Evaluation of effective spatial resolution in reconstructed PET images

J. Maus[1], F. Hofheinz[1], S. Meister[1], J. Pietzsch[1], J. van den Hoff[1,2]

1) Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiopharmaceutical Cancer Research, Dresden, Germany
2) Universitätsklinikum Carl Gustav Carus, Klinik und Poliklinik für Nuklearmedizin, Dresden, Germany

Motivation

- Spatial resolution is one of the key parameters for assessment of PET scanner performance.
- Commonly determined with point or line sources or standardized NEMA measurements.
- Does not allow to study the finite object size and contrast effects known to affect iterative image reconstruction performance.

➡ We present an approach to determine the spatial resolution at finite background for extended objects.

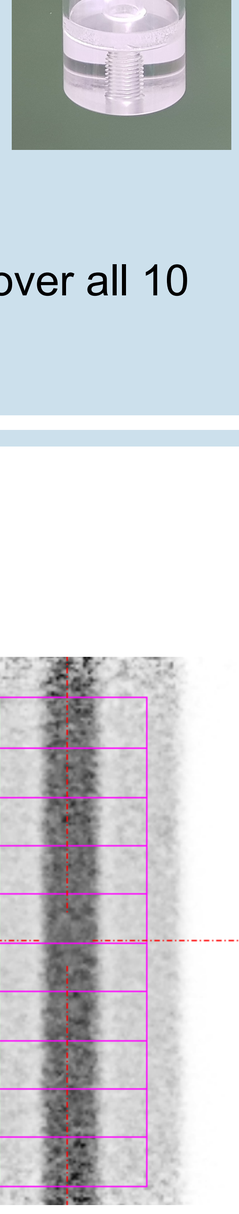
➡ The method was applied to 3 preclinical PET/CT systems (1x Bruker Si78 PET/CT, 2x Mediso nanoScan PET/CT).

Methods

- Dedicated cylindrical phantom (⌀ 3.5 cm) with a cylindrical insert (⌀ 1 cm).
- F-18 measurements: with two background (BG) / target (FG) contrasts (0:1, 1:3).

#	Contrast Ratio (BG:FG)	FG conc. [MBq/ml]	BG conc. [MBq/ml]
1	0:1	2.16	0.00
2	1:3	0.51	0.17

- PET image of cylindrical insert was split into 10 axial segments / volume-of-interest (VOI)
  - Spatial resolution assessed as the full width at half maximum (FWHM) of the point spread function (PSF) approximated by a isotropic Gaussian.
  - FWHM determination from a fit of the convolution of the considered object (homogeneous rod) with the PSF to the reconstructed image data.
  - full 3D vicinity evaluation of each rod by transforming the data to cylindrical coordinates relative to the respective object center/axis.
- Mean and SD calculation of spatial resolution over all 10 VOIs



Example 1:3 PET image with 10 delineated VOIs

Results

- Without background activity, we obtained FWHM 1.18 ± 0.04 mm and 1.21 ± 0.04 mm for the nanoScan PET/CT systems, but severe Gibbs artefacts could be observed.
- The Si78 PET/CT system achieved FWHM 2.07 ± 0.08 mm in high contrast measurements while not showing any Gibbs artefacts.
- At 3:1 contrast, resolution of both systems decreases to FWHM 2.43 ± 0.23 mm and 2.34 ± 0.12 mm for the nanoScan systems and to 3.21 ± 0.31 mm for the Si78 PET/CT system – without any notable Gibbs artefacts.

Contrast Ratio (BG:FG)	FWHM [mm] nanoScan PET/CT 1	FWHM [mm] nanoScan PET/CT 2	FWHM [mm] Si78 PET/CT
0:1	1.18 ± 0.04	1.21 ± 0.04	2.07 ± 0.08
1:3	2.43 ± 0.23	2.34 ± 0.12	3.21 ± 0.31

Conclusions

- All investigated small-animal PET systems have a strong contrast dependent spatial resolution.
- While the two nanoScan PET/CT systems showed a substantial better image resolution, the standard image reconstruction seems to be more prone to Gibbs artefacts due to a too aggressive resolution recovery approach.

➡ Method represents a viable approach in assessing the spatial resolution of small animal imaging systems.

- Optimizations of reconstruction parameters are currently underway with the aim of reducing the adverse effects of Gibbs artefacts on quantification and improving reconstructed image resolution at finite background. The respective measurements could unfortunately not be performed in time due to Corona pandemic related restrictions.