Benchmarking **maprt**® and first clinical experience: a novel solution for collision-free non-coplanar treatment planning

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- Introduction & clinical context

- What is **maprt**® ?

- Accuracy evaluation of **maprt**®

- First experience of **maprt**®

- Conclusion

Introduction & clinical context

## Centre Georges-François Leclerc, Dijon, Burgundy, France

- More than 2100 patients per year treated by RT
  - 90% modulated RT: IMRT or VMAT
  - 30% SBRT

- 5 linacs:
  - 2 Halcyon (Varian), 1 Truebeam (Varian), 1 Truebeam stx (Varian): all equipped with alignRT
  - 1 MRIdian (Viewray)

- alignRT users since 2020

- maprt® users since September 2023

- RT in the 2020s: sharp increase in indications for SBRT and reirradiation

  - Increasing complexity of RT planning (more OAR dose constraints)
  - More non coplanar beam configurations

  - Increase the risk of undeliverable plan → collision risks
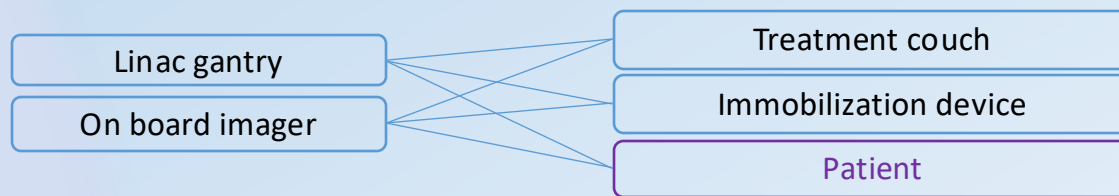 - Increase of dry run for plan testing
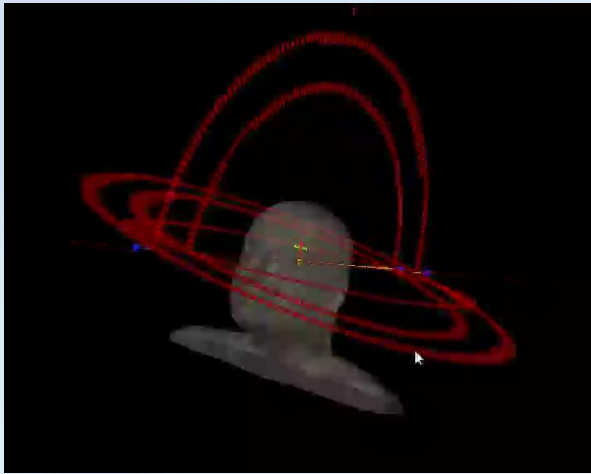
Hippocampal-sparing whole brain radiotherapy
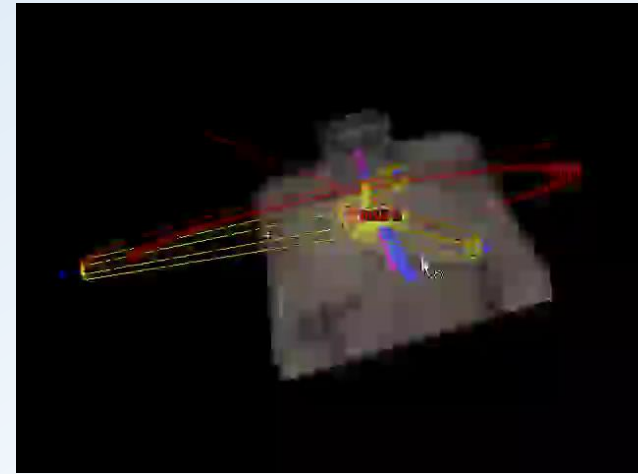
Lung tumor close to OAR

- ## Different types of collisions

Linac gantry		Treatment couch
On board imager		Immobilization device
		Patient

- ## Today practices: Dry run (with or without patient)

  Avoid collision risk
  Increase linac occupancy
  Increase RTT/physicist workload
  Increase patient time

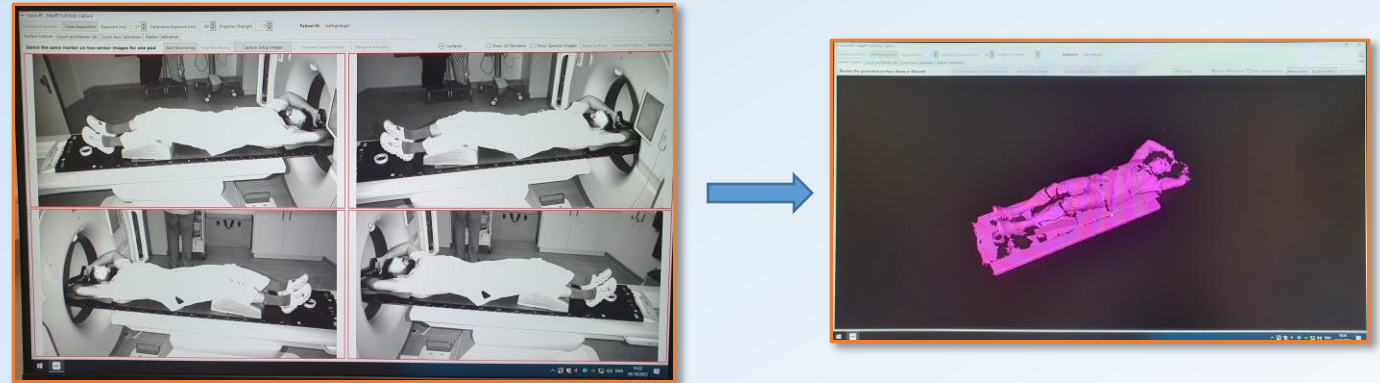Solution: collision detection tool with limited additional workload

maprt®

What is **maprt**® ?

- **maprt**® works with:

2 additional lateral cameras
installed at the CT scan

b.

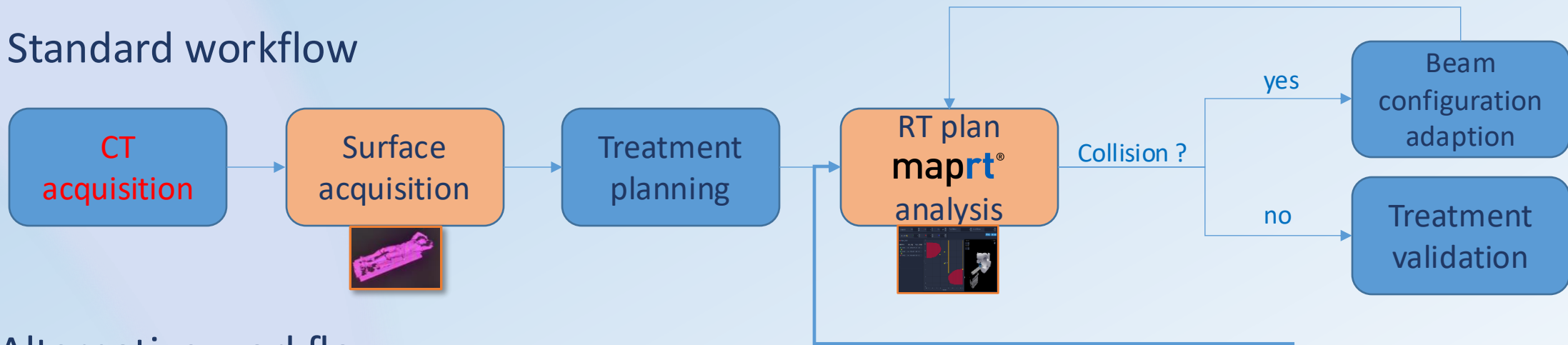**1 acquisition software**: patient surface
and immobilization devices

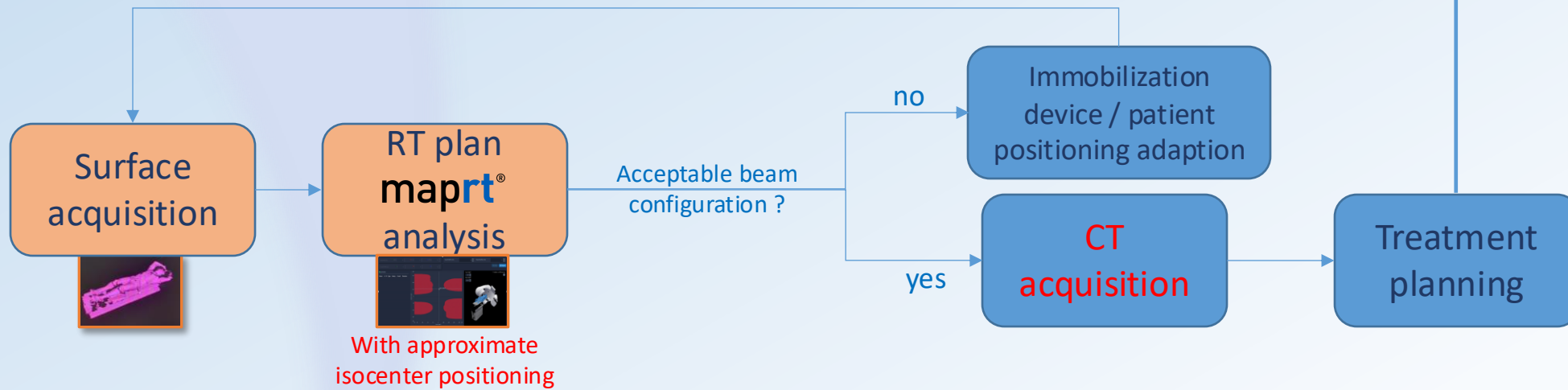**1 analysis software**: simulation of
the patient and linac interactions

- Analysis software:

- ## Standard workflow

```
CT acquisition → Surface acquisition → Treatment planning → RT plan maprt® analysis → Collision ?
   yes → Beam configuration adaption
   no → Treatment validation
```

- ## Alternative workflow

```
Surface acquisition → RT plan maprt® analysis (With approximate isocenter positioning) → Acceptable beam configuration ?
   no → Immobilization device / patient positioning adaption
   yes → CT acquisition → Treatment planning
```

Suitable for complex and/or atypical positioning, examples:
- positioning of inferior limbs
- positioning of arms in VMAT breast or apical lung treatments

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Accuracy evaluation of **maprt**®
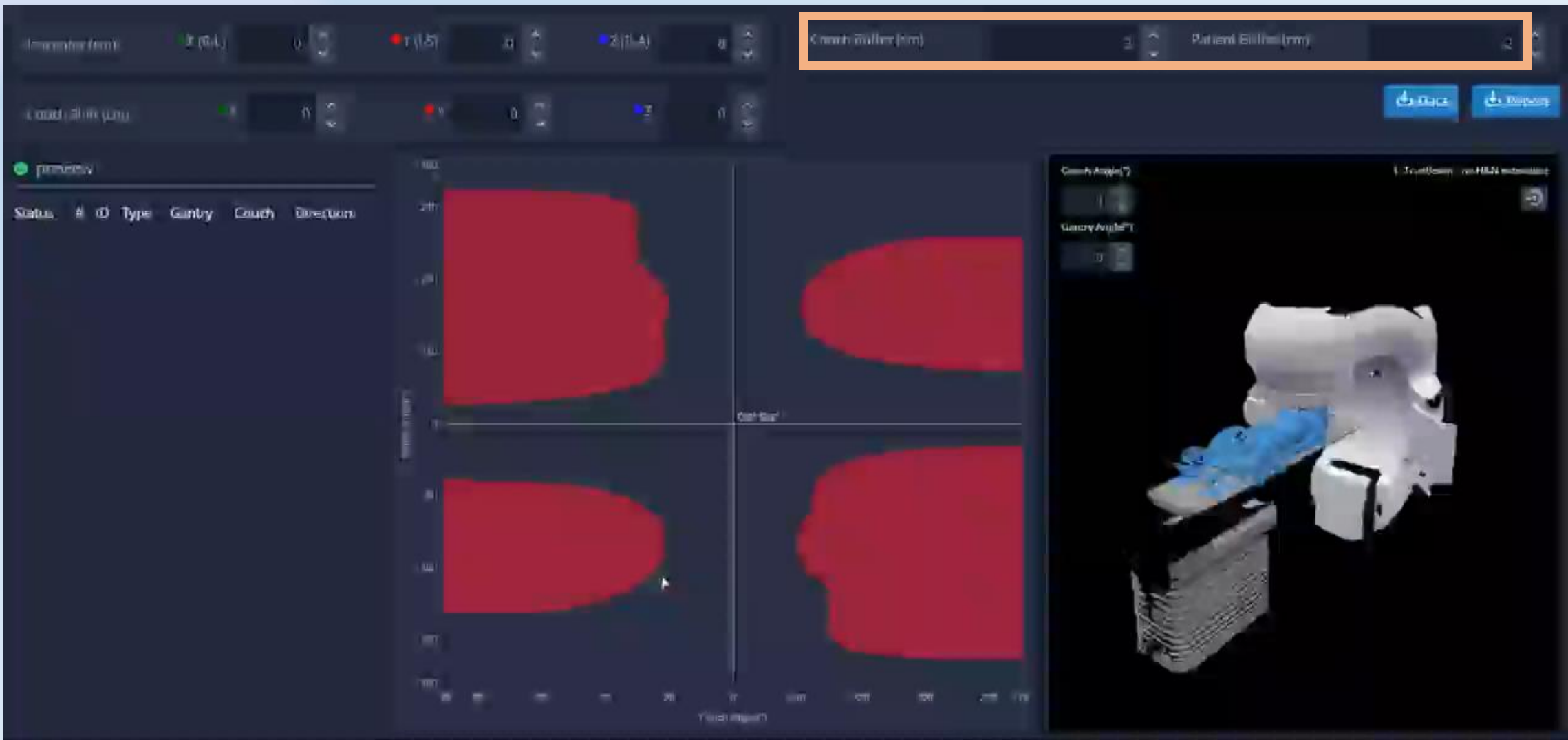
How accurate and reliable are the collision limits predicted by **maprt**® ?

Use of a simple polystyrene phantom $30 \times 35 \times 40$ cm^3

1. 64 limit positions selected on the clearance map with buffer 0 cm
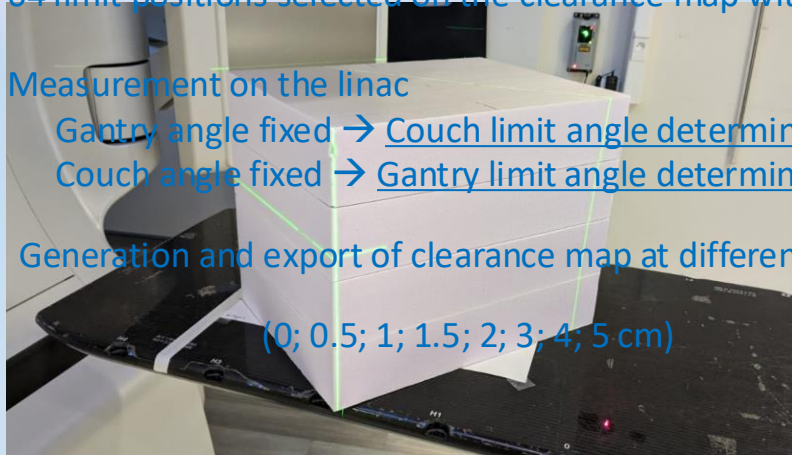
2. Measurement on the linac
   Gantry angle fixed → Couch limit angle determining
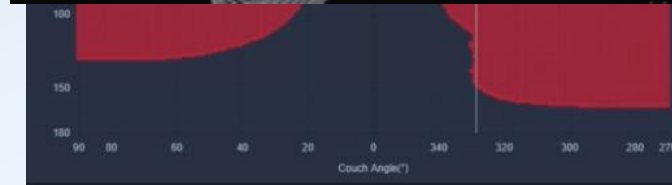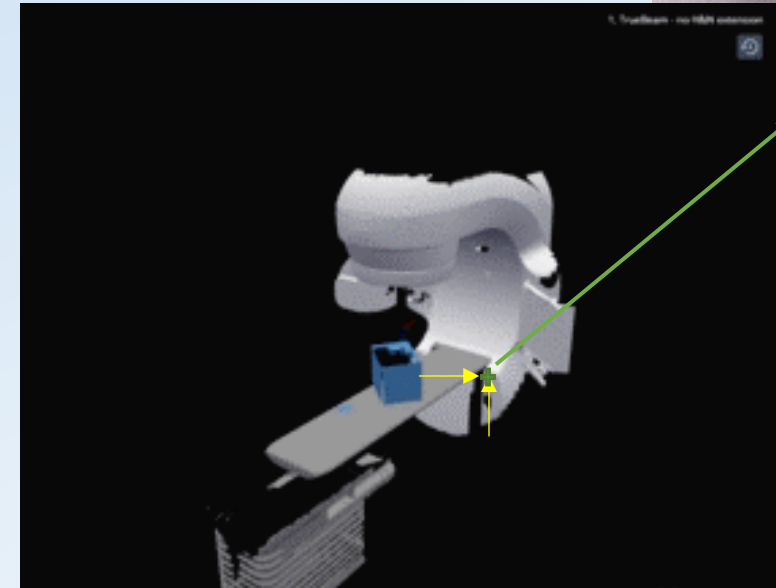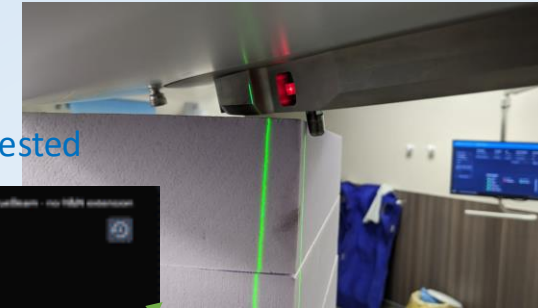   Couch angle fixed → Gantry limit angle determining

3. Generation and export of clearance map at different buffer size

   (0; 0.5; 1; 1.5; 2; 3; 4; 5 cm)

4. VBA script analysis

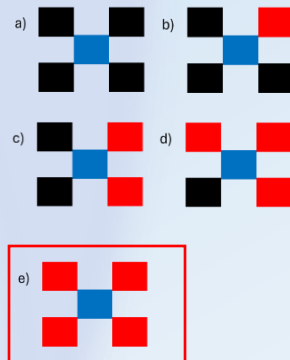Characterization of the limit position according to the buffer size

a)
b)
c)
d)
e)

Agreement ?

Definition of a safe buffer size

11 isocenters phantom positions tested

Clearance map with buffer 0 cm
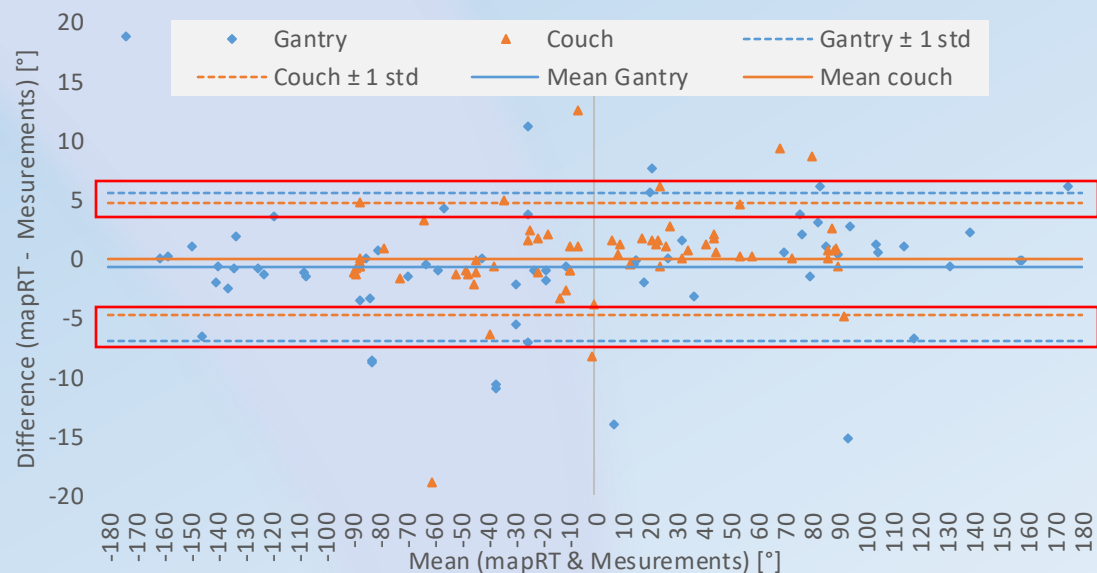
MapRT - Measurement @ buffer = 0 cm	Gantry	Couch
Mean difference [°]	-0.5	-0.1
Standard deviation [°]	6.2	4.8

Average of the difference close to 0 → Agreement acceptable

High standard deviation → Buffer is required

Bland-Altman plot Measurement vs mapRT with a buffer size = 0 cm

Safe buffer

Agreement rate between measurements and mapRT clearance map according to the buffer size

Buffer	0	0.5	1	1.5	2	3	4	5
All - All	4.6%	58.5%	64.6%	73.8%	80.0%	95.4%	98.5%	98.5%
Machine - Phantom	4.3%	47.8%	56.5%	78.3%	87.0%	100.0%	100.0%	100.0%
PID - Couch	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Machine - Couch	9.5%	61.9%	71.4%	76.2%	85.7%	100.0%	100.0%	100.0%
kVd - Couch	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
kVs - Couch	0.0%	58.3%	58.3%	58.3%	58.3%	91.7%	91.7%	91.7%

From buffer size = 3 cm → 100% collisions (linac/table/PID/Patient) are well predicted

mapRT v1.1: kVd and kVs only one position modelized

First experience of **map**rt®

maprt® use on a 11-month period

- September 2023: MapRT v.1.0

- February 2024: MapRT v.1.1 (small bug fixed)

- June 2024: MapRT v.1.2 (software optimization)

900 treatment plans prospectively checked for collisions during planning (by dosimetrist or physicist)

- On two linacs: Truebeam (Varian) and TPS: Eclipse v17 (Varian)

- All treatment technic : VMAT, IMRT and Conformal RT

- Coplanar and Non coplanar beam configurations

- No cancer site restriction

- 2 cm buffer size based on VisionRT recommendations (accuracy study not finalized yet)

- 22 plans (2.4%): collision anticipated/avoided with mapRT

- 6 plans (0.6%): collision detected during dry run/first session
  1 with kVd
  1 with immobilization device too thin…
  4 others due to oversights: no 3D surface acquired at simulation or plan not tested in mapRT

- Excluding these particular situations, no treatment was postponed or cancelled due to collision when using mapRT

- 165 plans (18.4%): optimized based on clearance map to increase the range of arc amplitude, couch rotation or isocenter positioning

- Examples of clinical collisions detected thanks to **maprt**®
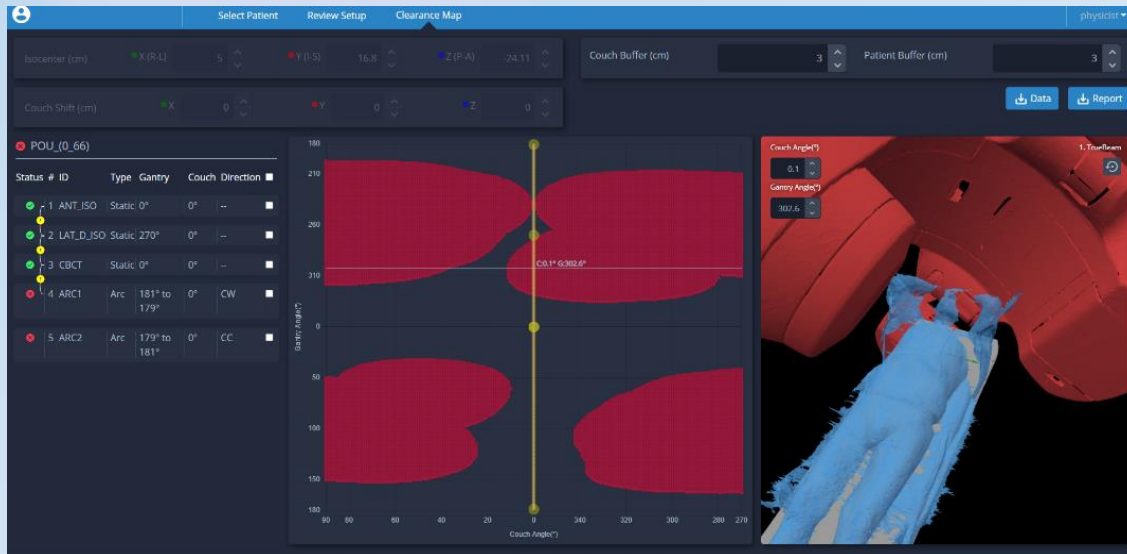
Lung case planned with coplanar arcs where the machine collisioning the elbow and the immobilization device
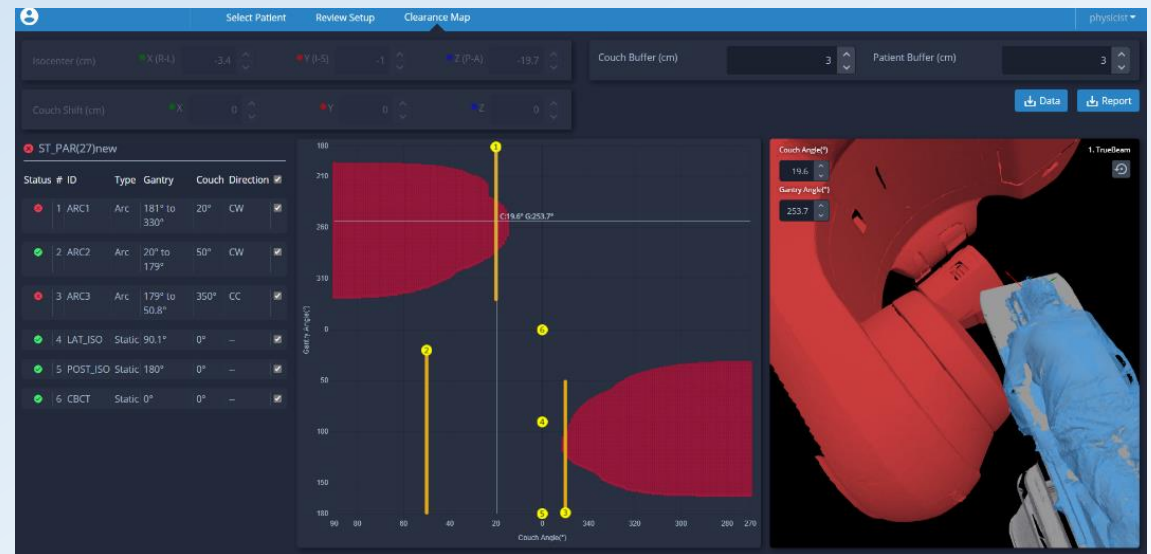
Cranial steretotactic planned with non-coplanar arcs where the machine collisioning the elbow of the patient even if it is along the body

- System is reliable even with a reduced 2 cm wide buffer value

- Excluding 4 cases due to human insights, only 2 out of 900 plans (0.2%) encountered a collision

- 1 of these collisions due to an inherent limitation of the kVd modeling (several positions of kV imager are available since July 2024)

- 22 collisions cases avoided were for coplanar beams (arms above the head and posterior isocenter): collisions are not only a concern for non coplanar treatment → all treatment could benefit from MapRT

- More than 10-year long experience of non coplanar treatments use for intra and extracranial sites

→ explains the limited number of collisions detected (22/900, 2.4%)

→ probably greater for clinics newly starting a non coplanar treatments program for extra cranial pathologies
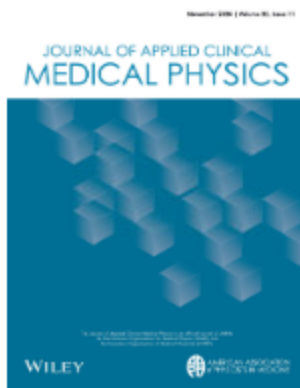
Conclusion

- mapRT intrinsic accuracy evaluated

- For a safe use, the buffer size (patient + couch) at:
  - 3 cm according to our accuracy study including very singular limit points on the clearance map
  - 2 cm according to our clinical experience including only classical limit points

- Beam configuration secured and optimized

- Next step: remove systematic dry runs

- Time saved for the planner, the patient and the RTT

- mapRT is not only a collision prediction tool → simplify and make safer non coplanar workflow

  (see Mathieu Gonod's presentation this afternoon)

More information about this work in this article (accepted, in production):

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Thank you for your attention

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