XFEL Special Diagnostics Devices

(WP18)

Rack Installation Requirements in the Injector (XTIN)

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Abstract

This document presents the status of the rack installation planning for the WP18 Special Diagnostics devices in the XFEL Injector. Locations and size of vacuum components, required rack space for electronics, and AC power and cooling requirements are summarized.

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1. Injector Overview

All WP18 Special Diagnostics devices that will be installed in the injector will be located in XTIN TGA room UG07/R008. A schematic of this part of the injector is shown in Fig. 1. The following WP18 Special Diagnostics devices are foreseen: 1 BAM, 1 EOD, 1 TDS and 2 kickers for TDS screen station. Space for electronics in the injector was originally not foreseen and is very limited. However, the front-end electronics for the BAM and EOD needs to be placed in close proximity to the vacuum components (distance < 1 m). The position of the racks is preliminary as the placement and size of supports and girders has not been decided yet. Special 12U/16U rack containers for installation in the injector are described in a technical specification (Specification: Special 12U/16U rack containers, W. Wierba, K. Oliwa and C. Gerth, EDMS D00000002193921).

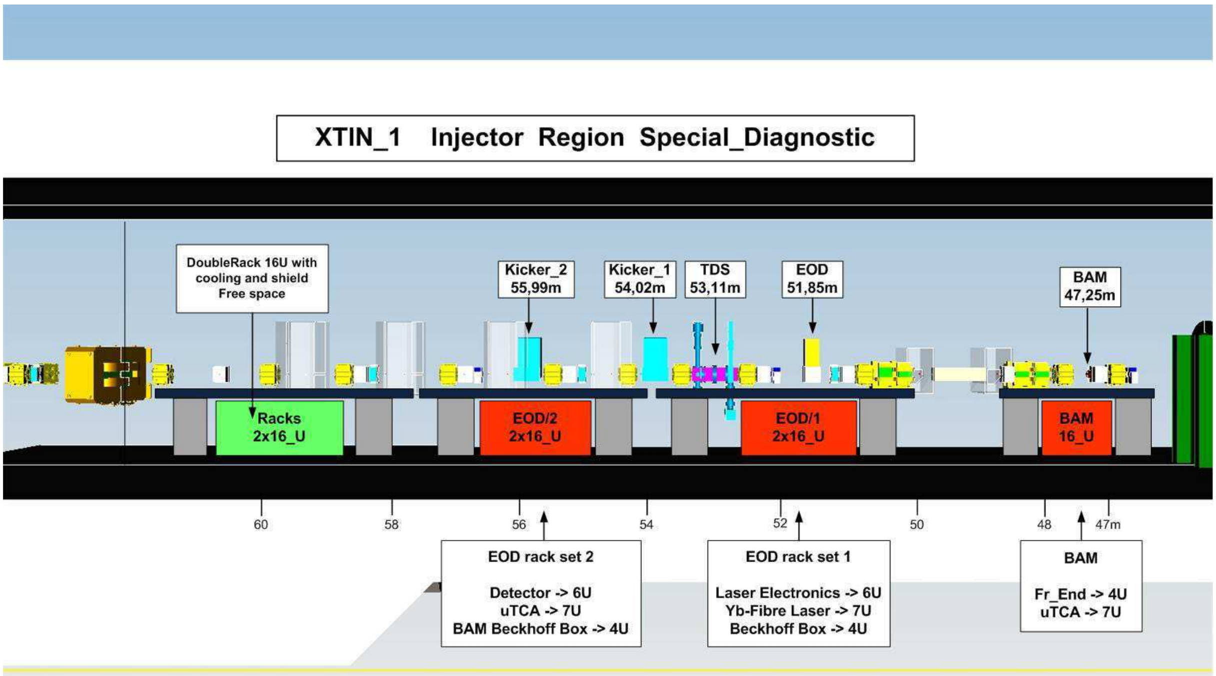

Fig. 1. Injector region overview.

2. BAM_1 (Bunch Arrival Monitor)

The length of the vacuum component (BAM pick-up) is < 150 mm.
The BAM_1 z position is 47.2 m in XTIN UG07/R008.

2.1 Location and Space for electronics

There will be 4 RF signal cables going from the BAM pick-up to the electronic racks. The length of the signal cables has a major impact on the time resolution and should not exceed 1 m. This requirement can only be fulfilled if the electronic racks are located directly underneath the BAM pick-up. The shortest possible signal cables will then be $l < 1$ m.

The BAM_1 needs 15U space for electronics. It will consist of:

- Front-end electronics (link box) ñ 4U
- µTCA crate ñ 7U
- Beckhoff control (Stepper Motor Driver) ñ 4U

The space for racks is foreseen at $z = 47$ m.
The Beckhoff control box could be located at larger distance (e.g. rack room XTIN UG05/R011).

2.2 AC Power and Cooling

Foreseen AC power consumption is 1.3 kW. The cooling power is 1.3 kW.

2.3 Master Oscillator and Synchronization

The front-end electronics (link box) will be connected to 4 fibre optical cables from the master laser oscillator (MLO).

3. EOD_1 (Electro Optical Detector)

The length of the vacuum component is 110 mm.
The EOD_1 *z* position is 51.8 m in XTIN UG07/R008.

3.1 Space for electronics

The EOD needs 30U space for electronics. It will consist of:

- Laser electronics ñ 6U
- Yb-fibre laser ñ 7U
- Detector ñ 6U
- Beckhoff control (Stepper Motor Driver) ñ 4U
- µTCA crate ñ 7U

For this device the length of the optical fibre (1*PM) from the Yb-fibre laser to the vacuum unit is crucial (< 2 m). For the proposed position of electronic racks, the length of fibre optics will be less than 2 m (estimated). The detector (2*SM) and µTCA crate could be located at slightly larger distance (< 10m). The Beckhoff control (incl. stepper motor drivers, etc.) could be located at larger distance (e.g. rack room XTIN UG05/R011).
The space for racks is foreseen at $z = 51$ m.

3.2 AC Power and Cooling

Foreseen AC power consumption is 2 kW. The cooling power is 2 kW.

3.3 Master Oscillator and Synchronization

The EOD laser electronics requires 1.3 GHz and 54 MHz from the master oscillator.

4. TDS (Transverse Deflecting Structure)

The length of the TDS is 700 mm from flange to flange.
The TDS *z* position is 53.1 m in XTIN UG07/R008.

4.1 Space for electronics

All additional TDS equipment (e.g. LLRF system, klystron, modulator, etc.) will be placed in XSE 5^{th} floor (XSE UG05/R022). For this device the length of signal cables is not critical as drifts will be corrected by a slow feedback. There will be ~3 coax cables from the TDS to the electronics rack (XSE UG05/R022 or XTIN UG05/R011).
The temperature control to stabilize the TDS at 45∞C can be placed in XSE UG05/R022.

4.2 AC Power and Cooling

Foreseen AC power consumption for TDS electronics is 1.5 kW and the cooling power is 1.5 kW.
Foreseen AC power consumption for Klystron and Modulator is ~15 kW and the cooling power is ~15 kW.
Foreseen AC power consumption for high-power RF electronics is 2 kW and the cooling power is 2 kW.

4.3 Infrastructure Requirements

The TDS LLRF system (XSE 5^{th} floor) requires 1.3 GHz from the master oscillator.

5. KICKER_1

The length of the vacuum component is 450 mm from flange to flange.
The KICKER_1 *z* position is 54.0 m in XTIN UG07/R008.

5.1 Space for electronics

The HV pulser needs to be located in close vicinity to the beamline and directly attached to the kicker in order to achieve a small inductivity.

The KICKER_1 needs 26U space for electronics. It will consist of:

- 2 Power Supplies ñ 6U
- 2 Controllers ñ 6U
- 2 µTCA crate ñ 7U

All electronics will be placed in XTIN UG05/R011.

5.2 AC Power and Cooling

Foreseen AC power consumption is 4 kW. The cooling power is 4 kW.

5.3 Master Oscillator and Synchronization

None.

6. KICKER_2

The length of the vacuum component is 450 mm from flange to flange.

The KICKER_2 *z* position is 56.0 m in XTIN UG07/R008.

6.1 Space for electronics

The HV pulser needs to be located in close vicinity to the beamline and directly attached to the kicker in order to achieve a small inductivity.

The KICKER_2 needs 26U space for electronics. It will consist of:

- 2 Power Supplies ñ 6U
- 2 Controllers ñ 6U
- 2 µTCA crate ñ 7U

All electronics will be placed in XTIN UG05/R011.

6.2 AC Power and Cooling

Foreseen AC power consumption is 4 kW. The cooling power is 4 kW.

6.3 Master Oscillator and Synchronization

None.

7. Rack Occupation

The proposed rack occupation is presented in Fig. 2.

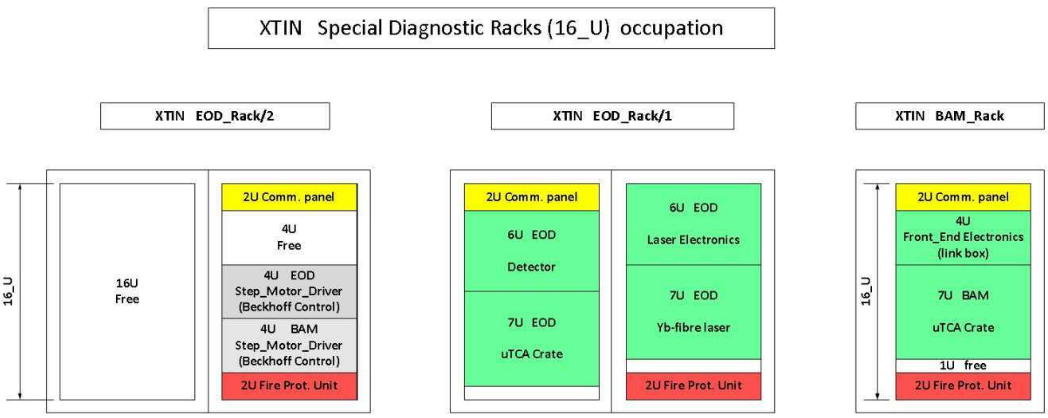

Fig. 2. Proposed Special Diagnostics rack occupation in the injector.

Rack space in EOD_Rack/2 could be used by other groups or the rack could become obsolete if the Beckhoff control boxes would be located at larger distance (e.g. rack room XTIN UG05/R011).

8. 3D Placeholder

The proposed position of Special Diagnostics racks (placeholders) in injector complex has been implemented in Solid Edge 3D model and send to Thorsten Stoye (QA) for implementation in Global XFEL 3D model. The isometric view of injector complex is shown in Fig. 3.

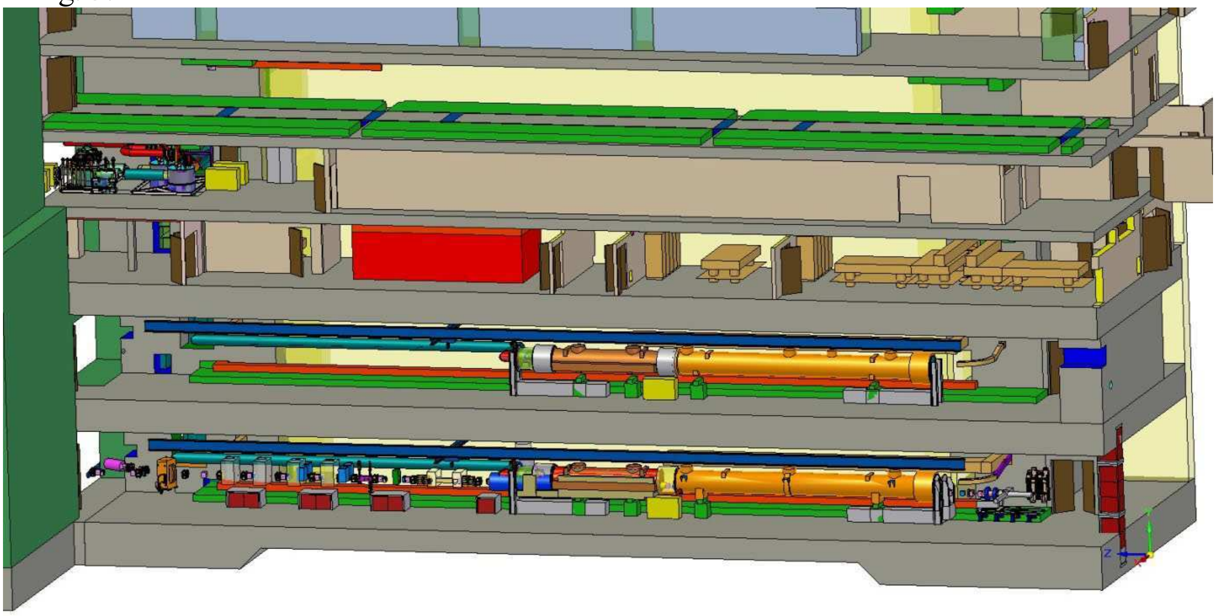

Fig. 3. Isometric view of Special Diagnostics racks implemented in injector 3D model.

9. Radiation Shielding

There is not enough space in the injector in order to shield the special 16U electronic racks using 10 cm thick heavy concrete shielding. It is necessary to design a very compact and thin radiation shielding, most probably based on lead. The maximum thickness of such a shielding should not exceed 25 mm.

The radiation shielding should avoid radiation damages and SEU (Single Event Upset) to the electronics over a few years of operation. The heavy concrete radiation shielding which is under design for XFEL linac sections L1, L2 and L3 cannot be used as it is too thick.

The standard operation dose in FLASH tunnel has been measured several times. The expected dose in FLASH Injector region can be estimated to be ~160 Gy in 10 years. For XFEL, we have to assume the worst case for which the dose is increased by the factor of 10: This means $1.6 * 10^3$ Gy in 10 years.

Calculations show that 10 mm of lead plus 3 mm of boron added plastic (Boron) should be sufficient radiation shielding for gamma flow factor of 1/20. In injector and bunch compressor regions of XFEL, it is necessary to have gamma flow less than 1/200. The radiation shielding for those requirements has to be designed.

We foresee that the radiation shielding will be screwed directly to the container frame (no additional support). The shielding should have openings for cables on top of the rack and some removable cover to shield the cableís meander.

The shielding should have 3 sliding doors on front and rear side. The simplified concept of such doors is shown in Fig. 4.

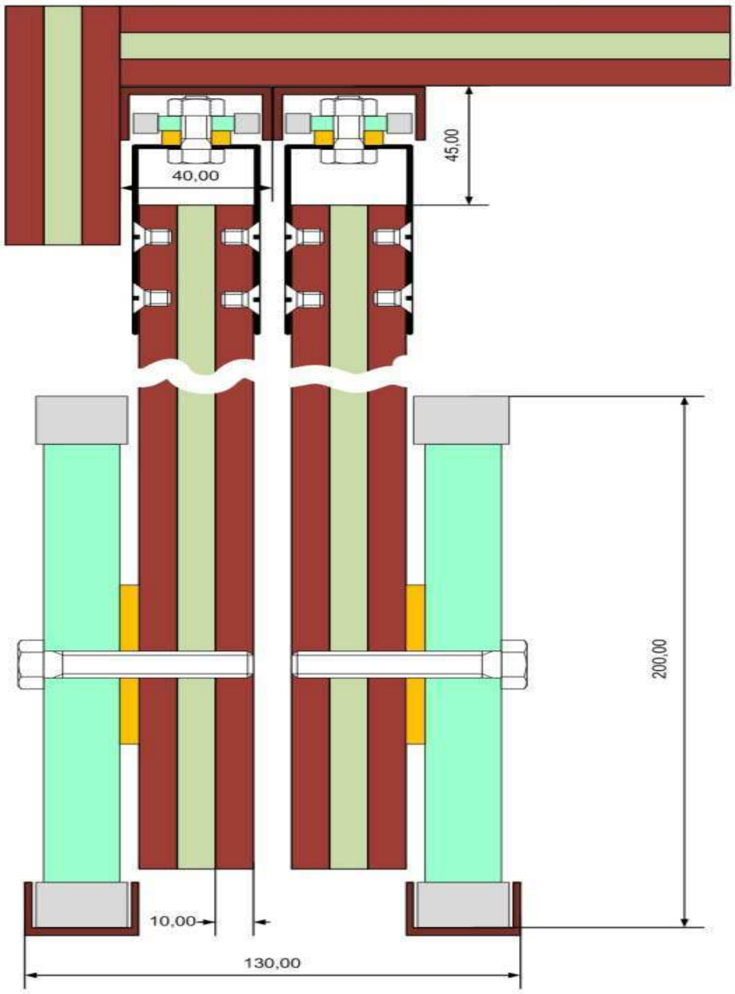

Fig. 4. Idea of radiation shielding sliding doors.

A detailed design of the radiation shielding is an important task.