SGRT BIG BENEFITS BETTER WORKFLOWS

London County Hall
[across the river from Big Ben]

27-28 Nov, 2025

SGRT COMMUNITY

Missing Metrics for Digitalised Objects-Based Radiotherapy QA

Example of CT-Reference and Captured Surfaces

L. Lorgeou[1], J. Farah[2], I. Bessières, L. Aubignac[1], M. Gonod[1]

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CGFL
CENTRE GEORGES FRANÇOIS LECLERC
Ensemble, dépassons le cancer

Introduction

2020 2021 2022 2023 2024 2025 2026

alignrt®

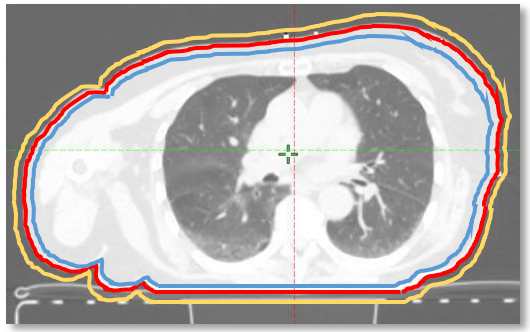
alignrt®

alignrt® InBore™

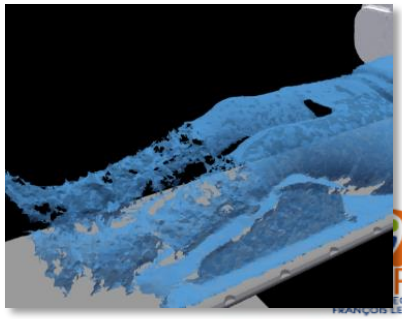
alignrt® InBore™

simrt™

maprt®



	Capabilities	Based on	Risks
alignrt®	Patient positioning & monitoring	Surface acquisition External body contour	With daily IGRT – Repeat initial setup Whitout daily IGRT – dose delivery errors
simrt™	Respiratory cycle measurement	Surface acquisition	4D reconstruction error CTV/OAR localization error
maprt®	Collision avoidance – Predictive	Surface acquisition RT Plan	Collision



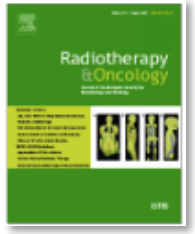
Introduction

2020 → 2021 → 2022 → 2023 → 2024 → 2025 → 2026

Quality assurance for nonradiographic radiotherapy localization and positioning systems: Report of Task Group 147

Twyla Willoughby, Joerg Lehmann, José A. Bencomo, Shirish K. Jani, Lakshmi Santanam, Anil Sethi, Timothy D. Solberg, Wolfgang A. Tomé, Timothy J. Waldron

First published: 08 March 2012 | https://doi.org/10.1118/1.3681967 | Citations: 113



Guidelines

ESTRO-ACROP guideline on surface guided radiation therapy

P. Freislederer, V. Batista, M. Öllers, M. Buschmann, E. Steiner, M. Kügele, F. Fracchiolla, S. Corradini, M. de Smet, F. Moura, S. Perryck, F. Dionisi, D. Nguyen, C. Bert, J. Lehmann

Available online 31 May 2022 https://doi.org/10.1016/j.radonc.2022.05.026

AAPM task group report 302: Surface-guided radiotherapy

Hania A. Al-Hallaq, Laura Cerviño, Alonso N. Gutierrez, Amanda Havnen-Smith, Susan A. Higgins, Malin Kügele, Laura Padilla, Todd Pawlicki, Nicholas Remmes, Koren Smith, Xiaoli Tang, Wolfgang A. Tomé

First published: 18 February 2022 | https://doi.org/10.1002/mp.15532 | Citations: 130

Parameter	Label	Specification	Recommended tolerance
Static Accuracy	A1	Isocentre	1 mm/1° SRS: 0.5 mm/0.5°
	A2	Translational shifts	2 mm
	A3	Rotational shifts	1°
	A4	Impact of camera occlusion	*1 mm/1°*
	A5	Couch rotation	1 mm/1° SRS: 0.5 mm/0.5°
	A6	Setup/loading position	1 mm/1°
End to end positioning test	E1	End to end test	2 mm/1°

→ **System performances without checking surface quality**

→ **SGRT surfaces**

→ **CT based external contour**

patient localization and monitoring systems, and therefore, apply to SGRT. TG-147 reiterates the goal of a combined accuracy of less than 2 mm, following TG-142,[30] or 1 mm whenever SRS/stereotactic body RT (SBRT) procedures are planned.

Static localization accuracy	▪ Localization accuracy of offset phantom over a reasonable clinical range (i.e., ±100 mm range from isocenter)	≤2 mm ≤1 mm for SRS/SBRT
Dynamic localization accuracy	▪ 4D spatial localization accuracy ▪ Frame rate characterization for clinically reasonable scenarios ▪ Latency threshold (may depend on clinical workflow)	▪ per TG-142 ▪ per spec. ▪ within 100 ms of expected value

→ Need for a more advanced QA between reality and 3D models

6.1.2 | Overview of additional QA tests to assess algorithm accuracy

For the emerging applications discussed above, it is imperative that the fidelity of the acquired surfaces is confirmed. QA tests to verify if the acquired surfaces

ISO → Fidelity

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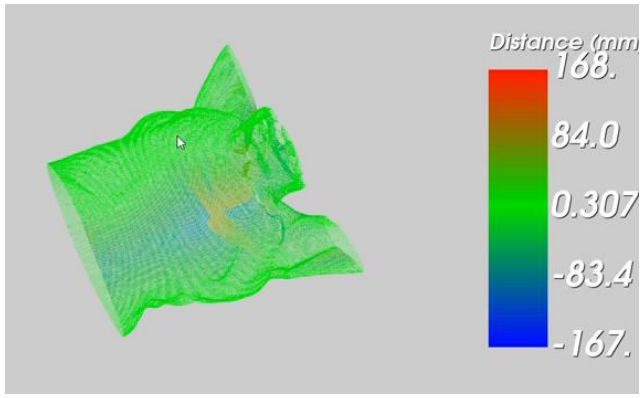
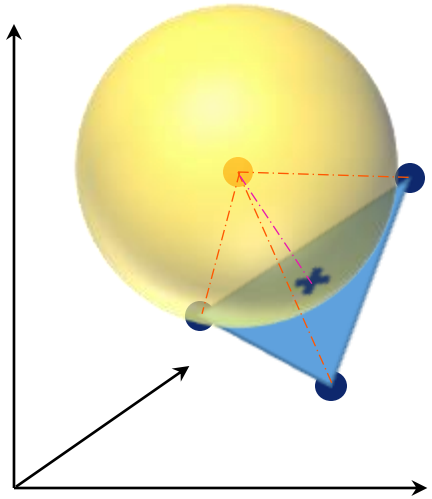
Degree of resemblance

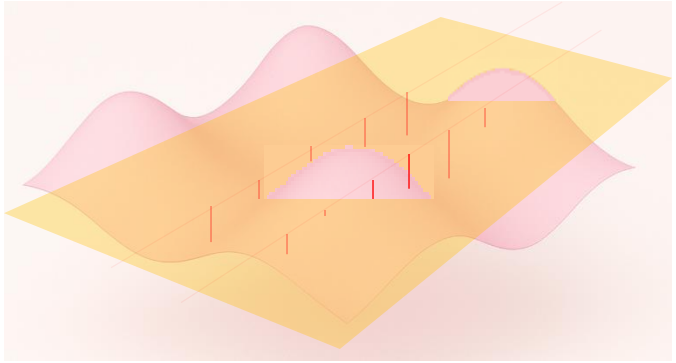
Introduction

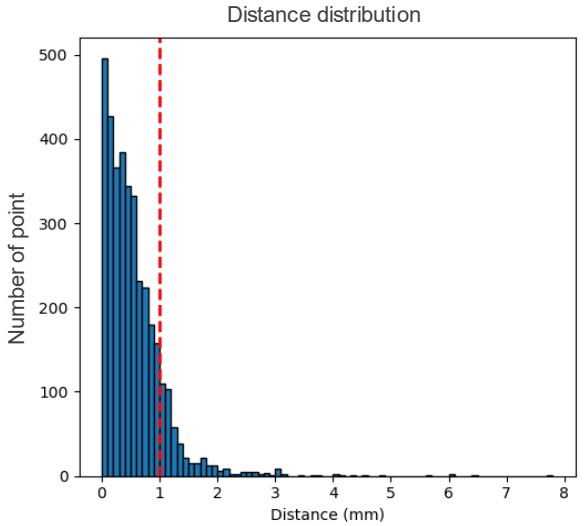
Selected metrics





- **Distances** with respect to 2 objects: Minimum distance Point – Surface
- **Similarity** @Xmm
  - Percentage of points within X mm
- **Roughness** ~ Noise of a surface
  - Standard deviation of the distances between the analyzed surface and a mean plane of a given dimension

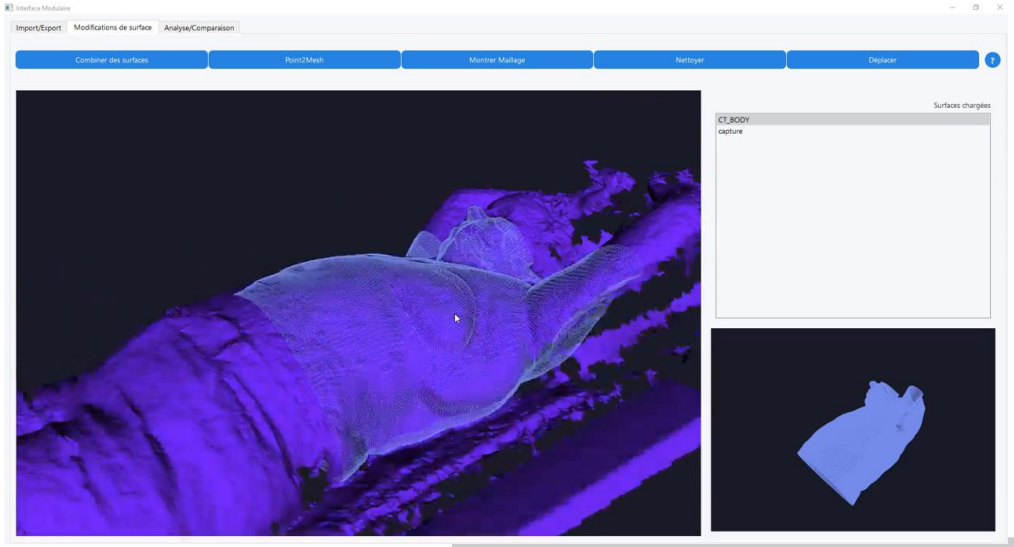


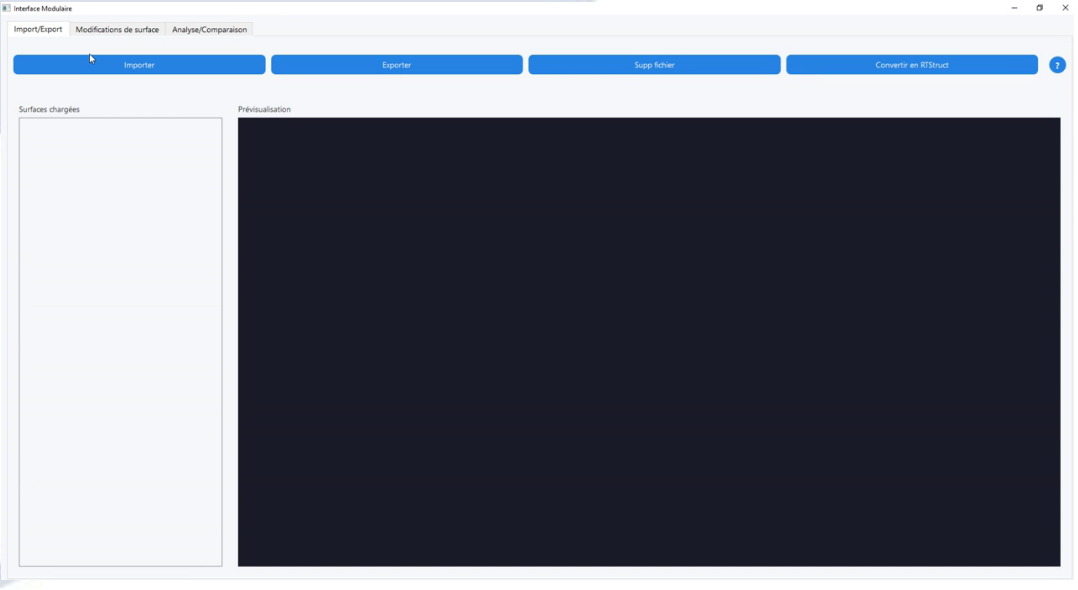


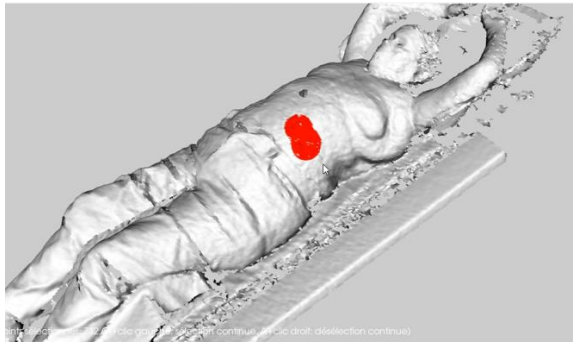
Material & Methods

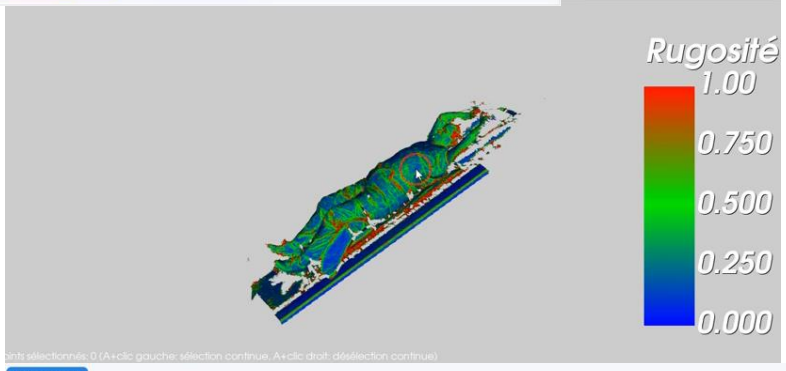
Python-based tool

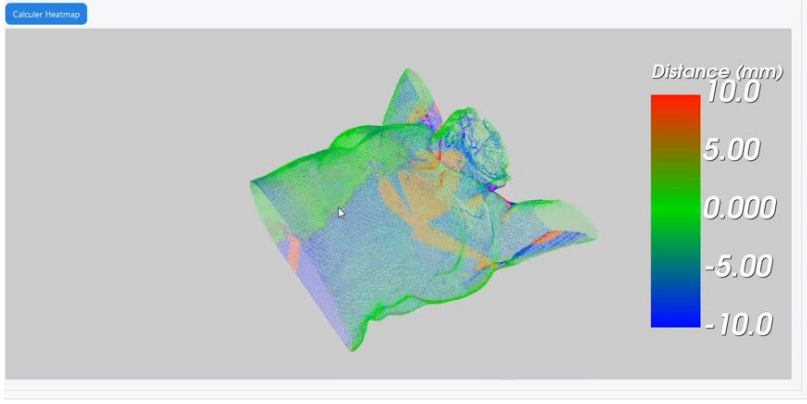
- Multi-file: .obj & .dcm (RTStruct)
  - 3D object manipulation / filtering
  - .obj <-->.dcm converter
- Manual and Auto Registration (Homemade FRICP)
- Qualitative and quantitative comparison
  - Registration vector
  - Similarity
  - Roughness







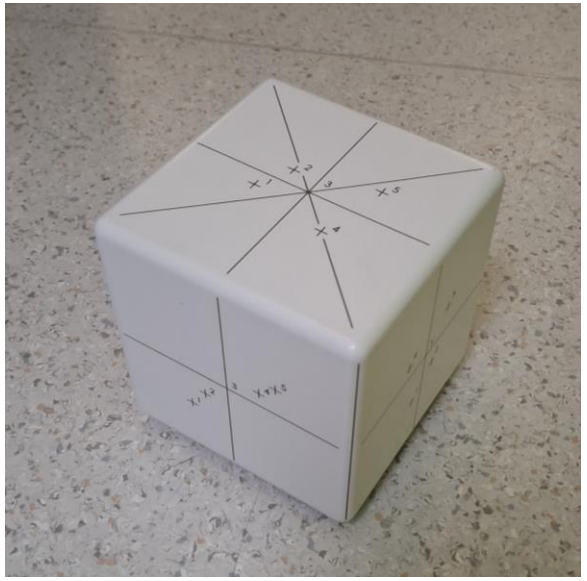


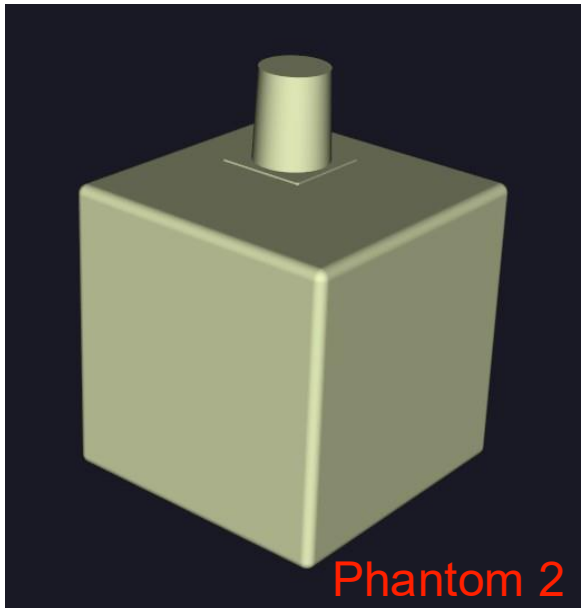


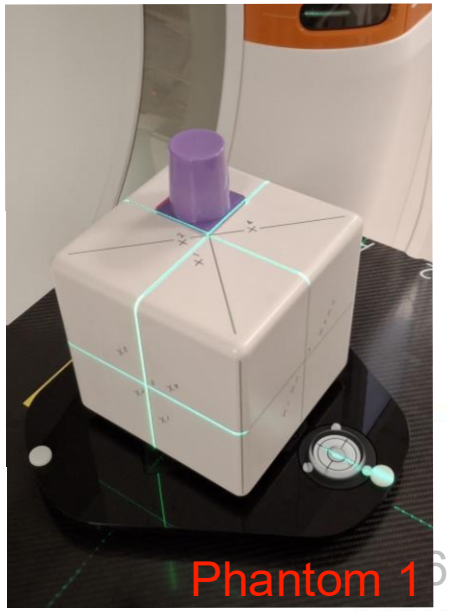
Material & Methods

Phantom design

- Phantom 1: Physical phantom
  - Cube SRS 20 x 20 x 20 cm^3 (VisionRT)
  - Yogurt with water cylinder D3.6 x h4.9 cm
- Phantom 2: 3D numerical object (SolidWorks)
  - Cube SRS 20 x 20 x 20 cm^3 (VisionRT)
  - Yogurt with water cylinder D3.6 x h4.9 cm
- Phantom 3:
  - Emily (VisionRT): Female torso





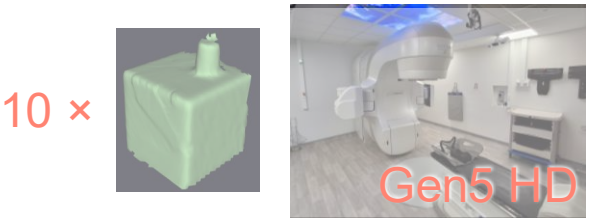


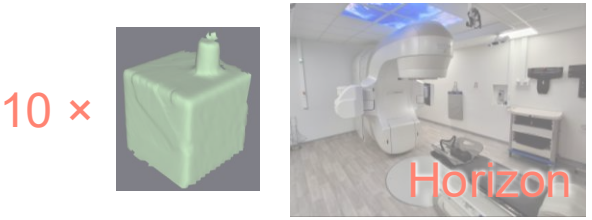
Material & Methods

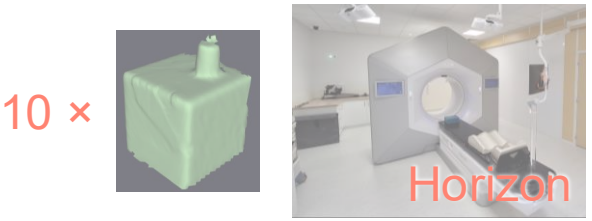
Study 1: Similarity of SGRT surface capture

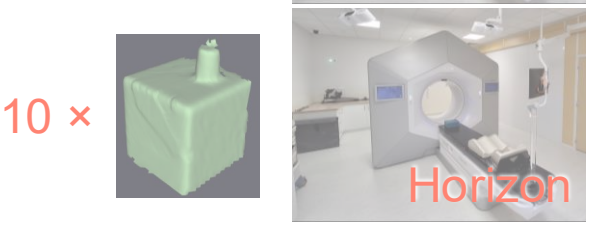
- **Percentage of points below the 1 mm threshold?**

- Phantom 1 aligned on laser
  - 10 AlignRT reference capture
- Registration between AlignRT capture and phantom 2
- **Similarity evaluation**





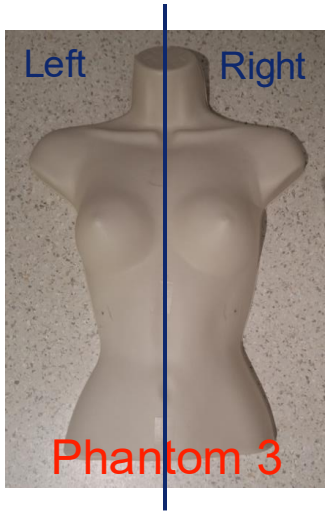




Study 2: Roughness of SGRT surface capture

- **Imaging capabilities through the FOV?**

- Phantom 3 aligned on VRT & LAT laser
  - 7 mapRT acquisition through 120 cm LNG in the FOV
- Lateralized **roughness analysis**
  Hypothesis: Lateralized from the 0 LAT i.e. Surface reconstruction is linked to the camera side.

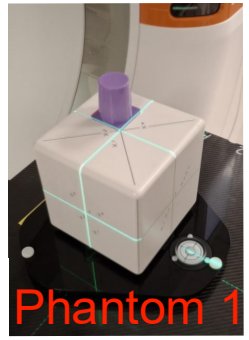


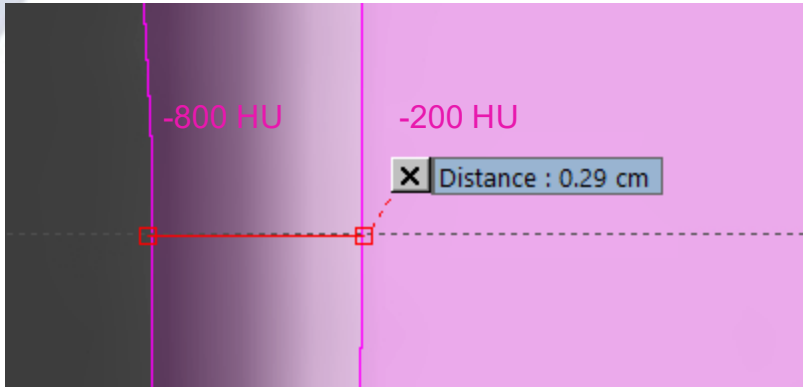
Material & Methods

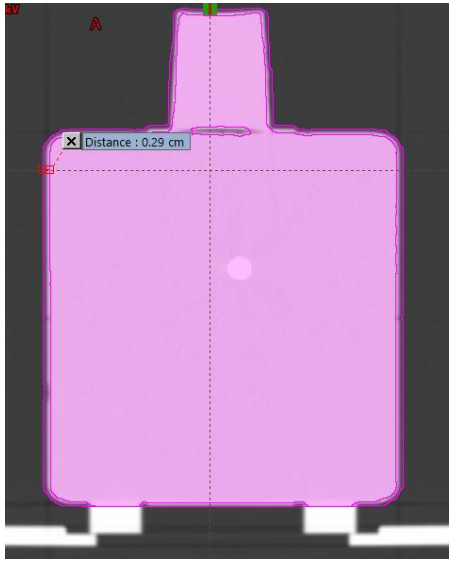
Study 3: Similarity of CT based external contour

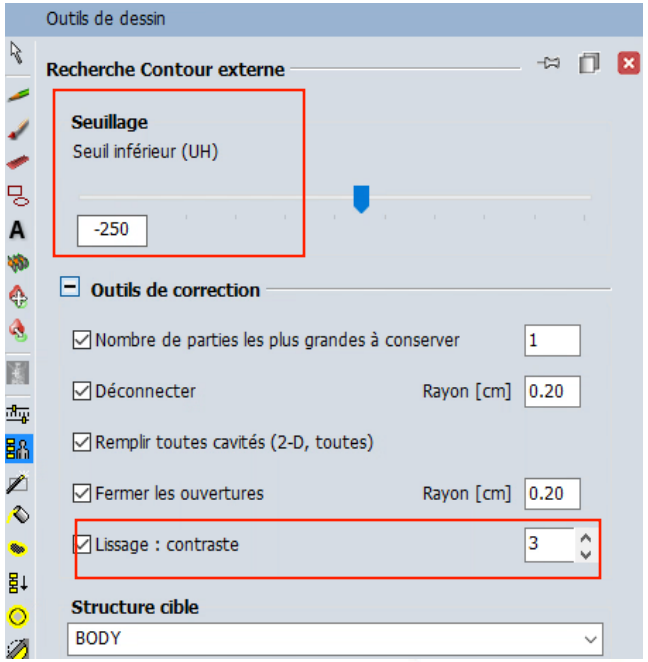
- **Best combination of parameters for generating the external contour?**

- Phantom 1 aligned on laser
- CT-Scan (Siemens go.sim) and export to ARIA v17 (Varian)
- External contour generation with Eclipse v17 (Varian)
  - HU threshold [-900;-200]
  - smoothing [1;15]
- Registration between Body [HU;Smooth] and Phantom 2
- **Similarity evaluation**





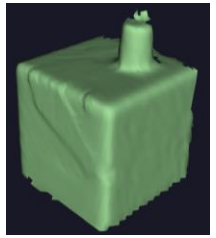


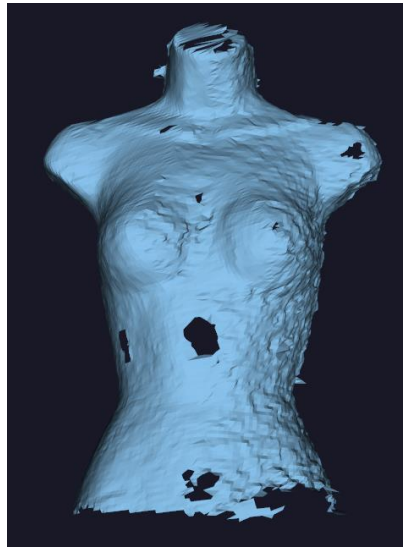


Results

Study 1: Similarity of SGRT surface capture

- **Percentage of points below the 1 mm threshold?**



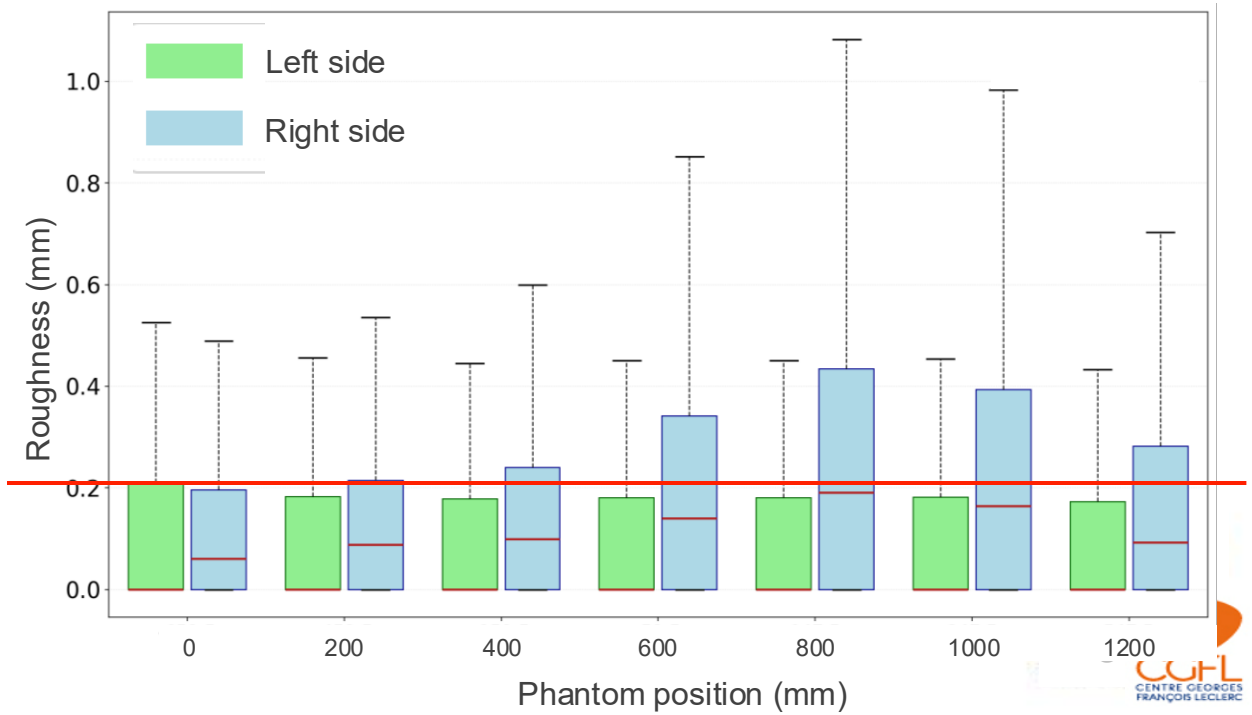


System	Horizon 1 Halcyon	Horizon 2 Halcyon	Gen5 HD TrueBeam	Horizon 3 TrueBeam
Similarity @1mm	79 %	63 %	85 %	83 %

Study 2: Roughness of SGRT surface capture

- **Imaging capabilities through the FOV?**

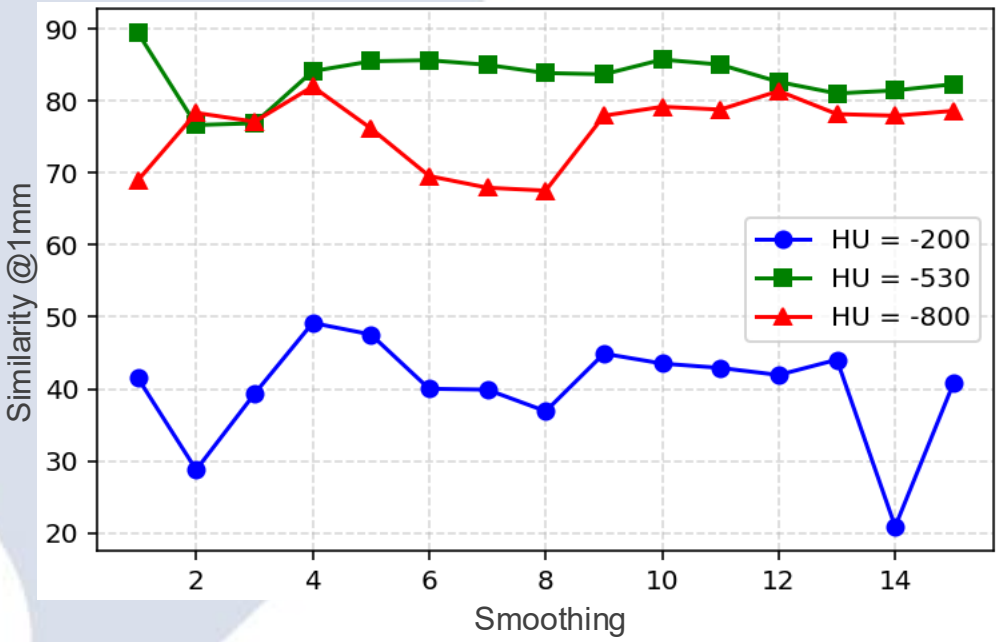
- Mean left roughness ~ 0.1mm
- Mean right roughness ~ 0.2mm
  - Moisture on the optical filter



Results

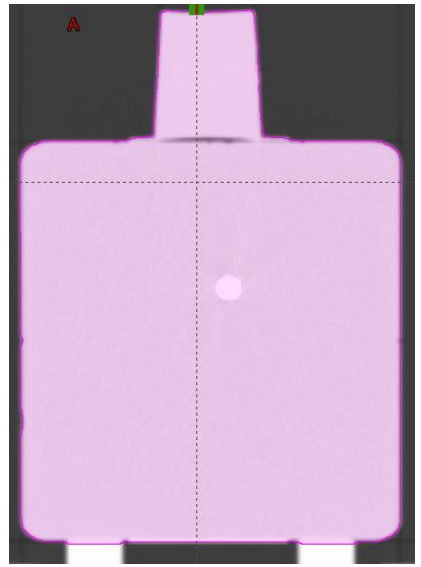
Study 3: Similarity of CT based external contour

- **Best combination of parameters for generating the external contour?**



Evolution of the similarity @1mm as a function of smoothing for three HU threshold values

	Optimal	Actual – SRS masks	Actual – Other
[HU;Smoothing]	[-530;1]	[-850;3]	[-250;3]
Similarity @1mm	90 %	78 %	39 %



Discussion & Conclusion

Python-based QA tool

- Manipulation of .obj and .DCM files – Visualization, conversion, registration, qualitative & quantitative comparison

New metrics for Fidelity

- Similarity & Roughness
  - Reproductible & Quantitative

→ Similarity & roughness are a necessary and complementary to the “accuracy” tests QA

Clinical impact

- CT based external contour: optimized selection of HU & smoothing parameters
- Similarity analysis & roughness: quantitative analysis to detect sub-optimal surface quality → Quality monitoring to trigger performance checks (ACO calibration, Preventive Maintenance, …)
- Digitalized objects & predictive tools (MapRT is one example):
  - Critical surface QA

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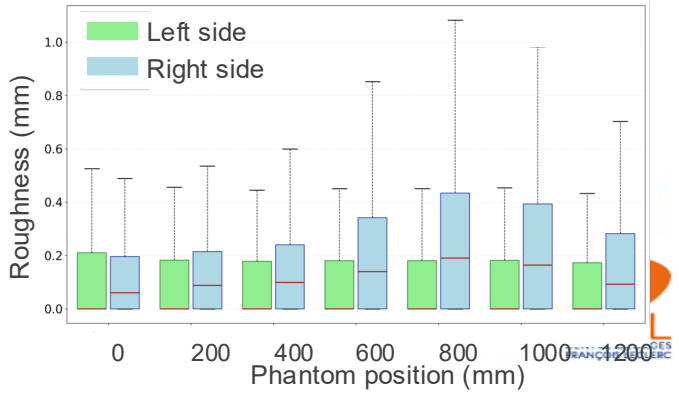
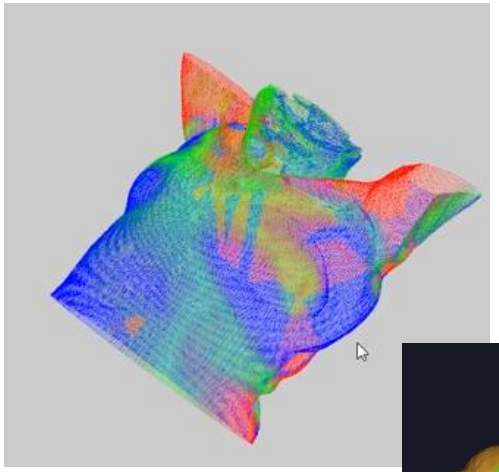


Perspective

Software

- Handling object files from other manufacturers
- Improvement of features:
  - .obj to .dcm converter

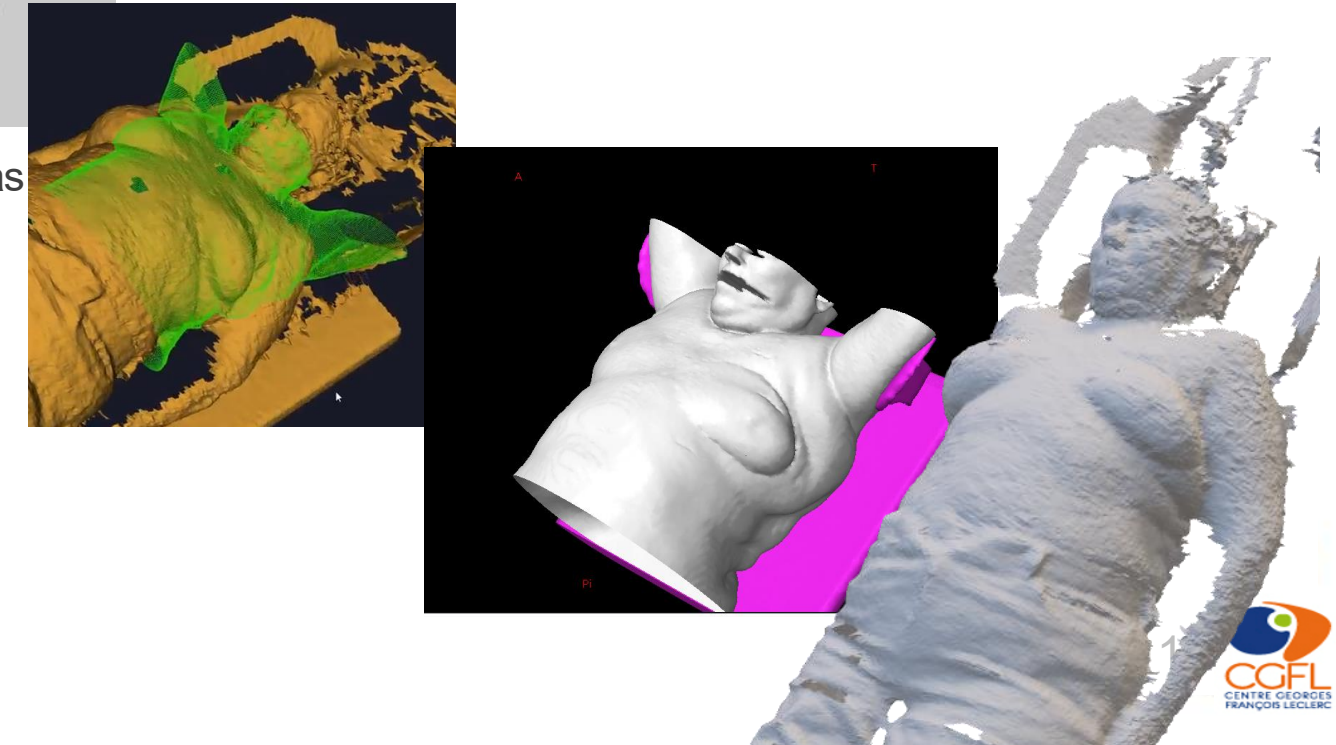


Clinical perspective

- Immobilization device evaluation
  - Deformation / settling
- Correction of mapRT / TPS patient position
  - CT couch sag / Patient movements
- Patient surface used for dose evaluation
- …

QA perspective

- Implementation of a QA program for the cameras
- InBore evaluation
- Benchmark over other installations
- Comparison to the other vendors



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