Title

Introduction to the tokamak GOLEM operation
Practical guide

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on behalf of the tokamak GOLEM team
for the Torino Politecnico, Italy

December 4, 2022

Production

- Everything via `http://golem.fjfi.cvut.cz/Torino`
  - This presentation
  - Control rooms
  - Contact: Vojtech Svoboda, +420 737673903, svoboda@fjfi.cvut.cz
  - Videoconference https://meet.jit.si/golem

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- Data handling @ the Tokamak GOLEM

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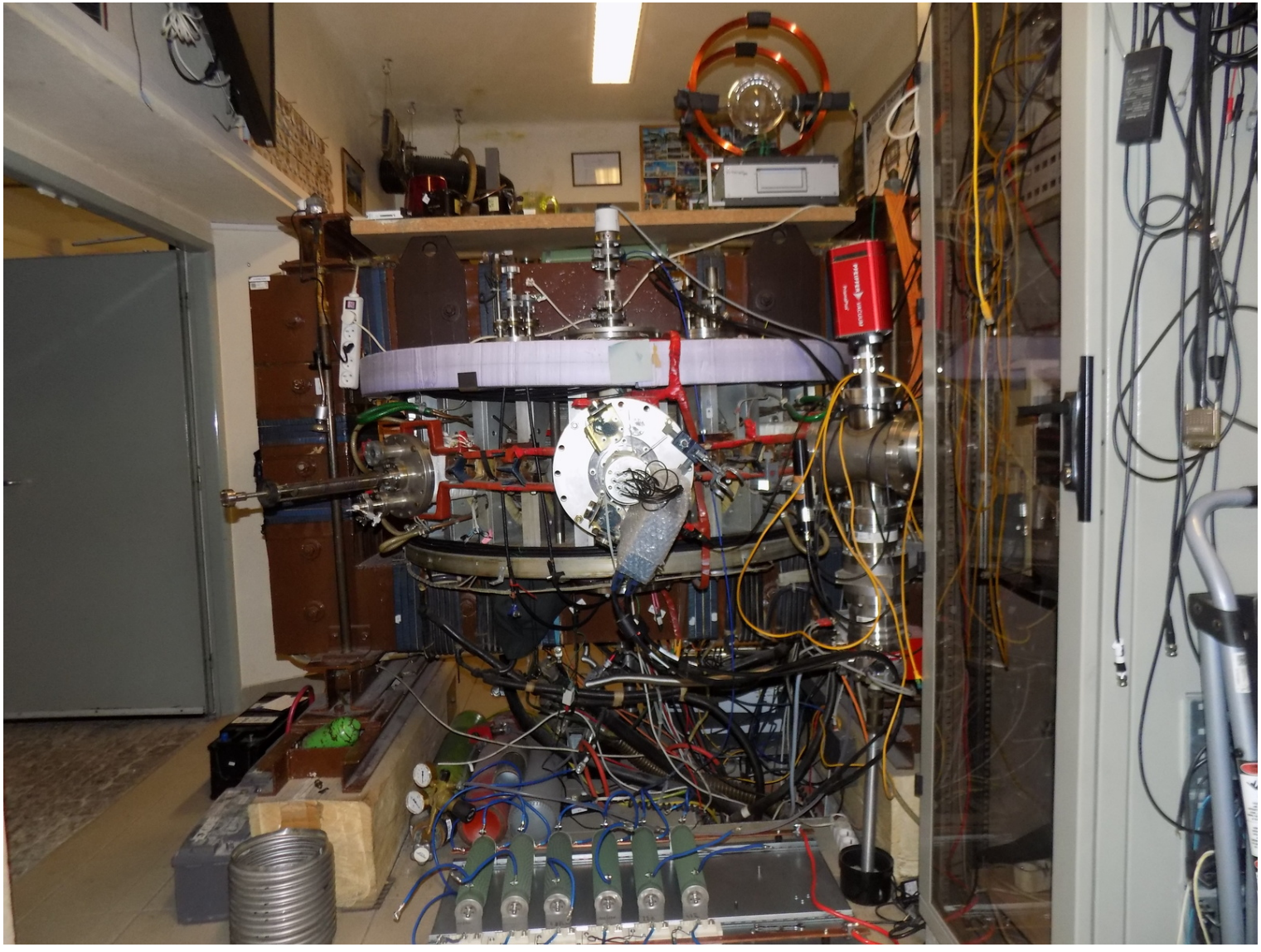
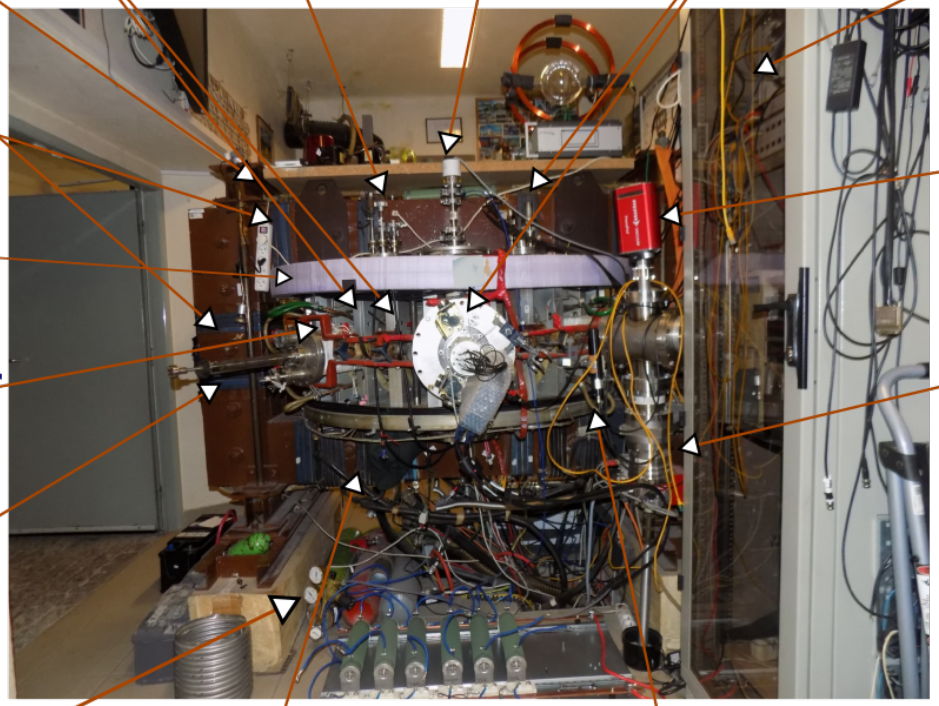
Infrastructure room (below tokamak) 10/16

Infrastructure room (below tokamak) 10/16

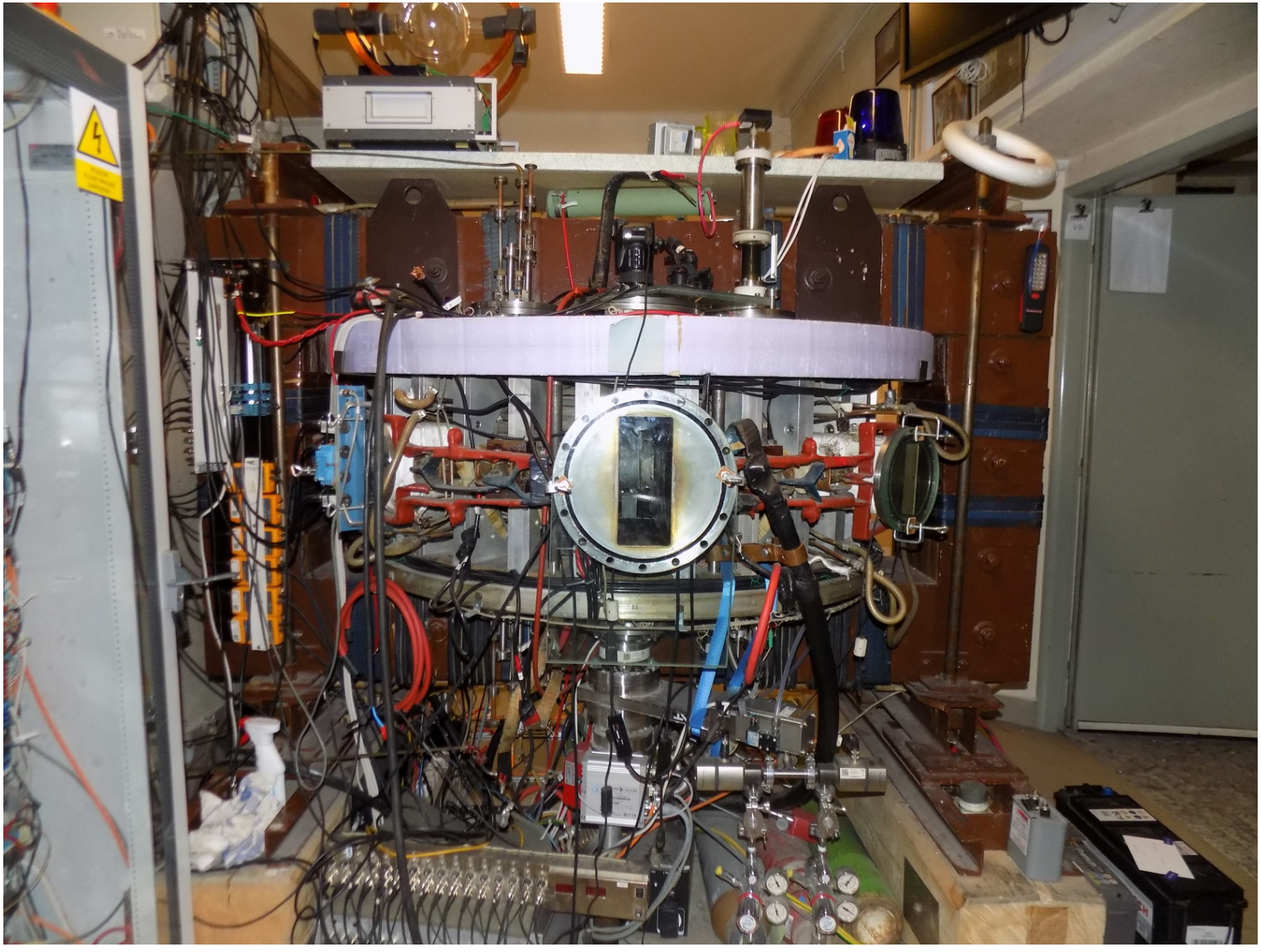
Tokamak room (North) 10/16



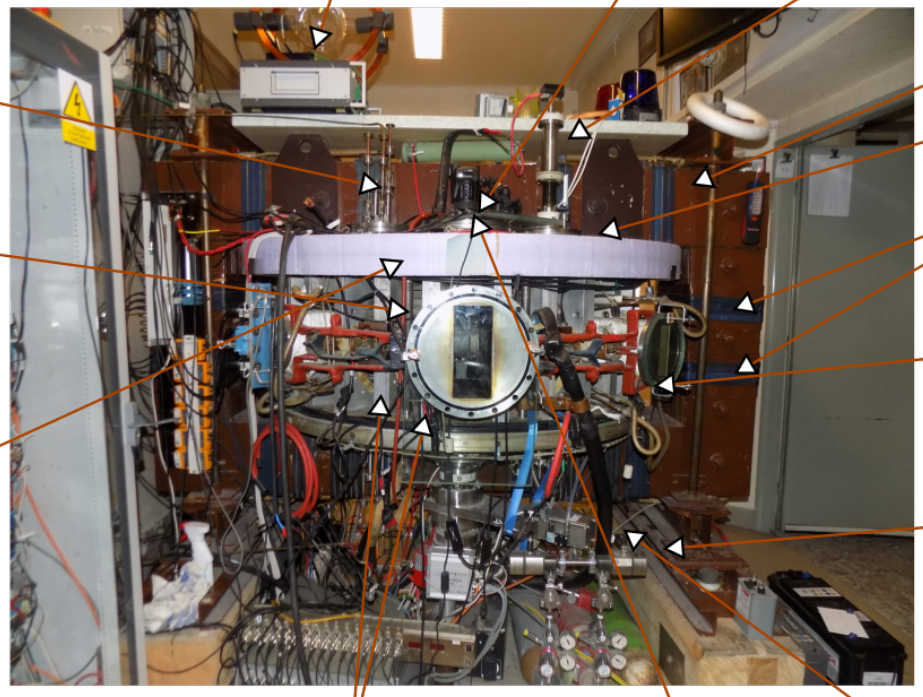
Tokamak room (North) 10/16



Tokamak room (South) 10/16



Tokamak room (South) 10/16



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GOLEM **basic** Data Acquisition System (DAS)

- $U_I, U_{B_t}, U_{I_{p+ch}}, I_{rad}$
- $\Delta t = 1\mu s / \ f = 1MHz$.
- Integration time = 40 ms, thus DAS produces 6 colums x 40000 rows data file.
- Discharge is triggered at 5th milisecond after DAS to have a zero status identification.

Data file example, DAS $\Delta t = 1\mu s / f = 1MHz$ (neutral gas into plasma breakdown focused)

t	$\approx U_I$	$\approx U_{\frac{dB_T}{dt}}$	$\approx U_{\frac{d(I_{p+ch})}{dt}}$	$\approx I_{rad}$
:	:	:	:	:
:	:	:	:	:
first	$\approx$	7405	lines ..	
:	:	:	:	:
:	:	:	:	:
0.007383	1.53931	0.390015	0.048828	0.001831
0.007384	1.53686	0.395508	0.067749	0.00061
0.007385	1.54053	0.391235	0.079956	0.00061
0.007386	1.53686	0.38147	0.072632	0
0.007387	1.54297	0.397949	0.059204	0.00061
0.007388	1.54053	0.384521	0.05249	0.00061
0.007389	1.54053	0.39856	0.068359	0.001221
0.00739	1.54053	0.393677	0.082397	0.001221
0.007391	1.53809	0.38208	0.072632	0.001221
0.007392	1.54297	0.400391	0.056763	0.00061
0.007393	1.54419	0.383911	0.053101	0.00061
0.007394	1.53931	0.397339	0.068359	0.001221
0.007395	1.54297	0.391846	0.084229	0.00061
0.007396	1.54541	0.394897	0.074463	0.00061
0.007397	1.54297	0.388184	0.056763	0.001221
0.007398	1.54297	0.391846	0.056763	0.00061
0.007399	1.54297	0.394287	0.06897	0.00061
:	:	:	:	:
:	:	:	:	:
next	$\approx$	32500	lines ..	
:	:	:	:	:
:	:	:	:	:

Data access

All the recorded data and the settings for each discharge (shot) are available at the GOLEM website. The root directory for the files is:

`http://golem.fjfi.cvut.cz/shots/<#ShotNo>/`

The most recent discharge has the web page:

`http://golem.fjfi.cvut.cz/shots/0`

Particular data from DAS specified with `<DASname>` and `<DASchannelidentifier>` have the format:

`http://golem.fjfi.cvut.cz/<#ShotNo>/<DASname>/<DASchannelidentifier>`

Jupyter (python)

```python
import numpy as np
import matplotlib.pyplot as plt

shot_no = 33993
identifier = "LoopVoltageCoil_raw.csv"
DAS='DASs/StandardDAS/'
# create data cache in the 'golem_cache' folder
ds = np.DataSource('golem_cache')
#Create a path to data and download and open the file
base_url = "http://golem.fjfi.cvut.cz/shots/"
data_file = ds.open(base_url + str(shot_no)+ '/' +DAS +identifier)
#Load data from the file and plot to screen and to disk
data = np.loadtxt(data_file,delimiter=",")
plt.plot(data[:,0], data[:,1]) #1. column vs 2. column
plt.xlabel('Time [ms]');plt.ylabel('$U_1$ [V]');
plt.savefig('graph.jpg')
plt.show()

#Run it: save it as script.py and run "python script.py" or execute in a
    ceel in a Jupyter Notebook
```

Matlab

```
ShotNo=33993
baseURL='http://golem.fjfi.cvut.cz/shots/';
diagnPATH='/DASs/StandardDAS/LoopVoltageCoil_raw.csv';
%Create a path to data
dataURL=strcat(baseURL,int2str(ShotNo),diagnPATH);
% Write data from GOLEM server to a local file
urlwrite(dataURL,'LoopVoltage');
% Load data
data = load('LoopVoltage', '\t');
% Plot and save the graph
f = figure('visible', 'off');
hold on
plot(data(:,1)*1000, data(:,2), '.') ;
xlabel('Time [ms]')
ylabel('U_l [V]')
hold off
print -djpeg plot.jpg
close(f)
exit;
```

Octave

```
ShotNo=33993
baseURL='http://golem.fjfi.cvut.cz/shots/';
diagnPATH='/DASs/StandardDAS/LoopVoltageCoil_raw.csv';
%Create a path to data
dataURL=strcat(baseURL,int2str(ShotNo),diagnPATH);
% Write data from GOLEM server to a local file
urlwrite(dataURL,'LoopVoltageCoil_raw.csv');
% Load data
data = load('LoopVoltageCoil_raw.csv', '\t');
% Plot and save the graph
plot(data(:,1), data(:,2), '.') ;
xlabel('time [ms]')
ylabel('U_loop [V]')
saveas(gcf, 'plot', 'jpg');
exit;
```

Gnuplot

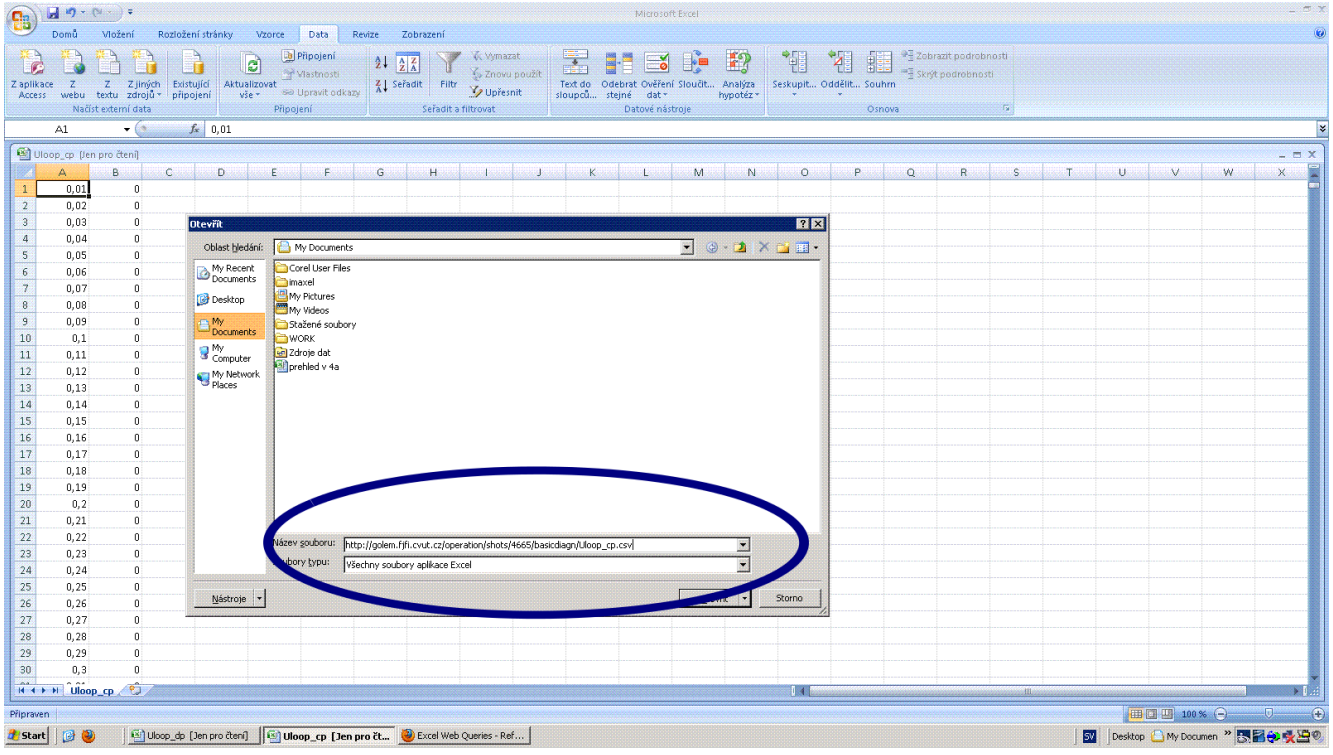
```
identifier = 'LoopVoltageCoil_raw.csv' ;
ShotNo = '33993'
# Create a path to the data
DAS='DASs/StandardDAS/'
baseURL='http://golem.fjfi.cvut.cz/shots/'
DataURL= baseURL.ShotNo.'/'.DAS.identifier
set datafile separator ',';
set title "Uloop for #".ShotNo;
# Write data from GOLEM erver to a local file
! wget -q @DataURL ;
# Plot the graph from a local file
set xrange [0:0.02];set xlabel 'Time [s]';set ylabel 'U_l [V]'
plot identifier u 1:2 w l t 'Uloop'
```

GNU Wget

GNU Wget is a free software package for retrieving files using HTTP, HTTPS and FTP, the most widely-used Internet protocols. It is a non-interactive commandline tool, so it may easily be called from scripts, cron jobs, terminals without X-Windows support, etc.

- Runs on most UNIX-like operating systems as well as Microsoft Windows.
- Homepage: `http://www.gnu.org/software/wget/`
- Basic usage:
  - To get U_l: wget `http://golem.fjfi.cvut.cz/utils/data/<#ShotNo>/loop_voltage`
  - To get whole shot: wget -r -nH –cut-dirs=3 –no-parent -l2 -Pshot `http://golem.fjfi.cvut.cz/shots/<#ShotNo>`

Excel



File→Open→

`http://golem.fjfi.cvut.cz/utils/data/<#ShotNo>/<identifier>`

Spredsheets (Excel and others)

are not recommended, only tolerated.

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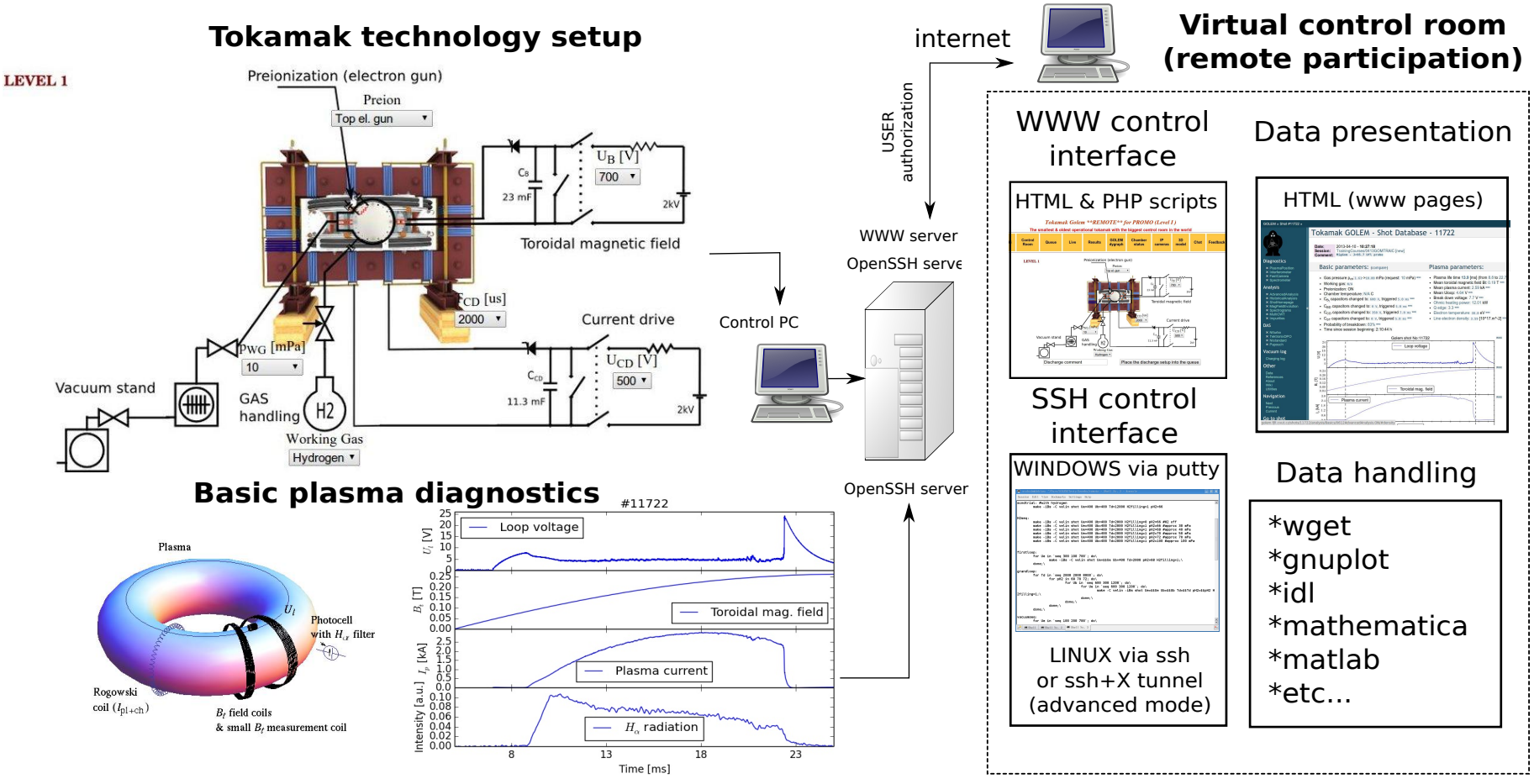
The global schematic overview of the GOLEM experiment



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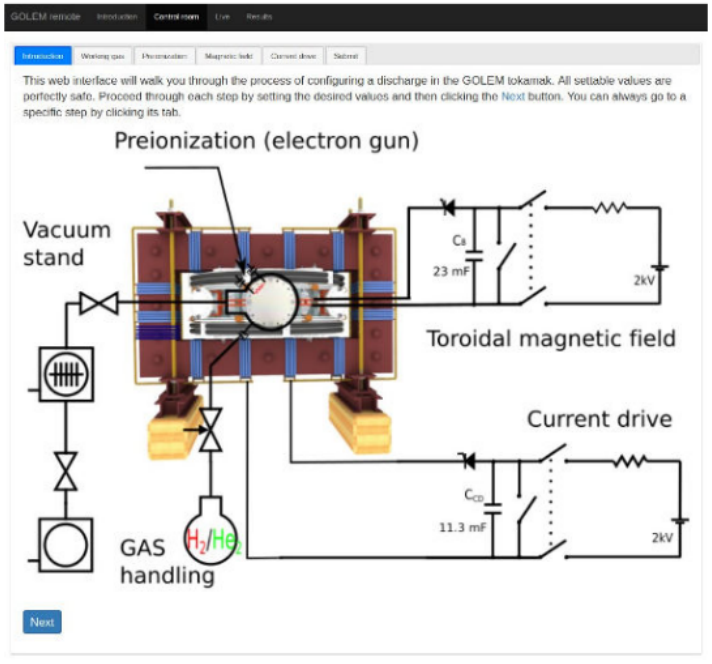
  - Videoconference https://meet.jit.si/golem

Recommended values for the GOLEM tokamak operation



- Preionization: Top electron gunn
- Gas: Hydrogen. A Working gas pressure: p_{WG} [mPa] $< 0, 40 >$ mPa
- A voltage to charge the Current drive field E_t capacitor: U_{E_t} [V] $< 400, 700 >$ V
- A voltage to charge the Toroidal magnetic field B_t capacitor: U_{B_t} [V] $< 600, 1200 >$ V
- Time delay of the E_t trigger with respect to the B_t trigger: T_{CD} [μs] $< 0, 10000 >$ μs

Fee: postcard from the venue of remote measurements

Acknowledgement

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Students, teachers, technicians (random order):

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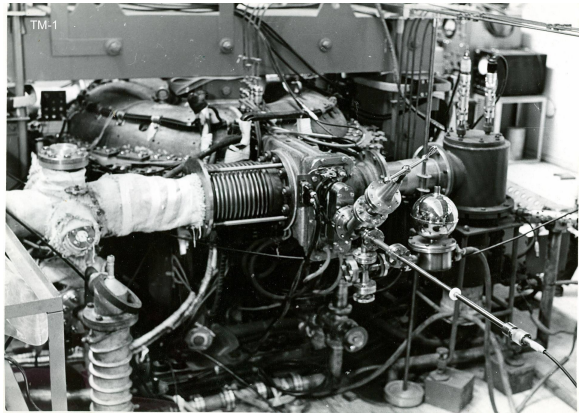
Thank you for your attention

Tokamak TM1
@Kurchatov Institute near Moscow
~1960-1977



SCIENCE

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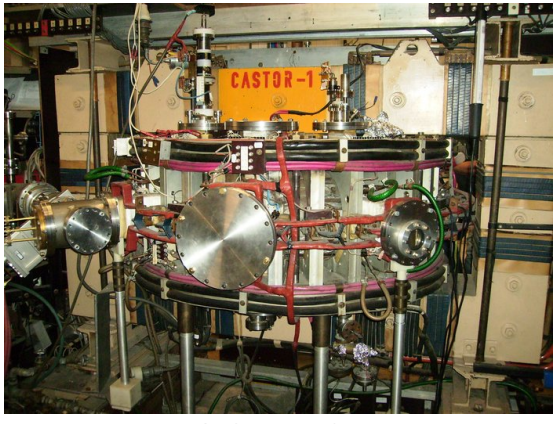

SCIENCE
& education

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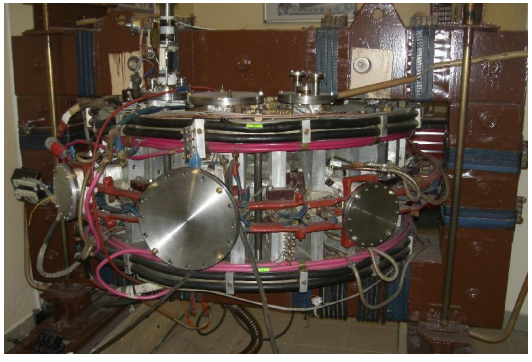
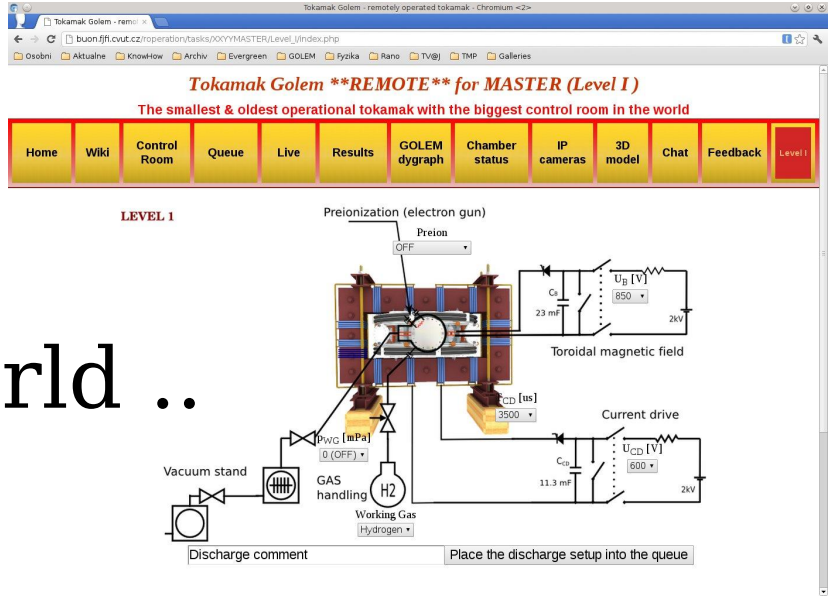


EDUCATION
& science

... with the biggest
control room
in the world ..



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References I

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