

WG8

Training and Dissemination

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on behalf of WG8

RD51 Collaboration Meeting, December 8, 2023

Working Group 8 - Training and Dissemination

Discussions started \approx 1.5 years ago during RD51 Future Day

First activity to organise school with lectures + lab exercises

-> forming of WG8: Training and Dissemination

During 2023:

13 meetings of WG8

+ numerous smaller meetings dedicated to lab exercise preparations

WG8 mailing list with >50 members

Job opportunities

Posting job opportunities on RD51 website and via mailing list

Please send us any openings you would like to advertise

The screenshot shows the RD51 Collaboration website. At the top, there is a navigation bar with the RD51 logo and menu items: HOME, ORGANISATION, ACTIVITIES, MEETINGS, DOCUMENTS, and OTHER LINKS. A sidebar on the left contains links for Instrumentation conferences (MPGD-related), Safety, RD51 Pictures, and Job Opportunities. The main content area is titled "Job Opportunities" and includes a brief introduction and an email address for submitting new openings. Below this is a table listing four current job openings.

Job description	Institution	Date posted	Link	Contact
Post-doctoral research associate position on dark matter searches	University of Hamburg	November 2023	Description	Konstantinos Nikolopoulos
Post Doctoral Fellow at Hall B	Jefferson Lab, USA	October 2023	Description	Kondo Gnanvo
PhD position at Bari on MPGD-HCAL	Bari University	August 2023	Description	Luigi Longo
2-years postdoc position at INFN section of Bari, Italy on high pressure TPC with optical read-out	INFN Bari	July 2023	Contact	Emilio Radicioni

School planning - survey

18 responses to survey

Most are interested / available as tutor

Many available to tutor assembly / operation / characterisation exercises

Many ideas / comments for lab sessions on detector characterisation

Some suggestions for readout lab exercise

Which lab exercise topic(s) would you like to be a tutor for?

Answered: 18

A. Detector assembly: 9 (19.15%)

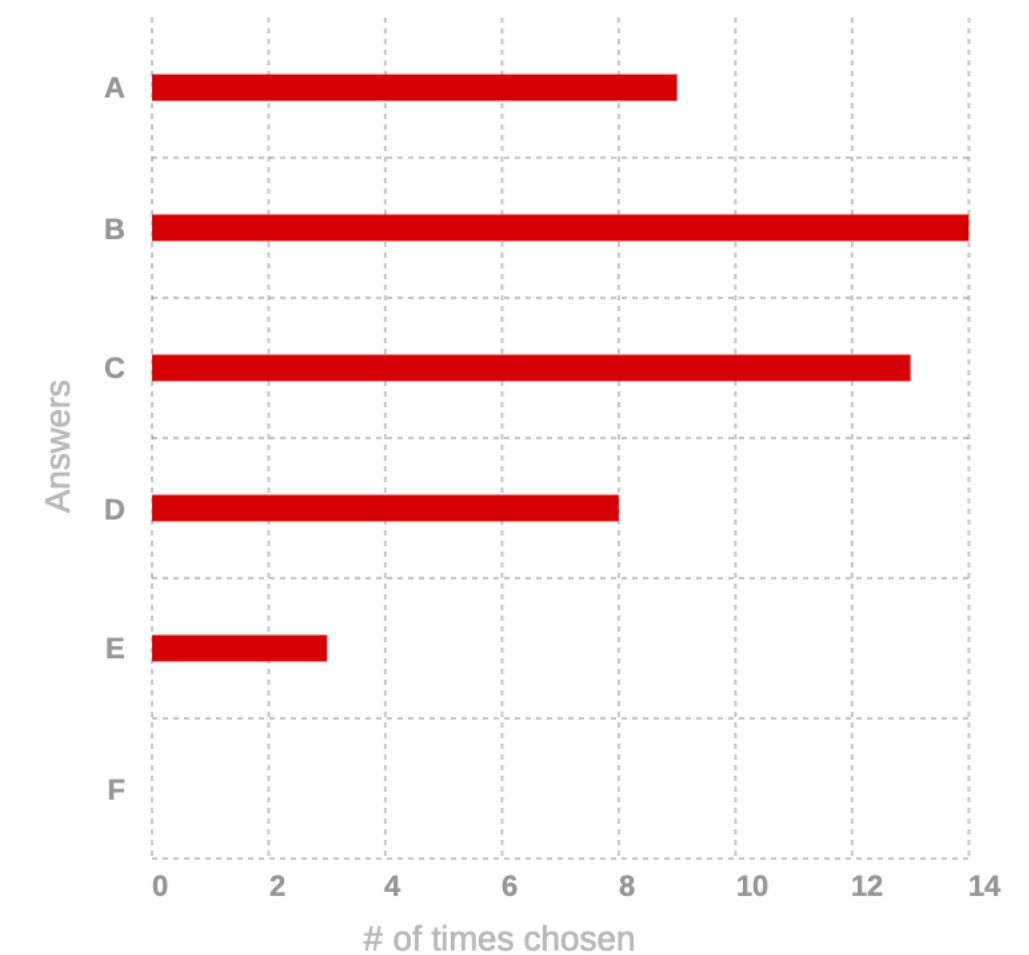
B. Detector operation: 14 (29.79%)

C. Characterisation (e.g. gain measurement): 13 (27.66%)

D. Readout techniques (e.g. tracking, electronic, optical readout): 8 (17.02%)

E. Simulation: 3 (6.38%)

F. Other (please specify below): 0 (0.00%)



Do you consider a group size of 3-4 students reasonable for lab exercises?

Answered: 18

A. Yes: 17 (94.44%)

B. No: 1 (5.56%)



Overview

Regular school focused on MPGDs and techniques of MPGD development

- **Sharing knowledge** and expertise about MPGDs
- Establishing **good practices** and approaches for common tasks and measurements in studying and developing detectors
- Applications of MPGDs

Lecture topics

- **Gas detectors physics**

- Historical introduction: MWPC to MPGD
- Energy Loss: Coulomb Interactions
- Drift and Diffusion of Charges
- Avalanche multiplication
- Gas properties

- **MPGD technologies**

- Detector geometries
- Resistive elements
- Beyond working point physics
- Discharges and mitigation in gaseous detectors
- State-of-the-art MPGDs (high rate, precise timing, resistive elements)

- **Readout technologies**

- Electronic readout
- RD51 SRS readout demonstration
- Optical & hybrid readout

- **Simulation and modelling**

- Signal formation
- Modelling approaches
- Simulation frameworks & tools

- **Manufacturing techniques**

- Photolithography / etching / drilling
- Advanced pattern techniques and additive manufacturing

- **Applications**

- High Energy Physics
- Applications beyond HEP
- Beyond fundamental research

Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 - 9:00	Registration				
9:00 - 10:00	Introduction: Gas detectors (F. Sauli)	Gas detector physics 2: beyond working point physics (P. Gasik)	Modelling and Simulation 1 (R. Veenhof)	Electronic readout techniques (M. Lupberger)	MPGDs in HEP applications (P. Iengo)
10:00 - 11:00	Gas detector physics 1 (F. Sauli)	MPGD technologies 2: State-of-the-art MPGDs (E. Oliveri)	Modelling and Simulation 2 (P. Verwilligen)	RD51 SRS readout demonstration (M. Lupberger)	Applications beyond HEP: nuclear physics, dark matter searches, neutrino physics (M. Cortesi)
11:00 - 11:30	Break	Break		Break	Break
11:30 - 12:30	MPGD technologies 1 (E. Ferrer Ribas)	Manufacturing techniques (R. De Oliveira)	ATLAS visits	Optical & hybrid readout techniques (D. Pinci)	Applications beyond fundamental research (J. Bortfeldt)
12:30 - 13:00	MPT visit	Group photo + MPT visit	MPT visit	MPT visit	MPT visit
12:30 - 14:00	Lunch break	Lunch break	Lunch break	Lunch break	Lunch break
14:00 - 18:00	Lab session	Lab session	Lab session	Lab session	Lab session
18:00 - 21:00		Student poster session			

Tutors & Lecturers

Huge amount of work in preparing lab exercises, lab book, lectures and visits!

Tutors		Lecturers		Visits, demonstration, organisation
Piotr Gasik	Gianni Bencivenni	Fabio Sauli	Piet Verwilligen	
Maria Teresa Camerlingo	Marco Cortesi	Esther Ferrer Ribas	Michael Lupberger	Michael Lupberger
Givi Sekhniaidze	Sara Leardini	Piotr Gasik	Davide Pinci	Lucian Scharenberg
Luca Moleri	Marta Lisowska	Eraldo Oliveri	Paolo Iengo	Rui De Oliveira
Marco Sessa	Giorgio Orlandini	Rui De Oliveira	Marco Cortesi	Betrand Mehl
Paolo Iengo	Piet Verwilligen	Rob Veenhof	Jona Bortfeldt	Givi Sekhniaidze
Davide Fiorina				George Iakovidis
Riccardo Farinelli				Aimilianos Koulouris
				Veronique Wedlake

and many others during lab book preparation and planning...

Thank you!

Applications

Opened applications in February with deadline end of July

>60 applications for 24 places, applications reviewed selection done by selection committee

In addition to school applications, registration for lecture program (in-person & remote)

>120 registrations for lecture program

Lecture program

14 lectures of 1h each

Time for discussions and questions
Questions during first day leading also to follow-up discussion of GEM hole geometry by Fabio.

≈40-50 people in Salle Dirac
+ ≈40 people connected via Zoom



All lectures recorded and available on Indico agenda

Registration to event necessary for download



Visit program

Visits to ATLAS cavern and MicroPattern Technologies workshop are organised

ATLAS cavern
organised in 3 groups

MPT Workshop
small group every day



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Poster session

Students were invited to present their current or previous work during dedicated poster session after lab exercises on Tuesday evening.

Lively discussions and exchanges during poster session in Main Building Mezzanine.

Posters uploaded and accessible on Indico page:

<https://indico.cern.ch/event/1239595/sessions/485794/#20231128>



Lab schedule

Small groups: 4 students each

Split in 6 groups, each group will perform 5 different lab exercises

Lab 1 Detector assembly	Lab 2 Detector operation	Lab 3 Detector characterisation	Lab 4 Readout techniques	Lab 5 Detector simulations
Survey of different MPGD technologies with microscope, electrical testing of amplification structures, assembly of detector stack	Familiarity with typical lab instrumentation, gas systems, HV supplies, readout chains, signal shapes, basic operation and readout	In-depth detector characterisation, voltage scans of drift/transfer/amplification fields, effect of change of operating conditions	Electronic and optical readout techniques, e.g. tracking, imaging, basic reconstruction	Introduction to Garfield++ based simulation, basic modelling, electric field map, microscopic tracking

	Monday	Tuesday	Wednesday	Thursday	Friday
Group 1	Lab 1 Location E	Lab 2 Location A	Lab 3 Location B	Lab 5 Location H	Lab 4 Location D
Group 2	Lab 1 Location F	Lab 2 Location B	Lab 3 Location A	Lab 5 Location H	Lab 4 Location C
Group 3	Lab 1 Location G	Lab 2 Location D	Lab 4 Location D	Lab 3 Location A	Lab 5 Location H
Group 4	Lab 2 Location A	Lab 1 Location E	Lab 4 Location C	Lab 3 Location B	Lab 5 Location H
Group 5	Lab 2 Location B	Lab 1 Location F	Lab 5 Location H	Lab 4 Location D	Lab 3 Location A
Group 6	Lab 2 Location D	Lab 1 Location G	Lab 5 Location H	Lab 4 Location C	Lab 3 Location B

Lab book

Detailed lab book prepared by tutors

For each lab:

- **Introduction** - background - link to lectures
- **Experiment setup** - detectors / instrumentation used
- **Work plan** - description of exercise including open questions
- Additional (optional) exercises

To prepare students ahead of exercise and aid discussions during lab session

Lab exercises guided by tutors

<https://indico.cern.ch/event/1239595/attachments/2600086/4803190/LabBook-RD51MPGDSchool.pdf>



Exercise 3 A: Gain, transparency, and Ion Back Flow (IBF) measurements in $\text{ArCO}_2\text{C}_4\text{H}_8(93:5:2)$ with resistive Micromegas detectors

Detector(s) under test:
Resistive micromegas detectors

Micromegas are single stage amplification gaseous detectors based on parallel plate electrode structure. The gas volume is divided into two gaps by means of a stainless steel micro-mesh: one gap between the mesh and the cathode plane, of a few mm (the conversion and drift gap), and the other gap between the mesh and the anode plane of about 0.1 mm (the amplification gap), with the anode hosting the read-out elements, usually micro-strips. An electric field of a few hundred V/cm is applied between the mesh and the cathode, in the drift region, while a more intense electric field with values of 40-50 kV/cm is supplied in the thin gap between the mesh and the strips (in the amplification region). For high rate applications and/or intense flow of highly ionising particles, discharge effects are greatly mitigated with the implementation of a layer of resistive strips facing the amplification gap [1]. This is, for example, the solution developed by ATLAS for operations up to few kHz/cm^2 [2].

Figure 1: Layout of Resistive strip micromegas bulk (CASE A)

References

[1] T. Alexopoulos, J. Burnens, R. de Oliveira, G. Glonti, O. Pizzirusso, V. Polychronakos et al., *A spark-resistant bulk-Micromegas chamber for high-rate applications*, *Nucl. Instrum. Meth. A* 640 (2011) 110.
[2] T. Kawamoto, S. Vlachos, L. Portecorvo, J. Dubbert, G. Mikenberg, P. Iengo et al., *New Small Wheel Technical Design Report*, Tech. Rep., CERN-LHCC-2013-006, ATLAS-TDR-020 (2013).

In the experience, the detector under test might also be a resistive micromegas bulk with pad readout (CASE B)

LAB 4 "READOUT TECHNIQUES"

Exercise A - Position-sensitive delay-line readouts

Introduction.

The most common readout technique for two-dimensional gaseous avalanche detectors is based on the Center-of-Gravity readout method and employs a large number of amplifiers and shaping electronics for the channel-by-channel analysis [ref]. An alternative, effective method for reducing front-end electronics costs while maintaining high spatial resolution is to use fast delay-line circuits as readouts [refs] - see figure 1.

Figure 1. Operational principle of delay-line readout: the localization capability is derived from the time difference between the signals sensed at the two ends of the delay-line.

Delay-line readouts consist of many LC (inductor-capacitor) cells (figure 2) that are connected to individual anode or cathode strips [ref]. Localization information is derived based on the propagation times of the induced signals traveling along the delay-line and processed directly by fast current pre-amplifiers at both ends of the delay-line. It is important for linearity and timing response to be accurate due to the time difference, which is influenced by the time delay per cell and the performance of the fast pre-amplifiers.

The delay-line readout can provide a submillimeter position resolution at counting rates exceeding 1 MHz. Most common applications for readout detectors include small area MPGD-based X-ray imaging [ref], low-pressure parallel-plate avalanche counter (PPAC) for heavy-ion physics [ref], small-area Micro-Channel-Plate (MCP) [ref], and multi-wire proportional chamber [ref].

Include figure 1a-d

All detectors feature a gas vessel, a drift electrode, a readout electrode, and an amplification structure. After the assembly, all detectors can/will be used in the next LAB activities.

The experimental setup and the instrumentation.

1. GEM

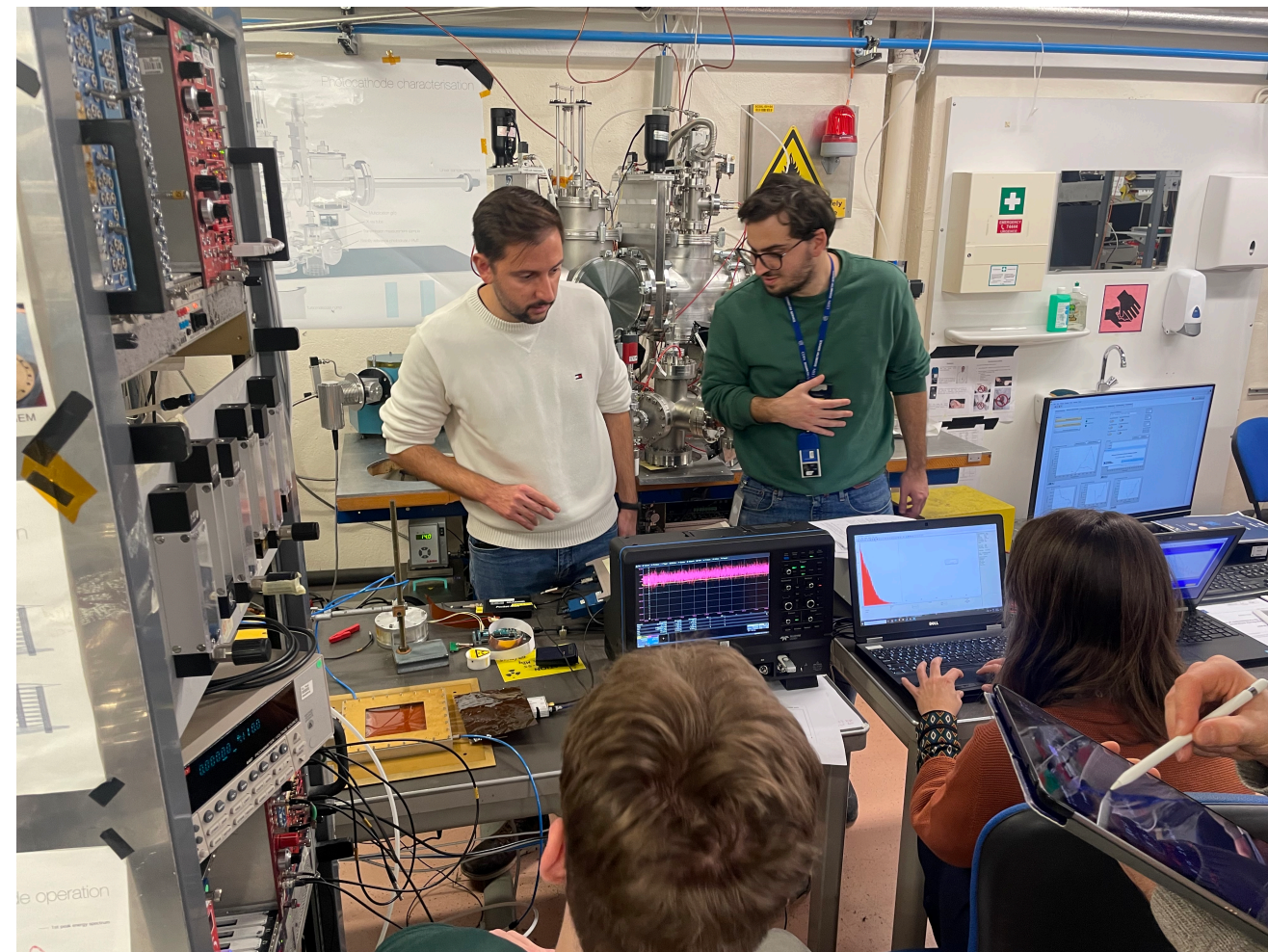
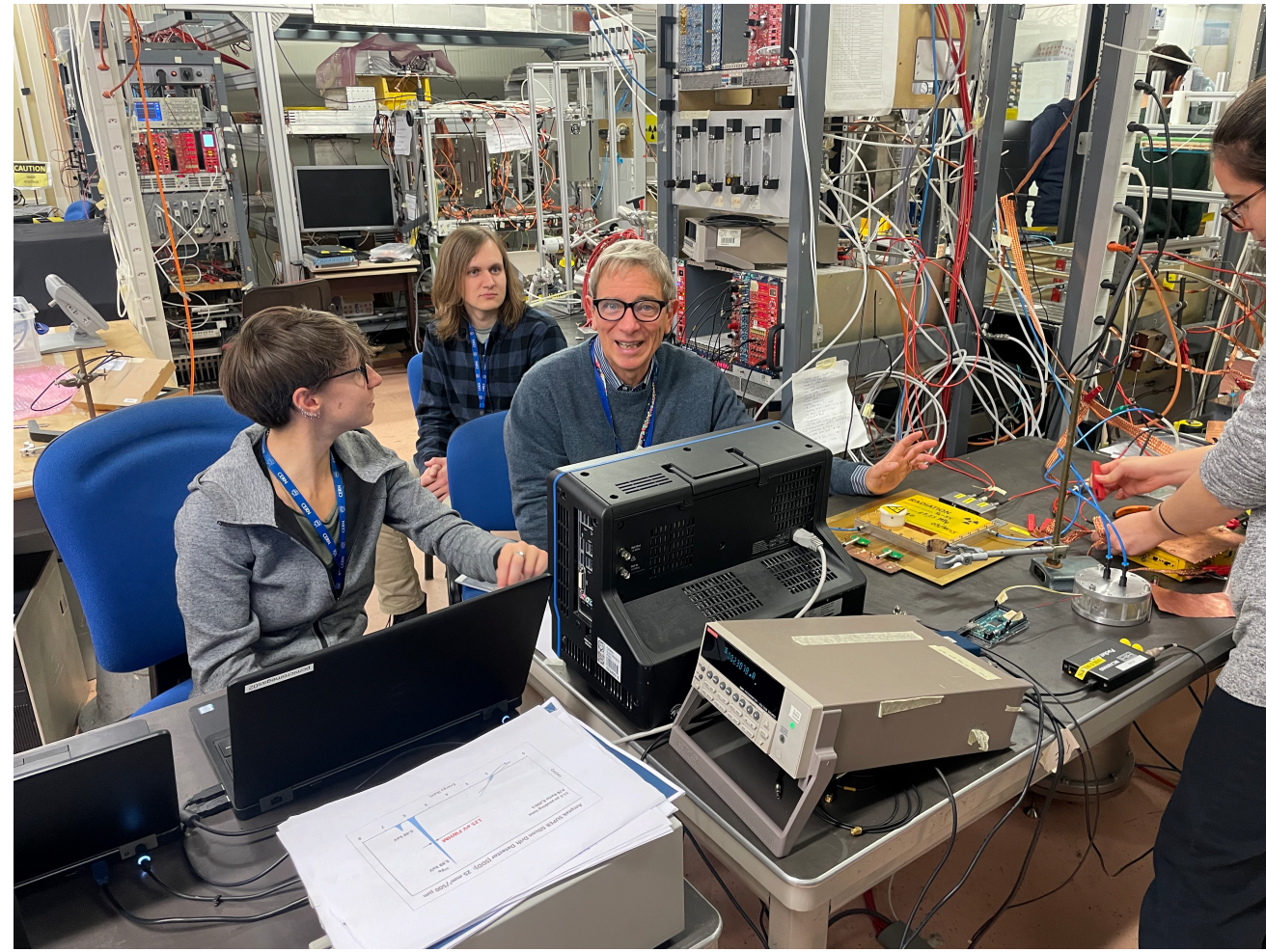
Figure 2 shows a view of the setup and its biasing scheme. The detector vessel contains a $10 \times 10 \text{ cm}^2$ GEM structure with a readout anode below and a drift cathode above it.

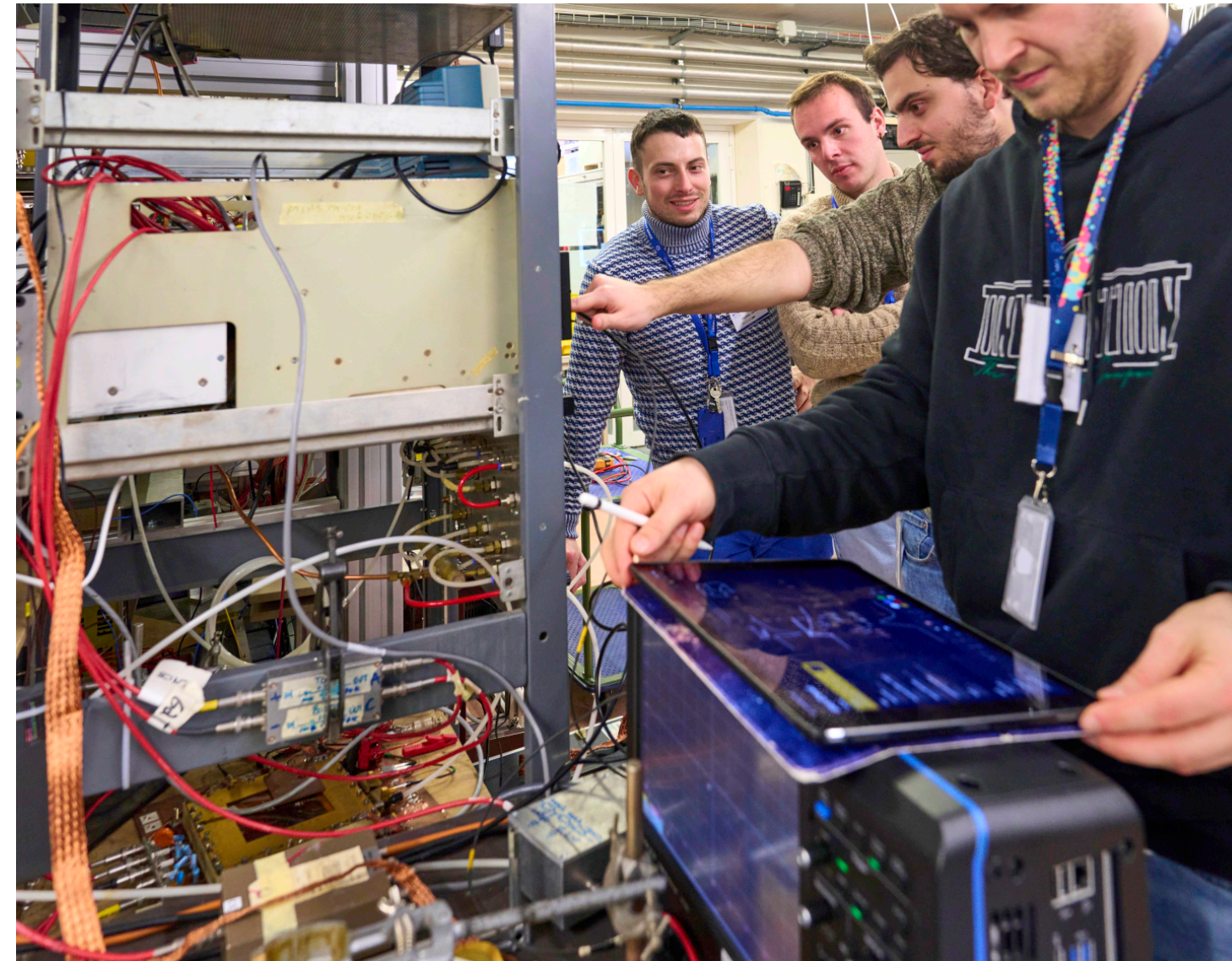
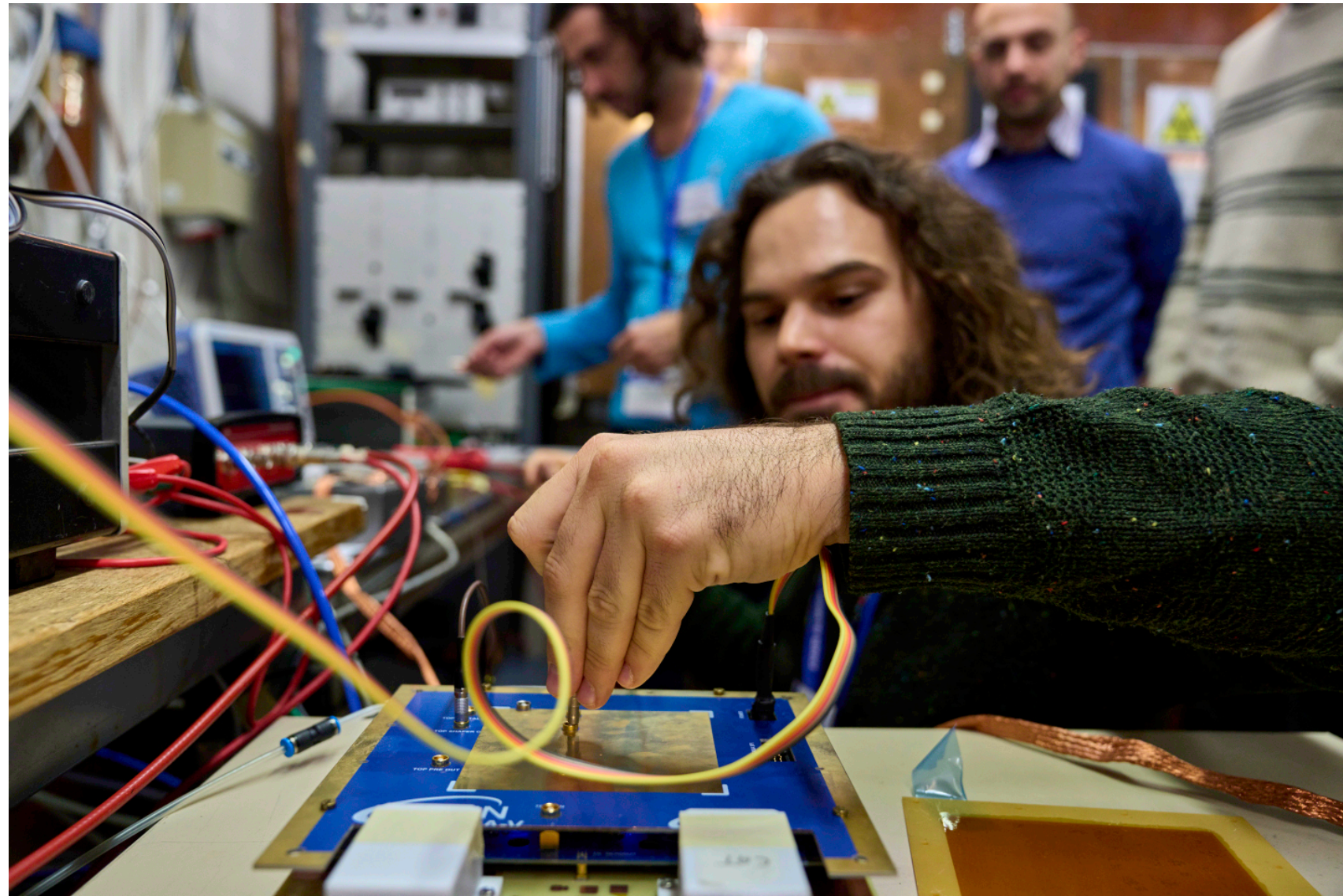
The cathode is made of a 1.5 mm thick PCB coated with copper on one side (xxx μm thick aluminumized mylar foil suspended on a 1.5 mm thick FR4 frame or, ...). The distance between the cathode and the amplification structure (drift gap) is xxx mm.

The standard GEM foil, produced by CERN PCB workshop with the double-mask technology, consists of a 50 μm thick polyimide (Apical) foil covered on both sides with a 5 μm copper layer, perforated with holes with 50 μm inner and 70 μm outer hole diameter at a pitch of 140 μm. The readout electrode, which serves as the anode, is made of xxx. The distance between the GEM and the anode (induction gap) is set to 2 mm.

6

Lab exercises





Student presentations

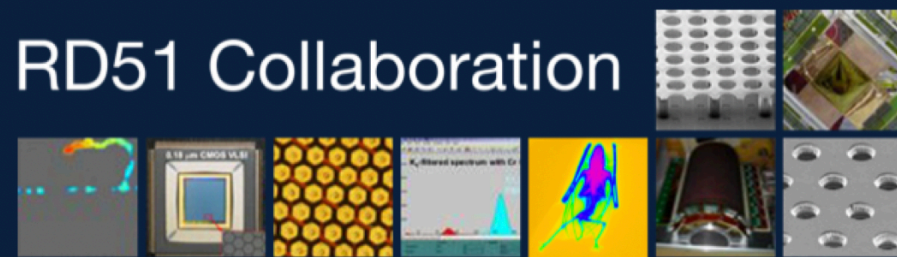
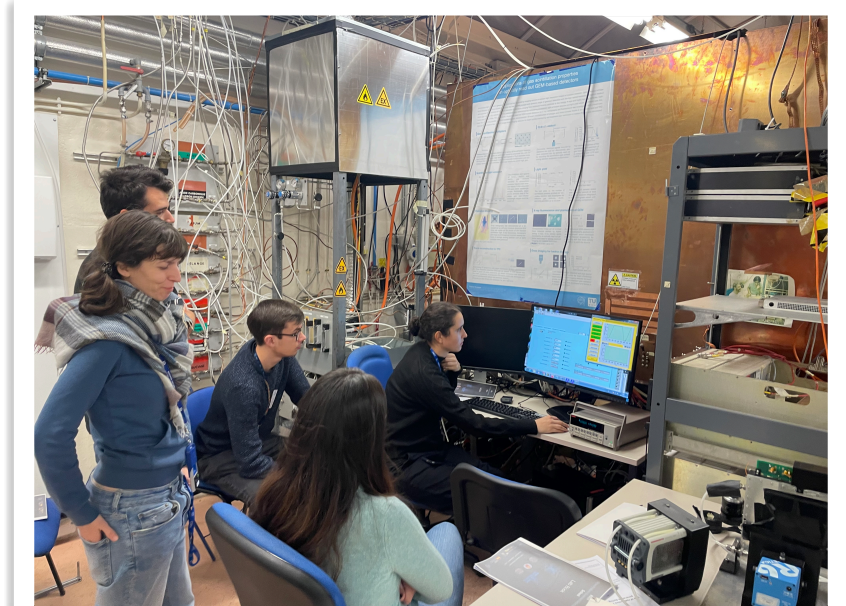
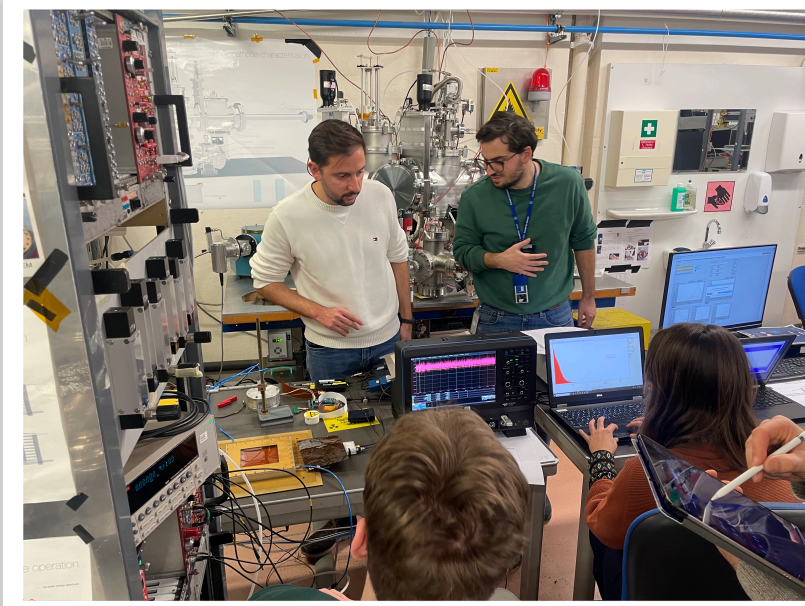


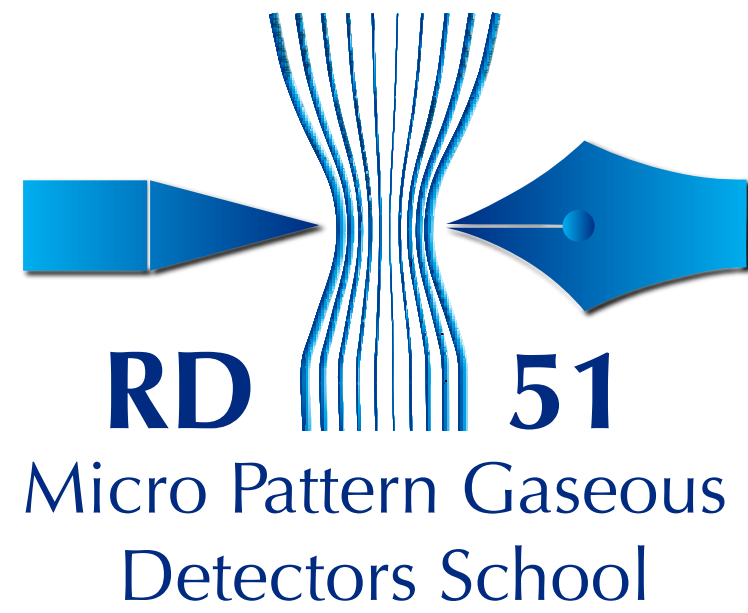
Students are invited to give 10min presentations during WG8 session of RD51 Collaboration Meeting (<https://indico.cern.ch/event/1327482/>) on Friday, Dec 8

Presentation to explain the setup and experimental methods of one of the lab exercises
Can contain results obtained during the exercise as well as additional analysis performed.
Some open questions and further analysis are given in the lab book.

Each group can present one lab exercise during the meeting

Thank you RD51 MPGD School





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WG8 mailing list

<https://e-groups.cern.ch/e-groups/EgroupsSubscription.do?egroupName=rd51-wg8>