SGRT in Detection of Secondary Patient Movement Caused by Pitch and Roll Corrections in Pelvic Radiotherapy

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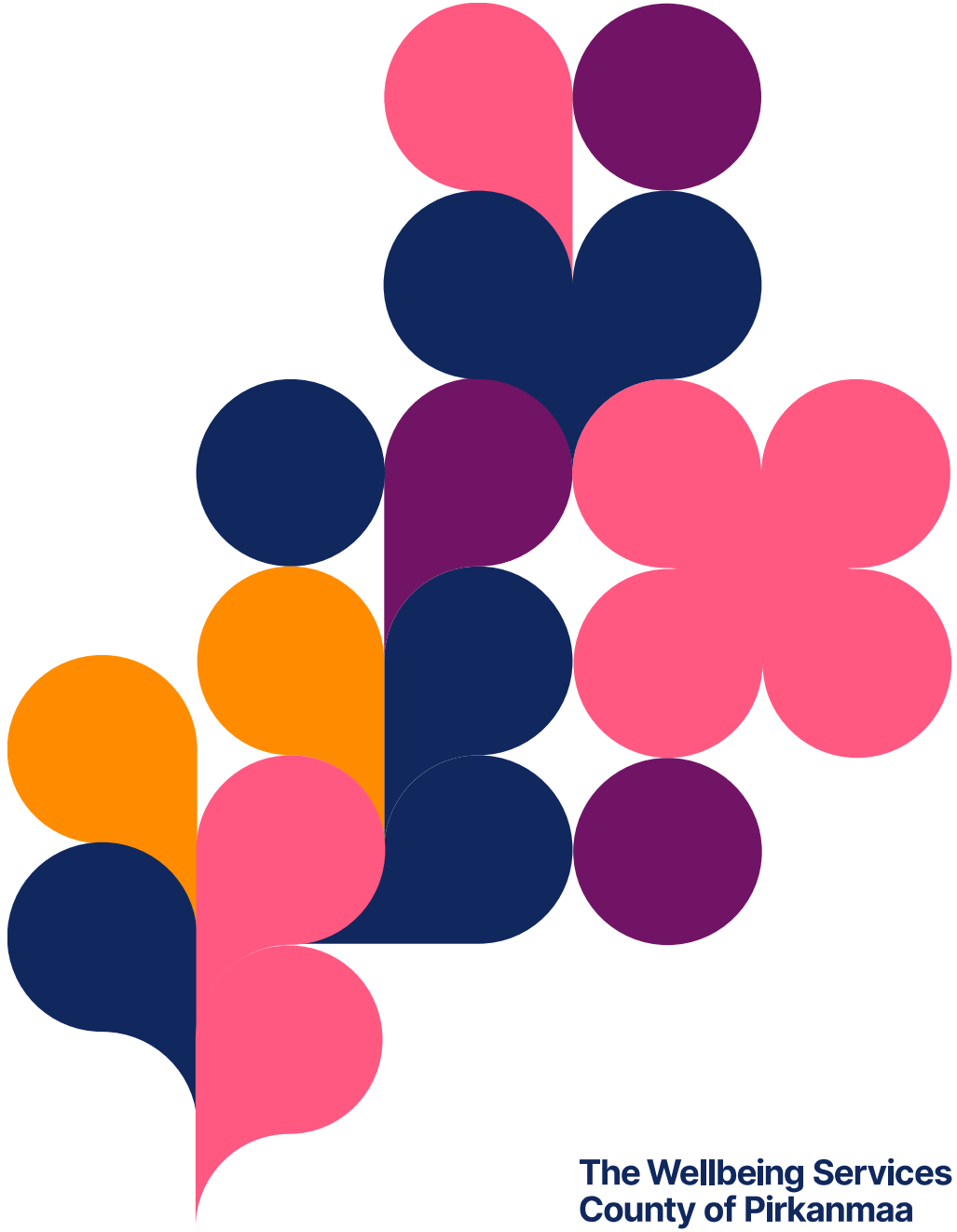

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Technical note

The accuracy of surface imaging in detecting secondary patient motion caused by pitch and roll corrections in pelvic radiotherapy

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Radiotherapy for prostate cancer
Radiotherapy for cervical cancer

ABSTRACT

Background and objective: Correction of rotational setup errors by tilting the treatment couch improves target dose accuracy and prevents healthy tissue overdosage in external beam radiotherapy. However, couch tilts may cause secondary patient motion. This study aimed to quantify the secondary motion caused by pitch and roll corrections and to evaluate the feasibility of surface imaging for detecting the secondary motion in pelvic radiotherapy.

Methods: Setup cone-beam computed tomography images and surface imaging data of 337 fractions of 22 patients were retrospectively collected. The secondary motion was quantified by the residual setup deviations observed in verification cone-beam computed tomography images acquired in 91 fractions with > 1° pitch or roll corrections. The secondary motion observed in the surface imaging data was compared to that observed in the cone-beam computed tomography images in 73 fractions.

Results: Average residual errors of 0.7 mm/1° (R = 0.95) and –1.3 mm/1° (R = –0.87) were observed in longitudinal and lateral directions after pitch and roll corrections, respectively. The 95% limits of agreement between surface imaging and cone-beam tomography imaging residual errors were (–2.2, 1.5) mm in longitudinal direction and (–1.3, 1.1) mm in lateral direction.

Conclusion: Pelvic radiotherapy patients seemed to have shifted downwards on the treatment couch during couch tilts. The secondary motion could be accurately detected by surface imaging, although respiratory motion reduced the accuracy in longitudinal direction.

Tampere University

ANNELE HEIKKILÄ

Rotational and Inter-Isocentre Setup Errors in External Beam Radiotherapy

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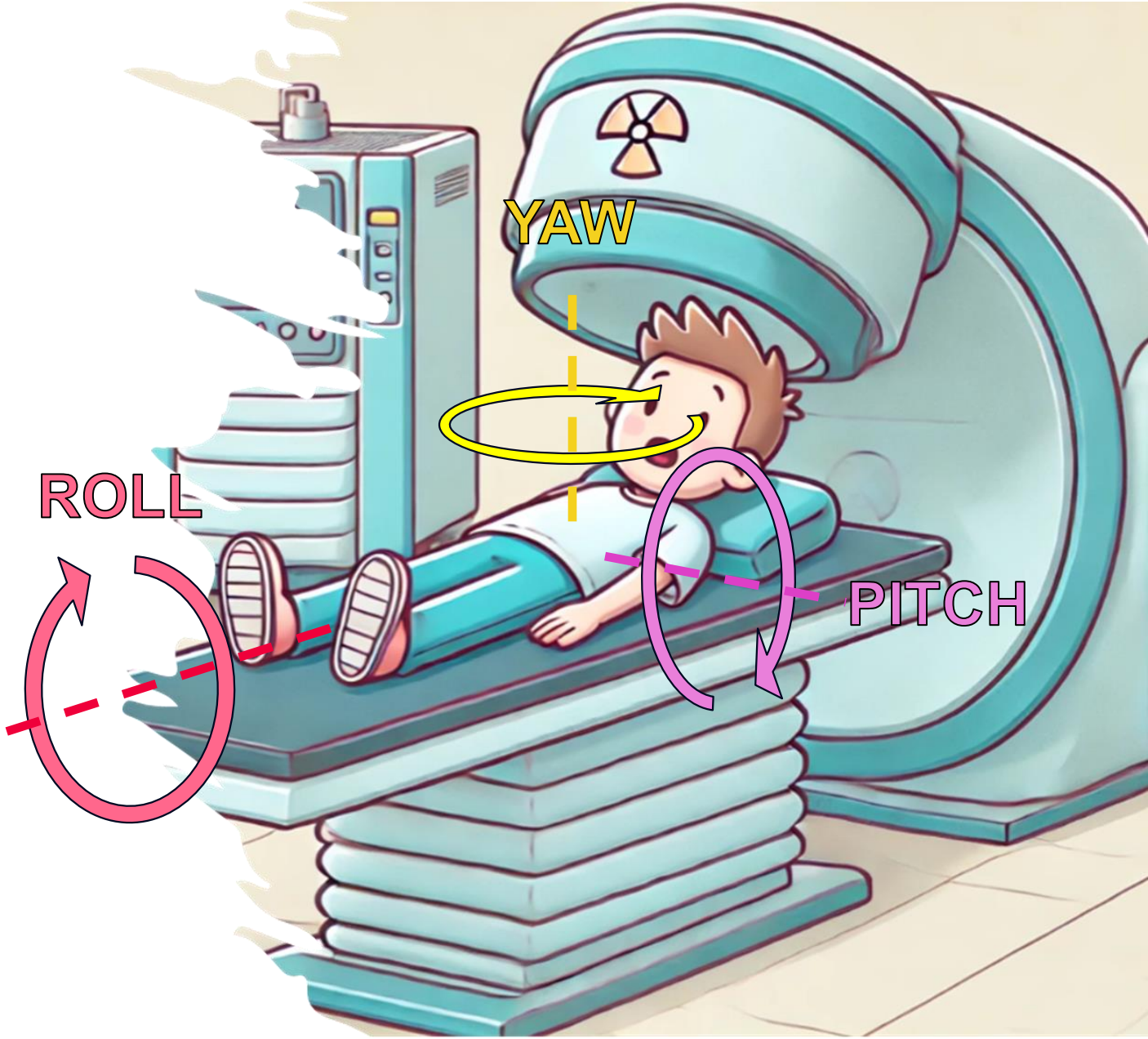
6D corrections

Regular treatment couch:

- VRT, LNG, LAT = 3D
  + Couch rotation (YAW) = 4D
  + PITCH and ROLL = 6D



”How does the patient feel when the couch is tilted?”

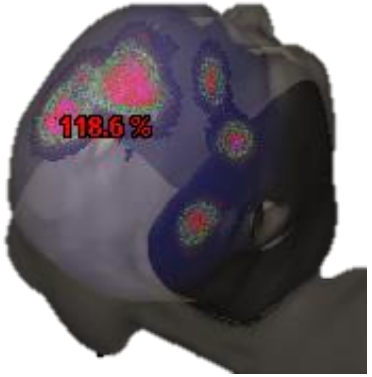
Image by ChatGPT

6D corrections – do they matter?

In theory:

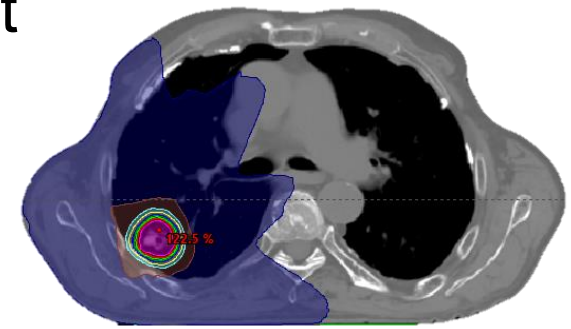
SLOPE \ DISTANCE	2 cm	5 cm	10 cm	20 cm
1°	0.3 mm	0.9 mm	1.7 mm	3.5 mm
2°	0.7 mm	1.7 mm	3.5 mm	7.0 mm
3°	1.0 mm	2.6 mm	5.2 mm	10.5 mm

6D corrections – do they matter?

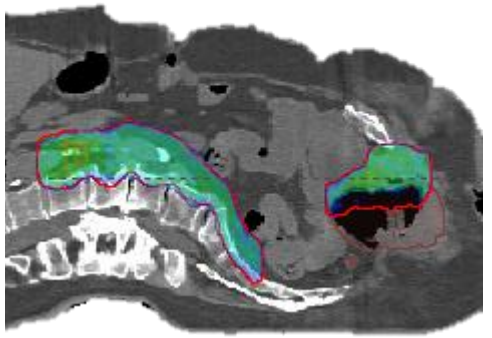


PTV (or CTV) coverage – depends on the case

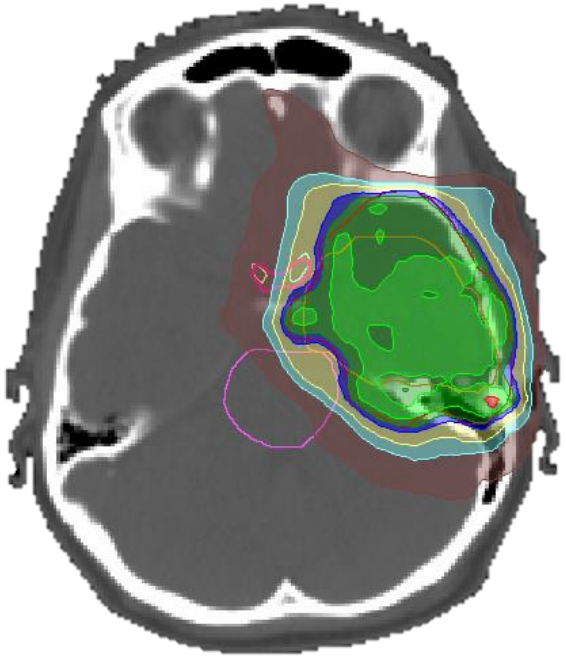
- Multiple brain metastases, one isocenter – obviously important



- Small(ish) or roud(ish) single targets – not so much
- Large and/or complex targets – more important at distant parts



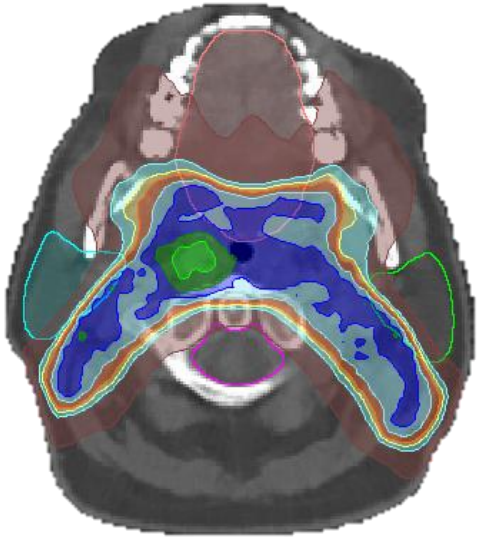
6D corrections – do they matter?



Organs at risk – potentially much more important!

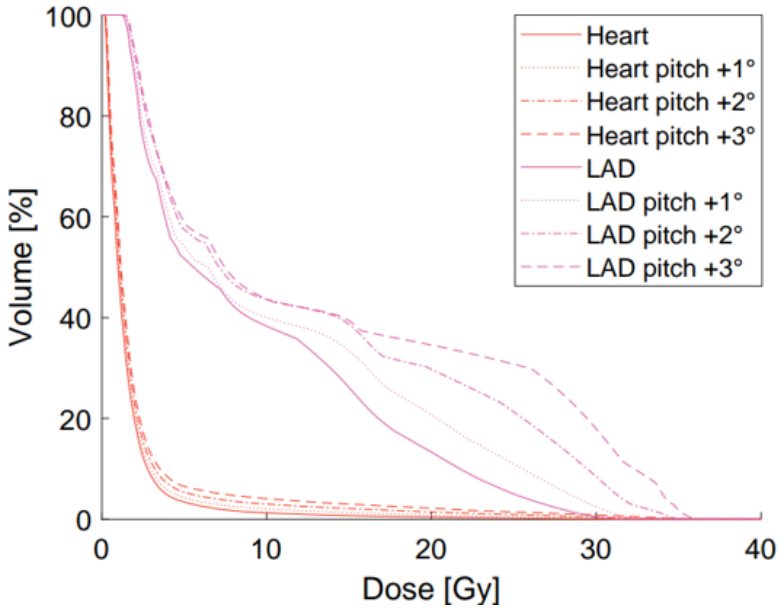
- If no margin is used for OAR

- Often OAR are very close to or partially overlapping PTV and far from isocenter



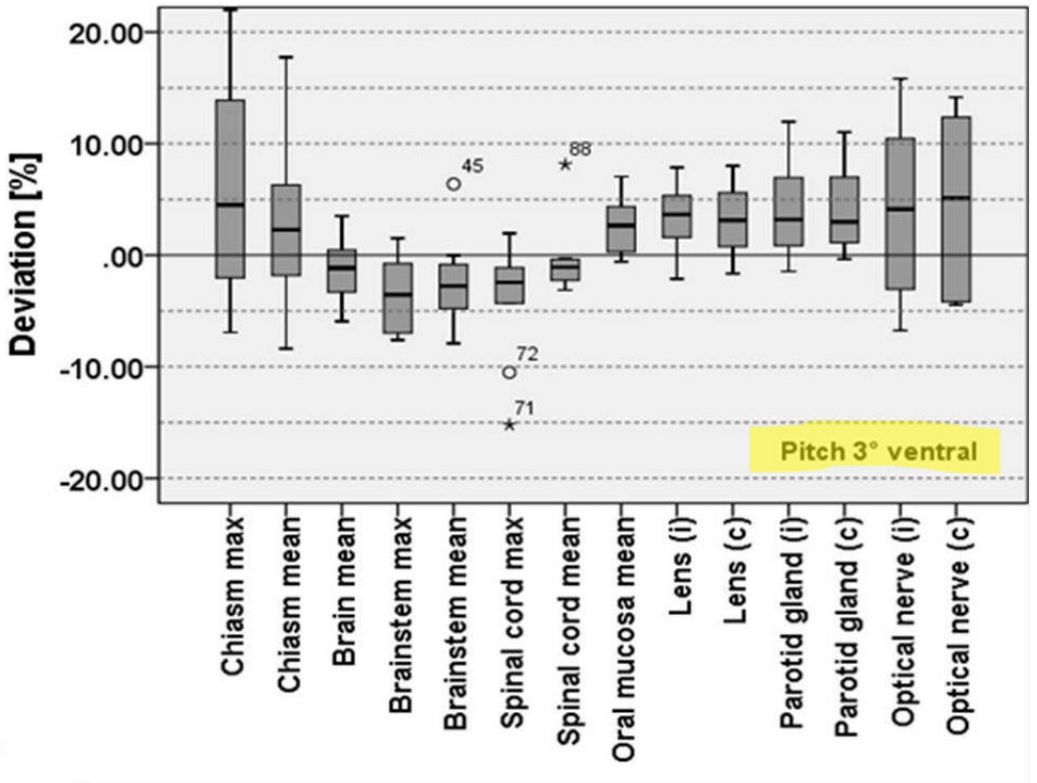
6D corrections – do they matter?

Tangential breast fields



Heikkilä A, et al. Phys Med 2024;117:103203

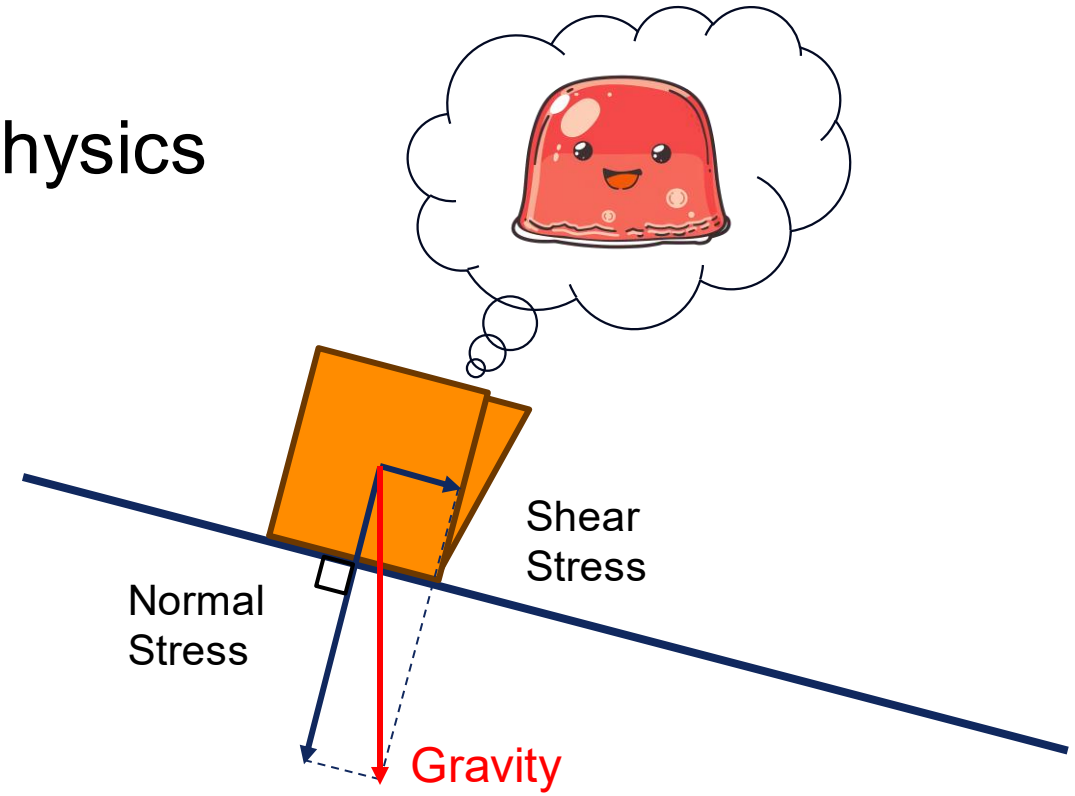
H&N



Stieb S, et al. Br J Radiol 2018;91(1091):20170704

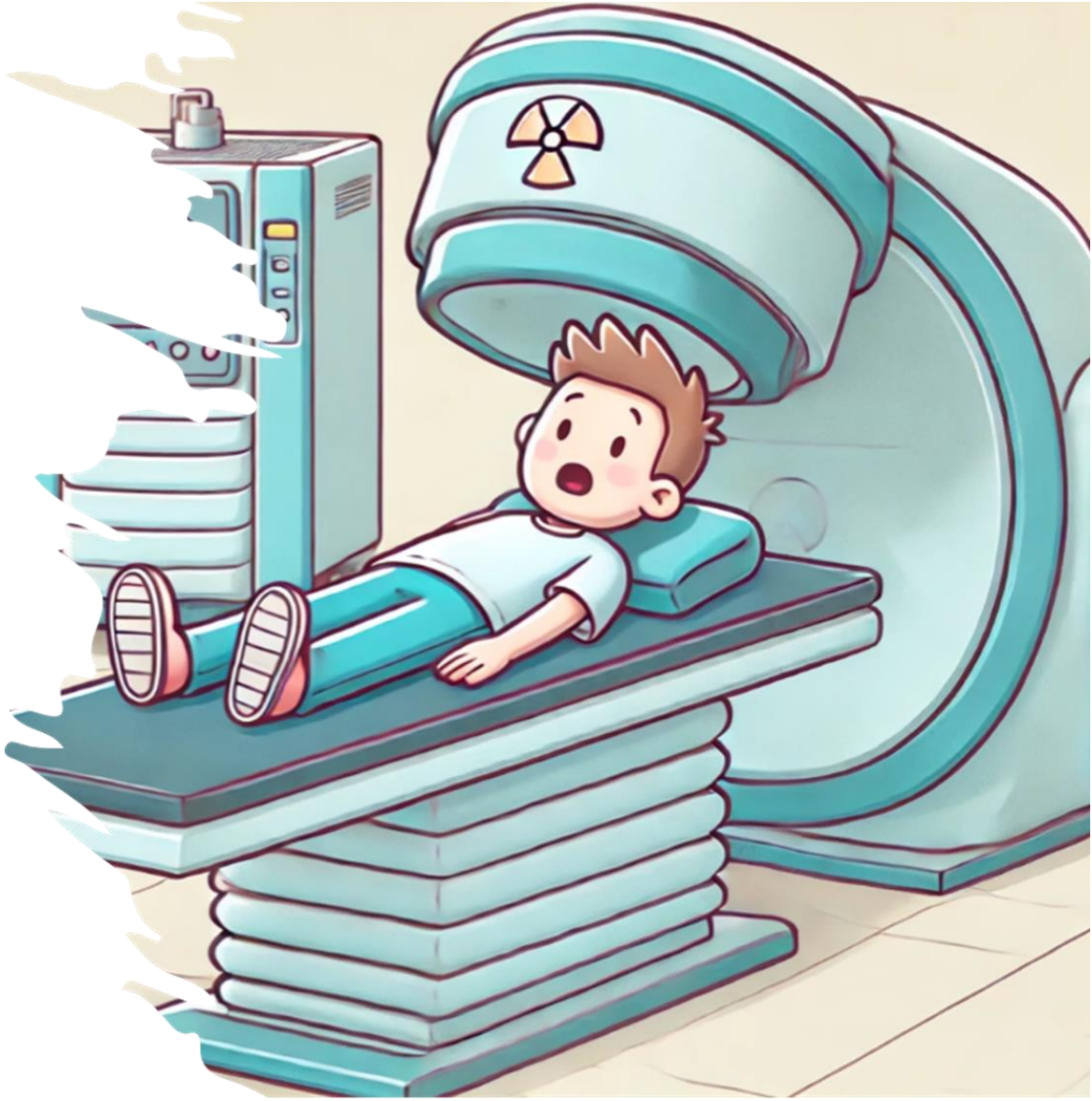
Secondary patient movement

- Physics



Tilt + center of gravity shift

→ Pressure distribution → Counteraction

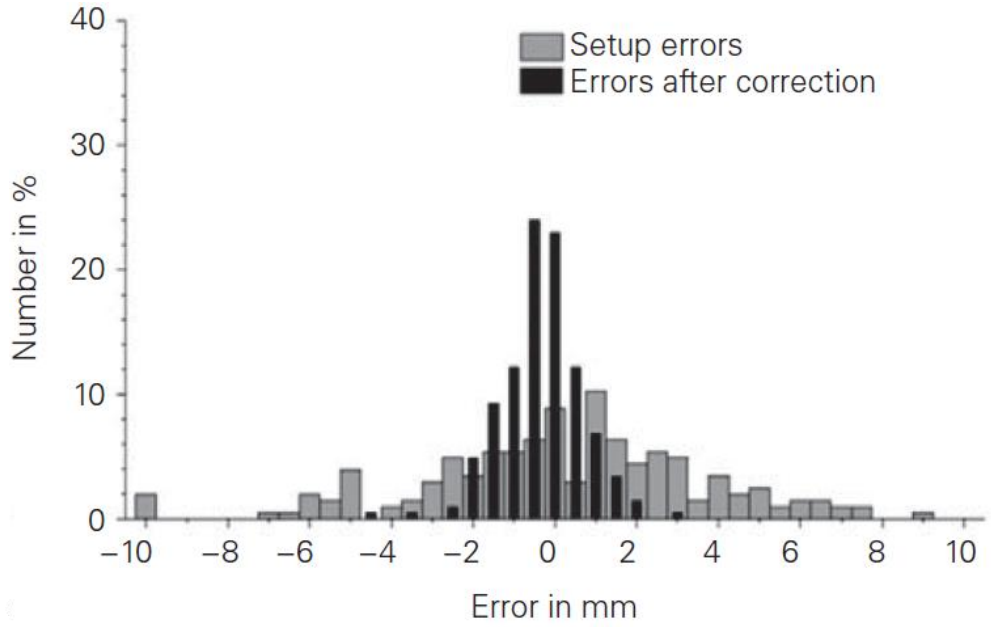


”How does the patient feel when the couch is tilted?”

Image by ChatGPT

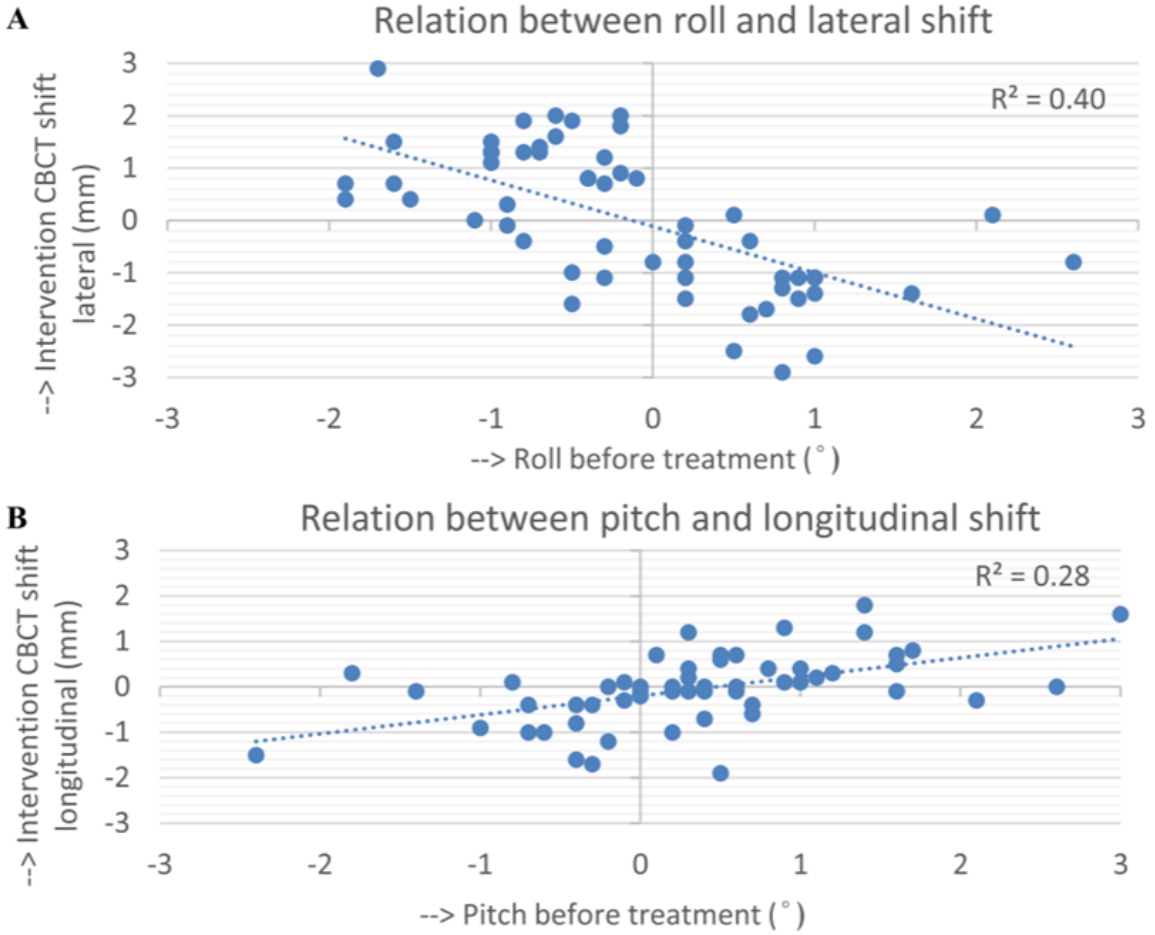
Secondary patient movement

Mostly prostate – only knee support



Guckenberger M, et al. Strahlenther Onkol 2007;183:307–13

Spine SBRT – no immobilization



Remmerts de Vries IF, et al. Int J Radiation Oncol Biol Phys 2024;118(2):525-32

Secondary patient movement

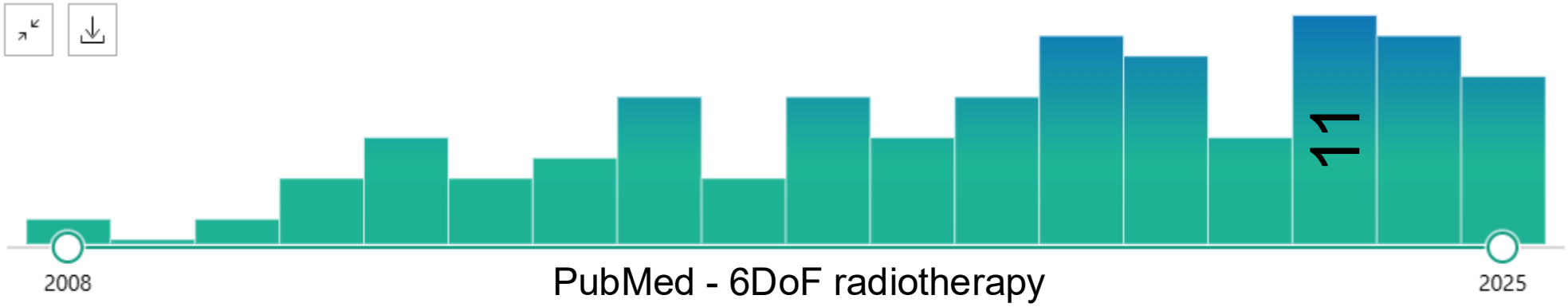
No significant secondary movement observed in patients with mask fixation

- Guckenberger M, et al. Strahlenther Onkol 2007;183:307–13 , Ohtakara K, et al. Radiother Oncol 2012;102:198-205

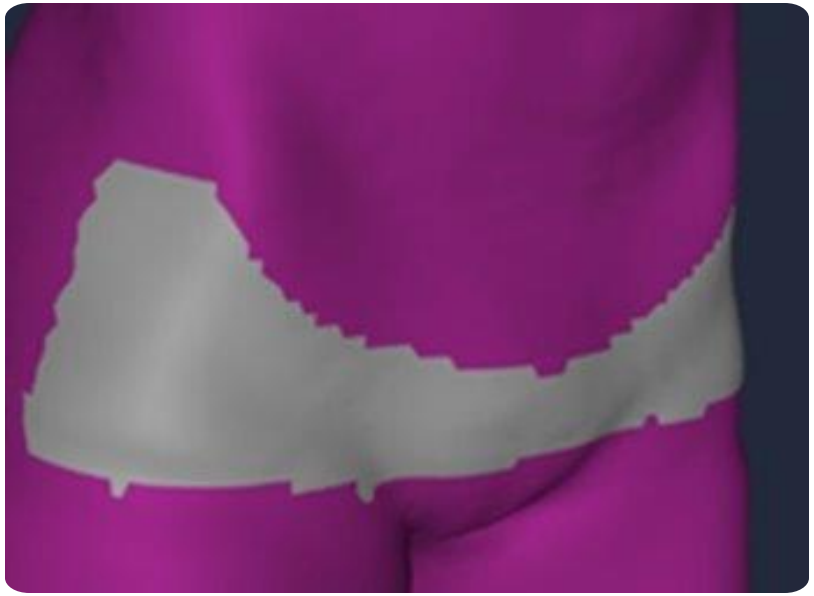
Secondary movement observed in some prostate patients

- Linthout N, et al. Radiother Oncol 2007;83:168-74, Graf R, et al. Strahlenther Onkol 2010;186:544-50

- The correlation between pitch/roll and secondary movement was not analysed
- Speculation that residual errors may be related to large 6D corrections



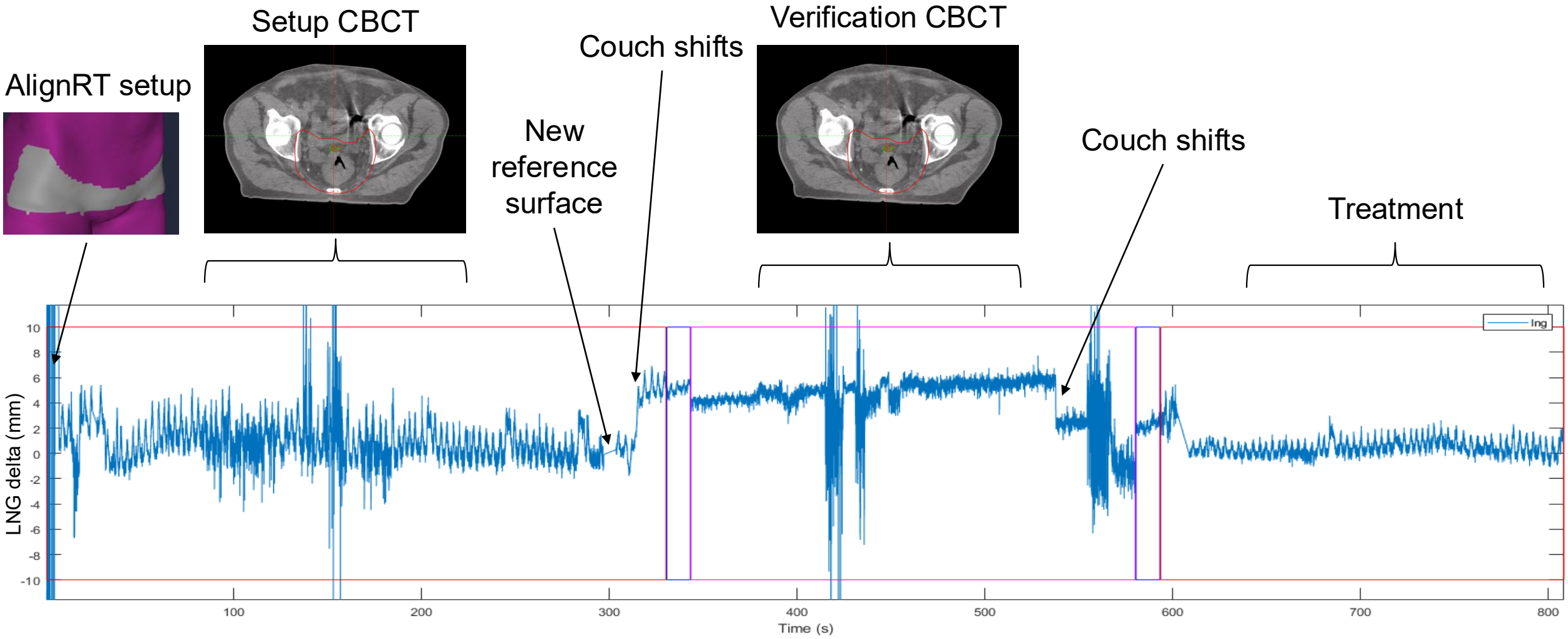
SGRT study



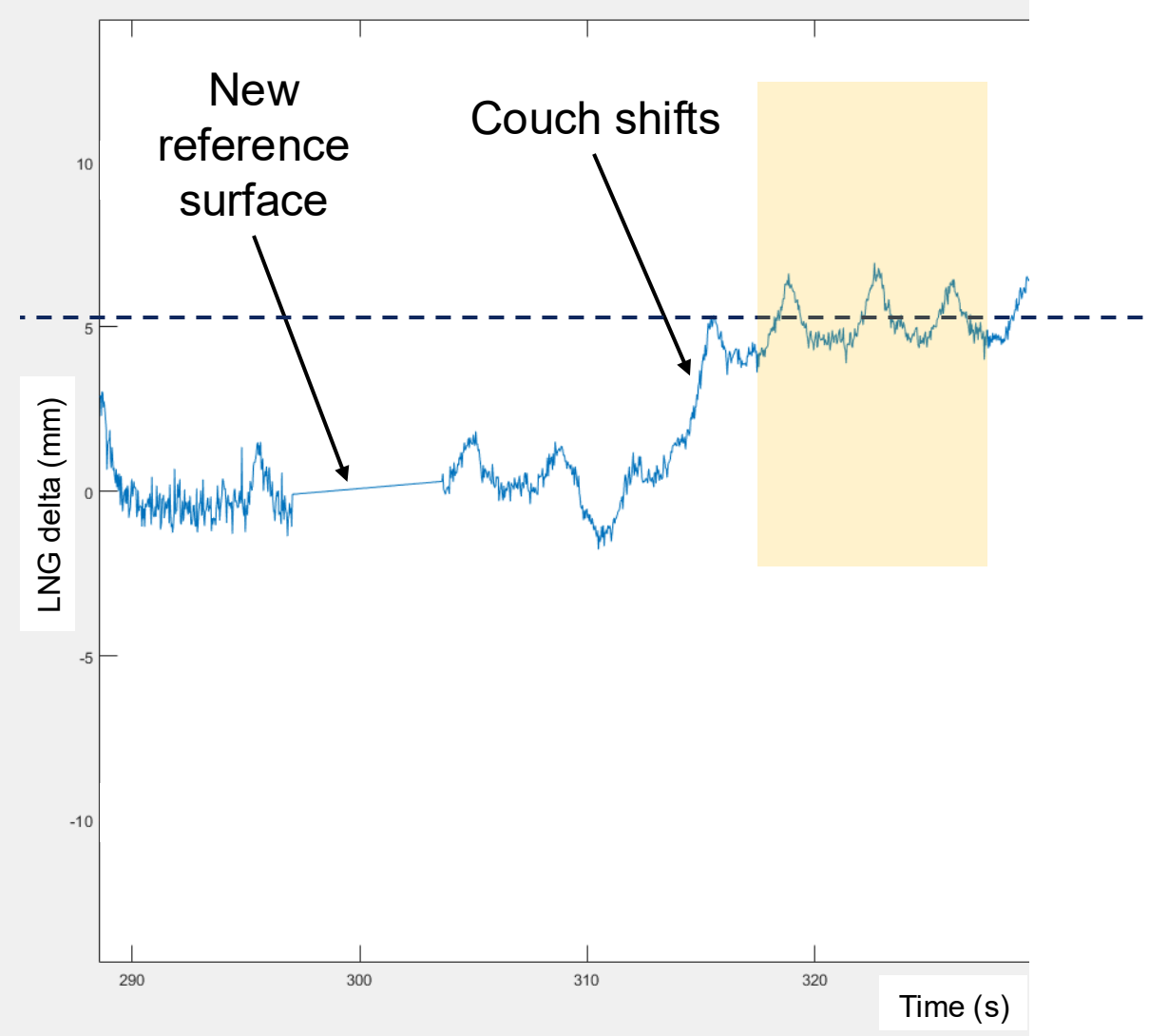
- Pelvic radiotherapy patients
  - Rectum, cervix, prostate bed, bone metastases
  - Bone match CBCT

- 22 patients
  - Verification CBCT was taken if pitch or roll correction >1°
    - 91 verification CBCTs

SGRT study - workflow



SGRT study – zoom to couch shifts



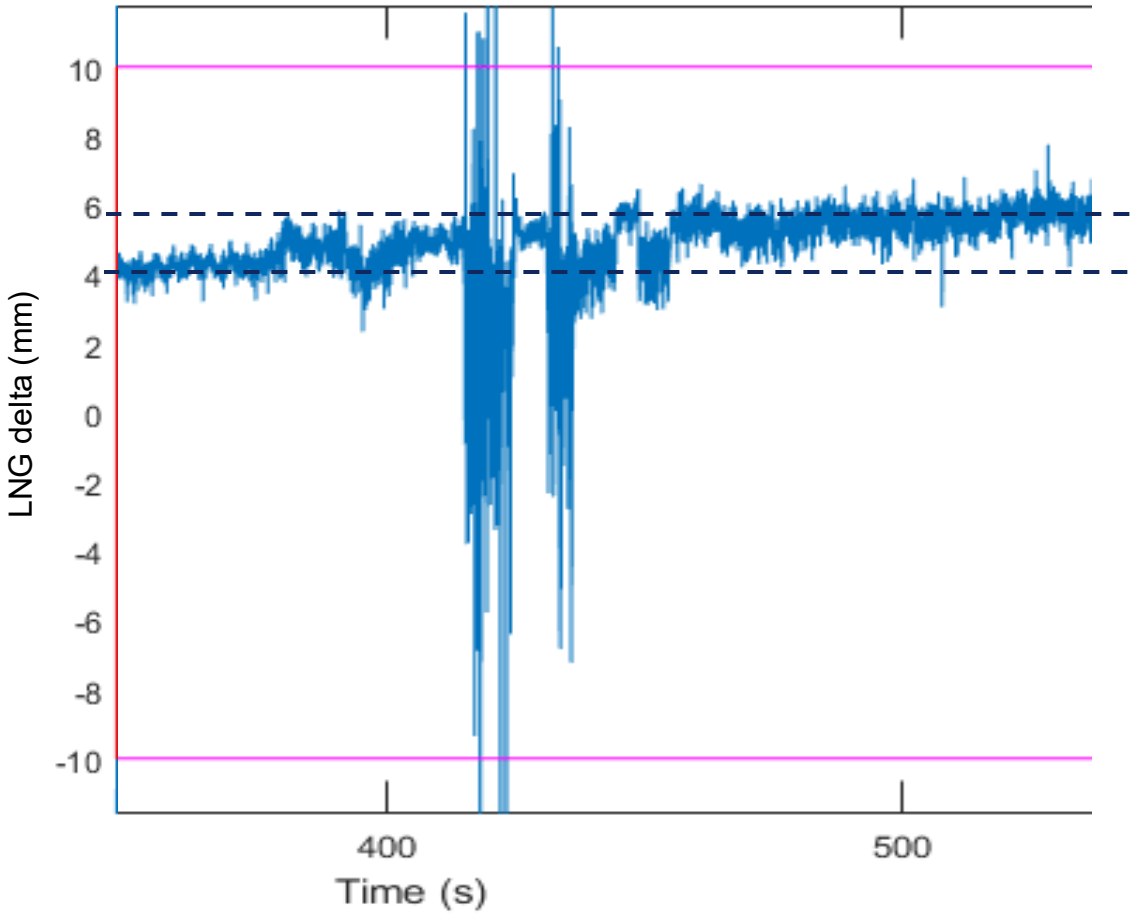
Couch movements
- 3 degree pitch
- 1 mm lng

AlignRT shifts calculated
- 10 s time window

AlignRT showed 5 mm shift
- 4 mm shift due to secondary motion?

CBCT verification
- 4 mm residual error in lng
- Couch shifts

SGRT study – observation during CBCT

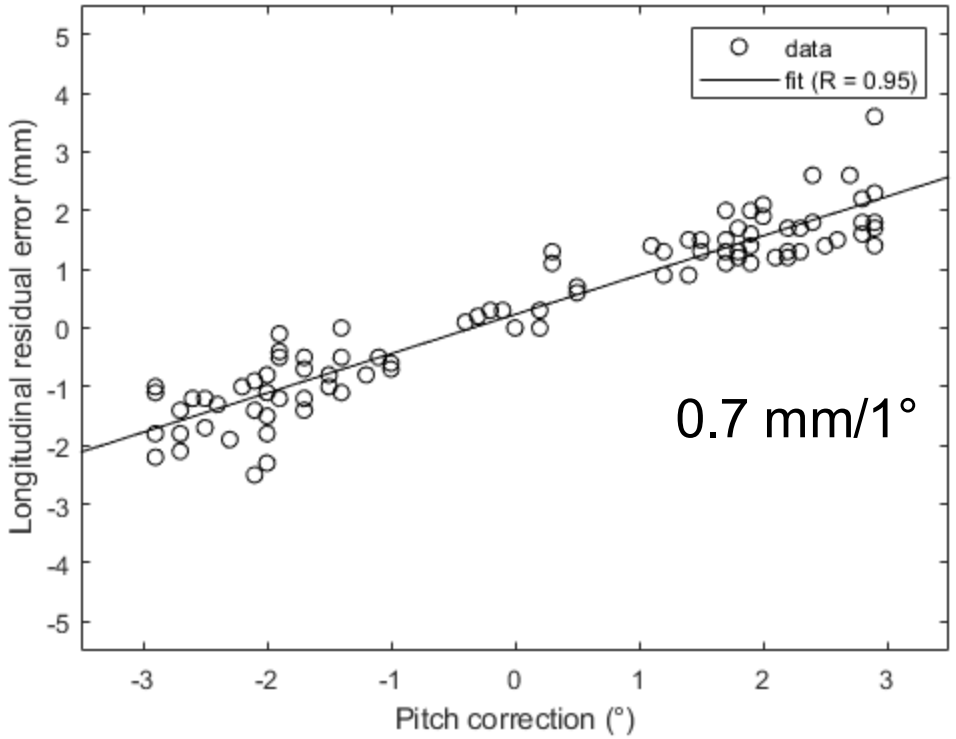


AlignRT shows 1.5 mm drift during CBCT

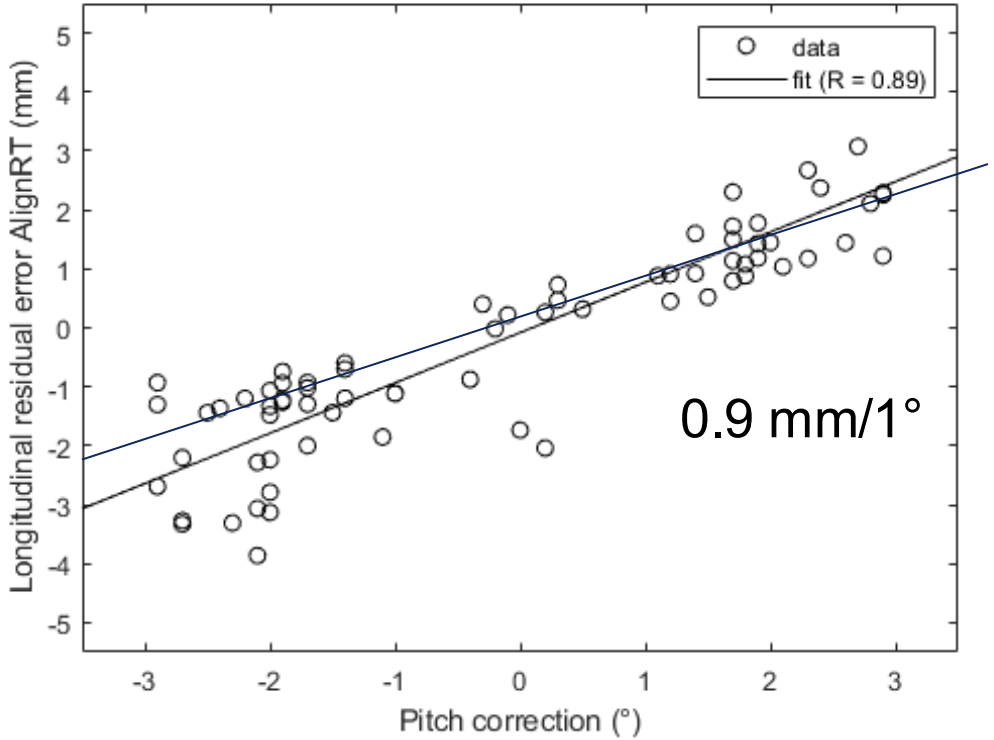
- Relaxation?
- Still secondary motion?

SGRT study – RESULTS

Verification CBCT

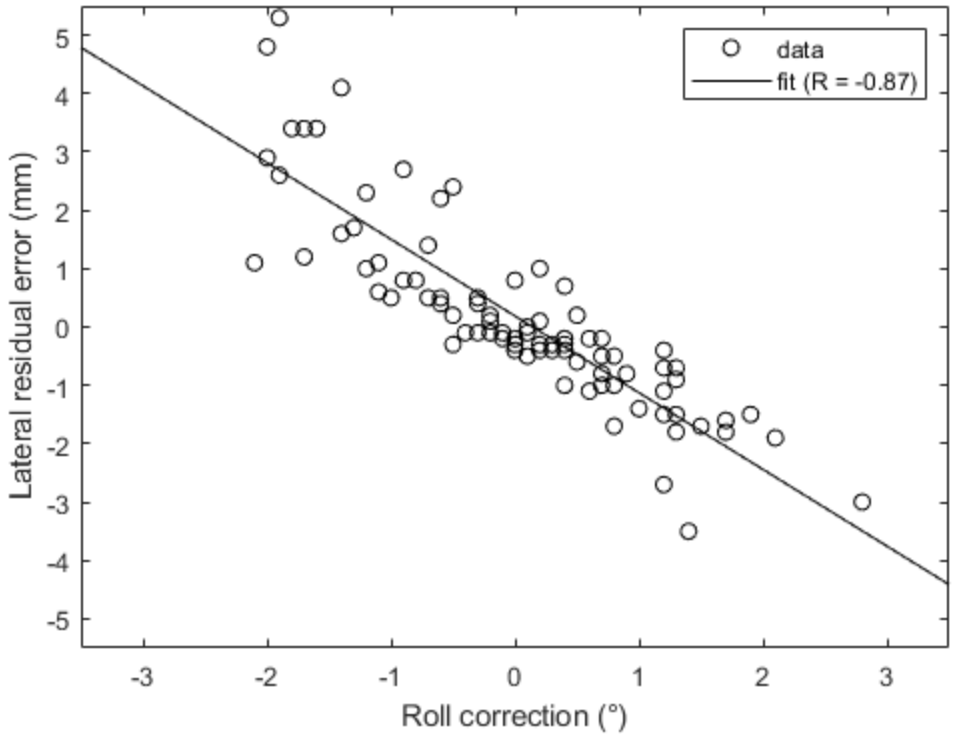


AlignRT

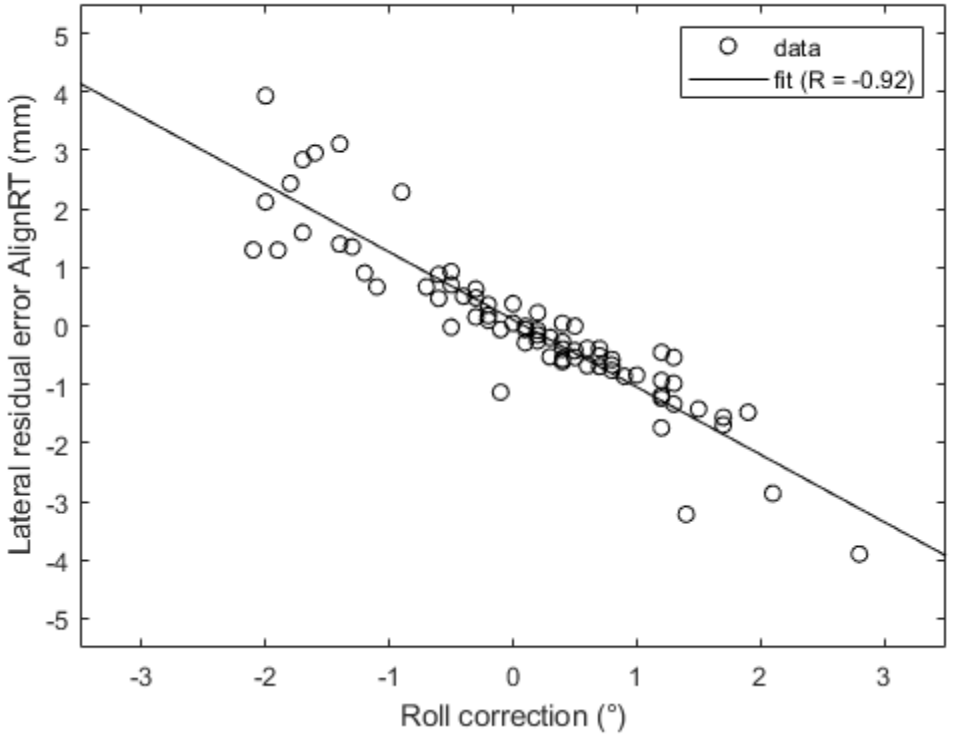


SGRT study – RESULTS

Verification CBCT

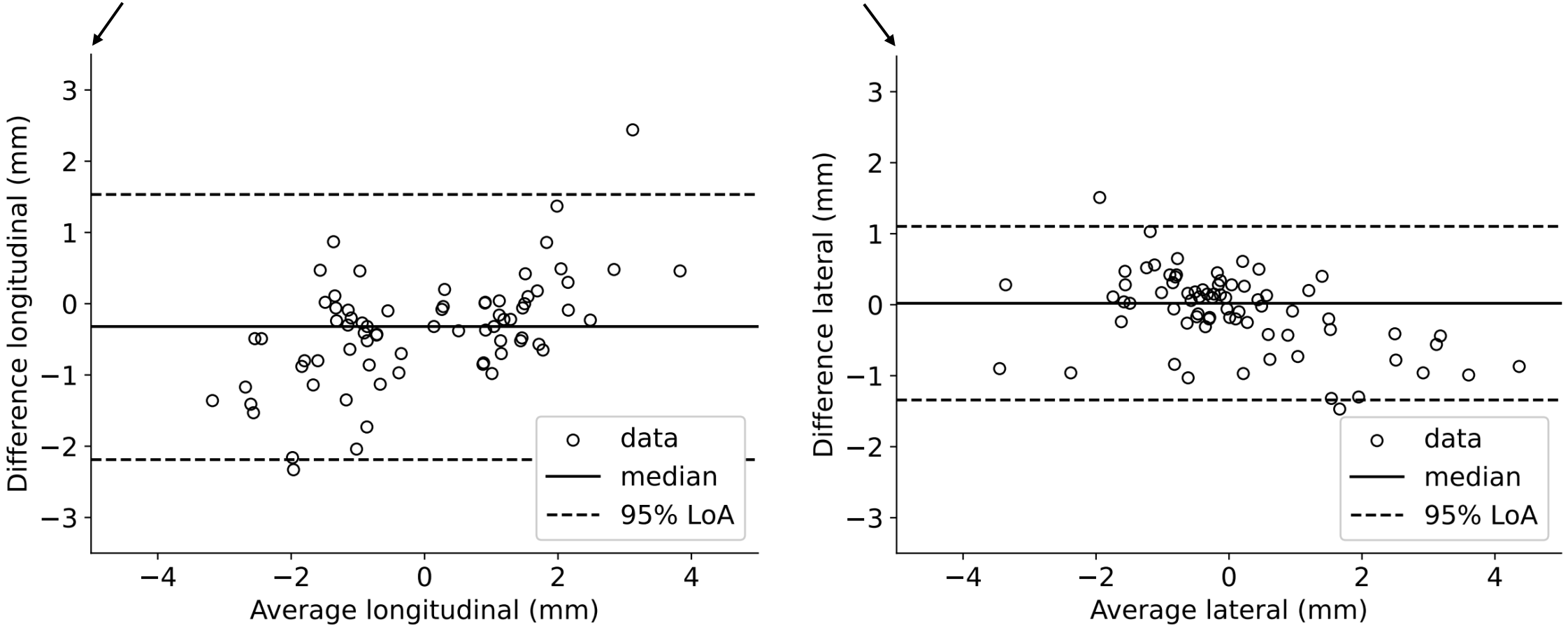


AlignRT



SGRT study – RESULTS

Disagreement between CBCT and AlignRT



Average between CBCT and AlignRT

SGRT study – RESULTS

Limitations of the study

- Only 22 patients
- New reference surface was not gated
  - Longitudinal signal is distorted by breathing motion → more deviation in data
  - Analysis using exhale phase?
- No dosimetric estimation of secondary motion effect
  - Clinical relevance of secondary motion?

SGRT study – CONCLUSIONS

Patients with light or no fixation would benefit from secondary motion correction

- kV, kV/kV, CBCT, SGRT?

AlignRT was able to detect secondary motion – compared to CBCT

- 95% Limits of Agreement -1.3 mm and 1.1 mm in lateral direction
- 95% Limits of Agreement -2.2 mm and 1.5 mm in longitudinal direction

SGRT study – CONCLUSIONS

Possible workflow:

Setup CBCT → CBCT translations → New reference surface

→ Back to 3D-3D match → CBCT rotations

→ correct secondary movement with AlignRT

Based on this study

- Residual error after SGRT correction should be within 2mm

BUT

Requires validation!

- CBCT?

Thank you for your attention!

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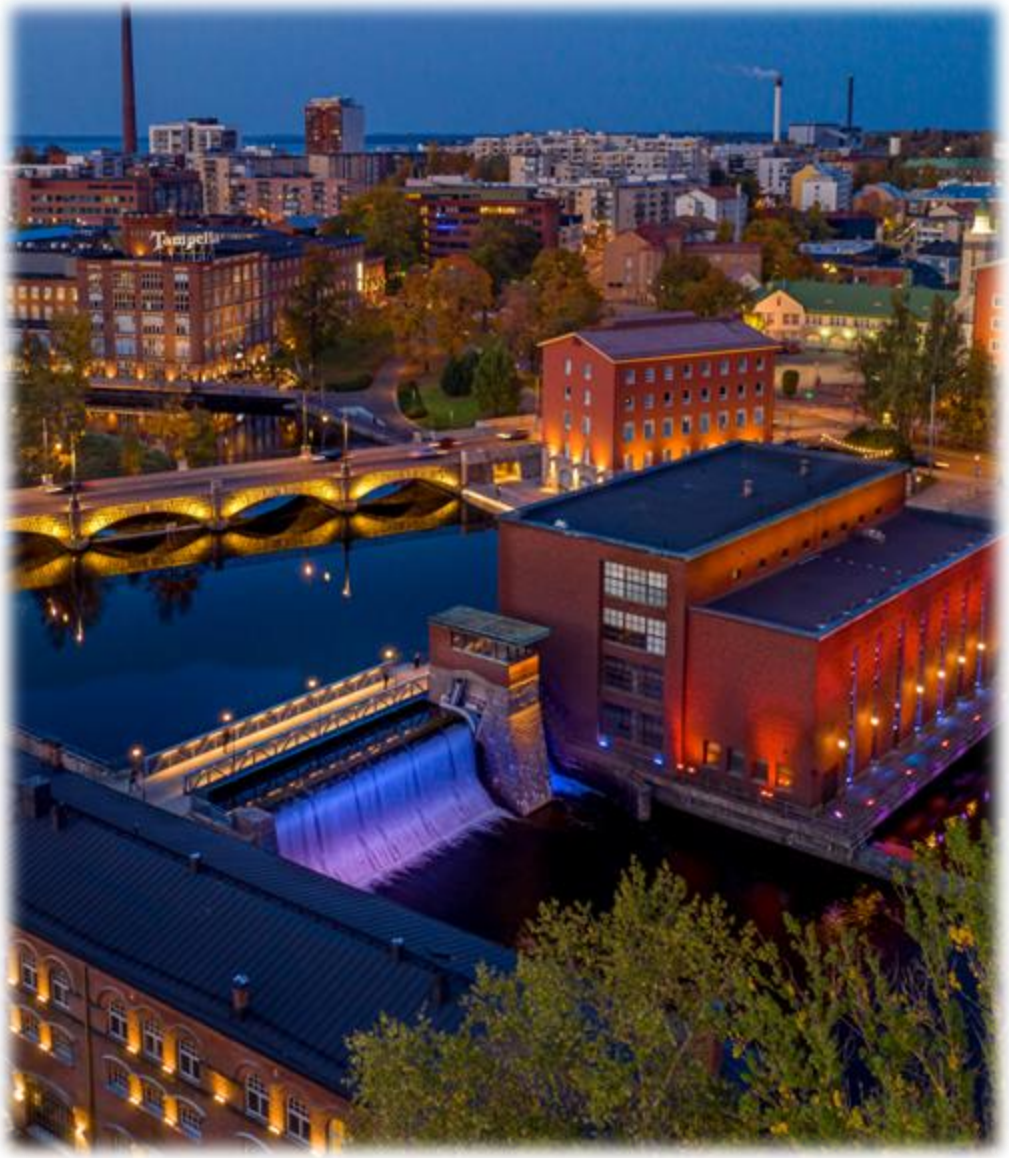

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