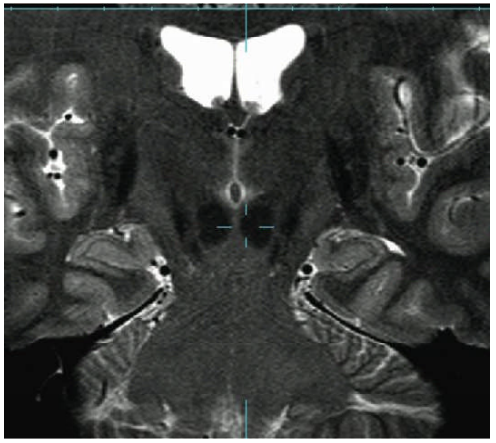
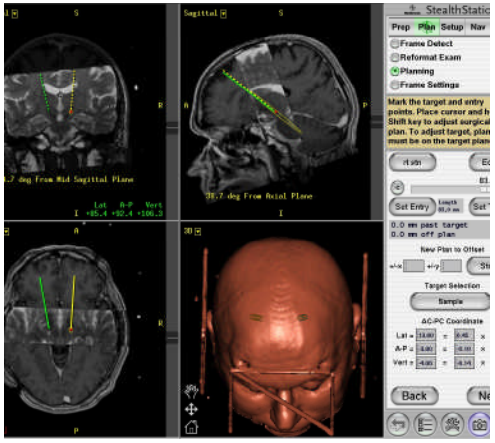
# *Interventional MRI for DBS Implantation*

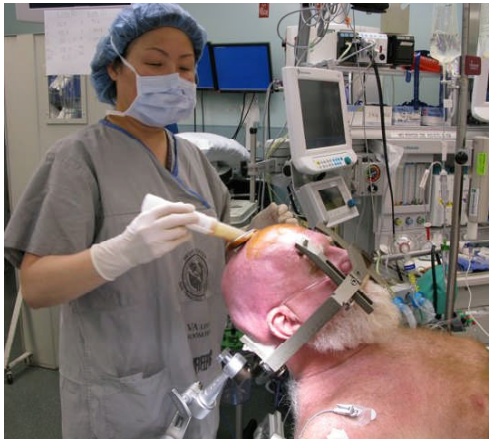
*Paul Larson, MD*

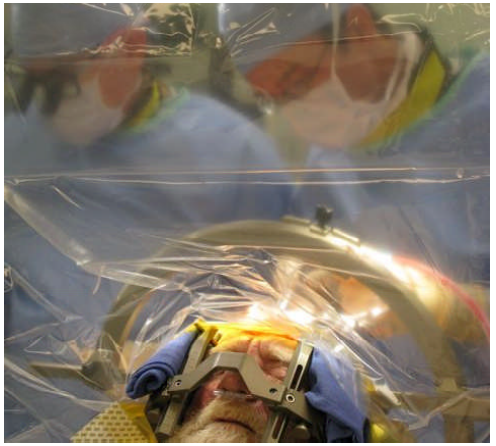
**Associate Professor, Neurological Surgery**
**University of California, San Francisco**

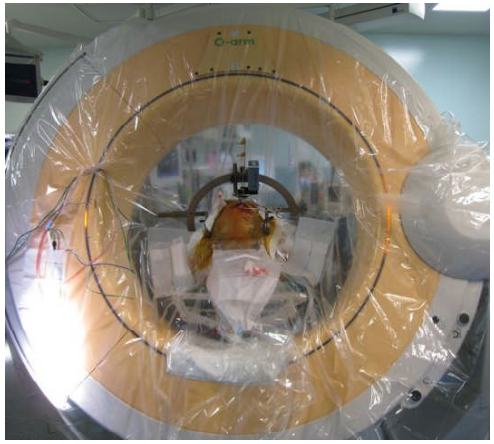
**Chief of Neurosurgery, Director CanOp**
**San Francisco VA Medical Center**




StealthStation
Prep
Plan
Setup
Nav
Frame Detect
Reformat Exam
Planning
Frame Settings
Sagittal
Set Entry
Target Selection
Sample
Back

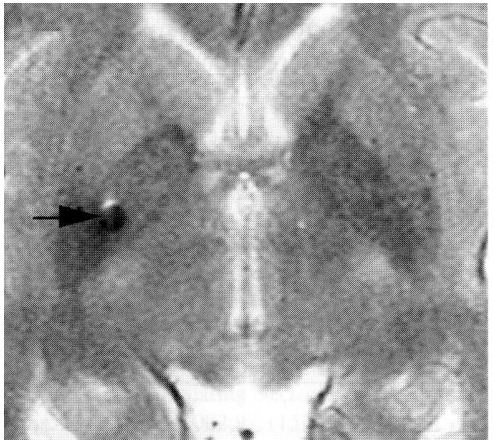





O-arm


O-arm


PHILIPS



# *Traditional DBS*

**Traditional methods:**

*Frame-based*

*Microelectrode recording*

*Multiple brain penetrations*

*Awake patient*

# *Traditional DBS*

**Disadvantages...**

*Requires awake, cooperative patient*

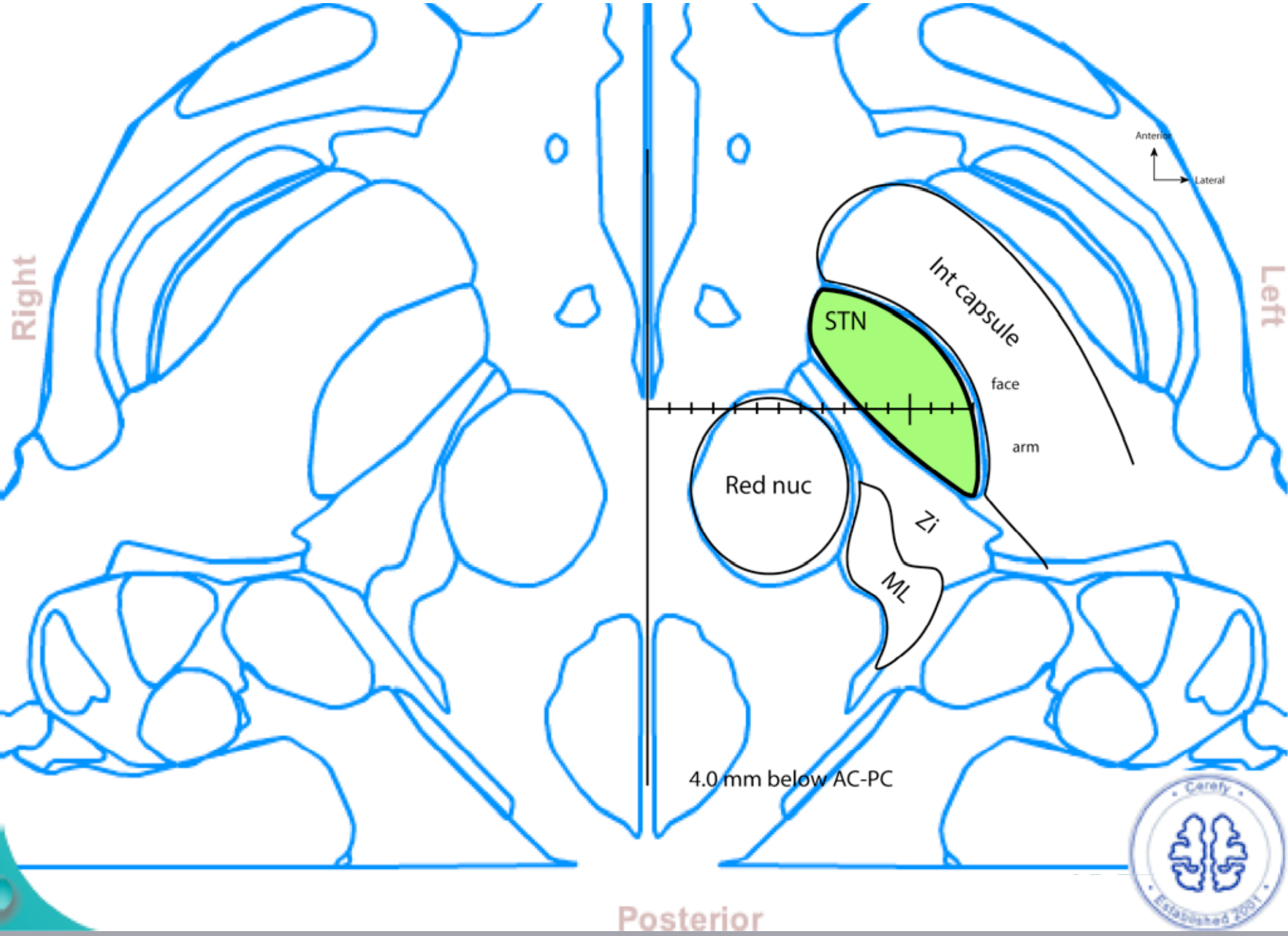
*MER technically demanding, adds time to the procedure*

*Targeting relies on pre-operative imaging, cannot account for brain shift*

*No immediate feedback*


# *iMRI*


Right
Left
Posterior


Anterior
Lateral
Right
Left
Int capsule
STN
face
arm
Red nuc
Zi
ML
4.0 mm below AC-PC
Posterior

Obeso,Vitek,DeLong et al, 2001

Lozano, Abosch et al, 2002

Lanotte, Rizzone et al, 2002

Saint-Cyr, Lozano et al, 2002

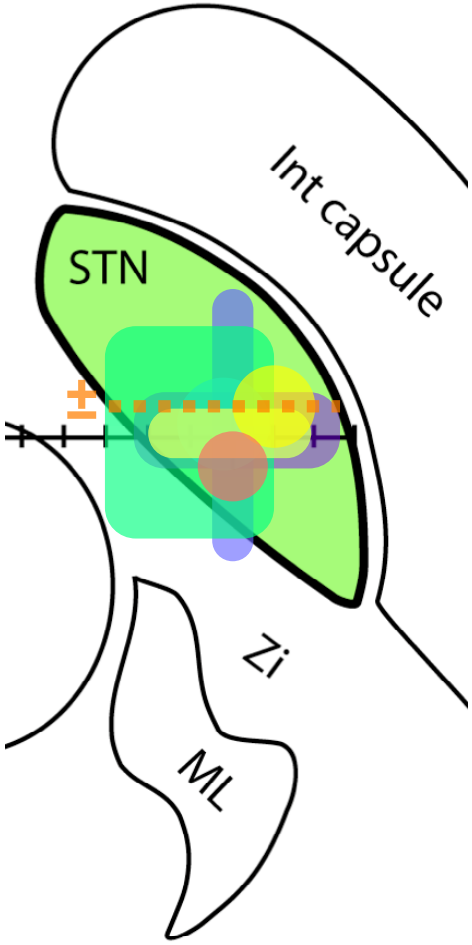
Starr, Marks et al, 2003

Bronte-Stewart, Heit et al, 2004

Goodman, McClelland et at, 2005

Rezai, Kopell, Gross et al, 2006

Others...



# *The "UCSF" target*

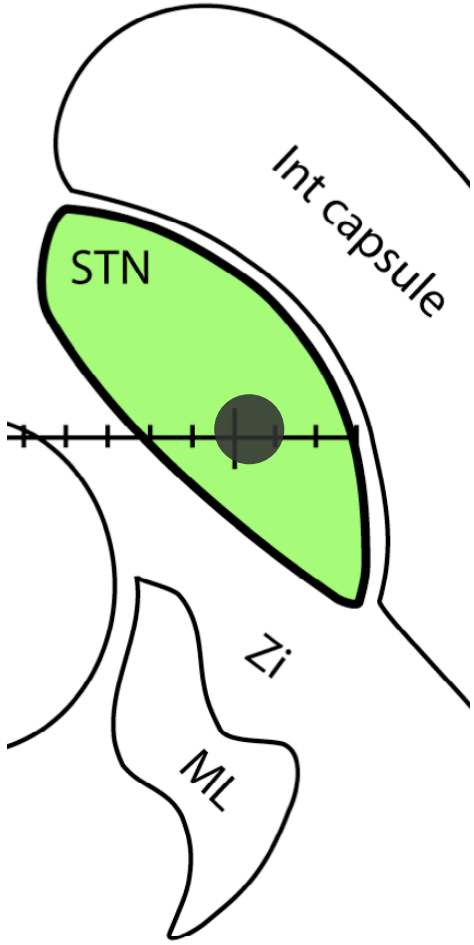
**AC-PC based (indirect) targeting:**

**X = 12**

**Y = -3**

**Z = -4**

**Then, modification based on direct targeting with T2 weighted imaging**

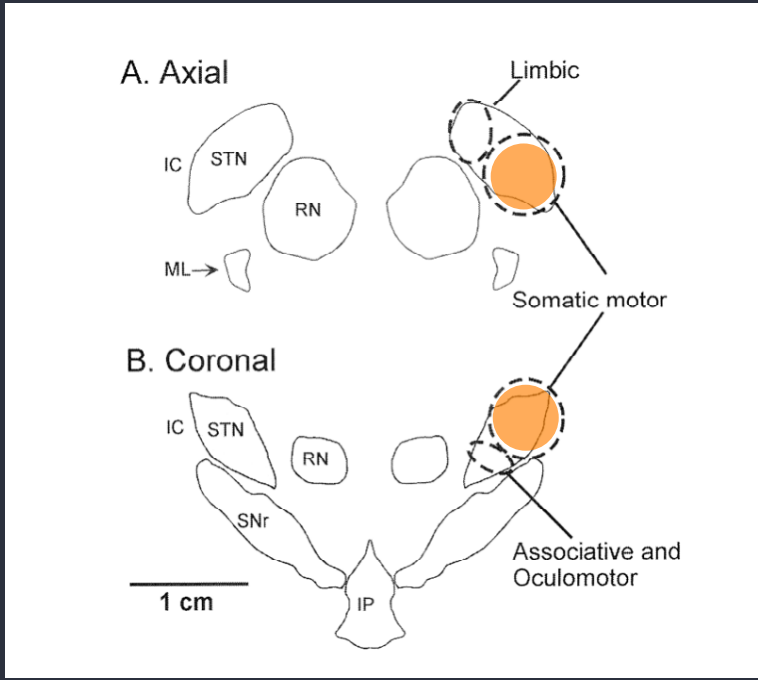


# *iMRI and the STN*

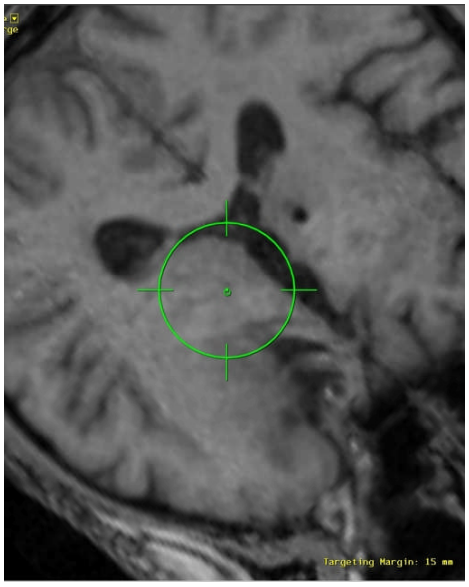
**Ideal target for iMRI**

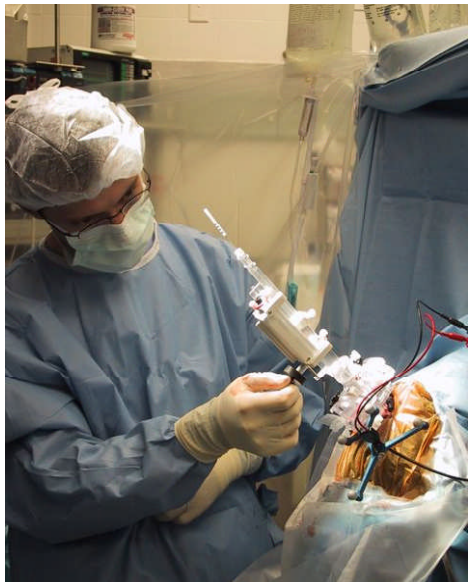
**Visible on MRI imaging**

**Placement of lead in motor area associated with good outcomes**



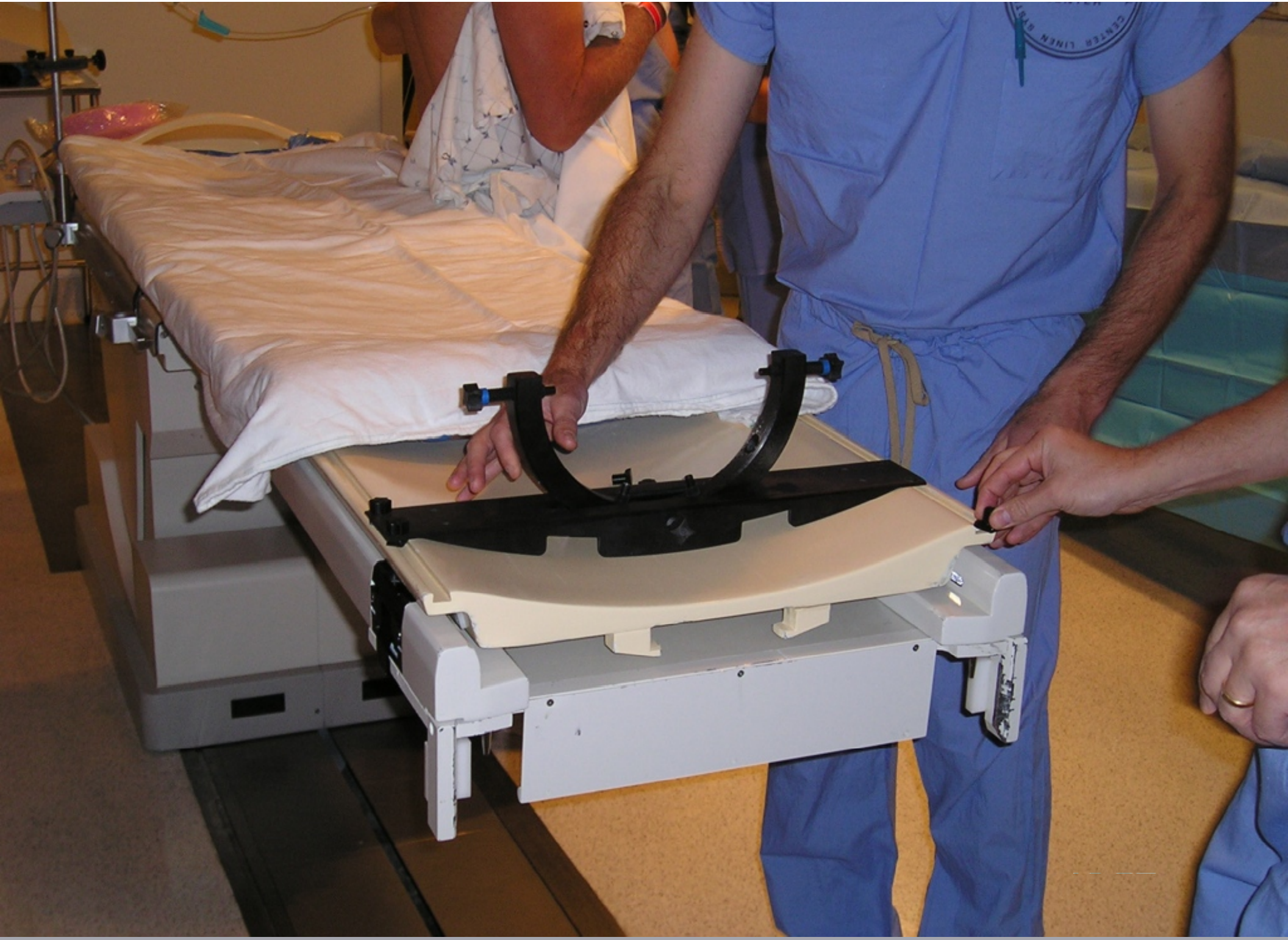

Stand-By
PHILIPS
Medical Systems



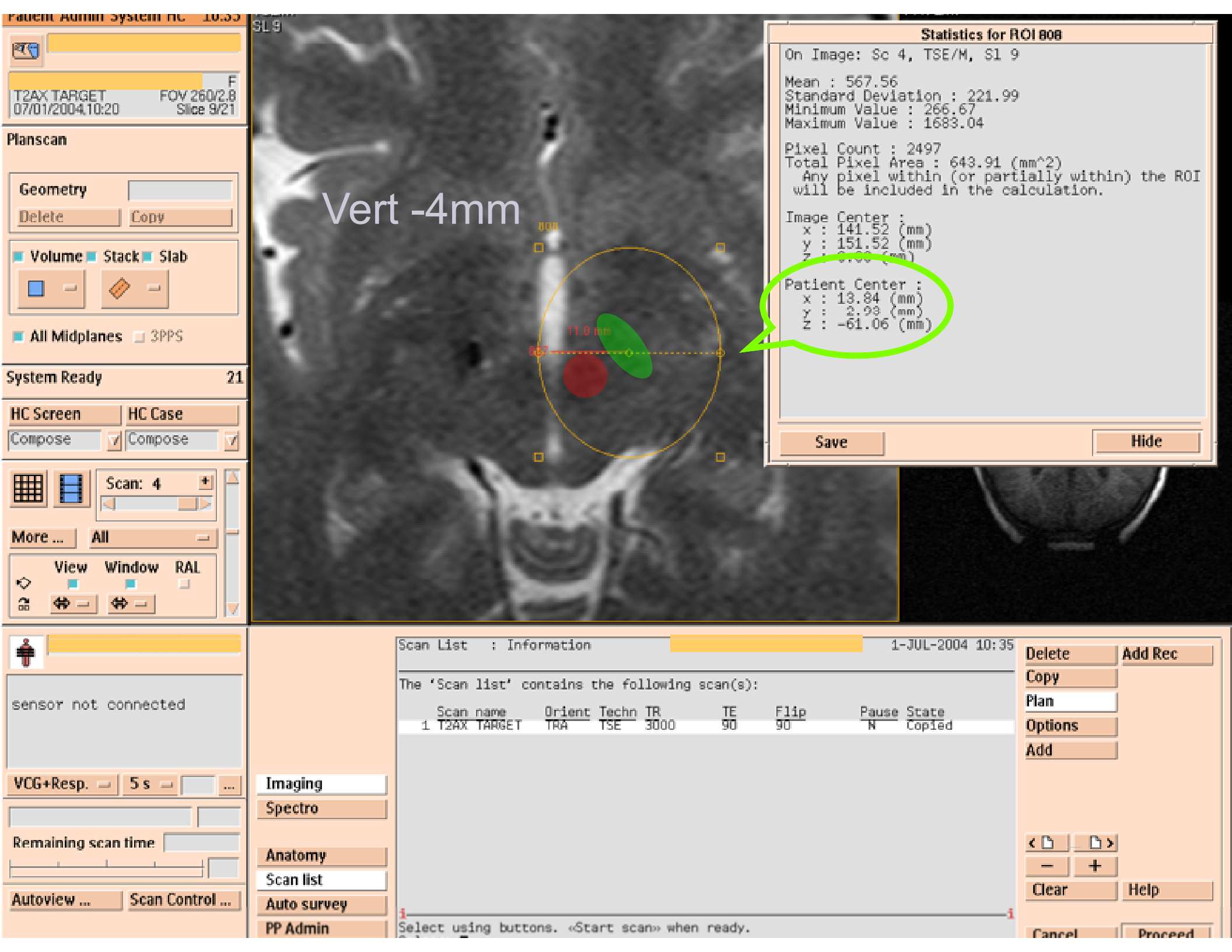
# *Frameless DBS*

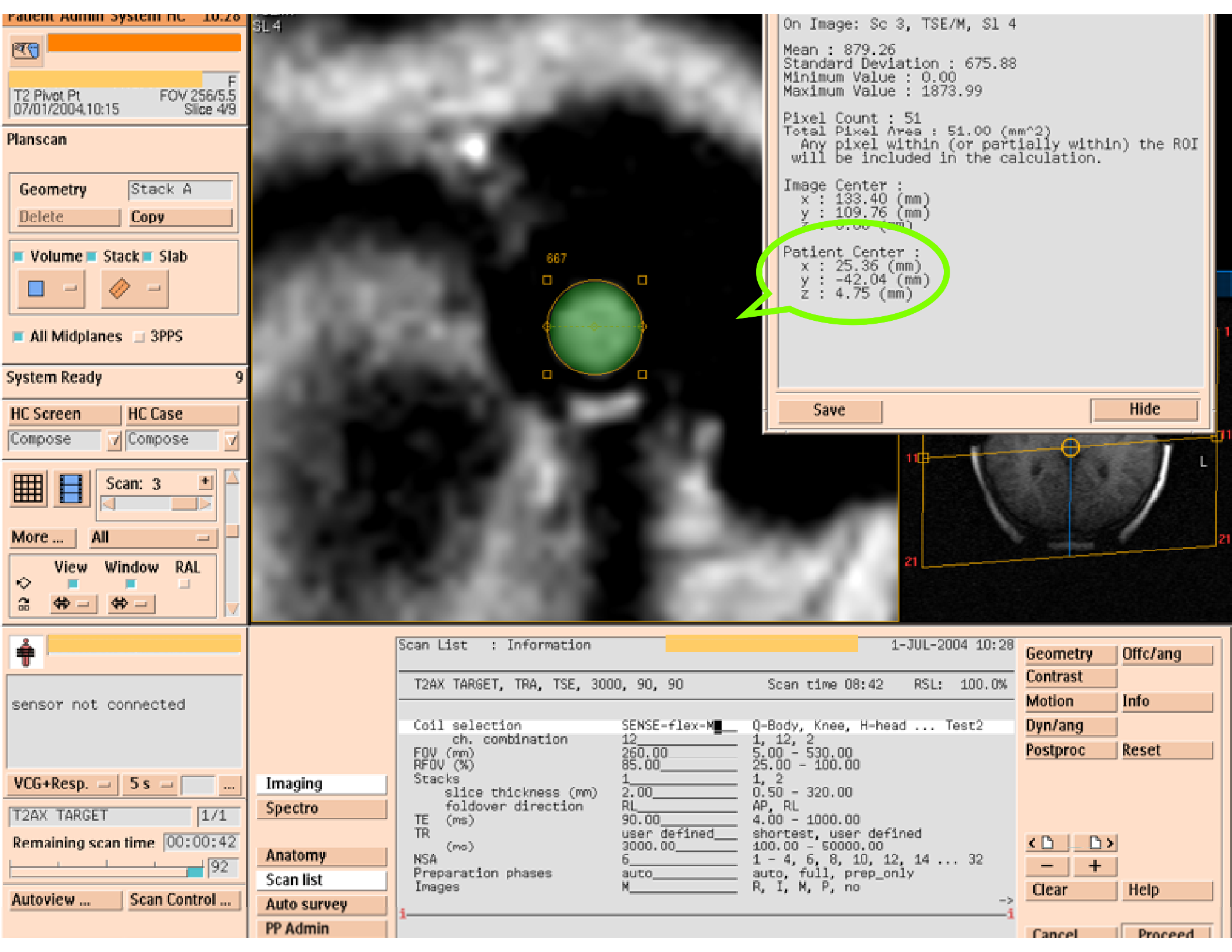

Fluid stem
NexFrame

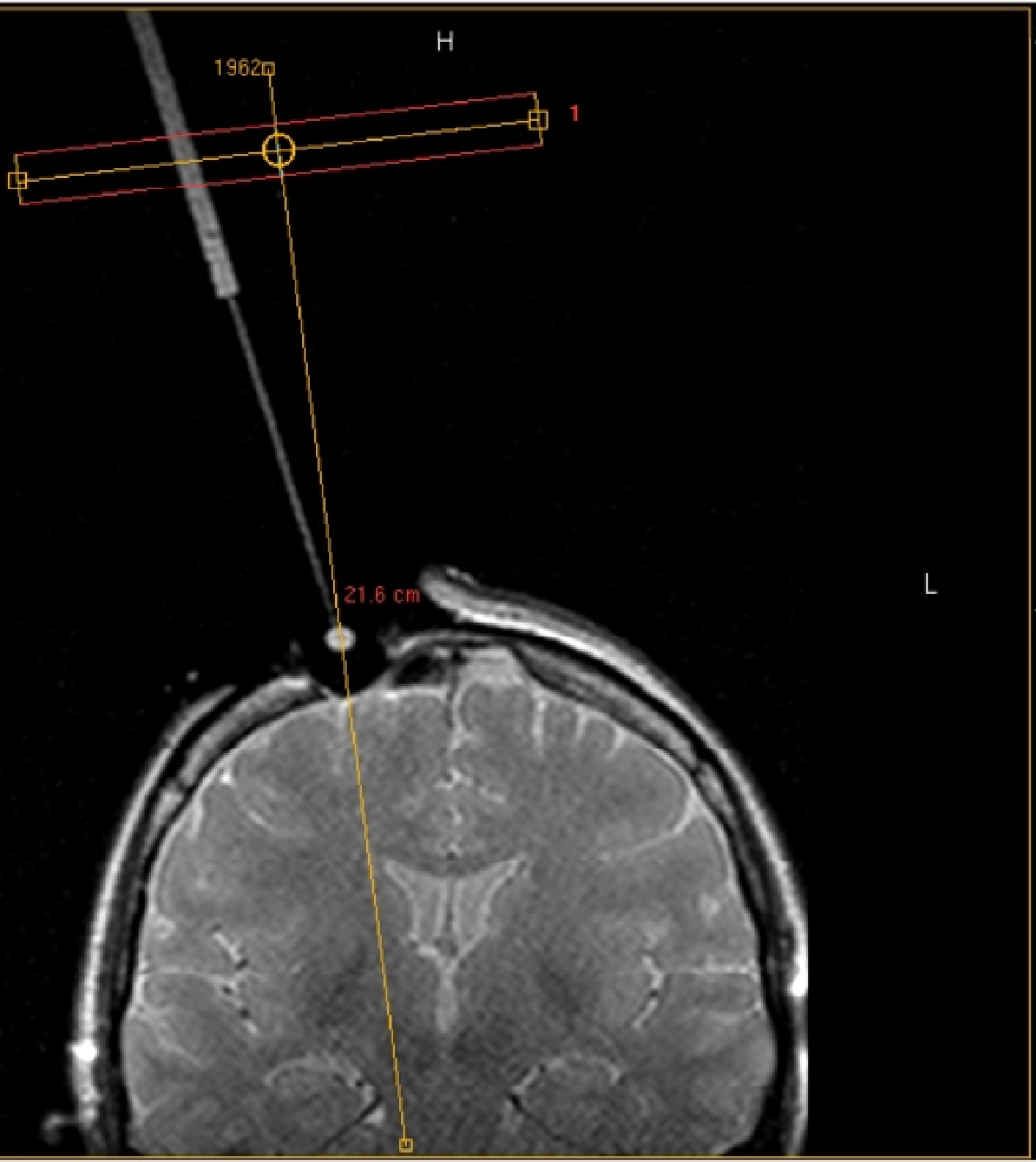


# *Coils*

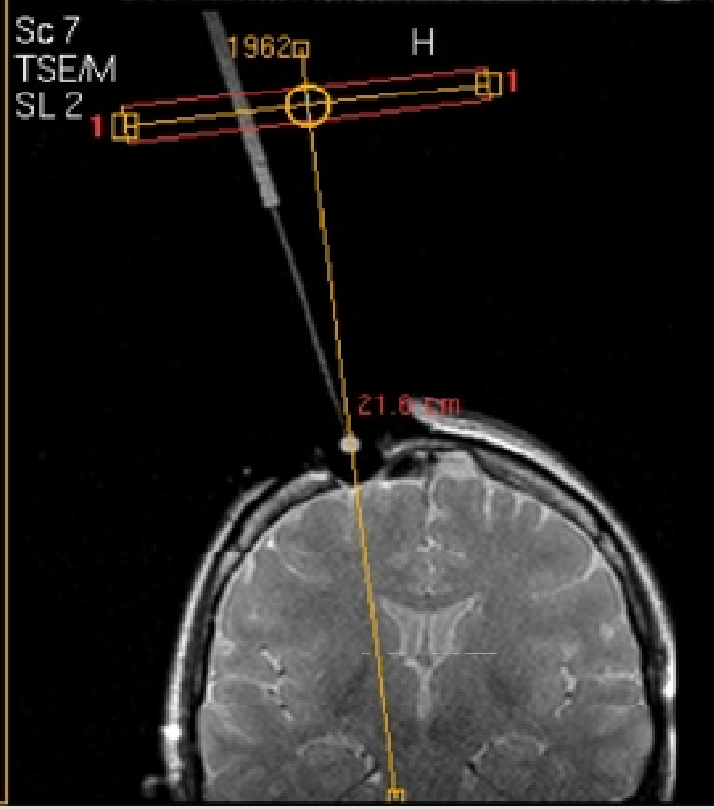
Loop coils

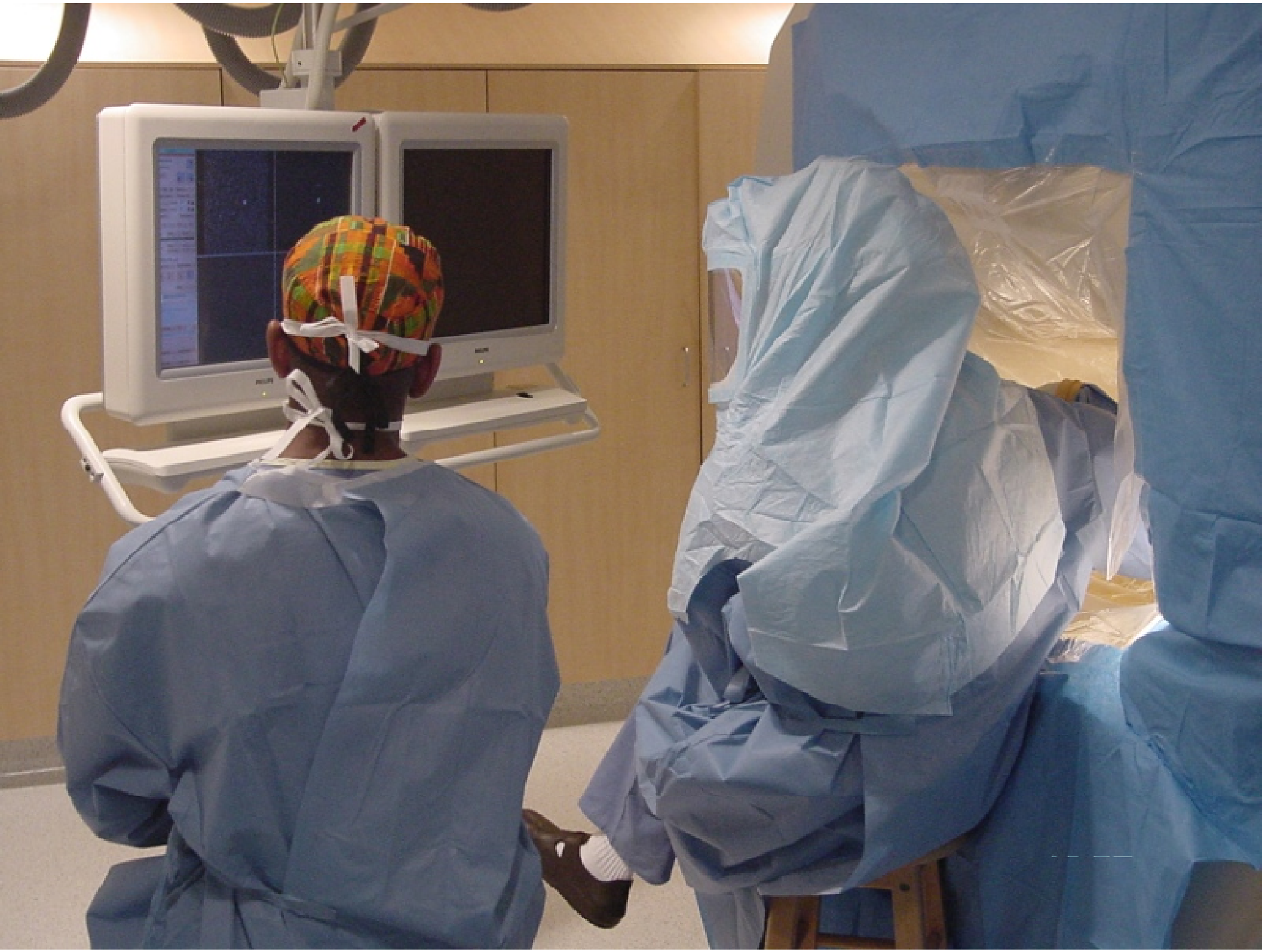

Vert -4mm
Statistics for ROI 808
On Image: Sc 4, TSE/M, Sl 9
Mean : 567.56
Standard Deviation : 221.99
Minimum Value : 266.67
Maximum Value : 1683.04
Pixel Count : 2497
Total Pixel Area : 643.91 (mm^2)
Any pixel within (or partially within) the ROI will be included in the calculation.
Image Center :
x : 141.52 (mm)
y : 151.52 (mm)
Patient Center :
x : 13.84 (mm)
y : 2.98 (mm)
z : -61.06 (mm)
Save
Hide
T2AX TARGET
07/01/2004.10:20
FOV 260/2.8
Slice 9/21
Planscan
Geometry
Delete
Copy
Volume
Stack
Slab
All Midplanes
3PPS
System Ready
21
HC Screen
HC Case
Compose
Compose
Scan: 4
More ...
All
View
Window
RAL
sensor not connected
VCG+Resp.
5 s
Remaining scan time
Autoview ...
Scan Control ...
Imaging
Spectro
Anatomy
Scan list
Auto survey
PP Admin
Scan List : Information
1-JUL-2004 10:35
The 'Scan list' contains the following scan(s):
Scan name Orient Techn TR TE Flip Pause State
1 T2AX TARGET TRA TSE 3000 90 90 N Copied
Delete
Add Rec
Copy
Plan
Options
Add
Clear
Help
Cancel
Proceed
Select using buttons. «Start scan» when ready.

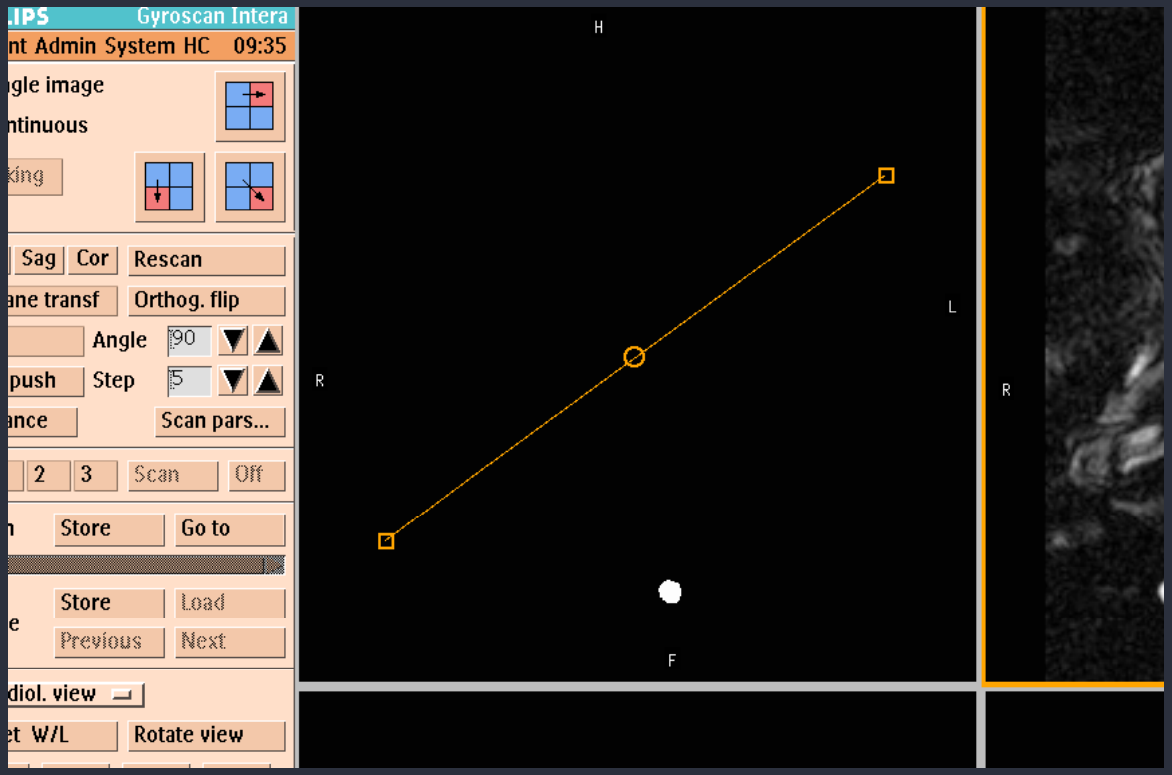

SL 4
667
On Image: Sc 3, TSE/M, Sl 4
Mean : 879.26
Standard Deviation : 675.88
Minimum Value : 0.00
Maximum Value : 1873.99
Pixel Count : 51
Total Pixel Area : 51.00 (mm^2)
Any pixel within (or partially within) the ROI
will be included in the calculation.
Image Center :
x : 133.40 (mm)
y : 109.76 (mm)
Patient Center :
x : 25.36 (mm)
y : -42.04 (mm)
z : 4.75 (mm)
Save
Hide
T2 Pivot Pt
07/01/2004,10:15
FOV 256/5.5
Slice 4/9
Planscan
Geometry
Stack A
Delete
Copy
Volume
Stack
Slab
All Midplanes
3PPS
System Ready
9
HC Screen
HC Case
Compose
Compose
Scan: 3
More ...
All
View
Window
RAL
sensor not connected
VCG+Resp.
5 s
T2AX TARGET
1/1
Remaining scan time
00:00:42
92
Autoview ...
Scan Control ...
Imaging
Spectro
Anatomy
Scan list
Auto survey
PP Admin
Scan List : Information
1-JUL-2004 10:28
T2AX TARGET, TRA, TSE, 3000, 90, 90
Scan time 08:42
RSL: 100.0%
Coil selection SENSE-flex-M Q=Body, Knee, H=head ... Test2
ch. combination 12 1, 12, 2
FOV (mm) 260.00 5.00 - 530.00
RFOV (%) 85.00 25.00 - 100.00
Stacks 1 1, 2
slice thickness (mm) 2.00 0.50 - 320.00
foldover direction RL AP, RL
TE (ms) 90.00 4.00 - 1000.00
TR user defined shortest, user defined
(ms) 3000.00 100.00 - 50000.00
NSA 6 1 - 4, 6, 8, 10, 12, 14 ... 32
Preparation phases auto auto, full, prep_only
Images M R, I, M, P, no
Geometry
Offc/ang
Contrast
Motion
Info
Dyn/ang
Postproc
Reset
Clear
Help
Cancel
Proceed

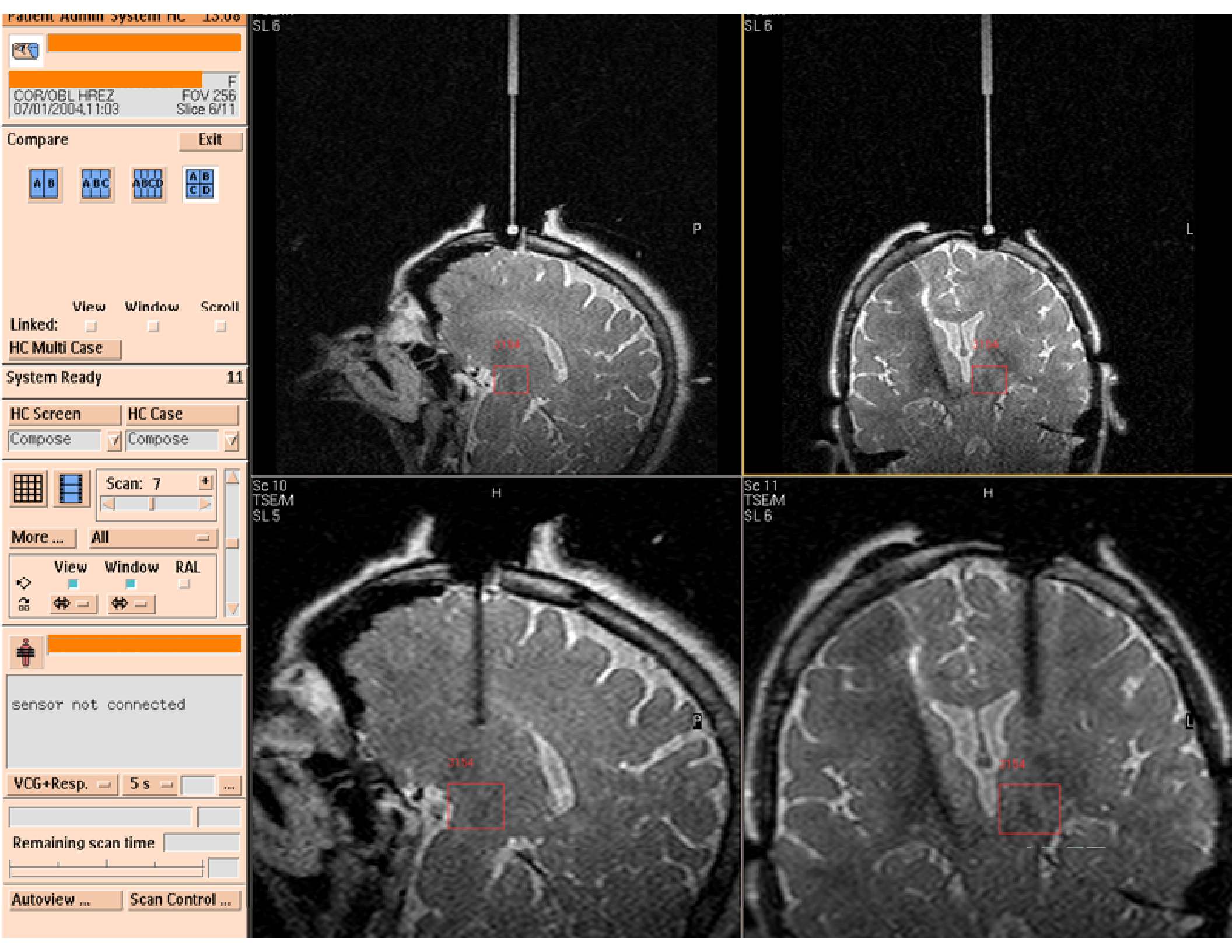

H
1962
1
21.6 cm
L

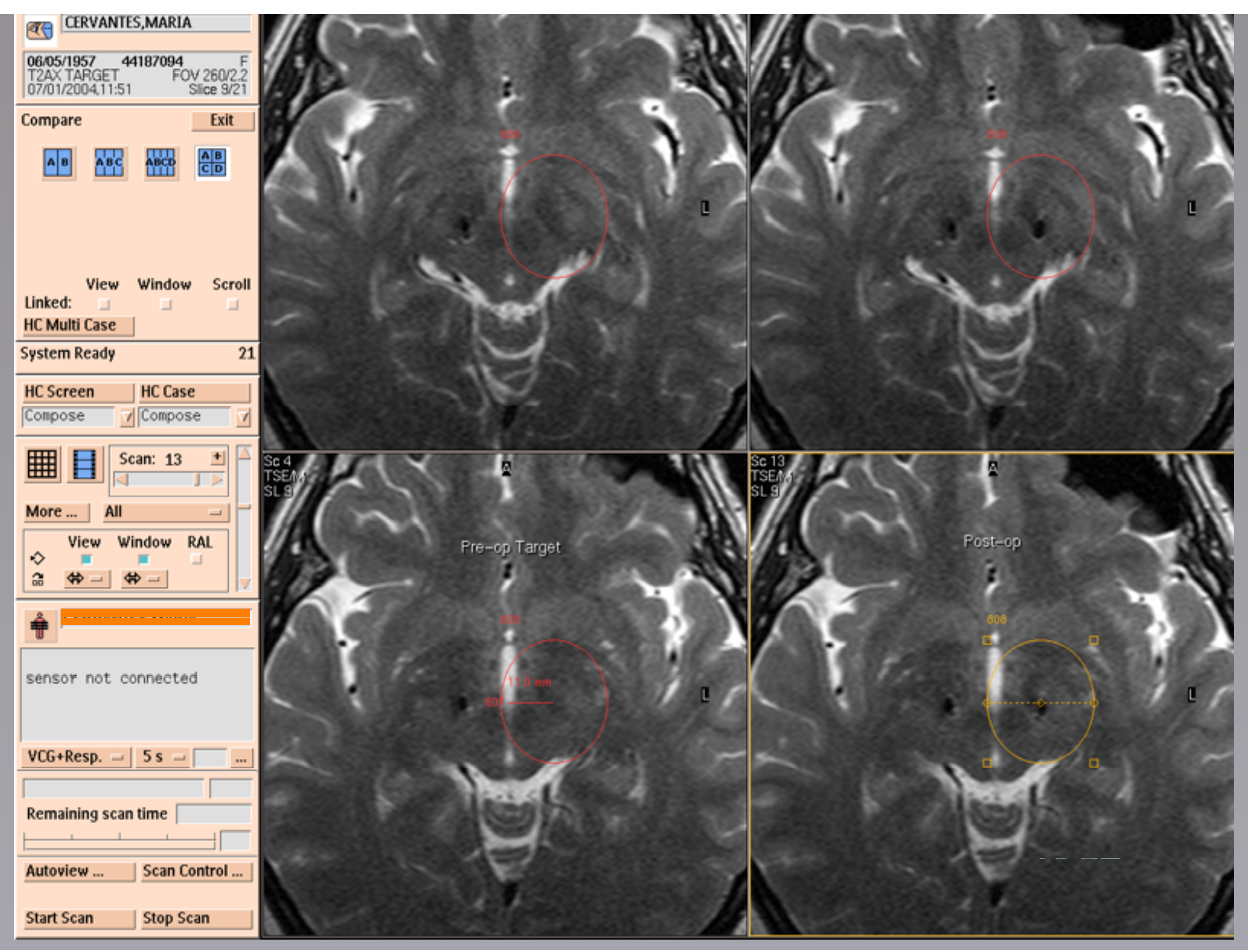

Sc 8
TSE/M
SL 2
H
1
1


Sc 7
TSE/M
SL 2
1962
H
1
1
21.6 cm




IPS
Gyroscan Intera
nt Admin System HC
09:35
gle image
ntinuous
king
Sag
Cor
Rescan
ane transf
Orthog. flip
Angle
90
push
Step
5
ance
Scan pars...
2
3
Scan
Off
Store
Go to
Store
Load
Previous
Next
diol. view
et W/L
Rotate view
H
L
R
F
R


COR/OBL HREZ
07/01/2004,11:03
FOV 256
Slice 6/11
Compare
Exit
View
Window
Scroll
Linked:
HC Multi Case
System Ready
11
HC Screen
HC Case
Compose
Compose
Scan: 7
More ...
All
View
Window
RAL
sensor not connected
VCG+Resp.
5 s
Remaining scan time
Autoview ...
Scan Control ...
SL 6
P
SL 6
L
Sc 10
TSEM
SL 5
H
Sc 11
TSEM
SL 6
H


CERVANTES,MARIA
06/05/1957 44187094 F
T2AX TARGET FOV 260/2.2
07/01/2004,11:51 Slice 9/21
Compare
Exit
View Window Scroll
Linked:
HC Multi Case
System Ready 21
HC Screen
HC Case
Compose
Compose
Scan: 13
More ...
All
View Window RAL
sensor not connected
VCG+Resp.
5 s
Remaining scan time
Autoview ...
Scan Control ...
Start Scan
Stop Scan
Sc 4
TSEM4
SL 9
Pre-op Target
11.0 mm
Sc 13
TSEM4
SL 9
Post-op

# *iMRI - advantages*

True real-time image guidance

Accounts for brain shift and variations in anatomy

“One pass” placement, no MER

Patient asleep

Procedure time reduced

Immediate detection of complications

# *Application accuracy*

**53 STN electrodes in 29 patients**

*87% of leads were placed in a single pass*

*Maximum number of brain penetrations per lead = 2*

*"Tip error" defined as difference between expected and actual tip coordinates in AC-PC space*

*Mean tip error = 2.2 ± 0.92 mm*

# Application accuracy

| Technique | X error | Y error | Z error | Vector $(X^2+Y^2+Z^2)^{1/2}$ |
|---|---|---|---|---|
| iMRI | -0.07 +- 0.96 | 0.15 +/- 1.10 | 1.36 +/- 1.27 | 2.18 +/- 0.92 |
| Frame-based stereotaxy | -0.76 +/- 1.48 | 0.57 +/- 1.73 | 0.86 +/- 2.14 | 3.06 ±1.41 |
| p-value for difference between iMRI and frame-based errors | 0.004* | 0.009* | 0.129 | .0001* |

*=statistically significant difference in 2-sample unpaired t-test for equality of means at p<.05

# *Clinical outcomes*

**13 of 19 pts undergoing bilateral implantation completed pre- and >6 month post-op on/off testing (average f/u 9 months)**

*Pre-op*

*Off meds 49 ± 13*

*On meds 19 ± 8*

*Post-op*

*Off meds (on stim) 19 ± 14  (mean improvement of 60% vs off baseline)*

# *Complications*

**No hemorrhages**

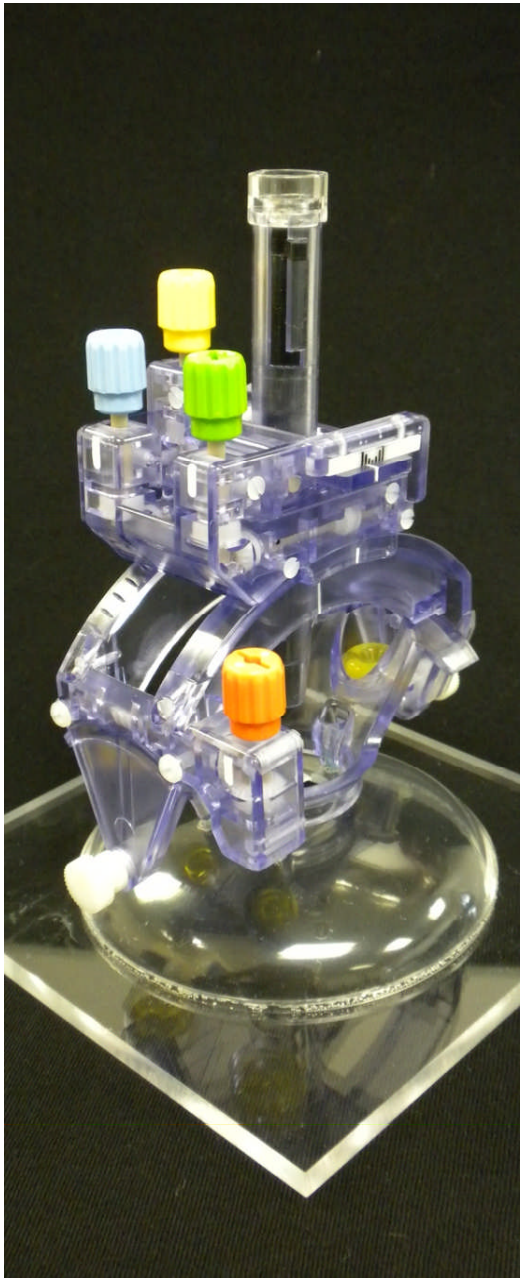
**2 infections**

*Both occurred in the first 10 patients before availability of an MR-compatible drill*

*No infections in the subsequent patients*

# *NexFrame*

**Although adequate, does have limitations...**



# *ClearPoint*

**A completely novel, fully integrated system specifically designed to perform iMRI-guided DBS in any 1.5T scanner**