provision center for PROTONTHERAPY

COMMISSIONING A CYCLOTRON-BASED GANTRY SYSTEM FOR PENCIL BEAM SCANNING

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OBJECTIVES

Explain….

1. How to commission a gantry based PBS system.
2. The beam data requirements for a pencil beam scanning (PBS) proton therapy model.
3. What the future holds for PBS delivery systems

Show and tell….

1. The dosimetry equipment used for commissioning
2. In–house modifications, tools, software used in commissioning and QA.

PROVISION CENTER FOR PROTON THERAPY

IBA C230 Proton Therapy System

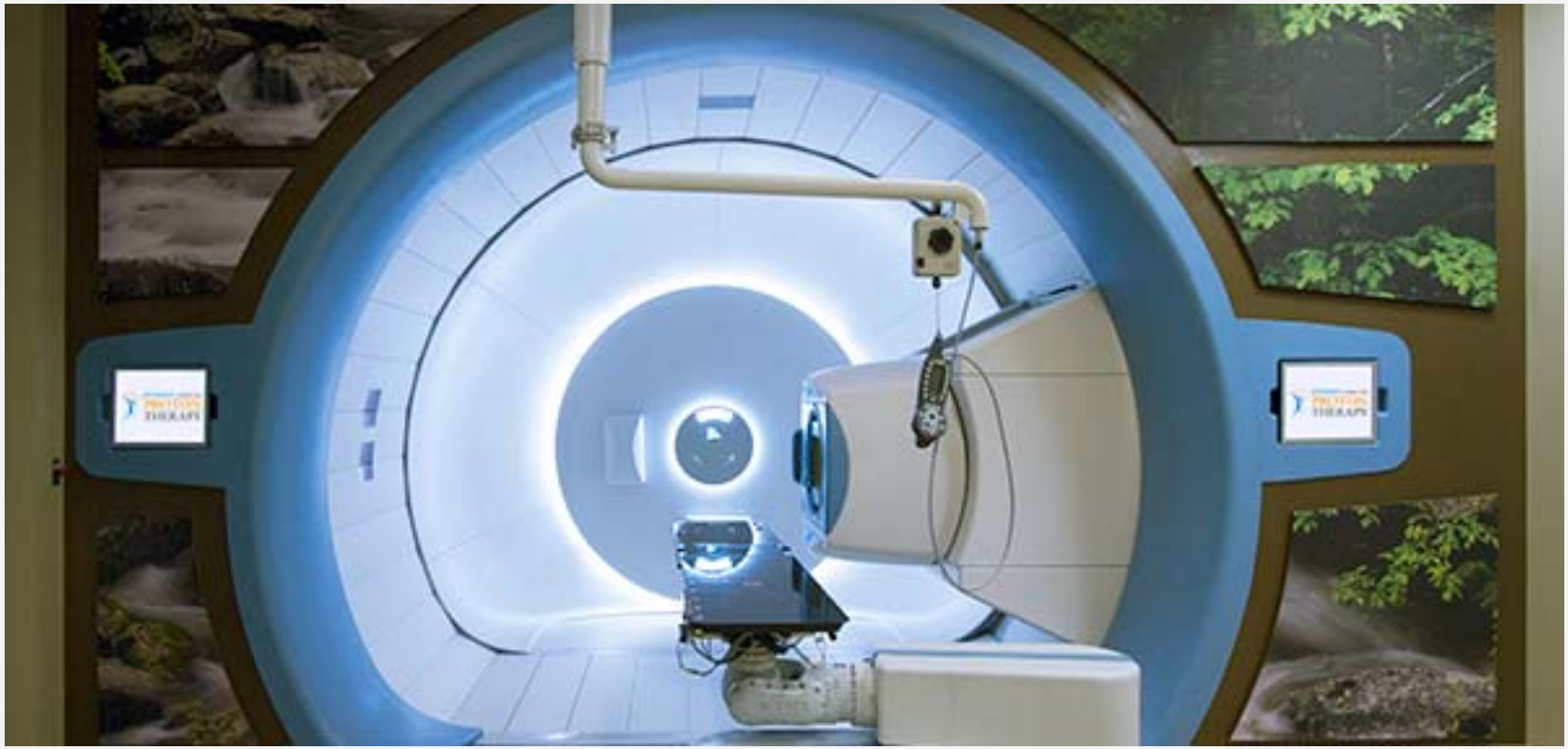
Mosaiq Oncology Information System

Verisuite (Medcom) IGRT Sysytem

RayStation TPS

KUKA Robotic Patient Positioning System

IBA Dosimetry Equipment



ACCEPTANCE

SAFETY

MECHANICAL

COLINEARITY

LASERS

ISOCENTRICITY

IMAGE QUALITY

PPS

RANGE

OUTPUT (TRS-398)

SPOT POSITION

SPOT SHAPE

IGRT

CONNECTIVITY

GANTRY FACTORS

COMMISSIONING/QA EQUIPMENT

Lynx

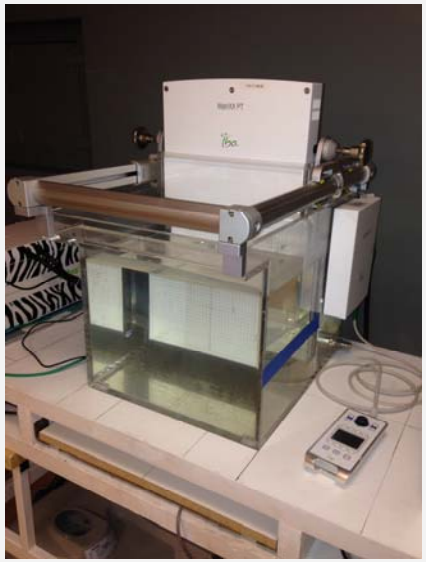
IBA Zebra (MLIC = Multi Layer Ion Chamber)

IBA MatriXX PT (2D Ion Chamber Array)

IBA DigiPhant (Water Tank)

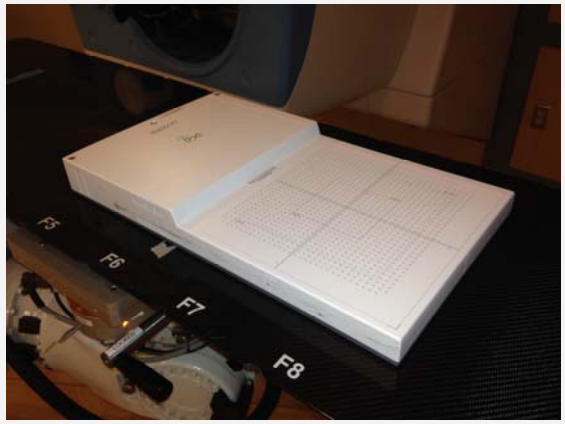
IBA Lynx (Scintillator/CCD Camera System)

IBA PPC05 (Parallel Plate Ion Chamber)



DigiPhant

Zebra



MatriXX PT

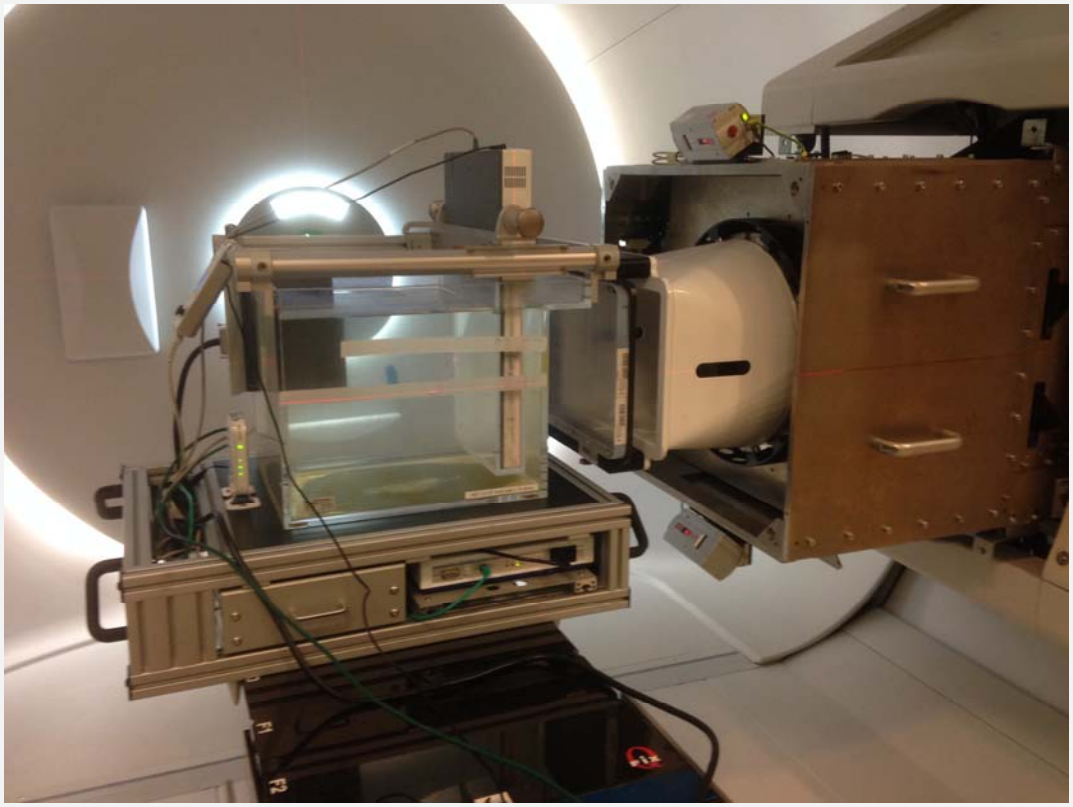
PPC05

COMMISSIONING/QA EQUIPMENT

Cart System

COMMISSIONING/QA EQUIPMENT

Cart System



TPS COMMISSIONING DATA

System Requirements

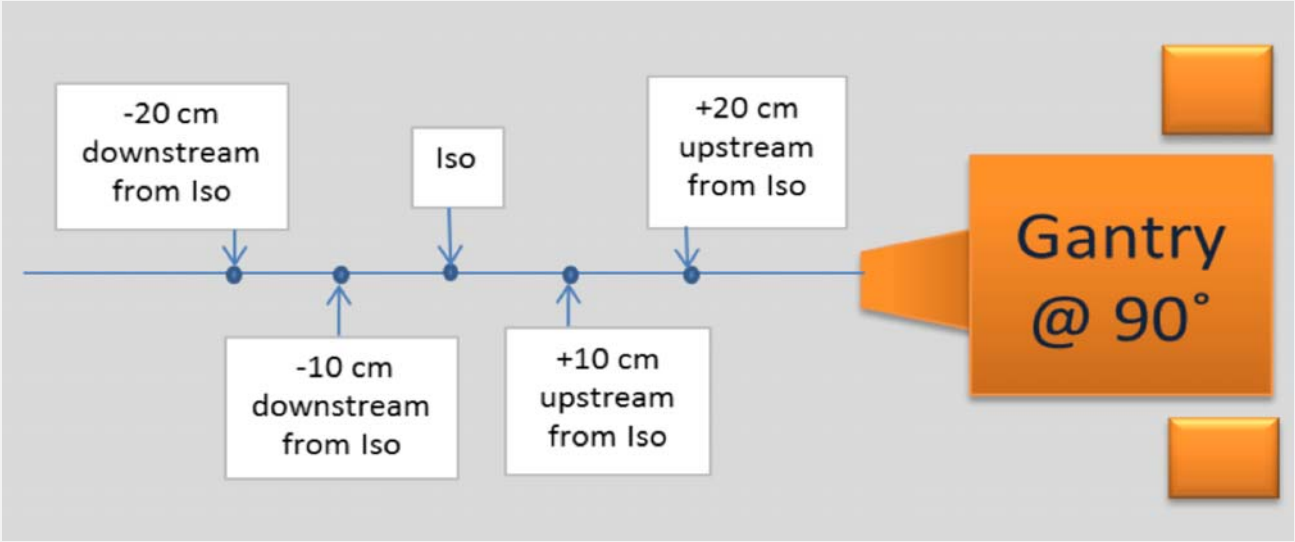
- Support for discrete spot position (step and shoot)
- Support for continuous choice of beam energies
- Range shifters of fixed thickness mounted at a fixed position along the axis. Any number of range shifters can be defined.
- All beam data is invariant w.r.t.
  - Magnitude of beam deflection in X and Y
  - Gantry angle

MACHINE DATA SPECIFICATIONS FOR RAYSTATION PBS		
Machine Name	GTR1	
Min Nominal Beam Energy Limit	98.5	MeV
Max Nominal Beam Energy Limit	226.08	MeV
Max Scan Field Size (@ Iso)	30X40	cm
Spot Tune ID	4.0	
Snout ID	30x40	
Snout Position	0-50	cm
Range Shifter Material	Acrylic	
Range Shifter ID	RS40	
	RS75	
	RS0	
Range Shifter Physical Thickness	3.5	cm
	6.5	cm
	0.0	cm
Range Shifter WET	4.0	cm
	7.5	cm
	0.0	cm
Supported Gantry Angle	0-360	degrees
Supported Couch Angles	0-360	degrees
Coordinate System (See Diagram)	IEC 61217	
Minimum MU per Spot	0.02	MU
Maximum MU per Spot	12	MU

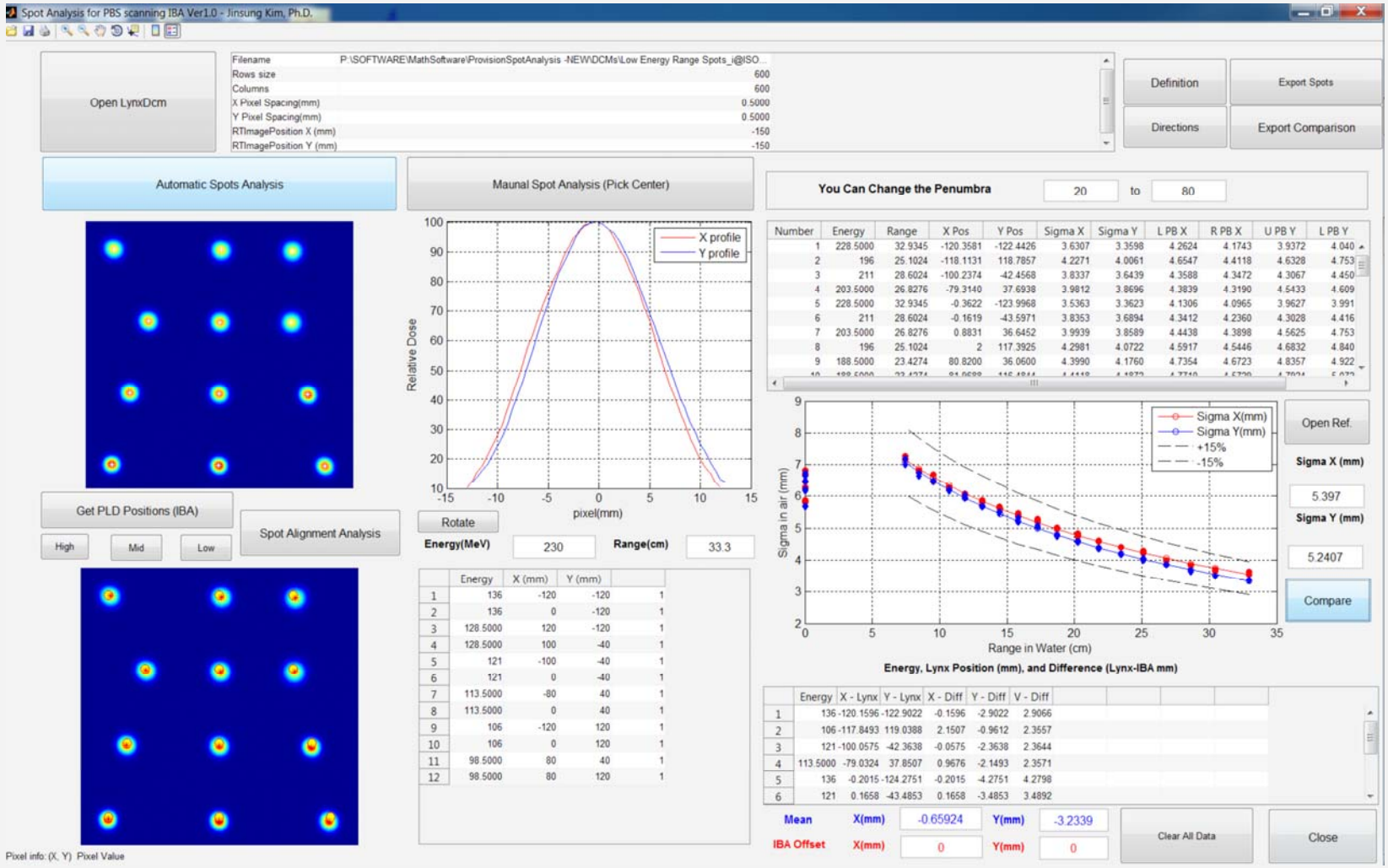
TPS COMMISSIONING DATA

Beam Spot Shape

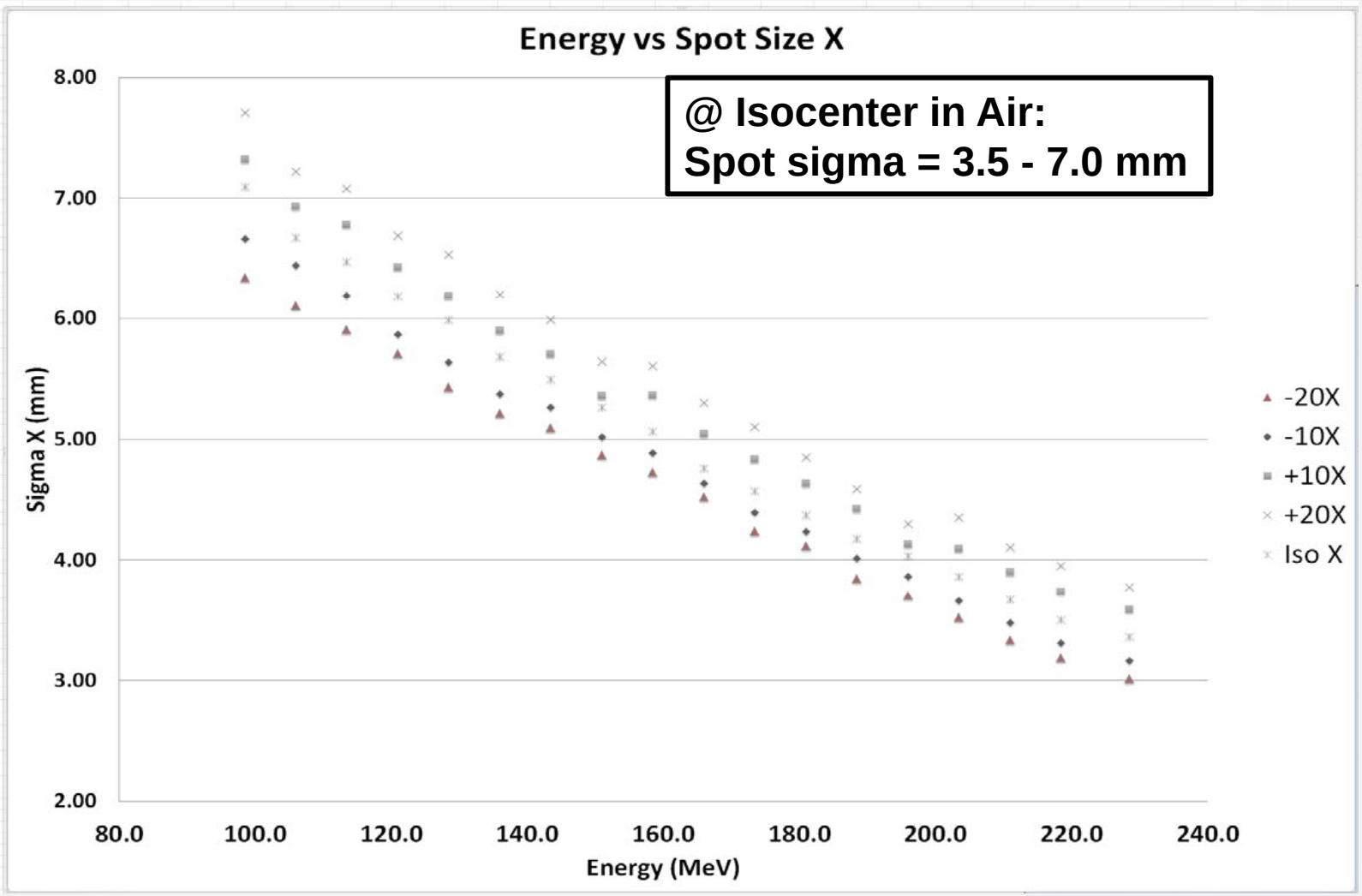
- Use same energies as Bragg peak measurements.
- In air single spot fluence profiles along the Gantry X and Y axes.
- A minimum of three planes at three different distances along the beam axis. Five are recommended.
- We measured planes at Isocenter, ±10cm and ±20cm



TPS COMMISSIONING DATA



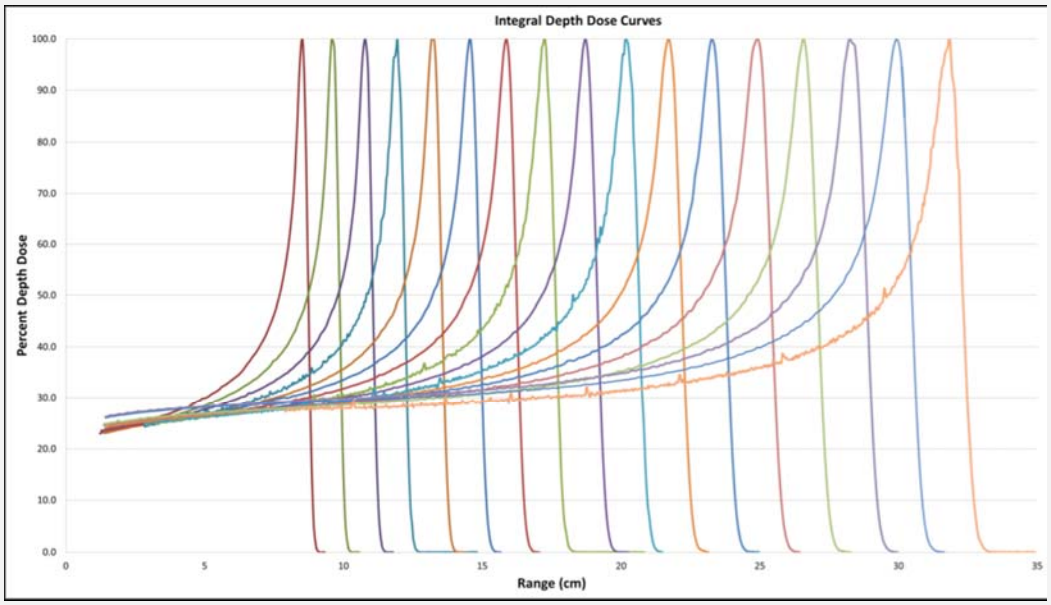
TPS COMMISSIONING DATA



TPS COMMISSIONING DATA

Pristine Bragg Peaks

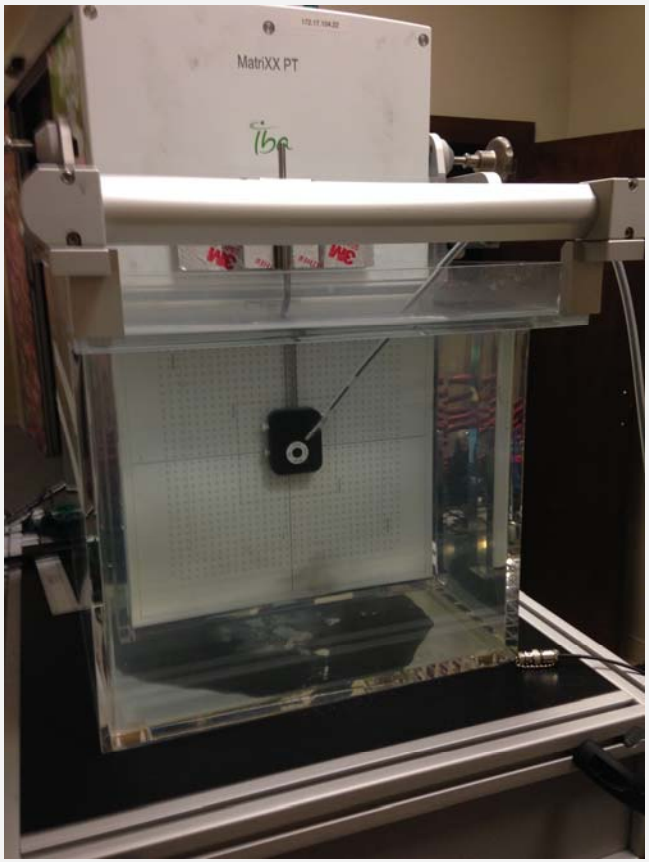
- In Water
- Integrating ion chamber (PTW Bragg Peak Chamber)
- Include max and min energies
- Energy spacing of 1-2 cm
- Measure with continuous pencil beam positioned at central axis



TPS COMMISSIONING DATA

Absolute MU Calibration

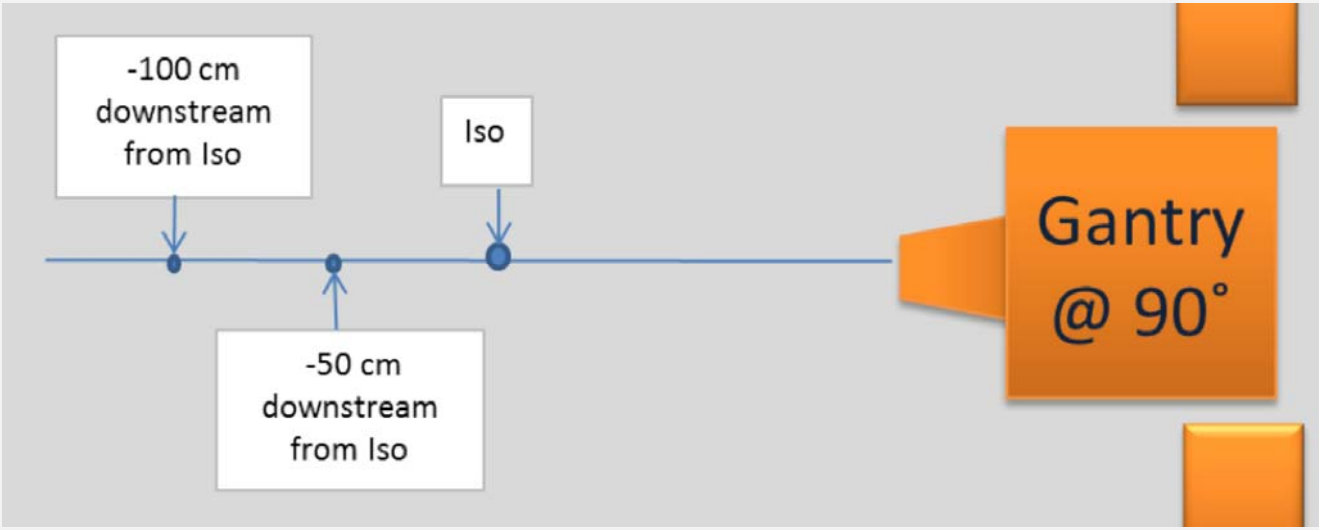
- In Water
- Calibrated parallel plate chamber (IBA PPC05)
- Use same energies as Bragg peak measurements.
- Use scanned mono-energetic beams.
- Performed at a depth midway between 1cm and one half the position of the Bragg peak maximum
- Record the following:
  - Isocenter to phantom surface distance
  - Depth of measurement
  - Scanning area
  - Spot spacing



TPS COMMISSIONING DATA

Virtual Source Axis Distance

- Fluence profiles along the gantry X and Y in air for a squared scanned field.
- Profiles are measured at three different positions along the beam line axis within the range of therapeutic interest.
- Measurements should be repeated for different energies within the beam energy limits
- We measured SAD = 213cm



TPS COMMISSIONING DATA

Range Shifter

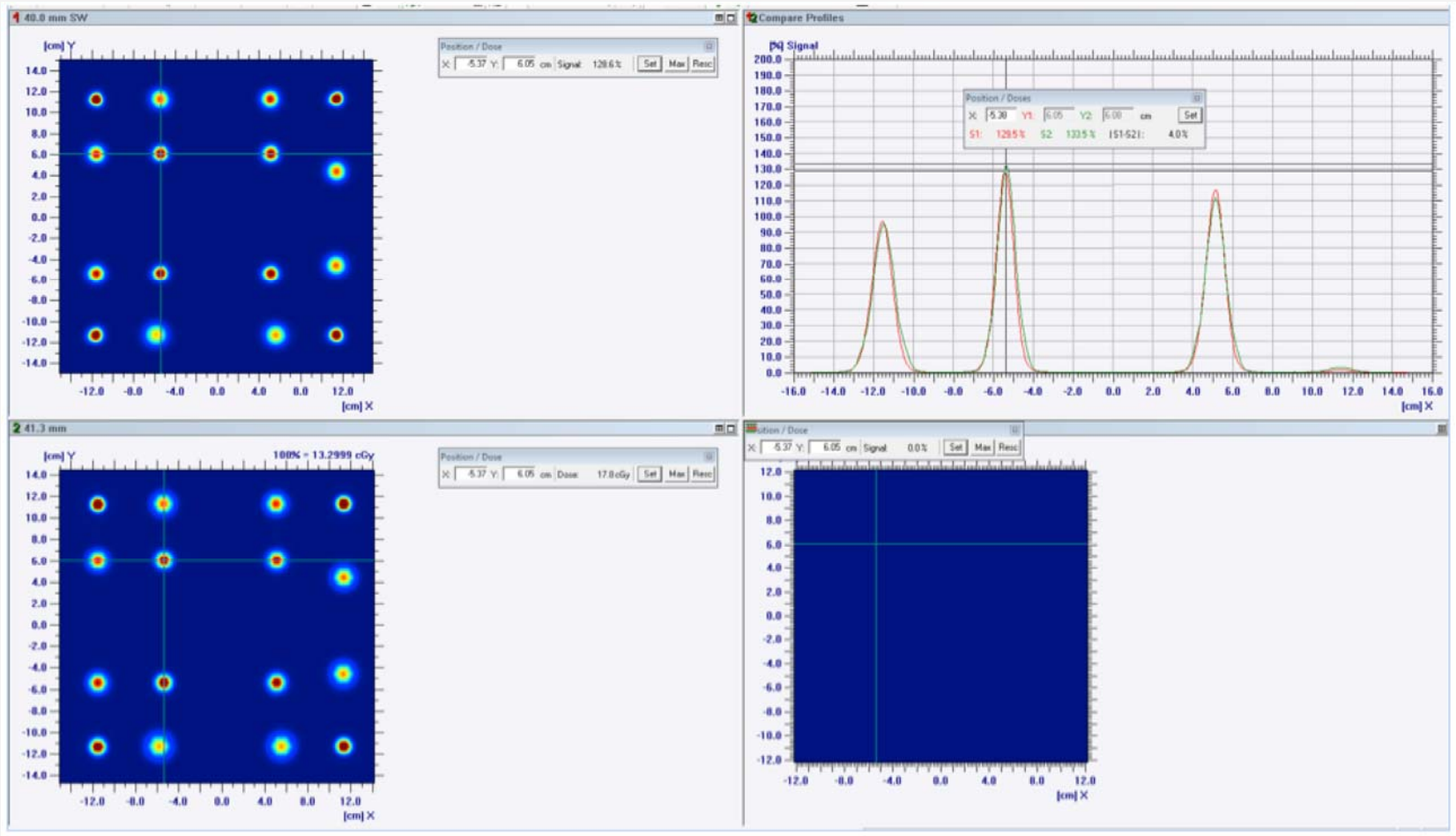
- The effect of a range shifter is in the RayStation dose engine, and no beam modeling data is therefore required.
- We use acrylic range shifters with a WET of 75mm (physical 65mm) and 40mm (physical 35mm).

Snout 30X40cm with 75mm
WET range shifter

Snout 18cm with 75mm
WET range shifter

TPS VERIFICATION

Spot Position & Shape (MatriXX PT)

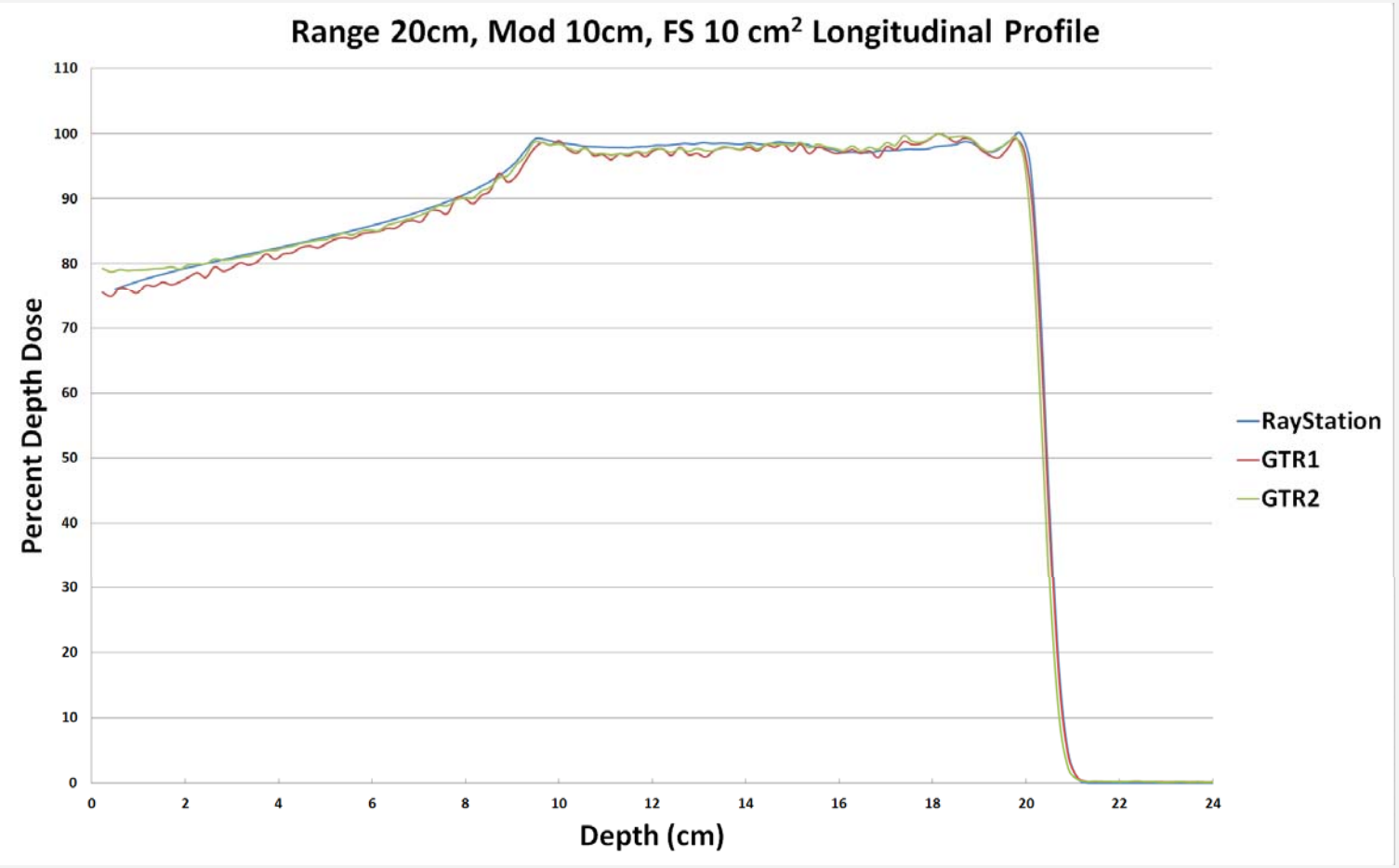


TPS VERIFICATION

Single Energy Longitudinal Profile (MLIC)

TPS VERIFICATION

SOBP Longitudinal Profile (MLIC)



END-TO-END TEST

DOSE PLANE EVALUATION

Analysis Criteria

Absolute Gamma

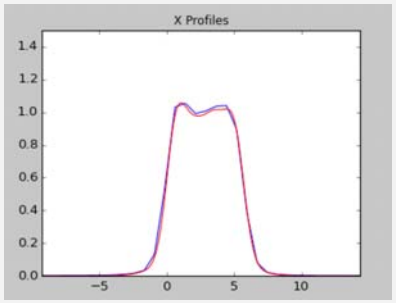
>90% Passing

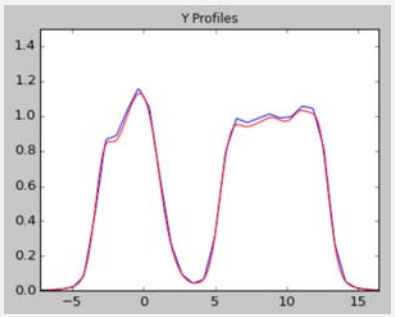
3%/3mm

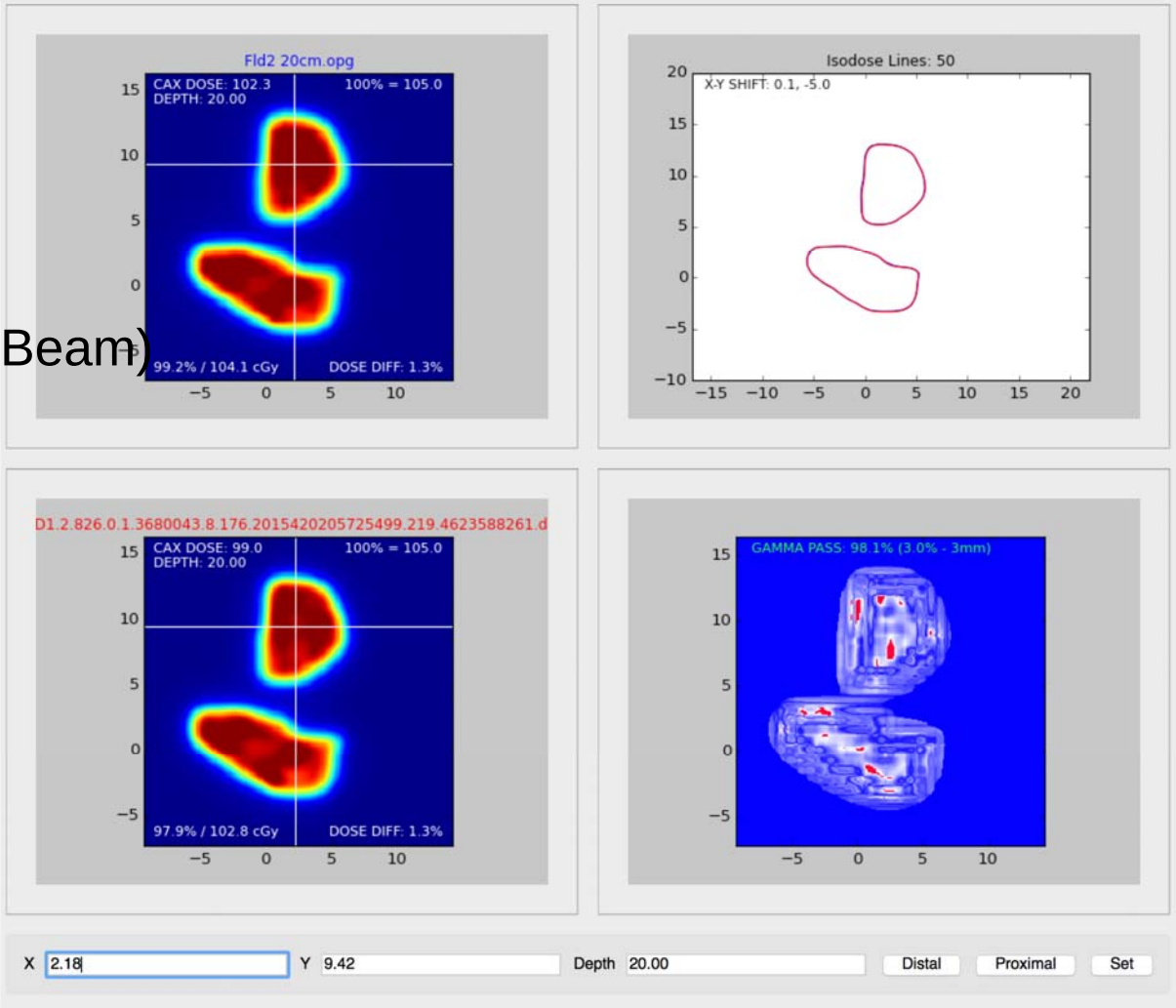
✔ Range

✔ Alignment

(Lasers vs Proton Beam)







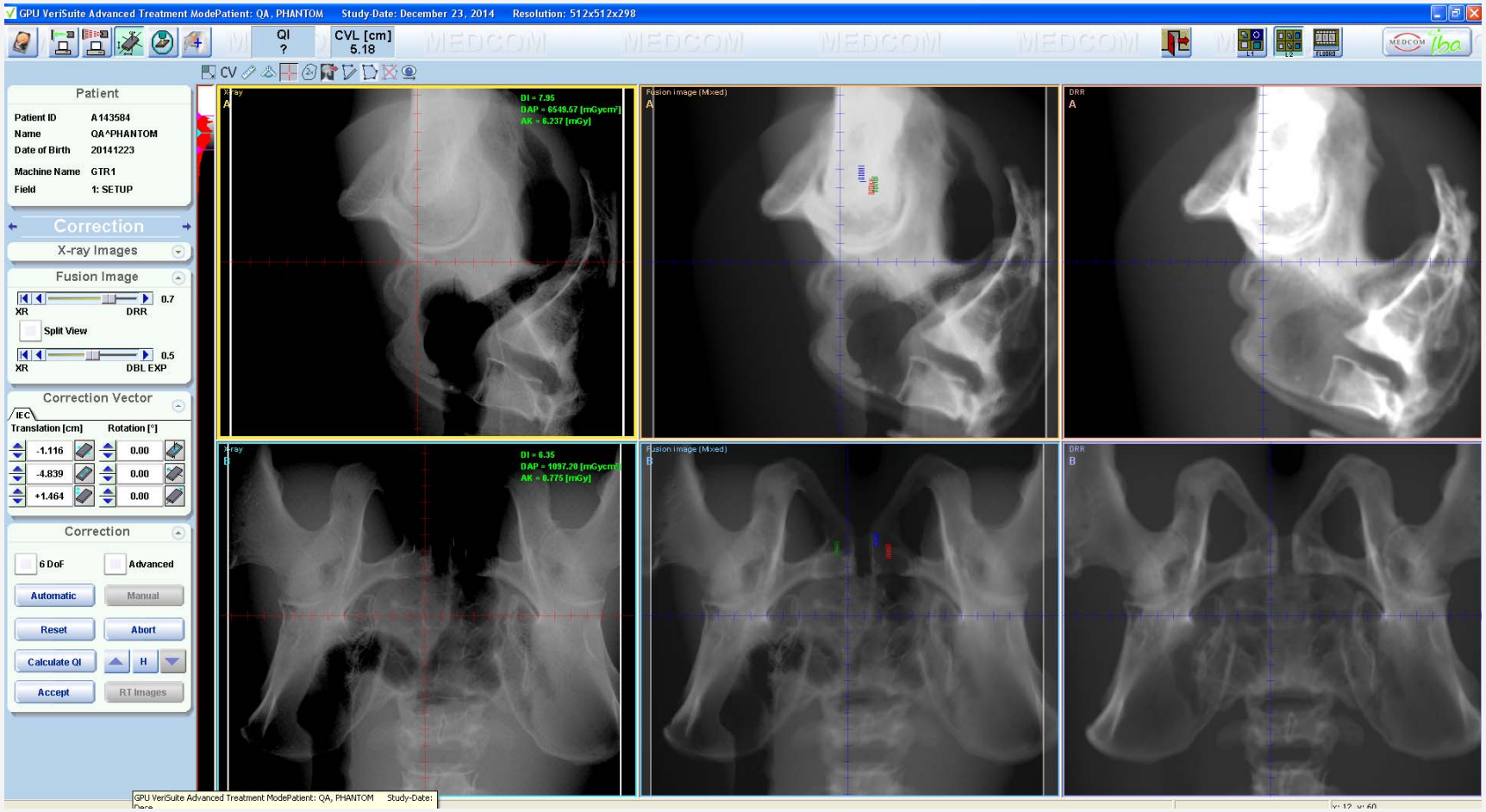
IGRT COMMISSIONING

Verisuite (Medcom)

- Orthogonal stereoscopic X-rays that rotate with the gantry
- Software is interfaced with Mosaiq and IBA
- Takes in the patients planning CT from Mosaiq and reconstructs its own DRRs based on beam angle and snout position. Can also show structure set in beams eye view.
- Transfers correction vectors to the PPS to align patient.
- Transfers images back to Mosaiq image list

IGRT COMMISSIONING

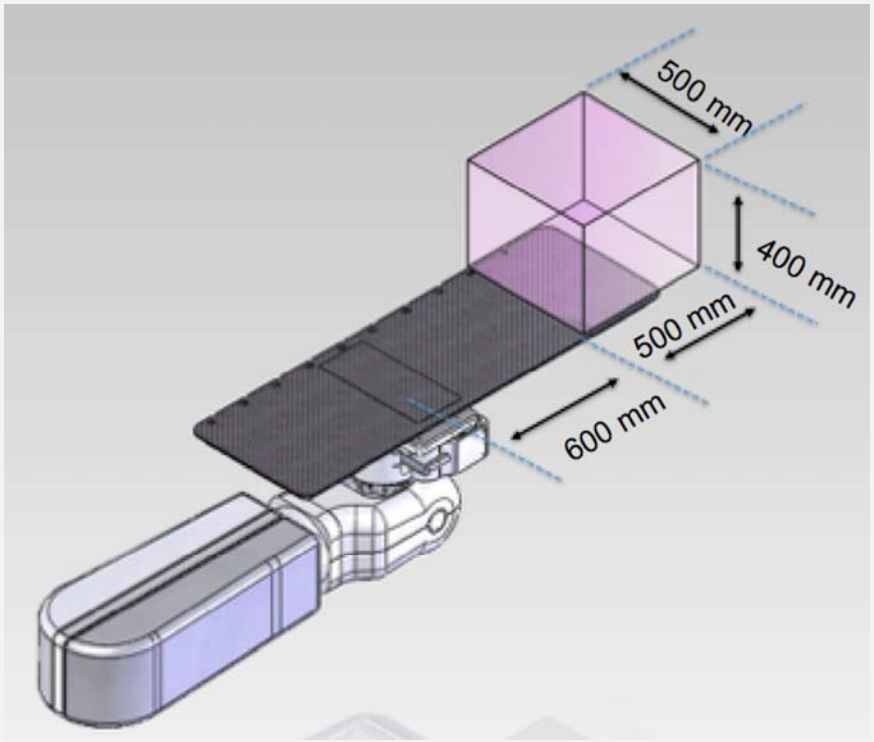
Verisuite (Medcom)



IGRT COMMISSIONING

Patient Positioning System (PPS)

- KUKA Robotic couch
- Box of validation: The treatment isocenter must be in the box of validation to achieve the PPS accuracy specification (66% of GOTO <0.5mm and 0.2˚).
- Table correction necessary for passive scattering gantries. Table position is gantry dependent to correct isocenter.
- Beam optic corrected gantry does not require a table shift.



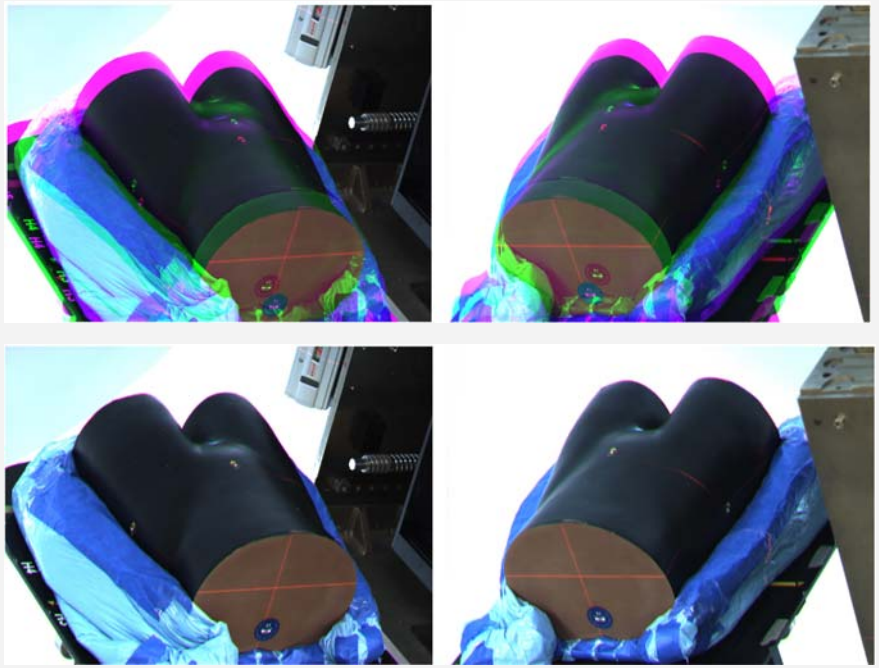
OIS COMMISSIONING

MOSASIQ for protons

- Very limited compared to photons
- Cannot manually create proton beams
- Cannot create setup beams under a proton Rx
- Hidden beams cause interface problems with Verisute
- Physical vs RBE dose
- Images from verisuite transfer to mosaiq unassociated

FUTURE UPGRADES/PROJECTS

- New IBA software upgrade with decrease interlayer switching time from 4s to 1.2s.
- Change beamlines to easily transfer patients between beam matched rooms.
- Auto-association of images after sent from Verisuite computer
- In-air patient QA using IBA spot scanning logs
- Camera tracking system for patient positioning



FUTURE PBS SYSTEMS

- Proton systems are moving towards PBS delivery systems
- Fast inter-layer energy change time
- Beam parameter matching
- Move table/gantry/snout from outside Tx room
- Image from outside Tx room
- Beam optics corrects for gantry angle wobble
- Multiple spot sizes (large and small vs apertures)

THANK YOU SEAAPM!