SRS and SBRT on Halcyon/Ethos

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Conflict of Interest declaration

- ORLAM group has collaborated with VisionRT to develop SGRT solutions for Halcyon
- ORLAM is a reference center for VisionRT visits
- The opinions expressed are my own and do not represent VisionRT or ORLAM official positions
- I received Honoria from Vision RT to attend this meeting

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2018-2019

Clinac 2100 | Clinac 2100 | Halcyon | Halcyon | Halcyon | Halcyon | Halcyon | Halcyon | EDGE

2023

First patient june 2023 (more than 900 patients treated)

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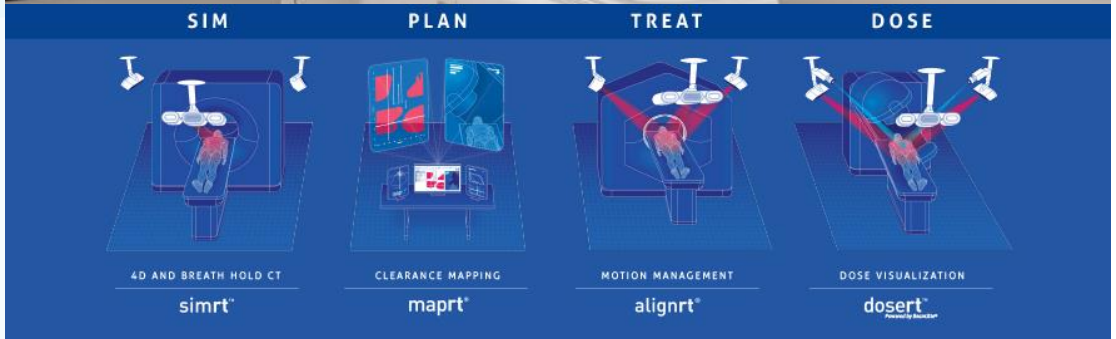
2018-2019

Clinac 2100 | Clinac 2100 | Halcyon | Halcyon | Halcyon | Halcyon | Halcyon | Halcyon | EDGE

2023

First patient june 2023 (more than 900 patients treated)

2026



United Imaging
URT Linac 506C
(Linac + CT)
Full adaptive workflow
AlignRT
MapRT
DoseRT

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Why InBore changes everything

- ❑ Conventional SGRT: monitoring can be interrupted by gantry and imaging system occlusions.
- ❑ InBore SGRT: continuous line of sight throughout treatment.
- ❑ Enables true real-time intrafraction monitoring and breath-hold verification.

Context SRS/SRT Halcyon

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Evidence Supporting SRS/SRT on Halcyon™

- ❑ Li et al., Frontiers in Oncology (2019): Halcyon™ coplanar VMAT meets clinical constraints for multiple brain metastases.
- ❑ Good conformity for targets >1 cm and acceptable dose gradients.
- ❑ Efficient coplanar workflow with stable dosimetric performance.

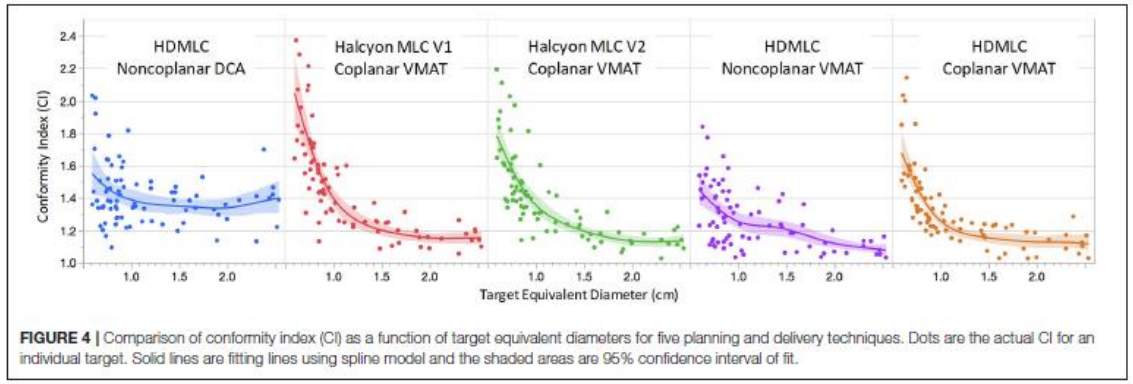

FIGURE 4 | Comparison of conformity index (CI) as a function of target equivalent diameters for five planning and delivery techniques. Dots are the actual CI for an individual target. Solid lines are fitting lines using spline model and the shaded areas are 95% confidence interval of fit.

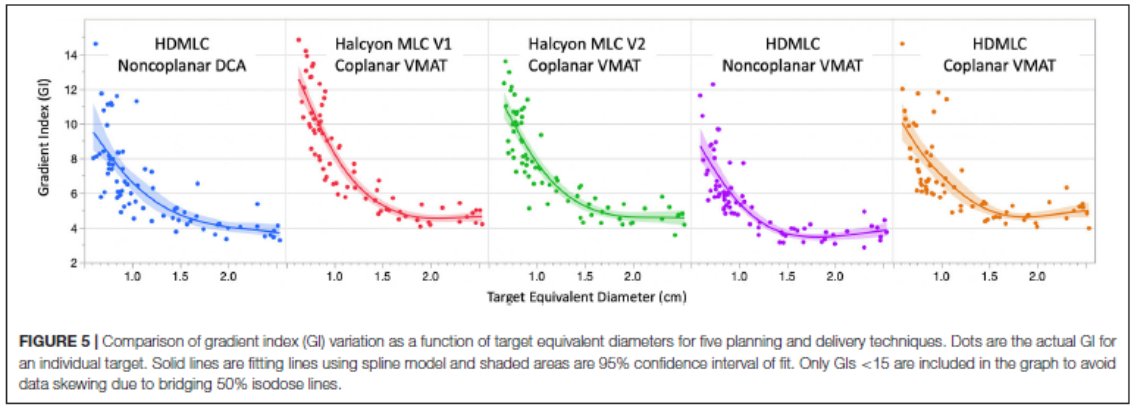

FIGURE 5 | Comparison of gradient index (GI) variation as a function of target equivalent diameters for five planning and delivery techniques. Dots are the actual GI for an individual target. Solid lines are fitting lines using spline model and shaded areas are 95% confidence interval of fit. Only GIs <15 are included in the graph to avoid data skewing due to bridging 50% isodose lines.

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Context SRS/SRT Halcyon

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Evidence Supporting SRS/SRT on Halcyon™

- Palaysi et al., Physica Medica (2026): Halcyon™ coplanar VMAT meets clinical constraints for brain metastases.

Table 5. Comparison of dosimetric parameters between Halcyon™ and HyperArc plans.

Category	Metric		Halcyon™	HyperArc	*p-value*
Target (PTV/GTV)	PTV D100 (%)		98.1 ± 0.6	98.1 ± 0.6	*NA*
	GTV Dmin (%)		104.3 ± 1.4	105.4 ± 1.0	*0.182*
	GTV Dmean (%)		109.8 ± 1.0	110.4 ± 1.7	*0.123*
	Conformity Index		1.07 ± 0.06	1.04 ± 0.02	*0.055*
	Paddick Index		0.94 ± 0.05	0.96 ± 0.02	*0.056*
	Gradient Index		4.01 ± 0.64	2.85 ± 0.64	***0.004***
	D2cm (%)		39.9 ± 7.5	22.9 ± 5.8	***0.001***
Organs at Risk (OARs)	Normal brain (cc)	V24 Gy	12.7 ± 14.2	8.0 ± 9.2	***0.001***
		V28.8 Gy	4.1 ± 6.2	2.4 ± 3.6	***0.014***
	Brainstem (Gy)	Dmax	3.6 ± 4.0	4.7 ± 3.7	***0.016***
		D0.5 cc	2.8 ± 3.0	2.9 ± 1.7	*0.733*
	Spinal cord (Gy)	Dmax	2.7 ± 8.5	3.5 ± 8.3	***0.001***
		D0.35 cc	1.5 ± 4.6	2.3 ± 4.8	***0.001***
	Optic pathways (Gy)	Dmax	1.3 ± 1.1	1.9 ± 2.0	*0.622*
		D0.2 cc	1.0 ± 0.9	1.6 ± 1.8	*0.519*

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SRS/SRT Halcyon: open masks

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Advantages:

- **Pre-positioning to correct rotations**
- **Real-time monitoring**
- **Tolerances: ±1 mm**
- **Non-ionizing**

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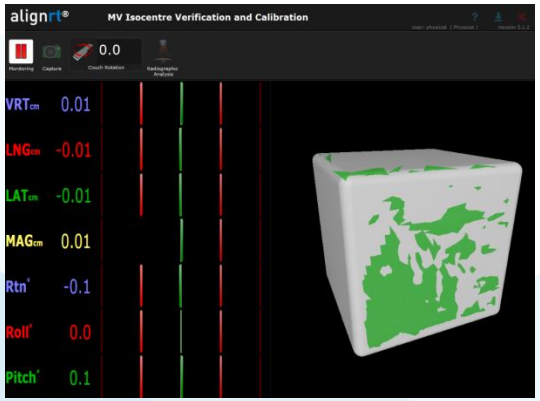
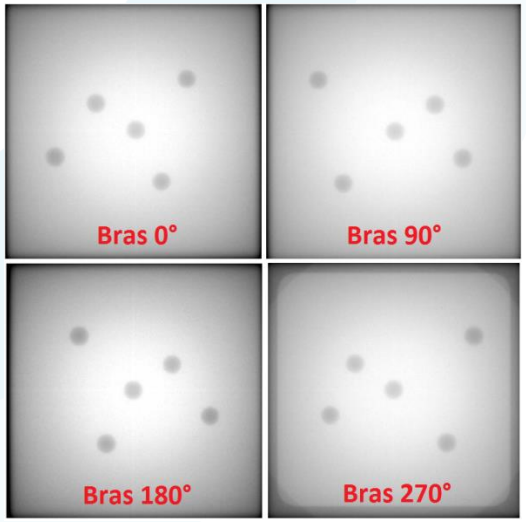
VRT Iso - MV Iso Calibration: SRT or SRS

Center the cube using the Halcyon laser setup



Encoded phantom in VRT:Position adjustment after AlignRT® monitoring→ Alignment to the VisionRT® isocenter

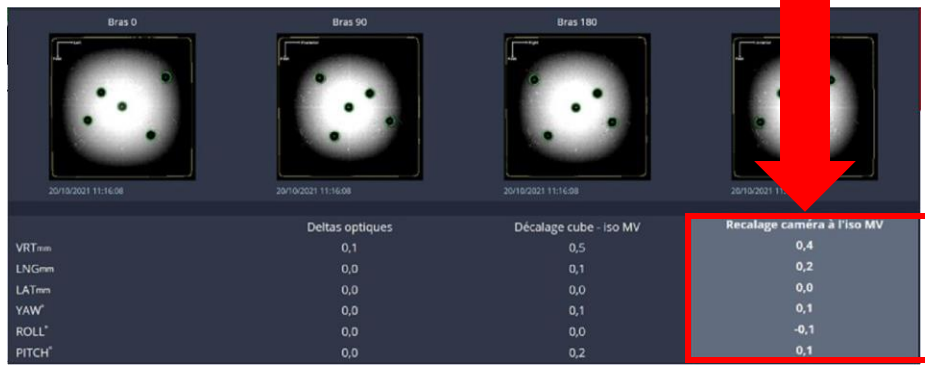


Acquire MV images at the four cardinal gantry angles → Determine the expected isocenter = LINAC isocenter

If the difference between AlignRT® and MV exceeds 1 mm or 1° → recalibration is required

/!\ Perform extrinsic calibration

Maximum tolerances for calibration acceptance:Translations: 1 mmRotations: 1°



Nguyen D et al Investigating the robustness of the AlignRT InBore™ co-calibration process and determining the overall tracking errors. Phys Med. 2023 Apr;108:102567.

Context SRS/SRT Halcyon

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ELSEVIER

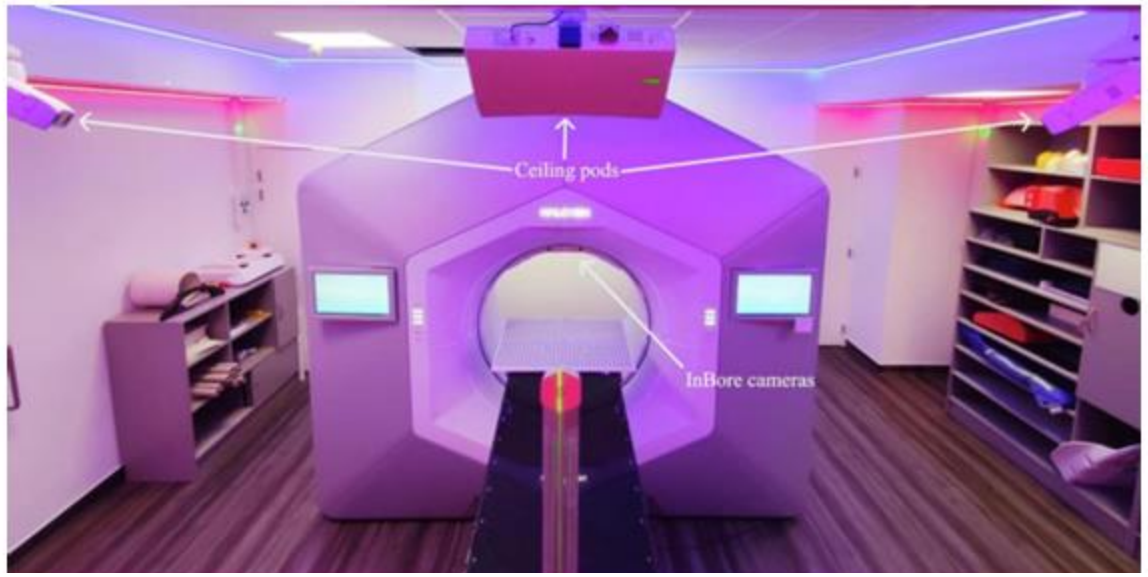
Physica Medica

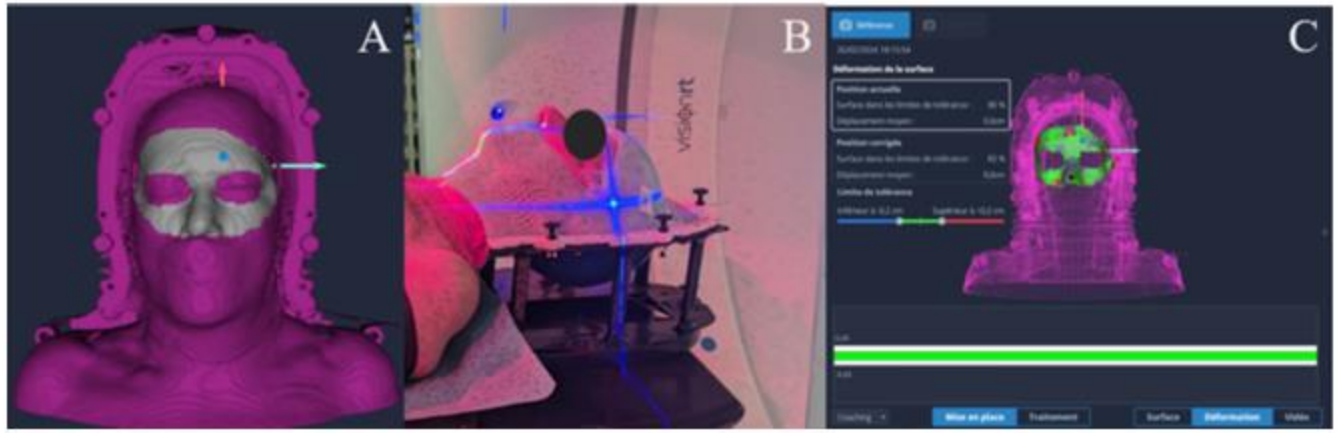
journal homepage: www.elsevier.com/locate/ejmp

Feasibility of intracranial stereotactic radiotherapy on Halcyon™ with SGRT and open-face masks

Estelle Palaysi [a,*], Daniel Nguyen [a], Jad Farah [b], Nicolas Barbet [a], Mustapha Khodri [a]

[a] ORLAM's Group, Department of Radiation Oncology, Mâcon, Villeurbanne, Lyon, France
[b] Vision RT Ltd., London, United Kingdom





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Context SRS/SRT Halcyon

Table 1
Study population as a function of mask type (closed or open-face), SGRT usage (AlignRT® InBore), and treatment platform.

Group	Mask Type	SGRT	Platform	N (fractions)
G1	Closed	No	Halcyon™ (Site A)	25
G2	Closed	Yes	Halcyon™ (Site A)	25
G3	Open-face	Yes	Halcyon™ (Site A, B and C)	25 (each site)
G4	Open-face	Yes	TrueBeam™ (6DoF, Site D)	25

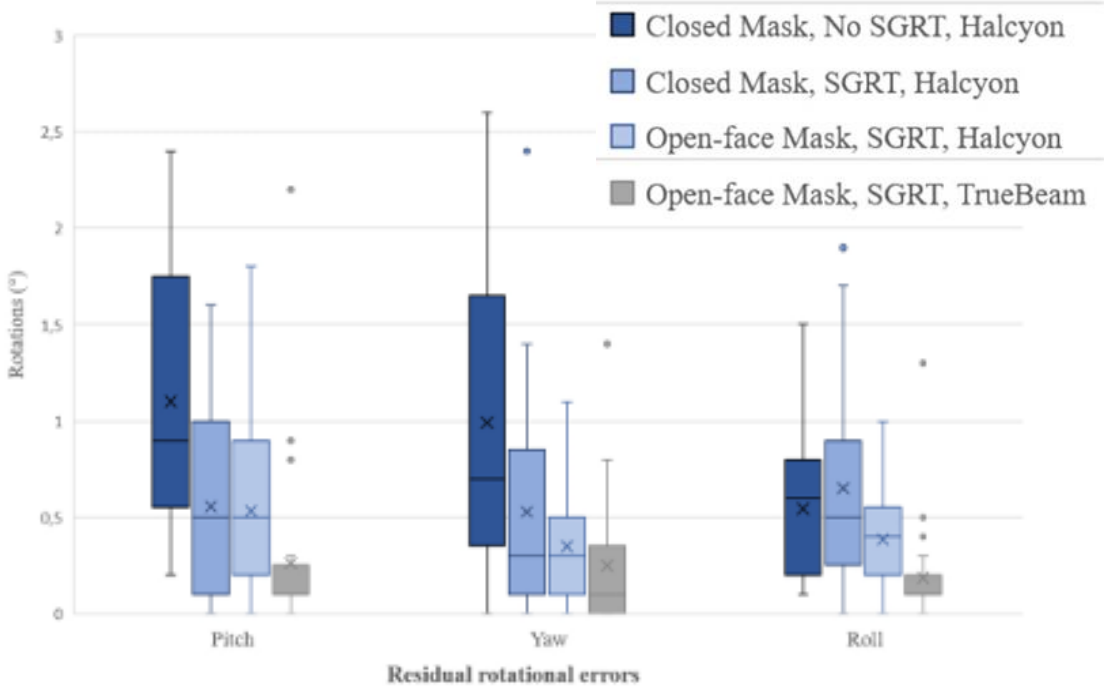

Fig. 4. Boxplots showing residual rotational setup errors (in degrees) in yaw, pitch, and roll for the four patient groups: G1 (Halcyon™, closed mask, no SGRT), G2 (Halcyon™, closed mask with SGRT), G3 (Halcyon™, open mask with SGRT), and G4 (TrueBeam™, open-face mask with 6DOF couch, SGRT).

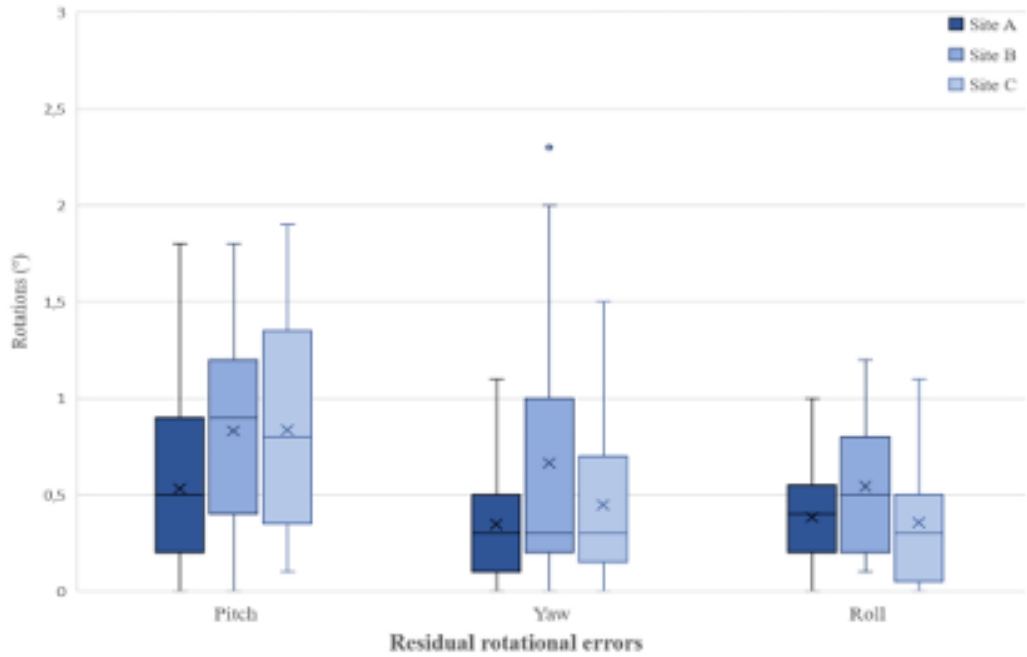

Fig. 5. Boxplots of residual rotational setup errors (in degrees) in pitch, yaw, and roll across the three clinical sites using the G3 workflow (Halcyon™, open mask with SGRT, Sites A-C).

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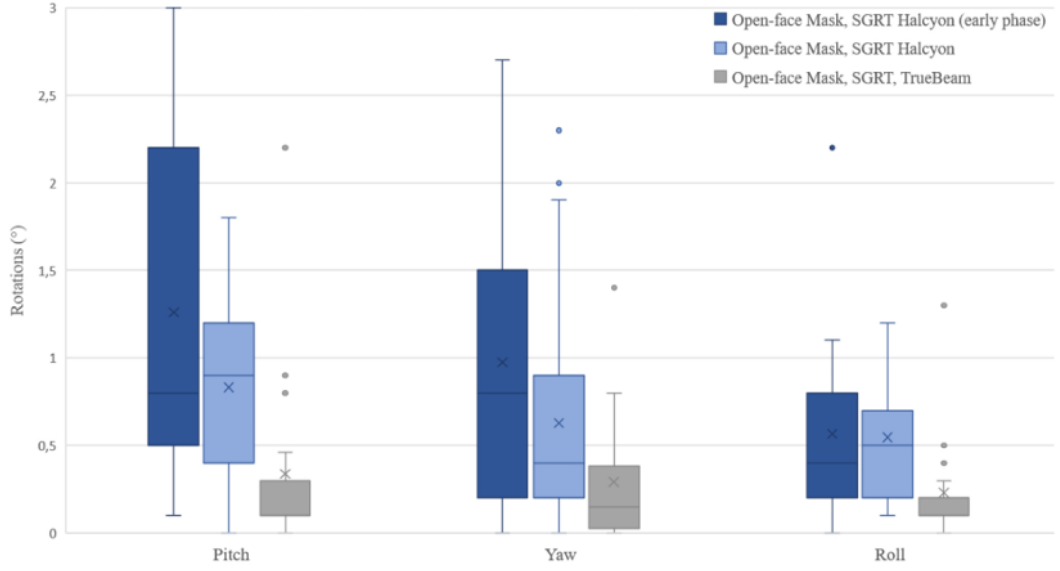
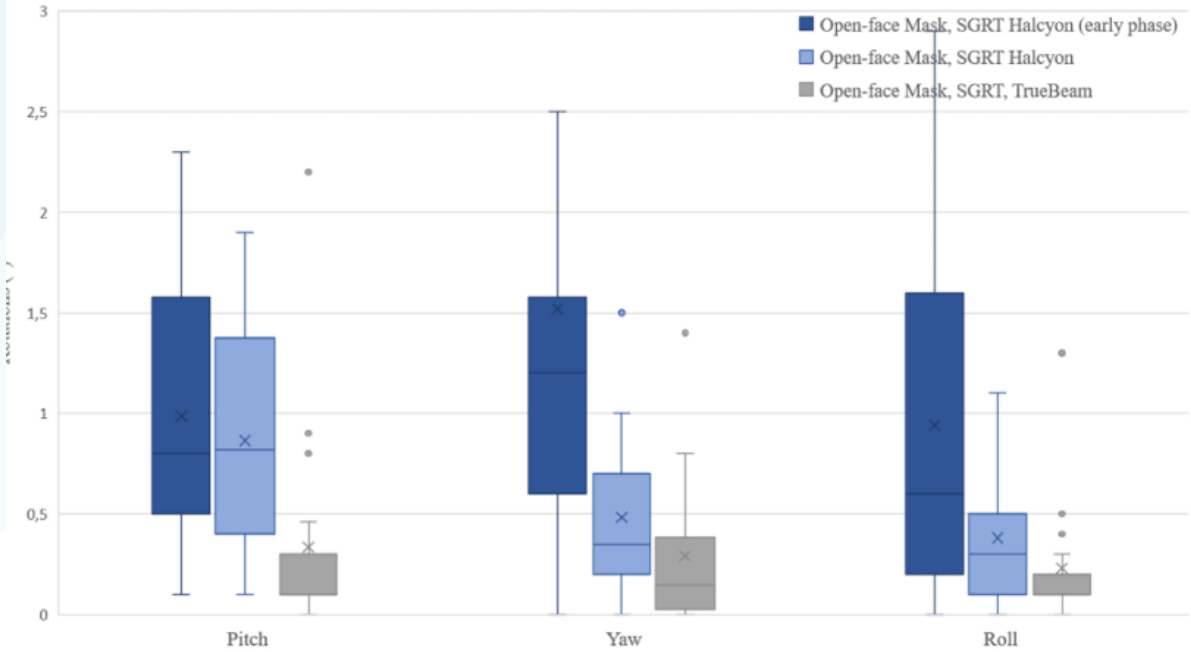
Appendix B. Early-phase setup results.



Residual rotational errors (Site B)



Residual rotational errors (Site C)

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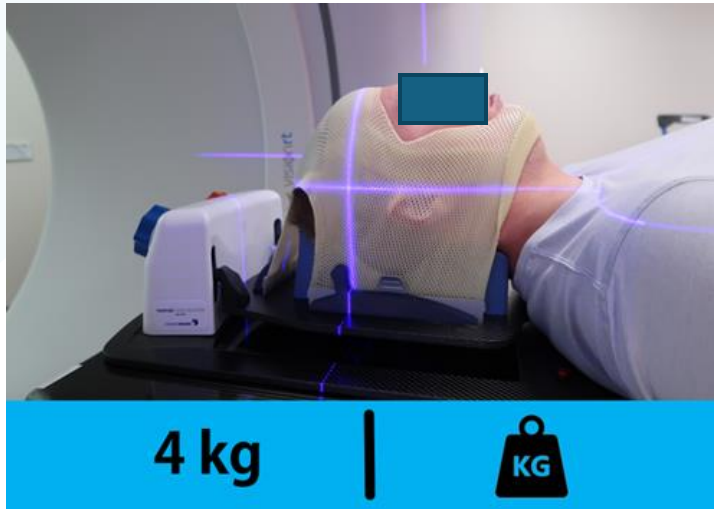
Can we correct rotations errors before imaging?

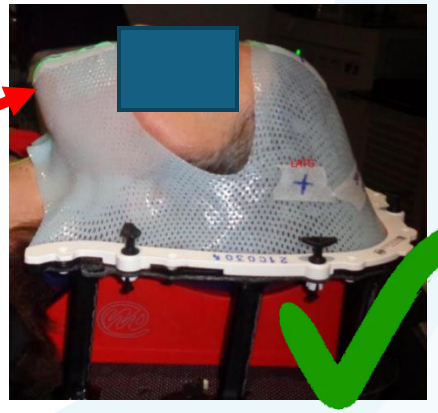
Evaluate if combining **SGRT**, an open-face mask, and the **TruPose™ Head Adjuster**
→ achieves setup accuracy comparable to a TrueBeam™ with 6DoF couch

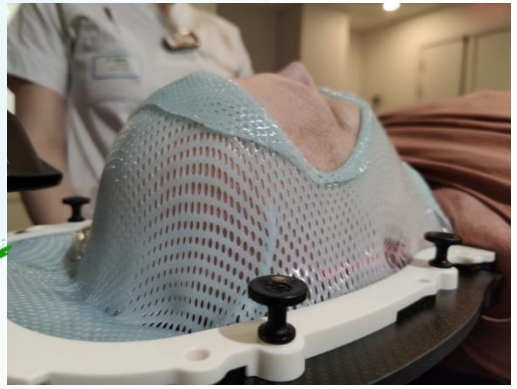


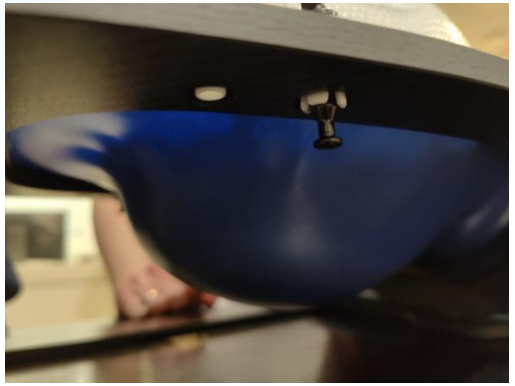
Molding the thermoformed mask on the patient's head

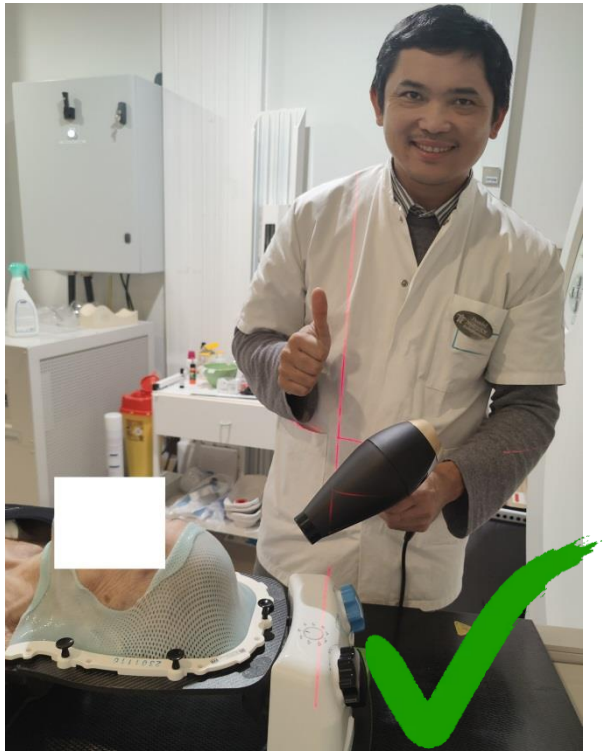
Careful Molding of the Open-Face Thermoplastic Mask:

- ❑ For intracranial SRS/SRT: chin must be lowered to expose the face region to the SGRT cameras
- ❑ Elevated chin is only appropriate for head & neck treatments
- ❑ Use a **cold-air hair dryer** to ensure full drying and precise shaping, especially in key areas such as the **chin**, **forehead**, **nape of the neck**, and **skull**. This helps to quickly set the shape and ensure optimal immobilization.
- ❑ Mask must be fully dry before CT simulation









Using a hair dryer with cold air to quickly set the mask

Influence of Three ROIs on Intracranial Stereotactic Treatments

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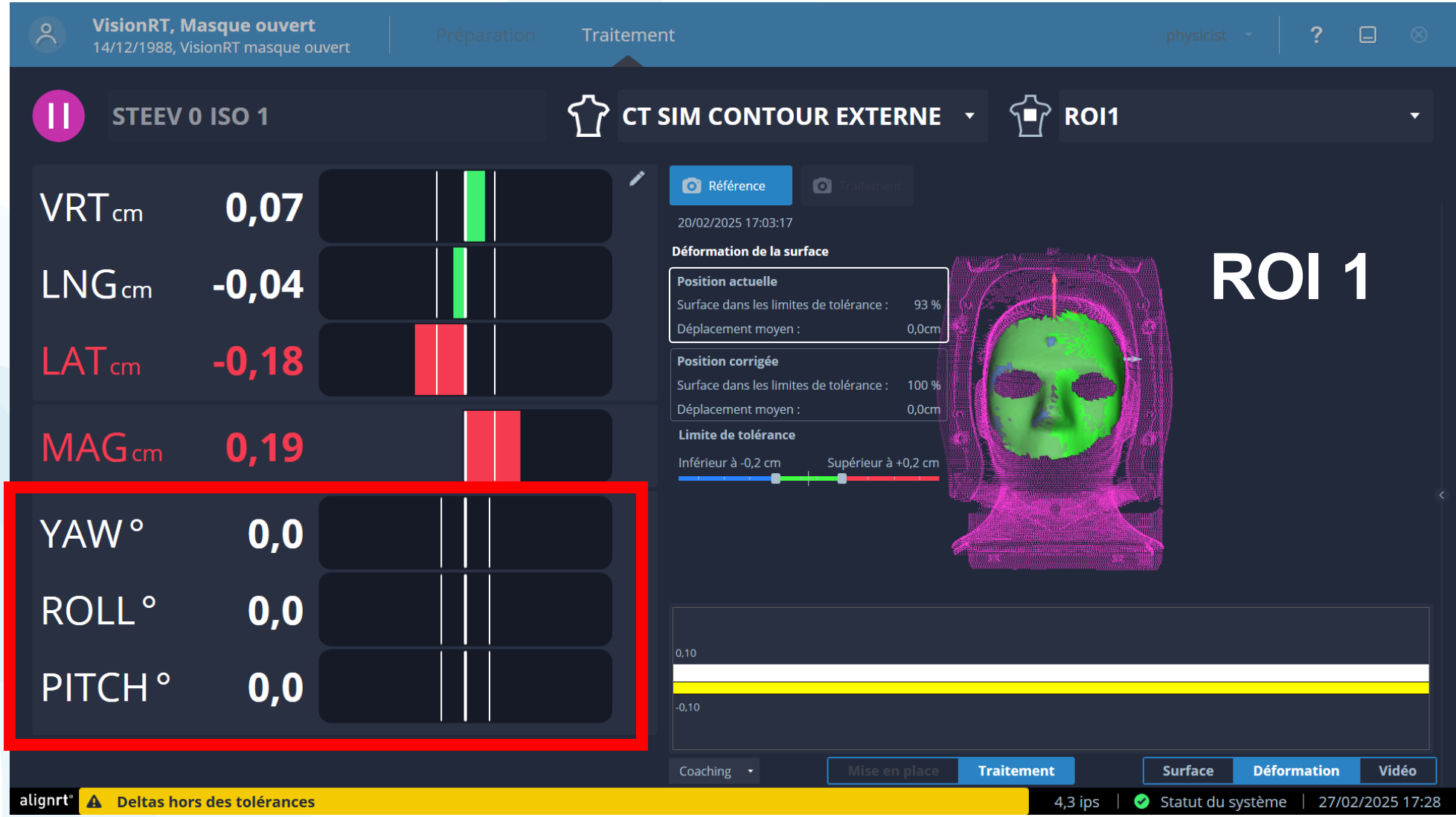
ROI 1



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Influence of Three ROIs on Intracranial Stereotactic Treatments

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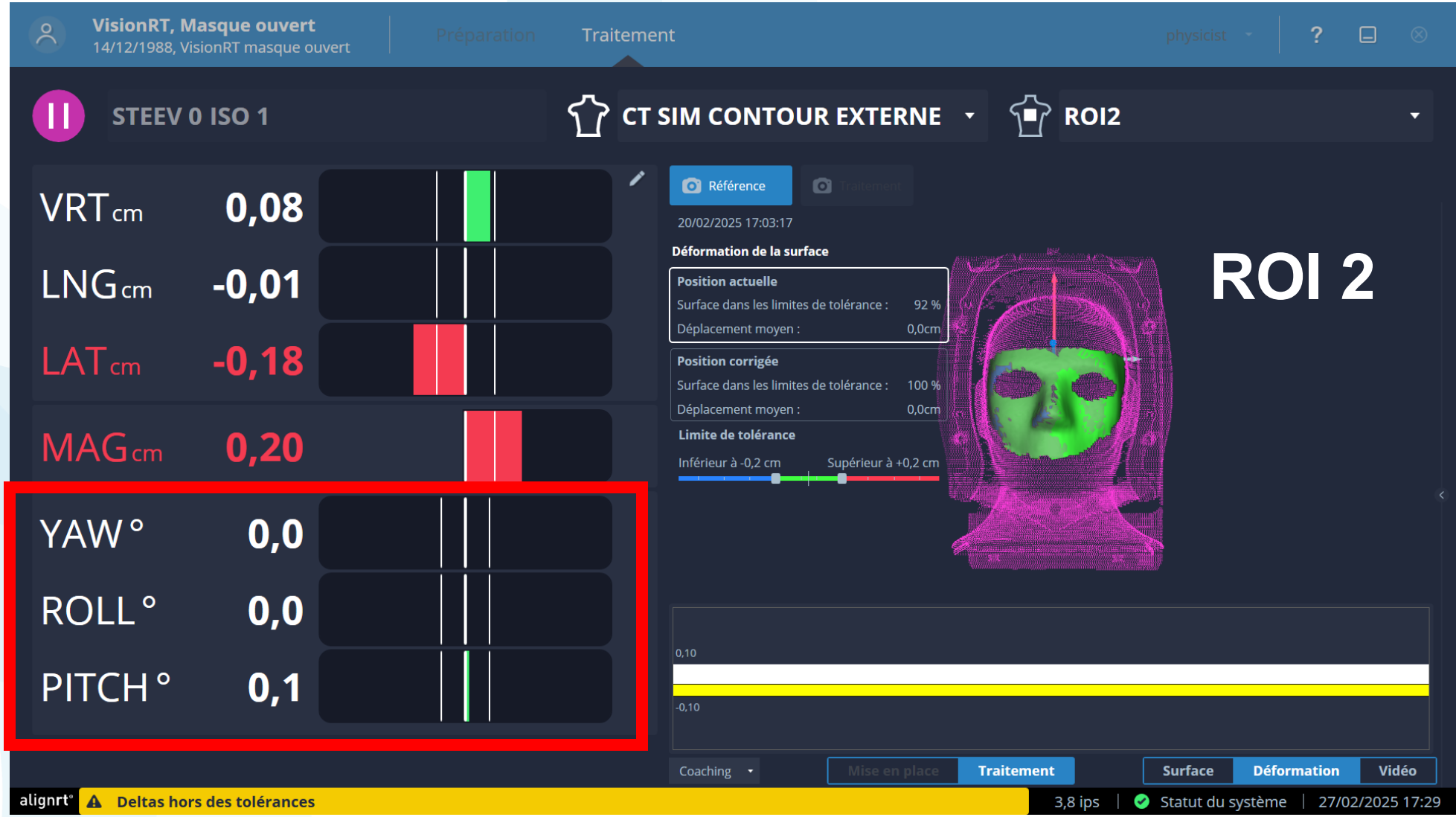
ROI 2



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Influence of Three ROIs on Intracranial Stereotactic Treatments

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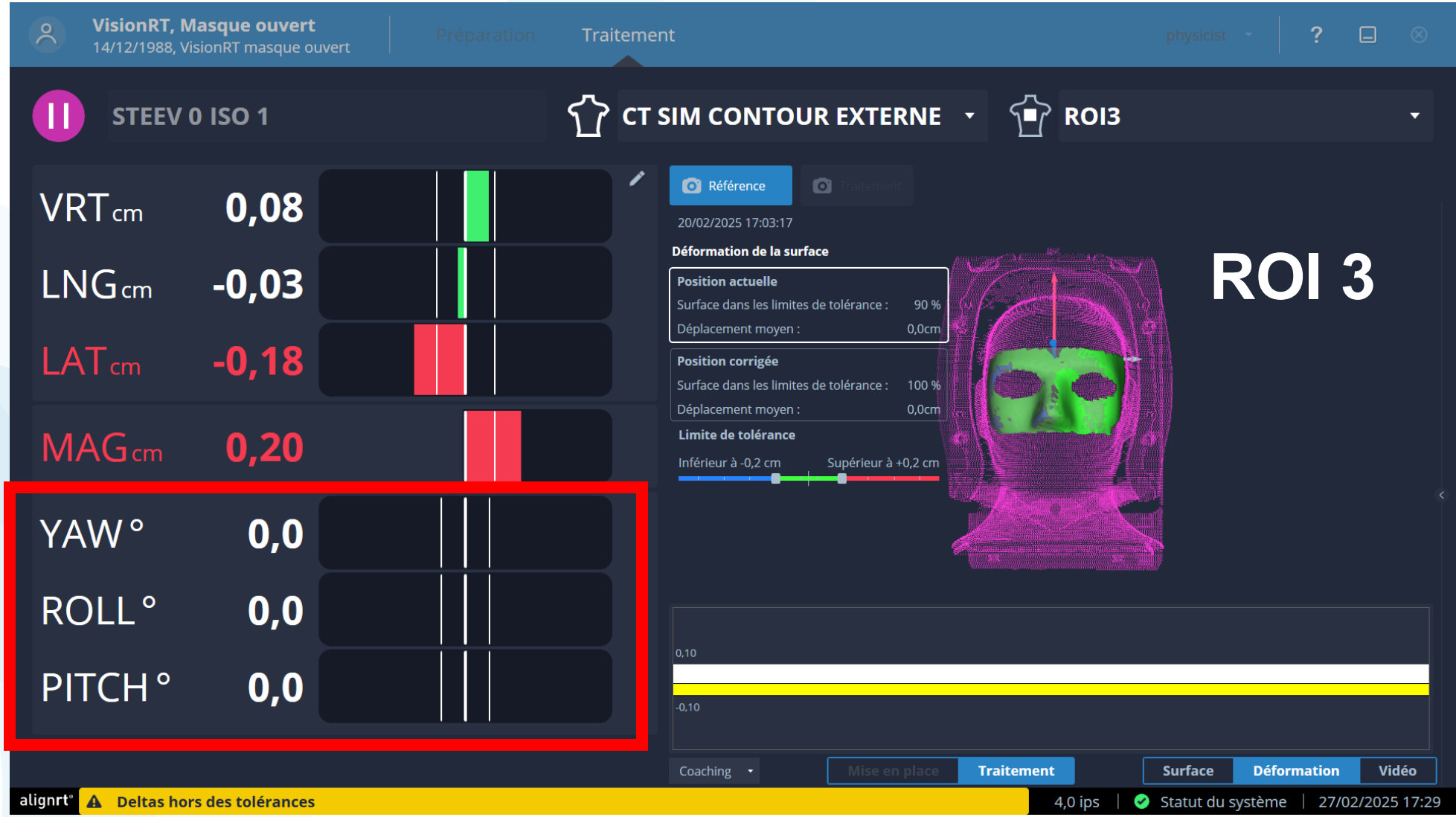
ROI 3

ROI does not affect VRT rotation values
➔ Bore-Linac = no cameras occlusions versus C-arm Linac



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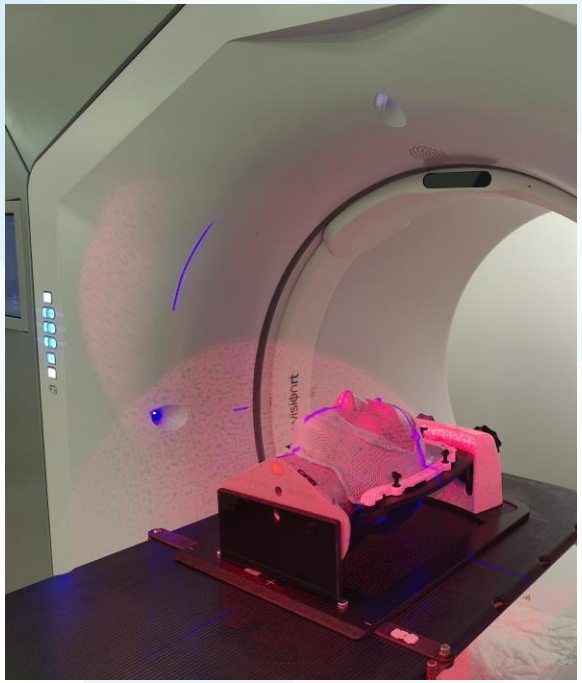
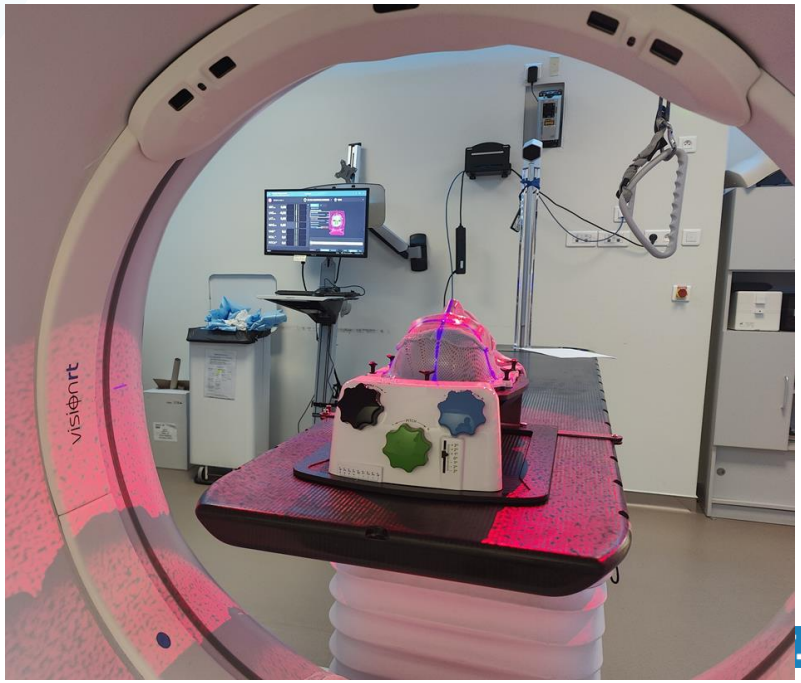
TruPose™ Head Adjuster

- Mechanical platform for **pitch, roll, yaw** adjustments
- ±4° roll/yaw, ±3° pitch range
- 3 color-coded knobs + safety clutch
- Compatible with Type-S, Orfit, and DSPS mask systems





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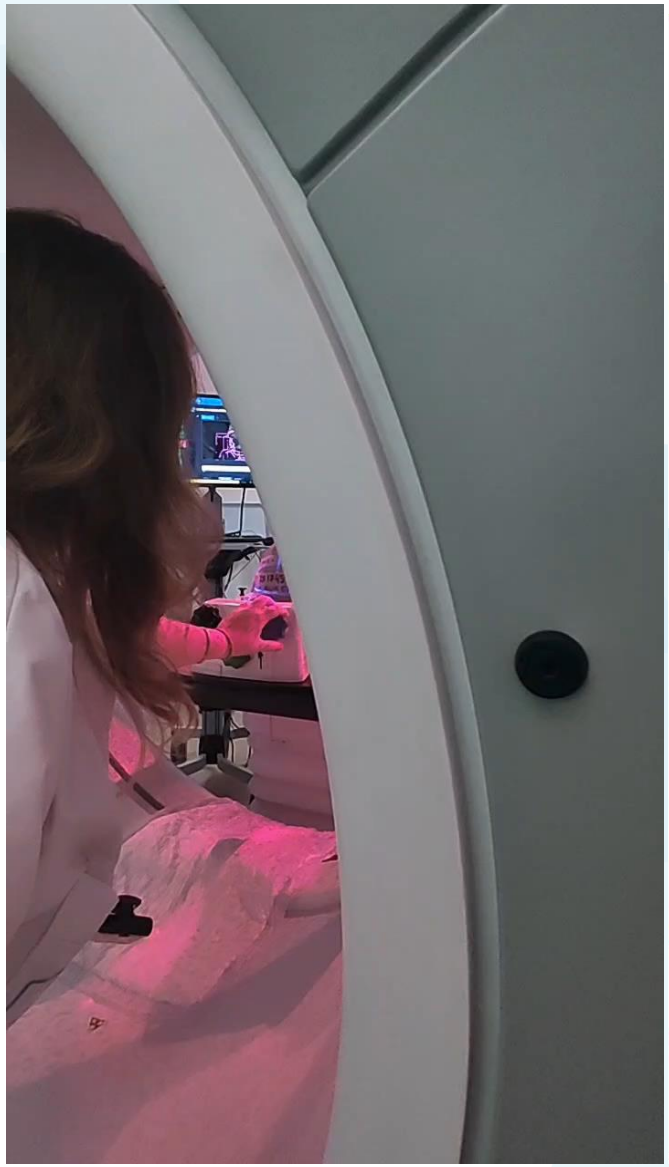
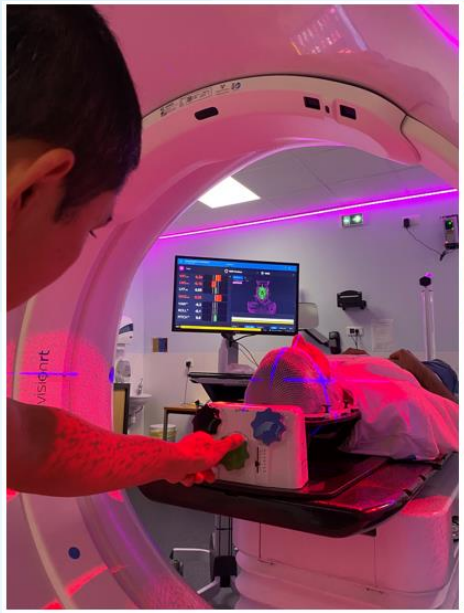
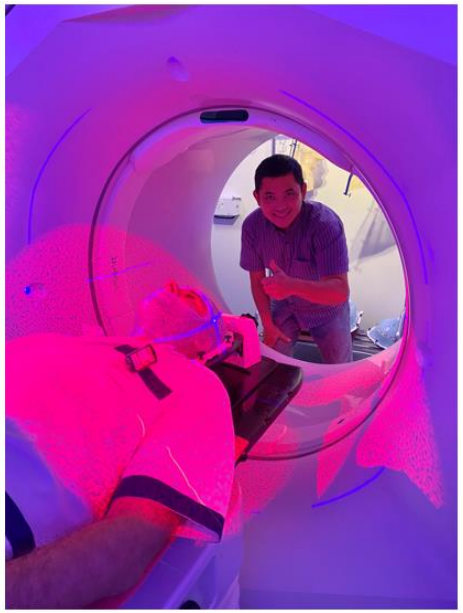
Trupose: Rotation adjustments

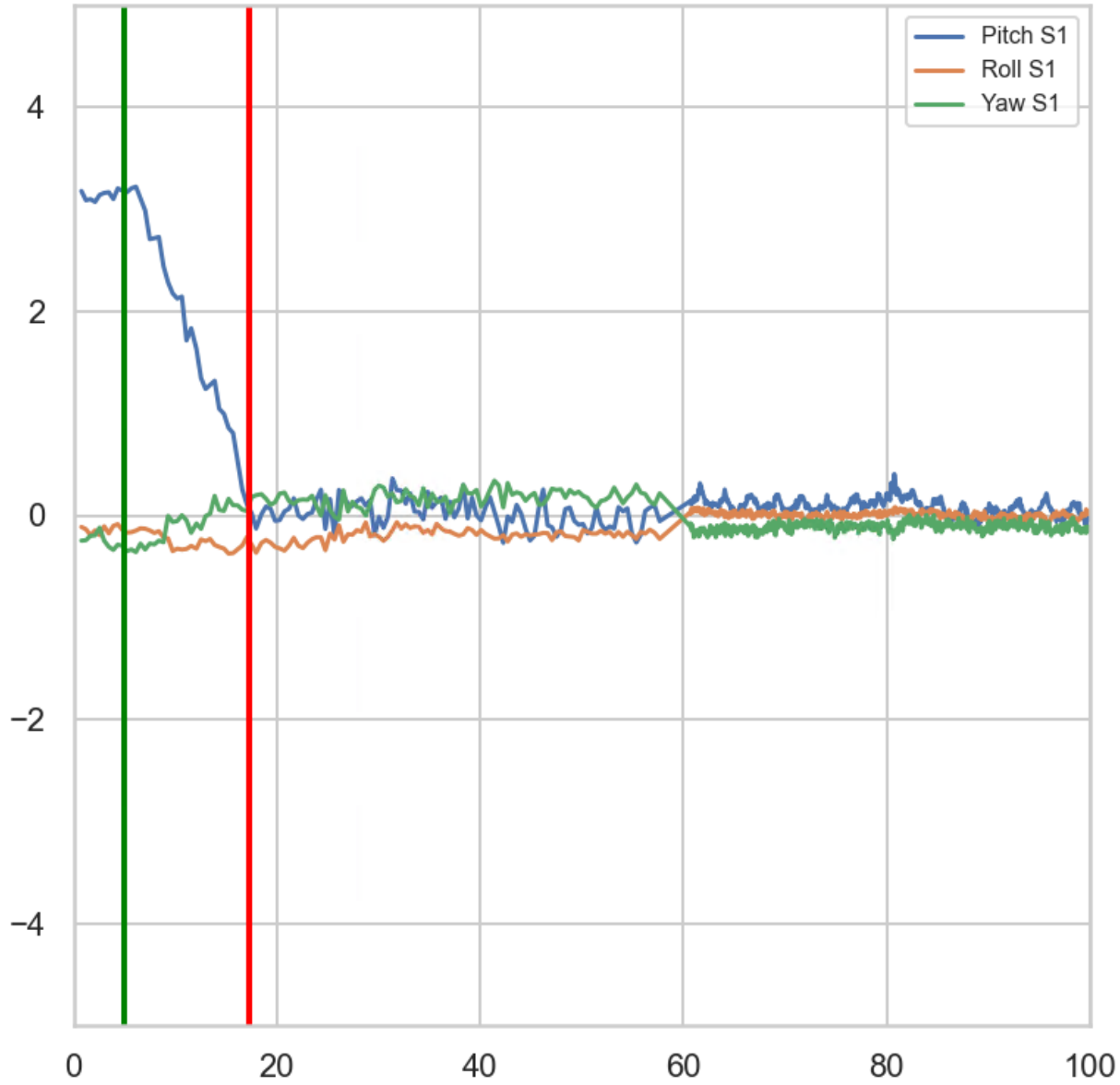






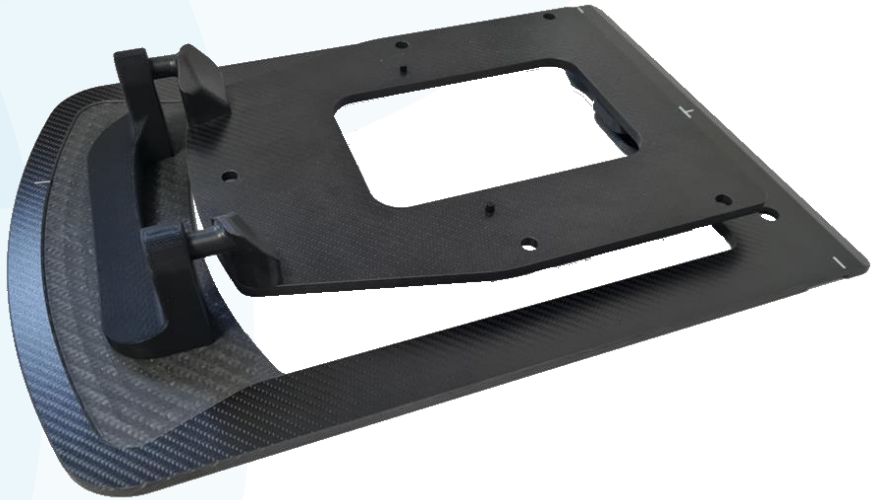
Easy and real-time rotation error corrections with RTD values from AlignRT displayed

Trupose: Rotation adjustments



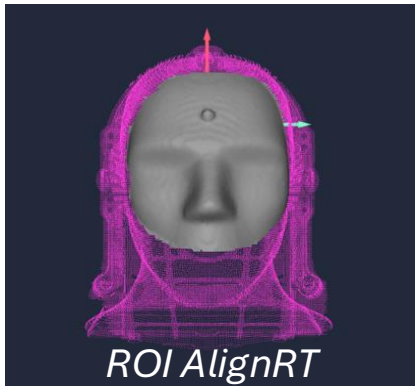
Practical Workflow

- ❑ CT simulation geometry reproduced using fixed TruPose™ Static base
- ❑ SGRT deltas guide incremental rotational adjustments during setup
- ❑ Additional micro-adjustments possible after CBCT and during treatment if RTD values exceed tolerances
- ❑ Continuous monitoring ensures stability until beam-on
- ❑ Total adjustment time typically <1 minute



SGRT–CBCT Correlation Study on Phantom

- ❑ STEEV™ cranial phantom (Sun Nuclear) with open 3-point mask (MacroMedics)
- ❑ Controlled rotational offsets generated via AlignRT®
- ❑ Acquisition of CBCT for each induced offset
- ❑ Rotation range tested: **0° to 2°** (Yaw / Roll / Pitch)
- ❑ Comparison between:
  - AlignRT® measured deltas
  - CBCT rigid-registration results (translations + rotations)



STEVE™ Results Overview: translations

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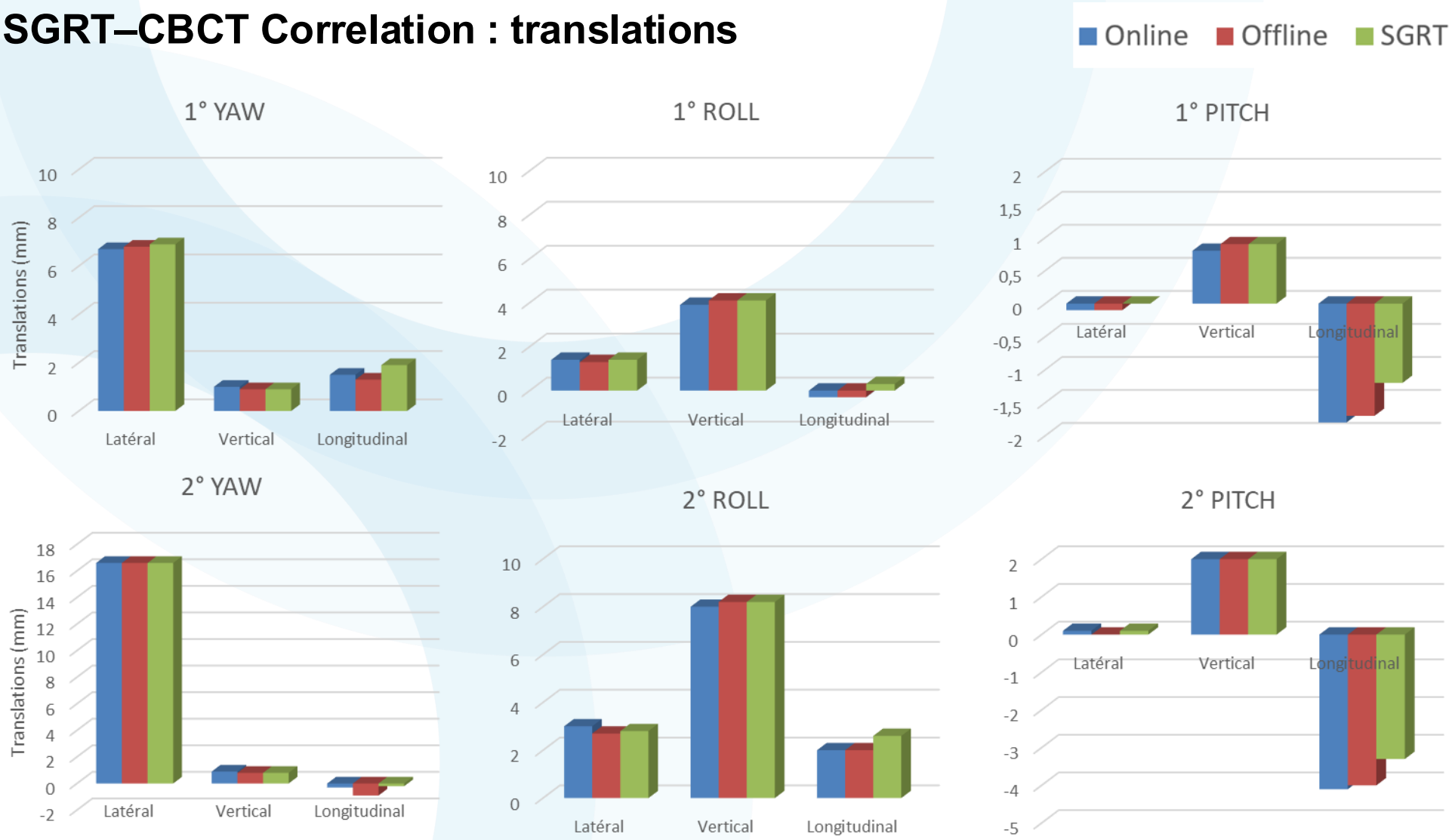
SGRT–CBCT Correlation : translations



SGRT-CBCT Correlation

LAT	0,1 mm ± 0,0
VRT	0,0 mm ± 0,0
LNG	0,6 mm ± 0,1

No compensation of rotations by translations...

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STEVE™ Results Overview: rotations

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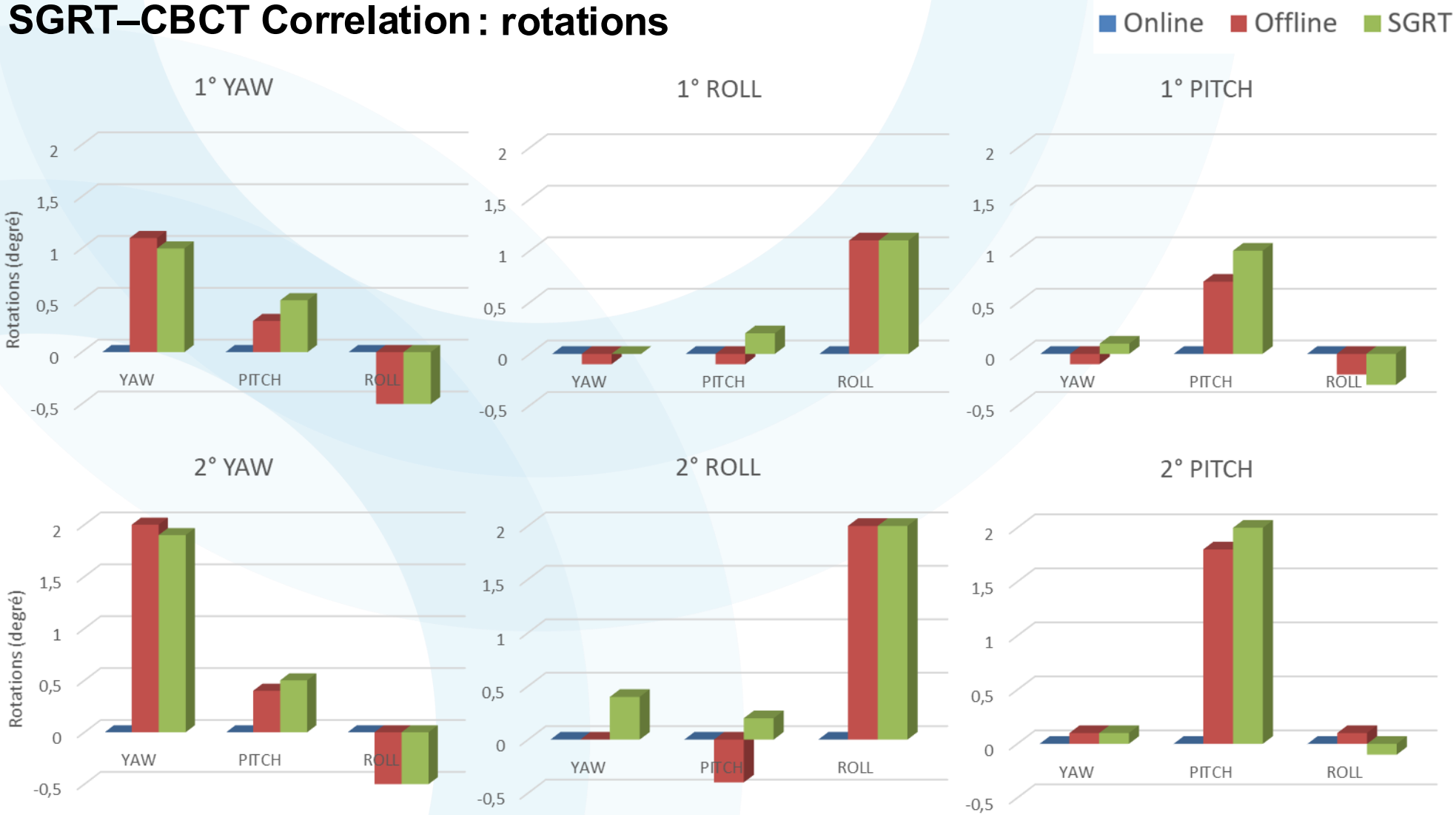
SGRT–CBCT Correlation : rotations



SGRT–CBCT Correlation

YAW	0,1° ± 0,1
ROLL	0,1° ± 0,1
PITCH	0,3° ± 0,2

SGRT showed sub-degree agreement with CBCT for all rotational axes

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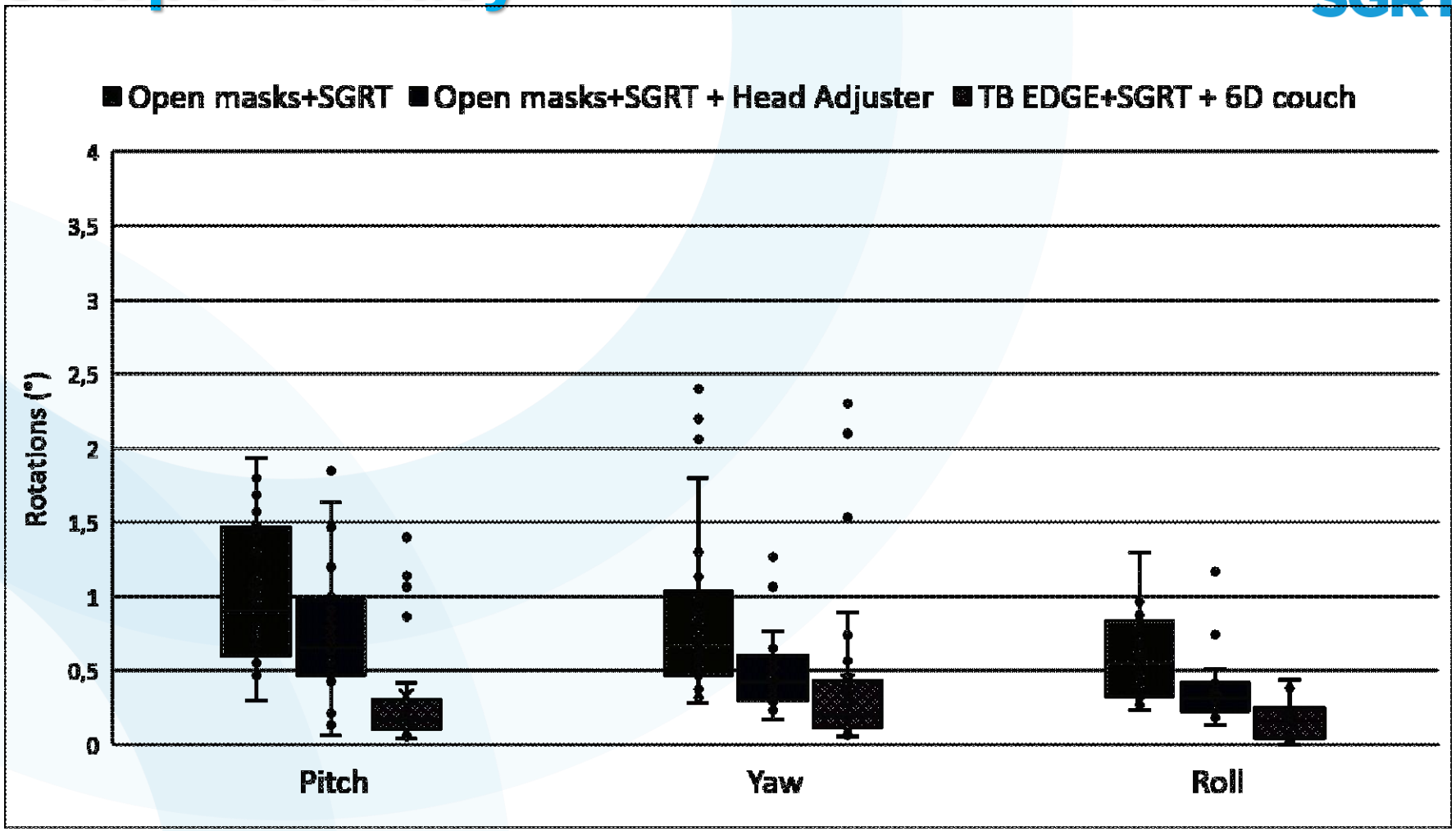
Methods

- 75 fractions analyzed → 3 groups
  A: SGRT only (Halcyon™)
  B: SGRT + TruPose™ (Halcyon™)
  C: SGRT + 6DoF couch (TrueBeam™)
- Metrics: residual rotational error

Results: Setup Accuracy

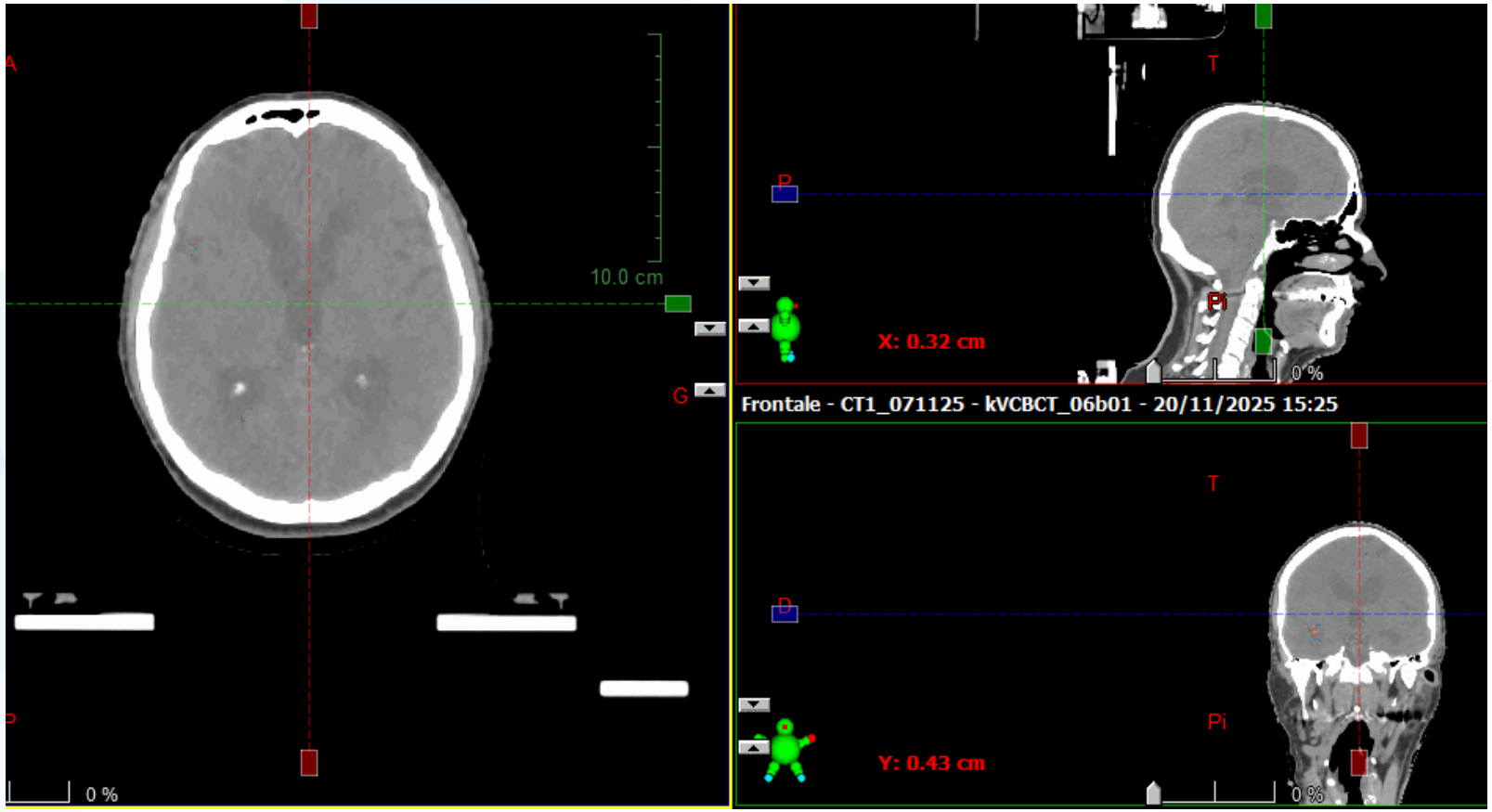


→ Halcyon™ + TruPose™ ≈ 6DoF precision

Statistically significant difference ($p < 0.001$), but both workflows remain within sub-degree rotational accuracy.

Results: Setup Accuracy

- Head adjuster position differs due to manual rotation adjustments.
- Despite this, the skull position is nearly identical between CBCT and CT, confirming accurate immobilization.



SGRT + TruPose™ for Intracranial Setup

- Stable and reproducible cranial tracking with SGRT
- Fast, real-time rotational corrections with TruPose™
- Residual rotations usually <1°
- Consistent alignment from CBCT to beam-on
- Provides rotational control on bore-type LINACs without 6DoF
- Still valuable with Halcyon™ 5 + PerfectKinetix™ for rapid <0.5° pre-imaging alignment

Conclusion

- SGRT reliably detects and guides correction of rotational misalignments
- Mechanical rotational adjustment improves setup accuracy on Halcyon™
- Method integrates smoothly into existing SGRT-based brain workflows

Lung SBRT with SGRT

❑ Lung SBRT DIBH with Halcyon:

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▸ J Appl Clin Med Phys. 2020 Dec 20;22(1):261–270. doi: 10.1002/acm2.13146

Clinical validation of ring-mounted halcyon linac for lung SBRT: comparison to SBRT-dedicated C-arm linac treatments

Damodar Pokhrel [1,✉], Justin Visak [1], Lana C Critchfield [1], Joseph Stephen [1], Mark E Bernard [1], Marcus Randall

Target volume	Parameters	Truebeam VMAT	Halcyon VMAT	*P*-value
PTV	PTVD99 (Gy)	49.1 ± 1.9 (47.8–56.2)	48.7 ± 1.5 (47.7–54.1)	**0.04**
	CI	1.00 ± 0.03 (0.97–1.07)	1.01 ± 0.03 (0.98–1.09)	n. s.
	HI	1.23 ± 0.04 (1.2–1.4)	1.24 ± 0.03 (1.2–1.3)	n. s.
	GI	4.34 ± 0.9 (3.40–7.07)	4.64 ± 1.1 (3.5–7.6)	**0.004**
	D_{2cm} (%)	51.7 ± 4.5 (44.6–61.6)	52.1 ± 5.5 (44.9–62.3)	n. s.
	GD (cm)	1.16 ± 0.23 (0.83–1.62)	1.23 ± 0.25 (0.85–1.71)	**0.001**
ITV	D_{min} (Gy)	53.4 ± 2.3 (49.4–56.9)	53.4 ± 2.5 (48.9–58.2)	n. s.
	D_{max} (Gy)	61.5 ± 2.5 (57.7–68.3)	62.2 ± 1.7 (59.0–65.7)	n. s.
	D_{mean} (Gy)	58.1 ± 1.9 (55.4–63.1)	58.6 ± 1.71 (55.5–61.8)	n. s.

Dose to OAR	Parameters	Truebeam VMAT	Halcyon VMAT	*P*-value
Spinal cord (Gy)	D_{max}	8.3 ± 5.0 (1.7–16.1)	8.8 ± 4.1 (3.1–14.9)	n. s.
	$D_{0.25cc}$	7.5 ± 4.5 (1.5–13.8)	8.0 ± 3.7 (2.8–13.5)	n. s.
Heart/pericardium (Gy)	D_{max}	22.2 ± 17.4 (0.31–53.6)	22.6 ± 17.7 (0.39–53.6)	n. s.
	D_{15cc}	10.5 ± 8.5 (0.2–33.2)	10.8 ± 8.6 (0.27–34.1)	n. s.
Esophagus (Gy)	D_{max}	12.0 ± 9.4 (2.5–41.0)	12.7 ± 8.8 (3.8–40.5)	n. s.
	D_{3cc}	7.6 ± 5.6 (1.9–24.7)	8.5 ± 5.7 (2.8–26.2)	**0.004**
Trachea/bronchial tree (Gy)	D_{max}	17.8 ± 19.0 (0.3–55.4)	17.3 ± 18.7 (0.4–54.8)	n. s.
	D_{4cc}	8.1 ± 10.4 (0.2–36.6)	8.2 ± 10.5 (0.3–37.3)	n. s.
Skin (Gy)	D_{max}	17.1 ± 5.1 (8.8–28.3)	17.7 ± 4.9 (10.6–28.0)	n. s.
	D_{10cc}	10.7 ± 3.1 (6.1–16.5)	11.6 ± 3.0 (7.5–16.9)	**0.001**
Ribs (Gy)	D_{max}	45.6 ± 10.1 (28.8–57.2)	46.0 ± 10.6 (27.8–58.0)	n. s.
	D_{1cc}	37.1 ± 9.6 (24.9–53.1)	37.1 ± 9.5 (23.9–53.6)	n. s.
Normal lung	V_{20Gy} (%)	3.3 ± 2.3 (0.7–9.7)	3.5 ± 2.5 (0.7–10.0)	n. s.
	V_{10Gy} (%)	8.0 ± 4.5 (2.3–20.7)	8.4 ± 4.5 (2.6–21.0)	**<0.001**
	V_{5Gy} (%)	13.7 ± 5.7 (6.2–28.4)	14.6 ± 5.8 (7.0–29.1)	**0.001**
	MLD (Gy)	2.8 ± 1.3 (1.2–6.3)	3.0 ± 1.3 (1.4–6.7)	**<0.001**

❑ Lung SBRT DIBH with Halcyon:

Contents lists available at ScienceDirect

Physics and Imaging in Radiation Oncology

journal homepage: www.sciencedirect.com/journal/physics-and-imaging-in-radiation-oncology

Original Research Article

Reproducibility of surface-based deep inspiration breath-hold technique for lung stereotactic body radiotherapy on a closed-bore gantry linac

Daniel Nguyen [a,*], Rebeca Reinoso [a], Jad Farah [b], Sena Yossi [a], Fabrice Lorchel [a], Victor Passerat [a], Estelle Louet [a], Isabelle Pouchard [a], Mustapha Khodri [a], Nicolas Barbet [a]

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[b] Vision RT Ltd., Dove House, Arcadia Avenue, London N3 2JU, United Kingdom

Introduction

Lung SBRT DIBH on Halcyon V2.0

SGRT : AlignRT and AlignRT Inbore

- 3 camera pods:
  - 2 cameras
  - 1 projector
- 1 ring camera

- Patient positioning
- Setup
- Monitoring

Methodology

Treatment workflow

DIBH SBRT workflow:

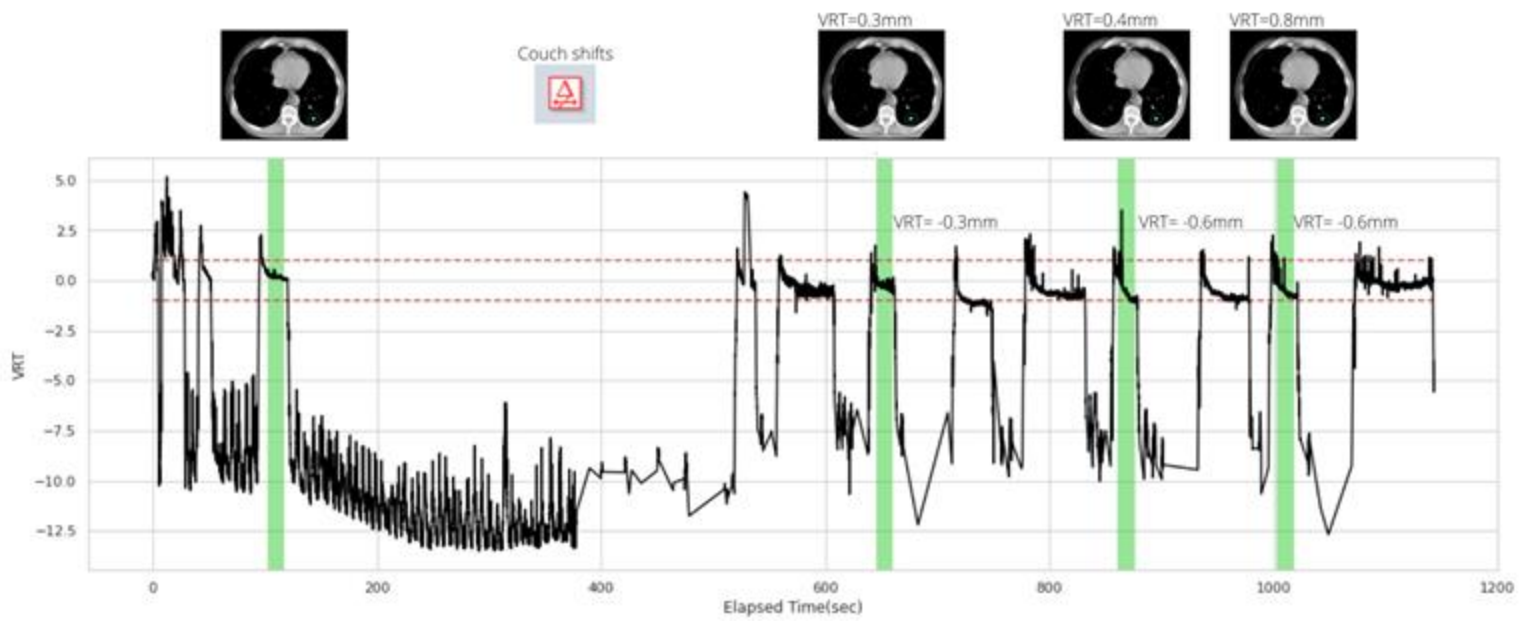
- 4 DIBH CBCT per treatment fraction:
  - Imaging/repositioning
  - Inter and intra-fractional control

DIBH Threshold:

- VRT = **±1 mm**
- 5DoF = ±2 mm / °

Methodology

Data analysis



Tumour motion

- Intrafraction

Amplitude = |max(3CBCTshifts) − min(3CBCTshifts)|

- Interfraction

median(3CBCTshifts)

SGRT

- Intra-Interfraction: surface-based DIBH position (reproducibility purposes)

Results

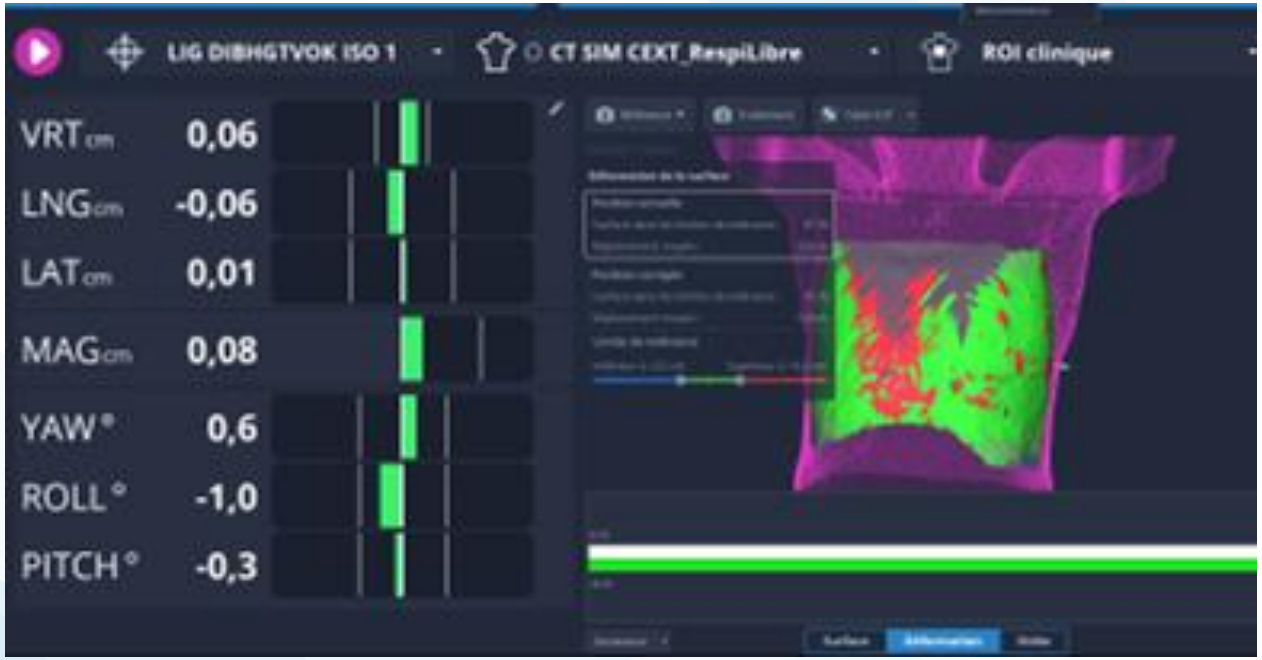
Intrafraction tumour motion: CBCT analysis

Median amplitude of tumour movement:

- 0.2 mm - 1.9 mm in 3 translational DoF
- 0.2º o to 2.7º in the three rotational DoF.

Tumour remains in the PTV (CTV + 5 mm) during all DIBH

Results



Intrafraction: SGRT vs kV-CBCT

- 90.9% of SGRT DIBH measurements were within tolerance.
- Two patients showed ~25% of LNG values below −2 mm.
- One patient showed ~25% of LAT values below −2 mm.
- All patients maintained breath-hold reproducibility within ±1 mm in the VRT direction.

Conclusion

- Halcyon enables high-quality SRT/SBRT delivery with dosimetric accuracy suitable for stereotactic treatments.
- SGRT provides accurate, real-time patient monitoring, supporting frameless and motion-managed workflows.
- The combination of Halcyon and SGRT improves precision, patient comfort, and treatment efficiency.

Take-Home Message

"Halcyon + SGRT: delivering stereotactic radiotherapy with precision, safety, and efficiency."

SGRT COMMUNITY

Thank you for your attention