Baseline RPC Gas Mixture for the Daya Bay Reactor Neutrino Experiment

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As stated in sec. 6.3.2 of the Daya Bay Experiment TDR, the baseline RPC gas mixture is Ar/R134A[1]/Isobutane[2]/SF_6 (75.4/20/4/0.6 volume ratios), as also used in the OPERA experiment.[3] This gas mixture is favorable in that it is nonflammable (Isobutane ≤ 4%), and it permits efficient operation of the RPC's at a relatively low voltage (due to the large proportion of Ar) with reduced amounts of Freon compared to the RPC gas mixtures used in BaBar[4] and Belle.[5]

A gas mixture with high argon content is unstable against UV-induced discharges, so a small amount of SF_6 is added. Both R134A and SF_6 can contribute to global warming, and their so-called global-warming-potential indices were assigned in 1996,[6] with the index of SF_6 being 18.4 times larger than that of R134A. The global-warming-potential index of the OPERA gas mixture is smaller than that of the BaBar mixture (35% R134A) and comparable to that of the Belle mixture (30% R134A).

Several studies of RPC gas mixtures have been made by members of the Daya Bay experiment:

(1) IHEP: Lihua Ma, *A Preliminary Result of Gas Percentage Experiment*, DocDB #1752 (Jan. 14, 2008)

(2) Houston: K. Lau, L. Lebanowski and G. Xu, *Study of RPC Gas Mixture*, DocDB #1785 (Jan. 31, 2008).

(3) Princeton: C. Lu, *Test OPERA Gas Mixture on IHEP RPC with 8-m-long Strip*, DocDB #1133 (Aug. 1, 2007).

All three groups agree that reducing the isobutane to 4% doesn't cause a loss of efficiency. Within the Daya Bay Experiment, only Princeton has tested OPERA gas mixture, with results consistent with OPERA's publication.

To date, use of Freonless gas mixtures in RPC's comes with some loss of efficiency (see footnote 5).

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[1] R134A = $C_2H_2F_4$. Production of this and other Freons, as well as SF_6, is being reduced with time since they contribute to depletion of the Earth's ozone layer.
[2] Isobutane = C_4H_{10} in a three-armed conformation. N-butane = C_4H_{10} chain. Butane-silver is a lower-cost mixture of about 30% isobutane and 70% n-butane.
[3] A. Mengucci *et al*., Gas mixture studies for stream operation of Resistive Plate Chambers at low rate, Nucl. Instr. & Meth. **A583**, 264 (2007). Refs. 3-5 are posted at http://puhep1.princeton.edu/~mcdonald/examples/detectors/
[4] H. Band *et al*., *Study of HF Production in BaBar Resistive Plate Chambers*, SLAC-PUB-12854 (Feb. 2, 2008).
[5] Y. Hoshi *et al*., *Freonless Gas Mixture for Glass RPC Operated in Streamer Mode*, Nucl. Instr. & Meth. **A508**, 56 (2003).
[6] http://www.climnet.org/resources/GWP.htm

Based on these arguments we have adopted the OPERA gas mixture as our baseline RPC gas mixture. The baseline Daya Bay RPC gas system is designed for four gas components, including the small amount of SF_6.

Studies are ongoing to evaluate the viability of gas mixtures with slightly different proportions with a goal of lowering the global-warming-potential index, and lowering the cost of the mixture.