MUID GAS R&D RESULTS STUDIES FOR PHENIX MUON IDENTIFIER

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This note summarizes the results of the ORNL gas R&D for the PHENIX muon identifier. All tests were performed with a cosmic muon stand as shown in Fig. 1.

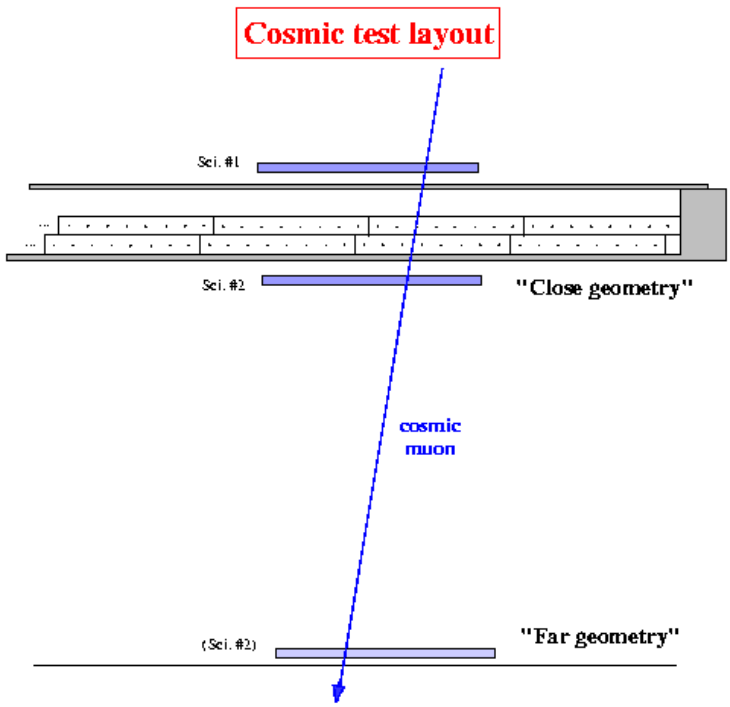

Figure 1: Cosmic ray test stand used in these studies.

Limited Streamer Tubes (LST) of the Iarocci type are used in the muon identifier in PHENIX and will operate in the proportional mode. A prioritized criteria list for gas search is the following:

The gas must allow operation of the PHENIX muon identifier with high efficiency over a relatively long HV plateau. Long here is considered to be $\sim$ 10% of the nominal voltage to guard against performance degradation due to variations of atmospheric pressure and of cell-to-cell amplification.

The gas must be fast enough that high efficiency ($\geq$ 92%) is achieved within a narrow time window (roughly 80 nsec). PHENIX MUID is used in the trigger which means that any particle whose signal in the LST arrives at the FEM more than 106 nsec after the earliest possible signal will be lost. We lose some of the potential time window of 106 nsec to variations in propagation time along the LST anode wire, to different flight times, and to different cable lengths; thus, 80 nsec is the effective time window.

The gas must be relatively inexpensive. The MUID has a volume of roughly 50 cubic meters. Past experience has shown that the LSTs should have one full gas volume

exchange per day. Until we show that a lower flow rate is possible, we must use this flow rate as a baseline.

Preferably, the gas should be not flammable. It must not be explosive.

The gas should allow successful operation in proportional mode. The desire to run in proportional mode is primarily motivated by longevity, stability, and uniformity of operation concerns associated with the difficulty in servicing the panels after installation into PHENIX. Streamer mode is harder on the tubes. Also, streamer mode requires higher operating voltages and, thus, significantly more expensive HV supplies.

We tested several of the standard gas mixtures used to operate similar tubes. We can summarize these measurements with the PHENIX muon identifier LSTs as follows:

Ar/CO_2 mixtures — In general these mixtures were too slow and had unacceptably short efficiency plateaus as a function of HV. Bubbling the mixture through alcohol did not have a significant effect in extending the plateau to higher voltage.

P10 — We never reached 100% efficiency with this gas before breakdown started. Alcohol did not help.

Ar/isobutane — The “proportional” mixtures (high in argon) also suffered from a short efficiency plateau before breakdown. The “streamer” mixtures (high in isobutane) had the expected long efficiency plateau, but not until the voltage was high enough that they were operating in streamer mode. All of these mixtures were rather slow.

CF_4/isobutane — This mixture worked beautifully. It was much faster than any other gas we tested and had a very long efficiency plateau. The only problem is that CF_4 is prohibitively expensive if we need to flush LSTs once per day, even at a CF_4 concentration of 10%.

CH_4 — The plateau was very short.

Isobutane — Pure isobutane worked very nicely. We were worried about the possibility of this being an explosive (not just flammable in safety regulations) and were warned about isobutane polymerization. But, this pointed us on the right track; we needed to find a gas to dilute the isobutane without detrimentally affecting it.

Isobutane/N_2 — We thought that N_2 might be a good diluter gas, but the chambers were audibly sparking before we achieved any efficiency.

Isobutane/CO_2 — The combination of these gases, in a wide variety of ratios, satisfied our requirements. This is a proportional mode gas, and both components are relatively inexpensive. We may want to run with a flammable concentration of isobutane. Results for efficiency, single’s rates and timing are summarized in two figures below. Figure 2 shows the efficiency and singles plateaus, as functions of the HV setting, for the different ratios. The plateaus are quite wide and are within reach of the HV supplies already ordered. Figure 3 shows the effiency versus gate width for the same mixtures. All show saturation at very high efficiency by 80 nsec.

The ratio of the two gases in our mixture does not seem to be critical for performance. However, somewhere between 90% CO_2 and pure CO_2, the behavior must deteriorate since pure CO_2 has a very narrow efficiency plateau and is relatively slow. So far, the only difference we see between different ratios is the gas gain (at the middle of plateau). Figure 4 shows the most probable value of the signal amplitude for different gas ratios. One may want to choose robust detector operation (a 50/50 mixture) or to minimize safety hazard and expense (10/90 isobutane/CO_2).

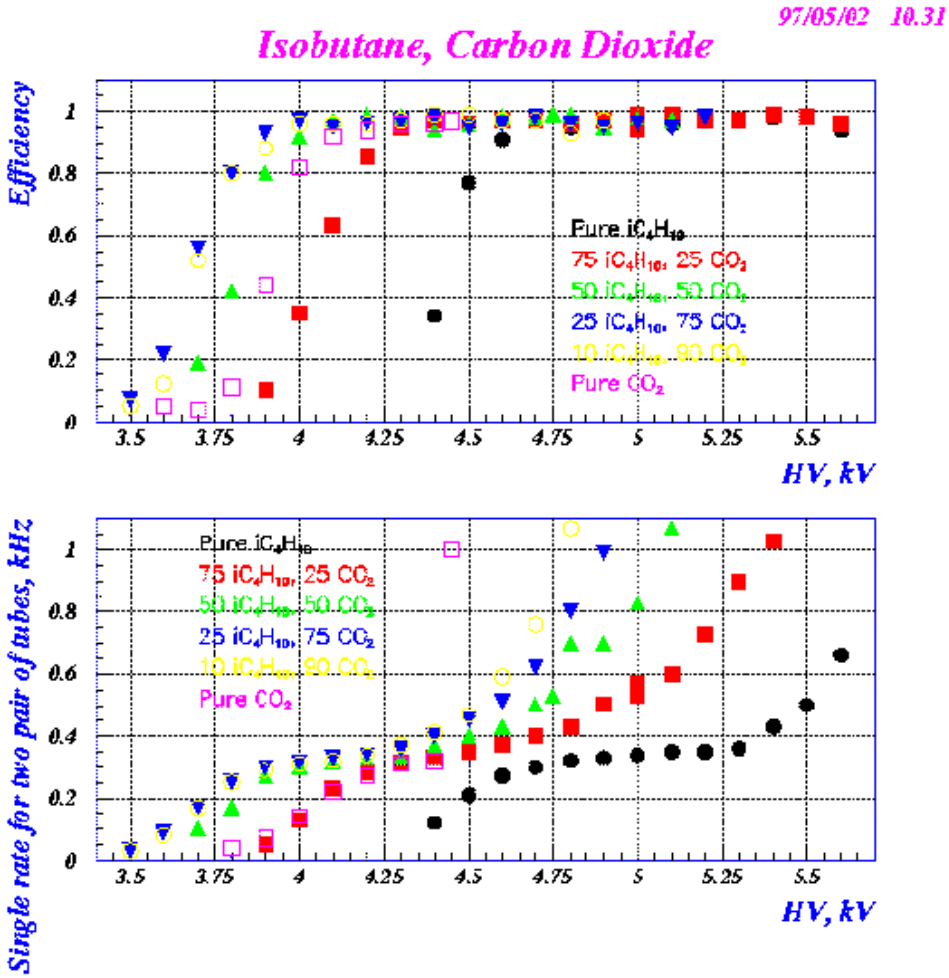

Figure 2: Efficiency and single's plateaus as functions of high voltage for different ratios of isobutane and CO_2.

As a result of these studies, we have found a gas mixture (isobutane/CO_2) which satisfies all of the requirements for the PHENIX muon identifier; this mixture was approved as a baseline for detector operation. There is a very wide range of acceptable composition ratios.

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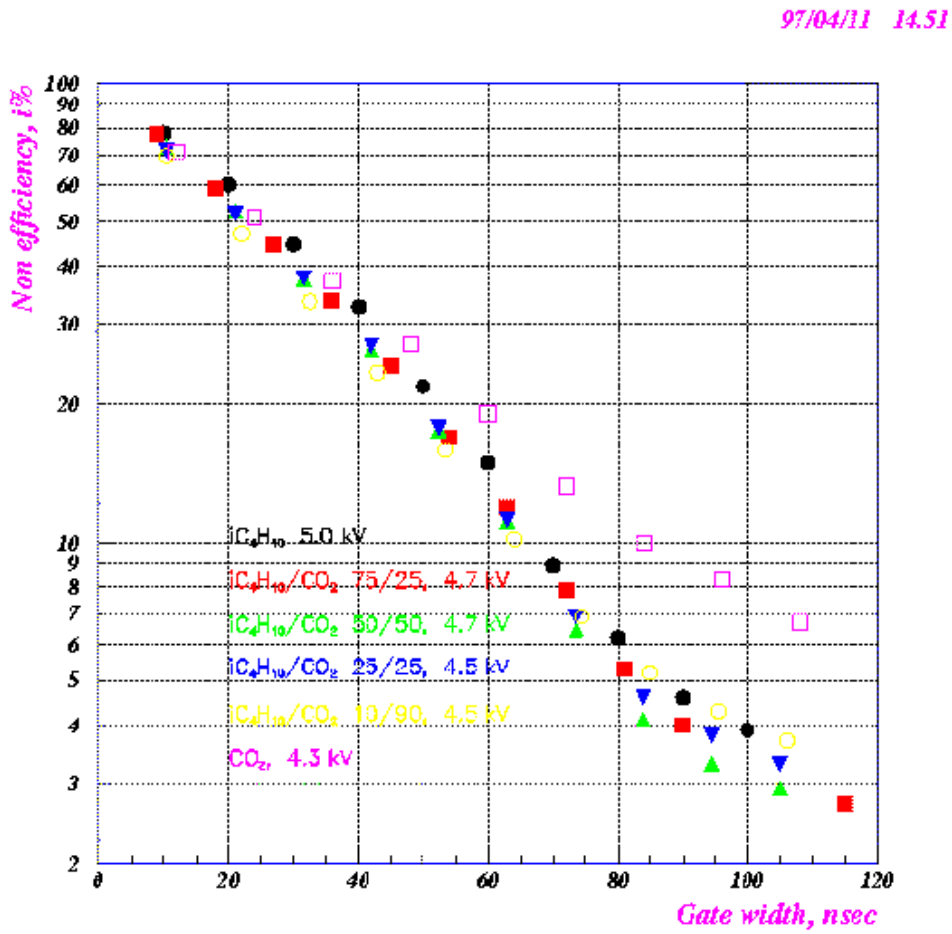

Figure 3: Inefficiency as a function of LVL1 trigger gate width for different ratios of isobutane and CO_2.

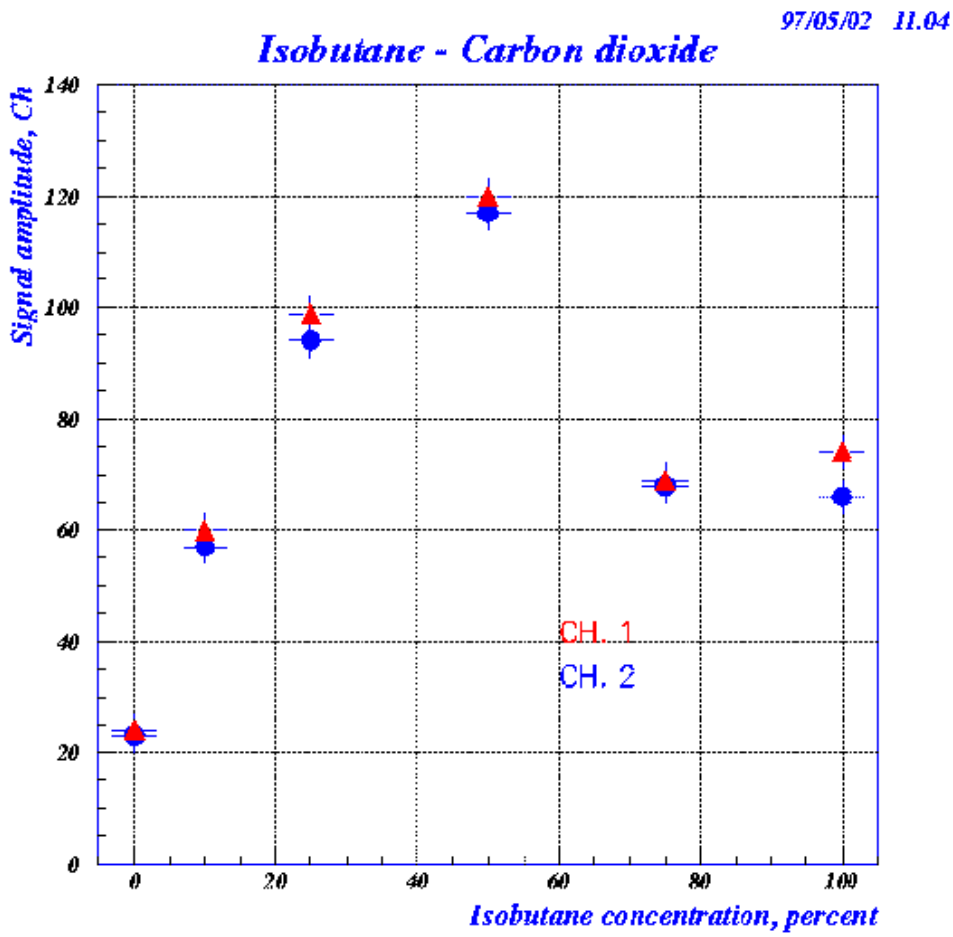

Figure 4: Most probable signal amplitude for different ratios of isobutane and CO_2.