Development and evaluation of high-resolution gamma camera for animal imaging

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Abstract

Recently, α-ray emitting radionuclides, which can treat cancer locally and effectively, have been attracting attention in the field of nuclear medicine. Among these, ^{211}At, which is produced in cyclotrons in Japan, is particularly promising. Therefore, it is important to visualize the distribution of ^{211}At in vivo during targeted radioisotope therapy. Currently, human SPECT is used for ^{211}At imaging in animal studies, with a typical resolution of approximately 5-10 mm. However, the resolution is insufficient for animal imaging experiments because of small sample sizes. Therefore, we developed high-resolution gamma cameras for mouse imaging that are inexpensive and easy to use. Here, we experimented with 81 keV γ-rays from ^{133}Ba , which have a similar energy of X-rays emitted by ^{211}At. By applying a correction method for image distortion and source intensity, a resolution of 0.6 mm was achieved. Additionally, a camera capable of imaging the entire mouse body is necessary to track drug dynamics. Therefore, we are working on expanding the device to a 10×10 cm² size while preserving its resolution.

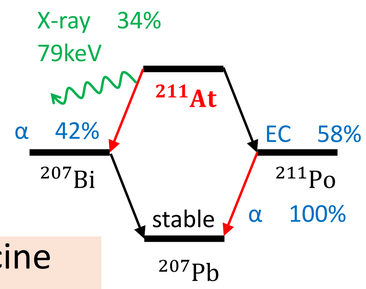
Introduction

◆ Targeted Radionuclide Therapy

- Expectations for α-ray emitting radionuclides
- α-ray emitting radionuclides : Short range and high energy deposit
- ⇒ Effective and localized treatment

◆ α-ray emitting radionuclides ^{211}At

- Actual 100% alpha-ray emitting nuclide
- Can be produced in Japanese cyclotrons
- Emits 79 keV X-rays that can be imaged



➢ ^{211}At is particularly promising in nuclear medicine
➢ Visualize the distribution of ^{211}At is important

◆ Radiological imaging in animal experiments

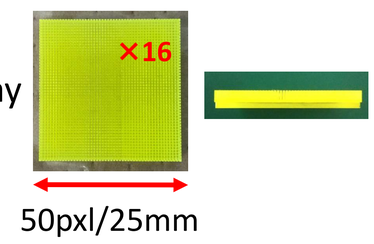
- Resolution of human SPECT (5-10mm) is not sufficient
  ⇒ higher resolution is needed
- To confirm drug distribution in vivo
  ⇒ whole body imaging of animals at once

➢ Development of a high-resolution, large-area gamma camera

Detector configuration

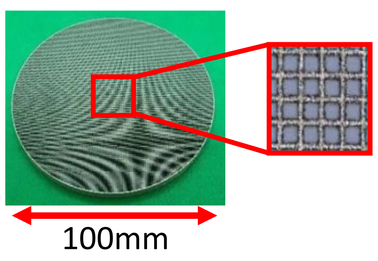
◆ Scintillator

- Dicing Pixelized GAGG(= $Gd_3(Ga,Al)_5O_{12}(Ce)$) array
- 1pixel: 0.5×0.5×t2mm^3
- Light guide: t1mm
- 50×50pixels/Scintillator ×16



◆ Collimator

- Tungsten parallel collimator
- Produced by 3D printer
  ⇒ High-definition structure
- ϕ100mm
- Pitch: 0.5mm



"TORAY" Innovation by Chemistry

◆ Photodetector

- Multi-pixel photon counter (MPPC) array
- 50×50 mm^2 ×4
- Resistor divider circuit on the back of each MPPC
- Signal readout at 4 ends

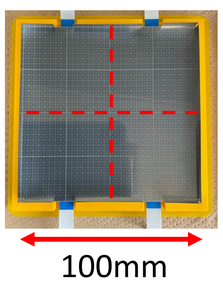


Image Reconstruction Method

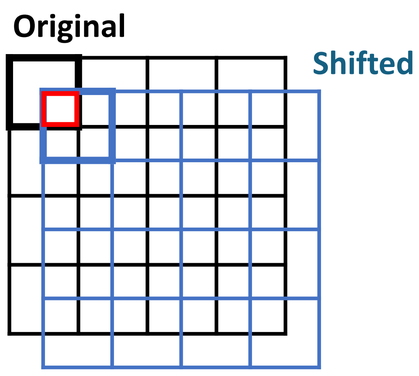
◆ Sub-pixel shift

- One of the super spatial resolution methods
  (Several low-resolution images→high-resolution image)

◆ Steps

1. Obtain the original image and the shifted image (shifted by half a pixel in both axes)
2. Calculate the average value of the overlapped area of the 2 images

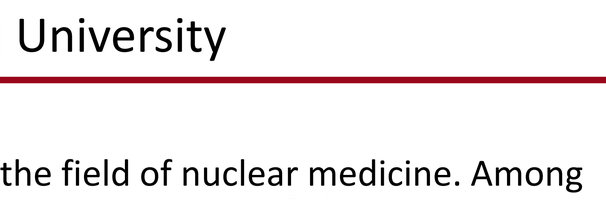
⇒ Generates an image with half the pixel size



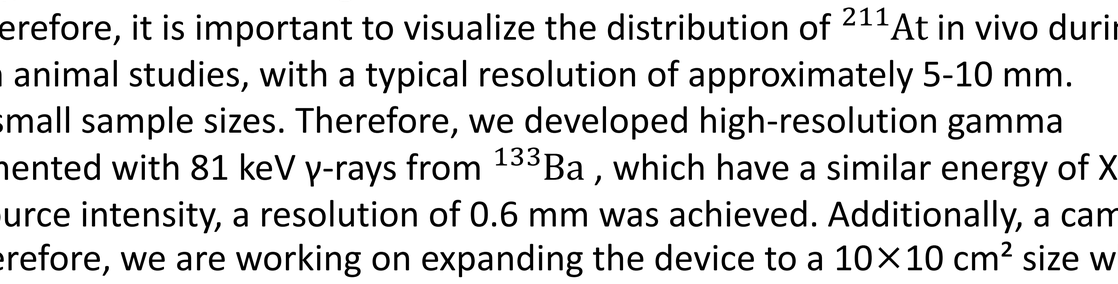
Imaging of ^{133}Ba source

◆ Conditions

- Point source is placed far away from the slit
  ⇒ Nearly parallel rays
- Width of slit : 1.2, 1.0, 0.8, 0.6mm
- Apply pixel shift method
- Energy window : 81±10 keV



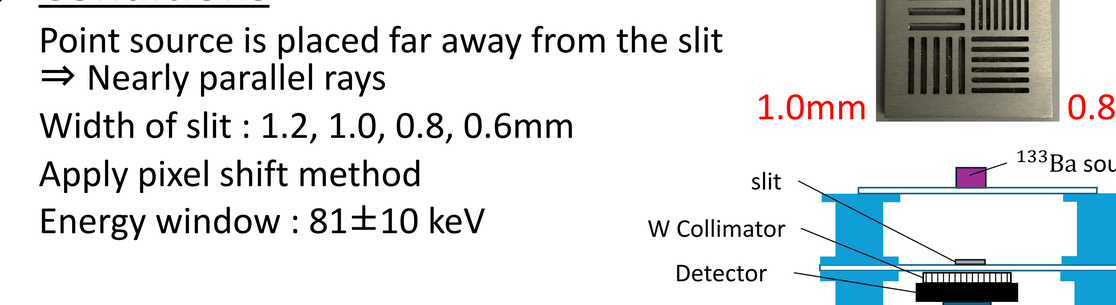
◆ Normal SPECT reconstruction



➢ The shape of the slit is apparent
➢ Peak separation is not clear

◆ With pixel shift methods

- Total statistics are the same as Normal SPECT reconstruction

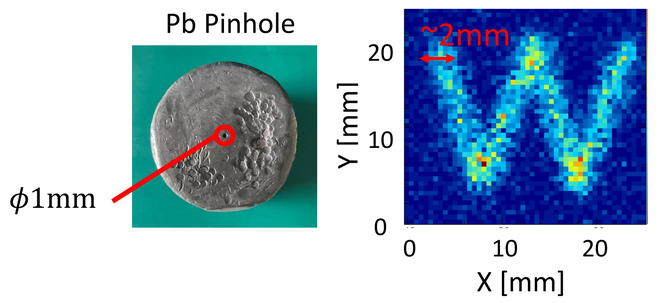


✓ 0.6mm slits separated!
✓ Improved visual separation of slits
✓ Suggests the usefulness of pixel shift methods

Imaging of moving ^{241}Am source

◆ Conditions

- Measurement time : 1 h
- Energy window : 60±10 keV
- ^{241}Am source (ϕ 1mm)
- Move the detector to draw the letter "W"



✓ Successful tracking of the moving source

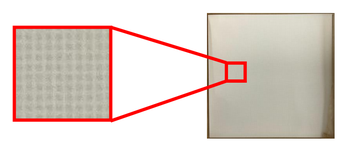
Conclusion & Future work

◆ Conclusion

✓ Development of a High-Resolution Gamma Camera for animal Imaging
✓ Achieved 0.6mm slit separation in ^{133}Ba standard source imaging
✓ Suggests the usefulness of pixel shift methods
✓ Moving source was successfully imaged

◆ Future work

✓ Completing a 100 × 100mm^2 size detector
✓ Conducting in-vivo imaging of ^{211}At
✓ Development and imaging of a device of the same configuration using CsI scintillator



CsI(Tl) scintillator
1 pixel ： 0.5 × 0.5 × t3mm^3