PlasmaLab@CTU

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

Progress of the PlasmaLab@CTU

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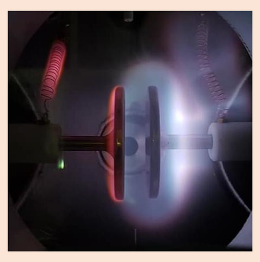
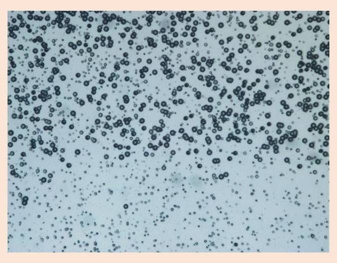
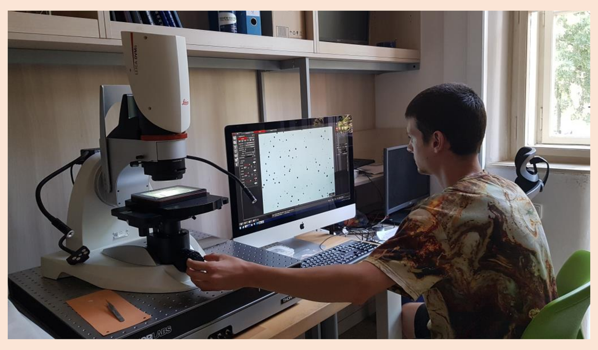
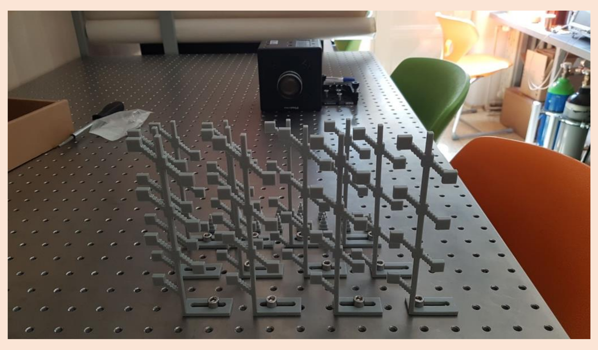
Teaching

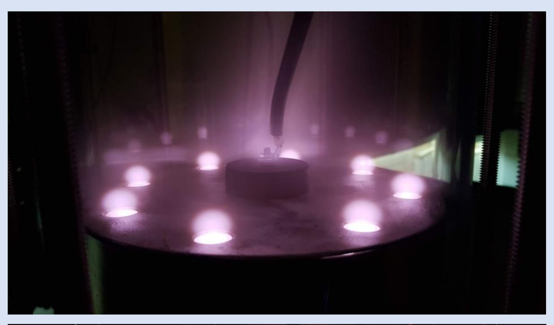
- **Bc theses**
  - Ondřej Bareš, PlasmaLab at CTU – **Magnetic diagnostics**, 2021
  - Daniel Švorc, PlasmaLab – **Resonance cavity**, 2022
  - Laura Thonová – **Study of negative corona discharge and plasma jet for medical purposes**, 2022
    - At the University of Chemistry and Technology
    - Partially done in PlasmaLab@CTU
- **Regular classes**
  - **Laboratory Work in Plasma Physics 1, 2** (PRPL)
    - MSc, two groups: upstairs or tokamak
  - **Laboratory of Plasma Diagnostics** (UPP)
    - Bc, two groups which swap
- **Projects**
  - **Seminar on Plasma Physics** (SFP)
    - Micro-projects in 2021, 2022 (resonance cavity), 2023 – (magnetic stand)
  - **Research Project** – Microwave propagation in plasma (linear magnetic trap)
  - **Global Talent Mentoring project** - An Exploration of the Tokamak and MDH instabilities (Magnetic islands)
    - Kalea Wen – from USA, fully remote cooperation
  - **High School students project** – discharge tube
- **Others**
  - Microscope
    - Detectors of fusion protons from the pinches
      - **plasma focus PF-1000**, IFPiLM, Warsaw, Poland
      - **plasma focus MAIZE**, University of Michigan, USA
      - **plasma focus PFZ-200**, CTU, Prague, Czech Republic
    - Langmuir probes for the COMPASS tokamak
      - Komm, M., et al. "On the applicability of three and four parameter fits for analysis of swept embedded Langmuir probes in magnetised plasma." **Nuclear Fusion** 62.9 (2022): 096021
    - Calorimetry probe for runaway electron heat load measurements at COMPASS
      - Caloud, J., et al., "Calorimetry probe for runaway electron heat load measurements at COMPASS", **proceedings of EPS** 2022
  - Calibration of cameras
    - Calibration of tomographic cameras for the Golem tokamak
    - See poster of Sara Abbasi

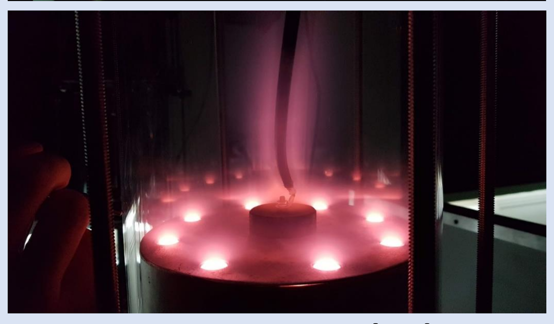
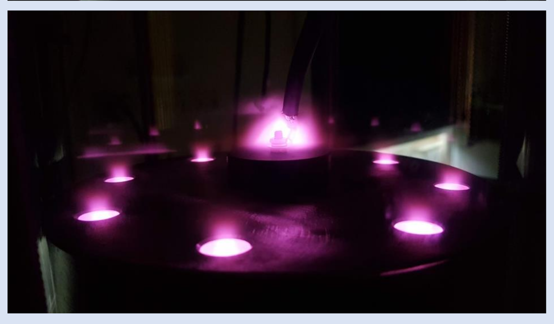




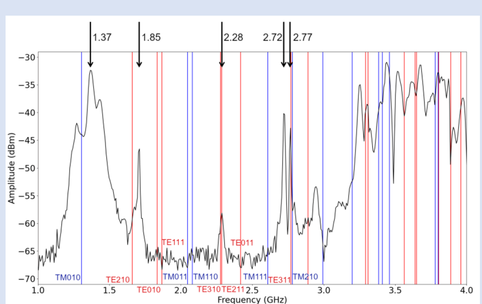





Resonance cavity experiment

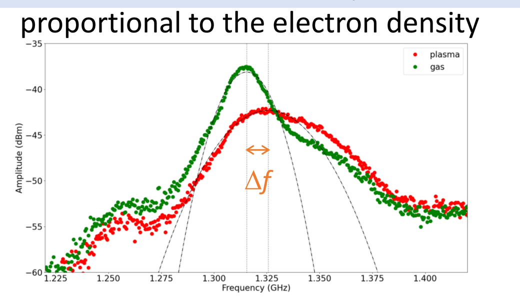



Spectrum of the resonator



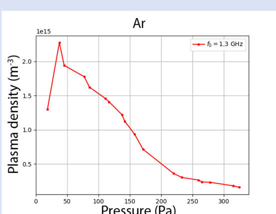
Measurement method

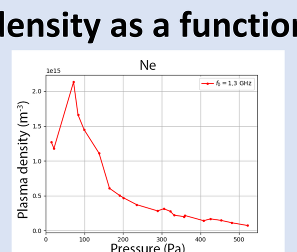
Shift of the resonance peak is proportional to the electron density

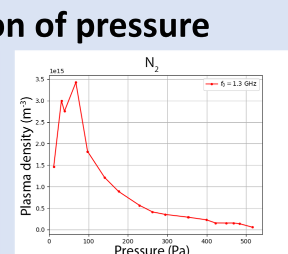


- Study of microwave resonator: estimation of resonance spectra
- Study of plasma – microwaves interaction: density estimation from the cavity resonance
- Fusion Relevance: Microwaves (ECRH) are a prime heating tool for fusion plasmas

Electron density as a function of pressure







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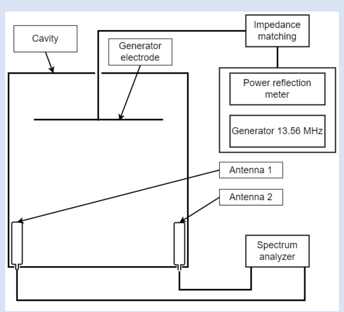


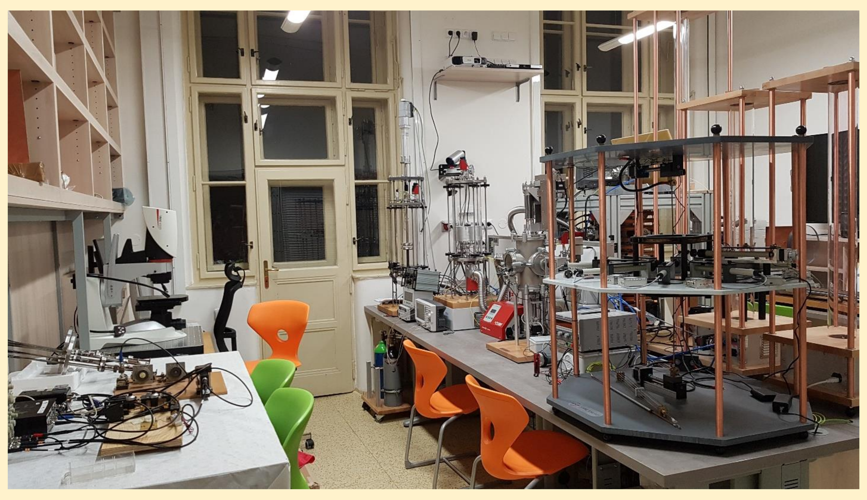
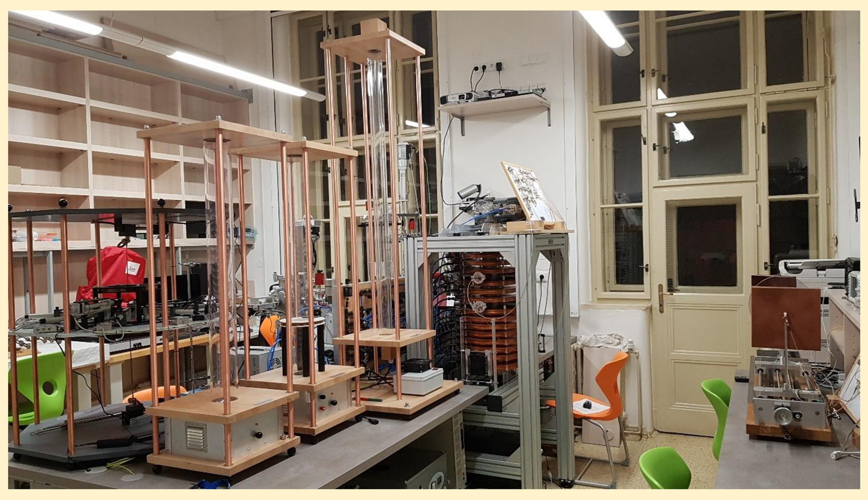
- **Cavity**
  - Stainless steel, cylindrical
  - R = 88 mm, L = 95 mm, (L = 70 mm)
- **Antennas**
  - 2 loop antennas ~ 10 mm diameter
  - Bottom lid, measure azimuthal magnetic field
- **Source**
  - Plasma generation, up to 70 W
- **Gases**
  - Ar, He, Ne, N_2, air
- **Pressure**
  - ~ 1 Pa – ~ 600 Pa, depends on gas

PlasmaLab@CTU

- CTU has fusion programmes for Bc, MSc, PhD for past 10 years
- For PhD programme Double degree with Ghent University + all other levels – Bc, MSc…
- Built in 2017 – 2022
- Remotely controlled
  - After COVID times remote control laboratories emphasized its importance
  - PlasmaLab@CTU has good experience with remote control especially in the pandemic situation and for international campaigns

Upstairs

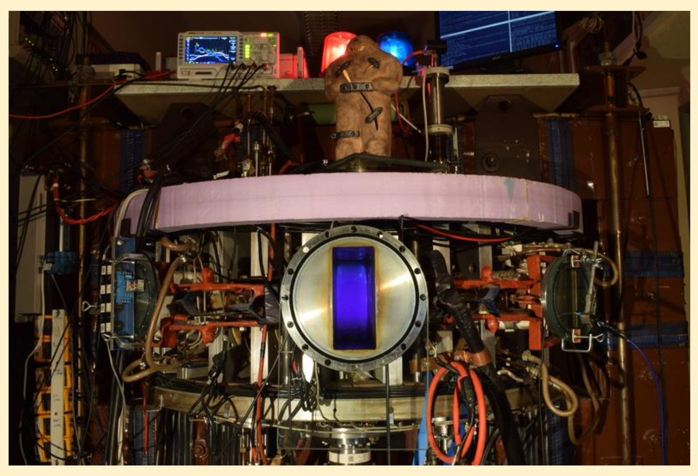
- **Workspace 1 – Plasma**
  - Linear magnetic trap
  - Paschen curve
  - Discharge tubes
  - Resonance cavity
- **Workspace 2 – Magnetic and electric fields**
  - Magnetic stand
  - Electrostatic probes stand
  - Microwave interferometry
- **Workspace 3 – Optics**
  - Laser spectroscopy
  - Sonoluminescence
  - 3D microscope

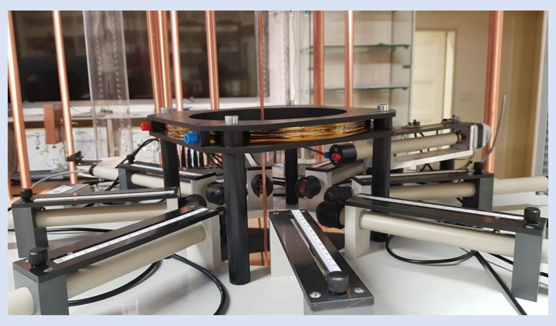
Downstairs

- **Workspace 4 – GOLEM tokamak**
  - Established tokamak in CTU
  - Fully remotely controlled

Vessel major radius: R_0 = 0.4 m
Vessel minor radius: r_0 = 0.1 m
Plasma minor radius: a = 0.06 m
Toroidal magnetic eld: B_t < 0.5 T
Plasma current: I_p < 8 kA
Discharge duration: τ_p < 25 ms

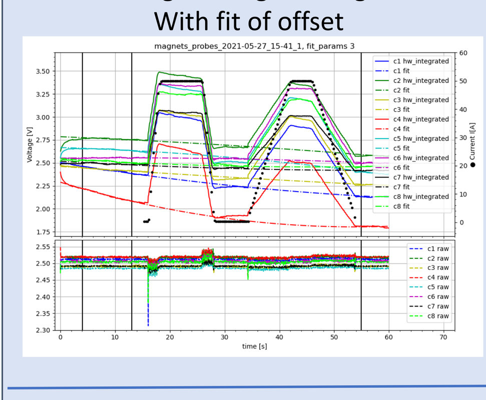


Magnetic stand

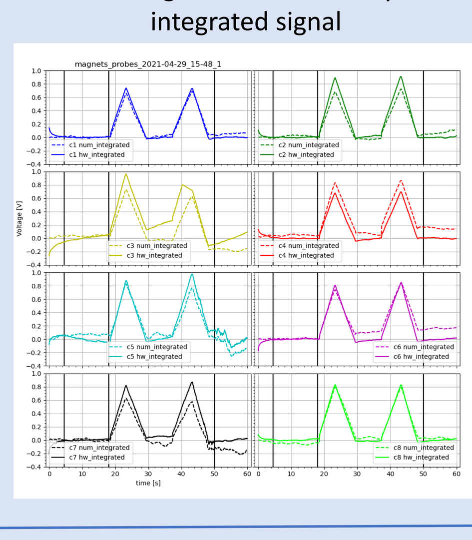



- 8 coils
  - 8 mm radius, 11 mm length,
  - 1000 loops
  - Individually manipulated
  - Output: raw signal, analog integrated signal
- 1 coil
  - separate, exchangeable head,
  - remotely controlled position
- Wire:
  - DC current source up to 100 A
  - Remotely controlled position

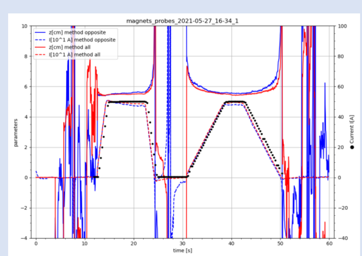
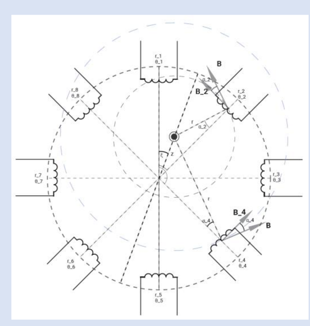
Analogue integrated signal With fit of offset



Analog versus numerically integrated signal

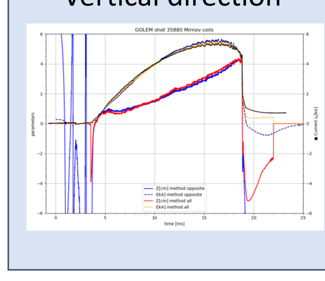


Position calculated from
a) two opposite coils
b) all coils

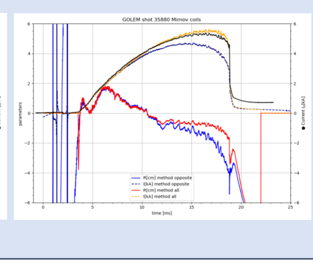



Measurement on the Golem tokamak

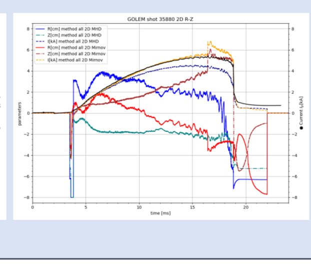
Vertical direction



Horizontal direction

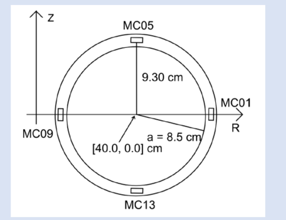


Mirnov coils & MHD ring coils



a) Comparison of signal from two opposite coils versus from all coils combined
b) Comparison of signal taken from the ring of Mirnov coils (4) and MHD ring coils (16)

Mirnov coils used for measurement of plasma position



Cooperating laboratories

PlasmaLab@TU/e

- Laboratory with the same concept
- Eindhoven University of Technology, Netherlands

- Remote laboratory
- Instituto Superior Técnico, Lisbon, Portugal

Acknowledgement

- PlasmaLab@CTU was built in the scope of the project: CZ.02.1.01/0.0/0.0/16_017/0002248.
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