First Year Report

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During the first year of my PhD, I worked with the superconducting magnets group at INFN Genova. In particular, my efforts were mainly focused on the design of superconducting magnets using FEM modelling. In this context, I worked on the preliminary design of the new detector magnet for the ALICE experiment at CERN, which will be installed for the upgrade to ALICE3 during the LHC's LS4 in 2033.

Magnetic Design of a canted detector Solenoid

Canted cosine theta (CCT) windings are often chosen for the fabrication of accelerator magnets. This innovative winding technique can also be adapted for use in detector magnets, introducing a dipole component to the magnetic field alongside the conventional solenoid field. By incorporating this dipole component, the momentum resolution at low emission angles is significantly enhanced, providing improved performance and accuracy in particle detection.

Design of ALICE3's detector solenoid in MgB2

In the LS4 of LHC one of the planned upgrades includes the conversion of the Alice detector magnet, from a resistive, 0.5 T magnet to a superconducting 1 to 2 T solenoid. This advance will reduce power consumption from the current 8 MW to about 0.5 MW. An even greater improvement would be possible by using an MgB_2 based conductor, instead of the conventional choice of an Nb-Ti cable. This is due to the higher T_c of MgB_2 ,39 K, compared to the 9.2 K of Nb-Ti, which allows an operational temperature up to 20 K, implying more efficient cryogenics and higher stability. While opting for a design based on Nb-Ti conductor is the easiest choice due to its established technology, MgB_2, although not extensively utilized in the construction of large magnets, presents enticing prospects. The low field requirement and the large size of the solenoid (over 3 m in diameter) make it a suitable application for MgB_2. Of course, an R&D effort is required to develop a suitable MgB_2 cable, as well for the magnet design.

Thermal simulations of the superconducting magnet's quench

When manufacturing a superconducting magnet, it is important to study the quenching of the magnet in order to design an appropriate protection system. Common protection strategies are to add quench heaters or to use the dissipation due to the eddy currents generated in the winding cylinder during discharge to smooth the transition to the normal conductive state of the magnet, while an external dump resistor discharges some of the stored energy. The quench problem is an electro-thermo-magnetic transient problem and can be solved using widely available software. Models of this type have been created for ALICE and we have produced the first designs of the protection system using LEDET, while a dedicated ANSYS model will be required to simulate the formation of eddy currents in the winding cylinder.

Workshops and Conferences

- Cern Accelerator School (CAS): Mechanical & Materials Engineering for Particle Accelerators and Detectors, Sint-Michielsgestel (NL), 2-15 June 2024.
- ALICE3 Days, CERN, Genève (CH), 24-26 June 2024.
- Applied Superconductivity Conference (ASC), Salt Lake City – Utah (USA), 1-7 September 2024.

Courses and schools attended

- *Applied Cryogenics*, Riccardo Musenich, INFN.
- *Design of Superconducting Magnets*, Stefania Farinon, INFN.
- *Acceleratori di Particelle*, Andrea Bersani, INFN.
- Cern Accelerator School (CAS): Mechanical & Materials Engineering for Particle Accelerators and Detectors, Sint-Michielsgestel (NL), 2-15 June 2024.