Integration of ITER diagnostic ports in BINP

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DSM DESIGN

The diagnostic ports integrated by BINP, are made according to a single unified principle - modular design (see Figure 1). In-vessel part of the diagnostic ports consists of the following main components: diagnostic first wall (DFW), diagnostic shielding module (DSM) port plug structure (PPS).

The space around the diagnostics is filled with a shielding trays consisting of a stainless-steel tray and a boron carbide ceramic bricks. Since the shielding trays are standardized and have a discrete step, there are significant gaps between the diagnostics and shielding trays. To eliminate these gaps, a stainless-steel blocks (backfilling) are used that are installed on the DSM and fill this empty space as much as possible

The components are manufactured by different manufacturers and subsequently assembled BINP. The diagnostic shielding modules manufacturing is under responsibility of the port integrator, the other two components are developed and supplied by a central team.

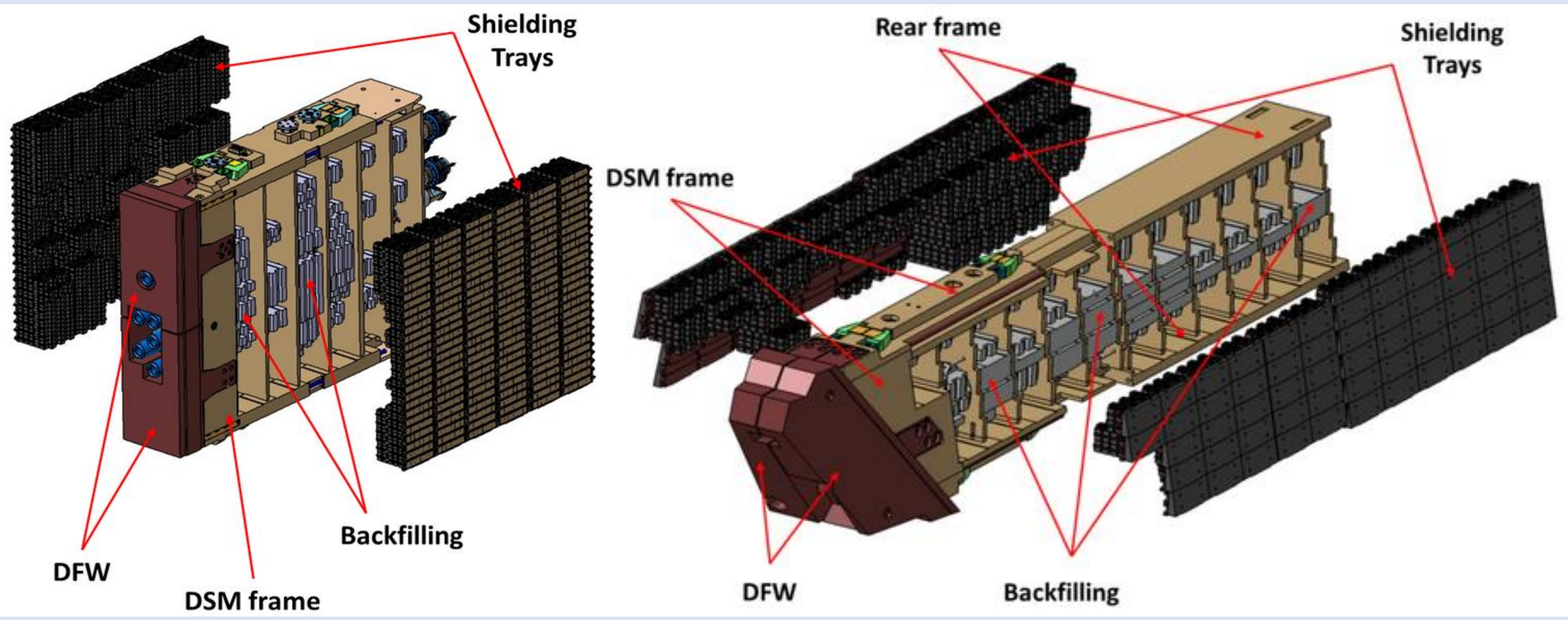

Figure 1 – In-port shielding structures in DSM of EPP (left) and UPP (right)

MANUFACTURABILITY

As a part of the preparation for the manufacturing, a series of technological studies (R&D) were carried out (both by the BINP and by the ITER central team) for confirmation the usability of the proposed technologies. A typical cooling system has been developed for the DSM of the equatorial and upper ports (Figure 3, left). A prototyping of complicated places was carried out, including the manufacture of gun-drilling channels (up to 2 m length), welding of blind holes. Special design of cooling channels caps (Figure 3, right) was applied to provide the feasibility of their ultrasonic inspection, which was confirmed by R&D investigations results.

One more important issue is welding of diagnostics flanges to the port plug structure (at the closure plate). Main issue for this task is completing full penetration welding and inspection in conditions of great constrains. For successful realization of the welding procedure on the closure plate BINP is to use the automatic TIG orbital device (see Figure 4), which provides the welding from the inner part of the flanges and resolves the issue with external restriction.

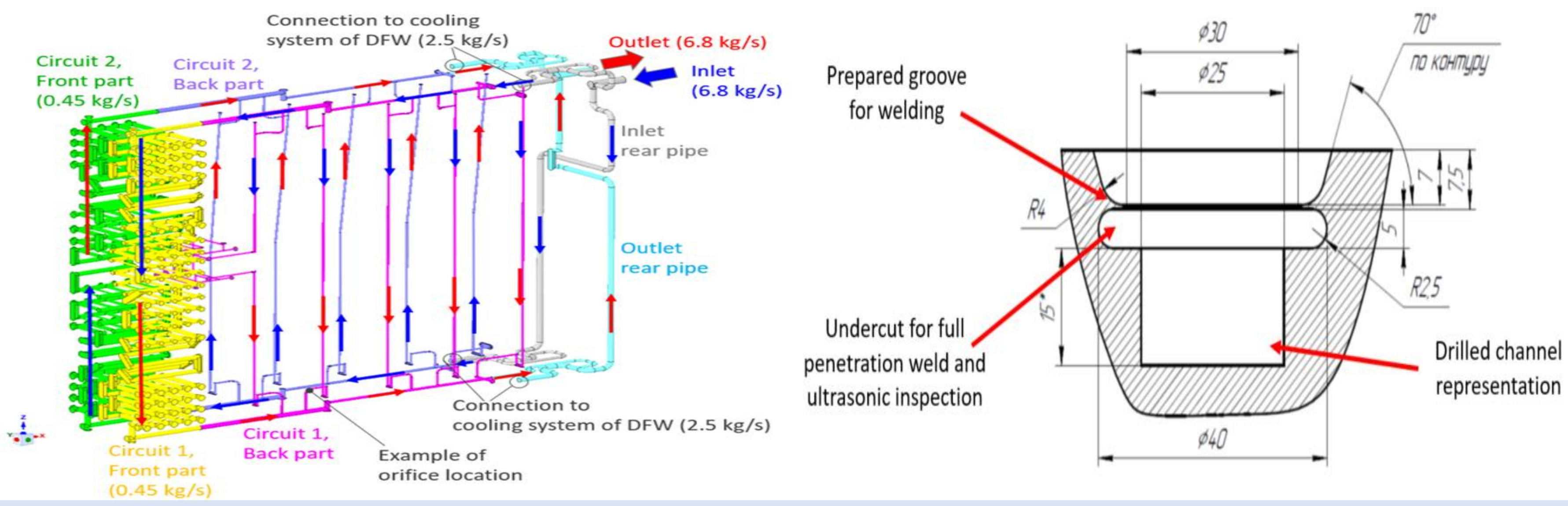

Figure 3 – EPP#11 DSM#2 cooling system (left) and gun-drilled channel cup (right)

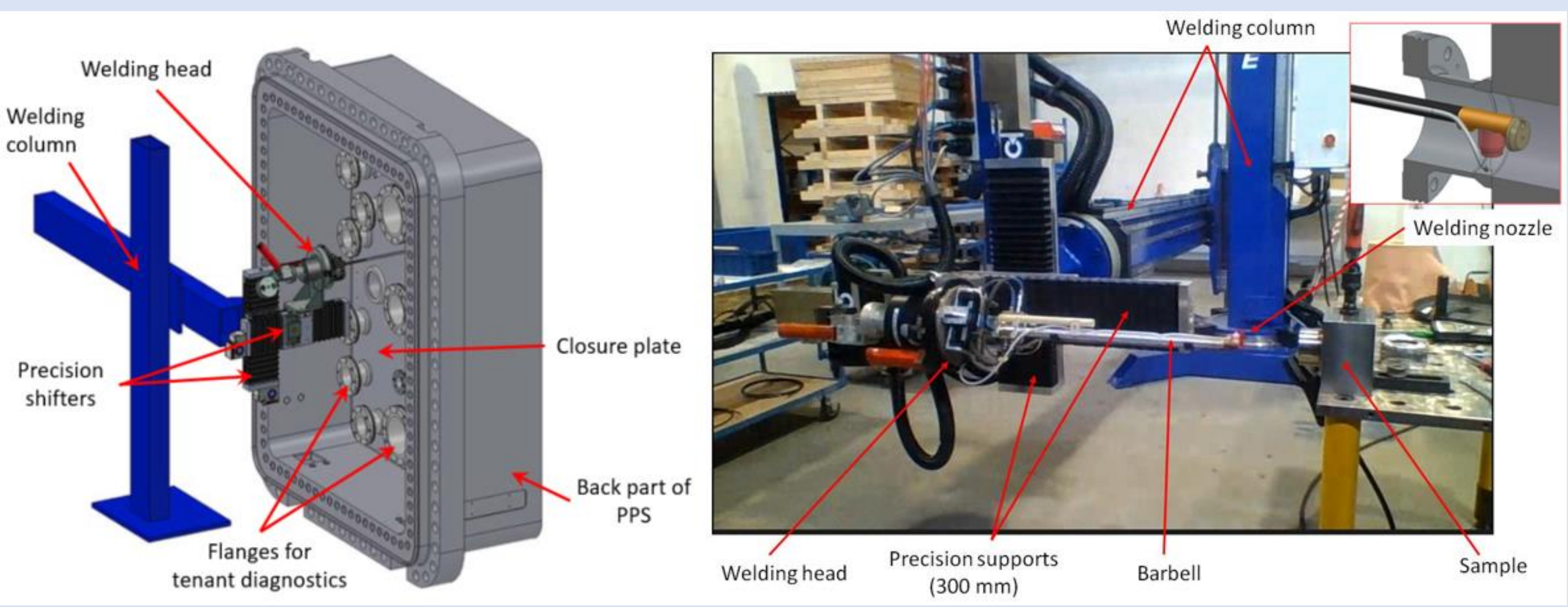

Figure 4 – Orbital robotized machine is to be used for flanges and tubes welding

ASSEMBLY HALL PREPARATION IN BINP

The other key point is the preparation of an assembly hall on the territory of the BINP (Figure 2, left). The complexity of creating an assembly hall for diagnostic ports lies in the aggregate of key requirements for technological processes, in dimensions and masses of assembled products, as well as in the place of production of various components.

The main technological requirements are compliance with the cleanliness of the premises according to the requirements of the first class of cleanliness according to the RCC-MR code during all assembly operations and testing, as well as carrying out of an acceptance tests in a clean room. A critical restrictions for the creation of the assembly hall are the weight of the equatorial port plug which is 48 tons and a length of the upper port plug (about 6 meters).

As a part of the preparations for assembly operations of large-sized products (diagnostic port plugs), a unique instrumentation have been developed for handling and lifting (Figure 2, right).

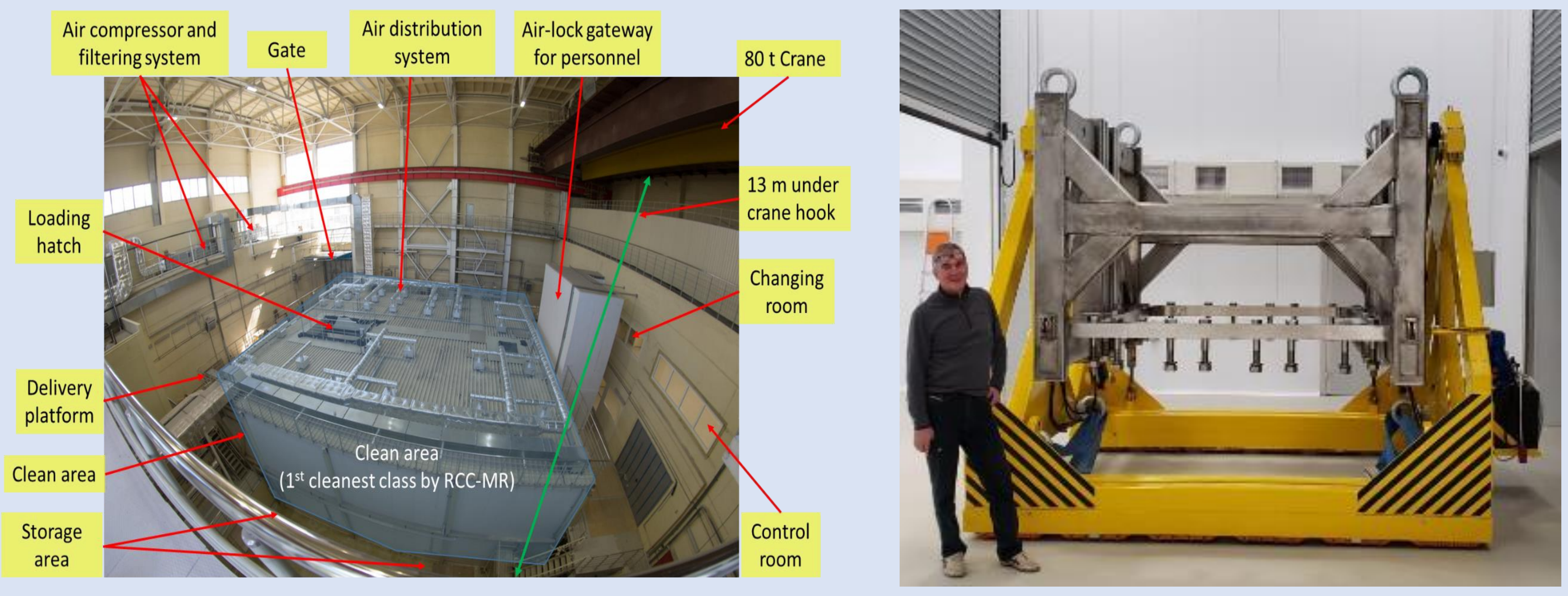

Figure 2 – Assembly hall with the clean room (left) and EPP#11 tilting device (right)

BORON CARBIDE FOR NEUTRON SHIELDING

The investigations on the possibility of using the different materials for the manufacturing, were carried out. One of this, is use of Boron Carbide as a shielding material for neutron protection (Figure 5, left). Boron carbide (B_4C) ceramic bricks are located inside port plugs. Since a huge number of bricks are located in a vacuum, the main requirement for the property of ceramics is a low value of the outgassing rate. According to tests results, after a year in a vacuum, the outgassing rate was reached $2.95 \cdot 10^{-9}$ $Pa \cdot m^3 \cdot s^{-1} \cdot m^{-2}$, which meets ITER Vacuum Handbook requirements.

The activation of the samples was measured after irradiation by fast neutrons with averaged energy of 5.68 MeV. The dose rate of boron carbide samples was 50 µSv/h after the end of irradiation and 0.14 µSv/h (natural background level) after 3 days. The Gamma spectrum is presented at Figure 5, right.

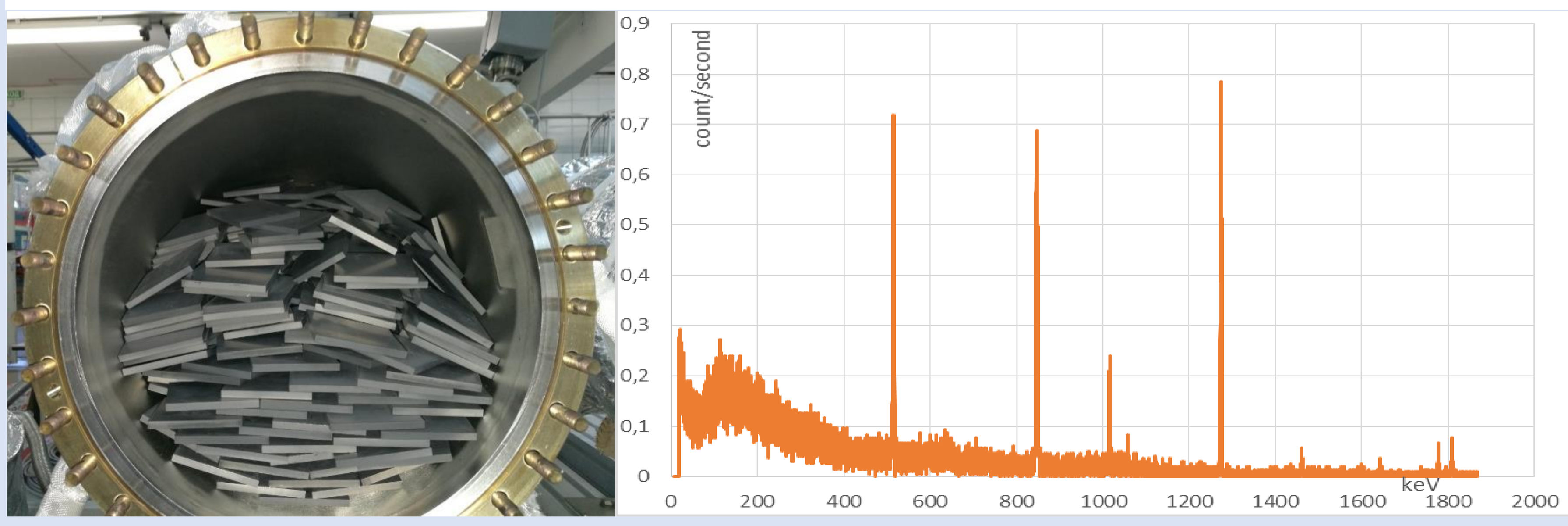

Figure 5 – B_4C ceramics (left) and its Gamma spectrum after activation by neutrons (right)

CONCLUSION

- Integration of the equatorial and the upper RFDA diagnostic ports demonstrated applicability of a single unified principle – modular design of different diagnostics ports.
- Applicability of shielding blocks from boron carbide ceramics has been demonstrated.
- Manufacturing technics for supporting design solution have been prepared and demonstrated.
- Assembly hall have been designed, constructed and successfully passed clean acceptance test. Now it ready for assembly starting.