EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

PLASMALAB@CTU - NEW FACILITIES IN SUPPORT OF FUSION EDUCATION

Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague (FNSPE)

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20th Conference of Czech and Slovak Physicists

September 10, 2020

Contents

- Fusion education at FSNPE
- PlasmaLab@CTU
  - Facilities
  - Remote control
- Teaching in PlasmaLab@CTU

Fusion education at FNSPE

Physics and Technology of Thermonuclear Fusion

- 13 years of experience, approx. 70 Bc + 50 MSc graduates
  - 5-10 Bc + 20 MSc + 10 PhD students enrolled at present
- The BSc programme (3 years)
- The MSc programme (2 years)
- PhD programme 5th year at present, this year we are expecting first graduates
- New accreditation this year
- MSc for foreign students: Fusion EP
- Joint PhD programme in „High temperature plasma physics and thermonuclear fusion“with Ghent University
  - ESF supported, to be launched now. University of Padova may join in via Ghent University.
- For the joint degree, a new lab is being built = **PlasmaLab@CTU**

High temperature plasma and fusion technology laboratory

- 2017 – 2022, ERDF (European Research and Development Funds) project in support of the joint PhD programme
- Four units:
  - **Plasma** – in site
    - Linear magnetic trap
    - Paschen curve
    - Discharge tubes
    - Resonance cavity
  - **Magnetic and electric fields** – in site
    - Magnetic field
    - Probes
    - Microwaves
  - **Optics** – in site
    - Laser spectroscopy
    - Sonoluminescence
    - 3D microscope
  - **GOLEM tokamak** (modernization, in particular feedback system)

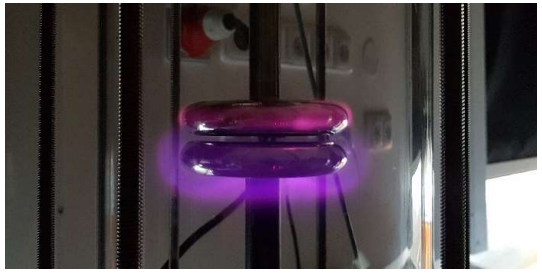
} upstairs

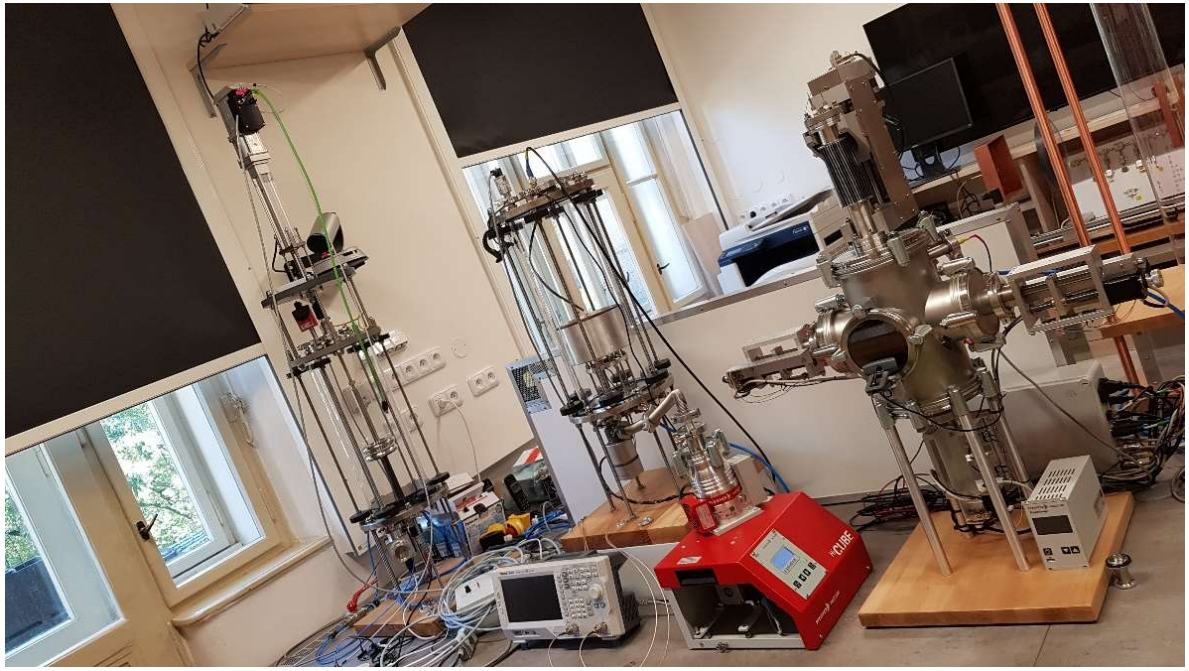
PlasmaLab@CTU – remote access

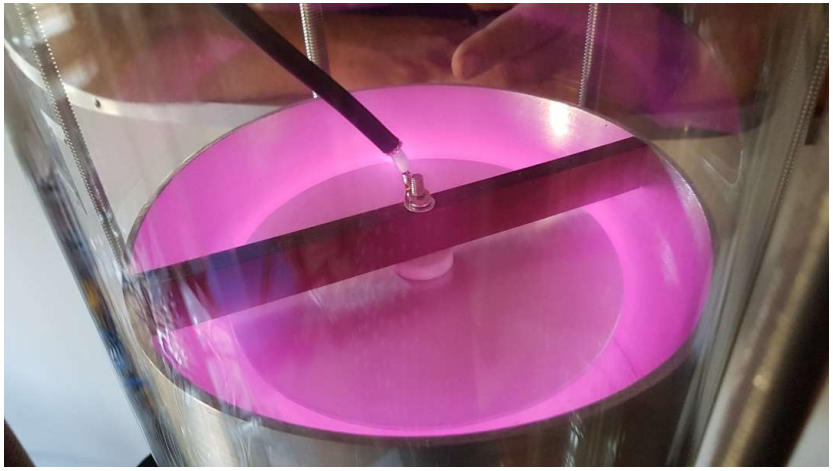
- GOLEM fully remote
- The rest as much as possible:
  - Most of the devices is controlled by LAN or USB
  - LAN: oscilloscopes, spectral analyzer, vacuum gauges etc., some sources – directly to the network
  - USB: step motors, some sources – controlled by Arduinos or/and Raspberries Pi
  - Each experiment is controlled by a Raspberry Pi, that controls other components
  - Common part – gas control has it's own Raspberry Pi

PlasmaLab@CTU - Plasma

- Paschen curve,
- Resonance cavity



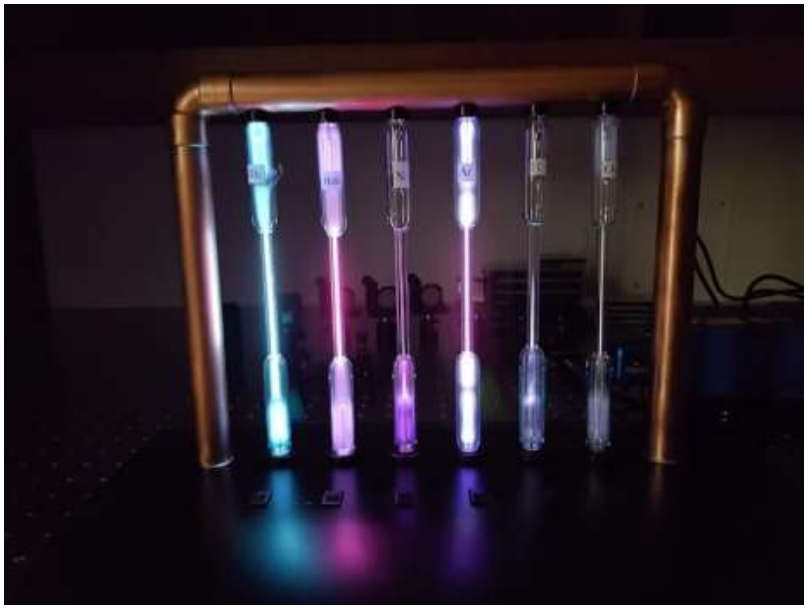


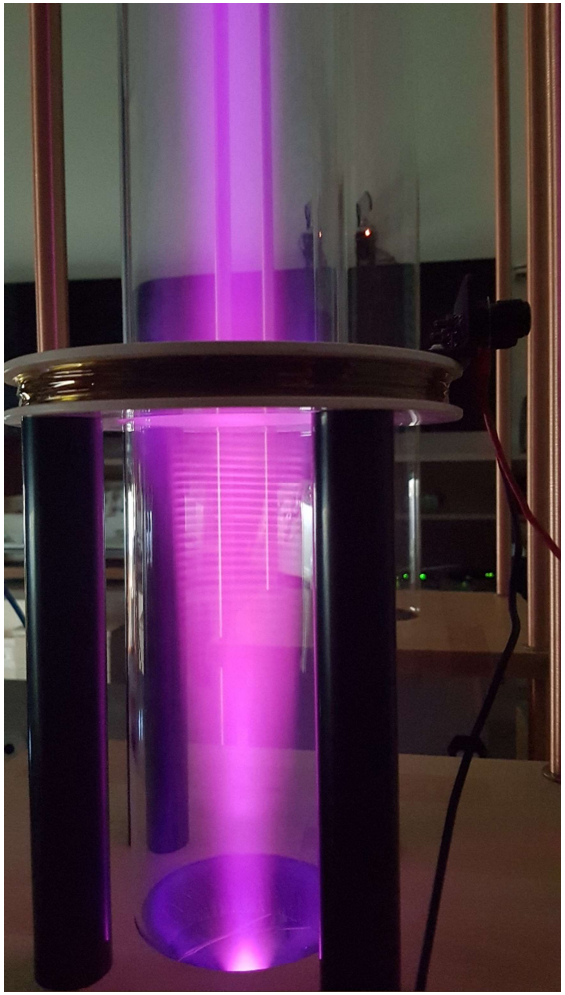


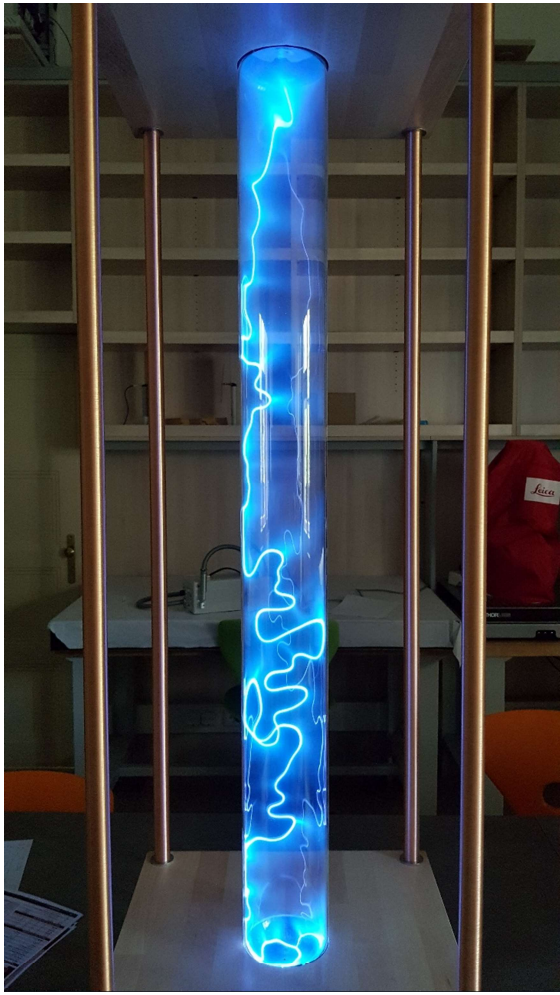
PlasmaLab@CTU - Plasma

Discharge tubes

- Spectral tubes (CO_2, N_2O, N_2, Ar, H_2, O_2)
- Tube with variable pressure
- Iodine tube

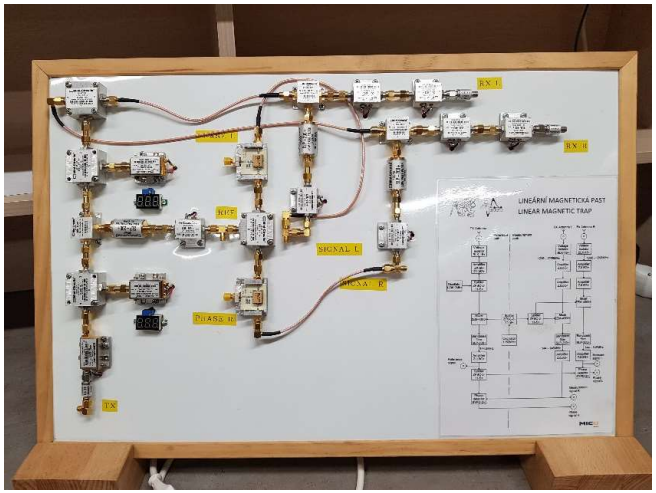


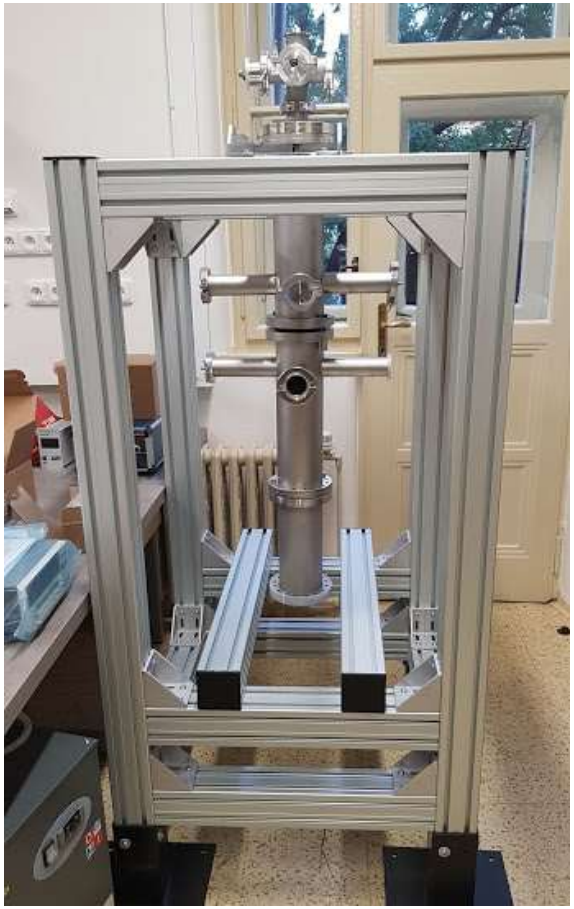




Linear magnetic trap

- Study of microwaves propagation along and across magnetic field
- Mag. field in the center ~ 100mT
- Penning discharge



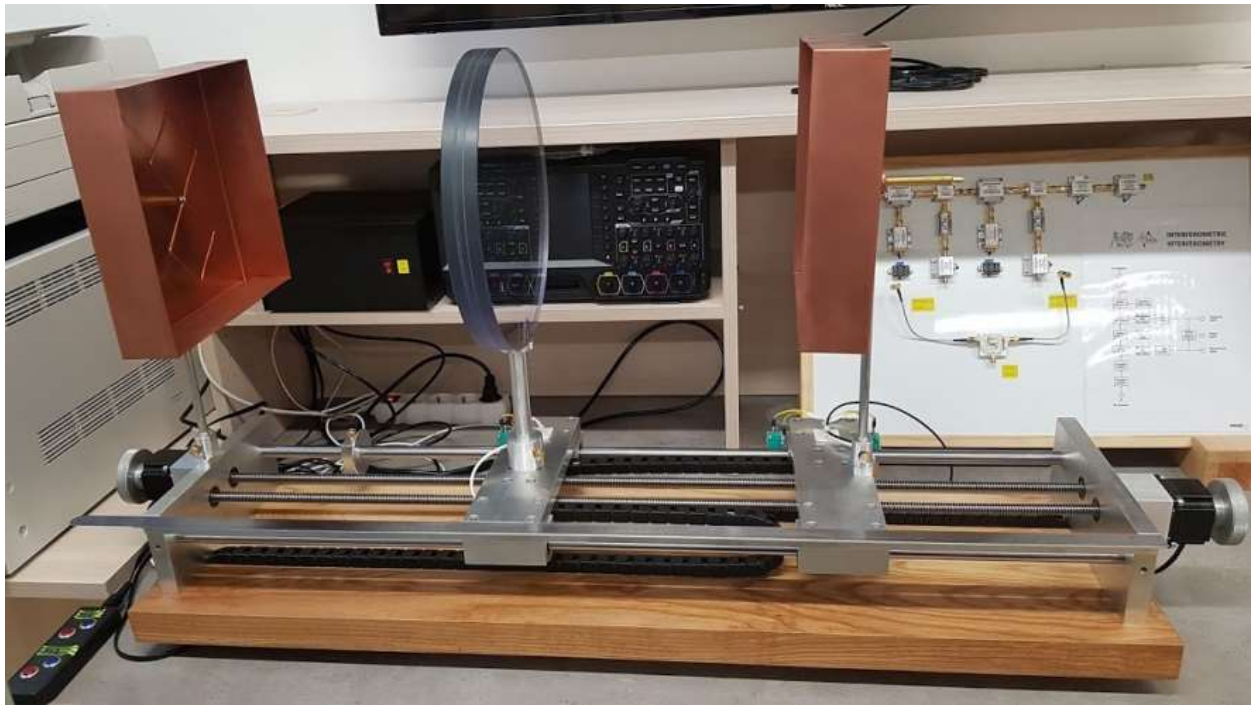


PlasmaLab@CTU – Magnetic and electric fields

Magnetic field

"tokamak feed back"

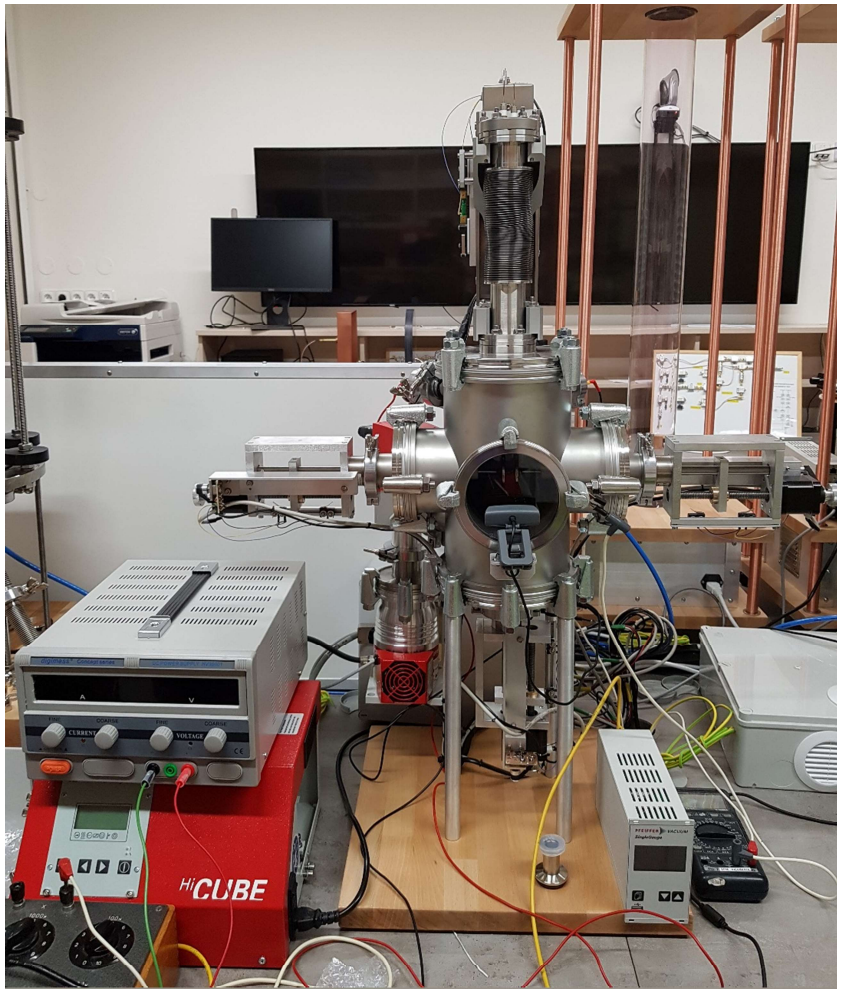
Interferometry



PlasmaLab@CTU – Magnetic and electric fields

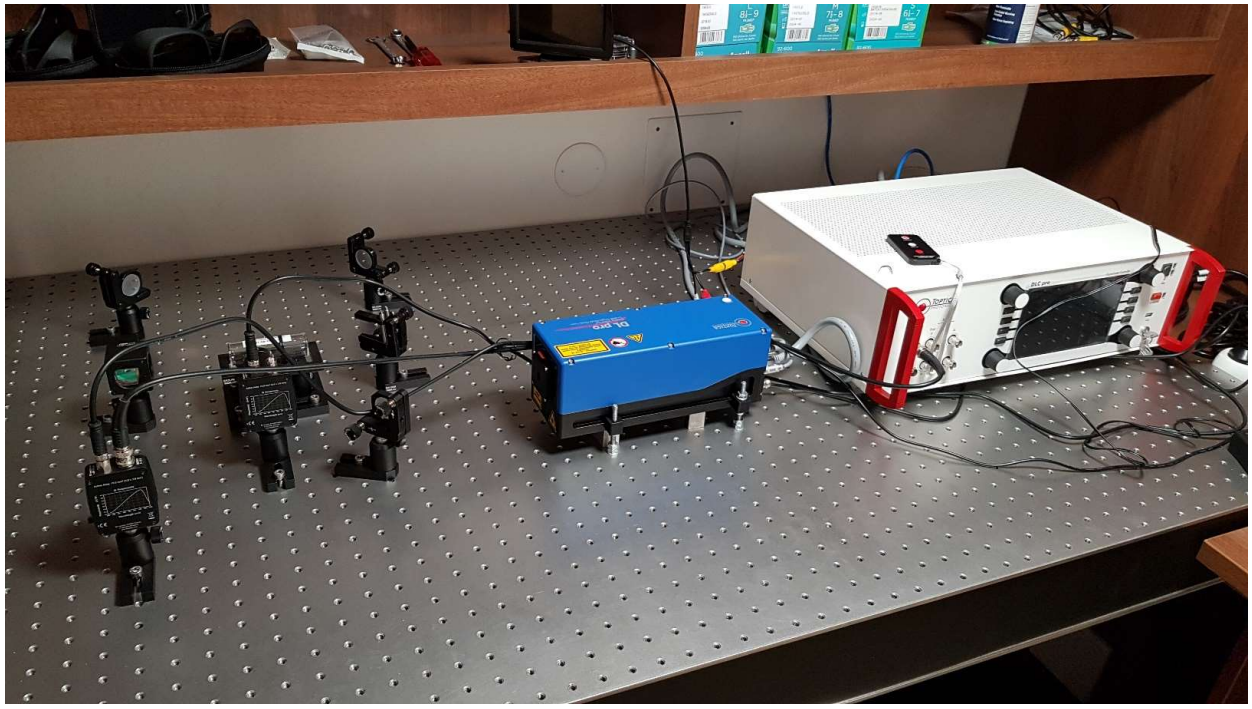
Probes

- Top: Exchangeable probes:
  - Double and triple Langmuir
  - Emissive probe
  - Anything else
- Bottom: single Langmuir probe
- DC discharge



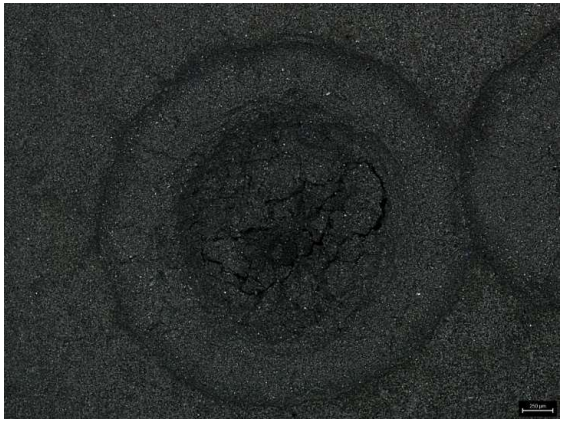
PlasmaLab@CTU - Optics

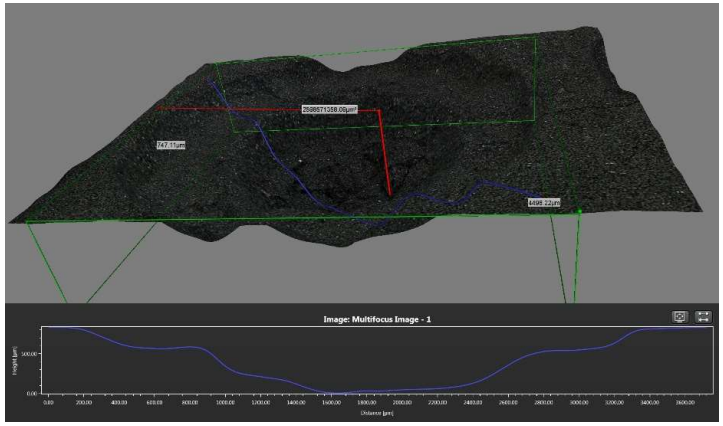
Laser spectroscopy

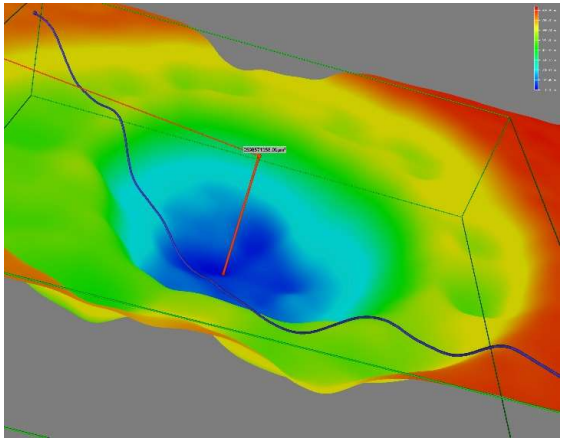


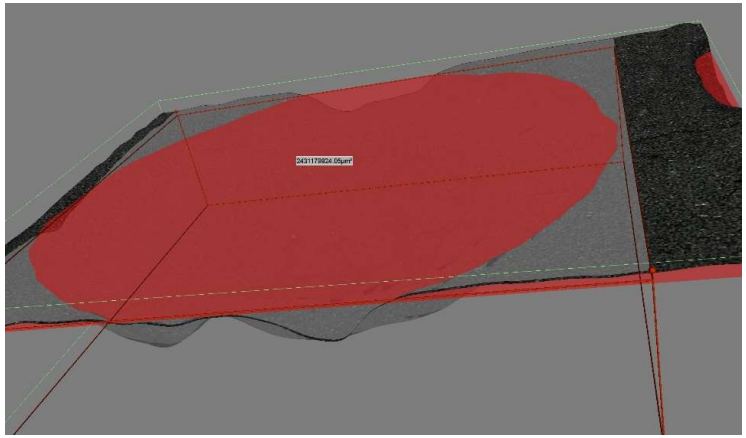
Sonoluminescence

3D Microscope





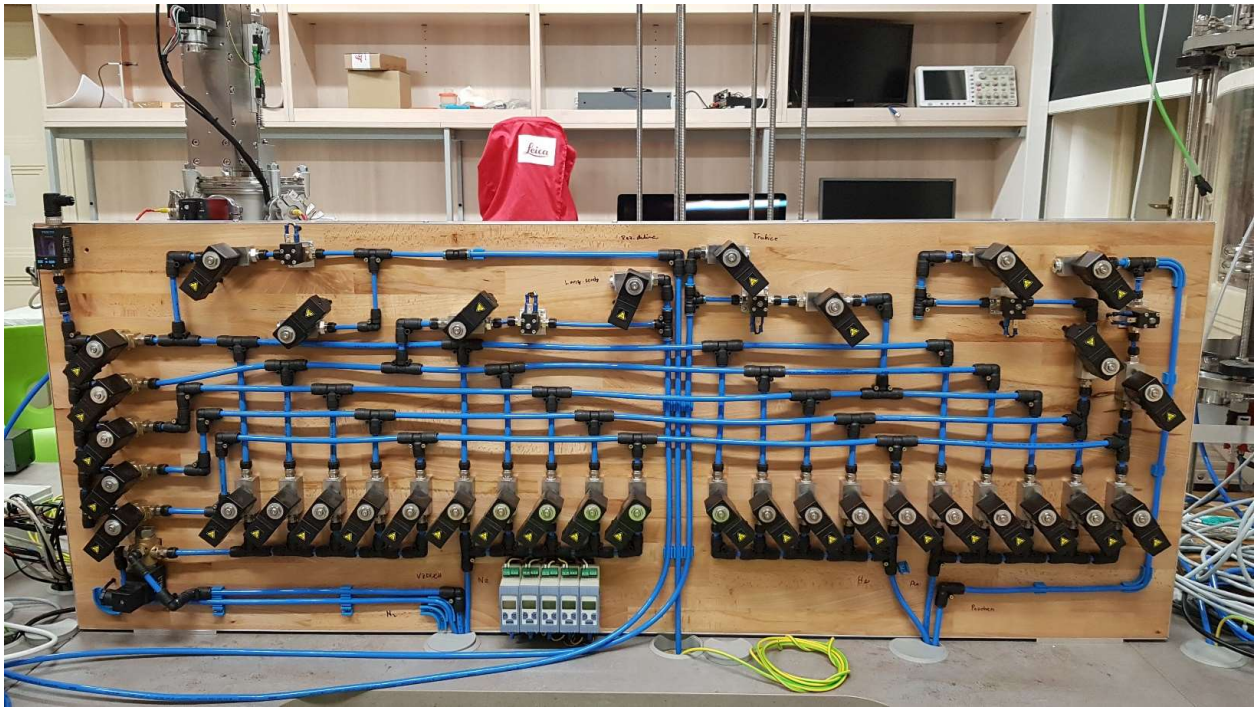




PlasmaLab@CTU - common

The Cube

Gas system



PlasmaLab@CTU – GOLEM tokamak

- New poloidal field coils and primary winding coils – last year, finished
- New control system electronics is finalized

PlasmaLab@CTU – GOLEM tokamak

Teaching in PlasmaLab@CTU

- GOLEM
  - Summer/Winter schools
  - Remote campaigns
  - Lab work (PRPL etc.)
- Upstairs
  - Primarily for PhD students, will run for all levels: Bc, MSc, PhD
  - 6 MSc students last year (PRPL)
  - This year, with new accreditation: Bc students in the summer semester

Conclusions

- PlasmaLab@CTU is being built, commissioned, put into operation and upgraded
- First students are being trained in the PlasmaLab@CTU

http://www.plasmalab.cz

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