Romania @ CERN - Exhibition
ALICE Sector

The message

- Could we unravel the History of Universe based on experiments in terrestrial laboratories?

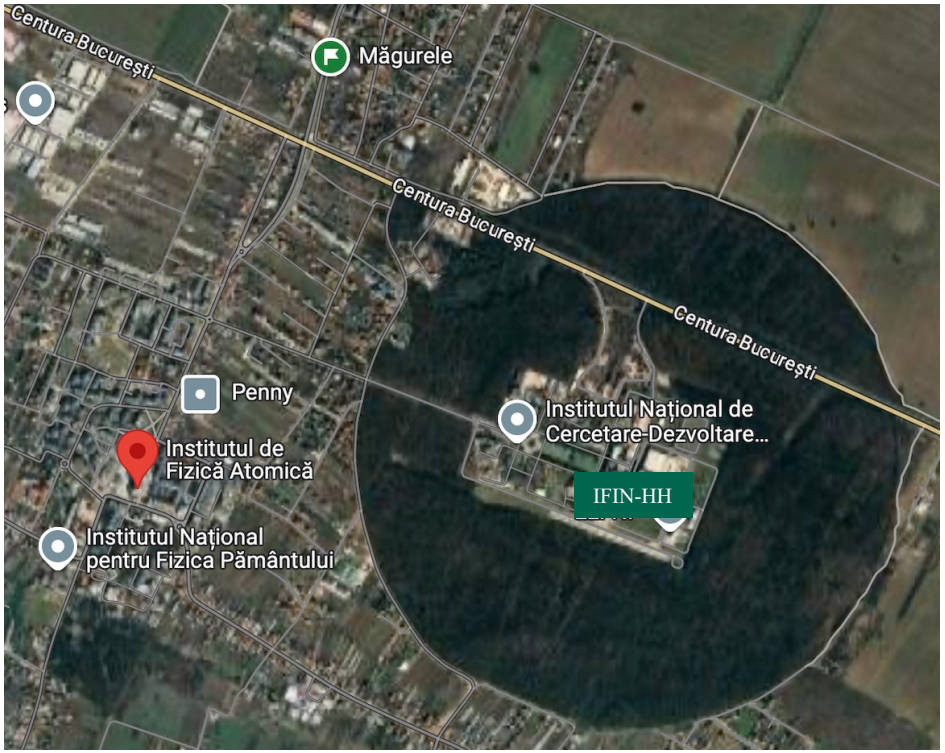
- How to become visible and competitive in Large Scale International Collaborations

- Developed and produced in Romania for CERN

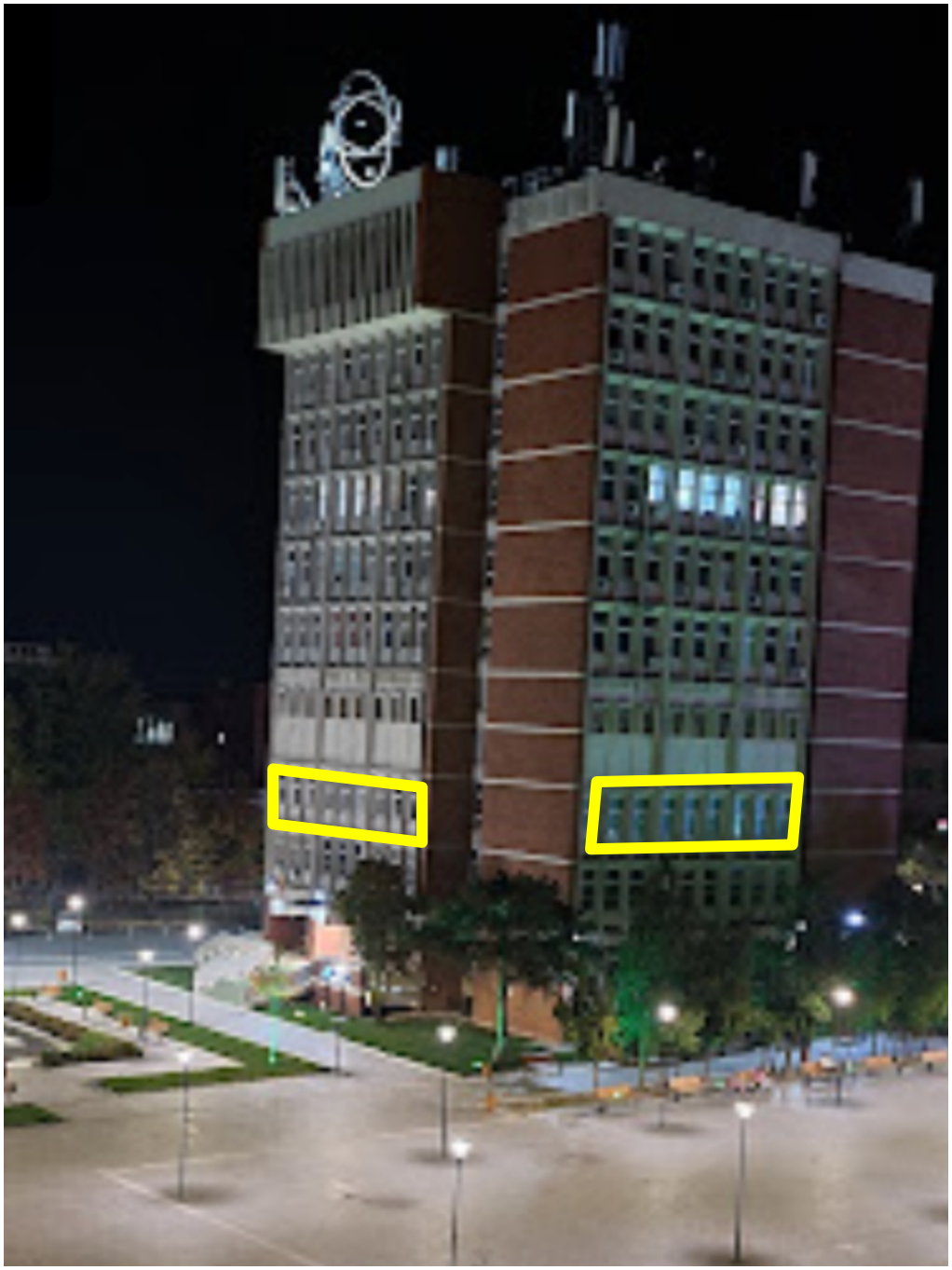
- Would you like to operate by yourself some of the detectors and learn the working principles on which are based large and complex configurations used in CERN experiments ?

Follow us!

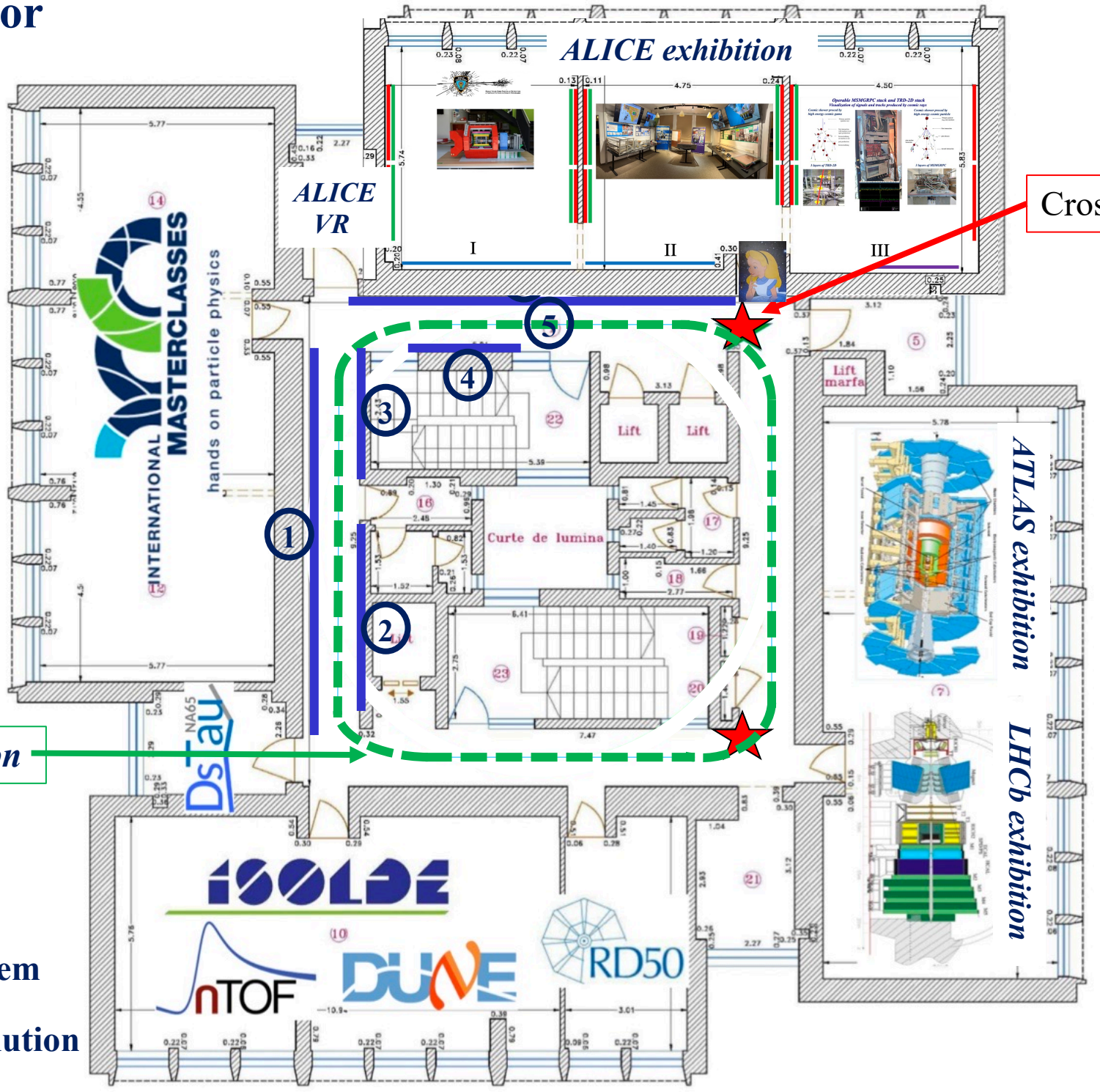
Romanian Science Gateway IFA building, 2nd floor



IFA, Atomistilor street, no. 407
Magurele 077125
ifa-mg.ro
021 457 4493



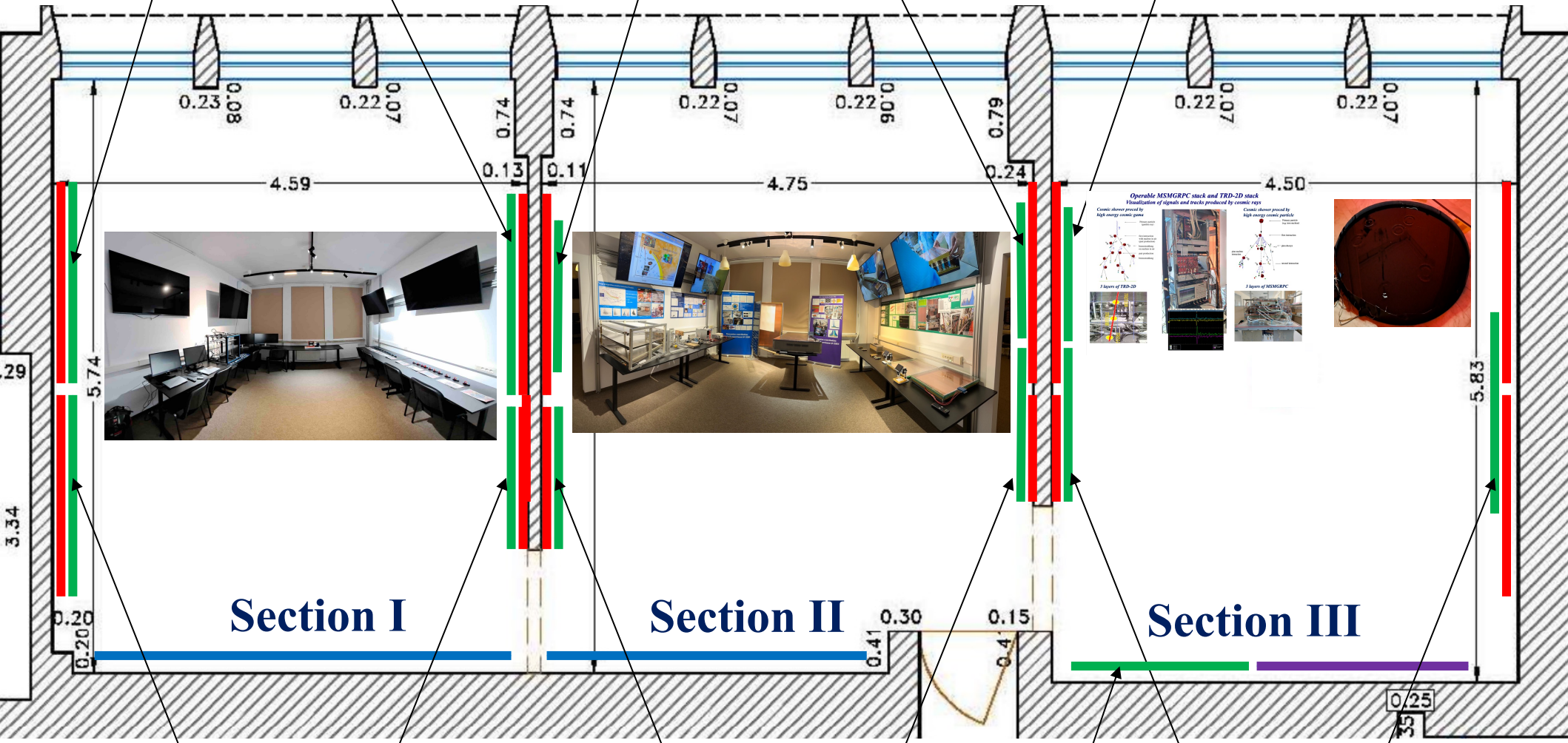
Second floor



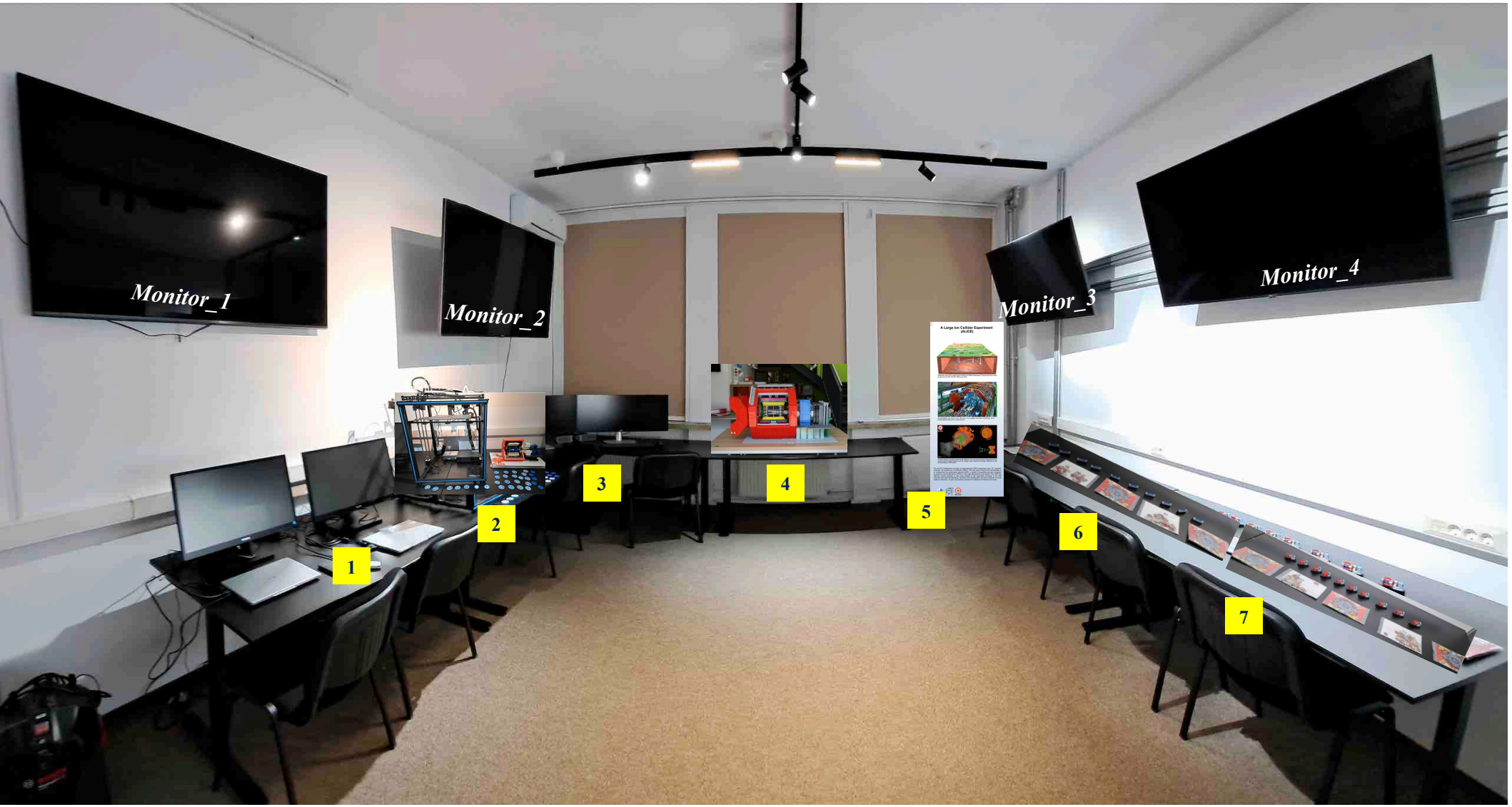
1. LHC tunnel
2. LHC dipole
3. LHC RF system
4. Universe evolution
5. ALICE Experiment, collision annimation

ALICE exhibition - entrance hall

ALICE exhibition



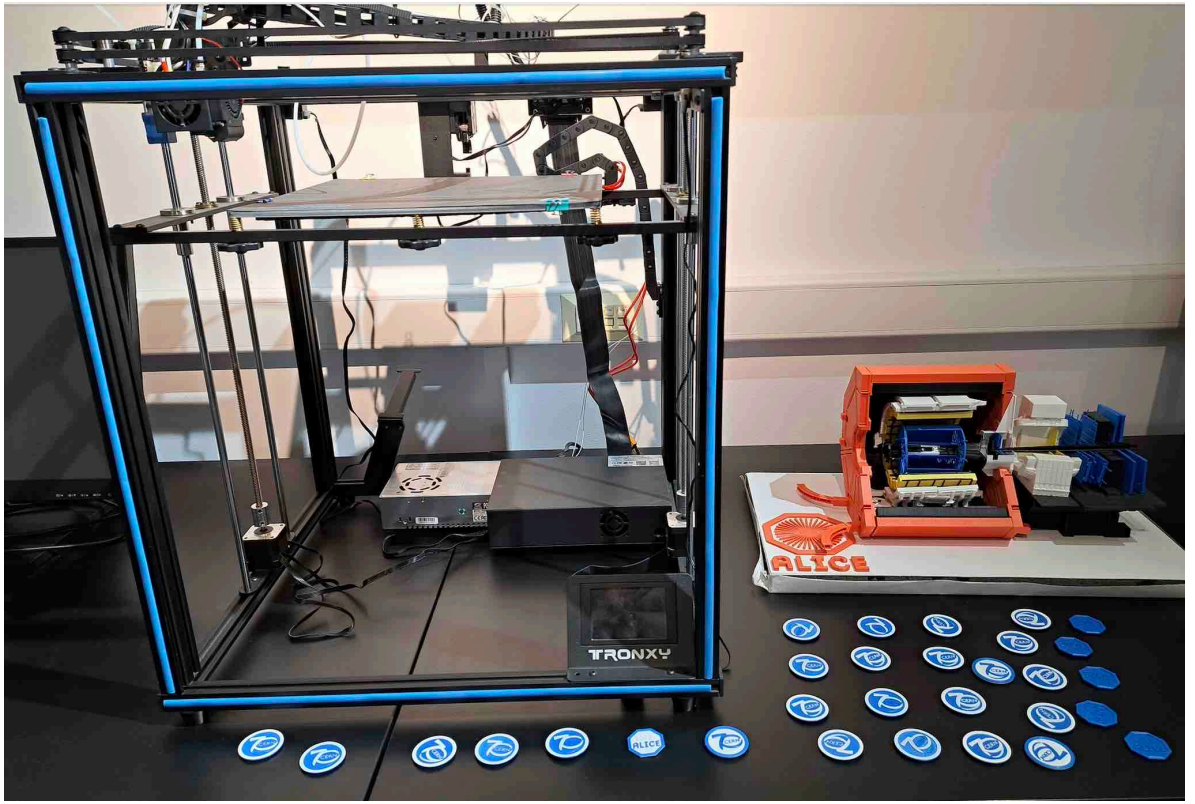
Section II



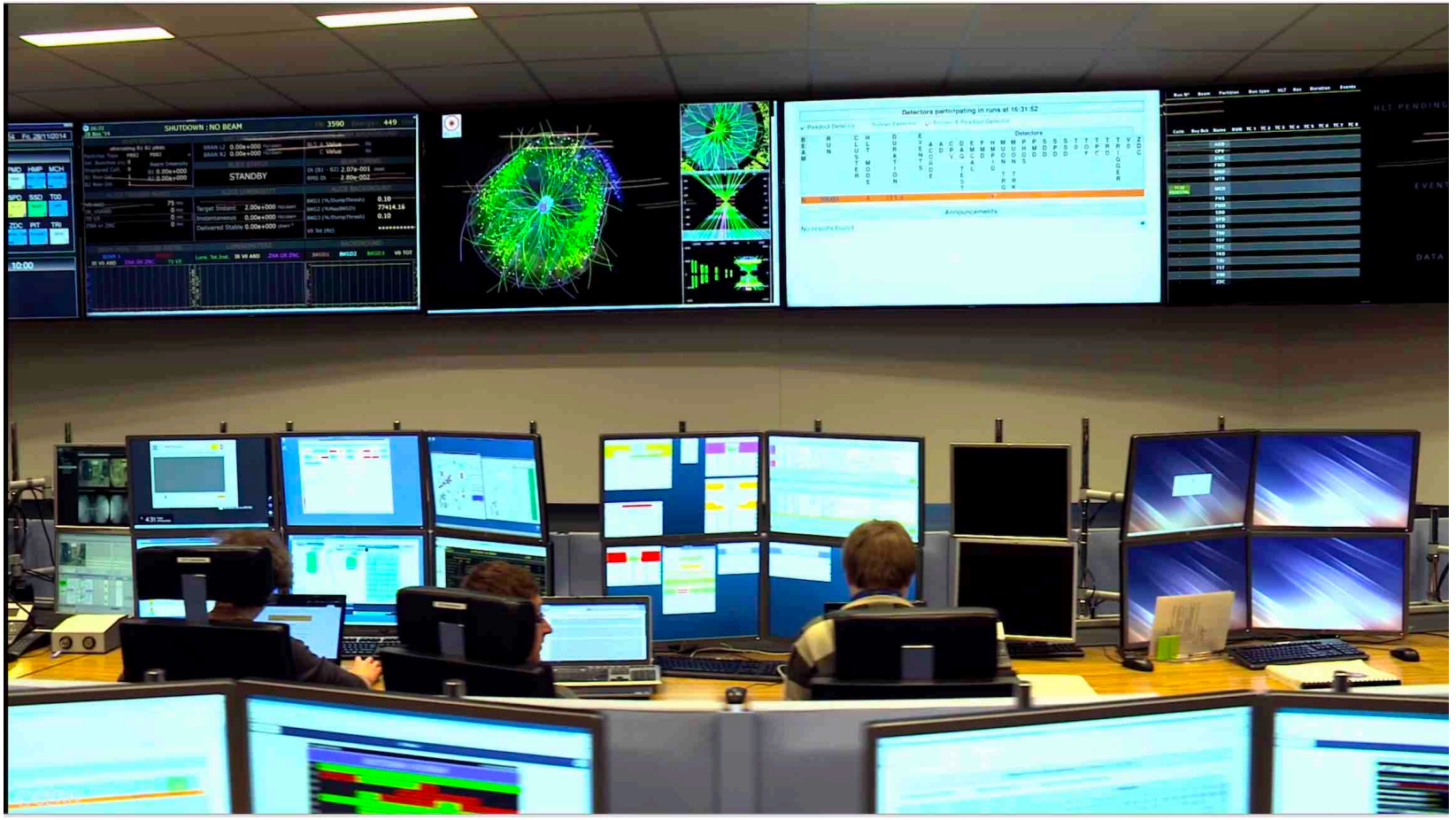
1 ***QUIZ - LHC - ALICE***

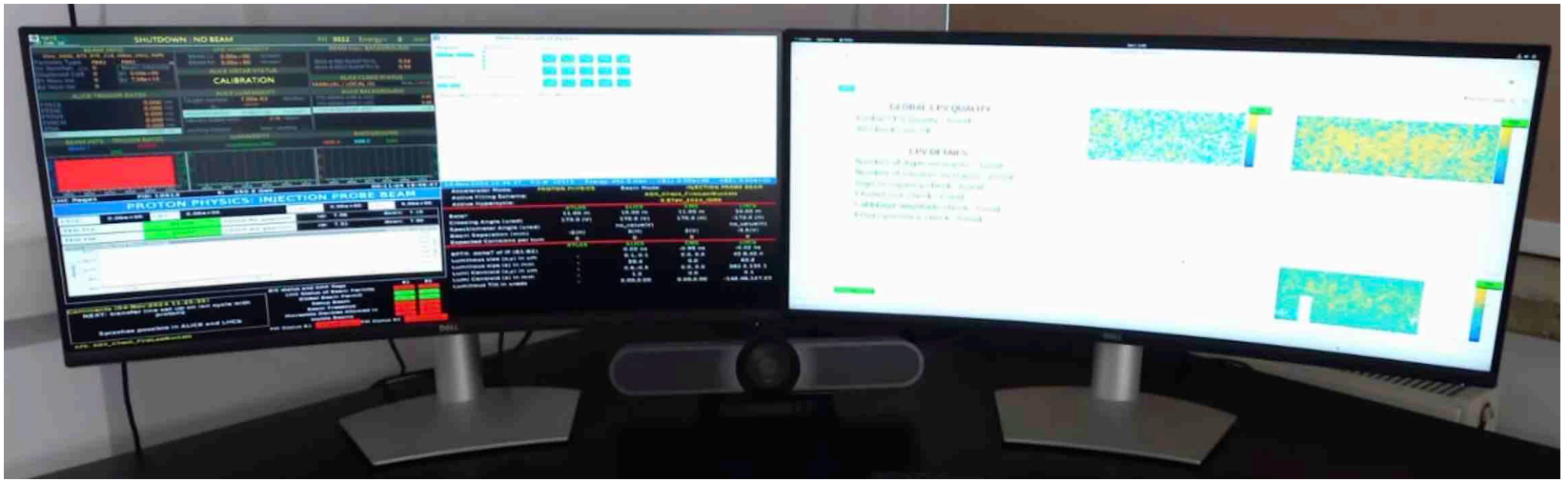
Monitor_1
Information for quiz

2 ***3-D printer, mini-ALICE experiment***
magnet appliques with CERN 70th anniversary



3 *Live connection to the ALICE Control Room + Monitor_2*

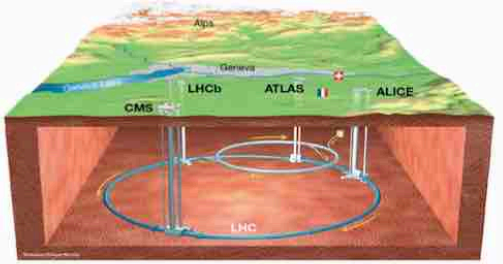




4 *Larger size ALICE-LEGO)*

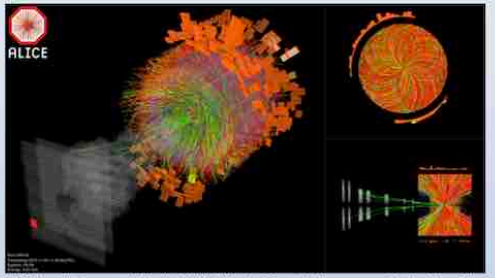
5 ***Roll-up***

A Large Ion Collider Experiment (ALICE)



Schematic view of the Large Hadron Collider at CERN (Switzerland / France) with the 4 main experiments: ALICE, ATLAS, CMS, and LHCb.

ALICE detector has 16 m x 16 m x 26 m (h x l x L), weights more than 10.000 tons, and is located approximately 60 m below ground.



A Pb-Pb collision recorded by the ALICE detector. The color lines represent trajectories of the reconstructed charged particles and the orange towers depicts the energy measured by the electromagnetic calorimeters.

The ALICE Collaboration consists of approximately 2000 researchers from 171 research institutes, 40 countries on 5 continents (2024). The main goal of the ALICE Collaboration is to characterise the quark-gluon plasma (QGP), a system of quasifree particles, predicted by quantum chromodynamics (QCD) at very high temperature and density. The QGP has relevant impact because it may have existed in the expanding Universe in the first microseconds after the Big Bang. Therefore, the Collaboration has built a detector to study hadrons, electrons, muons, and photons produced in collisions of hadrons and nuclei.

CERN

ALICE

6 *Puzzles and Lego for different LHC components*

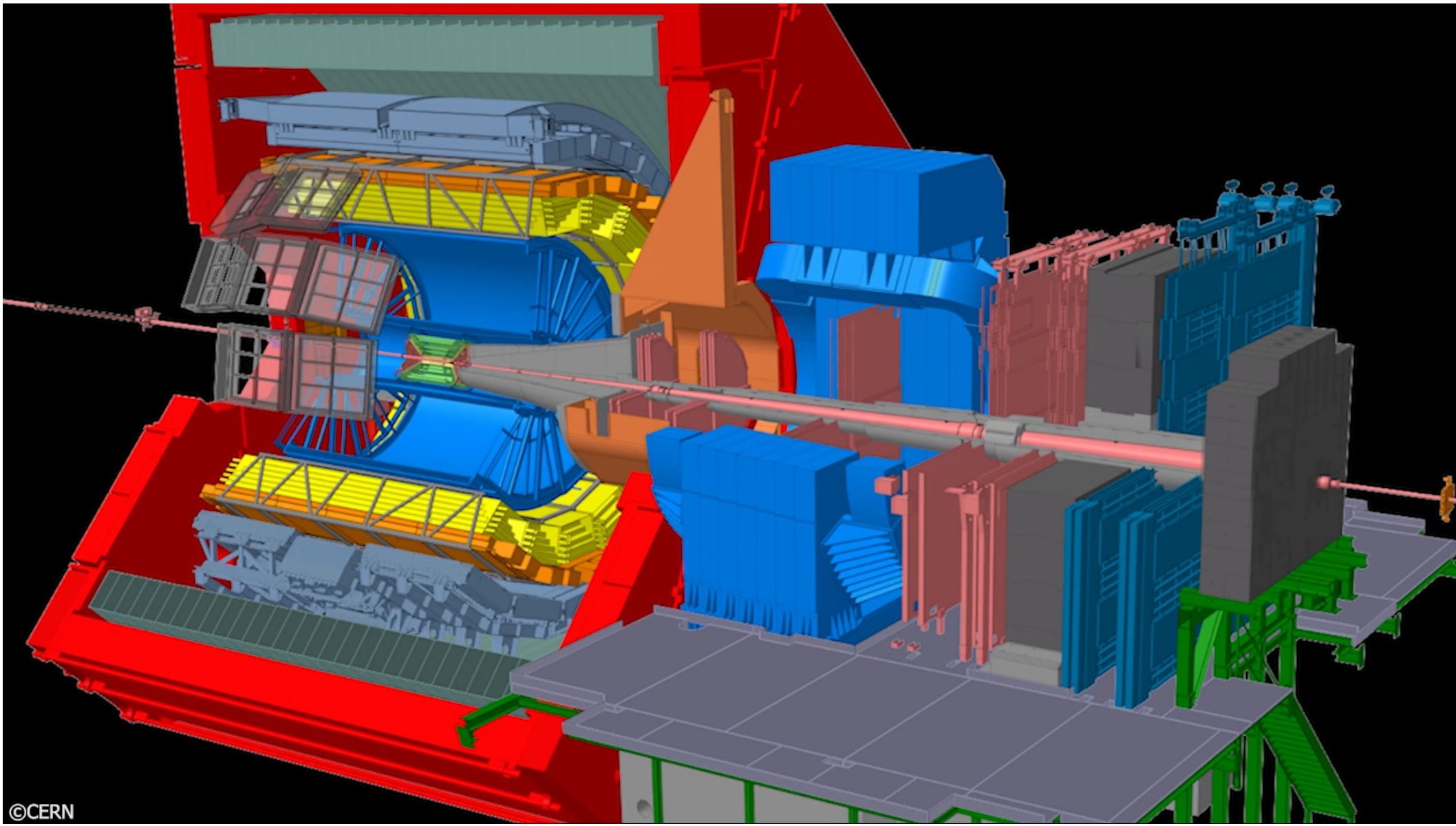
Instructions on Monitor_3

7 *Puzzles and Lego for different ALICE components*

Instructions on Monitor_4

Short throw projector Section I

Event produced by colliding hadrons in ALICE experiment



Short throw projector Section II

How the hadrons are accelerated by Radio Frequency (RF) cavities in the Large Hadron Collider (LHC)

Section II

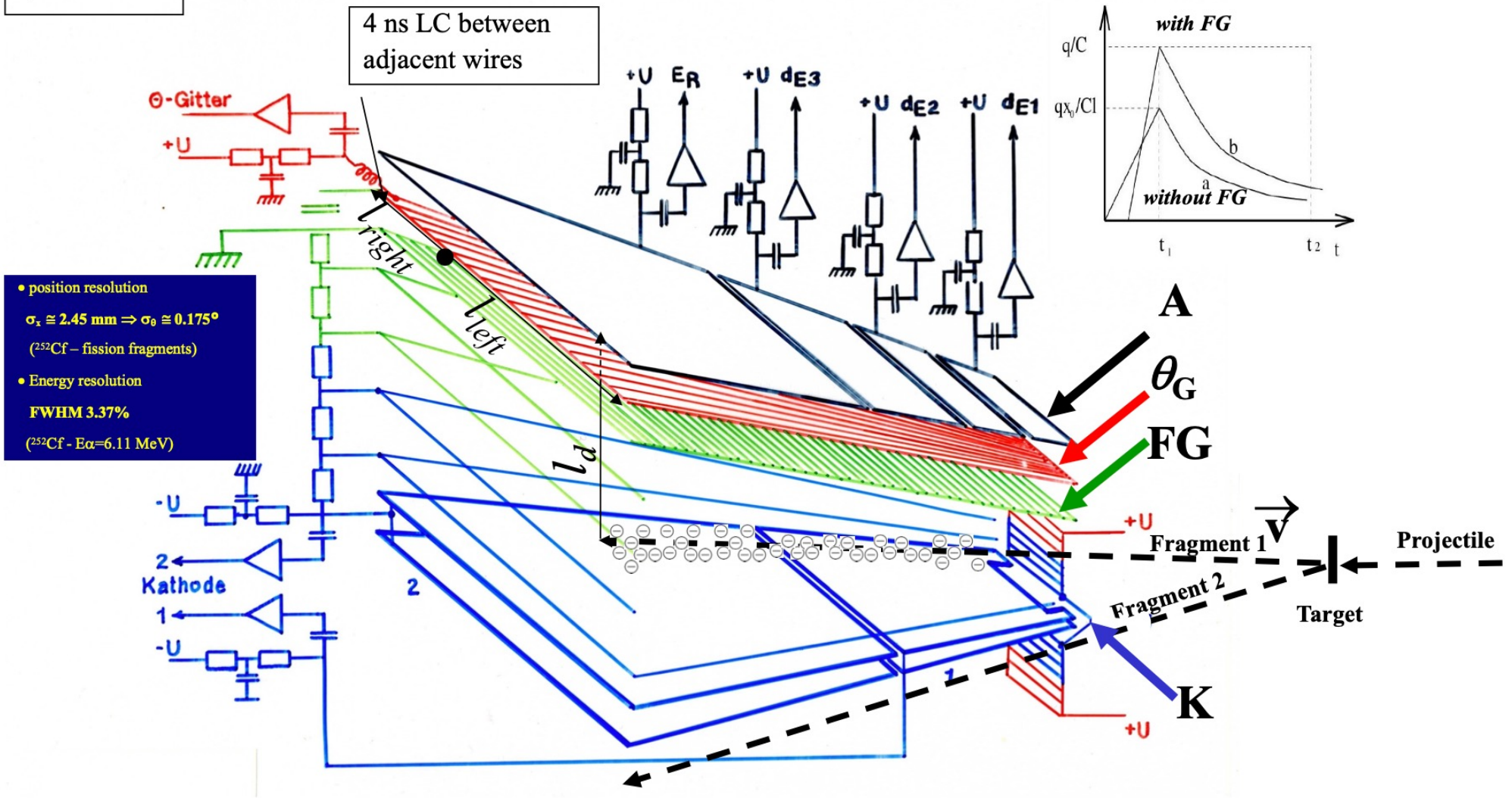

From precursors up to the state of the art detectors used in the ALICE Experiment at LHC for which development, construction and operation the Romanian groups had and have an essential contribution
Monitor_1
Monitor_2
Monitor_3
Monitor_4
New generation of gas detectors
1
2
3
4
5
6
7
8
9

Section II
Monitor_1

On Monitor_1 is displayed the information from the following pages

1 Large area position sensitive Ionization Chamber (IC) working principle

$\vec{v} \sim \perp \vec{E}$



$l_{left}-l_{right} \sim (t_{left}-t_{right}) \Rightarrow \theta_{lab}$; $l_d \sim (t_{drift}-t_{start}) \Rightarrow \varphi_{lab}$

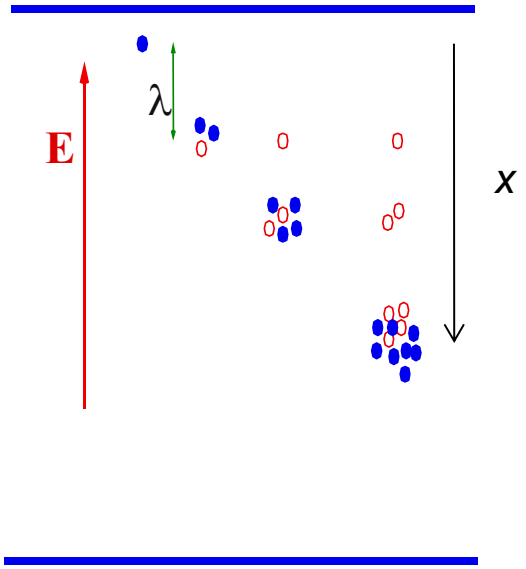
$-dE/dx = (aZ^2c^2/v^2)\ln[bv^2/(c^2-v^2)]$

since the logarithmic term varies slowly with energy (velocity) and

$\Rightarrow \underline{dE/dx \sim MZ^2/E}$ $\quad v^2 = 2E/M$

1 Parallel Plate Avalanche Counter (PPAC) working principle

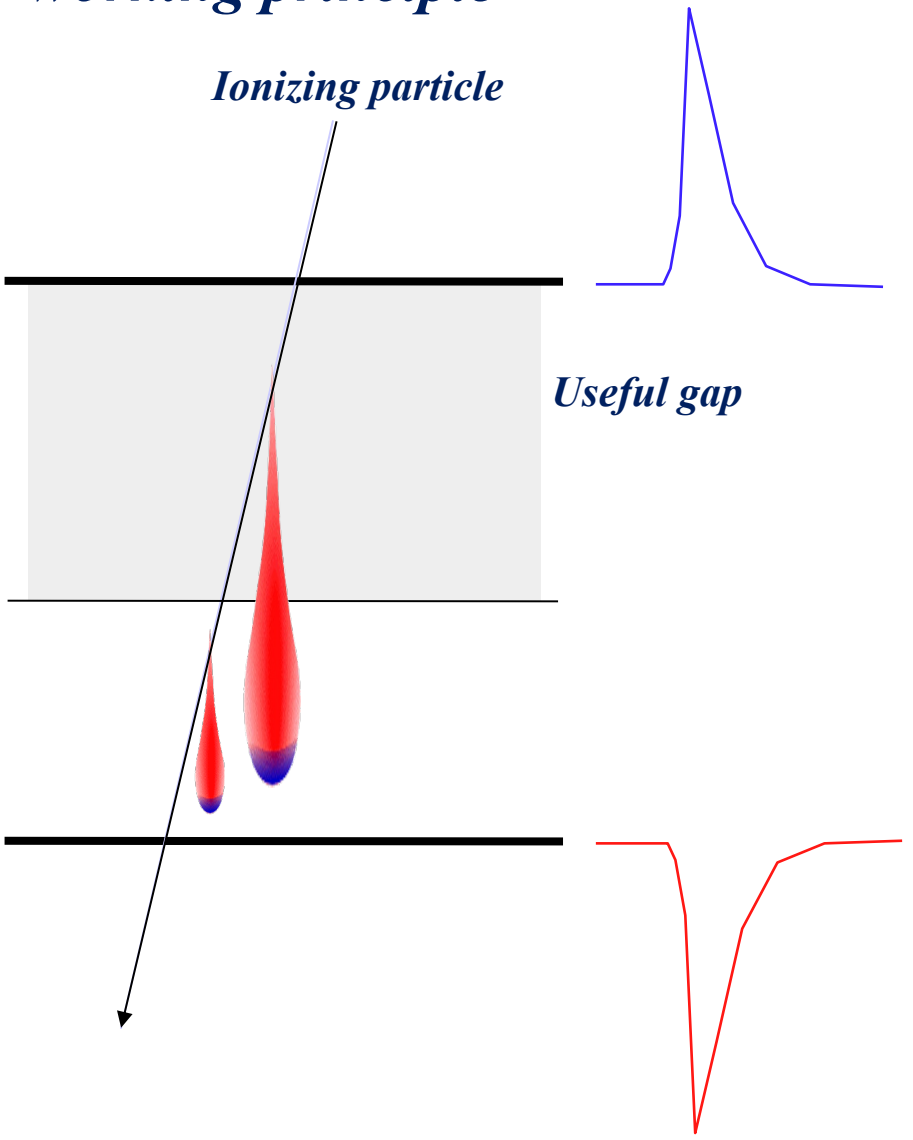
Multiplication factor (Gain)



$$dn = n\,\alpha\,dx$$

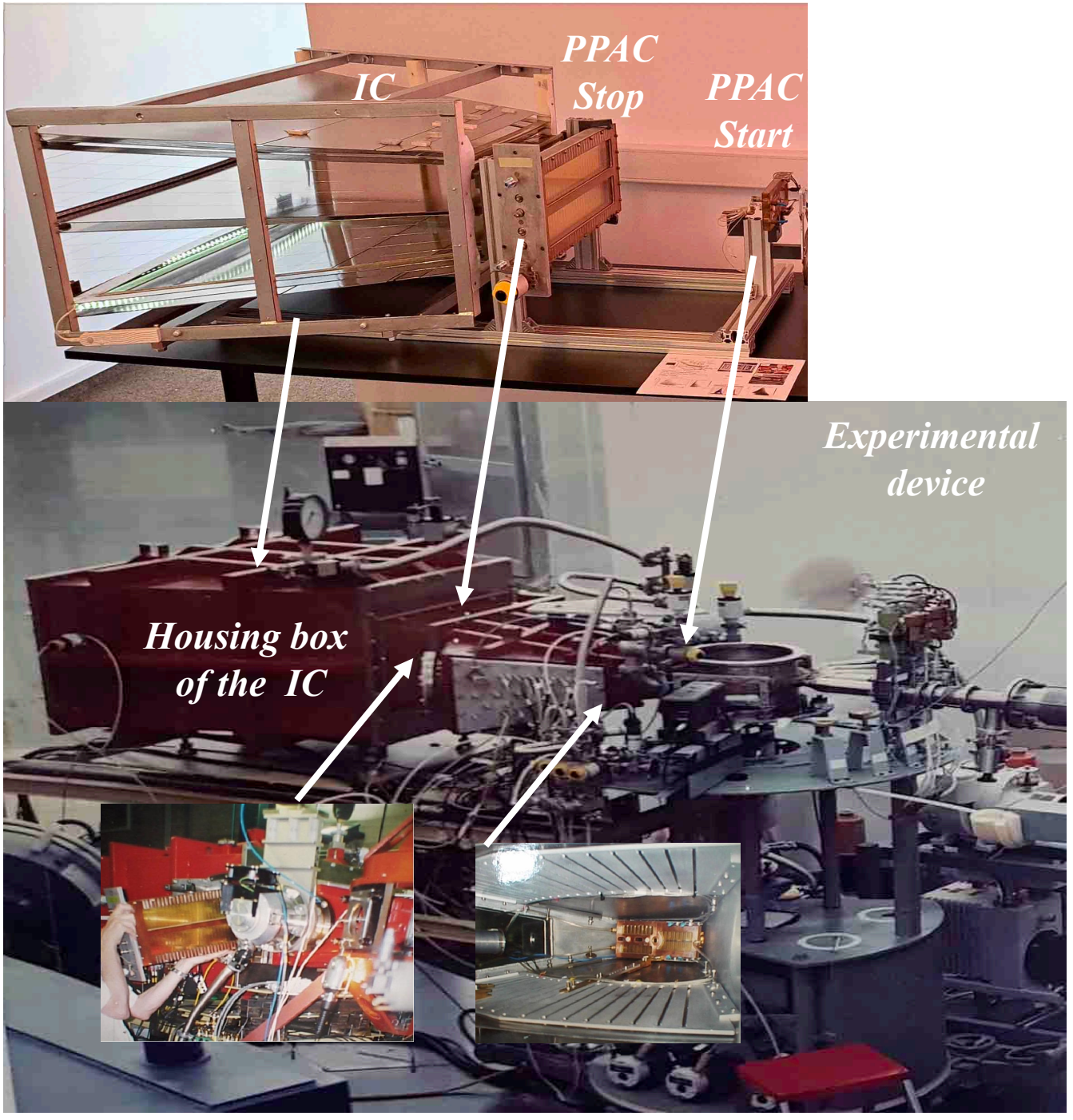
$$n(x) = n_0 e^{\alpha x}$$

$$M(x) = \frac{n}{n_0} = e^{\alpha x}$$



1 Large area position sensitive Ionization Chamber

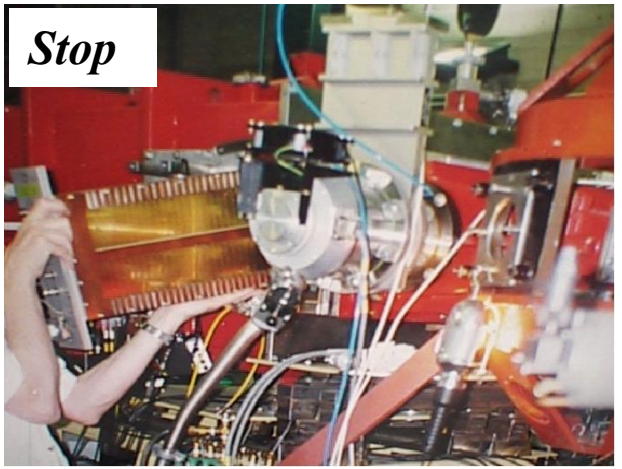
Real structure of an experiment presented in the exhibition

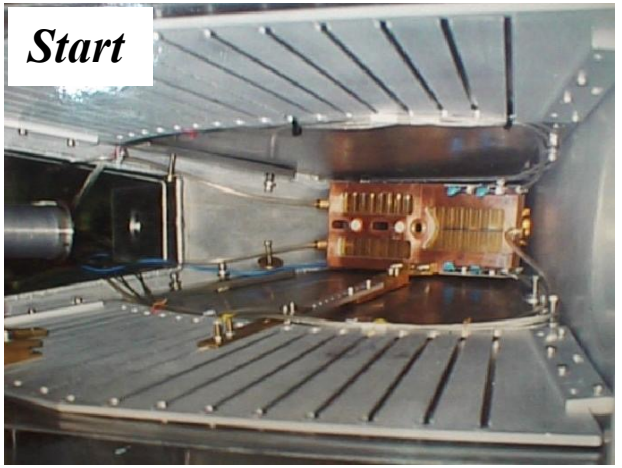


Associated electronics

1 Large area position sensitive Ionization Chamber

Mounting the IC and PPACs in the experiment





Examples of identification in atomic number Z of the reaction products

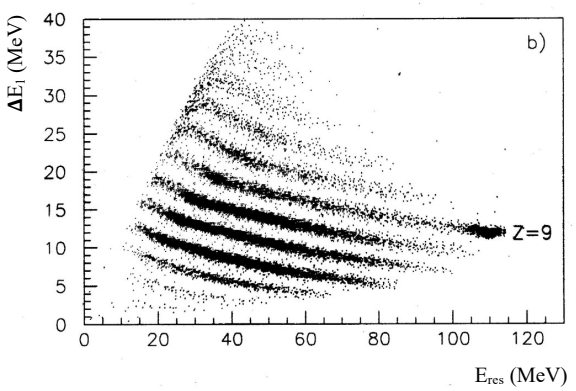
$-dE/dx = (aZ^2c^2/v^2)\ln[bv^2/(c^2-v^2)]$

since the logarithmic term varies slowly with energy (velocity) and $v^2 = 2E/M$

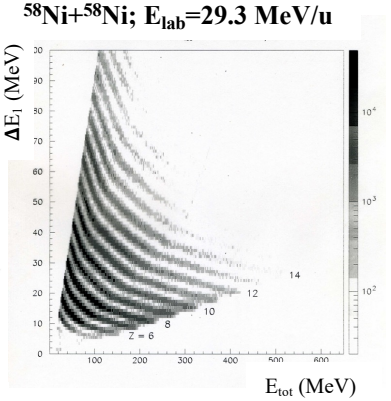
$\Rightarrow dE/dx \sim MZ^2/E$

$v = distance_{(PPADStop - PPADStart)}/(T_{stop}-T_{start})$

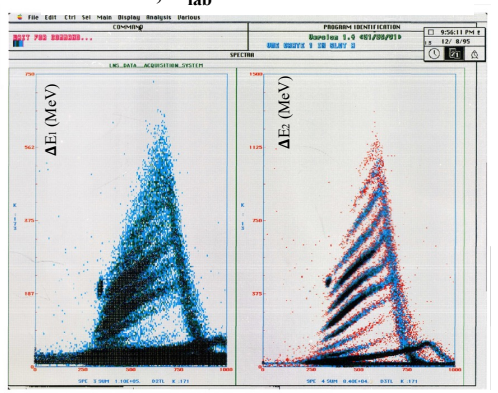
$^{19}F+^{27}Al$; E_{lab}=120 MeV



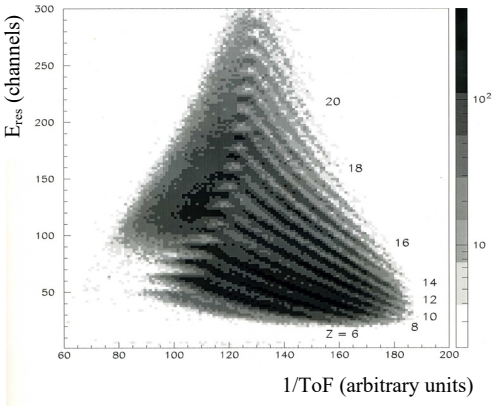
$^{58}Ni+^{58}Ni$; E_{lab}=29.3 MeV/u



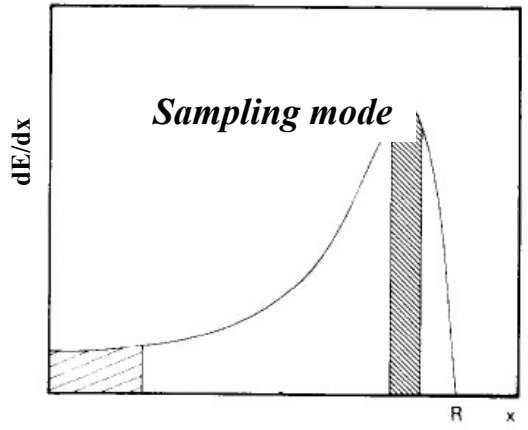
$^{19}F+^{27}Al$; E_{lab}=111.4 MeV



$^{58}Ni+^{58}Ni$; E_{lab}=29.3 MeV/A



2 *Bragg geometry Ionization Chambers (BGIC)*
Plastic/Liquid scintillators



R ⇒ *Heavy ion range (A,Z,β)*

⇒ *Bragg peak amplitude (Z)*

⇒ *Specific ionization (Z,β)*

E ⇒ *Integral over the curve*

A - fragment mass
Z - fragment charge
β - v/c

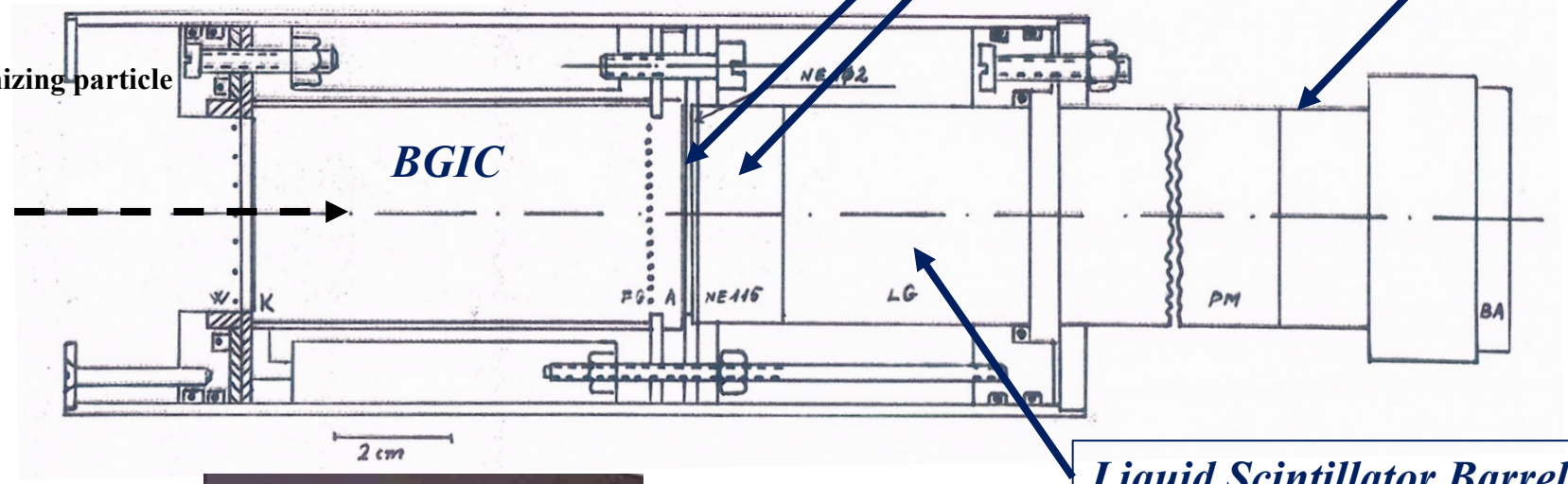
Photomultiplier Tube (PMT)

Fast Plastic Scintillator

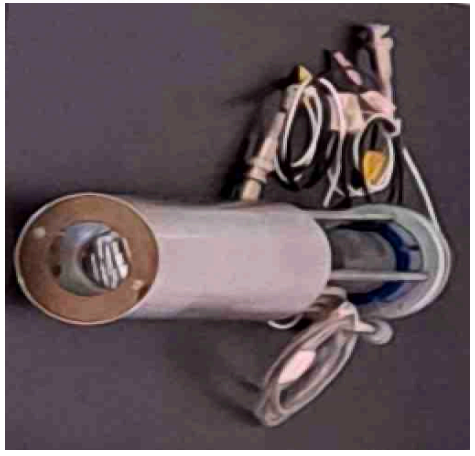
Slow Plastic Scintillator

ionizing particle

BGIC



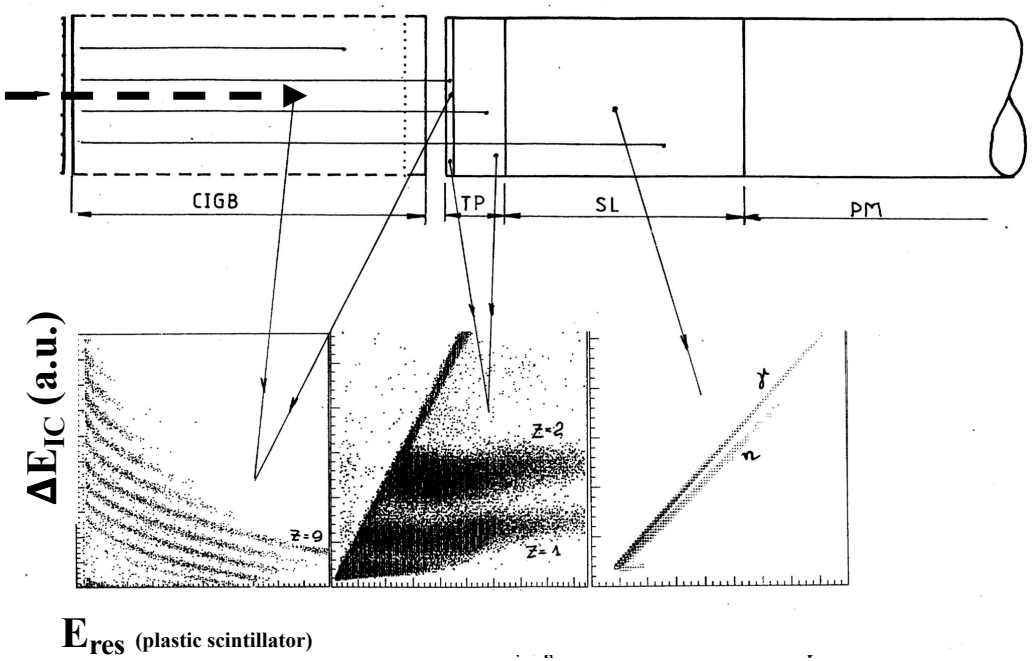
Liquid Scintillator Barrel



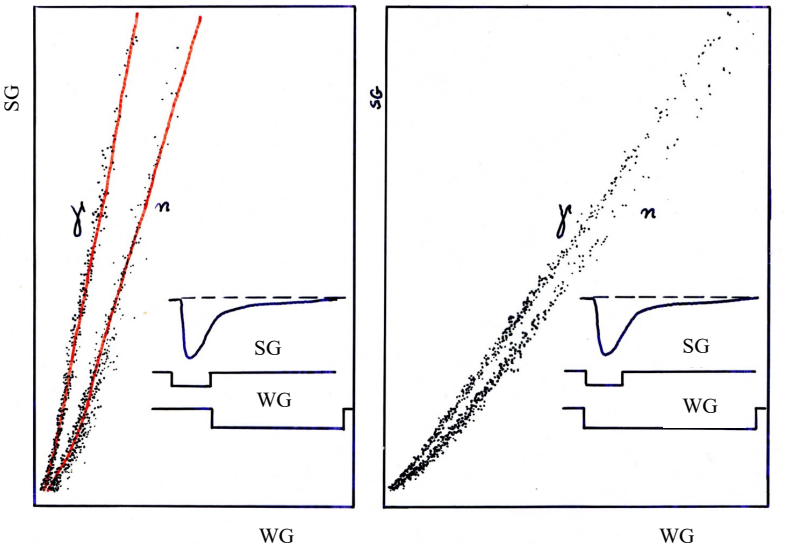
Real Detector - exposed

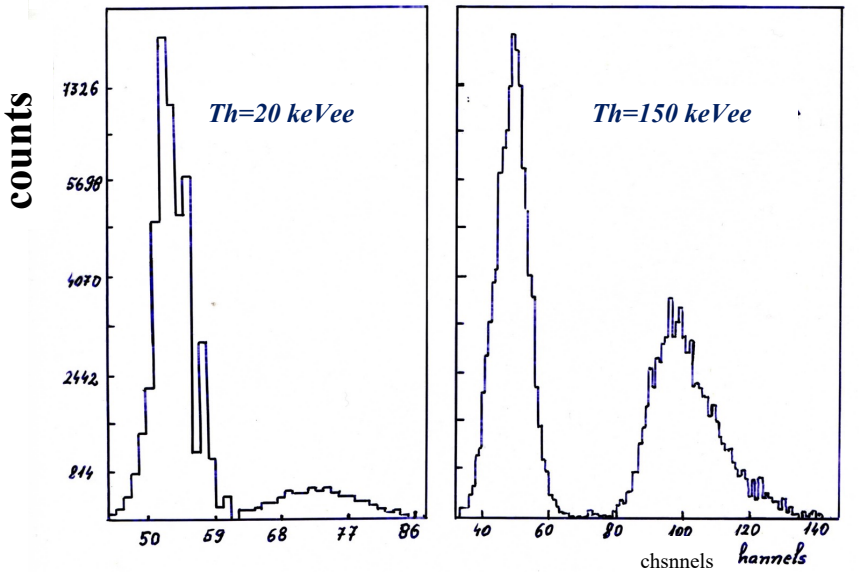
2 Bragg geometry Ionization Chambers Plastic/Liquid scintillators

Operation mode and Particle Identification (PID) performance



^{252}Cf





Associated electronics

NE213- liquid scintillator

τ_f=3.7 nsec

τ_s=90 nsec

$A(t) = A_f e^{-t/\tau f} + A_s e^{-t/\tau s}$

τ_f, $\tau_s \neq (dE/dx, Z)$

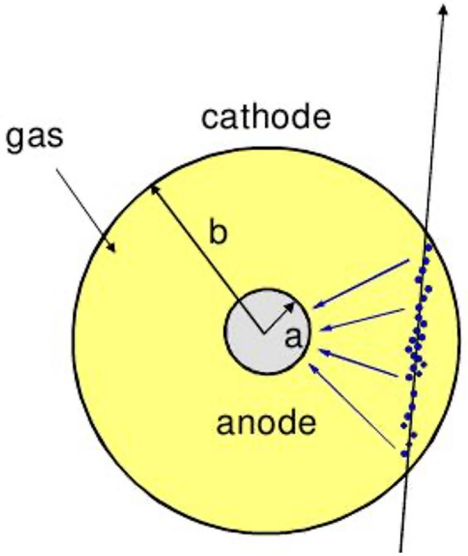
$A_f/A_s = f(dE/dx, Z)$

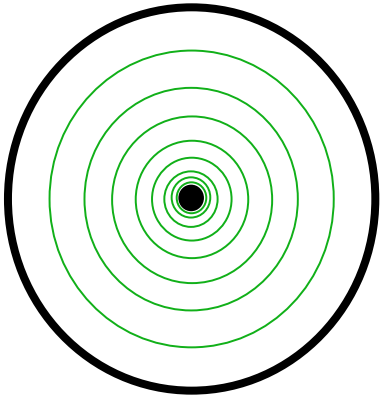
3 Single Wire Proportional Counter - PC working principle

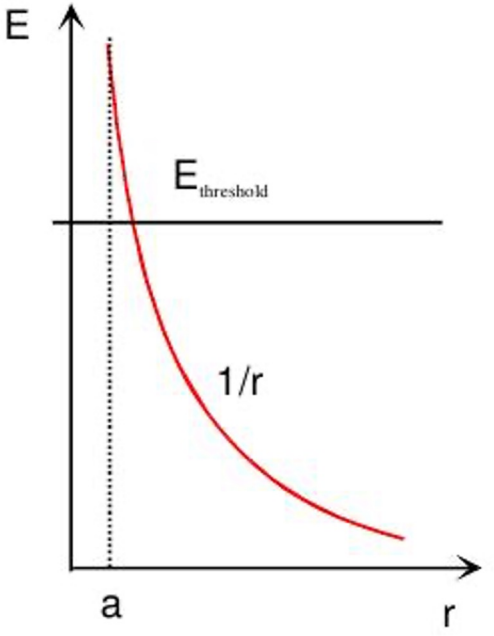
Electric field:

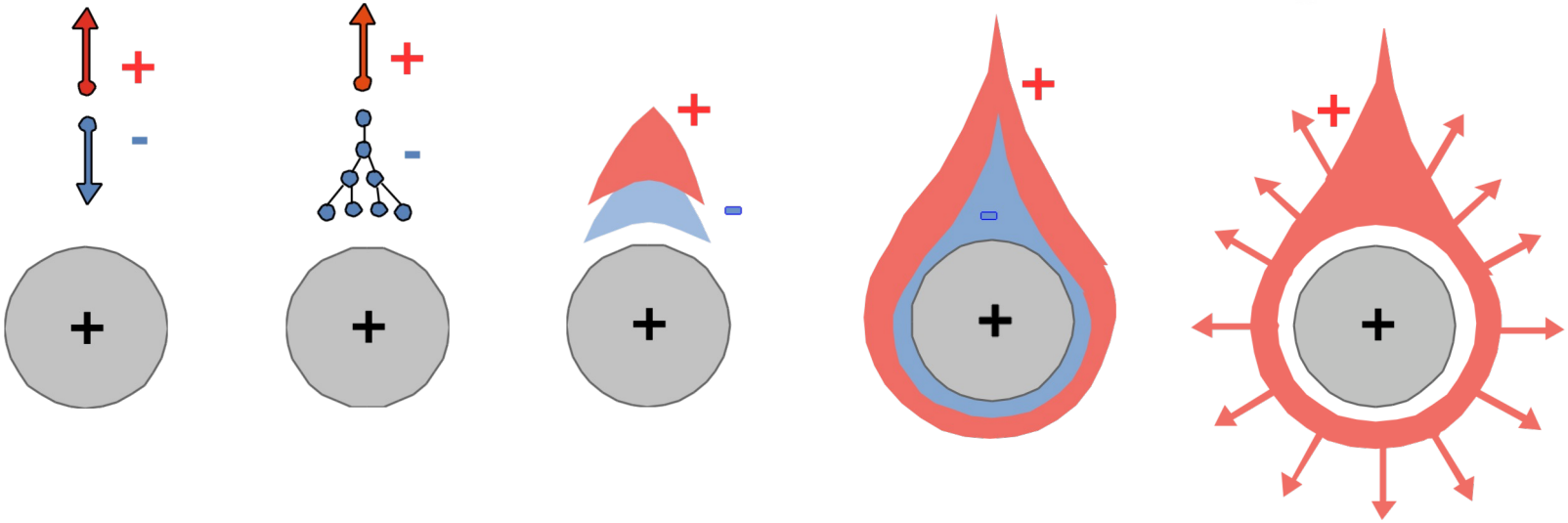
$$E(r) = \frac{CV_0}{2\pi\varepsilon_0}\frac{1}{r}$$

$$C = \frac{2\pi\varepsilon_0}{\ln(b/a)}$$



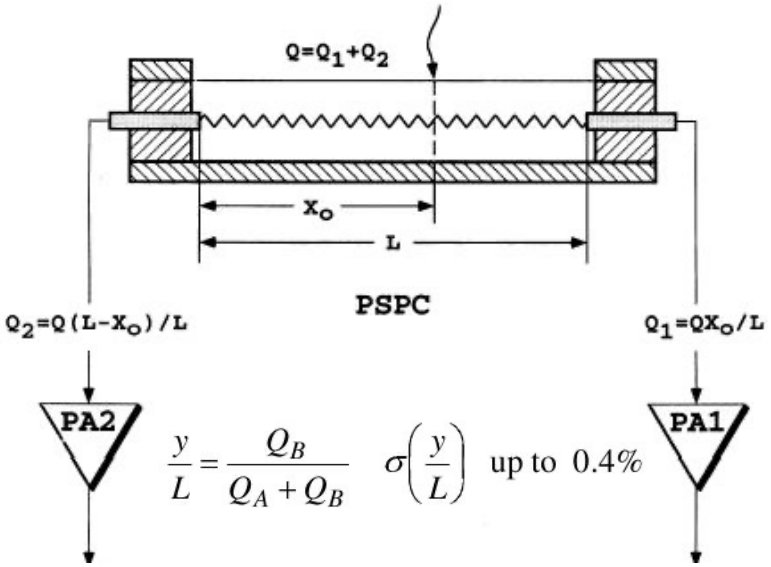


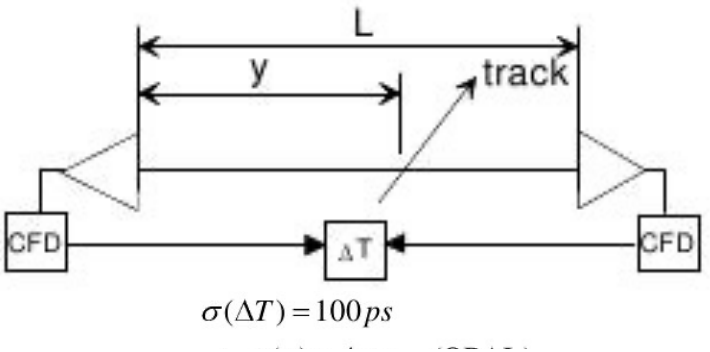




3 Resistive wire proportional chamber

Working principle



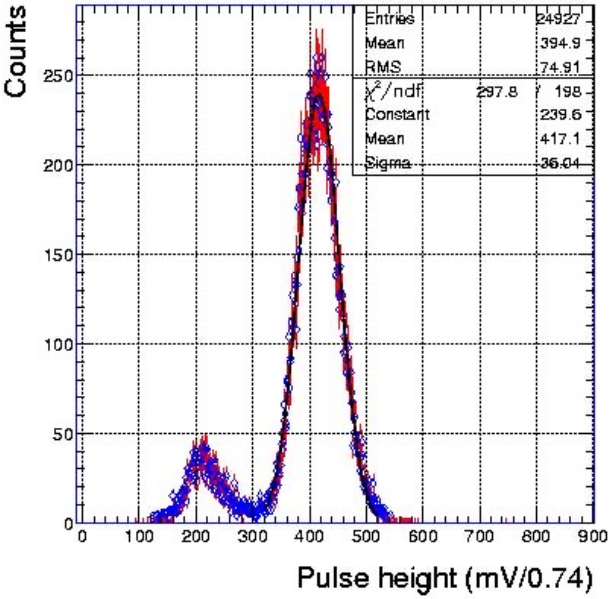


Ni-Cr 12 μm wire - ~10 kΩ/m

- *position resolution FWHM ~ 300 μm (^{241}Am - E_α=5.479 MeV)*

Energy resolution

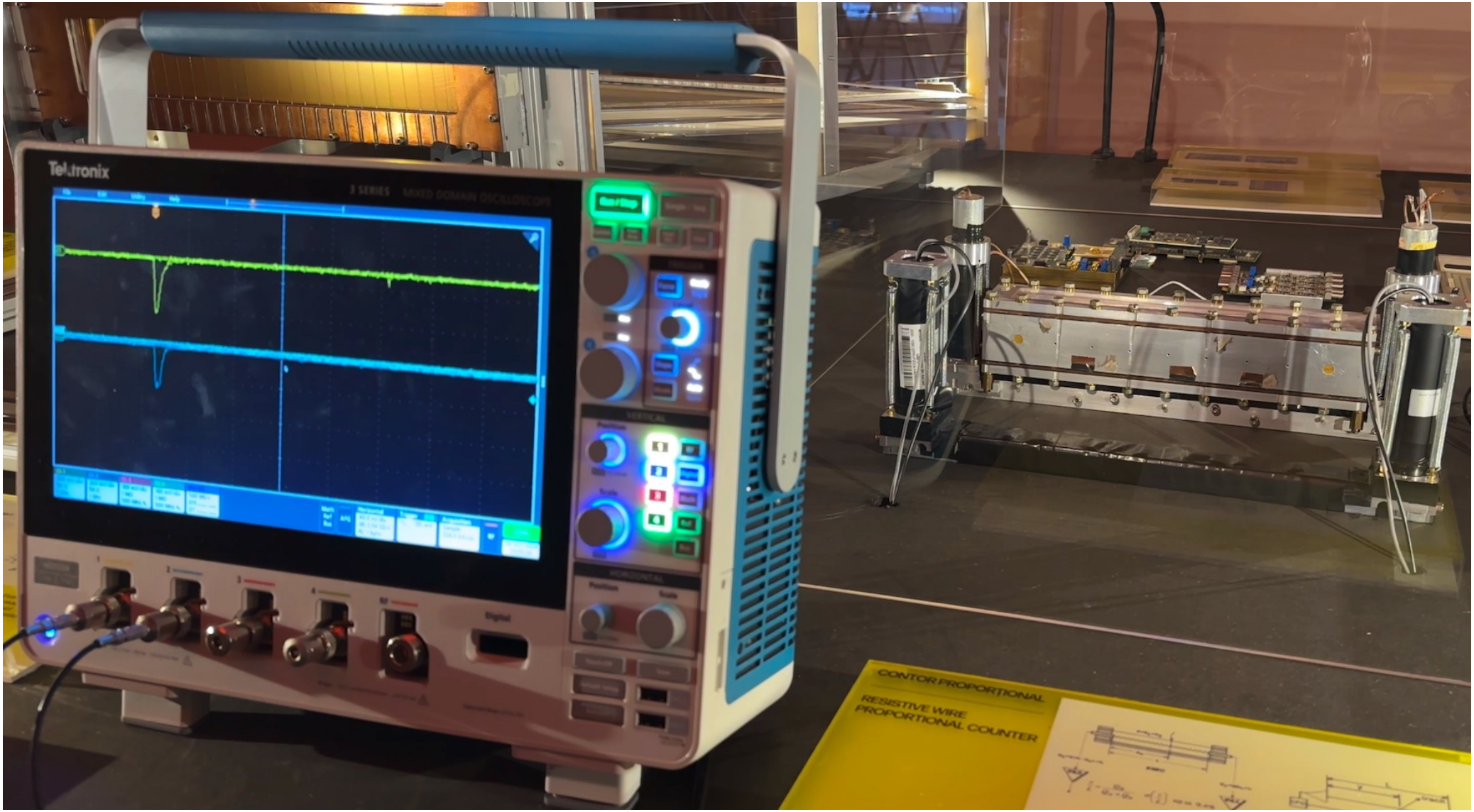
X-ray, ^{55}Fe E=5.9 KeV



Energy resolution FWHM 15.7% (^{55}Fe X ray – 5.9 keV)

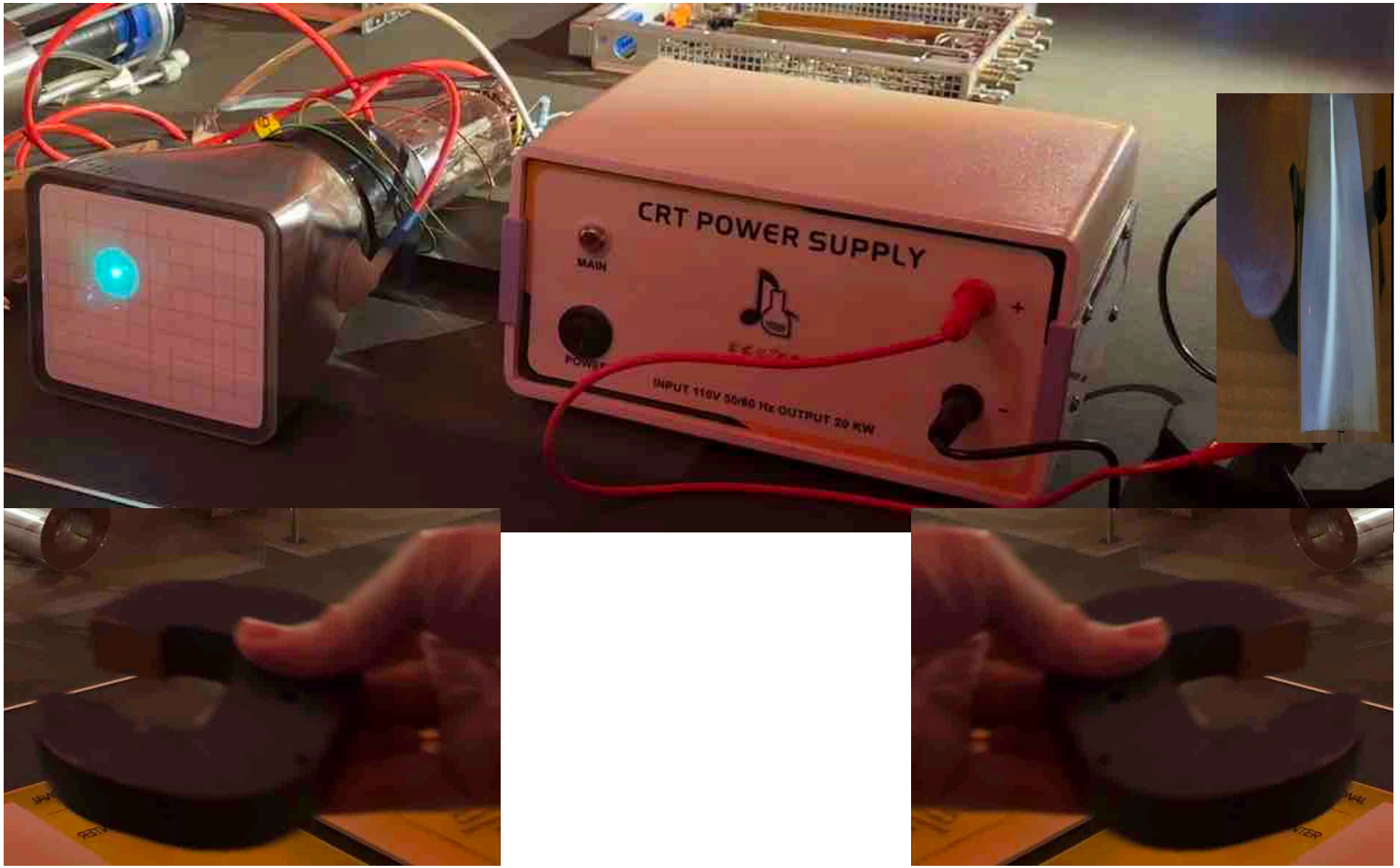
3 *Resistive wire proportional chamber + Plastic scintillator*

Operable setup - signals produced by cosmic rays



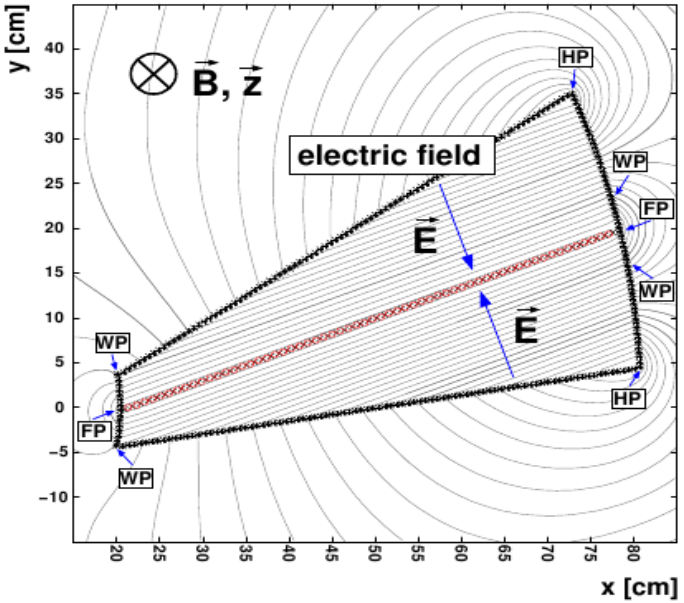
3

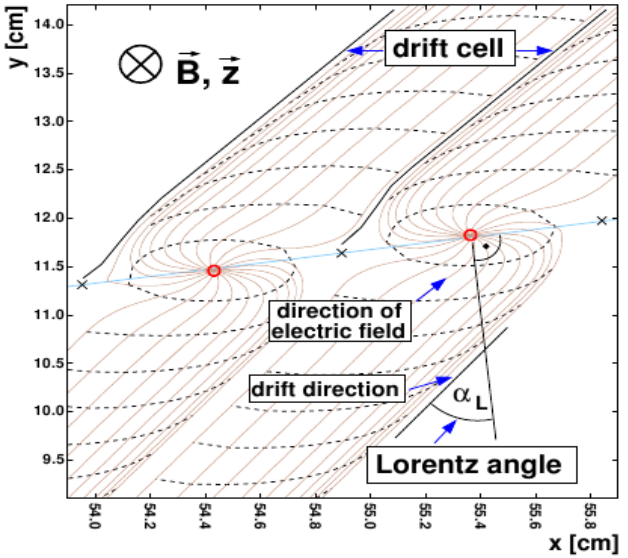
Working cathodic tubes, visualization of electron beams and their deviation in a magnetic field
Demonstration of working principle of tracking detectors



3 *From single-wire proportional chamber to multi wires*

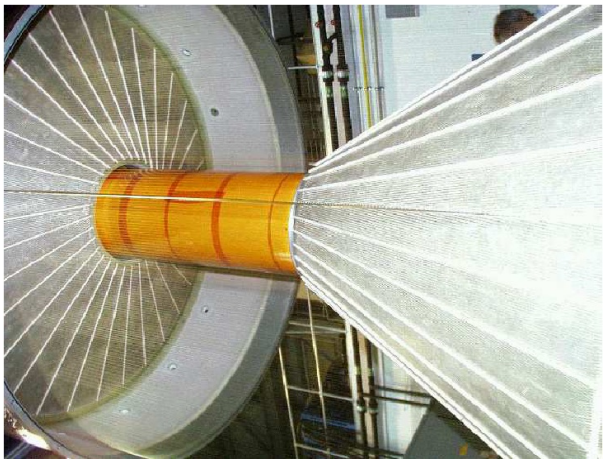
Central Drift Chamber (CDC)



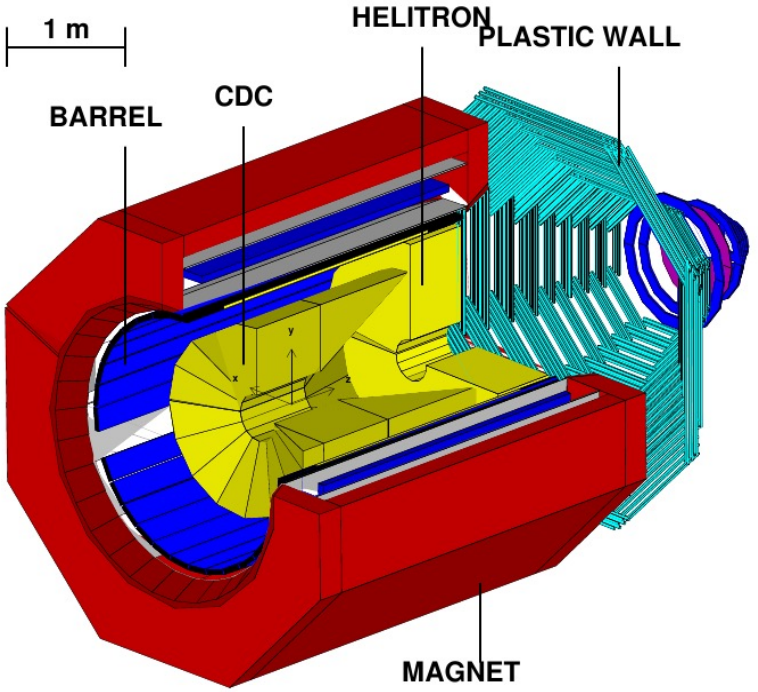


- field cage wire
- potential wire
- sense wire
- equipotential line
- sense (anode) plane
- drift trajectory
- line of equal drift time

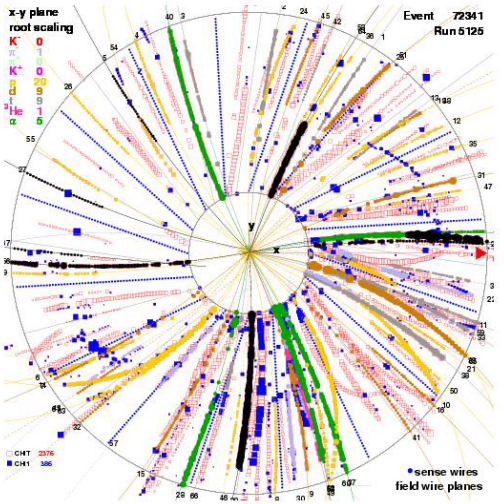
CDC - inner structure



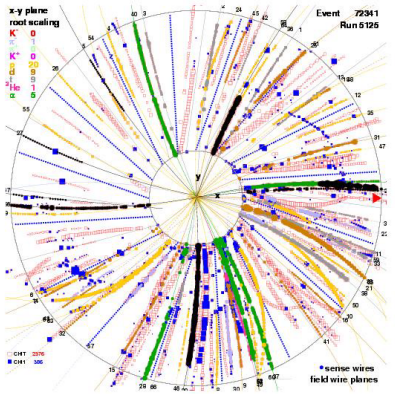
FOPI experimental device



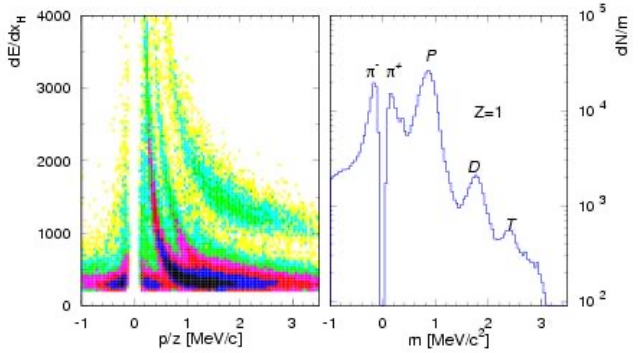
Tracks produced by ionizing particles in CDC

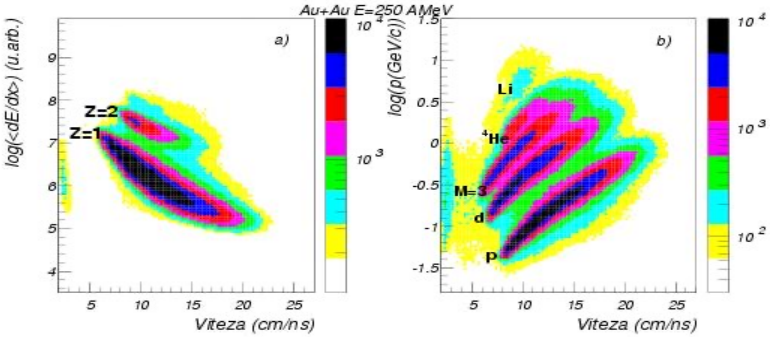


3 Identification of the reaction products using CDC in a solenoidal magnet



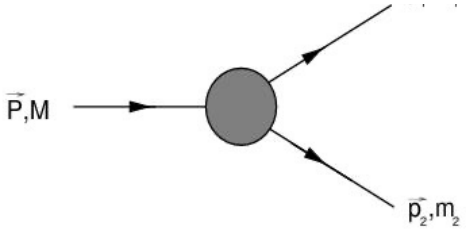
$B\rho \sim Mv/q$



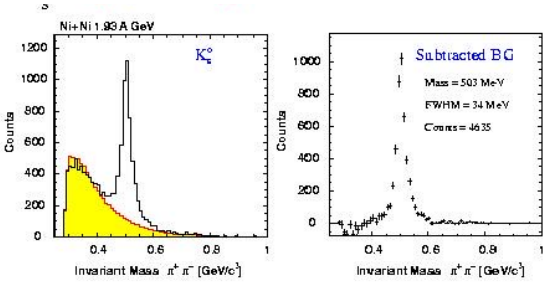


From single single plastic scintillator to a Plastic Wall (PW)

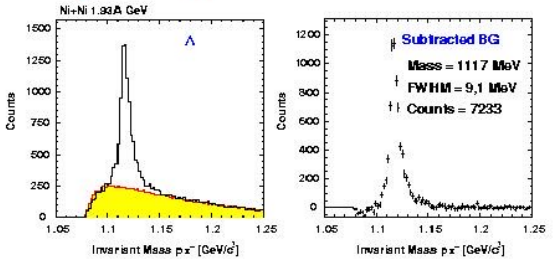
Reconstruction of decaying neutral particles



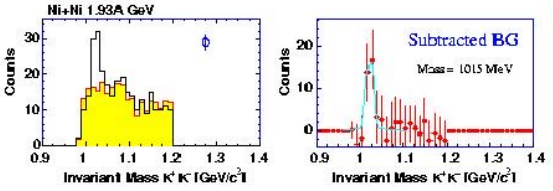
$$E = E_1 + E_2$$
$$\vec{P} = \vec{P}_1 + \vec{P}_2$$
$$E^2 = \vec{P}^2 + M^2$$
$$M_{inv} = \sqrt{(E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2}$$
$$f_{BW}(E, E_R) = \frac{P_{Fit}}{(E - E_R)^2 + (\Gamma/2)^2}$$

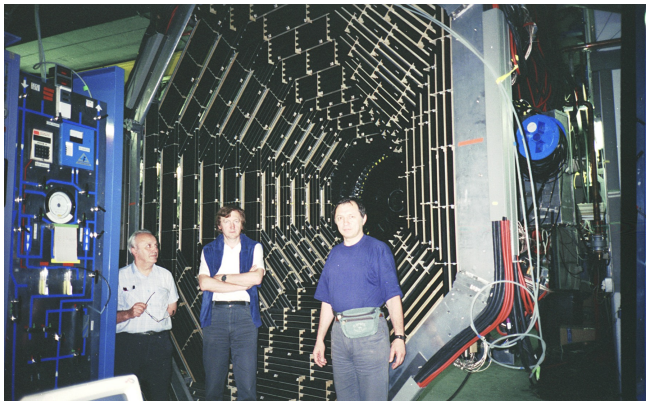


$\Lambda \rightarrow p\pi^-$ with 64 % BR

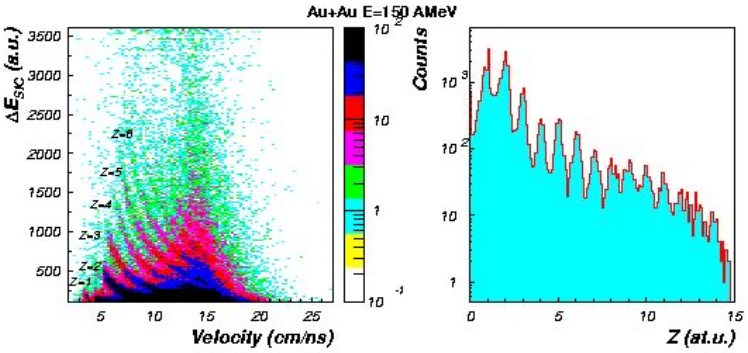


$\phi \rightarrow K^+K^-$ with 50 % BR





Reaction products identification using the energy loss an time from PW



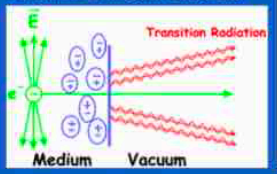
Section II
Monitor_2

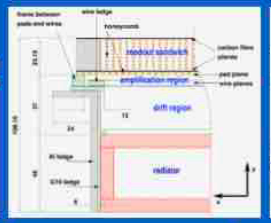
On Monitor_2 is displayed the information from the following pages and details on assembling and testing ALICE TRD chambers activities

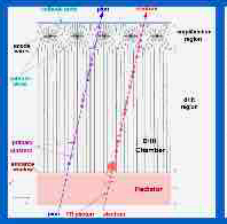
4 *ALICE - Transition Radiation Detector (TRD) - Roll-up*

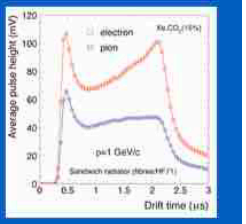
ALICE - Transition Radiation Detector (TRD)

TR is created when a charged particle crosses boundary of different dielectric constants

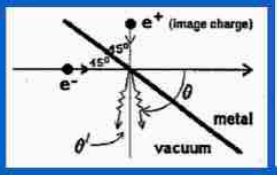


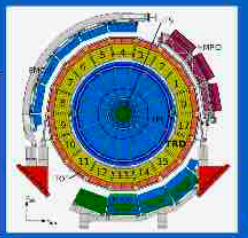






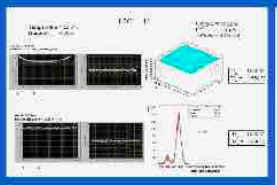
- fields have to be readjust
- some are emitted as TR similar with:

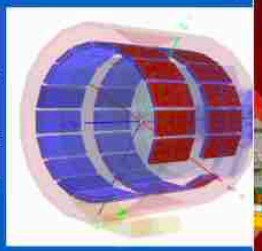


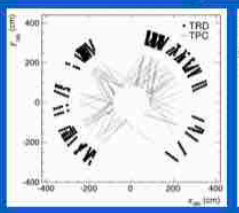


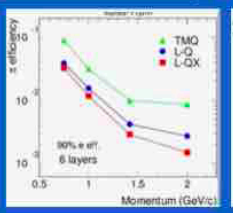
Purpose:
- electron ID in central barrel p>1GeV/c

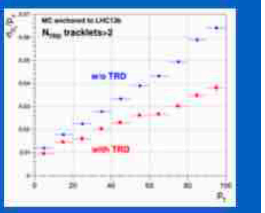
Parameters:
- 18 supermodules segmented in 6 layers, 5 stacks
- 540 modules ~ 750m²
- Lenghth: 7m
- X/X0 ~ 15%
- 28 m³ Xe/CO_2 (85:15)
- 1.2 million channels
- 15 TB/s on-detector badwidth







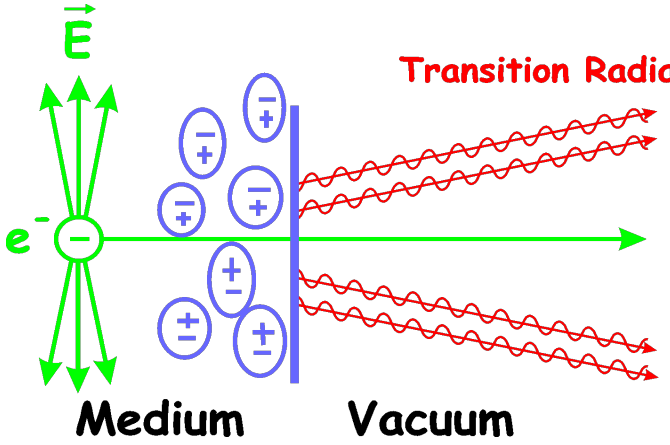




Romanian contribution to ALICE experiment @ CERN

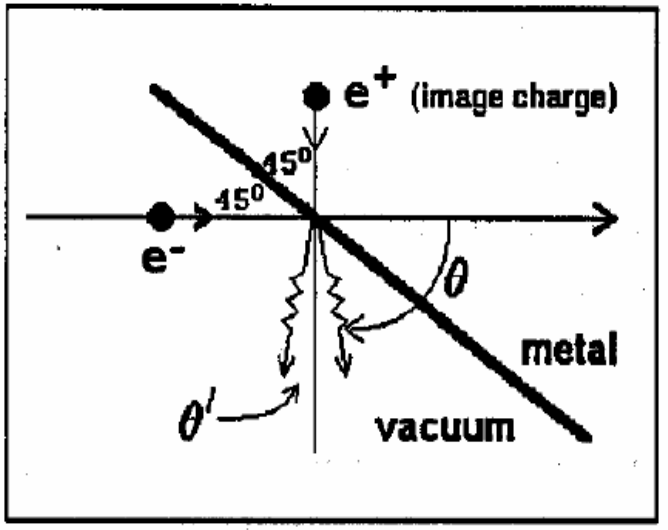
4 *TRD- working principle*

- TR is created when a charged particle crosses boundary of different dielectric constants

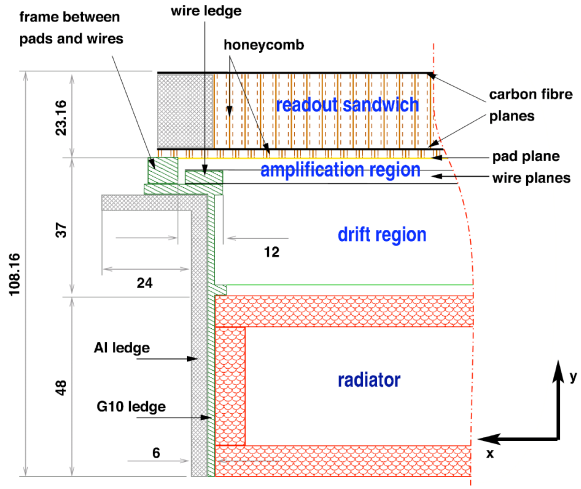


- fields have to be readjusted
  ⇒ some are emitted as TR

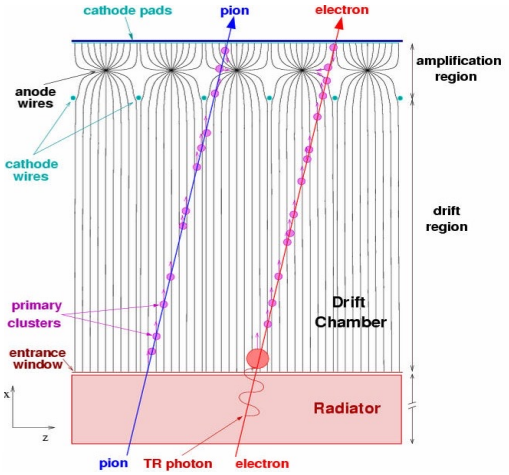
similar with:



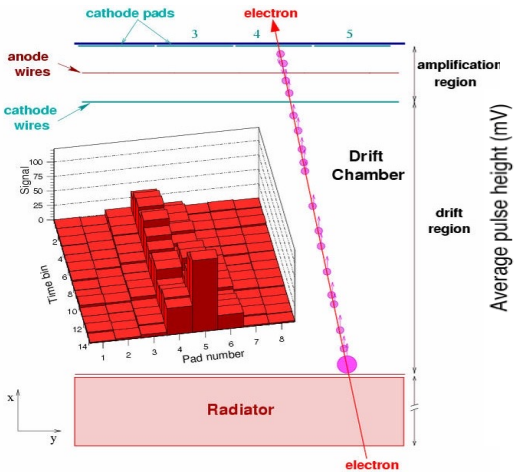
TRD structure details

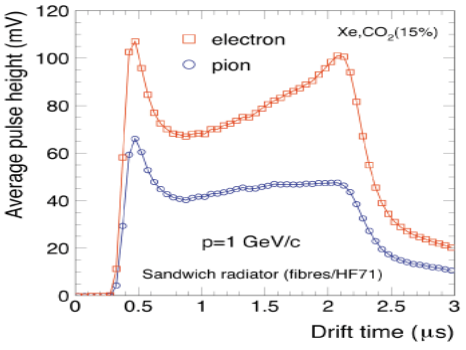


Ionization process



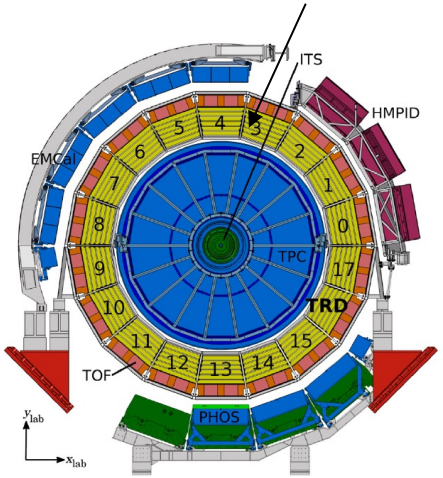
Signals produced by electrons and pions





4 ALICE - TRD

Structure



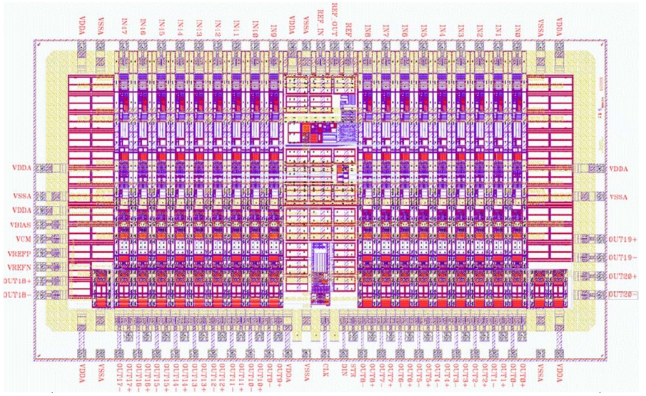
Purpose:

- *electron ID in central barrel p>1GeV/c*

Parameters:

- *18 supermodules segmented in 6 layers, 5 stacks*
- *540 modules ~ 750m²*
- *Lenghth: 7m*
- *X/X_0 ~ 15%*
- *28 m³ Xe/CO_2 (85:15)*
- *1.2 million channels*
- *15 TB/s on-detector badwidth*

FEE - ASIC - PASA

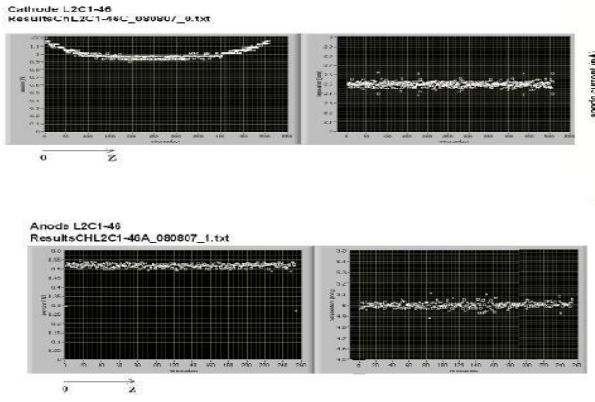


Winding multi-wire electrodes

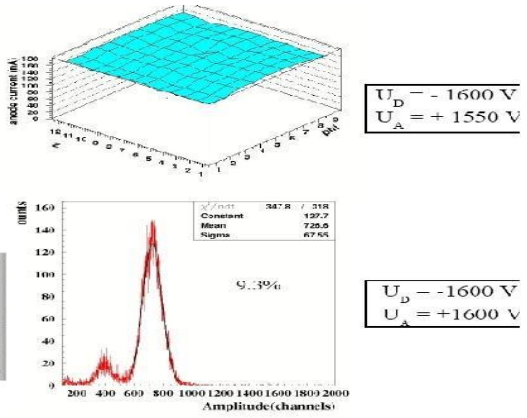
Assembling multi-wire electrodes

Pad-plane quality control

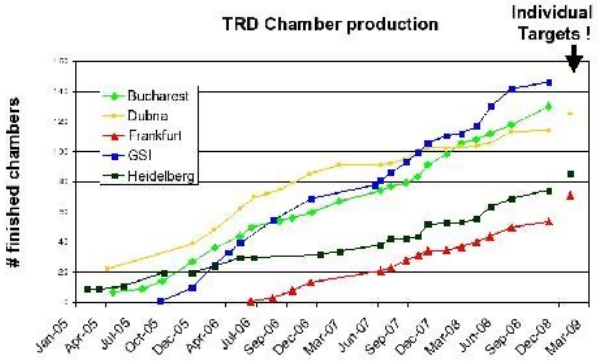
Wires mechanical tension an position measurement



Gain uniformity and energy resolution measurement

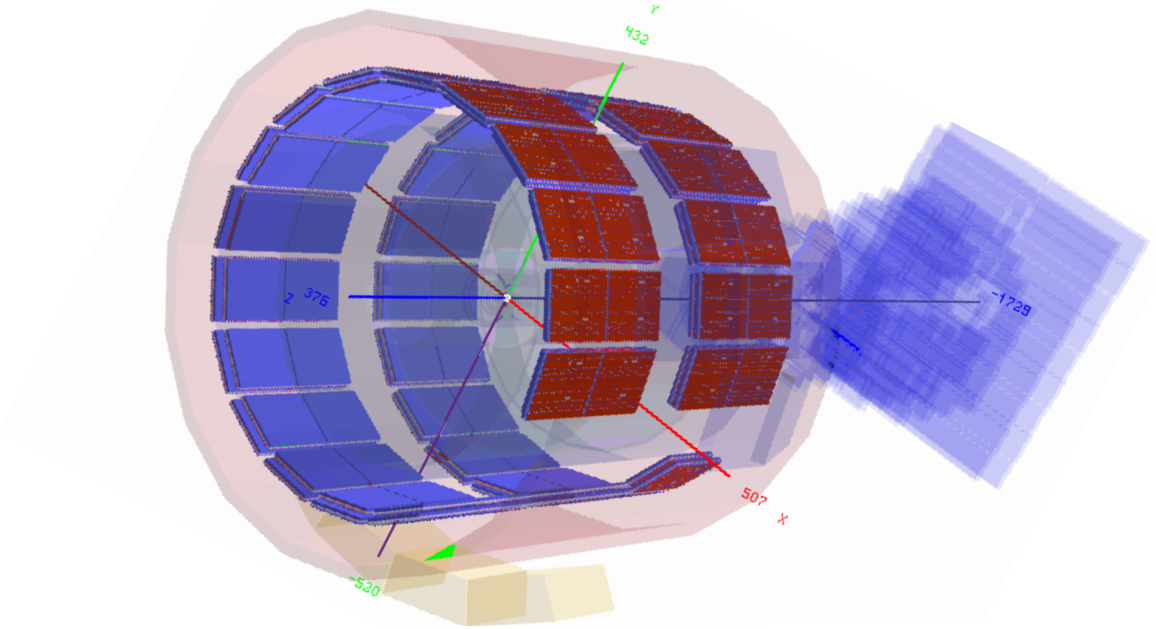


TRD Chamber Production

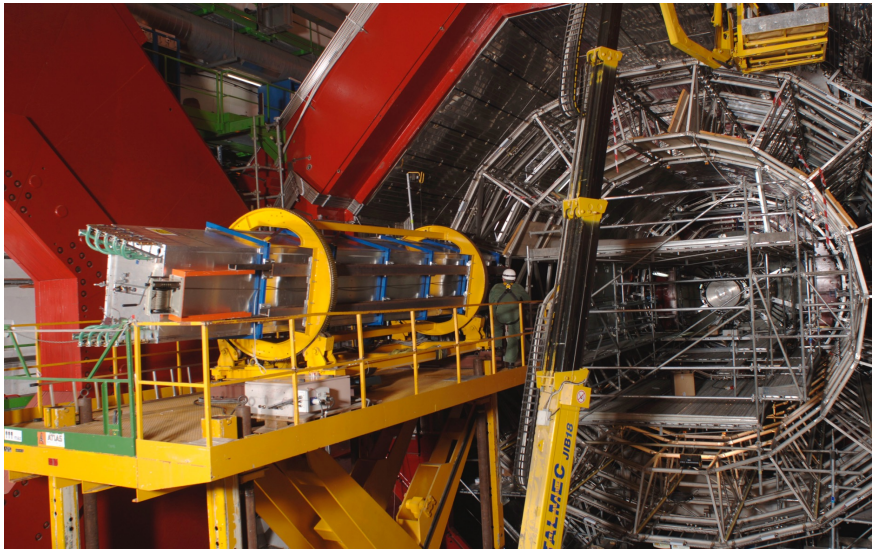


4 ALICE - TRD

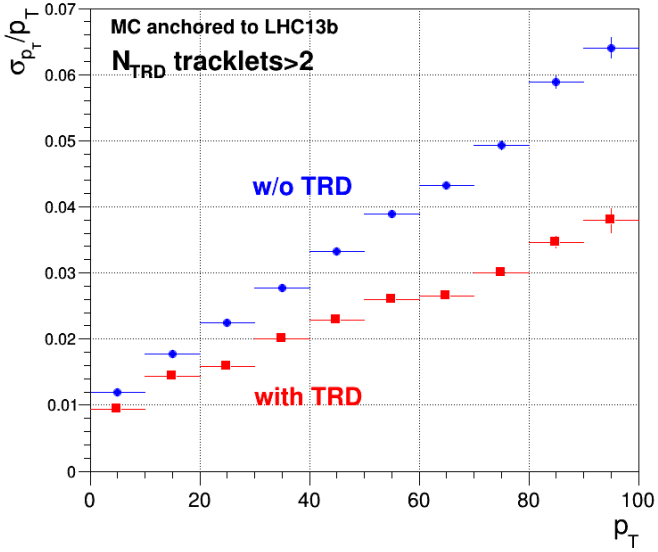
Regions of the ALICE-TRD equipped with the chambers assembled and tested in Hadron Physics Department



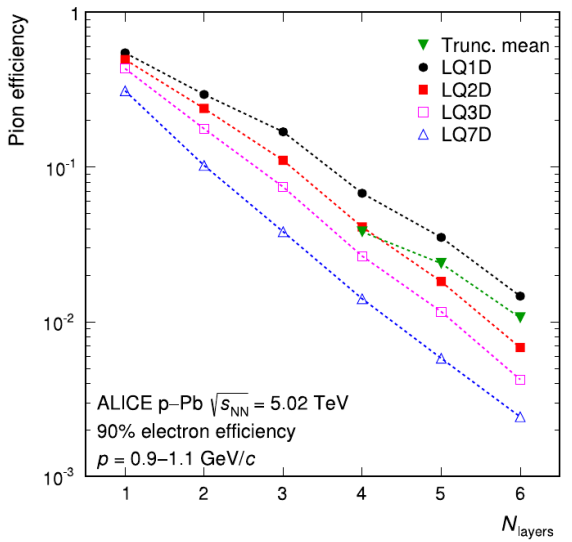
Insertion of TRD super-modules in the Alice Experiment



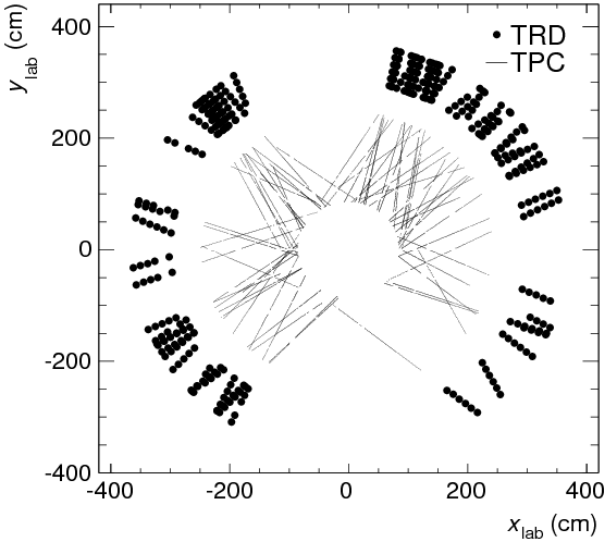
Improvement of transverse momentum resolution using TRD tracklets



Electron/pion discrimination

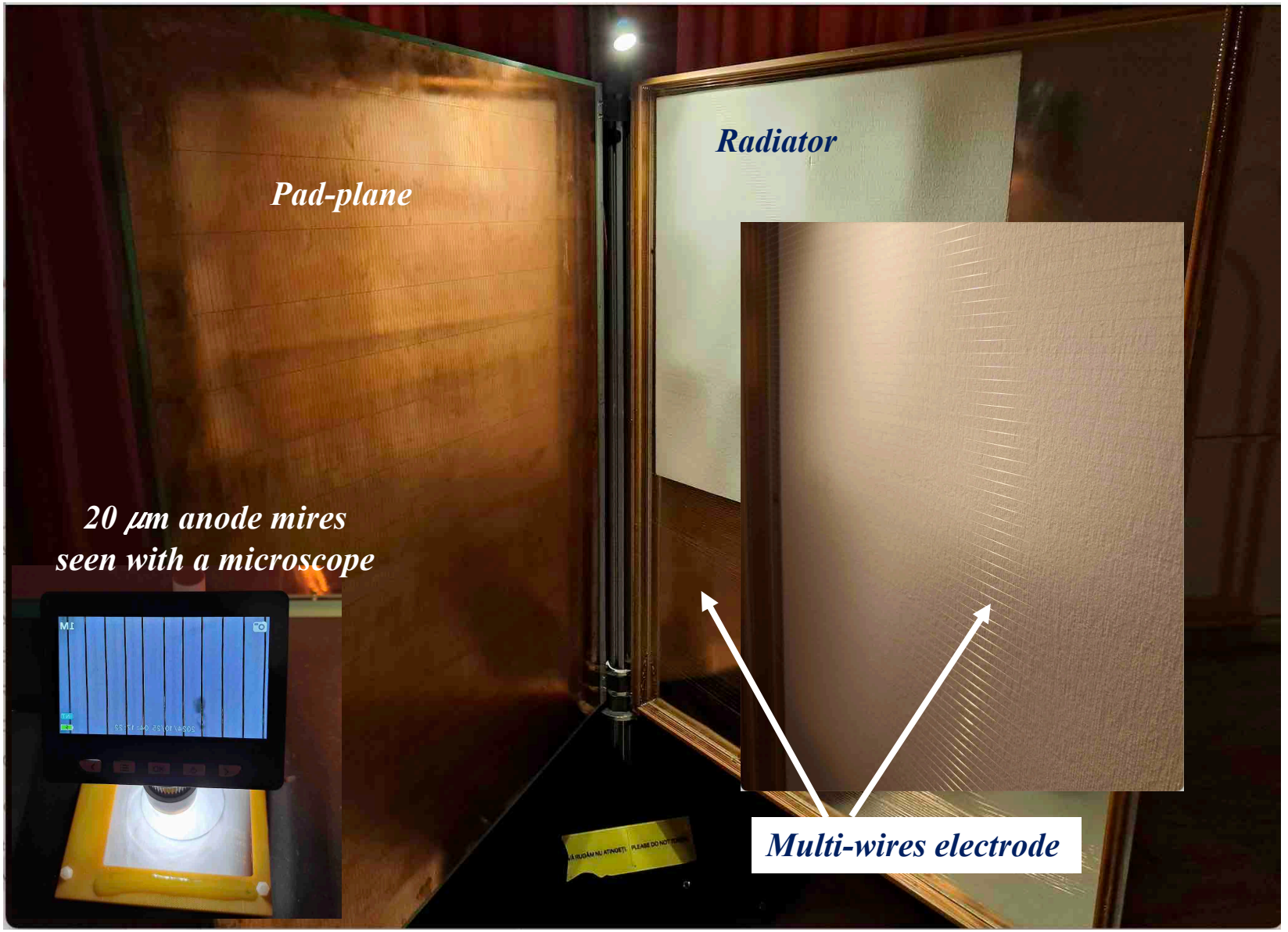


Tracks produced by cosmic rays



5 ALICE - TRD - real size exposed chamber

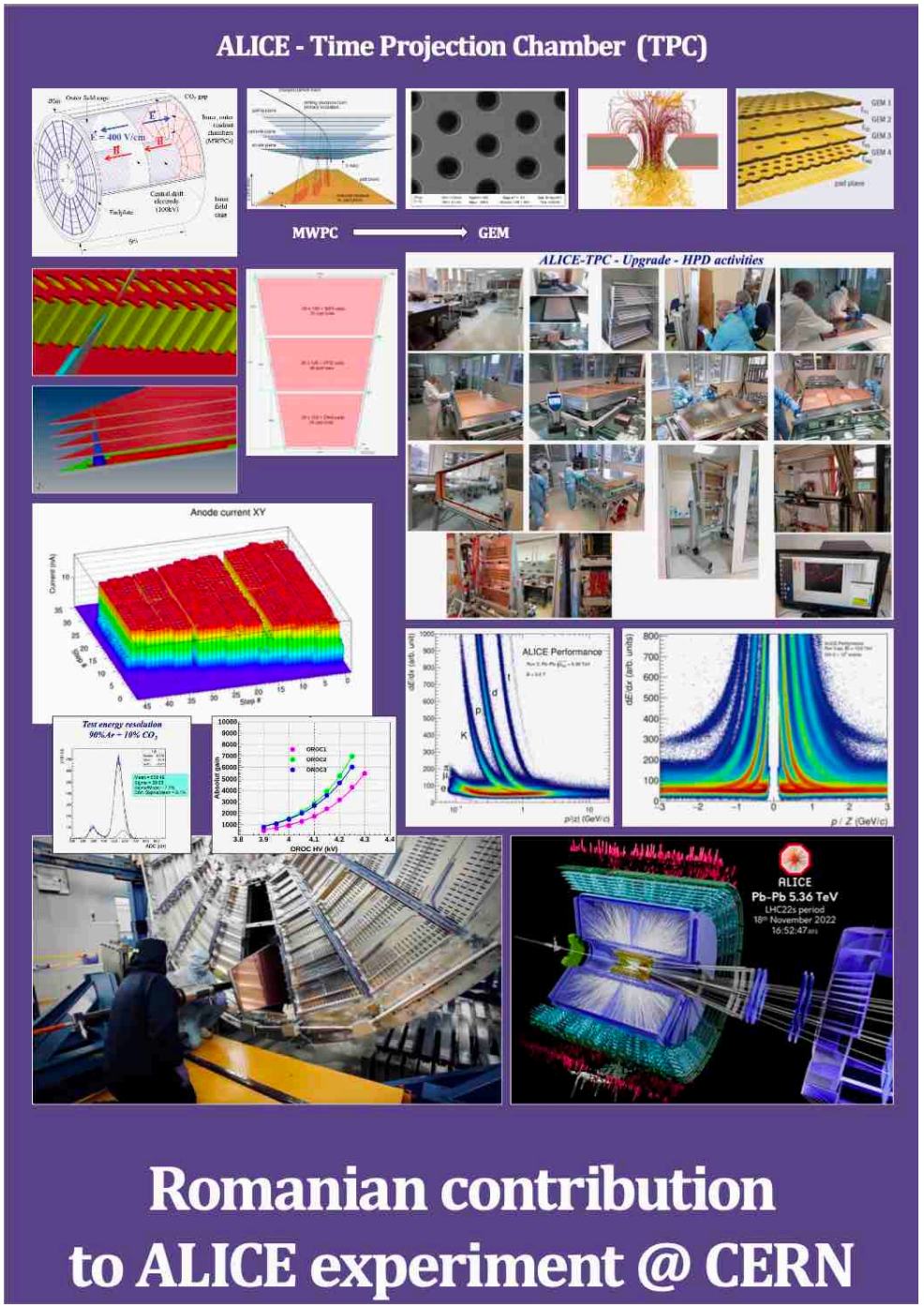
The inner structure of ALICE-TRD chamber and how the signals from the pad plane are transported to the front-end electronics can be followed on an exposed real chamber



Section II
Monitor_3

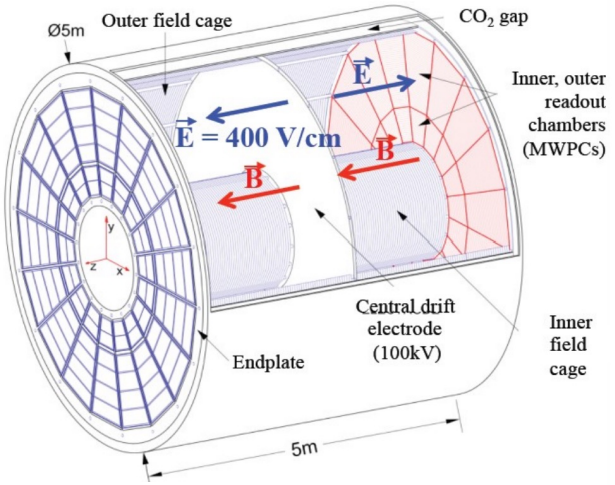
On Monitor_3 is displayed the information from the following pages and details on assembling and testing ALICE-TPC OROC chambers activities

6 *ALICE - Time Projection Chamber (TPC) Read-Out Chamber (ROC) based on GEM - technology - Roll-up*

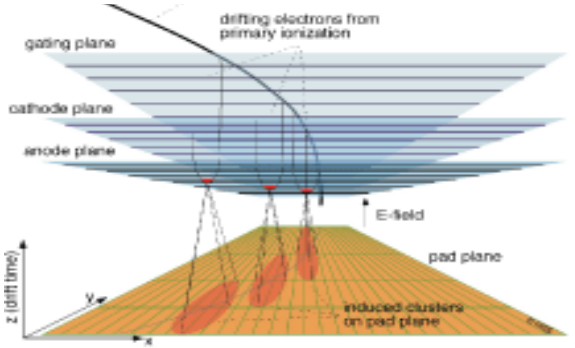


6 ALICE - TPC

TPC structure

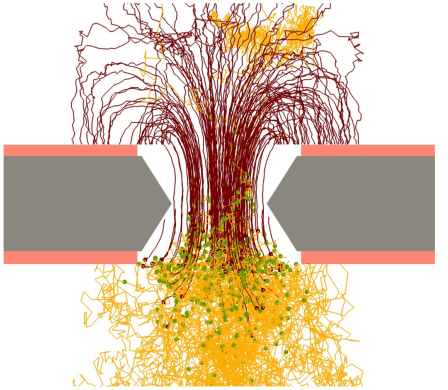


Working principle of a multi-wire read-out chamber

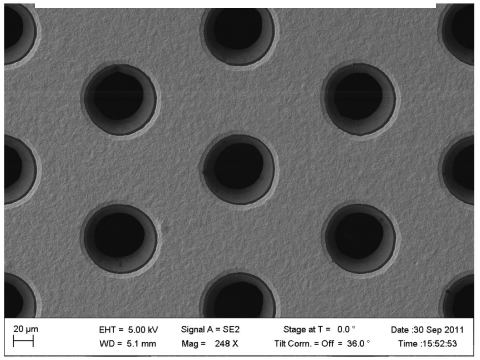


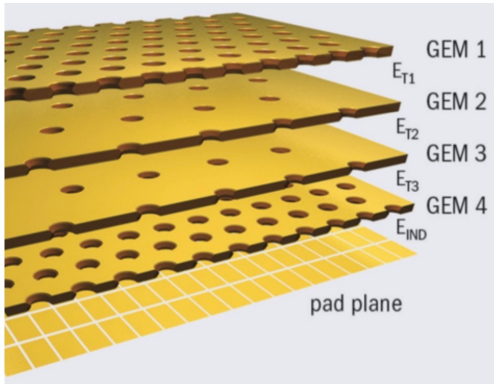
MWPC

Working principle of Gas Electron Magnifier (GEM)

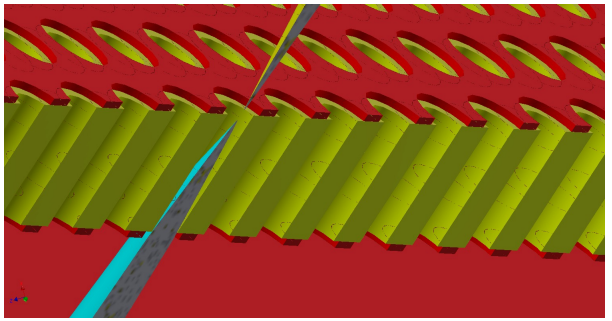


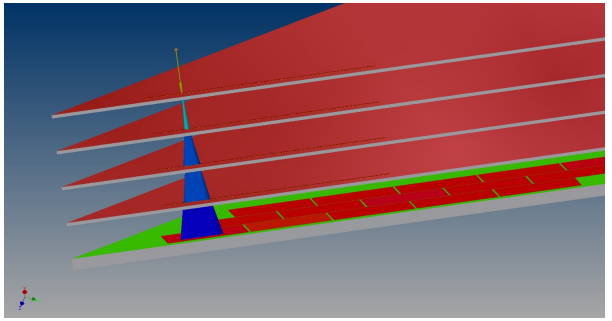
GEM structure



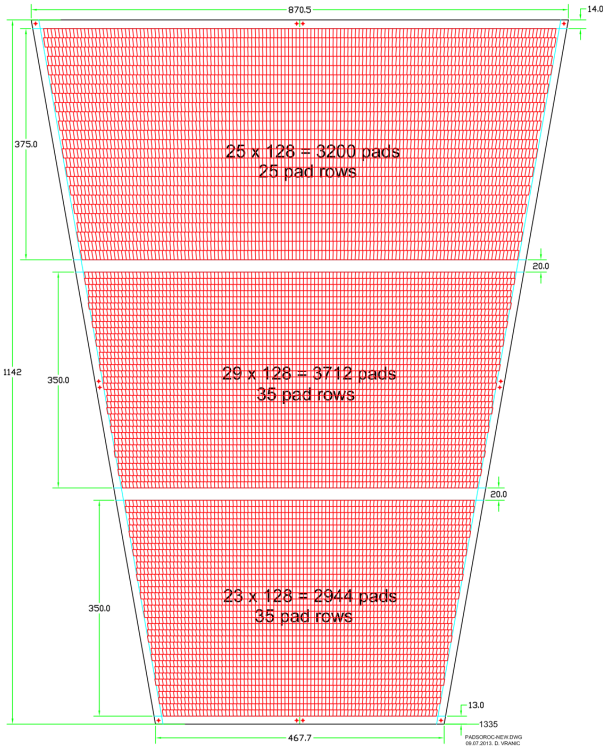


Avalanche development in a stack of 4 GEM foils



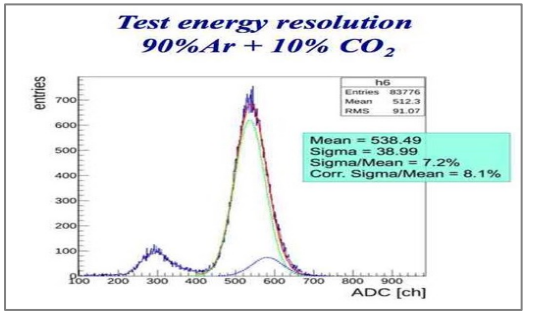


Pad=plane structure

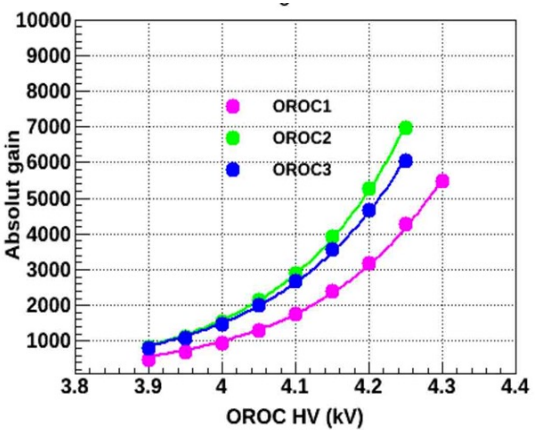


6 ALICE - TPC Outer ROCs (OROCs)

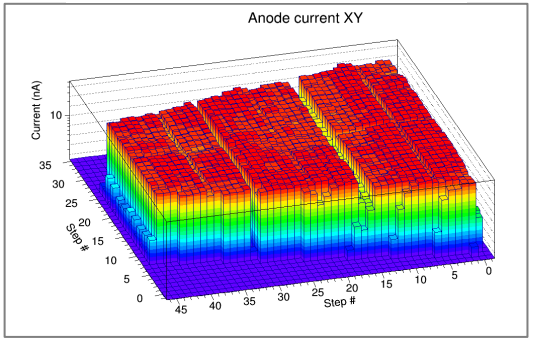
Energy resolution



Gain as a function of applied voltage

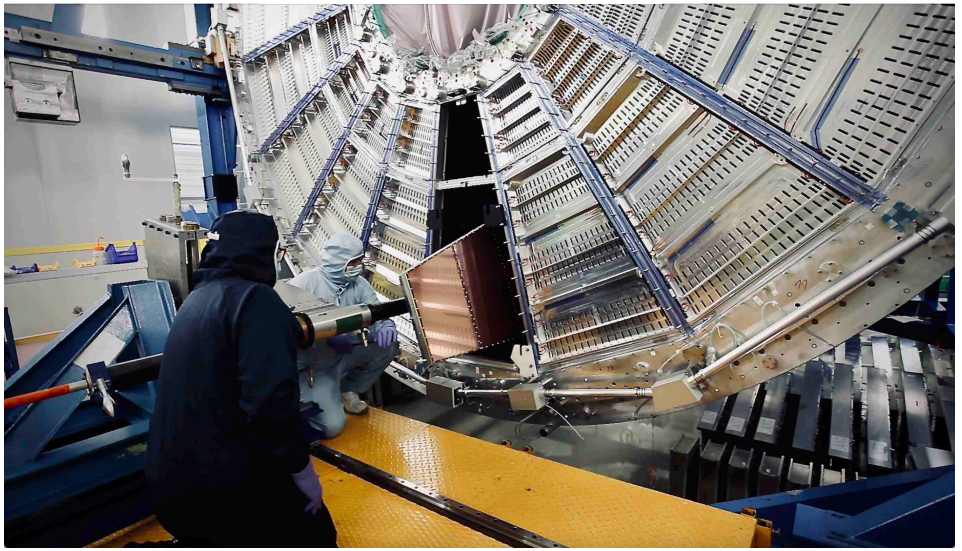


Gain uniformity

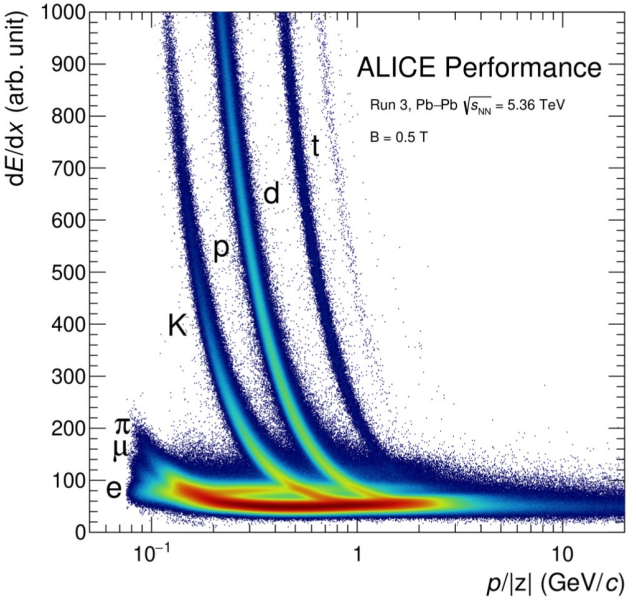


6 ALICE - TPC

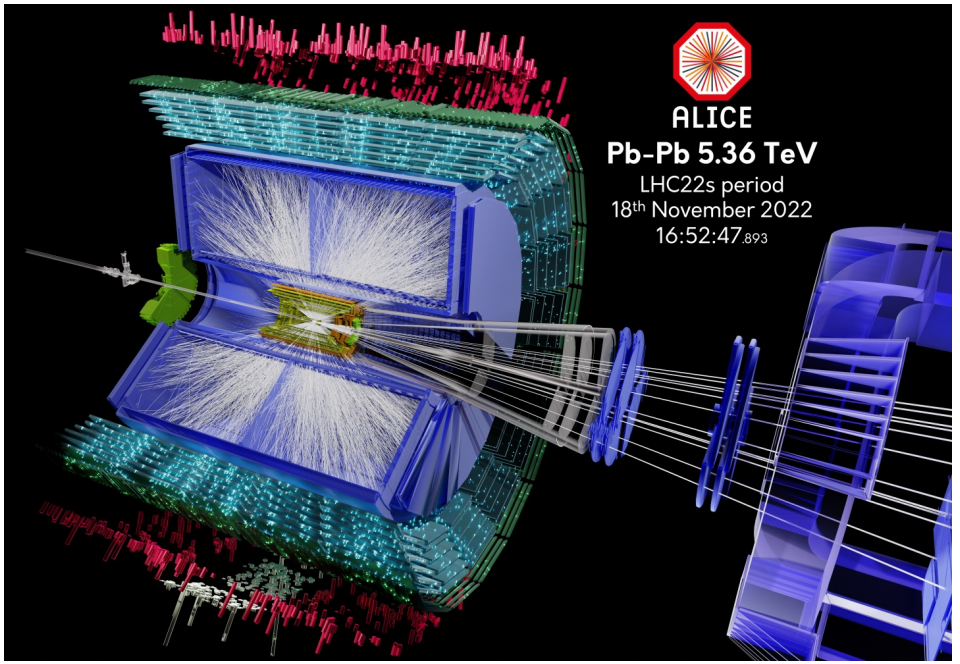
Mounting the OROCs in TPC

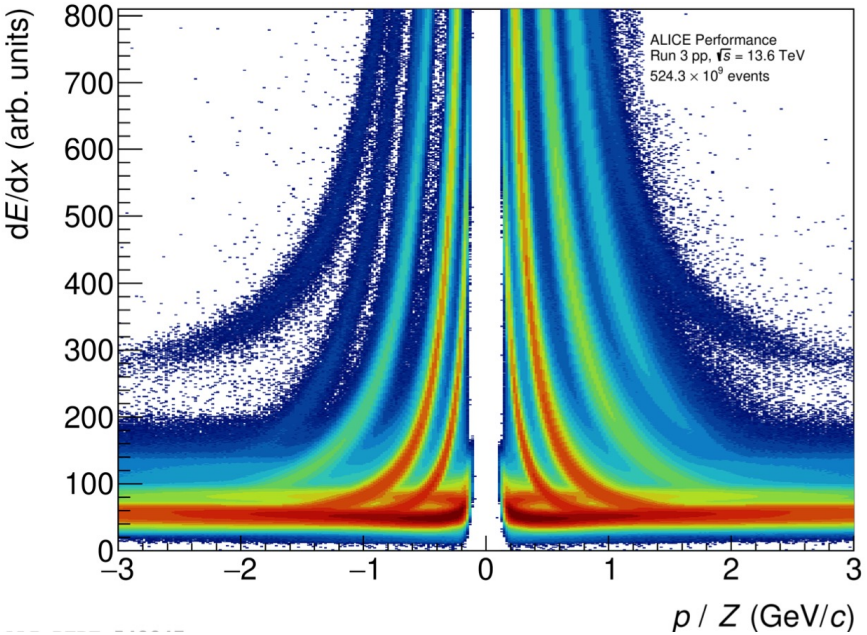


Charge particle identification performance



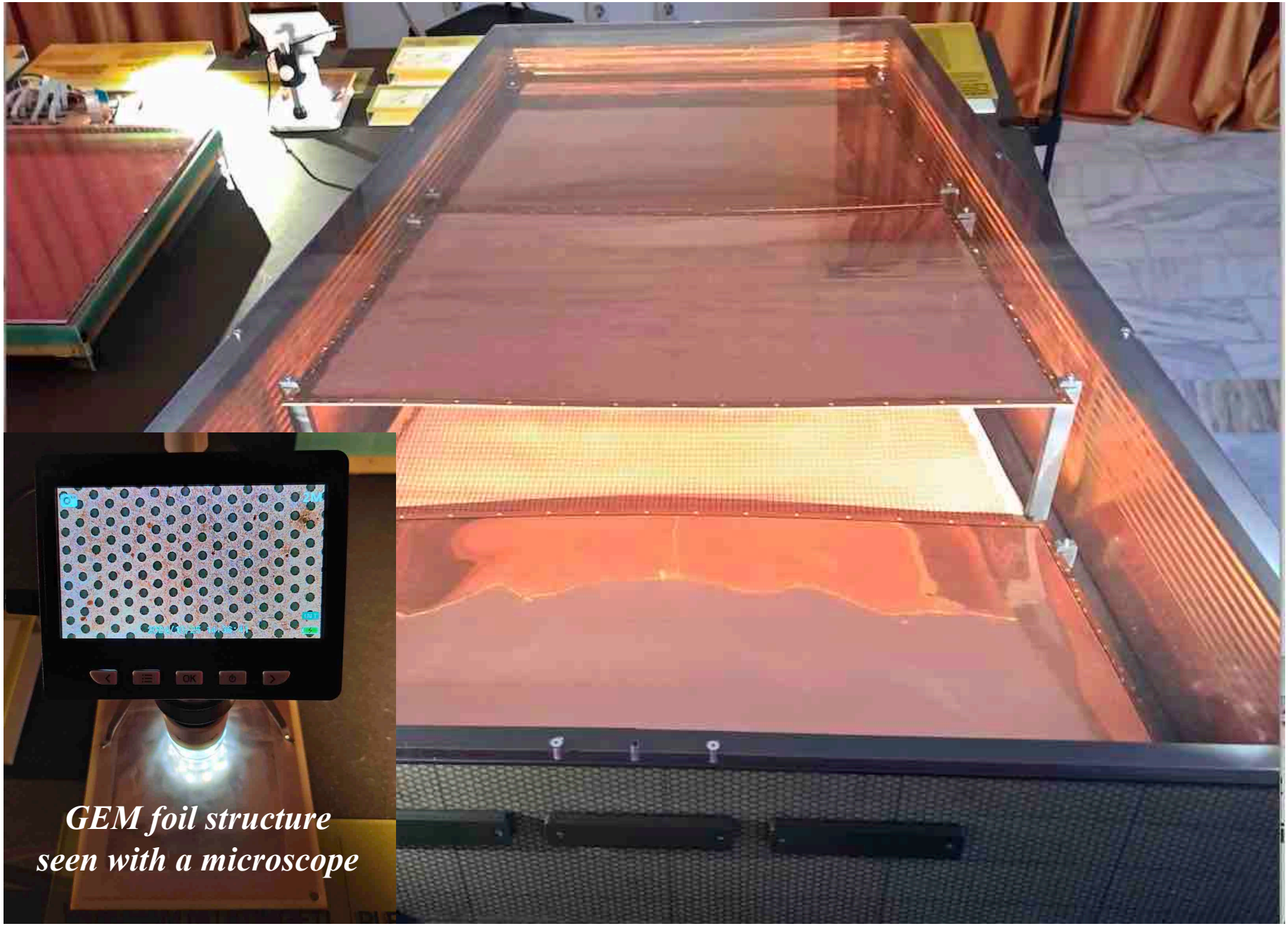
Tracks produced by charged particles in the ALICE Experiment





7 ALICE TPC-OROC

Real size structure - exposed



GEM foil structure seen with a microscope

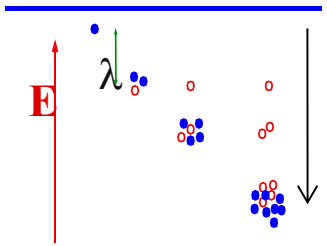
Section II
Monitor_4

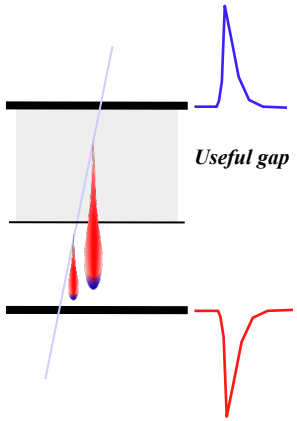
On Monitor_3 is displayed the information from the following pages and details on assembling and testing MSMGRPC and TRD-2D

8 Resistive Plate Counters (RPC)

Working principle

Multiplication factor (Gain)



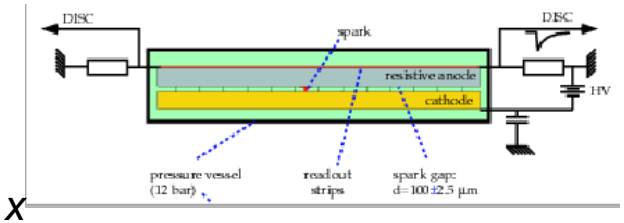


$$dn = n\,\alpha\,dx$$

$$n(x) = n_0 e^{\alpha x}$$

$$M(x) = \frac{n}{n_0} = e^{\alpha x}$$

Pestov Counter

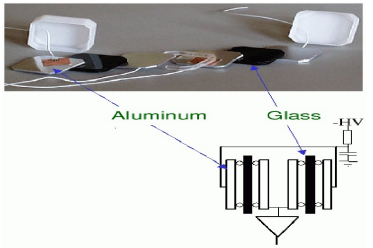


Y.V.V. Pachomchuck et al. , Nucl. Instr. And Meth. A 93(1971) 269

Advantages:
- -Very good σ_t (~25 ps)
- Position information: x, y

Drawbacks:
- high pressure operation (12 bar)
- 4.5 kV
- tails in the time spectrum
- needs special glass

Single Cell RPC

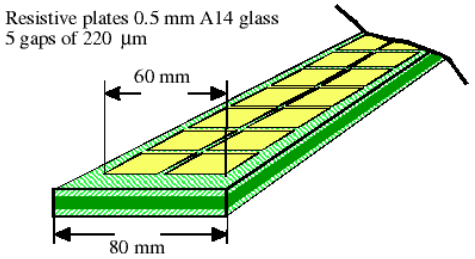


P.Fonte et al.,CERN-EP 27/9/99

Advantages:
- Very good σ_t (~44 ps)
- commercial glass
- 1 atm pressure operation

Drawbacks:
- edge effects
- unrealistic for large area configuration

Multi-Gap RPC - pad rows readout

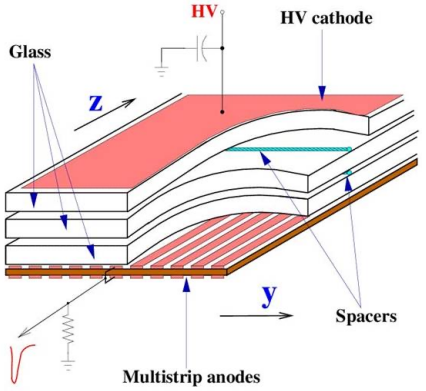


ALICE TOF - TDR CERN / LHCC 2000-12

Advantages:
- Very good σ_t (~60 ps)
- commercial glass
- -1 atm pressure operation

Drawbacks:
- edge effects, cross talk
- no position information over the pad sizes; tracking device is needed for position dependence correction

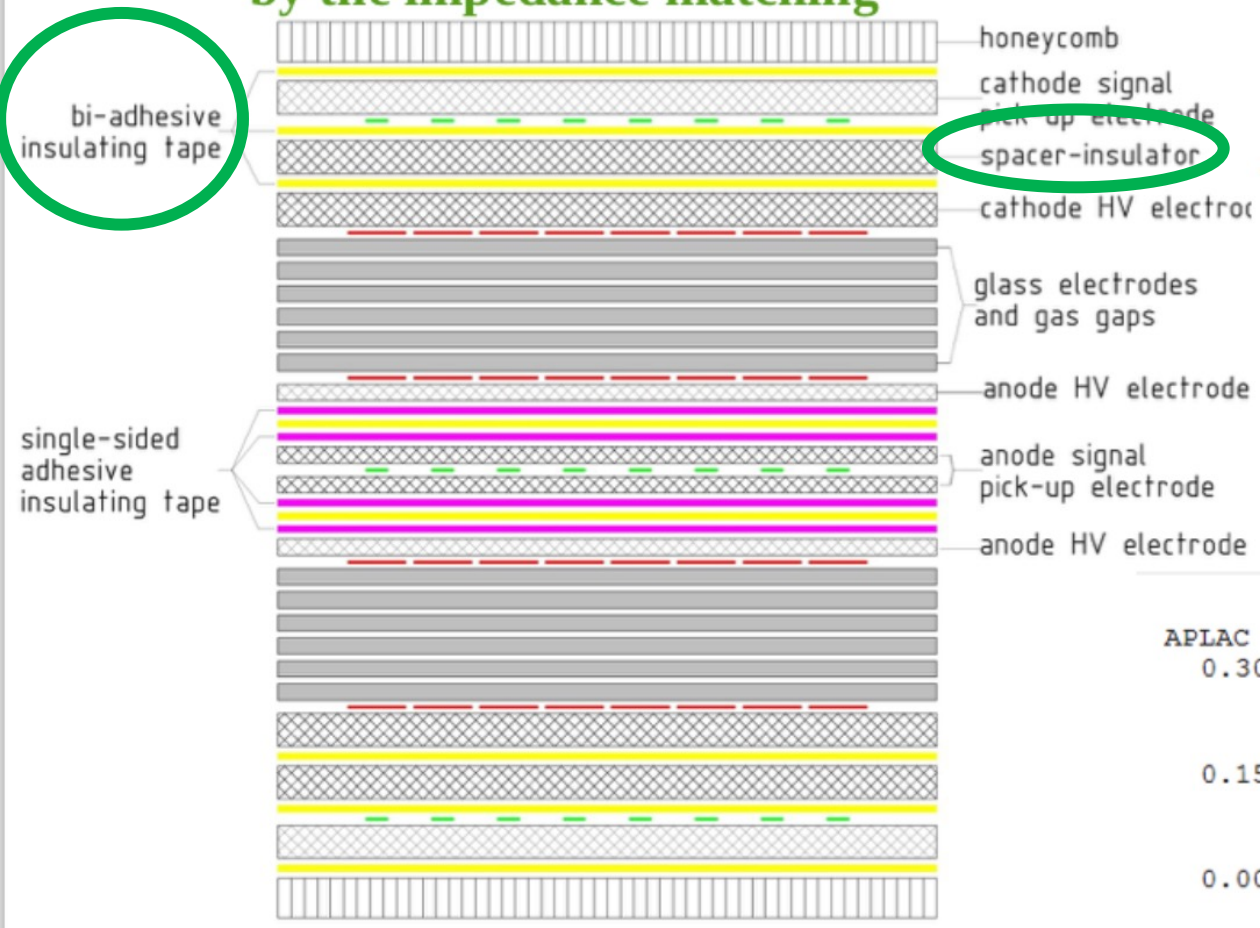
Multi-Strip Multi-Gap Resistive Plate Counters (MSMGRPC)

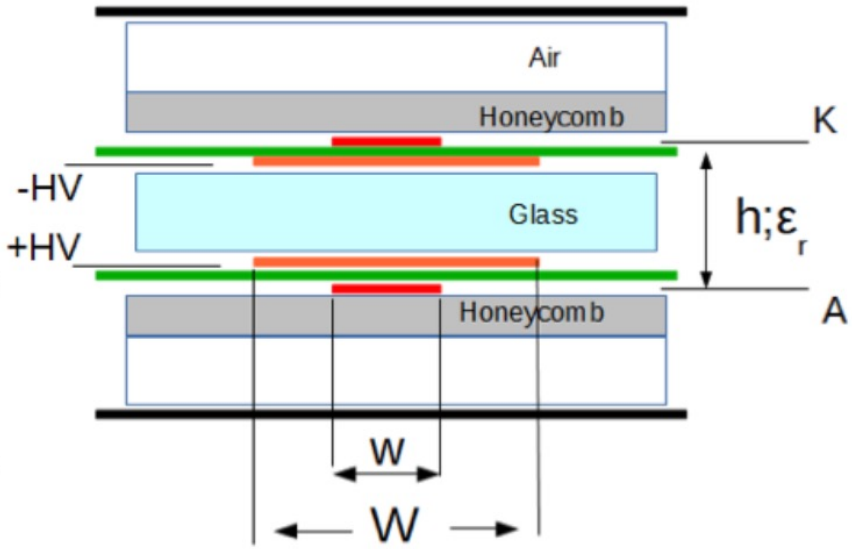


M. Petrovici et al. NIM A487(2002)337

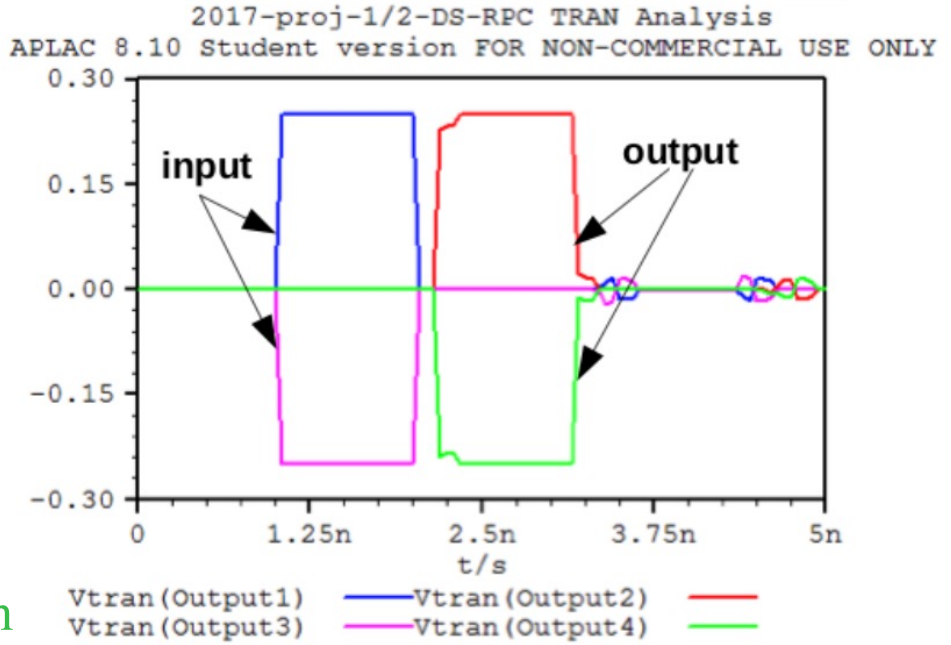
8 MSMGRPC2018 - structure details

Granularity adjustment decoupled by the impedance matching



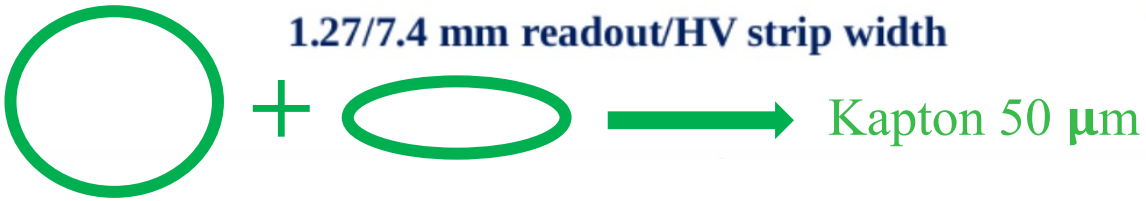


h = equivalent dielectric thickness
ε = equivalent dielectric constant



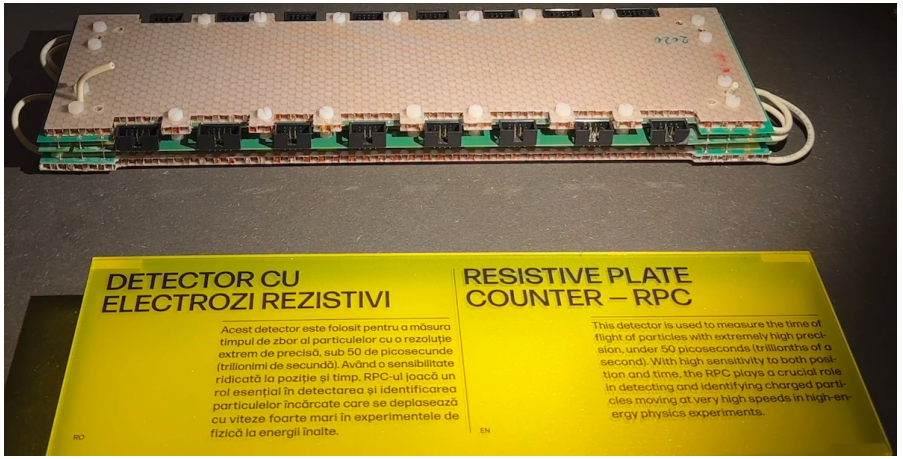
APLAC predicted 97 Ω for

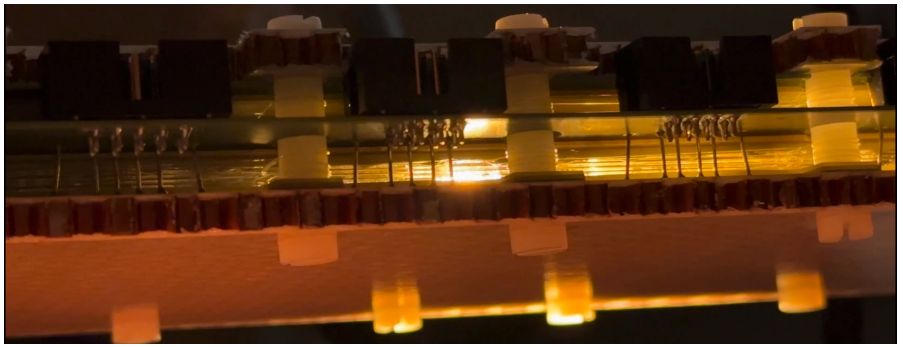
1.27/7.4 mm readout/HV strip width

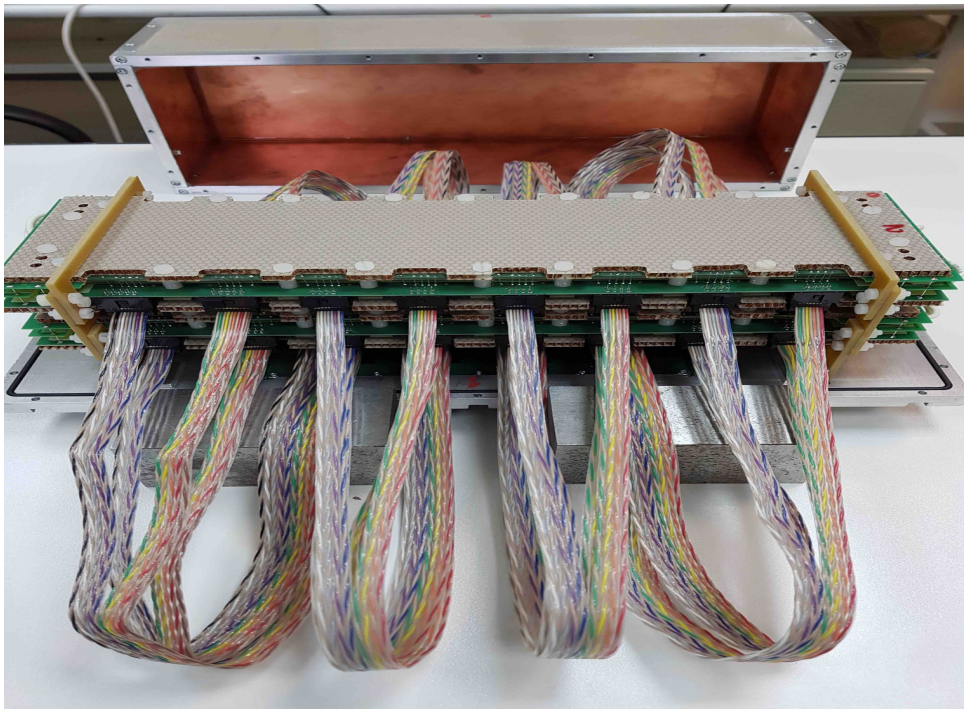


D. Bartos et al., arXiv:1708.02707 [physics.ins-det]

8 MSMGRPC - exposed components

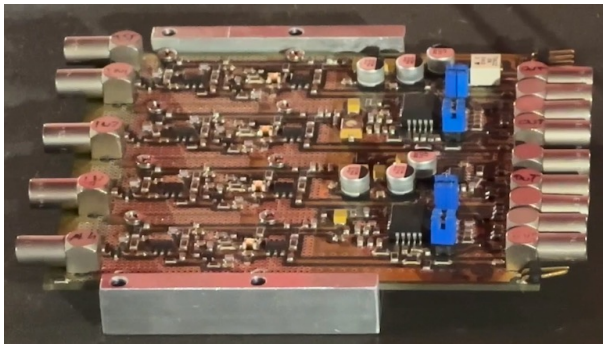






Fast Amplifiers

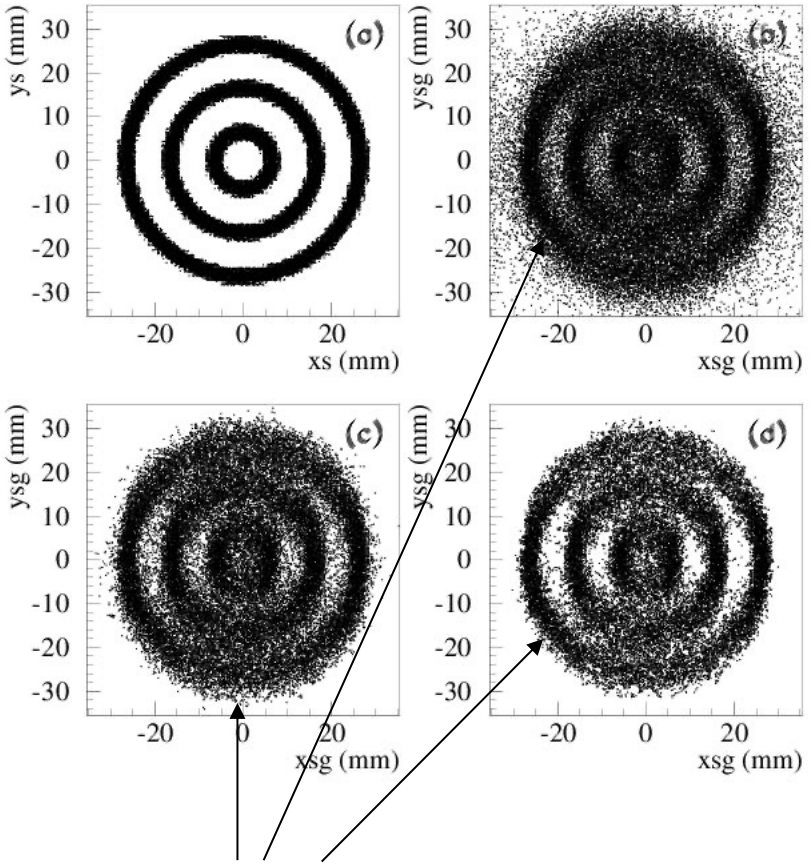
4 channels SMD technology



8 channels ASIC

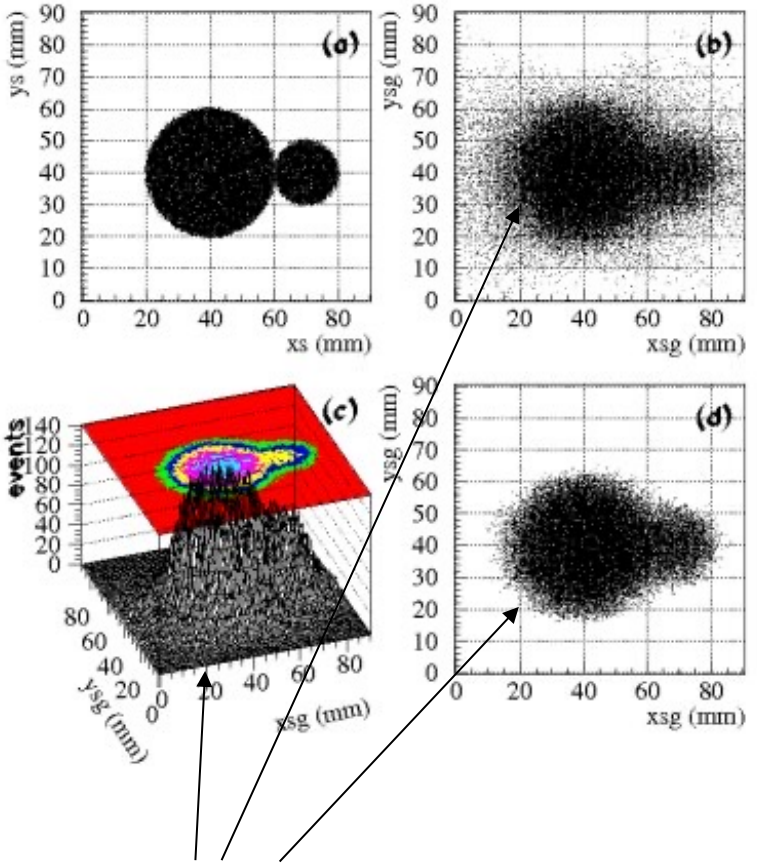
8 MSMGRPC - potential application

2D distribution of a positron emitting source



2D reconstructed distribution

2D distribution of a positron emitting source



2D reconstructed distribution

9 Two dimensional position information multi-wire PC

Schematics

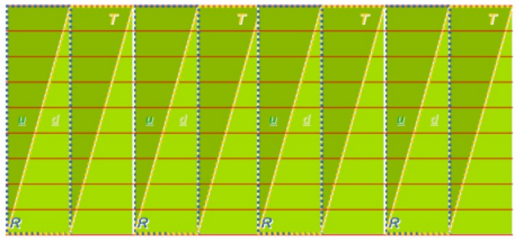


Photo taken from the entrance window

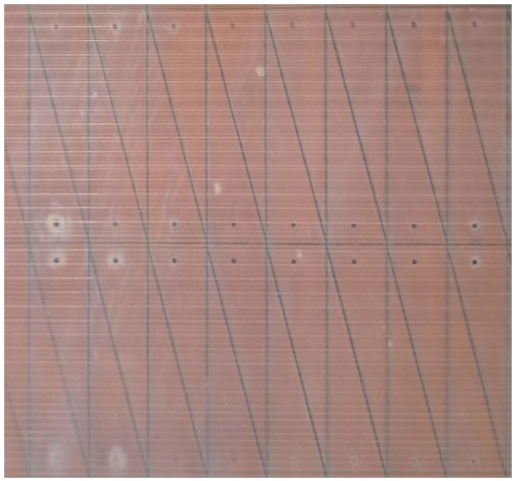
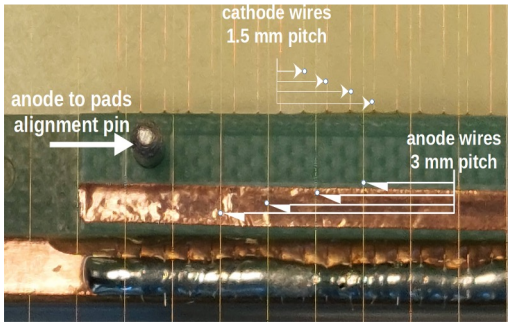
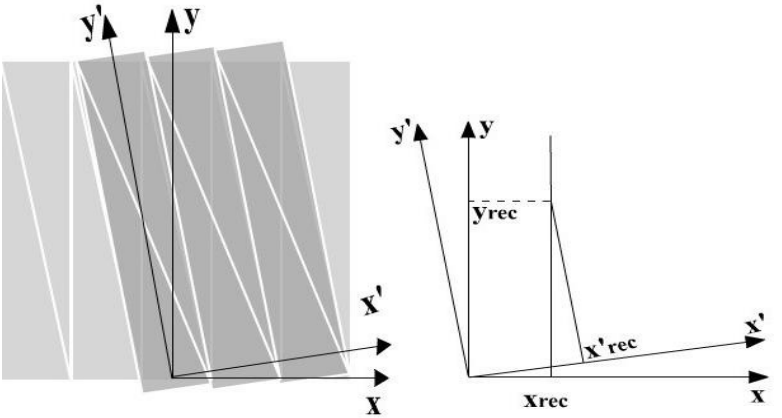


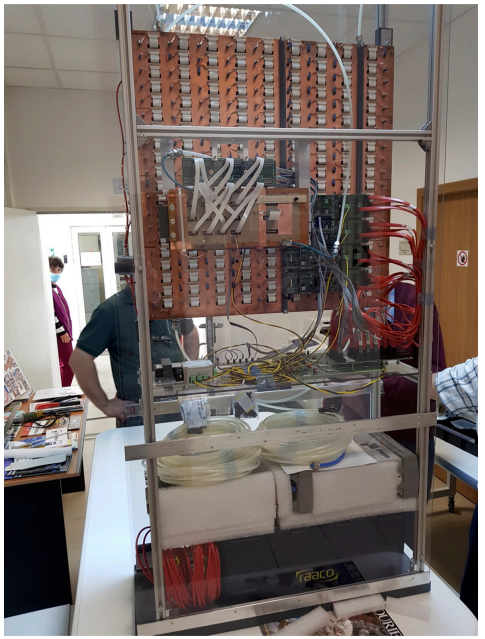
Photo taken from the pad-plane



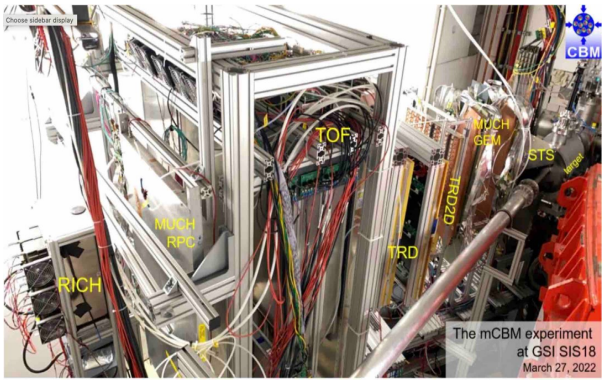
2D - position reconstruction principle



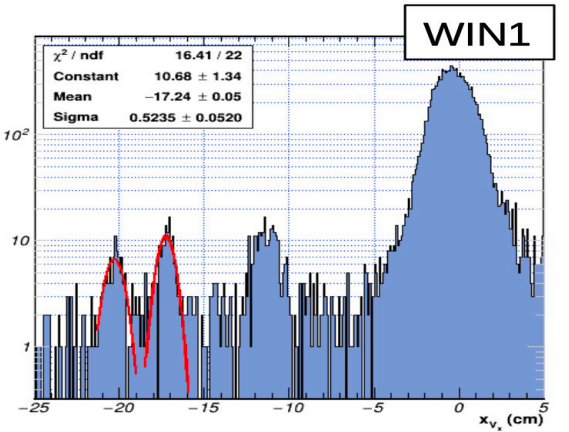
60x60 cm2 chamber partially equipped with Front-End Electronics (FEE)



Experimental configuration for inn-beam tests

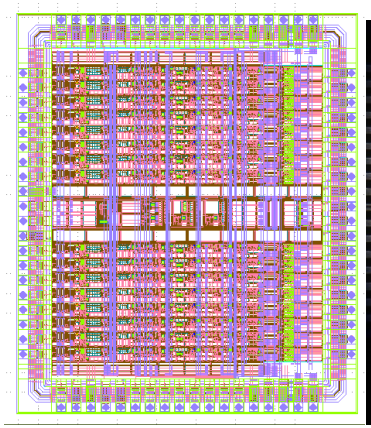


Position reconstruction of the sources of the reaction products

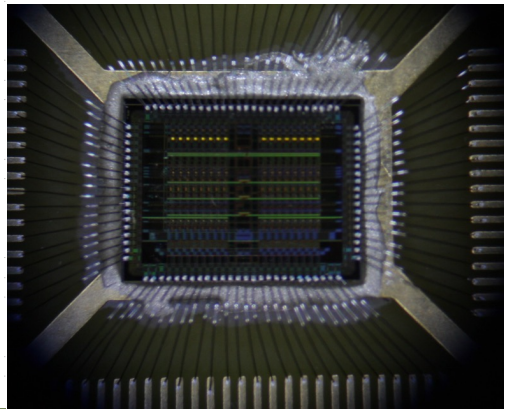


9 Two dimensional position information multi-wire PC Frontend Electronics and Data processing

FASP design

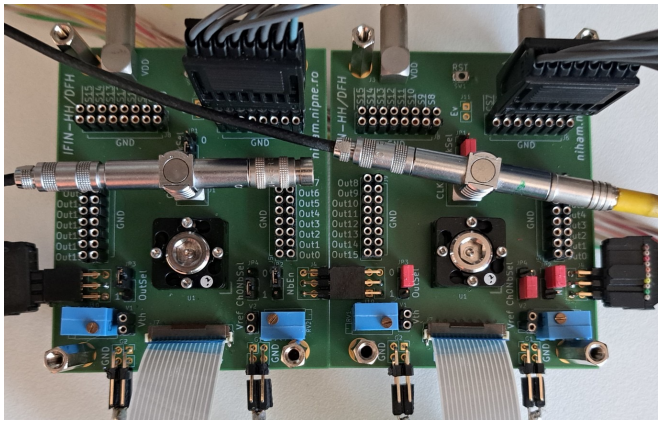


FASP bonding

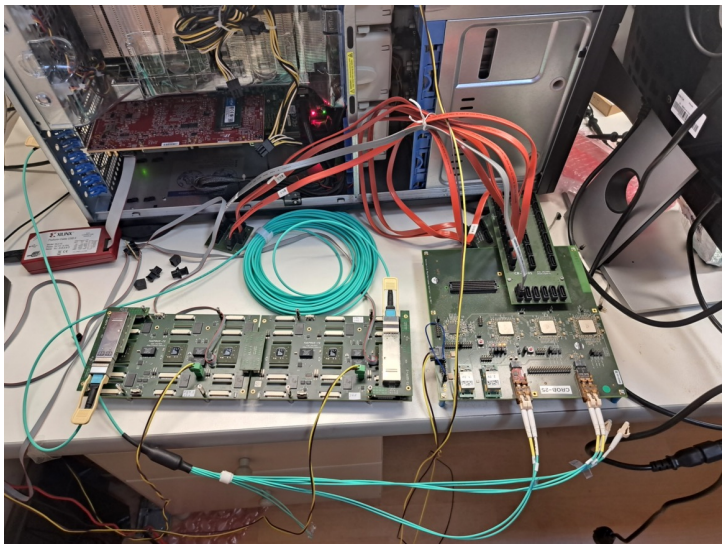


FASP packaging

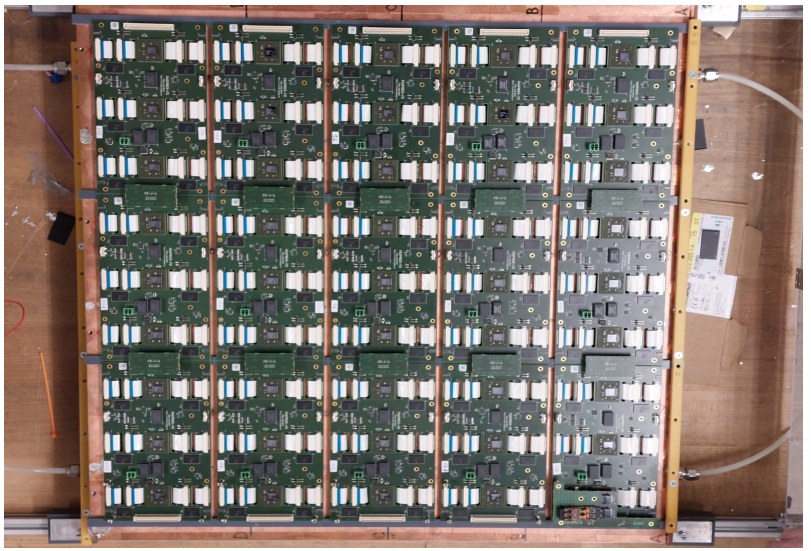
FASP test motherboard



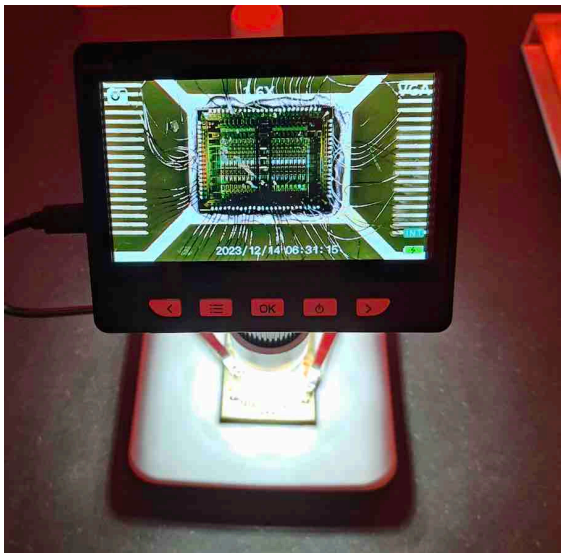
New FEE board (FASPRO3-F)
12 FASPs (new package)
6 ADC chips (32 channels each),
3 PolarFire FPGAs and side
connectors for various configurations



60x60 mm^2 TRD-2D chamber, completely equipped with 15 FASPRO3-FEE boards processing 2,880 signal channels

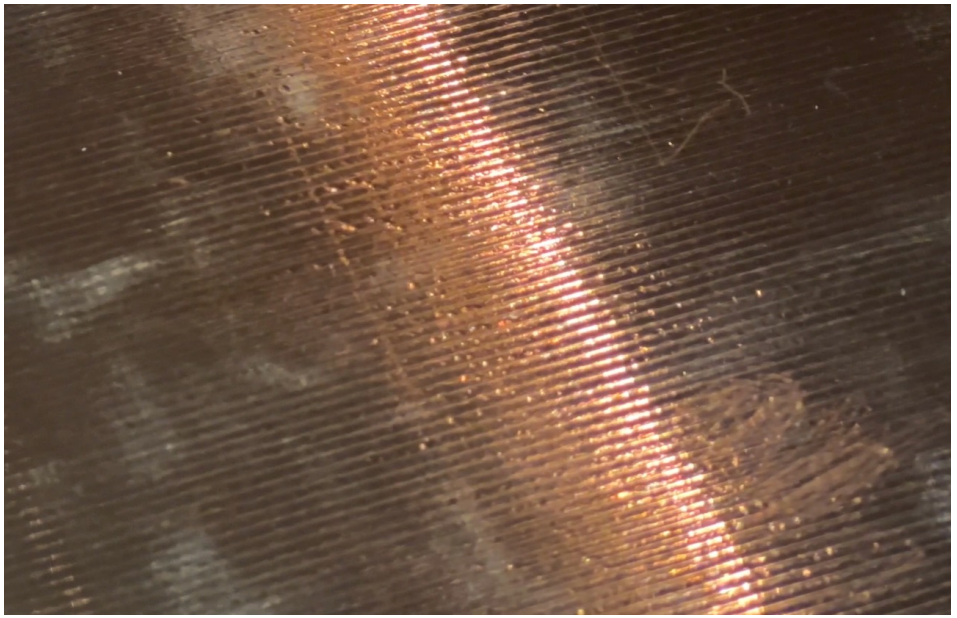


ASIC CHIP
seen with a microscope

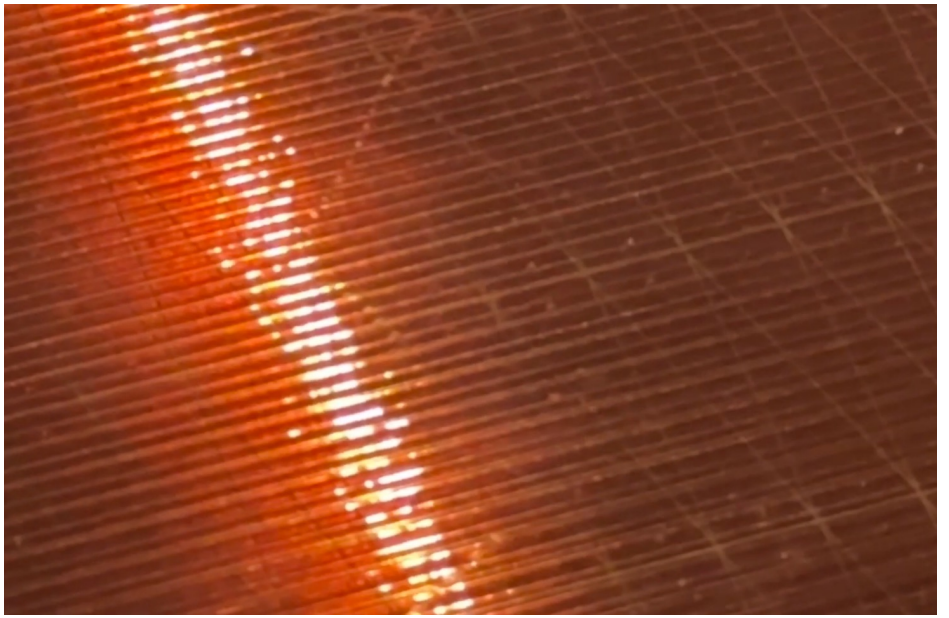


Two dimensional position information multi-wire PC exposed components

Entrance window with multi-wire cathode

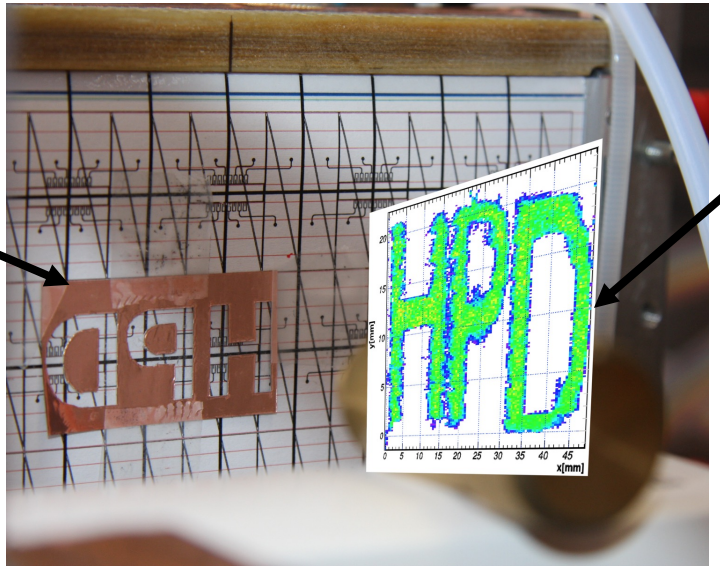


Pad-plane with with multi-wire anode



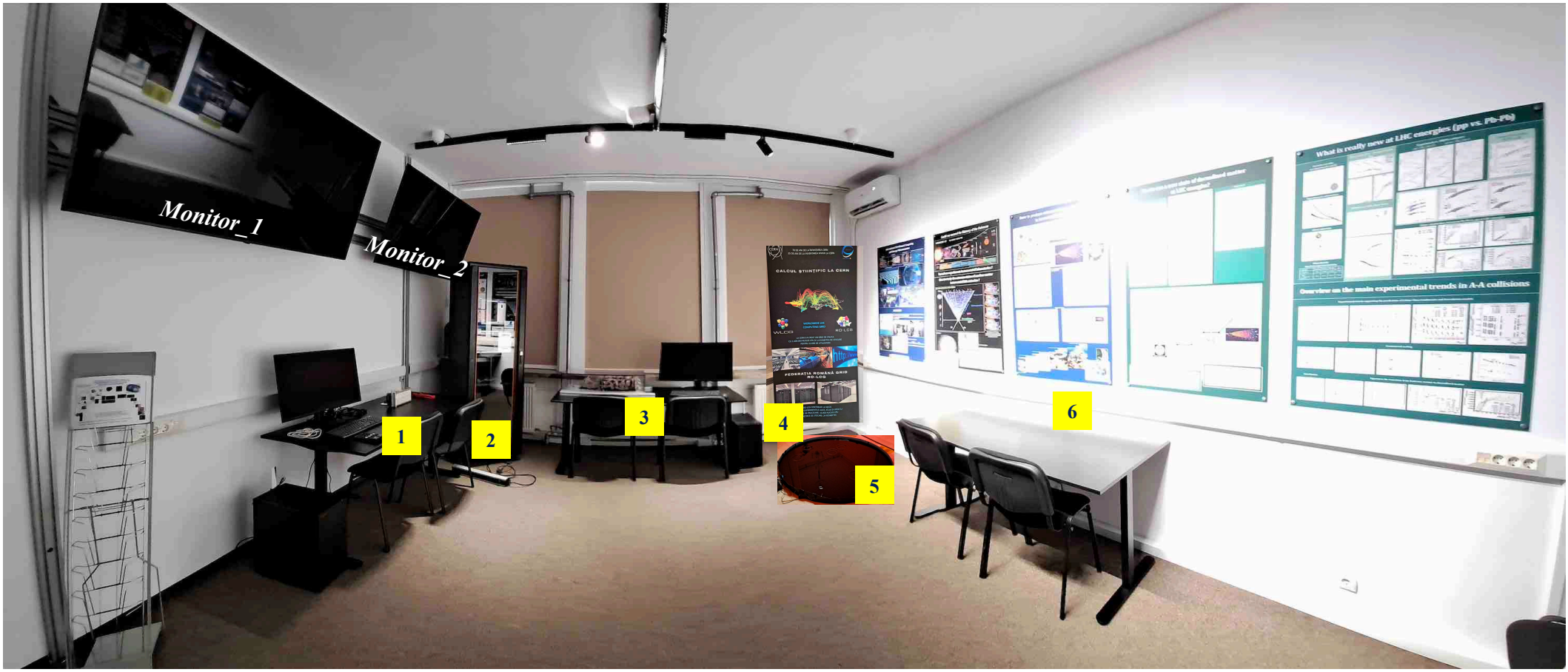
Potential application

Cu foli screen with HPD achronim cut out illuminated by a ^{55}Fe X-ray source (2 mm thick letters)



Reconstructed image

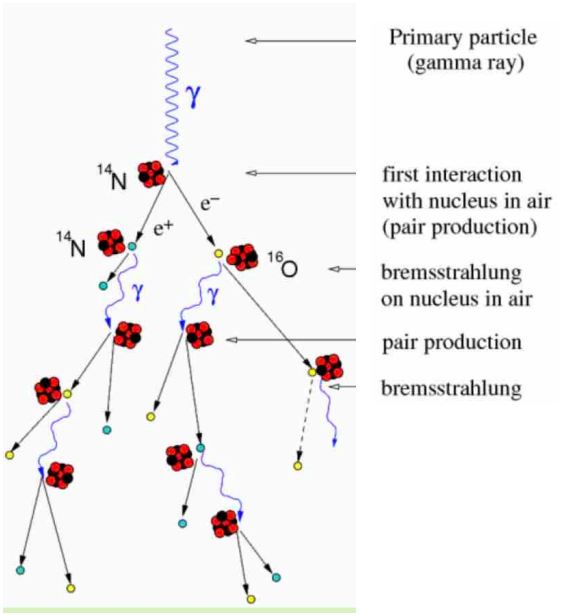
Section III


Monitor_1
Monitor_2
1
2
3
4
5
6
CALCUL ȘTIINȚIFIC LA CERN
What is really new at LHC energies (pp vs. Pb-Pb)
Overview on the main experimental trends in A-A collisions

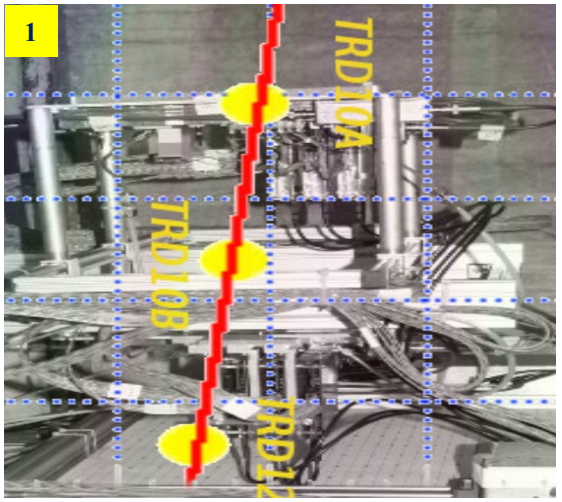
Operable MSMGRPC stack and TRD-2D stack

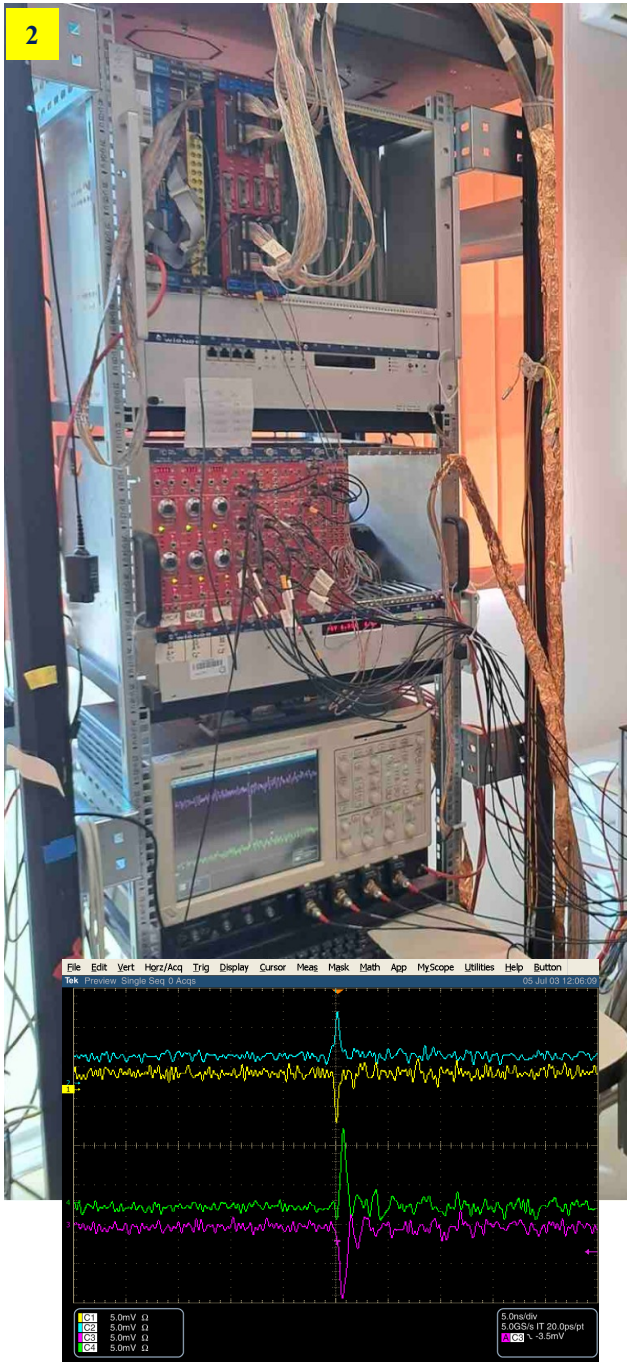
Visualization of signals and tracks produced by cosmic rays

Cosmic shower proced by high energy cosmic gama

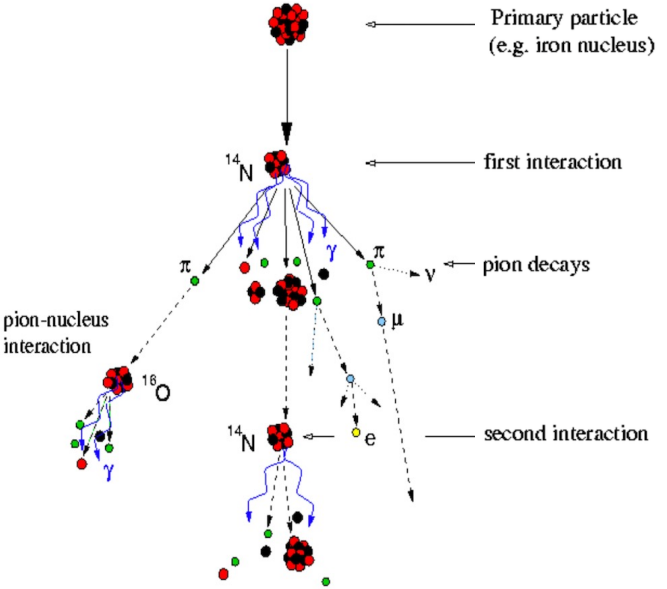


3 layers of TRD-2D

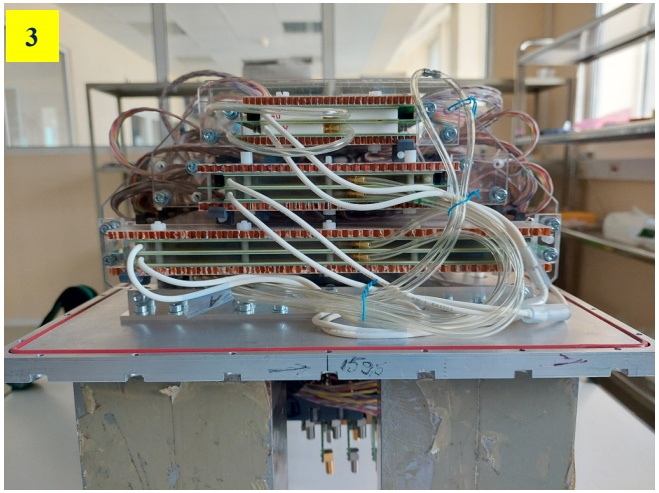




Cosmic shower proced by high energy cosmic particle

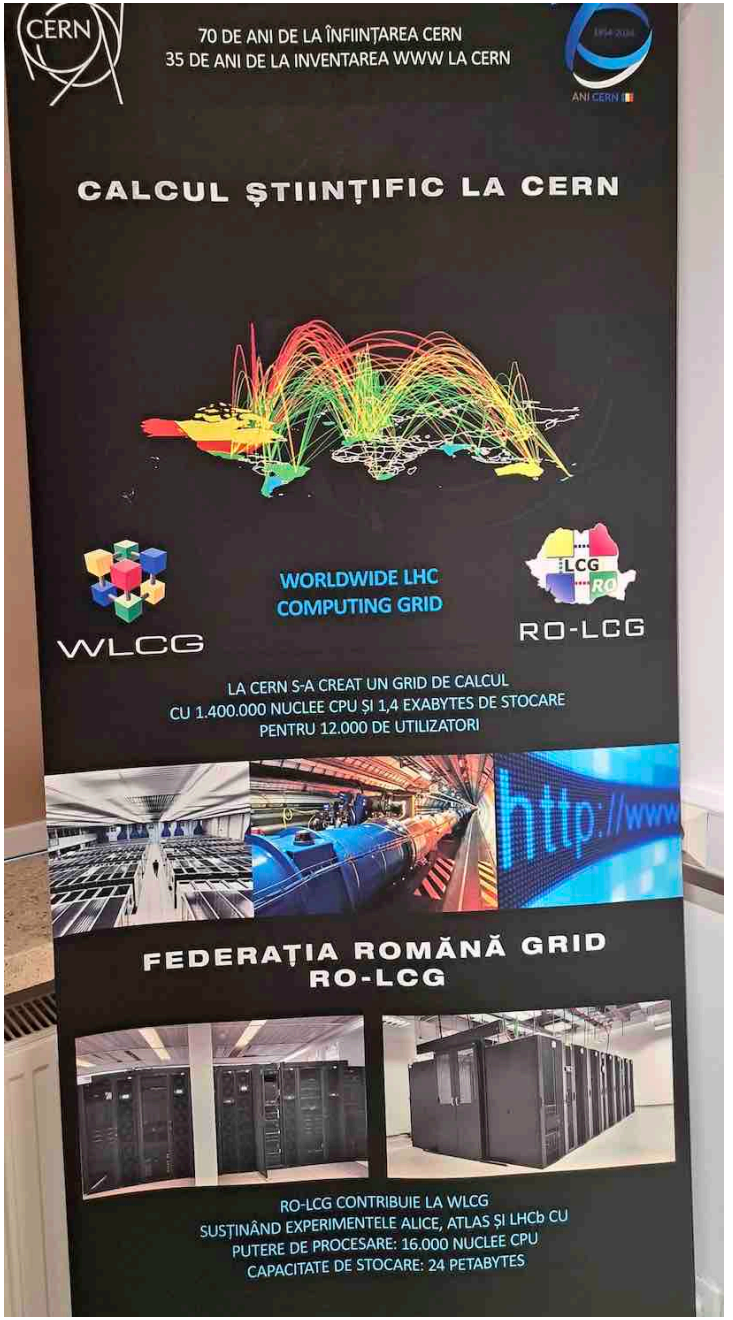


3 layers of MSMGRPC



Section III

Roll-up GRID activities



Section III

Cosmic "soup"

Sugestive set-up which triggers circular ways in a watter pool in th eplaces where gamma rays from a cosmic shower are detected

6

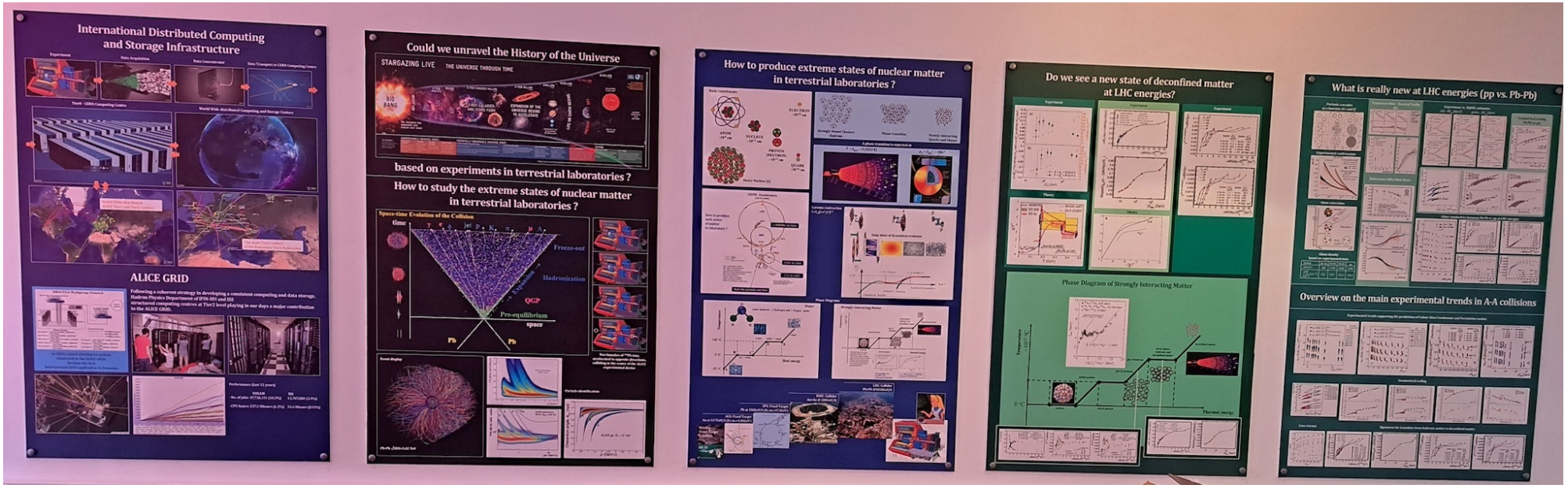
A serries of posters starting from physics motivation how to find the properties of the properties of matter produced in hadrn collisions at LHC can be accessed by detecting and identify the particles in the experimental setup and aspects of physics at which Romanian groups had and continue to have esential contribution.

Grid computing

Relativistic heavy ion collisions, physics motivation

Phase transitions Classic vs. Strongly Interacting matter

pp vs. A-A at LHC energies



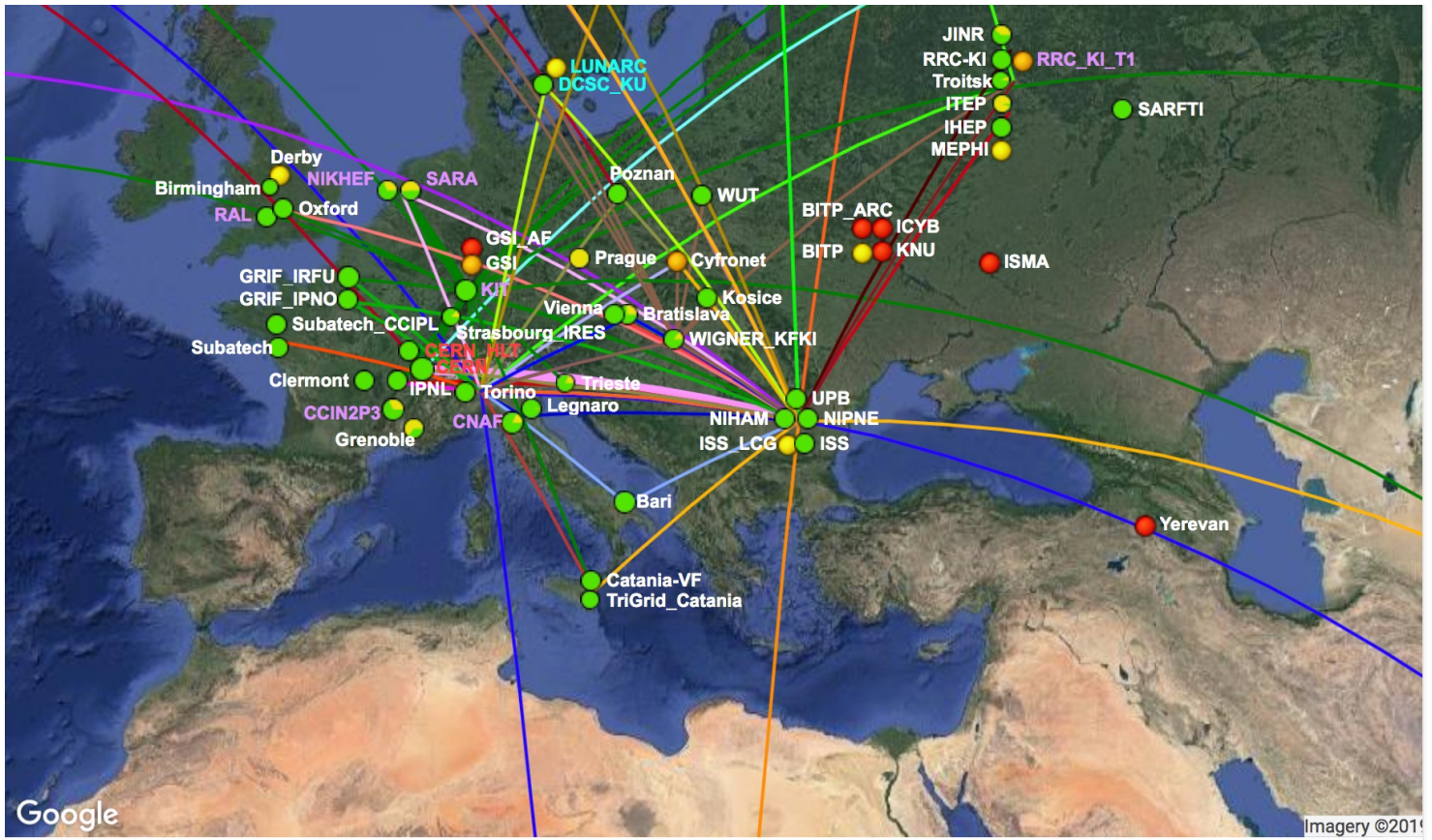
Section III
Monitor_3

Interactive animation with a collision produced by two spheres controlled by moving the hands

Section III
Monitor_4

GRID activities

Live monitoring of traffic connections,
running jobs, resources involved and computing hours



Room - ALICE VR

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