4th International Workshop on PET in Lymphoma

Menton (France), Palais de l'Europe,
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Metabolic volume measurements in lymphoma
Methodology

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Literature data

The Tumor Burden is an important prognostic tool in Lymphoma …

Volume CT

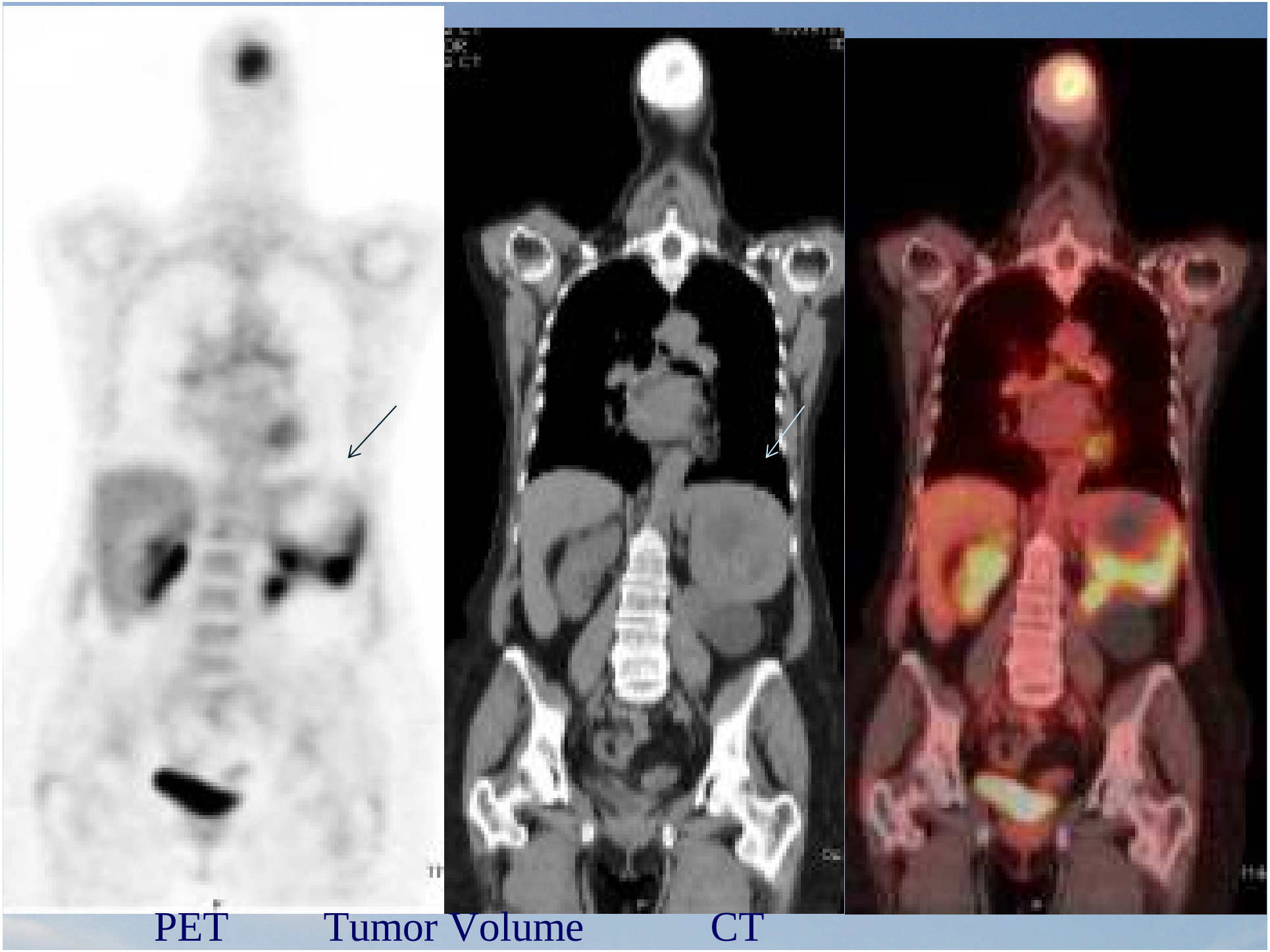
Morphologic information

Contour definition

…but the definition on CT images is complex and time consuming

PET vs CT in HL/NHL Staging

Study	Pts	Modality	Sensitivity (%)	Specificity (%)
Newman (‘94)	16	PET	100	100
		CT	91	100
Thill (‘97)	27	PET	100	NA
		CT	77	
Buchman (‘01)	52	PET (N)	99.2	100
		CT (N)	83.2	99.8
		PET (E)	100	99.4
		CT (E)	80.8	99.4
Schaefer (‘04)	60	PET/CT (N)	94	100
		CT (N)	88	86
		PET/CT (E)	88	100
		CT (E)	50	90
Hutchings (‘06)	99	PET/CT (N)	92.2	99.3
		CT	82.6	98.9


PET
Tumor Volume
CT

FDG PET

- Metabolic information (SUV)

but

- The metabolic tumor volume definition needs some rules

BTV definition: which method?

SNM
Advancing Molecular Imaging and Therapy

Several strategies in using PET for target volume definition in radiotherapy treatment planning are being investigated:

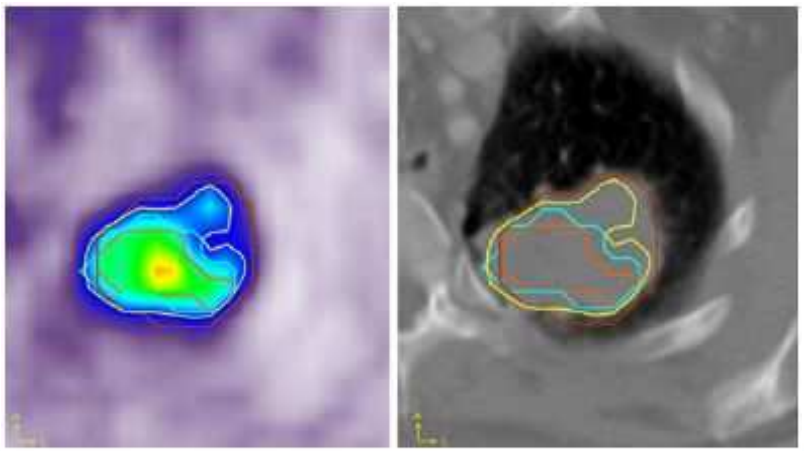
- **visual contouring**
- **Fixed or relative threshold** (SUV=2.5, 30-40-50 % of peak activity…)
- **adaptive threshold** (dependence on Signal/Bkg ratio and lesion size, dependence on reconstruction algorithm…)
- **gradient based** (adaptive region growing)
- **statistical techniques** (fuzzy locally adaptive bayesian, Markov models, k-means clustering…)

Reproducibility

Robustness

Accuracy

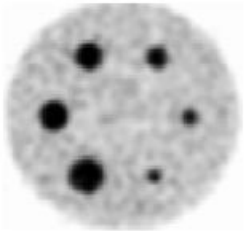
Automation



Zaidi H et al. Eur J Nucl Med Mol Imaging. 2010 Nov;37(11):2165-87

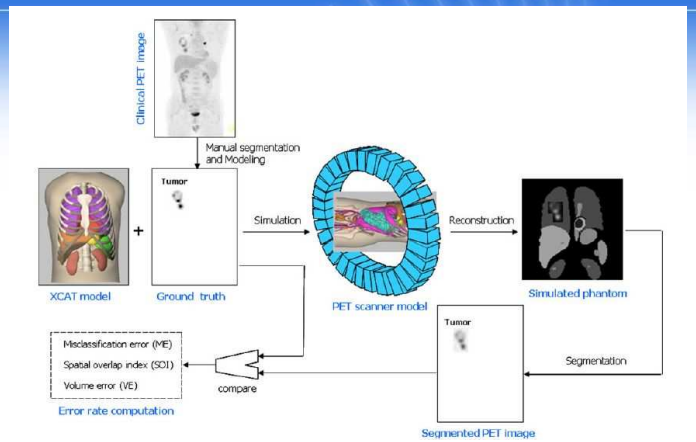
Validation = *"fidelity to the truth"*

SNM
Advancing Molecular Imaging and Therapy



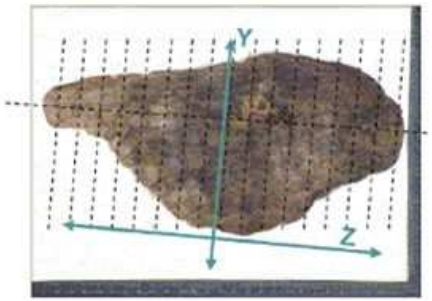
Spherical and homogeneous objects

Anthropomorphic phantoms



Simulated data

Ground truth



Histopathological data

<u>BUT</u> the histopathological data evaluation is particularly complex, given that:

- PET study must be performed before surgical resection of the tumor
- the effects of sample shrinkage in the different conditions (in vivo and and in vitro) must be considered.

<u>The volumetric analysis of the the surgical specimen must be done through an accurately and reliably procedure</u>.

Methods

13 fillable objects

- Different Volume (range 0.5-1700 cm3)
- Shape
- Complexity
- Filled with a solution of water and 18F (different activity and background)
- Acquired with PET/CT.

Methods

- The Volume was calculated on CT and PET images separately and blindly by radiologist and nuclear medicine physician.

PET/CT evaluation

2 semiautomatic segmentation softwares

- **PET VCAR** - Volume Computer Assisted Reading – GE Healthcare (FDA approved)
  Nuclear Medicine Dept – Reggio Emilia (Italy)

- **KEOSYS software**
  Nuclear Medicine Dept – Créteil (France)

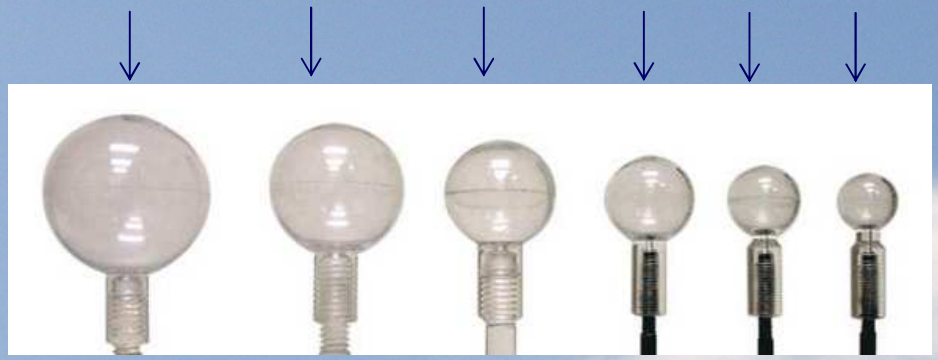
PET/CT evaluation

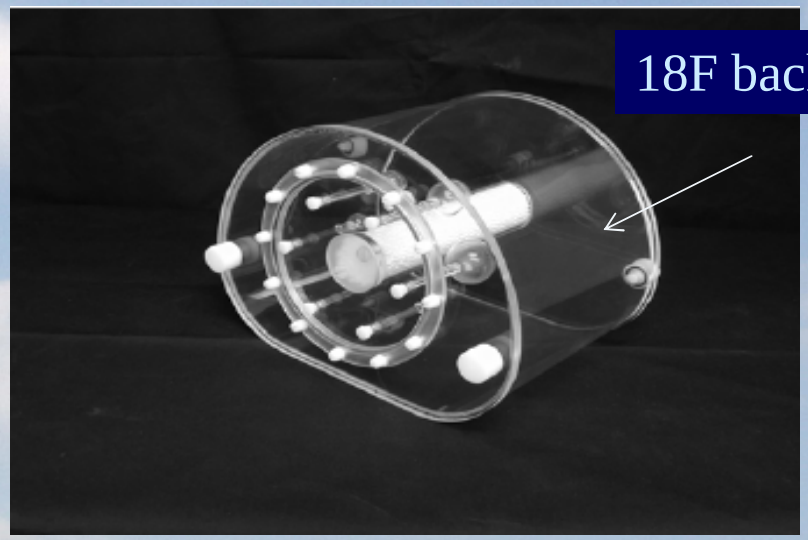
PET Volume calculation was performed using for contouring different thresholds (35-40-45-50-55-60% of SUV max).

CT and PET Volumes were compared with the actual volumes.

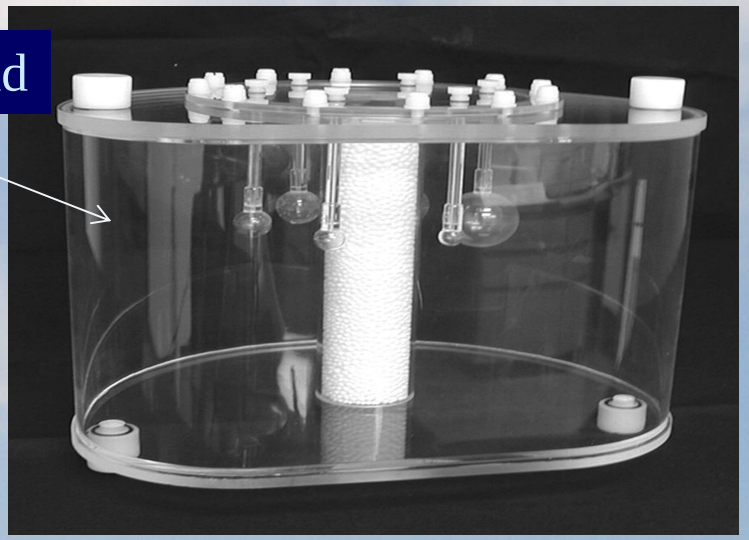
NEMA Phantom

Sferes filled with 18F

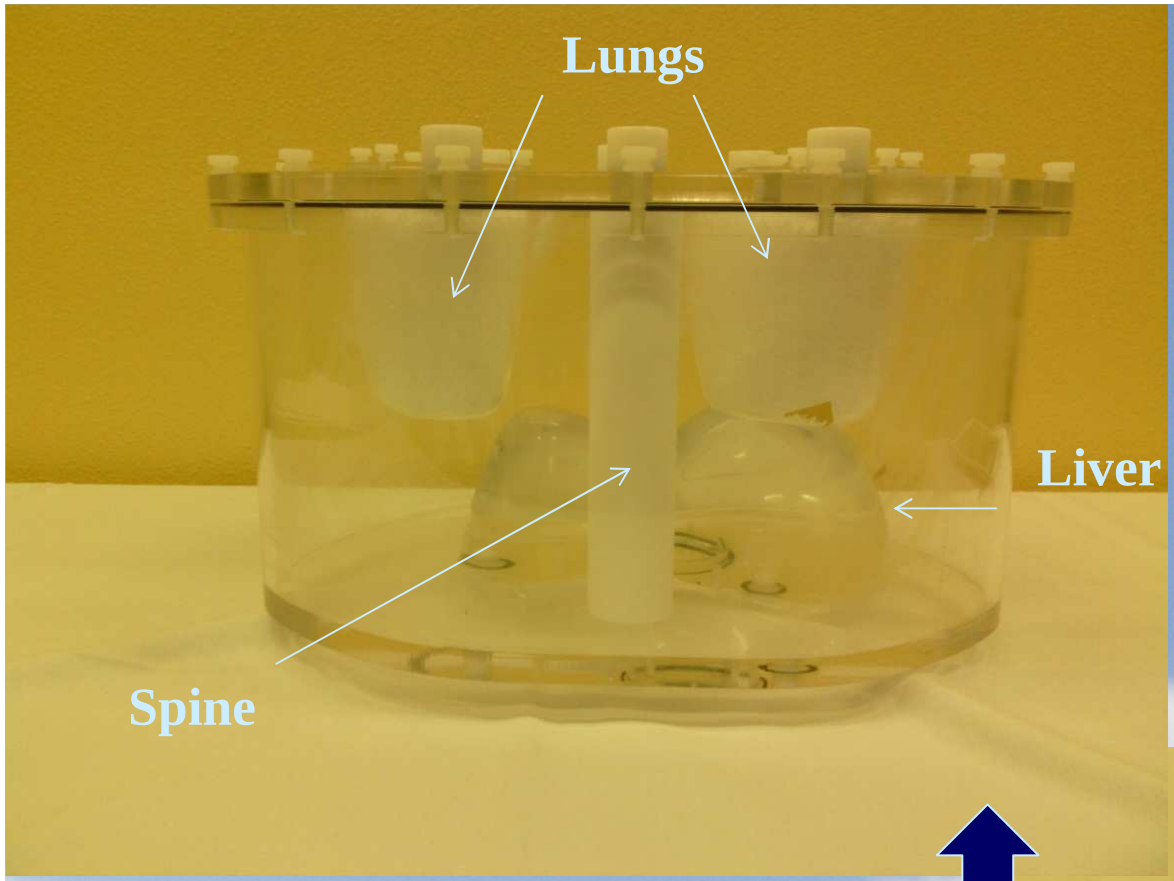




18F background



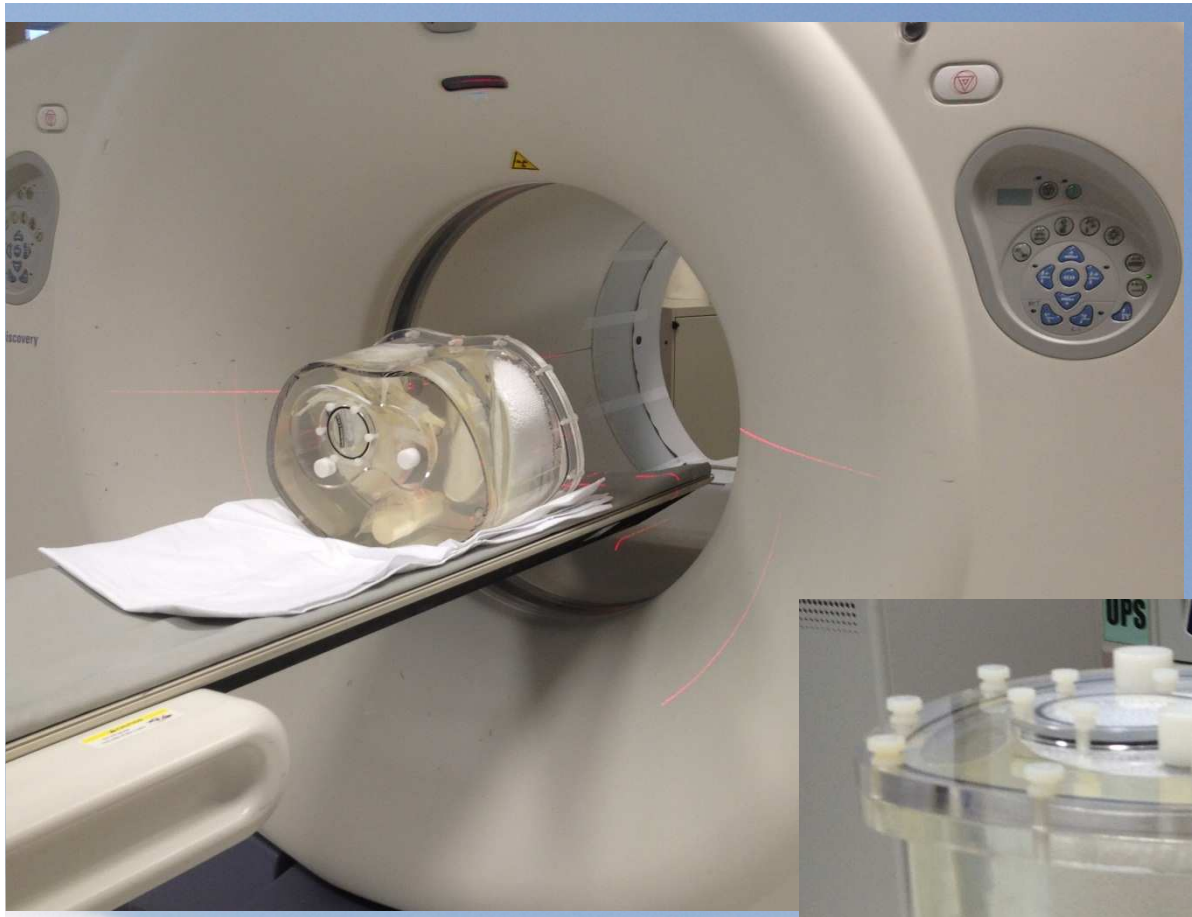
Saline bags
+ 18F

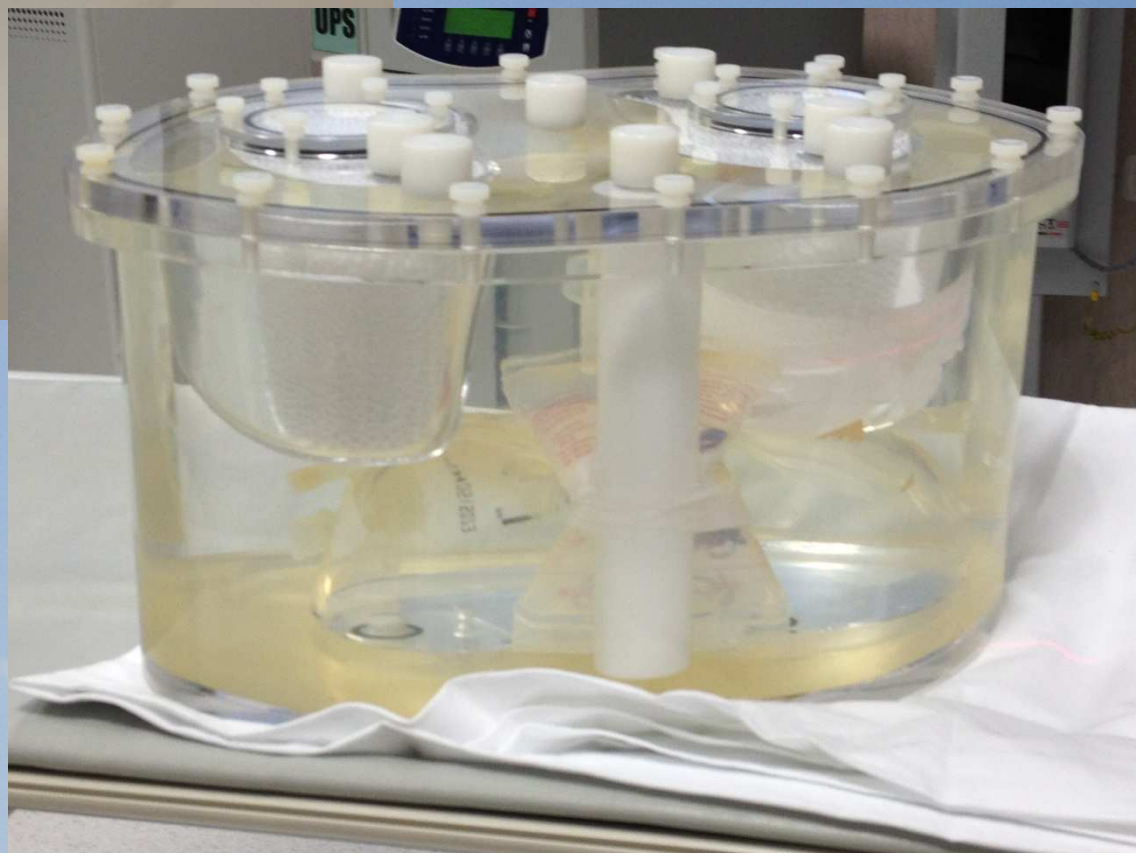


Anthropomorphic Phantom

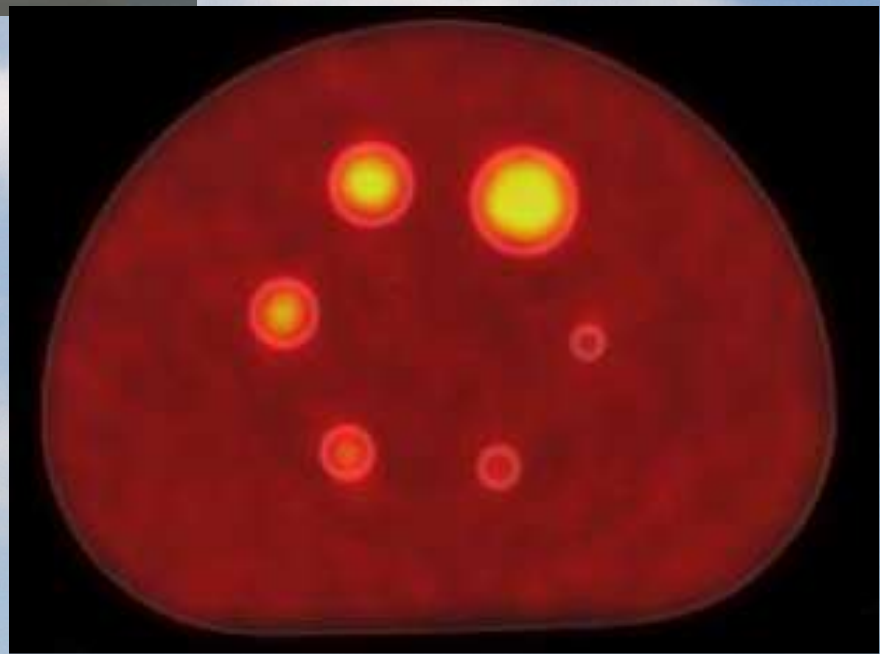
Saline bags
+ 18F

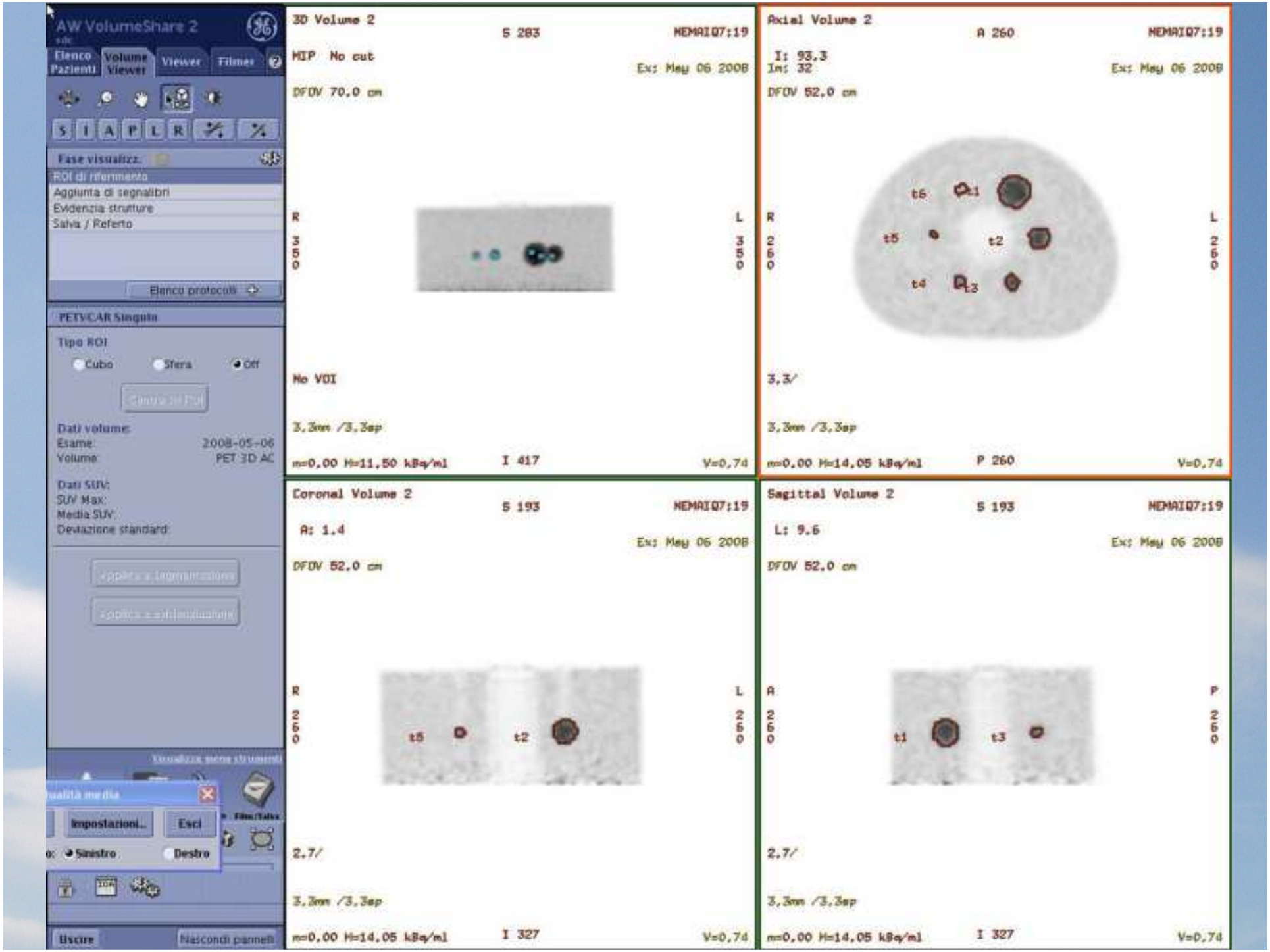
Anthropomorphic Phantom





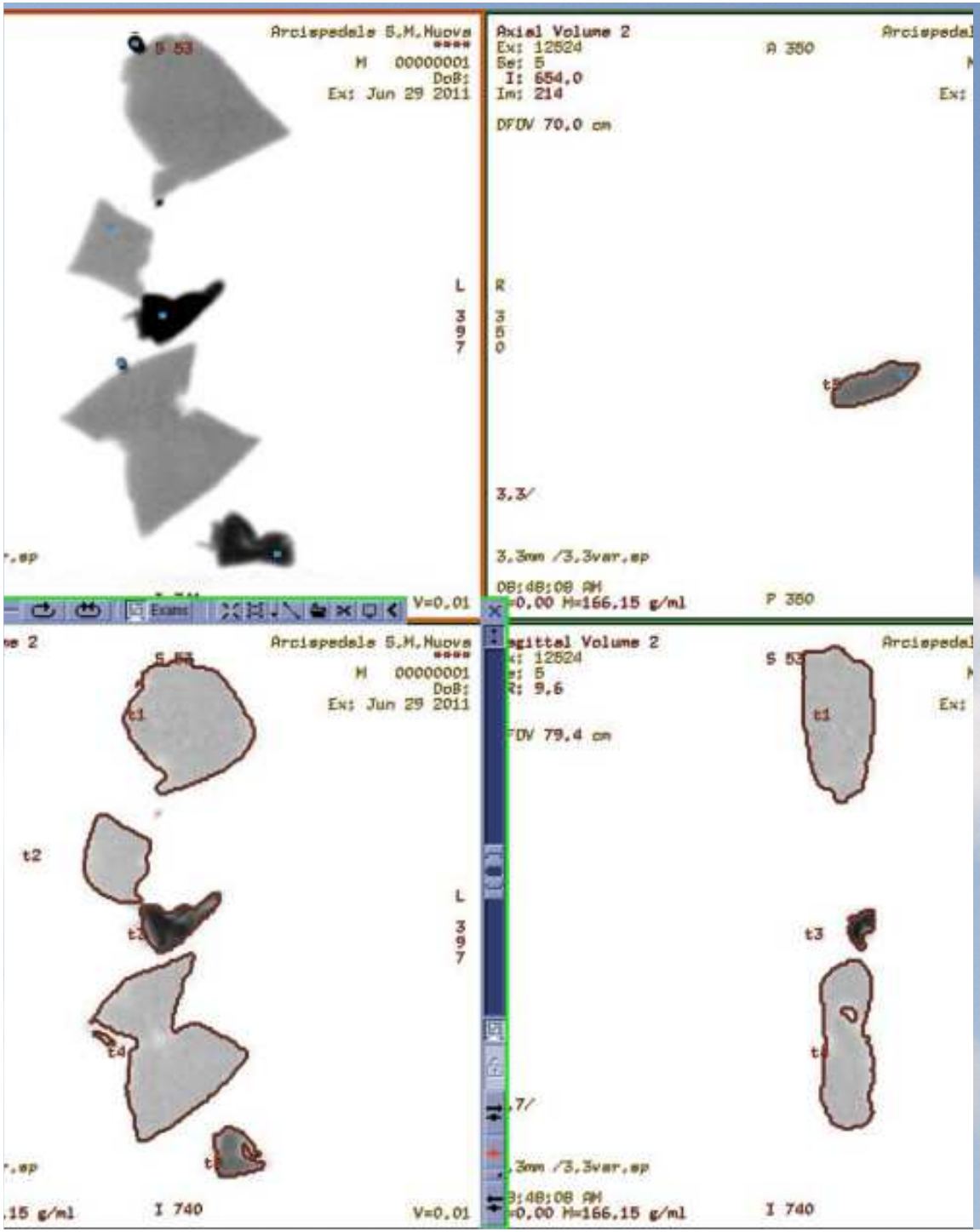
NEMA Phantom

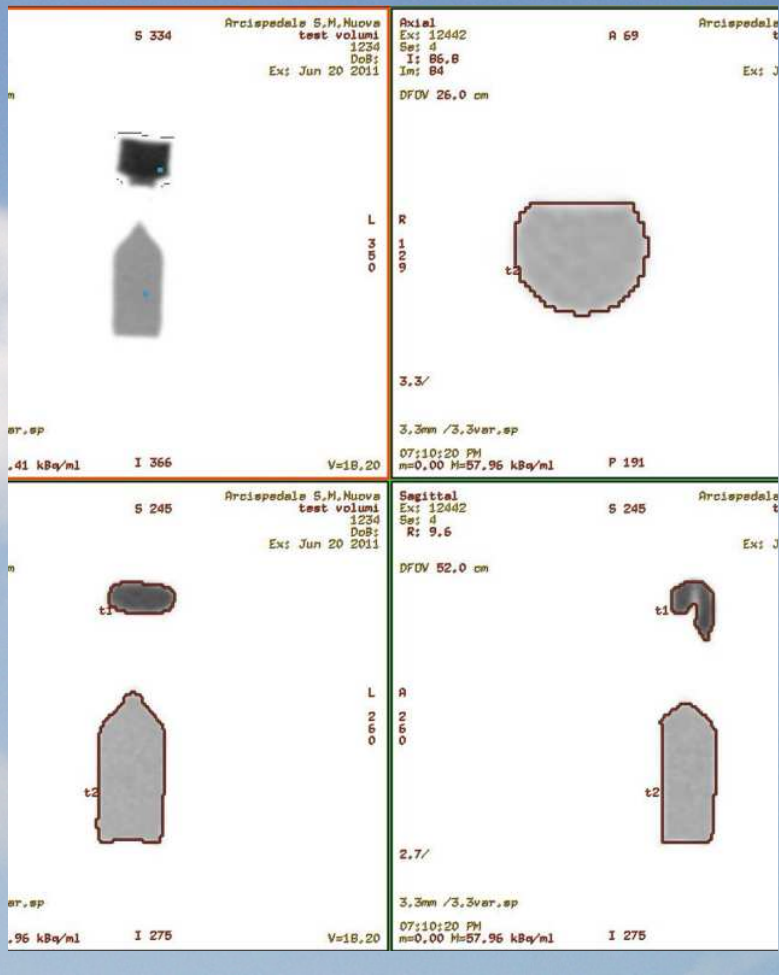


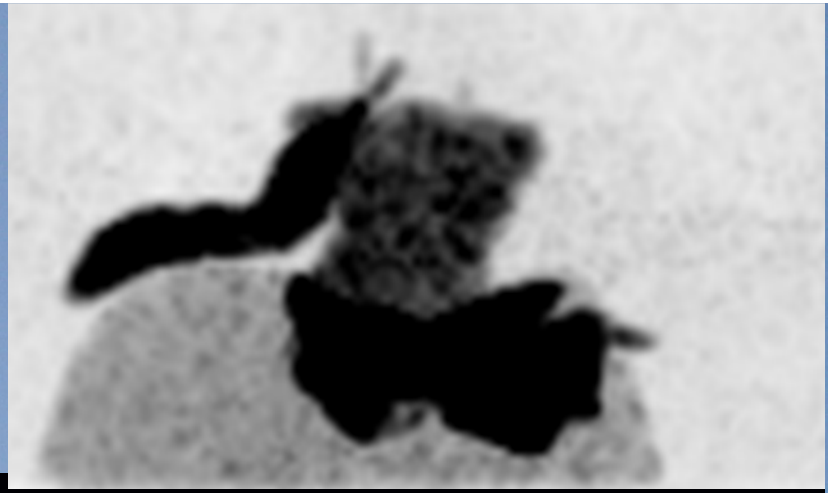

AW VolumeShare 2
Elenco Pazienti
Volume Viewer
Viewer
Filmer
Fase visualizz.
ROI di riferimento
Aggiunta di segnalibri
Evidenzia strutture
Salva / Referto
Elenco protocolli
PETVCAR Singulo
Tipo ROI
Cubo
Sfera
Off
Dati volume:
Esame: 2008-05-06
Volume: PET 3D AC
Dati SUV:
SUV Max:
Media SUV:
Deviazione standard:
Impostazioni...
Esci
Sinistro
Destro
Uscire
Nascondi pannelli
3D Volume 2
S 283
MEMAIQ7:19
MIP No cut
Ex: May 06 2008
DFOV 70.0 cm
R
L
No VOI
3.3mm /3.3sp
m=0.00 M=11.50 kBq/ml
I 417
V=0.74
Axial Volume 2
A 260
MEMAIQ7:19
I: 93.3
Im: 32
Ex: May 06 2008
DFOV 52.0 cm
t6
t1
t5
t2
t4
t3
3.3/
3.3mm /3.3sp
m=0.00 M=14.05 kBq/ml
P 260
V=0.74
Coronal Volume 2
S 193
MEMAIQ7:19
A: 1.4
Ex: May 06 2008
DFOV 52.0 cm
2.7/
3.3mm /3.3sp
m=0.00 M=14.05 kBq/ml
I 327
V=0.74
Sagittal Volume 2
S 193
MEMAIQ7:19
L: 9.6
Ex: May 06 2008
DFOV 52.0 cm
A
P
t1
t3
2.7/
3.3mm /3.3sp
m=0.00 M=14.05 kBq/ml
I 327
V=0.74

Saline bags

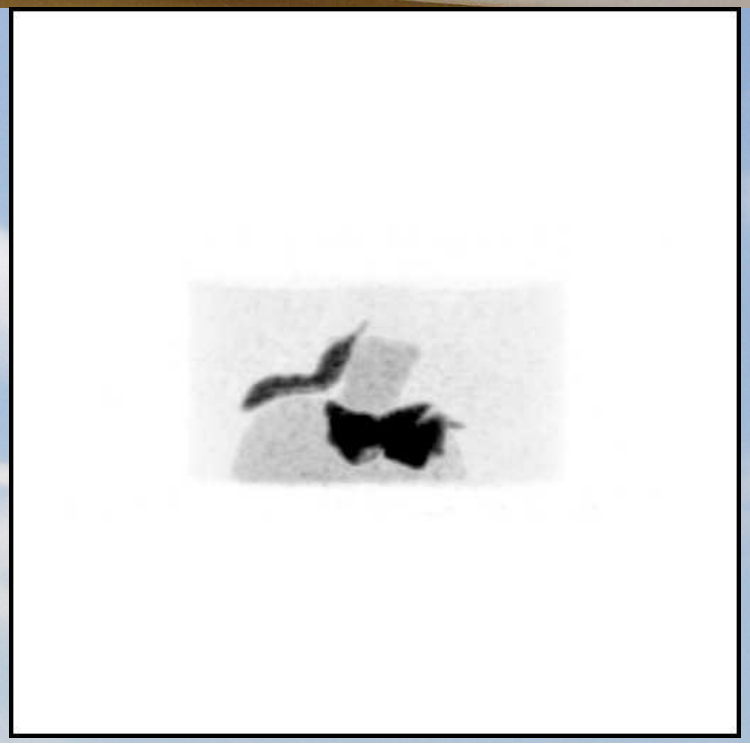
Bottles

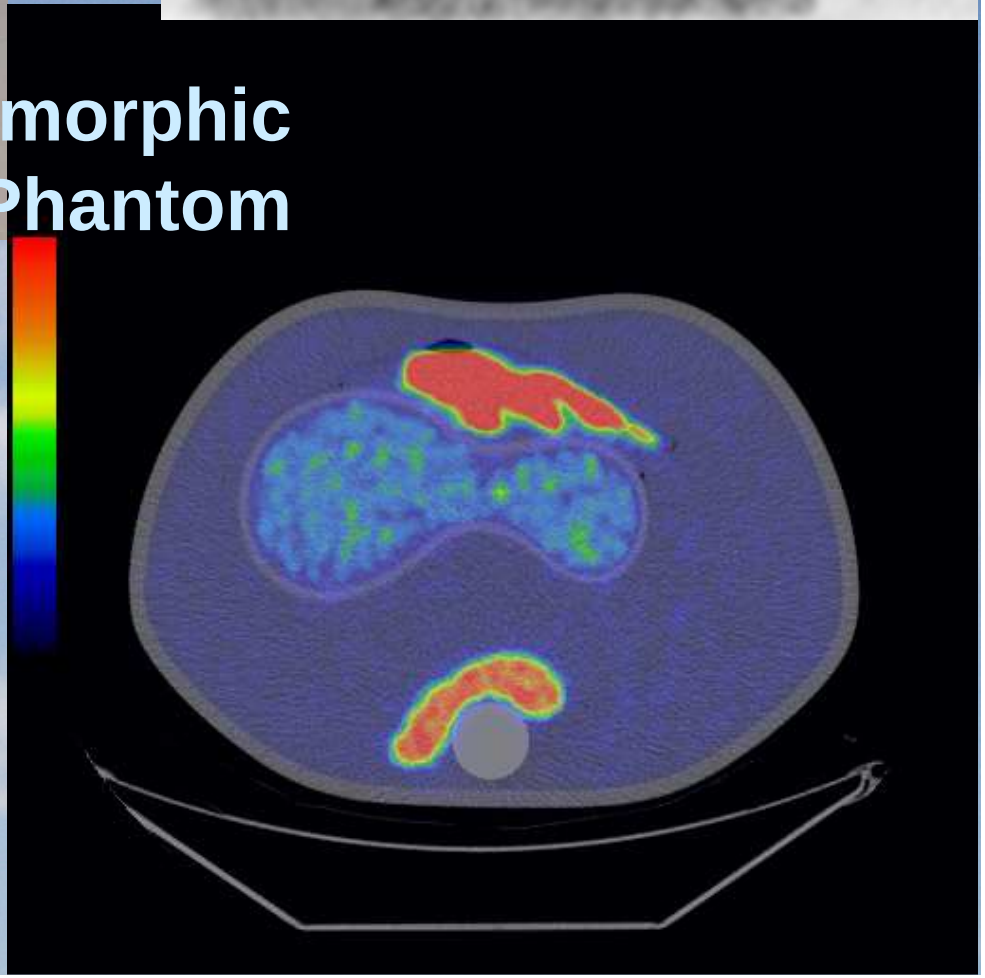






Anthropomorphic Phantom

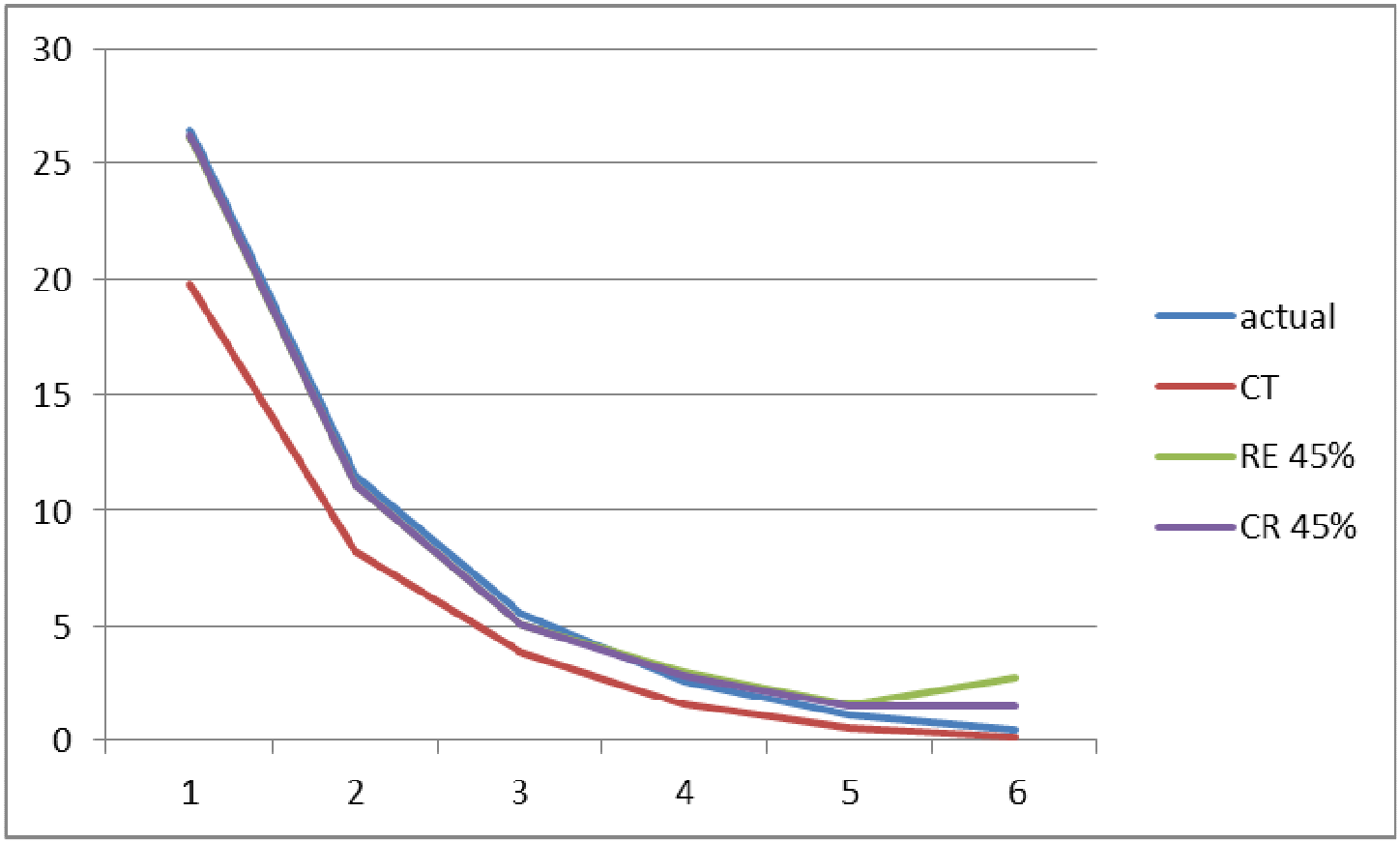




actual	CT	RE 45%	CR 45%
26,5	20	26,2	26,2
11,5	8,2	11,1	11,1
5,6	3,9	5,1	5,1
2,6	1,57	3	2,9
1,1	0,57	1,6	1,5
0,5	0,16	2,8	1,5

Nema phantom
Result comparison

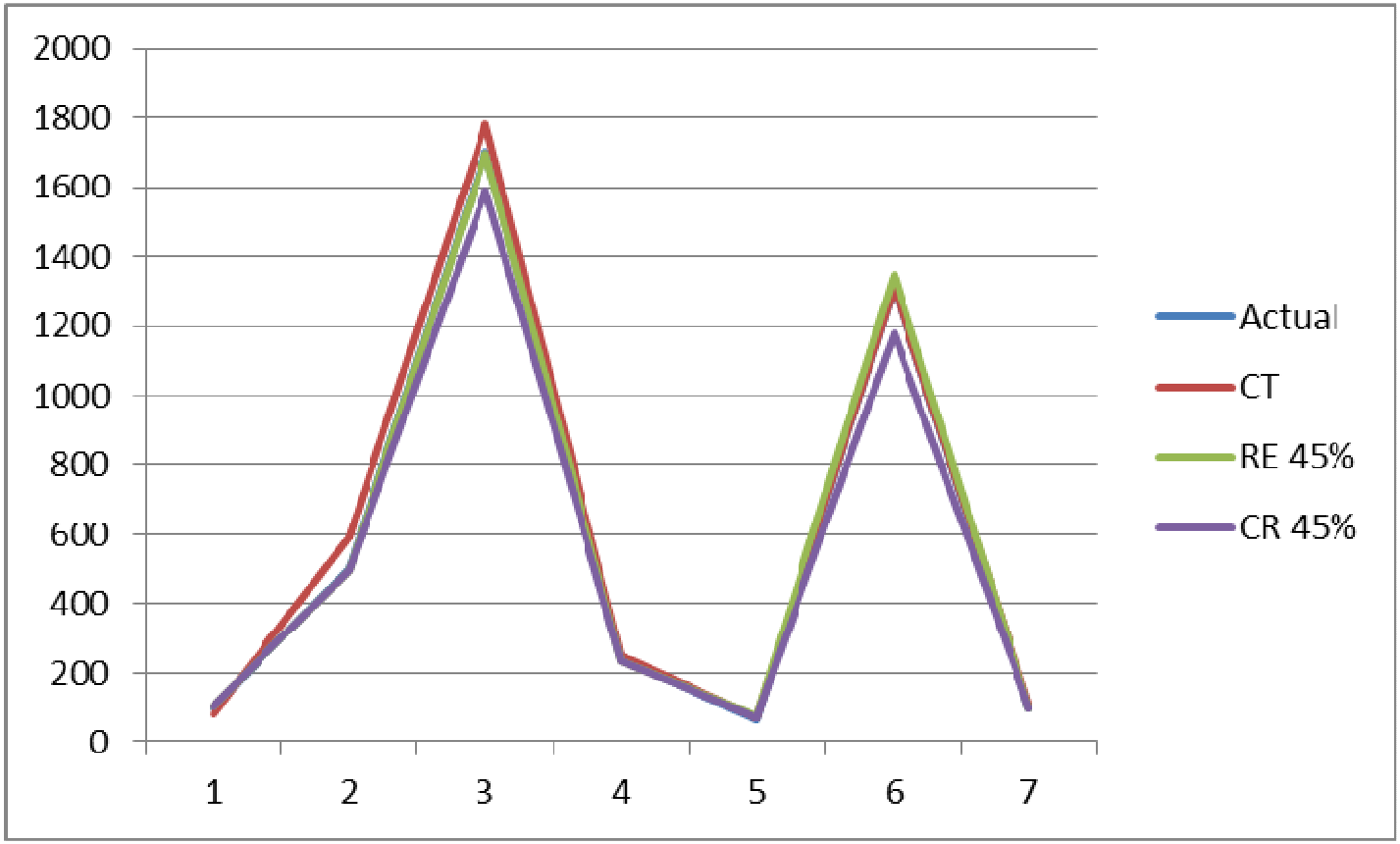
Best threshold: 45%

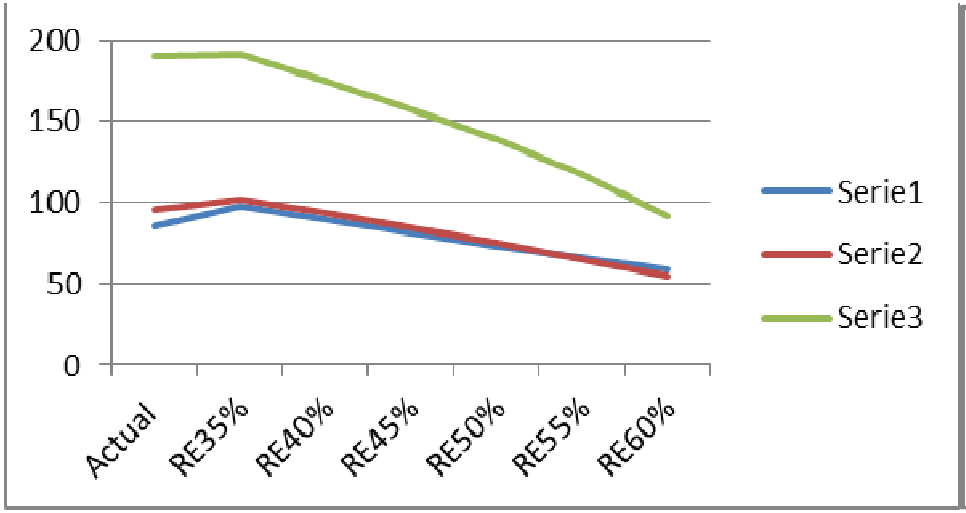


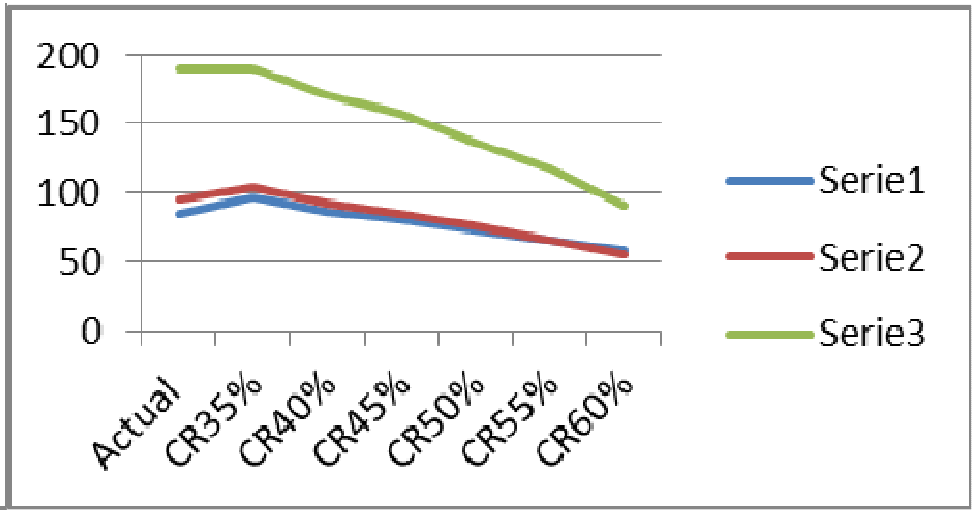
actual	CT	RE 45%	CR 45%
101	85	106	106
501	589	494	494
1700	1779	1696	1592
239	250	233	233
70	71	78	76
1310	1314	1352	1176
100	114	102	101

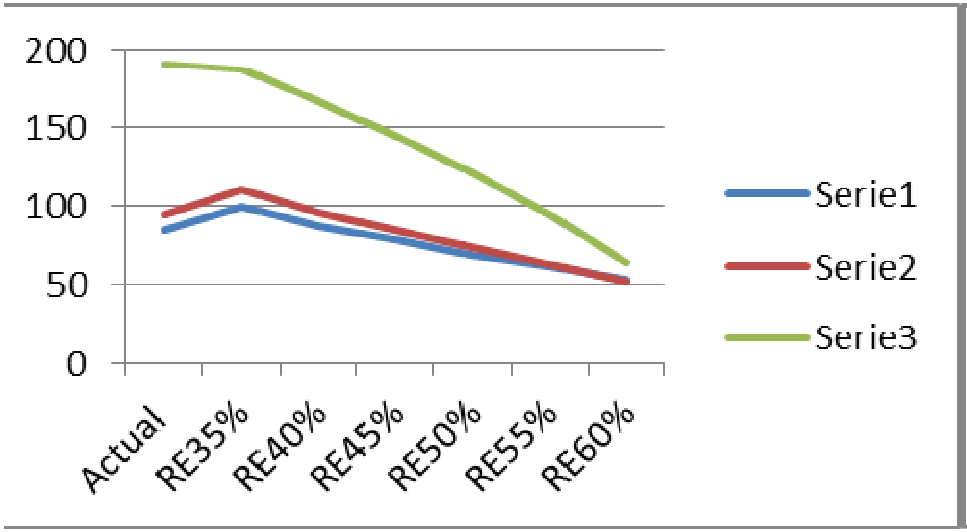
Saline bags

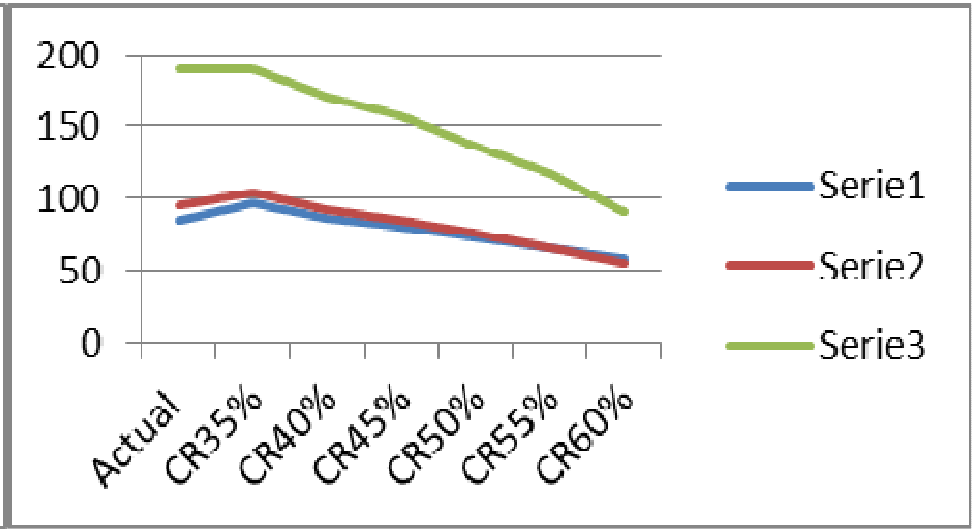
Best threshold: 45%





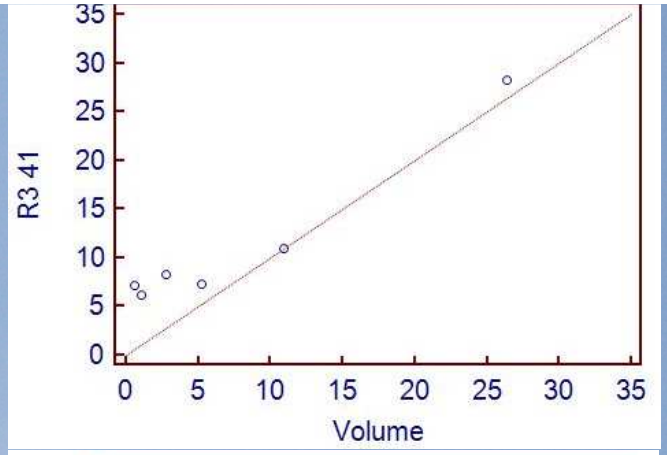


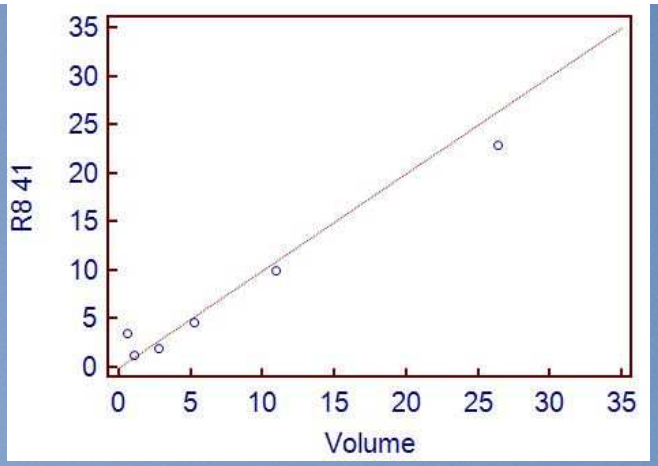


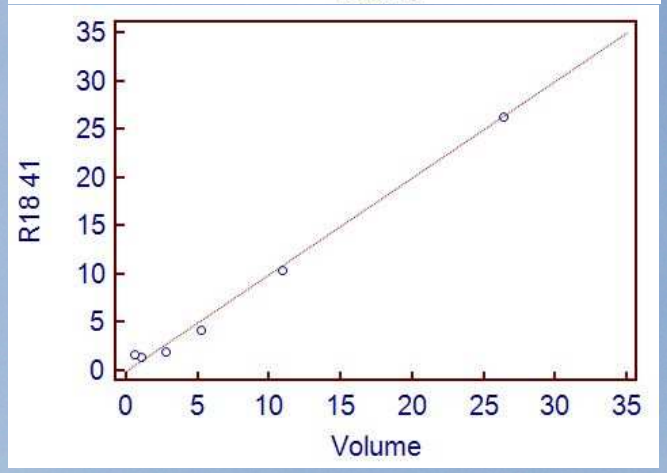


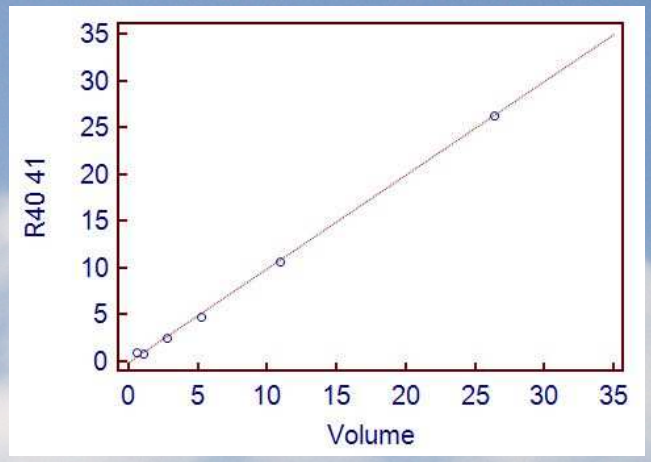
Anthropomorhic phantom

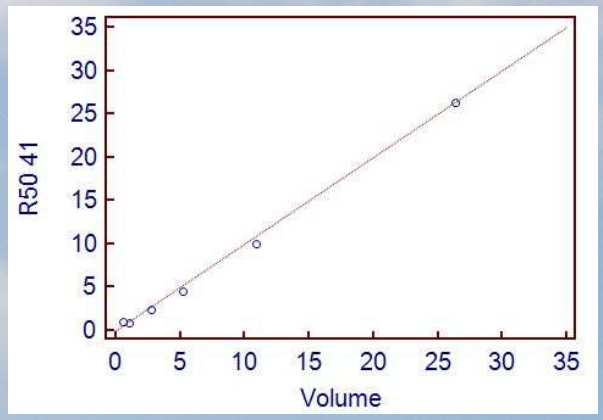
Actual
85
95
190











Nema phantom results with different background

Best thresholds: 41%

Patients

The two methods were then applied on

patients with Hodkin Lymphoma and

non-Hodgkin Lymphoma

- Threshold
- 41%
- Variable, according to visual evaluation

Integration of FDG-PET/CT into external beam radiation therapy planning

Technical aspects and recommendations on methodological approaches

D. Thorwarth[1]; T. Beyer[2,3]; R. Boellaard[4]; D. De Ruysscher[5]; A. Grgic[6]; J. A. Lee[7]; U. Pietrzyk[8,9]; B. Sattler[10]; A. Schaefer[6]; W. van Elmpt[5]; W. Vogel[11]; W. J. G. Oyen[12]; U. Nestle[13]

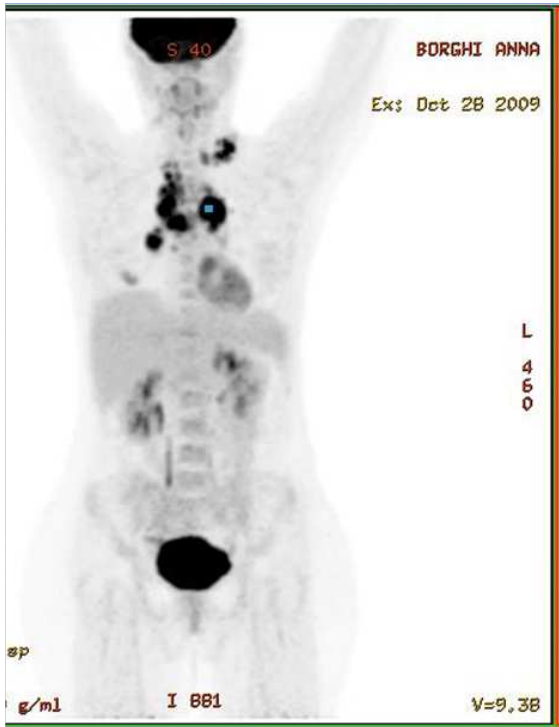
Nuklearmedizin. 2012 Apr 3;51(3)

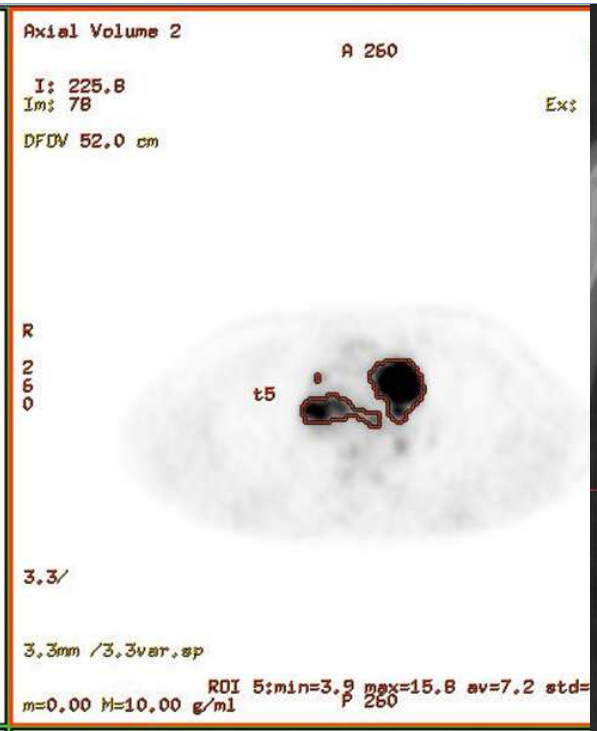
Recommendations for the use of positron emission tomography and positron emission tomography–CT for radiotherapy planning in research projects

E J SOMER, L C PIKE and P K MARSDEN

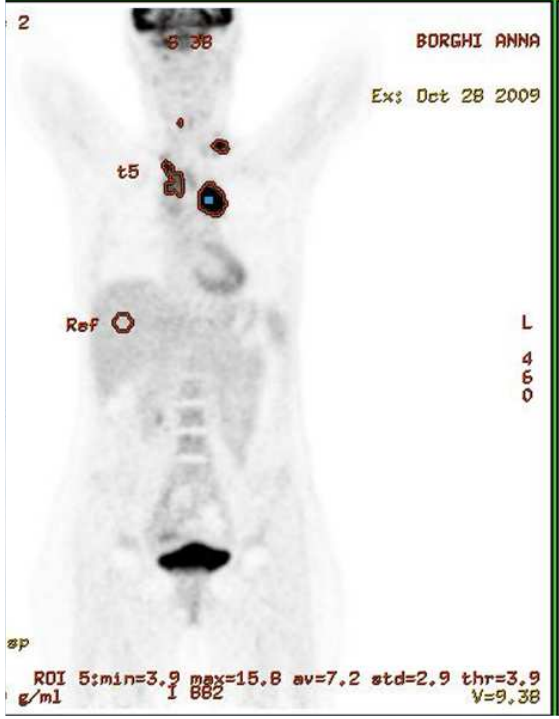
Br J Radiol. 2012 Feb 28.

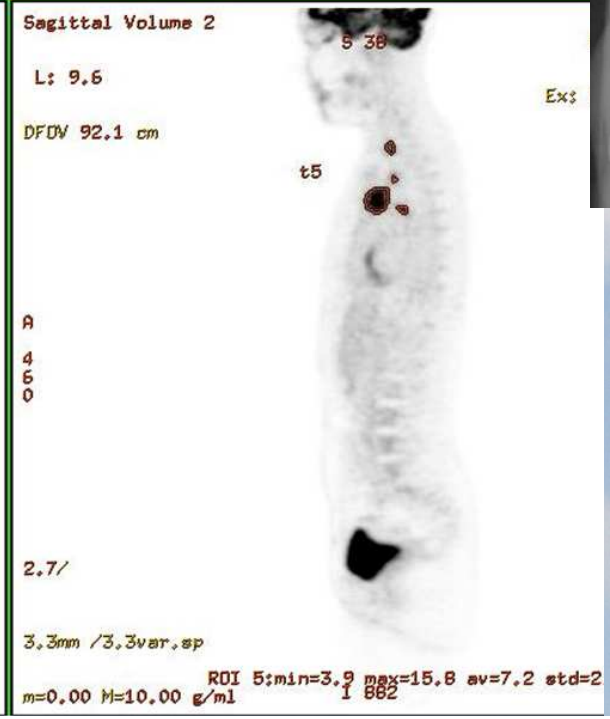
- **Automated delineation techniques** (particularly those based upon fixed intensity thresholds) **should be avoided**, but may be assessed as part of a parallel trial.
- Registration algorithms used for indirect planning should be validated on a per-application basis. **Non-rigid algorithms should be used with caution.**
- **Contouring should be performed jointly** by two experts from radiotherapy and nuclear medicine.
- If PET/CT is used for direct planning, the scanner, software and protocols, patient couch and external lasers should be integrated into the local oncology **quality management system** to ensure there is an agreed understanding of QC requirements

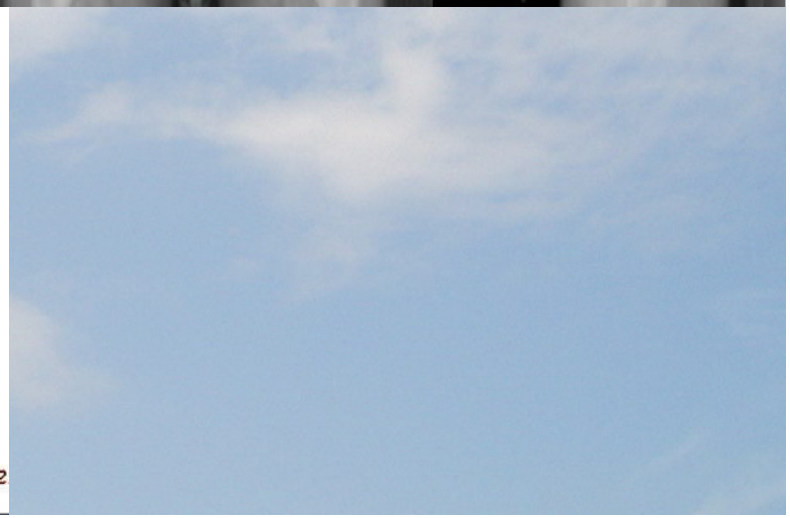

S 40
BORGHI ANNA
Ex: Oct 28 2009
L
4
6
0
sp
g/ml
I 881
V=9.38

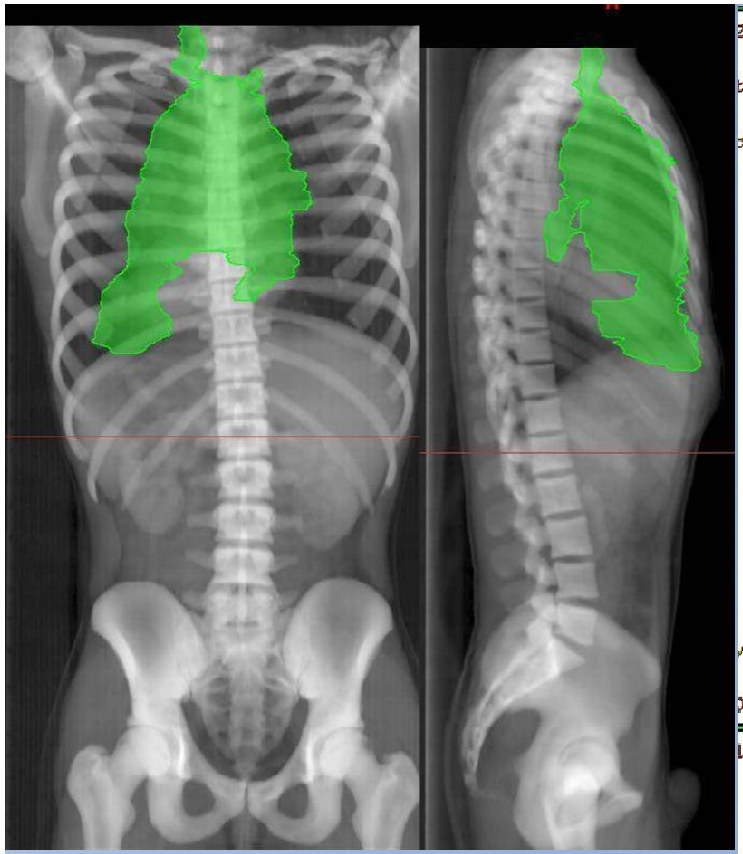

Axial Volume 2
A 260
I: 225.8
Im: 78
Ex:
DFOV 52.0 cm
R
2
6
0
t5
3.3/
3.3mm /3.3var.sp
ROI 5:min=3.9 max=15.8 av=7.2 std=
m=0.00 M=10.00 g/ml
P 260

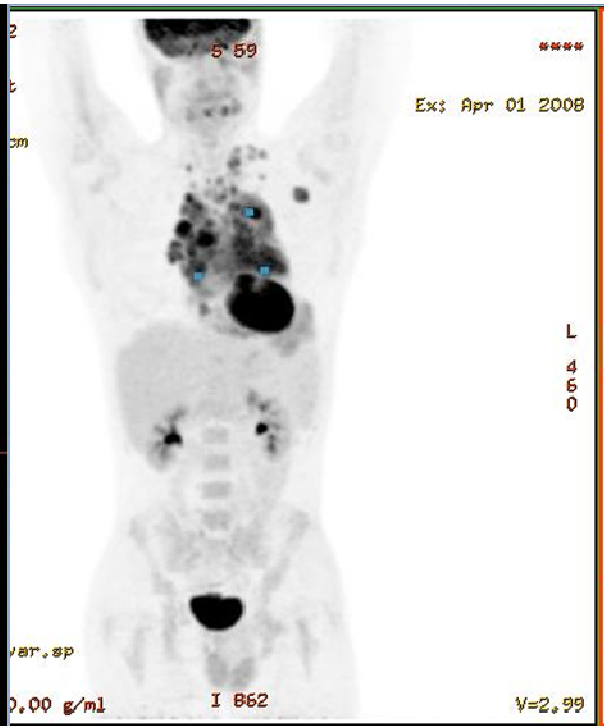

H
H
F
F

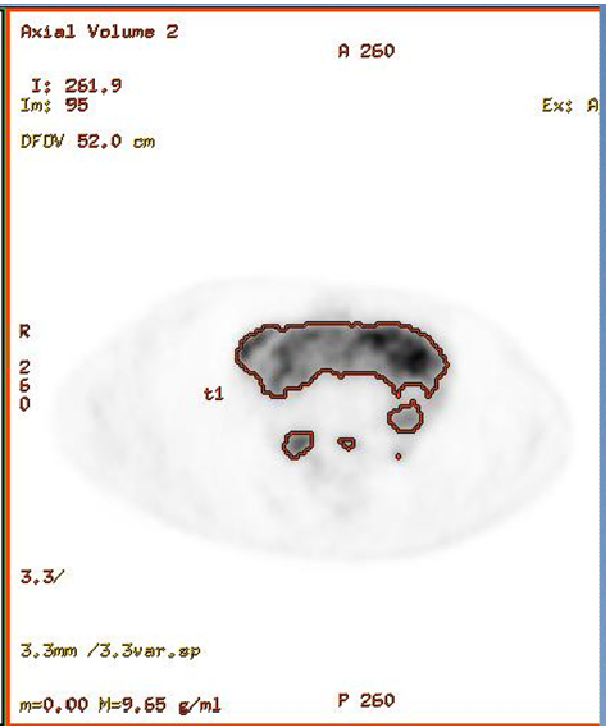

2
S 38
BORGHI ANNA
Ex: Oct 28 2009
t5
Ref
L
4
6
0
sp
ROI 5:min=3.9 max=15.8 av=7.2 std=2.9 thr=3.9
g/ml
I 882
V=9.38

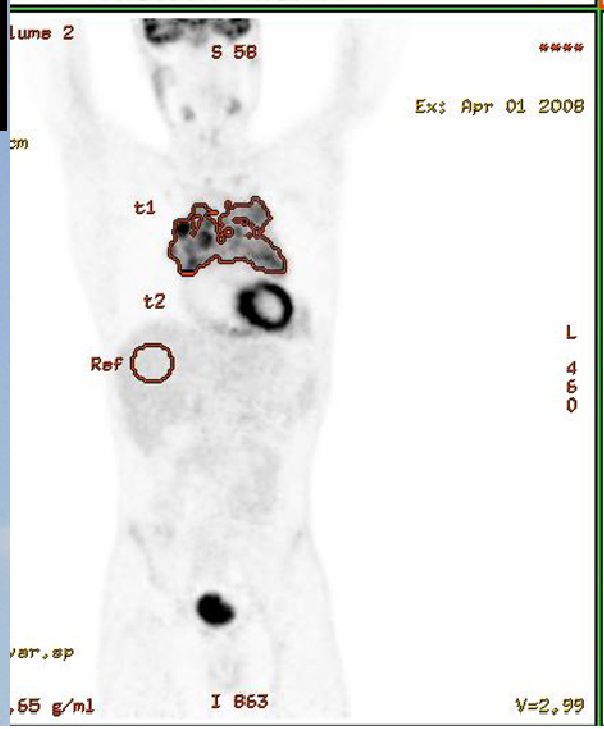

Sagittal Volume 2
S 38
L: 9.6
Ex:
DFOV 92.1 cm
t5
A
4
6
0
2.7/
3.3mm /3.3var.sp
ROI 5:min=3.9 max=15.8 av=7.2 std=2
m=0.00 M=10.00 g/ml
I 882

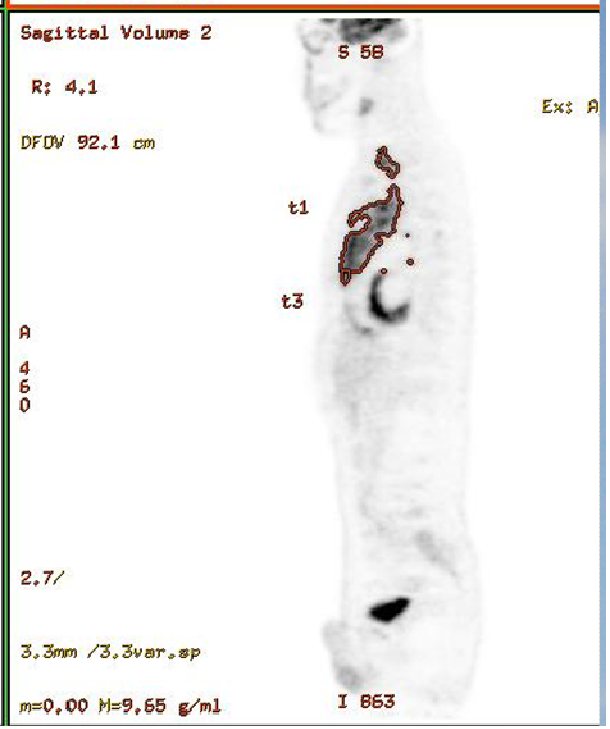








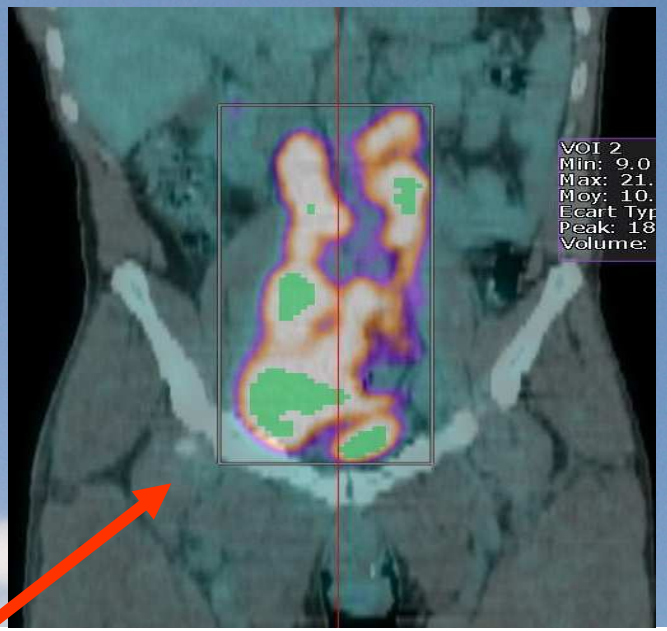


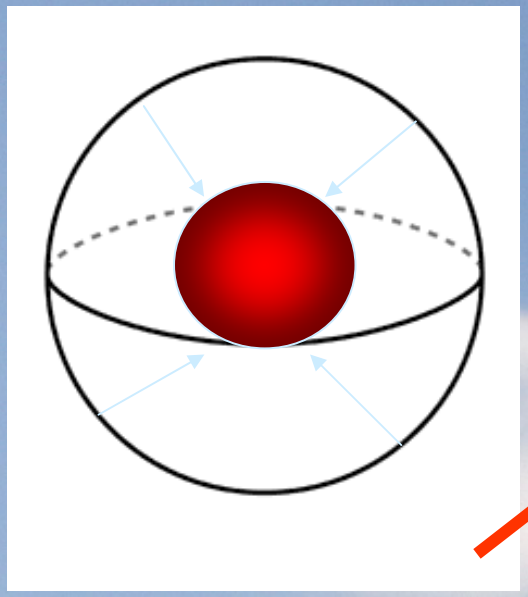


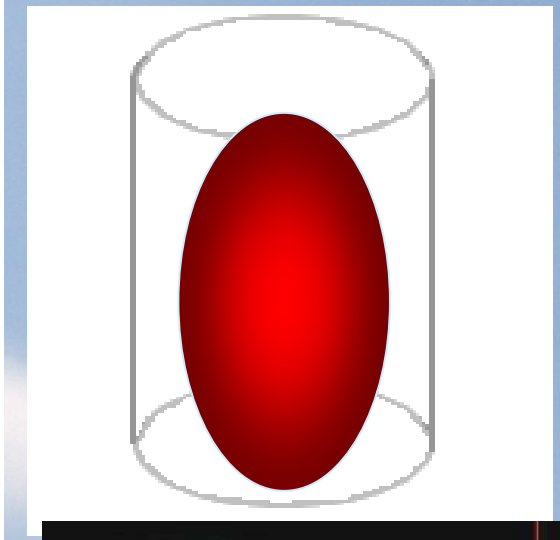
Problems

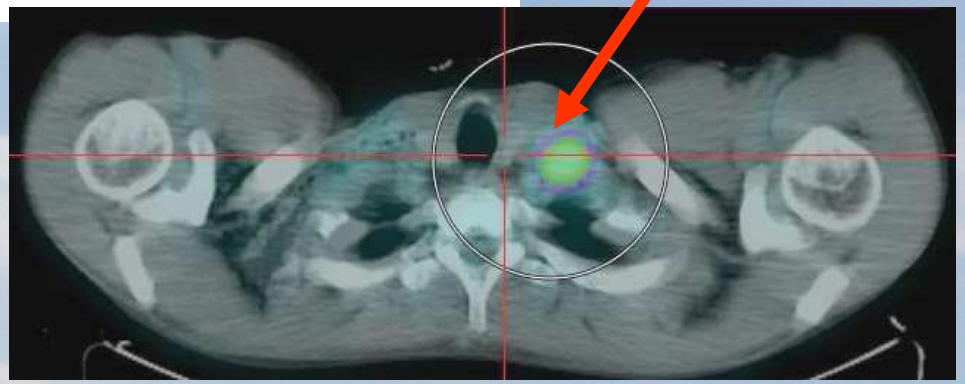
- Not homogeneus lesions (different SUV max)
- Background (organs with high uptake,….)

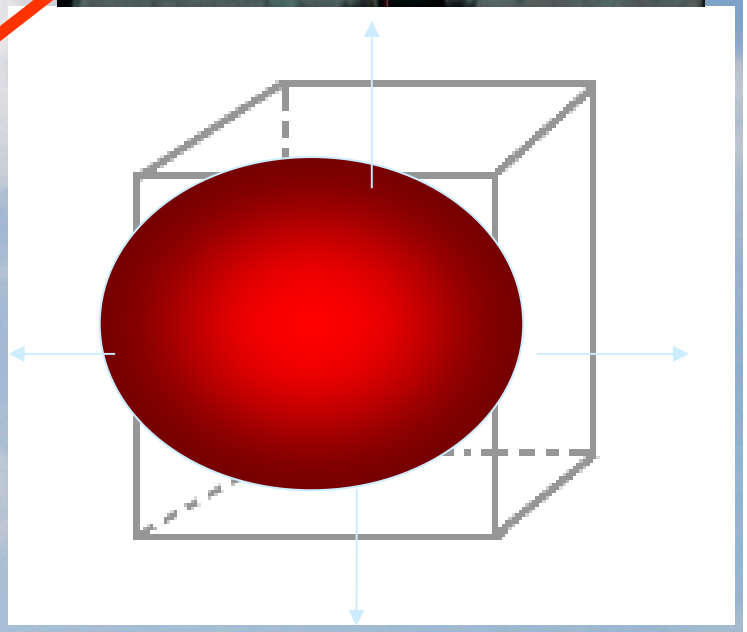
Choice of the Volume of Interest



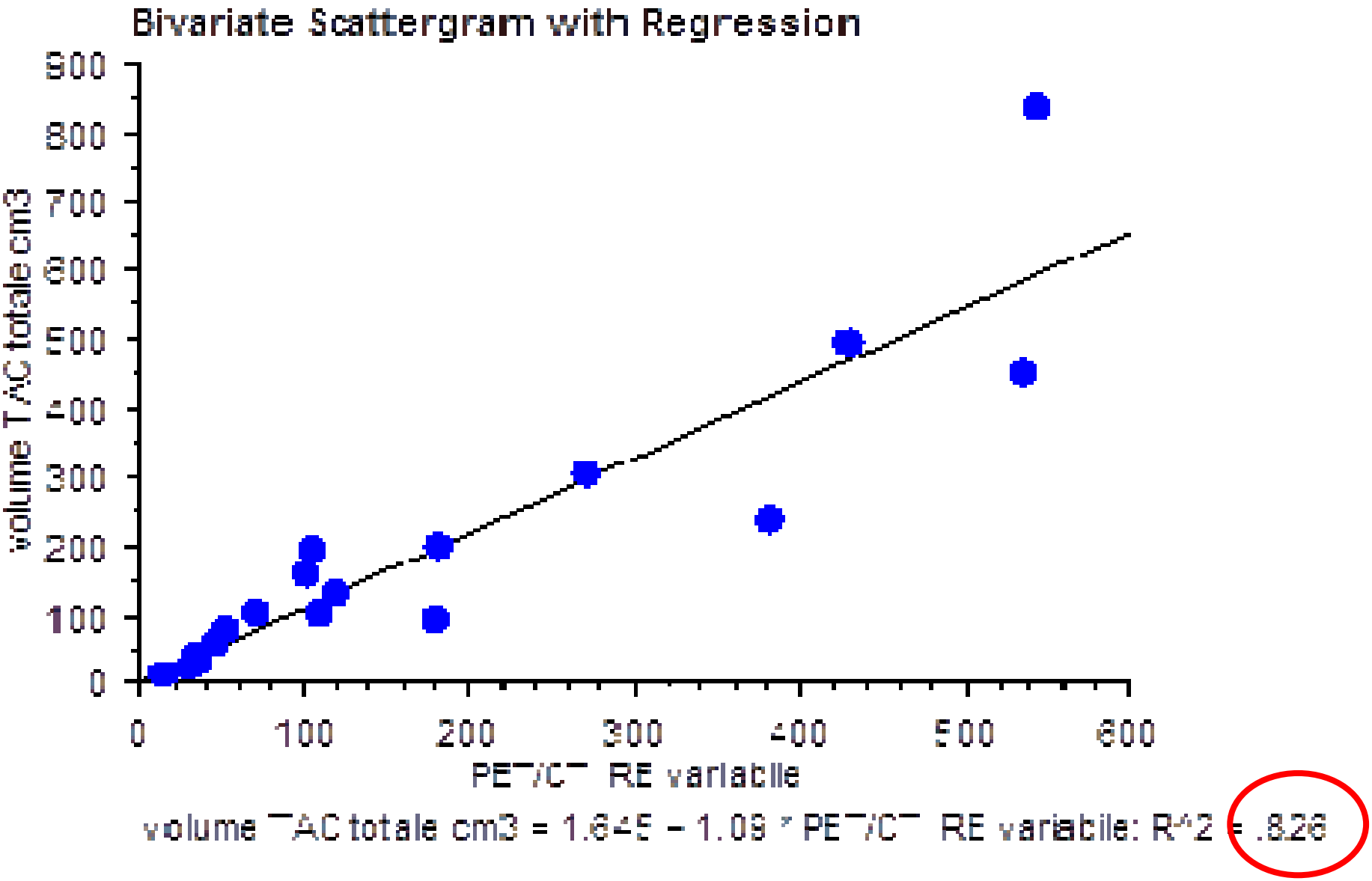




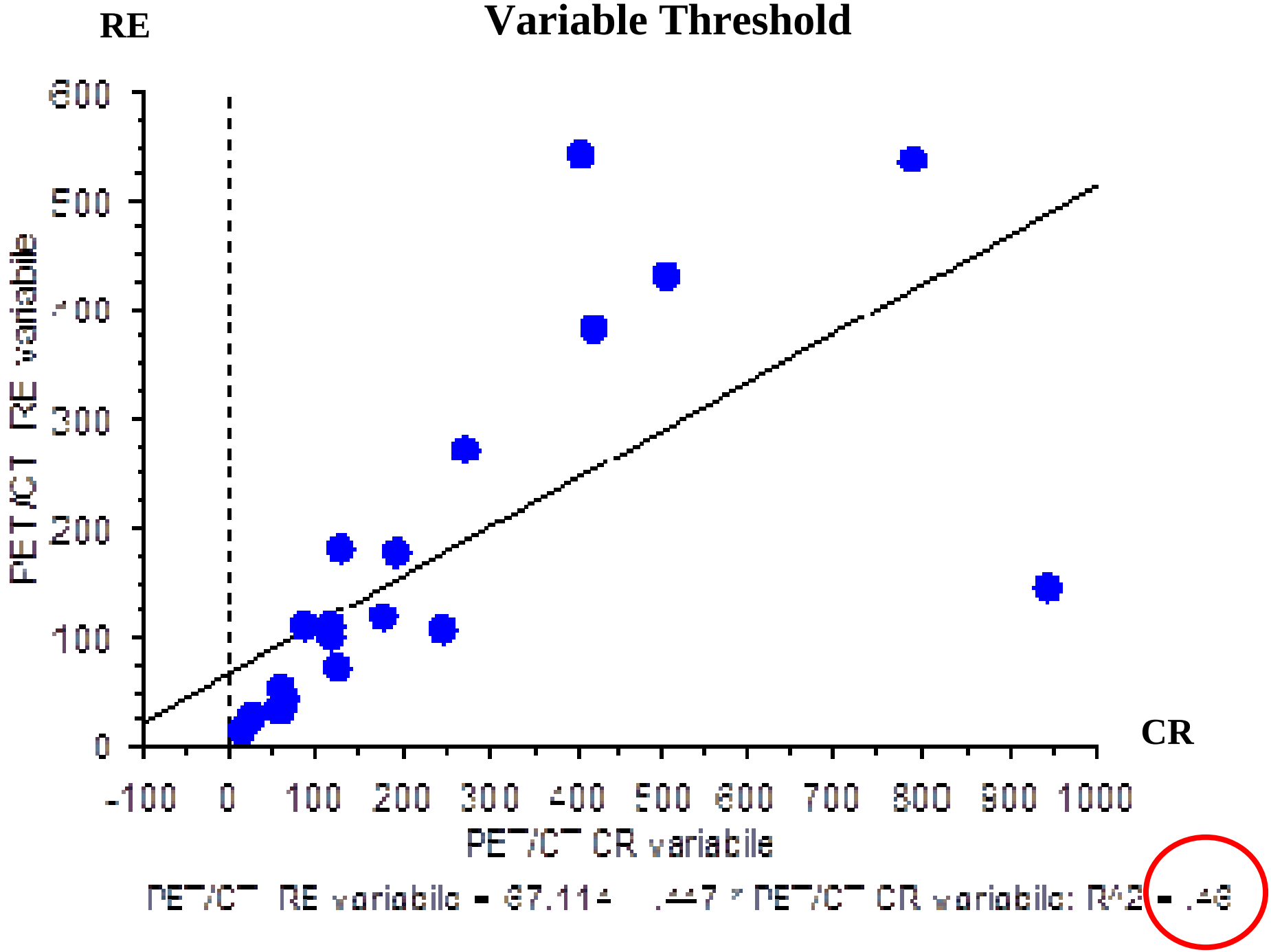


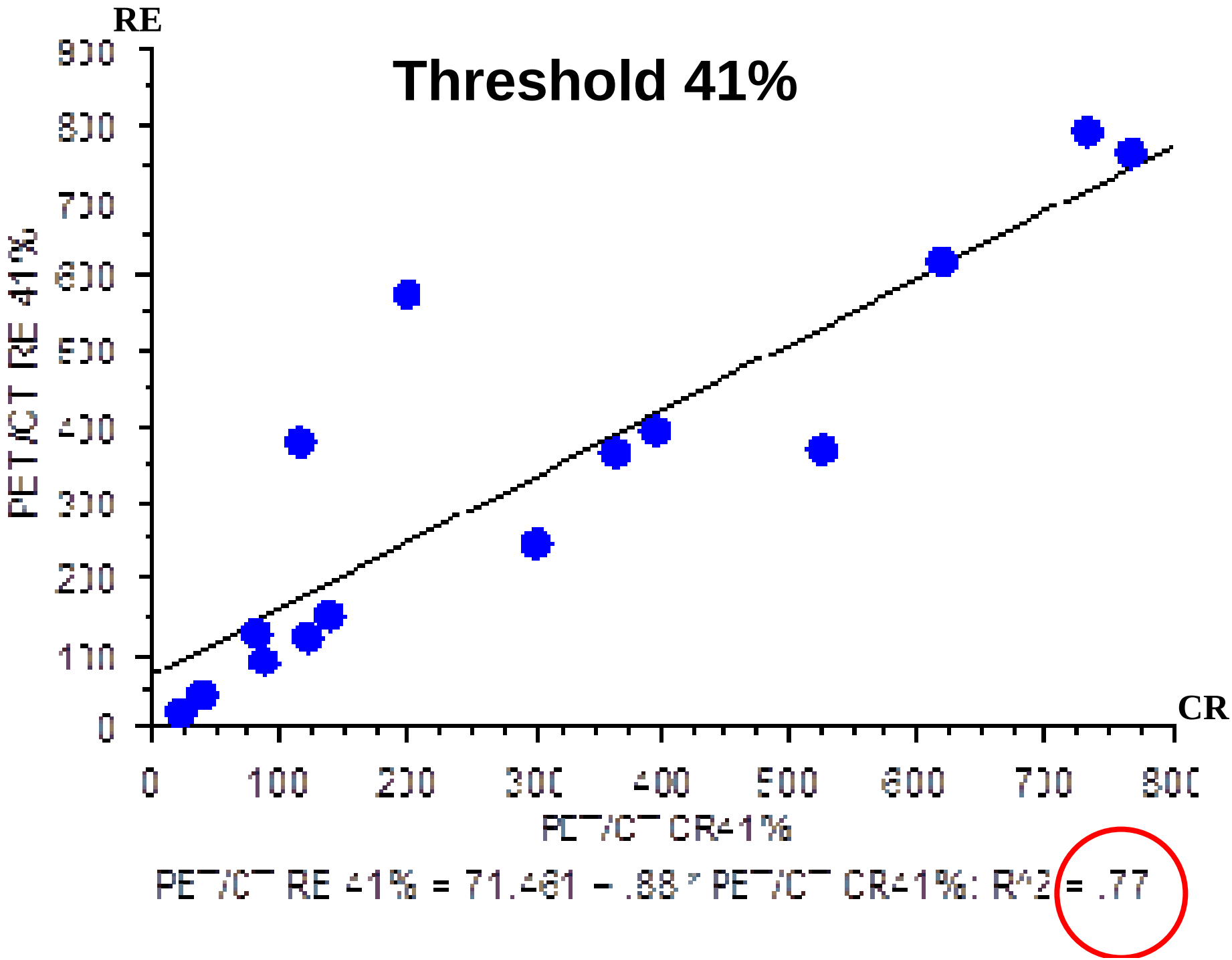


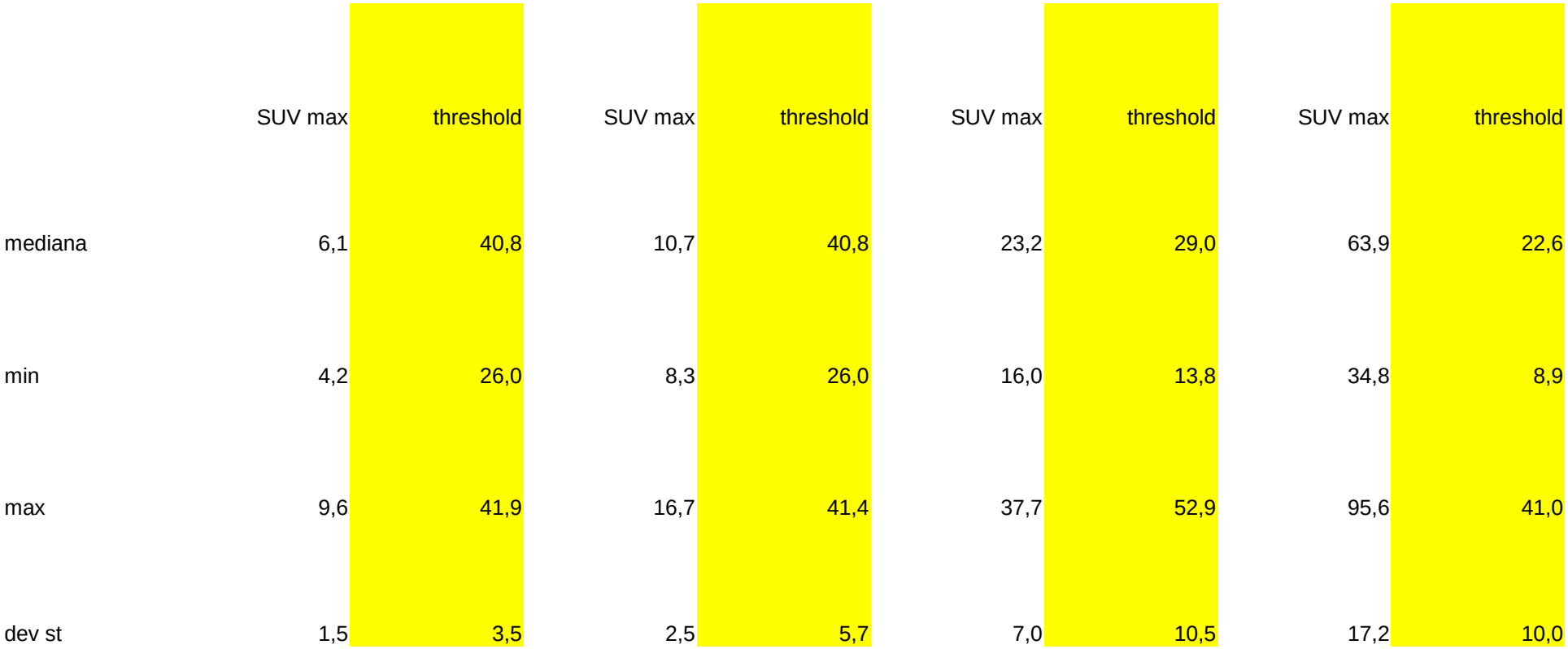
Comparison CT with PET (variable threshold)



Variable Threshold




RE
Threshold 41%
PET/CT RE 41%
CR
0
100
200
300
400
500
600
700
800
PET/CT CR41%
PET/CT RE 41% = 71.461 – .88 * PET/CT CR41%; R^2 = .77



Method of quartiles applied to variable threshold

SUV max	<10	10-16	17-37	>37
Threshold	41%	41%	29%	22%

PET VCAR

Advantages

- Easy to use
- Fast (5'-15'/patient)
- FDA approved

Disadvantages

- Expensive (it needs hardware)

KEOSYS

Advantages

- Easy to use
- Large availability

Disadvantages

- Not Fast
- Sperimental

Conclusions

- The results with PET-VCAR and Keosys softwares are comparable
- Others methods are available

- Clinical validation in big groups of lymphoma patients needs


Thanks for your attention