

RIBF Users Group Town Meeting

1. Report on the activity of RIBF Users Group/UEC (Wimmer)
2. Report from RNC (Yoneda)
3. Report on the activity of RIBF Theory Forum (Yoshida)
4. A plan for the RIBF upgrade (Uesaka)
5. Others (if any)

Report from the RIBF Users Group

K. Wimmer (U. Tokyo)

RIBF Users Meeting 2018

- 2018/09/05 – 2018/09/06
 - hosted by UEC
 - 19 talks
 - within the RIBF week
 - SAMURAI Workshop (9/3 – 9/4)
 - RIBF Users Meeting (9/5 – 9/6)
 - SUNFLOWER Workshop (9/6 – 9/7)
 - thesis award jointly with RNC (awarded to T. Nishi)
 - registration fee
 - 1000 JPY (for break and others)
 - 2000 JPY (for dinner)

Organization

- LOC invited presentations to cover all fields within the RNC
- participants from around the world

Country	Number
Japan	49
Germany	5
France	4
US	2
UK	1
Vietnam	1
Hong Kong	1
Bulgaria	1
total	64

Balance for registration fee

	Income	Outgoing	Balance
registration fee	64,000 JPY		
break		25,340 JPY	
name plate		6,201 JPY	
dinner	82,000 JPY	89,220 JPY	
	146,000 JPY	120,761 JPY	25,239 JPY

RIBF Users Meeting 2019

- planning of the next RIBF Users Meeting 2019
- present plan:
 - date: the 1st week of September (9/2 –)
 - place: RIKEN Nishina hall
(RIBF hall is occupied by another event)
 - call for joint organization with collaborations
 - sessions organized by UEC (similar to last year)
 - sessions organized by individual collaboration
 - thesis award will be announced shortly

Elections for the next UEC

- present members (2017 - 2021):
 - K. Wimmer (chair)
 - S. Sakaguchi
 - Y. Watanabe
 - W. Horiuchi
 - T. Matsumoto
- outgoing members (2015 - 2019):
 - T. Isobe
 - T. Nakamura
 - S. Ota
 - Y. Kanada-En'yo
 - K. Yoshida
- term ends March 31
- elections for five new members starting next week

RIBF Status Report

Ken-ichiro YONEDA

User Liaison Group

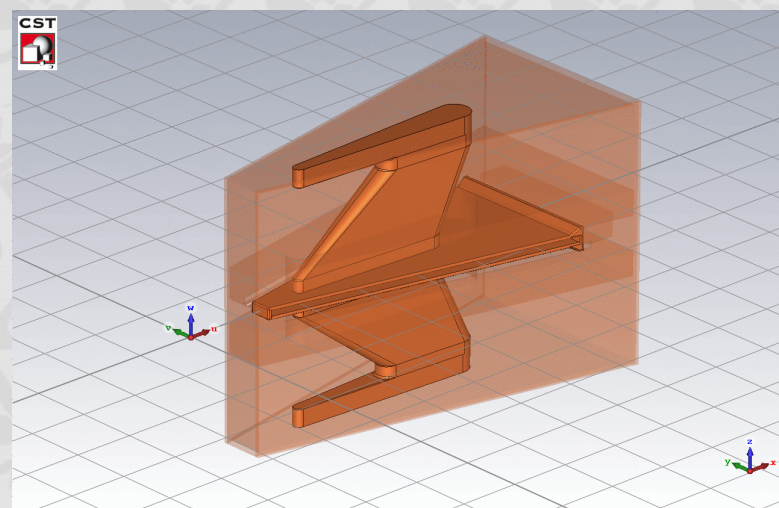
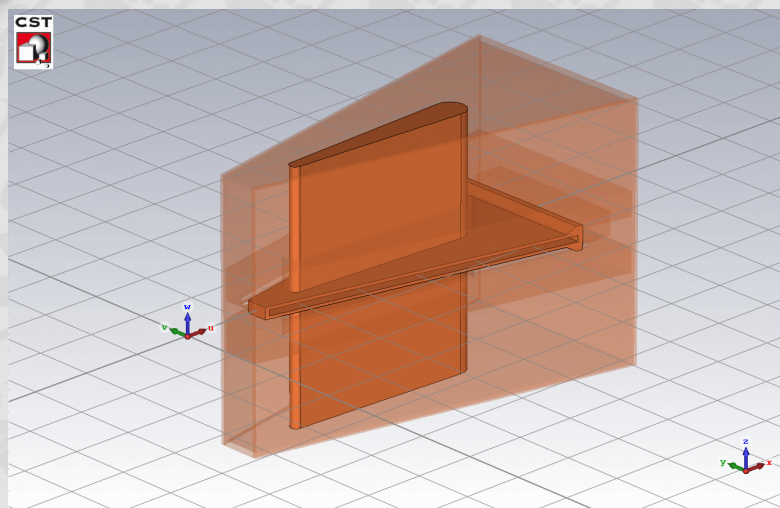
RIKEN Nishina Center

RIBF User Group Town Meeting

Kyushu University, Fukuoka, 14 March, 2019

- RRC RF Troubles
- RIBF Beam Time Operation in FY2018
- Beam Time Plan in and after 1st Half of FY2019
- Announcements

picture by K.Yamada



- old cooling water pipe → renewed
- Frequency coverage 20-45MHz → 16-38.7MHz
V acceleration 18.25 MHz to be in the range
(U acceleration also 18.25 MHz)

経緯

1/17(Thr) 22時過ぎ
#1共振器の真空悪化
→MT中断
→水路45からの漏水確認

1/18(Fri)
午後 #1共振器後退
→リーク箇所特定
SHI来所

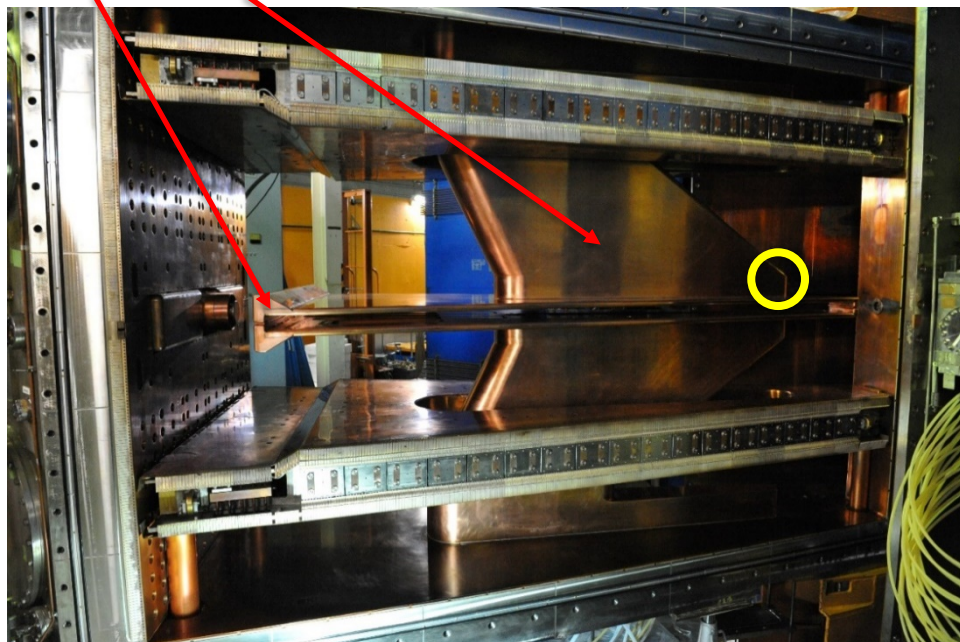
1/19(Sat)
戸畑製作所来所
→13時-17時 溶接補修

1/20(Sun)
#1共振器前進
真空引き開始

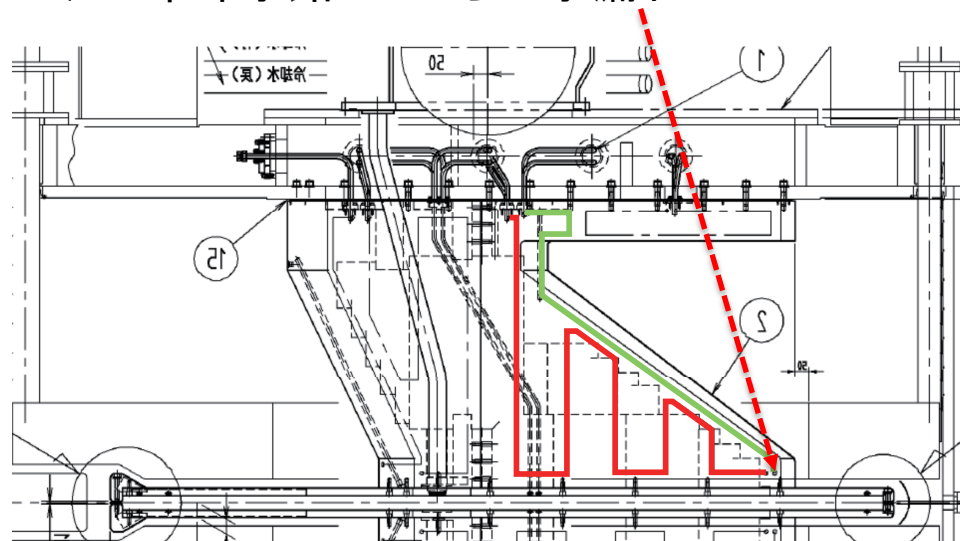
1/21(Mon)
加速再開

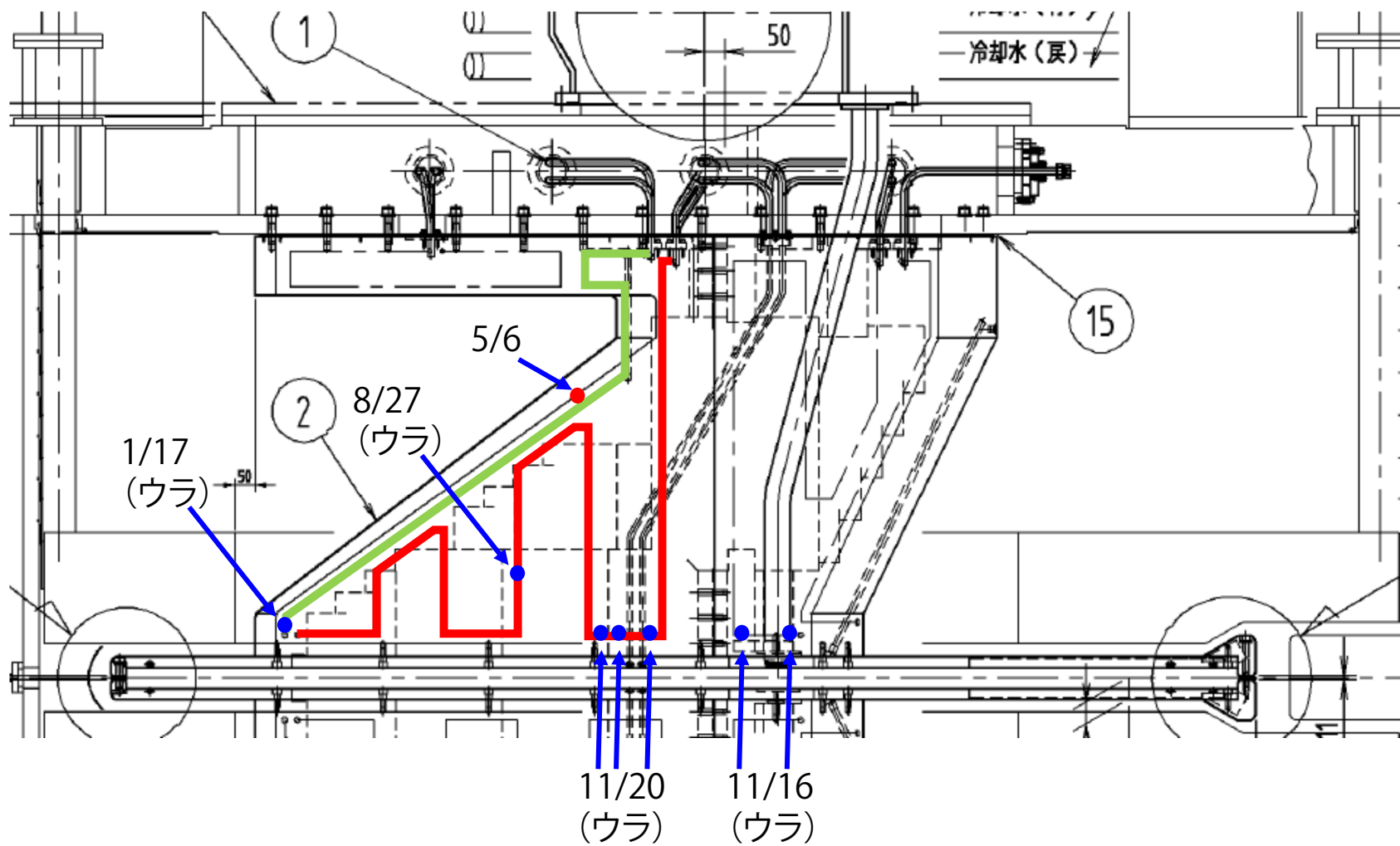
ディー ステム

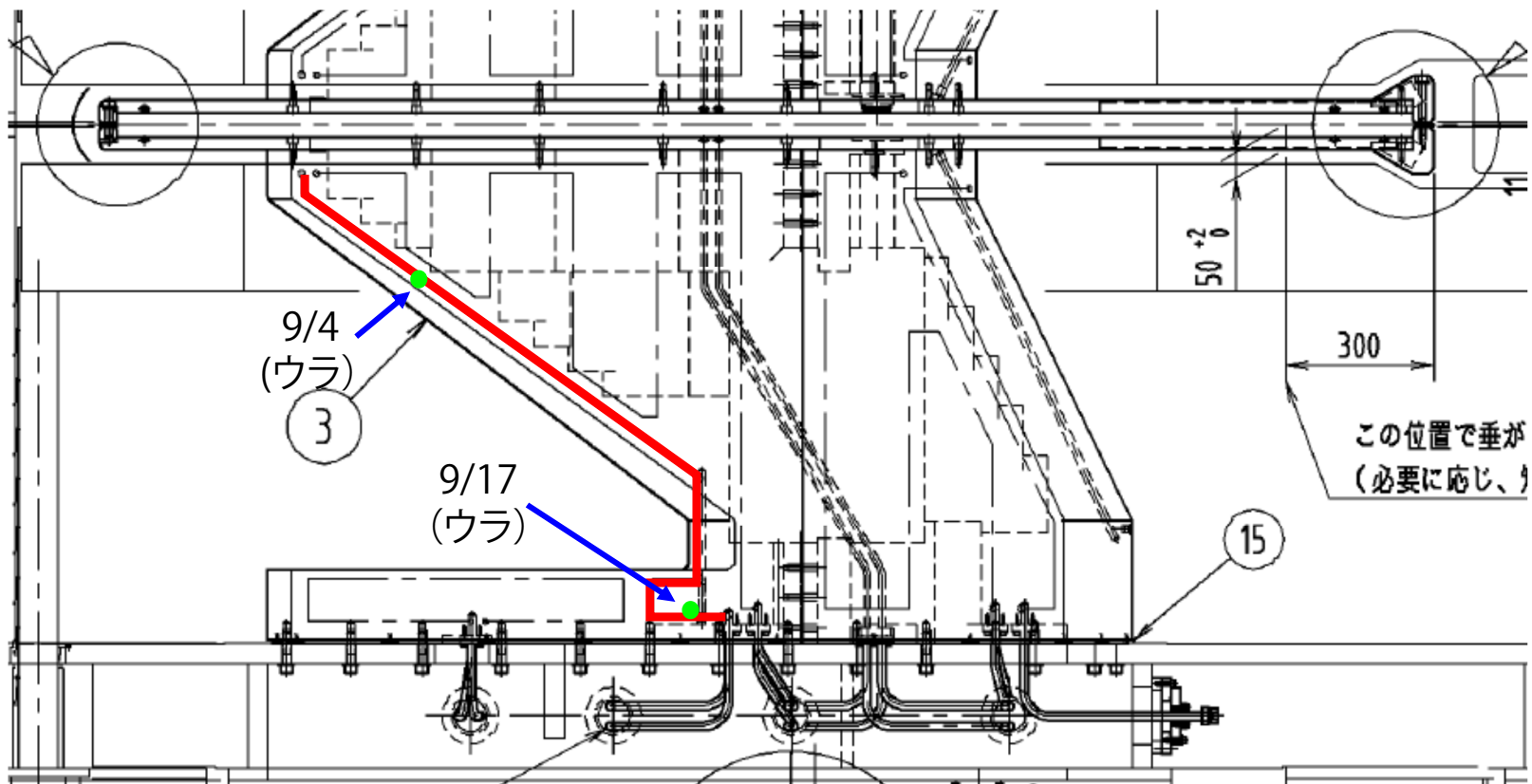
Report by O.Kamigaito



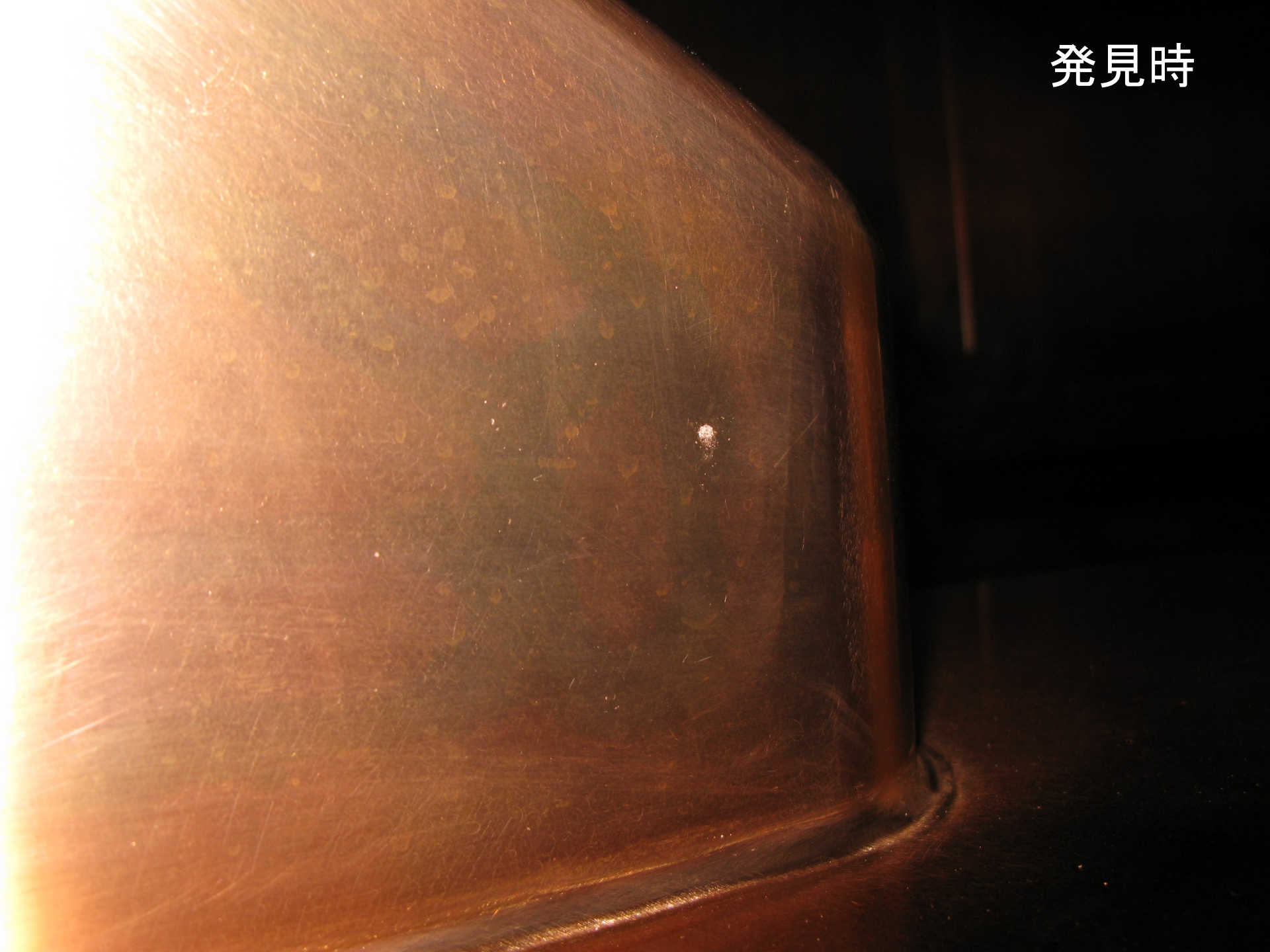
ステム冷却水路#45からの水漏れ







発見時



スヌープで確認



溶接1回目



2019/01/19 13:52

溶接2回目



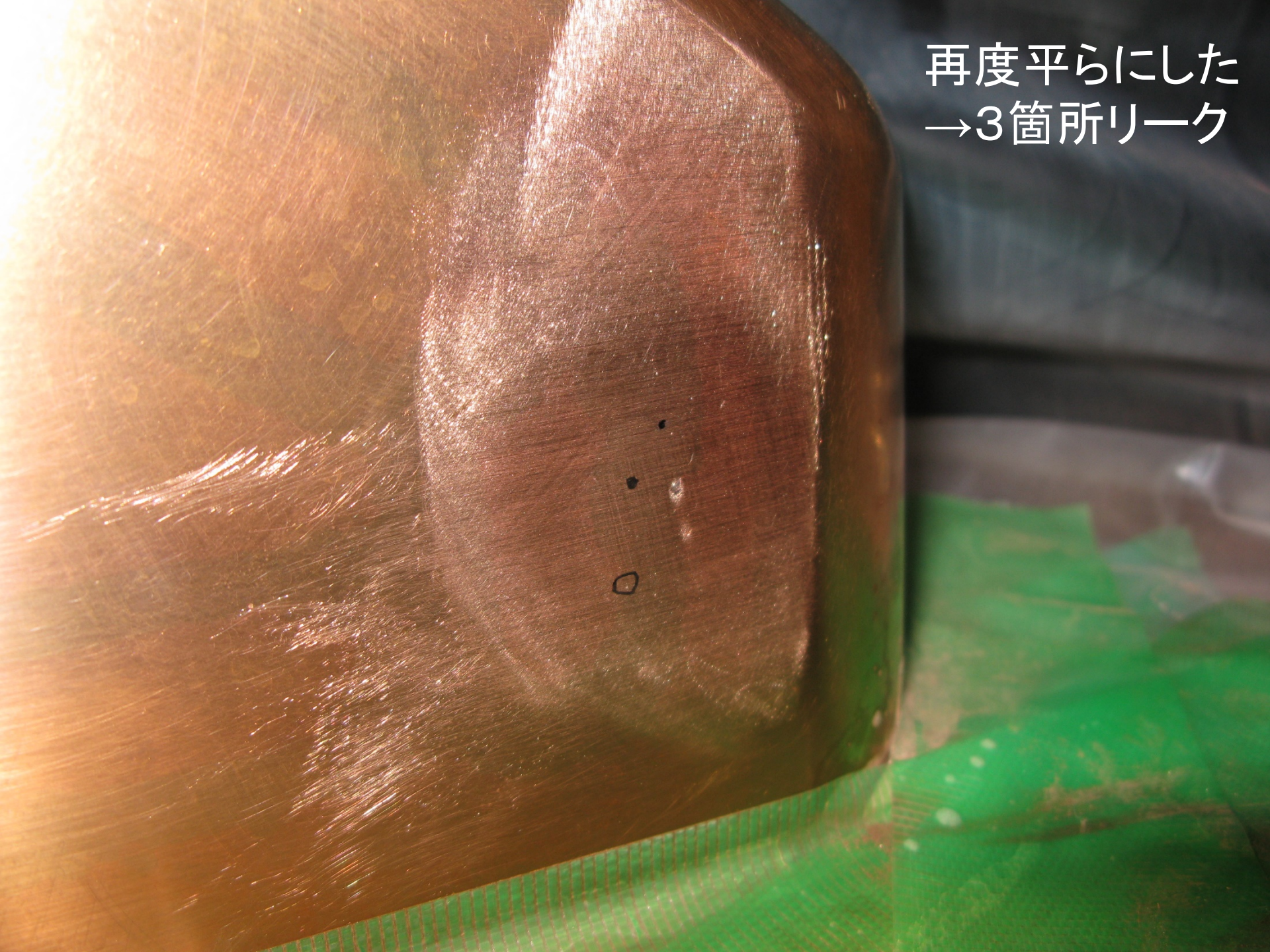
2019/01/19 14:14

溶接3回目



2019/01/19 14:28

再度平らにした
→3箇所リーク



修理完了



- Any time there is a risk of water leakage
- The recovery requires at least 4 days of beam down time
- Accelerator group and maker company under discussion



Beam Time Schedule Sep-Dec 2018

September

November

November 2018

October

December

December 2018

SHE@E6

in-beam gamma

Rare RI Ring

BRIKEN

238U

moment

Prop. No.	Leader	Course	Part.	Energy	Intensity	Time	End-time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
September 2018																																					
[Grid with colored blocks representing beam time for various experiments]																																					
October 2018																																					
[Grid with colored blocks representing beam time for various experiments]																																					
November 2018																																					
[Grid with colored blocks representing beam time for various experiments]																																					
December 2018																																					
[Grid with colored blocks representing beam time for various experiments]																																					

Prop. No.	Leader	Course	Part.	Energy	Intensity	Time	End-time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
December 2018																																					
[Grid with colored blocks representing beam time for various experiments]																																					

Beam Time Schedule Jan-Mar 2019

January

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	Start-time	End-time	January 2019																				
									1	2	3	4	5	6	7	8	9	10	11	12									
AVF stand-alone									<div style="text-align: right; font-size: 2em; font-weight: bold;">SHE@E6</div>																				
IMPACT18-01	-07	奥野 広樹 H. OKUNO	AVF-C03 of E7B	d	12	10 pA	13:29	9:00	1/11																				
DA17	-03	森田 浩介 K. MORITA	E6 (GARIS2)				1/7	9:00	3/7	9:00																			

February

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	Start-time	End-time	February 2019																				
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
AVF stand-alone									<div style="text-align: right; font-size: 2em; font-weight: bold;">SHE@E6</div>																				
R0702	-AVF4	-97	羽場 宏光 H. HABA	AVF-C03 of E7B	d	12	10 pA	2	3/2	9:00																			
R0702	-AVF4	-98	羽場 宏光 H. HABA	AVF-C03 of E7B	α	7.25	1 pA	2	2/11	9:00																			
ML1801	-AVF53	-02	横北 卓也 T. YOKOKITA	AVF-C03	¹⁸ O	6.07	1 pA	1.5	2/18	9:00																			
ML1712	-AVF51	-01	J. HU	E7A(CRIB)	²⁴ Mg	8	125 pA	7	2/22	9:00																			
DA17	-03	-06	森田 浩介 K. MORITA	E6 (GARIS2)			1/7	9:00	3/7	9:00																			

March

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	Start-time	End-time	March 2019																					
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
AVF stand-alone									<div style="text-align: right; font-size: 2em; font-weight: bold;">SHE@E6</div>																					
IMPACT18-01	-AVF51	-01	J. HU	E7A(CRIB)	²⁴ Mg	8	125 pA	7	2/22	9:00																				
R0702	-AVF4	-99	羽場 宏光 H. HABA	AVF-C03 of E7B	d	12	10 pA	2	3/2	9:00																				
R0702	-AVF4	-100	羽場 宏光 H. HABA	AVF-C03 of E7B	α	7.25	20 pA	1	3/6	9:00																				
AVF-RRC									<div style="text-align: right; font-size: 2em; font-weight: bold;">SHE@E6</div>																					
R0702	-RRC4	-14	羽場 宏光 H. HABA	E3B	¹⁴ N	135	500 pA	1	3/10	9:00																				
B0702	-RRC1	-127	阿部 知子 T. ABE	E5B	⁵⁶ Fe	90	1 pA	3hrs	3/13	9:00																				
B0702	-RRC1	-128	阿部 知子 T. ABE	E5B	¹² C	135	0.1 pA	3hrs	3/14	9:00																				
ML1807	-RRC60	-04	泉 雅子 M. IZUMI	E5B	¹² C	135	1 pA	1.5	3/14	15:00																				
AVF-RRC-IRC									<div style="text-align: right; font-size: 2em; font-weight: bold;">SHE@E6</div>																					
B0702	-RRC1	-10	阿部 知子 T. ABE	E5B	⁴⁰ Ar	160	1 pA	4hrs	3/13	9:00																				
ML1807	-RRC60	-03	泉 雅子 M. IZUMI	E5B	⁴⁰ Ar	160	1 pA	1.5	3/12	13:00																				
DA17	-03	-06	森田 浩介 K. MORITA	E6 (GARIS2)			1/7	9:00	3/7	9:00																				

⁷⁸Kr SAMURAI

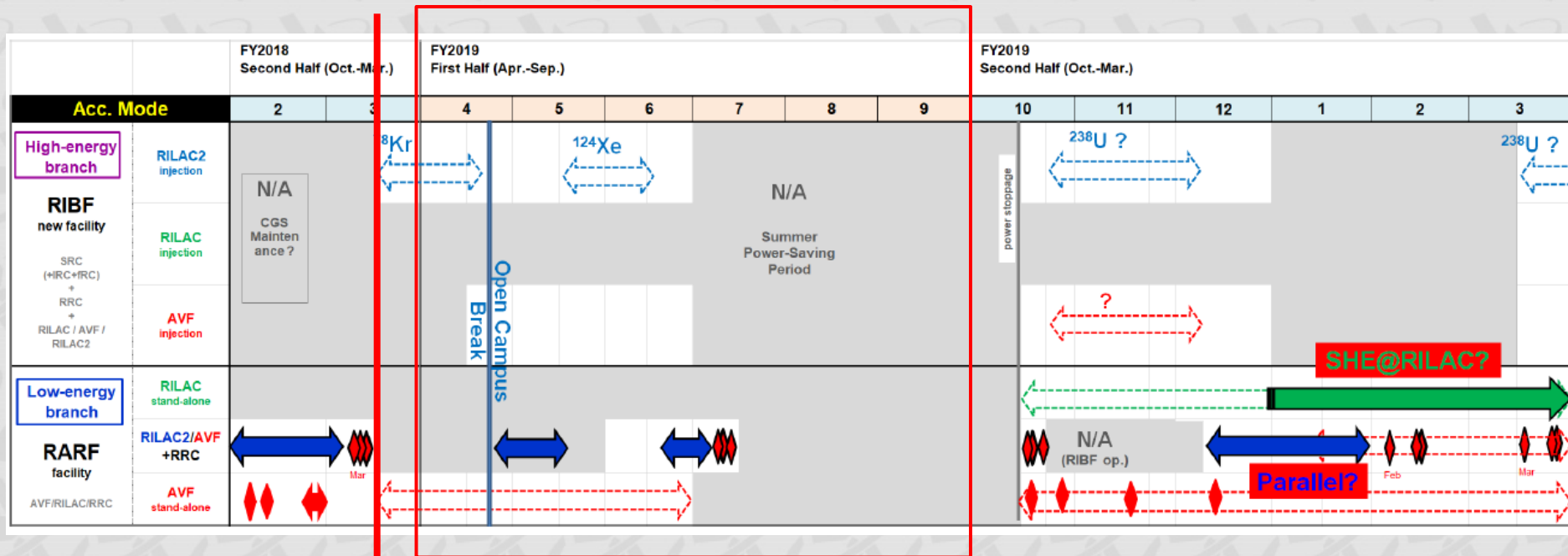
Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	Start-time	End-time	March 2019																					
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
RIBF (SRC)									<div style="text-align: right; font-size: 2em; font-weight: bold;">SHE@E6</div>																					
NP1406	-SAMURAI04	-01	V. PANIN	SAMURAI	⁷⁸ Kr	345	300 (max) pA	5.5	3/22	9:00																				
NP1612	-SAMURAI11	-01	菅野 隆史 M. SUGANO	SAMURAI	⁷⁸ Kr	345	90 (max) pA	0.5	3/27	9:00																				
NP1712	-RIBF166	-01	藤田 智 T. SONODA	PALIS	⁷⁸ Kr	345	max	0.5	3/28	9:00																				
NP1712	-RIBF151R1	-01	K. WIMMER	BigRIP0-ZD0	⁷⁸ Kr	345	300 (max) pA	4	3/28	21:00																				

in-beam gamma

Beam Time Operation -- FY2019 1st Half

- No BT time from mid-July to October
 - Roof & wall repair of Nishina bldg.
- ^{78}Kr and ^{124}Xe for SRC-BigRIPS
- 10-day holiday = SHE

Now



Beam Time Schedule Apr-Jul 2019

April

June

June 2019

SHE@E6

SHE@E6

in-beam gamma

beta decay

SAMURAI

2p

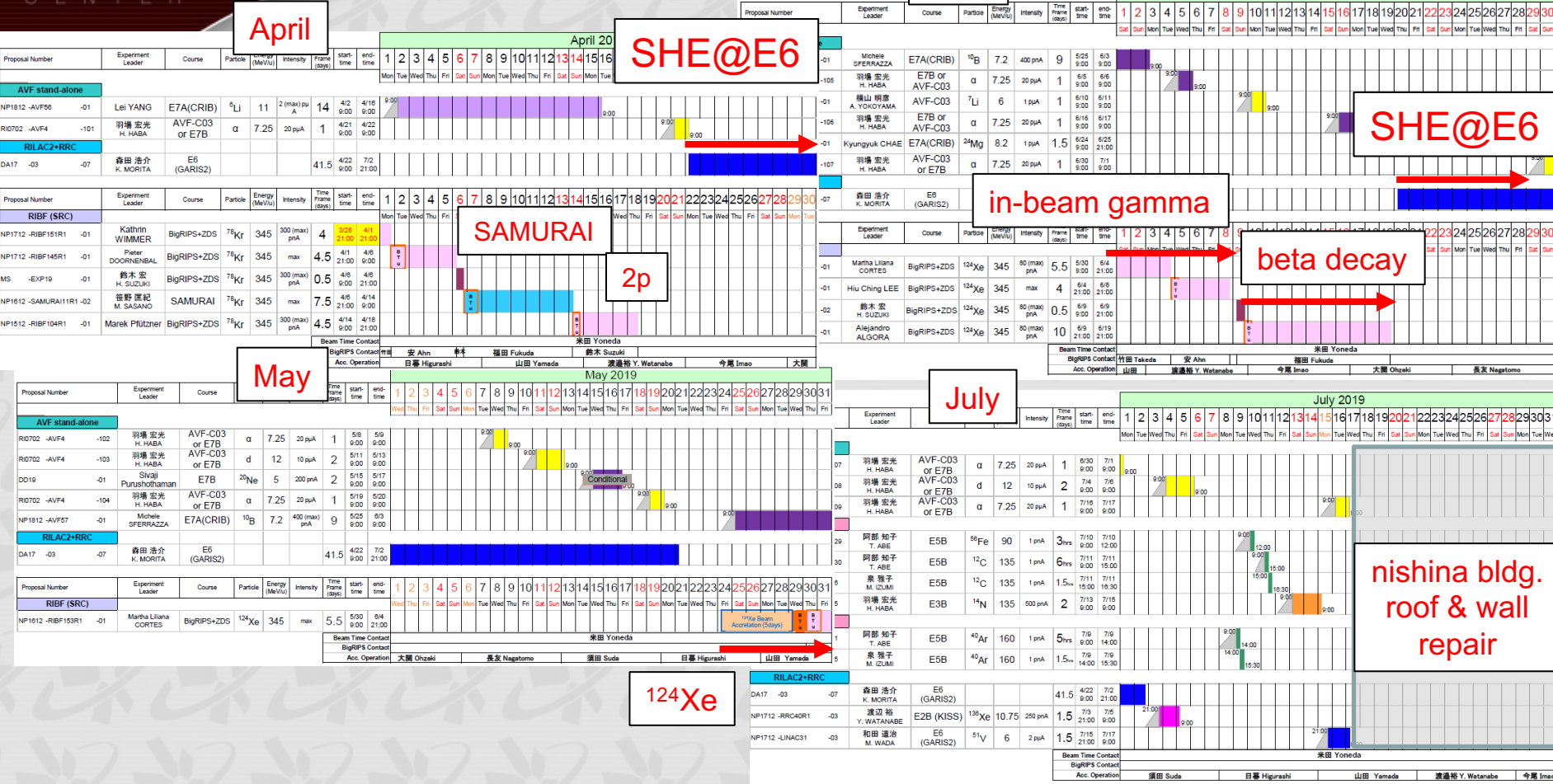
May

July

July 2019

¹²⁴Xe

nishina bldg.
roof & wall
repair



Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
AVF stand-alone								
NP1812 -AVF56	-01	Lei YANG	E7A(CRIB)	⁶ Li	11	2 (max) pA	14	4/2 9:00
RD702 -AVF4	-101	羽場 宏光 H. HABA	AVF-C03 or E7B	α	7.25	20 pA	1	4/2 9:00
RILAC2+RRC								
DA17 -G3	-07	森田 浩介 K. MORITA	E6 (GARIS2)				41.5	4/22 9:00

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
RIBF (SRC)								
NP1712 -RIBF151R1	-01	Kathrin WIMMER	BigRIPS+ZDS	⁷⁸ Kr	345	300 (max) pA	4	4/23 21:00
NP1712 -RIBF145R1	-01	Peter DOORNENBAL	BigRIPS+ZDS	⁷⁸ Kr	345	max	4.5	4/1 21:00
MS -EXP19	-01	鈴木 宏 H. SUZUKI	BigRIPS+ZDS	⁷⁸ Kr	345	300 (max) pA	0.5	4/8 9:00
NP1812 -SAMURAI11R1	-02	佐野 匡紀 K. SASANO	SAMURAI	⁷⁸ Kr	345	max	7.5	4/8 21:00
NP1512 -RIBF104R1	-01	Marek Pflützner	BigRIPS+ZDS	⁷⁸ Kr	345	300 (max) pA	4.5	4/14 9:00

Beam Time Contact	Acc. Operation
米田 Yoneda	安 Ahn, 榎本, 福田 Fukuda, 鈴木 Suzuki, 日暮 Higurashi, 山田 Yamada, 渡邊裕 Y. Watanabe, 今尾 Imao, 大関

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
AVF stand-alone								
RD702 -AVF4	-102	羽場 宏光 H. HABA	AVF-C03 or E7B	α	7.25	20 pA	1	5/8 9:00
RD702 -AVF4	-103	羽場 宏光 H. HABA	AVF-C03 or E7B	α	12	10 pA	2	5/11 9:00
DD16	-01	Sivaji Purushothaman	E7B	²⁰ Ne	5	200 pA	2	5/15 9:00
RD702 -AVF4	-104	羽場 宏光 H. HABA	AVF-C03 or E7B	α	7.25	20 pA	1	5/19 9:00
NP1812 -AVF57	-01	Michele SFERRAZZA	E7A(CRIB)	¹⁰ B	7.2	400 (max) pA	9	5/25 9:00
RILAC2+RRC								
DA17 -G3	-07	森田 浩介 K. MORITA	E6 (GARIS2)				41.5	4/22 9:00

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
RIBF (SRC)								
NP1512 -RIBF153R1	-01	Martha Liliana CORTES	BigRIPS+ZDS	¹²⁴ Xe	345	max	5.5	5/3 9:00

Beam Time Contact	Acc. Operation
米田 Yoneda	大関 Ohzaki, 長尾 Nagatomo, 須田 Suda, 日暮 Higurashi, 山田 Yamada

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
-01	Michele SFERRAZZA	E7A(CRIB)	¹⁰ B	7.2	400 pA	9	5/25 9:00	6/3 9:00
-105	羽場 宏光 H. HABA	E7B or AVF-C03	α	7.25	20 pA	1	5/5 9:00	5/5 9:00
-01	榎山 明彦 A. YOKOYAMA	AVF-C03	⁷ Li	6	1 pA	1	6/10 9:00	6/11 9:00
-106	羽場 宏光 H. HABA	E7B or AVF-C03	α	7.25	20 pA	1	6/16 9:00	6/17 9:00
-01	Kyungyuk CHAE	E7A(CRIB)	²⁴ Mg	8.2	1 pA	1.5	6/24 9:00	6/25 21:00
-107	羽場 宏光 H. HABA	AVF-C03 or E7B	α	7.25	20 pA	1	6/30 9:00	7/1 9:00

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
RIBF (SRC)								
-07	森田 浩介 K. MORITA	E6 (GARIS2)					41.5	4/22 9:00
-01	Martha Liliana CORTES	BigRIPS+ZDS	¹²⁴ Xe	345	80 (max) pA	5.5	5/3 9:00	6/4 21:00
-01	Hui Ching LEE	BigRIPS+ZDS	¹²⁴ Xe	345	max	4	6/6 21:00	6/8 21:00
-02	鈴木 宏 H. SUZUKI	BigRIPS+ZDS	¹²⁴ Xe	345	80 (max) pA	0.5	6/9 9:00	6/9 21:00
-01	Alejandro ALGORA	BigRIPS+ZDS	¹²⁴ Xe	345	80 (max) pA	10	6/9 9:00	6/19 21:00

Beam Time Contact	Acc. Operation
米田 Yoneda	竹田 Takeda, 安 Ahn, 福田 Fukuda, 大関 Ohzaki, 長尾 Nagatomo

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
AVF stand-alone								
07	羽場 宏光 H. HABA	AVF-C03 or E7B	α	7.25	20 pA	1	6/30 9:00	7/1 9:00
08	羽場 宏光 H. HABA	AVF-C03 or E7B	α	12	10 pA	2	7/4 9:00	7/6 9:00
09	羽場 宏光 H. HABA	AVF-C03 or E7B	α	7.25	20 pA	1	7/18 9:00	7/17 9:00
29	阿部 祐子 T. ABE	E5B	⁵⁶ Fe	90	1 pA	3	7/10 9:00	7/10 12:00
30	阿部 祐子 T. ABE	E5B	¹² C	135	1 pA	6	7/11 9:00	7/11 15:00
5	泉 雅子 M. IZUMI	E5B	¹² C	135	1 pA	1.5	7/11 9:00	7/11 15:00
5	羽場 宏光 H. HABA	E3B	¹⁴ N	135	500 pA	2	7/13 9:00	7/13 9:00

Proposal Number	Experiment Leader	Course	Particle	Energy (MeV/u)	Intensity	Time Frame (days)	start-time	end-time
RILAC2+RRC								
DA17 -G3	-07	森田 浩介 K. MORITA	E6 (GARIS2)				41.5	4/22 9:00
NP1712 -RRC4R1	-03	渡辺 祐 Y. WATANABE	E2B (KISS)	¹³⁶ Xe	10.75	250 pA	1.5	7/3 9:00
NP1712 -LINAC31	-03	和田 達博 M. WADA	E6 (GARIS2)	⁵¹ V	6	2 pA	1.5	7/15 9:00

Beam Time Contact	Acc. Operation
米田 Yoneda	須田 Suda, 日暮 Higurashi, 山田 Yamada, 渡邊裕 Y. Watanabe, 今尾 Imao

Announcements (1/2)

- Member list on the web
... can we stop?
- UEC servers updated
OS maintenance expired ... replacement necessary
registration & voting system had troubles
sorry for inconvenience caused
- Mailing list updated
majordomo (old mailing list system) ... last update in 2000
There were troubles for distributing emails
updated to “MAILMAN”
sorry for confusion caused

Announcements (2/2)

- Next NP-PAC
to be held on 16 (Mon) – 18 Dec (Wed)

- RIBF Symposium and Mini-Workshop

http://www.nishina.riken.go.jp/ulic/ulic_apply.html

[Symposium]

Objective: Exchange views among researchers in a relevant field.

Maximum amount of financial support: 500,000 JPY

Deadline: Application must be submitted in March and in September.

[Mini-Workshop]

Objective: To solve specific problem. Analysis meeting is acceptable.

Maximum amount of financial support: 150,000 JPY

Deadline: Applications will be accepted all the time being reviewed
and evaluated immediately.

Activity report of the RIBF Theory Forum

Kyoto Univ.
Kenichi Yoshida

RIBF Theory Forum

The first term inaugurated August 2006 by Sakurai

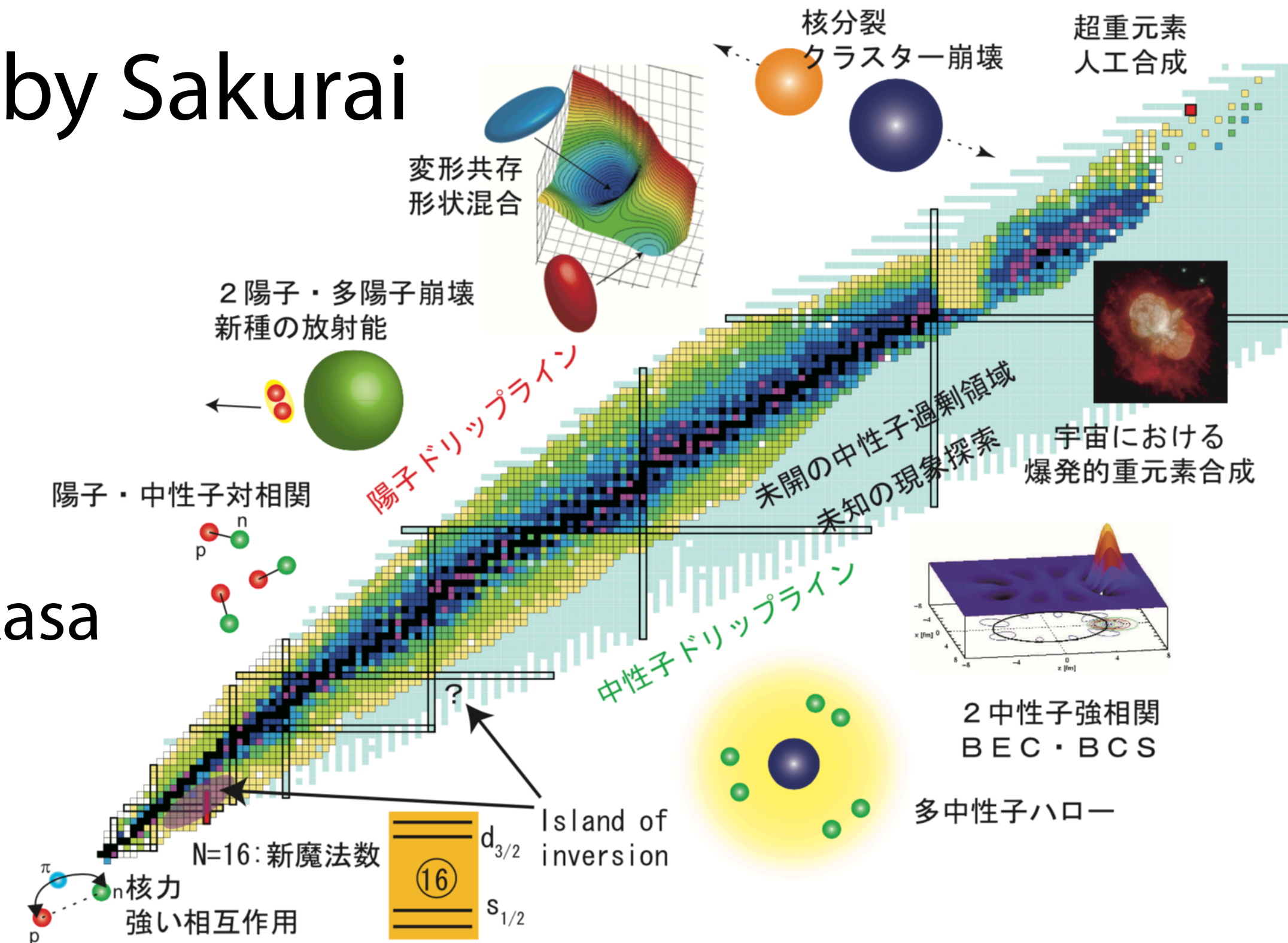
Hagino, Honma, Itagaki, Kanada-En'yo, Kohama,
Matsuo, Mochizuki, Nakatsukasa, Ogata, Ono,
Ustuno, Yabana

2007-: Theoretical nuclear physics lab. by Nakatsukasa

「RIBFの物理」 was published

The second term from November 2014

Mission: to propose something interesting for the future of RI physics



Many-nucleon correlation

Collective motion

Nucleosynthesis

Abe, Aritomo, Horiuchi, Kimura,
Liang, Matsumoto, Minato,
Nakazato, Nishimura, Yoshida

Superheavy element

Equation of state

We had discussions based on the interests of the members

during five meetings 2015-2016

New species of physics emerge from diverse, multifaceted, and unorganized environment

放談会 Hodan-kai

ideas are freely discussed in a frank atmosphere
low threshold for students

The 1st: "expanding the world of exotic nuclei", 31 Jul. - 2 Aug., 2017

The 2nd: "for the future of physics of exotic nuclei", 18-20 Feb., 2019

The 3rd: Feb., 2020

Organization of WS/mini-WS on each subject;

Mini-WS on Synthesis of superheavy element@RIKEN; 23 May, 2016

WS on R-process in the era of GW@RIKEN; 20-22 Jun., 2018

WS on R-process and nuclear physics@YITP; 22-24 May, 2019



RIBF高度化計画

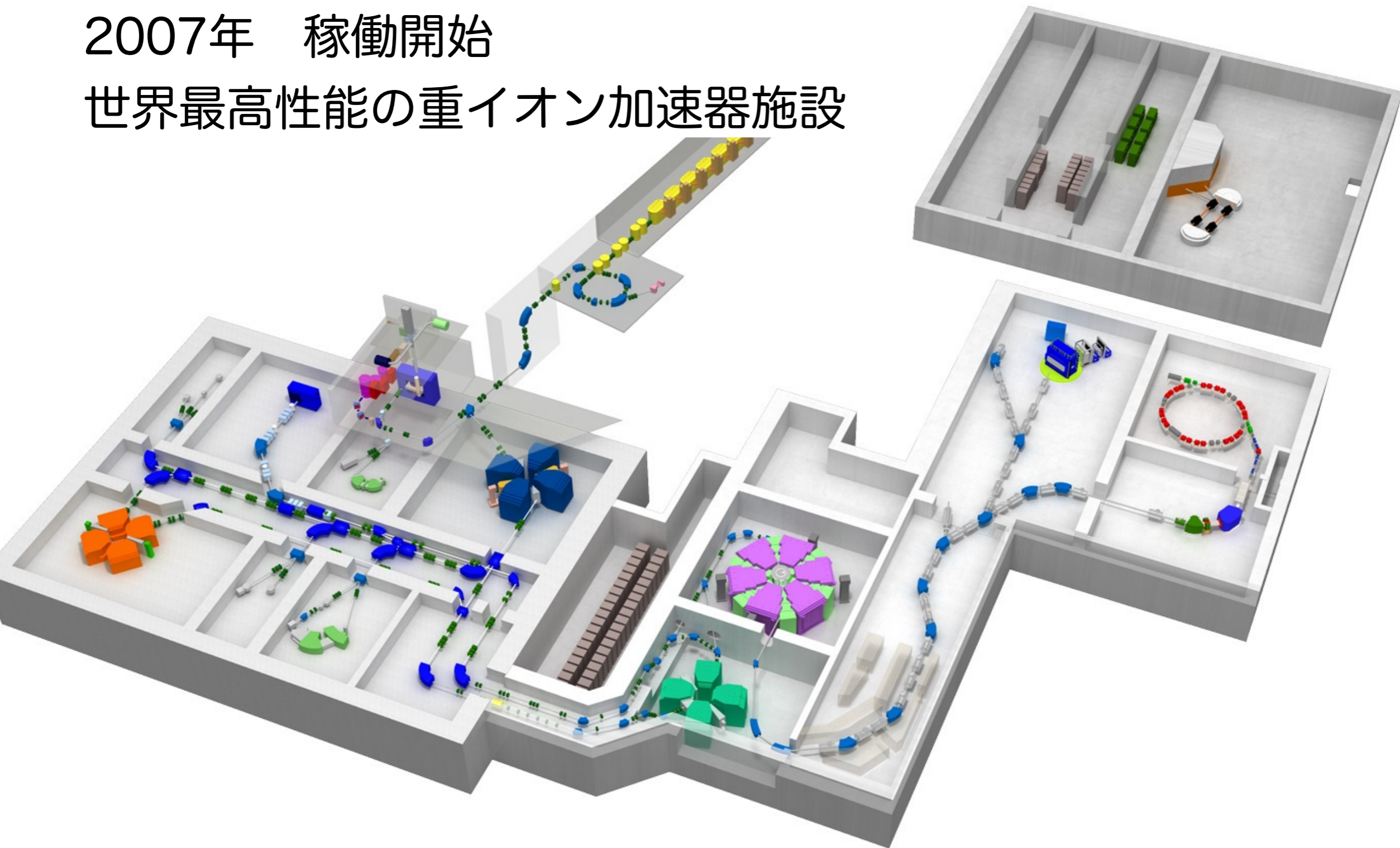
上坂友洋

理研仁科加速器科学研究センター

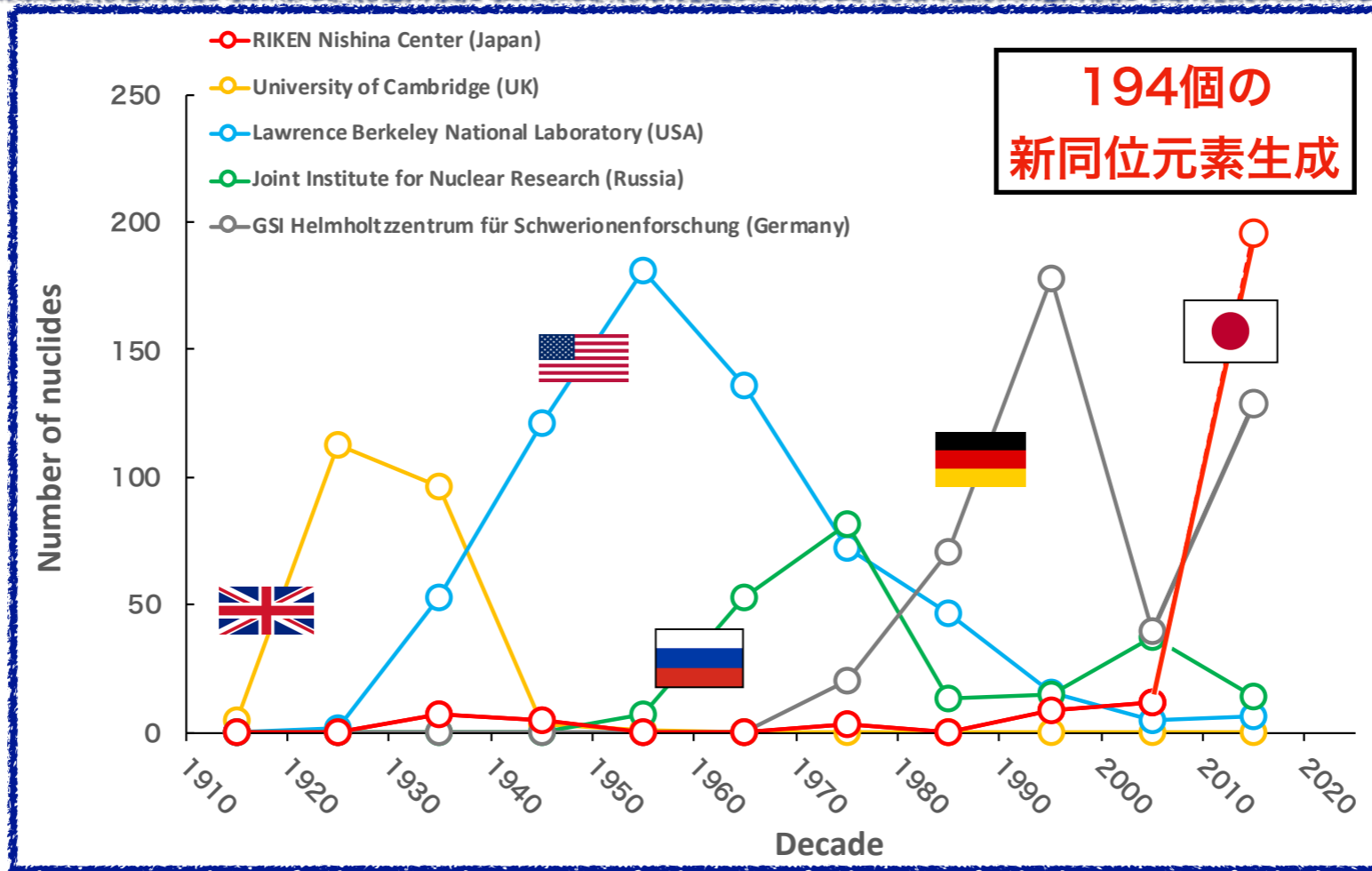
現RIビームファクトリー

2007年 稼働開始

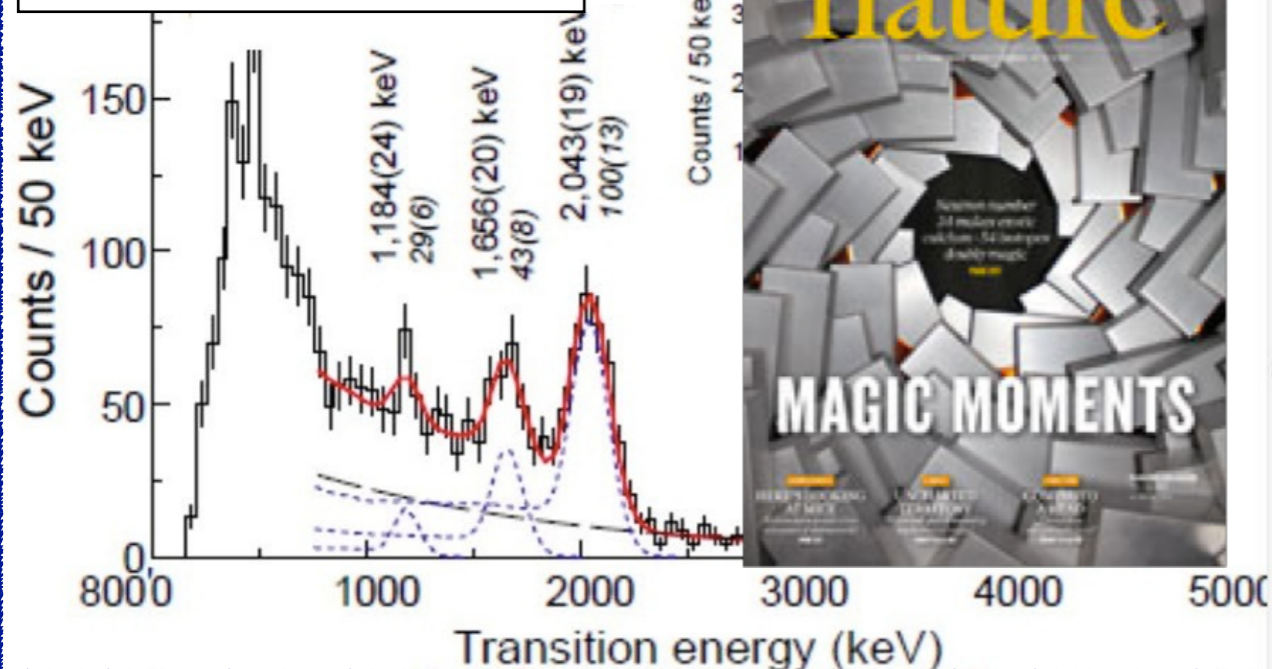
世界最高性能の重イオン加速器施設



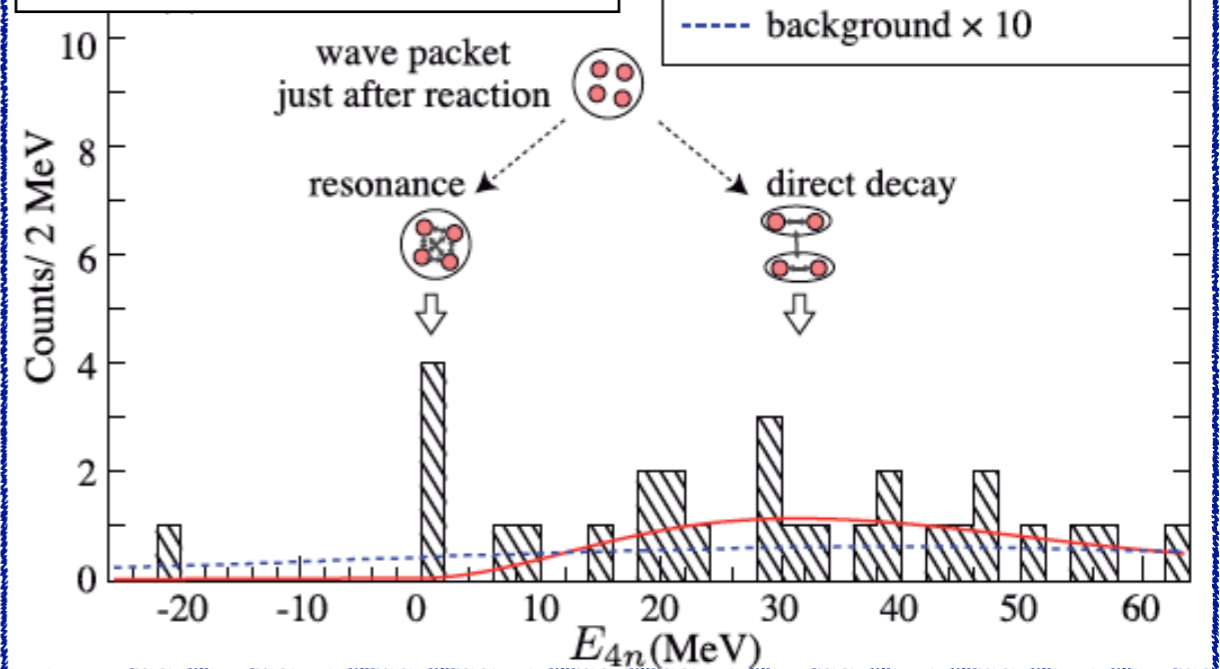
RIBFの成果(1)



新魔法数34の発見



テトラ中性子の発見



RIBFの成果(2)

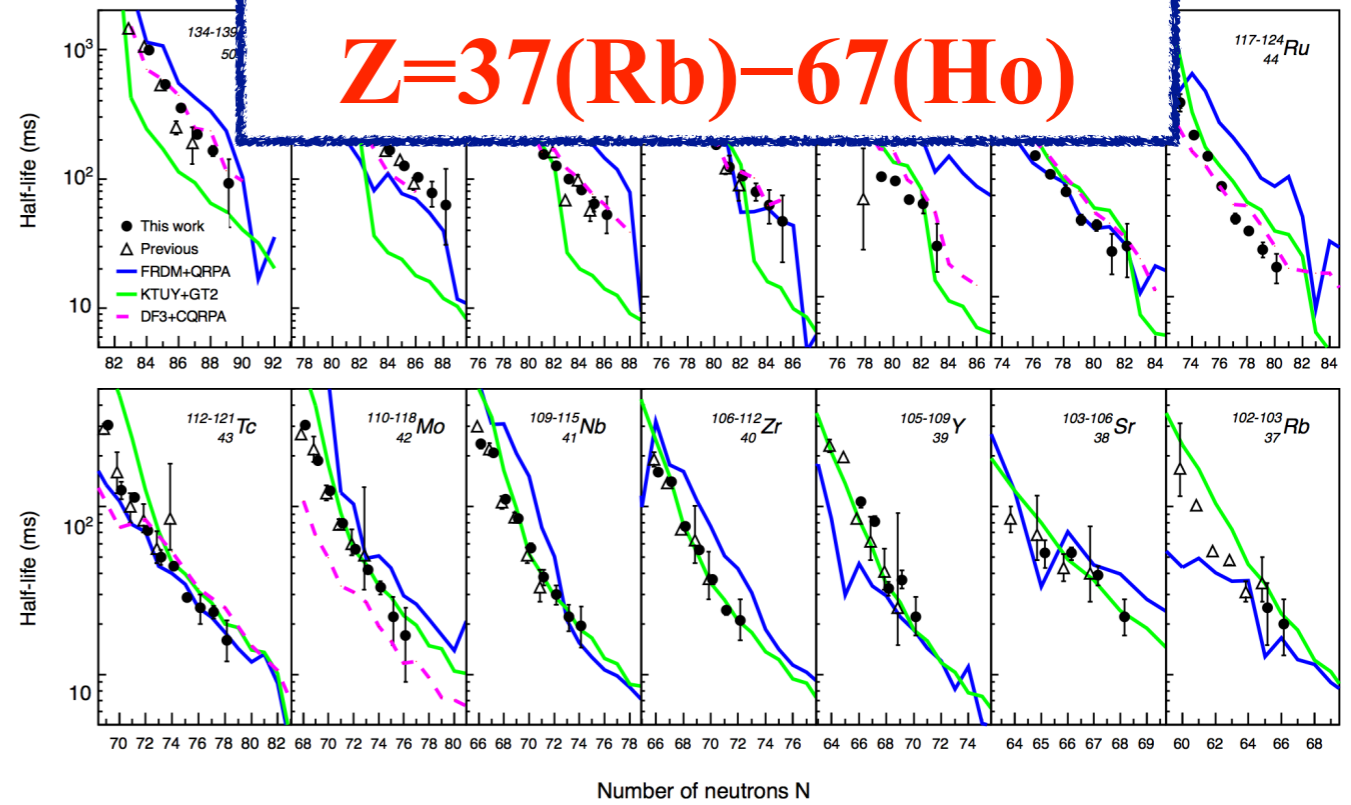
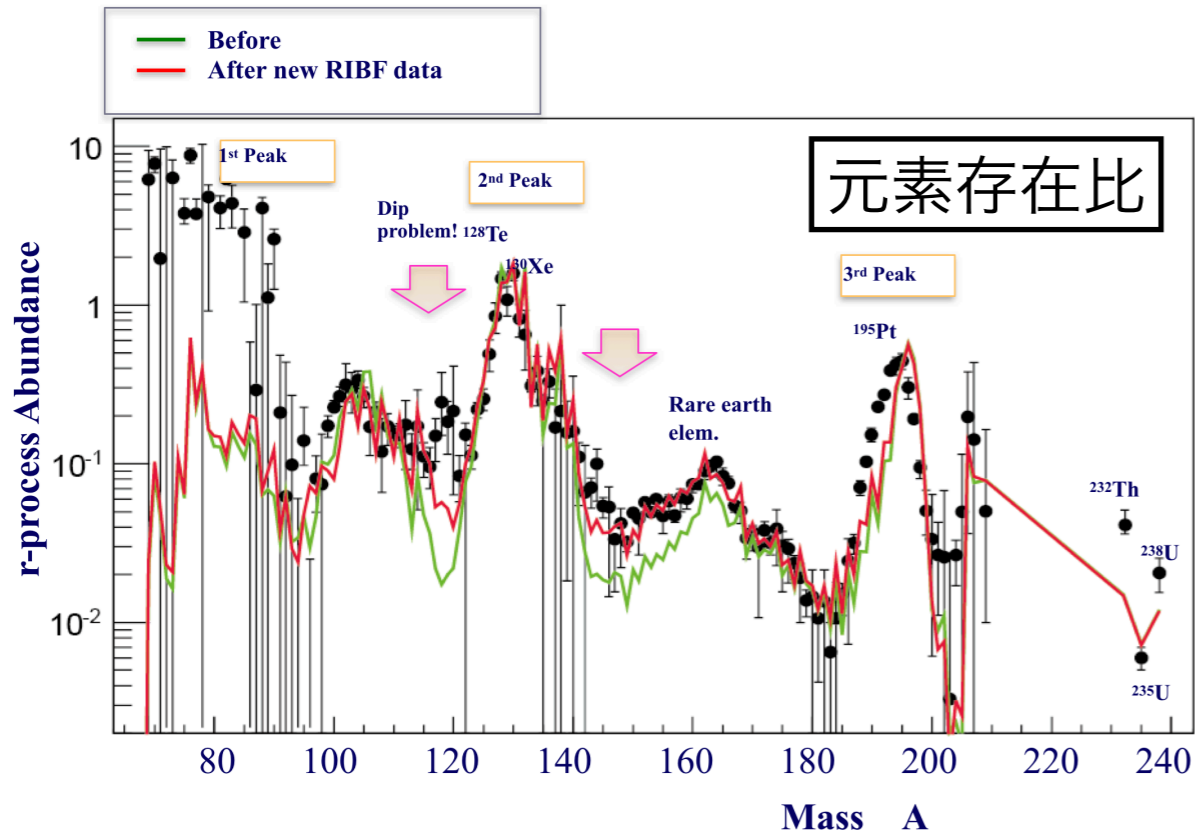
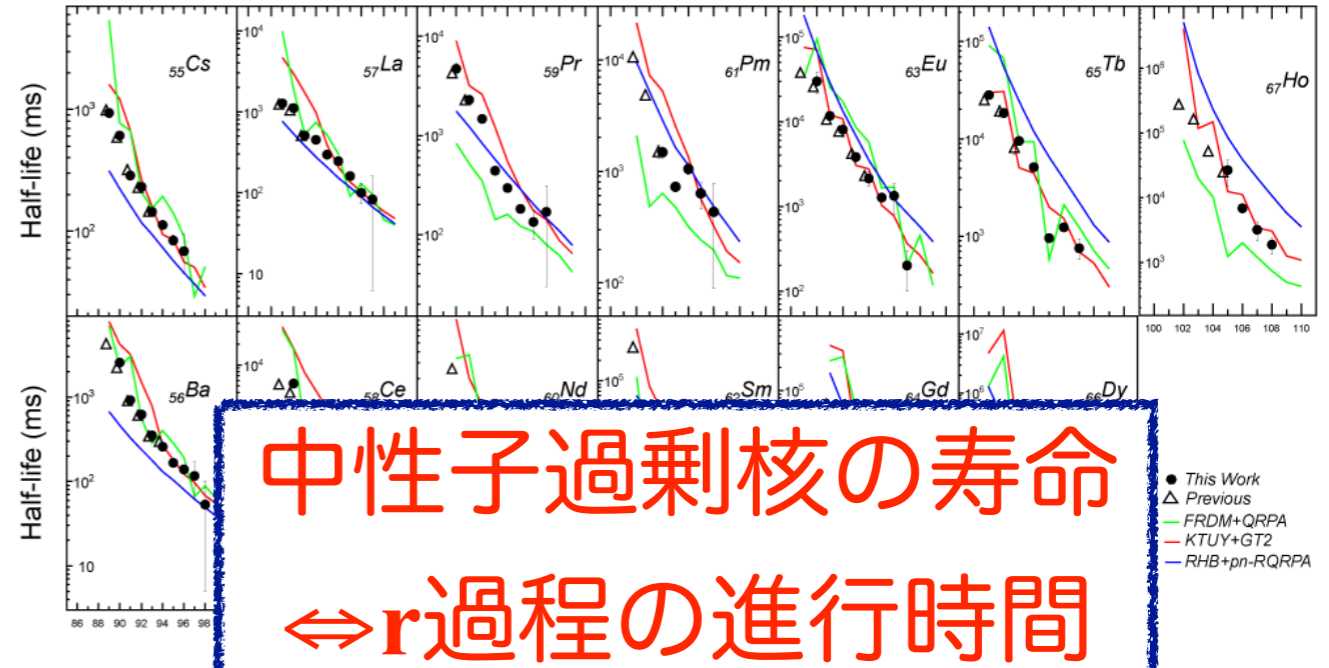
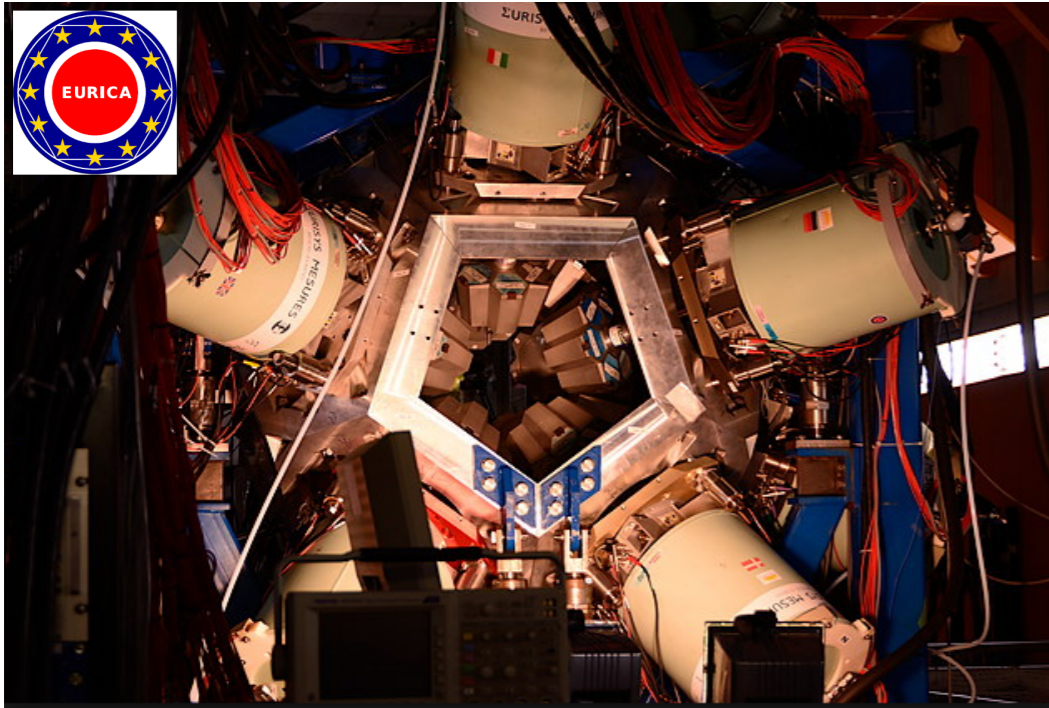


IUPAC Periodic Table of the Elements

Key:																	
atomic number		Symbol		name		standard atomic weight											
1 H hydrogen [1.007, 1.009]	2 He helium 4.003																
3 Li lithium [6.938, 6.997]	4 Be beryllium 9.012																
11 Na sodium 22.99	12 Mg magnesium [24.30, 24.31]																
13 B boron [10.80, 10.83]	14 C carbon [12.00, 12.02]	15 N nitrogen [14.00, 14.01]	16 O oxygen [15.99, 16.00]	17 F fluorine 19.00	18 Ne neon 20.18												
19 K potassium 39.10	20 Ca calcium 40.08	21 Sc scandium 44.96	22 Ti titanium 47.87	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.38(2)	31 Ga gallium 69.72	32 Ge germanium 72.63	33 As arsenic 74.92	34 Se selenium 78.96(3)	35 Br bromine [79.90, 79.91]	36 Kr krypton 83.80
37 Rb rubidium 85.47	38 Sr strontium 87.62	39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.96(2)	43 Tc technetium	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57-71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89-103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganeson
57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0			
89 Ac actinium	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium			

RIBFの成果(3)

r過程元素合成研究を**仮説駆動科学**から**データ駆動科学**へ



RIBF高度化計画

RIBF高度化計画:マスタープラン2020

ビーム強度増強計画

^{238}U ビーム (345 MeV/u) 2 pμA

^{51}V , ^{54}Cr 5 → ≥ 6 MeV/u, 5 pμA

平成28年度補正予算で実施済

理研仁科、東大CNS、KEK素核研WNSC、阪大RCNPの共同提案
予算規模 100億円/5年間 (FY2021-2025)

我々の宇宙を形作る重元素はどこから来たのか？

r過程第3ピークへ、核分裂サイクル

中性子物質研究

元素はどこまで存在するのか？

周期表第8周期への挑戦(≥ 119 番元素)

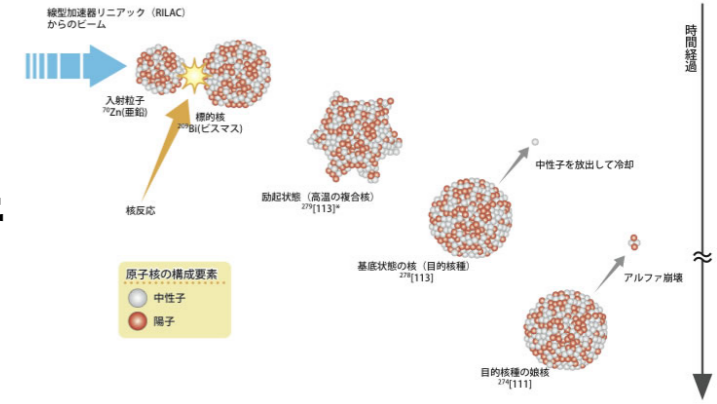
加速器はどのように社会に貢献できるのか？

核変換研究 → 櫻井さん

RIBF高度化計画:マスタープラン2020

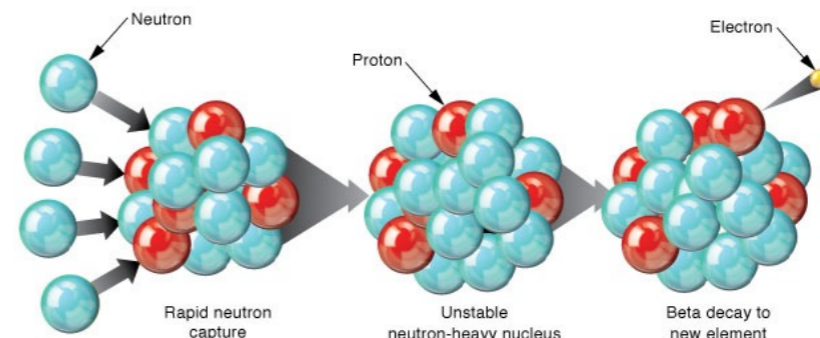
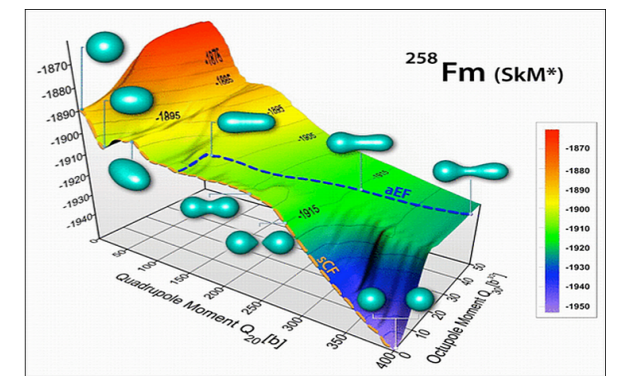
「存在する元素から新しい元素へ」
核反応ダイナミクス
物理学的基盤に基づく「錬金術」

新元素合成
核融合
多核子移行



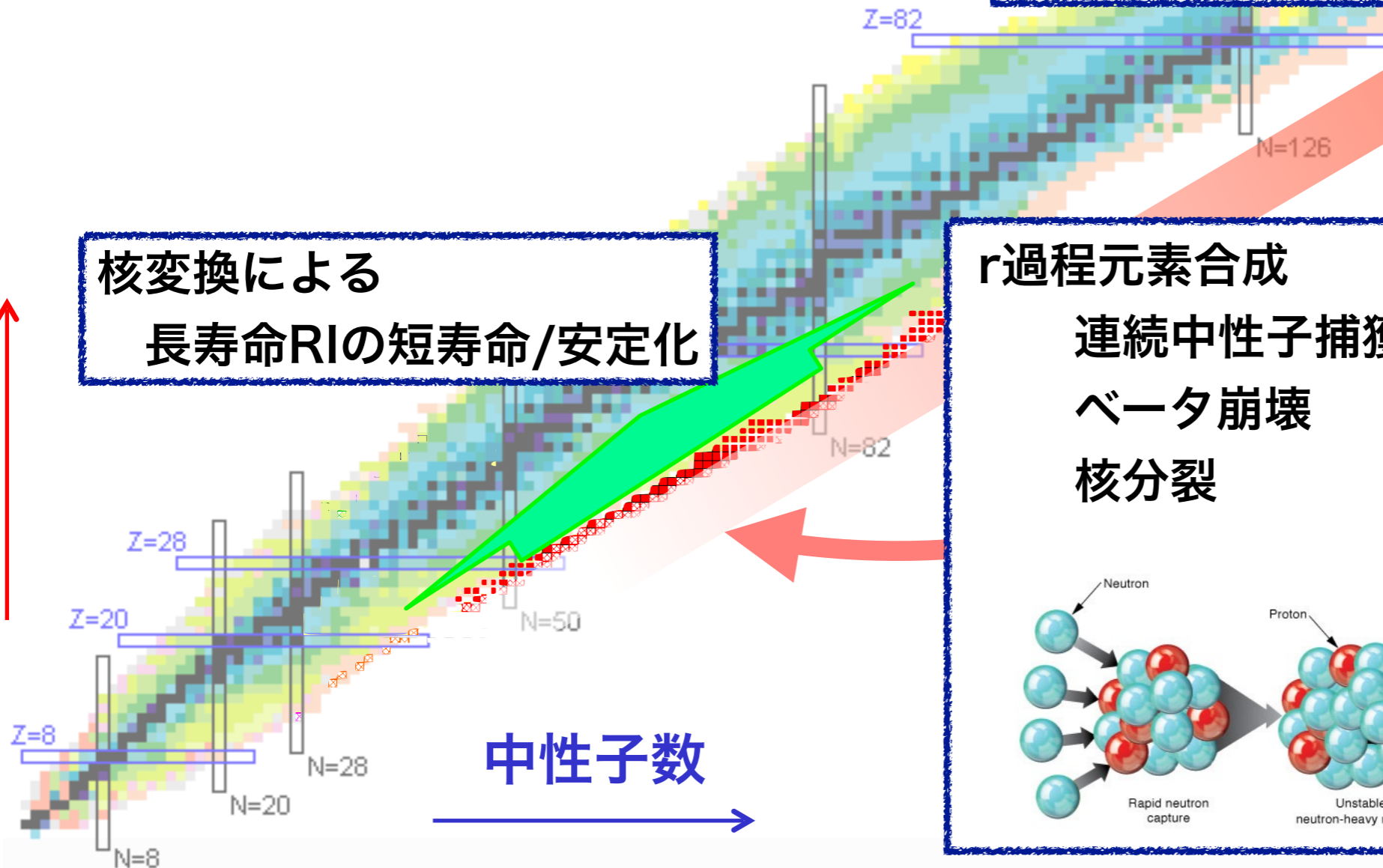
核変換による
長寿命RIの短寿命/安定化

r過程元素合成
連続中性子捕獲
ベータ崩壊
核分裂



陽子数

中性子数



周期表第8周期への挑戦

族	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57-71 未発見の元素	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89-103 未発見の元素	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
8	119	120	121-	156	157	158	159	160	161	162	163	164	139	140	169	170	171	172
9	165	166											167	168				

119番元素の合成

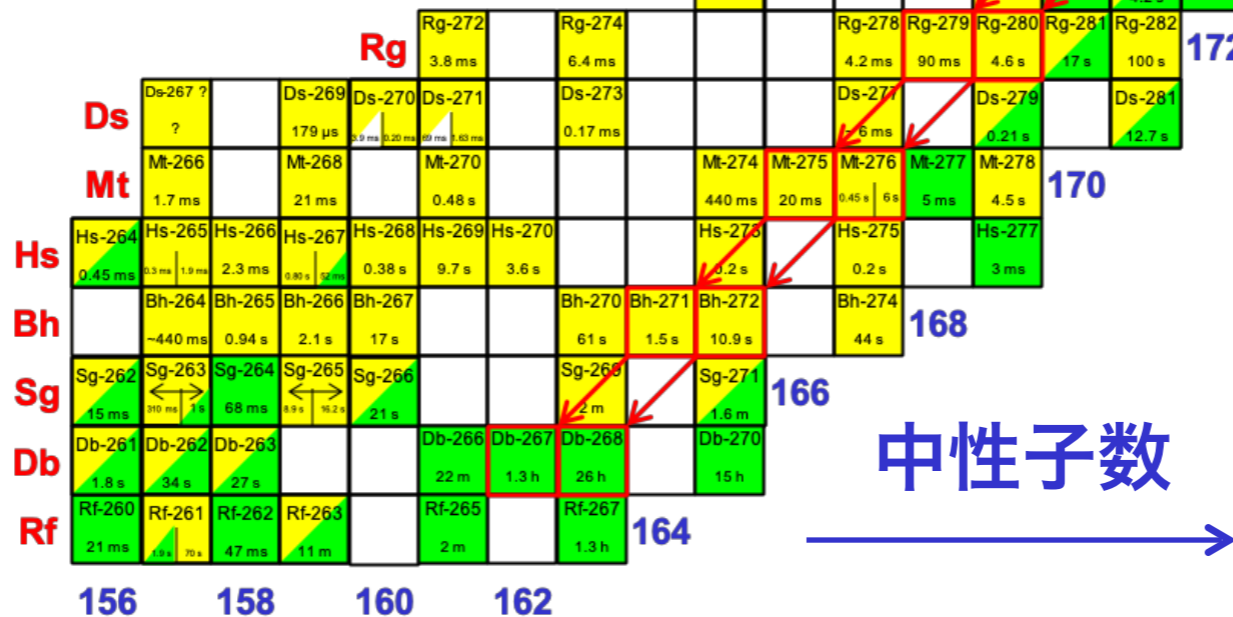


6	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
7	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
8	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155

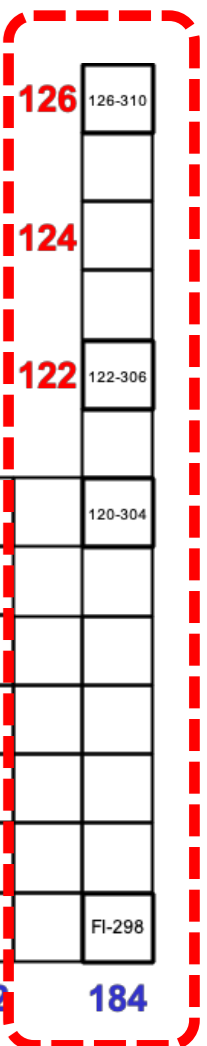
8	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138
---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Pyykkö, Phys. Chem. Chem. Phys. **13**, 161 (2011).

陽子数

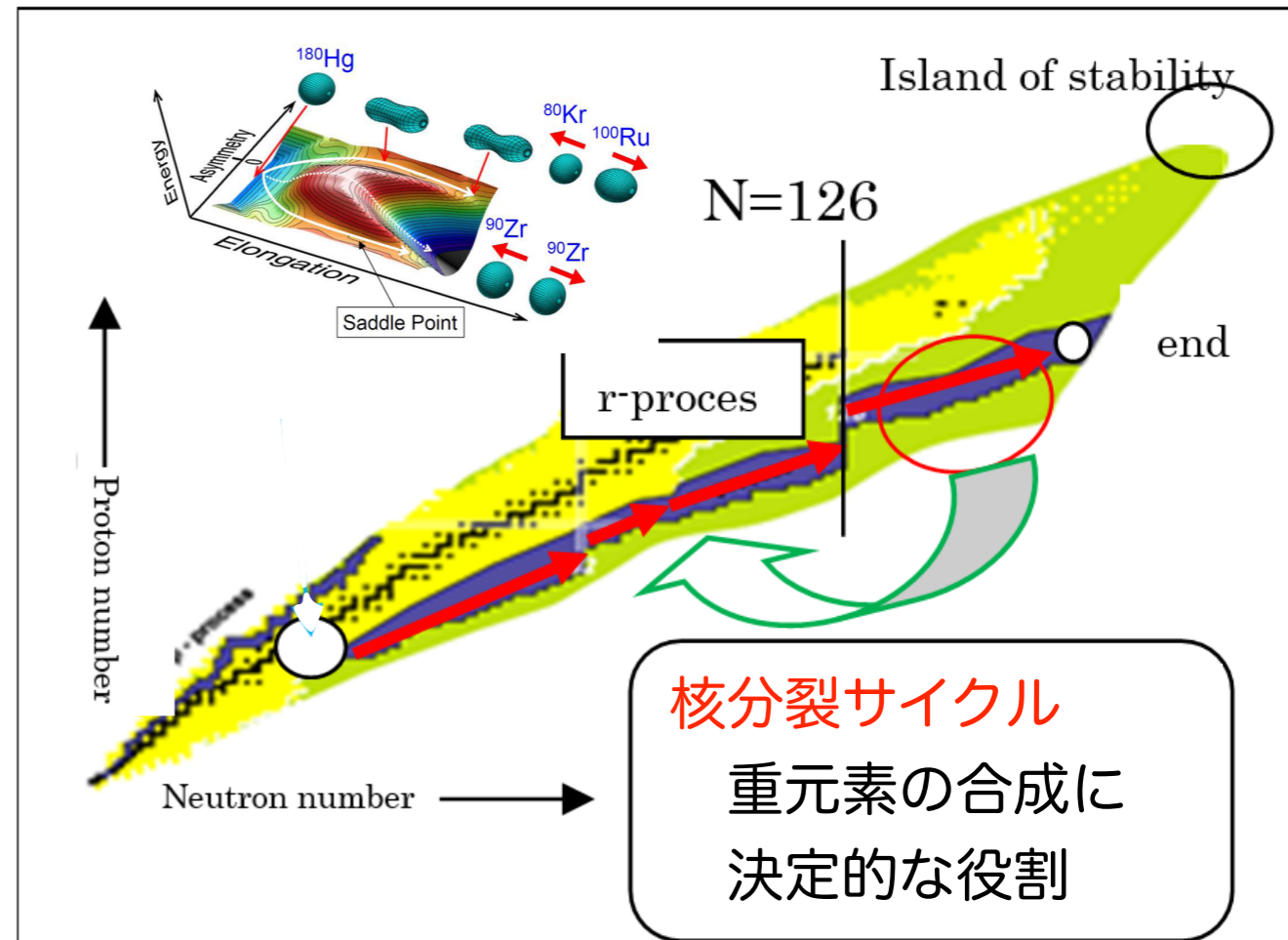
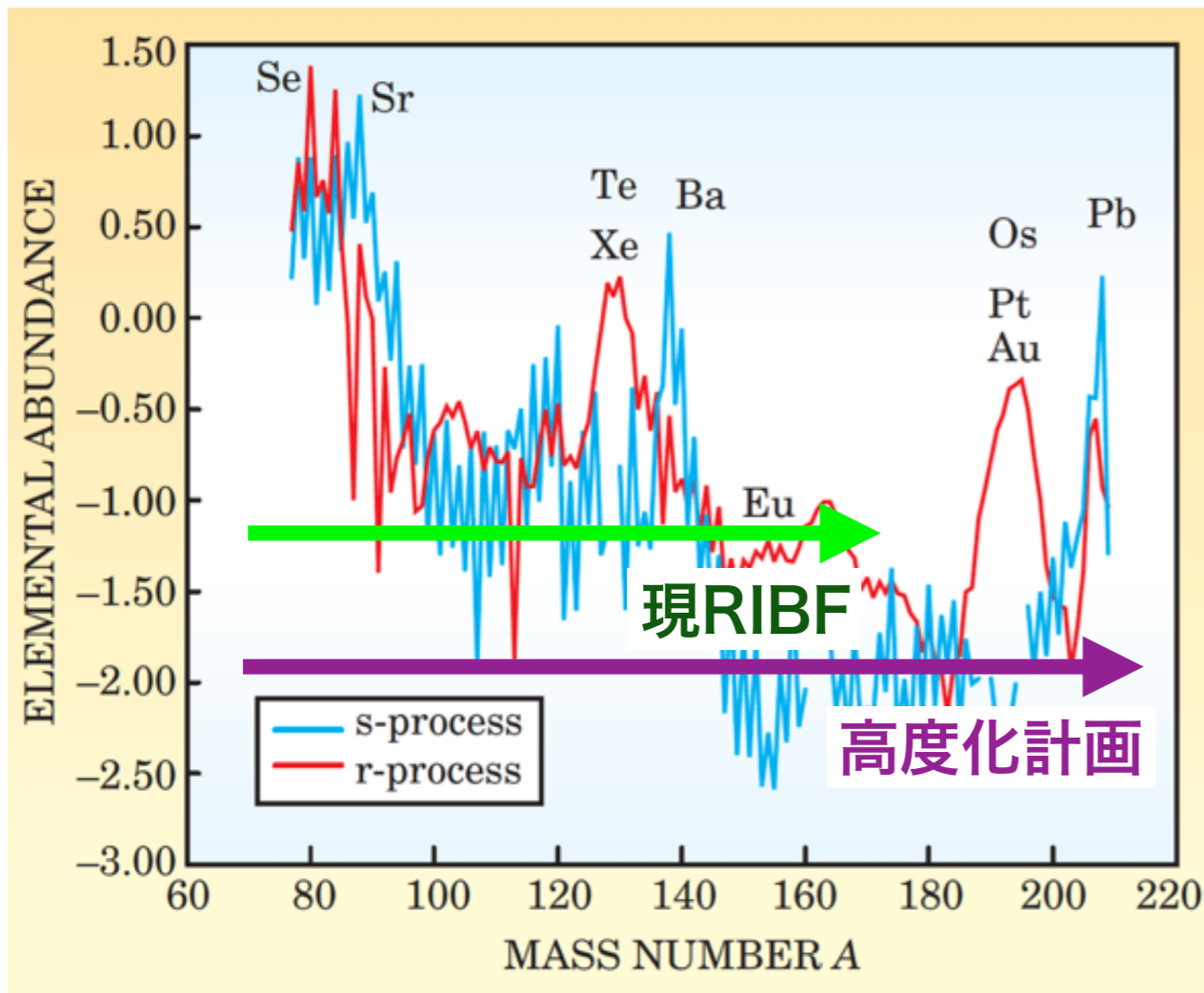


安定の島？



中性子星合体時代の宇宙核物理研究

r過程第3ピーク(質量数>180)への展開
核分裂サイクル

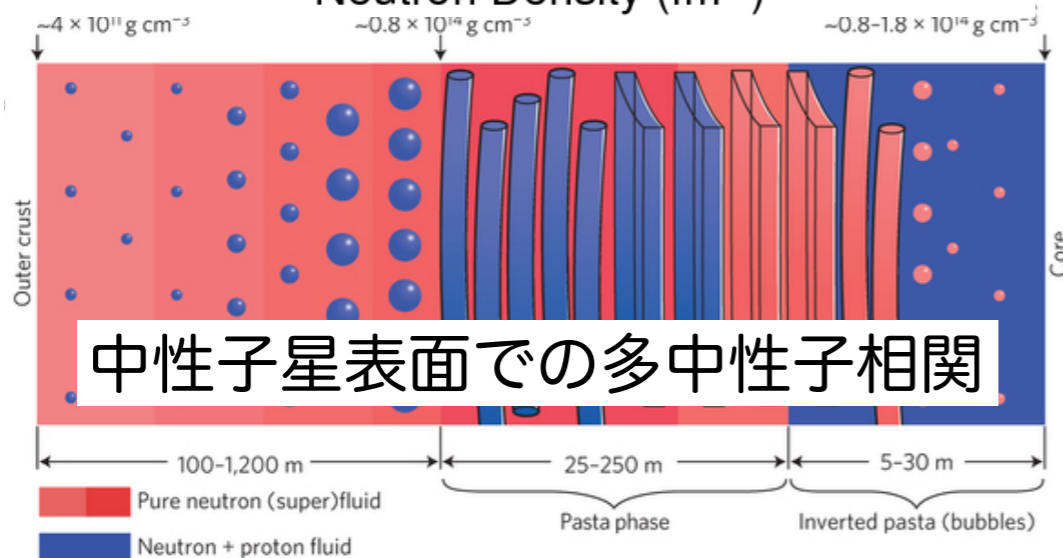
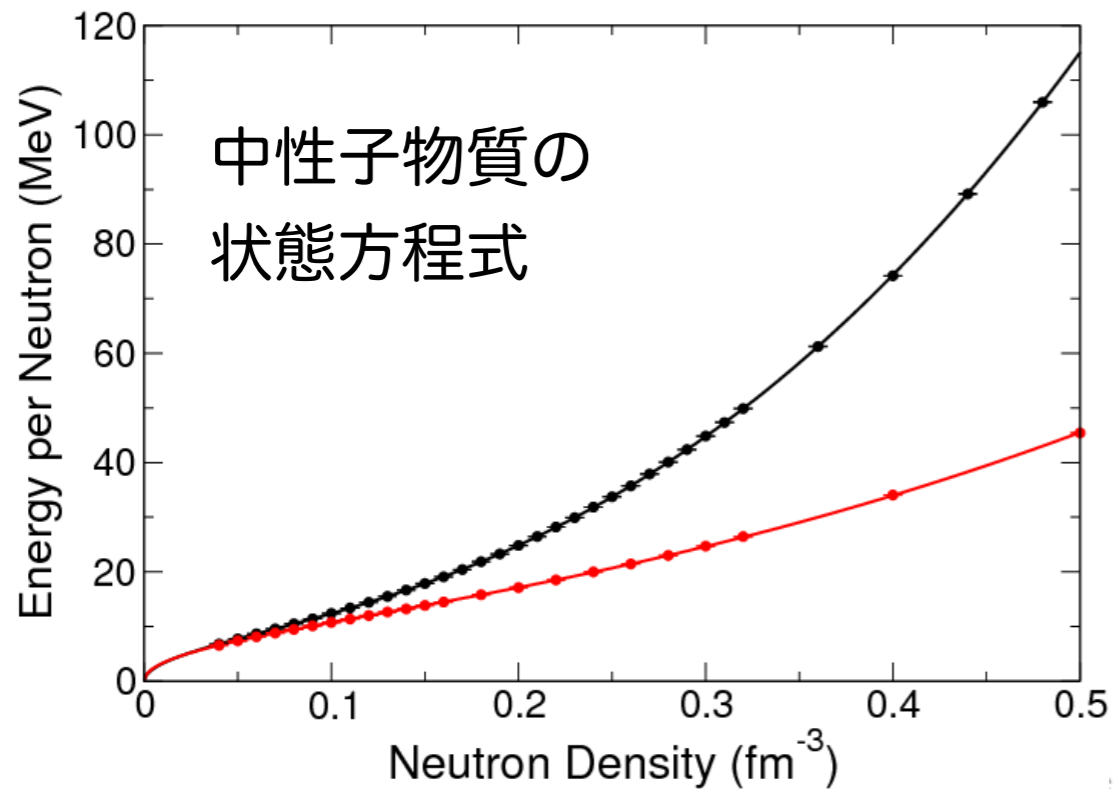


中性子星合体時代の宇宙核物理研究

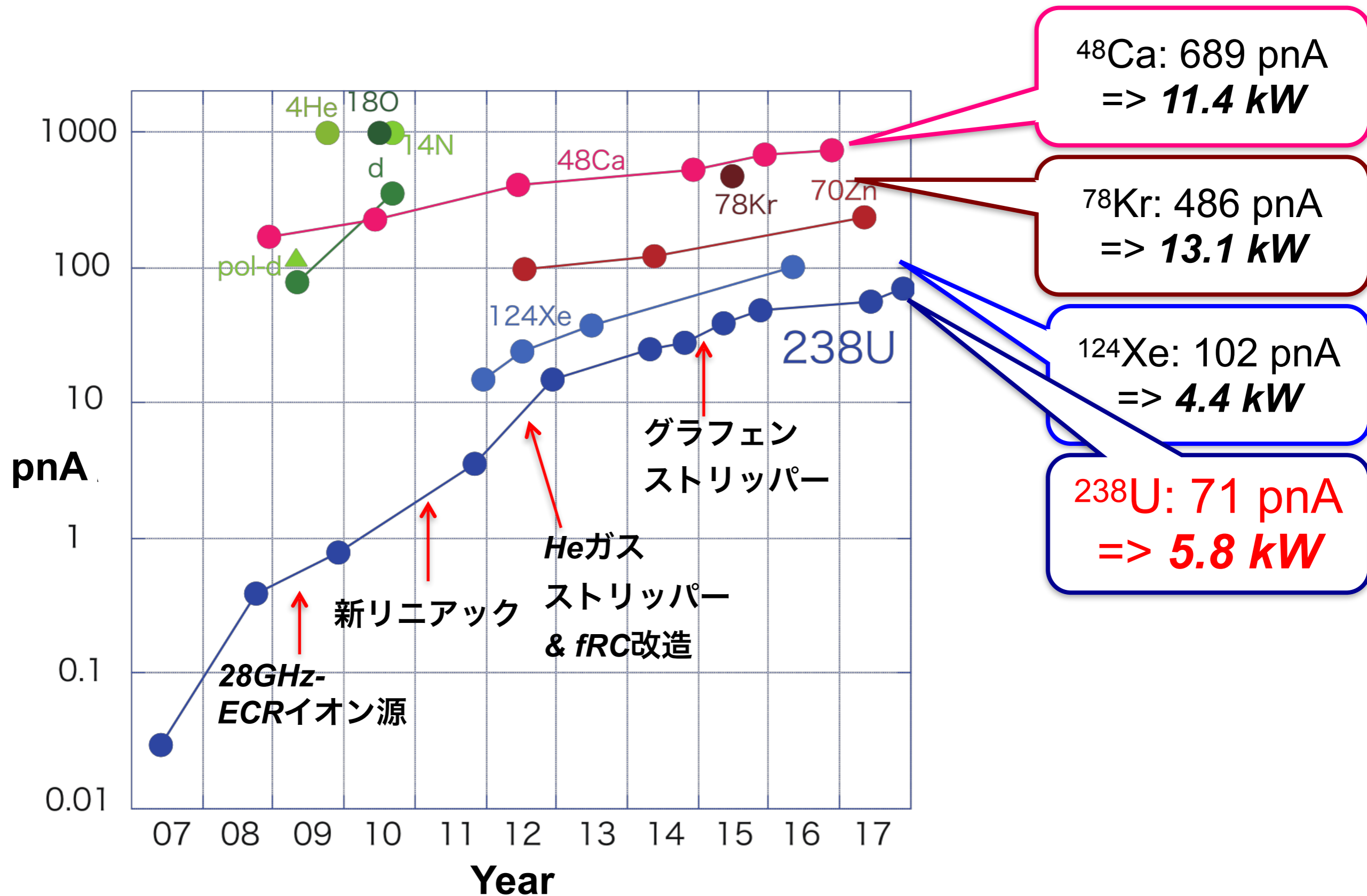
中性子物質研究

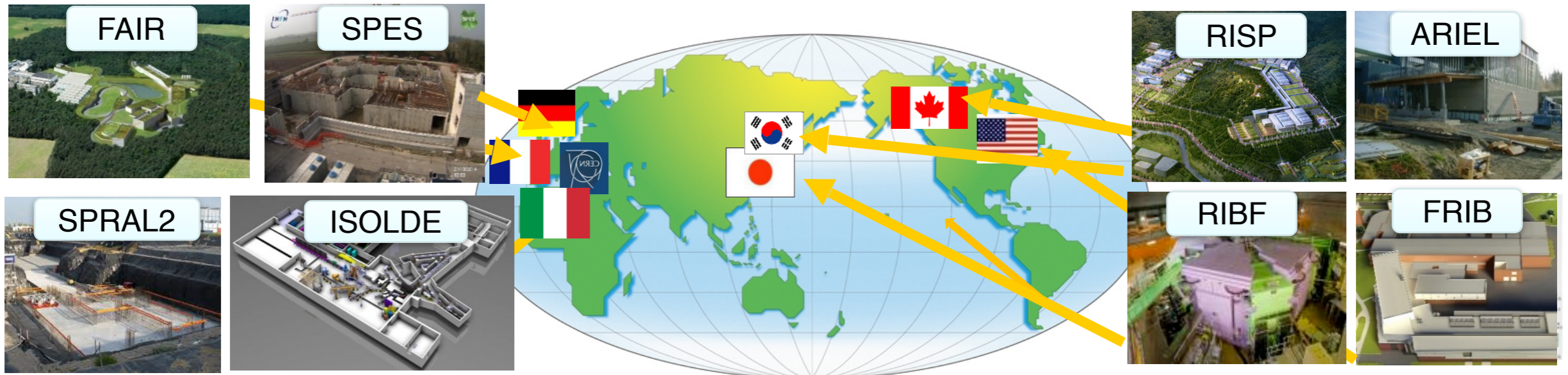
状態方程式研究 ↔ ハドロン物理、宇宙観測、理論との連携

多中性子相関 中性子星表面の構造形成



ビーム強度の向上: ウラン加速のフロントランナー





Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027		
RIBF	実験開始			施設完成									RIBF大強度化			RIBF2							
FAIR												建設開始							実験開始				
★ FRIB	→ 高いRI生成能力を有する施設							建設開始					実験開始										
ARIEL					建設開始								実験開始										
SPRAL2					建設開始								実験開始 (Phase-I)										
SPES						建設開始					実験開始		施設完成										
ISOLDE							建設		4 MeV達成		10 MeV達成												
RISP											建設開始					実験開始							
HIAF												建設開始							実験開始				

マスタープラン2017からの進展

ビーム強度増強計画

^{238}U ビーム (345 MeV/u) 2 pμA

^{51}V , ^{54}Cr 5 → ≥ 6 MeV/u, 5 pμA

平成28年度補正予算で実施済

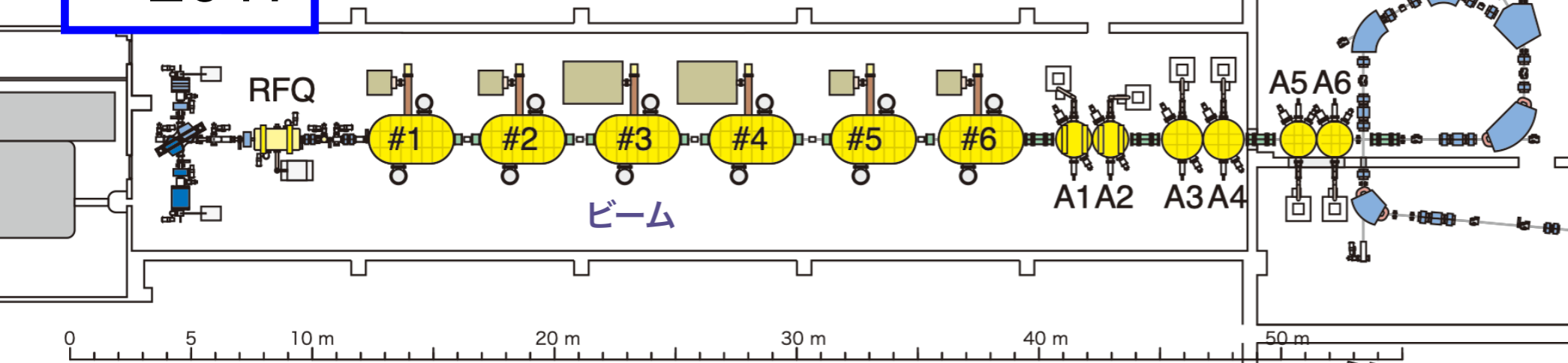
RILAC 超伝導化

低エネルギー領域での超伝導線形加速器を開発、ビーム強度5倍へ

- 119番・120番元素合成の実験効率が5倍
- 医療用など有用なRIの大量製造が可能に

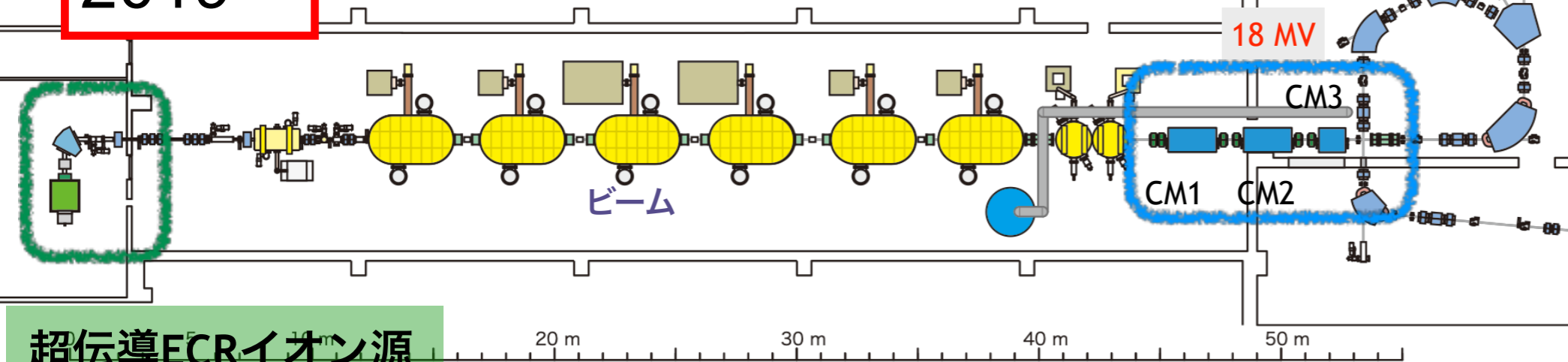
~2017

線形加速器 RILAC



2019~

超伝導線形加速器 SRILAC



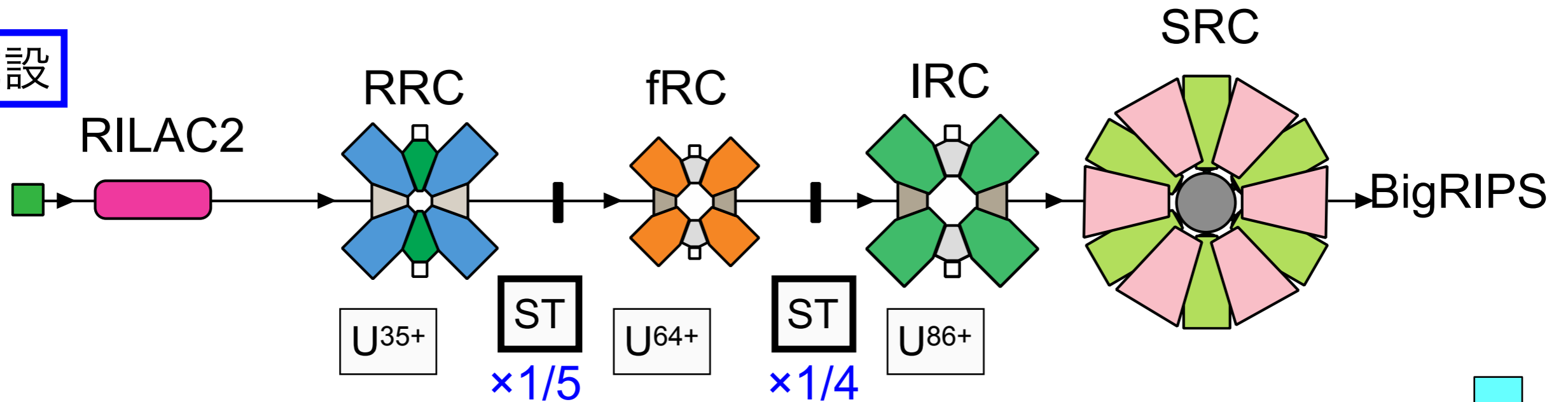
超伝導線形加速器
クライオモジュール



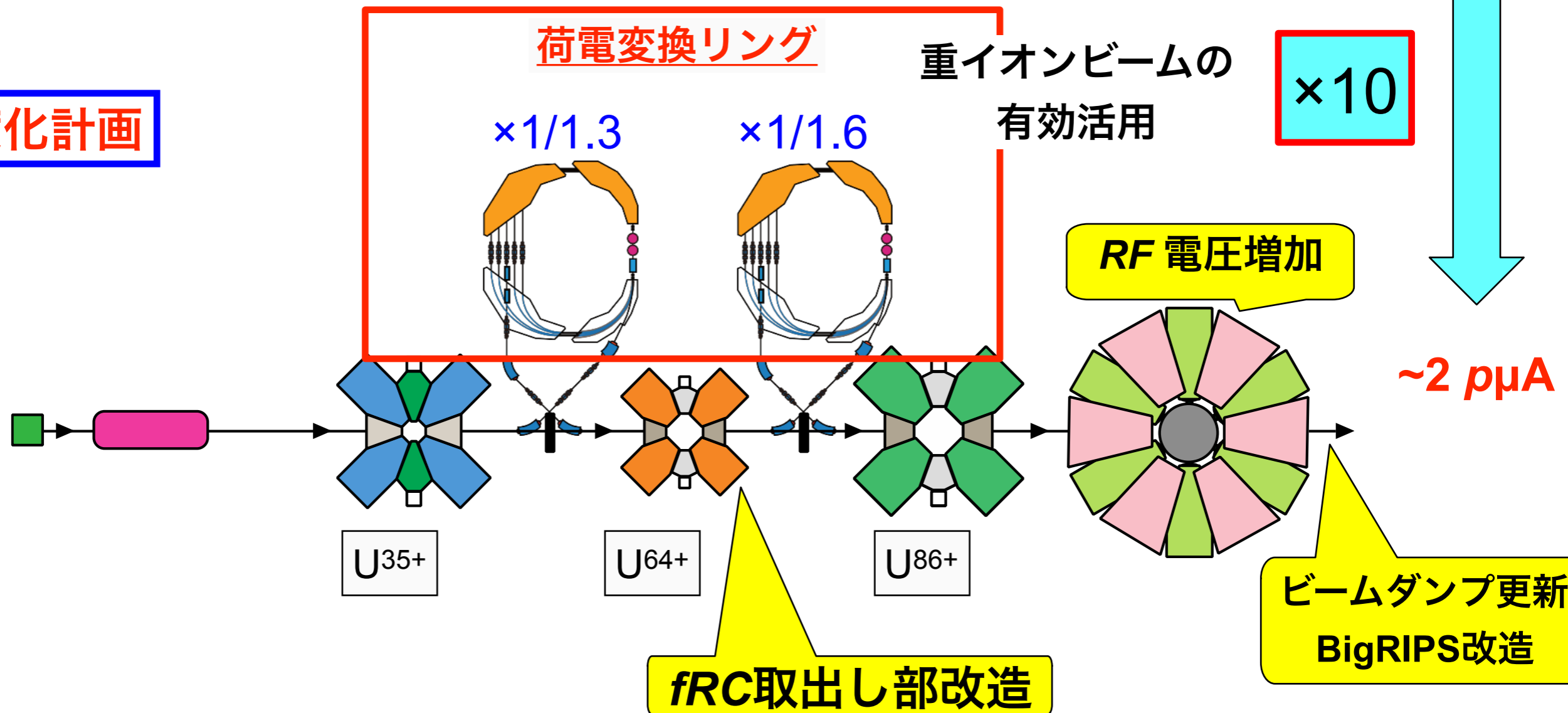
超伝導ECRイオン源

RIBF高度化2020

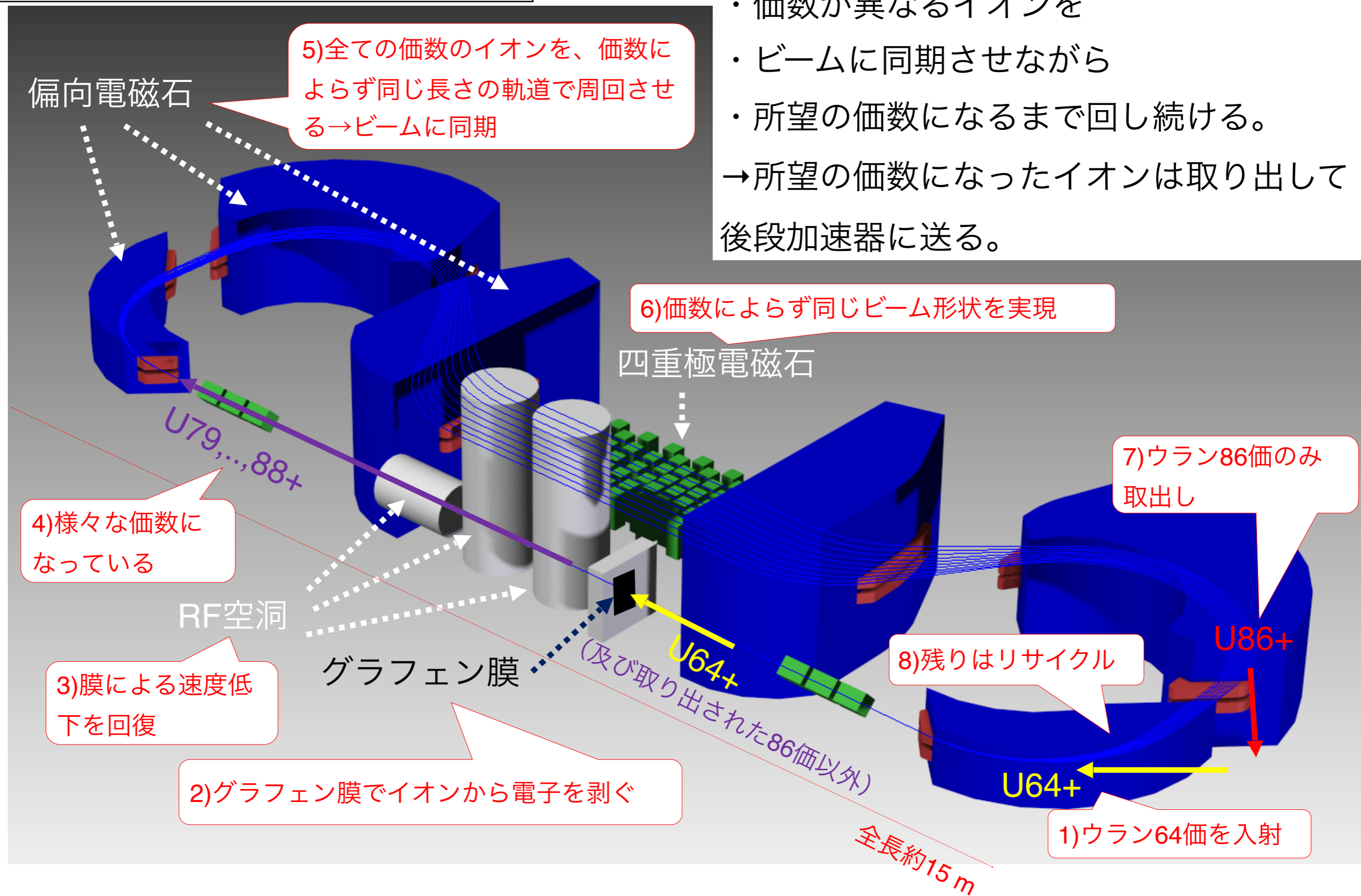
現施設



高度化計画



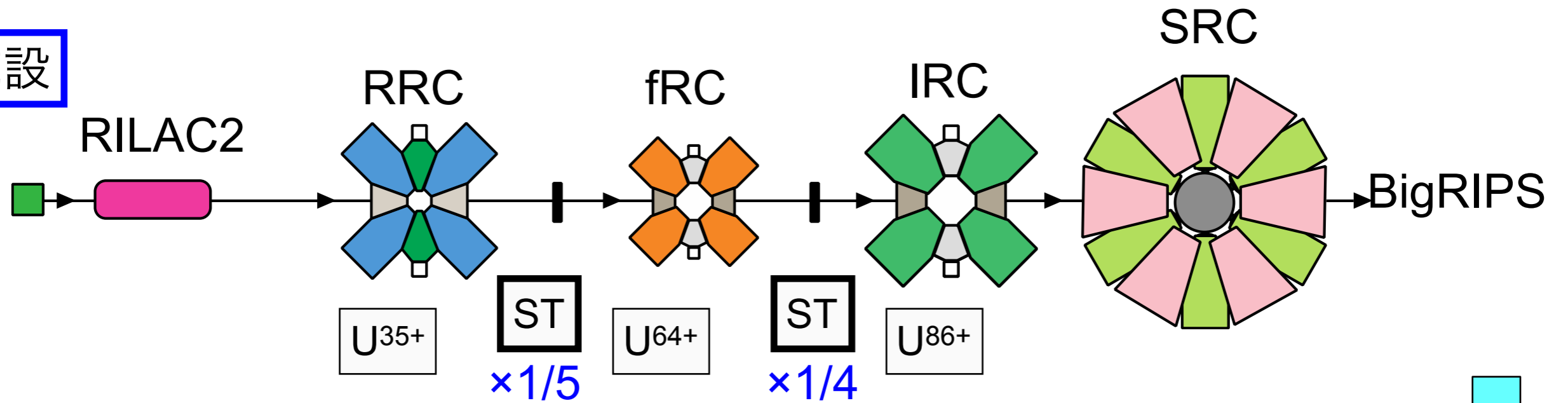
荷電変換リング (CSR)



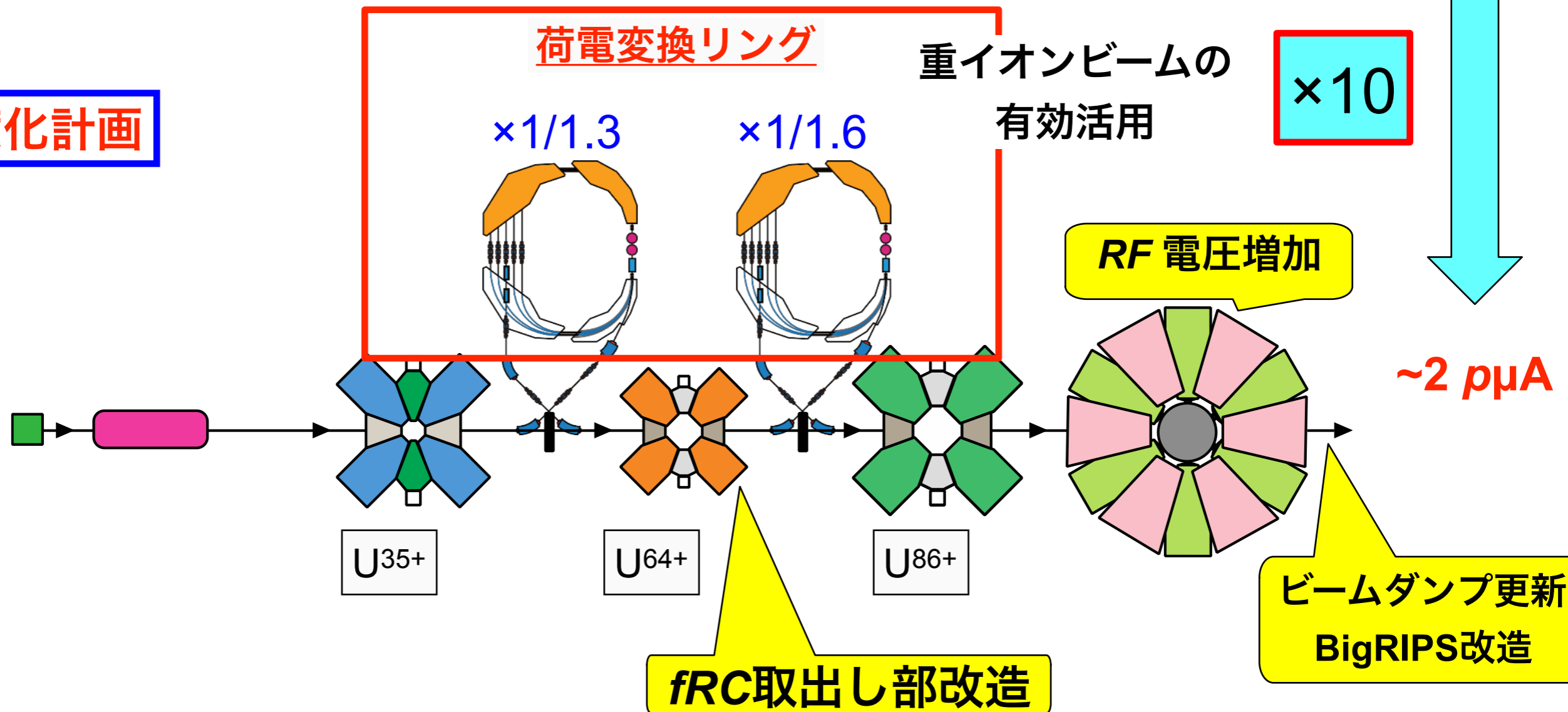
- 価数が異なるイオンを
 - ビームに同期させながら
 - 所望の価数になるまで回し続ける。
- 所望の価数になったイオンは取り出して後段加速器に送る。

RIBF高度化2020

現施設



高度化計画



RIBF+ vs. FRIB

線形加速器 + サイクロトロン

345 MeV/u

U 0.07 pμA → 2 pμA

13 kW → 160 kW

2007— / 2024—

加速器

エネルギー

ビーム強度

最大パワー

スケジュール

超伝導線形加速器

200 MeV/u

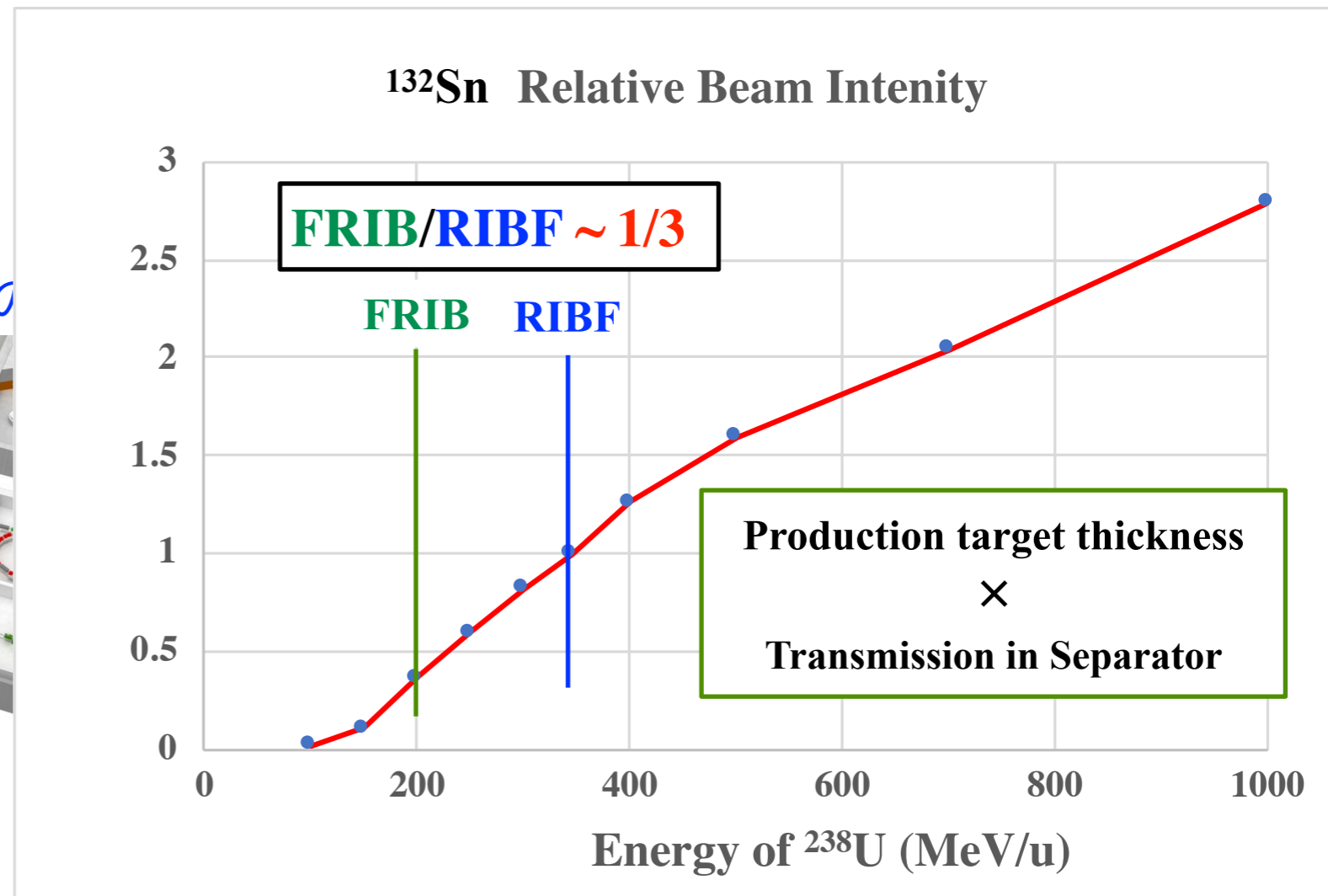
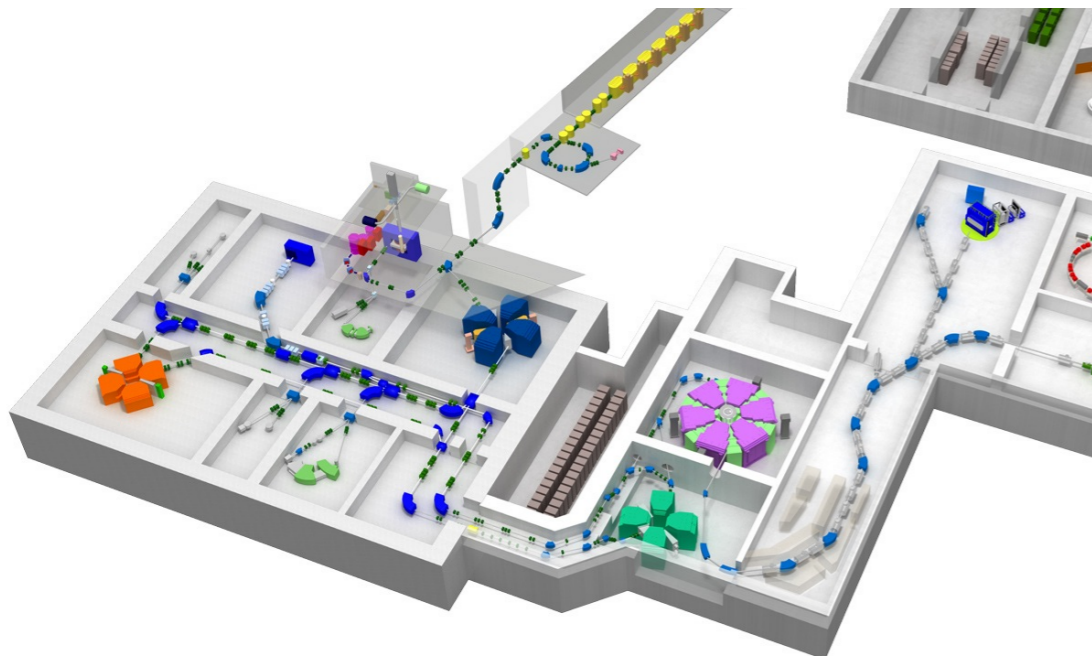
U 8 pμA

400 kW (U)

2022完成

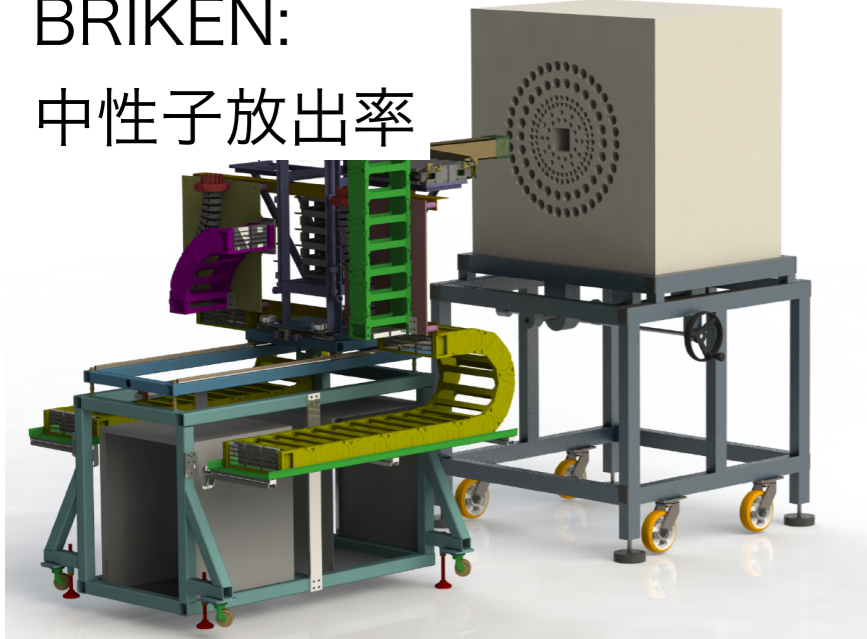
ZDS, SAMURAI, Rare RI Ring
SLOWRI, GARIS, SCRIT,
OEDO/SHARAQ, KISS

多くのユニークな基幹装置群はRIBFの

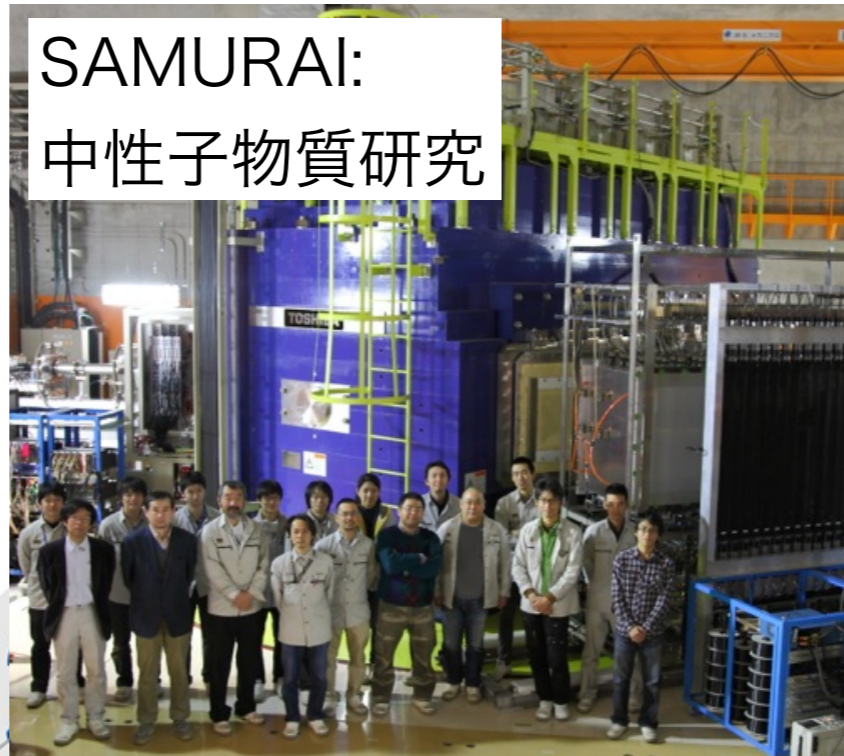


RIBFが世界に誇る基幹装置群

BRIKEN:
中性子放出率



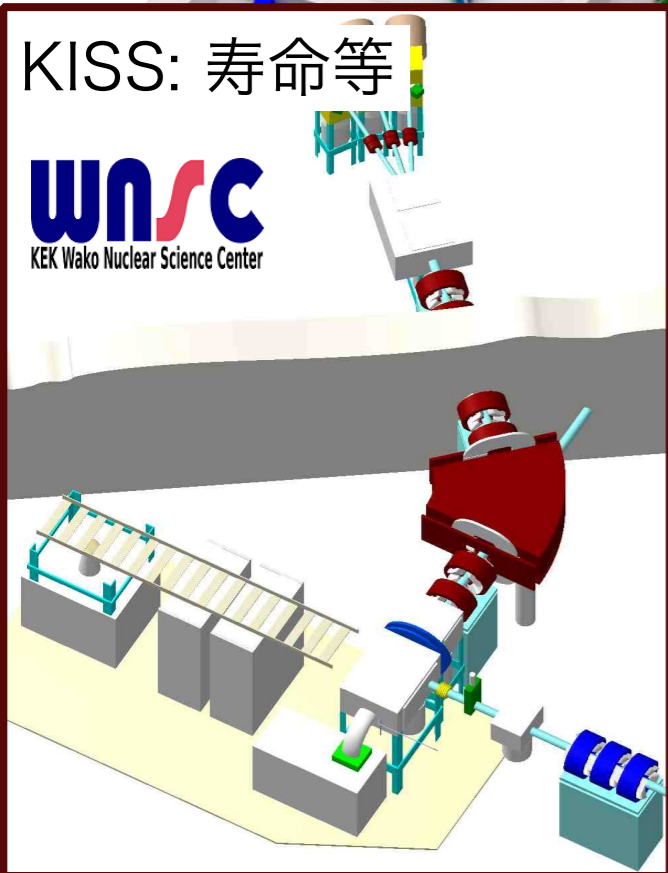
SAMURAI:
中性子物質研究



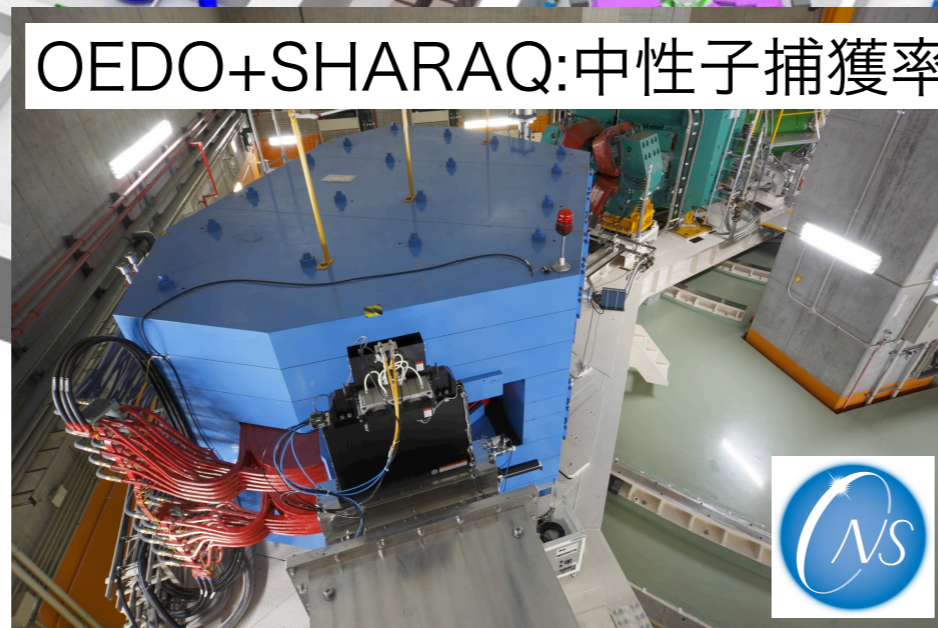
SCRIT: 電荷半径



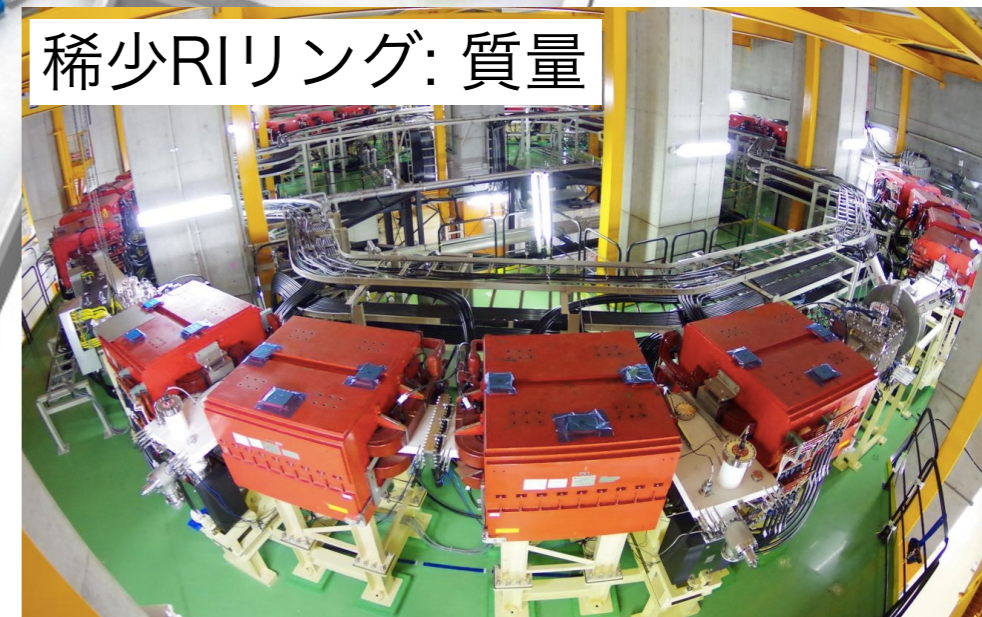
KISS: 寿命等



OEDO+SHARAQ: 中性子捕獲率



稀少RIリング: 質量



実施体制

実施組織: 理化学研究所仁科加速器科学研究センター (センター長: 延與秀人)

協力組織: 東大原子核科学研究センター

KEK素粒子原子核研究所和光原子核科学センター

阪大核物理研究センター

上記の4組織による四者協議会を発足させ、
責任を明確に分掌した計画の実施・運営を進める。



RIBF高度化計画:マスタープラン2020

ビーム強度増強計画

^{238}U ビーム (345 MeV/u) 2 pμA

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予算規模 100億円/5年間 (FY2021-2025)

我々の宇宙を形作る重元素はどこから来たのか？

r過程第3ピークへ、核分裂リサイクル
中性子物質研究

元素はどこまで存在するのか？

周期表第8周期への挑戦(≥ 119 番元素)

加速器はどのように社会に貢献できるのか？

核変換研究