Pressure profile simulation for the PETRA III frontends

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PETRA III will be a high brilliance, small emittance, third generation synchrotron radiation source [1]. The undulators will deliver photon beams with small cross sections and therefore the components in the frontend will be as compact as feasible. The resulting narrow cross sections of the vacuum system will yield a small conductivity in the whole frontend. The design of the vacuum system is now at an advanced state so that the initial design of the vacuum system has been revised. The vacuum specification [2] demands for a hydrocarbon and dust free vacuum system. To provide this, the beamline will be initially pumped down with a dry pumping station [3] to a pressure of 10^{-6} mbar. After reaching this pressure, the pumping station will be switched off and a set of ion getter pumps will pump the frontend continuously. To extend the lifetime of the ion getter pumps, it is necessary that the pressure in the pumps will be below 10^{-6} mbar during operation. The simulation shows, compared to the first design step, that especially at the high power slit systems and during the start of operation a high amount of gas will be photo desorbed. To cope with this, additional pumps will be installed in the frontends. For the simulation of the pressure profile in the beamline system a Monte Carlo simulation code (Molflow [4]) was used, which was developed by R. Kersevan (ESRF, Grenoble, France).

There are two different types of desorption. On the one hand there is thermal desorption and on the other hand photo desorption. The photo desorption is mainly localised at the high power slit systems, were the undulator beam is shaped. This strong localised desorption and the bad conductance of the frontend causes that the pumps near by the desorption source have to cope with the complete generated gas load. The photo desorption yield is dose dependent and by this the gas load will decrease with the number of absorbed photons. The thermal desorption is distributed over the whole system and all pumps participate on pumping this gas load.

In the beamline starting phase a huge amount of photo desorbed gas is expected at the high power slit systems. Photodesorption is mainly caused by undulator radiation, rather than by Bending Magnet radiation. As a worst-case condition, we assumed the standard 5 m PETRAIII undulator [1] with a machine current of about 200 mA. The spectrum of the undulator was calculated with SPECTRA [5] and afterwards integrated up to a photon energy of 100 keV. By this, we got a photon flux of round about ~10^{19} ph/s. To get an estimate of the amount of photo desorbed gas we used a desorption yield of 0,01molecules/ph. This is a experience value from the ESRF. Using this number we got a gas load of ~10^{-3} mbarl/s.

The first simulation shows (Figure 1), that the pressure in the frontend is determined by the gas load caused by the photo desorption and that the pressure in the getter pump at the high power slit system is higher than 10^{-6} mbar. Therefore the pumping speed has to be increased at the high power slit systems at the start of operation.

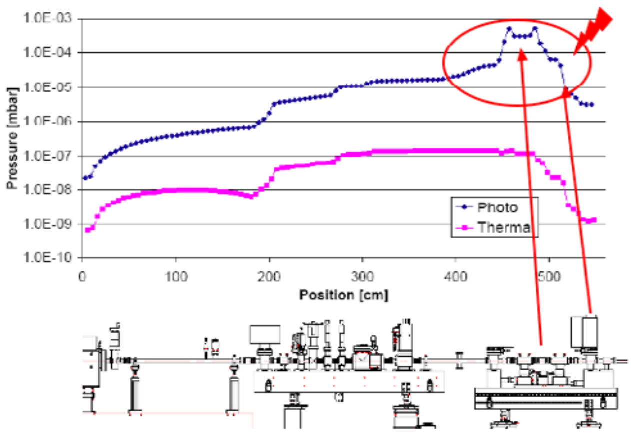

Figure 1: Comparison of thermal and photo desorption in the previous design.

By increasing the pumping speed to 2000 l/s (compared to previous 150 l/s) around the high power slit systems the pressure inside the ion pumps can be kept below 10^{-6} mbar (Figure 2 and 3).

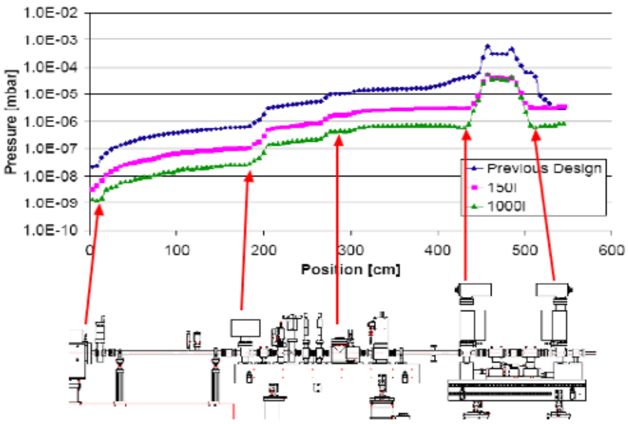

Figure 2: Comparison of the pressure profiles caused by photo desorption at the first slit system.

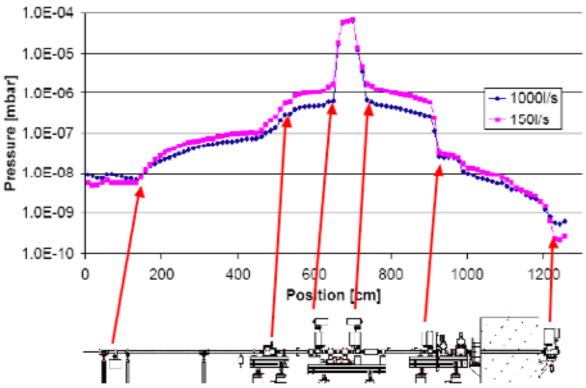

Figure 3: Comparison of the pressure profiles caused by photo desorption at the second slit system.

The space in the frontend is strongly limited and therefore it is not possible to reach such a high pumping speed with pure ion getter pumps. The upper limit related to the space is a 150 l ion getter pump. There are two ways to increase the pumping speed above this limit. The first is to install on the top of the 150l pump an additional titan sublimation pump. The drawback of this solution is that this type of pump needs an extra vessel. Other wise the sublimated titanium could cause shortcircuits in the ion getter pump. The second possibility is to use Non-Evaporable-Getter modules (NEG) (Figure 4), which can be installed inside the pump vessel of the 150 l pump. Another advantage of the NEG module is the higher capacity compared to the titanium sublimation pump.

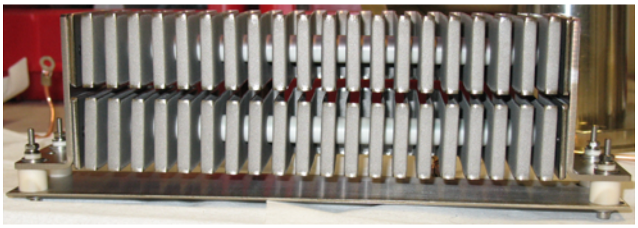

Figure 4: NEG module for installation inside the 150 l pump.

References

[1] PETRAIII “A low Emittance Synchrotron Radiation Source”, Technical Design Report DESY 2004-035, 211-218 (2004)
[2] “Hasylab Vacuum Guidelines for Beamlines and Experiments”, Hasylab Homepage
[3] M. Degenhardt et al., “Mobile dry pumping station for PETRA III beamlines”, this report
[4] “MOLFLOW User´s Guide”, available by the author Roberto Kersevan
[5] SPECTRA, Takashi Tanaka and Hideo Kitamura, SPring-8/RIKEN