GEM TN-93-298

Purification of Liquid Krypton for GEM

David C. Rahm
Brookhaven National Laboratory

February 9, 1993

Abstract:

Following tests at Brookhaven and at CERN, it became clear that special precautions and purification will be necessary to use Kr in a calorimeter as compared to using Ar. My conclusions are that GEM must be very careful in the choice of construction materials and provide for purification of the Kr in both the liquid and gas phases.

9 February 1993

PURIFICATION OF LIQUID KRYPTON FOR GEM

David C. Rahm
Physics Department
BROOKHAVEN NATIONAL LABORATORY

ABSTRACT

Following tests at Brookhaven and at CERN, it became clear that special precautions and purification will be necessary to use Kr in a calorimeter as compared to using Ar. My conclusions are that GEM must be very careful in the choice of construction materials and provide for purification of the Kr in both the liquid and gas phases.

Experimental Observations

In the summer of 1992 a test run with a liquid Krypton accordion style calorimeter was performed at Brookhaven National Laboratory. [1–2] The Krypton came from Novosibirsk in the framework of the GEM collaboration. The Kr was tested by Prof. Elena Aprile of Columbia University and found to be as good as any other commercial Kr that she had used. Her calorimeter was a very clean calorimeter using only materials that could be pumped down to a good vacuum. In contrast our calorimeter used Rohacell foam inside the cryostat as insulation and as excluder of liquid between the calorimeter and the cryostat wall where the beam would pass. CERN experiments NA-31 and NA-34 used Rohacell in liquid Argon calorimeters, with no negative effect on the performance of the calorimeter. The experience from NA-34 showed that the foam holds considerable water, which was partially removed by pumping, but the residual gas, even after several days of pumping, was still water. Prof. Aprile did a test in Kr with a piece of Rohacell in the cryostat, and found that it was not possible to achieve as good a vacuuum and that there was a marked decrease in the electron signal.

Our test used accordion plates fabricated using the CERN RD3 equipment. First we ran with liquid Ar for several weeks and had very good signals. The Ar was emptied and the cryostat pumped before the Kr was introduced. The signals from our test cell in the

liquid Kr, using the ionization signal from alpha particles, showed a large reduction in the signal. As Kr was added the signal got better until the filling was stopped. Then the signal started to fall until we put our purifier into service.

The purifier used Oxisorb from MG Industries (Messer Greisheim in Germany), followed by a getter purifier from SAES Pure Gas, which is claimed to remove essentially all impurities from a noble gas. With a flow rate of about 20 liters of gas per minute we were able to continuously increase the test cell signal, when the gas sample was drawn from liquid at the bottom of the cryostat. When we switched to drawing the gas from the gas phase in the cryostat, the improvement in the signal stopped and the signal started decreasing. This behavior demonstrated that our impurities were concentrated in the liquid phase. This conclusion was further reinforced by the increased rate of loss of signal as the calorimeter was emptied by removing gas from the top of the cryostat.

One supplementary test during the period when we were purifying from the liquid phase was to bypass the getter purifier, so that only the Oxisorber was used. The rate of increase of the test signal was unchanged, so it seems that the Oxisorber alone was capable of removing our set of impurities.

Previous experience with additives in liquid Ar using a test cell with an alpha particle source showed no significant loss of the electrons as they drifted in a high field and across a small gap (10kv/cm and 2mm gap). [3] Essentially all the loss was due to recombination at the origin of the ionization. In our Kr tests there was signal loss seen due to both loss at the origin and loss during the drift. The same impurities that caused us no trouble at 90^0K, were very bad at 123^0K.

After the test run at Brookhaven I went to CERN to work with the RD-3 collaboration on a test of the new 2m long accordion electromagnetic liquid Ar prototype. While at CERN I was able to have a number of very fruitful discussions. I described our results to D. Schinzel and G. Kesseler of the NA-48 experiment which had a prototype liquid Kr calorimeter. Their experience was different than ours at Brookhaven. With a comparable flow rate of purification, they were unable to stop a continual loss of signal. Tests with gas samples showed that the impurities were as much in the gas phase, as in the liquid phase. They had verified previously that none of the construction materials in the calorimeter were responsible for the signal loss. In the next test they changed their electrical feedthroughs

which they suspected to be leaking, and found that even without purification, the signal was high and stable over 2 weeks of running. It thus appears that their previous contaminant was probably oxygen from leaks.

There were presentations at CERN on gas purification by the firms SAES Getters and by Messer Greisheim. New getters are under development which should make for somewhat simplified systems in the future. SAES appears to be the world leader in getters, their materials being used for high vacuum pumping in LEP at CERN and in the transfer line for the low energy heavy ion beam at Brookhaven. When I investigated buying a purifier, I was told by a former competitor that the SAES system was the only product on the market that would remove essentially all inpurities from a noble gas.

The large Oxisorb cartridge, from MG Ind., that we used has two different materials inside. The Oxisorb material is chromic tri-oxide which interacts with oxygen, with branched chain hydrocarbons, and with a number of other chemicals. The other component is molecular sieve 5A which is very good for water removal. While at the presentation by Messer Greisheim, someone from the Icarus project reported on the use of a special Oxisorb cartridge, the body of which they made and that Messer Greisheim filled. The cartridge is about 10 cm i.d. and about 80 cm long. They filled their test vessel with liquid Ar passing through the cartridge, at a rate of about 1/2 m^3 per hour of liquid. This is a very high rate compared to gaseous purifiers. They found that their drift lifetime was very long, corresponding to an equivalent oxygen contamination of much less than 1 ppb. Oxisorb will work down to liquid nitrogen temperatures.

Recommendations

I would recommend that the calorimeters for GEM should have provisions for purifying both in the liquid and gas phases. The cryostats should have provisions for withdrawing liquid from the bottom and returning it to the top. This will require a cryogenic pump to overcome the resistance in the Oxisorb liquid phase cartridges (resistance mainly due to the particulate filter in the input and output lines). In addition there should be provision for purification in the gas phase by withdrawing liquid from the bottom, gasifying it and returning it to the top of the cryostats. It would also be prudent to have the capability of purifying the liquid in the storage dewars, and or, when filling or emptying them.

It now seems clear that Rohacell should not be used in liquid Kr. Some other method of excluding liquid must be used. The testing by NA-48 showed no problems with normal printed circuit boards, Kapton, or with poly-vinyl-chloride insulated wires. It would be worth while testing other types of foams.

Acknowledgments

I wish to thank Prof. E. Aprile for her tests with our Kr and with Rohacell in Kr. D. Fournier and other members of the RD3 collaboration have been always helpful. Special thanks go to G. Kesseler and D. Schinzel who communicated to me the results of their tests for the NA-48 experiment, and to P. Picchi and S. Suzuki of the Icarus project.

References

1. B. Aubert et al. (RD3 Collaboration),Nucl. Instr. and Meth. A309, 199 (1991).
2. D. Lissauer, 26th Intl. Conf. on High Energy Physics, 6-12 Aug, 1992 Dallas, TX..
3. D. Rahm,Nucl. Instr. and Meth. A316, 67 (1992).