# Advanced design and control of superconducting materials for applications

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The grand challenges that are being faced by scientists developing superconductors for applications are driven by a number of projects and proposals, from those with the aim of expanding the frontiers of human knowledge, e.g. the studies for next generation hadron colliders, to those with a direct societal impact, including innovative gantries for the hadron therapy of cancer, NMR spectrometers at the highest resolution, compact fusion devices, and novel applications in the electric infrastructure and in the field of hydrogen-based mobility. Each of these technologies calls for superconductor R&D tailored to its specific operating conditions—temperature, magnetic field, mechanical stresses, radiation environment. This requires the development of processing routes with a full control of the nanoscale dimensions and scalable at the industrial level. Among the main research directions, two are the most prominent nowadays: (1) a strong focus on pushing the low temperature superconductor $Nb_3Sn$ towards its ultimate performance, mainly driven by the high-energy physics programs; (2) some innovative and more fundamental rethinking about $YBa_2Cu_3O_{7-x}$ conductors that may bring revolution in magnet engineering. The corresponding research activities must (i) build on fundamental material science, a vast range of experimental investigations, from low temperature/high magnetic field measurements to advanced analytical tools, eventually accompanied by machine learning data processing (ii) have pilot production capability to drive and accompany the transition to technical superconductors relevant for industrialization. The aim of this talk is to introduce some examples of the activities running in the Group of Applied Superconductivity at DQMP to provide scope and motivation for targeted R&D in various domains of superconductor technology.