Contribution ID: **45** Type: **Oral**

Performance of new generation of Resistive Plate Chambers operating with alternative gas mixtures

Thursday 9 November 2023 11:25 (25 minutes)

The standard gas mixture for the Resistive Plate Chambers (RPC), composed of $C_2H_2F_4/i-C_4H_{10}/SF_6$, allows the detector operation in avalanche mode, as required by the high-luminosity collider experiments. The gas density, the low total charge delivered inside the gas and the comfortable avalanche-streamer separation guarantee high detection efficiency, rate capability and slow detector ageing.
The standard RPC gas mixture is mostly based on Hydrofluorocarbons, HFCs, extensively used in the refrigeration industry. The Hydrofluorocarbons are now considered to be non-eco-friendly gases for their high Global Warming Potential (GWP). The SF_6 has the largest GWP, 22900, but, due to its low concentration, it contributes only with few tens of units to the total value. The major contribution comes from the main standard gas mixture component, the $C_2H_2F_4$ (R134a, GWP $\sim$ 1300). This gases are not recommended for industrial uses anymore, thus their availability will be increasingly difficult over time and the search for an alternative gas mixture is then of absolute priority within the RPC community.
There are several studies on going which use different approach to find an alternative gas mixture suitable for experiment which work in high-radiation environment, as those operating at the Large Hadron Collider (LHC). One approach is to replace the standard gas with a mixture of HFO1234ze/CO_2/i-C_4H_{10}/SF_6, being the HFO1234ze/SF_6 the main gas component and obtaining a gas mixture with a GWP $\approx$ 200, totally due to the SF_6.
The second approach, currently under study by ATLAS and CMS collaborations, is to introduce a small fraction of CO_2 in the standard gas mixture and by reducing the amount of SF_6. This approach gives a higher-GWP gas mixture, $\approx$ 1162, but leads to the possibility to use it even for RPC with thin gas gap (1 mm) without observing worse performance in terms of efficiency. Moreover, the presence of less fluorine molecules inside the gas could lead to the possibility to not observe an accelerate aging.
In this presentation the results on the performance achieved using a 1 mm gas gap RPC with both types of gas mixtures are reported. For several gas mixtures, the detection efficiency, streamer and after-pulse probability, current and time resolution are reported. Moreover, the possibility to reduce the SF_6 fraction and to replace it at all with a new gas, the HFO1233zd, is also reported.
The RPC performance are studied under strong photon irradiation which reproduces the gamma background of the ATLAS cavern and that expected during the High-Luminosity phase of the LHC.

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Session Classification: New gas mixtures and gas mixture degradation