IMPROVING
THE ENTIRE RT WORKFLOW

SGRT:
GAME CHANGER

A safe workflow for non-coplanar radiation therapy in H&N cancer

THE 2024 ANNUAL MEETING
OF THE SGRT COMMUNITY

28 & 29 Nov 2024

etc.venues County Hall (London)

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CGFL
CENTRE GEORGES FRANÇOIS LECLERC
Ensemble, dépassons le cancer

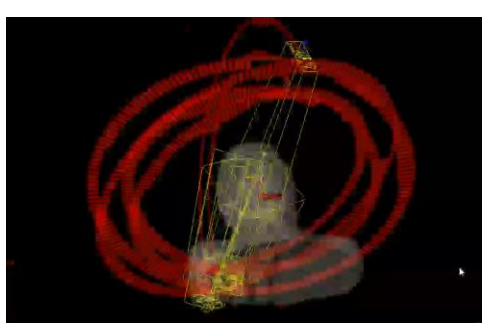
Introduction

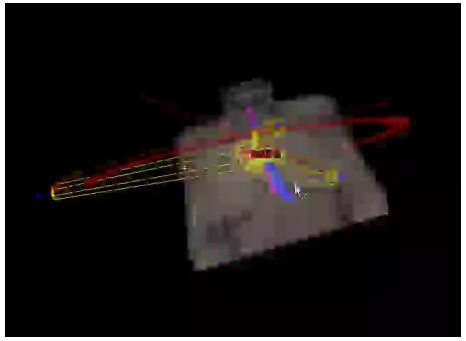
- Increasing the complexity of treatment
  - Increase restrictivity of OAR dose contraints, proportion of SBRT and re-irradiation

➔ Increasing beam configuration complexity
  ➔ Multiplying treatment fields
  ➔ Increase proportion of N-Cop treatments

Year	Activity distibution	Complexification	Number of detected « collisions » at Dry run
2021	Conformal: 44% IMRT/VMAT: 31% SBRT: 25%	–	11
2022	Conformal: 35% IMRT/VMAT: 29% SBRT: 35%	–	11
2023	Conformal: 14% IMRT/VMAT: 57% SBRT: 29%	+	30
2024	Conformal: ~1% IMRT/VMAT: ~69% SBRT: ~30%	++	

➔ Increased risk of unfeasable plans





- Lung: Kim, Sang-Tae (2020) *DOI: 10.1259/bjr.20190596*
- Lung: Ma, Min (2021) *DOI: 10.1002/acm2.13197*
- Head & Neck: Gayen, Sanjib (2020) *DOI: 10.3857/roj.2020.00143*
- Head & Neck: Woods, Kaley E (2022) *DOI: 10.3390/cancers14040939*
- Mediastinal: Rossi, Linda (2021) *DOI: 10.3389/fonc.2021.619929*
- Breast: Frengen, J (2023) *DOI: 10.1080/0284186X.2023.2264488*
- SBRT: Biau J (2022) *DOI:10.1016/j.ctro.2022.11.007*
- SBRT: Lincoln J (2023) *DOI: 10.1088/1361-6560/ace23f*
- Multi: Bertholet J (2023) *doi.org/10.1002/mp.16899*
- Multi: Loebner HA (2023) *DOI:10.1002/mp.16533*

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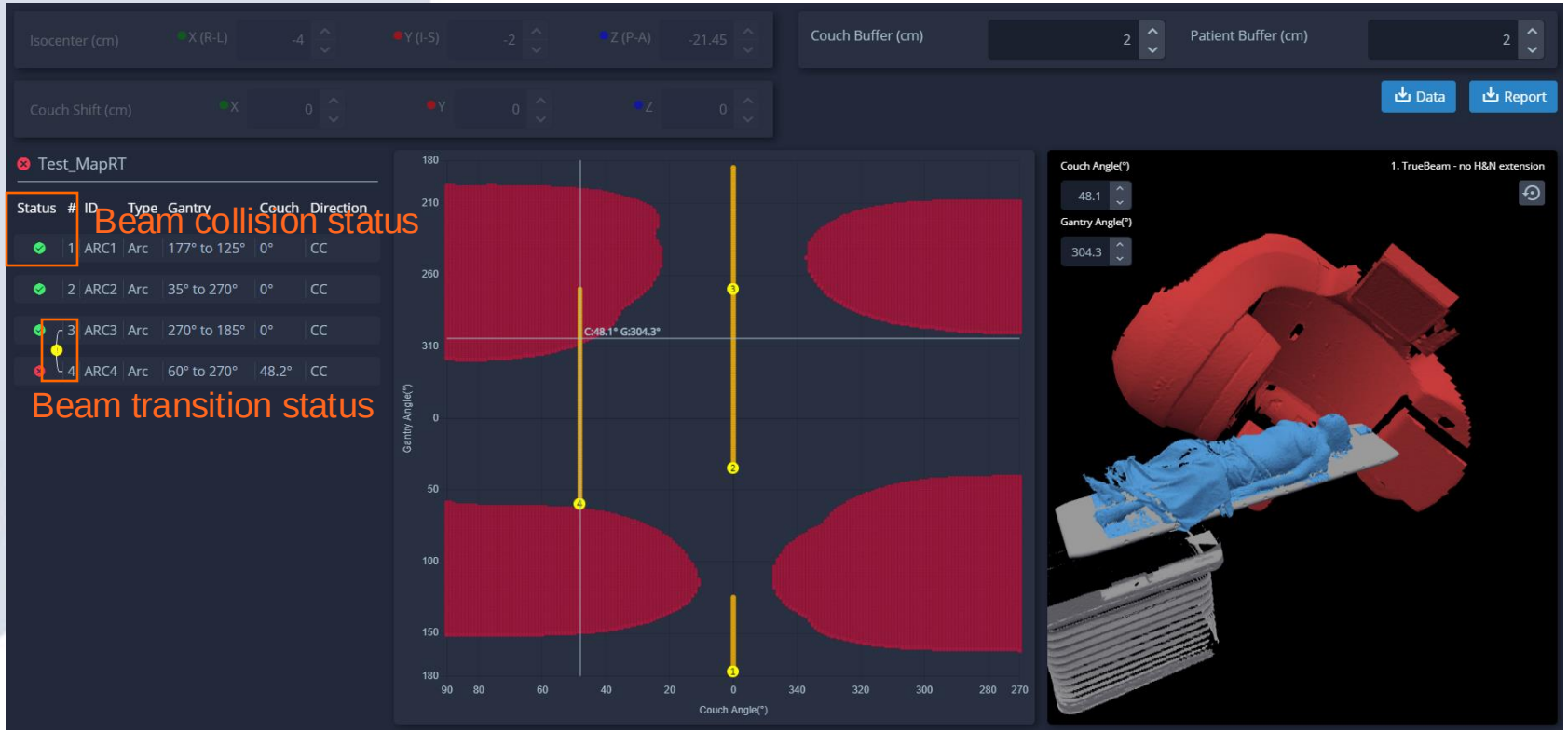
Introduction

- Secure N-Cop plans
  - Schedule a Dry Run session
  - RTT have to go in-room for couch rotation between fields
    - ➔ Machine time: *Dry Run ~ 20 min || Couch rotation by RTT ~ + 30 s / rotation*
  - Sept 2023: maprt®



Treatement

Dry run
Fields test

Treatment fractions
CBCT
Arc1
Arc2
Couch rotation → in-room
Arc3
Arc4

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Introduction

- 1 year feedback

Year	Activity distibution	Complexity	Number of detected « collisions » at Dry run
2021	Conformal: 44% IMRT/VMAT: 31% SBRT: 25%	–	11
2022	Conformal: 35% IMRT/VMAT: 29% SBRT: 35%	–	11
2023	Conformal: 14% IMRT/VMAT: 57% SBRT: 29%	+	30
2024	Conformal: ~1% IMRT/VMAT: ~69% SBRT: ~30%	++	

  - Sept 2023 – June 2024: All plans for all patients ~900 plans
    - 22 unfeasible treatment avoided even if the planner was sure of himself
    - ~ 50 plans: mapRT analysis before beam configuration
    - ~ 165 plans optimised with MapRT
    - 6 remaining « unfeasible treatment»

→ 4: acquisition or export oversigths
→ 1: CBCT collision ➔ CBCT inserted in mapRT v1.2 June 2024
→ 1: too thin immolisation device part ➔ Buffer = 3 cm (after evaluation – paper JACMP dec 24)

  - May 2024 – Oct. 2024: 0 unfeasible plan
  - No need to perform on-machine beam configuration tests during the planning step

Time consumming

- CT Daily QA < 5 min
- Surface acquisition at CT< 1 min
- Plan check calculation < 1min

Introduction

- 1 year feedback

  ➔ Confidence in collision avoidance map

  → Dry run ?

  → N-cop: In-room RTT for couch rotation ?

Year	Activity distibution	Complexity	Number of detected « collisions » at Dry run
2021	Conformal: 44% IMRT/VMAT: 31% SBRT: 25%	–	11
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2023	Conformal: 14% IMRT/VMAT: 57% SBRT: 29%	+	30
2024	Conformal: ~1% IMRT/VMAT: ~69% SBRT: ~30%	++	6 (Jan - May) 0 (June – Nov)

- What is the impact on "non-complex" treatments?
  - Search for the site with the greatest advantage of N-cop planning
    - Head & Neck
      - Trade-off OAR sparing / PTV coverage
      - Impact on DVH ?
      - Impact on expected toxicities ?
      - Impact on treatment duration ?

Treatment

Dry run

Fields test

Treatment fractions

CBCT

Arc1

Arc2

Couch rotation → in-room

Arc3

Arc4

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Introduction

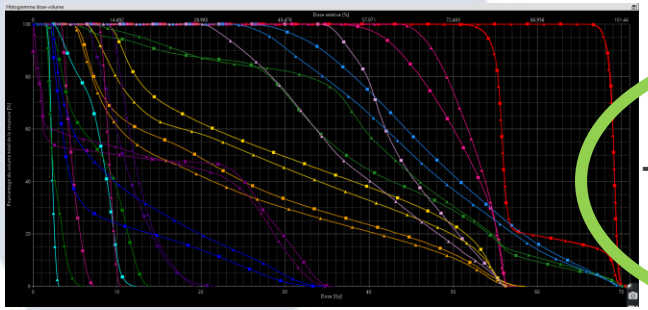
- Head & Neck: actual workflow

Treatment planning

maprt®

42 non-coplanar arcs

→ Collision status
→ Beam optimisation



→ Improved DVH

True ?

Treatment

Dry run

Field tests

MET et fractions

CBCT
Arc1
Arc2
Couch rotation → RTT in-room
Arc3
Arc4

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Material & Method

- Reference plans

- 2-3 Cop arcs
- RapidPlan (Varian) v17 – PO/AAA v17

- **10 patients with bilateral CTV**
- **Dose 66/70 Gy – SIB**

- **DVH evaluation according to local practices**

→ **Same PTV coverage**

- Evaluated plans

- 4 N-Cop partial arcs
- Manual optimisation – PO/AAA v17

→ **Influence on OAR ?**

→ **Gains on DVH ?**

→ **Gains on expected toxicities?**

→ **Workflow duration**

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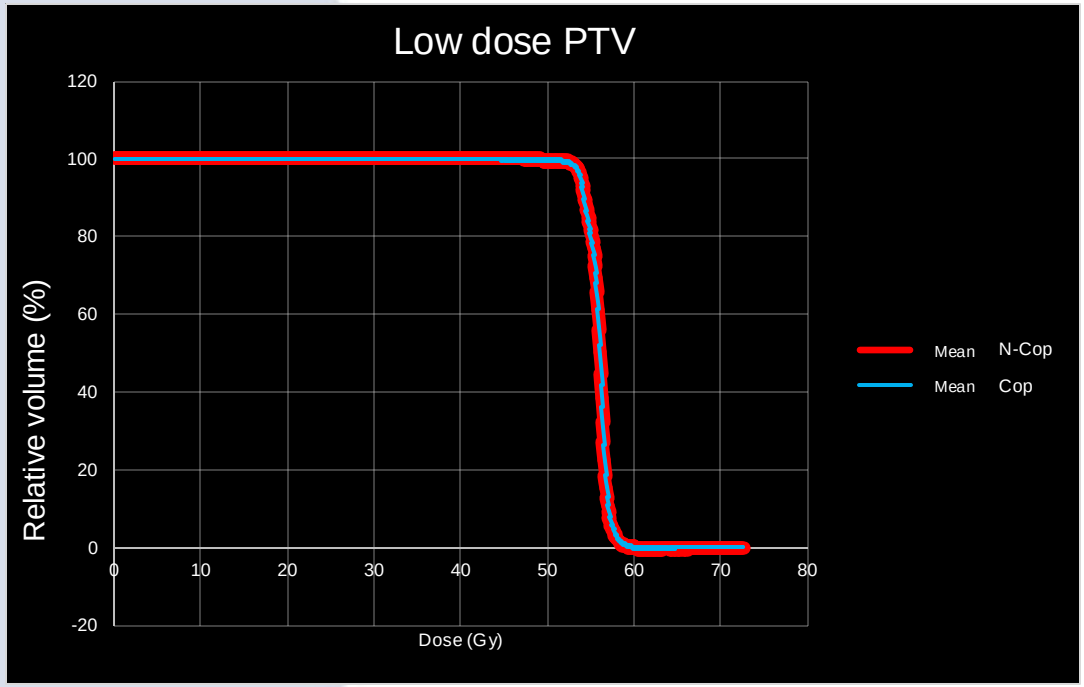
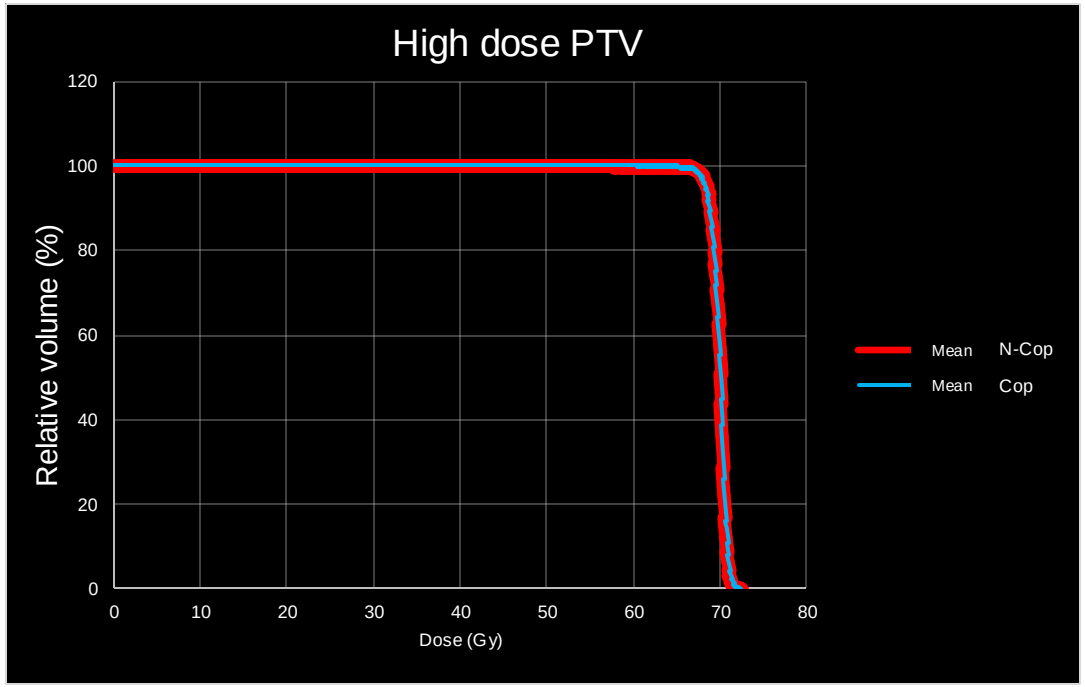
Results

- DVH differences: PTV





D95% = -0.0 Gy
D105% = -0.4 Gy

D95% = -0.0 Gy
D105% = -0.0 Gy

- = N-Cop advantage

+ = Cop advantage

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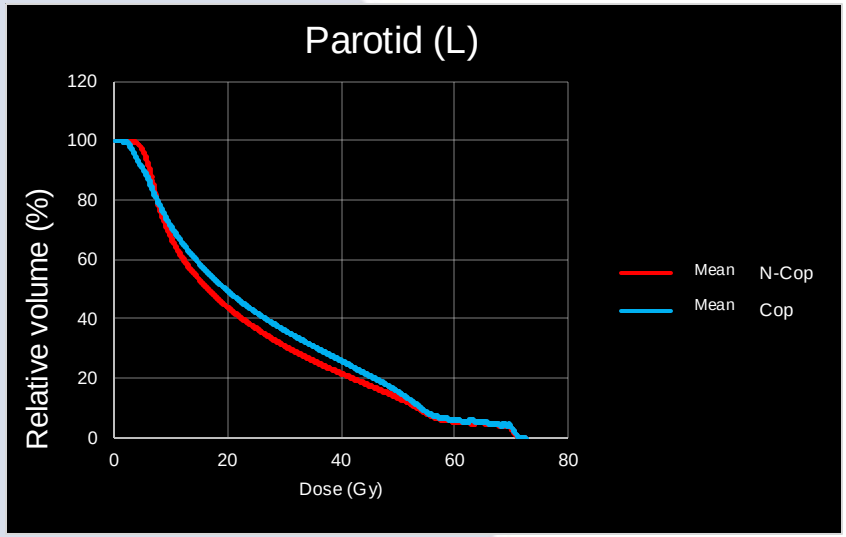
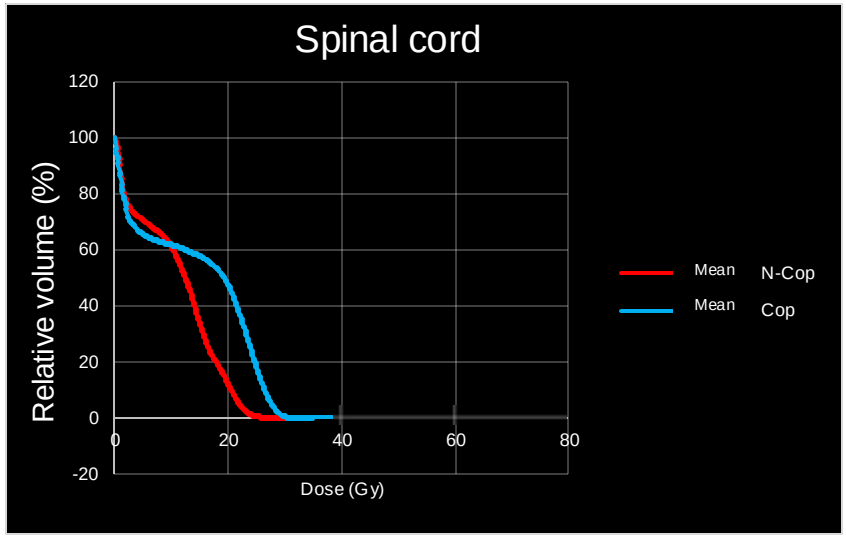
Results

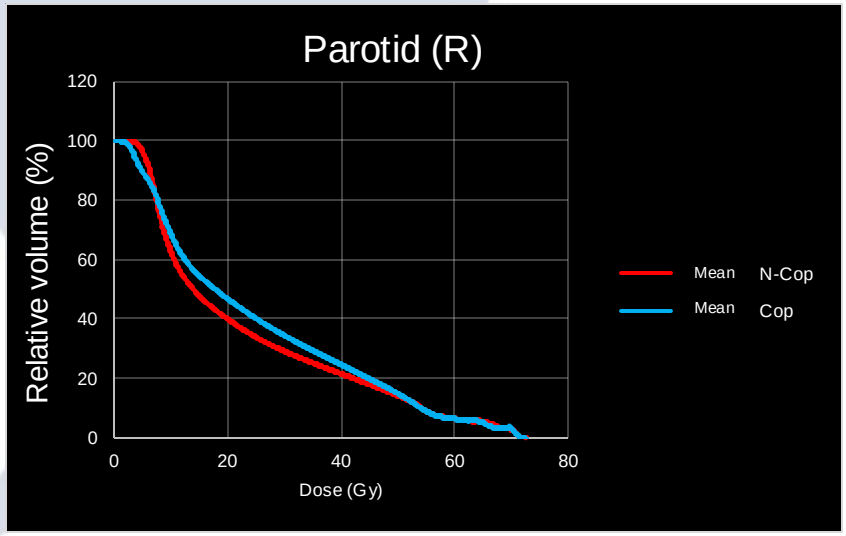
- DVH differences: Parotids, spinal cord



D_{mean} = -1.8 Gy



D_{max} = -7.3 Gy



D_{mean} = -1.8 Gy

- = N-Cop advantage

+ = Cop advantage

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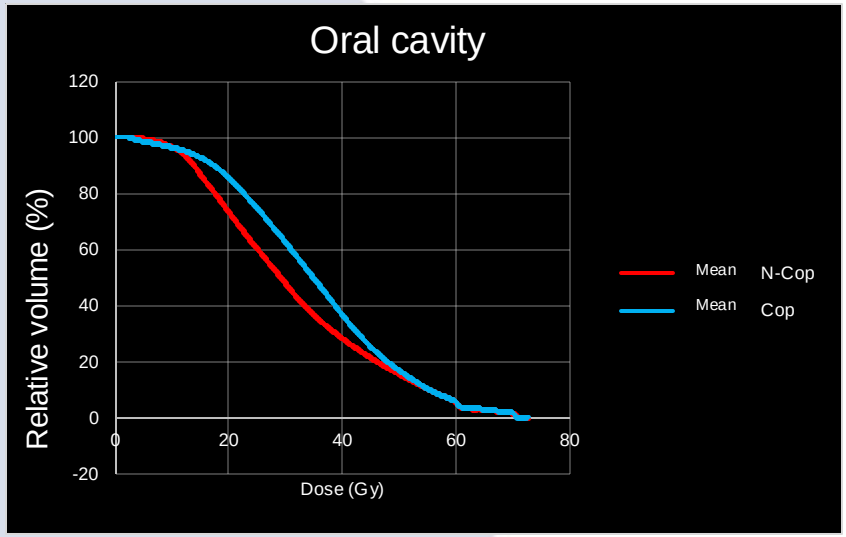
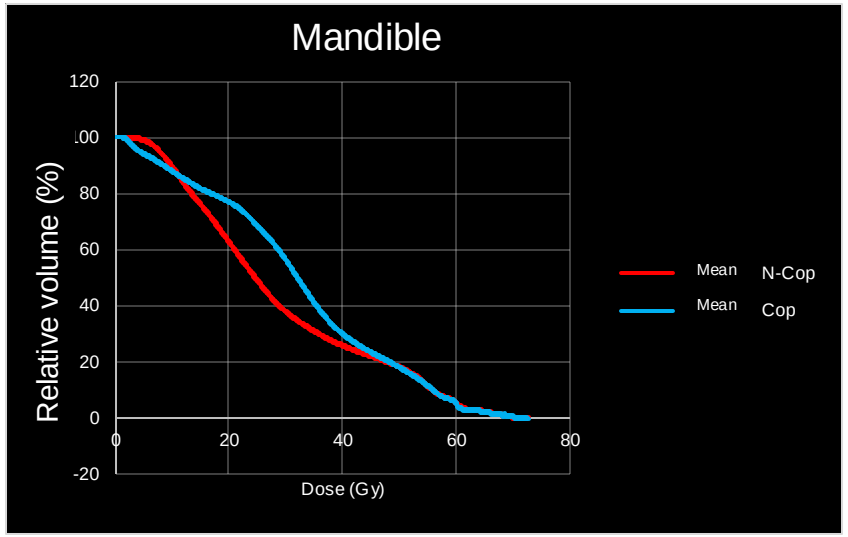
Results

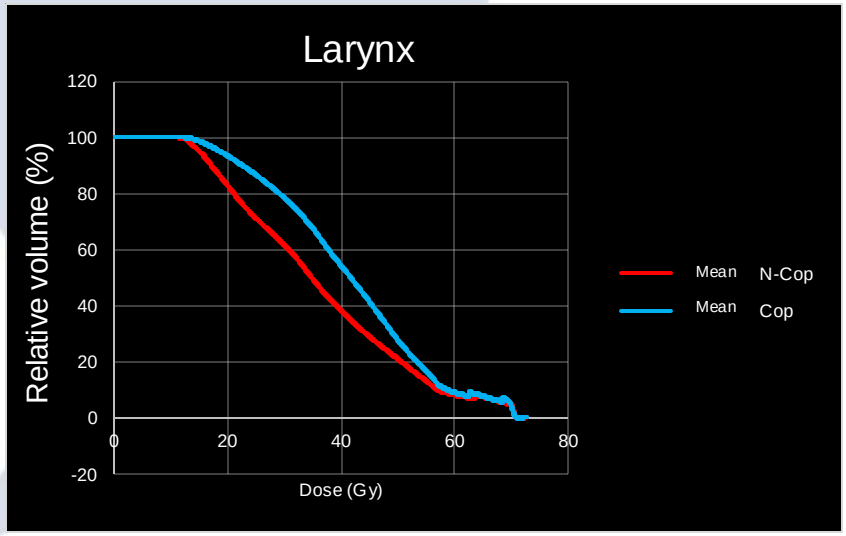
- DVH differences: Oral cavity, Larynx, Mandible, Œsophagus



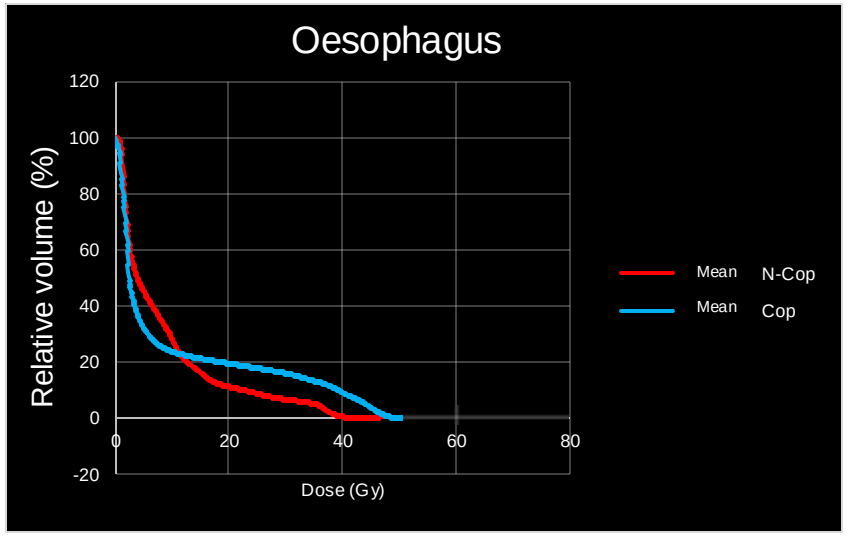
D_{mean} = -3.6 Gy



D_{mean} = -3.4 Gy
D_{max} = -0.1Gy



D_{mean} = -5.2 Gy
D_{max} = 0.0 Gy



V_{35Gy} = -8.2 %
$D_{30\%}$ = +4.4 Gy

- = N-Cop advantage

+ = Cop advantage

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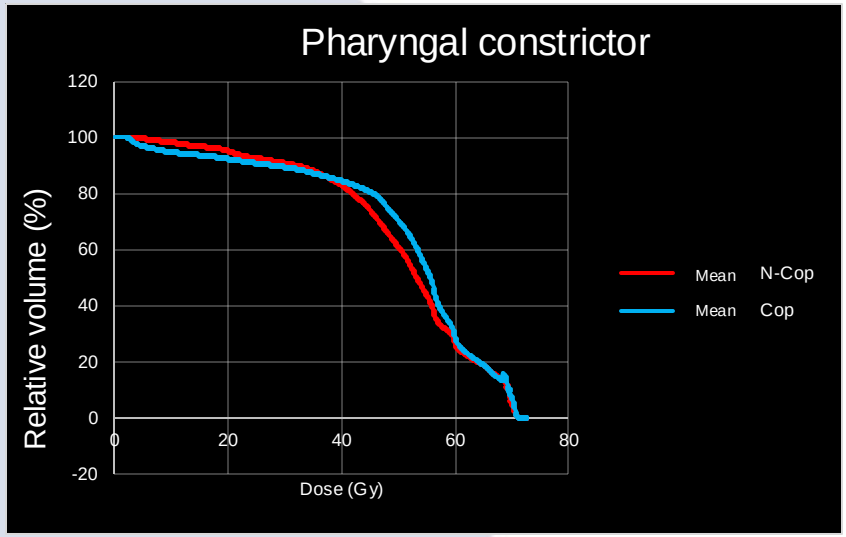
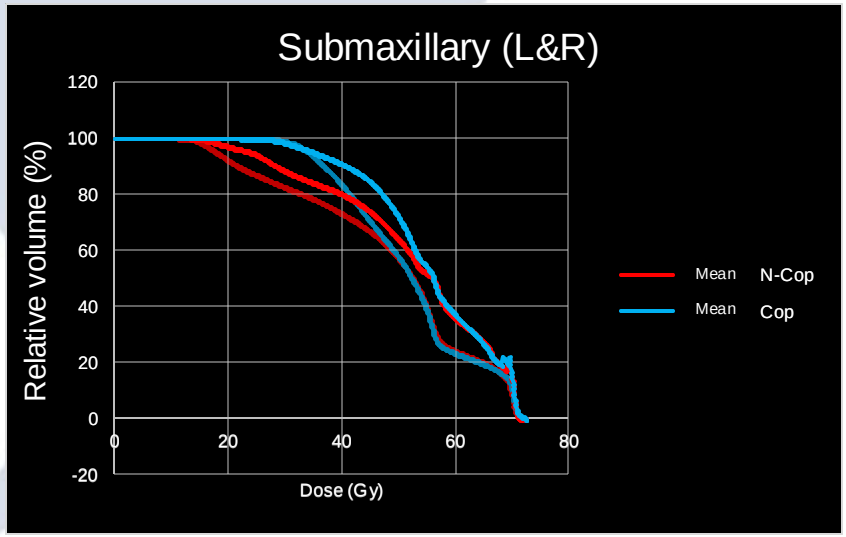
Results

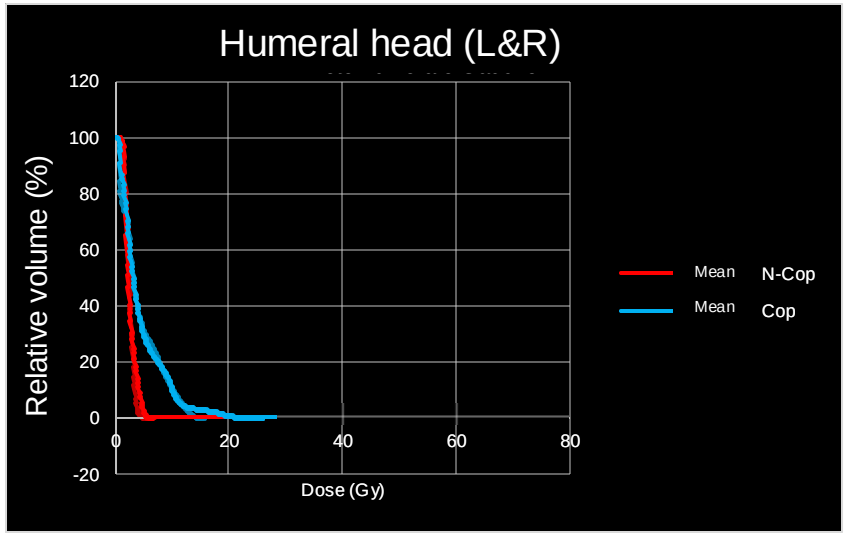
- DVH differences: Pharyngal constrictor, Submaxillary, Humeral head



D_{max} = -0.7 Gy



D_{mean_R} = -2.1 Gy
D_{mean_L} = -3.1 Gy



$D_{5\%\_R}$ = -3.7 Gy
$D_{5\%\_L}$ = -5.9 Gy

- = N-Cop advantage

+ = Cop advantage

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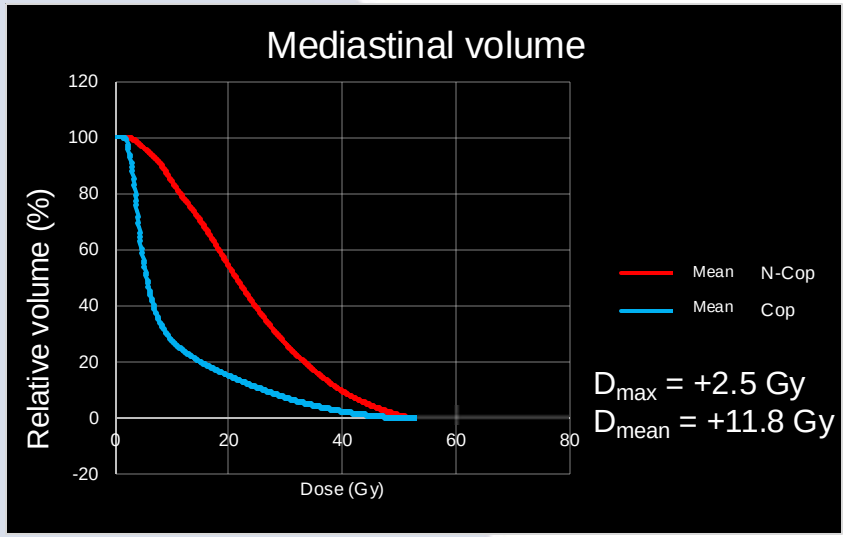
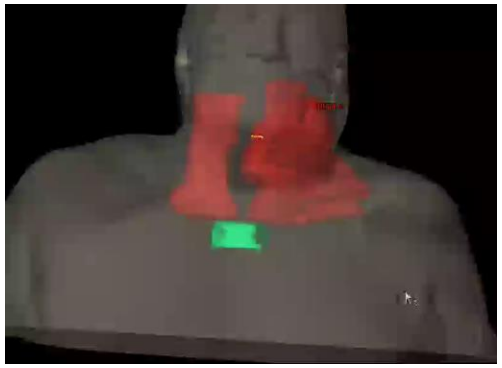
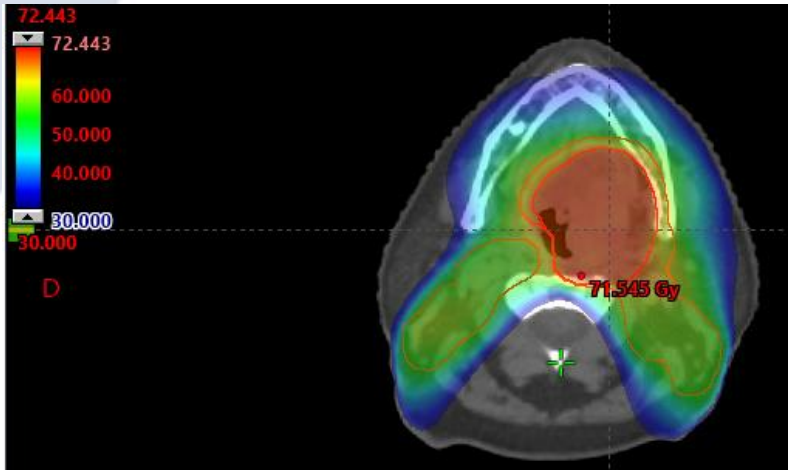
Results

- DVH differences: Mediastinal volume

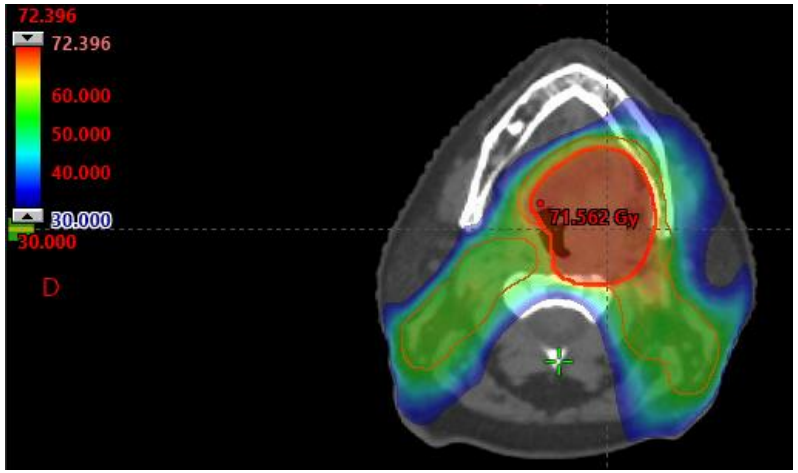




Organ	D_{max} (Gy)	D_{mean} (Gy)
Ant chamber (R)	+0.6	
Ant chamber (L)	+1.3	
Chiasma	+0.4	
Cochlea R	-1.7	+0.5
Cochlea L	+0.5	-0.3
Brainstem	-2.2	



Cop



N-Cop

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Results

- Toxicity differences
  - Gains on DVH ≠ gains on expected toxicities
  - Evaluation of toxicities rate:

    → Cop – N-cop

Review › Int J Radiat Oncol Biol Phys. 1991 May 15;21(1):109-22.
doi: 10.1016/0360-3016(91)90171-y.

Tolerance of normal tissue to therapeutic irradiation

B Emami [1], J Lyman, A Brown, L Coia, M Goitein, J E Munzenrider, B Shank, L J Solin, M Wesson

Affiliations + expand

PMID: 2032882 DOI: 10.1016/0360-3016(91)90171-y

Emami, B. (1991). Tolerance of normal tissue to therapeutic irradiation. IJROPB doi.org/10.1016/0360-3016(91)90171-Y

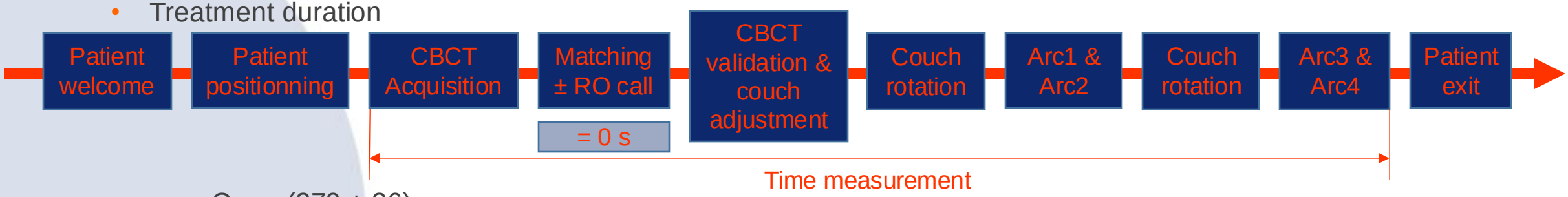
Emami, B. (2013). Tolerance of normal tissue to therapeutic radiation. *Reports of radiotherapy and Oncology*, *1*(1), 123-7.

Organ	Number of patients	Toxicity
Cochlea (R)	-2	Hearing loss for 15% of patients
Larynx	-1	Œsophagitis Grade ≥2
Parotid (L)	-1	Xerostomia
Parotid (R)	-1	Xerostomia

- No negative results on N-cop plans

Results

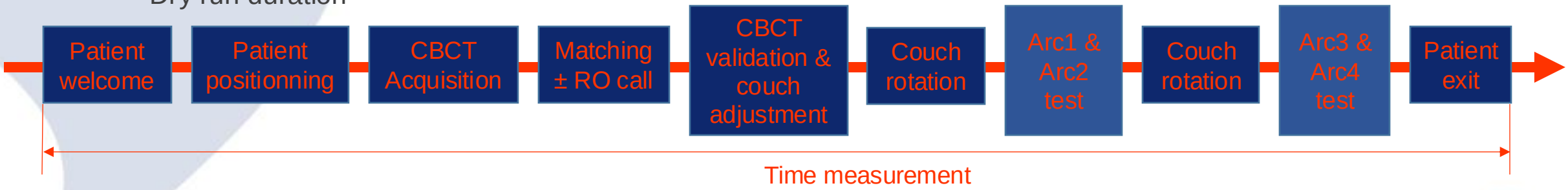
- Workflow duration
  - Treatment duration



- Cop= (270 ± 36)s
- N-Cop= (371 ± 9)s (+101 s)
- N-Cop with MapRT= (319 ± 9)s (+49 s)

➔ For 35 N-Cop MapRT fractions: 35x49 = +1715 s
➔ Dry run MapRT removable: - 1431 s
➔ For 35 fractions: + 284 s (< 5 min) / patient

  - Dry run duration



- Dry Run N-Cop = (24 ± 8.5) min (1431 ± 508)s
- Dry Run N-Cop with MapRT= (0 ± 0) min (0 ± 0)s

Conclusion

- → Duration < +5 min / patient treatment
- → Improvement on DVH
- → Improvement on toxicities rate
- → Only ten patients

→ Practice changes

→ RTT & RO adoption
(Dry run / rotations out of the bunker)

→ O-ring machine and couch rotation ?

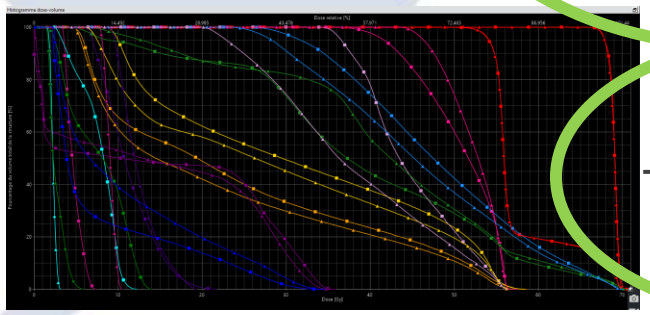
Treatment planning

maprt®

4 partial N-cop arcs

OK

→ Collision status
→ Beam optimisation



→ HDV improved

OK

Treatment

Dry run

Fields test

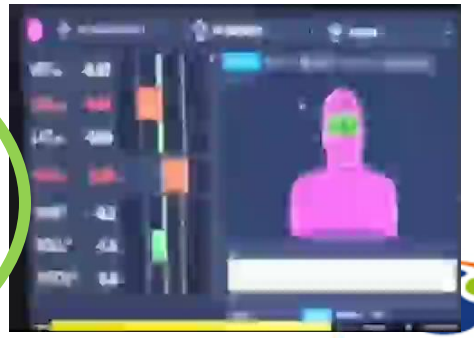
To discuss with RTT & RO

MET et fractions

CBCT
Arc1
Arc2
Couch rotation → RTT in room
Arc3
Arc4

Patient monitoring
Open masks

To discuss with RTT & RO



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Outlook

Dynamic Trajectory RadioTherapy (DTRT)

Dosimetrically motivated beam-angle optimization for non-coplanar arc radiotherapy with and without dynamic collimator rotation

MEDICAL PHYSICS

Jenny Bertholet[1] | Chengchen Zhu[1] | Gian Guyer[1] | Silvan Mueller[1] | Werner Volken[1] | Paul-Henry Mackeprang[1] | Hannes A. Loebner[1] | Marco F. M. Stampanoni[2] | Daniel M. Aebersold[1] | Michael K. Fix[1] | Peter Manser[1]

Technical note: Feasibility of gating for dynamic trajectory radiotherapy – Mechanical accuracy and dosimetric performance

MEDICAL PHYSICS

Accepted: 23 May 2023

Hannes A. Loebner[1] | Daniel Frauchiger[1] | Silvan Mueller[1] | Gian Guyer[1] | Paul-Henry Mackeprang[1] | Marco F. M. Stampanoni[2] | Michael K. Fix[1] | Peter Manser[1] | Jenny Bertholet[1]

Impact of the gradient in gantry-table rotation on dynamic trajectory radiotherapy plan quality

MEDICAL PHYSICS

Accepted: 10 September 2023

Hannes A. Loebner[1] | Silvan Mueller[1] | Werner Volken[1] | Philipp Wallimann[1] | Daniel M. Aebersold[1] | Marco F. M. Stampanoni[2] | Michael K. Fix[1] | Peter Manser[1]

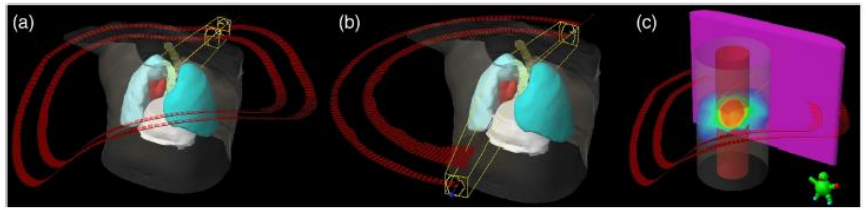


FIGURE 1 DTRT trajectories (a), VMAT arcs (b) and motion phantom with DTRT trajectories (c) for the lung cancer case. The PTV is shown in red, lungs in blue, spinal cord in yellow, oesophagus in green, heart in white and the body surface in translucent grey. The red bands indicate the beam incidences of the DTRT and VMAT plan respectively.

Phys. Med. Biol. **69** (2024) 185009

A dosimetrically motivated pathfinding approach for non-isocentric dynamic trajectory radiotherapy

Gian Guyer, Jenny Bertholet, Silvan Mueller, Chengchen Zhu, Werner Volken, Daniel M Aebersold, Peter Manser and Michael K Fix*

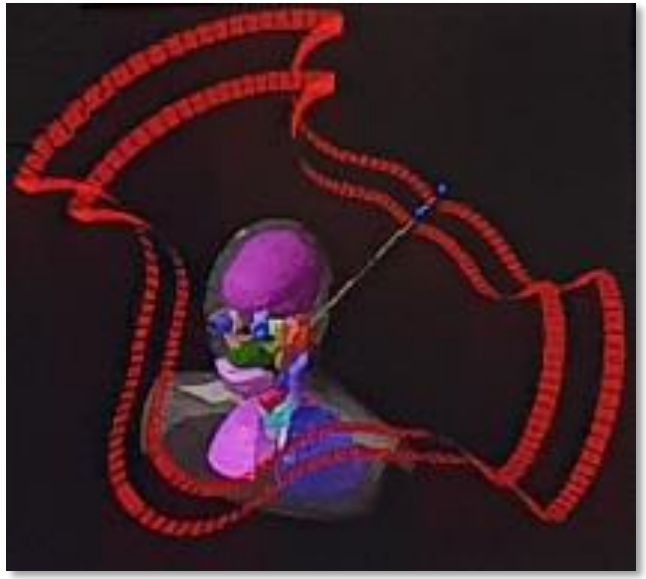
MEDICAL PHYSICS

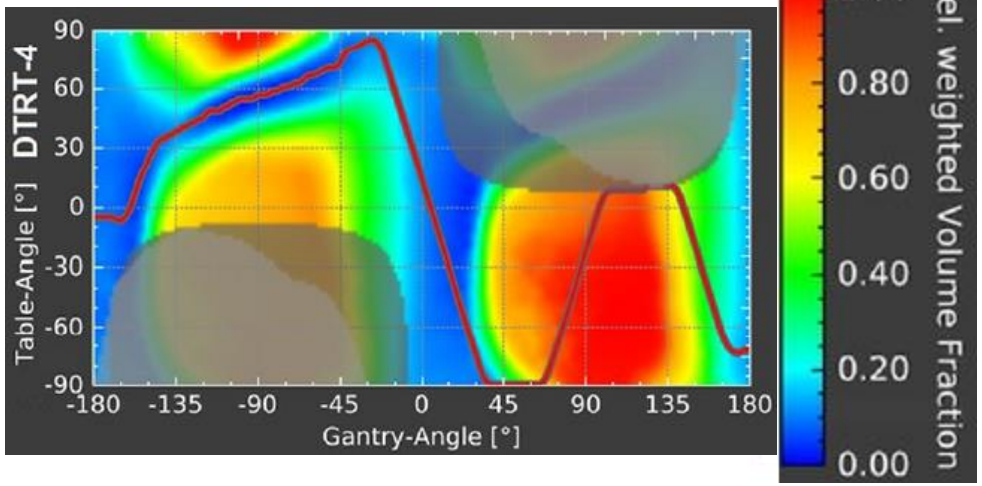
Dosimetric optimization for dynamic mixed beam arc therapy (DYMBARC)

DOI: 10.1002/mp.17467

Received: 19 April 2024 | Revised: 24 August 2024 | Accepted: 30 August 2024

Chengchen Zhu[1] | Gian Guyer[1] | Jenny Bertholet[1] | Silvan Mueller[1] | Hannes A. Loebner[1] | Werner Volken[1] | Julius Arnold[2] | Daniel M. Aebersold[1] | Marco F. M. Stampanoni[3] | Michael K. Fix[1] | Peter Manser[1]





Outlook

Dynamic Trajectory RadioTherapy (DTRT)

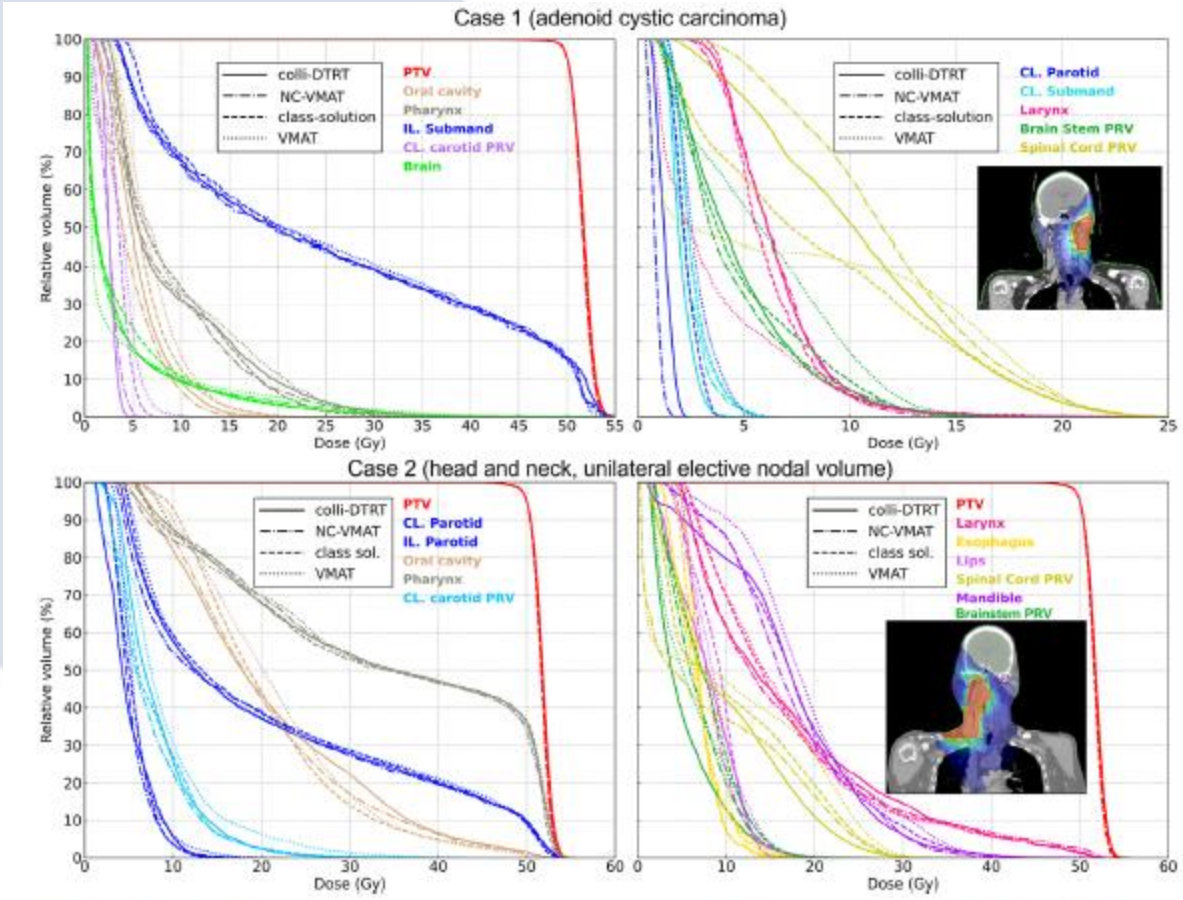


FIGURE 2 DVHs for the head and neck cases (1, top and 2, bottom). The inserts show a coronal view of the colli-DTRT dose distribution (color scale: 5%–109% of the prescription dose).

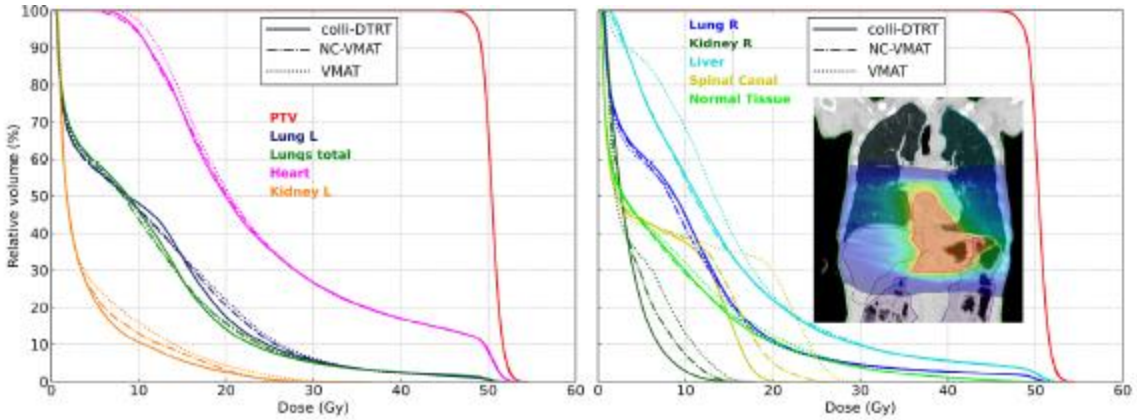


FIGURE 5 For case 4 (esophagus), score map at the first optimization and the last trimming step (2nd trimming) for colli-DTRT (top left) and NC-VMAT (top right) and the DVHs for all plans (bottom). The insert in the DVH shows a coronal view of the colli-DTRT dose distribution (color scale: 5%–109% of the prescription dose).

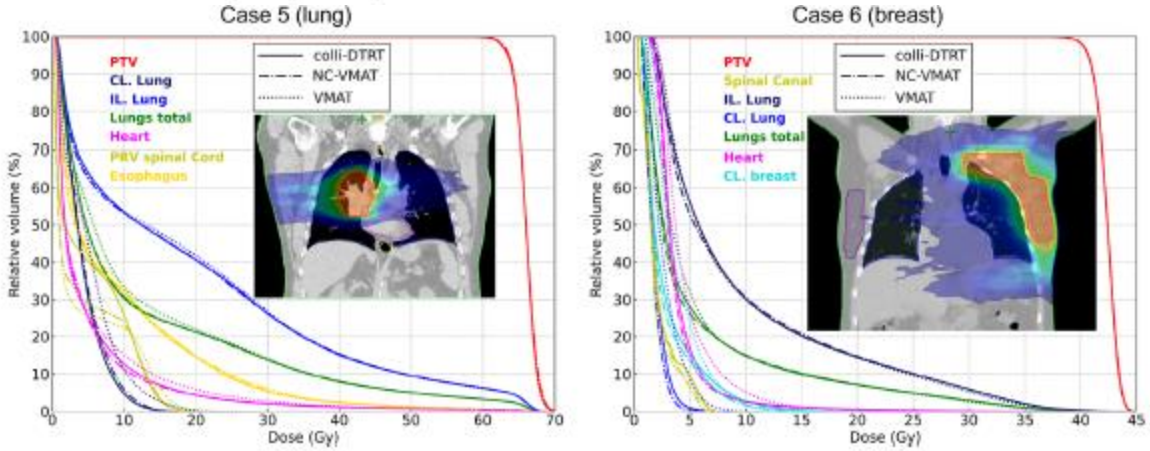


FIGURE 6 DVHs for case 5 (lung, left) and case 6 (breast, right). The inserts show a coronal view of the colli-DTRT dose distribution (color scale: 5%–109% of the prescription dose).

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IMPROVING
THE ENTIRE RT WORKFLOW

SGRT:
GAME CHANGER

A safe workflow for non-coplanar radiation therapy in H&N cancer

THE 2024 ANNUAL MEETING
OF THE SGRT COMMUNITY

28 & 29 Nov 2024

etc.venues County Hall (London)

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