Use of EPIDs for Non-Routine Linac QA

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Disclosure

• This project received support from Varian Medical System.

Learning Objectives

• Introduce examples of recent development of EPID based non-routine quality assurance (QA).

• Be aware of the limitations of the new implementation.
Benefit of EPID based QA
• Available on modern linacs – lower cost
• Enable automation – higher efficiency and reduce possibility of human errors
• Enable standardization – both delivery and analysis
• Opportunity for machine benchmarking

Image courtesy Varian.com and Elekta.com

EPID based routine QA
• Many studies have demonstrated EPID can be used as a reliable and effective tool for some routine linac QA.
  ► DailyQA

EPID based routine QA
  ► Machine performance check (MPC)
Non-routine machine tests and QA

- Efforts have been made to design and expand EPID based measurement to non-routine machine test and QA.

- Non-routine QA
  - Less frequently performed
  - Unique specifications
  - For verification and/or modeling purpose
  - Baseline for future measurement

- Examples:
  Measurement in linac acceptance test, beam energy verification, beam matching, etc.

EPID based measurement in acceptance test

- Aim: To develop a process utilizing the onboard kV and MV EPIDs to perform rapid acceptance testing (AT) on Varian linac which:
  - Minimizes the dependence on 3rd party tools & user expertise and
  - Significantly reduces the time required to perform the AT
  - Enables simultaneous establishment of lifelong routine QA/QC leveraging EPID, automation & cloud-based data processing

- Approaches:
  - The conventional AT tests and tolerances was used as a guide – 45 tests that call for customer demos.
  - EPID based tests are proposed to perform as much tasks as possible.
  - The procedure was carried out on Varian Truebeam utilizing XML controlled machine motion and EPID images.
  - The proposed process was evaluated on one Linac at WashU and one Linac at UCSD

Yaddanapudi et al., Med. Phys. 44 (7), 2017

EPID based ATP phantoms

- Phantoms
  - (A) custom built phantom for photon beams; (B) phantom plate showing the steel plugs, CXS spheroids and resolution plug; (C) double wedge phantom used for AT of electron beams; (D) IsoCal® phantom used with the HPC
EPID based Jaws parallelism test

- Independent jaw locations with respect to steel-spheres embedded in the phantom are automatically analyzed on EPID images to test the skewness as well as the positional accuracy.

- Results: The skew over 20 cm for the X1 and Y2 jaws was 0.20° and 0.17°; no skew observed on the X2 and Y1 jaws.

EPID based MLC static positioning test

- Images were taken with standard MLC pattern from Vendor. The MLC leaf positions relative to the crosshairs are measured.

- Results1: The deviations 0.13±0.46 mm at 5 cm, 0.45±0.23 mm at 15 cm;

- Results2: Position deviation of 0.10 mm for A-side at 10 cm and 0.15 mm for B-side at 10 cm.

Beam energy verification

- Conventional AT test for Varian: Wellhoffer Buddleship (measure PDD, BPs)

- Ionization chamber array (e.g. IC Profiler)
  - Tuning beam energy by changing Bending Magnet Current then measure PDD and Beam profile.
  - Conclusion: Flatness based metrics were found to be more sensitive to energy changes than PDD for photon beams.
Beam energy verification with EPID

- Correlate the beam energy change with the flatness change of beam profile
- Photon -- open field
- A 1% change in PDD (at 10 cm depth) resulted in a 2.5% change in flatness for a 6 MV.

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Beam energy verification

Electron – double wedge phantom
- Beam profile under the wedge is used for analysis.
- Electron Results
  - Line shift was observed and the trend is correlated to the energy shift
  

EPID based beam matching verification

- Concept of beam matching
  - PDD, BP are matched (<1%).
  - EPID based beam matching verification
- The 1D Gamma of the PSM-corrected profiles between the three linacs showed 100% passing rate for 6MV and 6FFF and 97% for 10 MV with 1mm/1% criteria. The maximum difference of output factors was 0.18% among all the measurements except for 2x2 cm2 with 0.6% difference.

Sun et al. EPID-Based Beam Matching for Linear Accelerators. AAPM Poster Med Phys. 2015;44.
Considerations

- EPID calibration
  - Mechanical calibration
  - Reasonable tolerance
  - Uncertainty analysis
  - Dosimetry calibration
  - Vendor provided calibration
  - Pixel sensitivity Map
- EPID imaging Artifact (ghosting, saturation, etc.)
  - Ghosting effect
  - Saturation
  - Dead pixel
- Maintenance and regular QA for EPID

Pixel Sensitivity Map

- PSM is used to normalize the variations in response of each pixel.
  - Large field overlapping irradiation
  - Alternative beam and dark-field (ABDF) image acquisition
- Results
  - Cross machine beam matching after PSM correction.
  

Conclusions

- The use of EPID can be extended to non-routine QA
- The developed AT process demonstrated that at least 25/45 (56%) of the tests which required customer demo can be streamlined and be performed using EPIDs
- The preliminary data shows that EPID can be used for beam energy and profile verification.
- Beam matching verification can be done with EPID.
- Imager calibration is critical and require regular QA and maintenance.
Acknowledgements

WashU
Sasa Mutic
Murty Goddu
Baozhou Sun
Hua Li
Douglas Caruthers

U of Iowa
Sidhar Yaddanapudi

UCSD
Todd Pawlicki
Taylor Harry

Varian Medical System