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Performance Evaluation of A Prototype PET Detector With High-Growth-Rate Scintillator and Wavelength-Shifting Fibers

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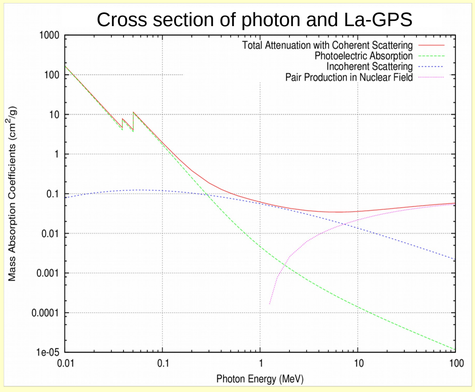
Introduction

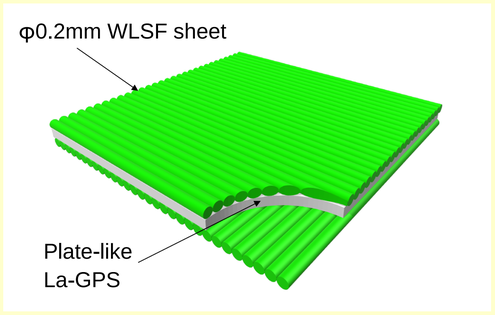


Photon cross section in scintillator[1]

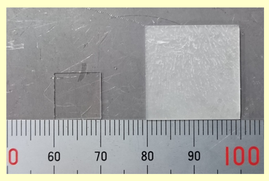
- In scintillator, Compton scattering occur 4 times as much as photoelectric absorption with 0.511-MeV gammaray[1]
- Compton scattering makes PET's images unclear.

Identifying scattering events in scintillator is important for PET.

Our detector

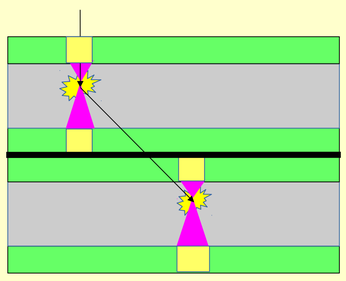


Layers of Plate-like HGR La-GPS and WLSF
・HGR La-GPS[2] ($[Ce_{0.01}La_{0.24}Gd_{0.75}]_2Si_2O_7$)
Lower cost (about one-fifth the cost of normal crystals)



Left : Normal-crystal (1 cm × 1 cm)
Right : HGR crystal (2 cm × 2 cm)

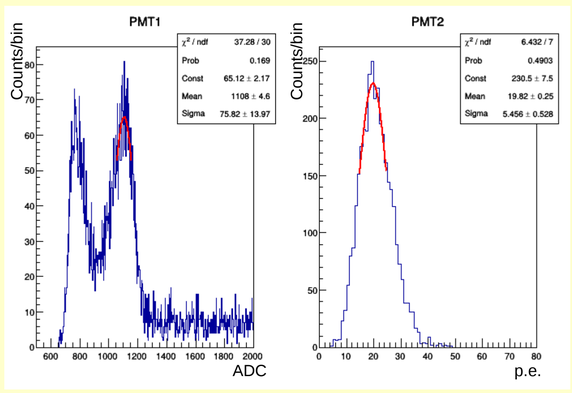
・Layers
Measuring Z-component and identifying scattering event
・WLSF[3]
Measuring X- (top surface) , Y- (bottom surface) component and energy deposit

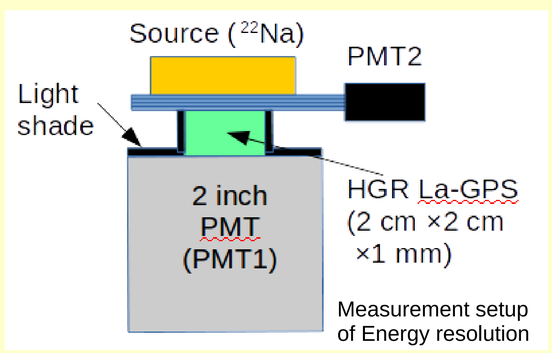


Identifying and analysis method

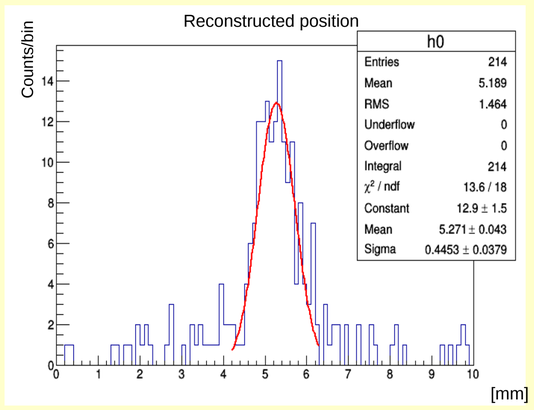
Signals from plural layers
→Considering as a scattering event
→Regarding the nearest point to the body as the first emission point

Experimental data about resolution





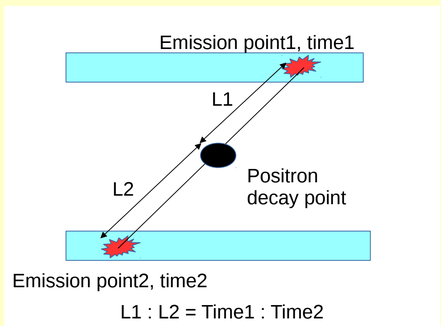
Measurement setup of Energy resolution



$N_{p.e.}$ at 511-keV with 2 WLSF sheets :
19.8 p.e. ± 5.46 p.e. (σ)[4]
(single-face, single-end readout)
↓
79.2 p.e. ± 10.9 p.e. (σ)
(double-faces, double-ends readout)
Energy resolution : 32.3% (FWHM)

Position resolution : 1.04 mm[4]
(FWHM)

Simulation method and results



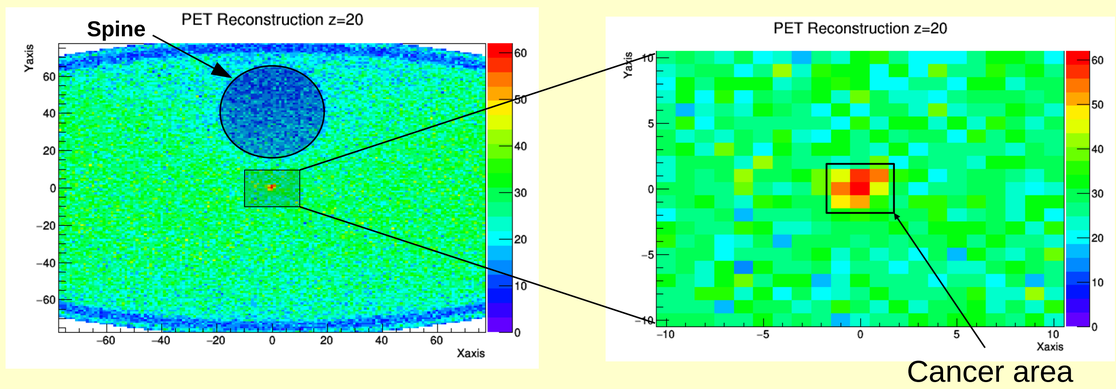
Reconstructing method

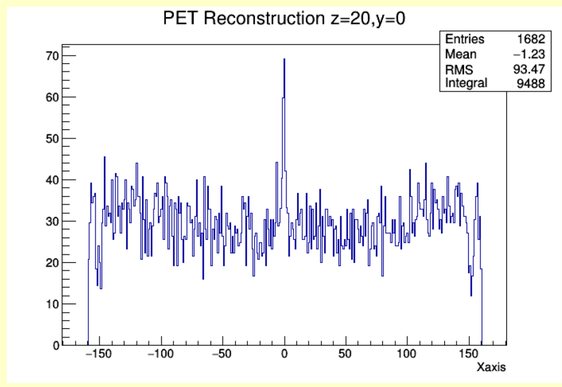
①Measuring 71.5 p.e. – 86.9 p.e. in 2 detectors
②Analyzing first emission points (scattering event : adopting nearest point to the body)
③Calculating positron decay point by the method in left figure

$$pos_{decay} = \frac{time_1 pos_2 + time_2 pos_1}{time_1 + time_2}$$

④Filling decay point in histogram (bin-size : 1 mm)

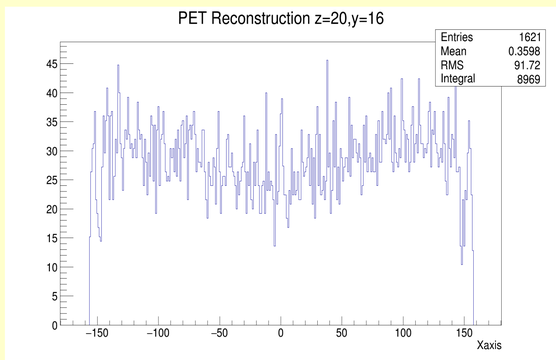
Result





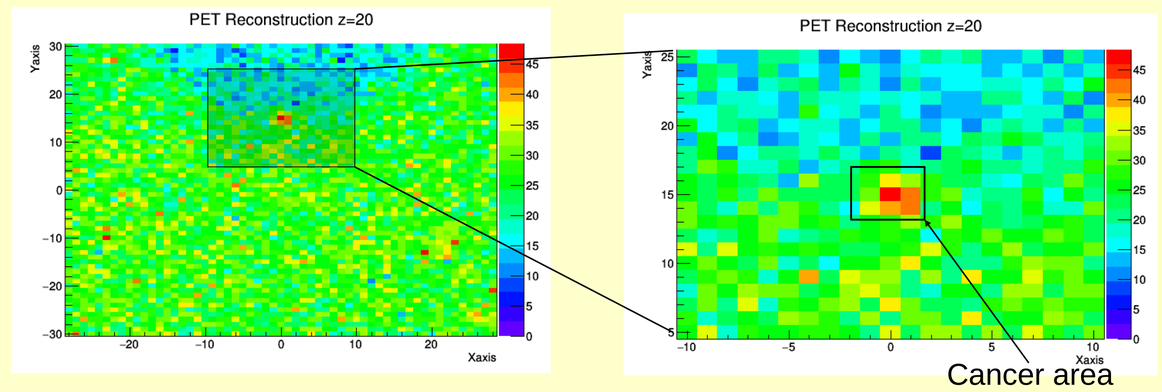
①Center of human
Background level : 28.2 (σ=5.31)
Cancer level : 22.2

Counts in cancer area are more than 3σ in background.

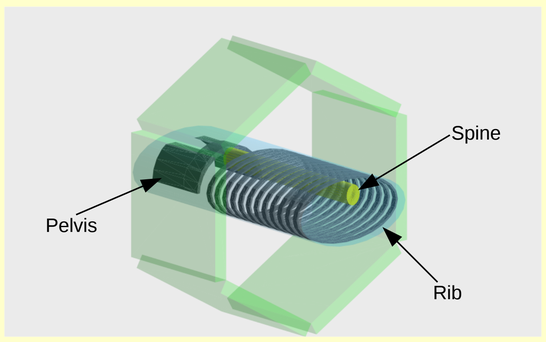


②Beside spine
Background level : 26.2 (σ=5.12)
Cancer level : 11.3

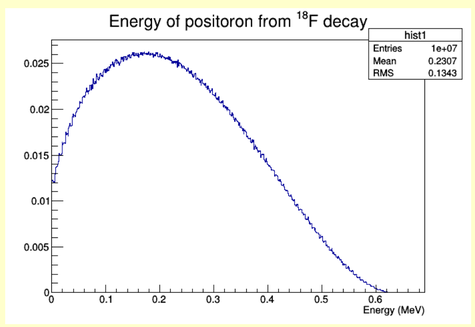
Around the surface of spine, Count in voxels might become lower.
Therefore, Cancer around bones is hard to identify.



Simulation geometry and parameters



Parameter	Quantity
Radioactivity concentration (normal tissue)	2 MBq/kg
Radioactivity concentration (cancer)	10 MBq/kg
Width resolution	1 mm
Depth resolution	1 mm
Energy resolution	32.3% (FWHM)
Time resolution	No error



・Human phantom :
– Including 12 ribs, a spine and a pelvis (They have no emission of positron)
・Positron energy : ^{18}F decay energy
・Detector : 1 mm thickness La-GPS × 24 layers × 6 detectors
・Cancer area : 3 mm × 3 mm × 3 mm cube
Position : ①Center of human
②Beside spine
・Threshold : 71.5 p.e. – 86.9 p.e.

Discussion and conclusion

・The detector performance (32.3% energy resolution and 1.04 mm position resolution) are sufficient to identify almost all 3 mm cancer; however, cancer on bones have a possibility of missing.

・The surface of bones is hazy. This problem seems to proceed from wide energy threshold. It appears that higher growth rate scintillator can emit more photoelectrons, and improve energy resolution.

Reference

[1] Berger M J,et al. : NIST XCOM: Photon Cross Section Database
http://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html
(retrieved on the 18th of October 2017)
[2] C&A Corporation La-GPS(Ce) Product information
http://www.c-and-a.jp/GPS.html (retrieved on the 20th of October 2017)
[3] kuraray Wavelength Shifting Fibers catalog
http://kuraraypsf.jp/psf/ws.html (retrieved on the 20th of October 2017)
[4] K. Fujihara et al., "Evaluation of Position Resolution for a Prototype Whole-Body PET Detector Based on Suppressing Backgrounds by Compton Scattering", ANIMMA 2017

Acknowledgement

We would like to thank C&A corp. for providing La-GPS scintillators.