The GOLEM tokamak bibliography

The tokamak GOLEM team

SGS 2022 relevant

Official GOLEM Articles

Cerovsky et al.: Progress in HXR diagnostics at Golem and COMPASS tokamaks **Cerovsky˙2022**

J. Cerovsky et al. "Progress in HXR diagnostics at Golem and COMPASS tokamaks". In: *Journal of Instrumentation* 17.01 (2022), p. C01033. DOI: 10.1088/1748-0221/17/01/c01033. URL: https://doi.org/10.1088/1748-0221/17/01/c01033.

Abstract: Scintillation detectors are widely used for hard X-ray spectroscopy and allow us to investigate the dynamics of runaway electrons in tokamaks. This diagnostic tool proved to be able to provide information about the energy or the number of runaway electrons. Presently it has been used for runaway studies at the Golem and the COMPASS tokamaks. The set of scintillation detectors used at both tokamaks was significantly extended and improved. Besides NaI(Tl) (2 × 2 inch) scintillation detectors, YAP(Ce) and CeBr3 were employed. The data acquisition system was accordingly improved and the data from scintillation detectors is collected with appropriate sampling rate (300MHz) and sufficient bandwidth (100MHz) to allow a pulse analysis. Up to five detectors can currently simultaneously monitor hard X-ray radiation at the Golem. The same scintillation detectors were also installed during the runaway electron campaign at the COMPASS tokamak. The aim of this contribution is to report progress in diagnostics of HXR radiation induced by runaway electrons at the Golem and the COMPASS tokamaks. The data collected during the 12th runaway electron campaign (2020) at COMPASS shows that count rates during typical low-density runaway electron discharges are in a range of hundreds of kHz and detected photon energies go up to 10MeV (measured outside the tokamak hall). Acquired data from experimental campaigns from both machines will be discussed.

Kulkov et al.: Detection of runaway electrons at the COMPASS tokamak using a Timepix3-based semiconductor detector **Kulkov˙2022**

S. Kulkov et al. "Detection of runaway electrons at the COMPASS tokamak using a Timepix3-based semiconductor detector". In: *Journal of Instrumentation* 17.02 (2022), P02030. DOI: 10.1088/1748-0221/17/02/p02030. URL: https://doi.org/10.1088/1748-0221/17/02/p02030.

Abstract: Runaway electrons are considered dangerous for the integrity of tokamak vacuum vessels. To secure the success of the future tokamak-based machines, reliable diagnostics and mitigation strategies are necessary. The COMPASS tokamak supported the research of runaway electron physics via regular experimental campaigns. During the last two experimental campaigns dedicated to runaway electrons, a semiconductor detector with a Timepix3 readout chip, Si sensor, and the SPIDR readout system was tested. Time evolution signals, energy measurements, and sensor snapshots collected with the Timepix3-based detector are presented.

Conference proceedings

Macha et al.: Self-induced transport barrier in the helium plasma on the tokamak Golem **MachaEPS22-a**

P. Macha et al. "Self-induced transport barrier in the helium plasma on the tokamak Golem". In: vol. July. Europhysics conference abstracts. 2022. URL: https://indico.fusenet.eu/event/28/contributions/64/attachments/78/1153/EPS_2022_article.pdf.

Abstract: Transport barriers and transmissions into different regimes of plasma confinement are currently very discussed topics. The lattes research showed a connection between transport barriers and E × B shear flows, which are able to suppress turbulent structures by tearing them apart. This process leads to better particle and also temperature confinement. Therefore, there is a significant effort for transport barrier studies. Usually, transport barriers are induced by an external electric field, which is used for plasma biasing. This method is useful, however, spontaneously formed transport barriers can provide more information about the processes taking place in a tokamak plasma. In this paper, the self-induced transport barrier in the helium plasma on the tokamak GOLEM is observed and analyzed.

Macha et al.: Tokamak Golem for fusion education - chapter 13 **MachaEPS22-b**

P. Macha et al. "Tokamak Golem for fusion education - chapter 13". In: vol. July. Europhysics conference abstracts. 2022. URL: https://indico.fusenet.eu/event/28/contributions/164/attachments/178/1152/EPS_2022_golem_article.pdf.

Abstract: The contribution is devoted to the description of several students projects, related mainly to edge plasma diagnostics, investigation of selected issues of tokamak physics and plasma performance on the GOLEM tokamak, particularly: i) Plasma stabilization, ii) A research on runaway electrons (RE) physics, iii) Plasma edge studies with electrostatic probes and iv) Tomography.

Master thesis

M. Tunkl: Development of a new runaway electron diagnostics method based on strip semiconductor detectors **TunklMT**

M. Tunkl. "Development of a new runaway electron diagnostics method based on strip semiconductor detectors". Master Thesis. 2022. URL: http://golem.fjfi.cvut.cz/wiki/Presentations/Students/MasterThesis/22TunklMarek.pdf.

Abstract: In this master's thesis, new diagnostics of runaway electrons on the GOLEM tokamak were developed. First, a simulation in the Geant4 toolkit was created to evaluate the effect of the backscattering of the runaway electrons from the limiter. Then, a silicon-based strip detector probe was designed and constructed with respect to the simulation result. Finally, the measured data were analyzed and compared to the relevant diagnostics and simulation results. Furthermore, a new scintillation detector was constructed from a silicon photomultiplier and a LYSO crystal. The signal from the silicon photomultiplier exhibited good characteristics. Even with multiple superimposed peaks, it was possible to reconstruct their original height and thus obtain the hard X-ray spectrum of the entire plasma discharge.

Bachelor projects

J. Chlum: Implementation of tomographic inversion on the Golem tokamak. **ChlumBP**

J. Chlum. "Implementation of tomographic inversion on the Golem tokamak." Bachelor project. 2022. URL: http://golem.fjfi.cvut.cz/wiki/Presentations/Students/BachelorProjects/22ChlumJakub.pdf.

Abstract: The topic of this bachelor's thesis is visible light tomography of tokamak plasma and its implementation on the GOLEM tokamak. The thesis includes a theoretical summary of radiation processes in tokamak plasmas in the visible spectrum. The thesis then summarises the principles of the tomography inversion task and its solution with emphasis on the minimum Fisher Tikhonov regularization algorithm used here. The practical part of the thesis includes the calibration of two fast cameras for the their use both on the tokamak and separately. The calibration was tested by the tomographic inversion of a known emissivity profile. Finally, the tomography was tested on experimental data from the GOLEM tokamak. Its limitations and errors were discussed and options for futher development were suggested.

High School Students' Professional Activities

E. Pumprlová: Vliv tlaku pracovního plynu na generaci ubíhajících elektronů v tokamaku Golem. **pumprSOC**

E. Pumprlová. "Vliv tlaku pracovního plynu na generaci ubíhajících elektronů v tokamaku Golem." High School Students' Professional Activities SOČ. 2022. URL: http://golem.fjfi.cvut.cz/wiki/Presentations/Students/HighSchoolActivities/22PumprlovaRunaaways.pdf.

Abstract: This study investigates how working gas pressure affects the generation of runaway electrons in the tokamak GOLEM. The aim is to describe this relationship and the course of runaway electron generation in tokamak. The theoretical framework of this study inquiries into the topic of runaway electrons, the practical part tests a hypothesis: in low pressure plasma the number of runaway electrons is going to be greater than in plasma of higher pressure. The experimental part also includes the data analysis, which portrays the course of generation of runaway electrons. Scintillation detectors were used to collect the data, the analysis of values measured was conducted in the programming language Python. The experiment confirmed the hypothesis and the results opened new subjects to study more closely.

M. Pokorný: Sondová měření parametrů okrajového plazmatu na tokamaku Golem s pomocí motorizovaného manipulátoru **pokorSOC22**

M. Pokorný. "Sondová měření parametrů okrajového plazmatu na tokamaku Golem s pomocí motorizovaného manipulátoru". High School Students' Professional Activities SOČ. 2022. URL: http://golem.fjfi.cvut.cz/wiki/Presentations/Students/HighSchoolActivities/22PokornyProbes.pdf.

Abstract: This SOC thesis focuses on the measurement of edge plasma parameters using electrical ˇ probes at the GOLEM tokamak. In the theoretical part of the work, a basis for understanding plasma and its behavior is given and some general principles of thermonuclear fusion and tokamaks are presented. Finally, a theoretical basis for the measurement of edge plasma parameters by electrical probes is provided with an accent on the double tunnel probe. The practical part of the work first focuses on the process of putting into operation a new motorized probe manipulator and its application at the GOLEM tokamak. Moreover, the course and results of experimental measurements with the double tunnel probe are presented. Within two discharge series, we were able to

measure axial profiles of ion saturated current thanks to the new motorized manipulator. Firstly, a calibration of the probe was done and axial profiles of ion saturated current were measured. Afterwards, measurements and calculations of parallel and perpendicular components of the Mach number of plasma rotation were performed. Furthermore, the time dependence of the parallel component of the Mach number in a parallel probe orientation to magnetic field lines was measured. Finally, two methods of calculation of the Mach number related to the axial profiles of ion saturated current were compared. The data received from ion saturated current axial profiles and Mach number measurements is in accordance with the results of multiple articles related to this topic.