

NEMA Performance Evaluation of the DISCOVERY MI 25 cm Axial Extent Digital PET/CT Scanner

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Disclosures

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- SIEMENS research grant

Introduction

- Performance characterization was conducted according to NEMA NU2-2012.
- Data was collected from 3 centers (MDA, UW, MGH) and averaged.
- Data for:
 - Spatial resolution
 - Sensitivity
 - Count rate
 - Accuracy
 - Timing and energy resolution*
- Comparison with other systems are also provided







Detector block

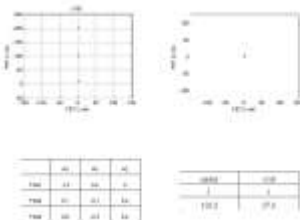
9x5=45; total slices is 2n-1= 89



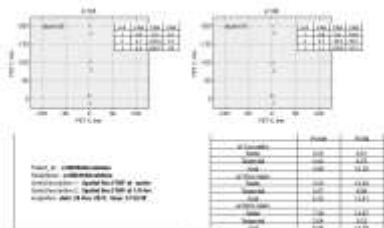
4x3 "optical block" The light from those crystals is directed towards a single SiPM chip.
 What's hard to see in the figure is that the chip is a hex device, with 3x2 operationally independent devices on it.
 So the light encoding is 12 crystals to 6 SiPM channels.
 picture shows twelve blocks, or an assembly of 16x9 crystals, that is nominally 64x48 mm in size.



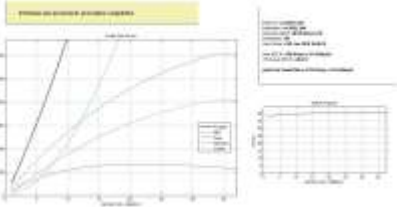
Spatial Resolution



Spatial Resolution



Count Rate



268.9 kcps @21 kBq/cc

Image Quality

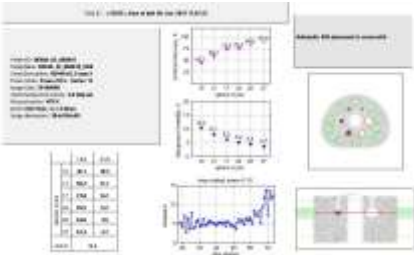


Image Quality

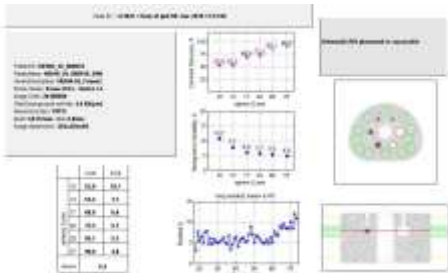
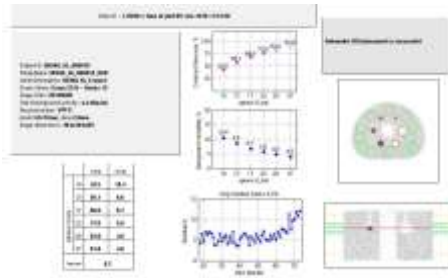
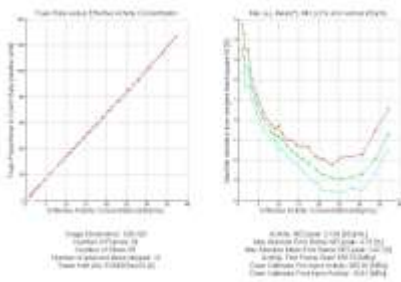


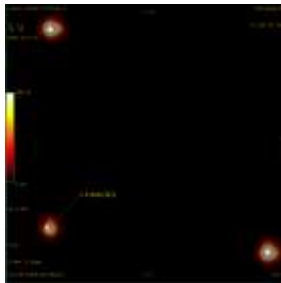
Image Quality



Accuracy



Alignment



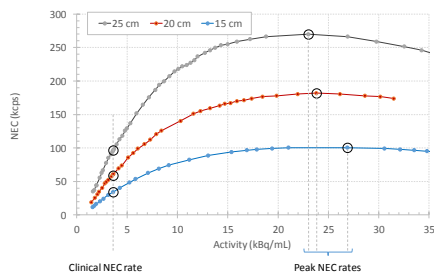
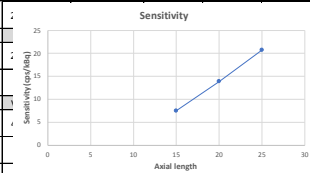
Overall summary from 3 centers:

Parameter	Result	Parameter	Result
Spatial resolution, FBP			
Radial, 1 cm	4.30 ± 0.21 / 8.79 ± 0.02	Sensitivity	(cps/kBq)
Tangential, 1 cm	4.28 ± 0.07 / 8.54 ± 0.14		Center
Radial, 10 cm	5.51 ± 0.05 / 10.5 ± 0.10		10 cm
Tangential, 10 cm	4.56 ± 0.02 / 8.88 ± 0.21		20.84 ± 1.13
Radial, 20 cm	6.49 ± 0.26 / 13.0 ± 1.0		20.91 ± 0.943
Tangential, 20 cm	5.01 ± 0.06 / 9.13 ± 0.26		
Radial, 30 cm	6.56 ± 0.33 / 13.7 ± 1.2		
Tangential, 30 cm	5.01 ± 0.06 / 9.13 ± 0.26		
Spatial resolution, IR			
Radial, 1 cm	3.79 ± 0.06 / 7.74 ± 0.06		
Tangential, 1 cm	3.91 ± 0.09 / 7.74 ± 0.16		
Radial, 10 cm	4.21 ± 0.18 / 8.68 ± 0.11		
Tangential, 10 cm	4.73 ± 0.09 / 8.89 ± 0.05		
Radial, 20 cm	3.98 ± 0.02 / 7.79 ± 0.07		
Tangential, 20 cm	4.48 ± 0.54 / 9.23 ± 0.27		
Radial, 30 cm	7.15 ± 0.01 / 12.8 ± 0.04		
Tangential, 30 cm	4.29 ± 0.20 / 8.46 ± 0.22		
Radial, 40 cm	4.91 ± 0.30 / 9.29 ± 0.05		
Counting rate statistics			
		Peak NEC rate	296.3 ± 4.58 kcps
		Peak NEC activity	20.8 ± 0.48 kBq/ml
		Peak true rate	1719 ± 98.3 cps/kBq
		Peak true activity	34.5 ± 1.01 kBq/ml
		Peak NEC SF	40.2 ± 0.26 %
		Maximum error	3.81 ± 1.0 %
Image Quality, IR			
		CR, IRV	
		10 mm	46.2 ± 10.1 / 9.26 ± 1.6 %
		13 mm	54.3 ± 3.4 % / 7.07 ± 0.93 %
		17 mm	66.1 ± 2.6 % / 5.38 ± 0.65 %
		22 mm	71.1 ± 2.1 % / 4.37 ± 1.2 %
		28 mm	85.3 ± 1.9 % / 3.80 ± 1.4 %
		37 mm	89.3 ± 1.4 % / 3.45 ± 1.4 %
		Average lung error	5.85 ± 1.1 %
		Timing resolution	391.7 ± 5.51 ps
		Energy resolution	9.58 ± 0.05 %

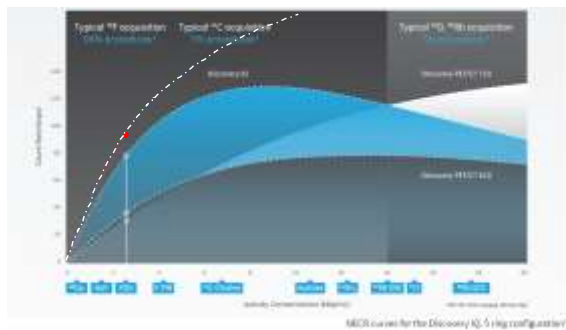
FBP = filtered back projection, FWHM = full width at half maximum, FWTM = full width at tenth maximum, IR = iterative reconstruction, NEC = noise-equivalent counting, SF = scatter fraction, CR = contrast recovery, IRV = background variability.

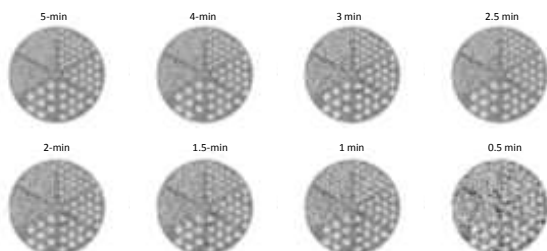
System comparisons

	DMI 5 Ring	DMI 4 Ring	DMI 3 Ring	D-710	PET/MR	D IQ 25cm
Sensitivity (cps/kBq)						22.8/20.4
Count Rate						
Peak NECR (kcps@kBq/ml)						124@9.1
Scatter Fraction at PNECR (%)						36.2
Image Quality $4/1$ ratio (%)						QCI(8/12)
Hot contrast (10, 13, 17, 22 mm)						22,44,68,76
Cold Contrast (28, 37 mm)						73,81
Bkg Var (10,13,17,22,28,37 mm)						3,3,2,3,3,3
Lung Error	5.8	4.9		18.2	5	9.3
Accuracy (%)	3.6	3.14		3.5	2.9	3.9

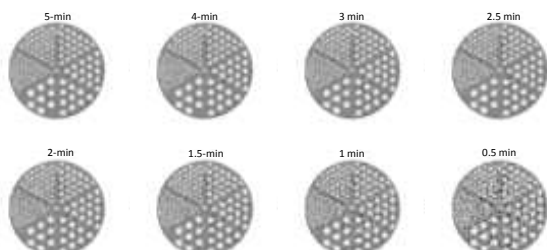


Slide courtesy of Paul Kinahan, additional data courtesy of John Sunderland





The images of the ACB spatial resolution section reconstructed with the OSEM reconstruction including time-of-flight and point-spread-function corrections for 2 iterations, 17 subsets, and 5 mm cut-off frequency post-reconstruction filtering. All 5 resolution sectors of 6.4, 7.0, 9.5, 11.1 and 12.7 mm are visible for the images of 1.5 to 5 min/bed.



The images of the ACB spatial resolution section reconstructed with the Q.Clear reconstruction of parameter=350. All 6 resolution sectors of 4.8, 6.4, 7.0, 9.5, 11.1 and 12.7 mm are visible for the images of 1.5 to 5 min/bed.

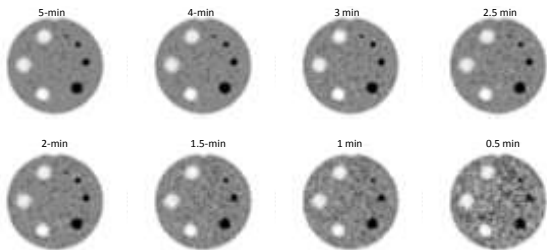
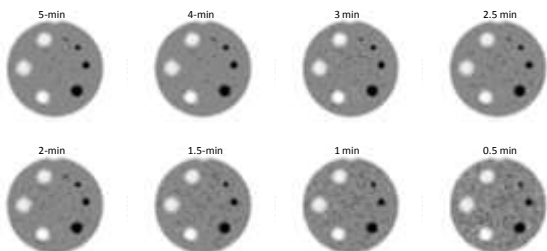


Figure 3. The images of the ACR contrast resolution section reconstructed with the OSEM reconstruction including time-of-flight and point-spread-function corrections for 2 iterations, 34 subsets, and 5 mm cut-off frequency post-reconstruction filtering. All four high contrast cylinders of 8, 12, 16 and 25 mm diameter are visible for the images of 2 to 5 min/bed.

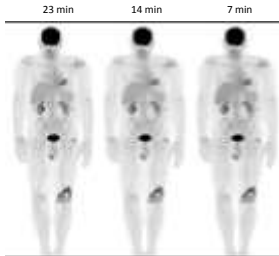


The images of the ACR contrast section reconstructed with QClear of parameter=350. All four high contrast cylinders of 8, 12, 16 and 25 mm diameter are visible for the images of 2 to 5 min/bed.



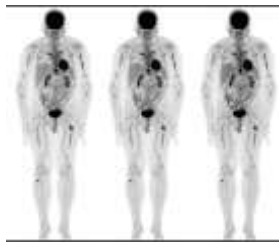
Total of 4 beds

12 min 8 min 5.3 min
MP images of a patient with BMI=35 with injection activity of 11.5 mCi and uptake time of 60 min. The images from left to right correspond to the scan time of 3, 2 and 1.3 min/bed. The total times from left to right for the three scans were 12, 8 and 5.3 min.



MIP images of a patient with BMI=28 with injection activity of 11 mCi and uptake time of 68 min. The total acquisition times were 23, 14 and 7 min from left to right corresponding to 3, 2 and 1 min/bed, respectively, for 5 beds from head to mid thigh and 2, 1 and 0.5 min/bed, respectively, for 4 beds over the legs.

Total of 9 beds



MIP images of a patient of BMI=27 with injection activity of 2.8 mCi and uptake time of 72 min. The images from left to right were 3, 2 and 1 min/bed for 9 beds for the total scan time of 27, 18 and 9 min, respectively.

Conclusion

- DMI-5 rings, currently the commercial system with the highest sensitivity, count rate performance.
- Allows faster scan times and/or lower injected activity
- Leads to better patient experience
- Currently working on optimizing clinical protocols (Acquisition and reconstruction parameters).



Total of 9 beds

MP image of a patient with BMI-30 with injection activity of 7.8 mCi and uptake time of 75 min. The total acquisition time was 8 min: 1 min/bed for 5 beds from head to mid-thigh, and 45 sec/bed for 4 beds over the legs.



MP image of a patient with BMI-28 with injection activity of 6.3 mCi and uptake time of 61 min, who could not hold still due to severe pain. The total acquisition time was 5 min with 1 min/bed for 5 beds. There was motion artifact in the right wrist area.
