Russian Research Centre
KURCHATOV INSTITUTE

ELECTROSTATIC RID EXPERIMENT

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Reference design of the Residual Ion Dump (RID) for the ITER NBI system is based on an electrostatic deflection of the residual negative and positive ions to in-line dump panels.

According to 4-channels beam line concept, RID forms four narrow (about 100 mm in width) vertical channels with the aid of 5 panels (1.8 m long and 1.7 m in height). Two middle panels are negatively biased with about 20 kV.

This concept has the advantage of compact design with quite moderate power density (PD) load onto the panels – peak PD is less 8 MW/m^2.

However, such a concept has never been tested in any operating NBI system, all of them use magnetic deflection systems with remote ion dumps.

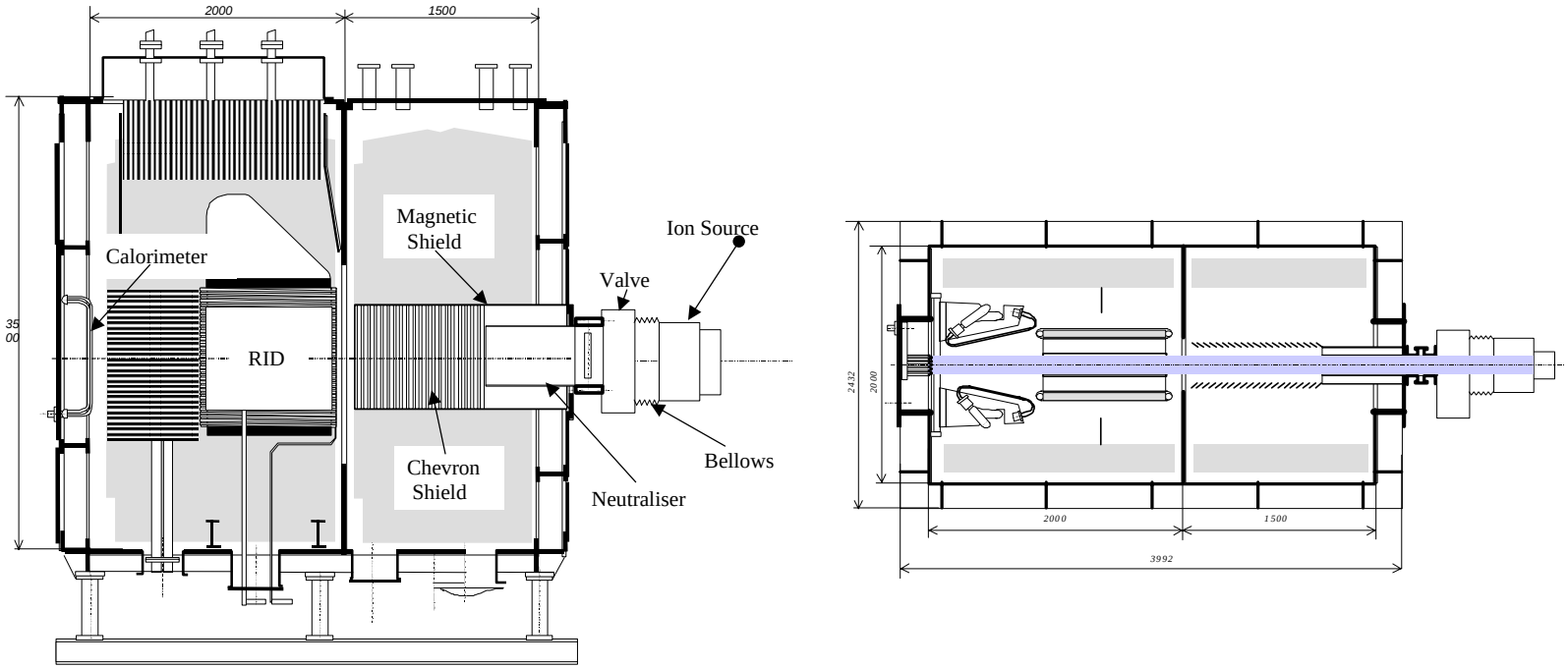
Experimental investigation of the electrostatic RID concept is now started at the test stand IREK in the Kurchatov Institute.

- positive hydrogen ion beam

- one RID channel with two panels, one panel under negative potential

- special magnetic system which produces rather uniform vertical magnetic field in the RID volume.

The main physical question is in secondary electrons production and their behaviour in the crossed electric and magnetic fields, that can have an influence on the high voltage holding and state of operability.

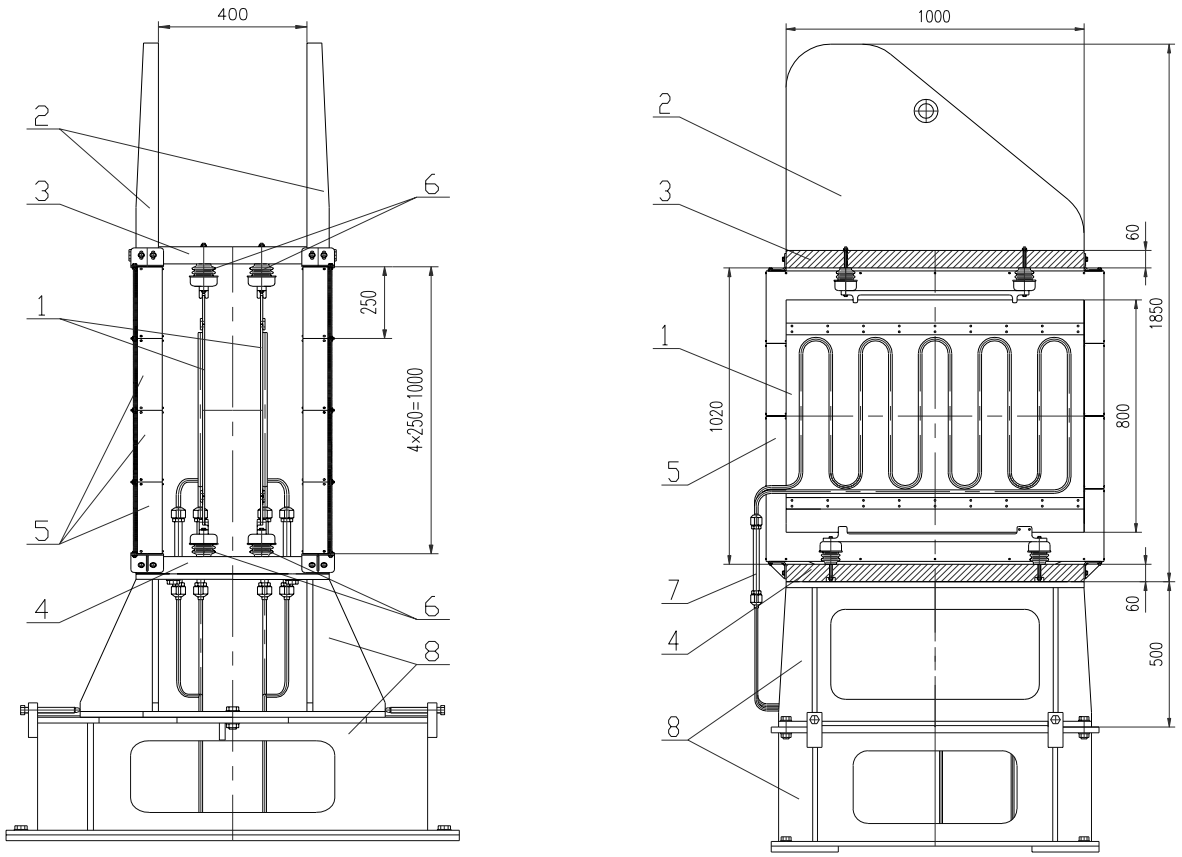


The experimental RID layout in vacuum vessel of the IREK test injector

Ion source with multi-slit extractor 12x36 cm can produce a beam of positive hydrogen ions with maximum parameters 60 A/60 keV/1.5 s.

The beam parameters for the RID experiment are chosen as:

Ion source current	15 – 20 A
Ion energy	35 – 50 keV
Neutralisation efficiency	0.6 – 0.5
Residual ion current	8 – 10 A
Beam-on pulse duration	1 s



The experimental RID axial and side views.

1 – RID panels; 2 – Magnetic box side plates; 3, 4 – Magnetic box top and bottom yokes; 5 – Electro-magnetic coils; 6 – Support insulators with screen caps; 7 – Insulation break; 8 – Support frames.

RID Parameters

Channel width	0.15 m
Panel axial length	1.0 m
Panel height	0.8 m
Negative deflecting potential	up to 10 kV
Max. Power to the HV panel	600 kW
Secondary electron emission	about 30 A

Required deflection voltage: $U_d \cong 0.18\ U_{IS}$

Calculations of thermal and stress parameters of the beam dumping panel at maximum power density 4 MW/m^2 and 1 s pulse:

Maximum surface temperature	180 C
Maximum equivalent stress	20 MPa

Views of the RID magnetic system and the RID inside the IREK vacuum vessel (deflecting panel is on the right).

The RID magnetic system (MS) is to provide a vertical magnetic field (B_z) to simulate the ITER NBL conditions.

Secondary electrons drift in the crossed **ExB** fields occurs when a cycloid height becomes less than the channel width.

$$h = 11.4\ E/B^2 < d \quad \text{[cm, V/cm, Gs]}$$

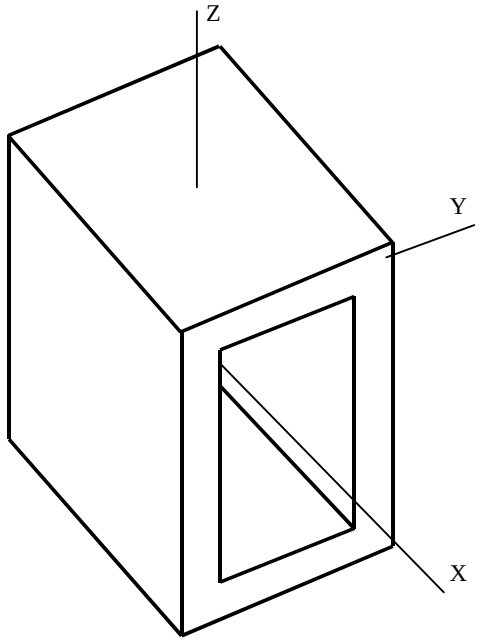
For U_d = 9 kV this requires B_z > 21.5 Gs.

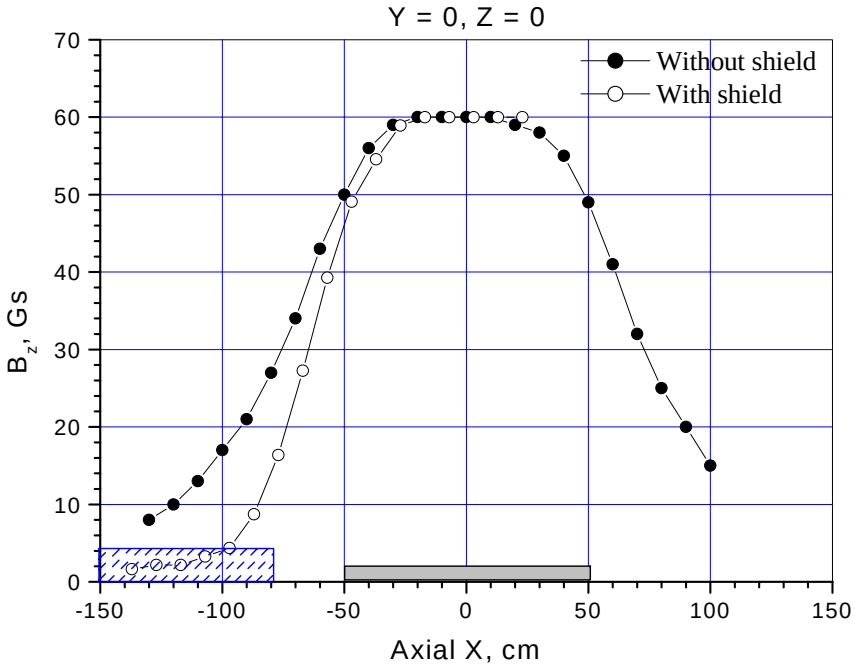
Moreover, the MS is designed to produce B_z up to 130 Gs.
This gives an ability to carry out an investigation of the residual ion beam deflection in horizontal plane and its damping on the panels with use of the magnetic field only (Magnetic RID).

Parameters of the MS

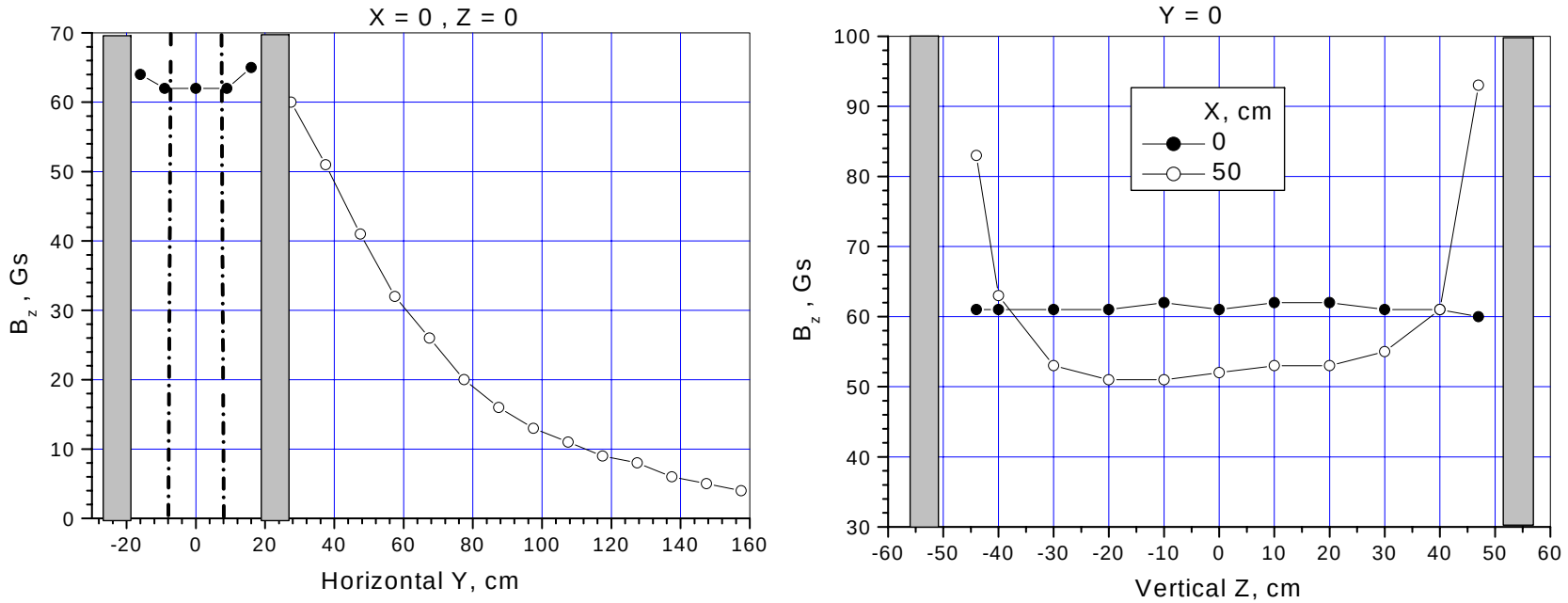
Size of the “magnetic box”:	
Width/ Length/ Height	0.4 / 1.0 / 1.02 m
Side plates and yokes thickness	60 mm
Total number of the coils	8
Number of turns in the coil	95
Maximum current in one coil	30 A
Voltage	20 V
Maximum B_z	130 Gs

Vertical magnetic field distributions in the RID MS (total current in 8 coils - 110 A).





Vertical magnetic field distributions in the RID MS (cont.)



Advantage of such MS configuration - very uniform B_z inside the “magnetic box”.
Disadvantage - quite high magnetic flux at the both sides of the box.

First experimental results.

Initially the RID was tested on the voltage holding without the beam.

Minus 10 kV was applied to the deflecting panel and hydrogen pressure was increased up to 0.2 Pa – no breakdowns was observed with an increase of magnetic field up to 100 Gs.

But with the beam on, breakdowns occur which initiate high current discharges → a protection system switches off the deflecting voltage.

Two reasons were found in charge of:

1) a large outgassing from the panel,

2) the copper tubes were connected with stainless steel adapters with use of silver brazing and silver marks were found out.

The silver marks were screened and panel cleaning was performed with use of magnetic deflection of the beam onto the panel.

The HV conditioning is continuing with slow increase of U_d.

Conclusion

The electrostatic RID with magnetic system is assembled and installed in the IREK test injector.

Experimental work has been started.