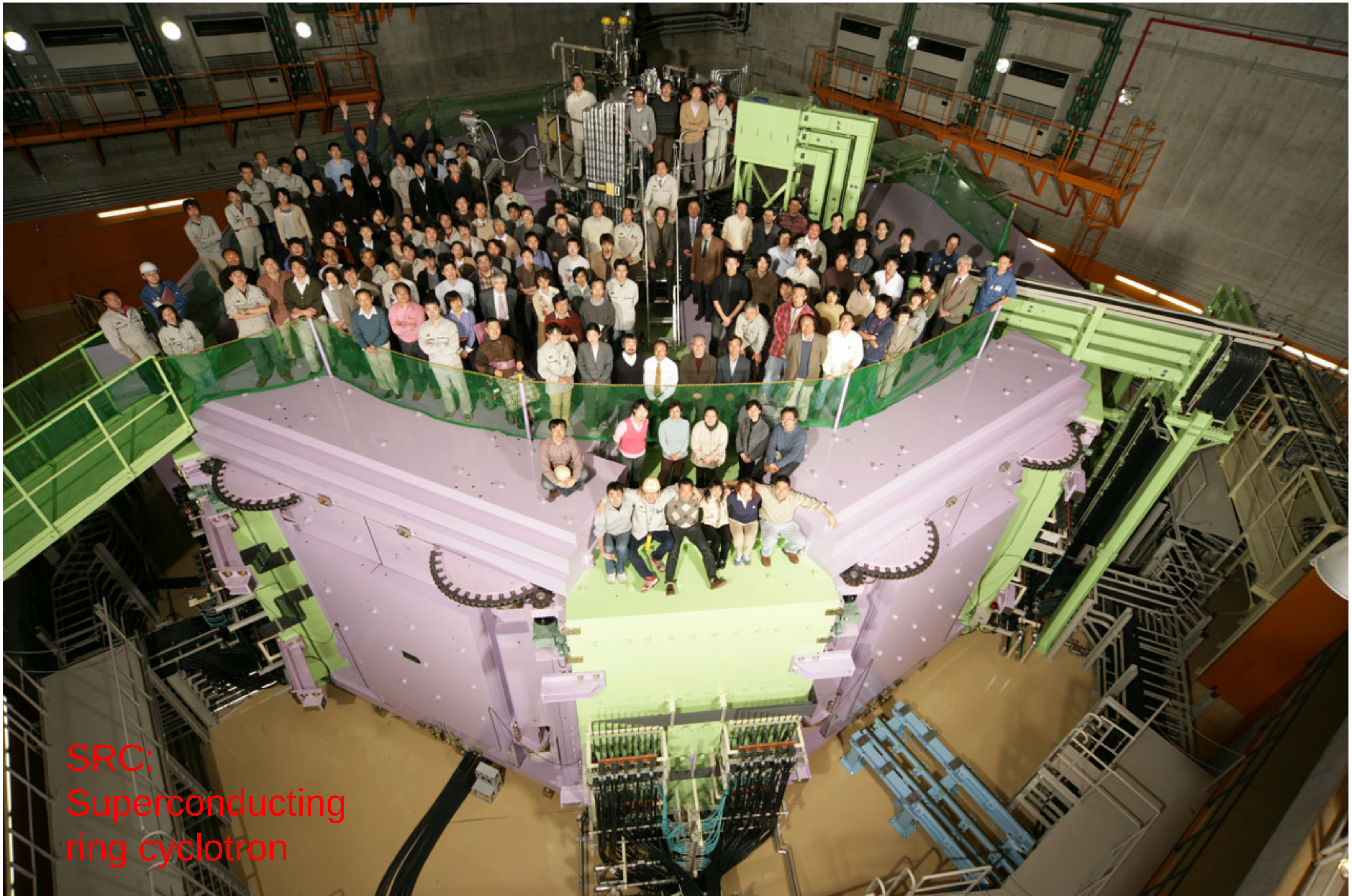
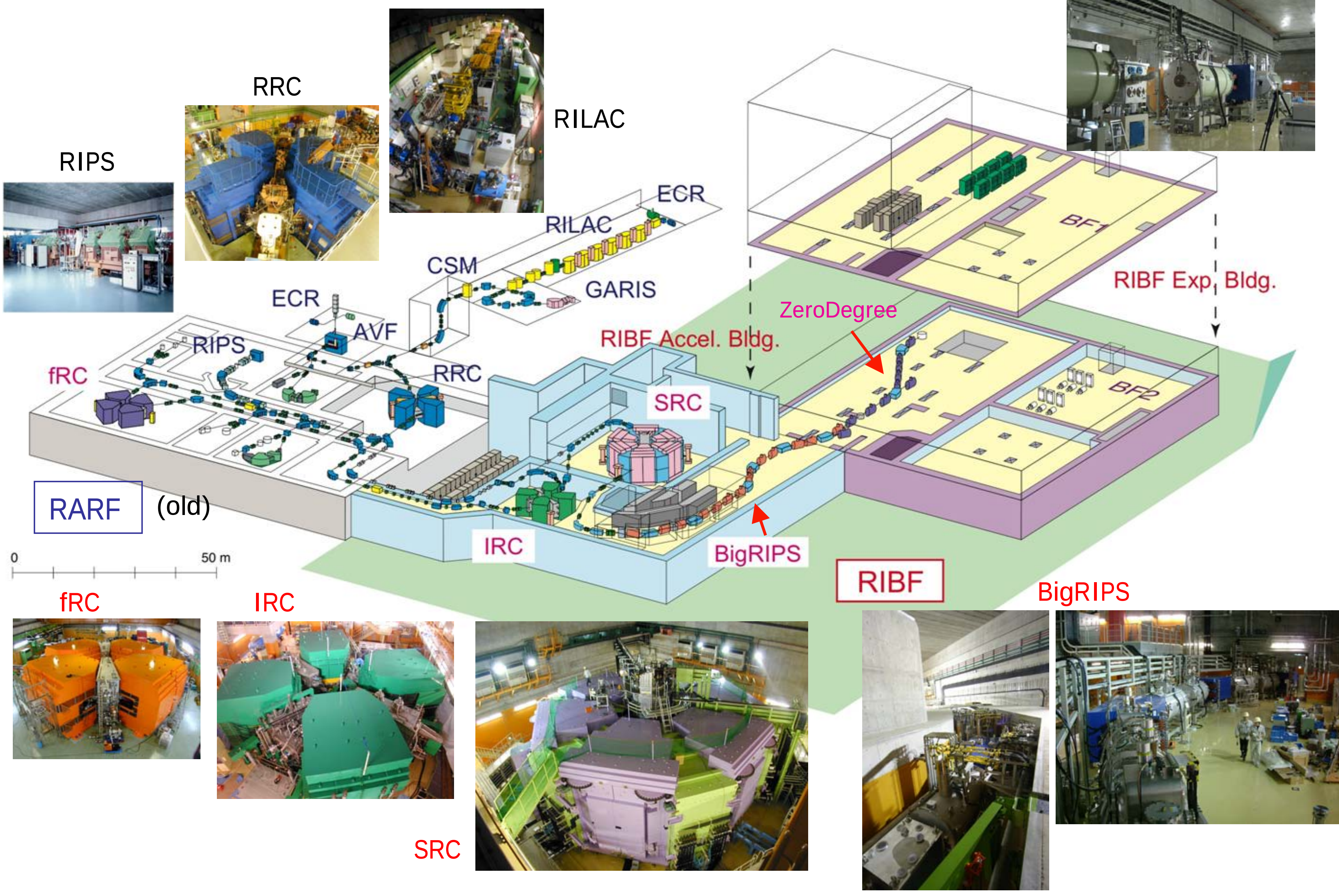
Overview of the accelerators at RI beam factory (RIBF)

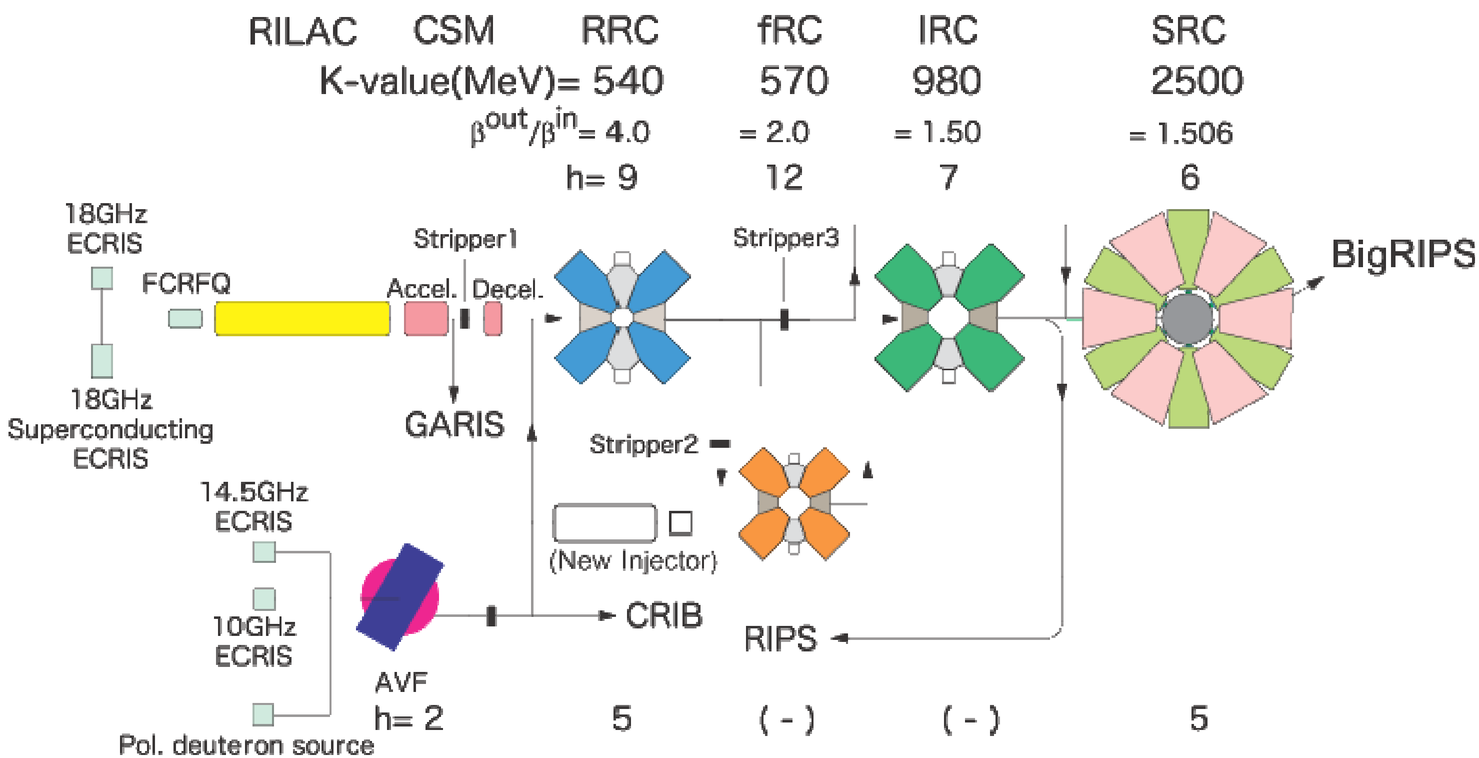
Overview of the RIBF accelerators



Layout of RIKEN RI beam factory (RIBF) in 2007



Configuration of the RIBF accelerator complex

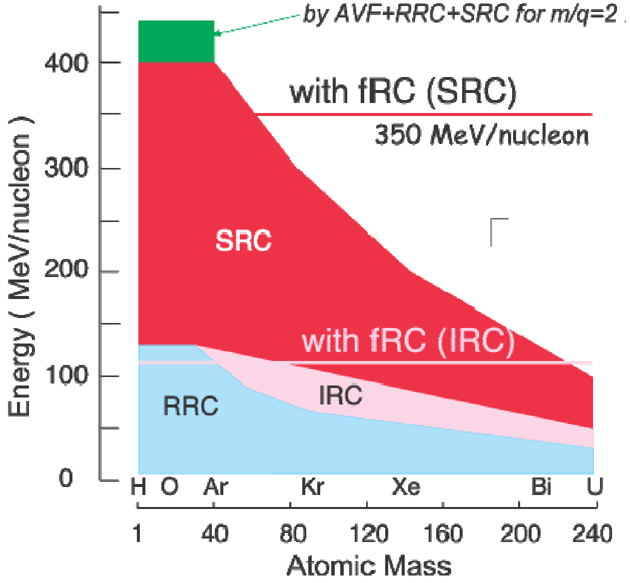


At RIBF, heavy ion beams are accelerated by a cascade operation of a linac and four ring cyclotrons: RRC, fRC IRC and SRC cyclotrons. There are different modes in the cascade operation.

Goal performance of RIBF cyclotrons

- Max. energy= 345 MeV/u up to U ions
  400 MeV/u for light A ions
- Intensity= 1 pμA up to U ions ($6x10^{12}$ par./sec)

  -> provide us with a very unique opportunity to produce RI beams based on the in-flight scheme.
  -> Production reaction: in-flight fission of U beams as well as projectile fragmentation
- Max. beam power= 82 kW (^{238}U at 345MeV/u)

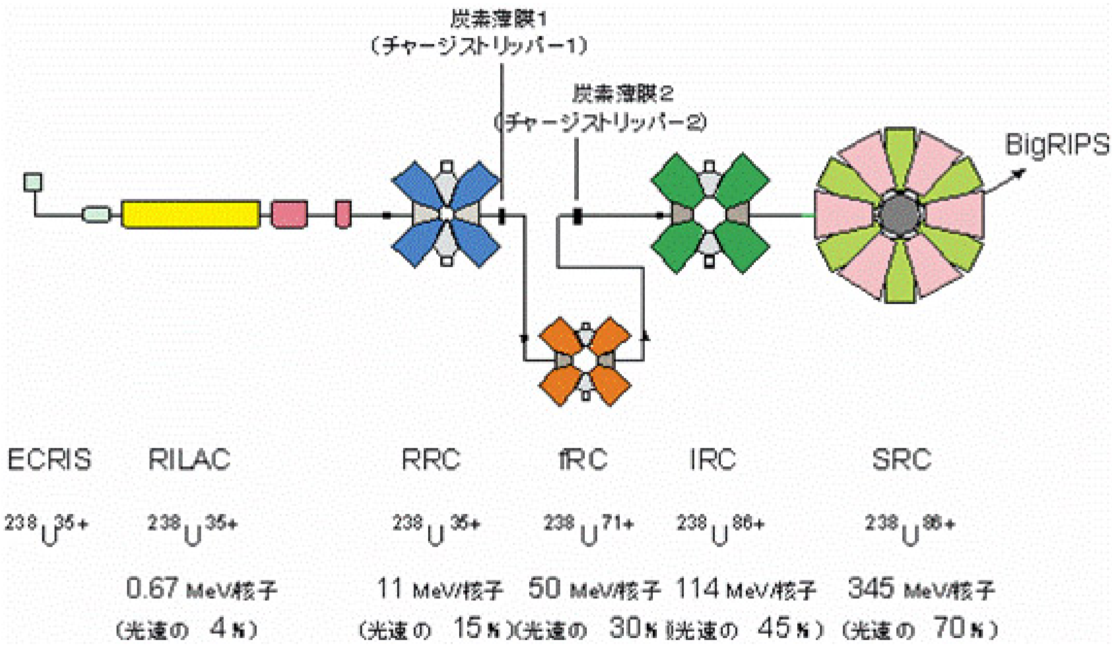


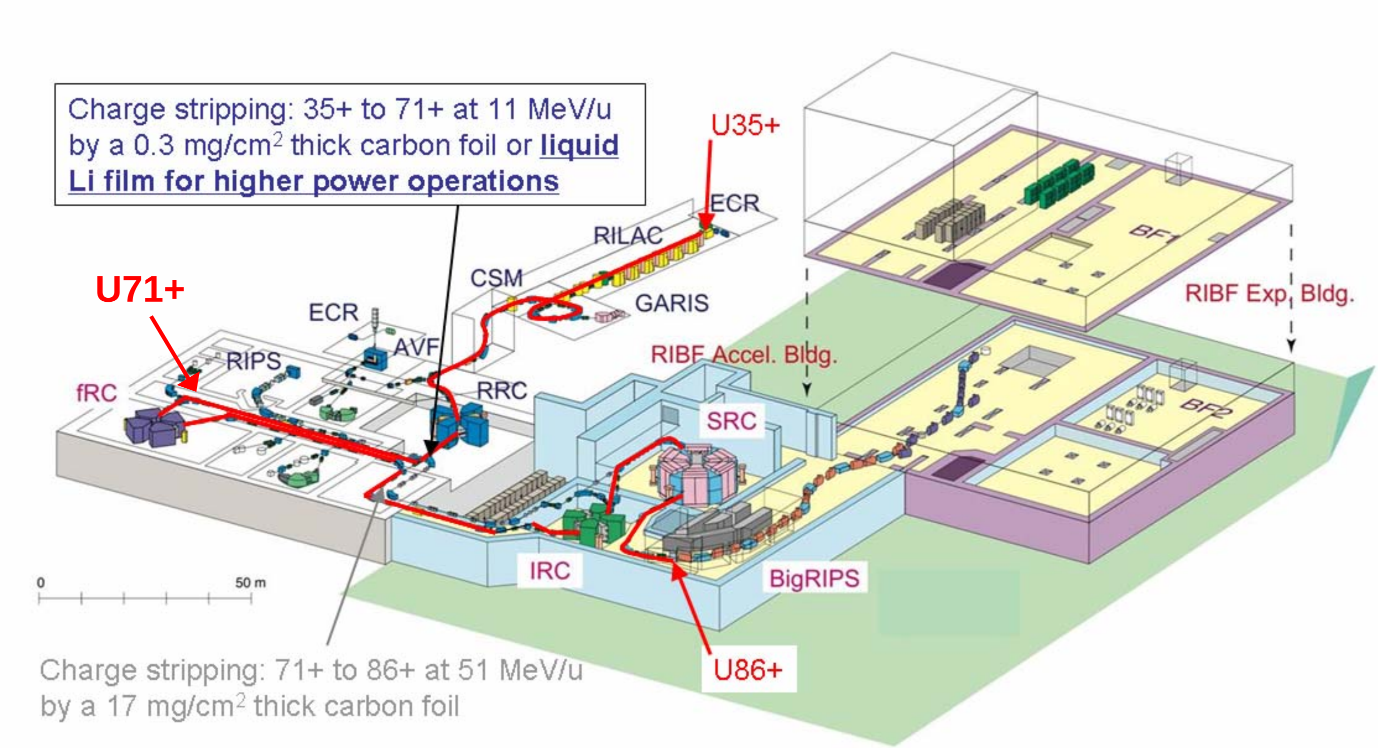
Max. energy achieved!
But intensities much lower the goal!
(5 orders of magnitude for U beams.)

Recent RIBF commissioning

Dec. 28th, 2006 First beam $^{27}Al^{10+}$ 345 MeV/u
March, 2007
12th First $^{86}Kr^{31+}$ beam at 345 MeV/u several pnA.
23rd First $^{238}U^{86+}$ beam at 345 MeV/u and 0.002 pnA
May 16th-June 3rd, 2007
^{238}U beam at 345 MeV/u and 0.02 pnA max (~$1x10^8$ pps)

Acceleration scheme of U beams at RIBF



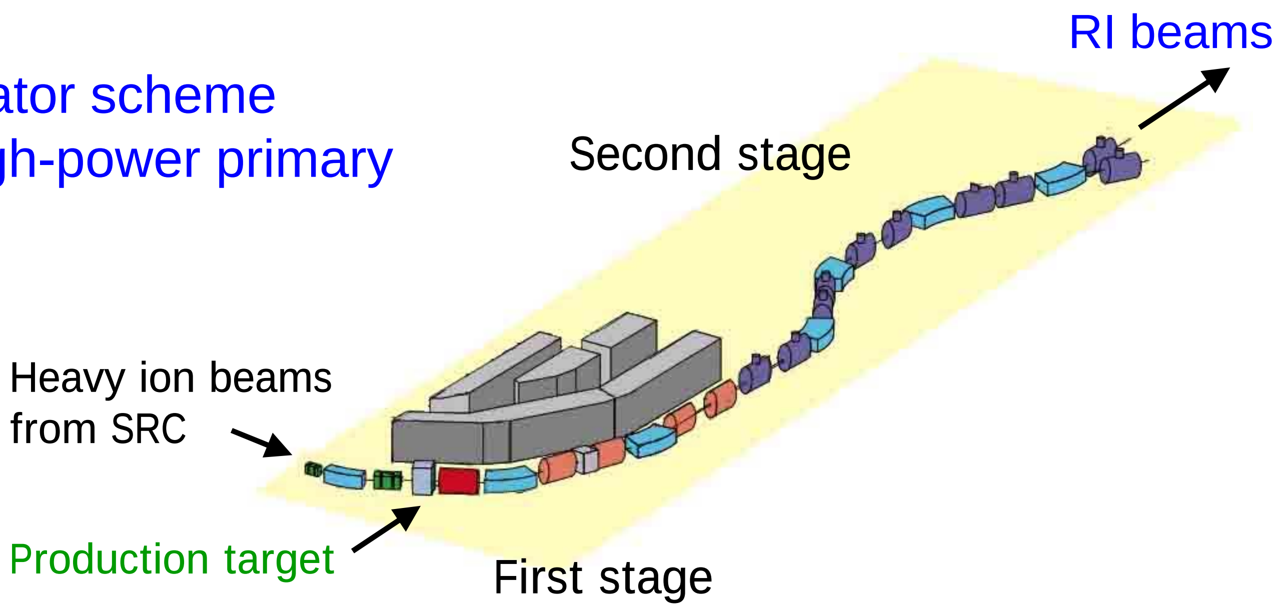


Overview of BigRIPS in-flight separator

Overview of BigRIPS in-flight separator

BigRIPS is one of the next generation in-flight separators which have upgraded features. Recently commissioned after 5-year construction period.

Major features of BigRIPS
1) Use of in-flight fission of U beams
2) Large acceptances
3) Superconducting
4) Two-stage separator scheme
5) High intensity, high-power primary beams

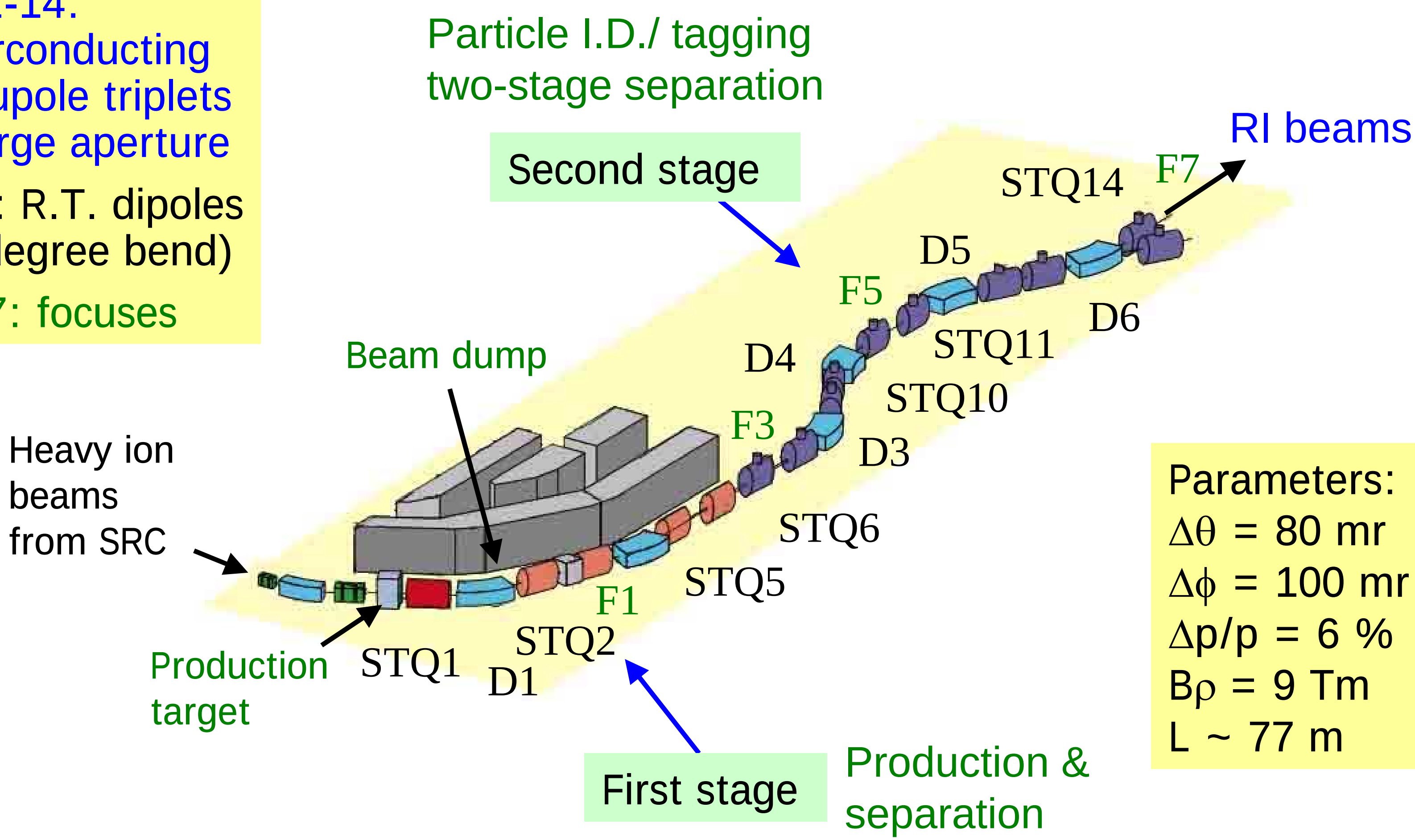


BigRIPS: a superconducting large-acceptance high-power two-stage in-flight RI-beam separator

STQ1-14: superconducting quarupole triplets w/ large aperture

D1-6: R.T. dipoles (30-degree bend)

F1-F7: focuses



Parameters:

$\Delta\theta$ = 80 mr

$\Delta\phi$ = 100 mr

$\Delta p/p$ = 6 %

$B\rho$ = 9 Tm

L ~ 77 m

BigRIPS acceptances vs. reaction kinematics of in-flight fission at 345 MeV/u

BigRIPS acceptances
$\Delta\theta$ = 80 mr
$\Delta\phi$ = 100 mr
$\Delta p/p$ = 6 %

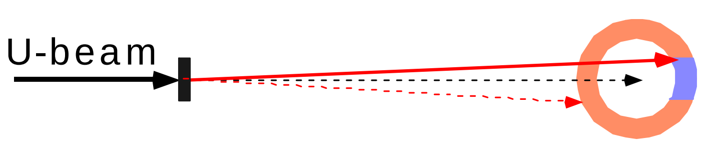
→ Comparable to the spreads of fission fragments

The large acceptances of BigRIPS allows us to produce RI beams very efficiently by using in-flight fission of U beam.

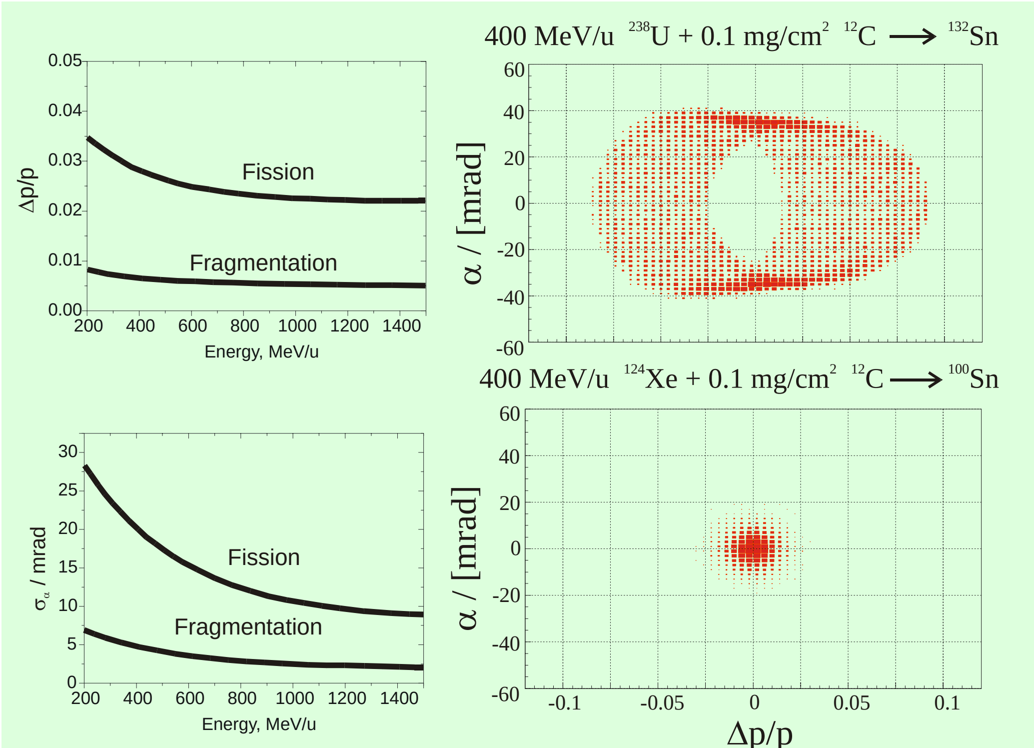
BigRIPS were designed for the in-flight fission at our energies.

Kinematics of in-flight fission of U beam at 345 MeV/u

Large spreads: ~100 mr,~10 %

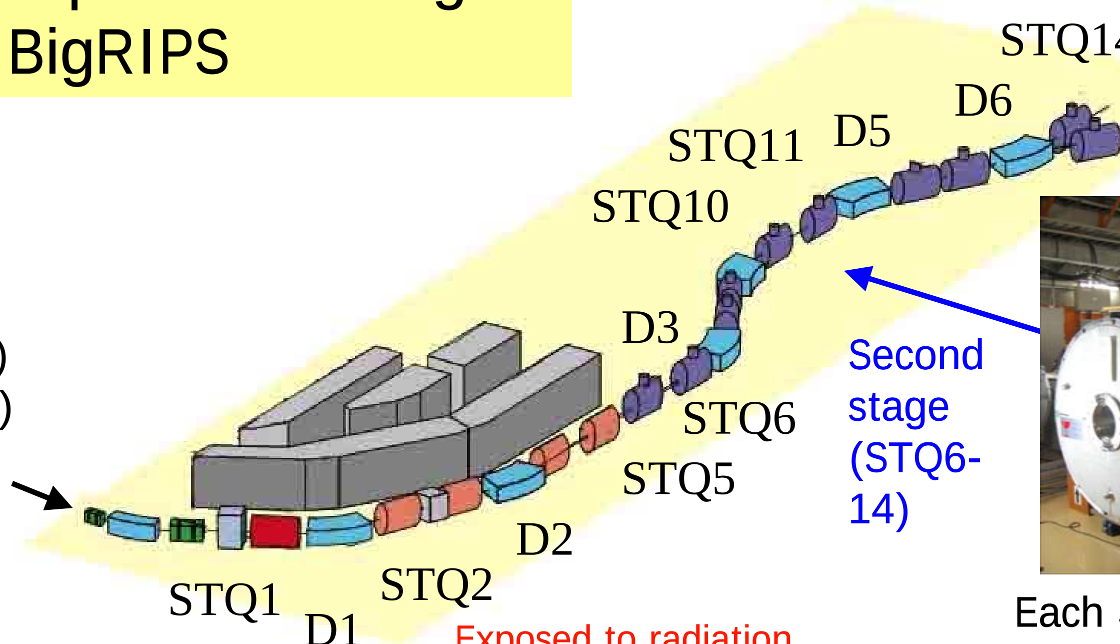


In-flight fission



Large-aperture superconducting quadrupoles @ BigRIPS

STQ features:
> Bore radius= 12 cm
> Two different cryogenic schemes
A large plant (1st stage)
Cryo-coolers (2nd stage)



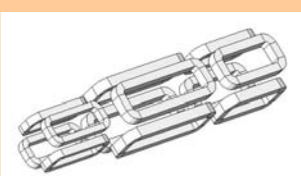
Second stage (STQ6-14)

Each STQ cooled by a stand-alone cryo-cooler system ~2.5 W/STQ

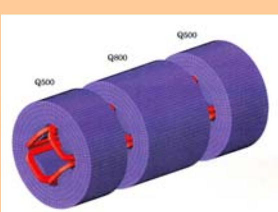
Exposed to radiation heat loads

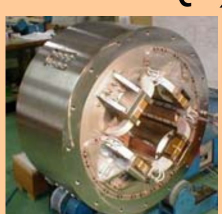
First stage (STQ1-5)

Air-core (STQ1)



Superferric (rest of STQs)



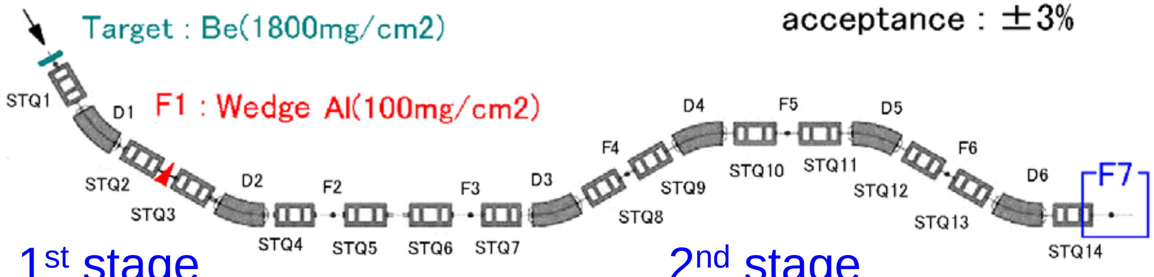


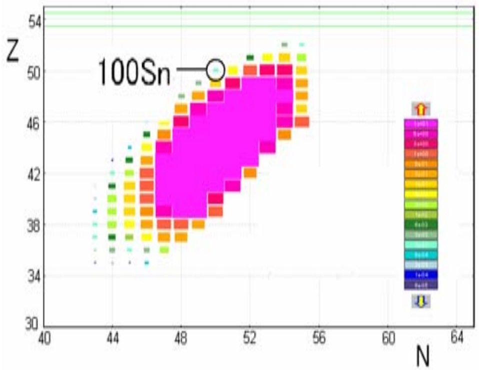
Cooled by single cryogenic plant (Linde TCF50S) through a transfer line. ~ 510 W (extra ~300 W)

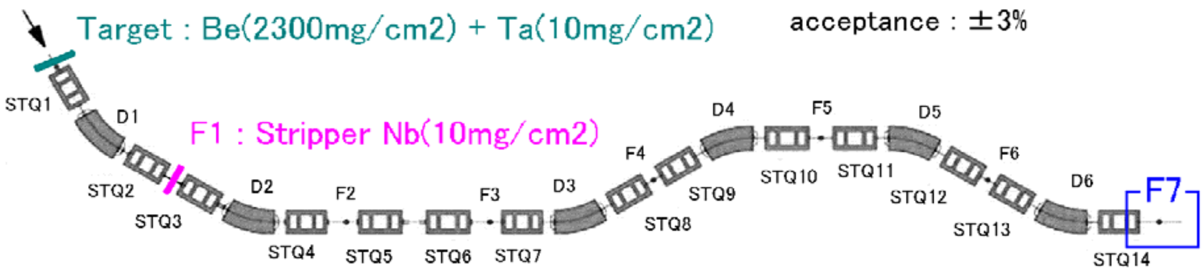
Two-stage separation (stripper + wedge) @ BigRIPS

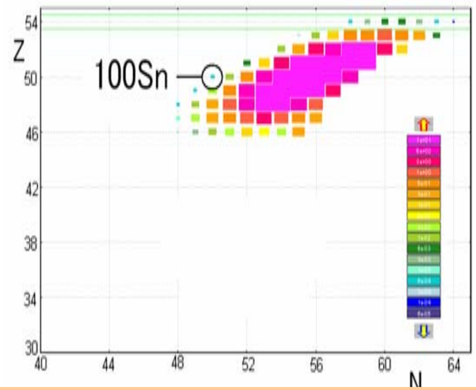
LISE++ simulation: ^{124}Xe(54+) 350MeV/u → ^{100}Sn

H. Kimura et. al

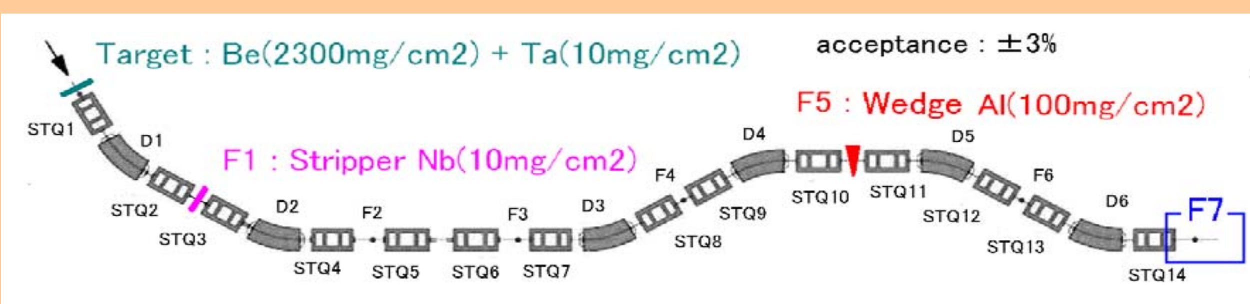


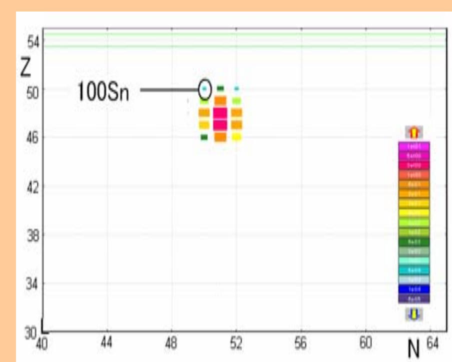






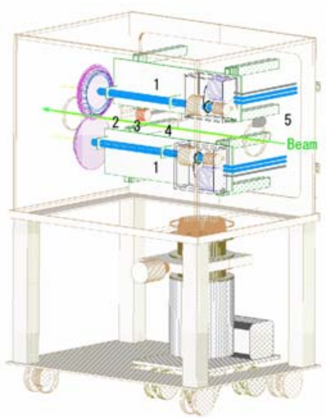
Two-stage separation with stripper (1st stage) and degrader (2nd stage)

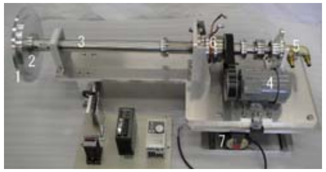




Critical issues caused by high-intensity, high-power beams

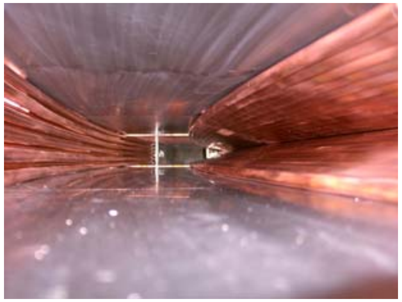
High-power target





Rotating target
@ BigRIPS

High-power beam dump



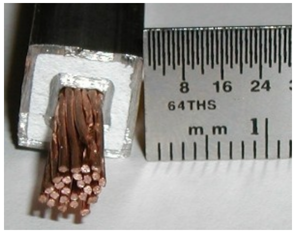
Beam dump
@BigRIPS

Water cooled by
using Cu swirl &
screw tubes

Maintenance, remote handling & radiation safety issues

Pillow seals
@BigRIPS

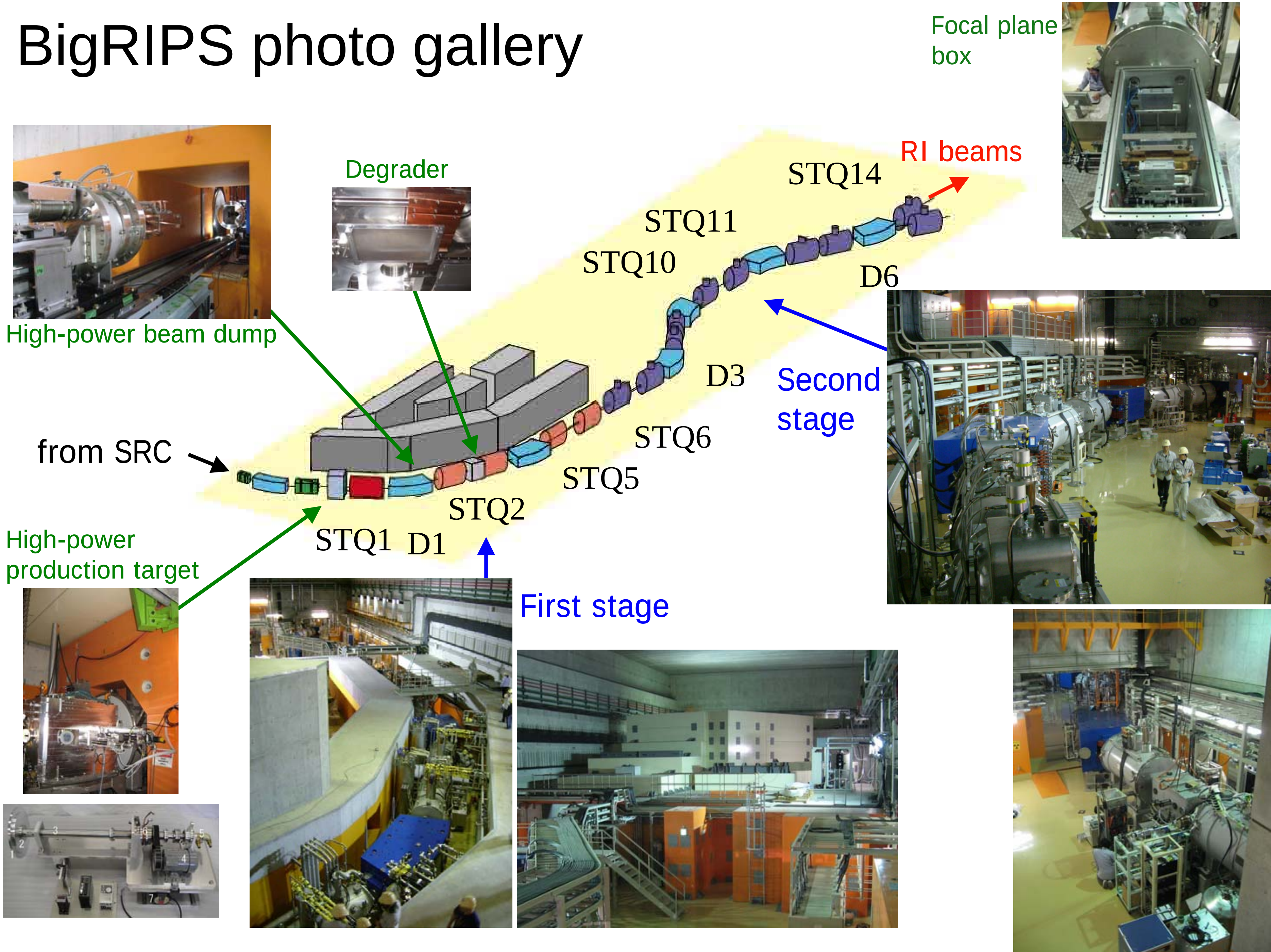
Radiation-hard superconducting magnet
Damage & heat load issues



R&D
@NSCL/MSU

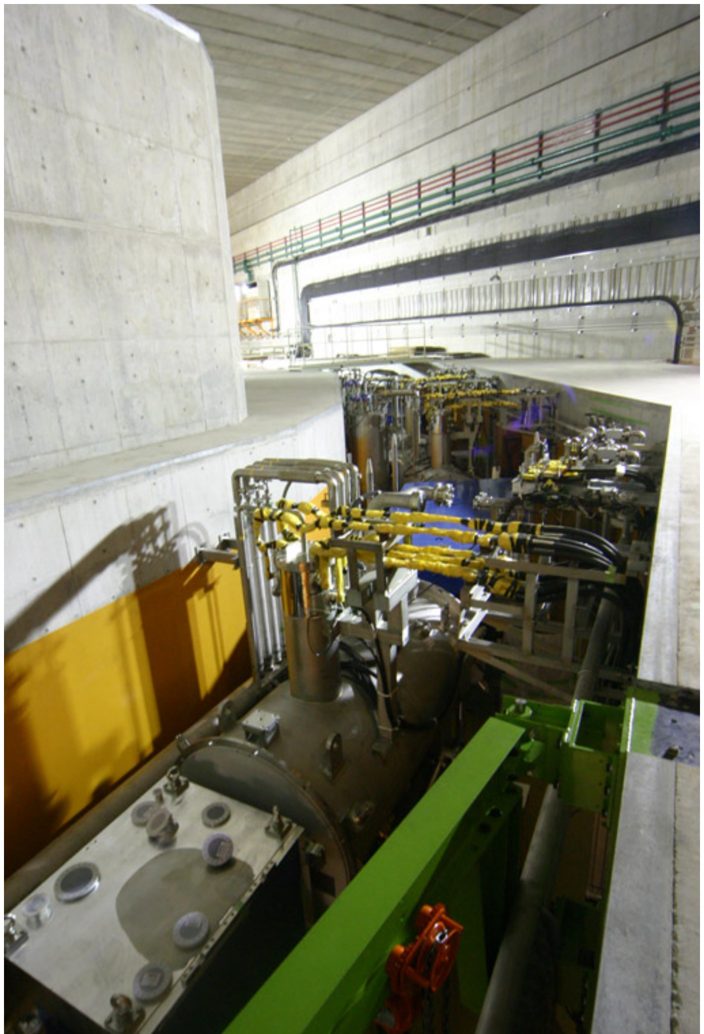
Expert-meeting collaboration on the critical issues is going on.

BigRIPS photo gallery

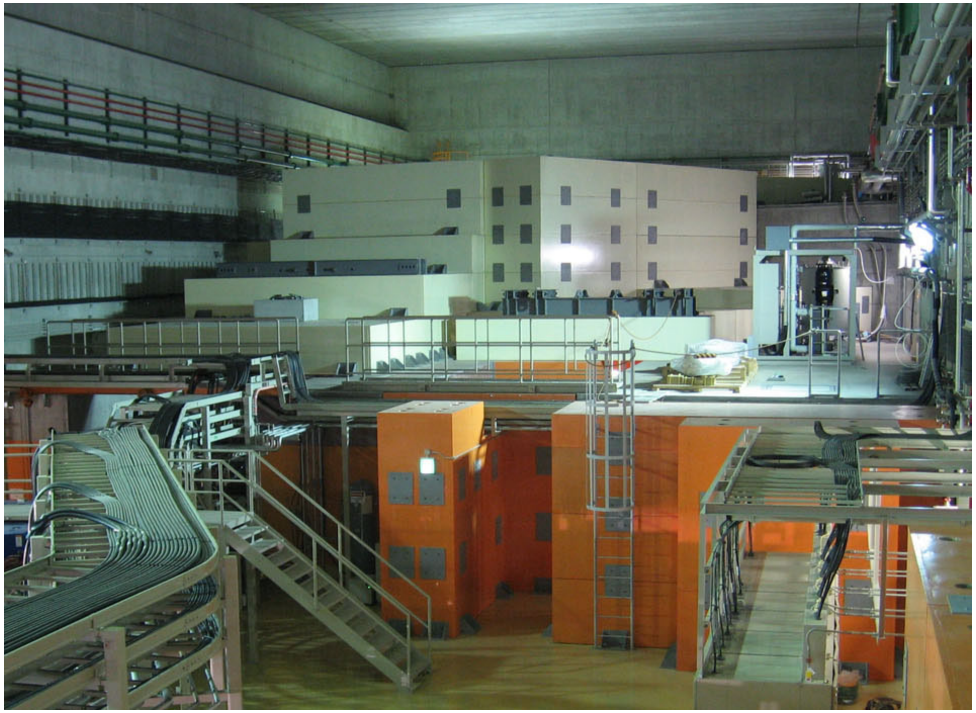


BigRIPS first-stage

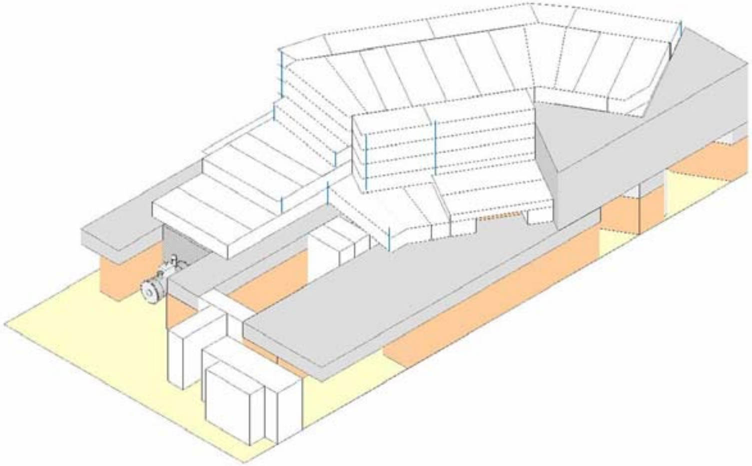
Courtesy of S. Bishop (left) & A. Saito (right), Oct. 2, 2006

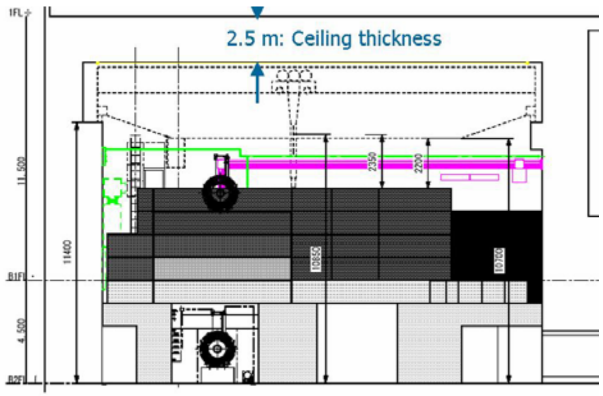


BigRIPS second-stage



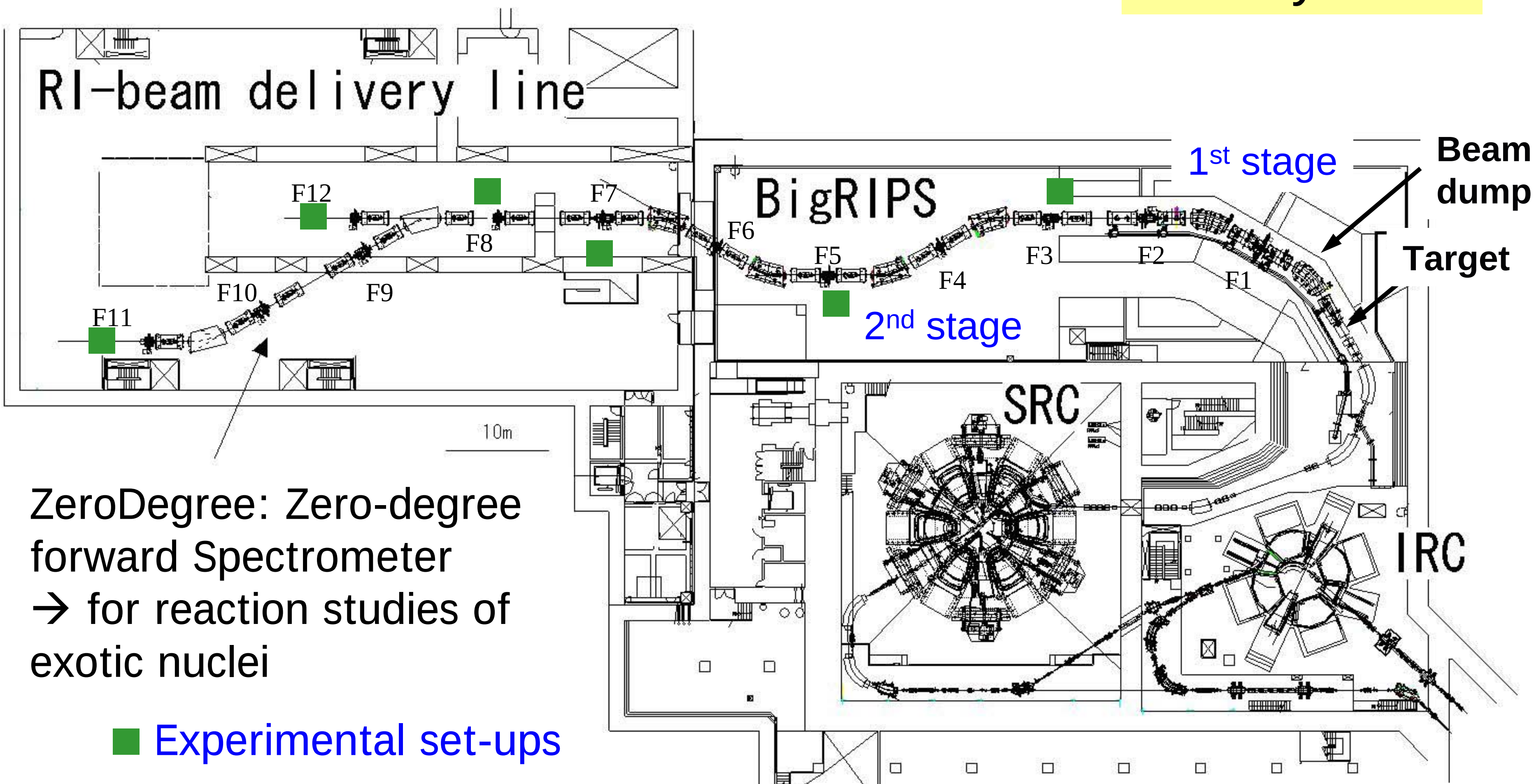
The BigRIPS first-stage covered by thick radiation shields





The BigRIPS second-stage with some local radiation shields

ZeroDegree spectrometer/ RI-beam delivery line



ZeroDegree: Zero-degree forward Spectrometer
→ for reaction studies of exotic nuclei

■ Experimental set-ups