MicroPET Focus 120 scanner use at high-count rate

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INTRODUCTION & METHODS

Kinetic modeling of physiological processes using imaging techniques requires an accurate measurement of the time-activity curves of the tracer in plasma, known as the arterial input function (IF). The IF can be obtained by manual blood sampling, can be derived from PET images, or continuously measured by the use of small counting systems such as beta microprobes [1]. However, some beta microprobe systems can obligate the use of activities higher than those typical for the imaging system. In the present study, the NEMA NU4-2008 image quality (IQ) phantom was used to evaluate the image quality of the microPET Focus 120 at high activity values.

- Eight emission scans of 20 minutes were performed with decreasing activity starting from 109 MBq to 3.7 MBq (total activity in the field-of-view).
- Attenuation correction was obtained from transmission measurement using the ^{57}Co point source.
- To study the effect of normalization in high count rate studies, several normalization scans were performed using activities ranging from 18 to 176 MBq.
- Images were reconstructed with all corrections using Fourier rebinning and filtered backprojection algorithm.
- A ratio between phantom scan prompt count and normalization scan prompt count was computed to highlight the dependency between image quality and normalization.

HIGHLIGHTS

IQ NEMA phantom image superimposed on the normalization image. Activities used in phantom and for normalization were 100 and 20 MBq, respectively. Normalization list mode data were histogrammed and reconstructed using FBP algorithm.

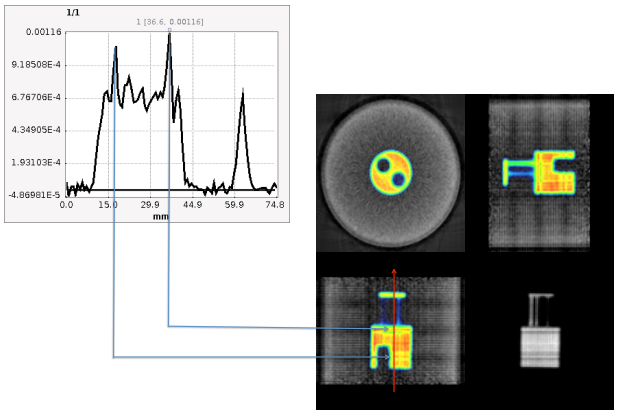

Figure 1: a) IQ NEMA phantom 18F image superimposed on the normalization image and b) profile through the phantom showing detector-bloc-patterned artifact.

RESULTS & DISCUSSION

All high activity reconstructed images showed a detector-block-patterned artifact with an overestimation of the counts when normalization activity is higher than that used in the IQ phantom and underestimation of the counts when normalization activity is below the activity used in the phantom. This artifact is likely due to the pulse pile-up in the detectors. A pile-up event occurs when two or more photons strike a detector within its electronic integration time. Ideally, the pile-up signal has a much greater amplitude than the single photon, and it is rejected by energy discrimination. Many of the physical requirements for high resolution PET detector system, such as its finite stopping power, non-uniform delivery of light to the photomultipliers, and large energy discrimination windows, allow many pile-up events to be accepted as valid data. Pile-up events can cause loss of resolution and contrast in the image.

Table 1: Prompt count ratio phantom/Normalization.

Phantom (MBq)\Norm. (MBq)	18	23	53	114	138	176
3.7	0.63	0.24	0.10	0.08	0.06	0.05
5	0.85	0.33	0.13	0.10	0.09	0.07
10	1.7	0.66	0.26	0.21	0.17	0.13
30	5.13	1.98	0.78	0.62	0.52	0.40
50	8.72	3.37	1.33	1.06	0.89	0.69
70	12.05	4.66	1.84	1.46	1.23	0.95
90	15.16	5.87	2.32	1.84	1.55	1.20
109	17.73	6.86	2.71	2.15	1.81	1.40

Using the same high activity for acquisition and normalization considerably reduces the patterned-artifact but does not eliminate it entirely. Table 1 shows the ratio between Prompt count in IQ phantom and Prompt count in the normalization phantom at varying activity both in IQ phantom and normalization cylinder. Ratio in red highlight combinations with which the artifact is not visible or highly reduced in the image.

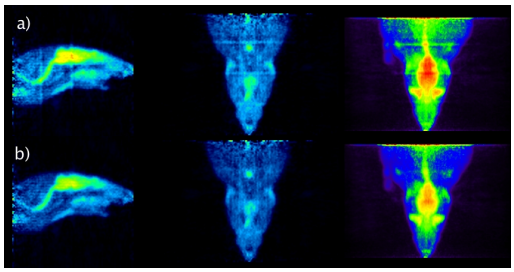

Figure 2: Rat image of a new compound, a) Data were normalized with 20 MBq normalization file and b) data were normalized using a 150 MBq normalization file.

Figure 2 shows the image of a new compound developed in our laboratory. It has the property to highly accumulate in the brain (in the field-of-view of the scanner). Detector-bloc-pattern artifact is clearly present when 20 MBq normalization is used (fig 2 a) and considerably reduced when using the 150 MBq normalization.

SUMMARY

The observed artifact is due to pulse pile-up in the detectors at high count-rate. A dedicated rejection of the pulse pile-up event does not seem to be implemented for the microPET Focus 120. An alternative would be to re-calibrate the detectors with higher activity values to prevent any pile-up effect or to create an attenuation volume into which phantoms or small animals could be inserted thus decreasing the artifact. This latter option is under development.

REFERENCES

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[2] Germano G. et al., A Study of data loss and mispositioning due to pileup in 2-D detectors in PET, IEEE Trans. Nucl. Sci. vol 37 pp. 671-675 (1990)

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