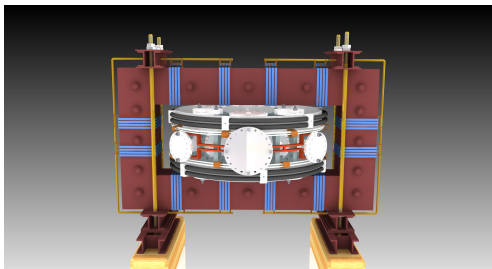


Golem 2009

Vojtěch Svoboda

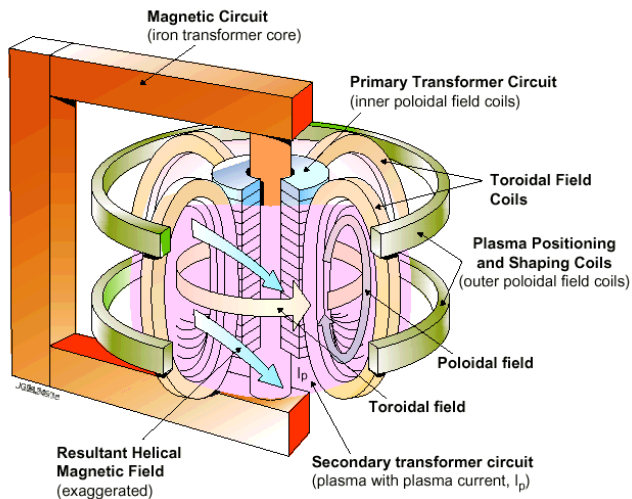
28. ledna 2010



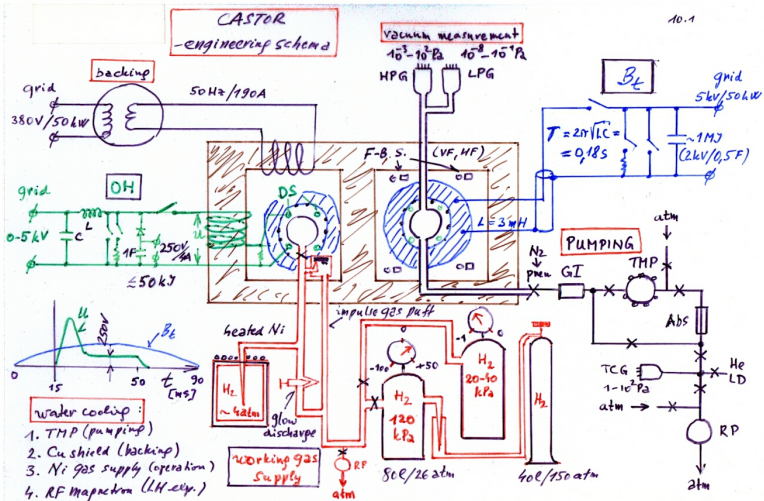
Outline

- 1 Introduction
- 2 Milestones
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Magnetic confinement - Tokamak



Engineering scheme of the GOLEM tokamak

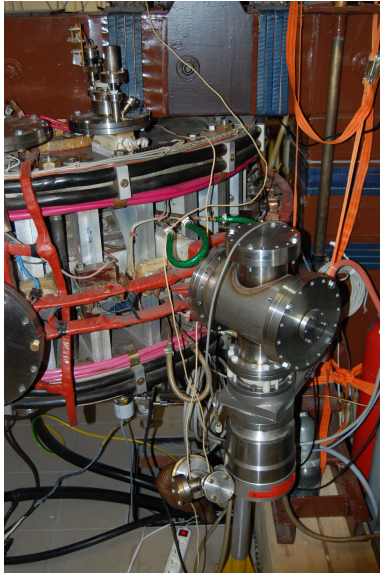


Outline

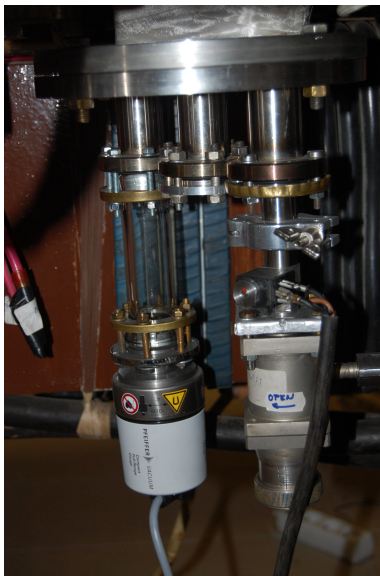
- 1 Introduction
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- Vacuum.
- Energetics: capacitor banks for B_t & E_t .
- Control system.
- DAS.

Vacuum - pumping



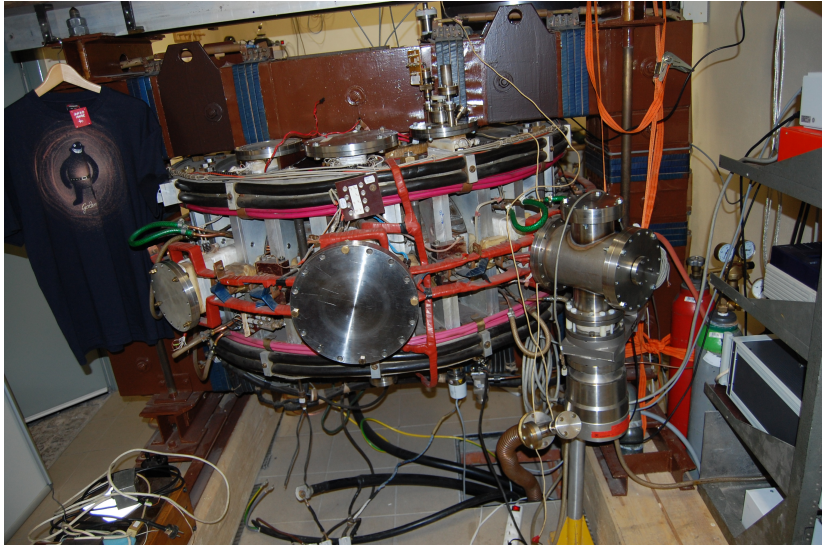
Vacuum - measurement



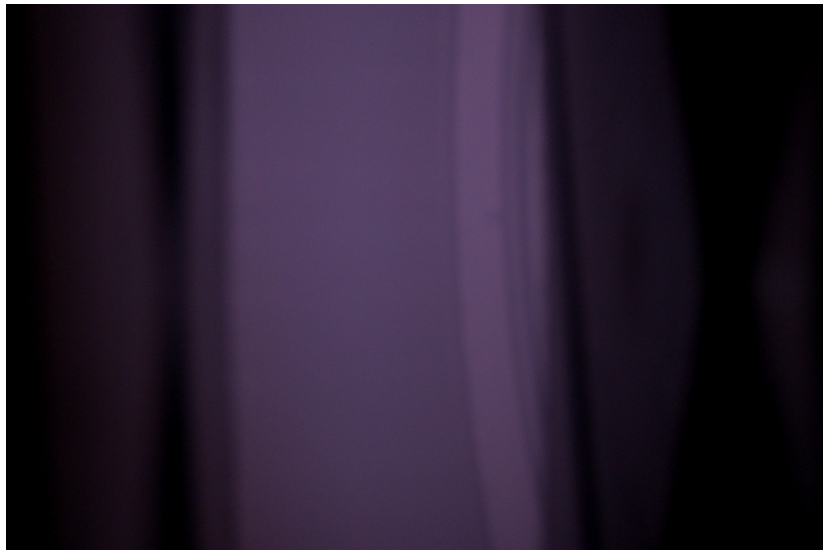
Panel



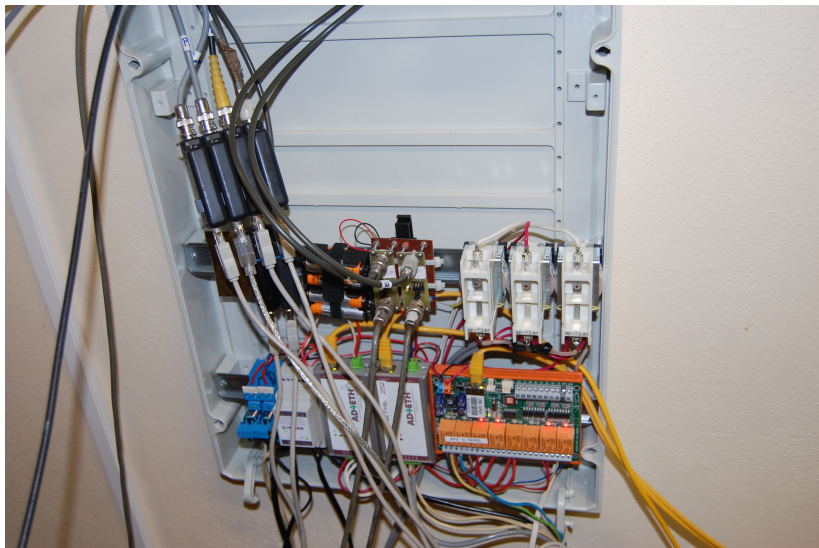
Baking



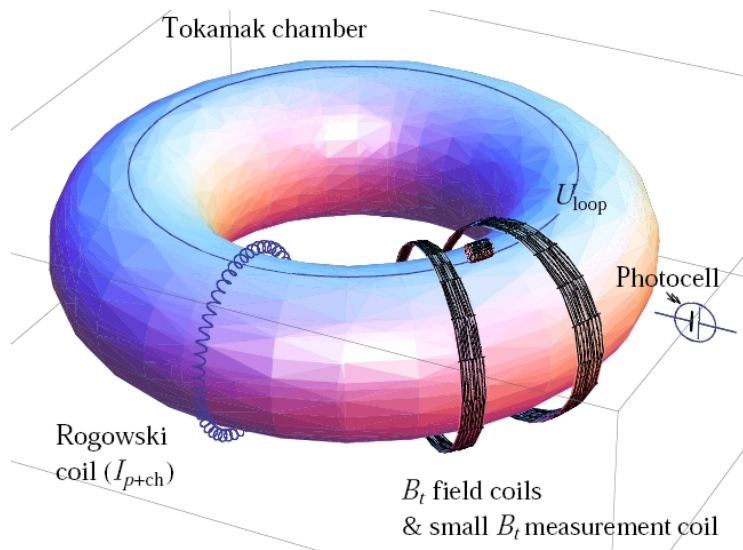
8th June 2009: Golem first plasma - glow discharge



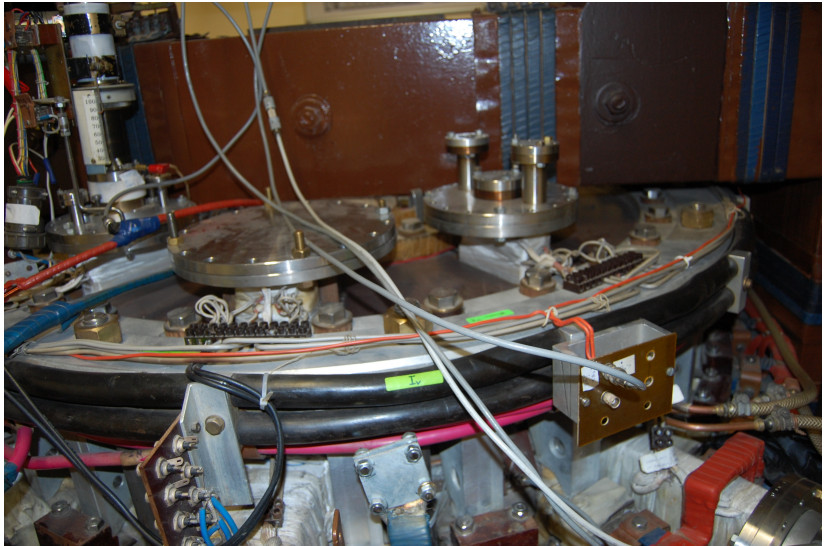
Control system DAS & trigger



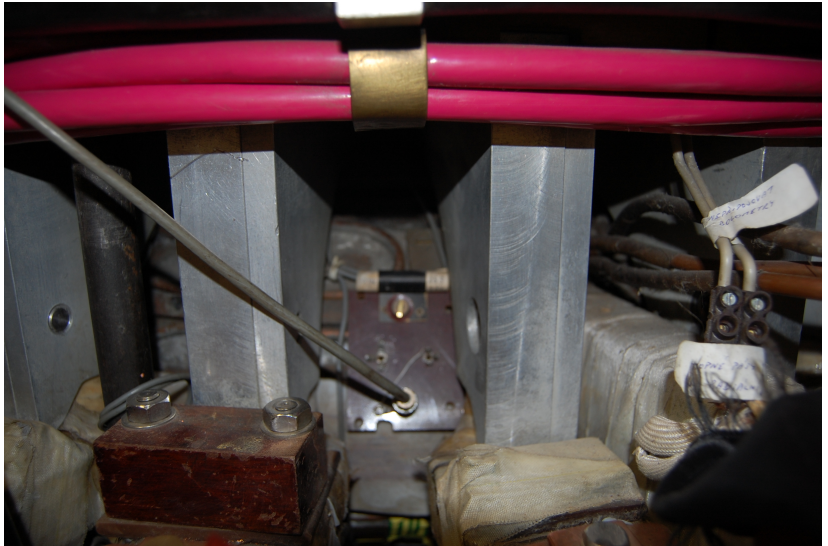
Basic plasma diagnostics in tokamak GOLEM



Loop voltage U_{loop}



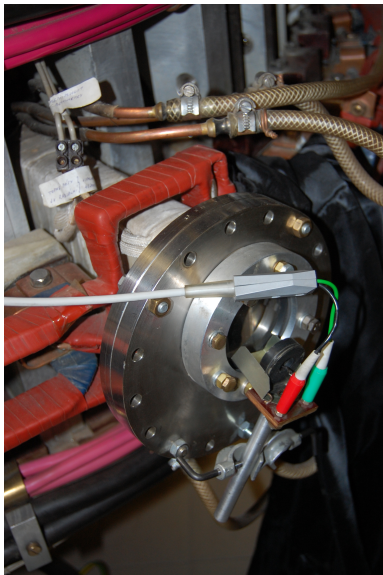
DAS No:2 Magnetic field B_t



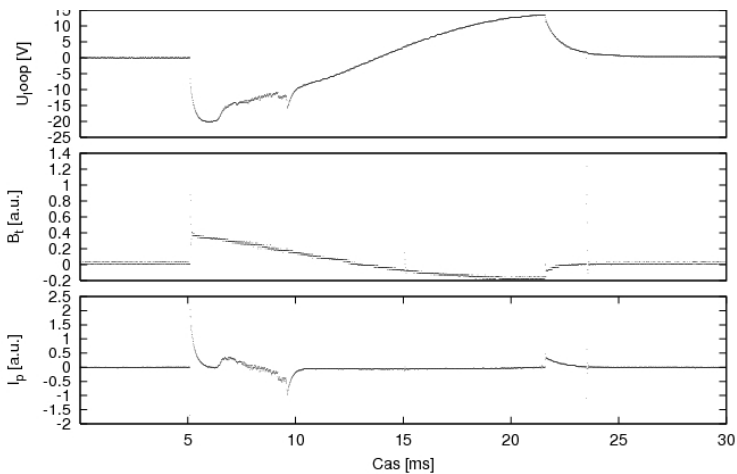
DAS No:3 Plasma current I_p



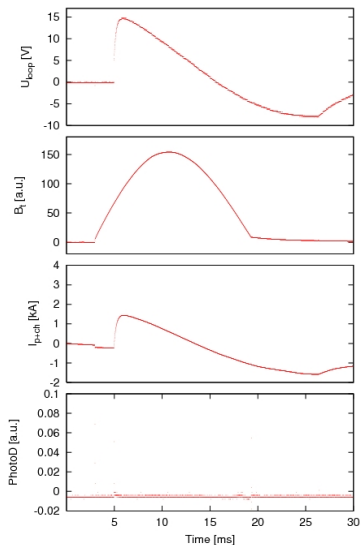
DAS No:4 Plasma radiation in the visible part of spectrum



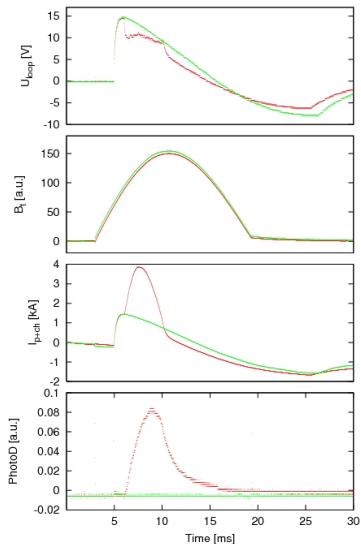
9th July 2009: Golem first tokamak plasma



DAS without working gas (no discharge)



DAS plasma discharge with working gas



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Remote handling

4 parameters to change: $U_{C_{Bt}}, U_{C_{Et}}, \tau_d, p_{H2}$

- Web interface.
- SSH/Putty `golem@fjfi.cvut.cz .. makefile`
- offline batch file

Web interface - control room

Welcome to the remote control room of the GOLEM tokamak

- Select H₂ pressure (approx.): mPa &
- Select voltage of the capacitor bank for the toroidal magnetic field B_t in the range of (400..1000)V: U_{C_Bt}=
- Select voltage of the capacitor bank for the ohmic heating (OH) in the range of (100..700)V: U_{C_Et}=
- Select the time delay between B_t and OH (0..10000) [us]: T_d=

ShotNo: 1645 : H2 filling,

Batch tokamak control (ssh/putty)

firsttrial: #without hydrogen

```
make shot Ue=400 Ub=400 Td=2000 H2filling=0 pH2=68
```

scndtrial: #with hydrogen

```
make shot Ue=400 Ub=400 Td=2000 H2filling=1 pH2=66
```

H2seq:

```
make shot Ue=400 Ub=400 Td=2000 H2filling=0 pH2=66
```

```
make shot Ue=400 Ub=400 Td=2000 H2filling=1 pH2=66
```

```
make shot Ue=400 Ub=400 Td=2000 H2filling=1 pH2=68
```

```
make shot Ue=400 Ub=400 Td=2000 H2filling=1 pH2=70
```

```
make shot Ue=400 Ub=400 Td=2000 H2filling=1 pH2=72
```

```
make shot Ue=400 Ub=400 Td=2000 H2filling=1 pH2=100
```

firstloop:

```
for Ue in 'seq 300 100 700'; do
```

```
    make shot Ue=$Ue Ub=400 Td=2000 pH2=68 H2filling=1;
```

```
done;
```


Remote handling - promotions

- 14th September 2009: Inauguration. Prague, Czech republic.
- 17th September 2009: first remote handling from the Institute of plasma physics, Czech Academy of Sciences.
- 22nd September 2009: first remote handling from abroad - Innsbruck, Austria.
- 24nd September 2009: remote handling from Kudowa Zdroj, Poland.
- 6th October 2009: remote handling from Nancy, France.
- 8th October 2009: remote handling from Budapest, Hungary.
- 14th December 2009: remote handling from Ghent, Belgium.
- 14th January 2010: first oversea remote handling from Costa Rica.

The third czech tokamak in operation - Tokamak.cz



Remote handling - practica

- September 2009: SUMTRAIC.
- 14th January 2010: First “heavy” measurement from abroad - 70 shots. Daniel Refy & spol. from Budapest.

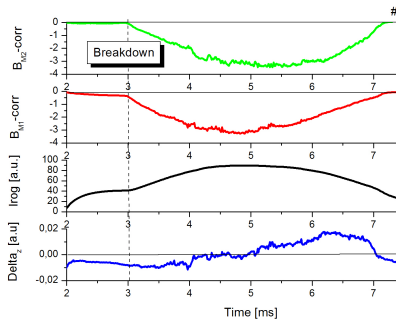
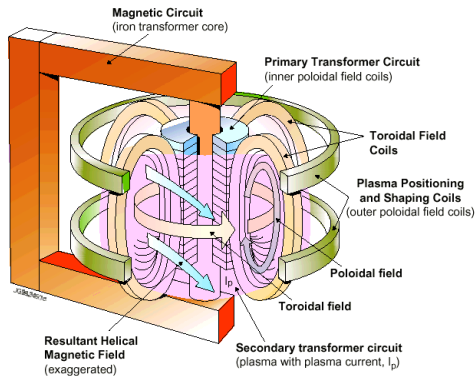
First attempts to optimize the pulse

- Parallel or antiparallel B_t & I_p orientation (Jan Stöckel contrib. thursday evening).
- Dynamic stabilization (Jindřich Kocman contrib. wednesday morning).

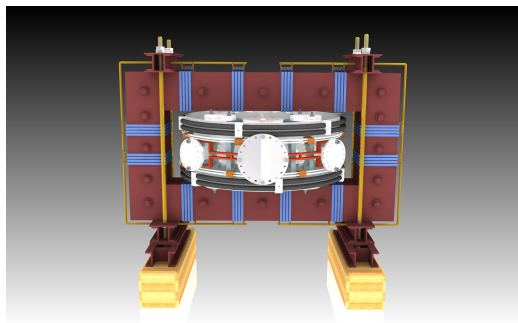
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Jindřich Kocman - plasma position control



FEL Petr Liška & Ondřej Pluhař - 3D vmrl model



- Tokamak & infrastructure room.
- Function specific behavior.
- Link to the virtual control room → virtual shots.

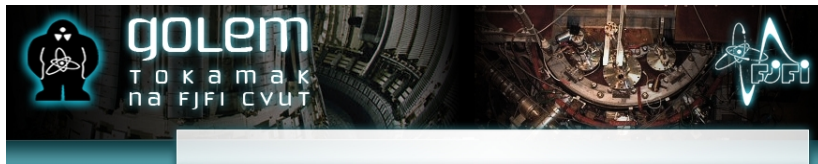
Special offer for the FTTF students

- Online/offline Golem experiments.

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- Vacuum components.
- Microwave components.
- DAS system - 48 x 1MHz channels.
- Z pinch (prof. Kubeš).
- RTG diagnostics.
- Feedback stabilization.
- Magnetic diagnostics.
- Langmuir probes.
- 2x field of bolometers.



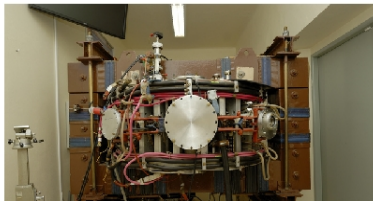
OPERATION

- CONTROL ROOM
- EXP. ARRANGEMENT
- LAST SHOT
- ARCHIVE

TM1 →
CASTOR ↔
GOLEM

- HOME
- NEWS
- HISTORY
- SCHEME

... somewhere, in the ancient cellars of Prague, there is hidden indeed „ infernal “ power. Yet it is the very power of celestial stars themselves. Calmly dormant, awaiting mankind to discover the magic key, to use this power for their benefit...



Other matters

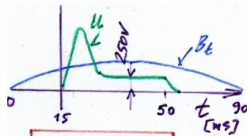
- Golem.
- Golem geocaching.
- Golem collections.
- Postcards from remote measurements

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Future

- Hunt for a better vacuum $\approx 10^{-4}$ Pa.
- Hunt for a 40 ms pulse.



- Breakdown pulse.
 - Dynamic stabilization.
 - Feedback stabilization.
-
- Preionization.
 - DAS routines.
 - FUSENET 60 kEUR?? (3 years).
 - Completing practica.
 - **Science**

Conclusions

- Golem now in operation!

References I

1 Introduction

2 Milestones

3 Operation

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6 Future milestones