ACR PET Accreditation

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THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER
Making Cancer History™

Division of Diagnostic Imaging
X-RAYS AND RADIOACTIVITY
UT M.D. Anderson Cancer Center

Goals

- Sets quality standards for facilities (personnel, equipment and policies) to continuously improve the quality of care given to patients
- Offers Nuclear Medicine physicians an opportunity for comprehensive review and evaluation of their facilities, personnel qualifications, image quality, equipment, quality control procedures and quality assurance programs through a *peer review mechanism*.
- The program is educational in nature and is ***voluntary*** (at least for now)

History

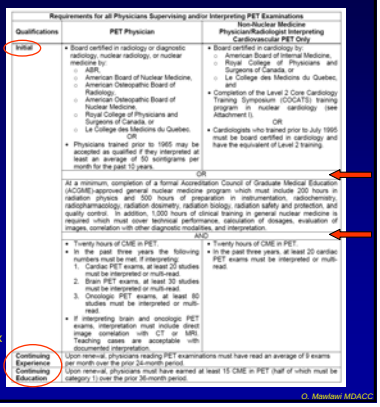
- Initial intent to start program was in 2000
- Pilot program in 2001 with 11 sites
- Program began in 2002
- Program was developed and directed by the committee on Nuc Med Accreditation of the Commission on Quality and Safety

Program Requirements

- Personnel Qualifications
  - Physicians

All information is available at:

http://www.acr.org/accreditation/nuclear.aspx



Requirements for all Physicians Supervising and/or Interpreting PET Examinations

Qualifications	PET Physician	Non-Nuclear Medicine Physician/Radiologist Interpreting Cardiovascular PET Only
Initial	• Board certified in radiology or diagnostic radiology, nuclear radiology, or nuclear medicine by: ○ ABR, ○ American Board of Nuclear Medicine, ○ American Osteopathic Board of Radiology, ○ American Osteopathic Board of Nuclear Medicine, ○ Royal College of Physicians and Surgeons of Canada, or ○ Le College des Medicins du Quebec. OR • Physicians trained prior to 1995 may be accepted as qualified if they interpreted at least an average of 50 scintigrams per month for the past 10 years.	• Board certified in cardiology by ○ American Board of Internal Medicine, ○ Royal College of Physicians and Surgeons of Canada, or ○ Le College des Medicins du Quebec, and • Completion of the Level 2 Core Cardiology Training Symposium (COCATS) training program in nuclear cardiology (see Attachment I). OR • Cardiologists who trained prior to July 1995 must be board certified in cardiology and have the equivalent of Level 2 training.
	OR	
	At a minimum, completion of a formal Accreditation Council of Graduate Medical Education (ACGME)-approved general nuclear medicine program which must include 200 hours in radiation physics and 500 hours of preparation in instrumentation, radiochemistry, radiopharmacology, radiation dosimetry, radiation biology, radiation safety and protection, and quality control. In addition, 1,000 hours of clinical training in general nuclear medicine is required which must cover technical performance, calculation of dosages, evaluation of images, correlation with other diagnostic modalities, and interpretation.	
	AND	
	• Twenty hours of CME in PET • In the past three years the following numbers must be met, if interpreting: 1. Cardiac PET exams, at least 20 studies must be interpreted or multi-read. 2. Brain PET exams, at least 30 studies must be interpreted or multi-read. 3. Oncologic PET exams, at least 80 studies must be interpreted or multi-read. • If interpreting brain and oncologic PET exams, interpretation must include direct image correlation with CT or MRI. Teaching cases are acceptable with documented interpretation.	• Twenty hours of CME in PET. • In the past three years, at least 20 cardiac PET exams must be interpreted or multi-read.
Continuing Experience Continuing Education	Upon renewal, physicians reading PET examinations must have read an average of 9 exams per month over the prior 24-month period. Upon renewal, physicians must have earned at least 15 CME in PET (half of which must be category 1) over the prior 36-month period.	

Program Requirements

- Personnel Qualifications
  - Technologists
  - Physicists

Requirements for PET Technologist and Medical Physicist		
Qualifications	**PET Technologists**	**Medical Physicist for PET**
Initial	• ARRT(N) or NMTCB registered or equivalent state license for nuclear medicine technology OR • Completion of a training program in nuclear medicine that must include training in the basic and medical sciences as they apply to nuclear medicine technology and practical experience in performing nuclear medicine procedures.	• Board certification in medical nuclear physics or radiologic physics (recommended), and • Familiarity with the principles of radiation protection; the guidelines of the National Council on Radiation Protection and Measurements; laws and regulations pertaining to the use of the equipment being tested; the function, clinical uses, and performance specifications of the imaging equipment; and calibration processes and limitations of the instruments and techniques used for testing performance, and • 40 hours of on-site practical experience providing physics support at established PET centers, each of which has performed a minimum of 500 cases. This requirement must be completed within the 12 months preceding submission of application.
Continuing Education	15 hours continuing education in PET in the last three years (recommended)	Upon renewal, physicist must have earned at least 15 CME in PET (half of which must be category 1) over the prior 36-month period.

Program Requirements

- In addition:
- A supervising nuclear medicine or PET physician must be designated to have the primary responsibility for nuclear medicine or PET at the facility.
- Each physician and each medical physicist are required to complete and sign an attestation signifying compliance with training, licensing, and CME requirements.
- The supervising physician must agree that no imaging procedures will be performed by personnel who do not meet the specified requirements.
- Each facility should maintain detailed documentation supporting the qualifications of personnel at the site.

Application

- Diagnostic modality accreditation program application – (online at www.acr.org)
- Two step process
  - Step 1: submit required information about practice including policies, procedures, personnel qualifications, equipment, and FEES
  - Step 2: once step 1 is approved, testing package is sent to site. Package includes instructions (phantom & clinical images), forms and labels.

Fees

Accreditation Fees	
Cycle	**Fees**
Accreditation (Initial cycle and renewal)	$1200 facility fee Plus per unit (module 1, 2, or 3): One module $600 Two modules $1200 Three modules $1800
Repeat	$600 per module, if repeating clinical exams $600 if repeating phantom
Reinstate/Corrective Action Plan	$600 facility fee $600 for each module or sub module
Add Units (mid cycle)	Per unit (module 1, 2, or 3): One module $600 Two modules $1200 Three modules $1800
Add New Modules (mid cycle)	$600 per module
Replacement Certificate	$65 per certificate
Phantom	$2536 ECT phantom and the PET faceplate (can be used for both SPECT and PET acquisitions) $1521 ECT phantom (for SPECT only) $ 2028 PET phantom (for PET only) $ 1017 PET faceplate made to fit an existing flangeless or flanged ECT phantom

Note: Fees subject to change without notice.

Testing – Step 2

- PET ACR accreditation is module based
- There are 3 modules:
  - Oncology
  - Brain
  - Cardiac
- For each module clinical and phantom images are required
- Application material is time critical
  - 45 days for return of a completed packet
  - Clinical and phantom images should be within ±30 days of one another.
- ACR accreditation is facility based – all scanners in the facility must be accredited or be not in service!

Clinical Images

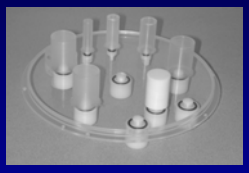
- **Module 1** - **Oncology** – submit two exams, one of which must be abnormal. The exams can be any combination of a whole body and/or chest and abdomen, with and without measured attenuation correction.
- **Module 2** - **Brain** – submit two exams, one of which must be abnormal, with attenuation correction.
- **Module 3** - **Cardiac** – submit two exams, one of which must be abnormal, with and without measured attenuation correction, if available.

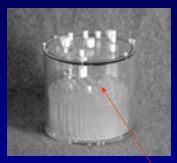
Clinical Images

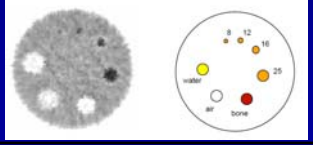
- Images should be labeled with: patient name, patient age (or date of birth), patient identification number, date of exam, and institution name. The technologist's name and initials, should also be indicated.
- *ALL images for ALL submitted studies must be labeled for laterality and orientation. This is now a **Pass/Fail** criterion.*
- A dated physician report stating the type of exam performed, the findings, and the clinical history must accompany all exams.
- Scoring will be based on: radiopharmaceutical bio-distribution, image acquisition, processing, and display parameters, as well as film and report identification. ***Images of models or volunteers are NOT accepted.***

Phantom Images

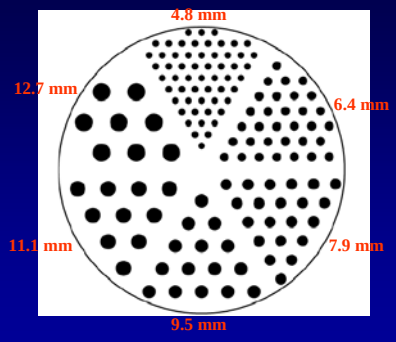
- Uses the ACR (Esser phantom)







Take OFF the spheres



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Phantom Images - Materials

- ACR Phantom
- 3 60 cc syringes
- 2 3 cc syringes
- Dose calibrator (properly calibrated)
- A 1 liter container/bottle
- Gloves
- Water
- F-18
- Some chucks

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Phantom Images - Procedure

From the column on the right, select the administered FDG whole-body dose.

1) Measure F-18 doses and enter values with times on work sheet (next page).
2) Add **Dose A** to a 1000 ml container. Mix and withdraw a 60 ml test **dose #1**. Set aside.
3) Withdraw 40 ml using a second 60 ml syringe and fill the 4 appropriate chambers in the phantom top.
4) Thoroughly mix **Dose B** in phantom background.
5) Remove 60 ml test **dose #2** from the phantom background.
6) Measure activity of test **dose #1 and #2** in dose calibrator; record in sheet.
7) Inject **dose #2** back in phantom. Fill remaining space with water and mix.
8) Scan at the specified time.

Phantom Dose Chart

Patient Dose	Dose A mCi	Dose B mCi
4 mCi	0.140	0.330
6 mCi	0.210	0.495
8 mCi	0.280	0.660
10 mCi	0.350	0.825
12 mCi	0.420	0.990
14 mCi	0.490	1.154
16 mCi	0.560	1.319
18 mCi	0.630	1.484
20 mCi	0.700	1.649

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Phantom Images - Procedure

Date:_____

Phantom Dilution Worksheet
Enter dose and time below

	Dose	Time	Dose Ratios
Patient Dose:			
FDG dose (A), mCi:			FDG Doses: B/A (enter ratio value below)
FDG dose (B), mCi:			
Test dose #1, µCi:			Test Doses: 1/ 2 (enter ratio value below)
Test dose #2, µCi:			
Actual start time of phantom scan:			

When entering SUV parameters for the PET scanning protocol assume a 70 kg patient and use the Patient Dose (e.g. 10 mCi) from above with the measurement time entered for dose A.

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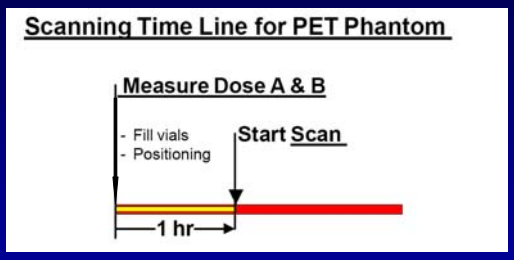
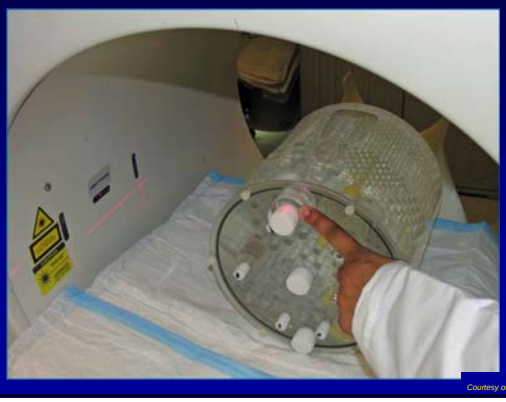
Phantom Images - Procedure



The suggested dilutions would result in an SUV of 1 in the phantom background and an SUV of 2.5 in the cylinders assuming no partial volume effects.

Phantom Images - Positioning



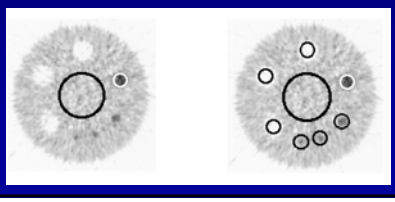
Courtesy of P. Esser PhD

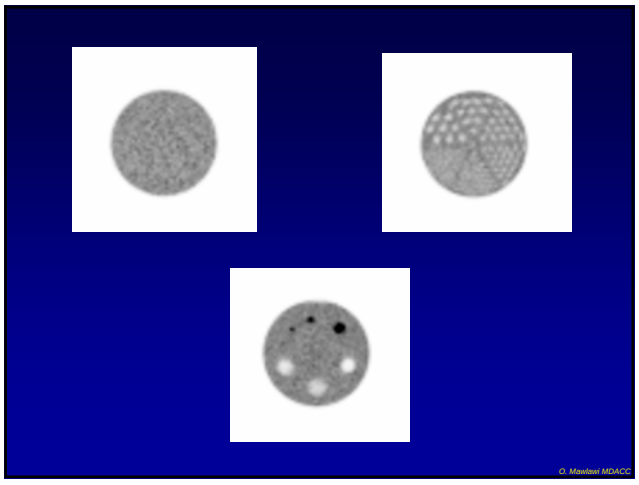
Phantom Images

- Phantom is scanned using standard clinical protocol parameters.
- 1 or 2 FOV can be used depending on scanner
- Images are reconstructed using standard clinical protocol parameters.
- Images should be reformatted to generate 1cm thick slices

Phantom Images

- Select the slice that best shows all 4 small cylinders
- Draw an ROI to encompass the 25 mm cylinder – copy to all other cylinders
- Draw a large ROI in the central background
- Report SUV for all regions on SUV analysis worksheet form





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SUV Analysis Worksheet

Date: ___ / ___ / ___

Patient Dose:_____ PET(/CT) Model: _____

From the ROI data of minimum (min.), maximum (max.) and mean SUVs (SUV parameters: patient dose and 70 kg weight) fill in Table 1 and 2 below. If the smallest vials are not visible, leave entries blank.

A) Contrast – Table 1

	Hot Vial 8 mm	Hot Vial 12 mm	Hot Vial 16 mm	Hot Vial 25 mm
max. SUV				

B) Scatter/Attenuation – Table 2

	Background	Bone	Air	Water
mean SUV				
Min. SUV				

C) Ratio Calculations (using data from Tables 1 & 2 above):

max. vial SUV to mean background SUV e.g., Contrast = 8mm SUV / bkgd SUV	8mm/bkgd	12mm/bkgd	16mm/bkgd	25mm/bkgd

max. vial SUV to max. 25 mm vial e.g., Contrast = max16 mm SUV / max 25 mm SUV	8mm/25mm	12mm/25mm	16mm/25mm

min. air or water to min. bone e.g., ratio = min air SUV / min bone SUV	air/bone	water/bone

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Nuclear Medicine/PET Accreditation Program Testing Materials Checklist

Be sure to keep copies of the completed application, submitted images and any additional submitted information on file for future reference.

Please ensure that all items below are complete before returning the submission to the ACR for accreditation review. An incomplete submission may cause significant delays in the review process.

- ☐ Quality Assurance Questionnaire.
- ☐ The most recent Medical Physicist Survey Report for each unit to include documentation of any corrective action required.
- ☐ The most recent NRC and/or state inspection results for the facility to include documentation of written responses to any violations.
- ☐ Test Image Data sheets (on for each examination, appropriately labeled).
- ☐ A copy of the dated physician report for each examination submitted.
- ☐ A copy of the written procedure for each examination submitted.
- ☐ Clinical images with appropriate labels. Use labels for the applicable exam only. For example, use "Oncology Abnormal" labels for one exam and "Oncology NL/Abnl" labels for another exam.
- ☐ One set of phantom images, one Site Scanning Data Form, one Quality Control Summary (appropriately labeled), as well as appropriate worksheets from each unit being accredited.

Please return all materials to:
Nuclear Medicine/PET Accreditation Program
American College of Radiology
1891 Preston White Drive
Reston, VA 20191-4397

The enclosed labels show when your testing materials are due to the ACR. Failure to meet this due date will jeopardize completion of your accreditation. If your facility is renewing its accreditation, we cannot guarantee completion before your ACR certificate expires.

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ACR RADIOLOGY

Nuclear Medicine Practice Accreditation Program — **Clinical Test Image Data Sheet**

Whole-Body/Regional PET Imaging

○ **Normal** ○ **Abnormal**

Patient ID Data: **Patient ID #**_____**Date of Study**_____
Patient Height _____ **Weight** _____

PATIENT /IMAGE DATA

1) To be filled out by institution. Incomplete data could delay review process.
2) Include Whole-Body/Regional PET imaging written procedure.

Type of Tomograph: (Manufacturer and Model)		**Transmission Source:** (eg. Ge-68 rods, Cs-137 point, x-ray) Specify:	
		Source in service date, if appropriate:	
Radiopharmaceutical	Agent: ○ F-18 FDG	○ Other (specify):	
	Dose:	mCi	
Patient Preparation			
○ Diabetic	○ Non-diabetic	○ Fasting hrs	○ Fed, specify:
Baseline glucose measured? ○ YES ○ NO		Insulin given? ○ YES ○ NO, specify:	
If YES, mg/dl		Glucose given? ○ YES ○ NO, specify:	
Intervention used to minimize urinary activity? ○ YES ○ NO If YES, describe:			
Other pharmacologic preparation? ○ YES ○ NO If YES, specify:			
Controlled environment? ○ YES ○ NO If YES, describe:			
Whole-Body/Regional PET Study - Acquisition			
Transmission scan ○ YES ○ NO		Number of bed positions acquired:	
If Yes: ○ pre-injection, patient not moved			
○ pre-injection, patient moved between transmission and emission scan			
○ post-injection			
Scan duration per bed position:			
Emission scan ○ YES ○ NO		Number of bed positions acquired:	
Scan duration per bed position:			
Percentage overlap between bed positions:		%	

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Interval betl-ween injection and start of emission imaging:			mins.
Zoom factor:		Matrix:	
Frame rate(s):	secs/ frame	If second frame rate:	secs/ frame
Total imaging time:	min	Total true events: (for entire study, if available)	cts
Acquisition mode:	○ 3D ○ 2D		
Was PET QC performed on day of study:	○ YES ○ NO	Specify:	
Calibration value applied:	○ YES ○ NO	Calibration date:	
Patient motion assessment	○ YES ○ NO	Specify:	
Processing			
Random correction: ○ YES ○ NO		Scatter correction: ○ YES ○ NO	
Decay correction: ○ YES ○ NO			
Attenuation correction: ○ YES ○ NO			
Attenuation type: ○ measured ○ calculated (estimated)			
If measured: ○ segmented ○ nonsegmented			
Zoom: ○ YES ○ NO If YES, zoom factor:			

	Transmission	Non-attenuation Correction	Attenuation Correction
Reconstruction method: (FBP, OSEM, other):			
XY filter (type/cutoff/unit):			
Z filter (type/cutoff/unit):			
Slice thickness:	mm	mm	mm
Pixel size:	mm	mm	mm
Matrix size:			

Quantitative imaging analysis? ○ YES ○ NO If YES, specify:

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Acquisition and Reconstruction Parameters (Whole Body Protocol)

Type of PET(/CT) unit: _____

Enter all appropriate acquisition parameters below (list other parameters that may be relevant):

Time per bed position:
Transmission scan: _____ Emission scan: _____
Number of bed positions:_____
Matrix size: _____ Zoom:_____

For CT:

Topogram: mAs_____kVp_____

CT: mAs _____, kVp _____, Nsan. Slices_____, Thickness _____mm

Are different protocols used for children? ○ Y ○ N
Describe any modified pediatric protocols and dose reduction techniques: _____

Enter all reconstruction parameters below:

Transmission Reconstruction Parameters

Type of reconstruction (OSEM, FBP, etc.): _____
OSEM: iterations_____, Subsets _____
Processing Filter: _____, Setting: _____
Slice Thickness: _____cm

Additional information:

_____
_____

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American College of Radiology
Nuclear Medicine Accreditation Program
1891 Preston White Drive, Reston, VA 20191-4397

Place label here

PET Phantom – Site Scanning Data Forms

Please complete one copy of these data forms for each unit being evaluated. Photocopy the forms for additional units. Detailed instructions for scanning the PET phantom are attached. Please print or type. Please place your Phantom Data Form Label in the space above. Return completed form with phantom images.

Equipment

PET or PET-CT INFORMATION

Unit Vendors: check one

○ PHG Philips ○ GEMS GE ○ SIEC Siemens (or CTI)
○ OTH Other, specify:

PET Model Name	CT Model Name/Slices	Year of Manufacture	Year of Installation	Date of Last Hardware Upgrade	Serial Number
	/				

PROCESSING SOFTWARE

Version of Software	Vendor	Date of Last Software Upgrade	Operating System (e.g., UNIX)

Has all submitted data from the PET system been processed with this computer system? ○ Y ○ N

TRANSMISSION SOURCES (if used)

Type / Number of Sources	Vendor	Total Activity, mCi	Date of Installation	Time since Installation	Frequency of Updates
/					

Make corrects to fields below based on the actual resolution test pattern of phantom model being used:

Rod sizes (small to large): 4.8 6.4 7.9 9.5 11.1 12.7 mm
Cylinder sizes (small to large): 8 12 16 25 mm

Other information or comments: _____

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PET Quality Control Summary (Brief Descriptions)

Type of PET unit: _____

QC for PET Scanner	Frequency	Last Performed (mm/dd/yy)
QC for CT (for PET/CT units)		
QC for Diagnostic Displays/Printers		

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Electronic Submission

- Send two CDs per unit with the same clinical cases on each.
- Send One CD per unit containing the phantom images
- You must embed your viewer on the image CDs.
- Labels that were sent with the testing packet should be placed on CD cover.
- CD viewer should be capable of showing:

1. Facility name
2. Patient name (first and last)
3. Patient age or date of birth
4. Patient identification number
5. Date of examination
6. Type of exam
7. Slice thickness
8. Acquired Matrix
9. Acquisition time (indicated or easily calculated)
10. Images labeled as to laterality and orientation

Evaluation

- Based on three different metrics
  - Contrast
  - Resolution
  - Uniformity
- All on a scale of 1-5
- A score of 2 in two areas or a 1 in any area is considered a FAIL

Evaluation

PET Phantom:

Contrast:

Satisfactory:	12 mm vial is resolved with low contrast; larger vials resolved with high contrast
Marginal:	16 mm vial is resolved with acceptable contrast; larger vials resolved with high contrast

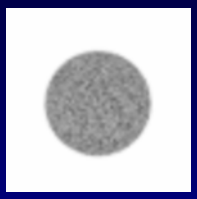
Spatial Resolution:

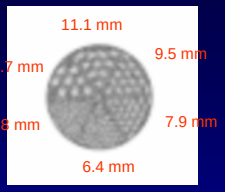
Satisfactory:	9.5 mm rods are resolved with low contrast; larger rods are resolved with high contrast
Marginal:	11.1 mm rods are resolved with low contrast; larger rods are resolved with high contrast

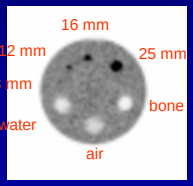
Uniformity:

Satisfactory:	Artifacts are seen in only a few slices of the complete set but are not thought to be clinically significant.
Marginal:	Strong artifacts are seen in a small number of slices.

A phantom acquisition with two or more marginal scores for any category will be failed.







Acceptance Testing Using NEMA Standards

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MD Anderson Cancer Center

What is NEMA?

The acronym stands for: National Electrical Manufacturers Association

- In 1991 a task group from the SNM published a set of measurements to standardize the *performance characterization of PET scanners*.
- At the same time, NEMA formed its own committee to address the same issue and ended up publishing a standard that adopted the SNM publication however with some refinements. That standard became the NU 2-1994.
- Also at the same time, the European Economic Community underwent a similar process which resulted in an International Electrotechnical Commission (IEC) standard.
- The NEMA and IEC are two different standards although similar in purpose.
- Recently, the NEMA standard has been updated. The new document is known as the NU 2-2001 which is still different from the IEC standard.

Two NEMA Standards:

- NU2-94: Mainly used for neuroimaging (2D).
- NU2-01: Mainly used for whole Body imaging (2D/3D).

The original NEMA standard (NU 2-94) was developed for PET scanners that were used in 2D mode and had a limited axial FOV.

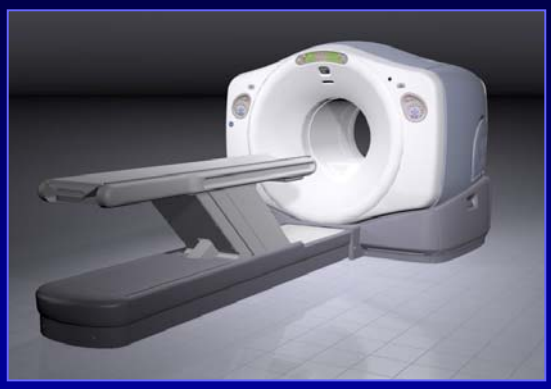
New scanner developments which acquire data in 3D and have large axial FOVs, as well as the major shift in the use of PET from neuroimaging to whole body imaging necessitated updating the NEMA standard.

Performance Characterization Measurements:

NEMA NU2-94 (2D)
- Transverse/Axial Resolution
- Sensitivity
- Scatter Fraction
- Count Rate and deadtime
- Uniformity
- Accuracy of count rate, scatter & attenuation correction

NEMA NU2-01 (2D/3D)
- Spatial Resolution
- Sensitivity
- Scatter Fraction/Count Rate Performance
- Image Quality
- Accuracy of count losses and randoms correction

Discovery PET/CT platform



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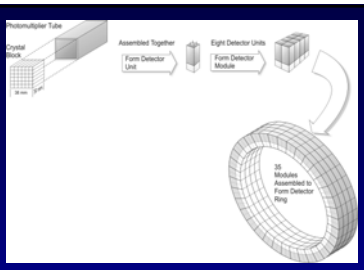

PET System Design	DST
Detector type	BGO
Detector size (mm)	6.3*6.3*30
Arrangement(det/blk)	6*6
Number of blk/ring	70 (420 det/ring)
Total number of det.	10080
Number of rings/slices	24/47
Axial sampling (mm)	3.27
Energy window	375-650
Diameter (detector-detector)	889
Patient port (cm)	70

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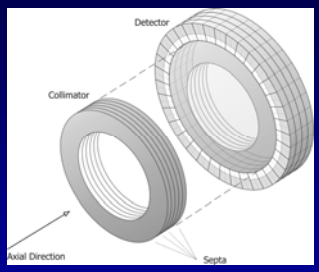
2D and 3D imaging capability using septa



System Design	DST
Septa size (mm)	54 x 0.8 (117*1)
2D axial spanning	± 5
3D axial spanning	± 23

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NEMA 94 & 2001 Phantoms

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Performance Characterization we will perform:

NEMA NU2-01 (2D/3D)

- Spatial Resolution
- Sensitivity
- Scatter Fraction/Count Rate Performance
- Image Quality
- Accuracy of correction for count losses and randoms

Daube-Witherspoon M. et al JNM, 43(10) 1398-1409, 2002

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Spatial Resolution:

This test measures the capability of the PET system to localize the position of a point source of activity after image reconstruction. The measurement is done using Multiple point sources suspended in air at different locations.

- 3 point sources are made from a solution with an activity concentration of 5mci/cc
- The point sources are positioned at (0,1), (0,10), and (10,0) in center of axial FOV
- Data is acquired for 1 min in 2D and 3D modes.
- Images were reconstructed using FBP (2D) and FORE +FBP (3D)
- Use 256*256 matrix, 25cm FOV, centered at (5,-5), with ramp filter at 4mm cutoff
- No correction for dead time
- Repeat with sources positioned at 4cm from edge of axial FOV.
- Final results are the average of the two measurements.

- Analysis is done by measuring the FWHM and FWTM in the radial and tangential directions

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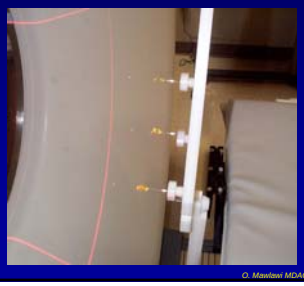
NU2-01 Spatial Resolution setup



6 mCi/cc, pipette three 1ul drops onto a slide. Recon (FBP, FORE) 256*256 over a 25 cm FOV. Point Sources are located at (0,1), (0,10), (10,0).

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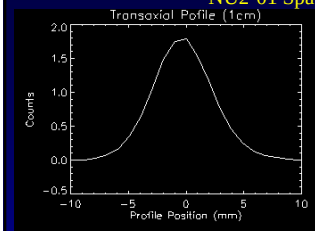
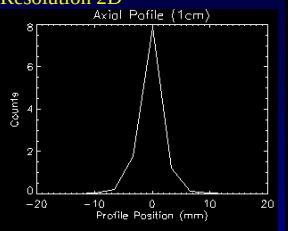
NU2-01 Spatial Resolution 2D





Results for 1 cm source

Trans FWHM:	6.13198 (mm)
Trans FWTM:	11.5838 (mm)
Axial FWHM:	5.18200 (mm)
Axial FWTM:	9.88173 (mm)

Results for 10 cm source

Radial FWHM:	6.99282 (mm)
Radial FWTM:	13.0039 (mm)
Tang. FWHM:	6.72525 (mm)
Tang. FWTM:	12.3854 (mm)
Axial FWHM:	6.12650 (mm)
Axial FWTM:	12.3992 (mm)

MDA resolution

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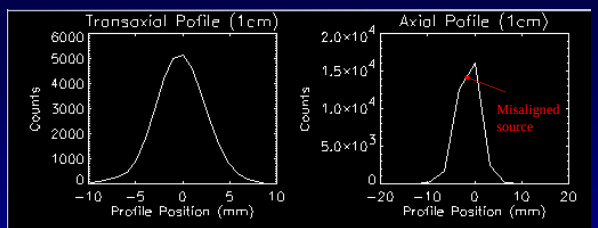
NU2-01 Spatial Resolution 3D



Results for 1 cm source

Trans FWHM:	6.11409 (mm)
Trans FWTM:	11.6839 (mm)
Axial FWHM:	5.97538 (mm)
Axial FWTM:	10.9906 (mm)

Results for 10 cm source

Radial FWHM:	6.78070 (mm)
Radial FWTM:	12.8040 (mm)
Tang. FWHM:	6.77996 (mm)
Tang. FWTM:	12.3961 (mm)
Axial FWHM:	6.69178 (mm)
Axial FWTM:	12.3631 (mm)

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Sensitivity:

This test measures the number of detected coincidence events per second for every unit of activity in the FOV. The test is performed with very low activity levels to minimize the effect of count losses. Measurements of sensitivity are made with increasing amounts of attenuating material, the results are then plotted and extrapolated to give the scanner sensitivity with no attenuation.

- A line source is filled with ~0.1 mCi of F-18 and threaded into an aluminum sleeve
- Setup is suspended in center FOV, data is acquired for 1min in 2D and 3D modes.
- Add a second aluminum sleeve, repeat acquisition.
- Repeat process for 5 aluminum sleeves
- Repeat all the process after repositioning setup at R=10cm

- Analysis is done by fitting sensitivity values and extrapolating to zero attenuation.

$$R_j = R_0 \exp[-2\mu X_j]$$

- Slice sensitivity is calculate by: $S_i = \frac{R_{i,i}}{R_{tot}} S_{tot} \qquad R_{tot} = \sum_i R_{i,i}$

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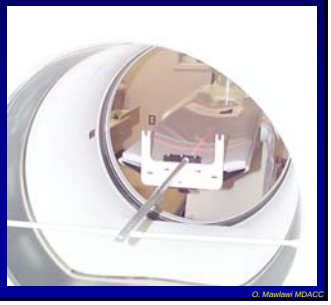
NU2-01 Sensitivity Setup



250 uci in the line (2.2 cc)

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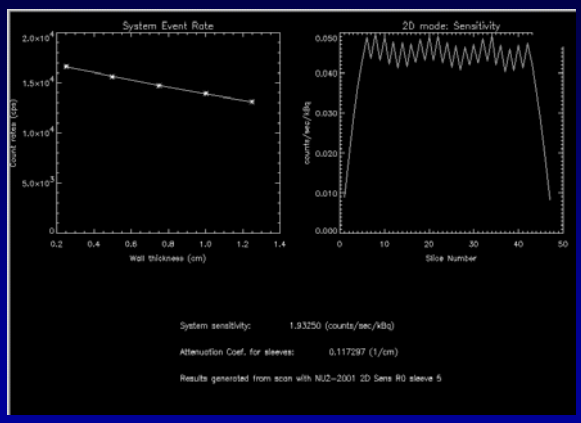
NU2-01 Sensitivity R=0 2D



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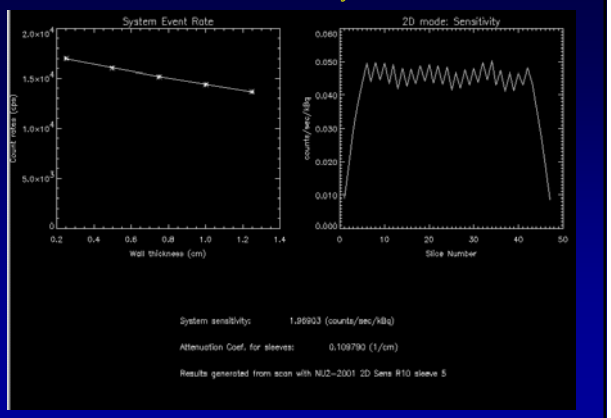
NU2-01 Sensitivity R=10 2D



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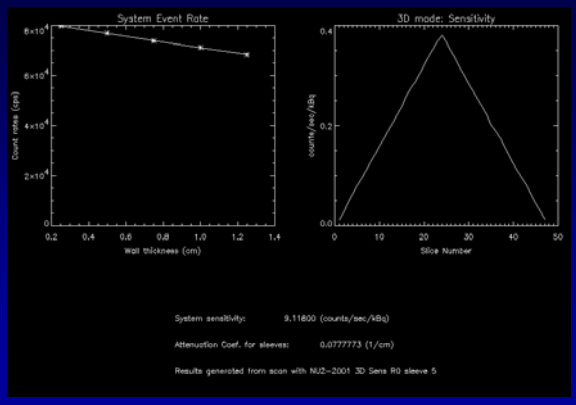
NU2-01 Sensitivity R=0 3D



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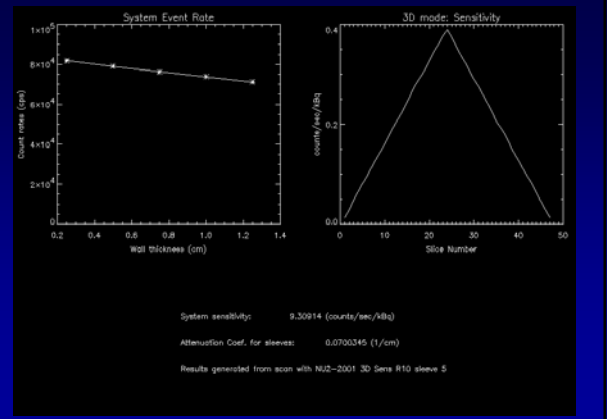
NU2-01 Sensitivity R=10 3D



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NU2-01 Sensitivity (cps/KBq)

Sensitivity	R=0 cm	R=10 cm
2D	1.9325	1.96903
3D	9.118	9.30914

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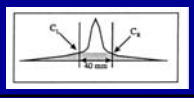
Count Rate and Scatter Fraction

The scatter fraction (SF) portion of this test measures the sensitivity of the scanner to coincidence events caused by scatter while the count rate test measures the performance of the PET scanner across a range of radioactivity levels. The SF measurement is done at activity levels where system dead time and randoms are negligible.

- Fill line source (70mCi 2D, 40mCi 3D) of F-18 and thread it into the scatter phantom.
- setup is placed on the couch in the center FOV with the line source close to couch.
- Data is acquired in dynamic mode as 4*15min, 14*25min with 25 min delays.
- Total time is ~13hrs.

- Analysis is done on sinograms with no corrections applied.
- 3D data was processed using SSRB.
- SF was measured using the last frame of the dynamic data.
- Scatter was calculated within a radius of 12cm from center of phantom.
- Scatter under the peak was estimated by interpolation between ±2cm from center.



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Count rate analysis was done in a 24 cm FOV using the following formulas where i and j are the slice number and acquisition number respectively.

$$R_{tot_j} = \sum_i C_{tot_i} / T_{acq_j} \qquad R_{t_j} = \sum_i (C_{tot_{t,j}} - C_{r+s_{i,j}}) / T_{acq_j}$$

$$R_{r_j} = \sum_i \{R_{tot_{i,j}} - (R_{t_{i,j}} / (1 - SF_i))\} \qquad R_{s_j} = \sum_i (SF_i / 1 - SF_i) R_{t_{i,j}}$$

$$R_{NECR_j} = \sum_i R^2_{t_{i,j}} / \sum_i (R_{tot_{i,j}} + R_{r_{i,j}}) \qquad R_{NECR_j} = \sum_i R^2_{t_{i,j}} / \sum_i R_{tot_{i,j}}$$

C: counts
T: Time
R: Rate

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NU2-01 Scatter Fraction/Count Rate Setup

70 mCi in 5.2 cc line

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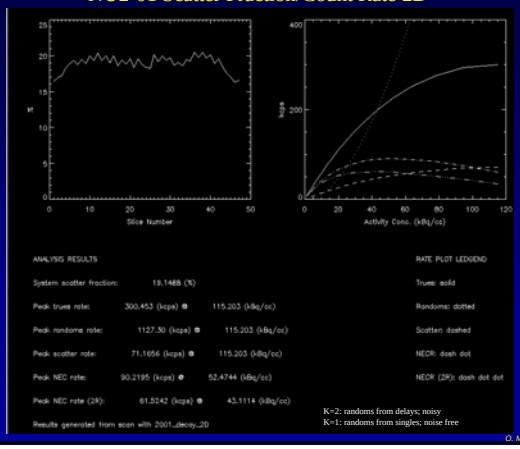
NU2-01 Scatter Fraction/Count Rate 2D



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NU2-01 Scatter Fraction/Count Rate 3D

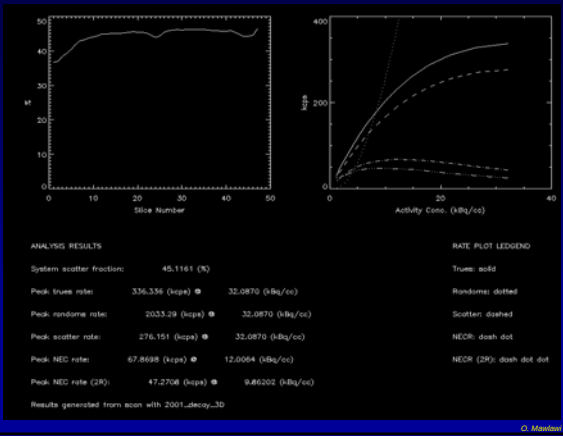


Image Quality:

This test attempts to measure the performance of the scanner in a condition that simulates a whole body clinical scan. The test uses hot and cold spheres of different sizes in a volume of non-uniform attenuation. Activity is also placed outside the FOV. Image quality is reported in terms of image contrast and SNR of hot and cold spheres.

- The IEC background is filled with ~5.3 kBq/cc
- The 4 smallest spheres of the IEC phantom are filled with 4 times background
- Two largest spheres are filled with regular water
- Scatter phantom was filled with total activity of 116 MBq/cc (~ background)
- Both phantoms were positioned behind one another in the center FOV
- Data was acquired for 8.5 min (2D) and 7.5 min (3D) since CT was used for atten.
- Repeat with 4 smallest spheres of IEC phantom filled with 8 times background

- Analysis is done on images reconstructed using clinical protocols.
- ROIs are drawn on spheres an background.
- 12 background ROIs are drawn on central,±1cm,±2cm slices (total 60 rois).

The following parameters are calculated on the ROI values:

- Hot and cold sphere contrast for each sphere (j):

$$Q_{Hot_j} = ((C_{Hot_j} / C_{bkg_j}) - 1) / ((a_{Hot} / a_{bkg}) - 1) \qquad Q_{Cold_j} = (1 - (C_{Cold_j} / C_{Bkg_j})$$

- The percent background variability for each sphere (j):

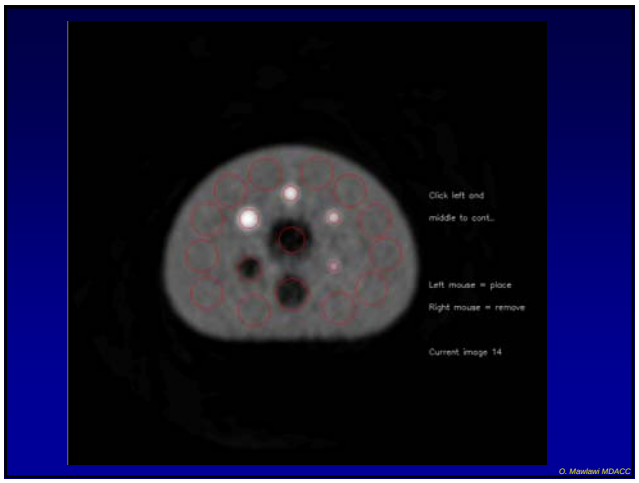
$$N_j = SD_j / C_{Bkg_j}$$

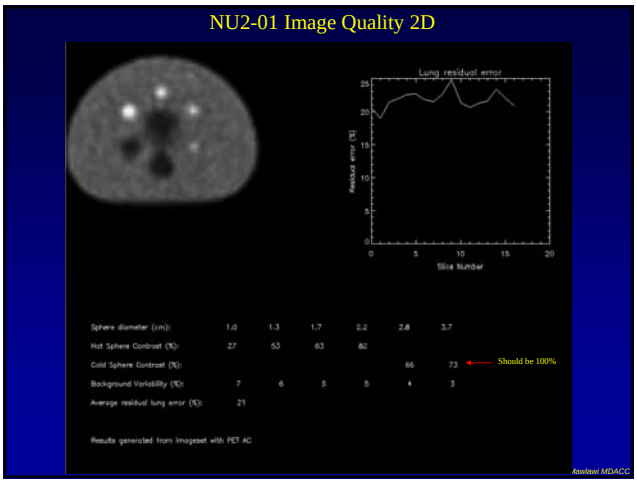
- The average residual lung error summed over all slices (i):

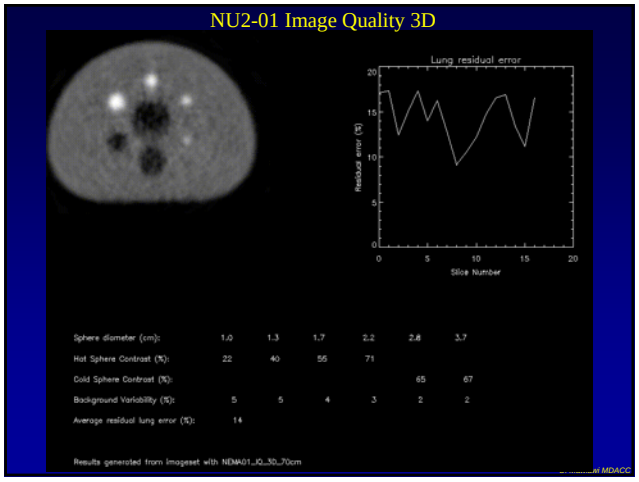
$$\Delta C_{lung} = \sum_i C_{lung} / \sum_i C_{Bkg}$$

NU2-01 Image Quality Setup

- 0.206 uci/cc in 10 Liter background
- 0.88 uCi/cc sphere concentration
- 4.7 mCi in the scatter phantom







Accuracy for correction of count losses and randoms:

The accuracy of count losses and randoms corrections is measured by comparing The trues rate calculated using count losses and randoms corrections with the trues Rate extrapolated from measurements with negligible count losses and randoms.

The test uses the data acquired during the count rate and scatter fraction test.

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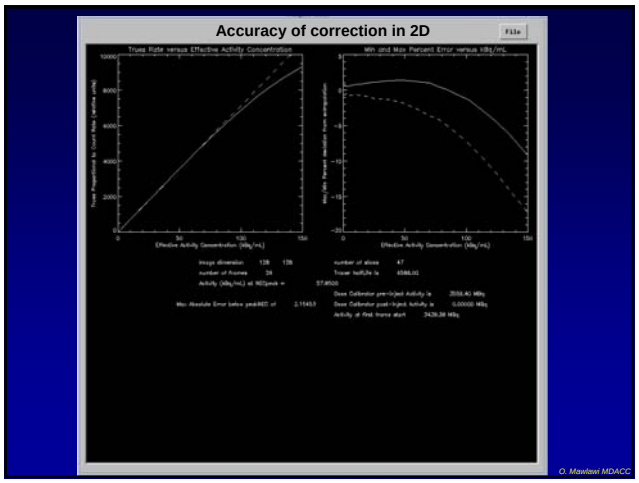
Accuracy of correction in 2D
File
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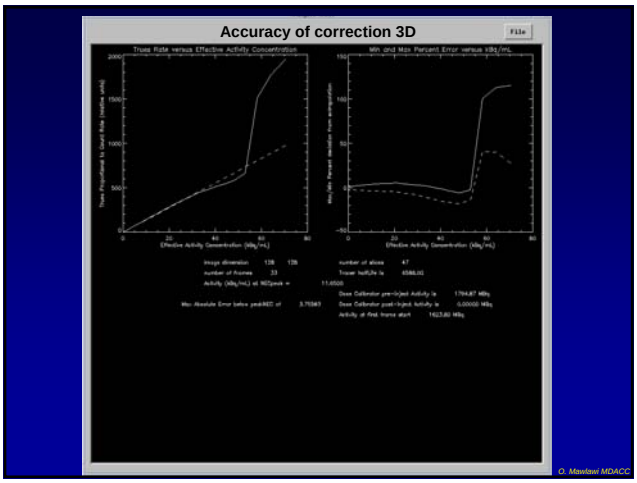
Accuracy of correction 3D
File
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