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Perspectives for the "green"use of fluorocarbons in Cherenkov gas radiators.

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Saturated fluorocarbons (SFCs: CnF(2n+2)) are chosen for their optical properties as Cherenkov radiators, with C4F10 and CF4 currently used at CERN in the COMPASS and LHCb RICH detectors. New RICH detectors are being considered, which might again use C2F6 as a radiator gas, possibly blended with CO2.
Non-toxicity, nonconductivity, non-flammability and radiation resistance has also made SFCs ideal coolants: C6F14 liquid cooling is used in all LHC experiments, while C3F8 evaporatively cools the ATLAS silicon tracker using compressors or a thermosiphon recirculator exploiting the hydrostatic advantage of the 92m cavern depth.
These fluids, however, have high GWPs (5000–10000*CO2), and represented around 37% of CERN's CO2-equivalent emissions in 2022. There is thus an impetus to reduce their use through improved monitoring and circulation system design.
Spur-oxygenated fluoro-ketones, with CnF2nO structures, can offer similar performance to SFCs with but with very low, or zero GWP. These fluids do not exist in large quantities over the full CnF2n "matrix", but the radiation tolerance and thermal performance of 3M NOVEC 649® (C6F12O) was sufficiently promising for it to be considered as a C6F14 replacement for cooling photomultipliers. Additionally, subject to optical and further material compatibility testing, C5F10O could (if blended with N2, Ar or CO2) replace both C4F10 and CF4 in Cherenkov detectors for a lower overall radiator GWP 'load'. The thermodynamics of C5F10O (mw 266) circulation is likely to be very similar to C5F12 (mw 288), for which there is heritage experience from the DELPHI RICH and SLD CRID as well as crossover from evaporative cooling experience at CERN.
Improvements in leak reduction around large gas volume radiator volumes should be considered. through the use of thin (5-10 cm) containment plenums purged with a light gas - which can be the same as the light component of the radiator itself - with gas continuously aspirated from the plenum for analysis.
Ultrasonic gas mixture analysis is very sensitive to concentration changes of a heavy vapour in a light carrier, and is used for real-time monitoring of C3F8 coolant leaks from the ATLAS SCT silicon tracker into N2-flushed environmental volumes. A typical C3F8 sensitivity of better than 10−5 is achieved.
This presentation outlines various approaches to GWP reduction in Cherenkov gas radiators using saturated fluorocarbons and fluoro-ketones. Different approaches to monitoring, kinetic and thermodynamic circulation are discussed.

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