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LHC Injectors Upgrade

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Engineering Parameters

Functional Specifications of the Vertical Distribution Septum BISMV

ABSTRACT:

For the LINAC4 PSB injection scheme, the time resolved slices of the 160 MeV H- beam have to be distributed to the 4 rings of the PSB and to the Head and Tail Dump. The BISMV shall consist of 3 pairs of vertically deflecting septum magnets housed in a common vacuum chamber. The septa shall deflect the slices through angles of approx 130 mRad (Ring 1) and 160 mRad (Ring 4 and 2). The vertical bending magnet BTV50 corrects the deflection immediately after BISMV to a horizontal trajectory towards the PSB Injection section.

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HISTORY OF CHANGES

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1. Introduction

To facilitate H- injection from Linac4 to the PS Booster via the transfer line the BISMV (Booster Injection Septum Magnet Vertical) provides the vertical deflection of the 160 MeV H^- beam to rings 1, 2 and 4 of the booster. Currently this system is capable of deflecting 50 MeV protons and comprises an assembly of ferrite type magnets in an "omega" section vacuum tank (see fig. 1.). The current system shall be replaced with a UHV compatible vacuum chamber incorporating 3 sets of double septum magnets, pulsed from 3 individual power supplies via transformers typically 10:1 ratio.

This functional specification defines the parameters and operating conditions of the BISMV. The interface between the BISMV vacuum tank and the injection line vacuum chamber shall also be presented.

Figure 1 — Currently installed BISMV

2. Magnet & Beam Parameters

The BISMV distributes the 4 beams [1] to the four rings of the Booster. The tank also contains the so-called Head and Tail dumps which absorb the rise and falling edges of the chopped beam. In the Linac4 there should be no beam to the dumps apart from the case of a chopper failure. The dumps are rated to absorb one full beam impact before the beam interlock system can stop the beam. [2]

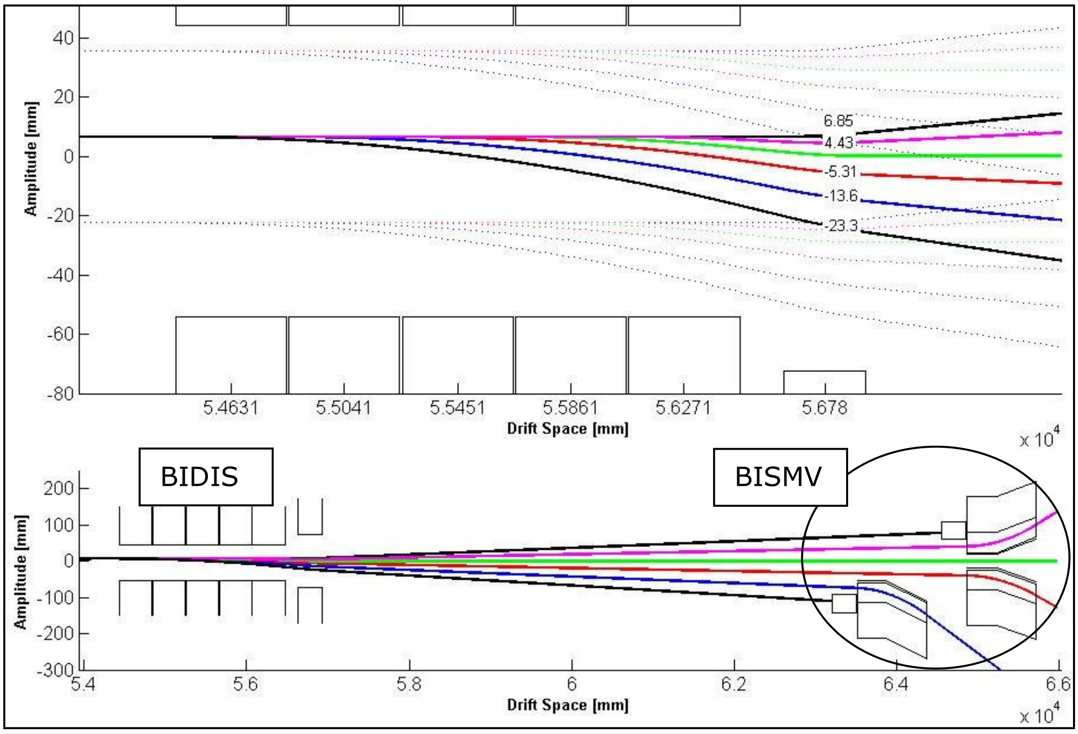


Figure 2-Vertical Deflection elements in transfer line

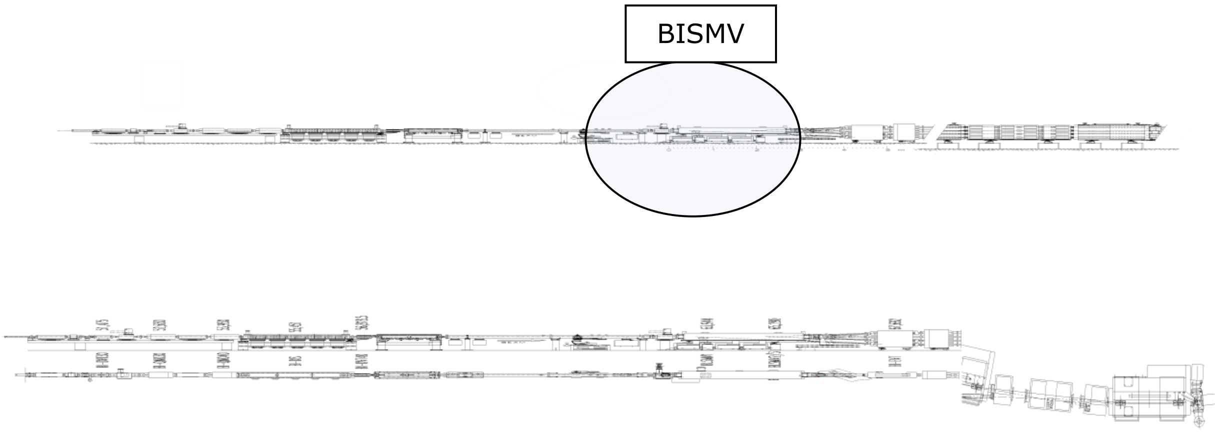


Figure 3- transfer line

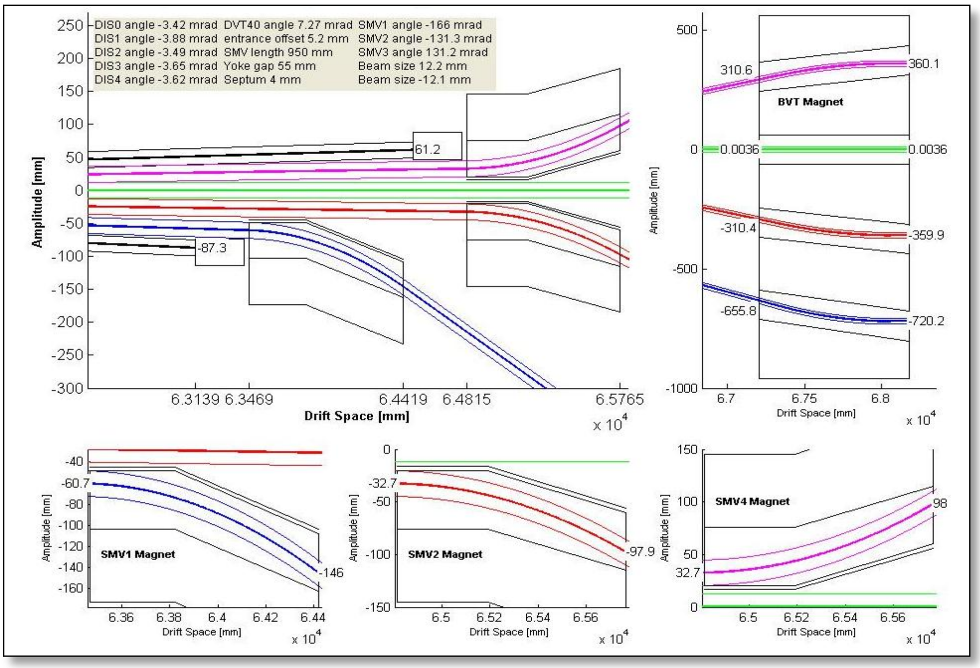
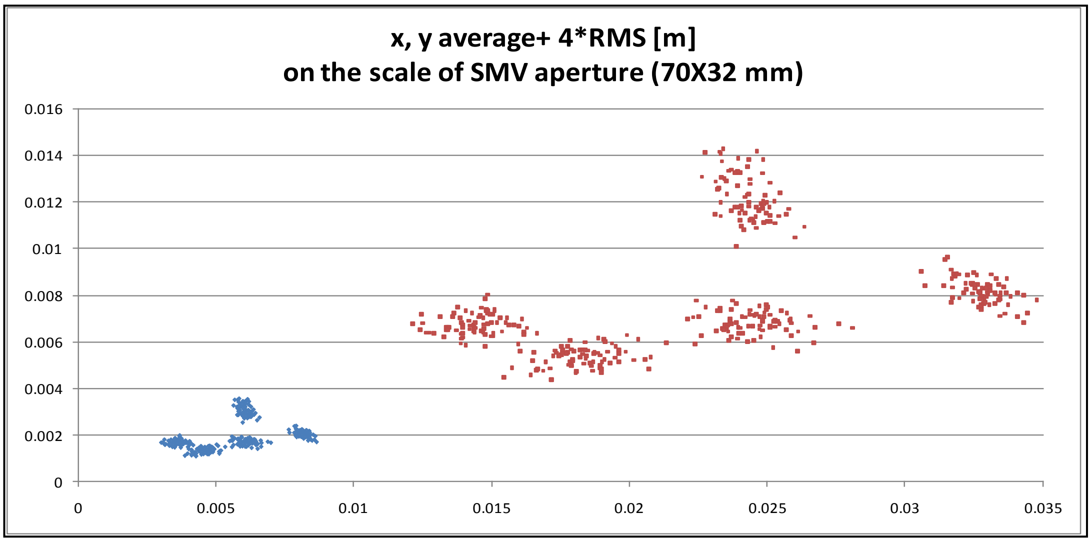
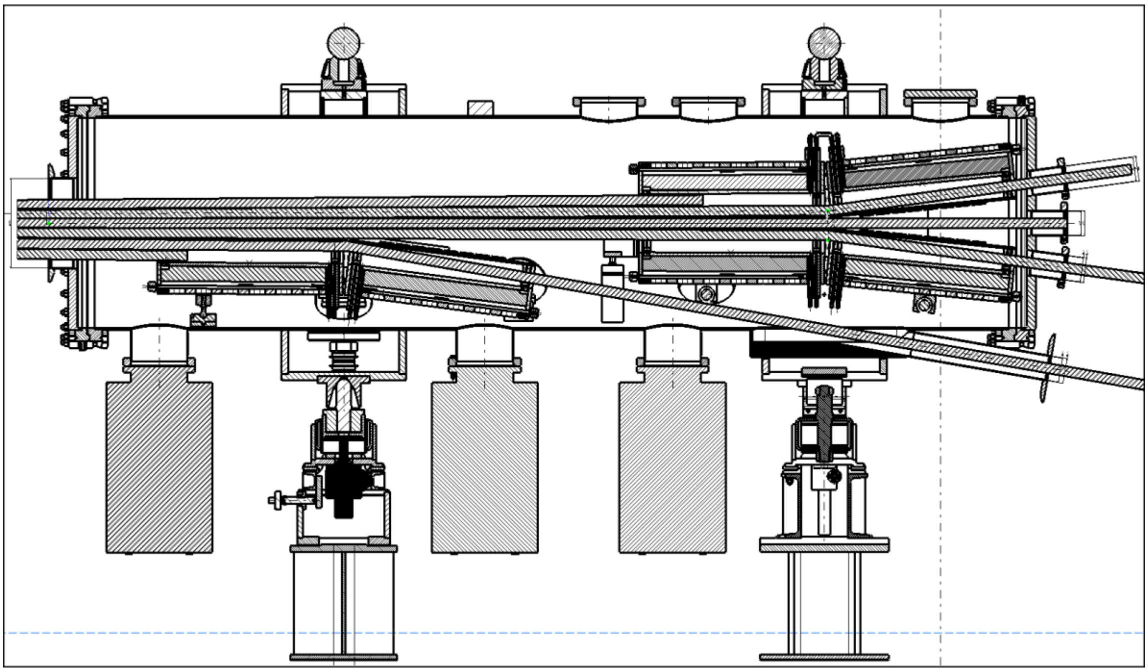


Figure 4-Vertical Deflection of the BISMV and BVT



at SMV	D=0			D=1.4	
	bigbeta	medium	small	medium	small
x RMS [mm]	6.1	6.1	8.2	3.5	4.5
y RMS [mm]	3.0	1.7	2.0	1.7	1.3

The BISMV magnets are represented in their 3d modelled form below. In the tables below the nominal parameters for the magnet and beam are listed.



1x Entry Flange Quick Disconnect diameter 332mm.

4x Exit Flanges “ Conflat” DN63 with diameter 67/70 mm tubes.

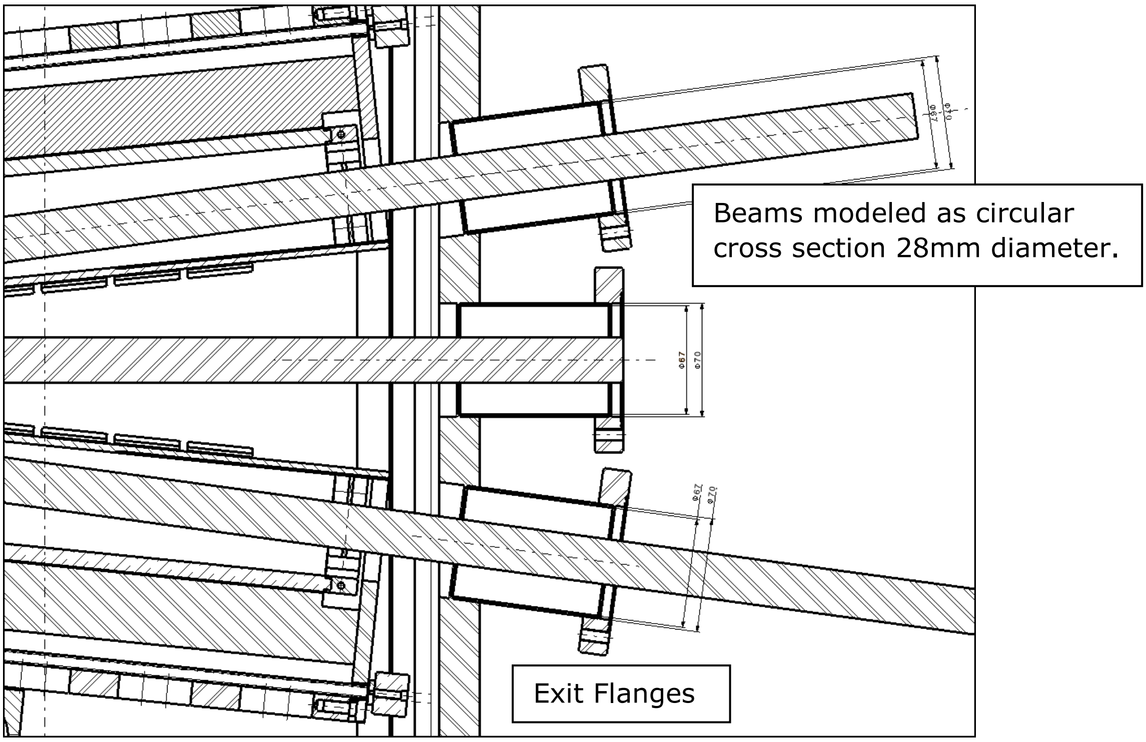


Figure 5-Magnet layout (no supports shown)

2.1 Magnet Parameters

2.1.1 Electrical & Magnetic

Maximum ratings per magnet

Particle	P	Integrated Bdl	0.329 T.m
Kinetic Energy	160 MeV	Induction in gap	0.357 T
Particle Deflection	173 mRad	Current	19873 A
Septum Thickness	4, max 5 mm	I rms	820 A
Gap Height (distance between poles-Horizontal)	70 mm	I rms Current density septum	2.5 A/mm2
Gap Width (Beam Acceptance in vert. Plane)	62.4 mm,	I rms Current density Rear cond.	1 A/mm2
Magnetic Length	960 mm	Magnet Resistance	0.2 mΩ
Rear Conductor Thickness	10 mm	Magnet Inductance	1.22 μH
Height Rear Conductor	69 mm	Power Consumption	100 W (~)
Number of Turns	1	Water Flow per cooling channel in septum	3 l/min (~)
Rise Time	1 ms (~)	Total water flow	2.6 l/min (~)
Repetition Rate	1.1 Hz	Water speed in septum	8 m/s
Lamination W x H	120x150 mm	Total water temp. rise	0.2 K

3. Vacuum

The vacuum tank houses three pairs of conventional septum magnets which are aligned during the installation stage and do not have any associated remote movement systems. The vacuum pumping is provided by three ion pumps mounted on the underside of the tank. Penning and Pirani gauges are fitted to the tank together with a vent valve for intervention purposes. A bake out system is integrated in each magnet system and is powered by an external electrical supply by means of DN35 feedthroughs. The 3d model of the assembly is shown below in fig. 6. The magnets shall be baked at 200 °C and the vacuum ion pumps at 300 °C. The internal bake out system consists of vacuum compatible heating elements incorporated in each magnet. The pumps shall be baked using conventional jackets of sufficient power rating and controlled with thermostats.

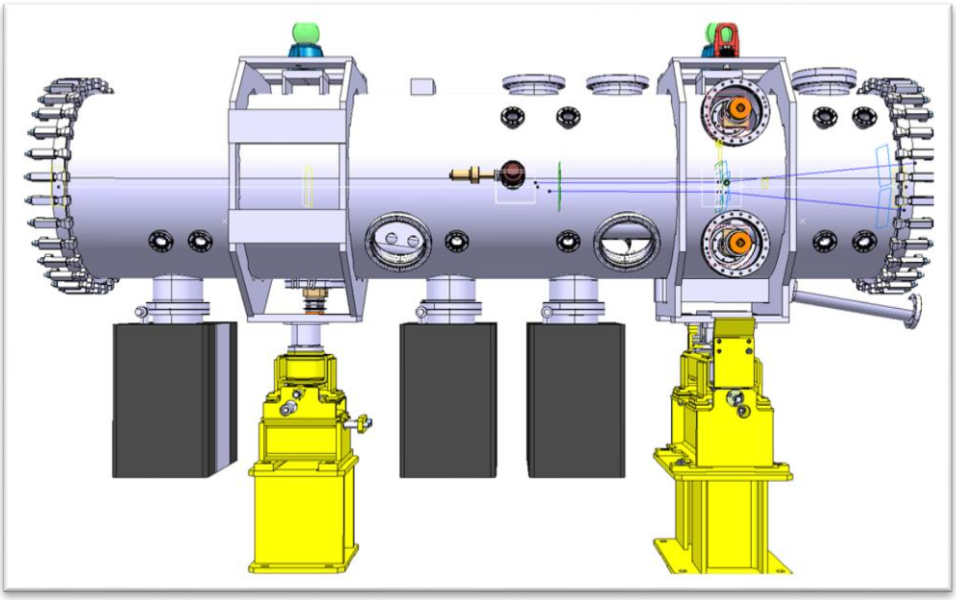


Figure 6-Proposed Vacuum Tank

The downstream end of the vacuum tank shall be fitted with conflate type flanges and connect to a new modified vacuum chamber. The existing chain clamps (see fig. 7), shall be replaced and a quick disconnect facility shall be integrated which shall allow for rapid disconnection and removal of the tank. The upstream end cover of the vacuum tank shall be fitted with a quick disconnect 250mm diameter flange.

3.1 Magnet Steel Parameters

Lamination Cross section is shown below and a total of approximately 9000 of these laminations will be used to construct 6 magnets which will be installed in the vacuum tank. For the purposes of calculating the total outgassing rate, each lamination has a total area of 23524mm^2 (double sided).

The magnet steel characteristics are currently being analysed for their vacuum compatibility and the values for outgassing rate will be provided by TE/VSC. The total pumping capacity will be determined by this specific outgassing rate.

Type: M330-35A non-orientated grain, thickness 0.35 mm.

Insulation type: Stabolit 20 on both faces

Supplier: Thyssenkrupp

For the results of the vacuum outgassing rates refer to, EDMS 1097059.

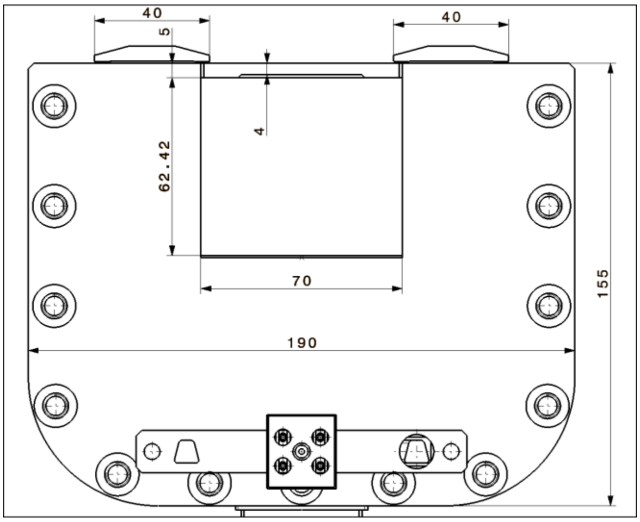


Figure 7-Magnet Cross section

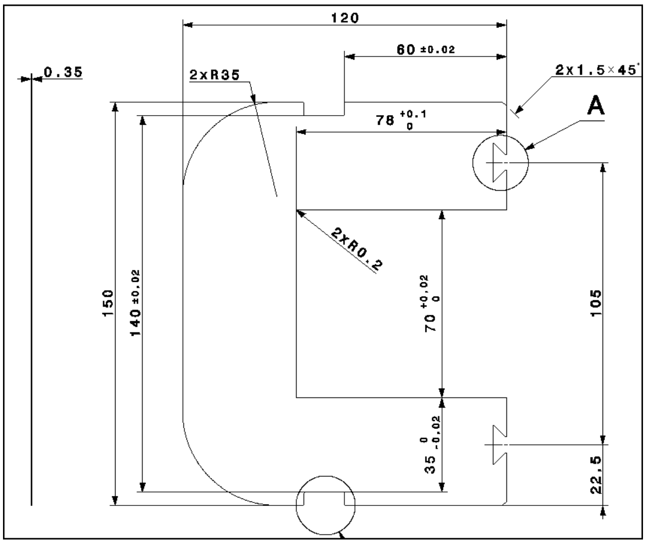


Figure 8-Lamination Cross section

3.2 Equipment

3 Ion pumps Type Starcell 500 (410 ltrs /sec)

1 Penning / Pirani Assembly

1 Vent valve (Metallic) DN16

3 Bake out jackets on Ion Pumps

1 DN150 Conflat flange shall be available for the eventual fitting of a turbo pump.

3.3 Integration in Transfer line

The vacuum tank shall replace the current system which is shown in the figure xx. The final entry and exit flange types shall be confirmed by TE/VSC with the choice of retaining the current flange (chain clamp installed in 1977) and fitting the tank with a compatible system or modifying the booster vacuum line to install modern up to date UHV flanges.

Fig. 7 Current downstream flange

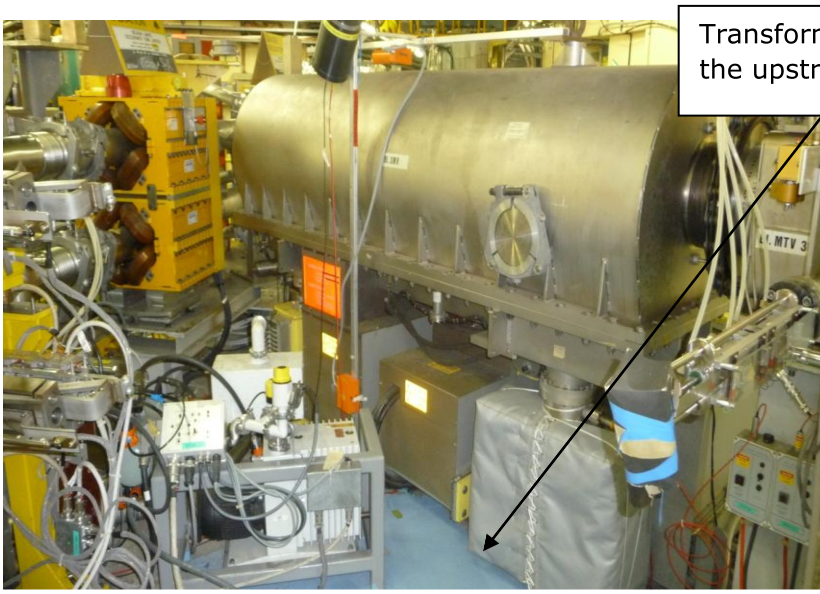
Fig. 8 Current upstream flange

4. Electrical System

The magnets are individually pulsed via a pulse transformer for each magnet which shall be located adjacent to the vacuum tank. The transformer for the upstream magnets shall be positioned on the Booster side of the vacuum tank whilst the transformers (2 off) for the downstream magnets are positioned on the PS side of the vacuum tank. The connection between the transformers and the magnet power feedthroughs is the responsibility of TE/ABT and comprises a sandwich type stripline of sufficient cross section to limit the RMS current density to less than 4 Amm^{-2}. The power feedthroughs shall be of the standard septa type used throughout the PS complex and rated at 34 kA and UHV compatible.

4.1 Proposed transformer Positions

Transformer 1 position (for the upstream pair of septa)



Transformer positions 2&3 (for the downstream pairs of septa)

4.1.1 Transformer layout

The transformers (1 per magnet pair) have been selected as similar to type SMH26 (to be confirmed by TE/EPC) and shall be installed at the sides of the vacuum tank. Space required for each transformer is 1x1x0.5 m^3. The positions shall be fixed following discussions with EPC to define the stripline connection.

4.1.2 Current Measurement

Responsibility of EPC to determine the position and type of current measurement device, (e.g. Pearson type)

4.1.3 Protective Covers

This is the responsibility of EPC and all electrical connections shall be protected according to standard regulations for the accelerator environment.

5. Dumps

The design, manufacture and installation of the Head and Tail dumps are the responsibility of EN/STI and the vacuum tanks shall be fitted with access ports for the easy and rapid installation and removal of the dumps from the vacuum tank. The internal supports will allow for accurate alignment of the dumps in a rapid manner, reducing the radiation doses in the event of interventions. The dumps can also be removed from the vacuum chambers to allow for maintenance or intervention on the magnet systems.

Currently the dumps have been estimated at 40x40mm2 x 200mm length and this space has been allocated for the dumps in the vacuum tank.

Refer to EDMS [1]. For more detailed information.

6. Cooling

The magnets are cooled with demineralised water and shall be supplied from the main booster supply system 13 Bar.

6.1 Cooling parameters

The cooling flow per magnet shall be approximately 2.6 litre/min which equates to a total cooling flow requirement for the 3 pairs of septa to 7.8 litres/min. The cooling flow has been determined based on a pressure drop of approx. 12 Bar on the magnet cooling circuit.

7. Alignment

The procedure for aligning the magnets shall be detailed at a later date. In principle, the magnet pairs shall be assembled together in a rigid structure and pre-aligned on a marble calibrated surface in respect to each other. The magnet pairs shall then be installed in the vacuum tank where they will be adjusted in respect to the external fiducials on the target supports. The magnet tank shall then be installed in the transfer line and aligned with the aid of the surveyors.

Alignment precision:

Vertical ± 0.1mm

Radial ± 0.2mm

Longitudinal ± 0.5mm

8. Installation

- The transport of the complete assembled vacuum tank and septa shall be carried out in the following order:
- Transfer of completed systems to PSB
- Using access shaft in Building 361 lower the complete assembly to the ground floor of PSB ring using the local crane (361) to place the system on trolley.
- Transfer assembly to access shaft on PS side of PSB on trolley
- Raise system (via access hole) using transfer line crane and install in transfer line

9. Modifications

The BI.MTV30 shall be displaced approximately 300-400mm upstream of its current position. This will enable integration of the tail dump in the upstream section of the vacuum tank.

Modifications to the cooling pipes in the vicinity of the BISMV supports may be necessary and this shall be established at a later stage in conjunction with EN/CV.

[1] https://edms.cern.ch/file/1166277/PBU-OTH-EP-0001 v.1
BASELINE DESIGN PARAMETERS FOR PSB INJECTION REGION

[2] https://edms.cern.ch/file/1145567/0.1/LIU_PSB_HeadTailDump.pdf
HEAD & TAIL DUMPS FOR THE BOOSTER INJECTION REGION