Indiana University Health Proton Therapy Center

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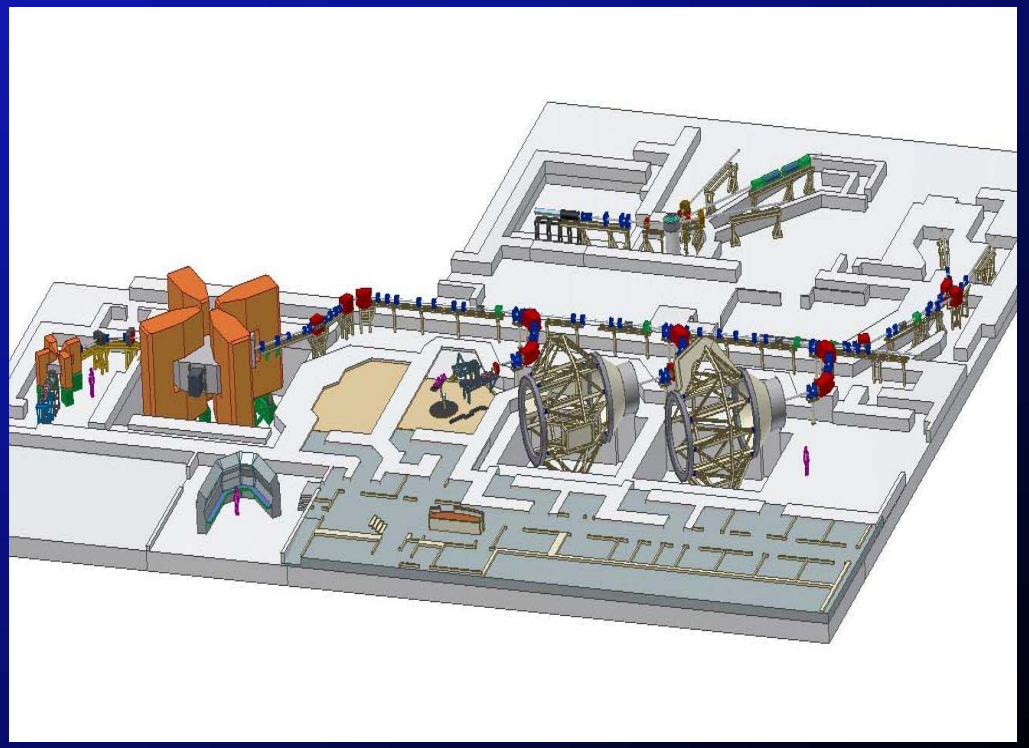
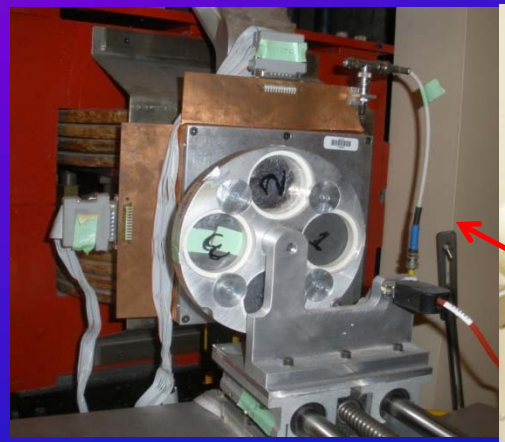
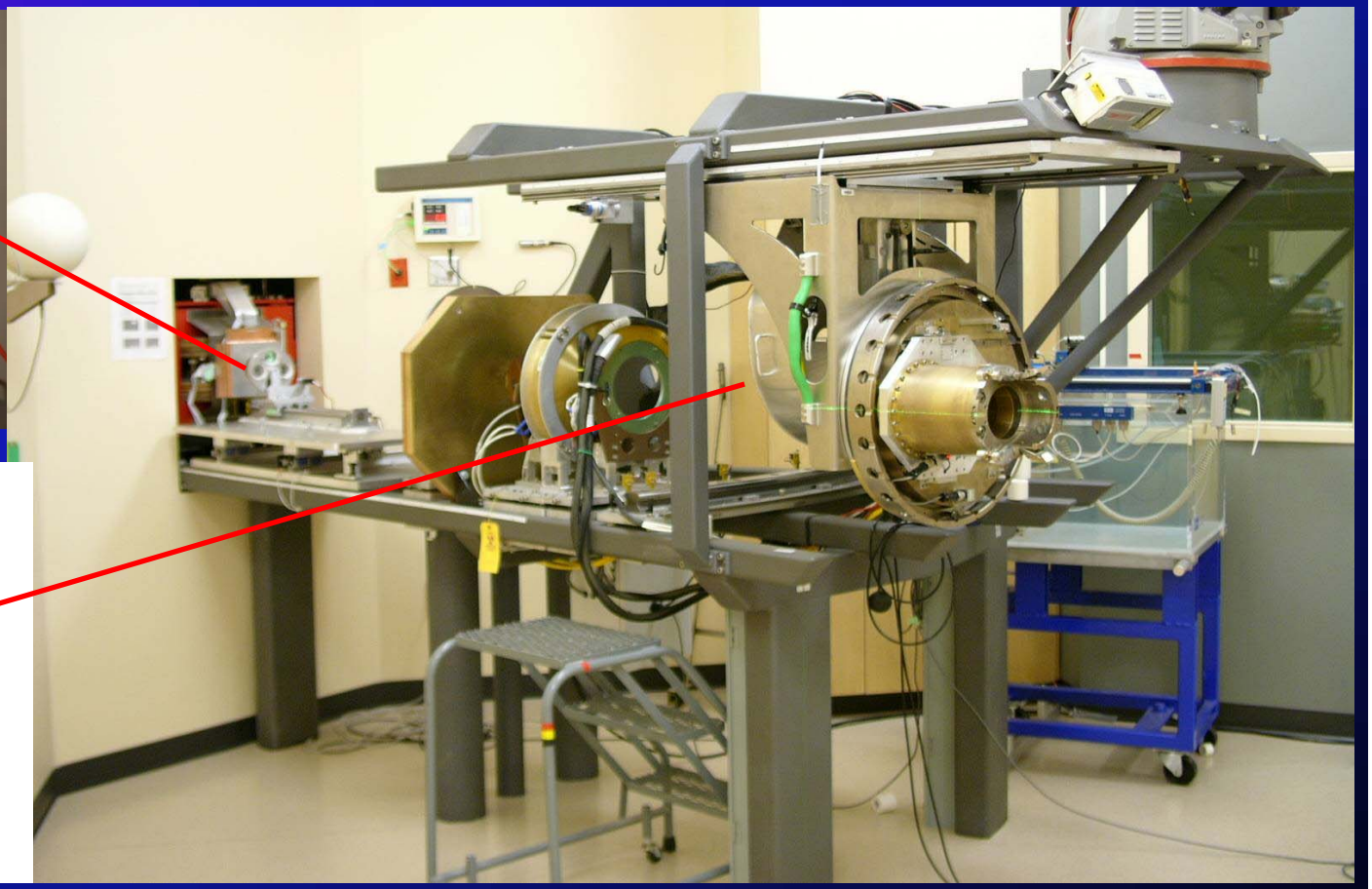
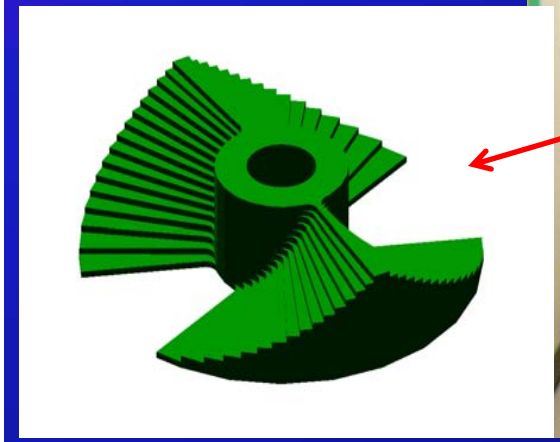


Machine configuration and layout



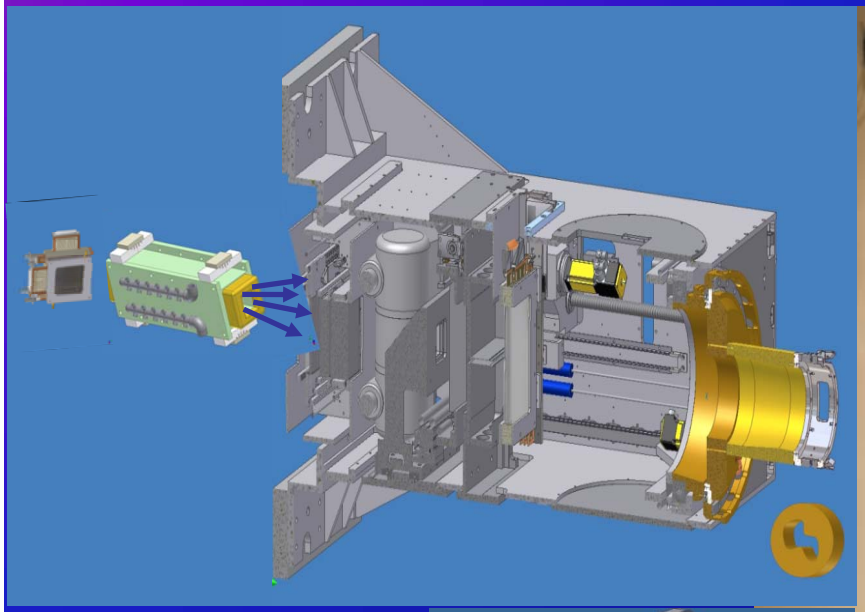




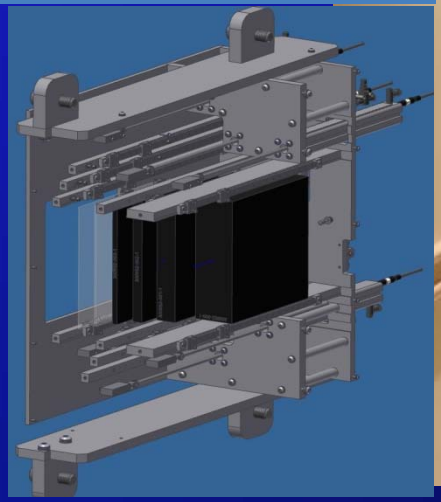
Fixed beam line, double scattering and propeller

Gantry room

Uniform scanning nozzle and snout



Range modulator



Indiana University Health Proton Therapy Center

- 3 snout sizes (10cm, 20cm and 30cm)
- 30-40 patients treated per day
- Typical patient mix (present time): prostate (30%), H&N (30%), Peds+brain (40%)

Indiana University Health Proton Therapy Center

- Current Clinical Staffing
  - 6 physicists and 2 medical physics assistants
  - 8 therapists and 3 therapist assistants
  - 3 dosimetrists
  - 5 radiation oncologists (4 treat patients between the PTC and the IU Cancer Center).

Daily Machine QA

- MPA/Physicist performs the QA:
  - Alignment
    - Lasers, snout, x-rays and DR panels, gantry, light-field
  - Safety
    - X ray systems, barcode scanner, intercom, cameras, panic button, patient positioner, floor panels, interlocks
  - Beam
    - Output constancy, flatness and symmetry, radiation survey (Friday only)
- Typically takes 30 minutes per room
- Therapist check room readiness
  - Patient positioner, gantry, snout, DDS, BDS

Daily QA

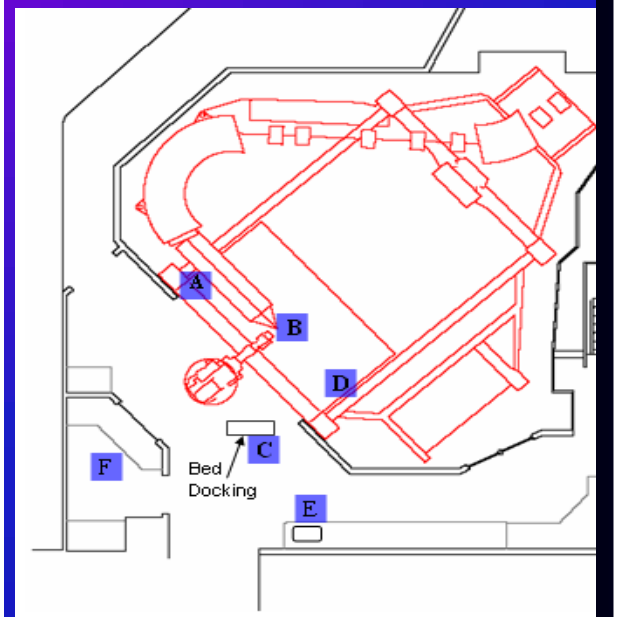


Figure 1 - TR2 Radiation Testing Positions

Measured Exposure Rates:

Position A: = _____ mRem/hr
Position B: = _____ mRem/hr
Position C: = _____ mRem/hr
Position D: = _____ mRem/hr
Position E: = _____ mRem/hr
Position F: = _____ mRem/hr

Signed: _____

Date: _____
Time: _____ Time Room Ready: _____

Alignment Checks

1	Alignment of room lasers at isocenter
2	Snout alignment
3	Snout position / PPIC
4	X-ray system alignme
5	Gantry alignment
6	Light field alignment

Safety Checks

7	X-ray system accele
8	Patient positioner ac
9	Beamline interlocks/s
10	Beamline xray
11	Floor panels
12	Barcode scanner
13	Patient distress butto
14	X-ray Collimators
15	Audio - Intercom
16	Camera and room m

Beam Checks

1	PPICS, DDS, BDS in Dosimetry Mode; TRCS in Service Mode				
2	DDS motors and LCD backup counters working and recording				
3	MIRS - Interlock and radiation monitoring				
21	Output Quality Assurance				
	Output =	0.998	cGy / MU		
	RCI1 =	2.175	RCI2 =	2.417	ChamberID = MatriXX
	CV 1 =	2.078	CV 2 =	2.315	
	DDS: Pr =	985.7	Tr =	20.4	Ctp = 1.0221
					Offs = -0.0504
22	Transverse Quali				
	IP Flatness =	2.05%	IP Symmetry =	0.01%	
	CP Flatness =	2.28%	CP Symmetry =	0.31%	

Room Readiness

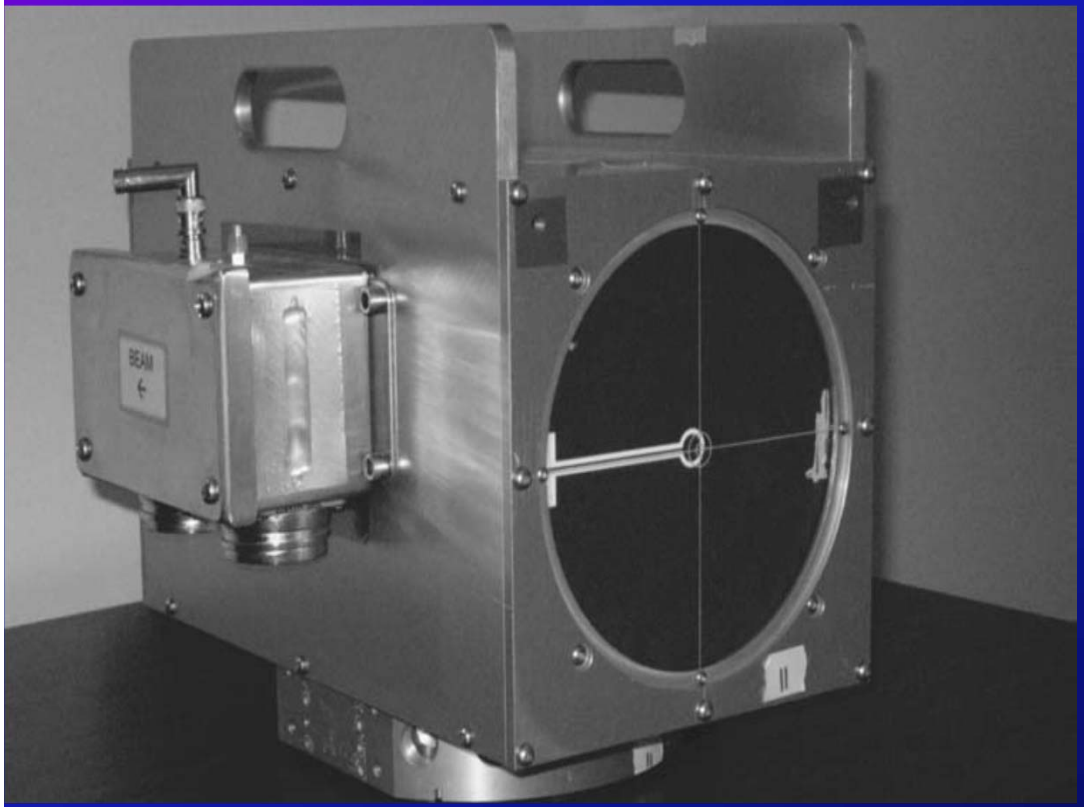
23	Check RAF Box		Reboot TRCS	
	PP at Intm Position		Pendant put away	
	Gantry at 270degs		MatriXX put away	
	Snout retracted		TRCS in Treat Mode	
	Bed mech clamped locked		DDS in Treat Mode	
	Ap/Comp put away		BDS in Treat Mode	
	Deleted values in QA sheet		PPICS in Treat Mode	

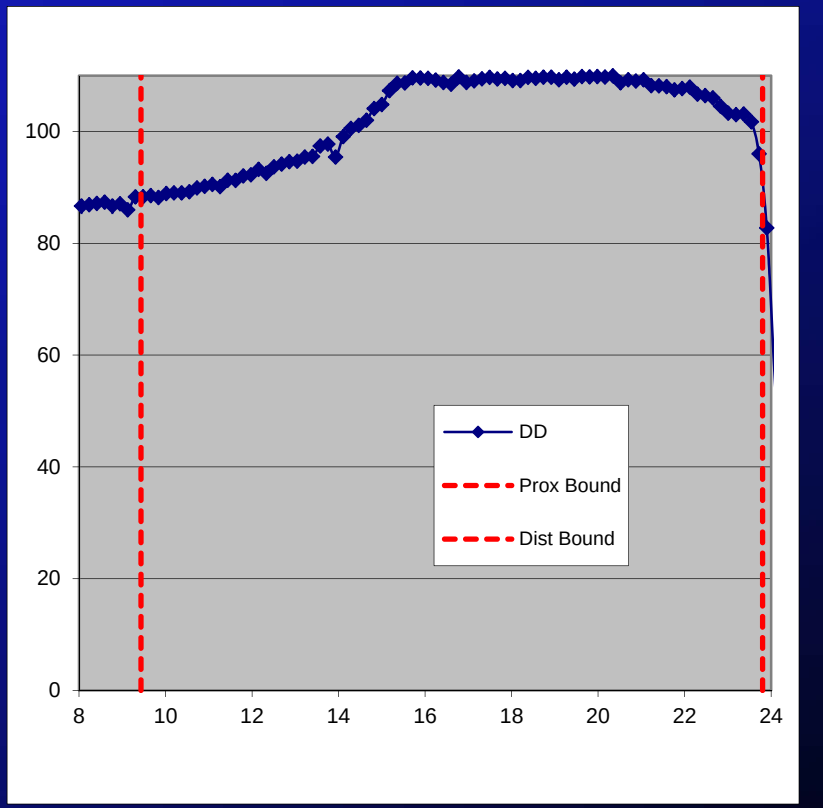
Comments:

Monthly QA (gantry room)

- Output factor for the reference condition in water phantom with calibrated IC and Elect.
- Range and SOBP (2.8, 10, 14.5cm) for 10cm field-size for three energy ranges: low, medium and high using a MLIC
- Symmetry and flatness at the middle of 10cm SOBP for the 3 snout sizes (10, 20 and 30cm) and the three energy ranges (low, medium and high) with MatrixX
- Typically takes 4-5 hours per room

SOBP measurement with MLIC





- **Range and SOBP Extent: MLIC Measurement Results**

Pass Criteria:

1) R90: difference between R90 of requested range and measured R90 ≤ 0.1cm
2) SOBP Extent: difference between requested SOBP and measured SOBP ≤ 0.5cm

Req Range	SOBP	R90	SOBP Extent	Result
24	2.80	23.9	2.87	Pass
R90=23.8	10.0	23.9	9.95	Pass
	14.5	23.9	14.5	Pass
16	2.80	15.9	2.80	Pass
R90=15.8	10.0	15.9	10.0	Pass
	15.3	15.9	14.8	Pass
11.6	3.0	11.5	3.07	Pass
R90=11.4	10.1	11.4	10.1	Pass

- **Beam Flatness & Symmetry: Matrixx Results**

Pass Criteria:

1) Flatness: within ±3% for Inplane and Crossplane directions
2) Symmetry: within ±3% for Inplane and Crossplane directions

	11.6R / 10.1SOBP			16R / 10.0SOBP		
Snout	Flatness (%)	Symmetry (%)	Result	Flatness (%)	Symmetry (%)	Result
12	1.98/2.34	0.90/0.38	Pass	2.05/2.99	0.28/0.03	Pass
20	1.34/1.01	0.09/0.28	Pass	1.61/1.33	0.91/0.54	Pass
30	NA	NA	-------	NA	NA	-------

	24R / 10.0SOBP		
Snout	Flatness (%)	Symmetry (%)	Result
12	1.81/1.80	0.21/0.29	Pass
20	1.62/2.08	0.37/0.58	Pass
30	NA	NA	-------

- **Measured In-Water Output Factor**

Pass Criteria:

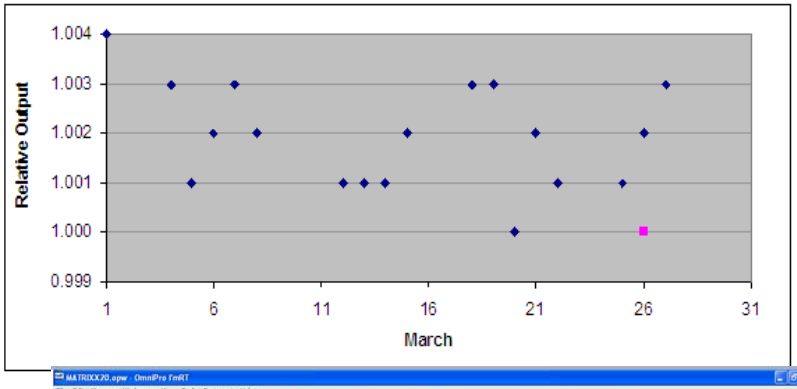
1) TR2: OF within 1.0% of 0.995 cGy/MU
2) TR3: OF within 1.0% of 1.000 cGy/MU

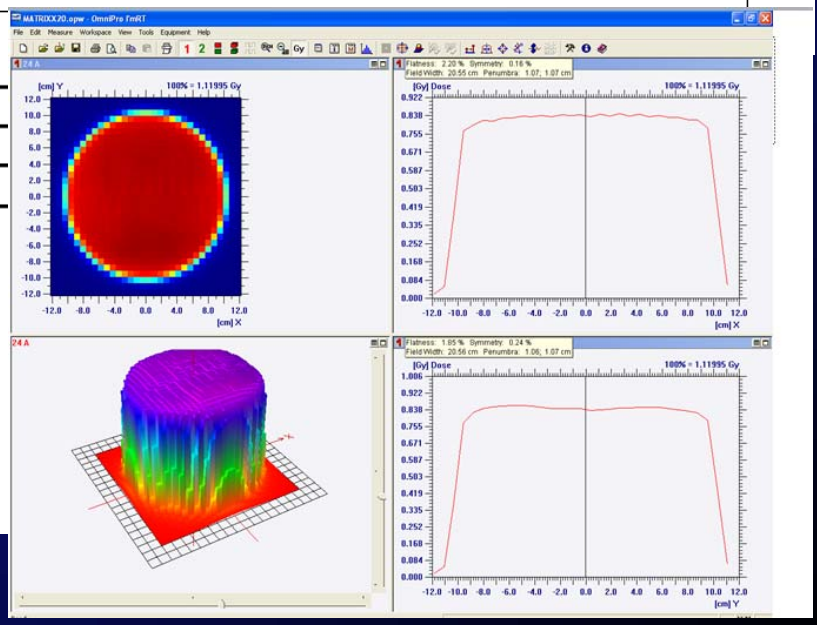
Room	Measured OF	Results
TR3	1.00	Pass

- **Output Factor Trend**

Graph should include:

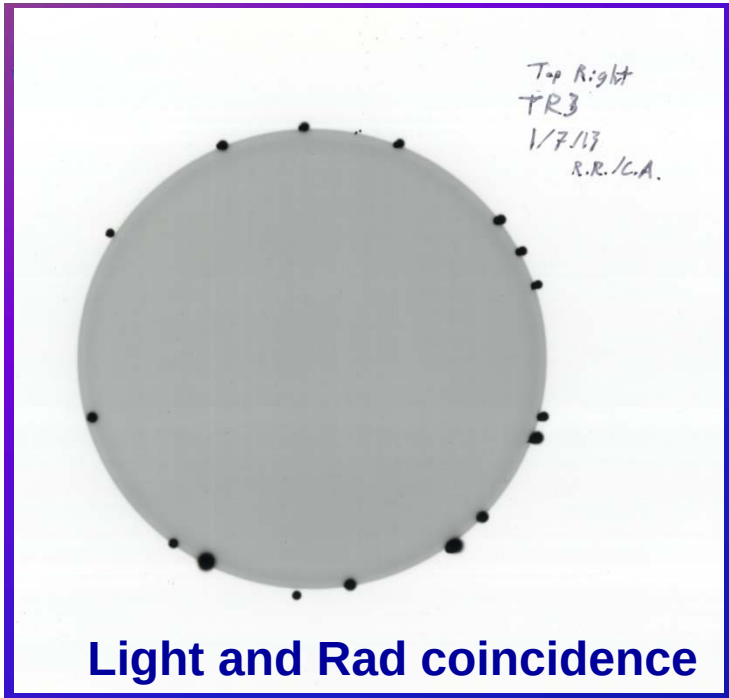
1) Daily QA Matrixx OFs
2) Evening QA in-water OFs



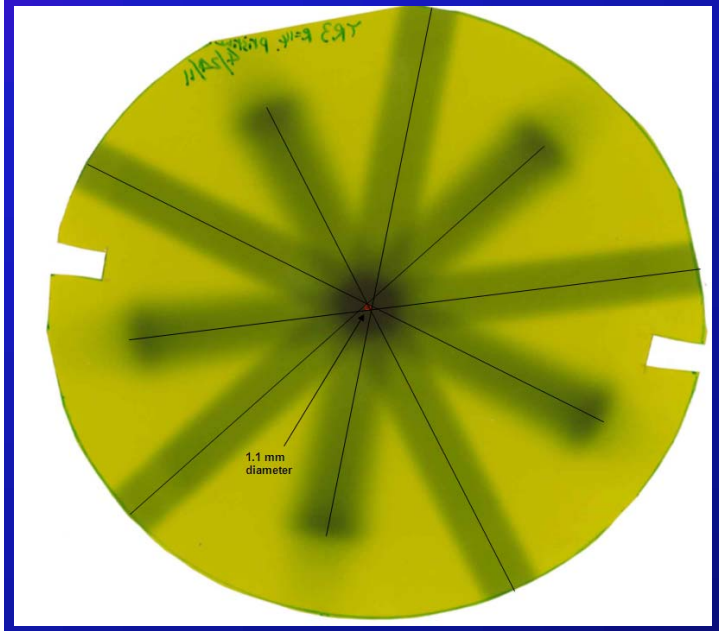


Annual QA

- Additional QA (not performed in monthly):
  - Gantry isocentricity with star-shot
  - Linearity of OF-MU, OF-Cvolt, OF constancy-dose rate,
  - OF vs gantry angle
  - All three snout alignment at full extension/retraction
  - Snout position check at 270^{o} and 90^{o} at full extension/retraction for all three snouts.
  - X-ray source tests:
    - kVp calibration, exposure reproducibility, timer accuracy, mAs linearity, HVL
- Dosimetry protocol: TRS398
  - ADCL calibrated Advanced Markus chamber and electrometer.

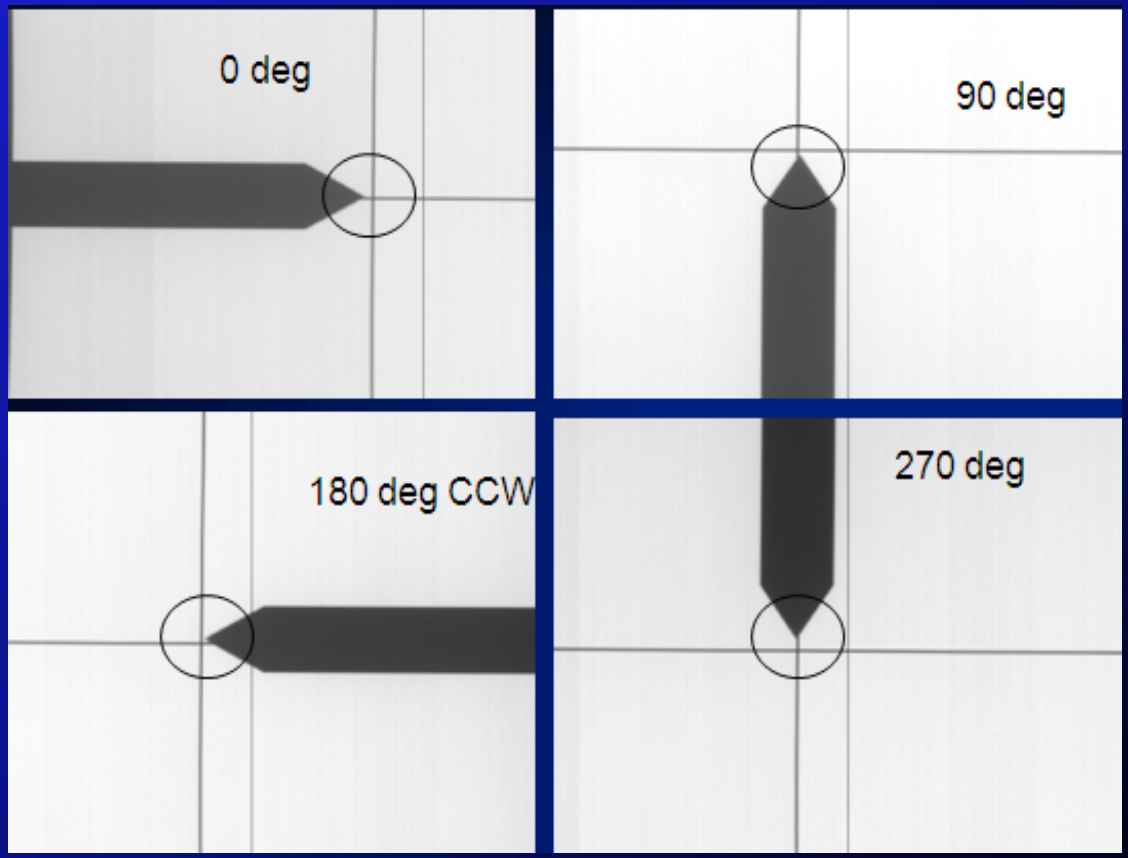


Light and Rad coincidence



Star shot

Mechanical Isocenter Check with pointer and x-rays

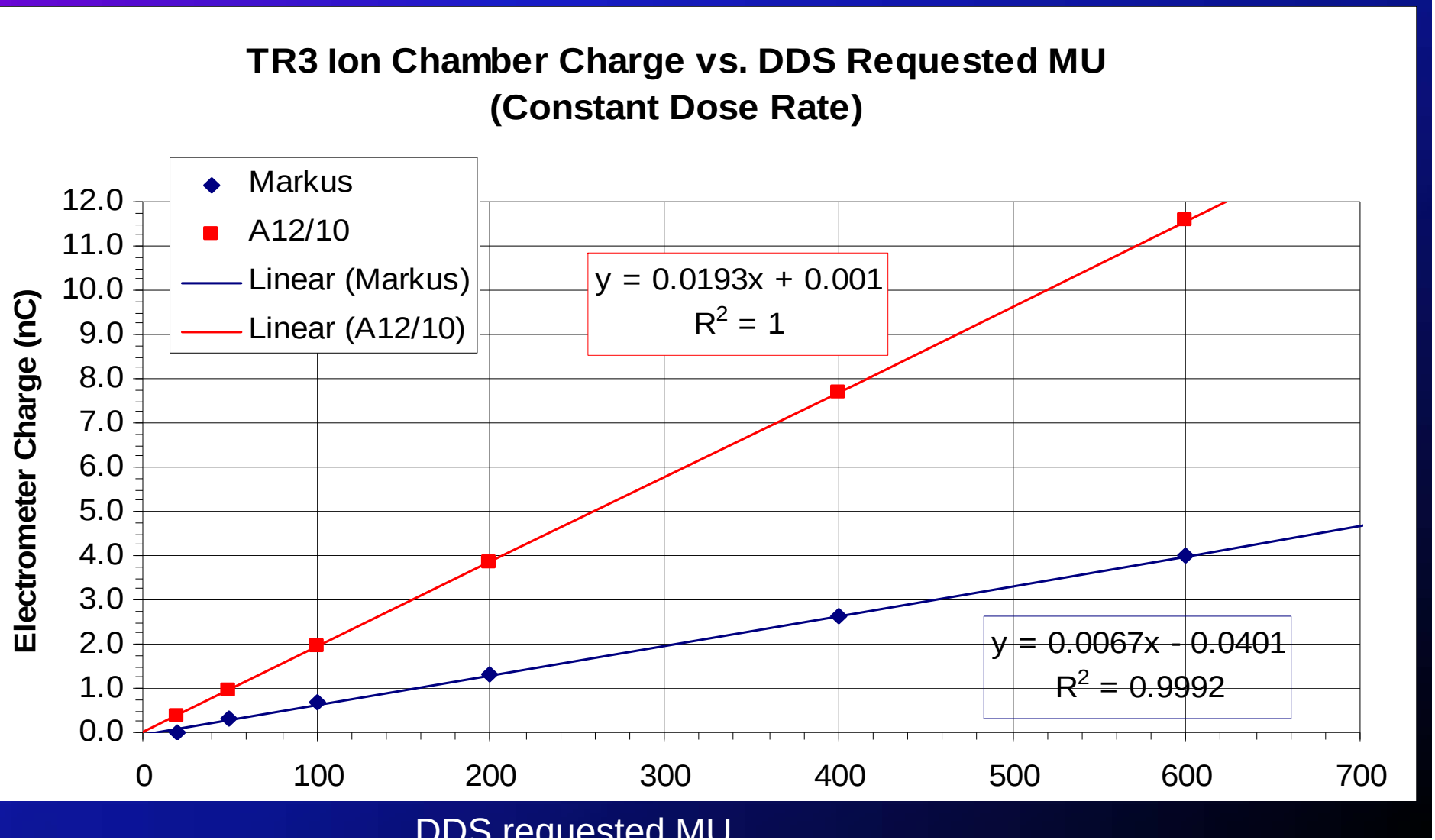


Patient Support System

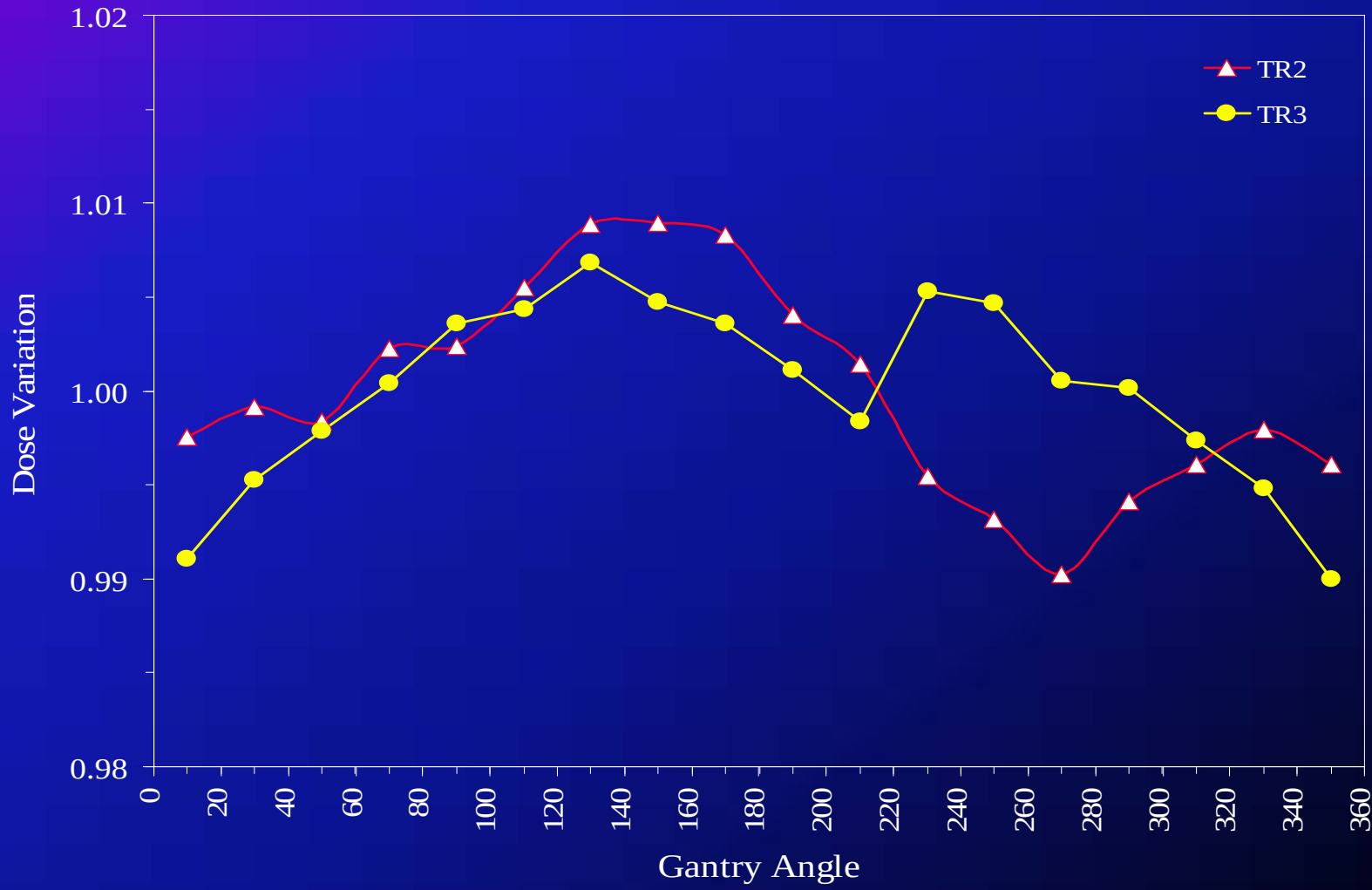
Treatment Table & Robotic systems QA

- Degree of freedom:
  (x, y, z), Pitch, roll, Yaw
- Motion accuracy
- Reproducibility
- Adoptability
- Compatibility
- Safety

Dose monitor linearity



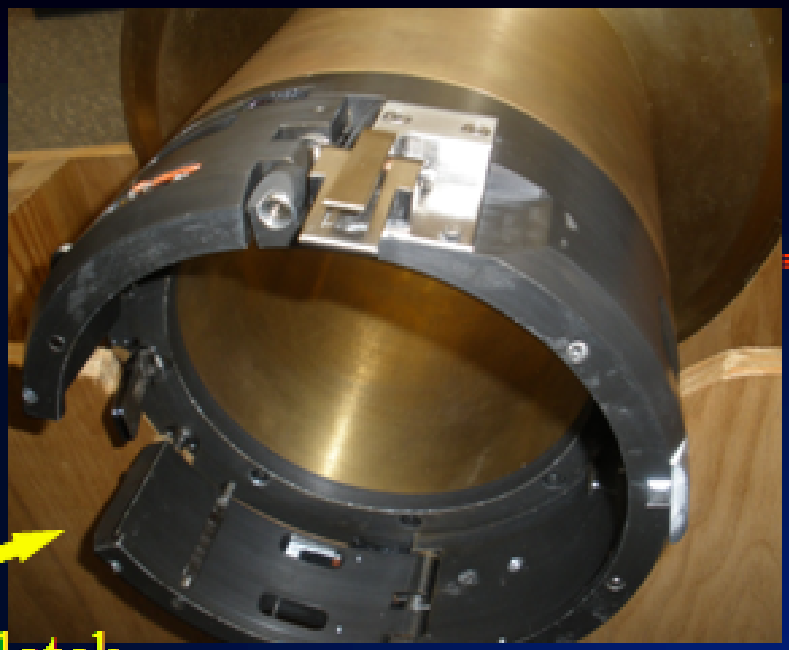
OF variation with gantry angle



Patient Specific QA

- Relative output factor measurements in water phantom of aperture and compensator for each field
  - For field size<3cm diameter, measurements taken at different points along SOBP to locate appropriate point of measurement (MLIC was used before).
- QA tolerances
  - Relative output factor ±2% for both open (aperture only) and closed (with compensator)
    - Re-measure to confirm discrepancy
    - Move IC along SOBP to examine change in OF to understand the discrepancy

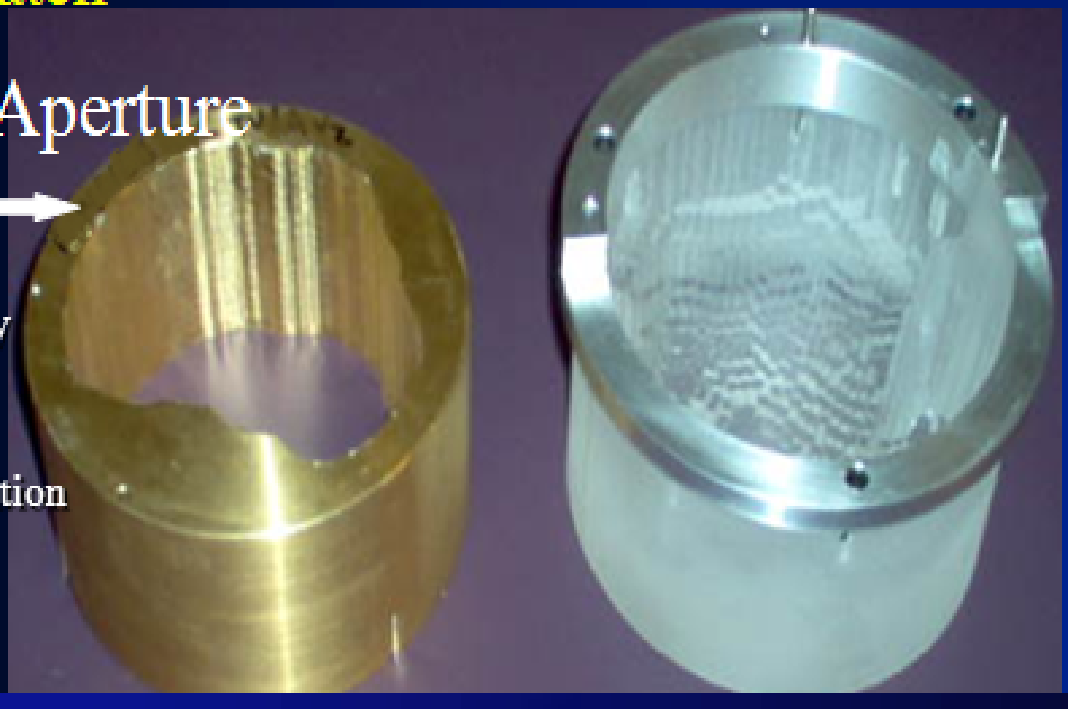
Proton Snout, sizes, 10, 20, 30 cm diameter



Snout latch

Brass Aperture

1. Accuracy
2. Weight
3. Composition



Lucite Compensator

1. QA on depth and fidelity of drilling
2. Minimum thickness of integrity
3. Quality of plastic (vendor variability)
4. Safety: Mechanical attachment issue

INDIANA UNIVERSITY

Unique Implementations at IUHPTC

- Quarterly QA
  - Absolute cross-calibration of all IC available (4)
  - Laser alignment
  - Robot alignment, constancy
  - 10cm snout alignment at full retraction/extension w/ x rays and four cardinal gantry angles
  - X ray and DR panel alignment using x rays
  - Light and radiation coincidence
  - Emergency stop and emergency power in wall outlet

Top 3 items in our wish list (if we could have them in the future)

- Commercial Imaging system for Image Guidance (eg., MedCom, kVCT, In-room CT)
- Spot scanning
- Record-and-verify system

Acknowledgement

- Chris Allgower
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- IUCO Engineering staff
- IUCO software engineers

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