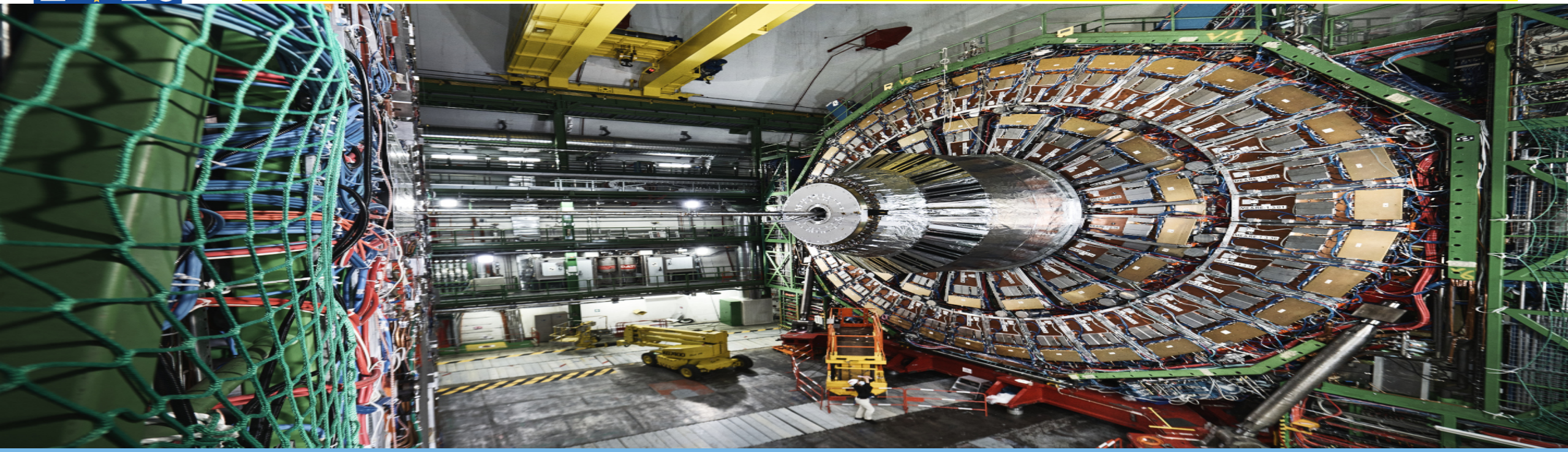
WP 32 – JRA14: MPGD-HP
Micropattern Gaseous Detectors for Hadron Physics



Bernhard Ketzer – University of Bonn

Fulvio Tessarotto – INFN Trieste

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

WP 32 – JRA14: MPGD-HP
Micropattern Gaseous Detectors for Hadron Physics

Coherent effort on MPGD by world experts from:

University of Aveiro,

Österreichische Akademie der Wissenschaften,

University of Glasgow,

Technische Universität München,

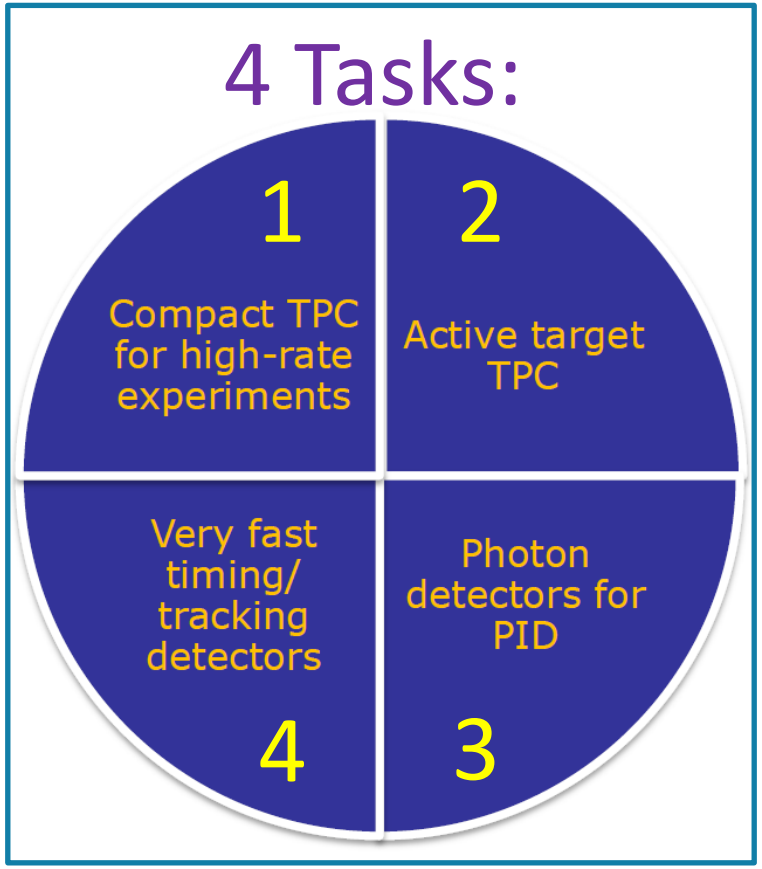
Rheinische Friedrich-Wilhelms-Universität Bonn,

GSI,

INFN-Bari, INFN-Trieste,

CEA-Saclay,

Participant number	40	10	2	8	44	30	13	24
Short name of participant	UAVR	UBO	OeAW	GSI	UGLASGOW	INFN	TUM	CEA
Person-months per participant:	6	12	3	4,5	3	14,5	5,5	5,5



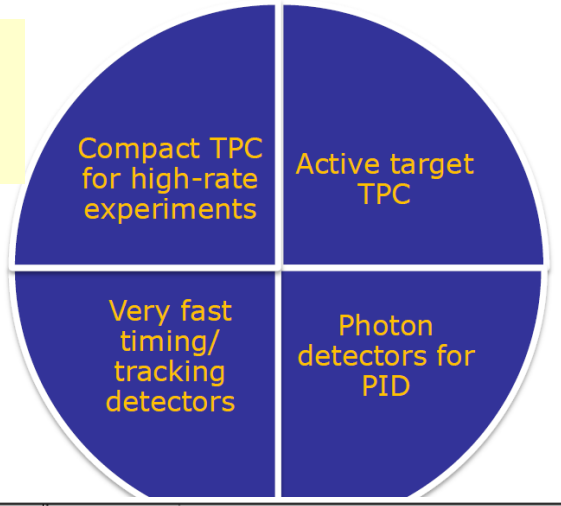
Objective:

improve gaseous detector capabilities for:

Tracking ***Particle identification***

Photon detection ***Timing***

3 milestones, 5 deliverables



Work package number	32
Work package acronym	MPGD_HP
Work package title	JRA14-Micropattern Gaseous Detectors for Hadron Physics

TASKS/Subtasks	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Compact micro-pattern TPC for high-rate experiments																
1.1 Numerical simulations for MPGDs																
1.2 Development of prototype TPC for high rates																
2. Active target TPC																
2.1 Active target TPC																
3. Photon detectors for PID																
3.1 Construction of a Minipad Modular PD																
3.2 Test of diamond-based photoconverters																
3.3 Test of windowless RICH PD prototype																
4. Very fast timing by Micromegas-based Cherenkov PDs																
4.1 Fast Cherenkov MM																

D32.1	Minipad Modular PD	WP32	30 - INFN	Demonstrator	Public	36
D32.2	Fast Cherenkov Micromegas Detector	WP32	24 - CEA	Demonstrator	Public	42
D32.3	A small-scale prototype of the high-rate TPC	WP32	13 - TUM	Demonstrator	Public	48
D32.4	Simulation results on energy ranges and resolutions in active target TPC	WP32	10 - UBO	Report	Public	48
D32.5	Publication of the diamond-based photoconverter performance in gaseous PDs	WP32	30 - INFN	Report	Public	48

Milestone title	Due Date (in months)	Means of verification
Design of prototype high-rate TPC	24	CAD production drawings
Investigation of beam-induced noise	27	Report
Diamond-based photocathode QE in gas	30	Submission of journal article to International Peer Review

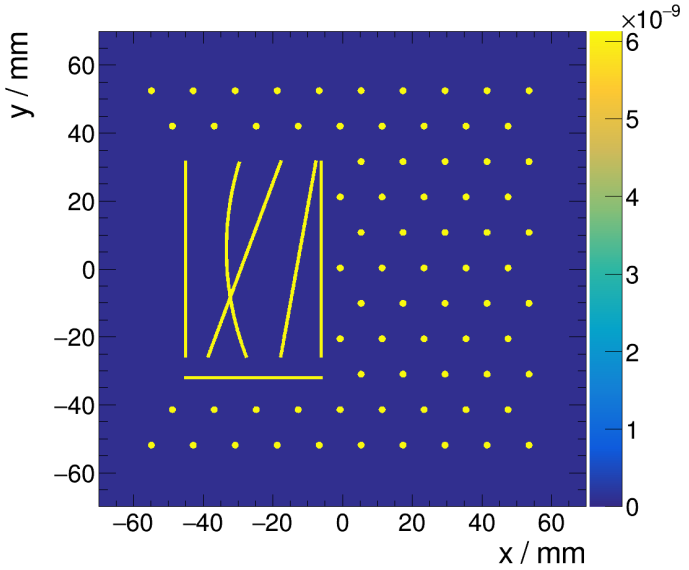
Contracts to: **Chandradoy Chatterjee (INFN – Trieste)**
Martin Hoffmann (University of Bonn)
Luciano Velardi (INFN – Bari)
Triloki Triloki (INFN – Trieste)

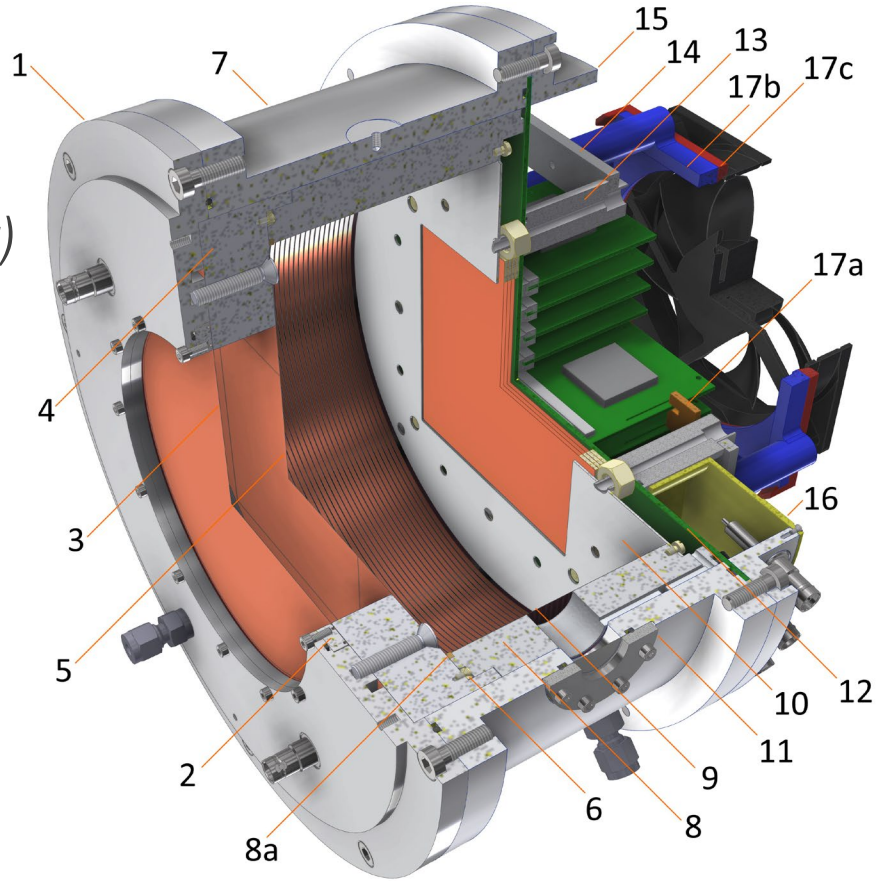
The milestones of Task 1 and Task 2 have been achieved in due time.
The remaining milestone will be reached before December 31st.

Task 1: compact TPC for high rate

University of Bonn

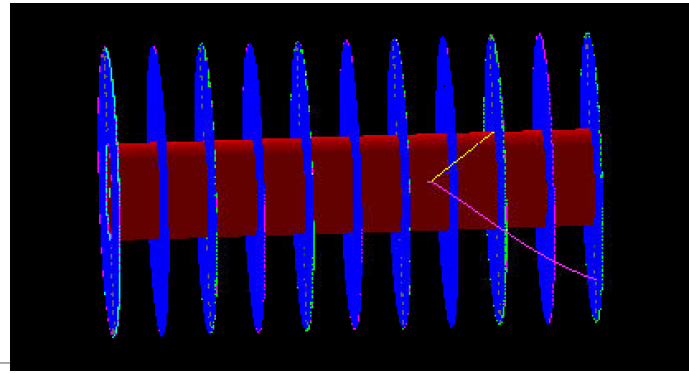
- *Design of Prototype High-Rate TPC ready* ***(Milestone 80)***
  - *uses UV laser system to monitor/calibrate distortions due to space charge*
  - *Cathode with specially designed pattern of dots / tracks (Al deposition on Cu)*
  - *triple or quadruple GEM stack*
  - *precision field cage*
  - *hexagonal readout pads*
  - *T2K AFTER chip for readout*



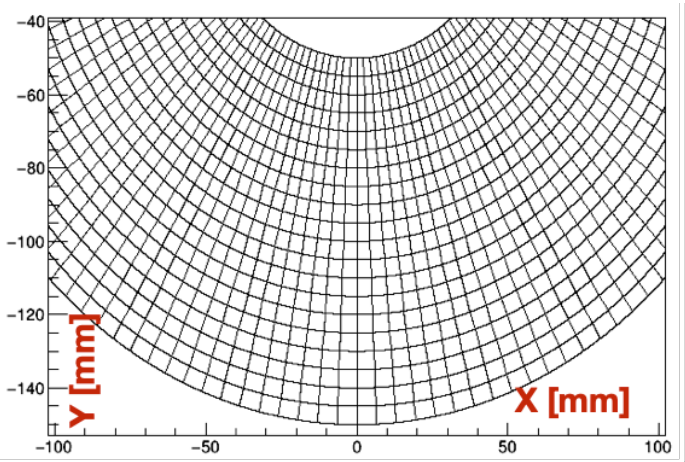


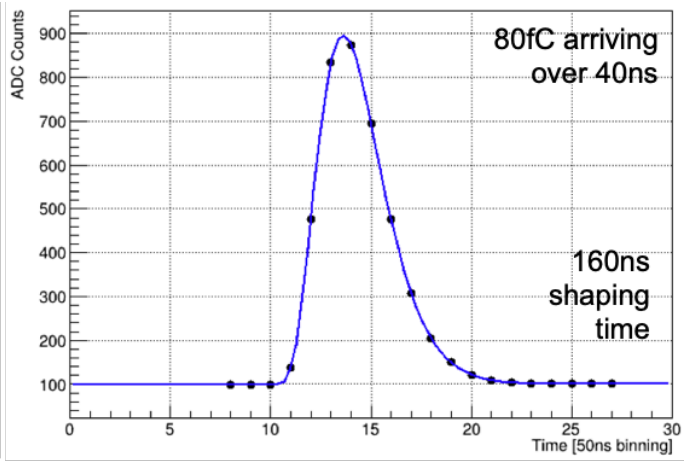
D. Schaab, PhD Thesis, Univ. Bonn, 2021

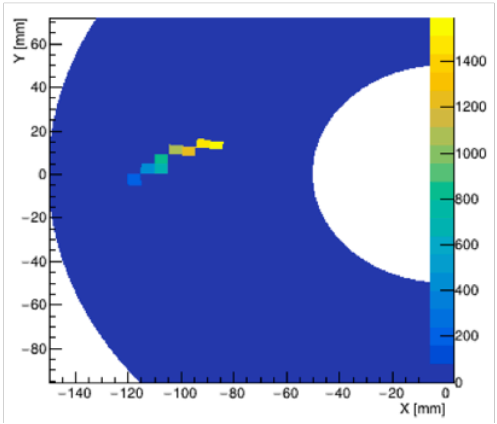
Task 1: compact TPC for high rate

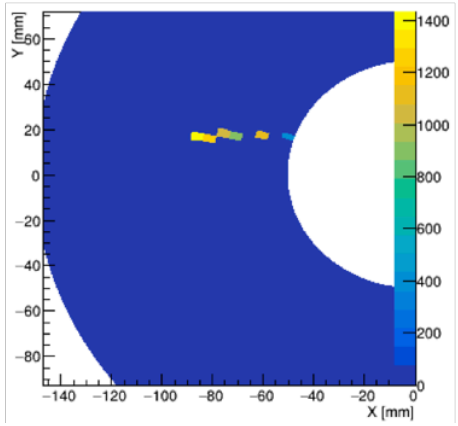


University of Glasgow









1. Development of design of multiple time projection chamber (mTPC) for upcoming meson structure studies at Jefferson Lab (JLab) continues on track

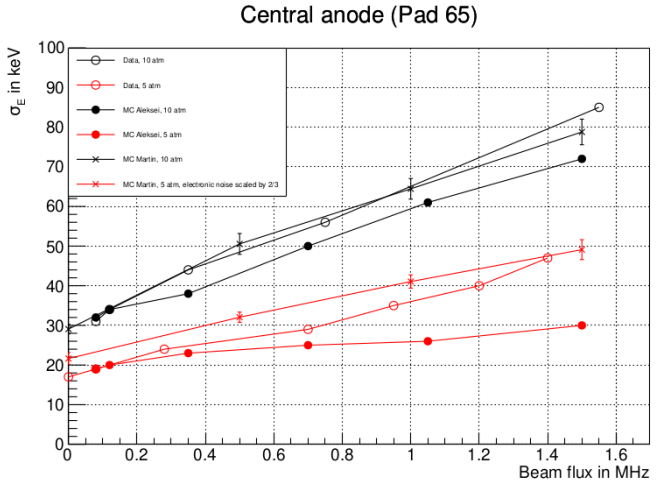
2. Mostly Geant4, Garfield++ and MAGBOLTZ simulations to optimise mTPC design

3. Additionally colleagues at JLab testing readout ASIC front end card prototype which is being used as input for simulations

4. Colleagues at University of Virginia building hardware for first prototype to be constructed and tested before Summer 2022

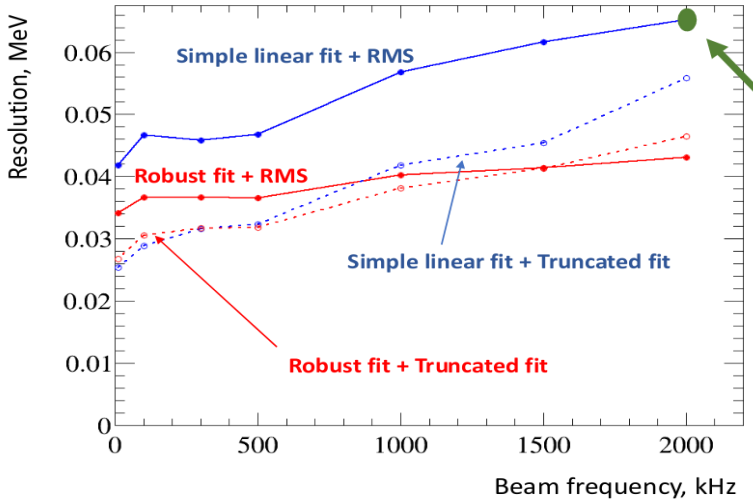
Task 2: active target TPC

Analysis of the signals *(Milestone 81)*



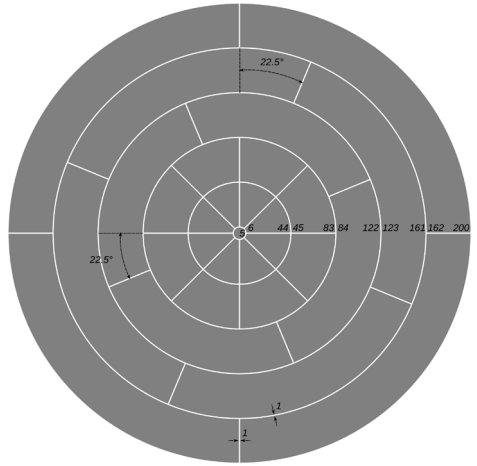
- ACTAF TPC at MAMI, 96% He, 4% N2
- Pulse energy: 1.5 MeV, 720 MeV electrons
- Simulated energy resolution of the central pad is in agreement with measured data
- Cooperation with A. Dzyuba (PNPI)

Results and comparison

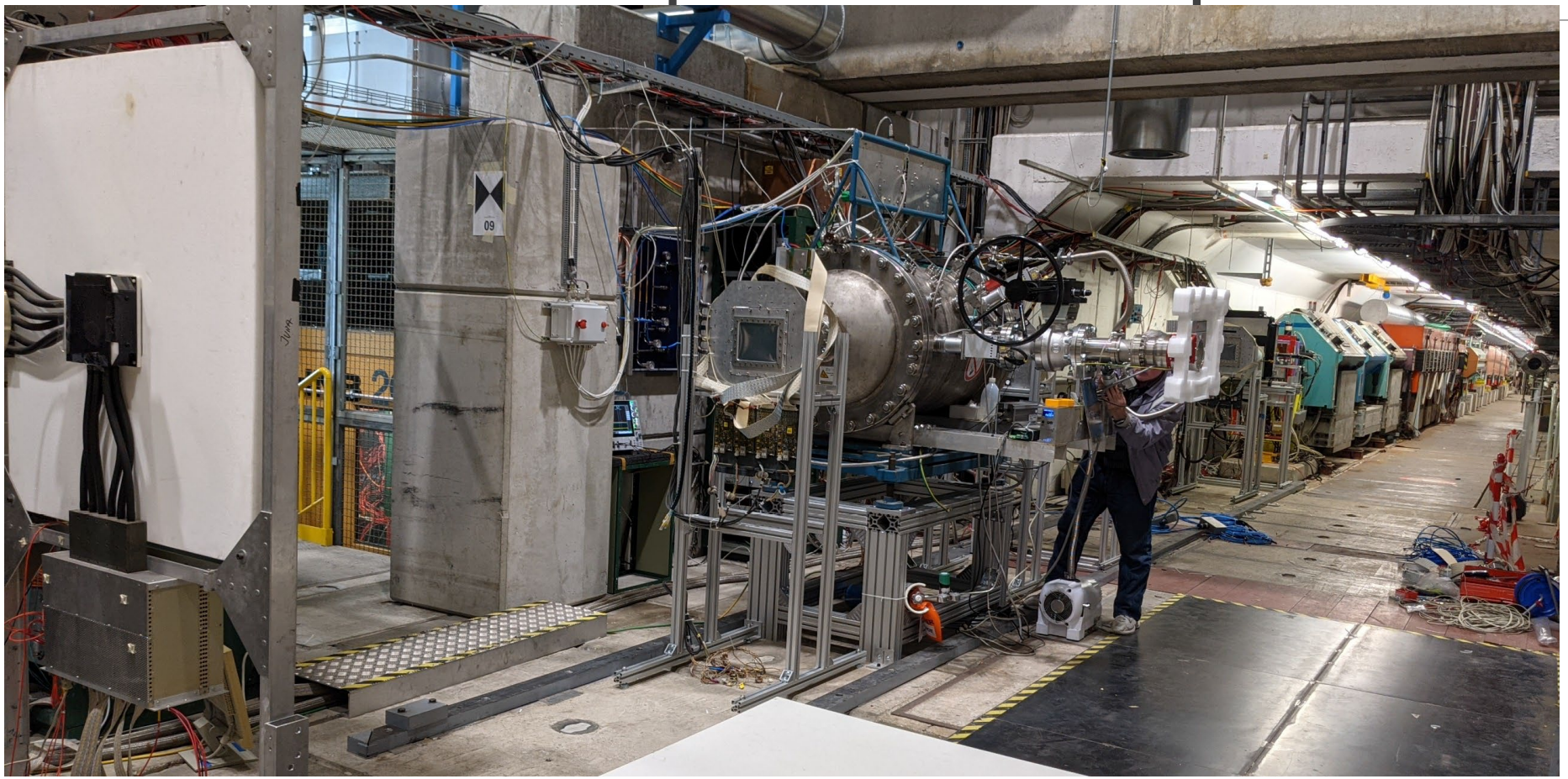


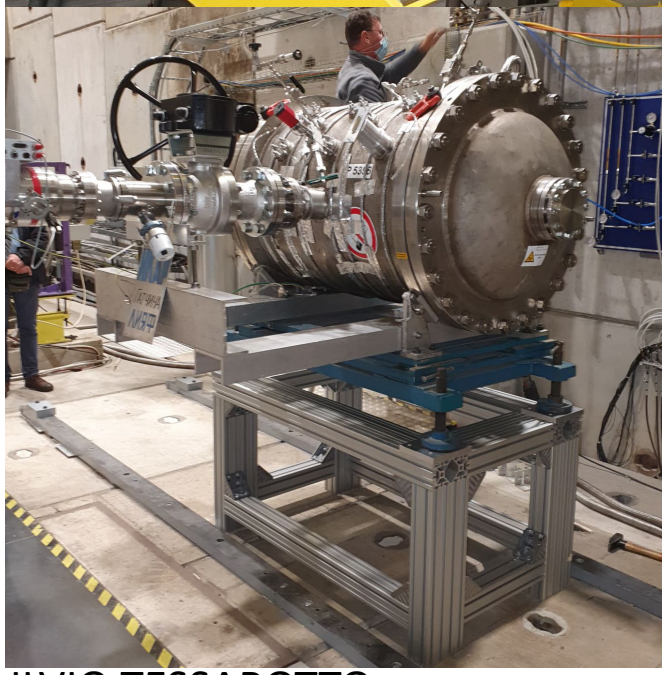
- Calibration matters!
- Simple linear fit + RMS to be compared with TGeant-based predictions
  - 65.0 ± 1.5 keV (with an energy bias)
  - 64.8 ± 1.4 keV (with more included muon hits)
- Nice agreement

- IKAR TPC for pilot run 2021, 8 Bar H2
- Proton: (1.4 – 1.6) MeV, 100 GeV muons
- Analysis of pilot run starting
- Cooperation with A. Dzyuba (PNPI)



Task 2: active target TPC
AMBER proton radius pilot run

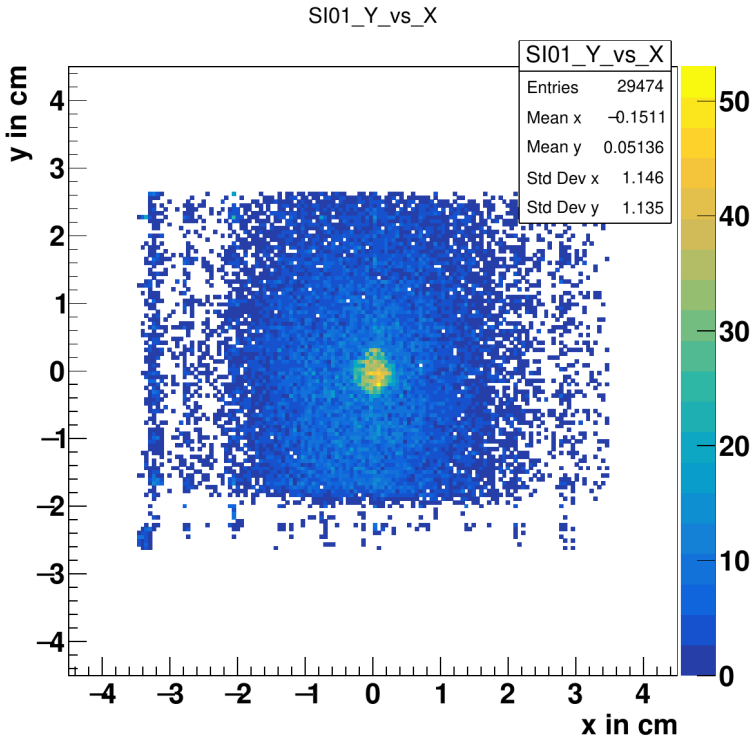


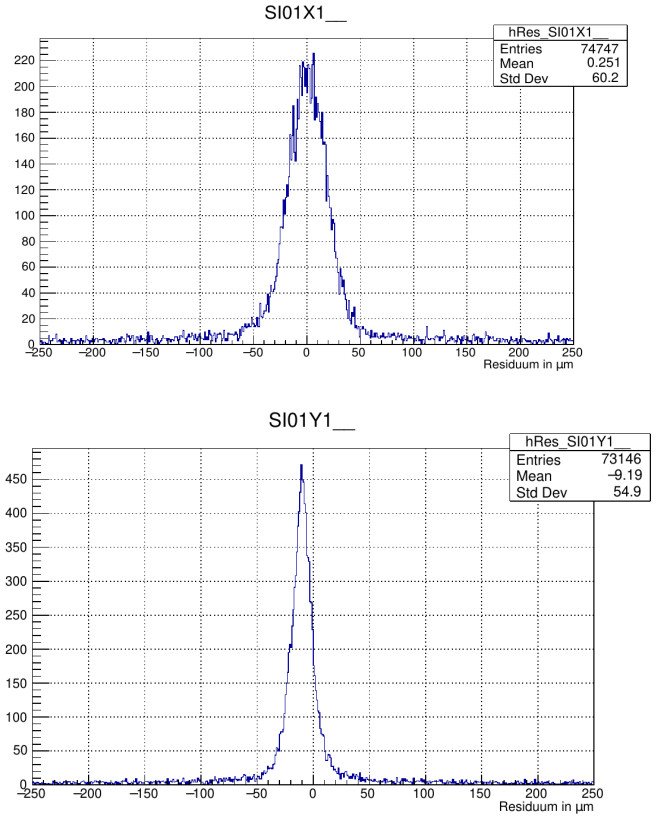


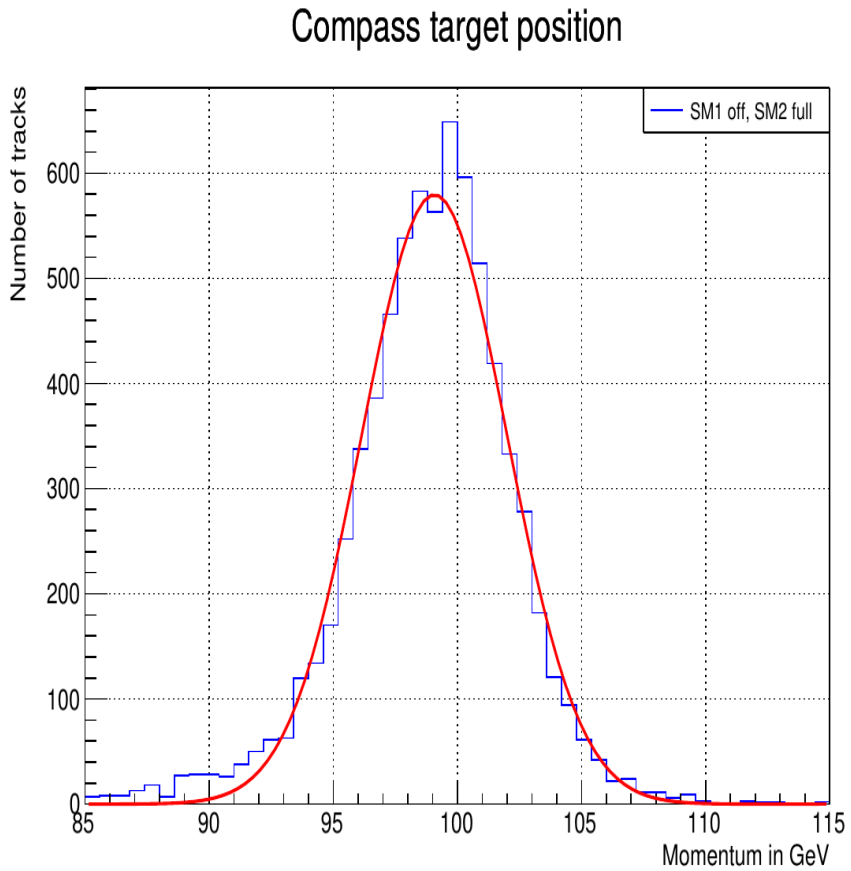
CERN M2 beam line

Task 2: active target TPC
AMBER proton radius pilot run

- Successful data taking during October 2021
- First reconstruction ongoing



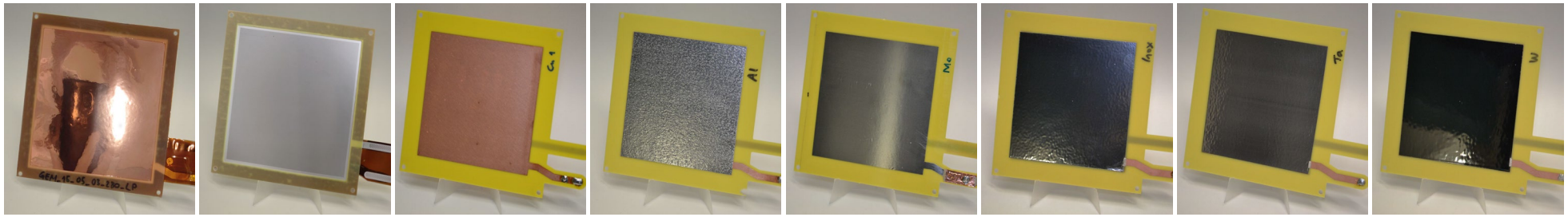




Task 3: Photon Detectors for PID

systematic THGEM discharge study

TUM



Cu GEM | Al GEM | Cu THGEM | Al THGEM | Mo THGEM | Inox THGEM | Ta THGEM | W THGEM

Studying the effect of the foil material composition on the formation of electrical discharges

Using optical spectroscopy to analyse discharge light

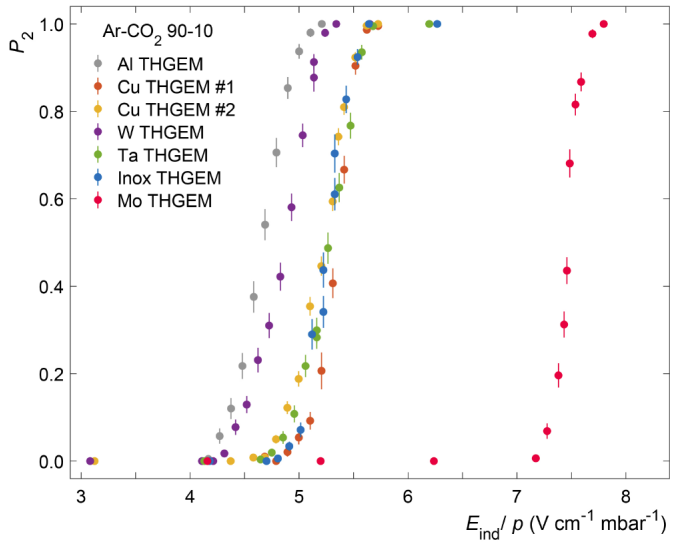
- Foil material evaporation during primary discharges is observed in GEMs but not in THGEMs
- Better dissipation of generated heat from discharges with THGEMs

No material dependence observed for primary discharge stability

Clear material dependence observed for secondary discharge stability

- Using Molybdenum as the electrode layer shown to be a great candidate for stable operation with extreme fields

NIM A 1019 (2021) 165829

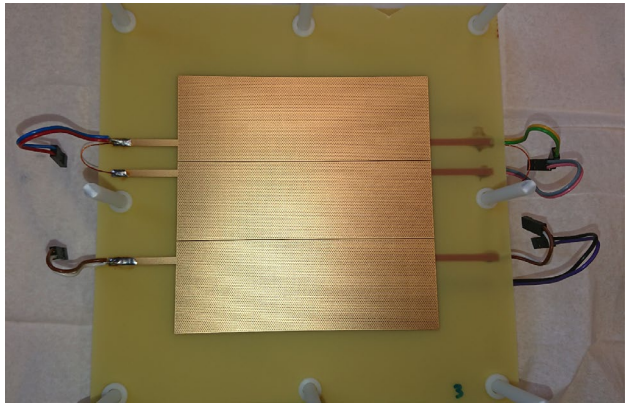


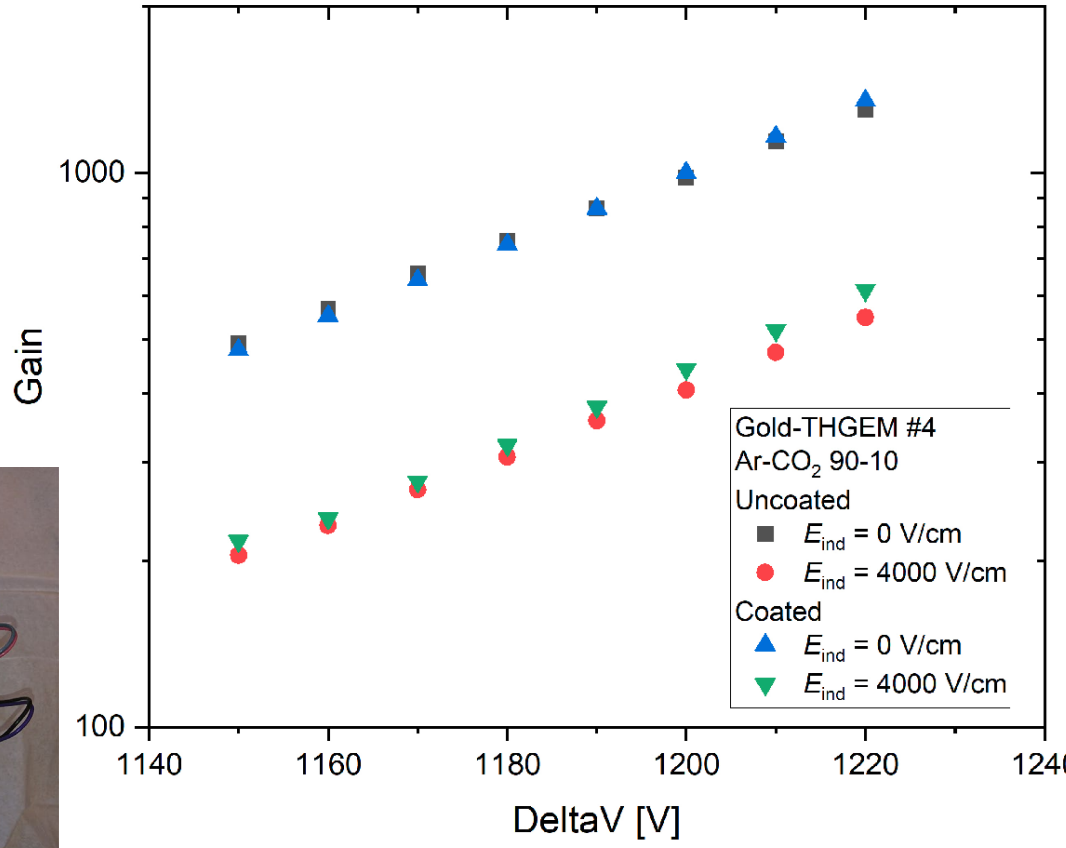
Task 3: Photon Detectors for PID

photon detection with THGEMs

TUM

- **Working principle**
  - THGEM coated with photosensitive material
  - Multiply electrons from photoelectric effect with THGEM
  - Segmented readout plane for position information
- **Commissioning ongoing with D2 lamp**
  - Successful coating of THGEMs with CsI at TUM
  - THGEM maintained performance





Task 3: Photon Detectors for PID

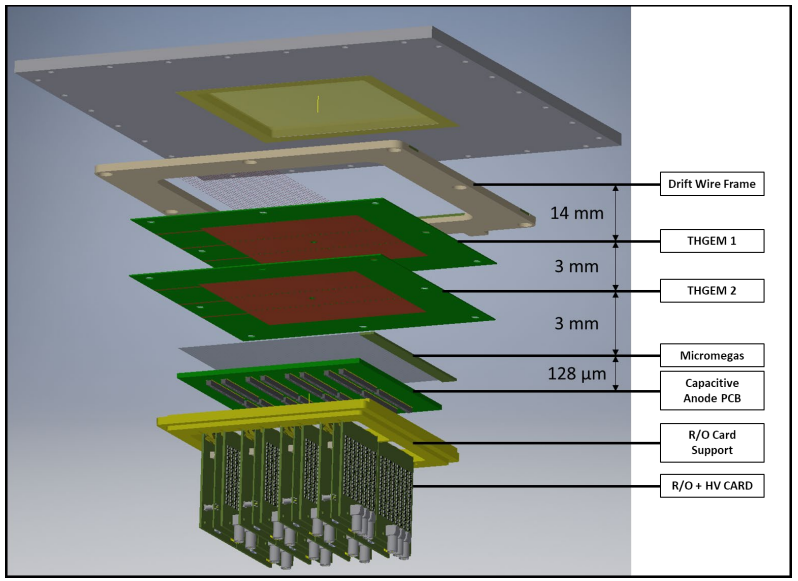
New THGEMs

INFN - Trieste

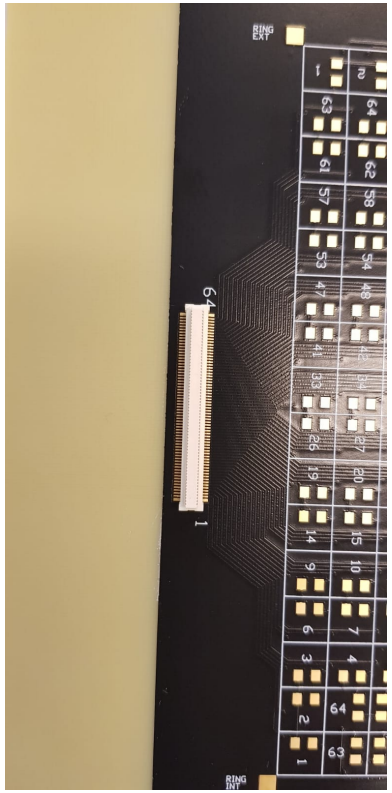
Modular structure: all components and services within the active area.

Prototype with 10x10 cm^2 active area.

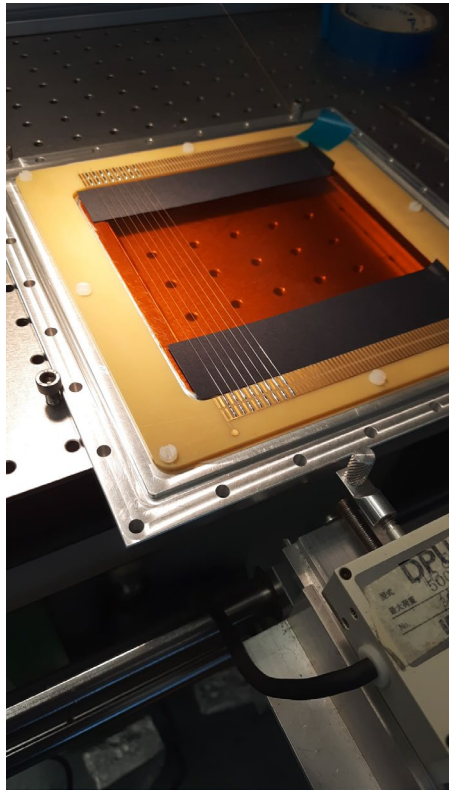
1024 square pads of 3x3 mm^2 with 0.5 mm inter-pad space



New prototype under construction.



Anode layout geometry developed, compatible with APV25 and VMM readout systems



VMM tests ongoing.

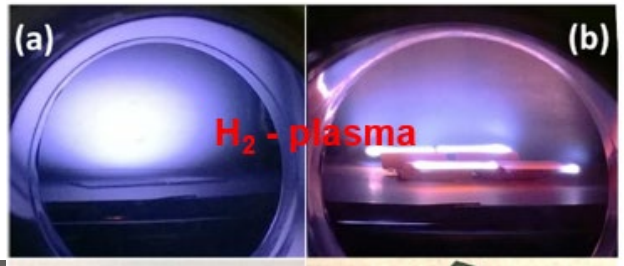
Task 3: Photon Detectors for PID

INFN - Bari

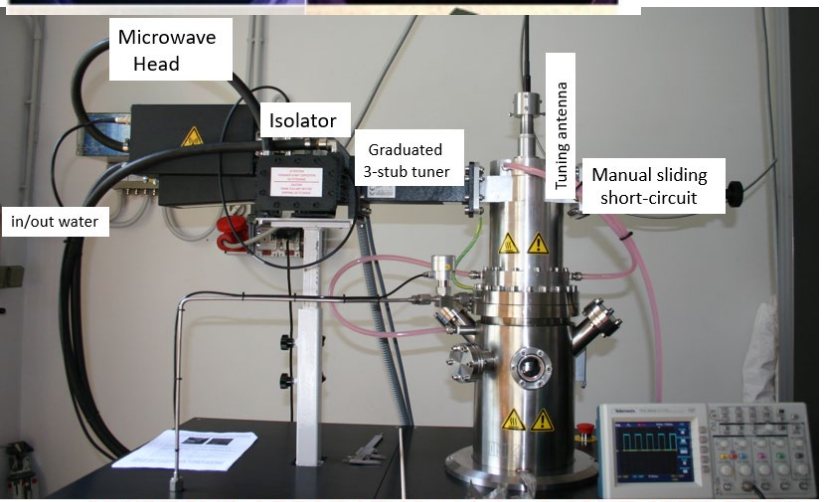
Systematic Study of *Quantum Efficiency* and *Gain* on 3 types of ND particles

new UV photocathode:
hydrogenated nanodiamond powder

Types of ND particle (untreated)	Hydrogen treatment of ND in Microwave H_2 Plasma (Treated =hydrogenated)
ND E6 grain size 250 nm	H-ND E6 grain size 250 nm
ND D&T grain size 250 nm	H-ND D&T grain size 250 nm
ND BDD* grain size 500 nm *Boron-Doped Diamond	H-ND BDD* grain size 500 nm

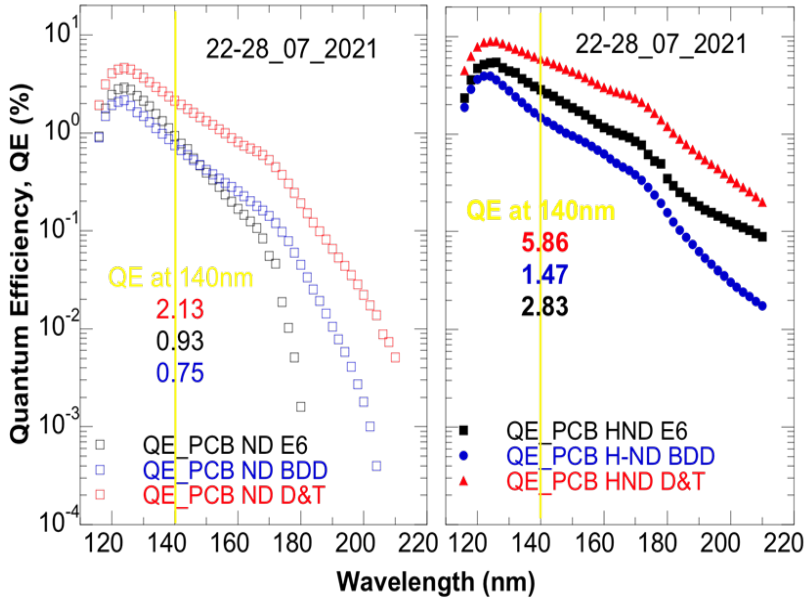


Substrates:

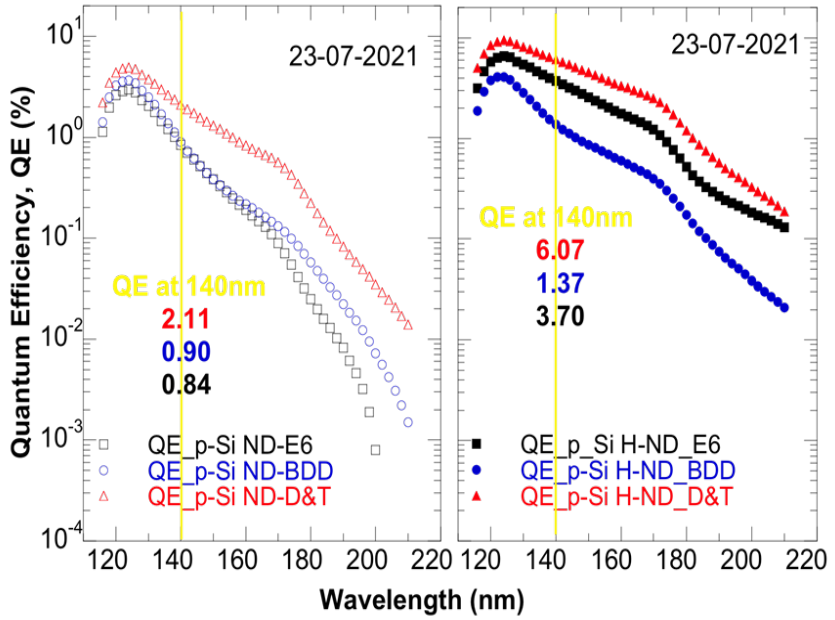


MWPECVD APPARATUS at lab of (CNR-ISTP BARI)

PCB



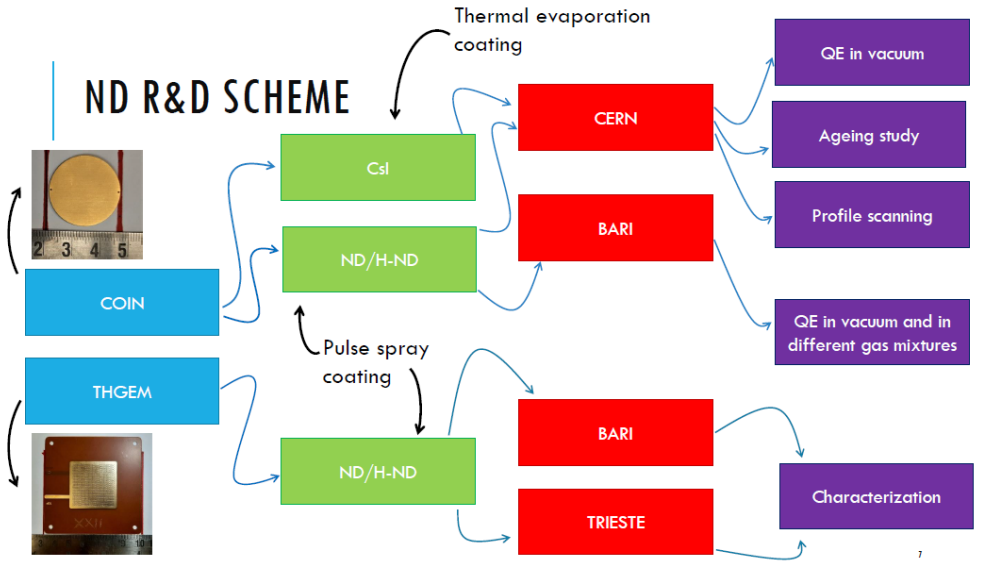
SILICON

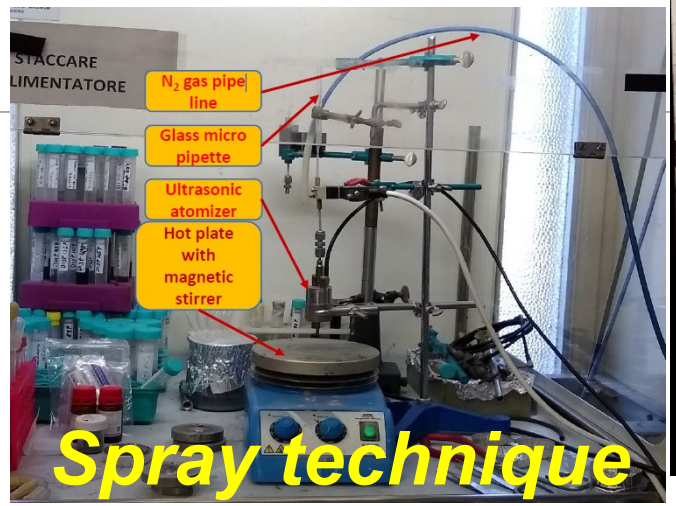


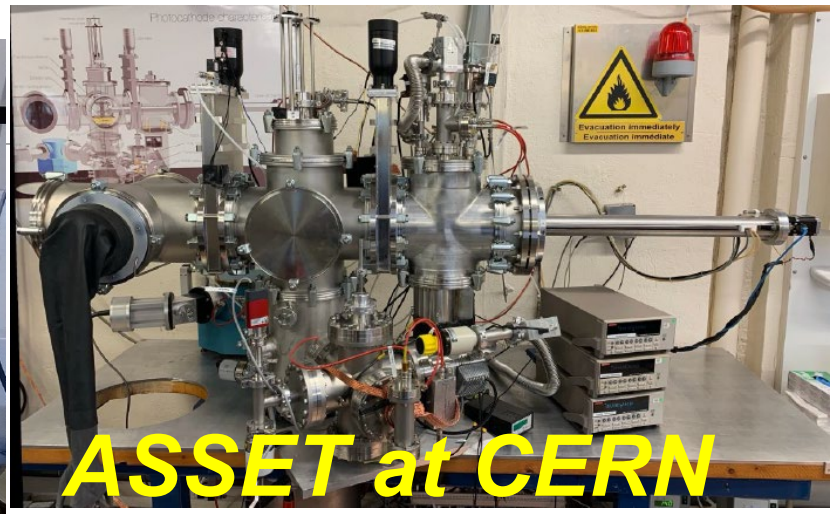
Task 3: Photon Detectors for PID

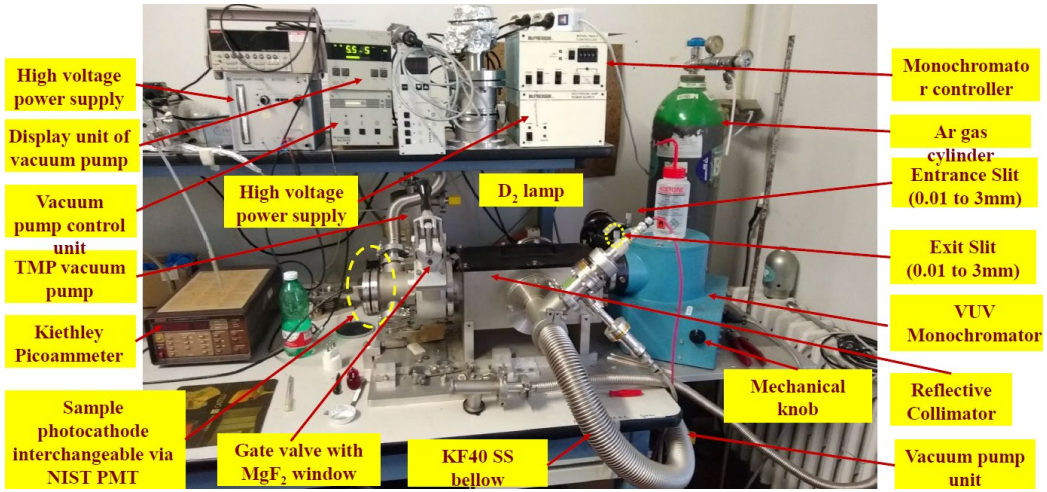
H-ND characterization

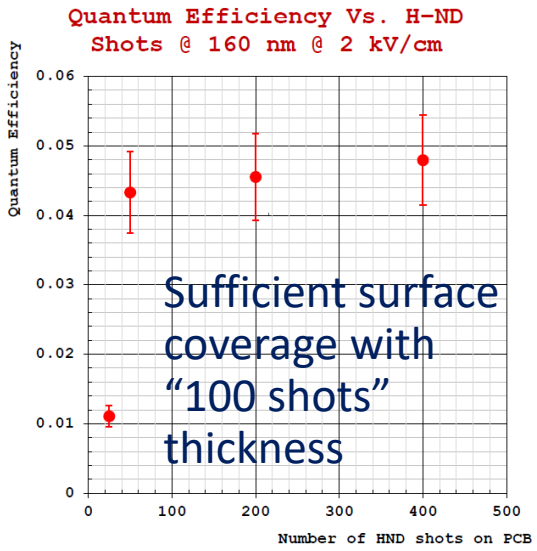
INFN – Bari, Trieste

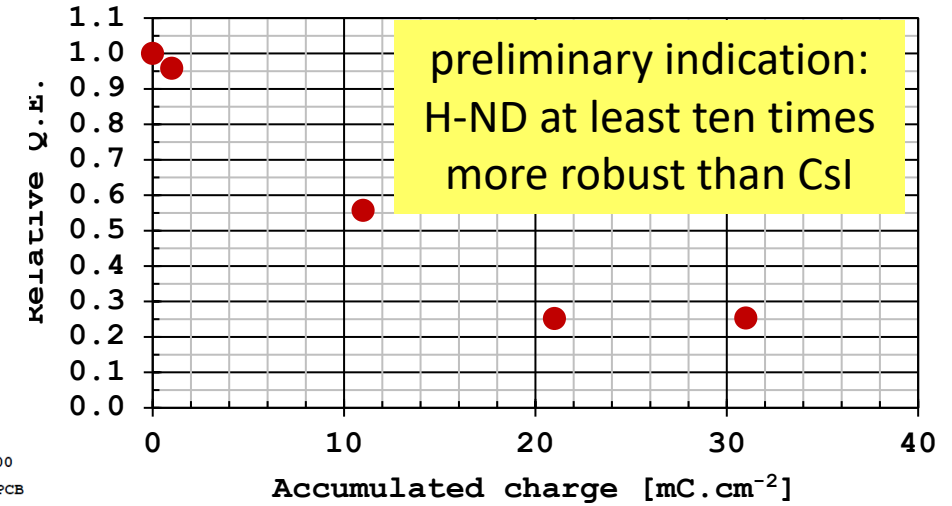








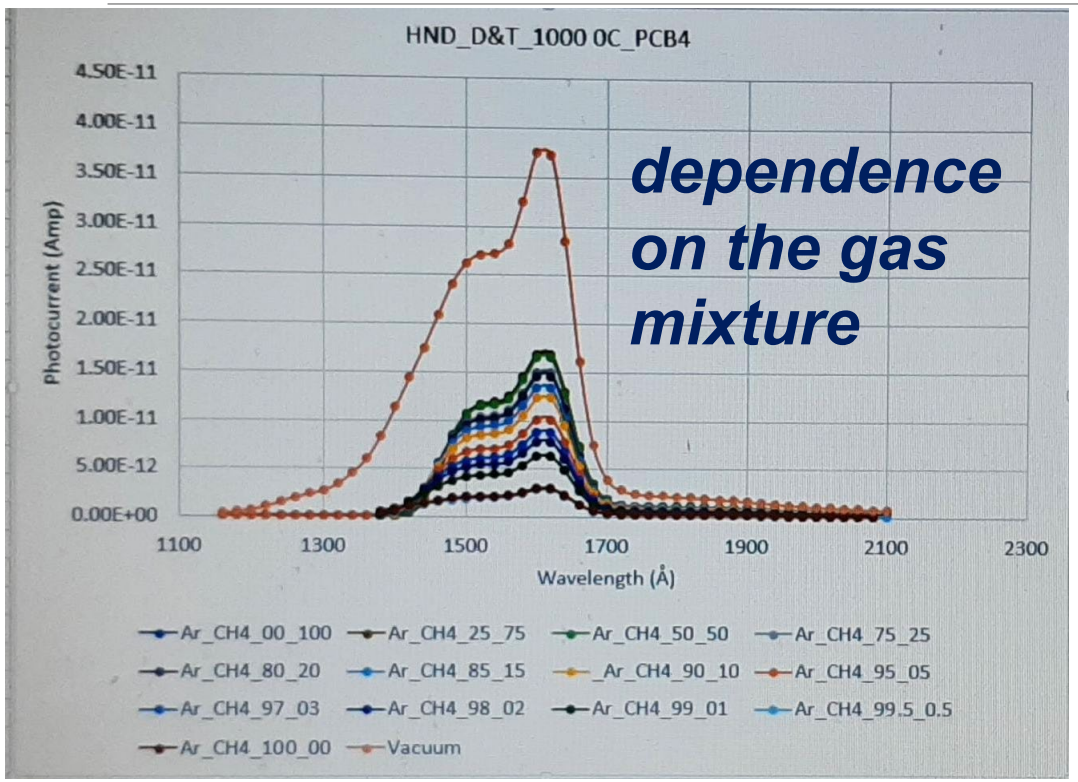


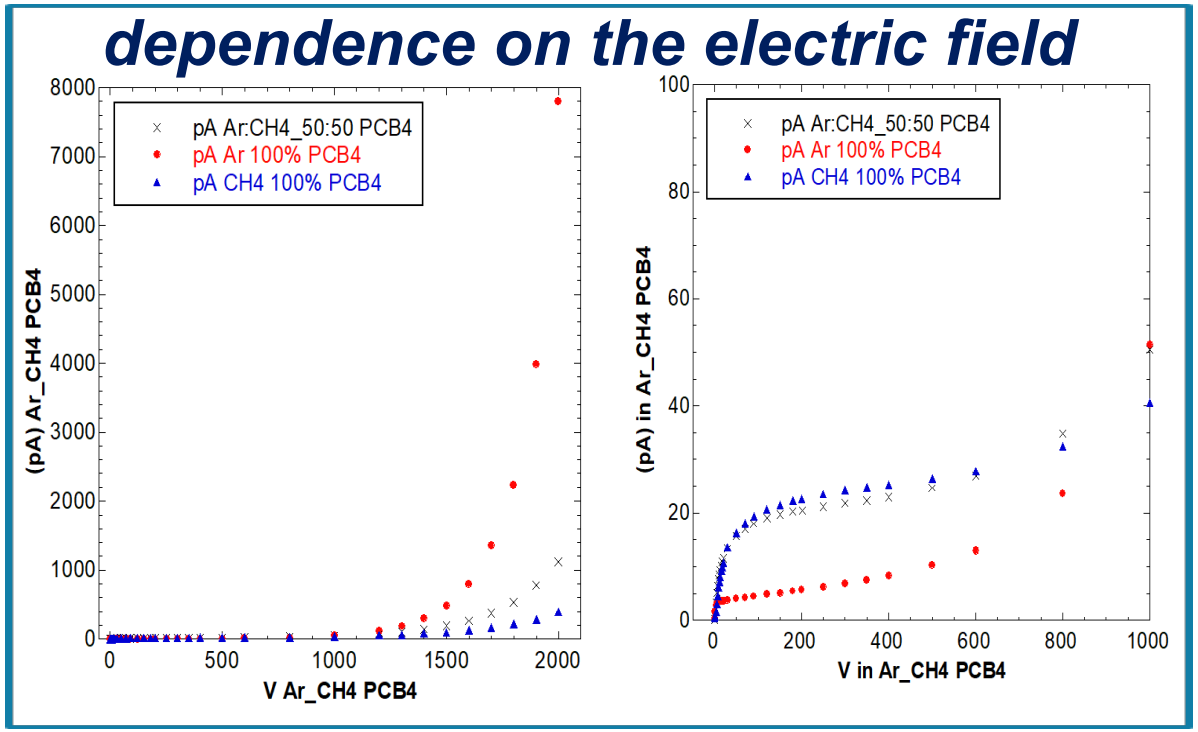


Task 3: Photon Detectors for PID

INFN – Bari, Trieste

PCs+H-ND: photocurrent measurements in different conditions





Set of systematic measurements performed in Bari
→ the milestone in December 2021 will be achieved

Task 4: very fast timing/tracking

Picosec: Micromegas-based detector concept

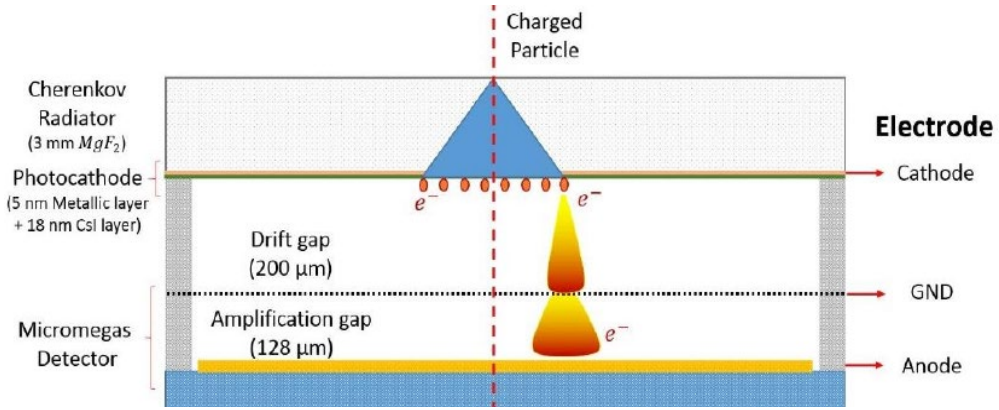
Primary electron produced on photocathode using Cerenkov light from 1-5 mm-thin MgF_2 radiator

Thin (200 μm) drift region to minimize diffusion effects and perform preamplification

→ time resolution ~47 ps for single photoelectrons, ~24 ps for 150 GeV muons

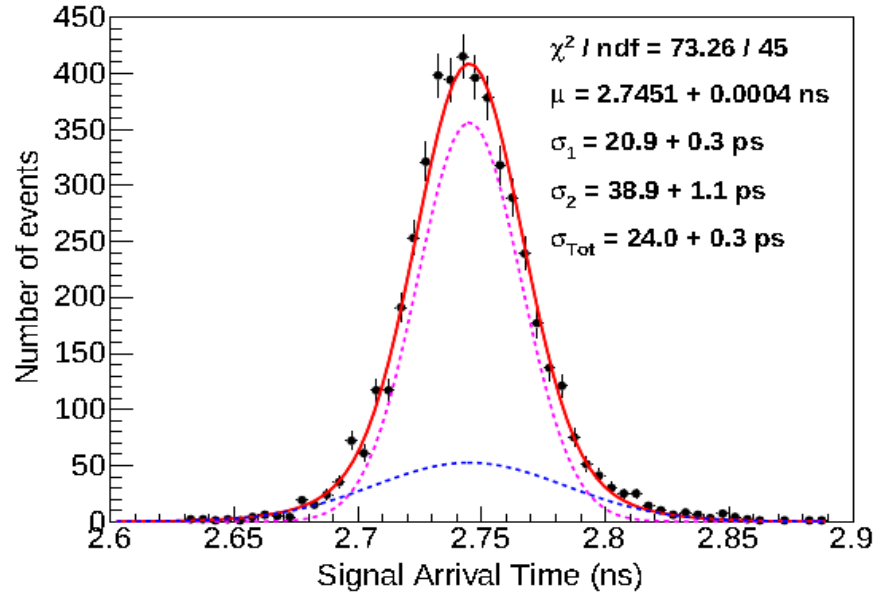
Limitations: spatial resolution at mm level, fragility of the CsI layer on photocathode

Saclay



NIM, A 903 (2018) 317–325

J. Va'vra & I. Manthos talks, MPGD2019

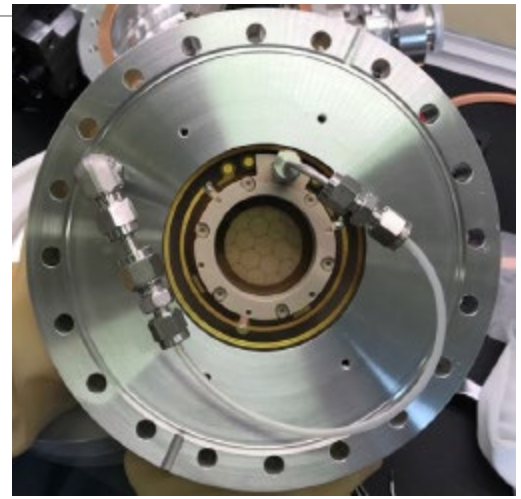


Prototype successfully tested at CERN (last week)

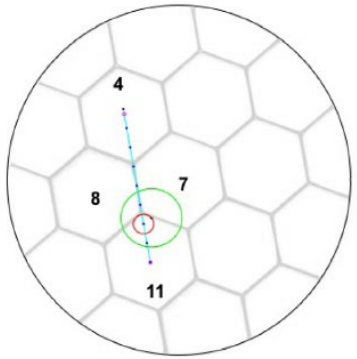
Task 4: very fast timing/tracking

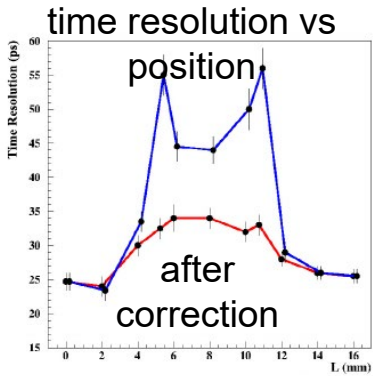
Multi-channels prototypes

Saclay



1 5cm-large prototype showed degraded time resolution, but offline reconstruction and analysis allowed to reach 30ps maximum time resolution





S. Aune et al., NIM A 993 (2021) 165076

New prototypes produced, still 5cm-large but with better planarity and a resistive layer. Optimized front-end amplifiers. Several photocathodes tested: CsI, DLC (3 to 10nm), B_4C (4 to 12nm)

Tested with muon beam at end of October 2021 SPS beam tests, very promising online results, analysis will start soon

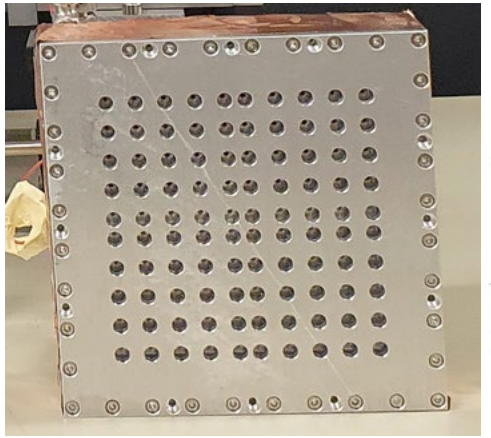
R&D foreseen on impact of the resistive layer and its resistivity. Different connection schemes of the resistive layer considered

Task 4: very fast timing/tracking

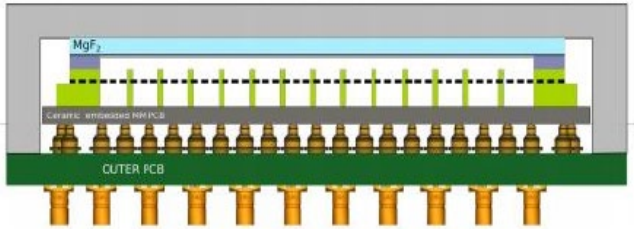
First prototypes produced by CERN with square and hexagonal pixels. Tested on muon beam end of October, promising online results, analysis to be started

Quite complicated board with large material budget: sandwich of PCB + 3 layers of ceramics + PCB connected through springs to insure planarity and therefore time resolution

New “thin” board under study



1-channel and 8-channels amplification cards



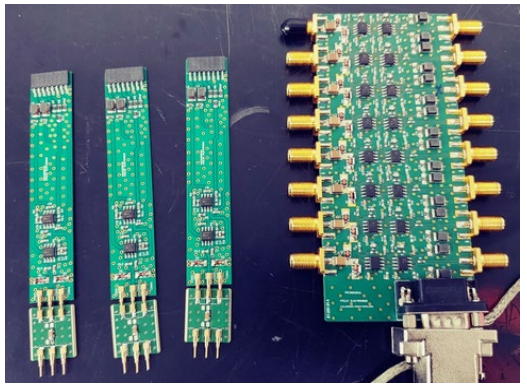
16-channels SAMPIC acquisition module

Discrete front-end fast preamplifiers, optimization ongoing

8-channels cards produced, with same performance as 1-channel ones

Digital readout based on SAMPIC high-resolution TDC chips

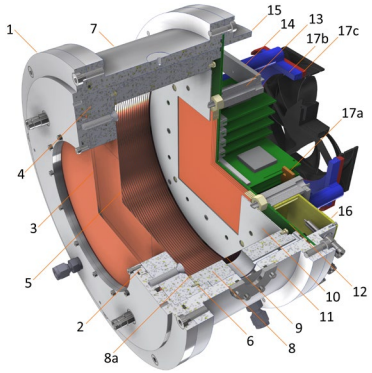
Next steps: higher density front-end cards (16 or 32 channels) with multi-channels connectors and flat cables; 256-channels TDC crate based on 64-channels SAMPIC modules



JRA 14 MPGD-HP Summary

The WP 32 activities are on track despite Covid-19.

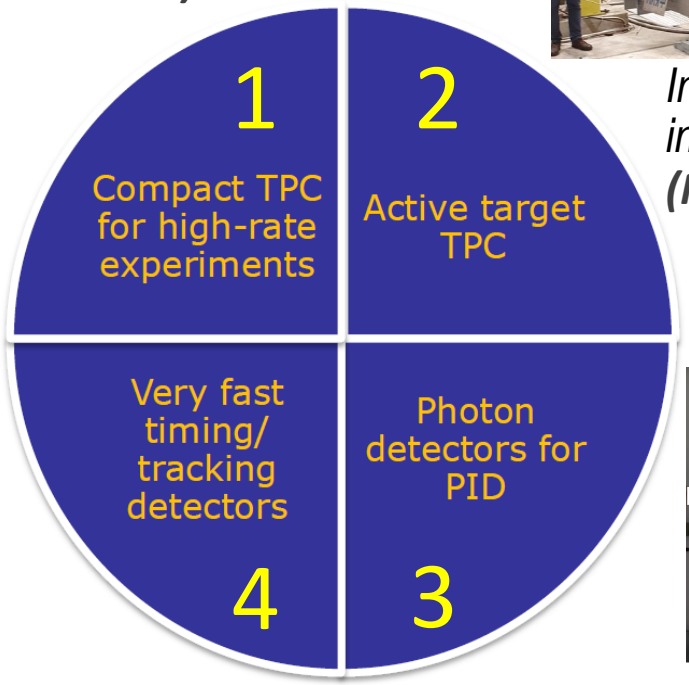
Milestones are achieved in due time



Design of Prototype High-Rate TPC ready ***(Milestone 80)***

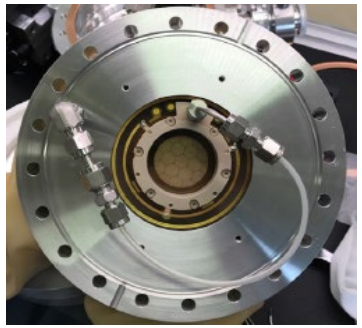
Investigation of beam induced noise performed ***(Milestone 81)***.

IKAR TPC operated for AMBER pilot run



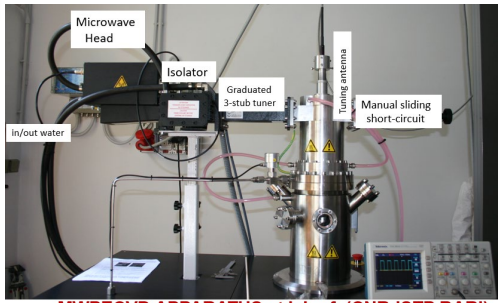
MultipleTPC design and prototyping

Multichannel Picosec prototype, resistive anode and different photcathodes



Large area Picosec prototype and new frontend

QE of hydrogenated nanodiamond ***(Milestone 81)***



THGEM-based photon detectors optimization