Exploring QCD Matter with ALICE – From First Ideas to a Precision Experiment

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Quantum Chromodynamics gives rise to remarkable phenomena, from the confinement of quarks and gluons in ordinary hadronic matter to the emergence of a quark–gluon plasma at extreme temperature and density. Heavy-ion collisions at the LHC provide a unique opportunity to create and study this state of matter in the laboratory.

ALICE was conceived as a dedicated experiment for this purpose. Turning this concept into reality required detector technologies that pushed – and sometimes appeared to exceed – what was technically feasible. Since the mid-1990s, Heidelberg has played a major role in this development, from the construction of the original experiment to the major upgrades that have transformed ALICE into a high-rate precision experiment.

In this talk, I will follow the evolution of ALICE through three decades of technological and scientific challenges, from the construction of the original detector through the discoveries of the first two LHC running periods to the fundamentally upgraded experiment of Run 3 and 4. Selected physics highlights will illustrate how our picture of the quark–gluon plasma has evolved together with the experimental capabilities.

Finally, I will look ahead to ALICE 3, a next-generation experiment designed to address questions beyond the reach of the present detector. On the occasion of 30 years of ALICE activities in Heidelberg, the talk will also highlight the important role played by Heidelberg and the German ALICE community in this scientific and technological journey.