ELTE and space technology related activities

Eötvös Loránd University
Faculty of Science https://ttk.elte.hu/en
Faculty of Informatics https://www.inf.elte.hu/en/

L. Viktor TÓTH
(Institute of Physics and Astronomy)

We have been educating space researchers since over 100 year: ELTE alumni Zoltán Bay (1900-1992)

- Hungarian physicist, inventor, pioneer of space research

- MSc in math-phys at our university

- PhD with highest honour at our university in 1926

- **led one of the first 2 teams who measured the Earth-Moon distance using a radar (*)**

- defined *meter* based on the speed of light

100 years later **ELTE** hosted the **space scientist**

UNISPACE
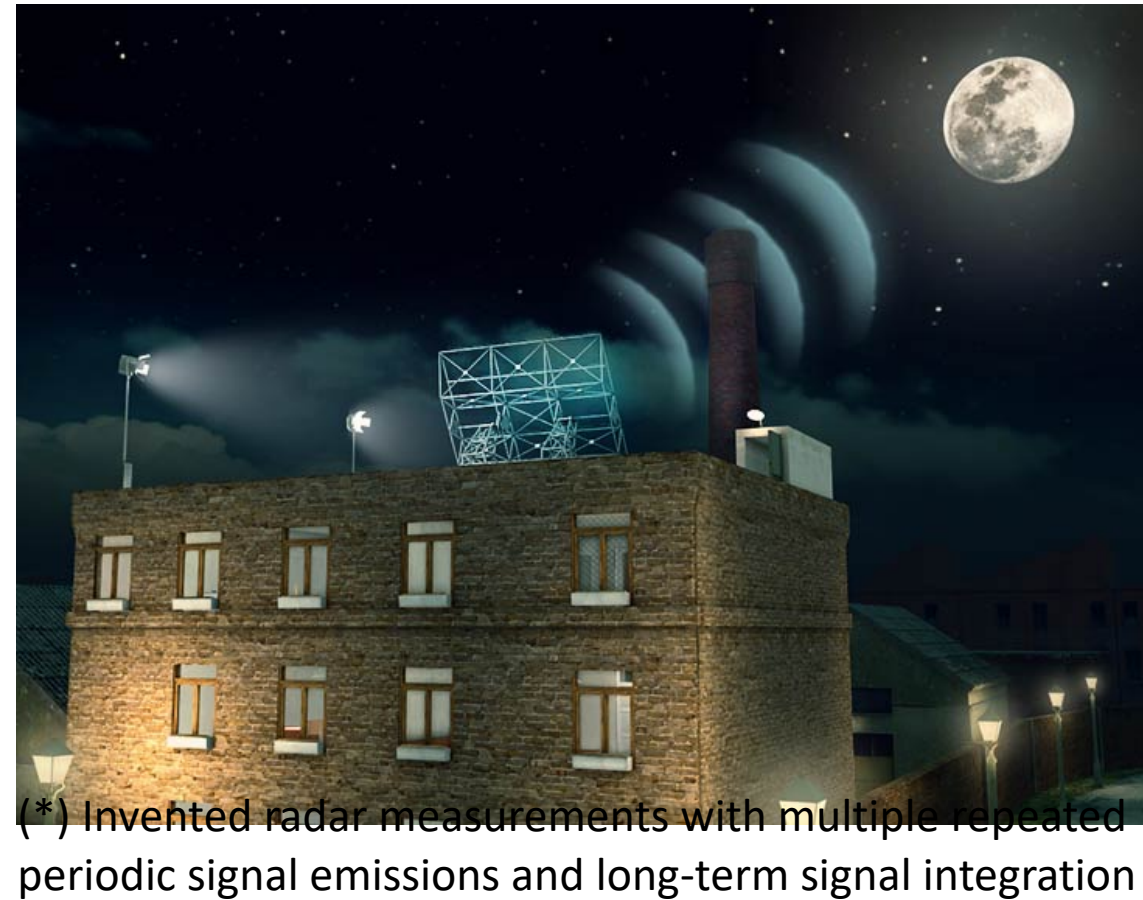
(*) Invented radar measurements with multiple repeated periodic signal emissions and long-term signal integration

ELTE – research today

- 15 researchers at ELTE have over 10,000 citations each.

- 14 researchers at ELTE have a Hirsch index above 50.

- on a yearly average ELTE researchers publish 3000 articles in scientific journals; 2000+ book chapters; 150+ edited books

- ELTE academic staff members hold 260+ leading positions in international research associations and are members of 1000+ editorial boards of international scientific journals

- ERC grants, H2020 projects, MOMENTUM research groups …

Nobel laurate (2023) **ELTE** alumni (Physics) Ferenc KRAUS
6th alumni awarded with Nobel price
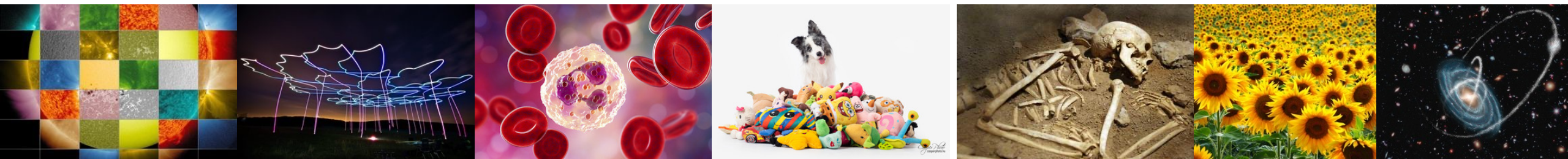
ELTE excellences, credits – a brief selection

- Earth Observation applications – yield estimation and change detection

- Space Weather and Space Safety – satellite and ground-based measurements

- Geophysics: geomagnetic activity – step towards protecting critical infrastructure

- Studies of wave propagation in magneto-ionic media

- Artificial intelligence applications

- Geoinformatics

- Inventing and testing new structural materials for spacecrafts

- Design and development of instruments used in astronomy and geophysics related space programs

Earth Observation applications – yield estimation (Ferencz+ 2004)

- A new vegetation index: General Yield Unified Reference Index (GYURI)

- Data: National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) data during the vegetation period.

- Annual yield data for eight crops and eight years (1991–93, 1996–2000) in Hungary, estimated by the robust method vs those provided by the Hungarian Statistical Office.

- The unit of all data is 100 kg ha^{-1} except for sugar beet and maize for silage where it is 1000 kg ha^{-1}
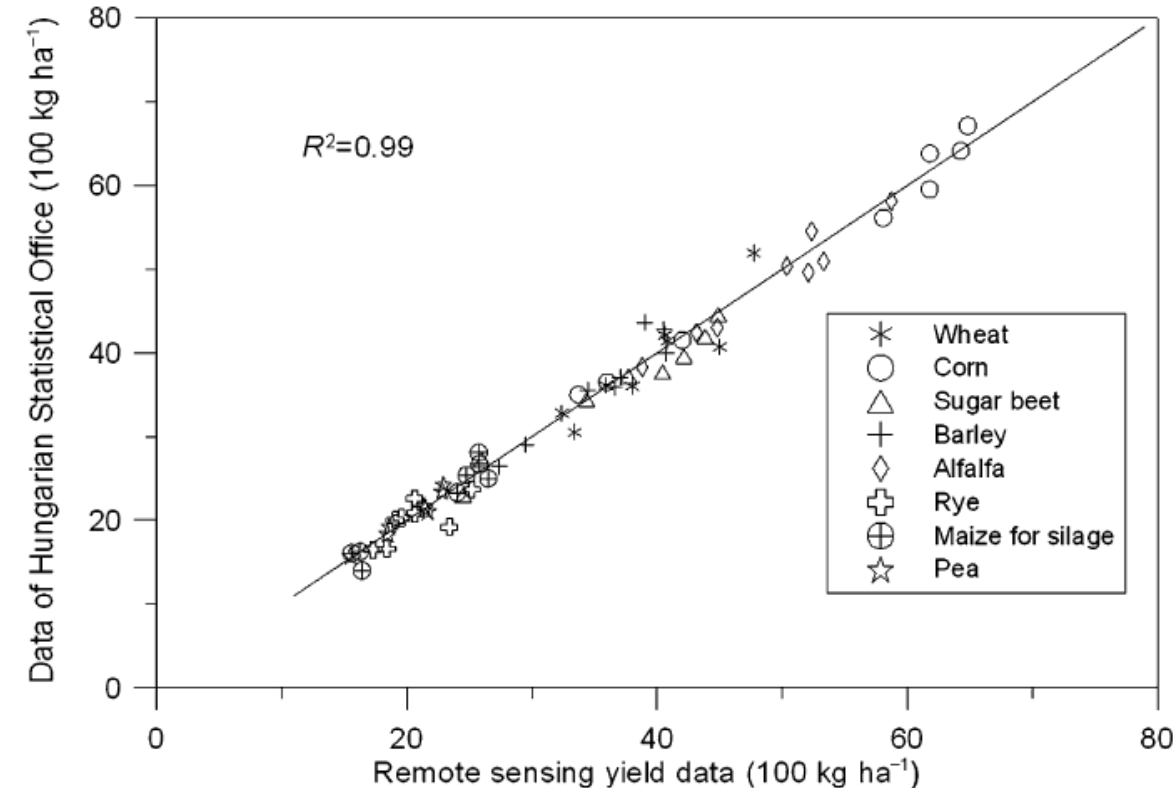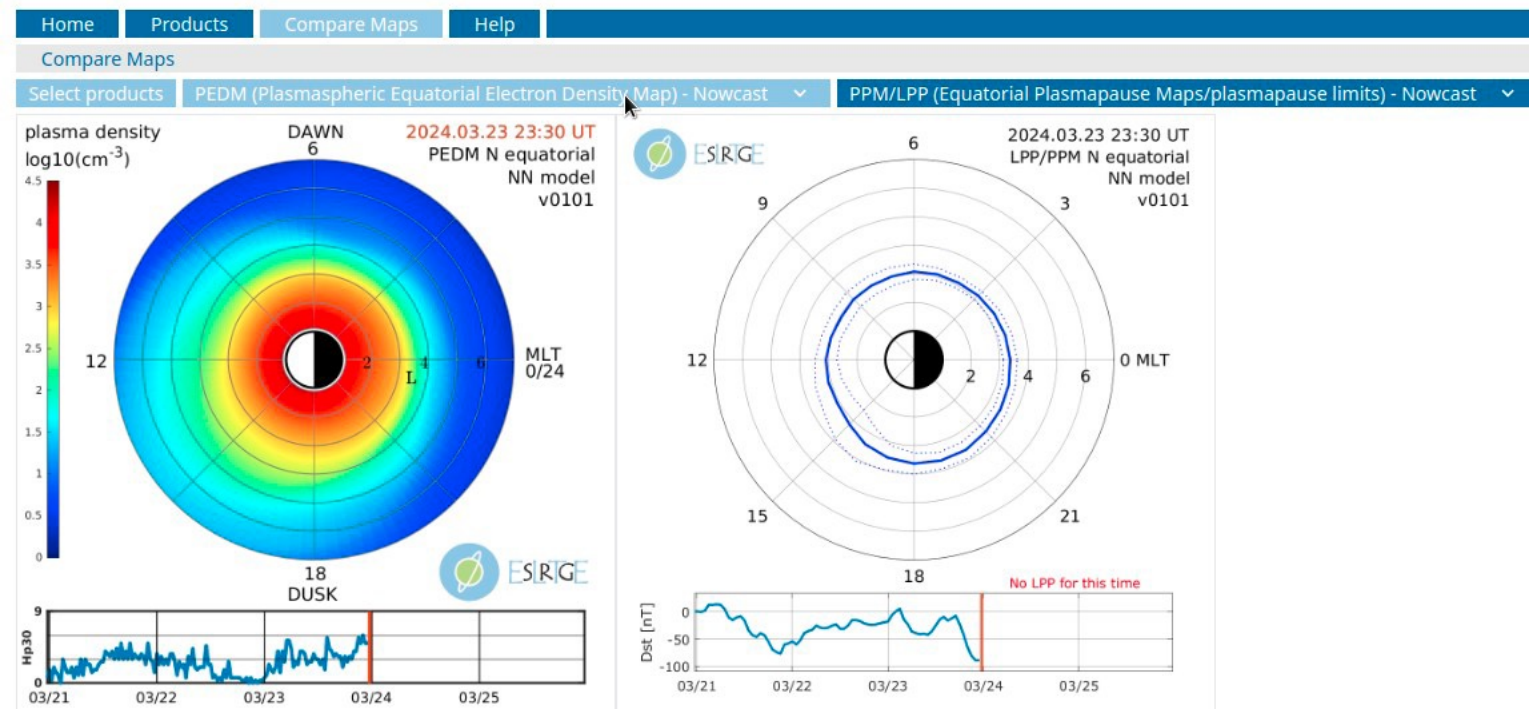
Space Weather and Space Safety

ESA **PLASMA** project

- Plasmaspheric Products for Space Weather Services

- Space Science & Engineering Ltd (prime); **ELTE SRG;** Earth Physics and Space Science Institute

- Plasmasphere and plasmapause models based on satellite and real time ground-based data (whistler - AWDANet, FLR – EMMA networks).

- It is public since 15 March 2024: https://swe.ssa.esa.int/elte-plasma-federated

PLASMA Plasmaspheric products for specification of Earth's plasma environment

Space Weather and Space Safety – Horizon Europe FARBES project

- Partners of Forecasting Actionable Radiation Belts Scenarios, (2023-2025):
  - **ELTE (coordinator)**
  - ONERA (France), IAP (Prague, Czechia), NKUA (Athens, Greece), British Antarctic Survey (Cambtidge, UK), Los Alamos National Laboratory/New Mexico Consortium (Los Alamos, USA)
- Ambition: simple, achievable predictions that are of utility to satellite operators:
  - Time to most severe environment
  - Most severe flux reached
  - Time to the end of the event.
- Method:
  - We start with an accurate initial state specification of both environment and drivers using readily available real-time innovative ground-based input parameters, driving state-of-the-art diffusive radiation belt models to "now".
  - We then base our forecast methodology on scenario-based predictions of subsequent behaviour of a few key quantities of interest to spacecraft operators (listed above).

Space Weather and Space Safety – Automatic Whistler Detector and Analyzer Network

- Ground based data used in PLASMA, POPRAD and FARBES projects
- Founded and led by **ELTE-SRG**
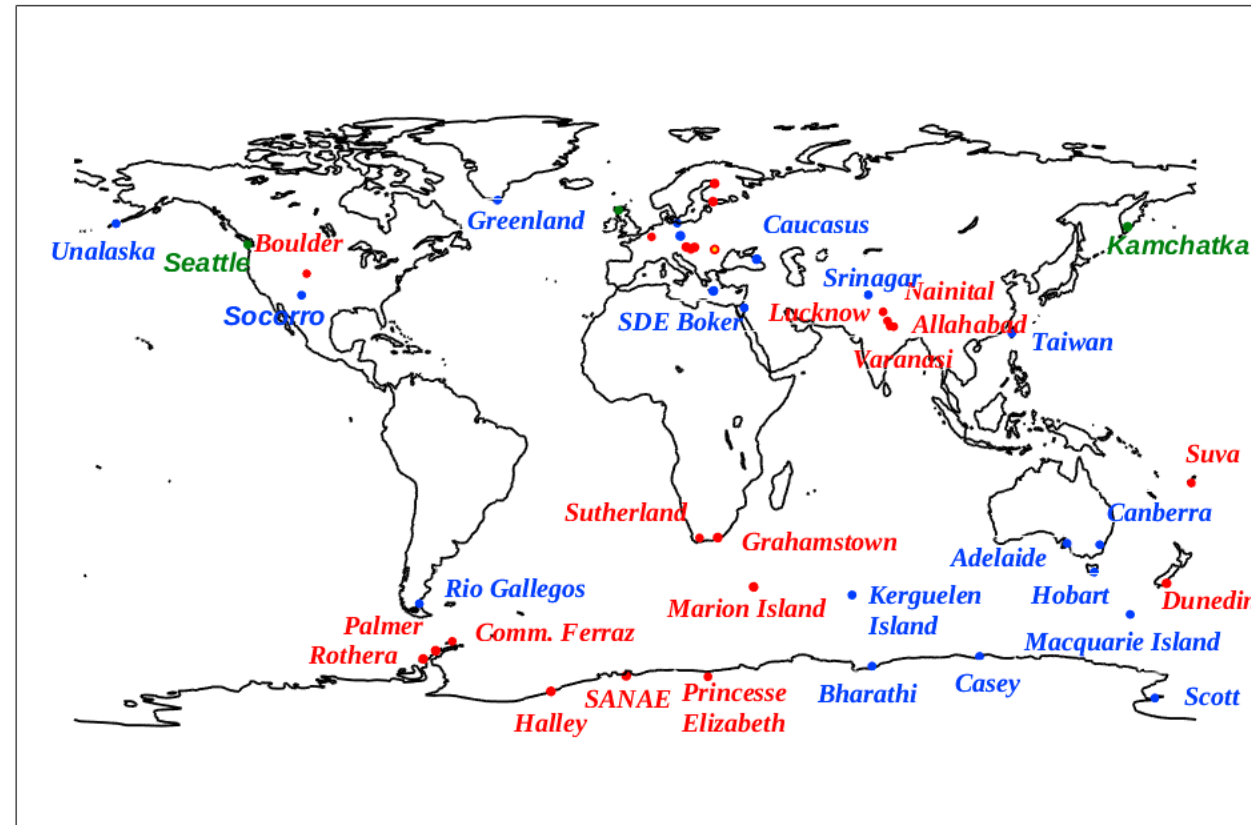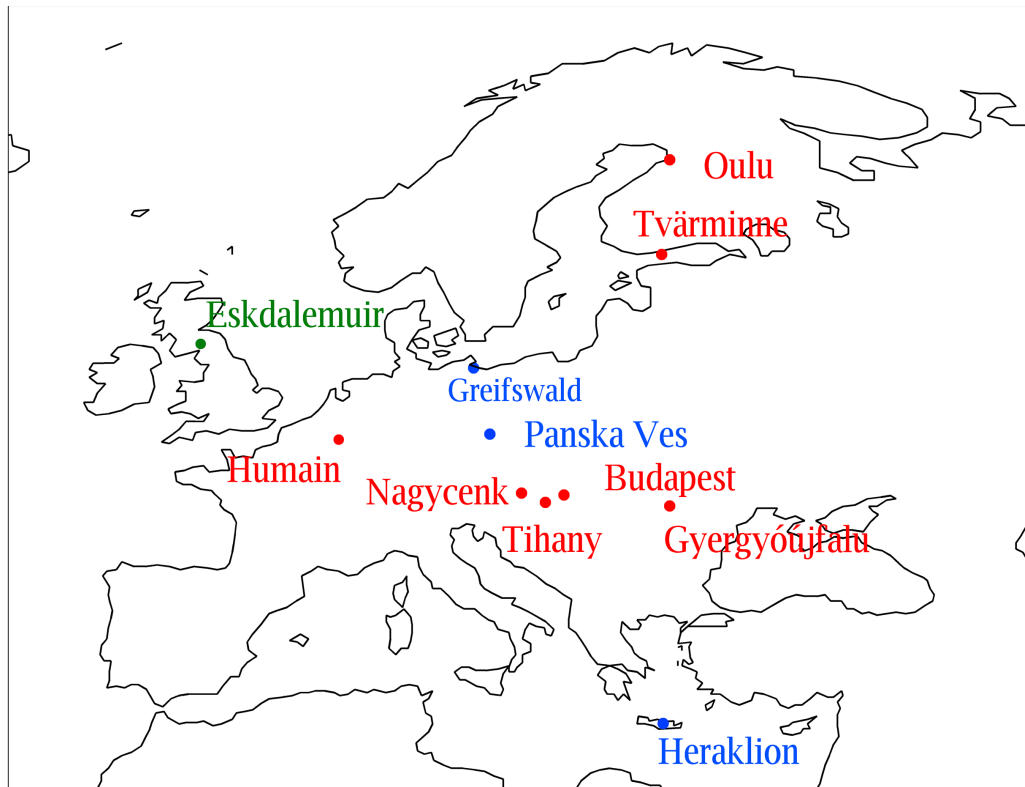
measuring geomagnetic activity –
a step towards protecting critical
infrastructure: the European
Meridional Magnetometer Array

- ground based data used in
  PLASMA and FARBES projects
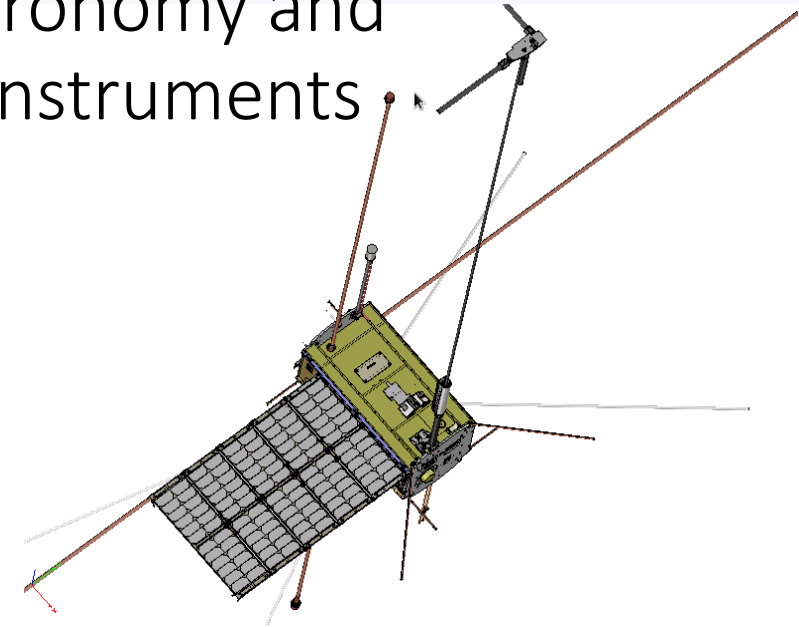- **ELTE-SRG** – EPSS cooperation
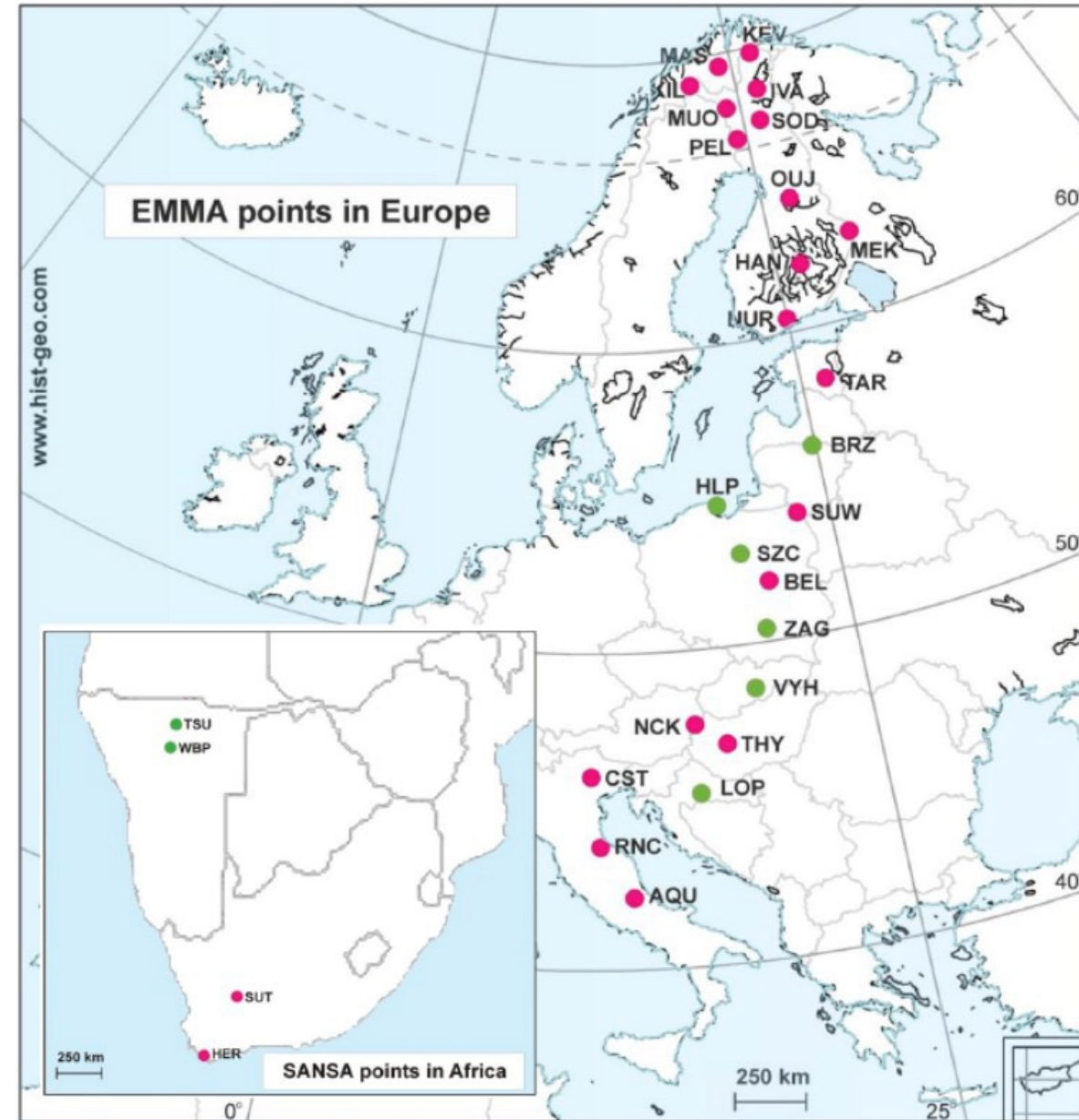
Design and development of instruments used in astronomy and geophysics related space programs – Plasma wave instruments

- Signal Analyzer and Sampler (SAS) ELF-VLF series: in cooperation with BL Electronics (BLE) Ltd (Hungary).
  - SAS1 (IK-24), SAS2 (COMPAS)
  - SAS3 (Chibis-M, RELEK/Vernov, ISS –Obstanovka experiment).
- BepiColombo mission: Intelligent Signal Detector Module in Plasma Wave Instrument, Mercury Magnetospheric Orbiter

Design and development of instruments used in astronomy and geophysics related space programs – Plasma wave instruments

- SAS3-T on **Trabant** satellites
  - with IKI (Ru), BLE, Bonn Hungary Electronics Ltd. (H), Space Science & Engineering Ltd (H).
  - Main goal: measuring 6 components of ELF-VLF waves 0-80kHz and download all raw data (~130Gbyte/day).
  - It is suspended, efforts are made to convert it to a national/ESA project

- Probing of the Plasmasphere, Radiation Belts and Ionosphere (**POPRAD**) ESA PRODEX project to test a VLF transmitter with loop antenna in a plasma chamber, with BLE and West Virginia University (USA):
  - **Systematic** probing of the *plasmasphere* by transmitting pulses in the frequency range of 1-10kHz
  - **Systematic** probing of *energetic electron* populations by generating frequency steps in the range of 1-10kHz.
  - **Systematic** probing of the *ionosphere* by VLF pulses - "inverse fractional hop whistler or VLF TEC "
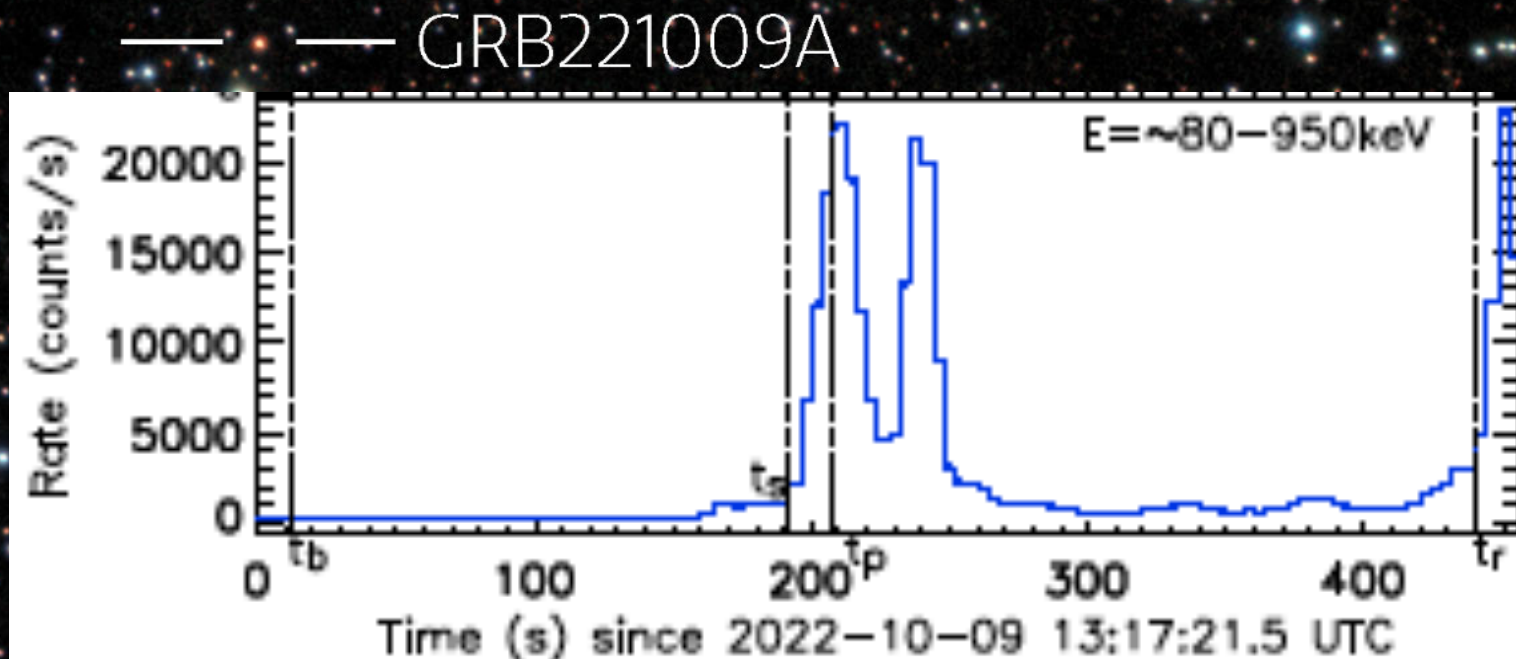
Design and development of instruments used in astronomy and geophysics related space programs – GRBAlpha


- a 1U CubeSat in-orbit demonstration mission

- 75 x 75 x 5 mm CsI(Tl) scintillator detector to detect gamma-ray transients

- PI: András Pál (HUN-REN Konkoly Obs. & **ELTE**)

- built by a collaboration of HUN-REN Konkoly Obs.; Hiroshima University; Spacemanic s.r.o.; Needronix s.r.o.; **ELTE**; Nagoya University; Brno University of Technology and Masaryk University

- primary goal is to demonstrate the feasibility of the timing-based localization of such energetic phenomena with a fleet of nanosatellites bearing scaled-up versions of our detector setup

- the smallest considering both operational and built ever astrophysical space X-ray observatory – a technology demonstration for CAMELOT.

GRB221009A an extraordinarily bright long-duration GRB, detected by GRBalpha without saturation


GRB221009A

Ripa et al.2023
https://www.aanda.org/articles/aa/full_html/2023/09/aa46128-23/aa46128-23.html

Design and development of instruments used in astronomy and geophysics related space programs – THESEUS
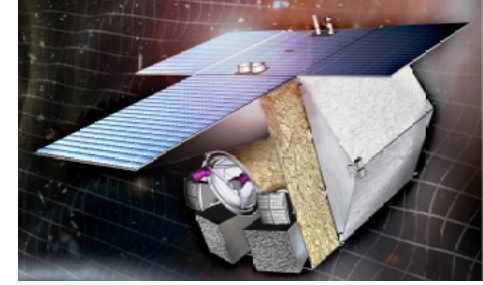
- Transient High-Energy Sky and Early Universe Surveyor

- ESA M class mission in phase A

- GRB multiwavelength detection and evaluation

- Hungarian HW participation is yet to be defined

- **ELTE** may contribute to the designing and manufacturing of the on-board calibration unit (CUA) of the IRT
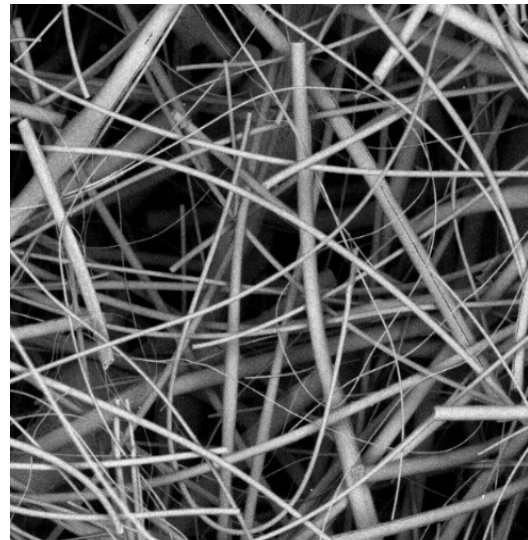 - together with the University of Debrecen
  -
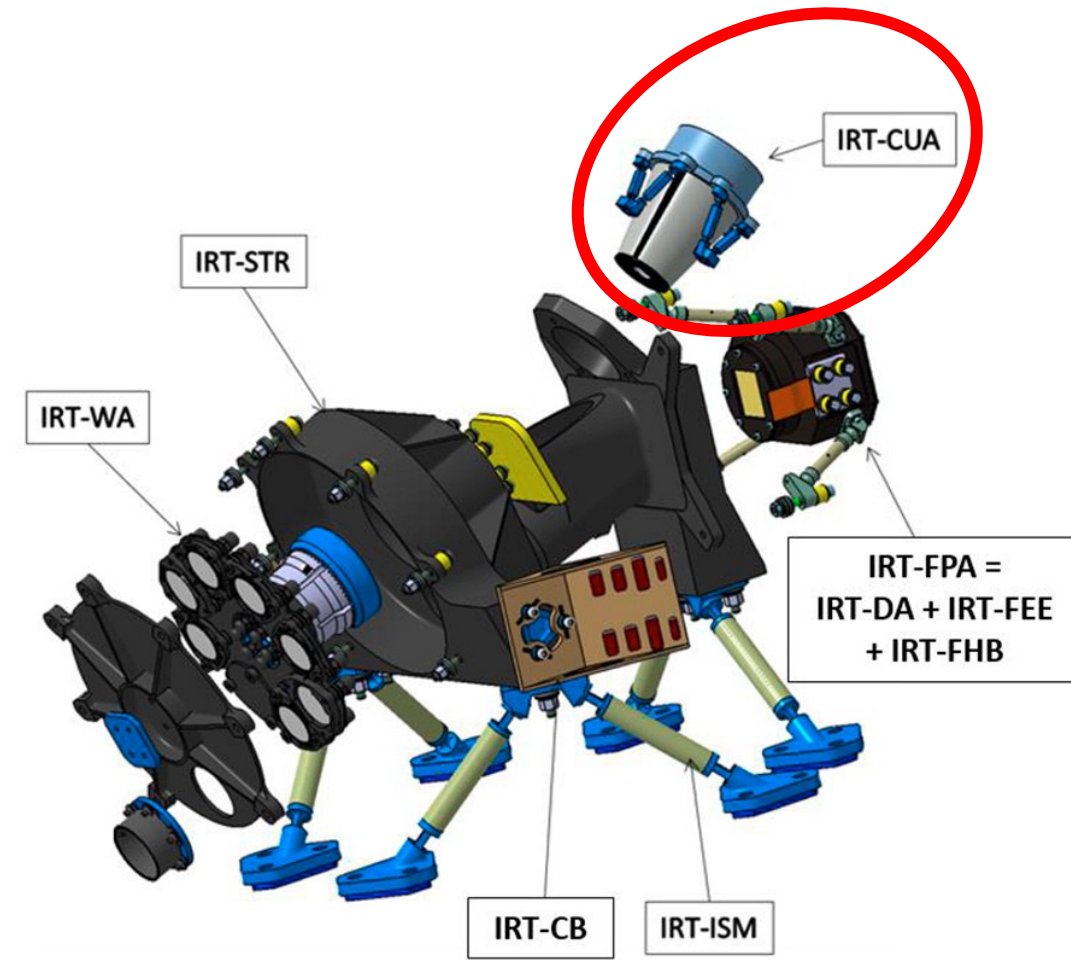
Inventing and testing new structural materials for spacecrafts
Ultra-light nanoporous aluminium oxide fibers for high temperature insulation
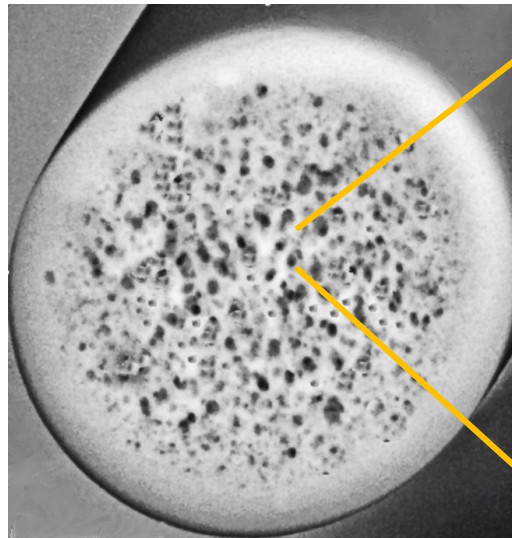
ELTE Institute of Chemistry PI: Katalin SINKÓ

- Nanoporous Al_2O_3 fibers are synthesized by special sol-gel method and drawn by centrifugal solvent spinning technique.

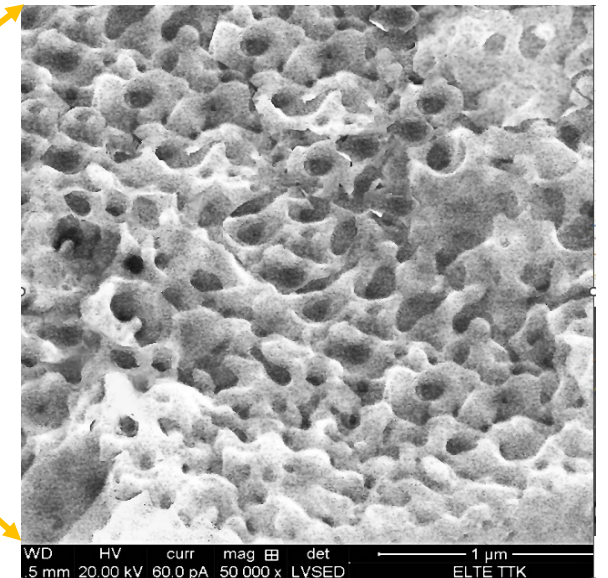- TRL5-6 technology level – H-ION Kft

800 °C (8 000x)   **1600 °C** (50 000x)

diameter of fibers:
2-20 µm;

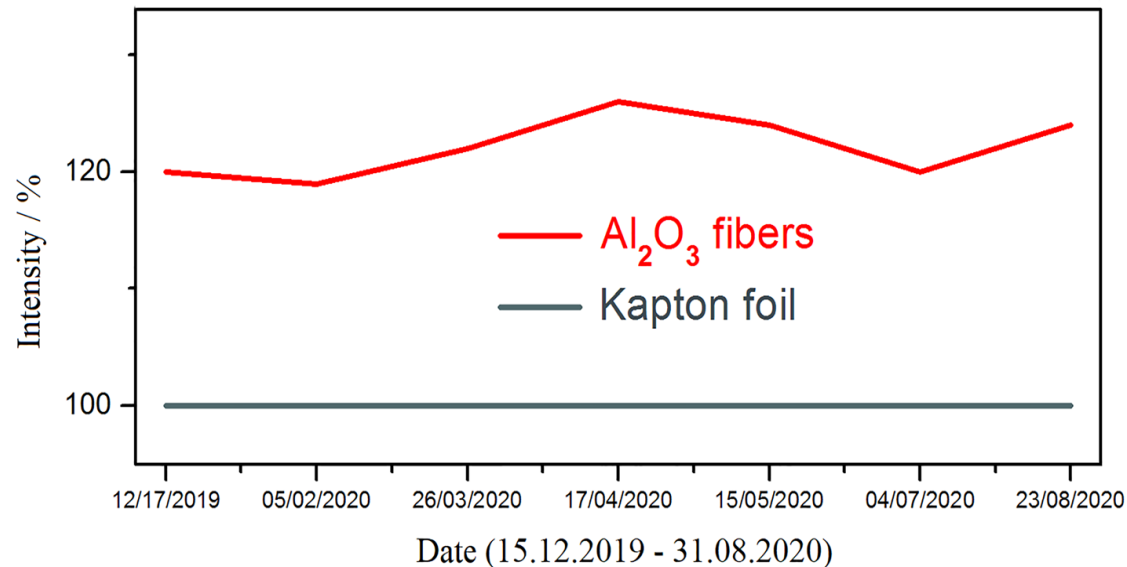pore size: 40-70 nm;

porosity: 58-65 %

thermal conductivity:
0.038 W/(mK)

Inventing and testing new structural materials for spacecrafts
Ultralight nanoporous **aluminium** oxide insulation materials

- The fibers were tested in lab and a 1 year flight on board the ATL-1 nanosat (built with BME)

Thermal insulation ability of Al_2O_3 fibers correlated to that of Kapton foil
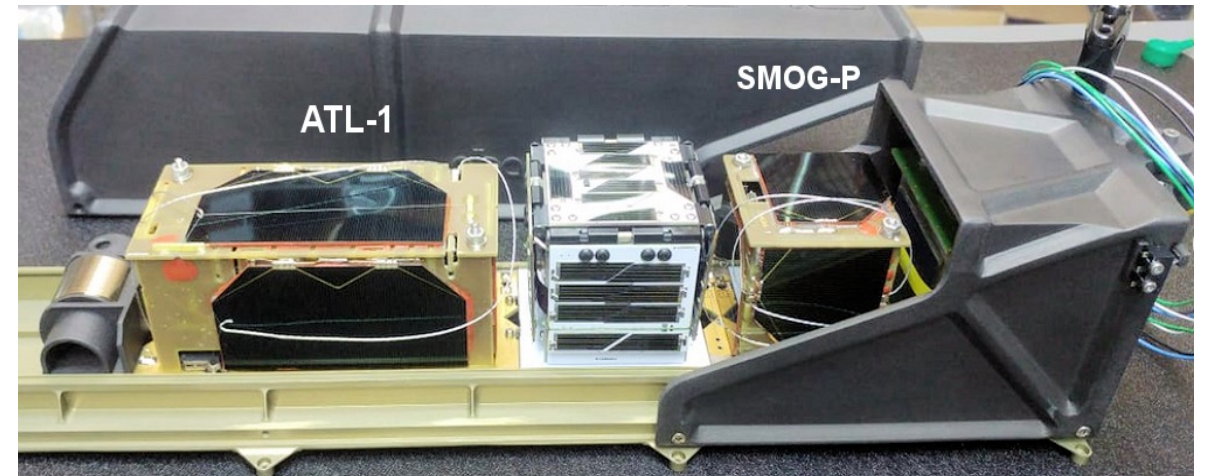
- P. Ádám, L. Dudás, O. Temessi, K. Sinkó CEAS Space Journal 15:671–680 (2023)
- P. Ádám, O. Temesi, Z. Dankházi, C. Voniatis, J. Rohonczy, K. Sinkó Ceramics Int. 48, 4:5499-5508 (2022)

Artificial intelligence applications – competences at the Faculty of Informatics

- **Composite Artificial Intelligence**
  - a new, pragmatic branch of the application of intelligent methods
  - uses a combination of different artificial intelligence techniques to achieve the best possible result
- **Computational intelligence**
  - One method to produce intelligent machine behavior is drawing inspiration from solutions from nature and biology
- **Artificial Neural Networks (ANNs)**
  - mathematical models of the structure and functioning of the human brain and nervous system
- **Evolutionary Technology**
  - a collection of problem-solving methods inspired by evolution.
  - Common to these methods is that they represent possible solutions to a problem as genes of abstract units, 'individuals'

Artificial intelligence applications – competences at the Faculty of Informatics

- Fuzzy Systems
  - summary term for methods based on non-binary logic
  - In everyday human thinking, few things are as clean-cut, or as 'black or white', as the yes-or-no, 0 or 1 world of classical logic.
  - This fuzzyness of the real world is appreciated in fuzzy systems, when the truth value of propositions is given by a function, rather than a yes or no statement.

- Cognitive Robotics
  - The ever-improving technology makes ever more complex computation possible in real time.
  - This possibility, combined with modern computational methods, made the application of Cognitive Robotics more wide-spread.
  - In these systems, the behaviour (i.e., movement, interaction, etc.) of robots is controlled by complex models resembling human cognition.

- Please visit the AI Department in the 1st coffee break for a guided tour!

Faculty of Informatics – students in space related competitions

- Fourth Applied Engineering Competition "Hungarians on Mars" (2009)

- Gergely Pais, a student of the ELTE Faculty of Informatics, was also a member of the international student team on Monday, which was the best of 25 teams in the 2014 Space Apps Challenge idea.

- CASSINI Hackathon: Space for Defense & Security (2023) – silver medal for the team of the Faculty of Informatics

- **Poseidon AI:** comprehensive solution for marine cyber security threats

- uses the so-called Generative Adversary Network (GAN) machine learning model

- a digital twin AI system with a HERO and a VILLAIN

- HERO protects the ship's IT system against attacks, while VILLAIN simulates operation and creates perfect attacks

- HERO is learning and being prepared for defense using simulations and real ship data from Galileo & Copernicus