BNCT System Using 30MeV H^- Cyclotron

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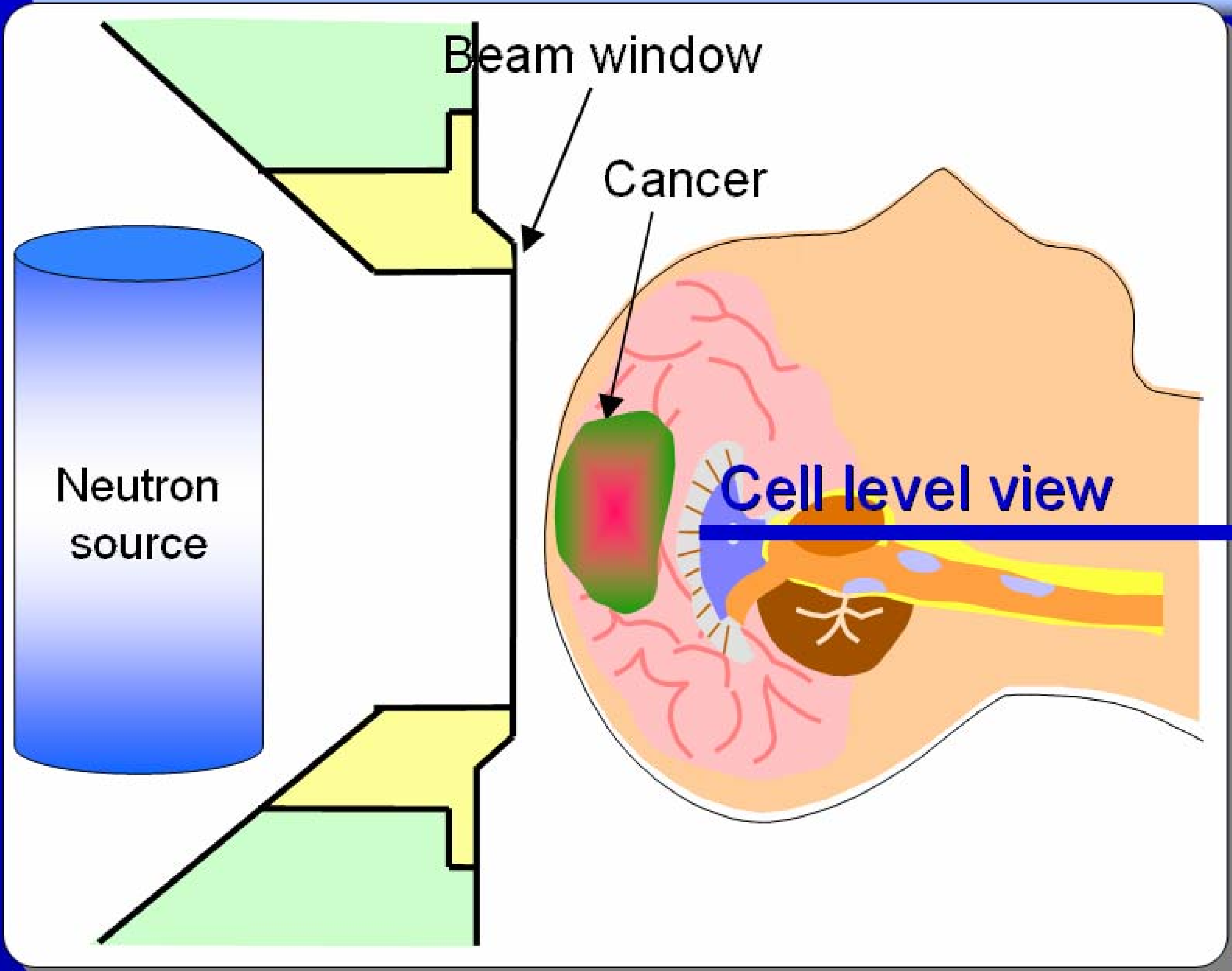
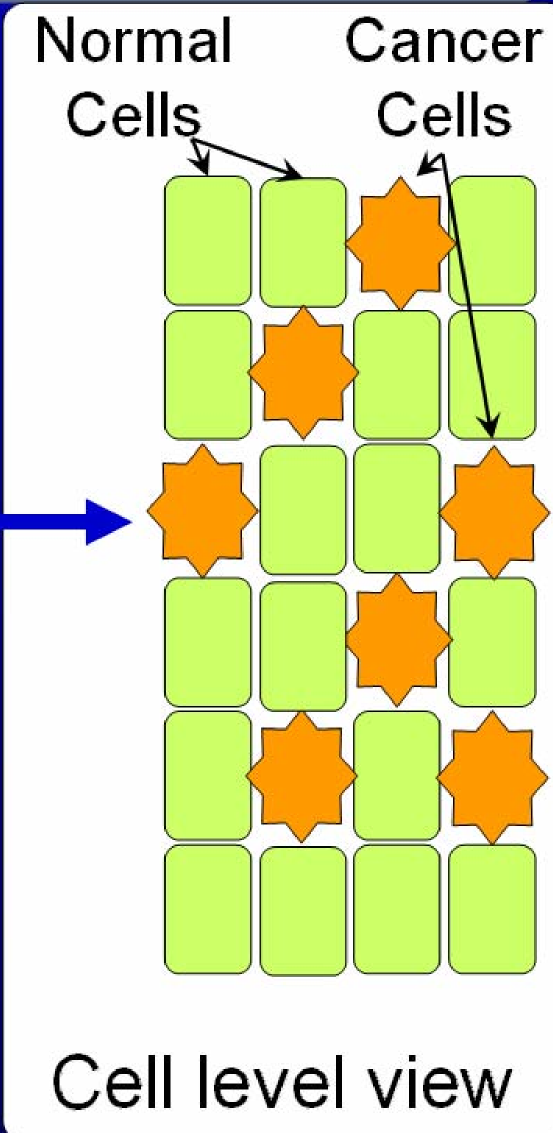
1. Accelerator-Based Boron Neutron Capture Therapy (BNCT) System
2. Current Status of Sumitomo BNCT System at Kyoto Univ.
3. Schedule and Future Plan

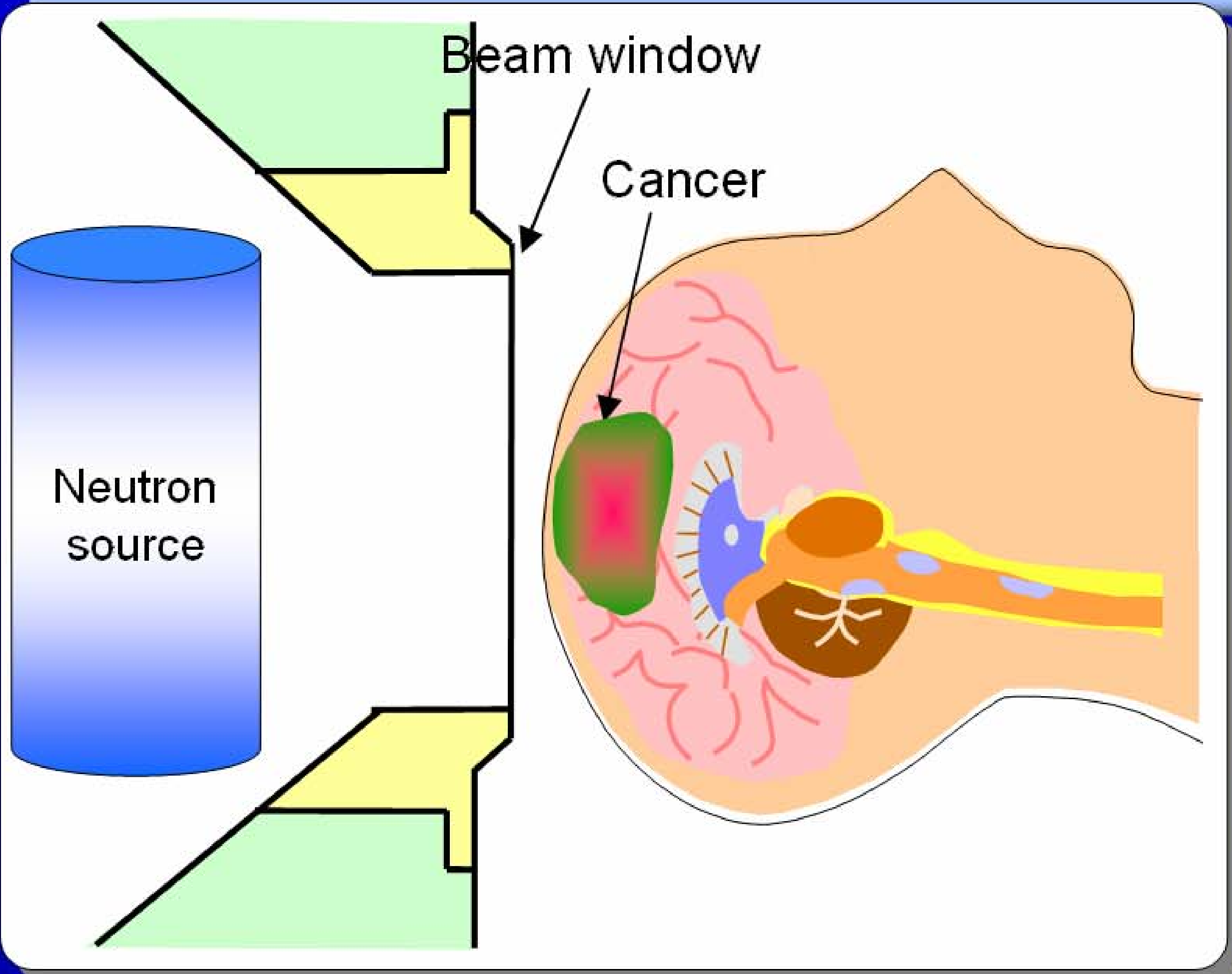
1. Accelerator-Based Boron Neutron Capture Therapy (BNCT)

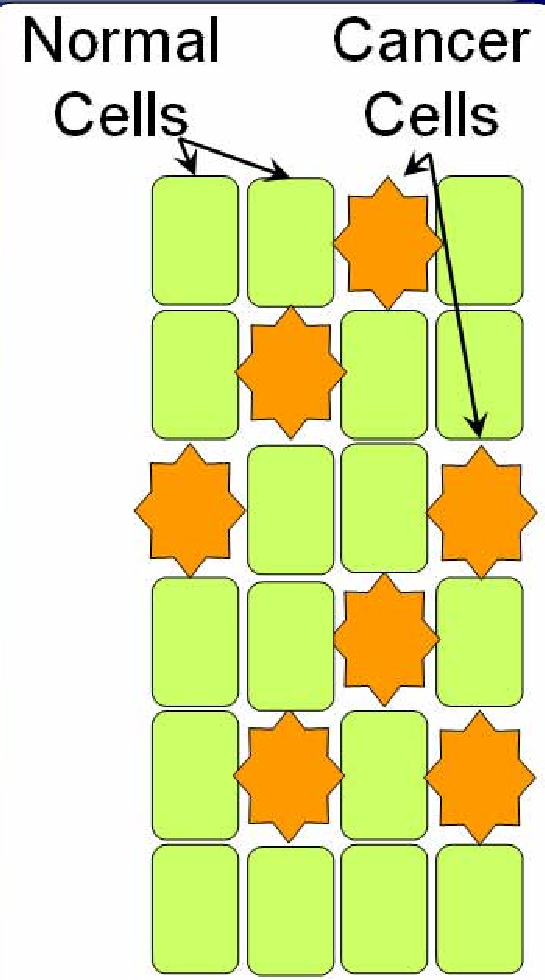
1-1. BNCT principle





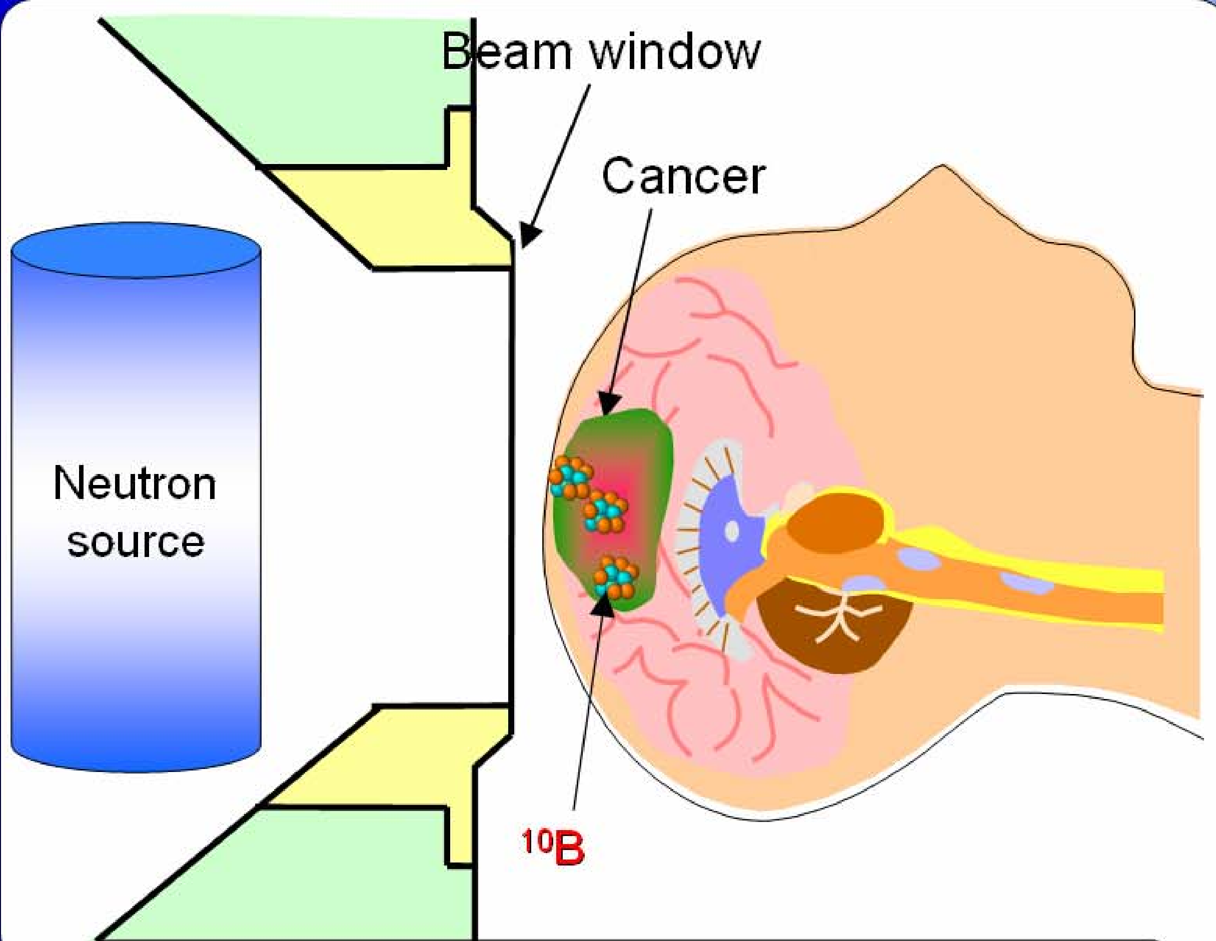
1-1. BNCT principle



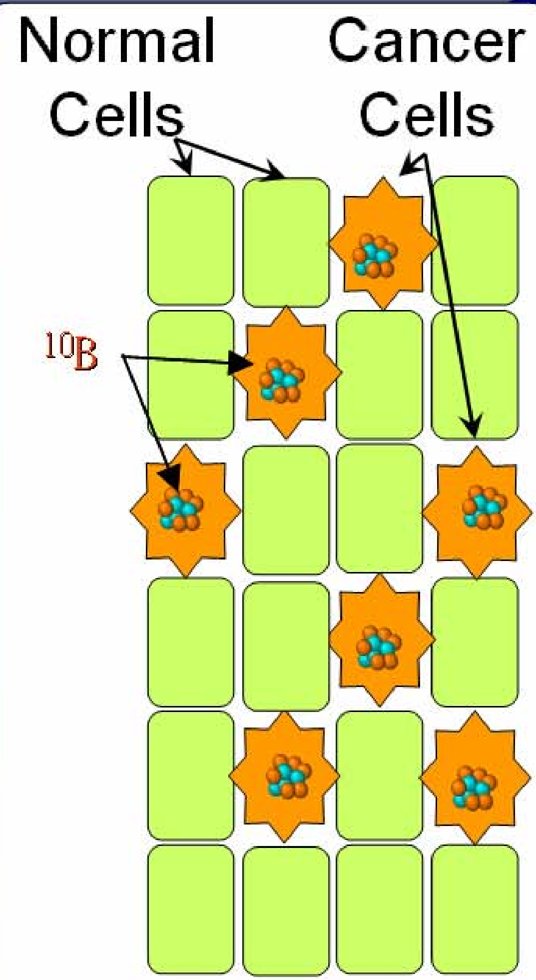


Cell level view

1-1. BNCT principle

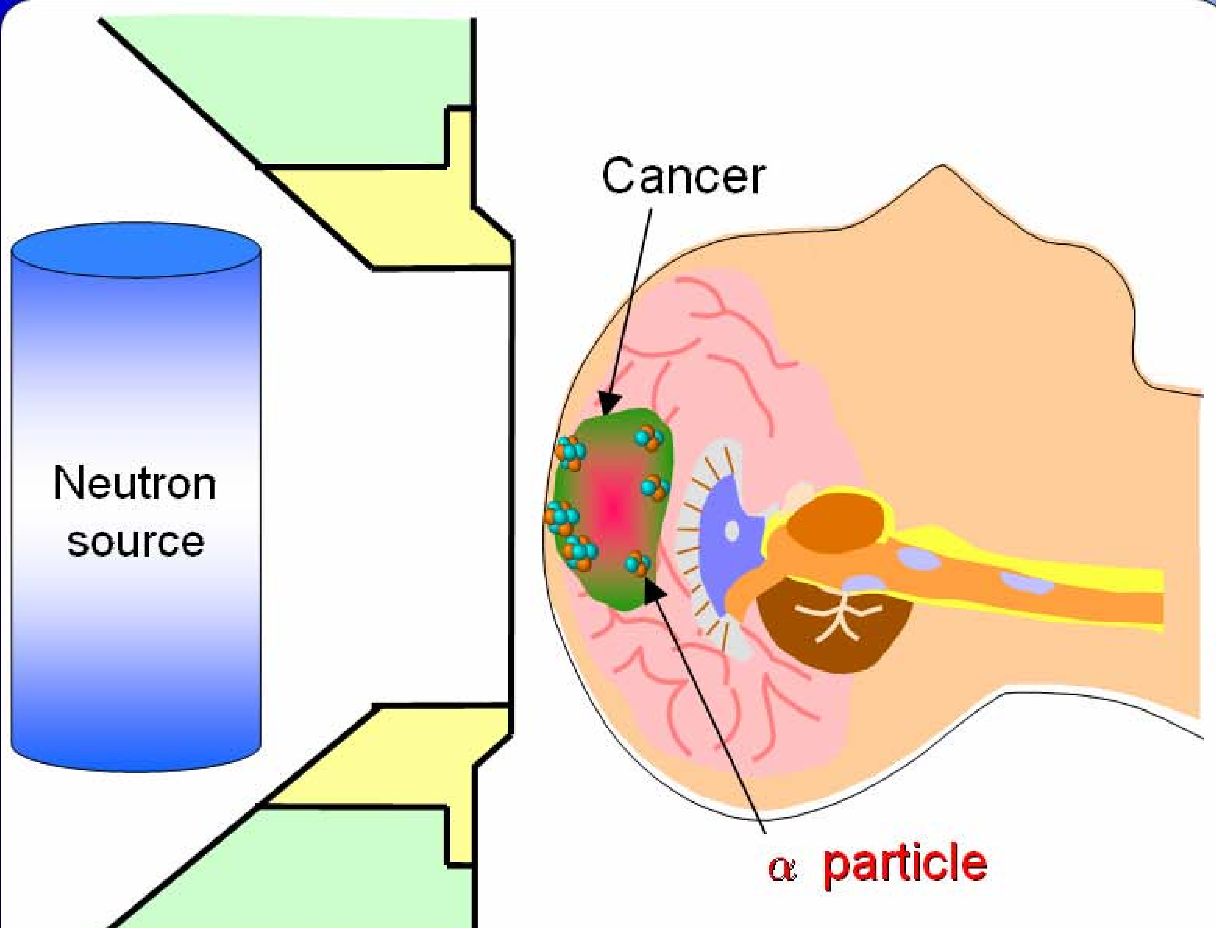


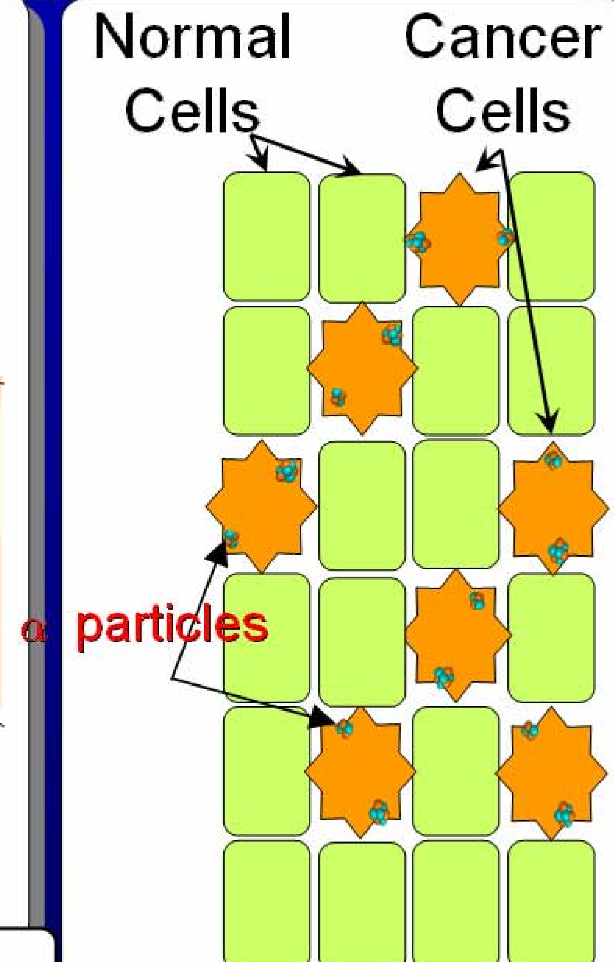
Boron-10 tagged compounds are injected , which accumulate in cancer cells



Cell level view

1-1. BNCT principle

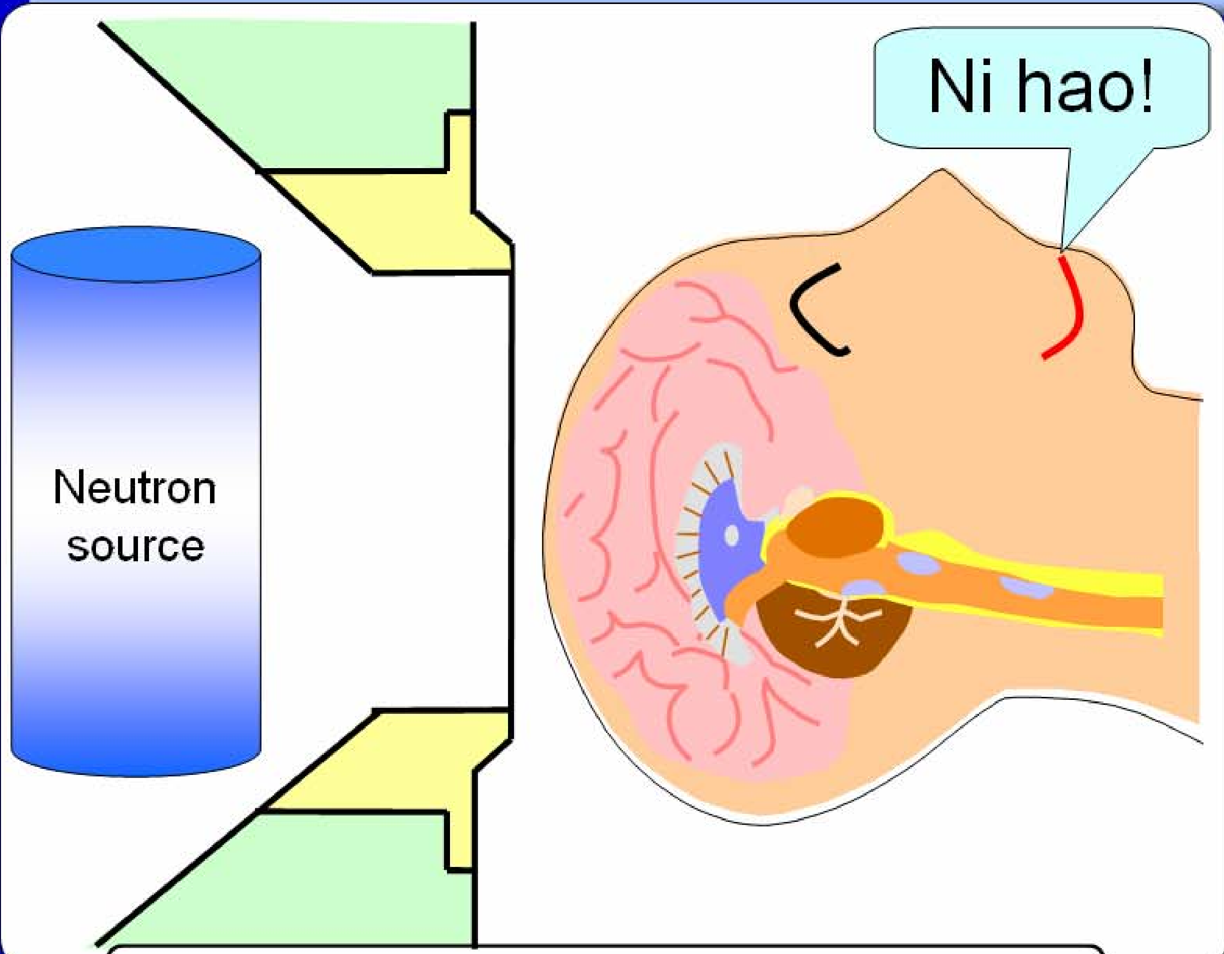




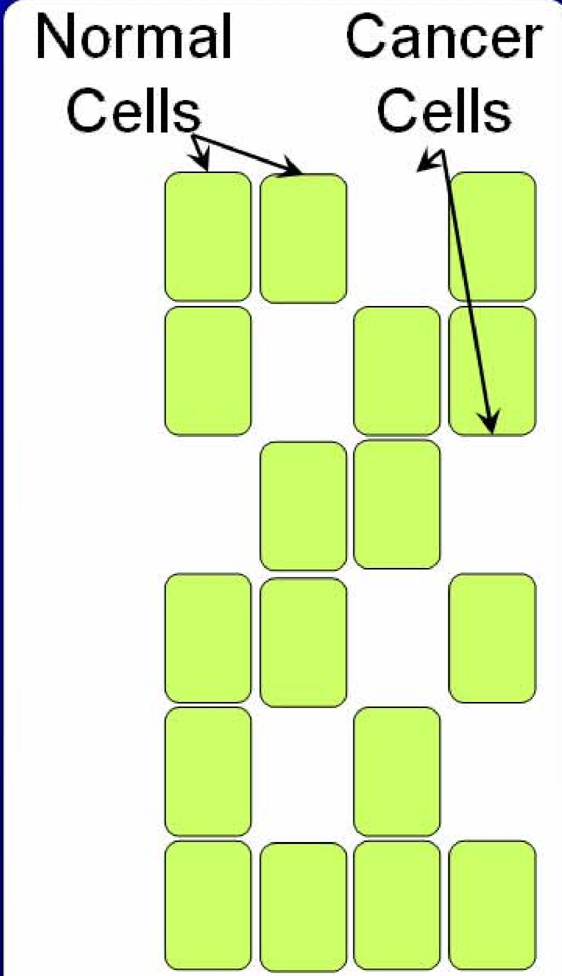
α and ^{7}Li particles are created by nuclear reaction of thermal neutron and ^{10}B

Cell level view

1-1. BNCT principle



Then, created α and ^{7}Li particles destroy only cancer cells

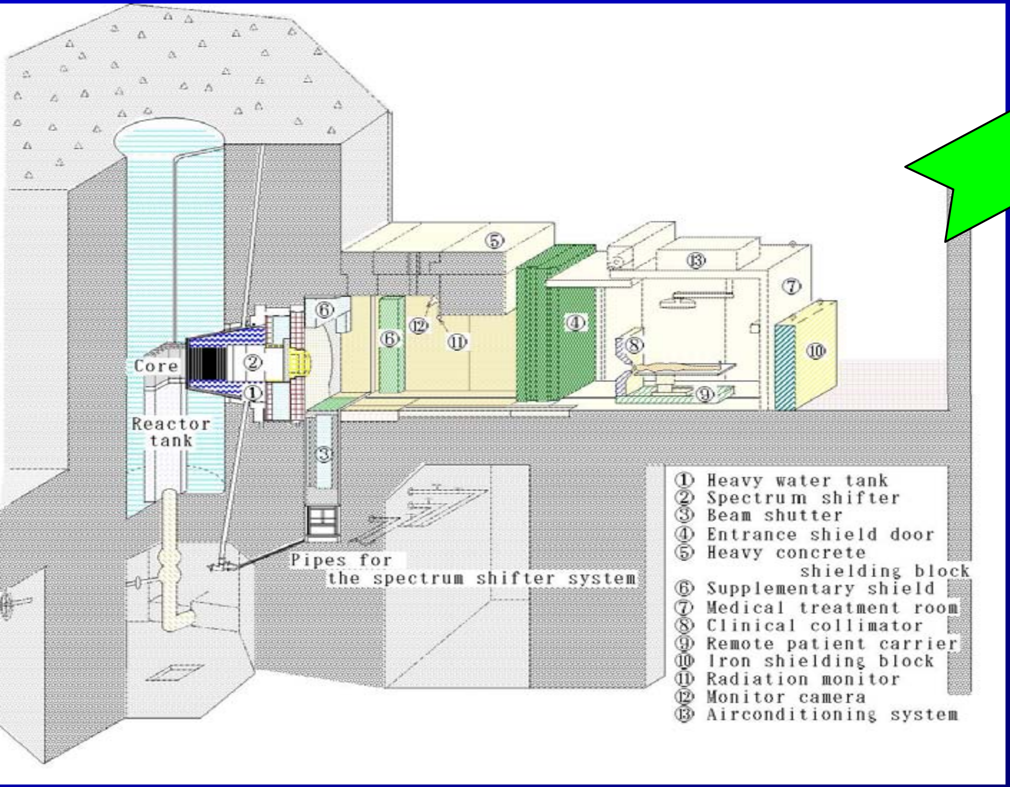


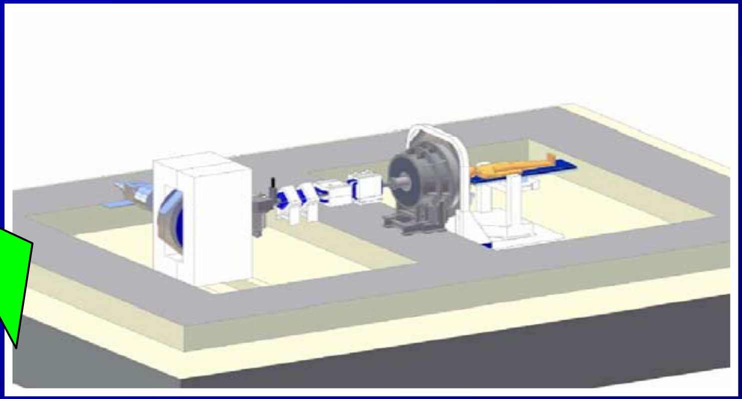
Cell level view

1-2. Nuclear reactor to accelerator

SHI

Conventional BNCT system
with nuclear reactor



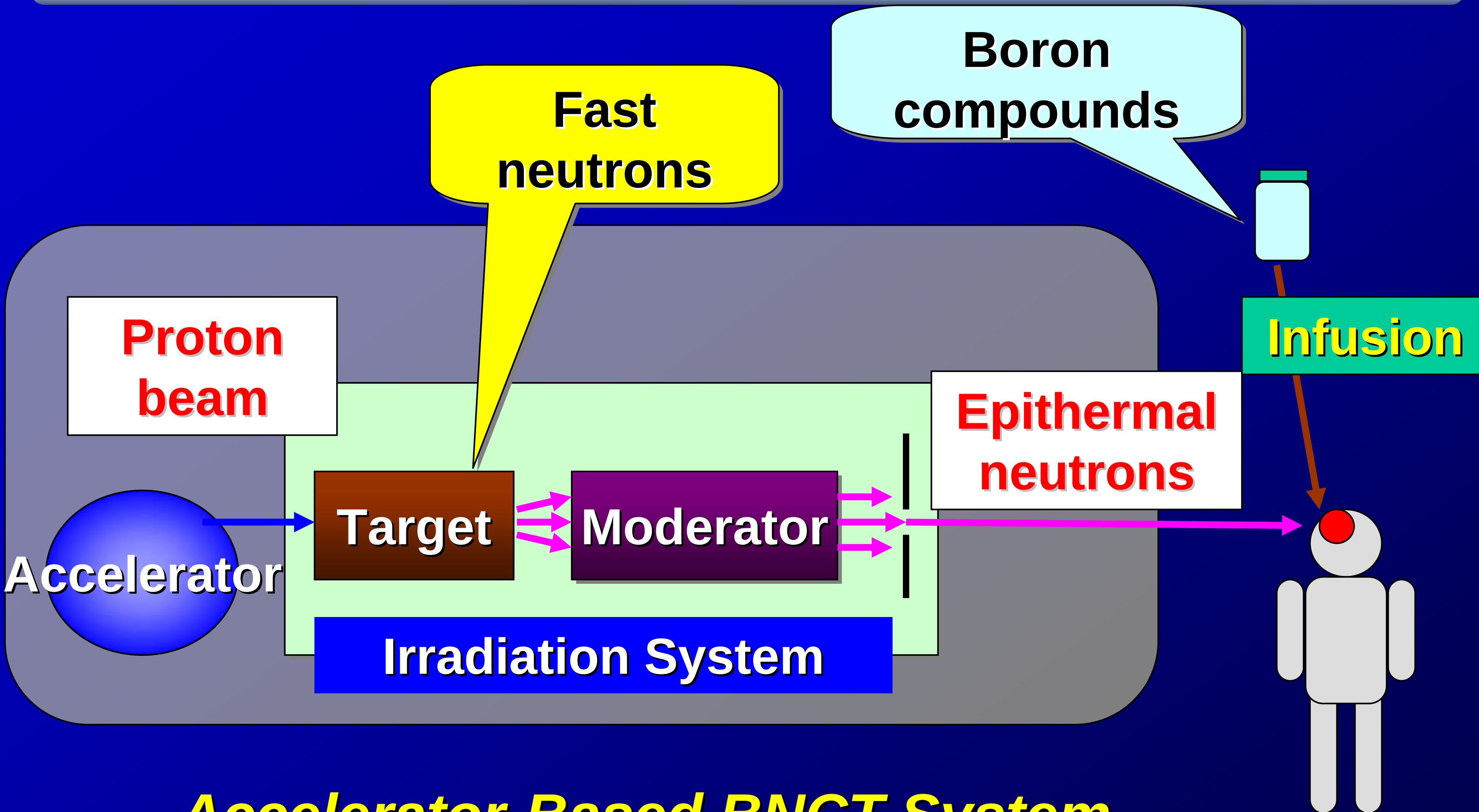


Accelerator based BNCT

- Easy to manage
- Compact
- Acceptable to the public

Accelerator is desirable in hospitals

1-3. Basic configuration



Accelerator-Based BNCT System

1-4. Comparison of accelerators

SHI

stop
warning
go

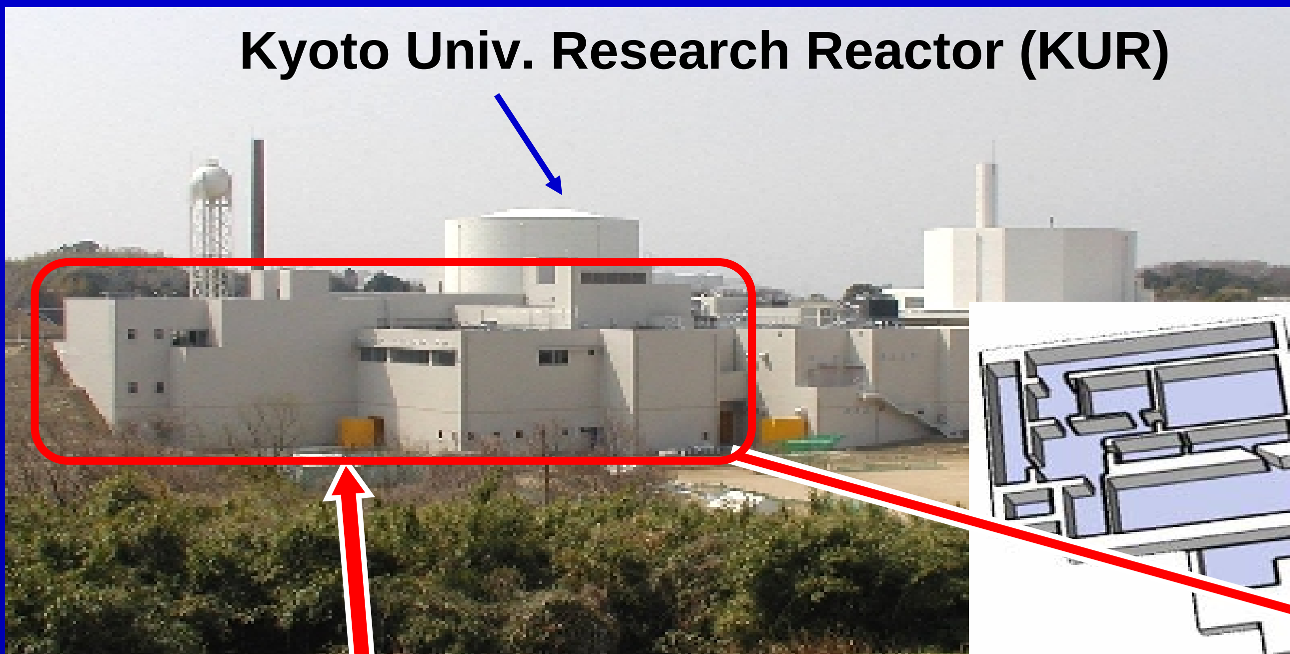
	Cyclotron	Middle Energy Linac	Low Energy Linac (Electrostatic or RF)
Energy	10 ~ 30 MeV	10~15 MeV	~ 3 MeV
Average Beam Current	1 ~ 3 mA	2~3 mA	~20 mA
Target	Beryllium (Solid)	Beryllium (Solid)	Lithium (Solid/Liquid)
Accelerator Size	~3 m	~10 m	~3 m
Neutron Energy at Target	~30 MeV (peak at ~1MeV)	~15 MeV (peak at ~1MeV)	~1 MeV
Moderator Size	Larger	Larger	Smaller
Radiation Shield	Larger	Larger	Smaller
Technical Hurdle	Almost nothing	High duty linac	High current linac Target

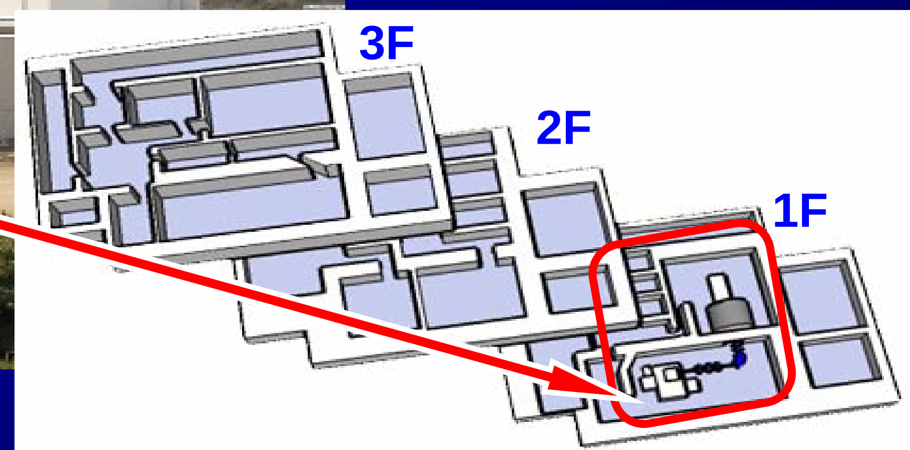
We selected cyclotron

2. Current Status of Sumitomo BNCT System at Kyoto Univ.

2-1. BNCT in Kyoto Univ.

Kyoto University Research Reactor Institute (KURRI) and Sumitomo Heavy Industries (SHI) started collaboration in 2007

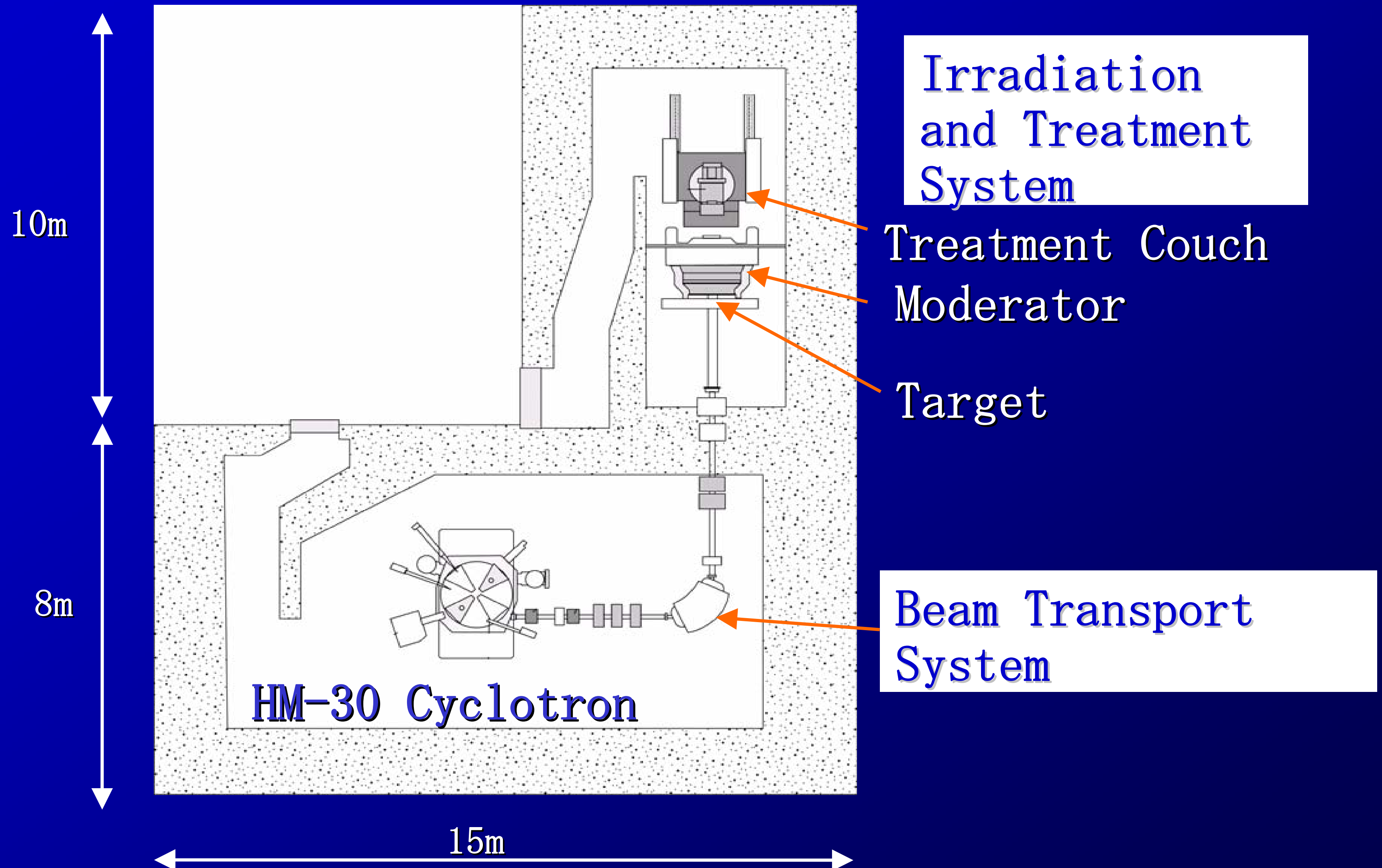




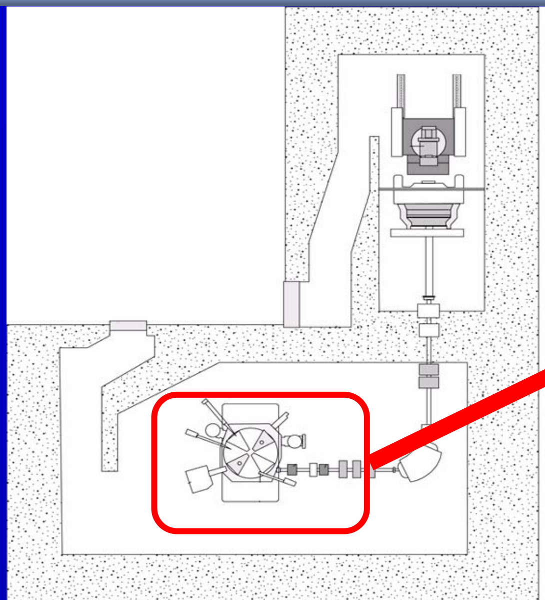
Innovation Research Laboratory

The BNCT system was installed in 2008

2-2. Layout of the BNCT system



2-3. HM-30 cyclotron for BNCT



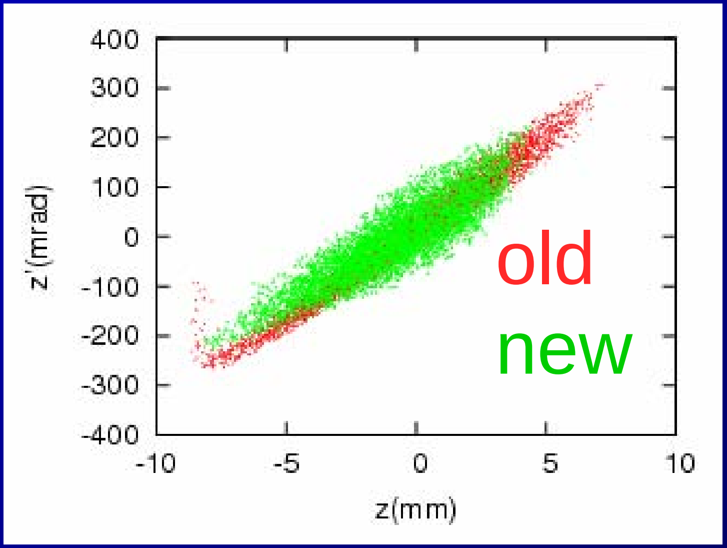
Accelerator Name	HM-30
Particle	H^-
Energy	30 MeV
Extraction Method	Foil stripping
Maximum Beam Current	1.1 mA (2 mA is possible)
Maximum Power	33 kW (60 kW)
Size	W 3.0 m × D 1.6 m × H 1.7 m
Weight	60 tons

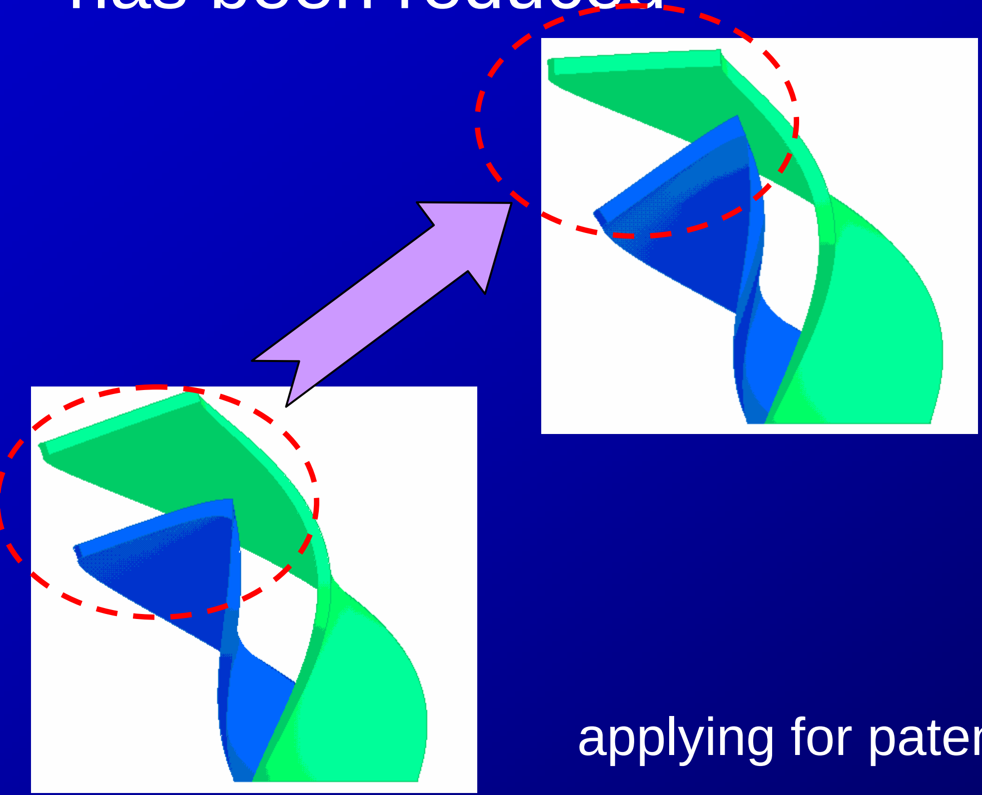
2-4. Features of HM-30

- Injection
  - 15 mA volume cusp type H^- ion source
  - Two solenoids and one RF buncher in LEBT
  - New type tilted spiral inflector for axial injection
- Acceleration
  - Designed with a Runge-Kutta tracking code for minimizing beam off-centering and maximizing beam transmission
- Extraction
  - Carbon foil stripper

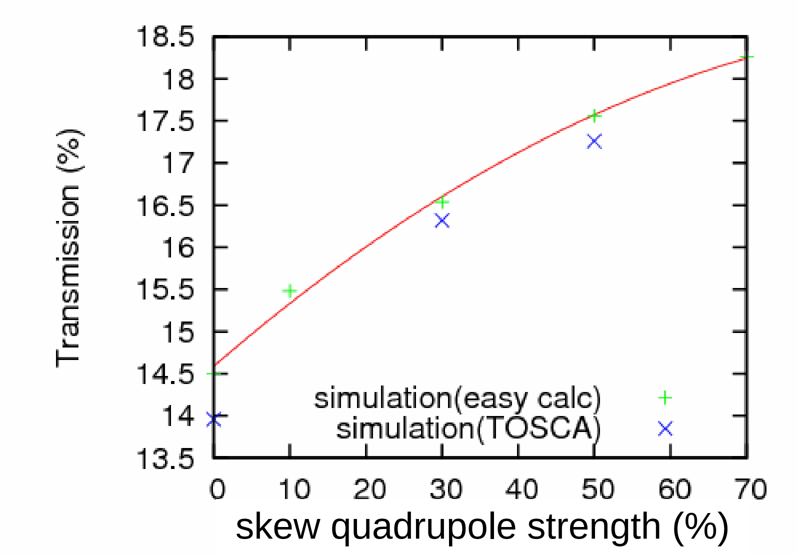
2-5. New type spiral inflector

By adding skew-quadrupole component to the electric field, the vertical beam divergence has been reduced





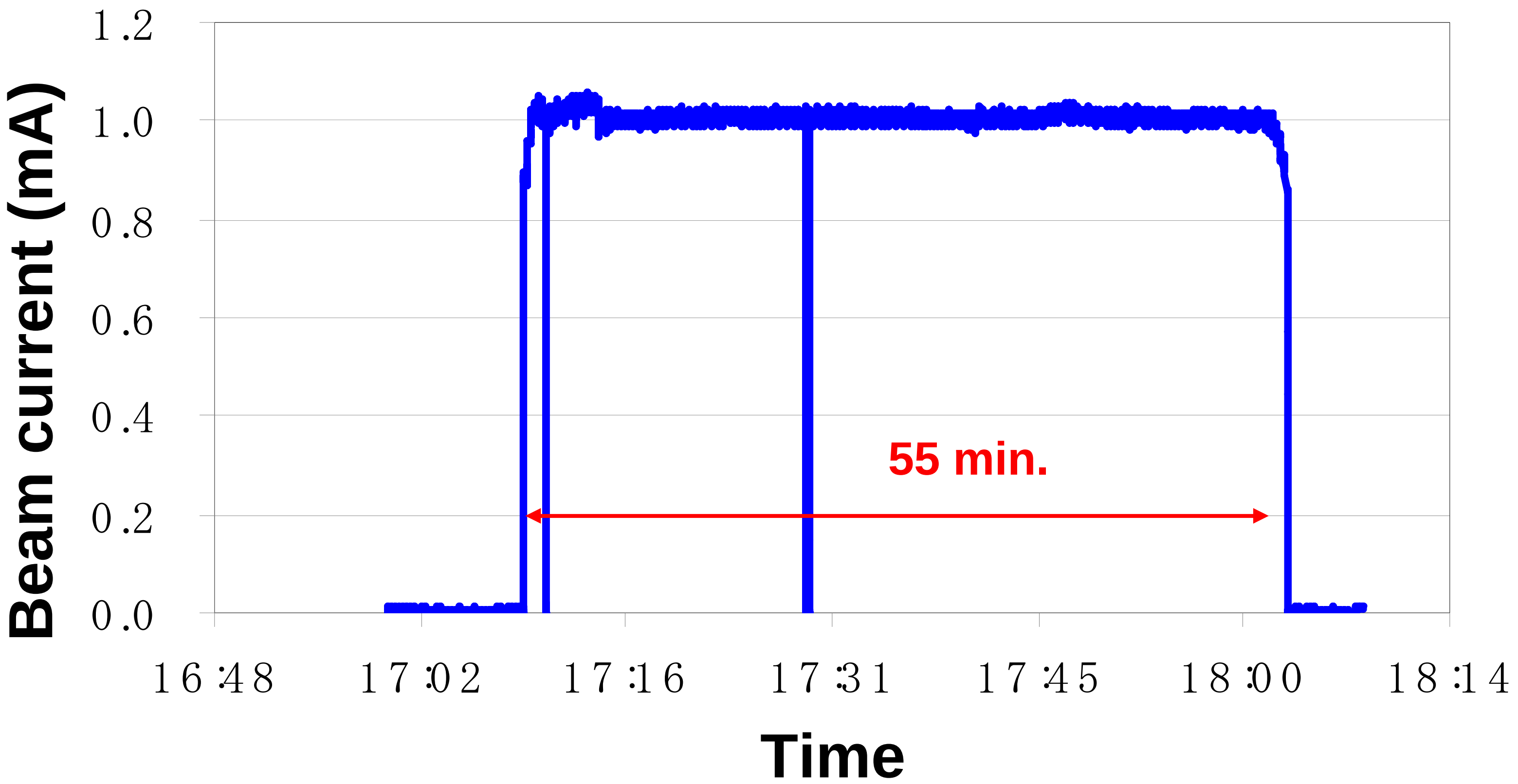
applying for patent



by beam tracking

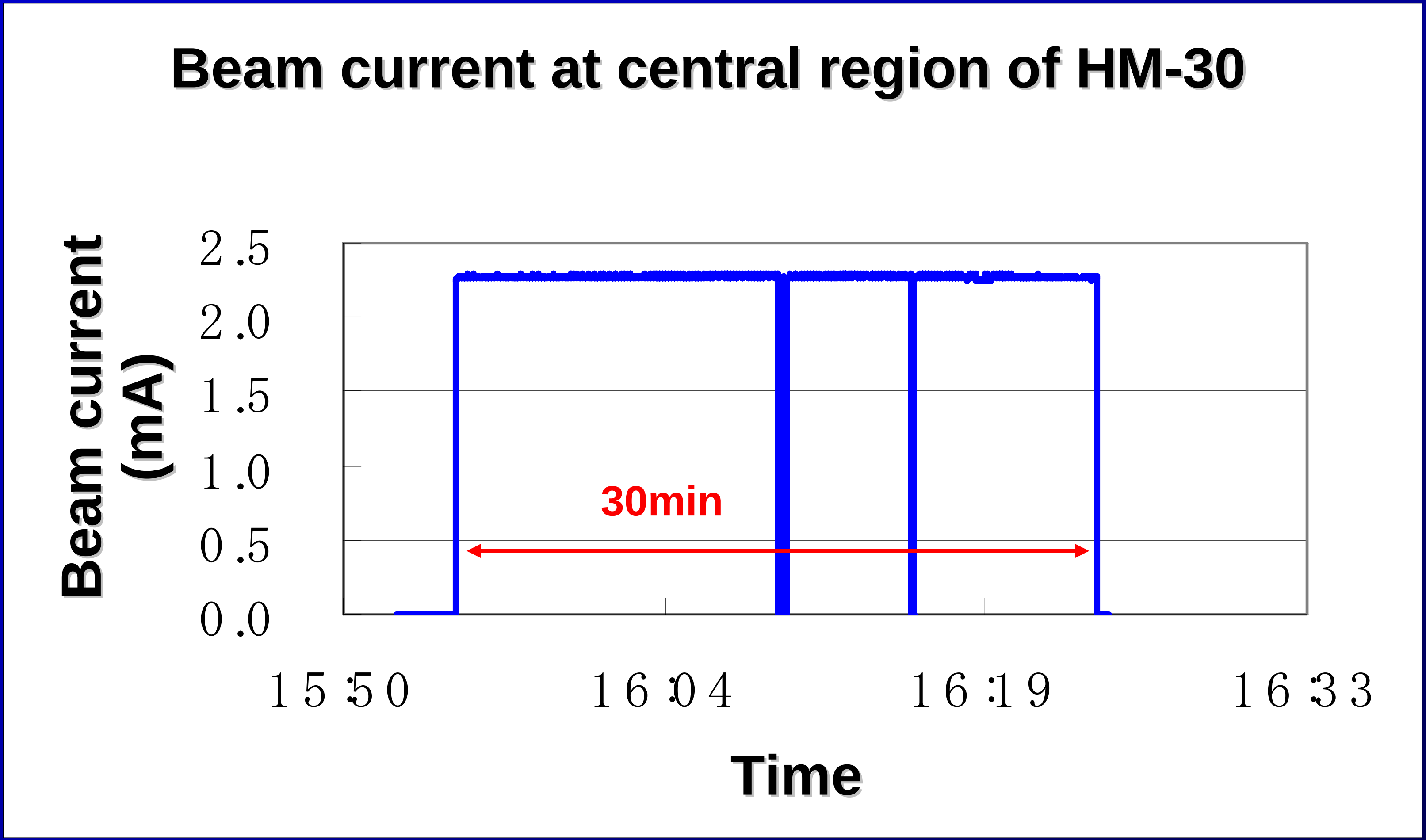
2-6. Examples of beam current (1)

The maximum current is limited to 1.1 mA by KURRI's regulation



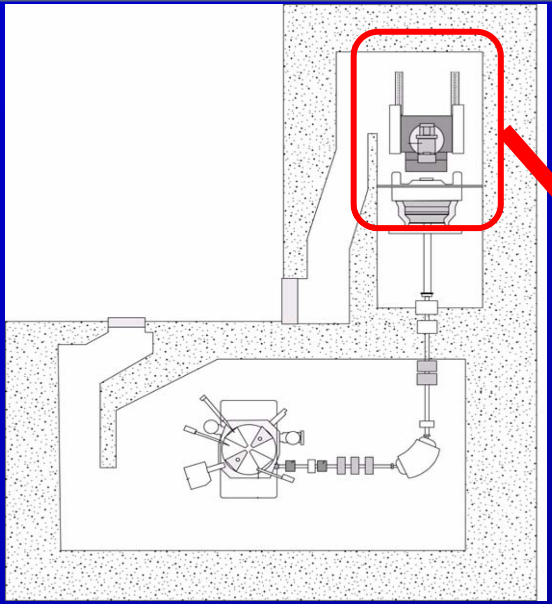
Beam current at target position is very stable during about 1 hour operation

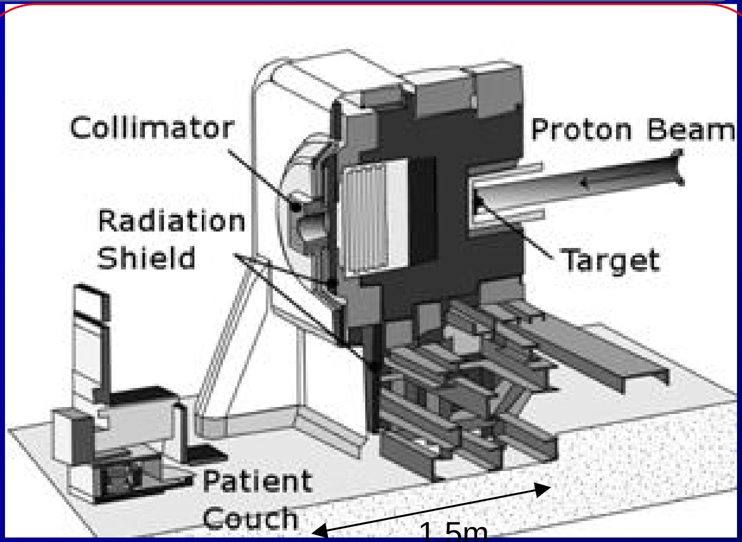
2-6. Examples of beam current (2)

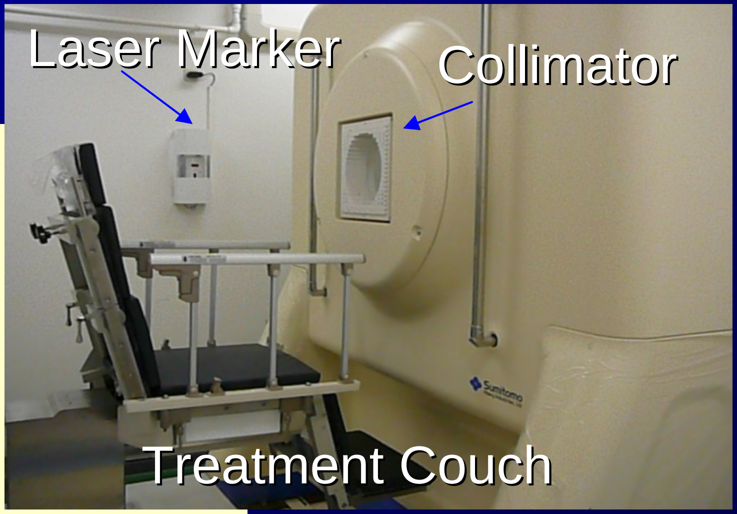


Beam current at central region is very stable, and exceeds 2mA

2-7. Irradiation system







Irradiation Port Horizontal, Fixed (1set)

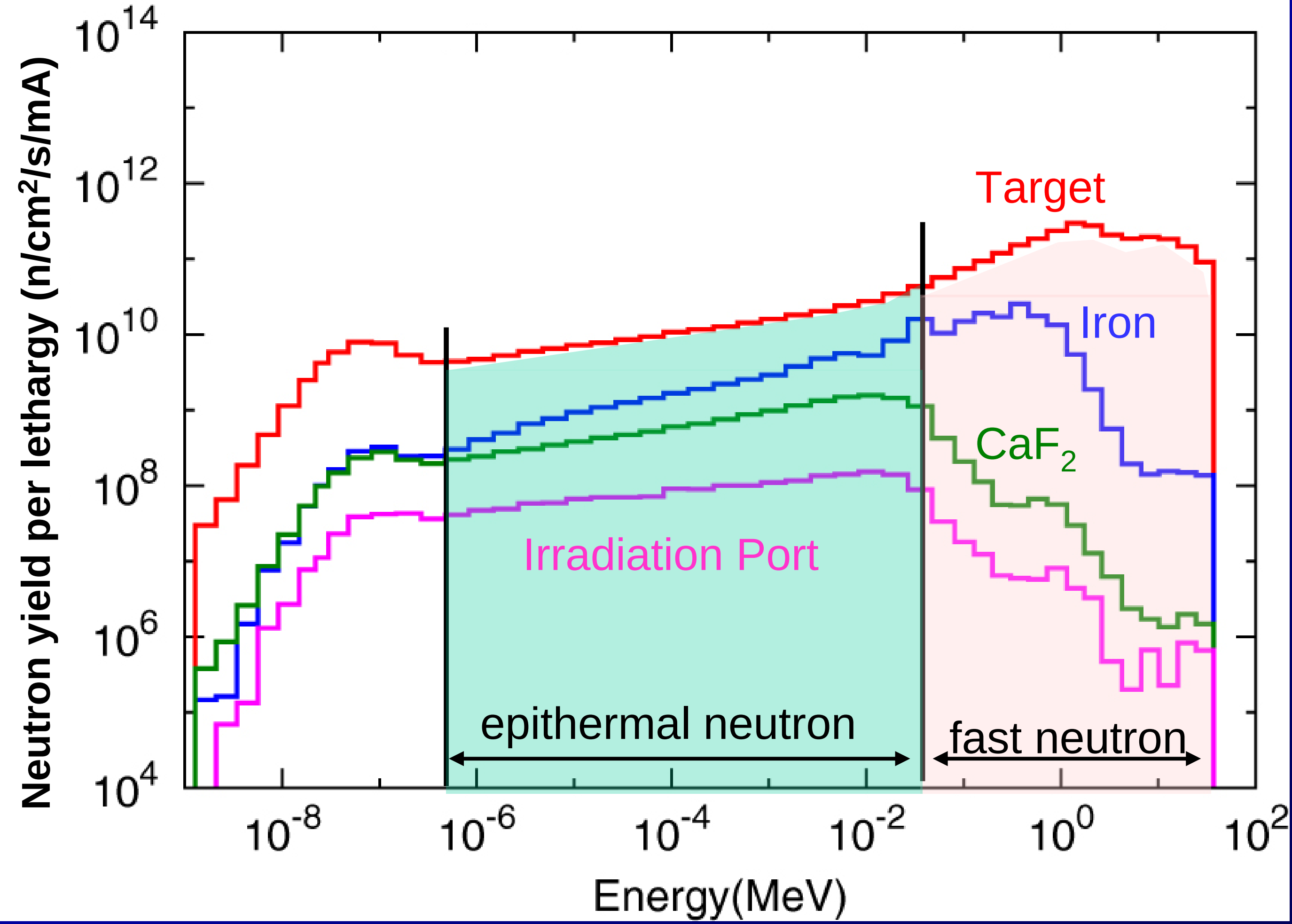
Thermal Neutron Flux
(at 20mm depth in the water phantom)
1.8×10^9 n/cm^2/sec/mA

Field Size 250mm × 250mm

Treatment Couch Bed and Chair (Changeable)

Patient Positioning Laser Marker and X-ray system

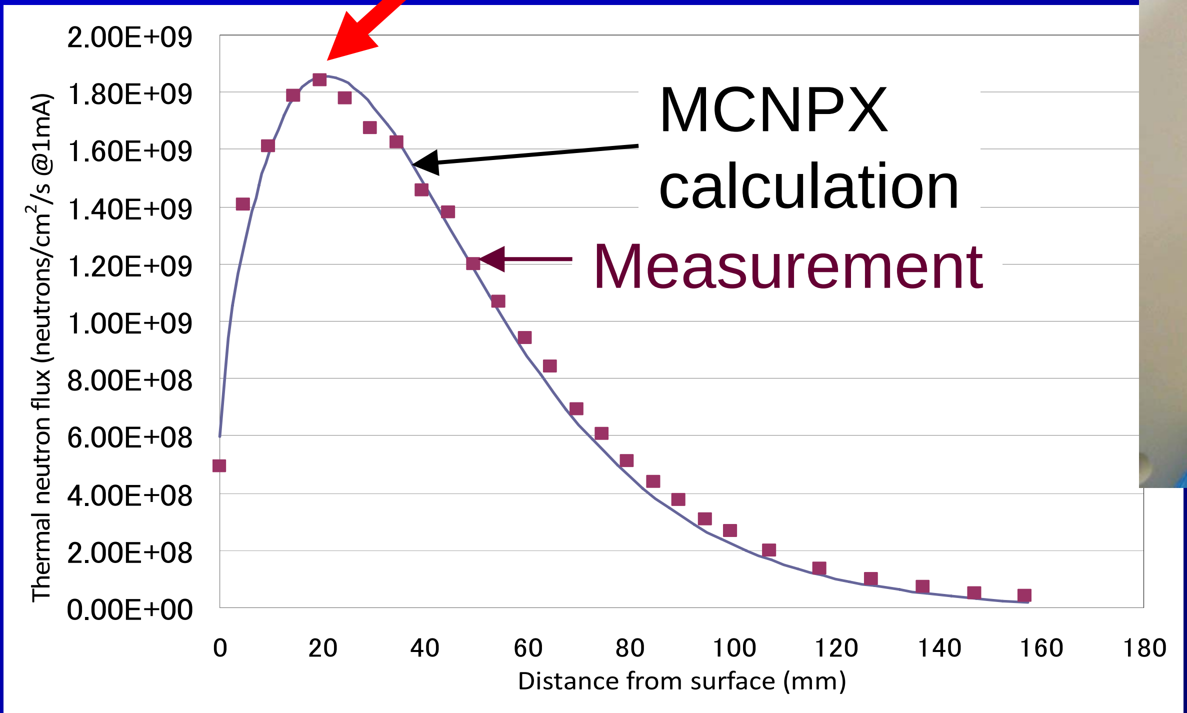
2-8. Neutron yield



Fast neutrons are moderated to epithermal region

2-9. Neutron flux at 1mA

1.8×10^9 n/cm²/s thermal neutrons



Water Phantom

Attained enough neutrons for treatment

3. Schedule and Future Plan

3-1. Schedule

2008/9 Installed in KURRI
2009/1 Commissioning Test Started
2010/2 Dosimetry and Cell / Animal Test Completed

Now we are working for obtaining approval of medical product registration in FY2012

Summary

Kyoto university and Sumitomo developed a BNCT system using 30 MeV H^- cyclotron.

Peak thermal neutron flux is 1.8×10^9 n/cm^2/sec in a water phantom, which is enough for a BNCT treatment.

We finished animal tests in 2010. Now we are working for obtaining approval of medical product registration in FY2012.


Thank you for your attentions!