Low Beam Intensity Monitoring at CNAO

CNAO, Milano INFN and Roma (INFN and La Sapienza)
groups

VIII FOOT Collaboration Meeting – 12/06/2020

Goals of the Beam Monitor for low intensities

- **Goal**: Provide a feedback to the Dose Delivery system and to the research teams when working in the CNAO experimental room about the beam properties at low intensity, in terms of:
  1. primary ions counting
  2. beam position
- **Motivations**: when beam rate intensity is < 1 MHz, CNAO standard beam monitors (layers of parallel-plane ionization chambers closed in two BOX equipped with strips and pixels to measure the beam flux and x-y position) are almost 'blind' and so not able (very inefficient) to count the number of the impinging primaries ions
- The goal is to develop a monitor to measure rates up to 10 MHz covering an active area of ~ 13 x 13 cm^2 able to provide feedback about the beam position with an experimental resolution on both views (x,y) of ~1mm

Adopted technology

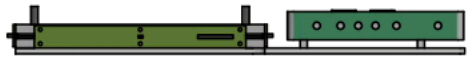
- Two layers (x-y) of plastic scintillating fibers (squared, 1 mm side) readout by SIPMs. The SIPM dimension drives the resolution and the number of channels: currently a 1mm^2 solution is foreseen.
- 128 fibers per layer will be read on the two sides of the plane alternately, for a total of 64 channel per side and an overall number of 256 channels for the whole detector
- Aluminum frame @ 25 cm from beam isocenter, holding the SIPMs boards and readout system.
- A custom CAEN - A55CIT4 / DT5550W is the proposed readout system (still some tests and investigations are necessary) handling128 channels: 2 of such boards can manage the readout of the whole detector, each board reading a BM view.

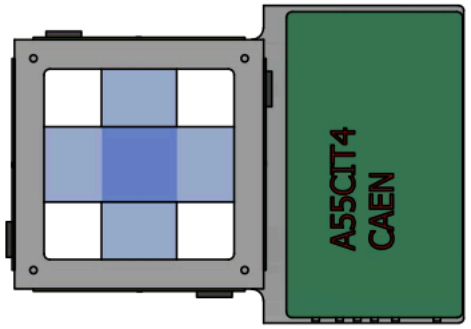
Adopted technology

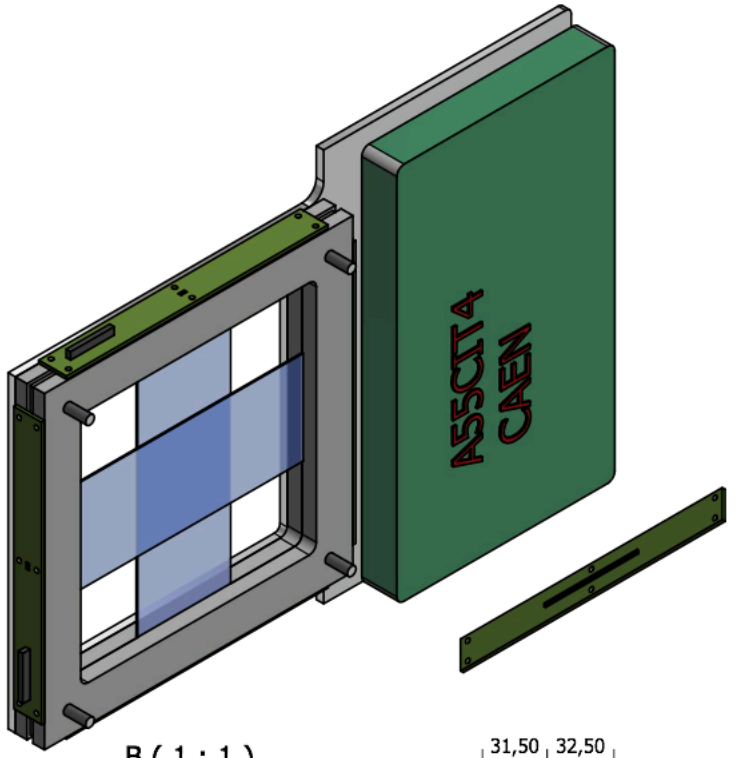
scheda elettronica con SiPM posizionati in modo da leggere fibre diverse su ambo i lati (B).

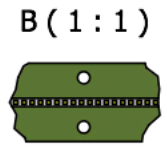
i fori di fissaggio della scheda sono sfalsati per permettere di leggere i piani di fibre ad altezze diverse.

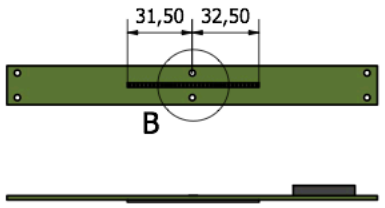
si può montare la scheda CAEN ruotata di 90 gradi.











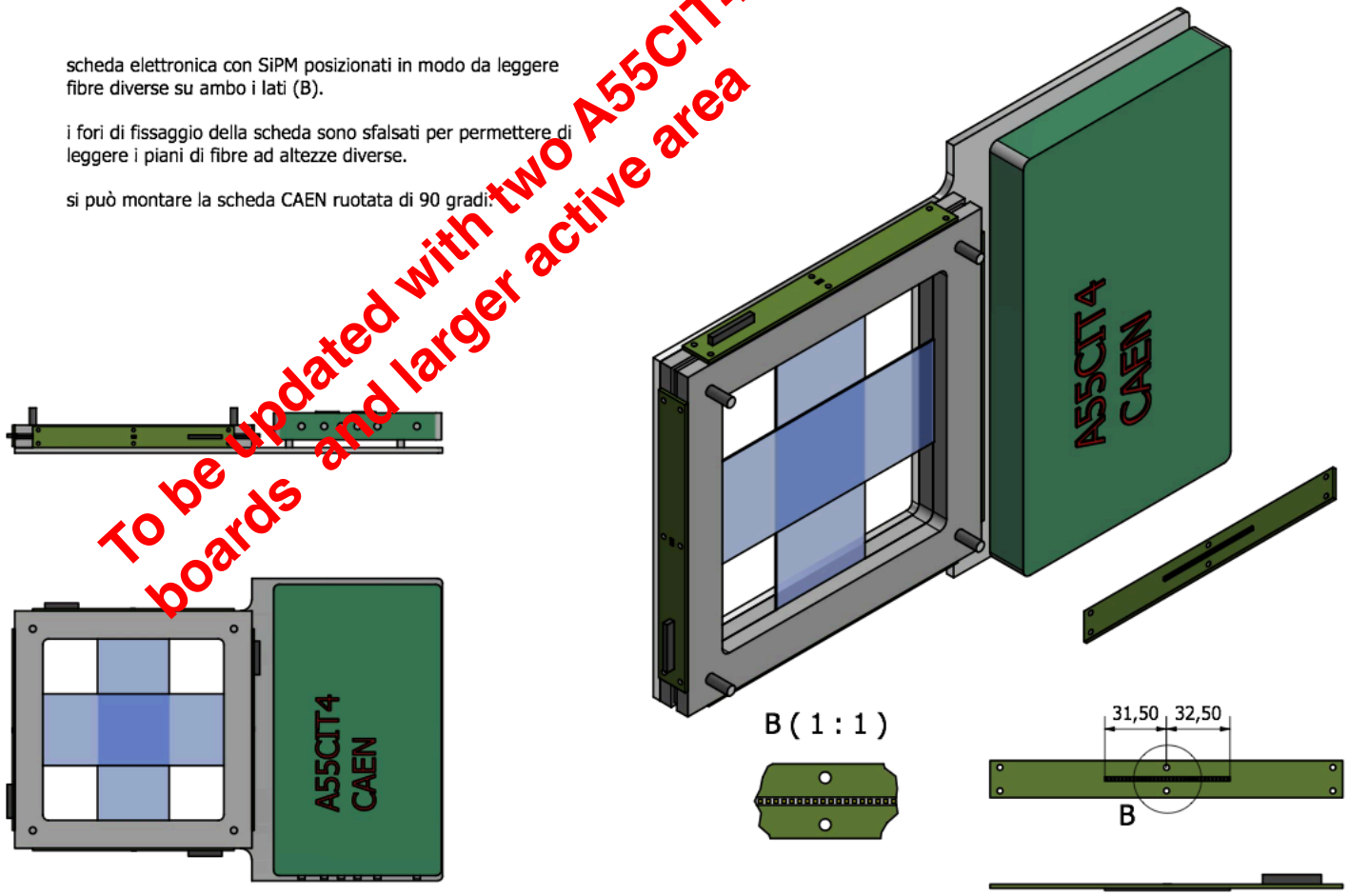
Adopted technology

scheda elettronica con SiPM posizionati in modo da leggere fibre diverse su ambo i lati (B).

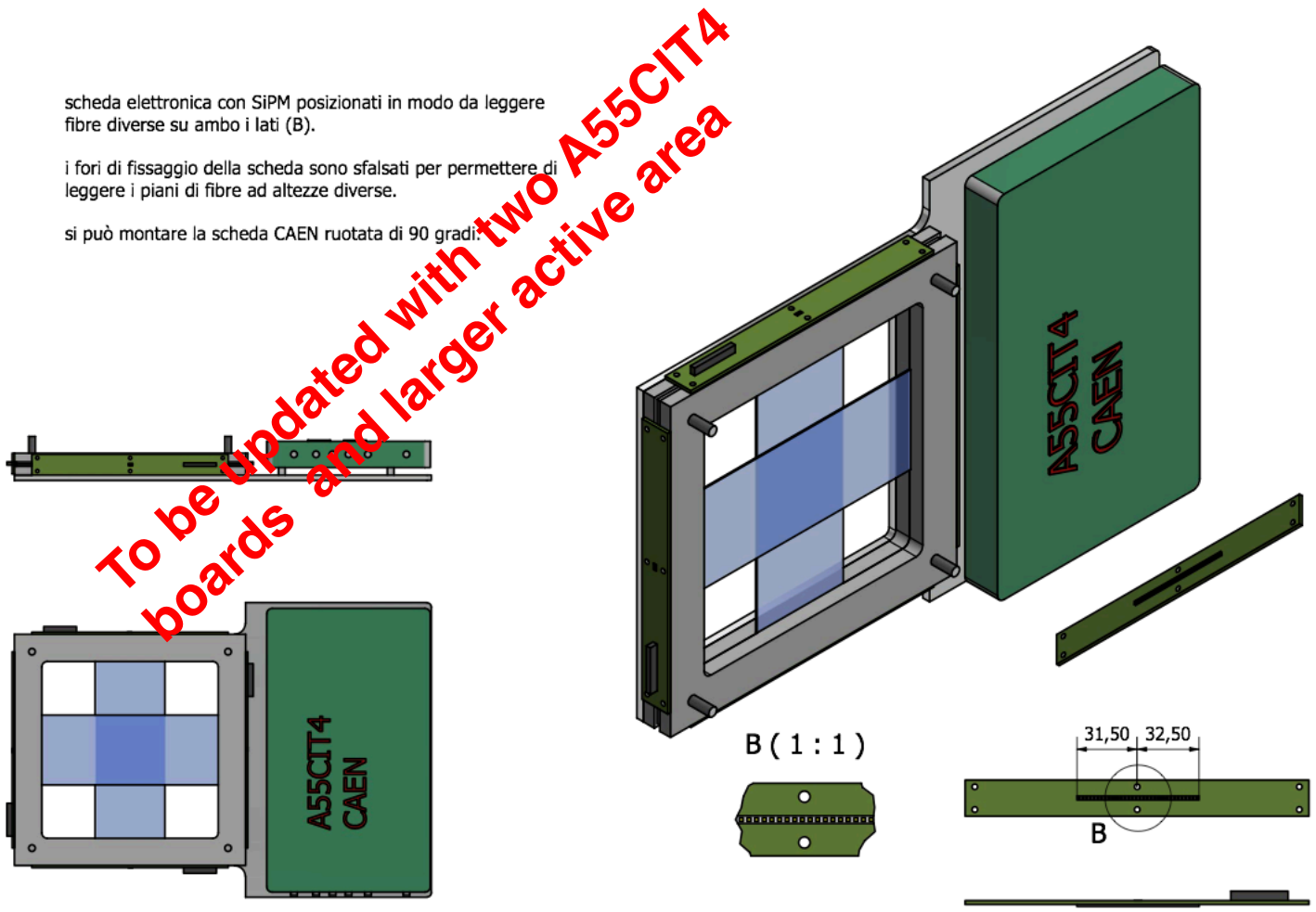
i fori di fissaggio della scheda sono sfalsati per permettere di leggere i piani di fibre ad altezze diverse.

si può montare la scheda CAEN ruotata di 90 gradi

To be updated with two A55CIT4 boards and larger active area



Adopted technology

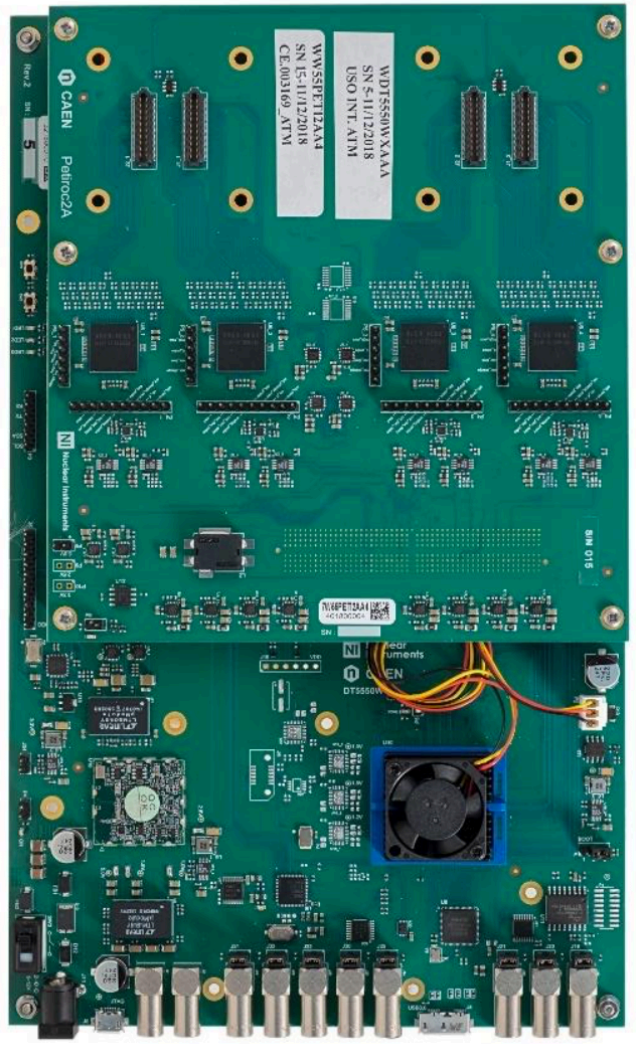


Further requests:

1. in order to take care of aging effects the aluminum frame with the two layer of scintillators fibers have to be replaceable with new layers
2. The BM has to be removable from the beam axis for groups that don't need it

The readout system

- The readout system is composed of:
  - A55CIT4 that host four CITIROC 1A WeeROC ASICs, managing 32 channels each, and providing a power supply for SiPM
  - DT5550W motherboard hosting a Xilinx XC7K160T (Kintex-7 family) FPGA
- Two readout modes:
  1. Photon counting (providing the ID of the hit channels up to 10 MHz)
  2. Analog Charge Integration: measuring released charge in a dynamic range 0-400 pC up to 100 kHz
- The wanted operational mode is Photon Counting: from next week start to check the expected characteristics of the board



A55CIT4

DT5550W

Conclusions

- A detector to be used as monitor in the CNAO experimental room for the case of low beam rate intensity is in the planning stage
- The monitor has to be able to measure rates up to 10 MHz, covering an active area of ~ 13 x 13 cm^2 of scintillating fibers read by SiPM, and to provide feedback about the beam position with an experimental resolution on both views (x,y) of ~1mm
- The adopted technology guarantee a low material budget minimizing fragmentation of the beam in the monitor itself, and a dynamic range spanning from protons and carbons provided beam energies at CNAO
- The readout system is now available after delay due to the lockdown and tests to verify the expected characteristics are going to be started at SBAI laboratory in Rome …