Golem #9 2016 - from #20411 to #22926

Mariánská 2017

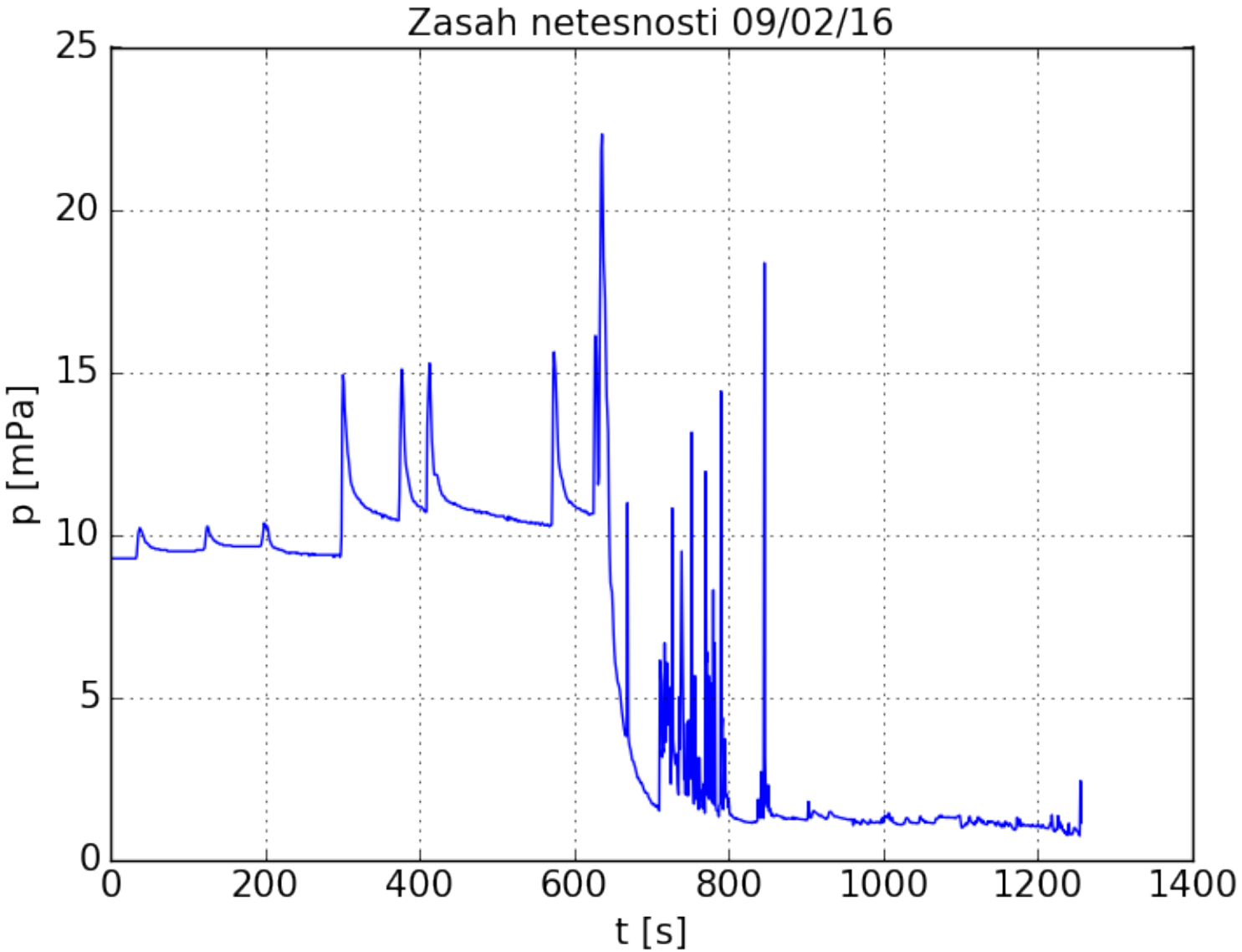
Vojtěch Svoboda

The Forecast 2016

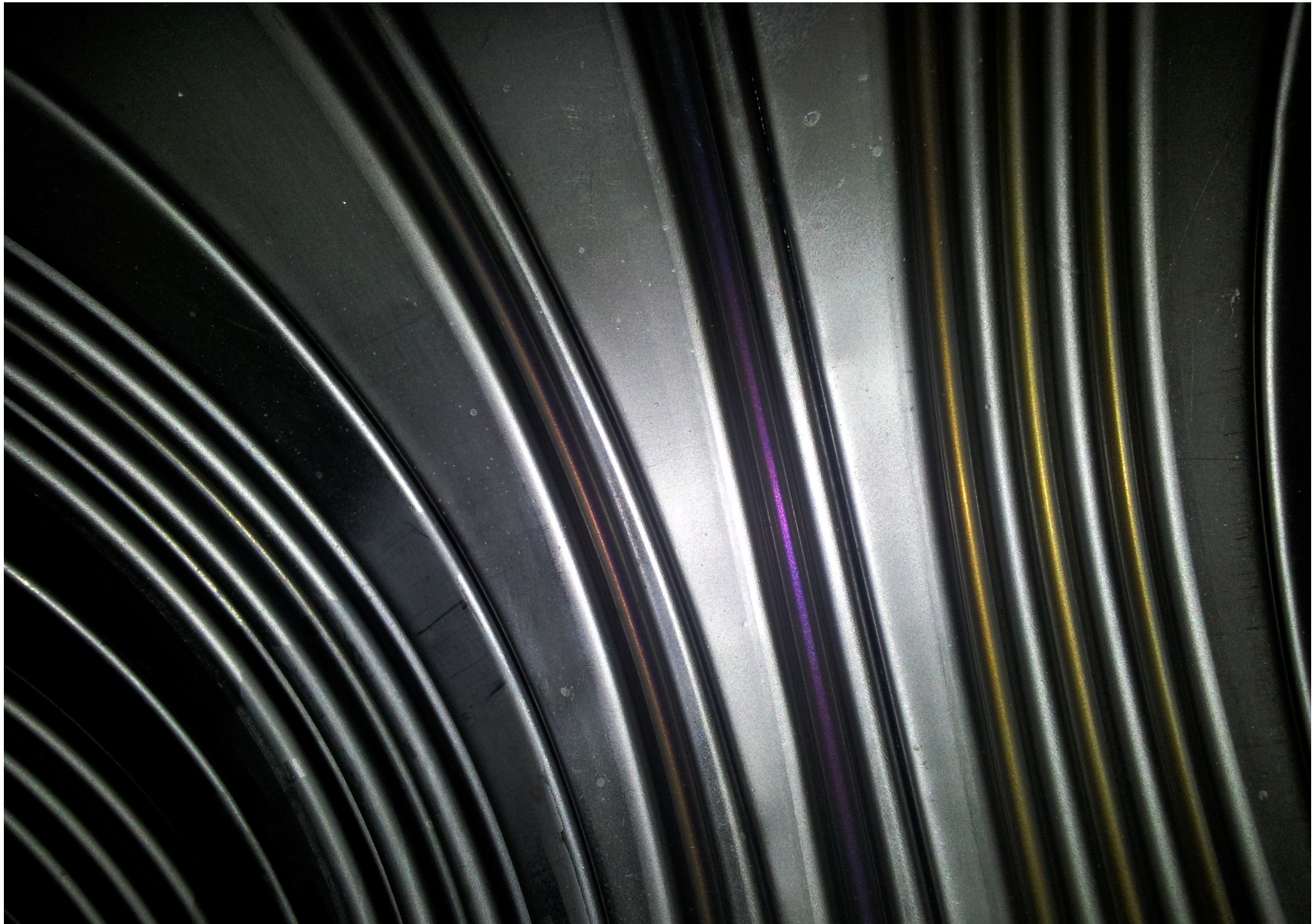
- The Night of Scientists II. ✓
- Traditional TRAIning Courses: FUMTRAIC IV ✓, SCIWTRAIC VI ✓, HUNTRAIC V ✓, SUMTRAIC@GOLEM VIII ✗(SOFT), EMTRAIC@GOLEM IV ✗(not scheduled).
- Bachelor thesis ✓: Tatiana Okonechnikova - 3D model defended.
- Diploma thesis IV cont ✓: Bořek Leitl - Bolometry.
- papers in FUSENGDES,. ✓, AJP ✗(No energy) .. ?
- +Training courses from Kiten, Grenoble, Belgrade, Kobenhaven, Torino, Padova.

Outline

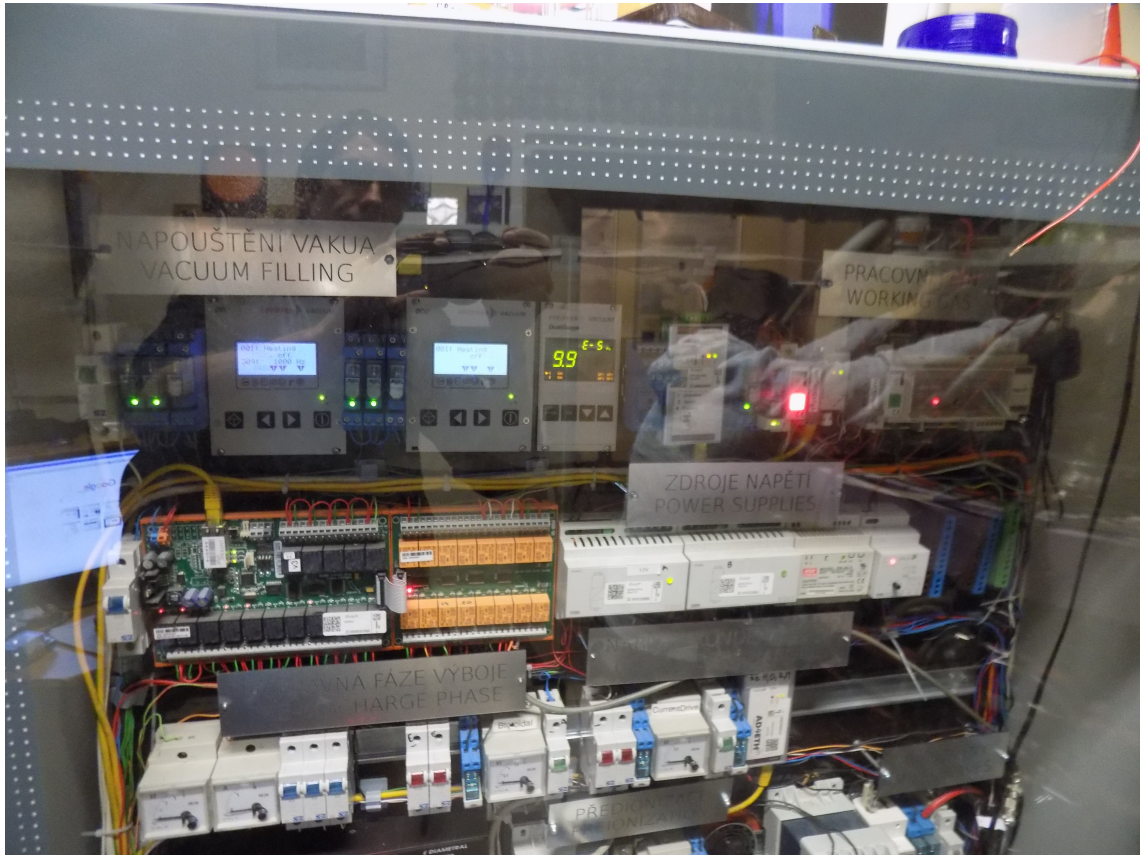
Leakage 090216 hit



Suspicious Place

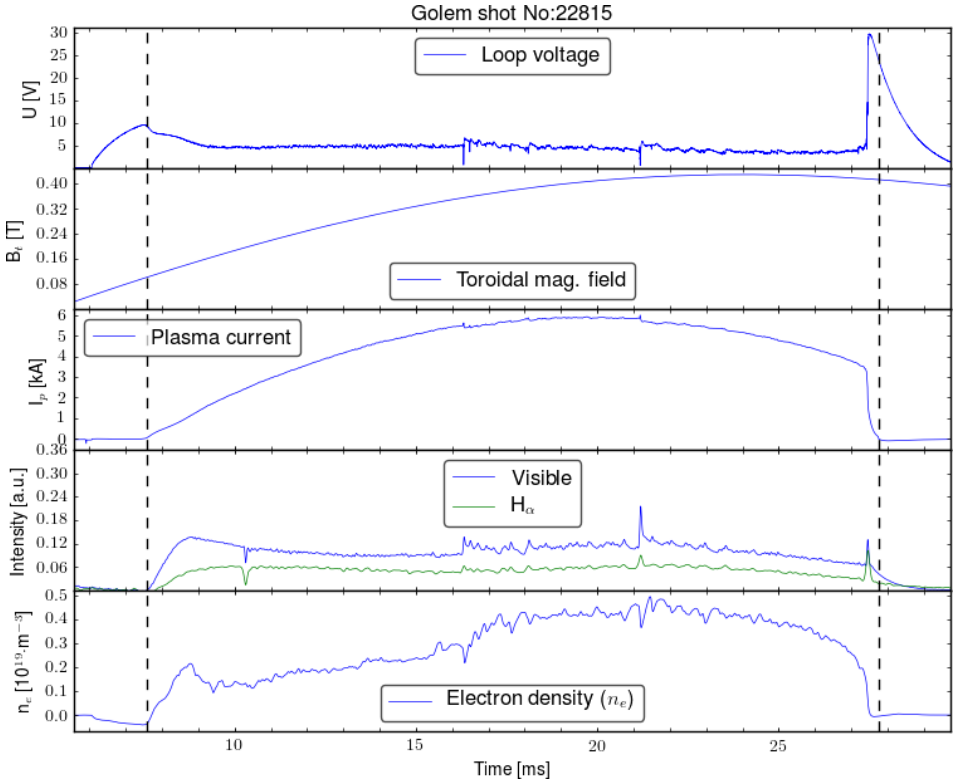


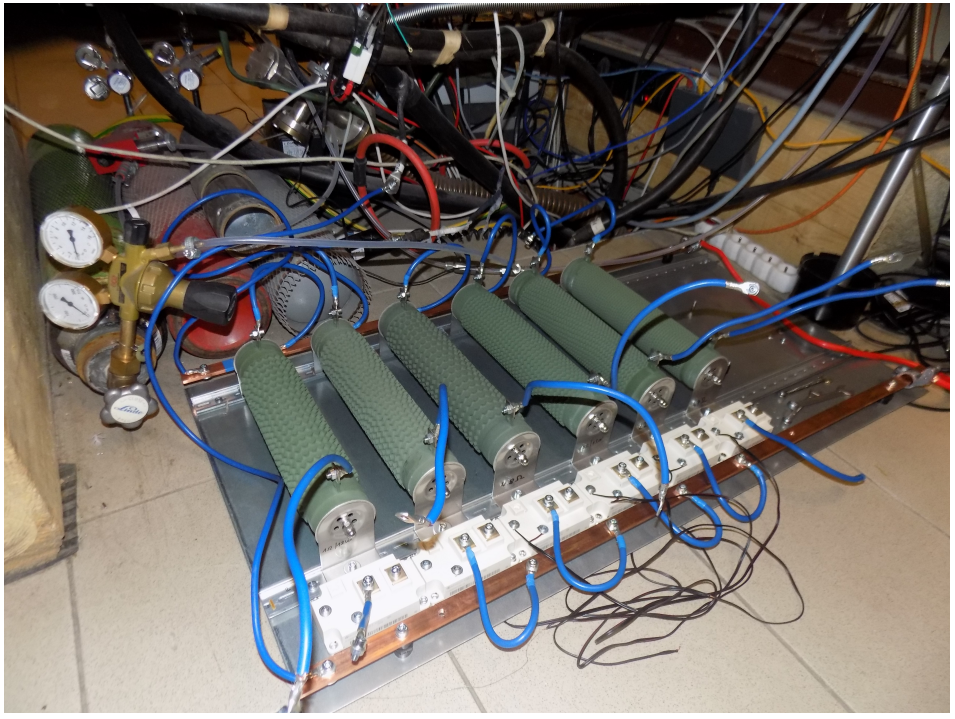
12/16: $p < 0.1$ mPa



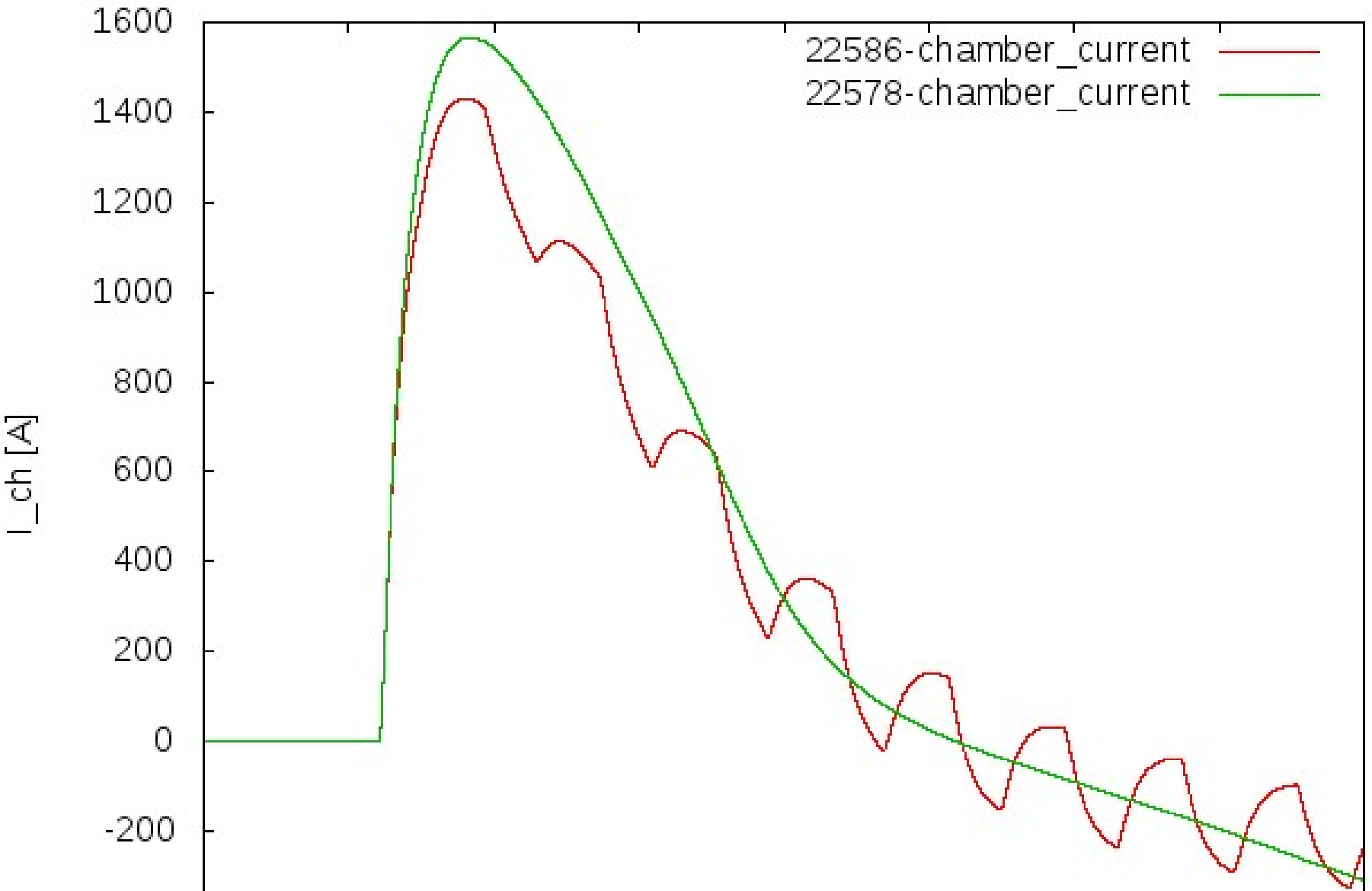
Dobrá zpráva pro Vojtu Munzara (zápočet)

Current drive stabilization

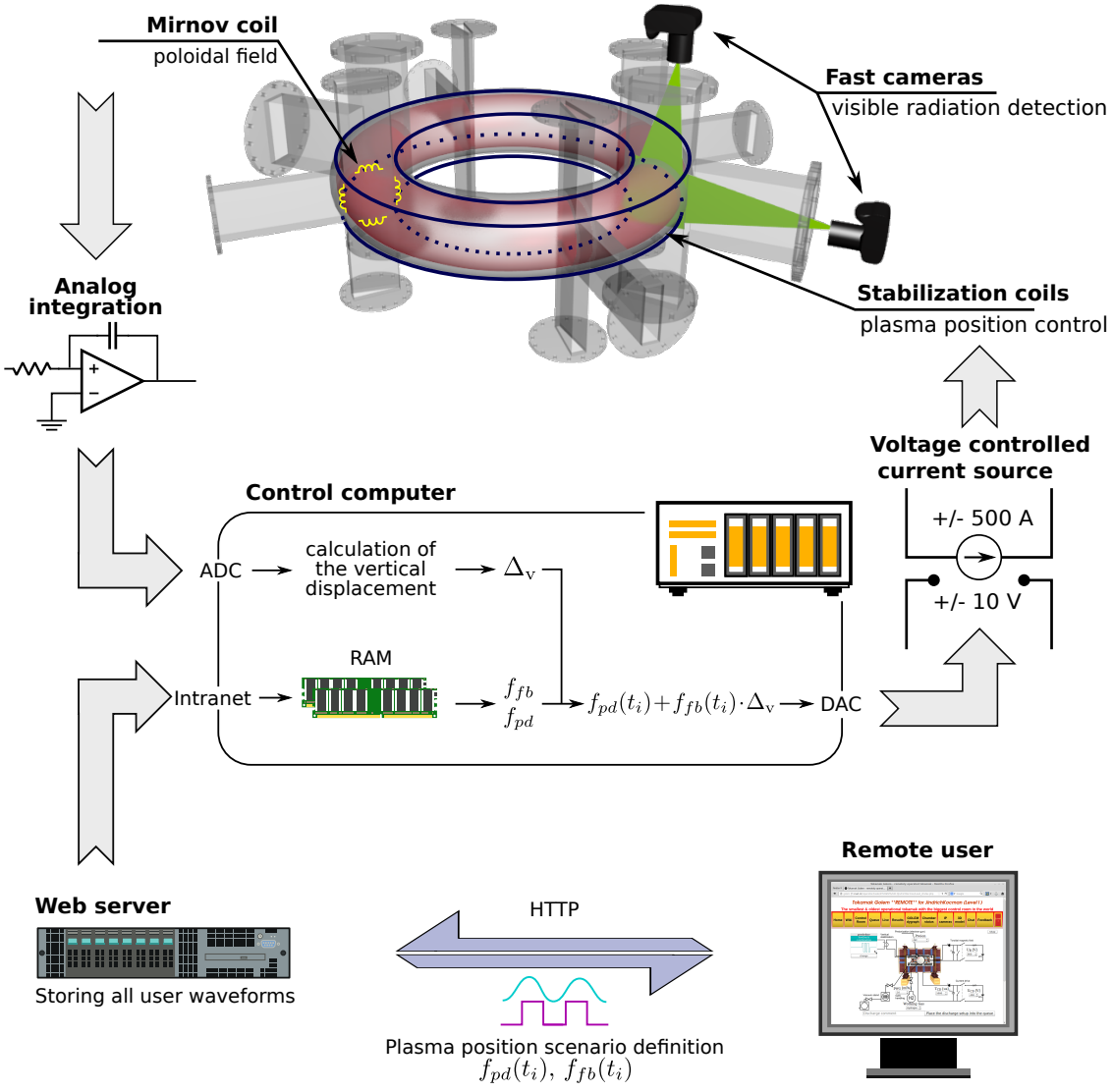




Plasma current stabilization



JK (+Foton): Stabilization



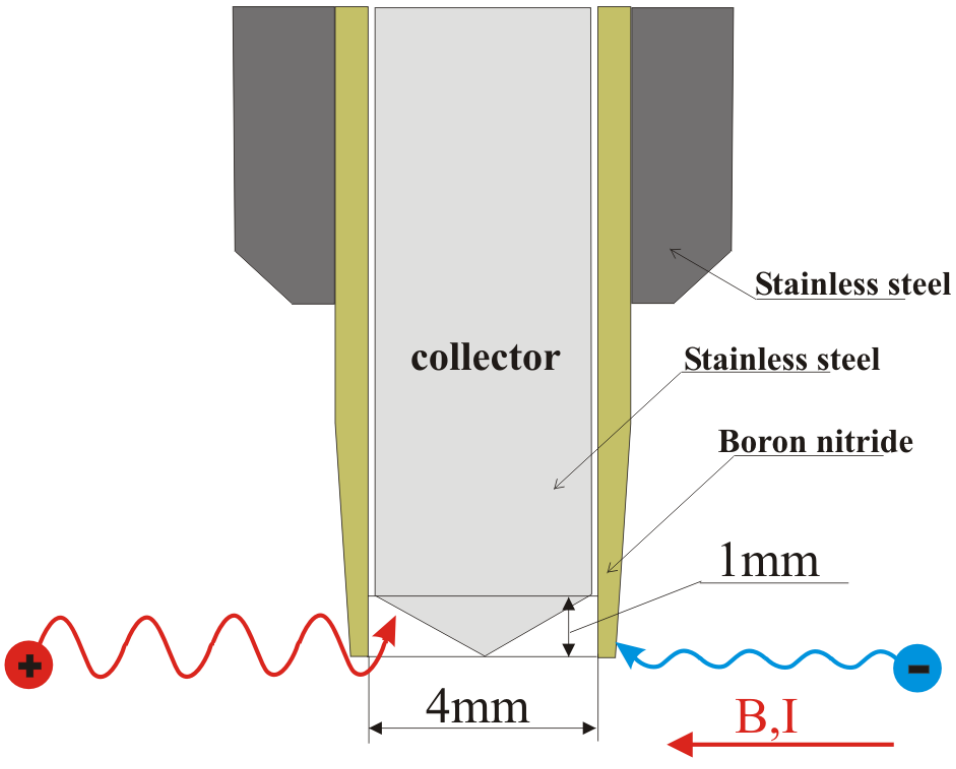
MW launcher v.III for preionization (TP)

1216: Final solution

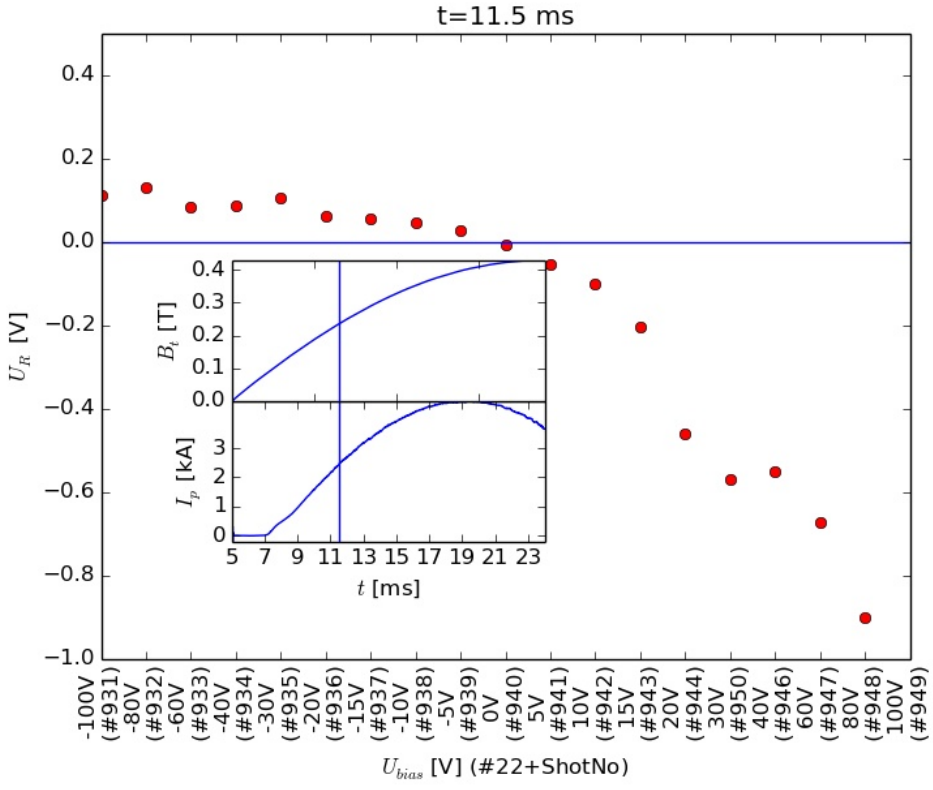
??

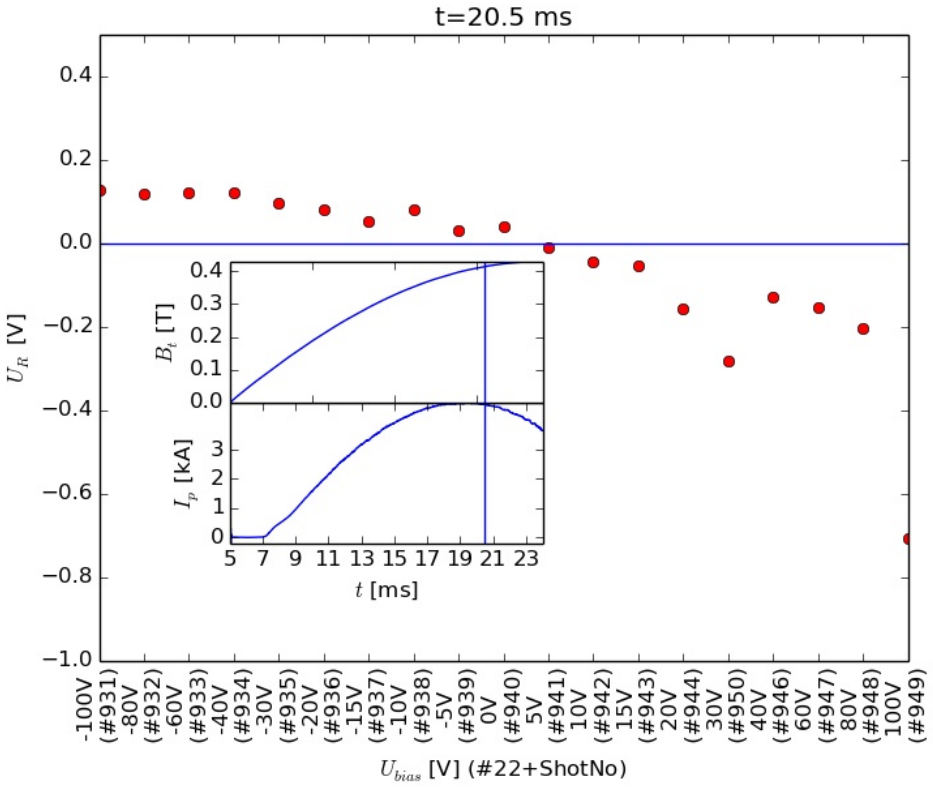
Outline

Ball pen probe



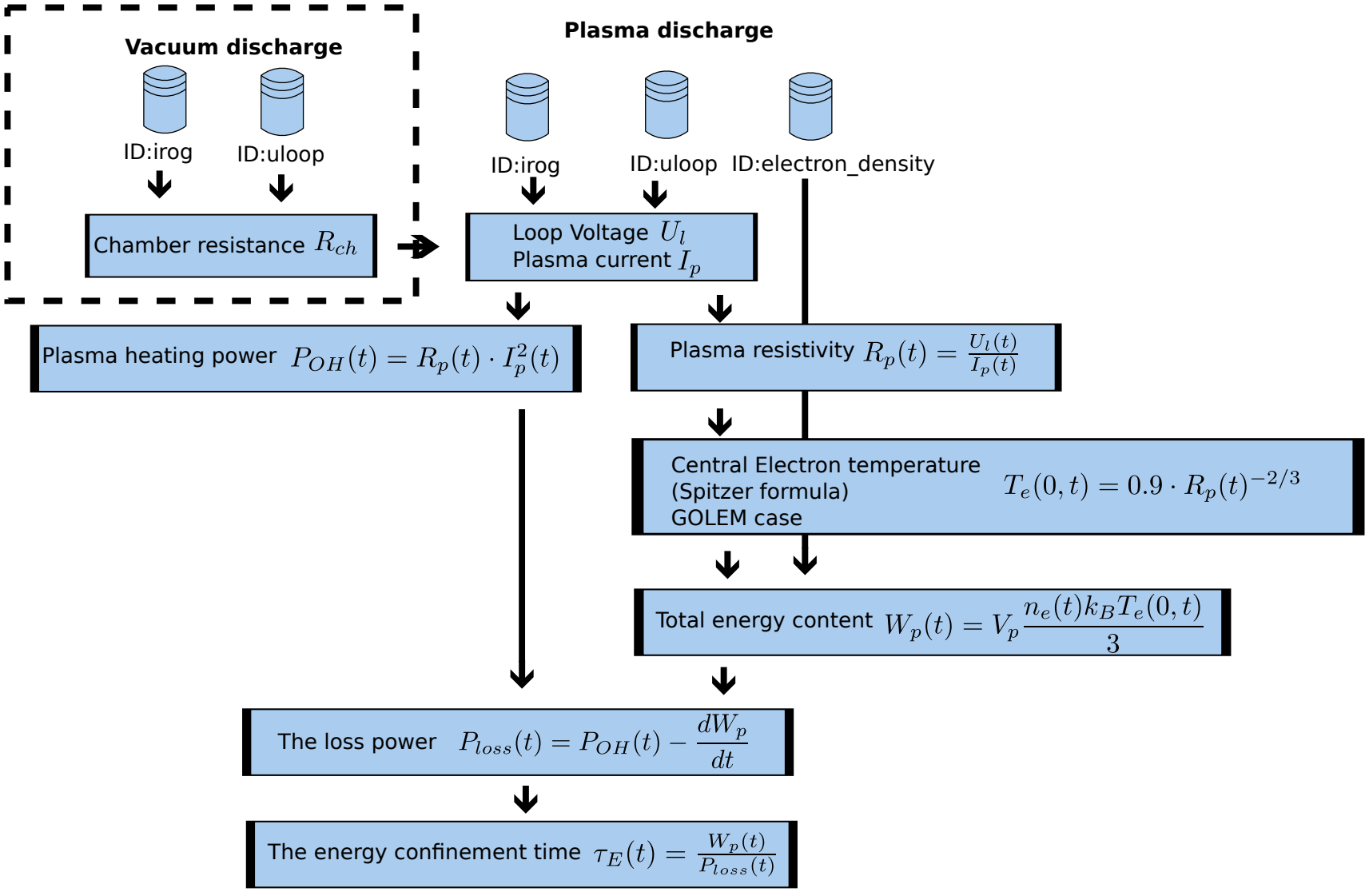
VA characteristic symmetry with B_t





Outline

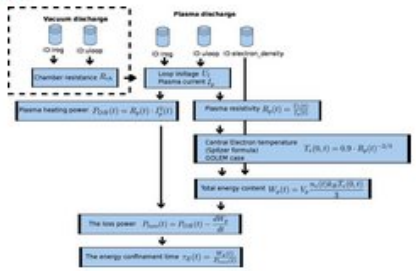
Towards Energy confinement time τ_E



Jupyter & Matlab implementations

Tokamak GOLEM - electron energy confinement τ_E calculation

Strategic flowchart



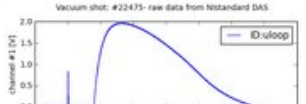
Python Intro

In [1]:
```
# NOTE: Please use  python 2 version of language/kernel

# First we import the necessary modules (libraries)
import matplotlib.pyplot as plt
import numpy as np
import sys
from scipy.integrate import cumtrapz
from scipy import constants

# The following line activates the inline plotting backend in the notebook.
%matplotlib inline

# Next we define some fundamental constants and parameters
RogowskiCalibration = 5.3e6  # Calibration for Rogowski coil
UloopCalibration = 5.5 # Calibration for U loop measurement
V_p = 0.057 #m^3 Plasma volume
k_B = constants.k # Boltzmann constant
eV = constants.e # 1 eV equivalent to J
baseURL = "http://golem.fjfi.cvut.cz/utils/data/"
VacuumShotNo = 22475
PlasmaShotNo = 22471

#The following function will download the text file of the given data in the given shot
and read it into an array and return it.
ds = np.DataSource()

def open_data(shot_no, data_id):
    f = ds.open(baseURL + str(shot_no) + '/' + str(data_id) + '.npz')
    return np.load(f)
```

Chamber resistance R_{ch} calculation from vacuum shot

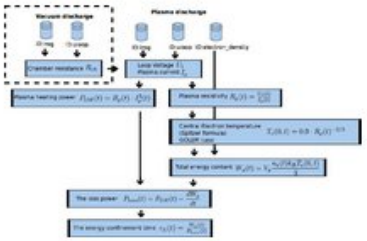
Plot raw data from NIstandard DAS

In [2]:
```
# First let's get the data from the DAS in the columns specified by the given identifie
rs.
IDuloop = open_data(VacuumShotNo,'uloop')
IDirog = open_data(VacuumShotNo,'irog')
time =  np.linspace(IDuloop['t_start'],IDuloop['t_end'], len(IDuloop['data']))

# Let's show raw data:
f,ax = plt.subplots(2,sharex=True)
f.suptitle('Vacuum shot: #'+str(VacuumShotNo)+ '- raw data from NIstandard DAS')

f.subplots_adjust(hspace=0.05)
ax[0].set_ylim(0,2)
ax[0].set_ylabel('channel #1 [V]')
ax[0].plot(time*1e3, IDuloop['data'],label='ID:uloop')
ax[1].set_ylim(-.1,0.3)
ax[1].set_ylabel('channel #3 [V]')
ax[1].plot(time*1e3, IDirog['data'],label='ID:irog')
ax[1].set_xlabel('Time [ms]')
[a.legend(loc='best') for a in ax]
plt.show()
```



Tokamak GOLEM - electron energy confinement time τ_E calculation

Strategic flowchart



Initialization

First we clear matlab workspace and define fundamental constants and parameters

```
clc; clear; close all

VacuumShotNo = 22475;          % Vacuum shot number
PlasmaShotNo=22471;            % Plasma shot number
baseURL='http://golem.fjfi.cvut.cz/utils/data/';

RogowskiCalibration=5.3e6;   % Calibration for Rogowski coil [A/V(10us)] 03/2010, CASTOR calibration (Mr. Zacek), 10 us sampling, Mr. Zacek states 5.3e6 A/Vs
UloopCalibration=5.5;        % Calibration for U_loop measurement
Mu0=4*pi*1e-7;               % [H/m] Permeability
kB=1.3806503e-23;            % [J/K] Boltzmann constant
eV=1.60217646e-19;           % [J/eV] 1 eV equivalent to J

MajorRadius=0.4;             % [m]
LimiterPosition=0.085;       % [m] max plasma radius    0.05 for ring with Mach probes
MeanPlasmaRadius=0.060;      % [m] mean plasma radius without any stabilization
PlasmaVolume=pi*LimiterPosition^2*2*pi*MajorRadius; % [m^3]
```

Chamber resistance R_{ch} calculation from vacuum shot

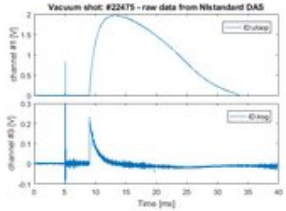
Plot raw data from NIstandard DAS (Data Acquisition System)

First let's get the data from the DAS in the columns specified by the given identifiers

```
Ul = str2num(webread([baseURL num2str(VacuumShotNo) '/uloop']));
Ir = str2num(webread([baseURL num2str(VacuumShotNo) '/irog']));
```

Let's show raw data

```
figure(1);
h1 = subplot(2,1,1);
plot(Ul(:,1)*1e3,Ul(:,2))
ylabel('channel #1 [V]'); set(gca,'XTickLabels',[]); ylim([0 2]); xlim([0 40])
legend('ID:uloop')
title(['Vacuum shot: #' num2str(VacuumShotNo) ' - raw data from NIstandard DAS'])
h2 = subplot(2,1,2);
p = get(h1, 'pos'); p(2) = p(2) - p(4)*1.1; set(h2,'pos',p) % proper position of subplot
plot(Ir(:,1)*1e3,Ir(:,2))
ylabel('channel #3 [V]'); xlabel('Time [ms]'); ylim([-.1 0.3]); xlim([0 40])
legend('ID:irog')
```



Get real physical quantities from raw data

Physical quantities can be obtained by multiplying the raw data by appropriate calibration constants. In the case of the current, the derivative is measured, so the signal has to be numerically integrated.

U_l from ID:uloop needs only multiplication

```
U_l = Ul(:,2)*UloopCalibration;
```

Chamber current I_p needs offset correction, integration and calibration

```
offset = mean(Ir(Ir(:,1)<-.004,2)); % Up to 4 ms no signal, good zero specification
I_ch = cumtrapz(Ir(:,1),Ir(:,2)-offset);
I_ch=I_ch*RogowskiCalibration;
```

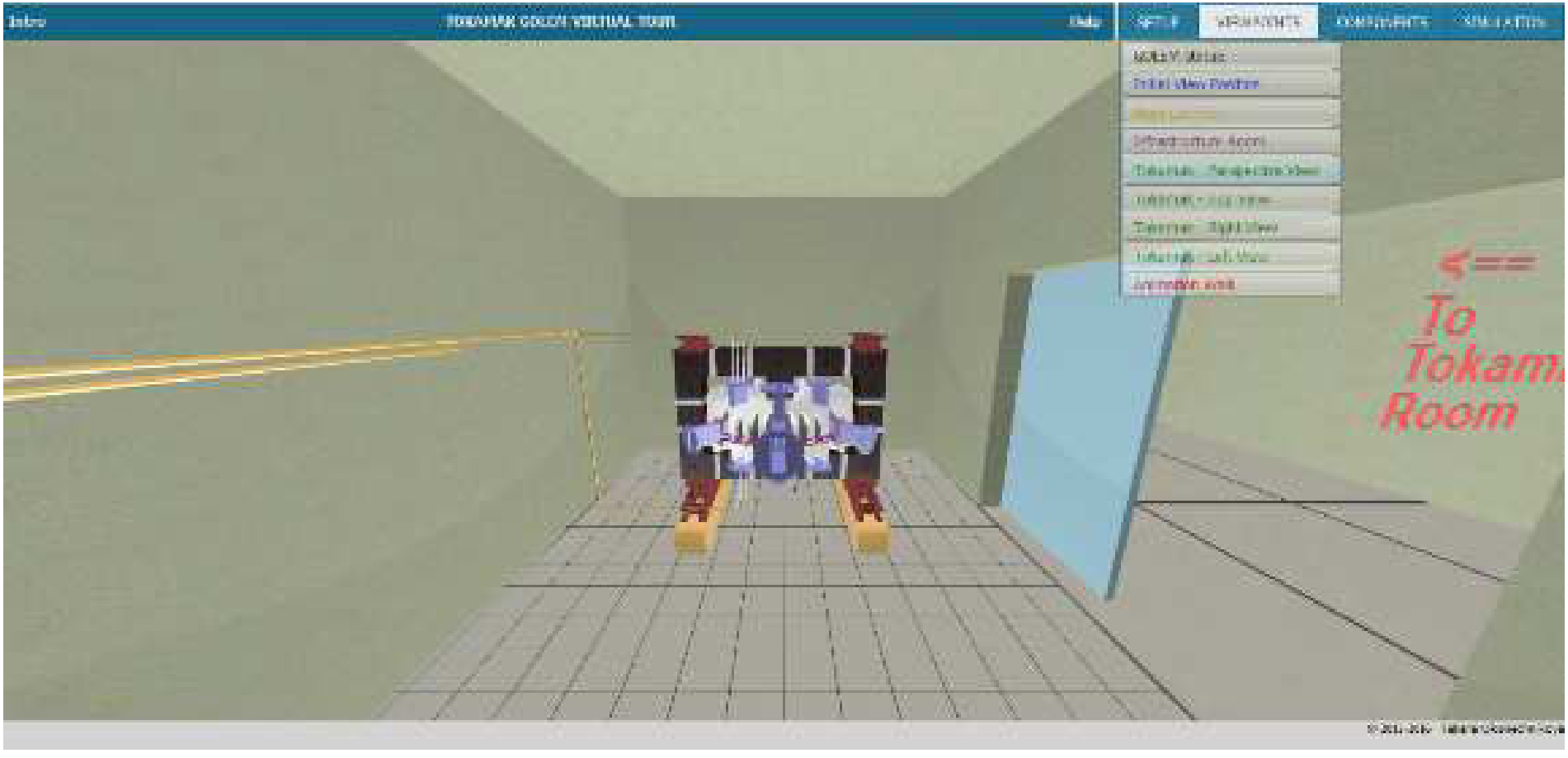
And let's plot it

```
figure(2);
h1 = subplot(2,1,1);
plot(Ul(:,1)*1e3,U_l)
ylabel('U_l [V]'); set(gca,'XTickLabels',[]); ylim([-4 12]); xlim([0 40])
legend('Loop voltage')
title(['Vacuum shot: #' num2str(VacuumShotNo) ' - real data'])
```

Bořek L - Bolometers

??

TO: Tokamak GOLEM - virtual model



Martin Hetflejš - REs

Full Screen
Full Screen
Full Screen

Katedra: KF *Akademický rok:* 2016/17

ZADÁNÍ BAKALÁŘSKÉ PRÁCE

Posluchač: Martin Hetflejš

Obor: Fyzika a technika termojaderné fúze

Zaměření: ---

Název práce: Charakterizace záření X produkovaného uniklými (nespoutanými, "runaway") elektrony na tokamaku Golem

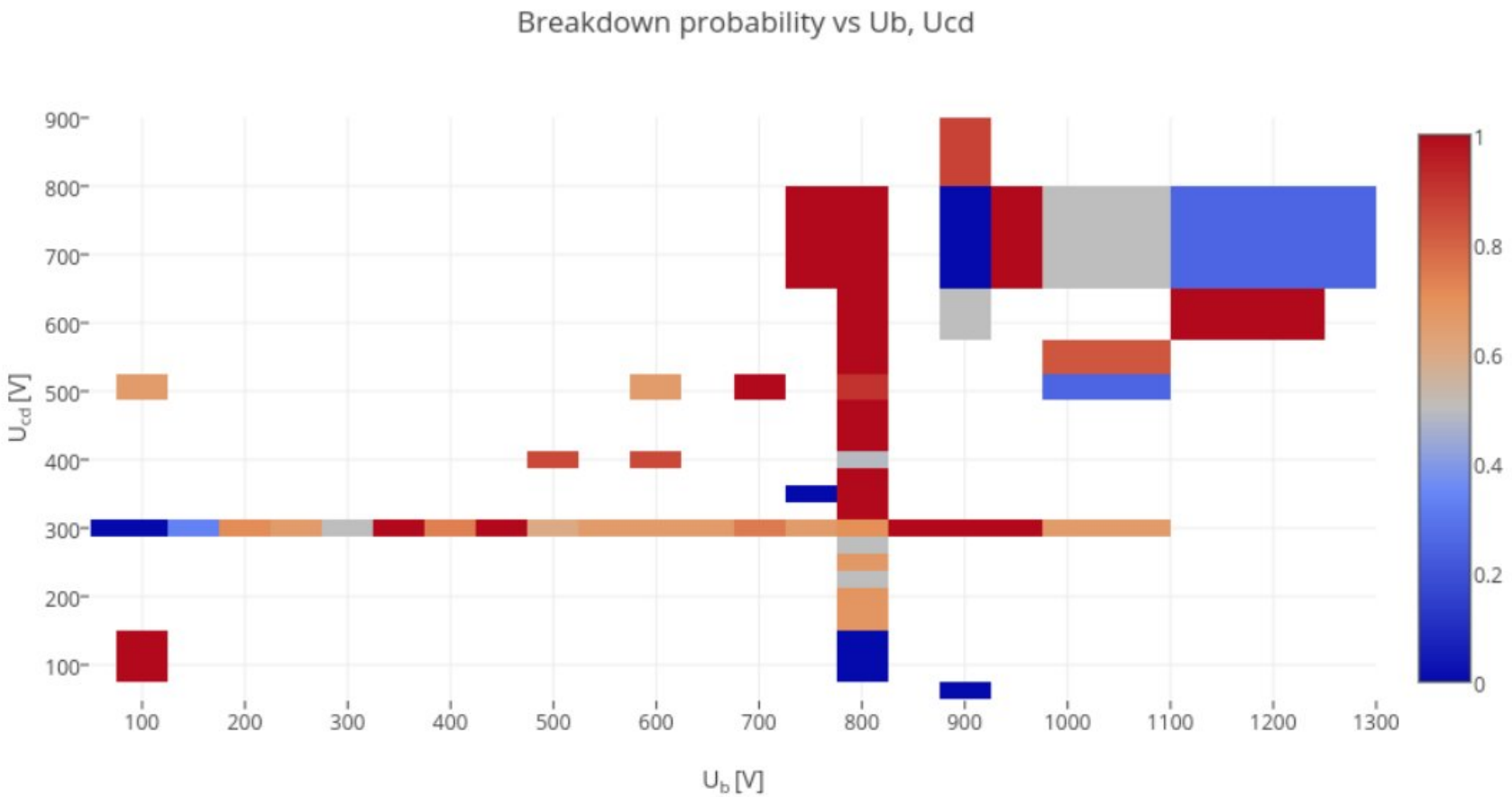
Název práce: Characterization of X-rays produced by runaway electrons on Golem tokamak

Osnova:

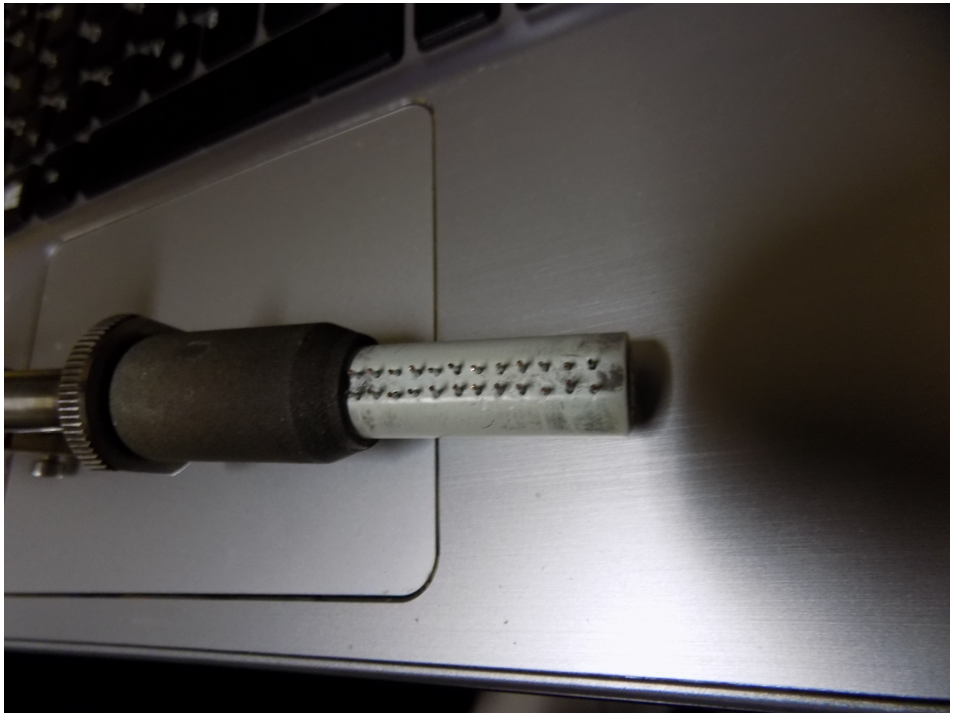
1. V úvodní části popište tokamak Golem a uveďte jeho parametry (nastavitelné i měřitelné). Definujte pojem „runaway“ elektrony. Uveďte obecně známé znalosti těchto elektronů, nebo alespoň hypotetické předpoklady o jejich vzniku a chování. Z úvodní části by mělo vyplynout, proč je třeba se zabývat měřením vlastností těchto elektronů.
2. V rešeršní části proveďte detailní rešerši odborných článků a studentských prací na téma

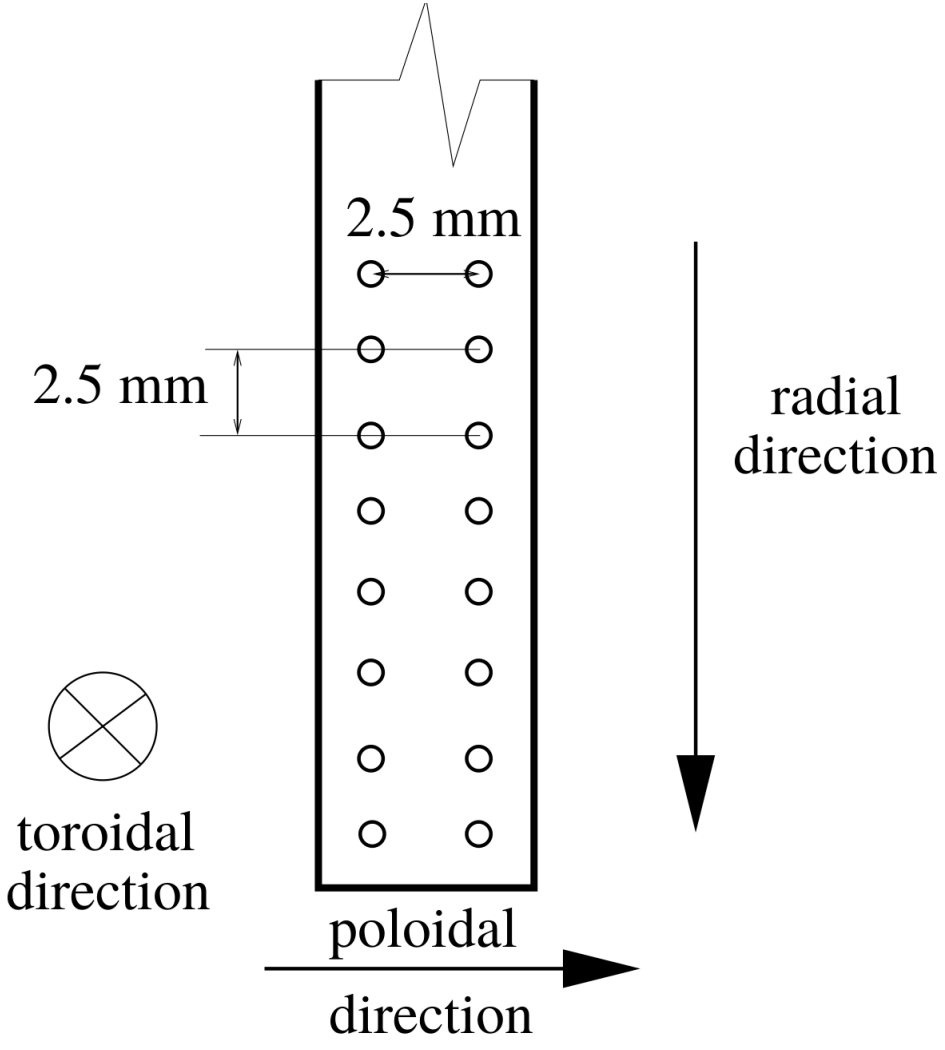
JV: Breakdown probability

Pravděpodobnost průrazu

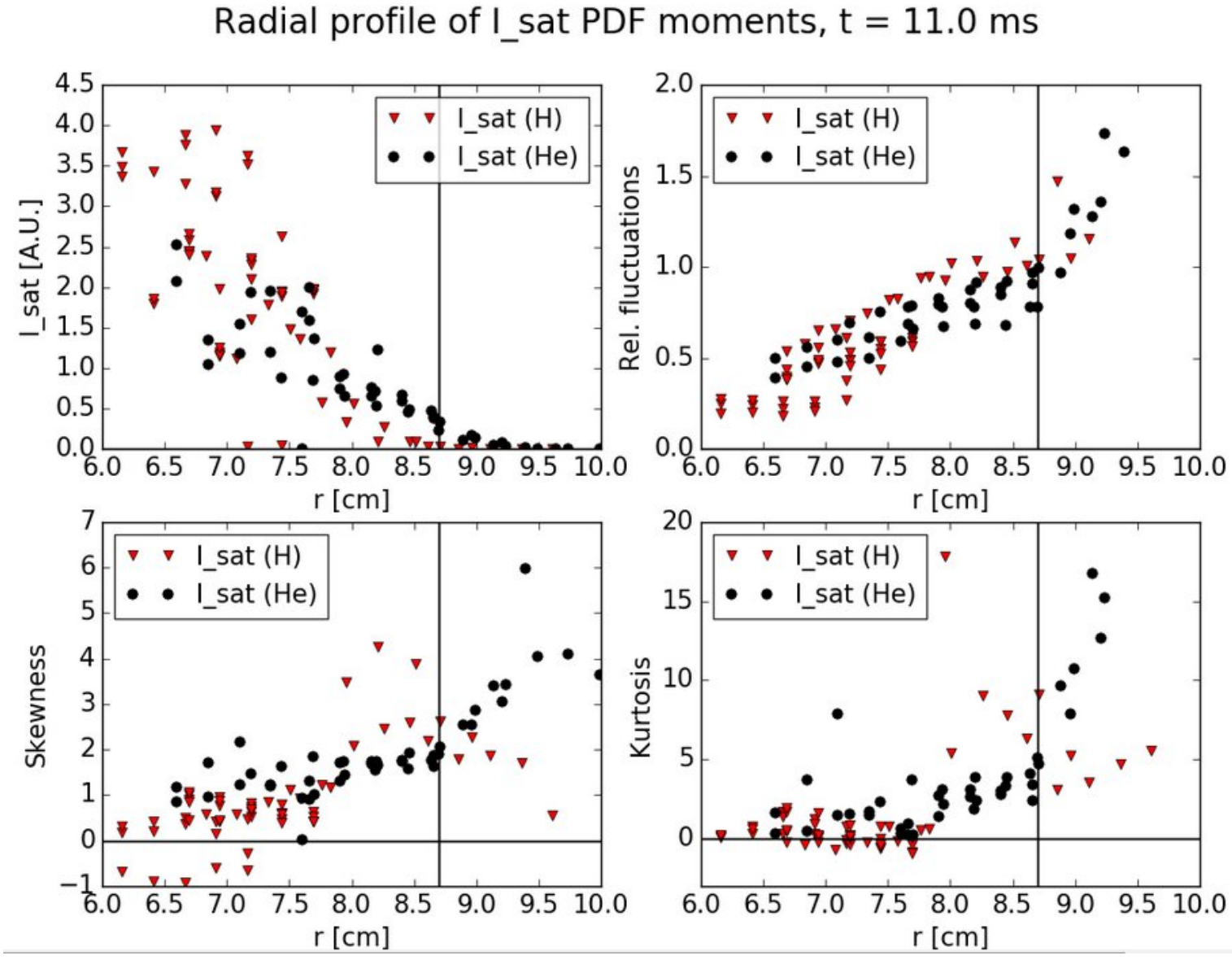


Double rake probe

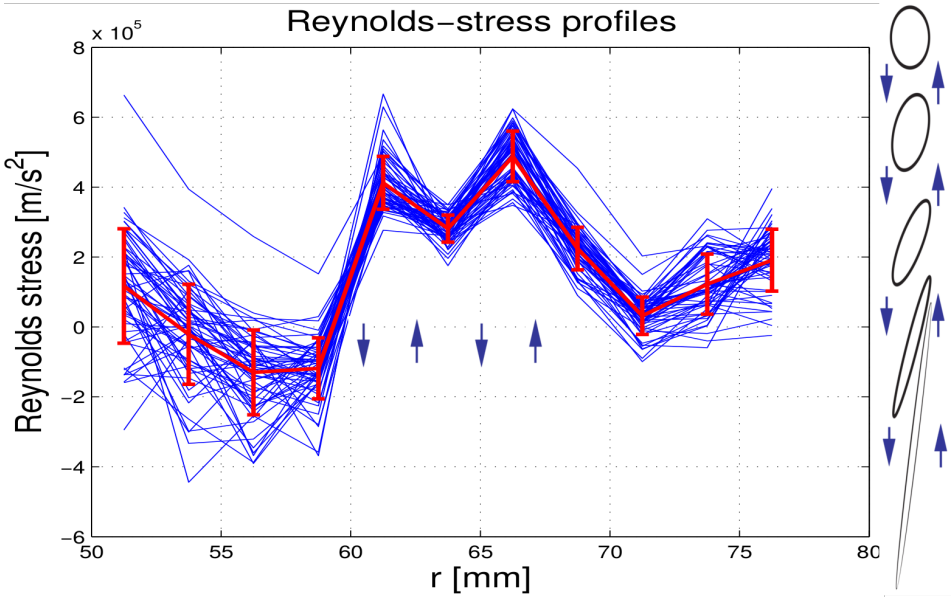


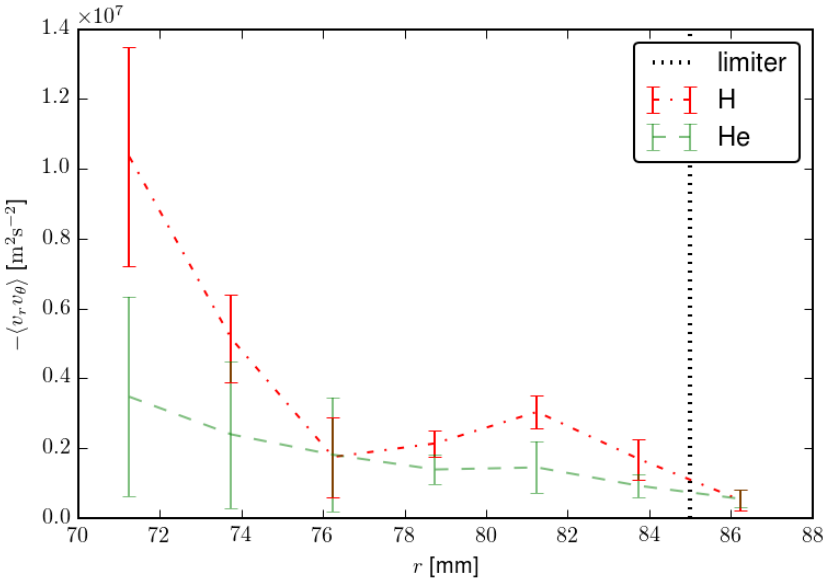


KJ: Izotopic studies on the double rake probe

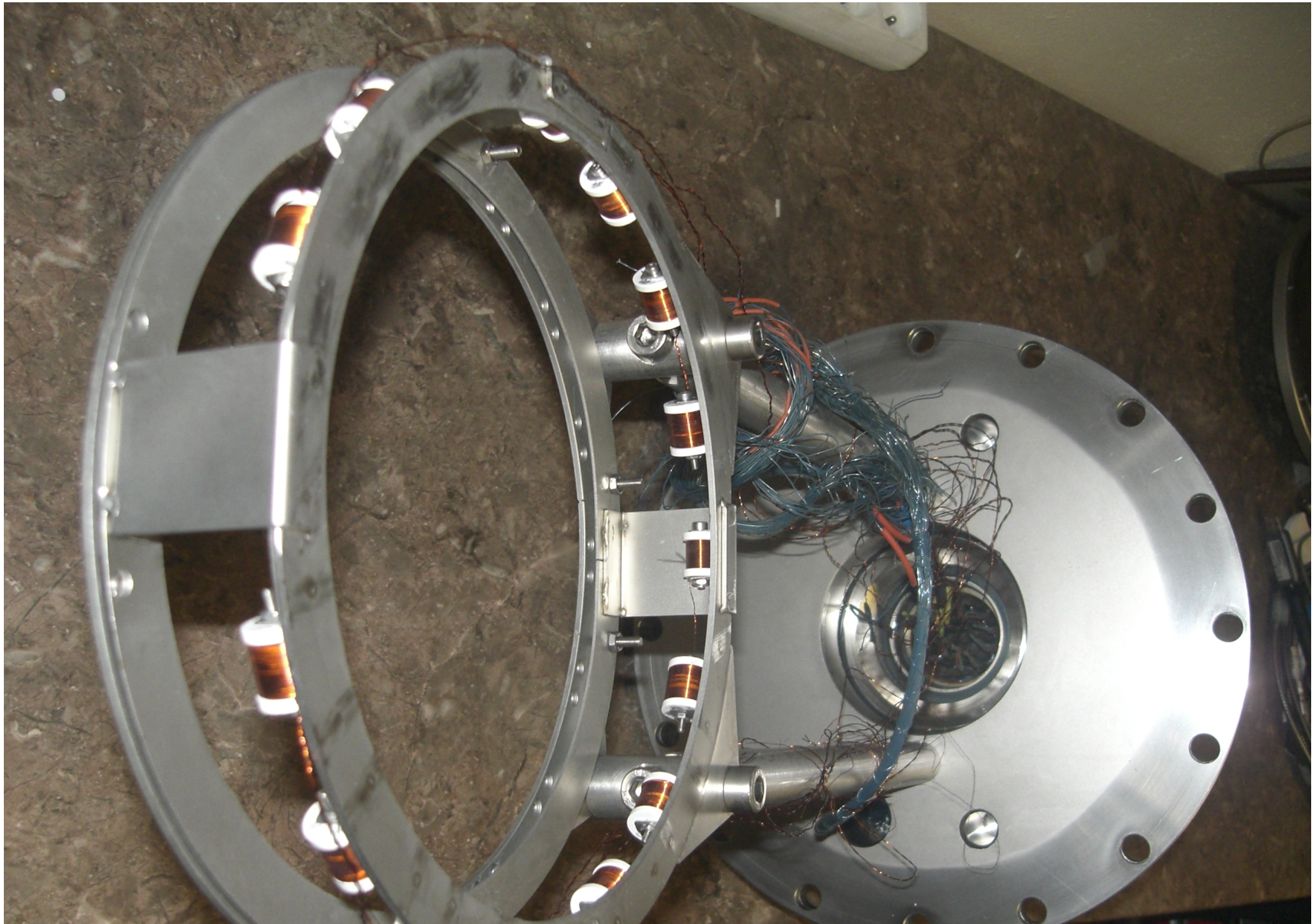


OG: Reynolds stress

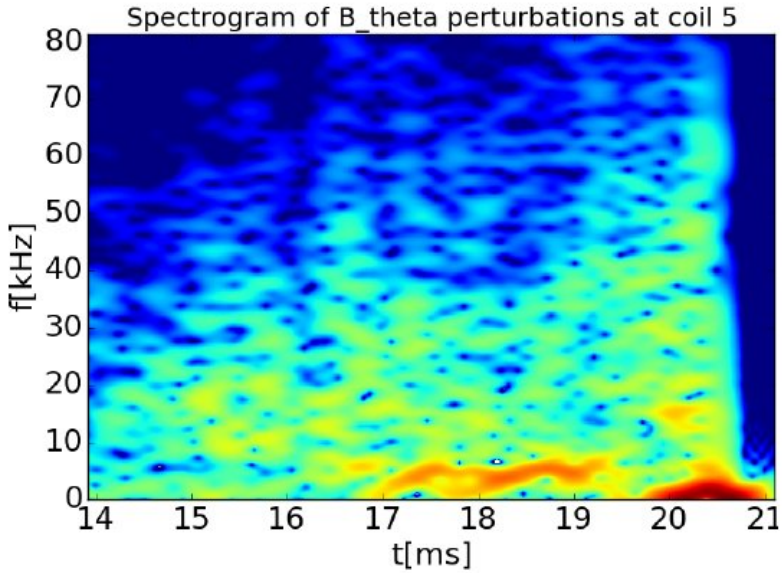


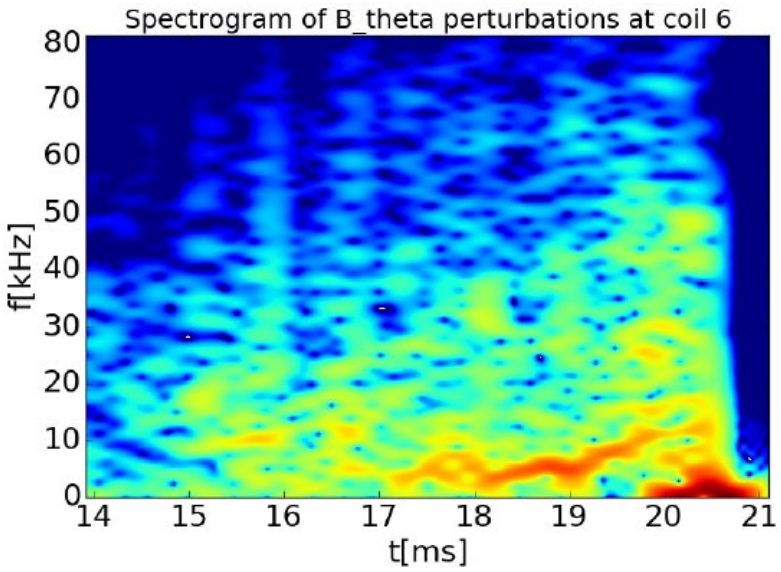


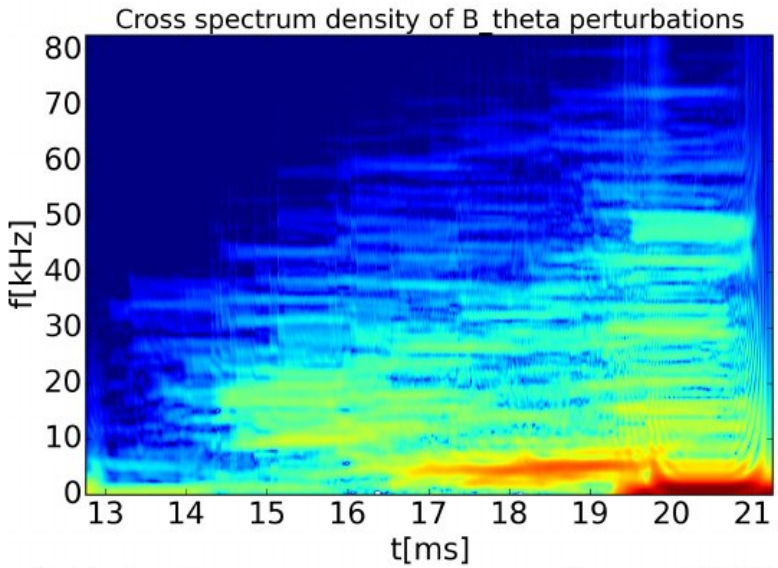
MHD ring

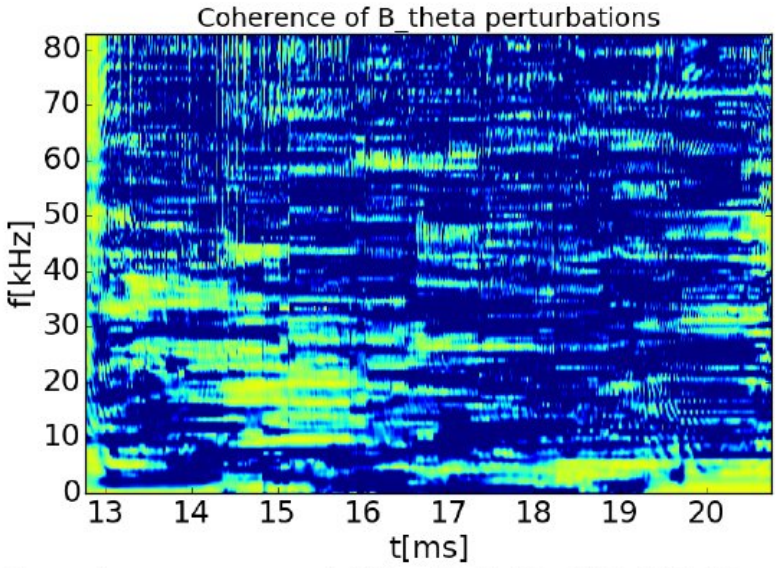


MM: MHD studies



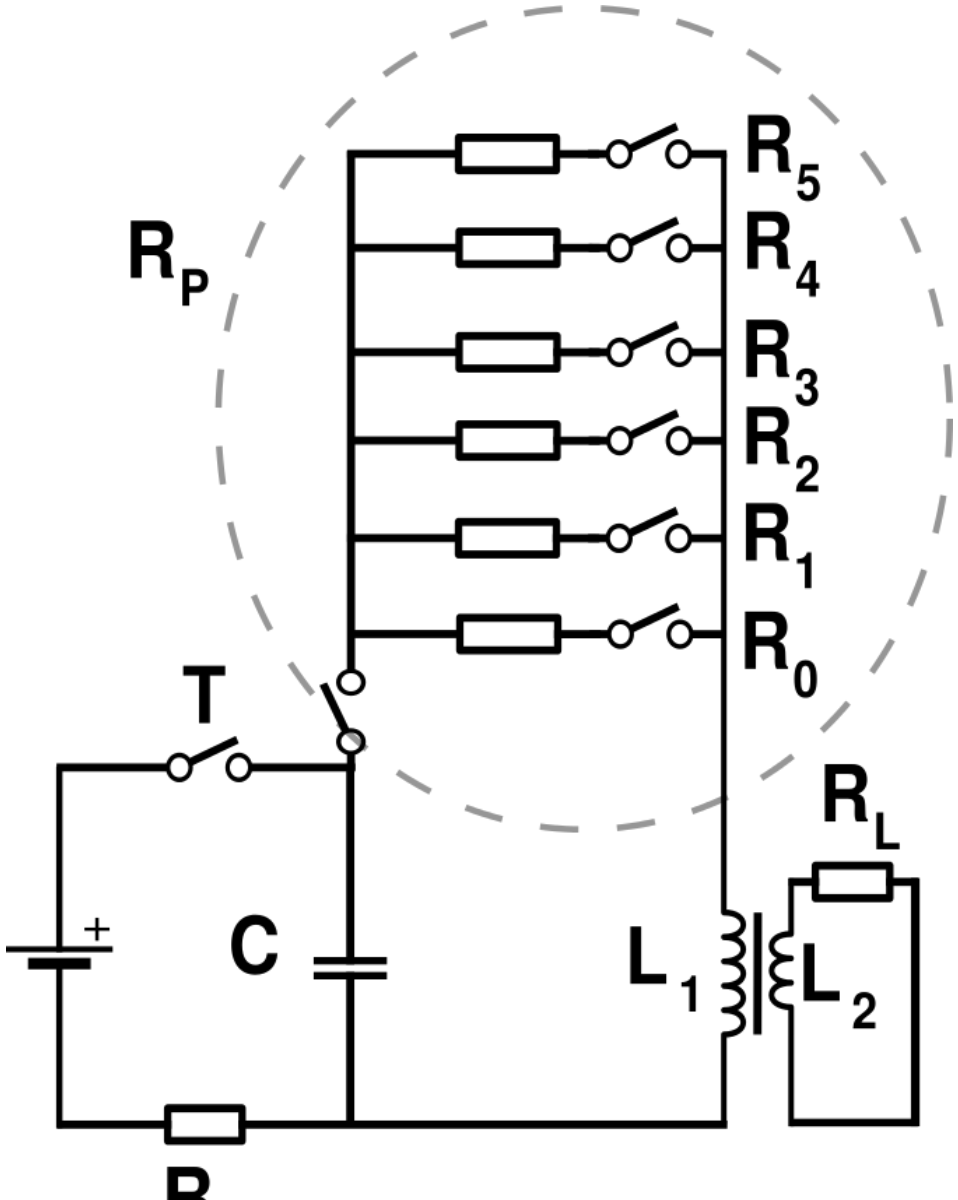


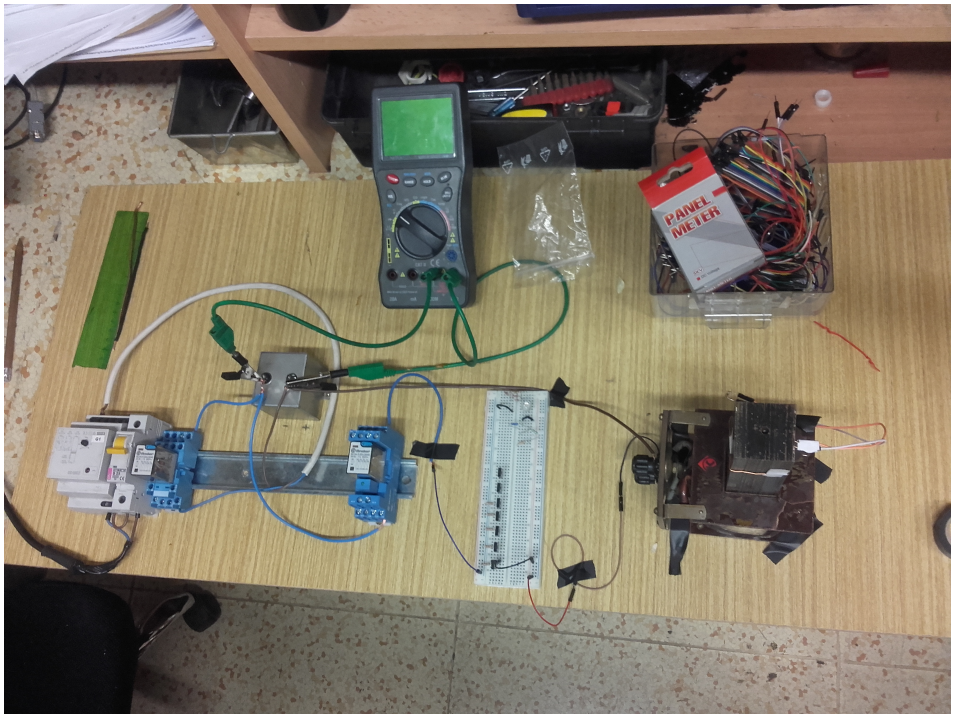




Výsledky prezentované na EPS 2016 v Leuvenu. Výstřel č.#10579.

JS & MŠ: Current drive stabilization





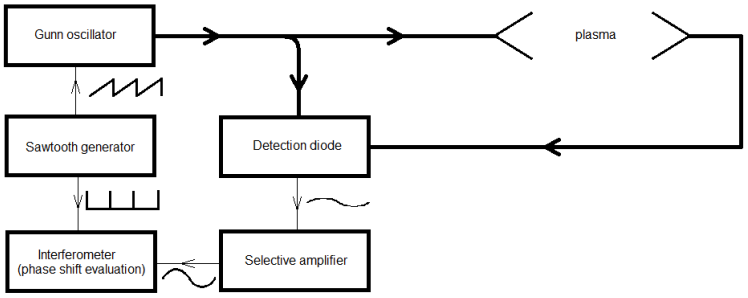
Studium ubíhajících elektronů na tokamaku GOLEM

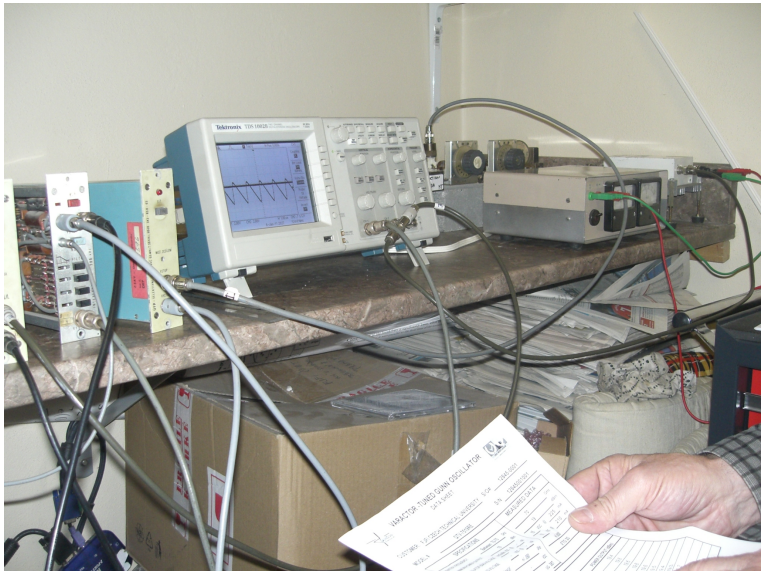
Jaroslav Čeřovský

České vysoké učení technické v Praze
Fakulta jaderná a fyzikálně inženýrská

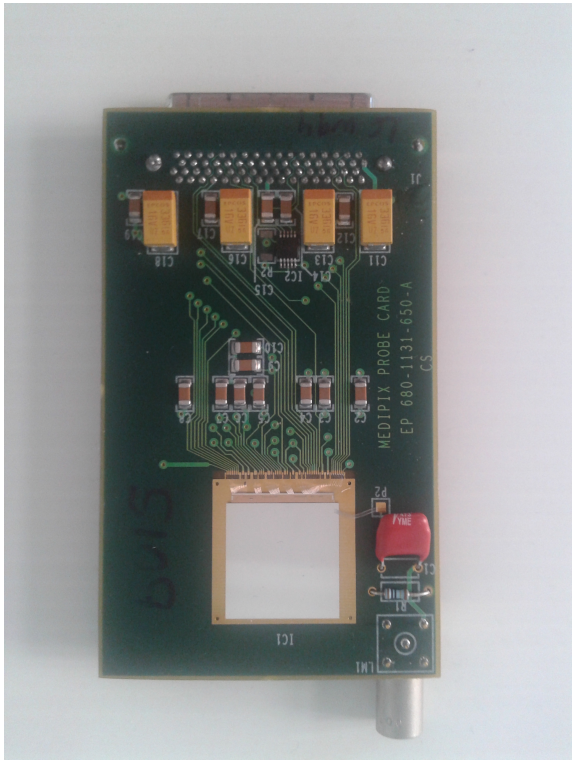
24. listopadu 2016

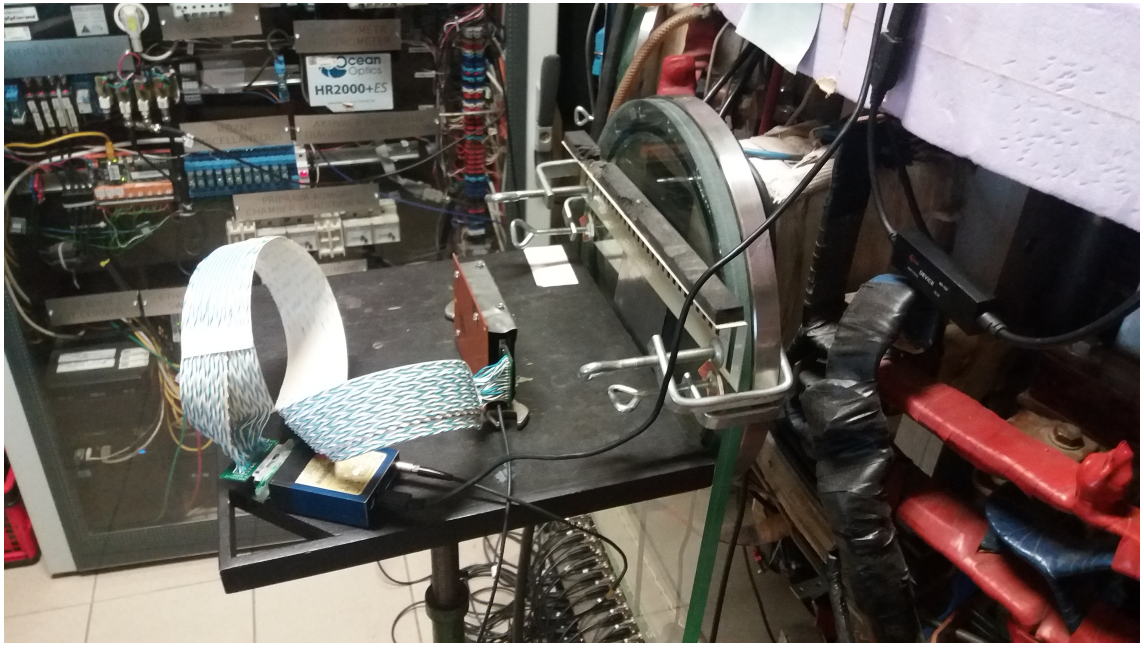
MF: Interferometry





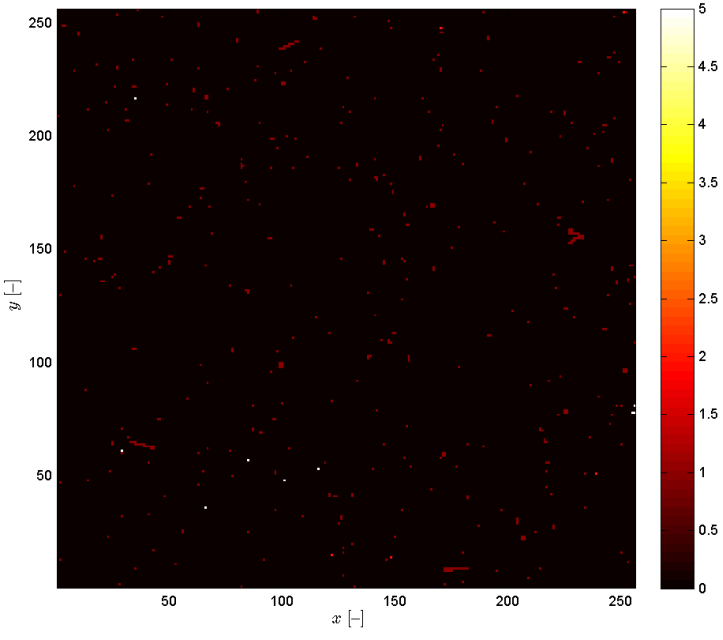
PŠ: Timepix



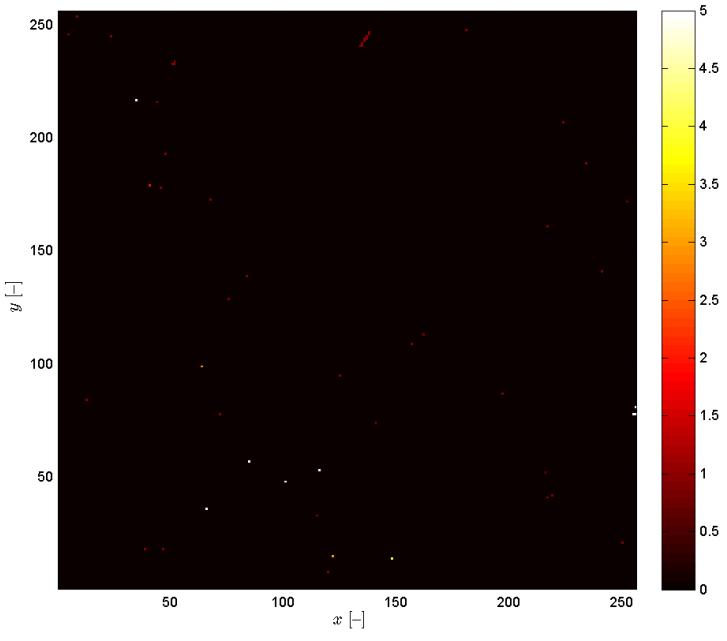


PŠ: timepix 'results'

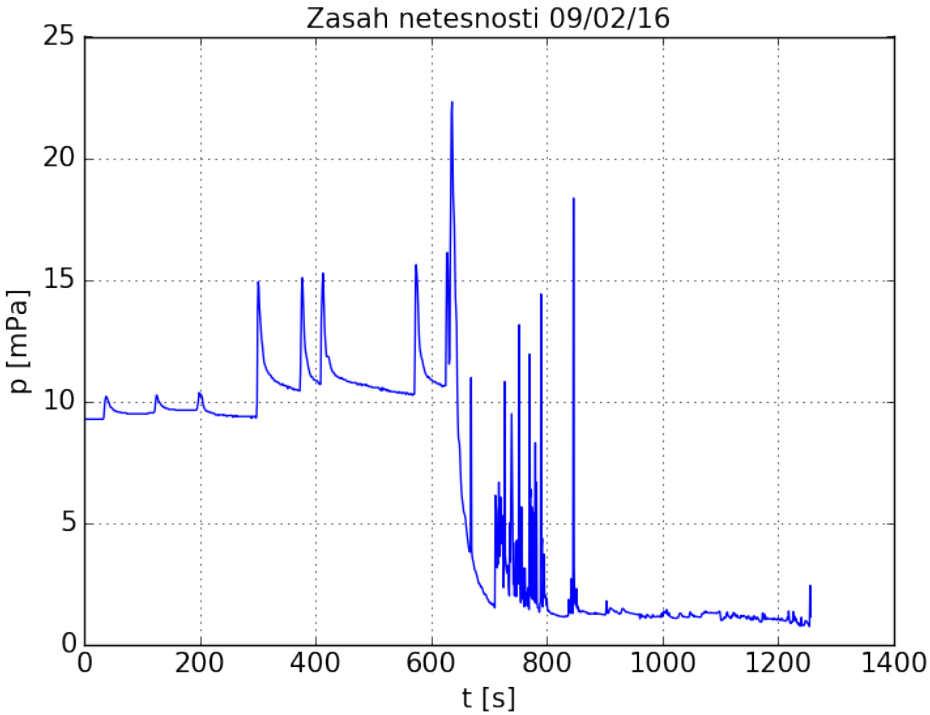
Plasma discharge

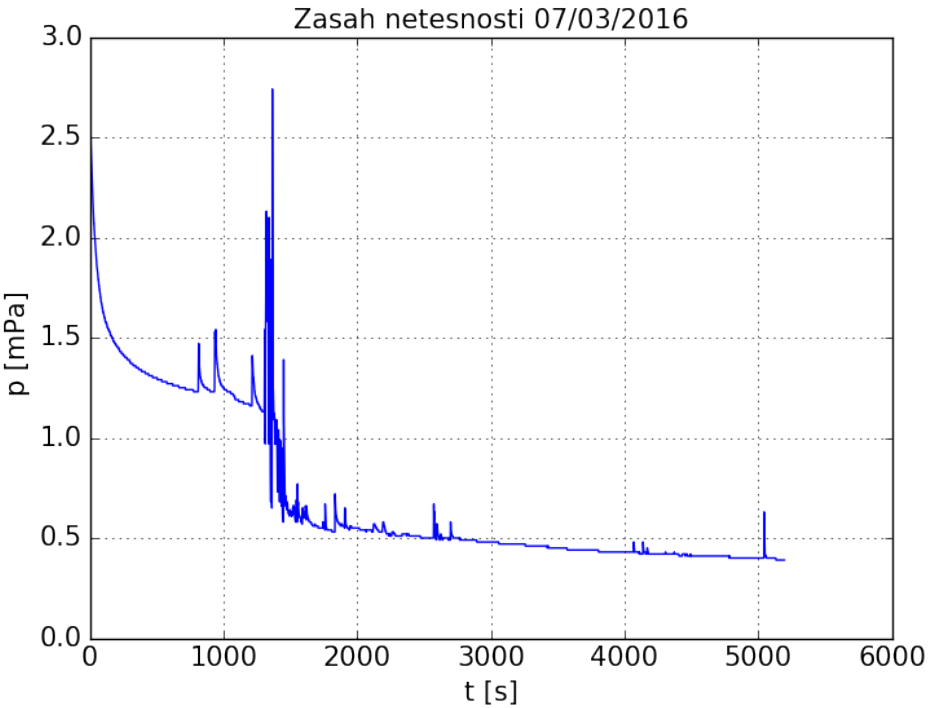


Vacuum discharge

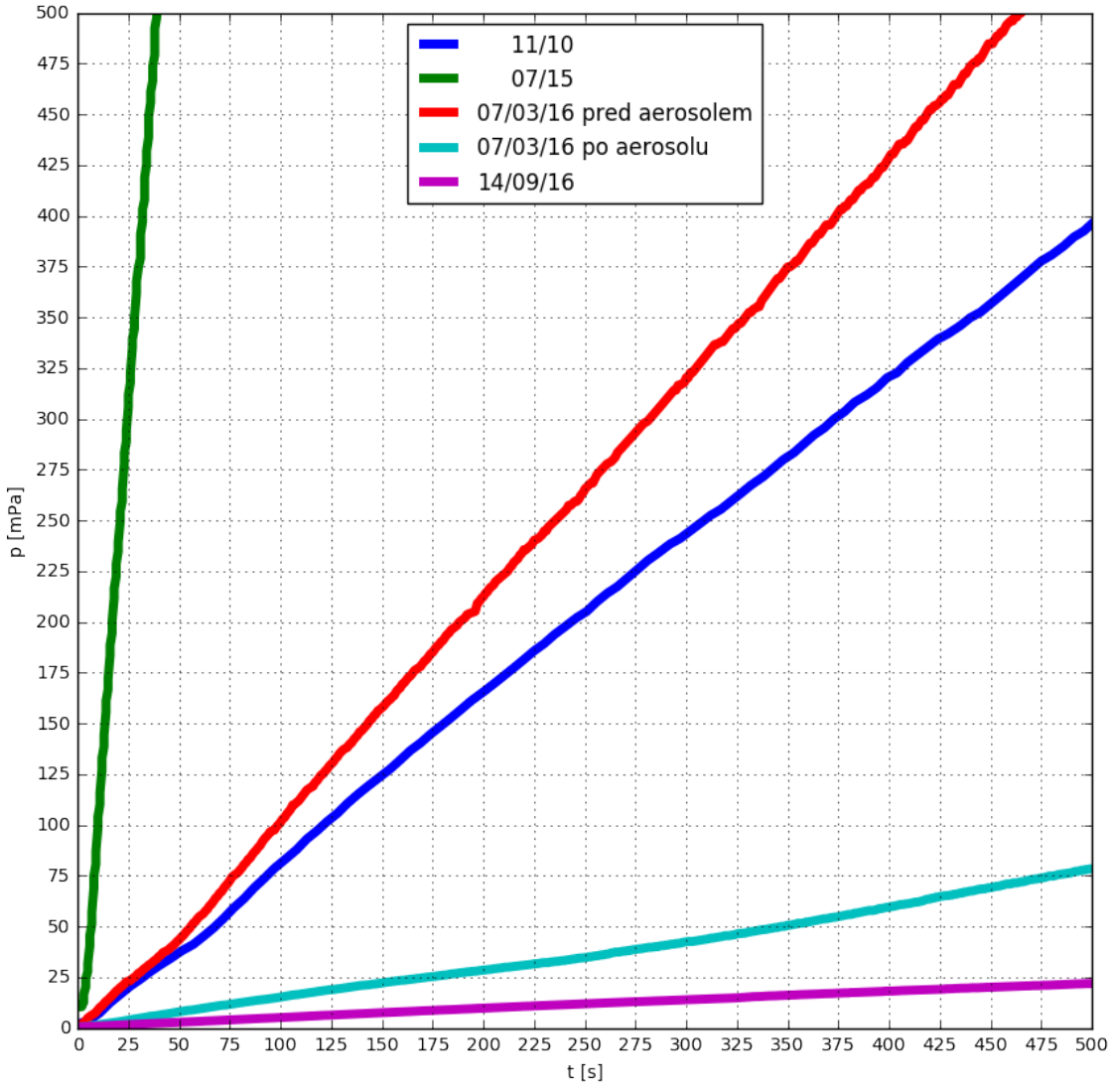


VM (& VS): Vacuum leakage hits





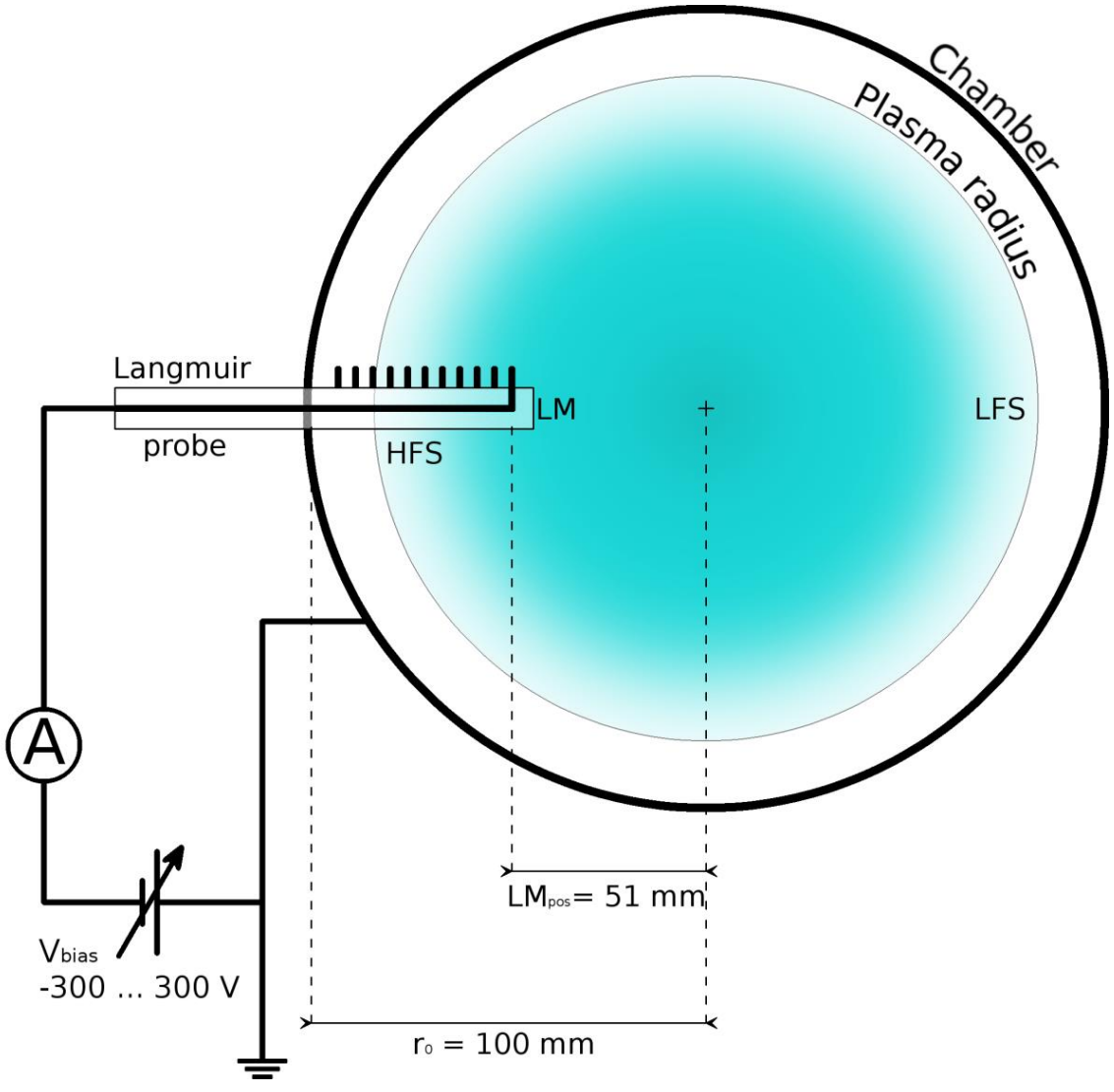
VM: Chamber condition



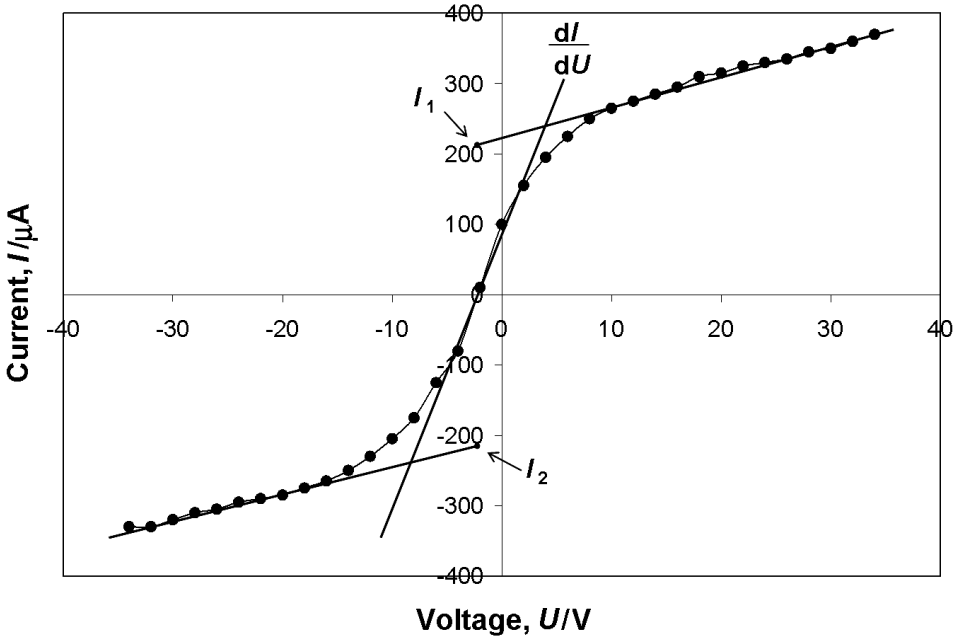
MS

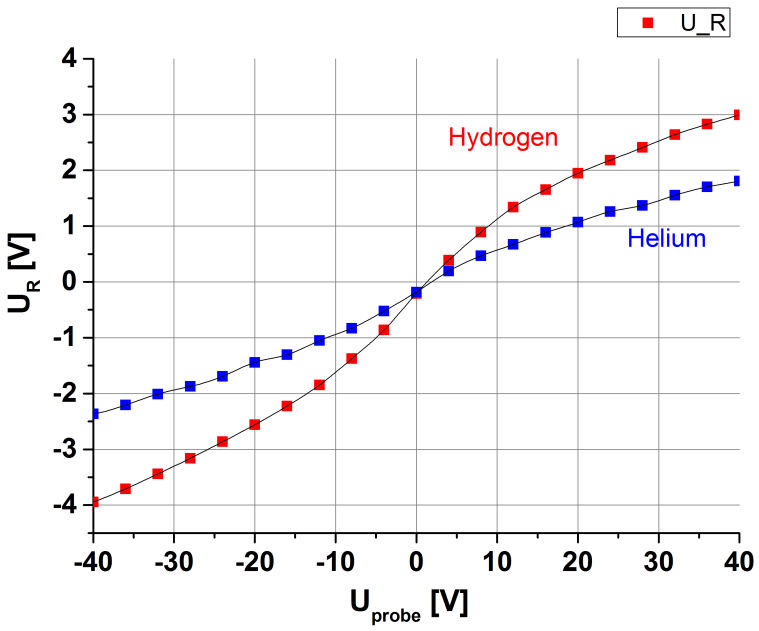
Spectroscopic studies

Glow discharge VA characteristic of the LP



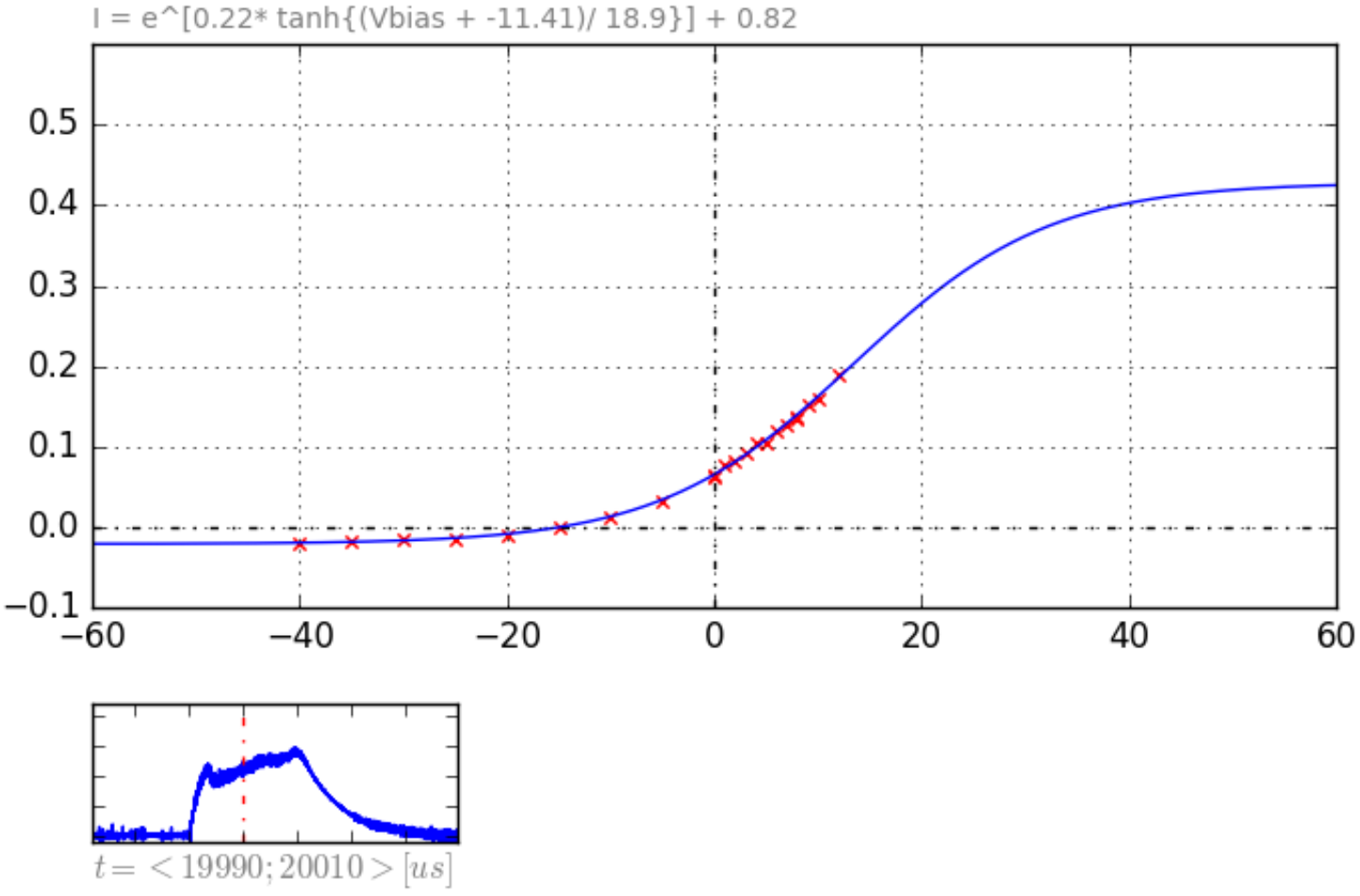
OT & MB & ŠM: Glow discharge isotopis studies





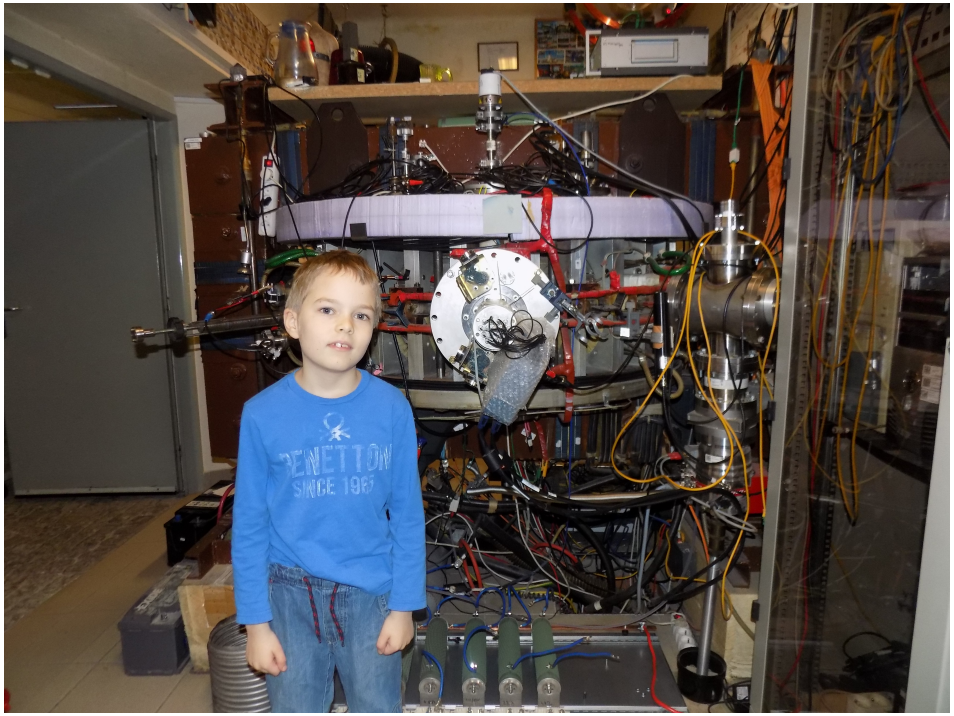
MO: VA characteristic automated analysis via python

Suché prosím ...



Outline

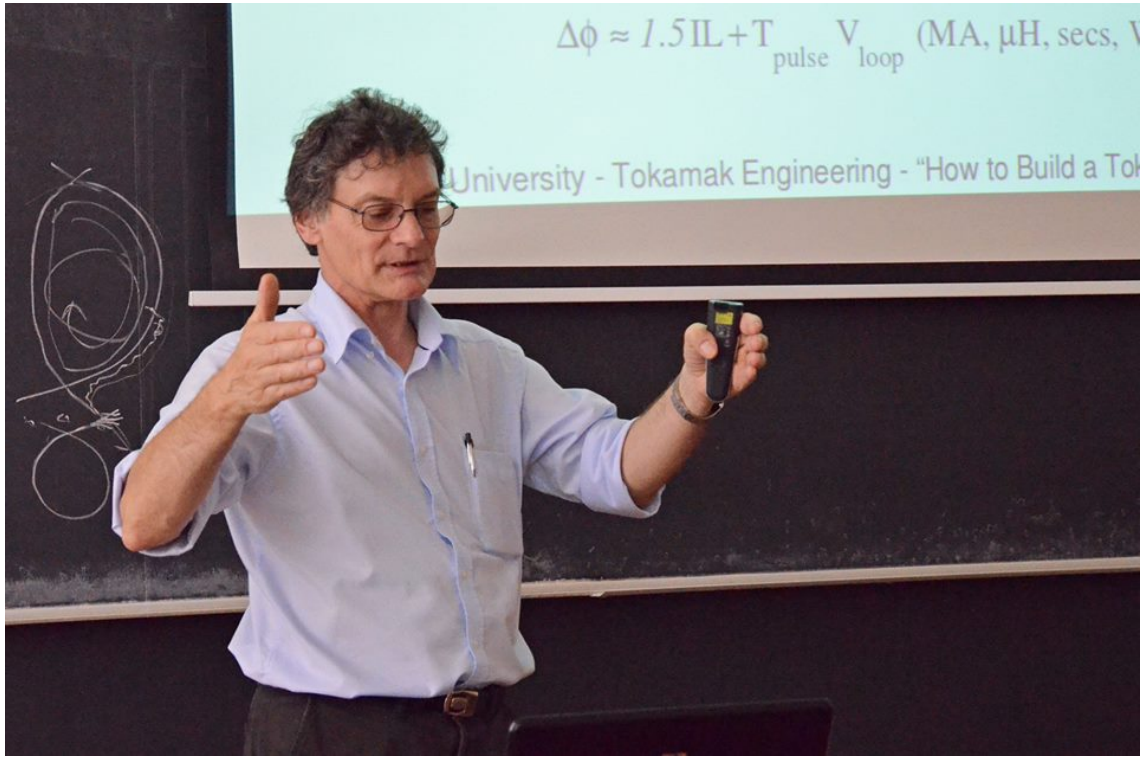
Adam 7 let, sdDH ➙pIJ ➙MSMTmKV



Adam byl úplně nadšený .. Ráno při příchodu do školy každému, včetně ředitelky, nadšeně vyprávěl o včerejší návštěvě Tokamaku. Měl se převlíkat na tělocvik, ale byl tak zaujatý svojí přednáškou, že se zasekl v pohybu, seděl v šatně ve slipech, tepláky v ruce a jen pusa mu jela a oči zářily, jak vyprávěl o energii budoucnosti :-) .... Adam se těší, že 3 roky před maturitou už bude studovat na Fakultě jaderné fyziky :-)

0217: FUSENET GA@Prague

9/16: Thomas Noel Todd lecture for FTTF students

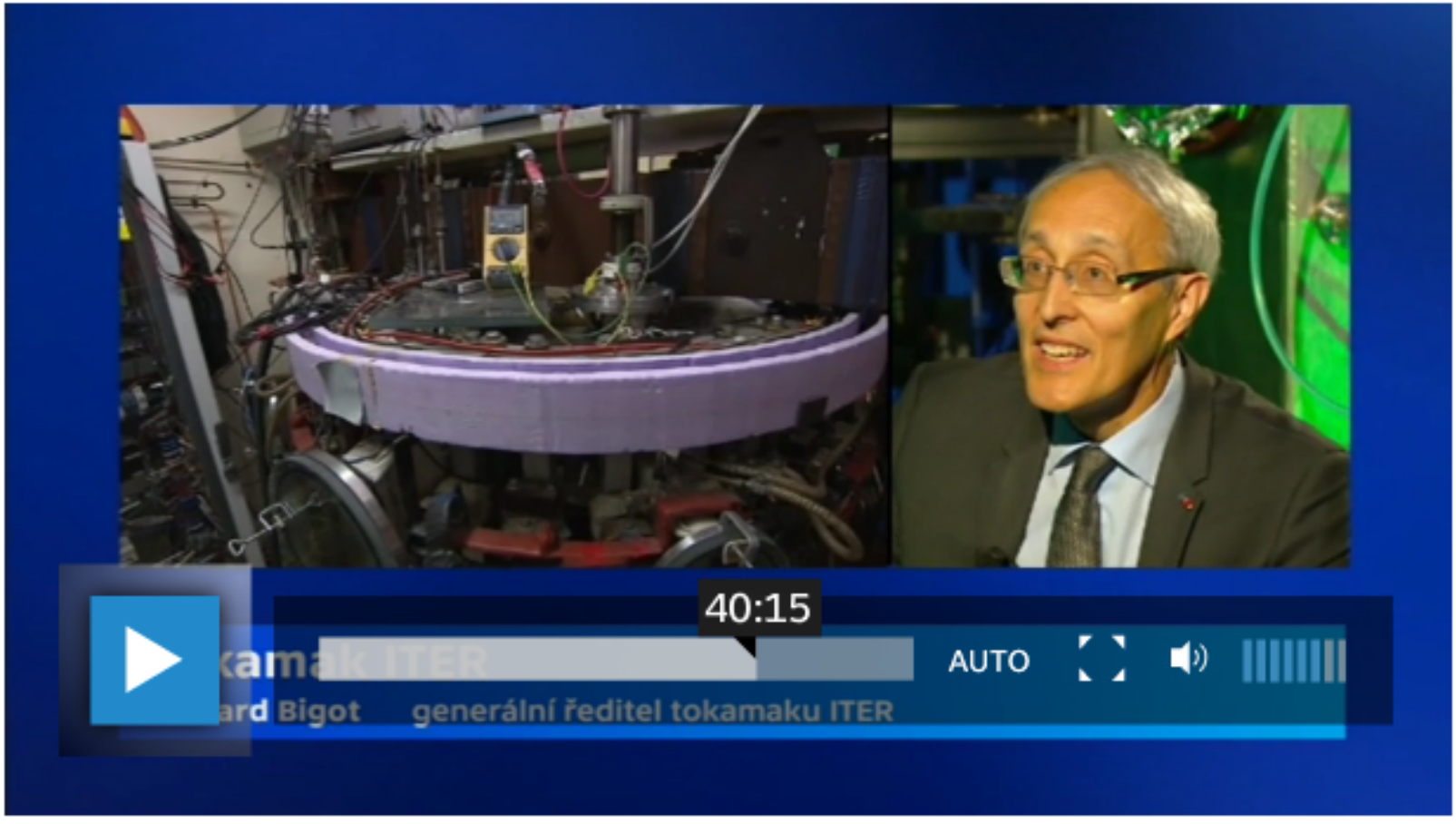


Lecture

How to build a tokamak.

To be continued ..

0916: ITER DG, Mr. Bernard Bigot (Shot #22185)



Quotation from Czech Television Hydepark

I am very pleased with the GOLEM ...

0916: Albert II, Prince of Monaco (Shot #22407)

So .. we can say :-)

GOLEM: First ever tokamak operated from the ITER site.

2016: First tokamak plasma configured at the ITER site.

Outline

2016: FUSENGDES

G Model
FUSION-8751; No. of Pages 7

ARTICLE IN PRESS

Fusion Engineering and Design xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

Remote operation of the GOLEM tokamak for Fusion Education

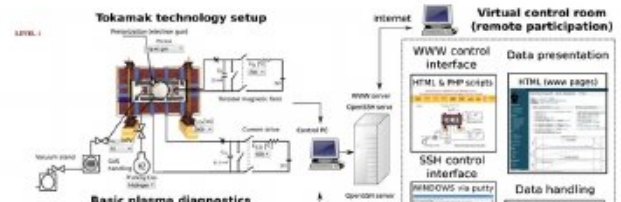
O. Grover[a], J. Kocman[a], M. Odstrcil[c], T. Odstrcil[e], M. Matusu[a], J. Stöckel[a,b], V. Svoboda[a,*], G. Vondrasek[a], J. Zara[d]

[a] Faculty of Nuclear Sciences and Physical Engineering CTU Prague, CZ-115 19, Czech Republic
[b] Institute of Plasma Physics AS CR, Prague CZ-182 21, Czech Republic
[c] University of Southampton, Southampton SO17 1BJ, UK
[d] Faculty of Electrical Engineering CTU Prague, CZ-166 27, Czech Republic
[e] Max-Planck-Institut für Plasmaphysik, D-85748 Garching, Germany

HIGHLIGHTS

- The remote operation of the tokamak GOLEM for educational purposes.

GRAPHICAL ABSTRACT



43^{rd} EPS: Tokamak GOLEM for fusion education - chpt 7

- Installation and tests of the new HXR detector based on YAG scintillator were done.
- Studies of magnetic islands were conducted with use of an array of 16 Mirnov coils.
- Unification of previous virtual reality models of the whole tokamak GOLEM was done using x3dom format.
- A double rake probe with Langmuir pins was installed to measure zonal flows.
- Radial profile of Mach number was measured by a Mach probe.
- Vacuum chamber wall conditioning experiments took place at tokamak GOLEM with the purpose of efficient specification of its ideal technological parameters.
- The influence of the toroidal magnetic and electric field polarity on the shot start-up phase of the discharge was investigated.

2016: Journal of Physics: Conference Series

6th International Workshop & Summer School on Plasma Physics 2014 (IWSSPP'14) IOP Publishing
Journal of Physics: Conference Series **768** (2016) 012002 doi:10.1088/1742-6596/768/1/012002

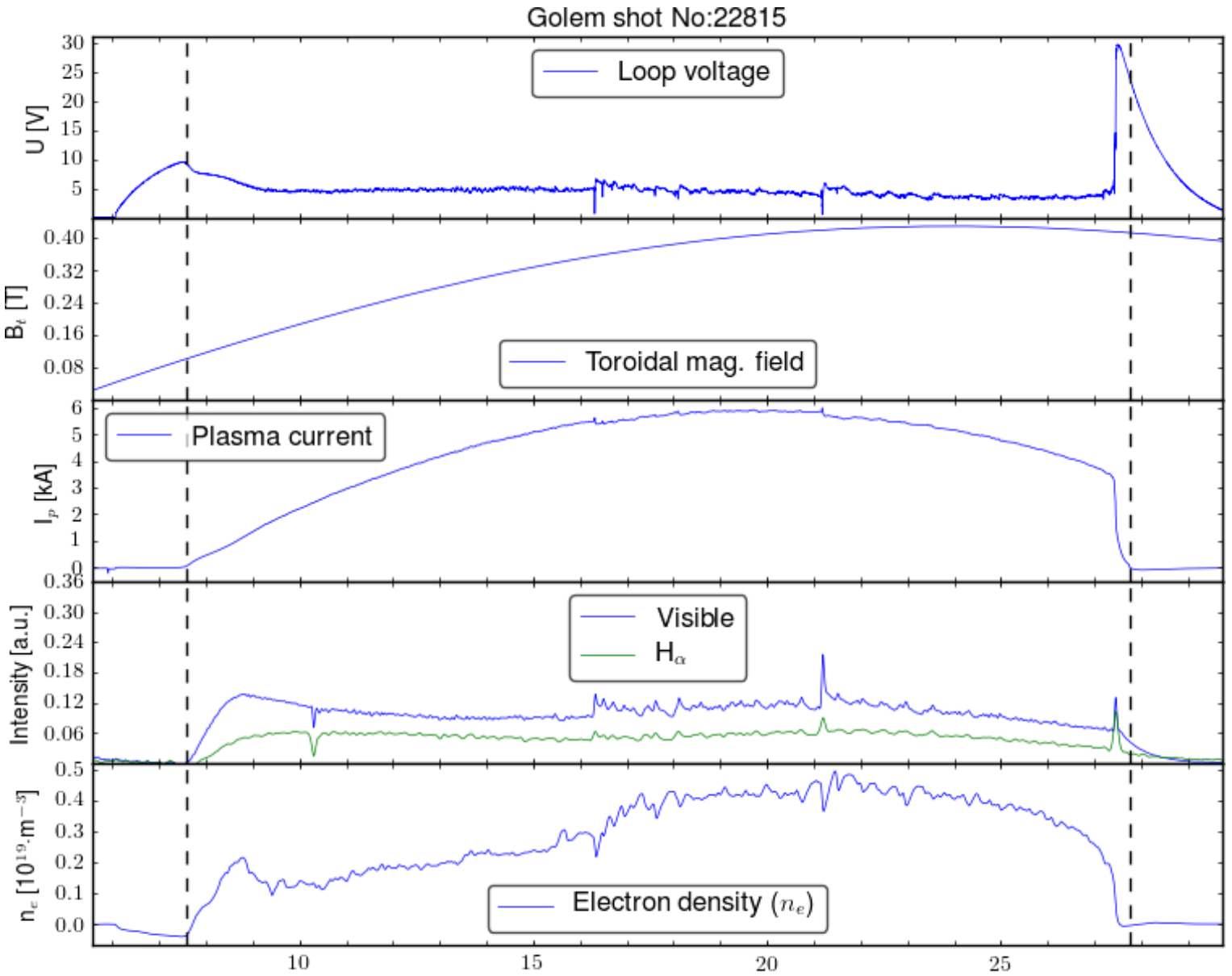
Remote operation of the GOLEM tokamak with hydrogen and helium plasmas

V Svoboda[1], A Dvornova[2], R Dejarnac[3], M Prochazka[4], S Zaprianov[5], R Akhmethanov[7], M Bogdanova[8], M Dimitrova[3,6], Zh Dimitrov[5], O Grover[1], L Hlavata[4], K Ivanov[5], K Kruglov[7], P Marinova[6], P Masherov[7], A Mogulkin[7], J Mlynar[1,3], J Stockel[1,3,4], A Volynets[8]

[1]Faculty of Nuclear Physics and Physical Engineering CTU, Prague, Czech Republic
[2]Moscow Engineering Physics Institute (MePhi), Moscow, Russian Federation
[3]Institute of Plasma Physics, AS CR, Za Slovankou 3, 182 00 Prague, Czech Republic
[4]Faculty of Chemistry, Brno University of Technology, Brno, Czech Republic

Outline

12/16: $\tau_p > 20$ ms (OF & JČ)



Fusion in Europe 4/2016

FUSION IN EUROPE

NEWS & VIEWS ON THE PROGRESS OF FUSION RESEARCH

AN UNREAL REALITY PUSHES FUSION SCIENCE

JET – THE MOST SUCCESSFUL PERFORMANCE IN YEARS

HOW TO TAME PLASMA TURBULENCE

CHANGING

Because it must face up to various challenges in terms of maintenance, designing, engineering, training, studying and entertaining, fusion has been at the forefront when it comes to exploring the features of Virtual Reality. The Culham Centre for Fusion Energy was one of the first laboratories which used the, at the time, new computer simulations for its Remote Handling Facility. According to Tom Mainelli, a future market analyst and expert for Devices & AR/VR from the International Data Corporation, it won't be long before other areas will jump onto the bandwagon into another reality: "VR will fundamentally change the way many of us work."

ENTERTAINING

"We should definitely make good use of high tech to present a high tech research like fusion", says Tamás Szabolics from the Wigner Research Center for Physics. Two years before the mobile game 'Pokemon go' was launched, the software engineer from EUROfusion's Hungarian Research Unit created a fusion app. Visitors at Wigner's booth at the 23rd Sziget Festival were able to scan a book with their mobile phones and have additional videos and information displayed on their devices. "People were amazed by the flashing plasmas and impressive tokamak interiors", he continues. The engineer enjoyed coding the programme. "Now that I have the experience, I will be able to enhance the app by adding 3D models", he says. Unfortunately, the VR fusion app is not yet available.

COOPERATING

The potential applications afforded by VR as a future standard tool in complex science and industry are increasing. Various scientific fields are collaborating in the search for feasible solutions, such as the European Spallation Source, a large scientific project based in Lund (Sweden). Their engineers are currently working with RACE experts to develop VR simulations for operations in the Active Cells Facility.

PLAYING

Want to give it a go? Try out EUROfusion's "Operation Tokamak" game. It lets you operate fusion plasma using strong magnetic fields. But be careful, the fusion fuel can become too hot and destroy the machine. The game is available for Android and IOS and can be downloaded here:

www.euro-fusion.org/operation-tokamak/

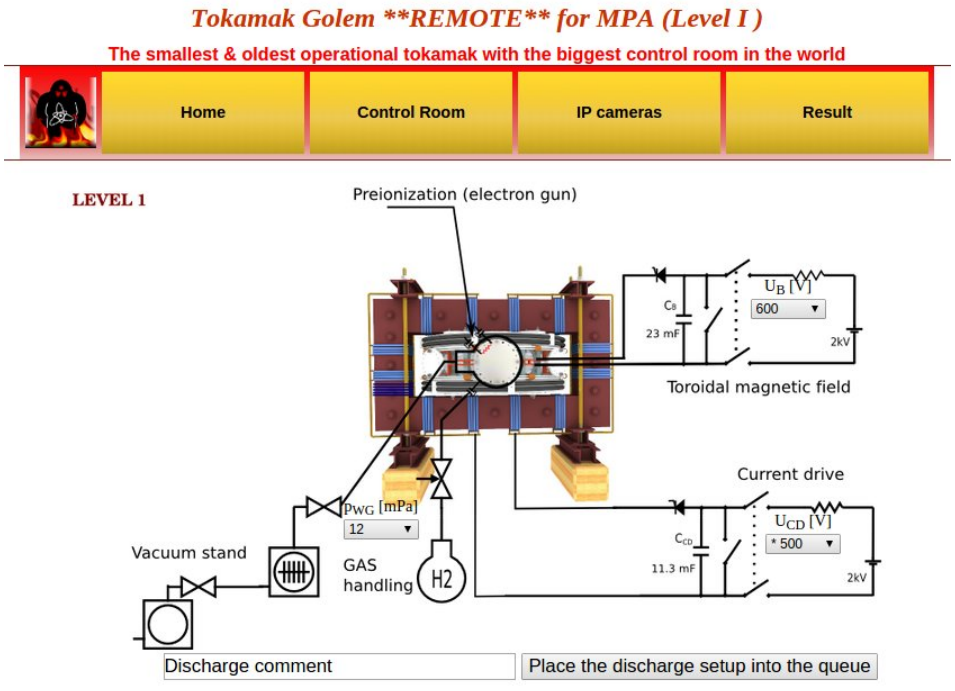
STUDYING

You don't need to be a colleague in England or France to virtually enter a tokamak. The Faculty of Nuclear Sciences and Physical Engineering at the Czech Technical University in Prague allows everyone to remotely operate the faculty's small tokamak Golem. Students from over 20 countries have already conducted breakdown studies, generated runaway electrons or undertook magnetohydrodynamic activity observations.

Controlling the hot fuel: players of EUROfusion's Operation. Picture: EUROfusion

Outline

GOLEM discharges for broad public .. @ ITER



- Live.
- As simple as possible.
- 3 parameters B_t, E_t, p_H.
- Cooperation with the ITER PR.
- ?? Every first Wednesday in the month
- ?? 24 hours of operation
- Web based application. First sketch ready.

Tokamak GOLEM control system

.. to be completed

Forecast 2017

- The Night of Scientists III.
- FUMTRAIC IV, SCIWTRAIC@GOLEM VI, HUNTRAIC V, SUMTRAIC@GOLEM VIII, EMTRAIC@GOLEM III.
- GOMTRAIC ?? (3 days)
- Bachelor thesis ?
- Diploma thesis IV cont.
- papers in FUSENGDES, AJP .. ?
- TRAICS: Eindhoven, Bangkog.

Expectations 2017

- FUSENET (mail Mark 0116)
- Application for Joint degree program submitted.
- Application for PlasmaLab@CTU program submitted.
- Better Control room conditions

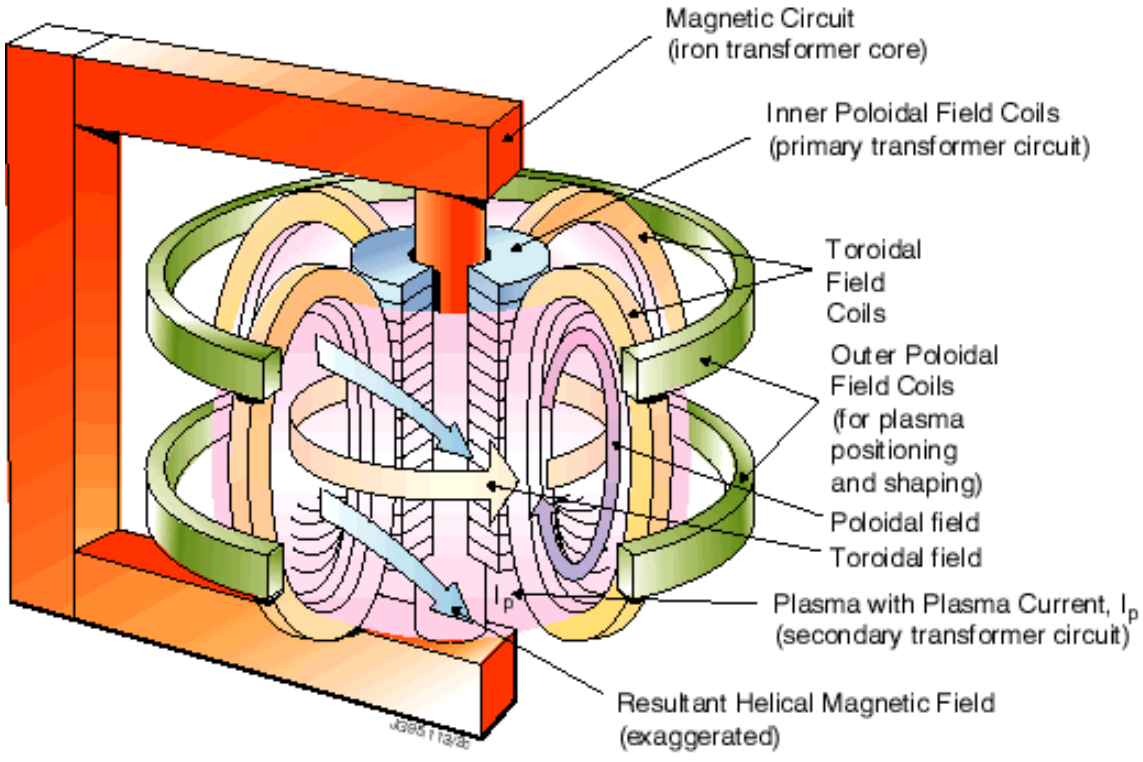
44^{th} EPS @ Belfast, Severní Irsko (23.-26.6)

KDO CHCE JET? Za penize z SGS

Nabídka pro nejproduktivnějšího.

Fee: Abstrakt (02), Poster (06), Sborník (06)

Russian word: Tokamak - magnetické kačenky



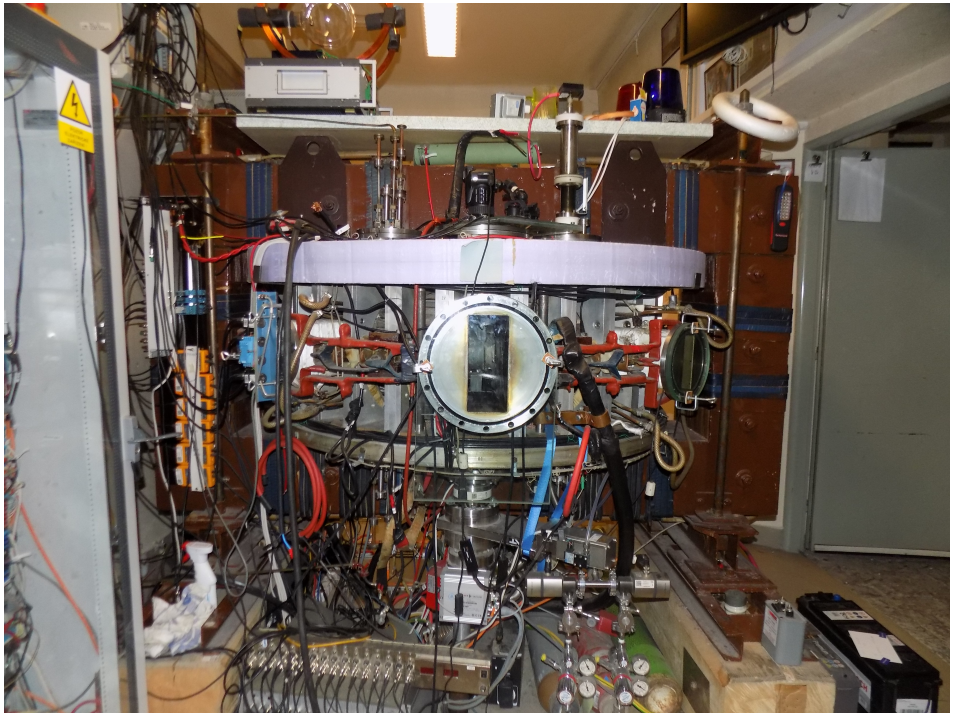
Toroidalnaja kamera s magnitnymi katuskami (měkce)

Toroidalnaja kamera s magnitnymi katuskami (tvrdě)

0916: Noc vědců - řeholnice mezi návštěvníky

- Na počátku světa tu byl jen vodík.
- Hvězdy jsou velké plynové koule hýřící energií Pánu Bohu do oken.
- Naše těla jsou takový hvězdný popel.

Violin 4 tokamak (GOLEM)



12/16: Trojan horse - shift

golem.fjfi.cvut.cz/shots/22816//

GoogleCal Top 100 Osobni KnowHow Evergreen GOLEM Fyzika Rano Aktualne Duše Sinew bla Jango

GOLEM » Shot #22816 »

Tokamak GOLEM - Shot Database - 22816

Date: 2016-12-02 - **13:39:42**
Session: SessionPreparation/2016
Comment: `JarCer - B scan for HXR U_B=1100, U_cd=500`

Congratulation, you have reached nuclear fusion.
The following explosion destroyed half of Prague and radioactive fallout contaminated whole Europe.
Have a nice day

Basic parameters: (compare)

- Gas pressure p_{ch}: `0.16`->`27.98` mPa (request: 28 mPa) WIKI
- Working gas: `H`
- Preionization: Upper el. gun
- Chamber temperature: 23.60 C
- C_{B_t} capacitors charged to: `1100 V`, triggered `5.0 ms` WIKI
- C_{BD} capacitors charged to: `0 V`, triggered `5.0 ms` WIKI
- C_{CD} capacitors charged to: `500 V`, triggered `6.0 ms` WIKI
- C_{ST} capacitors charged to: `0 V`, triggered `5.0 ms` WIKI
- Level of noise (dBt) in room: 0.005 V

Plasma parameters:

- Plasma life time **20.0** [ms] (from 7.3 to 27.3)
- Mean toroidal magnetic field Bt: 0.33 T WIKI
- Mean plasma current: 5.63 kA WIKI
- Mean Uloop: 5.26 V WIKI
- Break down voltage: 9.9 V WIKI
- Ohmic heating power: 29.65 kW
- Q edge: 2.7 WIKI
- Electron temperature: `59.9` eV WIKI
- Line electron density: `5.50` [10^17.m^-2] WIKI

Diagnostics
- ✓ Interferometer
- ✓ Spectrometer
- ✓ FastCamera
- ✓ HXR

Analysis
- ✓ ShotHomepage
- ✓ AdvancedAnalysis
- ✓ Impurities_TO

DAS
- ✓ TektronixDPO
- ✓ NIstandard
- ✓ Papouch_St
- ✓ NIoctopus

Vacuum log

Other
- Data
- References
- About
- Wiki
- Utilities

Navigation
- Next
- Previous
- Current

Go to shot
22816 Go

Acknowledgement

Financial:

FUSENET, MSM 6840770039, MSM 6840770014 and A1581, SGS SGS11/131/OHK4/2T/14.

Students, teachers, technicians (random order):

Vladimír Fuchs, Ondřej Grover, Jindřich Kocman, Tomáš Markovič, Michal Odstrčil, Tomáš Odstrčil, Gergo Pokol, Gabriel Vondrášek, František Žácek, Lukáš Matěna, Honza Stockel, Jan Mlynář, DG ITER BB, Sabina Grifith, Jára Krbec, Tatiana Okonechnikova, Radan Salomonovič, Tomáš Peltán, Vladimír Linhart, Martin Matušů, Katka Jiráková, Dáša Hodková, Jiří Žára, Ondra Ficker,