Quality Assurance of the GammaPod™ System using the SRS MapCHECK®

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INTRODUCTION

• GammaPod is an emerging gamma irradiation device dedicated to breast stereotactic radiotherapy[1]

• It delivers highly-conformal dose for boost, partial-breast irradiation, or neo-adjuvant stereotactic radiosurgery

• Annual quality assurance (QA) of this system using radiochromic films is the current practice, but it is laborious and time-consuming[2]

AIMS

• To develop a quality assurance pro... MapCHECK® with the StereoPHAN... Corp, Melbourne, FL)

METHODS

• **GammaPod™ system** (Xcision Medical Systems, LLC; Columbia, MD)
  ▪ A novel breast stereotactic radiotherapy device that has received 510(k) clearance from the U.S. Food and Drug Administration
  ▪ 25 rotary cobalt-60 sources with collimators at 15 and 25 mm
  ▪ A dual-cup system with stereotactic fiducials used for breast immobilization, which provide a specific set of coordinates for fast and accurate localization[3]
  ▪ It dynamically paints dose to the target while the couch translates continuously in space
  ▪ Equipped with a dedicated GammaPod treatment planning system using Monte-Carlo generated dose kernels

Figure 1. The GammaPod™ unit at out center, with its coordinate system labelled (left). The dual-cup system contains a pink flange, inner and outer cups. In the outer cup, stereotactic fiducials arranged in a spiral shape are used for fast and accurate localization (right upper). The assembled dual-cup system (right lower).

METHODS (CONTINUED)

• **A custom-designed plastic holder for the SRS MapCHECK®**
  ▪ Size-fitted to the StereoPHAN™
  ▪ A notch at its interior to promote reproducible setup of the StereoPHAN™ in the holder
  ▪ A rotatable holder with three locking latches that allow dose measurements in both XY and YZ planes
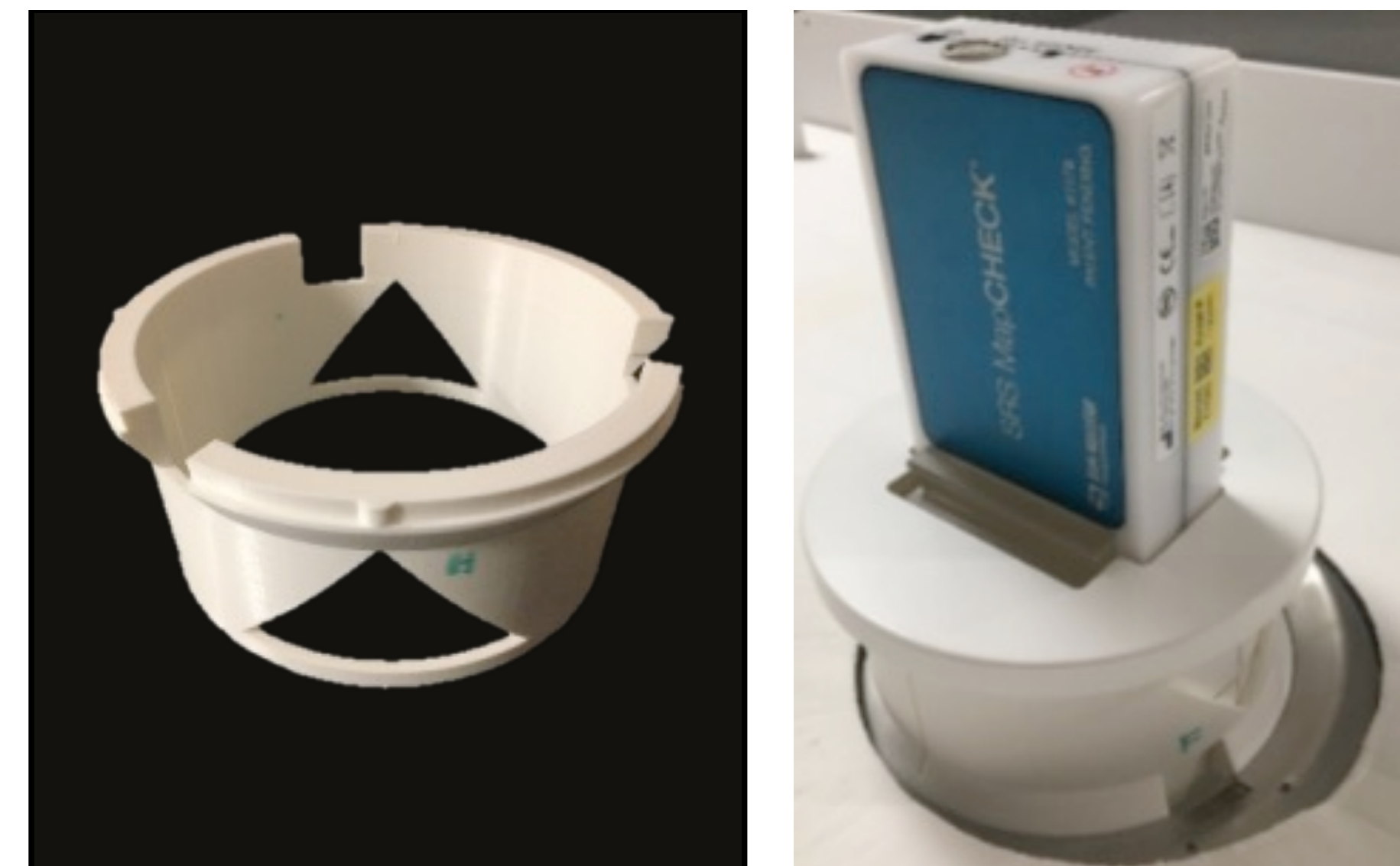

Figure 2. The plastic holder for the SRS MapCHECK® device (left) and its setup for dose measurement on the GammaPod™ system (right).

• **GammaPod™ QA tests using the SRS MapCHECK®**
  ▪ Reproducibility of dose delivery in two consecutive shots
  ▪ Dose profile constancy check compared to the baseline measurements
  ▪ Couch motion accuracy by measuring shifts in dose maps with and without couch motions

RESULTS

• **Reproducibility of dose delivery**
  ... field, the dose maps from two consecutive measurements ... mean difference of -0.07% (range: -0.21-0.07%) for the 15-... and 0.11% (range: -0.13-0.28%) for the 25-mm collimators.
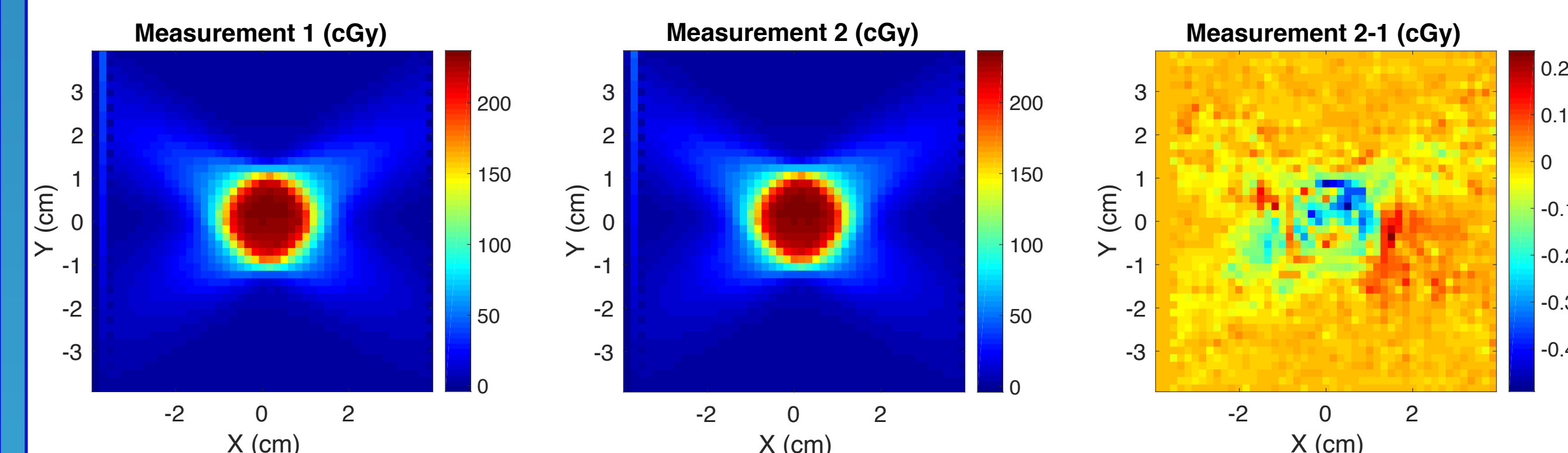

Figure 3. Reproducibility of dose delivery in two consecutive shots. Dose maps from two single-shot deliveries using the 15-mm collimators and their difference. Note that the dose measurement was conducted in the XY plane.

RESULTS (CONTINUED)

• *Dose profile constancy*
  ▪ Dose maps acquired for the 15- and 25-mm collimators, and normalized to their respective maximum values
  ▪ The central axis dose profiles in the Y-Z plane extracted and compared to those established at baseline
  ▪ Both Y- and Z-axis dose profiles consistent with established baseline measurements, with 100% gamma passing rate using the 3%/0.5mm criteria
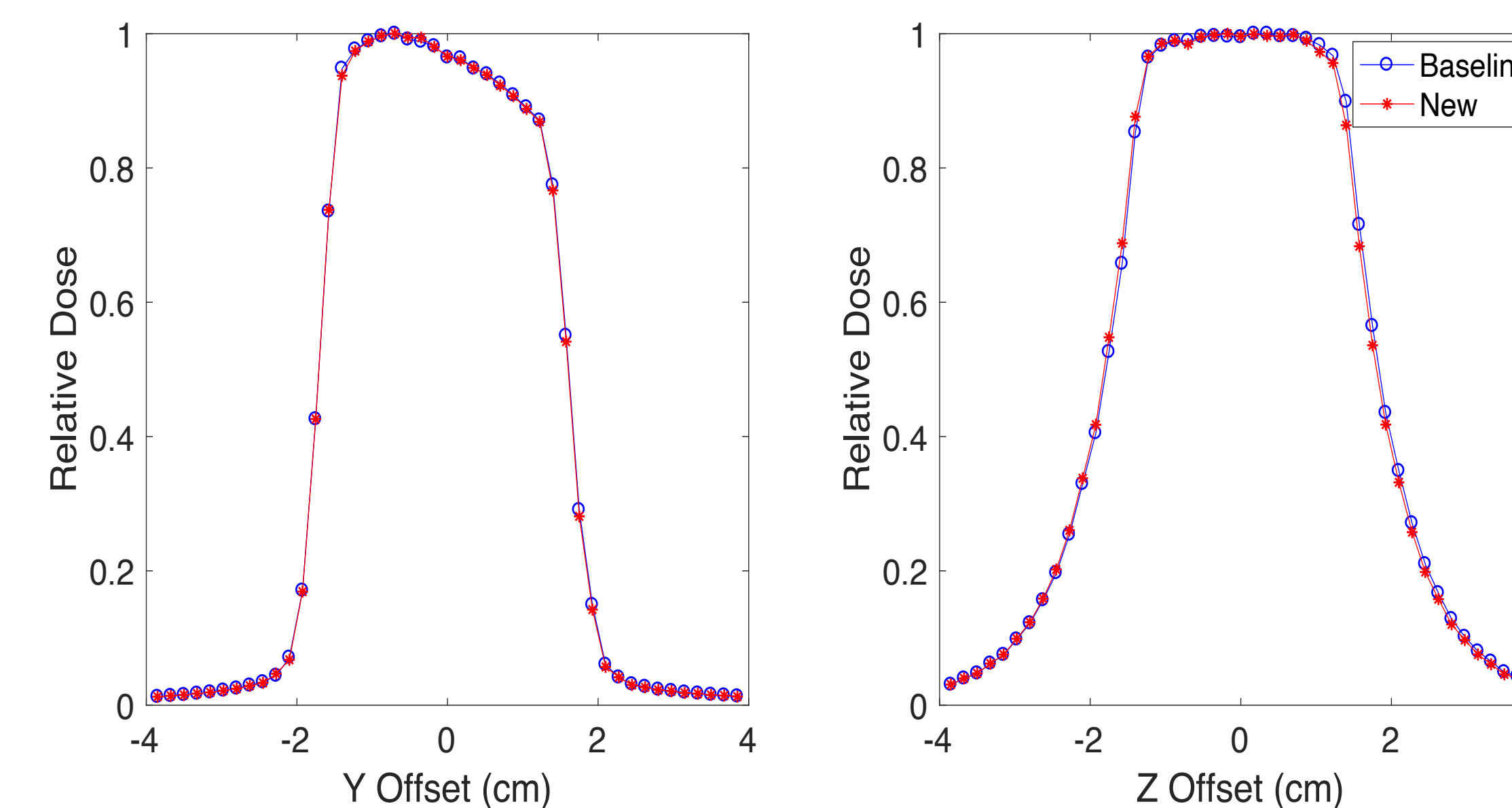

Figure 4. Central axis dose profile constancy check for the 25-mm collimators. The newly acquired Y- and Z-axis dose profiles are similar to the baseline measurements, with 100% gamma passing rate using the 3%/0.5mm criteria.

• *Couch motion accuracy*
  ▪ During GammaPod radiotherapy, accurate couch motion is critical because the couch translates the patient along the planned path so that the target receives the desired dose distribution
  ▪ To measure couch motion using the SRS MapCHECK®, dose maps with and without couch motion were acquired
  ▪ A 2D linear interpolation was implemented to increase the spatial resolution by 40 times, from 1.75 to 0.04375 mm
  ▪ Then couch motion was quantified by finding the translations that resulted in the smallest difference between the two maps
  ▪ When a nominal couch motion at 0.3 mm was applied, the measured couch motion was 0.30625 mm.
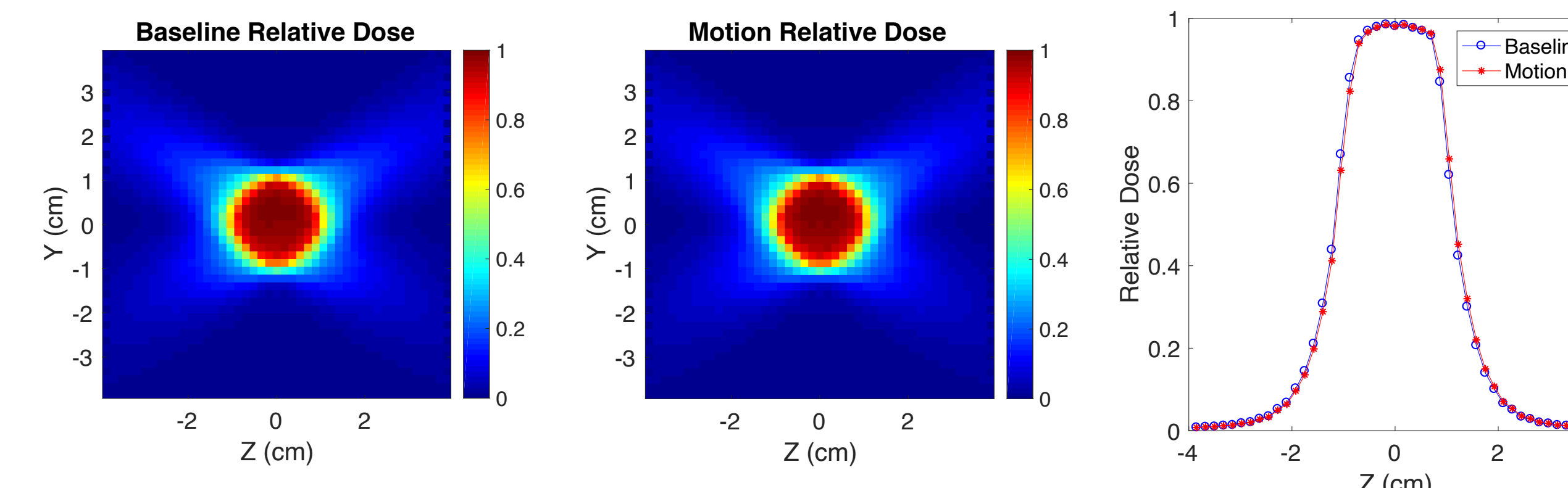

Figure 5. Dose maps and their Z-axis central dose profiles at baseline and after a couch motion of 0.3 mm along the Z direction. Note the motion profile shows a slight shift from the baseline one.

RESULTS (CONTINUED)

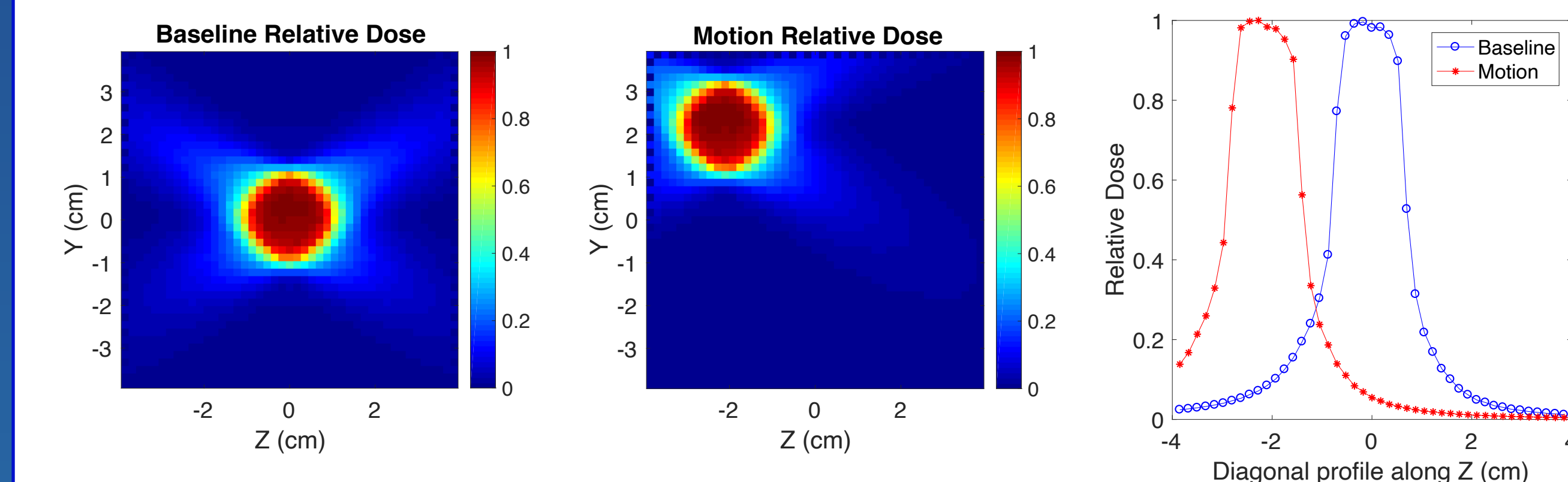▪ With a nominal couch motion at 21.0 mm, this method also accurately quantified such couch motion.

Figure 6. Dose maps and their diagonal profiles along the Z-axis, at baseline and after a couch motion of 21.0 mm along both Y and Z directions.

FUTURE PLAN

• No measurement-based GammaPod plan verification available yet

• We are investigating the feasibility of utilizing the SRS MapCHECK® in patient-specific plan verification

• Technical changes include calibrating this device in the Co-60 beam for absolute dose measurement, registering it in the GammaPod stereotactic coordinate, and creating patient-specific verification plans on the SRS MapCHECK® phantom

CONCLUSIONS

• This pilot study demonstrated the feasibility and reproducibility of quality assurance of the GammaPod™ system using the SRS MapCHECK®

• The utility of this device for dose delivery reproducibility, dose profile constancy, and couch motion accuracy has been shown

• Ongoing studies are being conducted to investigate its utility in patient-specific plan verifications

REFERENCES

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3. Becker SJ, Niu Y, Mutaf Y et al. Development and validation of a comprehensive patient-specific quality assurance program for a novel stereotactic radiation delivery system for breast lesions. J Appl Clin Med Phys. 2019 Dec;20(12):138-148.