

Development of an additional filtration system by 3D printing for the implementation of new X-ray beam qualities used in diagnostic radiology.

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1. Introduction

The Calibration Laboratory (LCI) of the Nuclear and Energy Research Institute (IPEN/CNEN) offers calibration services for radiation measurements instruments used in radiation protection, diagnostic radiology and radiotherapy. LCI produces radiation qualities and irradiation conditions which are in accordance with the national and international standard requirements [1, 2]. In order to establish the recommended radiation qualities for diagnostic radiology, X-ray beams generated in laboratory are modified for the irradiation conditions found in equipment routinely used in healthcare services [3, 4].

2. Methodology

In this work, a new additional filtration system was developed to be adapted to the existing filter system at LCI. The new filter support can be coupled to the *PTW® Filter Wheel*, installed at the LCI X-ray system (fig.1).



Figure 1: Pantak X-ray irradiator system and PTW filter wheel at LCI/IPEN.

The models were also developed to fit each specific drawer of each filter to be used in the laboratory routine, coupled to the specific sensors that fit the spaces of the support part. Fig. 2 shows the model developed at the opensource software OpenSCAD [5].

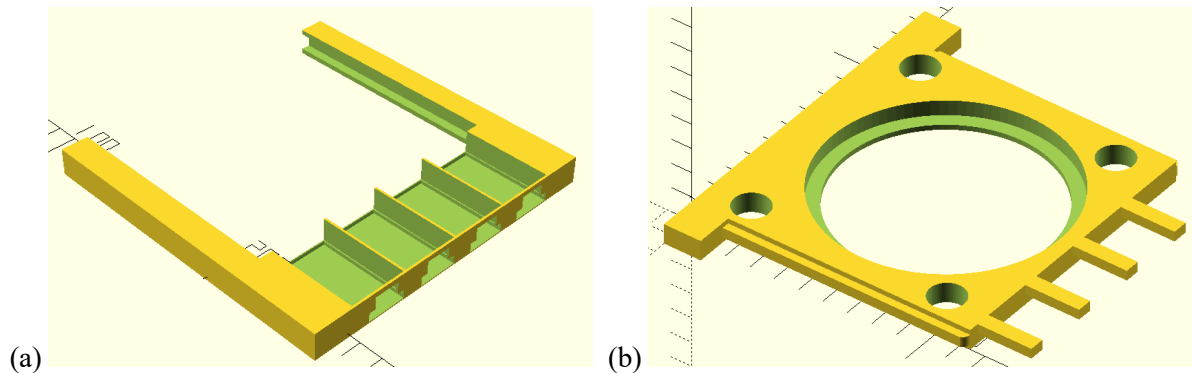


Figure 2: Prototype developed at OpenSCAD opensource software of (a) support and (b) drawer.

Using a FDM 3D printer, a support model and a set of drawers were printed for the placement of additional filters [6, 7] (fig.3).

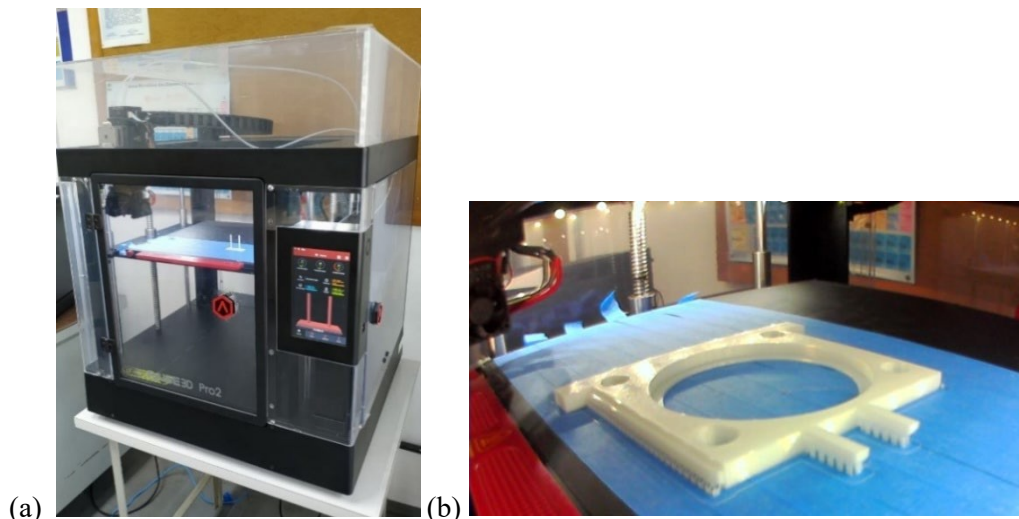


Figure 3: (a) image of the FDM 3D printer (Raise3D PRO [8]), (b) and the drawer been printed.

In order to be able to give versatility to the current calibration system, the prototype of the drawer and of the support was printing using PLA (polylactic acid) filament, with settings adjusted for printing without skirt (contour involving the piece). The purpose for that was reducing the problems of precision in the first layer. It was also used for infill density of 25%, with retraction and infill speed in 60mm/s, so that it had a sufficient infill adjustment to avoid deformation and sufficient print time for drawer to maintain stamina when fitting with the support. This option is suitable for PLA printing, including prior calibration on the X, Y and Z axes of the table, improving printing accuracy.

Additionally, a microcontroller based on Arduino, microswitches, low- and high-level programming, allow checking of drawer status and integration of information with the laboratory control system. The system allows the recognition of the filter inserted in the drawer from sensors attached to the support.

3. Results and Discussion

Fig. 4 shows the assembly for support with the four sensors attached in the spaces and the contact of the drawer (in this example with Al filter).

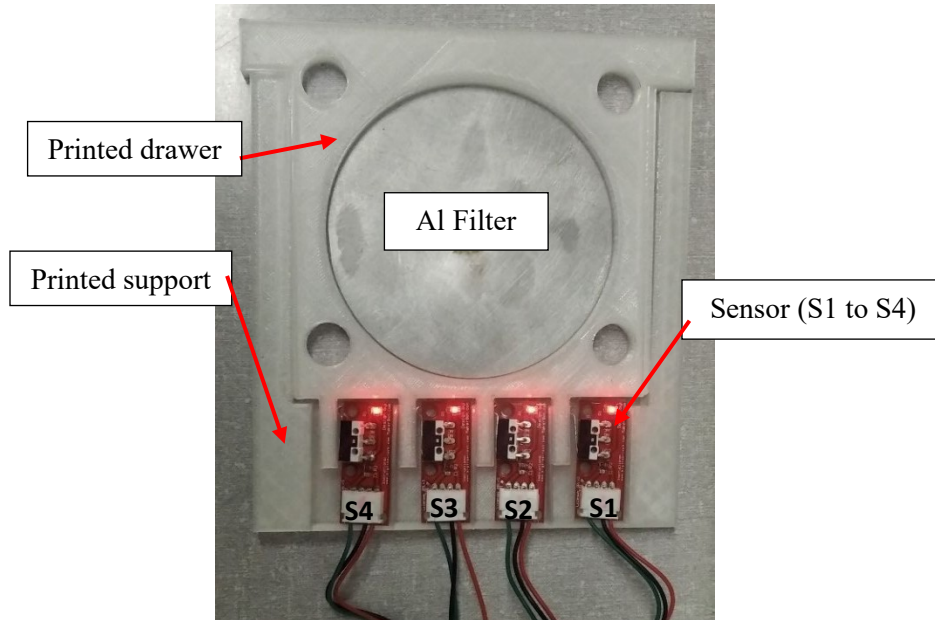


Figure 4: image of drawer and support with the sensors at the bottom of support.

And, Fig. 5 shows the schematic situation for recognition and register of the filter.

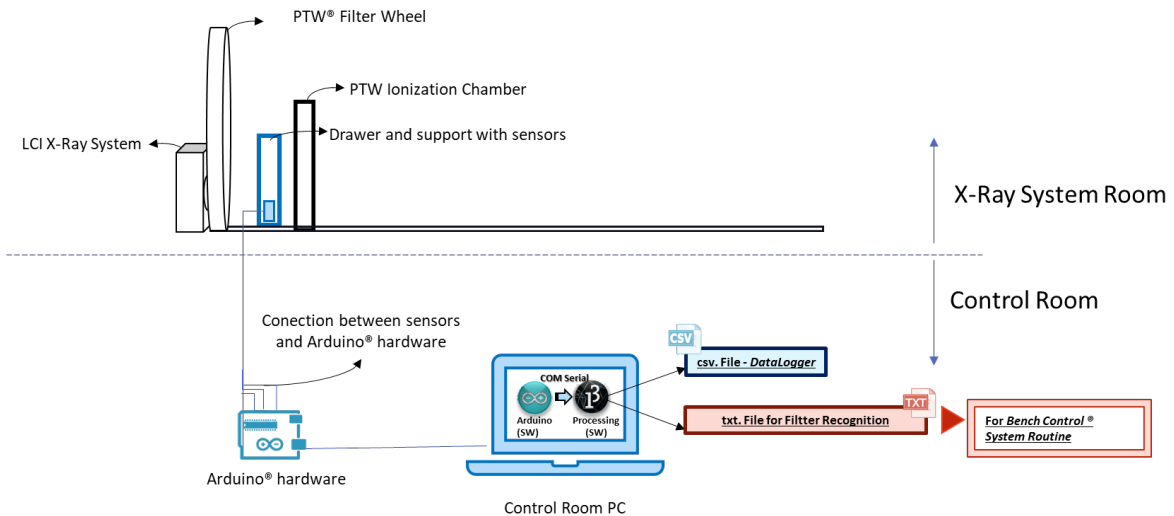


Figure 5: the whole schematic situation for recognition of the filter attached in the drawer.

In this situation, the Arduino® software recognize the specific filter attached at the draw, by the sensor in high state. The combination of sensors generates a specific data at the COM serial. This serial communicates with the Processing® software, that generates both .csv file (*DataLogger.csv*) and a .txt file. The .txt file will be used for filter recognition, implemented at the routine for *PTW Bench Control®*, at the PC Control Room. The *PTW® Bench Control®*, finally, indicates what filter is located at the *PTW® Filter Wheel*.

Tests were carried out to verify the usability of the system in the routine, adding Ag (silver) and Cu (copper) filters, for the characterization of attenuated radiation beams of interest in diagnostic radiology [9, 10].

4. Conclusions

In view of the activities carried out, this work is in the final phase for the adequacy for the LCI X-ray system, for usability of the new system of recognition of additional filter in the routine. Thus, with the operation of the system, new qualities of radiation can be implanted.

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