

Commissioning of NIRS Gantry and KCC i-Rock

National Institute of Radiological Sciences
Naoya Saotome





Introduction

History and collaboration



KCC i-ROCK

Commissioning of commercial scanning system



NIRS Gantry

Commissioning of NIRS's Gantry with superconducting magnet





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NIRS Gantry

Commissioning of NIRS's Gantry with superconducting magnet



OUR EVOLUTION

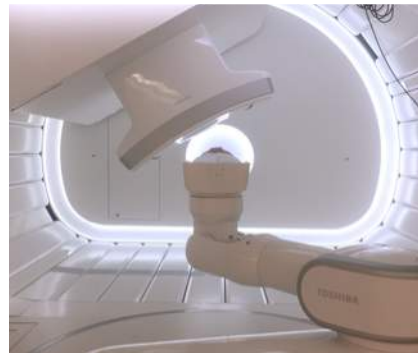
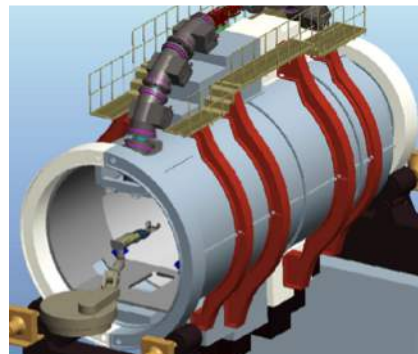
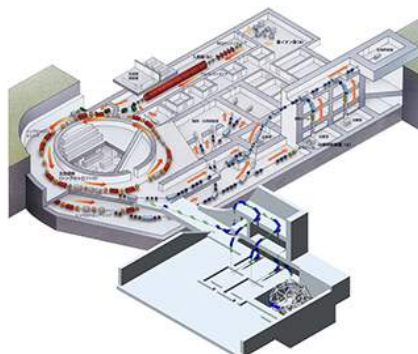
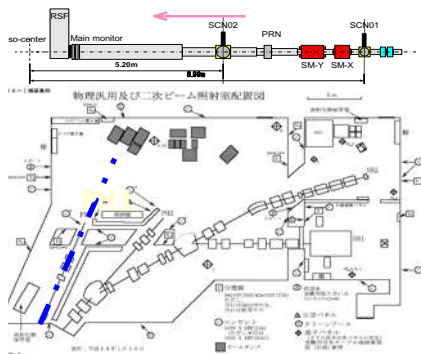


2008
Experimental port
for scanning

2011
New treatment rooms
with scanning

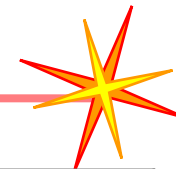
2015
Commercial machine
with scanning

2017
Superconducting
Gantry for carbon ion



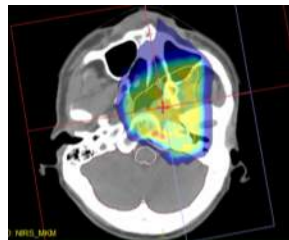
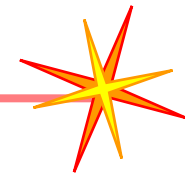
By courtesy of Toshiba

OUR RECENT PROGRESS



	2013	2014	2015	2016	2017	2018	2019	2020
KCC	<p>△Building construction start(12/12)</p>	<p>□Installation start (14/5)</p>	<p>★Accelerate 430MeV/u (15/1)</p> <p>★Multiple-energy operation and scanning irradiation(15/2)</p>	<p>★Treatment start (15/12)</p>				
NIRS		<p>▽Beam commissioning start(10/13)</p>	<p>★Treatment start(15/2)</p>			<p>Energy scanning</p>		
	<p>Gantry</p>	<p>□Installation start(15/1)</p>		<p>▽Beam commissioning start (16/1)</p>			<p>★Treatment start (17/4,plan)</p>	

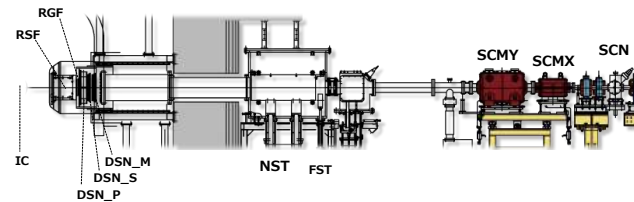
OUR COLLABORATION



USING
(TREATMENT)



DESIGN

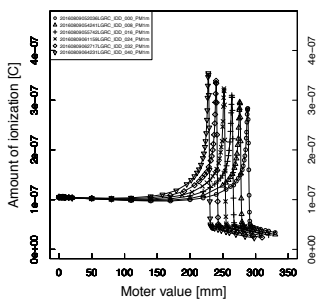


COLLABORATION



COMMISSIONING

DEVELOPMENT






**National Institute of
Radiological Sciences**

2017/2/23

Naoya Sotome(NIRS)



Introduction

History and collaboration



KCC i-ROCK

Commissioning of commercial scanning system



NIRS Gantry

Commissioning of NIRS's Gantry with superconducting magnet

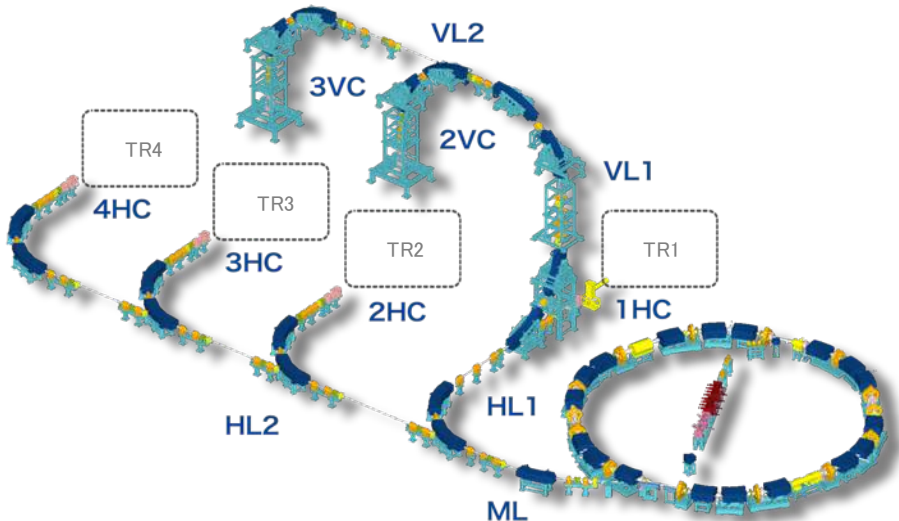


Specification of KCC

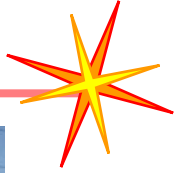


- Combination of a compact dissemination treatment system and pencil beam 3D scanning technique designed by NIRS
- Moving target treatment is available with respiratory-gated and rescanning technique

item	specification
Ion	C ⁶⁺
Energy	140-430MeV/u
Max. field	220 x 220 mm ²
Max. dose rate	2 Gy/L/min
Beam intensity	1.2x10 ⁹ pps
Irradiation type	3D Scanning
Treatment rooms	Horizontal: 2 rooms Horizontal and Vertical: 2 rooms
Vender	Toshiba



Building Construction



March, 2013



October, 2013

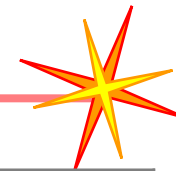


January, 2014

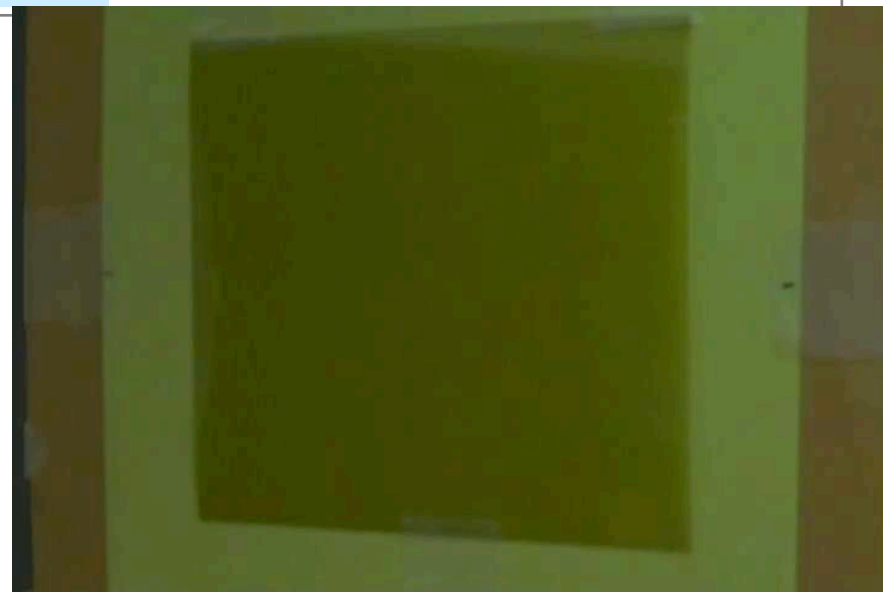
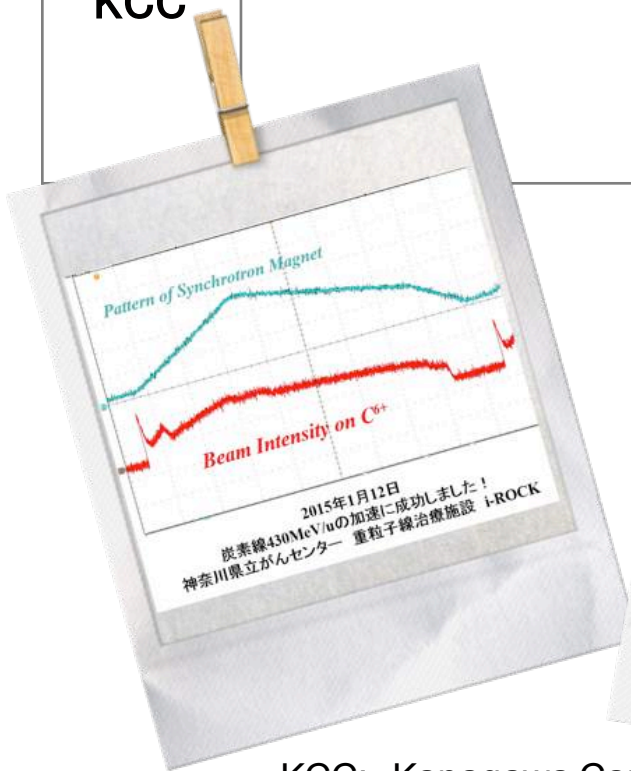


Completed in October 2014

OUR RECENT PROGRESS



	2013	2014	2015	2016	2017	2018	2019	2020
KCC		<ul style="list-style-type: none"> △ Building construction start(12/12) □ Installation start (14/5) 	<ul style="list-style-type: none"> ★ Accelerate 430MeV/u (15/1) ★ Multiple-energy operation and scanning irradiation(15/2) ★ Treatment start (15/12) 					



KCC: Kanagawa Cancer Center

IRS: National Institute of Radiological Sciences

DARUMA CEREMONY

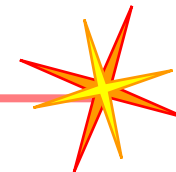


Celebrate of success in the Multiple-energy operation and scanning irradiation



2017/2/23

Naoya Saotome(NIRS)



NON-scanned beam test

- ✈ Beam intensity
- ✈ Beam position
- ✈ Beam size
- ✈ Beam on/off response

Scanned beam test

- ✈ Scanned beam position
- ✈ Field uniformity
- ✈ Complex field
- ✈ Dose monitor performance
- ✈ Position monitor performance

Beam data collection for TPS

- ✈ Beam size
- ✈ Beam divergent
- ✈ Integral depth-dose
- ✈ Dose monitor unit

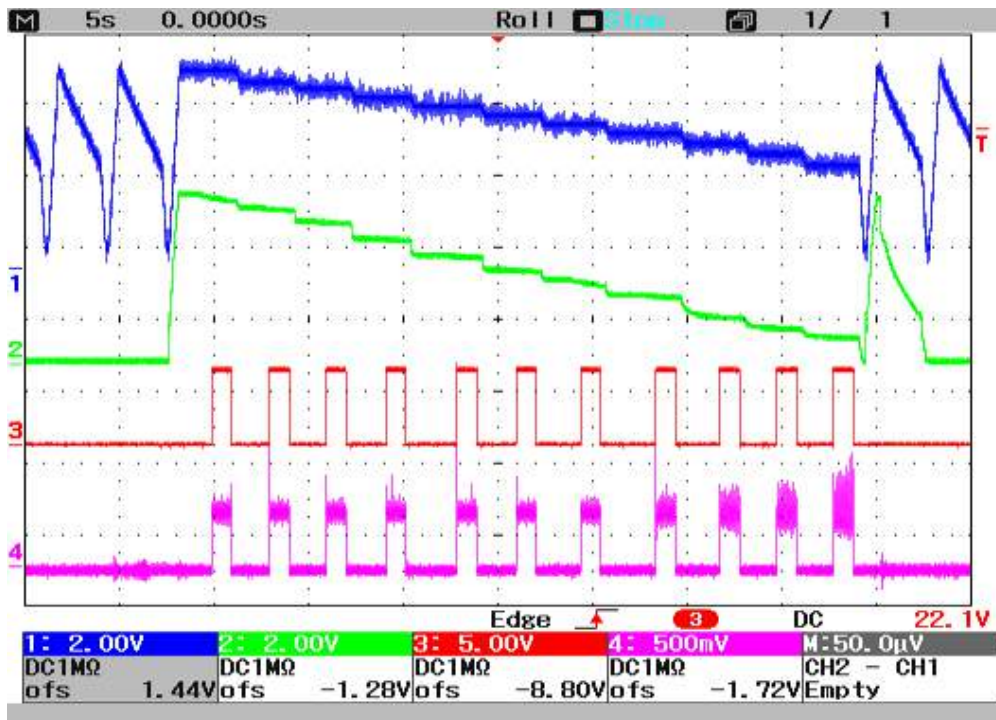
Overall verification

- ✈ Interlock check
- ✈ Information transfer check
- ✈ Coordinate check
- ✈ End-to-End test
- ✈ Training for staff
- ✈ Beam matching

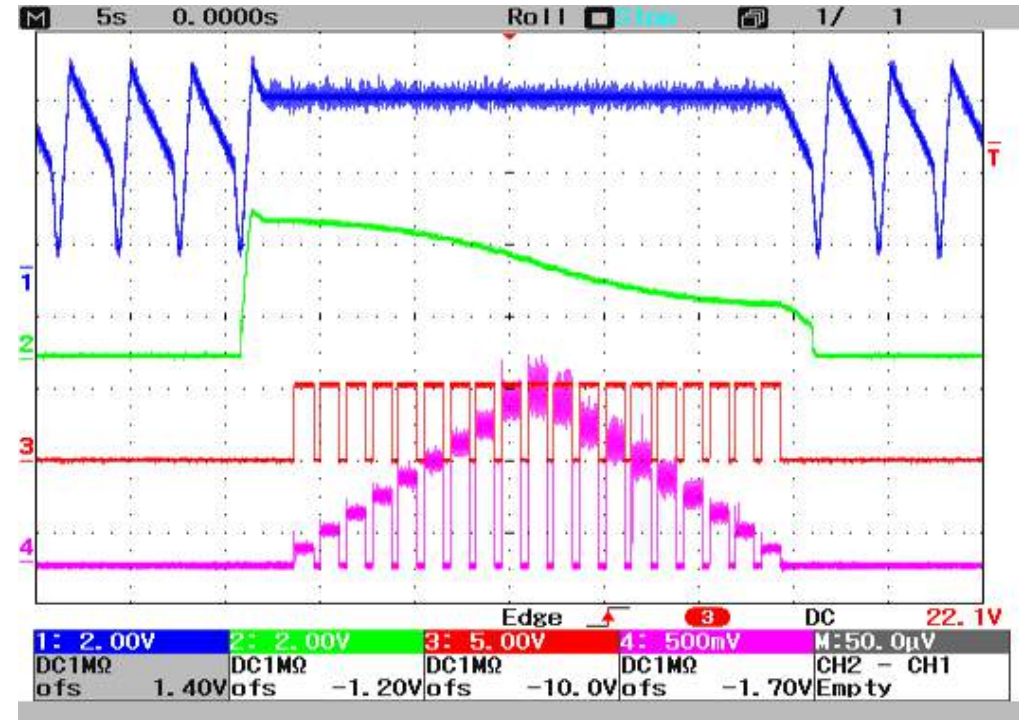
Beam intensity



Extended FT + Multiple Energy Operation



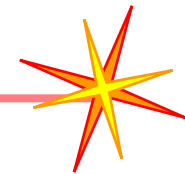
Extended FT + Intensity Modulation Operation



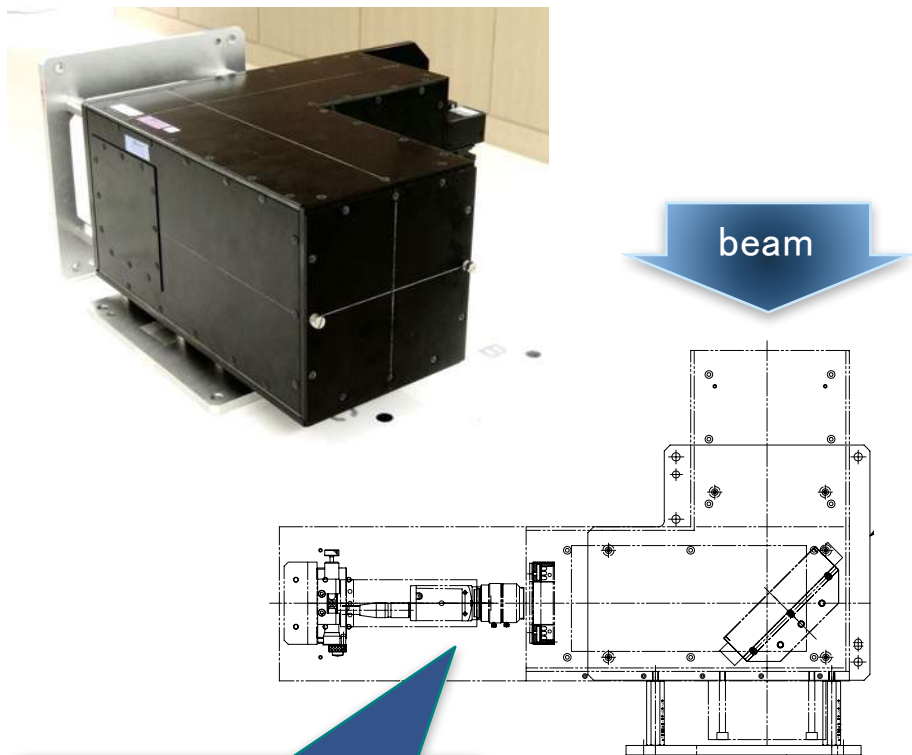
Blue: BM current, Green: DCCT, Red: Enable signal of extraction, Pink: Dose monitor

Constancy of the intensity and the ripples are suppressed within 20%

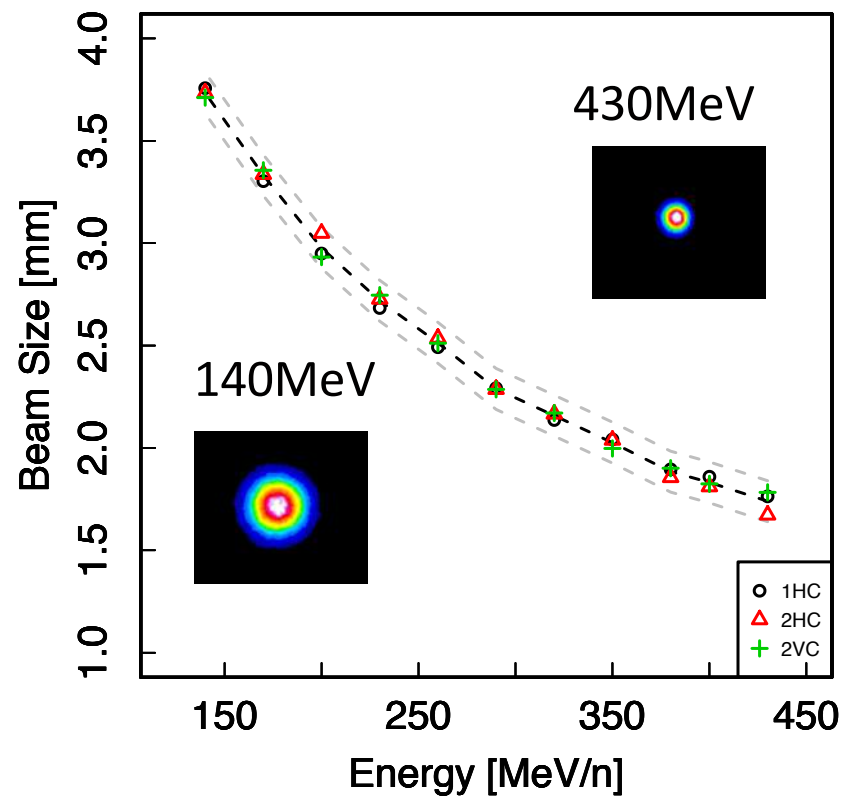
Beam size and position



Screen monitor for spot



- Beam shape was adjusted as round shape
- Beam size was adjusted within 10 percent from designed
- Beam size for each treatment port were matched



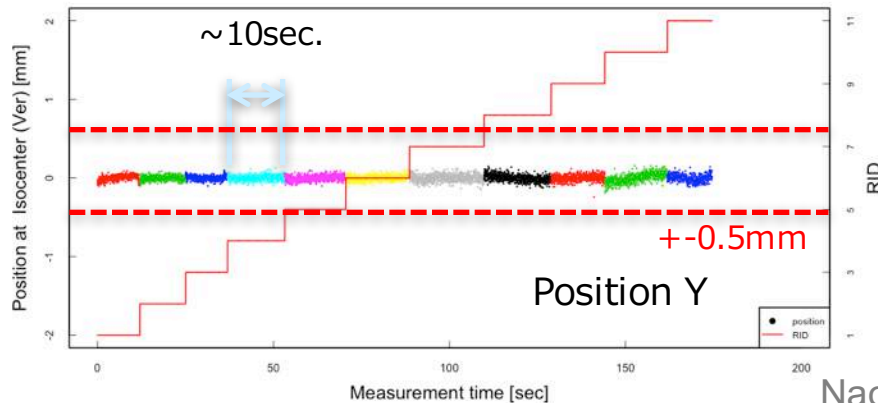
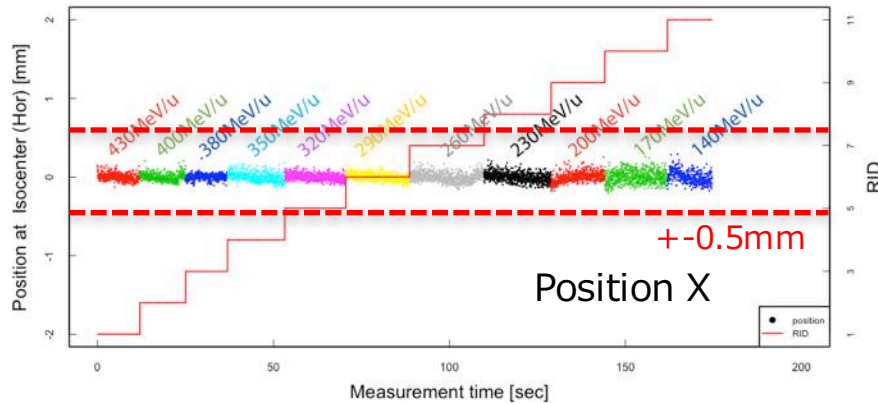
CCD camera

Beam size and position

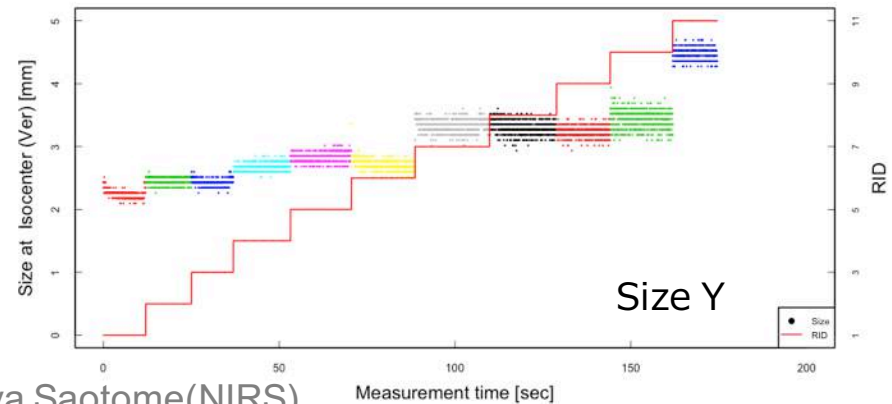
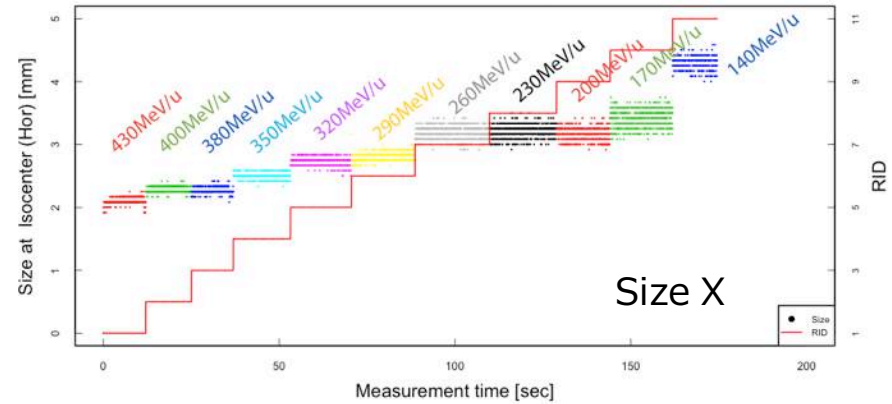


- ✈ Beam position stability was within ± 0.5 mm
- ✈ Beam size stability was within ± 0.5 mm from design

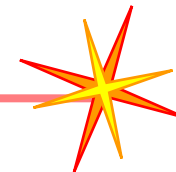
Beam position (2VC)



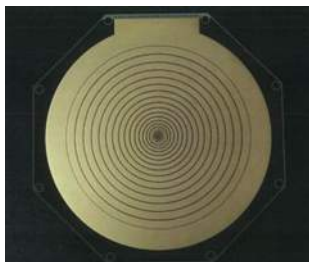
Beam size (2VC)



Integral depth dose



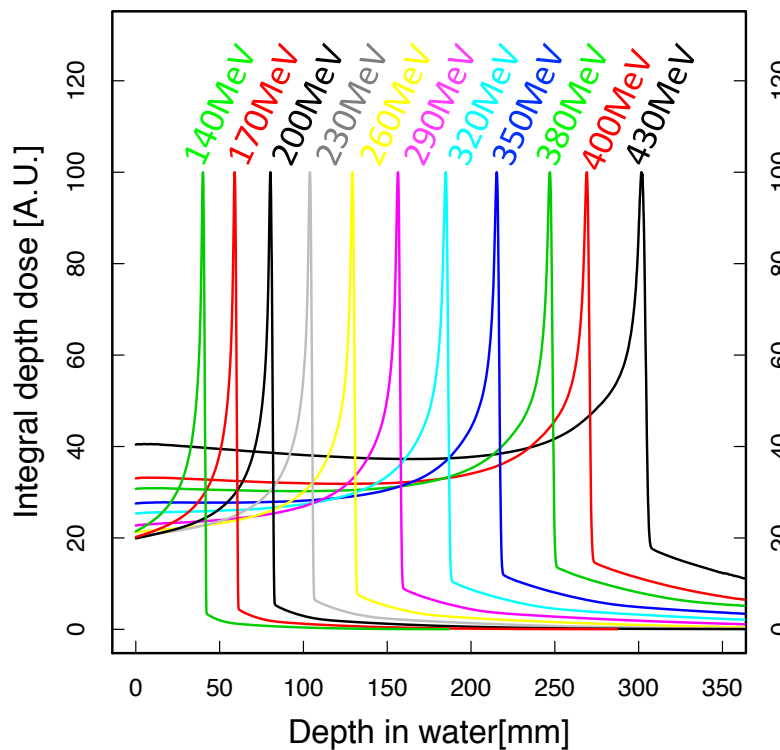
Concentric Ionization chamber



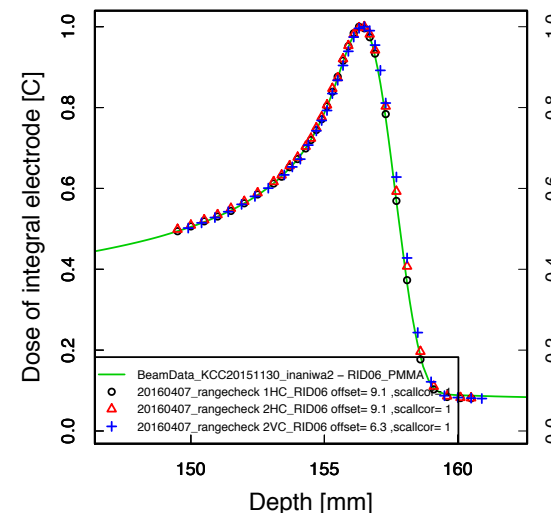
3D Water phantom



IDD for 11 energy beams



- Beam energy/range was adjusted
- Residual range for each treatment port were matched
- Lateral distribution was used for TPS beam modelling



Scanned beam position



Screen monitor for field



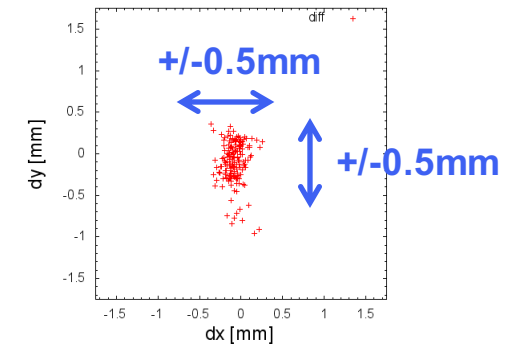
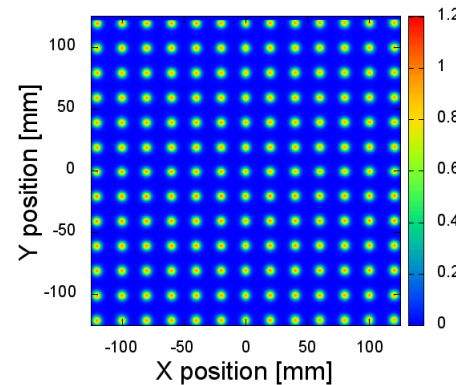
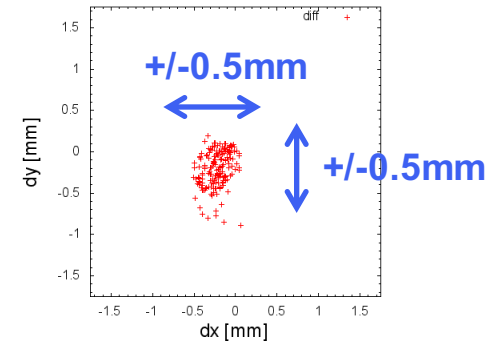
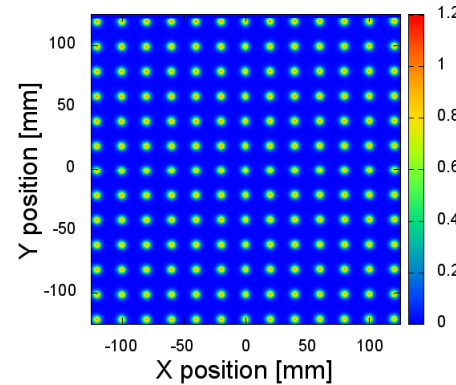
430MeV/u

- ✓ 240x240mm² field
- ✓ 20 mm pitch

380MeV/u

- ✓ 240x240mm² field
- ✓ 20 mm pitch

- ✈ Scanned beam position for every beam energy was checked
- ✈ Beam shape was adjusted as round shape at any position
- ✈ The precision of the scanned beam position was verified within ± 0.5 mm.



Field uniformity



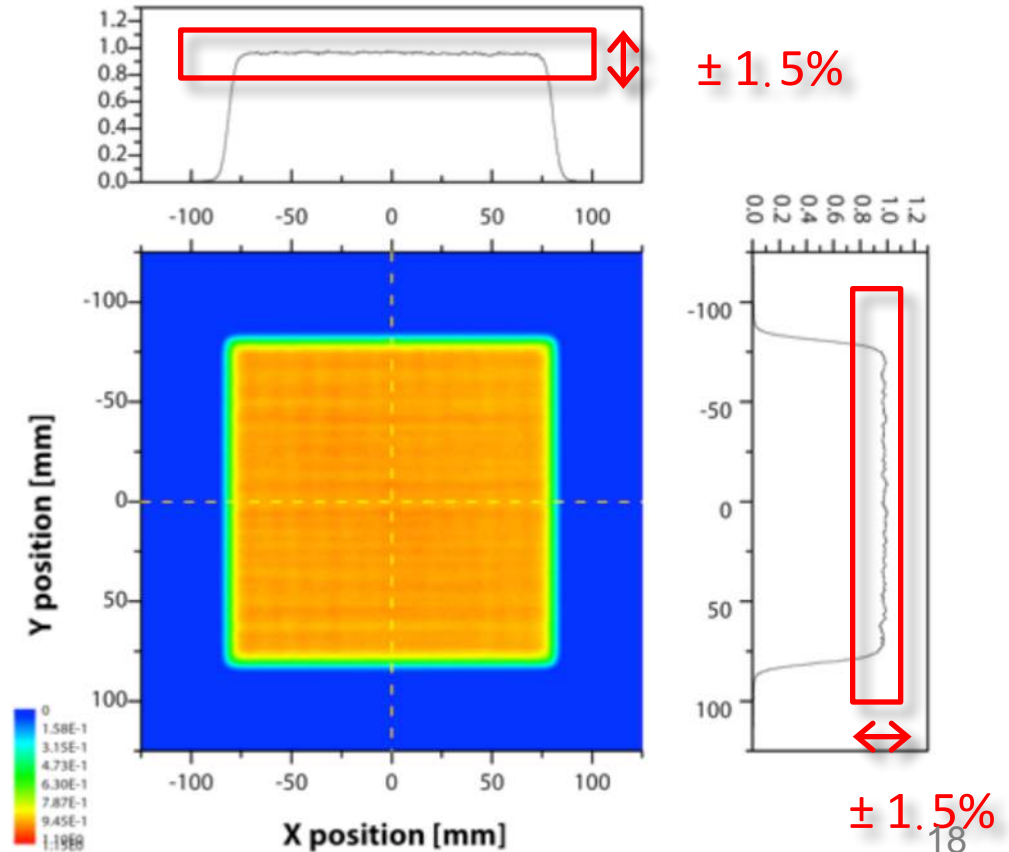
- Field uniformity for every beam energy was checked
- The flatness of the uniform field was verified within $\pm 1.5\%$

Screen monitor for field



290MeV/u

- ✓ 150x150mm² field
- ✓ 2mm pitch

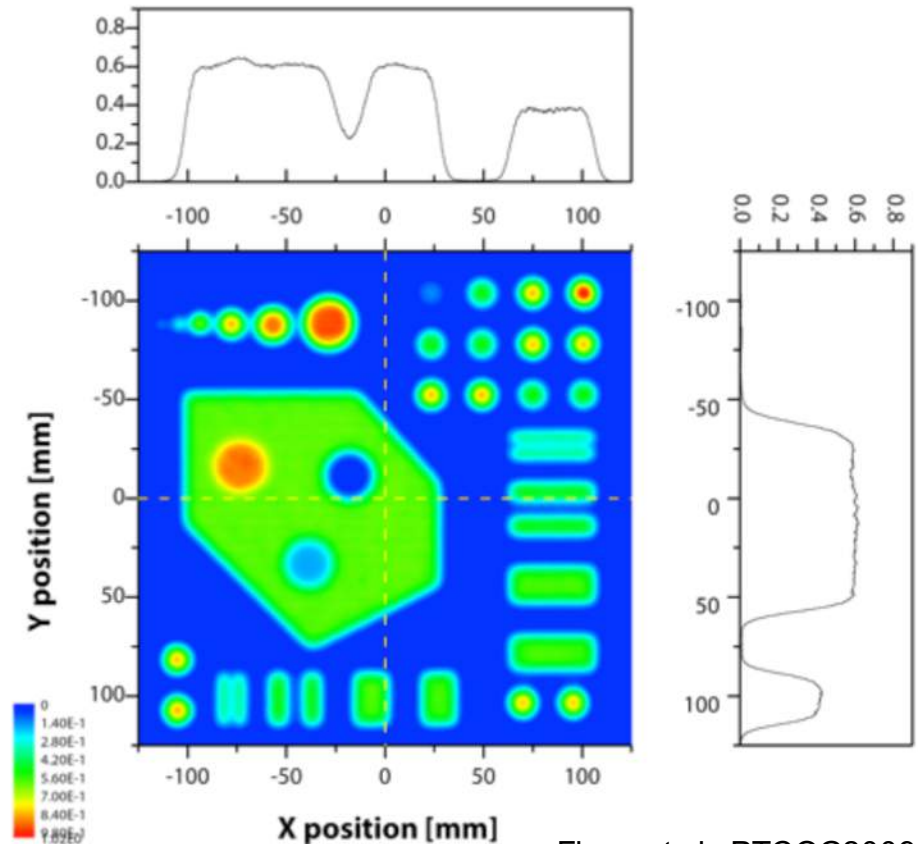
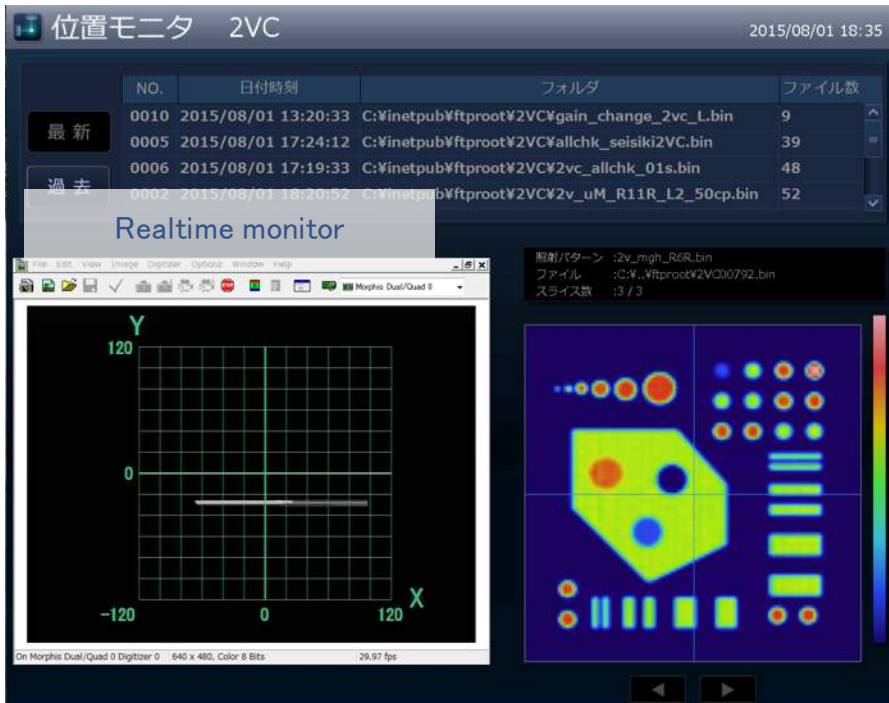


Complex field



Position monitor system

- Beam intensity, dose, and beam position were modulated
- Complex field for every beam energy was checked
- The dose distribution was compared with plan and confirmed

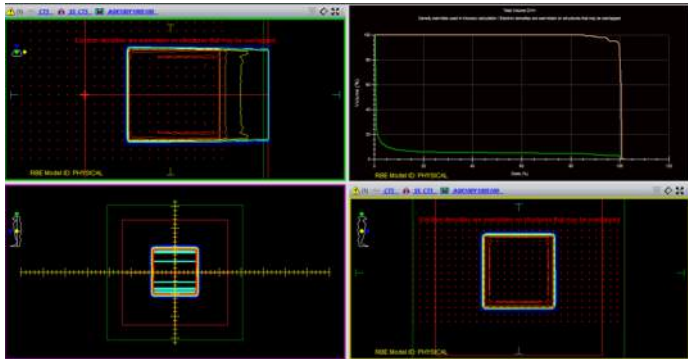


3D dose distribution



Treatment planning

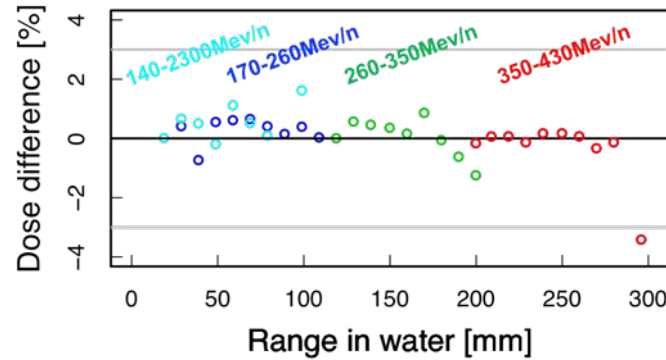
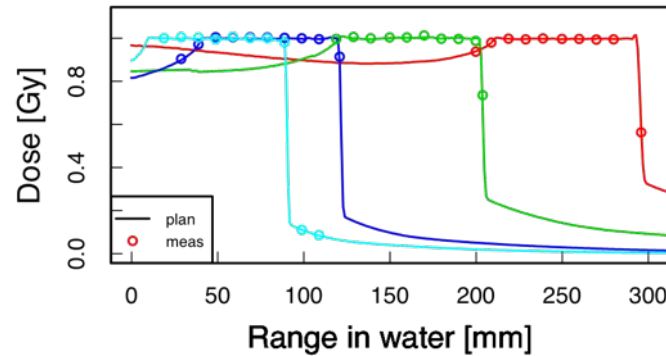
- Rectangle shape irradiation fields were planned
- Dose distribution on the depth and lateral direction were compared with planned dose distribution



3D Water phantom

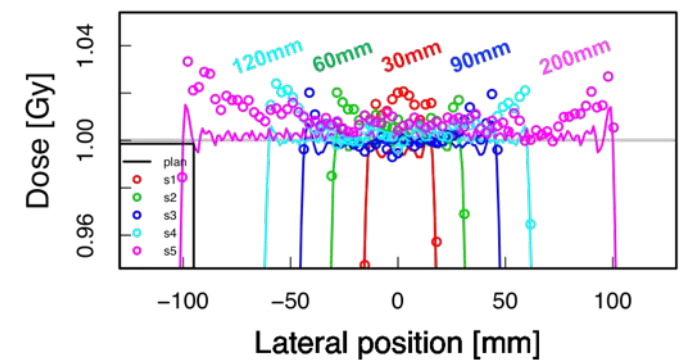
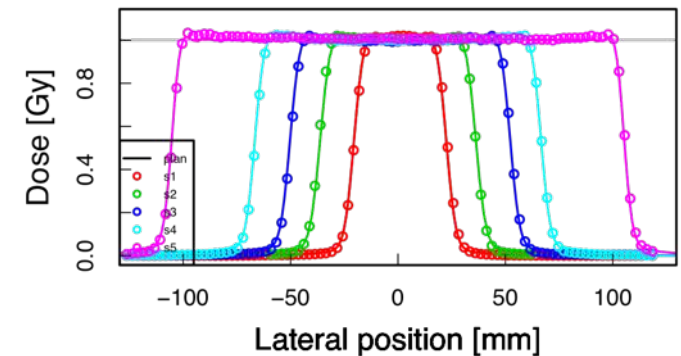


Depth dose distribution

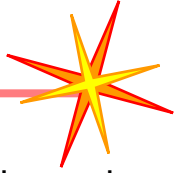


Naoya Saotome(NIRS)

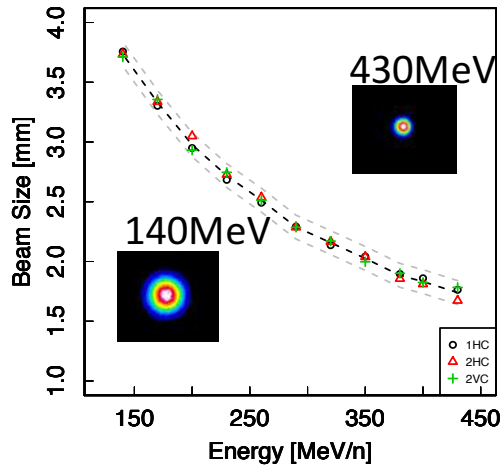
Lateral dose distribution



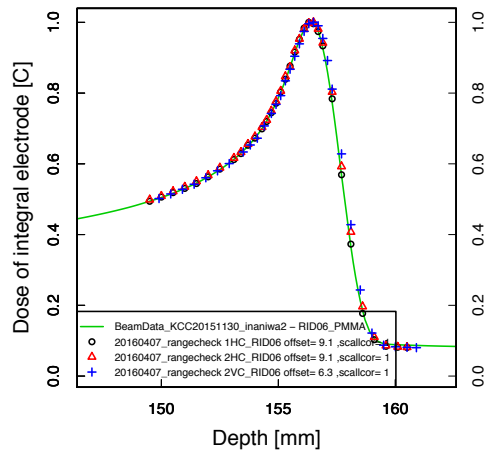
Beam matching



Beam size matching

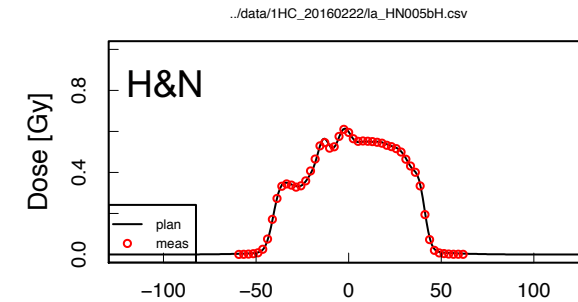
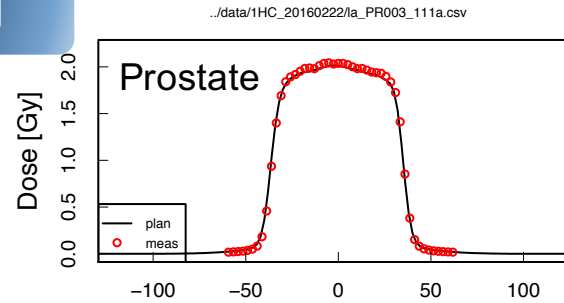


Range matching

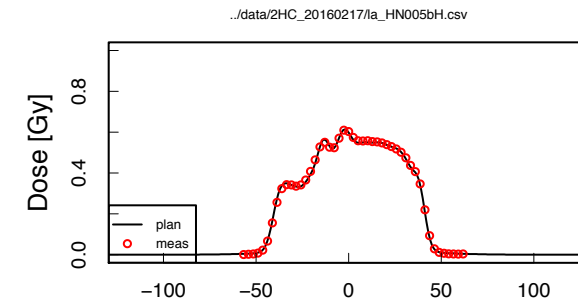
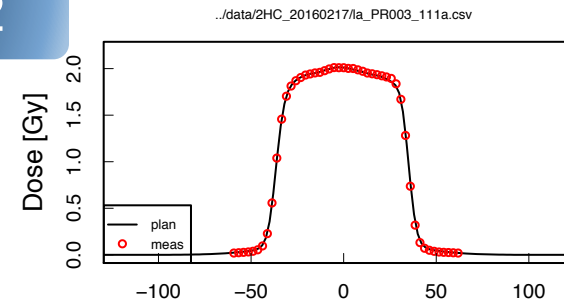


- Sample patient field for Prostate and H&N were planned
- The plan were deliver and measured at each treatment rooms
- Beam size and range matching brought dose distribution matching

Room 1

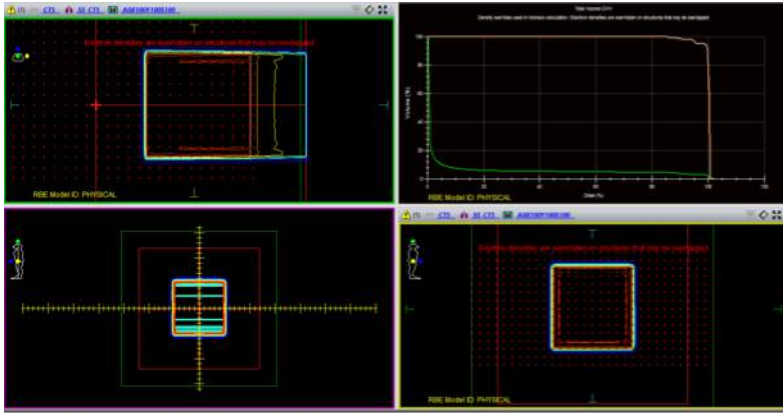


Room 2



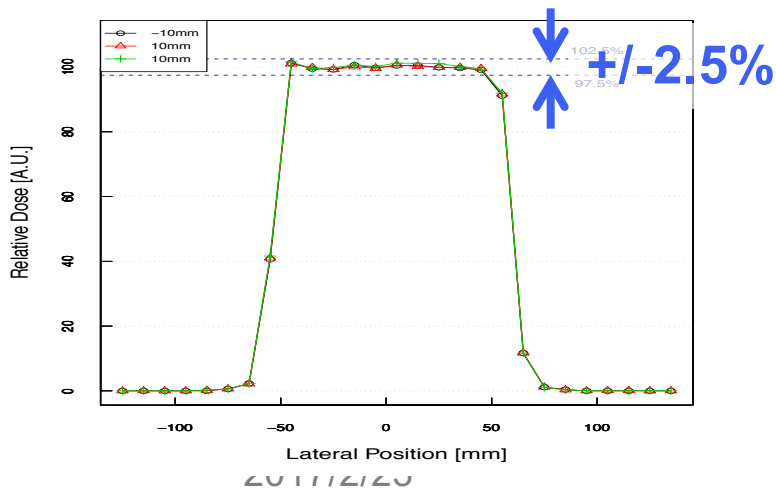


Treatment planning

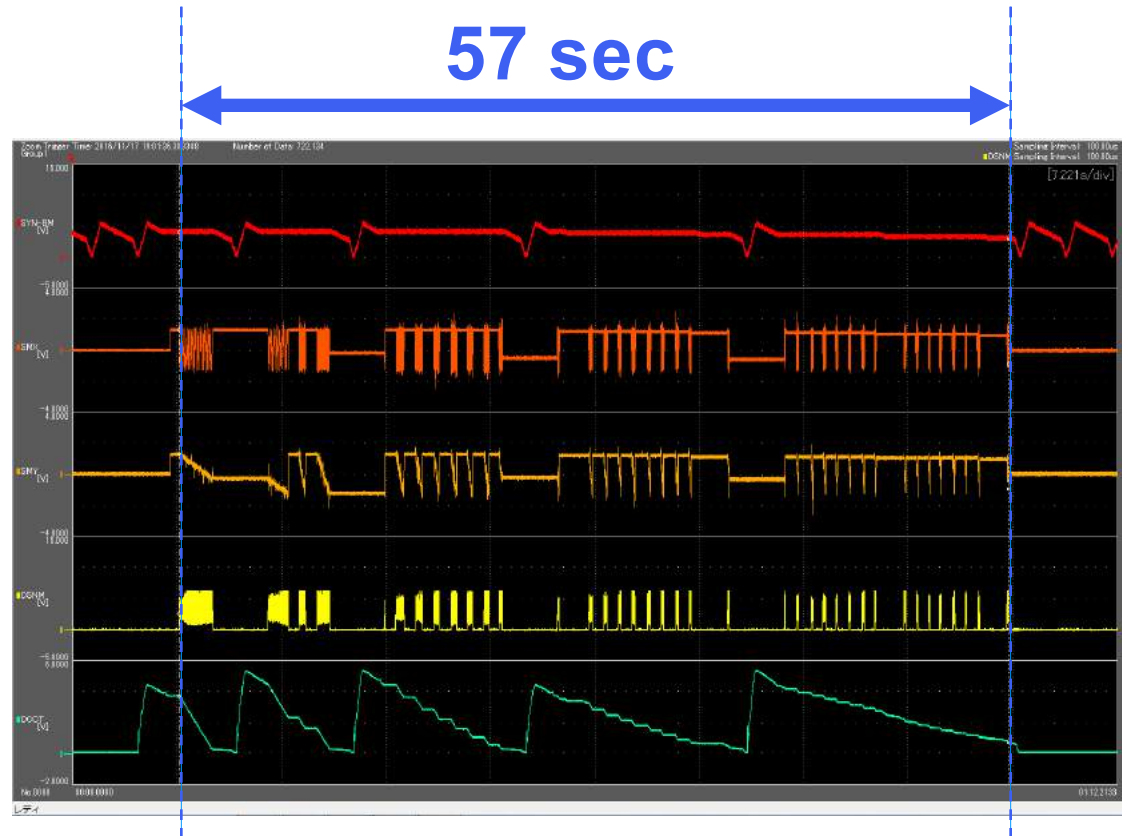


- 2Gy of physical dose to 10x10x10cm³ cubic target was planned
- The dose homogeneity was better than $\pm 2.5\%$

Lateral dose distribution



57 sec



DARUMA CELEMONY



Celebrate of first treatment day





Introduction

History and collaboration



KCC i-ROCK

Commissioning of commercial scanning system

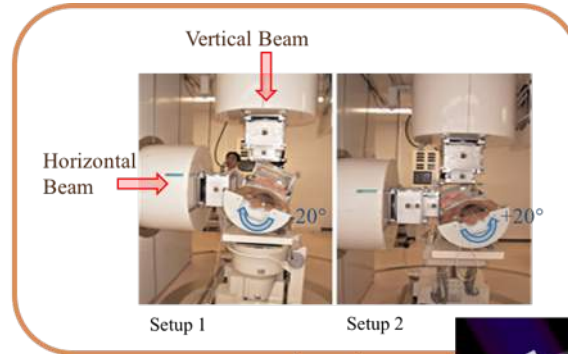


NIRS Gantry

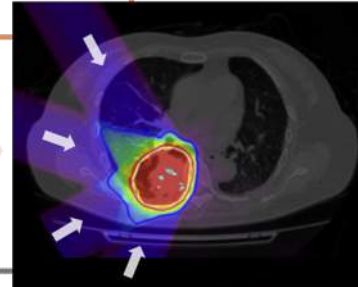
Commissioning of NIRS's Gantry with superconducting magnet



ADVANTAGES OF GANTRY

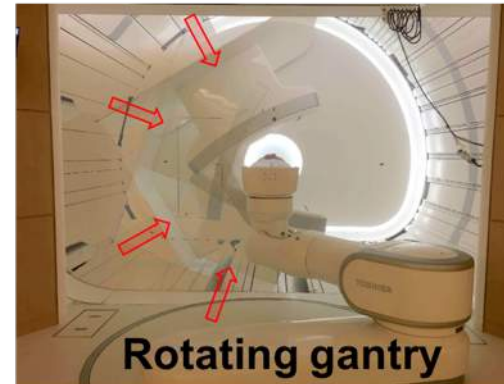


Fixed beam port

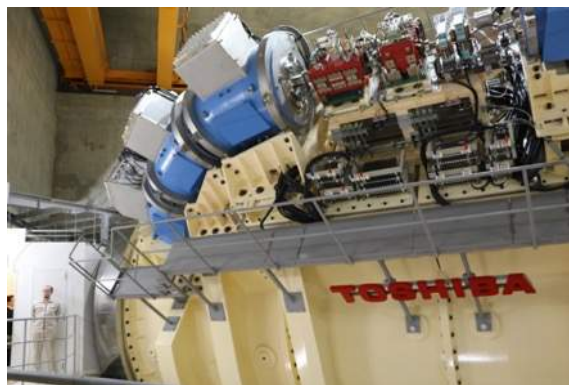
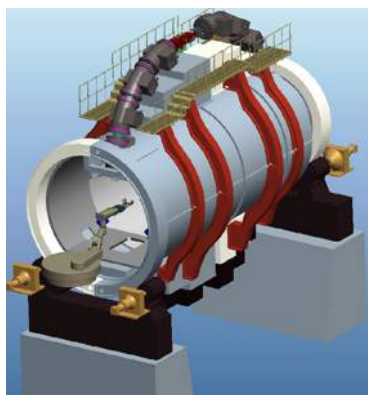
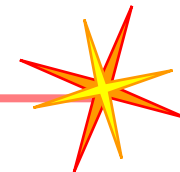


Advantage of a rotating gantry

1. Relaxing the patient's pain
2. Availability of the challenging treatment plan (IMPT)
3. Accurate dose delivery
4. higher patient throughput



Specification of NIRS's Gantry



- Function combined superconducting magnets were employed
- Moving target treatment is available with respiratory-gated and rescanning technique

item	specification
Ion	C ⁶⁺
Energy	48-430MeV/u
Max. field	200 x 200 mm ²
Irradiation type	3D Scanning
Rotating angle	+/- 180 degree
Magnet type	Superconducting magnet
Beam orbit radius	5.45 m
Length	13 m
Weight	300 ton
Vender	Toshiba



Construction and installation



Mar, 2013



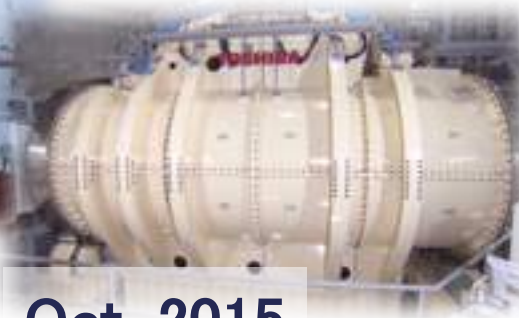
May, 2014



June, 2015



Jan, 2015



Oct, 2015

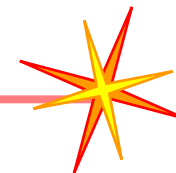


Gantry room



Treatment room





NON-scanned beam test

- ✈ Beam intensity
- ✈ Beam position
- ✈ Beam size
- ✈ Beam on/off response

Gantry angle dependence check

- ✈ Beam position
- ✈ Beam size
- ✈ Dose output

Scanned beam test

- ✈ Scanned beam position
- ✈ Field uniformity
- ✈ Complex field
- ✈ Dose monitor performance
- ✈ Position monitor performance

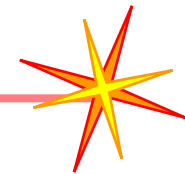
Beam data collection for TPS

- ✈ Beam size
- ✈ Beam divergent
- ✈ Dose monitor unit

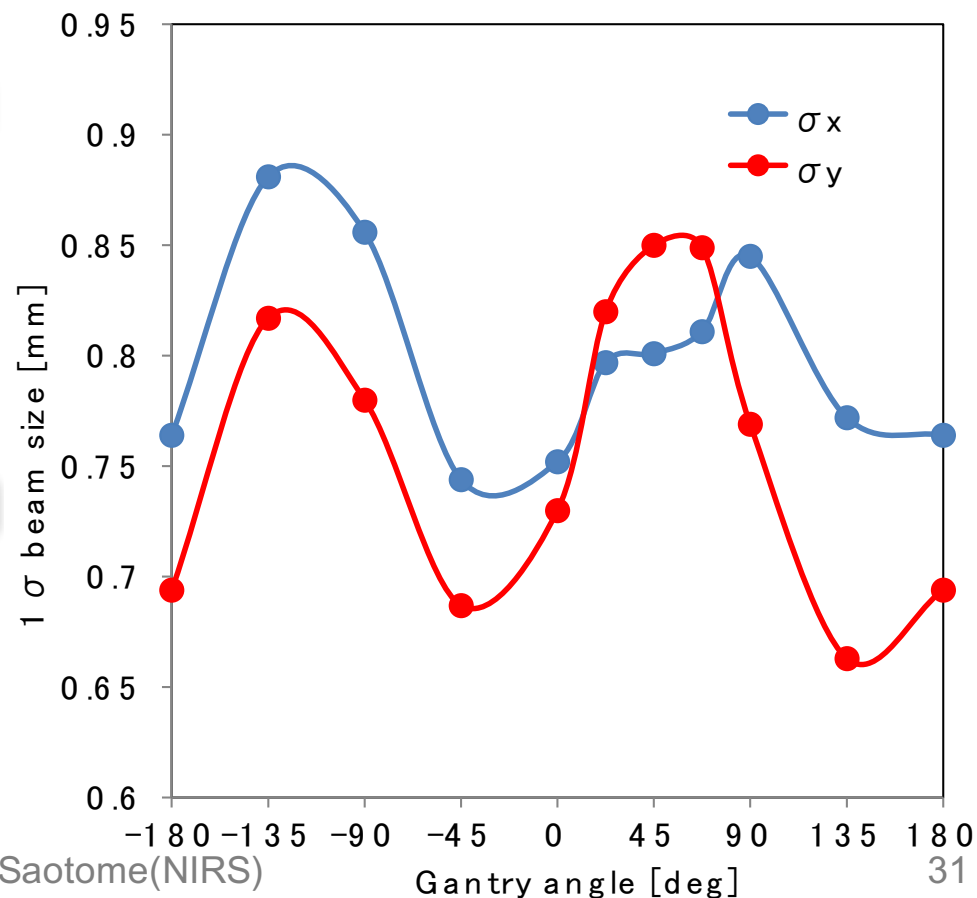
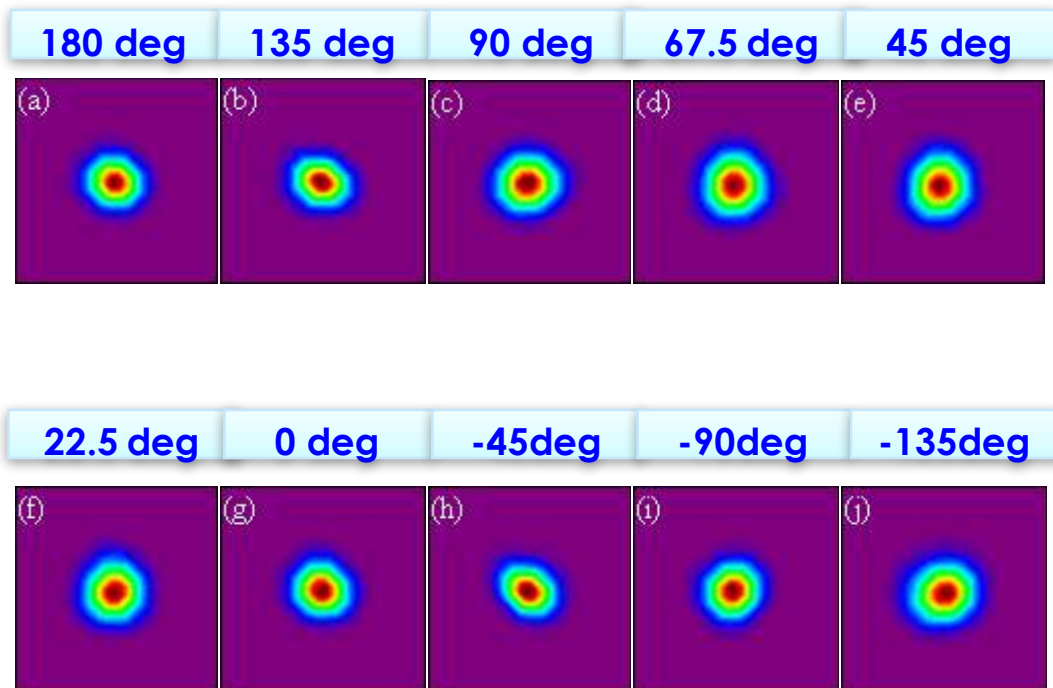
Overall verification

- ✈ Interlock check
- ✈ Information transfer check
- ✈ Coordinate check
- ✈ End-to-End test
- ✈ Training for staff
- ✈ Beam matching

Angle dependence of the beam size



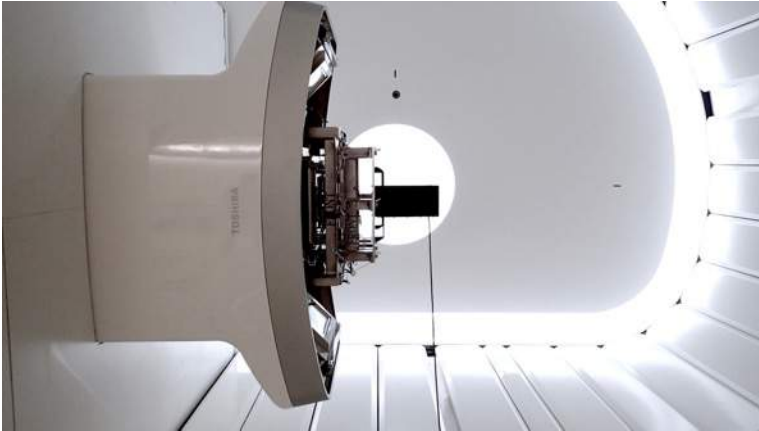
- Angular dependence of a beam size and shape at the isocenter (E=430 MeV/u)



Angle dependence of the beam size

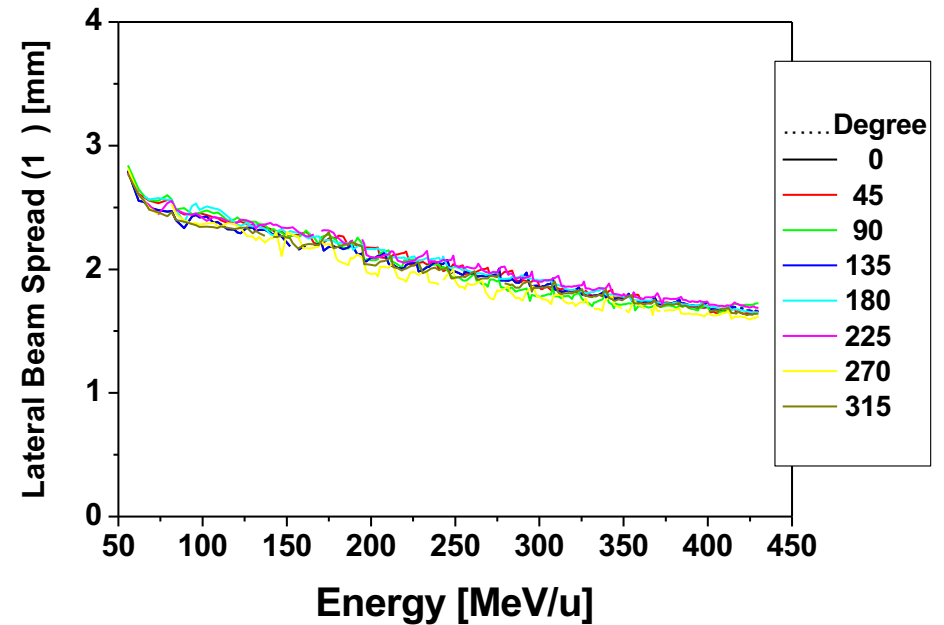
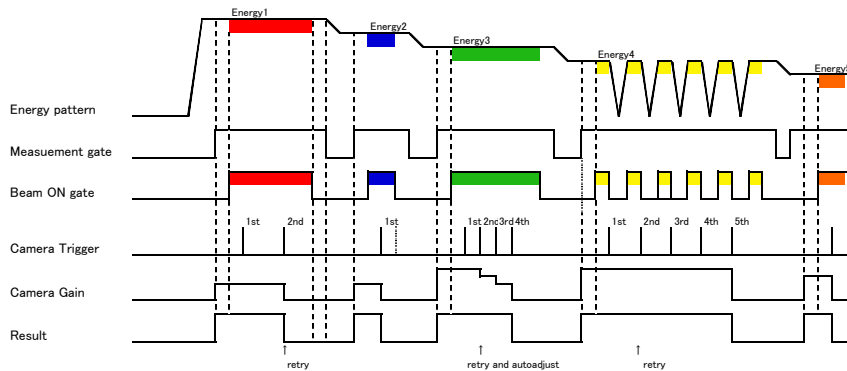


Screen monitor for spot



- The accuracy of the beam size and beam position for every gantry angle were checked
- The measurement was performed with sequence (15min for 200Energy)
- Angle dependent of the beam size is less than 10%

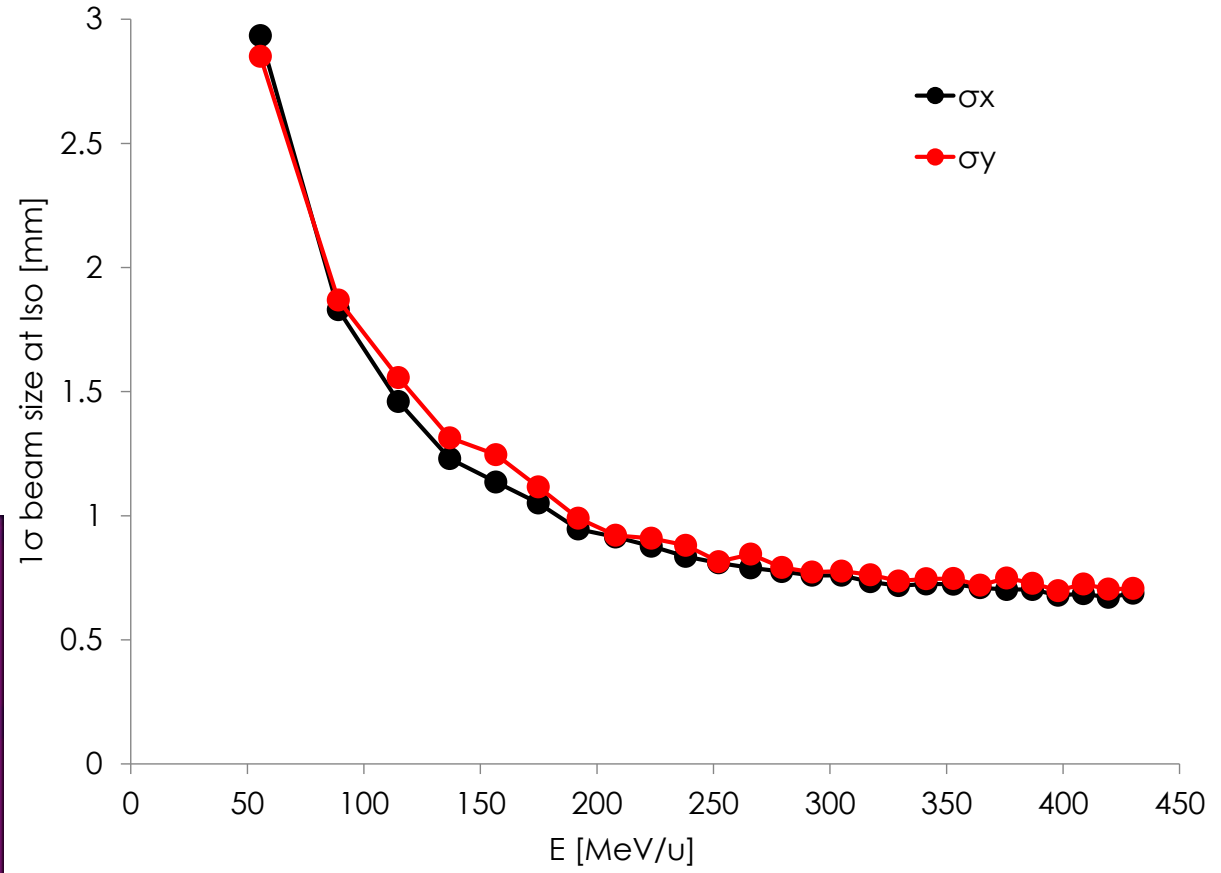
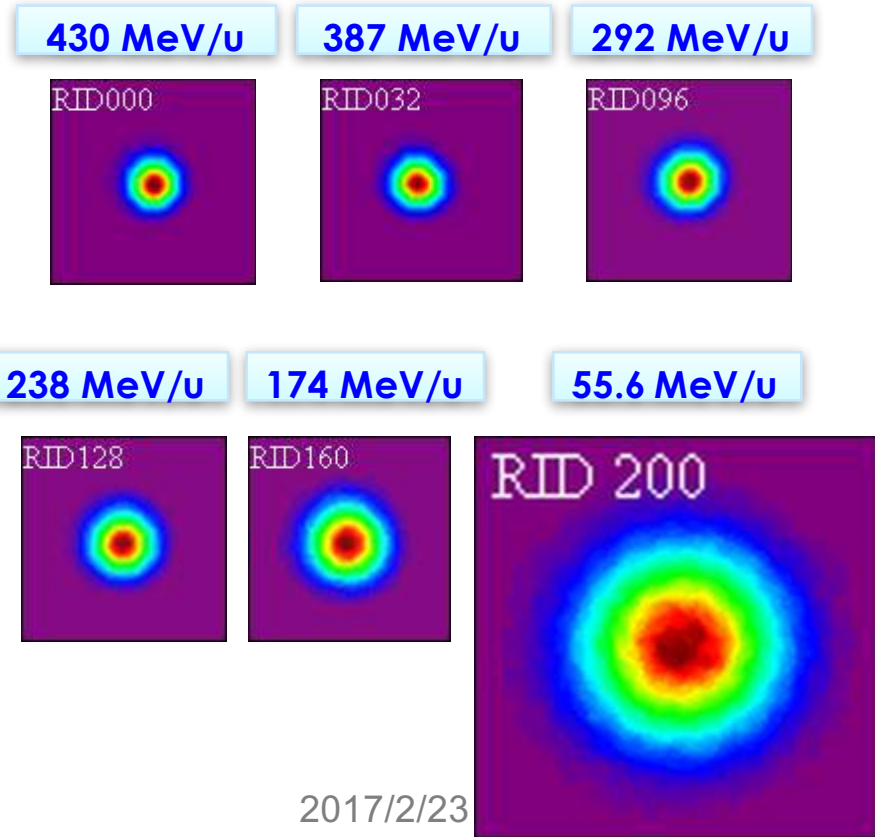
Measurement sequence



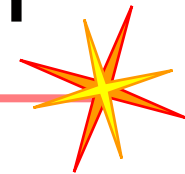
Beam size



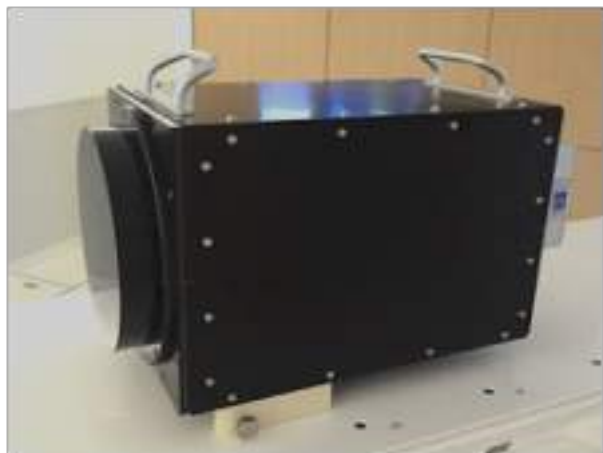
- Beam tuning was made for various beam energies
- (E=430~55.6 MeV/u)



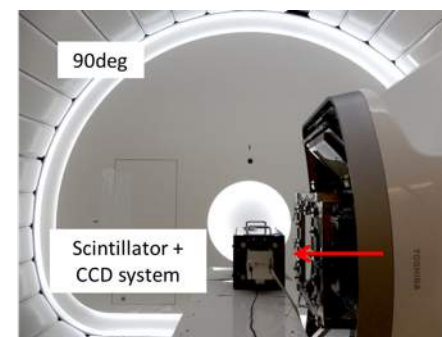
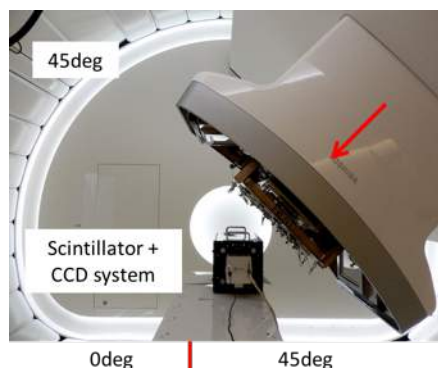
Angle dependence of the beam position



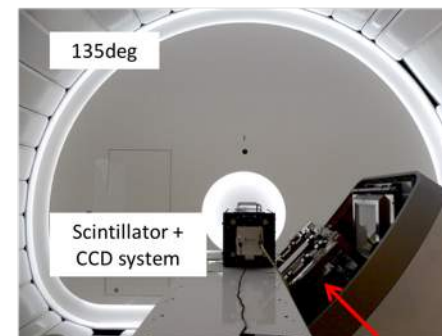
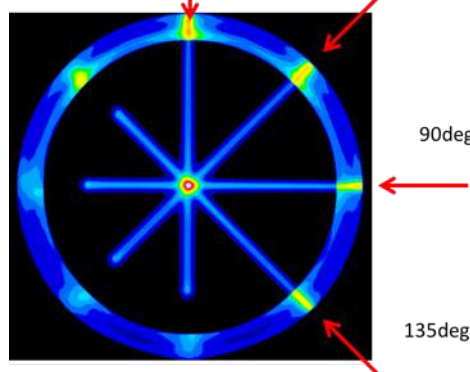
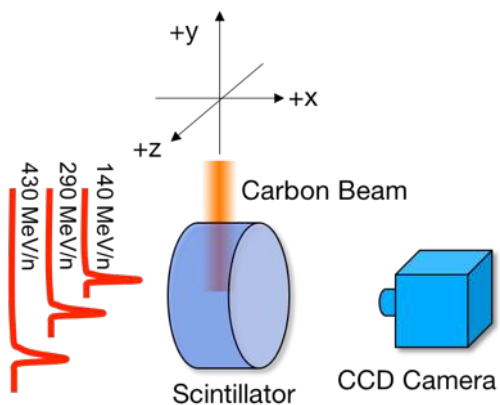
Digital starshout device



- The accuracy of the isocenter position and gantry angles are checked using digital starshout device
- Beam position accuracy for each gantry angle was confirmed within +/- 0.5mm.

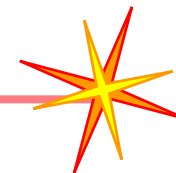


3D Water phantom



Naoya Saotome(NIRS)

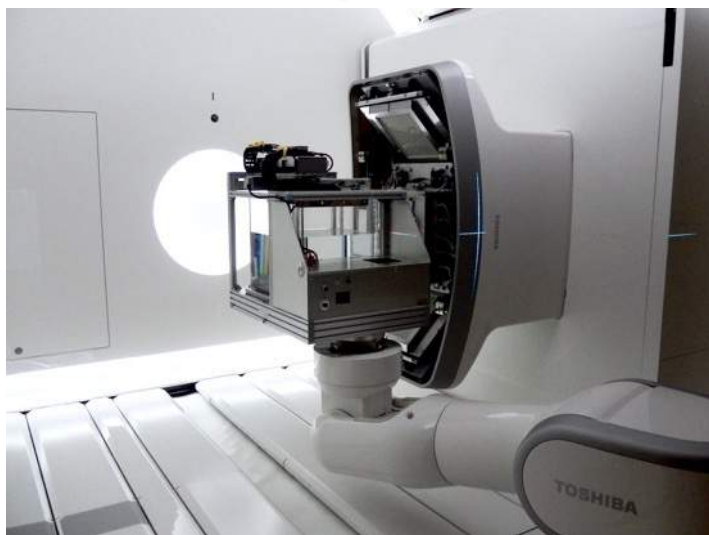
Integral Dose Distribution



Concentric Ionization chamber

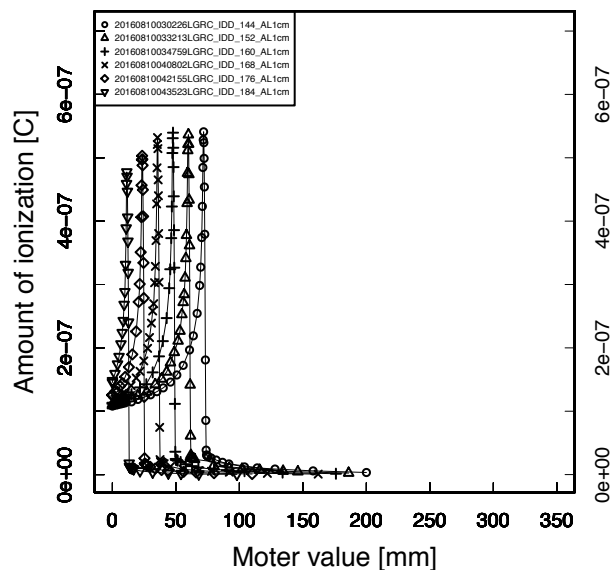


3D Water phantom

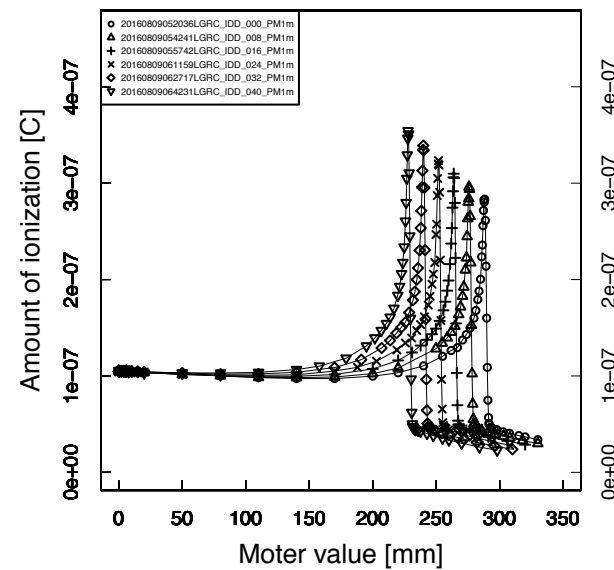


- Beam energy/range was adjusted
- Lateral distribution was used for TPS beam modelling

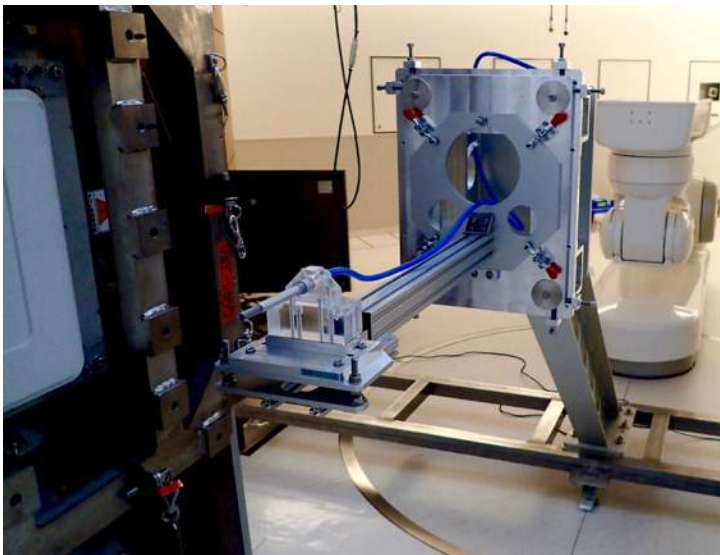
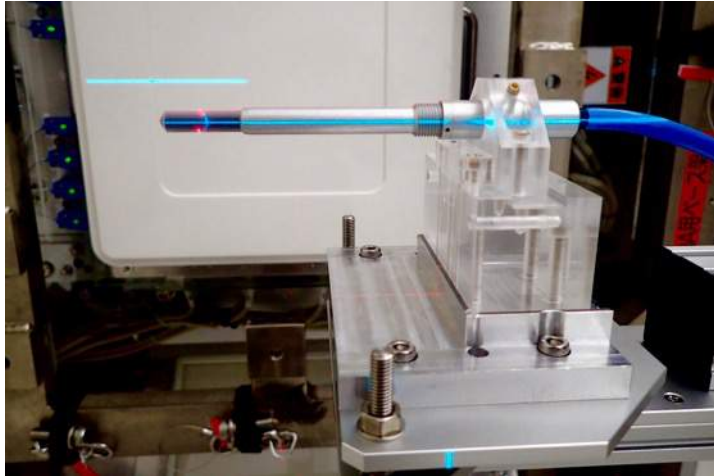
Low energy



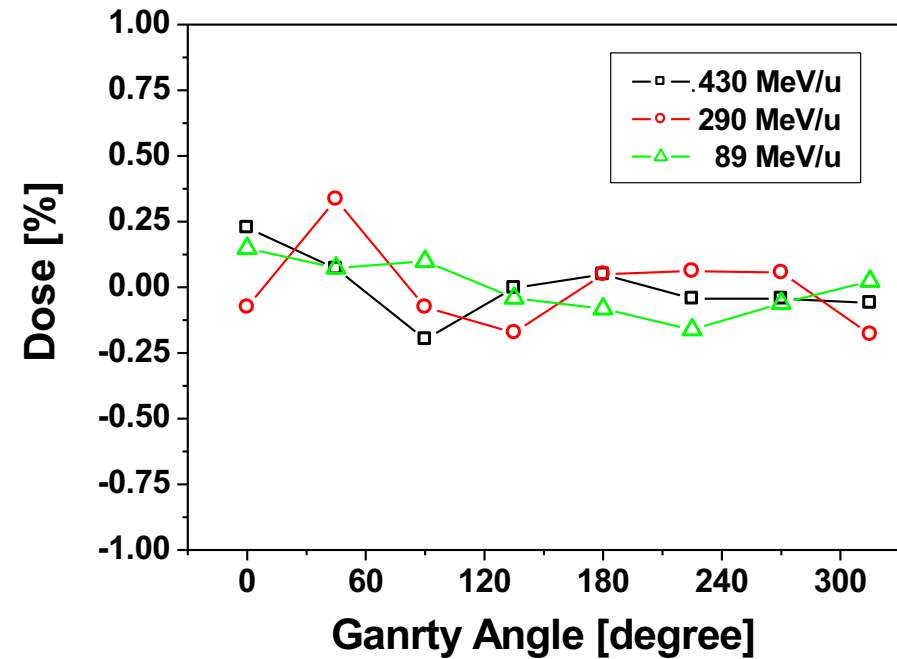
High energy



Dose output



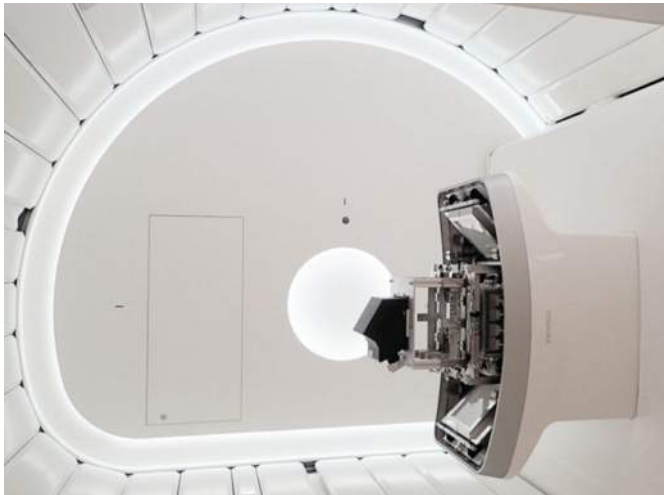
- Dose output for every gantry angle was checked using fano type ionization chamber
- Angle dependence of the dose output was less than 0.5%



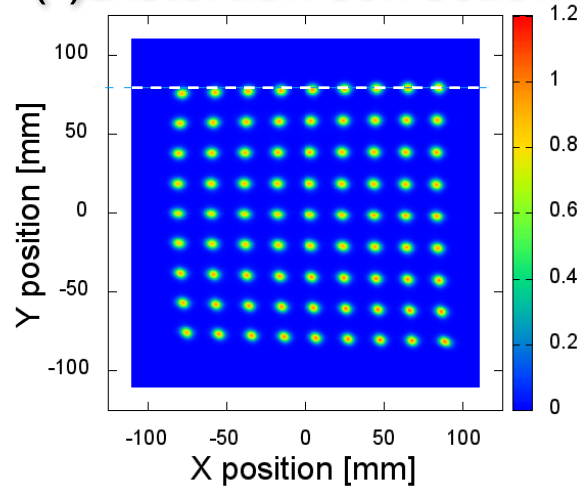
Scanned Beam Position



Screen monitor for field

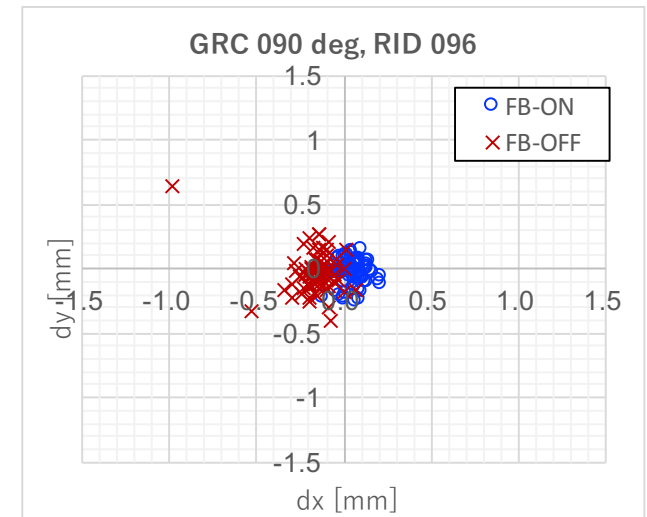
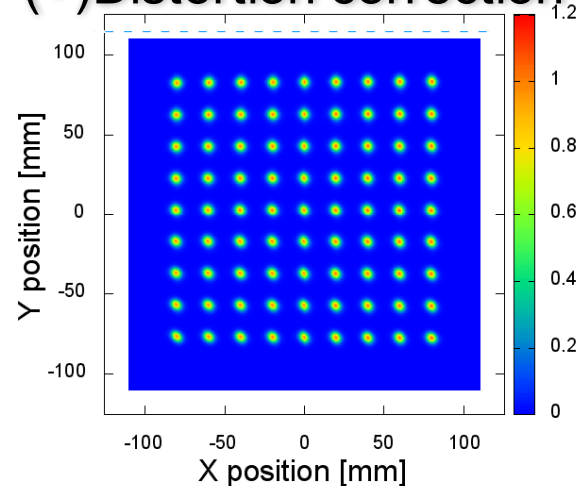


(-)Distortion correction

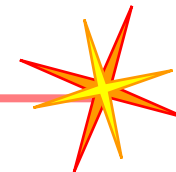


- ✈ Scanned beam position for every beam energy and gantry angle was checked
- ✈ Beam shape was adjusted as round shape at any position and any gantry angle
- ✈ The precision of the scanned beam position after the distortion correction was verified within ± 0.5 mm.

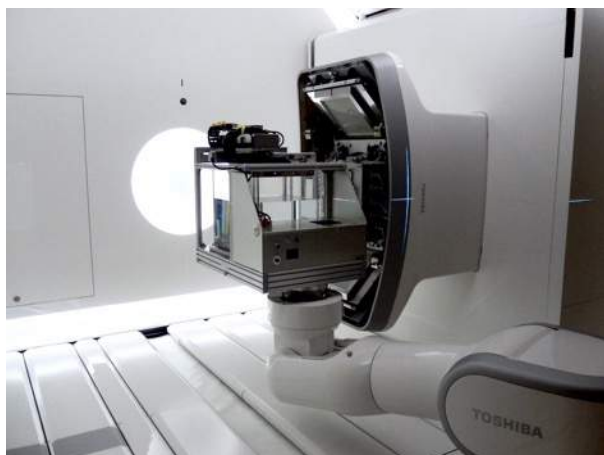
(+)Distortion correction



3D dose distribution

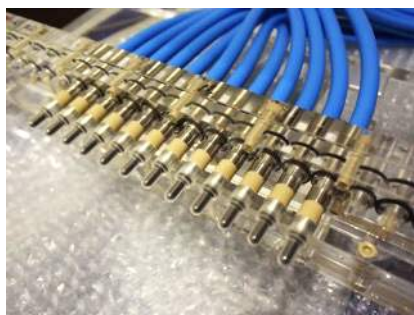


3D Water phantom

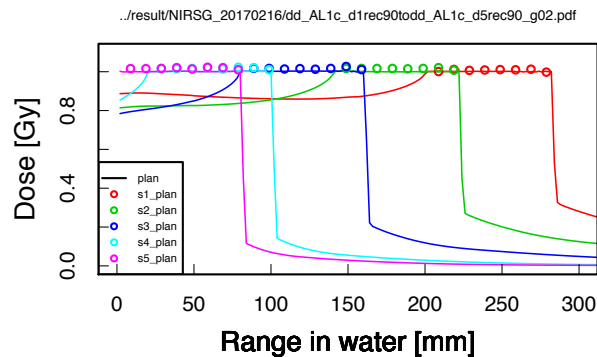


- Rectangle shape irradiation fields were planned
- Dose distribution on the depth and lateral direction were compared with planned dose distribution

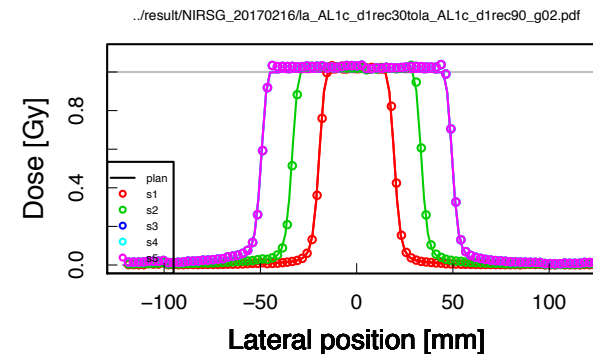
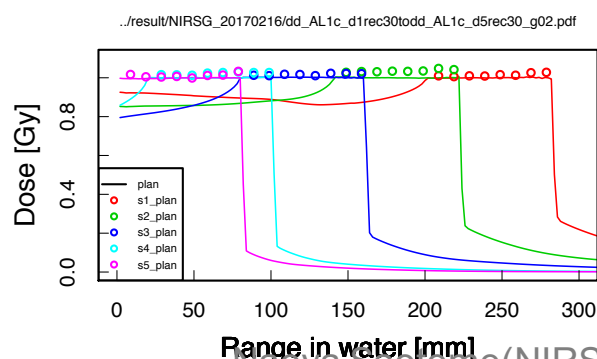
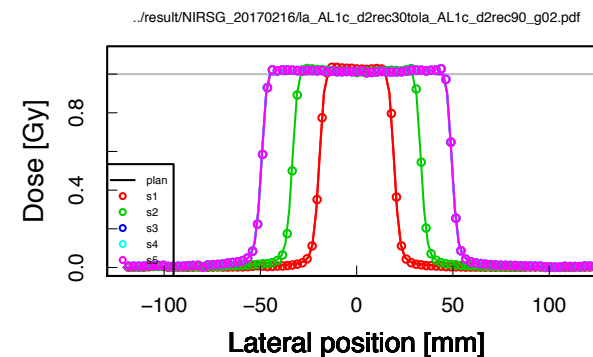
Pin-point chamber array



Depth dose distribution



Lateral dose distribution



3D dose distribution



3D Water phantom

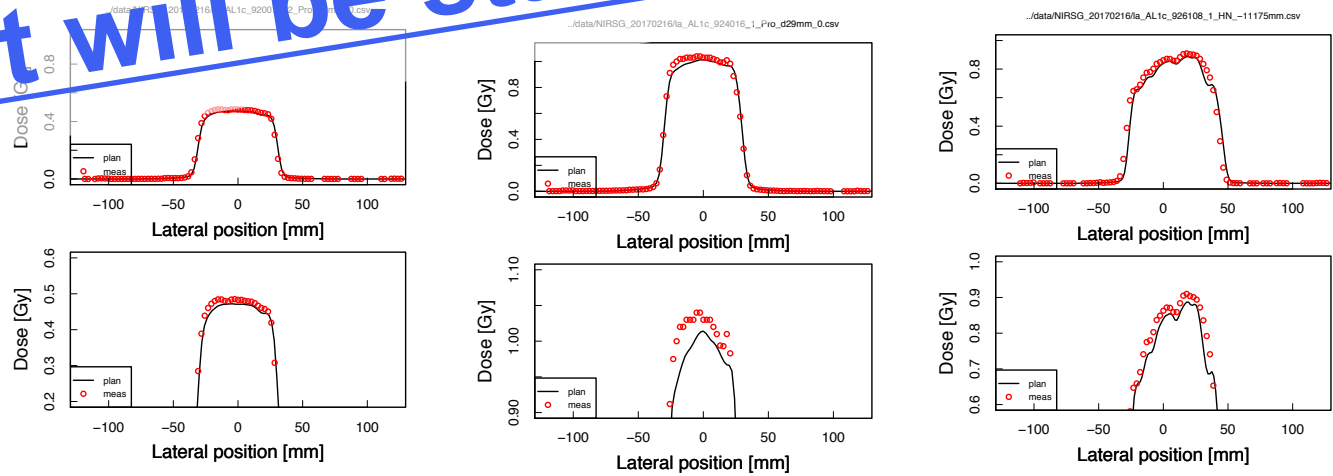
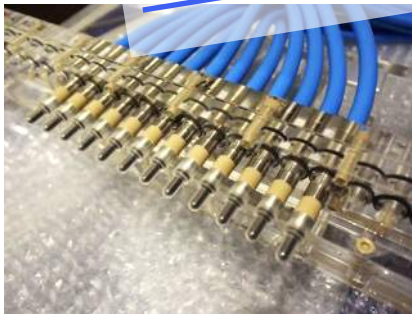


- Rectangle shape irradiation fields were planned
- Dose distribution on the depth and lateral direction were compared with planned dose distribution

Lateral dose distribution

Treatment will be start next April!!

Pin-point chamber array





- ✈ **Fast scanning system dedicated for moving target was succeeded at NIRS**
- ✈ **Commercial system which is combination of a compact dissemination treatment system and pencil beam 3D scanning technique was constructed at KCC**
- ✈ **Treatment using superconducting rotating-gantry will be started in near future**