Performance Measurements of a Novel Mobile NeuroPET-CT

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NeuroPET-CT is a mobile full-ring PET-CT system

Brain Imaging

“Small” Animal Imaging

Pediatric Imaging
NeuroPET-CT was installed at Massachusetts General Hospital in November, 2011
NeuroPET-CT

CT
✓ 140 kVp at 7.5 mA
✓ 60 rpm, 1440 views/sec
✓ 3264 detector channels
✓ 8 axial channels

PET
✓ FOV: 25 cm in diameter
  22 cm in axial length
✓ 77700 2.4×2.4×10 mm LYSO crystals (dual-layer)
✓ 12096 SiPMTs
✓ GPU reconstruction engine
PET Detectors

Detector modules
7 x 3 x 4 = 84 blocks

Crystal and SiPMT arrays
2.4 x 2.4 x 1 cm (dual-layer)
2 cm thickness
# Dedicated Brain PET

## ECAT HRRT vs. NeuroPET-CT

<table>
<thead>
<tr>
<th></th>
<th>ECAT HRRT</th>
<th>NeuroPET-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal</td>
<td>LSO/LYSO (dual-layer)</td>
<td>LYSO/LYSO (dual-layer)</td>
</tr>
<tr>
<td>Crystal Size</td>
<td>2.1 x 2.1 x 10 mm³</td>
<td>2.4 x 2.4 x 10 mm³</td>
</tr>
<tr>
<td>PMT</td>
<td>Conventional PMT</td>
<td>SiPM</td>
</tr>
<tr>
<td>DOI method</td>
<td>light decay time</td>
<td>light spread pattern</td>
</tr>
<tr>
<td>DOI Resolution</td>
<td>10 mm</td>
<td>10 mm (not implemented yet)</td>
</tr>
<tr>
<td>FOV (diameter)</td>
<td>312 mm</td>
<td>250 mm</td>
</tr>
<tr>
<td>FOV (axial length)</td>
<td>250 mm</td>
<td>220 mm</td>
</tr>
<tr>
<td>Detector modules</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Detector blocks in each module</td>
<td>9 x13 = 117</td>
<td>3x4 = 12</td>
</tr>
<tr>
<td>Crystals in each block</td>
<td>128</td>
<td>925</td>
</tr>
<tr>
<td>PMTs in each module</td>
<td>140</td>
<td>1728</td>
</tr>
<tr>
<td>CT</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Portability</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Spatial Resolution

#### 2D-FBP

<table>
<thead>
<tr>
<th>R [cm]</th>
<th>ECAT HRRT Transverse [mm]</th>
<th>NeuroPET-CT (D) Transverse [mm]</th>
<th>NeuroPET-CT (M) Transverse [mm]</th>
<th>ECAT HRRT Axial [mm]</th>
<th>NeuroPET-CT (D) Axial [mm]</th>
<th>NeuroPET-CT (M) Axial [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.65</td>
<td>3.10</td>
<td>3.19</td>
<td>3.0</td>
<td>3.30</td>
<td>4.79</td>
</tr>
<tr>
<td>5</td>
<td>N/A</td>
<td>3.62</td>
<td>3.51</td>
<td>N/A</td>
<td>3.54</td>
<td>5.23</td>
</tr>
<tr>
<td>10</td>
<td>3.05</td>
<td>4.93</td>
<td>4.39</td>
<td>5.40</td>
<td>4.45</td>
<td>5.81</td>
</tr>
</tbody>
</table>

#### 3D OP-OSEM (HRRT), MLEM (NeuroPET-CT)

<table>
<thead>
<tr>
<th>R [cm]</th>
<th>ECAT HRRT Transverse [mm]</th>
<th>NeuroPET-CT (D) Transverse [mm]</th>
<th>NeuroPET-CT (M) Transverse [mm]</th>
<th>ECAT HRRT Axial [mm]</th>
<th>NeuroPET-CT (D) Axial [mm]</th>
<th>NeuroPET-CT (M) Axial [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.30</td>
<td>2.40</td>
<td>2.69</td>
<td>2.50</td>
<td>3.22</td>
<td>4.7</td>
</tr>
<tr>
<td>5</td>
<td>N/A</td>
<td>2.65</td>
<td>3.03</td>
<td>N/A</td>
<td>3.54</td>
<td>5.31</td>
</tr>
<tr>
<td>10</td>
<td>2.93</td>
<td>4.10</td>
<td>3.84</td>
<td>3.40</td>
<td>4.31</td>
<td>6.18</td>
</tr>
</tbody>
</table>

NeuroPET-CT(D): direct plane  
NeuroPET-CT(M): MRD=11.7 cm

Spatial Resolution

FBP

MLEM
Sensitivity
point source at the center of FOV

![Graph showing sensitivity as a function of lower energy cut in keV, with data points for NeuroPET-CT: MRD=21.5 cm and NeuroPET-CT: MRD=11.7 cm.](image)
Sensitivity
point source at the center of FOV

Sensitivity
Line source (NEMA): normalized to 70-cm

- NeuroPET-CT: MRD=21.5 cm
- NeuroPET-CT: MRD=11.7 cm

[Graph showing sensitivity as a function of accumulated sleeve thickness.
Sensitivity values range from 0.4 to 2.0%.
Accumulated sleeve thickness ranges from 0 to 14 cm.]
Sensitivity

Line source (NEMA): normalized to 70-cm

Sensitivity
Line source (NEMA): normalized to 70-cm

HR+ results: measured at Massachusetts General Hospital
Sensitivity
Line source (NEMA): normalized to axial FOV

- NeuroPET-CT: MRD=21.5 cm
- NeuroPET-CT: MRD=11.7 cm
Sensitivity
Line source (NEMA): normalized to axial FOV

HR+ result: measured at Massachusetts General Hospital
Counting Rates

![Graph showing coincidence rate vs. activity concentration. The graph includes four lines representing Prompts, Random, TRUE, and Scatter.](image)
Counting Rate

NEC rate of about 38 kHz for 3.7 kBq/ml

Green band: 100-kg patient, SUV=1.5, 200-400 MBq injection dose
Dominoid Phantom

Hole size/spacing (mm): 4.7/9.6, 3.9/8, 3.5/7.2, 3.2/6.3, 2.7/2.55, 2.4/4.7
Conclusions

- NeuroPET-CT is a mobile full-ring PET-CT scanner that achieved
  - good spatial resolution
  - high sensitivity
  - good NEC rate
- More NEMA tests, phantom and patient studies are needed in the future to assess its performance.
THANK YOU!