The ACPSEM Medical Image Registration Special Interest Group (MIRSIG) Online Webinars

The **current seminar** (1200, Tue 1st September 2020) is chaired by Ben Archibald-Heeren.

- Talk 2: **Image registration applications and case studies**

Presented by Adam Yeo(Physics)

Webinar activities!!

-Use the "Q&A" to ask questions!

Live Poll!

Poll information will be used to confirm CPD, so it is important to participate!

Post webinar survey!

Please answer survey when email is sent

Seminar material available online!

Please see https://www.acpsem.org.au/About-the-College/Special-Interest-Groups/MIRSIG

Be more involved!

1. MIRSIG welcomes professions from all disciplines, including radiation therapists and radiation oncologists
2. Sign up to the MIRSIG mailing list (https://www.acpsem.org.au/Home , click myACPSEM, click speciality groups, tick MIRSIG)
3. Join MIRSIG as a member, email mirsig@acpsem.org.au

Peter Mac
Peter MacCallum Cancer Centre
Victoria Australia

MIRSIG

MIRSIG Webinar

DIR case study: H&N re-treatment and overlap assessment

ACPSEM
Australasian College of Physical Scientists & Engineers in Medicine

Adam Yeo (PhD)
Medical Physicists, Peter MacCallum Cancer Centre

Disclaimer

- No conflict of interest…

(Comparison performance of commercial DIR systems)

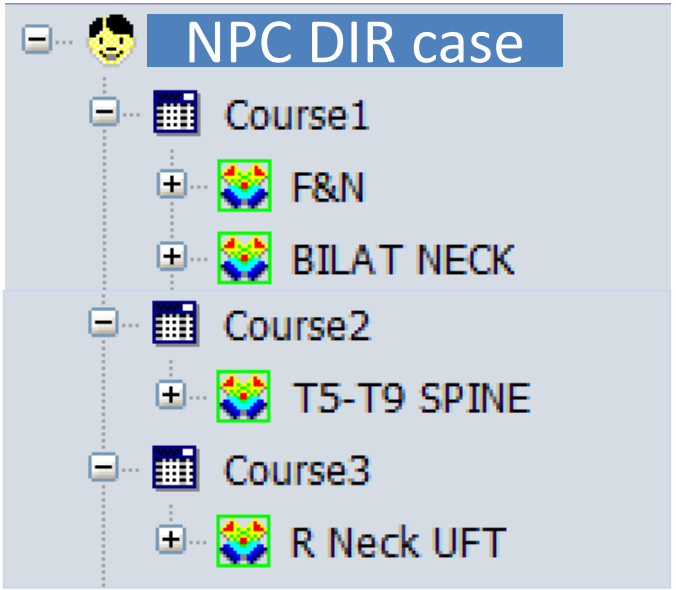
- Was used in TRW2020 and VIC/TAS training day

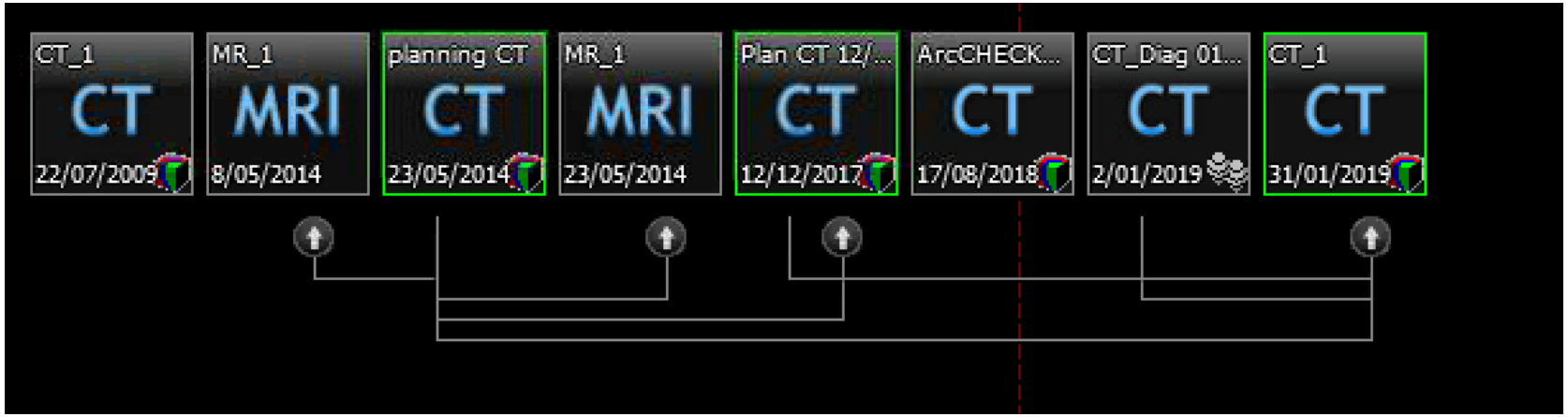
TROG CANCER RESEARCH

ACPSEM Australasian College of Physical Scientists & Engineers in Medicine

ACPSEM Vic/Tas Branch

Case: H&N- NPC, 3 RT courses over 4.5 years





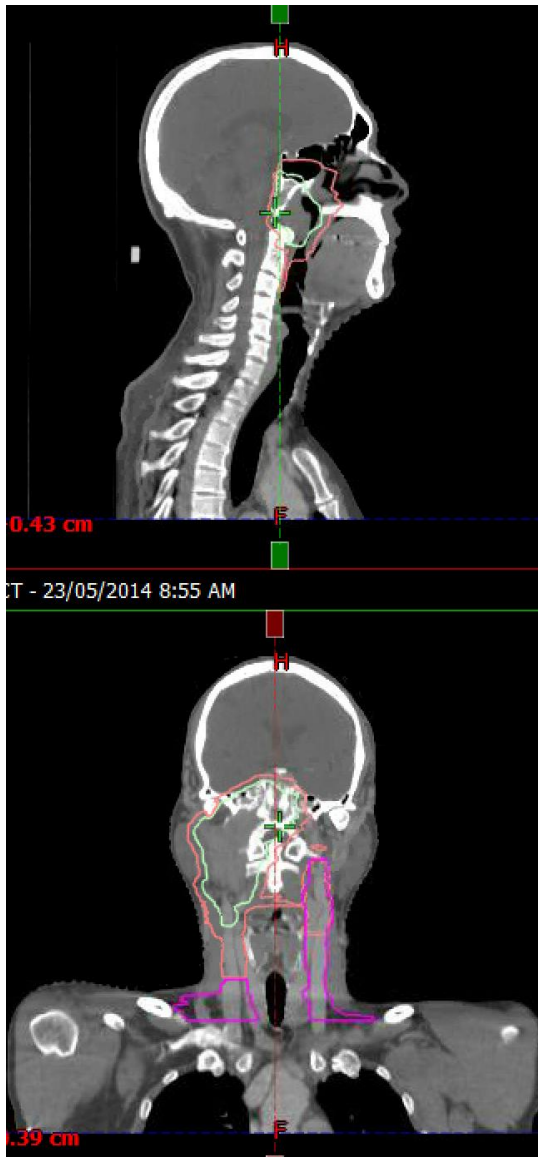
→ **Lots of multi-modal images and registration sets !!**

Course 1 (Jun 2014): T4N1M0, 70/35/7 (Bilat Neck 56/35/5), disease very close to SC & BS

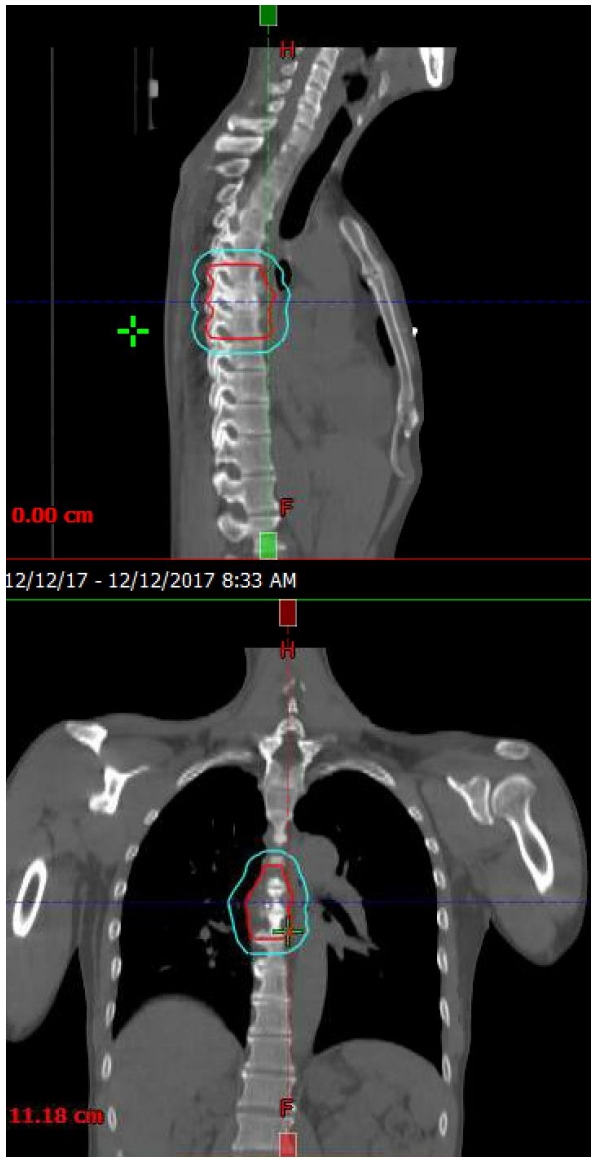
Course 2 (Dec 2017): T4N1M1, 20/5/1 (T5-T9 Spine, LDP), no overlap with Course 1

Course 3 (Jan 2019): T4N2M1, 25/10/2 (LDP **re-irradiation** to residual progressive disease)
→ Immunotherapy trial then palliative chemo
→ Rt Neck fungating tumour: pain, stiffness, hence **difficult to position** patient

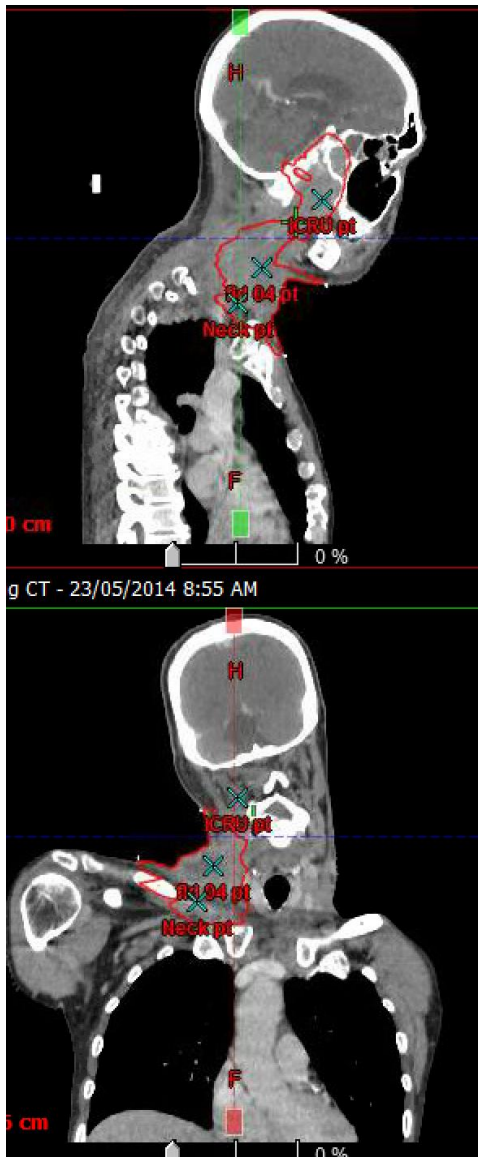
What to consider?



Course 1 (HN+BilatN)



Course 2 (T7-9)



Course 3 (Rt N re-tx)

Q0: What to consider? (multi-choice)

Any issues with:

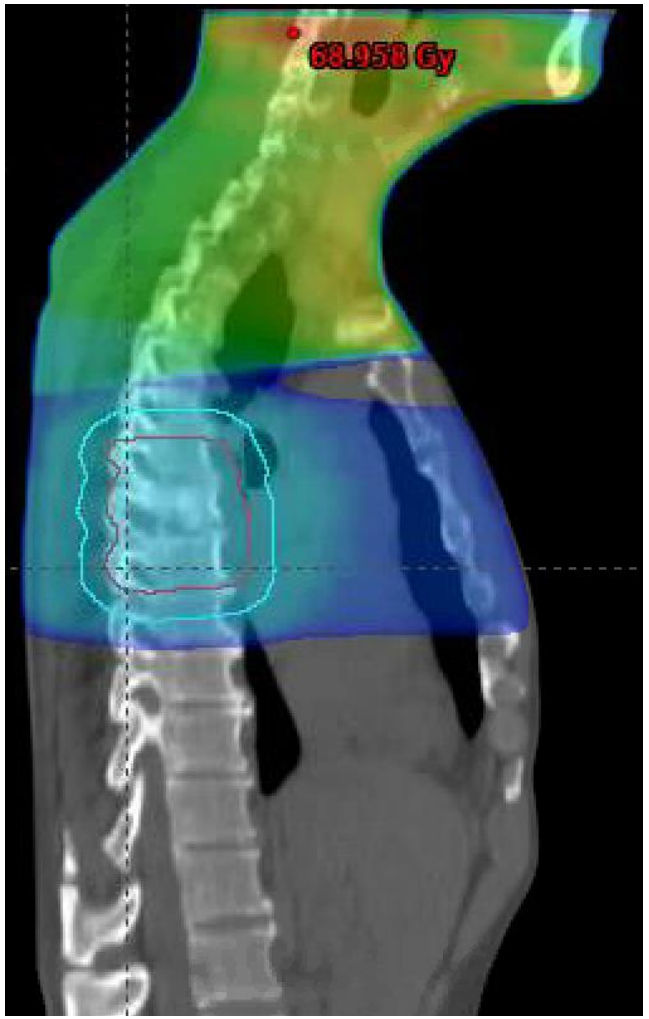
- Scan ranges
- Setup positioning
- Weight/tumour mass change
- Overlap assessment
- Any other comments??

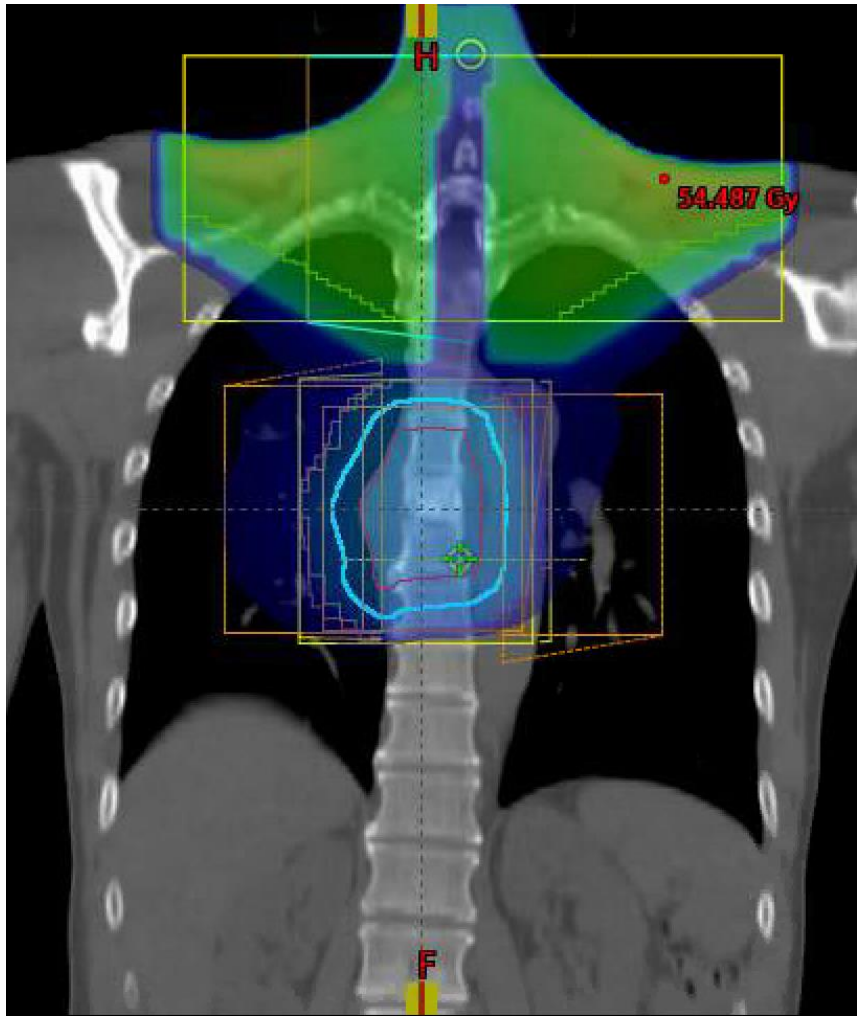
Overlap assessment: Course 1 & 2

Q1: Is RIR sufficient for overlap assessment?

- Yes
- No
- Don’t know

Poll question 1

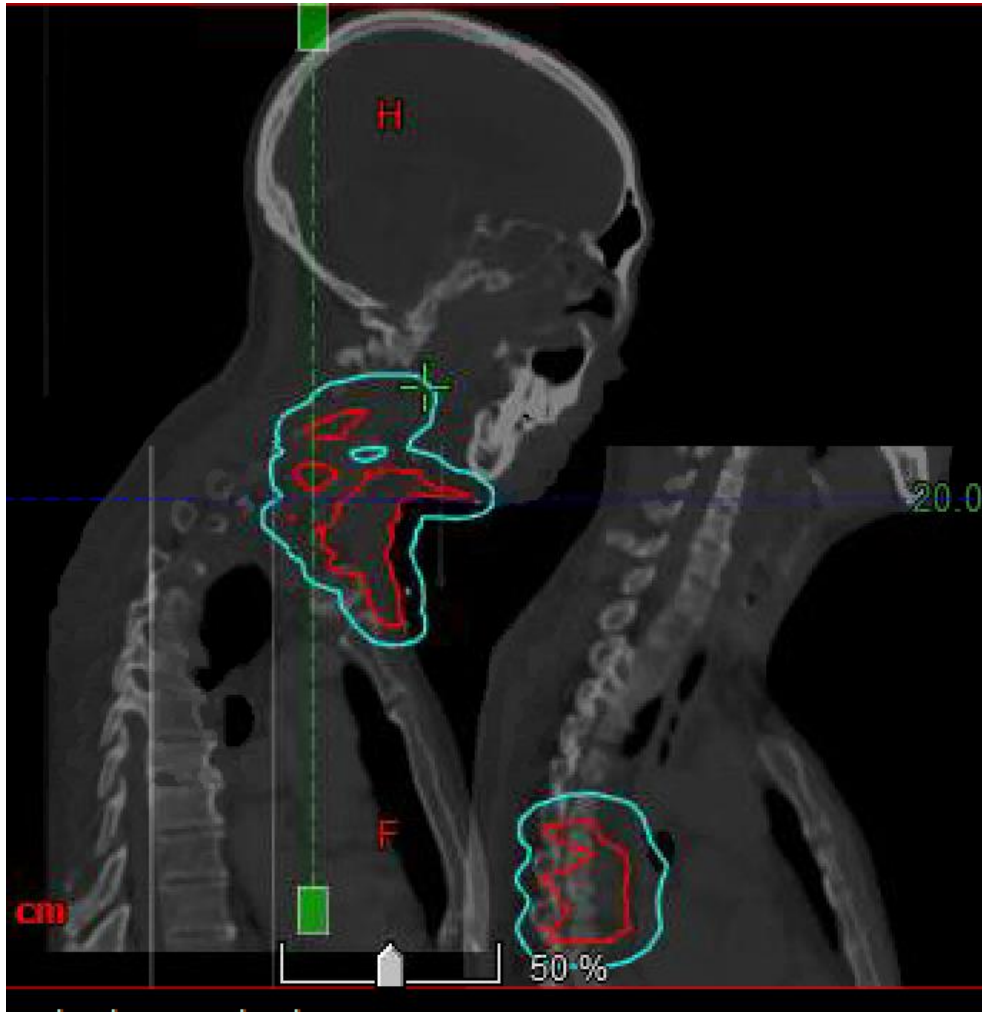




Overlap assessment: Course 2 & 3

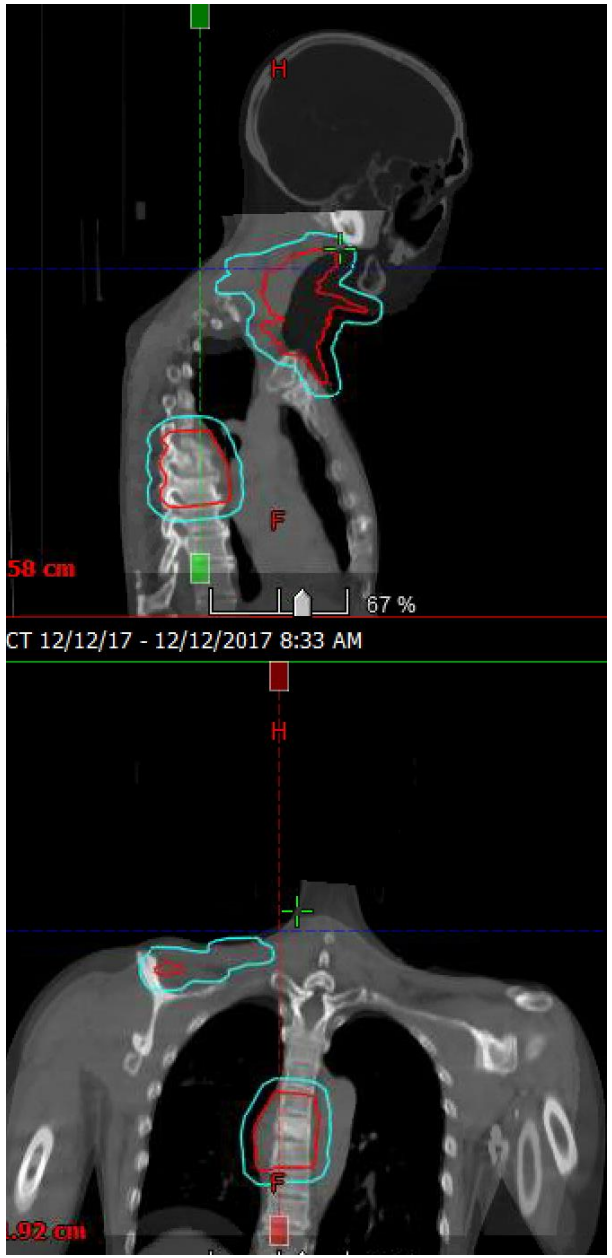
Q2:Given difficulties on Cx 3,
How and where to match it against Cx2?

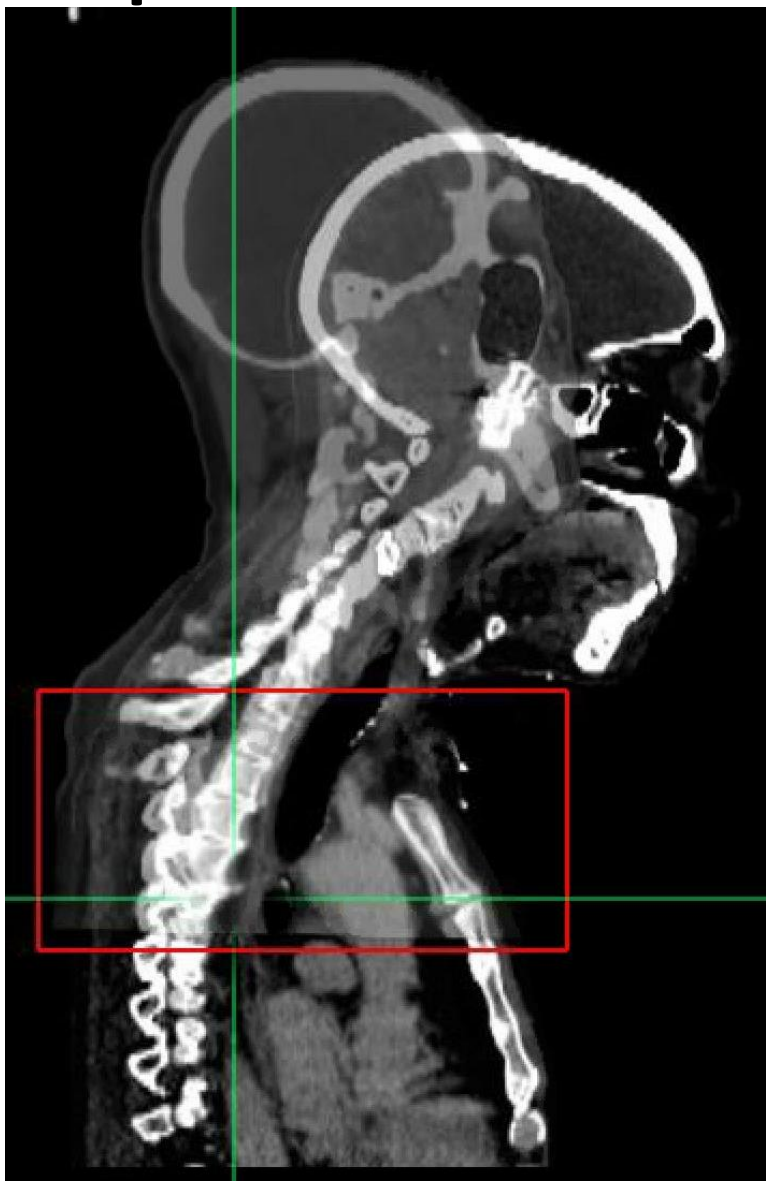
1) RIR based on Spine PTV
2) RIR based on possible max-dose area
3) RIR based on Neck PTV
4) DIR based on VOIs

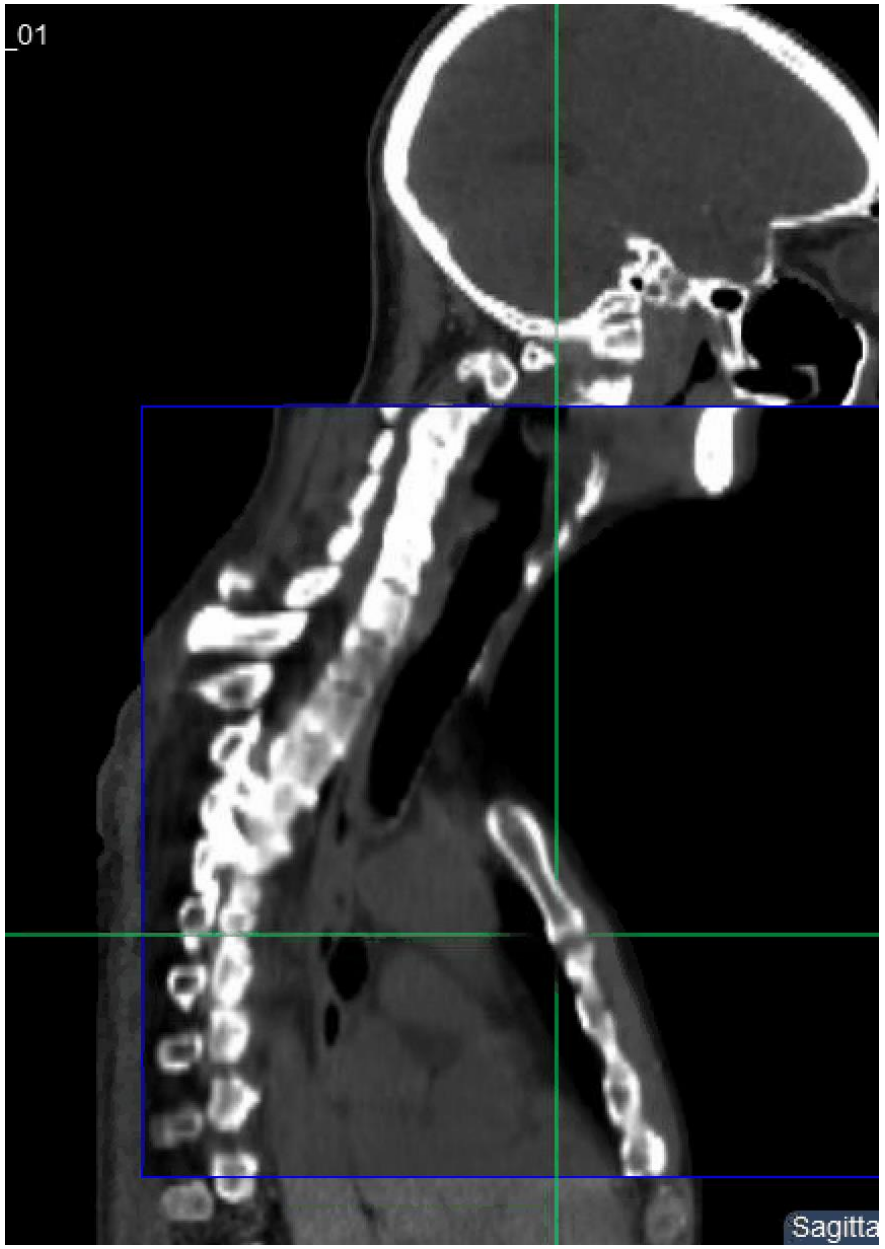


Poll question 2

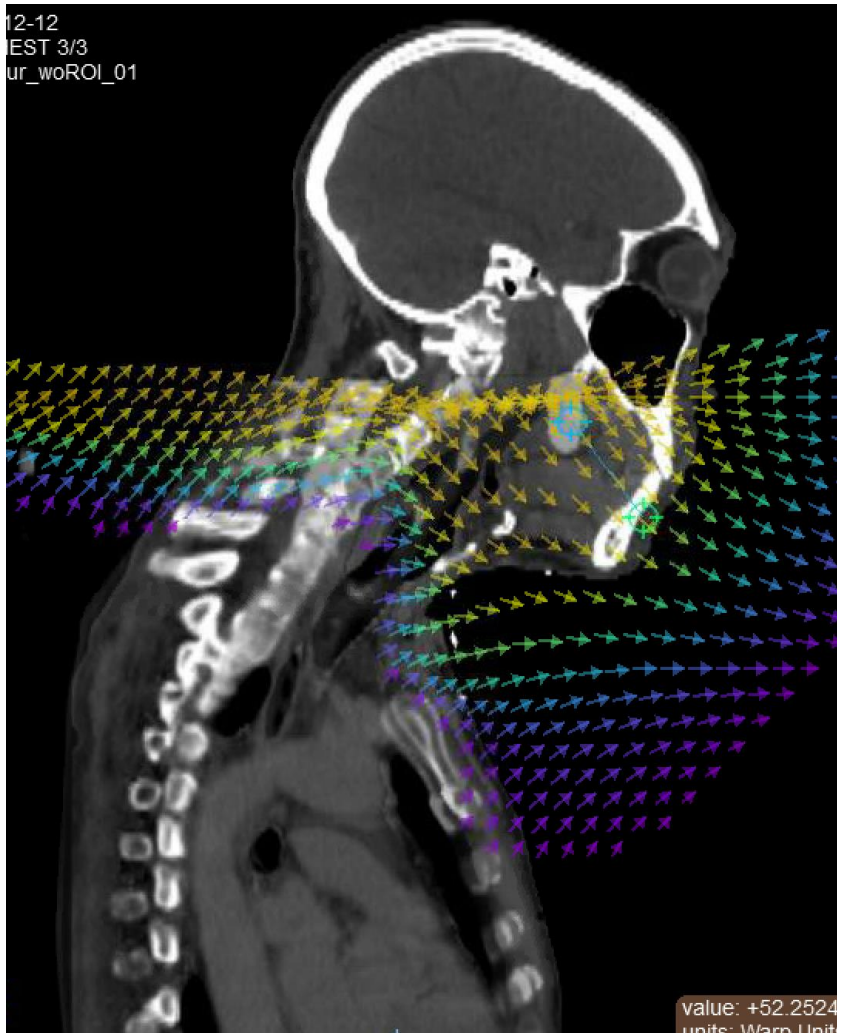
RIR based on Spine PTV



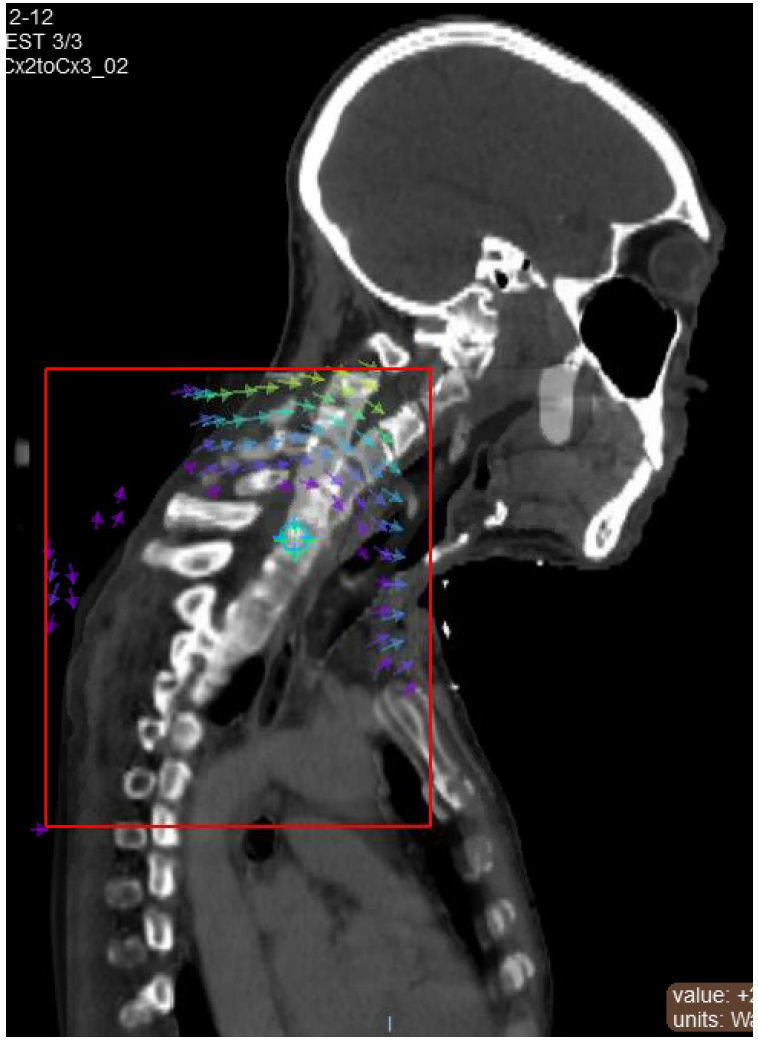




DIR based on Spine PTV



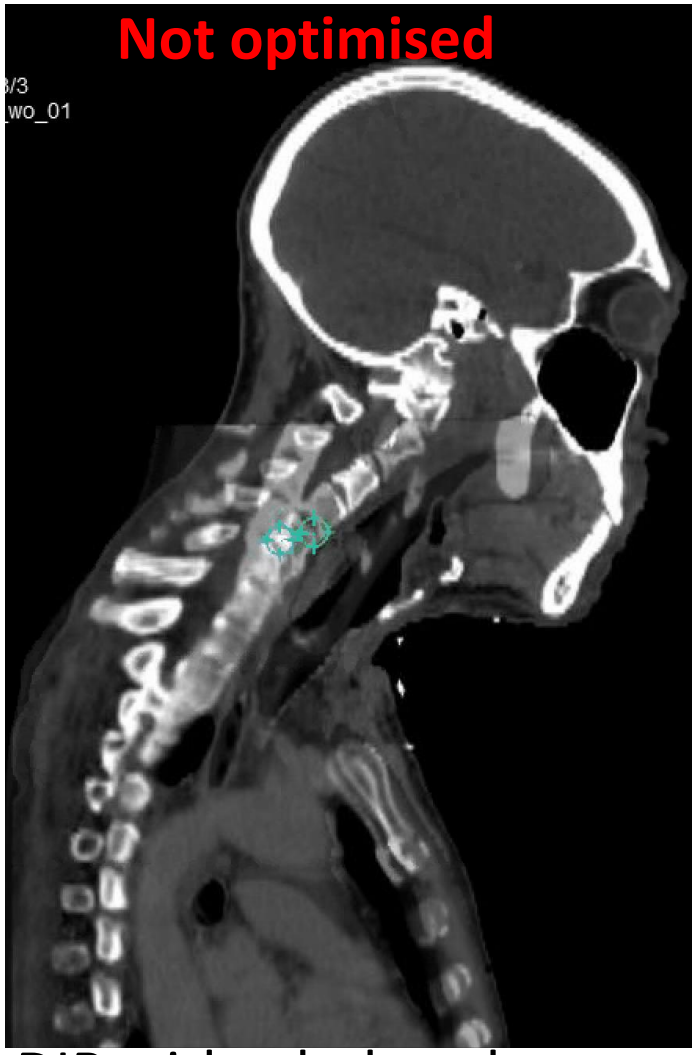
DIR for whole volume



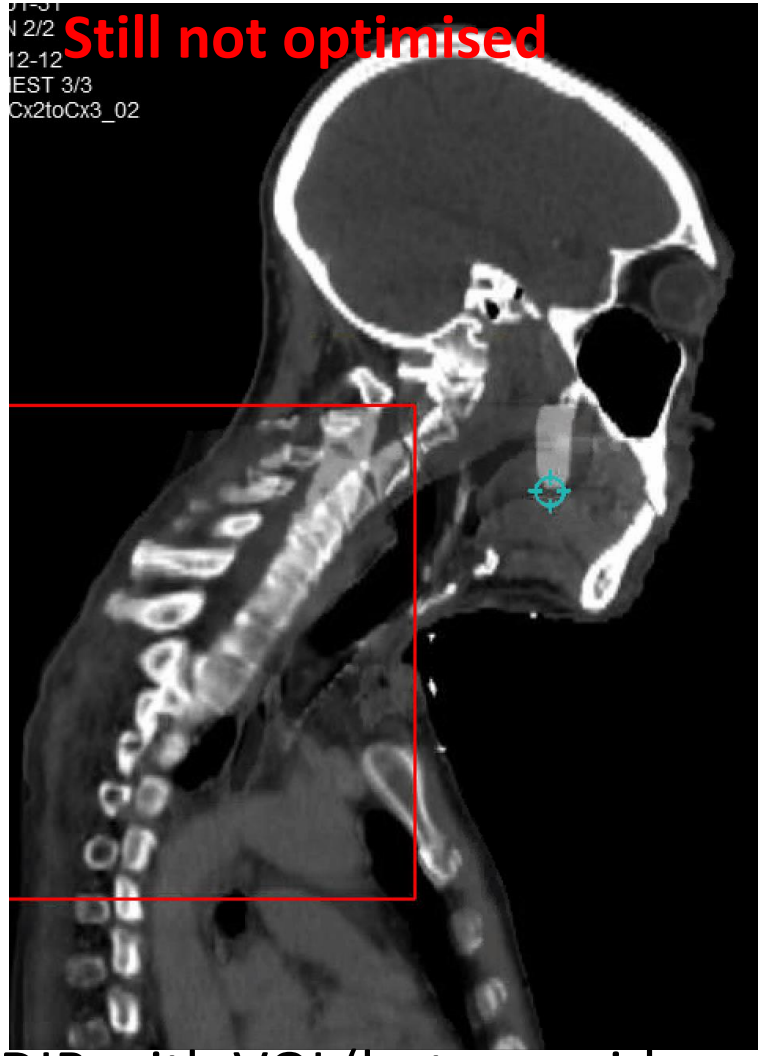
DIR with VOI

Compartmental approach !

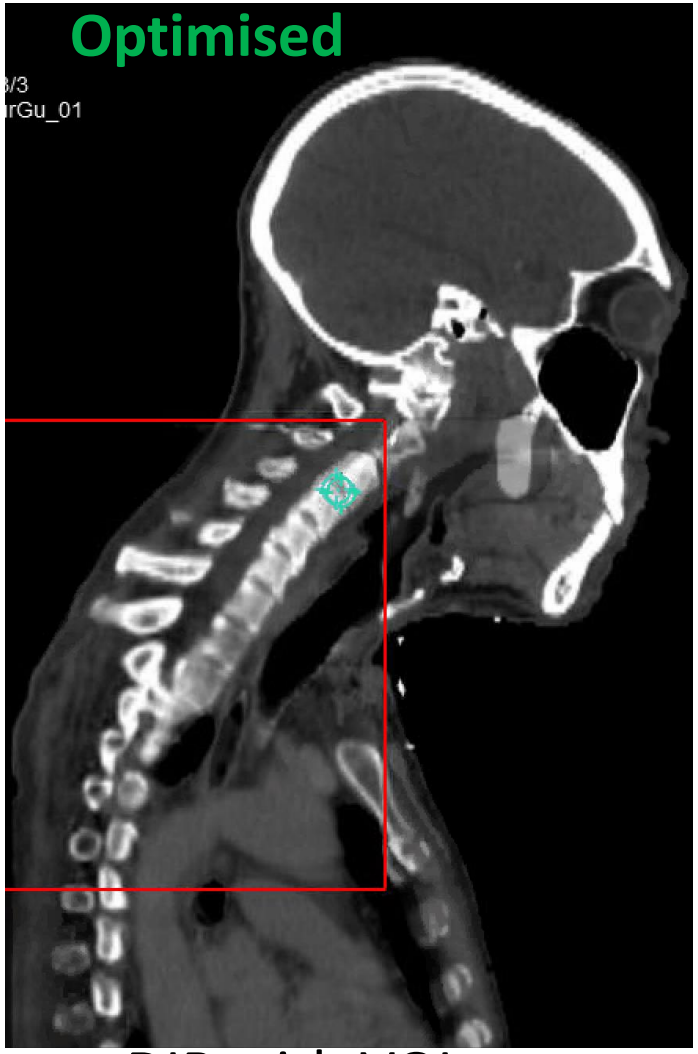
DIR based on Spine PTV



DIR with whole volume
→ Unlimited deformation
→ Wrong spine correlation



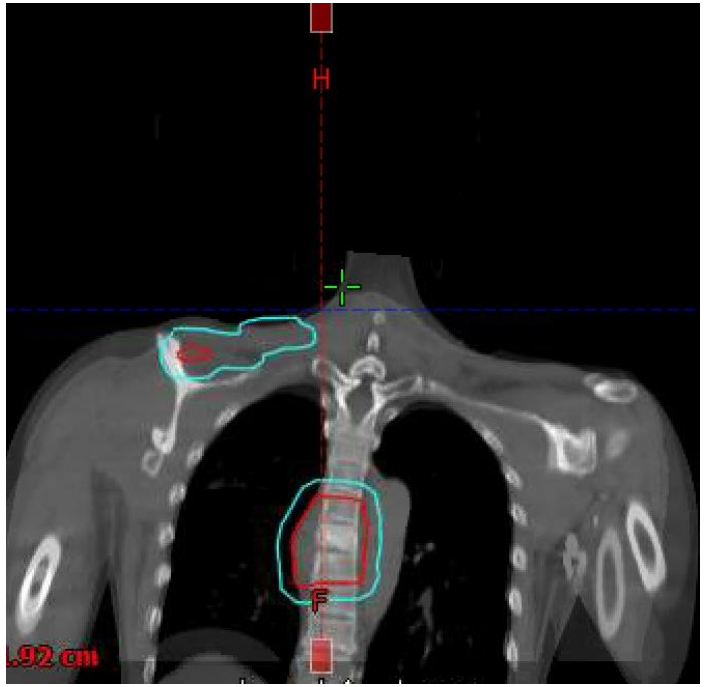
DIR with VOI (but no guidance)
→ No boundary condition
→ Spine mismatch

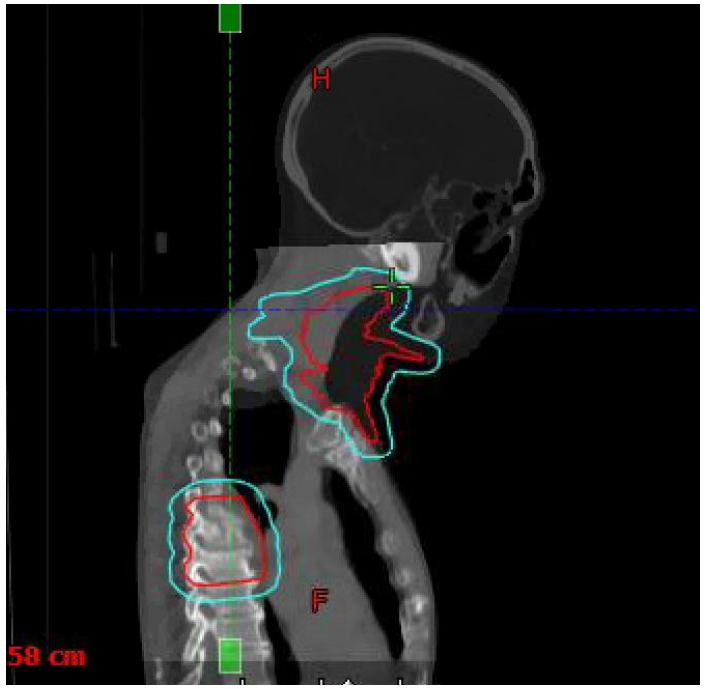


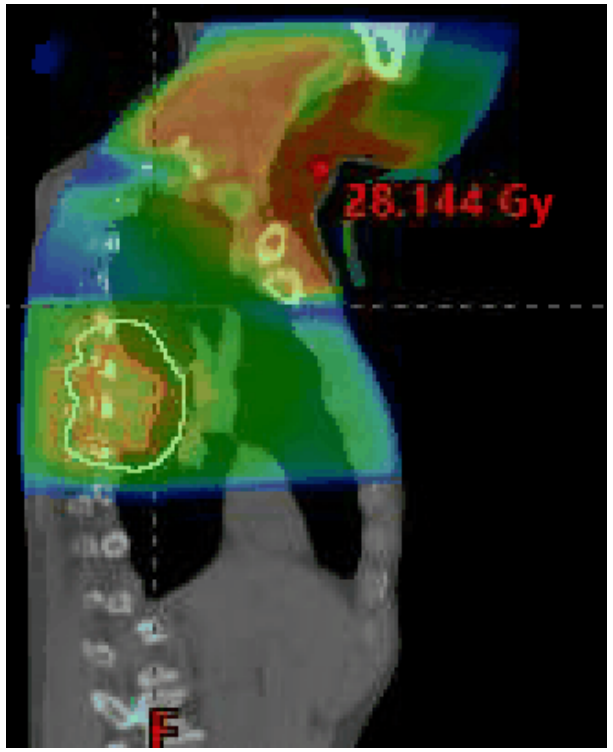
DIR with VOI
→ Limited deformation
→ Spine matched

Q3: We've performed our fist DIR in this case. What is the next step?

Overlap assessment Course 2 and 3

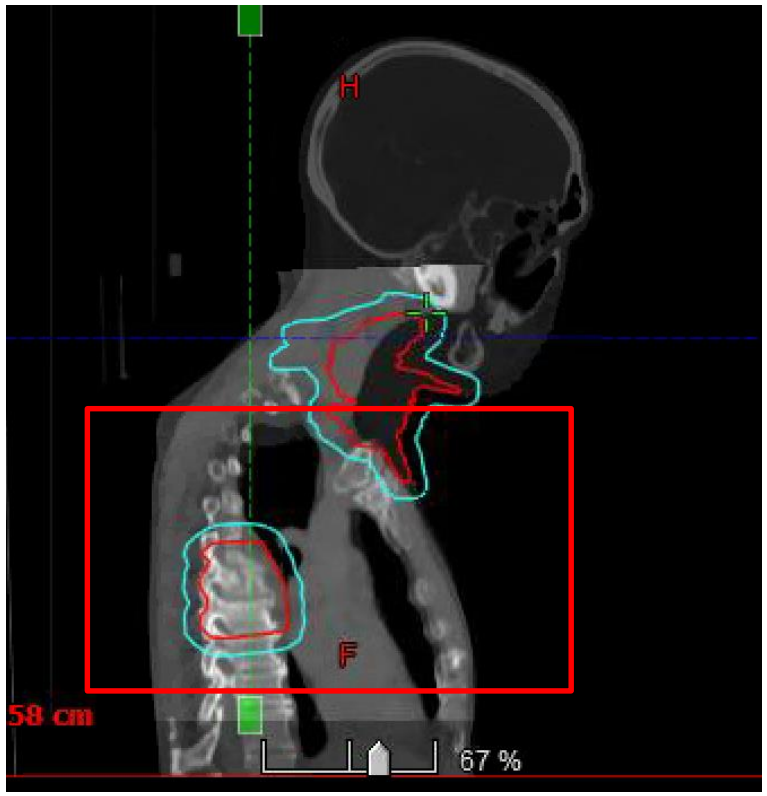


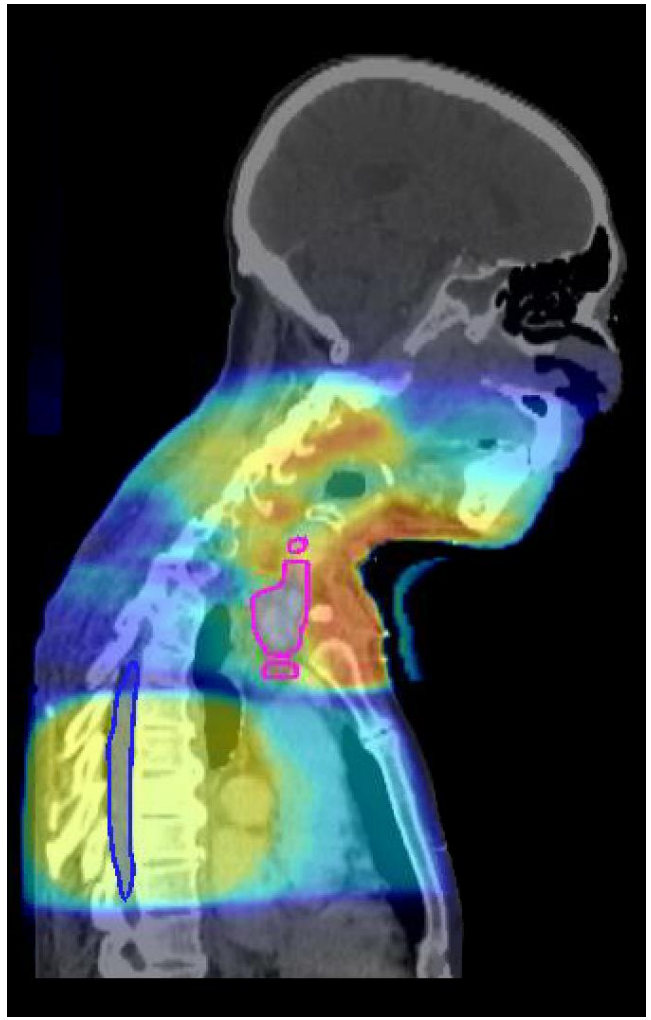


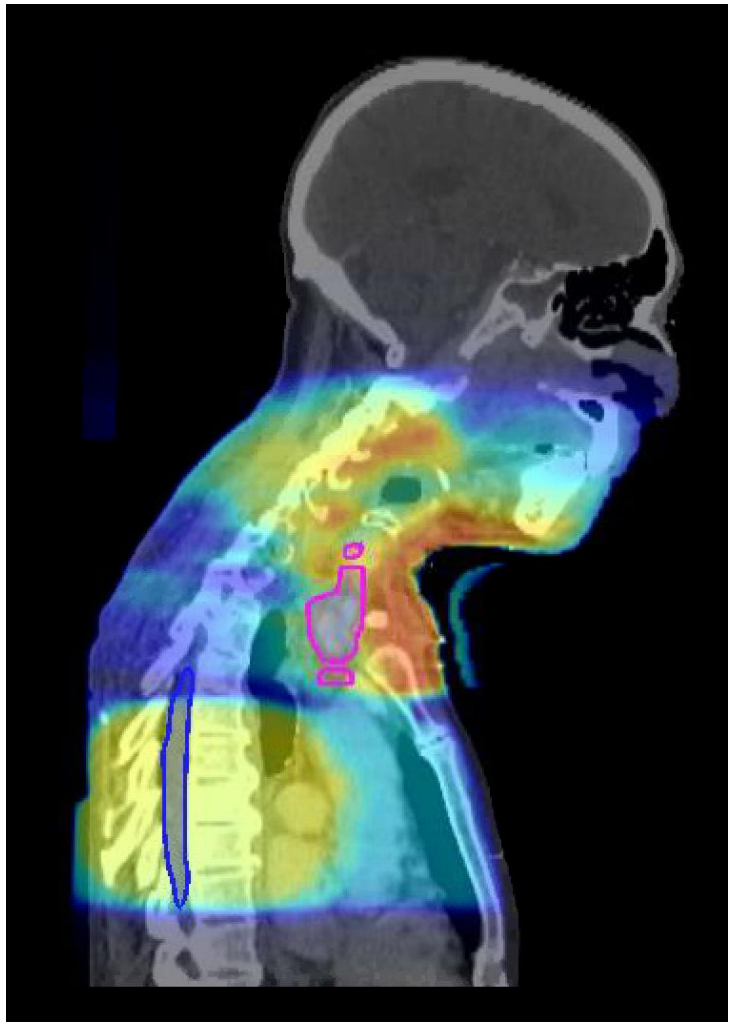


Current practice based on RIR

Overlap assessment Course 2 and 3

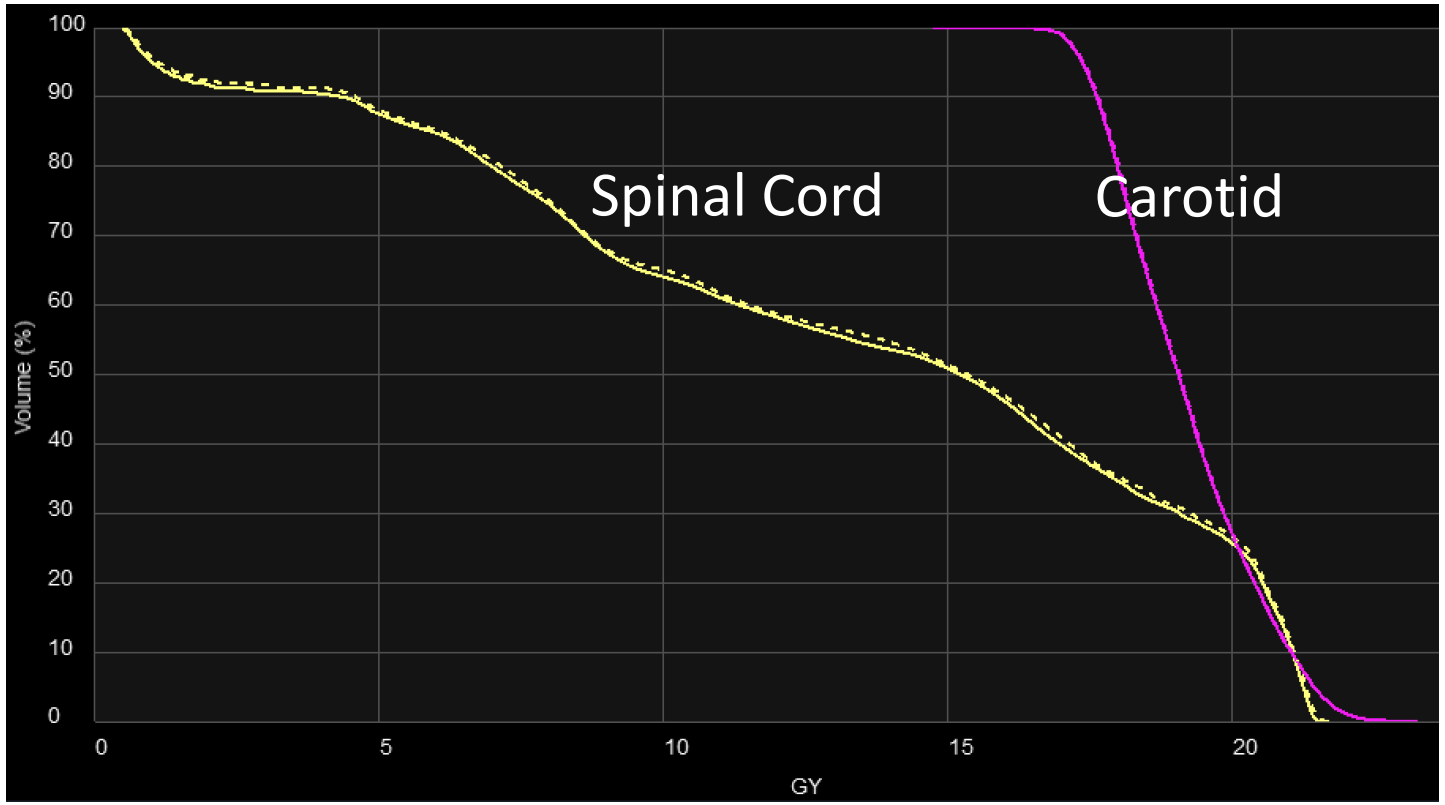


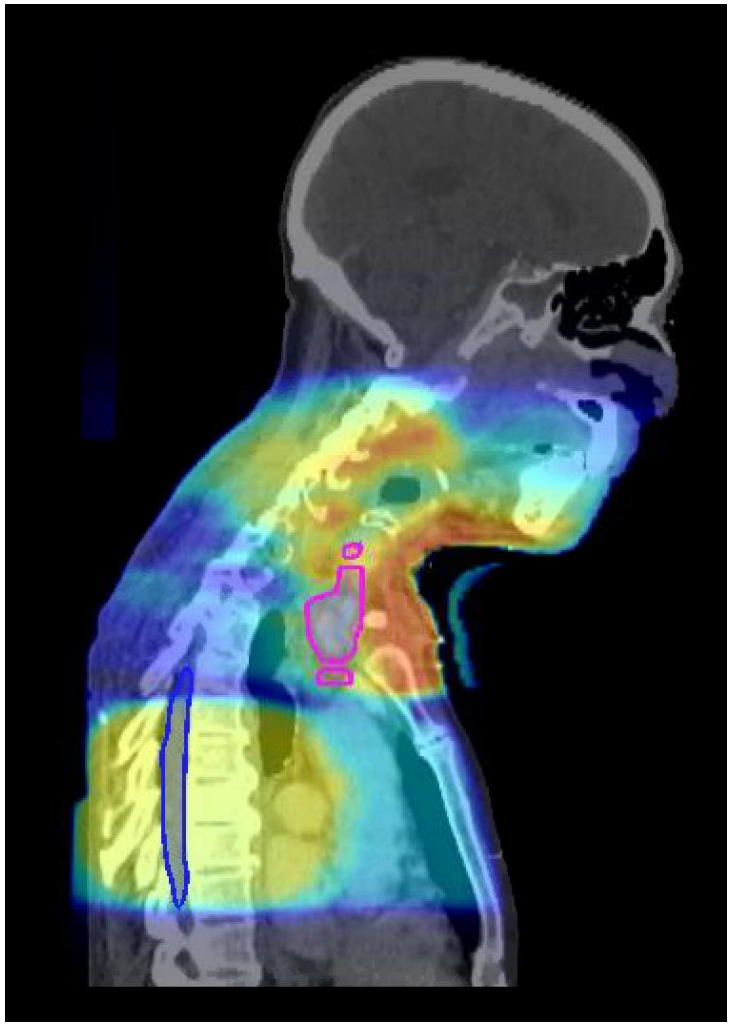




RIR vs DIR

Overlap assessment Course 2 and 3





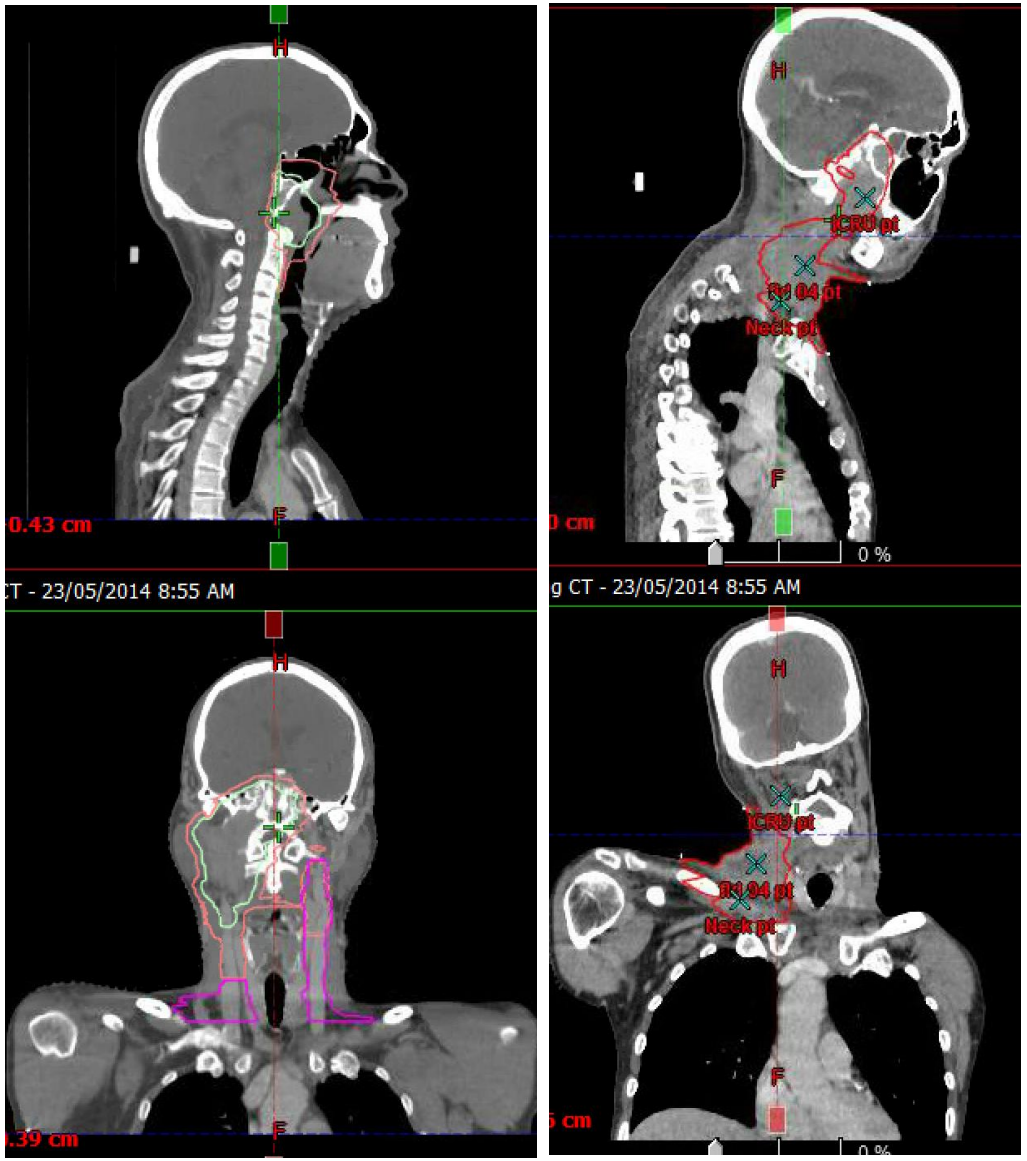
What if dose is overlapped on Carotid?

→ DIR dose assessment is warranted

Overlap assessment: Course 1 & 3

Q4:Given difficulties on the new (Cx 3), How and where to match it against Cx1?

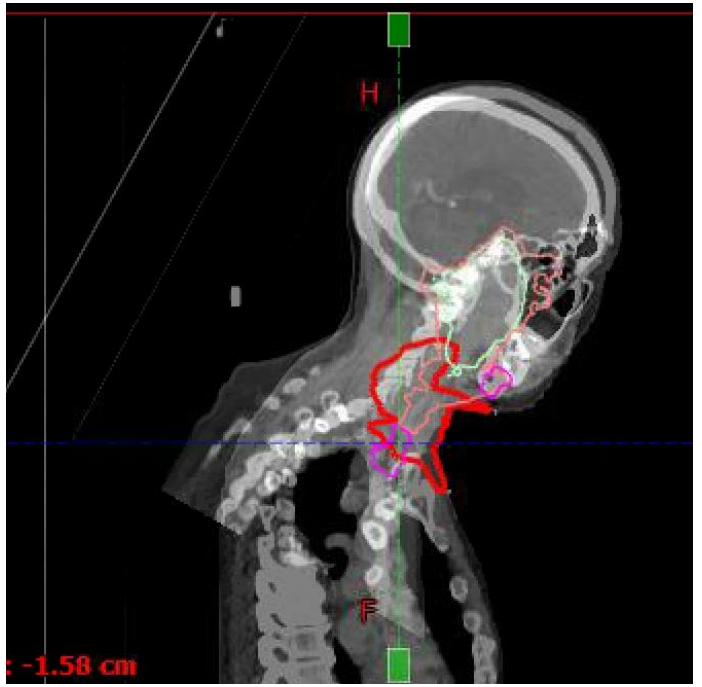
1) Whole-volume
2) Brain
3) C-Spines or Neck
4) GTV on the new scan
5) Possible max-dose area
6) T-spines

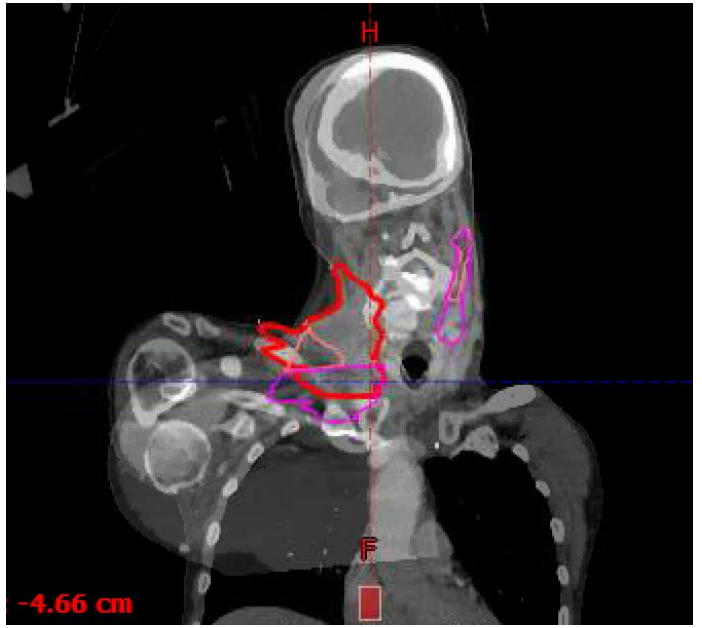


Overlap assessment: Course 1 & 3

Q5: Is **RIR** sufficient
for overlap assessment?

- Yes
- No
- Don’t know

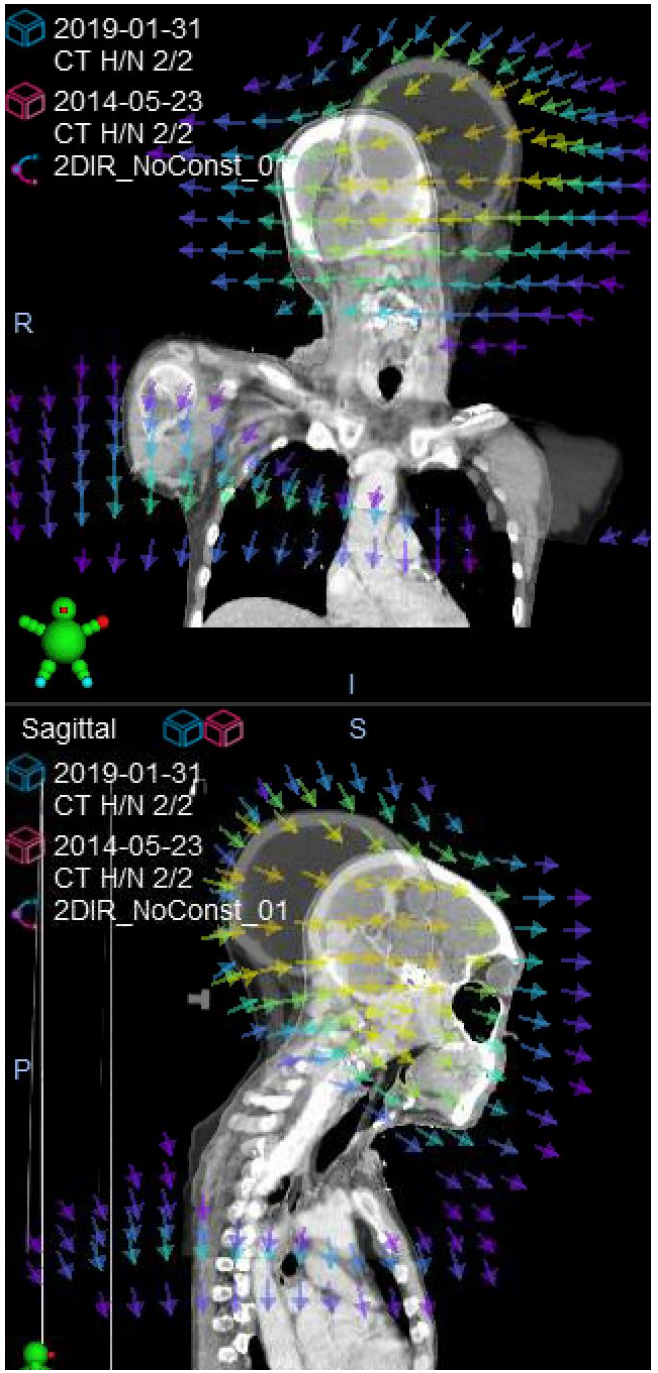




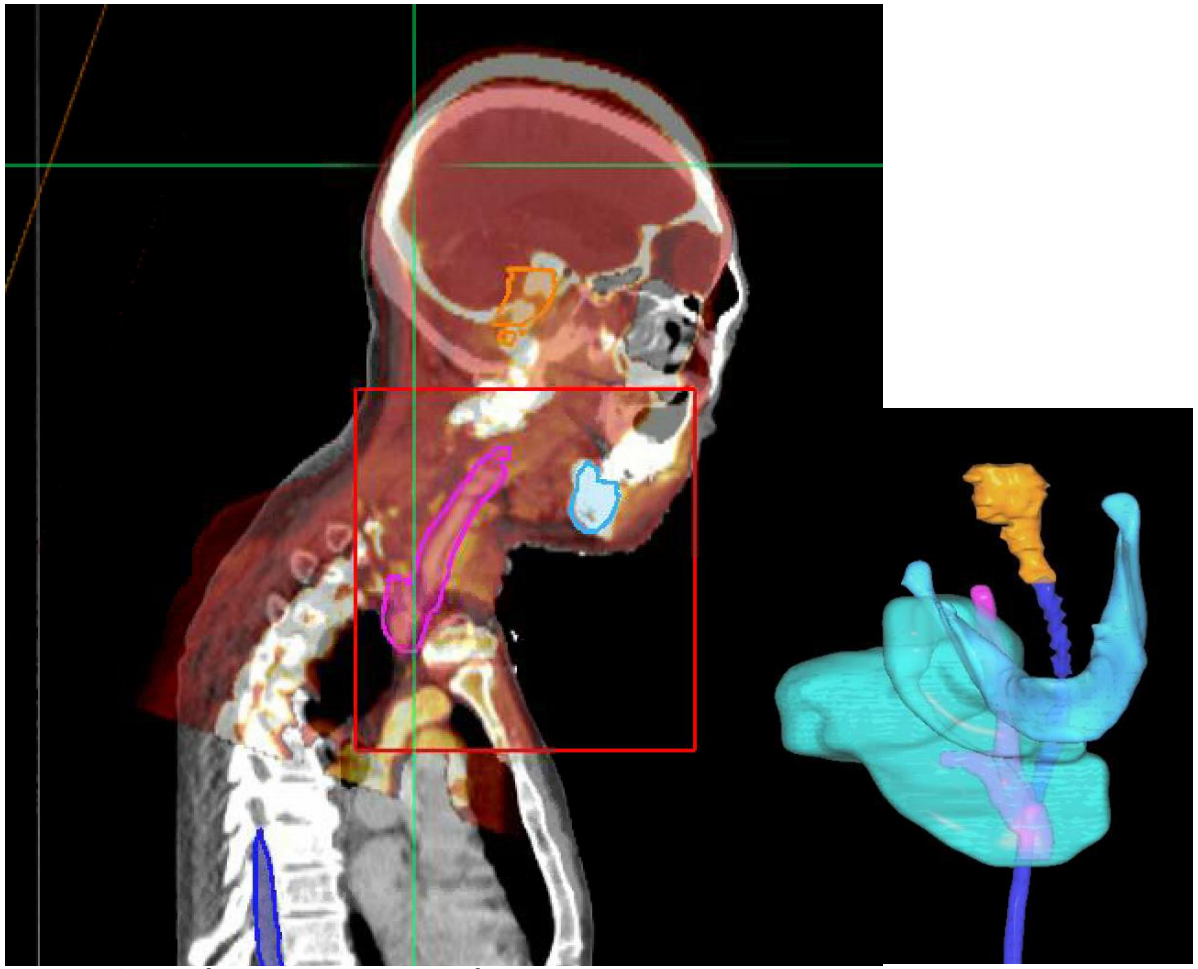
Overlap assessment: Course 1 & 3

Q6: If it's deemed that **DIR** is required,
How and where to match?

1) Based on whole volume (an example shown)
2) Based on Spine near-max area
3) Based on CTVs on the old scan
4) Based on GTV on the new scan
5) Based on VOIs (whatever your own interest…)



Compartmental approach for DIR!



Local DIR for (a bit large) VOI with constraints:

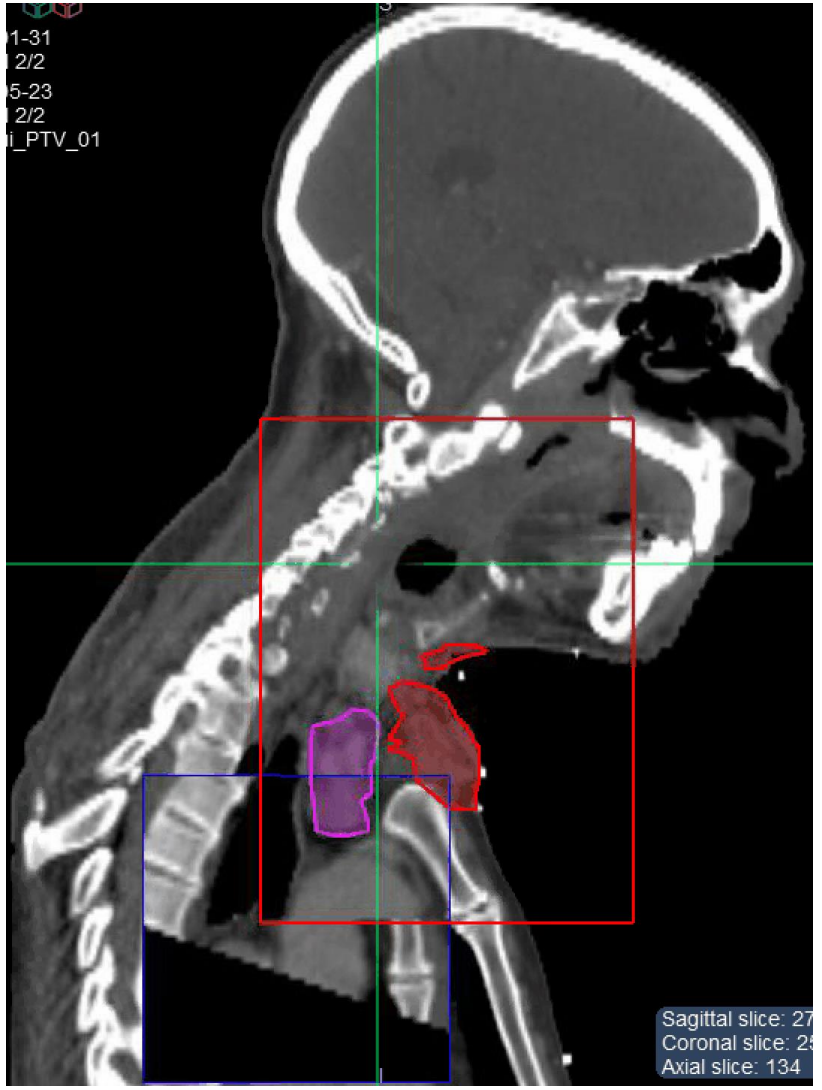
→ To include the re-treated PTV

→ Larger VOI → greater extent of motion/def

→ Hence, greater chance for error

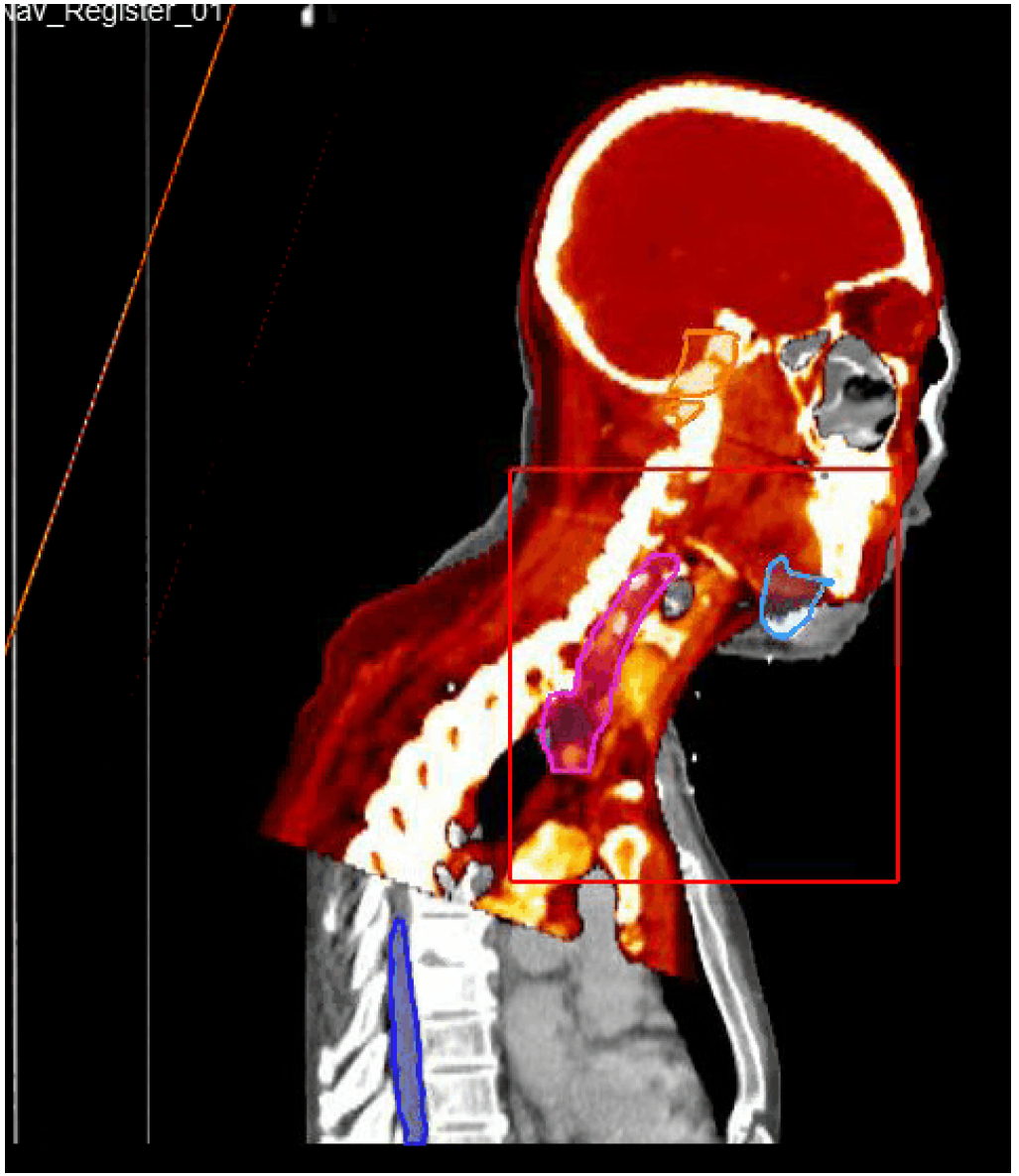
How do we validate?

- Anatomy (qualitative)
- Dice
- TRE
- Grid/Jacobian map



How do we validate?

- Anatomy (qualitative)
- Dice
- TRE
- Grid/Jacobian map



How do we validate?

- Anatomy (qualitative)
- Dice
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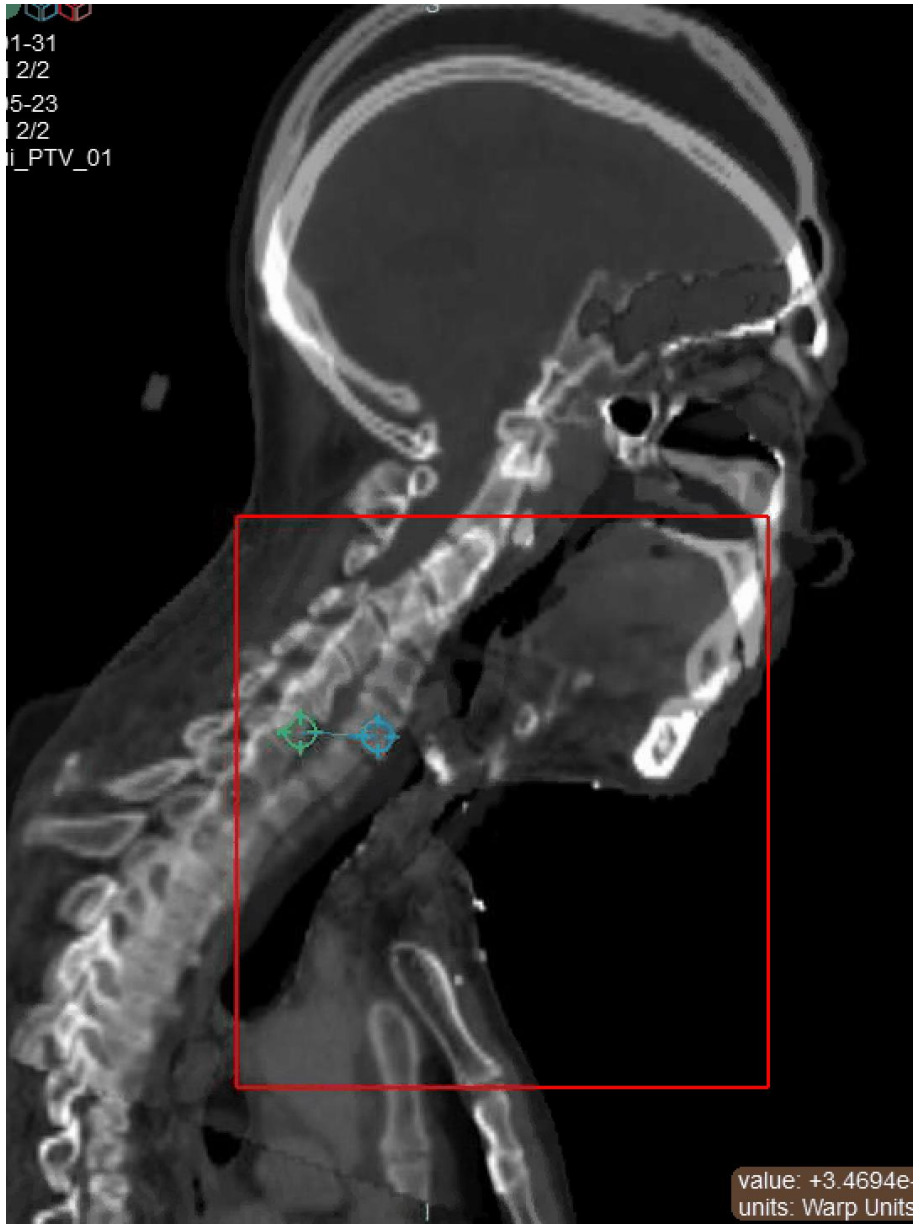
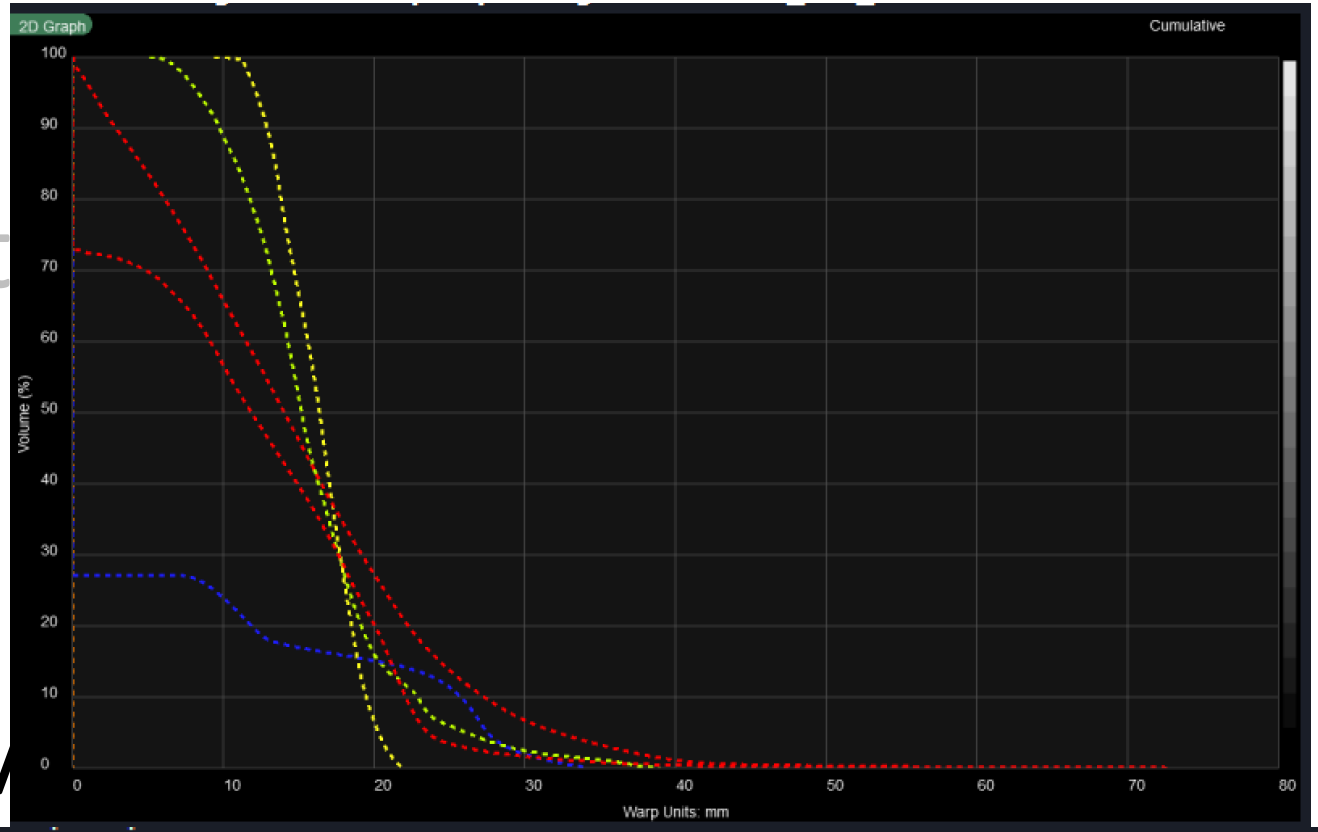
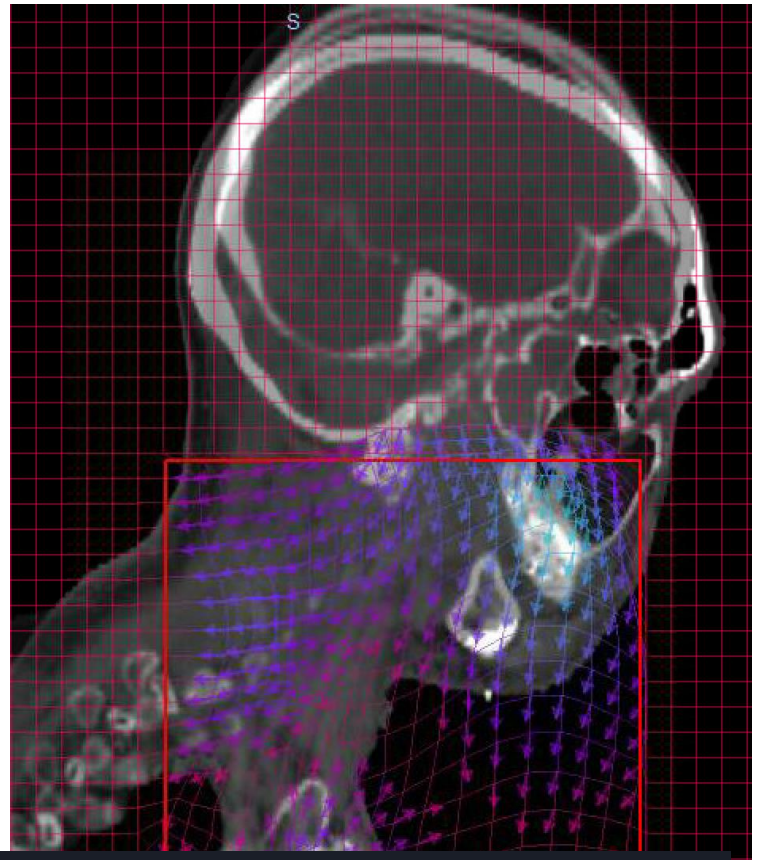
- Grid/Jacobian map



How do we validate?

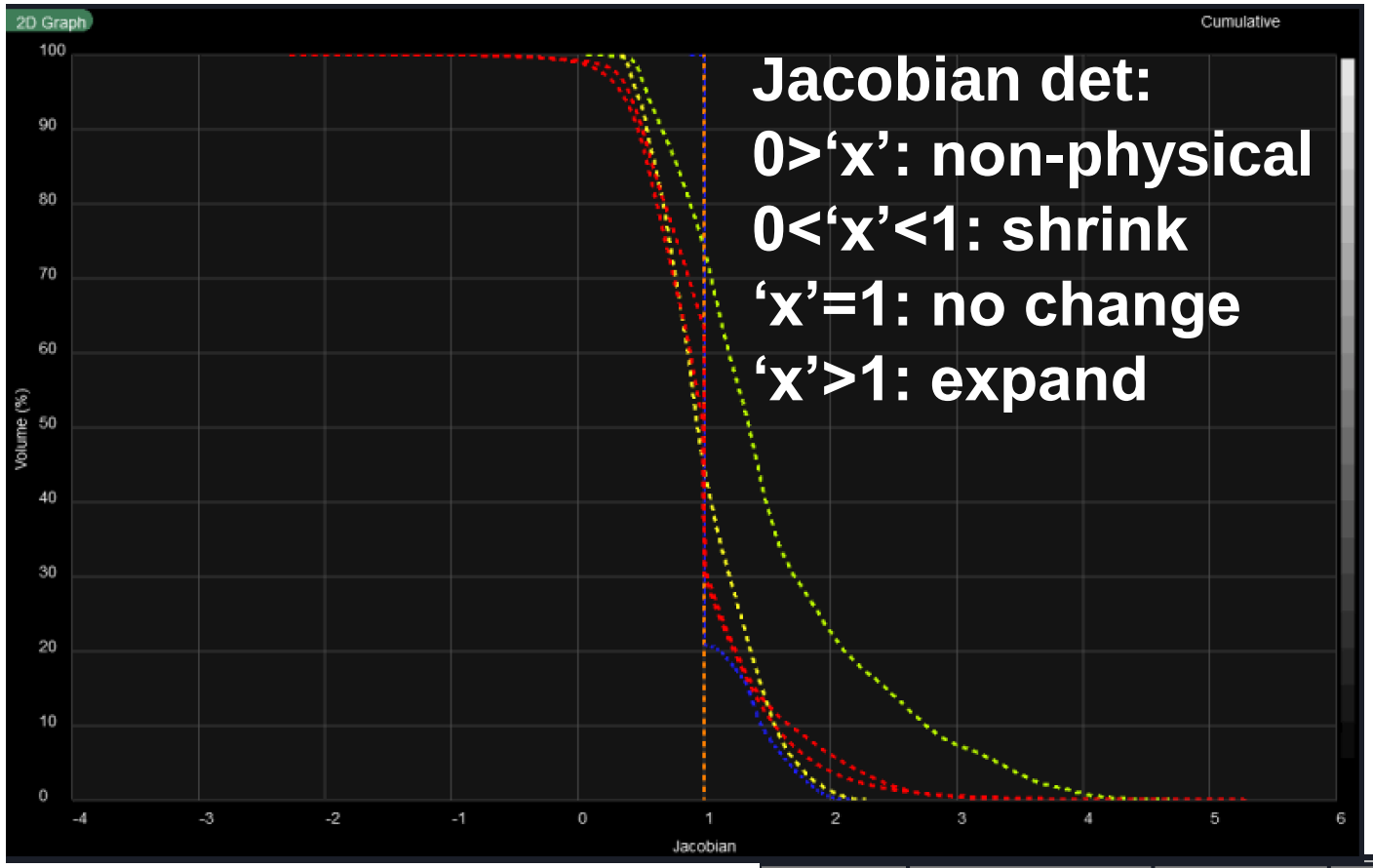
- Anat
- Dice
- TRE
- Grid/



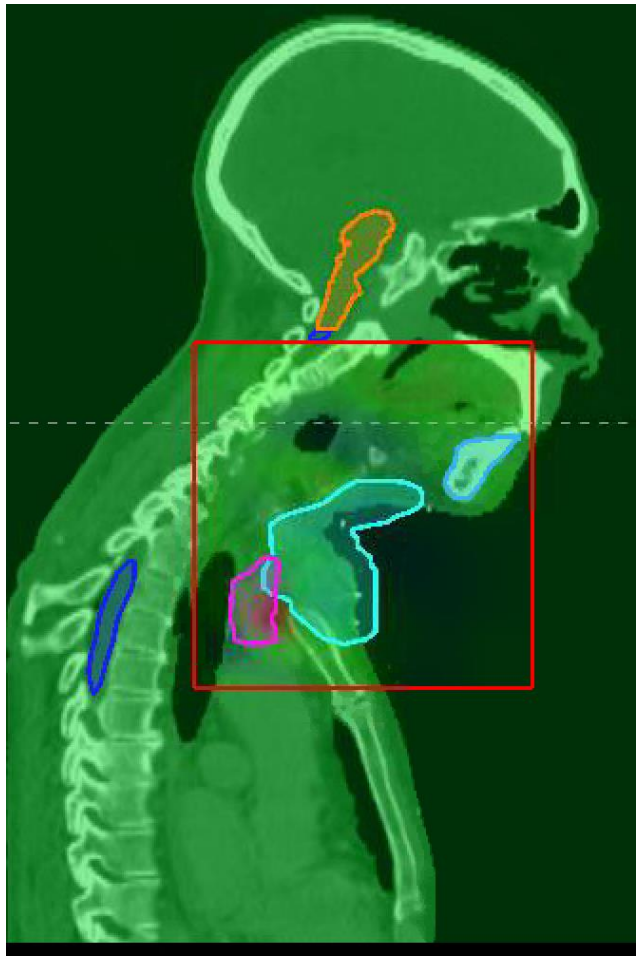


	Name	# Bins	Volume (cc)	Min / Mean / Max .		
	A_Carotid	512	17.9 cm^3	5.06 Warp Units: mm	15.91 Warp Units: mm	38.97 Warp Units: mm
	BrainStem	512	29.0 cm^3	0.00 Warp Units: mm	0.00 Warp Units: mm	0.00 Warp Units: mm
	SpinalCord	1024	35.4 cm^3	0.00 Warp Units: mm	5.45 Warp Units: mm	34.24 Warp Units: mm
	Larynx	512	45.0 cm^3	9.37 Warp Units: mm	16.23 Warp Units: mm	22.00 Warp Units: mm

How do we validate?



Jacobian det:
0>‘x’: non-physical
0<‘x’<1: shrink
‘x’=1: no change
‘x’>1: expand



	Name	# Bins	Volume (cc)	Min / Mean / Max .		
	A_Carotid	512	17.9 cm^3	0.06 Jacobian	1.54 Jacobian	4.69 Jacobian
	BrainStem	512	29.0 cm^3	1.00 Jacobian	1.00 Jacobian	1.00 Jacobian
	SpinalCord	1024	35.4 cm^3	0.89 Jacobian	1.10 Jacobian	2.18 Jacobian
	Larynx	512	45.0 cm^3	0.34 Jacobian	1.01 Jacobian	2.28 Jacobian
	GTVp	512	477.5 cm^3	-1.47 Jacobian	1.04 Jacobian	3.73 Jacobian
	Region of Interest	512	6229.6 cm^3	-2.29 Jacobian	0.98 Jacobian	5.34 Jacobian

What is the next step? (no question)

Need to see the original dose on the new image for the comparison: RIR vs DIR

If it’s worth doing DIR, then

need to see the sum dose on the new image for the comparison: RIR vs DIR

Cx1 dose on Cx3 image

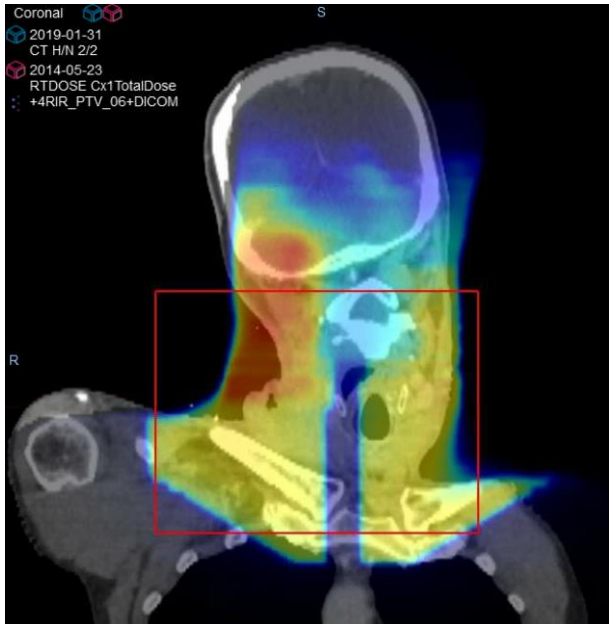
RIR:

Q7. Is it worth to proceed further for deformable dose accumulation? Or rigidly accumulate dose?

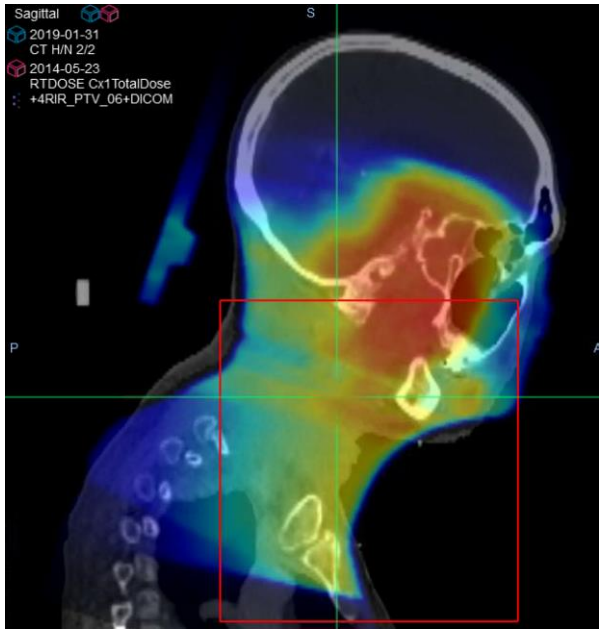
-Yes, worth trying
-No, do rigid dose sum
-Don’t know

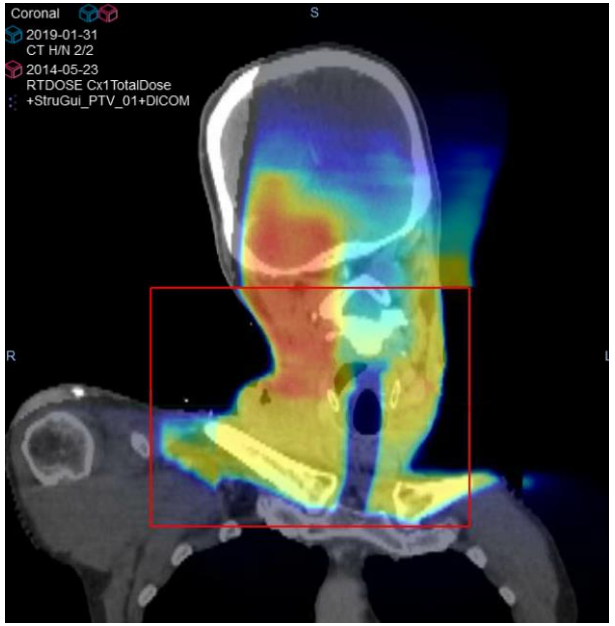
DIR:

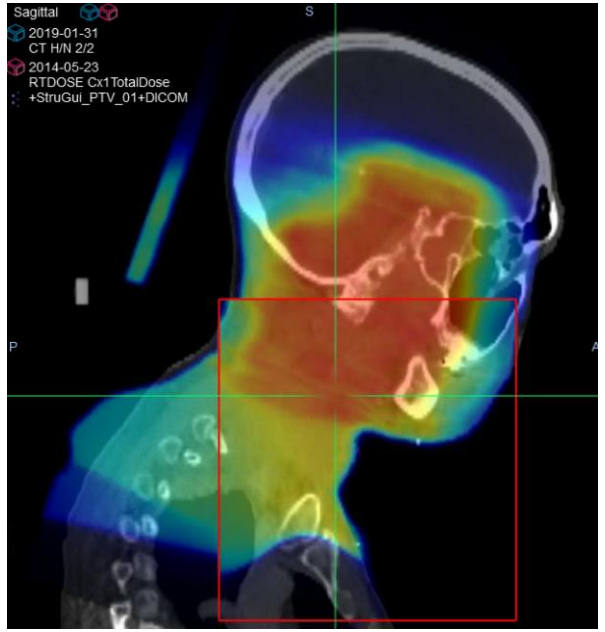
Coronal



Sagittal





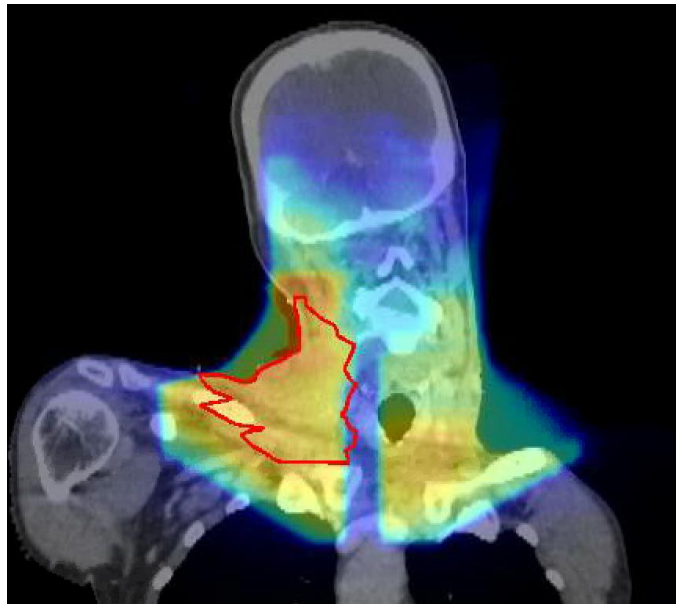


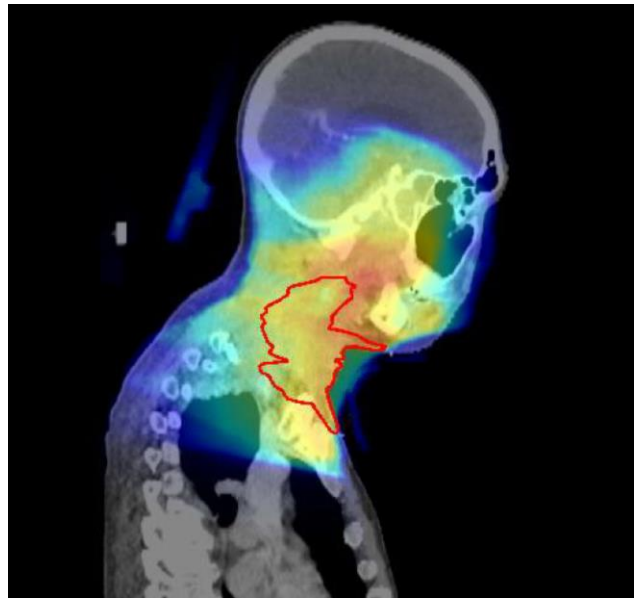
Sum dose on Cx3 image

Coronal

Sagittal

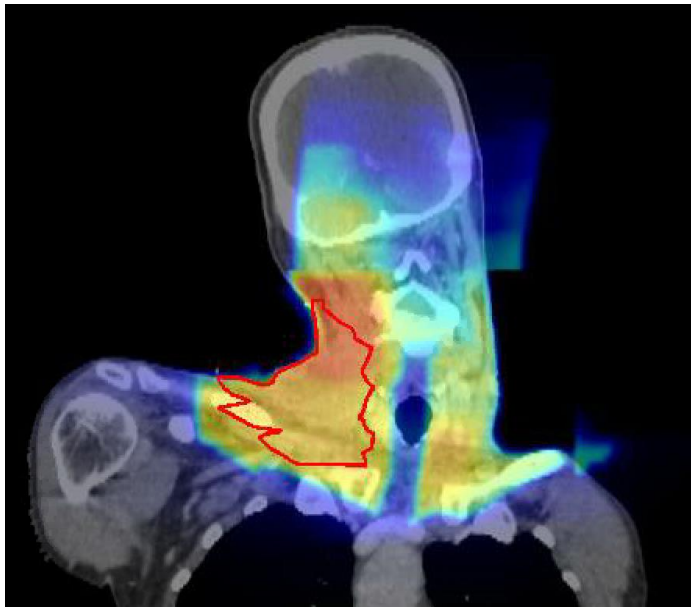
RIR:

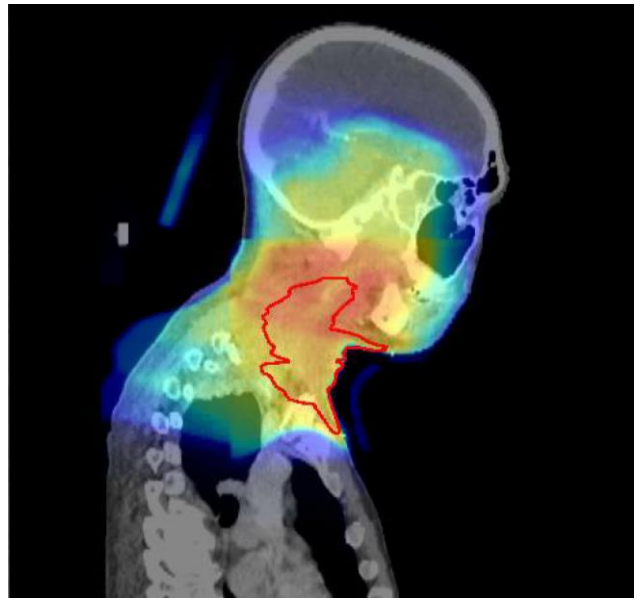




Q8. What is the next step?

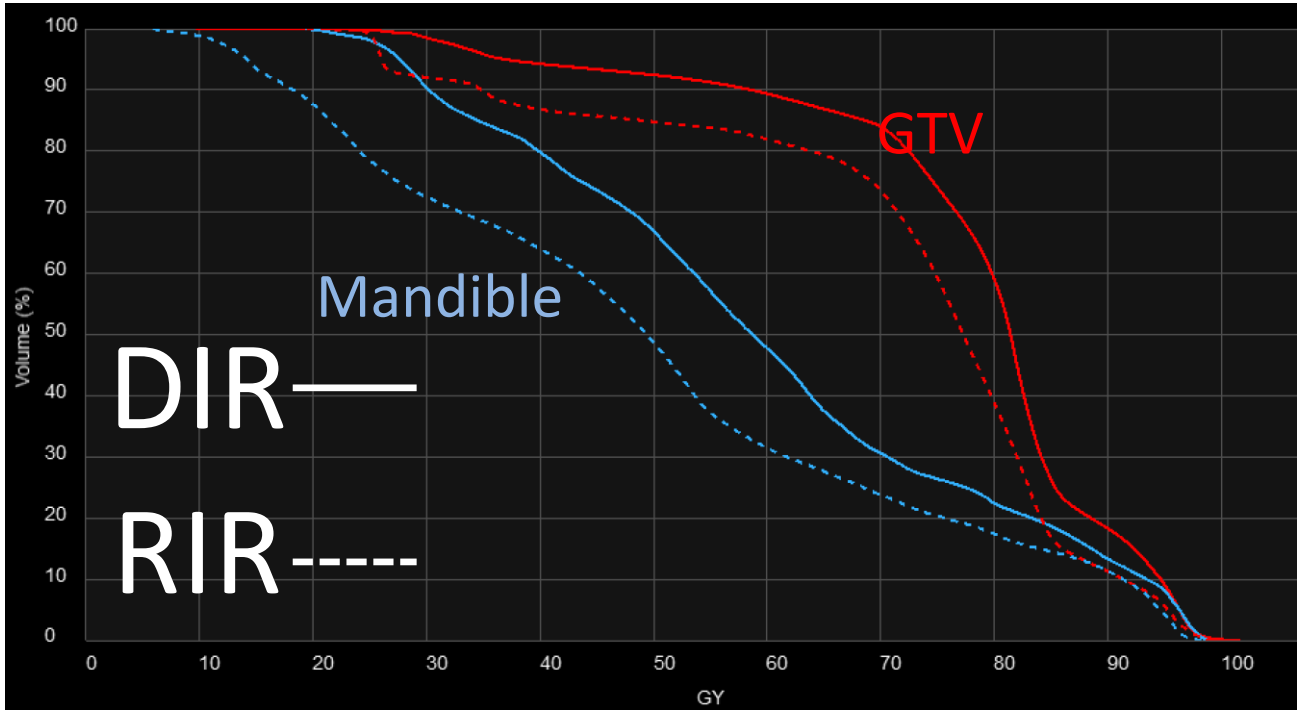
DIR:



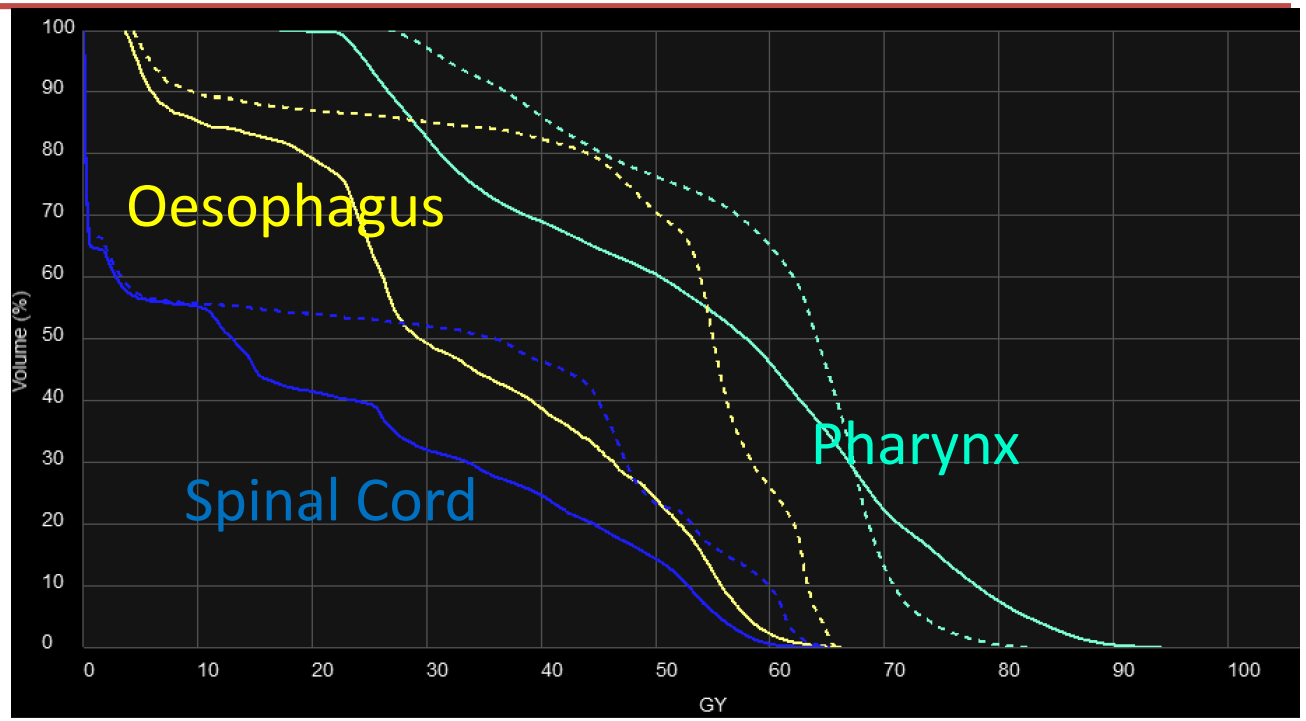


DVH of the sum dose

RIR: under-estimate dose where volumes are NOT overlapped within body (i.e. dose wrongly spread out)



RIR: over-estimate dose to nearby OARs where volumes are overlapped still within body



Take home notes

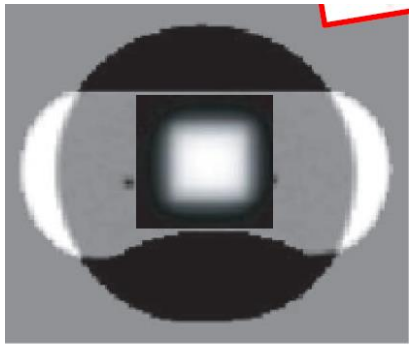
1. The performance of DIR is ill-defined
→*not enough* to judge with a single Q-metric

2. Need to understand limitations of given DIR options

3. It's all about optimization process
→ Diff algorithms perform differently

4. DIR can be possibly better than RIR in certain scenarios.

THANKS!



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Can your DIR do better than this?

The ACPSEM Medical Image Registration Special Interest Group (MIRSIG) Online Webinars

Questions and Answers from the September 2020 Webinar Chaired by Ben Archibald-Heeren (Talk 2 by Adam Yeo)

Question 1: If single metrics cannot be relied upon… then how should we be using them?

Answers: Each metrics has its own advantages and limitations. Relying on a single metric does not provide us the whole picture.
For example, dice index is only for checking DIR performance at structure boundary (not inside or in-between contours) – this can be a good enough metric for contour propagation application.
TRE based on point-features are checking only at those points, also if these high-contrast features are used to 'drive' DIR calculation (which is the case for all commercially available DIR solutions) and we use the same features/locations to 'check' its performance, it sounds circular and biased for checking). One way to get away from this bias is proposed the paper below:

- Med Phys. 2013 Oct;40(10):101701. doi: 10.1118/1.4819945.

DIR performance in low-contrast region can be validated if one can obtain ground truth dose or SUV distributions on deformed geometry. This can be applicable for dose-warping or adaptive target delineation.
Jacobian determinant can be useful to exclude non-physically deformed area from analysis but no information re actual accuracy of DIR.

Note DIR performance will be inevitably depending on input images, meaning that it's image modality specific, body-site specific, image quality specific, and also application specific. As such, all available and relevant metrics will need to be used for different DIR applications. Personally speaking, the best practice as of today would be to identify imitations and perform risk-benefit assessment according to each of departmental need.