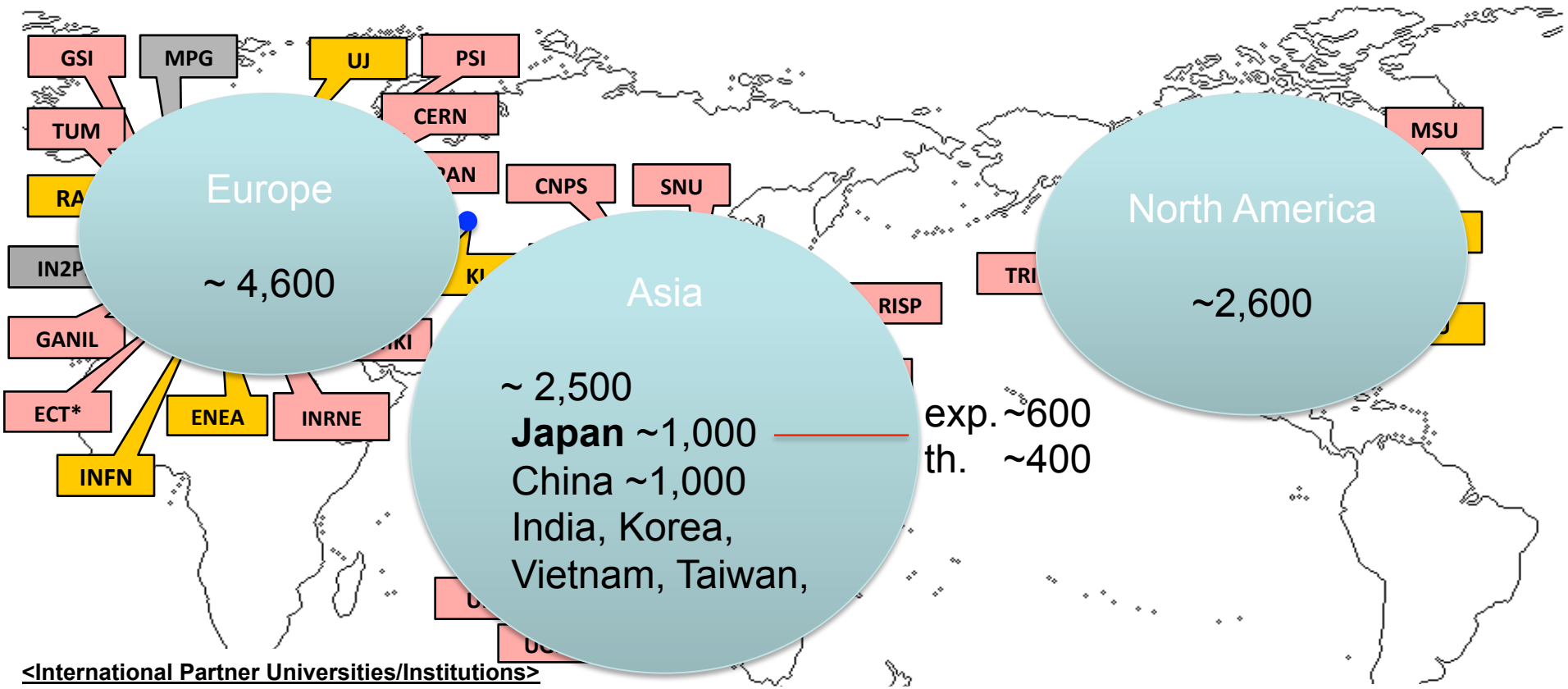
Research activities and opportunities in Japan -- exotic nuclei --

Tohru Motobayashi
RIKEN Nishina Center

Size of nuclear physics communities (in 2011)
Facilities in Japan
RCNP, Osaka Univ.
RIKEN **RIBF**
opportunities for graduate-course students
(RIKEN's examples)

Size of nuclear physics communities (H. Sakai, 2011 for ANPhA)

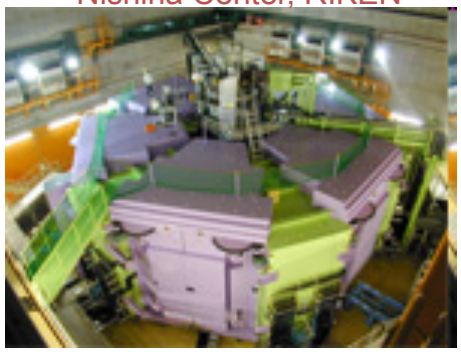


<International Partner Universities/Institutions>

ATOMKI: Institute of Nuclear Research of the Hungarian Academy of Sciences (Hungary)
BNL: Brookhaven National Laboratory (USA)
CARN: Carn University (France)
CERN: European Organization for Nuclear Research (Swiss)
CNPS: council for China (China)
CU: Columbia University (USA)
ENEA: National Institute for New Technologies, Energy and Environment (Italy)
ECT*: European Centre for Theoretical Studies in Nuclear Physics and Related Areas (Italy)
GANIL: Grand Accelerateur National D'Ions Lourds (France)
GSI: GSI Helmholtzzentrum für Schwerionenforschung GmbH (Germany)
IBS, RISP: Institute for Basic Science, Rare Isotope Science Project (Korea)
IFJ PAN: Henrik Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences (Poland)
IMP, CAS: Institute of Modern Physics, Chinese Academy of Science (China)
IN2P3: National Institute of Nuclear Physics and Particle Physics (France)
INFN: Natinal Institute of Nuclear Physics (Italy)
INRNE: Institute for Nuclear Research and Nuclear Energy (Bulgar)
ITB: Institut Teknologi Bandung (Indonesia)
ITS: Institut Teknologi Sepuluh Nopember (Indonesia)
JINR: Joint Institute for Nuclear Research (Russia)
KI: Kurchatov Institute (Russia)
LNZ: Lanzhou University(China)
MSU: Michigan State University (USA)
MPG: Max Planck Institute (Germany)
NAJ: Nanjing University (China)
PKU: Peking University (China)
PSI: Paul Scherrer Institute (Swiss)
RAL: Rutherford Appleton Laboratory, SFTC (UK)
SJTU: Shanghai Jiao Tong University (China)
SNU: Seoul National University (Korea)
TRIUMF: TRIUMF (Canada)
TUM: Technische Universitat Munchen (Germany)
UGM: Universitas Gadjah Mada (Indonesia)
USM: Universiti Sains Malaysia (Malaysia)
UJ: University of Jyvaskyla (Finland)
UNPAD: Universitas Padjadjaran (Indonesia)
VAEC: Vietnam Academy of Science and Technology (Vietnam)

Accelerator facilities for nuclear physics (RI beams: in red)

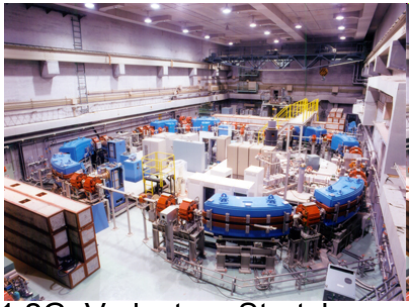
Nishina Center, RIKEN



K2600 **RIBF**

Heavy ion (RIB)

Research Center for Electron Photon Science, Tohoku University (**ELPH**)



1.2GeV electron Stretcher

e^-

SPring-8 (RIKEN/JASRI)

8GeV e - Synchrotron

photon

RCNP, Research Center for Nuclear Physics, Osaka University

K400 Cyclotron

light ion / light heavy ion

HIMAC at National Institute of Radiological Sciences

800MeV/A Synchrotron

heavy ion (therapy)

J-PARC, KEK/JAEA)

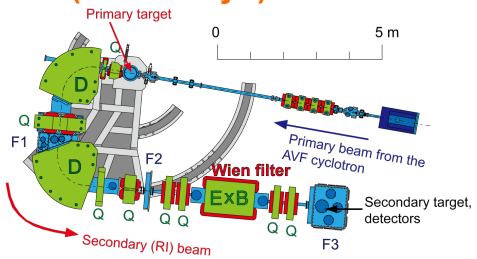
30GeV Proton Synchrotron

π, K, μ, n, (ν)

Smaller

Accelerator facilities for nuclear physics

CNS (Univ. Tokyo)

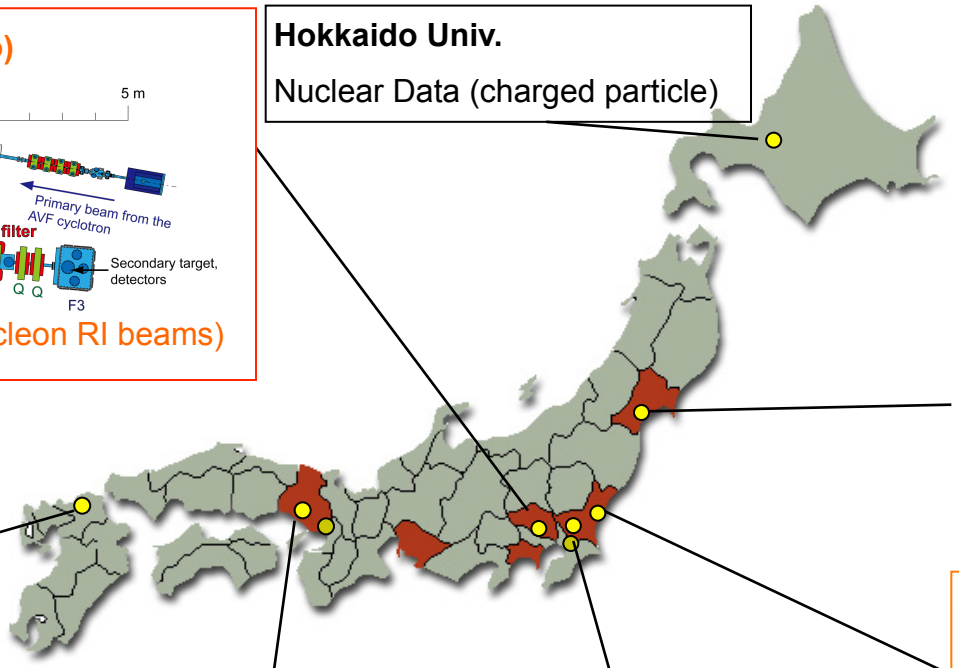


CRIB (~5 MeV/nucleon RI beams)

RI beam

Hokkaido Univ.

Nuclear Data (charged particle)

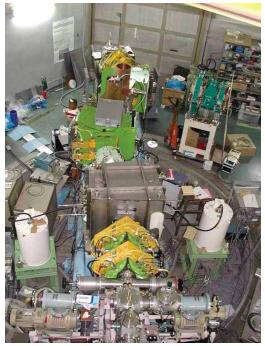


CYRIC (Tohoku Univ.)

Cyclotron (p 90 MeV)

light ion

Kyushu Univ.

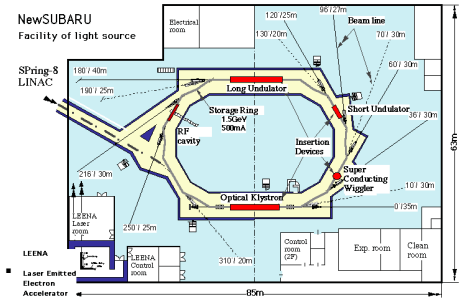


Tandem (~9 MV)

p, d, C, O, ..

- Jan. 2015

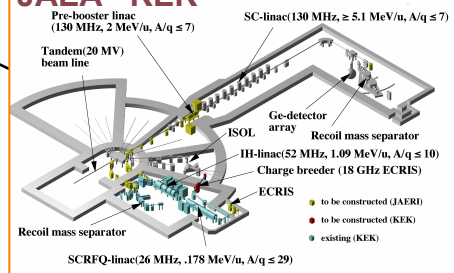
NEW SUBARU



SOR (2-10 MeV photons)

photon (inverse Compton)

JAEA - KEK



TRIAC (RI beams) → Tandem

heavy ion

RI beams: - 2011

Tsukuba Univ.

Tandem → Vdg. (earthquake)

RCNP, Osaka Univ. – high-precision experiments with light beams
RI beams by fragmentation, direct reactions

K2600 **RIBF**

RI beam

1.2GeV electron Stretcher

e^-

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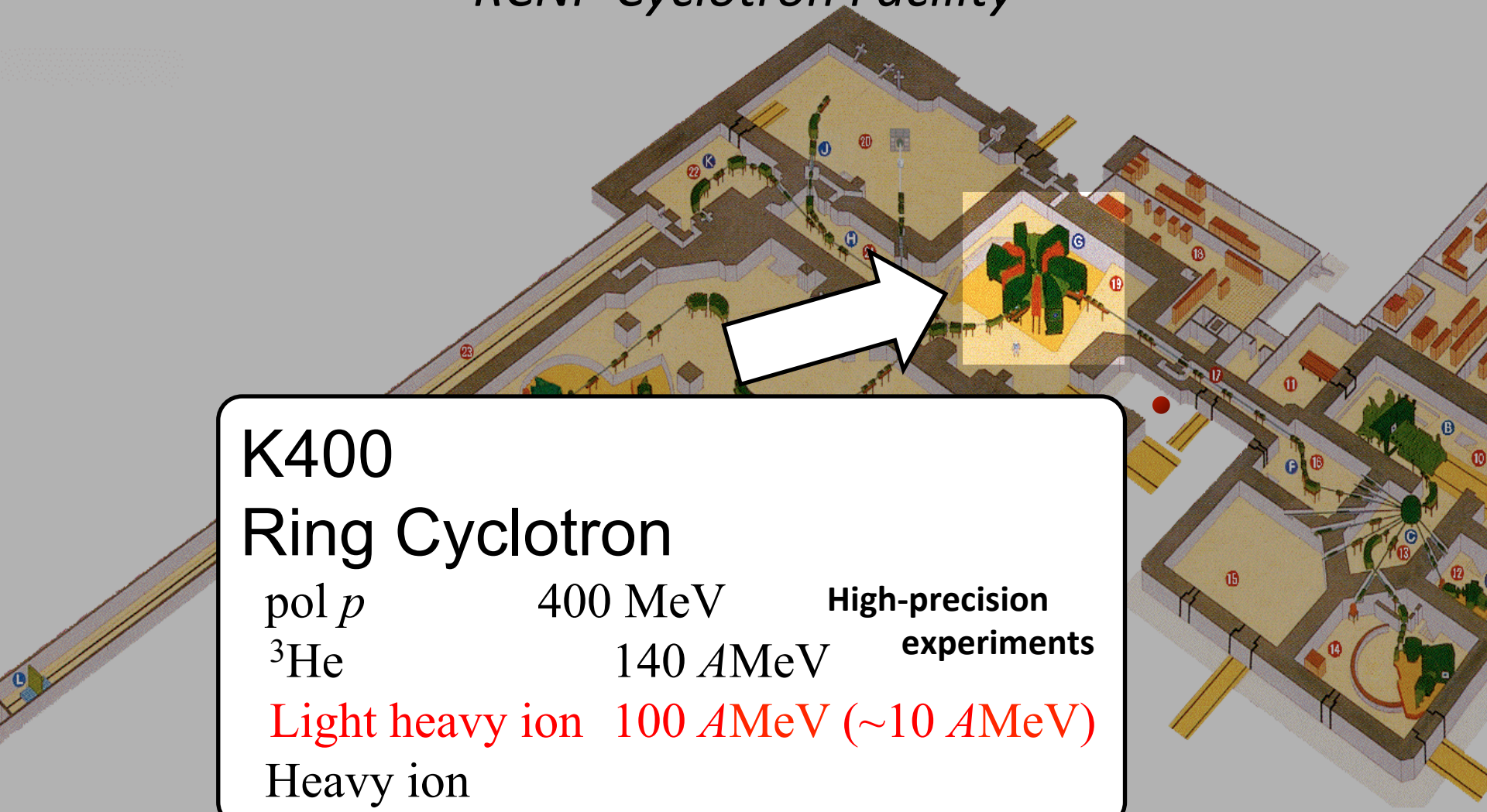
π, K, μ, n, (ν)

RCNP Cyclotron Facility

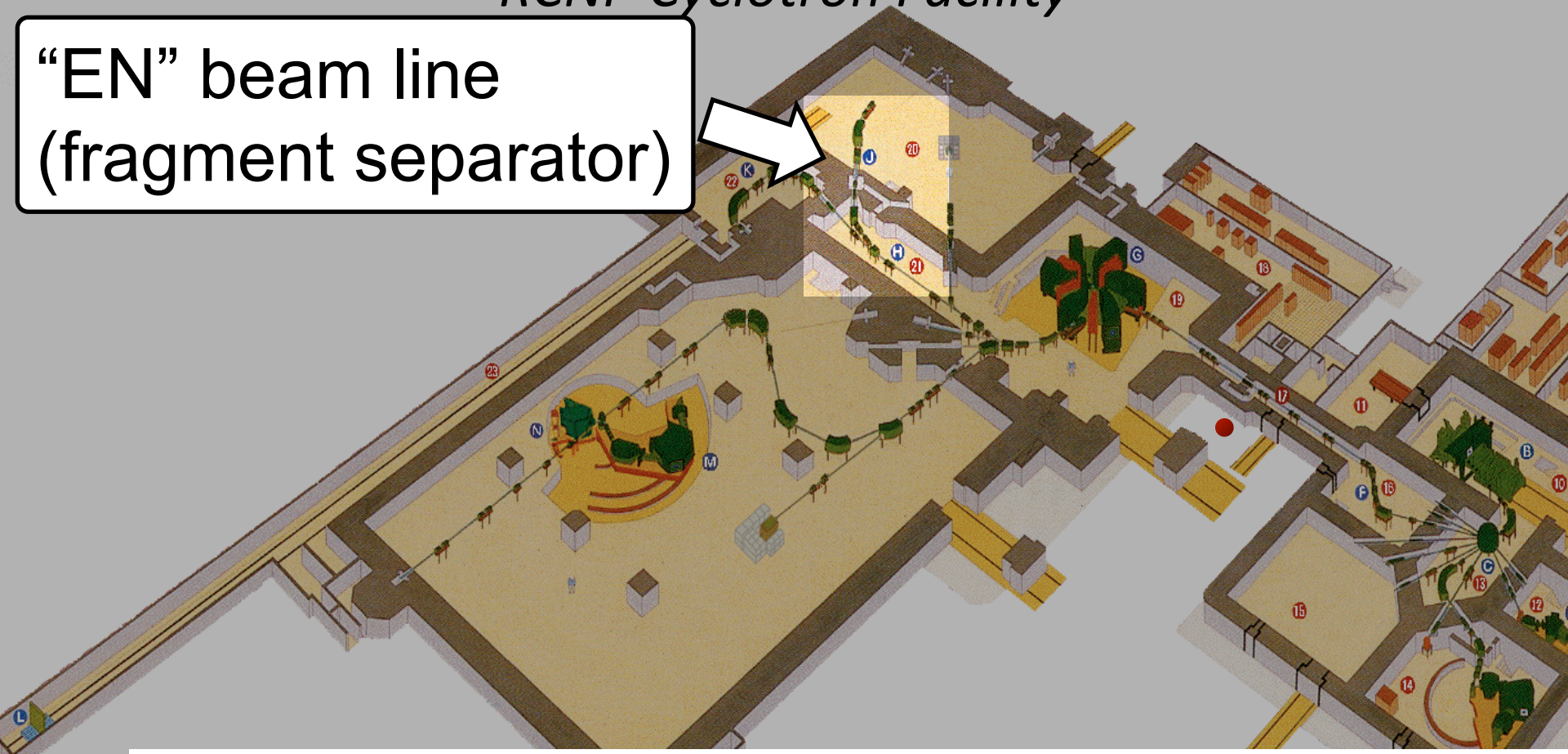


K400
Ring Cyclotron

pol p	400 MeV	**High-precision experiments**
^{3}He	140 AMeV	
Light heavy ion	100 AMeV (~10 AMeV)	
Heavy ion		

RCNP Cyclotron Facility

"EN" beam line
(fragment separator)



e.g.

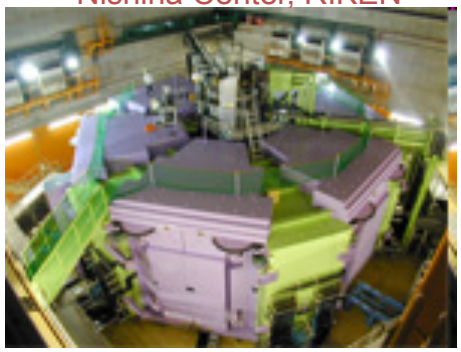
5.5 MeV/nucleon ^{17}N beam by ^{9}Be(^{18}O,^{17}N) at 9.3 MeV/nucleon ← bypass of AVF

high-spin (23/2^{+}) isomer in ^{135}La ← ^{17}N+^{124}Sn fusion

A. Odahara, reported in ARIS2014

RIKEN RIBF – new-generation facility in operation; nrecent highlights

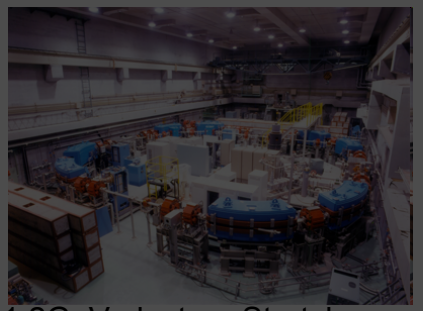
Nishina Center, RIKEN



K2600 **RIBF**

RI beam

Research Center for Electron Photon Science, Tohoku University (**ELPH**)



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8GeV e - Synchrotron

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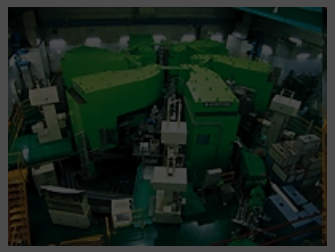

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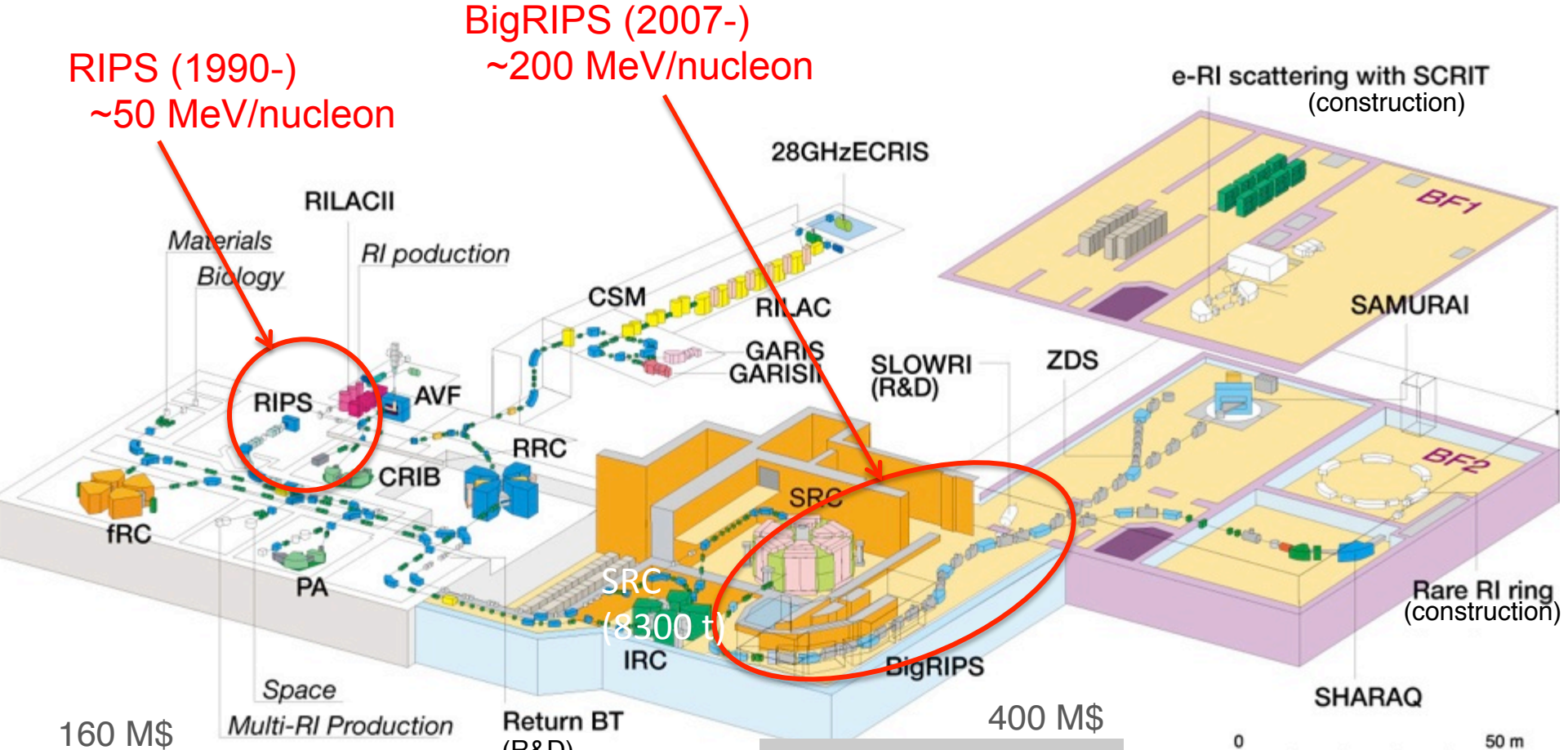
π, K, μ, n, (ν)

RIBF – a new generation RIB facility in operation
with world highest capability of **providing RI beams** in coming years!



160 M$

135 MeV/nucleon
for light nuclei (1986-)

400 M$

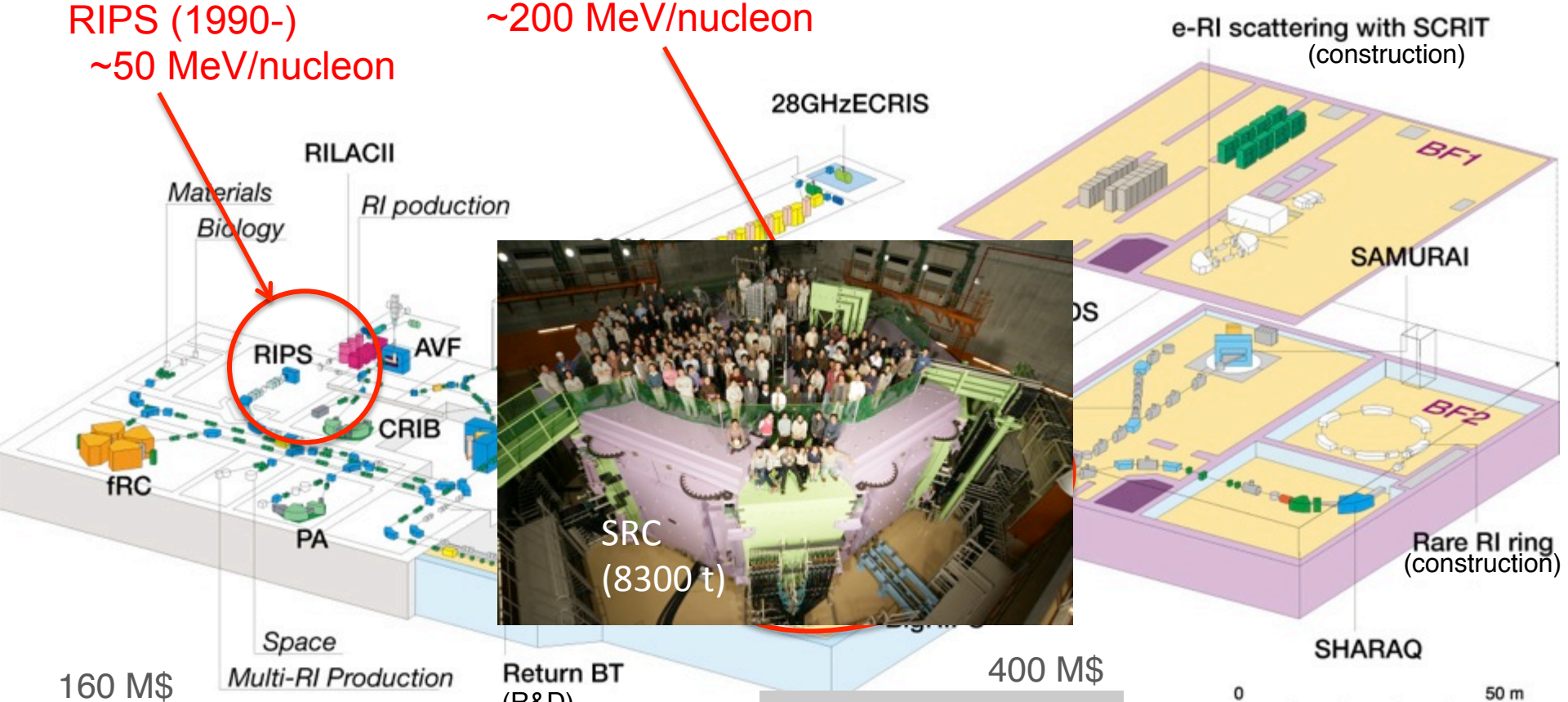
345 MeV/nucleon
up to U (**2006**-)

experimental
equipment

RIBF – a new generation RIB facility in operation
with world highest capability of **providing RI beams** in coming years!

RIPS (1990-)
~50 MeV/nucleon

BigRIPS (2007-)
~200 MeV/nucleon



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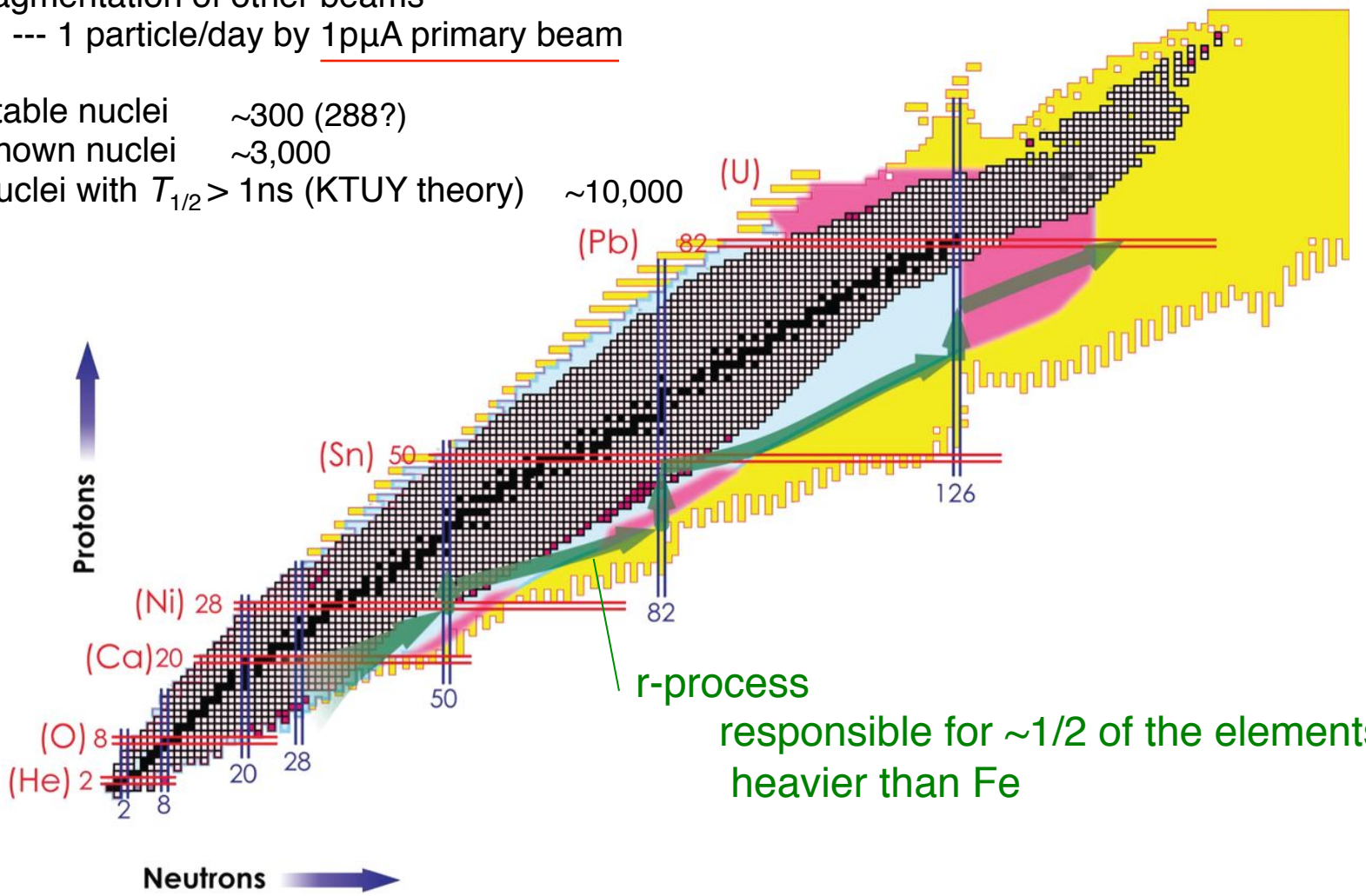
Nuclear chart potentially covered by RIBF

- fission + fragmentation of ^{238}U beams
- fragmentation of other beams
  --- 1 particle/day by 1pμA primary beam

- Stable nuclei ~300 (288?)
- Known nuclei ~3,000
- Nuclei with $T_{1/2}$ > 1ns (KTUY theory) ~10,000



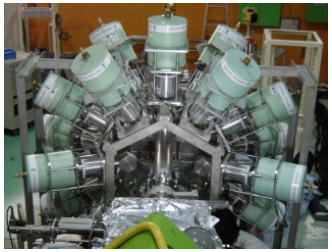
r-process
responsible for ~1/2 of the elements
heavier than Fe

Motobayashi T , and Sakurai H Prog. Theor. Exp. Phys. 2012;2012:03C001

PTEP
Progress of Theoretical and Experimental Physics

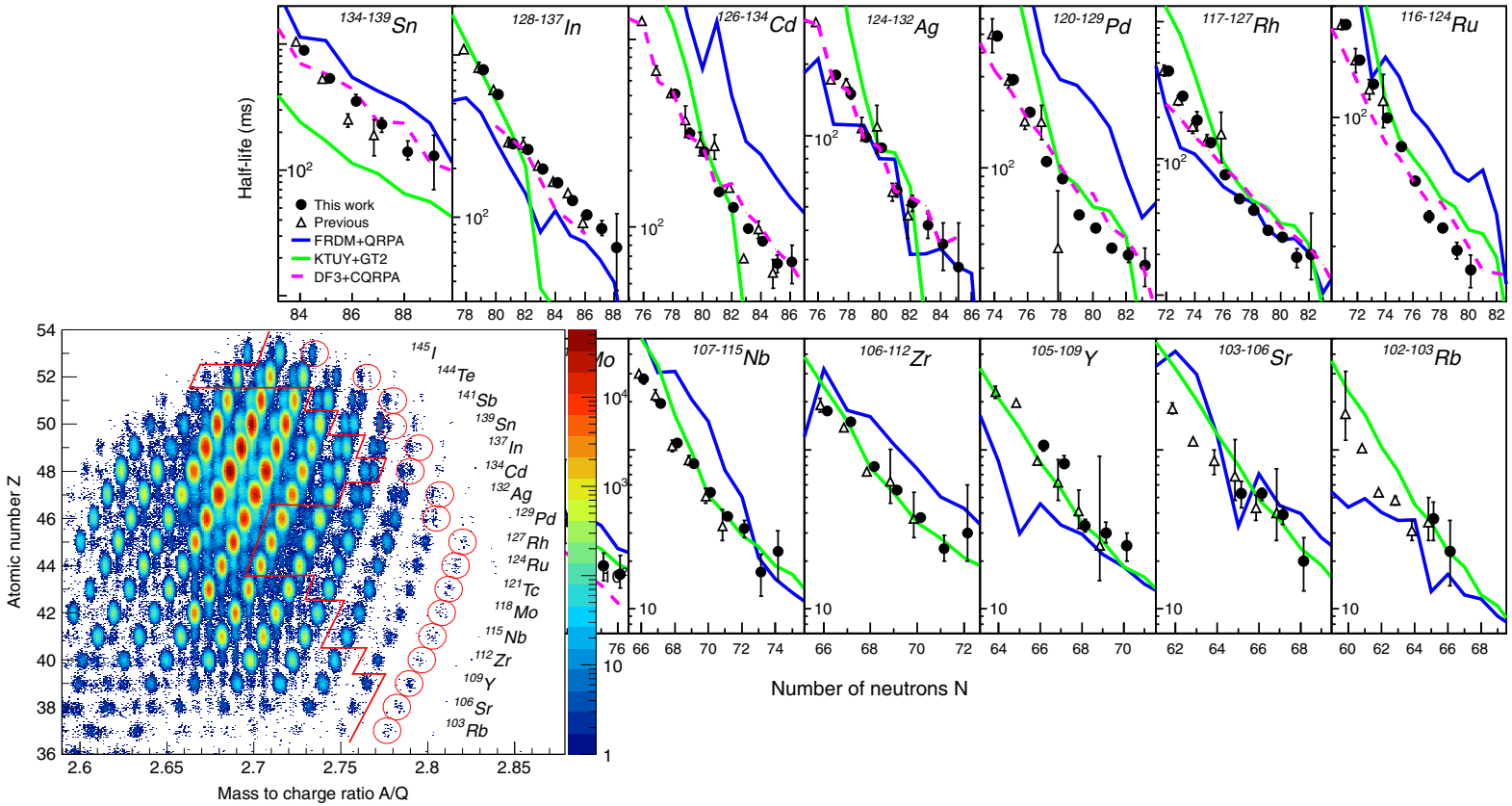
110 (40 new) half lives measured

EURICA + WASABI



12 EUROBALL clusters at RIKEN

many r-process nuclei

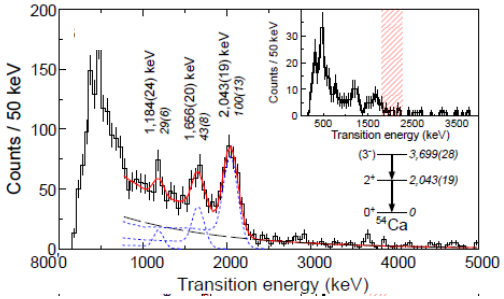


Lorusso, Nishimura, *et al.*, PRL 114, 192501 (2015)

July 2015 Pisa

Low-lying bound states measured by deexcitation γ-rays with DALI2 by direct reactions (inelastic, nucleon removal, …)

c.f. Alexandre Obertelli's lecture



SRC

reaction product
^{54}Ca (identified)

ZeroDegree Spectrometer

BigRIPS

DALI2

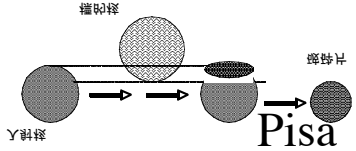
^{70}Zn primary beam

2ndary target (Be)
proton removal reaction

secondary beams
Including ^{55}Sc

production target (Be)

projectile fragmentation



July 2015

Pisa

γ-ray measurement
186 NaI(Tl) schintillators
with Doppler-shift correction

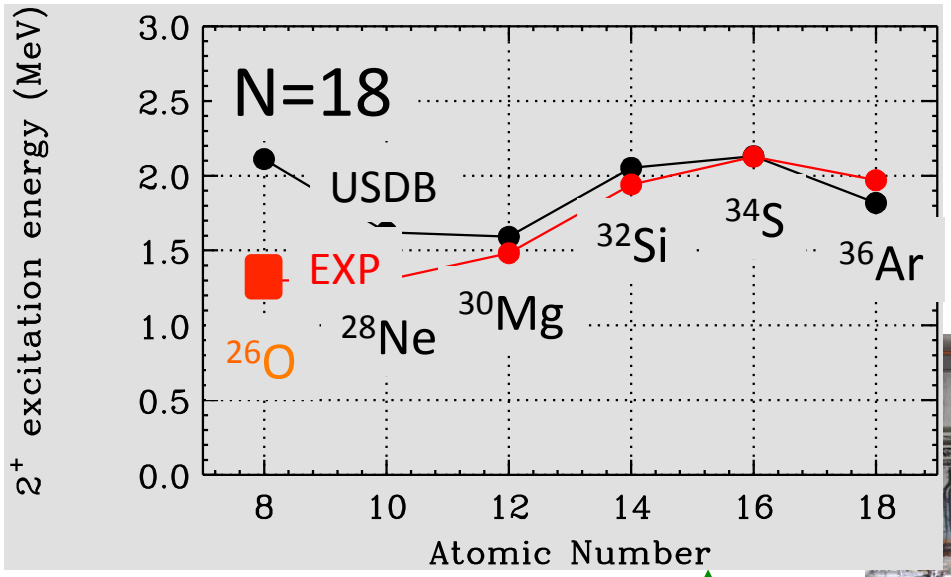
$^{27}F+C \rightarrow {}^{26}O^{*} \rightarrow {}^{24}O+2n$ ----- one neutron removal (knockout)

Being analyzed.

$E_r(^{26}O_{gs}) \lesssim 50keV$ (preliminary)

A lower limit will also be obtained.

unbound states in ^{26}O



Ground state

5 times higher statistics

→better determination of energy

Excited state at ~1.3MeV

First observation

Most probably 2^+

No peak at ~4.2MeV

RIKEN's Programs for Junior Scientists*

* general for all research fields of RIKEN

・For doctoral candidates

International Program Associate (IPA) (Non-Japanese PhD students)

Long term IPA (*Duration: 1 to 3 years, in principle*)

Short term IPA (*Duration: 3 to 6 months, in principle*)

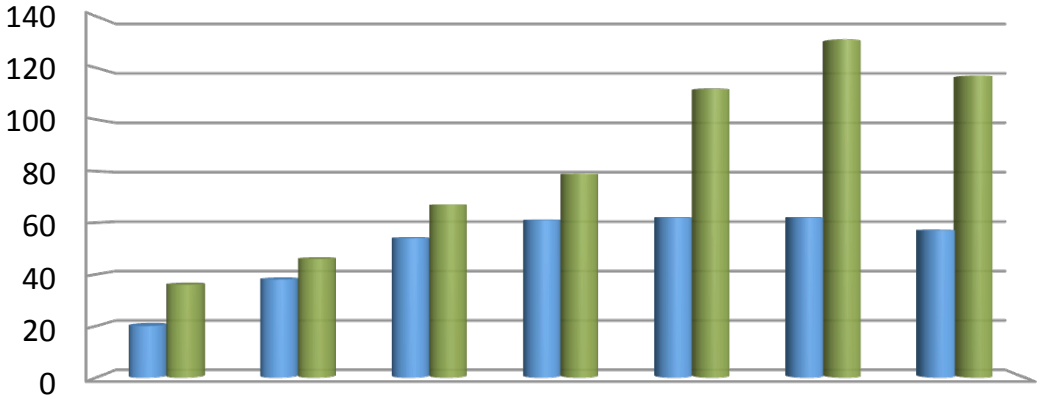
Junior Research Associate (JRA) (PhD students in Japanese graduate school*)

* (4 years for university), 2 years for master, 3 years for doctor

・For postdoctoral researchers

Foreign Postdoctoral Researcher (FPR) (Non-Japanese)

Special Postdoctoral Researcher (SPDR)



Number of Junior Scientists in IPA/ FPR Programs

	2008	2009	2010	2011	2012	2013	2014
FPR	20	38	54	61	62	62	57
IPA	36	46	67	79	112	131	117

IPA details

Compensation:

- ✓ A daily allowance of 5,200 yen
- ✓ Free on-campus housing

  OR

  Housing allowance for off-campus apartment
- ✓ Roundtrip transportation fee
- ✓ Insurance premium covered by RIKEN or university

* The portion paid by RIKEN may differ depending on the stipulations in the agreement with the partnering university. If the candidate receives other financial support such as scholarships from universities/institutions other than RIKEN, the payment made by RIKEN will be reduced accordingly.

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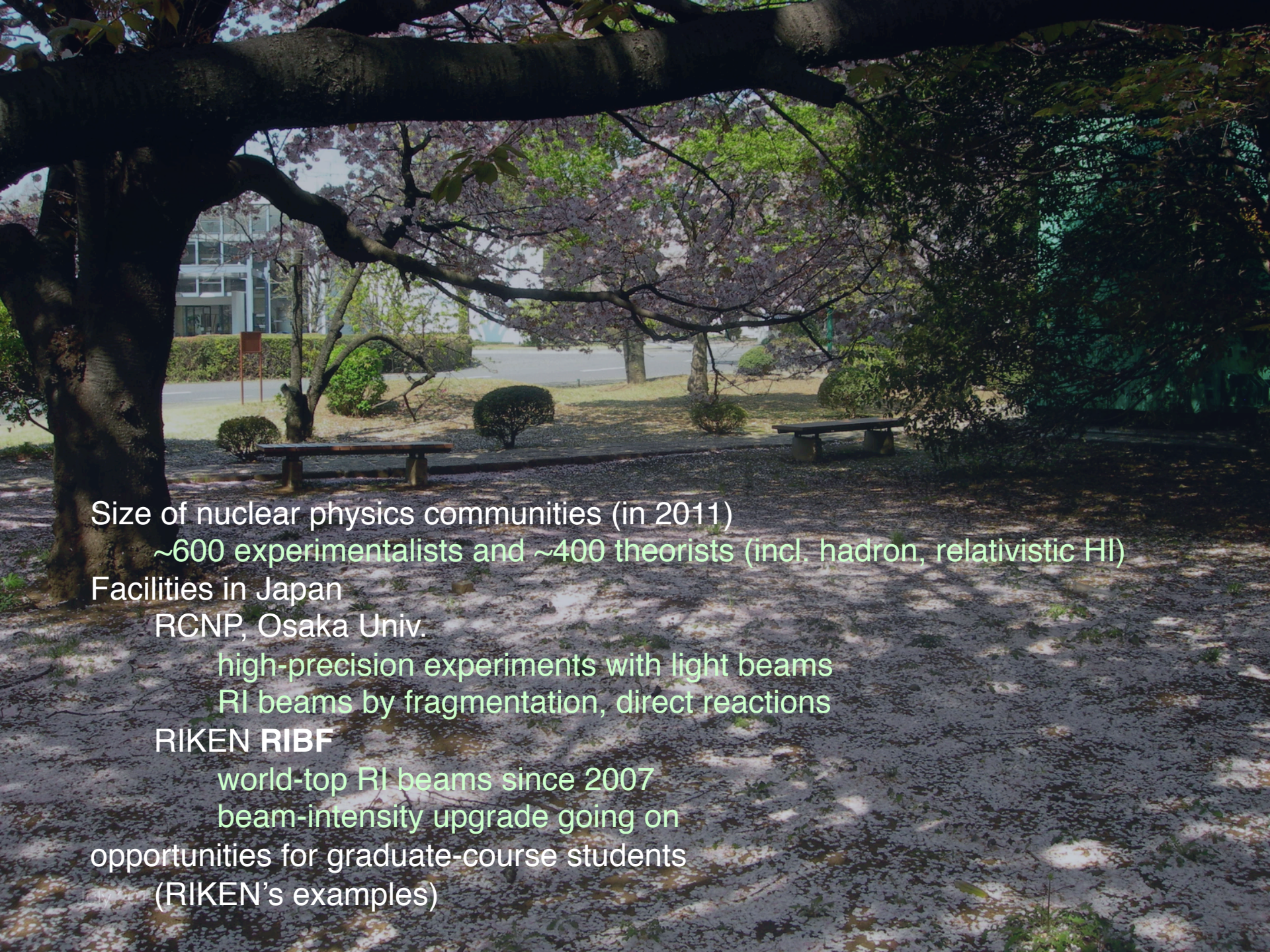
more details: **http://www.riken.jp/en/careers/programs/**

uesaka@riken.jp

motobaya@riken.jp

Note: many support programs for doctor course students



Size of nuclear physics communities (in 2011)

~600 experimentalists and ~400 theorists (incl. hadron, relativistic HI)

Facilities in Japan

RCNP, Osaka Univ.

high-precision experiments with light beams

RI beams by fragmentation, direct reactions

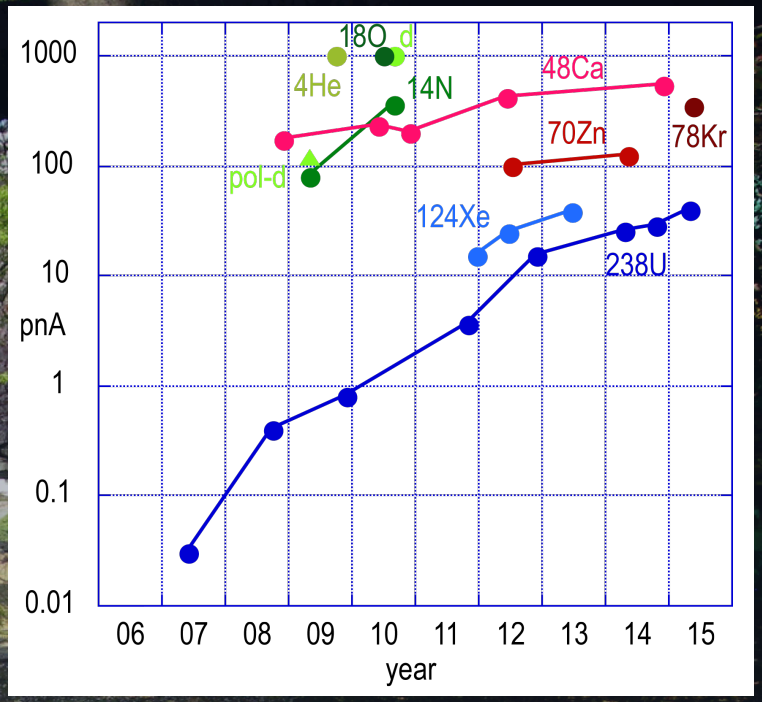
RIKEN **RIBF**

world-top RI beams since 2007

beam-intensity upgrade going on

opportunities for graduate-course students

(RIKEN's examples)



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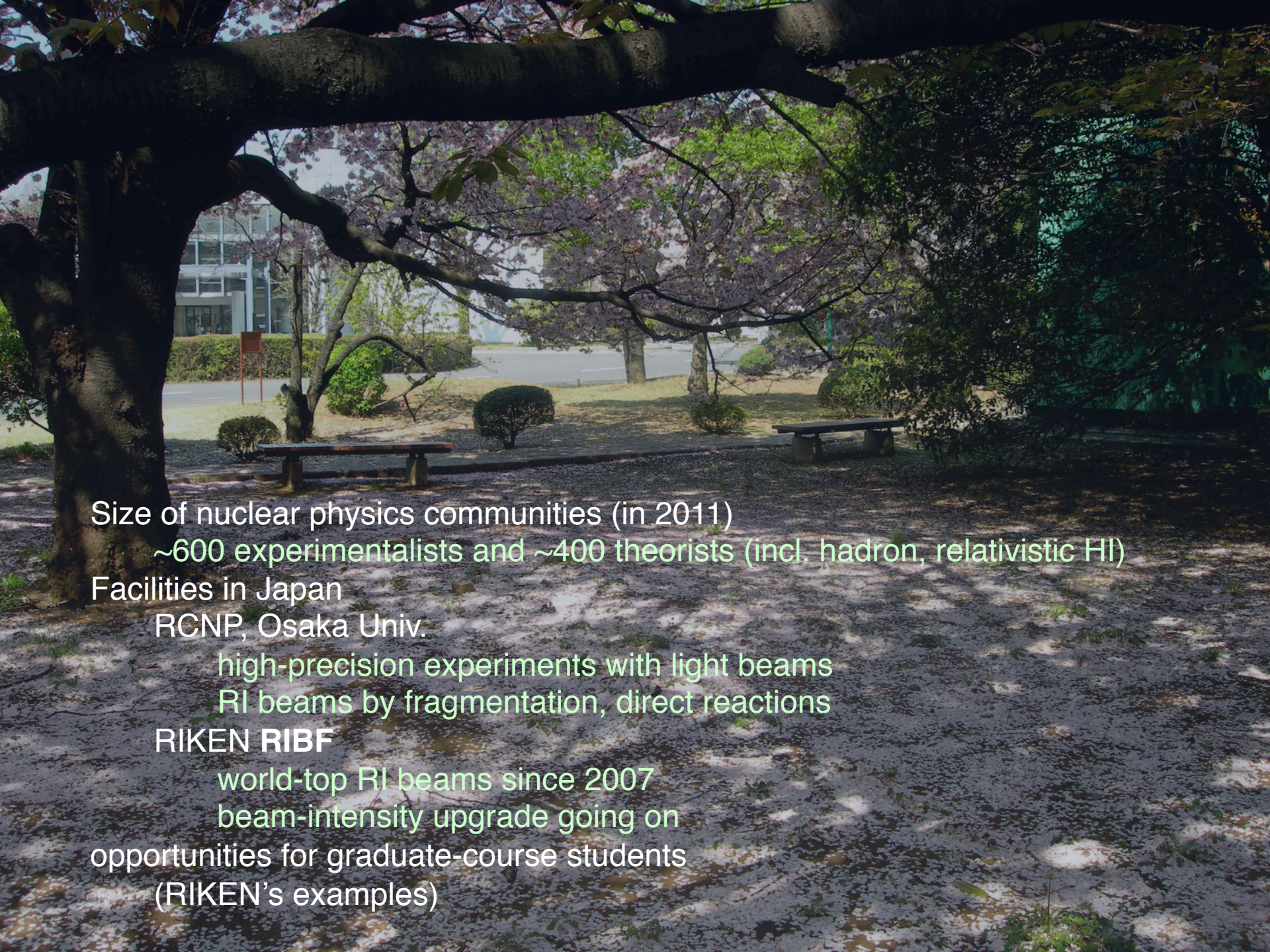

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