New Treatment Research Facility Project at HIMAC

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IPAC10, Kyoto, JAPAN, 25th May, 2010
Contents

1. Introduction
2. Design and specifications
3. Overview of project status
4. Summary
Physical Advantage of Heavy Ion

High longitudinal dose localization due to the Bragg peak.

High transverse dose localization due to the low scattering.
Biological Advantage

Introduction

LET dependence on RBE, OER

Biological Depth-Dose Distribution of 6cm SOBP
1984: Heavy ion therapy project started under “National Comprehensive 10-year Strategy for Cancer Control”.

1988-93: Construction of HIMAC.

1994: Carbon-ion RT started at 21st June 1994

2003: approved ”Highly Advanced Medical Technology”

2004-05: Design and R&D for Downsized C-ion RT Facility

2006-09: Construction of Pilot Facility at Gunma Uni.


HIMAC (Heavy Ion Medical Accelerator in Chiba)

**HIMAC facility**

- Ion species: High LET (100keV/μm) charged particles → He, C, Ne, Si, Ar
- Range: 30cm in soft tissue → 800MeV/u (Si)
- Maximum irradiation area: 22cm Φ
- Dose rate: 5Gy/min
- Beam direction: horizontal, vertical
Milestone of HIMAC Radiotherapy

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Introduction

Treatment Period: 43 wks
1st Term (Apr—Aug):
18.5wks
2nd Term (Sept—Feb): 24.5wks
Treatment: 4 days per week
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Gunma University Heavy-Ion Medical Center

Treatment Room

Synchrotron

10Ghz-ECR

Injector Linac
APF-IH

4. Compact Facility
Introduction

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2010: 1\textsuperscript{st} Patient treated at Gunma at 16\textsuperscript{th} March 2010.

Motivation

HIMAC therapy needs to be upgraded.

Upgrading irradiation system
- raster scanning system
- rotating gantry system
Upgrading control system
Upgrading patient handling system
Upgrading treatment planning system

Further development of heavy-ion therapy
- Adaptive therapy
- Intensity modulated Ion Therapy (IMIT)

New treatment facility project
Motivation ~ adaptive therapy

Intra & interfractional changes from time resolved imaging (seconds to days) using CT/FPD devices could be feed-back to the treatment planning. The rich information could extend to replan, 4D plan and patient registration etc.
Motivation ~ IMIT

Gantry with 3D scanning makes it possible to realize Intensity Modulated Ion Therapy (IMIT).

- Improved dose conformity and steeper dose gradients
- Further reduction of integral dose
- Less sensitivity to range uncertainties and other sources of uncertainty

IMIT plan example
1. Introduction
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1. Ion species: $^{12}\text{C}, {^{16}}\text{O}$ ($^{11}\text{C}, {^{15}}\text{O}$)
2. Irradiation method: Hybrid raster scanning
3. Range: ~30cm in water
4. Maximum irradiation area: 22cm square
5. Delivered Intensity: $10^7 - 10^9$ pps (for C ions)
6. Treatment rooms: 3 = 2 H&V + 1 rotating gantry
Adaptive Therapy by 3D Scanning

1) Beam utilization efficiency $\sim 100\%$
2) Irradiation on irregular shape target
3) No bolus & collimator

1) Sensitive beam error
2) Longer irradiation time
3) Sensitive to organ motion
Adaptive Therapy by 3D Scanning

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3D Scanning Method

Rescanning with Gated Irradiation
In order to realize the rescanning with gating within acceptable irradiation time, we have studied following strategy.

1. Treatment planning for fast scanning  ⇒  ×5
2. Modification of acc. operation  ⇒  ×2
3. Fast scanning magnet  ⇒  ×10

100-times speed up !!
Fast scanning system

Design and R&D work were carried out.

### Design & Spec

- **3D scanning irradiation**
- Max field size: 220 mm²
- Max SOBP: 150 mm
- Max energy: 430 MeV/u
- Moving target: OK
- Beam size: 3~6 mm ($1\sigma$)
- Ene. change: RSF

Fast scanning system

Design and R&D work were carried out.

Fast scanning system

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Fast scanning system

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Fast scanning system

Design and R&D work were carried out.

Gantry design

1) IMIT
2) Reduction of Patient’s Load

- 3D scanning irradiation
- Max field size 150 mm²
- Max SOBP 150 mm
- Max energy 430 MeV/u
- Moving target OK
- Beam size 3~6 mm (1σ)
- Ene. change RSF
- Total weight 350 ton
HIMAC

NIRS

Floor plan

Treatment rooms : 3
Simulation rooms : 2
Preparation rooms: 6
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Mar. 2010, new treatment building construction has been completed.
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Treatment room / Simulation room

Simulation room

Treatment room

April, 2010
Treatment Hall

Entrance

Preparation room
Treatment Hall

Entrance

Preparation room
Beam line devices

Beam line dipole magnet

Quadrupole magnet

Installation of devices is in progress.
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Construction of the building is completed.

Performance of 3D rescanning is verified.

Installation & commissioning will be carried out in this year.

First patient is scheduled in next March.
Acknowledgement

Thank you for your attention