

# Quality control of plastic scintillators for the total-body J-PET scanner

Łukasz Kaplon, on behalf of the J-PET Collaboration

Faculty of Physics, Astronomy and Applied Computer Science, Total-Body Jagiellonian-PET Laboratory, Center for Theranostics, Jagiellonian University, Kraków, Poland

lukasz.kaplon@uj.edu.pl

<https://koza.if.uj.edu.pl/pet/>

## Introduction and objectives

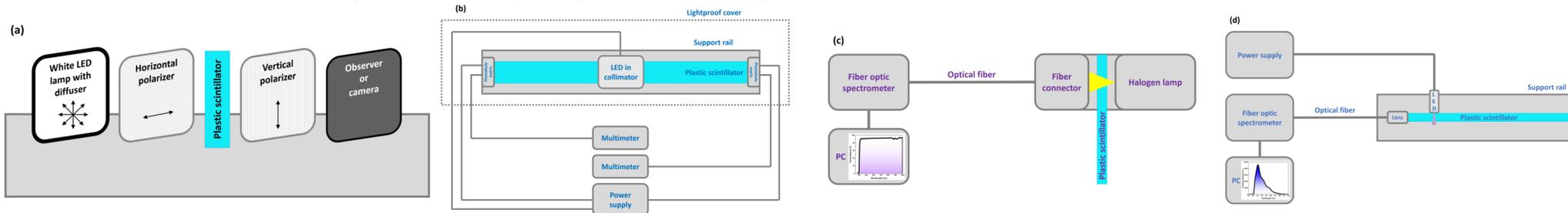
Total-body Jagiellonian positron emission tomography (TB-J-PET) is based on long plastic scintillators [1] which decrease cost of the scanner [2]. Total-body PET scanners enable positronium imaging [3], measurements of polarization of photons [4] and beam therapy monitoring [5]. Development of TB-J-PET requires application of transparent plastic scintillators with low light attenuation [6] to build long modules with silicon photomultipliers attached at both ends of the scintillators. For modular TB-J-PET construction we choose BC-408, one of the most transparent plastic scintillator from our previous measurements [7]. The purpose of this research is to:

- perform quality control measurements of 1570 pieces of plastic scintillators with dimensions 6 mm × 30 mm × 330 mm, all surfaces polished: faces as-cast and edges diamond-milled;
- confirm dimensions of the plastic scintillators and reject from J-PET tomograph construction scintillators with optical and mechanical defects;
- verify transverse and longitudinal transparency: transmittance at the wavelength of maximum emission and technical attenuation length.

## Materials and methods

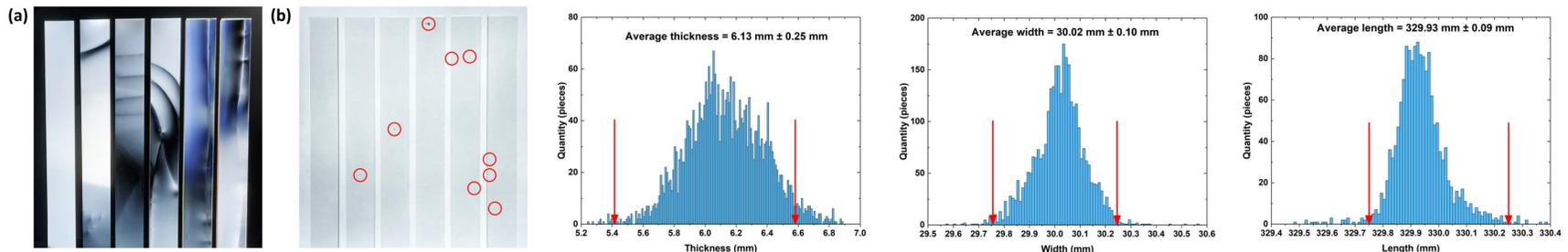
Quality control of the plastic scintillators consists of five techniques:

- visual inspection for optical and mechanical defects to qualify them for warranty replacement;
- dimension measurements of each scintillator to qualify them for warranty replacement if any dimension of the scintillator exceeds the dimensional tolerance limit;
- optical light transfer test of selected scintillators on setup consisting of exciting LED and matrix of photodiodes to confirm optical homogeneity of the scintillators;
- transverse transmission spectra measurements of random chosen scintillators from each batch to confirm its high optical transmittance for emitted light;
- longitudinal transmission via performing of technical attenuation length measurements of random chosen scintillators from each batch.

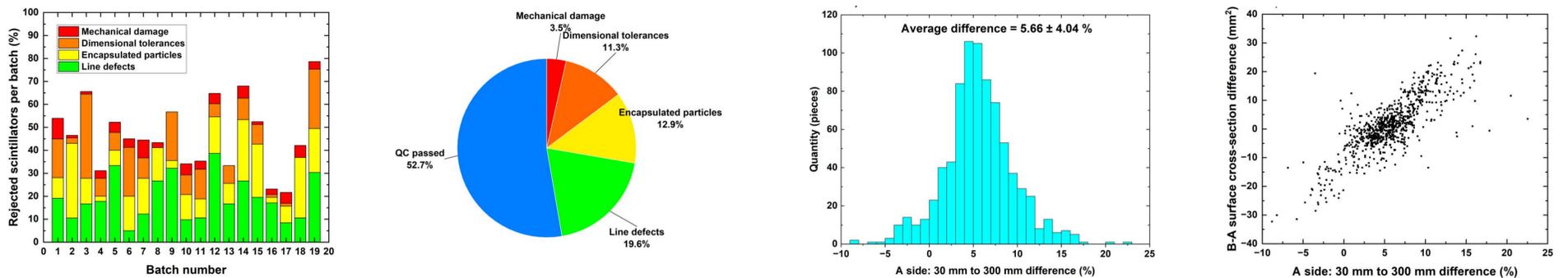


Schemes of experimental setups of plane polariscope for line defects screening under cross-polarized light (a), light transfer test (b), transmission spectra (c) and for technical attenuation length (d) measurements.

## Results

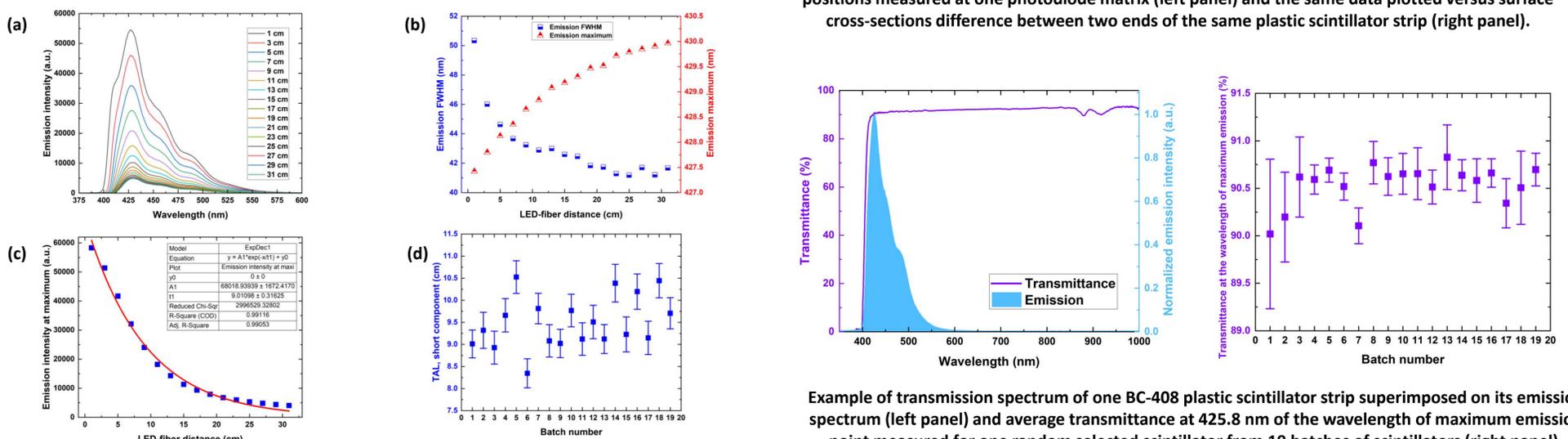


Defects in plastic scintillators: (a) line defects imprinted on as-cast surface of BC-408 scintillator viewed in plane polariscope, (b) encapsulated particles in the volume of BC-408 scintillator viewed against the background of a white lamp, red circles denote location of the defects. Dimension distributions of the BC-408 plastic scintillators with faces as-cast (thickness) and edges diamond-milled (width and length). Red arrows indicate the maximum dimensional tolerance ranges: ± 0.25 mm for width and length and ± 0.58 mm for thickness.



The distribution of the different causes of rejection between 19 batches of plastic scintillator (left panel) and the total percentage sum of each rejection cause in whole scintillator delivery (right panel).

Results from light transfer measurements: distributions of percentage signal differences for two positions measured at one photodiode matrix (left panel) and the same data plotted versus surface cross-sections difference between two ends of the same plastic scintillator strip (right panel).



Emission spectra of BC-408 plastic scintillator change with LED-fiber distance (a), properties of the emission spectra (b), example of dependency of the emission intensity at spectrum maximum from LED-fiber distance (c), short component of TAL measured for random selected scintillator from 19 batches of scintillators (d).

Example of transmission spectrum of one BC-408 plastic scintillator strip superimposed on its emission spectrum (left panel) and average transmittance at 425.8 nm of the wavelength of maximum emission point measured for one random selected scintillator from 19 batches of scintillators (right panel).

## Conclusions

- 40.4% scintillators with dimensions outside of tolerance and with optical and mechanical defects were rejected from tomograph construction.
- Obtained results confirm high transparency of ordered BC-408 scintillators for construction of long modules of the TB-J-PET scanner.
- Small optical signal differences at the level of about 5.66% between both ends of the same scintillator strip will result in uniform timing properties along the length of the scintillator in next generation J-PET scanner.

## References

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## Acknowledgments