

# **SPECT in Radiotherapy Planning**

## **Experience at the WBRC**

**Ryan Smith**

**William Buckland Radiotherapy Centre  
The Alfred Hospital  
Melbourne, Australia.**



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# Overview

- **The WBRC & The Alfred NM Department**
- **Radiotherapy Treatment Planning**
- **SPECT in Radiotherapy**
- **Phantom Tests**
- **SPECT Treatment**
- **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

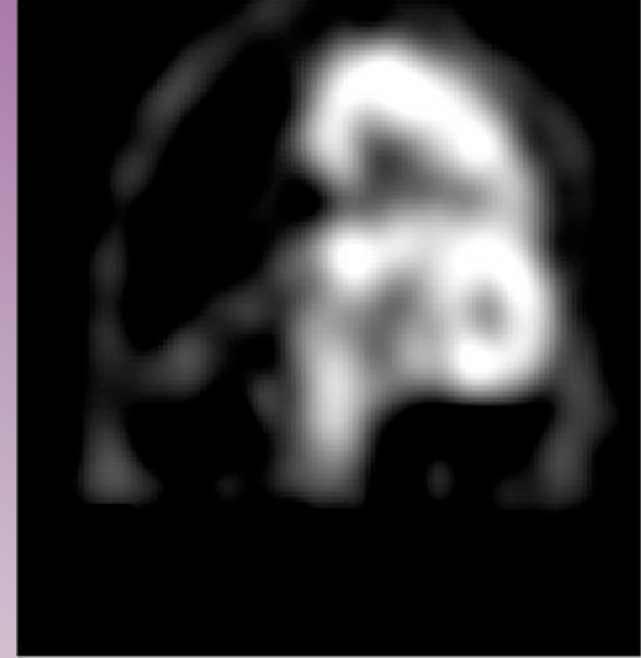
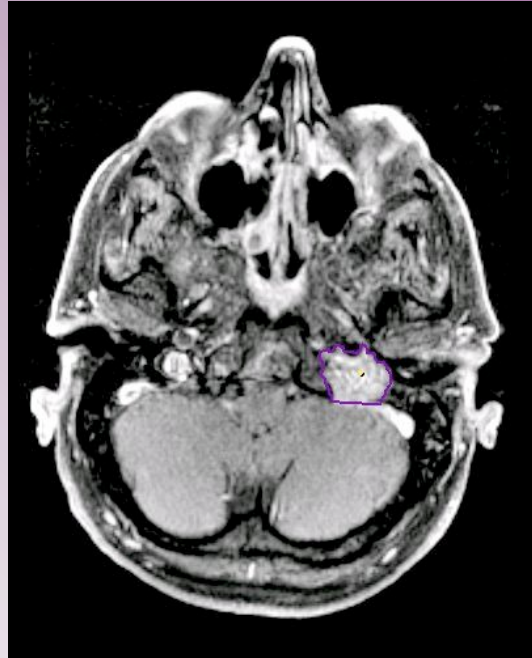
10mm slice CT “low-dose” scanner  
Image FOV 450mm



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# Radiotherapy Treatment Planning



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# SPECT in Radiotherapy

## LUNG CANCER

SPECT Lung Perfusion scans provide in 3-D the functionality of lung tissue, and may provide feedback to the RT planner as to where to place treatment beams to avoid this high perfusion zone.

A study from the Duke University showed that SPECT was useful in detecting 48% of patients with hypoperfused regions. In 11% of patients, the RT beams were moved to avoid highly functional lung tissue.

## BRAIN

Hamilton et al, from the University of Chicago have used functional areas of the brain, provided by SPECT to design treatments that spare 'functional' regions in the treatment of brain tumors.

Iodine-123-alpha-methyl-L-tyrosine (IMT) is an amino acid that has been shown to be actively accumulated in brain tumors and not in normal brain tissue. IMT uptake in the brain can be visualised by SPECT.

Grosu et al, Munich, 30 patients studied with non-resected glioma, found that 23% had IMT tumor uptake 2cm outside the GTV volume defined by a T2 weighted MRI. Suggests that IMT-SPECT imaging may result in target modifications compared to when planned with MRI alone.



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# Phantom Tests

Test the connectivity of the NM and RT Planning system  
File format, data transfer and RT system worth

Test the RT image fusion, Co-registration status

Assess the localisation methods



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# Phantom Tests

## RANDO Head Phantom



# Phantom Tests

## Localisation

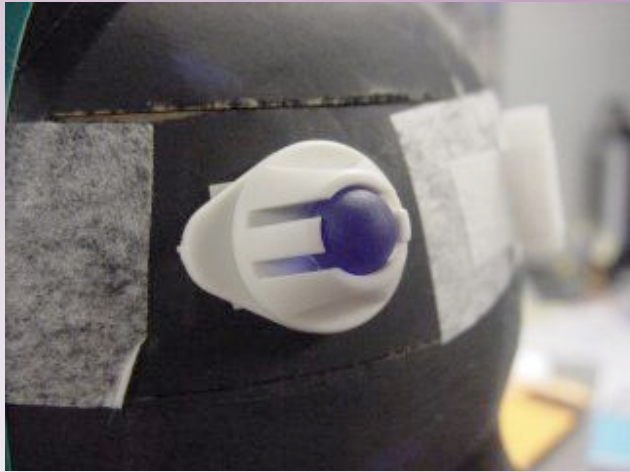


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# Phantom Tests

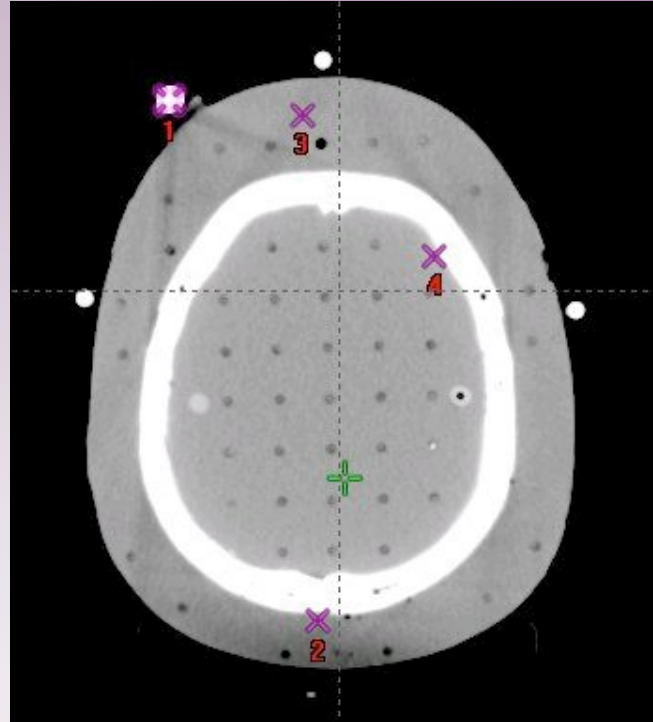
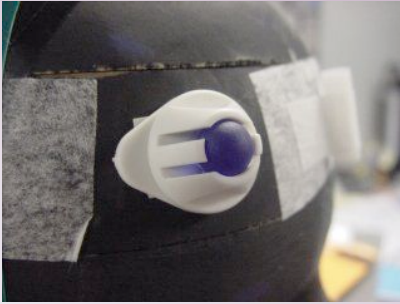
## Localisation



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# Phantom Tests

## Localisation



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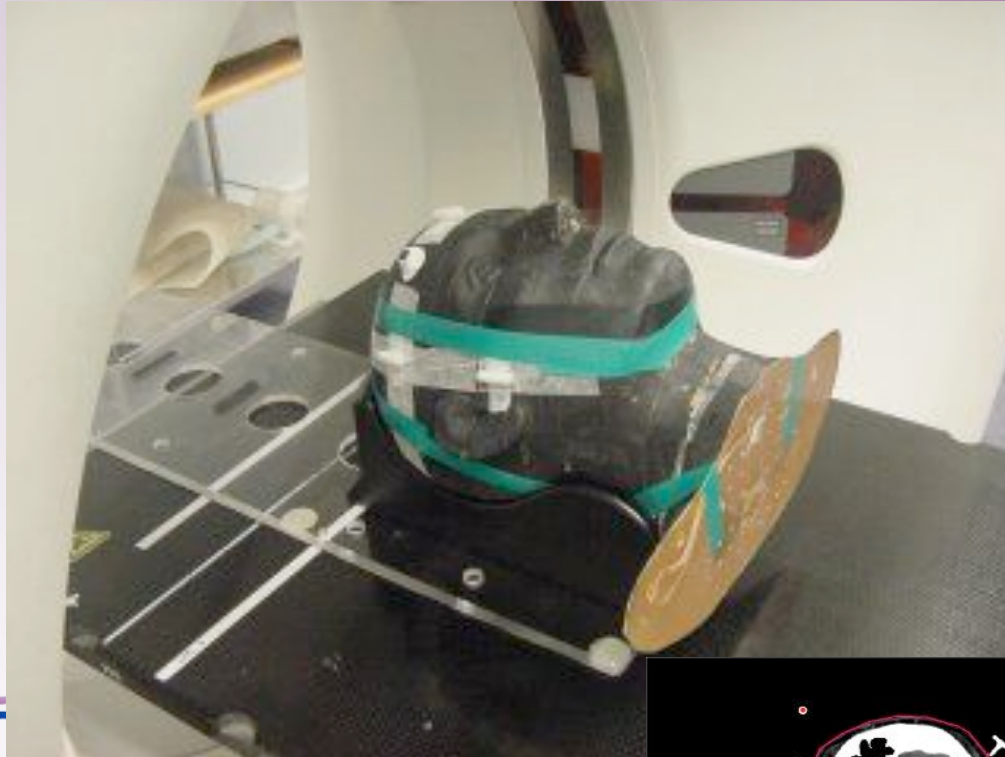
# Phantom Tests

## SPECT / CT Scan



# Phantom Tests

## Radiotherapy CT Scan



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# Phantom Tests

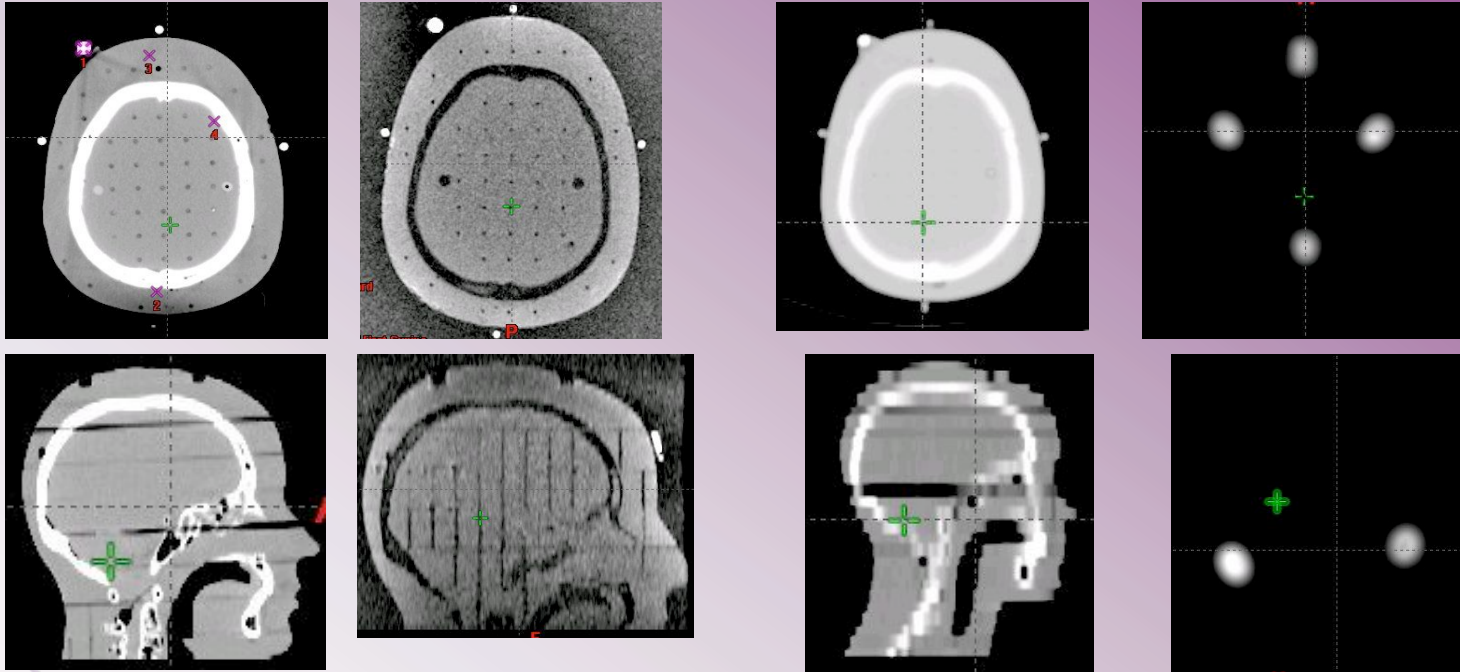


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# Phantom Tests

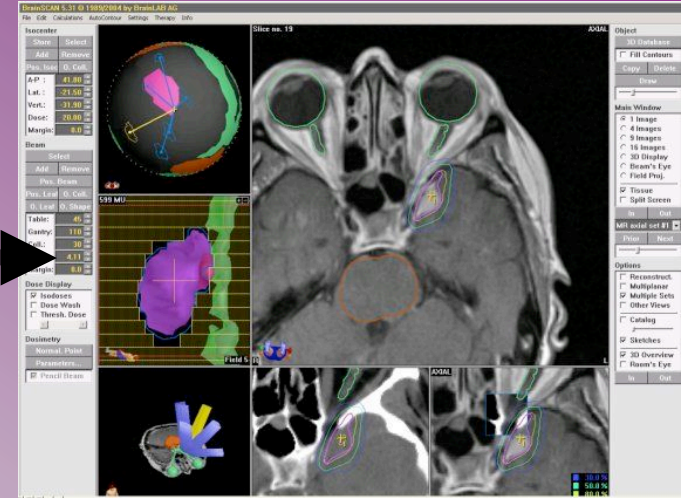
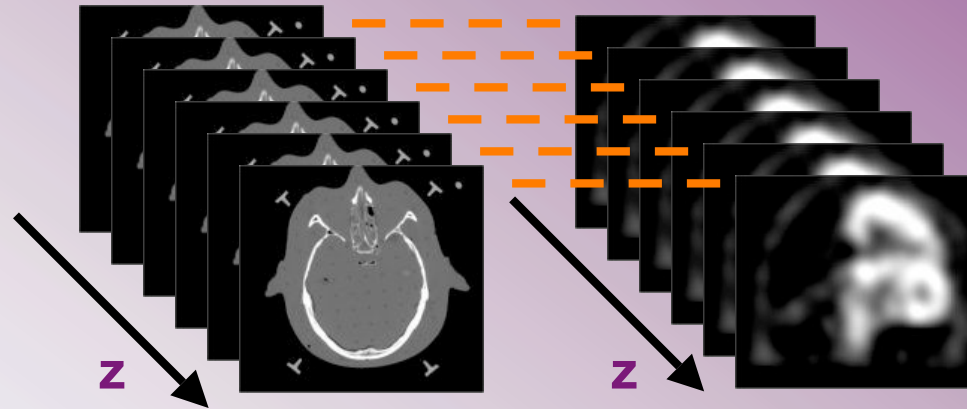
## Image Sets



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# Co-registered Data Sets



Re-sampled CT axial ----- SPECT data set (128 slices)

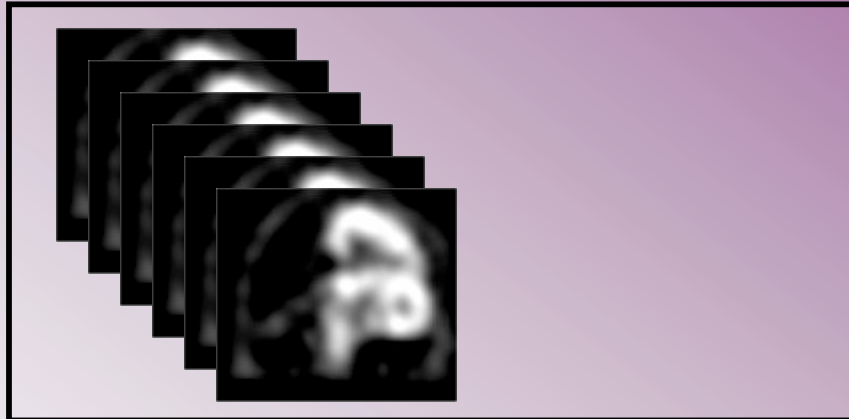
Slice to slice equivalence.  
z positions match.



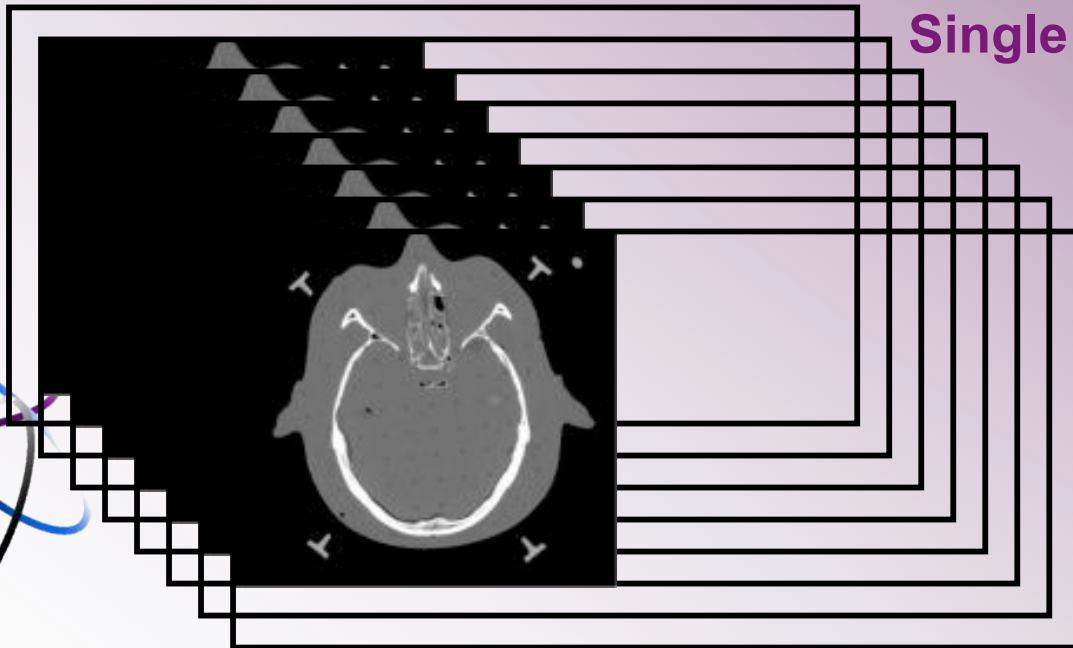
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# Data Formats



Multi-Frame Image File



Single Image File

DICOM  
Vendor Specific  
TIFF



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# RT Planning System Image Import

**CT**  **Axial, No Gantry Tilt** **DICOM, Vendor Specific(Filter)**

**MR**  **Axial, Cor., Sag.,** **DICOM, Vendor Specific(Filter)**

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**SPECT**  **Axial, Cor., Sag.,** **DICOM + Function Image Support (Multi-Frame)**

**Co Reg.**  **Axial** **DICOM + (?)**



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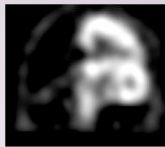
**Share DICOM origin ?**



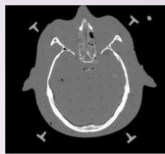
# RT Image Import Work-around

Convert the multi-frame single image SPECT data sets into multiple single CT image files

Unique Identifier(UID) – Service-Object Pair Class (SOP Class)



UID 1.2.840.10008.5.1.4.1.1.20



UID 1.2.840.10008.5.1.4.1.1.2

**Extreme caution:**

**Ensure Image orientation is maintained**

**Pixel scaling is not compromised**

**Grey scale levels are not re-sampled**

**Patient information is not lost or switched**

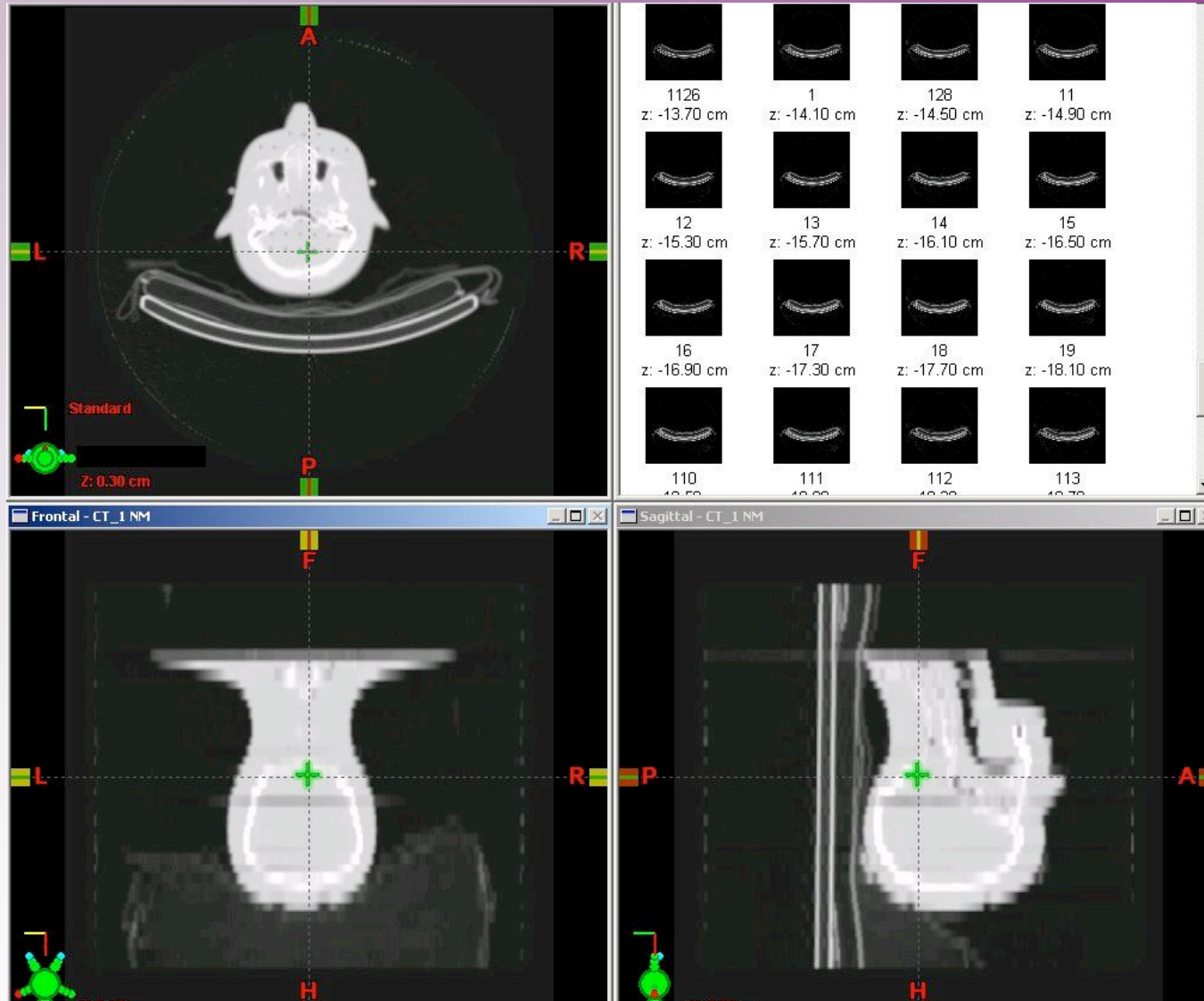


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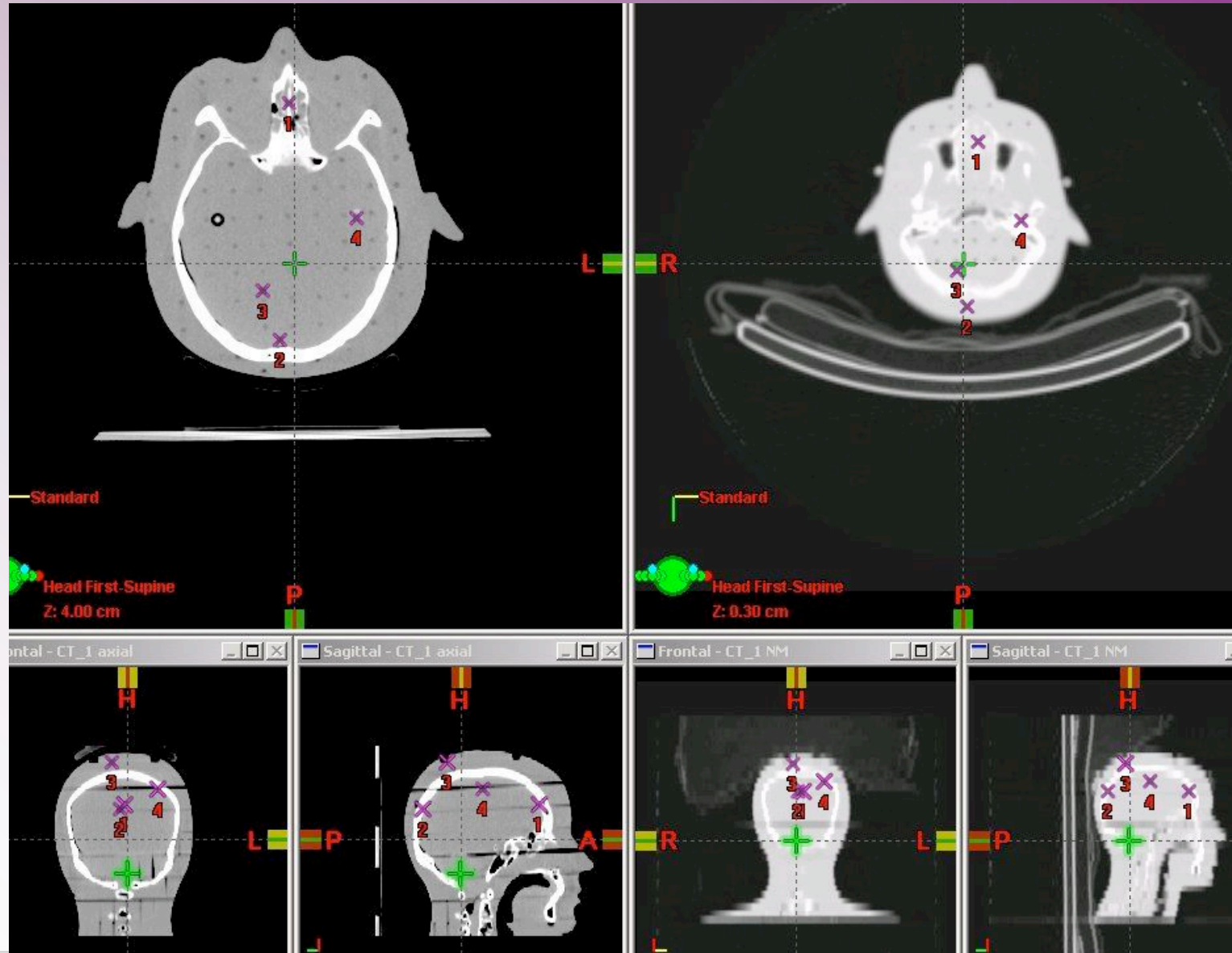
<http://www.rsna.org/Technology/DICOM/intro/>

# Planning System



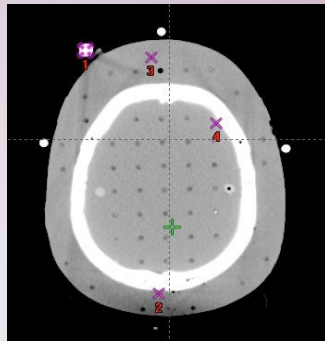
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# Planning System

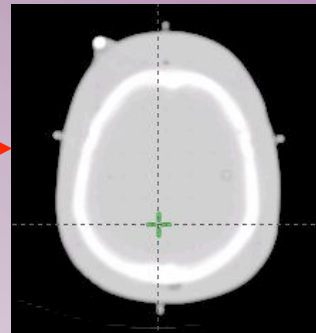


# Planning System

Proposed alignment method of co-registered data sets

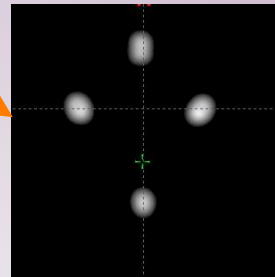


Fuse



Anatomical  
pairs  
Fiducial Markers

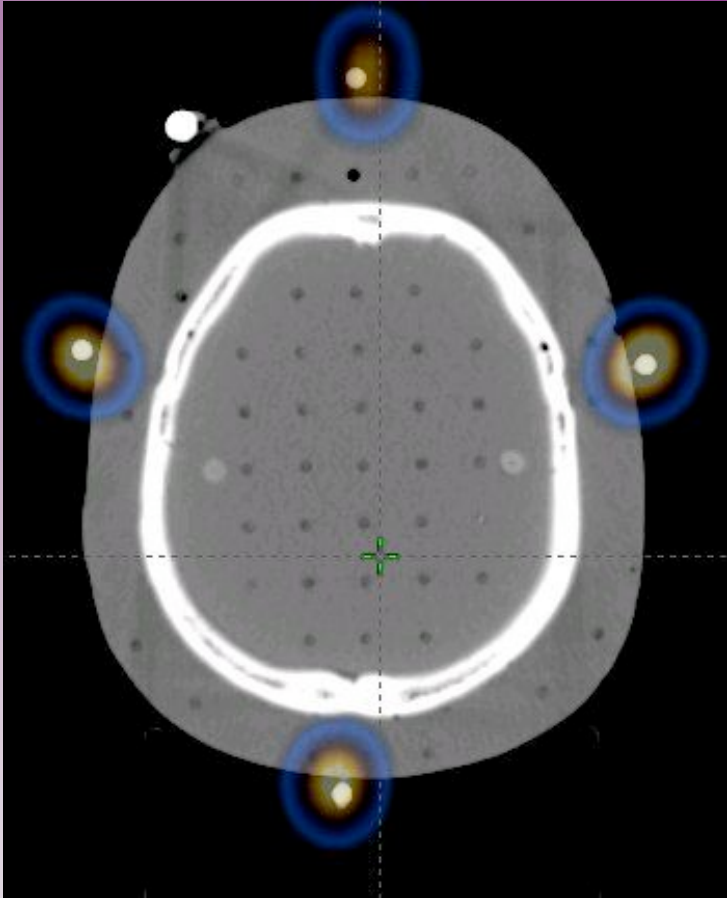
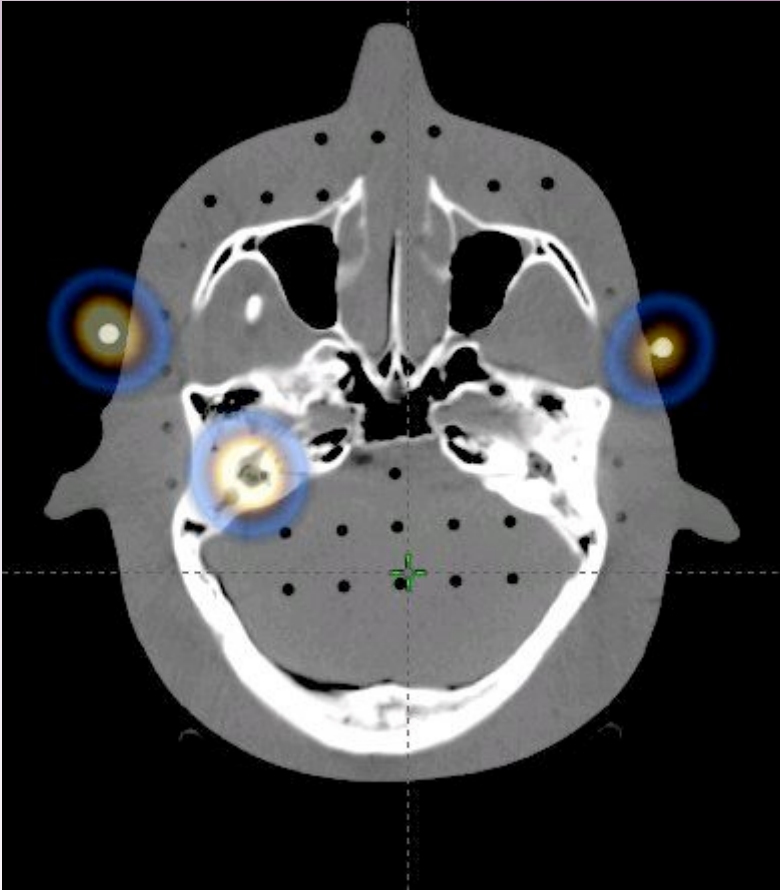
Transform  
Matrix



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# Blended Result



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eFilm Workstation 1.5.3

# DICOM Tools

## DicomWorks

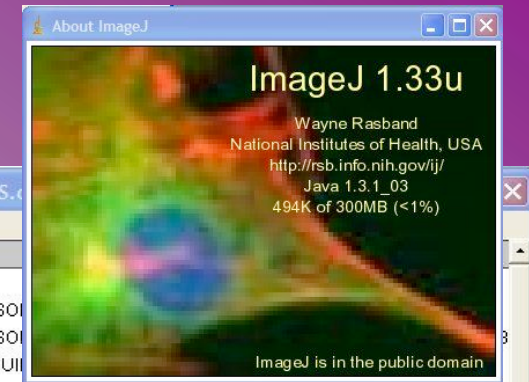
The #1 DICOM viewer!



```

Hex Workshop - [GENERA-2.DCM]
File Edit Disk Options Tools Window Help
[H] [D] [B] [S] [L] [F] [D] [S] [U] [←] [→]
00000000 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000010 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000020 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000030 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000040 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000050 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000060 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000070 0000 0000 0000 0000 0000 0000 0000 0000 .....
00000080 4449 434D 0200 0000 554C 0400 D200 0000 DICM...UL.....
00000090 0200 0100 4F42 0000 0200 0000 0001 0200 ...OB.....
000000A0 0200 5549 1A00 312E 322E 3834 302E 3130 ..UI..1.2.840.10
000000B0 3030 382E 352E 312E 342E 312E 312E 3220 008.5.1.4.1.1.2
000000C0 0200 0300 5549 3A00 312E 322E 3834 302E ...UI.:1.2.840.
000000D0 3131 3336 3139 2E32 2E31 3132 2E32 3531 113619.2.112.251
000000E0 3130 2E31 302E 372E 3937 2E31 312E 3131 10.10.7.97.11.11
000000F0 3332 3832 3131 3135 2E39 3635 2E32 3233 32821115.965.223
00000100 3600 0200 1000 5549 1400 312E 322E 3834 6.....UI..1.2.84
00000110 302E 3130 3030 382E 312E 322E 3100 0200 0.10008.1.2.1...
00000120 1200 5549 1400 312E 322E 3834 302E 3131 ..UI..1.2.840.11
00000130 3336 3139 2E36 2E31 3132 0200 1300 5348 3619.6.112...SH
00000140 0E00 654E 5445 4752 4120 322E 3531 3130 ..eNTEGRA 2.5110
00000150 0200 1600 4145 0A00 4449 5343 4F56 4552 ....AE..DISCOVER

```



```

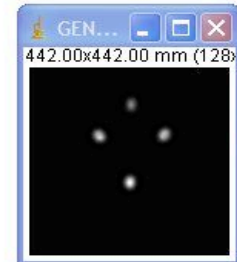
Info for GENERA47_DS...
File Edit

0002,0002 Media Storage SO
0002,0003 Media Storage SO
0002,0010 Transfer Syntax UI
0002,0012 Implementation Class UID: 1.2.840.113619.6.112
0002,0013 Implementation Version Name: eNTEGRA 2.5110
0002,0016 ---: DISCOVERY

0008,0008 Image Type: DERIVED\PRIMARY\RECON TOMO\EMISSION
0008,0012 Instance Creation Date: 20051124
0008,0013 Instance Creation Time: 204333.0000
0008,0014 Instance Creator UID: 1.2.840.113619.6.112
0008,0016 SOP Class UID: 1.2.840.10008.5.1.4.1.1.20
0008,0018 SOP Instance UID: 1.2.840.113619.2.112.25110.10.7.97.11.1132821115.855
0008,0020 Study Date: 20051124
0008,0021 Series Date: 20051124
0008,0022 Acquisition Date: 20051124
0008,0023 Image Date: 20051124
0008,0030 Study Time: 125435.00
0008,0031 Series Time: 162752.00
0008,0032 Acquisition Time: 125435.00
0008,0033 Image Time: 193155.00
0008,0050 Accession Number: NM054568759-BRNP
0008,0060 Modality: NM
0008,0070 Manufacturer: GE MEDICAL SYSTEMS, NUCLEAR
0008,0080 Institution Name: Alfred Nuclear Medicine
0008,0090 Referring Physician's Name:
0008,1010 Station Name:
0008,1030 Study Description: Brain Perfusion Spect
0008,103E Series Description: IRACSC OSEM
0008,1060 Name of Physician(s) Reading Study:
0008,1070 Operator's Name:
0008,1090 Manufacturer's Model Name:

0009,0010 ---: GEMS_GENIE_1
0009,1001 ---: GEMS_GENIE
0009,1010 ---: Bone TCSC Xray E
0009,101E ---: 1.2.840.113619.2.112.25110.10.7.97.11.1132821115.855.8533
0009,1020 ---: IRACSC OSEM
0009,1040 ---: VAN EVERY^BRUCE
0009,1042 ---: 20051121

```



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# SPECT Treatment

**PATIENT :**

**1998 presented with severe epilepsy**

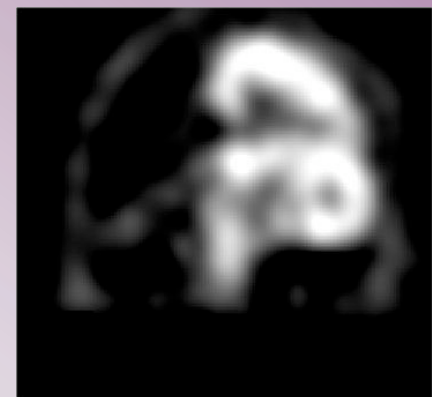
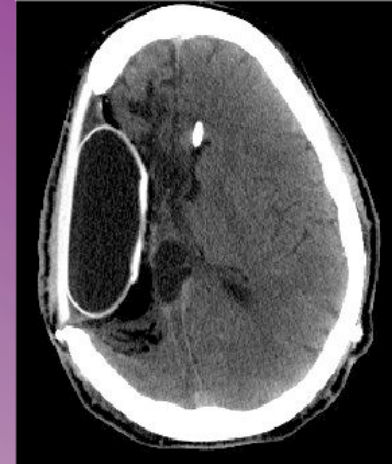
**Front right hemispherectomy, cavity filled with prosthesis**

**5 to 10 events per day (vague & slow)**

**left arm seizure, no loss of consciousness**

**Not living independently**

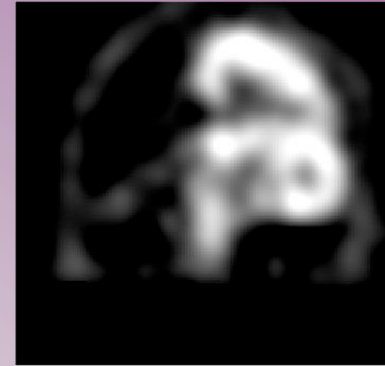
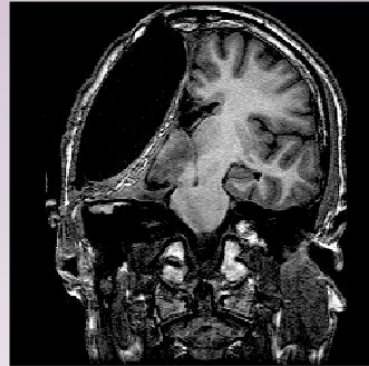
**Referral from Royal Melb. Hosp., provided co-registered MRI & SPECT data**



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# Patient Data Sets



Co-registered data sets in a vendor specific format.

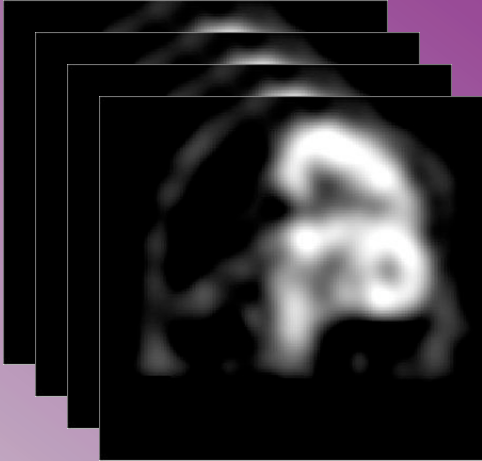
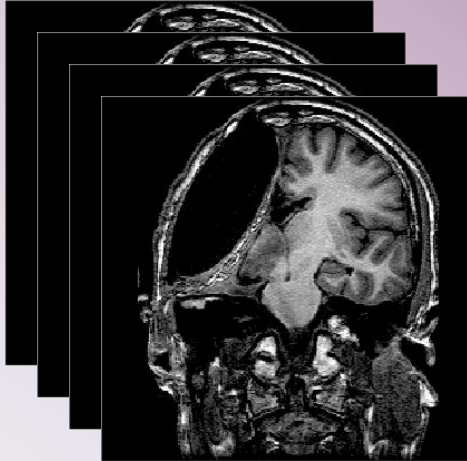
Re-sampled & formatted into DICOM Coronal and Axial.  
Trevor Ackerly – PMCI, Melbourne.



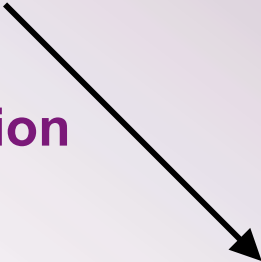
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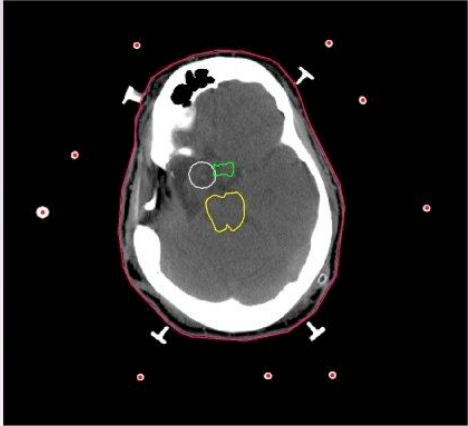
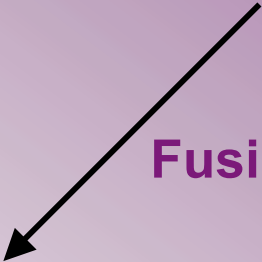
# Patient Data Sets



Fusion



Fusion



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# CT – MR Fusion

File Edit Mode View Cursor Options Help

**RADIONICS ImageFusion™**

**Results**

Patient: \_\_\_\_\_

Average Landmark distances (mm)

Total:	4.3
In-plane:	2.9
Out-plane:	2.4
L-R:	-1.3
A-P:	2.2
S-I:	2.4

Auto fuse

Show Landmarks Panel

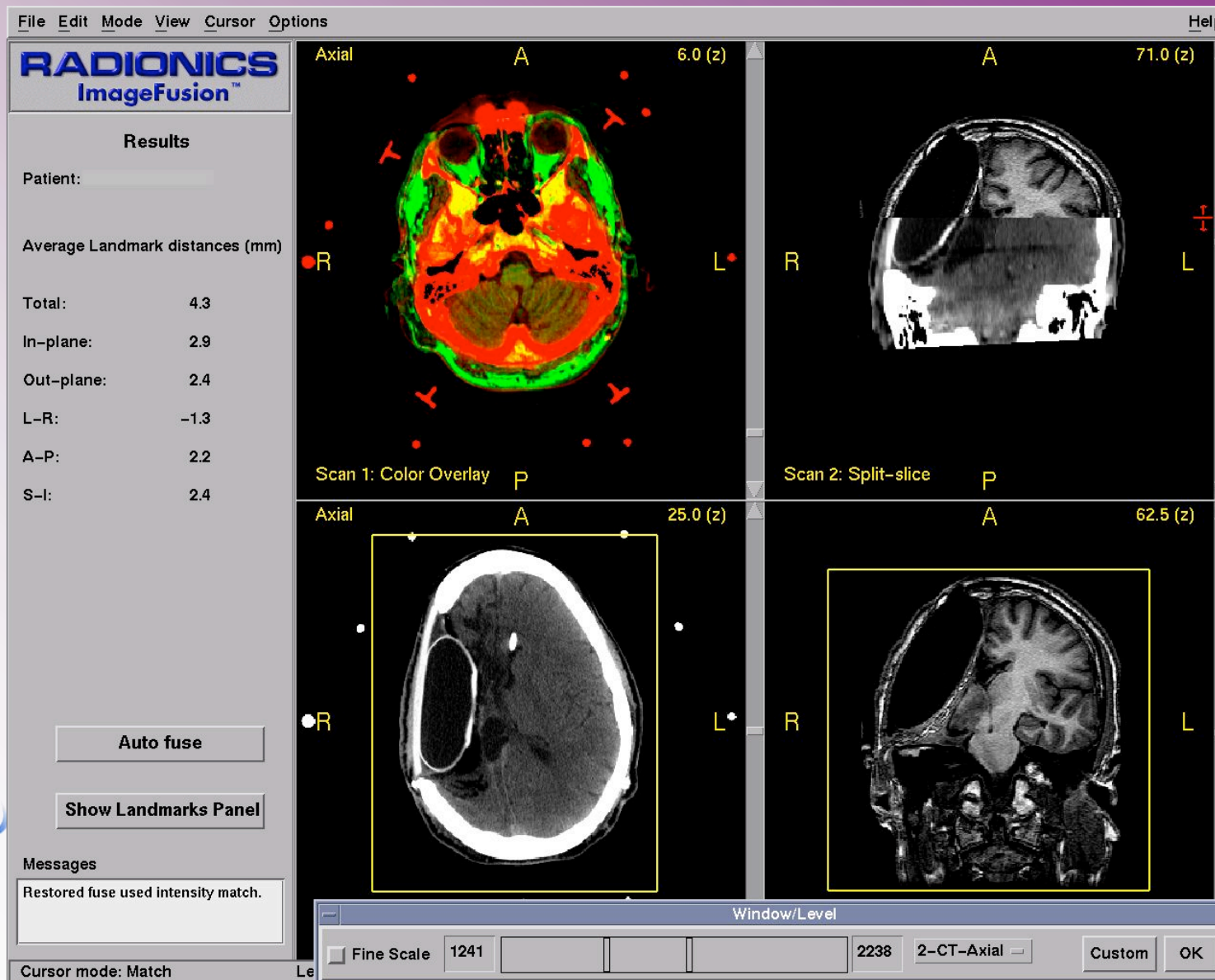
Messages

Restored fuse used intensity match.

Cursor mode: Match

Window/Level

Fine Scale 1241 2238 2-CT-Axial Custom OK



Top-left: Axial A 6.0 (z) Scan 1: Color Overlay

Top-right: Axial A 71.0 (z) Scan 2: Split-slice

Bottom-left: Axial A 25.0 (z)

Bottom-right: Axial A 62.5 (z)



# Transform Matrix

The screenshot displays a medical software interface with a text editor window open. The text editor contains the following content:

```
CT
124
256 x 256
0.820131 x 0.820131 [mm]
1.500000 mm

940 -- Lower window level
2088 -- Higher window level
0 255 0 255 0 123 - Crop Windows
0.000000 -- Starting couch position

# Fusion Matrix
0.9884772 -0.1723966 -0.0518962 -36.5298903
-0.0092386 0.2367705 -0.9625082 107.4528884
0.1782670 0.9521446 0.2325100 -114.0770728
0.0000000 0.0000000 0.0000000 1.0000000

# Landmark Locations and Names
4
202.14 160.21 4.00 103.63 145.00 14.80 "R. Eye" 15.00 21.00
278.37 148.78 4.00 175.24 145.00 17.89 "L. Eye" 15.00 25.50
257.02 176.22 21.00 146.34 85.00 37.13 "Ant L vent" 66.00 55.50
288.28 288.28 23.00 157.65 105.00 88.30 "Post L vent" 72.00 132.00

# Default Landmark List
10 -- Number of landmarks

"R. Eye"
"L. Eye"
"Bas. Artery"
"Pit. Stalk"
"Cereb. Duct"
"Ant R vent"
"Ant L vent"
"Post R vent"
```

The text editor window is overlaid on a medical software interface. The background shows a CT scan of a head with a red outline and a yellow circle. The interface includes a menu bar (File, View, Re...), a toolbar with icons for Rotate, Zoom, and Pixel to Pixel, and a window control bar at the bottom with 'Window/Level' and '3-CT-Axial'.



# CT - SPECT Fusion

File Edit Mode View Cursor Options Help

**RADIONICS**  
ImageFusion™

**Results**

Patient: \_\_\_\_\_

Average Landmark distances (mm)

Total:	4.3
In-plane:	2.9
Out-plane:	2.4
L-R:	-1.3
A-P:	2.2
S-I:	2.4

Auto fuse

Show Landmarks Panel

Messages

Restored fuse used intensity match.

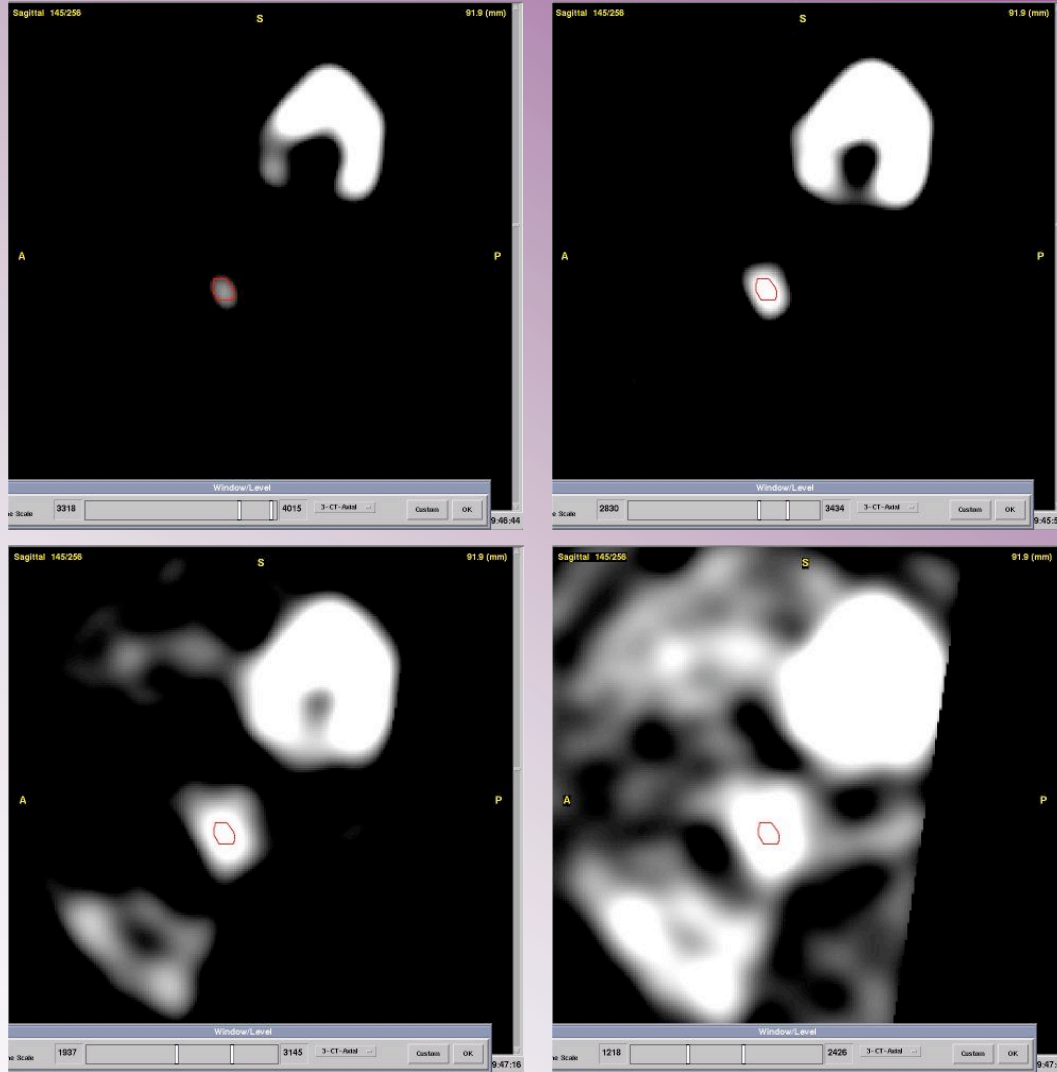
Cursor mode: Match

Window/Level

Fine Scale 1381 | 3979 2-CT-Axial Custom OK



# Target Definition : How to define target?



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# Treatment Planning

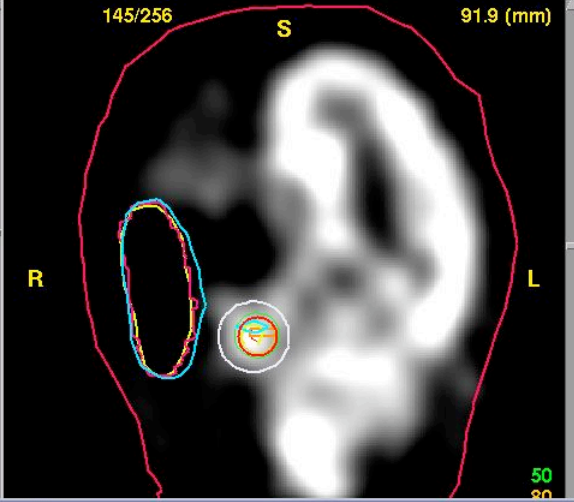
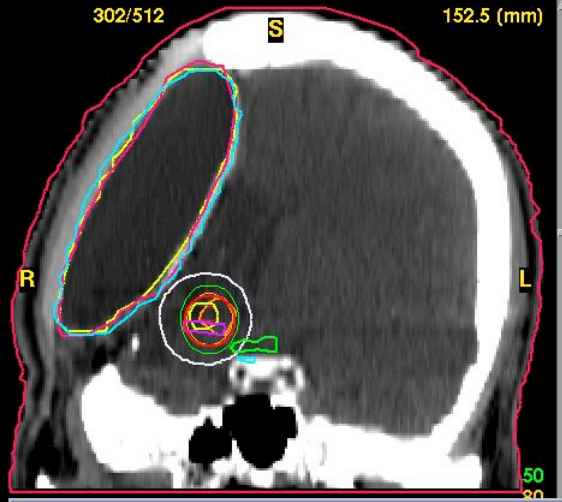
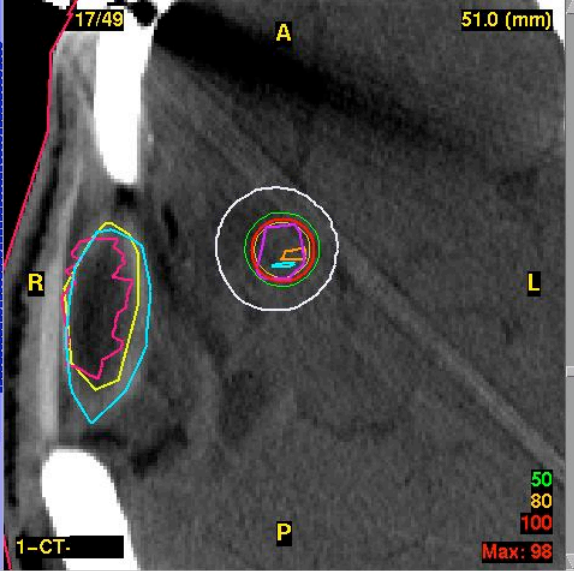
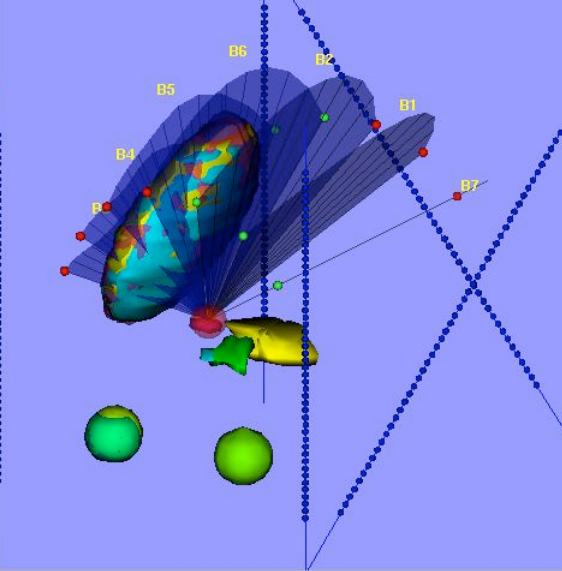
File Edit Mode View Cursor Help

## RADIONICS XKnife RT™

Patient Name: \_\_\_\_\_

Course | Plan | Target | Isocenter | Beam | Dose

- Surface Dose Summary
- Dose Volume Histograms
- Volume Dose
  - Threshold: \_\_\_\_\_ 80
- Slice Dose
  - Levels: 100, 80, 50



Window/Level

Fine Scale 1646 3631 3-CT-Axial Custom OK



# Treatment Planning

TREATMENT :

June 2003

20Gy to 80% isodose

1.5cm circular collimator

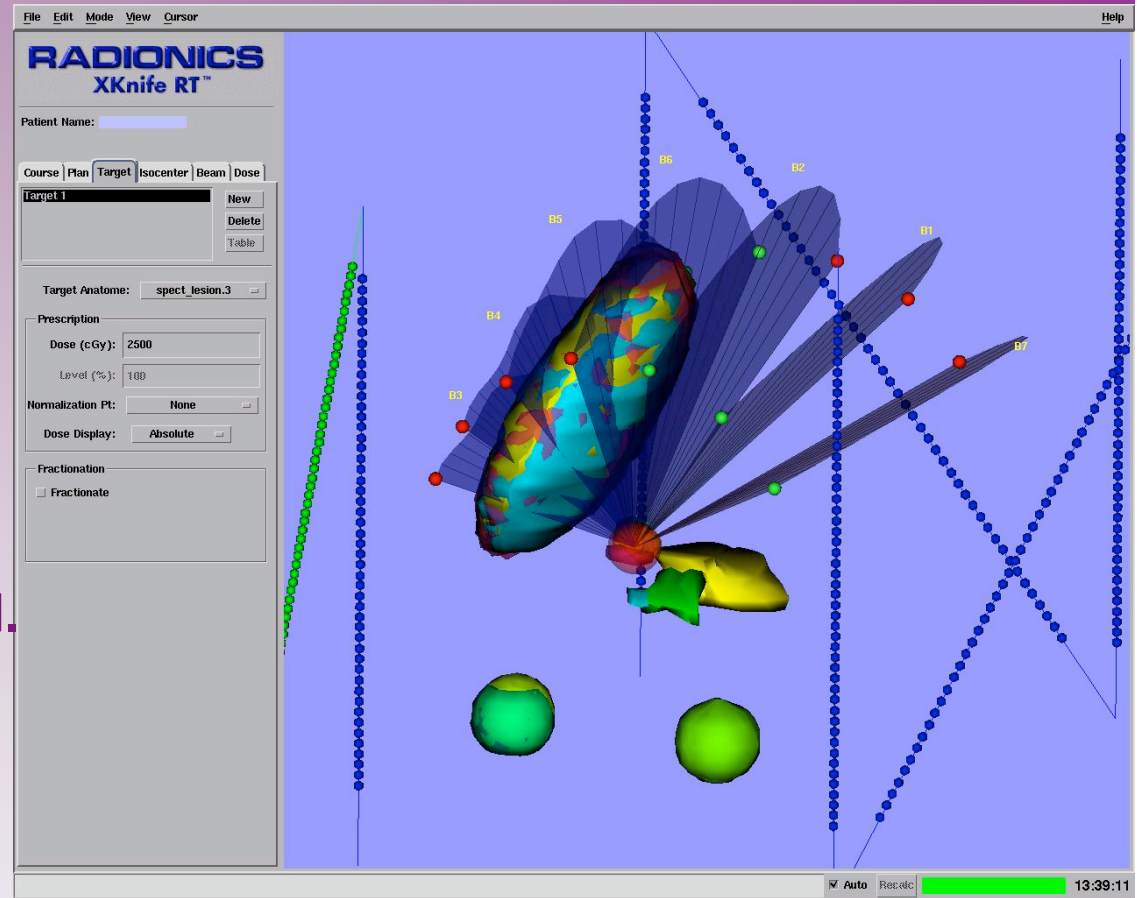
7 Arc Beams

1 to 3 events per day

less intense seizures

reduced anit-epileptic med.

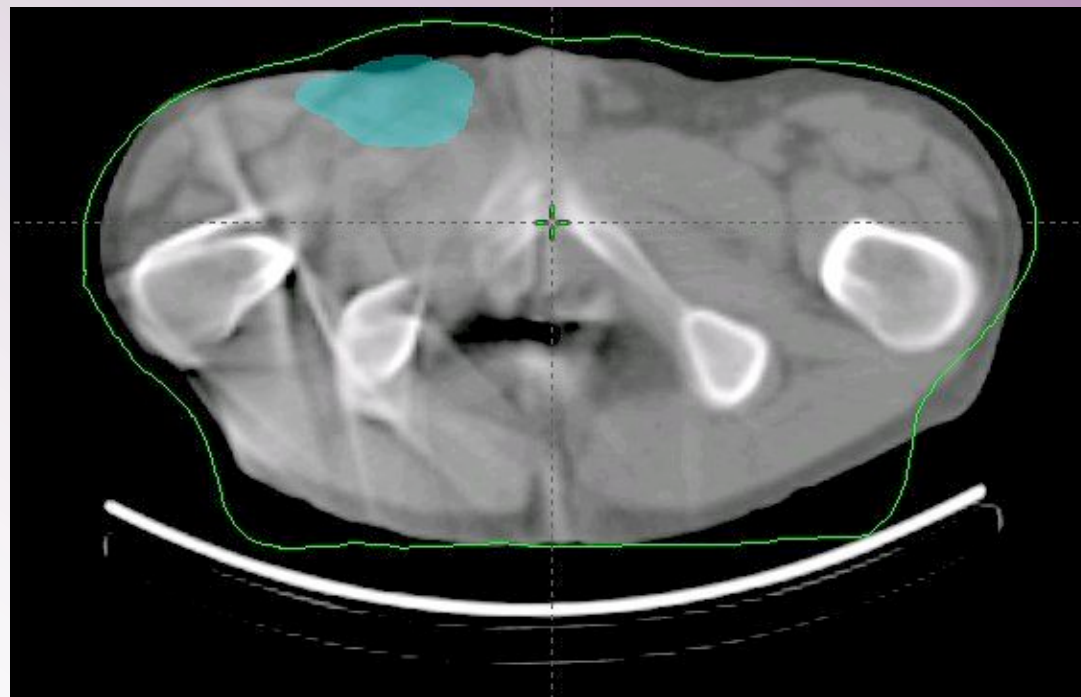
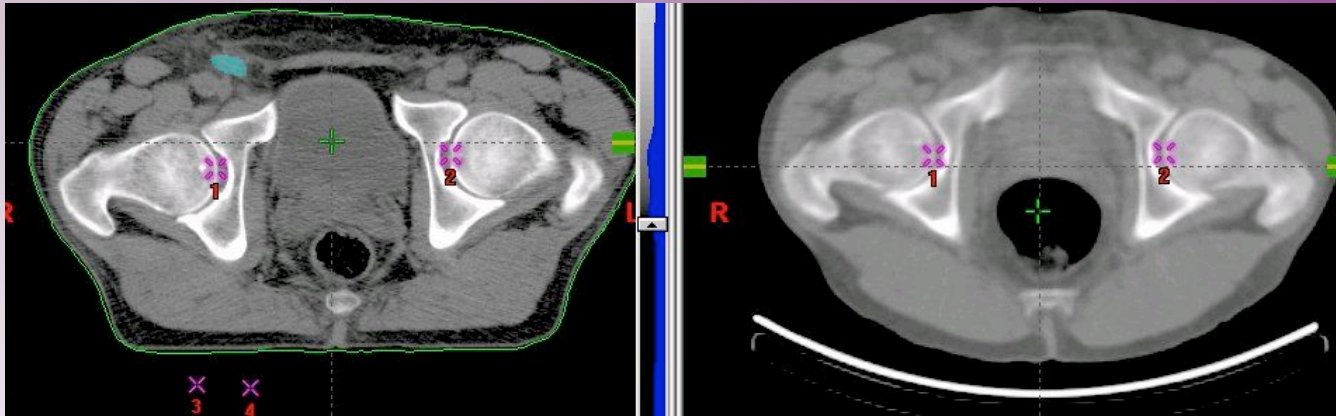
Now living on his own



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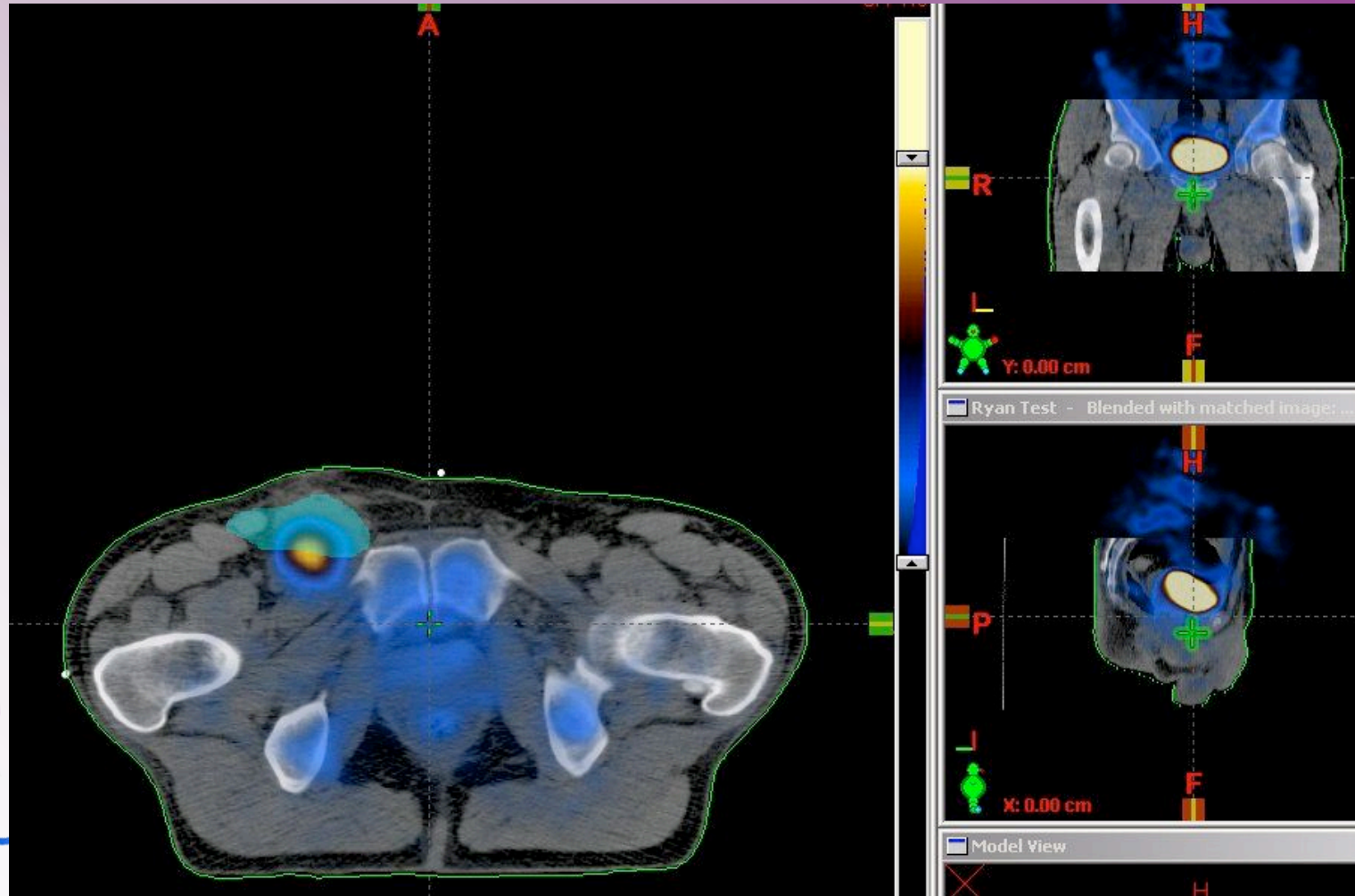
# Patient Setup



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# Patient Setup



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# Future

Overcome the data transfer issues with the external beam planning system.

Simplify the data conversion process :

Dedicated Workstation

In-house software

Vendor Specific Import filter

Integrate PET (SPECT) data into regular virtual simulation sessions.



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# Points

**Co-registered data**

**transfer and incorporation into RT planning systems**

**Window Width/Level determination for target definition in RT planning systems**

**Localisation systems used and patient setup**

**Acknowledgments:**

**Mr Bruce Van Every, Physicist, The Alfred NM Dept.**



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