



# Simulation System for the Wendelstein 7-X Safety Control System

J. Schacht<sup>1</sup>, A. Wölk<sup>1</sup>, S. Pingel<sup>1</sup>, U. Herbst<sup>1</sup>, D. Naujoks<sup>1</sup>, and the W7-X Team

<sup>1</sup>Max-Planck-Institute for Plasma Physics, EURATOM Association, Greifswald, Germany

## Motivation

### Software versions for safety system

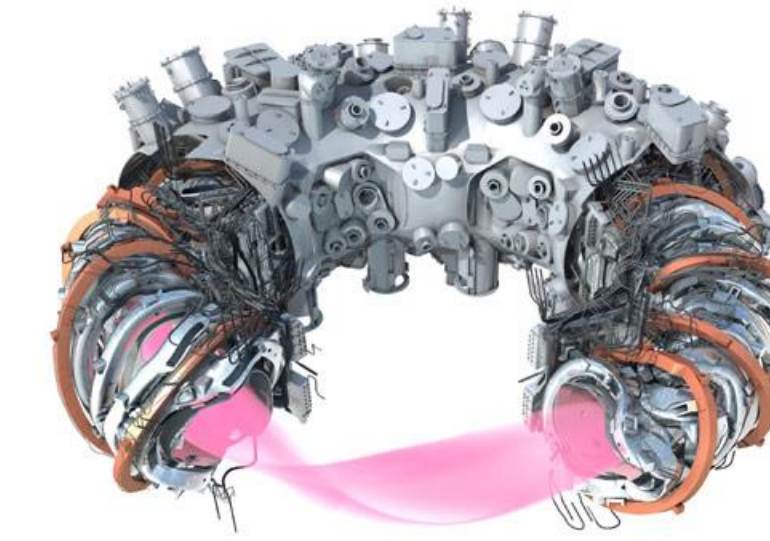
time	
March 2015	Safety software for the commissioning of the vacuum systems, cryo system and torus hall signalization
	Enhanced safety software for commissioning of superconducting magnet system
	Enhanced safety software for radiation protection
	Final software version für operation phase OP1.1
Dec 2015	Operation phase OP1.1
March 2016	Final software version für operation phase OP1.2a
July 2017	Operation phase OP1.2a
Sep 2017	Final software version für operation phase OP1.2b
Dec 2017	Operation phase OP1.2b
March 2018	Final software version für operation phase OP1.2b
Apr 2018	Operation phase OP1.2b
Dec 2018	...

The superconducting stellarator W7-X needs for a safe operation a well defined and tested safety system:

- I. The W7-X control system allows a safe and flexible control of preparation and conducting of discharges.
- II. For every new operation phase an enhanced version of the central safety system (cSS) is necessary.
- III. The effort for integration tests and validation of the software for cSS is very high.
- IV. A simulation system allows developing and testing the safety software before commissioning and helps to meet the high quality requirements.

A simulation platform for the cSS was introduced for integration tests and validation of the cSS software for the operation phase OP1.2b.

### W7-X in operation



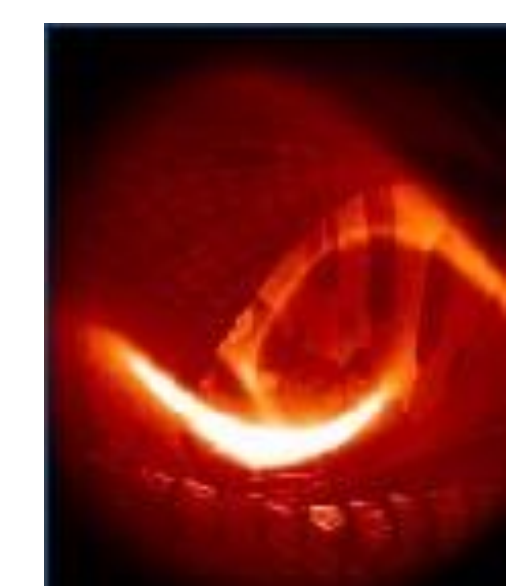
CAD model of W7-X



View on W7-X in the torus hall



German chancellor Dr. Merkel started the first H2-plasma discharge



Video of the first H2-plasma discharge (3. February 2016)

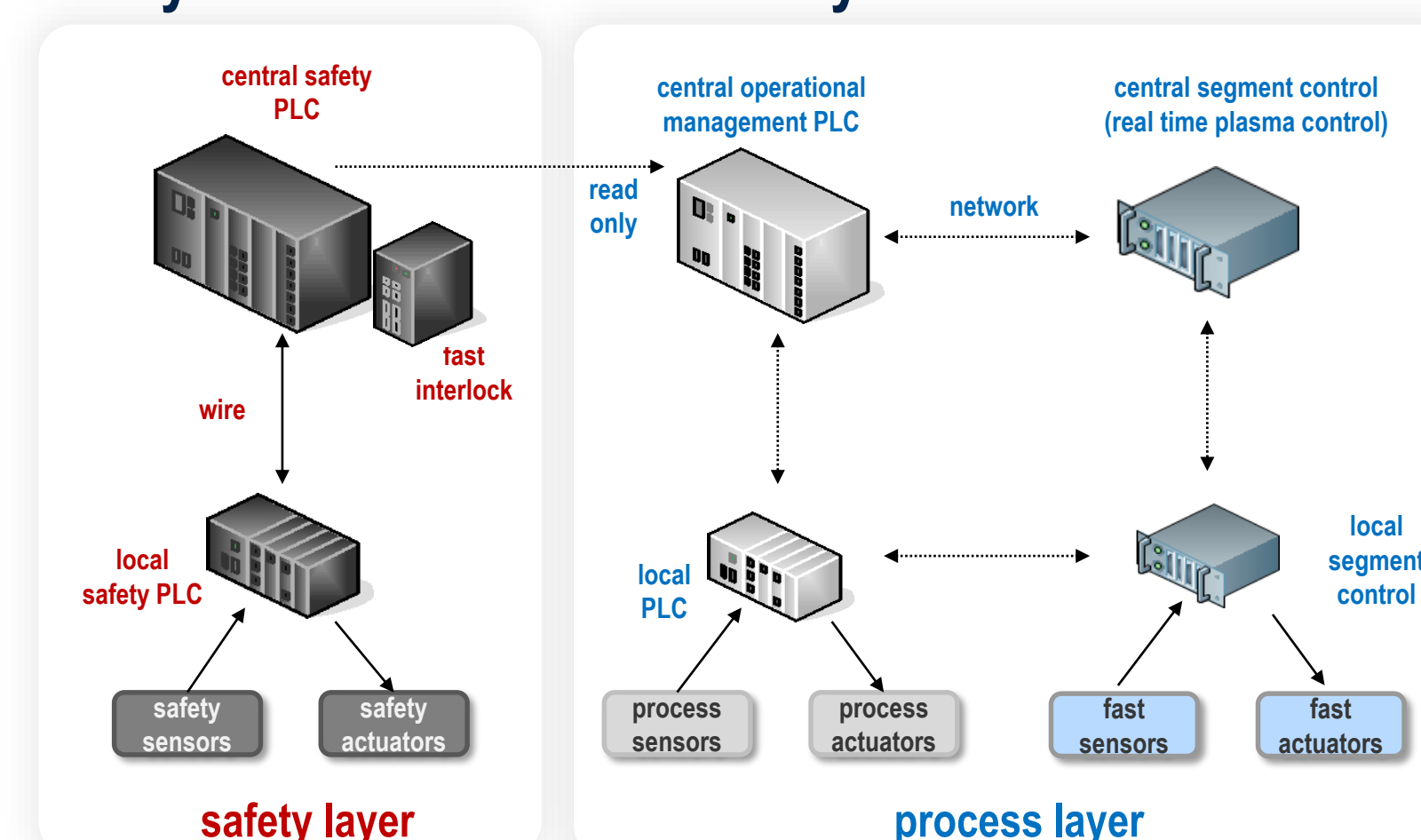
## Safety-System Overview

### Safety system architecture

#### Functions of the safety system:

- I. Ensures personal safety and investment protection,
- II. Supervision of access control into the different zones of the radiation protection area,
- III. Emergency stop system,
- IV. Control of the safety states of W7-X,
- V. Signalization (warnings and alarms),
- VI. Realization of safety functions:
  - personnel safety,
  - device protection,
- VII. Communication interfaces:
  - Central Operation Management (cOPM) (Ethernet),
  - Fast Interlock System (Ethernet),
  - Control components (safety signal interface),
  - Data archive (Ethernet),

#### Layers of the W7-X control system



Redundant safety PLC and Profibus-Safe fibre ring lines



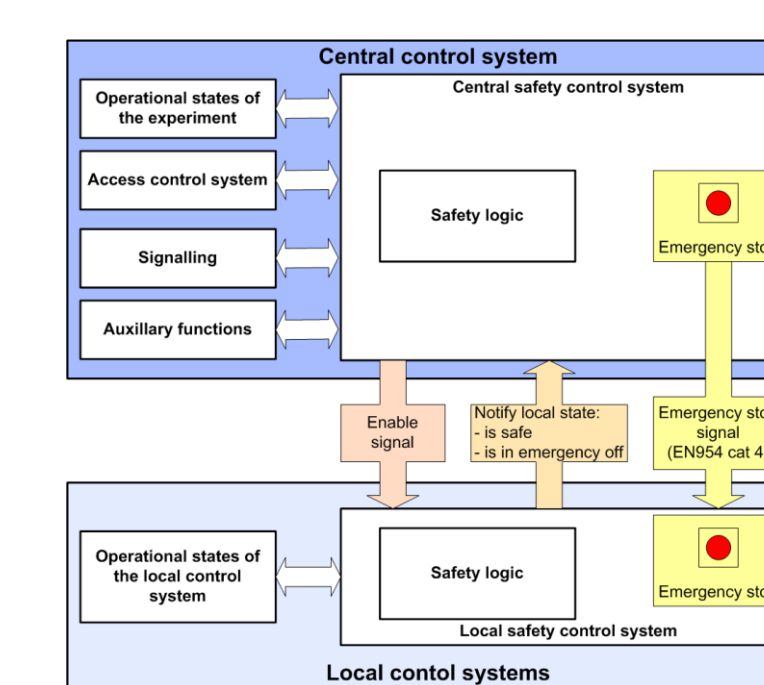
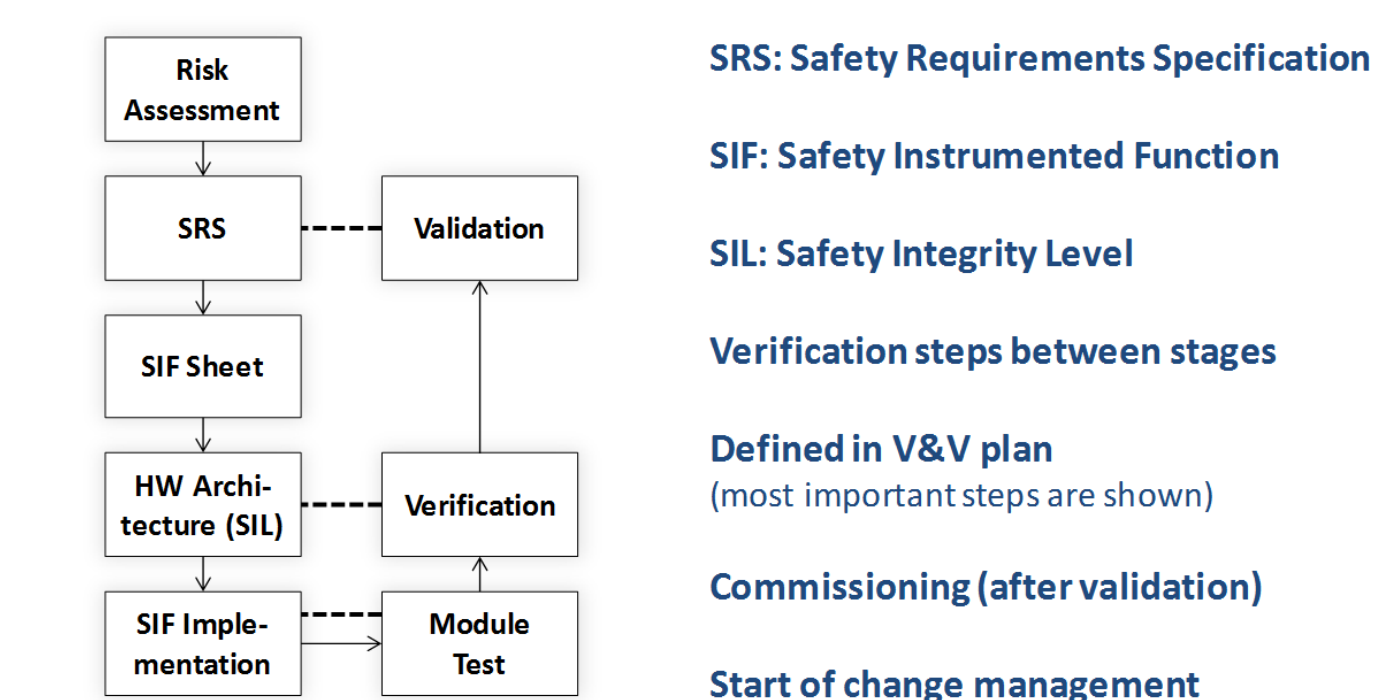
Cabinet for cSS signal interfaces



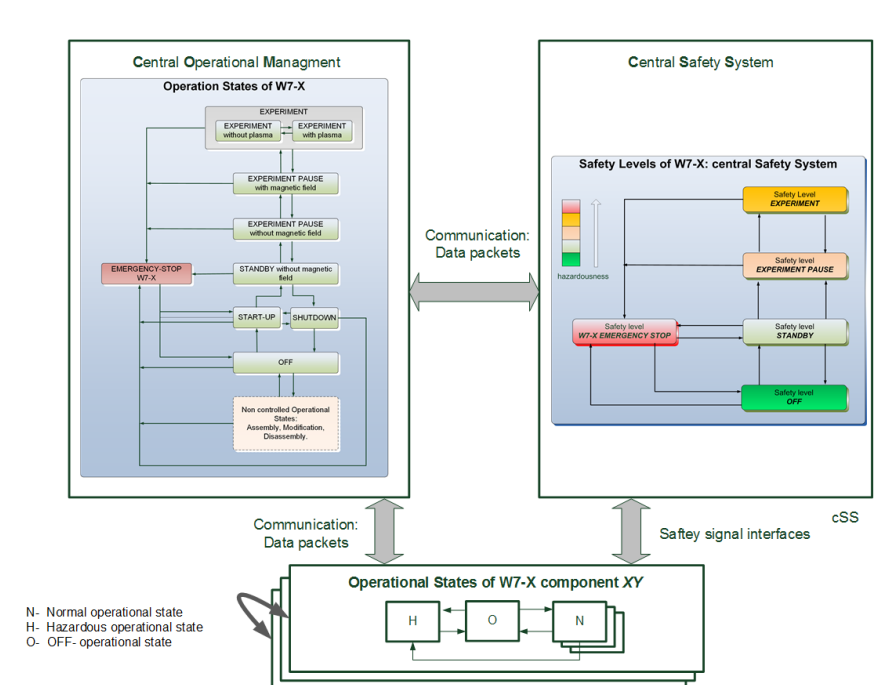
Emergency stop switch and signalization in the torus hall

#### Development process

Definition phase for functional safety along EN/IEC 61511:  
„Functional safety - Safety instrumented systems for the process industry sector“



Interfaces of the safety logic of cSS

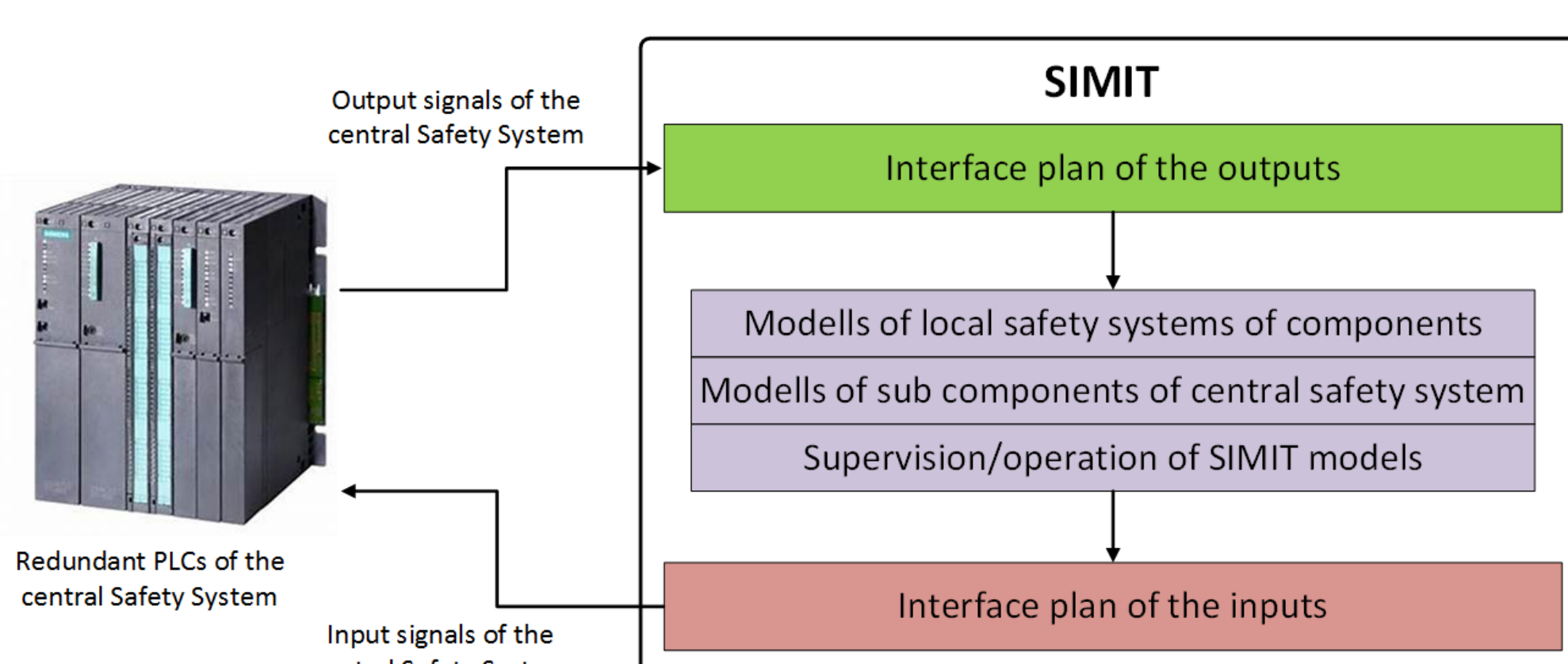


Finite state machines for operational states (cOPM) and safety states (cSS)

## SIMIT based simulation platform for the W7-X safety system

#### Architecture of SIMIT (Fa. Siemens):

- **Modeling system:**  
The simulation models are created and the interfaces to the coupled partners are configured in the modeling system.
- **Control system:**  
The simulation model runs in the control system. The simulation model communicates with the coupled safety program of redundant PLCs of the cSS simulation platform.

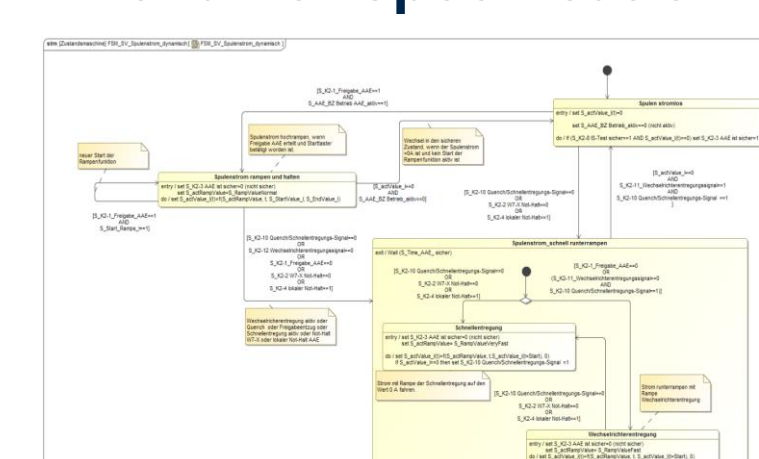


Architecture of SIMIT simulation platform

#### Realization:

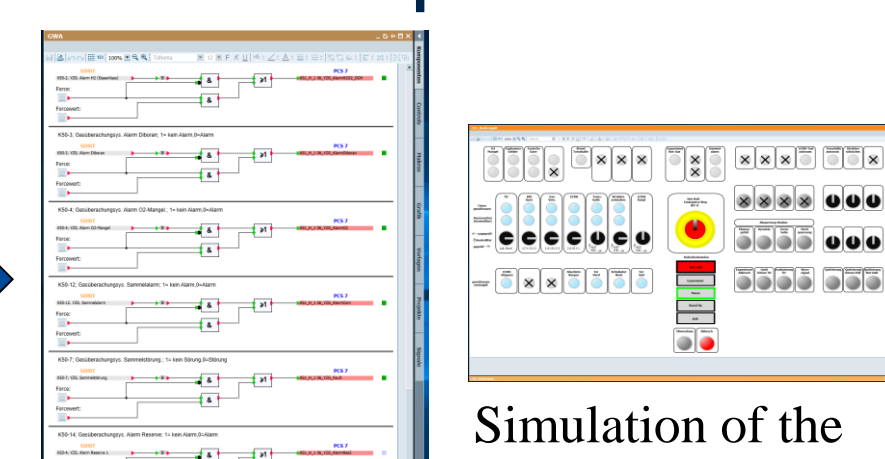
- Installation of a simulation system, consisting of:
  - 2x PLC S7-417,
  - Profibus safe network and profibus coupling device,
  - Windows PC equipped with SIMIT V9.0
  - Processing of about 2000 safety Input/Output signals,
  - Implementation of simulation models for:
    - 21 technical components,
    - 5 operation diagnostics (e.g. laser systems),
    - 12 diagnostics,
    - Signalization, access control, gas warning system, ...

#### Behavior specification



Finite state machine for the control of power supplies of magnet system

#### SIMIT implementation

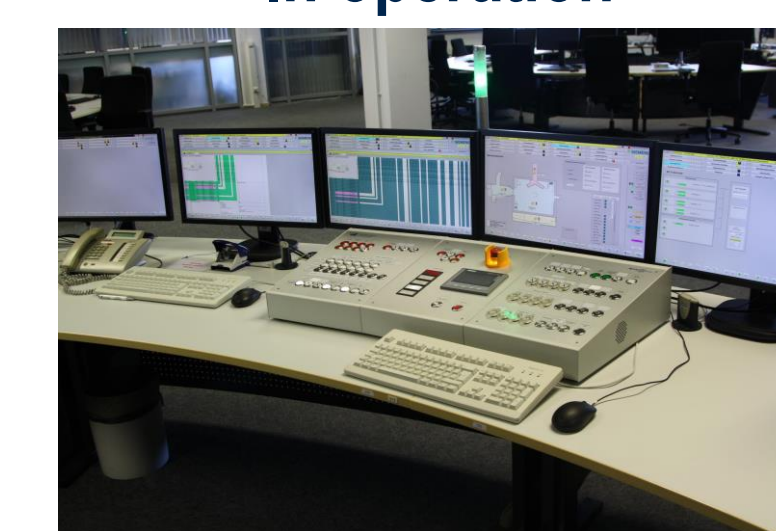


SIMIT graphical program chart

#### Results:

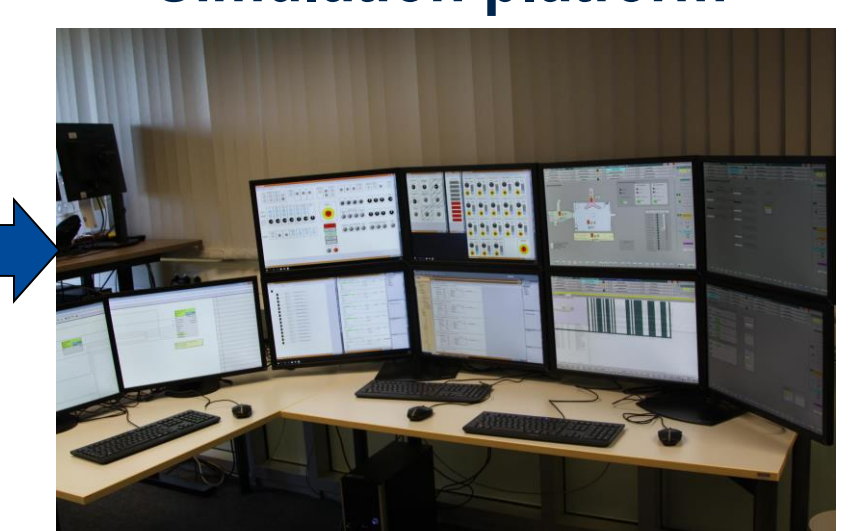
- W7-X operation and safety software development are possible at the same time,
- Early detection and correction of configuration and software errors,
- Shorter commissioning period due to:
  - a tested configuration,
  - extensively tested software,
- Significantly reduced on site debugging,
- Education of the cSS operators,

#### In operation



cSS operator workplace in W7-X control room

#### Simulation platform



cSS-SIMIT workplace with: WinCC operator stations, PCS-7 engineering stations, SIMIT operator stations.