

## **REPORT ON LITHUANIA ASSOCIATE MEMBERSHIP AT CERN**

**2017–2018**

**prepared by the CERN Coordination Committee in Lithuania**

In 2016 the National Strategic Council for Research, Development and Innovation, chaired by the Prime Minister approved the Action Plan on CERN Associated Membership 2017-2021, appointing the Ministry of Education, Science and Sport as the main coordinator and the Ministry of Economy and Innovation in charge of industrial networking and establishment of CERN BIC.

In 2018 the Confederation of Lithuanian Industrialists was nominated as Liaison Office for CERN in industry and Academy of Sciences – Liaison Office for CERN in research, development and innovation. Also national committee for CERN activities under the Academy of Sciences was established.

During the recent years strong partnership has been maintained between the President Office, the Government, business and academic stakeholders to enhance the activities in CERN related areas. Moreover the collaboration with Latvia and Estonia regarding CERN areas of interests and the share of best practices has been developed. With the endorsement of CERN and in cooperation with the higher education institutions of Estonia and Latvia, the CERN Baltic Group (CBG) was established aimed to foster particle physics and accelerator technology research and education community in the Baltic states. Two major Lithuanian universities – Kaunas University of Technology (KTU) and VU – signed the CBG Memorandum of Understanding (MoU) in May 2018 at CERN.

The first year of CERN associated membership showed that both academic and business sectors have many challenges in absorbing the possibilities of membership. It should be acknowledged that the performance of research and industry in CERN related areas remains one of priorities at political agenda.

The financial duty of year 2018 for CERN was fulfilled

### *Research and development in 2018*

The research and development related to CERN programmes is supported according to the Action plan for a period of 2018-2021 approved by the Minister of Education, Science and Sport. The Lithuanian Academy of Sciences is authorized to coordinate implementation of high quality research projects. Six research groups applied for and obtained funding to carry out their CERN-related R&D projects. Four of those are from Vilnius University (VU), investigating the radiation damage of Si detectors, developing fast scintillation detectors, theoretically investigating the CMS detector data, and developing CMS software. One group from Kaunas University of Technology (KTU) deals with the improvement of the coatings used in accelerators at CERN. One more group, from the Lithuanian University of Health Sciences in Kaunas, investigates the tumour resistance to radiation therapy. The groups have applied for the funding of their research projects till 2020.

In addition to state budgetary funding, other funding sources are being sought and allocated for participation in the CERN activities:

- Data Analysis and Semiconductor Research groups participated in a project application “Silicon and Gas Radiation Detector Development Exchange Programme for High Energy Physics Instrumentation and Societal Detector Applications” (PI Archana Sharma, CERN) under call H2020-MSCA-RISE-2018. The consortium consisted of 30 participants from around the world, including CERN. The project CAPSTONE was not funded.
- Photoelectrical Phenomena and Semiconductor Optoelectronics research groups participated in HORIZON 2020 project No 654168 “Advanced European Infrastructures for Detectors at Accelerators – AIDA-2020” (WP14 – Infrastructure for advanced calorimeters; WP15 – Upgrade of the beam and irradiation tests infrastructure); also, in a project supported by the Central Agency of the Project Management (CPVA LR) 01.2.2-CPVA-K-703-02 “Centre of technologies of the contactless and remote detection of ionizing radiations” (2018–2021).
- Semiconductor Optoelectronics research group has an experience in ultrafast and spatially-resolved semiconductor spectroscopy and exploited this experience and available experimental capabilities for studying the fast processes in scintillation detectors. The group is a member of Crystal Clear Collaboration (RD 18) at CERN and currently takes part in preparation of TDR for the coming Barrel Timing Layer upgrade for the CMS. The group participates in HORIZON 2020 project AIDA2020, which is initiated and led by researchers at CERN, also participated in Proof of Concept funding under AIDA-2020 project proposal “Fast neutron detection using optical readout based on free carrier absorption“, in preparing two Letters of Intent for Horizon 2020 program (project leader Barbara Erasmus): “PbWO4 – ultrafast scintillator for picosecond timing” (spokesperson: Carlos Munoz Camacho, IPN Orsay, France) and “Search for fast and radiation hard new scintillators” (spokesperson: Kai-Thomas Brinkmann, Justus-Liebig-Universität, Gießen, Germany) in application with CERN and other partners for a project of programme ATTRACT. Currently, the group has two projects funded by the EU structural Funds via the the Lithuanian Research Council: “Neutron flux detection system with optical readout” (no. 01.2.2-LMT-K-718-01-0041), 2018-2022, and “Fast scintillators for radiation detectors; FARAD” (no. 09.3.3-LMT-K-712-01-0013) 2018-2022. The group was a member of the COST Action FAST ended in 2018. During the implementation of this project, the group hosted 7 short term scientific missions (STSM) from partner institutions, PhD student Augustas Vaitkevičius participated in three STSMs to Fondazione Bruno Kessler, Trento, Italy, and Justus-Liebig-University, Giessen, Germany.
- Photoelectrical Phenomena research group is a member of CERN RD50 collaboration and participated in LMT supported project of the call “Toward Future Technologies” LAT-01/2016 “Development of the MOCVD GaN based technology for fabrication of position and spectrum selective detectors of ionizing radiations”; LMT supported project 01.2.2-LMT-K-718-01-0013 “Creation of the prototype wide-spectrum dosimetry system for various purpose monitoring of irradiations” (2018-2022); in agreement of the bilateral collaboration Vilnius University – IMEC (Belgium) “On characterization of the MOCVD GaN grown on Si”; in bilateral collaboration projects with Belarus University (Belarus), with University of Helsinki (Finland) on implementation of the CERN RD50 project tasks; in bilateral collaboration with Ammono-Unipress (Poland) on characterization of the HVPE-AT grown GaN materials and detector structures.

- VU as an institution in the Widening country submitted a Twinning proposal under Horizon 2020 programme, where CERN together with Institut Laue–Langevin in Grenoble, France are internationally leading counterparts. The proposal is currently under evaluation.

Seeking to build stronger cooperation with the partner institutions and to accelerate the development of research capabilities of academic institutions, Vilnius university, CERN and Institut Laue–Langevin in Grenoble submitted a Twinning proposal under Horizon 2020 programme. It is expected that institutions with longer experience and a higher scientific impact will teach VU how to boost scientific performance and how to be more efficient in scientific work. The proposal is currently under evaluation.

### *University studies*

The Experimental Nuclear and Particle Physics Centre (Centre) was established at Vilnius University in the beginning of 2017 as national centre to strengthen the research in experimental and particle physics in Lithuania and also as a pre-requisite to signing the Associate Membership agreement. It operates on the funds allocated on a yearly basis by the Ministry of Education and Science (Ministry of Education, Science and Sports, as of January 1, 2019). The Centre has an interim Chair and an administrative officer (part-time). It is planned that in 2019 the Centre will become a coordinating body of institutional network between Kaunas (Kaunas University of Technology, Lithuanian University of Health Sciences, Lithuanian Energy Institute) and Vilnius (Vilnius University, Vilnius Gediminas Technical University, Centre for Physical Sciences and Technology) and the joint research activities will strengthen not only research but also higher education in CERN related areas.

Five new courses in experimental and theoretical particle physics and closely-related IT subjects were introduced at bachelor level. These courses became a part of the ordinary study program offered to students who entered the university in the fall of 2017, and they run in 2018 according to the curriculum requirements.

Courses “Materials research” and “Materials science” were improved with added parts and laboratory training tasks related to radiation damage and measurement of parameters of defects created by irradiation in semiconductors were delivered for students as well. The “Electronics” course was elaborated by adding the pulse processing used in HEP.

Students performed research on experimental particle physics (CMS data analysis) in 2018, under the training program “Promotion of Students’ Scientific Activities” supported by the Lithuanian Research Council. Special scholarships at Centre have been established to support the students who actively participate in CERN-related projects. Three students at the Faculty of Physics and one at the Faculty of Chemistry and Geosciences have received them.

VU Faculty of Physics has one PhD student in theoretical particle physics and during 2016–2018, three PhD students defended their thesis on photoelectrical phenomena research relevant to CERN areas of interests

Four students of physics attended the course “Particle interaction with matter and the detector design principles” delivered by prof. Christoph Schäfer (CERN) at VU and visited CERN CMS under supervision of dr. A. Juodagalvis in 2017. These students continue their studies at PhD level at Vilnius

university and also the Master studies at Vilnius University, University of Bergen and at the University of Oxford, respectively.

The Centre also supported few students to participate in the school “CERN Spring Campus 2018” (Riga, Latvia).

### *Education and outreach*

The Outreach group of the Centre conducted several events in 2018. Among those, the “International MasterClass: Hands on Particle Physics 2018” (organized by IPPOG) was moderated together with the Vilnius Gediminas Technical University (VGTU) staff, and around 80 participants, mainly schoolchildren, could visit laboratories of the Centre for Physical Sciences and Technology (FTMC). Three introductory lectures were given, and the students analyzed real CMS data events. The findings were discussed in the videoconference with 4 other international universities and CERN moderators. The CMS virtual visit for Lithuania was hosted by KTU in 2018 as part of the European Researchers’ Night event. For education and outreach 12 Wilson cloud chambers were constructed, and a web page for requesting them was set up, see <http://www12002.vu.lt/cern/mokslinink-grupes/daleli-fizikos-skaidos-grupe> .

The lectures with a stress on fundamental research specific to CERN were delivered for different audiences during national science festival “Spaceship Earth”, at the Lithuanian Academy of Sciences, at secondary schools and business clubs both in 2017 and 2018.

An interim chair of the VU Centre prof. Juozas V. Vaitkus delivered a series of lectures on CERN related activities, achievements and challenges at secondary schools in Vilnius, at conferences of LITNET and “Leaders' club anniversary”, at advanced physics school “Physics Olympus”, for Vilnius university students. The activities of Lithuania in CERN related projects were presented during a symposium at University of Florida and for the IUPAP Governing board and Commissions’chairs meeting in Vilnius on November 1, 2018.

The smart TV screens on the 2nd floor of National Centre of Physical and Technological Sciences are installed and display live footage from CERN ATLAS and CMS experiments. The exhibition of CERN related activities is in preparation at the same location.

Seeking to strengthen science for citizens activities in Lithuania, a book by Frank Wilczek “A Beautiful Question: Finding Nature’s Deep Design” was recommended to the Lithuanian Academy of Sciences for its popular science bestsellers translation program, and recently the book (under the title in Lithuanian “The Beauty of Universe”) has been published and is distributed free of charge.

VU portal has published six news articles at <http://naujienos.vu.lt/tag/cern/> regarding CERN in 2018, with portions contributed by dr. A. Juodagalvis. A journalist of the Lithuanian National Broadcaster (LRT) Algirdas Acus visited CERN and authored two 40 min interview episodes about CERN in his TV clip series “Beyond here and now” (“Anapus čia ir dabar”). Recordings are available at

<https://www.lrt.lt/mediateka/irasas/1013703605/anapus-cia-ir-dabar> (with prof. Christoph Schäfer),  
<https://www.lrt.lt/mediateka/irasas/1013707445/anapus-cia-ir-dabar> (with prof. John Ellis).

On November 6, 2018 the CERN Honorary Member François Flückiger participated in the *Annual Economic Forum '18* conference organized by the Confederation of Lithuanian Industrialists and delivered a lecture *Business and Science Cooperation in Information Technology: The CERN Case*.

A group of Lithuanian teachers will go to CERN on March 5-9, 2019. The CERN Baltic Teachers Programme event will host teachers from Estonia, Latvia, and Lithuania. Participation is coordinated by Education Development Center (UPC).

#### *Co-operation and other activities within CERN areas of interests*

VU hosted a CERN Baltic Group – CBG – working group for studies meeting (in July). The advanced courses for master students are discussed under the CBG initiative. Student training at CERN is among the topics discussed with the representatives from KTU. A joint Baltic program in particle physics, accelerator and related technologies is considered. The nearest general CBG meeting will take place in Tallinn at the end of January 2019. The CBG working group on CMS topics had a kick-off meeting chaired by dr. Aurelijus Rinkevičius: topics of mutual present and possible future interest for Baltic researchers were discussed. CBG web page is <http://indico.cern.ch/category/10023/>.

Representatives of Lithuania – the Ambassador Andrius Krivas, prof. Jūras Banys, prof. Eugenijus Butkus, prof. Leonas Valkūnas, dr. Andrius Juodagalvis, dr. Aurelijus Rinkevičius – regularly participated in the sessions of CERN Council and meetings of its committees. The concise reports on the topics discussed and actions approved at the meetings are available in the Lithuanian language on the Lithuanian Academy of Sciences web page <http://www.lma.lt/ataskaitos>.

VU IT engineers continue to play an important role in CMS computing and infrastructure operations. The number varies, but there are about 10 of them based at CERN. Most are recruited as CERN associated members of personnel (MPA) in a joint program between CMS experiment and VU after successfully completing their BS practice at CERN under the EU *Erasmus+* scheme. IT engineers together with dr. A. Juodagalvis and dr. A. Rinkevičius established a specific Lithuanians-at-CERN mailing group during preparation for the Associate CERN membership accession. Both online and live discussions of common topics are on its agenda <https://indico.cern.ch/category/7701/>, the group web page is <http://lithuanians-at-cern.github.io/> and the Facebook account is <https://www.facebook.com/lithuanians.at.cern/>.

According to information provided by CERN HR department on January 7th, 2019, 39 Lithuanians hold MPA in collaboration (MPAc) contracts, 1 Lithuanian has MPA training contract (MPAt), and there is 1 fellowship appointment. In 2018 there was one additional technical student (MPAt). 1 Lithuanian is a CERN staff member since 2018. 3 Lithuanians were selected for CERN summer programme in 2018.

The appointed industrial liaison officer (ILO) initially was Mrs. Gražina Tarvydienė from the Confederation of Lithuanian Industrialists (LPK), who recently left her position at LPK and the new nomination is pending.

According to information from CERN Industry, Procurement and Knowledge transfer department, in 2018 Lithuanian companies directly or indirectly provided supplies for approximately 70 kCHF.

### *Planning the future activities*

Lithuania recently hosted the CERN experts for evaluation of Lithuanian possibilities to establish CERN BIC in 2019. It is planned that Lithuanian CERN BIC will be located in Vilnius and Kaunas. The final discussions will be arranged during CERN-Lithuania meeting in January 2019.

In 2018 the International Advisory Board elected dr. Aurelijus Rinkevičius as a new Chair of the VU Centre. It is expected that he will take duties starting February 1, 2019.

Dr. A. Rinkevičius, due to his research work so far and after relevant inquiry, assures that CERN together with the CMS experiment (drs. Tiziano Camporesi and Stefano Mersi) identify the tracker project as the most prominent future project for Lithuania in terms of detectors, detector construction, commissioning, and data acquisition (DAQ). Tracker project supervises the Tracker Extended Pixels (TEPX) subproject that is envisaged as an excellent bridge for the future CMS needs and Lithuania's growing capacity. Further detailed discussions are ongoing, including those with ETH Zurich, PSI and Zurich University.

Also it is considered that the Centre in 2019 is becoming a national networking body for academic and business institutions operating in the areas of CERN research interests. Recently, Lithuanian Innovation Centre (LIC) was assigned with the responsibility to enhance technology transfer, therefore it is expected that LIC in cooperation with stakeholders and Lithuanian Confederation of Industrialists will strengthen academic and business cooperation, develop further an industry platform in the areas of CERN interests.

### *Appendix 1 – Awards and publications in 2018*

Rokas Mačiulaitis received the CMS achievement award (joining a number of other Lithuanians throughout the years): “for his excellent contributions to the Facilities group in Software and Computing”, nominated by assoc. prof. Markus Klute (MIT).

VU researchers are co-authors of 140 CMS papers published in 2018. In addition, a number of papers by individual VU groups have been published, the list is presented below.

#### *HEP theory group*

1. The Participants of the European Neutrino Town Meeting [from Lithuania: D. Jurčiukonis], Future Opportunities in Accelerator-based Neutrino Physics, *European Neutrino “Town” meeting and ESPP 2019 discussion* (Oct 22-24, 2018, Geneva, Switzerland). arXiv:1812.06739 [hep-ex].
2. D. Jurčiukonis and L. Lavoura, The three- and four-Higgs couplings in the general two-Higgs-doublet model, *JHEP* 12 004 (2018).
3. D. Jurčiukonis and L. Lavoura, Lepton mixing and the charged-lepton mass ratios, *JHEP* 1803 152 (2018).
4. V. Dūdėnas and T. Gajdosik, “Gauge dependence of tadpole and mass renormalization for a seesaw extended 2HDM,” *Phys. Rev. D* 98 (2018) no.3, 035034; doi:10.1103/PhysRevD.98.035034; [arXiv:1806.04675 [hep-ph]].

### *IT group*

1. J.-M. André, A. Mecionis, V. Rapševičius, M. Stankevičius et al. Presentation layer of CMS Online Monitoring System. CHEP 2018, accepted (2018)
2. M. Stankevičius, V. Marcinkevičius, & V. Rapševičius. Comparison of supervised machine learning techniques for CERN CMS offline data certification. Joint Proceedings of Baltic DB&IS 2018 Conference Forum and Doctoral Consortium Co-located with the 13th International Baltic Conference on Databases and Information Systems (Baltic DB&IS 2018), Trakai, Lithuania, July 1–4, 2018, 170–176 (2018).

### *Photoelectrical Phenomena research group*

1. E. Gaubas, T. Ceponis, L. Deveikis, D. Meskauskaite, J. Pavlov, V. Rumbauskas, J. Vaitkus, M. Moll, F. Ravotti, Anneal induced transformations of defects in hadron irradiated Si wafers and Schottky diodes, *Materials Science in Semiconductor Processing* 75 (2018) 157–165.
2. D. Meskauskaite, E. Gaubas, T. Ceponis, J. Pavlov, V. Rumbauskas, Characteristics of 1.6 MeV proton-irradiated GaN-based sensors, *Radiation & Applications*, doi: 10.21175/RadJ.2017.02.025.
3. L.F. Makarenko, S.B. Lastovskii, A.S. Yakushev, E. Gaubas, E. Pavlov, M. Moll. Impurity content influence on forming of interstitial bistable defect in Si. *Actual problems of solid state physics (in Russian)*, Vol. 3 (2018) 280-283.
4. Makarenko L. F., Lastovskii S. B., Gaubas E., Pavlov J., Moll M., Yakushevich H. S., Murin L. I. Injection annealing of the self di-interstitial – oxygen complex in p-type silicon, *Proceedings of the National Academy of Sciences of Belarus. Physics and Mathematics series*, 2018, vol. 54, no. 2, pp. 220–228 (in Russian).
5. J. Vysniauskas and E. Gaubas, Simulation of dynamic characteristics of GaN p-i-n avalanche diode operating as particle detector with internal gain *Lithuanian Journal of Physics* 58 (2018), 177–187.
6. E. Gaubas, T. Čeponis, D. Dobrovolskas, J. Mickevičius J. Pavlov, V. Rumbauskas, J.V. Vaitkus, N. Alimov, and S. Otajonov, Study of polycrystalline CdTe films by contact and contactless pulsed photo-ionization spectroscopy, *Thin Solid Films* 660 (2018) 231–235.
7. E. Gaubas, T. Ceponis, J. Mickevicius et al, Pulsed photo-ionization spectroscopy in carbon doped MOCVD GaN epi-layers on Si, *Semicond. Sci. Technol.* 33 (2018) 075015. 1.
8. E. Gaubas; T. Ceponis,; L. Deveikis,; et al., Electrical characterization of HVPE GaN containing different concentrations of carbon dopants, *Semicond. Sci. Technol.* 33(12) 125024, 2018.

### *Semiconductor Optoelectronics research group*

1. M.T. Lucchini, O. Baganov, E. Auffray, P. Bohacek, M. Korjik, D. Kozlov, S. Nargelas, M. Nikl, S. Tikhomirov, G. Tamulaitis, A. Vaitkevicius, K. Kamada, A. Yoshikawa, Measurement of non-equilibrium carriers dynamics in Ce-doped YAG, LuAG, and GAGG crystals with and without Mg-codoping, *J. Lumin.* 194, 1-7 (2018).

2. E. Auffray, R. Augulis, A. Fedorov, G. Dosovitskiy, L. Grigorjeva, V. Gulbinas, M. Koschan, M. Lucchini, C. Melcher, S. Nargelas, G. Tamulaitis, A. Vaitkevičius, A. Zolotarjovs, and M. Korzhik, Excitation Transfer Engineering in Ce-Doped Oxide Crystalline Scintillators by Codoping with Alkali-Earth Ions. *Phys. Status Solidi A*, 215, 1700798 (2018).
3. E. Trusova, A. Vaitkevicius, Y. Tratsiak, M. Korjik, P. Mengucci, D. Rinaldi, L. Montalto, V. Marciulionyte, G. Tamulaitis, Barium and lithium silicate glass ceramics doped with rare earth ions for white LEDs, *Opt. Mater.*, 84, 459-465 (2018).
4. G. Tamulaitis, G. Dosovitskiy, A. Gola, M. Korjik, A. Mazzi, S. Nargelas, P. Sokolov, and A. Vaitkevičius, Improvement of response time in GAGG:Ce scintillation crystals by magnesium codoping, *Journal of Applied Physics* 124, 215907 (2018).

### *Appendix 2 – Students and supervisors*

Dr. A. Juodagalvis currently leads the physics analysis efforts with two master students focusing on Drell–Yann precision studies. In addition to physics analysis, PhD student in computer and data sciences Mantas Stankevičius, cosupervised by assoc. prof. Valdas Rapševičius and dr. Virginijus Marcinkevičius, works on the machine-learning-based CMS data certification. On the other hand, assoc. prof. Thomas Gajdosik with one PhD Vytautas Dūdėnas and several master students is engaged in SUSY, neutrino physics and related phenomenological efforts.

During 2017–2018 VU Faculty of Physics had one PhD student in theoretical particle physics (Vytautas Dūdėnas, supervisor assoc. prof. Thomas Gajdosik), who will graduate soon. During 2016–2018, three PhD students defended their thesis on photoelectrical phenomena research relevant to CERN topics (supervisor prof. Eugenijus Gaubas).

Now, Laimonas Deveikis is a PhD student and Marijus Ambrozus entered MSc studies with a focus on CMS data analysis at the Faculty of Physics of Vilnius University; former VU students Anton Kunčinas and Simonas Draukšas continue MSc studies in particle physics at the University of Bergen and at the University of Oxford, respectively.