



Republic of Poland



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## A method for time calibration of PET systems using fixed beta-plus radioactive source

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### Outline

- 1. J-PET TOF-PET system
- 2. Calibration of TOF-PET systems established methods
- 3. Calibration of a single module of J-PET
- 4. Calibration between modules

## J-PET – (Time-Of-Flight) TOF-PET system





192 x Plastic scintillator



384 x Photomultiplier Tubes

### Principle of position reconstruction



Reconstruction of position of the hit based on the time difference between signals



384 modules to calibrate with each other

# Calibration of TOF-PET systems - established methods

reference detector & PMT,



Large phantom: Needs additional measurement, with large phantom to cover many LORs

Reference rotating system: Needs additional measurement, that scans over all detectors

Xiaoli Li et al., IEEE Transactions on Nuclear Science 63, 3 (2016) W. W. Moses and C. J. Thompson, IEEE Transactions on Nuclear Science 53, 5 (2006) M. Skurzok et al., Acta Phys. Polon. A 132, 5 (2017)



## Calibration of TOF-PET systems - established methods

Rotating radioactive rod: Needs additional measurement, that scans over all LORs





A. E. Perkins, M. Werner, et al., IEEE Nucl. Sci. Symp. Conf. Rec., pp. 2488-2491, 2005

#### Performed measurement



<sup>22</sup>Na source (1 MBq acitivity) in Kapton foil was placed between two layers of XAD4<sup>1</sup> (porous polymer) and inserted inside aluminum chamber. Chamber was placed inside J-PET, in the center of the detector. Measurement done to study Positronium Annihilation in XAD4.

#### Calibration measurement details:

- Fixed source in the center
- Calibration based on prompt + annihilation quanta

<sup>1</sup>https://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma/Product\_Information\_Sheet/1/xad4pis.pdf

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#### Calibration procedure

1<sup>st</sup> step: Calibrating Photomultipliers tubes, connected to one scintillator with each other



**Modules calibrated** 



2<sup>nd</sup> step: Calibrating all modules with each other at once



**Detector calibrated** 



## Calibration of a single module of J-PET



Perfect situation:

- Perfect time resolution
- Uniform irradiation of the strip



Rectangular distribution of Time differences

TDiffBA = TimeA - TimeB

### Calibration of a single module of J-PET



Real situation:

- Gauss-like smearing of photomultiplier
- Cosine squared distribution of irradiation for source in the center of the detector

TDiffBA = TimeA - TimeB

#### Calibration of a single module of J-PET



#### Calibration of a single module



TimeB<sub>new</sub> = TimeB<sub>old</sub>

#### Calibration between modules

#### Before Calibration (0 iteration)

#### After Calibration (3<sup>rd</sup> iteration)



## Conclusions

New Iterative Time Calibration procedure was developed for the J-PET. As a first calibration method of TOF-PET systems, it uses point-like source that emits prompt gamma quantum for calibration. Calibration was performed for <sup>22</sup>Na source in Kapton foil with XAD4 (porous polymer) around it.

Compared to other methods, there is no need to mount complicated setup for calibration in TOF-PET detector. Every possible pair of detector is calibrated at once.

#### Thank You for Your attention