SunCHECK™ Machine

SunCHECK Machine, an automated QA software solution: A centres 5 year experience evaluation

G. Martin et al., The Clatterbridge Cancer Centre, Liverpool, UK, ESTRO 2021 Abstract, PO-1720

- *"Purpose or Objective: Evaluate the key stages of the SunCHECK Machine implementation, including; initial viability, sensitivity testing, commissioning, long term use with 9 linacs and time saving quantification."*
- *"Results: Initial viability: A qualitative comparison of automated and manually analysed results showed good agreement and demonstrated a time saving benefit."*
- *"Long Term use: For 12 months the platform has successfully completed all QA across 9 linacs, >95% without intervention. Troubleshooting guides were produced for routine issues e.g. smooth profiles, adjust image registration, etc. SunCHECK Machine has enabled quantitative analysis of imaging tests where previous qualitative analysis was used."*
- *"SunCHECK machine has saved 22hours and 43mins, per linac, per year…Conclusion: The platform provided significant efficiency and quality benefits to the department. The simplifications allow technicians to acquire and manage the QA, rather than physicists."*

QA specification requirement by frequency	Previous Test	Time to acquire and analyse historically	SunCHECK equivalent	SunCHECK Machine time	Time saved per test	Time saved annually per test, per linac
Monthly Picket fence/DR+GS/LS	Monthly 6 MV RapidArc	35 mins	Monthly VMAT picket fence, dose rate and gantry speed, leaf speed	7 mins	28 mins	336 mins
Monthly kV Blade positions	Blade position checks	15 mins	Monthly kV field size	2mins	13 mins	156 mins
Monthly flatness/symmetry	Monthly Starcheck^{maxi}	45 mins	Monthly flatness and symmetry	3 mins	42 mins	504 mins
Monthly kV contrast and resolution	Monthly KV Image quality	10mins	Monthly Leeds test/ Tor18fg	3mins	7 mins	84 mins
Monthly CBCT HU and other	Monthly Catphan	20 mins	Monthly Catphan	10 mins	10 mins	120 mins
Three monthly Radiation Field size MLC and Jaw	Monthly Hole Phantom	30 mins	Three monthly field size/centre	5 mins	25 mins	100 mins
Six monthly radiation isocentre	Monthly Hole Phantom	30 mins	Six monthly Winston Lutz	15mins	15mins	-
Annual Flatness/symmetry (all gantry angles)	Annual Profiles with Gantry angle Starcheck^{maxi}	60 mins	Annual flatness and symmetry with gantry angle	10 mins	50 mins	50 mins
Field size at extended SSD	Annual field size at extended SSD	15 mins	Annual field size at 150cm SSD	2 mins	13 mins	13 mins
	TOTAL	**230 mins**	**TOTAL**	**57 mins**	**173 min**	**22hours 43mins**

Comparison of Vendor-Dependent Versus Commercially-Available, Independent LINAC Quality Assurance (QA) for Daily QA

C Stambaugh, C Melhus, Tufts Medical Center, U.S., PO-GeP-T-234, AAPM 2020

- *"Conclusion: The number of parameters assessed with SCM (SunCHECK Machine) exceeded four times the parameters accessed with MPC."*
- *"SCM (SunCHECK Machine) can obtain dosimetry results more efficiently and can provide a more user-friendly interface that can be adjusted to the specific clinic's needs to achieve complete DQA data collection."*
- "While MPC is attractive due to the built-in nature of the testing…the need for a second platform for the remaining DQA tests as well as the greater efficiency of SCM, make SCM a more appropriate tool for DQA"

SunCHECK™ Machine & IC PROFILER™ Accuracy Studies

Water Equivalent Studies

Clinical Experience Implementing An Ion Chamber Array for Monthly Beam Constancy Versus Ion Chamber in Water

D Barbee et al, NYU Langone Health, U.S., PO-GeP-T-186, AAPM 2020

- Focus: SunCHECK Machine Monthly, using IC PROFILER
- *"The Sun Nuclear IC PROFILER with Quad Wedges (ICP) was used in conjunction with SNC Routine, a web-based QA system, to measure monthly beam quality and output across six Varian Truebeams over the course of fifteen months."*
- Time savings - *"Results: ICP reduced overall measurement time compared to FCW (farmer chamber in water) for photons and electrons by 50% and 66%, respectively."*
- More consistent – *"R50 and D10 beam quality measurements were more consistent using ICP than FCW with RMSE values of 0.05 and 0.19 mm for electrons and 0.14 and 0.53% for photons, respectively."*
- *"Conclusion: The combination of IC PROFILER with proper baselines and the [SunCHECK Machine] system provides similar output measurement, more consistent beam quality, and improved efficiency in comparison to a Farmer chamber in water technique."*

Quantification of beam steering with an ionization chamber array

S. Gao, et al., The University of Texas MD Anderson Cancer Center, Houston, TX, U.S., J Appl Clin Med Phys 2018 May; 19(3):168-176

- Focus: SunCHECK Machine Annual, using IC PROFILER
- *"We have demonstrated that with the correct equipment and procedures, a 2D detector array can be used to steer linear accelerator photon and electron beams and achieve a resultant beam symmetry that matches that of a 3D water scanning system."*
- *"Use of the ICA (IC Profiler) greatly speeds up the steering process because of its real-time feedback and reduces effort by eliminating the need to setup a 3D water scanning tank."*
- *"No significant differences were found among the various array calibrations even though they spanned 4 yrs suggesting that the device has good short-term reproducibility and long-term stability with respect to the array calibrations."*

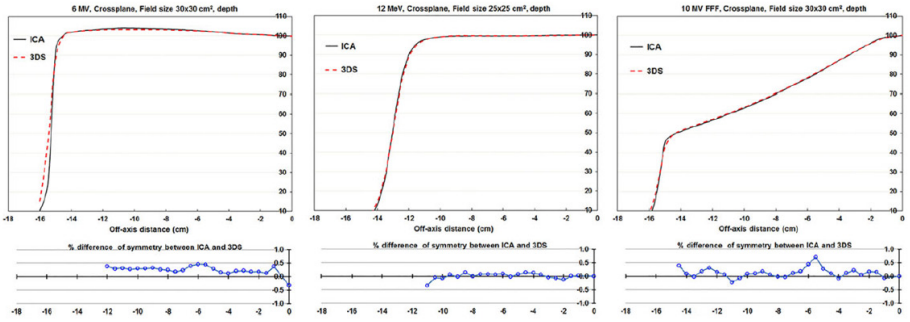

FIG. 5. Samples of profiles measured with a 2D ionization chamber array (ICA) and 3D Scanner (3DS) (upper chart) and differences in point-by-point symmetry (lower chart).

Quality Assurance of Beam Energy and Output for Gated Treatment Delivery Using IC PROFILER and Quad Wedges

L. Hu, et al., NYU Langone Health, New York, NY, U.S., SU-K-SAN1-5, 2019 AAPM Talk/Abstract

- Study using IC PROFILER and Quad Wedges to test Gating beam stability at very low doses
- *"IC PROFILER provided stable energy and output measurement for very low MU delivery, validating its use for gating QA."*
- *"Mean IC PROFILER deviations for MU bursts <3MU and all IC PROFILER standard deviations were an order of magnitude smaller than ion chamber"*

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Measuring Beam Energy and Symmetry Constancy with an Ion Chamber Array

Varian Reference Bulletin 100052071-01, December 2010, Varian Medical Systems, Inc., Palo Alto, CA

- Uses Dual Wedges for energy checks on Varian Medical Systems® Linac beams (6-20 MV and 4-22 MeV)
- *"The investigation has yielded the following results: This device can measure beam energy and symmetry changes with a sensitivty comparable to a Wellhofer water phantom*
- *This device can measure beam profiles with a repeatability comparable to a Wellhofer water phantom"*

Measurement of changes in linear accelerator photon energy through flatness variation using an ion chamber array

S. Gao, et al., The University of Texas MD Anderson Cancer Center, Houston, TX, U.S., Med. Phys. 40 (4), April 2013

- Uses Diagonal Flatness for energy checks on Varian Medical Systems® Linac flattened beams
- *"Our measurements indicate that there is a strong correlation between changes in photon energy and changes in the diagonal normalized flatness, FDN. In contrast, we found that PDD changes were not as sensitive to changes in photon energy particularly when the beam energy was reduced below the nominal energy."*

Beam Quality Verification Using IC PROFILER with Quad Wedge Accessories

L. Tirpak, et al., Sun Nuclear and Varian Medical Systems® Co-Authored 2016 Technical Bulletin P1018976

- *"Conclusion: Energy verification using IC PROFILER with Quad Wedge accessories can yield results with accuracy comparable to water tank measurements.*
- *For Varian TrueBeam accelerators, the accuracy (3 standard deviations) of calculated D10 and R50 metrics was shown to be 0.45% and 0.05 cm, respectively.*
- *The reproducibility of results (3 standard deviations) is 0.1% for D10 and 0.03 cm for R50.*
- *"The setup of an IC Profiler and accessories is much simpler than the setup of a water scanning system. This means that the IC Profiler is less prone to errors and uncertainties, which provides more consistent reproducible results."*

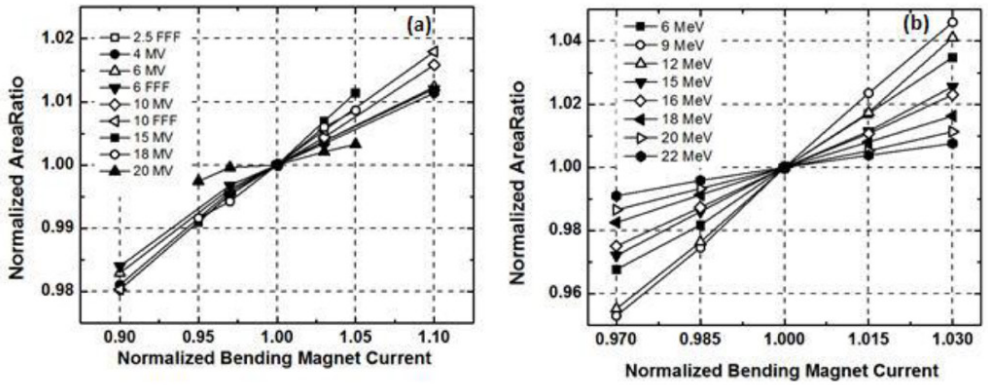

Figure 4: Relative change in AreaRatio as a function of bending magnet current for photon (a) and electron beams (b). The lines are drawn as a guide for the eye and do not represent a linear fit.

Use of AutoTest BeamPro™ for rapid set-up of Photon and Electron Beams

Elekta White Paper, Elekta, Stockholm, Sweden, 2016

- Uses Dual Wedge Tray for energy checks on Elekta Linac beams (6MV and 4-22 MeV)
- *"Conclusion: AutoTest BeamPro™ makes use of widely available ion chamber array technology as an alternative to traditional water phantoms for preliminary system set-up."*
- *"The system has the advantage of eliminating some of the user-dependent sources of inconsistency and provides beam profiles and analysis in real time thereby enabling very efficient tuning and set-up of the beams."*
- *"AutoTest BeamPro™ therefore represents a major step forward in the ability to prepare systems for customer acceptance quickly and consistently."*

Clinical implementation of photon beam flatness measurements to verify beam quality

S. Goodall, et al., Brighton and Sussex University Hospitals NHS Trust, Brighton, UK, J Appl Clin Med Phys, 2015, Vol 16:6

- Uses Diagonal Flatness for energy checks on Elekta Linac flattened beams
- *"Conclusion: A strong liner correlation was shown between…TPR15/5 and FDN (Diagonal Flatness) values for 6 and 10 MV photon beams across multiple Elekta linacs."*

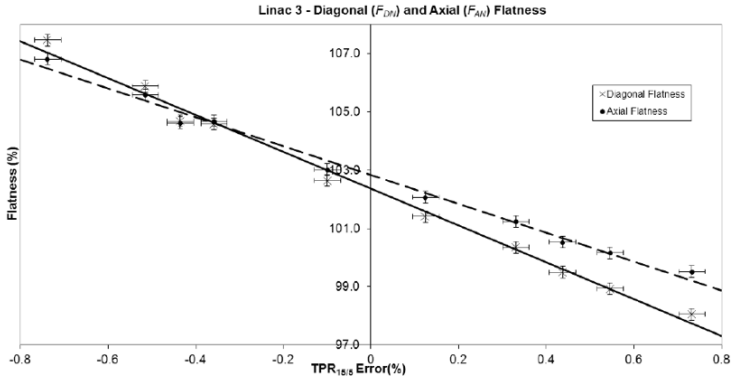

FIG. 1. The variation of diagonal normalized flatness (solid line $R^2 = 0.9924$) and axial normalized flatness (dashed line $R^2 = 0.9908$) with $TPR_{15/5}$ error (%) for linac 3 at a nominal energy of 6 MV.

TG-198 on Annual Equipment

AAPM Task Group 198 Report: An implementation guide for TG 142 quality assurance of medical accelerators

J. Hanley, et al., Princeton Radiation Oncology, Monroe, NJ, U.S., Med. Phys., April 2021, https://doi.org/10.1002/mp.14992

- *"If film dosimetry or ionization chamber arrays were used during the commissioning process to establish the baseline flatness as a surrogate for photon beam quality, then the same device can be used to measure beam quality on an annual basis."*

IC PROFILER and 1D SCANNER™ for Varian Medical Systems® Halcyon™ System

Acceptance and verification of a Halcyon-Eclipse linear accelerator-treatment planning system without 3D water scanning

S. Gao, et al., The University of Texas MD Anderson Cancer Center, Houston, TX, U.S., J Appl Clin Med Phys, Aug 2019;1-7

- Study successfully compares IC PROFILER with 1D SCANNER vs. a 3D scanner to accept and commission the Halcyon/Eclipse system.

IC PROFILER for TBI Validation

Extended SSD VMAT treatment for total body irradiation

G. Pierce, Tom Baker Cancer Centre, Calgary, AB, Canada, J Appl Clin Med Phys, 2019; 20:1:200-211.

- Provides a method using an IC PROFILER at three inline positions to validate VMAT-based TBI treatments.

Daily QA™ 3

CyberKnife Output Constancy Utilizing Daily QA3 Device

T. Reynolds, et al., AAPM 2019 Abstract, PO-GePV-T-269

- Four year constancy and suitability study comparing Daily QA 3 to Ion Chamber measurements
- "The DQA3 device showed a good agreement with ion chamber measurements making it a suitable device for detection of output variations during routine measurements."

When a Good Monitor Chamber Goes Bad: Diagnosing Atmospheric Communication of a Sealed Monitor Chamber

T McCaw, et al., AAPM 2018 Abstract, SU-I-GPD-T-323

- *Conclusion: "Daily output variations measured with two independent systems on a TrueBeam STx were found to highly correlate with atmospheric conditions during a period in which the monitor chamber was suspected to be communicating with the atmosphere. Additional measurements acquired during controlled temperature variation of the monitor chamber confirmed atmospheric communication of an originally sealed chamber."*

Long-term experience of MPC across multiple TrueBeam linacs: MPC concordance with conventional QC and sensitivity to real-world faults

M. Pearson, Guys and St. Thomas Hospital, London, UK, J Appl Clin Med Phys 2020; 21:8:224–235

- Compares MPC results with conventional results over 3-year period across 8 Linacs
- *"In total, there are 50 true negative and 27 false negative out of tolerance MPC results."*
- They chose to measure with an ion chamber monthly instead of every 3 months due to erratic variability of MPC to Ion Chamber readings:
  - *"It is not possible to eliminate all false positives and negatives, due to the inherent instability of the MV panel output measurement"*
- *"In order to mitigate the effect of false negatives, on occasion that the daily MPC fails, we repeat the MPC measurement with a new setup, and if there is a repeated beam measurement failure, we measure output with an independent device — the DailyQA3."*
- *"The number of output re-baselining events ranged from 2 to 5 for each Linac over the measurement period, equating to one to two rebaselines per year."*

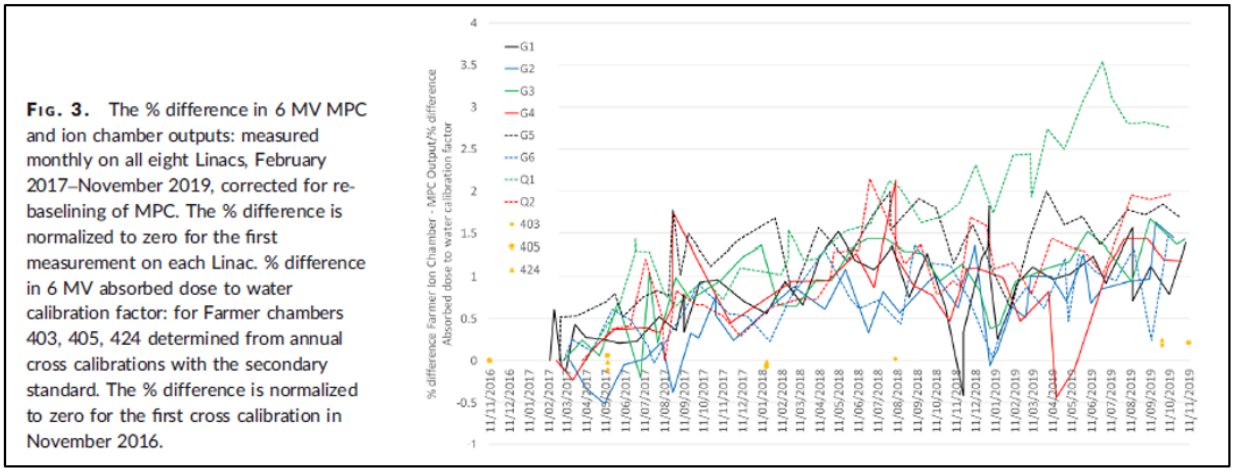

Fig. 3. The % difference in 6 MV MPC and ion chamber outputs: measured monthly on all eight Linacs, February 2017–November 2019, corrected for re-baselining of MPC. The % difference is normalized to zero for the first measurement on each Linac. % difference in 6 MV absorbed dose to water calibration factor: for Farmer chambers 403, 405, 424 determined from annual cross calibrations with the secondary standard. The % difference is normalized to zero for the first cross calibration in November 2016.