Characterization of He plasmas at the edge of the GOLEM tokamak

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

P. Mácha[1], V. Svoboda[1], J. Adámek[2], J. Stöckel[2]

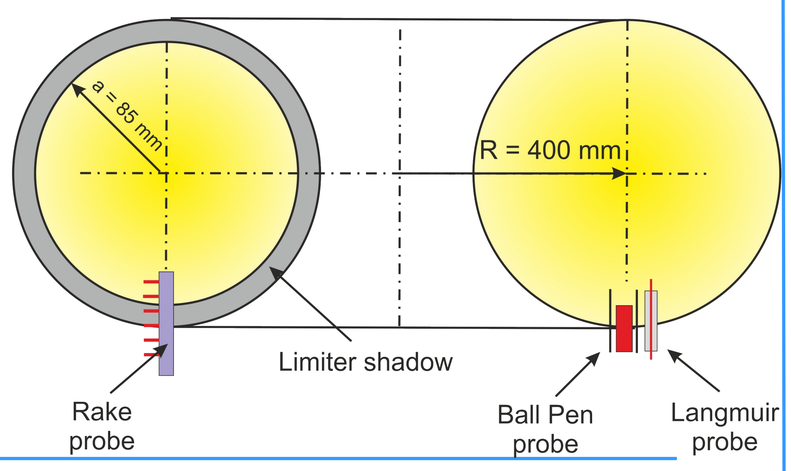
[1]*Faculty of Nuclear Sciences and Physical Engineeting, Czech Technical University in Prague, Czech Republic*
[2]*Institute of Plasma Physics, Czech Academy of Sciences, Prague, Czech Republic*

Introduction

The GOLEM tokamak [1] is the oldest tokamak in the world, which still operational, and serves for education of future fusion specialists in the Czech Republic as well as a training facility of students throughout the world, because of its unique fully remote control system. Here, we present results of measurements of the radial profiles of the edge electron temperature and plasma potential in Helium plasma, performed by means of a novel probe head composed by the Ball Pen Probe and the Langmuir probe [2] located at the same magnetic surface. Furthermore, fluctuations of the floating potential measured by a radial array of Langmuir tips are analyzed in the same discharge by several statistical techniques.

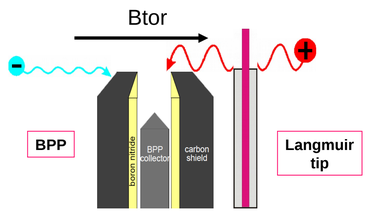
The GOLEM Tokamak

- R = 0.4 m, a = 0.085 m, B_T < 0, 5 T
  I_p < 8 kA, n_e < 1 x 10^{19} m^{-3}
- Pulse length up to 20 ms
- Circular poloidal limiter
- Routine operation in Hydrogen or in Helium
- Reasonable reproducibility at a relatively high repetition rate (a discharge per 3 minutes)



Probe diagnostics at GOLEM

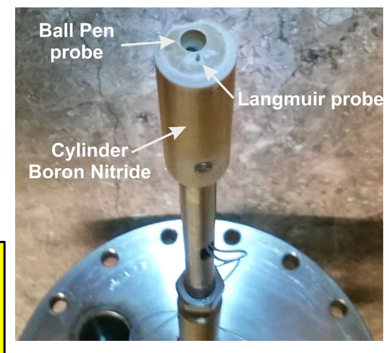
Ball Pen Probe (BPP) combined with the **Langmuir tip** simultaneous measurements of the plasma potential and electron temperature with temporal resolution 1 μs



$T_e = (V_{fl\,-BPP} - V_{fl\,-LP})/\alpha$

$V_{fl\text{-}BPP} = \Phi$

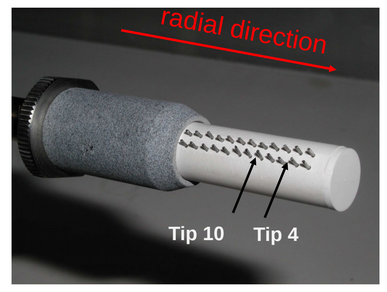
$\alpha = 2 \pm 0{,}2$ in Helium plasma



Collector is retracted by 2,3 mm inside the dielectric tube

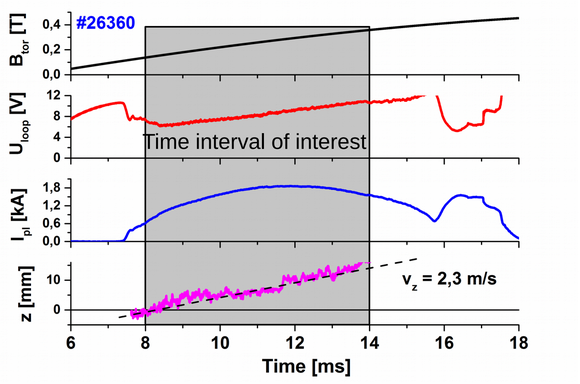
Rake probe

Array of Langmuir floating tips oriented in radial/poloidal direction



Radial/poloidal distance between adjacent tips is 2,5 mm

Evolution of the discharge #26360 in Helium



Toroidal magnetic field 0,14 - 0,36 T

Loop voltage 7.4 - 10,6 V

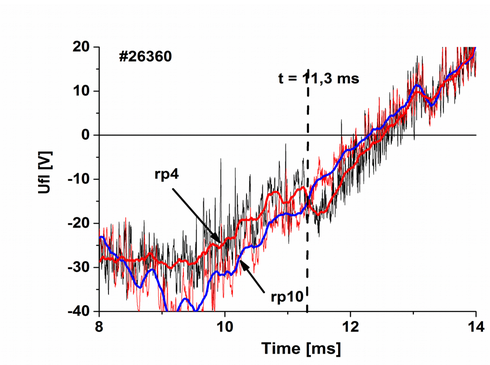
Plasma current 0.6 -1,85 kA

Vertical position 0 -14 mm

Edge safety factor q(a) ~ 11, Line average density ~ 1.5 10^{18} m^{-3} , Central electron temperature ~ 35-40 eV

Floating potentials of the tips 4 & 10 measured by the rake probe

Evolution of the floating potential

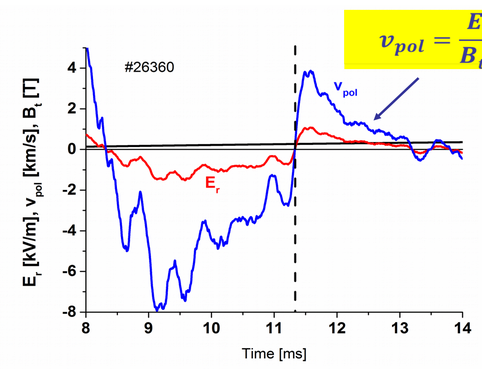


Radial distance between tips 4&10 is Δ = 2,5 mm

=>

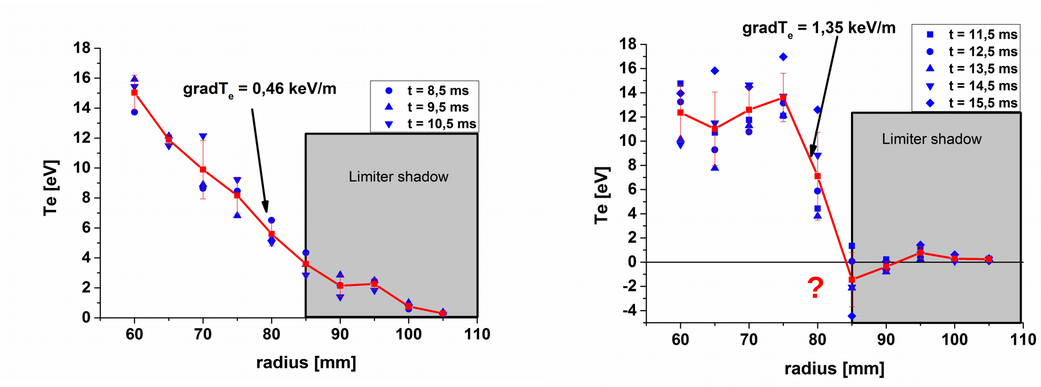
Evolution of the radial electric field and ExB velocity

$$v_{pol} = \frac{E_R}{B_{tor}}$$



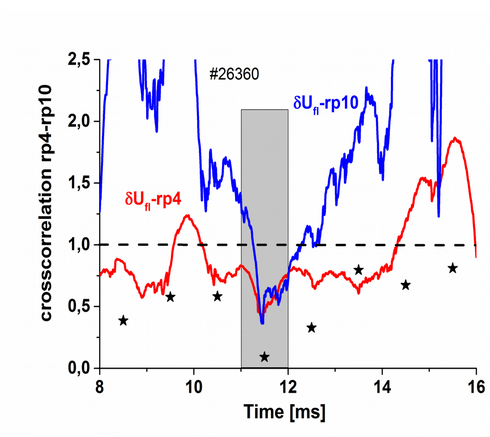
Reversal of the radial profile of E_r and observation of the poloidal velocity shear at **t ~ 11.3 ms**

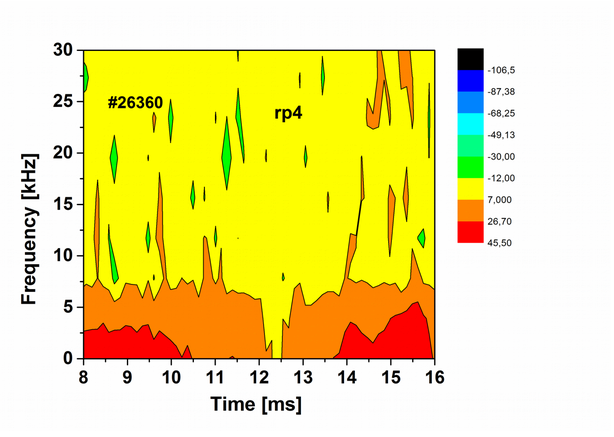
Radial profiles of the edge electron temperature measured by the combined probe head BPP&LP



A steep gradient of the electron temperature is formed spontaneously in the proximity of the limiter radius at **t ~ 10,5 – 11,5 ms**

Reduction of edge plasma turbulence and decorrelation of floating potential fluctuations

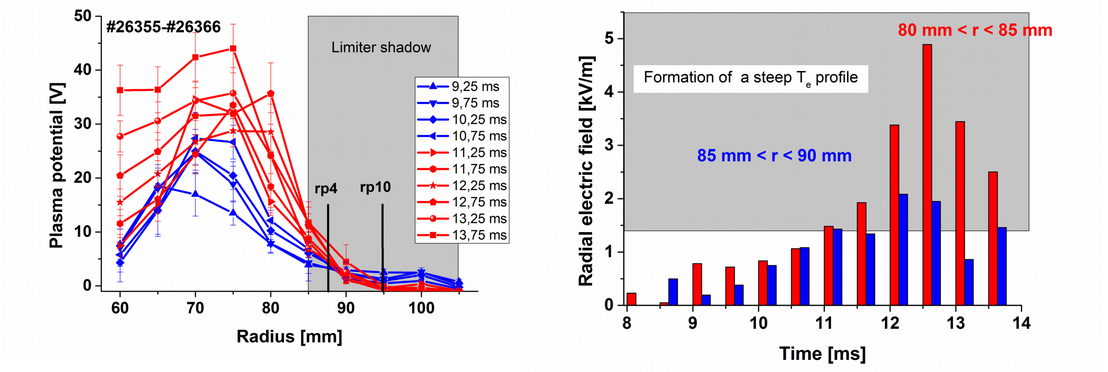




- Fluctuations level decreases significantly between t = 11-12 ms
- Cross-correlation coefficient (**stars**) between tips 4 and 10 of the rake probe drops below 0,1

Reduction of low frequency fluctuations is evident, but observed ~ 1 ms later

Radial profiles of the plasma potential and its gradient measured by BPP



$$E_r = -\frac{V_{fl(4)} - V_{fl(10)}}{\Delta r}$$

- A steep gradient of the plasma potential is formed after t = 11 ms
- A steep gradient of the edge electron temperature is observed when the radial electric field E_r > 1,5 kV/m

Conclusions

- Steep gradients of electron temperature and plasma potential are spontaneously formed at the proximity of limiter in a particular time (~11,3 ms)
- The shear of the poloidal velocity occurs at the limiter radius at the same time is observed
- A significant reduction of floating potential fluctuations accompanied with their decorrelation is observed

[1] V. Svoboda, et al., Fusion Engineering and Design, **68**, (2011), pp. 1310-1314

[2] J. Adamek, et al., Rev. Sci. Instr. **87**, (2016), 043510

machap11@fjfi.cvut.cz, vojtech.svoboda@fjfi.cvut.cz, adamek@ipp.cas.cz, stockel@ipp.cas.cz,