TIPP09
Electron Tracking Compton
Gamma-ray Camera for Drug Design
and Medical Imaging
EPOCHAL TSUKUBA March 14, 2009

Shigeto Kabuki¹, Hidetoshi Kubo¹, Kentaro Miuchi¹, Hiroyuki Kimura², Hiroo
Amano², Hidekazu Kawashima³, Masashi Ueda³, Yui Makamoto³, Kori
Togashi³, Hideo Saji², and Toru Tanimori¹

¹, Department of Physics, Graduate School of Science, Kyoto University;
², Department of Patho-Functional Bioanalysis, Graduate School of Pharmaceutical Sciences,
Kyoto University;
³, Department of Diagnostic Imaging and Nuclear Medicine, Kyoto University
Department of Physics, Kyoto University, Japan

H. Kimura, H. Amano, H. Kawashima, H. Saji, M. Ueda
Department of Patho-Functional Bioanalysis, Kyoto University, Japan

Y. Nakamoto, T. Okada, K. Togashi
Department of Diagnostic Imaging & Nuclear Medicine, Kyoto University, Japan

R. Kohara, T. Nakazawa, O. Miyazaki, T. Shirahata, E. Yamamoto
Hitachi Medical Corporation, Japan

A. Kubo, E. Kunieda, T. Nakahara
Department of Radiology, Keio University, Japan

K. Ogawa
Department of Electronic Informatics, Hosei University, Japan
Molecular imaging & Motivation
Principle of Electron Tracking Compton Camera
Performance of Electron Tracking Compton Camera
New drug design for molecular imaging
Summary
Image the morbid life phenomenon and physiology of the living body at molecular level from the outside the body

(Radiology, 219 (2001).)
Molecular Imaging

New imaging material

Molecular Probe

Drug design • Clinical application

Bio Marker

Imaging detector

New Probe

Visualize
- PET : E=511keV
- SPECT : E<300keV
- New device

New device
New lots of RI available

- The development of new RI drug.
- Long life nuclide, metal nuclide
  \[\Rightarrow\] visualize the anti body, enzyme, protein reaction

Multi-RI Imaging

- Simultaneous observation of plural metabolism and interaction
Electronic track is caught with an original detector (Three patents).

- An arrival direction of the gamma ray is calculated for every event.
- Noise is rejected by momentum and geometry information $\alpha$.

$$\cos \alpha = \left( 1 - \frac{m_e c^2}{E_g} \right) \sqrt{\frac{K_e}{K_e + 2m_e c^2}}$$
Gamma-ray Imaging

Electron Tracking method

Real data 100 events

Simulation result
Schematic view of μ-PIC technology

μ-PIC
Micro Pixel Chamber

Gas sealed vessel

400mm
10x10cm² Camera
(GSO or LaBr₃)

- Number of pixels: 576
- Pixel size: 6 × 6 × 13mm³ (GSO)
  6 × 6 × 15, 20mm³ (LaBr₃)
- GSO Energy resolution: 10.0% (@662keV, FWHM)
- LaBr₃ Energy resolution: 6.5% (@662keV, FWHM)
- Position resolution: 6mm

Black : GSO
Red : LaBr₃
Developed ETCC

10x10cm² Camera

30x30cm² Camera

Scintillator

μTPC

K. Ueno poster  C-5
List mode MLEM

List mode Maximum Likelihood Expectation Maximization (Listmode MLEM)

10cm line source
365 keV image
### Measured sources

<table>
<thead>
<tr>
<th></th>
<th>Ce-139</th>
<th>Cr-51</th>
<th>Ba-133</th>
<th>I-131</th>
<th>Au-198</th>
<th>Na-22</th>
<th>F-18</th>
<th>Cu-64</th>
<th>Cs-137</th>
<th>Mn-54</th>
<th>Fe-59</th>
<th>Zn-65</th>
<th>Co-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy [keV]</td>
<td>167</td>
<td>320</td>
<td>354</td>
<td>364</td>
<td>412</td>
<td>511, 1275</td>
<td>511</td>
<td>511</td>
<td>662</td>
<td>835</td>
<td>1095, 1292</td>
<td>1116</td>
<td>1173, 1333</td>
</tr>
</tbody>
</table>

Energy dynamic range: 167 – 1333 keV.
Spatial resolution vs. Energy

Goal: Same resolution as human PET @ 511keV

Goal in 2009
Uniformity of ETCC

• Flat Panel size = FOV
• Energy = 365 keV

Uniformity |x, y| < 7 cm: 11.1% (1σ)
Example Images
Molecular Imaging
I-131-5IA nAChRs imaging
Drug Delivery System (DDS)
Au-198-nanoparticles
Double Clinical Tracer Imaging
FDG & I-131-MIBG
High energy nuclide Imaging
Zn-65-porphyrin Imaging
I-131-5IA nAChR imaging

I-131-5IA have been developed by the H. Saji lab for molecular imaging. We performed the imaging of nicotine acetylcholine receptor (nAChR) in the rat central nervous system using I-131-5IA.

The high accumulation in the brain was visualized.
Drug Delivery System (DDS)

Drug carrier candidates

Ribosome

Hemoglobin

Au nano particle

Drugs

Inside

Other organs

No side effect

TUS
Yuasa lab.
WEB page
Porphylin accumulation in tumors.

**Therapy**

- PDT (Photodynamic therapy)

**Diagnosis**

- PDD (Photodynamic diagnosis)

Application for cancer imaging

**E.G. Stomach Cancer**

This probe is available for the stomach cancer that it is hard to detect using FDG.

Porphylin $+^{59}\text{Fe, }^{54}\text{Mn, }^{65}\text{Zn imaging using ETCC}$
Compton Camera has a wide energy dynamic range and wide field of view.

We have developed the ETCC camera for molecular imaging.
- Spatial resolution 11mm (FWHM) @ 511 keV
- Uniformity 11.1% (1σ)

We have studied the new probes for molecular imaging.
- I-131-5IA
- double tracer I-131-MIBG & FDG
- Au-198 DDS
- Zn-65-Porphyrin