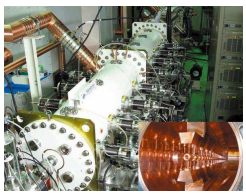
Installation of a compact injector at HIMAC

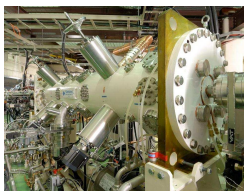
Toshinobu Sasano[A)] , Izumi Kobayashi[A)] , Masahiro Kawashima[A)] , Yusei Kageyama[A)] , Wataru Takasugi[A)]
Takeshi Takeuchi[A)] , Tetsuya Sakuma[A)] , Noriyuki Sasaki[A)] , Tadahiro Shiraishi[A)] , Keita Fukushima[A)] ,
Yoshiyuki Iwata[B)] , Masayuki Muramatsu[B)] , Eiichi Takada[B)]
A) Acclerater Engineering Coporation, 6-18-1 Konakadai, Inage-ku, Chiba-shi 263-0043, JAPAN
B) National Institute of Radiological Sciences, 4-9-1 Anagawa, Inage-ku, Chiba-shi 263-8555, JAPAN

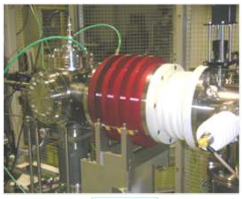
1. COMPACT INJECTOR

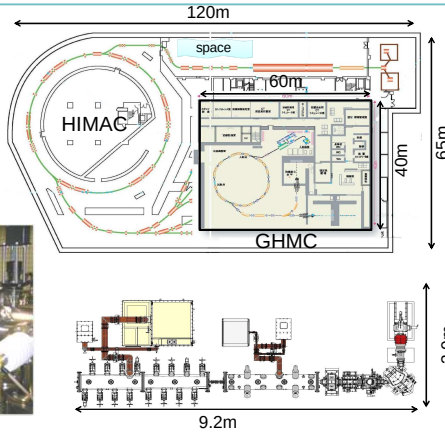
The compact injector system is a product of the R&D activity at NIRS to reduce the size and cost of the machine. Successful results led Gunma University to adapt the system model for GMHC, Gunma University Heavy Ion Medical Center.

The R&D machine can provide a carbon beam to the existing HIMAC synchrotron.


APF IH-DTL


RFQ


ECRIS



	Parameter	Unit	Compact injector Value	HIMAC injector Value
Ion source	Ion kind	–	$^{12}C^{4+}$	$^{12}C^{2+}$
	Energy	keV/u	10	8
	Extraction voltage	kV	30	24
RFQ	Injector energy	keV/u	10	8
	Extraction energy	keV/u	608	800
	Operating frequecy	MHz	200	100
	Tank inner diameter	mm	339	590
	Tank length	mm	2480	7250
	Required power	kW	120	186
	Maximum duty	%	0.4	0.4
DTL	Injector energy	keV/u	608	800
	Extraction energy	MeV/u	4	6
	Operating frequecy	MHz	200	100
	Tank inner diameter	mm	400-440	2160-2200
	Tank length	mm	3437	23877
	Required power	kW	360	2760
	Maximum duty	%	0.4	0.4

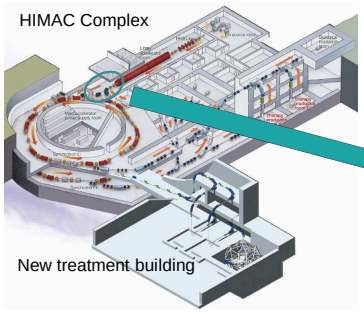
2. INSTALLATION OF COMPACT INJECTOR AT HIMAC

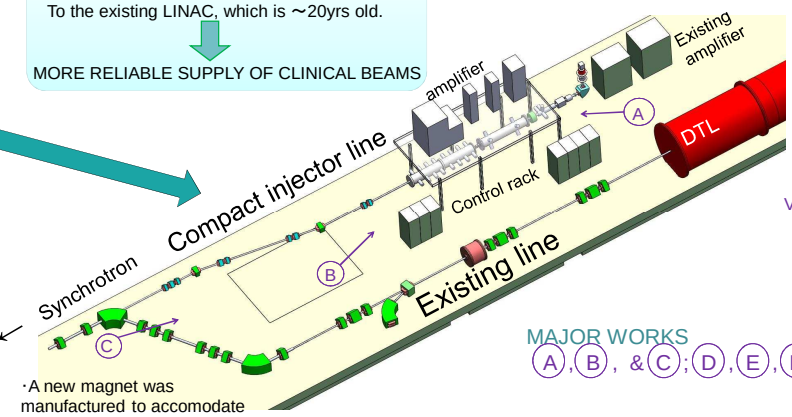
2.1 Installation of the injector

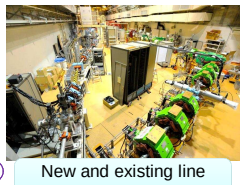
AIM!

BACKUP
To the existing LINAC, which is ～20yrs old.

MORE RELIABLE SUPPLY OF CLINICAL BEAMS



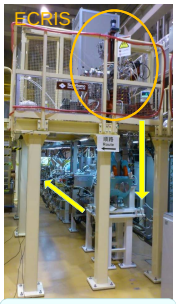



View from Ⓒ
New and existing line from the confluence

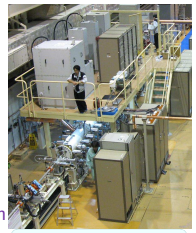
·A new magnet was manufactured to accomodate the straight line from the compact injector.

Installation was completed in March, 2011.

MAJOR WORKS
Ⓐ, Ⓑ, & Ⓒ; Ⓓ, Ⓔ, Ⓕ

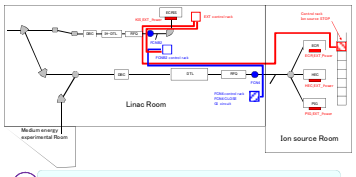


View from Ⓐ
Vertical arrangement of the ion source

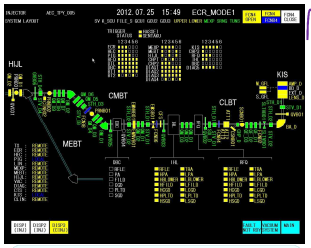

View from Ⓑ
Amplifiers are housed on the deck

2.2 Update of the control system

·Operability Improvement



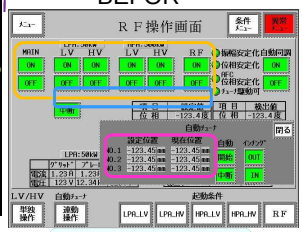
Ⓓ Changes to the safety-circuit diagram



Ⓔ Compatible Display with existing control system I/F

Ⓕ

BEFOR



Local Display at R&D environment

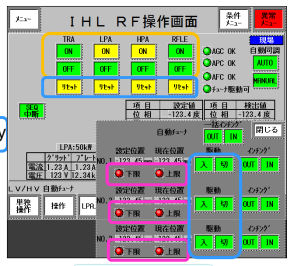
Operator view

The same specifications as the existing.

Improvement of operability

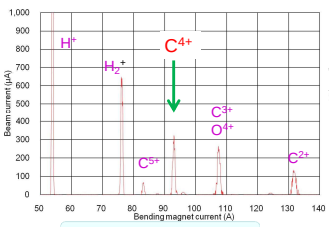
Additional necessary information

AFTER

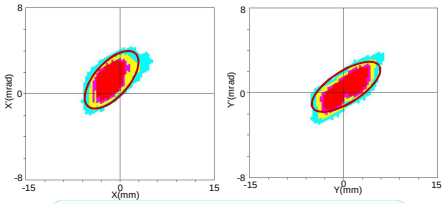


Local Display after installation

2.3 Beam commissioning



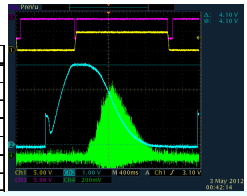
The spectrum of ECRIS



IH-DTL
Phase space distribution of extracted beam
X-axis（Left）Y-axis(Right)

Beam current and efficiency

Mesurement place	Beam current	Efficiency
Ion source	290 eμA	—
RFQ entrance	290 eμA	100 %
IH-DTLexit	240 eμA	83 %
After charge conversion($C^{4+}\rightarrow$)	300 eμA	125 %
Synchrotron entrance	5.77E+10 pps	100 %
Synchrotron acceleration	2.02E+9 pps	3.5 %
Synchrotron extraction	2.00E+9 pps	99.13 %


BLUE：DCCT
(Output in the ring)
GREEN：RMON2
(Beam current of extracted beam)

Acceleration and extraction from the synchrotron

3. PRESENT STATUS AND OUTLOOK

The compact injector was installed, and the beam initial effort began in March 2011. We have succeeded in adjusting the incident beam and have extracted the beam from the synchrotron. The intensity of the extracted beam was sufficient to ensure the standard quality treatment.

We are continuing to adjust in order to obtain the stability of the beam needed to treatment.

The installed compact injector gives us two linacs for CIRT, Carbon Ion Radiation therapy.