Industrial Application of Radioactive Ion Beam at RIKEN RI Beam Factory

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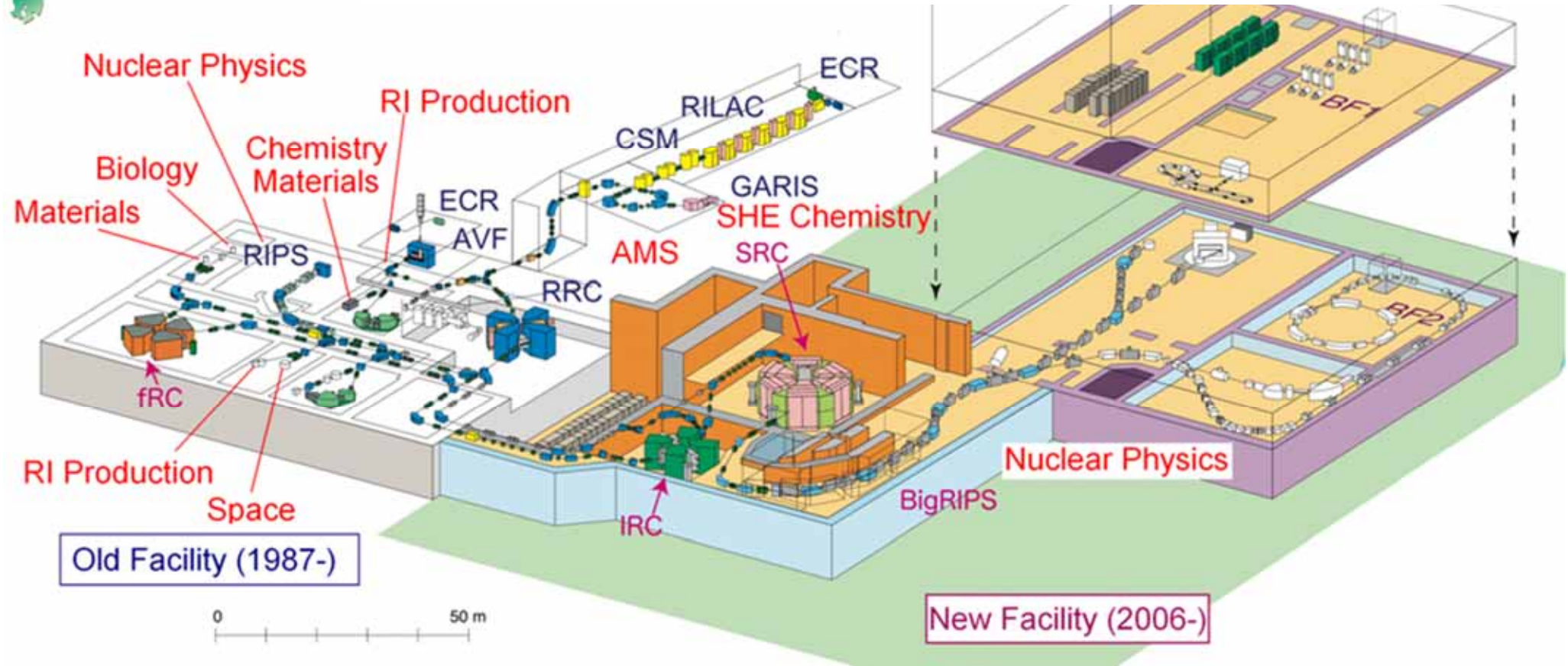
Outline

- Overview of RI Beam Factory (RIBF) at RIKEN NIshina Center (RNC)
- Framework of Industrial Use of RIBF
- Wear Diagnostics as an Example of Industrial Use of RI Beam

Overview of RI-Beam Factory (RIBF)

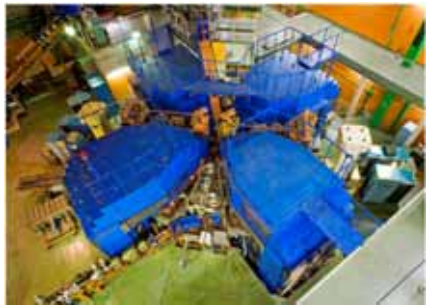
Accelerator complex at RNC for high-energy and high-intensity heavy-ion beams.
Beams of various radioactive nuclides (RI beams) are available.
One of the most advanced facility for nuclear physics in the world.



Ion Source

AVF

RI Production, Chemistry, Materials, Nuclear Physics



Ion Source

RILAC

FCRFQ

RRC

RI Beam (RIPS) Nuclear Physics

SHE Chemistry

AMS

Biology, RI Production, Materials Irradiation

Old Facility (1987-)

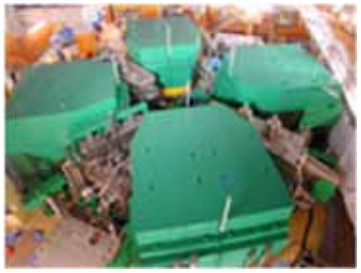
New Facility (2006-)

IRC

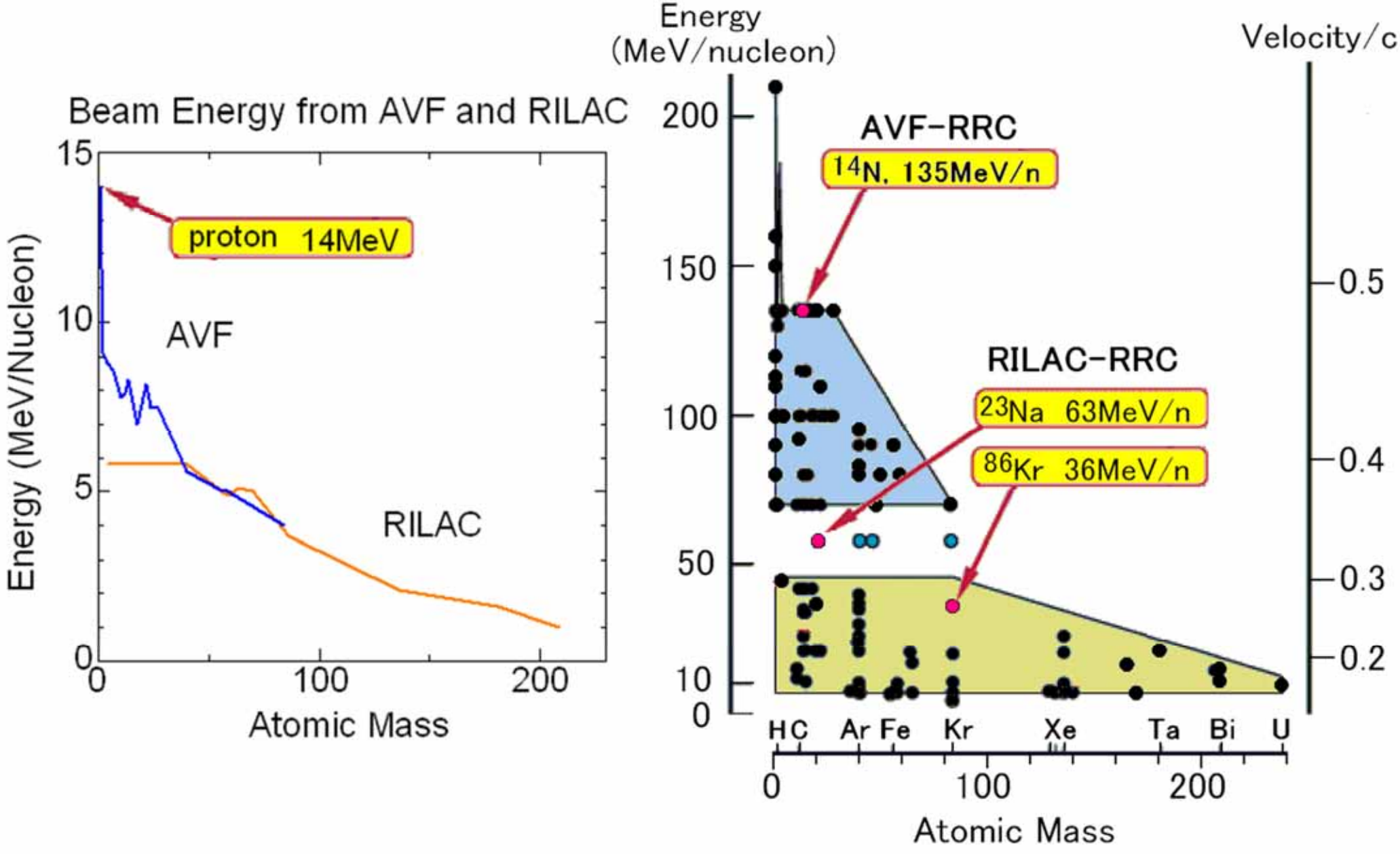
SRC

RI Beam (Big RIPS) Nuclear Physics

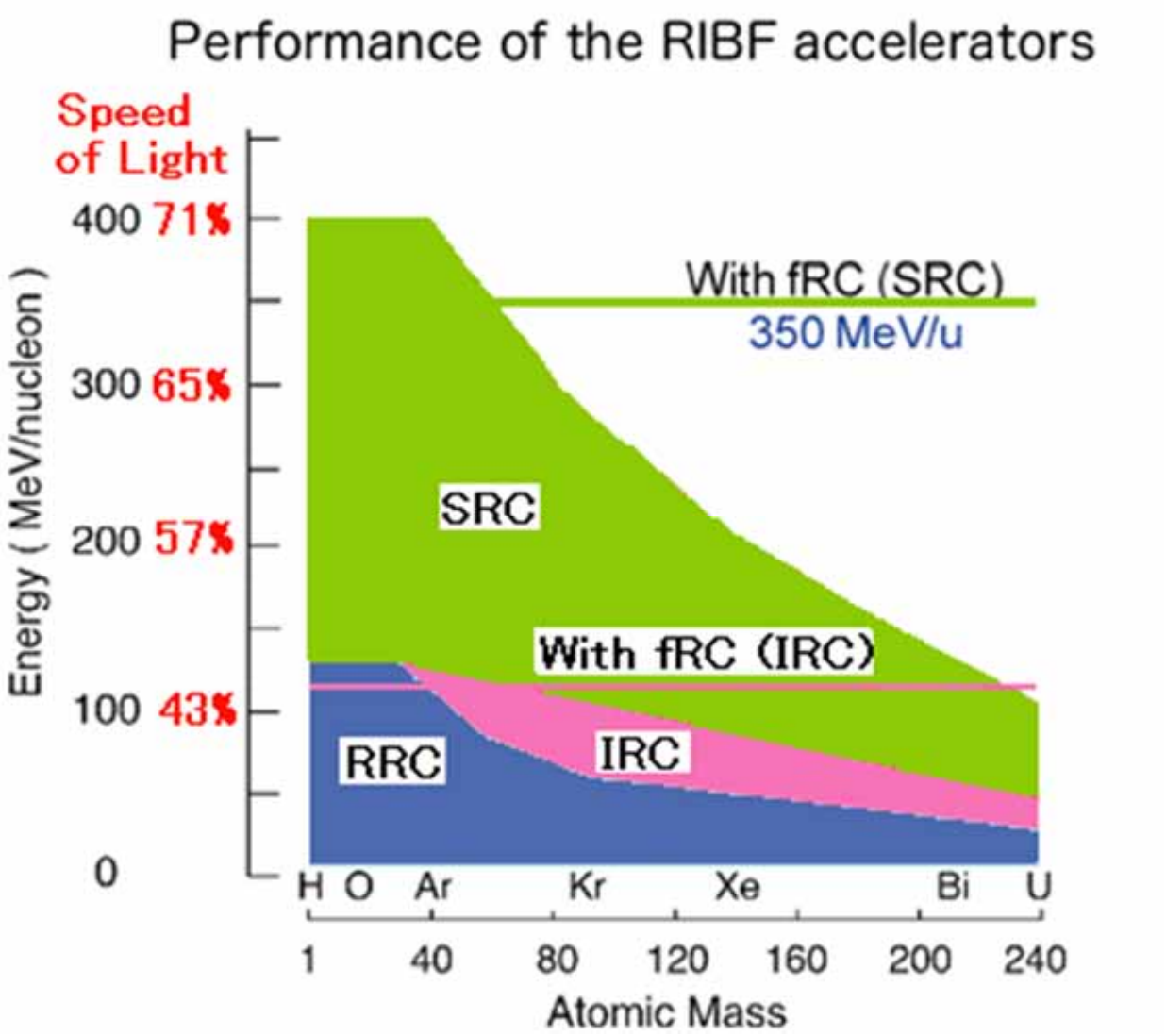
fRC



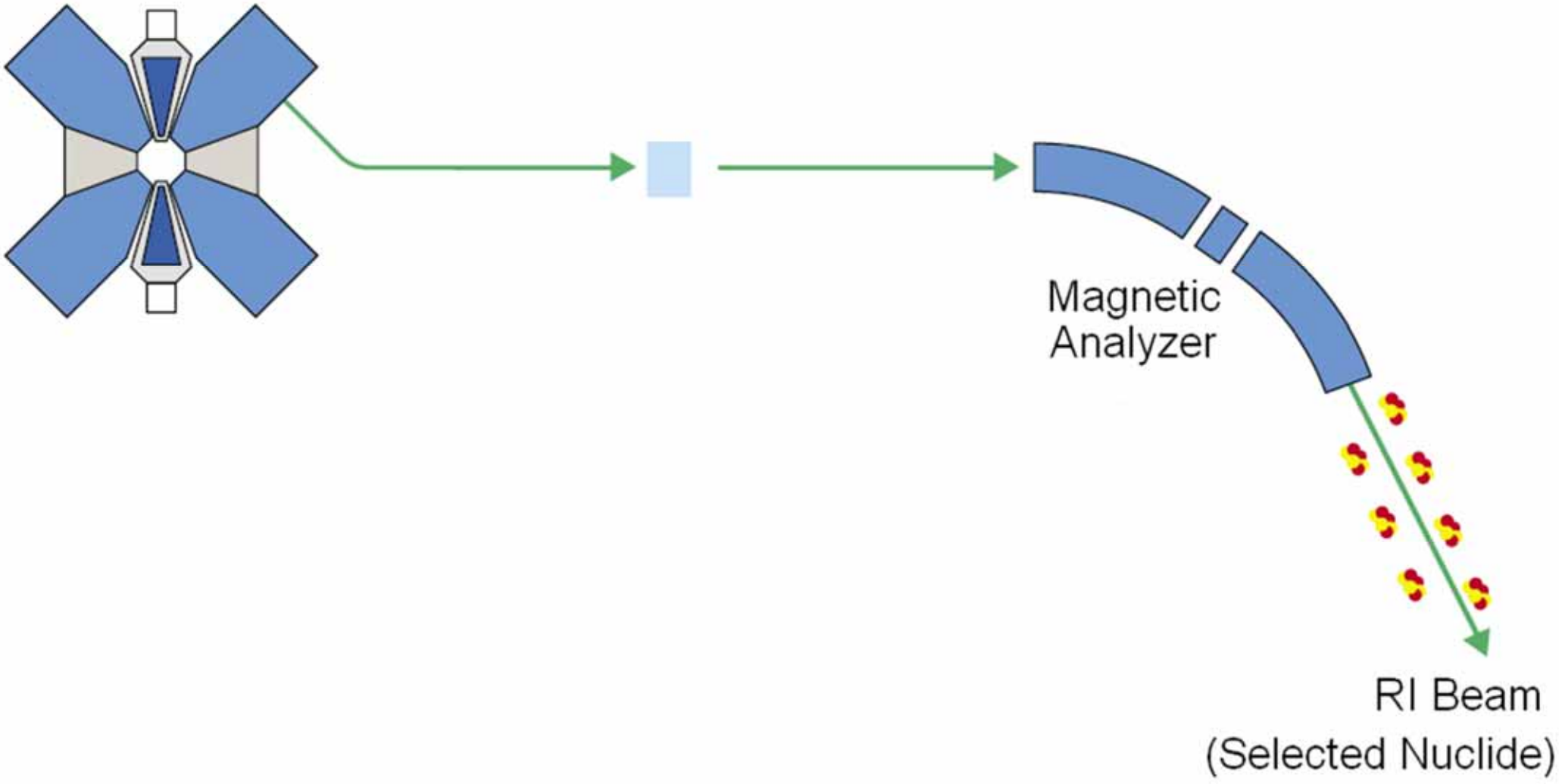
Beam Energy from Old Accelerators



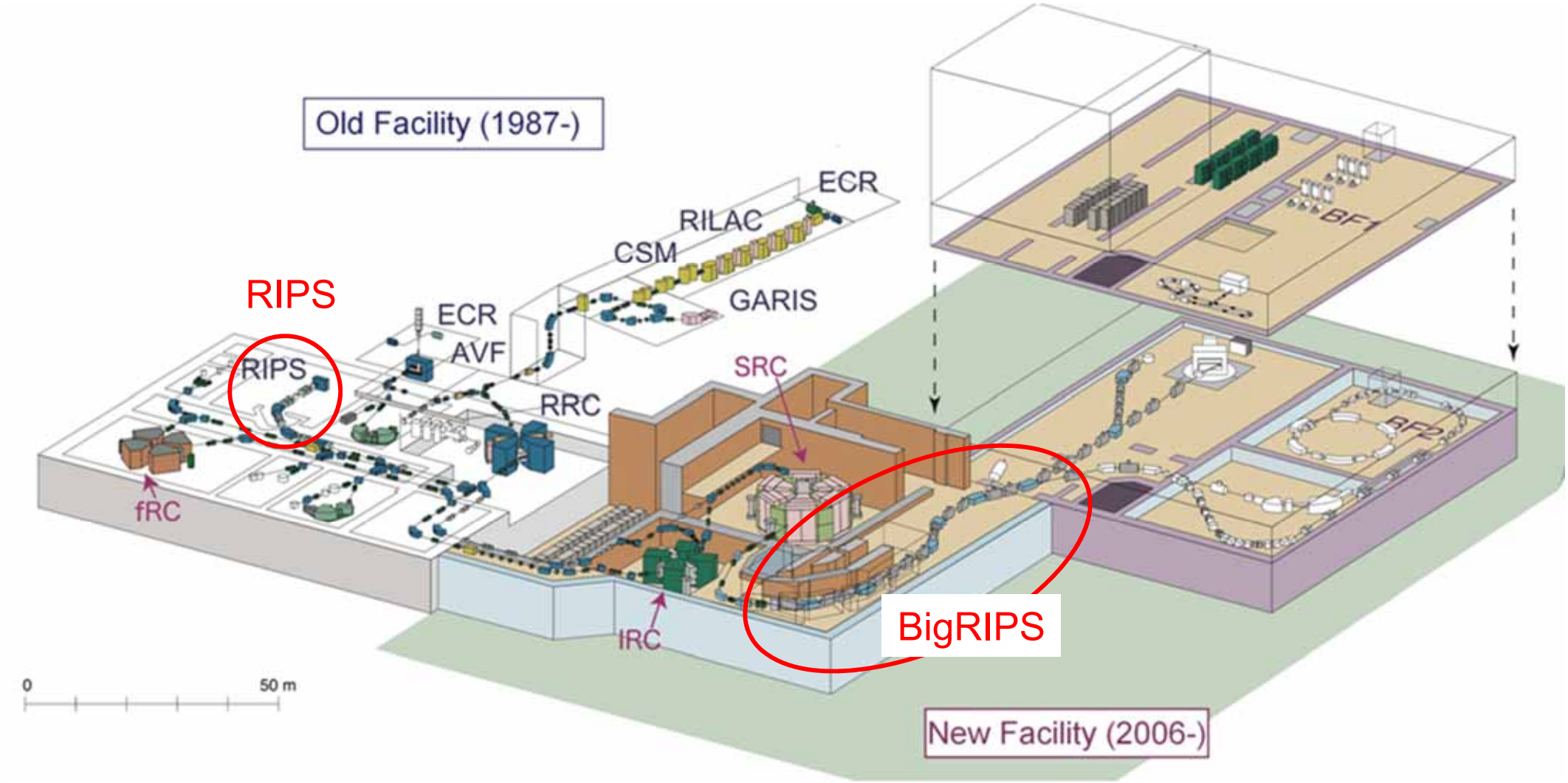
Beam Energy from New Cyclotrons



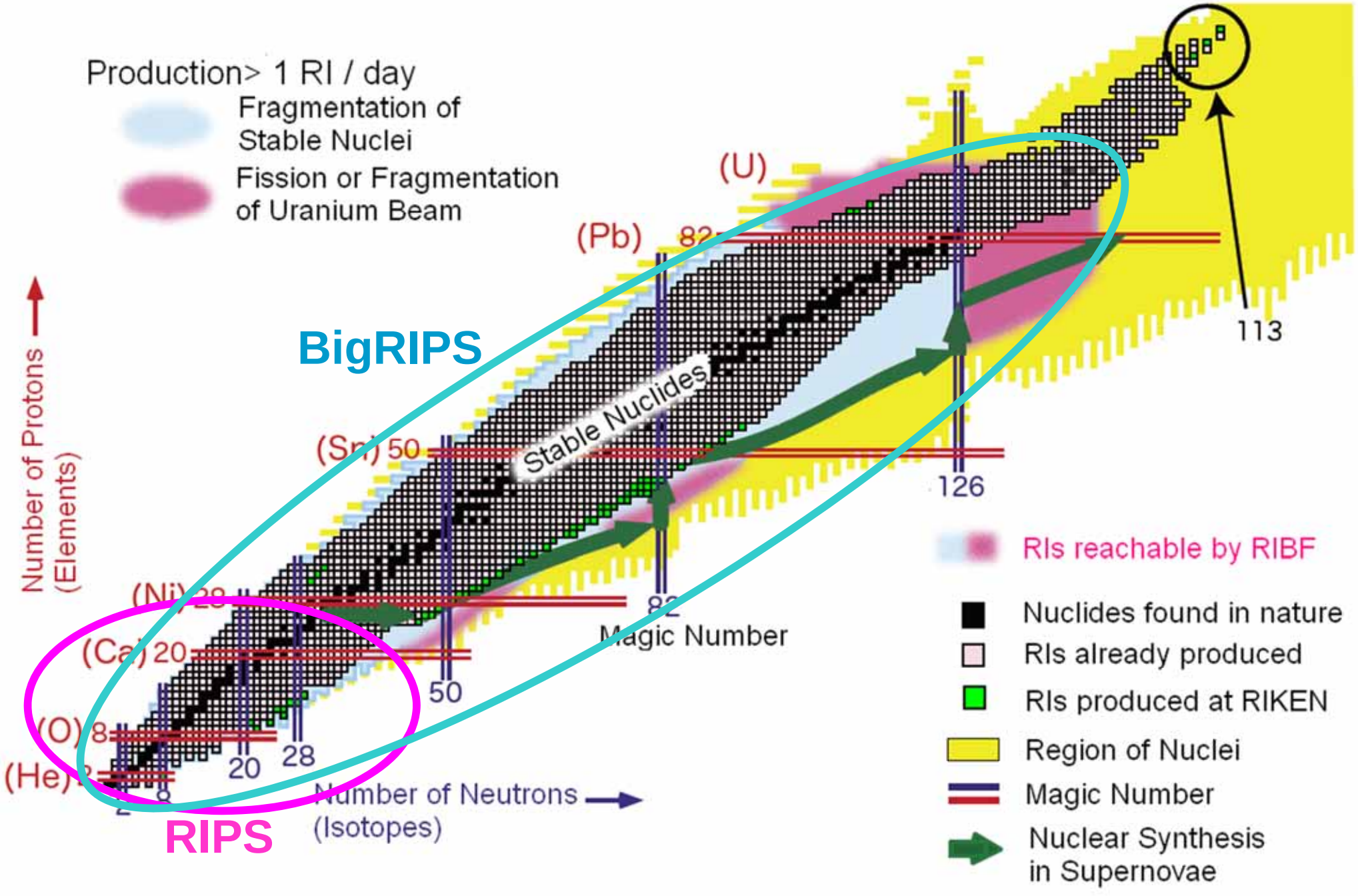
RI Beam Production with In-Flight Separator



In-Flight RI Separators at RIBF



RI Beam Nuclides Produced at RIBF

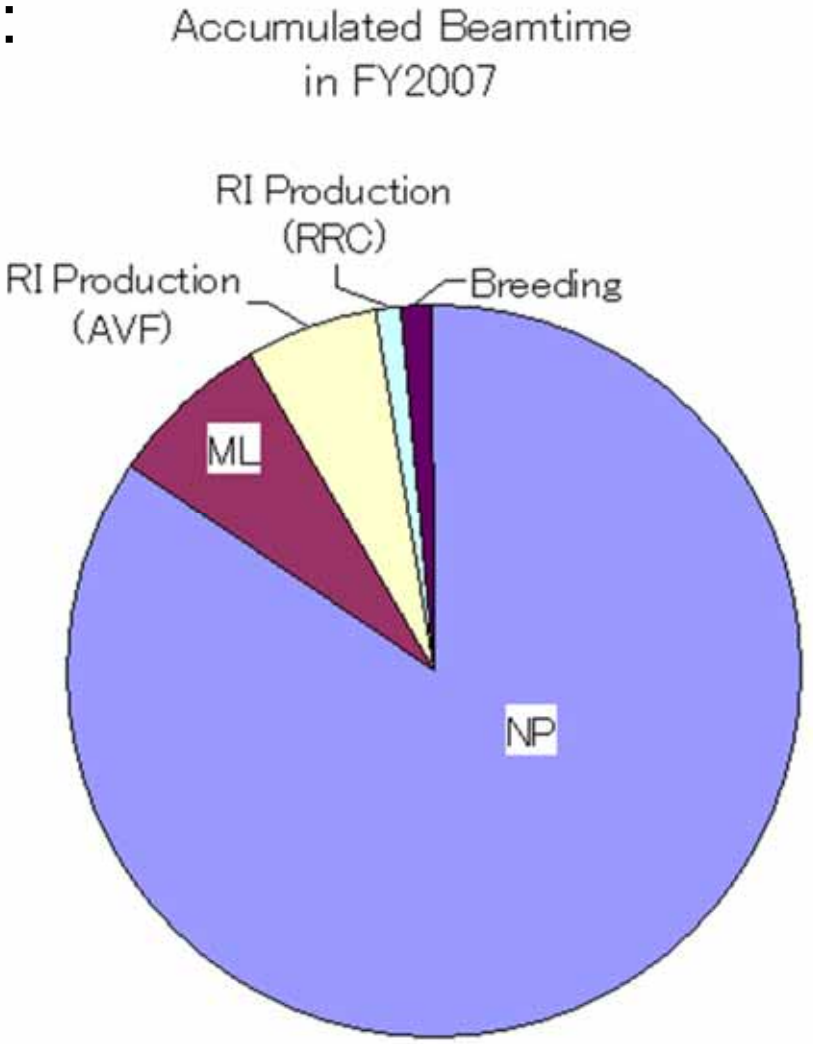


Categories of Experiments at RIBF

1. Academic Proposals approved by
   Program Advisory Committee (PAC):
   NP-PAC for Nuclear Physics
   ML-PAC for Material and Life
   Results are opened to public.

2. Projects of RNC, application of
   outcome of research
   a) Production of Radioisotopes
   b) Mutation Breeding of Plants

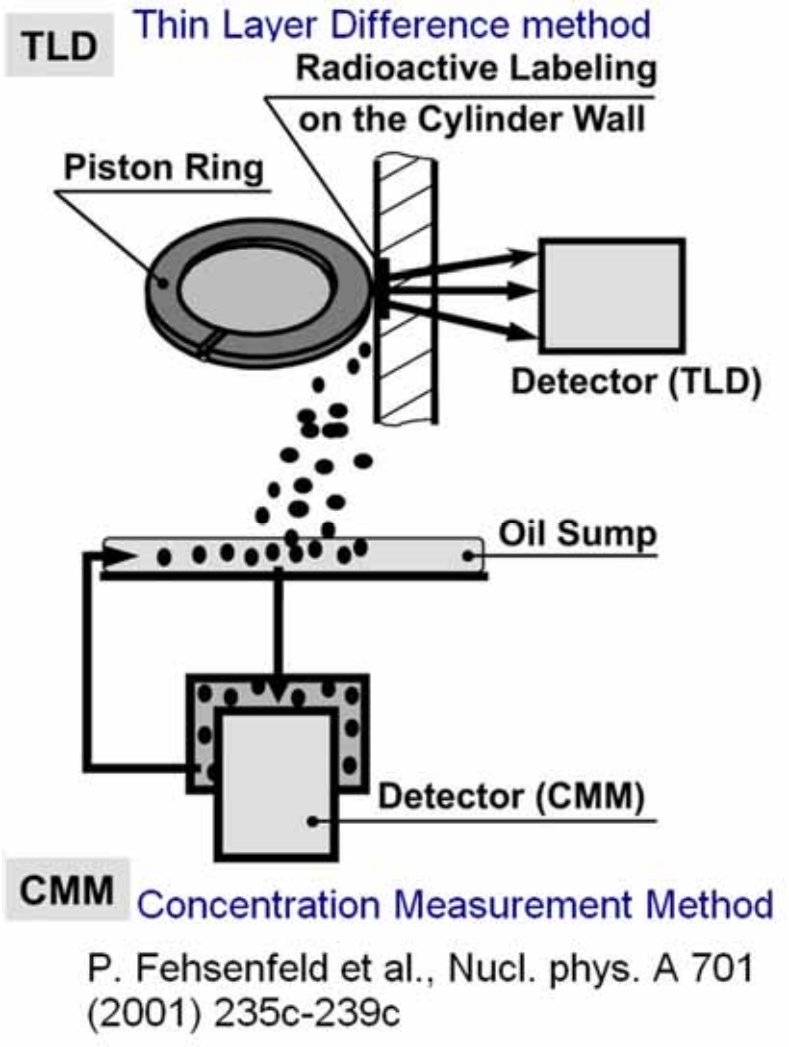
3. Industrial use (since 2009):



Industrial Applications of RIBF

- RIBF's old facility (AVF, RILAC, RRC and their beam lines; >20 years of operation) is opened to non-academic users including private companies in Japan.
- Users pay RIKEN for beam time (2 free trial uses).
- Users hold results and intellectual properties.
- A new “Industrial PAC” was established in Dec. 2009.
- Industrial PAC has met twice, reviewed 6 proposals and approved 5.
- 4 of them have been executed.
- This project started as Ministry of Education grant project in Nov. 2009-Sep. 2010.

Wear Diagnostics of Machine Parts with Radioactive Tracers



P. Fehsenfeld et al., Nucl. phys. A 701 (2001) 235c-239c

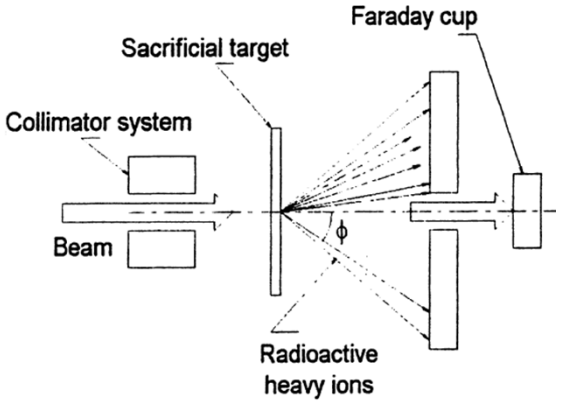
Production of Tracer Radioisotopes:

(1) Activation of sample material nuclei by ion beam irradiation

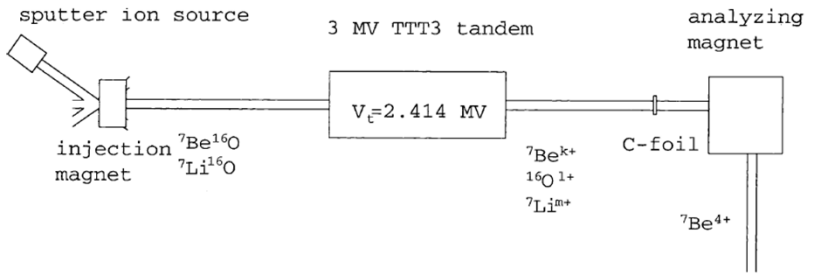
(2) Implantation of RI from outside

(2-1) Recoil nuclei from target

(2-2) Acceleration of RI from ion source

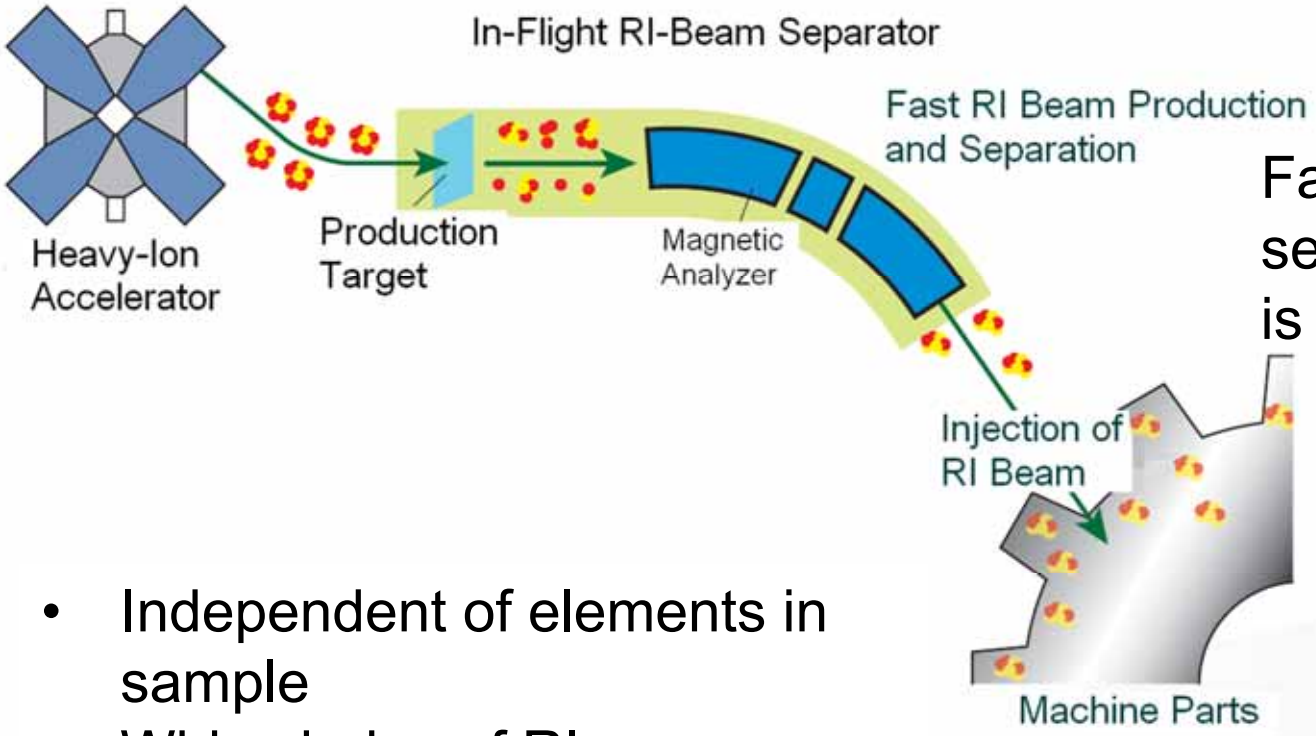


T. Sauvage et al., Nucl. Instr. and Meth. B143 (1998) 397-402.



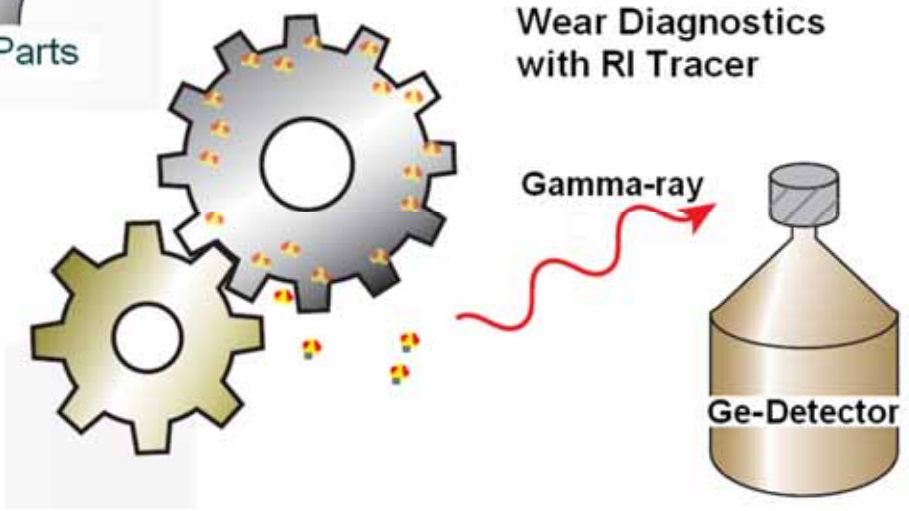
L. Gialanella et al., Nucl. Instr. & Meth. Phys. Res. B 197 (2002) 150-154.

Wear diagnostics using Separated RI-Beam



Fast RI beam produced and separated at in-flight separator is implanted in samples.

- Independent of elements in sample
- Wide choice of RI
- High purity of RI
- Depth profile controllable
- Non-destructive and small damage
- Samples are in atmosphere



Feasibility Study

(Trial Use proposed by SHI Examination & Inspection, Ltd.)

Beam time: 60h x 2

Feb. 2010 & Jan. 2011

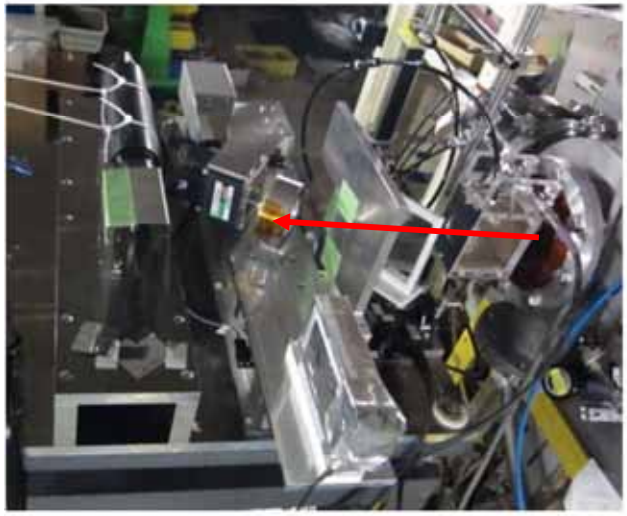
Facility: RILAC+RRC+RIPS

Primary Beam:

Na-23, 63MeV/u, 1pμA

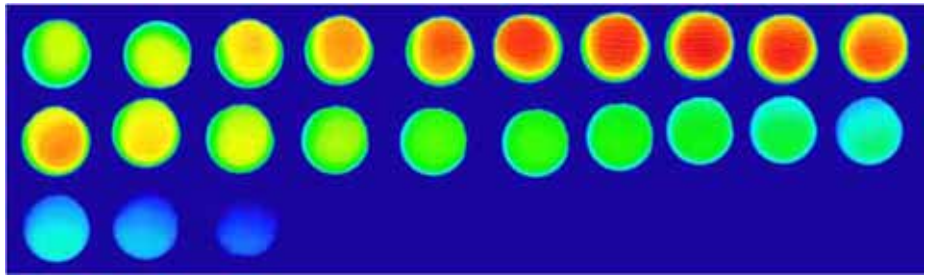
Secondary Beam:

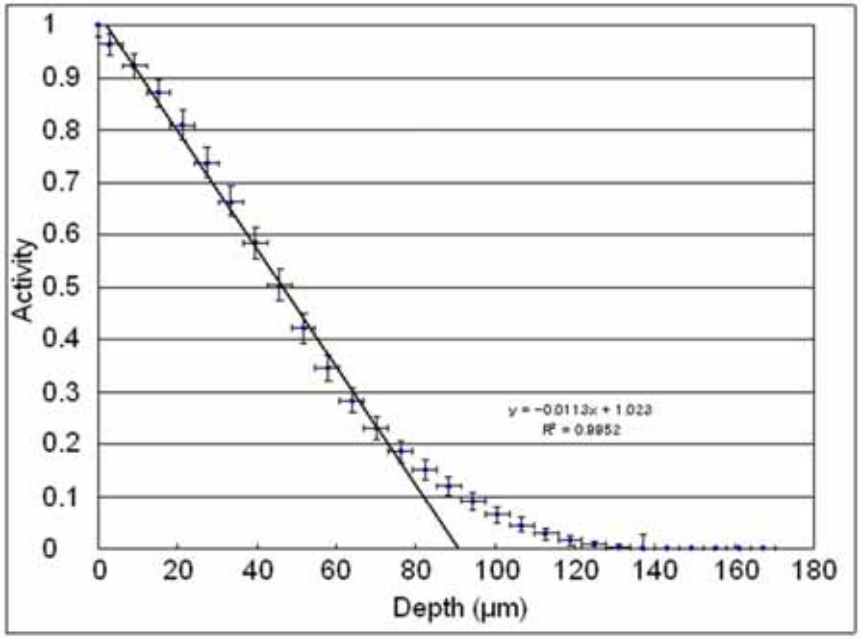
Na-22 (2.6y), 2×10^8/s



Results (Preliminary)

Stack of 6 μm-thick Al foils





Dose distribution is well uniform within 20mmφ
Dose-Depth profile is linear down to 80mm deep.

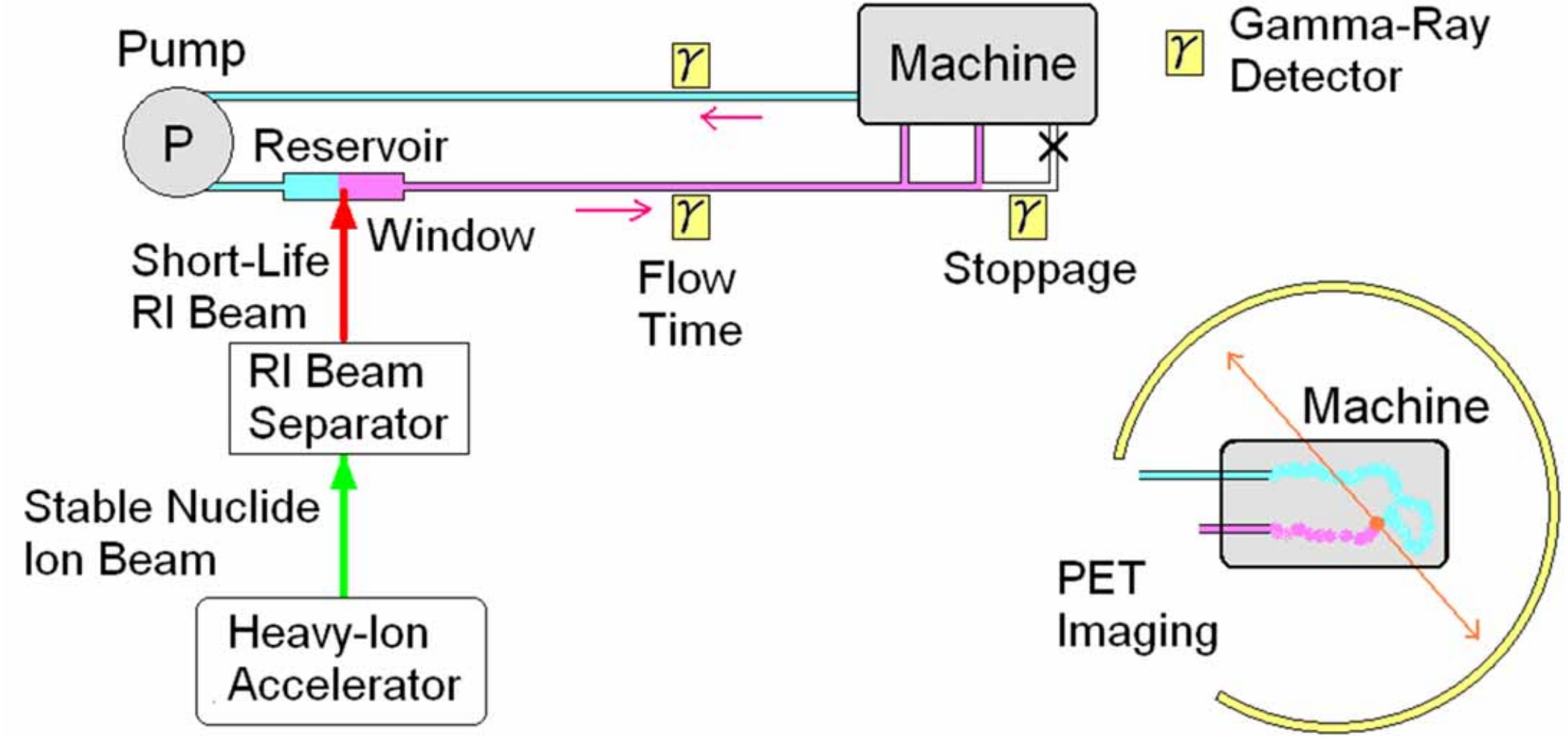
172 kBq of Na-22 was implanted in another sample in 26 hours.
⇒ This method seems promising.

Summary

- The RIBF provides high-energy heavy-ion beams and RI beams to various research fields.
- Industrial use of the RIBF has been started.
- Wear diagnostics with implanted tracers has been proposed and tried as an industrial application of RI beam.
- The results look promising, and the company is scrutinizing the commercial possibility/

Future Possibility of RI Beam Application

Use of short-life RI beam for real-time test of machines :
Monitoring fluids (lubricants, coolants, air etc) in running machine with RI implanted through a window.



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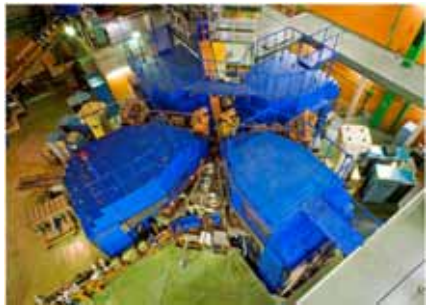

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