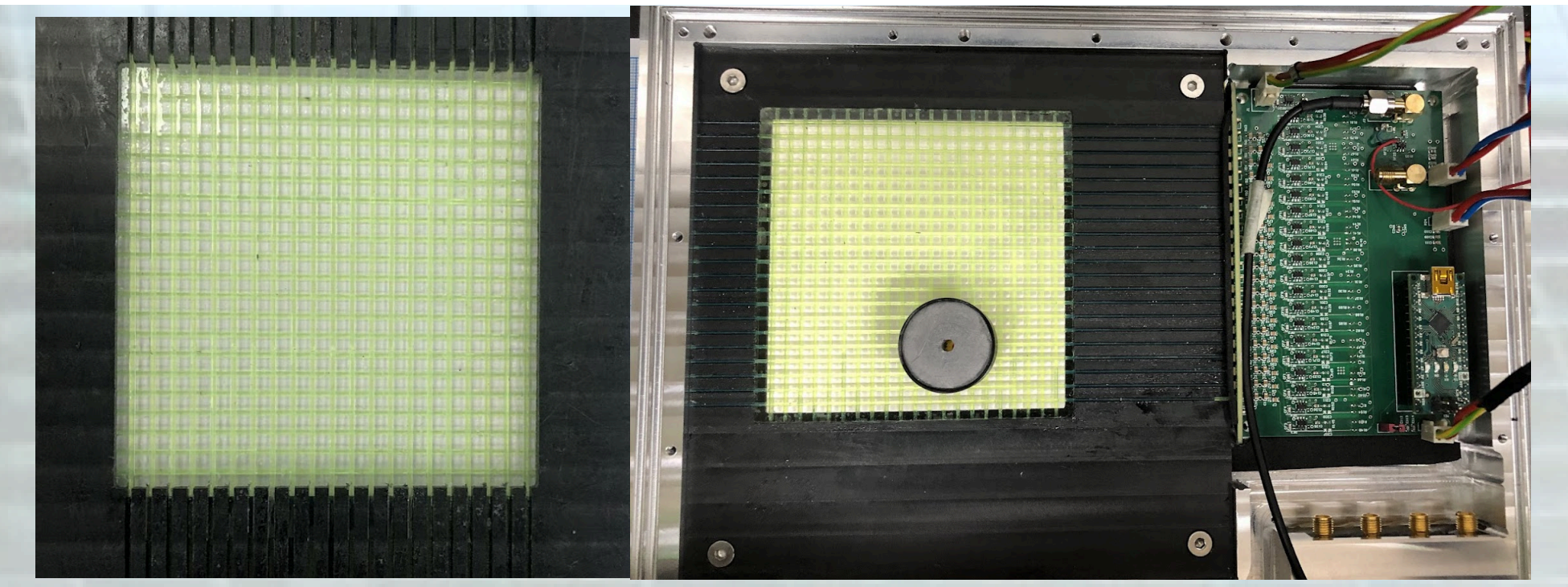
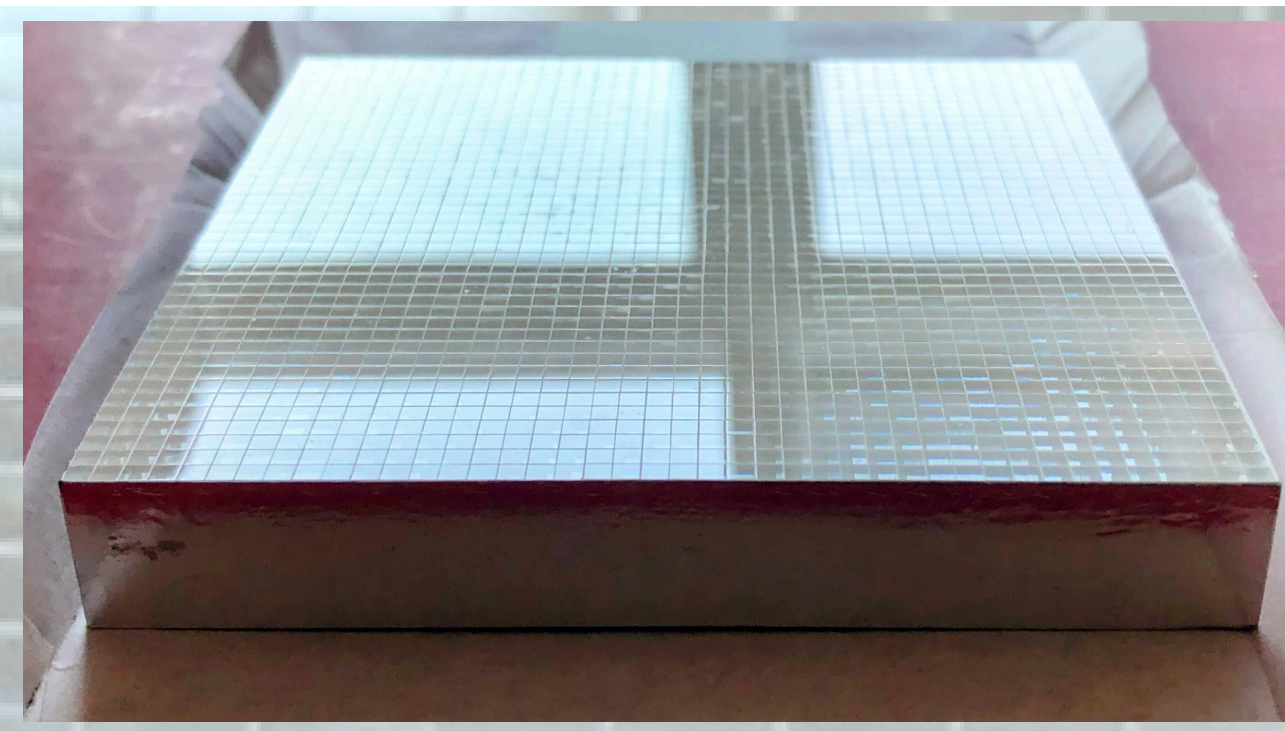


Center-of-Mass Electronics characterization for miniPET Implementation

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Abstract

Image reconstruction in positron emission tomography (PET) remains a significant technical challenge. In this work, we report the **characterization of front-end electronics (FEE) based on Anger logic** designed to read out an array of **21 Multi-Pixel Photon Counters (MPPCs)**. This photosensor array is **optically coupled to an array of wavelength-shifting (WLS) fibers** interfaced with a **LYSO crystal matrix**. The **FEE was characterized using an LED positioned in front of each MPPC**. Signal processing was performed within ROOT, allowing determination of the **single-photoelectron response**, and **Anger logic ratio for the MPPC array**. In addition, the relative motion of the two detector planes used for reconstruction was automated via an **Arduino-based control system**.

Historical development of PET

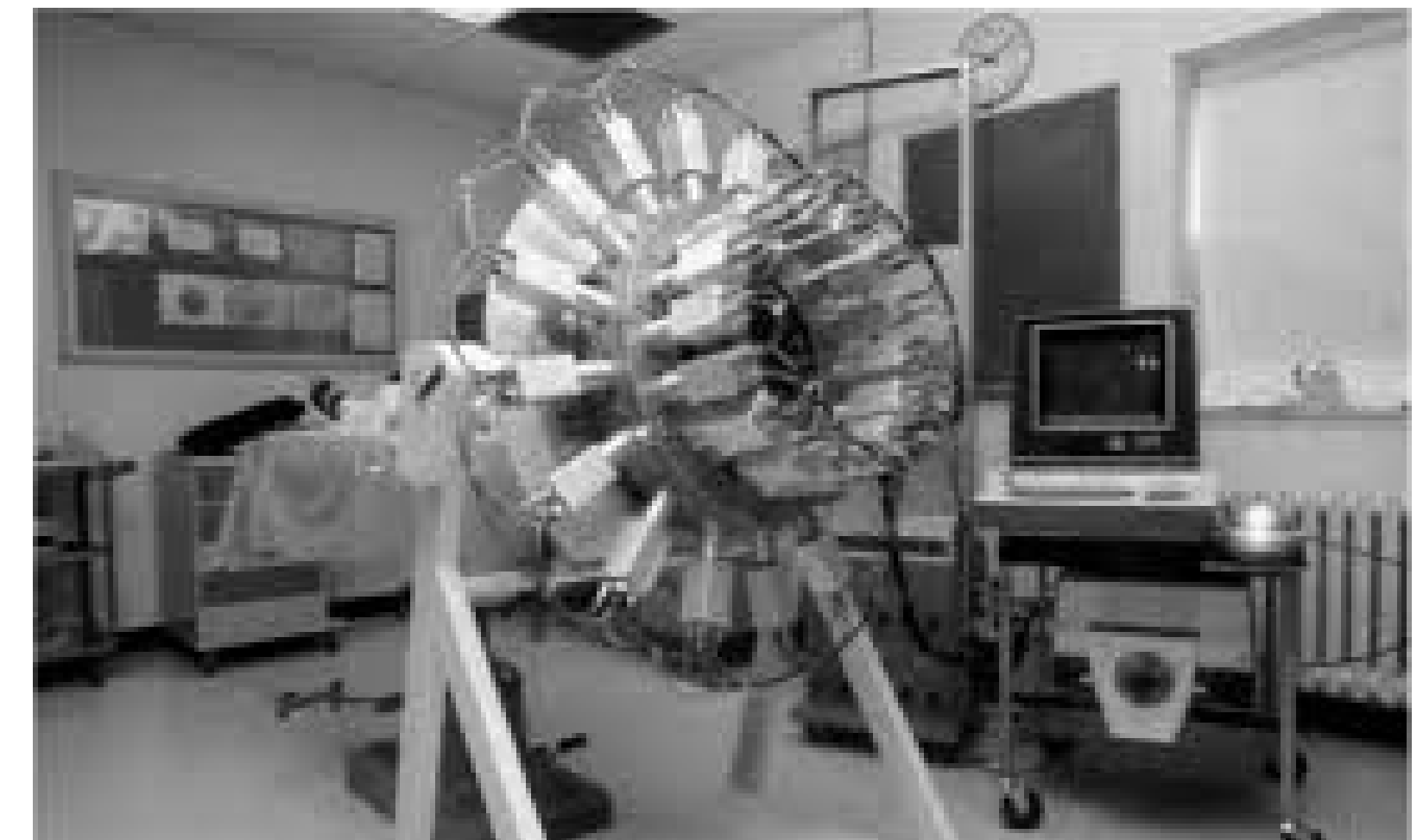
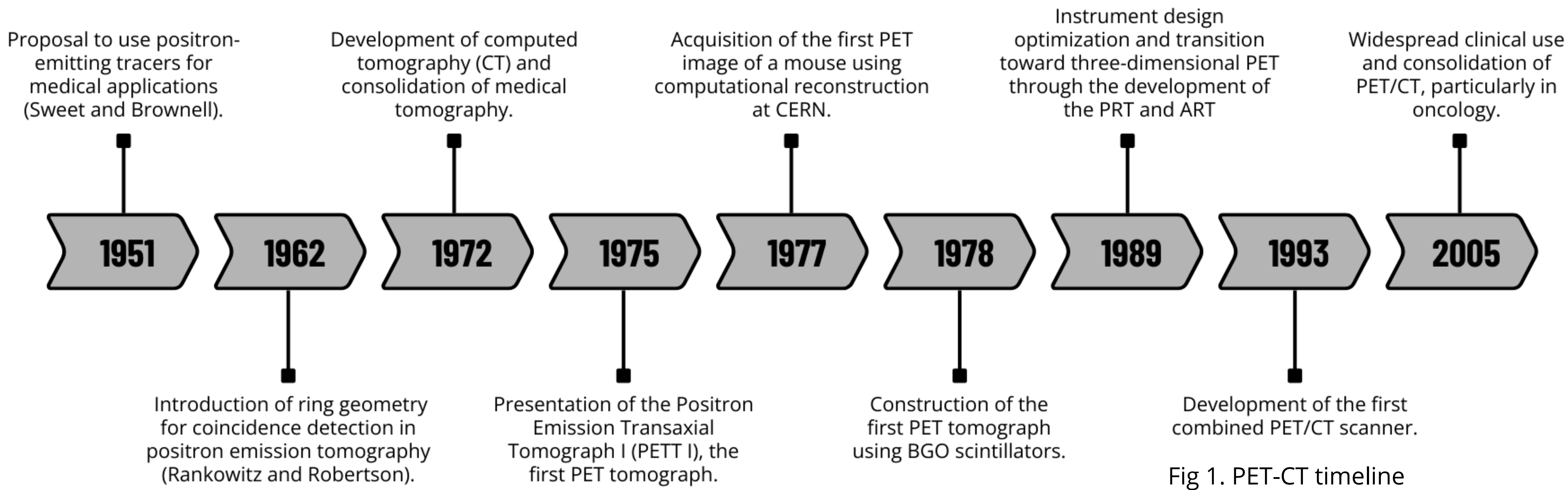


Fig 2. Photo of the original PET scanner developed by Chris Thompson and collaborators at Montreal Neurological Institute, called Positome

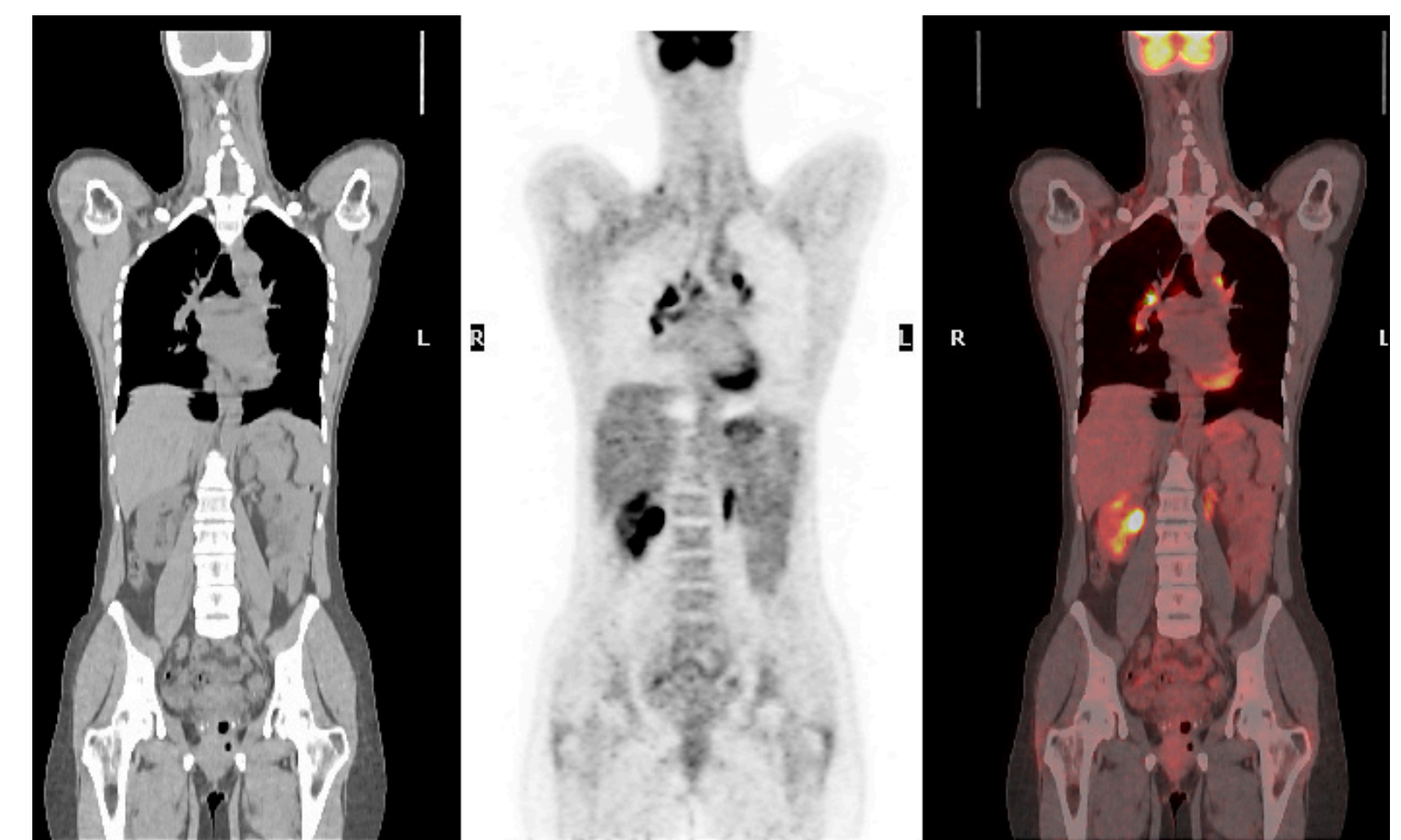


Fig 3. Fused PET/CT image combining functional and anatomical information

Experimental Setup

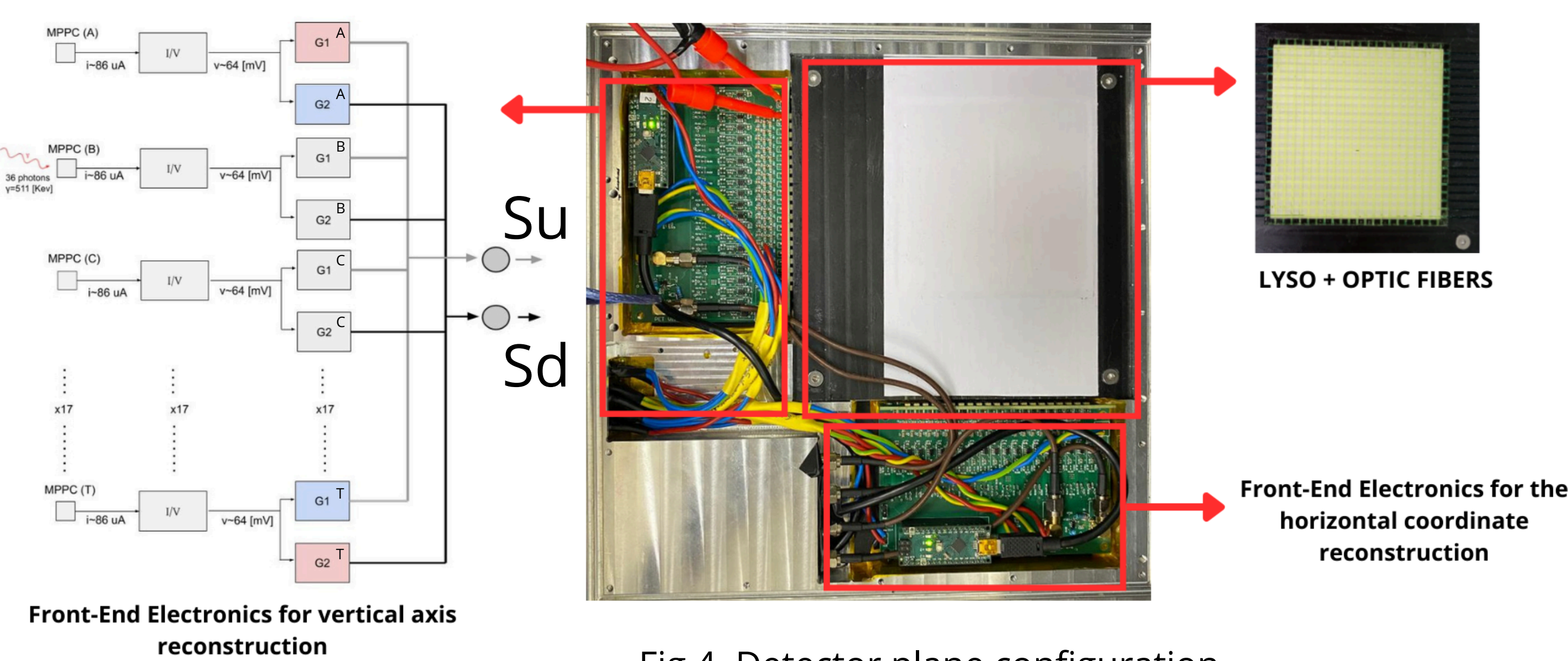


Fig 4. Detector plane configuration

The detector plane consists of a matrix of 42×42 LYSO:Ce scintillator crystals, each measuring $2 \times 2 \times 13 \text{ mm}^3$, coupled to WLS fibers that guide the scintillation light to an array of 21 MPPCs. Each MPPC converts the incident photons into **low-amplitude electrical signals**, which are **amplified by gain stages (G)** and **combined through analog summing to reduce the number of output channels**. The resulting signals are digitized and transferred for processing. This configuration also allows **DAC-based control of the overvoltage applied to each MPPC**.

To reduce the 21 MPPC signals to two outputs, an **Anger logic** was implemented, requiring a **symmetric gain configuration** (see for example red and blue channels in Fig. 4). The **summed signals** from the **upper (Su)** and **lower (Sd)** parts of the array are defined as:

$$S_u = \sum_i G_1^i \times Q_i \quad S_d = \sum_i G_2^i \times Q_i$$

The **interaction position** is estimated from their **center of mass (CM)**, which ranges from -1 to 1 , with more negative values indicating events closer to the lower region of the array

$$CM = \frac{S_u - S_d}{S_u + S_d}$$

Acknowledgments

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Results and Perspectives

An **LED was positioned in front of each MPPC**, and the DAC was set to bias **only one MPPC at a time with an overvoltage of 2V**. The LED amplitude was adjusted to define the **single-photoelectron signal**, corresponding to an **amplitude of 2.5 mV** (see Fig. 5). In a second step, data were collected and analyzed on an **event-by-event** basis using the ROOT to compute the **CM value**. During this process, an issue in the DAC mapping was identified, and an **improved MPPC mapping (DAC version 2) was implemented**. After applying this correction, the **system performance was significantly improved**, and the **individual channels could be clearly distinguished**. These results are promising and demonstrate that the FEE is capable of reconstructing the signal and correctly identifying which MPPC collects the light.

Future studies will focus on validating the remaining three FEEs, performing a full-system mapping, and characterizing the response of the LYSO array with a Na22 radioactive source.

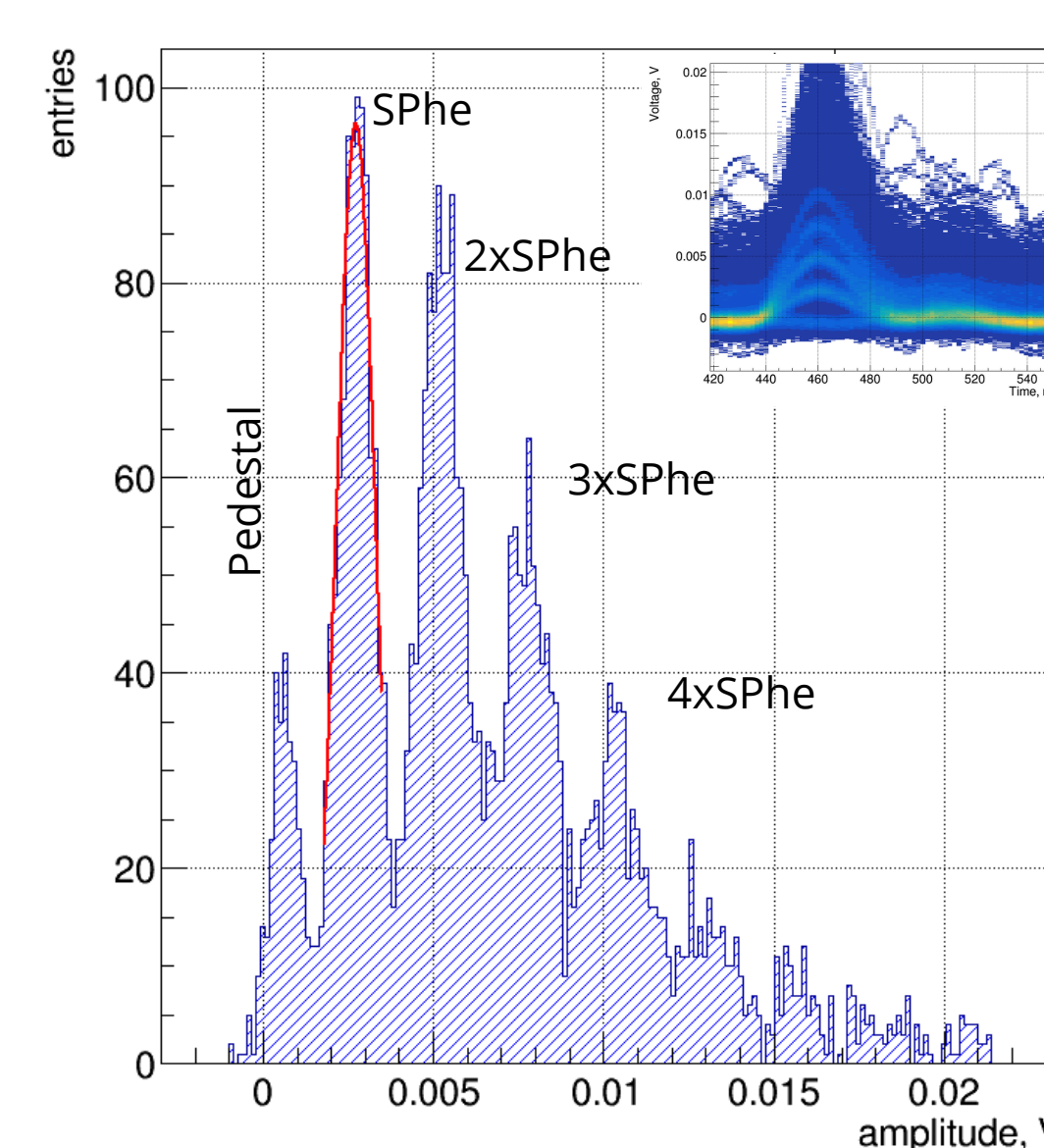


Fig 5. Single photoelectron response of the MPPC 21

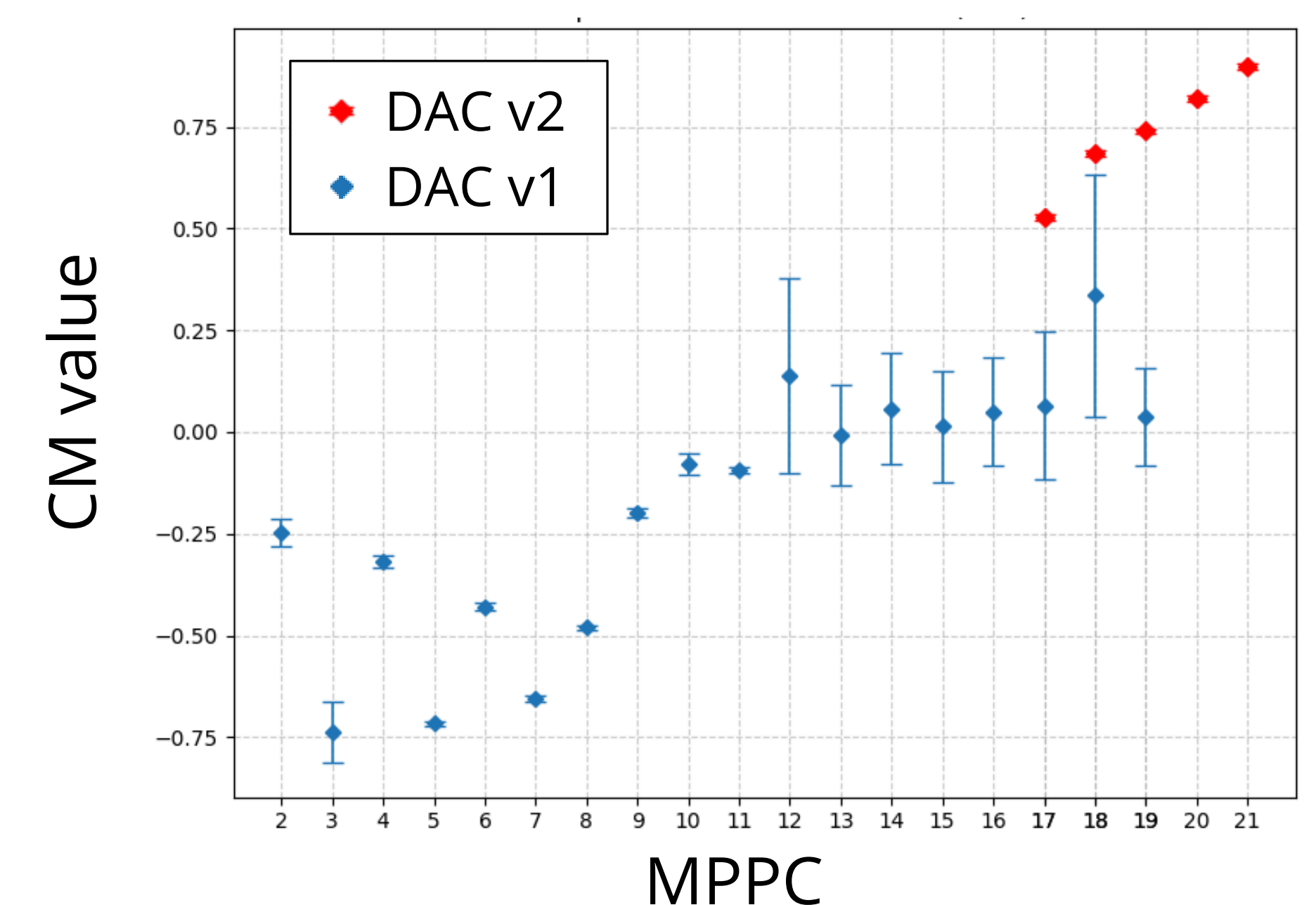


Fig 6. CM value over the axis scanning over the 21 MPPC