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NA62: HUNTING OUT THE SECRETS OF THE KAON

In September 2019, at the KAON 2019 conference in Perugia and at a seminar at CERN, in Geneva, the collaboration of the NA62 experiment at CERN, in which INFN physicists and technologists participate, presented its new results on the very rare decay of a charged kaon into a pion, a neutrino and an anti-neutrino. The results show two events recorded in the data gathered by the experiment in 2017 and add to one decay event recorded in the 2016 dataset.

In addition to these events, the NA62 collaboration presented new measures, obtained with unprecedented sensitivity, of the decay of a neutral pion into particles that are invisible to the experiment, like neutrinos or not yet known particles.

At the moment, the collaboration is analysing the data collected in 2018 and the experiment is getting ready for the new data-acquisition phase that will start in 2021, with an upgrade of the experimental apparatus aimed mainly at the reduction of the background, in order to perform high-precision measurements of the very rare kaon decay. The aim is to discover any anomalies in this process, to find behaviours that the Standard Model does not predict. The rare processes represent, in fact, a privileged access channel to what physicists define as New Physics, the physics that we do not yet know and that goes beyond our current theories.

The results obtained so far on over 2000 billion kaon decays are in line with the predictions of the Standard Model. However, by analyzing ever larger and ever more sensitive samples of data, divergences could emerge.

NA62 is an experiment that uses a beam of protons extracted from the Super Proton Synchrotron (SPS). These protons are collided with a beryllium target to generate an intense secondary beam with a significant percentage of kaons, the subject of the experiment's study. In contrast to the experiments that have, until

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now, studied this rare decay, such as E787 and E949 of the Brookhaven National Laboratory in the United States, NA62 studies the kaons "in flight", inside a volume under vacuum, which is more than 60 metres long. The "in flight" detection technique, does not require to "stop" the beam, it hence allows to study kaons of greater energy, with a consequent increase in the total number of observable decays.

The experiment is composed of numerous, high-performance, particle detectors (calorimeters, veto systems for charged and neutral particles, tracking and particle identification systems). Of particular interest, for its advanced technology, is the beam tracing system, developed with the coordination of INFN. The system allows to determine very accurately the position and time of the passage of the particles, thanks to thin silicon detectors, with a thickness of a few hundred microns, in which an innovative microchannel cooling system in carbon is used to dissipate the energy of the about 109 charged particles passing through it for every second of activity.

With the new data-taking phase, NA62 researchers hope to identify even particles that have never been revealed, as possible candidates for dark matter. They will study the products of the interactions between the proton beam and a very thick target, known as beam dump. It is expected that in the impact, all the energy of the beam will be absorbed by the target. However, some weakly interacting and still unknown particles could cross it: the challenge in this case would be to identify them.

The NA62 collaboration, led by the Italian Cristina Lazzeroni of the University of Birmingham, involves around 200 physicists in Europe, the United States, Canada, Mexico, and Russia, and INFN's commitment to the project stands out. Around one third of the participants are INFN researchers: more than 70 physicists and technologists contribute in a decisive way to the success of the experiment with important responsibilities both for the detector and for the experiment's complex data acquisition system. ■