ClearPEM evaluation in clinical environment

From LIP:
R. Bugalho, C S. Ferreira, J. A. Neves, C. Ortigão,
A. S. Rodrigues, J. C. Silva, R. Silva, J. Varela
From ICNAS:
N. C. Ferreira, J. Rio, F. Rodrigues

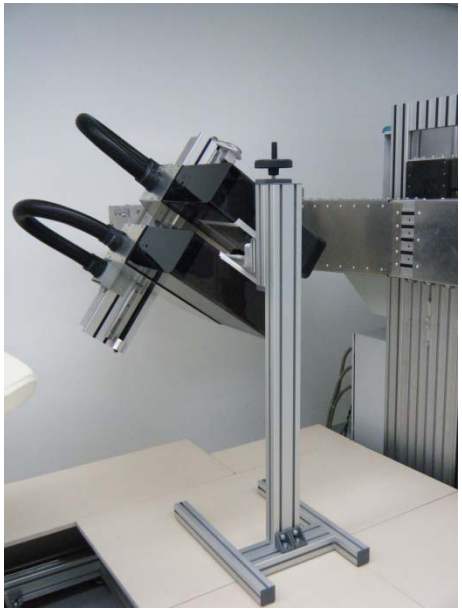
Jornadas LIP
Lisboa, 22nd April 2012

Main Activities @ ICNAS

Instituto de Ciências Nucleares Aplicadas à Saúde. Coimbra.

Previous to the clinical trials:

1



2

3

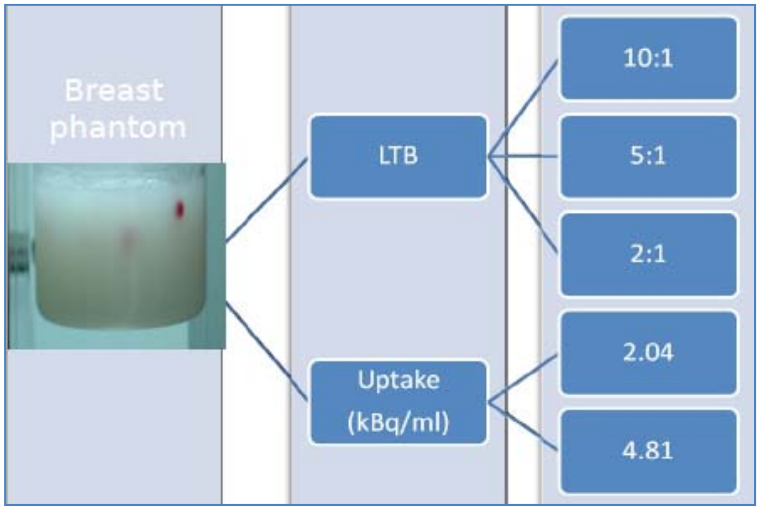
1. Performance evaluation with gelatin phantoms
2. Small Animal Imaging
3. Standard Operation Procedure elaboration and Clinical Training (positioning)

Performance Evaluation with Gelatin Phantoms

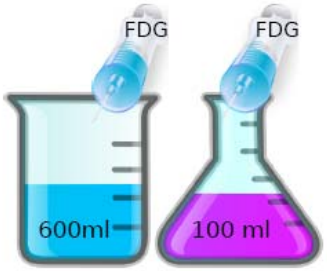
Uniform background and spherical lesions

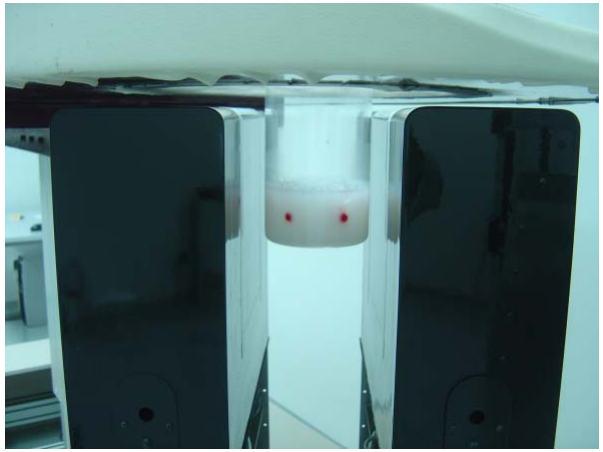
Made with gelatin and agar-agar

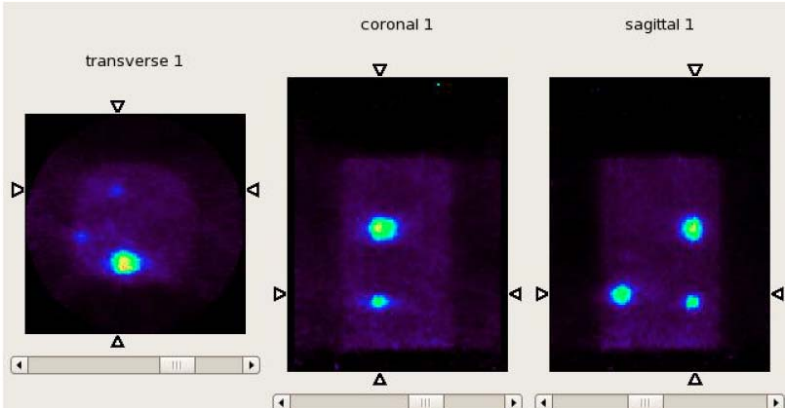
Cylindrical volume of 600 ml with diameter of 10 cm, where spherical lesions of different sizes are inserted.



Breast tissue	Uptake (kBq/ml)
Almost entirely fat	1.59
Scattered fibroglandular	2.04
eterogeneously dense	3.81
extremely dense	4.81

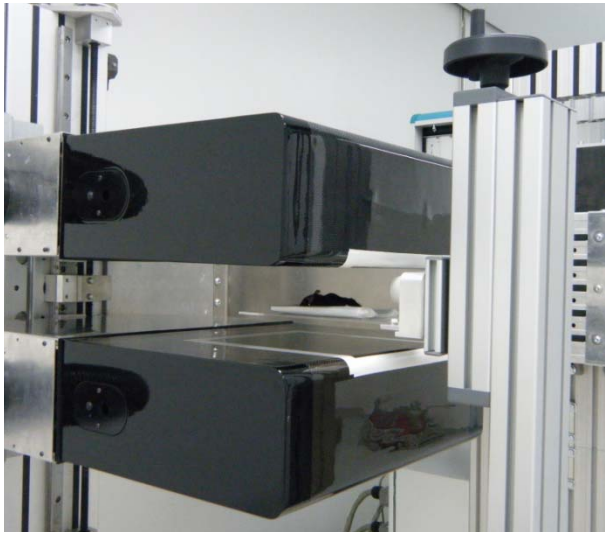


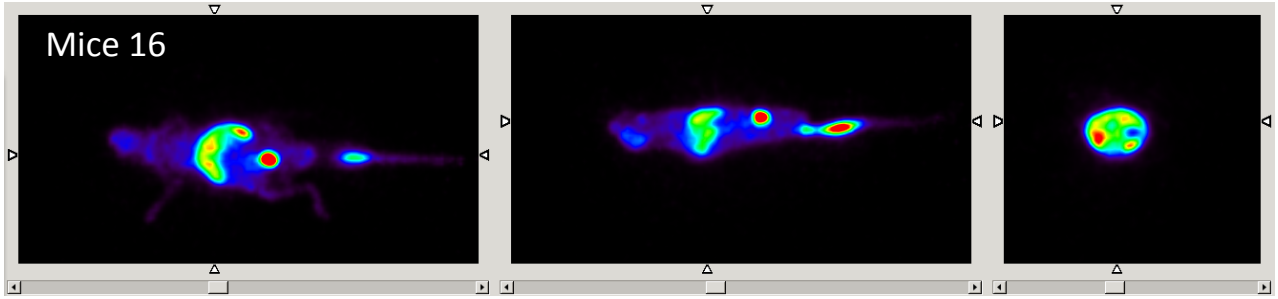


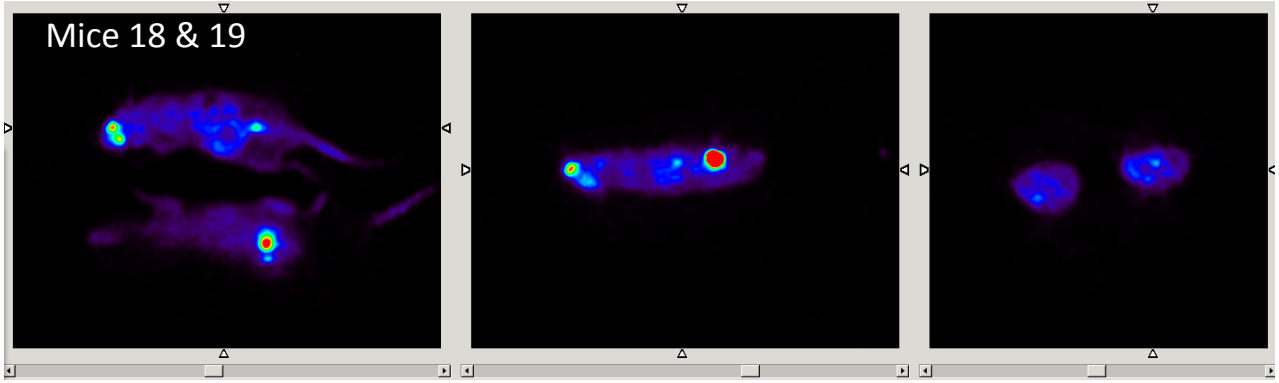


Example of phantom with lesions of 15, 10 and 5 mm diameter

ClearPEM for Small Animal







Images reconstructed with list-mode MLEM (vs June 2011), 8 iterations, voxel size 1x1x1.3 mm^3, gaussian filter with FWHM = 1.5 mm. No randoms nor attenuation corrections.

Clinical Trials

ClearPEM Exam Conditions:

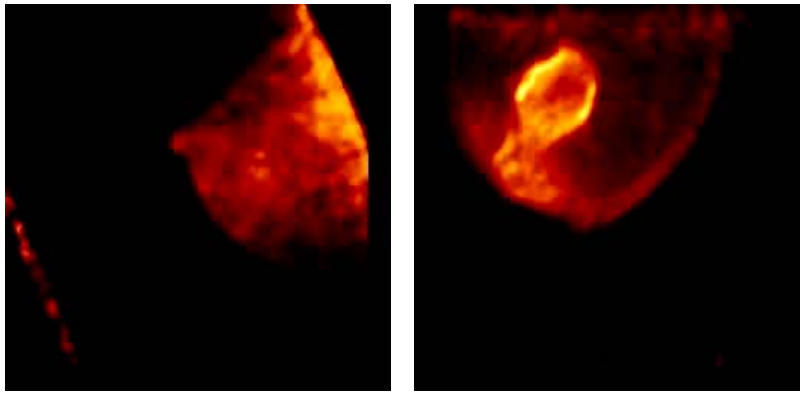
- The patient does PET/CT 40 min after FDG injection
- The PET/CT is 25 to 30 minutes long
- The ClearPEM exams are performed 1 hour and 10 minutes after de FDG administration
- No extra dose is required for the ClearPEM exam
- Patients perform a complete ClearPEM exam: breast (left and right) and axilla (left and right), starting with the side where the lesion was detected (in the clinical report file).
- Acquisition times:
  - 20 min for each breast (4 angles);
  - 12 min for each axilla (3 angles)

Clinical exams performed up to now:

#	Date	Age (yr)	Weight (kg)	FDG [mCi]	Detector Heads Distance (mm)			
					Breast-R	Breast-L	Axilla-R	Axilla-L
1	2011.11.25	39	73.5	9.30	160	160	450	460
2	2011.12.09	65	82	10.03	200	200	530	530
3	2011.12.27	39	54	6.65	130	130	430	400
4	2012.01.13	36	74	9.30	150	160	440	410
5	2012.02.10	76	81	10.20	--	170	--	480
6	2012.03.09	62	74	9.30	170	165	480	485
7	2012.03.09	77	64	8.60	150	130	450	430

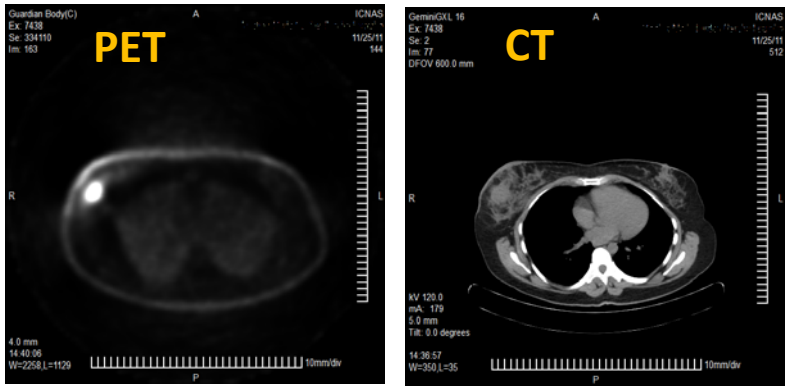
Eligibility:
Patients with indication for biopsy
Patients for a PET scan (staging)

Patient #1 : First Reconstruted Images (LM/STIR)

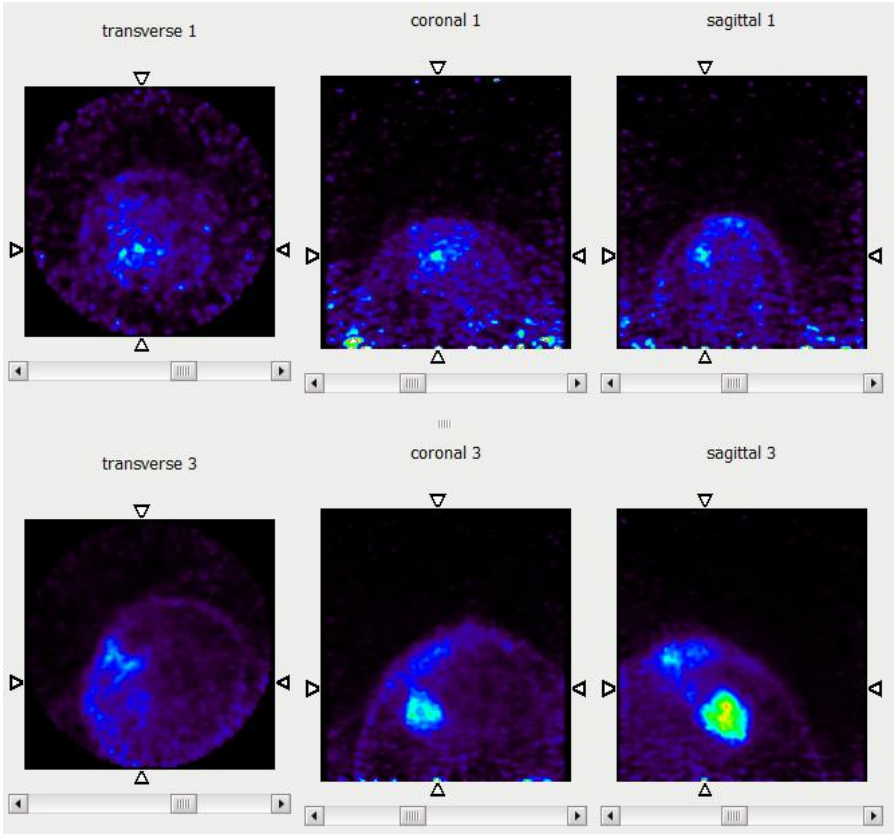


Volume rendering of the left and right breasts, reconstructed with list-mode MLEM (L Cao, vs Dez 2011), 8 iterations, voxel size 2x2x1.3 mm^3, gaussian filter with FWHM of 1.5 mm. No randoms or attenuation corrections.

PET/CT report



- Massive lesion in the right breast;
- Lesion in the right axilla;
- Dense area in the left breast, inconclusive.

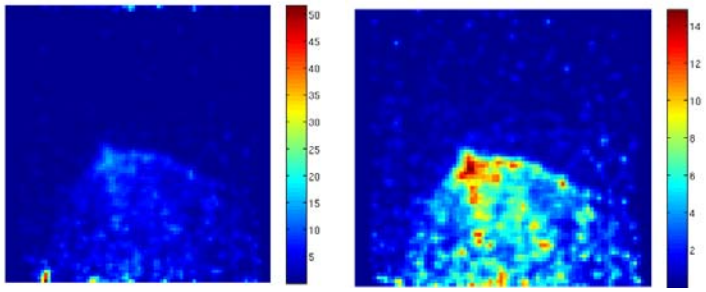


Reconstructed images of the left (up) and right (down) breasts, with STIR (OSMAPOSL), 5 iterations, voxel size 2x2x1.3 mm^3, gaussian filter with FWHM of 1 mm. No attenuation corrections.

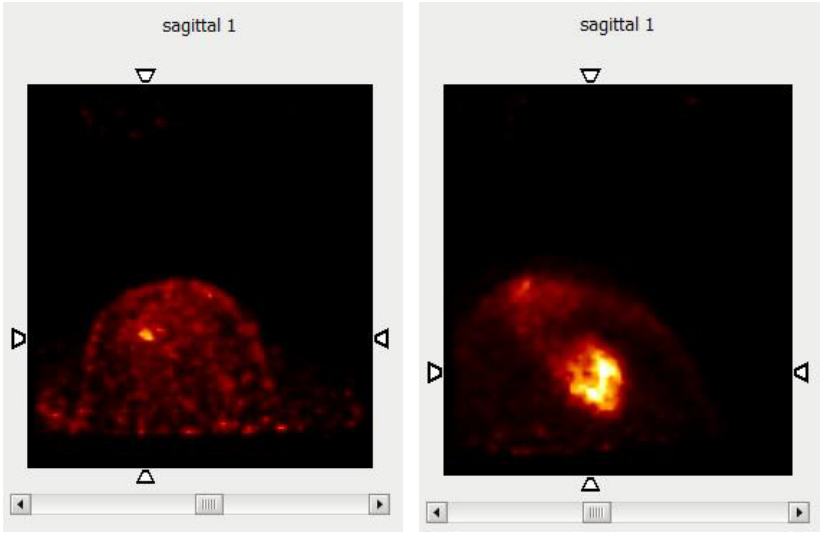
Patient #1 : Optimizing reconstruction parameters with LM

- Voxel size (1x1 or 2x2 mm^2)
- Gaussian filter with FWHM of 1, 1.5 or 2 mm
- Metz filter Power N=1,2,3
- Number of iterations (up to 20)

- New versions of the list mode reconstruction software



Left breast, image of the full FOV (left) and cropped (right) for statitical noise reduction (LM version Feb 2012)



Left and right breasts, reconstructed with list-mode MLEM (1st vs March 2012), with:
8 iterations,
voxel size 2x2x1.3 mm^3,
gaussian filter with FWHM = 1 mm.
With randoms correction (over corrected. New LM version available).
No attenuation corrections.

Exam # 1 : Statistics Evaluation

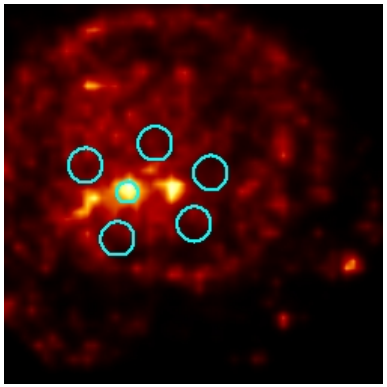
Lesion to background noise ratio (LTBN):

LTBN measures the lesion signal in units of noise standard deviation

$$LTBN = \frac{\mu_L - \mu_{Bk}}{\sigma_{Bk}}$$

Lesion detectability threshold LTBN = 3

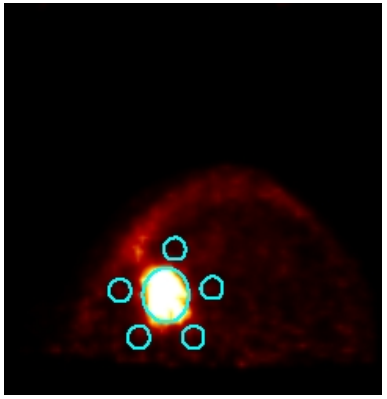
Exam # 1 Left Breast



	Mean	Standard Dev	LTBN
Lesion	26,316	5,33663	
ROI 1	9,8827	3,07206	5,3
ROI 2	8,55465	2,67728	6,6
ROI 3	5,66337	1,59813	12,9
ROI 4	7,1282	2,83606	6,8
ROI 5	7,20259	2,89263	6,6

Region of interest (ROI) dimensions:
Lesion (1): variable size
Bkgd (5): 10 mm diameter and 2 mm thickness

Exam # 1 Right Breast



	Mean	Standard Dev	LTBN
Lesion	151,292	34,2525	
ROI 1	22,6868	9,18892	14
ROI 2	21,3756	5,69747	22,8
ROI 3	29,094	16,2372	7,5
ROI 4	23,8208	12,0366	10,6
ROI 5	25,1098	6,67893	18,9

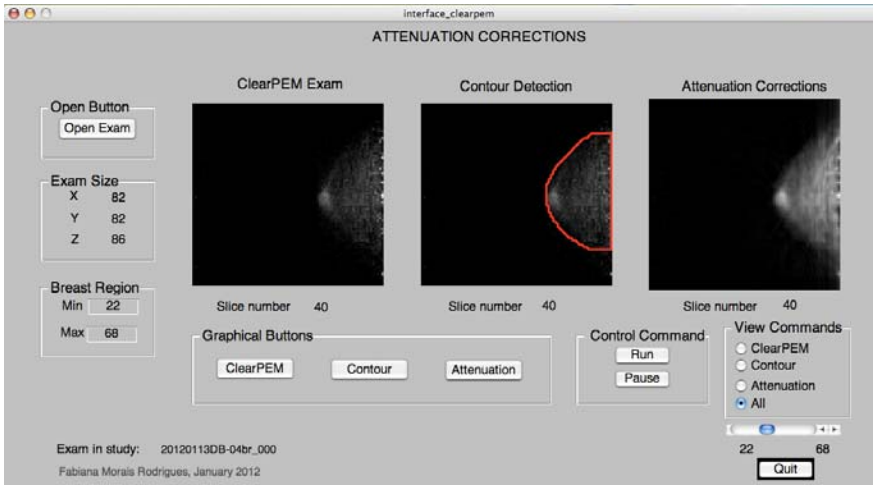
(LM version March 2012)

Overview of the results

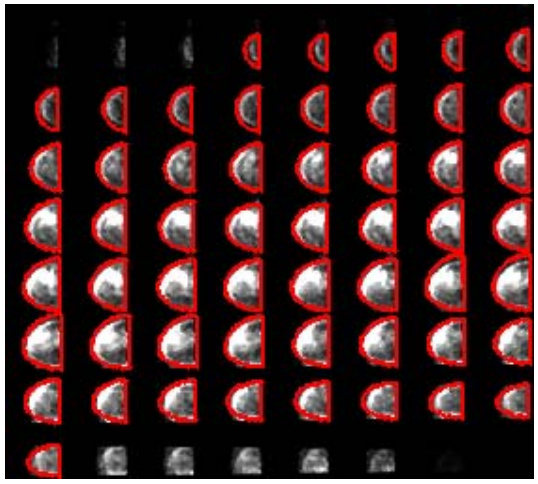
#	Lesion reported by PET/CT				Lesion detected on ClearPEM			
	Breast-R	Breast-L	Axilla-R	Axilla-L	Breast-R	Breast-L	Axilla-R	Axilla-L
1	yes	inconclusive	yes	no	yes	yes	yes	hot areas
2	yes	calcifications	Sugest biopsy	no	yes	hot areas	no	no
3	no	no	no	no	hot areas	hot areas	hot areas	hot areas
4	yes	no	no	no	yes	hot areas	dense areas	no
5	no	yes	no	adenopathy	no	yes	no	no
6	no	yes	no	adenopathy	no	yes	no	no
7	no	yes	no	no	no	yes	no	no

PRELIMINARY!
ClearPEM reconstructed images need clinical interpretation!

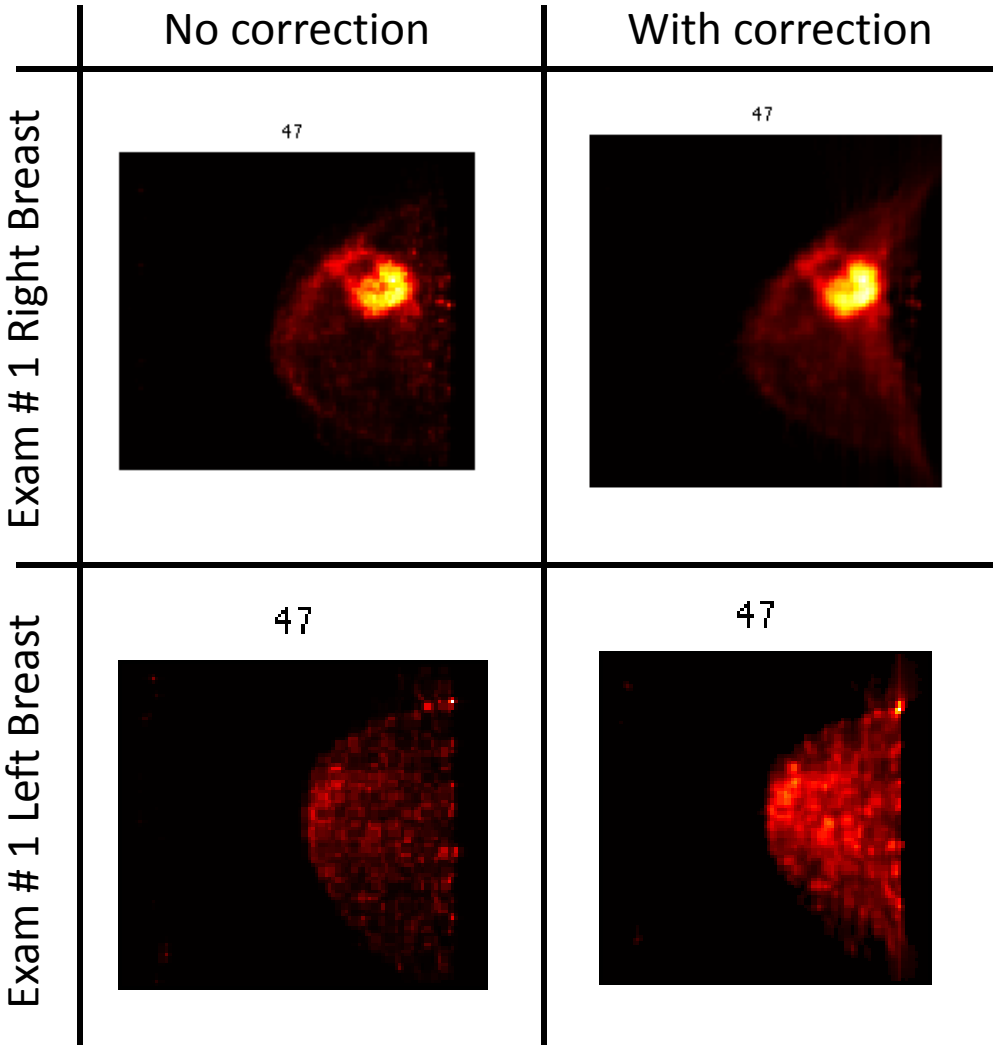
Attenuation Corrections for List mode



Contour detection, slice by slice:



[F. Rodrigues – ICNAS]



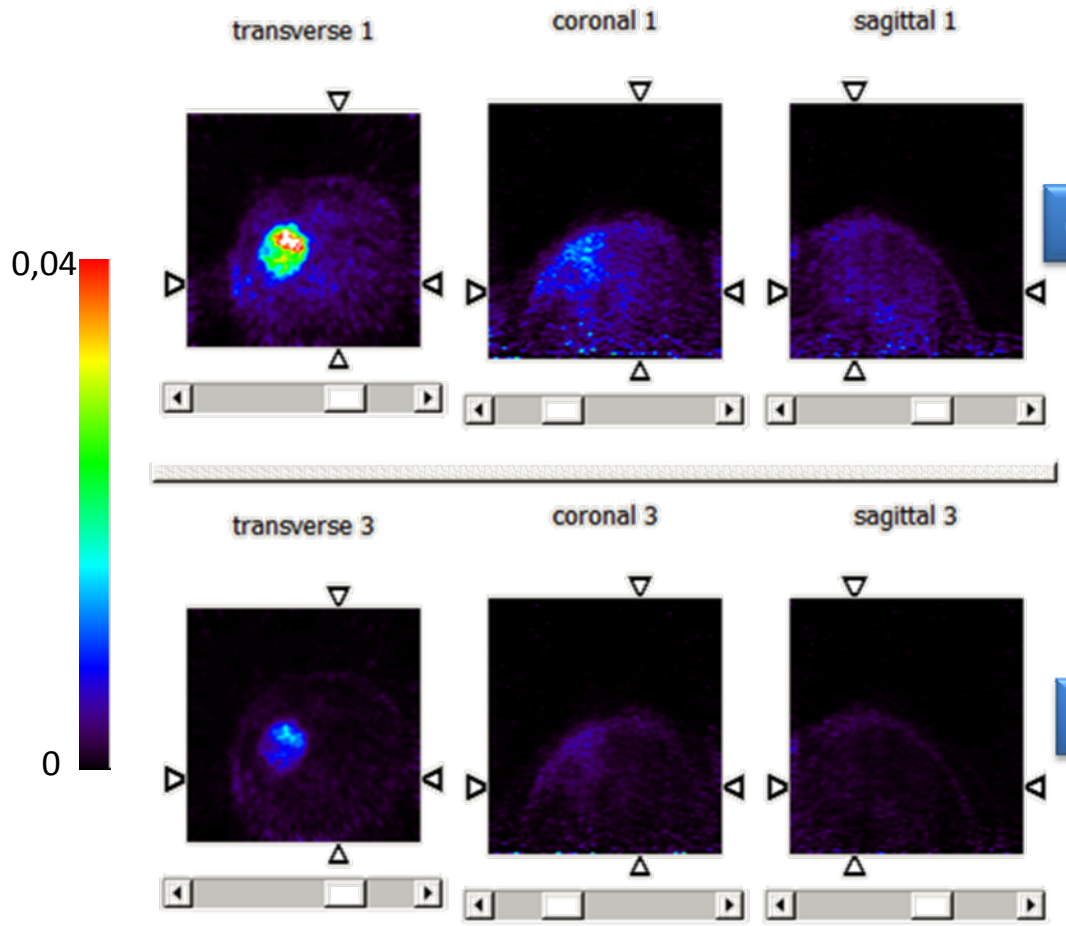
Compared images of the 8th iteration of list mode reconstruction with voxel 2x2 mm^2, gaussian filter with FWHM of 1mm, randoms correction applied

Attenuation Corrections for STIR and LM

Exam # 1 Right Breast

Data set with ~ 2.400.000 events

$$Contrast = \frac{M_{center} - M_{periphery}}{M_{periphery}}$$



Corrected

Contrast

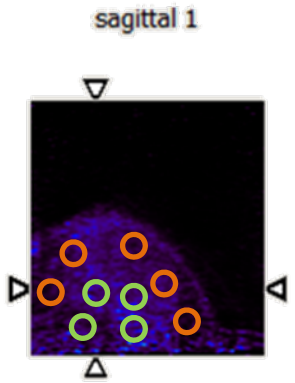
C_{corr}= 0,85

C_{NCorr} = 0,22

VOI center

VOI periphery

No correction



The central region of the breast has higher uptake than the periphery before correction.

[C.S. Ferreira – IBEB/LIP]

On going work

- Bad news:
  - Power cut @ ICNAS on the 14th March
  - ClearPEM robot did not recover
  - Axis 4 needs a new motor (costs 3000 eur)
  - Still waiting for institutional decisions
  - The clinical trials with ClearPEM @ ICNAS are on hold

- In the meantime:
  - Reconstructed images of the 7 exams were evaluated
  - Updated versions of the image reconstruction software with different parameters (voxel size, # iterations, filters) were tested
  - Attenuation corrections were implemented
  - Randoms correction is being studied and implemented

- ClearPEM reconstructed images need clinical interpretation (meeting on April 26th)