

Golem tokamak for education and training
 \approx 5 years at service

Vojtěch Svoboda, et al. for IBA 2014

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1 Introduction

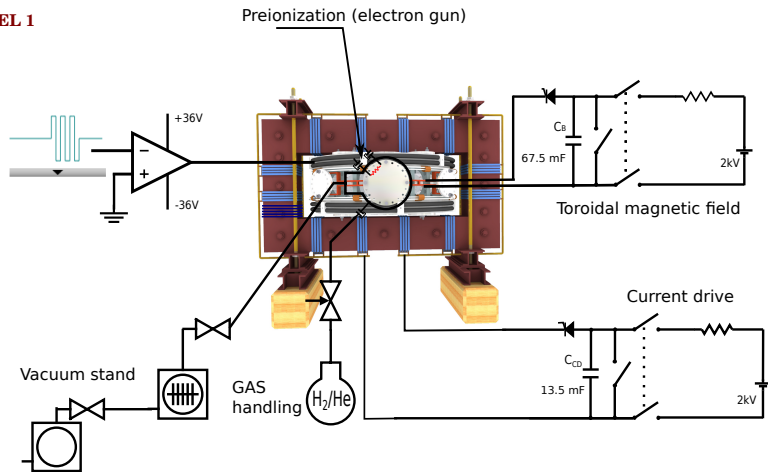
2 Inventory 2013/2014

- Technological achievements
- Education
- Science, Technology with ambition to be published?

3 Forecast 2014/2015

The smallest & oldest operational tokamak with the biggest control room in the world

LEVEL 1



Forecast 2013/2014

- Prague Museum Night (tomorrow).
- 5 high school students in the GOLEM team.
- FUMTRAIC III, GOMTRAIC III, SCIWTRAIC IV, HUNTRAIC III, SUMTRAIC day at GOLEM VI.
- IAEA joint experiment.
- Bachelor thesis
- Diploma thesis

Outline

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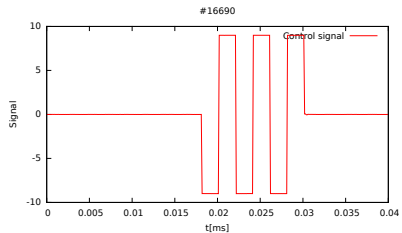
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Technological plans and challenges

From kludge to normal operation
(from chaos to order)

- HW .. OK, SW .. OK, Wiki reconstruction cont.
- Both E_{CD} orientation. .. OK
- Both B_t orientation. .. OK
- Breakdown optimization cont. .. X
- Plasma time length prolongation from 20 to 30 ms ... X
- Vertical stabilization. .. OK, not yet fully implemented
- Firing rate ≈ 1 RPM.
- Working gases H x He.

Vertical plasma position control



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Bachelor and Diploma thesis

- BT #4 completed: Richard Duban: Plasma flow velocity measurements on the tokamak GOLEM using Mach probe array diagnostics.
- BT #5 completed: Martin Matusu: Virtual model of tokamak GOLEM with a real physical core.
- BT #6 completed: Borek Leitl: Bolometric diagnostics at the tokamak GOLEM.
- BT #7 completed: Jakub Veverka: Breakdown studies at the tokamak GOLEM.
- DT #2 under construction: Jindra Kocman: Plasma position control at the tokamak GOLEM.

Workshops, Summer schools, etc.

- FUMTRAIC III ~ 10 students
- GOMTRAIC III X
- SCIWTRAIC IV ~ 13 students
- HUNTRAIC III ~ 4 students
- SUMTRAIC day at GOLEM VI ~ 15 students.
- The day on nucleus at GOLEM I ~ 8 students.
- Demonstrations, lectures from Garching I, Lemwig, Valaske Mezirici, Kitten, Garching II, Islamabad
- ~ 17 Excursions: + EMTRAIC, WIN

2 laboratory practice for regular Bachelor students

- V. Svoboda, J. Krbec, O. Grover et al.: High temperature plasma at the tokamak GOLEM.
- T. Markovic, J. Stockel et al.: Temperature measurement at the tokamak GOLEM

Prague Museum Night



TV popular project "Sun on the Earth"



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Poloidal asymmetries in particle flux in the SOL (R.Pitts at.al. Journal of Nuclear Materials, 1990.)

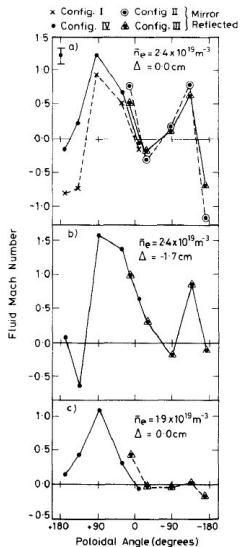
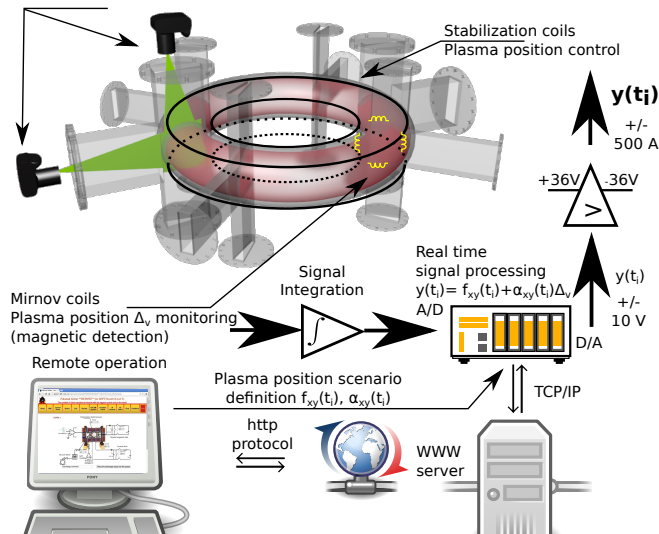


Fig. 5. Full poloidal distribution of Mach number. (a) $\bar{n}_e = 2.4 \times 10^{19} \text{ m}^{-3}$, $\Delta = 0.0 \text{ cm}$. (b) $\bar{n}_e = 2.4 \times 10^{19} \text{ m}^{-3}$, $\Delta = -1.7 \text{ cm}$. (c) $\bar{n}_e = 1.9 \times 10^{19} \text{ m}^{-3}$, $\Delta = 0.0 \text{ cm}$.

Advanced Remote Operation - SOFT 14

Fast cameras

Plasma position monitoring
(visible radiation detection)



Remote operation of the GOLEM tokamak with hydrogen and helium plasmas

A characteristic peak of fluctuation power is seen in hydrogen plasma at $f = 28$ kHz, which is missing in Helium. A high frequency peak in Helium plasma localized around 120 kHz is present. Figure 10 displays an example of the cross correlation between two probes, radially spaced by $d = 2.5$ mm.

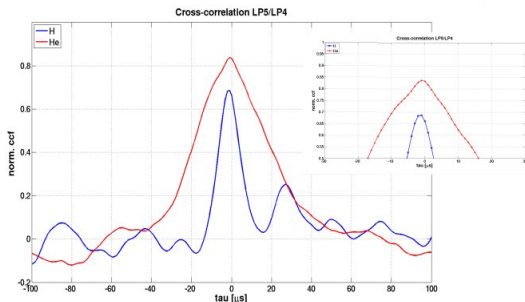


Figure 10. Cross correlation between probes 4 and 5 in H and He discharges. Zoom around the maximum is inserted.

The cross correlation between probes LP4 and LP5 is significant in H and He discharges, being 70 - 80%. The negative time lag, $\tau = -1$ μ s at the maximum of the cross correlation function, evident from the insert in figure 8, would imply a radial propagation of turbulent structures from LP4 to LP5. The velocity of this turbulent structure, or blob [8], can be simply estimated as $v_{\text{radial}} = d/\tau = 2.5$ km/s.

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Forecast 2014/2015

- The night of scientists (next Friday).
- FUMTRAIC IV, GOMTRAIC III (hopefully), SCIWTRAIC V, HUNTRAIC IV .. agreed, SUMTRAIC day at GOLEM VII.
- IAEA joint experiment.
- Bachelor thesis ?
- Diploma thesis II cont.
- papers in SOFT, AJP .. ?

Acknowledgement

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