International Training Course on Carbon-Ion Radiotherapy

NOVEMBER 28 – DECEMBER 3, 2016

NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCES (NIRS)

GUNMA UNIVERSITY HEAVY ION MEDICAL CENTER (GHMC)

	28,Nov. Mon.	29,Nov. Tue.	30,Nov. Wed.	1,Dec. Thu.	2,Dec. Fri.	3,Dec. Sat.
9:00	Opening address Guidance of Curriculum Overview of Ion Beam Radiotherapy	Physics 4-1 Beam Delivery and Dosimetry Passive Beam Delivery	Topics Radiation emergency exposure	Move to Gunma Univ.	Move to Gunma Univ.	Tour GHMC
9:30	Physics 1 Basic Knowledge	Physics 4-2 Beam Delivery and Dosimetry Scsnning Beam Delivery	Clinical 3 Lung Tumors			
10:00		Break	Break		Facility set-up & operation overview	Wrap up & Free Discussion
10:30	Physics 2 Accelerators	Physics 6 Radiation Protection for Facility Design	Clinical 4 Esophagus, HCC and Liver		Facility set-up & operation Accelerator Facility set-up & operation Irradiation	
11:00	Introduction of Participants	Physics 5 Facility Design	Clinical 5 Pancreas, Rectum		Facility set-up & operation Biology	Closing Address
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17:00						
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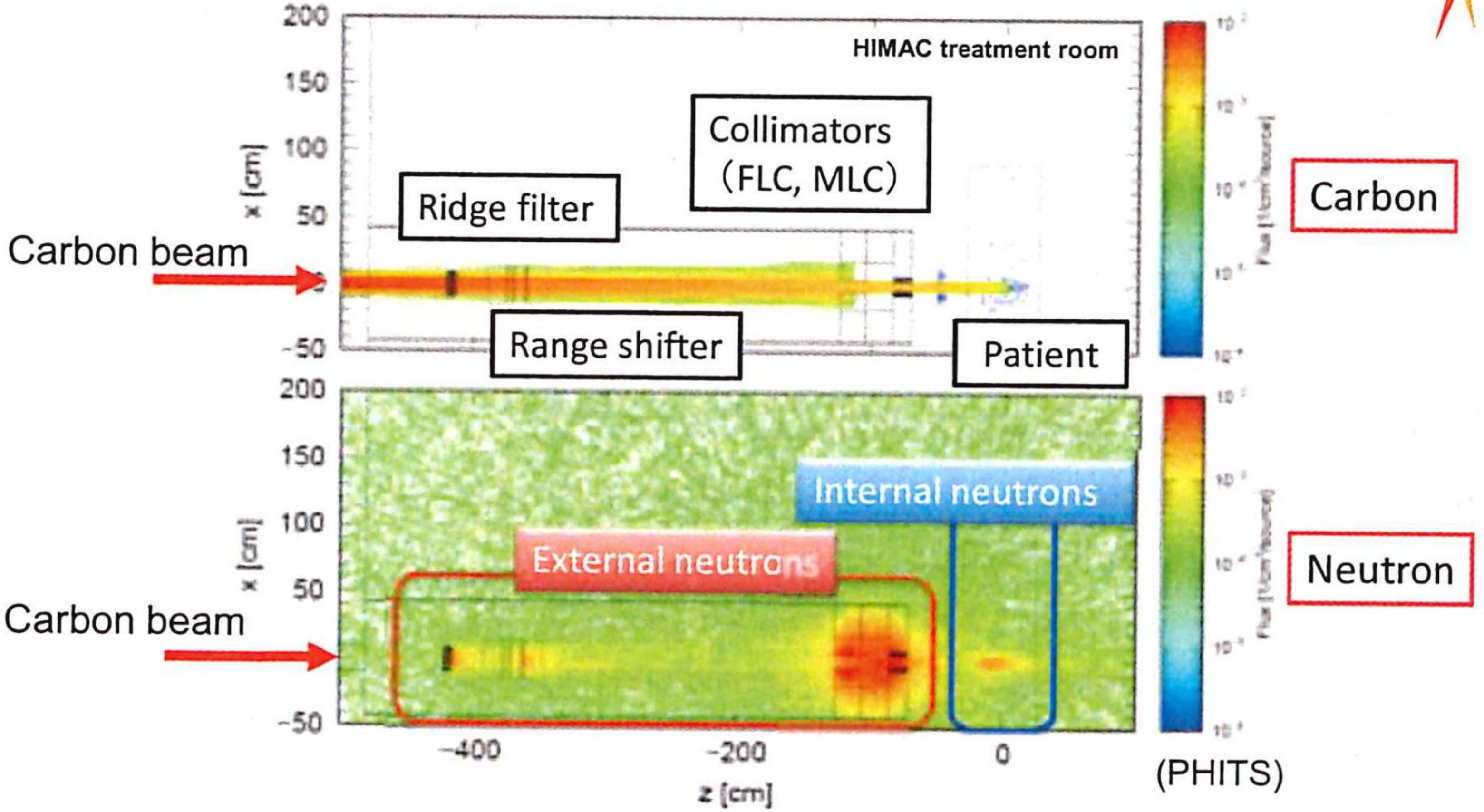
18:00						
18:30						

ITCCIR-2016 Program

Where are secondary neutrons produced? (Passive beam)



Production of secondary neutrons, resulting in unwanted dose to patient

Neutrons from which device contribute to patient dose the most?

NIRS HIMAC

Passive beam: Collimators ➔External neutrons

Active beam: Water (Patient) ➔ Internal neutrons

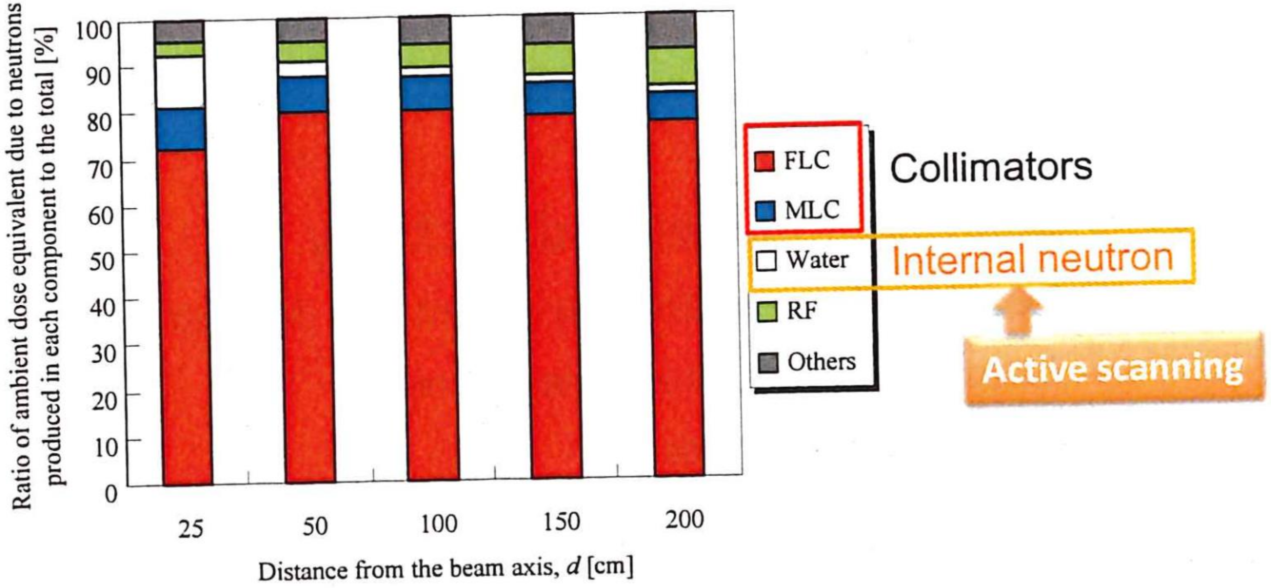


Fig.: Calculated ambient dose equivalent assuming the HIMAC beam line with passive method .

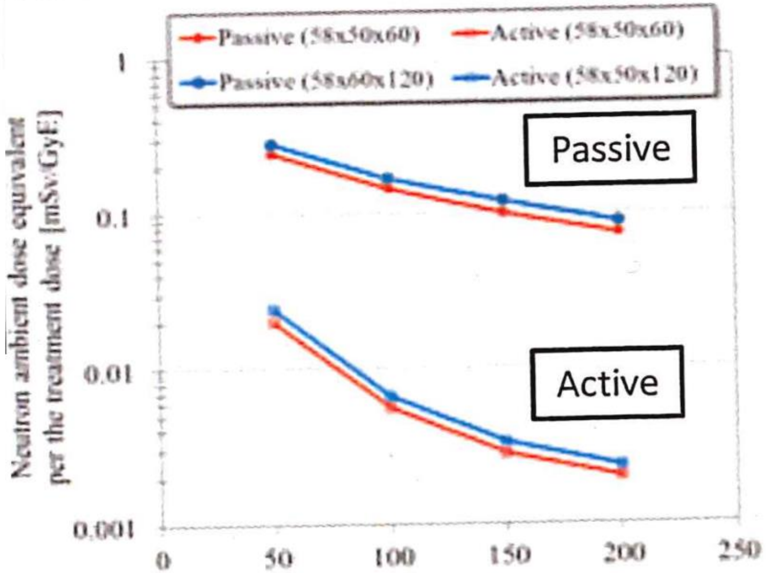
S. Yonai, N. Matsufuji, and T. Kanai, Med. Phys. 36: 4830-4839, 2009

Neutron contributions from beam devices

Comparison of measured neutron H*(10) at patient position between passive and active methods

Max. beam energy: 400MeV/u

Neutron ambient dose equivalent per treatment dose [mSv/Gy]



Distance from beam axis, d [cm]

- The difference was larger as the position became farther from beam axis. (~8%@d=50 cm, ~3%@ d≧150 cm)
  - External neutrons (produced in beam line devices): Passive >> Active
  - Internal neutrons (produced in a patient): Passive≒Active

S. Yonai et al., Radiat. Prot. Dosimetry, pp. 1–4, Oct. (2013). doi: 10.1093/rpd/nct251

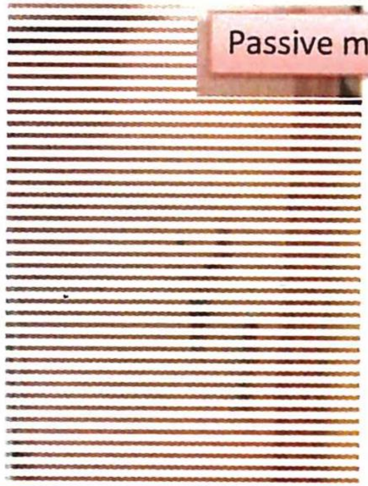
Comparison between the passive and active Carbon beam

Door of the treatment room

NIRS HIMAC

- Secondary neutrons in active scanning method reduce greatly.
- This leads to more flexible design of treatment room.

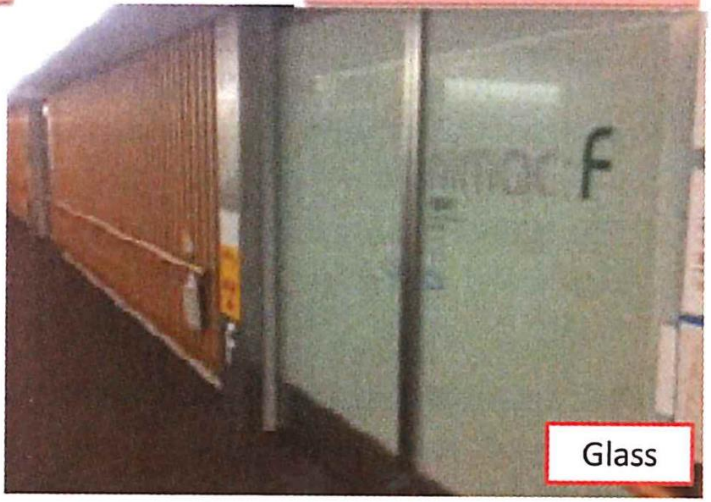
Passive method



B loading polyethylene (100 mm thick) in between 9 mm thick Irons

HIMAC

Active scanning method



Glass

New treatment room

Illustrating the flexibility of treatment room design with active beam

NIRS HIMAC

Nuclides produced in the CIRT treatment room

- Measurements with Portable HP-Ge detector

Radioactive nuclide	Half life	HIMAC*	New treatment facility*
Na-25	59.6 [s]	D	-
Al-28	2.24 [m]	D	D
Mg-27	9.46 [m]	D	D
Mn-52m	21.1 [m]	D	D
Sc-44	3.93 [h]	D	-
Na- 24	15.0 [h]	D	D
Co-55	17.5 [h]	D	-
Sc- 47	3.35 [d]	D	-
Mn- 52	5.59 [d]	D	-
V-48	15.9 [d]	D	D
Cr- 51	27.7 [d]	D	-
Fe- 59	44.5 [d]	D	-
Co- 58	70.9 [d]	D	-
Co-56	77.3 [d]	D	D
Sc- 46	83.8 [d]	D	D
Zn- 65	244 [d]	D	-
Co- 57	272 [d]	D	-
Mn- 54	312 [d]	D	D
Na- 22	2.60 [y]	D	-
Co- 60	5.27 [y]	D	-

* D: detected, -: Not detected

Detected nuclides in the CIRT treatment room

Occupational exposure

- There are many medical workers including physicians, radiological technologists (RTs) , medical physicists, nurses, and operators.
- RTs can receive the highest level of occupational exposures, because they generally have many opportunities to approach activated devices.
- Annual doses to RTs working in HIMAC were estimated based on measurements with the Si-semiconductor personal dosemeter.
  (S. Yonai et al., Radiat. Prot. Dosim., 170, 322-325, 2016.)
- The estimated annual $H_p(10)$ values with passive and active beams were estimated to be **less than 100 µSv and 10 µSv**, respectively.
- For occupational exposures, the dose limits recommended by ICRP are 20 mSv/year for effective dose.
  ➔ Annual doses for RTs in CIRT are much less than the dose limit.
  (This can depend on the number of patients, workflow and skills etc.)

Estimated annual dose to medical workers, occupational exposure

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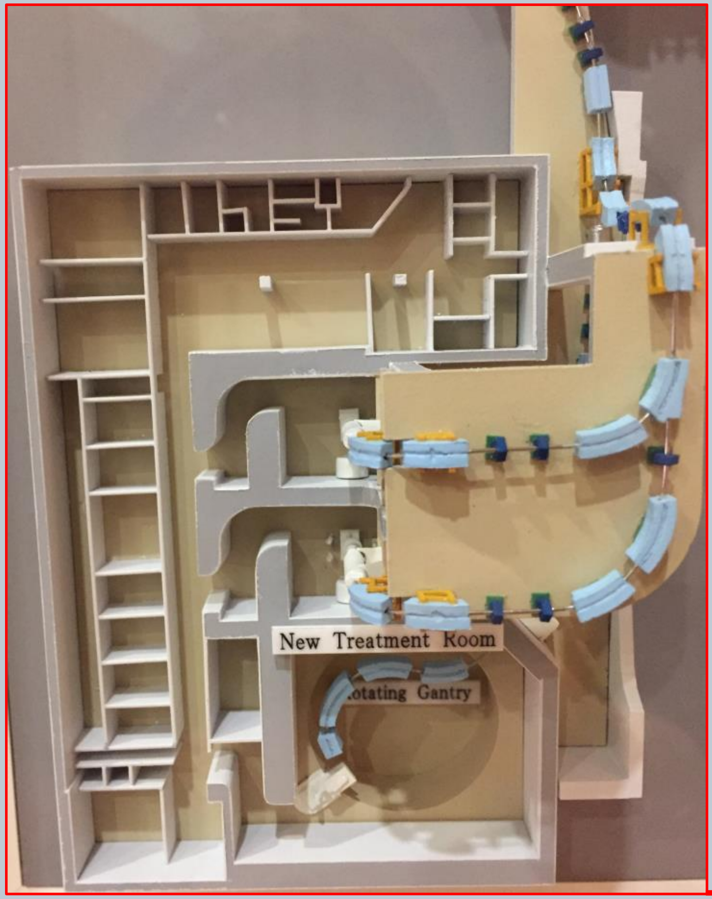
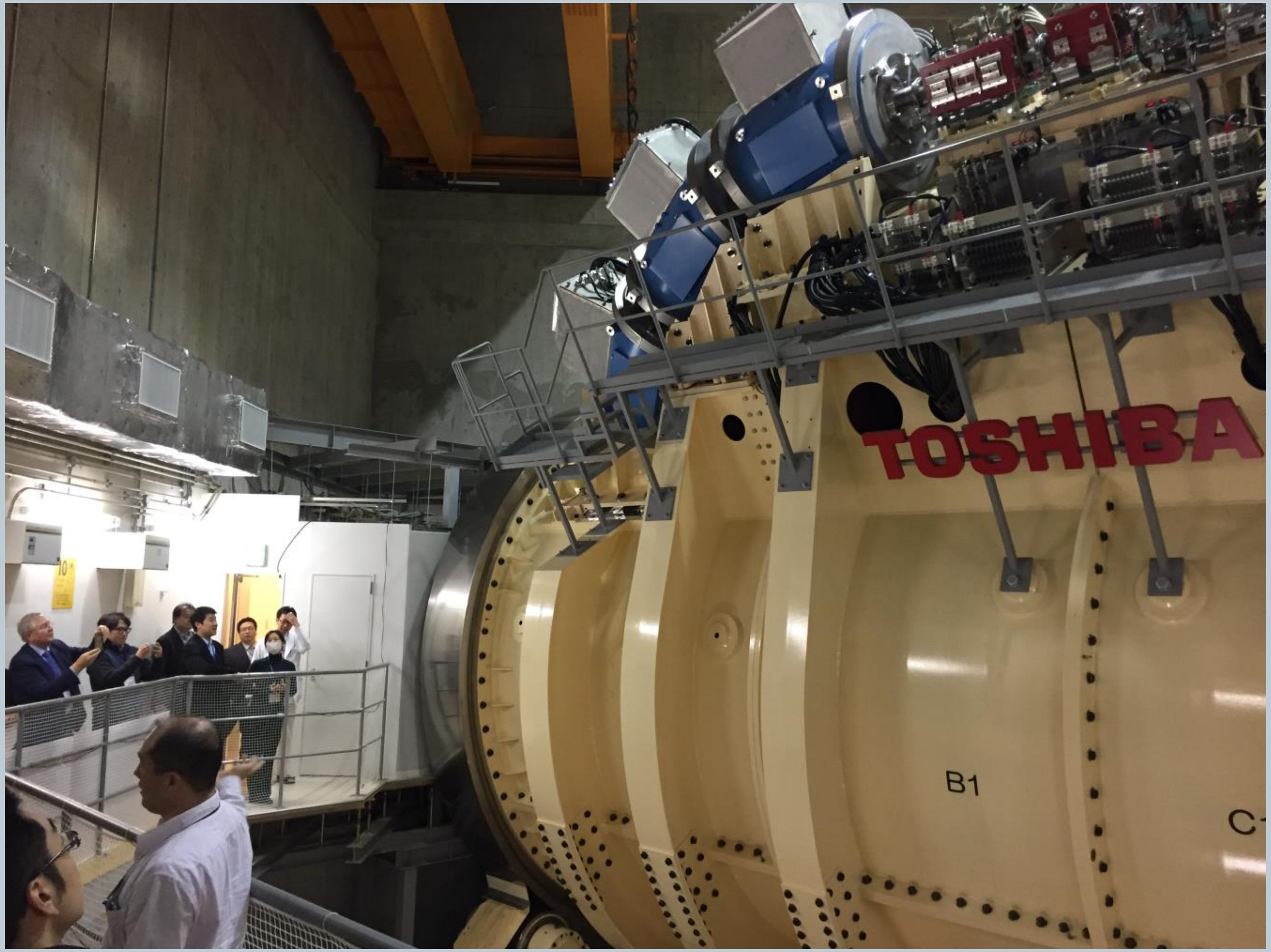
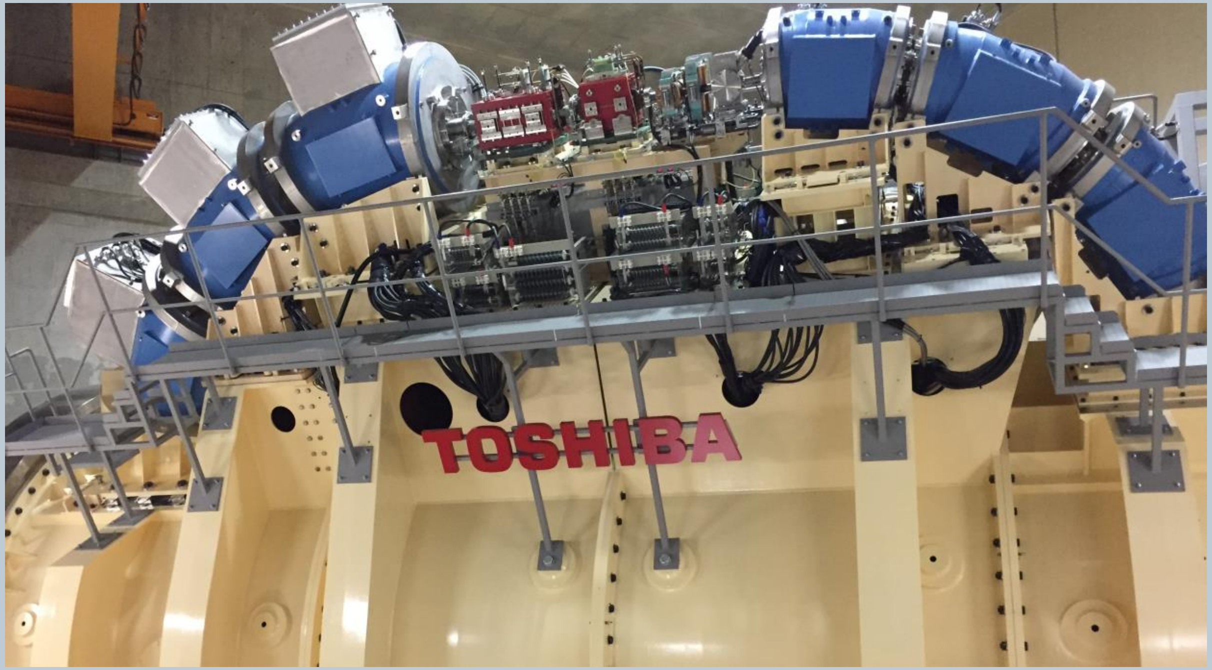


Model of Treatment Rooms at NIRS

Model of the NIRS Heavy Ion Medical Accelerator in Chiba

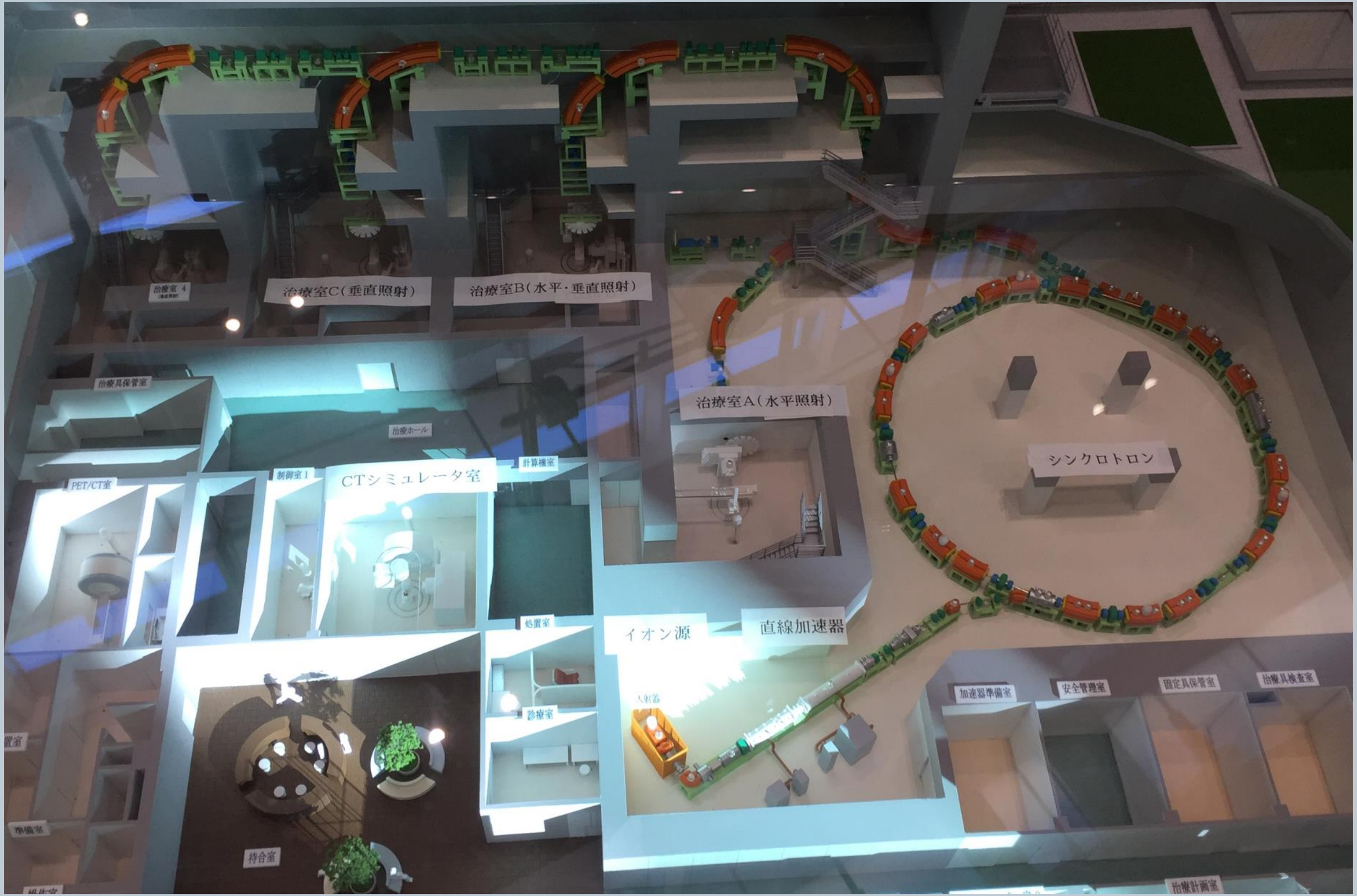
Treatment room with rotating gantry at NIRS



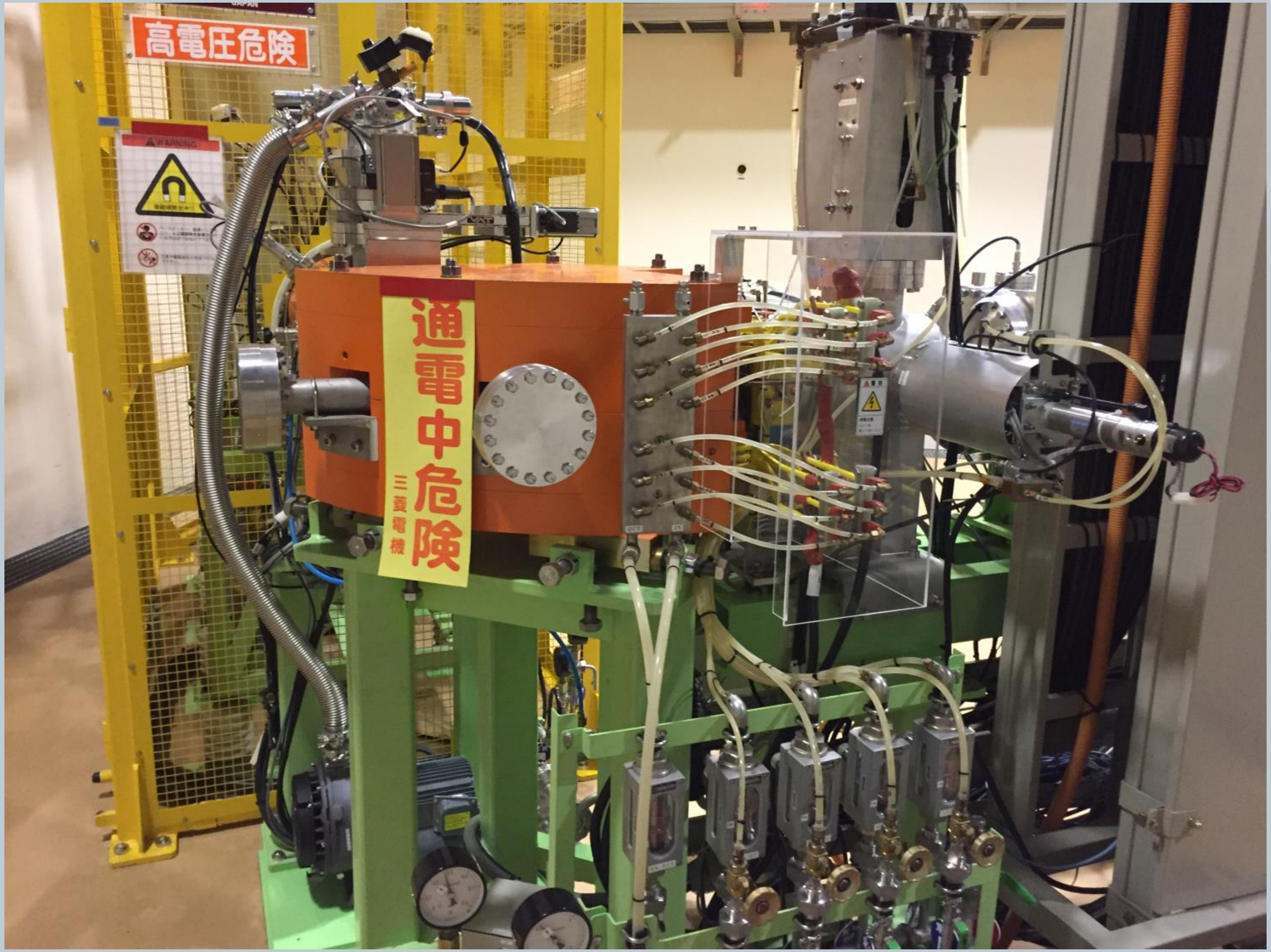


Behind the scenes of the treatment room with the rotating gantry at NIRS

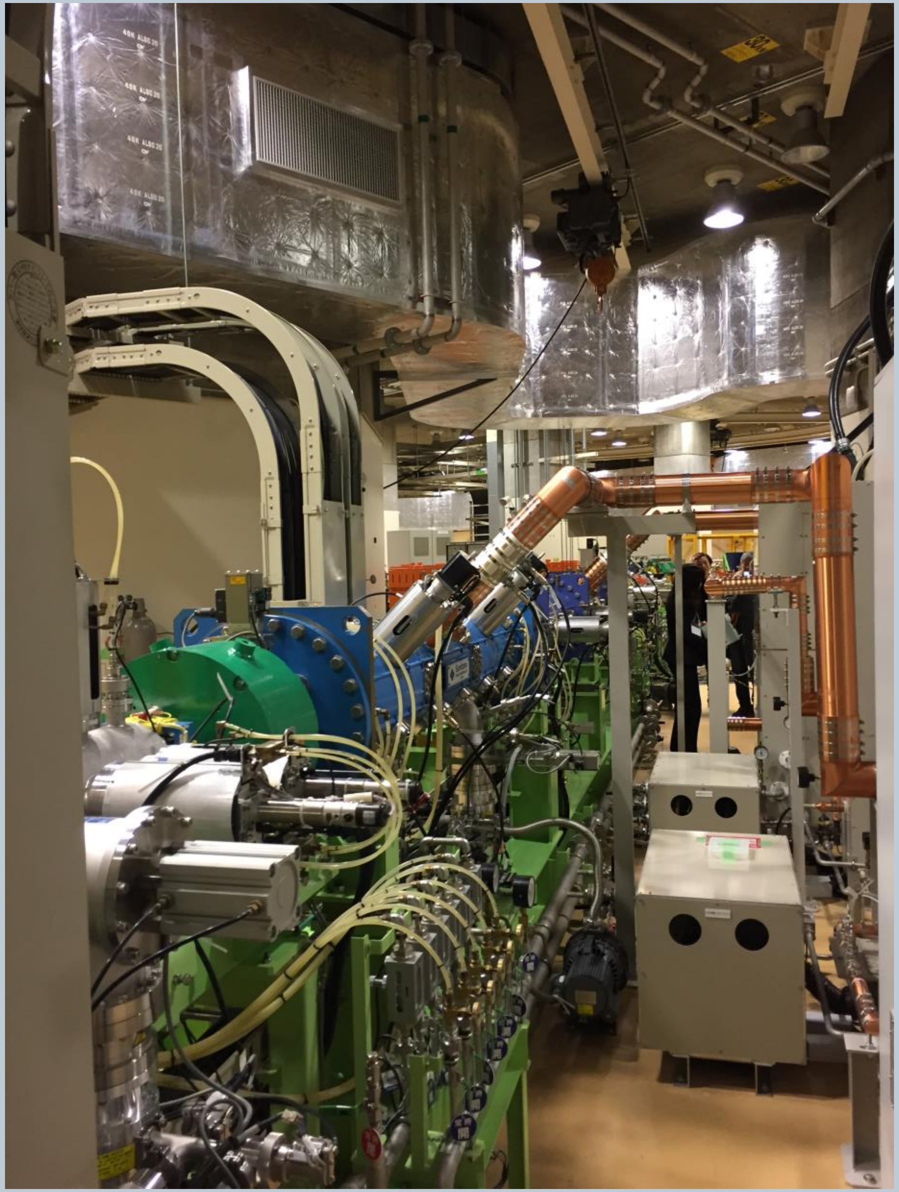
Behind the scenes of the treatment room with the rotating gantry at NIRS



Model of the Gunma University Heavy Ion Medical Center



Ion source

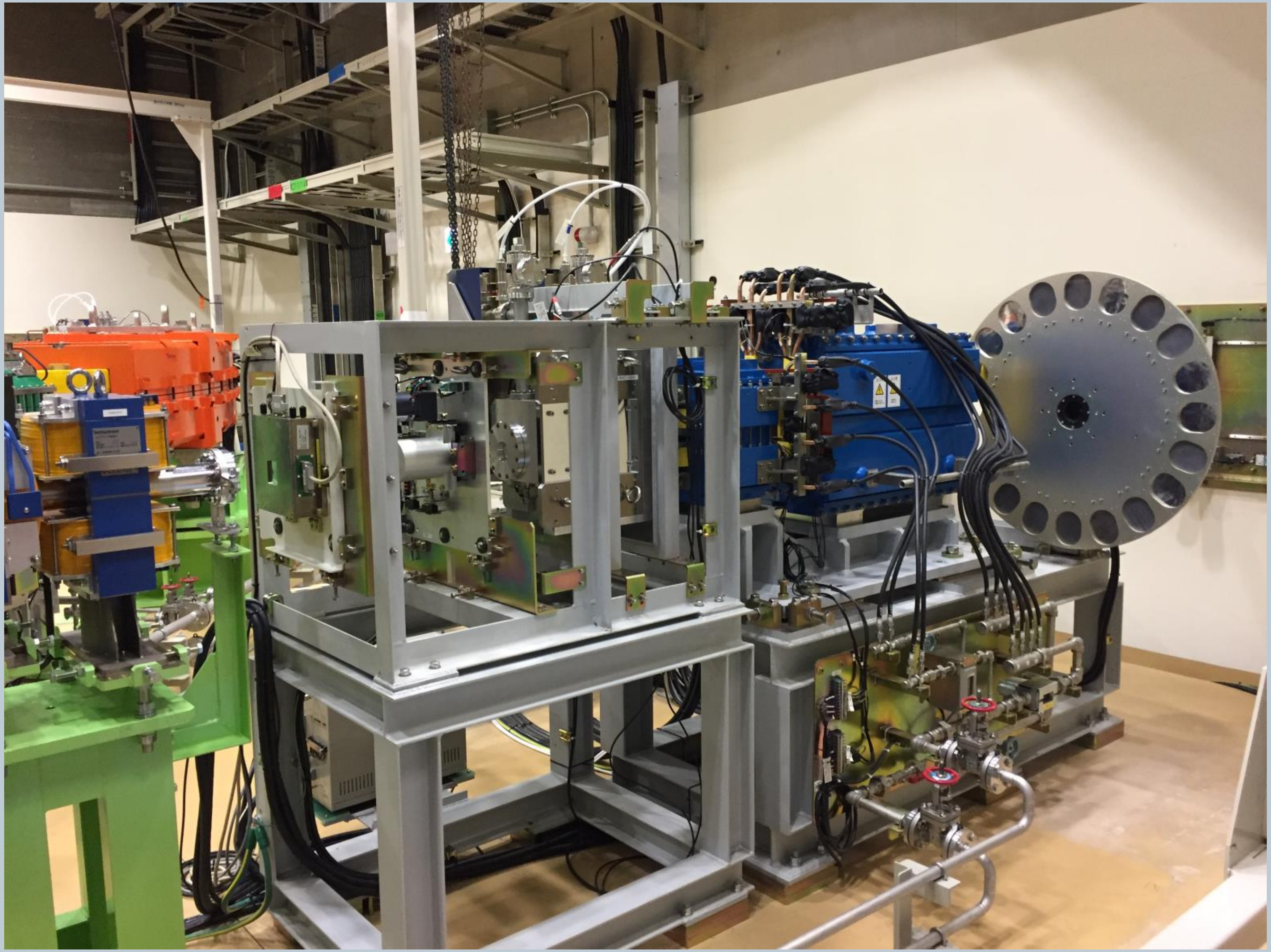


Linear accelerator

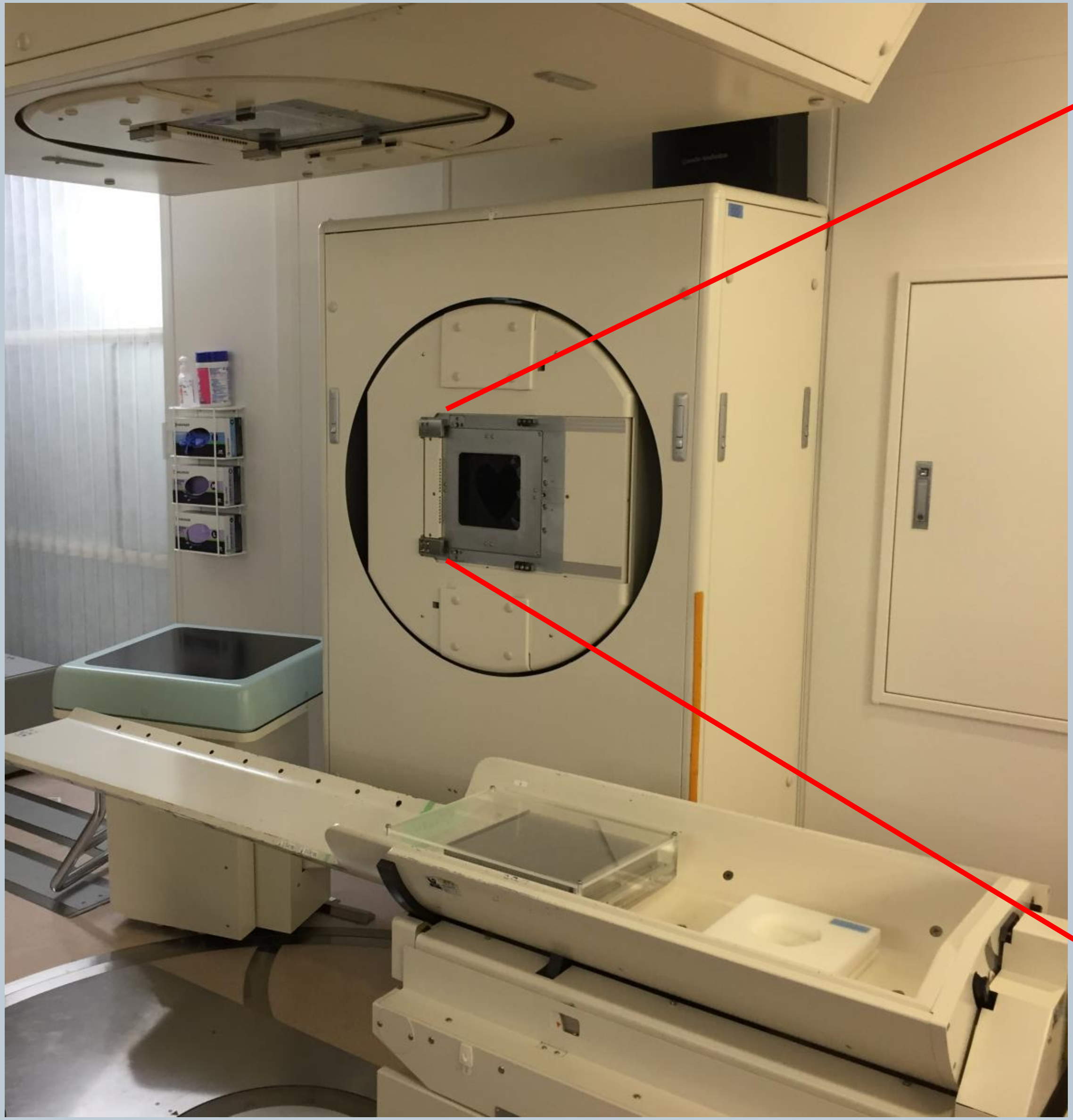
First half of the synchrotron

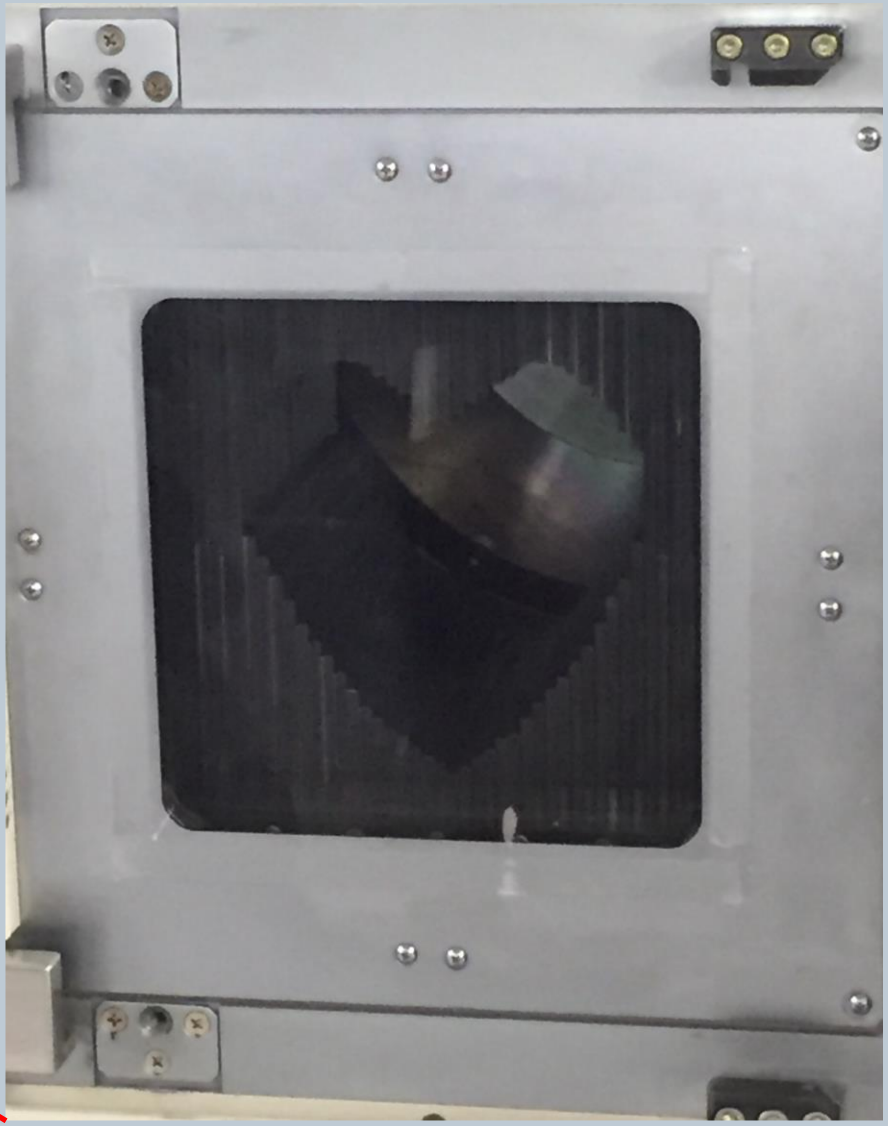
Second half of the synchrotron

On the outer rim of the synchrotron, beam is guided towards the treatment rooms



Beam is guided and prepared for delivery to the treatment rooms





Treatment room at GHMC

Collimator

The participants in the 2016 International Training Course on Carbon-Ion Radiotherapy