Data Acquisition system for real time operation of the CGEM Inner Tracker

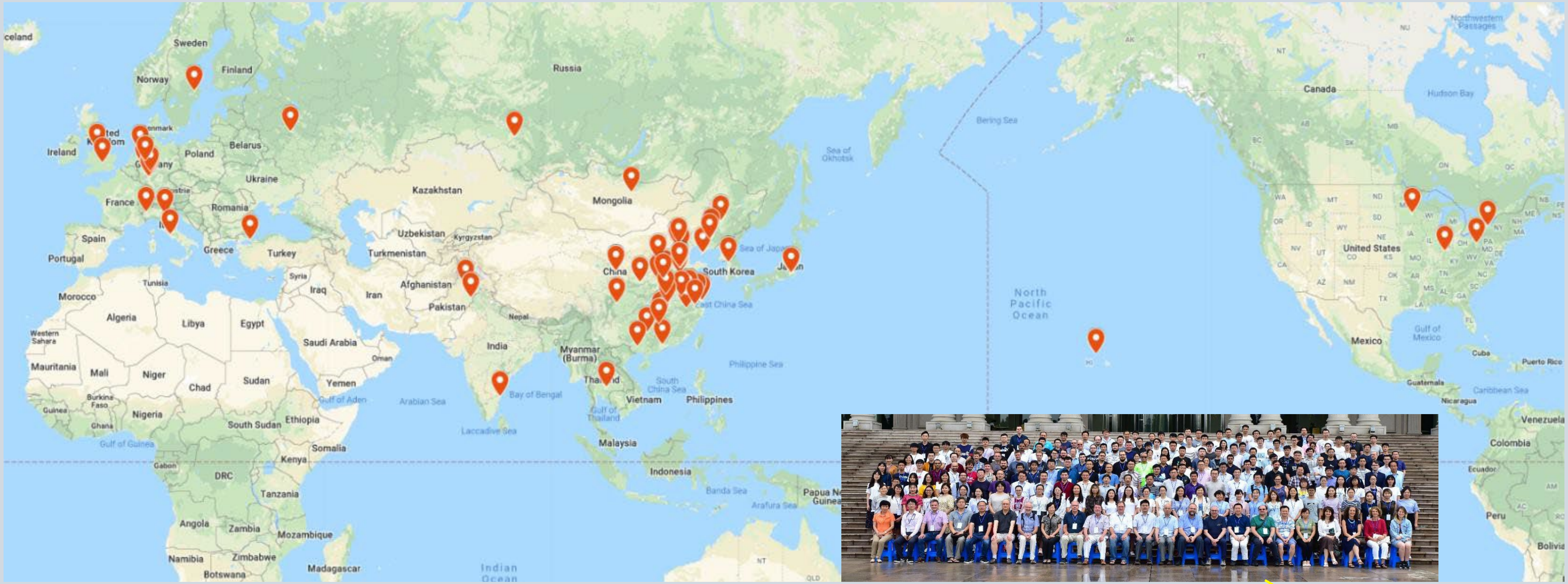
MICHELA GRECO, INFN Torino – University of Torino (Italy)

on behalf of CGEM-IT WORKING GROUP

INFN Istituto Nazionale di Fisica Nucleare SEZIONE DI TORINO

UNIVERSITÀ DI TORINO

BESIII Collaboration



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Istituto Nazionale di Fisica Nucleare
Sezione di Ferrara

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

INFN PERUGIA

INFN TORINO
Istituto Nazionale di Fisica Nucleare
Sezione di Torino

BESIII Italian Collaboration

15 countries, 72 institutions
~500 members

Beijing Electron Positron Collider

中国科学院高能物理研究所
Institute of High Energy Physics Chinese Academy of Sciences

Construction started: 1984

BEPC 1989-2005

L_{peak}=1.0x10^{31} /cm^{2}s

BEPCII 2008-now L_{peak}=1.0x10^{33}/cm^{2}s

E_{cm}: 2 — 4.95 GeV

BEPCII Upgrade foreseen in 2024

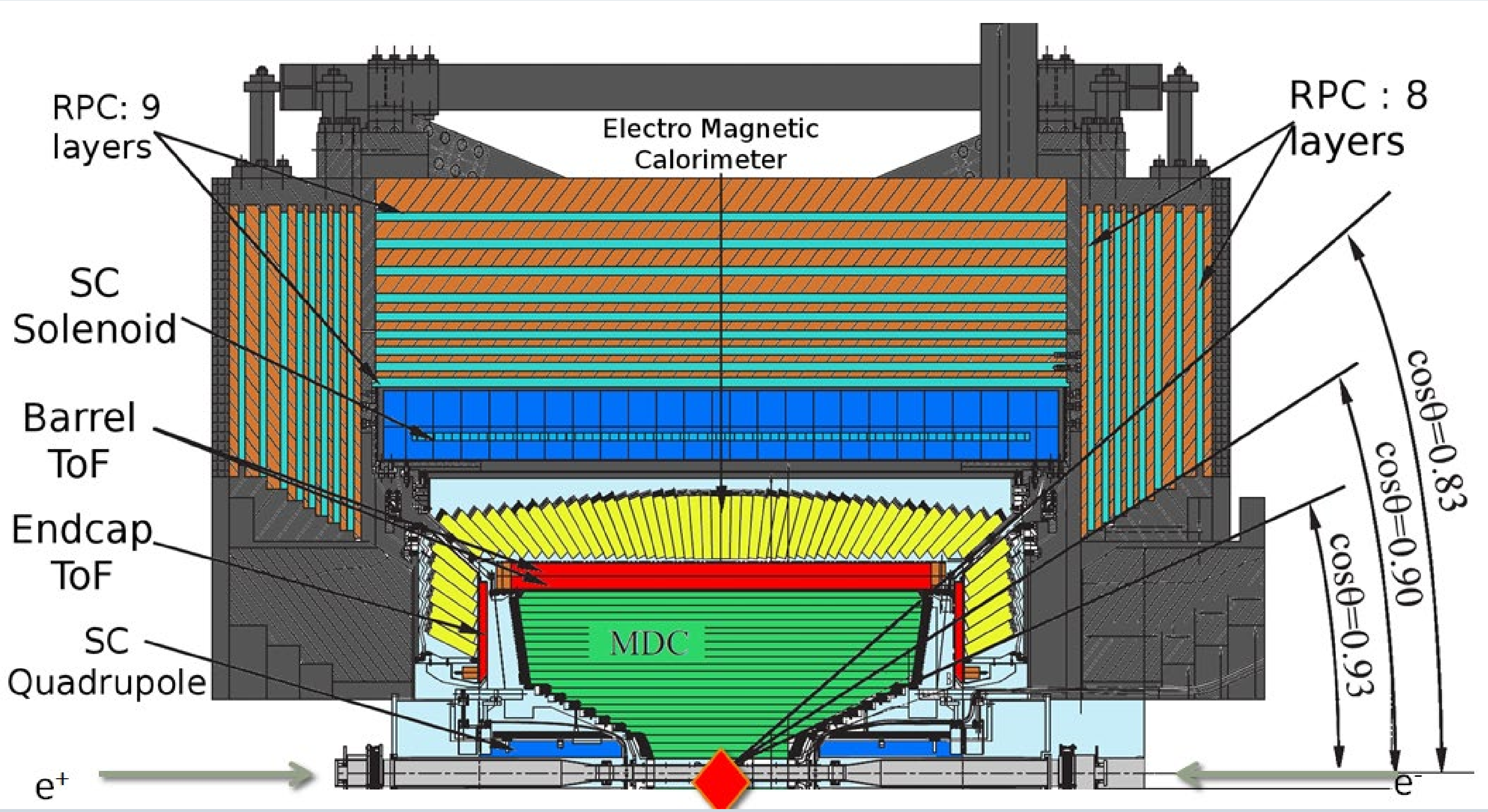
Beam energy >>2.8 GeV

Lx3 @2.35 GeV

BESIII

BESIII is designed to study physics in the tau-charm energy region.
BESIII has collected the J/ψ world largest data sample (10B).

It has been approved an extension of the data taking till 2030 (at least)



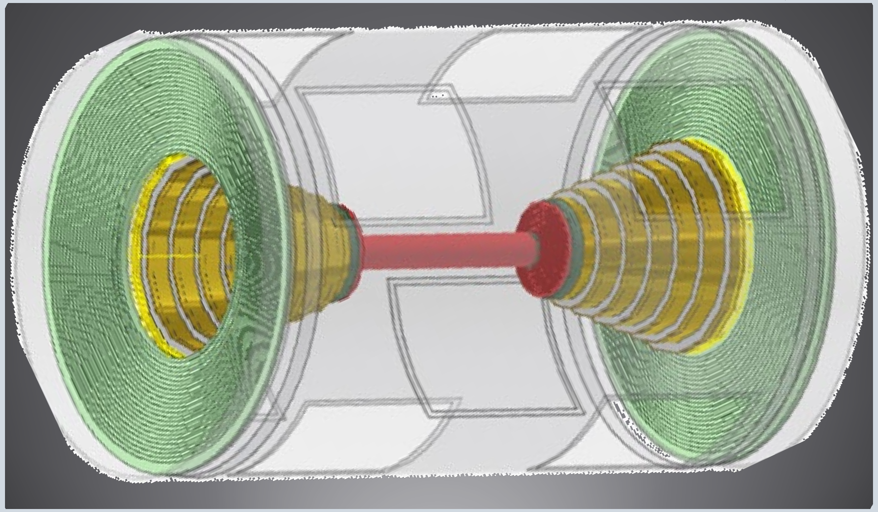
Total weight 750 tonnes, ~40,000 readout channels, Data rate: 5 kHz, 50 Mb/s

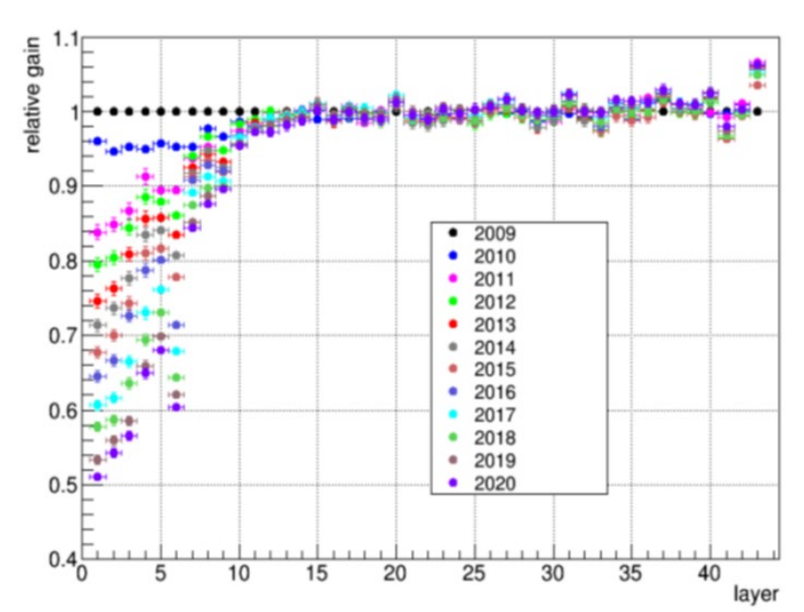
white paper on future physics program
Chinese Physics C 44, 2020

MDC, 0.5% at 1 GeV/c
CsI(Tl) calorimeter, 2.5% @ 1 GeV
BTOF, 70 ps / ETOF, 60 ps
dE/dx 6% e^- Bhabha scattering

BESIII Inner Tracker

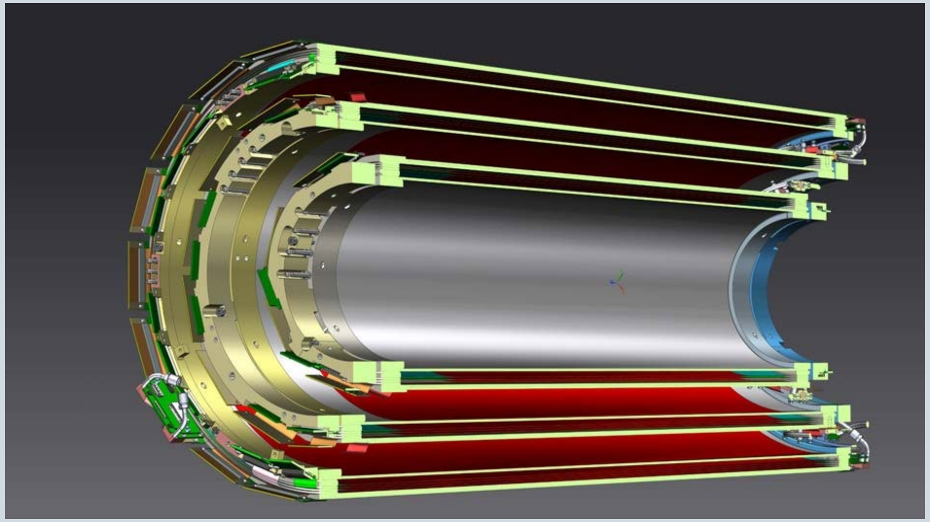
MDC>inner chamber

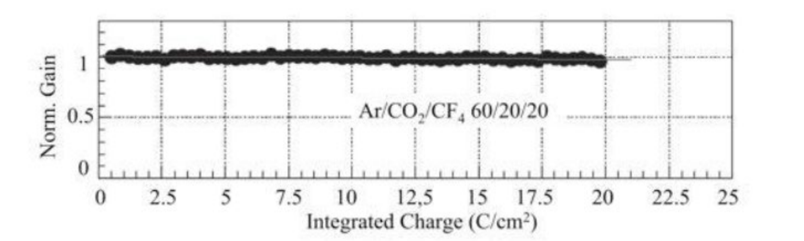




Aging
Gain loss/year
~ 4% on inner layers

CGEM> GEM technology



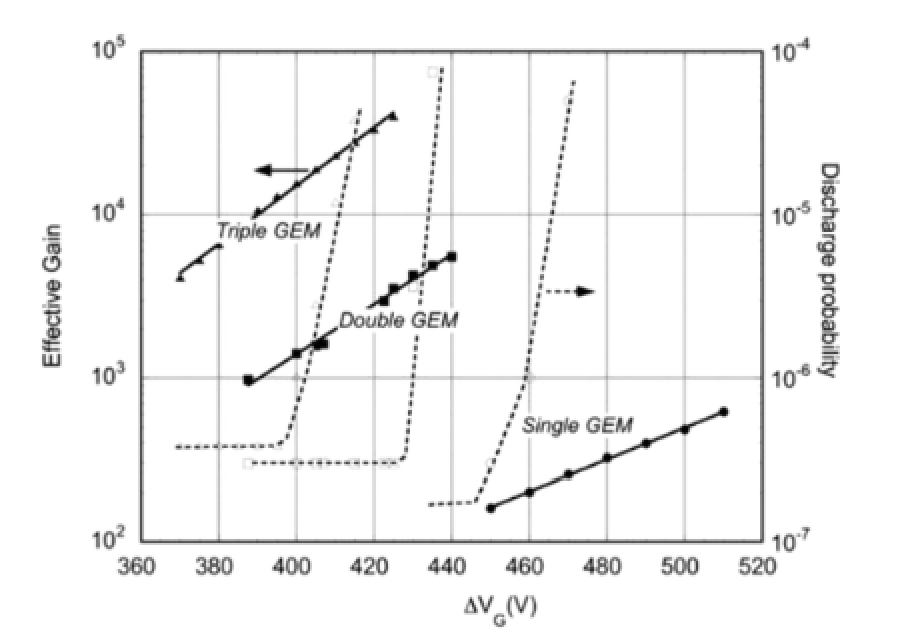


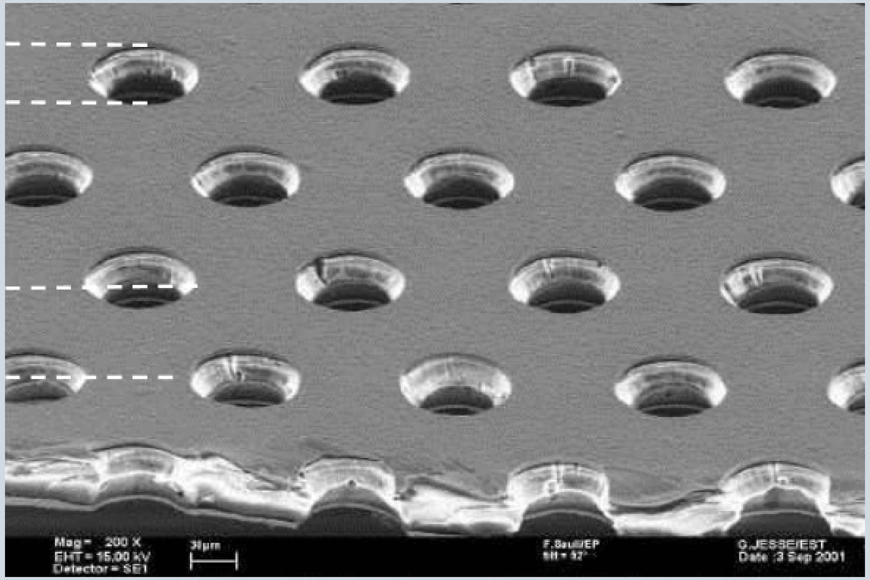
Low spatial charge
High rate capability
Fast response
Light support frame
Very low aging

GEM detectors

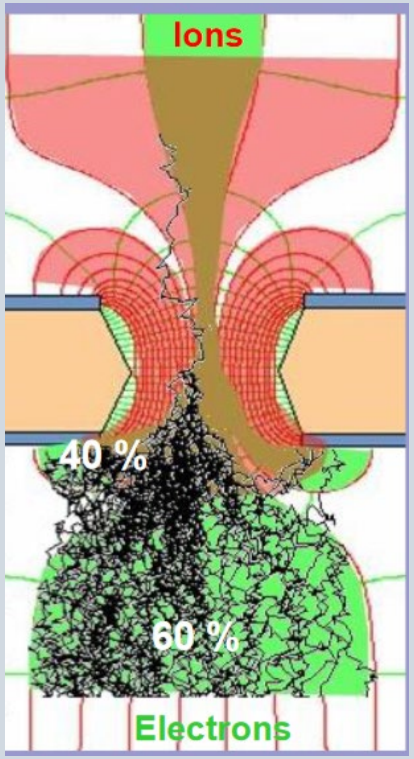
GEM (**G**aseous **E**lectron **M**ultiplier) is a Micro Pattern Gas Detector, invented by Sauli in 1997

- High rate capability
- High radiation hardness
- Scalable and flexible geometry





NIMA 386, 1997



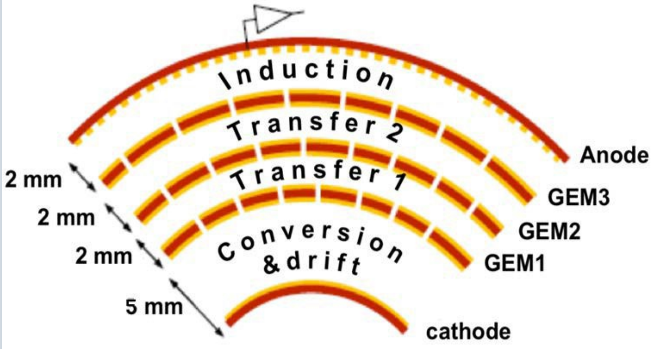
More layers of GEM grant high gain with lower applied voltages → lower spark rate

NIM A 2016, 805

CGEM>

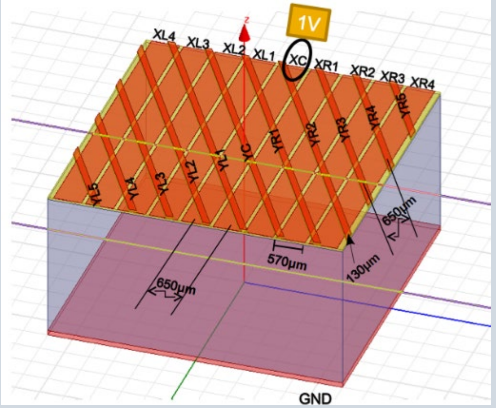
Cylindrical Gaseous Electron Multiplier

- σ_{xy} ~ 130 µm
- σ_z < 1 mm (~ 350 µm)
- σ_{pt}/p_t ~ 0.5% @ 1 GeV/c
- Operation in 1T magnetic field
- Material budget ~1.5% X_0
- High rate capability: 10^4 Hz/cm^2

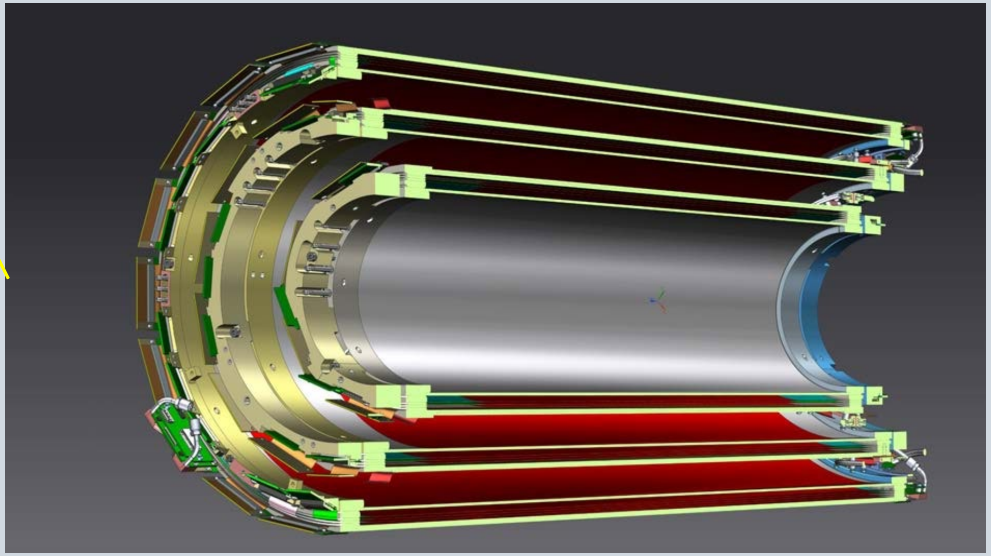


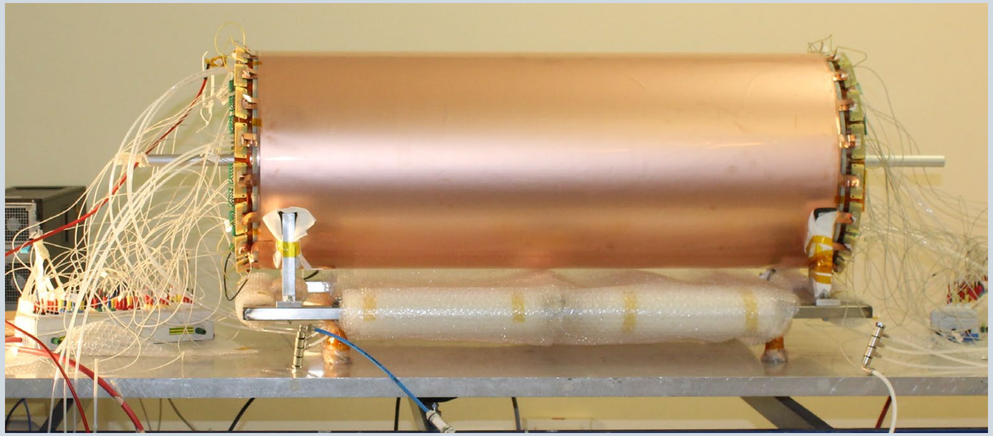
Symmetry 2022, 14(5), 905

Three layers of cylindrical triple-GEM
Each layer has two "views" to reconstruct the 3D position of the hits

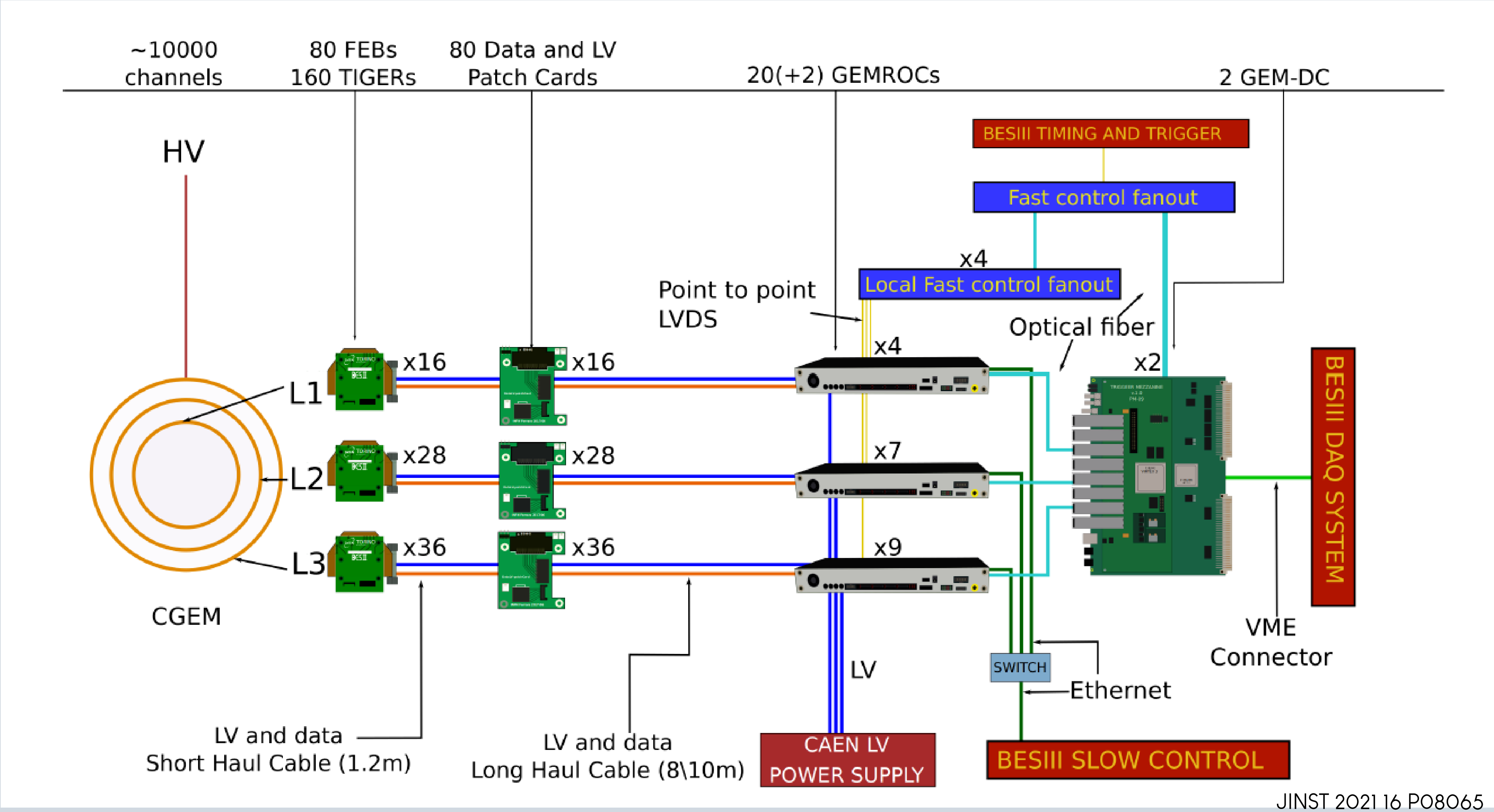


Ar-iC4H10 (90%-10%)
1.5/3/3/5 kV/cm





Readout chain



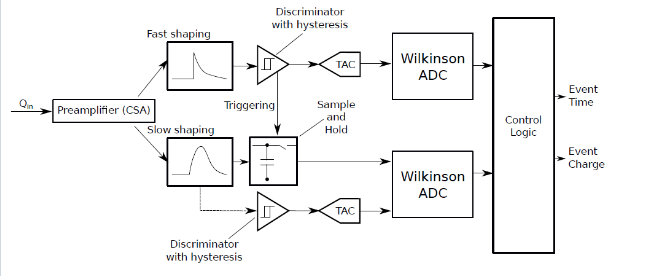
JINST 2021 16 P08065

TIGER+GEMROC

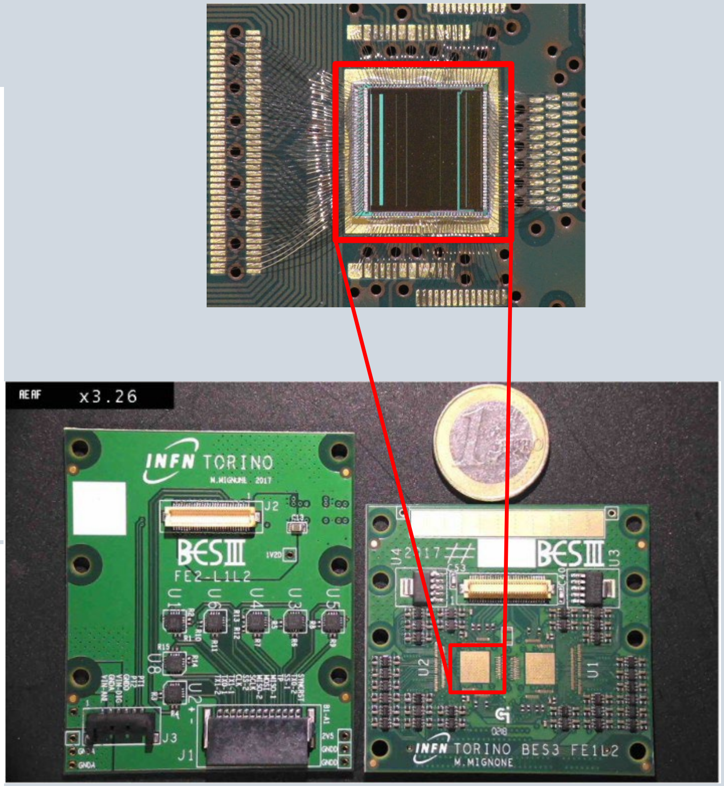
TIGER (Torino Integrated Gem Electronics Readout)
64-channels ASIC
charge and **time** readout

Sample & Hold
Time-over-Threshold

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



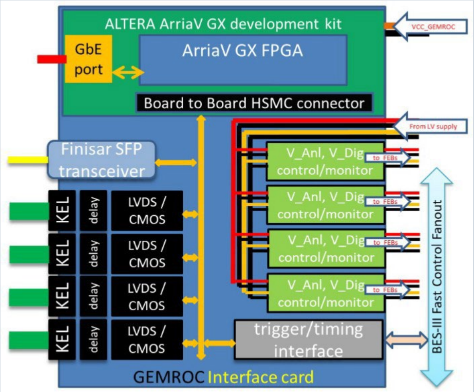
JINST 12 C07017



INFN-Torino

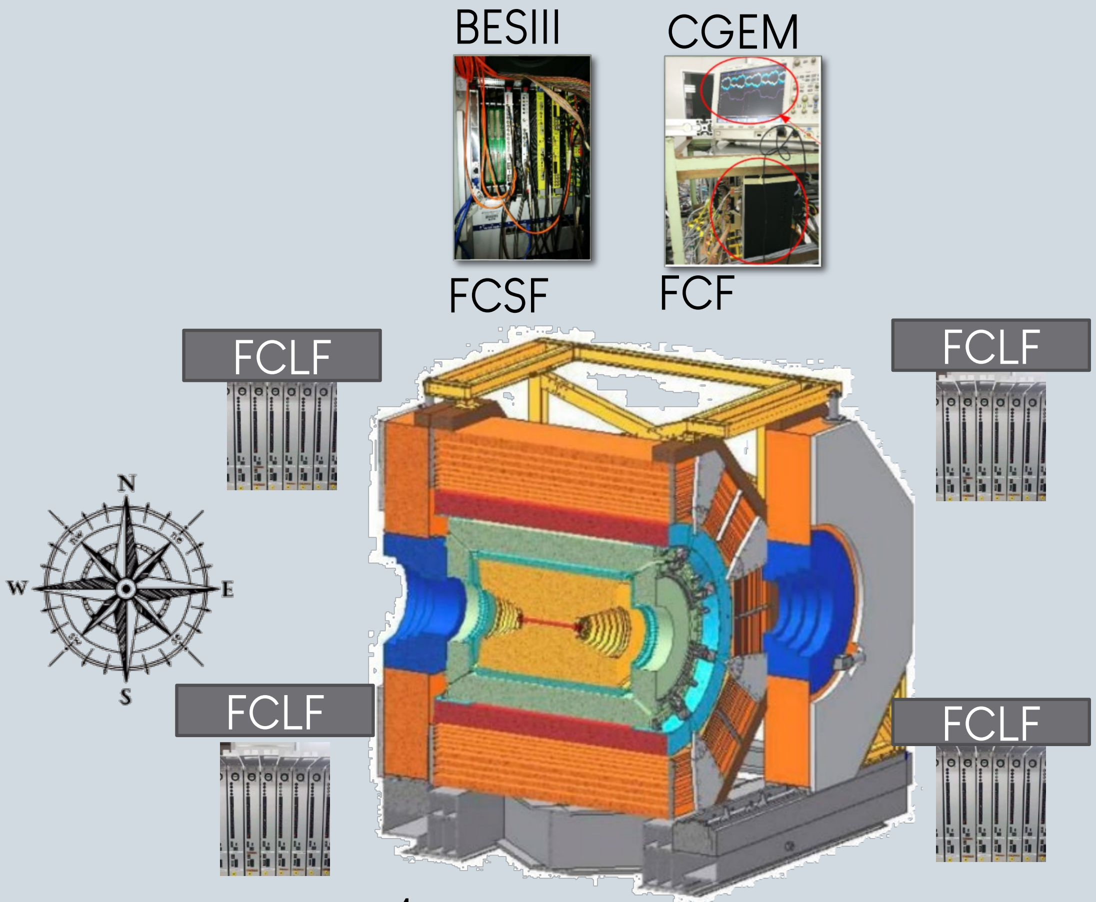
GEM Read Out Card

Power the FEBs
Monitor chips voltages and temperature
Configure the chips
Receive timing signals
Control data acquisition via optical links/Ethernet



INFN-Ferrara

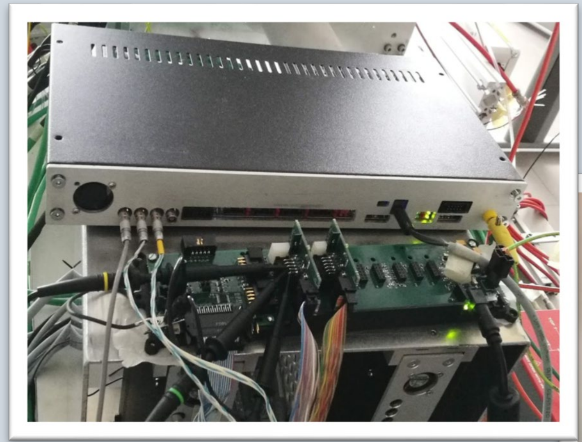
BESIII timing signals

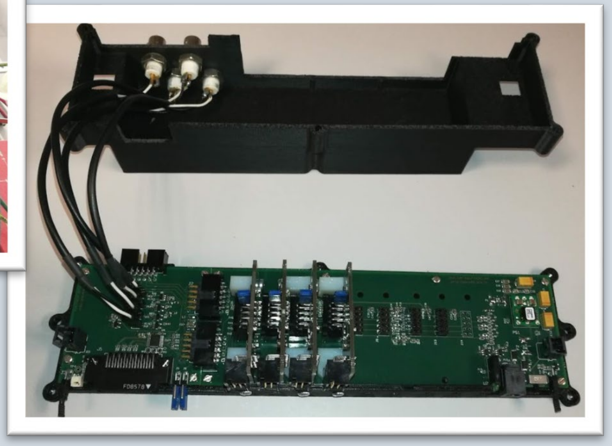


4 groups
of GEMROC modules

Fast Control system Fanout
a modified GEMROC module which connects to the CLK, L1, L1_CHK, FULL signals from the BESIII FCSF

Fast Control system Local Fanout
a low cost, not programmable, fanout module which connects to the CLK, L1, L1_CHK, FULL signals from FCF

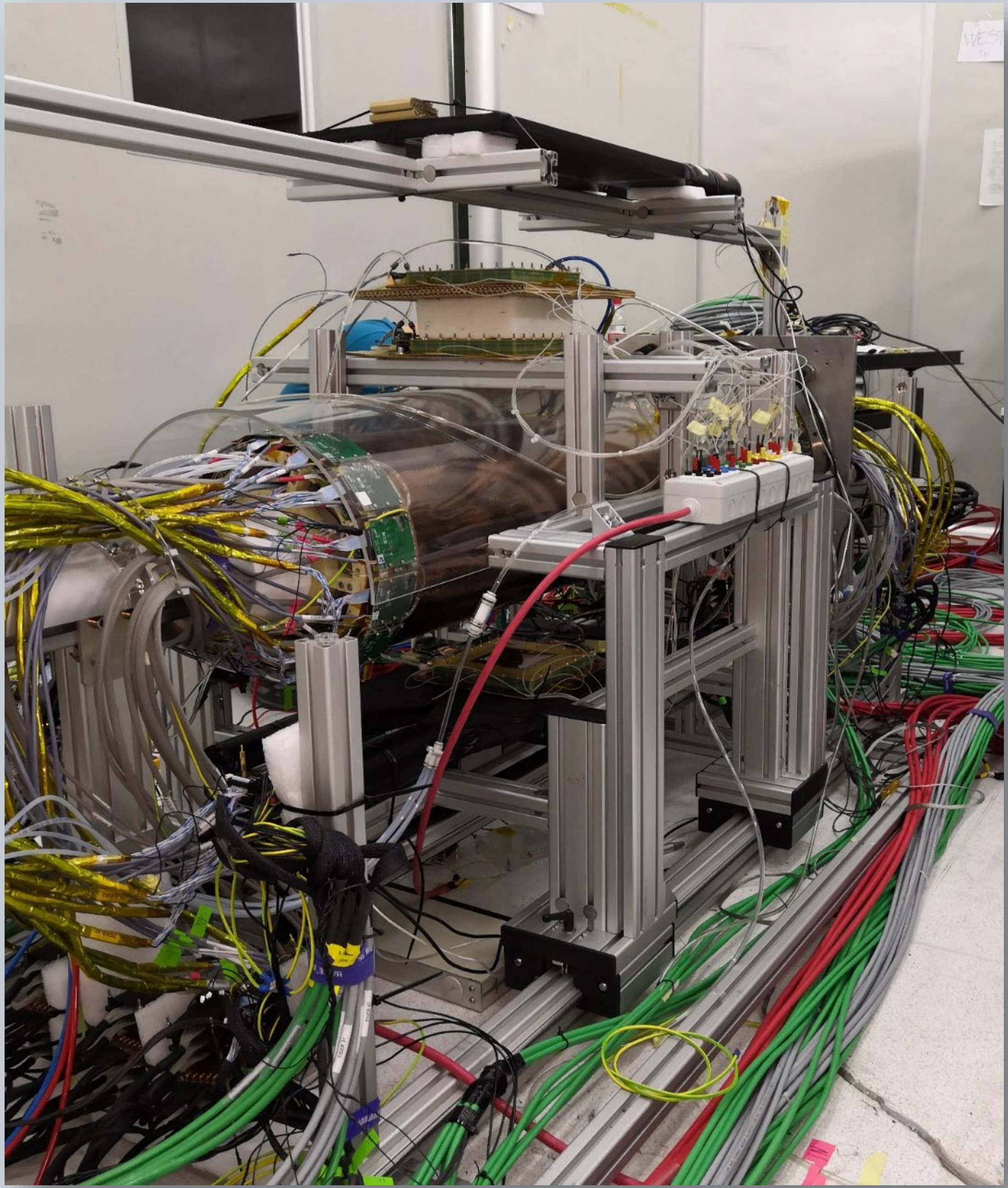


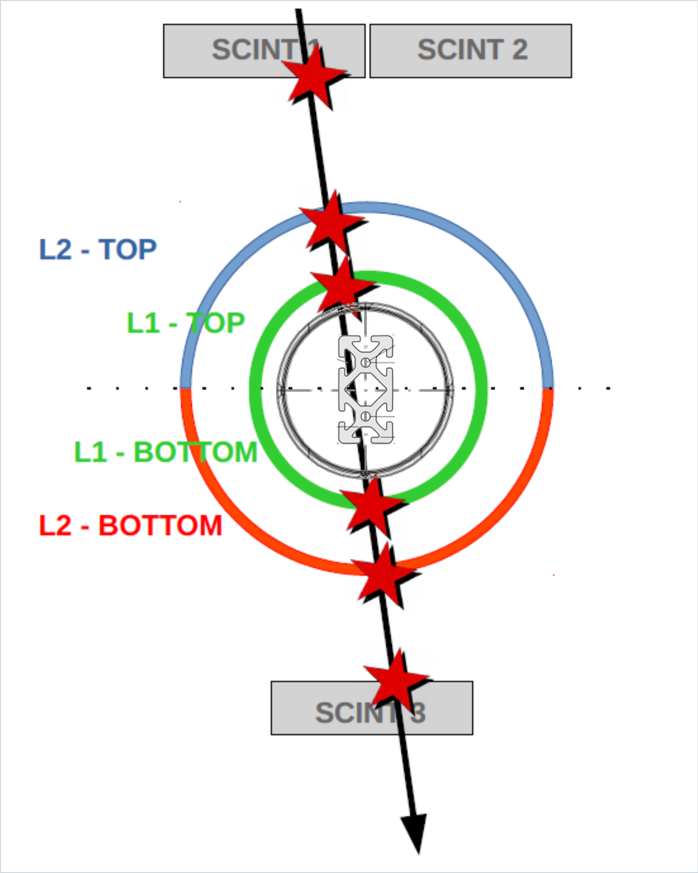


@A.Cotta Ramusino

Cosmic telescope in Beijing

~5.6k channels connected
Final LV/HV systems

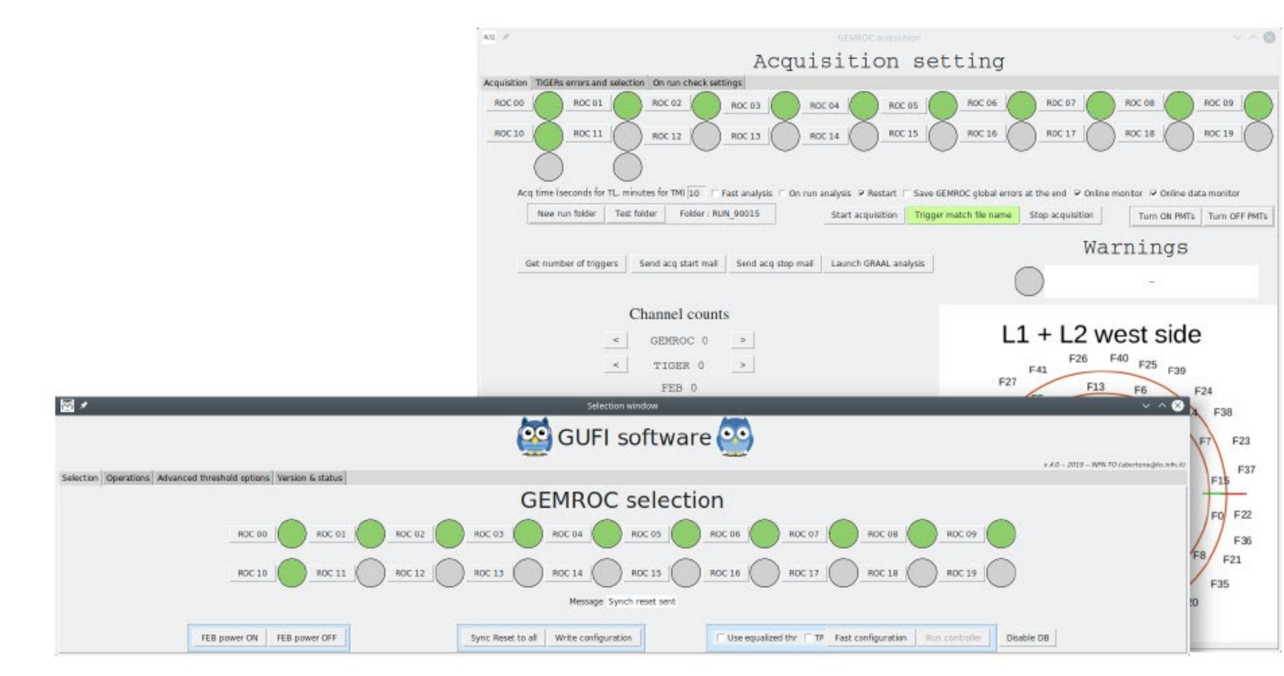


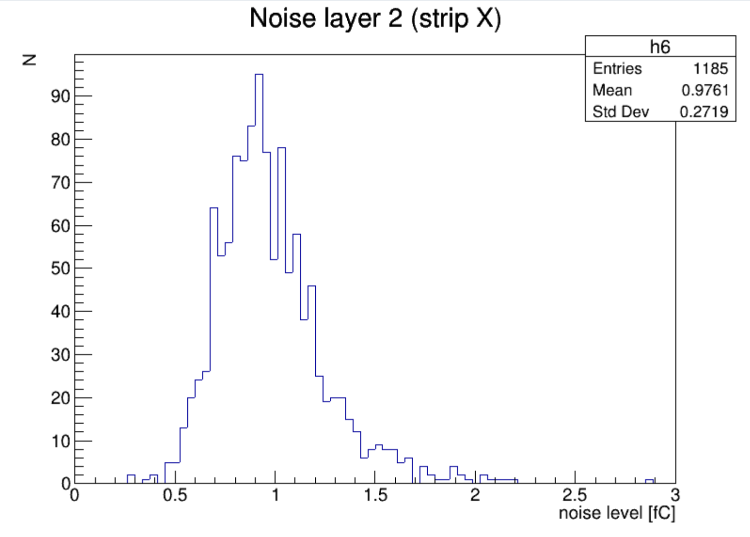


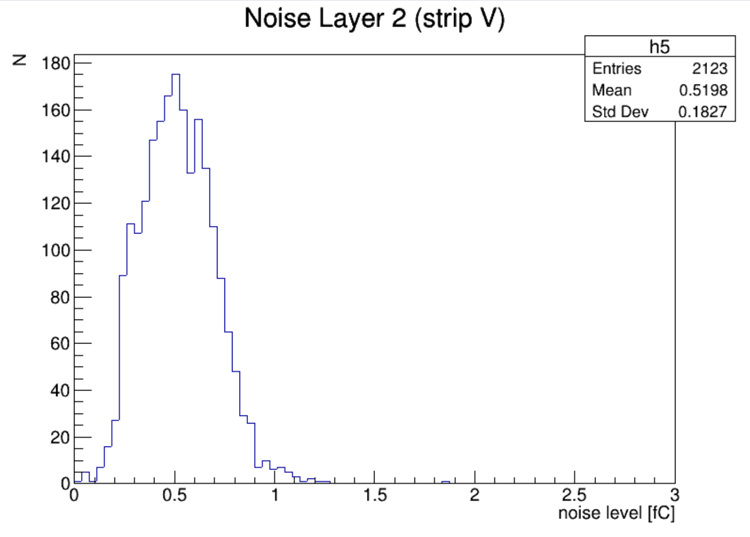
Control System: GUFI

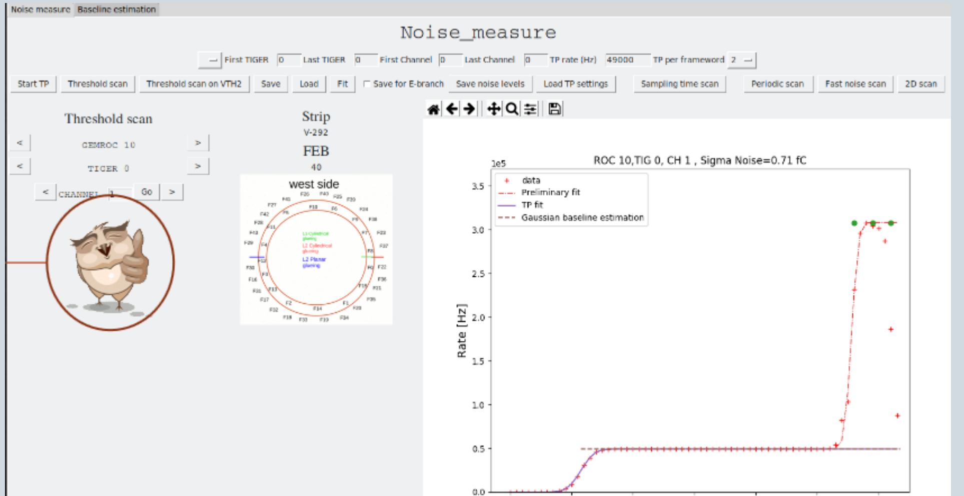
Graphical User Frontend Interface
to characterize, debug and test the system before the installation

standard and advanced features
tkinter Python library for graphical interfaces





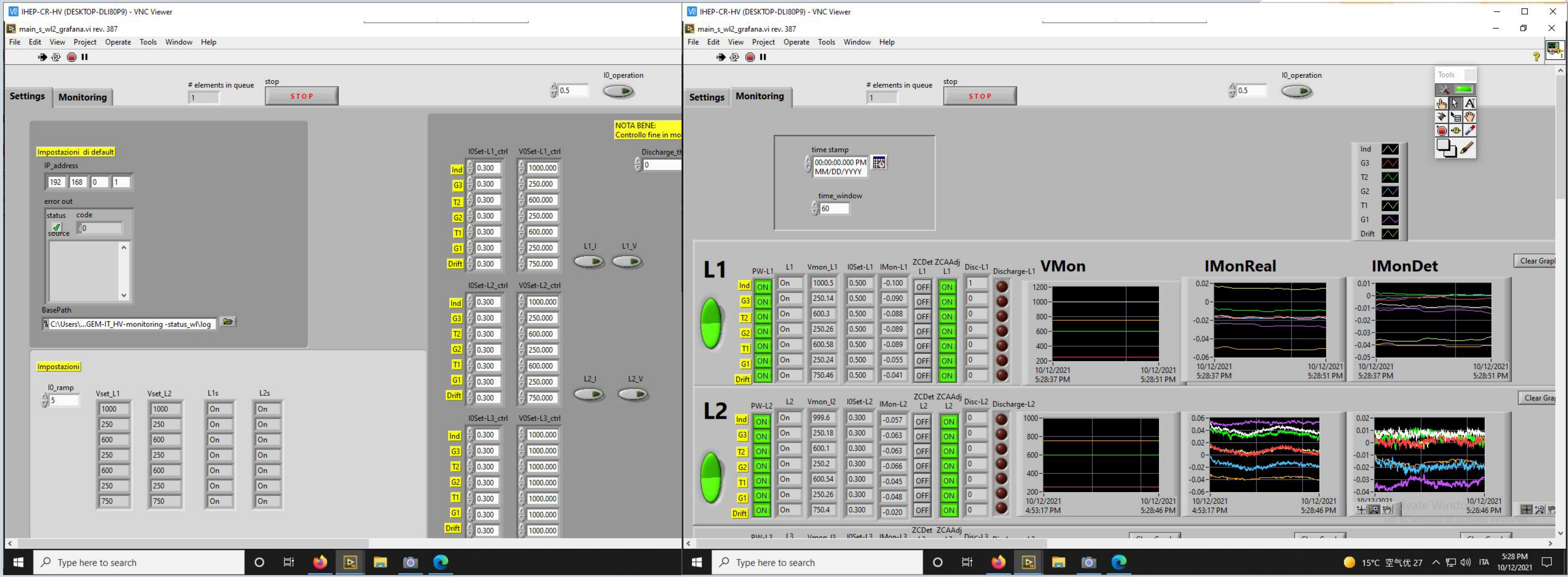




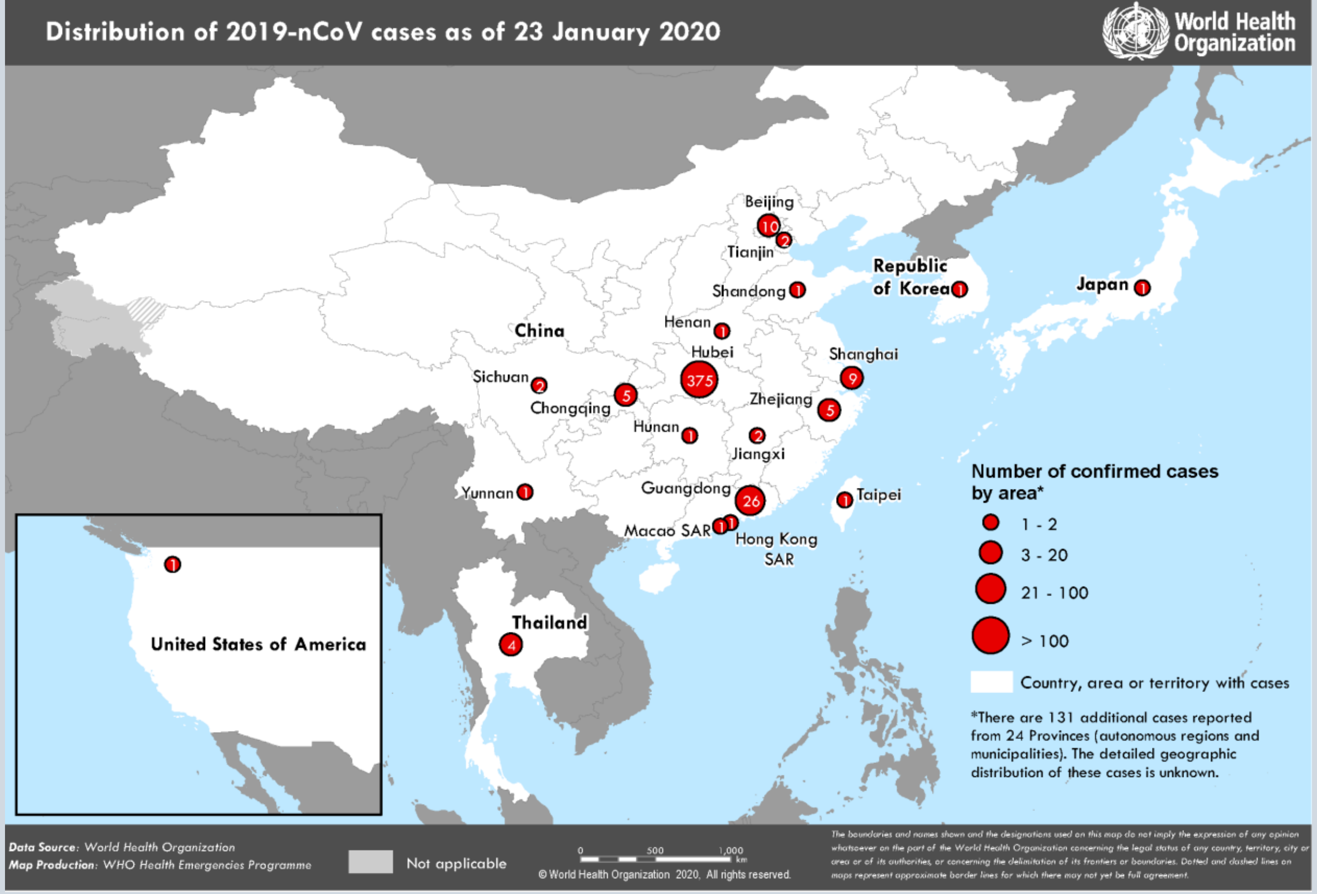
@A. Bortone

Control System: HV

to characterize, debug and test the system
before the installation



CGEM data taking



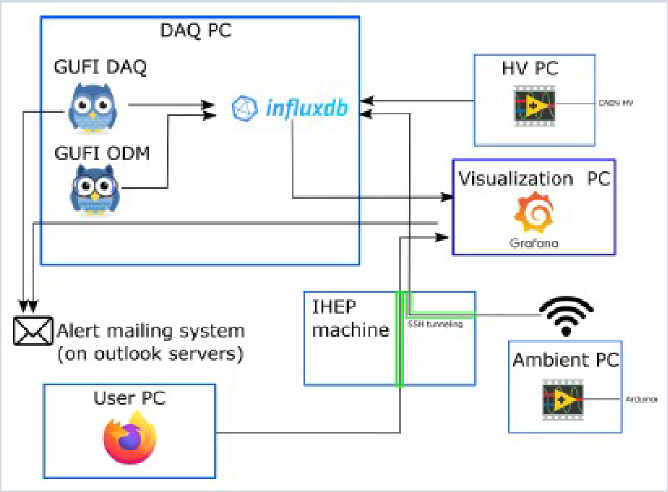
Remote data collection (more than 2 years) by the Italian groups.

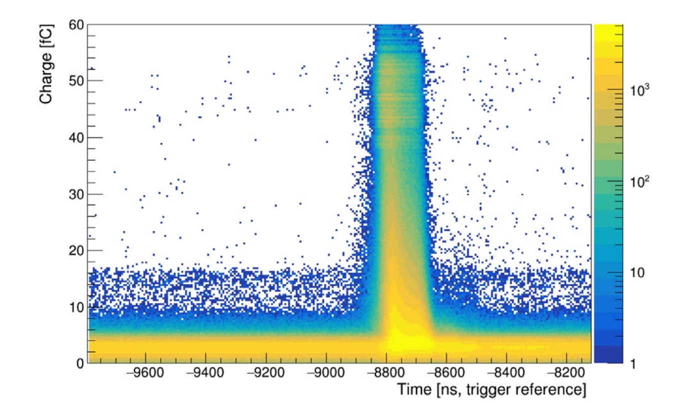
> RT monitoring of operations

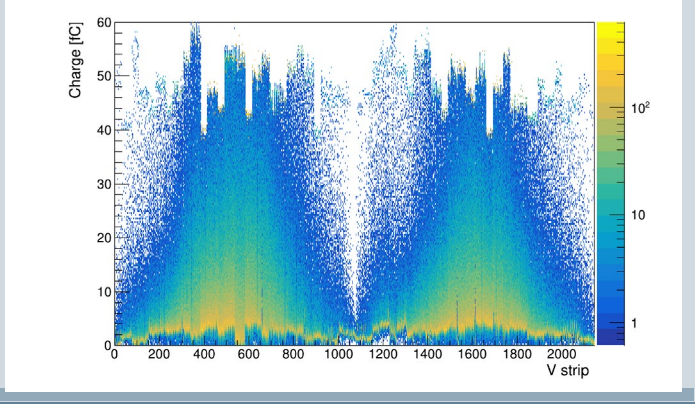
On-site operations thanks to the valuable help of colleagues from BESIII MDC team

In parallel, carry out integration activities on a small scale setup

RT monitoring







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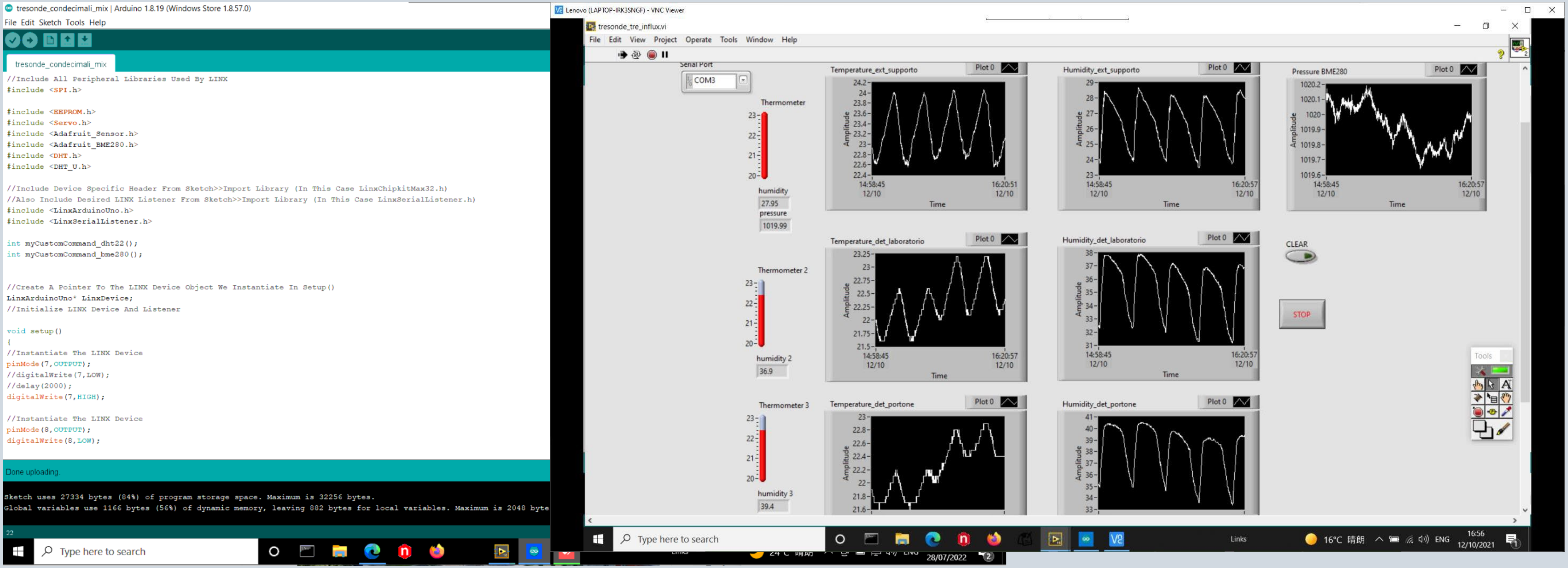
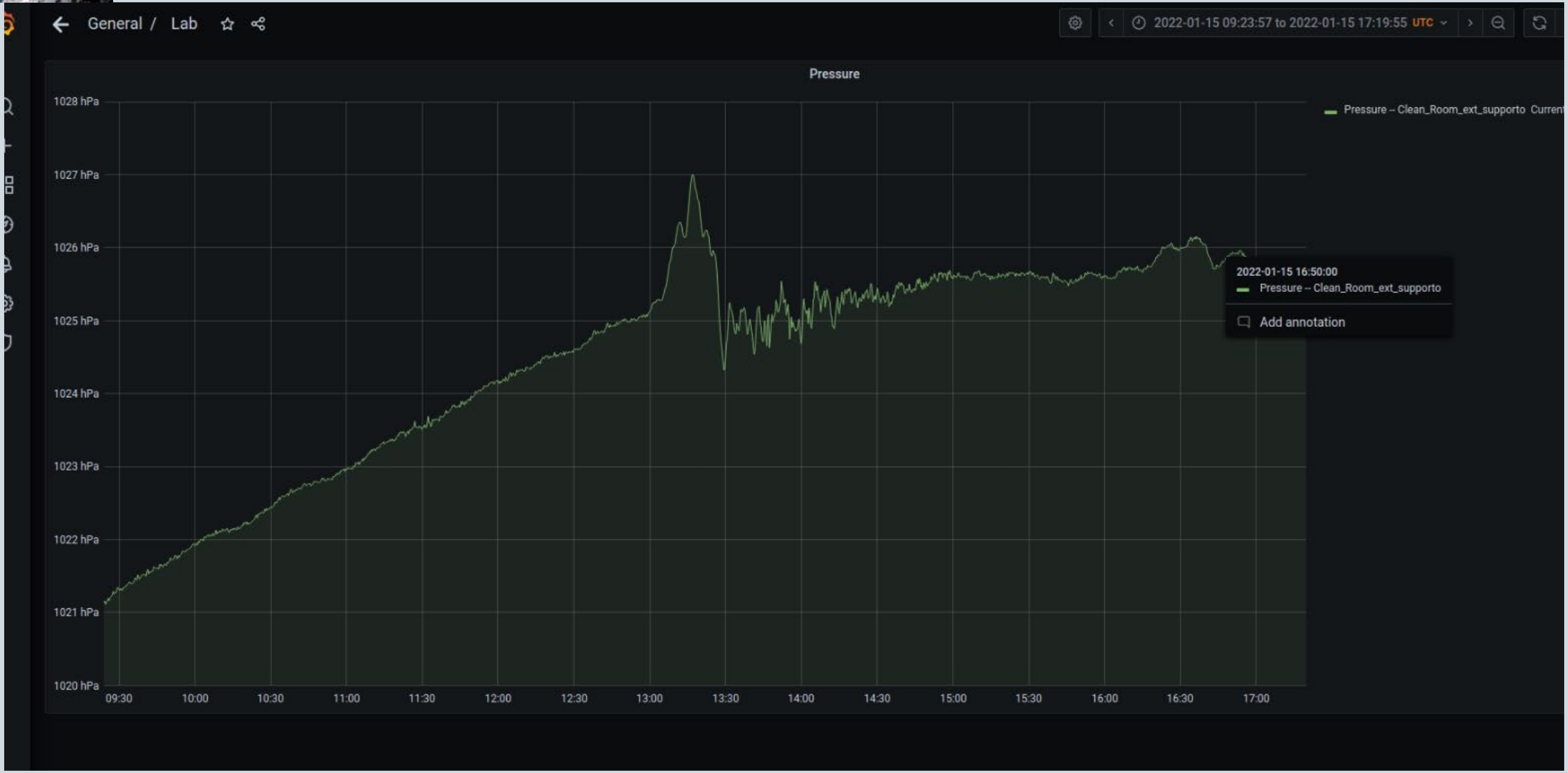
RT monitoring



RT monitoring

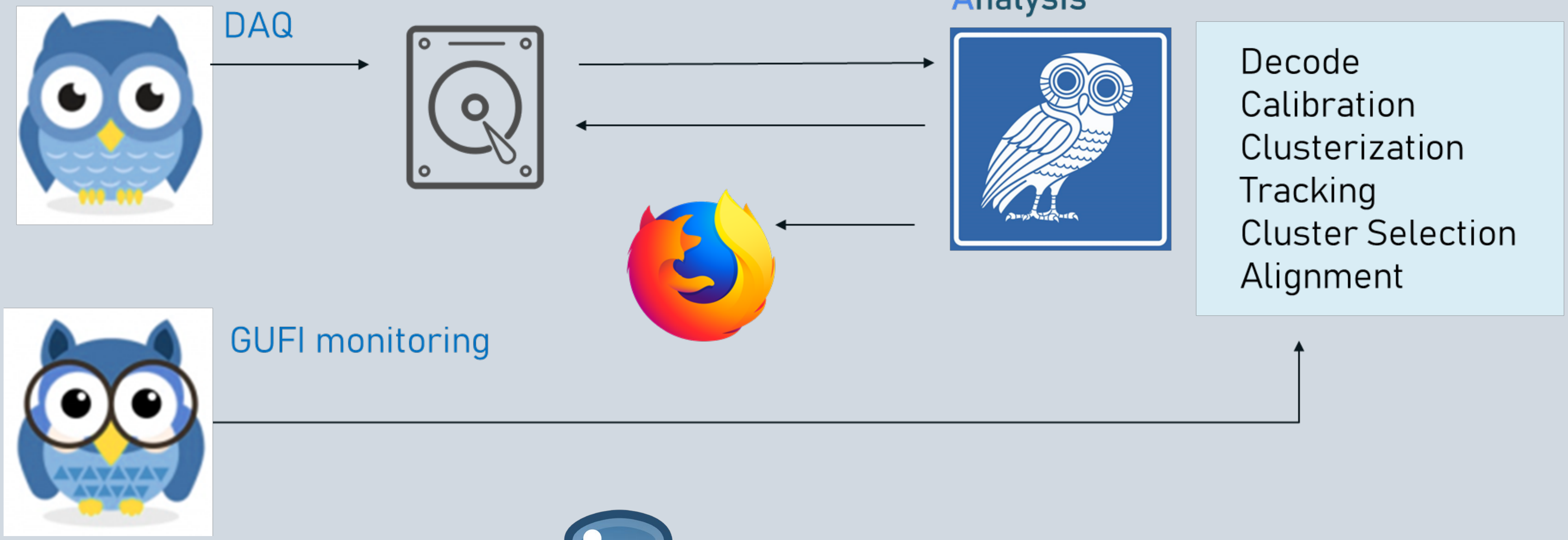
Hunga Tonga–Hunga Ha'apai eruption



Fast-Analysis tool: CIVETTA

CIVETTA
Complete Interactive VErsatile Test Tool Analysis

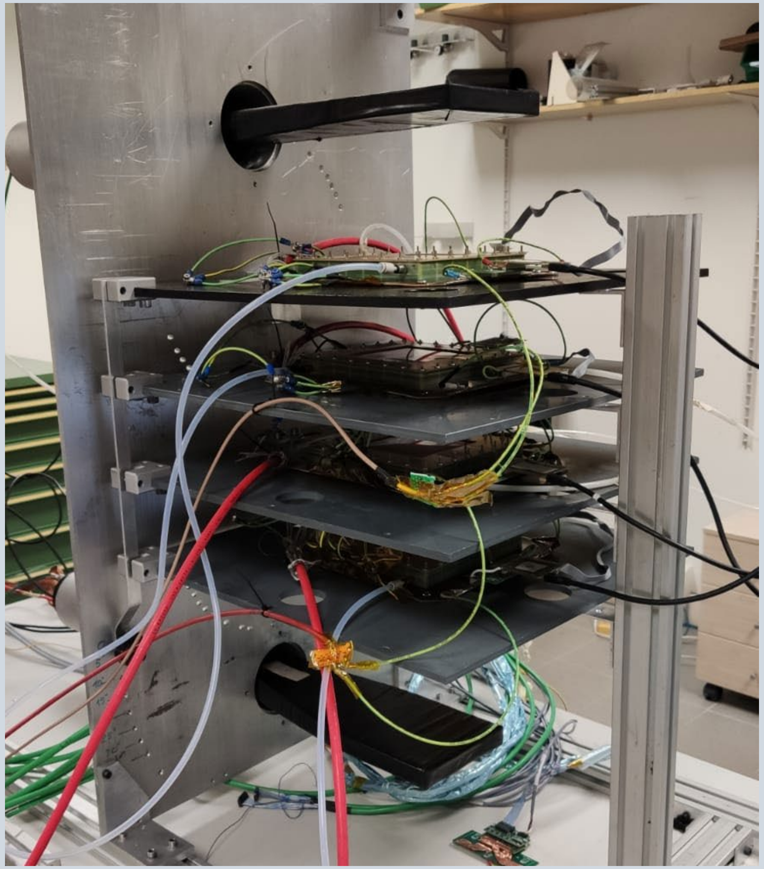
GUFI DAQ

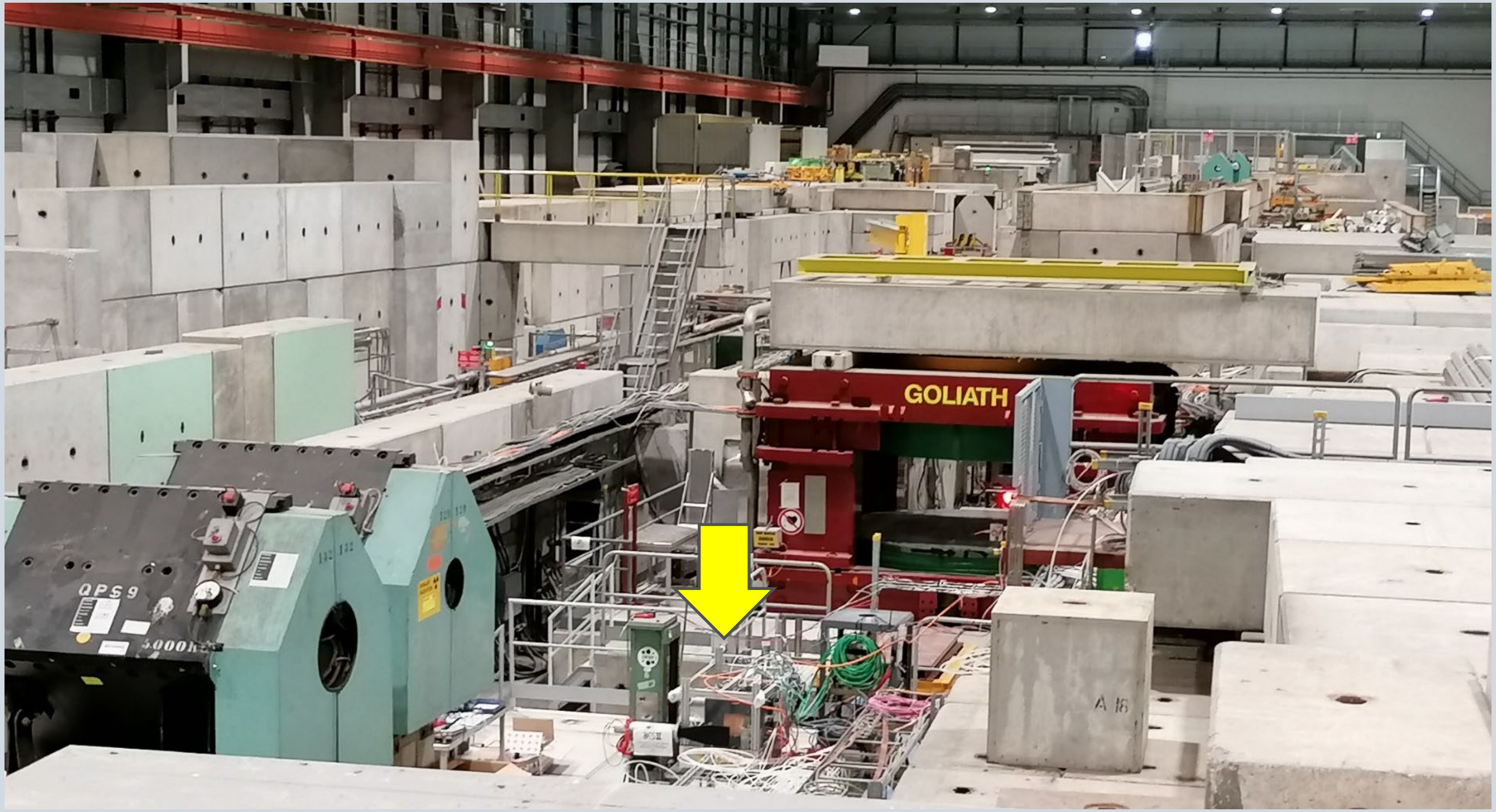


@A. Bortone

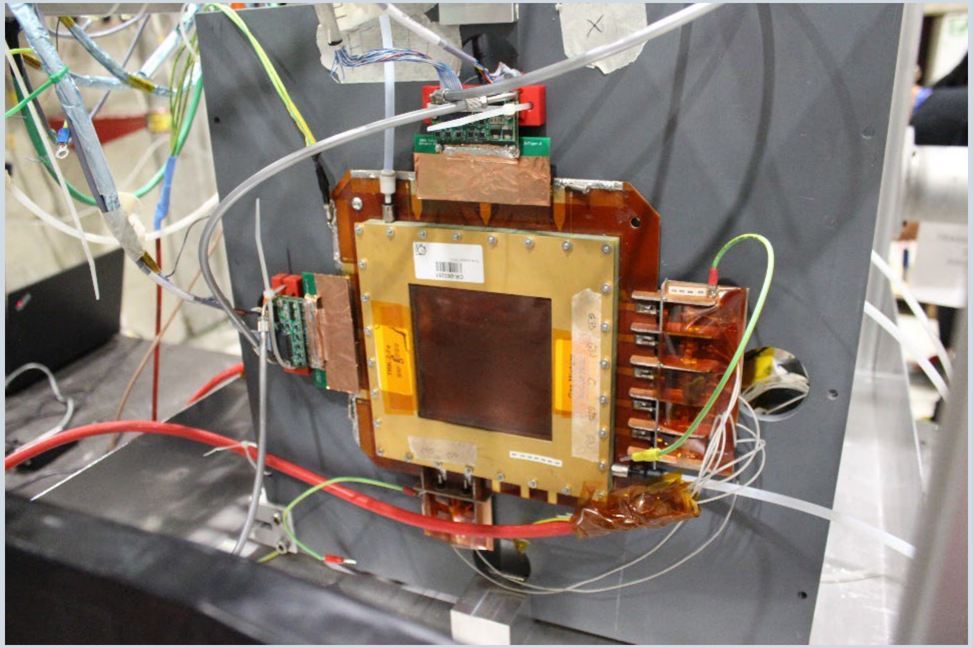
-complete metrics > performance of the detector
-software is fully parallelized at the sub-run level to take advantage of all CPU on the machine and maximize performance

Integration tests





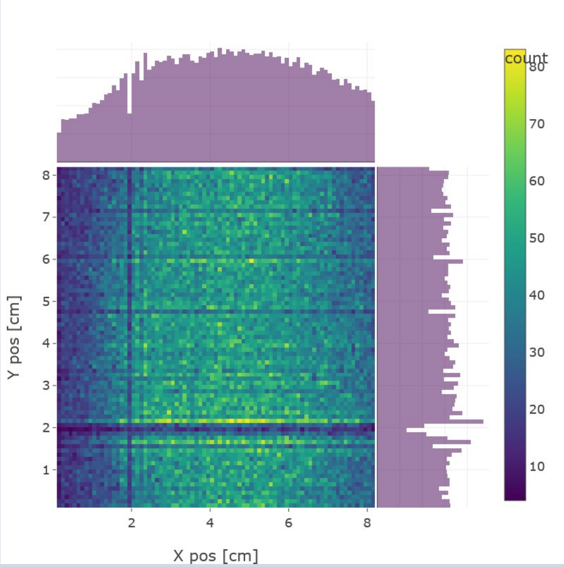
Integration tests



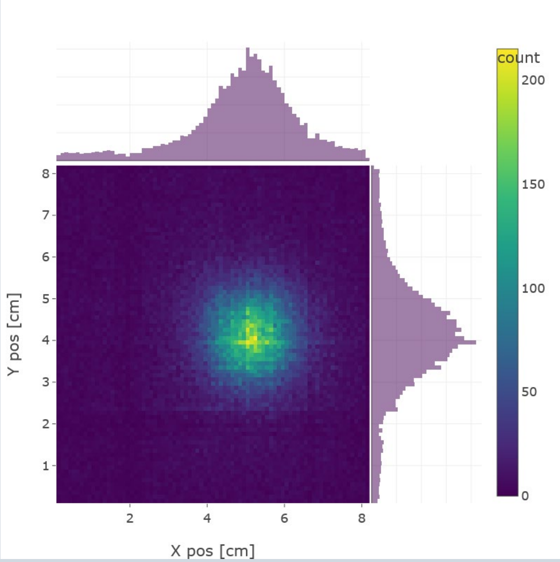
12/21 July 2021
RD51 test beam
@ H4 line CERN North Area, Prevessin

4.5 s spills
180 k muons
4M pions

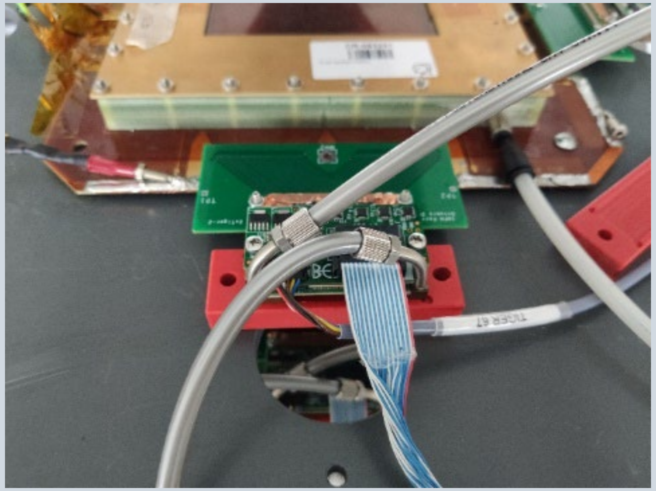
250 M triggers



Muons @80 GeV/c



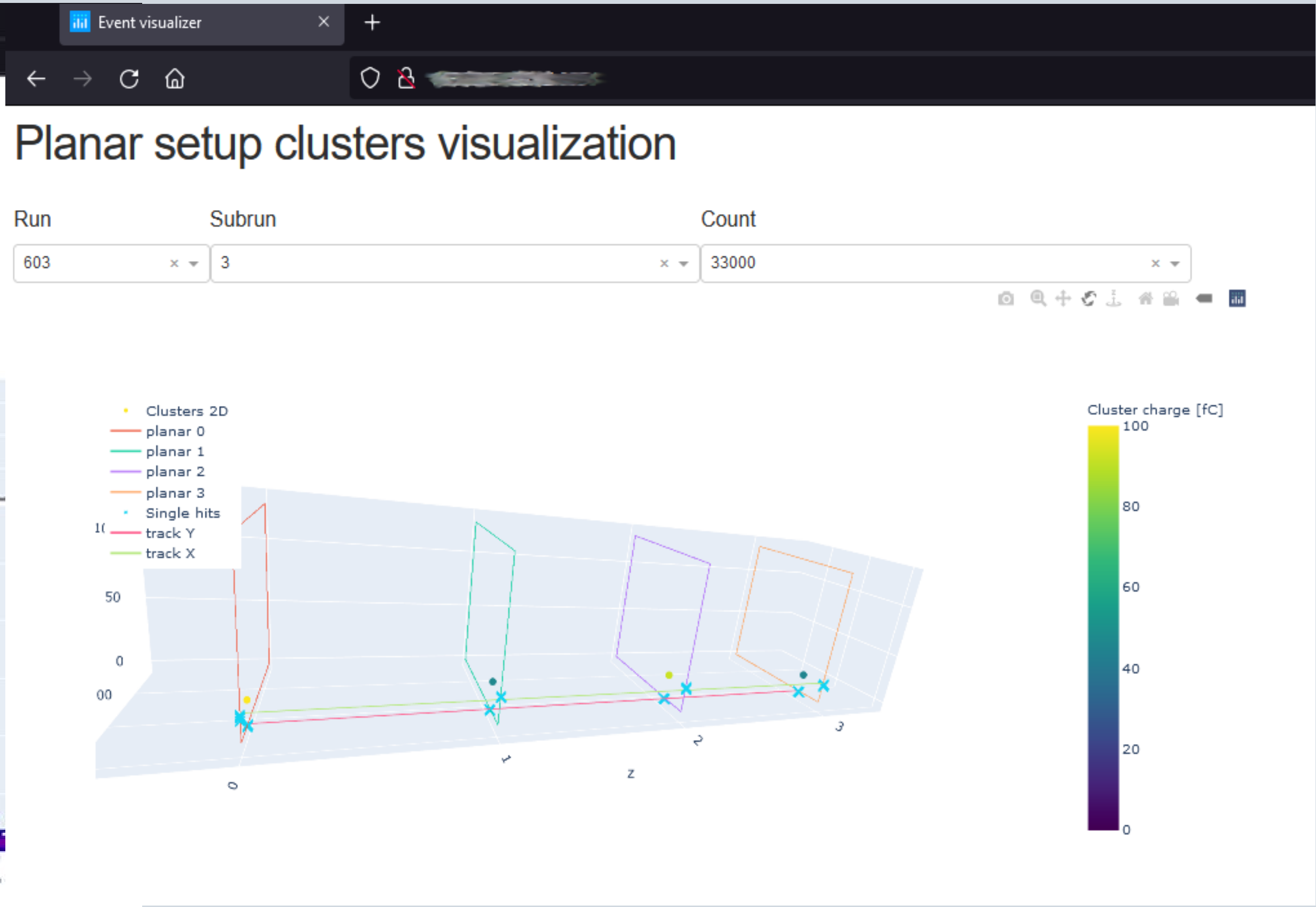
Pions @150 GeV/c



CIVETTA

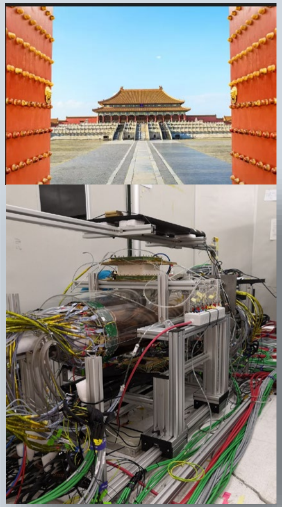
Online metrics and events visualization via web browser using Plotly-Dash
Immediately after run end on a subsample to check goodness

DAQ sw at TB: STRESS –TEST!



Offline Data analysis PM2021 ICHEP2022

Summary

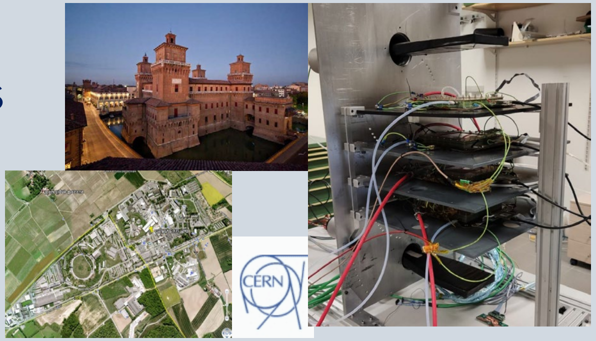


As the pandemic spread, we did not expect to manage operations remotely for such a long period of time.

The DAQ system, which was intended for a "short" startup, was set for a longer operation.

A RT monitoring system was developed to safely operate the CGEM detector.

A fast analysis tool was implemented to support integration tests at the small facility, operating in Ferrara and under the test beam@CERN.



The test beam was a real pressure test for the GUFI/CIVETTA system: everything was fine!

BESIIICGEM FEST

RISE

HORIZON 2020

謝謝

thank you