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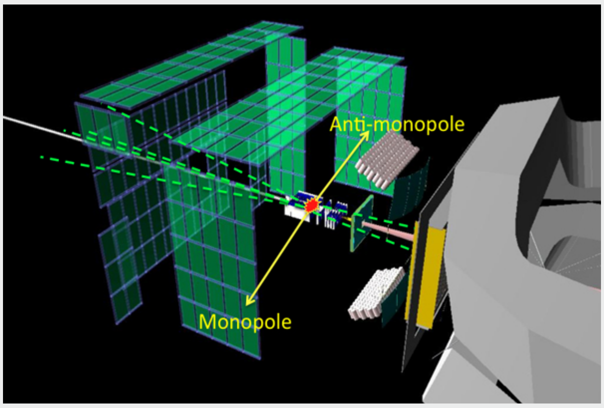

PURSUING THE QUEST FOR MAGNETIC MONOPOLES AT THE LHC WITH THE MoEDAL EXPERIMENT

There is one special particle, among all the unknown ones which physicists hope to discover with the restarting of the LHC: the magnetic monopole, the existence of which was theorised in 1931 by Nobel Laureate Paul Dirac. Italy has been committed to the quest for monopoles for decades, particularly thanks to researchers from the Bologna University and INFN division*.
Magnetic monopoles would represent the counterpart of the electric charge in Maxwell's equations of electromagnetism. In fact, while there are separate particles with a positive or negative electric charge, it is impossible to isolate a magnetic pole: if we break a magnet, we get two magnets, each with its own south pole and north pole.
The quest for magnetic monopoles, which began at the time of their theoretical introduction over 80 years ago, continues today with the MoEDAL experiment (The Monopole and Exotics Detector at the LHC). The search is being conducted by an international group of physicists from 21 institutions and 12 countries, including researchers from the Bologna INFN division.
To prove the existence of magnetic monopoles, MoEDAL makes use of stacks consisting of several sheets of two different types of nuclear track detectors: the CR39®, a polymer widely used for the production of sunglass lenses, and Makfrol®, a polycarbonate widely available on the market. The stacks cover a total area of approximately 25 m^2, close to the LHCb apparatus, one of LHC's four largest detectors, located at one of the collision points of the proton beams that circulate within the accelerator. If a magnetic monopole, produced by the collision of the LHC beams, passes through a stack it leaves a damage that is revealed by later chemical etching of the detector sheets. The monopole's passage would manifest itself as a sequence of micrometric conical etch-pits of equal size and shape, aligned in the various layers. No known particle would leave such a distinctive signature. For this reason, even just one single event of this type would herald the discovery of the magnetic monopole.

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The Grand Unification Theories, of electroweak and strong interactions, predict the existence of large mass magnetic monopoles, which may have been created in the early universe and be present today within cosmic rays as fossil particles. These monopoles were searched for in the late 1990s at the Gran Sasso National Laboratory, by the MACRO experiment (Monopole, Astrophysics and Cosmic Ray Observatory). Since no monopole was found MACRO could set a limit, still unbeaten, on the maximum flux of such incoming particles arriving on Earth from the cosmos.
The discovery of magnetic monopoles would provide a real breakthrough in the comprehension of the physics world, with regard to the understanding of electromagnetism, as well as in Astrophysics and in Cosmology. If monopoles are discovered at the LHC, it would imply they would also have been created in the early universe. As theoretical physicist Joseph Polchinski said at the 2002 Dirac Centennial Symposium, "the existence of magnetic monopoles is one of the safest bets that one can make about physics not yet seen". ■

* The development of this research in Italy is due in particular to Giorgio Giacomelli, Professor Emeritus at the University of Bologna and physicist at INFN, who died in 2014. Giacomelli's name is linked to the quest for monopoles at accelerators and in the cosmic radiation.