# Title

## The GOLEM tokamak for $5^{th}$ IAEA Joint Experiment

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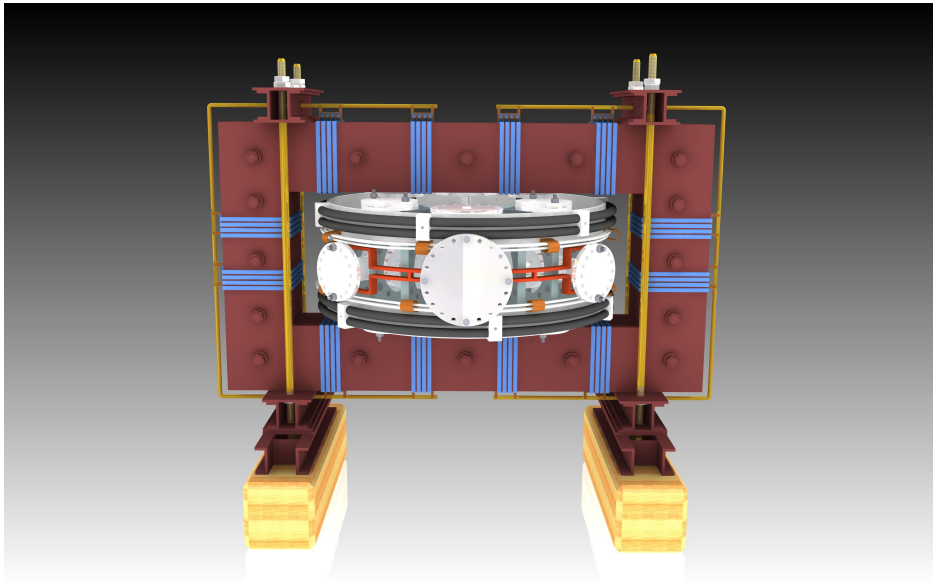

# Outline of the talk

1 Introduction

2 Tokamak GOLEM - experimental setup

3 Tokamak GOLEM for IAEA Joint Experiment

# Content

1 Introduction

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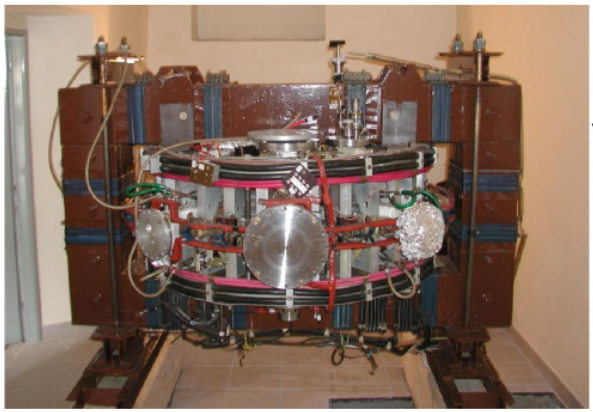
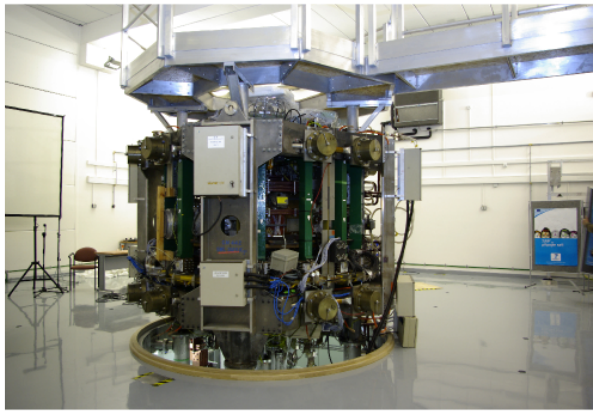
3 Tokamak GOLEM for IAEA Joint Experiment

# Tokamak GOLEM for Education - Historical Background

Kurchatov Institute near Moscow,
Soviet Union
1960: **TM1-MH**



Culham Centre for Fusion Energy
Great Britain
1989: **COMPASS-D**



1974

2006

Institute of Plasma Physics
Czech republic
**CASTOR** **COMPASS**

2008

Czech Technical University Prague
Czech republic
**GOLEM**

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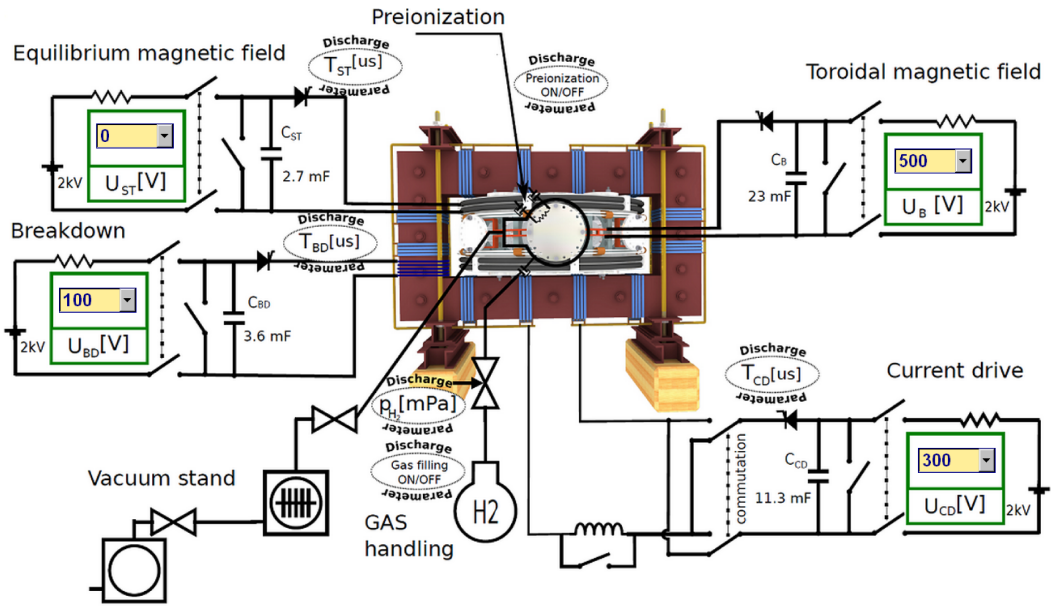
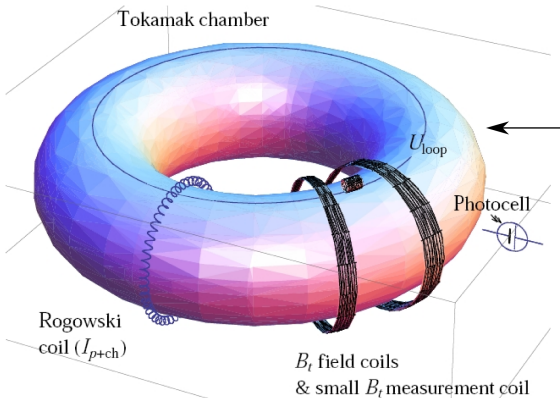
# Unique remote operation capability

internet

## Tokamak control room




## Plasma diagnostics




Control PC

OpenSSH server

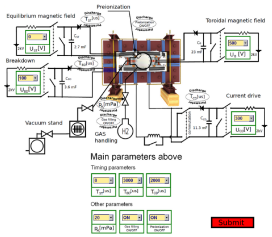
WWW server

OpenSSH server

## Virtual control room (remote participation)

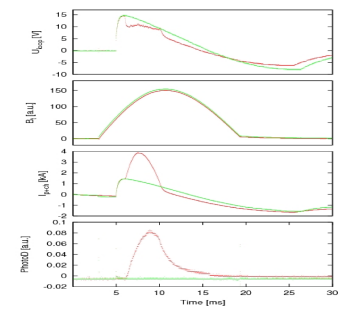
### WWW control interface

HTML & PHP scripts



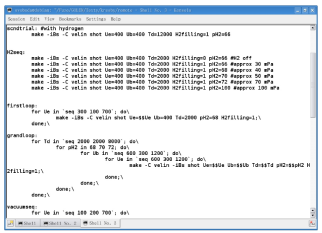
### Data presentation

HTML (www pages)




### SSH control interface

WINDOWS via putty

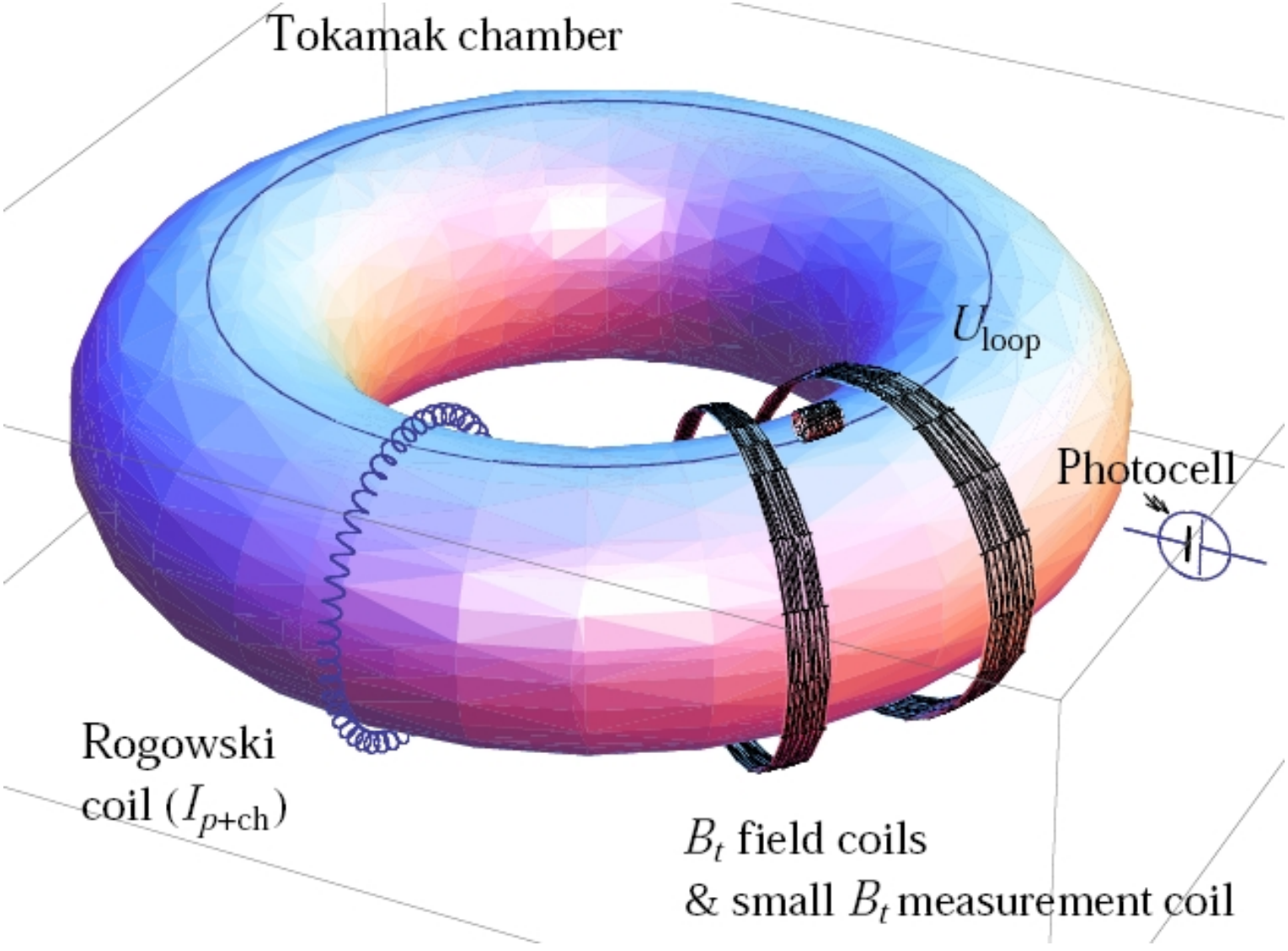


LINUX via ssh
or ssh+X tunnel
(advanced mode)

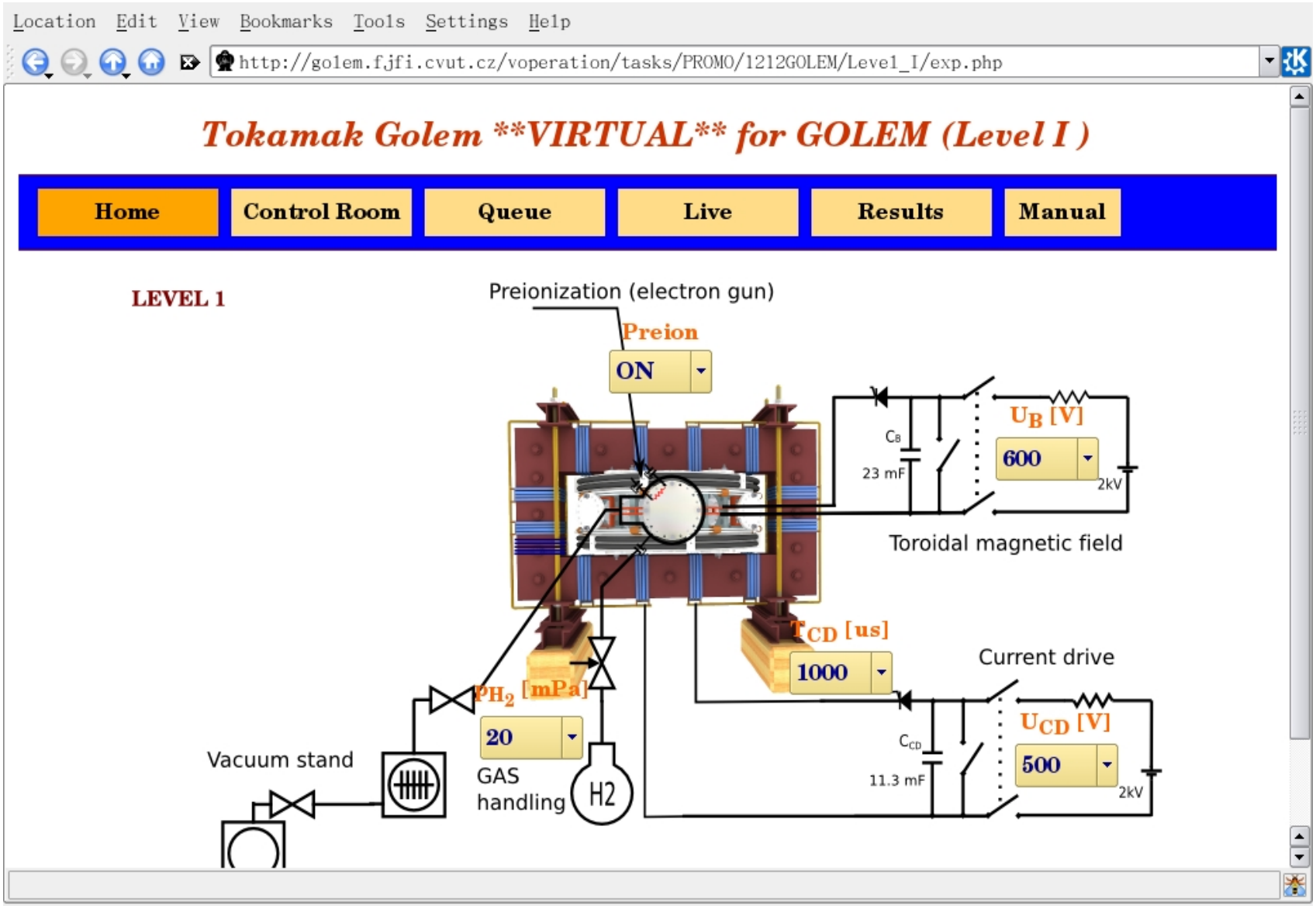
### Data handling

*wget
*gnuplot
*idl
*mathematica
*matlab
*etc...

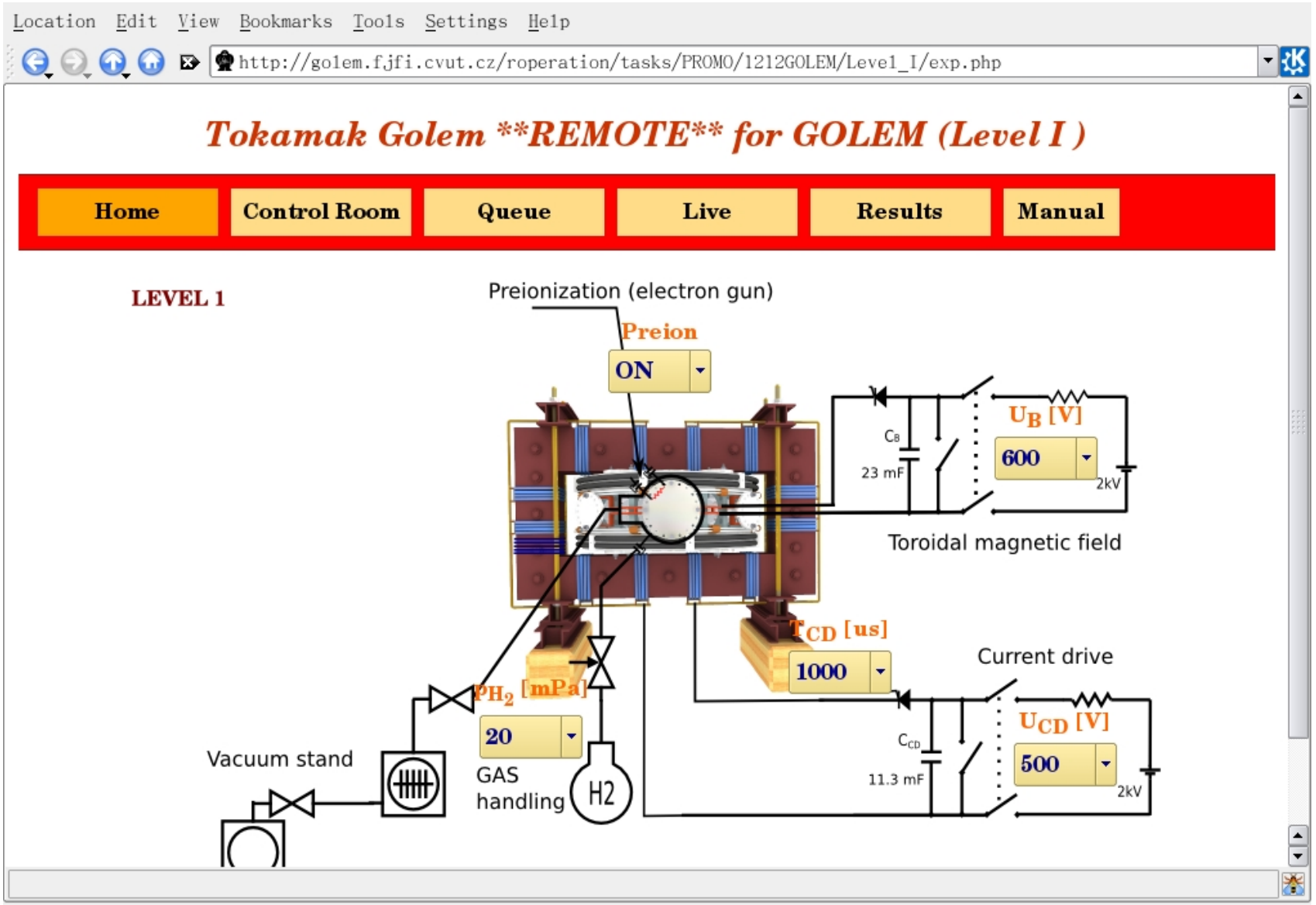
# Basic plasma diagnostics on tokamak GOLEM



# The GOLEM tokamak **virtual** Control Room - level I



# The GOLEM tokamak **real** Control Room



# The result webpage



Diagnostics

- ✕ PlasmaPosition
- ✓ Flukes
- ✕ MirnovCoils
- ✓ HXR
- ✓ FastCamera
- ✕ Spectrometer

Analysis

- ✓ AdvancedAnalysis
- ✓ ShotHomepage
- ✕ MagFieldEvolution
- ✕ MultiCWT
- ✕ MHD

DAS

- ✓ NIturbo
- ✓ NIstandard
- ✕ Papouch
- ✓ NIbasic
- ✕ Papouch

Vacuum + Energetics

Log

Other

Data
References
About

Navigation

Next
Previous
Current

Go to shot

9694 Go

# Tokamak GOLEM - Shot Database - 9694

[Template source]
[WebLog]

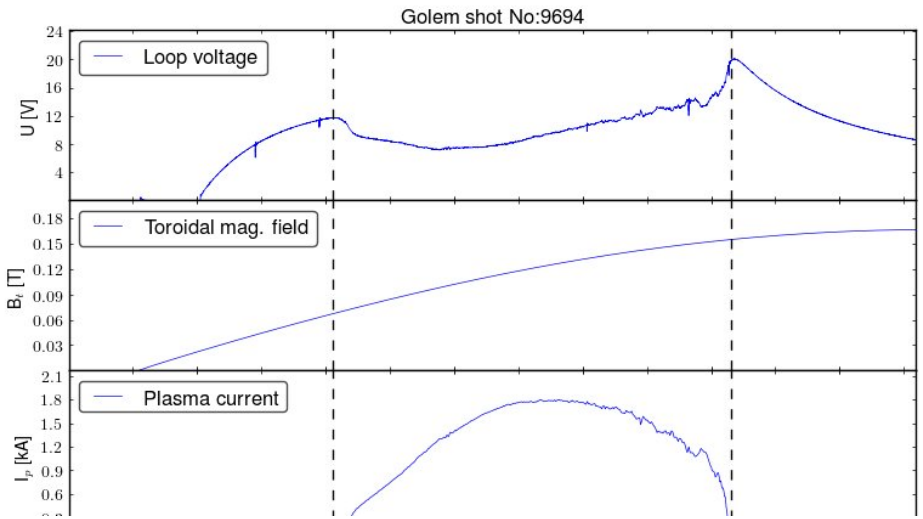
**Date:** 2012-09-07 - **121544**
**Session:** Technological/Software/Debugging/0912Optimization
**Comment:** `USER_A - three`

## Basic parameters:

- Chamber pressure $p_{chamber}$ : `1.27`-> `19.28` mPa (request: 20 mPa)
- Working gas: `N/A`
- Chamber temperature: N/A C
- $C_{B_t}$ capacitors ( 23.0 mF) charged to: `600 V`, triggered `5.0 ms`
- $C_{BD}$ capacitors (3.6 mF) charged to: `0 V`, triggered `5.0 ms`
- $C_{CD}$ capacitors (11.2 mF) charged to: `500 V`, triggered `6.0 ms`
- $C_{ST}$ capacitors (2.7 mF) charged to: `0 V`, triggered `5.0 ms`
- Max saturation of iron core transformator: 47%
- Time since session beginning: 0:51:47 h

## Plasma parameters:

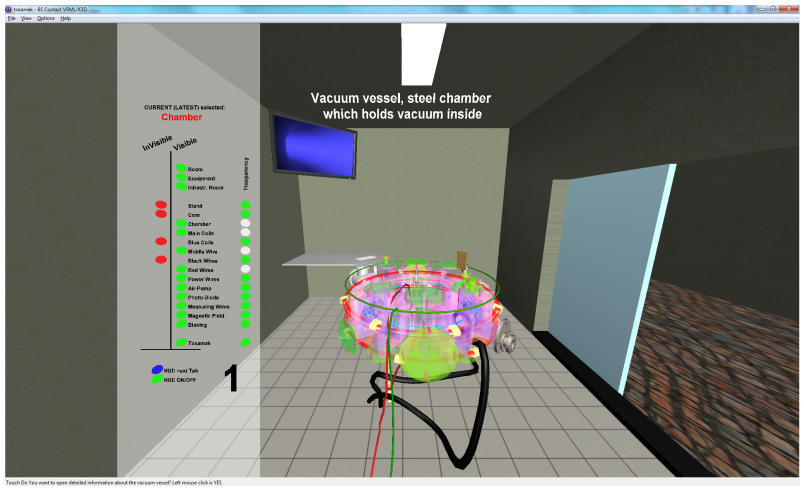
- Plasma life time **6.2** [ms] (from 8.1 to 14.3)
- Mean toroidal magnetic field Bt: 0.12 T
- Mean plasma current: 1.43 kA
- Mean Uloop: 9.71 V
- Break down voltage: 11.9 V
- Ohmic heating power: 13.87 kW
- Q edge: 7.6
- Central electron temperature: `25.3 eV`

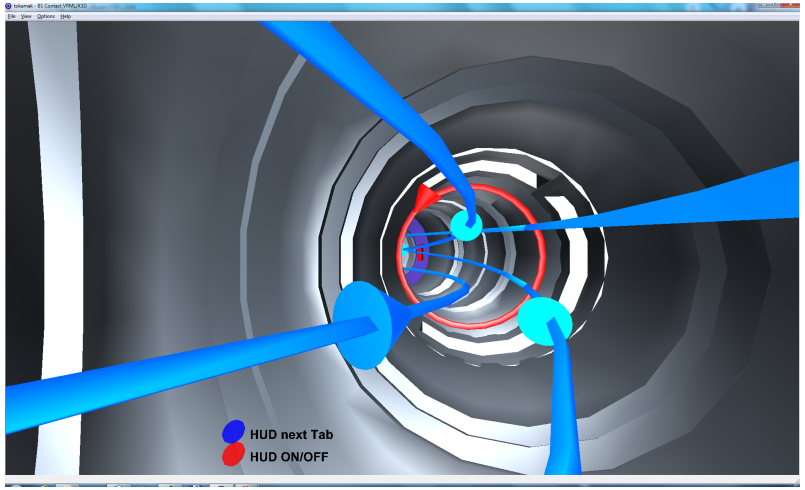


# The GOLEM tokamak virtual model



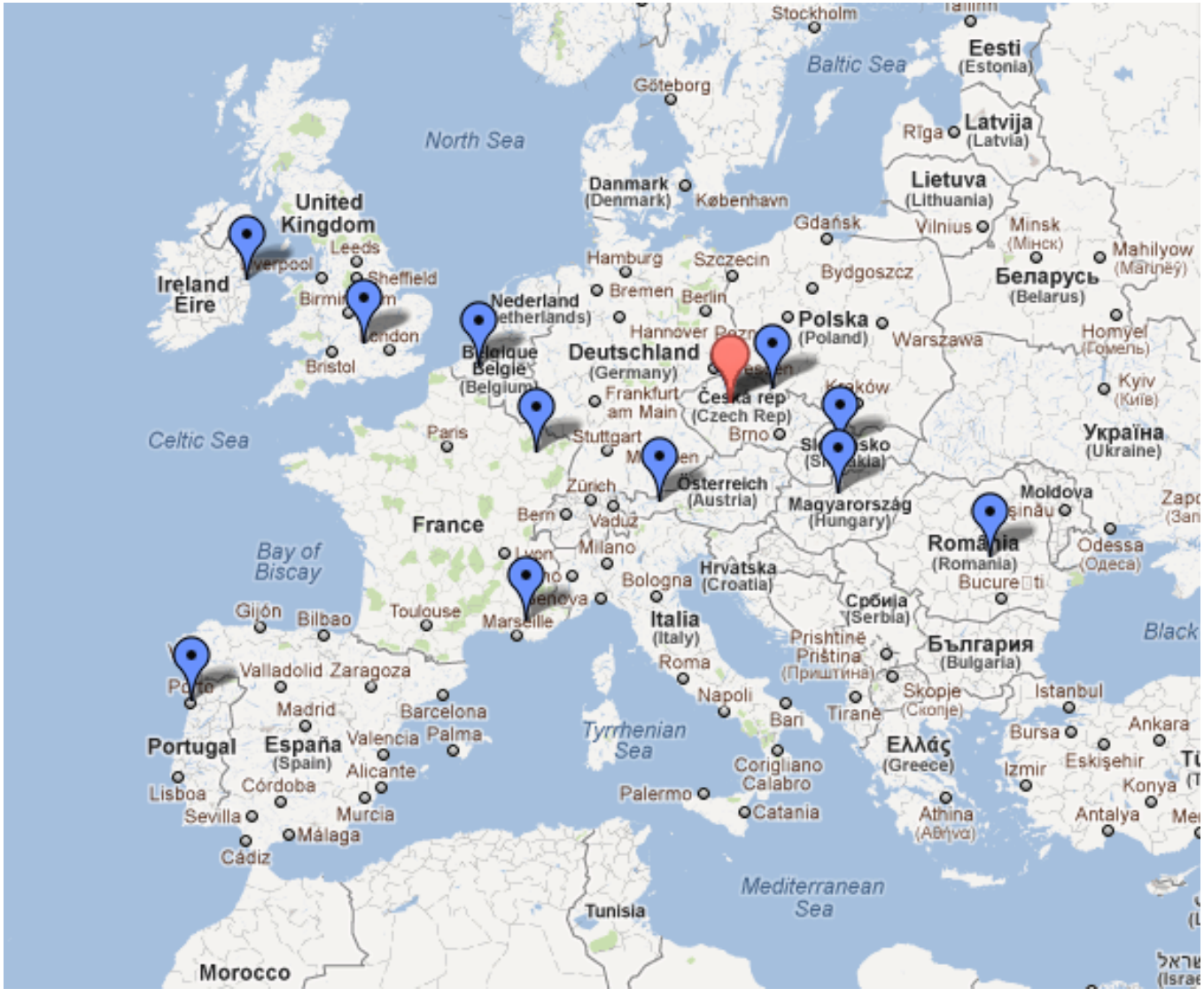
Tokamak Room & Infrastructure Room




Inner view & Inside chamber

# Remote sessions from Europe



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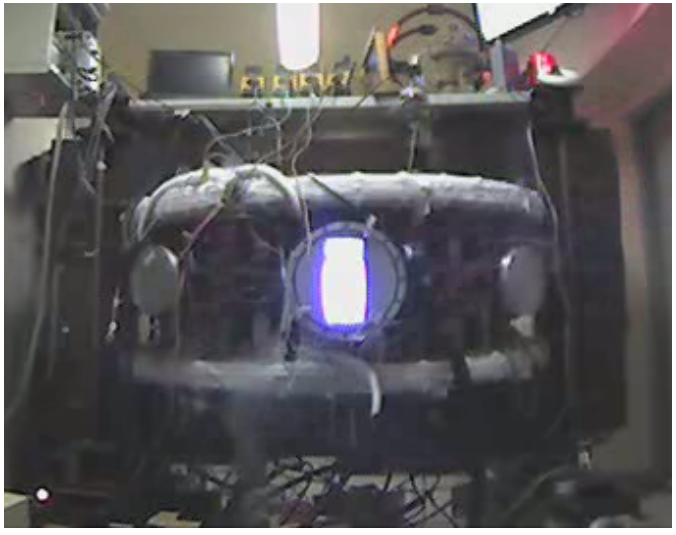
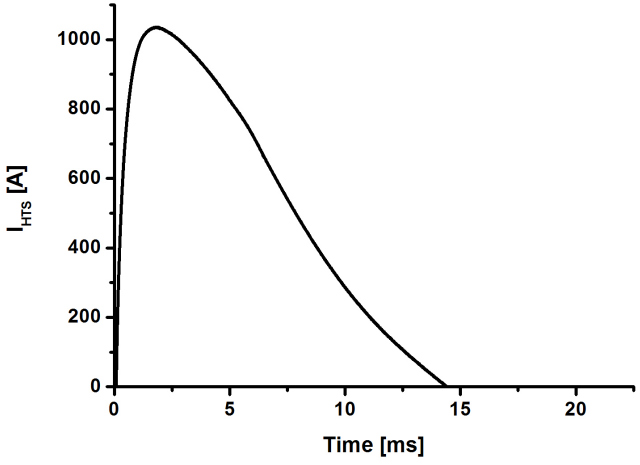
# Tokamak GOLEM for IAEA Joint Experiment
# 3 experiments

- Tests of HTS switch on GOLEM tokamak.
- Characterise resistivity dependence of HTS coils on current.
- Installation and investigation of RF pre-ionisation on GOLEM tokamak.

# High Temperature Superconductors first ever used on tokamak





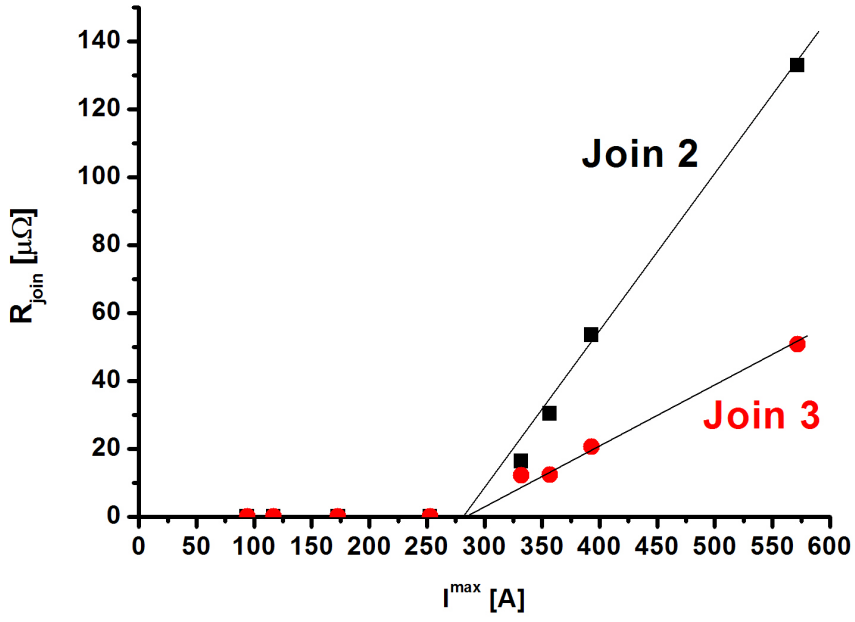

- 6 turns of the 2nd generation HTS (Re)BCO tape SCS12050-AP.
- Current ramp-up speed of up to $\approx 0.6$ MA/s .
- Current through the tape $\approx 1$ kA.
- Little "quench" effects observed for perpendicular magnetic field up to 0.5T

video

# Tests of HTS switch on GOLEM tokamak

- Background:
  - 3 types of power supply for Golem HTS: inductive, DC PS, capacitor bank.
  - Simplification of PS on Golem: operate HTS coil without any current supply.
- Scope and Method:
  - Install a HTS short-cut above the level of liquid N
  - After energising the coil with DC PS, add LN to make the shortcut superconducting and switch off the PS
  - Let the current decay and measure the decay time.
- The next step may be installation of heated short-cut which will operate after the heating is switched off.

# Characterise resistivity dependence of HTS coils on current.




- Background: Previous observation showed sudden increase in HTS resistivity above 250-300A of HTS current.
- Goal: To get more detailed data at the point of transition.
- Goal: To understand conditions and consequences of current quenches.

# Installation and investigation of RF pre-ionisation on GOLEM tokamak

- Background: RF pre-ionisation is a tool to to reduce AC losses during current ramp-up in HTS coils.
- Scope: to install a low-power magnetron at the EC fundamental harmonics for the toroidal field of 0.1T at 2.45GHz, 800W injected power.

# References I



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


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http://golem.fjfi.cvut.cz, 2007.


V. Svoboda, B. Huang, J. Mlynar, G.I. Pokol, J. Stockel, and G Vondrasek.
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*Fusion Engineering and Design*, 86(6-8):1310–1314, 2011.