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Study of the cosmic rays with the DAMPE experiment

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Summary. — The DArk Matter Particle Explorer (DAMPE) is a spaceborne experiment, installed on board an instrumented satellite, launched on 17 December 2015 into a Sun-synchronous orbit at an altitude of about 500 km. The detector is smoothly taking data since then and has collected more than $5 \cdot 10^9$ cosmic rays events in 3 years. DAMPE is the result of an active cooperation between Italy, China and Switzerland in order to pursue the following scientific goals: indirect research of dark matter particles, study of cosmic rays spectrum and high-energy gamma-ray astronomy. DAMPE is designed to operate for at least three years, and will probably be extended to a longer lifetime given the excellent current instrument status. In this paper the latest data analysis results will be presented.

1. – Detector description

DAMPE is characterized by 4 sub-detectors (from top to bottom): Plastic Scintillator Detector (PSD), Silicon-Tungsten-Tracker (STK), 3D imaging BGO calorimeter and the Neutron Detector [1].

The detector is capable to detect electrons/positrons, gamma rays, protons and heavy ions from few GeV to 100 TeV with an unprecedented energy resolution (*e.g.*, 40% at 800 GeV for protons). The high e/p rejection power of $\sim 10^5$, together with a relatively high geometrical acceptance, permits a detailed study of the electrons and positrons present in the cosmic rays, a key aspect for the anisotropy investigations in the incoming directions of these particles. Since 2016 DAMPE is smoothly taking data [2], with a rate of 5 Mevents/day; in 3.5 years the detector acquired $\sim$6.5 billions events, corresponding to 7 full scans of the sky.

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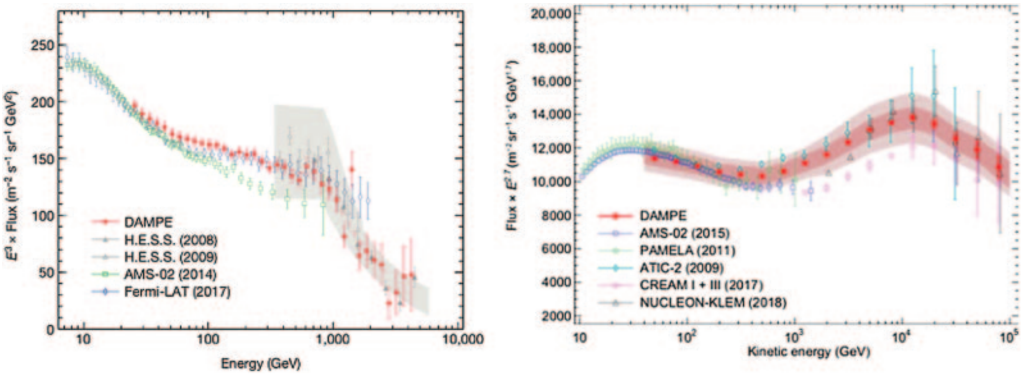

Fig. 1. – (Left) The CRE spectrum (multiplied by E^3) measured by DAMPE from 55 GeV to 2.63 TeV [3]. (Right) Proton spectrum from 40 GeV to 100 TeV measured with DAMPE [4].

2. – Analysis results

In 2017 the DAMPE Collaboration published the CRE spectrum up to 2 TeV [3], while the first direct measurement of cosmic ray proton spectrum up to 100 TeV [4] was released in 2019. Both these important measurements improve our understanding of the acceleration and propagation processes of the cosmic rays through the galaxy.

The CRE spectrum (on the left in fig. 1) highlights a break at $E \sim 0.9$ TeV, confirming the previous results found by the ground-based indirect measurements [5,6]. This result is based on the data recorded between 27 December 2015 and 8 June 2017 ($\sim$1.5 Mevents above 25 GeV). A robust electron/proton discrimination, whose method is based on image pattern recognition, and an affordable estimate of the residual proton background is fundamental. Together with the event pre-selection procedure, the rejection method discards 99.99% of the protons while keeping 90% of the electrons and positrons.

The proton spectrum (on the right in fig. 1) confirms the spectral hardening at $\sim$300 GeV found by previous experiments and reveals a softening at $\sim$13.6 TeV. This is the first time that an experiment directly measures the cosmic ray protons up to $\sim$100 TeV with high statistics. The results suggest the existence of a new spectral feature of cosmic rays at energies lower than the so-called *knee* and shed new light on the origin of Galactic cosmic rays.

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