R-I. "Lendület" innovative particle detector development

"Momentum" research team

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The activities of the group can be divided into two categories. The first concerns the rapid evolution of the laboratory infrastructure necessary for long-term future commitments. The second concerns initiating or continuing specific research subjects, developments on the high resolution single photon UV scanning, results from the Low Momentum Particle Detector (LMPD) for the NA61 Experiment, cosmic muon detection, activities for the ALICE Experiment, and education activities. These are reported below.

Refurbishment of the laboratory environment started last year and has been completed to match the necessary scientific requirements. This involved a substantial commitment on the side of the participants, including training in low-dust environments and precision gas systems. The main lab room (Building 2, room 111) includes equipment for the most sensitive test activities: gas distribution, precision high voltages, and various data acquisition systems (DAQ). The "Construction Lab" (Building 2) includes the clean compartment of 8 m^2 area, with a flat table assured for ISO5 (grade 100) quality. These developments are critical for the long-term competitiveness of the group. The laboratory became part of the National Research Infrastructure Survey and Roadmap (NEKIFUT).

Among the research objectives, the Leopard project (high-resolution scanning of thick gas electron multiplier (TGEM) structures with single UV photons) continued to be successful and has seen considerable improvements within the framework of the RD51 Collaboration. Now the classical GEMs, with a hole diameter of 50 μm, became visible, and therefore became an integral part of the AIDA2020 project; Task 12.4.4, with Wigner RCP as project leader. Figure 1 below shows high-resolution images of these, including a hole-by-hole gain map showing increased gain at the GEM edge (upper part of right panel).

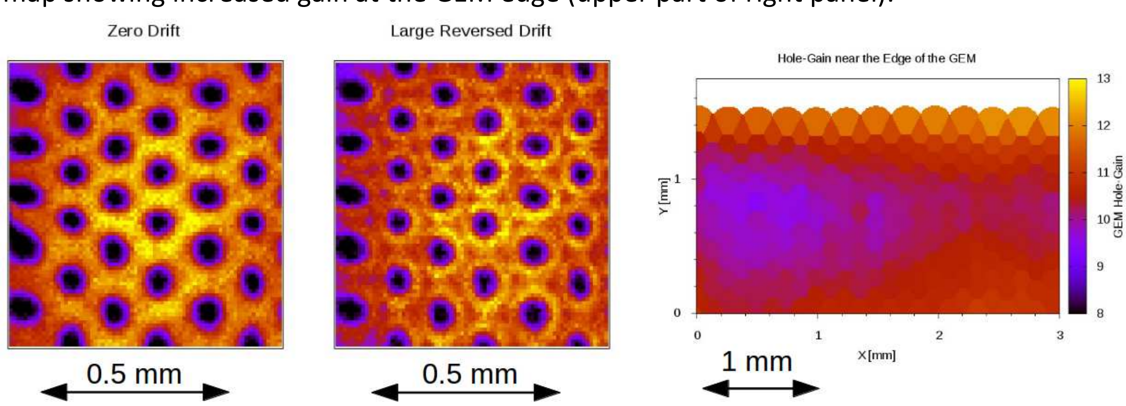

Figure 1. *Leopard images of a classical GEM layer. With improved resolution of 15 micron, the fine structures (left and middle) as well as single hole gains (right) are quantified.*

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Members of our research group are key participants at the **CERN NA61 (Shine) Experiment**. The Low Momentum Particle Detector, built in 2011-2012, has been fully calibrated during the year and its data has been analyzed. The purpose of the LMPD is to detect slow particles that are characteristic of the collision centrality in hadron-nucleus interactions. Figure 2 shows an image of the detector; single tracks emerging from the target are clearly detected (left panel).

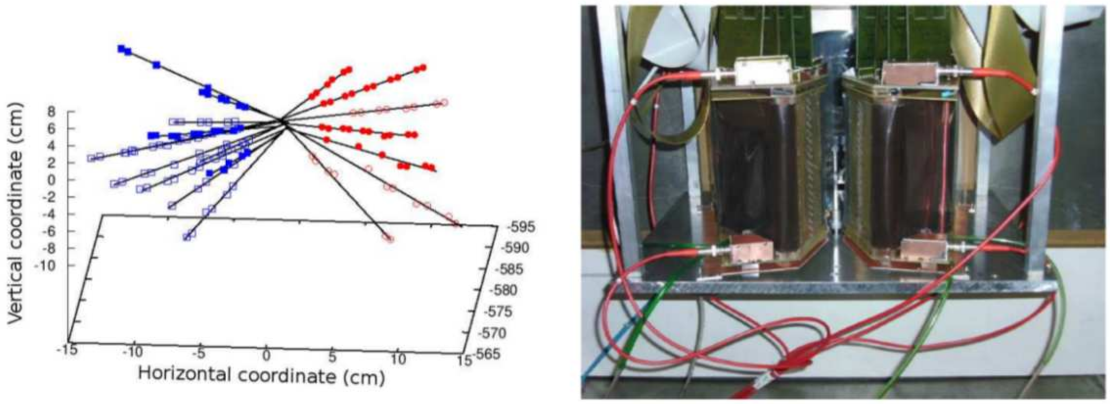

Figure 2. *The Low Momentum Particle Detector of the NA61 Experiment at CERN, constructed in 2011-2012. The tracks are clearly identified (left) emerging from the target which sits in the middle of the two halves of the detector (right)*

After the full calibration performed at CERN, and refined data analysis, published results show excellent tracking performance and demonstrated particle identification. The image of the target is shown in the left panel of Figure 3, whereas the capability to separate the particle charge (mostly protons and He isotopes) is shown in the right panel.

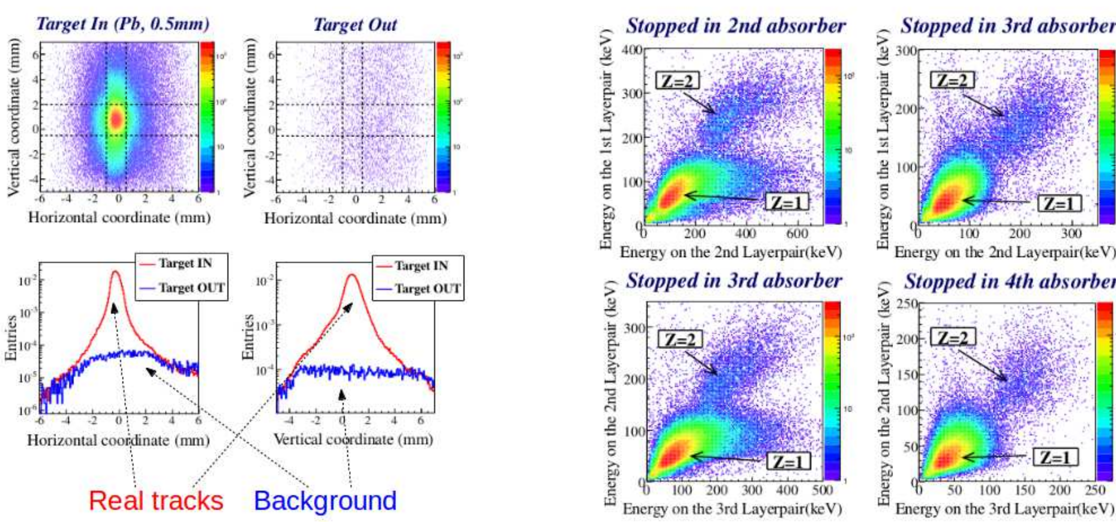

Figure 3. *The LMPD tracking performance is well demonstrated by the low level of background contamination below 1% fraction, whereas with a real target installed the trajectories emerge from a small spot (left). The LMPD can identify particles by ionization: H and He nuclei are clearly separated (right)*

Research activities for **cosmic muon detectors** were aimed at two directions: one is the earlier established underground flux observation, the other is transmission tomography to map the 3D structures of material placed inside the detector system. An example of the latter is shown in Figure 4, where the test objects appear clearly measured by cosmic muon scattering strength. Such detectors may find applications in security systems, for which a collaboration between NKE (National Security and Public Service University) and Wigner RCP has been initiated.

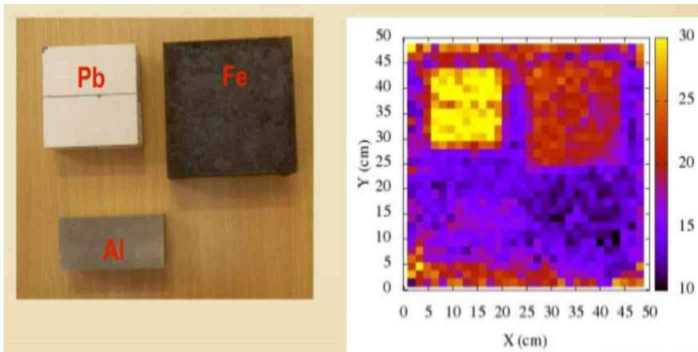

Figure 4. *Test objects (left) placed inside a cosmic muon detector can be imaged (right) by measuring muon scattering. High-Z materials such as lead provide a very strong signal, even if so thick that X-rays can not penetrate them.*

The collaboration with the **ALICE Experiment at CERN** has received a new boost from our group's entry to the Time Projection Chamber (TPC) Upgrade project. GEM detectors will replace the TPC readout chambers to enable continuous event readout, and consequently reach a 100-fold gain in speed.

Secondary school students, along with their teacher, Éva Oláh, were highly active. This activity received an "Útravaló" grant to support the education of students and common work. Approximately 10 students participated in the building and performance demonstration of the multi-wire proportional chamber (MWPC).

Grant

"Momentum" Program of the HAS (D. Varga, 2013-2018)

International cooperation

CERN NA61 Collaboration (A. Laszlo and K. Marton), CERN RD51 Collaboration (Gy. Bencze, G. Hamar and D. Varga), CERN ALICE Collaboration (G. Hamar, Gy. Bencedi and D. Varga)

Long term visitor

Kristian Engeseth, Bergen University (D. Varga, 3 weeks)

Publications

Articles

1. Hamar G, Varga D: High granularity scanner for MPGD based photon detectors.
   POS - PROCEEDINGS OF SCIENCE, TIPP2014 (Technology and Instrumentation in Particle Physics 2014. Amsterdam, The Netherlands, 02.06.2014-06.06.2014), Paper 056. 8 p. (2014)

2. Hamar G, Varga D: Close Cathode Chamber: cost efficient and lightweight detector for tracking applications. **POS - PROCEEDINGS OF SCIENCE**, TIPP2014 (Technology and Instrumentation in Particle Physics 2014. Amsterdam, The Netherlands, 02.06.2014-06.06.2014) Paper 066. 8 p. (2014)
3. Márton K, Kiss G, László A, Varga D: Low momentum particle detector for the NA61 experiment at CERN. **NUCL INSTRUM METH A**, 763: pp. 372-382. (2014)

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4. Oláh L, Barnaföldi GG, Hamar G, Melegh HG, Surányi G, Varga D: Applications of Cosmic Muon Tracking at Shallow Depth Underground. In: Astroparticle, Particle, Space Physics and Detectors for Physics Applications: Proceedings of the 14th ICATPP Conference, Como, Italy, 23.09.2013-27.09.2013, Eds.: LeRoy C, Rancoita P-G, Singapore: World Scientific, 2014. pp. 280-284.

See also: R-B.1, R-P.1

NA61/SHINE Collaboration

Articles

1. Abgrall N et al. incl. Fodor Z, Kiss T, Laszlo A, Marton K, Palla G, Sipos R, Tolyhi T, Vesztergombi Gy [139 authors]: Measurement of negatively charged pion spectra in inelastic p plus p interactions at p_{lab}=20, 31, 40, 80 and 158 GeV/c. ***EUROPEAN PHYSICAL JOURNAL C*** 74:(3) Paper 2794. 22 p. (2014)
2. Abgrall N et al. incl. Fodor Z, Kiss T, Laszlo A, Marton K, Palla G, Sipos R, Tolyhi T, Vesztergombi Gy [144 authors]: Measurements of production properties of K^0_S mesons and Λ hyperons in proton-carbon interactions at 31 GeV/c. ***PHYSICAL REVIEW C NUCLEAR PHYSICS*** 89:(2) Paper 025205. 12 p. (2014)
3. Abgrall N et al. incl. Fodor Z, Kiss T, Laszlo A, Marton K, Palla G, Sipos R, Tolyhi T, Vesztergombi Gy [148 authors]: NA61/SHINE facility at the CERN SPS: beams and detector system. ***JOURNAL OF INSTRUMENTATION*** 9: Paper P6005. 47 p. (2014)

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4. Marton K, Fodor Z, Kiss T, Laszlo A, Palla G, Sipos R, Tolyhi T, Vesztergombi Gy et al. [NA61/SHINE Collaboration]: Low momentum particle detector at the NA61/SHINE experiment. In: Astroparticle, Particle, Space Physics and Detectors for Physics Applications: Proceedings of the 14th ICATPP Conference, Como, Italy, 23.09.2013-27.09.2013, Eds.: LeRoy C, Rancoita P-G, Singapore: World Scientific, 2014. Ol. 8, pp. 377-381.

CBM Collaboration

1. Heuser J, Friese V, Ablyazimov T et al. incl. Kiss T, Tölyhi T, Wolf Gy [555 authors] : Measurement of rare probes with the silicon tracking system of the CBM experiment at FAIR. **NUCL PHYS A**, 931: pp. 1136-1140. (2014)
2. Höhne C, Ablyazimov T et al. incl. Kiss T, Tölyhi T, Wolf Gy [555 authors]: Measurement of dileptons with the CBM experiment at FAIR. **NUCL PHYS A**, 931: pp. 735-739. (2014)

See also: R-B. ALICE Collaboration, R-H. CMS Collaboration, R-H. NA49 Collaboration