Institute for Particle Physics and Astrophysics

SAFIR-I: First Time-Activity Curves in Rat Brain in vivo

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1 Introduction

The SAFIR collaboration has recently commissioned its first Positron Emission Tomography (PET) insert for a Bruker BioSpec 70/30 7T pre-clinical MRI, capable of handling decay rates reaching 500MBq, thereby enabling image acquisition time frames as short as 5s. This SAFIR-I insert with 54mm axial FOV has subsequently been used for a first in vivo study of a rat brain featuring truly simultaneous PET/MR image acquisition [1].

2 Materials

- We used the SAFIR-I PET insert (s. below) installed inside the Bruker BioSpec 70/30 MRI.
- Data acquisition and offline analysis were performed with in-house software (see [1]), image reconstruction was done using STIR [2]. The quantitative calibration of voxel values was extracted from PMOD [3].

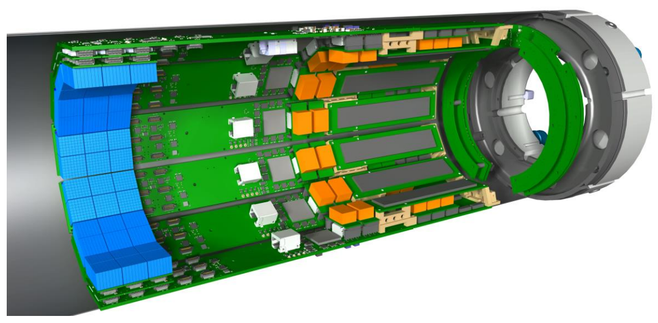

Fig. 1: Rendering of the SAFIR-I PET insert [1].

3 Methods

- The brain of a Sprague Dawley rat was imaged in vivo with 18F-Fluorodeoxyglucose (FDG), injected via femoral vein.
- A first injection with 29.5MBq triggered a 45min continuous measurement, which was followed by a second injection boosting the injected total activity to 314.6MBq. Again, an acquisition time of 45min was chosen. Both measurements commenced immediately upon injection.
- Quant. calib. of image voxel values achieved by imaging a 50ml Falcon tube with FDG in water at 1MBq/cc for 5 min.
- All acquired data was reconstructed using the same settings/cuts and without applying any attenuation, random, normalization or scatter corrections.

4 Results and Discussion

The time-activity curves (TACs) are shown below:

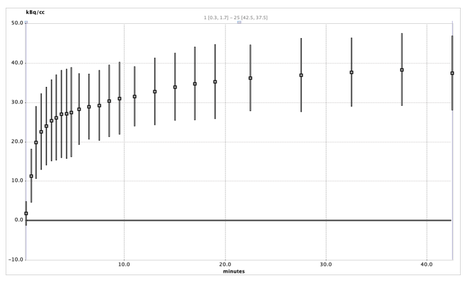

Fig. 2: TAC at low decay rate, whole brain, with standard deviation error bars.

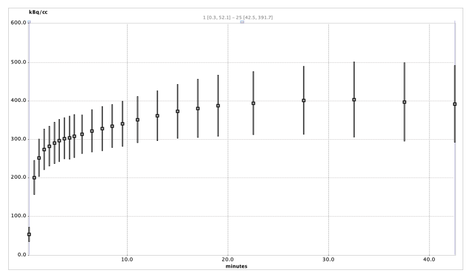

Fig. 3: TAC at high decay rate, whole brain, with standard deviation error bars.

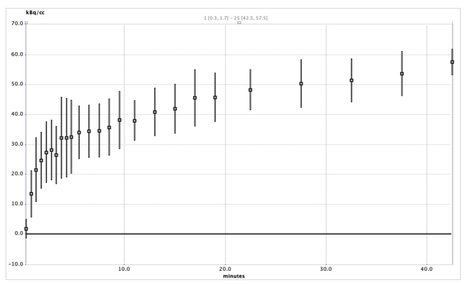

Fig. 4: TAC at low decay rate, cortex region, with standard deviation error bars.

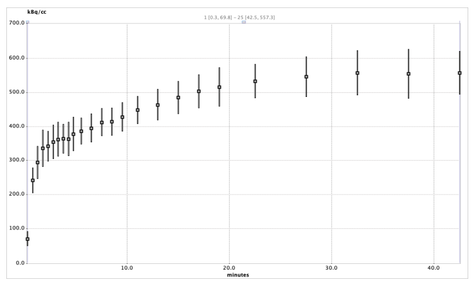

Fig. 5: TAC at high decay rate, cortex region, with standard deviation error bars.

The overall shape of the TACs matches the pharmacological expectation. The FDG uptake in the cortex and whole brain regions are consistent.

Data obtained at high decay rate allowed for smoother TACs and smaller errors on the data points consequent to better counting statistics.

However, the improvement on the errors compared to the low decay rate was smaller than expected from statistics and the errors are generally large. This is likely due to no data corrections having been applied to the image voxels. Further, the quantitative calibration method was not ideal for SAFIR-I featuring a non-linear response over all activities, with some data loss occurring at higher activities due to dead time and pile-up effects [4,5].

5 Conclusion & Outlook

- We have successfully conducted a first in vivo study of a rat brain using 18F with the SAFIR-I PET insert. Time-activity curves could be extracted for the whole brain and the cortex region based on the acquired data at low & high decay rates and using a measurement of an activity-filled Falcon tube for rough calibration.
- The quality of the TACs shows that SAFIR-I is capable of acquiring relevant quantitative PET images at injected activities stretching beyond 300MBq.
- In the weeks to come, data corrections will be included in the reconstruction algorithm and the quantitative calibration will be improved by incorporating data from a dedicated calibration phantom measurement at different decay rates.

References

1. P. Bebié, et al., “SAFIR-I: Design and Performance of a High-Rate Preclinical PET Insert for MRI,” Sensors, 21(21), 7037., Oct. 2021, https://doi.org/10.3390/s21217037
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Acknowledgment

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