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Developing a cryogenic heat pump for liquid xenon radon removal systems

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Future liquid xenon (LXe) dark matter detectors require the detector background event rate to be significantly lower non-shieldable solar neutrino background yielding the request that each radioactive background rate should be 10-times smaller than that from solar neutrinos. To achieve this ambitious goal for 222Rn, a reduction of the intrinsic 222Rn concentration to less than <0.1 µBq/kg in LXe is required —corresponding to less than one 222Rn atom in 160 mol xenon. The project "LowRad" aims to develop the technology for the next generation of radon and krypton removal systems by utilizing cryogenic distillation. Making use of the different vapour pressures of xenon and radon, radon can be removed from xenon through multiple evaporation and condensation steps in a column with partial reflux. To attain the goal of this low radon concentration, the throughput flow of the radon column must be increased from 65 kg/h, in current generation removal system of XENONnT, to O(750 kg/h), necessitating O(20) kW of heating and cooling power for the evaporation and reliquification. Therefore, a heat pump concept using liquid xenon (LXe) as the working medium is being developed. This poster will highlight the working principle of cryogenic distillation and required heat pump, as well as first results from the commissioning phase of the heat pump.

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