AIDAinnova (7.2)
MRPCs for fast timing at high incident flux of charged particles
Muon tomography: Low power, minimal gas use, excellent time resolution

EUROPEAN MEMBERS			
Name of the legal entity	Type	Country	Main contact person
INFN, Bologna	Institute	Italy	Gilda Scioli
Picotech SAS	Company	France	Crispin Williams
LIP-Coimbra	Institute	Portugal	Alberto Blanco
University of Clermont Ferrand	University	France	Cristina Carloganu

EXTERNAL MEMBERS			
Name of the legal entity	Type	Country	Main contact person
Tsinghua University	University	China	Yi Wang
Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	Institute	China	Zheng Liu
Seoul National University Bundang Hospital	Institute	South Korea	Do-Won Kim
Gangneung-Wonju National University	University	South Korea	Yongwook Baek
Benemérita Universidad Autónoma de Puebla	University	Mexico	Cecilia Uribe Estrada

Ongoing work

- MRPC task (gas, rate and timing)Test beam (CERN T10) in April 2023 (i.e. now) : Further tests of ecological gasses. Gas-tight boxes and readout boards to create series of MRPCs were built at Bologna; various glass sheets (including the new low-resistivity glass) will be tested.

- Hadron calorimeter task: Test of hadron calorimeter with low resistivity glass: [LIP group: Alberto Blanco, Luis Margato]
  Status : about to start tests with low resistivity glass

- picoTDC task: Program to build picoTDC with time resolution better than 5 ps. Bologna (+ South Korea)

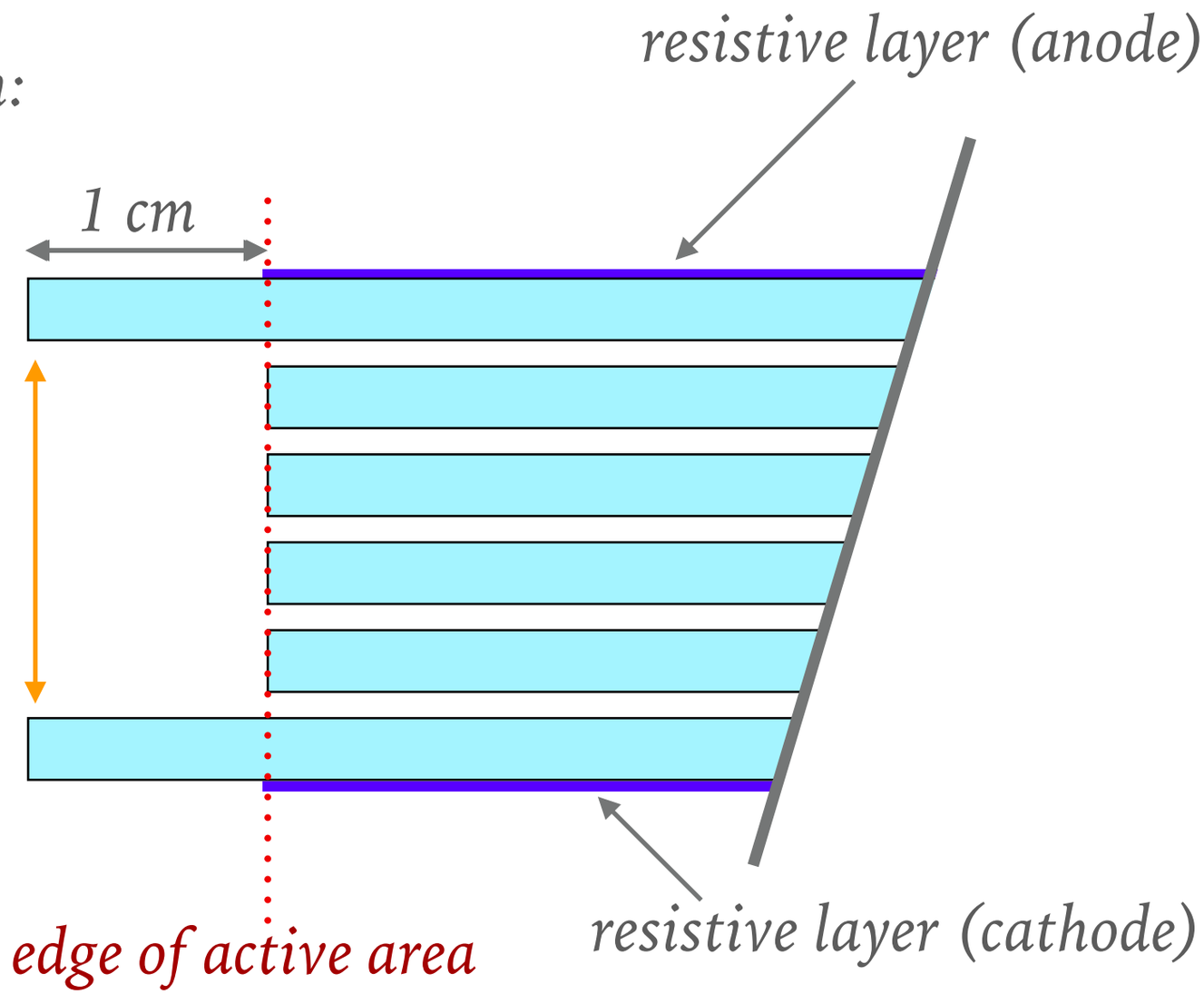
MRPC Glass sheets with low resistivity (10^9 Ωcm)

Two 10 gap double stack MRPCs have been built using the low-resistivity glass from Picotech.

Minor but disaster problem:

This works fine with 'soda lime' glass with resistivity of 10^{12} Ωcm

but with glass of resistivity of 10^9 Ωcm we have high dark current

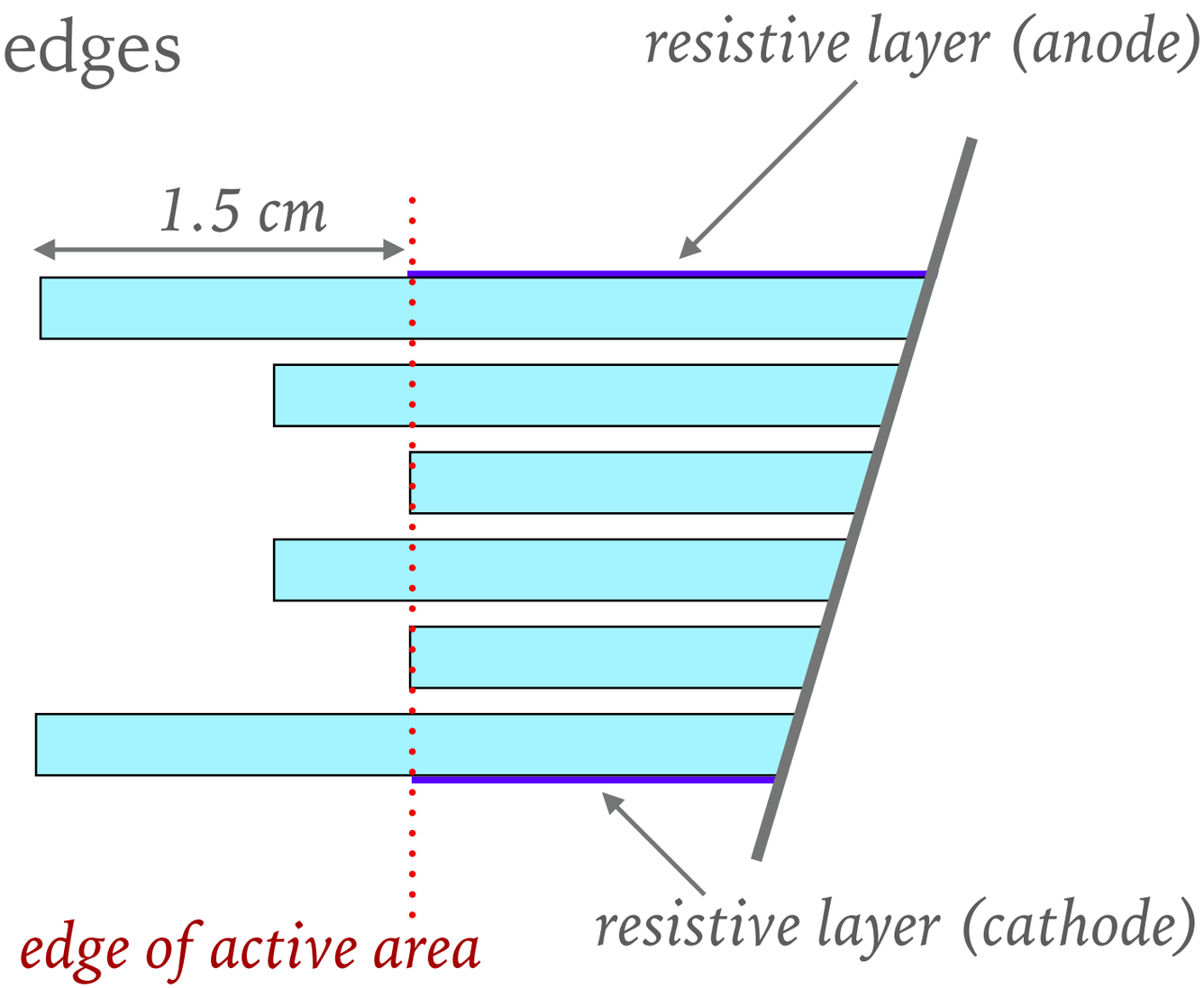


MRPC Glass sheets with low resistivity (10^9 Ωcm)

- Modified assembly
  extend edge zone outer glass
  offset inner glass edges

Now: dark current is

in nA region



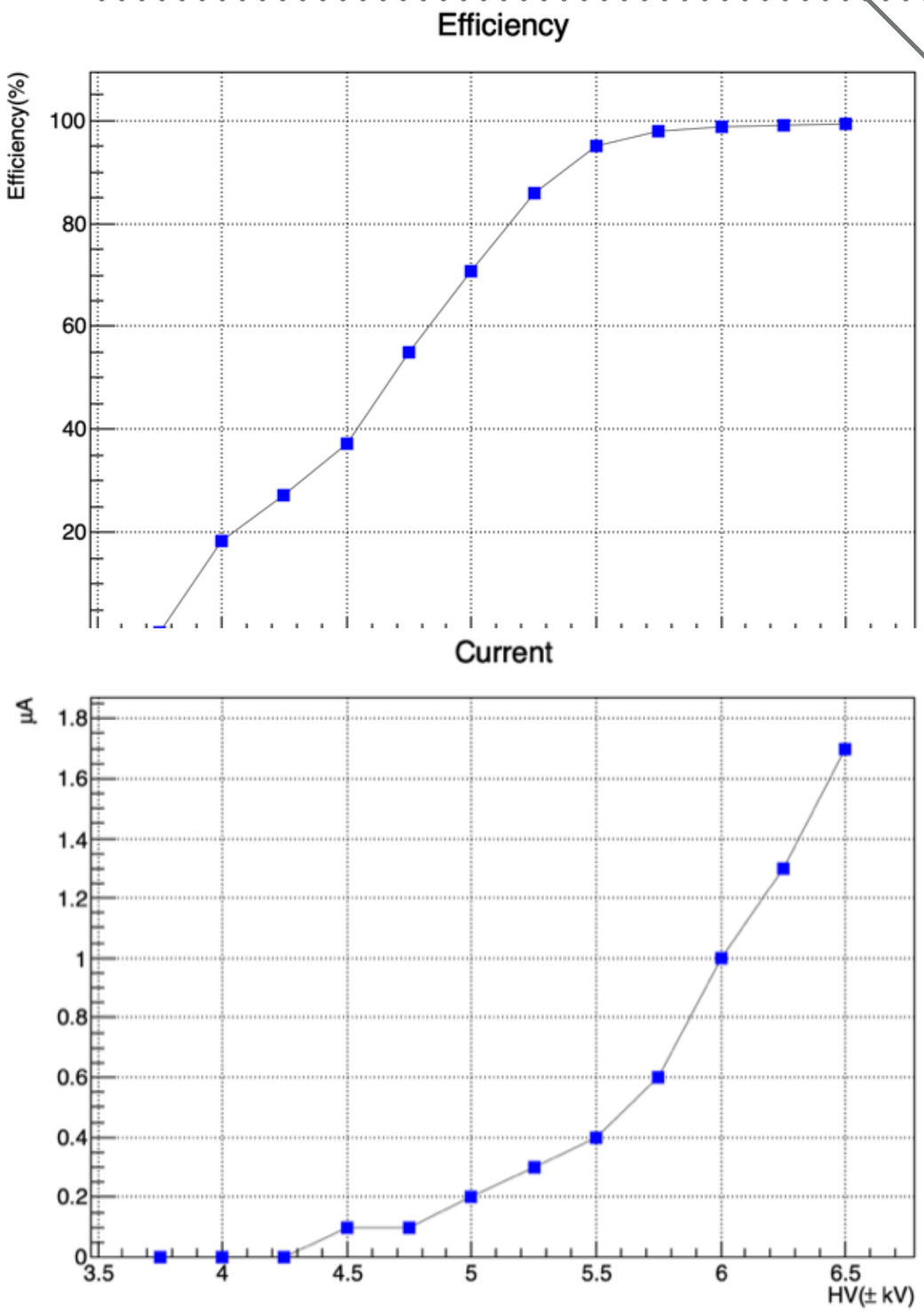
Fast timing MRPC

- X-Y strip type MRPC
  - Single stack 5 gaps with 230 µm Ceramic fishing line
  - Active area: 20cm x 20cm
  - Glass: 330 µm thickness
  - Strip: 5mm pitch(4mm width)
  - Signal output: single polarity, alternative positive or negative

- Beam test
  - LiROC+picoTDC: not ready
  - Use NINO card + HPTDC
    - For adaptation form single to differential signals, an interface card have been designed and manufactured for NINO card, recently

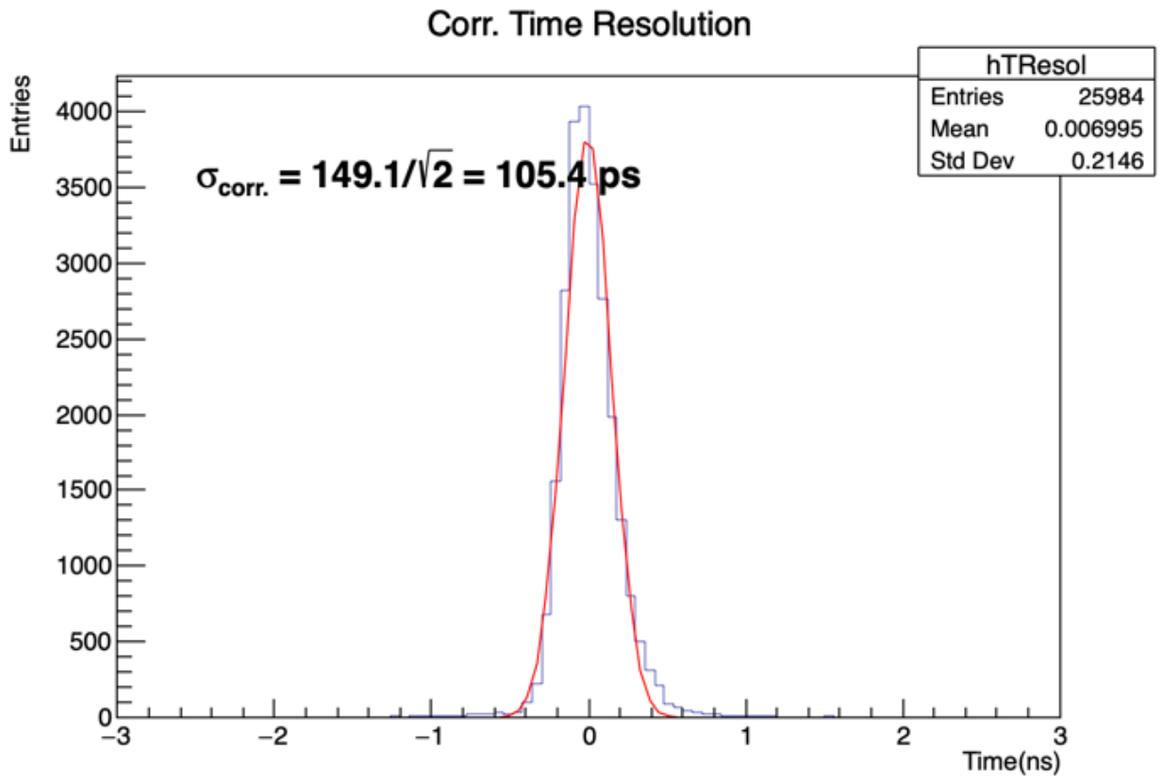
10 gaps of 230 micron (double stack) low resistivity glass

ceramic coated nylon fishing line



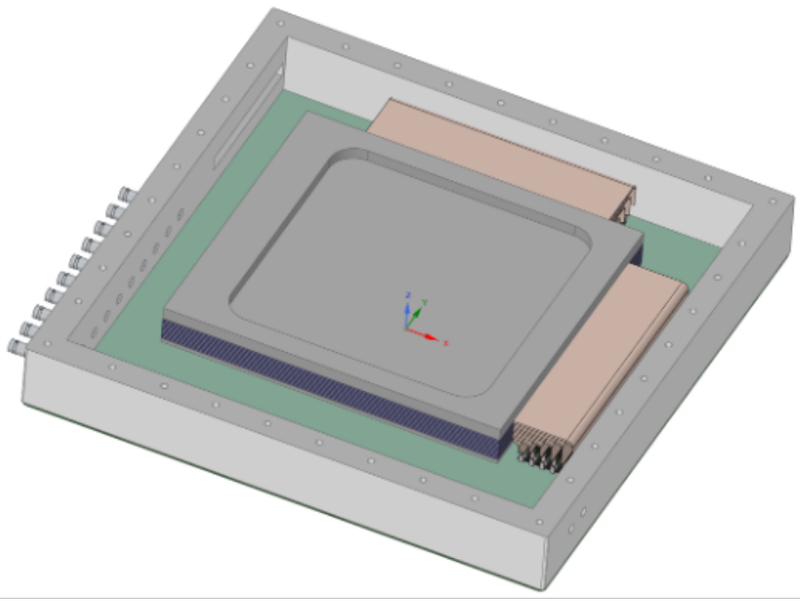
April Beam Test

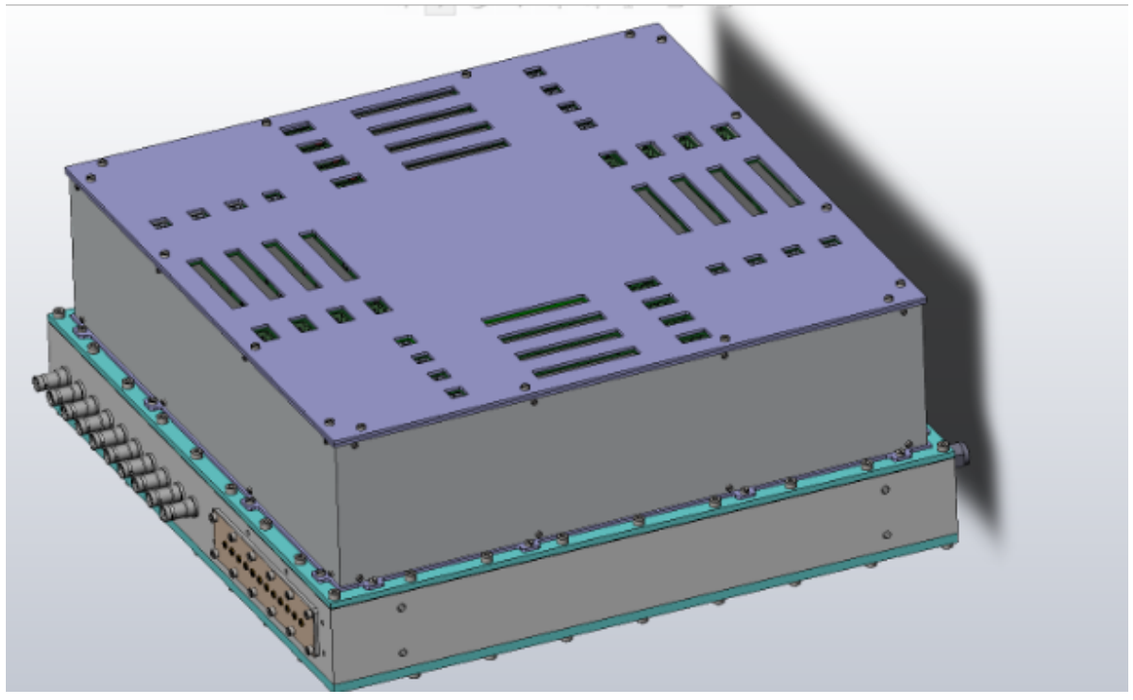
Time resolution reflects time resolution of timing scintillators



Multilayer 10B-RPC Detector. High rate RPC thermal neutron detector

Stack of 10 double gap RPCs units, 2 anodes glass plates facing a cathode aluminium plate coated with ~1-micron thick layer of B4C (enriched in 10B).
One unit is equipped with PICOTECH glass for high rate operation.
2D strip readout for high position resolution (~100 um) and fast electronic for timing.



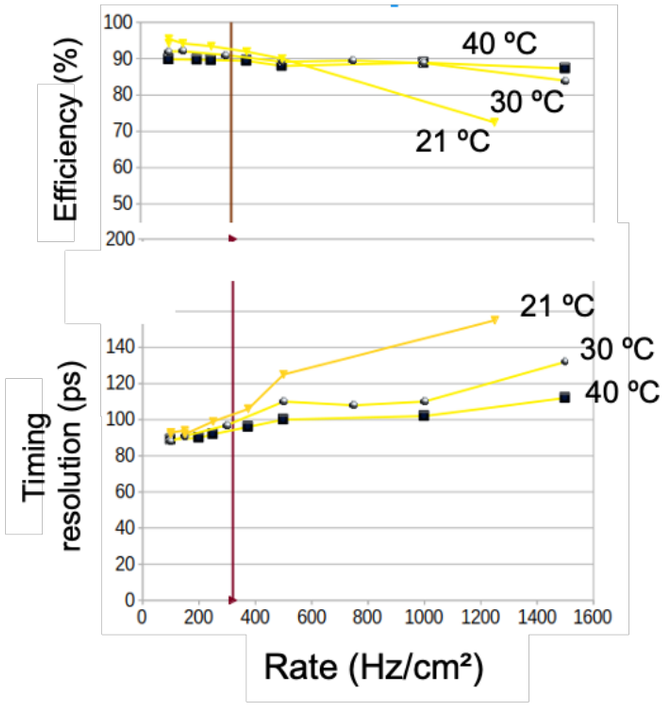


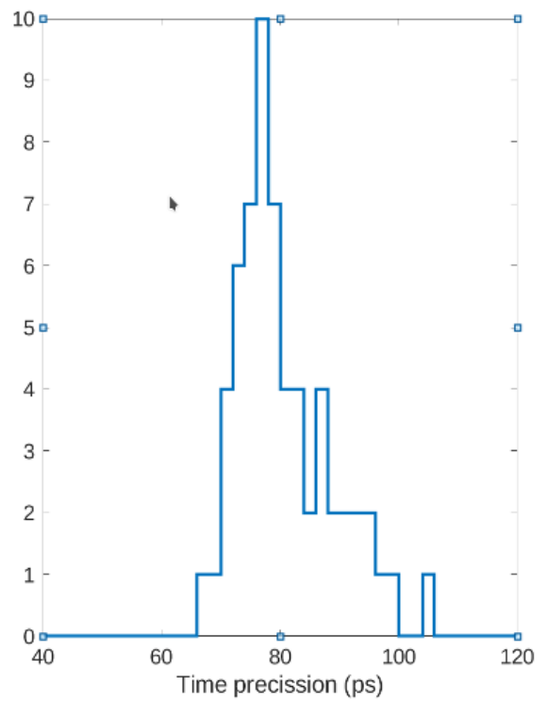
Stack of 10 double gaps and gas tight box closed together with FEE box

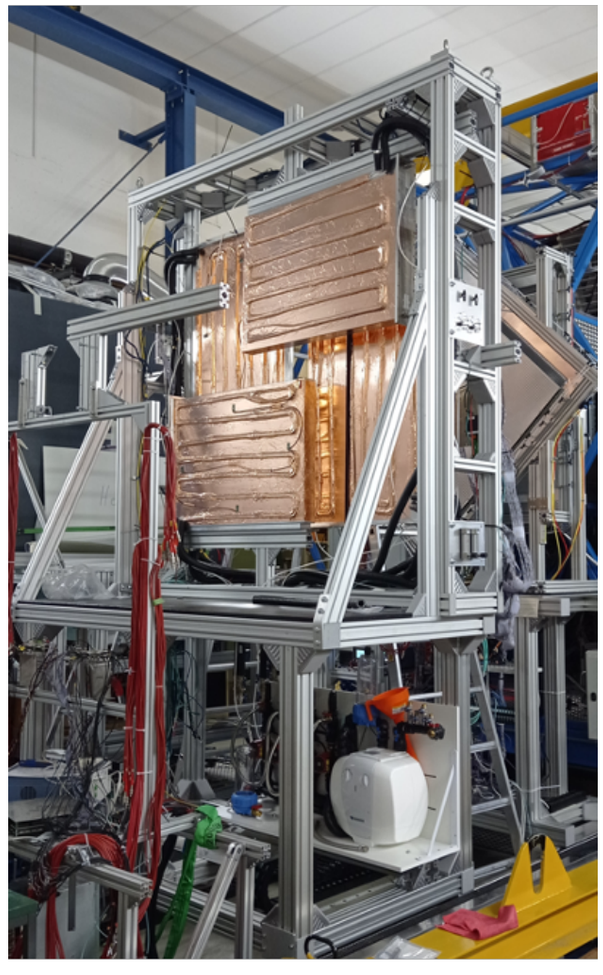
(Picotech supplied 15 sheets of Low resistivity glass resistivity 10^9-10^{10} Ω.cm)

Increasing the working temperature of a tRPC to increase count rate capability

- HADES Forward TOF.
- 128 individual electrically shielded [1] RPCs (cells). x4 300 µm gap.
- Stable operation during 6 weeks @ 32 ºC at a maximum count rate of ~ 1 kHz.
- Possibility of extent this concept to other materials/systems?







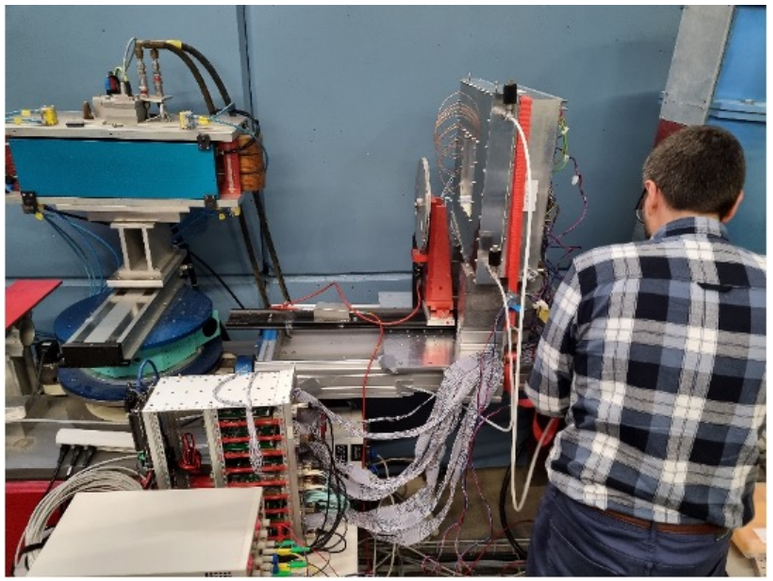
Route to high rate operation is reduction of resistivity of the glass

NIMA 1050 (2023) 168182

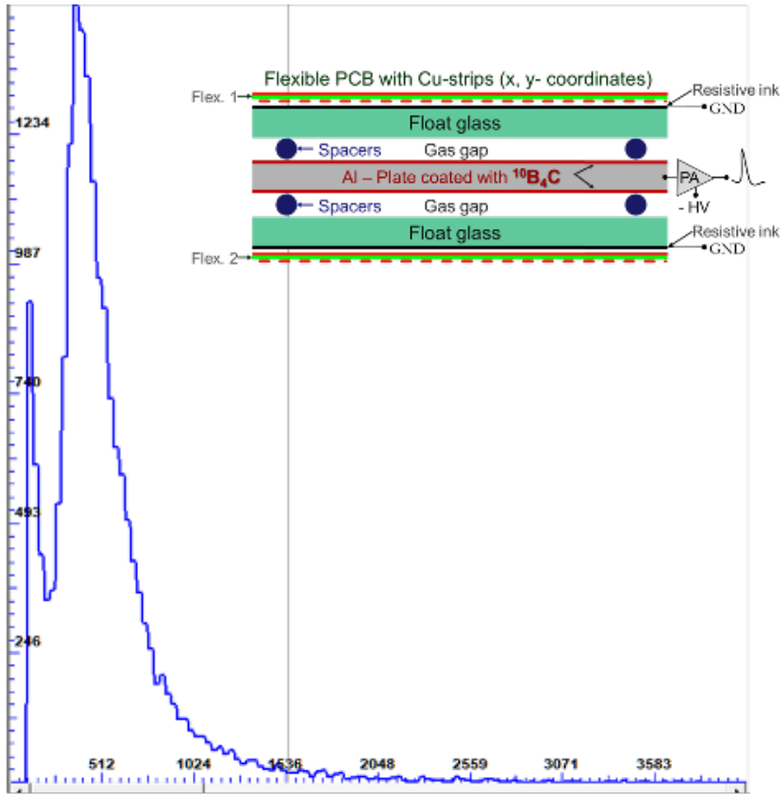
NIMA 1045 (2023) 16765

Multilayer ^{10}B–RPC Detector. High rate RPC thermal neutron detector

Prototype on a beamline at PSI: preliminary tests with neutrons

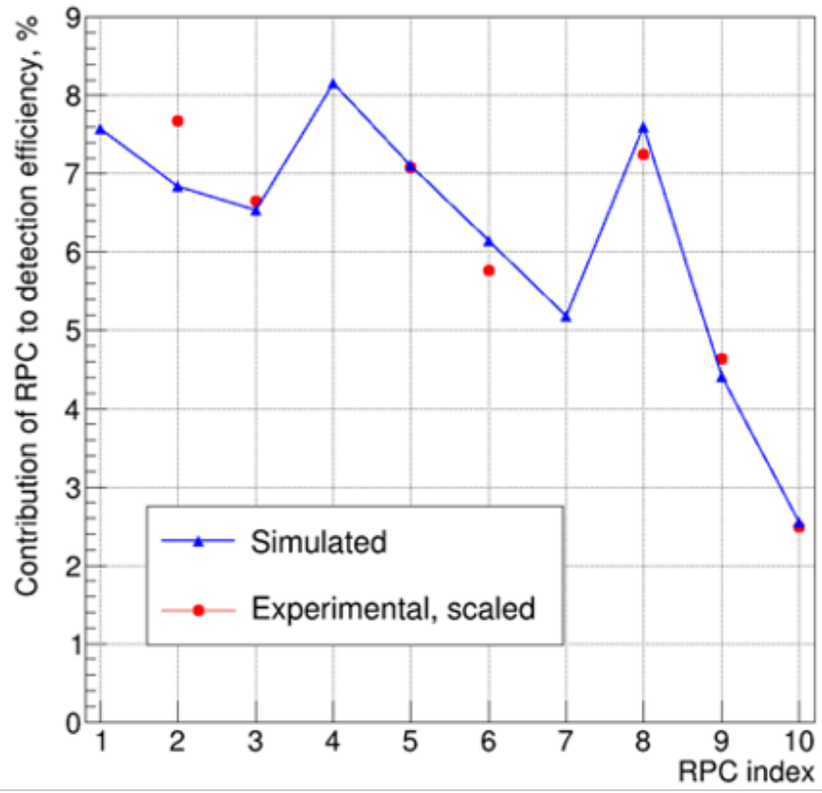


Charge spectra (Al-cathode signals) for the RPC10 made with Low Resistivity glass anode plates: HV = -2kV



Dark current (HV=-2 kV) **< 4 × 10^{-4} nA/cm²** (*comparable to the RPCs with anode plates in float glass*)

Contribution of each RPC in the stack for the neutron detection efficiency (experimental and simulated results)

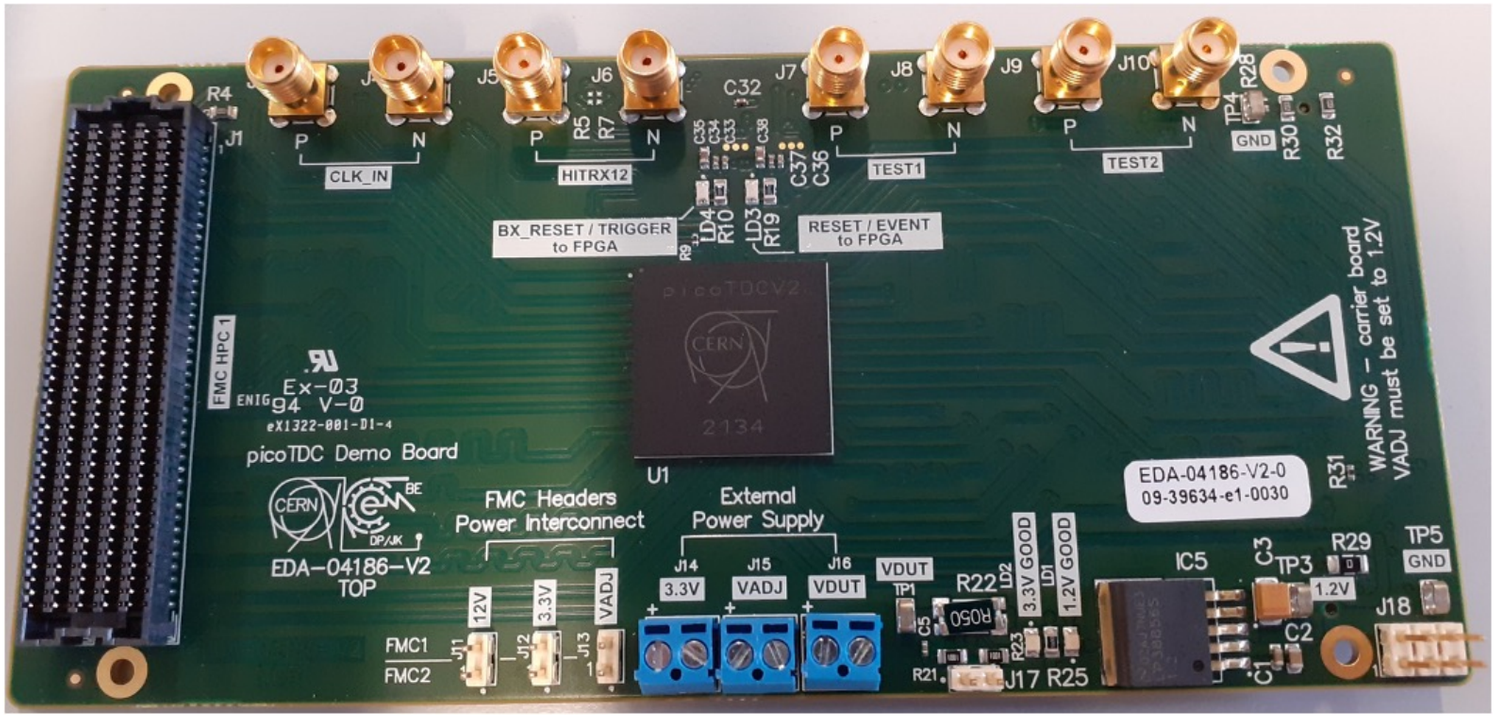


RPC10 behaves as expected from simulations

Note: RPC10 is the farthest one from the neutron entrance window - Explains the smaller contribution to det. efficiency

picoTDC demo board

64 channels



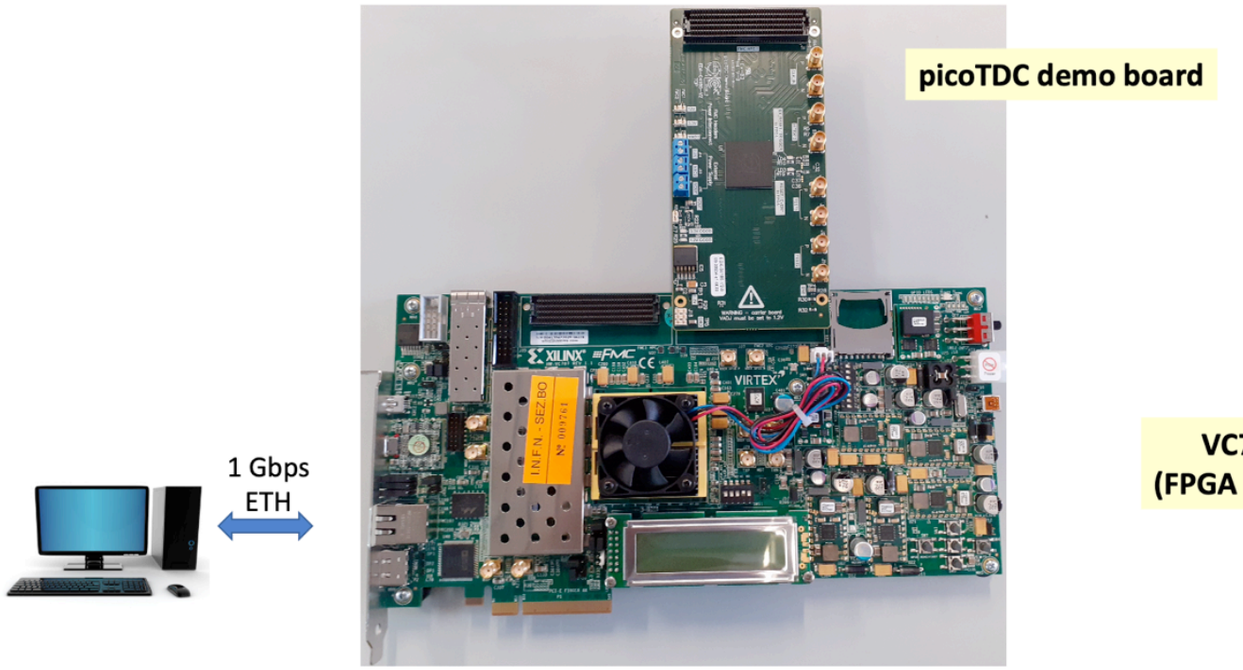
data to FPGA

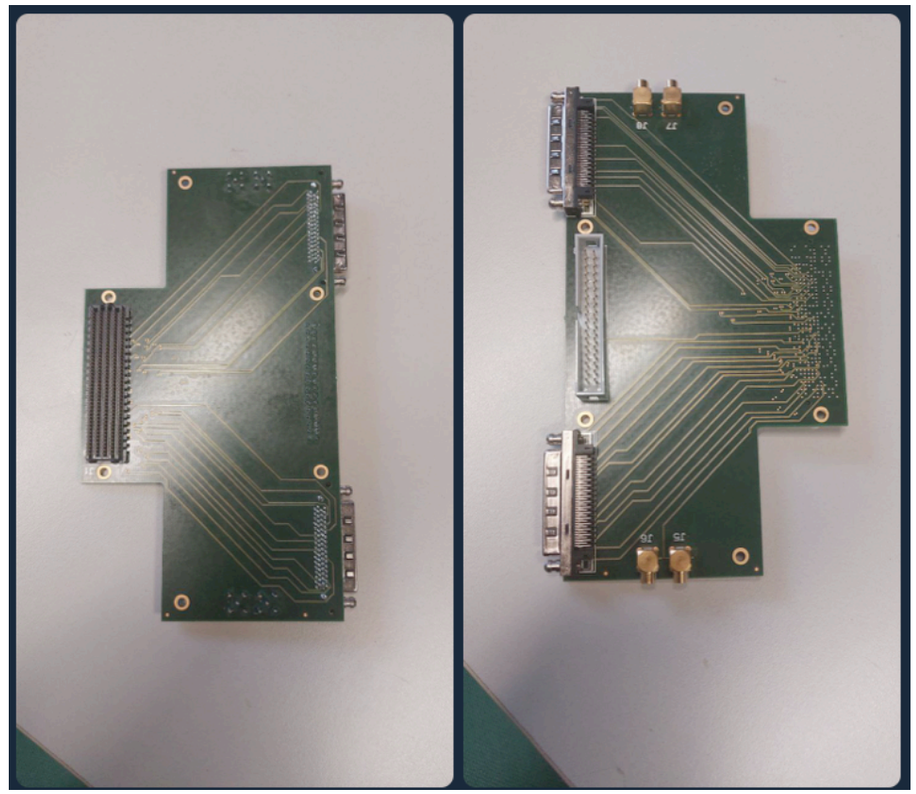
A pair of these picoTDC demo boards are now in Bologna in order to begin tests with the picoTDC ASIC (we also have 10 packaged picoTDC chips)

picoTDC cards for MRPC

This task aims to provide a general purpose housing the new CERN picoTDC for MRPC readout with NINO ASIC.
The card is designed to be flexible enough to be adapted also for other timing sensors (SiPM, LAPPD, LGAD) provided appropriate front-end is set up.

Status:
1) achieved from CERN picoTDC board/chip/software coupled with VC707 Xilinx evaluation board. Installed in Bologna.
2) designed and produced FMC card to connect MRPC NINO FEA to picoTDC
3) designed USB card housing 2 picoTDC: manages up to 128 channels: September 2022 INFN financed layout and production



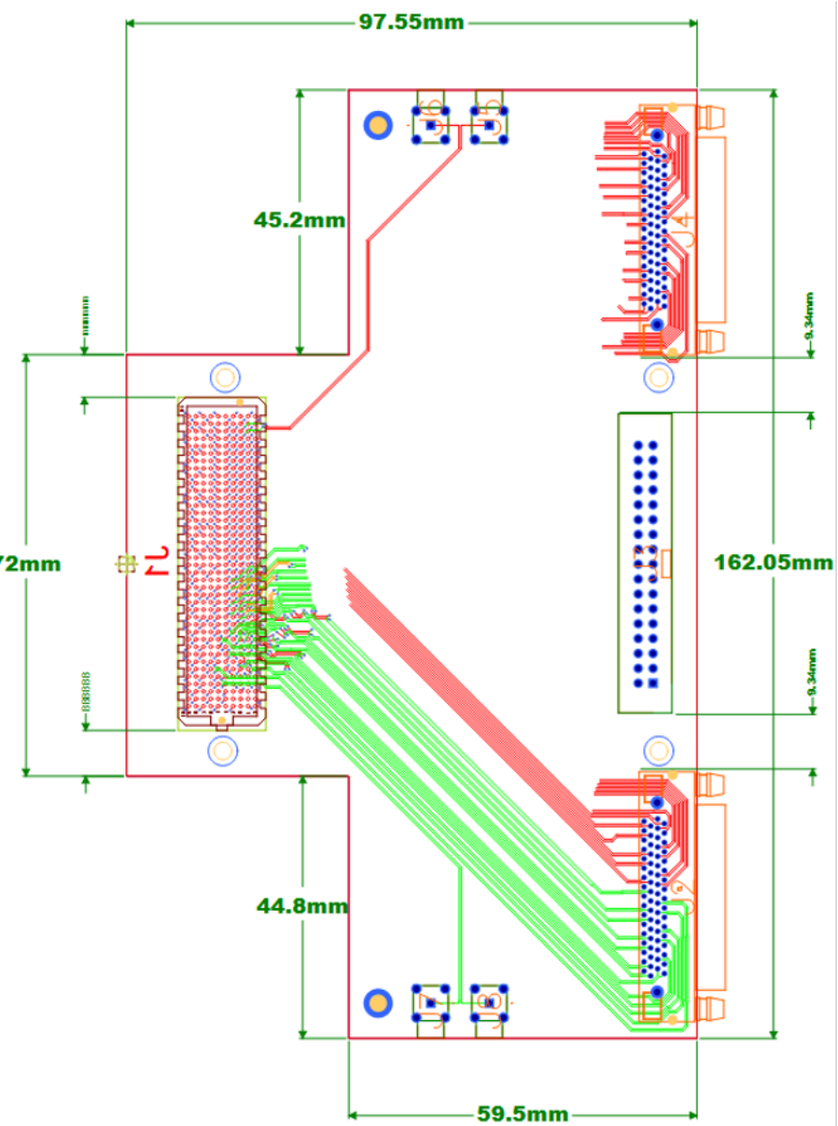


FMC adapter card

Outlook
- test in Bologna by Spring 2023
- use on test beams foreseen since Spring 2023 at CERN
- potential synergies with other groups (INFN/GE for LAPPD)

1 post-doc working 50% FTE on this task since Nov 2022

adapter board



Amphenol connector (24 channels)

dual in line connector (14 channels)

Amphenol connector (24 channels)

In the meanwhile, an adapter board is being designed.

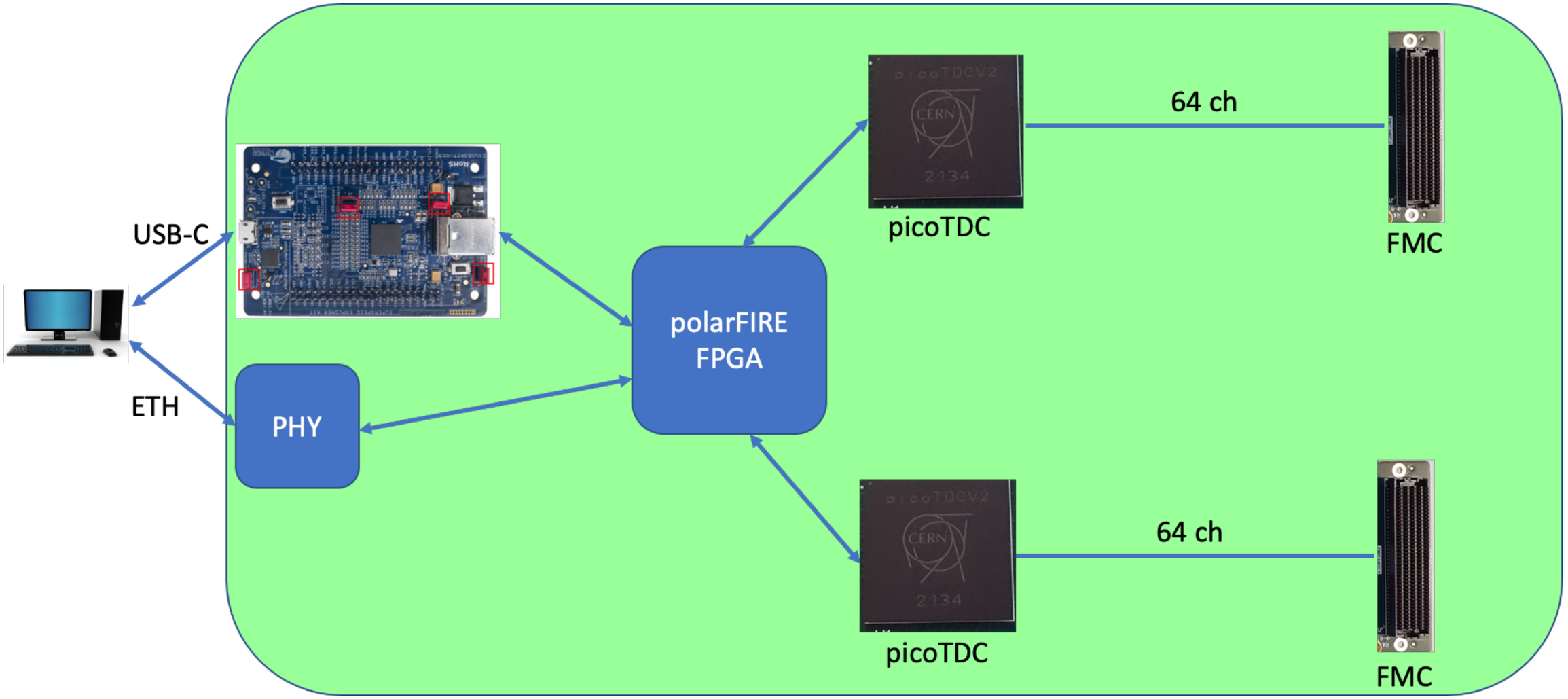
It allows to route the 64 channels to the picoTDC to 3 types of connectors:

- VHDCI (68 pin)(*)
- dual in line
- MCx

We plan to have this board built and tested by the end of July 2022

(*) these are legacy connectors used in ALICE TOF FEA with NINO ASIC. Useful for tests with MRPCs setup available in the group. The DIN and MCx connectors are general

picoTDC custom board



As a second step, we are designing a custom board with 2 picoTDCs and 1 FPGA for higher channel count and higher data rates. Through its USB-C interface it is designed as a general purpose card for test beams/lab tests using picoTDC not limited to MRPC sensors only.

Active participants

Yongwook Baek

Jinsook Kim

Sangwoo Park

Do-Won Kim

Despina Hatzifotiadou

T10 tests

Roman Zuyeuski

Alberto Blanco

Luis Margato

LIP ^{10}B tests

Pietro Antonioli

Casimiro Baldanza

Davide Falchieri

picoTDC test

Giovanni Torromeo