Crab cavity vacuum

Meeting Notes, 19/6/2015

Presents: O.Capatina, K.Artoos, V.Baglin, G.Vandoni, T.Capelli

We discuss the vacuum layout from the vacuum specification of the crab cavity region. In this region, close to interaction point, preserving the vacuum quality is paramount. The main constraint for vacuum layout is to guarantee stable vacuum conditions and reduce experiments background. Vacuum constraints are not the same as in other machines, typically cold linacs, in which the beam passes only once: the vacuum design applying there is different from what is needed in a circular machine and close to interaction points.

In addition, the integrity of the gate valves should also be taken into account. Gate valves cannot be opened under a pressure difference larger than 30mbar, otherwise the gate deforms and the valve cannot be made tight anymore.

EN/MME has foreseen a design where gate valves are used as simple plugs during assembly and cryostating, to preserve the clean dust-free conditions of the clean room until the installation in the tunnel. These gate valves have a manual actuator, accessible from outside the cryomodule, as a mechanical feedthrough through insulation vacuum. The plugs are installed on the cavity string in clean room, then the cavity string is cryostated, with the manual actuators connected from outside the cryostat.

We explore the possibility of using these gate valves as vacuum sector valves. The valve layout would then be the following:

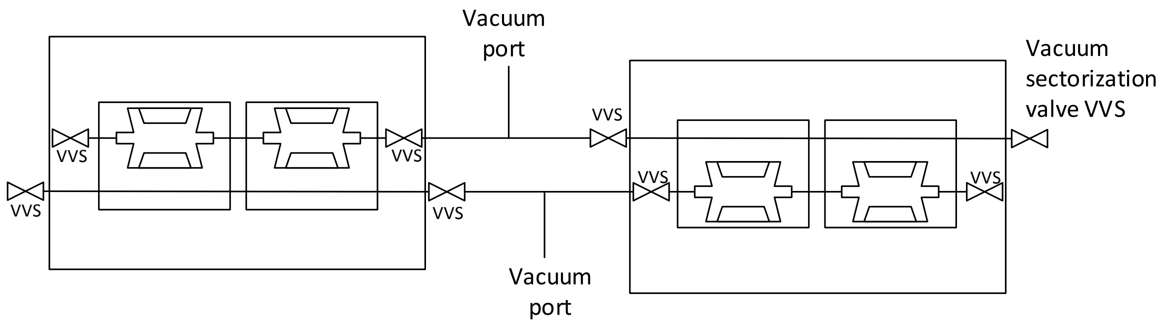

Figure 1: sector valve layout, with the plugs used as sector valves.

However, a sector valve needs to be interlocked by vacuum measurement immediately upstream of it, via a vacuum gauge, to ensure that no pollution of a clean vacuum occurs upon opening. Now, the Penning gauge on the Fundamental Power Coupler is not suitable for this scope, as vacuum conditions at the power coupler are not representative of those in the immediate proximity of the gate valve: indeed, the cold cavity in between constitute a huge cryopump. In addition to a vacuum gauge, a pumping port is also necessary, to restore vacuum in case of failure, for instance a power cut with subsequent warming up of the cavities. An additional vacuum port, accessing beam vacuum close to each sector valve, is then necessary. The cavity string would be transformed as follows:

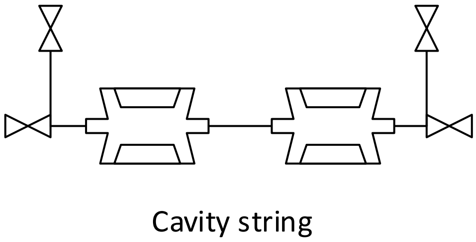

Figure 2: cavity string with an additional vacuum port upstream of the sector valve, plugged off by a small vacuum valve.

In this layout, the additional valve plugging off the beam vacuum port is located inside the cryomodule and requires an actuator outside, as well as an interface flange, like the plug-off gate valve.

The alternative, which was considered as baseline until now, is not to couple the functionalities of plug and sector valve. The layout is the following:

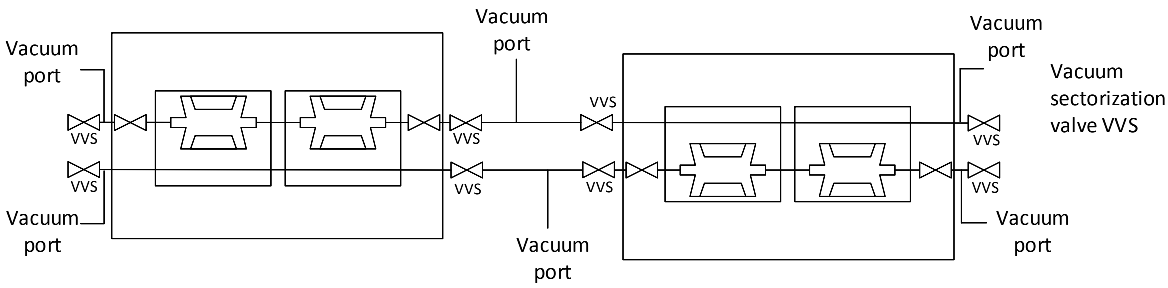

Figure 3: Vacuum sector valves are distinct from plugs. An additional port, ouside the cryostat, gives access to beam vacuum between sector valves for roughing and UHV pumping and monitoring, both for the cavity beam line and for the drift line.

While the first alternative (plug-off and sector valves functionalities all-in-one) presents the advantage to spare 2 valves per cryomodule, it complicates integration of an additional vacuum port in the internal tight volume of the cryomodule. The second solution (separation between plug-off and sector valve) impacts on the warm section’s integration and adds one valve, but preserves the cryomodule.

The second alternative seems preferable. Integrity of the plug-off gate valves is ensured by the use of the Penning gauge integrated in the FPC to check vacuum between the closed plugs before opening.

In SPS, the drift vacuum tube will not be present. The SPS vacuum layout follows the same logics as the second alternative:

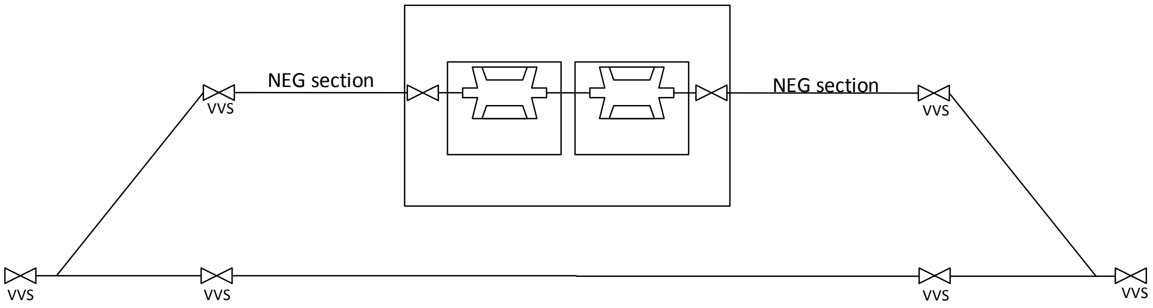

Figure 4: SPS vacuum layout for the Crab cavity cryomodule test

Vincent further explains the specification for the drift section, the second beam tube. Ofelia explains that the cavity form was optimized to accommodate the second beam tube. The internal diameter, 84mm, is the result of this optimization and not dictated by beam aperture considerations. The second beam tube will be in massive Nb, which should minimize the impedance. However, a beam screen is necessary in a cold section from vacuum stability considerations and electron cloud mitigation. The two alternatives are a) a concentrical beam screen, actively cooled with gaseous helium, and b) a butterfly vacuum chamber with a grid separating the beam chamber from the antechamber. The concentrical beam screen has a well proven design and is therefore the preferred solution.

Actions

The Technical design report asked by R.Calaga must be finalized before end July. It must contain the most advanced design choices we can provide up to now. V.Baglin will write the Vacuum section, completing and extending the contents of section 2.16 of the Preliminary Design report; the conclusions of the present discussion will be included.