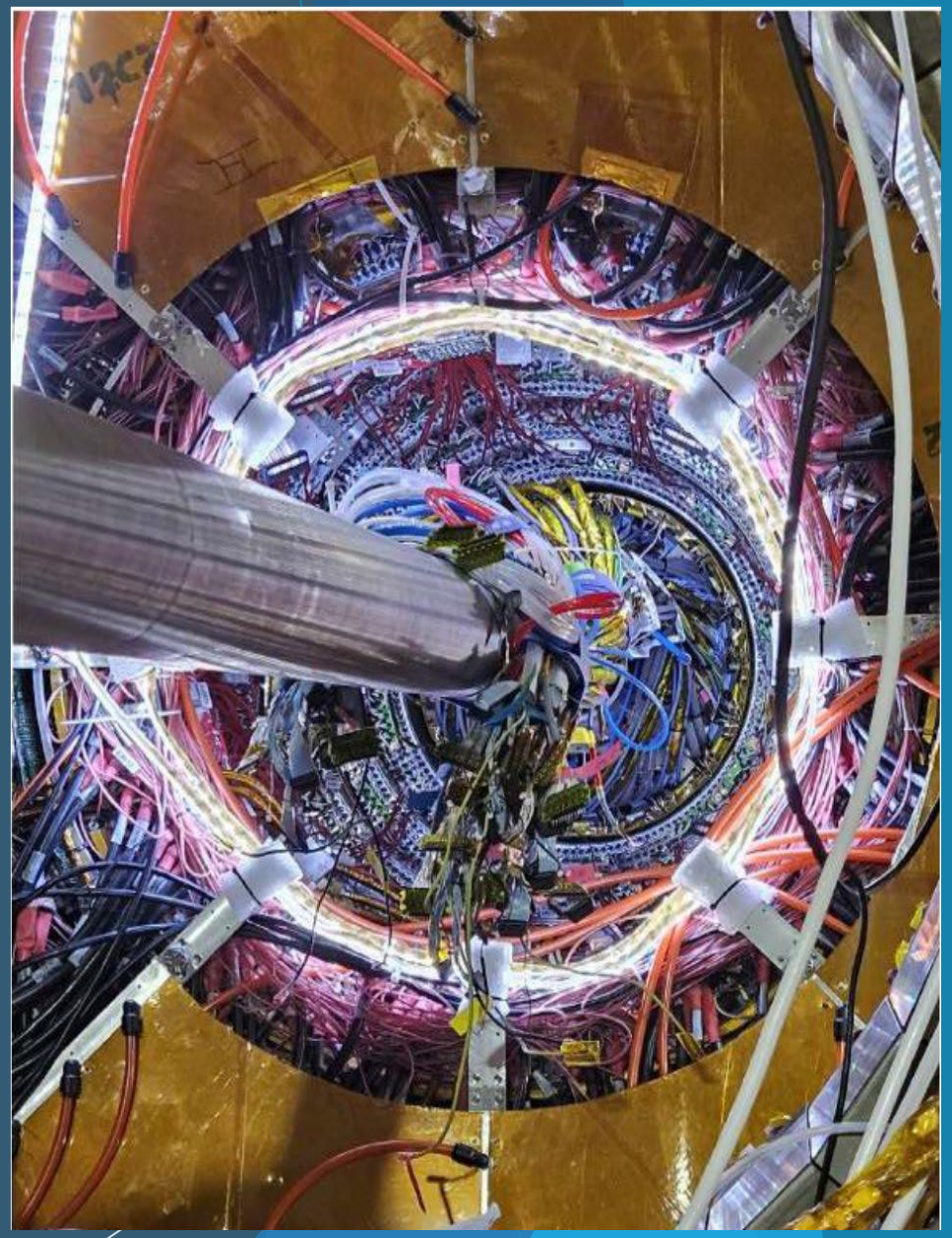


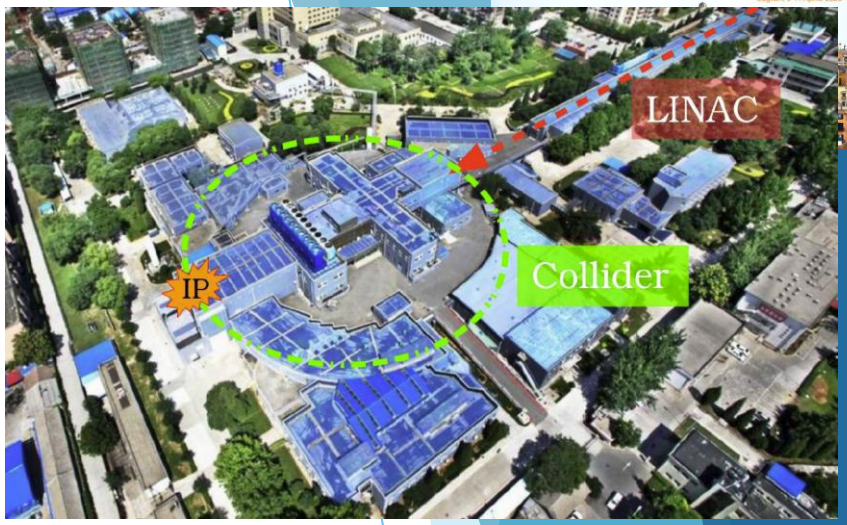
Il nuovo tracciatore interno di BESIII: CGEM-IT

Damiano Cabiati
INFN Torino- Università di Torino
in rappresentanza del **Gruppo CGEM-IT**

IFAE 2025 - 11 Apr 2025 - Manifattura Tabacchi - Cagliari

Institute of High Energy Physics Chinese Academy of Sciences

Beijing Electron Positron Collider II



E_{cm} = 2÷4.95 GeV

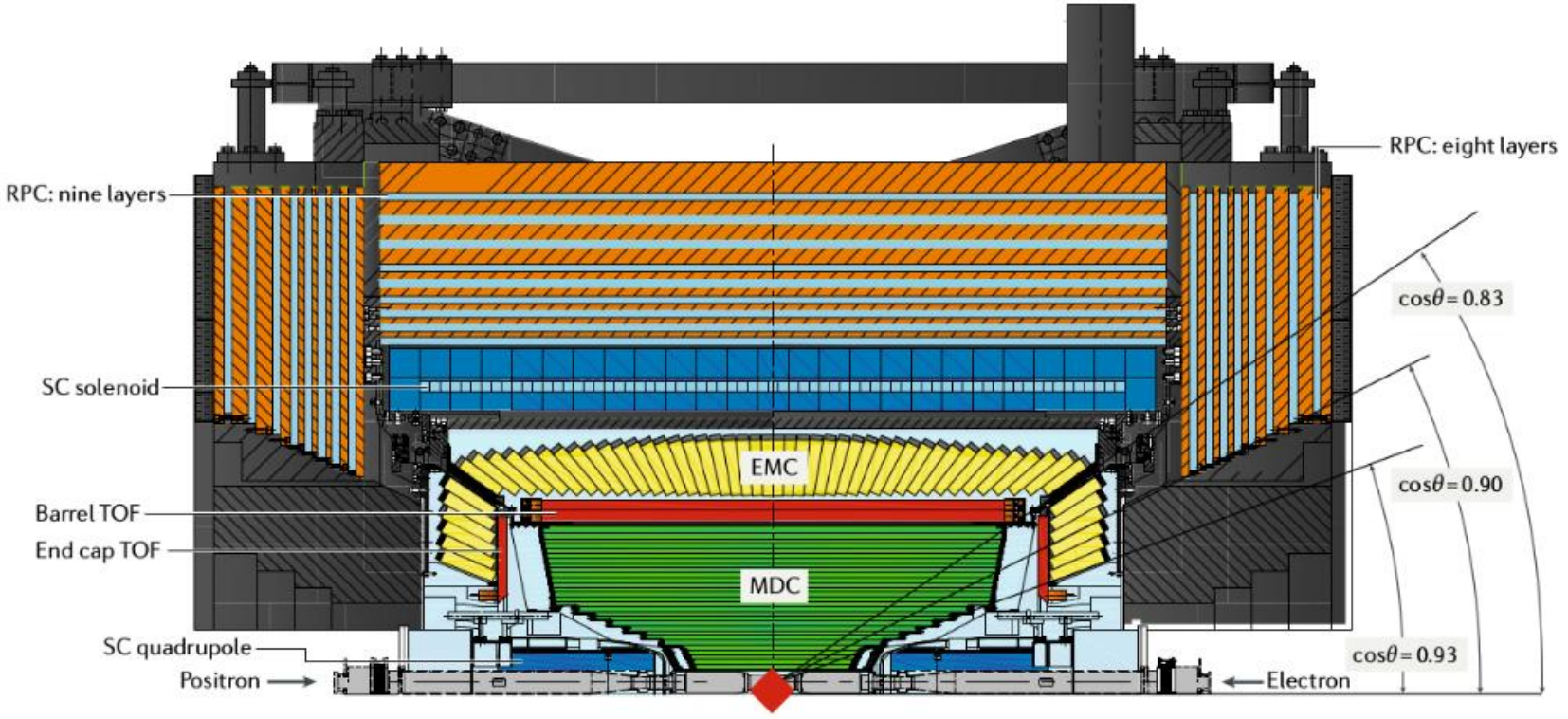
$L_{peak} = 10^{33}\ cm^{-2}s^{-1}$

J/ψ (10B eventi)

BEijing Spectrometer III

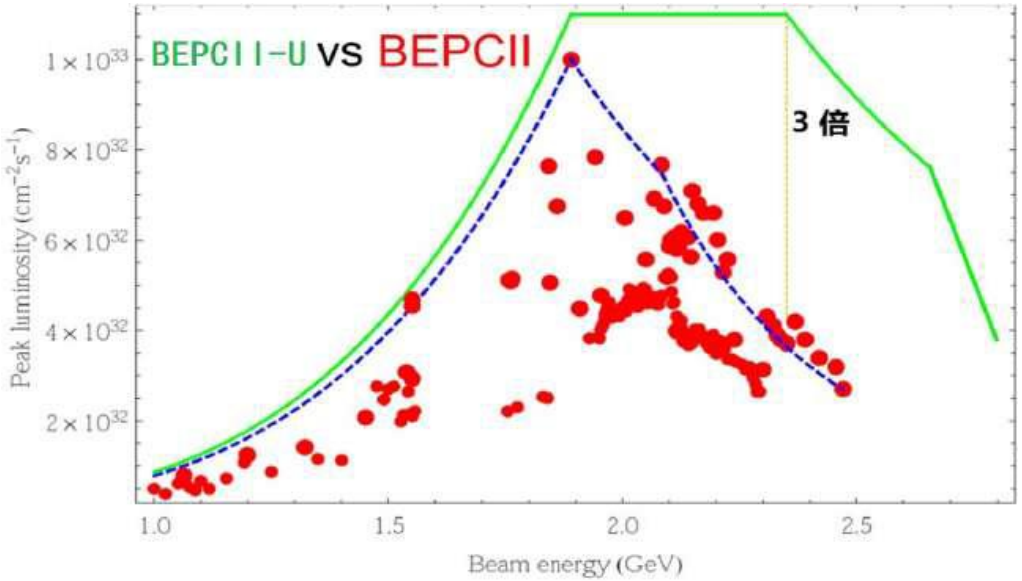
r = 2.5 m; l = 5.6 m; $\Delta\Omega/4\pi$ = 0.93; 21° < θ < 159°

- Contatori muoni (RPC)
  - $\delta_{r\varphi}$ = 1.4 – 1.7 cm
- Solenoide superconduttivo
  - Campo magnetico: 1 T
- Calorimetro elettromagnetico
  - risoluzione: 2.5 % @ 1 GeV/c
- Sistema di TOF
  - barrel: σ_t = 70 ps
  - endcap: σ_t = 60 ps
- Camera di deriva
  - σ_p/p = 0.5% @ 1 GeV/c
  - σ_x = 130 μm



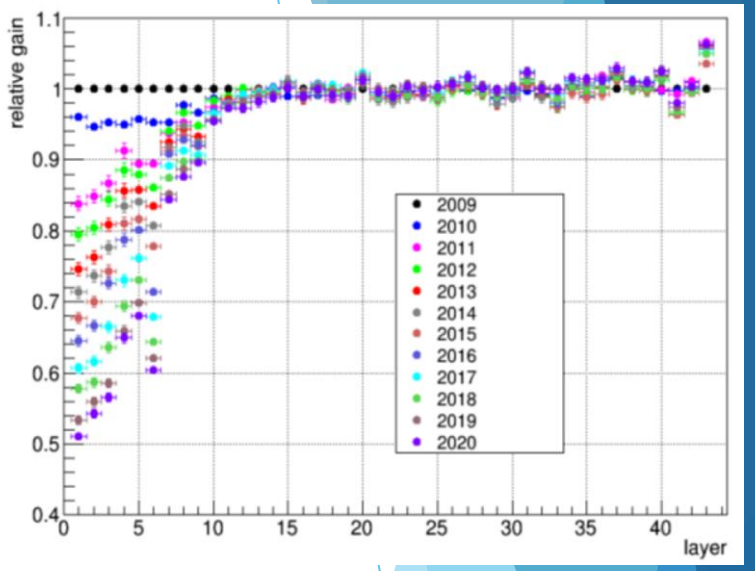
M. Ablikim et al 2010 NIM A 614-210
M. Ablikim et al 2020 Chinese Phys. C 44 040001

Aggiornamento BEPCII/BESIII

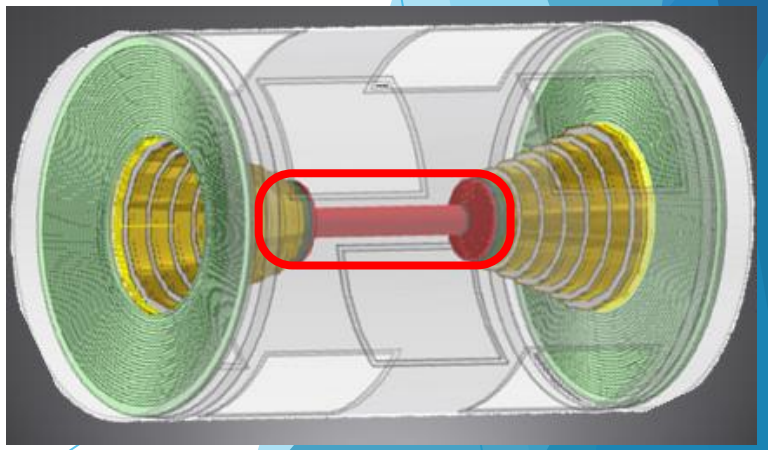


1) Aumento luminosità a $11x10^{32}$ $cm^{-2}s^{-1}$ @ 2.35 GeV (2025)
2) Aumento energia massima del fascio da 2.47 GeV a 2.80 GeV (2028)

Main Drift Chamber (MDC): perdita di guadagno per invecchiamento del 4%/anno per strati interni



Sostituzione Inner Drift Chamber (IDC) con nuovo rivelatore



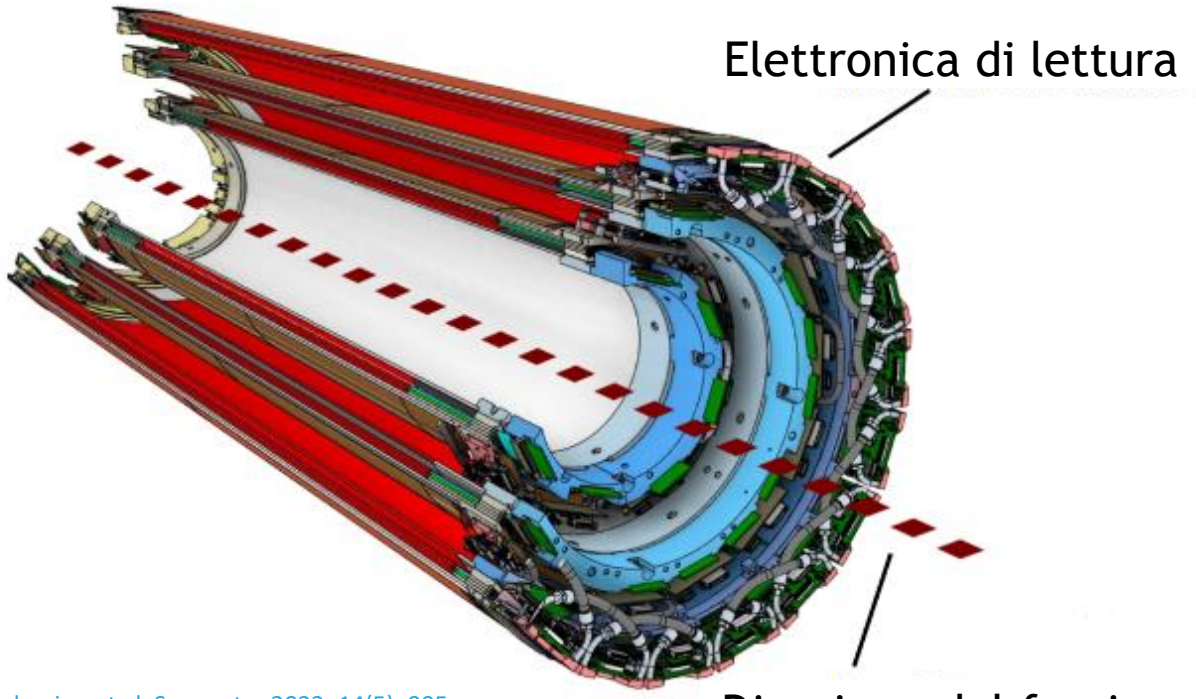
CGEM-IT

Cylindrical GEM (Gas Electrons Multiplier) – Inner Tracker

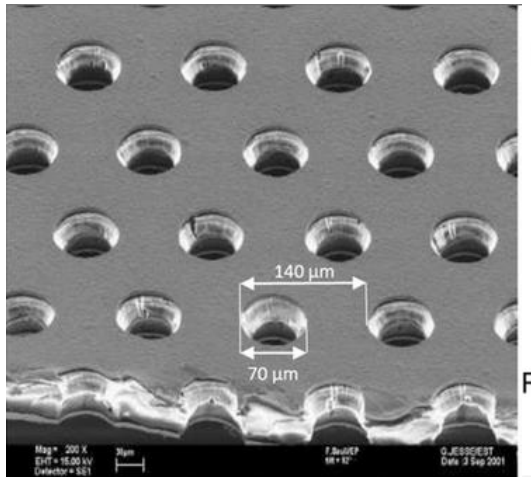
$Ar\text{-}iC_4H_{10}$

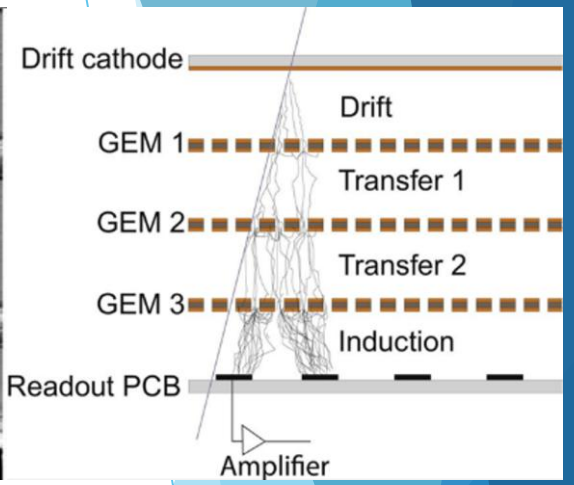
Rate sostenibile: 10^4 Hz/cm^2

$\sigma_{r\phi} \sim 130$ μm
$\sigma_z < 1$ mm (~ 350 μm)
$\sigma_{pt}/p_t \sim 0.5\%$ @ 1 GeV/c



I. Balossino et al. Symmetry 2022, 14(5), 905





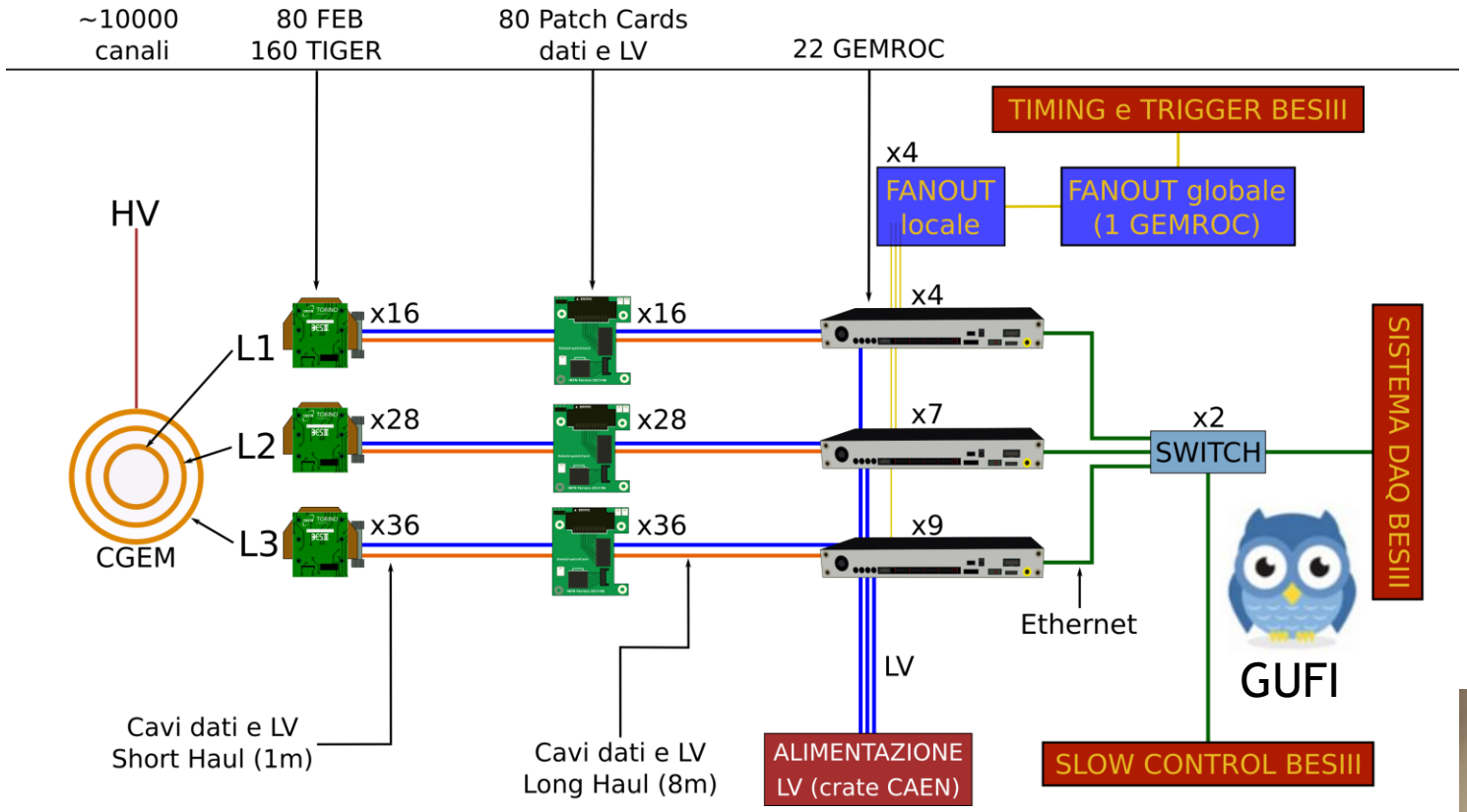
GEM: A new concept for electron amplification in gas detectors.

Requisiti

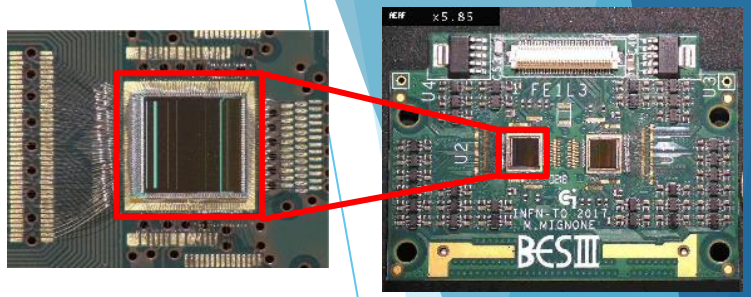
Uguagliare le caratteristiche della camera sostituita

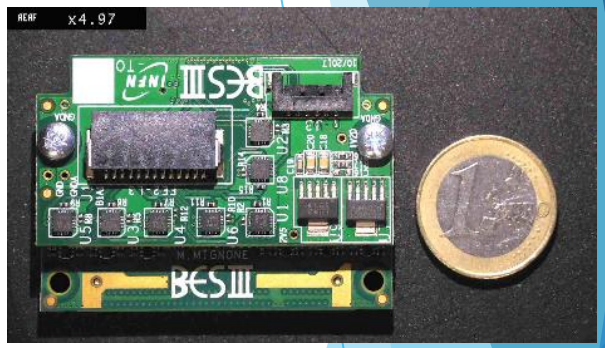
Migliorare:
- Resistenza all'invecchiamento
- Risoluzione asse z
- Ricostruzione di vertici secondari

Catena di lettura CGEM-IT



A. Amoroso et al. JINST 2021 16 P08065

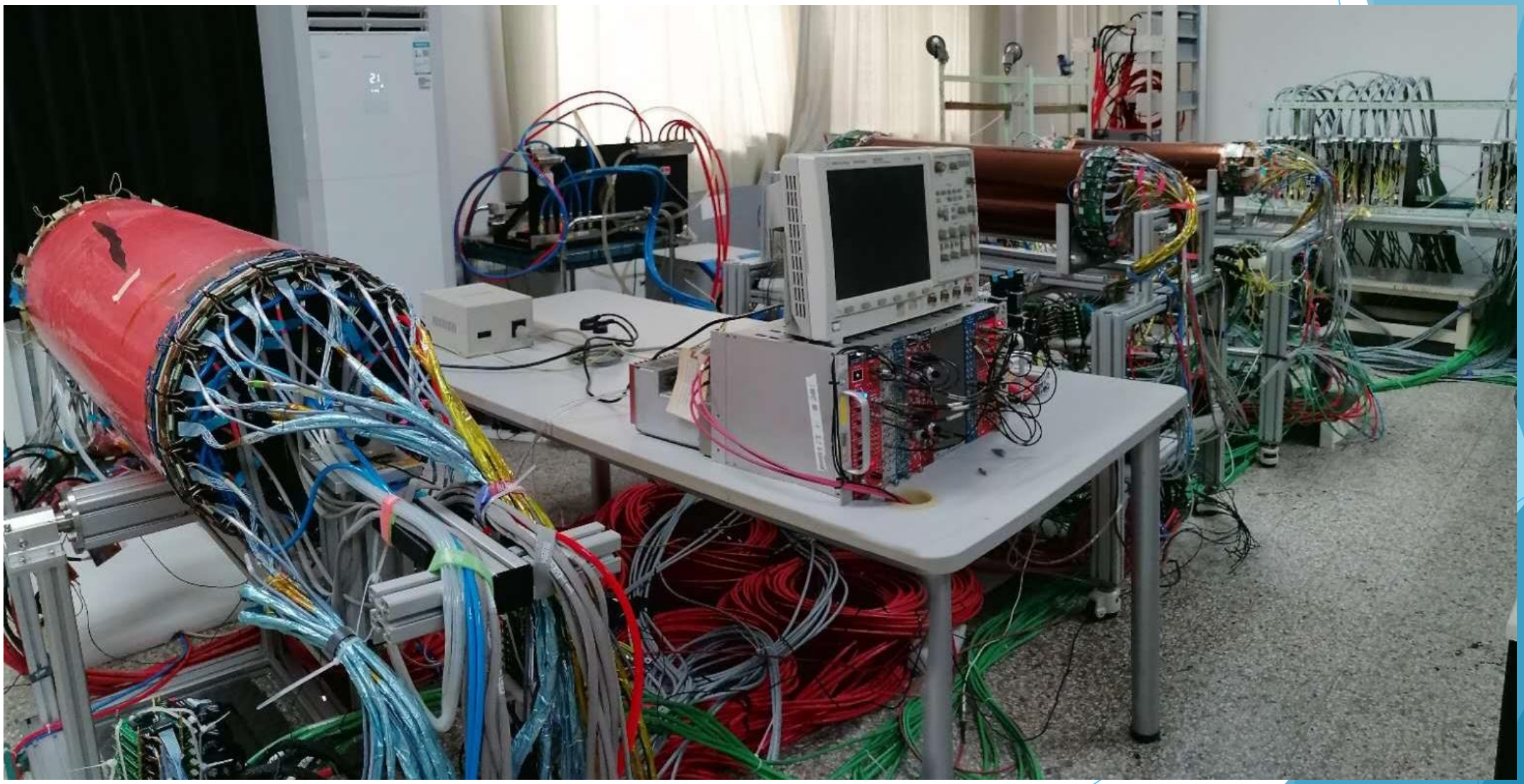




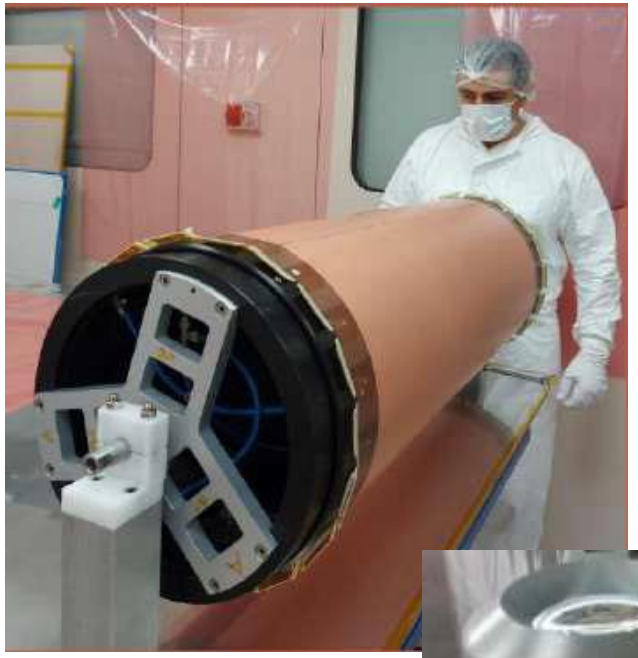
TIGER

GEMROC

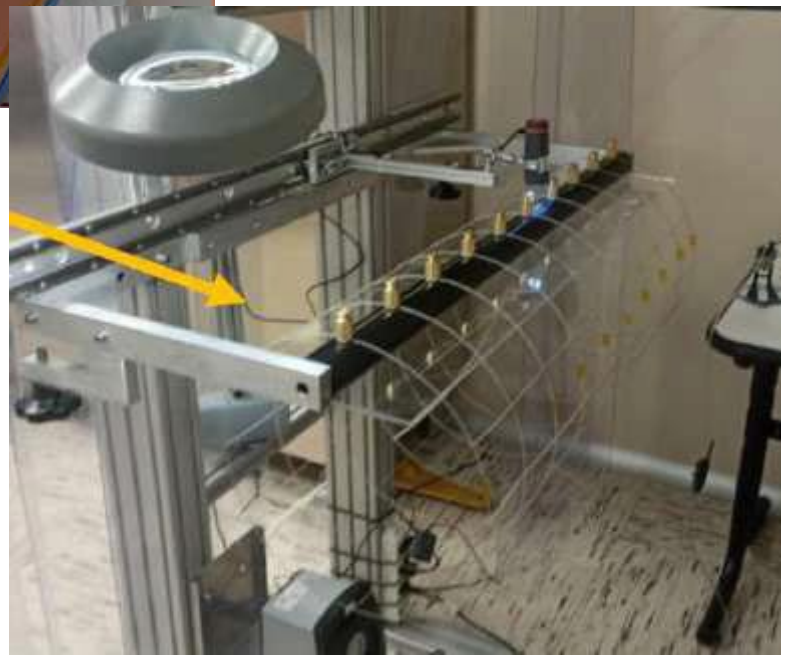
L1, L2 e L3



Costruzione L3



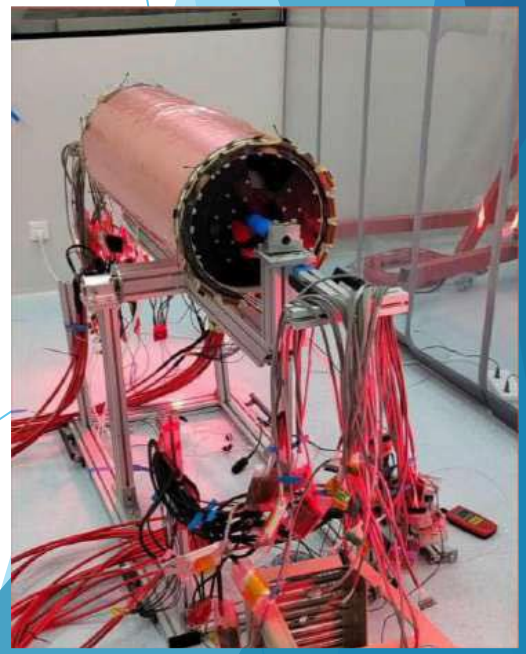
Elettrodi preparati su mandrini a Ferrara…



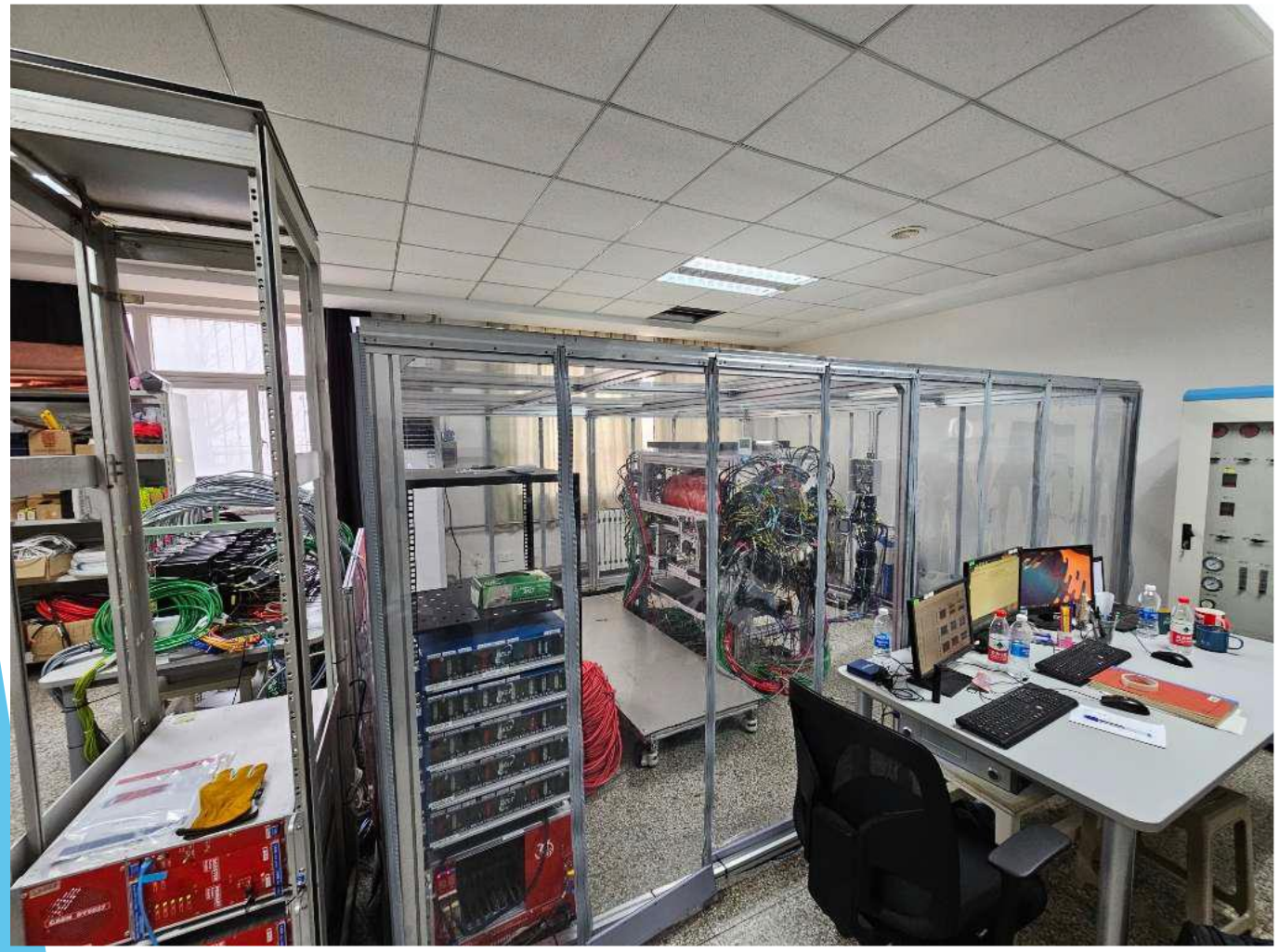
Griglie per evitare buckling

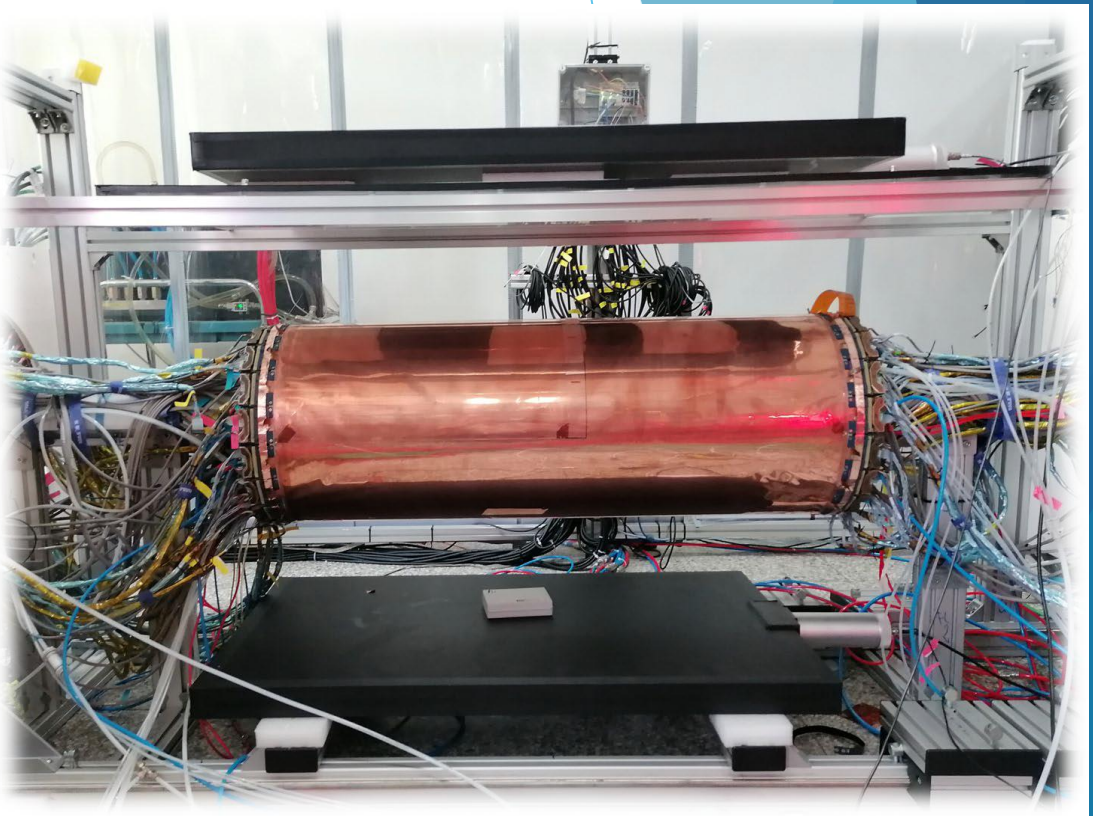
…e assemblati a Pechino

Test tenuta gas e HV in camera pulita



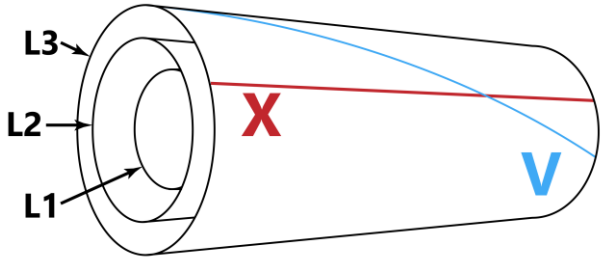
Campagna acquisizione cosmici





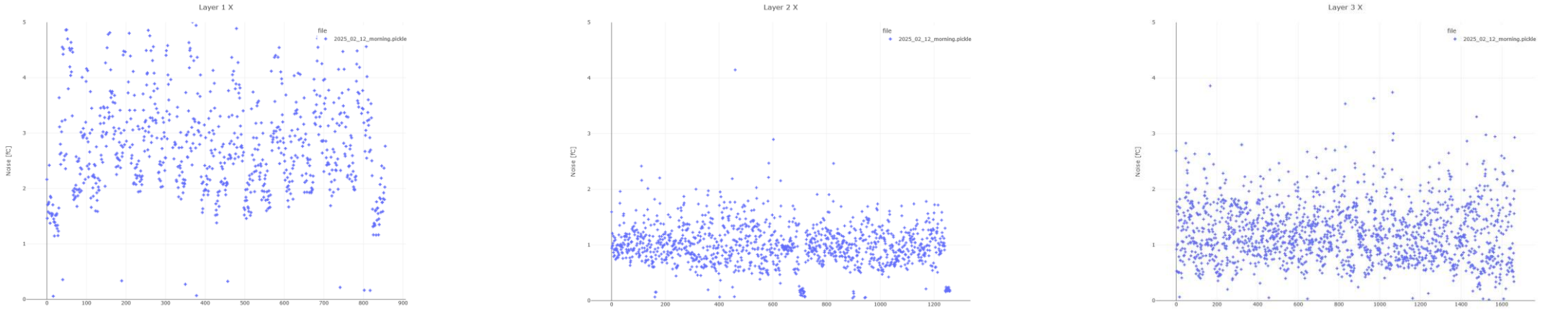
(Dic 2023 – Set 2024)

Livelli di rumore

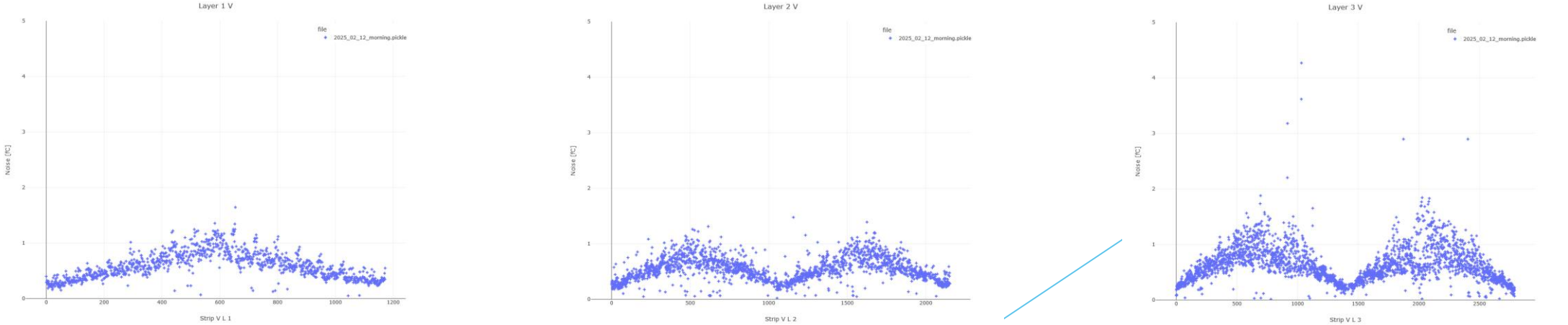


L1 L2 L3

X



V

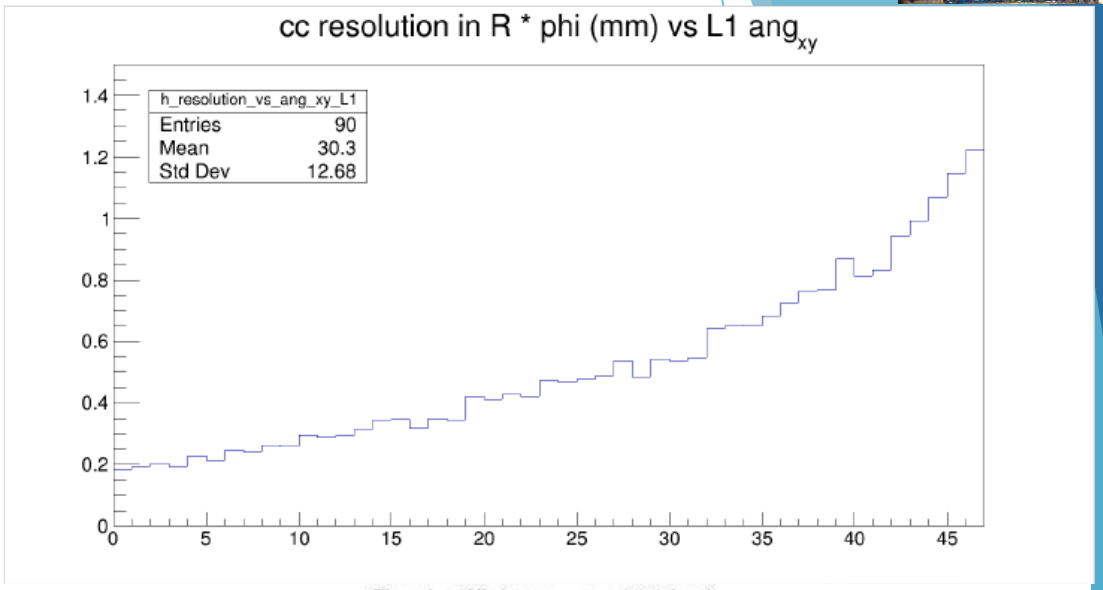


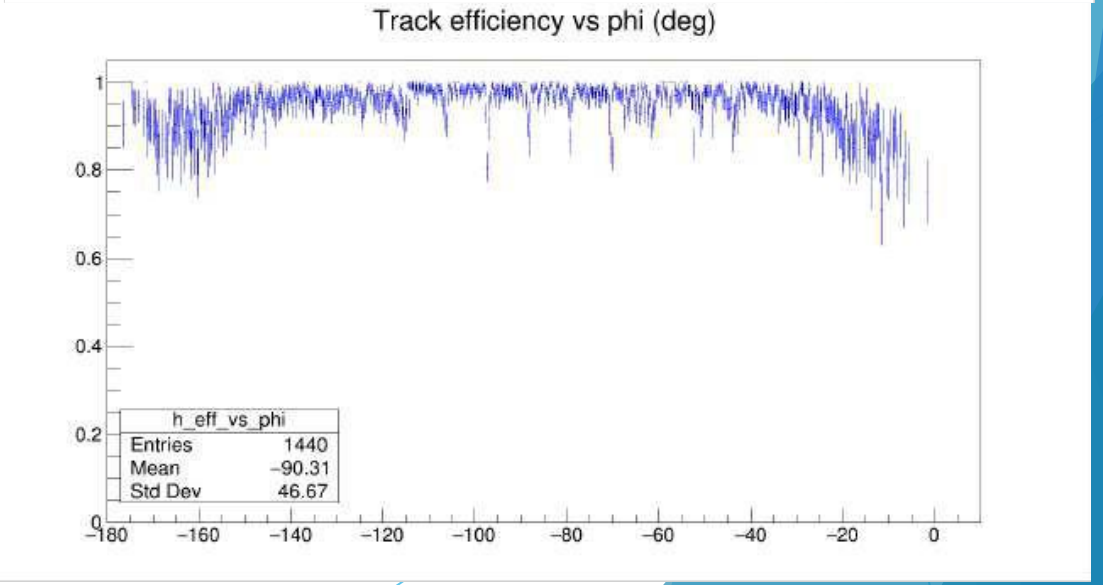
Risoluzione e efficienza

- Centroide di carica per angoli <5°:
  - risoluzione ~200 µm
- Algoritmo di µTPC ad angoli superiori

- Alta efficienza su tutti e tre i layer

- Installazione approvata a fine giugno 2024





Installazione CGEM-IT in BESIII

Trasferimento in hall

Cablaggio e servizi

Prima acquisizione cosmici

2 Ott 24

5 Ott 24

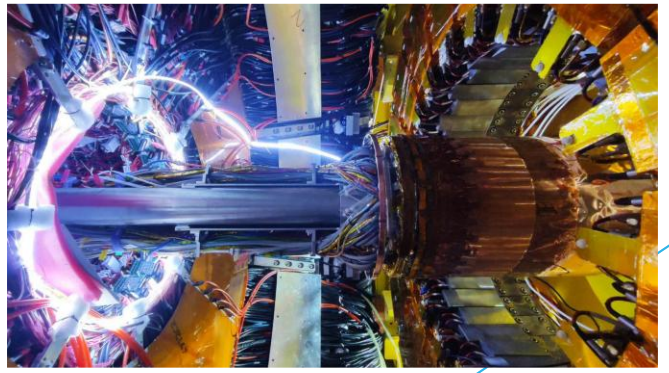
6-18 Ott 24

19 Ott 24

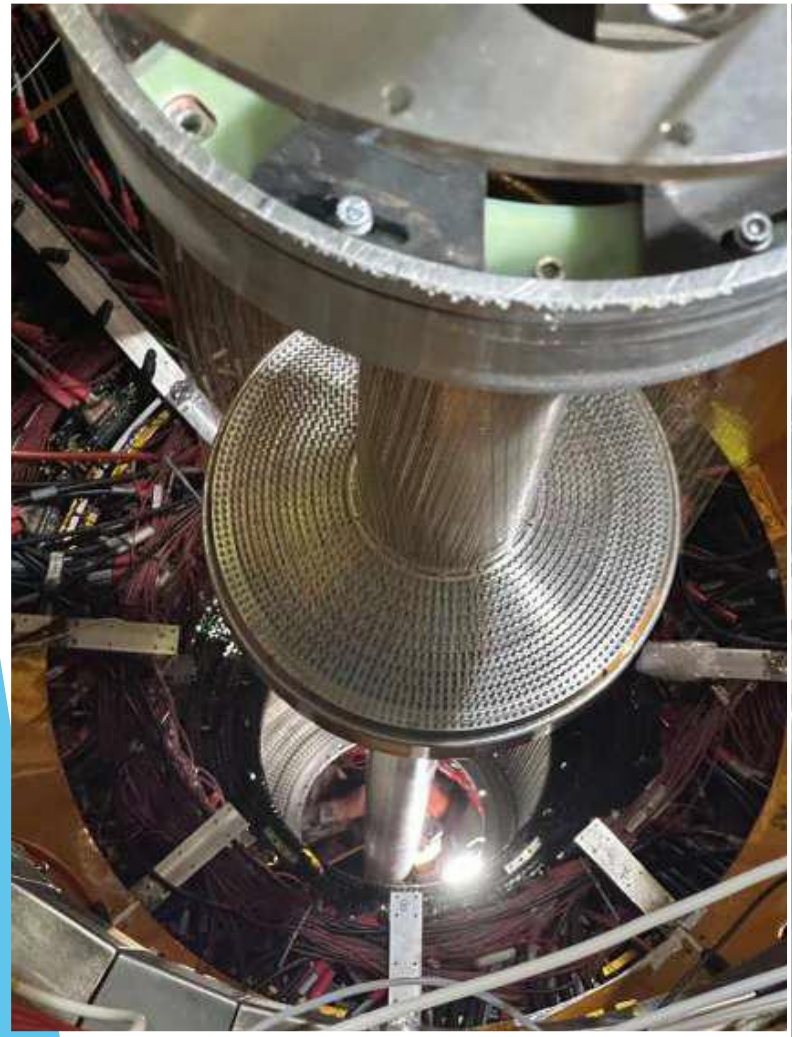
25 Ott 24

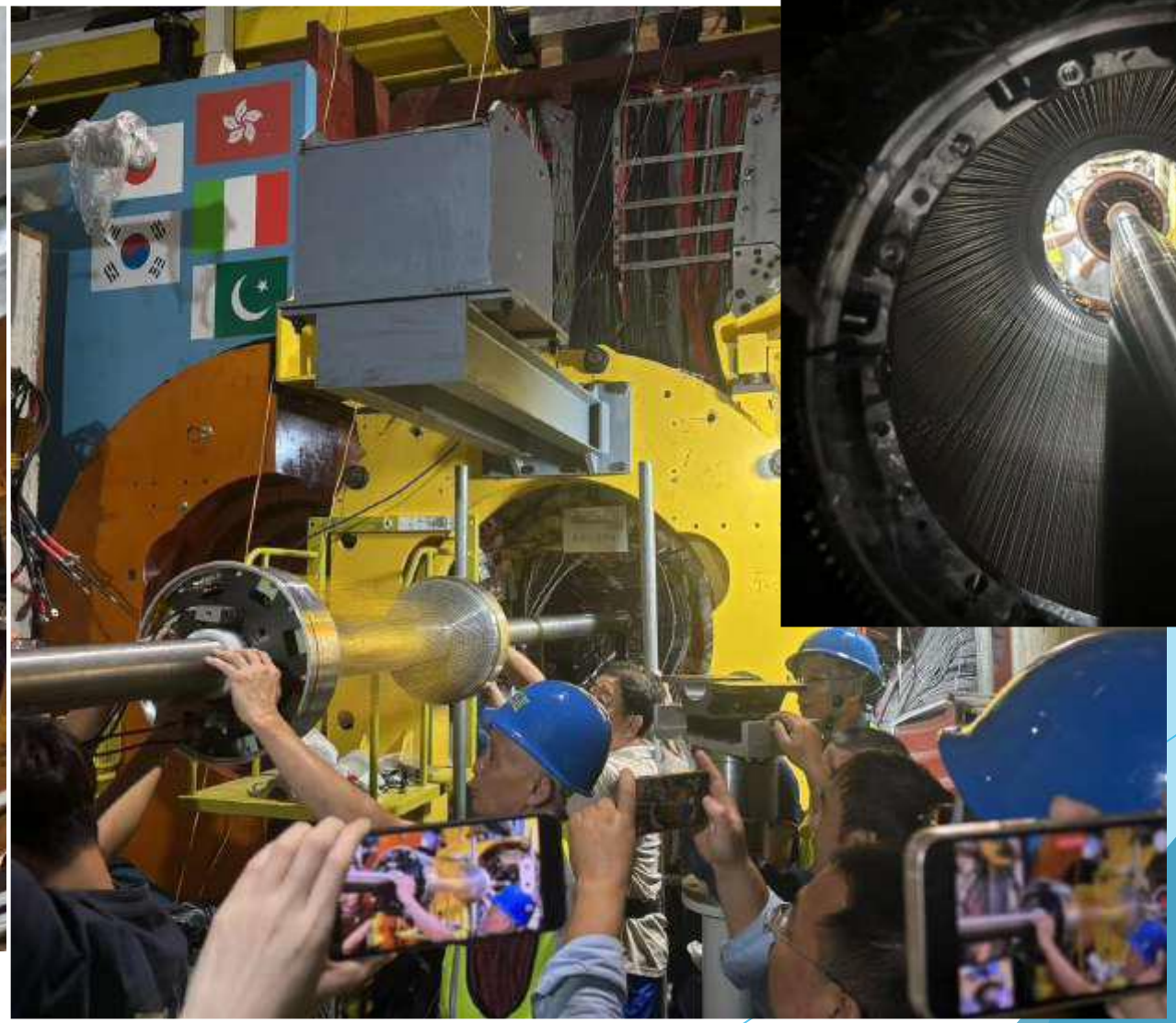
Inserimento in BESIII

Prima accensione in BESIII



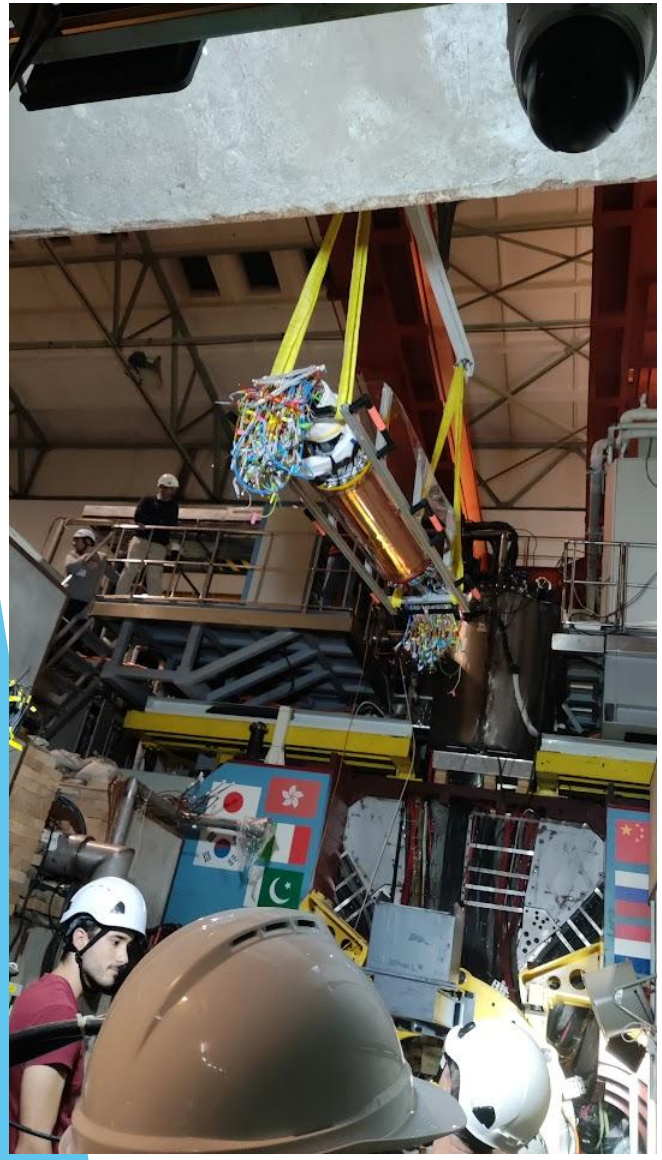
Estrazione IDC

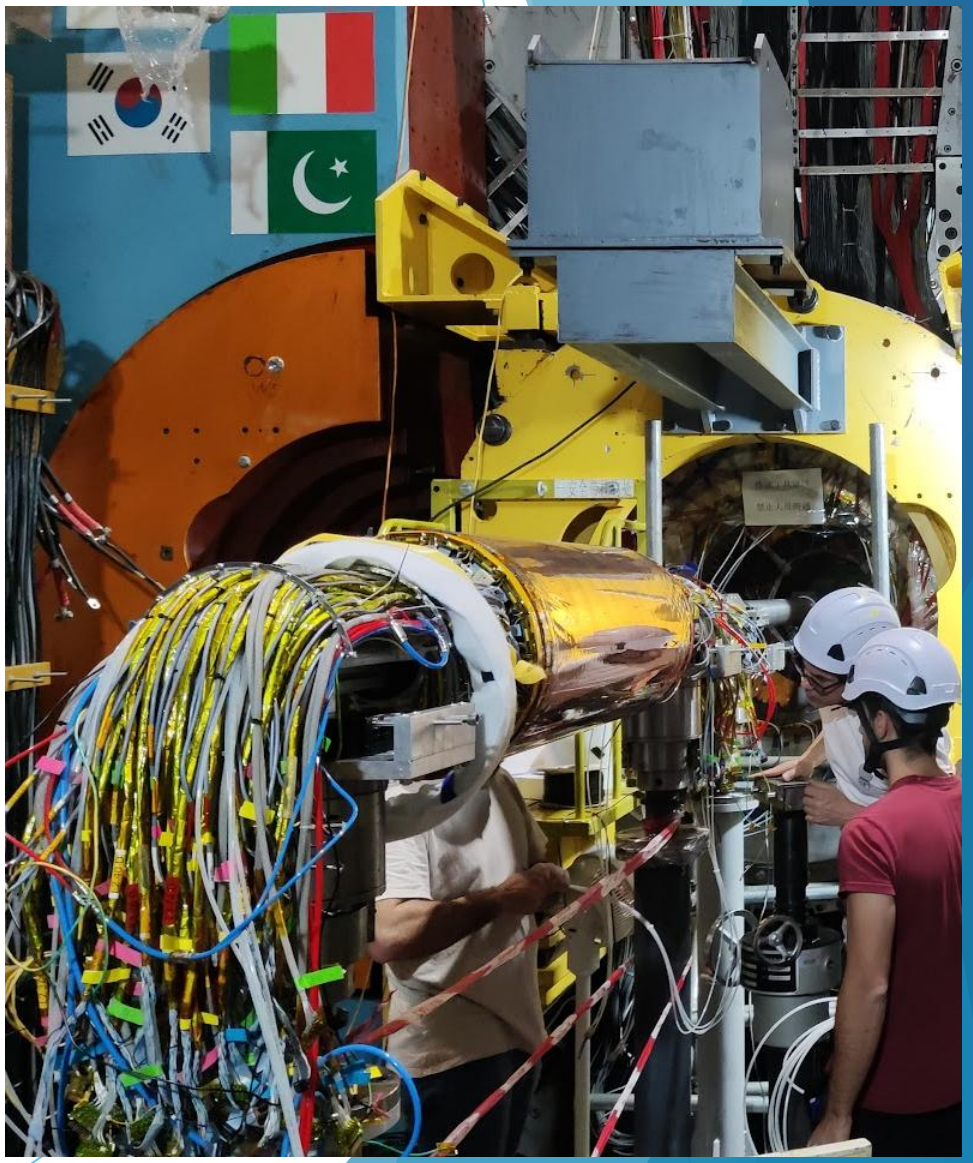




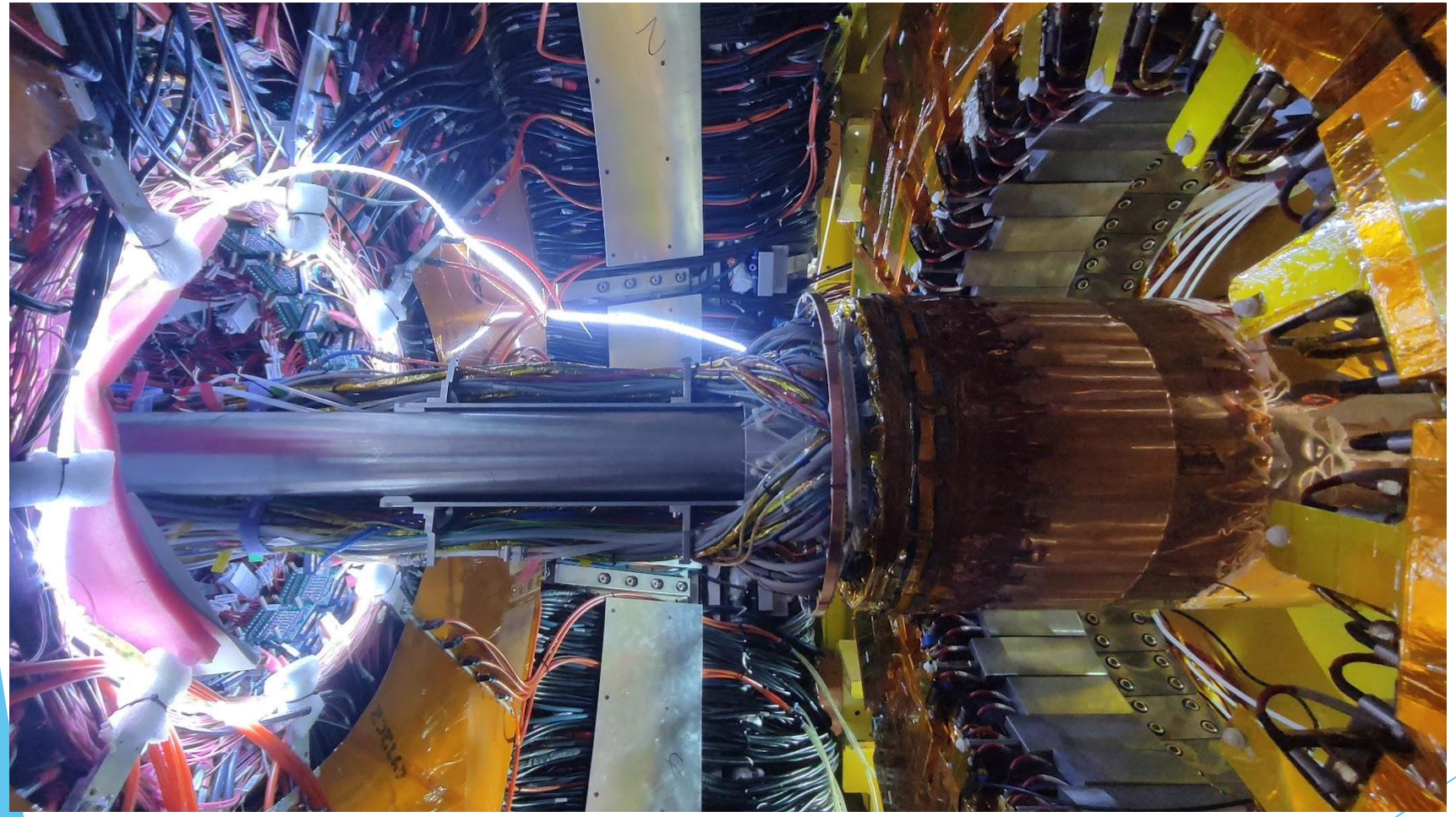
Trasferimento CGEM-IT

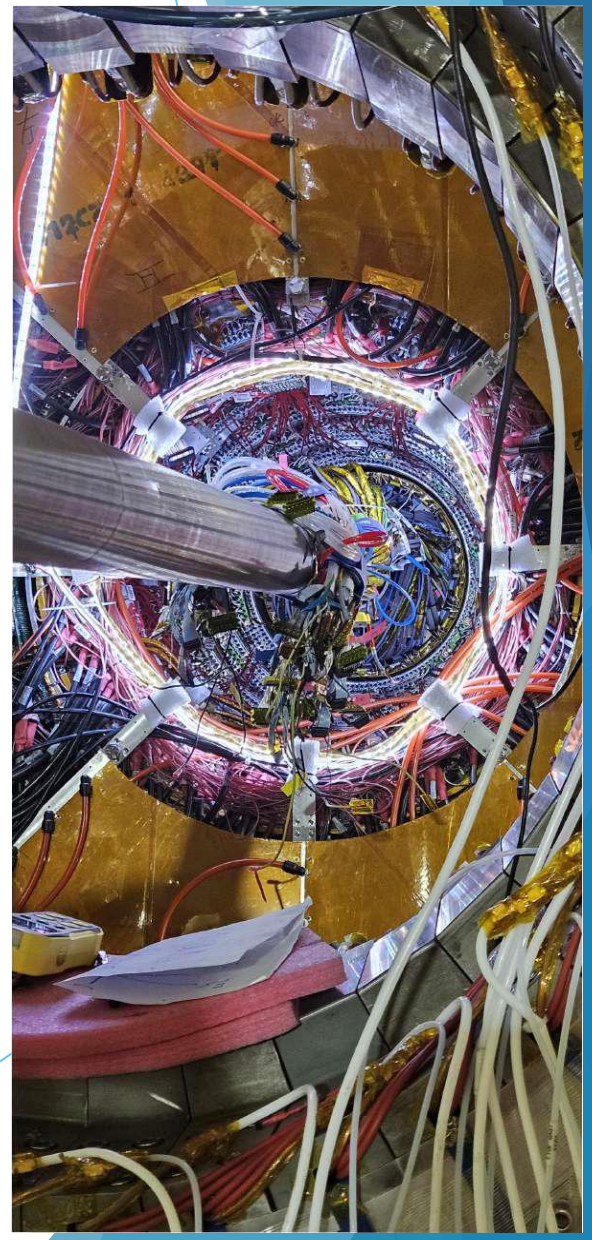
Inserimento in BESIII



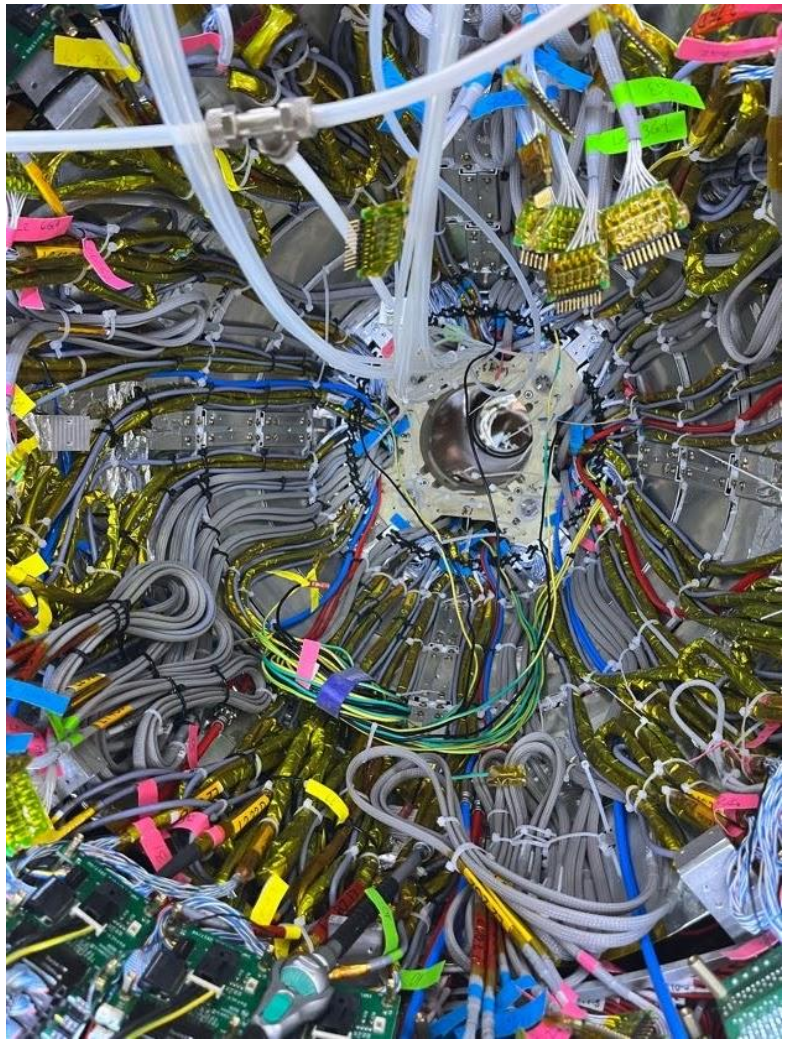


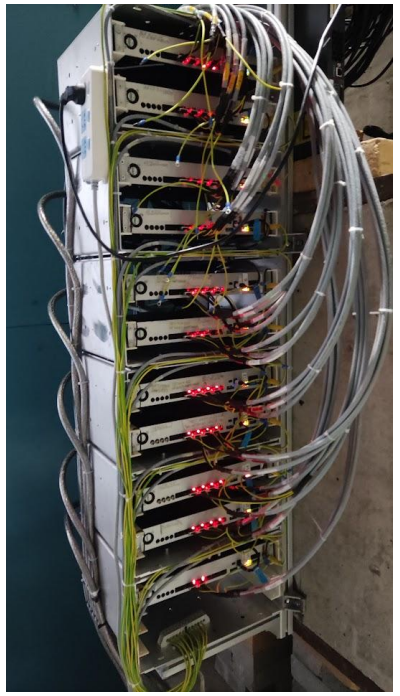
Inserimento in BESIII

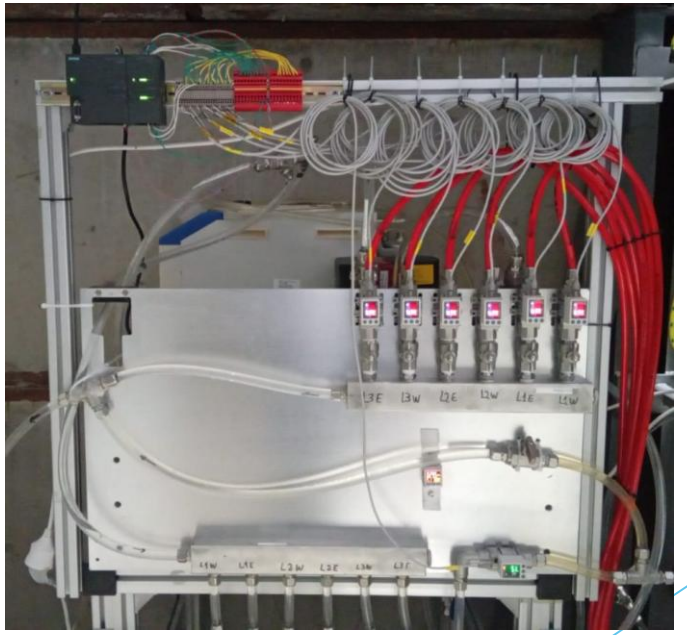




Cablaggio e servizi

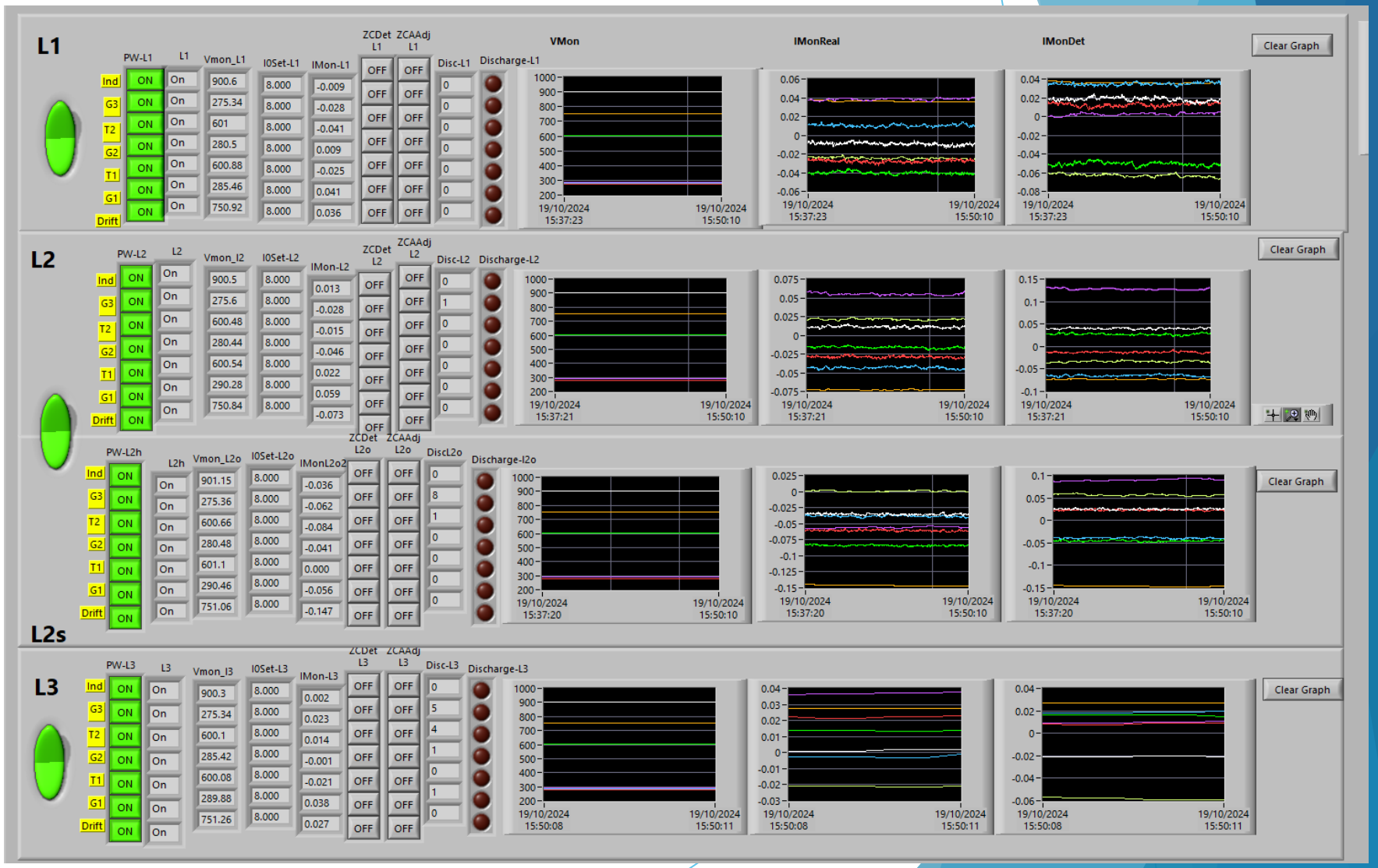






Prima accensione

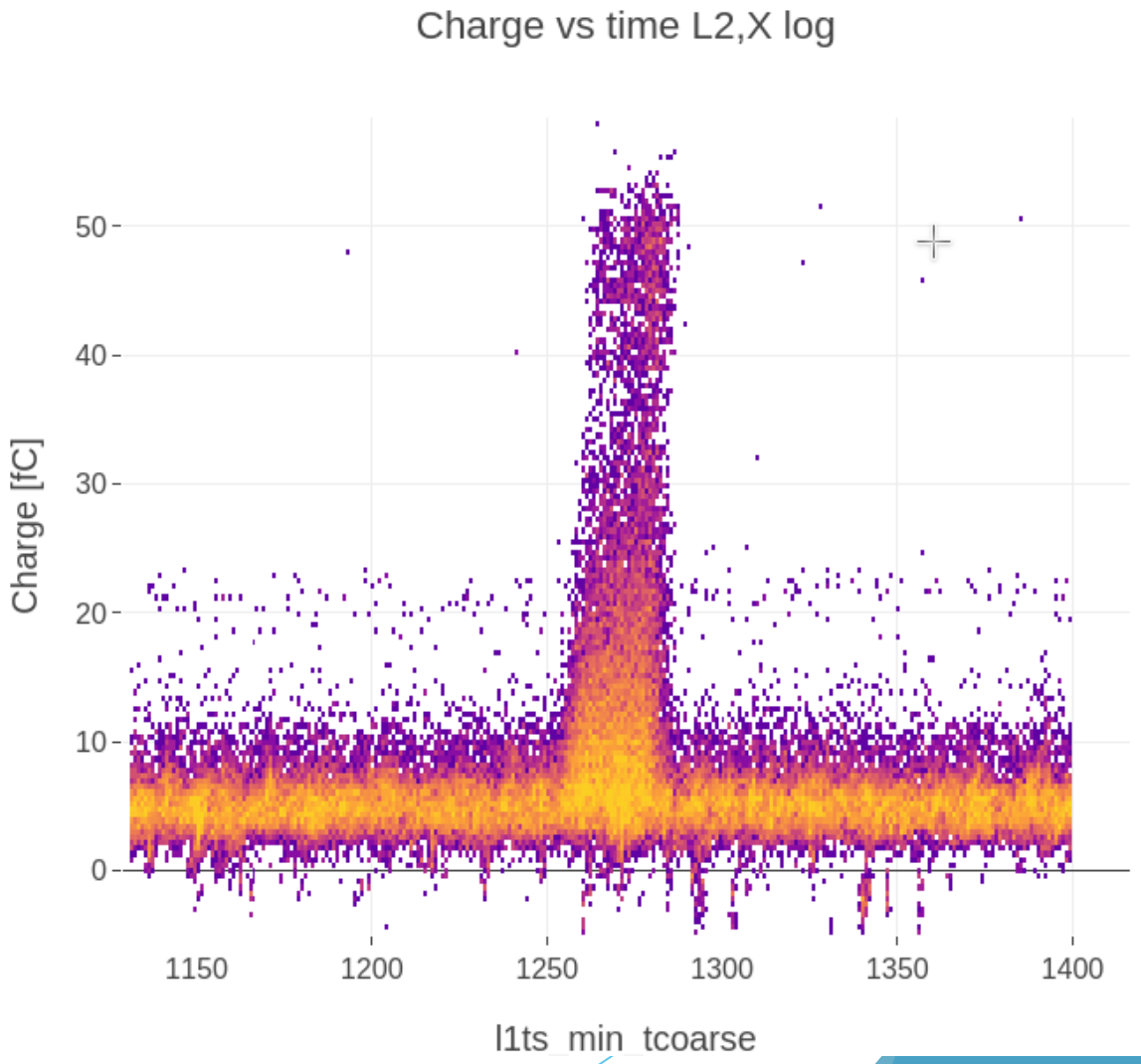
Valori operativi di HV raggiunti il 19/10



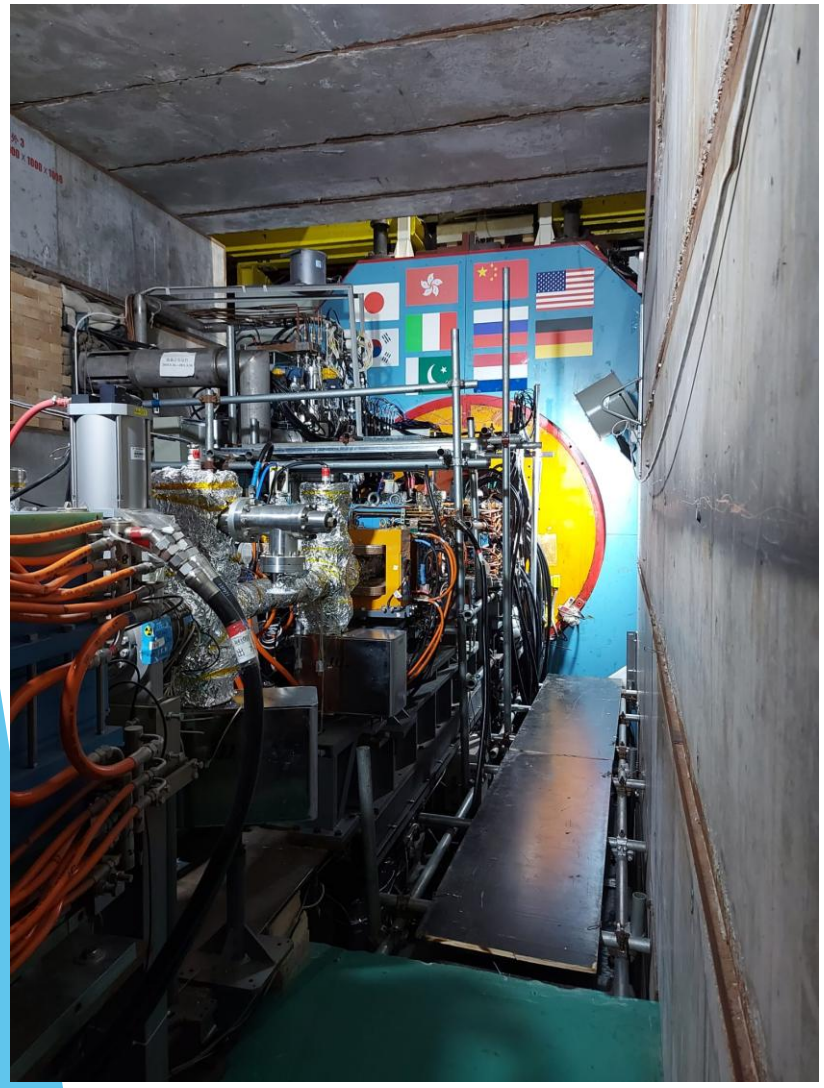
Acquisizione di cosmici in BESIII

- Per ogni trigger le GEMROC trasmettono i dati raccolti in una finestra di ampiezza regolabile, impostata a 1.6 μs

- Trigger generato da EMC, TOF e MDC



Chiusura BESIII



Conclusioni

Il CGEM-IT è il secondo rivelatore a GEM cilindrica mai costruito

10 mesi di campagna acquisizione cosmici (Dic 2023 – Set 2024):

- Efficienza 95% su tutti e tre i layer
- Risoluzione 200 μm con CC, algoritmo di μTPC in fase di sviluppo

Installato in BESIII e acceso per la prima volta a ottobre

Slow control e DAQ integrati nel software di BESIII

Acquisizione di cosmici insieme a MDC con trigger di BESIII in corso

European Commission | Horizon 2020 European Union funding for Research & Innovation

RISE Project 645664-BESIIICGEM, RISE-MSCA-H2020-2014
RISE Project 872901-FEST, H2020-MSCA-RISE-2019

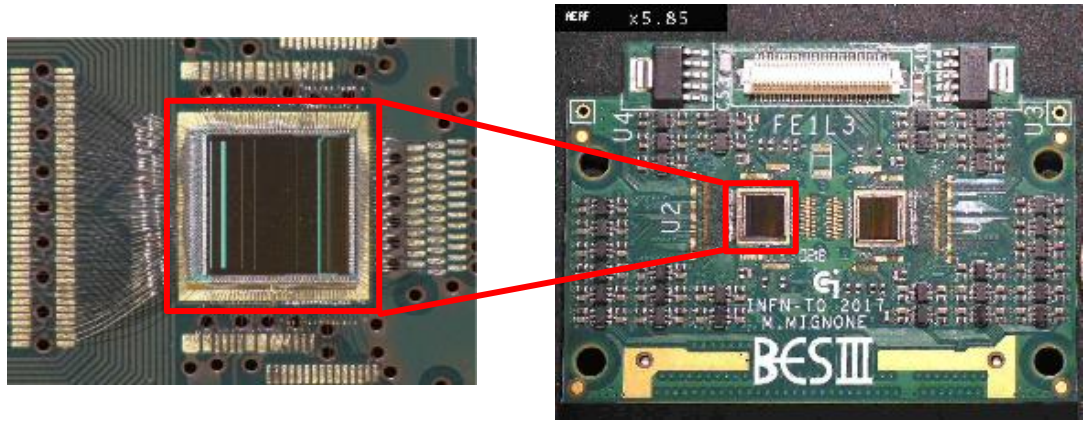
Grazie per l’attenzione!

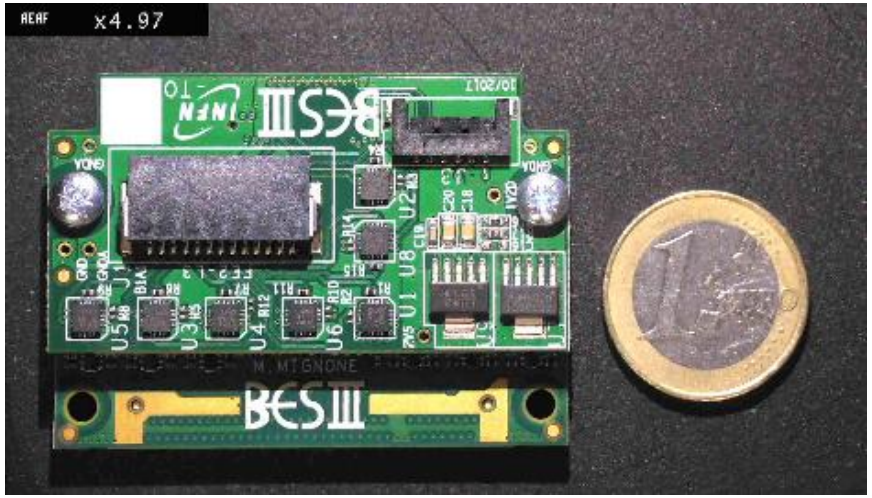
Slide di backup

TIGER

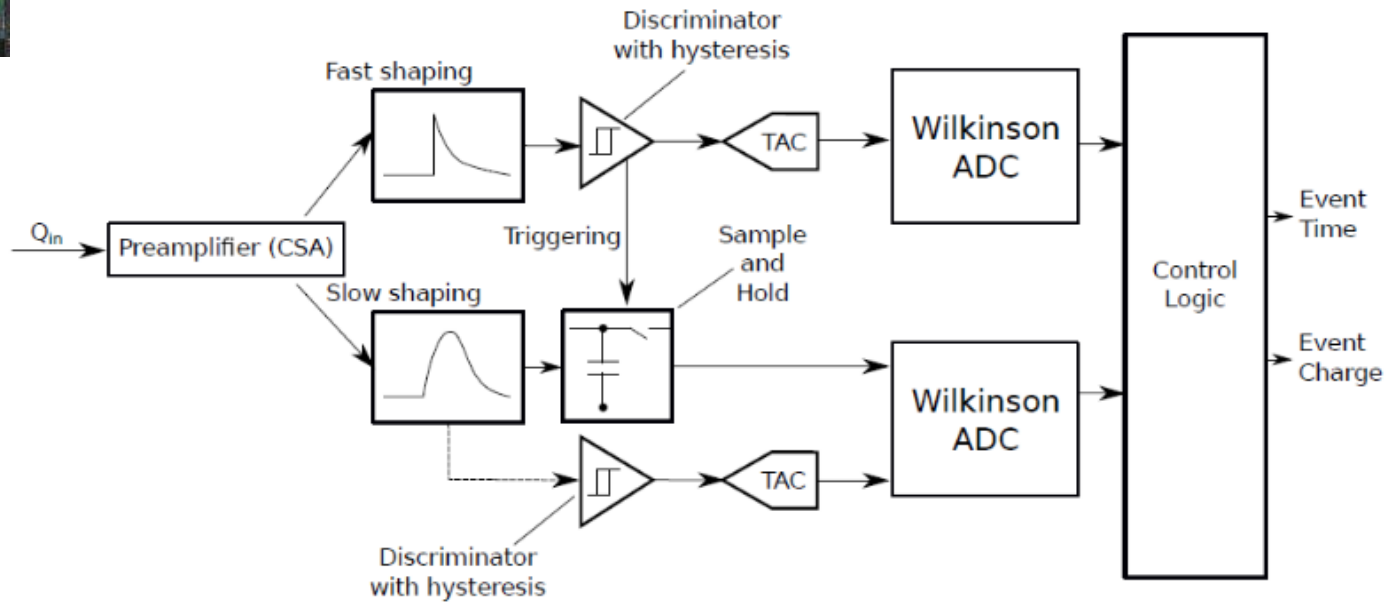
Torino Integrated GEM Electronics for Readout

Parameters	Value
Input Charge	2-50 fC
Input Capacitance	Up to 100 pF
Data Rate	60 kHz/ch
Readout Mode	Trigger-less
Non-linearity	<1%
Charge Collection Time	60 ns
Time resolution	<5 ns
Power Consumption	<12 mW/ch
Technology	110 nm process

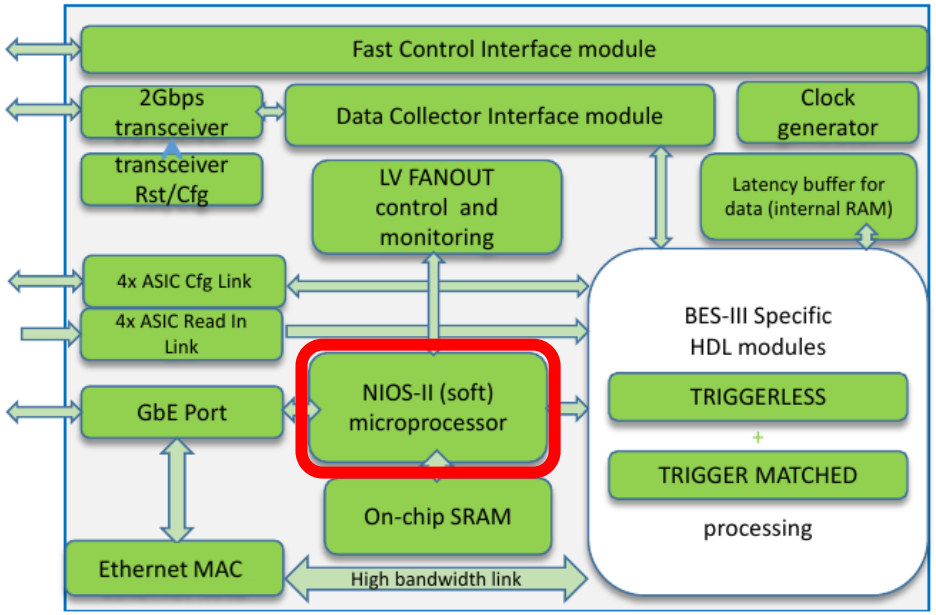




- 64 canali
- Misura tempo
- Misura energia
  - Sample and Hold
  - Time over Threshold



A. Rivetti et al., TIGER: A front-end ASIC for timing and energy measurements with radiation detectors



GEMROC
GEM ReadOut Card

ALTERA ArriaV GX development kit (5AGXB3ES FPGA)

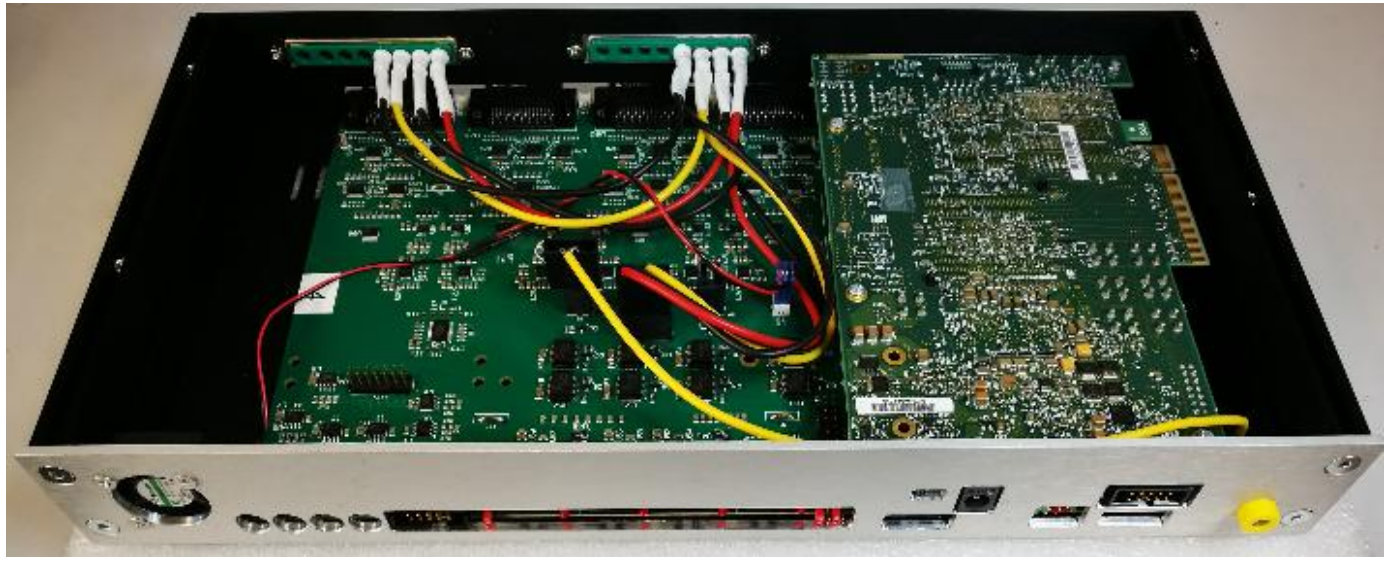
Interface card

- Alimentazione e monitoraggio FEB
- Distribuzione e simulazione segnali di timing
- Configurazione TIGER
- Controllo acquisizione dati

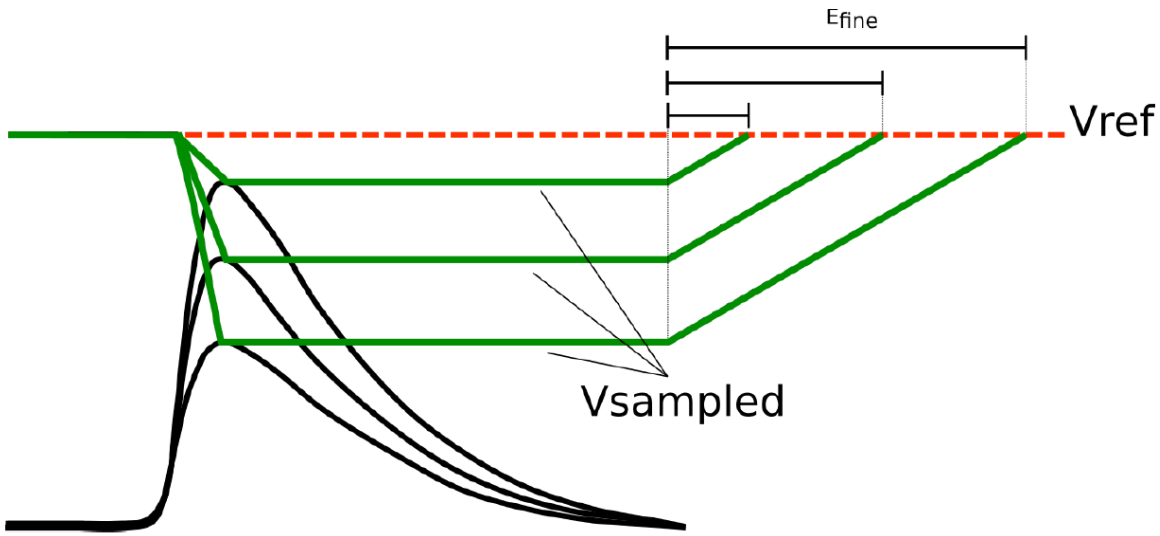
Firmware implementato in VHDL e Verilog

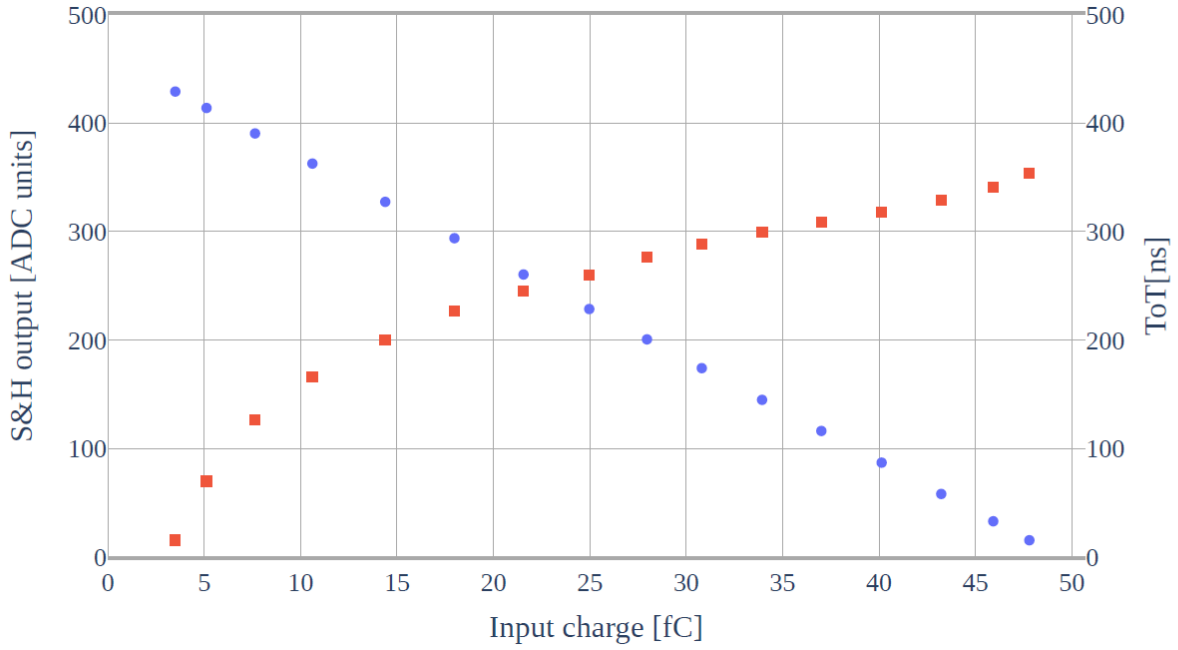
Coprocessore NIOS programmato in C++

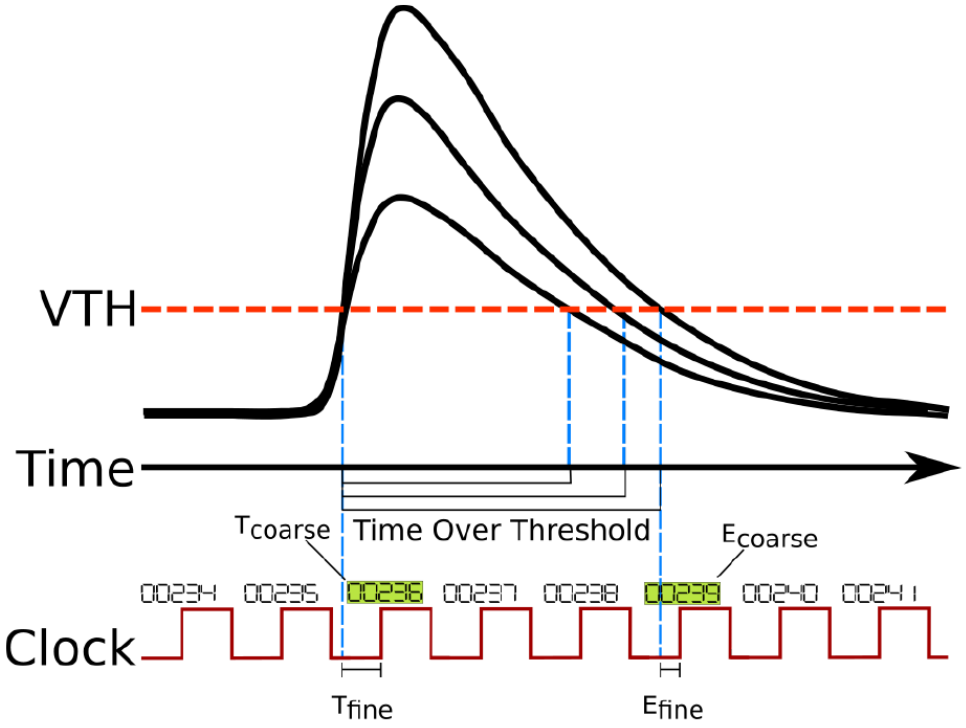
INFN Ferrara, A. Cotta Ramusino



Sample & Hold
Time over Threshold



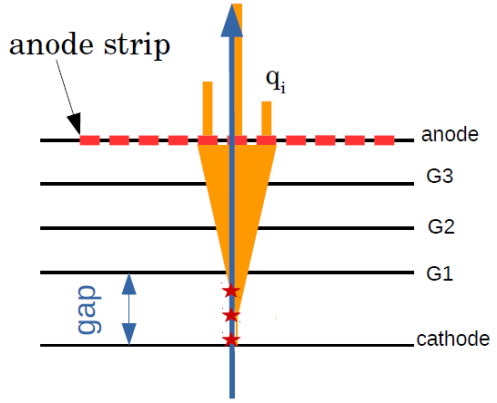




Charge Centroid VS micro Time Projection Chamber

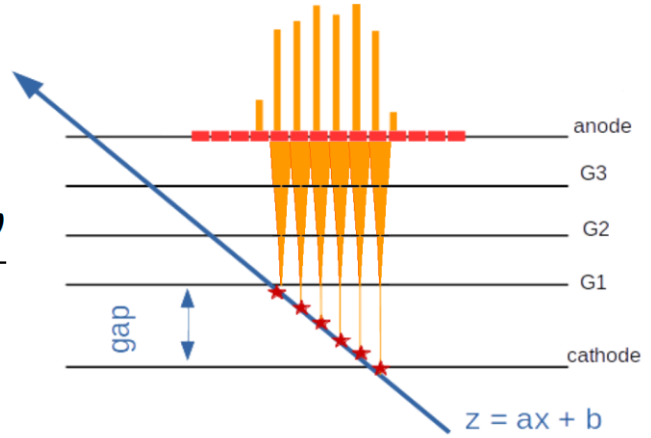
- CC: posizione particella come media delle posizioni hit, pesata sulla carica di ogni hit

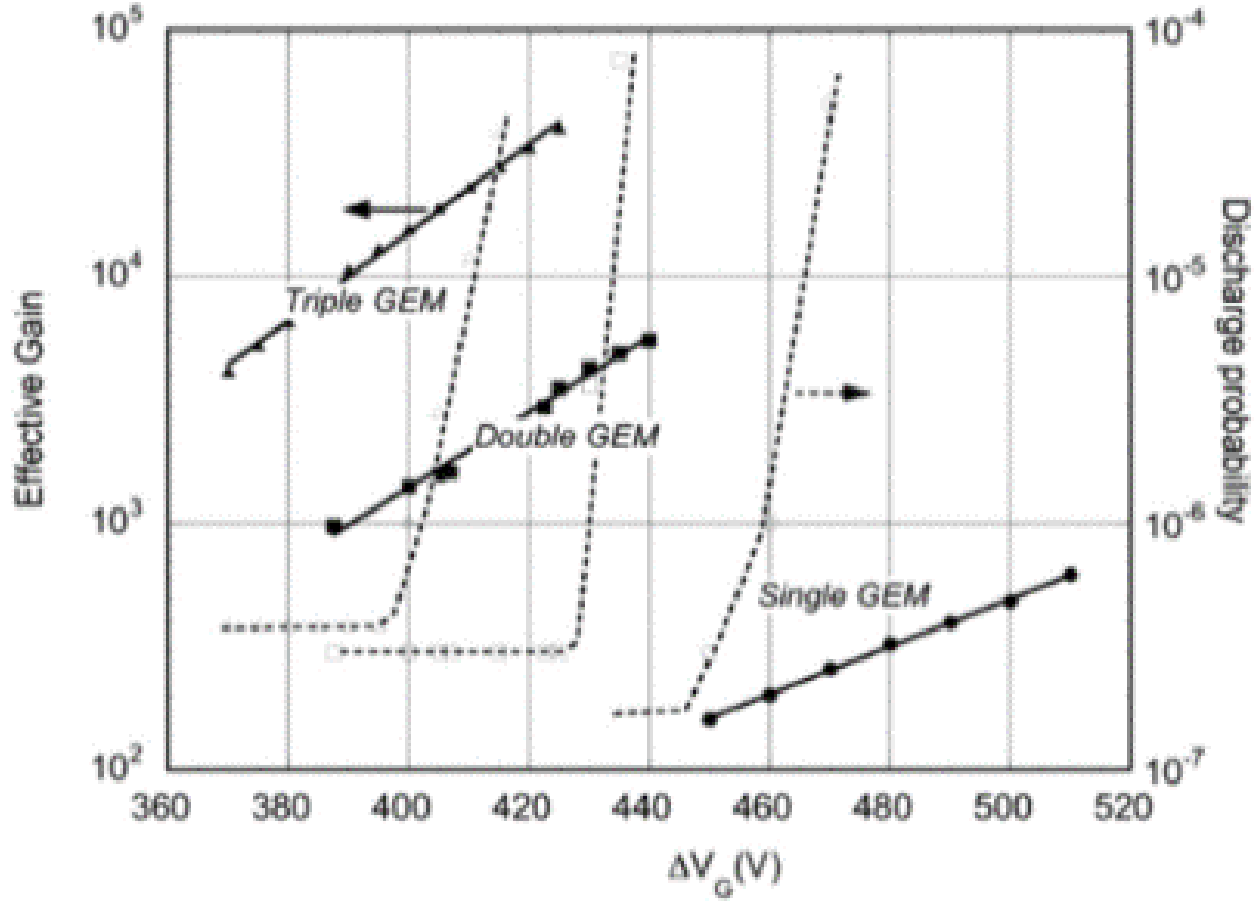
$$x_{CC} = \frac{\sum_{i=0}^{n_x} x_i q_i}{\sum_{i=0}^{n_x} q_i}$$



- µTPC: considera regione drift come piccola TPC, estrapola posizione particella con fit lineare che tiene conto di tempo e posizione degli hit

$$x_{\mu TPC} = \frac{gap/2 - b}{a}$$



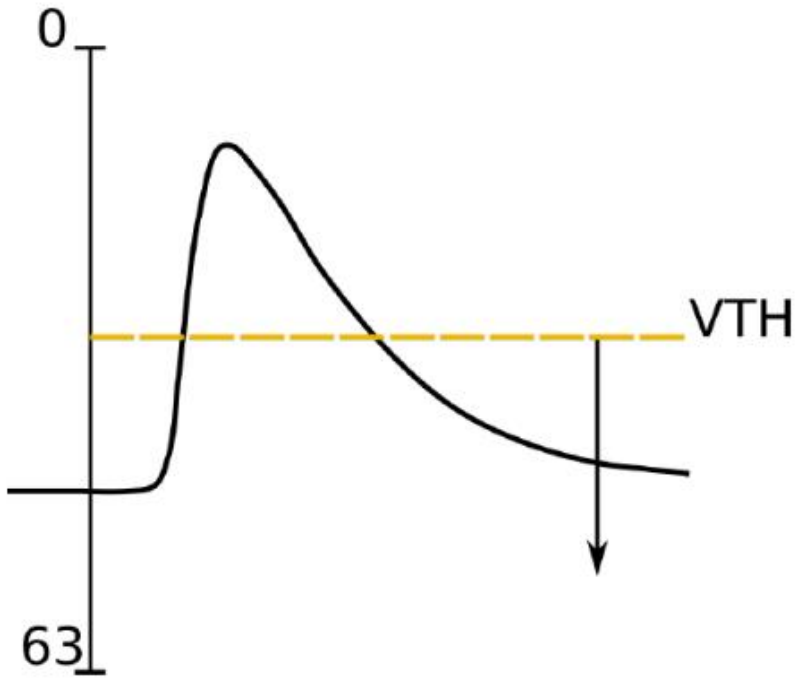

Effective Gain
Discharge probability
Triple GEM
Double GEM
Single GEM
10^5
10^4
10^3
10^2
10^{-4}
10^{-5}
10^{-6}
10^{-7}
360
380
400
420
440
460
480
500
520
ΔV_G(V)

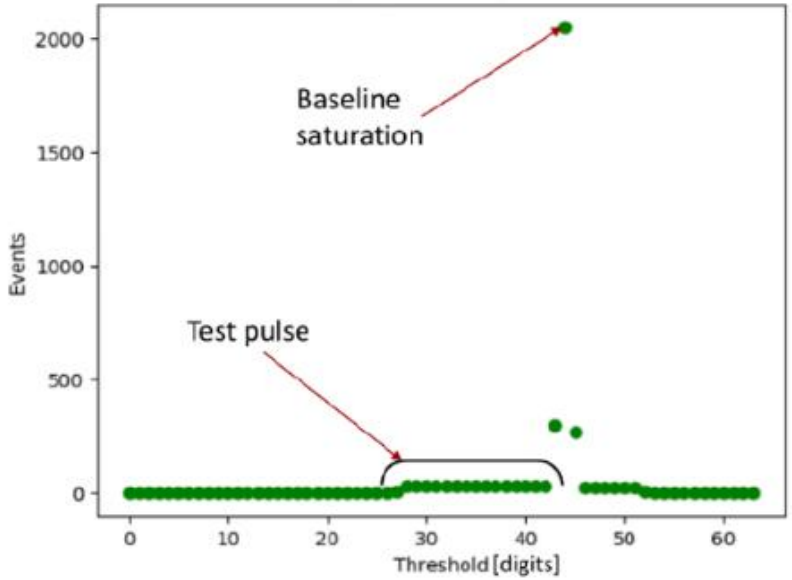
Threshold scan

Misure di rumore

Identificazione baseline

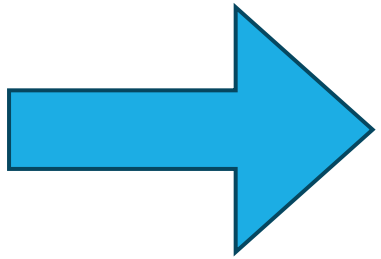
Monitoraggio stato canali





GUFI

~ 2 h



GEMROC

~ 5 min