

Investigation of runaway electrons at Golem

7th Meeting on Runaway Electron Modeling

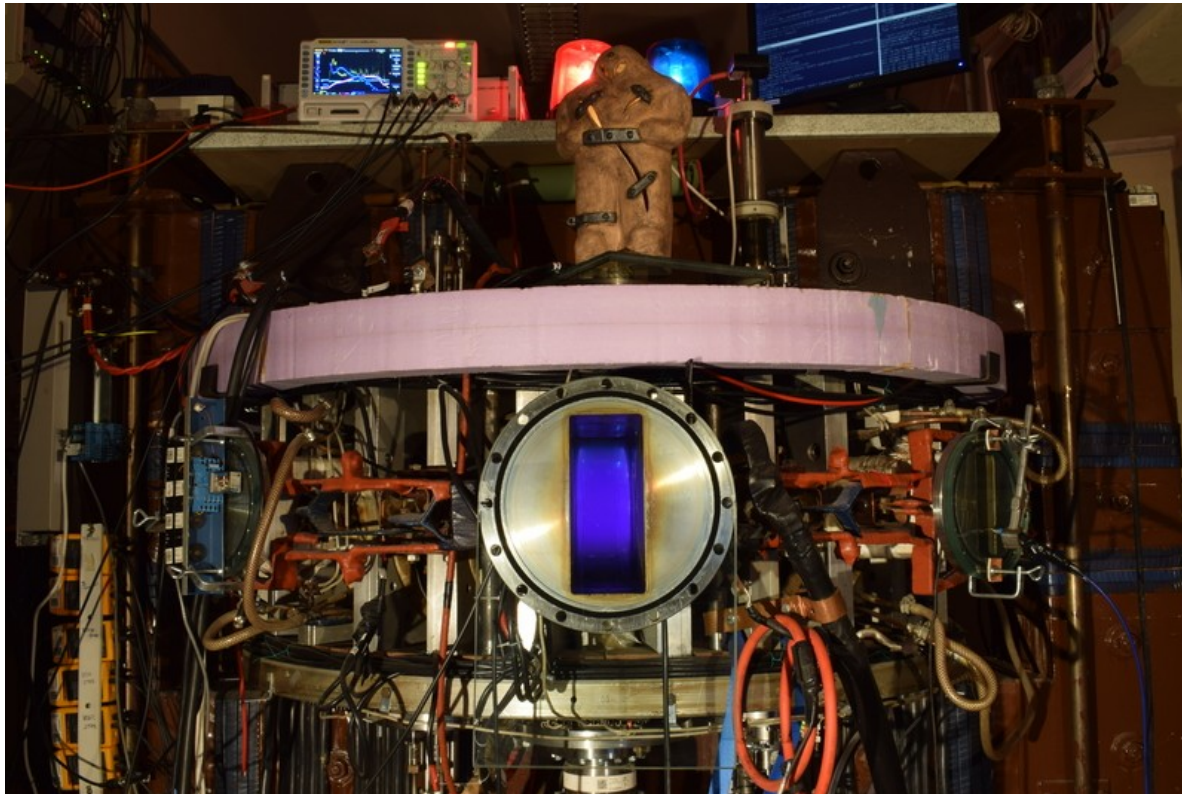
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- 1. Golem tokamak**
- 2. Experimental setup**
- 3. Center of Advanced Applied Sciences – CAAS**
- 4. Diagnostic developments**

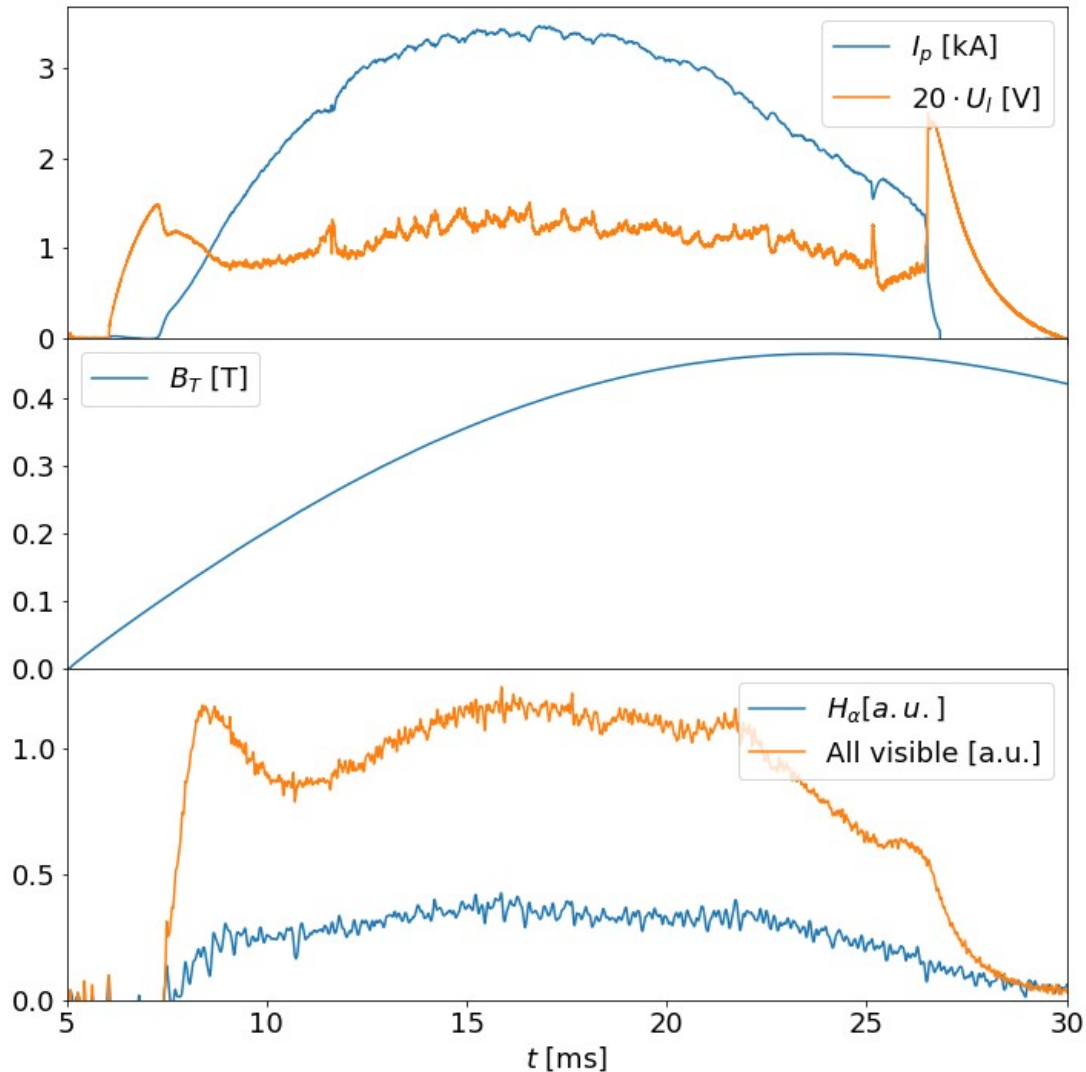
Golem tokamak



R [m]	0.4
a [m]	0.085
I_p^{\max} [kA]	10
B_T^{\max} [T]	0.8
t_p [ms]	20

- former tokamak CASTOR at IPP → now located at FNSPE CTU in Prague
- serves as an educational and training device for students of plasma physics
- testbed for diagnostics development
- scientific program: edge plasma and runaway electron studies

Typical Golem discharge



Parameters of discharge:

$$U_{cd} = 350 \text{ V}$$

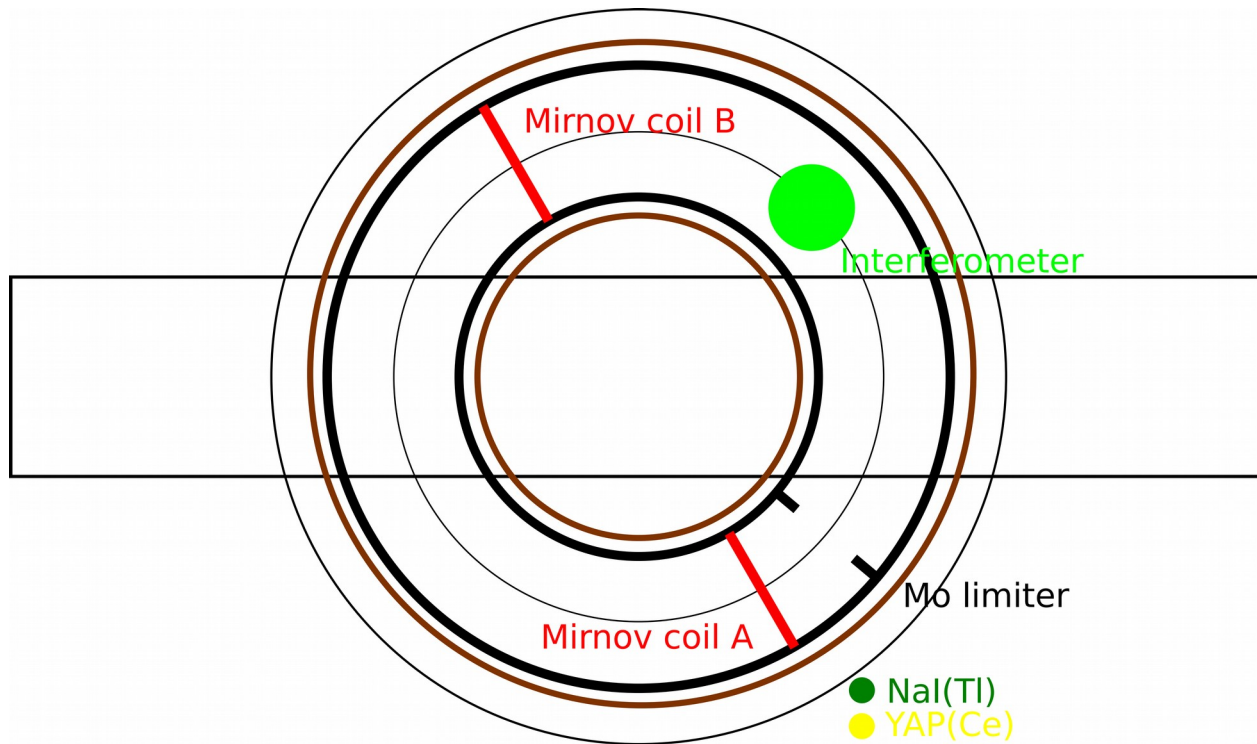
$$U_{bt} = 1200 \text{ V}$$

$$p_{wg} = 14 \text{ mPa}$$

$$t_d = 1 \text{ ms}$$

Upcoming upgrades:

- real time positional feedback
- gas puffing system
- fast camera
- new interferometer



RE related diagnostics:

NaI(Tl)
YAP(Ce)
Timepix detector
Strip detector
30 personal dosimeters

+ 2 additional NaI(TL)

Attempts of installation
of Cherenkov detector

Future diagnostics:

2 scintillation probes (YAP)
2 Timepix detector

Fast data acquisition

Tektronix MSO58
• sampling rate: up 35 Ms/s
• bandwidth: 500 MHz

Rich magnetic diagnostics:

2 rings of Mirnov coils (16 coils)
4 Mirnov coil at limiter



Working group PLASMA:

Faculty of Nuclear Sciences
and Physical Engineering
Faculty of Electrical Engineering
Faculty of Mechanical Engineering

possibility to share experiences with different types of plasma

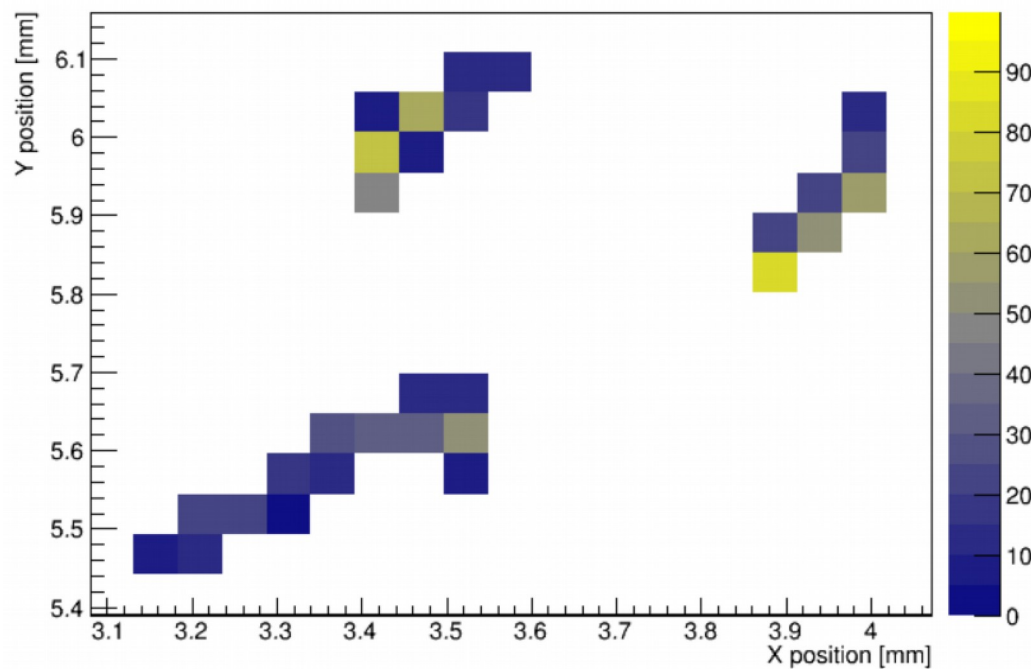
- tokamak, Z – pinch and laser plasma
- opportunity study different mechanisms of generation of fast particles

Center of Advanced Applied Sciences

- support of multidisciplinary research
- broad collaboration of different faculties of Czech Technical University

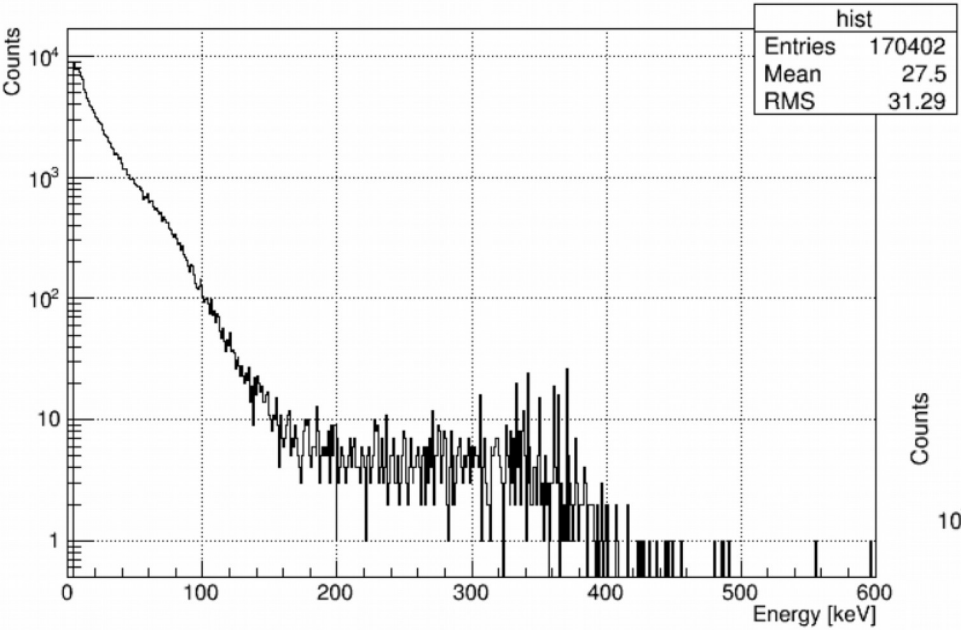
Participating faculties:

Faculty of Nuclear Sciences and Physical Engineering
Faculty of Civil Engineering
Faculty of Mechanical Engineering
Faculty of Electrical Engineering
Faculty of Architecture
Faculty of Information Technologies



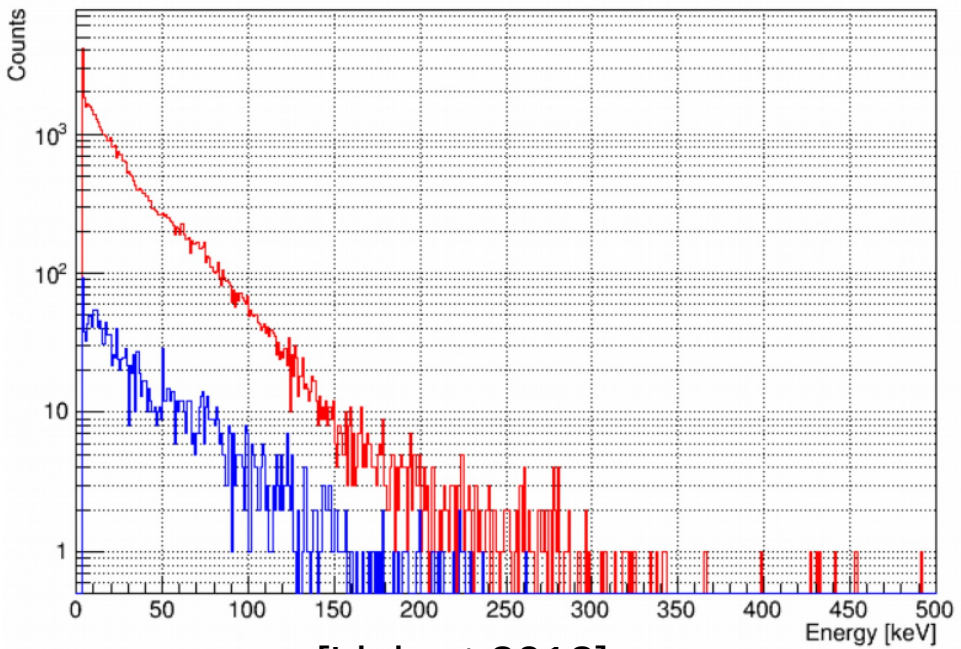
[Linhart, 2018]

- pixel semiconductor detector for detection of SXR and HXR radiation
- originally designed for imaging technique
 - capable to resolve several events simultaneously
- consists of Timepix3 chip and silicon sensor
 - readout chip and conversion layer (photons → charge)
- 65 536 independent pixels per chip
 - a large number of “independent” detectors → suppression of pileups



- recorded spectrum in Golem discharge #27758
→ maximum energy of RE around 500 keV?

- spectra recorded in forward and backward directions e. g. in current (blue) and co-current (red) directions
→ correlation with favourable direction of motion of RE

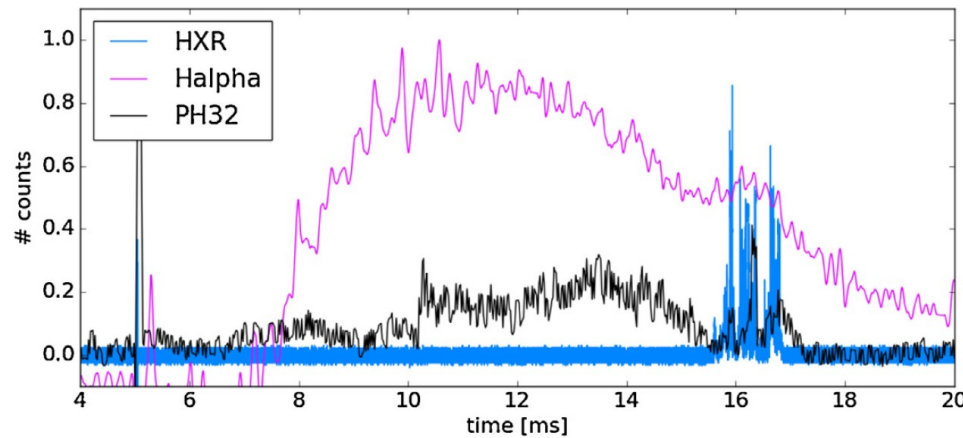
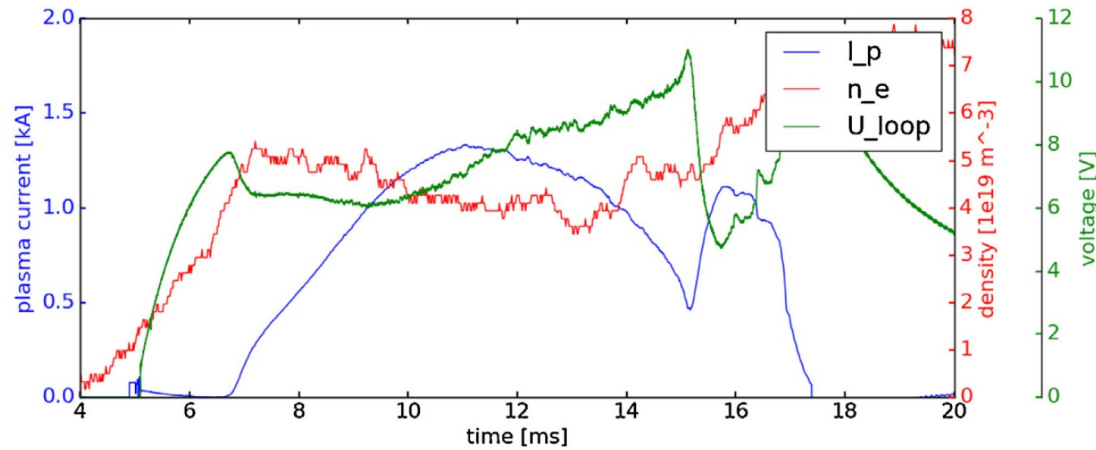


[Linhart 2018]



[Švihra 2018]

- silicon strip detector developed at the Center of Applied Physics and Advanced detection systems at FNSPE CTU
- different regimes of detector operation
 - hit counting
 - deposited energy measurement
- different modes of operation
 - high gain mode – sensitive to SXR
 - low gain mode – sensitive to protons or heavy ions



[Švihra 2018]

- the detector placed on a radial manipulator inside vacuum vessel
→ direct observation of RE
- first measurement with segmented semiconductor detector in the vacuum vessel of tokamak
- ongoing improvement of shielding against EMI

- a large number of diagnostics useful for investigation of runaway electrons
- development of novel diagnostic techniques

How can be Golem helpful for runaway electrons studies?

- [Linhart 2018] Linhart, Vladimir, et al. "First Measurement of X-rays Generated by Runaway Electrons in Tokamaks Using a TimePix3 Device with 1 mm thick Silicon sensor." IEEE Nuclear Science Symposium and Medical Imaging Conference (2018).
- [Svihra 2018] Svihra, Peter, et al. "Runaway electrons diagnostics using segmented semiconductor detectors." Fusion Engineering and Design (2018).