Gas Handling of SoLID Heavey Gas Cherenkov

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The SoLID Heavey Gas Cherenkov (HGC) uses C_4F_{10} gas (Perfluorobutane or Decafluorobutane) as the radiator gas. The gas is stable, non-toxic, non-explosive and non-reactive except with alkali halide metals. C_4F_{10} is not harmful to ozone but as being a perfluorocarbon compound, it is implicated as having a long atmospheric lifetime and high global warming potential and therefore is no longer manufactured in the US. Since it must be manufactured specifically for our application, the gas is expensive at $200 per Kg. For this reason, a gas system with recirculation by a distillation process which removes air and moisture from the gas will be designed for the detector so the gas can be reused.

The SoLID HGC detector is separated into two halves and total 10 segments to facilitate fabrication and handling [1]. The C_4F_{10} gas is operated at 1.5 atm and a temperature of 20 °C. Each half of the detector has an internal volume of 10 m^3 and requires ∼150 Kg of C_4F_{10} at 1.5 atm to fill. Total system volume 10 m^3 and requires ∼300 Kg of C_4F_{10} to fill.

The Hall B CLAS12 Low Threshold Cherenkov Counter (LTCC) is a C_4F_{10} Cherenkov also with a large volume (7.2 m^3 × 6) [2]. The LTCC gas system comprises a gas supply and metering unit, pressure control and protection, and C_4F_{10} distillation and recovery units [3], which is shown in Figure 1. After consulting with Jack Segal (Hall A) and George Jacobs (Hall B), they both agreed that SoLID HGC gas system could be accomplished using a similar design. George Jacobs is the Hall B expert in charge of the CLAS C_4F_{10} Cherenkov system.

In the LTCC gas system, the C_4F_{10} is supplied to the system from a container located in the gas shed (Bldg. 96B). Gas flows from the container into the hall via a temperature controlled stainless steel tube. For SoLID HGC, it is also possible to locate the supply container outside and flow the gas into the hall with tube. Another option is to put the gas supply in Hall A to avoid the gas consumption in the long tubes and the cost to build a gas shed.

Since the detector could not be pumped to vacuum, prior to an experiment the tank will be purged with nitrogen gas to remove water vapor and oxygen. Then the C_4F_{10} supply will be connected and each half of the detector will be slowly filled with the heavy gas from the

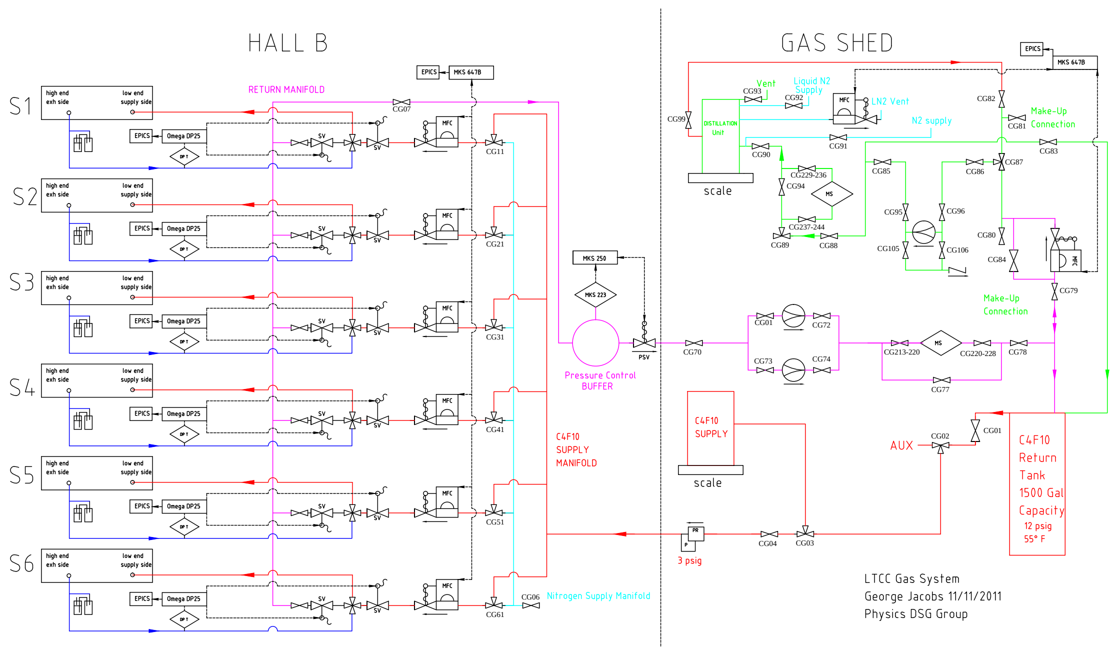

Figure 1: Diagram of the CLAS12 LTCC C_4F_{10} gas system. The diagram is provided by George Jacobs.

bottom by flushing the nitrogen gas out. A single fill will require roughly 900 Kg of gas for a nominal 3 volume gas exchange. The detector will be sealed after the gas filling process. Care will be taken in the design and construction of the detector to make sure that it is hermetically sealed since the detector is operated at 1.5 atm.

It would be possible to recover much of the C_4F_{10} by the end of an experiment or in the event of a re-fill situation (i.e. opening the detector to replace a PMT). The C_4F_{10} will be flushed out by nitrogen gas and be collected in a large return tank. Based on the Hall B experience, PID pressure control will be used to maintain a safe operating pressure in the detector. Gas recovery from the detector volume is most efficient when the return connection is at the detectors lowest point and the nitrogen gas supply connection is at the highest point. Gas from the return tank is first pumped through molecular sieve filters that removes water vapor from the gas. The gas then flows into the distillation unit where liquid N_2 is used to condense the C_4F_{10} gas, while venting out the air and any other gasses that do not liquefy in the unit.

The return tank can be located on a mobile trailer so the SoLID HGC could share the gas distillation recovery unit with the LTCC project. Figure 2 shows a diagram of this concept.

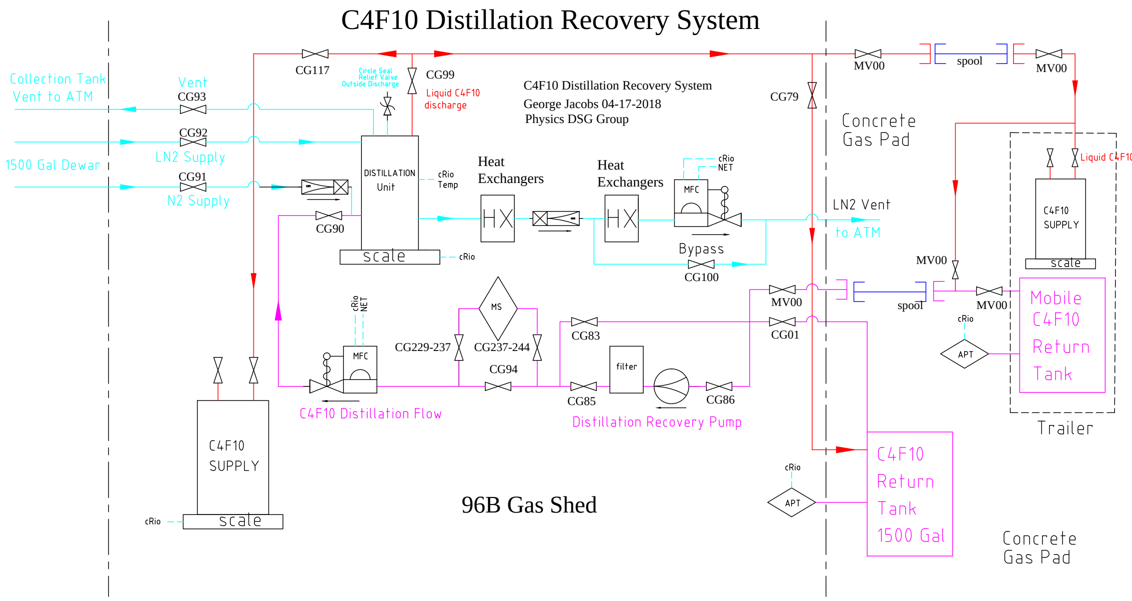

Figure 2: Diagram of the C_4F_{10} distillation recovery system. This diagram shows the concept of using a mobile return tank to collect gas from the detector volume in Hall A. The diagram is provided by George Jacobs.

The mobile return tank could be used in Hall A to collect gas from the HGC volume. The tank is then towed to the 96B gas shed for C_4F_{10} recovery. This might be the best option for gas recovery since it might reduce the expense in terms of gas as well as the design and labor inputs. This possibility will be investigated further together with all projects which might benifite from a shared gas distillation recovery unit.

With the help of Jack Segal and George Jacobs, we also did a brief budget estimation for the gas system. The material cost of the system is \$600k $\sim$ \$650k in total. It is separated into three major parts: \$200k for the C_4F_{10} supply tank and the filling system, \$200k for the return gas tank and the gas recovery system which is not shareable, and \$200k $\sim$ \$250k for the gas distillation unit. It also requires $\sim$2 FTE years to design and build this gas system. The cost could be reduced if we could share the gas distillation unit with CLAS12 LTCC and other projects.

References

[1] The SoLID Collaboration. *SoLID Updated Preliminary Conceptual Design Report*, 2017.

[2] The CLAS12 Collaboration. *CLAS12 Technical Design Report*, 2008.

[3] G. Jacobs et al. *The Hall B Low Threshold Cerenkov Counter Gas System*, 2016.