The discovery of element 113 at RIKEN

Kouji Morimoto

RIKEN, Nishina Center for Accelerator Based Science

26th International Nuclear Physics Conference (INPC2016)

Contents of my talk

- **Naming rights of element 113**

  Proposed name and symbol for element 113

- **The history of experiments aiming for element 113**

  The experiments stated in 2001 and finished in 2012

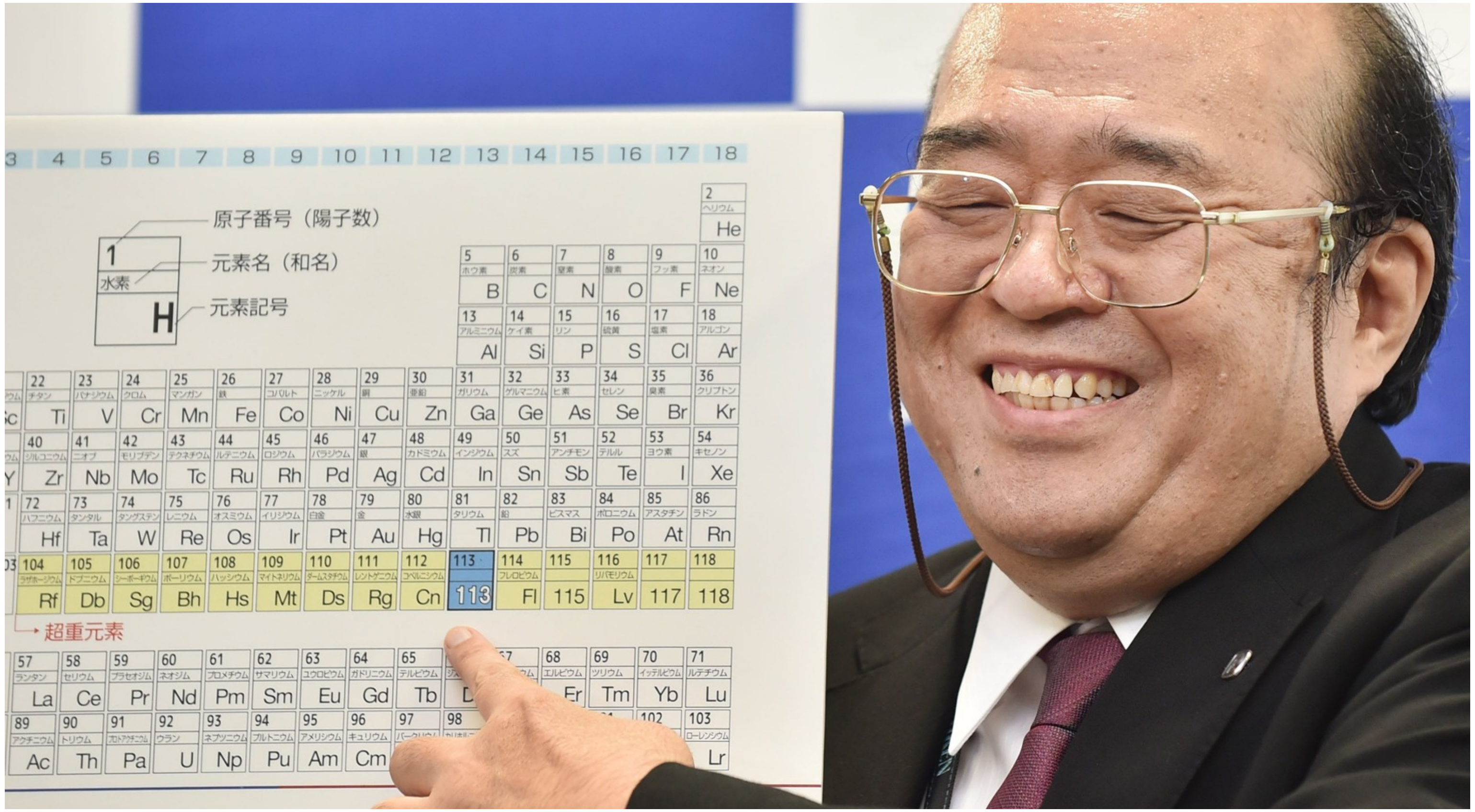
  All the results related to the ^{278}113 are shown **in time series**

- **Future plans**

  Development of new separator **GARIS-II**

  Upgrade plan of **LINAC accelerator**

IUPAC announced discoveries of element 113, 115, 117 and 118



Prof. Kosuke Morita

At last, IUPAC announced discoveries of element 113, 115, 117 and 118

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

Advancing Chemistry Worldwide

IUPAC Secretariat
PO Box 13757
Research Triangle Park, NC 27709 USA

Tel + 1 919 485 8700
Fax + 1 919 485 8706
secretariat@iupac.org
www.iupac.org

Executive Director
Dr. Lynn M. Soby

President
Dr. Mark C. Cesa (USA)

Vice President
Prof. Natalia P. Tarasova (Russia)

Past President
Prof. Kazuyuki Tatsumi (Japan)

Secretary General
Mr. Colin J. Humphris (UK)

Treasurer
Prof. John Corish (Ireland)

For Immediate Release

December 30, 2015

SUBJECT: **Discovery and Assignment of Elements with Atomic Numbers 113, 115, 117 and 118**

IUPAC announces the verification of the discoveries of four new chemical elements:

The 7th period of the periodic table of elements is complete!

The fourth IUPAC/IUPAP Joint Working Party (JWP) on the priority of claims to the discovery of new elements has reviewed the relevant literature for elements 113, 115, 117, and 118 and has determined that the claims for discovery of these elements have been fulfilled, in accordance with the criteria for the discovery of elements of the IUPAP/IUPAC Transfermium Working Group (TWG) 1991 discovery criteria. These elements complete the 7th row of the periodic table of the elements, and the discoverers from Japan, Russia and the USA will now be invited to suggest permanent names and symbols. The new elements and assigned priorities of discovery are as follows:

Element 113 (temporary working name and symbol: ununtrium, Uut

The RIKEN collaboration team in Japan have fulfilled the criteria for element Z=113 and will be invited to propose a permanent name and symbol.

Elements 115, 117 and 118 (temporary working names and symbols: ununpentium, Uup; ununseptium, Uus; and ununoctium, Uuo)

The collaboration between the Joint Institute for Nuclear Research in Dubna, Russia; Lawrence Livermore National Laboratory, California, USA; and Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA have fulfilled the criteria for element Z=115, 117 and will be invited to propose permanent names and symbols.

30 December 2015

Element 113

The RIKEN collaboration team in JAPAN have fulfilled the criteria for element Z=113 and will be invited to propose a permanent name and symbol.

Nihonium "Nh"

We proposed "**nihonium**" for the name and "**Nh**" for the symbol.

There are two ways to say "**Japan**" in Japanese: "**Nihon**" and "**Nippon**". Both literally mean **"the Land of Rising Sun"** and are widely used officially. We have therefore decided on "nihon", and by adding "-ium. The symbol will be "Nh" as an abbreviation for "nihonium".

Naming meeting

Photo. together with Nishina-sensei

The history of experiments for $^{278}113$

The history of experiments for ^{278}113

2001: GARIS + RILAC became ready to start.

Motivation was to produce a new element which is connected to known nuclei.

Then we started from following reproductions of GSI DATA.

$^{208}Pb + ^{58}Fe \rightarrow ^{208}Hs$, $^{208}Pb + ^{64}Ni \rightarrow ^{271}Ds$, $^{209}Bi + ^{64}Ni \rightarrow ^{272}Rg$ Succeeded well!

2003: Z=113 Start (Almost the same time, GSI 's 113 exp. started.)

$^{209}Bi(^{70}Zn,n)^{278}113$

1st event was observed on Jul. 2004.

2nd event was observed on Apr. 2005.

2009: $^{248}Cm(^{23}Na,5n)^{266}Bh$ (^{266}Bh is great grand daughter of $^{278}113$)

The results reinforced the information of known(anchor) isotopes of 113 decay chains.

And also established the cross-bombardment.

2010 (2004): $^{205}Tl(^{70}Zn,n)^{274}Rg$ (^{274}Rg is daughter of $^{278}113$)

No event was observed because Tl target couldn't stand against of intense beam.

2012 Aug.: 3rd event of ^{278}113 was observed.

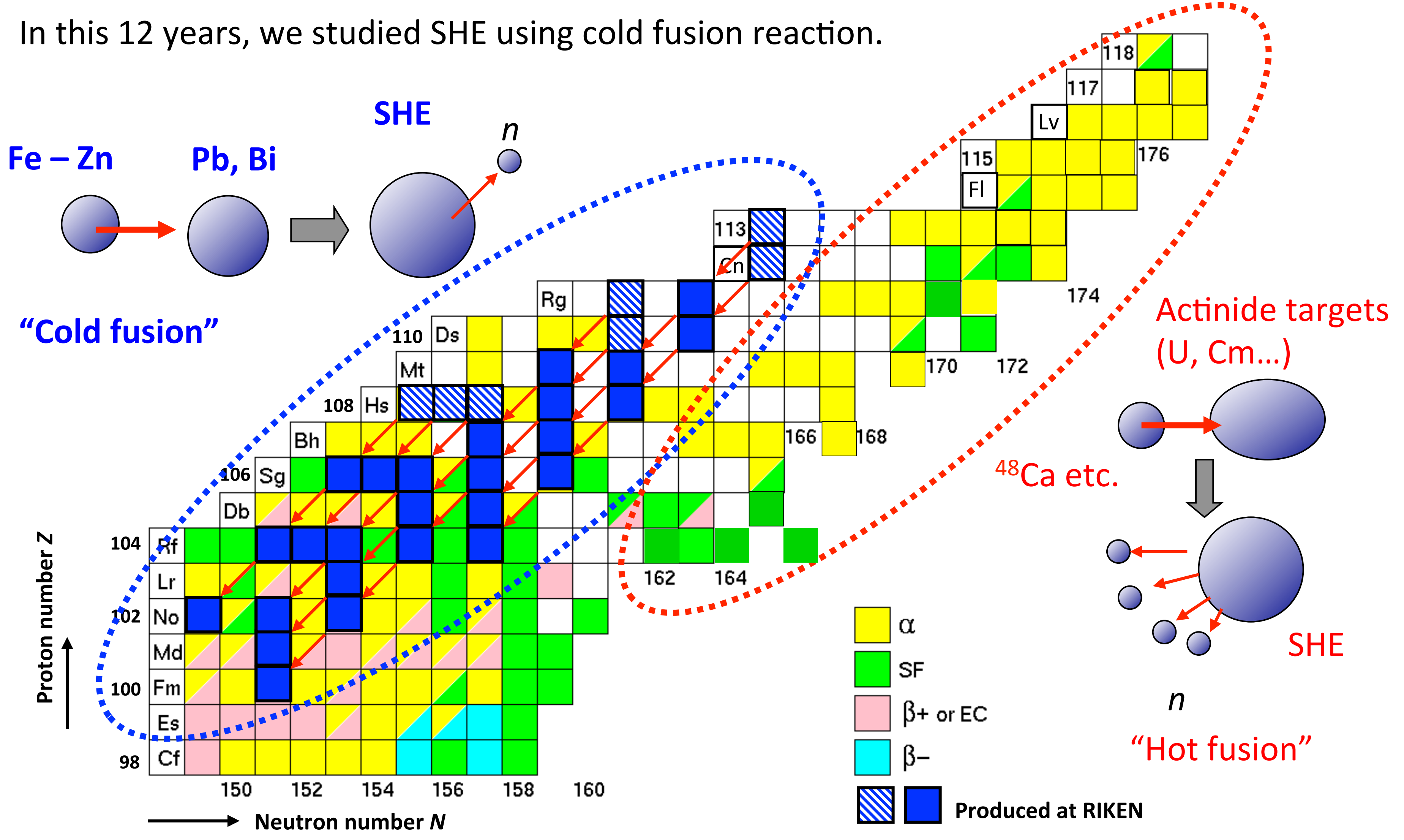
The observed decay chain consist of 6 alpha and connected to ^{254}Md.

2012 Oct.: Z=113 Finish

2015 Dec. IUPAC announced the verification of the discoveries of element 113.

Our research region

In this 12 years, we studied SHE using cold fusion reaction.



$^{209}Bi + ^{70}Zn \rightarrow ^{278}113 + n$

The irradiation was started in Sep. 2003.

1st event was observed on Jul. 2004.

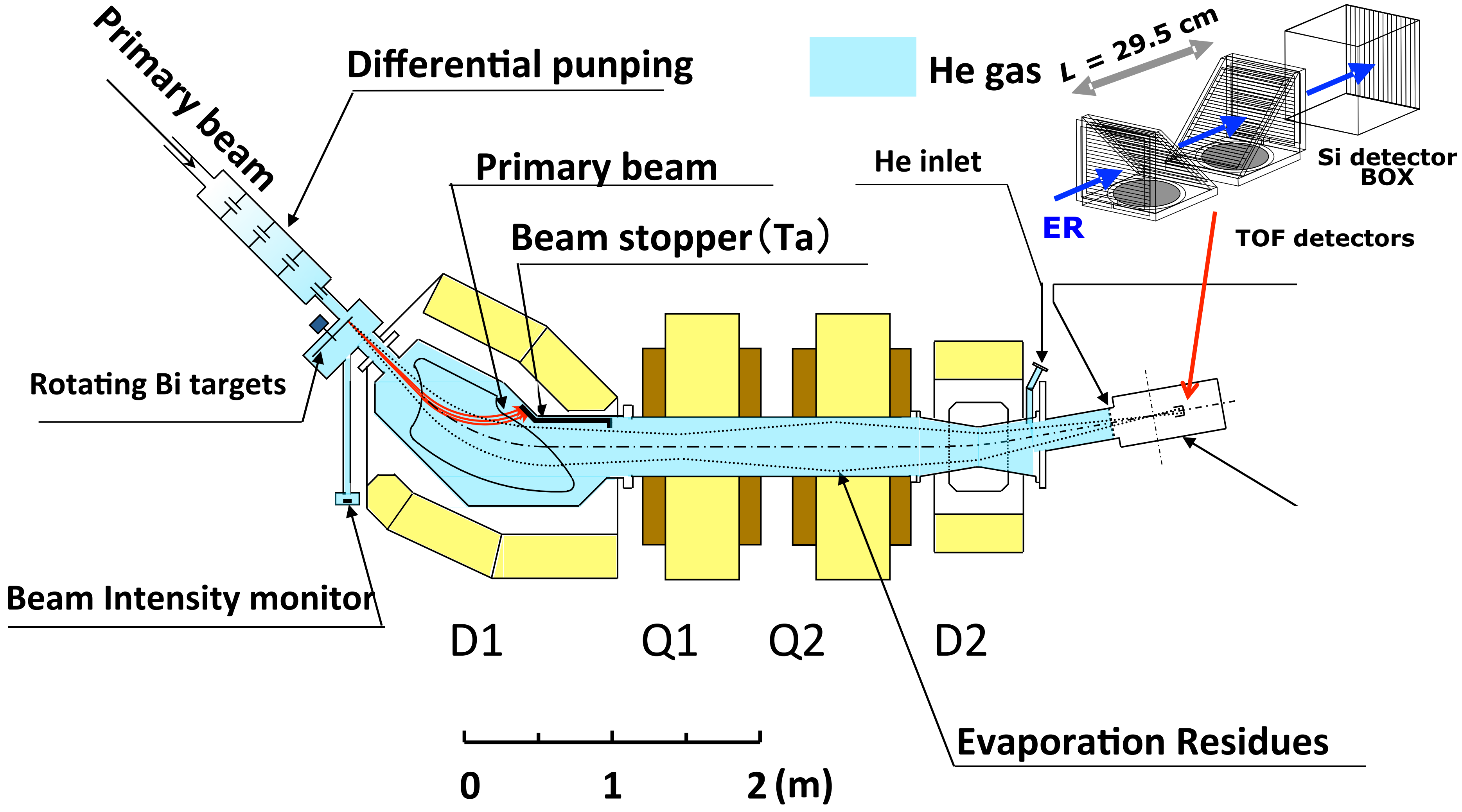
(J. Phys. Soc. Jpn. **73** (2004) 2593.)

2nd event was observed on Apr. 2005 .

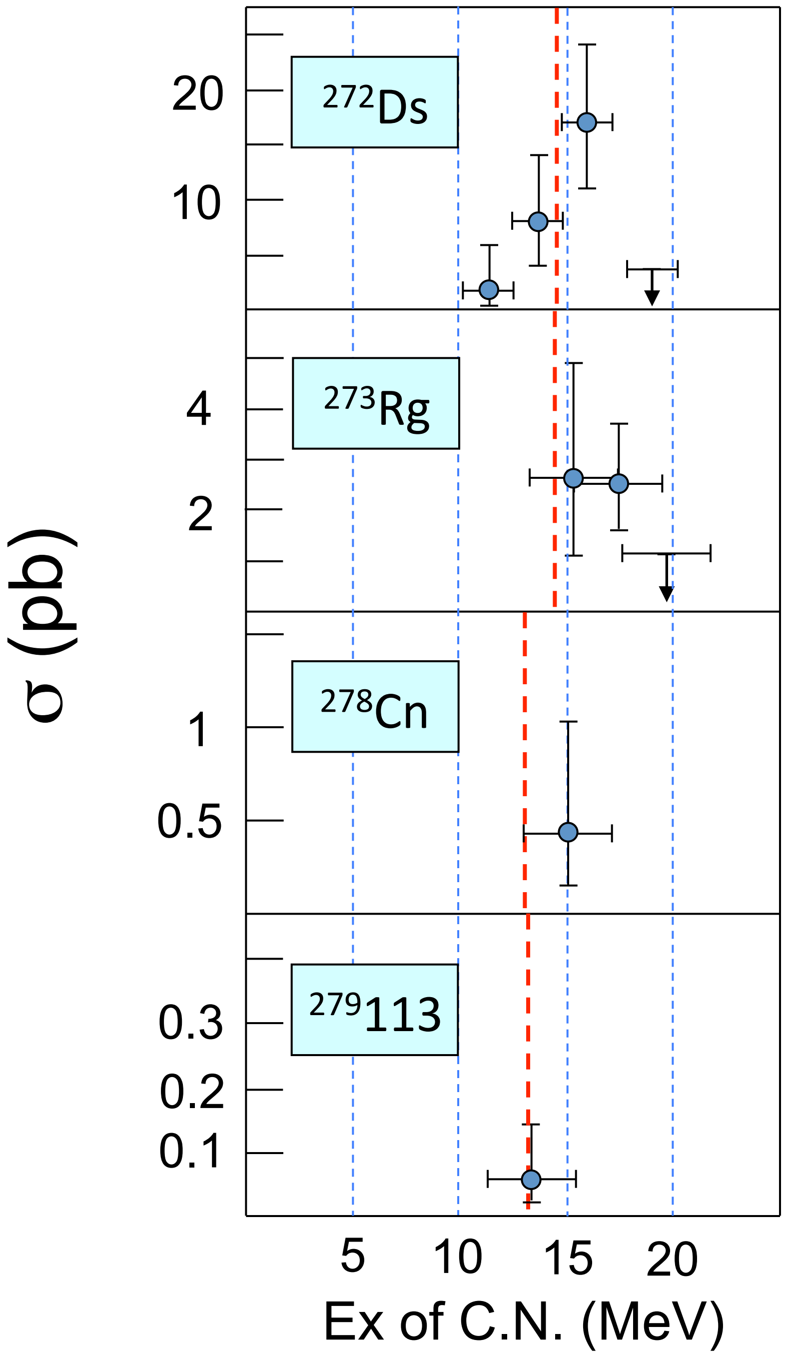
(J. Phys. Soc. Jpn. **76** (2007) 045001.)

Experimental setup for $^{278}113$

GARIS (Gas-filled recoil ion separator)



The 113 experiment was performed by using GARIS and Si detector box with ToF



Determination of incident Energy

We studied the **systematics of excitation function** for the ^{272}**Ds** and ^{273}**Rg**. The peak energies exists around a **threshold of fission after 1n emission** calculated by following mass tables. The beam energy was determined by this systematics.

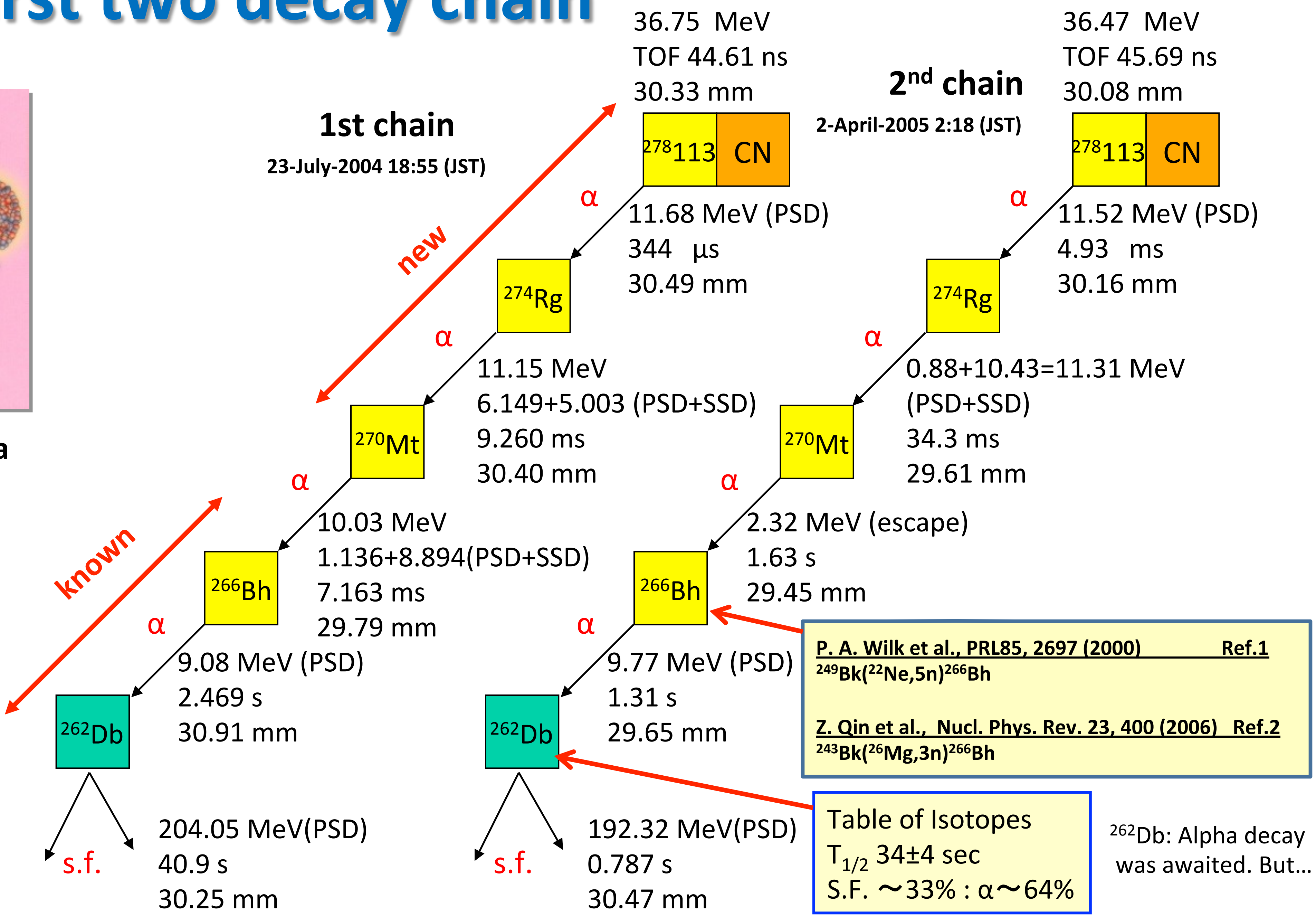
Threshold of fission after 1n emission calculated by following mass tables.

Masses of Beams & Targets
Audi & Wapstra, Nucl. Phys A565, 1 (1993)

Masses of Compound Nuclei
Myers & Swiatecki, Nucl. Phys. A601, 141 (1996)

The first two decay chain

Dr. Morita



^{248}Cm + ^{23}Na → ^{266}Bh + 5n

K. Morita, K. Morimoto, D. Kaji, *et al.*: J. Phys. Soc. Jap. 78(2009) 064201

As shown now, two decay chains of ^{278}113 were observed by using ^{209}**Bi** + ^{70}**Zn.**
Both Chain consist of four alpha decays and ended by spontaneous fission of ^{262}**Db**.

^{266}**Bh** and ^{262}**Db,** the daughter products of ^{278}**113,** are **known nuclei,** reports exsists.
The reports and the daughter products of ^{278}**113** were **consistent.**
Therefore **onece** we claimed that the ^{278}**113** were **clearly determined with Z and A**.

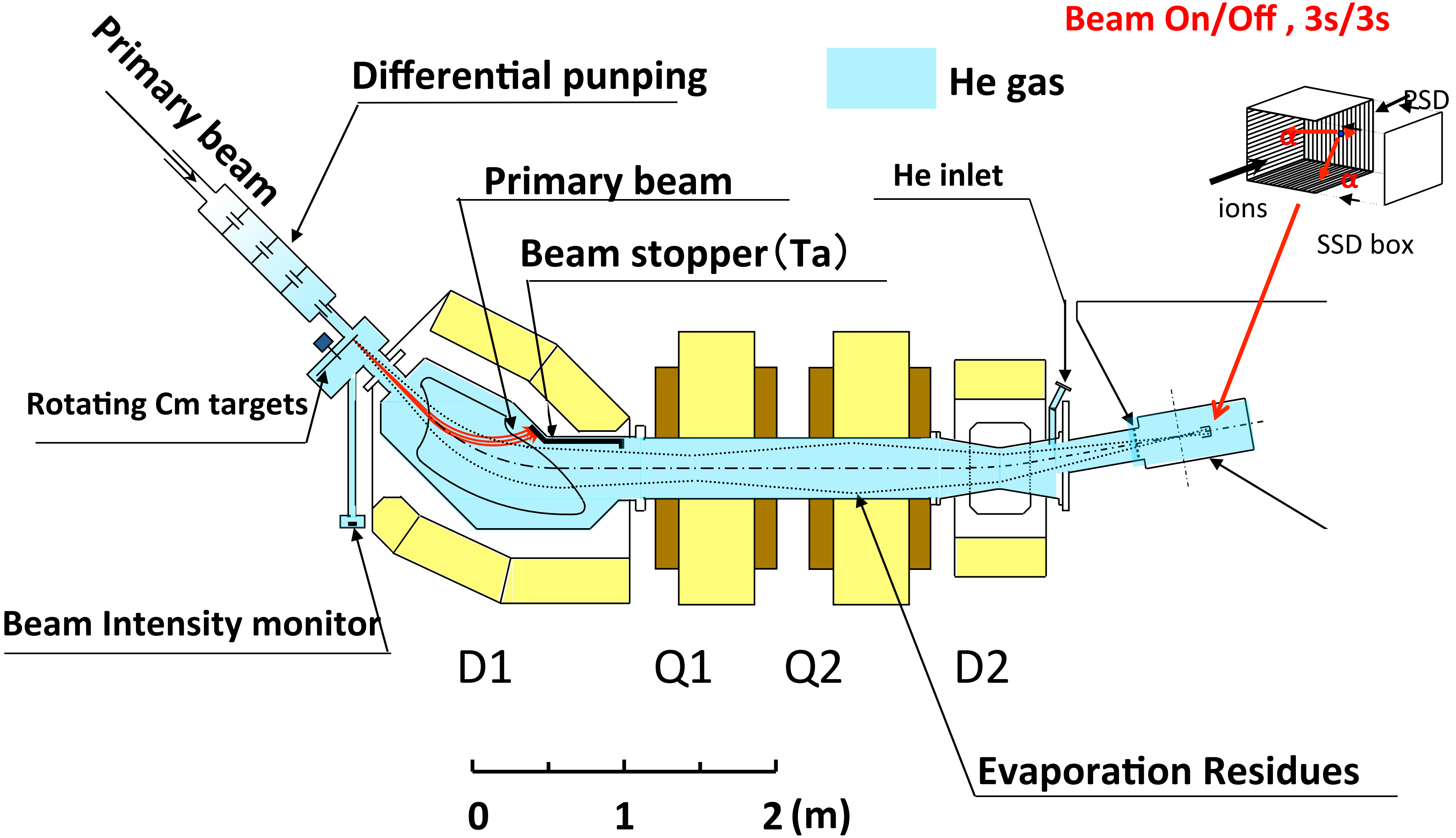
However

The **statistics** of the report of ^{266}Bh were **not enough**.
1 events: (**^{249}Bk + ^{22}Ne → ^{266}Bh**), LBNL, P. A. Wilk *et al.*, Phys. Rev. Lett. **85**, (2000)
4 events: (**^{243}Am + ^{26}Mg → ^{266}Bh**), IMP, Z. Qin *et al.*, Nucl. Phys. Rev. **23** (2006) (Chinese journal in English)

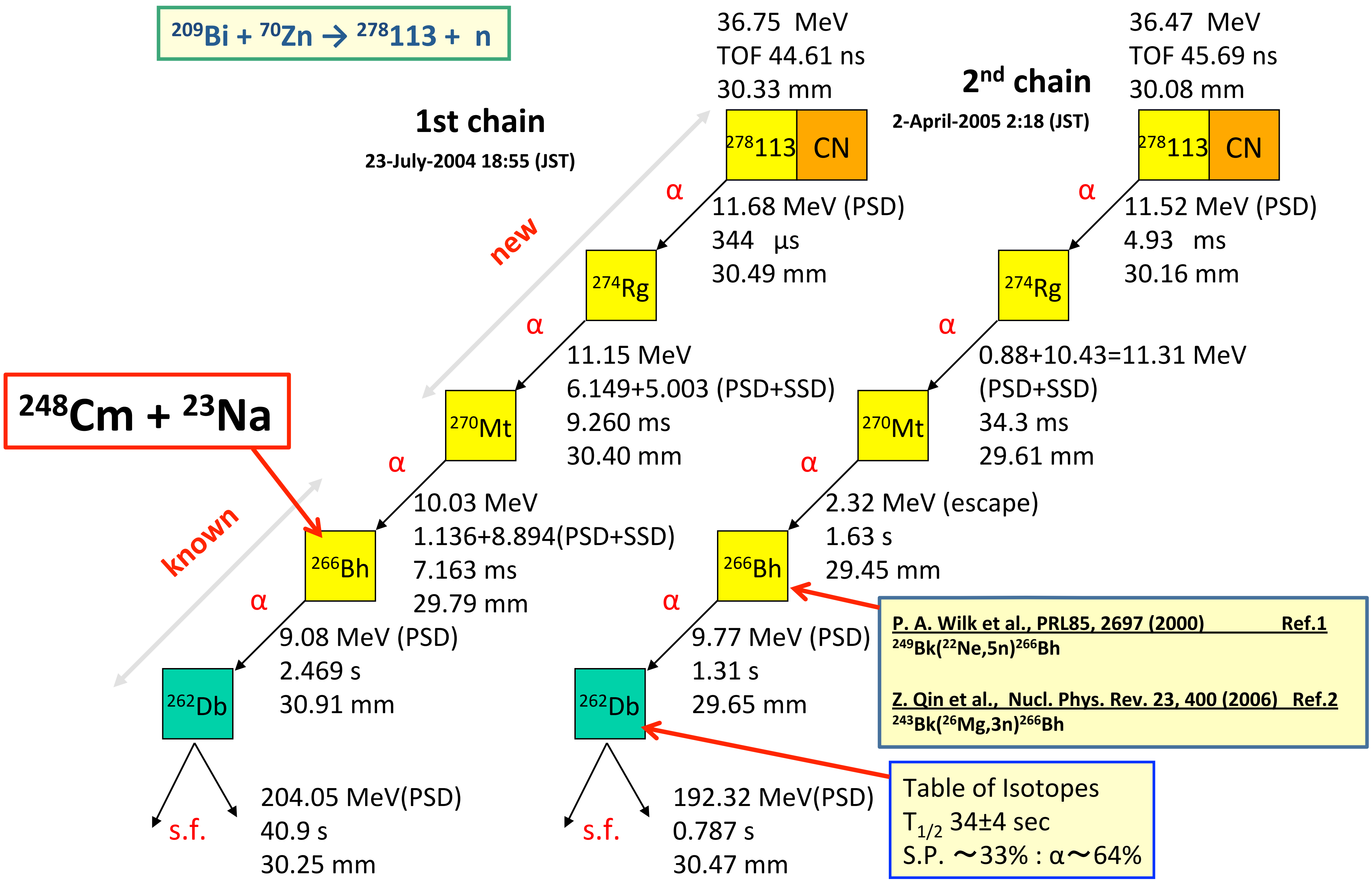
Motivation of this work was
to reinforce the information of known(anchor) isotopes of 113 decay chain.

Experimental setup for the Cm + Na → Bh

GARIS (Gas-filled recoil ion separator)



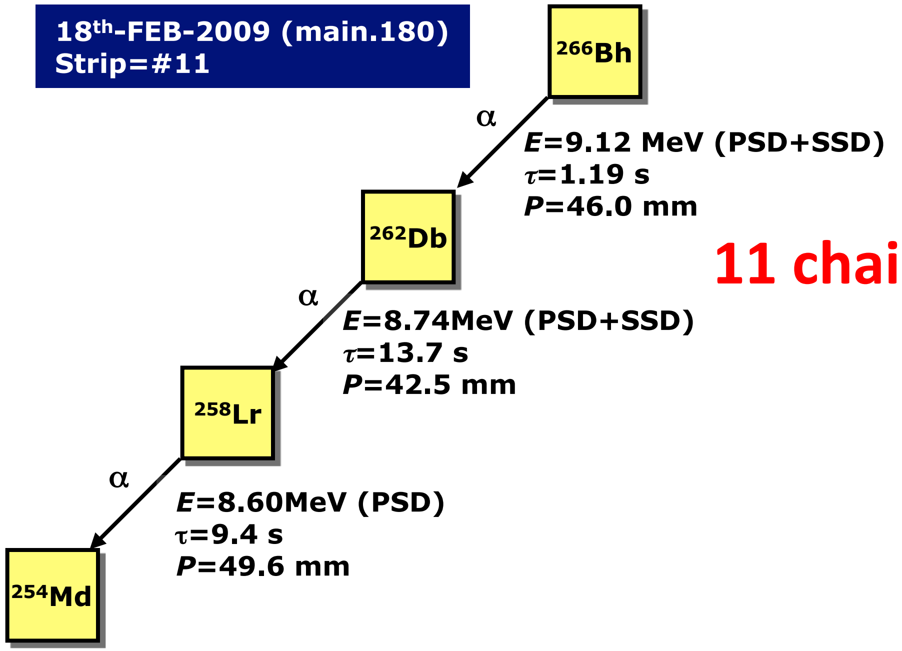
The Bh experiment was performed by using **GARIS** and **Si detector box** **without ToF detectors,** because recoil velocity is too low to passing through the ToF detectors.



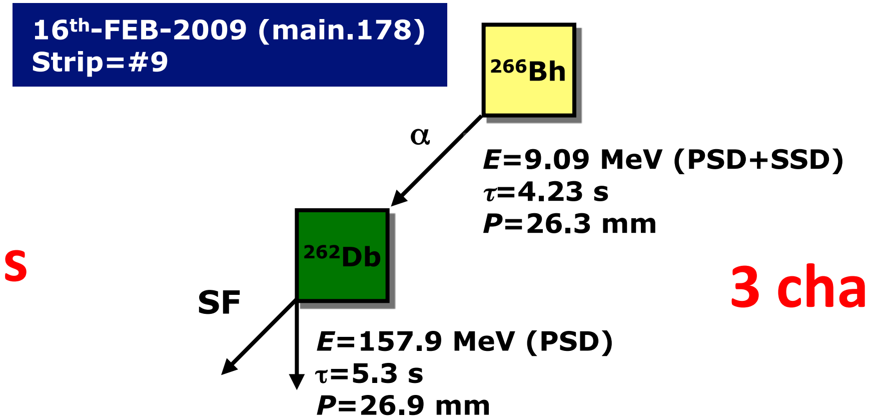
$^{209}Bi + ^{70}Zn \rightarrow ^{278}113 + n$
1st chain
23-July-2004 18:55 (JST)
2nd chain
2-April-2005 2:18 (JST)
36.75 MeV
TOF 44.61 ns
30.33 mm
$^{278}113$
CN
α
11.68 MeV (PSD)
344 μs
30.49 mm
^{274}Rg
α
11.15 MeV
6.149+5.003 (PSD+SSD)
9.260 ms
30.40 mm
^{270}Mt
α
10.03 MeV
1.136+8.894(PSD+SSD)
7.163 ms
29.79 mm
^{266}Bh
α
9.08 MeV (PSD)
2.469 s
30.91 mm
^{262}Db
s.f.
204.05 MeV(PSD)
40.9 s
30.25 mm
new
known
$^{248}Cm + ^{23}Na$
36.47 MeV
TOF 45.69 ns
30.08 mm
$^{278}113$
CN
α
11.52 MeV (PSD)
4.93 ms
30.16 mm
^{274}Rg
α
0.88+10.43=11.31 MeV
(PSD+SSD)
34.3 ms
29.61 mm
^{270}Mt
α
2.32 MeV (escape)
1.63 s
29.45 mm
^{266}Bh
α
9.77 MeV (PSD)
1.31 s
29.65 mm
^{262}Db
s.f.
192.32 MeV(PSD)
0.787 s
30.47 mm
P. A. Wilk et al., PRL85, 2697 (2000) Ref.1
$^{249}Bk(^{22}Ne,5n)^{266}Bh$
Z. Qin et al., Nucl. Phys. Rev. 23, 400 (2006) Ref.2
$^{243}Bk(^{26}Mg,3n)^{266}Bh$
Table of Isotopes
$T_{1/2}$ 34±4 sec
S.P. ～33% : α～64%

Example of the observed decay chains of ^{266}Bh

14 decay chains from ^{266}Bh were observed in total.



11 chains



3 chains

Fission branch of ^{262}Db was clearly observed.

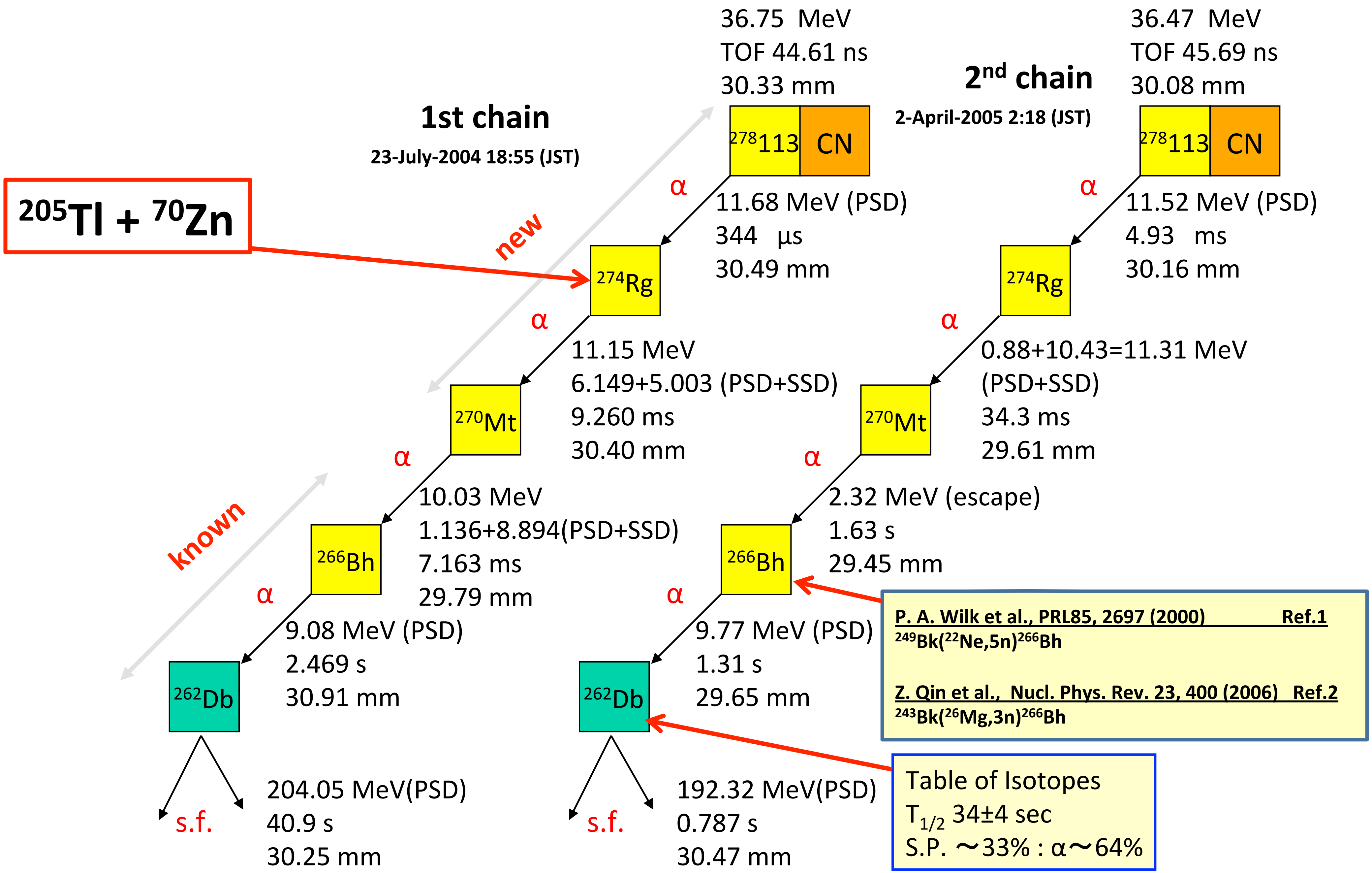
Now, the ^{278}113 decay chains clearly connected to the known ^{266}Bh and ^{262}Db !

$$^{205}Tl + ^{70}Zn \rightarrow ^{274}Rg + n$$

^{274}Rg is daughter of $^{278}113$.

In order to make further confirmation,
we tried to produce ^{274}Rg by $^{205}Tl(^{70}Zn,n)^{274}Rg$ reaction, two times.

Period 1:	2004/11/22 ～ 2004/12/15
Period 2:	2010/03/12 ～ 2010/03/29


205Tl + 70Zn
1st chain
23-July-2004 18:55 (JST)
2nd chain
2-April-2005 2:18 (JST)
new
known
36.75 MeV
TOF 44.61 ns
30.33 mm
278113 CN
α
11.68 MeV (PSD)
344 μs
30.49 mm
274Rg
α
11.15 MeV
6.149+5.003 (PSD+SSD)
9.260 ms
30.40 mm
270Mt
α
10.03 MeV
1.136+8.894(PSD+SSD)
7.163 ms
29.79 mm
266Bh
α
9.08 MeV (PSD)
2.469 s
30.91 mm
262Db
s.f.
204.05 MeV(PSD)
40.9 s
30.25 mm
36.47 MeV
TOF 45.69 ns
30.08 mm
278113 CN
α
11.52 MeV (PSD)
4.93 ms
30.16 mm
274Rg
α
0.88+10.43=11.31 MeV
(PSD+SSD)
34.3 ms
29.61 mm
270Mt
α
2.32 MeV (escape)
1.63 s
29.45 mm
266Bh
α
9.77 MeV (PSD)
1.31 s
29.65 mm
262Db
s.f.
192.32 MeV(PSD)
0.787 s
30.47 mm
P. A. Wilk et al., PRL85, 2697 (2000) Ref.1
249Bk(22Ne,5n)266Bh
Z. Qin et al., Nucl. Phys. Rev. 23, 400 (2006) Ref.2
243Bk(26Mg,3n)266Bh
Table of Isotopes
T1/2 34±4 sec
S.P. ∼33% : α∼64%

Summary of $^{205}Tl(^{70}Zn, n)^{274}Rg$

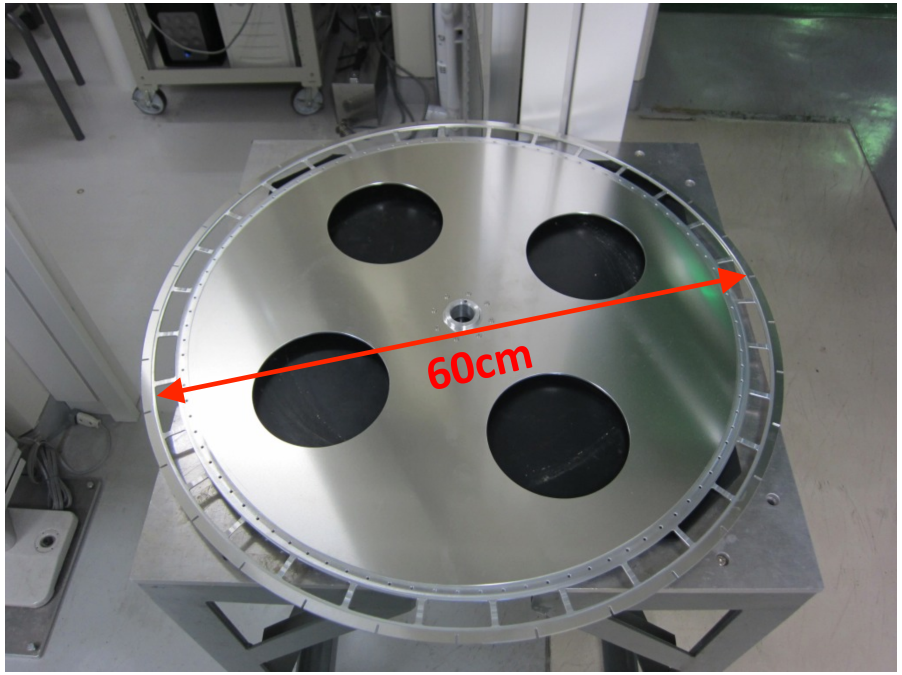
Period 1:	**2004/11/22 ～ 2004/12/15** (30cmΦ target) Target deterioration occur (thickness became un-uniform imediately) --> Tl target is weeker than Bi
Period 2:	**2010/03/12 ～ 2010/03/29** (60cmΦ target) We applied **60cmΦ wheel**, but not efficiently improved
Beam Energy	**341 MeV at target half depth**
Total Dose	**7.5×10^{18}**
Target Thickness	**450 μg/cm^2**
number of events	**0**
Cross section	**0.23 pb (upper limit)**
Irradiation time	**39 Days**
Beam Intensity	**～0.4 pμA**

Melting point
Tl: 302.5 ℃
Bi: 271.5 ℃
Pb: 327.5 ℃

Melting point of Tl is higher than Bi, but Tl target was weaker than Bi target.
The reason is still question mark.

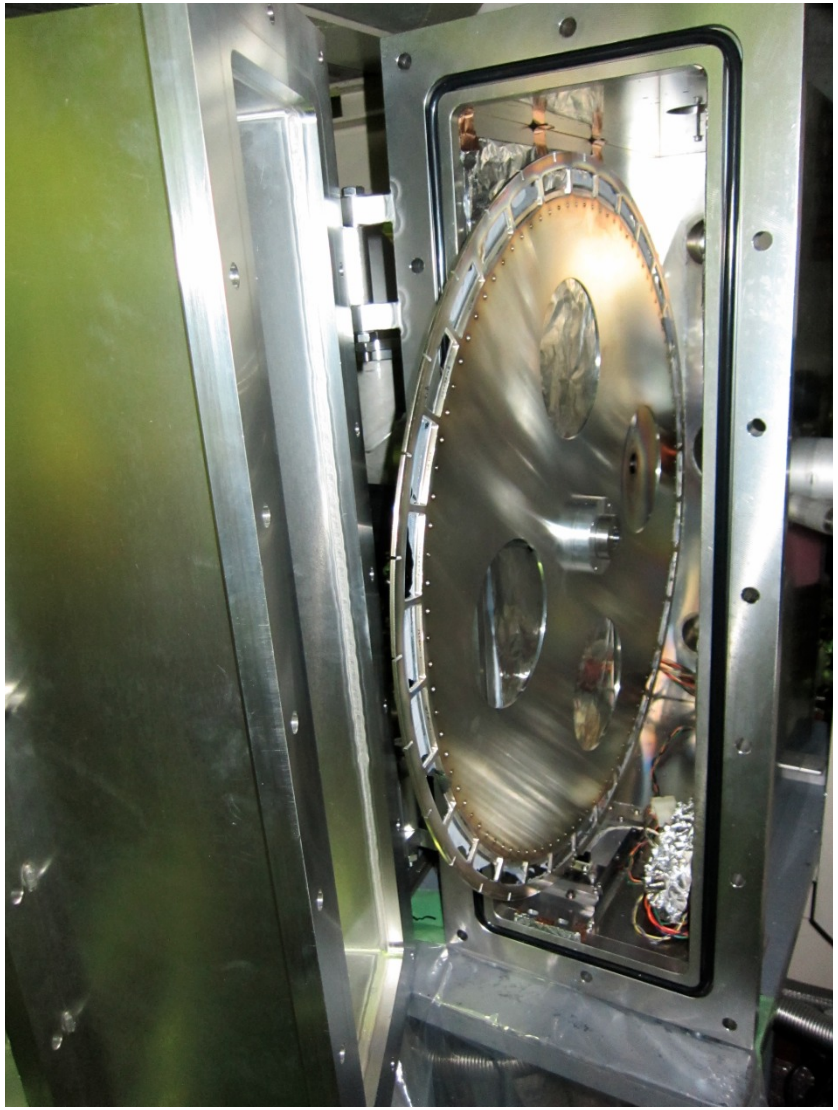
→ Gave up!

Newly developed 60cm target



Target wheel

In 2009 we developed a 60cm diameter rotating target system for **GARIS-I**. It was succeeded to work in the condition of **2000 rpm** and used in the experiment of Zn + Tl. (Period 2: 2010)



Target Camber

But the Tl target problem was not efficiently improved and we gave up the production of ^{274}Rg.

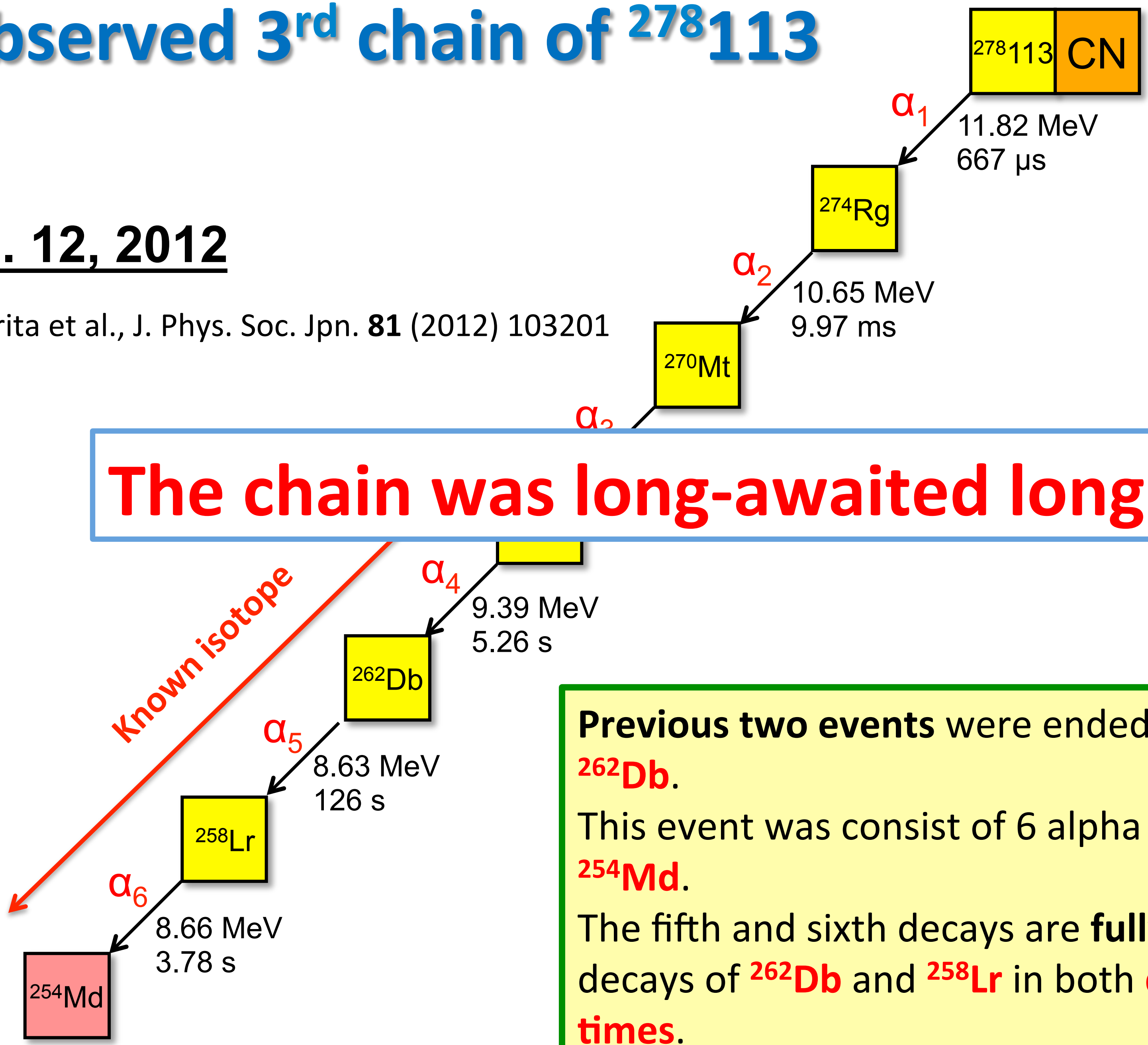
Then again,

we continued Bi+Zn → 113 experiment.

We continued the irradiation about 450 days from 2nd event.

At last the 3rd event came!

Newly observed 3rd chain of $^{278}113$



<u>Aug. 12, 2012</u>

K. Morita et al., J. Phys. Soc. Jpn. **81** (2012) 103201

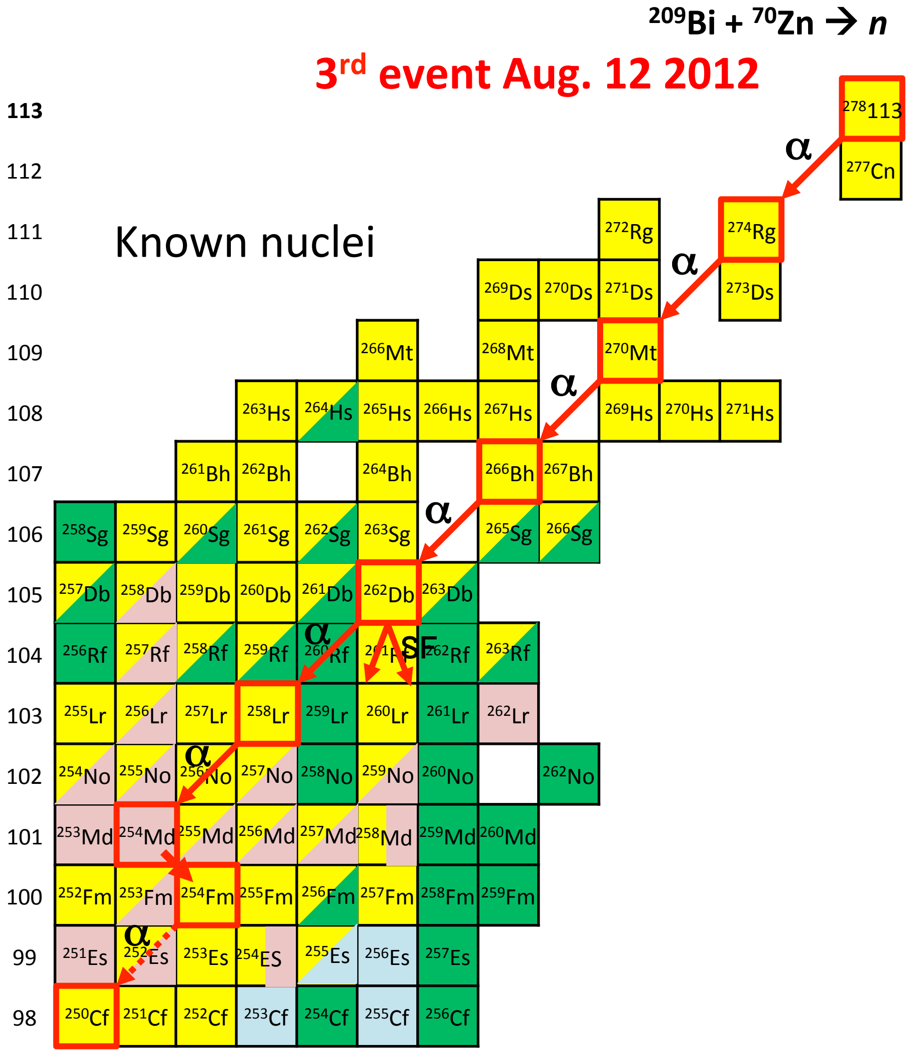
The chain was long-awaited long chain!

Previous two events were ended by spontaneous fission of **^{262}Db**.

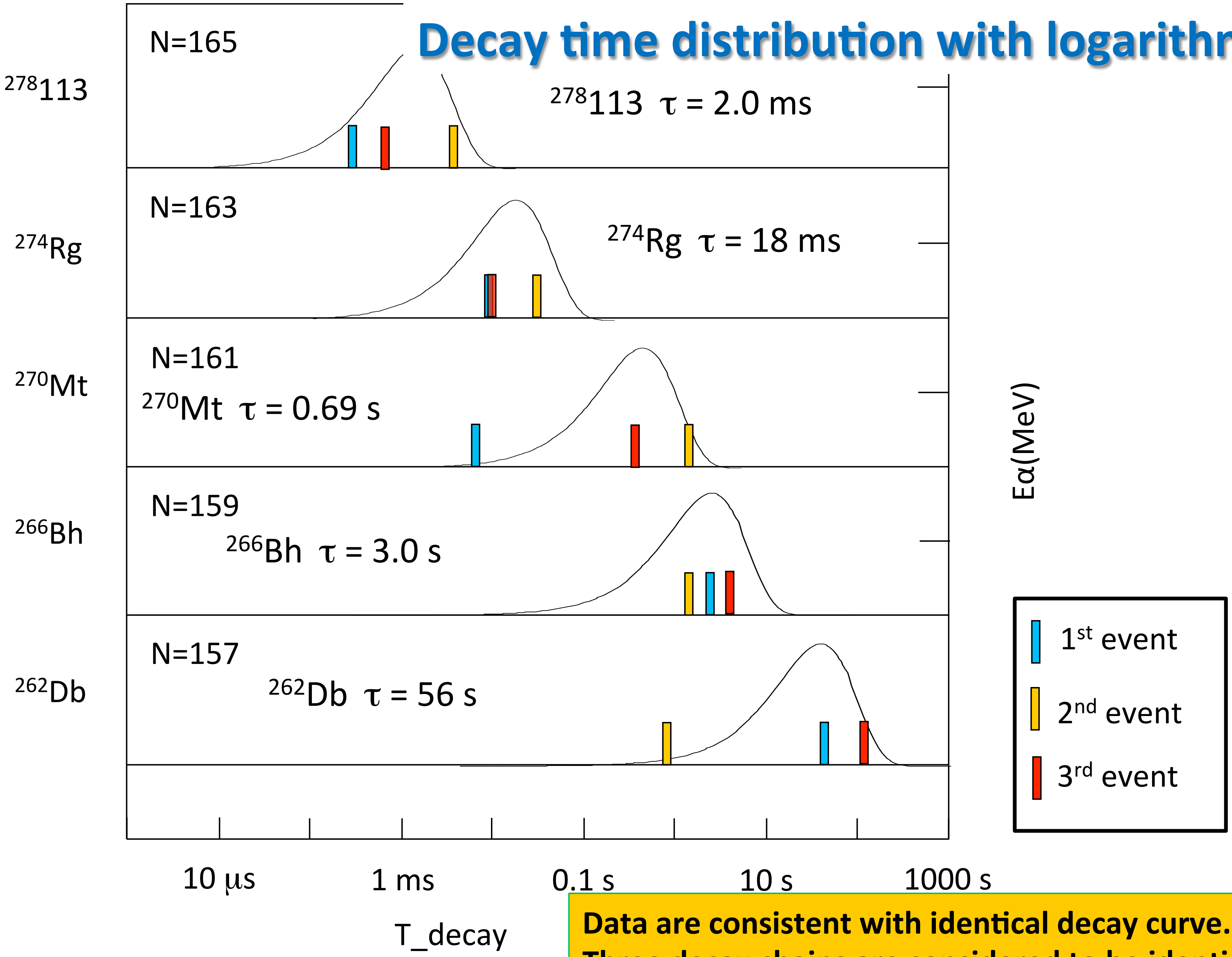
This event was consist of 6 alpha decays and **connected to ^{254}Md**.

The fifth and sixth decays are **fully consistent with** the sequential decays of **^{262}Db** and **^{258}Lr** in both **decay energies** and **decay times**.

Observed three decay chains on the nuclear chart

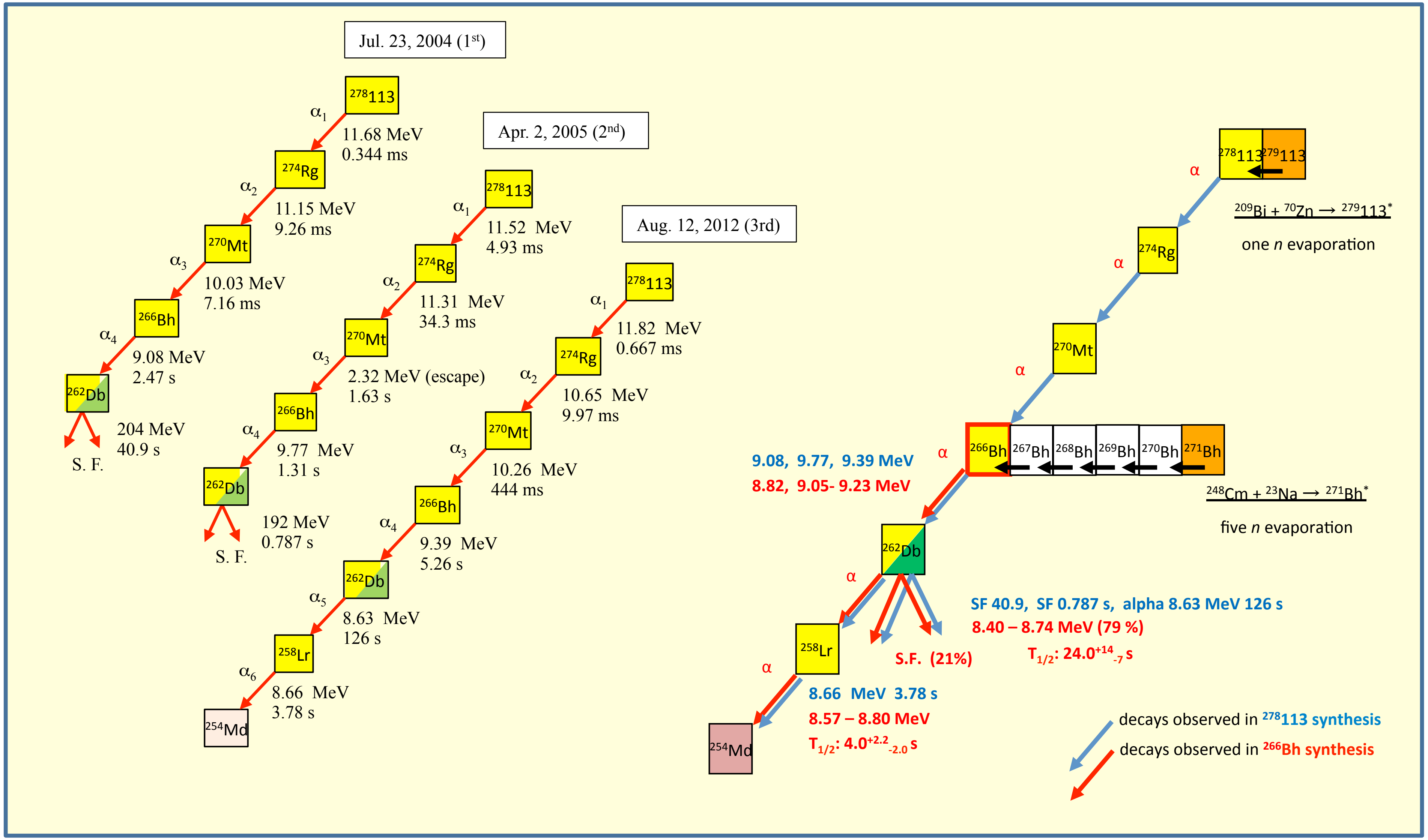


Decay time distribution with logarithmic scale.



Data are consistent with identical decay curve.
Three decay chains are considered to be identical.

Summary of the results related to $^{278}113$



The history of experiments for $^{278}113$

2001: GARIS + RILAC became ready to start.

Motivation was to produce a new element which is connected to known nuclei.

Then we started from following reproductions of GSI DATA.

$^{208}Pb + ^{58}Fe \rightarrow ^{208}Hs$, $^{208}Pb + ^{64}Ni \rightarrow ^{271}Ds$, $^{209}Bi + ^{64}Ni \rightarrow ^{272}Rg$ Succeeded well!

2003: Z=113 Start (Almost the same time, GSI 's 113 exp. started.)

$^{209}Bi(^{70}Zn,n)^{278}113$

1st event was observed on Jul. 2004.

2nd event was observed on Apr. 2005.

2009: $^{248}Cm(^{23}Na,5n)^{266}Bh$ (^{266}Bh is great grand daughter of $^{278}113$)

The results reinforced the information of known(anchor) isotopes of 113 decay chains.

And also established the cross-bombardment.

2010 (2004): $^{205}Tl(^{70}Zn,n)^{274}Rg$ (^{274}Rg is daughter of $^{278}113$)

No event was observed because Tl target couldn't stand against of intense beam.

2012 Aug.: 3rd event of $^{278}113$ was observed.

The observed decay chain consist of 6 alpha and connected to ^{254}Md.

2012 Oct.: Z=113 Finish

2015 Dec. IUPAC announced the verification of the discoveries of element 113.

$^{70}Zn + ^{209}Bi \rightarrow ^{278}113$ Beam Time Table

Beam Time Year	Period	net irrad. t. (days)	dose/sum [$\times 10^{19}$]	Cross section (fb)	events
2003	9/5 - 12/29	57.9	1.24/1.24	75 (upper)	0
2004	7/8 - 8/2	21.9	0.51/1.75	55	1
2005	1/20 - 1/23	3.0	0.07/1.82	52	0
2005	3/20 - 4/22	27.1	0.71/2.53	75	1
2005	5/19 - 5/21	2.0	0.05/2.58	74	0
2005	8/7 - 8/25	16.1	0.45/3.03	63	0
2005	9/7 - 10/20	39.0	1.17/4.20	45	0
2005	11/25 - 12/15	19.5	0.63/4.83	39	0
2006	3/14 - 5/15	54.2	1.37/6.20	31	0
2008	1/9 - 3/31	70.9	2.28/8.48	23	0
2010	9/7 - 10/18	30.9	0.52/9.00	21	0
2011	1/22 - 5/22	89.8	[illegible]	17	0
2011	12/2 - 12/19	14.4	[illegible]	17	0
2012	1/15 - 2/9	25.0	[illegible]	16	0
2012	3/13 - 4/17	33.7	0.79/12.69	15	0
2012	6/12 - 7/2	15.7	0.25/12.94	15	0
2012	7/14 - 10/1	55.0	0.97/13.91	22	1
Total		576	13.91	22	3

576 / 3 = 192,
1 event per 192 days!

SUBJECT: **Discovery and Assignment of Elements with Atomic Numbers 113, 115, 117 and 118**

IUPAC announces the verification of the discoveries of

four new chemical elements:

The 7th period of the periodic table of elements is complete!

The fourth IUPAC/IUPAP Joint Working Party (JWP) on the priority of claims to the discovery of new elements has reviewed the relevant literature for elements 113, 115, 117, and 118 and has determined that the claims for discovery of these elements have been fulfilled, in accordance with the criteria for the discovery of elements of the IUPAP/IUPAC Transfermium Working Group (TWG) 1991 discovery criteria. These elements complete the 7th row of the periodic table of the elements, and the discoverers from Japan, Russia and the USA will now be invited to suggest permanent names and symbols. The new elements and assigned priorities of discovery are as follows:

Element 113 (temporary working name and symbol: ununtrium, Uut

The RIKEN collaboration team in Japan have fulfilled the criteria for element Z=113 and will be invited to propose a permanent name and symbol.

Elements 115, 117 and 118 (temporary working names and symbols: ununpentium, Uup; ununseptium, Uus; and ununoctium, Uuo)

The collaboration between the Joint Institute for Nuclear Research in Dubna, Russia; Lawrence Livermore National Laboratory, California, USA; and Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA have fulfilled the criteria for element Z=115, 117 and will be invited to propose permanent names and symbols.

30 December 2015

Nihonium “Nh”

We proposed "**nihonium**" for the name and "**Nh**" for the symbol.

There are two ways to say "**Japan**" in Japanese: "**Nihon**" and "**Nippon**". Both literally mean **“the Land of Rising Sun”** and are widely used officially. We have therefore decided on "nihon", and by adding "-ium", the name for the new element with atomic number 113 will be "nihonium". The symbol will be "Nh" as an abbreviation for "nihonium".

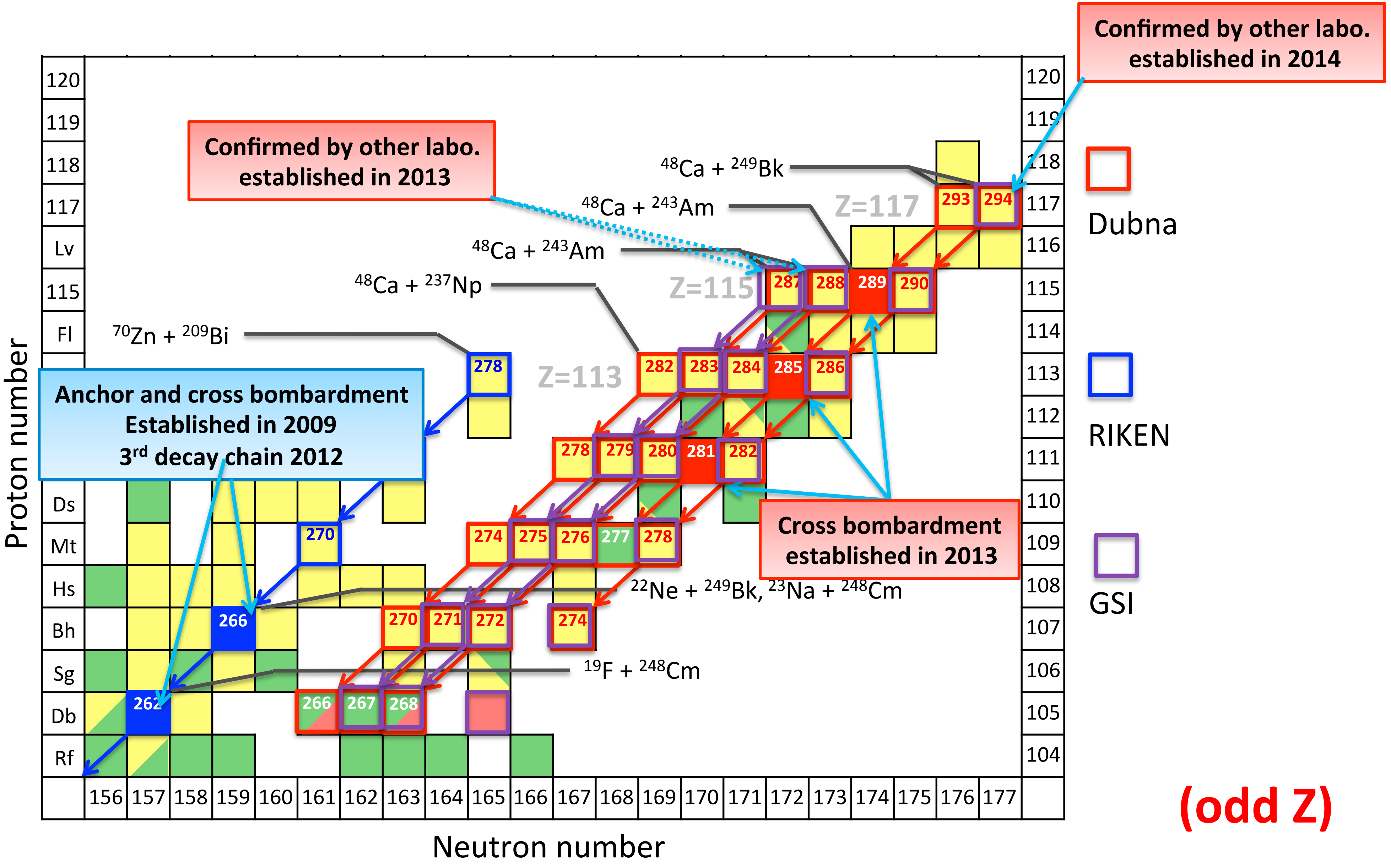
Naming meeting

Together with Nishina-sensei

Why RIKEN? Why not Dubna?

Dubna and USA collaboration team
also claimed the discovery of element 113

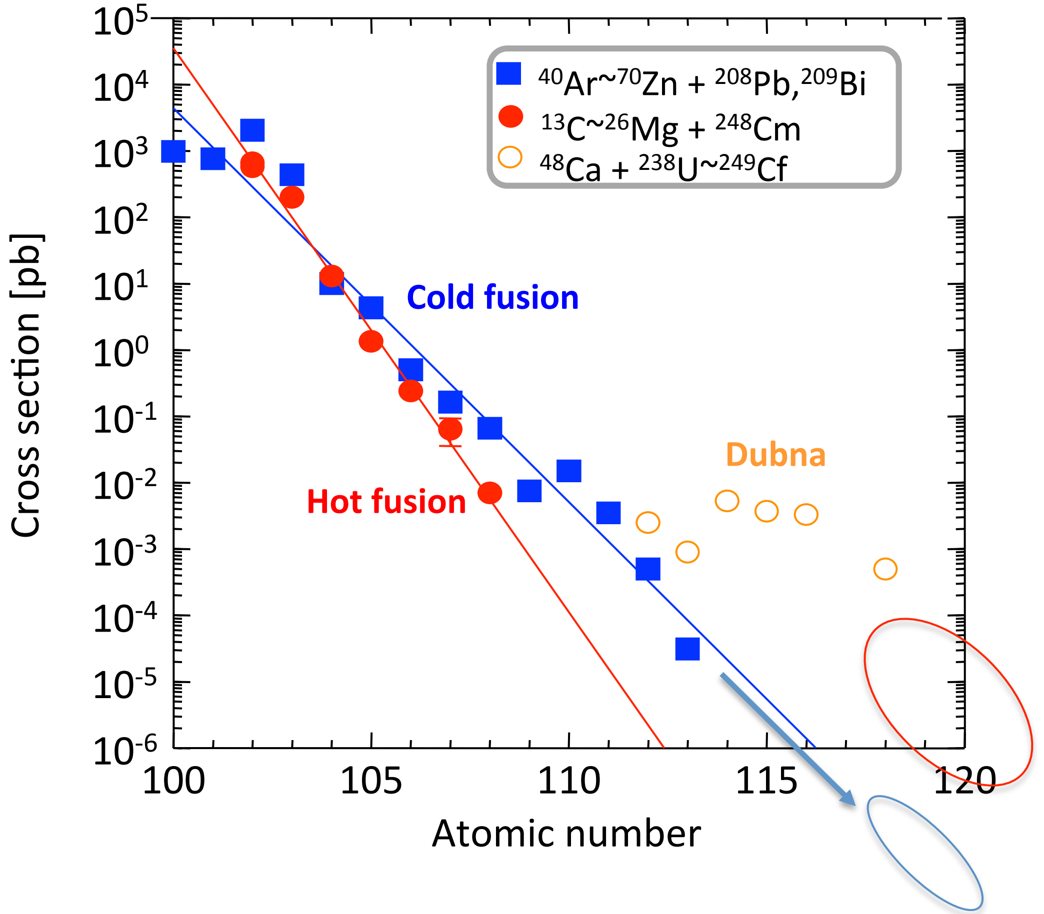
RIKEN team fulfilled the criteria, just before Dubna and USA team



Future plan

Cold fusion → Hot fusion

Further new element search using cold fusion is **hopeless**
because of its **small production cross-section**.

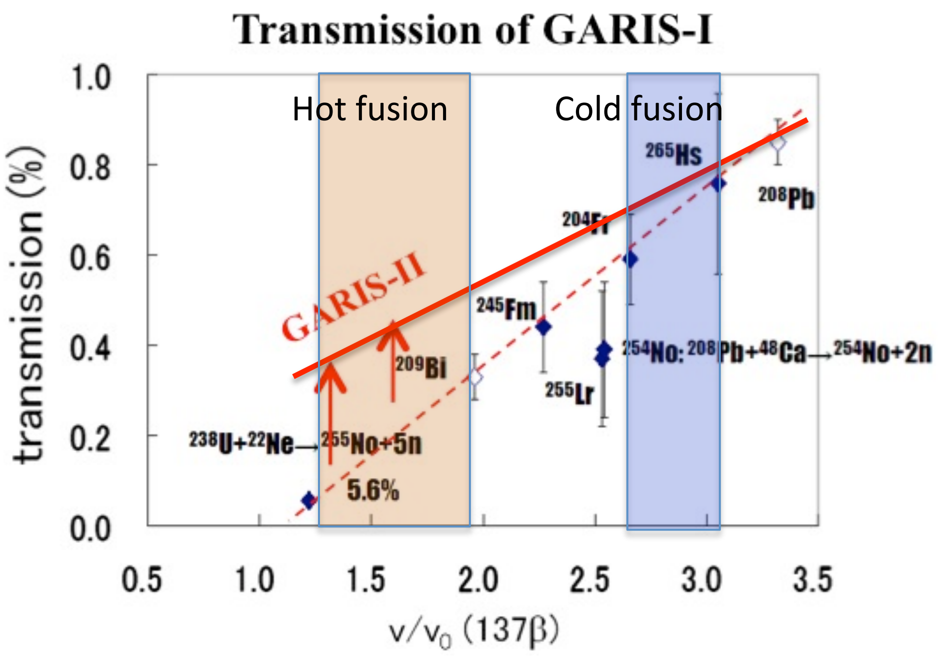


Z=113 (cold fusion)
22 fb, 1 event / 200 day

Development of GARIS-II

GARIS-I (present GARIS) has a high transmission efficiency for **symmetric reaction** (higher velocity products) like a **cold fusion** reaction.

GARIS-II was designed suitable for the **asymmetric reaction** like **a hot fusion reaction.**

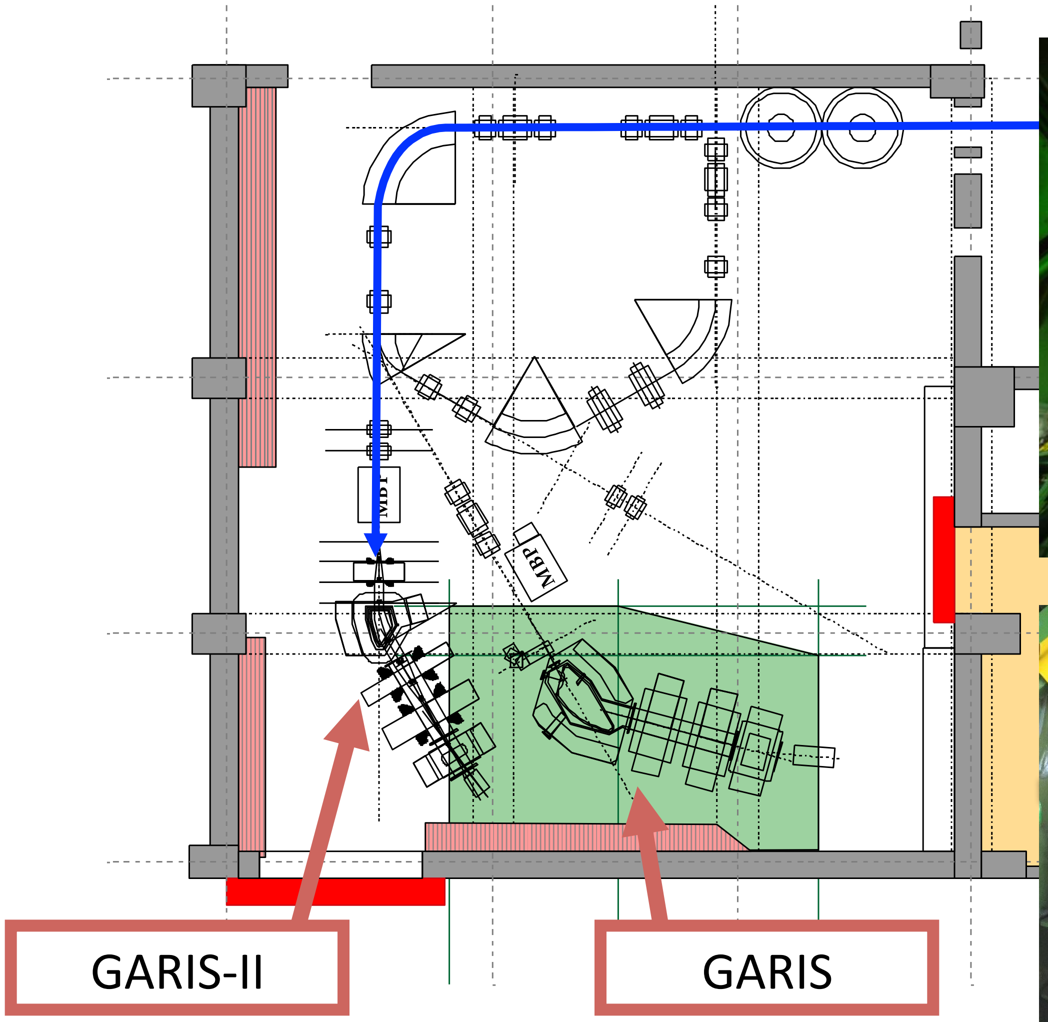


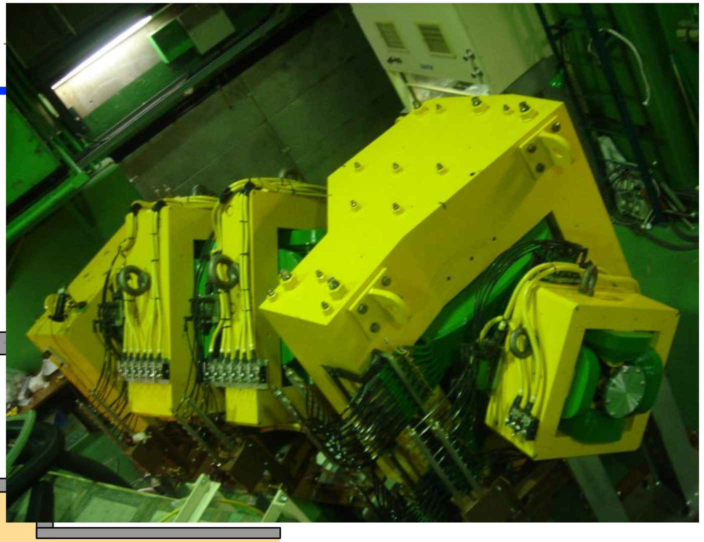
Asymmetric (hot fusion) reaction →
- Small momentum of ERs
- recoil effect of emitted neutrons
- multiple scattering of ERs with target atoms

→ Large angular acceptance required

GARIS		GARIS－II
$\Delta\theta = \pm 67 \quad mrad$	⇔	$\Delta\theta = \pm 55 \quad mrad$
$\Delta\phi = \pm 58 \quad mrad$		$\Delta\phi = \pm 120 \quad mrad$
$\Delta\Omega \approx 12 \quad msr$		$\Delta\Omega \approx 20 \quad msr$

New separator GARIS-II





Comparison
GARIS-II vs. World's working GFRS

	DGFRS	BGS	RITU	GARIS	TASCA (HTM)	TASCA (SIM)	GARIS-II
Configuration	DQ_hQ_v	Q_hD_hD	$Q_vDQ_hQ_v$	DQ_hQ_vD	DQ_hQ_v	DQ_vQ_h	$Q_vDQ_hQ_vD$
Total length [m]	4.0	4.7	4.7	5.8	3.5	3.5	5.1
Bend. Angle [deg]	23	25+45	25	45+10	30	30	30+7
Solid angle [msr]	8.8	45.0	10.0	12.2	13.1	4.3	18.5
*B*ρ(max) [Tm]	3.10	2.50	2.20	2.16	2.40	2.40	2.43
Dispersion [mm/%]	7.5	20.0	10.0	9.7	9.0	1.0	19.3
Transmission [%]	41*	49-59*	?	40*	60*	36*	70

GARIS-II Commissioning finished

^{40}Ar COM#2 (2 days) : NOV-2012

^{169}Tm(^{40}Ar,4n)^{205}Fr

^{208}Pb(^{40}Ar,3n)^{245}Fm

^{22}Ne COM#3 (2 days) : JUN-2013

^{197}Au(^{22}Ne,5n)^{214}Ac

^{205}Tl(^{22}Ne,5n)^{222}Pa

^{208}Pb(^{22}Ne,4n)^{226}U

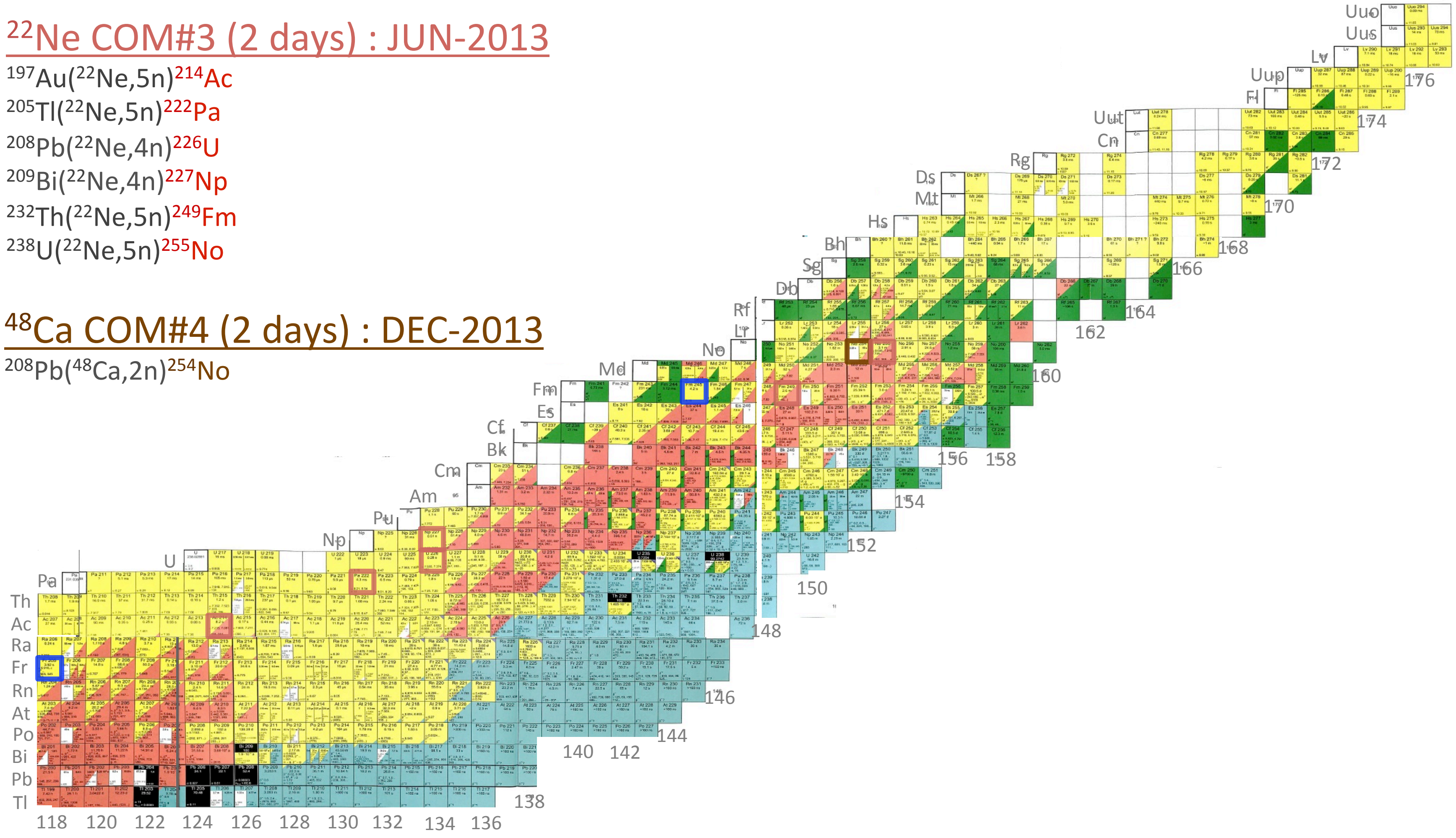
^{209}Bi(^{22}Ne,4n)^{227}Np

^{232}Th(^{22}Ne,5n)^{249}Fm

^{238}U(^{22}Ne,5n)^{255}No

^{48}Ca COM#4 (2 days) : DEC-2013

^{208}Pb(^{48}Ca,2n)^{254}No



GARIS-II Commissioning finished

^{40}Ar, ^{22}Ne, ^{48}Ca GARIS-II COM#2-4

^{23}Na BT#5 (7 days) : JUN-2014

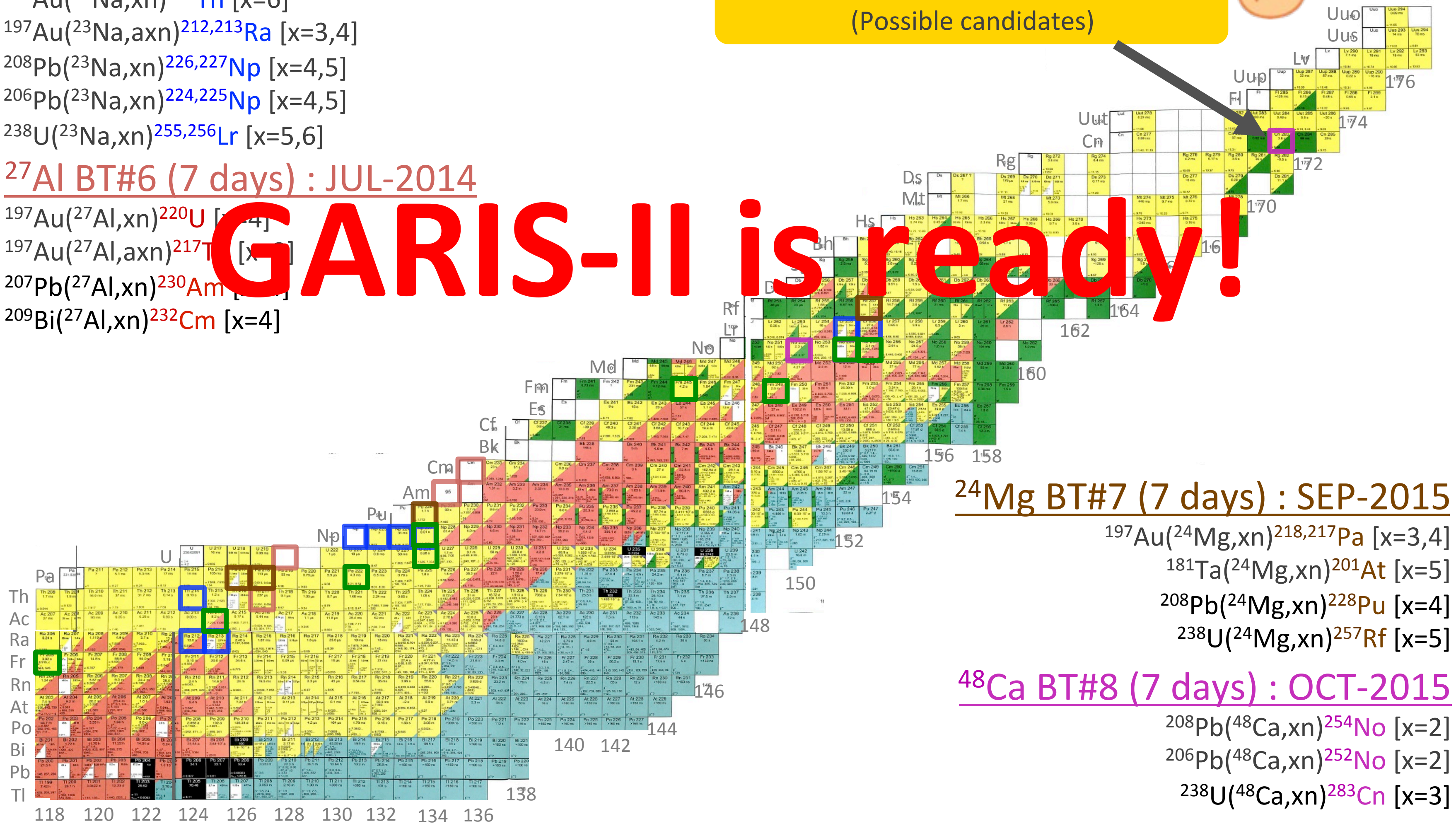
$^{197}Au(^{23}Na,xn)^{214}Th$ [x=6]
$^{197}Au(^{23}Na,axn)^{212,213}Ra$ [x=3,4]
$^{208}Pb(^{23}Na,xn)^{226,227}Np$ [x=4,5]
$^{206}Pb(^{23}Na,xn)^{224,225}Np$ [x=4,5]
$^{238}U(^{23}Na,xn)^{255,256}Lr$ [x=5,6]

^{27}Al BT#6 (7 days) : JUL-2014

$^{197}Au(^{27}Al,xn)^{220}U$ [x=4]
$^{197}Au(^{27}Al,axn)^{217}$T [x ... 3]
$^{207}Pb(^{27}Al,xn)^{230}Am$ [...]
$^{209}Bi(^{27}Al,xn)^{232}Cm$ [x=4]

$^{238}U(^{48}Ca,3n)^{283}Cn$
2 events / 4.5 days
(Possible candidates)

GARIS-II is ready!



^{24}Mg BT#7 (7 days) : SEP-2015

$^{197}Au(^{24}Mg,xn)^{218,217}Pa$ [x=3,4]
$^{181}Ta(^{24}Mg,xn)^{201}At$ [x=5]
$^{208}Pb(^{24}Mg,xn)^{228}Pu$ [x=4]
$^{238}U(^{24}Mg,xn)^{257}Rf$ [x=5]

^{48}Ca BT#8 (7 days) : OCT-2015

$^{208}Pb(^{48}Ca,xn)^{254}No$ [x=2]
$^{206}Pb(^{48}Ca,xn)^{252}No$ [x=2]
$^{238}U(^{48}Ca,xn)^{283}Cn$ [x=3]

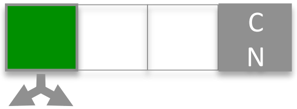
Observed decay chains

GARIS-II ready!

The reaction $^{48}Ca+^{238}U \rightarrow ^{286}Cn^{*}$ studied using GARIS-II

Preliminary

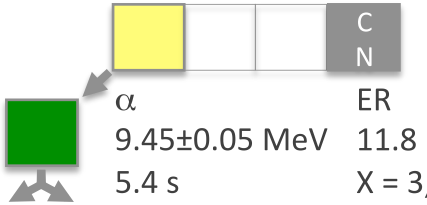
① 23th-OCT-2015, 10:07 (JST)



2-fold fission
172 MeV(=167+5)
14.4 s

ER
12.2 MeV
X = 4, Y = 12
(DSSD-1)

② 27th-OCT-2015, 01:05 (JST)

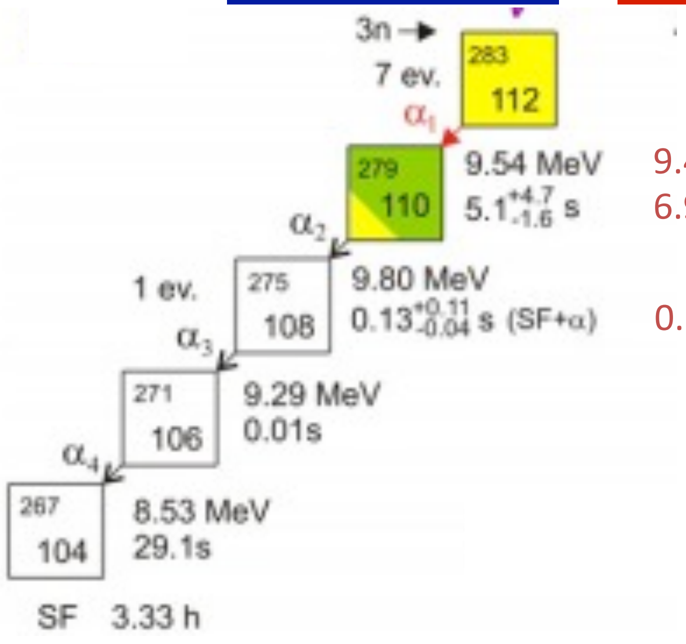


α
9.45±0.05 MeV
5.4 s

ER
11.8 MeV
X = 3, Y = 8
(DSSD-2)

2-fold fission
179 MeV (=137+42)
154 ms

Previous work | **This work**

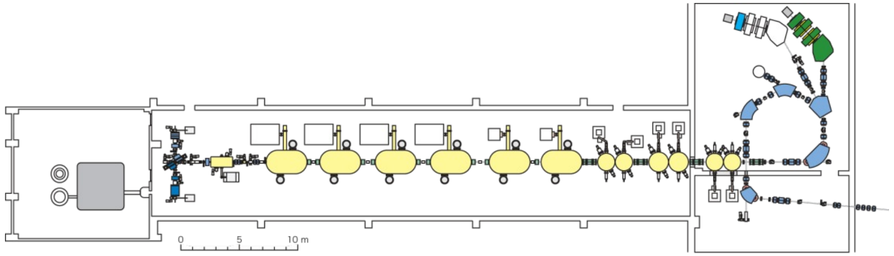


9.45±0.05 MeV
$6.9^{+12.6}_{-2.7}$ s

$0.11^{+0.53}_{-0.05}$ s

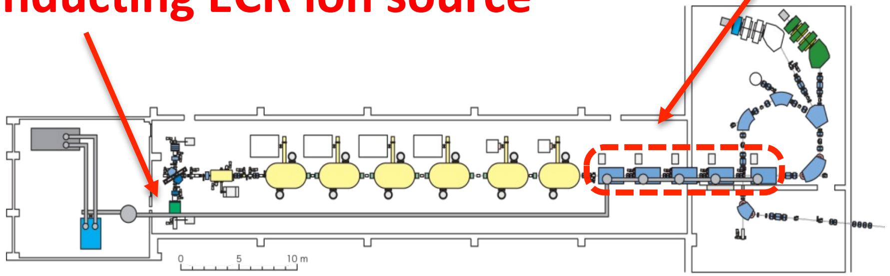
J. Phys. G: Nucl. Part. Phys. 34, R165 (2007)

Upgrade plan of RILAC (2017 -2019)



28GHz superconducting ECR ion source

Superconducting Linac



Stop operation: middle of 2017

Construction: 2017 - 2019

Restart operation: 2019

Beam intensity → more than 5 times

Future plan of SHE group

Present LINAC ?

- ^{248}Cm + ^{50}Ti → 118 For the study of the difference ^{48}Ca and other projectiles

New LINAC ?

- ^{248}Cm + ^{51}V → 119 new element search
- ^{248}Cm + ^{54}Cr → 120 new element search

Status of Cm target

^{248}Cm target will be ready by end of this year. (in collaboration with ORNL)

Status of ion source

- Ti: available, 0.5 pμA on target (in collaboration with IPHC)
- Cr: under development (in collaboration with IPHC)
- V: under development (in collaboration with IPHC)

Thank you for your attention!

Collaborators

RIKEN Nishina Center
K. Morita*, K. Morimoto, D. Kaji, H. Haba, H. Hasebe
K. Katori, Y. Kudou, T. Ohnishi, K. Ozeki,
A. Yoneda, A. Yoshida, Y. Wakabayashi

Tokyo University of Science
T. Sumita, K. Tanaka, J. Chiba

Saitama University
T. Akiyama, R. Sakai, S. Yamaki, T. Yamaguchi

Tohoku University
T. Suda, H. Kikunaga, T. Shinozuka

JAEA
H. Koura, S. Mitsuoka, K. Ooe, N. Sato,
A. Toyoshima, K. Tsukada

Niigata University
S. Goto, M. Murakami, M. Murayama,
Y. Kanaya, H. Kudo,

YITP Kyoto University
T. Ichikawa,

University of Tsukuba
A. Ozawa, K. Sueki

Yamagata University
Y. Fujimori, K. Mayama, T. Mashiko ,S. Namai,
M. Takeyama, F. Tokanai,

Osaka University
Y. Kasamatsu, Y. Kitamoto, Y. Komori, T. Kuribayashi,
K. Matsuo, D. Saika, A. Shinohara, T. Takabe,
Y. Tashiro, T. Yoshimura, E. Ideguchi

Kanazawa University
T. Nanri, D. Suzuki, I. Yamazaki, A. Yokoyama

Kyusyu University
K. Morita*, T. Tanaka, Y. Fujita