Quality Assurance Implementation in Proton Therapy Centers

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Houston

UT MD Anderson Cancer Center Proton Therapy Center, Houston

- Located about 1 mile away from the Main Campus and Ambulatory Clinical Building where traditional External Beam Therapy with X-rays, Electron with more than 20 Linacs and Brachytherapy are available

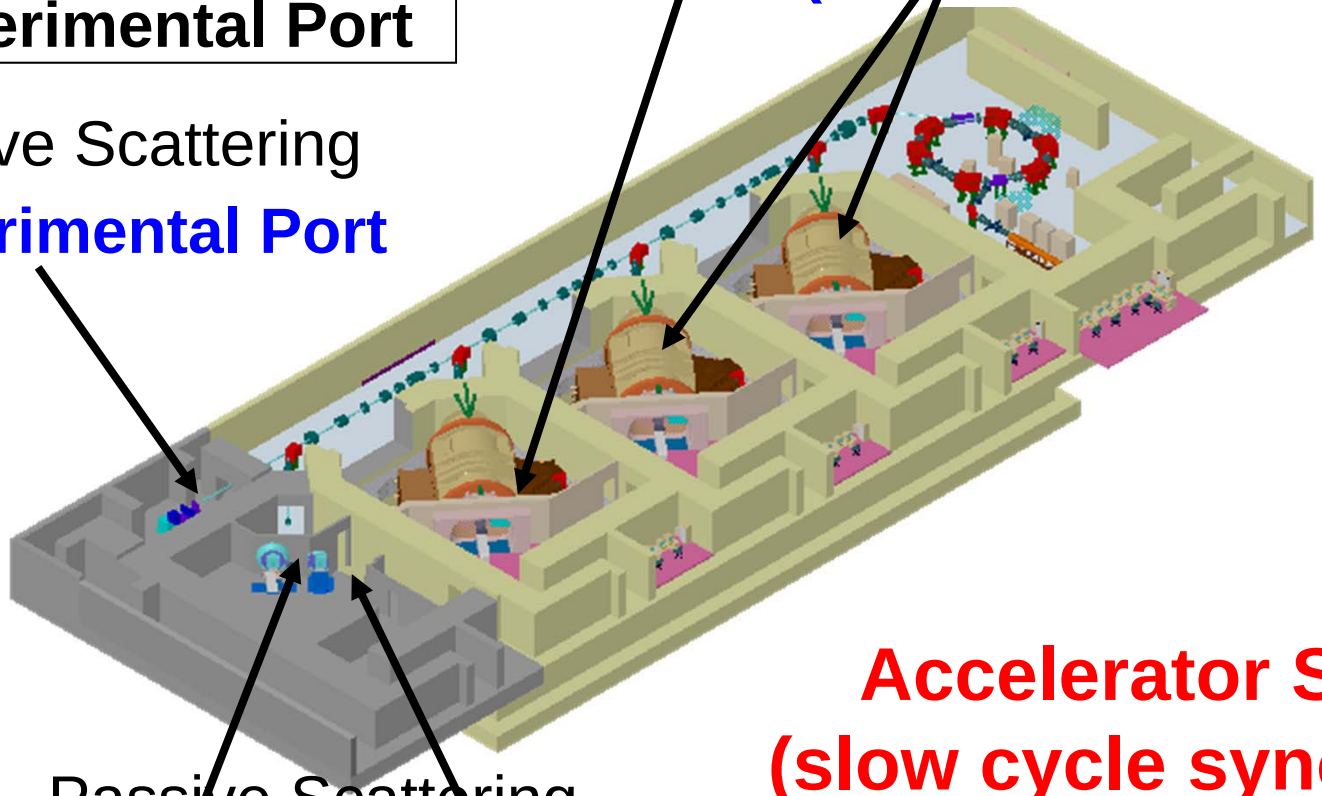
- Synchrotron based Hitachi ProBeat system

Proton Therapy Center - Houston

PTC-H
3 Rotating Gantries
1 Fixed Port
1 Eye Port
1 Experimental Port

Pencil Beam Scanning Port

Passive Scattering Port (Full rotational Gantry)



Passive Scattering
Experimental Port

Passive Scattering
Large Fixed Port

Eye Port

Accelerator System (slow cycle synchrotron)

UTMDACC Proton Therapy Center-Houston

- Number of patients treated per day: ~105
- Typical patient mix
  - Prostate: 35
  - H&N: 15
  - Lung and Esophagus: 25
  - CNS:15
  - Peds:10
  - Others: 5

All numbers are approximate

UTMDACC Proton Therapy Center-Houston

- Staffing
  - Physicists: 7
  - Physicist Assistants: 6
  - Therapists:15
  - Dosimetrists:8
  - Radiation oncologists: 50 +

Daily machine QA checks

- ✓ Dosimetric beam quality constancy (Dose/MU, distal Range, SOBP width, Spot position)
- ✓ Communication between different computer systems associated with treatment
- ✓ Functionality of imaging and patient positioning systems
- ✓ Functionality of critical safety interlocks

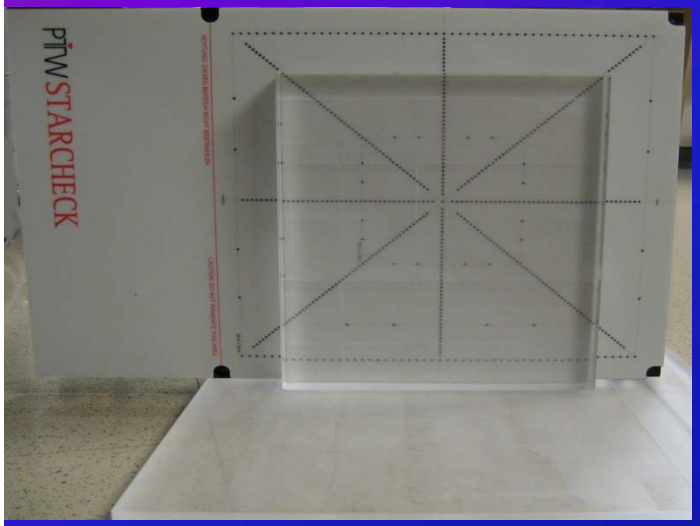
Daily Machine QA (continued)

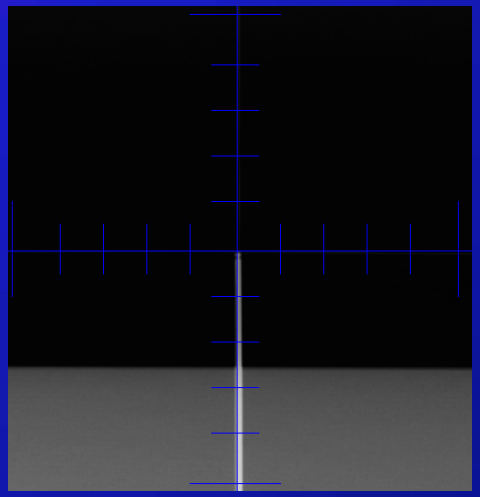
- Two physics assistants perform the morning machine QA
- A staff physicist is present on site as the supervisor
- Takes about 30 minutes per treatment unit
- Couch isocentricity is checked once in a week during the morning QA by Physics Assistants
- Daily QA report is reviewed by a staff physicist once in a week

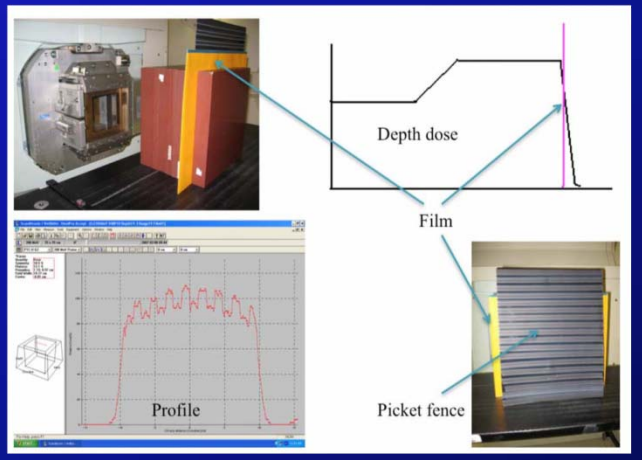
Monthly machine QA checks

- Constancy of radiation field Dose / MU, Distal range, SOBP width and flatness and symmetry at one gantry angle (270 or 0 or 90 degrees in each month)
- Range uniformity check
- Constancy of Output vs gantry angle
- Gantry mechanical isocentricity check
- Table translational motion accuracy and mechanical isocentricity checks
- Snout horizontal motion accuracy check
- Patient positioning system accuracy check
- X-rays and proton field coincidence check
- Done by Physicists, Proton Physics fellows, Residents and Physics Assistants, 12 to 16 Hours for each passive scattering gantry

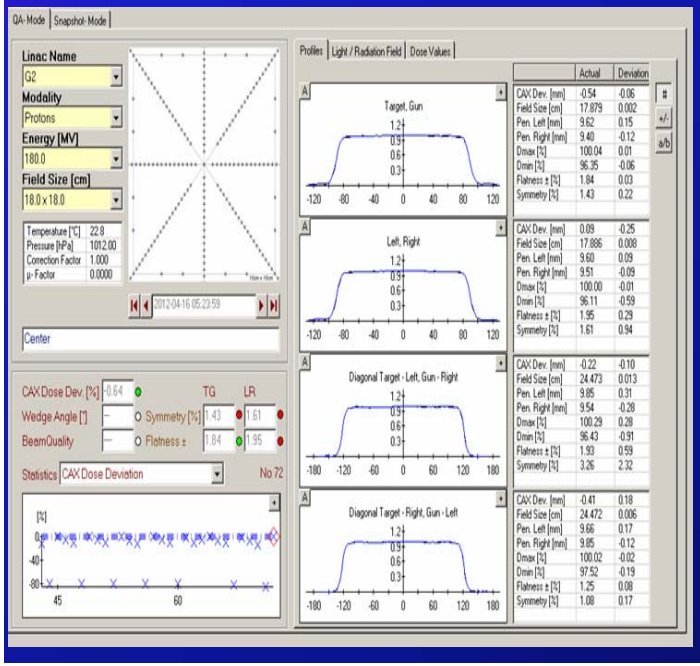
Some tools for monthly QA checks

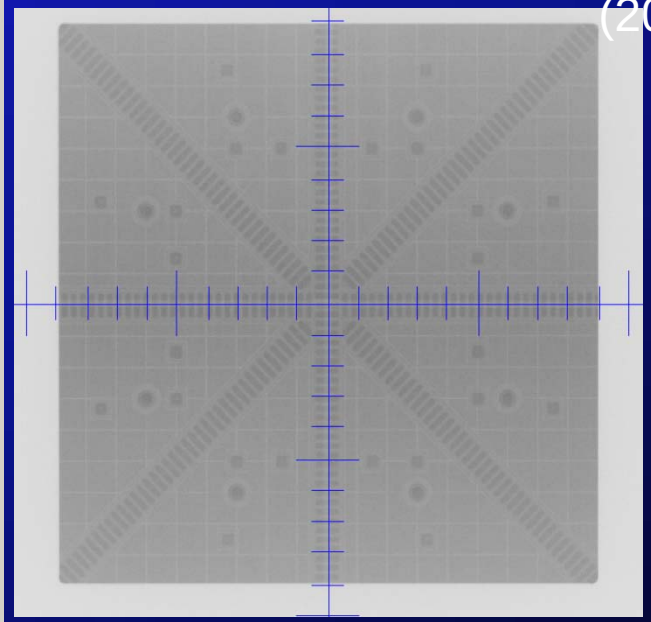






Arjomandy et al, MP,36 (20





Annual machine QA checks-Dosimetry

- Dose monitor system calibration
  - ✓Standard calibration: IAEA TRS-398 protocol with PTW 30013 Cylindrical Chamber
  - ✓Reproducibility, linearity, end effect
- Beam data constancy checks
  - ✓SOBP (PDD): Distal range, SOBP width, longitudinal penumbra width, Spot width
  - ✓Relative output factors, SOBP factors, Range shifter factors (needed for MU calculation), inverse square law validation
- Daily QA dosimetry baseline constancy checks

Annual machine QA checks-others

Mechanical

Couch

- ✓ Translational and rotational movements
- ✓ Vertical axis trueness and sagging

Gantry

- ➢ Rotational

  Mechanical, X-ray system, Proton beam isocentricity and coincidence
- ➢ Gantry angle indicator

Snout: Extension verification

Other checks

- ✓ RMW mechanical integrity
- ✓ Aperture compensator holder integrity
- ✓ Hand pendant functionality

X-ray system

- ➢ kVp, HVL and Timer accuracies
- ➢ Exposure reproducibility
- ➢ mA Linearity
- ➢ Output (exposure as a function of kVp)
- ➢ Image quality (High and low contrast resolution)
- ➢ Safety

Delivery system safety checks

- ✓ Door interlocks, crash buttons, radiation monitors
- ✓ Monitor unit and radiation time indicators
- ✓ Beam pause and abort buttons
- ✓ Radiation status indicator lights
- ✓ Audio visual patient monitors

Patient Specific QA (Passive scattering fields)

- MU verification measurement- 10 minutes per field + 15 minutes setup time

  Tolerance: 3% difference from calculation

  Outside tolerance: Use measured value
- Aperture and compensator QA-10 minutes per field (apertures must match with plan, compensator thickness tolerance < 0.5 mm)

  Outside tolerance: Re-fabricate
- Occasional 2-D dose verification for small fields

Current Patient Specific QA at PTCH for spot scanned beam

- Point dose measurement in “Fish Bowl” phantom for prostate treatment fields or in Plastic Water (PW) with a IC or MatriXX for others
- Depth dose measurement using MatriXX in solid phantoms
- 2-D dose verification at 3 to 5 different depths for each field with MatriXX in PW
- 10 minutes of room time for each depth + 30 minutes of setup and warm up time for measurement
- Pre-measurement Preparation, Post-measurement data analysis and report preparation and check: 4 hours for each patient

Patient Specific QA (Scanning beam)

- QA tolerance

  Point doses: Within 2% or 2 mm of calculation

  2-D dose distribution: 90% of the pixels have the passing gamma with 2% dose or 2 mm distance agreement criteria

- Actions if QA result exceeds tolerance

  Understand the source of disagreement and rectify any measurement and planning issues

Other Unique Implementations at our center

- Spot scanning proton beam therapy - SFO, SIB, MFO
- H+QA: Independent dose calculation module for spot scanning proton beam QA
- Robust optimization module
- Automatic spot position log file analysis software
- Accelerated Partial Breast Treatment

Top 3 items in our wish list

- 3-D Dose verification tools
- *In vivo* dose or range verification tools
- Volumetric in room image guidance

Thank you.