Institute of Experimental and Applied Physics, CTU in Prague

Ivan Štekl

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The Institute of Experimental and Applied Physics, CTU in Prague (IEAP CTU) was established in 2002 as a scientific and educational institute of the CTU in Prague, focusing on a research in the field of particle and subatomic physics performed in an international experiments.

Transformation of IEAP CTU into University Institute of CTU was approved by Academic Senate of CTU on January 10, 2018, and approved by Ministry of Education, Youth and Sports of the Czech Republic (MEYS).

Presentation outline:

1) Basic information about IEAP CTU in Prague
2) Activities in science and R&D&I
3) Selected items (M3,M4,M5) from 2019-2023 report, changes from 2014-2018
4) Final remarks

Main research areas at IEAP CTU:

(1) **CERN** (particle and nuclear physics, detection technologies, theory, ATLAS, MoEDAL…)

(2) **Underground research** (neutrino physics - 0ν and 2νββ decay; detection of atmospheric neutrinos KM3NeT; detection of dark matter; biology, environmental studies)

(3) **Space research** (pixel detectors on satellites, detection of high-energy cosmic rays)

(4) **Biomedical and material research** (imaging with X-rays and neutrons)

(5) **R&D of progressive detectors** (pixel and strip detectors, scintillating or gaseous detectors).

Balanced basic and applied research:

Fundamental research = 60% Applied R&D&I = 40%

Scientific Board of IEAP CTU (always with international composition, our institute strictly follows policy External Advisory Bodies for R&D&I, item 4.23 of M4 report):

1) Prof. Christer Fröjdh, Mid Sweden University, Sundsvall, Sweden
2) Prof. Nikolaos Mavromatos, King's College, London, UK
3) Dr. Alan Owens, European Space and Technology Centre (ESTEC), European Space Agency, Netherland
4) Prof. Dr. Marzio Nessi, FERMILAB, USA, INFN, Italy
5) Prof. Dr. Michael Campbell, CERN
6) Prof. Ruben Saakyan, University College London, UK
7) Prof. Anatoly Rozenfeld, Wollongong University, Australia
8) Prof. Alejandro Ibarra - Technical University Munich, Germany
9) Ing. Jiří Hůlka, National Institute for Radiation Protection, CR
10) Prof. RNDr. Anna Macková, Ph.D., Institute of Nuclear Physics, AS CR
11) Ing. Stanislav Pospíšil, DrSc. IEAP CTU in Prague
12) Ing. Jan Jakůbek, PhD., ADVACAM s.r.o.
13) Doc. Ing. Ivan Štekl, CSc., IEAP CTU in Prague (chair of Scientific Board).

Fundamental physics research at IEAP CTU in Prague (theory)

Double beta decay - nuclear matrix elements, exotic modes and mechanisms, LNV

Dark matter search - PICO, BSM phenomenology

X17 anomaly - VdG based experiment and theory

Cosmic neutrinos - KM3NeT, phenomenology

Neutron stars - state equation

Topological defects in QFT - magnetic monopole - MOEDAL

Fundamentals of QFT - dynamical SSB and renormalization of gauge theories

QFT of linearized gravity and gravitational waves - LISA

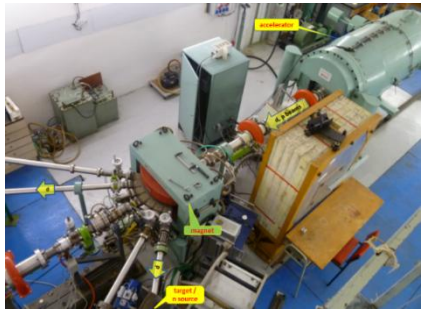
BSM theory and phenomenology - DM, baryogenesis, neutrino masses, neutrino elmag properties ….

SM and BSM collider phenomenology - ATLAS

IEAP CTU is distributed institute in CR and abroad:

1) Research infrastructures –

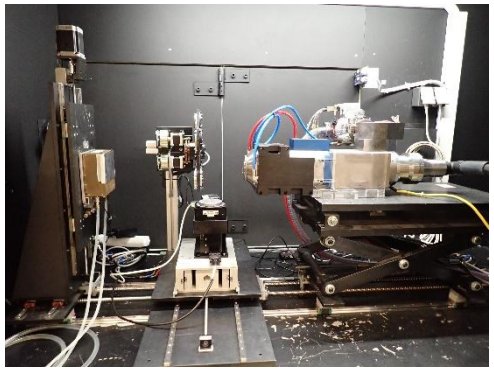
accelerator Van de Graaff (ESA approved source)
deep underground laboratory LSM (France)
small underground laboratory (shelter Bezovka)

2) Home infrastructure – Central detection and analytical laboratory, clean rooms,

X-ray imaging laboratory, radon laboratory, electronic laboratory, workshop






3) Common laboratories in CR – scanning electron microscopy (FT), CT (3.MF ChU), X-ray imaging and diffraction (ITAM AS), radon laboratory (NRPI), testing laboratory of scintillating detectors (NUVIA company)




Gradual progress of IEAP CTU (human resources, students, experts to practice)

Number of staff: 2018 = 66,8 FTE total / 11.9 FTE women
2023 = 68.9 FTE total / 16.2 FTE women

Positive age structure: 2019 = 27 people younger 35 years (early-stage researchers, 33.6/3.0 FTE)
2023 = 29 people younger 35 years (early-stage researchers,24.1/6.2 FTE)

Qualification structure: 2018 = 5 professors, 2 assoc. professors, 45.05/3.75 FTE researchers
2023 = 4 professors, 2 assoc. professors, 47.68/8.35 FTE researchers

International staff: 2018 = 31 researchers from abroad
2023 = 37 researchers from abroad (Slovakia 11, Germany 3, Japan 2, Netherland 2, Greece 1, Pakistan 1, India 2, UK 1, Austria 1, Russia 4, Portugal 1, Ukraine 2, Romania 1, Ireland 1, Kosovo 1, Syria 1, Sweden 1, Uzbekistan 1)

Education of highly qualified experts to practice (research, companies, spin-off…)
2018 = in total 57 former employees
2024 = in total 81 former employees

Students in IEAP CTU:
Till 2018 = already successfully finished: BSc. – 8; Diploma – 29; PhD – 33
Till 2025 = already successfully finished: BSc. – 25; Diploma – 47; PhD – 44
At present = 8 PhD. students, 18 BSc. and Diploma students (14 at 4 CTU faculties)

Financial progress of IEAP CTU (self-financing):

Budget development: 2010 = 49,98 mil. CZK (appr. 1 975 k€)
2020 = 122,45 mil. CZK (appr. 4 621 k€)
2023 = 120,91 mil. CZK (appr. 4 836 k€)

Research performance of IEAP CTU:

Module 1 (national competition of high-quality results):
Every university and research institution apply top results (biblio, non-biblio) into national competition (base of financial support distribution)

2018: total number of CTU results = 189; IEAP CTU = 2 (1x grade 2, 1x grade 3)

2023: total number of CTU results = 96; IEAP CTU = 6 (1x grade 1, 3x grade 2, 2 were not evaluated)

2024: total number of CTU results = 89 (65 biblio, 24 non-biblio); IEAP CTU = 7 (6 biblio, 1 non-biblio)

Number of employees CTU (2023) = 4 089
Number of employees IEAP CTU (2023) = 98 (2.4%)

Summary No.1:

a) Successful strategy in high quality science (IEAP provides almost 10% of top biblio results of CTU into national competition of distribution financial support)

b) Successful strategies for significant cooperation in R&D&I (national and international level), for long-term development of LRIs (VdG, underground laboratory LSM, France) and research centers (distributed laboratories in CR, abroad, companies)

c) International Scientific Board (important for international R&D&I)

d) Successful strategies in internationalization of the local environment and recruitment of experts from external environment (1/3 of IEAP staff is from abroad)

e) Successful strategy for attraction of new PhD students (IEAP CTU strict rule for funding students = standard salary, full concentration on PhD subject, supervised by IEAP CTU experts, possibility to participate on grant projects, co-authors of articles), for internationalization of PhD studies (students from abroad, reciprocity)

Challenge: gender balance (full support of WIE, flexible working hours….)

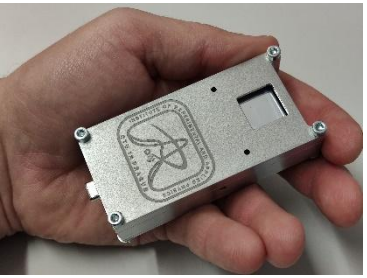
Summary of IEAP CTU Report – Module III

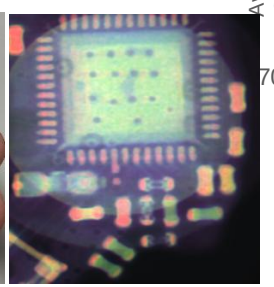
FORD 1. Natural Sciences

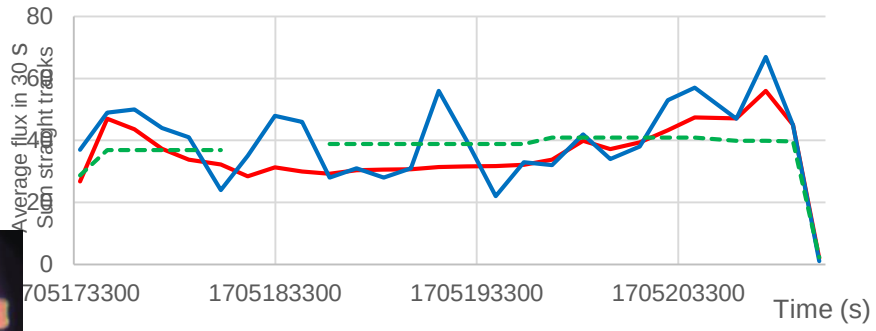
R&D&I fields = Natural Sciences; Engineering and Technology

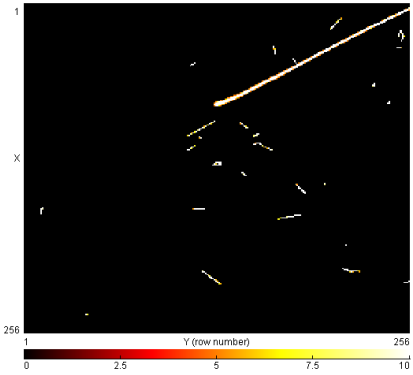
(physical + chemical + environmental + biological research; electronics + informatics + material research)

Our focus spans subatomic physics, particle physics, astrophysics, detector technologies and imaging in biology, zoology, preclinical research and material research. Recently, we have expanded our R&D&I efforts into space payloads and coordination polymers in chemistry.

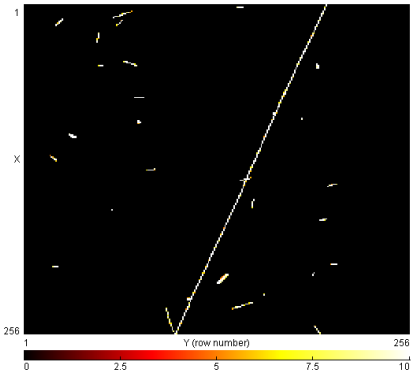




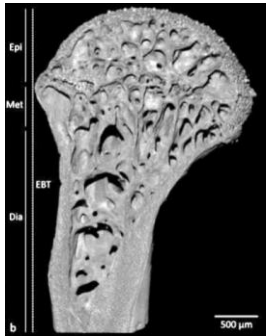


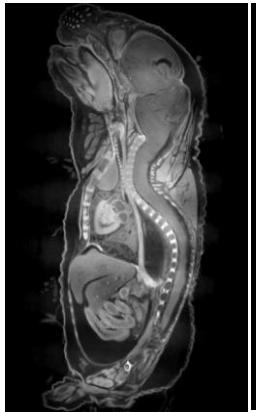


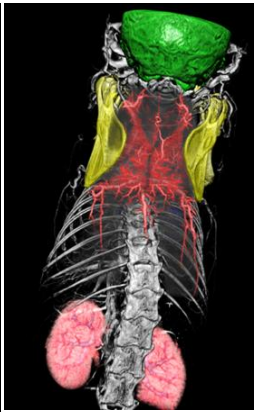
proton track



muon track







Recognition of international R&D&I community (selected examples, 2019-2023):

Total number of invited lecturers of our staff at foreign institutions = 69 (USA, Germany, Switzerland, Japan, China, Italy, France or Australia).

The number of lectures given by invited foreign scientists (USA, Germany, Switzerland, United Kingdom, France, Greece etc.) relevant to our R&D&I = 39

Staff members are active in evaluation of the research projects or programme calls in national or EU level

Activities and awards of early stage researchers (reviewers, invited lectures, best dissertations, e.g. see S. Gohl)

1) F. Šimkovic - ESET Science Award - Outstanding Personality of Slovak Science 2020, International Committee (chair Kip S. Thorne, Nobel prize winner in 2017)
2) *Y. Orikasa* – Outstanding Paper Award 2022, Physical Society of Japan
3) *I. Štekl* – representative of the Czech Republic in APPEC (EU community)
4) *S. Gohl* – The Outstanding Paper Award for Young Scientists – Scientific Commission C, 2021, Committee on Space Research, https://cosparhq.cnes.fr/
5) *S. Pospíšil* – The Glenn F. Knoll Radiation Instrumentation Outstanding Achievement Award for contributions to the development and application of pixelated radiation detectors in medical, high-energy and space science, 2020, IEEE Nuclear & Plasma Sciences Society.

Income of IEAP CTU in period of 2019-2023

IEAP CTU received 21 projects as a main applicant and 19 projects as a co-applicant. IEAP also solved 4 contract research projects.

Budget of IEAP CTU:

a) Funds from LCDRO (based on R&D&I results – articles, citations, patents..) = 50% of budget

b) Funds from projects (public resources) = 14 466 788 €

c) Revenues from contract research = 210 178 € (2x ESA, D-Orbit)

Results with impact to society (industry):

4 patents (1x in USA, 2x in EU, 1x in CR), 11 software packages, 6 prototypes, 1 utility patterns, 35 functional samples

Revenues from non-public resources = 295 545 €

(licence fee – Jablotron, Advacam, CERN; Rn detectors, MC simulation for antiradon, measurements on micro-CT, educational kit, VdG neutron beam time, test of valves, PCB repair…)

Popularisation of R&D&I and communication with the public:

1) Cooperation with secondary school teachers and students – regular seminars and summer internship for winners of national competition "Physics Olympiad", including textbooks and videos (e.g. *V. Wagner, V. Vícha and Z. Janout (both IEAP), The Boundaries of the Mendeleev's Periodic Table (or how to produce and study elements heavier than ever), Union of Czech Mathematicians and Physicists, Astra Print Hradec Králové, 2019)*

2) Organization of exhibitions – i) IEAP CTU Open Day (20th anniversary, 50 visitors);
ii) Exhibition in National Gallery ("In Depth and on the Surface", 2022-2023);
iii) Regular public visits under the theme "Science and Art" (institute's walls = an art exhibition space for paintings and other artworks. In 2021 – 2 events, each attracting around 40 attendees)

3) TV and radio (e.g. Czech Radio, R. Filgas, IEAP Space program; 4x Czech TV – S. Pospíšil, A. Owens, 2x I. Štekl)

4) Regular lecture cycles for Lifelong Learning Courses – 327 attenders (140 women)

5) Interviews abroad – i) Catalina Ramirez (Columbia), IAESTE student
ii) Santu Mondal (India), ATLAS video briefing
iii) Activities in Slovakia (10x in newspapers, 5x in TV or radio, 2x podcast)

6) Cooperation with The Institute of Contemporary History, Academy of Sciences CR – seminar and book „Czechoslovak nuclear and particle physics: between JINR and CERN", 2019, 551 pages.

7) IEAP CTU had a dedicated exhibition booth at the International Astronautical Congress in Dubai in 2021, in Paris in 2022 and Baku in 2023.

Our response for Recommendations from last evaluation:

1) *"The institute must apply for international projects based on their expertise in detecting and monitoring systems. It aims to focus on smart detecting systems and achieve the title of the centre of excellence in detecting & monitoring systems. Keep working in collaboration with companies. IEAP contributed to 29 projects. The total budget has been limited below 7.5 M EUR. The total amount of revenues from contract research has been limited to less than 300,000 EUR, which is considered small. Revenues from non-public sources have been limited to below 200,000 EUR."*

Response (shorten): Number of projects was increased to 40 (21 IEAP as a beneficiary and 19 as another participant). The total budget was substantially increased (from 8 M€ to 17,6 M€). IEAP CTU concentrated effort to apply international projects in detecting systems and was successful with 3 space projects (Radiation Monitor system in a Package, ERSA, and PAN) financed by ESA and EU.

2) *Try to develop integrated prototypes, which may attract the interest of local and foreign companies in the field of sensors, detectors and monitoring systems. Try to organize international conferences in the field of sensors, detectors and monitoring systems."*

Response: IEAP CTU increased the number of application results, from 22 results in the previous period to 57 (4 patents, 11 software, 6 prototypes, 1 utility model, 35 functional samples).

International conferences: IEAP CTU organized (in Prague) big international conference ANIMMA 2021 "Advancements in Nuclear Instrumentation Measurement Methods and their Applications" (296 participants) under the auspices of the Ministry of Industry and Trade of the Czech Republic represented by Karel Havlíček, Deputy Prime Minister. We regularly organize a conference (MEDEX'19, MEDEX'22, MEDEX'23 - neutrino physics and dark matter searches).

Remarks: RADECS 2026 Prague (radiation hardness of electronics, 600 participants, 50 companies); ANIMMA (R. Hodák is vice-chair) 2023, 2025, 2027 planned in Prague; MPGD 2026 Prague (micropattern gaseous detectors, 200 participants)

3) *"Choose an emblematic product/project which is within the capacities and know-how of your scientists and engineers in the field of detectors. Collaborate with an international patent office from the US or related to the US, under a beneficial contract."*

Response: Our effort was concentrated in this direction to develop a sophisticated detection unit for broad applications in space called HardPix. It was financed by company D-Orbit (UK) in the frame of the SWIMMR project. We signed an agreement with a US located patent expert to help us with the process in the USA (in 2024 we were able to obtain a US patent of authors S. Pospíšil and C. Leroy).

4) *"Awards - Keep working on this correct track. Emphasis in emblematic products with unique characteristics will bring higher awards.*
Recognition by the international community - Keep working in the same track, bearing in mind the smart specialization in well-chosen devices.
Popularization - Keep working in the same track, with emphasis on smart products delivered by your own research work."

Response (shorten):
- 3 prestigious awards (ESET Science Award, Glenn Radiation Award IEEE NPSS, Physical society Japan),
- members of editorial boards and several of us actively participate as referees of journals with high impact factor (including Nature)
- number of invited lectures of IEAP CTU staff in abroad = 69
- 39 invited speakers had lecture in IEAP CTU
- IEAP CTU has representatives on EU level, e.g. APPEC or ESFRI.

OVERALL ASSESSMENT

"The institute is working on the right track. Apart from that, deepening in the physics and the materials of the products developed by the Institute, will gain scientific knowledge and international recognition.
Apart from that, choosing a few emblematic projects based on the know-how gained at the Institute and developing them, will provide further international recognition. As an example, concerning space PhD technology, the monitoring and selection of space junk is important and could be such an emblematic flagship.
Then, the collaboration with a high-class international patent agency, based on paying after the product exploitation can result in a success story on exploitation. The Institute has the potential of a success story in detecting systems.
Finally, the Institute deserves the ability of awarding its own PhD works, with the proper collaboration with related Faculties, choosing proper methods for this, such as a chair in the Faculty."

Response: IEAP CTU followed carefully the recommendation concerning deepening in physics – more effort was given to fundamental physics (neutrino physics, dark matter, theory of weak interactions, direct participation in deep underground laboratories, nuclear physics on ISOLDE at CERN, KM3NeT).

We followed recommendations concerning space technologies as a possibility to reach further international recognition – more effort was given to develop sophisticated detection units for space financed by ESA as well as by companies (in total, 8 projects).

Concerning our PhD activities, it was decided to postpone the application and concentrate on the support of research students at the Bc., Master's and Ph.D. levels. IEAP CTU financially supports students during their research activities in the institute. Under supervision or co-supervision of IEAP CTU staff in period of 2019-2023 20 Bc. students, 21 Master's students and 11 PhD students defended theses.
(at present, we host students from 4 faculties of CTU).

Proven practices in IEAP CTU and plans for near future:

- regular evaluation of obtained results of IEAP CTU staff
- quick reaction on demands of projects (regrouping of teams)
- direct and intensive cooperation with industry (*spin-off company, common patents, licences, common projects*)
- extended reciprocal cooperation with partners from abroad (e.g. CNES, Cadarache, LNGS)
- recruitment of researchers from abroad for R&D in the Czech Republic
- support of professional education of Czech and foreign students (Bc., Diploma and PhD theses, IAESTE students, summer schools – IEEE NPSS)
- support of gifted young students (cooperation with secondary schools – teachers, students; organization of international summer schools)
- active participation in international conferences (IEEE, IWORID, ANIMMA, RADECS….).

IEAP CTU exists 23 years and developed from small institute to standard research institute at CTU in Prague with full self-financing (results, grants, commercialization)

Plans for future (near and far):

- Cooperation with Einstein telescope project (gravitational waves)

- Two projects of LRIs – i) extended project of deep underground laboratories (LSM, France; LNGS, Italy; CanFranc, Spain), new call of MEYS, recommendation of international referees.
  ii) new project: National Accelerator Center (and neutron sources), common effort of NPI AS CR, CTU, University in Ostrava – we opened discussion

- Equipment to Moon and Mars (e.g. pixel detectors for detection of water)

- Top PhD program with international partner (strict rules on students, limited number of students max. 5/year; long-term practice in technological companies, e.g. AI)

- Support of European activities in detection technologies, DRD1, DRD3, DRD4 (organized by CERN, IEAP CTU is partner)

- Active participation in preparation of national project to safety of nuclear energy (extension of running project CANUT II – Center of Advanced Nuclear Technologies).

Thank you for your attention