The RI Beams from the Tokai Radioactive Ion Accelerator Complex (TRIAC)

Collaborator

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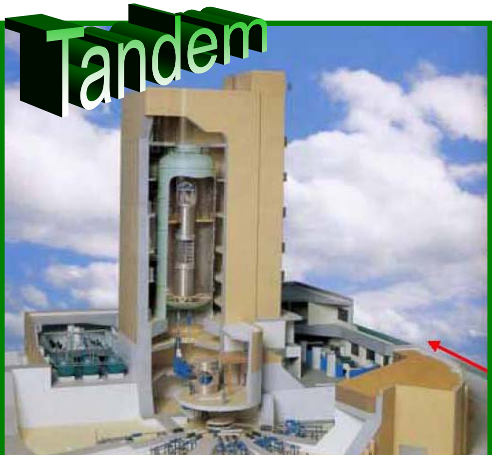
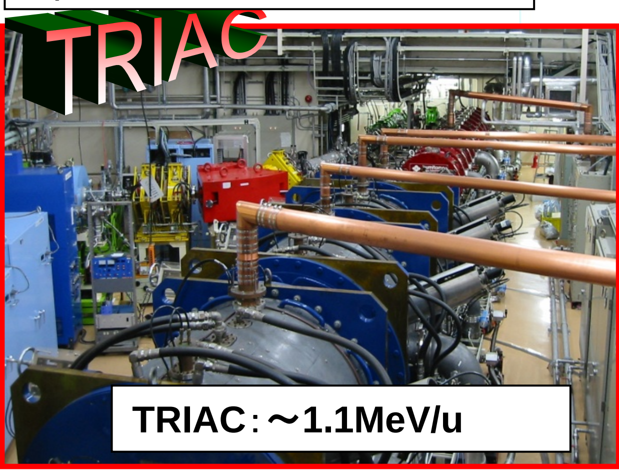
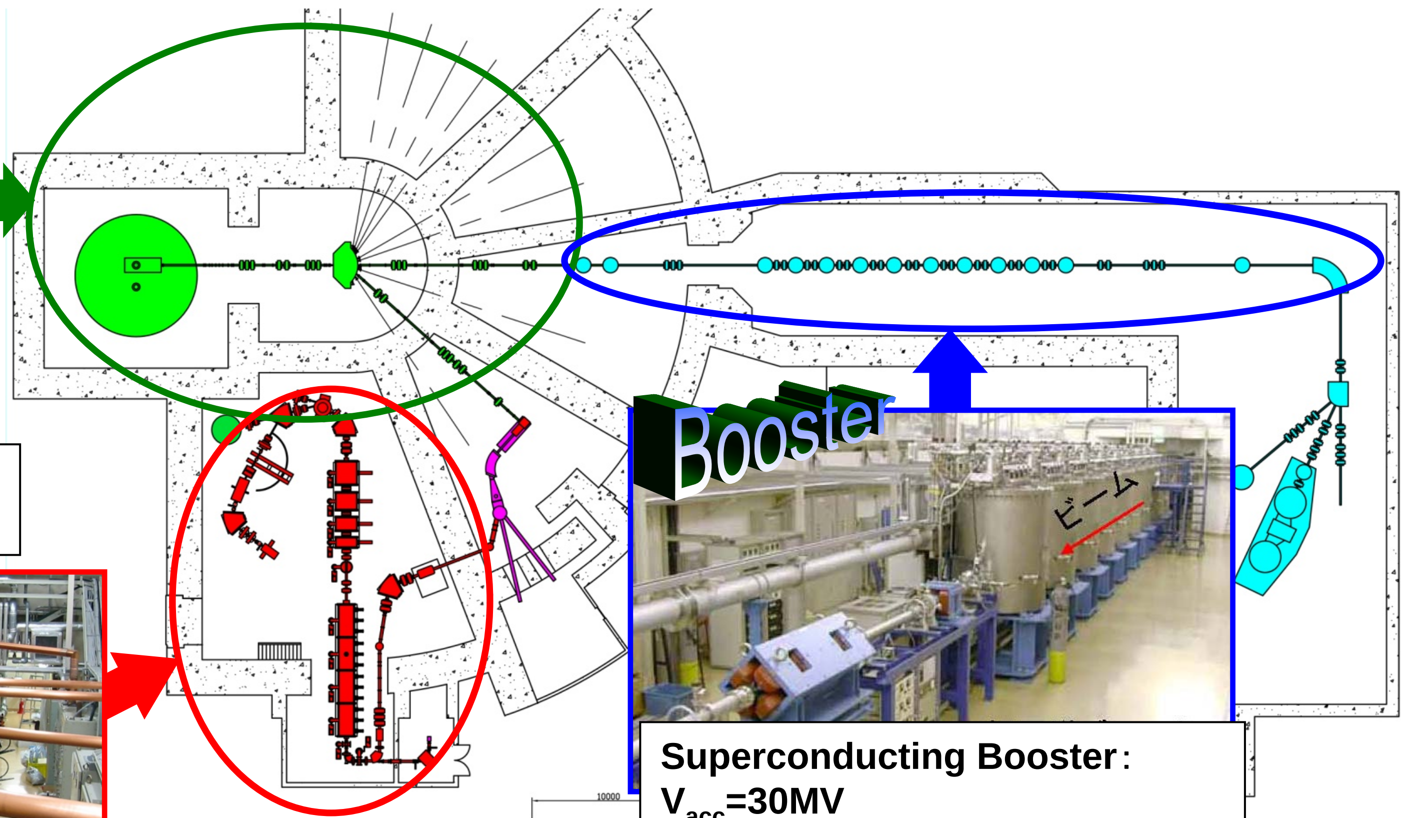
JAEA-Tandem facility



Tandem Accelerator: V_T=18MV (MODEL 20 UR)



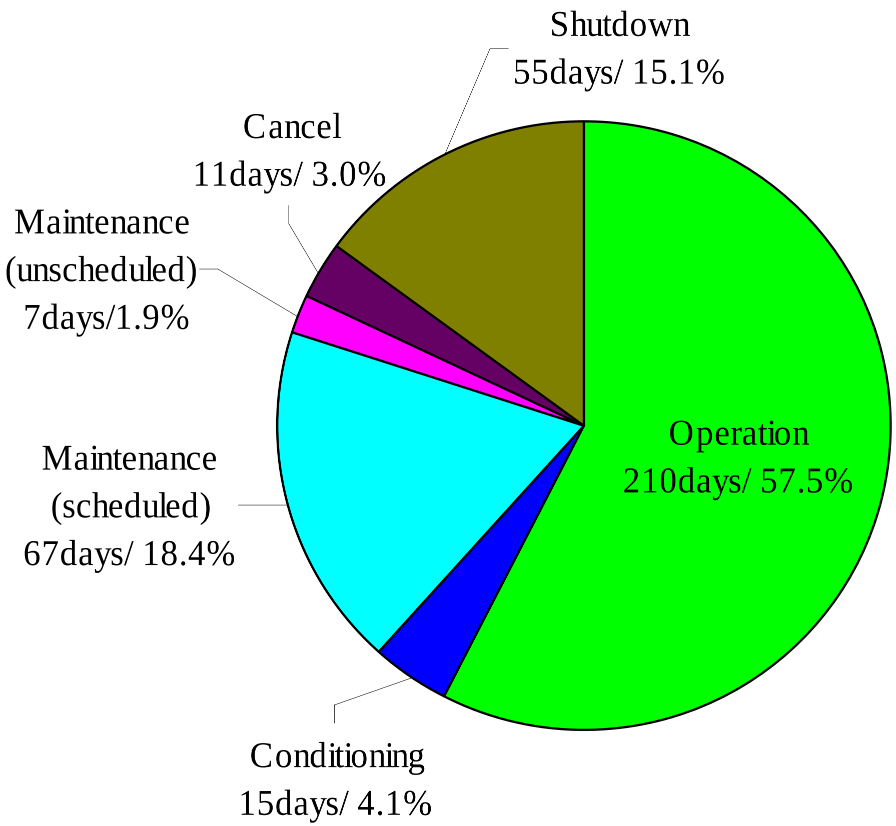
TRIAC: ～1.1MeV/u

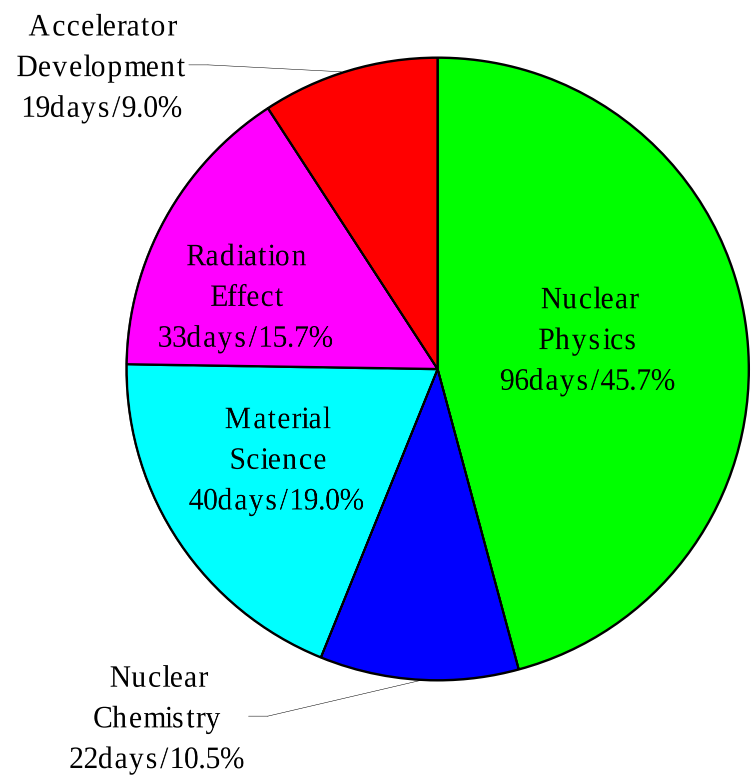


Superconducting Booster: V_{acc}=30MV

	Completion
JAEA-Tandem Accelerator	Aug. 1982
Superconducting Booster	Sep. 1994
TRIAC	Mar. 2005

Usage of beam times in FY2008





Operation of TRIAC: 23days
- Nuclear physics
- Material Science
- Accelerator development

Upgrade of JAEA-Tandem facility

Performance of JAEA-Tandem Accelerator

Terminal voltage	2.5~18MV
Beam current limit (official license)	H, D: 3 μA (>20 MeV), 10 μA(<20 MeV) Li, Be, B: 1 pμA Elements for Z≥6 (C): 2 pμA

- Replacement of acceleration tubes
- Replacement of 180-degree analyzing magnet at the high-voltage terminal
- Replacement of in-terminal ion source to a permanent-magnet type 14.5 GHz ECR ion source, SUPERNANOGAN
- Treatment of degraded superconducting resonators
- Fabrication of a prototype low beta superconducting twin quarter wave resonator (low-β twin-QWR)

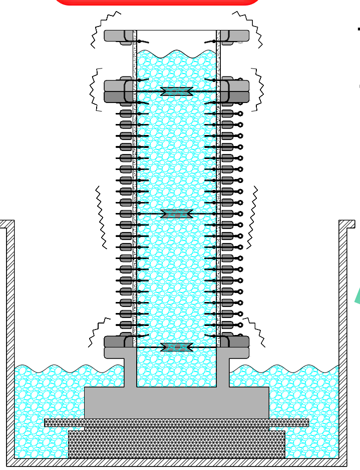
Upgrade of JAEA-Tandem Facility

Replacement of acceleration tubes

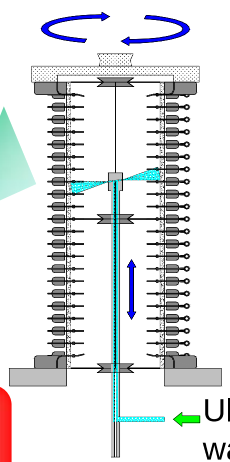
Initial performance of the maximum terminal voltage, V_T =17MV, got worse for years.

Replaced to compressed geometry tubes for the improvement of V_T up to 18-20 MV

Ultrasonic Cleaning



Remove micro-particles on the inside tube wall
→Reduce the conditioning time



High-pressure Water-jet Rinse

Baking in vacuum

200ºC, 2 weeks

Filled with N_2 gas to store

Original type
33gap/MV

Replaced at Jun. 2003

V_T=18MV

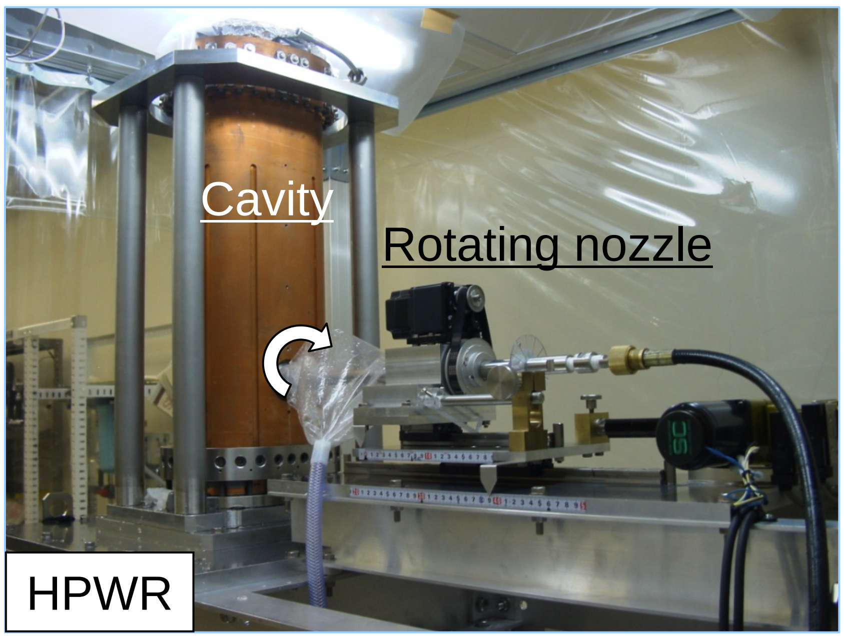
Compressed type
42gap/MV

Upgrade of JAEA-Tandem Facility

Recover of Superconducting Resonator

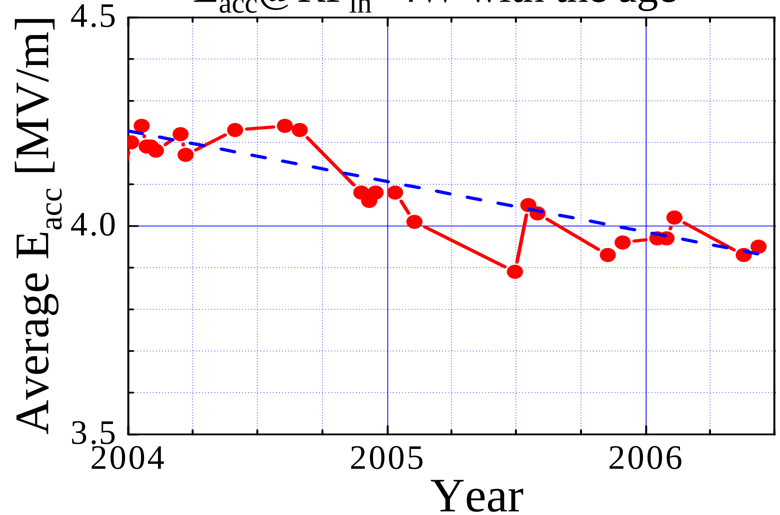
The acceleration electric field (E_{acc}) of superconducting cavities decreases to 4MV/m.

To remove small contaminations on the surface of niobium, treatment of superconducting resonators by using High-Pressure Water jet Rinse (HPWR) was carried out.

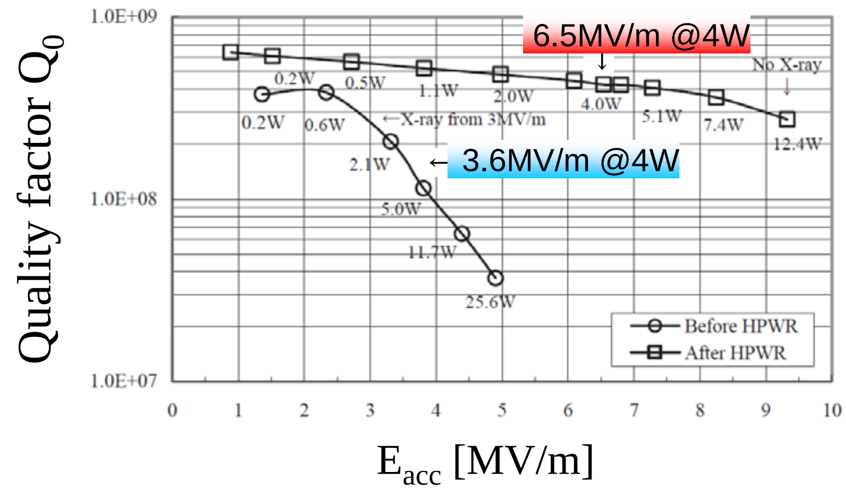


Water flow: 6 l/m, Pressure: 6~8 MPa

E_{acc}@RF_{in}=4W with the age

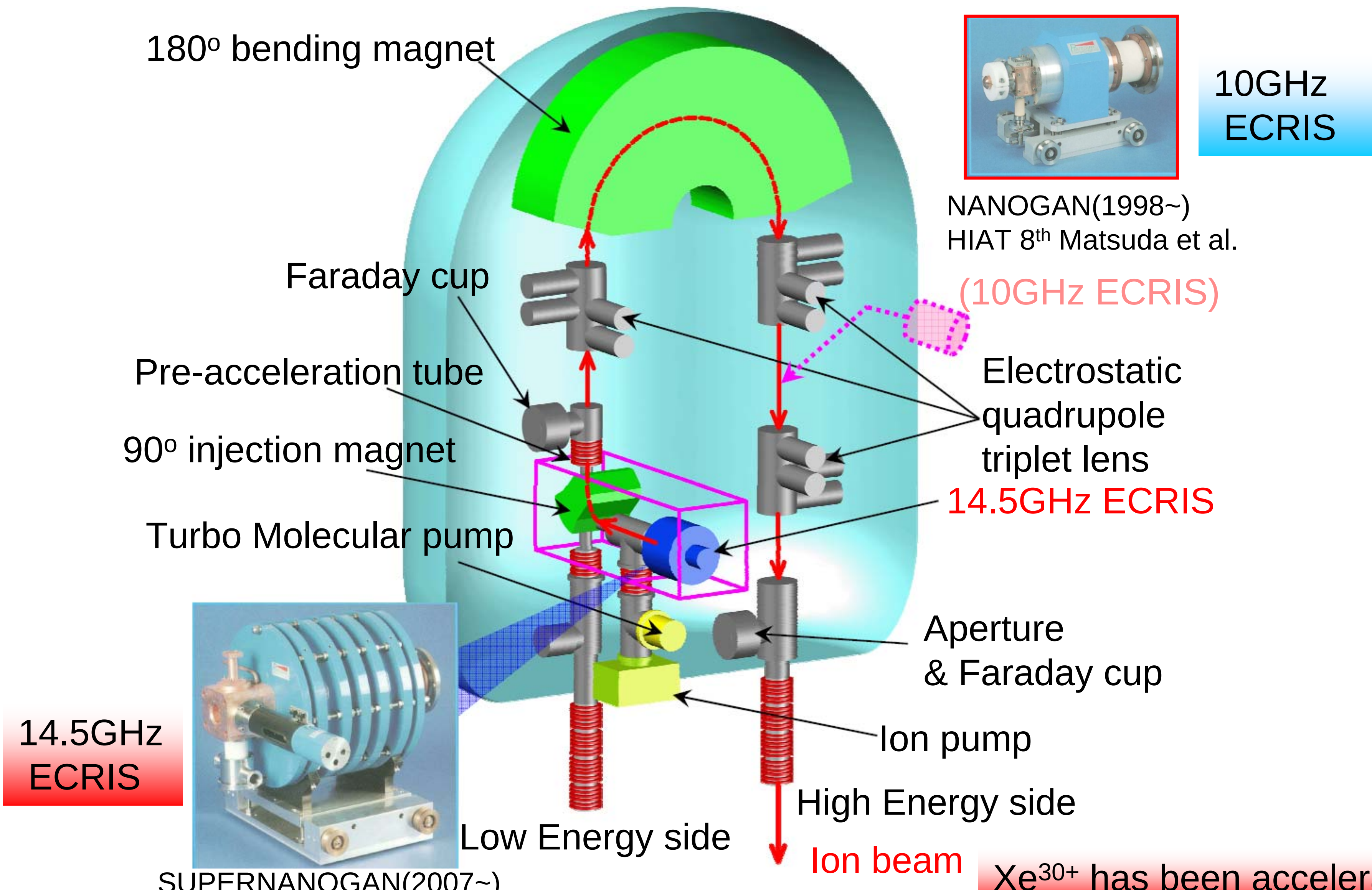


Effect of HPWR



Upgrade of JAEA-Tandem Facility

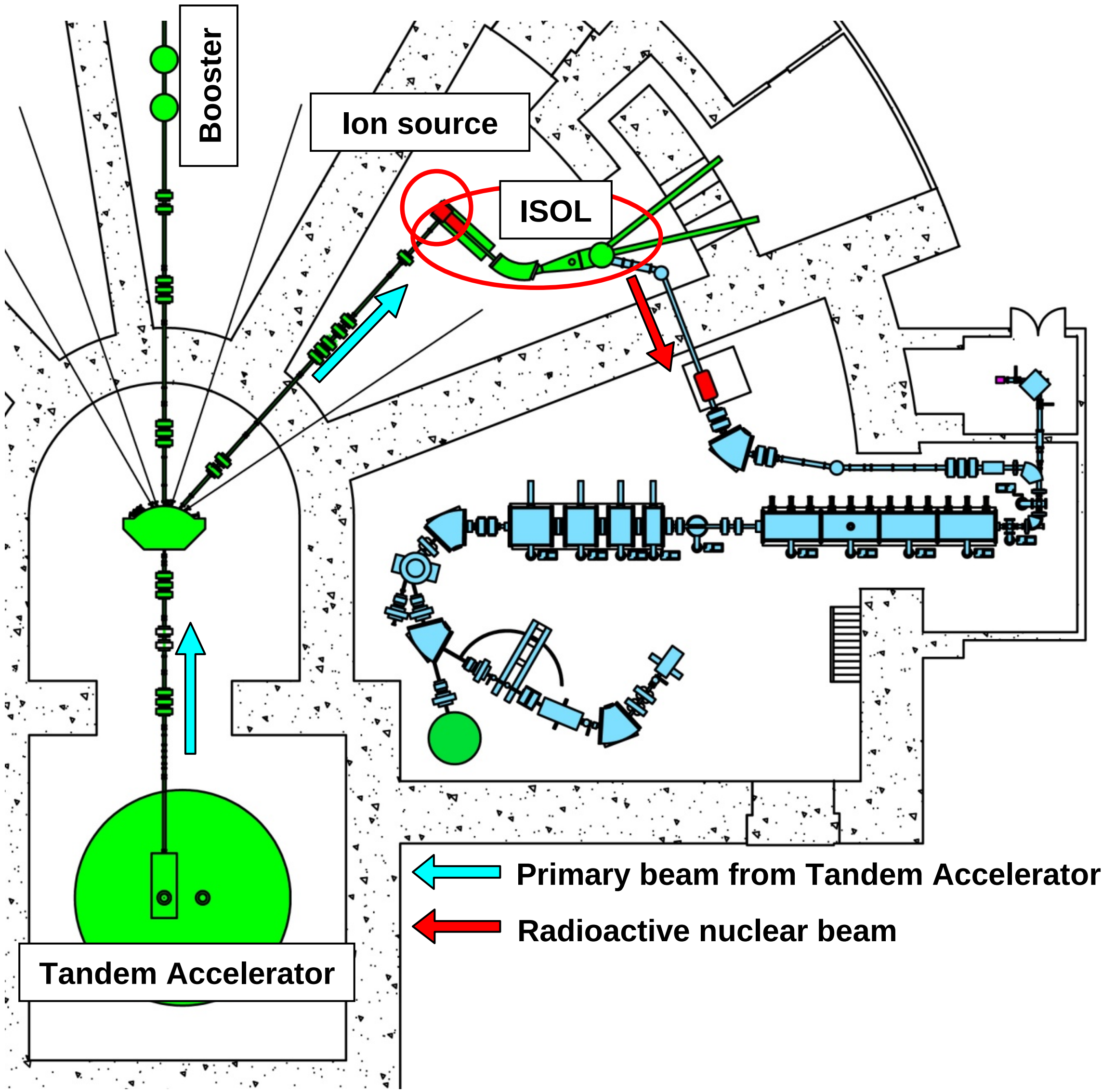
Replacement of in-terminal ECRIS



Xe^{30+} has been accelerated.

Layout of TRIAC

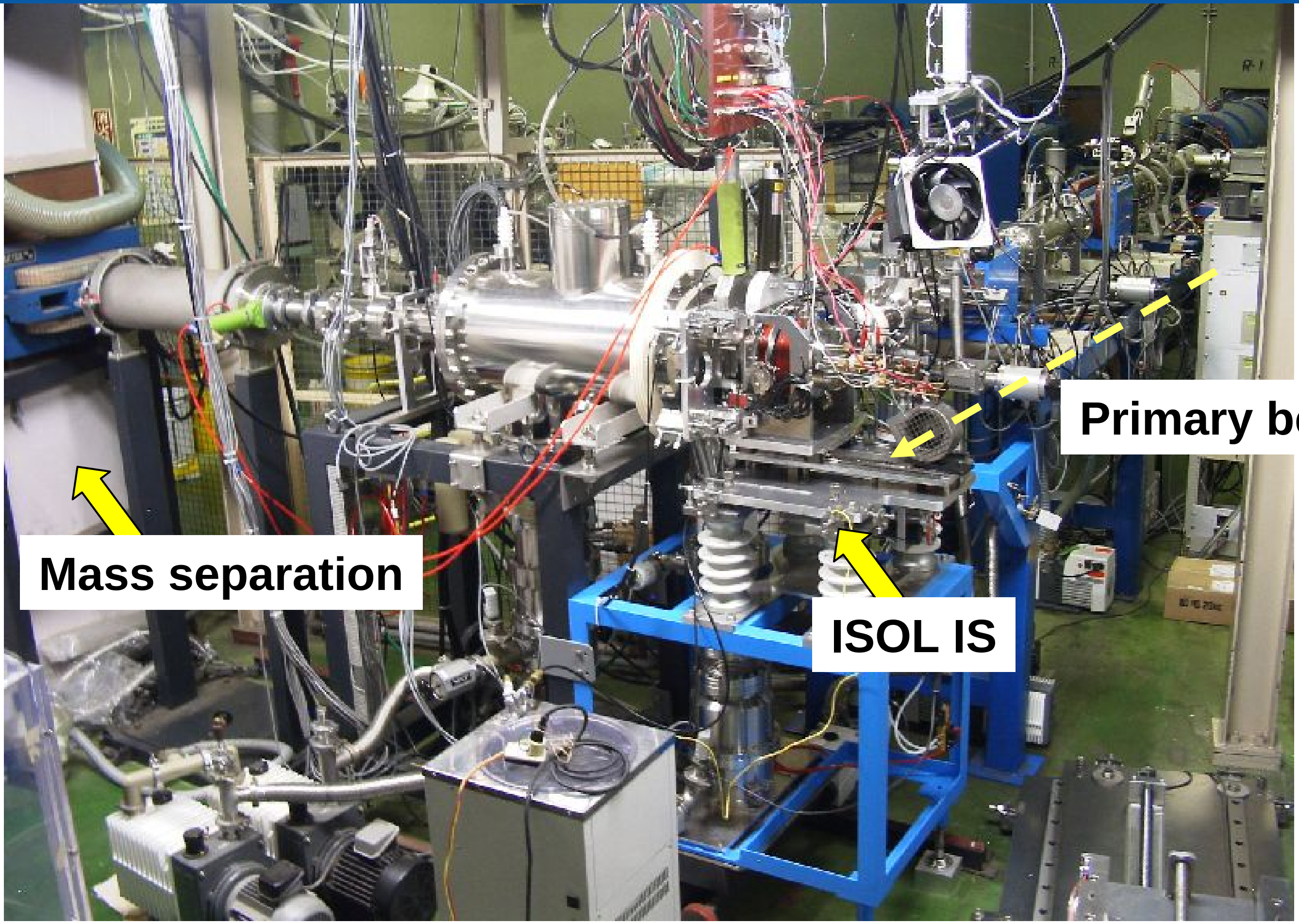
Tandem Accelerator:
Primary beam Driver to ISOL
Ion source： RI production and ionization
ISOL: RI separator and injector to TRIAC



H^{+}32MeV ~1μA

$^{7}Li^{3+}$64MeV ~200 pnA

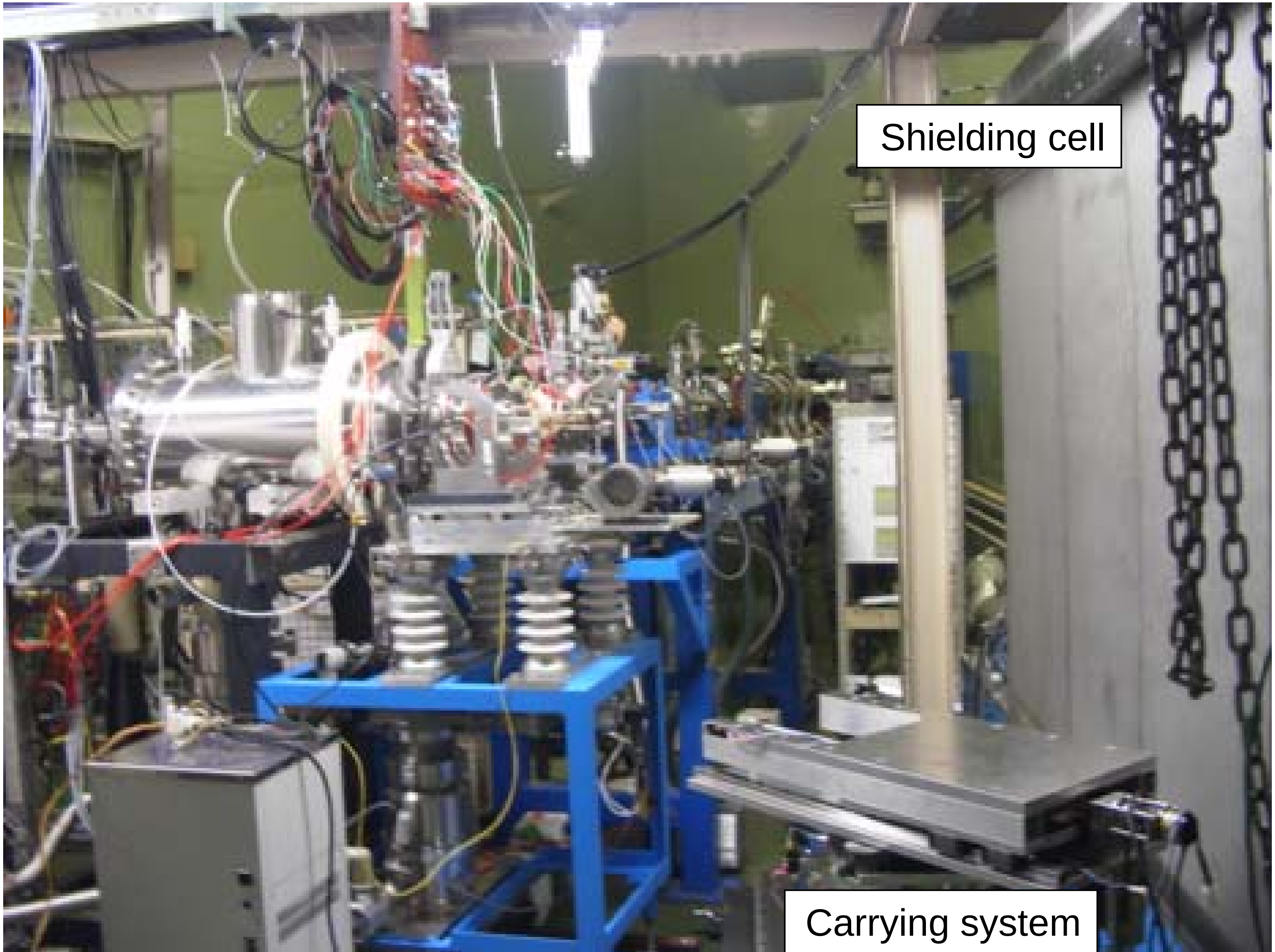
JAEA-ISOL



- Danfysik 9000-T
 (ISOLDE type)
- Resolving power: 1200

JAEA-ISOL

Safety Handling System of Target-Ion source Module



Tokai Radioactive Ion Accelerator Complex (TRIAC)

Layout of TRIAC

Tandem Accelerator: Primary beam Driver to ISOL

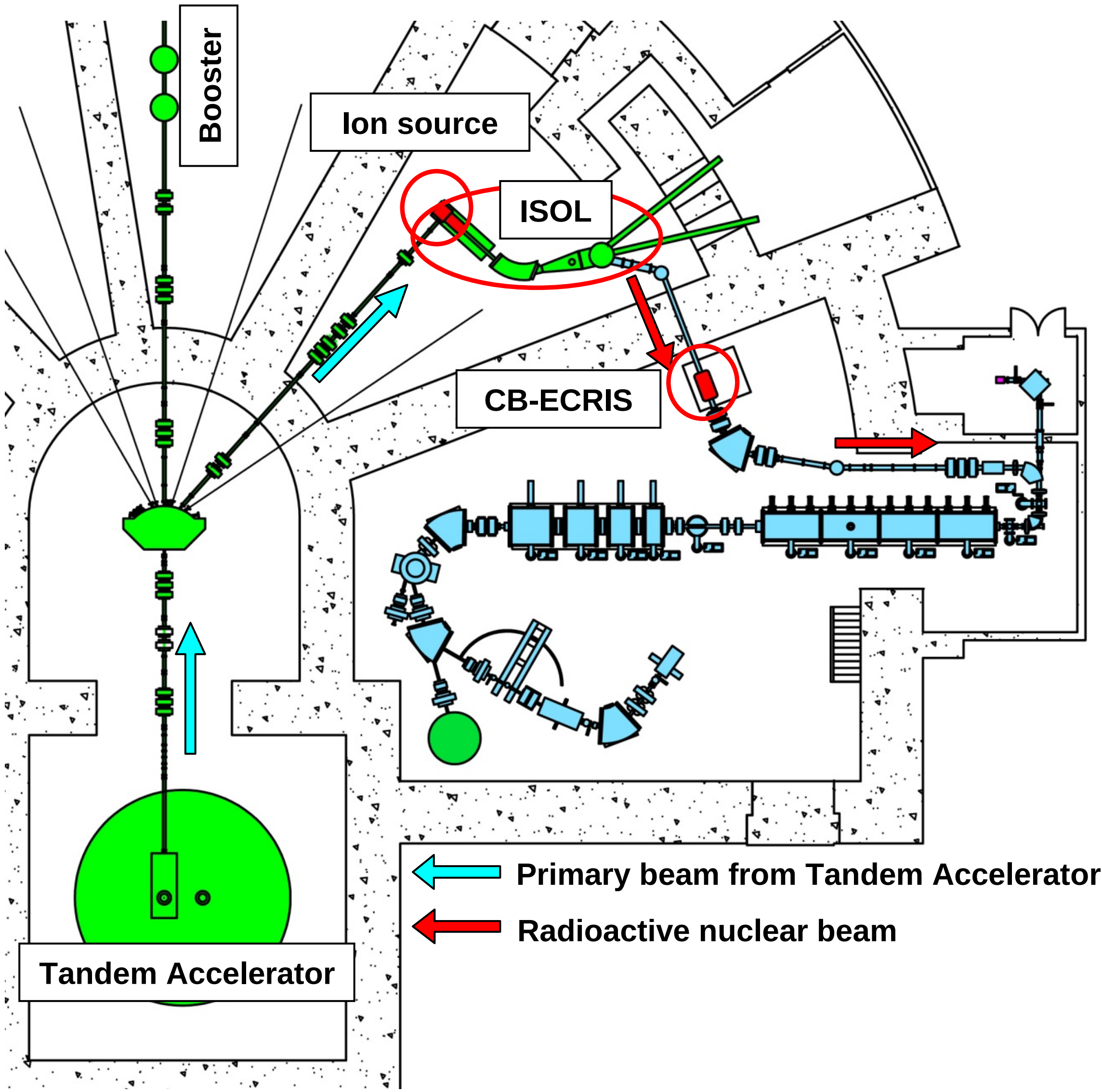
Ion source: RI production and ionization

ISOL: RI separator and injector to TRIAC

CB-ECRIS: Charge-breed 1+ ion to q+ ion

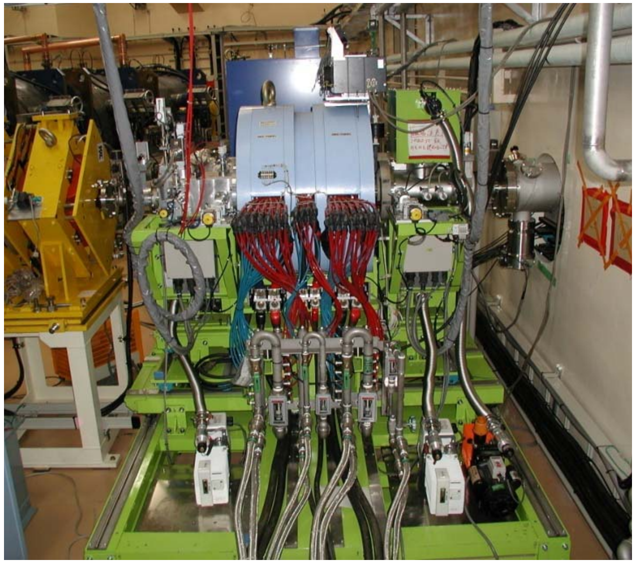
H^+32MeV ~1μA

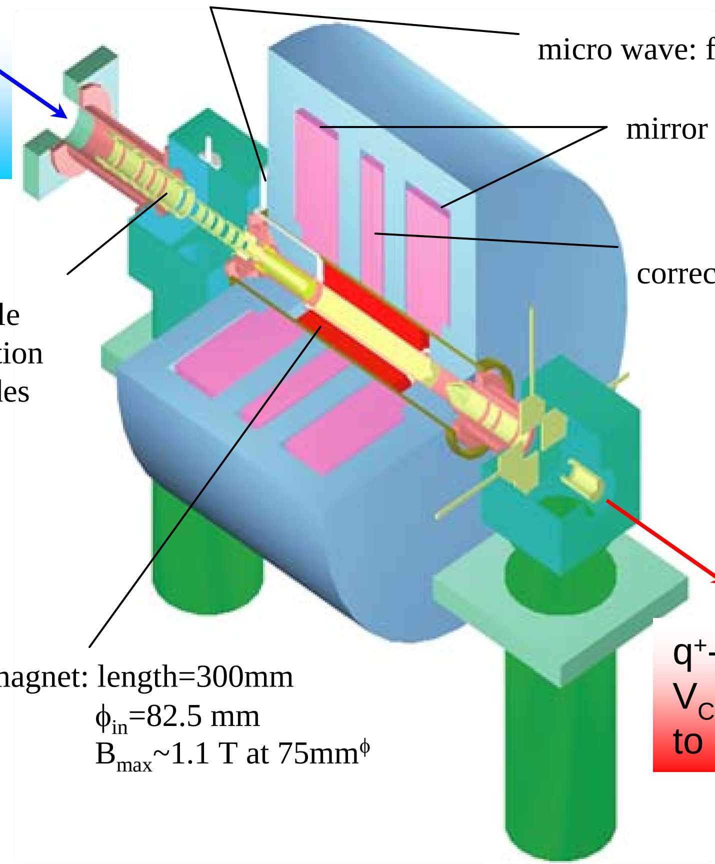
$^7Li^{3+}$64MeV ~200 pnA



Tokai Radioactive Ion Accelerator Complex (TRIAC)

18 GHz ECRIS as the charge breeder





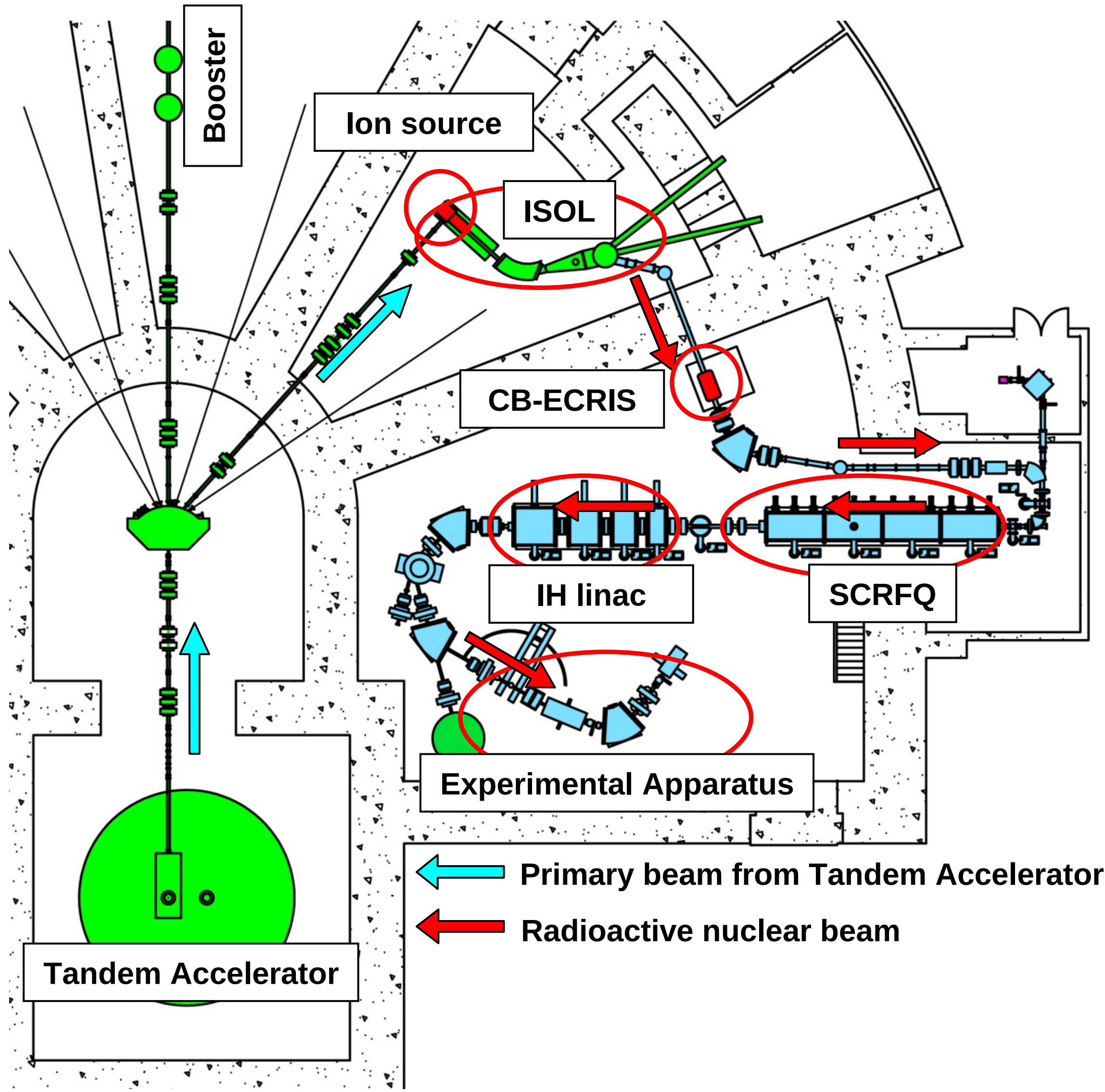
Layout of TRIAC

Tandem Accelerator:
Primary beam Driver to ISOL
Ion source：RI production and ionization
ISOL: RI separator and injector to TRIAC

CB-ECRIS: Charge-breed 1+ ion to q+ ion
SCRFQ-linac: Accelerate to 0.17MeV/u
IH-linac: Accelerate to 1.1MeV/u

H^+32MeV ~1μA

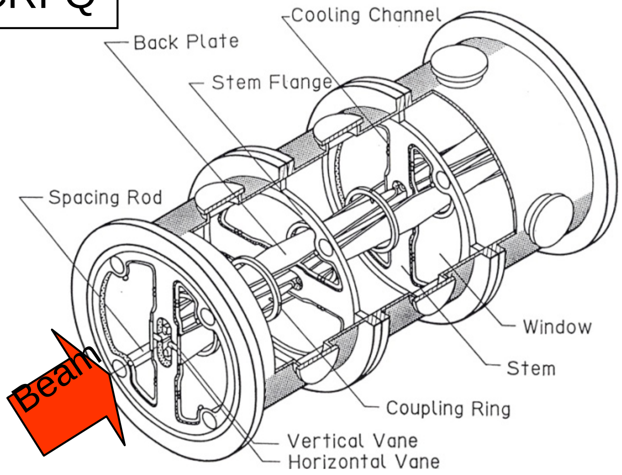
$^7Li^{3+}$64MeV ~200 pnA

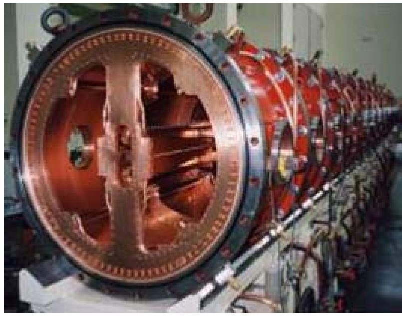


Tokai Radioactive Ion Accelerator Complex (TRIAC)

Performance of Linacs

SCRFQ



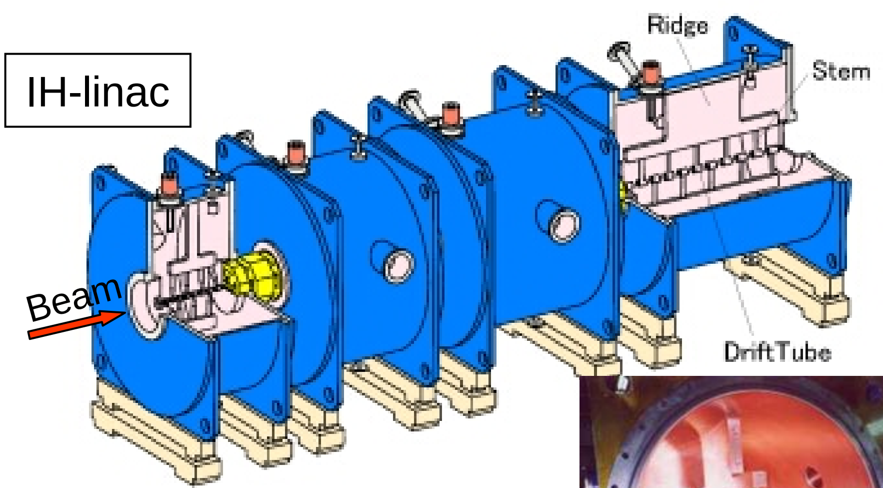


Split-coaxial-RFQ (SCRFQ) linac

Very compact (diameter = 0.9m)

RF frequency	25.96MHz
Input energy	2.1keV/u
Output energy	178kev/u (A/q≤28)
Transmission	>90%
Vane length	8.6m

IH-linac



Inter-digital H (IH) linac

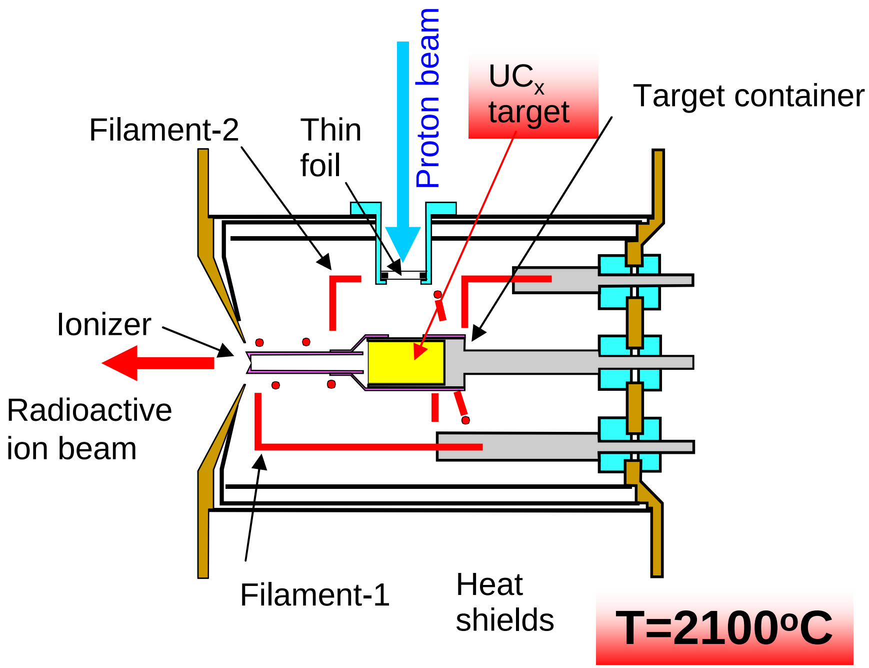
4 cavity tanks, 3 magnetic-quadrupole triplets

RF frequency	51.92MHz
Input energy	178keV/u
Output energy	0.14-1.09MeV/u (A/q≤9)
Total length	5.6m

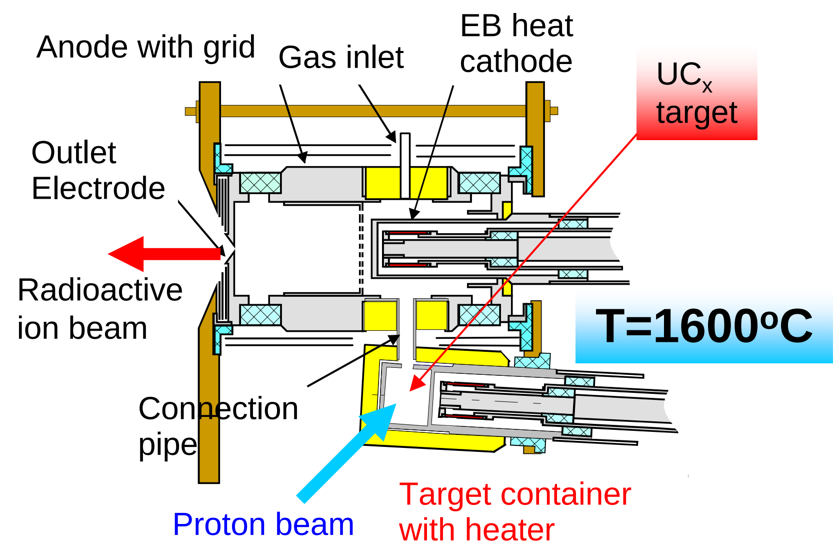
Total transmission of two linacs ~85%

Duty factor 20% ⇒ 100%

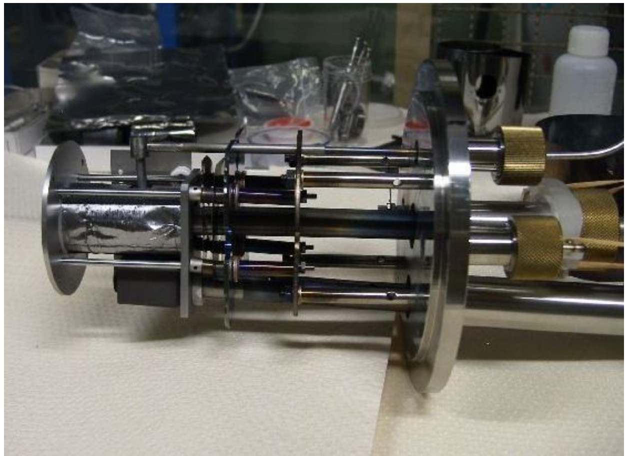
Development of Target-Ion Source System
Schematic view of Target-Ion Source systems



Uranium Target-Surface Ionization IS



Uranium Target-FEBIAD-B2 IS



Alkali, alkaline earth, and rare-earth elements

Gaseous and volatile elements

We could not observe short-lived isotopes of In, Sn.

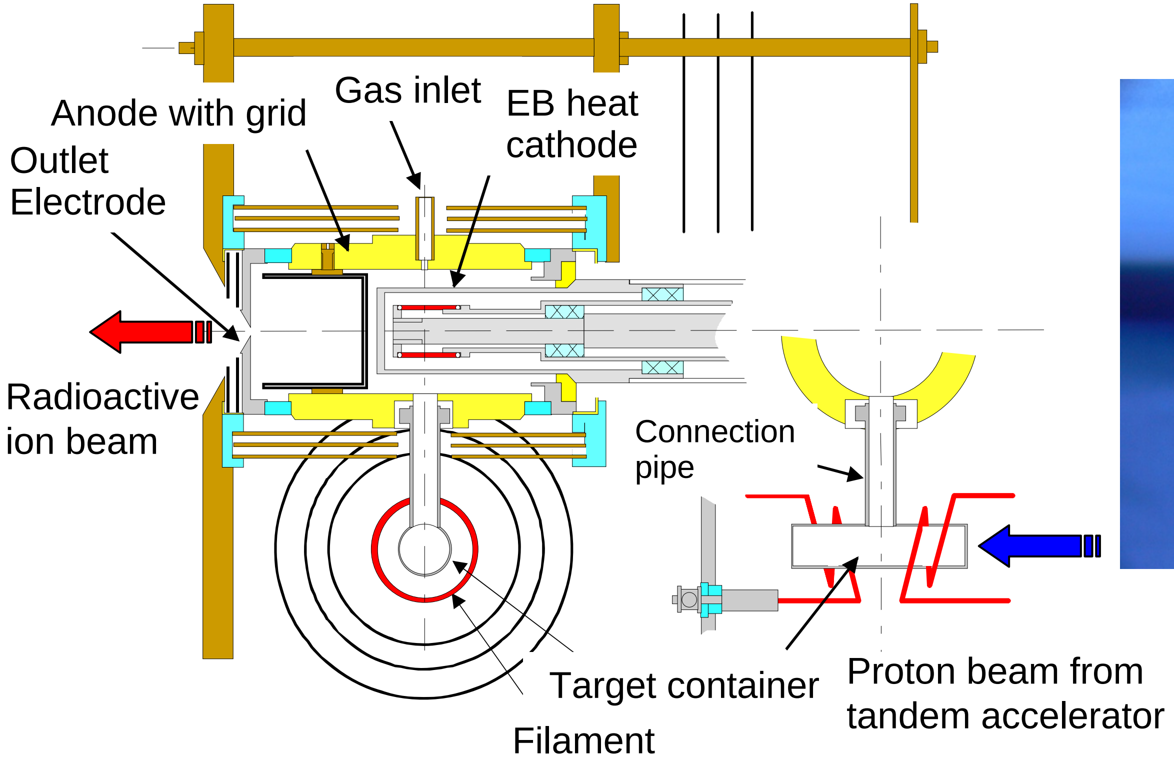
Development of Target-Ion Source System
U-FEBAID-E Ion Source

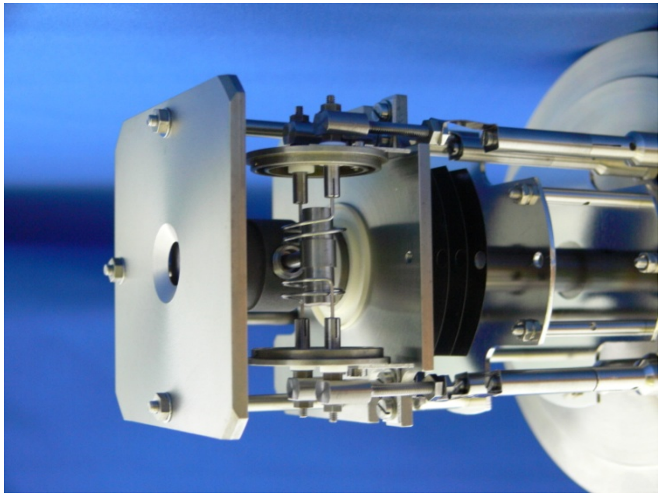
U-FEBIAD-B2 (1600ºC)

Separation efficiencies were miserably decreased for short-lived isotopes.

We could not observe short-lived isotpes of In, Sn

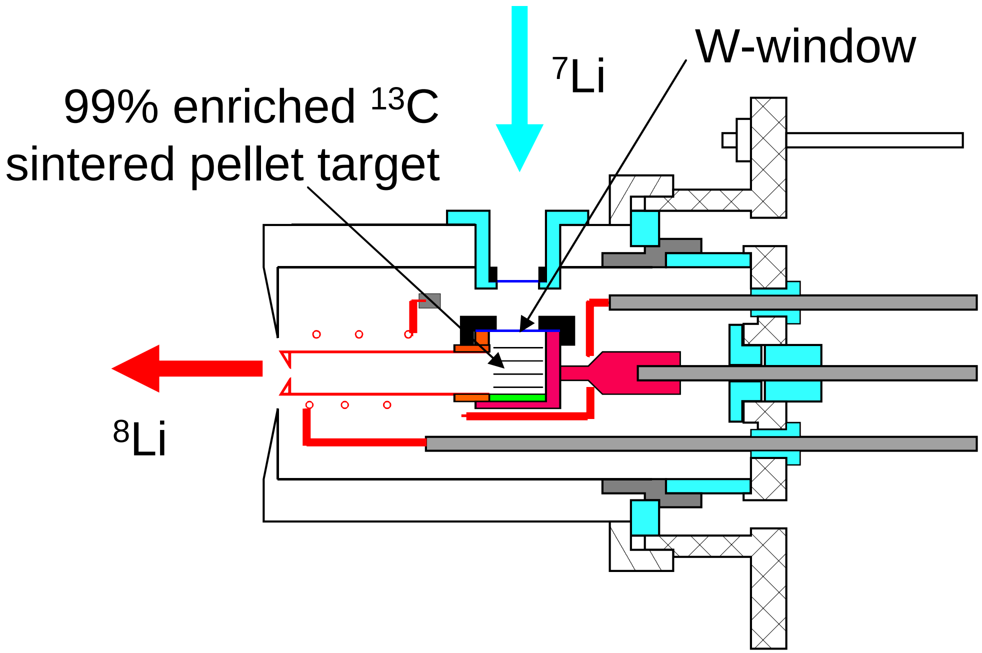
FEBIAD-E + Target container (>2000ºC) →Short release time is expected.





On-line test is in progress.

Development of Target-Ion Source System
Surface Ionization IS for Heavy ion reaction



Measurement of Li diffusion coefficients in Li ionic conductors

Search of highly excited state of ^{10}Be using deuteron elastic reaction to ^{8}Li

Search of highly excited state of ^{11}Be using deuteron elastic reaction to ^{9}Li

$^{13}C(^{7}Li, ^{8}Li)$

$^{7}Li^{3+}$ beam 67MeV ~100 pnA

1 x 10^{6} ions/s

$^{9}Li(T_{1/2}$=178 ms) ~10^{2} pps

Request: >5 x 10^{3} pps

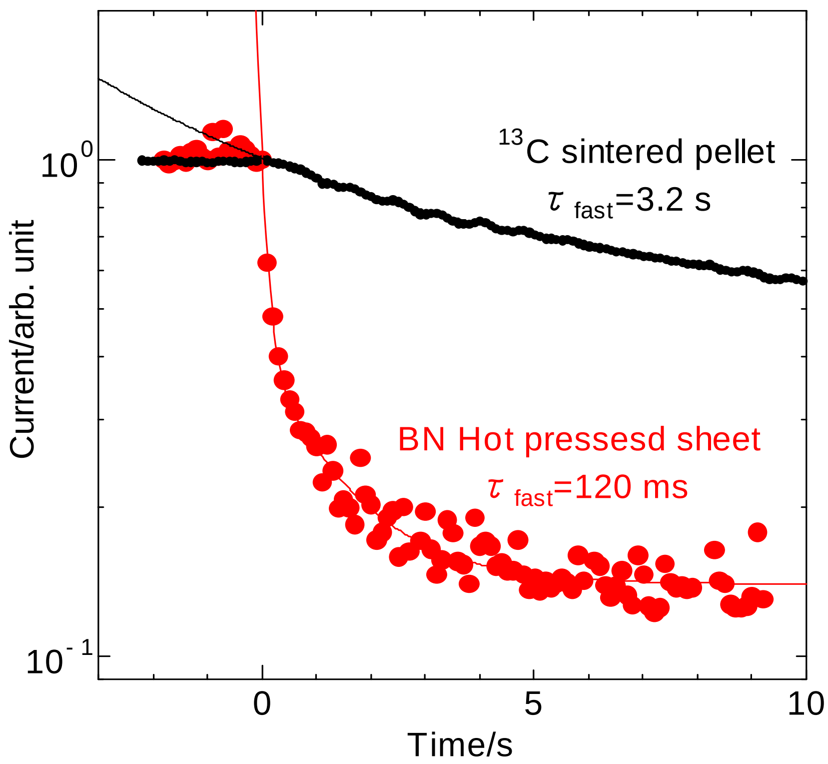
~~Increase a target weight~~

~~Increase a beam energy/current~~

Increase a release speed?

Release profile of Li

Release profile of Li by
Heavy ion implantation technique



Separation yield of $^{8}Li/^{9}Li$

A 99% enriched ^{13}C sintered pellet target

- ^{8}Li: ~10^{5} ions/s @100pnA ^{7}Li
- ^{9}Li: ~10^{2} ions /s @100pnA ^{7}Li

BN Hot pressed sheet target

- ^{8}Li: ~10^{5} ions/s @100pnA ^{7}Li
- ^{9}Li: ~10^{4} ions/s @100pnA ^{7}Li

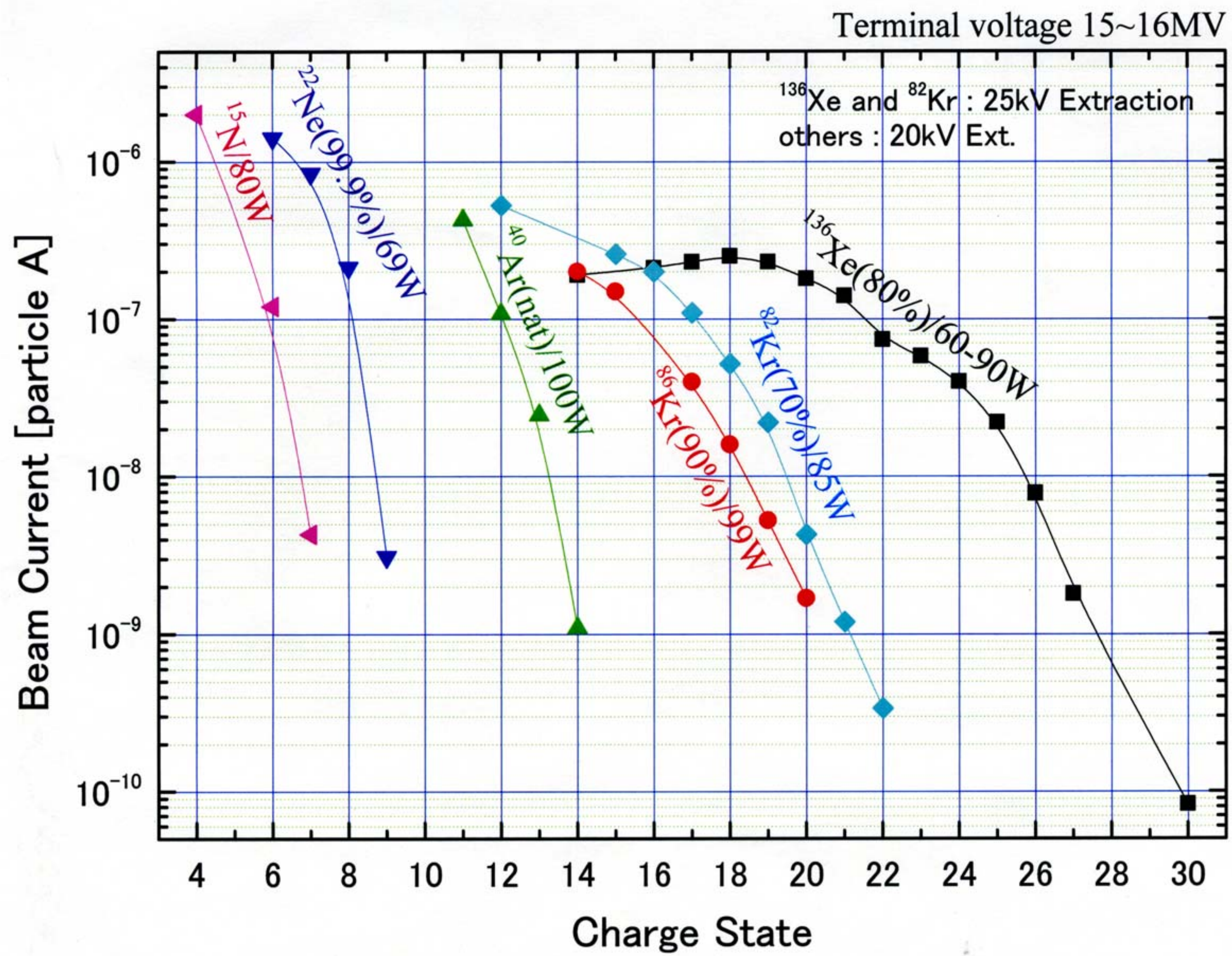
OUTLOOK

- Continuous upgrade enabled JAEA-Tandem facility to deliver a variety beams for experiments.
- Until now, TRIAC facility provides relatively weak intensity and low energy RNBs. However, we have produced good results by using ^{8}Li beam which is specialty of TRAIC facility.
- It is expected to allow further applications and progresses especially by use of the RNBs of medium-heavy neutron-rich isotopes.
- Development of the target-ion source system is one of the highest priority issues on operation of RNB facility.
- We will carry on the development for the facility.

Thank you for your attention.

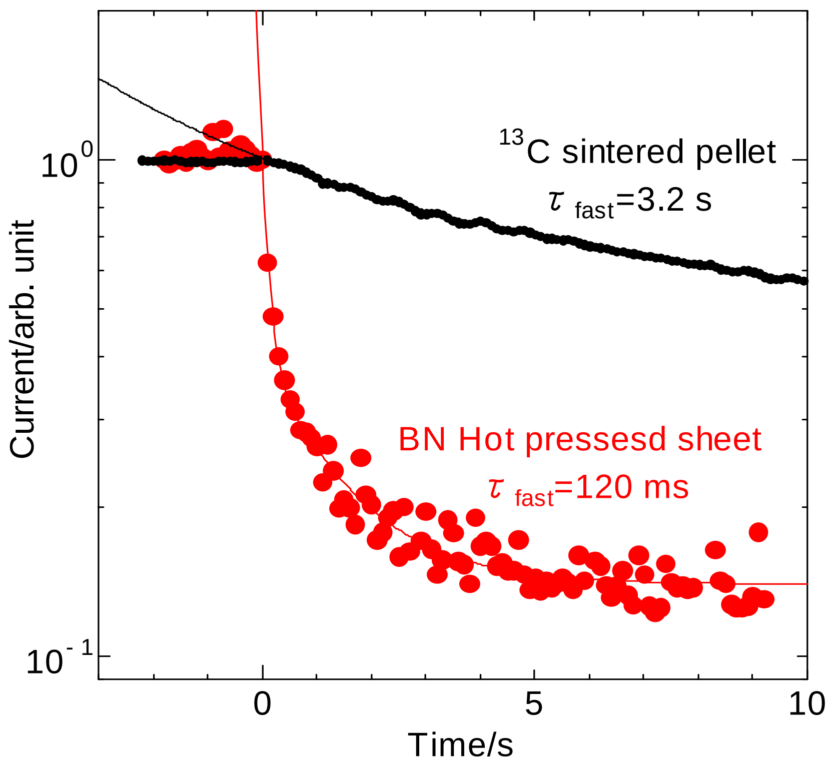
In-terminal ECRIS: SUPERNANOGAN

Acceleration results and performance



Release profile of Li

Release profile of Li by
Heavy ion implantation technique

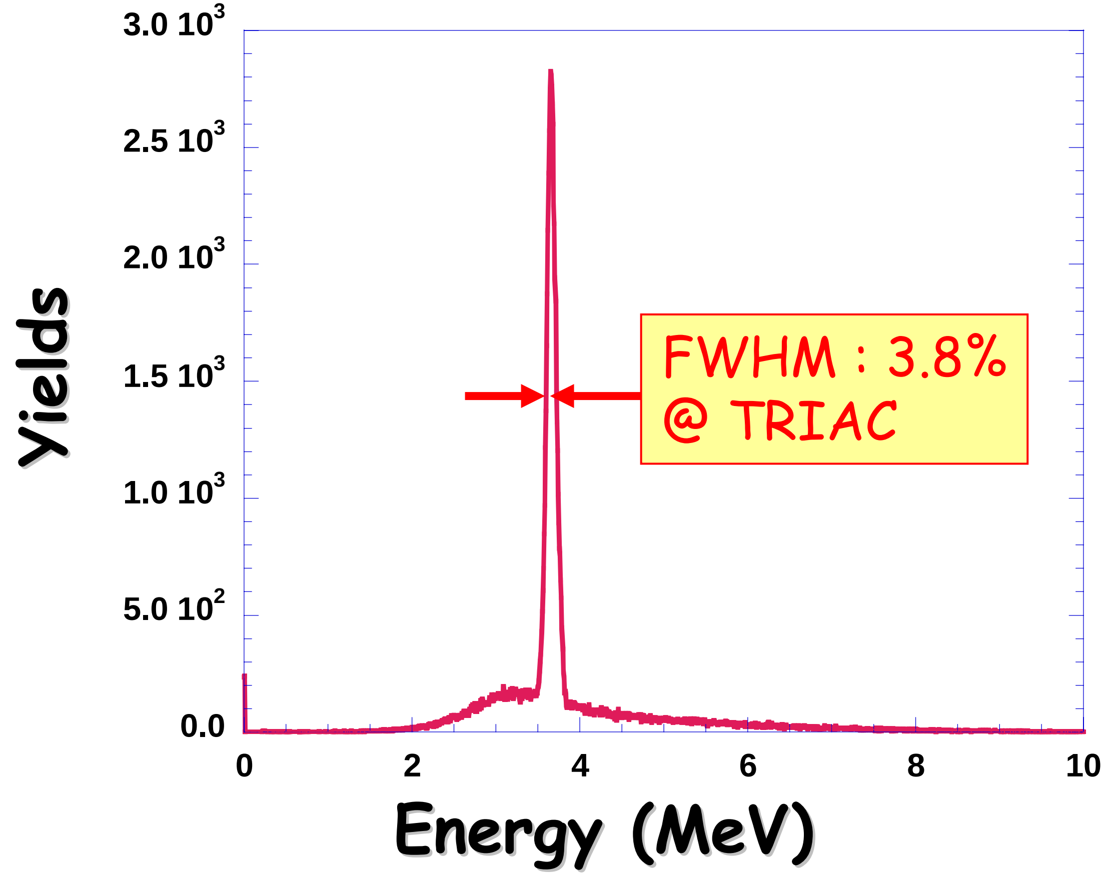


Separation yield of ^{8}Li/^{9}Li
A 99% enriched ^{13}C sintered pellet target
^{8}Li: ~10^{5} ions/s @100pnA ^{7}Li
^{9}Li: ~10^{2} ions /s @100pnA ^{7}Li
BN Hot pressed sheet target
^{8}Li: ~10^{5} ions/s @100pnA ^{7}Li
^{9}Li: ~10^{4} ions/s @100pnA ^{7}Li

Thickness dependence
Release time
0.6mm^{t} τ_{fast}=1.9s
0.2mm^{t} τ_{fast}=120ms
Improved
Separation yield
The ratio ^{9}Li/^{8}Li~1/10 did not change !!

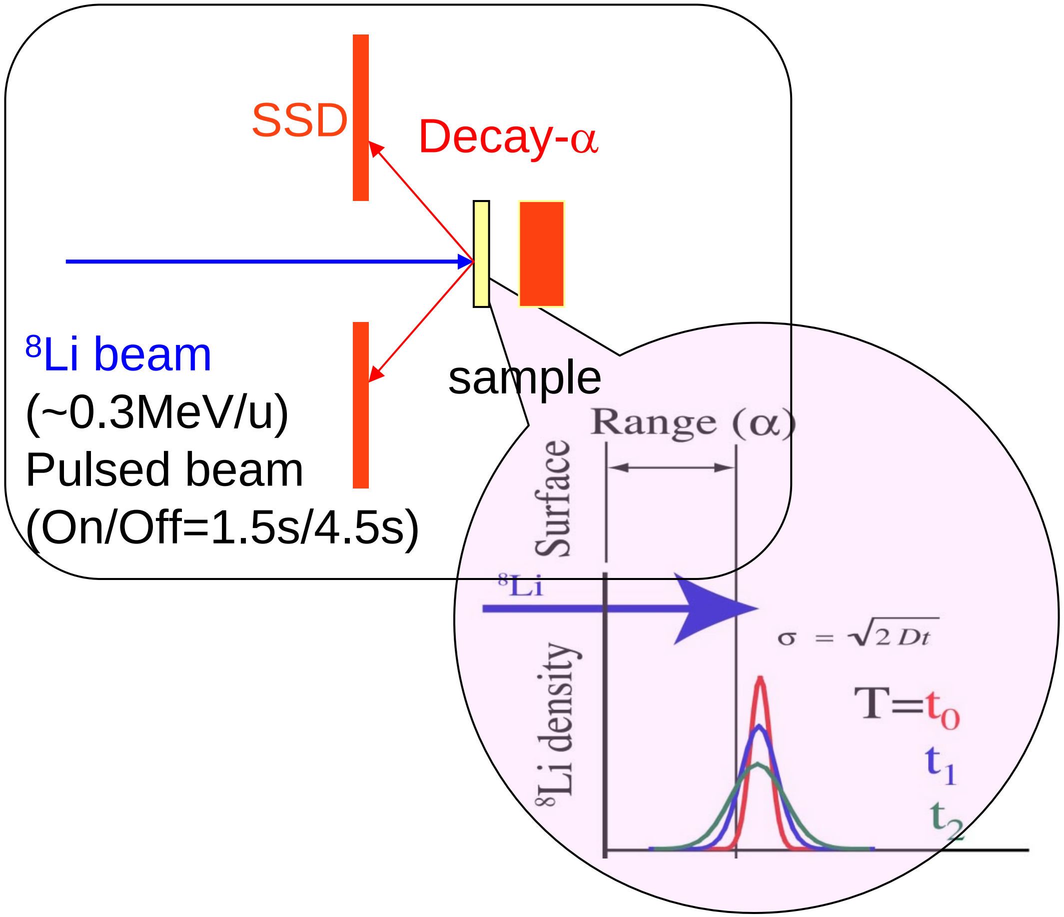
Profile of ^{8}Li beam

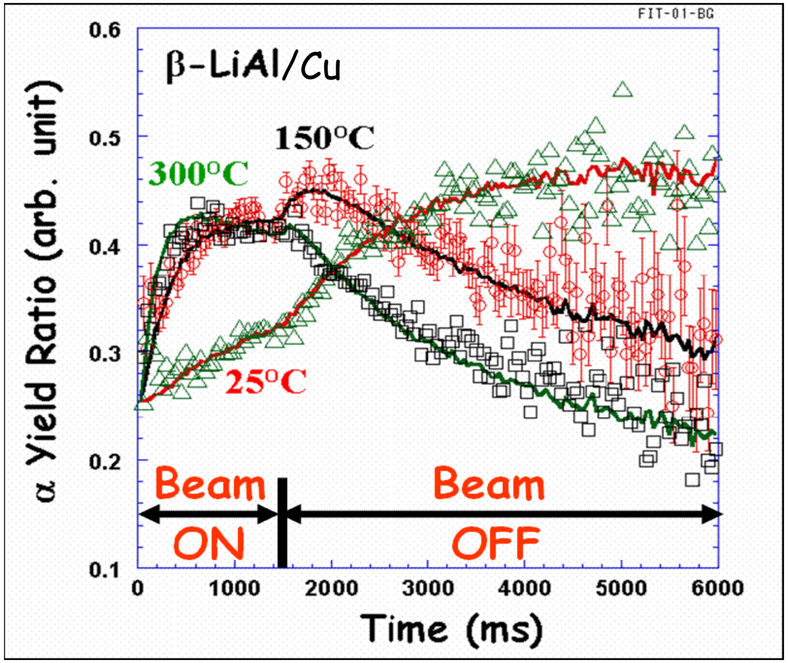
- Beam spot size ~ 7 mmϕ (FWHM)
- Energy resolution ~ 2 % (FWHM)



Application by use of ^{8}Li beam
Diffusion Study

S.C. Jeong et al., Nucl. Instrum. Meth. B230(2005)596.

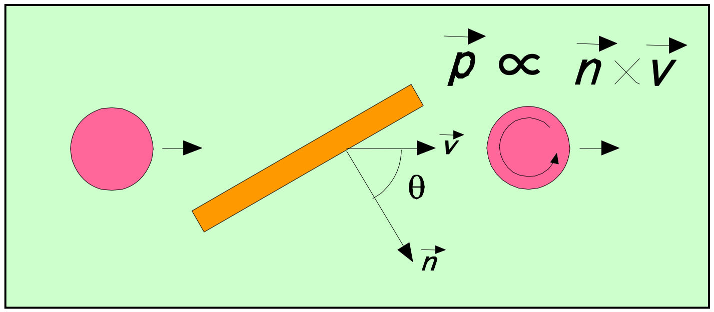


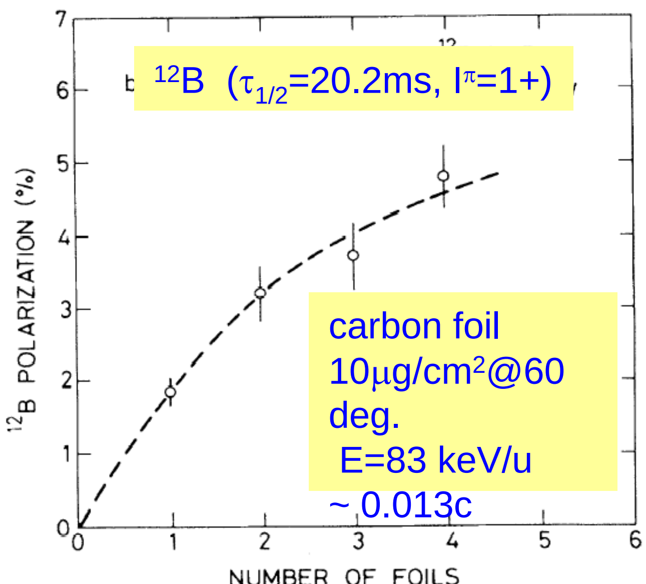


- Time spectrum of detected alphas: Diffusion and lifetime of ^{8}Li
- Non-destructive measurement of diffusion
- Rapid diffusion mechanism of Li-ions in the super ionic conductor materials

Application by use of ^{8}Li beam
Production of Polarized RNBs

- β-decay spectroscopy of spin-polarized RNB
- Nuclear electro-magnetic moments
- application for material science





(PRL 51 ('83) 180)

Tilted foil method

1. Asymmetric electron transfer

Atomic Polarization PRL47('81)487

2. Hyper-fine interaction

Atomic ➡ Nuclear Polarization

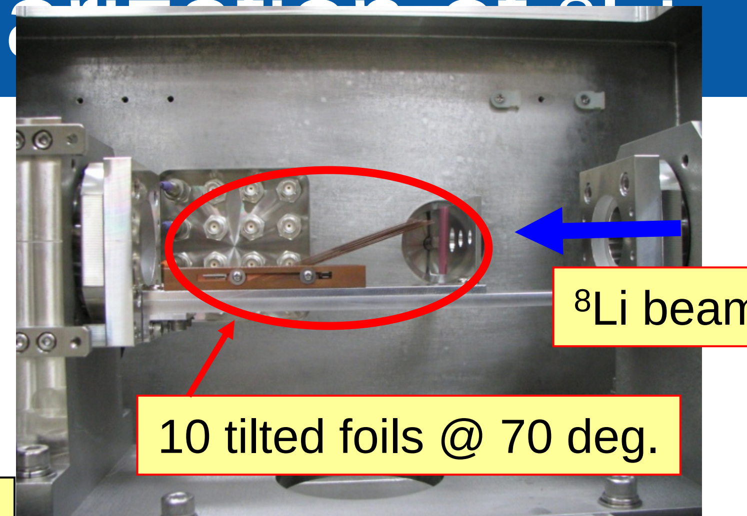
How about higher energy ?
heavier nuclei ?

Application by use of ^{8}Li beam

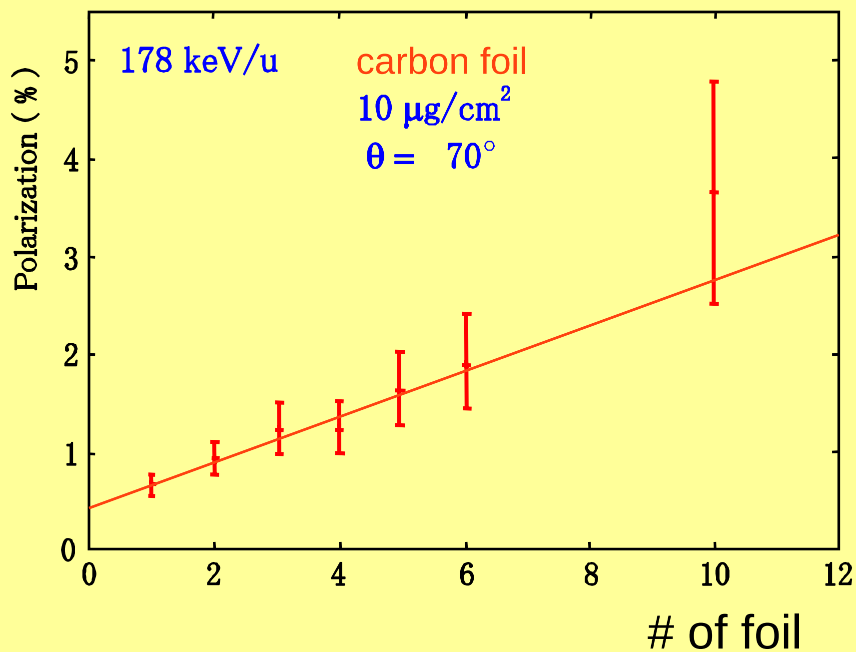
Experiment of pol

Feasibility study of tilted foil method
with ^{8}Li ($I^{\pi}=1^{+}$ $T_{1/2}$=838ms)

Spectroscopy of polarized RNBs
around ^{132}Sn



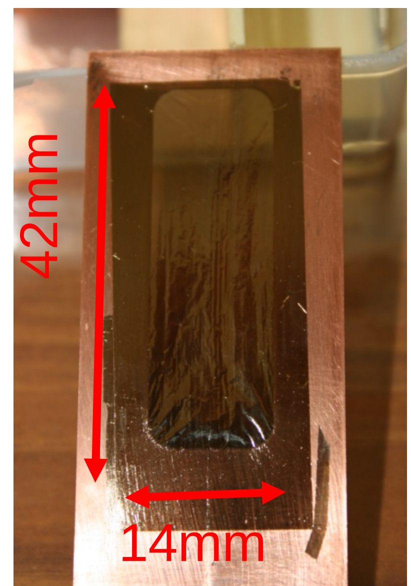
β-NMR setup
Magn
plastic
RF co



T

^{8}Li bea

carbon foil: 10μg/cm^{2} ~ 45 nm
polystyrene foil: 10~30 nm



Y. Hirayama et al.