

Short oral ID #19: Status and further development of the Trigger Time Event system for fusion experiment Wendelstein 7-X

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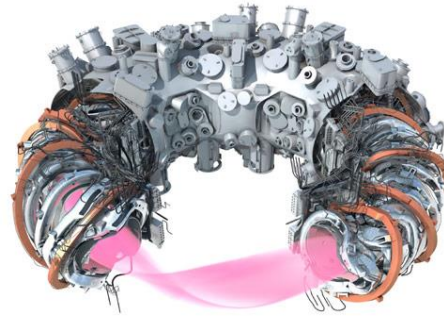
Outline

- **Introduction**
- **Status of Wendelstein 7-X**
- **TTE system**

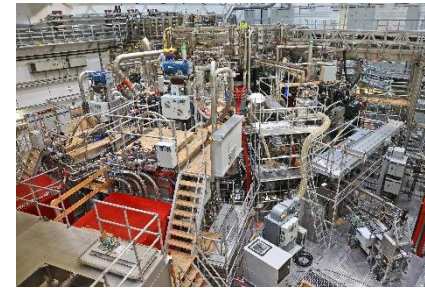
Introduction: W7-X operation status

Status of the superconducting stellarator experiment W7-X :

- 4 operational phases have been successfully completed, in which a total of 6,559 plasma discharges with a total plasma time of 473 min have been generated.
- The next operational phase (OP2.2) will begin with scientific plasma operation in September 2024.
- Commissioning of the Wendelstein 7-X facility has been underway since the beginning of 2024.
- The first plasma discharge in OP2.2 will be in June 24.
- The Trigger Time Event (TTE) system of W7-X as part of the CoDa system has functioned successfully during the operating phases to date.



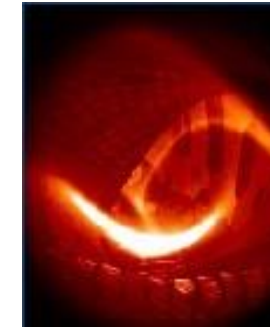
CAD model of W7-X



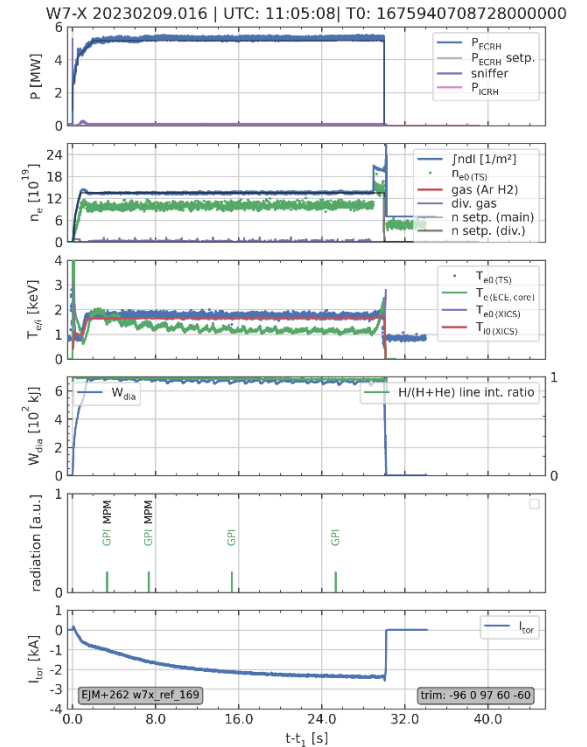
View on W7-X in the torus hall



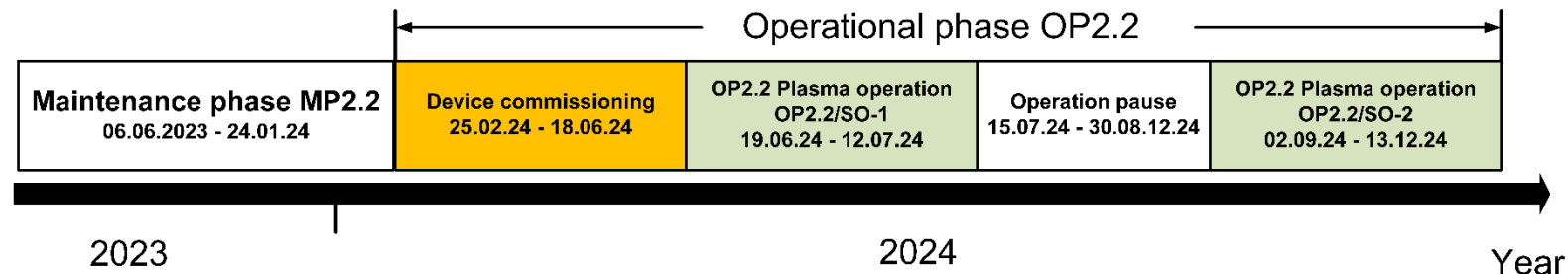
W7-X control room



Plasma discharge



High power plasma discharge in OP2.1:
(high power 5 MW / 30 s / 170 MJ)

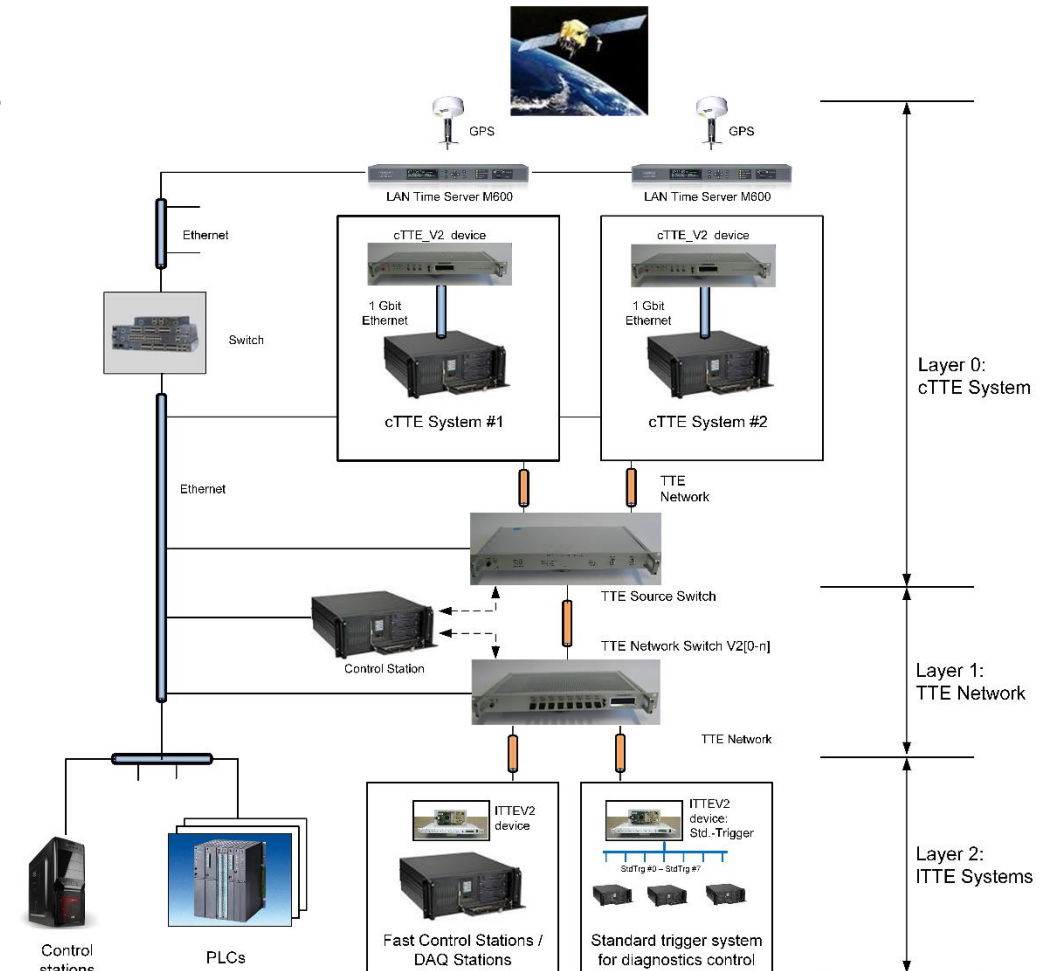


TTE system functions

Functions of the TTE system:

- I. Generation of a global time for all CoDa components of W7-X,
- II. Synchronization of all local time counters of the ITTE systems of the technical components and diagnostics,
- III. Providing event messages processing and standard trigger signals,
- IV. Providing time and trigger related functions like:
 1. Time capturing,
 2. Pulse sequence generation,
 3. Time delays,
 4. Impulse counter,
 5. Event message / trigger signal processing.

TTE system architecture

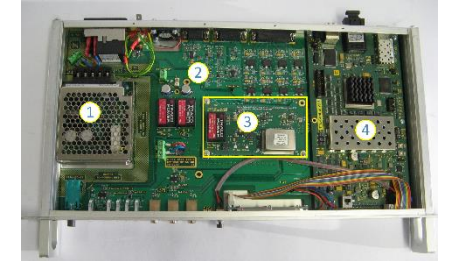


TTE system modifications / updates

- **Development of a new cTTE_V2 device:**
 - Based on ITTEV2 FPGA card,
 - 1 Gbit/s Ethernet interface,
 - Oven stabilized controllable oscillator,
 - Bidirectional optical network TTE network interface:
 - Send synchronization and time information,
 - Send / receive event messages,
 - Transmission delay measurement mode,
- **Update FPGA configuration of ITTE_V2 device:**
 - Bug fixing,
 - New pulse sequence generator device,
- **TTE network switch device:**
 - 8 uplink ports,
 - 1 downlink port,
- **IRIG-B converter device:**
 - Conversion of cTTE time information into an IRIG-B signal for synchronization of DAQ electronics.



cTTEV2 device: front view.



cTTEV2 device: top view.



TTE network switch device.



IRIG-B converter device.

Thanks for attention!

Please contact me during the poster session!

Poster session, Poster ID #19

The Trigger-Time-Event system for the W7-X Experiment

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ABSTRACT

The Trigger Time Event System is used by the control and data acquisition systems of the central control systems, the technical components and the diagnostics of W7-X for their time synchronization, for processing events and for generating and receiving trigger signals. This use cases makes it necessary to adapt the TTE system to the changing requirements of users.

After an introduction to the functions and structure of the TTE system, this contribution describes the current expansion status of the TTE system and the planned modifications and expansion of the hardware and software of the TTE system. Finally, the current status of the planned work on the TTE system for the upcoming W7-X operational phase Op2.2 is presented. The contribution ends with a summary.

FUSION EXPERIMENT W7-X

- I. The superconducting stellarator W7-X is equipped with 50 nonplanar and 20 planar coils.
- II. For plasma heating can be used: ECRH heating, Neutral Beam Injection (NBI), and Ion Cyclotron Resonance Heating (ICRH).
- III. W7-X is equipped with a large range of plasma diagnostic systems (56 diagnostics in OP2.2).
- IV. First plasma operation took place in December 2015.
- V. 4 operational phases have been successfully completed, in which a total of 6,559 plasma discharges with a total plasma time of 473 min have been generated.
- VI. The next operational phase OP2.2 will start the scientific plasma operation in September 2024.

FUNCTIONS OF THE TTE SYSTEM

- I. Generation of a global time for all CoDa components of W7-X.
- II. Synchronization of all local time counters of the ITTE systems of the technical components and diagnostics.
- III. Providing event messages processing and standard trigger signals.
- IV. Providing time and trigger related functions like:
 1. Time capturing,
 2. Pulse sequence generation,
 3. Time delays,
 4. Impulse counter,
 5. Event trigger processing.

W7-X CONTROL SYSTEM

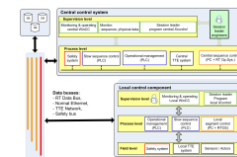


Fig. 1. W7-X control system structure

OPERATION OF W7-X

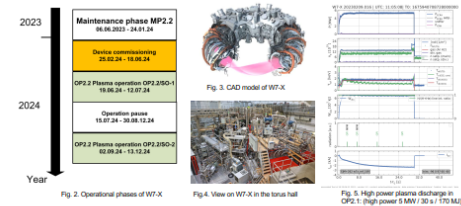


Fig. 2. Operational phases of W7-X



Fig. 3. CAD model of W7-X

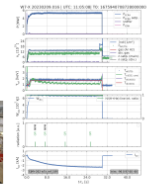


Fig. 4. High power plasma discharge in OP2.1 (high power 5 MW / 30 s / 170 MA)

TTE SYSTEM ARCHITECTURE

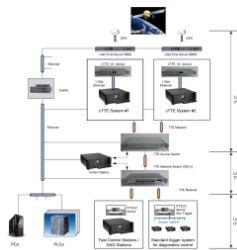


Fig. 6. Overview of TTE system architecture

NEW DEVELOPMENTS FOR THE TTE SYSTEM

- cTTE_V2 device:**
 - 19" housing,
 - Oven stabilized controllable oscillator,
 - Virtex 6-130T FPGA card,
 - Transmission delay measurement mode.
- IRIG B converter:**
 - Converts the TTE timing messages into a IRIG-B timing signal.
- TTE signal switch:**
 - Switching the cTTE transmission signal between cTTE_#0 / cTTE_#1.
- TTE network switch:**
 - 8 downlink ports,
 - Bidirectional data transmission,
 - Round Robin mode or priority mode for read out message FIFOs
- ITTE_V2 device:**
 - Redesign of Pulse Sequence Generator module,
 - Message sending also in direction of cTTE system.

TTE PROJECT STATUS

Due to the effects of the coronavirus pandemic, the original schedule for the TTE project had to be adjusted. The ITTE_V2 devices with modified FPGA program will be used in the upcoming OP2.2 operating phase. The new cTTE_V2 devices and TTE network switching devices will first be extensively tested in an test setup. The central TTE system will then be converted in the next maintenance phase MP2.3.