# PlasmaLab@CTU for fusion education - chapter 1: upgrades of magnetic diagnostics and lithium evaporator, educational activities

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The Czech Technical University in Prague (CTU) holds a unique position among European institutions in the field of fusion education. Its Faculty of Nuclear Sciences and Physical Engineering (FNSPE) offers comprehensive study programmes at the Bachelor's, Master's, and Doctoral levels in both Czech and English, specifically tailored toward plasma physics and nuclear fusion. CTU participates in prestigious international programmes, including a double-degree PhD programme with Ghent University and the European FusionEP Master's programme, reflecting its strong integration into the European fusion research community.

A cornerstone of CTU's fusion education is PlasmaLab@CTU [1]. This dedicated laboratory not only provides students with hands-on experience in plasma diagnostics and fusion-relevant experimental techniques, but also serves as a support structure for the community and a test bed for new concepts and ideas. The facility hosts a broad range of experimental setups, including a 3D optical microscope, a laser spectroscopy experiment, a sonoluminescence apparatus, Paschen curve measurement equipment, a resonance cavity, electrostatic and magnetic probe arrays, a linear magnetic trap, a microwave interferometry system, and various discharge tubes. A universal vacuum recipient (The Cube) and a 3D printer tops up the comfort of experimentalists. This laboratory is closely connected with the Golem tokamak. This diversity of equipment ensures that students gain practical exposure to the full spectrum of plasma diagnostic methods relevant to current and future fusion devices.

**Magnetic Diagnostics: The "Vrtichvost" Device**

A significant upgrade of the magnetic diagnostics stand at PlasmaLab@CTU has been completed. The centerpiece of this upgrade is the "Vrtichvost" device [2], a novel educational and research apparatus designed to simulate magnetic perturbations analogous to those encountered in tokamak plasmas. A photo of the core is in Fig. 1 The name "Vrtichvost" (Czech for "spinning tail") reflects the rotating nature of the device's core mechanism.

The device consists of an assembly of ten current-carrying wires arranged to model plasma current perturbations, replacing a single central conductor used in an alternative configuration. These wires are connected in series during the first test configuration (one up, one down etc.), generating a mode number n = 5 structure. The entire assembly rotates, a DC current of up to 8 A can be applied.

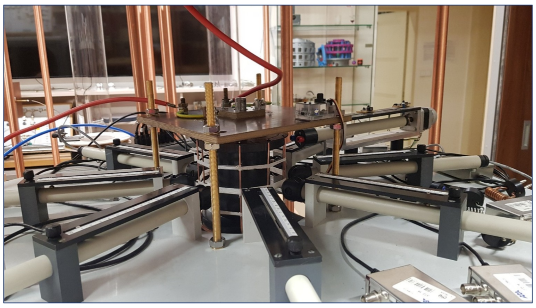

Figure 1: Vrtichvost: 10 copper wires on a rotating cylinder; carbon brushes on top, white threads for mechanical stability.

The device is surrounded by an eight-coil detection array arranged in the same poloidal geometry as the Mirnov coil systems used on tokamaks. This configuration allows students to directly observe and analyze the magnetic field structure associated with simulated magnetohydrodynamic (MHD) instabilities and magnetic islands.

**3D Microscopy Analysis: TAČR STEAM Project**

In collaboration with the TACR STEAM project (Super-Thermal Exchange via Advanced Micro-boiling) [3], PlasmaLab@CTU performed microscopy analyses of copper tile samples for active divertor cooling. The STEAM project targets a new generation of coolers capable of withstanding heat fluxes exceeding 100 $MW/m^2$.

Using the 3D microscope for material research, analyses of oxidized surfaces and cross-sectional lamellae were performed on samples after high-power plasmatron exposure. Measurements focused on the geometric characterization of lamellae structures and the visualization of surface microstructural changes. As a secondary outcome, selected microscopy images were used in an institutional exhibition and a calendar, contributing to public engagement with fusion research. An example of a detailed surface is in Fig. 2

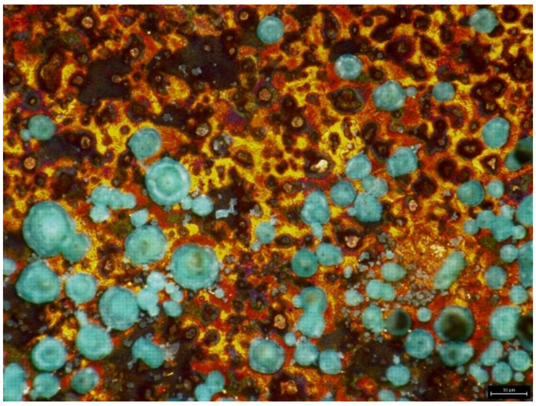

Figure 2: An example of an oxidized surface of a Cu sample for active cooling. The measure is 50 $\mu$m.

**Educational Activities and Outreach**

**EMTRAIC and Lithium Evaporation** For the past three years, PlasmaLab@CTU has contributed one task to the EMTRAIC winter school for FusionEP [4] Master's students, held at IPP Prague at the COMPASS tokamak. In 2025, the task focused on lithium evaporation experiments inside the vacuum cube [5], intended as a preparation of usage of Lithium in the GOLEM tokamak [1]. An example of a Li plasma in argon is in Fig. 3.

Figure 3: The Cube with Li evaporation experiment in EMTRAIC.

**First Nigerian School on Plasma Physics and Fusion Energy** PlasmaLab@CTU contributed remotely to the first Nigerian School on Plasma Physics and Fusion Energy, organized entirely by FusionEP students led by Godsfavour (Bohouš) Amanekwe who graduated in Prague. PlasmaLab provided a remote resonance cavity experiment, allowing Nigerian participants to engage with hands-on diagnostics. The school was officially recognized by the Nigerian Embassy in Prague [6].

**Week of Science and "Become a Woman Scientist" Event** PlasmaLab@CTU participated in the Week of Science at FNSPE [7], where secondary school students received training in physics and presented results at a student conference. The facility also hosted the „Become a Woman Scientist for a Day“ [8] event for secondary school girls, which included an afternoon experiment. The event received significant media coverage, including a two-minute shot on the main commercial Nova television channel in the evening news.

**Secondary School Research (SOČ): Fusor Project** Second-grade student is constructing a fusor aimed at achieving thermonuclear fusion in deuterium. Initial tests were performed in argon to safely optimize discharge parameters - a test cage is in Fig. 4. A new high-voltage power supply up to 30 kV is being manufactured for the project. In October 2025, the student presented the experiment at a seminar in his school.

Figure 4: A test version of a fusor cage in argon.

**Space filament, PR** PlasmaLab@CTU is testing "Space Filament" by Czech company Prusa, originally developed for and being used in space satellites. The goal is to evaluate its suitability for use inside our vacuum systems, with tests focusing on outgassing. Public outreach is also an important part of PlasmaLab@CTU's mission, helping to raise awareness of fusion research among the general public and inspiring the next generation of scientists. The laboratory regularly participates in public events and media activities, reaching audiences from secondary school students to the broader public.

**Conclusions**

PlasmaLab@CTU has undergone significant technical and educational development in the reported period. The "Vrtichvost" device represents a unique educational tool for demonstrating MHD-related magnetic perturbations in a tokamak-like geometry, enhancing the quality of training in magnetic diagnostics. The microscopy activities within the TAČR STEAM project demonstrate how the laboratory contributes to active research in plasma-facing components while generating public outreach materials. PlasmaLab@CTU has also expanded its educational reach nationally and internationally – from remote contributions to the first Nigerian school on plasma physics to fusor construction by a secondary school student – demonstrating a broad approach to fusion education at all levels. PlasmaLab@CTU remains a cornerstone of fusion education at CTU and a key asset for the European fusion community.

**Acknowledgements**

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