Measurement of the behaviour of residual gas particles on cryogenic surfaces to improve the simulation of dynamic vacuum effects

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Introduction

The dynamic vacuum refers to pressure rises occurring during beam operation in particle accelerators. It is caused by lost beam ions triggering stimulated desorption of gas particles from the walls which may cause even more beam loss. This has to be compensated by pumps as fast as possible to prevent a self-amplifying effect.
To achieve this, the cryogenic vacuum chambers of the SIS100 will act as surface pumps. They are able to pump gases according to their vapor pressure curves which are sufficiently low for stable beam operation for most gases. This is called *cryocondensation*. An important exception is hydrogen. Fortunately, it can be pumped to lower pressures by so called *cryosorption* if the surface coverage of the cold walls is sufficiently low [1]. This effect can be characterized by two parameters: The *sticking coefficient* describes the probability of a gas particle impacting on the surface to be bound. It is directly linked to the pumping speed provided by the cryogenic walls. The *mean sojourn time* describes how long a particle remains bound to a surface. Both parameters together determine the equilibrium pressure. Once known they will be used to improve the quality of simulation of the StrahlSim [2] code.

Measurement of the parameters

An UHV experiment (Figure 1) to determine these parameters is currently set up. The cold surface that will be tested is provided in the form of a small chamber which is cooled by a cold head. The target temperature range is 5 to 20 K. The measurement will be divided in two phases: At first, the pumping speed of the chamber is quantified at different temperatures and surface coverages to get the sticking coefficient. In the second phase, the corresponding equilibrium pressure is evaluated which yields the sojourn time.
To link the pressure values measured by the gauges to the desired parameters, the simulation code MolFlow+ [3] is used to perform a data inversion. An alternative method for interpretation of the data is the calculation of unknown vacuum properties like the pumping speed and the outgassing rate from known or measured properties like the pressures and the conductances. The VakDyn [4] equations, which are also the basis for the vacuum simulation in StrahlSim, provide a set of linear equations for this purpose. Simulations showed, that the warm part can be represented by two isobaric vacuum elements, but the cwt shows a continuous drop in pressure towards the cold chamber.

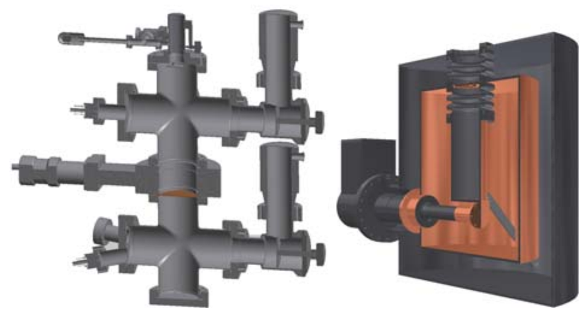

Figure 1: Draft of the planned experiment. Left side, top to bottom: Gas inlet with diffuser plate, first recipient with extractor gauge and turbo pump (closable with corner valve), gate valve to be closed for phase 2, defined conductance (copper bezel), second recipient with transition to the cold chamber, which is shown to the right. It consists of: A Cold-Warm-Transition (cwt) with a baffle, the inner chamber which is plated with copper for an equal temperature distribution, a copper radiation shield.

Current status and first measurements

The warm part is already in operation. The cold chamber is currently designed and built externally.
To calculate the integral outgassing in the warm part during pump down and after bake out, the corner valves are closed one at a time so the pumping speed for the valved off chamber is set to zero. The integral outgassing rate in this individual chamber is then equal to the gas flow through the bezel which can be calculated from the two measured pressure values.
Its value could be reduced by two orders of magnitude by baking the system at 200°C for 18 days. Thereby the most prominent residual gas species in the spectrum changed from water to hydrogen. The remaining water now originates mainly from the corner valves, which have been heated to only 100°C to protect the turbo pumps from excessive heat. Baking is continued to achieve lowest possible outgassing and thereby background for the experiments.

References

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