

**CASE Studentship: Application of low-latency
computing to automate on-treatment image verification for
adaptive radiotherapy
Charing Cross Perspective
Centre for the Clinical Application of Particles**

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Outline

- Project Overview
- Industrial partner
- Three stages of the project
- Charing Cross perspective

Project Overview

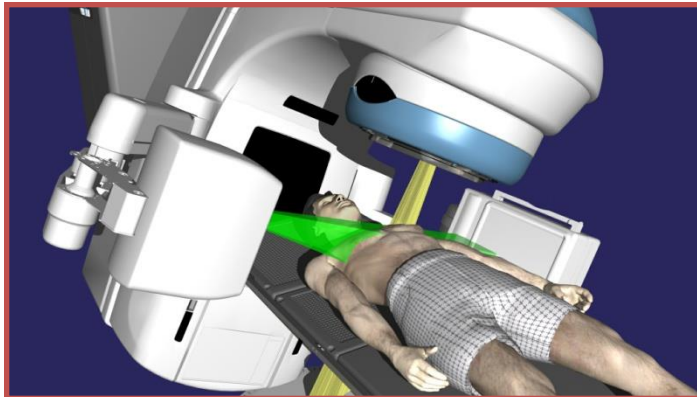
- Application of low-latency computing to automate on-treatment image verification for adaptive radiotherapy
 - facilitate fast and accurate adaptive radiotherapy (RT) by automating on-treatment verification of cone-beam CT (CBCT) scans

Project Overview

- Variation in tumour position is a major challenge in radiotherapy
 - reducing the precision of the dose delivered to the tumour
 - increasing the risk to healthy tissue
- CBCT is used to determine tumour position prior to treatment
 - manual intervention is required for image acquisition and matching.
- Propose using low-latency dataflow computing engines to automate these procedures
 - maximising the precision and reproducibility of dose-delivery
 - reducing the time spent in the RT suite

Project Overview

- CBCT on-treatment positional verification



Varian Medical Systems

Lung, ROBERT

Transversal - CT_Lung - CBCT 2006/10/16 08:50 - 1/1.0001 - 12:00 AM

Transversal - CT_Lung

3D / 3D Match

Head First Superior Z: 1.75 cm

Frontal - CT_Lung - CBCT 2006/10/16 08:50 - 1/1.0001 - 12:00 AM

Sagittal - CT_Lung - CBCT 2006/10/16 08:50 - 1/1.0001 - 12:00 AM

Y: -0.95 cm

X: -0.76 cm

Couch Shift (VAR_IEC Scale, All units in cm and degrees)

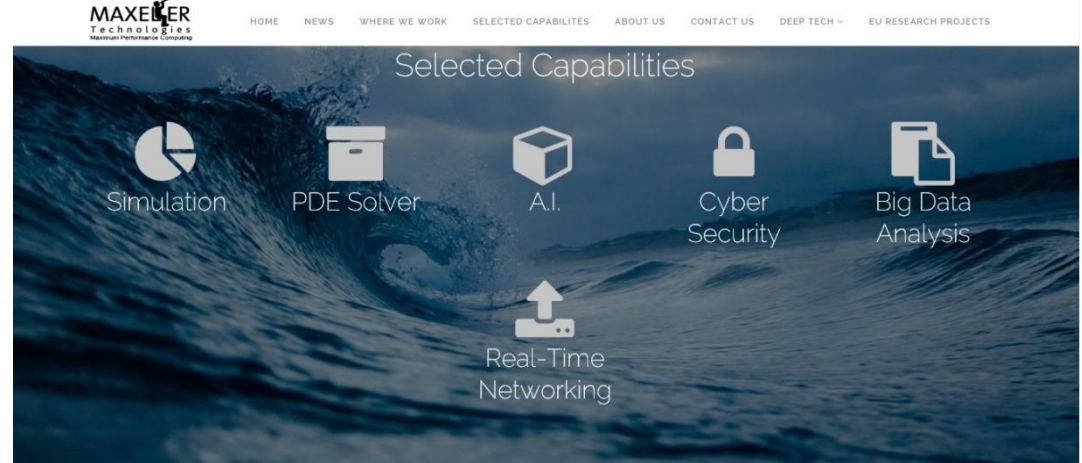
Raw Shift Values				Machine Values			
	SHIFT		SHIFT	TARGET	ACTUAL	SHIFT	
Couch Lat	1.9	Couch Pitch	-0.5	Couch Lat	1.9	0.0	1.9 <input checked="" type="checkbox"/> Include
Couch Lng	1.1	Couch Roll	0.8	Couch Lng	1.1	0.0	1.1 <input checked="" type="checkbox"/> Include
Couch Vrt	0.3	Couch Rtn	-0.6	Couch Vrt	0.3	0.0	0.3 <input checked="" type="checkbox"/> Include
		Couch Proj Rtn		Couch Rtn	0.0	0.0	0.0 <input checked="" type="checkbox"/> Include

Perform the anatomy match

1. Acquire 2. Analyze Cancel

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Industrial Partner



- Maxeler Technologies will provide the dataflow-computing expertise
 - Under the guidance of Prof Gaydadjiev (Director of Maxeler IoT labs and visiting professor at the Department of Computing, Imperial College), several Maxeler engineers will support the CASE student in various aspects of the project (software tools, software development, etc.)

Academic Supervision & Assistance

- Dr K Long
- Dr D Gujral, Consultant Clinical Oncologist
- Dr R McLauchlan, Consultant Radiotherapy Physicist
- Dr S Cooper, Lecturer in the Dyson School of Design Engineering
- K Le Calvez & Computational Oncology Group

Three stages of the project

- Stage 1 (9-12 months @ Charing Cross)
 - Development of the specification of feature-recognition and tissue classification metrics for the development of image processing algorithms
 - Selection of clinically-suitable CBCT images
 - A large set of images (<2000) will be selected from cancers of the head-and-neck, anus, and prostate
 - Image-processing code development

Three stages of the project

- Stage 2 (~12 months @ Maxeler)
 - Development of image-processing algorithms on low-latency, FPGA-based dataflow computing engines (DFEs) – code development and bench-marking
 - Exploiting Maxeler's compiler (Java-based, obviating need for VHDL/Verilog programming) and the Maxeler cluster of FPGA-based DFEs.

Three stages of the project

- Stage 3 (6-9 months @ Charing Cross)
 - Clinical evaluation of the image-processing systems
 - Integration, validation and performance evaluation

Charing Cross Perspective

- CBCT on-treatment positional verification in routine use for many sites

Site	Year	
	2016/17	2017/18
Prostate – total inc PR1	236	241
PR1	12	83
Anal canal	20	22
Head & neck	90	108

[Numbers courtesy of Suzanne Harrow]

Charing Cross Perspective

- Prostate



Charing Cross Perspective

- Prostate



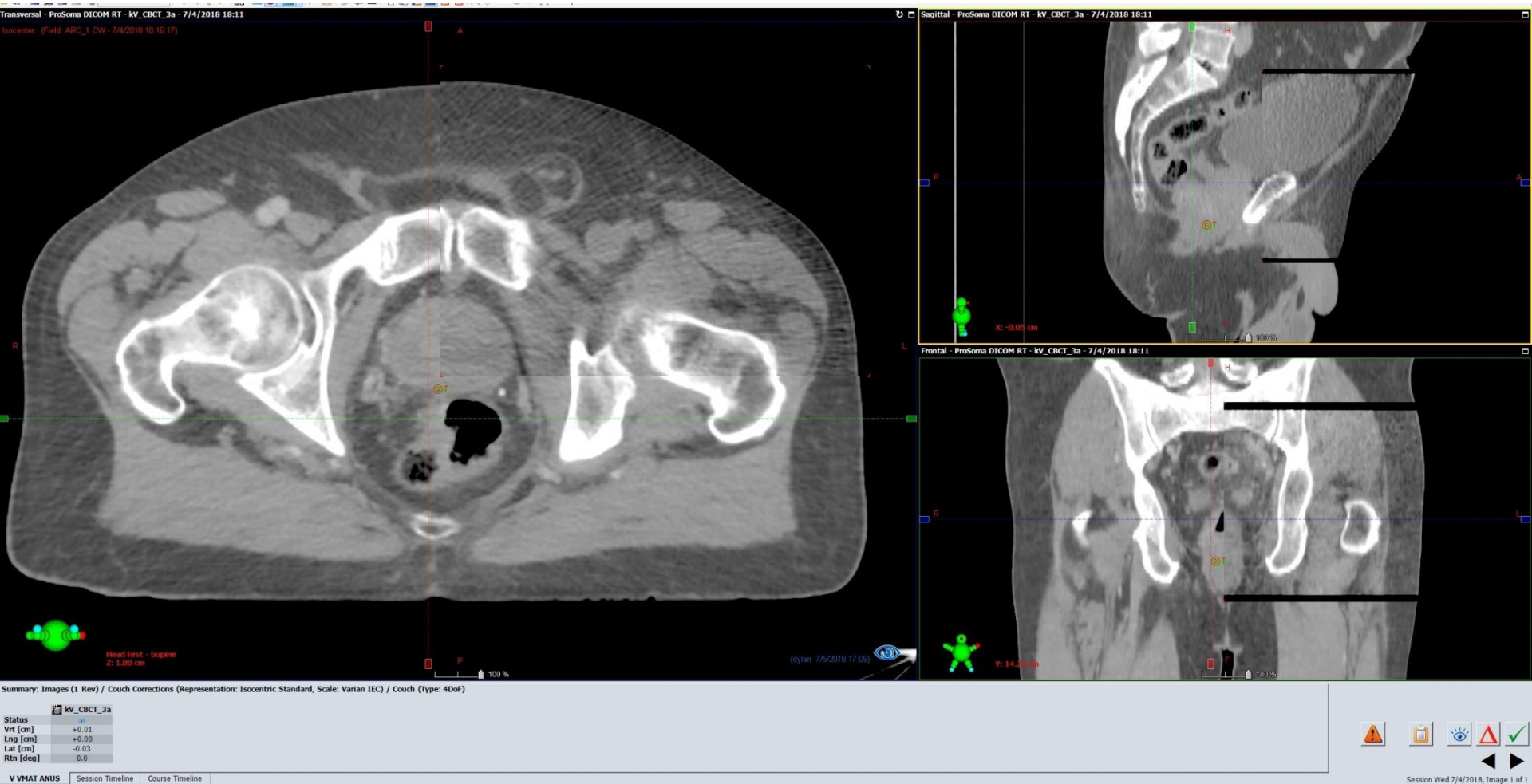
Summary: Images (1 Rev) / Couch Corrections (Representation: Isocentric Standard, Scale: Varian IEC) / Couch (Type: 4DoF)

kv_CBCT_2a	
Status	OK
Vrt [cm]	-0.04
Lng [cm]	0.00
Lat [cm]	+0.01
Rth [deg]	0.0



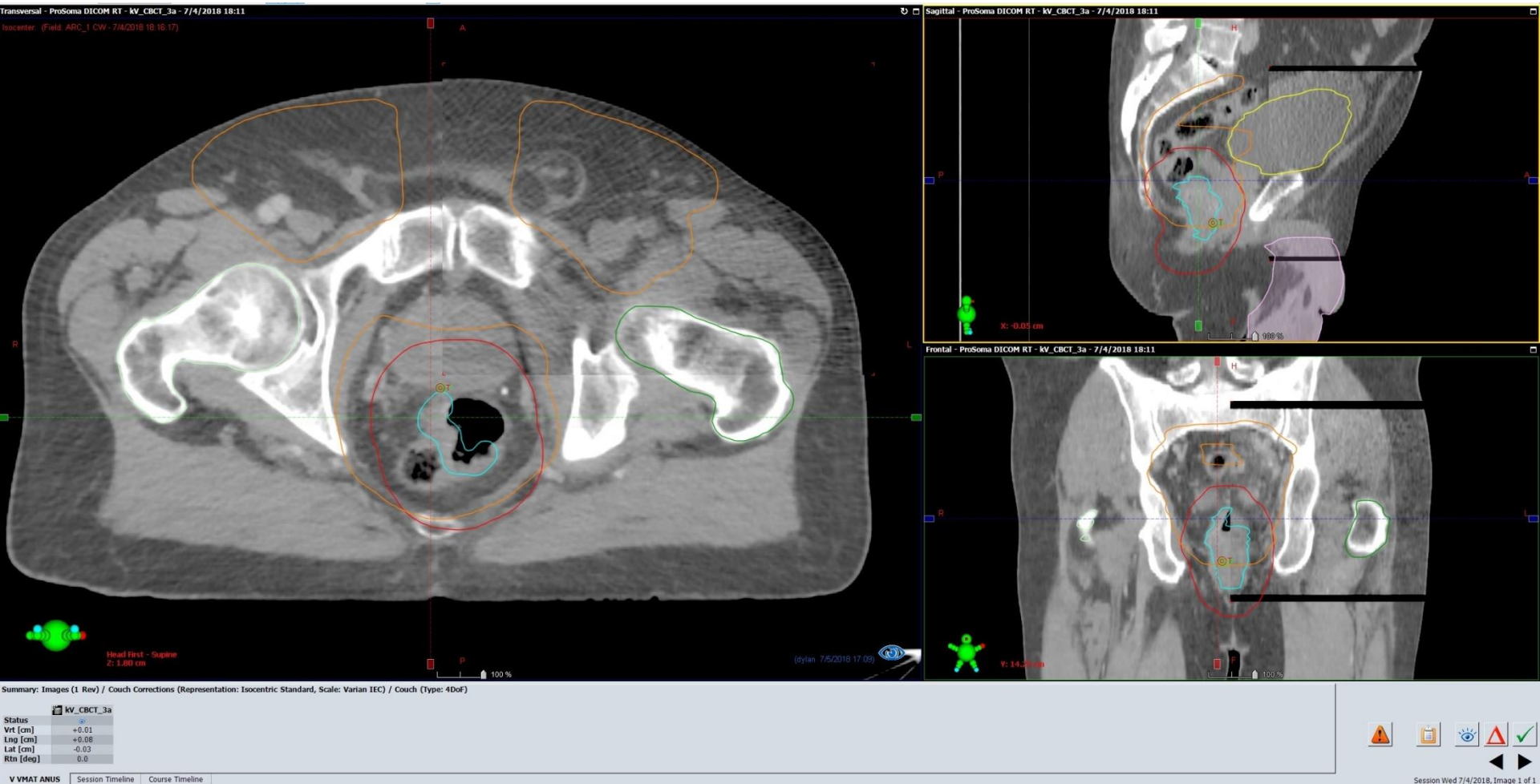
Charing Cross Perspective

- Anal canal



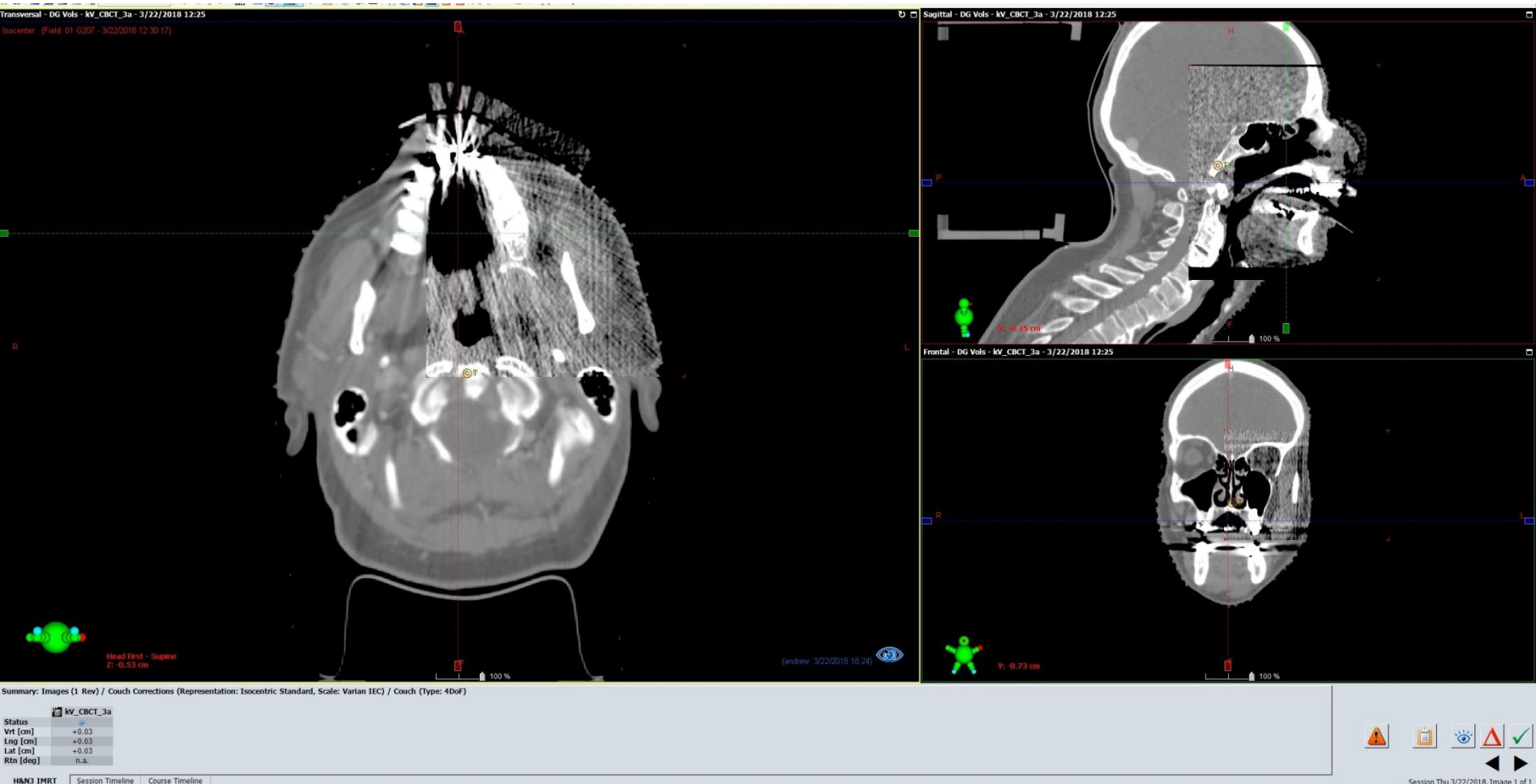
Charing Cross Perspective

- Anal canal



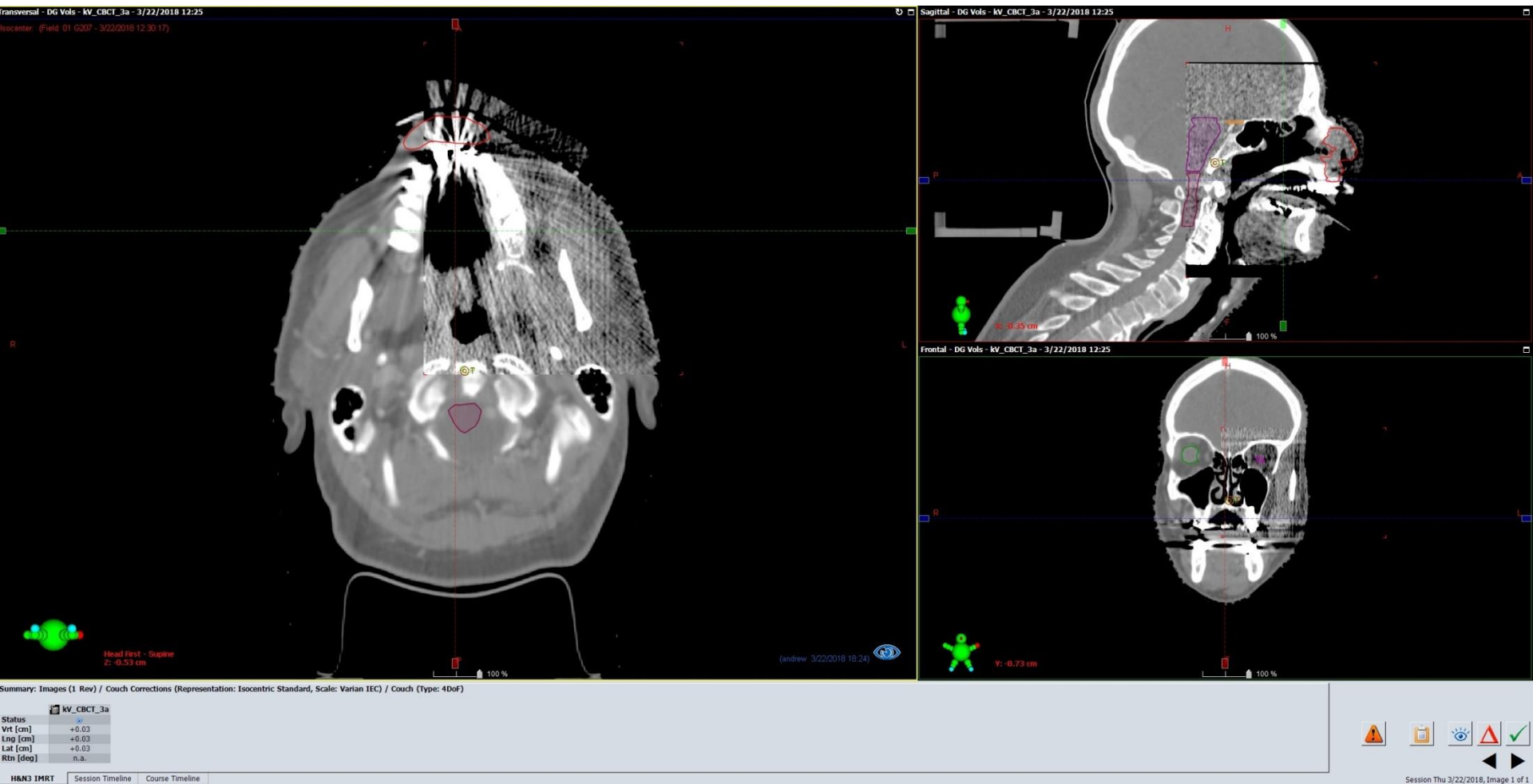
Charing Cross Perspective

- Head and Neck – Nasal cavity



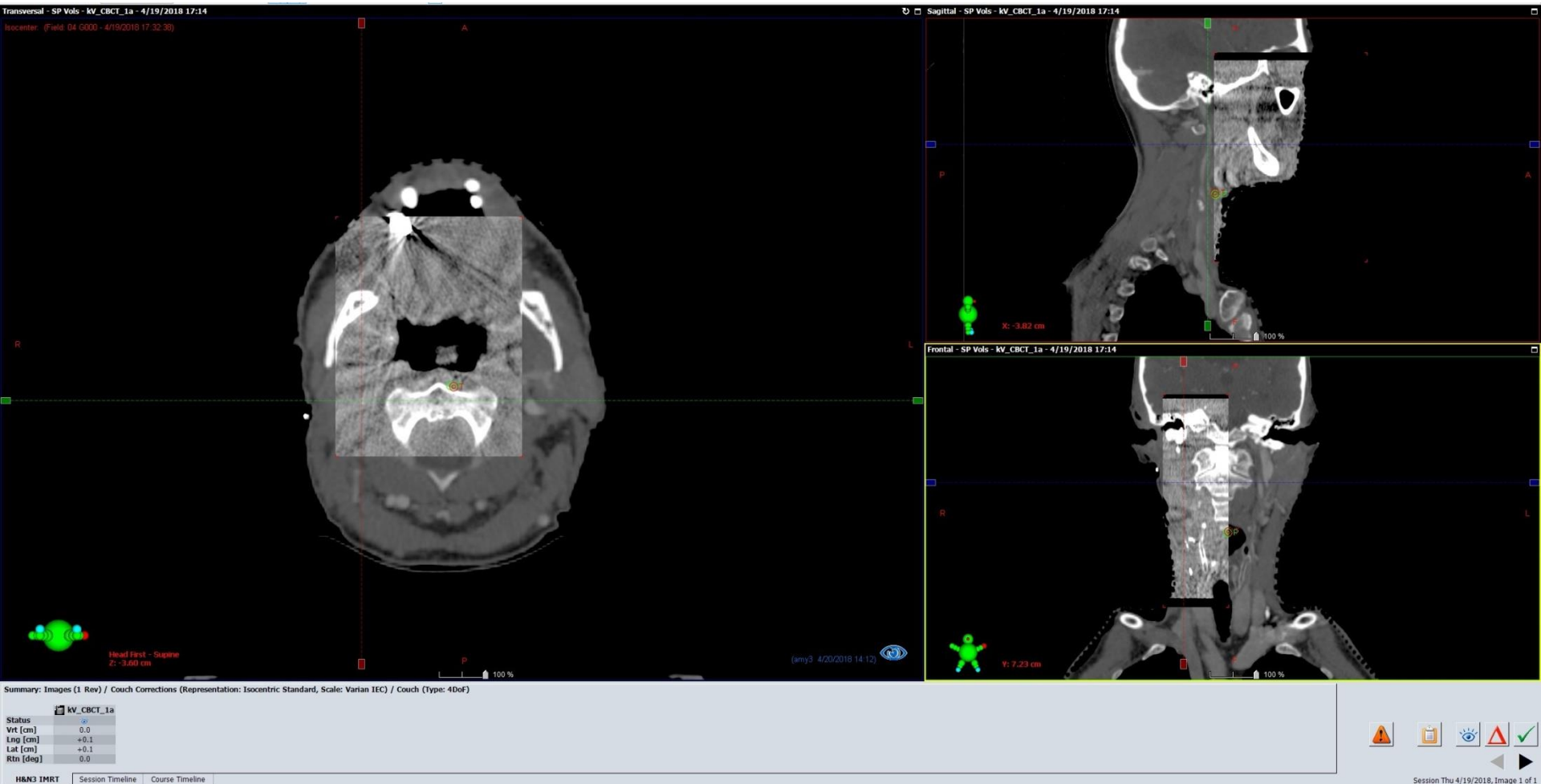
Charing Cross Perspective

- Head and Neck – Nasal cavity



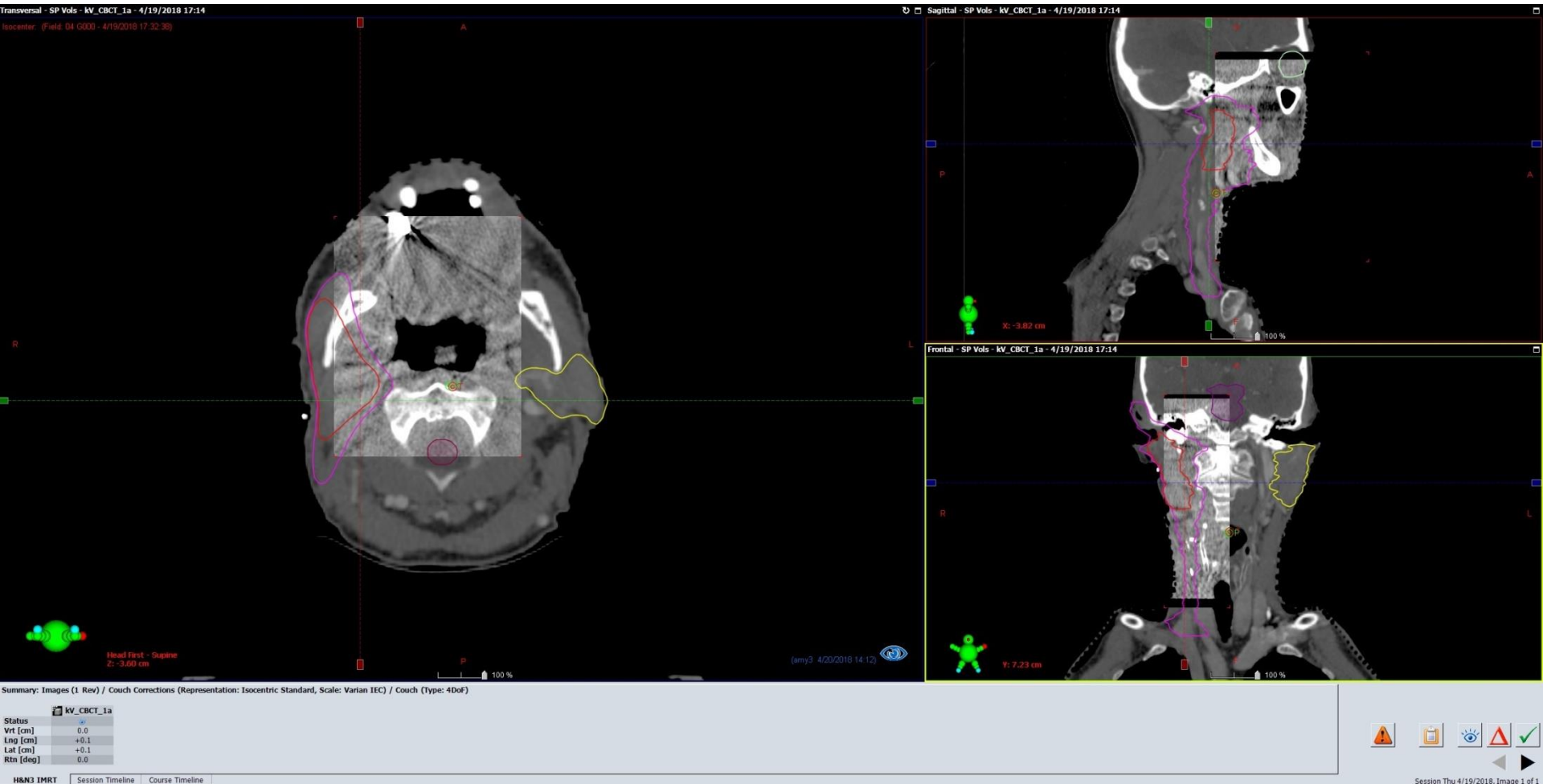
Charing Cross Perspective

- Head and Neck – Parotid



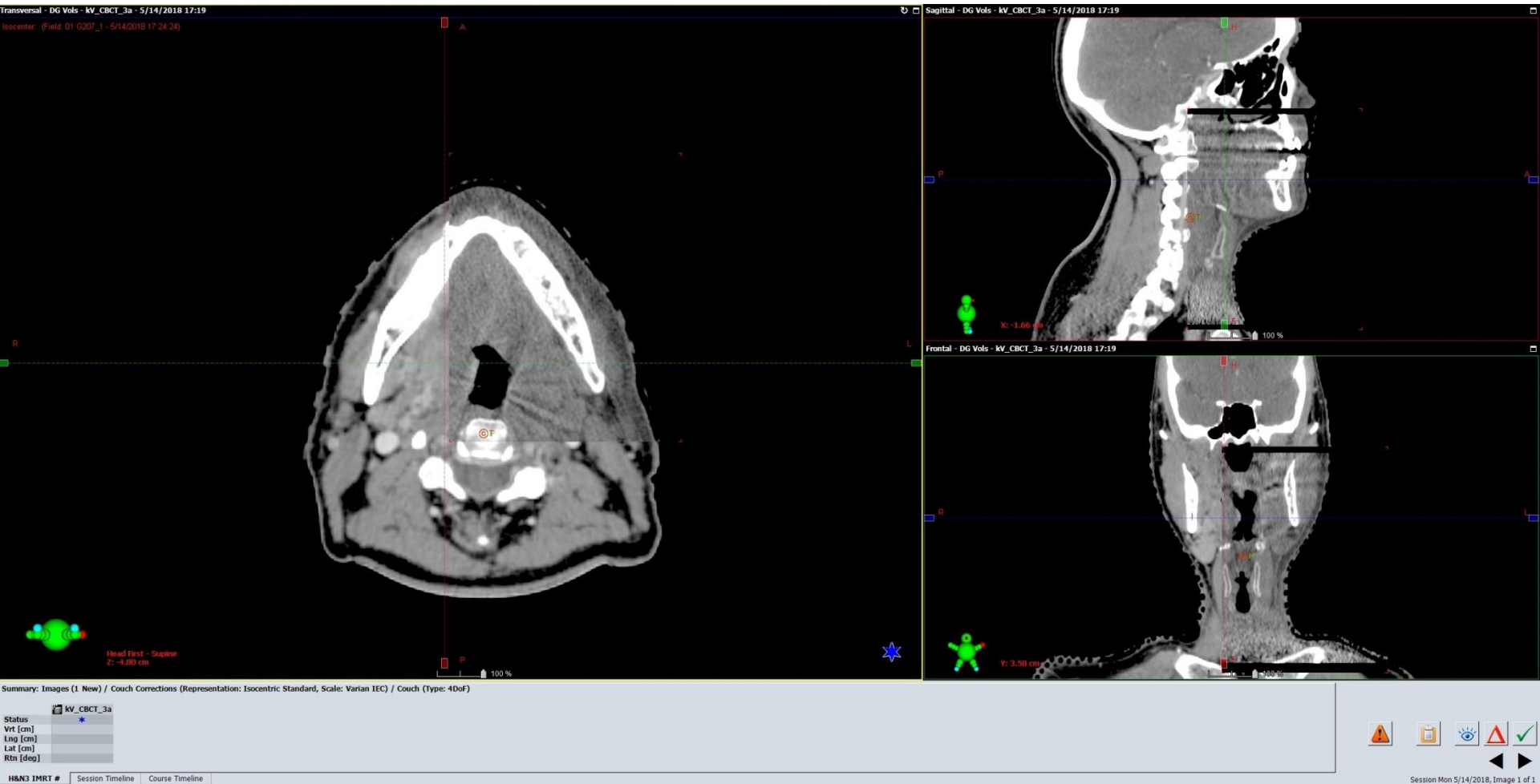
Charing Cross Perspective

- Head and Neck – Parotid



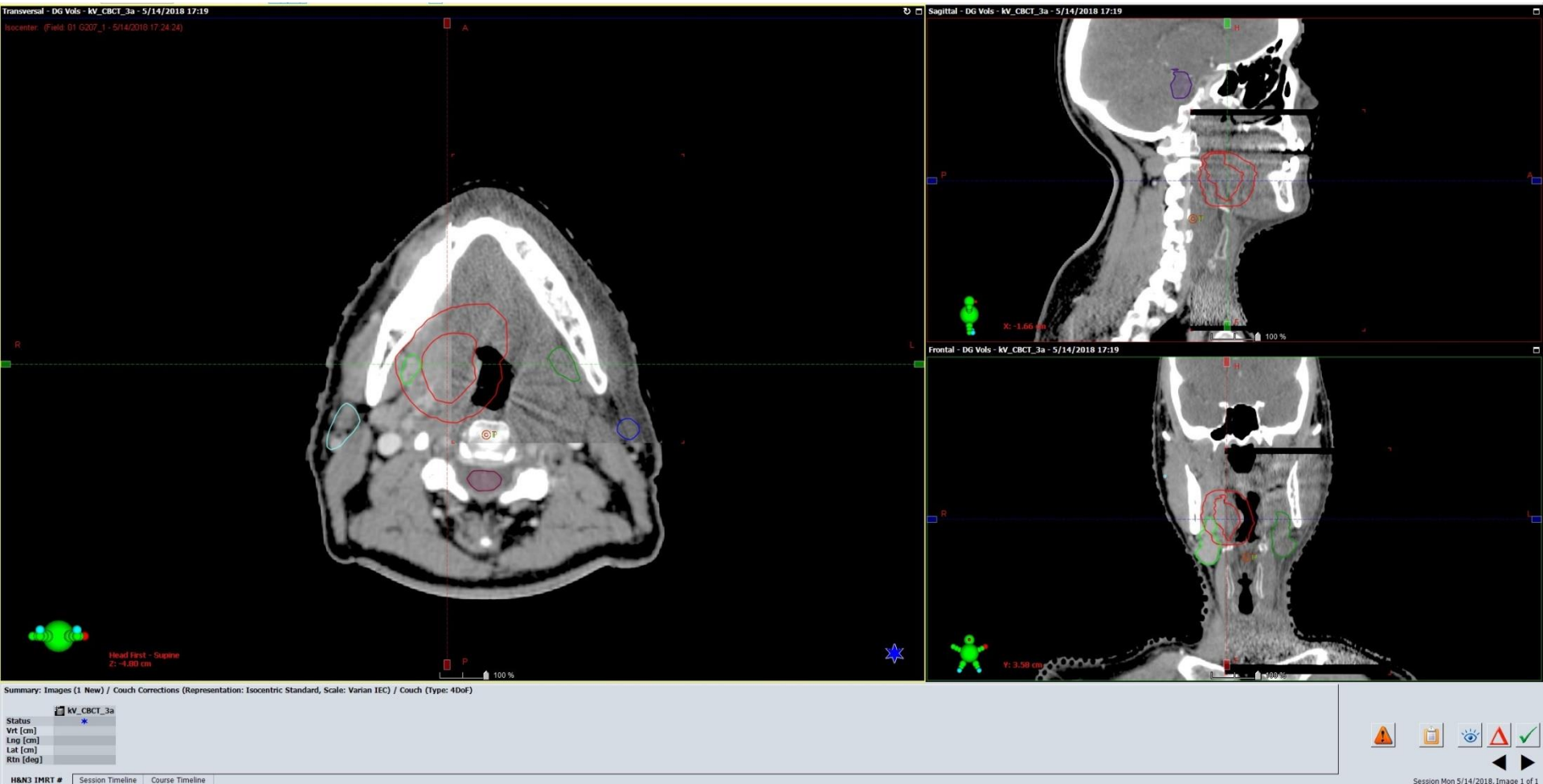
Charing Cross Perspective

- Head and Neck – Oropharynx



Charing Cross Perspective

- Head and Neck – Oropharynx



Charing Cross Perspective

- **Mission Statement: The development of a novel, real-time on-board imaging system**
 - *develop novel, real-time imaging systems: consider imaging techniques, image processing and feature recognition as well as real-time dose-deposition imaging*
- CASE studentship forms part of Short term plan (Yr1-3)
- Medium Term (Yr 3-6)
 - Adapt algorithms for next generation accelerator/detector systems
 - Integration of image-acquisition and image-processing systems, evaluation of performance and optimisation of algorithms and their implementation
 - To develop a prototype with automated image acquisition and processing for real-time dose-deposition imaging

Charing Cross Perspective

- **Mission Statement: The development of a novel, real-time on-board imaging system**
 - *develop novel, real-time imaging systems: consider imaging techniques, image processing and feature recognition as well as real-time dose-deposition imaging*
- Long Term (Yr 6-10)
 - To develop the prototype for commercial use
 - To integrate and test the prototype into a new laser accelerator system and assess quality and accuracy of real time dose deposition imaging
 - To set up collaborations with radiobiologists and medical physicists (within CCAP) for radiobiological testing of a new accelerator system, utilizing the prototype above for image processing, dose deposition in real-time and dose calculations