جامعة الملك فهد للبترول والمعادن
King Fahd University of Petroleum & Minerals

Summer Training Presentation

A Summary of the Projects Done with KFSH

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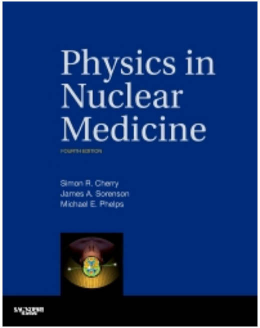
Outline

1. What is Nuclear Medicine?
2. SPECT
3. Collimator Resolution
4. Extrinsic & Intrinsic Uniformity

Outline

What is Nuclear Medicine?



The science and clinical practice of nuclear medicine involve the administration of trace amounts of compounds labeled with radioactivity (radionuclides) that are used to provide diagnostic information in a wide range of disease states.

Physics in Nuclear Medicine, 2012

Outline

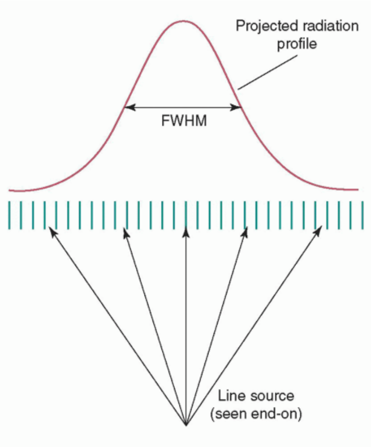
SPECT

Single Photon Emission Computed Tomography

- Detects tha gamma radiation emitted from the radionuclide substance that was injected inside the patient
- The images are functional images, showing the functions of the organs
- Usually integrated with CT, allowing for anatomical references
- Can take 2D, 3D, and multimodality images

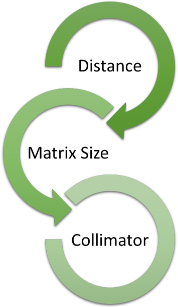
Outline

Collimator Resolution

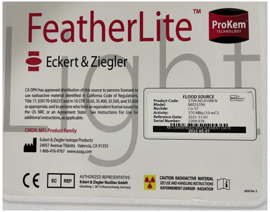


***Collimator Resolution** R_{coll} is defined as the full width at half maximum of the radiation profile from a point or line source of radiation projected by the collimator onto the detector.*

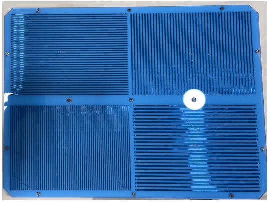
Experiment Setup & Goals



^{57}Co Flat Source

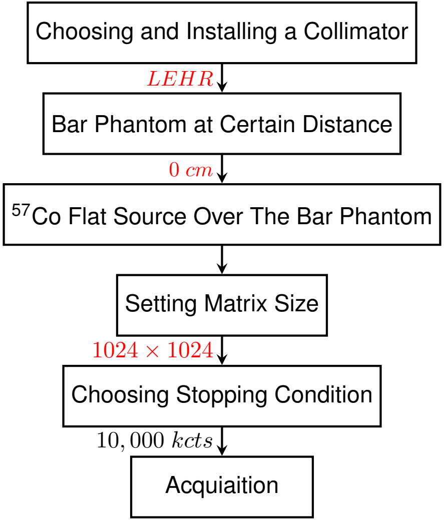


Bar Phantom



Three Collimators

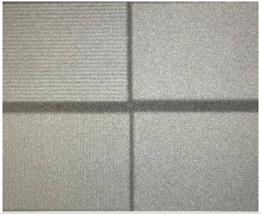
Method


Choosing and Installing a Collimator
$LEHR$
Bar Phantom at Certain Distance
$0\ cm$
^{57}Co Flat Source Over The Bar Phantom
Setting Matrix Size
1024×1024
Choosing Stopping Condition
$10,000\ kcts$
Acquiaition

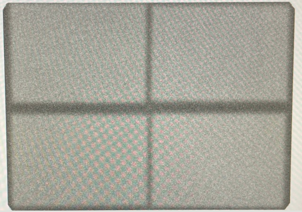
Distance Vs. Resolution

At 0 cm

At 5.5 cm

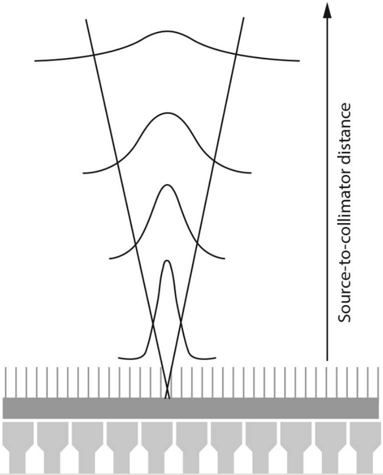


At 9.6 cm



Distance Vs. Resolution

Distance (cm)	Smallest Bar Resolved (mm)
0	2.5
5.5	3.0
9.6	None



Theoretical Estimation

Small Bar Resolved Estimations

$$\ell_{eff} = \ell - 2\mu^{-1}$$

$$R_{coll} \approx d(\ell_{eff} + b)/\ell_{eff}$$

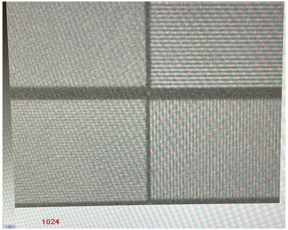
$$R_{coll} \approx 1.75SBR$$

Where b is the collimator to source distance, d is the diameter, ℓ_{eff} is the "effective length" of the collimator holes, and μ is the linear attenuation coefficient.

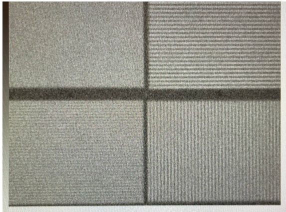
Distance (cm)	Estimated Smallest Bar Resolved (mm)	Smallest Bar Resolved (mm)
0	1.1	2.5
5.5	2.5	3.0
9.6	3.7	None

Matrix Size Vs. Resolution

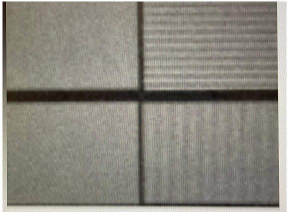
1024×1024



512×512

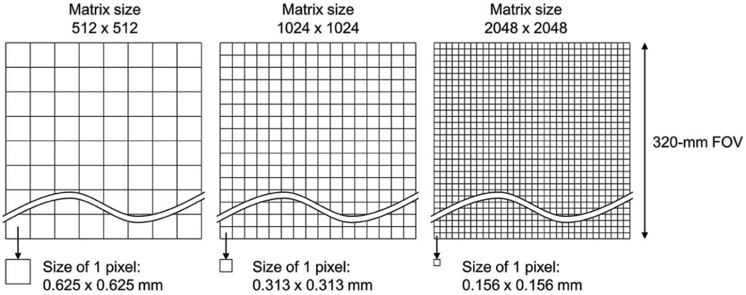


128×128



Matrix Size Vs. Resolution

Matrix Size	Pixel Size (mm)	Smallest Bar Resolved (mm)
1024x1024	0.6	2.5
512x512	1.2	2.5
128x128	4.8	None



Collimator Vs. Resolution

Collimator Vs. Resolution

Collimator	Smallest Bar Resolved (mm)
LEHR	2.5
MELP	2.5
HE	2.0

Collimators	LEHR	MELP	HE
Hole length (mm)	24.05	40.64	59.7
Septal thickness (mm)	0.16	1.14	2
Hole diameter across the flat source (mm)	1.11	2.94	4

The collimator resolution gets better when increasing the septal thickness and the length of the holes, allowing less scatter rays to enter the crystal. Wider holes do the oppsite, they increase the sactter and thus poorer resolution.

Outline

Extrinsic & Intrinsic Uniformity

Extrinsic & Intrinsic Uniformity

The gamma camera measures the intensity of emission form the source, and represents it as count per pixel. By using a uniform source, it is expected that the count per pixel should be the same across the image. Gamma camera ***Unifomity Test*** measures how uniform the images is when using a uniform source.

Test	Mcts	Int. CFOV	Int. UFOV	Diff. CFOV	Diff. UFOV
Extrinsic	10	≤5.00%	≤6.00%	≤3.50%	≤4.00%
Intrinsic	30	≤2.40%	≤2.80%	≤1.90%	≤2.20%

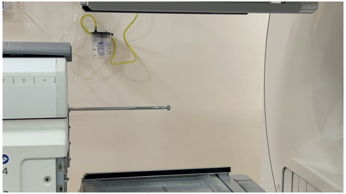
$$\text{Integral Uniformity} = \frac{Max\ cts/pixel - Min\ cts/pixel}{Max\ cts/pixel + Min\ cts/pixel} \times 100\%$$

$$\text{Differential Uniformity} = \frac{High - Low}{High + Low} \times 100\%$$

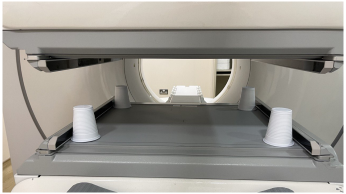
Test Setup

^{57}Co Flat Source

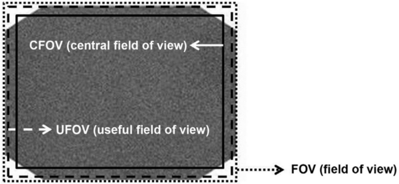
Built-in ^{57}Co Point Source

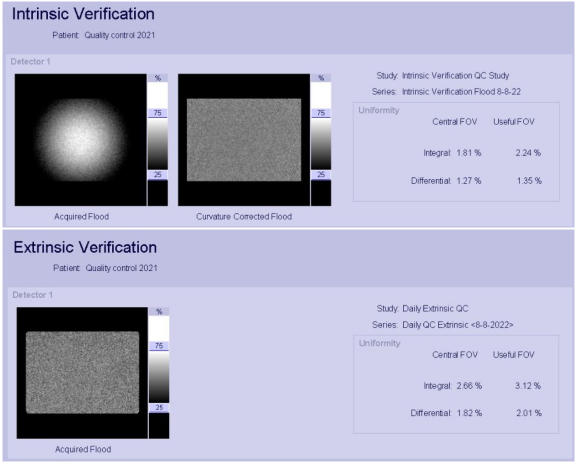


Four Cups



Extrinsic & Intrinsic Uniformity





Test Results

Mcts	Int CFOV	Int UFOV	Diff CFOV	Diff UFOV	Pass/Fail
5	3.58%	4.03%	2.86%	2.86%	Pass
10	2.64%	2.95%	1.92%	2.34%	Pass
15	2.53%	3.04%	2.02%	2.02%	Pass

Mcts	Int CFOV	Int UFOV	Diff CFOV	Diff UFOV	Pass/Fail
10	3.71%	4.47%	1.94%	2.17%	Fail
15	2.43%	3.07%	1.65%	1.65%	Fail
30	1.89%	2.06%	1.20%	1.34%	Pass

The intrinsic uniformity is more sensitive to counts, hence it failed when lower count was used

References

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Questions?

Thank you!