

Combining Functional Imaging with Radiation Treatment Planning

Experience at the WBRC

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Overview

- **The WBRC & The Alfred NM Department**
- **What is Radiation Therapy (RT) Treatment Planning ?**
- **Integration of Functional Data into Planning**
- **How is it useful ?**
- **Clinical Experience**
- **Future**



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The William Buckland Radiotherapy Centre

External Beam :

2 x Varian 21EX (EPI, MLC, etc)

1 x Varian 2100C (EPI, MLC, etc)

1 x Varian 600C (BrainLAB mMLC, EPI, etc)

Stereotactic Radiosurgery / Radiotherapy Program

GE Fxi Single Slice CT

Brachytherapy :

Nucletron HDR (~ 50 prostate patients per annum)

I-125 Seed Program (~70 prostate patients per annum)

RT Planning Systems :

Varian Eclipse

Nucletron PLATO

BrainLAB Brainscan

Radionics XKNIFE



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The Alfred Nuclear Medicine Department

GE Discovery VH Integrated Hybrid SPECT-PET/CT System

Dual-head PET & SPECT camera
1”(25.4mm) thick NaI Crystal
Energy Range 40 – 520keV

10mm slice CT “low-dose” scanner
Image FOV 450mm

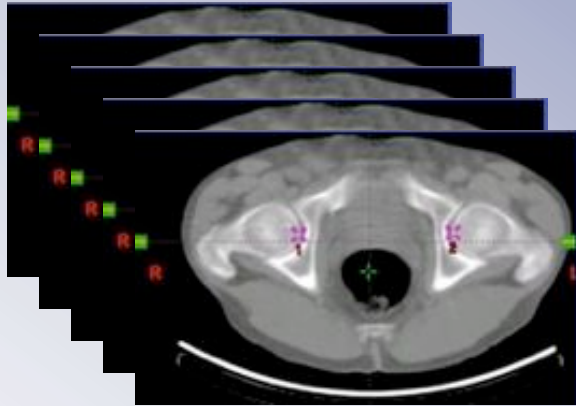


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RT Treatment Planning

A treatment site for a patient has been diagnosed, usually by Radiology or Nuclear Med. Imaging.



Why can't a radiotherapy centre just use these diagnostic images for RT treatment planning ?



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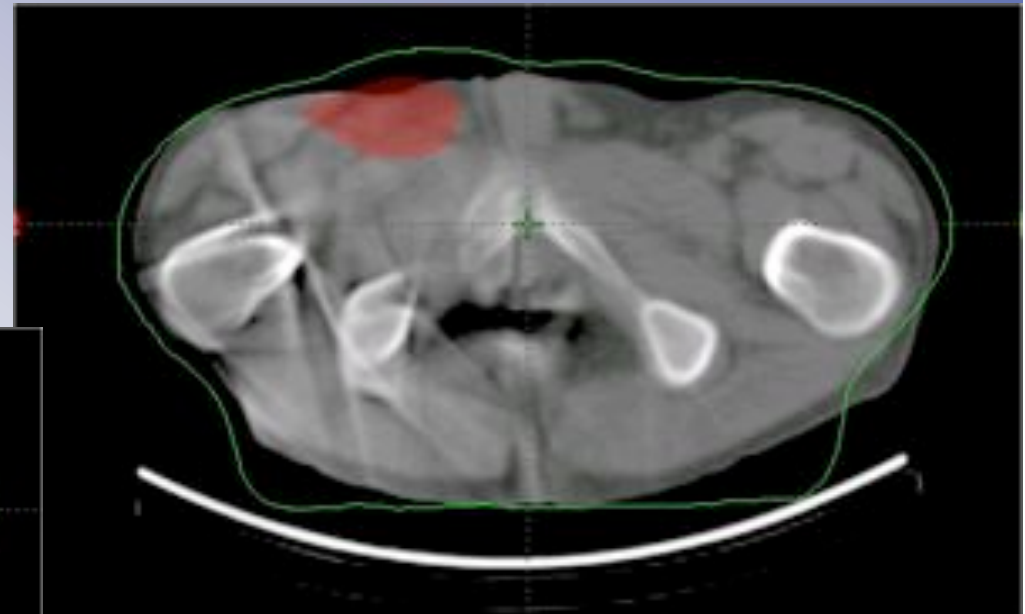
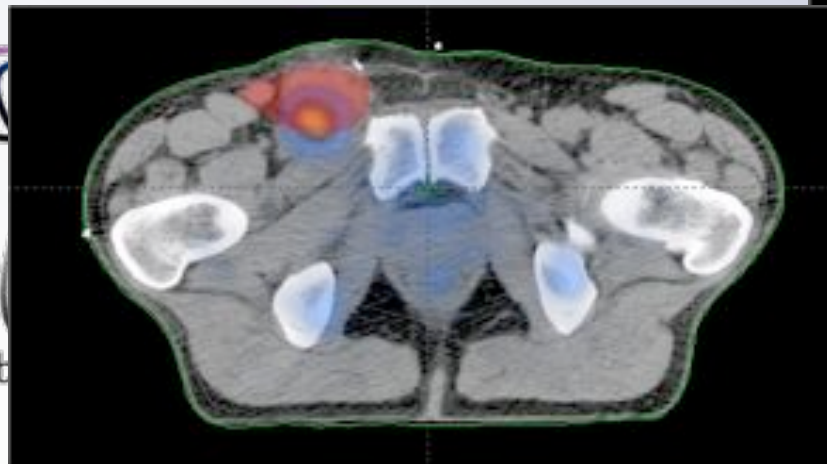
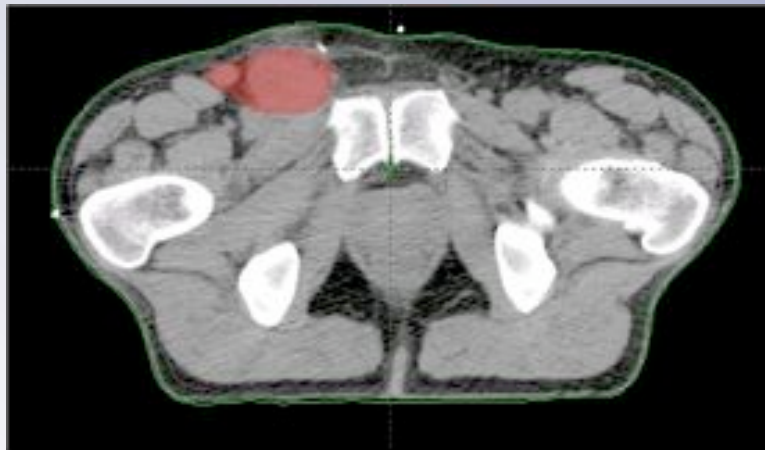
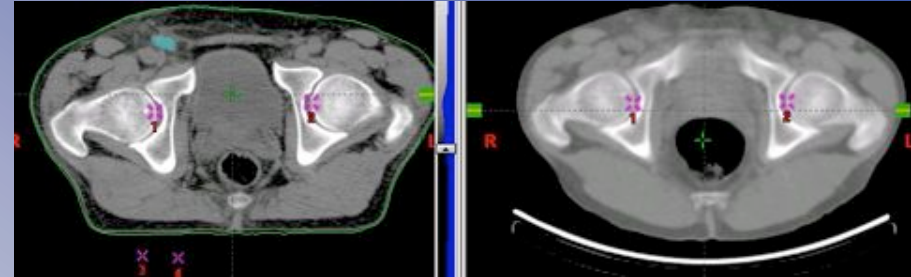
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RT Treatment Planning

Why can't a radiotherapy centre just use these diagnostic images for RT treatment planning ?

- Patient Geometry

Patient is not lying in treatment position.



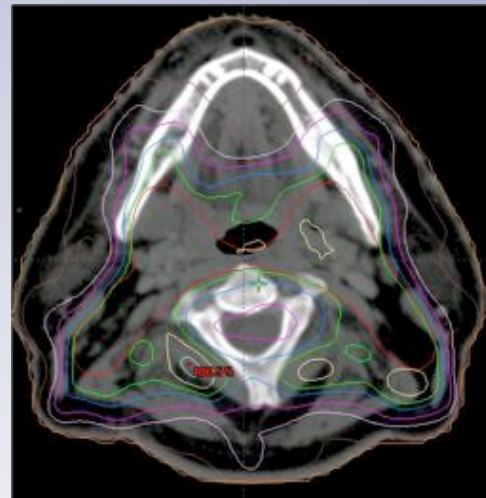
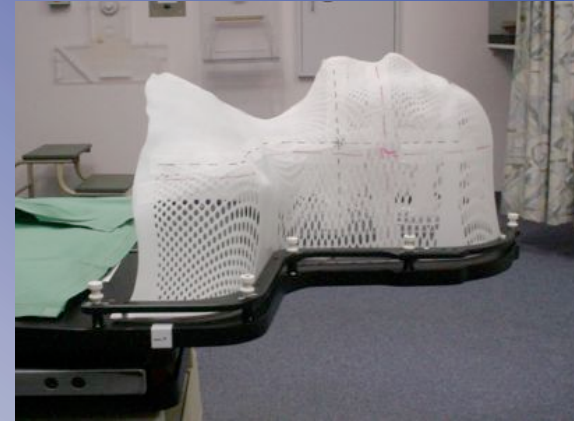
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RT Treatment Planning

Why can't a radiotherapy centre just use these diagnostic images for RT treatment planning ?

- Patient Setup Reproducibility
Patient is not setup using indexed fixation equipment.
- CT voxel data used in RT Treatment Dose Calculation
CT data – HU to electron density calibration required.



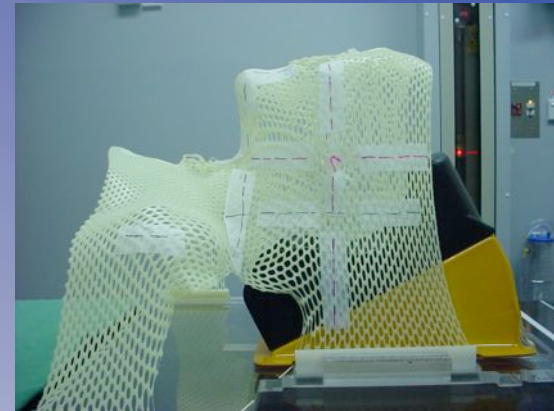
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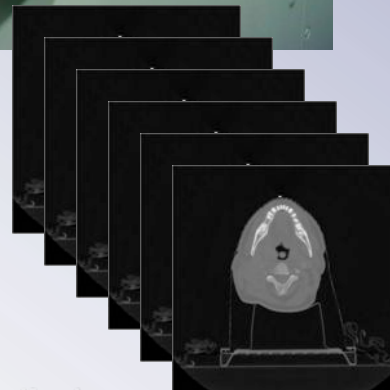
RT Treatment Planning

Begins with ...Simulation

Patient Setup on CT couch with
reproducible fixation



Images Acquired

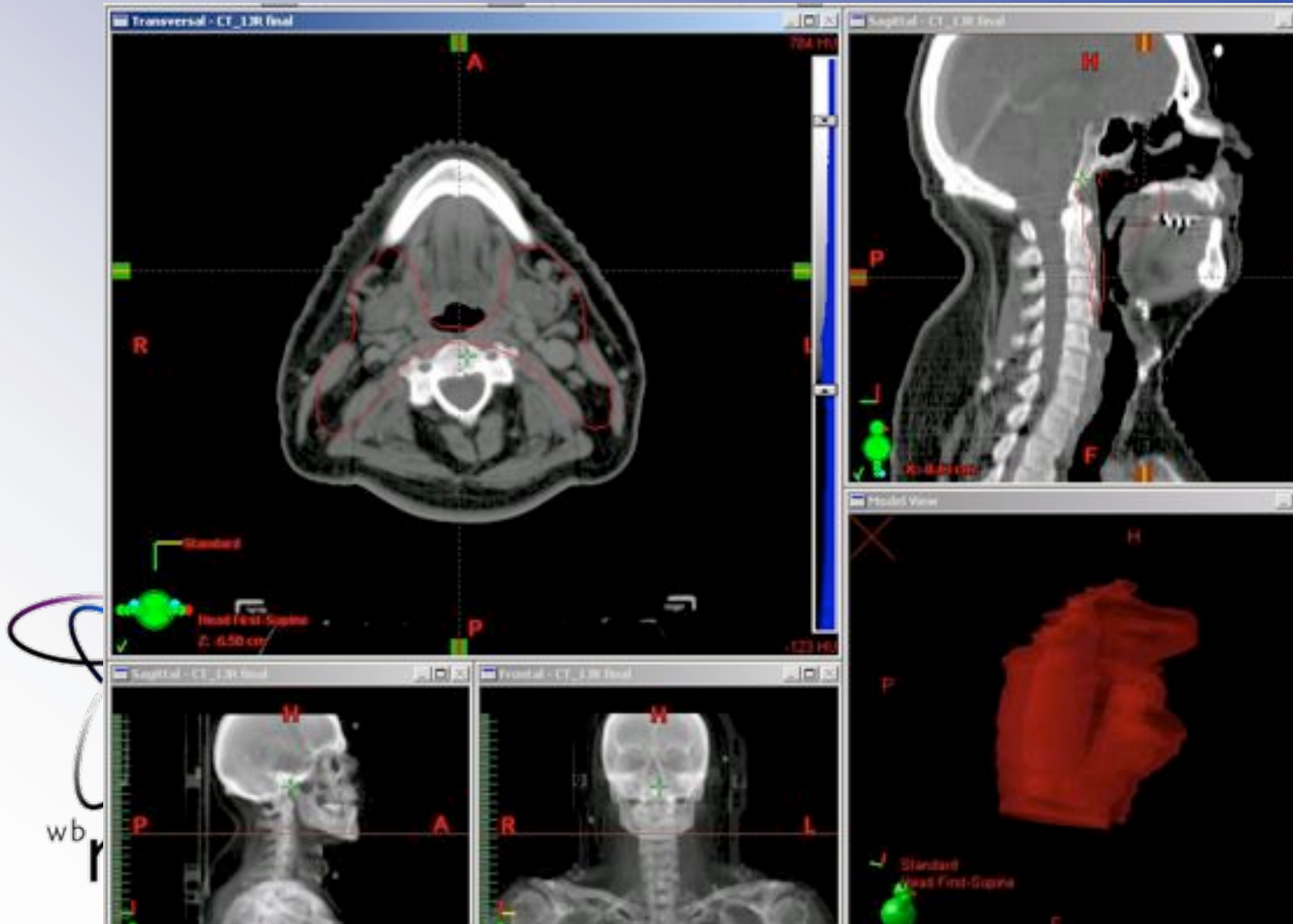


Sent to Virtual
Simulation Computer →

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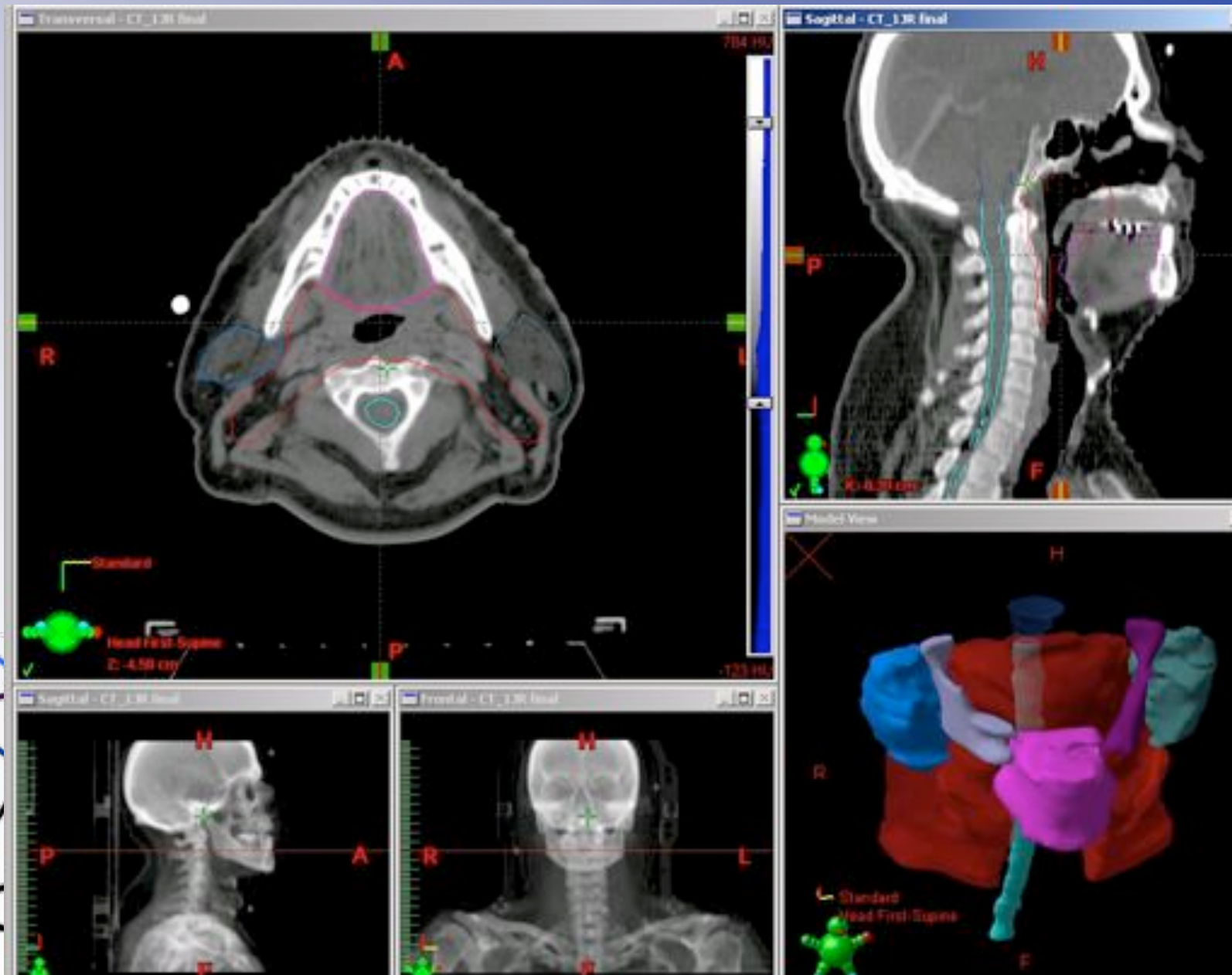
RT Treatment Planning

GTV and PTV outlined



RT Treatment Planning

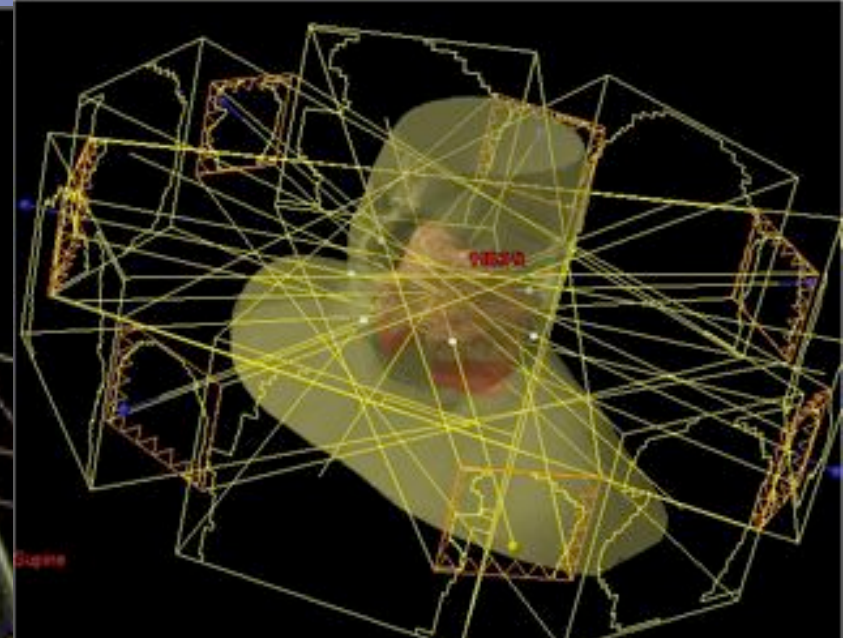
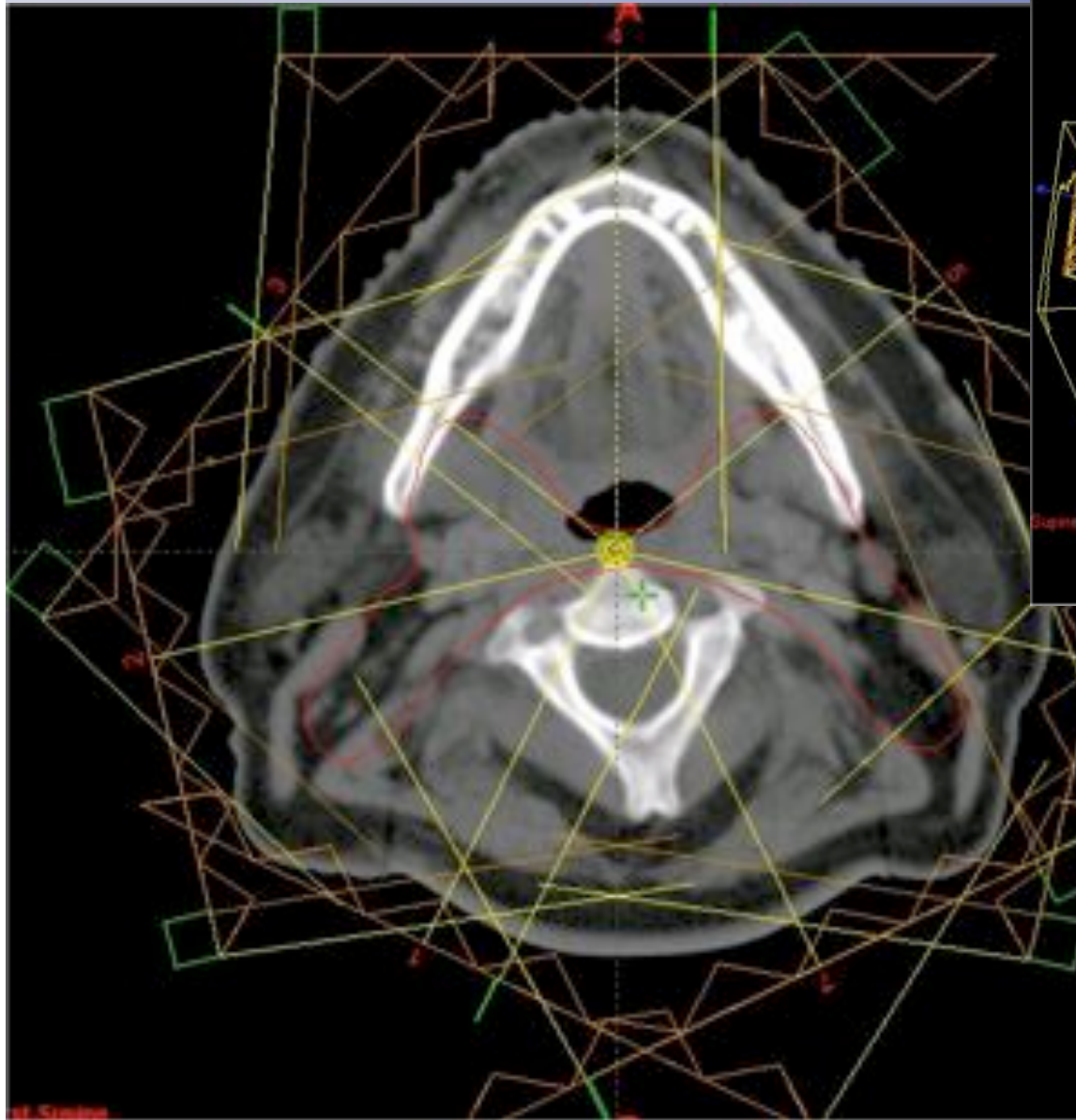
Critical structures outlined



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RT Treatment Planning

Isocentre defined and treatment beams added

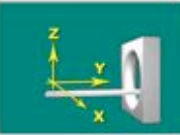


RT Treatment Planning

Isocentre position and field boundaries transferred to patient

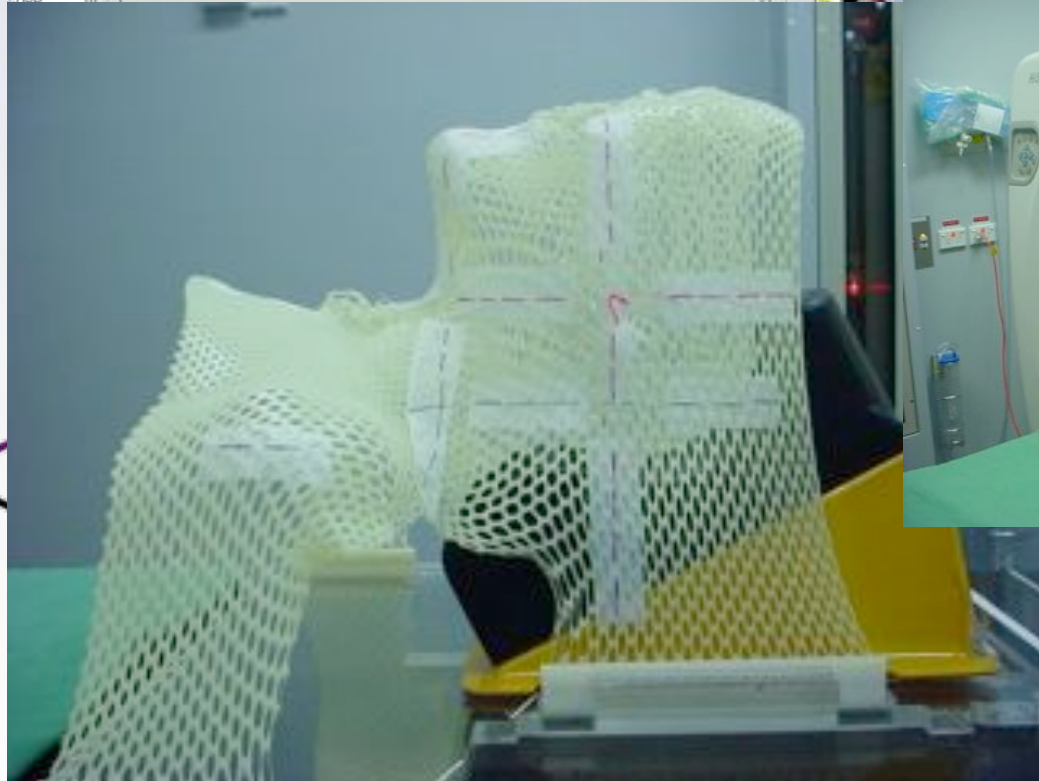
Virtual Simulation - Review and Export Points - LAP Dorado CT-1-3 (LAP Windows 2.0)

The table below shows information for all the points that will be exported to the laser alignment system. Red columns show the CT table readouts that must be positioned manually by moving the CT table.



To show the cross laser marking a point on the Body surface in the Model view, click the row of the point in the table.

Field(s)	Point	X [mm]	Y [mm]	Z [mm]	Laser(s)
3 AP Neck	Isocenter	-15	-87	-5	All



RT Treatment Planning

Patient goes home

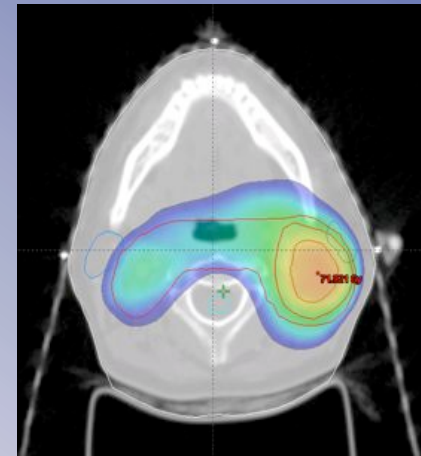
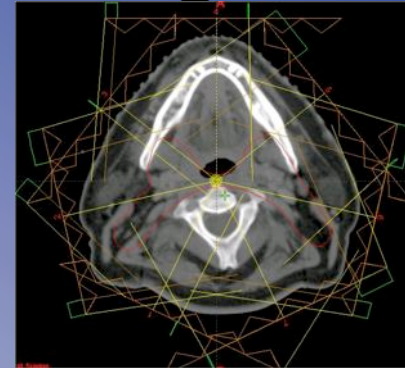
Simulation image and plan data then transferred to RT Planning computer

An optimal treatment plan is then created, treatment dose calculated

Achieve prescription dose coverage, minimal dose to critical structures

Patient returns a few days later to begin treatment

Patient treatment position is exactly the same as at simulation



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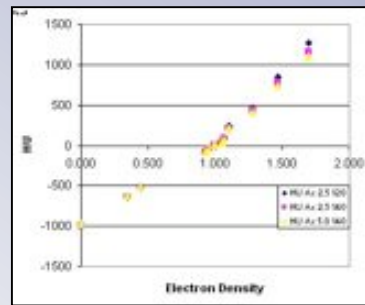
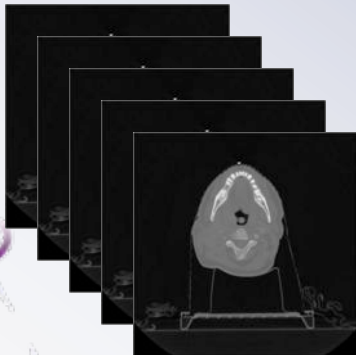
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Dose Calculation

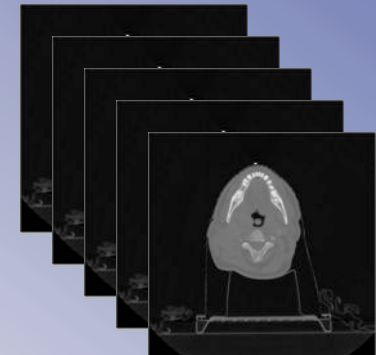


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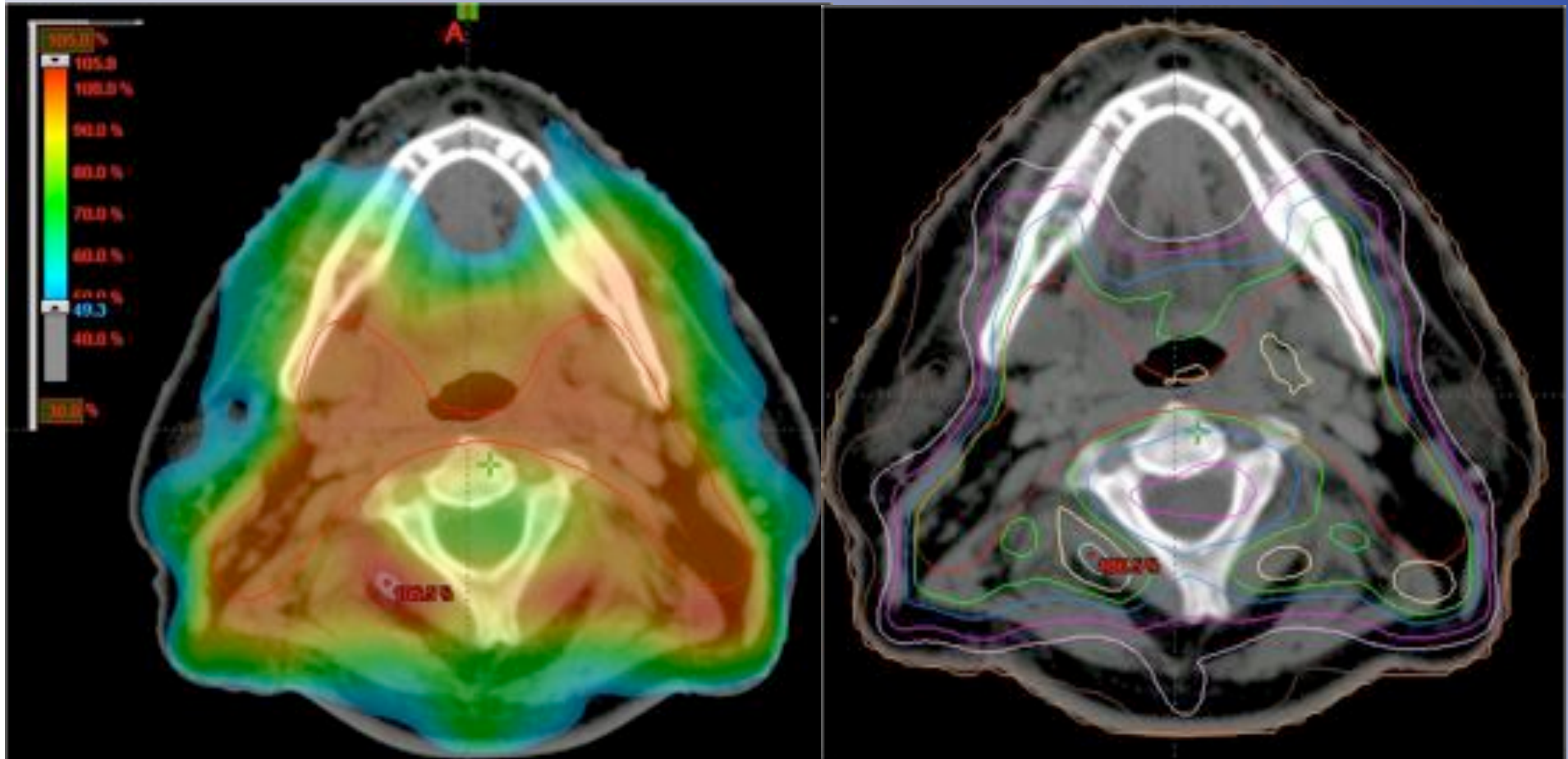
HU CT Data



ED CT Data



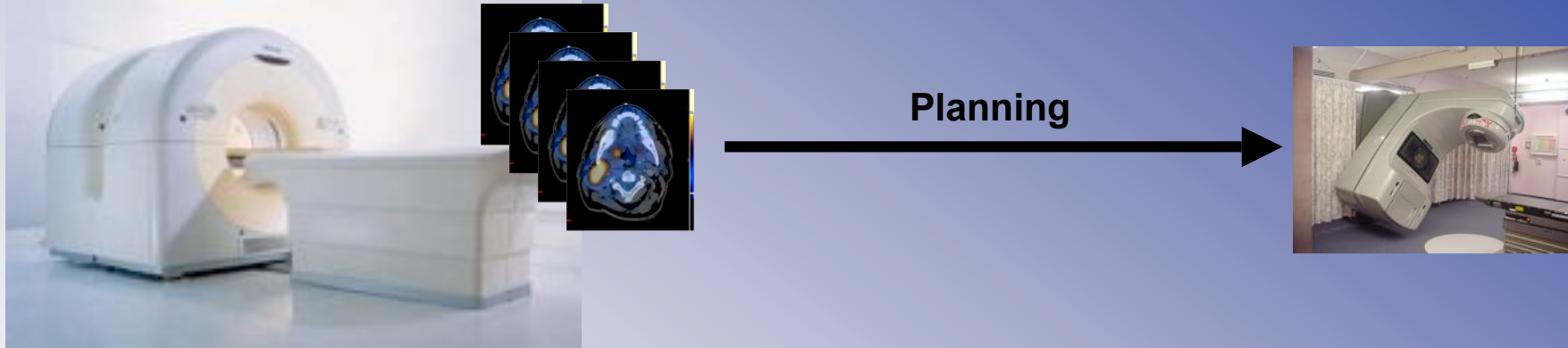
Treatment Planning



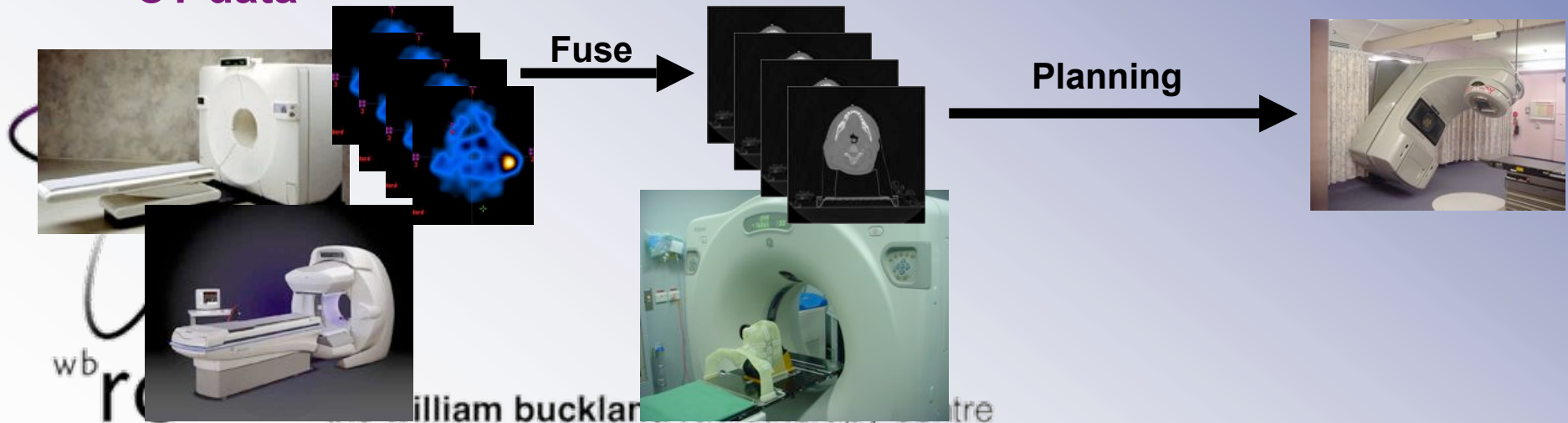
Integrate Functional Imaging

How to include functional imaging in the treatment planning process ?

1. Use data from a dedicated multi-modality (PET/CT) scanner



2. Import a functional imaging set and fuse with the RT simulation CT data



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Integrate Functional Imaging

1. RT requirements for a multi-modality scanner

Flat Top Couch

Patient Localisation System

Indexed Couch

Minimal Sag when extended

Electron Density / HU calibration

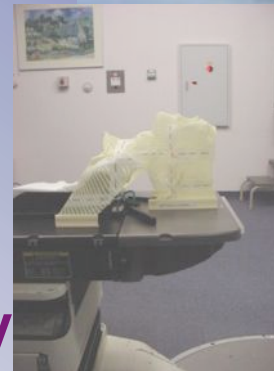
Large scanner aperture

Philips Brilliance 85cm / 60cmSFOV

Virtual Simulation

External Laser System (LAP) for patient skin/mask markings

Virtual Simulation Planning System available in scanner control room (or somewhere close)



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Integrate Functional Imaging

Advantages

RT planning have immediate access to both data sets

No Fiducial Marker / Anatomical Fusion of CT and functional data sets required – reduce possible errors



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Integrate Functional Imaging

2. Importing functional imaging from other non-RT systems

Patient needs to be setup and scanned in same position as in simulation CT position
i.e. proposed treatment position



Co-ordination of setup procedures between RT and Nuclear Medicine Department

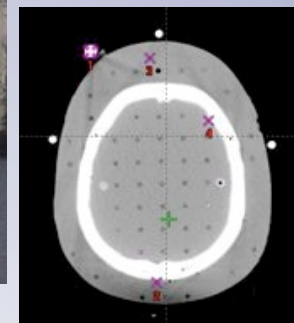


A fiducial marking system is required to match functional data set to RT simulation CT data

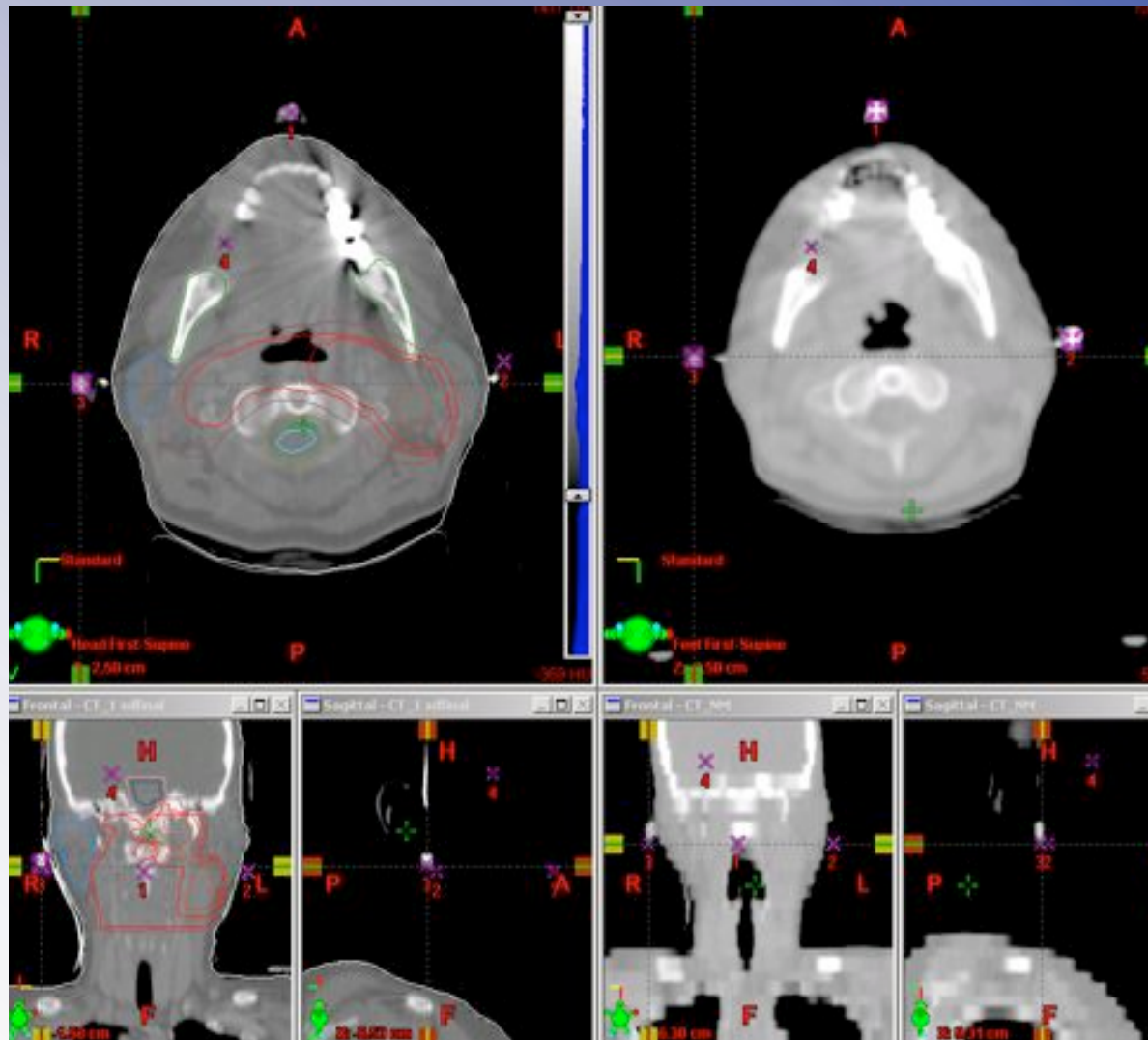
A removable flat top couch system required



Patient Localisation



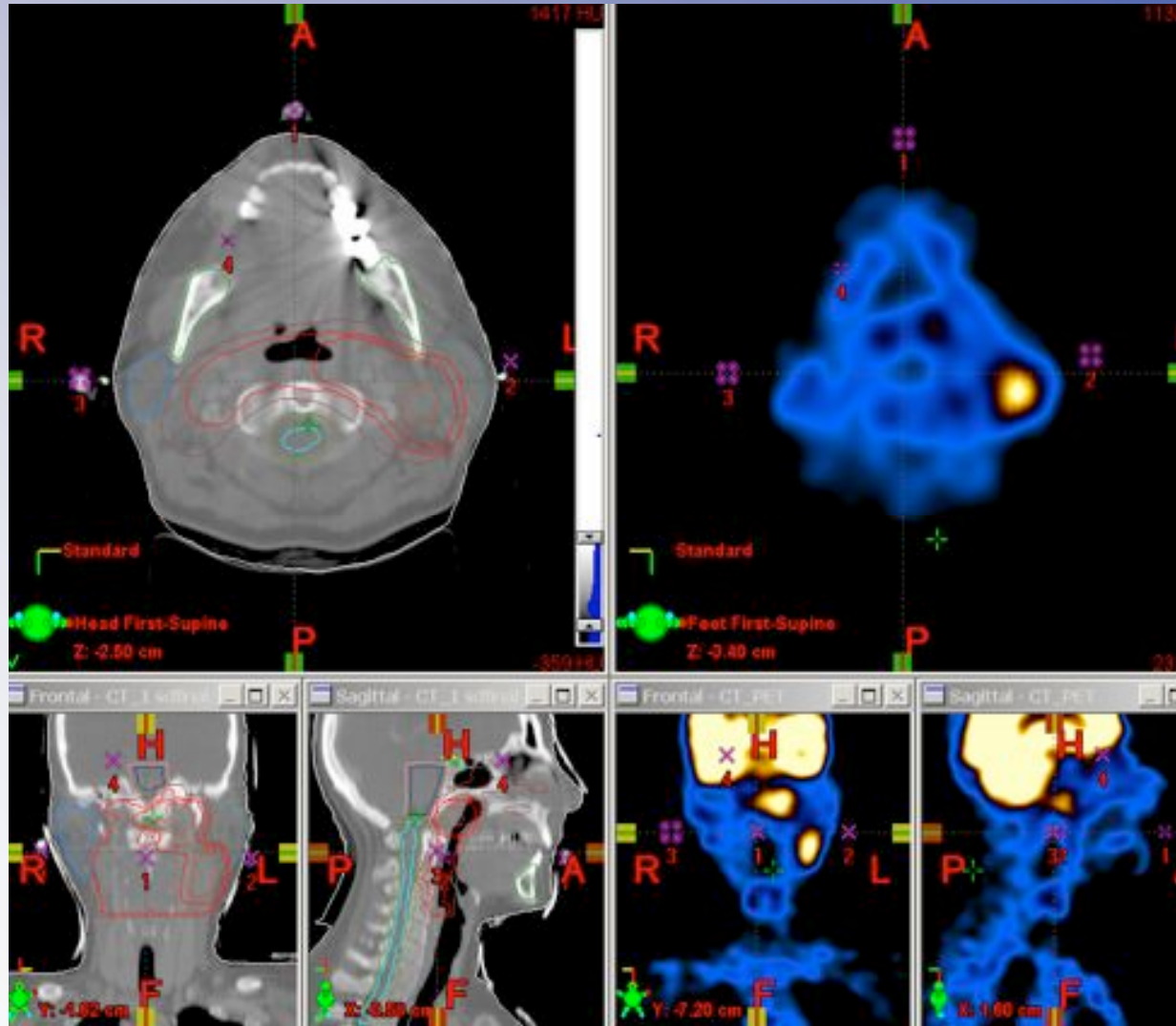
Integrate Functional Imaging



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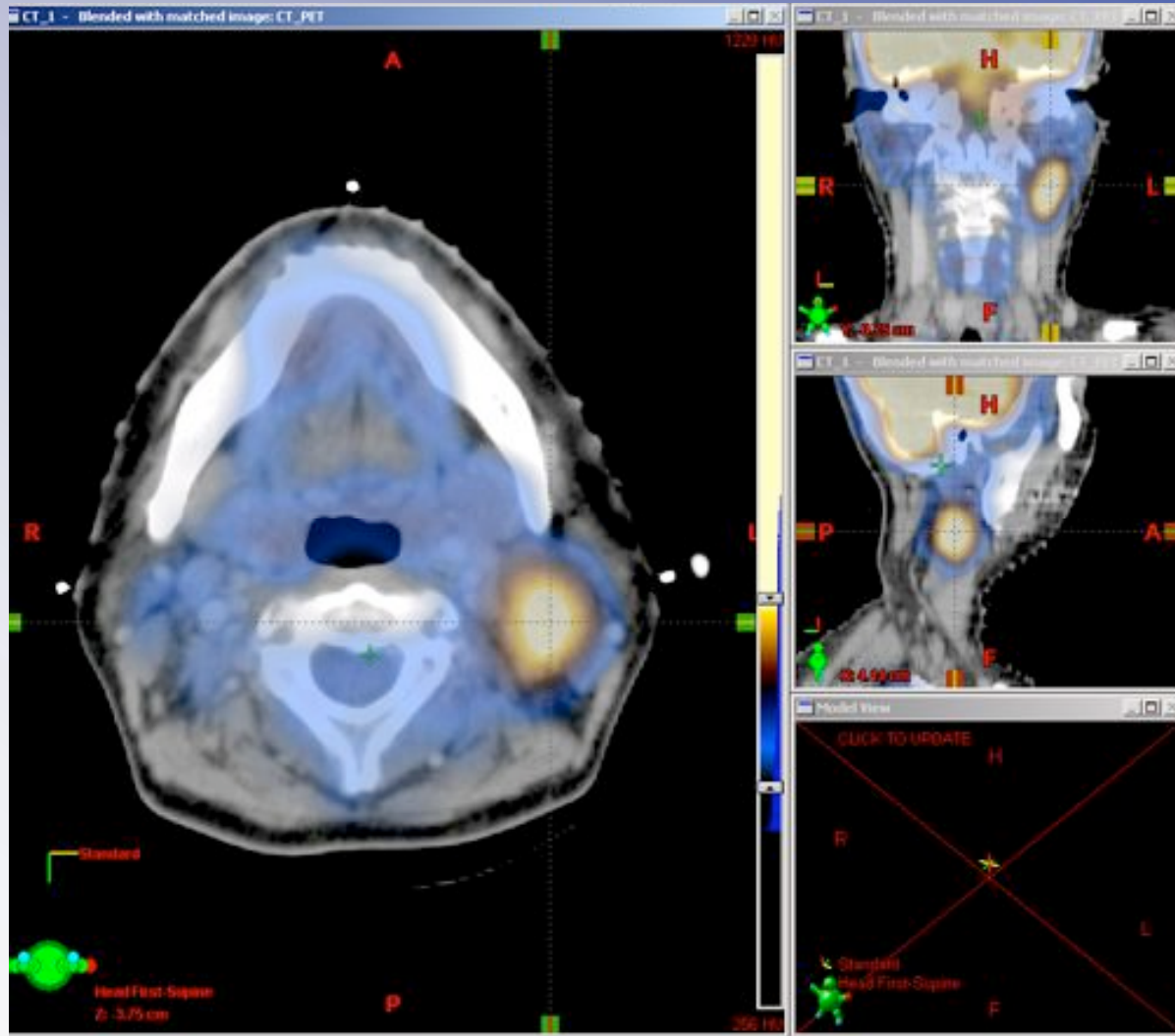
Integrate Functional Imaging



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Integrate Functional Imaging



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Integrate Functional Imaging

Advantages

RT department can take advantage of functional images without having PET/CT system.

Low cost option for NM department when using generic PET/SPECT scanner, such as GE Hawkeye

Disadvantages

Fusion of NM data to RT CT data

Patient setup variation

Data compatibility with RT planning system, RT planning system may require extra (\$\$\$) NM modality import modules to accept NM datasets



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Functional Imaging for RT Planning

Why include functional imaging in RT Planning ?

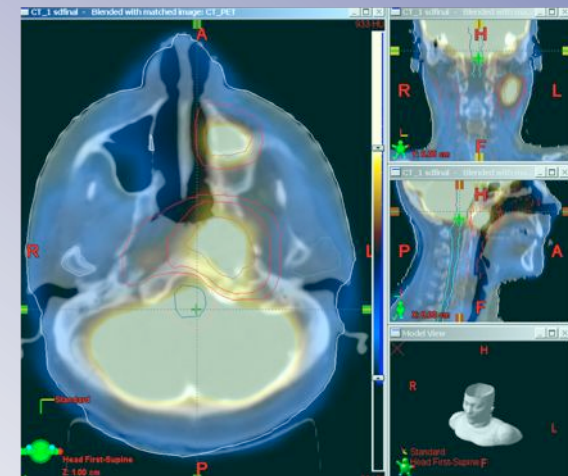
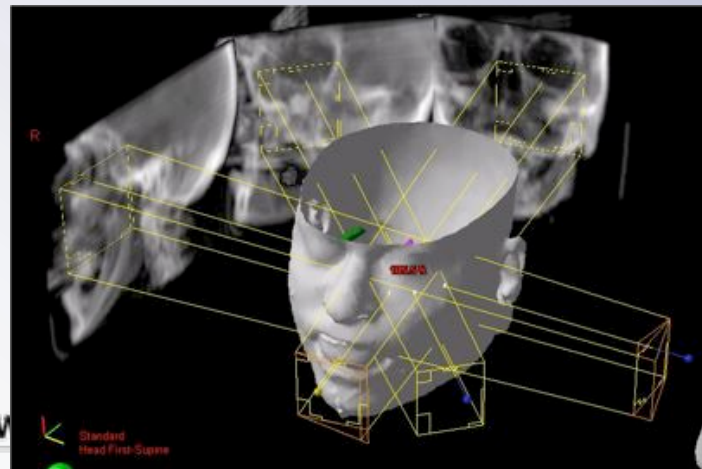
Provides confirmation of involved sites

May indicate previously unknown secondary sites

Gives RO direct geometrical correlation of positive sites

Provides reassurance for radical treatments (IMRT) where doses are high (70Gy)

If functional imaging can potentially change the treatment planning then it should be included in the planning process



Clinical Experience

**Treatment Sites : Base of Tongue, Tonsil, Nasopharynx,
Soft Palate**

Treatment Method : Intensity Modulated Radiation Therapy (IMRT)

Planned 3 patients – early processes

Planned 8 patients – with current method

**Identified 1 patient with secondary site that was not reported
on radiology diagnostic report (CT)**



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Clinical Experience

Nasopharyngeal Carcinoma

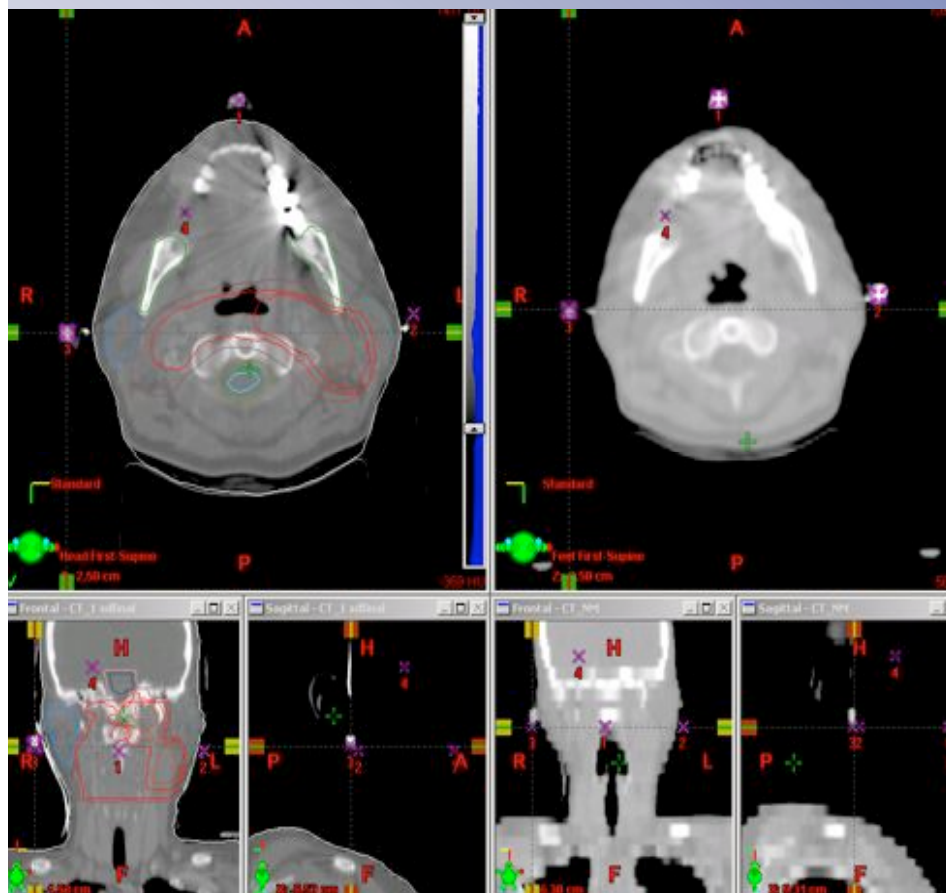
- 26 y.o. woman
- Presented with pain behind her left eye & left cheek numbness
- CT & MRI investigations
- locally advanced nasopharyngeal carcinoma with orbital extension and nodal metastasis
- Received therapy PET scan



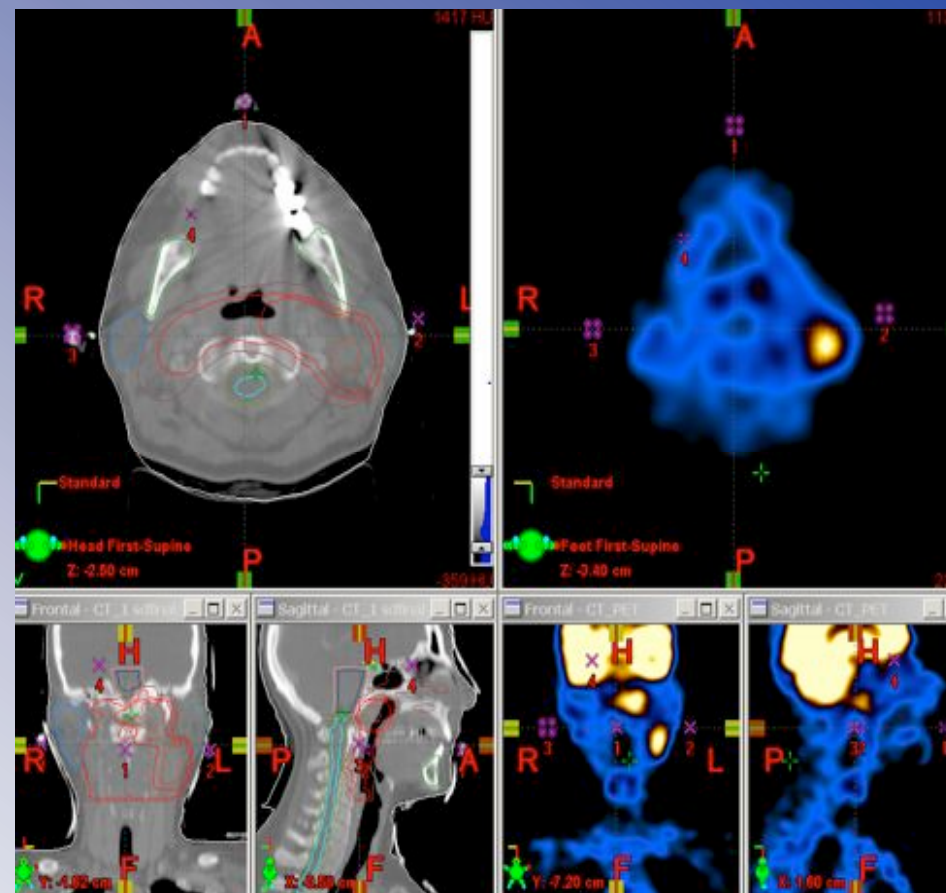
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Clinical Experience

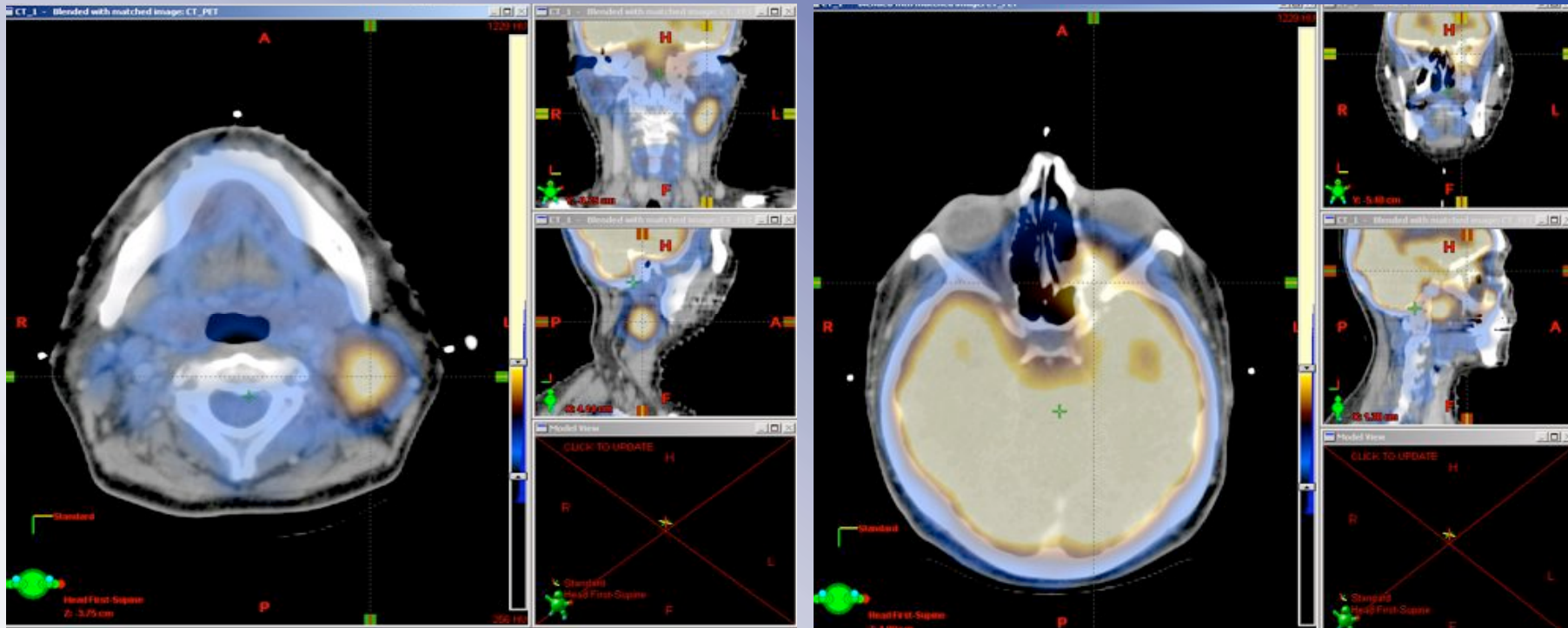


Sim CT & NM CT



Sim CT & NM PET

Clinical Experience



Left Positive Node

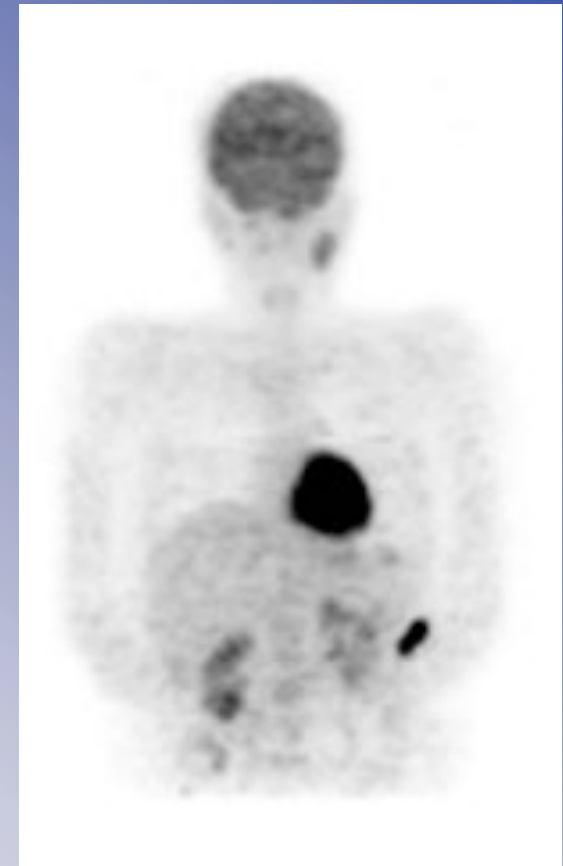
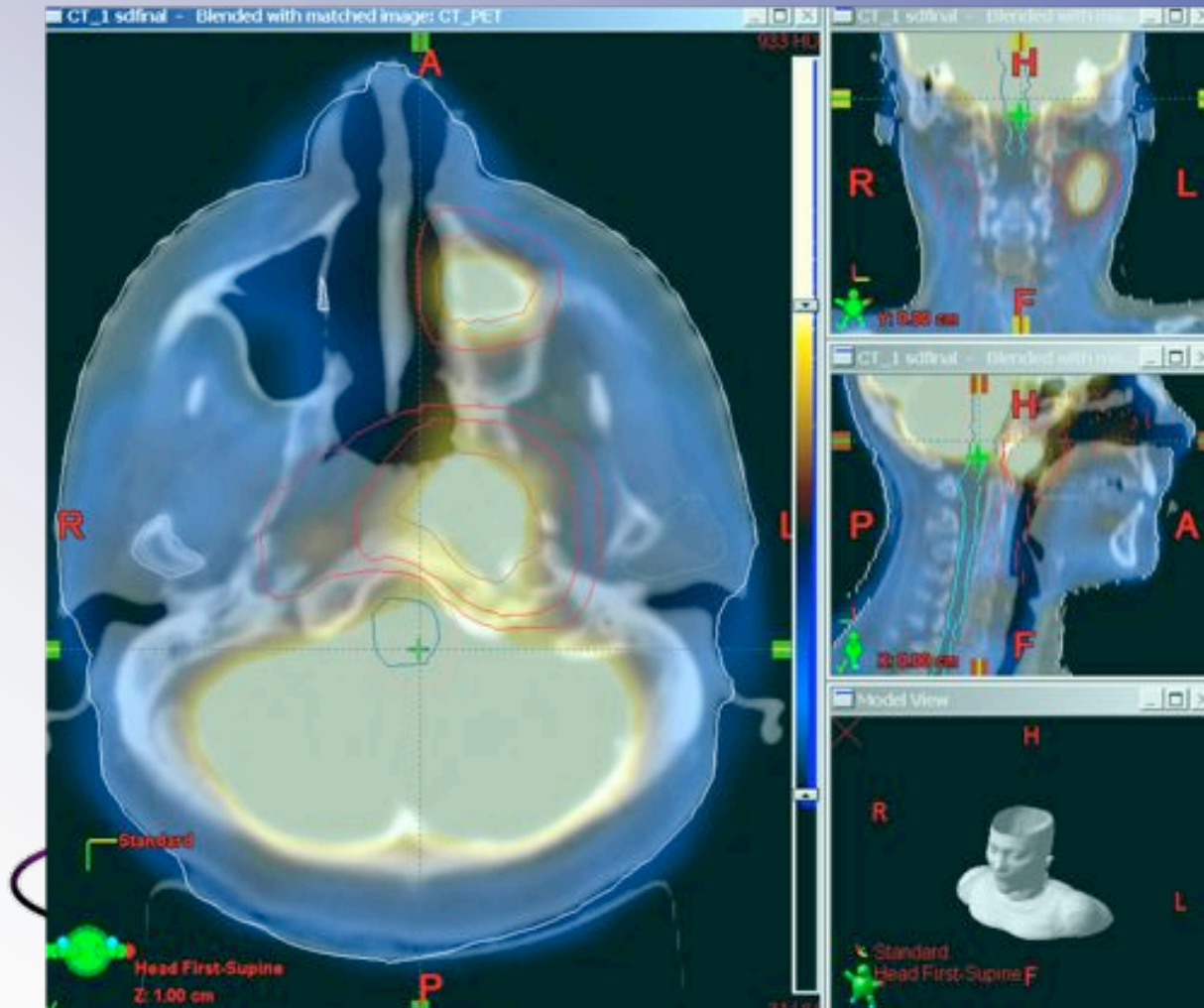
Orbit Extension



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Clinical Experience

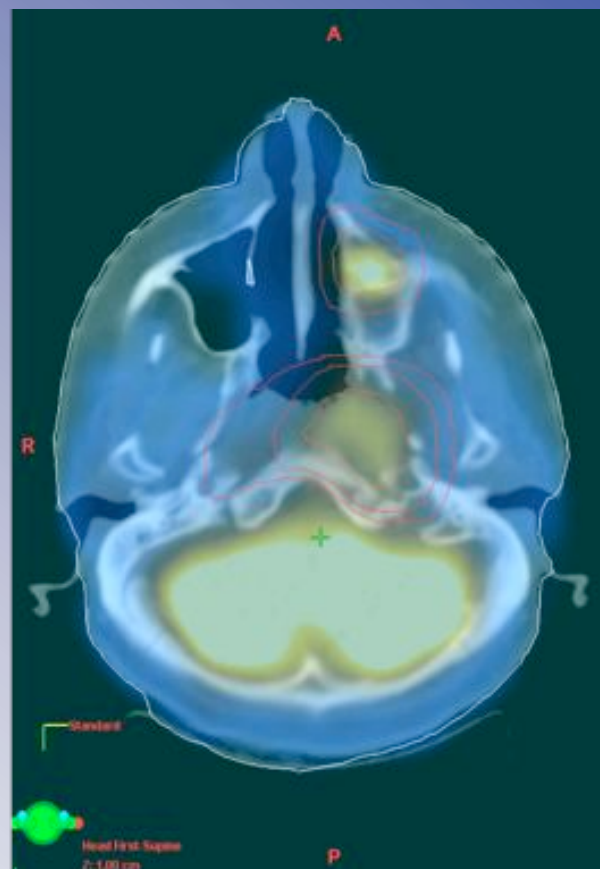
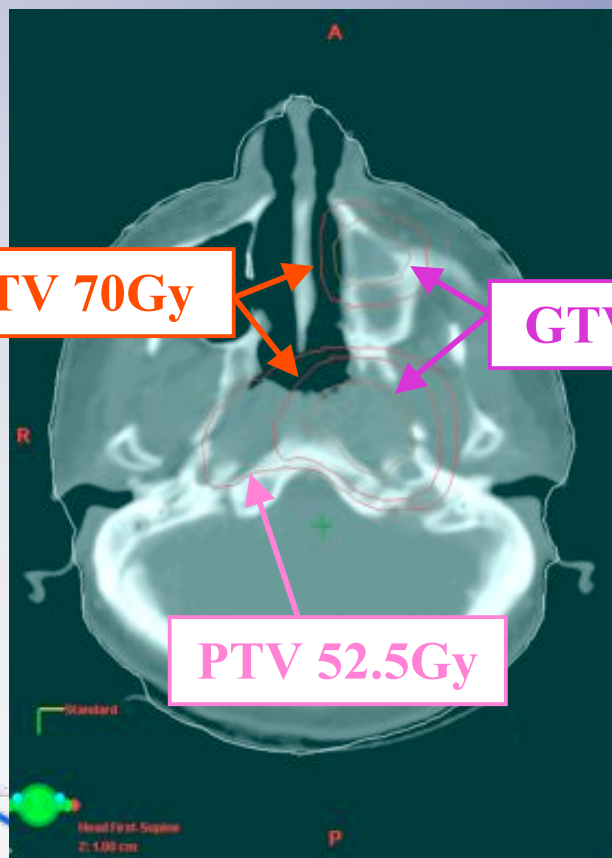


Primary & Maxillary Sinus

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Clinical Experience

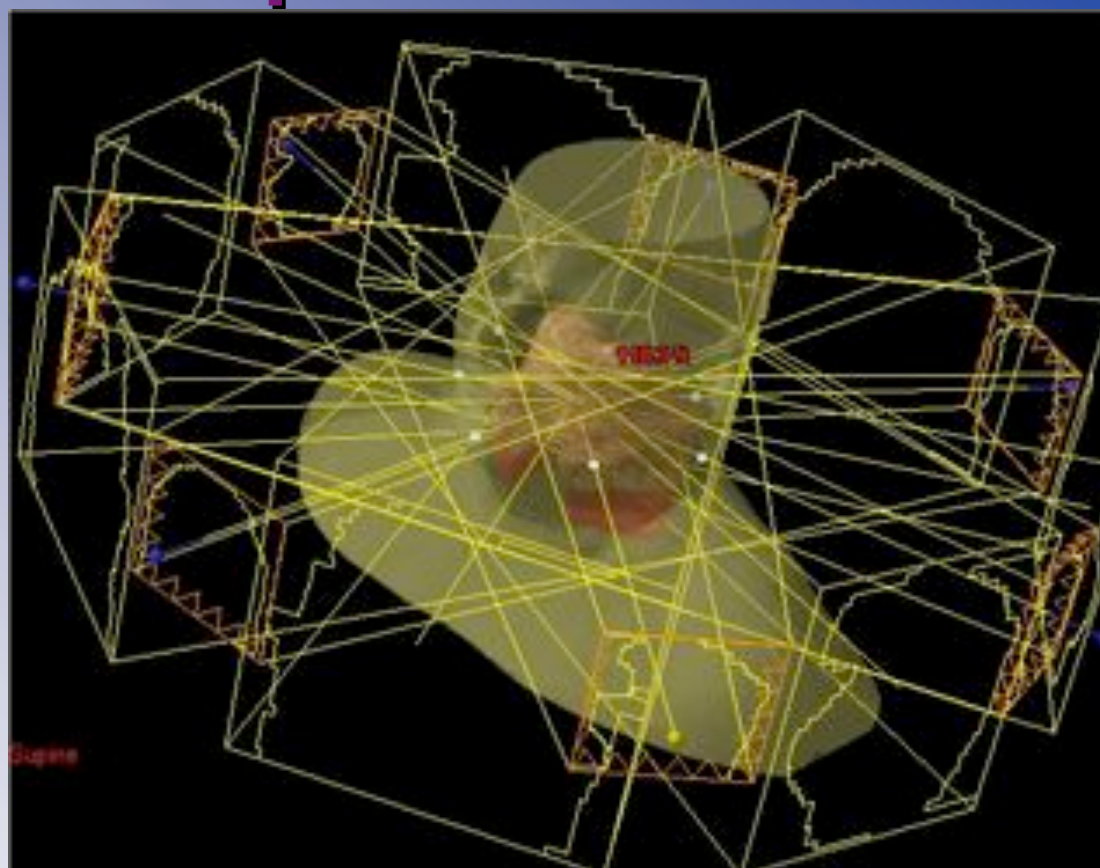
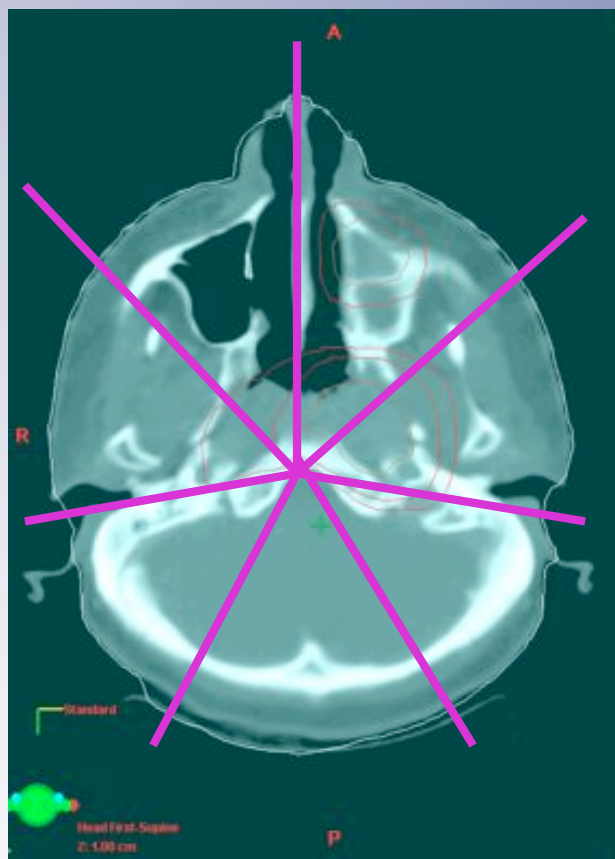


Primary & Maxillary Sinus



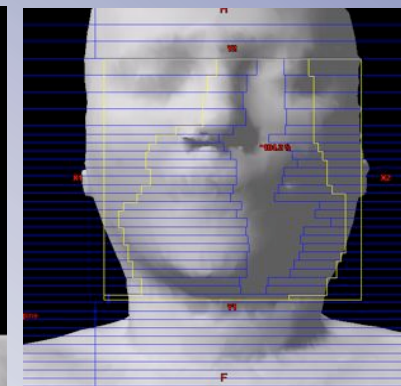
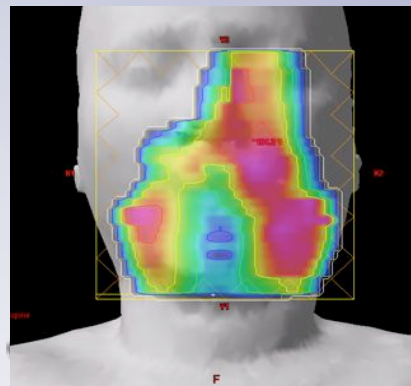
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Clinical Experience

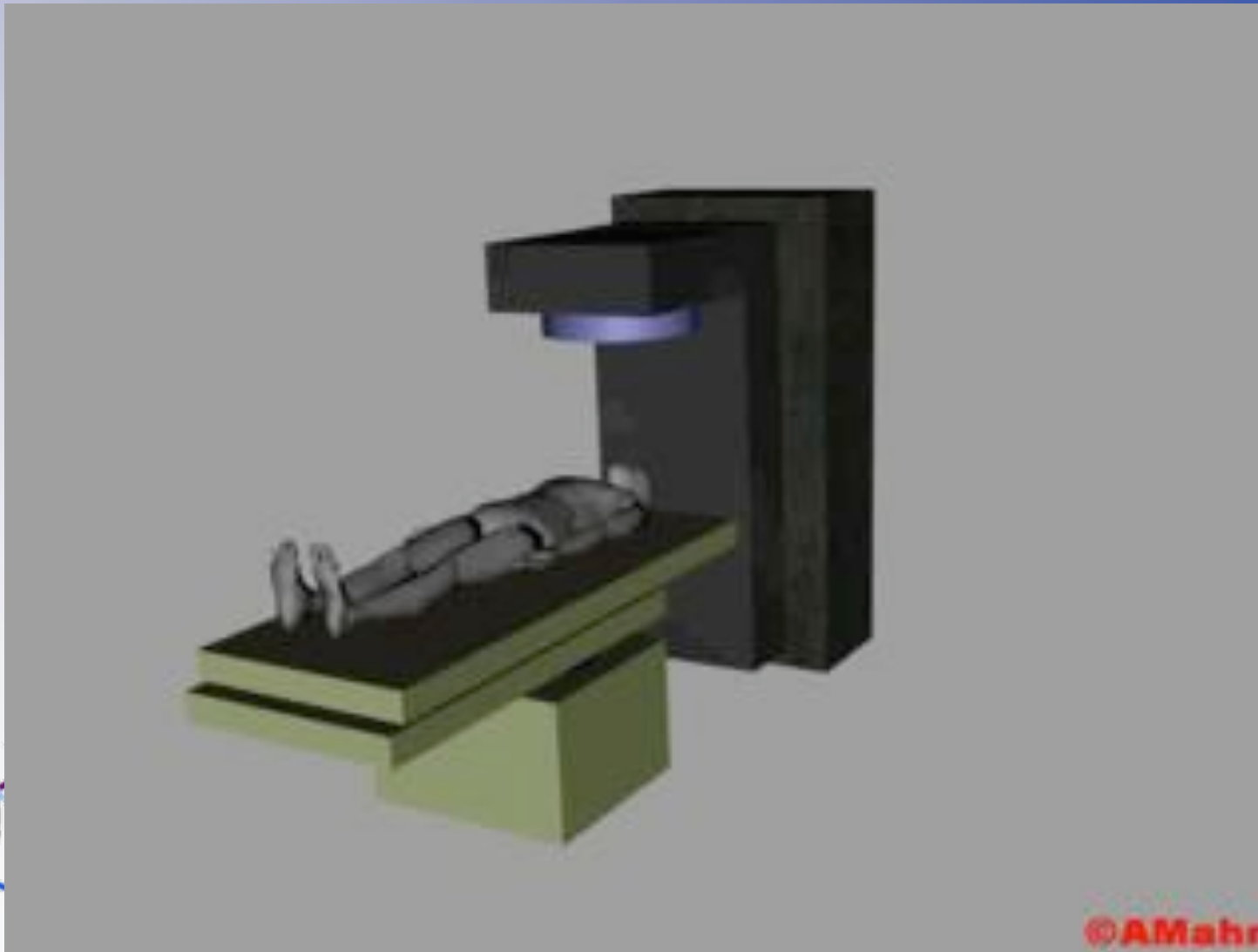


IMRT Field Arrangement

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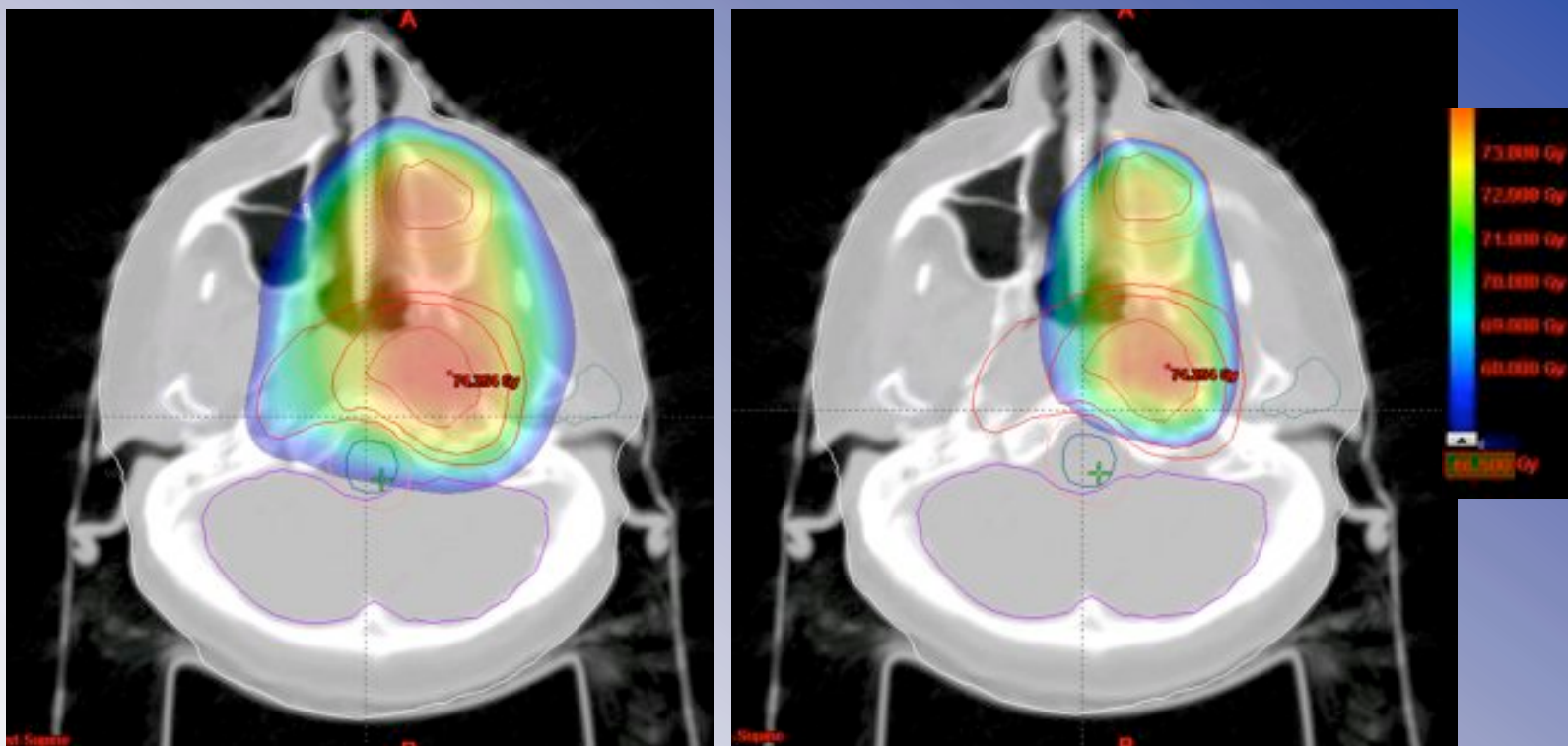
Clinical Experience



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Clinical Experience



52.5Gy – 66.5Gy – 75Gy

66.5Gy – 75Gy

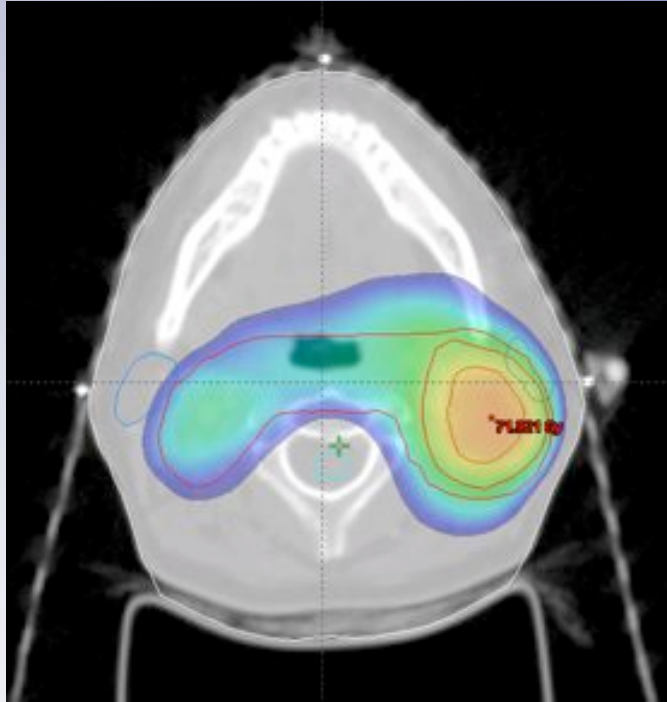
Dose Distribution - Primary & Maxillary Sinus



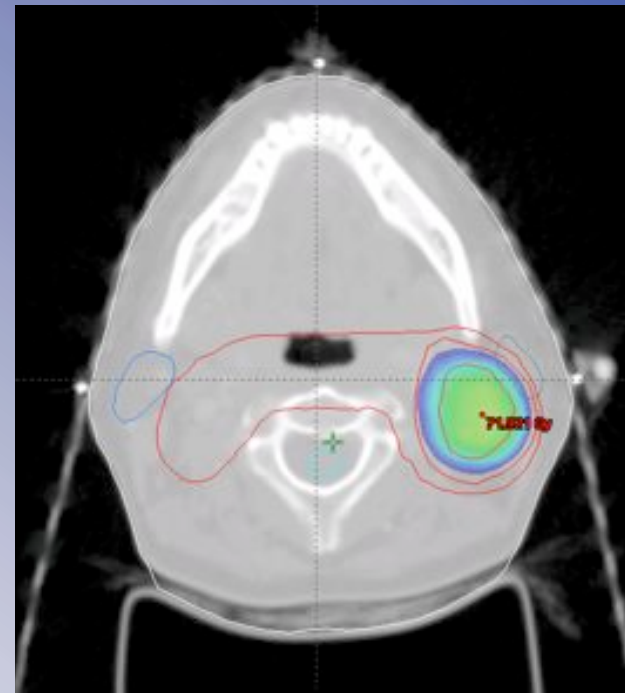
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Clinical Experience



52.5Gy – 66.5Gy – 75Gy



66.5Gy – 75Gy

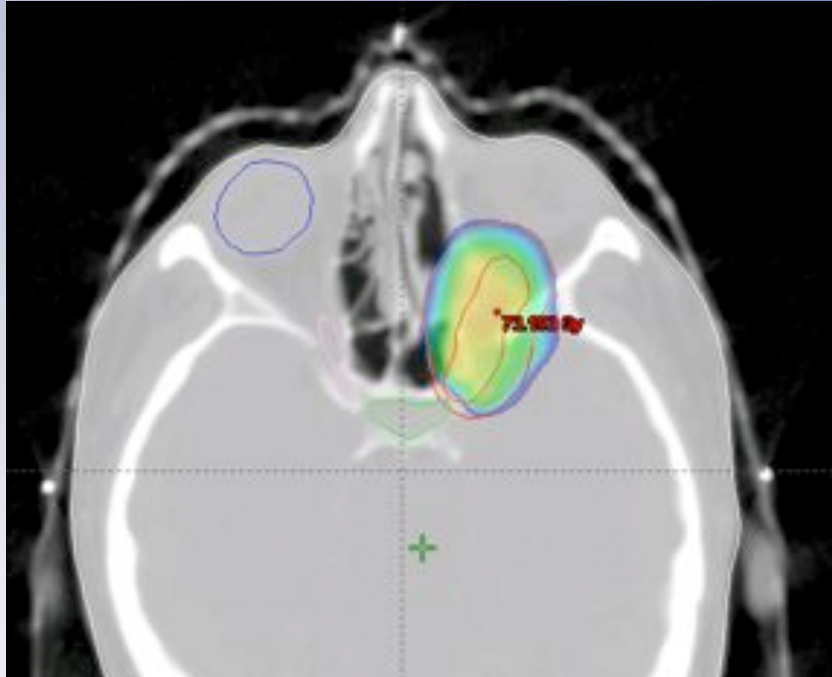
Dose Distribution – Left Node



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Clinical Experience



66.5Gy – 75Gy

Dose Distribution – Orbit Extension



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Future

NM Computer platforms to be able to import

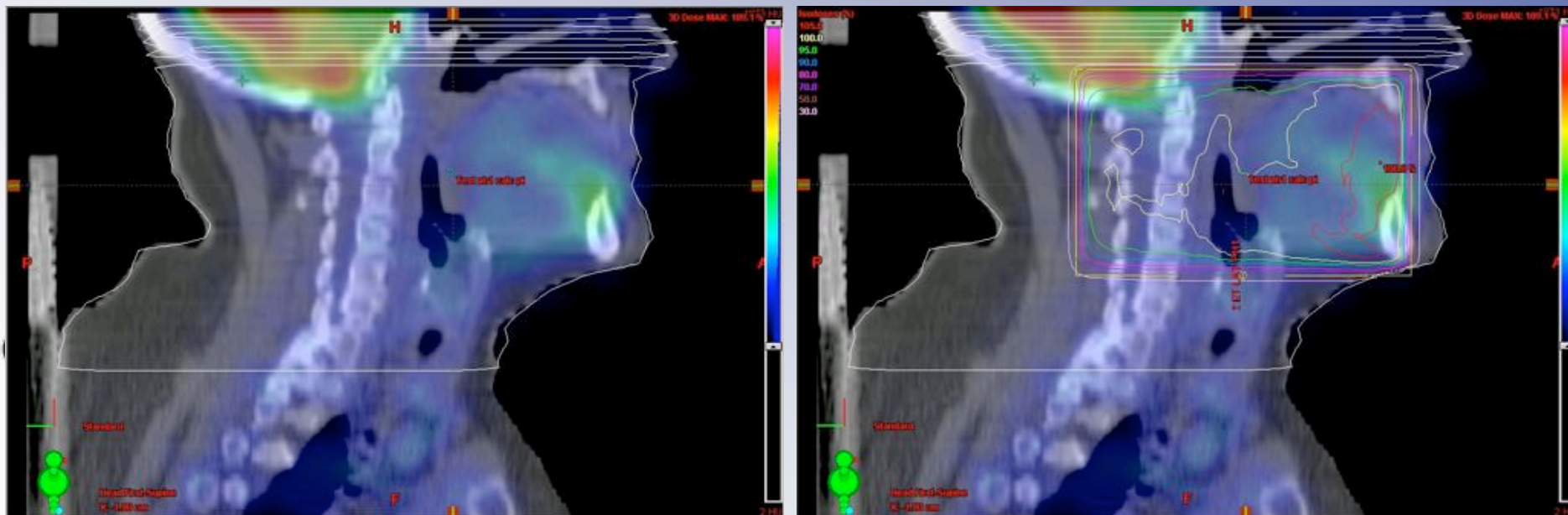
DICOM RT Dose

Structure Set

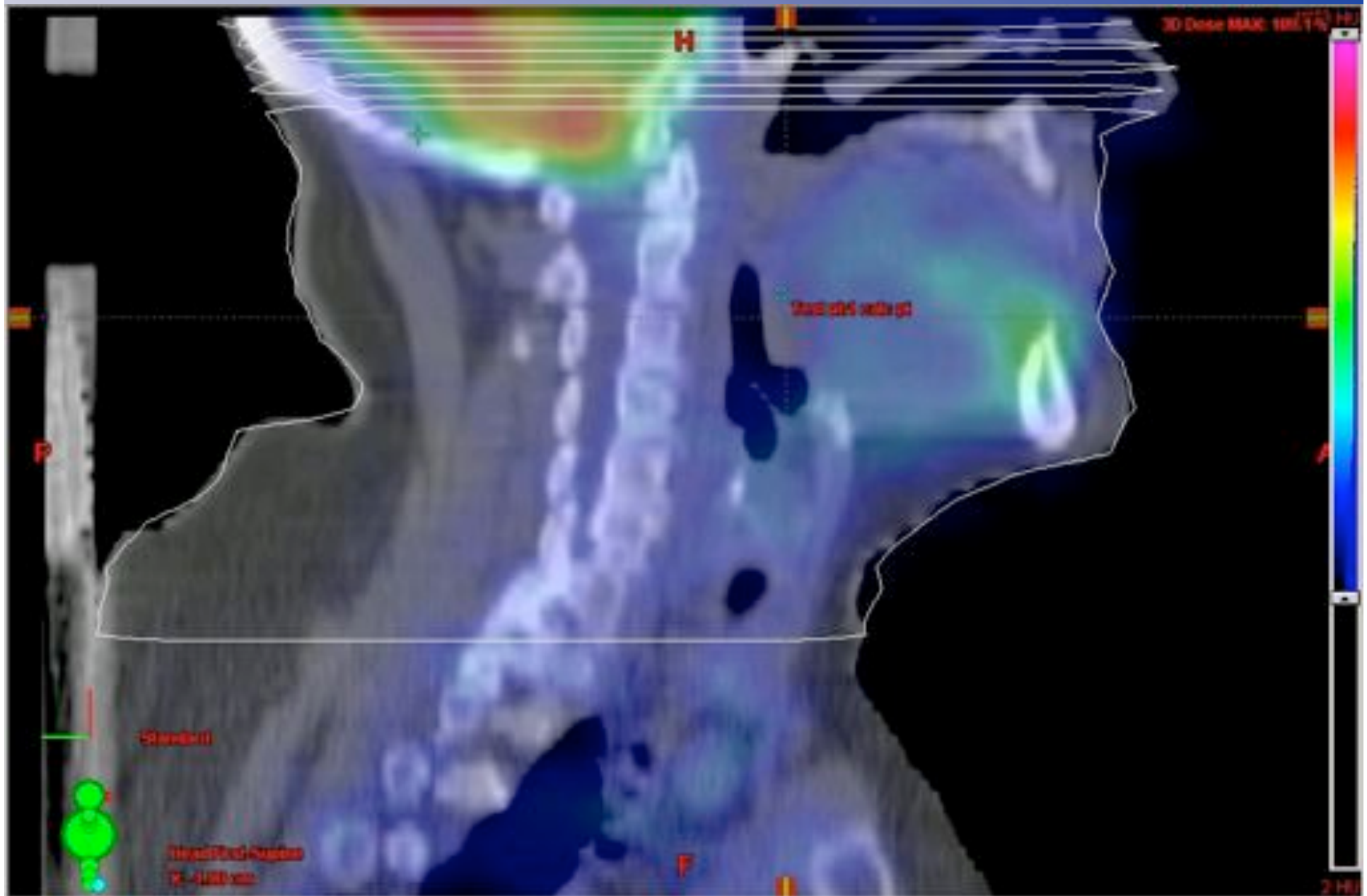
Plan

Useful for post treatment follow up PET.

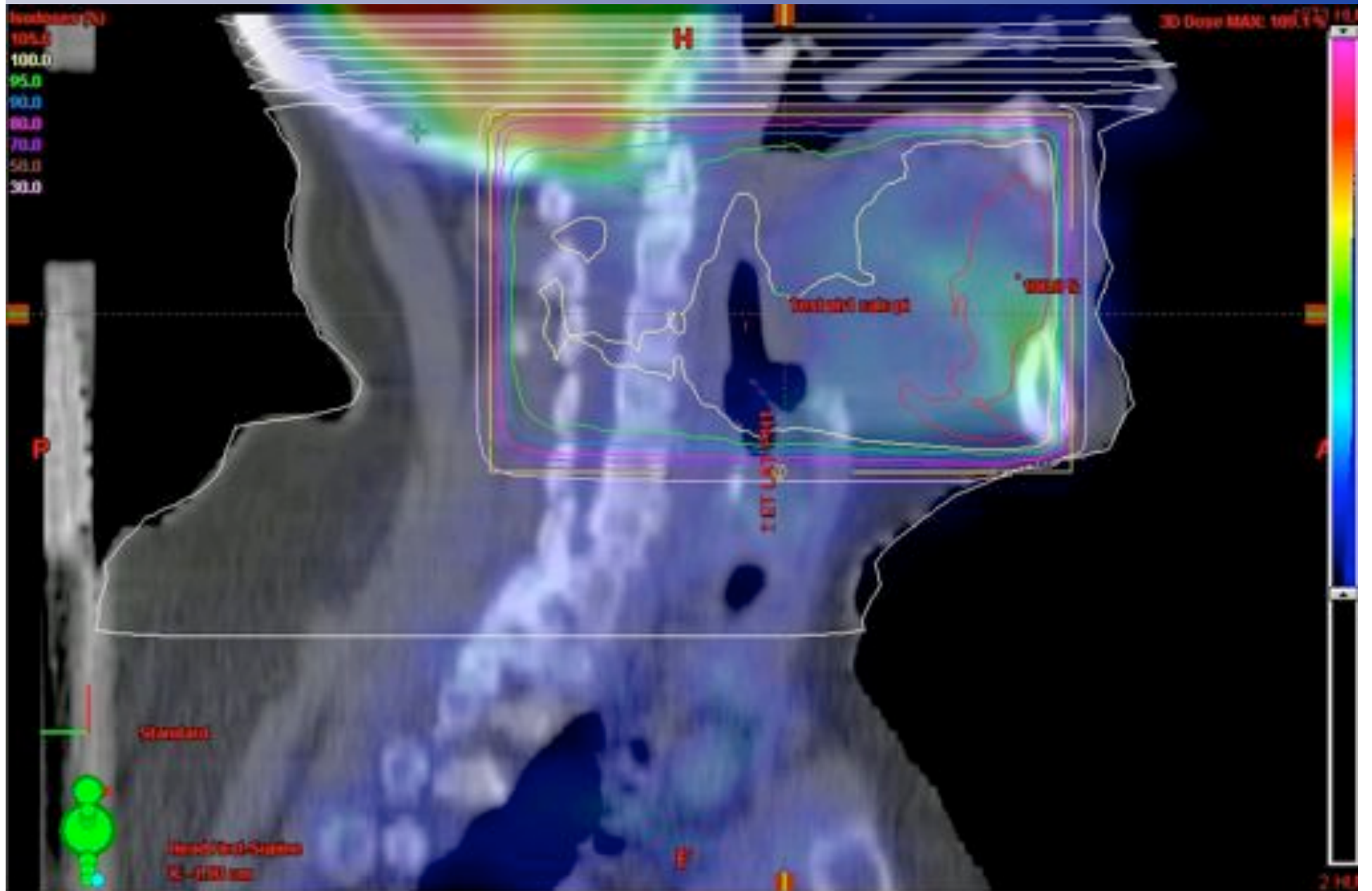
Review workstation to be able to display treatment fields,
dose distribution all overlaid on PET/CT data



Future



Future



Acknowledgments

Bruce Van Every, Physicist, The Alfred NM Dept.

Cherie Evans, Radiation Therapist, WBRC.

Phil Jones, Radiation Therapist, WBRC.



Prof Dr Wolfgang Schlegel and Dr Andreas Mahr for permission to show video clips from their video book:

“3D conformal radiation therapy” (2001: Heidelberg: Springer ISBN 3-540-14884-1)

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