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Developments, features and perspectives of radiopure crystal scintillators of the Cs2MCl6 family (M = Hf or Zr) to search for rare processes

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Recently there has been considerable interest in the development of crystal scintillators of the Cs2MCl6 family of metal hexachlorides (M = Hf or Zr) due to their exceptional scintillating properties. These materials offer high light yield (up to 40000 photons/ MeV), good linearity in the energy response, excellent energy resolution (< 3.5% at 662 keV in the best configuration) and excellent ability to discriminate between pulse shapes (PSD) of gamma (beta) and alpha particles.
First low-background measurements with Cs2HfCl6 (CHC) crystal scintillator were carried out over 2848 h deep underground in the STELLA laboratory at the Gran Sasso National Laboratory (LNGS) of the INFN, Italy. Its internal radioactive contamination was studied and presented here. Additionally, recent result on the alpha decay to the ground state of 174Hf with T1/2 = 〖3.8〗_(-0.9)^(+1.7) × 〖10〗^16 yr using a new CHC crystal scintillator is discussed, together with the future perspectives of these measurements.
Hereafter, Cs2ZrCl6 (CZC) crystal scintillators were studied in a series of experiments. The first measurement using two CZC (11 g and 24 g) was done in the DAMA/CRYS low-background setup deep underground at LNGS. Its chemical and radio- purity, residual radioactive contaminants, scintillation and PSD performance are presented here. The low-background measurements over 456.5 days demonstrated the crystals'high radiopurity showing a counting rate of 0.17 (kg · keV · yr)-1 at the Q_2β= 3.35 MeV of 96Zr resulting in first limits on 0ν2β decay for 96Zr within the experimental approach "source=detector"at the level T1/2 > 1017 - 1020 yr. Another measurement was subsequently carried out using three new CZC crystals which were encapsulated using a silicone-based sealant. The crystal growth technique, raw material purification, and post-growth material treatment are discussed.

Primary authors: LEONCINI, Alice (Università degli Studi di Roma Tor Vergata); INCICCHITTI, Antonella; CAPPELLA, Fabio; LAUBENSTEIN, Matthias; WANG, Peng; BELLI, Pierluigi; CERULLI, Riccardo; BERNABEI, Rita; NAGORNY, Serge; NISI, Stefano; NAHORNA, Viktoria; CARACCIOLO, Vincenzo; MERLO, Vittorio

Presenter: LEONCINI, Alice (Università degli Studi di Roma Tor Vergata)

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