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.

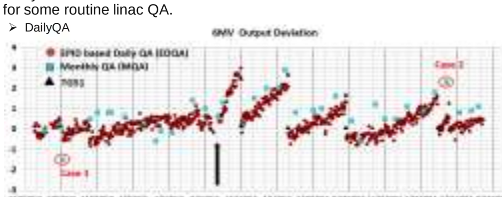
Benefit of EPID based QA

- 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

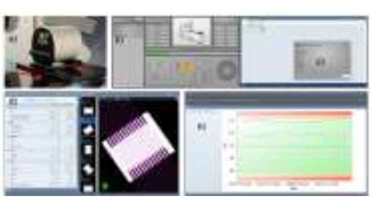
- Many studies have demonstrated EPID can be used as a reliable and effective tool for some routine linac QA.
  - ➢ DailyQA



Poster Abstract in J Appl Clin Med Phys. 2018 May; 19(3): 370–407
Submitted to Biomedical Physics & Engineering Express Apr 2018.

EPID based routine QA

- ➢ Machine performance check (MPC)



*Clivio et al. Radiation Oncology (2015) 10:97 tc. Med.Phys.**42**,5584-5594,2015*

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.

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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:
  - Minimize the dependence on 3rd party tools & user expertise and
  - Significantly reduce 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

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EPID based ATP phantoms

- Phantoms

(A) custom built phantom for photon beams; (B) phantom plate showing the steel plugs, CAX steel-spheres and resolution plug; (C) double wedge phantom used for AT of electron beams; (D) *IsoCal®* phantom used with the MPC

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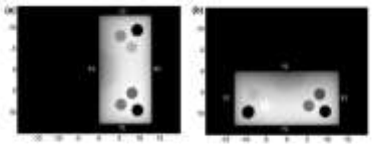
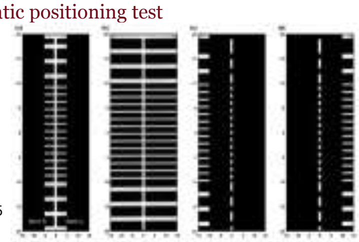
EPID based Jaws parallelism test

- 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.



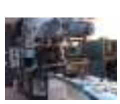
EPID based MLC static positioning test

- 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



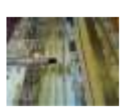
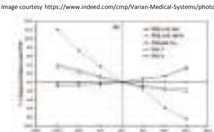


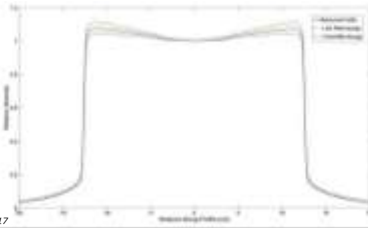
Image courtesy https://www.indeed.com/cmp/Varian-Medical-Systems/photos



Gao et al. Med. Phys. 40 (4), 2013

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.



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

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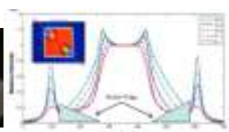
Beam energy verification

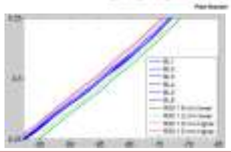
Electron – double wedge phantom

- Beam profile under the wedge is used for analysis.



- Electron Results

Line shift was observed and the trend is correlated to the energy shift



Cai et al. Use of electronic portal imaging device (EPID) for quality assurance (QA) of electron beams on Varian TrueBeam system. AAPM Poster Med Phys. 2015;42:3515.

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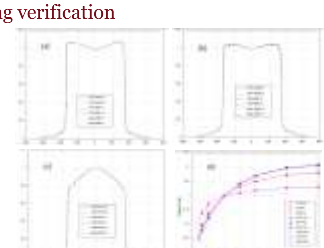
EPID based beam matching verification

- 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. 2017;44.

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Considerations

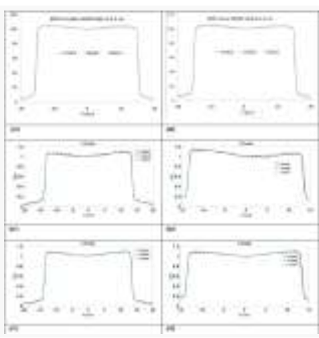
- EPID calibration
  - Mechanical calibration
    - Reasonable tolerance
    - Uncertainty analysis
  - Dosimetry calibration
    - Vender provided calibration
    - Pixel sensitivity Map
- EPID imaging Artifact (ghosting, saturation, .etc.)
  - Ghosting effect
  - Saturation
  - Dead pixel
- Maintenance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

Cai et al. J Appl Clin Med Phys 2018; 19:1: 73–85



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.

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