Processes and Tools for Re-thinking Linac QA

Todd Pawlicki
Division of Medical Physics & Technology
Department of Radiation Medicine & Applied Sciences
University of California, San Diego

UC San Diego

AAPM | Nashville, TN | July 2018

Disclosures

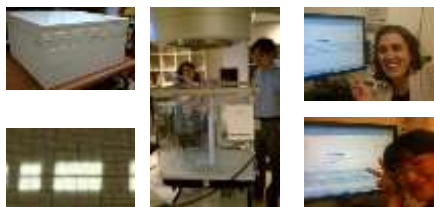- Founding partner
  - TreatSafely
  - Image Owl

UC San Diego

AAPM | Nashville, TN | July 2018

UC San Diego

AAPM | Nashville, TN | July 2018

UC San Diego — AAPM | Nashville, TN | July 2018

Impact on Quality Assurance

- TG-24 (1984)
  - Physical Aspects of Quality Assurance in Radiation Therapy
- TG-28 (1987)
  - Radiotherapy Portal Imaging Quality
- TG-40 (1994)
  - Comprehensive QA for Radiation Oncology
- TG-142 (2009)
  - Quality assurance of medical accelerators
- TG-114 (2011)
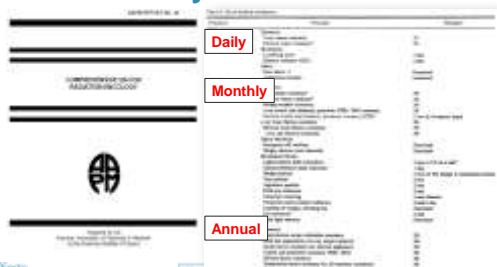 - Verification of monitor unit calculations for non-IMRT clinical radiotherapy

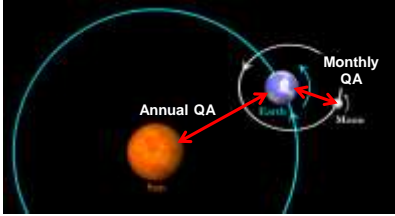UC San Diego — AAPM | Nashville, TN | July 2018

Quality Assurance

Daily

Monthly

Annual

UC San Diego — AAPM | Nashville, TN | July 2018

Testing Frequency

Monthly QA

Annual QA

UC San Diego   AAPM | Nashville, TN | July 2018

UC San Diego   AAPM | Nashville, TN | July 2018

Evolution of Recommendations

TG 40
↓
TG 142
↓
SAMS **TG 100**   Do not make sudden, major changes to your existing QA program.
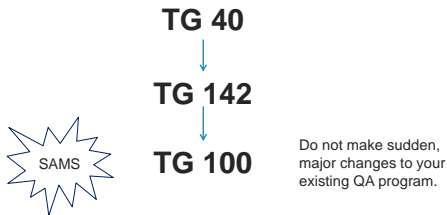
UC San Diego   AAPM | Nashville, TN | July 2018

EPID-Based QA and Automation

- Better use of existing technology, e.g., EPID
    - Eckhause *et al.* Med Phys, 2015
    - Sun *et al.* Med Phys, 2015
    - Yaddanapudi *et al.* Med Phys, 2017

- Standard methodology, e.g., MPC
    - Clivio *et al.* Radiat Oncol, 2015

- Process-based data analysis, e.g., SPC
    - Pawlicki *et al.* Seminars in Rad Onc, 2012.

UC San Diego   AAPM | Nashville, TN | July 2018

UC San Diego   AAPM | Nashville, TN | July 2018
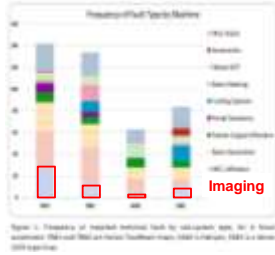
How robust is the imaging system?

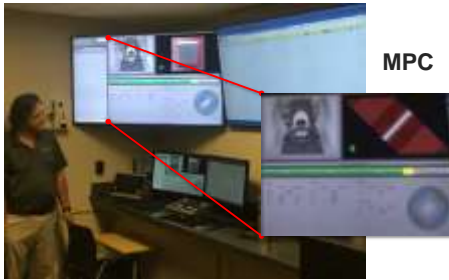UC San Diego   AAPM | Nashville, TN | July 2018

Imaging System Faults

- Assess clinical operation of the Halcyon focusing on machine faults

- Hoisak *et al.*
  - AAPM 2018

Imaging

MPC

MPC Results

Every Patient, Every Fraction

- Investigate sensitivity EPID images as an on-line QA method

- Favè and Moore
  - AAPM 2018

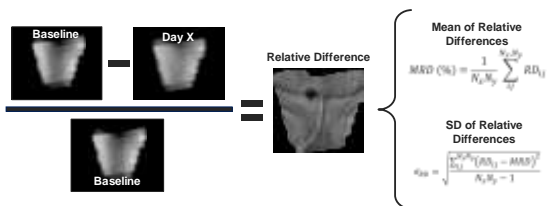Day 1   Day 2   Day 3   Day X
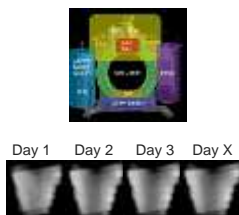
UC San Diego   AAPM | Nashville, TN | July 2018

Analysis Method

Favè and Moore
AAPM 2018

Baseline   Day X

-

=   Relative Difference

Baseline

Mean of Relative Differences

$$MRD\ (\%) = \frac{1}{N_x N_y} \sum_{ij}^{N_x, N_y} RD_{ij}$$

SD of Relative Differences

$$\sigma_{RD} = \sqrt{\frac{\sum_{i,j}^{N_x, N_y}(RD_{ij} - MRD)^2}{N_x N_y - 1}}$$

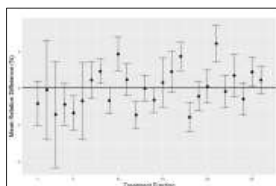UC San Diego   AAPM | Nashville, TN | July 2018

Results and Conclusions

Favè and Moore
AAPM 2018

- All but 1 fraction had an MRD within 2.0% of average

- σ_{RD} ranged from 0.7 – 2.9%

- σ_{RD} more sensitive than MRD for shifts and visual patient differences

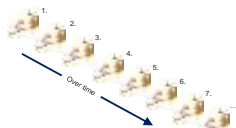UC San Diego   AAPM | Nashville, TN | July 2018

Quality and Safety

Per-patient based

Process based

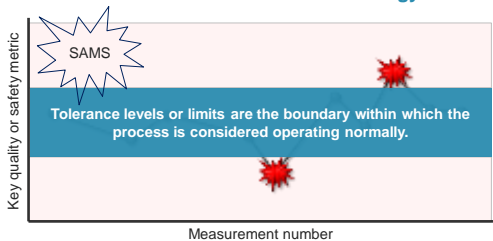Is it correct, did I do it correctly?

Each case is a go/no-go decision.

Are people and equipment doing it right?

How is the process performing?

AAPM | Nashville, TN | July 2018
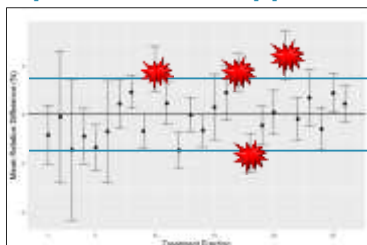

Statistics-Based Decision Strategy

SAMS

Tolerance levels or limits are the boundary within which the process is considered operating normally.

Key quality or safety metric

Measurement number

AAPM | Nashville, TN | July 2018

Simple Decision Support Tool

AAPM | Nashville, TN | July 2018

Current QA

Per-patient based Analysis

Process based Analysis

Future QA

Process based Analysis

Per-patient based Analysis
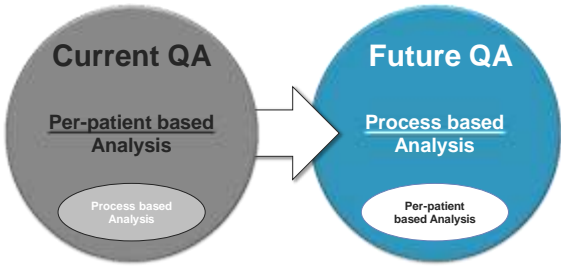
UC San Diego

AAPM | Nashville, TN | July 2018

Summary

- EPID-based QA will change our QA paradigm
  - Automated data collection and analysis

- Our focus will be on process analysis
  - Data collection will be largely automated

- More time for more impactful activities

UC San Diego

AAPM | Nashville, TN | July 2018