Golem #14 - from #34490 to #37805

Mariánská 2022

Vojtěch Svoboda

Outline

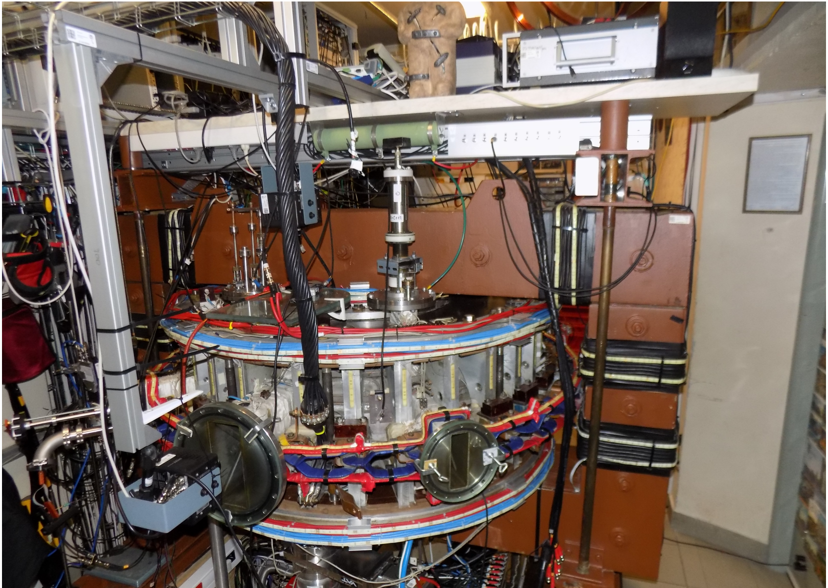
Forecast 2021

- The Night of Scientists V. ✗(#C19)
- FUMTRAIC VI ✓, SCIWTRAIC@GOLEM VIII ✗(#C19), HUNTRAIC VII ✓
- GOMTRAIC III (5 days)! ✗(#C19)
- Bachelor thesis ?
- Diploma thesis IV cont.
- papers in FUSENGDES, AJP .. ?
- TRAICS: Eindhoven, Bangkog ✗(?), Torino, Moscow,
- Runaways intensive studies (JČ, postdoc, GACR grant, Valérie,)
- Edge Plasma intensive studies (KJ, PM: TunnelP)
- End of the reconstruction ... start to exploit the facility.

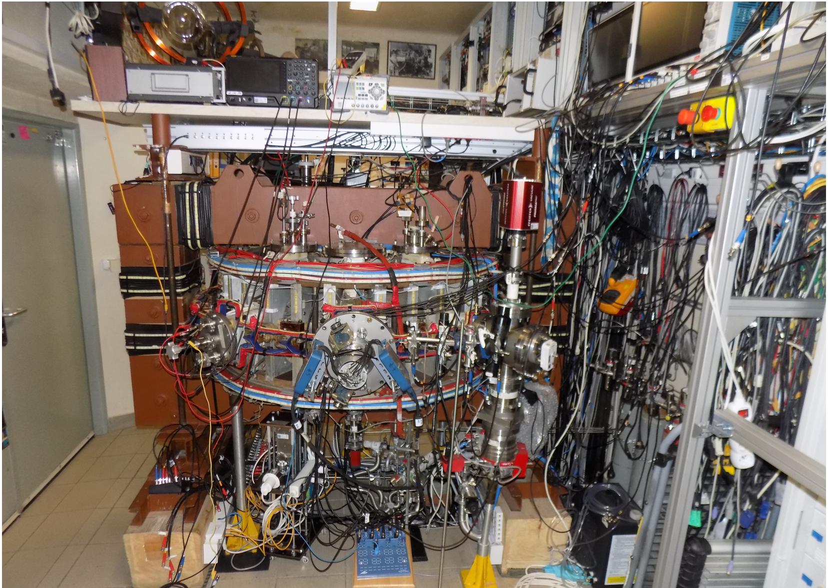
Outline

Honza

South 01/2022



North 01/2022

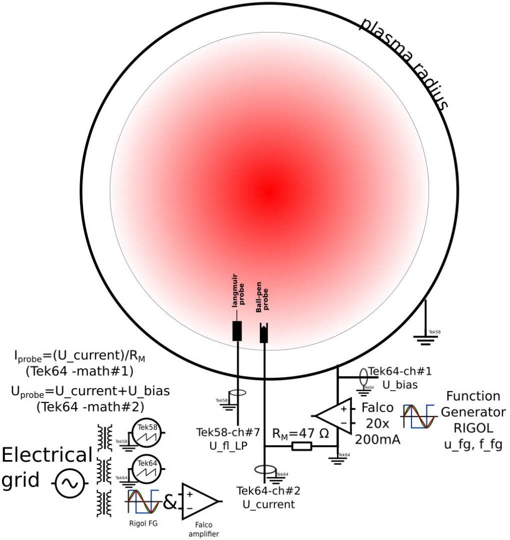


Outline

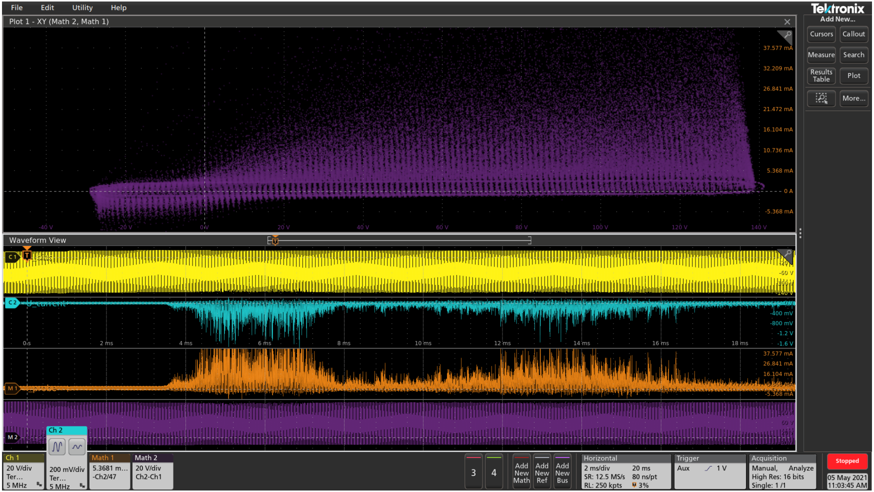
Outline

Dario Cipciar (Jiří Adámek): Swept BPP probe. MSc project. 2021

Dario Cipciar(Jiří Adámek): Swept BPP probe: complex set-up

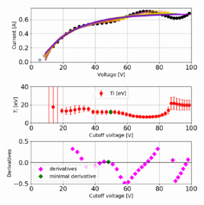


Dario Cipciar(Jiří Adámek): Swept BPP probe: Oscilloscope screenshot

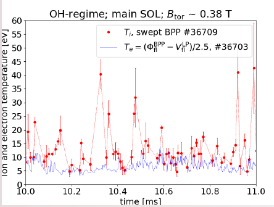


Fast ion temperature measurement using swept ball-pen probe. MSc thesis. 2021

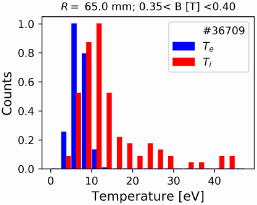
- Ion temperature is measured with 5 μs temporal resolution based on the measurements of the electron branch of a ball-pen probe (BPP) IV characteristics [3].
- The probe collector is biased with a voltage swept between -30V to +130 V at a frequency of 100 kHz.
- The T_i is obtained from $I(V) = I^{+}_{sat} \cdot \left(\exp(\alpha_{BPP}) \cdot [1 + K \cdot (V - \Phi)] - \exp\left(\frac{\Phi - V}{T_i}\right)\right)$, $\alpha = \ln \frac{I^{-}_{sat}}{I^{+}_{sat}} = 0.25 \pm 0.09 \, (B_t > 0.22 \text{ T})$.
- Cut-off fitting technique is applied to all the IV characteristics.
- Fluctuations of the ion temperature ranging between 5 eV up to 40 eV reveal the turbulent behavior of the edge plasma.
- NON-Gaussian shaped histograms of T_e and T_e are observed with a peak at low temperature and a tail towards high temperatures.



Cut-off technique.



Temporal evolution of T_i and T_e.

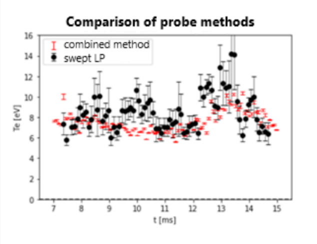


Histograms of T_i and T_e.

Macha, P., Cipciar, D. & Adámek, J. et al. @EPS 2021

Martina Lauerová (Kateřina Hromasová). Electron temperature measurements using Lang and BPP probes. SOČ project 2021

- Swept Langmuir probe – verified but complicated and time-consuming.
- Combined method (floating ball-pen and Langmuir probe) – straightforward and high time resolution, but rather new.
- It was verified that both methods give the same results.
- We suggest that the combined method is suitable for measuring the edge plasma T_e.

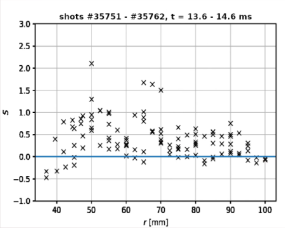


Time evolution of T_e in two identical GOLEM discharges, showing good correspondence between the two methods (#35729 − #35791).

Macha, P., Lauerová, M.. & Hromasová, K. et al. @EPS 2021

Aleš Socha (Kateřina Hromasová), Turbulent structuresusing using Double rake probe. SOČ project 2021

- Exchange turbulence (blob-hole pair generation and propagation) in the plasma edge enhances energy and particle losses.
- Double rake probe (tokamak bottom port) measured I_{sat} at $r = 37 - 90$ mm (limiter at $r = 85$ mm).
- I_{sat} histograms found asymmetric with positive skewness indicates the presence of blobs.
- Skewness seems to decrease to negative values at $r = 40$ mm, possible location of the blob birth zone.

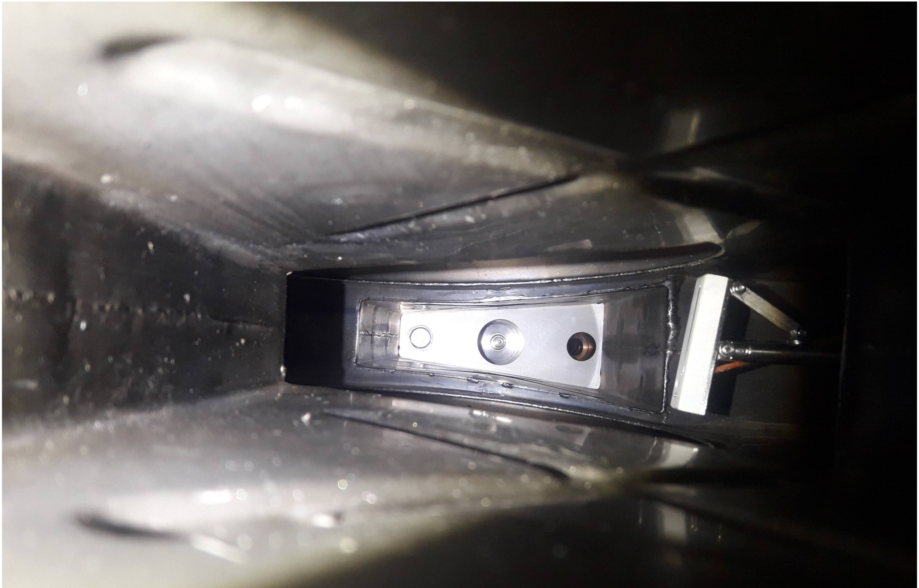


Radial profile of ion saturated current skewness. Positive values indicate the presence of blobs throughout the investigated region.

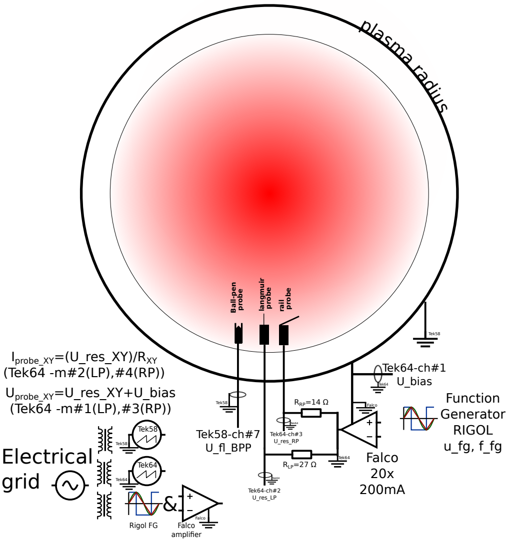
Macha, P., Socha, A.. & Hromasová, K. et al. @EPS 2021

Outline

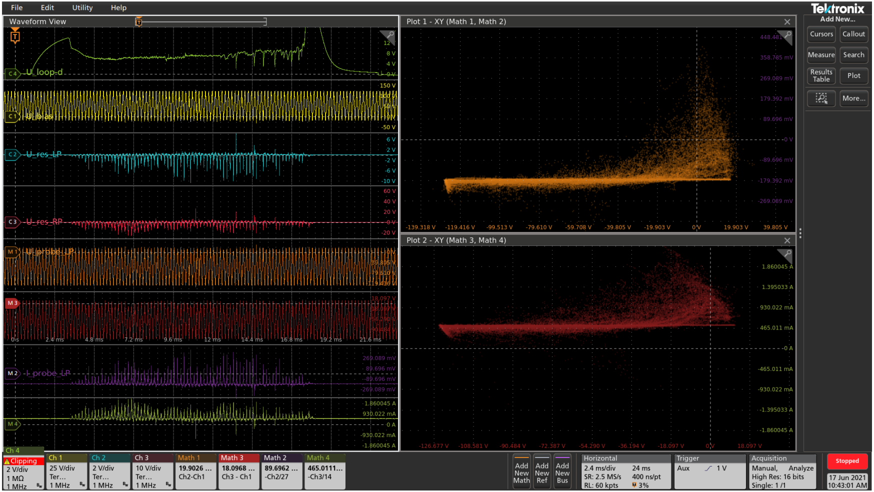
Jiří Malinak (Jiří Adámek): Rail probe. BSc project. 2021



Jiří Malinak (Jiří Adámek): Rail probe: complex set-up

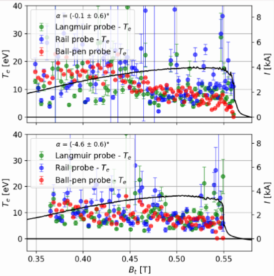


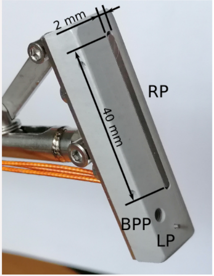
Jiří Malinak (Jiří Adámek): Rail probe: Oscilloscope screenshot



Electron temperature measurements using rail probe

- The rail probe concept can sustain exceptionally high heat flux and reduce the sheath expansion effect.
- A probe head consists of a rail probe (RP, length = 40 mm, wide = 2 mm), Langmuir probe (LP, length 1.5 mm, diameter 1 mm), and ball-pen probe (BPP) [4] has been designed
- Special manipulator with changable inclination to B_t within $\pm 10^\circ$ has been installed.
- Electron temperature is measured using a swept Langmuir and rail probe (f = 5 kHz) and a floating ball-pen probe.
- Capability of RP to reduce the sheath expansion effect was confirmed.
- Good agreement between LP, RP and BPP electron temperature measurements for large magnetic field.



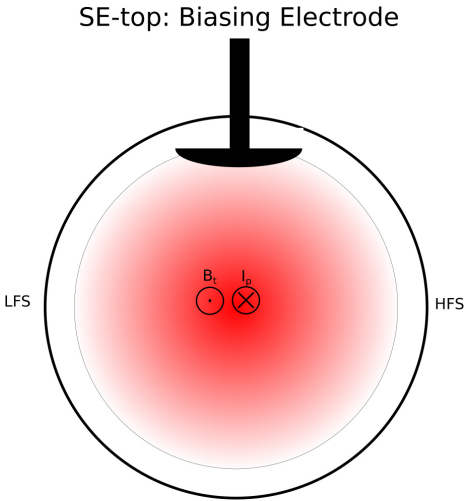


Left) Comparison of T_e measured by BPP, LP and RP. Right) Diagram of the combined probe head.

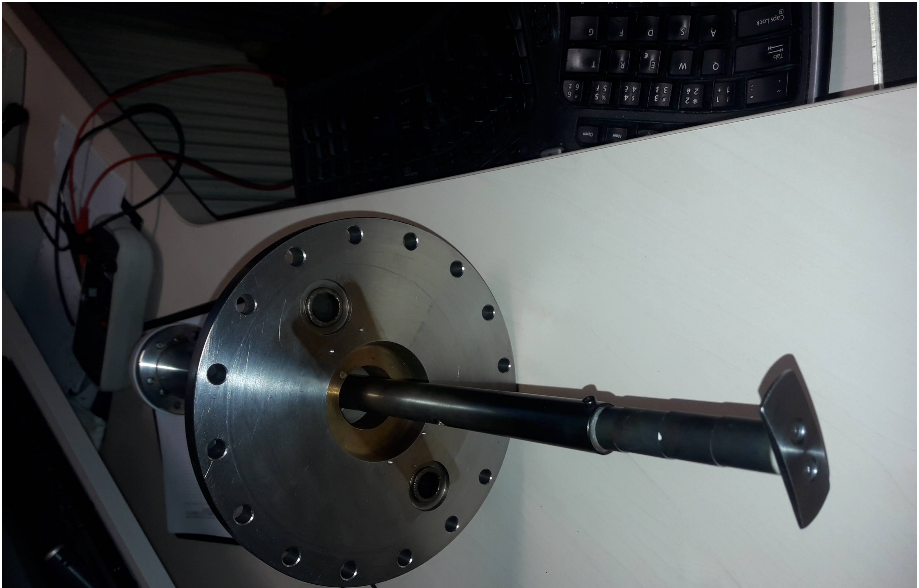
Macha, P., Malinak, J. & Adámek, J. et al. @EPS 2021

Outline

Sasha Melnikov & students. Biasing experiment. April, 2021



Biasing electrode

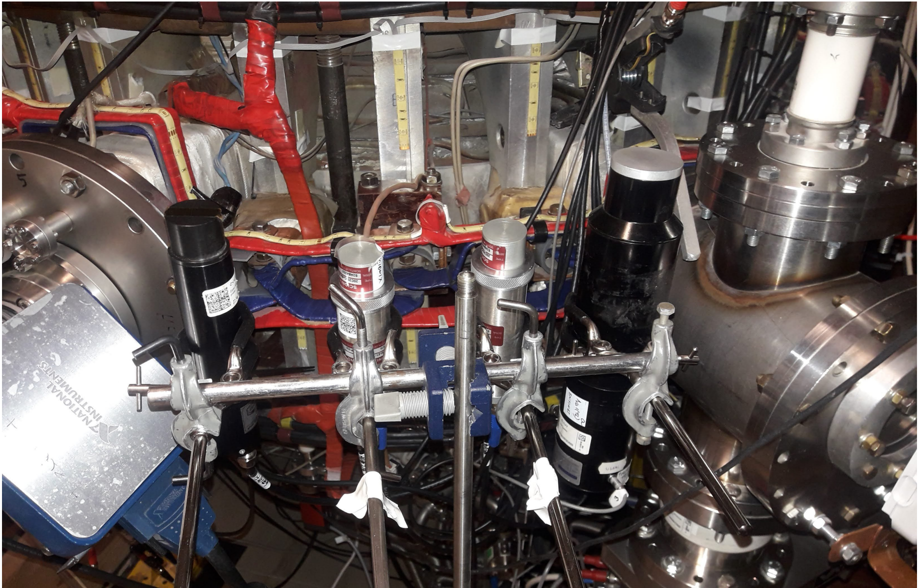


Biasing electrode with Double rake probe in tokamak

Outline

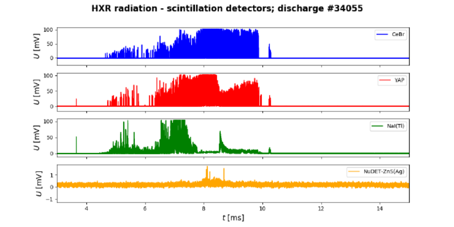
1. Introduction
2. Introduction
3. Current scientific topics
   - Edge plasma studies
     - Probes: BPP + Lang probes
   - Probes: Rail probe
   - Biasing experiments
   - Run Away Electrons
     - Diagnostics (CAAS project)
     - Physics
   - Others
     - Breakdown studies
     - Magnetohydrodynamic studies
4. Technology improvements
   - Plasma position Stabilization
5. Diagnostics improvements
6. Education
   - High school students

Lukáš Lobko (Jan Čeřovský, Ondřej Ficker): Měření ubíhajících elektronů na tokamaku GOLEM prostřednictvím scintilačních detektorů. Lab. work. 2021

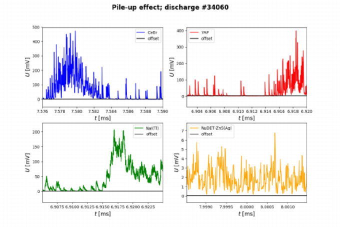


Measurements of HXR radiation

- Scintillation detectors were used for HXR spectrometry.
- Two problems occured:
  - Standard photomultiplier tubes of scintillation detectors can not withstand intensive HXR fluxes (NaI(Tl) detector drops around 8 ms).
  - Piled-up areas of signal - still too high HXR fluxes
- Optimal setup must be found by ensuring sufficient lead shielding and the distance from tokamak.



Comparison of HXR signals from 4 different scintillation detectors.



Comparison of piled-up signals and individual peaks.

Macha, P., Lobko, L. et al. @EPS 2021

Čeřovský, J. et al. Progress in HXR diagnostics at GOLEM and COMPASS tokamaks

COMPASS
INSTITUTE OF PLASMA PHYSICS ASCR

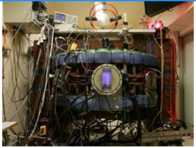
Progress in HXR diagnostics at GOLEM and COMPASS tokamaks

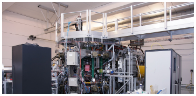
J. Cerovsky[1,2,*], O. Ficker[1,2], V. Svoboda[2], E. Macusova[1], J. Mlynar[1], J. Caloud[1,2] V. Weinzettl[1], M. Hron[1], the COMPASS team and EUROfusion MST1 team[**]
[1] *Institute of Plasma Physics of the CAS, Prague, Czech Republic*
[*] *contact: cerovsky@ipp.cas.cz*
[2] *Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Prague, Czech Republic*
[**] *See author list B. Labit el. al., 2019 Nucl. Fusion 59 086020*

GOLEM and COMPASS tokamaks

- the GOLEM tokamak [1] is a small size device operated at FNSPE CTU
- → former tokamak CASTOR operated at IPP in Prague
- serves mainly for educational purposes and for diagnostics testing (probes and various HXR detectors)

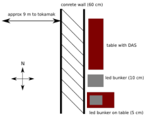
R [m]	a [m]	I_p^{max} [kA]	B_T [T]
0.4	0.085	< 8	< 0.8

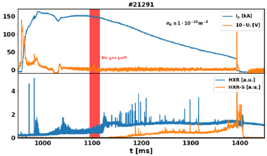




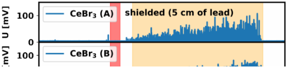
- the COMPASS tokamak [2] is a compact size tokamak operated at IPP Prague
- fields of research: H-mode physics, physics of plasma edge, plasma-wall interaction, physics of runaway electrons [3] and disruptions etc.

Experiments at COMPASS





- scintillation detectors located outside tokamak hall, protected from high photon flux



- HXR radiation detected mainly during RE beam phase

Physics

-

Outline

Y. Siusko et al. Breakdown phase in the golem tokamak and its impact on plasma performance

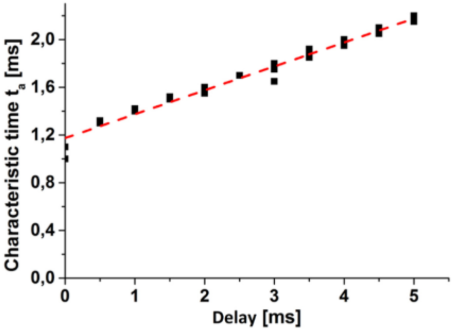


Fig. 10. The dependence of the characteristic (avalanche) time τ_a on the time delay.

Y. Siusko et al. Ukrainian Journal of Physics 66.3 (2021), pp. 231–239.

G.A. Sarancha et al. Hydrogen And Helium Discharges In The Golem Tokamak

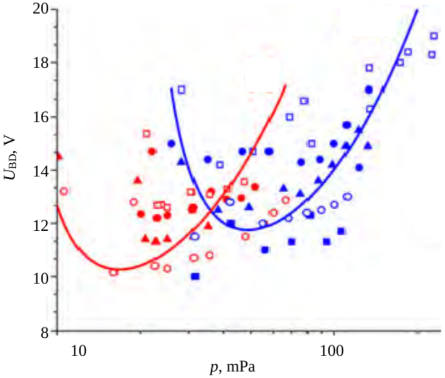


Fig. 6. Dependency of the breakdown voltage on the gas pressure for various U_{CD}: ■ — 400, ○ — 500, ▲ — 600, ● — 700, □ — 750 V; red line — H, blue line — He

G.A. Sarancha et al. PAST(TF) 4 (2021), pp. 92–110

G.A. Sarancha et al. Hydrogen And Helium Discharges In The Golem Tokamak

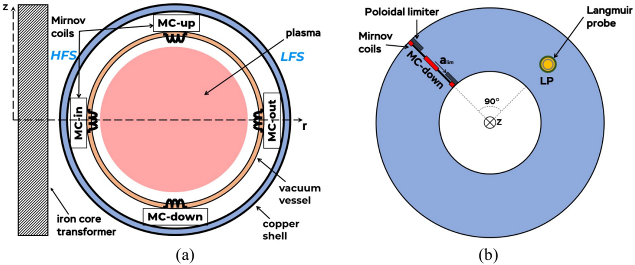
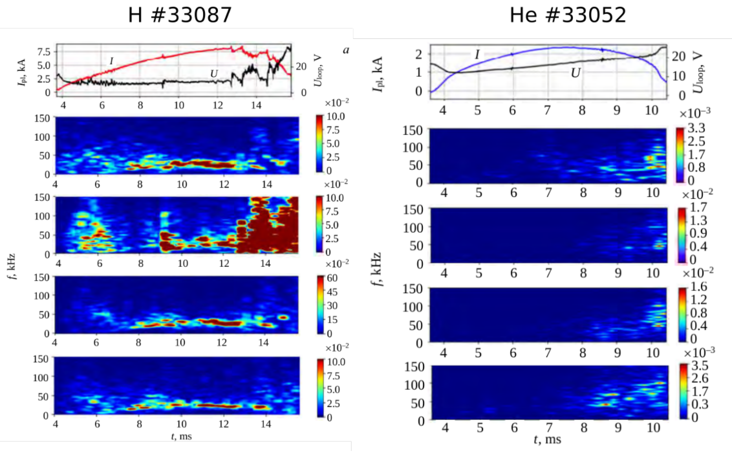


Figure 1. Arrangement of the GOLEM probe diagnostics (a) side view, (b) bottom view. Mirnov coils are installed behind the circular limiter, $a_{\text{lim}} = 0.085$ m. The Langmuir probe is shifted toroidally with respect to the Mirnov probes by 90°.

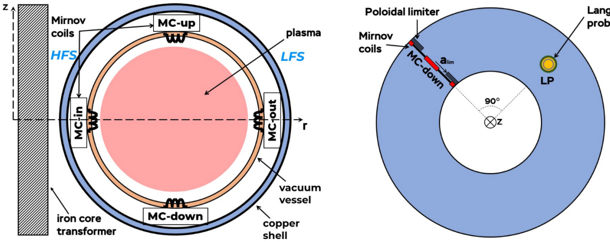
G.A. Sarancha et al. PAST(TF) 4 (2021), pp. 92–110

G.A. Sarancha et al. Hydrogen And Helium Discharges In The Golem Tokamak



G.A. Sarancha et al. PAST(TF) 4 (2021), pp. 92–110

G.A. Sarancha et al. Magnetic turbulence and long-range correlation studies in the GOLEM tokamak



(a) (b)

Figure 1. Arrangement of the GOLEM probe diagnostics (a) side view, (b) bottom view. Mirnov coils are installed behind the circular limiter, $a_{\text{lim}} = 0.085$ m. The Langmuir probe is shifted toroidally with respect to the Mirnov probes by 90°.

G.A. Sarancha et al. JPCS 2055.1 (2021), p. 012003

G.A. Sarancha et al. Magnetic turbulence and long-range correlation studies in the GOLEM tokamak

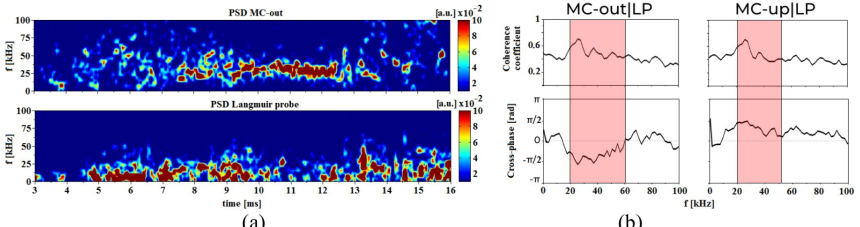


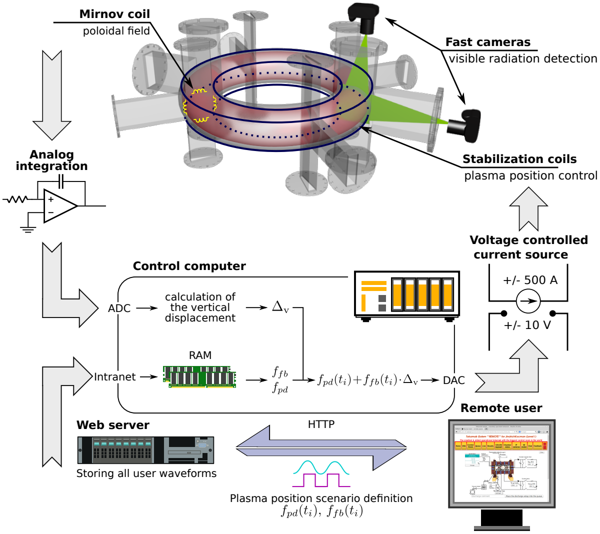
Figure 5. (a) Power spectral density of the signals of the MC-out (top) and Langmuir (bottom) probes and (b) quadratic coherence coefficient (top) and cross-phase between the signals of the magnetic and Langmuir probes (bottom).

G.A. Sarancha et al. JPCS 2055.1 (2021), p. 012003

Outline

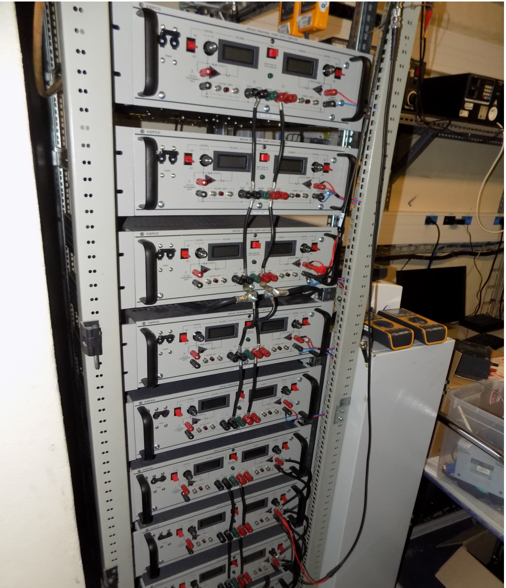
Outline

Plasma position stabilization



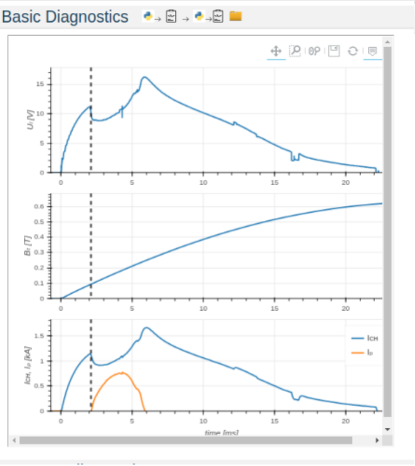
credit:[Svo+15]

Martin Humpolec (Daniela Kropáčková). External plasma stabilization. SOČ 2022



11/21 Martin Humpolec (štěstí? náhoda?)

#37571



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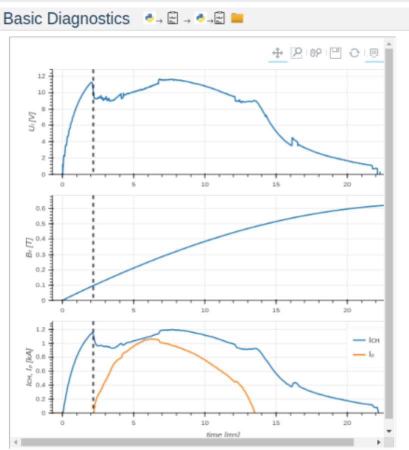
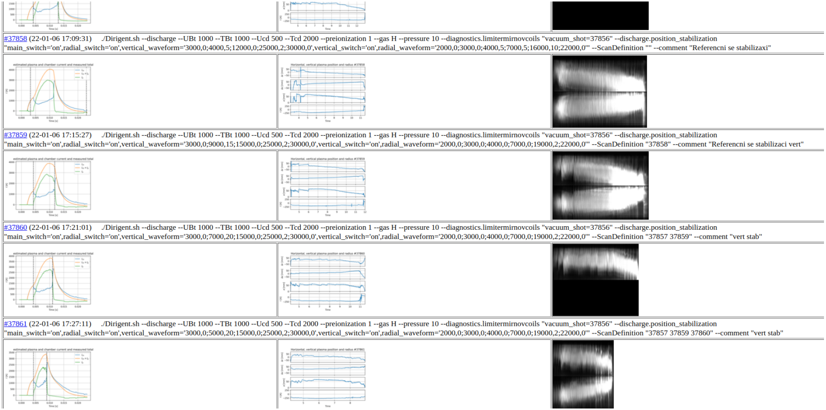


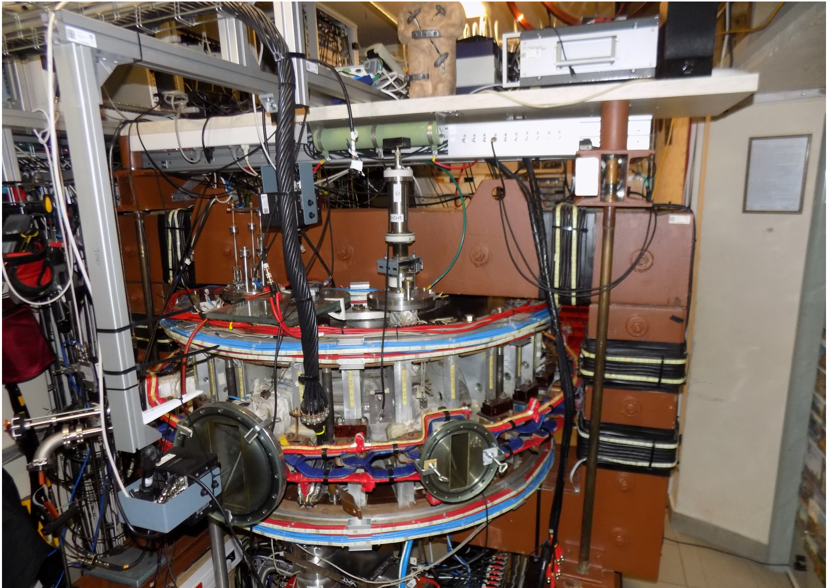
01/22 Martin Humpolec & Daniela Kropáčková: commissioning



`http://golem.fjfi.cvut.cz/shots/37895/Analysis/Homepage/psql/ShotsOfTheDay.php`

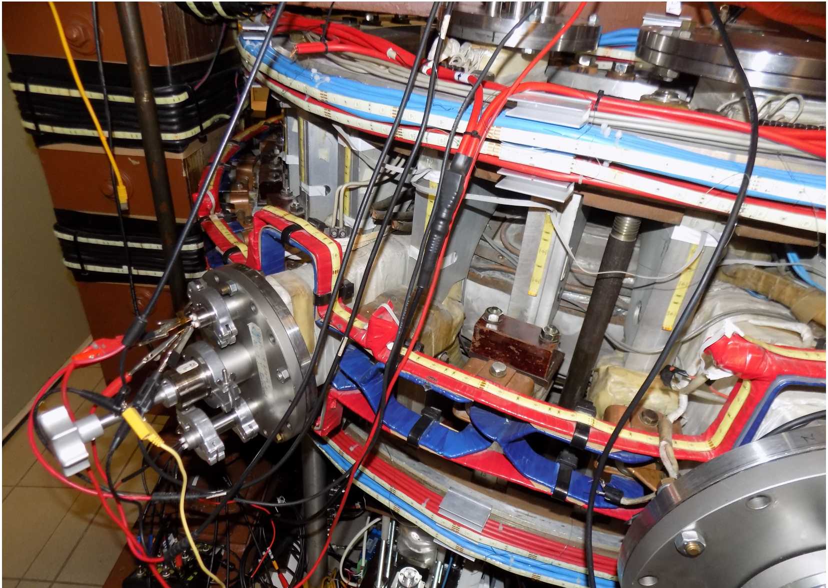
Outline

Fast cameras 2 tomography (Jakub & Jakub)

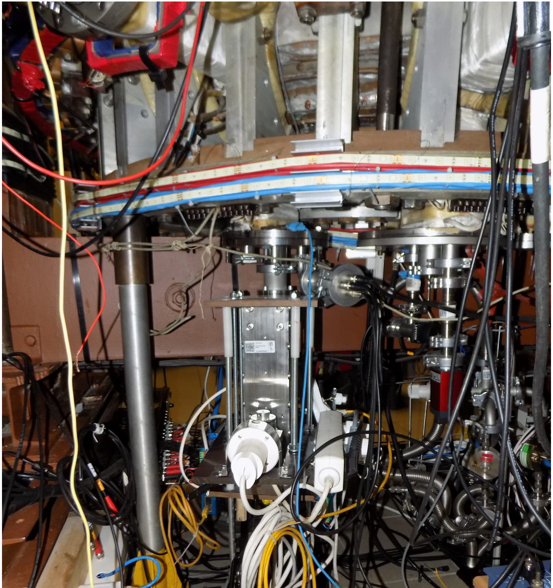


Bedna šampaňského: vyčuchání a znásilnění komunikace

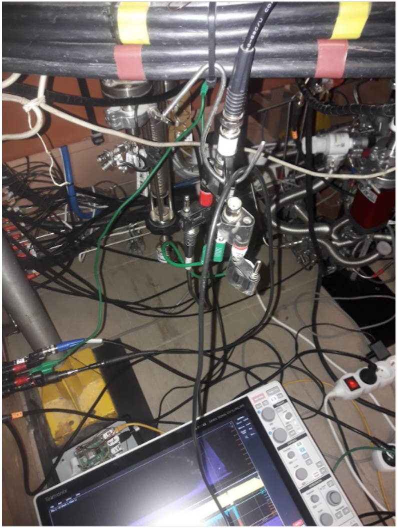
Calorimetry (J. Caloud)

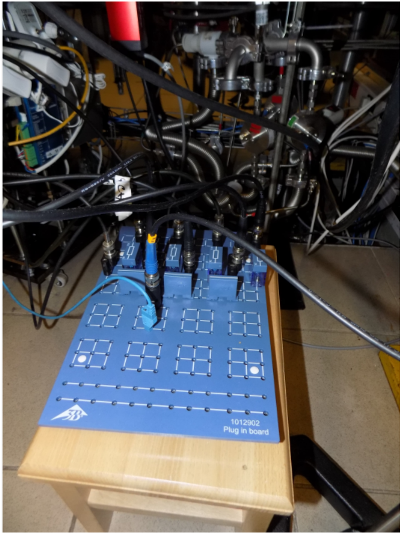


Motor driven Z-angle manipulator



Plug in modules





Outline

Undergraduate Projects

- Adéla Kubincová (Ondřej Kudláček). Sofistikované metody real-time řízeni tokamakových procesů. BP 2021.
- Štěpán Malec (Vladimír Linhart). HXR detection with Timepix3. VU 2021.
- Marek Tunkl (Michal Marcišovský?). Strip detector. DP 2021.

Postgraduate Projects

- Petr Mácha. Studium okrajového plazmatu v tokamacích pomocí pokročilých elektrických sond. DP 2020.
- Sergei Kulkov. Timepix3 for HXR detection. PhD 2020.
- Vladimir Ivanov. RE studies with ECRH radiometer.

Outline

Matyáš Horák (Katka Hromasová): Profil elektronové teploty v komoře tokamaku

SOČ středoškolská odborná činnost

facebook soč? soč

Hlavní stránka › Fóra › Forum pro soutěžící SOČ › Obhajoby – Praha › 42-kraj Praha-obory 1,2 › Odpověď na téma: 42-kraj Praha-obory 1,2

27 dubna, 2020 (11:30 am) #21104

Lucie Hunalová
Host

Děkujeme za odpovědi, nyní dostává prostor další soutěžící.

12:30 – 13:00 Matyáš Horák – Profil elektronové teploty v komoře tokamaku
Gymnázium Botičská

https://youtu.be/-OC_Elg0Gjk

Vítáme Vás, přejeme úspěšné obhajoby a prosíme o dodržení časového limitu. Děkujeme

1. Zajímal jste se i o reakci D-D?

2. Je princip měření Langmuirovou a ball-pen sondou založen na termoelektrickém jevu?

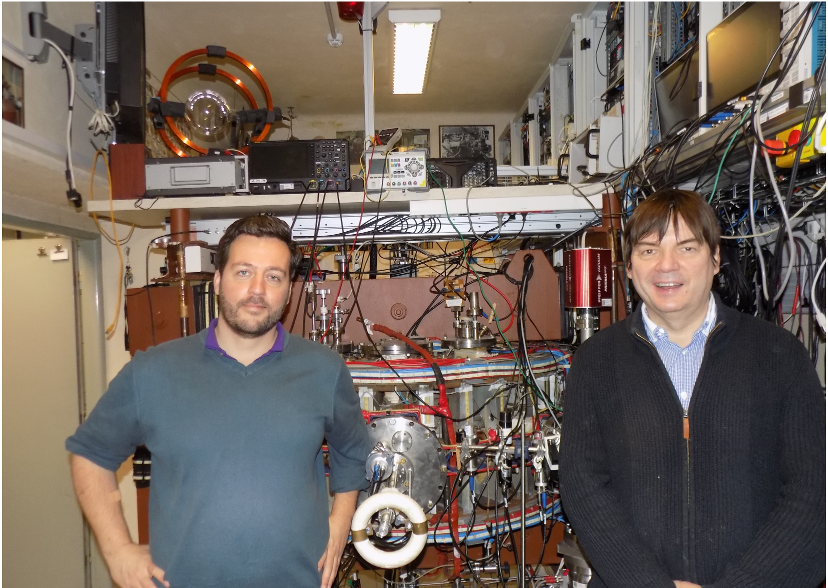
3. V textu se píše „V grafu 1 je také důležité si všimnout nápadné změny ve 14 ms a 20 ms."
Při pohledu na tento graf nám připadá mnohem zajímavější, co stalo v čase 18 ms. Zde pozorujeme výchylku ve všech měřených parametrech. Mohl byste vysvětlit, co tento jev způsobilo?

Aleš Socha (Katka Hromasová): Poloha zóny vytváření turbulentních struktur v okrajovém plazmatu tokamaku

Martina Lauerová (Katka Hromasová): Měření elektronové teploty na tokamaku GOLEM elektrickými sondami

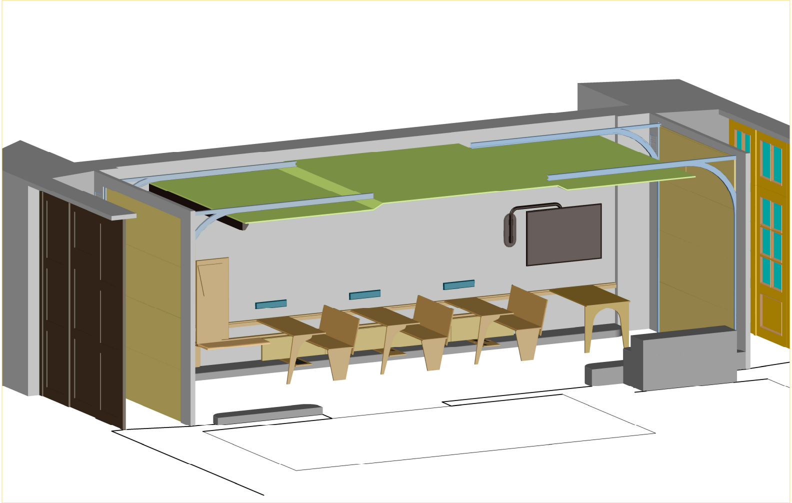
Outline

11/21 Guido Lange



Outline

Himmel, M. Průjezd, verze 2. 2020.



Kauza průjezd

Outline

Y. Siusko et al. Breakdown phase in the golem tokamak and its impact on plasma performance

doi:

Y.SIUSKO,[1] V.SVOBODA,[2] J.STOCKEL,[2] I.GARKUSHA,[1,3] D.SOLYAKOV,[1,3] I.GIRKA,[3] V.VOLKOV,[3] D.BONDAR,[3] V.KONDRATENKO,[3] A.BOYCHENKO,[3] A.KRUPKA,[3] D.BOLOTO,[3] D.DROZDOV,[3] O.SALMIN,[3] A.SHCHIBRYA[3]

[1] National Science Center Kharkov Institute of Physics and Technology
(1, Akademicheskaya St., Kharkov, 61108, Ukraine; e-mail: zhenya-syusko@kipt.kharkov.ua)
[2] Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
(Brehova 7, 115 19 Praha 1)
[3] V. N. Karazin Kharkiv National University, School of Physics and Technology
(4 Svobody Sq., Kharkiv, 61022)

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BREAKDOWN PHASE IN THE GOLEM TOKAMAK AND ITS IMPACT ON PLASMA PERFORMANCE

The effect of the breakdown phase on subsequent plasma parameters was investigated remotely in GOLEM tokamak. The dependence of breakdown voltage and the breakdown time versus the time delay between the trigger of the toroidal magnetic field B_t and the trigger of toroidal electric field E_t for different groups of the pressure magnitudes is built. The performed experiments have shown that for GOLEM tokamak the shorter is temporal delay - the better mean plasma parameters are obtained. In addition, the breakdown phase was discussed more detailed. In the discussion the analysis of the avalanche phase of the breakdown was made. The dominant mechanism of particle loses during avalanche phase, future steps, tasks were discussed and set.

K e y w o r d s: GOLEM, breakdown, avalanche, tokamak, particle losses, plasma parameters

1. Introduction

The initial stage (startup) of a tokamak discharge can be divided into three phases: breakdown, plasma formation, and current rise. The breakdown phase is characterized by a low degree of ionization. Colli-

arise, and the confinement is expected to increase significantly. The start-up phase of discharge in a TM-I-MH tokamak was investigated in [1]. The mechanism of particle losses in the phase preceding the formation of rotational transform was studied in the TM-1-MH tokamak in [2], and importance of stray magnetic

Y. Siusko et al. In Ukrainian Journal of Physics 66.3 (2021), pp. 231–239.

G.A. Sarancha et al. Hydrogen And Helium Discharges In The Golem Tokamak

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HYDROGEN AND HELIUM DISCHARGES IN THE GOLEM TOKAMAK

G.A. Sarancha[1,2], A.S. Drozd[1,3], I.A. Emekeev[1,2], S.A. Ganin[1,3], D. Kropachkova[4], I.S. Kudashev[1,3], V.V. Kulagin[1,3], M. Lauerova[4], A.V. Melnikov[1,2,3], N.S. Sergeev[1,3], O.D. Krokhalev[1,2], J. Stockel[4], V. Svoboda[4]

[1]*National Research Center «Kurchatov Institute», Moscow, Russia*
[2]*Moscow Institute of Physics and Technology (National Research University), Dolgoprudny, Russia*
[3]*National Research Nuclear University MEPhI, Moscow, Russia*
[4]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic*

The helium plasma properties and confinement remain an important area of research in modern fusion devices. This work is dedicated to the helium plasma initiation and control in a small-scale tokamak GOLEM compared to hydrogen plasma. Helium and hydrogen plasmas are comprehensively compared and the optimum operational conditions for the start-up are found. Long-range correlations between low-frequency (<50 kHz) electrostatic and magnetic oscillations are found, as well as broadband (<250 kHz) magnetic oscillations resolved in frequency and wave vector in helium plasma.

Key words: GOLEM tokamak, comparison of plasma discharges in hydrogen and helium, low-frequency electrostatic and magnetic oscillations.

DOI: 10.21517/0202-3822-2021-44-4-92-110

РАЗРЯДЫ В ВОДОРОДНОЙ И ГЕЛИЕВОЙ ПЛАЗМЕ ТОКАМАКА GOLEM

Г.А. Саранча[1,2], А.С. Дрозд[1,3], И.А. Емекеев[1,2], С.А. Ганин[1,3], Д. Кропачкова[4], И.С. Кудашев[1,3], В.В. Кулагин[1,3], М. Лауэрова[4], А.В. Мельников[1,2,3], Н.С. Сергеев[1,3], О.Д. Крохалев[1,2], Я. Штокель[4], В. Свобода[4]

[1]*Национальный исследовательский центр «Курчатовский институт», Москва, Россия*
[2]*Московский физико-технический институт (Национальный исследовательский университет), Долгопрудный, Россия*
[3]*Национальный исследовательский ядерный университет «МИФИ», Москва, Россия*
[4]*Факультет ядерных наук и физической инженерии, Чешский технический университет в Праге, Чешская Республика*

Свойства гелиевой плазмы и её удержание остаются важными темами исследований в современных термоядерных установках.

G.A. Sarancha et al. In PAST(TF) 4 (2021), pp. 92–110

G.A. Sarancha et al. Magnetic turbulence and long-range correlation studies in the GOLEM tokamak

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Journal of Physics: Conference Series **2055** (2021) 012003 doi:10.1088/1742-6596/2055/1/012003

Magnetic turbulence and long-range correlation studies in the GOLEM tokamak

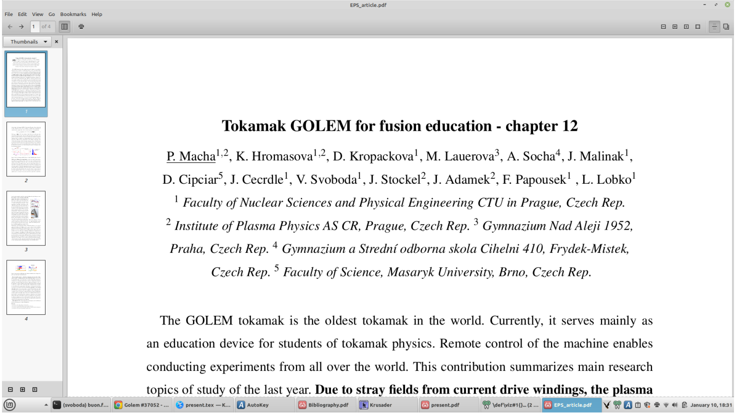
G Sarancha[1,2,5], V Svoboda[3], J Stockel[3] and A Melnikov[1,2,4]

[1] National Research Centre "Kurchatov Institute", Moscow, 123182 Russia
[2] National Research University "Moscow Institute of Physics and Technology", Dolgoprudny, 141700 Russia
[3] Czech Technical University in Prague, Prague, 16 00 Czech Republic
[4] National Research Nuclear University "Moscow Engineering Physics Institute", Moscow, 115409 Russia

[5] E-mail: sarancha.ga@phystech.edu

Abstract. The small university-scale tokamak GOLEM equipped with the electric and magnetic probes becomes a test bench for studying the plasma turbulence and Zonal Flows, which are the essential processes affecting the plasma confinement. The broadband (f_{BB} < 250 kHz) magnetic turbulence was detected for the first time using the Mirnov probes. The two-dimensional (frequency–wavelength) Fourier power spectra $S(k, f)$ of the magnetic turbulence indicate the turbulence poloidal propagation. The long-range correlations (LRC) between the signals of magnetic and electric probes installed at different toroidal cross-sections were detected in the low-frequency range (f_{LRC} < 60 kHz), which is similar to the plasma potential LRC range observed in other devices.

P. Mácha et al. Tokamak GOLEM for fusion education - chapter 12



Tokamak GOLEM for fusion education - chapter 12

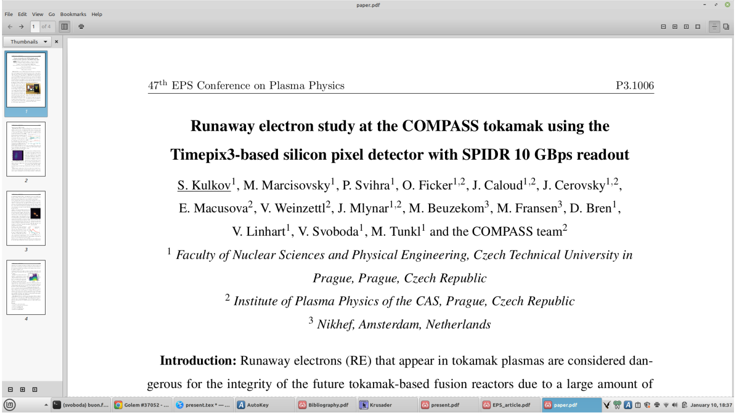
P. Macha[1,2], K. Hromasova[1,2], D. Kropackova[1], M. Lauerova[3], A. Socha[4], J. Malinak[1], D. Cipciar[5], J. Cecrdle[1], V. Svoboda[1], J. Stockel[2], J. Adamek[2], F. Papousek[1] , L. Lobko[1]

[1] *Faculty of Nuclear Sciences and Physical Engineering CTU in Prague, Czech Rep.* [2] *Institute of Plasma Physics AS CR, Prague, Czech Rep.* [3] *Gymnazium Nad Aleji 1952, Praha, Czech Rep.* [4] *Gymnazium a Stredni odborna skola Cihelni 410, Frydek-Mistek, Czech Rep.* [5] *Faculty of Science, Masaryk University, Brno, Czech Rep.*

The GOLEM tokamak is the oldest tokamak in the world. Currently, it serves mainly as an education device for students of tokamak physics. Remote control of the machine enables conducting experiments from all over the world. This contribution summarizes main research topics of study of the last year. **Due to stray fields from current drive windings, the plasma**

Europhysics conference abstracts. 2021, P4.1028

S Kulkov et al. Runaway electron study at the COMPASS tokamak using the Timepix3-based silicon pixel detector with SPIDR 10 GBps readout


47th EPS Conference on Plasma Physics P3.1006

Runaway electron study at the COMPASS tokamak using the Timepix3-based silicon pixel detector with SPIDR 10 GBps readout

S. Kulkov[1], M. Marcisovsky[1], P. Svihra[1], O. Ficker[1,2], J. Caloud[1,2], J. Cerovsky[1,2], E. Macusova[2], V. Weinzettl[2], J. Mlynar[1,2], M. Beuzekom[3], M. Fransen[3], D. Bren[1], V. Linhart[1], V. Svoboda[1], M. Tunkl[1] and the COMPASS team[2]

[1] *Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Prague, Czech Republic*

[2] *Institute of Plasma Physics of the CAS, Prague, Czech Republic*

[3] *Nikhef, Amsterdam, Netherlands*

Introduction: Runaway electrons (RE) that appear in tokamak plasmas are considered dangerous for the integrity of the future tokamak-based fusion reactors due to a large amount of

Europhysics conference abstracts. 2021, P3.1006

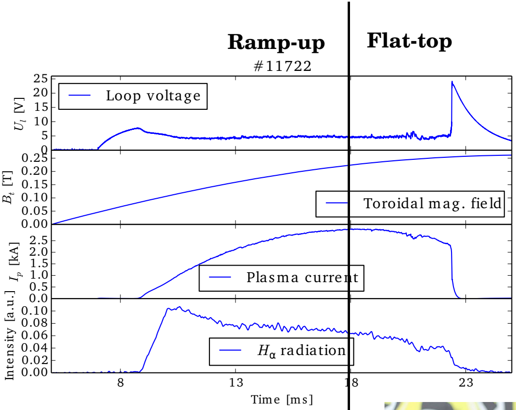
Outline

Outline

Generally

- After the COMPASS shutdown ... the only tokamak far wide.
- Fast spectrometry on specific lines.

Jan Buryanec (Vojtěch Svoboda): Plasma current control

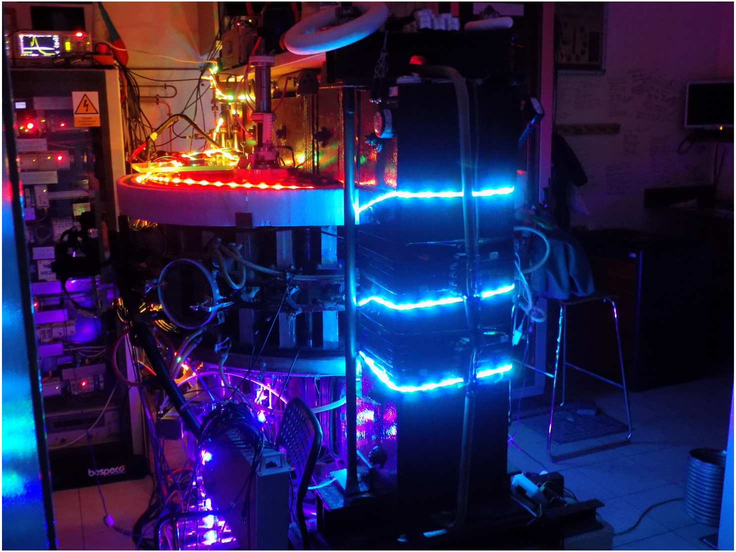


Transformer primary current control

Gas puff control

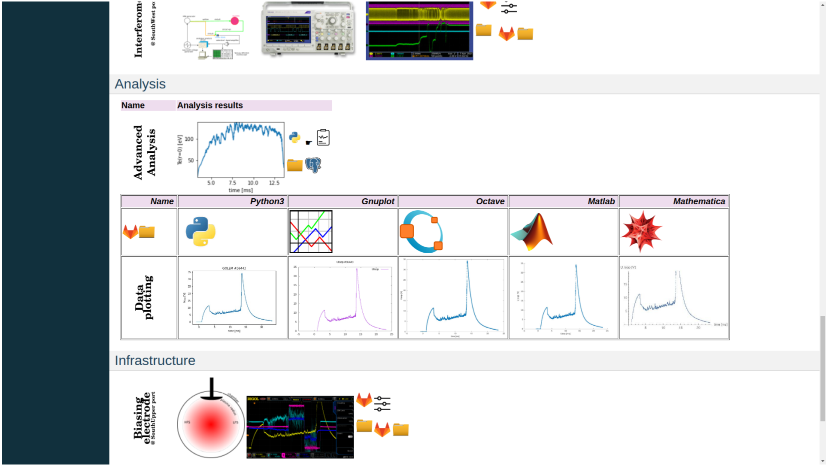
Gabo Vondrášek. Maxi přepínač

Martin Himmel & Honza Buryanec: LED experimental set-up



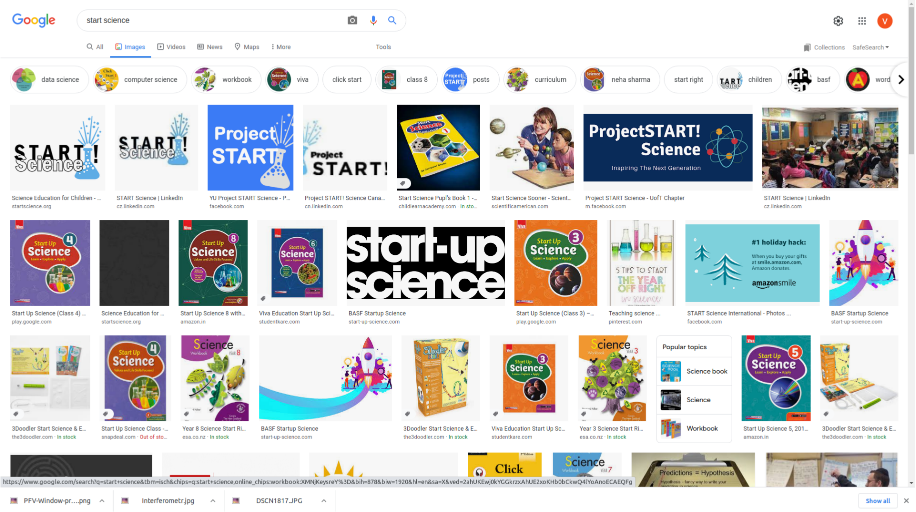
Oprava interferometru (na dobré cestě)

Free post discharge analysis script upload/access for trained students



http://golem.fjfi.cvut.cz/shots/36443/

Start to exploit all the stuff



To tu ještě nebylo ...

Nakonec, je tu ještě myšlenka, pokud by byla možnost na tokamak GOLEM dostat trochu deuteria, mohli bychom s pomocí NuDET detektoru ověřit přítomnost energií ubíhajících elektronů vyšších než 2,2 MeV. Totiž, HXR fotony o energii 2,2 MeV a vyšší dokáží iniciovat fotojaderné reakce s jádry deuteria za vzniku neutronů, které se dají NuDET detektorem lehce změřit včetně separace od HXR fotonů.

Lobko, L. Lab. work. 2021

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Acknowledgement

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Students, teachers, technicians (random order):

Vladimír Fuchs, **Ondřej Grover**, Gergo Pokol, Igor Jex, Martin Štefaňák, Gabriel Vondrášek, František Žácek, **Jan Stockel**, **Jan Mlynář**, Jaroslav Krbec, Vladimír Linhart, **Kateřina Hromasová**, Jaroslav Čeřovský, Martin Himmel, Marek Tunkl, Štěpán Malec **Petr Mácha**, Daniela Kropáčková, Martinal Lauerová, Aleš Socha, Ondřej Kudláček, Adéla Kubincová, Sergei Kulkov.

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G.A. Sarancha et al. "Hydrogen And Helium Discharges In The Golem Tokamak". In: *Problems Of Atomic Science And Technology, Ser. Thermonuclear Fusion* 4 (2021), pp. 92–110. DOI: 10.21517/0202-3822-2021-44-4-92-110. URL: https://doi.org/10.21517/0202-3822-2021-44-4-92-110.

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