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# Status of the COMPASS Tokamak Reinstallation in Institute of Plasma Physics AS CR

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## Introduction

The COMPASS tokamak, originally operated in UKAEA Culham, has recently started its operation in the Institute of Plasma Physics (IPP) AS CR in Prague, Czech Republic.

The COMPASS tokamak will be after putting in full operation in IPP Prague the smallest tokamak with a clear H-mode and ITER- relevant geometry (Fig. 1, Table 1). COMPASS is equipped with a unique fully configurable set of copper saddle coils for resonant perturbation techniques. ITER-relevant plasma conditions will be achieved by installation of two new neutral beam injection systems (2 x 300 kW), enabling co- and balanced injections. Installation of Lower Hybrid Wave system (3.7 GHz, 1 MW) is also envisaged. A comprehensive set of diagnostics focused mainly on the edge plasma is being installed. The scientific programme will be focused mainly on the edge plasma physics (H-mode studies).

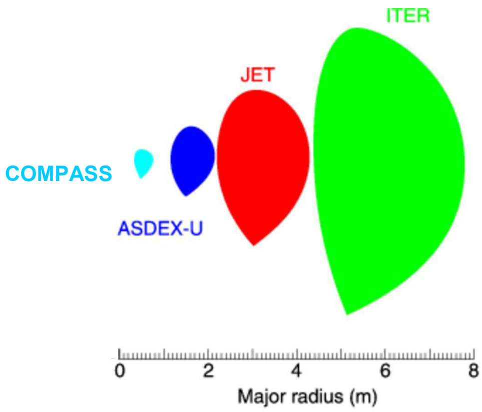


Figure 1: Comparison of plasma cross-section of tokamaks with ITER-like plasma shape.

| | |
|---|---|
| Major radius | 0.56 m |
| Minor radius | 0.2 m |
| Plasma current | <350 kA |
| Magnetic field | 0.8–2.1T |
| Triangularity | ~ 0.5 |
| Elongation | ~ 1.6 |
| Pulse length | < 1 s |
| NBI system | 2 x 0.3 MW |
| LHW system (3.7 GHz) | 1 MW |

Table 1: Main parameters of the COMPASS tokamak in IPP Prague

Presently, the COMPASS tokamak has been transported and installed into a new tokamak hall. All the main systems (power supplies, cooling, vacuum, CODAC etc.) have been designed, manufactured and commissioned. The first plasma has been generated in December 2008 and optimization of the plasma discharge is being performed presently. In this paper, we summarize and describe the present status of the tokamak and its main systems. We also briefly describe the obtained plasma parameters and performance.

**Power supply system**

The COMPASS-D tokamak required electrical input power of 50 MW for pulse duration about 2-3 s during its operation in UKAEA. Such power was accessible in Culham Laboratory directly from the 33kV grid. However, only 1 MW power is available from the 22kV grid at the campus of the Academy of Sciences in Prague, where IPP Prague is located. Therefore, several solutions to provide the necessary input power were considered. Installation of two flywheel generators was chosen as a solution (Fig 2). They will provide the necessary power (70 MW, 100 MJ) as well as a reasonable redundancy in case of a failure of one of them. The system then enables easy reconnection of the power supplies to power the tokamak only from one of the generators and operate with a reduced plasma performance.

Figure 2: Two fly-wheel generators for the COMPASS tokamak (2 x 35 MW).

**Diagnostics**

A comprehensive set of diagnostics is being installed in the COMPASS tokamak in order to meet the goals of the planned scientific programme. Most of the diagnostics are focused on the plasma edge, namely on the pedestal region. Therefore, the spatial resolution in the range of 1-3 mm is required for most of diagnostics listed below:

Diagnostics (2009)

- Magnetics (400 magnetic coils)
- Single channel interferometer
- Multichord spectroscopy (2D) $D_\alpha$, SXR, radiation losses
- Divertor probes
- 2 Fast Visible Cameras
- Li (Na, He) beam diagnostics

Diagnostics (2010)

- HR Thomson scattering – core + edge
- Edge reflectometry
- Advanced electrical probes (Tunnel probe, Ball-pen probe, etc)
- Radiometry (ECE)
- VUV spectrometer
- Neutral Particle Analyzer
- Atomic beam probe (edge current density mesurement)
- Rotation measurement

**Neutral Beam Injection heating system**

A new Neutral Beam Injection (NBI) system for additional heating and current drive will be installed in the COMPASS tokamak. It is a compact tokamak for which, due to a short trajectory of interaction between neutrals and plasma, the NBI power, energy and geometry is chosen carefully. NBI will provide a flexible heating and current drive system, which will consist of two injectors with particle energy 40 keV and 300 kW output power in deuterium, delivering approximately 600 kW of total power to the plasma. The basic configuration shown in Fig. 3 (left) is optimized for plasma heating.

The tangential injection is also optimal for absorption due to the longest passage through the plasma achievable on COMPASS. Both beams are aimed in co-direction with respect to the plasma current to minimize the orbit losses.

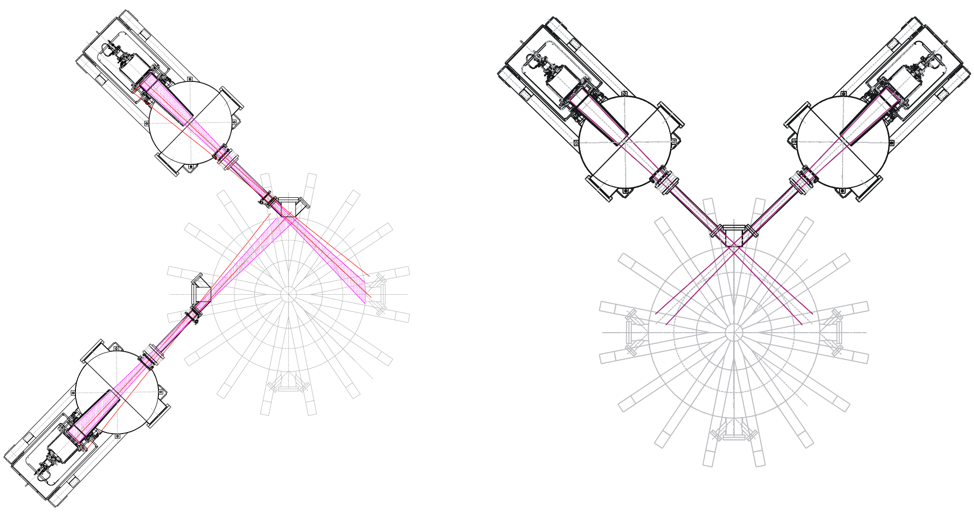

Figure 3: Top view on the NBI system layout. Left: co-injection, right: balanced injection

For balanced injection both injectors will be located at the same port, aiming in co- and counter-current directions as shown in Fig. 3 (right). With proper power modulation to compensate different orbit losses for co- and counter- beams, one can obtain NBI rating scenario with minimum momentum input.

**First plasma discharges**

Presently, the plasma performance is limited to the $B_T < 1$ T and lack of position stabilization. Main effort was devoted to study of the plasma breakdown and minimization of the necessary loop voltage. Typical plasma parameters during these studies are shown in Fig. 4. Figs 5 show the fast camera images in visible range of different phases of the shot - flat top phase and disruptions.

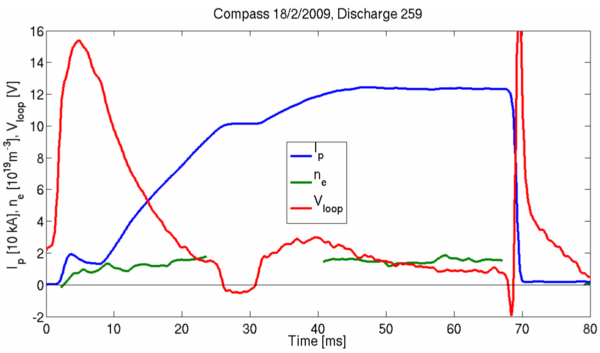


Figure 4: Temporal evolution of the loop voltage, plasma current and the line average density .

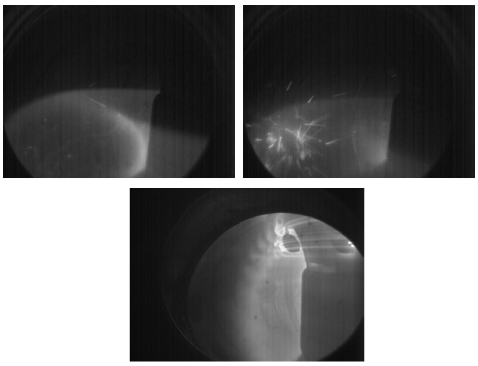

Figure 5: Images form the fast camera in the visible range – flat–top phase, and plasma disruption

**Conclusion**

The COMPASS tokamak has been recently put in operation and will reach the full plasma performance by end of 2009. COMPASS with NBI heated H-mode plasma will be - together with JET and ASDEX-U - one of few tokamaks with highly ITER relevant plasmas. COMPASS will allow, due to its size, a highly flexible, fast and low-cost implementation of technical modifications and programmatic adaptations if needed to optimize ITER relevant results. Therefore the device is particular suited for the exploration of novel regimes or concepts (such as the investigation of ELM mitigation by using saddle coils).