PEN as a Scintillator
Proof of Principle

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1 Introduction

In modern Particle Physics a cornerstone of particle detection are scintillators of various kind. A widely used scintillating material is BC408, which is quite expensive in comparison to everyday plastics. Recently studies of PEN suggested the usability as a scintillator. The aim of the reported studies are to confirm this and if possible quantify and compare the results to BC408.

In Order to do so, different Tests were made. First the group of future accelerators used their Setup for analyzing scintillator TWLs. The result was not as good as suggested by earlier reports. Because of this the Spectrum of PEN samples and BC408 scintillating were recorded and it confirmed a scintillating deficit by one order of magnitude and a brouder scintillation spectrum compared to BC408.

2 Experimental Setup

The first tests were made by a setup analyzing the homogeneity of emission and detection in a TWL sample, pictured in Figure 1. The blue Box with the Sr90 writing indicates the Strontium 90 β source used as a event generator.It has an activity of 13.9 MBq emitting electrons with a Energy of up to 2.27 MeV. The electrons first goes through the scintillator tile, connected to a readout board with amplifier and SiPM and then passes the trigger cube, a 5x5x5 mm scintillator cube, which trigers the recording of an event. The whole setting is in a light tight box, indicated by the black line, with a temperature sensor. The two SiPM signals are read out by a picoscope.

Following these tests the scintillation spectra were recorded by a Andor SR 303i A spectrometer equipped with an Andor DV420A OE Camera, which were connected to a computer via USB. When using these devices with the software provided, one should check whether all boxen in the calibration menu are checked! Otherwise the calibration is not put into the data. As Picture 2 indicates the samples were fixated at the spectrometer opening with an linear lens holder. The light entering the spectrometer was reduced by a Aluminum foil with a hole of the diameter 0.88mm. This was necessary because the scintillation light was too intense for the spectrometer. A UV-lamp, located above the sample was used for excitation, available radioactive sources were not active enough for this kind of measurement, so only measurements with the UV were done. The UV lamp consists of 4 ultraviolet LEDs with a wavelength of 365 nm. The whole setup was cloaked with a black dense cloak.

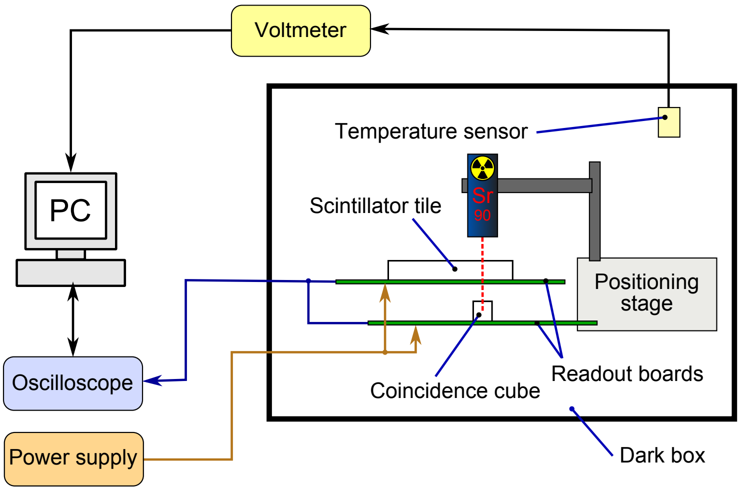

Fig. 1: Schematic drawing of the Homogeneity Testing Setup. Sr90 means a Strontium 90 source, the black box indicates a light tight box.

3 Results

3.1 Testing Effects of Grease

The goal of the first measurement was to find out if applying grease would improve the scintillation efficiency of PEN. In the first series of investigations it was found that the light yield was significantly less then that of BC408. As displayed in Table 1, for the samples without Grease, we get one order of Magnitude less counts, which can be seen as a measure of light yield, then for BC 408.

After applying grease the result improved for all PEN samples and the BC408. The result of T3B tileQ on the other hand got worse, by a factor of 5.

3.2 Spectrometer Results

BC408 has a high peak, with about 26,000 counts, at around 430 nm and two smaller ones at around 460 nm, about 17,000 counts, and 490 nm, about 9,000 counts, as can be seen in Picture 4. Half of the light yield is produced in the Interval of the highest peak, between 400 nm and 440. About three quarters of the light yield are produced in the interval of 400 nm and 480

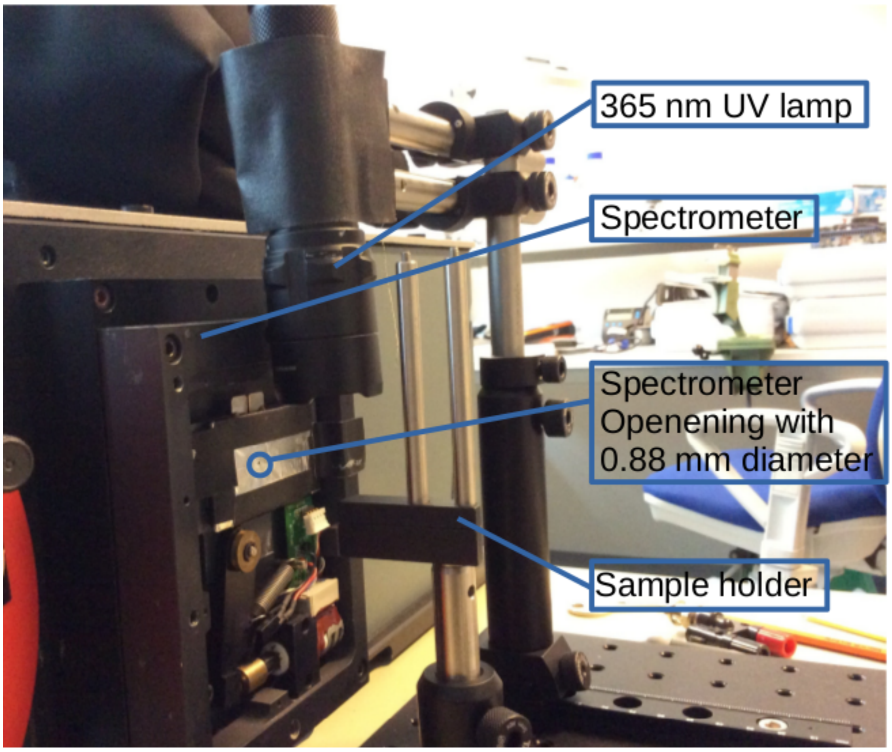

Fig. 2: Picture of the Spectrometer Setup, the opening of the Spectrometer had to be reduced due to the intensity of the scintillation light. During the experiment the setup was cloaked by a dense black cloak which can be seen in the upper left corner.

Tab. 1: All investigated scintillator samples with their mean count number averaged over all measured areas of the sample

Sample	With Grease	Number of Counts	Improvement
BC 408	No	21.41	
	Yes	29.51	38%
PEN TU Dortmund	No	1.074	
	Yes	1.623	51%
PEN 4,5mm	No	1.328	
	Yes	2.326	75%
PEN polished	No	2.763	
	Yes	3.753	36%
T3B tileQ	No	13.28	
	Yes	2.592	-80%

nm.

Compared to BC408 PEN has a much broader peak, which is at about 440nm. Also the light yield is not as big as that of BC408. In contrast to BC408 the light yield of PEN is much more distributed on a biger intervall of wavelength, shown in Picture 3. The spectrometer result resembles the result of the Grease Tests.

The Background radiation is neglectably small at around 3000 counts and will not be discussed further. The rise of the Background radiation at a wavelength below 400 nm is neglected since the spectra of the tiles are above 400 nm.

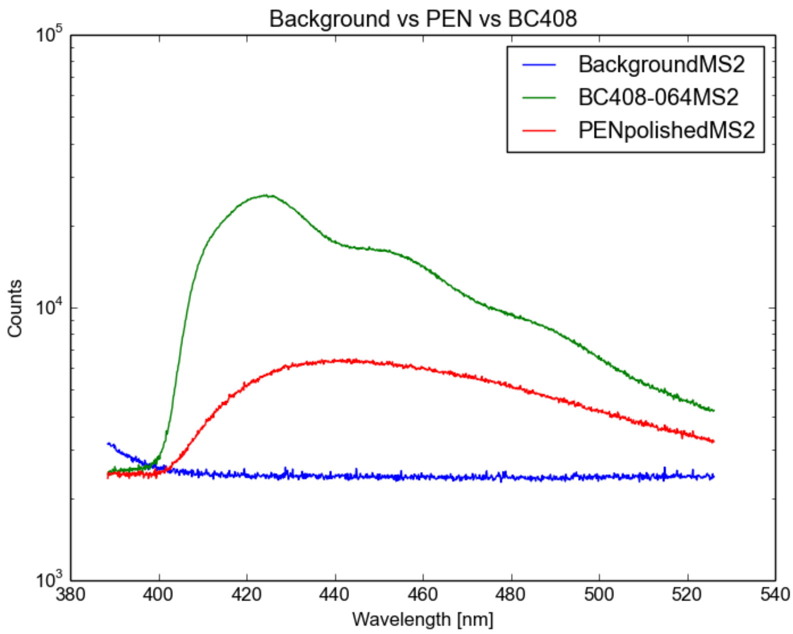

Fig. 3: Spectrum of the best PEN and BC408 tiles as well as the Background in a logarithmic graph. From this it is obvious that the background can be neglected. Further more it displays the difference of light yield of PEN, compared to BC408.

All the PEN so far was produced from rough material and formed into a standard tile in Germany by different institutes such as Frauenhofer Institute or TU Dortmund. The best results were presented in the plots. When one of the already produced, only 1 mm thick, tiles from Japan were tested, the result changed, as can be seen in Picture 5.

The thickness of a Tile has a great influence on the light yield as can be seen in Picture 6.

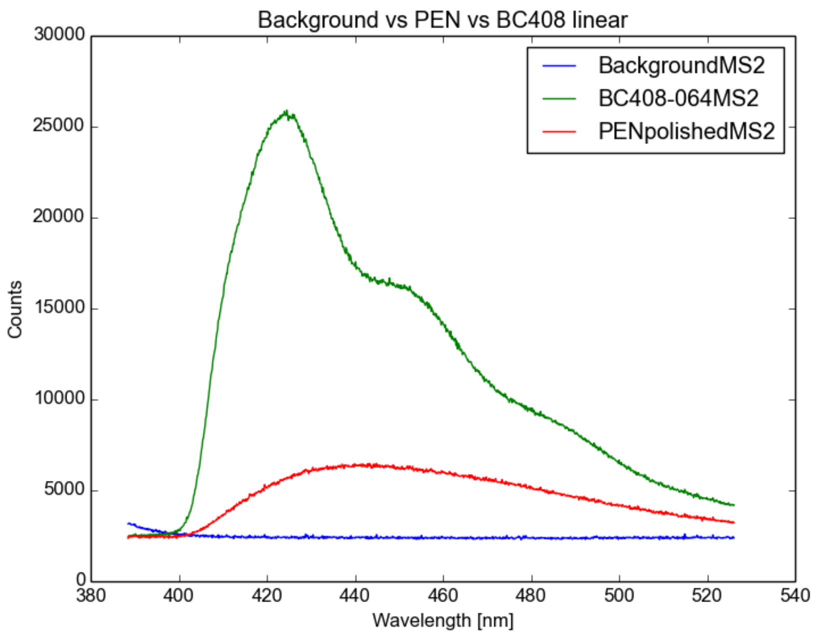

Fig. 4: Spectrum of the best PEN and BC408 tiles as well as the Background in a linear graph.

4 Conclusion

All in all the results show that claims of PEN, being as effective as BC408, are disproofen for the materiel processed in Germany. The light yield is smaller by a factor of 8 and the time between two measurements is higher compared to BC408. Non the less the Materiel in general is an interesting alternative for low background experiments where the time scale is not as important. For these purposes the processed materiel from Japan has to be investigated further, since it has a much better light yield then the PEN processed in Germany. Some questions arise looking at the result of this probe. First is it the exact same material as it was used in Germany? Second was there some special processing that influenced the properties of the sample and is this reproducible?

List of Figures

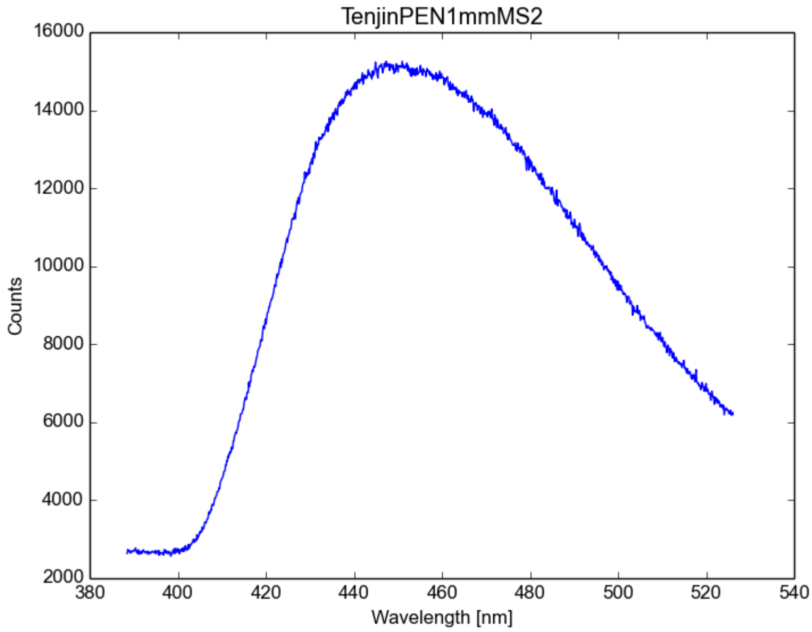

Fig. 5: Spectrum of 1 mm thick Tenjin tile. The light yield is about double the one produced by other PEN tiles that are three milimeter thick.

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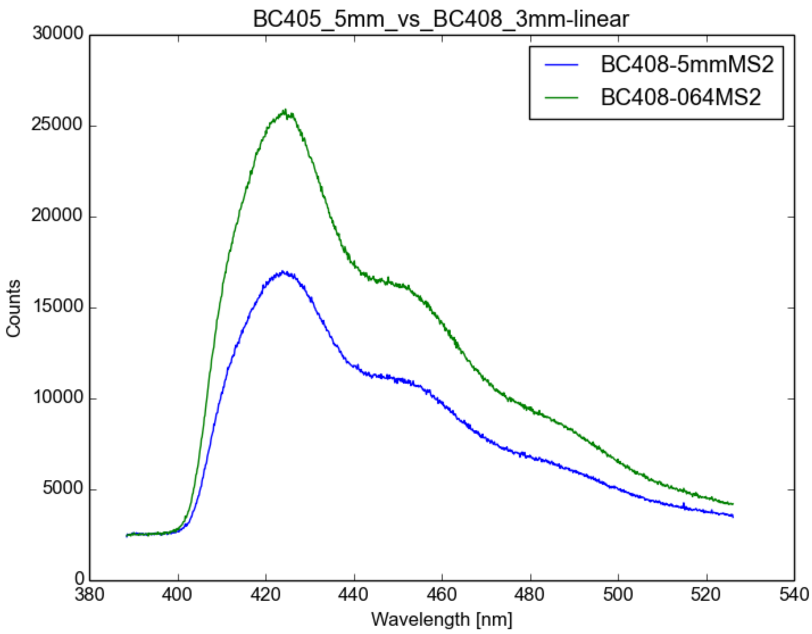

Fig. 6: Spectrum of 5 mm and 3 mm thick BC408 tiles. One can see the influence of thickness from the difference of the spectra.