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Contrived Vacuum Impedances in the Triplet Cryostat

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RHIC PROJECT

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ABSTRACT

The longitudinal vacuum conductance of cryostats housing standard dipoles and CQS magnet assemblies is such that one is able to use pressure differences between interconnects, created by external pumping, to resolve the location of He leaks into the cryostat to within one magnet interconnect. The large diameter of the RHIC triplet cryostat precludes exploiting its longitudinal conductance for the same purpose. Because of this, a baffle is being designed to partition the cryostat vacuum envelop, and thus add better resolution to the location of possible He leaks. The method is given for calculating the needed impedance of this baffle.

INTRODUCTION

In experiments with FullCell #2, it was determined that the equivalent room temperature (i.e., RT) longitudinal vacuum conductance of the cryostats housing the standard dipoles is ~86 ℓ/s. The conductance of a CQS with recooler is ~315 ℓ/s, and a CQS without recooler, ~130 ℓ/s. It was demonstrated that the location of real and contrived leaks could be located with great facility to within one magnet interconnect for these given conductances.

The large diameter of the RHIC triplet cryostat, even though occupied with two strings of magnets, results in it having a very large longitudinal conductance. This precludes one exploiting this conductance to locate potential He leaks at the various interconnects. Because of this, a *baffle* is being designed to partition the cryostat vacuum envelop, and thus create higher longitudinal resolution for locating He leaks.

When a leak occurs in a triplet cryostat, the cryostat will be pumped on with a turbomolecular pump attached to one of two available 100 mm ϕ pumpout ports. These ports are located on each side of the baffle. If the turbo pump is located on the side of the baffle having the He leak, the pressures on each side of the baffle will equilibrate to the same value. On the other hand, if the leak is on the side of the baffle opposite the turbopump, there will be a pressure gradient. The magnitude of this gradient, or pressure difference depends on the effectiveness of the baffle in partitioning the cryostat. Instrumentation ports are located on each side of the baffle so that through use of the same instrument - moved from port to port - the relative pressure difference may be determined.

Helium originating from one side of the partitioned cryostat can reach the other side by leaking through *holes* in the baffle. One can envision *leaky* regions operating at three different temperatures, $T_1<T_2<T_3$, as illustrated in Fig. 1. It is assumed that there are *leaks* in the baffle in each of these regions. As in the case of the RHIC sextants, *transverse conduits* connect each temperature region of a magnet interconnect.

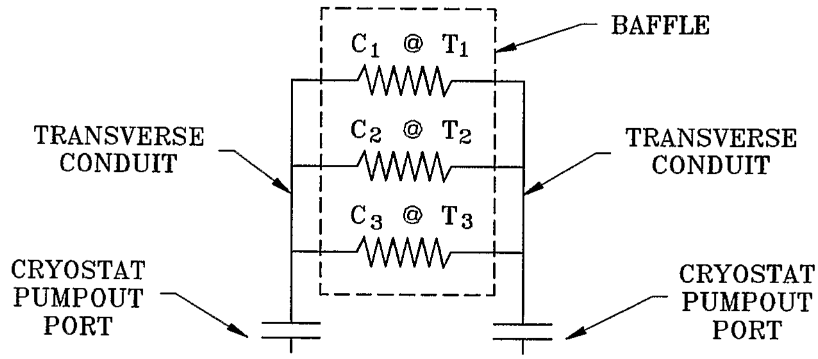

Figure 1. The longitudinal conductance associated with three temperature regions in a cryostat.

kmw
"baffle1"

THE PROBLEM AND ASSUMPTIONS:

What are the maximum size holes which can be tolerated in the baffle, in each temperature region, for one to able to detect on which side of the baffle a leak exists?

Define the following:

C_1 = conductance of holes in the baffle at T_1,
C_2 = conductance of holes in the baffle at T_2,
C_3 = conductance of holes in the baffle at T_3,
T_1 = 4.5 K,
T_2 = 55 K,
T_3 = 293 K,
P_n = the pressure in the region of T_n, Torr,
Q_n = size of He leak through C_n, Torr-ℓ/s,
Q_t = the total He leak rate, Torr-ℓ/s,
and, S_n = pump speed on baffle low pressure side,
= ~100 ℓ/s.

The value of the conductances of the transverse conduits, C_x, is very large such that:

$$C_x \gg C_n, \quad n = 1,2,3 \tag{1}$$

$$C_n = 31.1 \times (T_n/T_3)^{\frac{1}{2}} \times A_n \mathcal{L}\ /s, \qquad (2)$$

where, A_n = the T_n baffle leak area in cm². (3)

The implication of (1) is that, in the presence of a He leak in the cryostat, there will be an insignificant pressure gradient within any transverse conduit compared to the pressure gradient across the baffle. The pressure on each side of the baffle is measured at room temperature, T_3. We impose the following to afford adequate leak resolution:

$$P_{3H} = 1.1 \times P_{3L}, \qquad (4)$$

where, P_{3H} = the pressure on the leak side of the baffle,
and, P_{3L} = the pressure on the pump side of the baffle.

$$Q_t = Q_1 + Q_2 + Q_3. \qquad (5)$$

$$= \sum_{i=1}^{3} (P_{iH} - P_{iL}) \times C_i. \qquad (6)$$

Also, $Q_t = S_e \times P_{3L}$. (7)

Using thermal transpiration for all n, and x either L or H,[1]

$$P_{nx} = (T_n/T_3)^{\frac{1}{2}} \times P_{3x} \qquad (8)$$

Using (2) - (8), we find:

$$S/3.113 = A_1 \times (T_1/T_3) + A_2 \times (T_2/T_3) + A_3,$$

or, $2092\ cm^2 \approx A_1 + (12.\ 2 \times A_2) + (65.1 \times A_3)$.

[1] Kimo M. Welch, Capture Pumping Technology, An Introduction (Pergamon Press, Oxford, 1991), p. 258.