^{90}Y PET IMAGING:

OPTIMIZATION FOR PRECLINICAL SETTINGS

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Background:

^{90}Y (64.053 d) is commonly known as a 'pure' β--emitter with end-point energy of 2.28 MeV. Its decay has a minor (≈ 10-4) branch to the 0+ first excited state of ^{90}Zr at 1.78 MeV. The (0+→0+) de-excitation is constrained to follow 2-γ emission, internal conversion, or e--e+ pair creation (Ford 1955), which happens in 31.867 ± 0.47 out of million decays (Selwyn et al 2007, Langhoff and Hennies 1961).
For the last few years, 90Y was only imaged using bremsstrahlung (continuous energy spectrum x-rays) (Mansberg et al 2007). Imaging utilizing bremsstrahlung suffers from low quality images resulting in difficulties for quantification and lack off spatial resolution. However, the occurring annihilation photons allow the possibility of using coincidence imaging via PET. For the purpose of lowering the count rate originating from the bremsstrahlung x-rays, and, therefore, improving the count rate performance, Elmbt et al 2011 suggested to insert a thin copper cylinder (~2.4 mm thickness) into the detector array.

Aim:

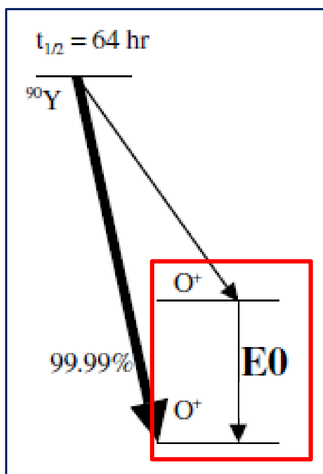
The aim of the presented work was to demonstrate the potential of ^{90}Y PET imaging while utilizing a copper insert as well as the resulting image quality and special resolution.

Methods:

For validation of the proposed theorem ^{90}Y and ^{18}F filled NemaNu4 phantoms were imaged with and without a copper filter (9.98 cm outer diameter, 28 cm length, 2.4 mm walls) in a fully equipped ALBIRA PET/SPECT/CT multimodality small animal scanner (Bruker BioSpin, Ettlingen, Germany). Resulting images were reconstructed using standard reconstruction settings of the Albira Imaging Suite and analyzed using PMod software (PMod Technologies Ltd, Zürich, Switzerland). Phantoms were filled with a total of 150 MBq of ^{90}Y and ^{18}F (75 MBq mainbody, hotspheres: 50 MBq and 25 MBq) in saline solution.

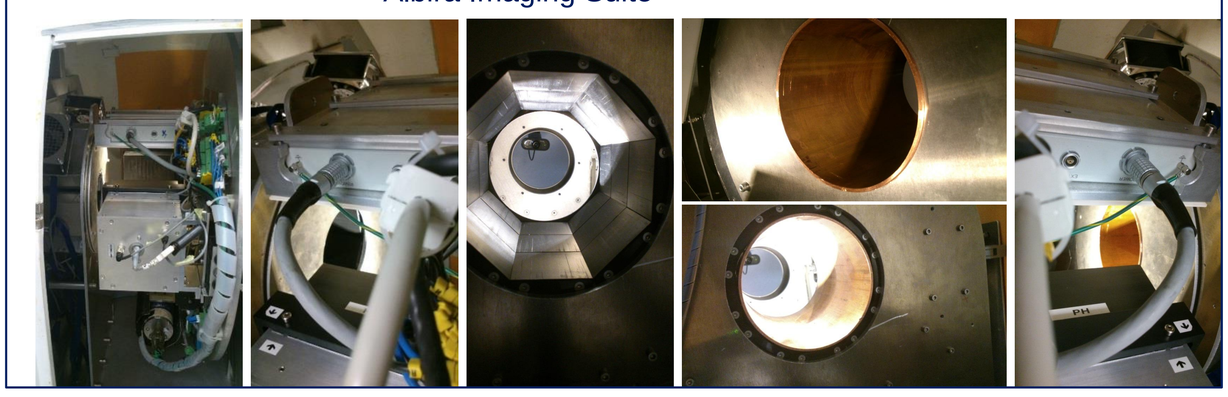
Results:

Resulting images of the ^{18}F filled phantom without copper insert granted standard resolution and quantification of the measured data. Images of the same phantom with the copper filter placed inside the detector array, image quality was drastically improved due to a reduced background. However, quantification of the measured data resulted in approx. 20 – 25 % reduced yields, depending on the amount of
activity within the measured ROI. The failure increased for lower activities. Imaging ^{90}Y filled phantoms resulted in grainy and not quantifiable images when not using the copper insert. Data acquisition for longer than 30 minutes resulted in no images. When using the copper insert while imaging the ^{90}Y phantom, within 60 minutes images of good special resolution could be obtained. Increased imaging times of up to 8 hours produced even higher image quality. Quantification of the obtained data remains problematic until now.

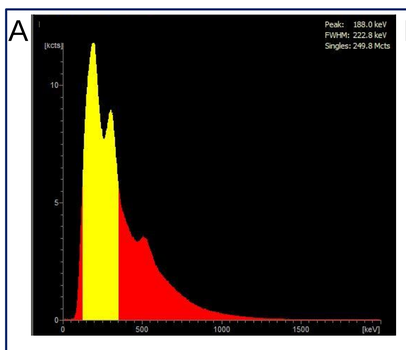


- $T_{1/2}$ = 64.053 d
- commonly known as a 'pure' β^--emitter with end-point energy of 2.28 MeV
- decay has a minor (≈ $10^{-}3$) branch to the 0^+ first excited state of ^{90}Zr at 1.78 MeV
- ($0^+ \rightarrow 0^+$) de-excitation is constrained to follow 2-γ emission, internal conversion, or e^-- e^+ pair creation (Ford 1955) – electric monopol transition (E0)
- frequency of pair production: 31.867 ± 0.47 out of million decays (Selwyn et al 2007, Langhoff and Hennies 1961).

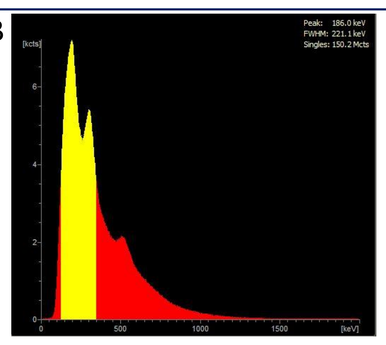
- ^{90}Y and ^{18}F filled NemaNu4 phantom was imaged with and without a copper filter (9.98 cm outer diameter, 28 cm length, 2.4 mm walls)
- Phantoms were filled ^{90}Y (50 MBq mainbody, hotspheres: 15 MBq and 7.5 MBq) and ^{18}F (15 MBq mainbody, hotspheres: 5 MBq and 2.5 MBq) in saline solution.
- reconstruction without attenuation and decay correction with Albira Imaging Suite



A



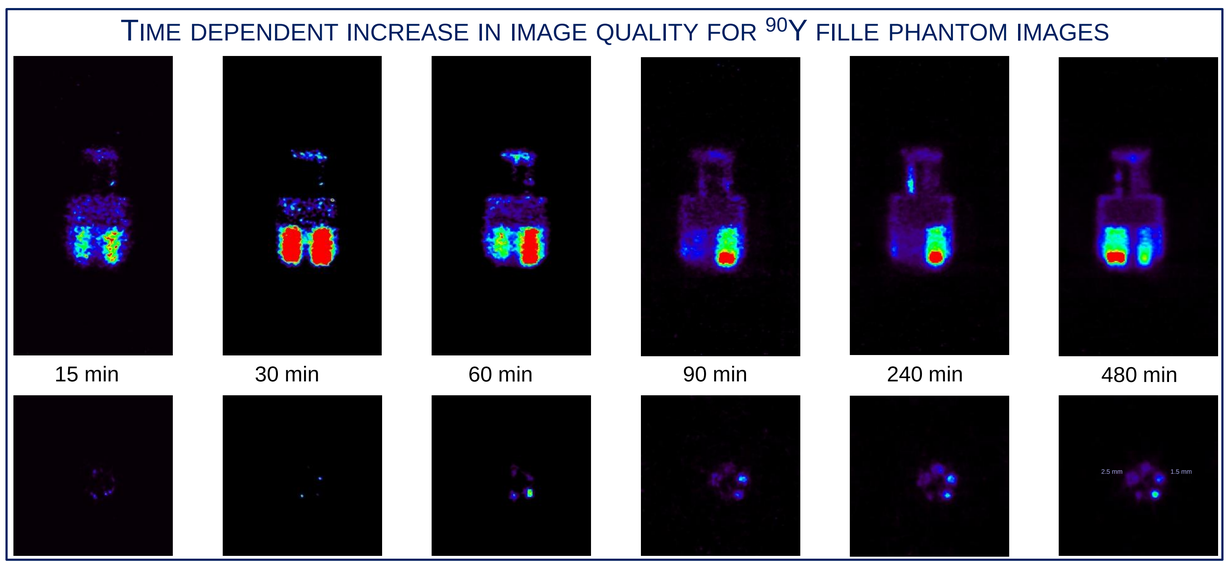
B



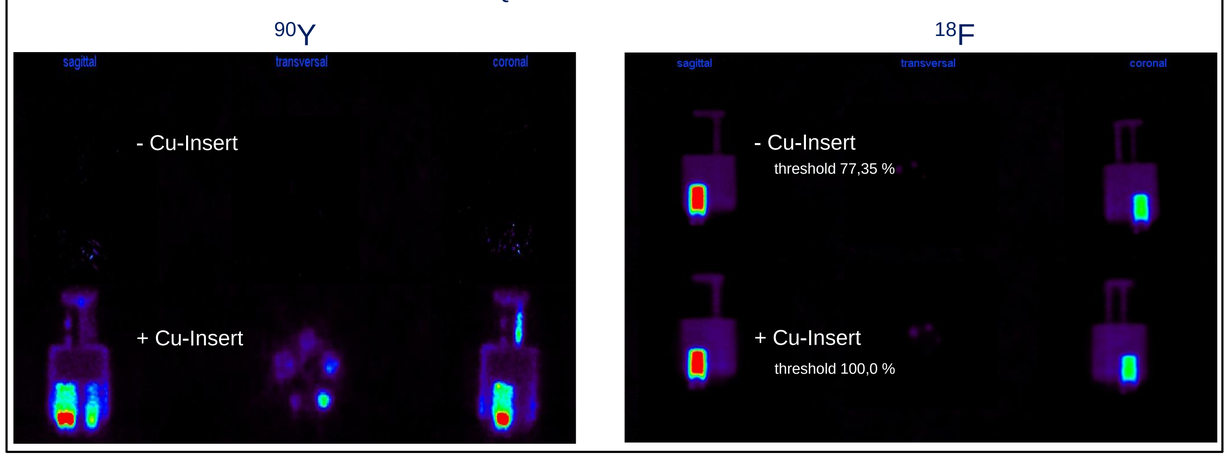
30 min continuous PET scan - measured energy spectrum

A)without Cu-filter: single events in main peak (188 keV): 249.8 Mcts
B)With Cu-filter: single events in main peak (188 keV): 150.2 Mcts

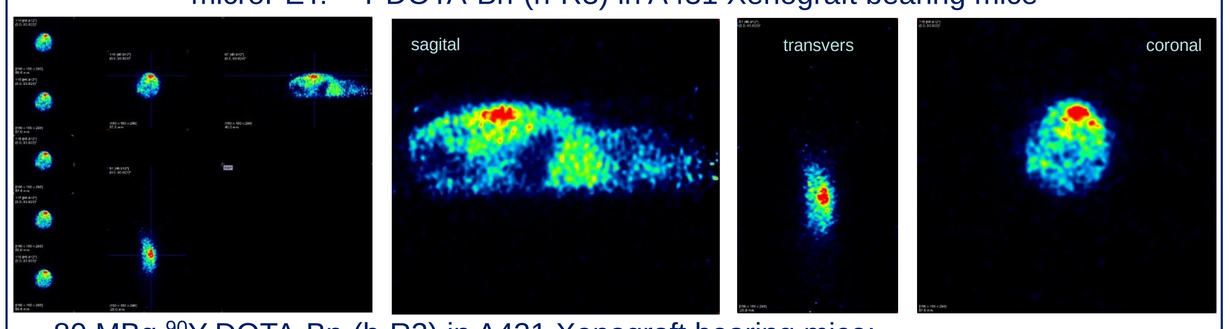
TIME DEPENDENT INCREASE IN IMAGE QUALITY FOR ^{90}Y FILLE PHANTOM IMAGES



COMPARING IMAGE QUALITY WITH AND WITHOUT CU-FILTER



microPET: ^{90}Y-DOTA-Bn-(h-R3) in A431 Xenograft bearing mice



- 80 MBq ^{90}Y-DOTA-Bn-(h-R3) in A431 Xenograft bearing mice;
- 60 min static PET accquisition (ALBIRA PET/SPECT/CT, Bruker Biospin, Ettlingen);
- MLEM reconstruction without attenuation-, scatter- and decay correctiosubcutaneous
- tumor on the back of the mouse clearly visible as well as the heart and little accumulation in liver

Conclusions:

^{90}Y PET data acquisition utilizing a copper insert to lower the count rate of the bremsstrahlung x-rays and therefore improve the count rate for the 511keV photons seems to be a promising approach to ^{90}Y dosimetry. However, more detailed measurements and analysis of the effect of the copper insert need to be carried out to enable quantification of ^{90}Y PET images.

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