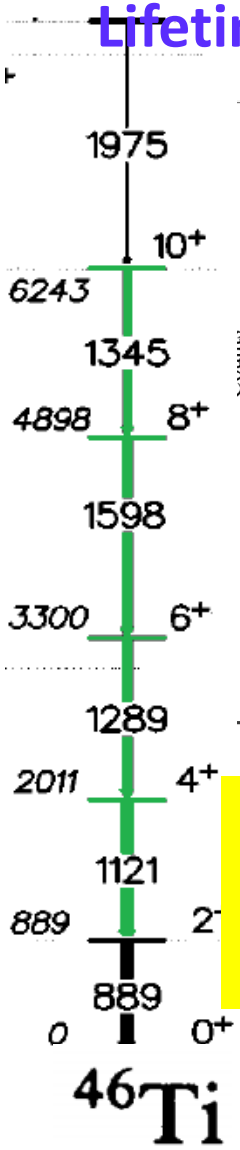
Determines the reduced electromagnetic transition probability, can be used to test nuclear structure models

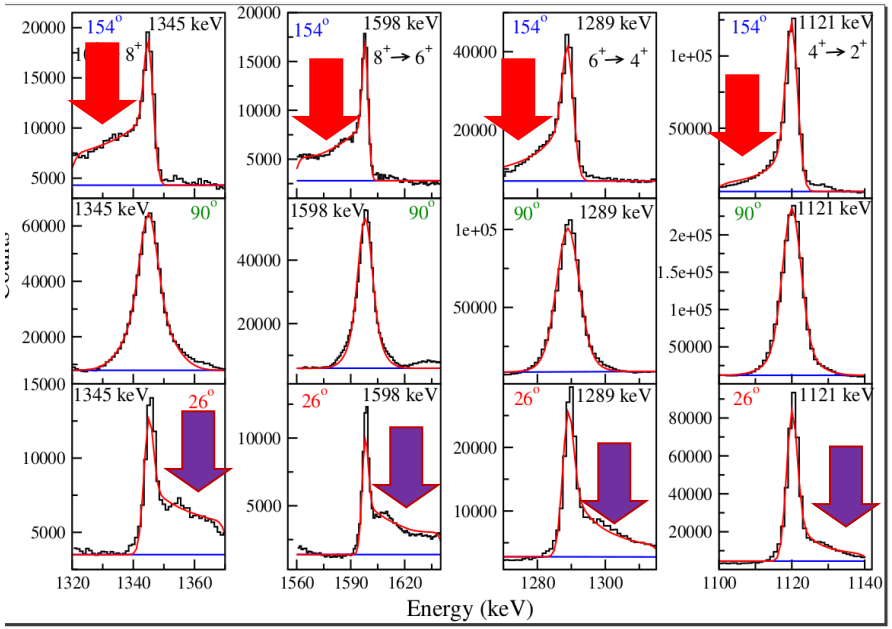


$$E_\gamma = E_0 \frac{\sqrt{1-\beta^2}}{1-\beta cos\theta}, \quad \beta = \frac{v}{c}$$

Commissioning run @ IMP

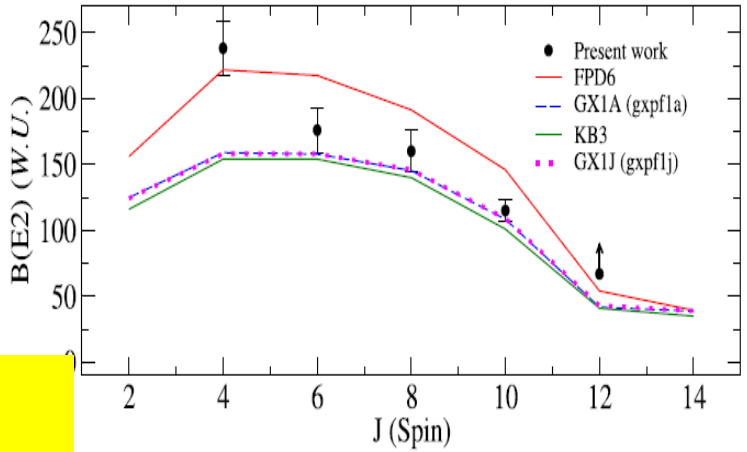
Lifetime measurement of nuclear excited state via DSAM method





$^{36}Ar + {}^{12}C$

→ ^{46}Ti (46mb)
→ ^{45}Ti (358mb)
→ ^{45}Sc (115mb)



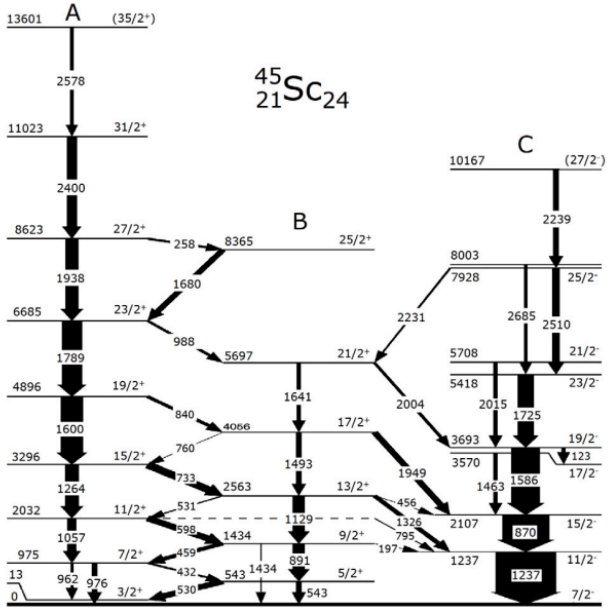
- Improve the lifetime precision
- Update the B(E2) values
- Clarify the configuration mixing issue

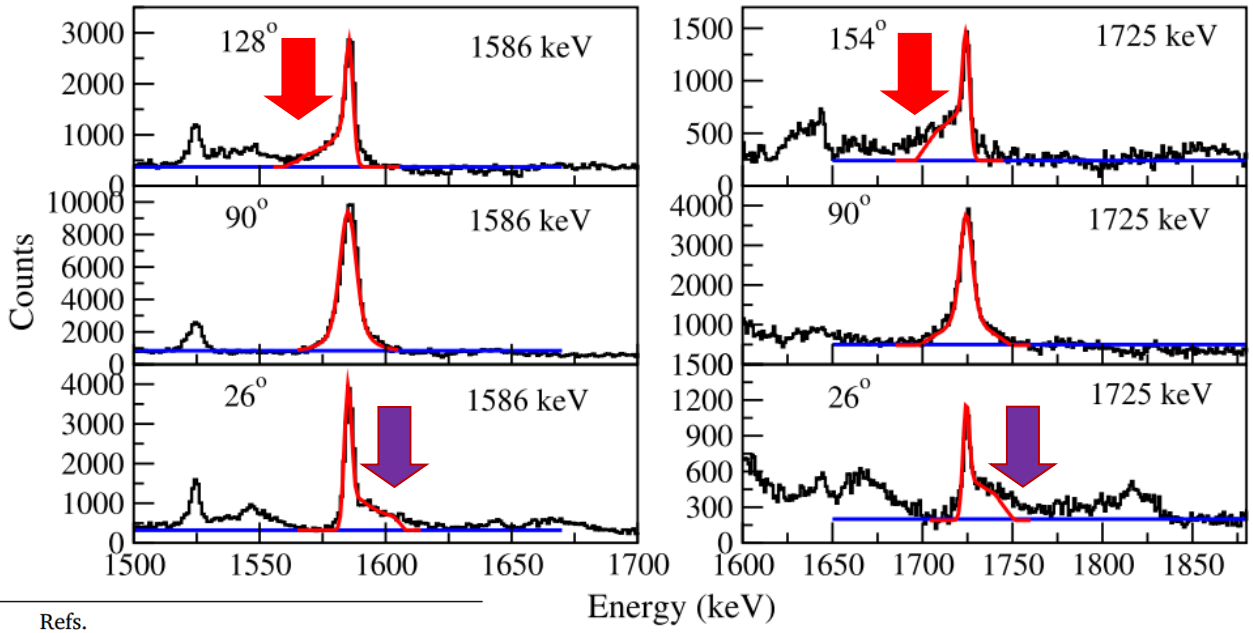
Nucl. Phys. A 1006 (2021)122116

Courtesy: Dr. A. Rohilla (IMP)

Commissioning run @ IMP

Lifetime measurement of nuclear excited state via DSAM method





E_γ (keV)	Spin ($\hbar$) $J_i \rightarrow J_f$	Lifetime τ (ps)	$B(E2)$ (e^2fm^4)	Q_t (eb)	Refs.
1237	$11/2^- \rightarrow 7/2^-$	–	–	–	Present
		2.60 (14)	108 (6)	1.22 (3)	Bednarczyk et al. (1998), Burrows (2008)
		2.60 (14)	108 (6)	1.22 (3)	
870	$15/2^- \rightarrow 11/2^-$	–	–	–	Present
		> 2.0	< 818	< 2.13	Bednarczyk et al. (1998), Burrows (2008)
		> 2.0	< 818	< 2.13	
1586	$19/2^- \rightarrow 15/2^-$	1.37 (14)	52 (5)	0.46 (2)	Present
		2.01 (20)	35 (4)	0.38 (2)	Bednarczyk et al. (1998), Burrows (2008)
	mean →	1.75 (18)	44 (5)[a]		
1725	$23/2^- \rightarrow 19/2^-$	1.89 (19)	28 (3)	0.32 (2)	Present
		1.90 (20)	28 (3)	0.32 (2)	Bednarczyk et al. (1998), Burrows (2008)
	mean →	1.90 (20)	28 (3)[a]		

Applied Radiation and Isotopes 199 (2023) 110863

Courtesy: Dr. A. Rohilla (IMP)

First collaborative run within Chinese collaboration

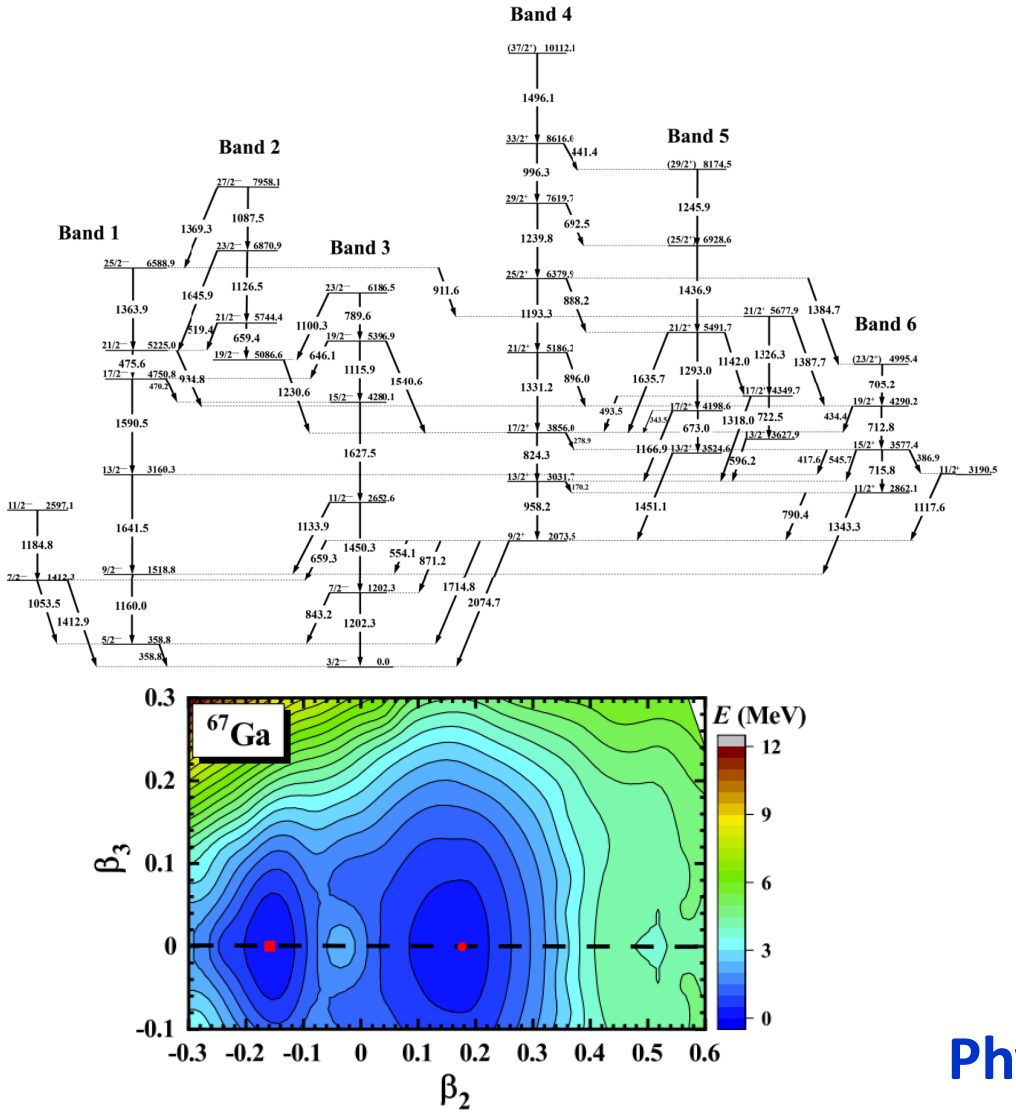
- IMP - Institute of Modern Physics, CAS
- PKU - Peking University
- SDU - Shandong University
- CIAE - China Institute of Atomic Energy
- etc.

More than 600 hours beam time

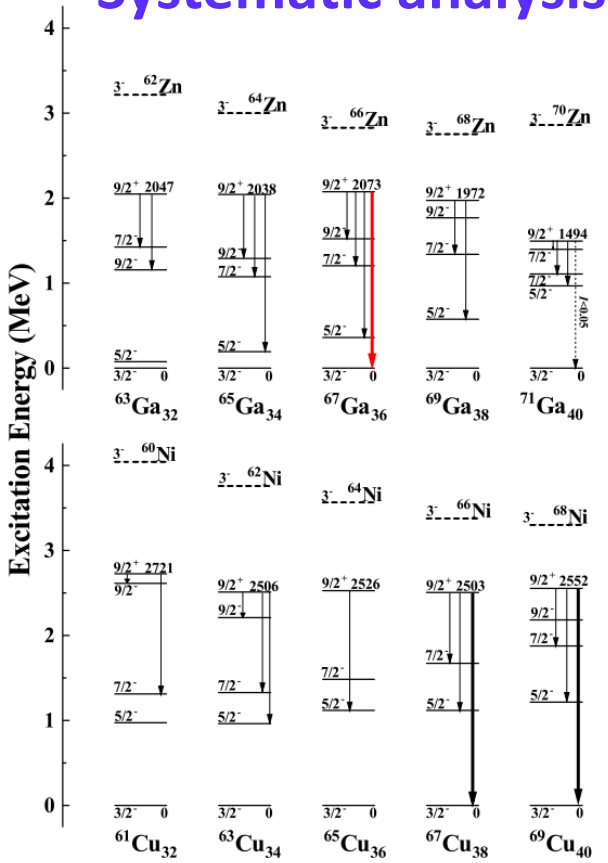
First collaborative run within Chinese collaboration

Output from 2021 campaign

Level scheme of 67Ga



Systematic analysis

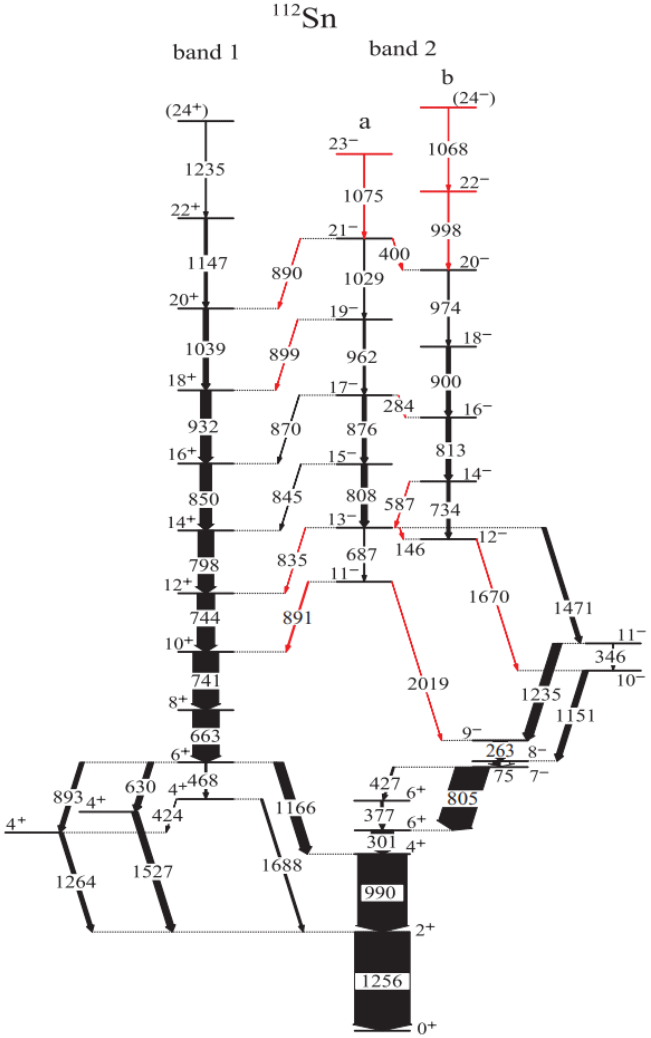


Courtesy: Dr. D. W. Luo(PKU)

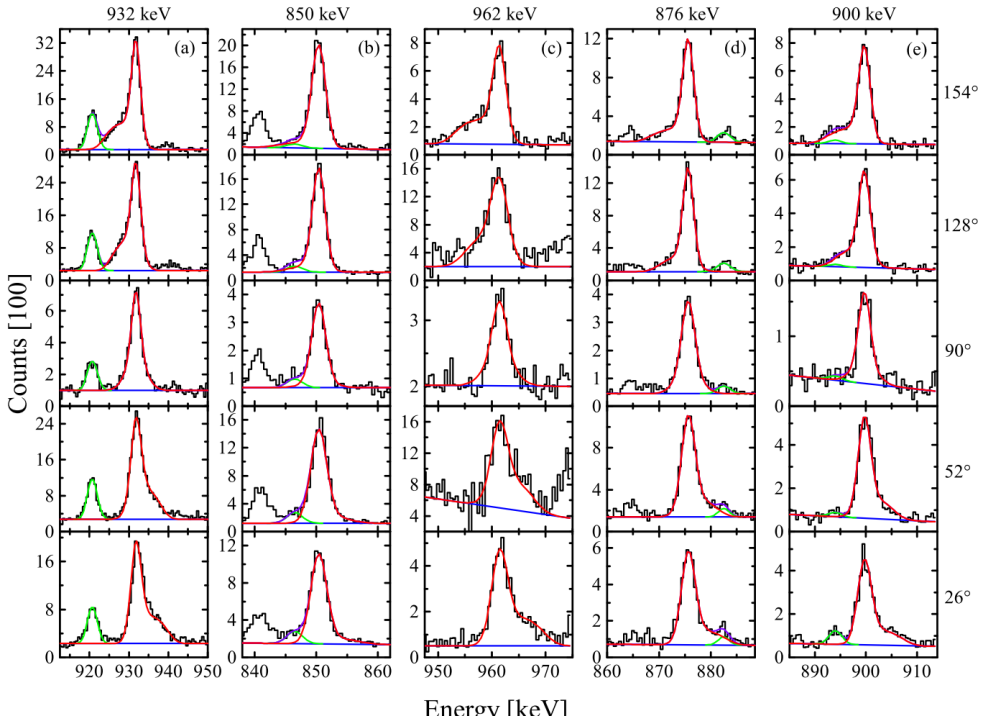
Phys.Rev. C 110, 024309 (2024)

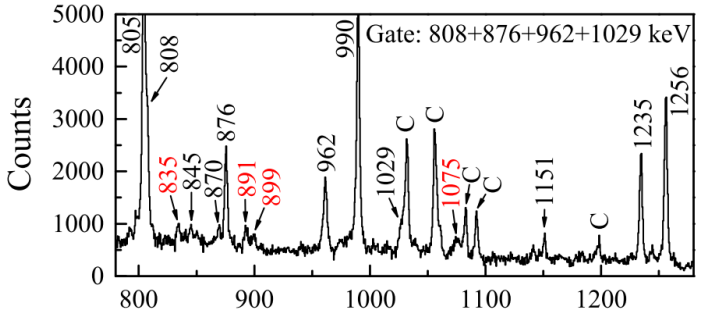
Output from 2021 campaign

Level scheme



DSAM lineshapes



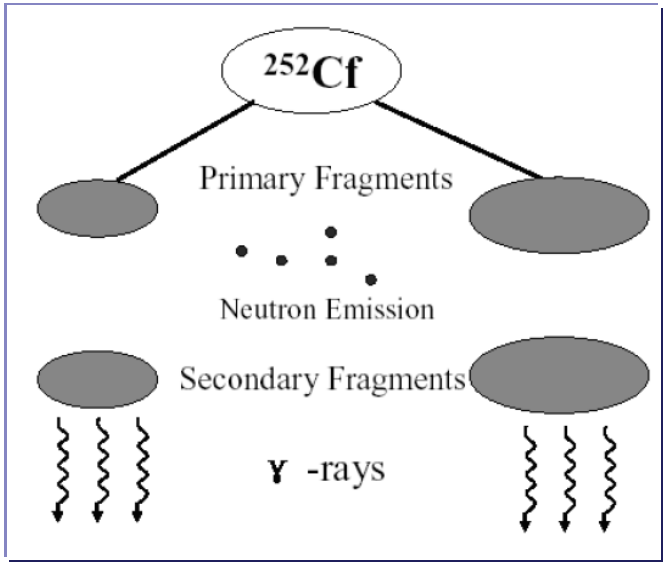


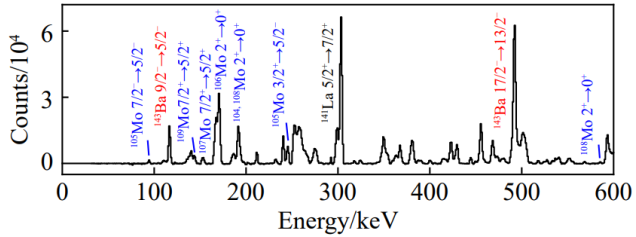
Gated spectrum

Phys.Rev. C 109, L051303 (2024)

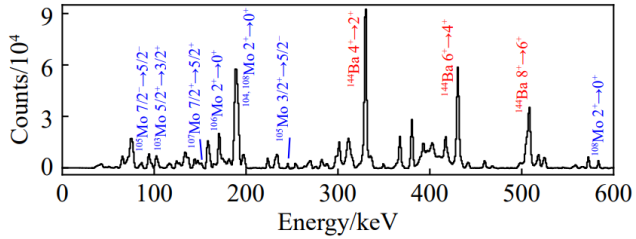
Courtesy: Dr. L. Mu(SDU)

Output from 2021 campaign





(a) ^{143}Ba 的 343-keV γ 跃迁($13/2^- \rightarrow 9/2^-$)开窗



(b) ^{144}Ba 的 199-keV γ 跃迁($2^+ \rightarrow 0^+$)开窗

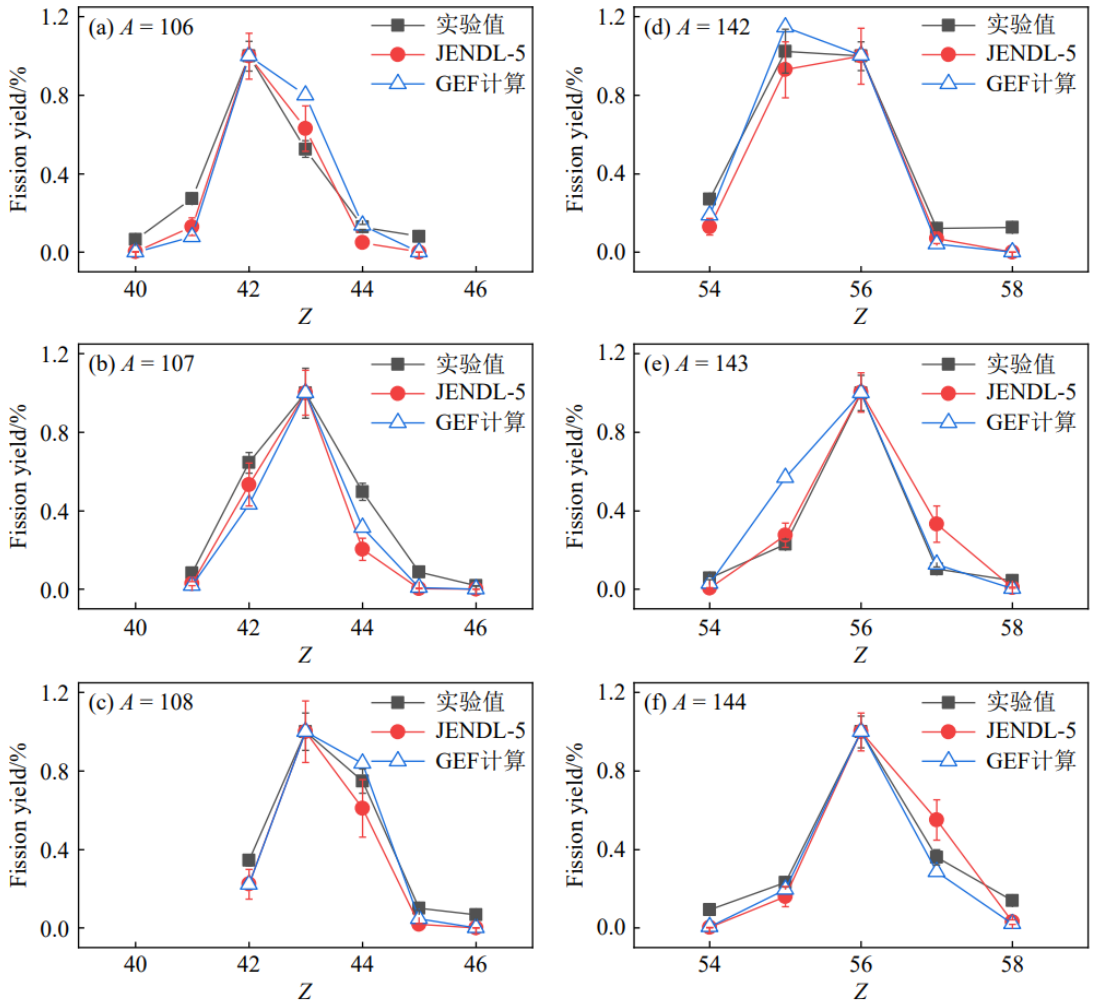


图 5　同量异位素的相对产额分布图(在线彩图)

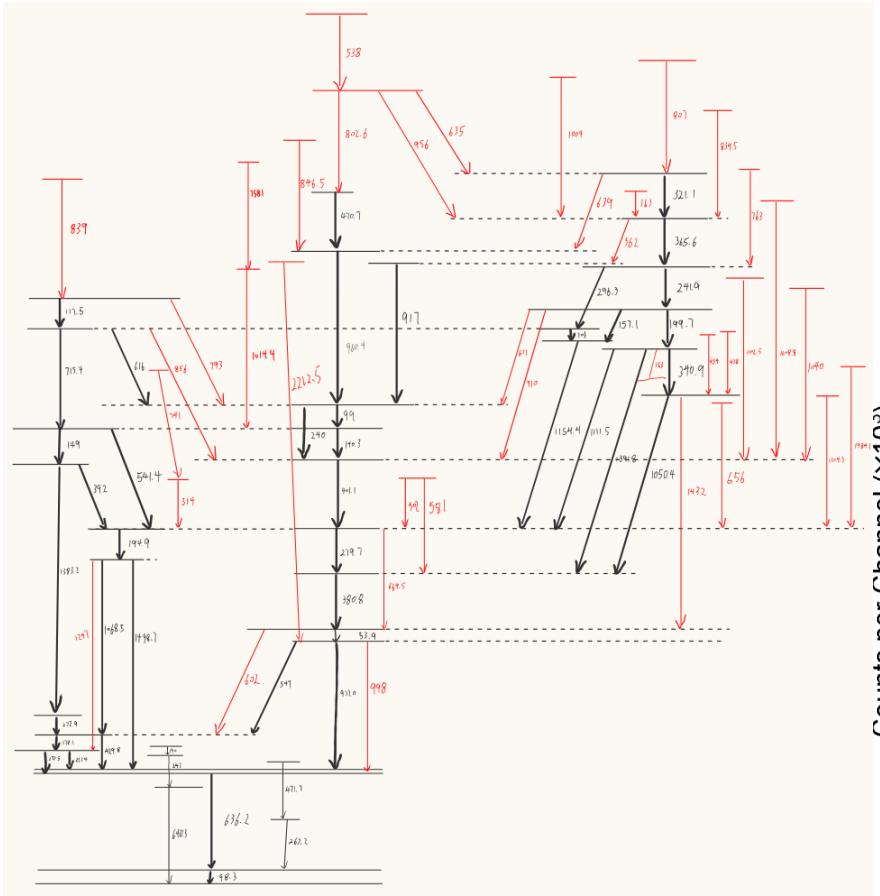
实心方块为实验值；实心圆为JENDL-5参考数据；空心三角为GEF计算结果。

Courtesy:Dr. Zheng Yun（CIAE）

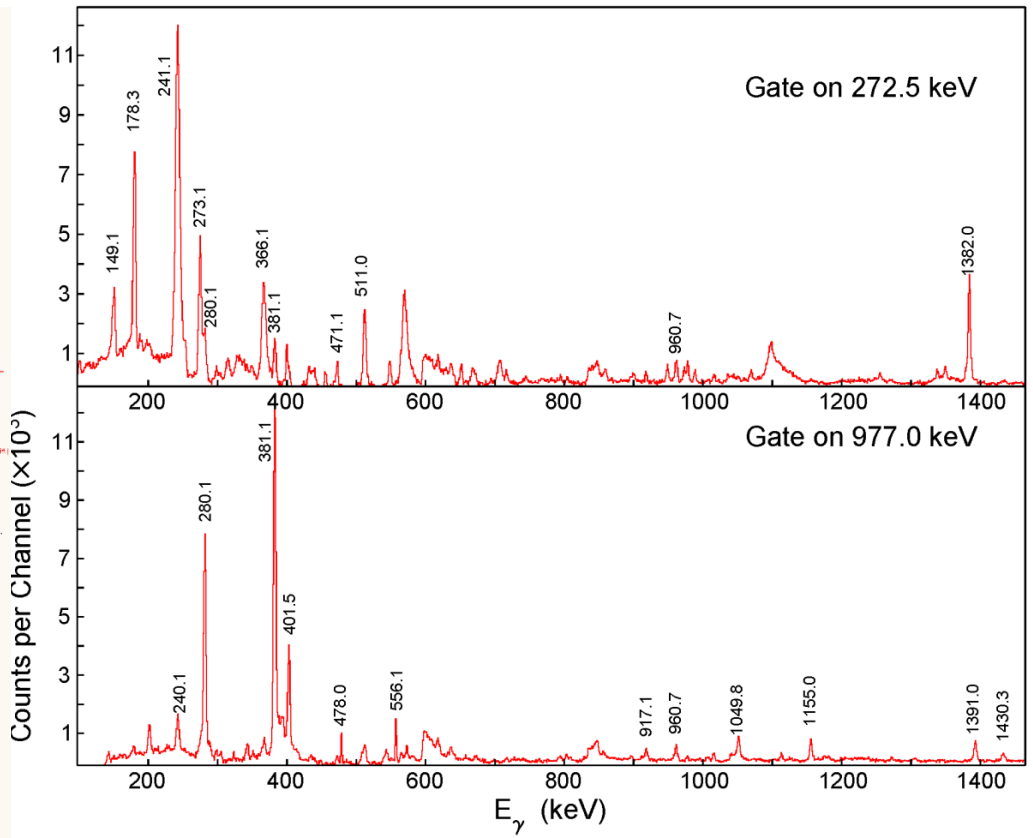
原子核物理评论 41卷, 2期: 687 - 692 (2024)

Output from 2021 campaign

Level scheme of 141Pr

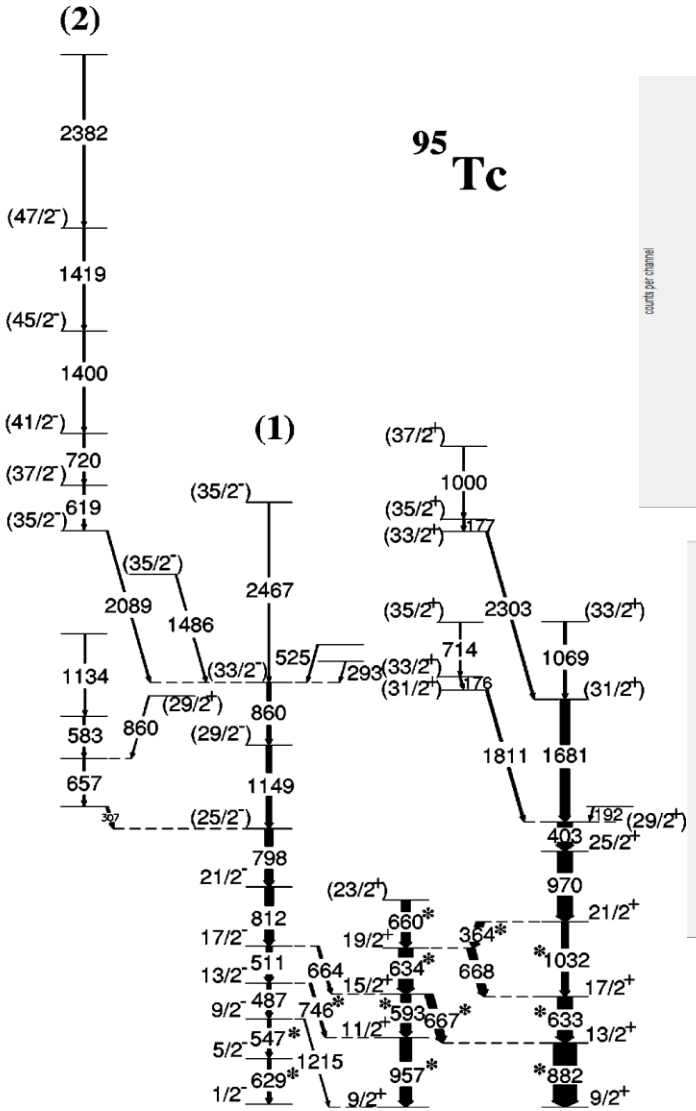


Gated specra

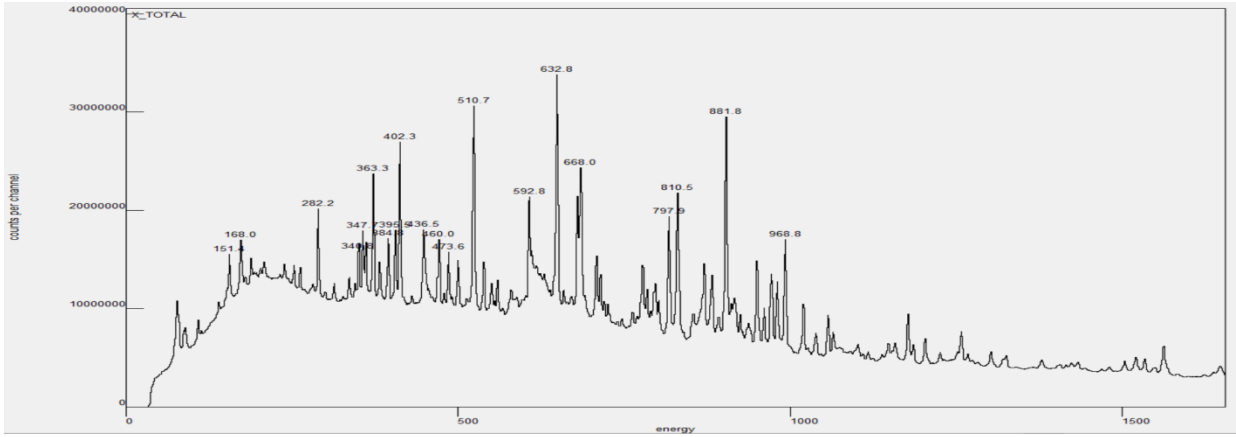


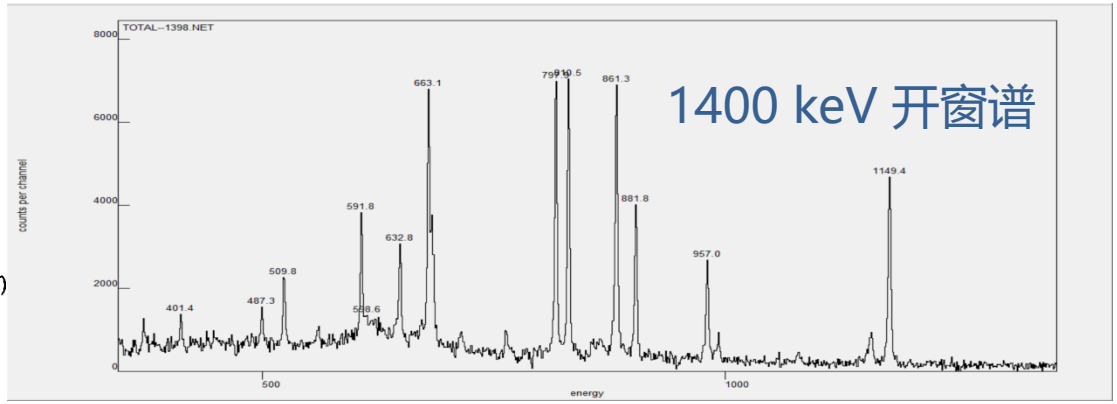
Courtesy: Dr. Wang Jianguo (IMP) && Dr. Ma Keyan(JLU)

Output from 2021 campaign



$^{12}C@62MeV+^{87}RbCl$



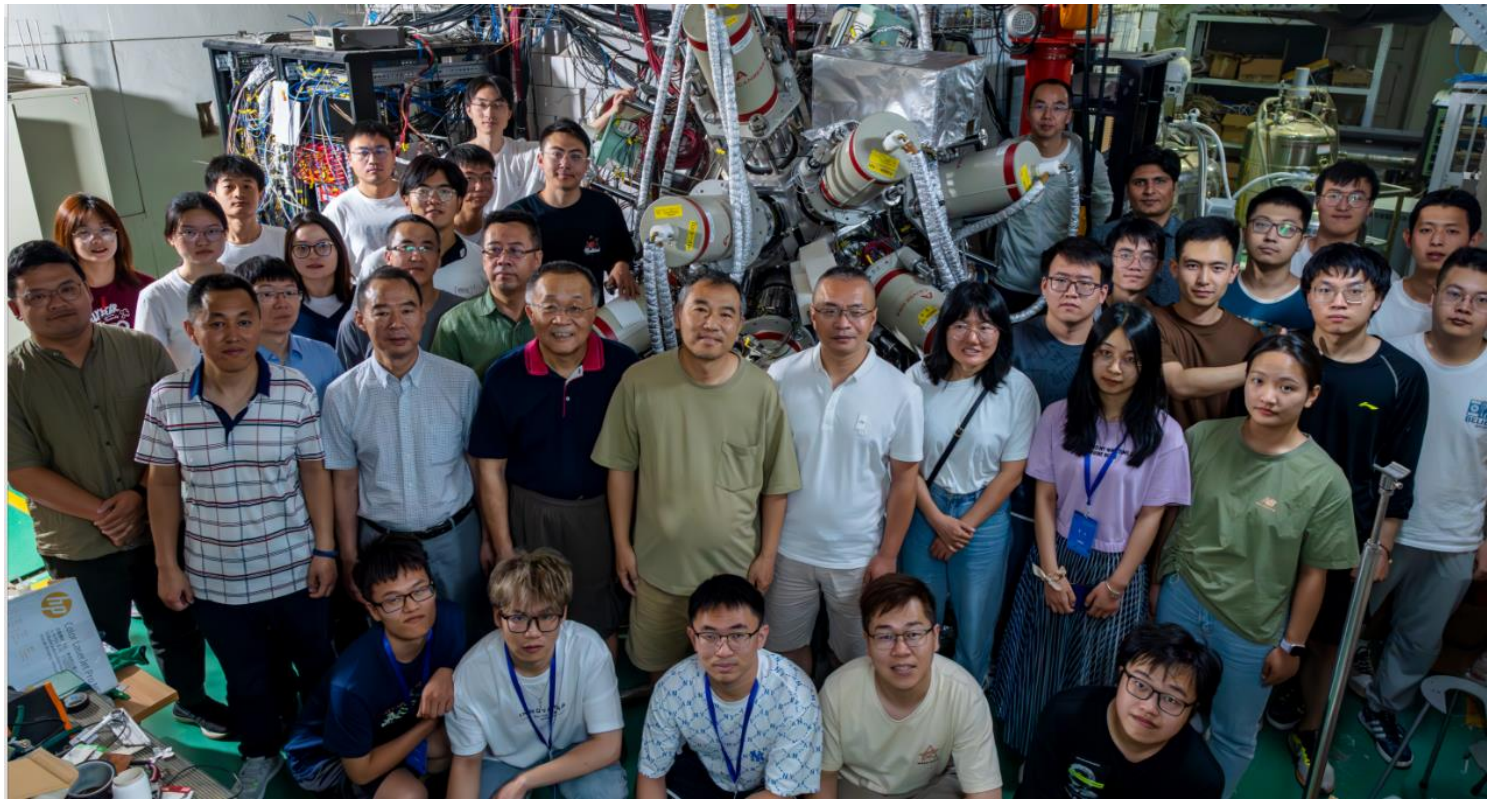


统计量： 两重统计量~150 × 10^6/小时(单探头平均计数率~12k/s)

Courtesy: Dr. Ding Bing (IMP)

Gamma campaign @2023

Gamma campaign @2023

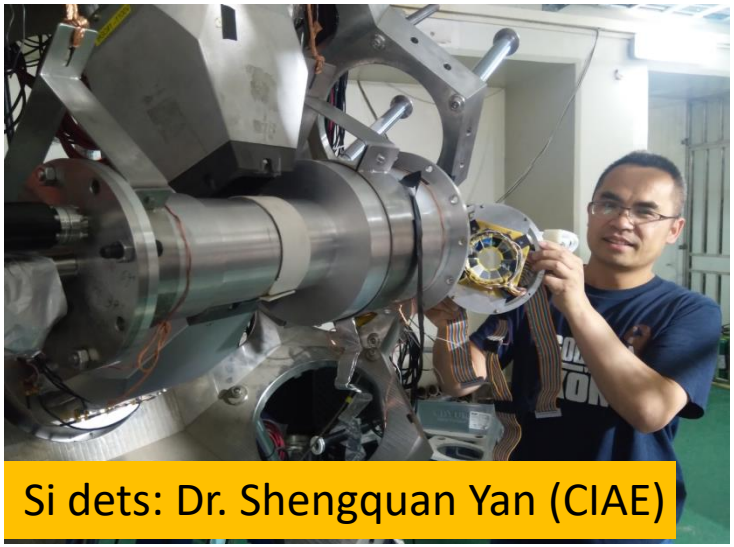


16 Coaxial HPGe
5 Clover HPGe
10 LaBr3
Si telescope
CsI ball

- IMP - Institute of Modern Physics, CAS （Dr. Fang Yongde, Dr. Guo Song）
- CIAE - China Institute of Atomic Energy （Dr. Yan Shengquan, Dr. Wu Xiaoguang）
- PKU - Peking University （Dr. Li Xiangqiang）
- etc.

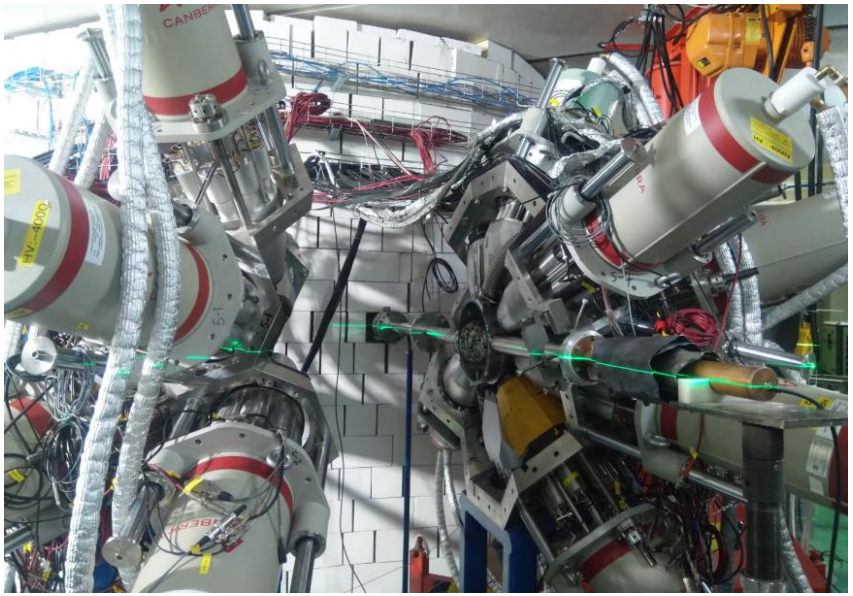
More than 500 hours beam time

Gamma campaign @2023

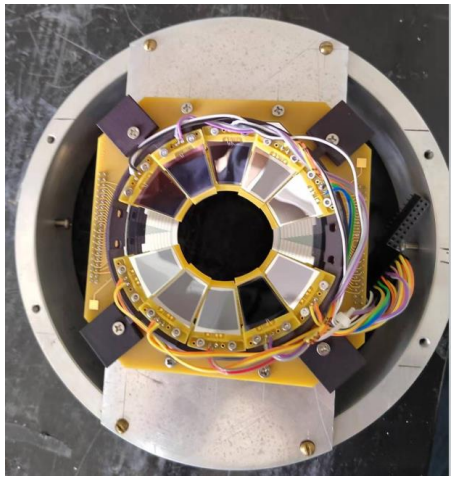


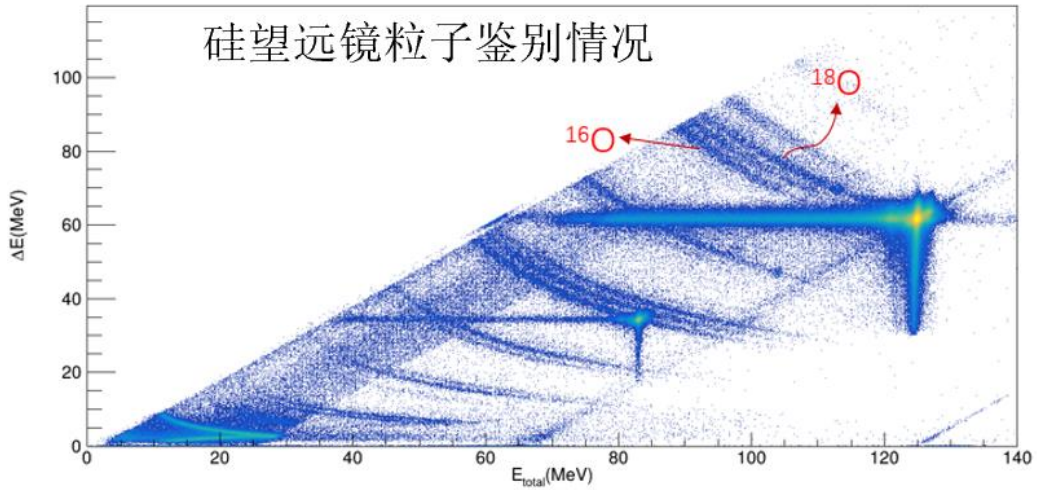
Si dets: Dr. Shengquan Yan (CIAE)

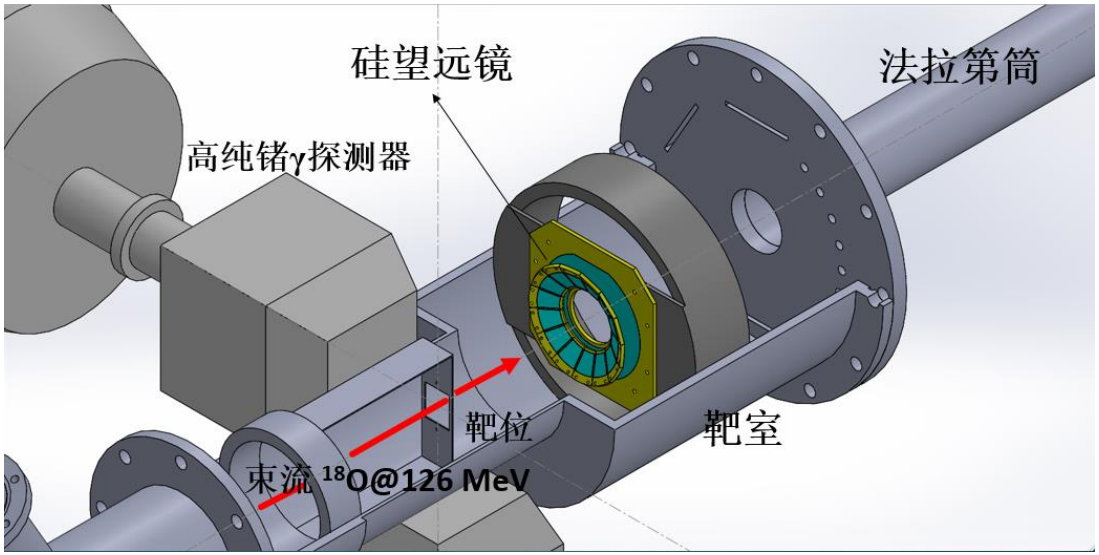
CsI dets: Dr. Yongde Fang (IMP)

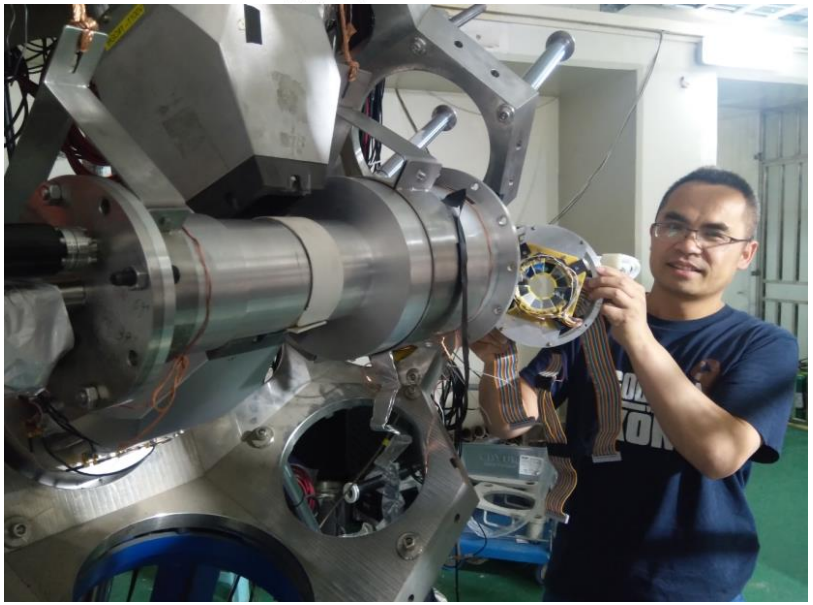


Gamma campaign @2023



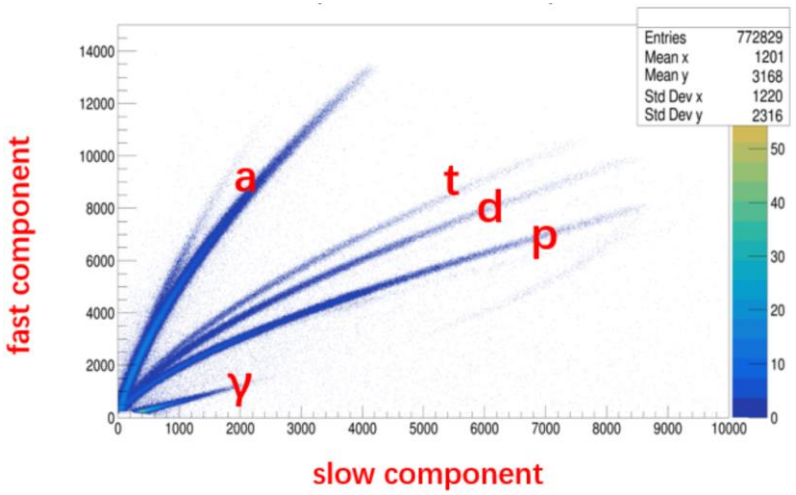


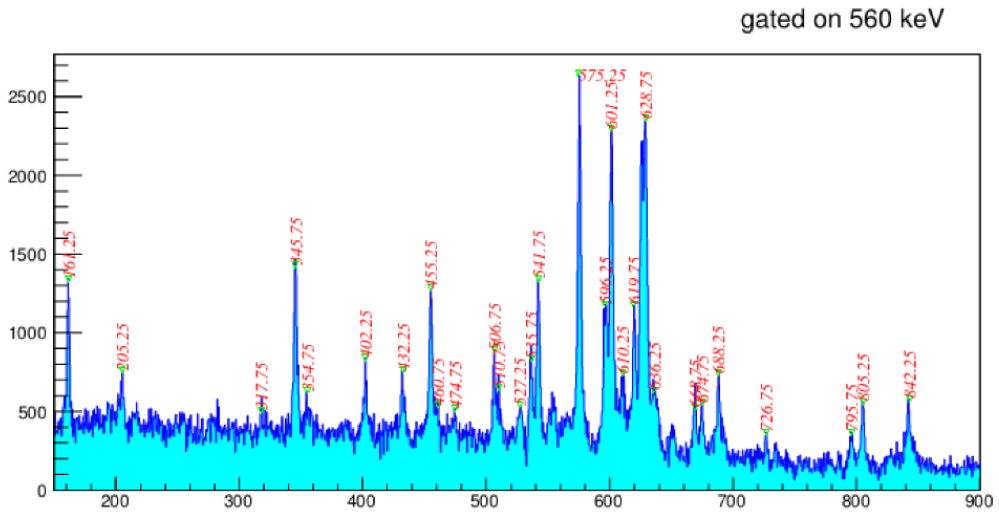




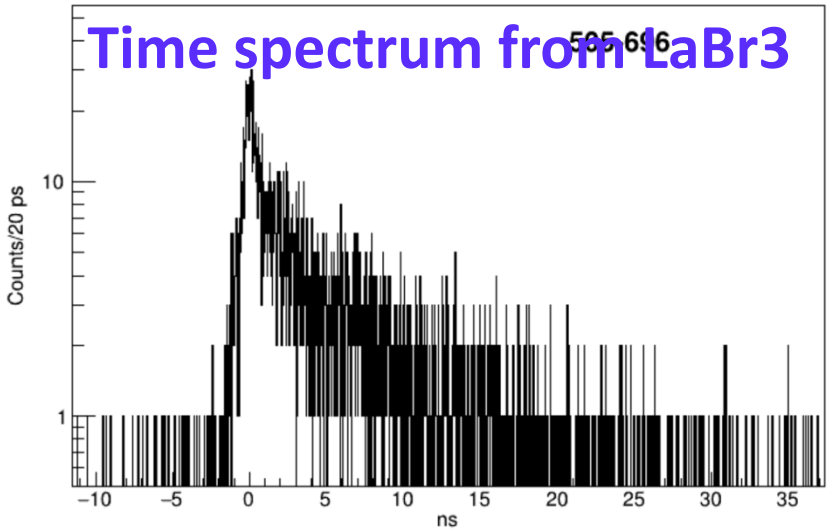
Courtesy: Dr. Yan Shengquan(CIAE)

Gamma campaign @2023

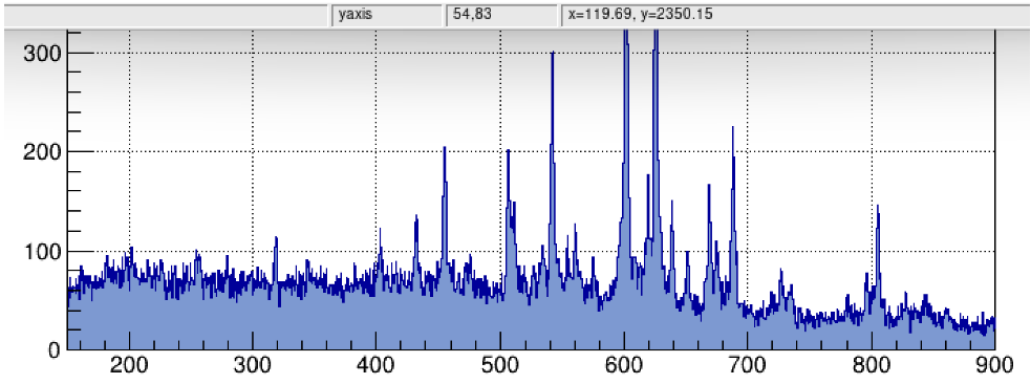




Time spectrum from LaBr3

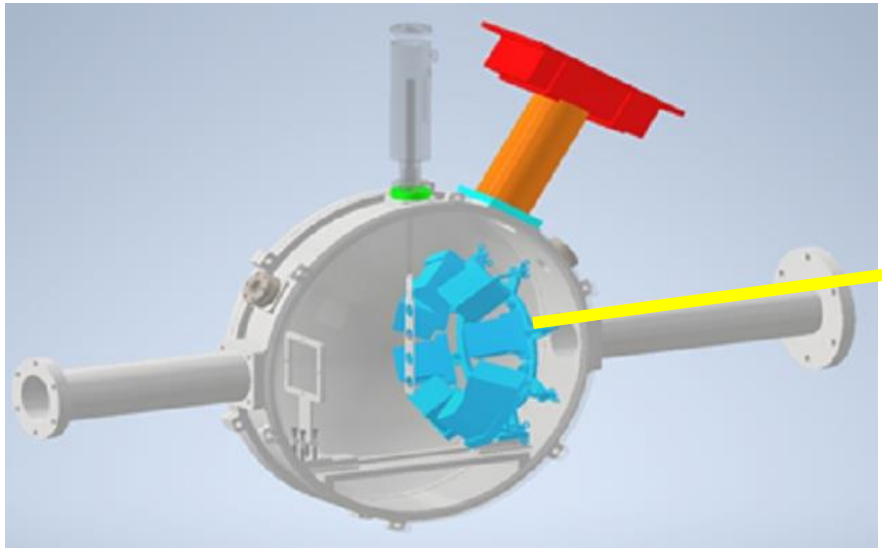


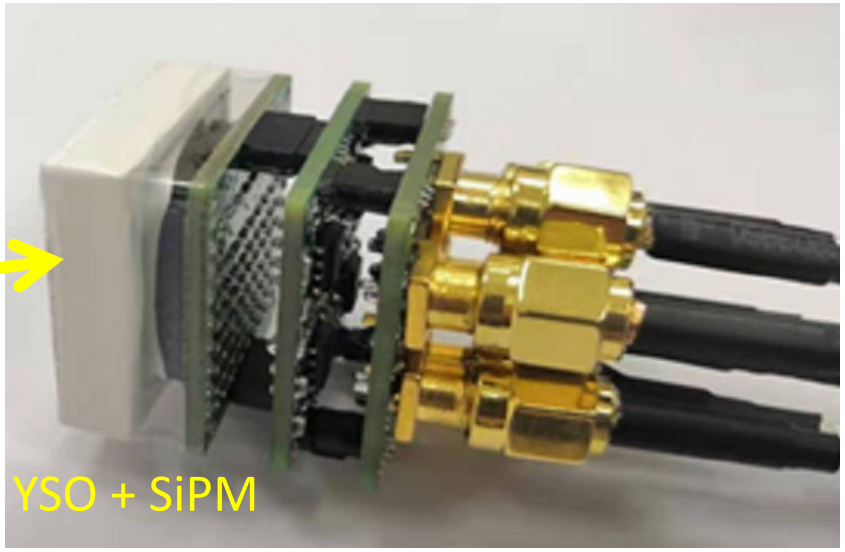
Courtesy: Dr. Fang Yongde (IMP)

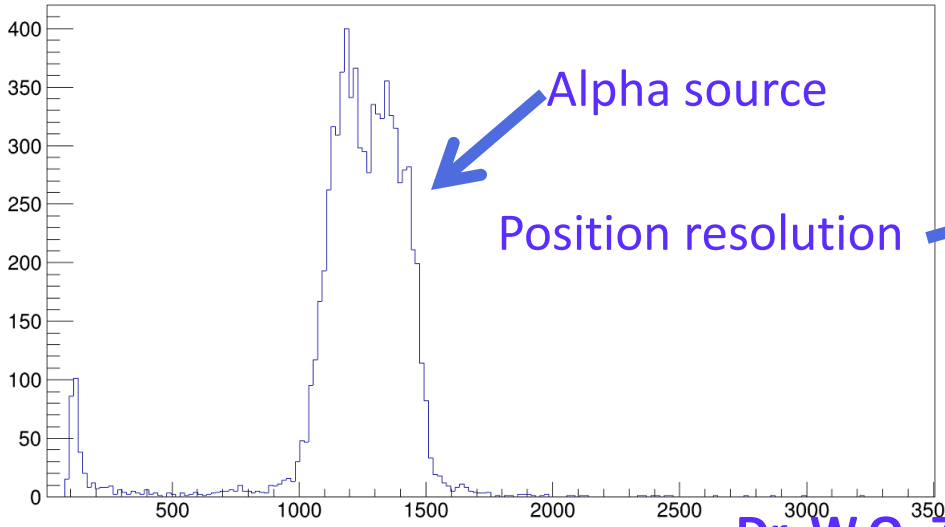


Gamma spectra w and w/o particle coincidence

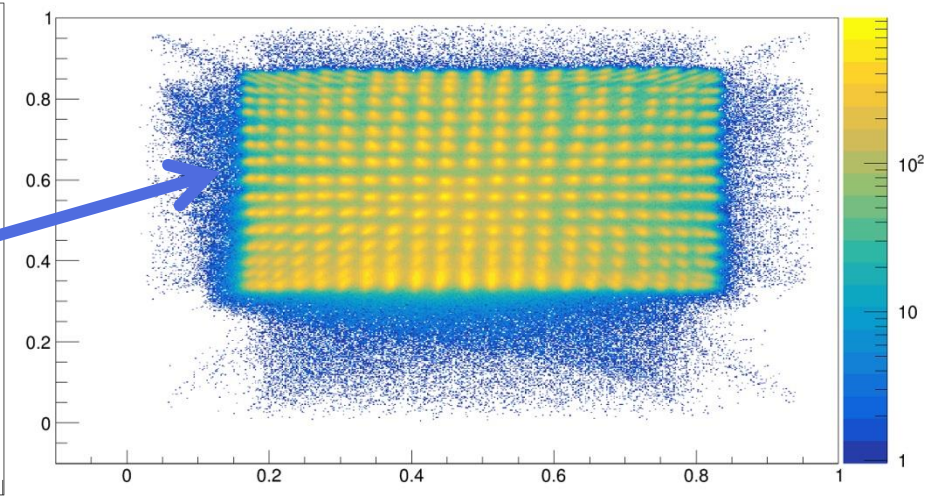
YSO array development @ IMP





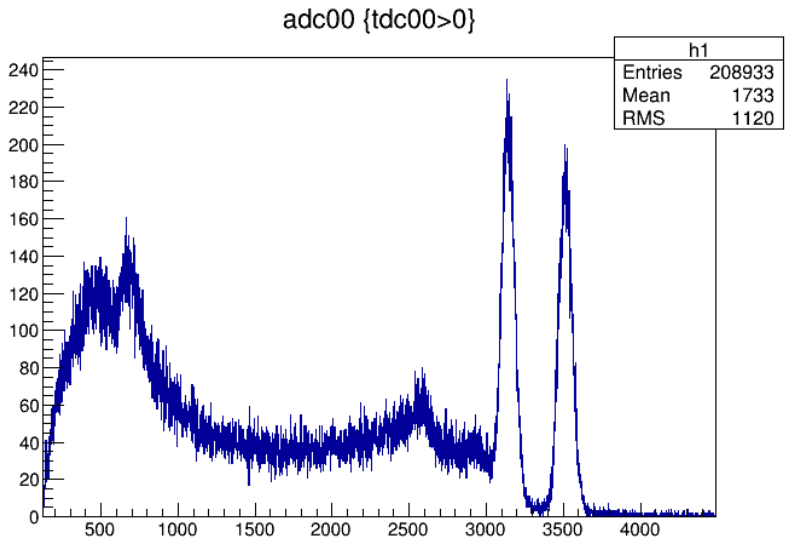


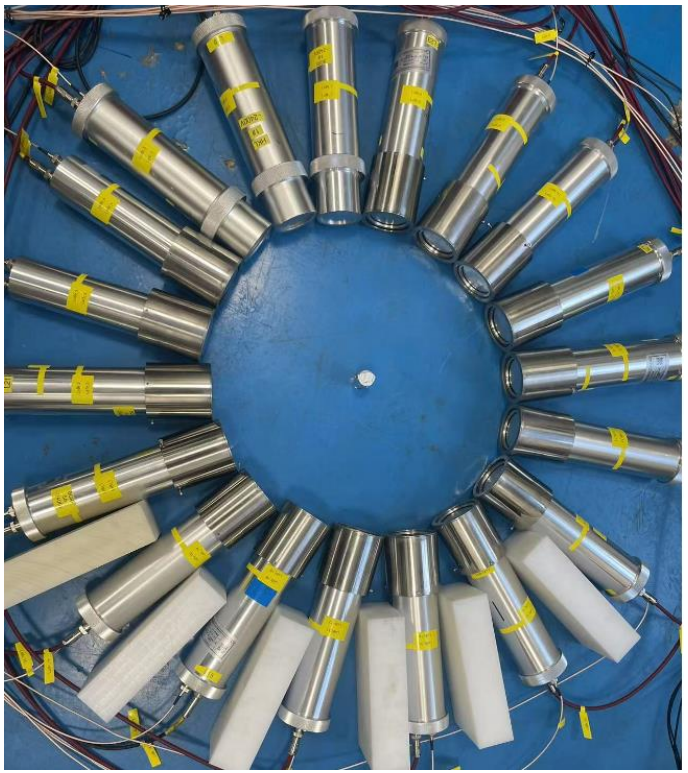
Position resolution



Dr. W.Q. Zhang (IMP) 2024 beam time

$LaBr_3$ detector development



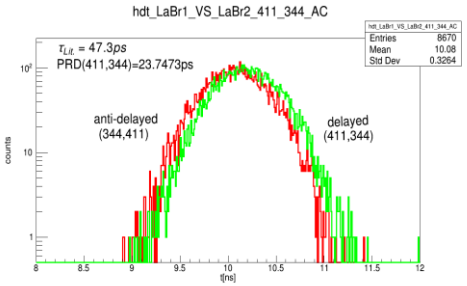


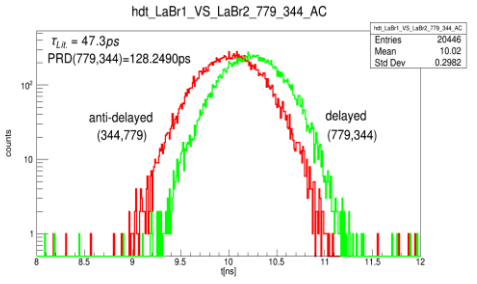
近物所 $LaBr_3$(Ce) 探测器

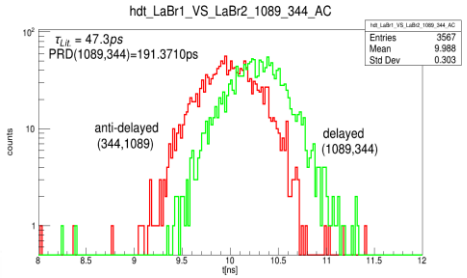
NO.	NAME	VALUE	ERROR
1	Constant	3.96314e+02	9.93133e+00
2	Mean	-1.54411e+02	1.01790e-01
3	Sigma	5.14260e+00	7.90737e-02

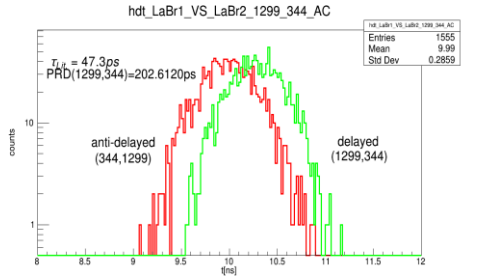
Time resolution:320 ps (FWHM)

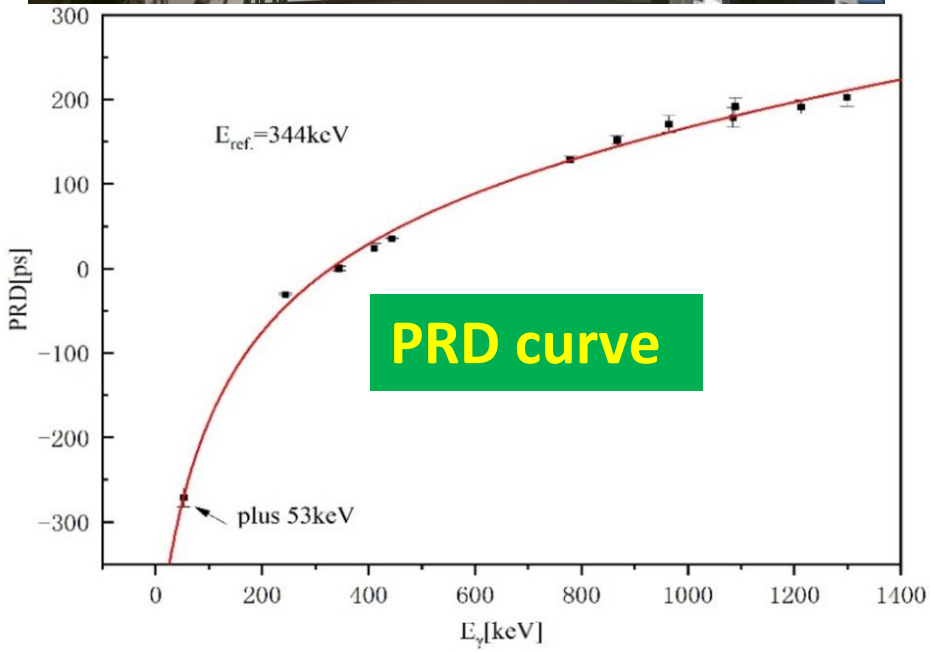
$LaBr_3$ detector development @ IMP



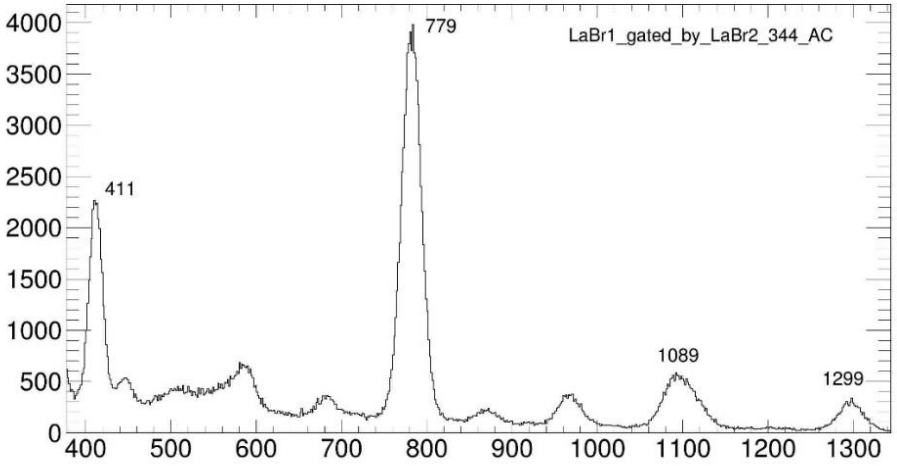






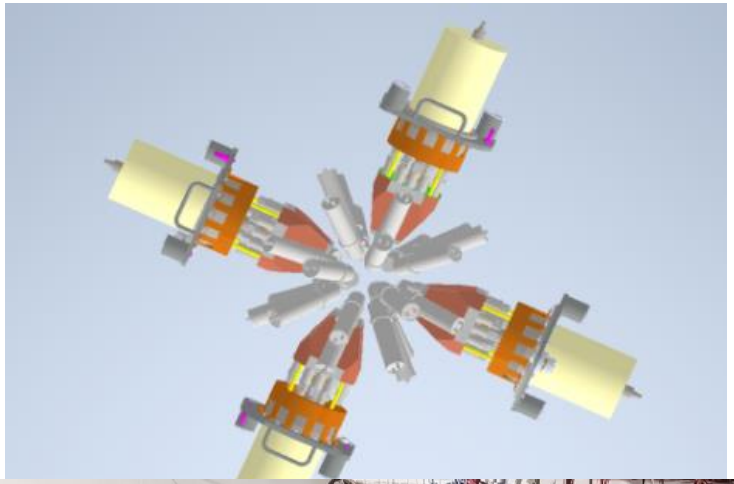


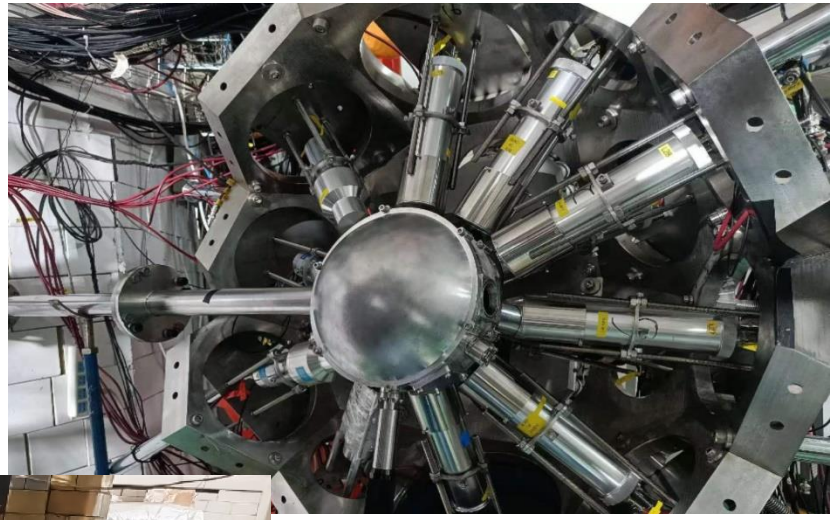
PRD curve



Courtesy: X. Ma (IMP)

HPGe - $LaBr_3$ hybrid array development @ IMP



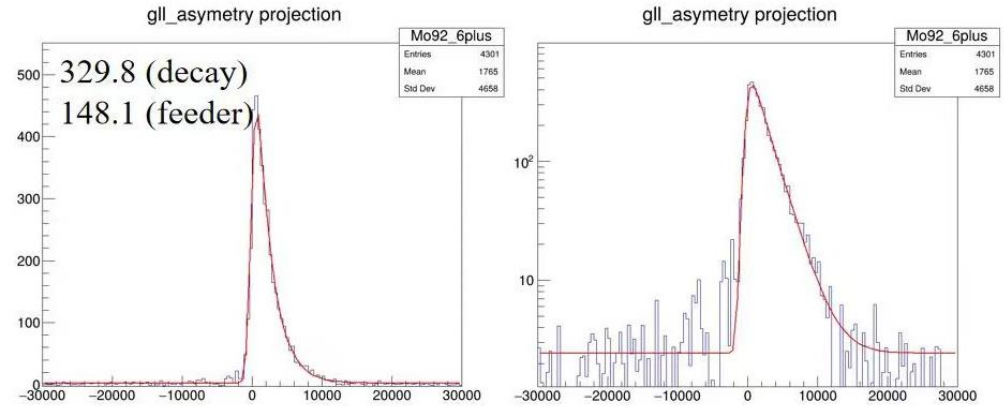


LaBr3+HPGE Hybrid
160 hours beam time

- Sun Yat-Sen University
  (Dr. Zhang Guangxin)
- Shenzhen University
  (Dr. Hu Shipeng)
- ^{36}Ar beam

HPGe - $LaBr_3$ hybrid array development @ IMP

Mo-92 6^+ TimeWindow = 40 ns
Ge: 1509 keV || 773 keV
All Det. Data

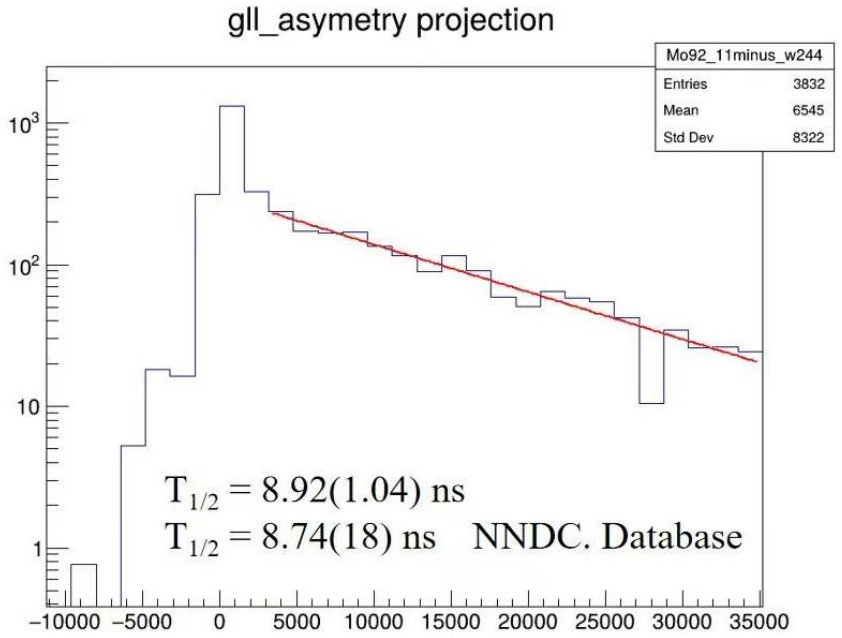


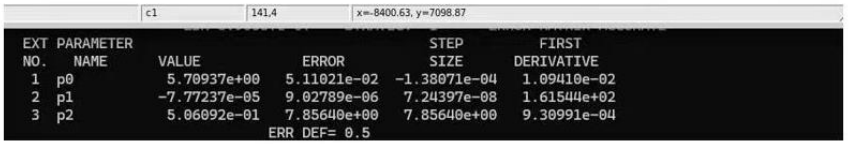
Fit Range:(-30000,30000)

$\tau = 2209.9(49.17)$ ps
$\tau = 2200(20)$ ps PHYSICAL REVIEW C 108, 064313 (2023)

$T_{1/2} = 1.53(0.34)$ ns
$T_{1/2} = 1.53(4)$ ns NNDC. Database

Mo-92 11^- TimeWindow = 40 ns
Ge:111 || 2064 || 244 || 773 || 1509
All Det. Data





EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	p0	5.70937e+00	5.11021e-02	-1.38071e-04	1.09410e-02
2	p1	-7.77237e-05	9.02789e-06	7.24397e-08	1.61544e+02
3	p2	5.06092e-01	7.85640e+00	7.85640e+00	9.30991e-04

ERR DEF= 0.5

Courtesy: Dr. Zhang Guangxin (SYSU)

Publications from HIRFL + IMP-DRAGON

N. T. Zhang, et al., Phys. Rev. C 90 (2014) 024621

Y. D. Fang, et al., Phys. Rev. C 91 (2015) 014608

Y. D. Fang, et al., Phys. Rev. C 93 (2016) 034615

G. S. Li, et al., Phys. Rev. C 99 (2019) 054617

G. S. Li, et al., Phys. Rev. C 100 (2019) 054601

G. S. Li, et al., Phys. Rev. C 101 (2020) 014606

G. S. Li, et al., Phys. Rev. C 102 (2020) 054607

A. Rohilla, et al., Nuclear Physics A 1006 (2021) 122116

A. Rohilla, et al., Applied Radiation and Isotopes 199 (2023) 110863

L. Mu, et al., Phys. Rev. C 109 (2024) L051303

Z. X. Zhou, et al., Phys. Rev. C 110 (2024) 024309

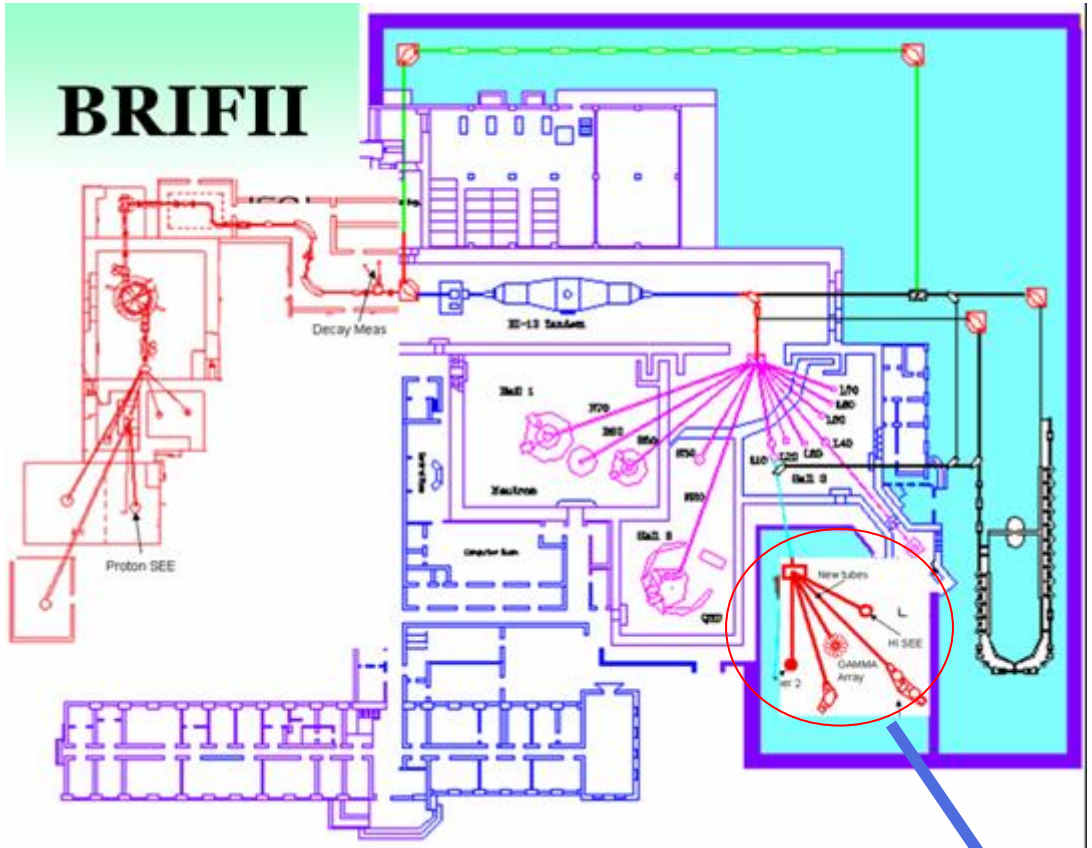
S. Guo, et al., Physics Letters B 828 (2022) 137010

S. Guo, et al., Phys. Rev. Lett. 128 (2022) 242502

J. J. Liu, et al., Phys. Rev. Lett. 128 (2022) 242502

… …

Main facilities depend on …



γ-spectroscopy studies

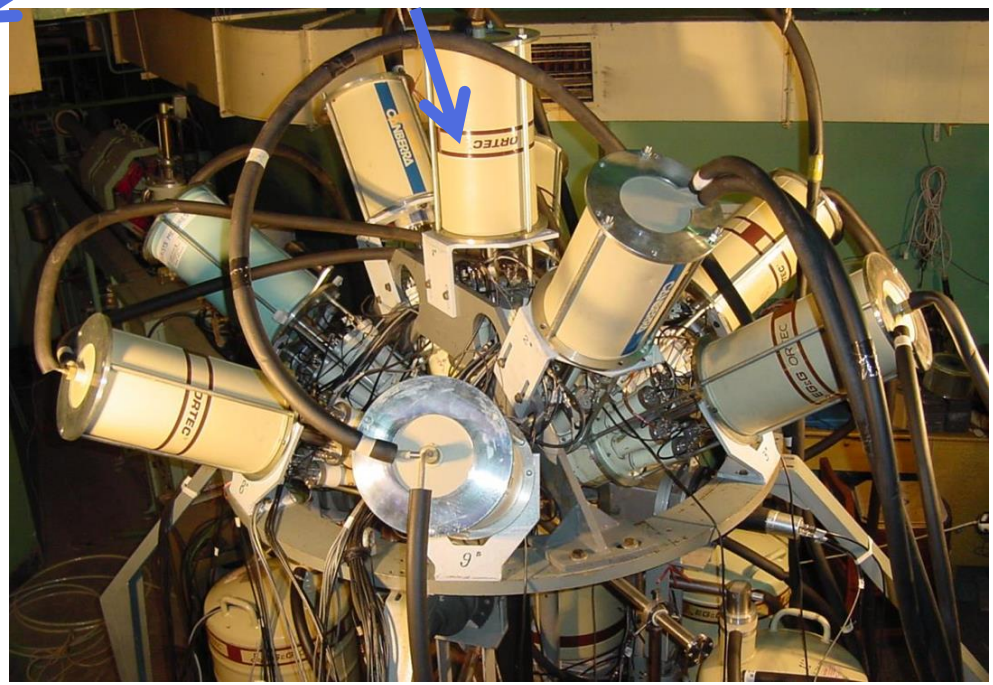
Beijing, HI-13 tandem

Lanzhou, HIRFL

Facility @ CIAE

HI-13 tandem accelerator

HPGe array



Picture of gate

Anti-Compton shield (AC)

Courtesy: Dr. Zheng Yun (CIAE)

Photos during experiment @ CIAE

Collaborations among universities and institutes

Courtesy: Dr. Zheng Yun (CIAE)

Cooperation of new era

➢Available γ-ray detectors:

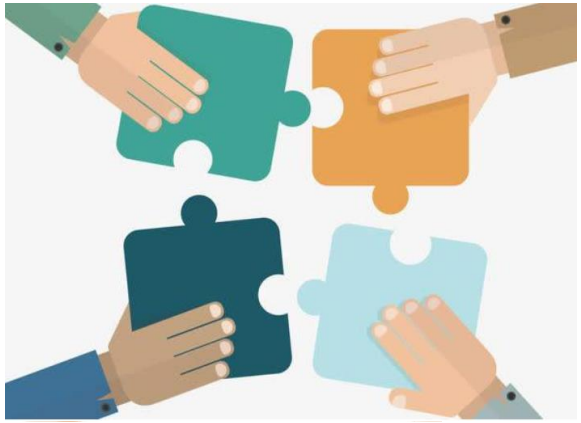
IMP (Lanzhou): HPGe > 16; Clover > 8; $LaBr_3$ > 4

CIAE (Beijing): HPGe > 10; $LaBr_3$ > 5

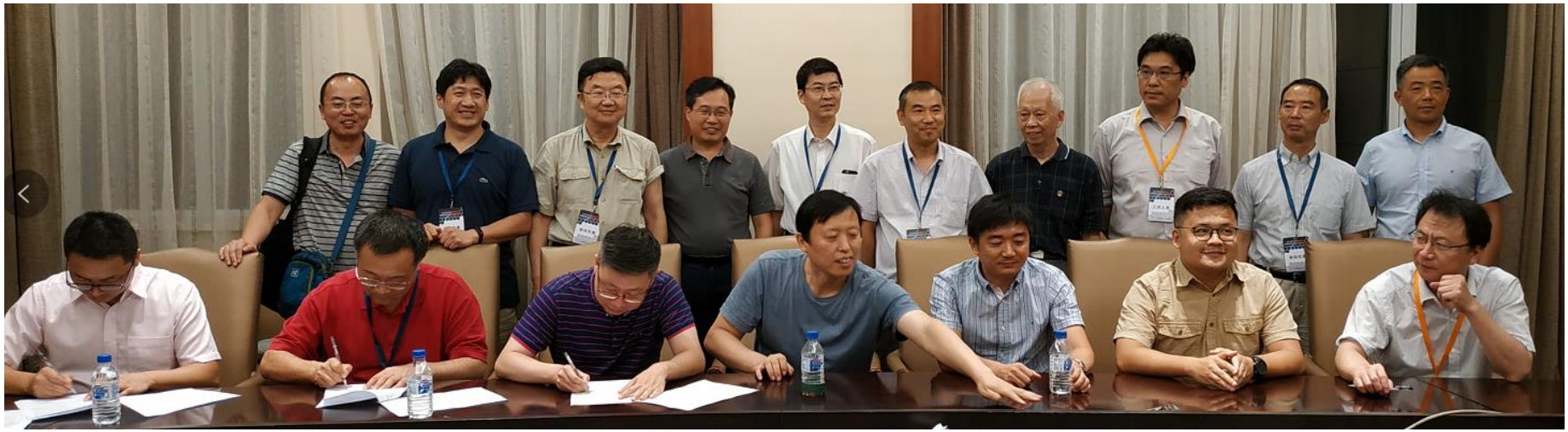
Shandong U. (Weihai): HPGe + $LaBr_3$ > 10

Beihang U. (Beijing): Clover + $LaBr_3$ > 6

… …

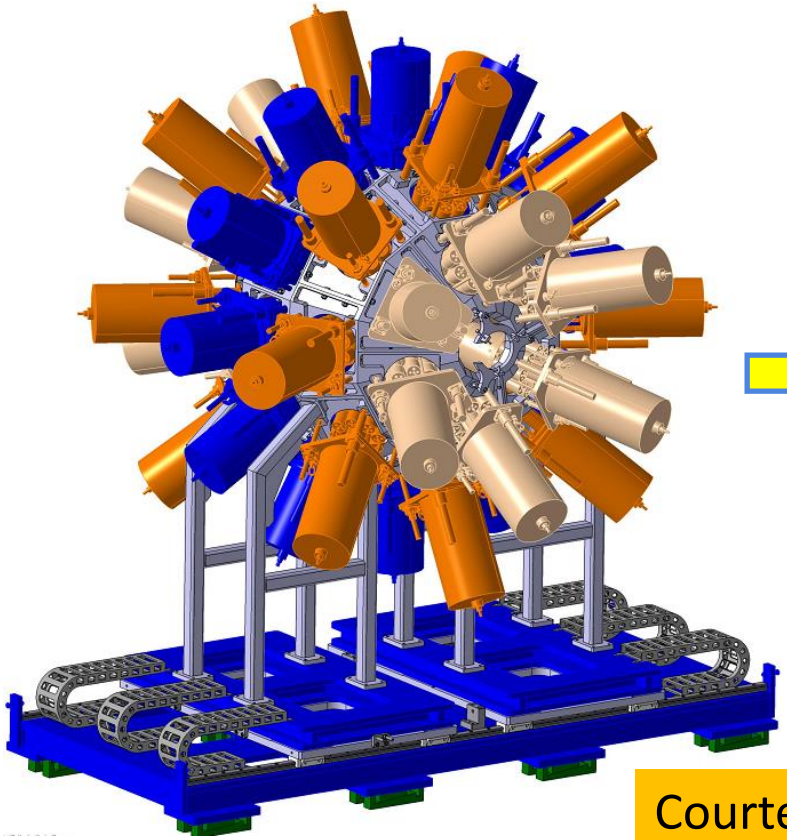


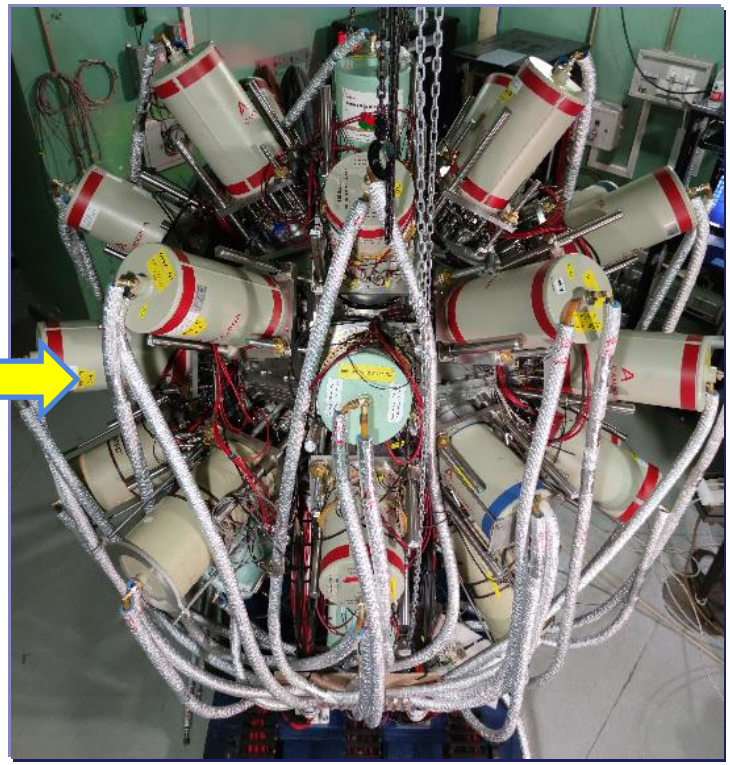
➢New cooperative agreement (2019)



To form a gamma pool in China…

China conjoint gamma array





Courtesy: Dr. Zheng Yun (CIAE)

16 coaxial HPGes (70%)-IMP

8 Clover HPGes (160%)-IMP

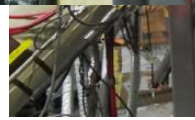
7 coaxial HPGes (35%)-CIAE

2 coaxial HPGes (70%)-CIAE

1 Clover HPGe（120%）-BUAA

2 coaxial HPGes (30%)-SDU

Experimental campaign at 2022 & 2025



Courtesy: Dr. Zheng Yun (CIAE)

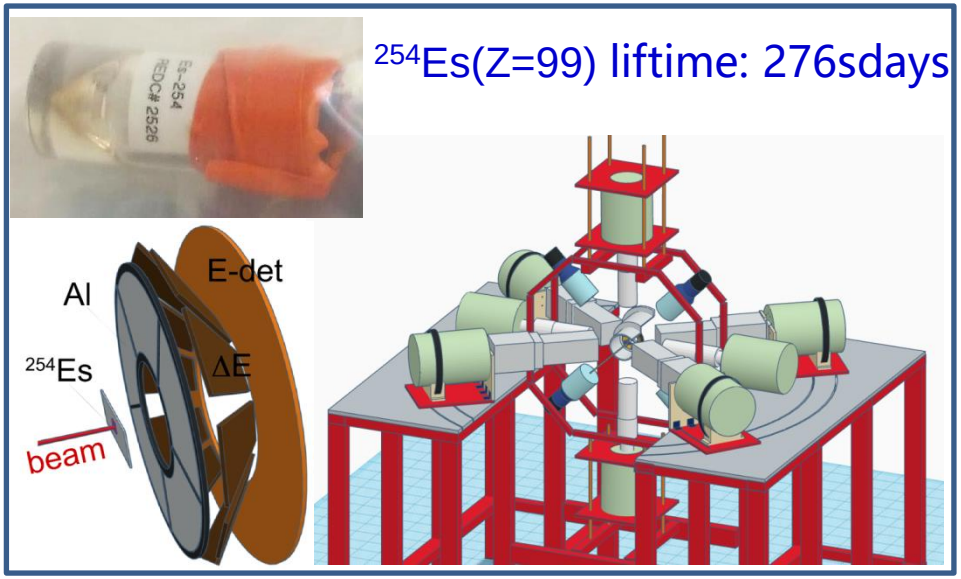
Contents

目录
CONTENTS

Successful collaboration with JAEA

Nuclear structure study on ^{256,258}No

$^{10}B+^{254}Es \longrightarrow {}^{256,258}No+\alpha xn$



MOU协议

For the Advanced Science Research Center,
Japan Atomic Energy Agency
(ASRC/JAEA)

Prof. Dr. Sadamichi Maekawa
Director General

Date: Jan. 15, 2018

For Institute of Modern Physics,
Chinese Academy of Sciences
(IMP/CAS)

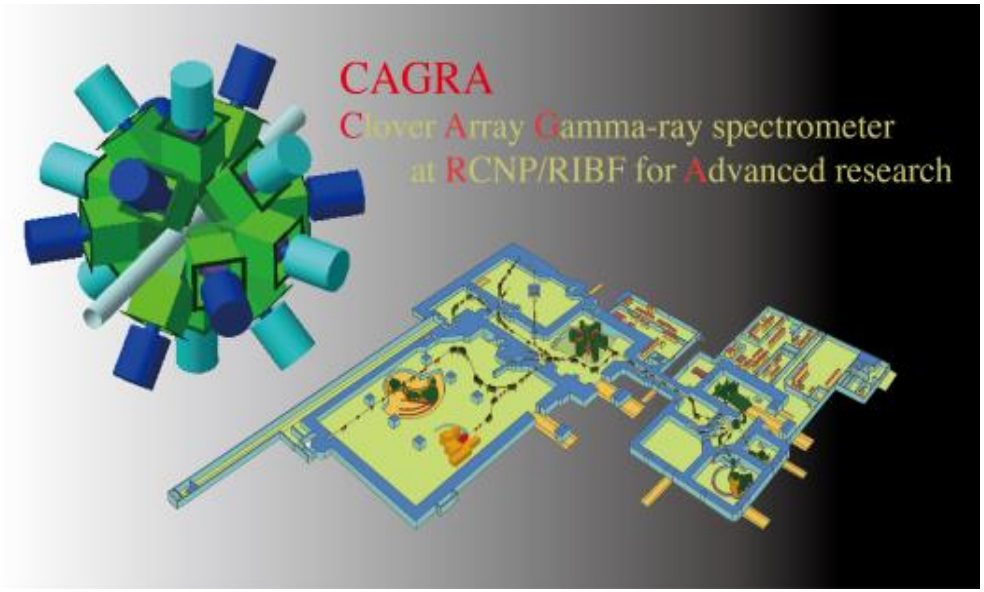
Dr. Guoqing Xiao
Director

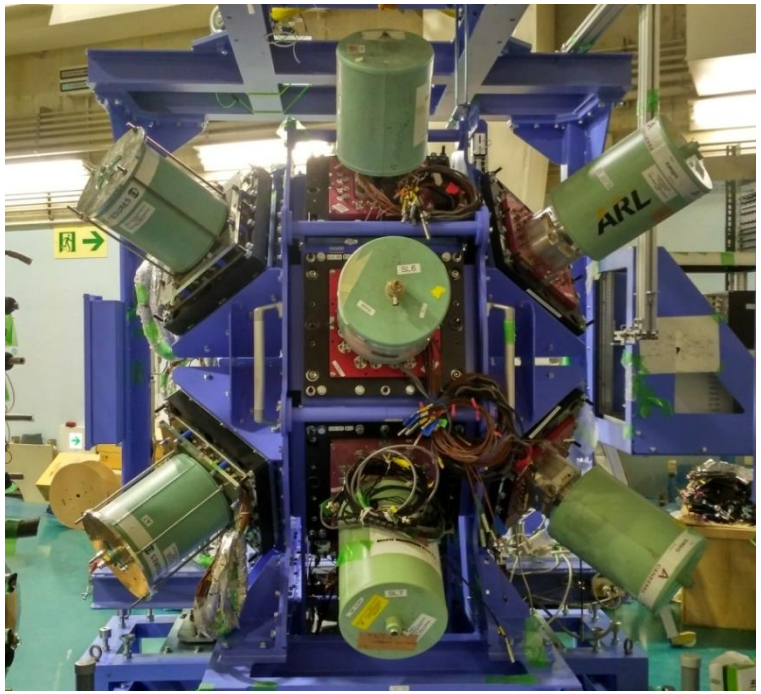
Date: Jan. 29, 2018

JAEA: Dr. Katsuhisa Nishio, *et al.*
IMP: Dr. Fang. Y. D, *et al.*

4 Clover detectors were employed in the project

Successful collaboration with RCNP





Collaboration: USA, Japan, China

16 Clover detectors + Acs, 2 from IMP

Performed experiment (2017):

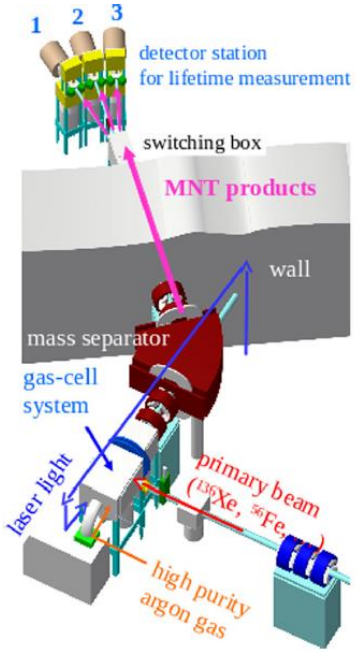
High-Spin States in ^{91}Y, ^{93,94}Nb and ^{94}Zr, by Dr. Liu. M. L *et al.*

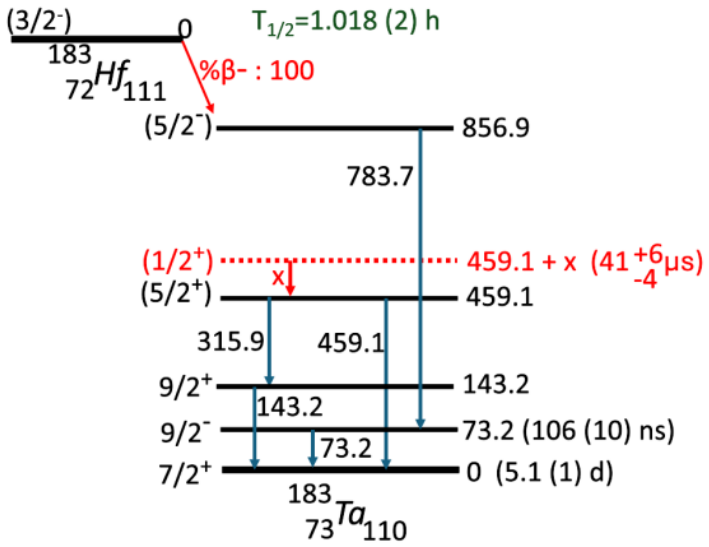
Approved beam time:

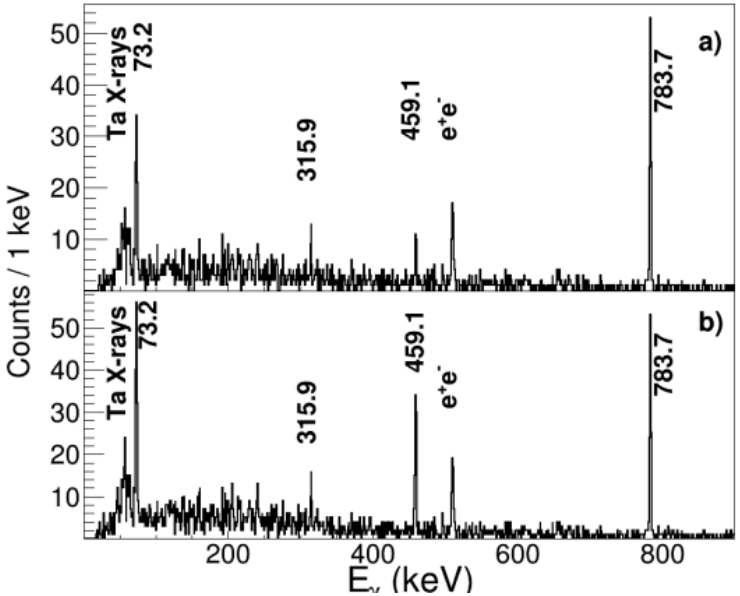
Linear Polarization Measurement in Wobbling Bands, by Dr. Guo. S *et al.*

Successful collaboration with KEK

The KISS project







4 IMP Clover detectors were employed for the project at 2020

They were employed again for the project at 2023

WNSC: Dr. Yutaka Watanabe, *et al.*

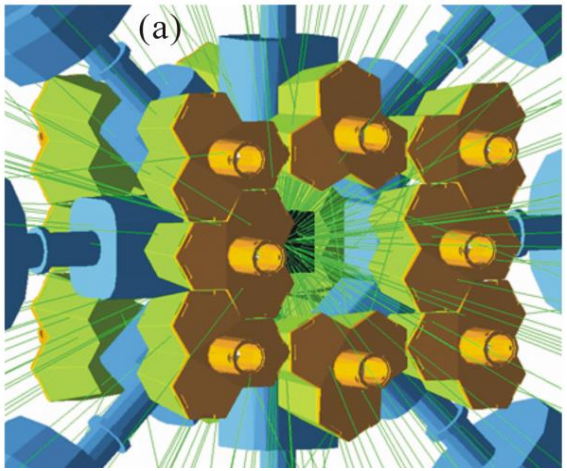
C2urie project at RIKEN

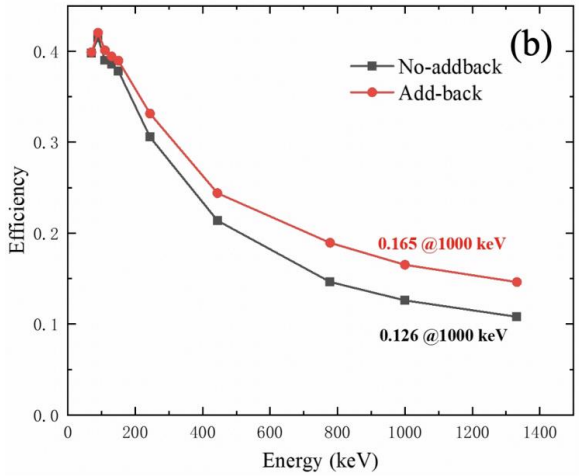
Decay Spectroscopy at the Radioactive Isotope Beam Factory (RIBF) at RIKEN

Organizers

Alejandro Algora
Andrea Jungclaus
Guang-Shun Li
Magda Gorska-Ott
Pieter Doornenbal
Shunji Nishimura
Yung Hee Kim

March 27 – 29, 2025 Valencia





Spokesperson (Only one person, Multiple spokespersons not acce			
Name	Shunji Nishimura		
Institution	RIKEN Nishina Center		
Title of position	Senior Researcher		
Address	2-1 Hirosawa, 351-0198 Wako, Japan		
Tel.		Fax	+8
Email	nishimu@ribf.riken.jp		

Co-Spokespersons:			
Name	Andrea Jungclaus		
Institution	Instituto de Estructura de la Materia, CSIC		
Title of position	Investigador Científico		
Address	C/ Serrano 113bis, E-28006 Madrid, Spain		
Tel.	+34 91 561 6800 ext. 943215	Fax	+3
Email	andrea.jungclaus@csic.es		

Name	Pieter Doornenbal		
Institution	RIKEN Nishina Center		
Title of position	Senior Researcher		
Address	2-1 Hirosawa, 351-0198 Wako, Japan		
Tel.	+81 048 462 1111 Ext. 4750	Fax	+8
Email	pieter@ribf.riken.jp		

Name	Magda Górska-Ott		
Institution	GSI		
Title of position	Group Leader		
Address	Planckstrasse 1, D-64291 Darmstadt		
Tel.	+49 6159 71 2917	Fax	+4
Email	m.gorska@gsi.de		

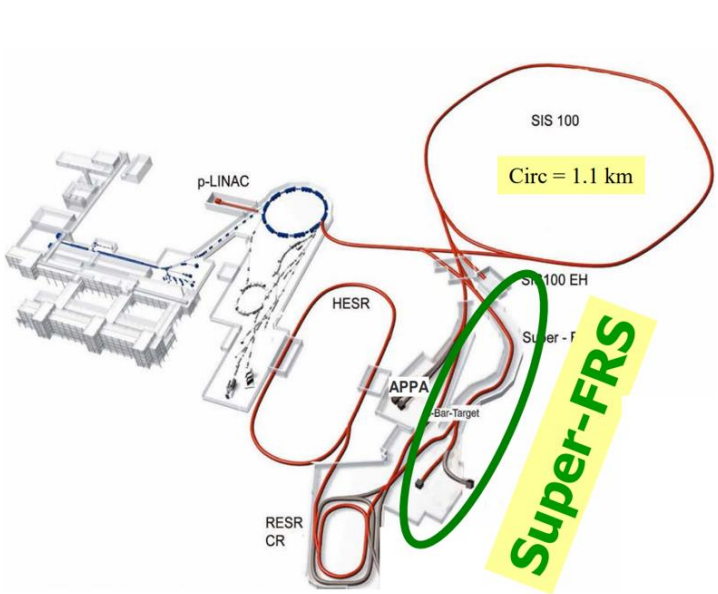
Name	Guang-shun LI		
Institution	Institute of Modern Physics, CAS		
Title of position	Group Leader		
Address	509, Nanchang Road, 730000, Lanzhou, China		
Tel.	+86-931-4969301	Fax	+8
Email	ligs@impcas.ac.cn		

Name	Yung Hee KIM		
Institution	Institute for Basic Science		
Title of position	Group Leader		
Address	55 Expo-ro, Yuseong-gu, Daejeon, Korea		
Tel.	+82-042-878-9623	Fax	+82-042-878-9610
Email	yunghee.kim@ibs.re.kr		

Contents

目录
CONTENTS

Plan of DESPEC at Super-FRS @ FAIR

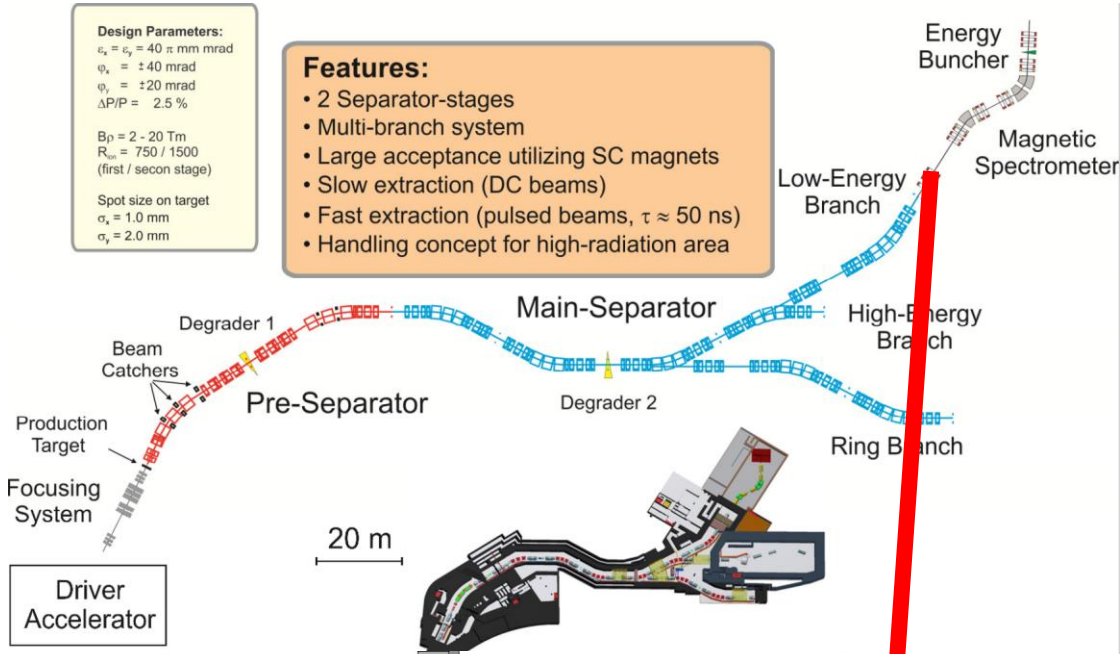


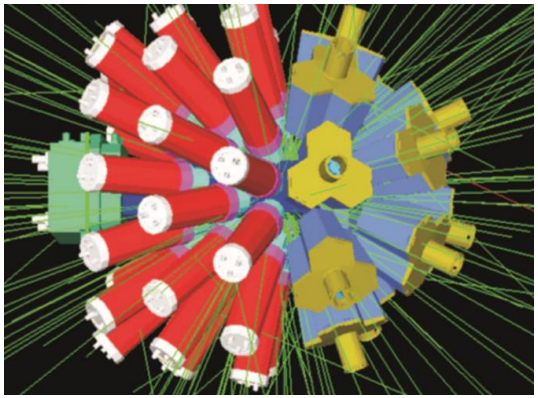
Design Parameters:
$\varepsilon_x = \varepsilon_y = 40\ \pi$ mm mrad
φ_x = ±40 mrad
φ_y = ±20 mrad
$\Delta P/P$ = 2.5 %

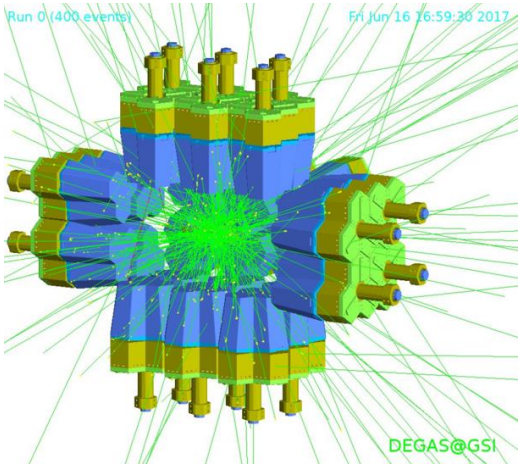
$B\rho$ = 2 - 20 Tm
R_{ion} = 750 / 1500
(first / secon stage)

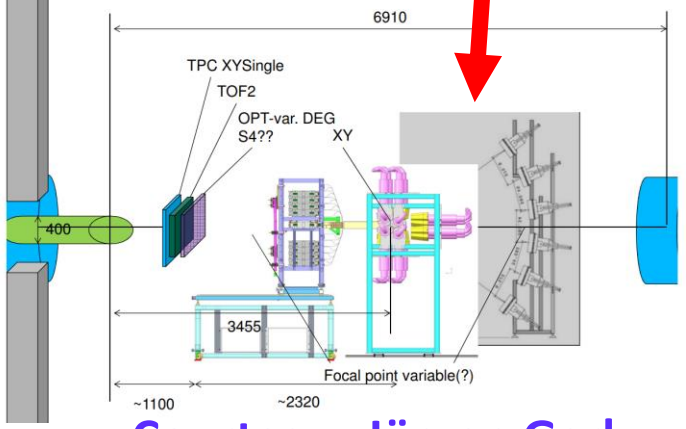
Spot size on target
σ_x = 1.0 mm
σ_y = 2.0 mm

Features:
- 2 Separator-stages
- Multi-branch system
- Large acceptance utilizing SC magnets
- Slow extraction (DC beams)
- Fast extraction (pulsed beams, $\tau \approx 50$ ns)
- Handling concept for high-radiation area









Courtesy : Jürgen Gerl

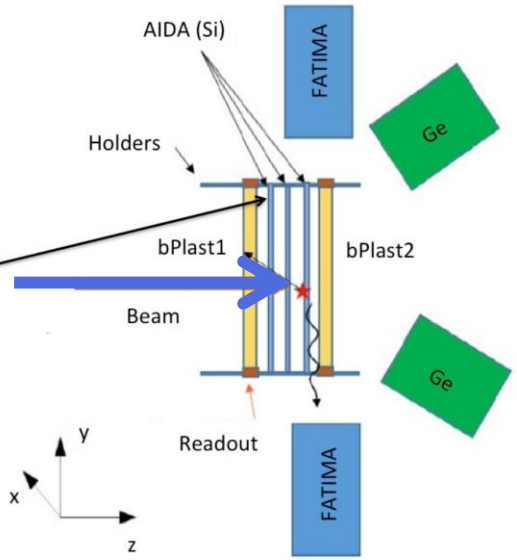
DESPEC Phase-0 programe 2022 – 2024 @ GSI

Experimental setup
@ implantation point

bPlast 1 and bPlast 2 ($H_{10}C_9$):
- 3mm thick
- (80x80) mm^2

AIDA Si:
- 1 mm thick
- 0.5 mm thick

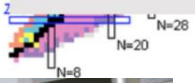
Distances:
bPlast 1
Air 15 mm
Si 1
Air 10 mm
Si 2
Air 10 mm
Si Si
Air 15 mm
bPlast 2



Rare-earth:
- **The Prolate-Oblate Shape Transition around A~190 (V. Werner, J.Jolie, P.H.Regan) -S452-**
- Mechanism of generation oblate shapes and collective rotation in Lanthanide nuclei: new island of oblate- prolate coexistence at the proton drip-line (G.-S.Li, C.Petrache)
-Structure evolution in highly-deformed rare-earth nuclei in the A~170 doubly-midshell region (H.M.Albers,N.Pietralla, J. Jolie)
-Investigation of Decay Properties and Excited Level Structure of very n-rich Hf Isotopes(J.Gerl) DTAS (RESUB)
-Beta-strength measurements of neutron-rich Ta-Re isotopes around A~190 (S. E. A. Orrigo , A. I. Morales , and J. Gerl) DTAS

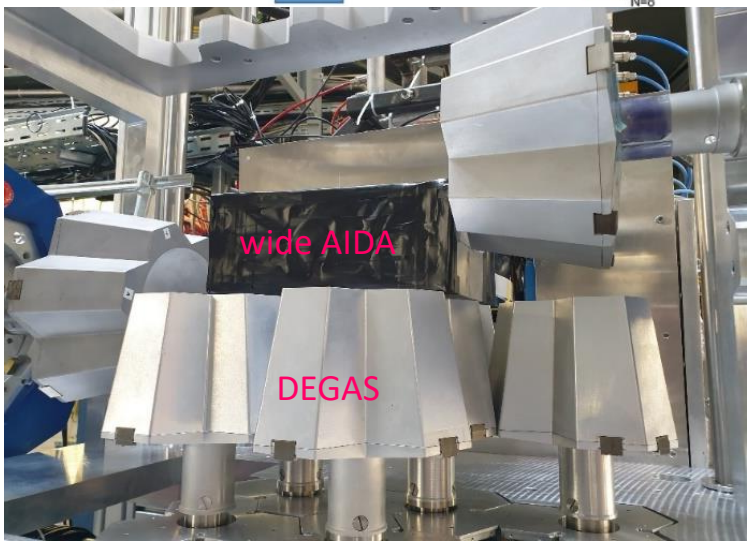
Approaching 100Sn:
- Core-breaking in the most neutron deficient Tin isotopes (G.Zhang, D.Mengoni)
-Shape coexistence in 84Mo: search for a spherical 16+ spin-trap isomer (M.Gorska, P. Ruotsalainen, A. Algora)
-Investigation of seniority along N=50 from lifetime measurements: 98Cd and 97Ag (LM. Fraile, A. Blazev)

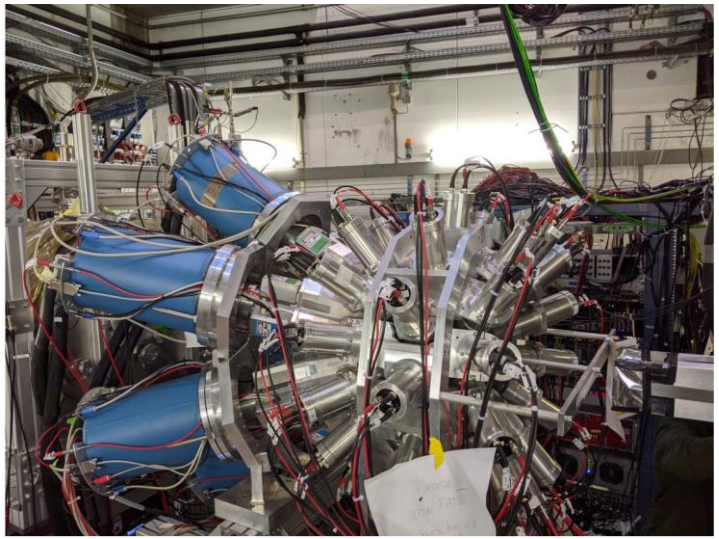
Around and beyond 208Pb:
- **Investigation of 220<A<230 Po-Fr nuclei lying in the south-east frontier of the A~225 island of octupole deformation (J.J.Valiente-Dobon, G. Benzoni) –S460-**
- **Study of N=126 nuclei: isomeric and beta decays in 202Os and 203Ir (Zs. Podolyak) – S450-**
- Spectroscopy of 230-232Ra: searching for an hyperdeformed shape isomer (J.J.Valiente-Dobon, A.Gottardo)
- Search for an octupole state after β-decay and isomerism in even-even Hg nuclei with N>126 (R.Palit, R.Lozeva)
- Nuclear structure at the edge of the r-process rare-earth element peak (T.Grahn)
- Approaching the N =126 r-process path; Single-particle orbitals below Z =82(A.Mistry, G.Benzoni, Zs.Podolyak)
-Inside the nuclear structure by measuring lifetimes: test of seniority breaking beyond 208Pb (R. Lozeva , L.M. Fraile) (RESUB)
-Measurements of heavy beta-delayed neutron emitters with A~220-230 using BELEN (N. Hubbard, H. M. Albers,O. Hall, A. Tarifeño-Saldivia) BELEN
- Investigation of the beta strength crossing N=126 and the formation of the 3rd r-process abundance peak (J.L. Tain, A.I. Morales, E. Nacher) DTAS



N, number of neutrons

AIDA

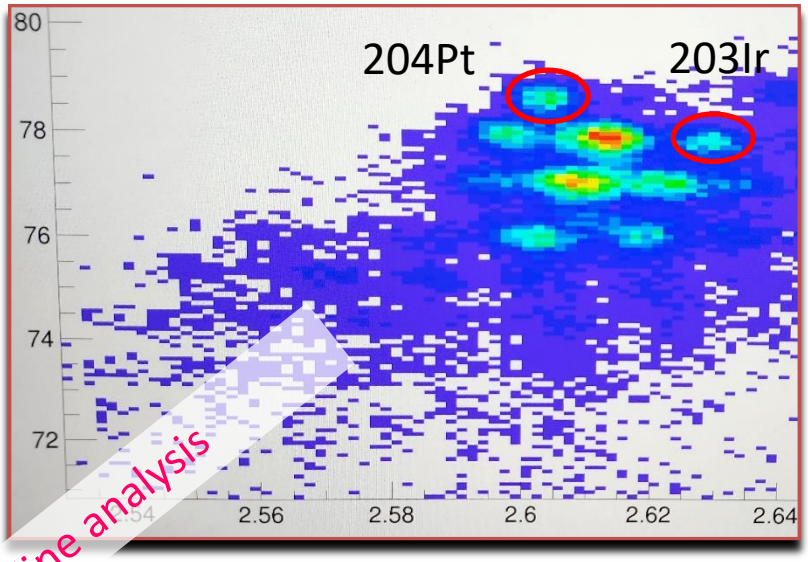




Isomeric and beta decays in ^{202}Os and ^{203}Ir @ GSI

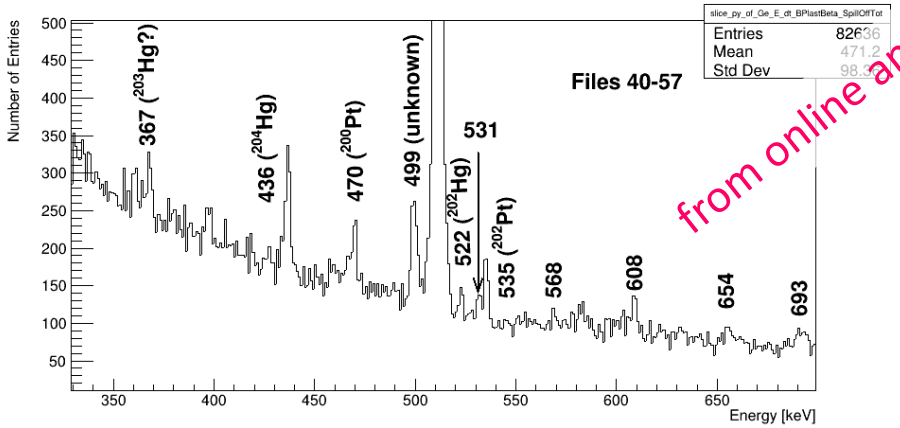
- 10^+, 7^-, 5^- isomers are predicted in ^{202}Os, while a longlived $11/2^-$ is predicted in ^{203}Ir.
- β decay half-lives will be determined and information on excited states in their daughter nuclei ^{202}Ir and ^{203}Pt will be obtained.
- The gained information is important both for our understanding of the shell evolution at N=126 and to provide more robust theoretical predictions on the properties of the r-process path N~126 nuclei.

Courtesy : Zs. Podolyak

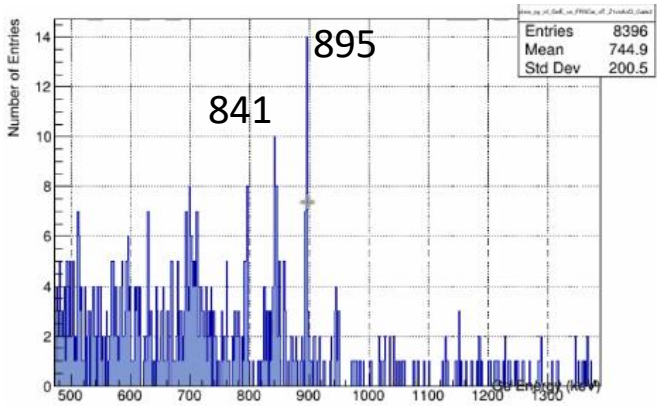


^{203}Ir: 36k (8k in 2006)

from online and nearline analysis



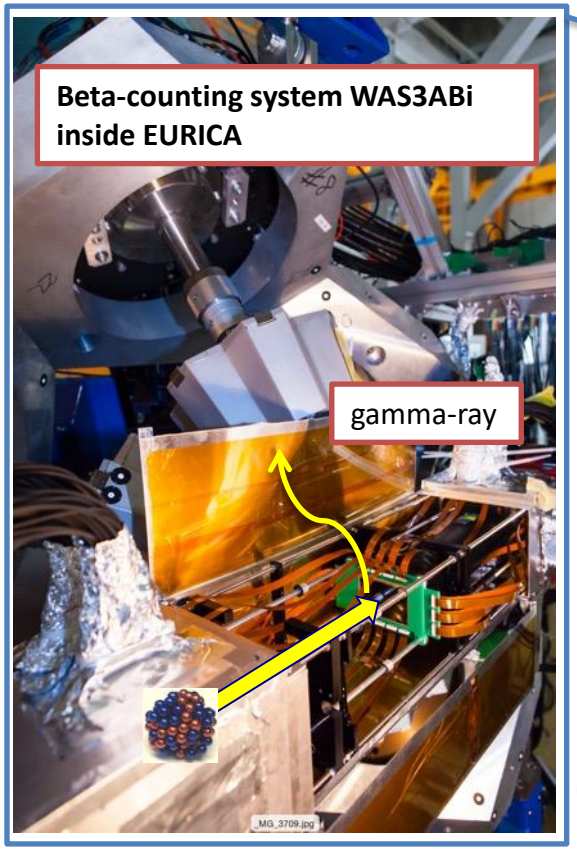
γ spectrum in coincidence with β particles (in bplast)

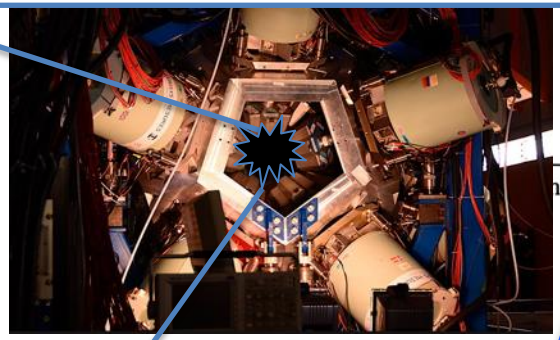


^{203}Ir isomer spectrum

EURICA Spectrometer @ RIBF

^{238}U … 345 MeV/u; int. 5 – 12 pnA





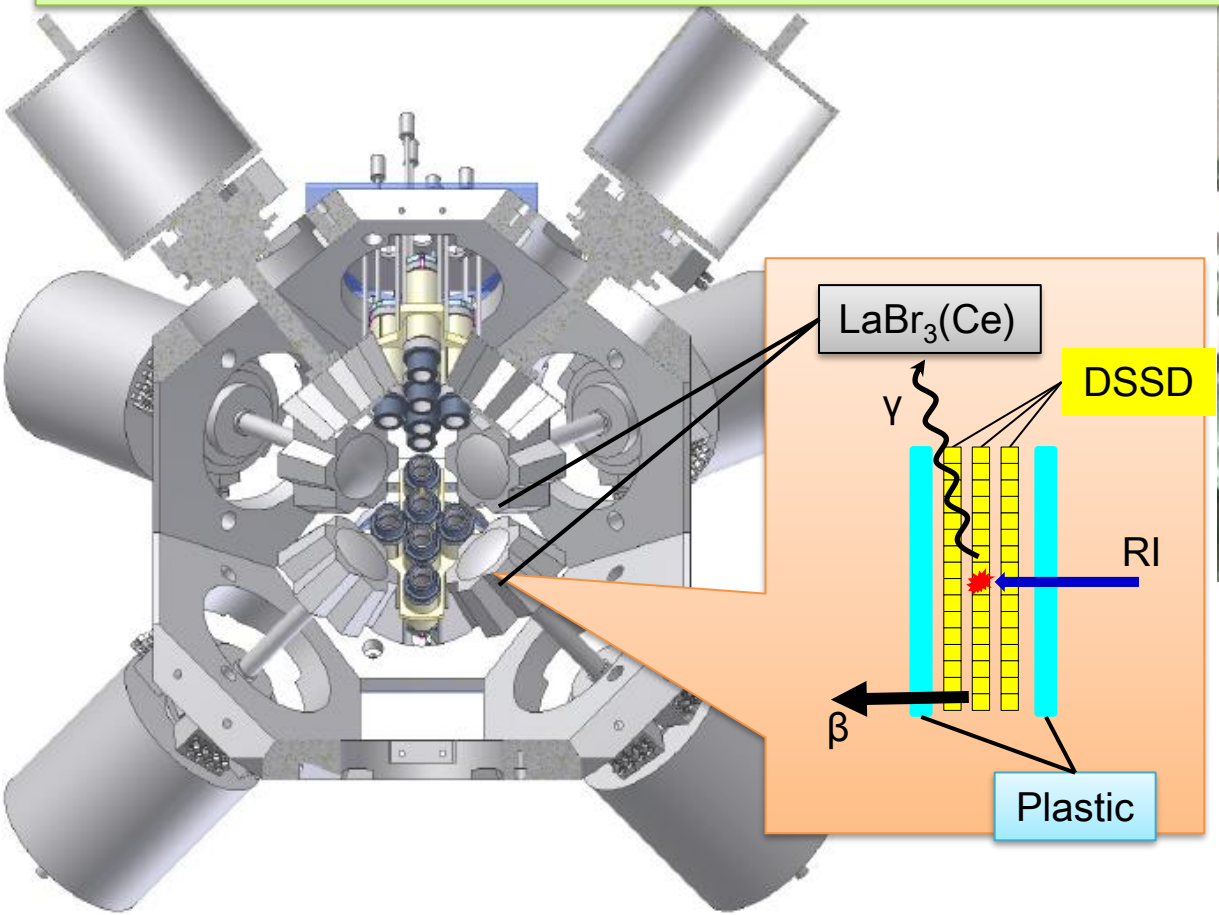
Primary Beam (^{238}U / ^{124}Xe / ^{78}Kr)

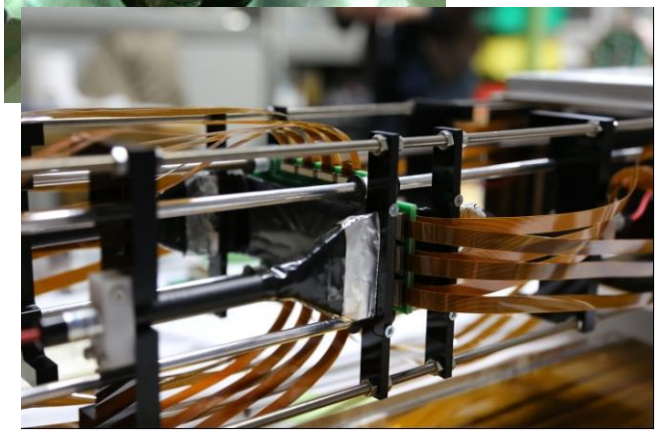
RI Beam

Courtesy : Shunji Nishimura

EURICA Spectrometer @ RIBF

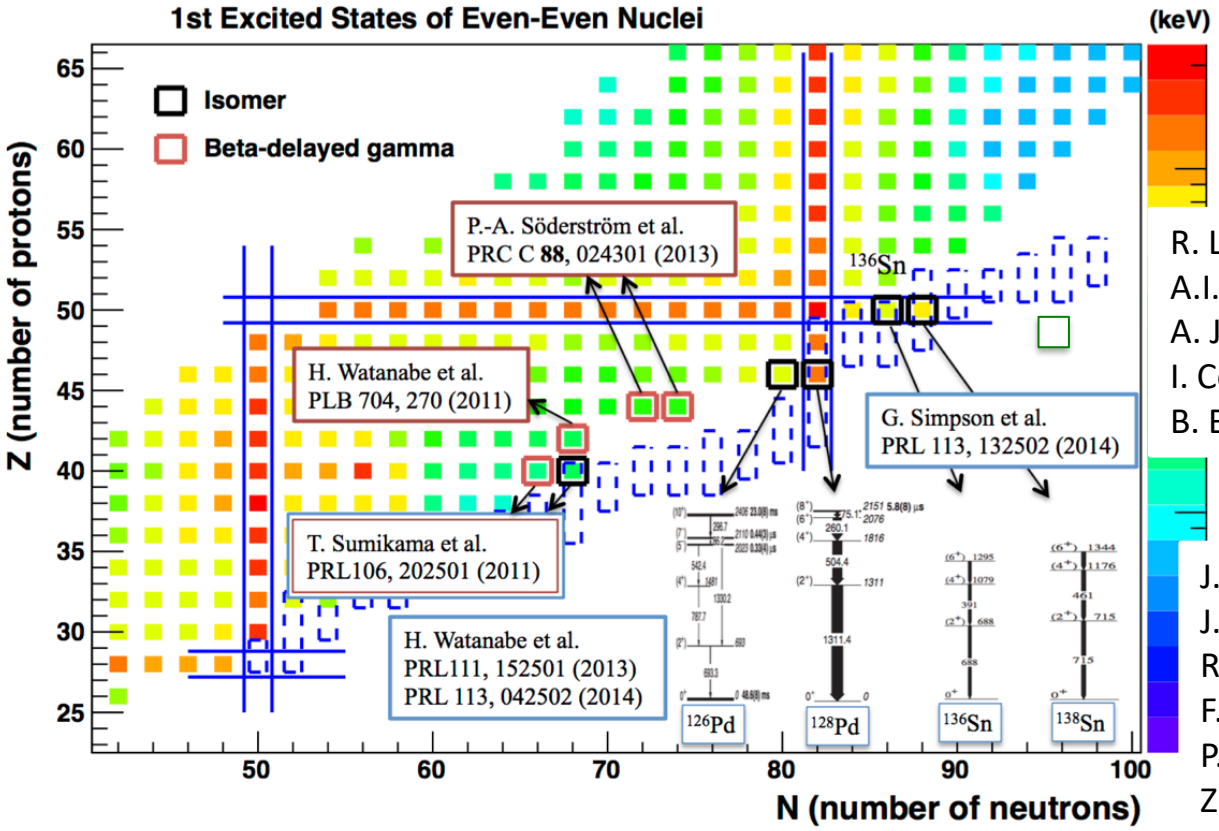
- 84 HPGe detectors from the EURICA collaboration
- 18 UK $LaBr_3(Ce)$ scintillators (Φ1.5"×2") for γ rays
- BC-418 plastic counters (2-mm thick) + DSSDs for β rays





Courtesy : Shunji Nishimura

Research results from RIBF



R. Lozeva et al. PRC 93, 014316 (2016)
A.I. Morales et al. PRC 93, 034328 (2016)
A. Jungclaus et al., PRC 93, 041301(R) (2016)
I. Celikovic et al. PRL 116, 162501 (2016)
B. Blank et al. PRC 93, 061301 (2016)

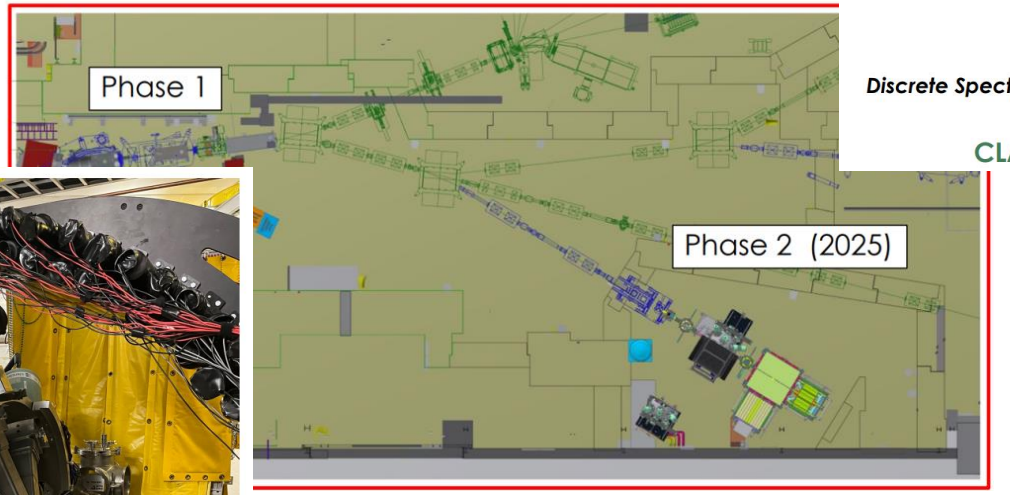
J. Taprogge et al, PRL 112, 132501 (2014)
J. Taprogge et al, PRC 91, 054324 (2015)
R. Lozeva et al., PRC 92, 024304(2015)
F. Browne et al., PLB 750, 448 (2015)
P.-A. Soderstrom, PRC 92, 051305 (2015)
Z.Patel et al.PRL 113, 0262502 (2014)

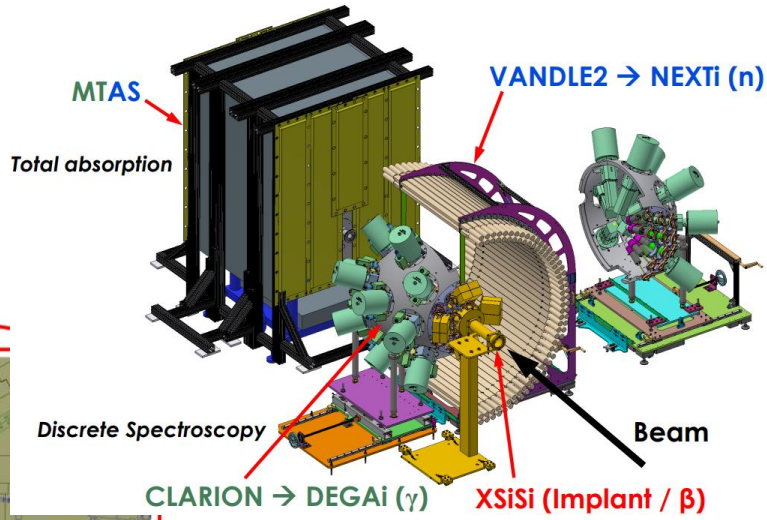
Publications： 64 papers
⋯ PRLx14+1, PLBx13+1, PRC(R)x6, PRC x 18+7, EPJAx1+1, PTEPx1, JSPSx1

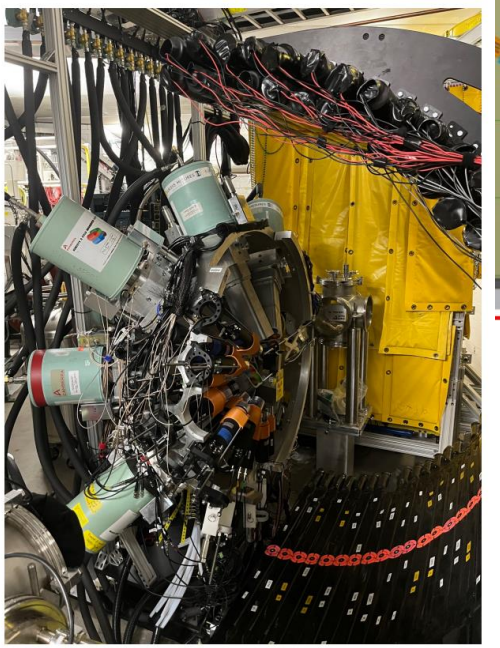
Courtesy : Shunji Nishimura

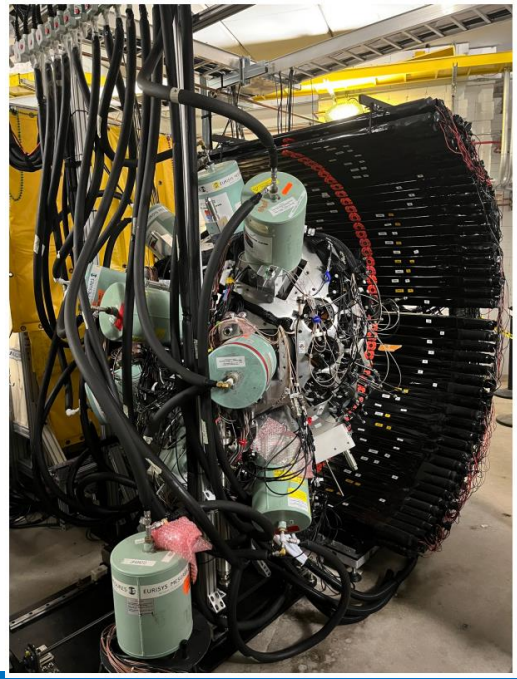
Experimental setup @ FRIB

FDSi Locations



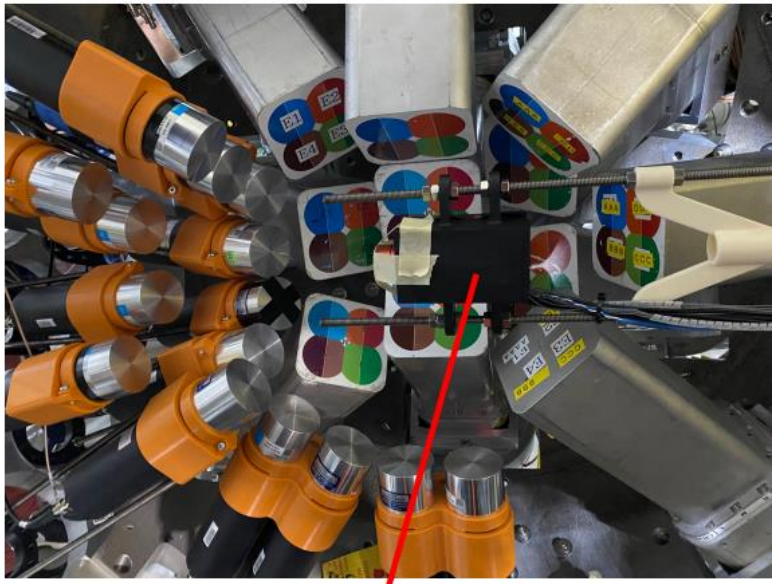


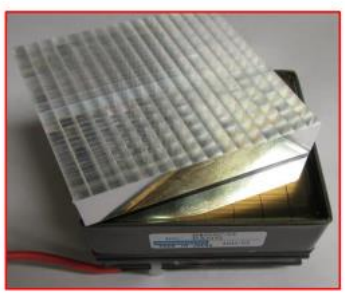


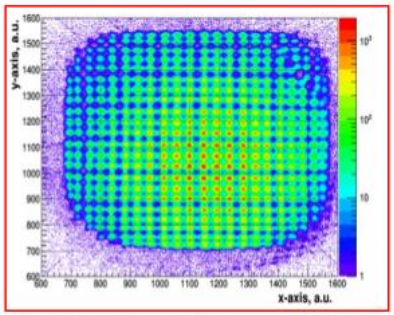


Courtesy : James M. Allmond (ORNL)

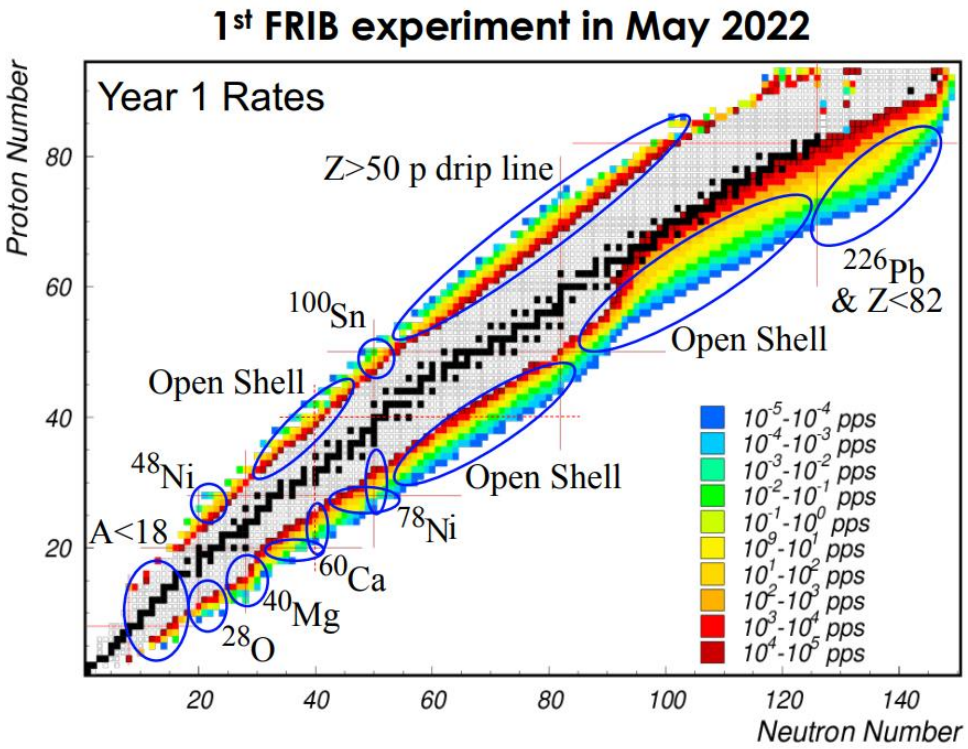
Experimental setup @ FRIB







Fast YSO Implant detector from UTK

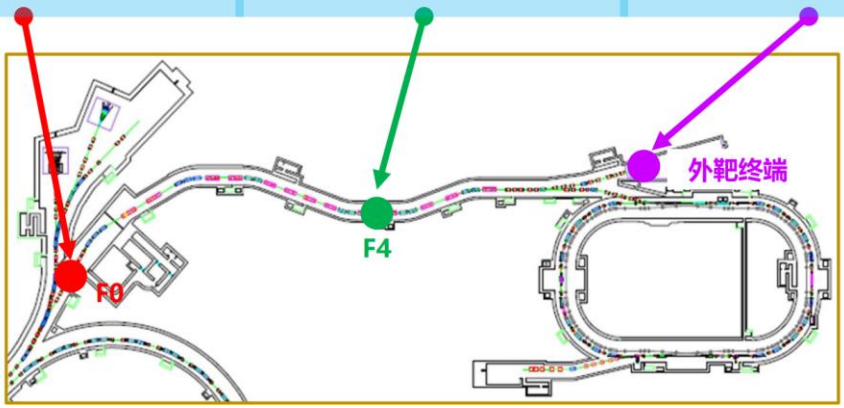


Courtesy : James M. Allmond (ORNL)

HIRIBL装置带来新研究契机

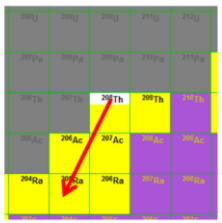
F0初级靶实验 | **F4次级靶实验** | **外靶终端实验**

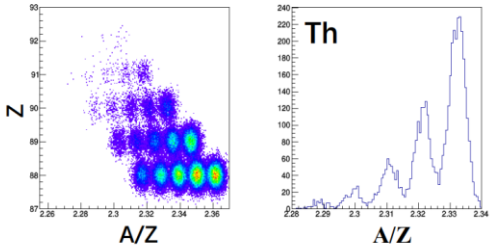
HFRS上可开展物理实验的区域



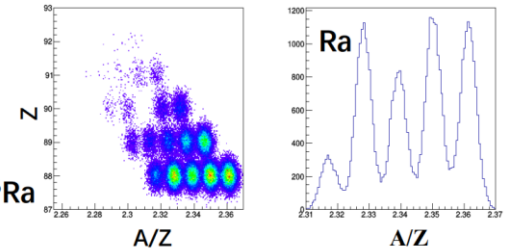
- **准确鉴别奇特核**
- **精确测量衰变信息**

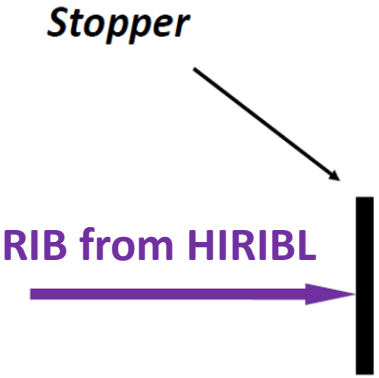
F0 – F4:
$^{238}U+^{12}C \rightarrow {}^{208}Th$
800AMeV
Bρ=10.66Tm



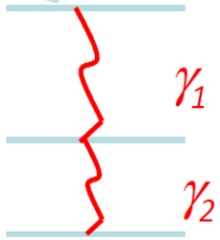


F4 – F6:
$^{208}Th+^{12}C \rightarrow {}^{205}Ra$
Bρ=10.22Tm





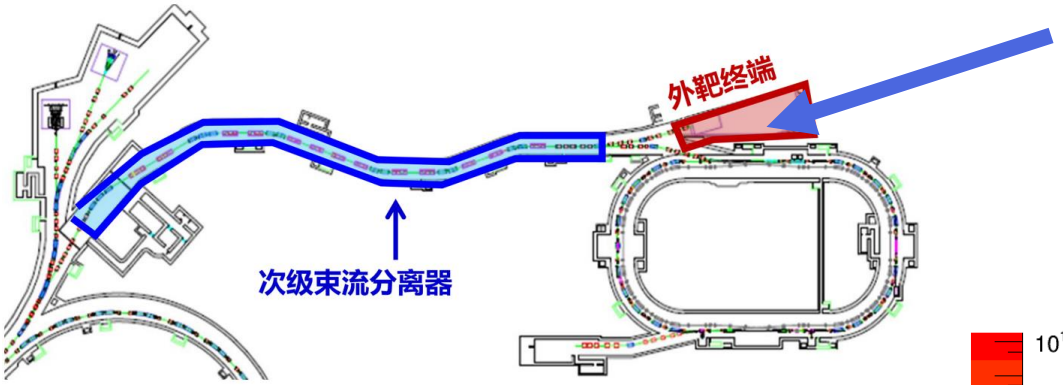
e.g. β-decay or isomeric decay

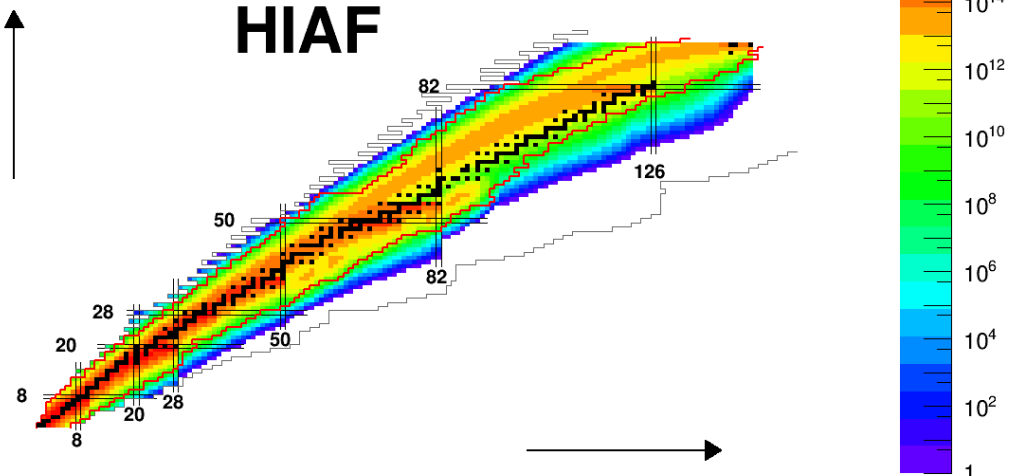


Get first information on lifetimes, decay modes, Q-values and scheme of excited levels

HRIBL + IMP-DRAGON

IMP-DRAGON: IMP-Detectors for Research by Analyzing Gamma-ray Observation in Nuclei



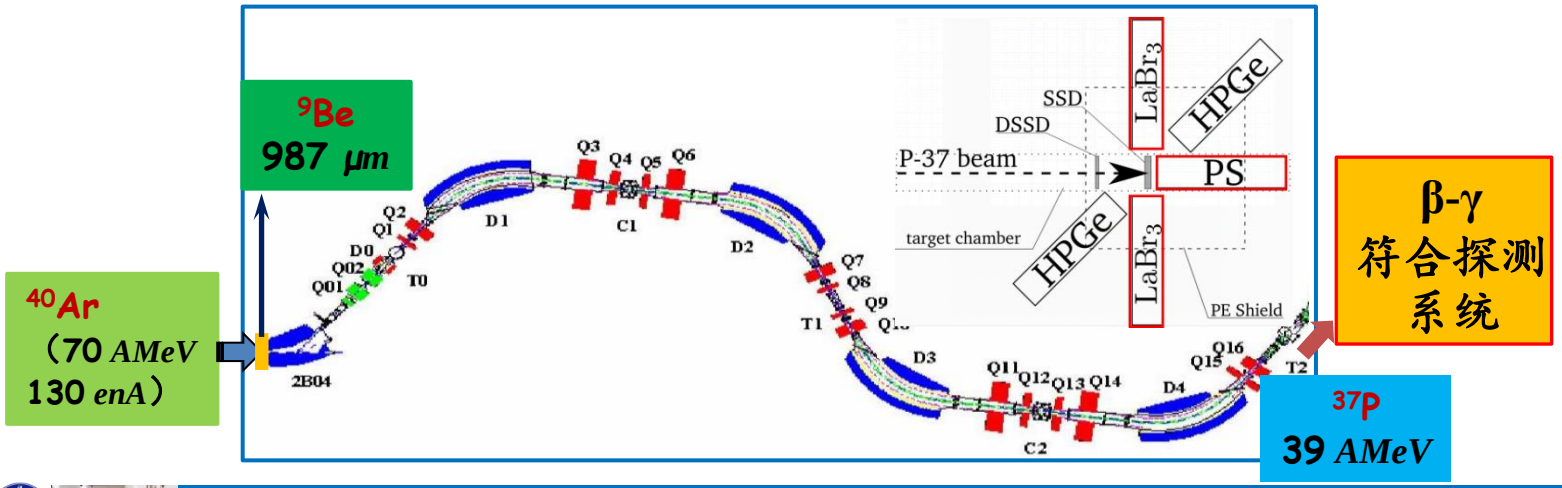


精细衰变谱学：

- **衰变寿命**
- **衰变能量**
- **衰变纲图**
- **衰变分支比**
- **激发态能级寿命（$LaBr_3$）**

研究原子核结构、检验理论模型、寻找新物理，如新幻数、形状共存、集体性质等

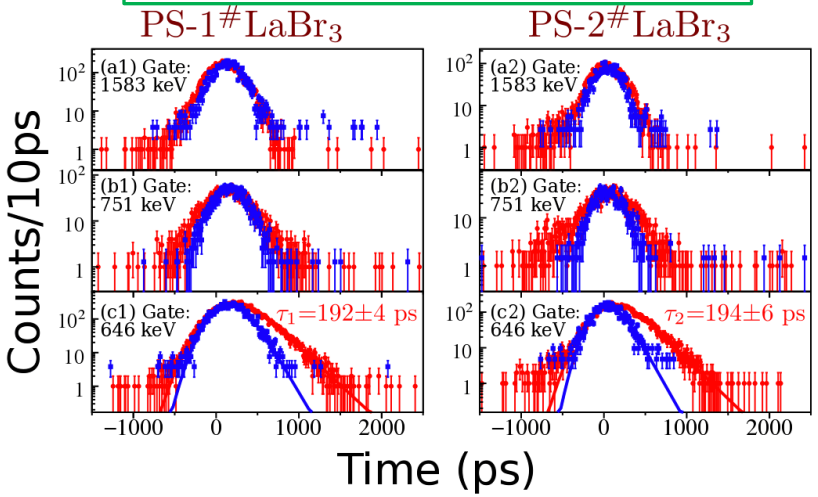
RIBLL1 + IMP-DRAGON

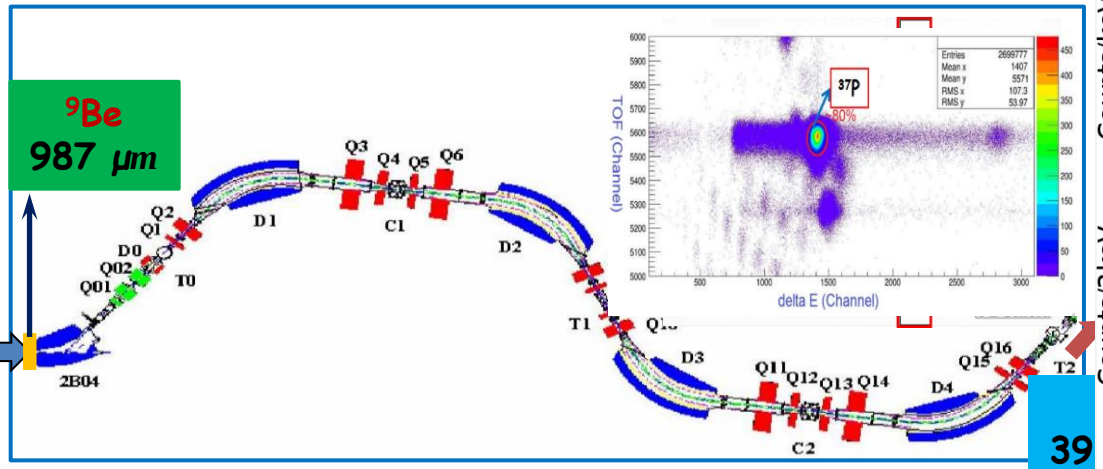


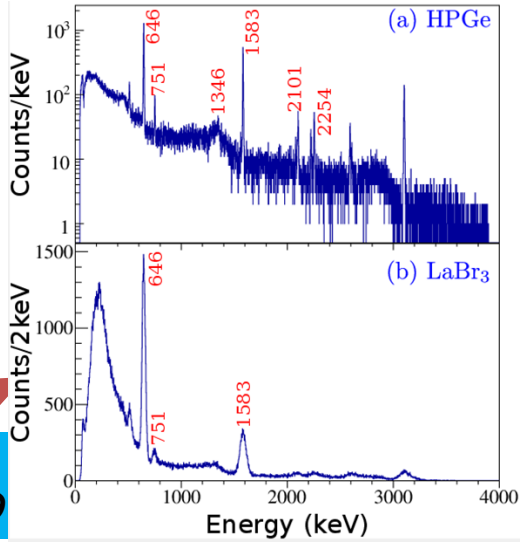
RIBLL1 + IMP-DRAGON

Phys. Rev. C 94, 044316 (2016)

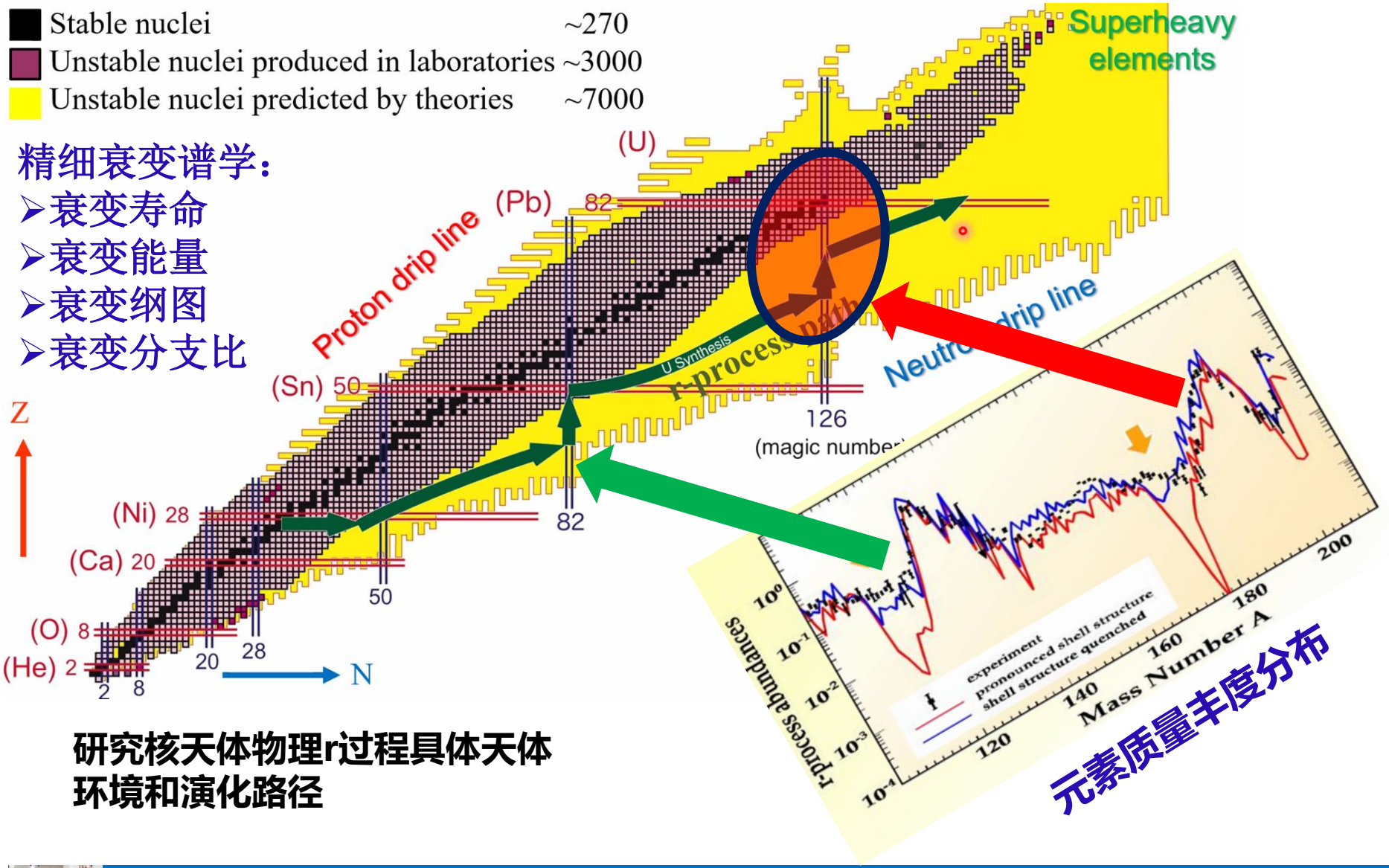
delayed and prompt time spectra







聚焦N=126附近奇特原子核

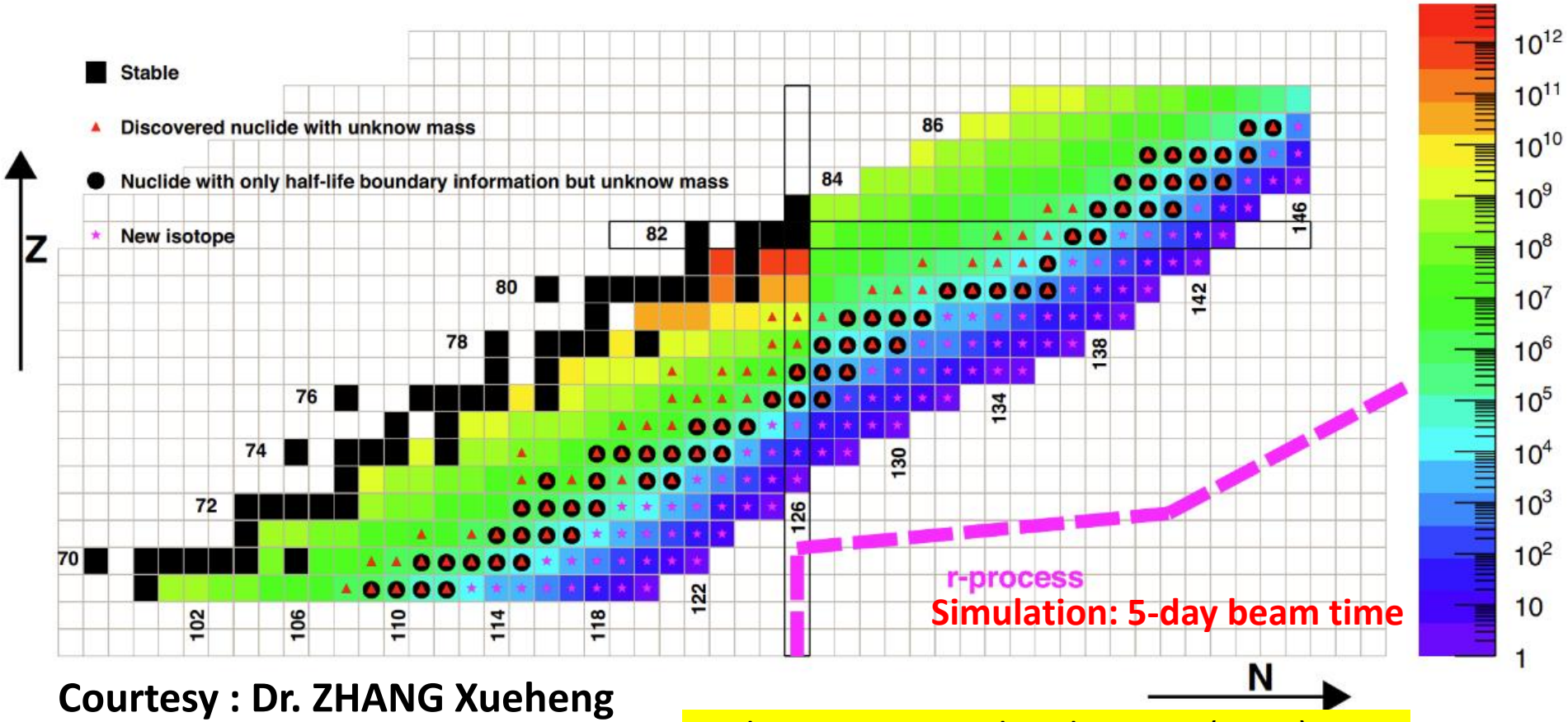


精细衰变谱学：

- 衰变寿命
- 衰变能量
- 衰变纲图
- 衰变分支比

研究核天体物理r过程具体天体环境和演化路径

Uniqueness at HIRIBL



Courtesy : Dr. ZHANG Xueheng

Nuclear Science and Techniques (2024) 35:97

- **Beam energy at HIAF larger than that at RIBF/FRIB**
  small charge distribution, better transmission, better statistics
- **Operation may early than FAIR, earlier sciences…**

Experimental status @ N = 126 region

-**fragmentation/spallation** of ^{238}U, ^{208}Pb (or ^{209}Bi)

fragmentation:

GSI/FAIR: FRS, ESR

RIKEN: BigRIPS, SLOW-RI, Rare RI ring

FRIB

spallation: ISOLDE, TRIUMF

-**multi-nucleon transfer** on ^{208}Pb (and ^{198}Pt)

with particle identification (thin target)

RIKEN/KEK: KISS

ANL

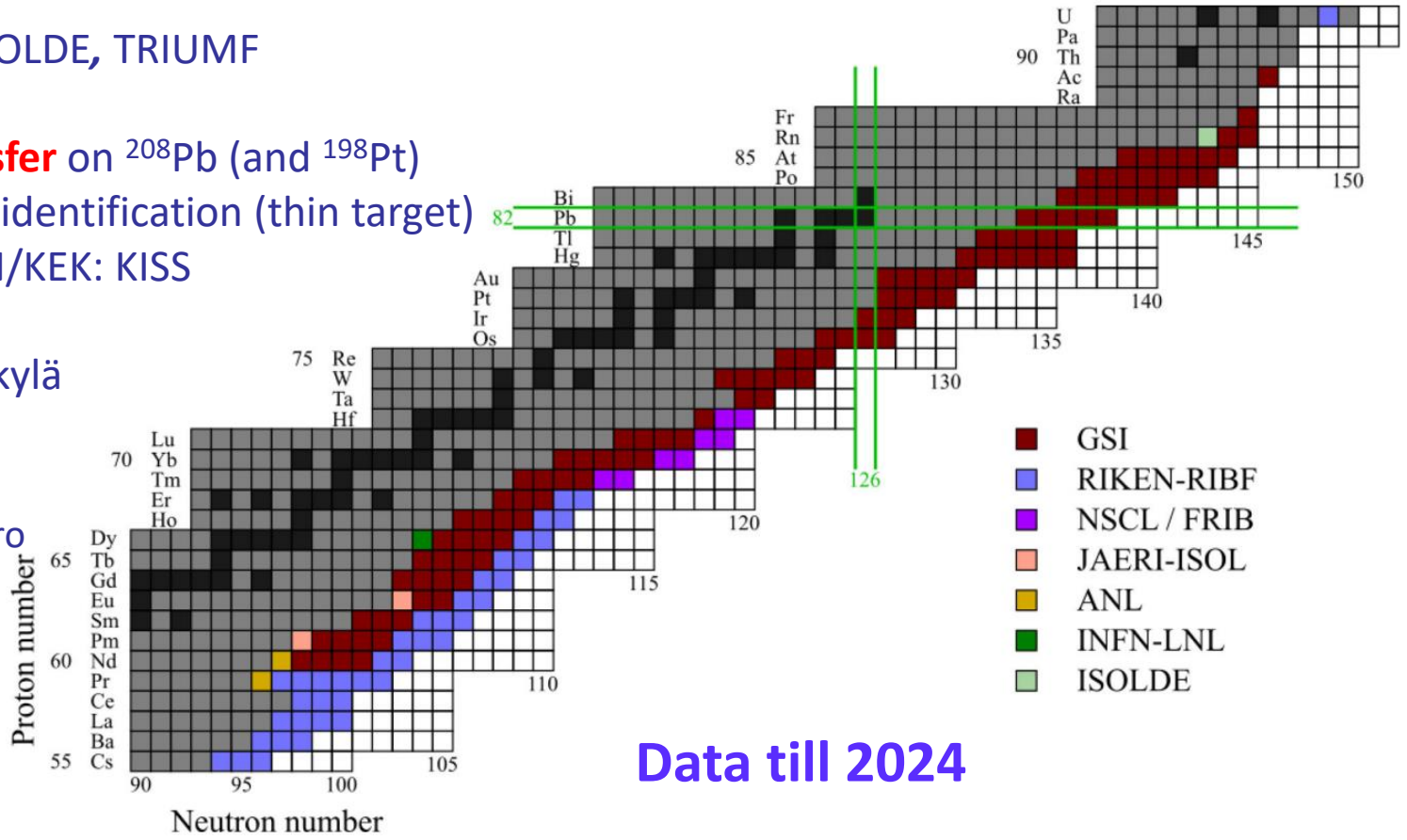
Jyväskylä

GSI

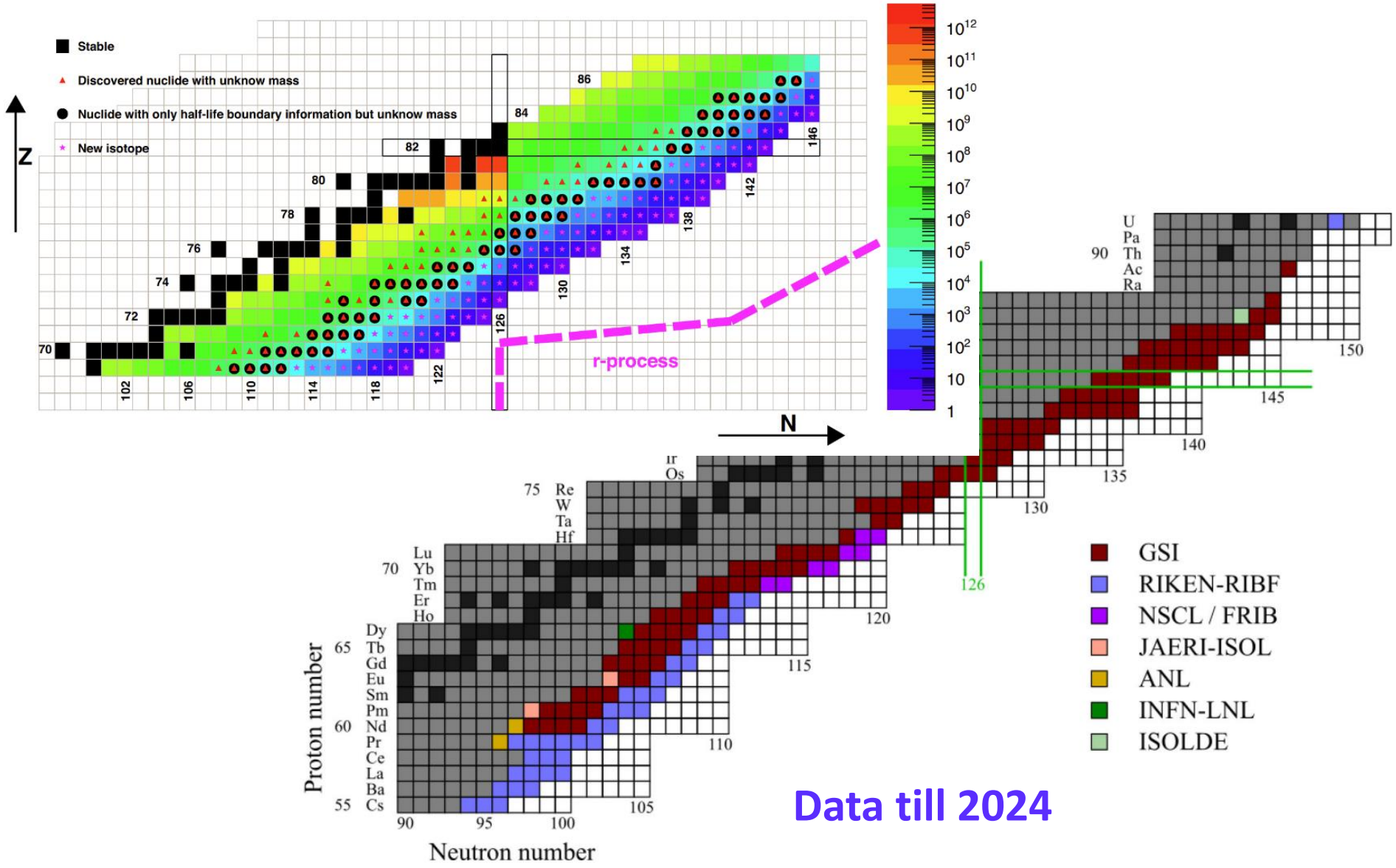
GANIL

Legnaro

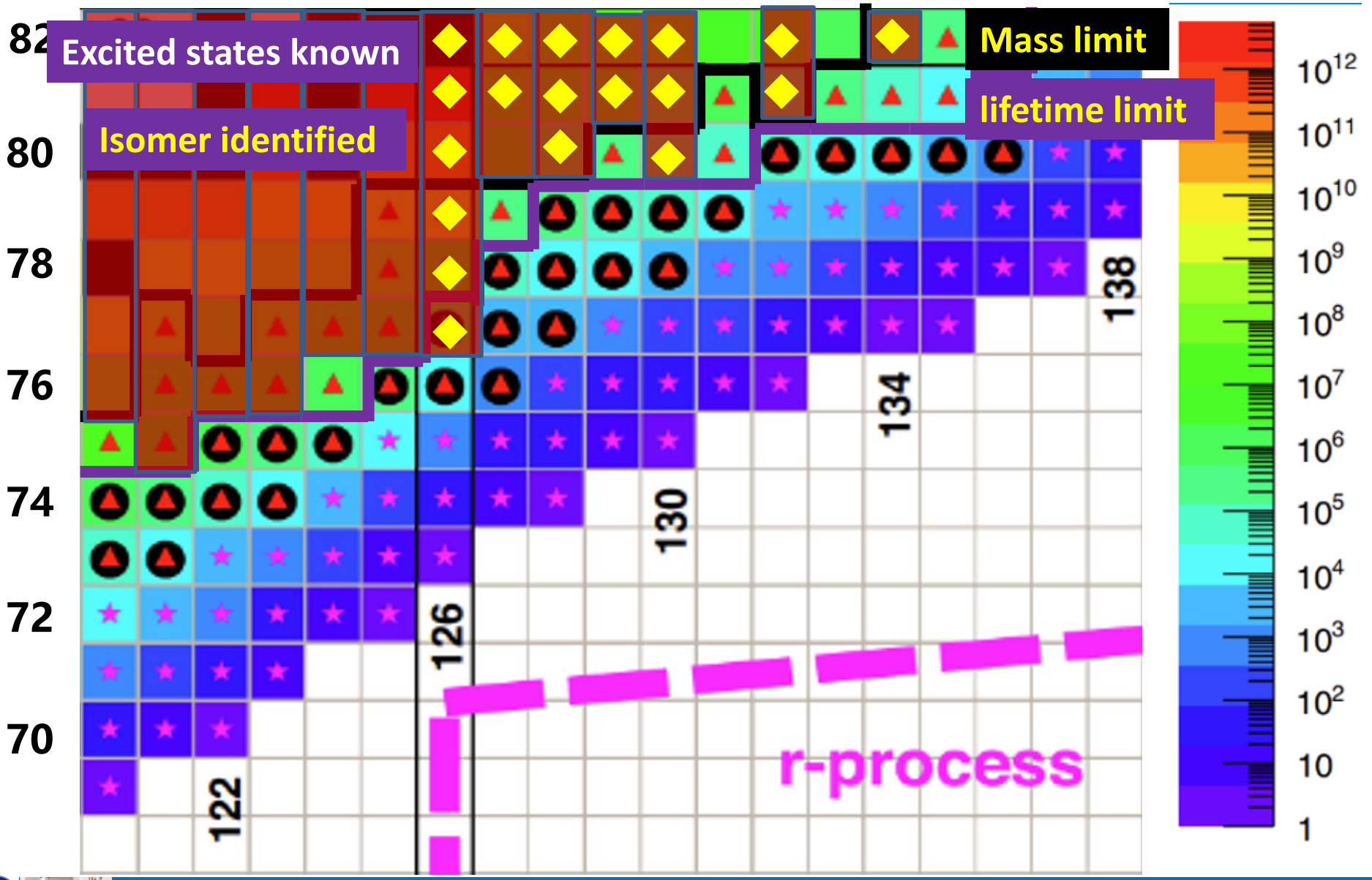
Courtesy : Zsolt Podolyak



Experimental status @ N = 126 region

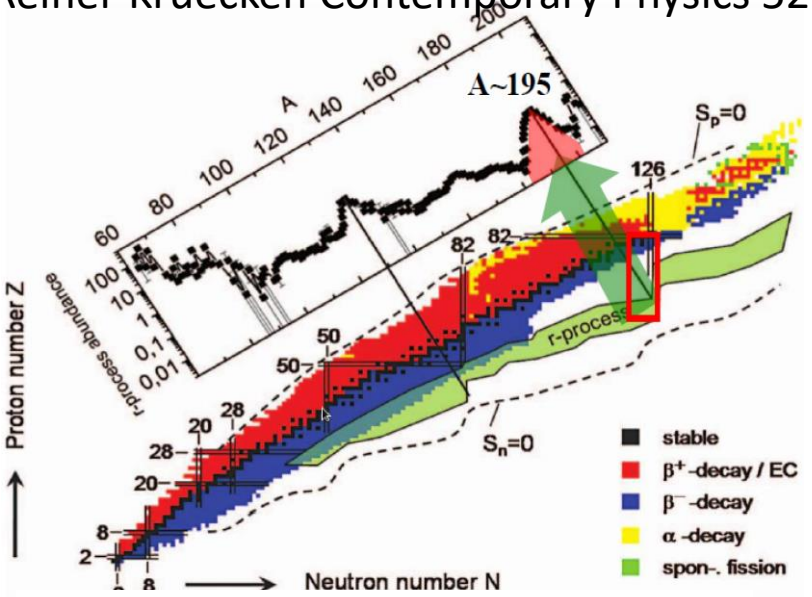


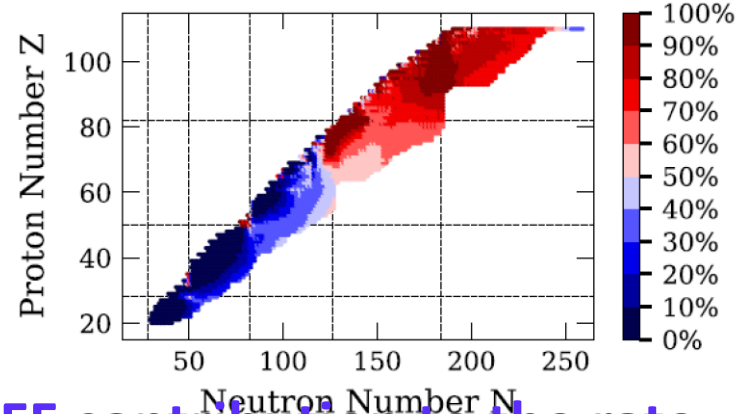
5 days beam time at HIRIBL with extraction of 13s : 3s



r-process with first-forbidden transitions

Reiner Kruecken Contemporary Physics 52(2), 2011, 101





FF contribution to the rate

FIG. 5. First-forbidden contribution to the rates. Dashed lines indicate the magic numbers 28, 50, and 82 for protons, and 28, 50, 82, 126, and 184 for neutrons.

GT transition VS FF transition

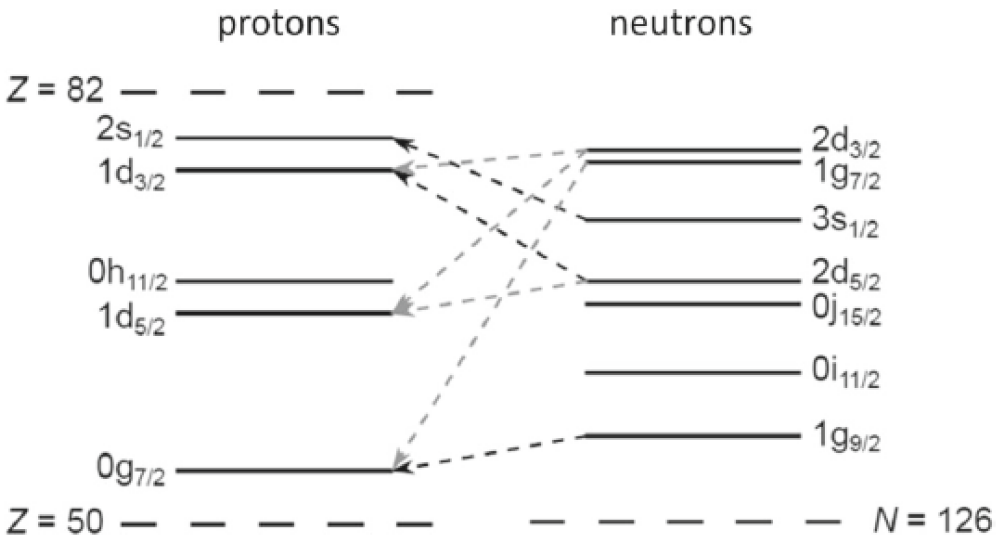
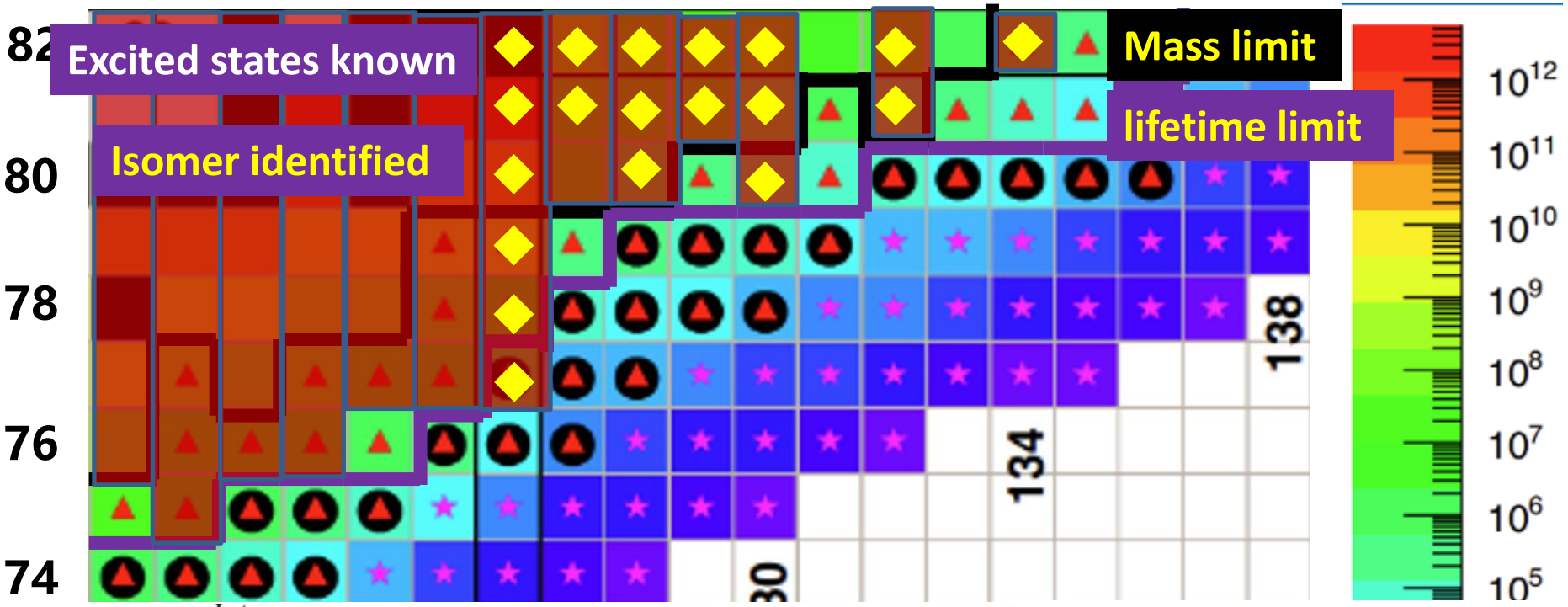
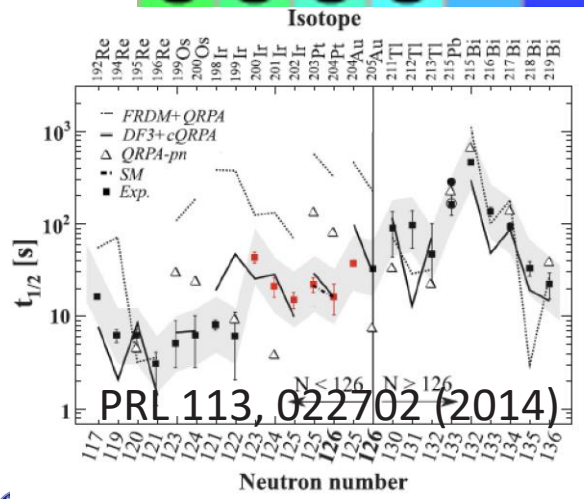


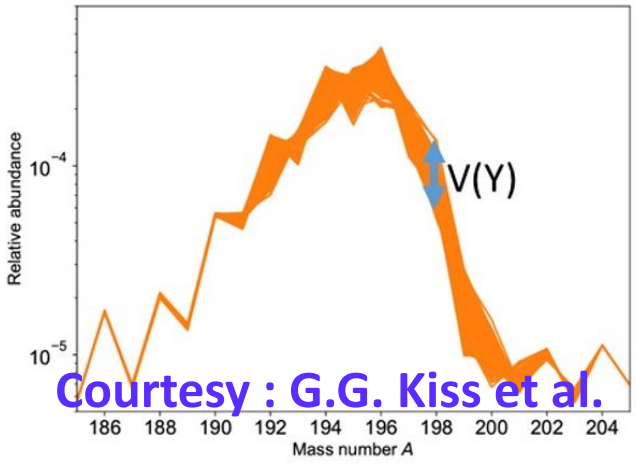
Fig. 13 Shell model orbitals for $50 < Z < 82$ and $126 < N < 184$. The ordering and energy spacing of the orbitals are from the level schemes of ^{207}Tl and ^{209}Pb respectively [36]. Arrows link proton-neutron pairs which are forbidden in β decay due to their $\Delta n = 1$ condition [150]

A = 195 peak VS beta-half life uncertainties

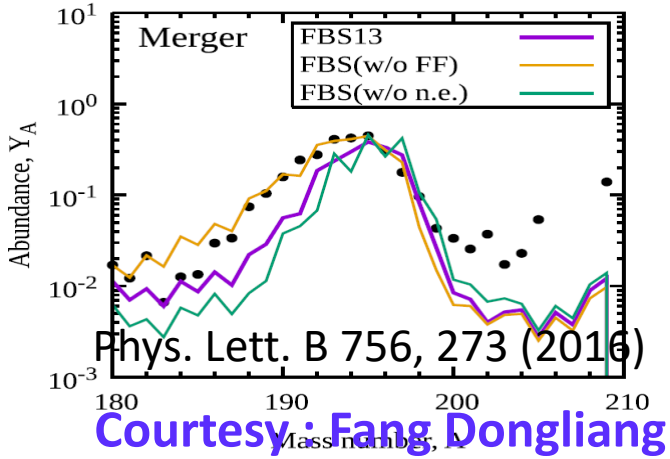




PRL 113, 022702 (2014)



Courtesy : G.G. Kiss et al.



Phys. Lett. B 756, 273 (2016)

Courtesy : Fang Dongliang

Level scheme VS shell model predictive power

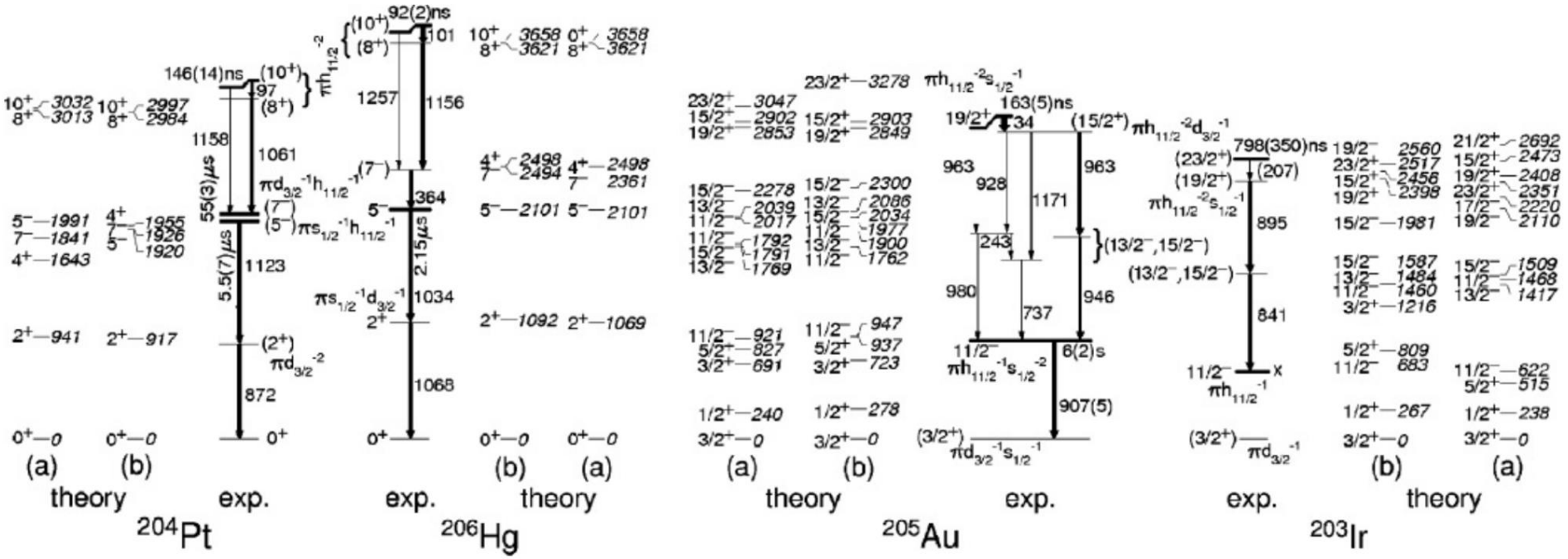
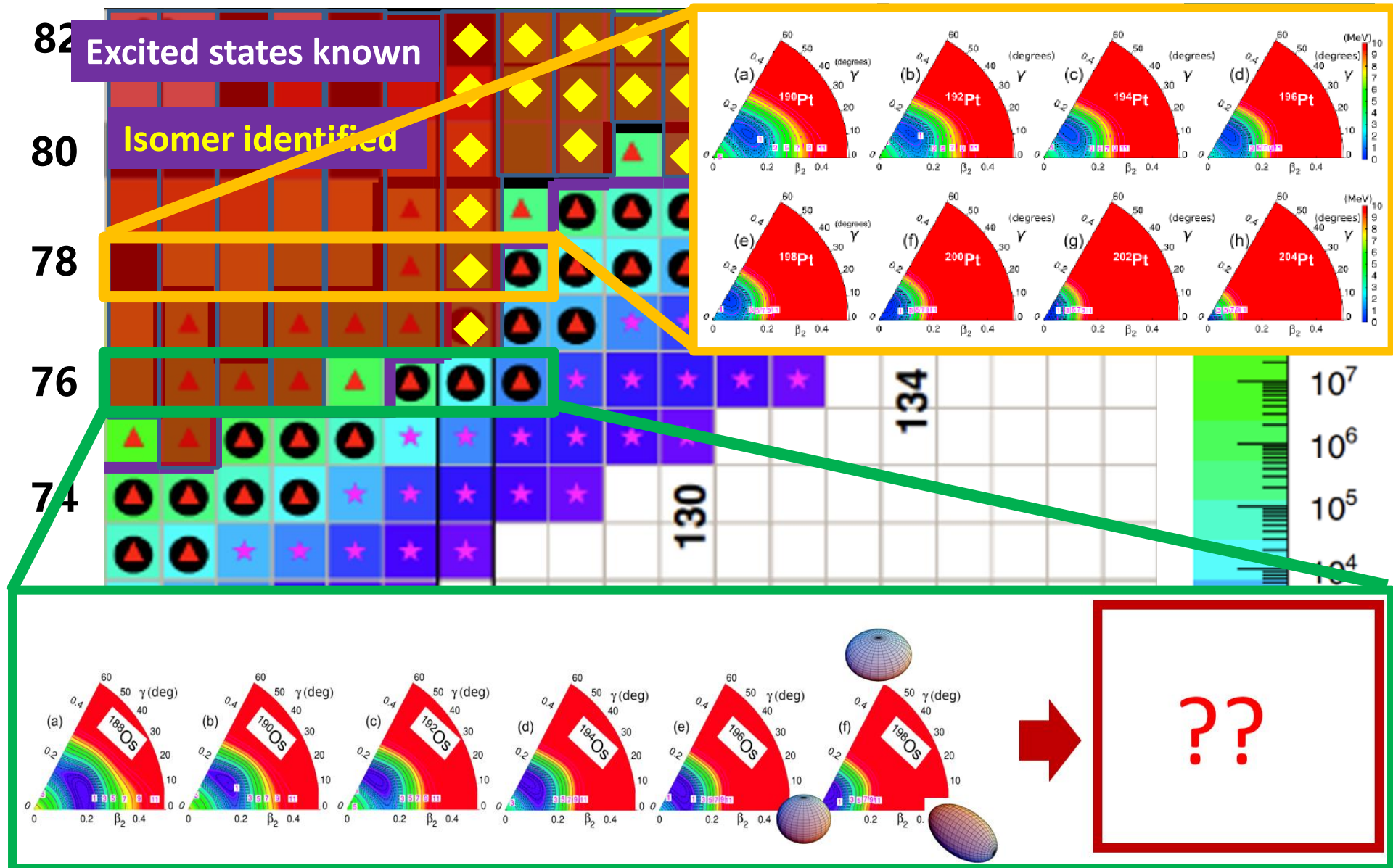


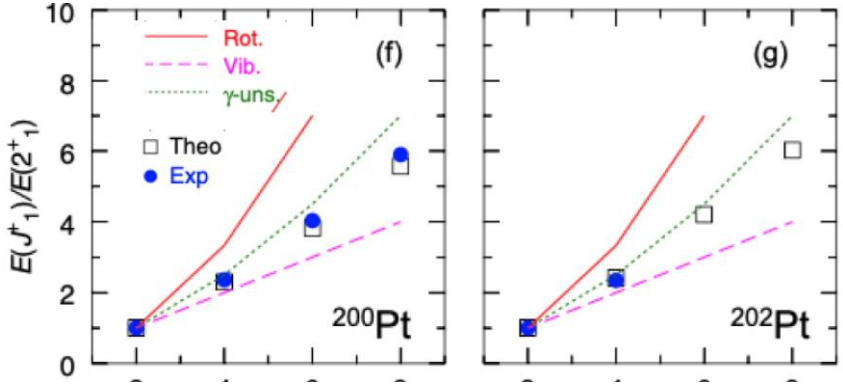
FIG. 7. Experimental and calculated partial level schemes of the $N = 126$ ^{206}Hg [5], ^{204}Pt, ^{205}Au and ^{203}Ir nuclei. Arrow widths denote relative intensities of parallel decay branches. The dominant state configurations are indicated. Theory (a) represents calculations using the Rydström matrix elements, while (b) are with the modified ones, as described in the text.

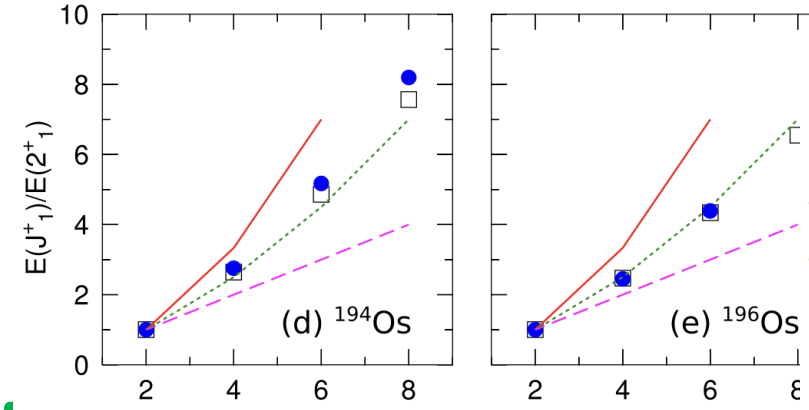
Calculations (b): modified to reproduce 204Pt and 206Hg
They improve predictions on 205Au and 203Ir!

A “rare” transition from prolate to oblate to spherical

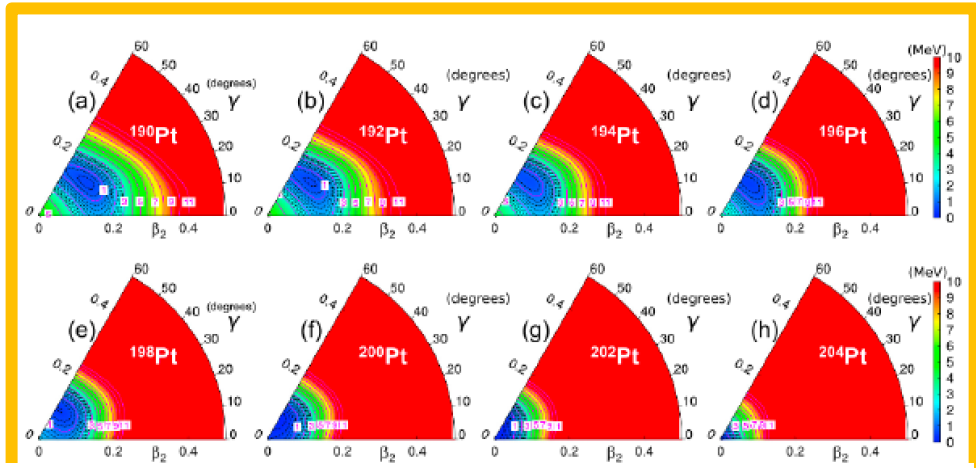


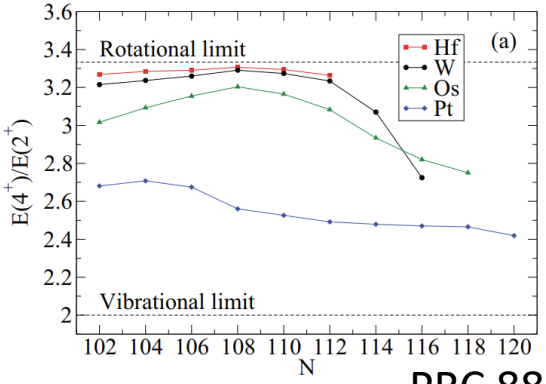
A “rare” transition from prolate to oblate to spherical

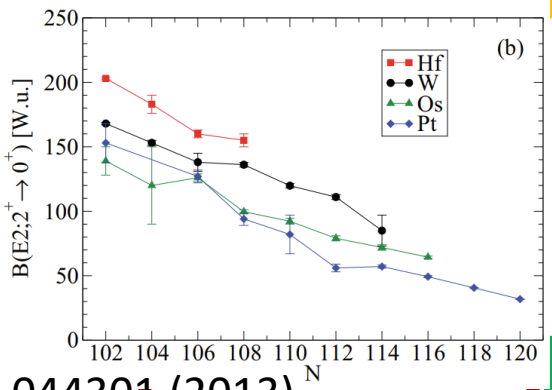




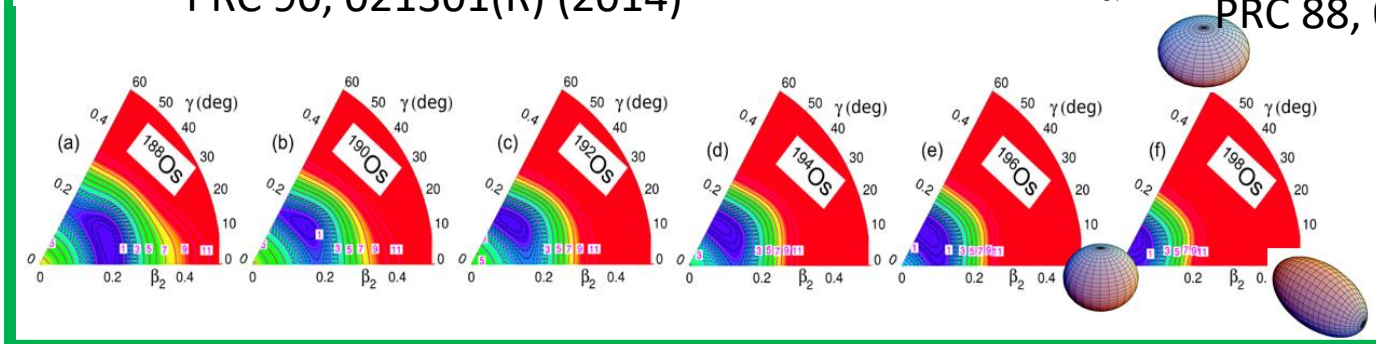
PRC 90, 021301(R) (2014)







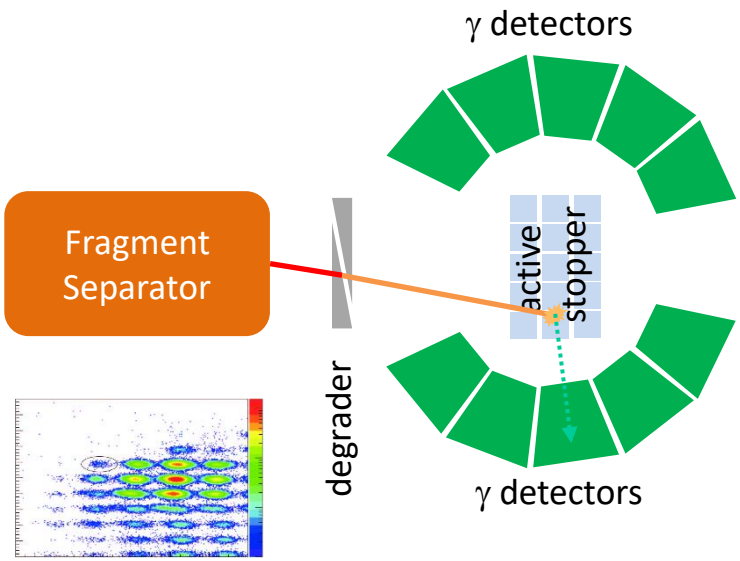
PRC 88, 044301 (2013)

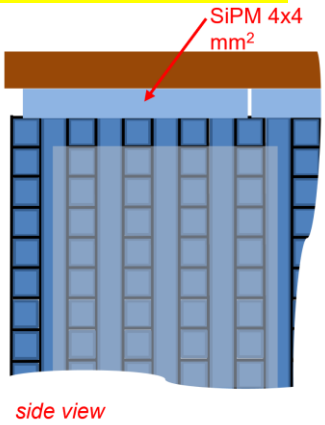


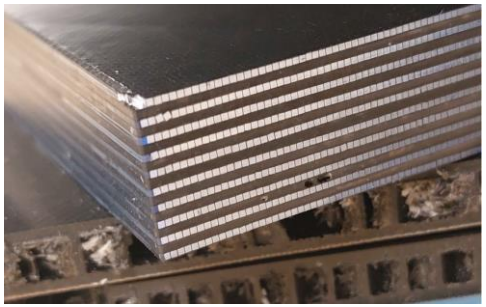
??

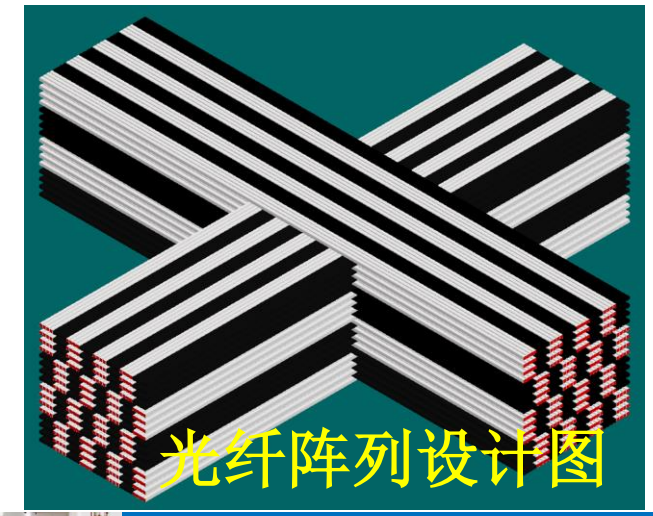
The active stopper development

NUSTAR/DESPEC – FIMP *(GSI Darmstadt , JSI Ljubljana, IMP Lanzhou)*







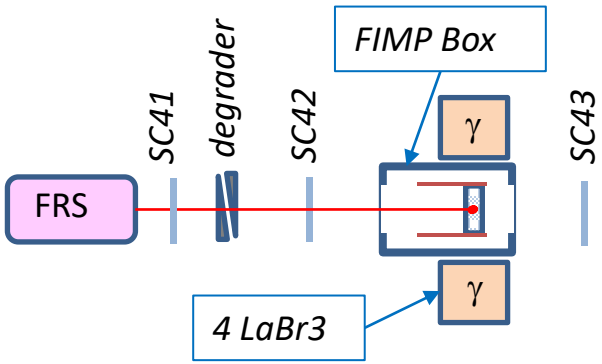


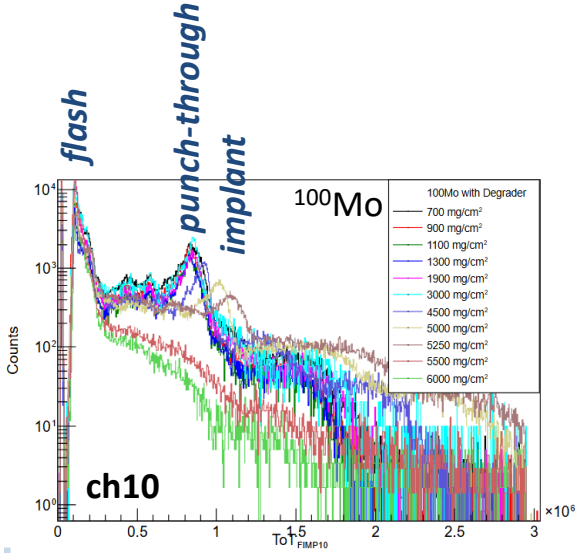
Aim of an active stopper

- stop wanted isotopes in the active volume
- provide 3D coordinates of implantation position
- provide decent time of implantation
- provide rough energy information
- measure subsequent β or α decay of an isotope
- provide 3D coordinates of decay position
- provide precise time of decay
- provide decent energy information
- correlate implantation and decay event
- correlate particle decay with coincident γ decay

The active stopper test @ GSI

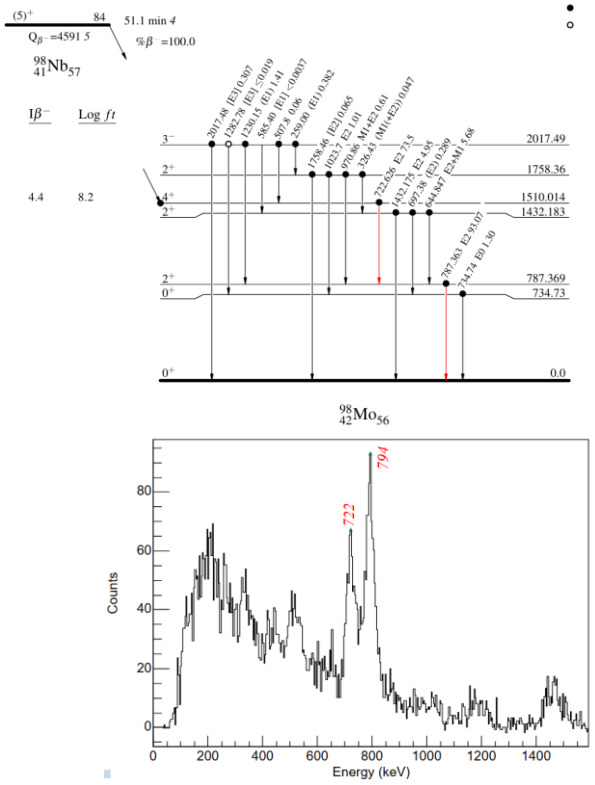
NUSTAR/DESPEC – FIMP *(GSI Darmstadt , JSI Ljubljana, IMP Lanzhou)*





implantation process

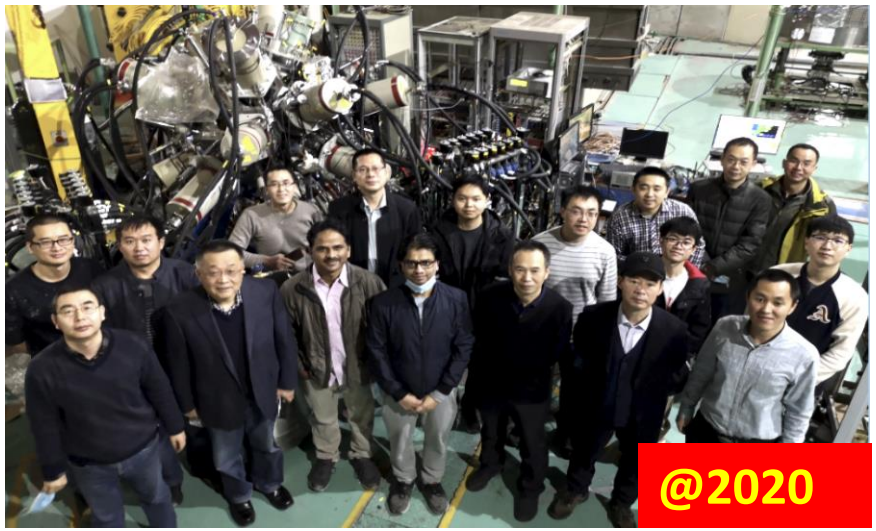
Data in analysis …



β-γ decay process

Courtesy : Jürgen Gerl

Domestic interested collaboration



➢ **Proceed with both primary and secondary beams**

International scientific advisors and collaborators

个人信息

姓名： Jürgen Gerl
国籍： 德国
方向： 实验核物理
工作单位： 德国GSI重离子中心
职称/职务： **原核谱学部门主任**

PIFI visiting Professor at IMP

个人信息

姓名： Giacomo de Angelis
国籍： 意大利
方向： 实验核物理
工作单位： 意大利Legnaro国家实验室
职称/职务： **原核物理部门主任**

PIFI visiting Professor at IMP

Collaborators:

- Pieter Doornenbal, RIKEN, Japan
- Shunji Nishimura, RIKEN, Japan
- Magda Górska, GSI, Germany
- Helena Albers, GSI, Germnay
- Dimiter Balabanski, ELI-NP, Romania
- Radomira Lozeva, IJCLAB, France
- Yung Hee KIM, IBS, Korea
- Jelena Vesić , JSI, Slovenia
- … …

Outlook

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

Thank you for your attention!