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

Collaborator

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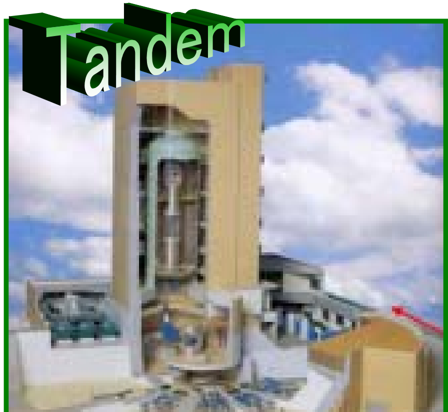
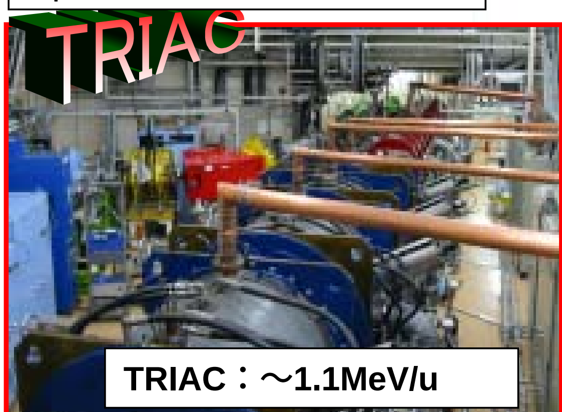
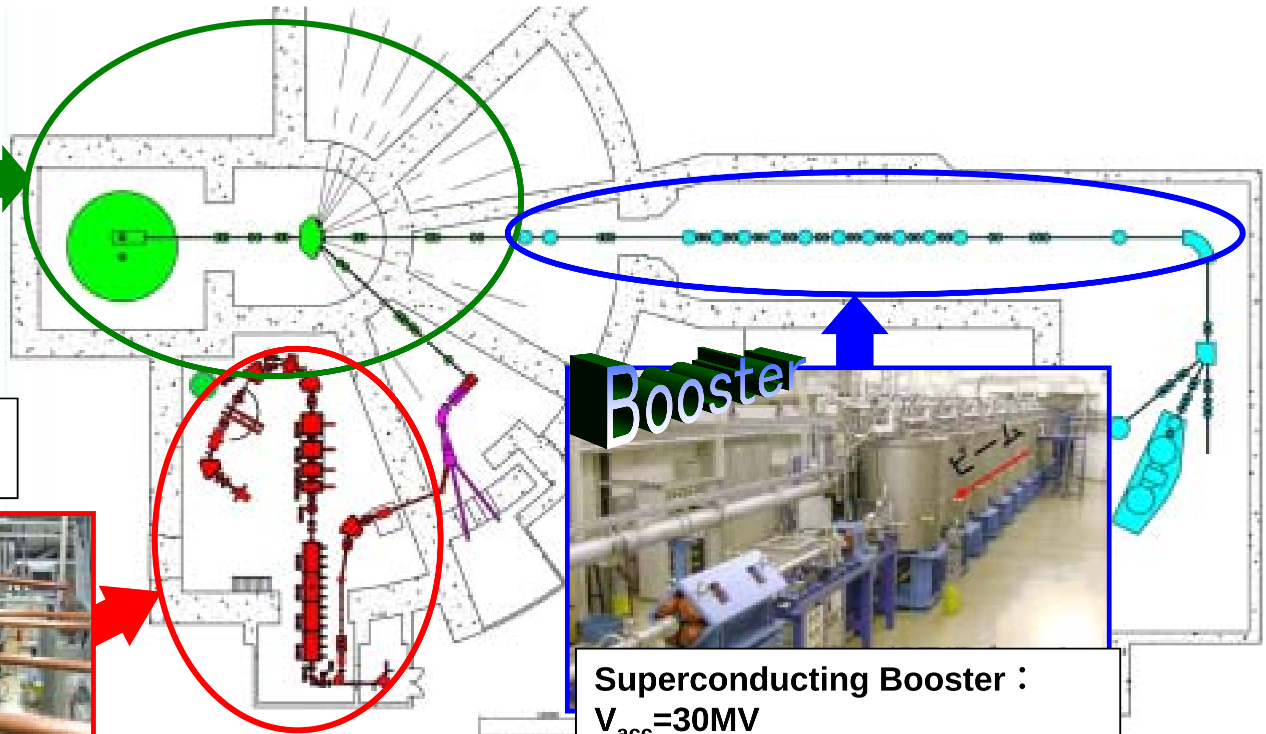
JAEA-Tandem facility



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



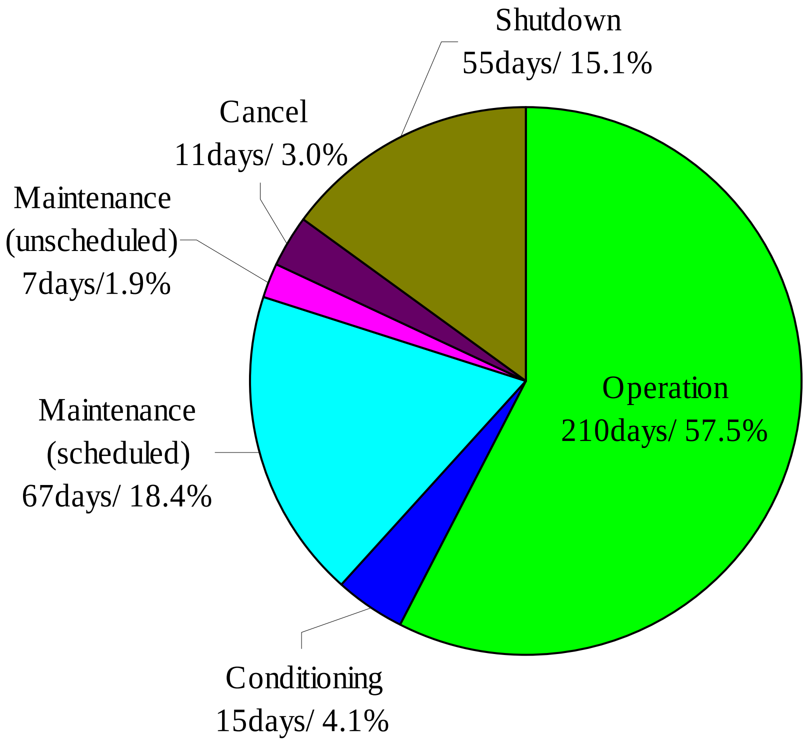
TRIAC：～1.1MeV/u

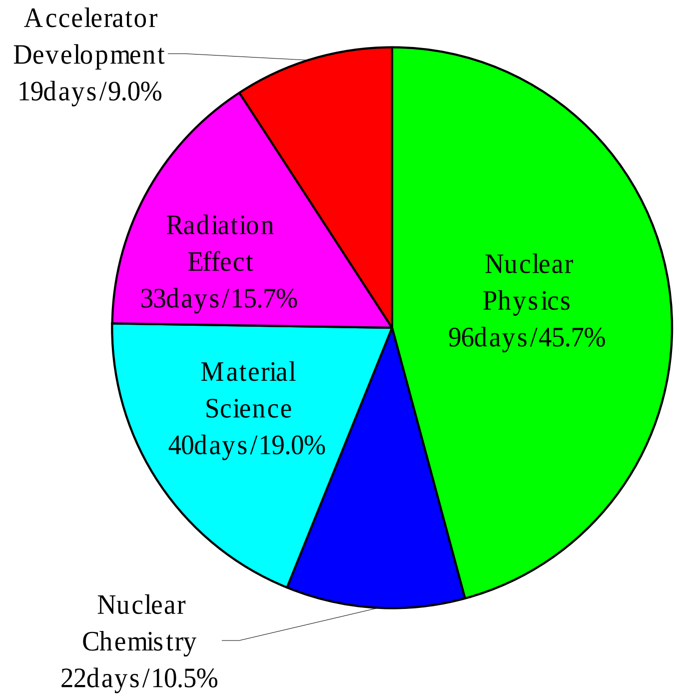


Superconducting Booster：
V_{acc}=30MV

	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)

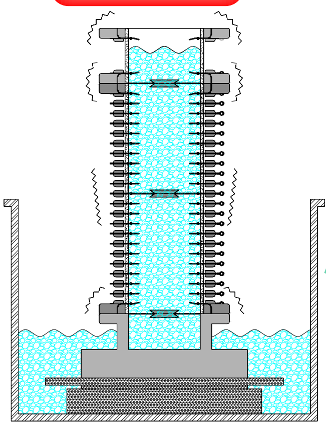
Upgrade of JAEA-Tandem Facility

Replacement of acceleration tubes

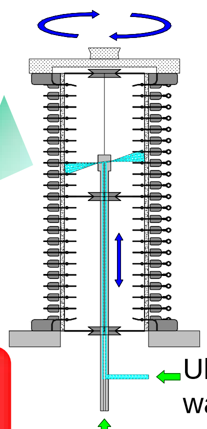
Initial performance of the maximum terminal voltage, V_T =17MV, got worse for years.

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

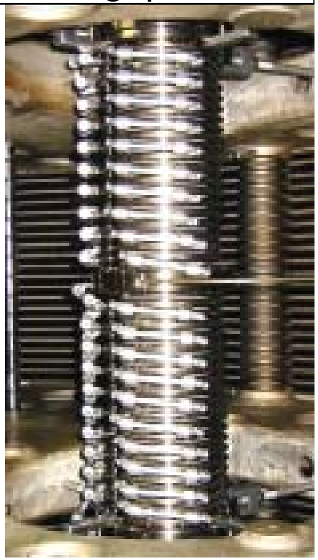
Filled with N_2 gas to store

Original type
33gap/MV

Replaced at Jun. 2003

V_T=18MV

Compressed type
42gap/MV



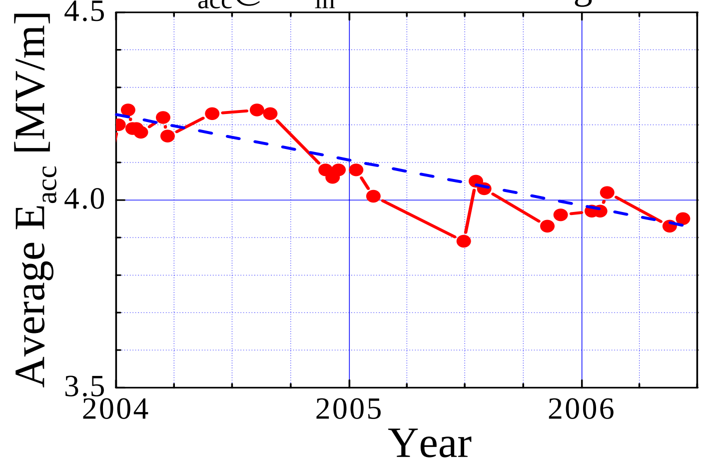
Upgrade of JAEA-Tandem Facility

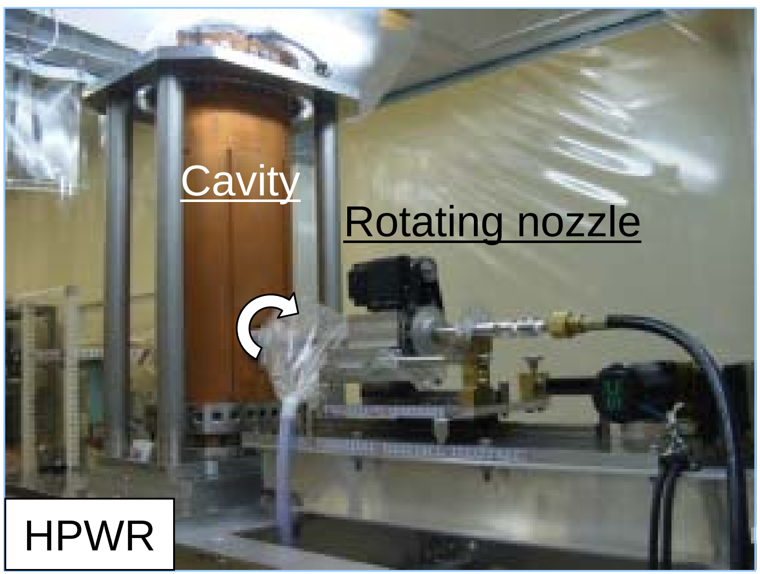
Recover of Superconducting Resonator

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.

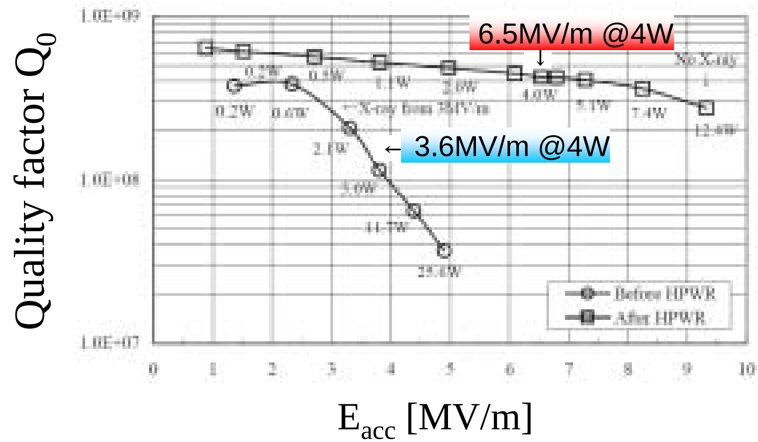
E_{acc}@RF_{in}=4W with the age





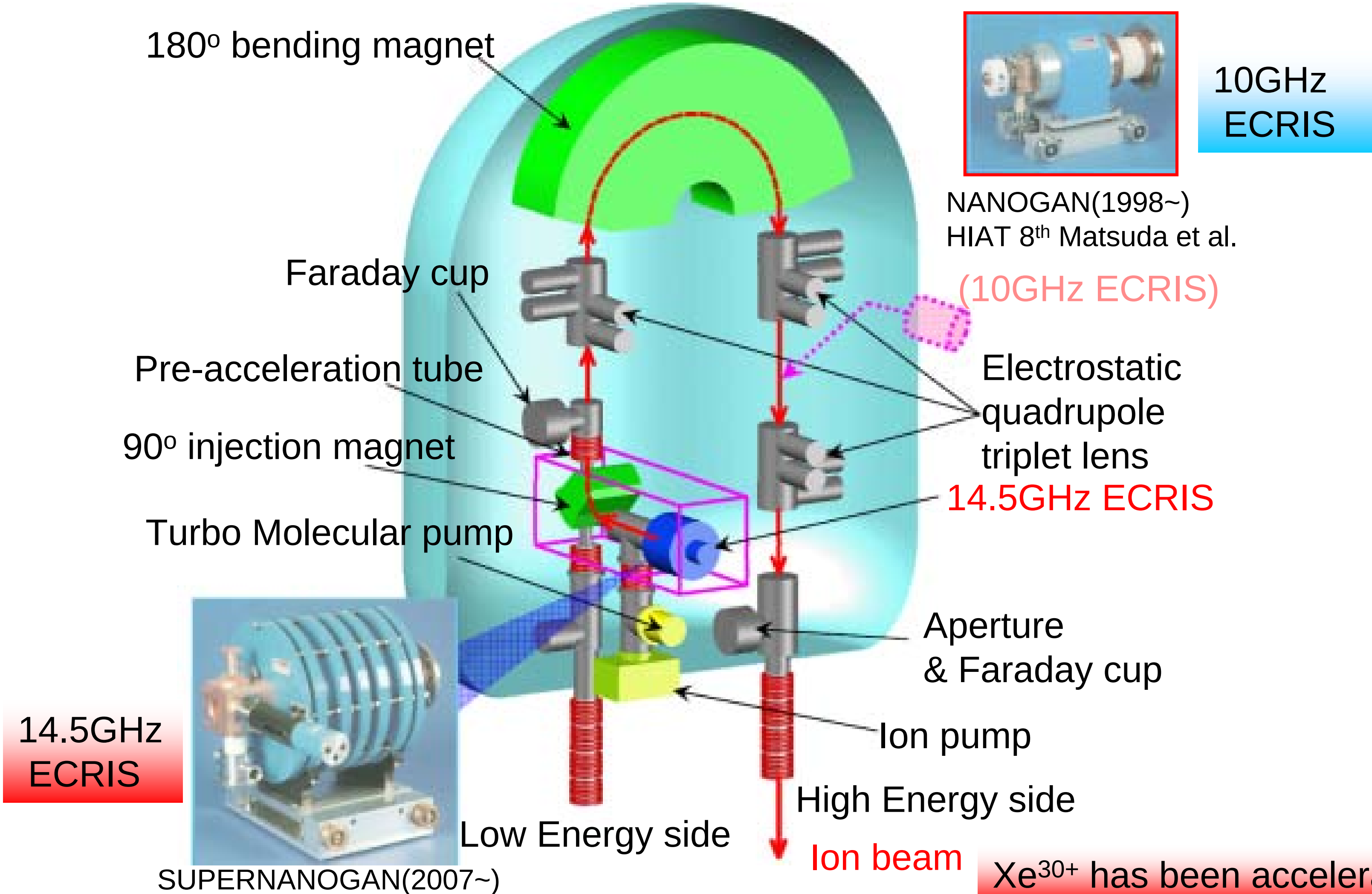
Water flow: 6 l/m, Pressure: 6~8 MPa

Effect of HPWR



Upgrade of JAEA-Tandem Facility

Replacement of in-terminal ECRIS



Xe^{30+} has been accelerated.

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

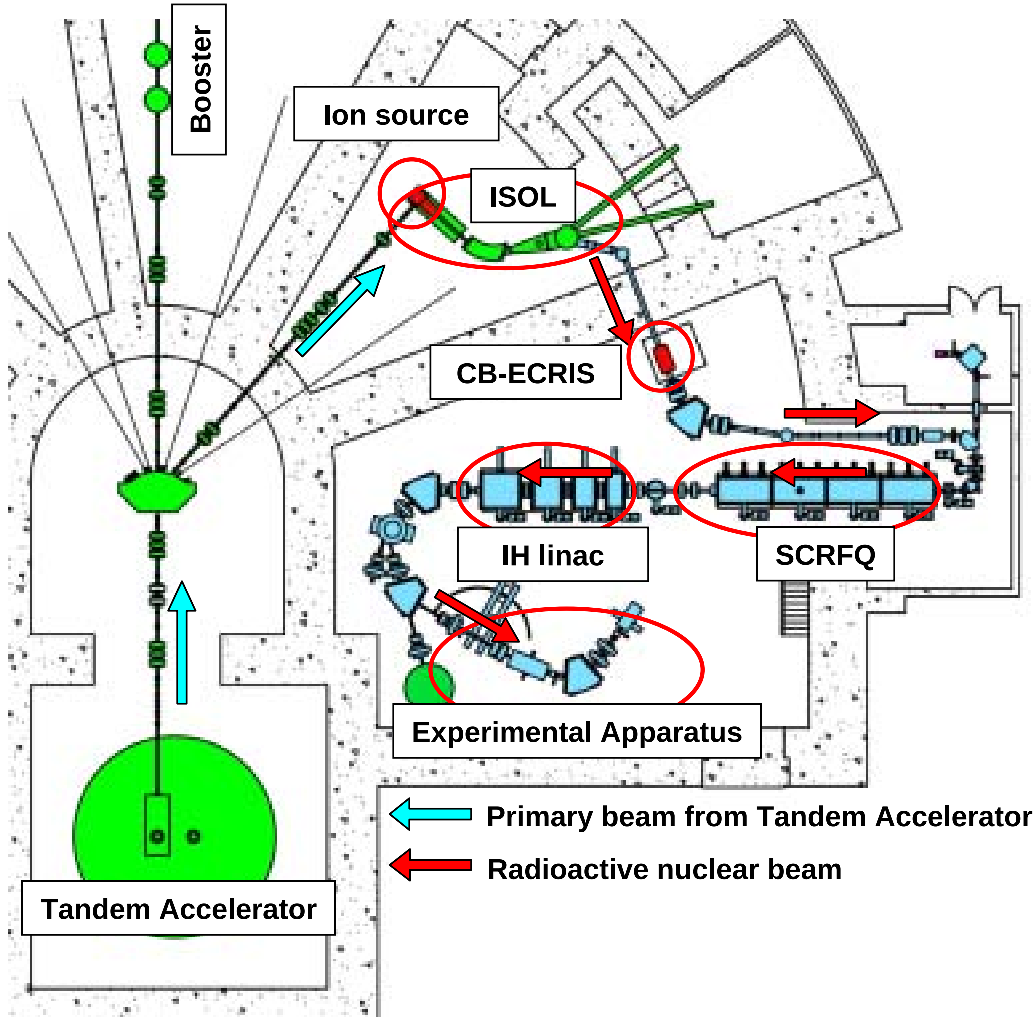
CB-ECRIS: Charge-breed 1+ ion to q+ ion

SCRFQ-linac: Accelerate to 0.17MeV/u

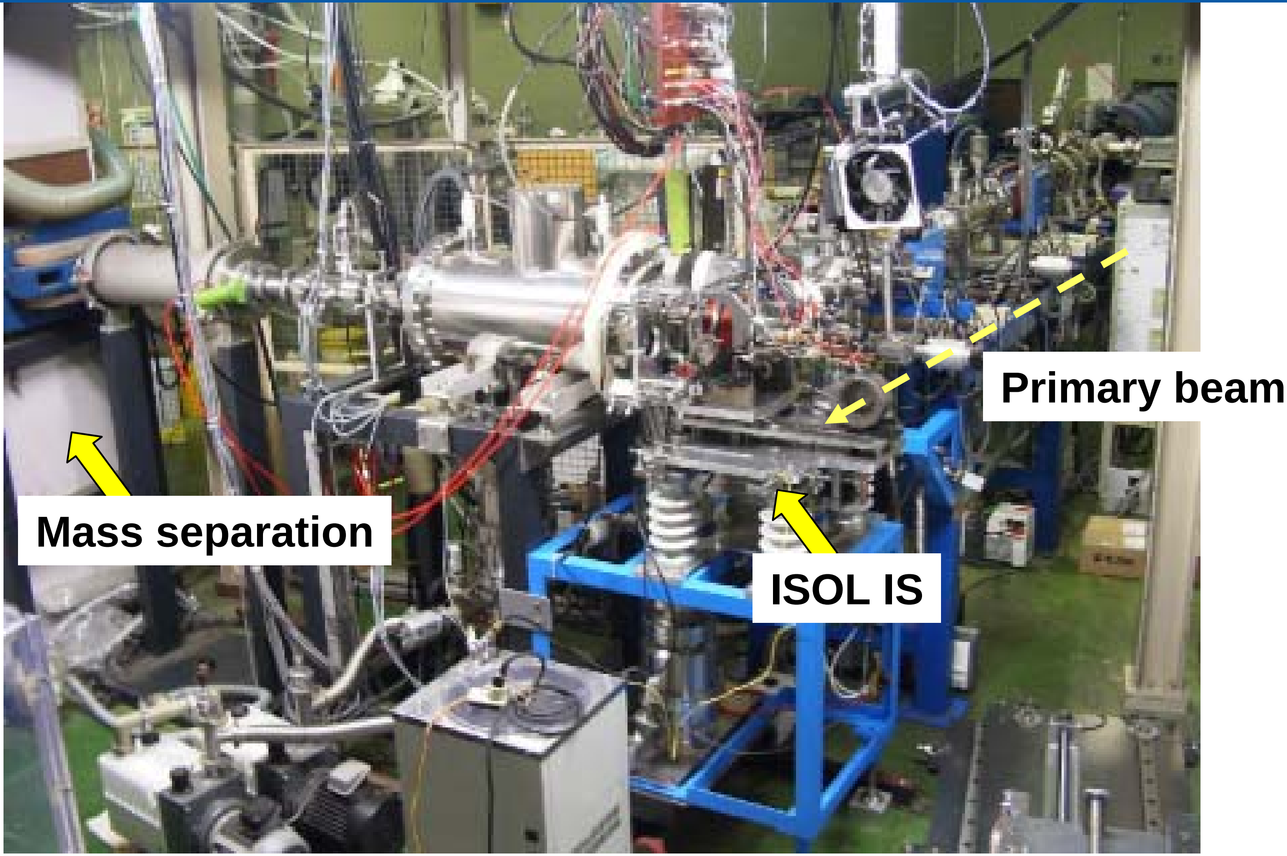
IH-linac: Accelerate to 1.1MeV/u

H^{+}32MeV ~1μA

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



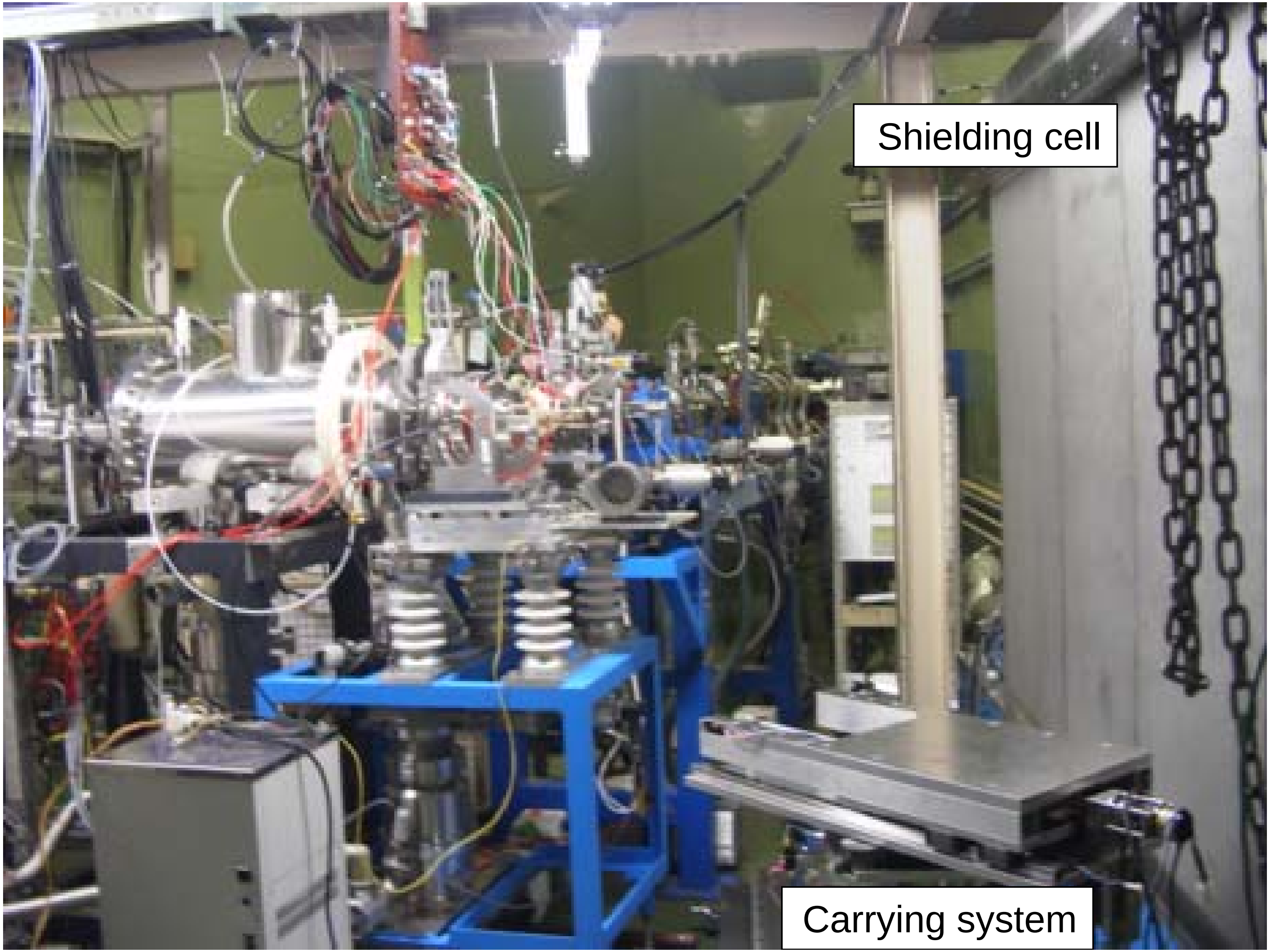
JAEA-ISOL



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

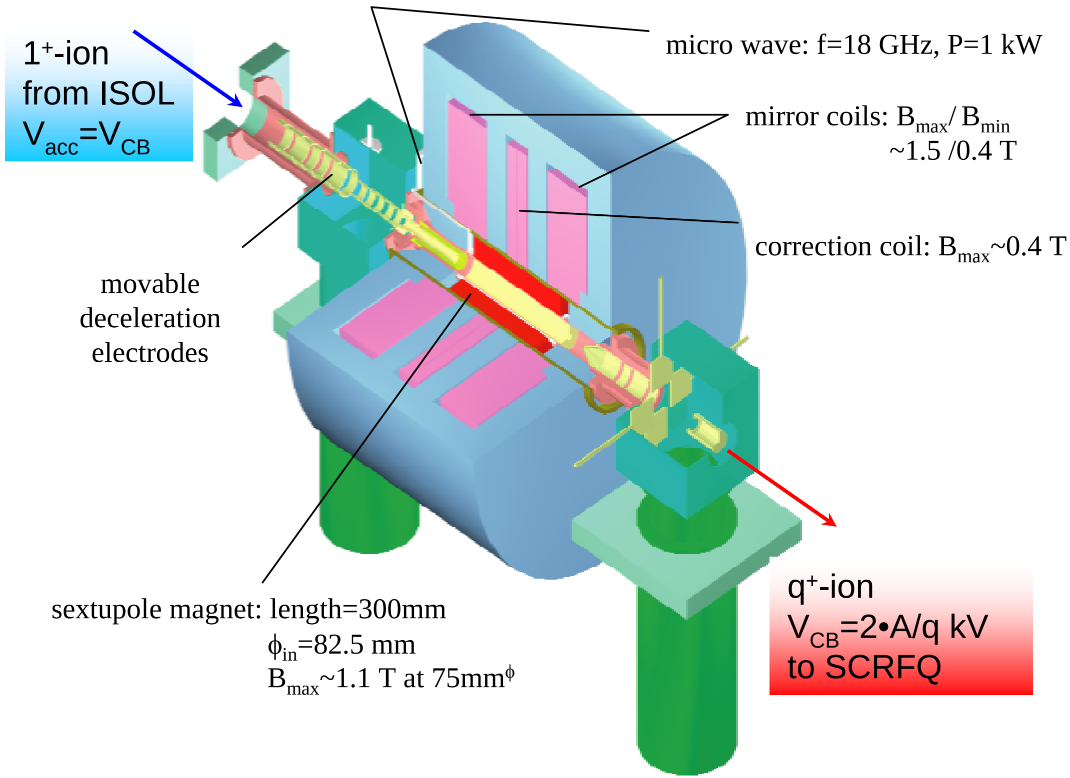
JAEA-ISOL

Safety Handling System of Target-Ion source Module



Tokai Radioactive Ion Accelerator Complex (TRIAC)

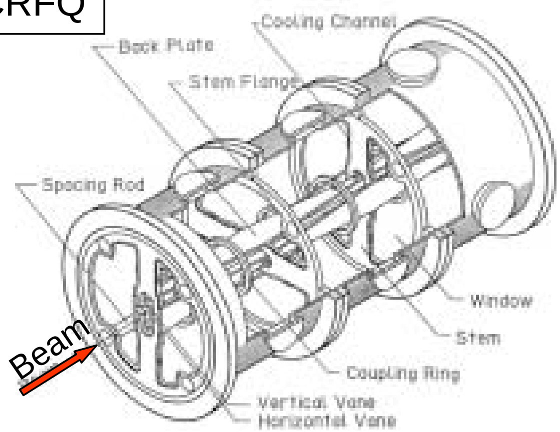
18 GHz ECRIS as the charge breeder

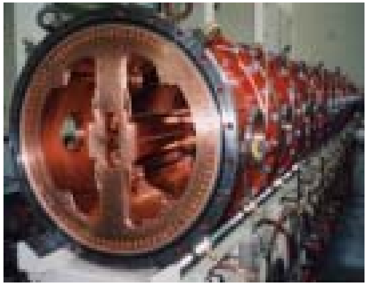


Tokai Radioactive Ion Accelerator Complex (TRIAC)

Performance of Linacs

SCRFQ





Split-coaxial-RFQ (SCRFQ) linac

Very compact (diameter = 0.9m)

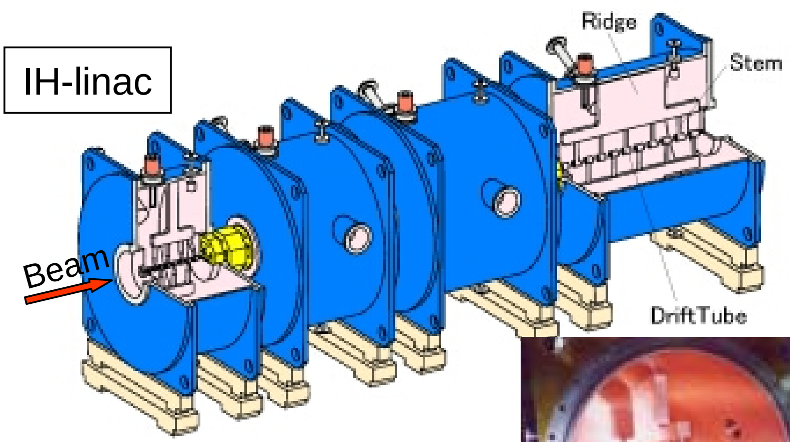
RF frequency	25.96MHz
Input energy	2.1keV/u
Output energy	178kev/u (A/q≤28)
Transmission	>90%
Vane length	8.6m

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

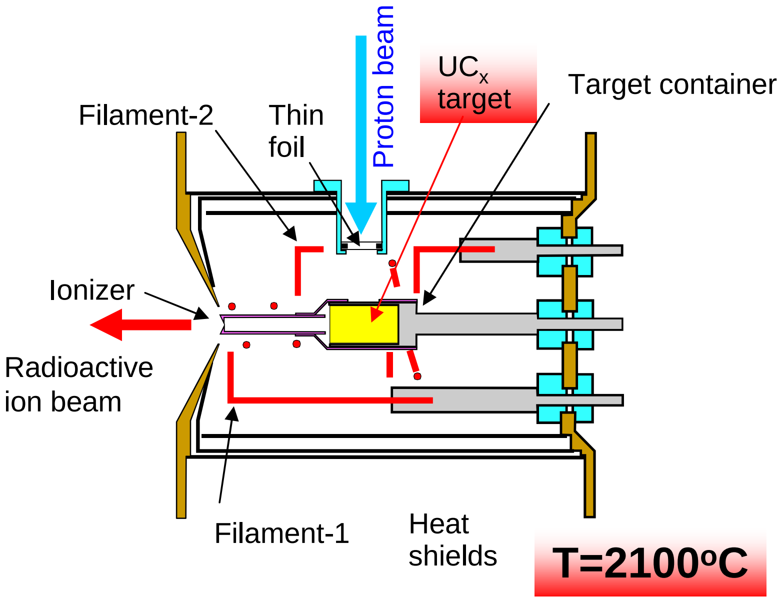
IH-linac



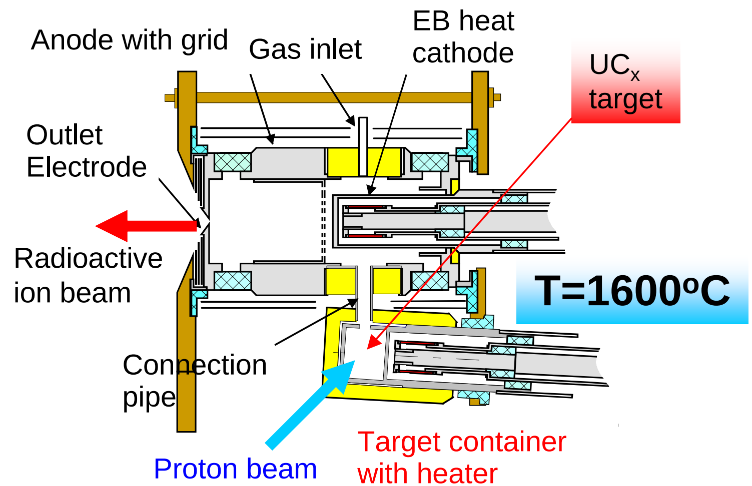
Total transmission of two linacs ~85%

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

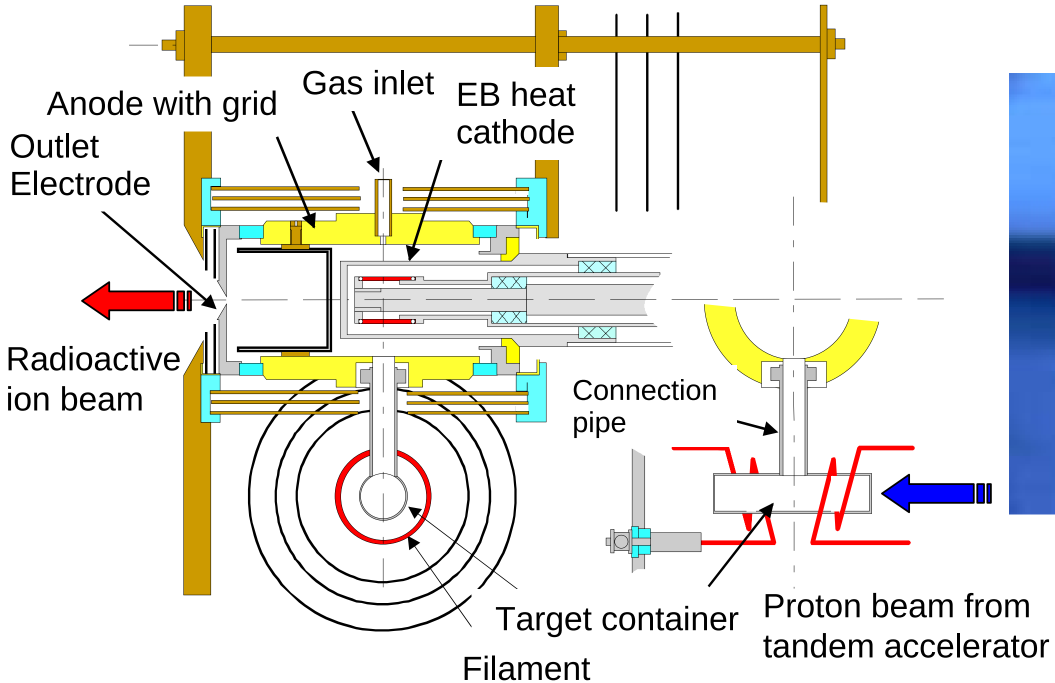
U-FEBAID-E Ion Source

U-FEBIAD-B2 (1600ºC)

Separation efficiencies were miserably decreased for short-lived isotopes.

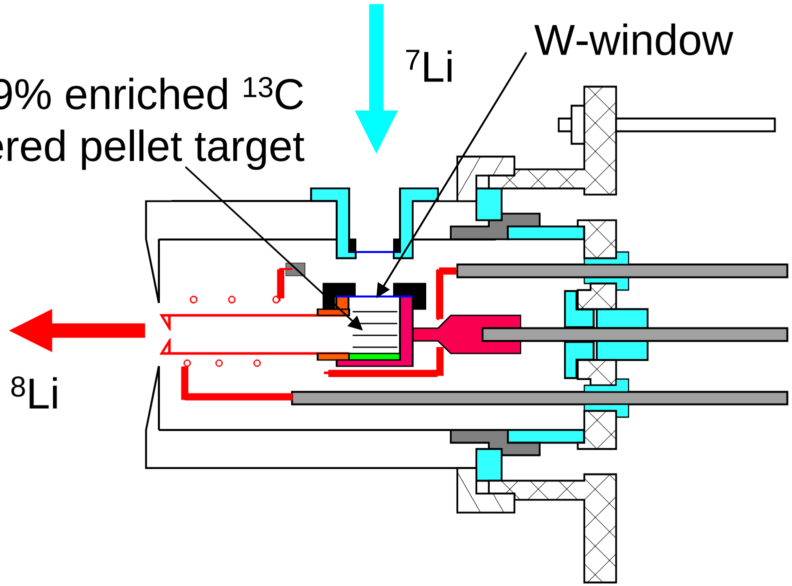
We could not observe short-lived isotpes of In, Sn

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



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

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

1 x 10^{6} ions/s

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

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

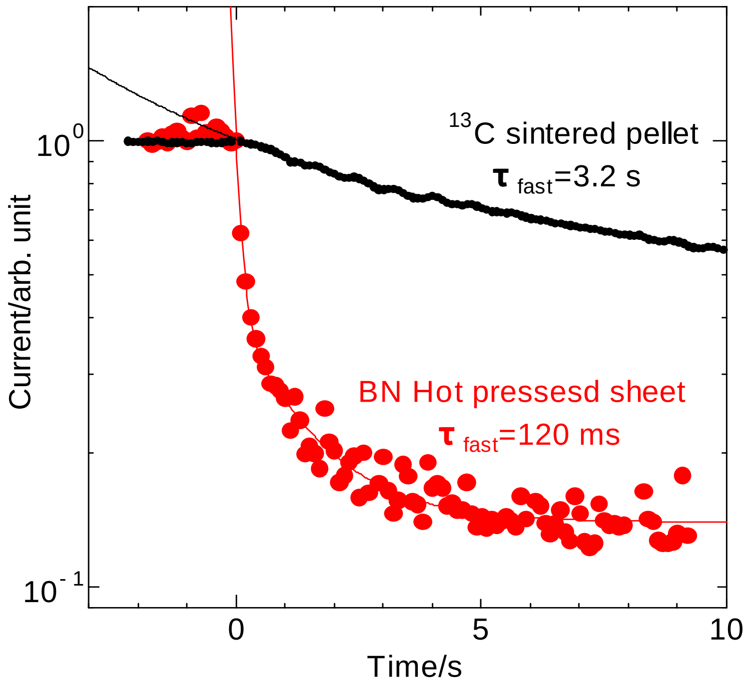
Request: >5 x 10^{3} pps

~~Increase a target weight~~
~~Increase a beam energy/current~~
Increase a release speed?

Development of Target-Ion Source System

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.

Appendix

Development of devices for In-terminal ECR-IS

- Installation environment
  - High-pressure SF_6 : 0.44 MPa
  - High-voltage spark
  - Limited supply capability
  - Limited space
- Countermeasure against High-pressure SF_6
  - Ion source
  - RF power supply
  - Devices
- Surge-protected designing of Control system and devices
- Optimization and simplification of parameters for stable operation
- Construction of maintenance-free and fail-safe system
- TMP Vacuum system under High-pressure SF_6

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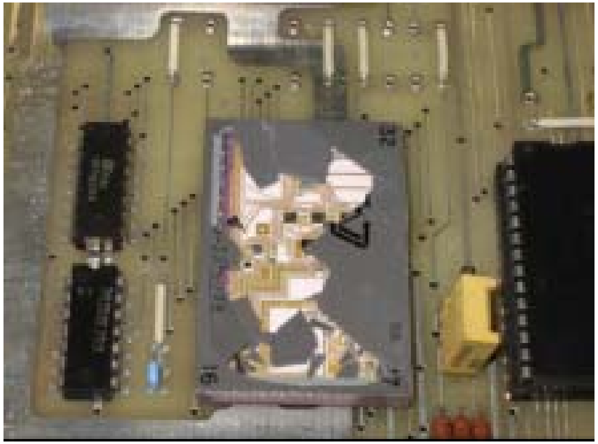
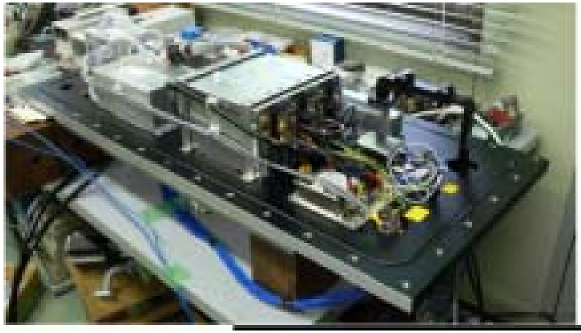
Examples of countermeasure



Broken ADC by High-pressure

After countermeasure



RF power supply assembled in pressure-resistant container

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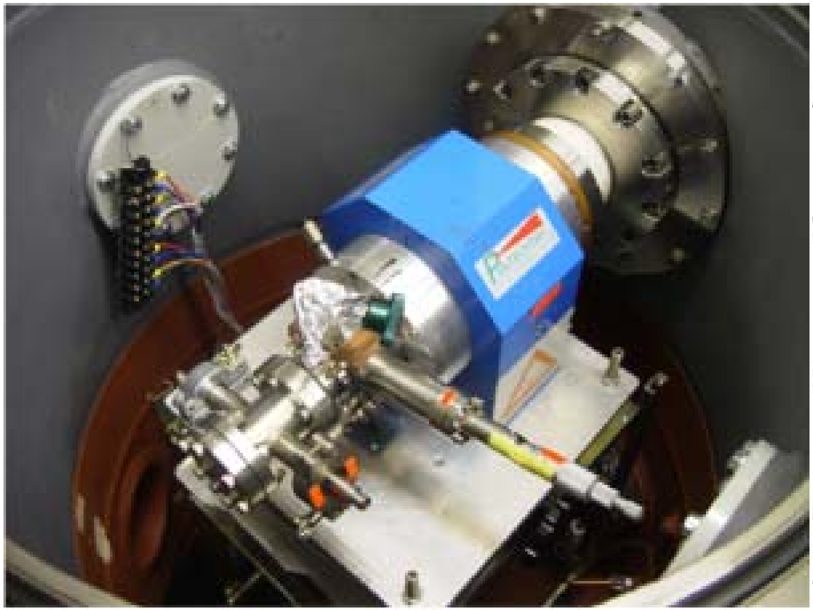
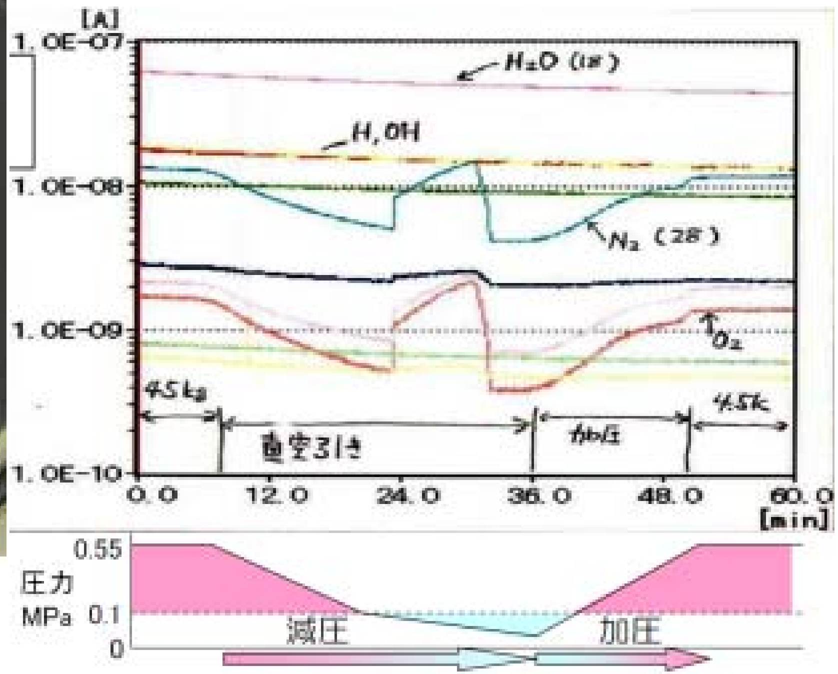
Leakage test by QMS





Leakage test by QMS at the high-pressure test bench.

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Upgrade of control system

Broken FET by surge

Multi-channel control module with optical communication

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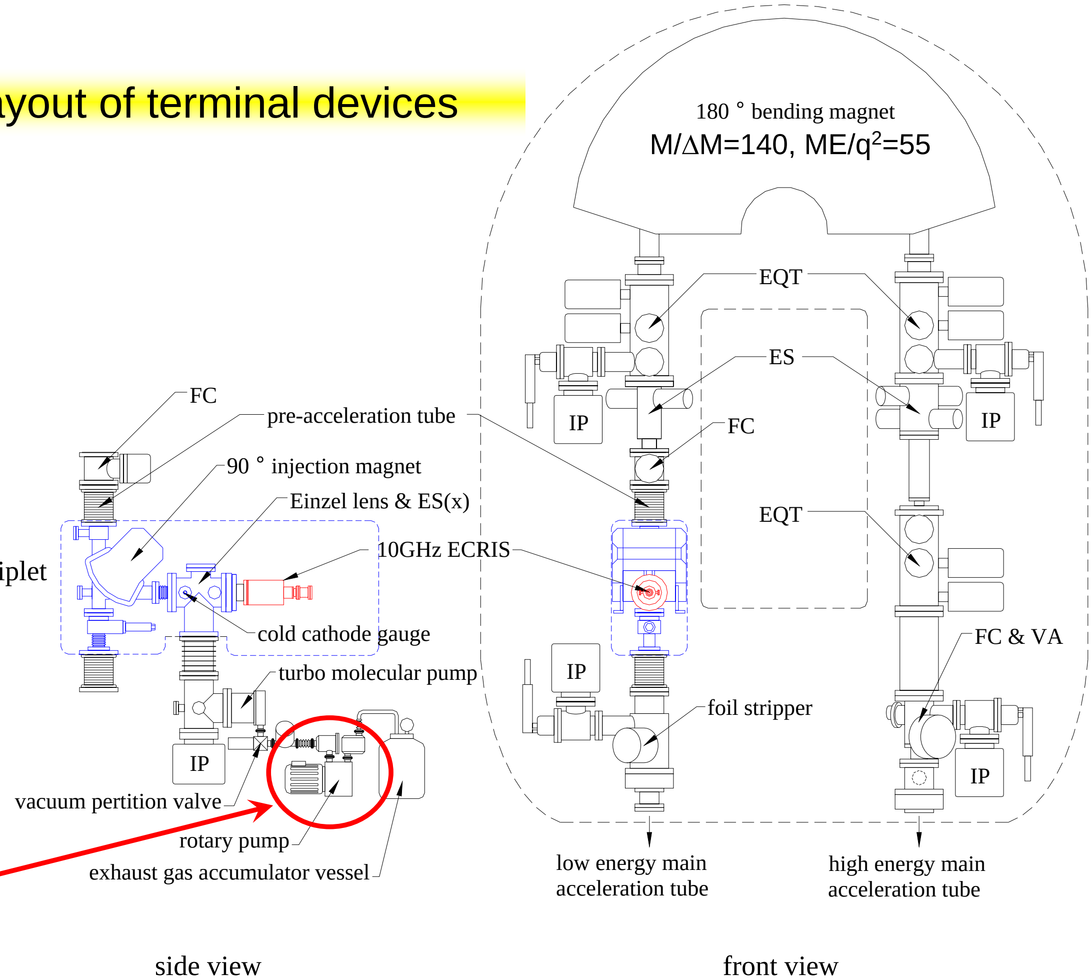
TMP Vacuum system

Layout of terminal devices

0kV potential (terminal)
80kV potential
110kV potential (source)

EQT : electrostatic quadrupole triplet
ES : electrostatic steerer
FC : faraday cup
VA : variable aperture
IP : ion sputter pump



Pressure tightened RP

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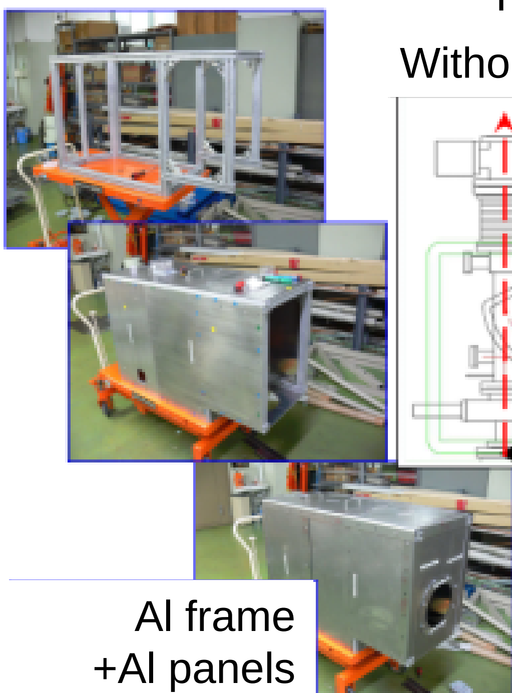
Reduce of leakage field

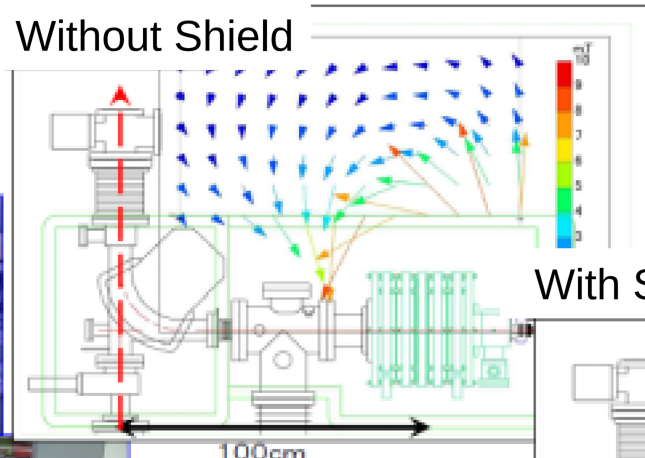
ECR-IS by strong permanent magnet

Leakage field (2 mT@beam line) bent ion beam !!
For the safety of maintenance with machine tools

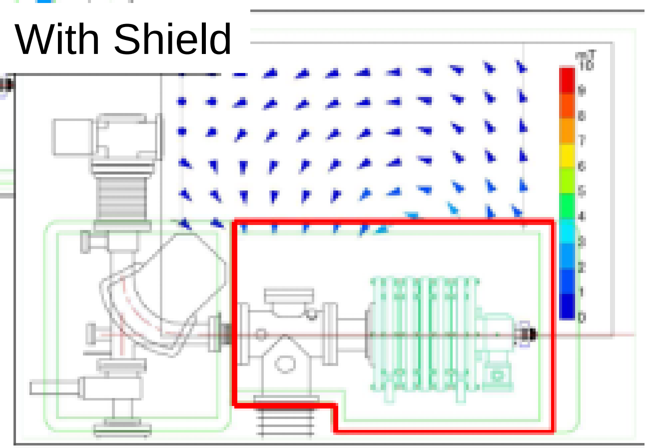


Al frame
+Al panels
+Fe panels

Without Shield



With Shield



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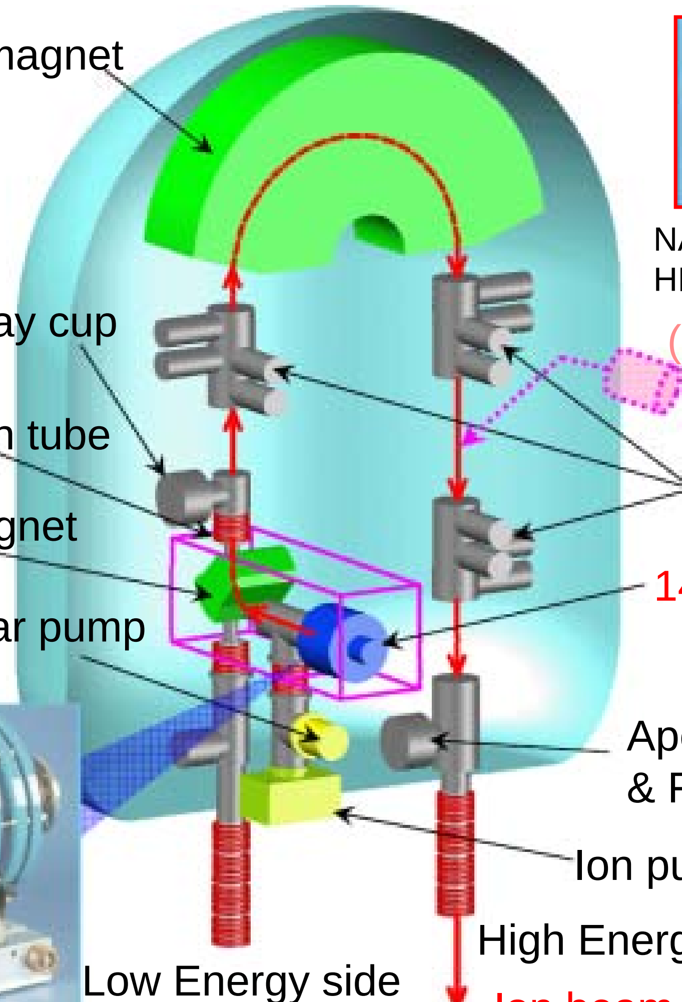
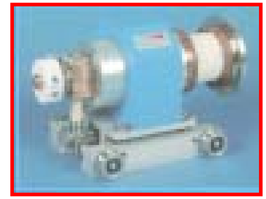
Upgrade of JAEA-Tandem Facility

Replacement of in-terminal ECRIS





10GHz ECRIS

NANOGAN(1998~)
HIAT 8th Matsuda et al.

14.5GHz ECRIS

SUPERNANOGAN(2007~)

Xe^{30+} has been accelerated.

In-terminal ECRIS: SUPERNANOGAN

Acceleration results and performance