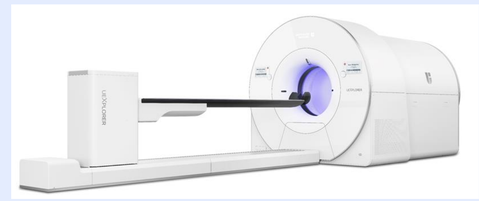
Relationships between noise-equivalent count rates for extended NEMA NU 2-like scatter phantoms and a human subject scanned using the EXPLORER total-body PET scanner



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Introduction

- Noise-equivalent count rate (NECR) is a performance metric that is used to evaluate the performance of PET scanners.

- Conventionally, NECR is measured by scanning the NEMA NU 2 scatter phantom (NECR phantom).

- The NECR phantom (at 70 cm) is considerably shorter than the ~ 2 m axial field of view (FOV) of the EXPLORER scanner, so we also measured NECR of the scanner using extended NECR phantoms (175 and 210 cm).

- We compared the phantom-based NECR measurements to NECR measurements derived from a human subject scan to determine the phantom length that best approximated the count rate and noise properties of a human subject in the EXPLORER scanner.

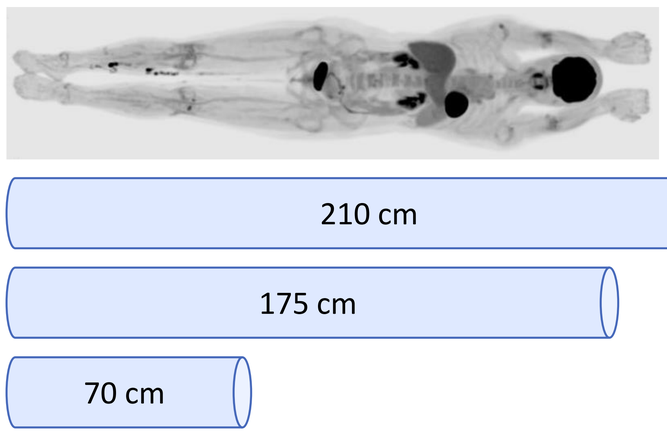

Fig. 1 (left). Size comparison between a 156 cm female subject to standard/extended NECR phantoms (approx. to scale). Fig. 2 (right). An extended NECR phantom on the patient bed.

Methods

- *Phantoms:* a standard NECR phantom, and two extended phantoms (175 and 210 cm long) were used to measure the NECR of the scanner.
- *Human subject:* a 1-hr dynamic PET scan was performed on a female subject (height: 156 cm, weight: 56 kg) injected with 250 MBq of FDG. Data from the last 5 minutes of the scan were used to calculate NECR.
- *Data analysis:*
  - **Phantoms:** data acquisition and analysis were performed according to the NEMA NU 2-2012 protocol.
  - **Human subject:** lines-of response (LORs) that did not intersect the human subject (determined based on the forward projection of a CT scan) were excluded from the NECR calculation.
- *Maximum unit difference (MUD):* the EXPLORER scanner consists of 8 PET detector module ring units, with each unit being ~ 24 cm in length. The maximum acceptance angle for coincidence events can be adjusted by changing the MUD.
  - The NECR was measured for MUDs of 0 – 4 to assess the effect of maximum acceptance angle on NECR. The MUD range corresponds to an axial "acceptance FOV" from ~ 24 cm to 120 cm.

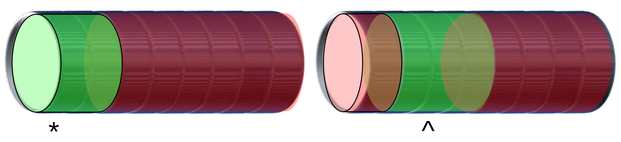

Fig. 2. A visual representation of the axial "acceptance FOV" based on MUD. (Left) MUD of 1 with the 1st PET unit (*) being the reference unit. (Right) MUD of 1 with the 3rd PET unit (^) being the reference unit.

Results and Discussion

- At 3.1 kBq/cc, the human-derived NECR was the highest with a MUD of 2 (1294 kcps), followed by MUDs of 3 (1255 kcps), 4 (1177 kcps), 1 (993 kcps) and 0 (434 kcps).

- Only the standard phantom had the highest NECR peak with a MUD of 4. The two extended phantoms had the highest NECR peaks at either MUDs of 2 or 3.

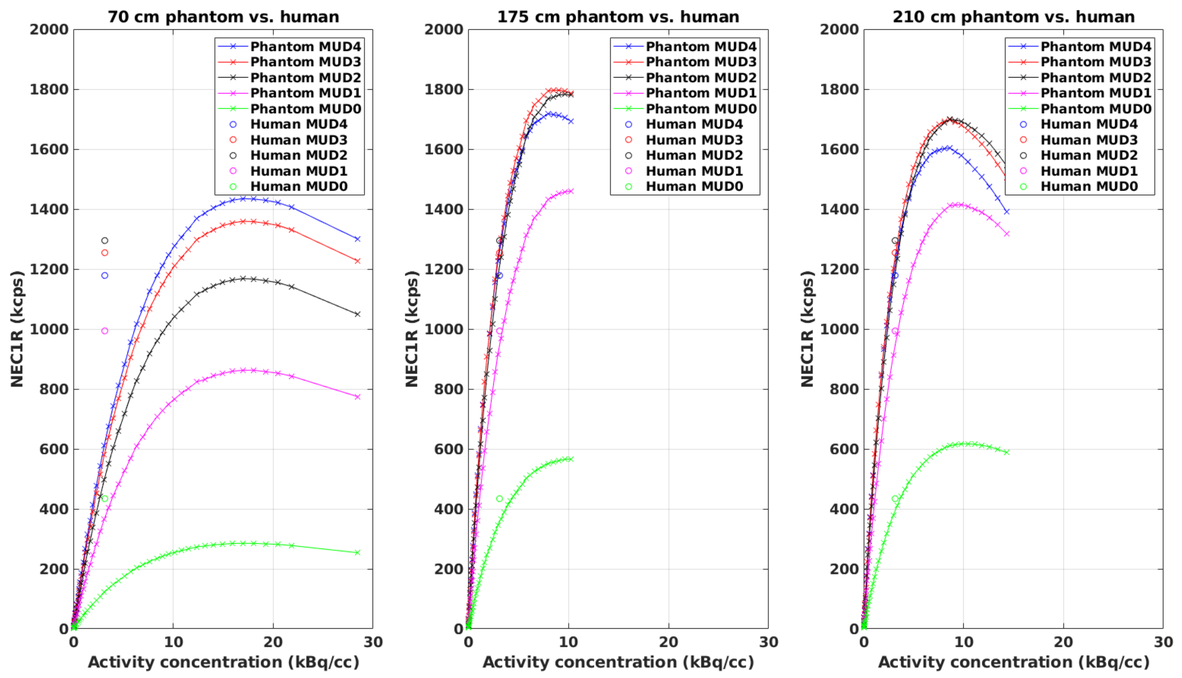

Fig. 3. NECR comparison between standard/extended NECR phantoms and the human subject.

- At first glance, it may seem natural to think that the larger the MUD, the higher the peak NECR since more true coincidences are collected when using a larger acceptance angle. However, a larger MUD also leads to an increased fraction of scattered and random coincidences in the data.

- Although time-of-flight (TOF) was not included in the assessment, the use of TOF-weighted NECR may increase the optimal MUD since TOF increases the value of true coincidences and reduces the importance of random coincidences.

- The excellent agreement between the human subject NECR and the 175 cm phantom NECR should not be over-interpreted. Human body habitus varies widely and a number of approximations were made in estimating the NECR for the human subject.

Summary

- Extended NECR phantoms may more appropriately reflect the count rate conditions encountered when imaging human subjects compared to the standard NEMA NU 2 scatter phantom, and this work suggests their future use for comparing the performance of long axial FOV PET scanners.

Acknowledgements

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