

Validation of using a MapCheck3 Diode Array on SBRT PSQAs

Chancelor Christensen, MS^{1,2}; Mohammed Kanber, MS^{1,2}; Wenhuan Jiang, PhD^{1,2} ; Jae Jung, PhD^{1,2}
¹East Carolina University, ²ECU Health Radiation Oncology



ABSTRACT

Purpose: MapCheck3 diode array in the MapPHAN phantom (Sun Nuclear Corporation, Melbourne, FL) appears as a reliable tool for IMRT/VMAT QAs. The objective of this work is the validation of the device for SBRT patient specific QAs (PSQA).

Methods: Seven patients treated previously with VMAT techniques were evaluated using MapCheck3. And the treatment fields were analyzed within two groups: 19 Lung SBRT fields that passed QAs using EPID and 7 SBRT fields (mixed sites) with low passing rate on EPID (e.g., due to ghosting or saturation under high-dose-rate FFF beams). The diode array was firstly calibrated in a Truebeam for 6FFF beams. Treatment plans were calculated over the QA phantom with the AAA algorithm and the RT Dose DICOM files were then imported into the SNC Patient software and compared with the measured dose distribution. Gamma test with a 10% threshold was used with evaluation criteria of 1mm distance to agreement and 3% absolute dose difference. Maximum gamma (MG), average gamma (AG), and the percentage of gamma values that are greater than 1 (PG1) were statistically analyzed between the QA results using MapCheck3 and EPID.

Results: In the first group, the average differences between Mapcheck3 and EPID on MG, AG, and PG1 were -0.58±0.29 (p=0.0003), -0.03±0.02 (p=0.2093), and -0.39%±0.95% (p=0.3627), respectively. The PSQA results from MapCheck 3 had a smaller MG but had similar AG and PG1 compared with using EPID. In the second group, MapCheck3 returned the average of MG, AG, and PG1 as 1.64±0.44, 0.31±0.06, and 3.47%±2.71%, respectively, providing 7 reasonable passing results.

Conclusion: MapCheck3 diode array in the MapPHAN is a robust tool for SBRT PSQAs. For the clinics using EPIDs as the primary PSQA device for workflow efficiency, MapCheck3 can be a great addition for verifying complex stereotactic deliveries.

Wen Jiang
 East Carolina University
 524 Moye Blvd, Greenville, NC 27834
 JIANGW25@ECU.EDU
 (252) 816-5328

INTRODUCTION

MapCheck3 diode array in the MapPHAN phantom (Sun Nuclear Corporation, Melbourne, FL) was designed to be a reliable tool for IMRT/VMAT QA to be in compliant with TG218. It is equipped with 1,527 *SunPoint2* diode detectors, providing a 26 x 32 cm² field size and a 0.23 mm² active detector area. In addition, MapPHAN is a water equivalent phantom can be attached to MapCheck3 for the helical-geometry beam delivery such as RapidArc, VMAT, and TomoTherapy.

Our clinic uses the EPID as the primary tool to streamline the patient specific QAs (PSQA) and validate IMRT/VMAT plans before the first treatment. However, we are also in search of an alternative for the Stereotactic Body Radiation Therapy (SBRT) PSQAs, which can provide a robust solution when the EPID reaches its limitations such as detector saturation at high dose rates.

This project is to validate one of the newest diode-array detectors in the market, MapCheck3 for SBRT PSQAs, providing a reference for the clinics interested in it.

METHODS AND MATERIALS

We randomly selected seven patients treated with VMAT/IMRT techniques that completed the PSQA with EPID and reevaluated them with the MapCheck3 approach. The treatment fields in the original plans were separated in two groups: 19 Lung SBRT fields that passed QAs using EPID; 7 SBRT fields with low passing rate on EPID (e.g., due to ghosting or saturation under high-dose-rate FFF beams) with the treatment sites including BrainMet, Scapula, prostate, and spine.

The MapCheck3 diode array was firstly calibrated in a Truebeam (Varian Medical System, Palo Alto, CA) for all beam energies. The verification plans were calculated over the MapPHAN phantom with the AAA algorithm (Version 16.1.2) as shown in Figure 1 and Figure 2: the red line indicates the detector area, and the blue line indicates the structure of MapPHAN phantom. The generated RT Dose DICOM files were then exported to the SNC Patient software and compared with the measured dose distribution: gamma test with a 10% threshold, 1mm distance to agreement, and 3% absolute dose difference.

Maximum gamma (MG), average gamma (AG), and the percentage of gamma values that are greater than 1 (PG1) were statistically analyzed between the QA results using MapCheck3 and EPID.

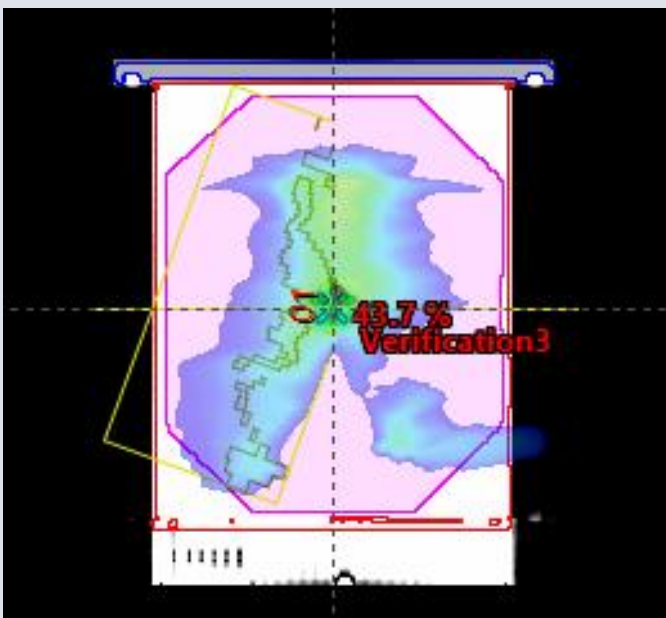
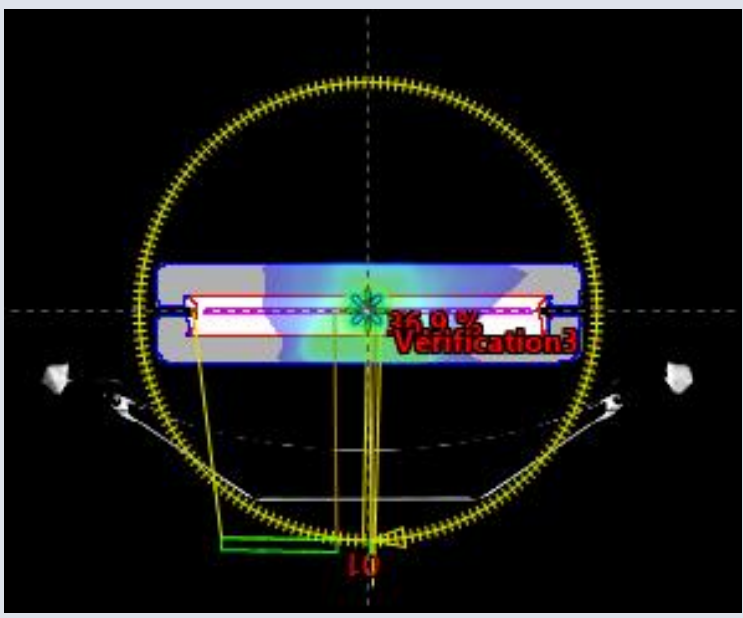


Figure 1. QA Plan in Transversal Plane Figure 2. QA Plan in Frontal Plane.

RESULTS

In Group 1 , the average differences between Mapcheck3 and EPID on MG, AG, and PG1 were -0.58±0.29 (p=0.0003), -0.03±0.02 (p=0.2093), and -0.39%±0.95% (p=0.3627), respectively. Comparing with EPID, MapCheck 3 had a smaller MG. Meanwhile, it had similar AG and PG1 compared with the result from EPID. The passing rate on lung SBRT using two devices are very close.

In Group 2 (EPID failed the PSQA), MapCheck3 provided 7 reasonable passing results with the average of MG, AG, and PG1 as 1.64±0.44, 0.31±0.06, and 3.47%±2.71%, respectively.

MapCheck3 provides similar results/passing rate (3%/1mm gamma criteria) in Group 1 (Figure 3). On the other hand, the fields in Group 2 all passed the PSQAs using Mapcheck3 (Figure.4) but had low passing rate using EPID. Fig 5.a and Fig 5.b show an example in Group 2: the field failed with a 68.9% passing rate using EPID but was able to pass with a 95.8% passing rate in MapCheck3.

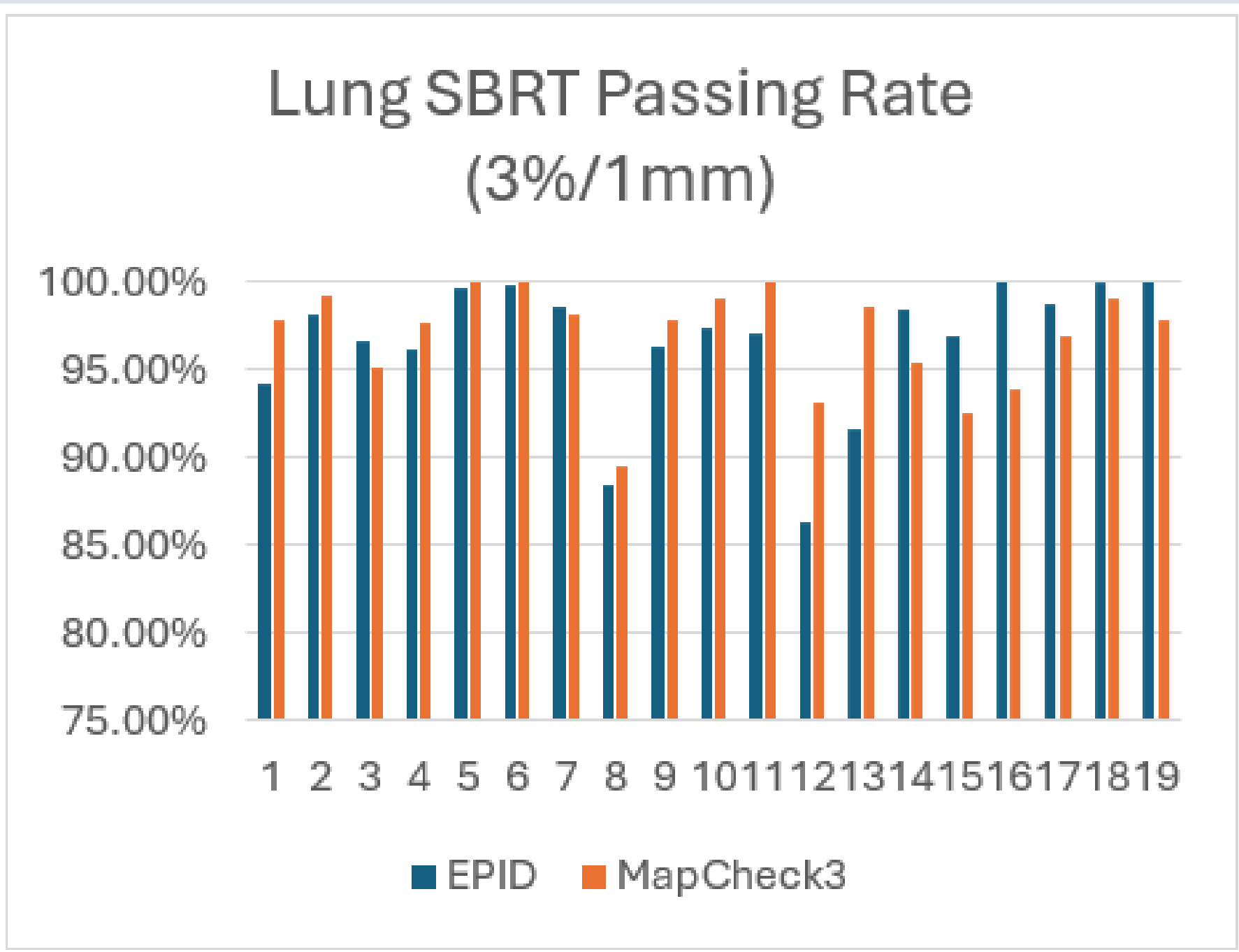


Figure 3. Comparison of passing rate on Lung SBRT QAs.

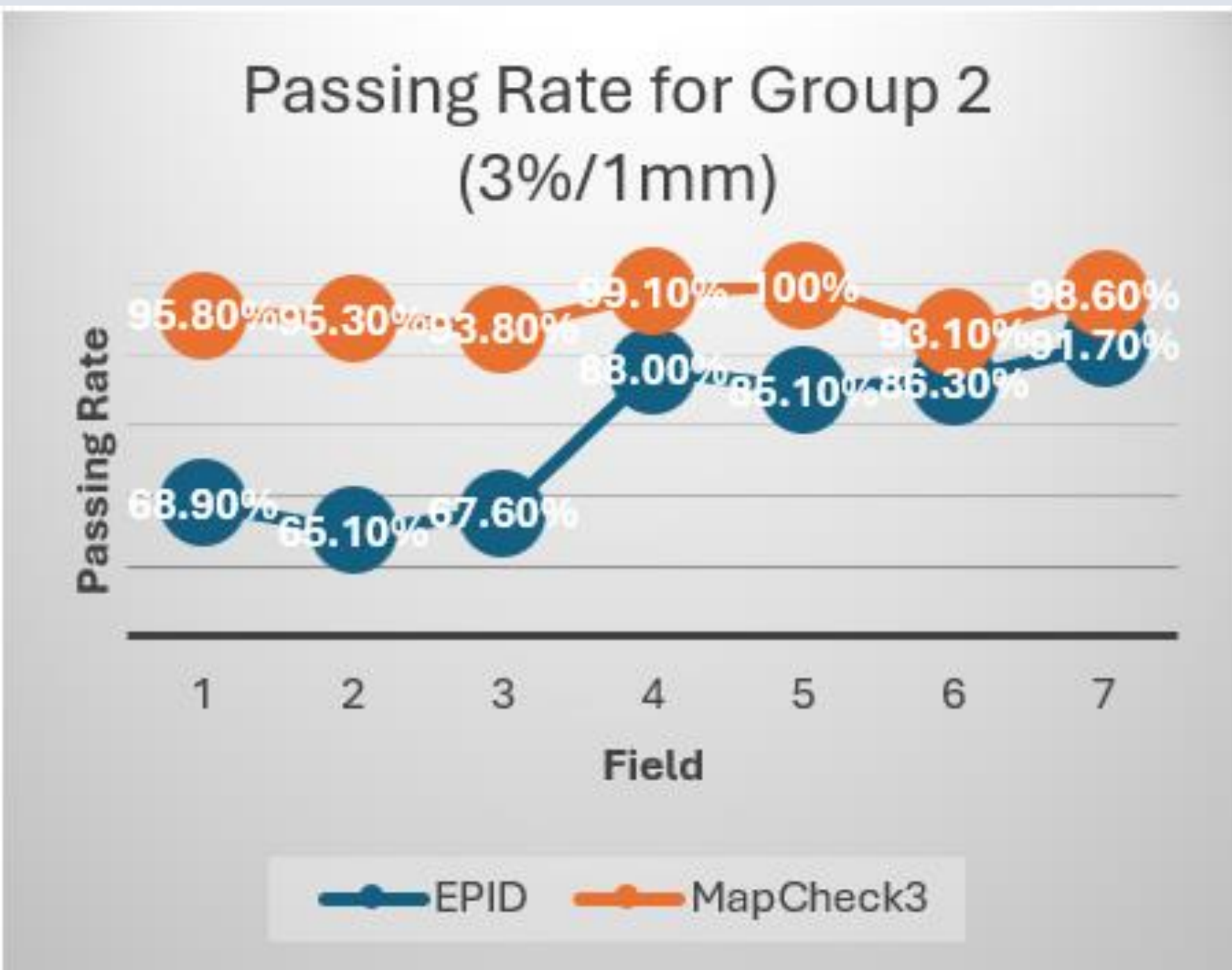


Figure 4. Comparison of passing rate in Group 2.

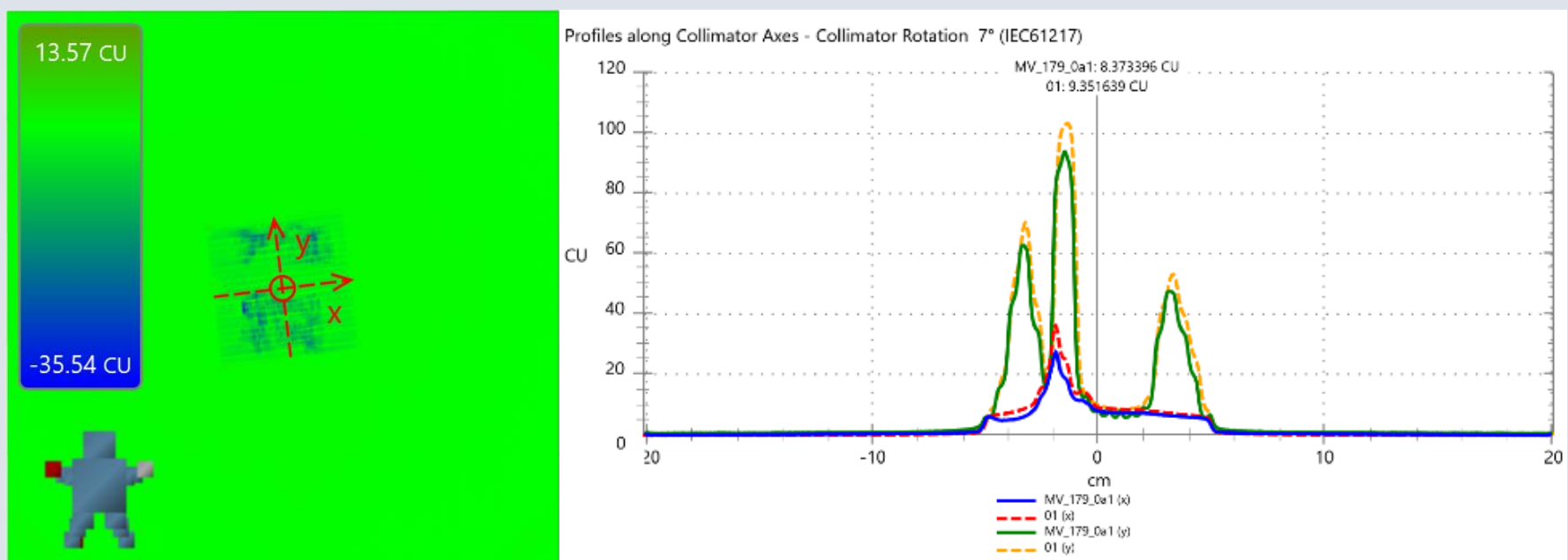


Figure 5a. Dose difference and its profiles along collimator axes. 68.9% passing rate (3%/1mm) using EPID

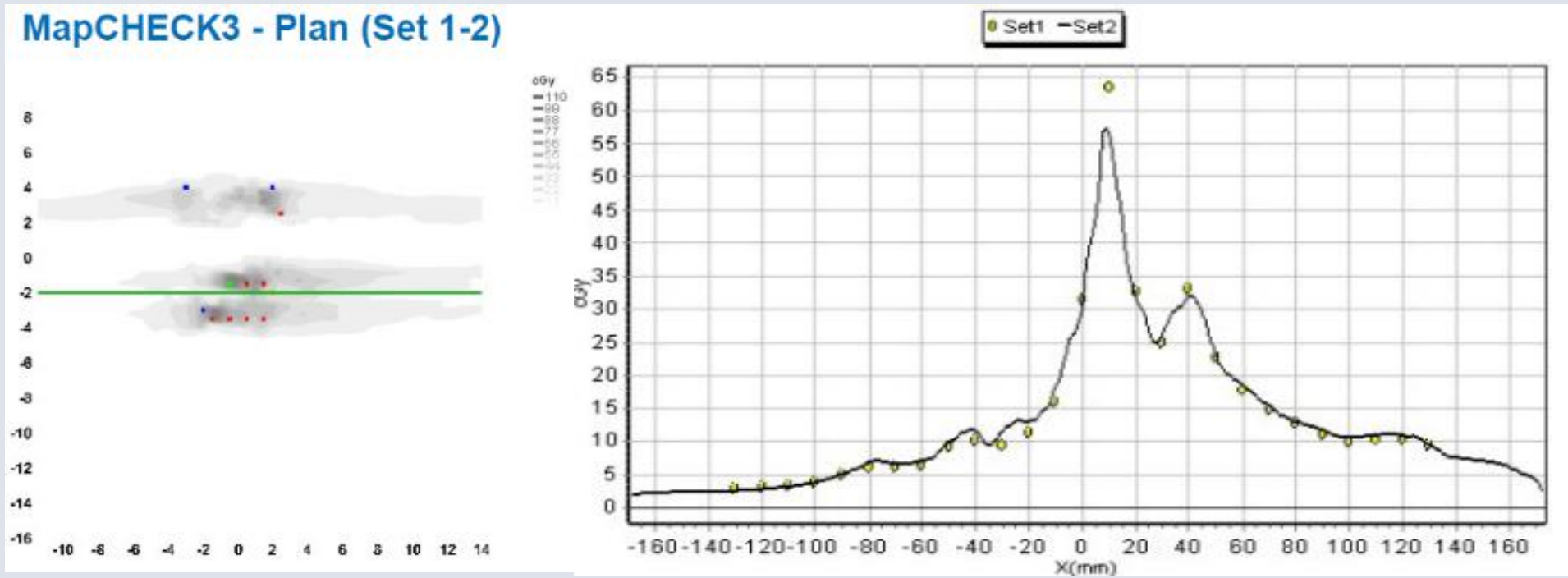


Figure 5b. Dose difference and its profiles along collimator axes. 95.8% passing rate (3%/1mm) using MapCheck3

DISCUSSION

The EPID based PSQA offers unparalleled workflow efficiency and high spatial resolution without the need for setting up physical phantoms. Therefore, it should not be replaced in a high-patient-volume clinic. However, the limitation of EPID in certain circumstances such as the cases showed in Group 2 demonstrates the necessity for the physicists to look for a second tool to evaluate the complex plans such as for SRS/SBRT.

For verification of SRS/SBRT plans, diode array detectors can directly measure the absolute dose (with valid dose/array calibrations). The diode arrays are highly stable and designed to handle massive dose rates without losing linearity, making them very effective for measuring FFF beams. The software used for diode array detectors apply real-time correction factors for gantry angles and dynamic pulse-rate variations to track fast-moving VMAT arcs. All those features overcome the limitations from EPID such as ghosting (signal lag between frames), directional backscatter, and dose rate saturation for FFF beams, etc..

CONCLUSIONS

MapCheck3 diode array detector housed inside the MapPHAN measures the absolute dose directly and is a very effective and robust tool for SBRT PSQAs (especially for the FFF beams). Therefore, MapCheck3 can be a great addition to the clinical practice for verifying complex stereotactic deliveries (SRS/SBRT), or a secondary option for the clinics using EPIDs as the primary PSQA device for workflow efficiency, when the EPID can not provide a reasonable result due to the device limitations.

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