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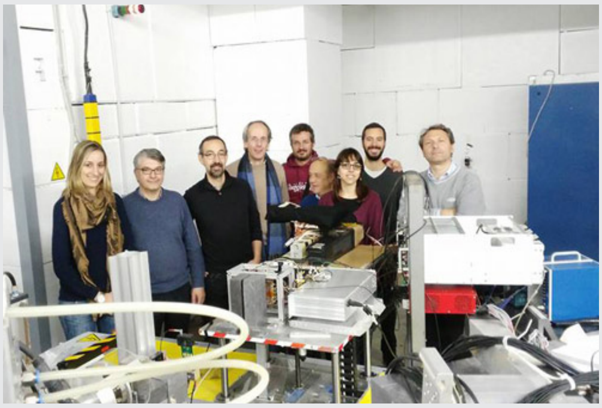

PADME: IN SEARCH OF THE DARK PHOTON

INFN recently gave the green light to PADME (Positron Annihilation into Dark Matter Experiment), that represents one of the most important results of What Next, the scientific review programme promoted in the INFN community to identify the most promising experiments and research fields on which to focus in the near future. PADME is dedicated to the search for the dark photon, a hypothetical particle similar to the electromagnetic wave photon but with a small mass, predicted by a number of recent theoretical models that describe dark matter. The experiment will be the result of an international collaboration already involving researchers from the MTA Atomki institute in Debrecen, Hungary, and from the University of Sofia, Bulgaria. The Ministry of Foreign Affairs and International Cooperation has also funded a project to start a collaboration with the American physicists, in particular with Cornell University.

The study of dark matter is one of the most fascinating frontiers of fundamental physics research. It is estimated that this unknown matter represents approx. 80% of all matter in the universe and 27% of the universe as a whole. Physicists understand neither what it is made of nor why, despite being so abundant at the cosmic level, its direct interactions with our ordinary matter have not yet been detected. The only certainty about its nature is that dark matter is made of something different from the particles that make up ordinary matter, such as protons, neutrons or electrons. One hypothesis, that on which the PADME experiment is based, is that dark matter is sensitive to a new type of force that is not one of the four fundamental forces that we know, i.e. gravitational, electromagnetic, strong nuclear and weak nuclear forces. This new force, as for the other four, is associated with a "messenger", in this case a photon, with properties similar to the ordinary photon but characterised by the fact of having a small mass. Physicists have called this hypothetical "messenger" the "dark photon". Thanks to its mass and its abundance in the universe, the dark photon could represent all or most of the dark matter. PADME could for the first time reveal the existence of this new force, thanks to a small but

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extremely accurate measurement apparatus, able to observe the production of dark photons in collisions of electrons and anti-electrons (positrons).

The experiment will enter into operation in the INFN Frascati National Laboratories (LNF) in a new experimental room of the linear accelerator test structure, the Beam Test Facility (BTF), and will be built around a calorimeter consisting of approx. 600 inorganic scintillating crystals. The positrons, coming from the accelerator, will reach a diamond target and, interacting with the atomic electrons, could produce dark photons together with a visible photon. In order to function, the experiment needs a magnetic field developed by a reserve magnet created at CERN and sent to the LNF to be used in the PADME experiment. The PADME calorimeter will provide an accurate measurement of the characteristics of the visible photon from which it is possible to extract valuable information on the existence and mass of the dark photon.

The PADME target and calorimeter are the result of innovative technologies developed in cooperation between industrial partners and the research world.

The PADME target is a polycrystalline artificial diamond membrane, one tenth of a millimetre thick, and constitutes an innovative device with detector function. It was developed by industrial partners in close collaboration with the INFN laboratories. The collaboration of INFN researchers with matter physicists has also led to the development of a new technique for electrode construction based on irradiation of the diamond surface with laser light to produce conductive graphite strips.

The calorimeter is the result of a technology created for particle physics, which then became widespread, due to its characteristics of granularity, high efficiency and density, in the field of medical imaging, such as PET (Positron Emission Tomography). ■