Development of Novel low-cost Gas Recirculation System for the RPCs chambers

B. Liberti[1] and E. Pastori[1], G. Aielli[2], P. Camarri[2], A. Di Ciaccio[1,2], R. Cardarelli[1], L. Di Stante[2], L. Pizzimento[1], G. Proto[2], A. Rocchi[1], R. Santonico[2]

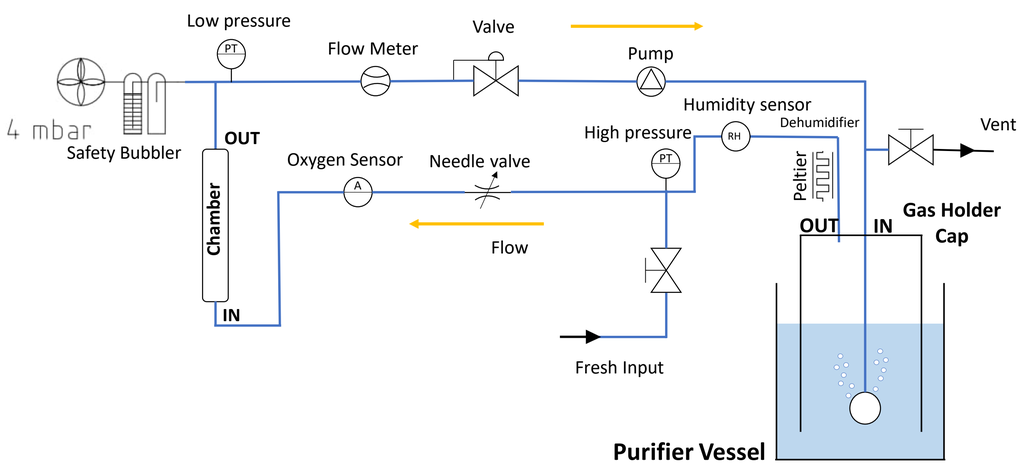
[1]INFN Roma Tor Vergata, [2]Università di Roma Tor Vergata

XVI Workshop on Resistive Plate Chambers and Related Detectors , CERN 26–30 Sept 2022

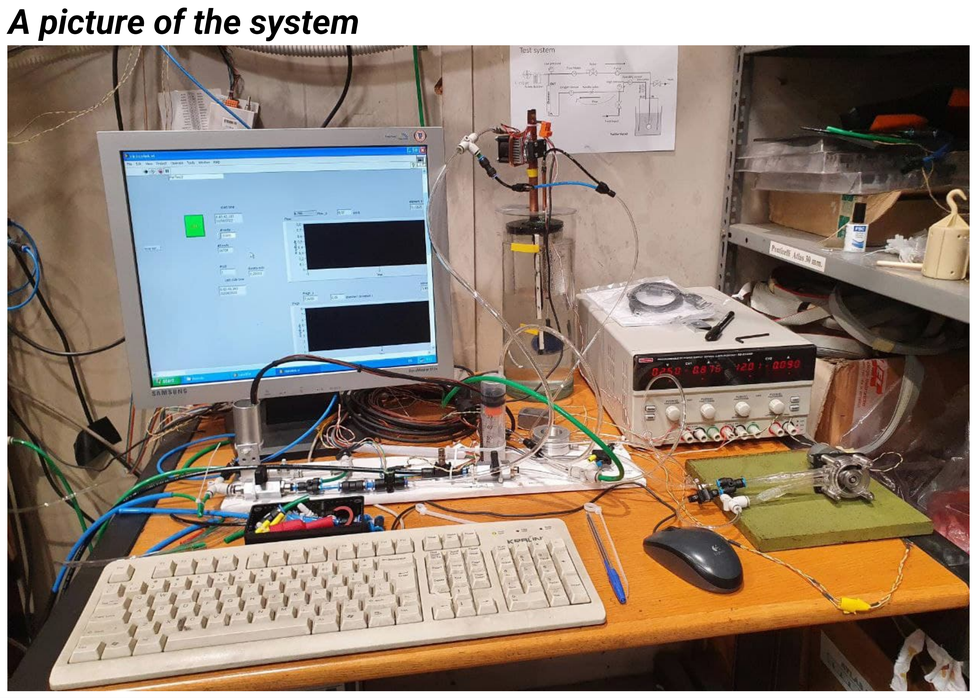
Introduction

The first prototype of a Gas recirculation system was built, based on a concept first developed by R. Santonico for the Argo experiment but never implemented. The key components of the system are a Valve which decouples the suction pump and the RPC chamber, keeping the internal pressure fixed at fraction of millibar above the atmospheric pressure; a Purifier Vessel where the circulating gas is flushed in water, to remove the impurities developed inside the detector which are expected to be soluble and trapped. The Purifier Vessel is based on the principle of the water-sealed Gas Holder where the weight of the lifting cap controls the Gas pressure (Phigh) keeping it constant. The Gas humidity at the output of the vessel is kept controlled with a Peltier Cell cooling a copper pipe where the gas is flushed. The circulating flow is adjusted with a needle valve. The pump used to circulate the gas must be very leaking tight seal, to prevent any possible air intake, eventually a peristaltic pump was chosen.

Process Flow Diagram



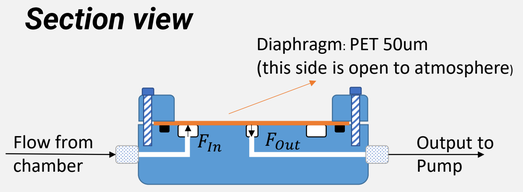
A picture of the system



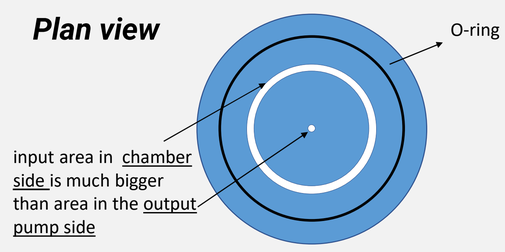
The Control Valve

This valve acts as a back pressure regulator, keeping the chamber pressure constant, regardless of environmental parameters, circulated gas flow and pump prevalence. It is made of an aluminium frame, with a PET foil in contact with the external atmosphere. It was built by modifying a prototype of a check valve first developed for the RPCs in the Atlas experiment. **The valve doesn't need any external control and the chamber pressure will depend only by the valve geometry, the PET foil stiffness and weight. Many valves can be installed in parallel** for better segmentation in a larger system. **This valve is intrinsically safe**, in case of an accidental leak in the chamber volume it will remain closed, preventing any possible air intake.

Section view



Plan view

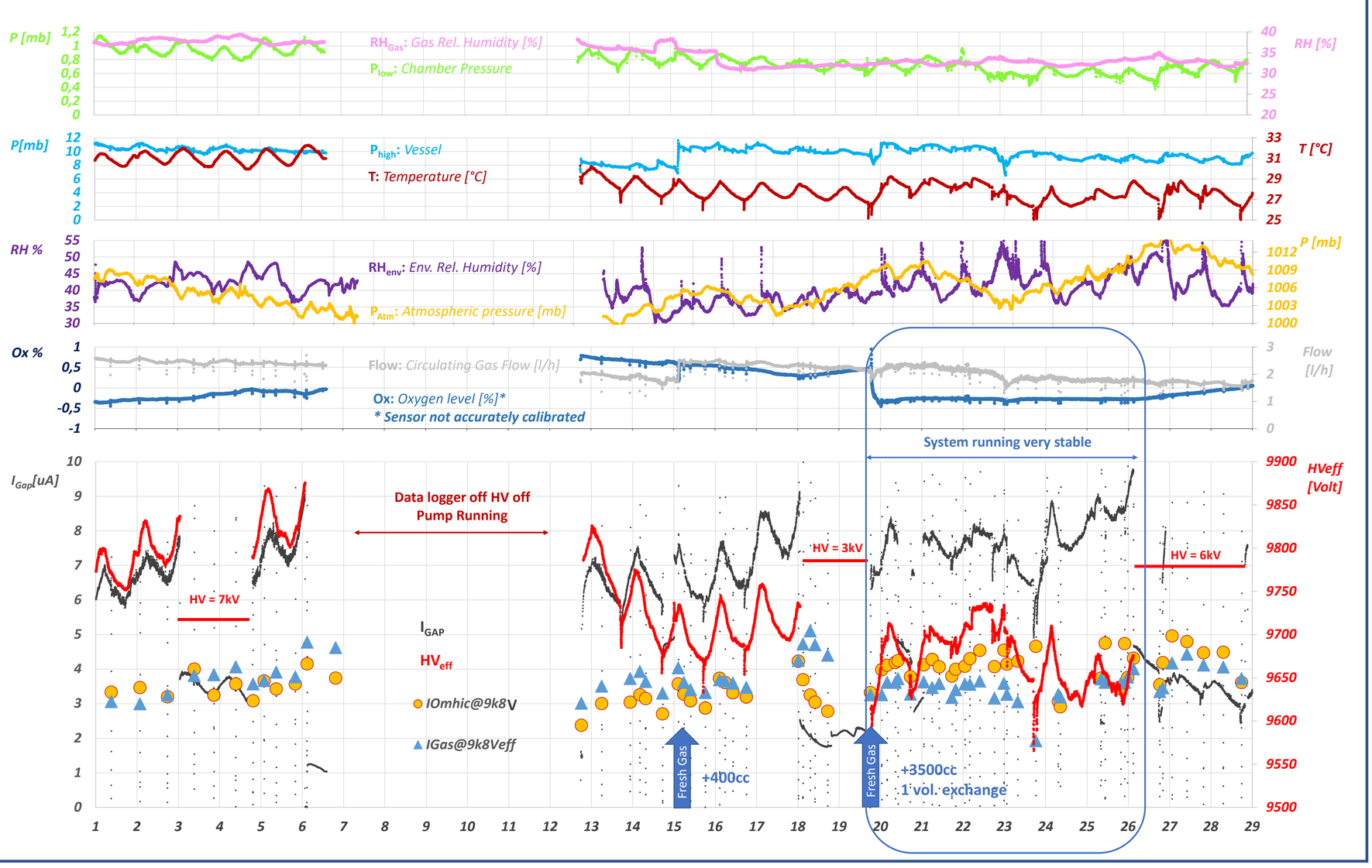


Test Setup

At the beginning of the test the Gas Holder Cap is in contact with the water at the lowest position. To prevent any possible contamination with the dissolved gas in the water this was previously boiled and sealed from the atmosphere with an oil veil. The system is flushed with fresh gas (Standard RPC Gas mixture: TFE iso-$C_2H_2F_4$(94.7%), iso-C_4H_{10} (5%), SF_6 (0.3%)) with the Vent valve open till the air inside the detector is completely removed. With the Vent valve closed the gas goes to fill the Gas Holder and its cap moves to the highest possible position where the vessel holds about 500 cc of Gas. The chamber used for the test is a very old prototype of the Atlas RPCs (86x172)cm, with a gas gap of 2 mm and a gas volume of about 2900 cc. It was needed to replace the old fragile gas Inlets to have very leak-tight seal Gas Volumes. Even though the measured leak rate of the whole system is about 300 cc per week, to prevent any possible air intake in the system, the chamber pressure must be kept always at a fraction of millibar above the atmospheric pressure. The applied HV was fixed at 9400 Volt and the expected working point is at around 9800 $Volt_{eff}$ under experimental environments condition.

Test Result

The system was kept working and monitored for 29 consecutive days. In the four drawings above the data recorded of the principal environmental and system parameters are shown. In particular, the first plot shows in Green the **Chamber Pressure that was always kept by the system between 0.5 and 1.1 mb** and in Pink the Gas Relative Humidity kept constant by the Peltier dehumidifier**.** The plot below shows the monitored Chamber parameters: the effective voltage applied (Red) and the total Gap current (Black). In addition, the ohmic extrapolated current at 9800 V (Orange) and the exponential Gas Current contribution at an effective applied voltage of 9800 V (Blue) are superimposed. These two parameters have been extracted from complete Voltage Current Scans carried out three times a day. After 6 days of stable working, the applied voltage has been reduced because of the fast current rising. Unfortunately, from day 7 to 12, the data logger shut down while the pump kept working properly until day 13, when the system was fully recovered. On day 15 an add of 400 cc of fresh gas was needed, to recover the intrinsic leak rate of the system. At day 18 the current rise again, probably due to the Oxygen level increasing, and the voltage was lowered again. After 2 days, surprisingly the chamber recovered, but since the oxygen level in the mixture was too high, one volume of fresh gas was exchanged. From day 20 **for more than 5 days the system run very stable with a very low level of oxygen**. We suspect that the previous oxygen increase was due to a water residual dissolved air. The last Oxygen increasing trend from day 26 must be further investigated, but it is probably due to a break in the system.



Conclusions and perspectives

The system was built just as a proof of concept, but the new control valve worked greatly since the first application. The most critical part in this system has been proved to be the sole active component: the pump, which therefore must be carefully selected. The system was able to keep a running chamber in stable condition for many days. Although proving the effectiveness of the water filter is still not possible, more information will come from analyzing the residual water in the vessel and planning further studies of the process.