The GOLEM data access

Vojtěch Svoboda & the GOLEM team

March 27, 2012

Outline of the talk

1. Introduction
2. GNU Wget
3. Data access
   - Basic parameters
   - Session parameters
   - Discharge setup
   - Basic diagnostics
4. GOLEM data import in various graphing utilities
   - Matlab
   - Octave
   - Gnuplot
   - Python
   - Mathematica
   - IDL
   - Excel
5. Usefull scripts
6. Conclusion

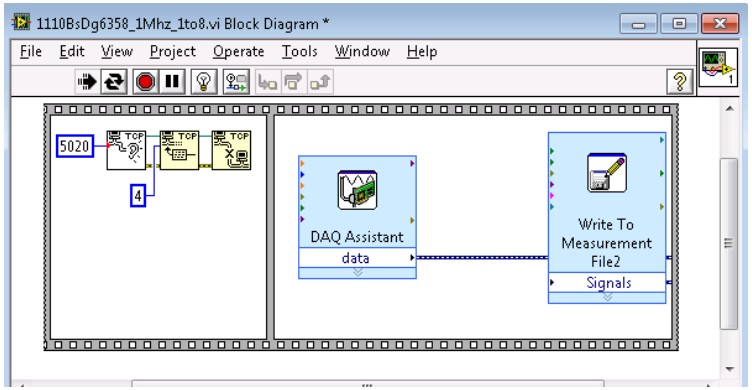
Content

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

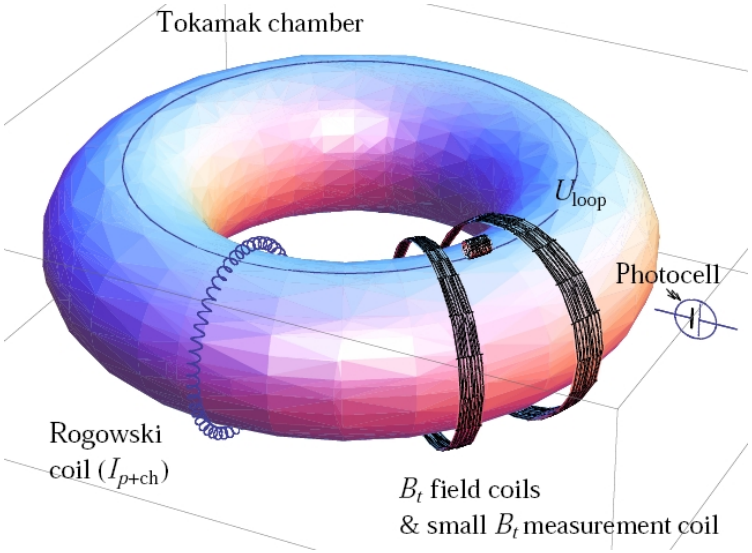
4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

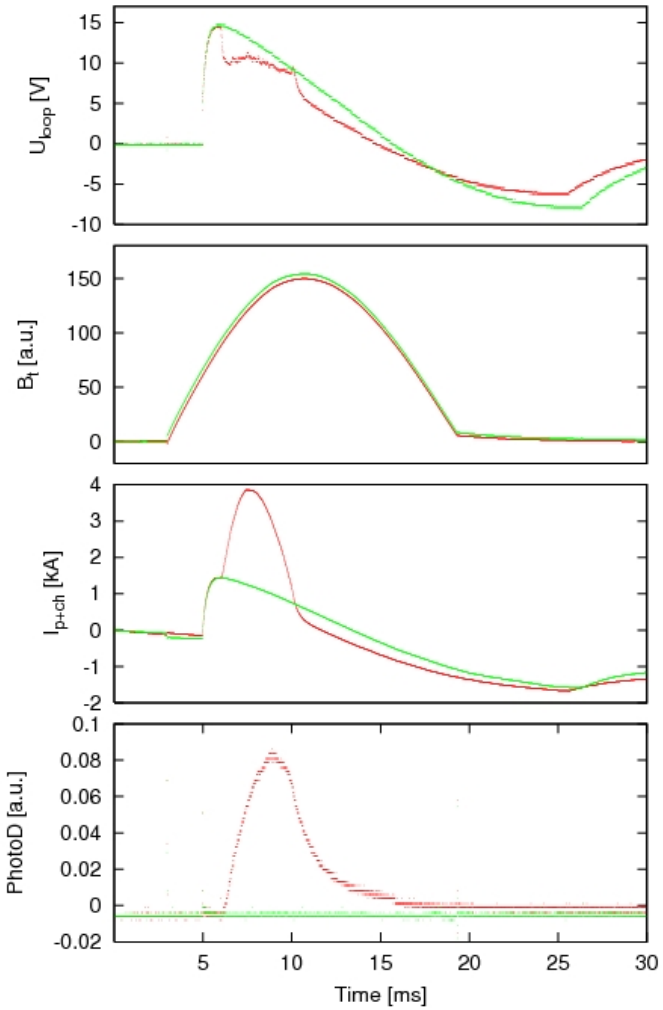
5 Usefull scripts
6 Conclusion

Basic plasma diagnostics in tokamak GOLEM



PXI system with PXIe 6358





Data Acquisition System based on: NATIONAL INSTRUMENTS

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

- $U_{loop}, U_{B_t}, U_{I_{pl+ch}}, I_{rad}, I_{H_\alpha rad}, I_{HXR}$.
- $\Delta t = 1\mu s/\ f = 1MHz$.
- 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 $\Delta t = 10\mu s/f = 100kHz$ (neutral gas into plasma breakdown focused)

t	U_{loop}	$U_{\frac{dB}{dt}}$	$U_{\frac{d(I_{pl+ch})}{dt}}$	I_{rad}
:	:	:	:	:
:	:	:	:	:
first	≈	870	lines ..	
:	:	:	:	:
:	:	:	:	:
0,008760	2,062738	0,170025	0,024531	0,003930
0,008770	2,052438	0,163909	0,018415	0,003930
0,008780	2,040528	0,131720	0,020025	0,004252
0,008790	2,028296	0,161012	0,022600	0,004574
0,008800	2,017995	0,168416	0,023887	0,003930
0,008810	2,003510	0,174853	0,028394	0,004252
0,008820	1,984519	0,159081	0,032256	0,004252
0,008830	1,964561	0,128823	0,042557	0,004896
0,008840	1,945892	0,177107	0,033222	0,005218
0,008850	1,928510	0,171634	0,036441	0,004574
0,008860	1,908552	0,161978	0,051892	0,004896
0,008870	1,890848	0,164231	0,047385	0,005540
0,008880	1,876041	0,159403	0,039338	0,005218
0,008890	1,860591	0,178394	0,039982	0,005861
0,008900	1,847071	0,173244	0,049638	0,006183
0,008910	1,834196	0,156506	0,052857	0,006505
0,008920	1,815526	0,162300	0,051248	0,006505
0,008930	1,792672	0,181935	0,059295	0,006827
:	:	:	:	:
:	:	:	:	:
next	≈	3100	lines ..	
:	:	:	:	:

Content

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

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 Uloop: wget `http://golem.fjfi.cvut.cz/operation/shots/4665/basicdiagn/Uloop_dp.csv`
  - To get whole shot: wget -r -nH –cut-dirs=3 –no-parent -l2 -Pshot http://golem.fjfi.cvut.cz/operation/shots/4665

Content

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Data access

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

`http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/`

Basic data of the shot series are collected at a page to be reached at:

`http://golem.fjfi.cvut.cz/operation/tasks/<session>/`

Actual discharge has the web page:

`http://golem.fjfi.cvut.cz/operation/currentshot`.

Actual session has the web page:

`http://golem.fjfi.cvut.cz/operation/currentsession`.

Basic data access

- Actual discharge number is at `http://golem.fjfi.cvut.cz/operation/ActualShotNo`.
- Actual session name is at `http://golem.fjfi.cvut.cz/operation/SessionNameDate`.

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Session parameters

link: `http://golem.fjfi.cvut.cz/operation/tasks/<sessionname>/Komora/<Parameter>`

where <Parameter>is

StartTime: session start time.

Aktual_PfeifferMerkaVakua: actual pressure in the chamber.

Aktual_TermoclanekNaKomore: actual chamber temperature.

Time_All: session log.

graph.jpg: session visual log.

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Basic parameters

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/<Parameter>`

where <Parameter> is

- ShotNo: the discharge number.
- wwwcomment: the discharge comment.
- starttime_: the /Central European Time/ time of the discharge.
- SessionNameDate: the full session address.
- SessionName: the short session address.
- date: the date of the session.

Vacuum and gas management

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/<Parameter>`

where <Parameter> is

Initial_PfeifferMerkaVakua: pressure in the chamber before the discharge preparation (vacuum level).

Aktual_PfeifferMerkaVakua: pressure in the chamber just before the discharge (working gas /H_2 or He/ pressure).

pressure_setting_mPa: desired working gas pressure.

Aktual_TermoclanekNaKomore: the chamber temperature before the discharge.

Prelonization: preionization switch ON/OFF $\sim$ 1/0.

H2filling: working gas filling switch ON/OFF $\sim$ 1/0.

Electromagnetic configuration of the discharge setup

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/nabijeni/<Parameter>`

where <Parameter> is

- Ub_limit: desired capacitor voltage U_B driving toroidal magnetic fied B_{tor}.
- Ucd_limit: desired capacitor voltage U_{CD} driving toroidal electric field E_{CD} for current drive.
- Ubd_limit: desired capacitor voltage U_{BD} driving toroidal electric field E_{BD} for plasma breakdown.
- Ust_limit: desired capacitor voltage U_{ST} driving vertical magnetic field E_{ST} for plasma stabilization.

Triggering configuration of the discharge setup

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/<Parameter>`

where <Parameter> is

Tcd_aktual: time delay for current drive electric field E_{CD} with respect to toroidal magnetic field B_{tor}.

Tbd_aktual: time delay for breakdown electric field E_{BD} with respect to toroidal magnetic field B_{tor}.

Tst_aktual: time delay for stabilising magnetic field B_{ST} with respect to toroidal magnetic field B_{tor}.

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Discharge basic diagnostics

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/basicdiagn/<Parameter>`

where <Parameter> is

usbscopes (tabs & decimal point format): raw voltage data from Data Acquisition System (Uloop,Bt,Ip+ch,UPhotoC,UPhotoCHalpha).

usbscopes_dc (tabs & decimal comma format): raw voltage data from Data Acquisition System (Uloop,Bt,Ip+ch,UPhotoC,UPhotoCHalpha).

Discharge basic diagnostics - extracts

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/basicdiagn/<Parameter>`

where <Parameter> (decimal point/comma point format) is

Uloop_dp.csv/Uloop_cp.csv: Loop voltage: $<t, U_{loop}>$.

Btoroidal_dp.csv/Btoroidal_cp.csv: B_{tor} coil: $<t, B_{tor}>$.

Irogowski_dp.csv/Irogowski_cp.csv: Rogowski coil: $<t, I_{ch+p}>$.

Iplasma_dp.csv/Iplasma_cp.csv: Rogowski coil: $<t, I_p>$.

Photod_dp.csv/Photod_cp.csv: Photocell: $<t, I_{rad}>$.

PhotodHalfa_dp.csv/PhotodHalfa_cp.csv: Photocell: $<t, I_{radH\alpha}>$.

Discharge appearance

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/basicdiagn/<Parameter>`

where <Parameter> is

- **Plasma:** Plasma appearance YES/NO $\approx$ 1/0.
- **PlasmaStart:** Plasma start time.
- **PlasmaEnd:** Plasma end time.
- **PlasmaTimeLength:** Plasma duration.
- **PlasmaStartRow:** Plasma start row in data series.
- **PlasmaEndRow:** Plasma end row in data series.

Discharge physical quantities measured from plasma start to plasma end

link: `http://golem.fjfi.cvut.cz/operation/shots/<shotnumber>/basicdiagn/<Parameter>`

where <Parameter> is

ElectronTemperature: central electron temperature (from Spitzer conductivity).

OhmicHeatingPower: ohmic heating power.

PlasmaTotalCharge: total charge.

MeanBt: mean B_{tor}.

MeanPlasmaCurrent: mean I_p.

MeanUloop: mean U_{loop};

Qedge: mean Q_{edge}.

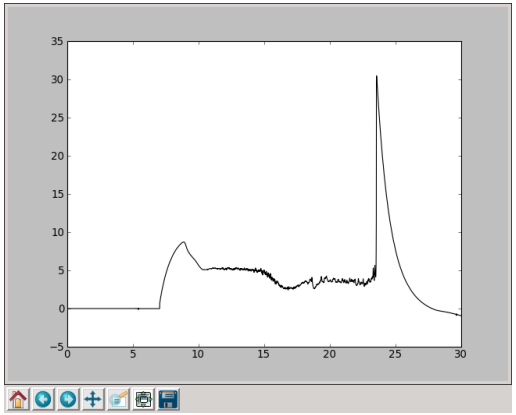
Content

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

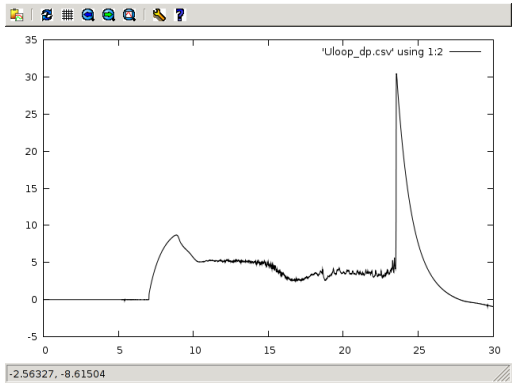
4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

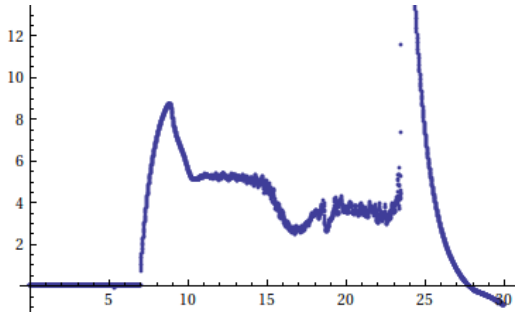
Plot 4665 U_{loop} graph



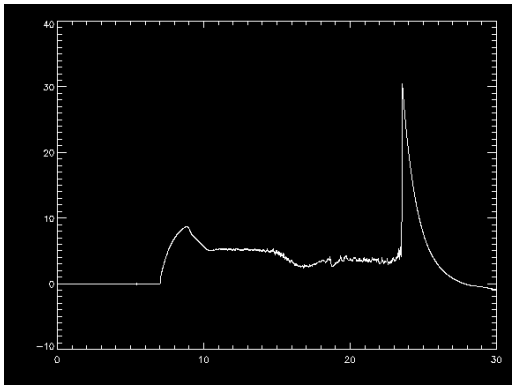
python



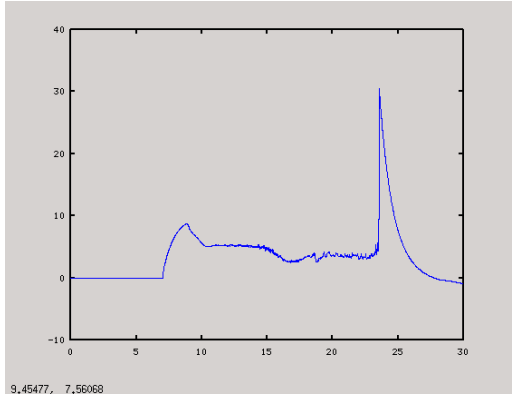
gnuplot



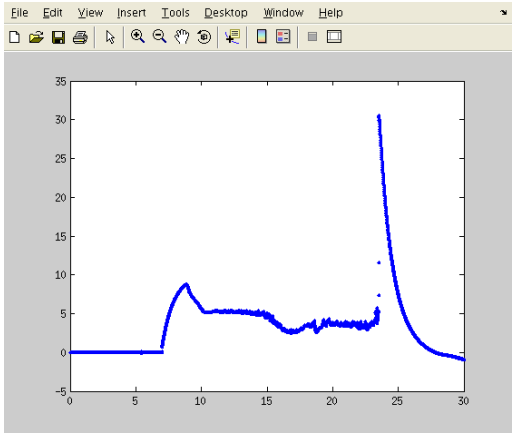
mathematica



idl



octave



matlab

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Matlab

```
ShotNo=4665;
baseURL='http://golem.fjfi.cvut.cz/operation/shots/';
diagnPATH='/basicdiagn/Uloop_dp.csv';
%Create a path to data
dataURL=strcat(baseURL,int2str(ShotNo),diagnPATH);
% Write data from GOLEM server to a local file
urlwrite(dataURL,'Uloop_dp.csv');
% Load data
data = load('Uloop_dp.csv');
% Plot the graph
plot(data(:,1), data(:,2), '.') ;
%exit;

% command line execution:
% matlab -nosplash -nodesktop -r Uloop
```

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Octave

```
ShotNo=4665;
baseURL='http://golem.fjfi.cvut.cz/operation/shots/';
diagnPATH='/basicdiagn/Uloop_dp.csv';
%Create a path to data
dataURL=strcat(baseURL,int2str(ShotNo),diagnPATH);
% Write data from GOLEM server to a local file
urlwrite(dataURL,'Uloop_dp.csv');
% Load data
data = dlmread('Uloop_dp.csv', ";");
% Plot the graph
plot(data(:,1), data(:,2)) ;
%exit;

% command line execution:
% octave --persist Uloop.m
```

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Gnuplot

```
set macros;
ShotNo = "4665";
baseURL = "http://golem.fjfi.cvut.cz/operation/shots/";
diagnPATH = "/basicdiagn/Uloop_dp.csv";
#Create a path to data
DataURL= "@baseURL@ShotNo@diagnPATH";
#Write data from GOLEM server to a local file
!wget -q  @DataURL;
#Plot the graph from a local file
set datafile separator ";";
plotstyle = "with lines linestyle -1"
plot 'Uloop_dp.csv' using 1:2 @plotstyle;
exit;

# command line execution:
# gnuplot Uloop.gp -persist
```

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Python

```
import matplotlib.pyplot as plt
from numpy import loadtxt
from urllib import urlopen

baseURL = "http://golem.fjfi.cvut.cz/shots/"
ShotNo = 4665
diagnPATH = "/basicdiagn/Uloop_dp.csv"
#Create a path to data
dataURL = urlopen(baseURL+ str(ShotNo) + diagnPATH)
#Load data from GOLEM server
data=loadtxt(dataURL, delimiter=';')
#Plot the graph
plt.plot(data[:,0], data[:,1], 'k-')
plt.show()

# command line execution:
# python Uloop.py
```

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Mathematica

```
baseURL = "http://golem.fjfi.cvut.cz/operation/shots/";
ShotNo = 4665;
diagnPATH = "/basicdiagn/Uloop_dp.csv";
dataURL = baseURL <> ToString[ShotNo] <> diagnPATH;
dataimp=StringSplit[Import[dataURL, "List"], ";", All]
data = ToExpression[dataimp];
graf=ListPlot[data]
Export["graf.png",graf]

(* command line execution: *)
(* mathematica Uloop.ma *)
```

Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

IDL

```
ShotNo=4665;
baseURL='golem.fjfi.cvut.cz/operation/shots/';
diagnPATH='/basicdiagn/Uloop_dp.csv';
;Create a path to data
dataURL=baseURL+STRTRIM(string(ShotNo),1)+diagnPath;
;Write data from GOLEM server to a local file
oUrl = OBJ_NEW('IDLnetUrl')
oUrl->SetProperty, URL_HOST = dataURL
fn = oUrl->Get(FILENAME='Uloop_dp.csv')
;Load data
data= read_ascii('Uloop_dp.csv',delimiter = ';')
;Plot the graph
plot,data.field1(0,*),data.field1(1,*)
;exit

;command line execution:
;idl Uloop.pro
```

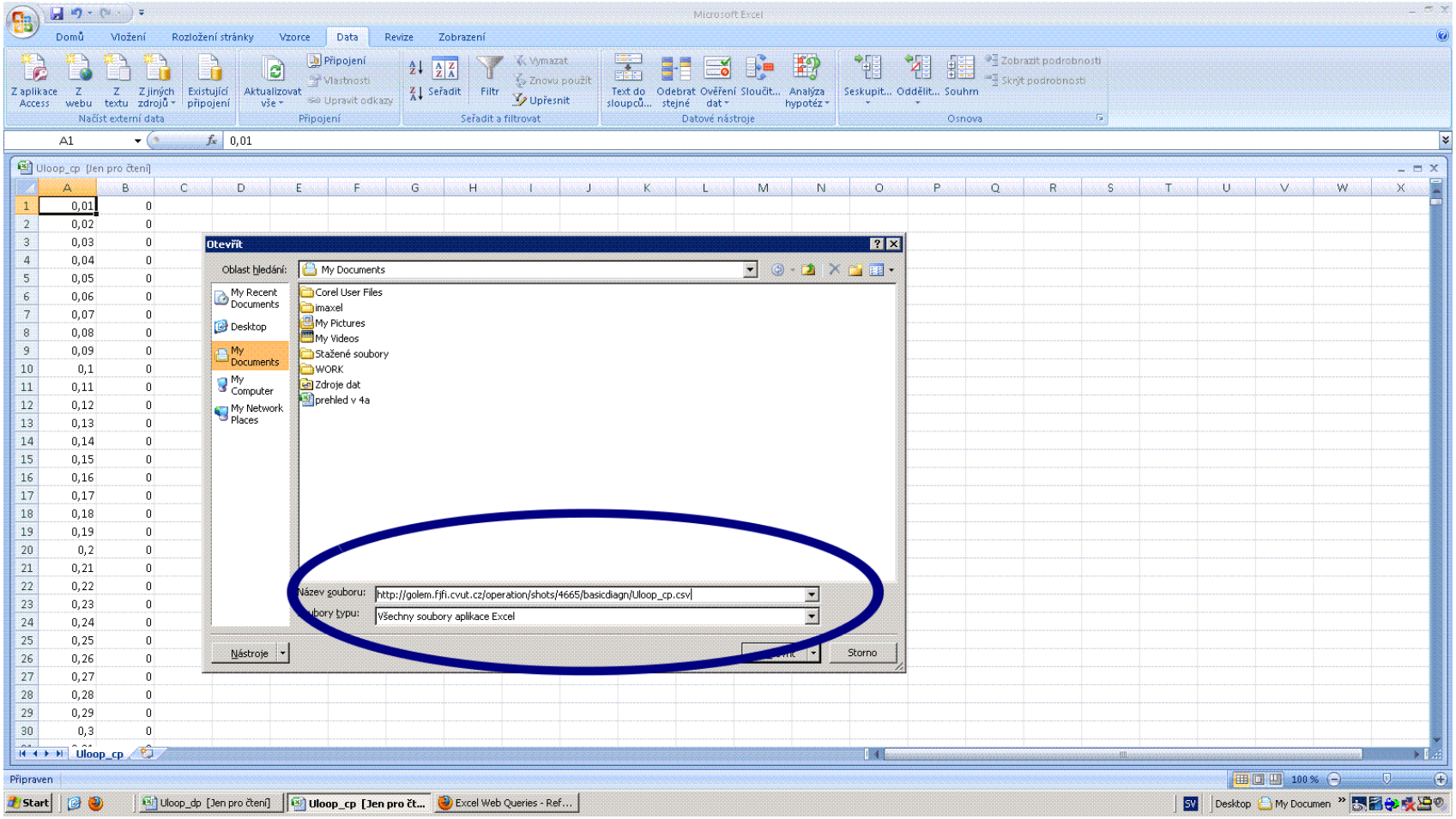
Outline

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Excel



File→Open→ `http://golem.fjfi.cvut.cz/shots/4665/basicdiagn/Uloop_dp.csv`

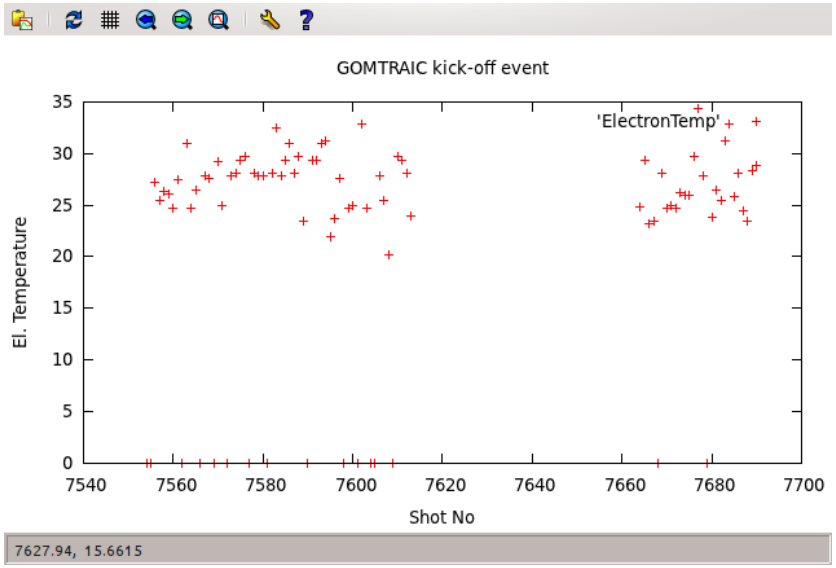
Content

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

Linux bash + Gnuplot




```
#/bin/sh

base=http://golem.fjfi.cvut.cz/operation/shots/
diagn=/basicdiagn/ElectronTemperature

for i in `seq 7554 7613` `seq 7664 7690`;
  do
    echo -n $i"\t";
    wget -q -O -  $base$i$diagn;
    echo "0";
  done > ElectronTemp;
echo "\
set xlabel 'Shot No';\
set ylabel 'El. Temperature';\
set title 'GOMTRAIC kick-off event'
plot 'ElectronTemp'" | gnuplot -persist
```

Content

1 Introduction
2 GNU Wget
3 Data access
- Basic parameters
- Session parameters
- Discharge setup
- Basic diagnostics

4 GOLEM data import in various graphing utilities
- Matlab
- Octave
- Gnuplot
- Python
- Mathematica
- IDL
- Excel

5 Usefull scripts
6 Conclusion

The call

Author will highly appreciate any comments, suggestions to the material presented. Especially we are looking forward to enrich the list of possible scripts in graphing systems (e.g. maple, origin, science, root, ...). Thank you in advance. Vojtech Svoboda, `mailto:svoboda@fjfi.cvut.cz`

Acknowledgement

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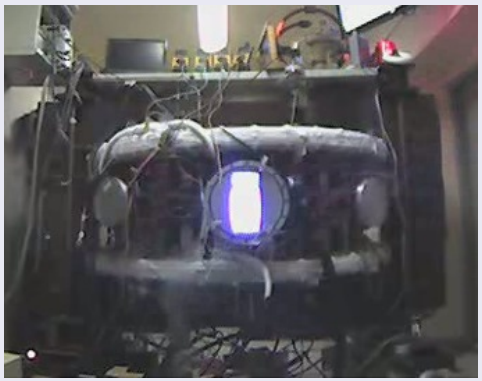
Special thanks: NATIONAL INSTRUMENTS™

Final

Thank you for your attention



http://gomtraic.fjfi.cvut.cz,
you are welcome.

References I

V. Svoboda, B. Huang, J. Mlynar, G.I. Pokol, J. Stockel, and G Vondrasek.
Multi-mode Remote Participation on the GOLEM Tokamak.
Fusion Engineering and Design, 86(6-8):1310–1314, 2011.

V. Svoboda, J. Mlynář, G. Pokol, D. Réfy, J. Stöckel, and G. Vondrášek.
Former Tokamak CASTOR becomes remotely controllable GOLEM at the Czech Technical University in Prague .
In *Europhysics Conference Abstracts. 37th EPS Conference on Plasma Physics (online: http://ocs.ciemat.es/EPS2010PAP/pdf/P2.111.pdf)*, volume 34A, 2010.

References II

Brotankova, J.
Study of high temperature plasma in tokamak-like experimental devices.
PhD. thesis 2009.

E. Bromova, I. Duran, O. Grover, J. Kocman, T. Markovic, M. Odstrcil, T. Odstrcil, O. Pluhar, J. Stockel, V. Svoboda, A. Sindlery, G. Vondrasek, and J. Zara.
The GOLEM Tokamak for Fusion Education .
In *Europhysics Conference Abstracts. 38th EPS Conference on Plasma Physics (online:http:/ocs.ciemat.es/EPS2011PAP/pdf/P1.021.pdf)*, volume 35G, 2011.