Evaluation of ARPRO beads as a Black top material for the AUGER upgrade programs

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1. Introduction

The current water tanks of the SD Auger detector presents a very long characteristics pulse width in response to single penetrating particles (muons). This prevent from extracting the muon content information from EAS signales. It is possible to speed-up the response of the tank by making the upper part of the walls black [1], although this would decrease the amount of first-bounce light.

The idea of having the top of the tank non reflective at the 95% level (or similar) involve some strong requirements on the design. The reflectivity should not be variable over a long term. The system should not contaminate water, e.g. chemicals should not leach into water over time. It should be possible to set-up prototype tests at modest cost and quickly, keeping in mind that the tests should be reversible, thus allowing to restore the SD to normal operation in the array.

A possible solution could be the replacement of the liners. The overall cost to build or modify the liners may be the same as building the liners in the first place. Moreover the field work to replace liners is difficult and time consuming. People and expertise following the first place liner are not part of the collaboration, and also the factory making the liners in Argentina is not operational any longer.

Another possible solution could be to add black polypropylene beads to the water, allowing a floating layer to blacken the top. This solution can only blacken the top, not the sides. The aim of the present study is to evaluate a possible material to be used as floating layer.

	Weight (mg)	Size (mm)	Density (g/l)
5118	1.2	3.5 – 5.5	18
5135	1.2	2.5-4.5	35
5915	2	1.5 – 3.5	150

Figure 1. Characteristic of the foam beads used in this study.

2. ARPRO beads samples

We have obtained some samples of black Polypropylene foam beads, ARPRO, from JSP[2]. ARPRO is an expanded polypropylene foam, industrially used for moulding a wide variety of finished parts. The beads incorporate mineral and organic element in a mix of copolymer and carbon black. The company produce beads of different size and density. The table in Fig **??** reports the size and density of the samples analyzed.

2.1. Static properties and dispersibility

All samples have some static charge that influence the way they behave when handled. Tests were made by dispersing spheres on the surface of the water.

The samples 5118,5135 make very difficult to form a layer of spheres on the top of the water. The characteristics of 5915 (the high density spheres) were much better. In fact while some staticity is still present, 5915 spheres will deposit easily on the surface of a water sample, forming a uniform strata. This configuration is also stable in time because of clear surface tension effects, 5915 sphere will continue in time to adjust themselves into forming a uniform layer on the top of the water.

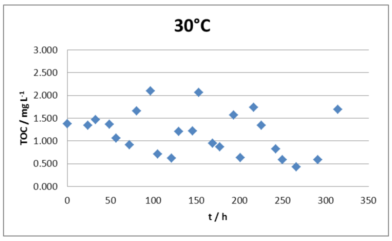

Figure 2. TOC in Water with spheres 5118 at 30 Celsius. 350 hr = 15 days.

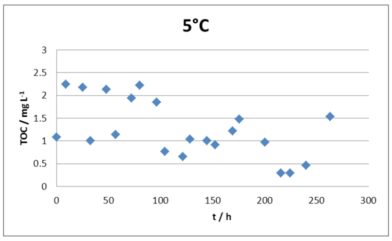

Figure 3. TOC in Water with spheres 5118 at 5 Celsius. 350 hr = 15 days.

3. Evaluation of TOC degradation of the water

The water in the Auger SD tanks should be not contaminated by the insertion and presence of the spheres. To assess the possibility of this effect, we have used as an indicator of water quality or cleanliness, the measure of TOC (Total Organic Carbon) in water as a function of time. For this study, a little reactor vessel was filled with roughly a liter of volume of MilliQ grade deionized water (the sizes of water are 14 cm diameter and 6.5 cm height). A layer of polypropilene beads has been deposited at the top of the water and measurements have been made of Total Organic Carbon in the Water.

The measurements have been made at 30 C and 5 C for 14 days. For the 5118 samples, measurements were made at 5 degrees C and 30 degrees C, as shown in Fig 4 and Fig 3. Note that the blank corresponds to a TOC of about 0.5 ppm.

After these initial tests, an ageing test was performed by depositing 5118 spheres and 5915 spheres in water at 80 Celsius for two weeks to accelerate the TOC degradation effect. It is estimated that this test is equivalent to several years at the lower operational temperature of the Auger experiment. Fig.6 shows the ageing test (80 Celsius) for both 5118 and 5915 spheres.

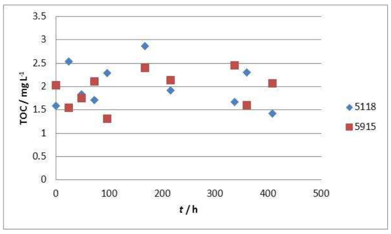

Figure 4. TOC in Water with spheres 5118 at 80 Celsius. 400 h = 17 days.

The following conclusions can be drawn, that are valid for both 5118 and 5915:

The insertion of the polypropylene beads introduces an initial degradation in the TOC (from a blank of 0.5 ppm to about 1.5 ppm). This degradation does not increase in time There is no significant temperature effect. Two weeks at 80 celsius (ageing) test showed no significant effet.

4. Study of the chemical stability

The differential scanning calorimetry (DSC) method has been used to understand the chemical stability and to study the phase transition of the beads.

The DSC has been made both for 5118 and for the higher density 5915. The amount of heat required to change the temperature of the beads has been analyzed.

Apart from the usual phase transitions of crystalline states, the 5915 DSC is perfectly smooth in the operating temperature region of Auger.

On the other hand the 5118 DSC shows clearly a vetrous-polymeric transition st arting at around 40 C.

Therefore the 5118 (low density) beads are less stable and could change their structure in time.

5. Estimate of the effect of winter time

On the field, the water around the PMT does not freeze presumbly for the insulation added over the PMTs (perhaps except very cold winter). For this reason we have filled the window with alcohol in order to prevent the freezing of the water around the PMT. The heat transfer from the rest of the surface is unimpeded and therefore the water may freeze on the rest of the surface. The vassel, the water and PMT "window" are inserted in a freezer. We record, via a camera, the freezing/unfreezing phases. At the end of the freezing cycle, the water surface shows the ice on top of the layer of beads, not only on the border of the

Figure 5. Ice on top of the layer of beads after the freezing phase.

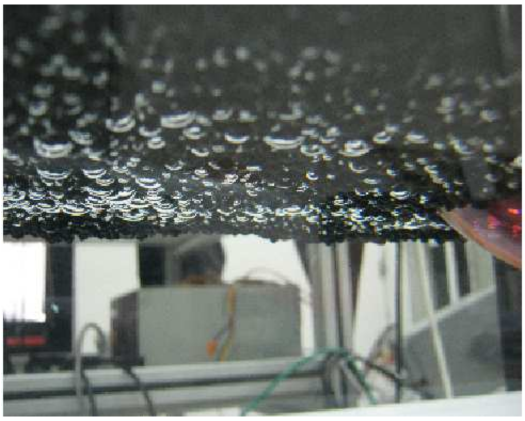

Figure 6. Air bubbles remaining below the black top layer after a freezing/unfreezing cycle.

container, as shown in Fig 6.

Analyzing the full sequence of the freezing cycle we evaluate that the layer of beads begins to freeze first. Once the layer expands,the beads begins to stick to the walls of the container. The frozen layer of beads stucks to the wall and does not follow the expansion of the water. The water pass over the beads layer. During the unfreezing phase, the layer of beads is the last to unfreeze. The beads remain attached to the walls. Unfortunately air bubbles can remain below the layer of beads, as shown in Fig **??**

6. Conclusions

In spite of a good chemical stability and of a low , the use of the ARPRO beads as a black top material appear very difficult given the difficulty of handling the material inside the AUGER water tanks. Moreover the introduction of air bubble after an unfreezing cycle would introduce in the tanks some uncertain behaviour very hard to be controlled

REFERENCES

1. Pryke C, Should the top surface of the water tank lining be black?, 1997 *Auger Experiment Note* **GAP-97-015**.
2. http://arpro.com/tech-docs/tech-docs.php and *http://www.jsp.com/en.*