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The Muoscope: a pocket muon detector with CMS technology

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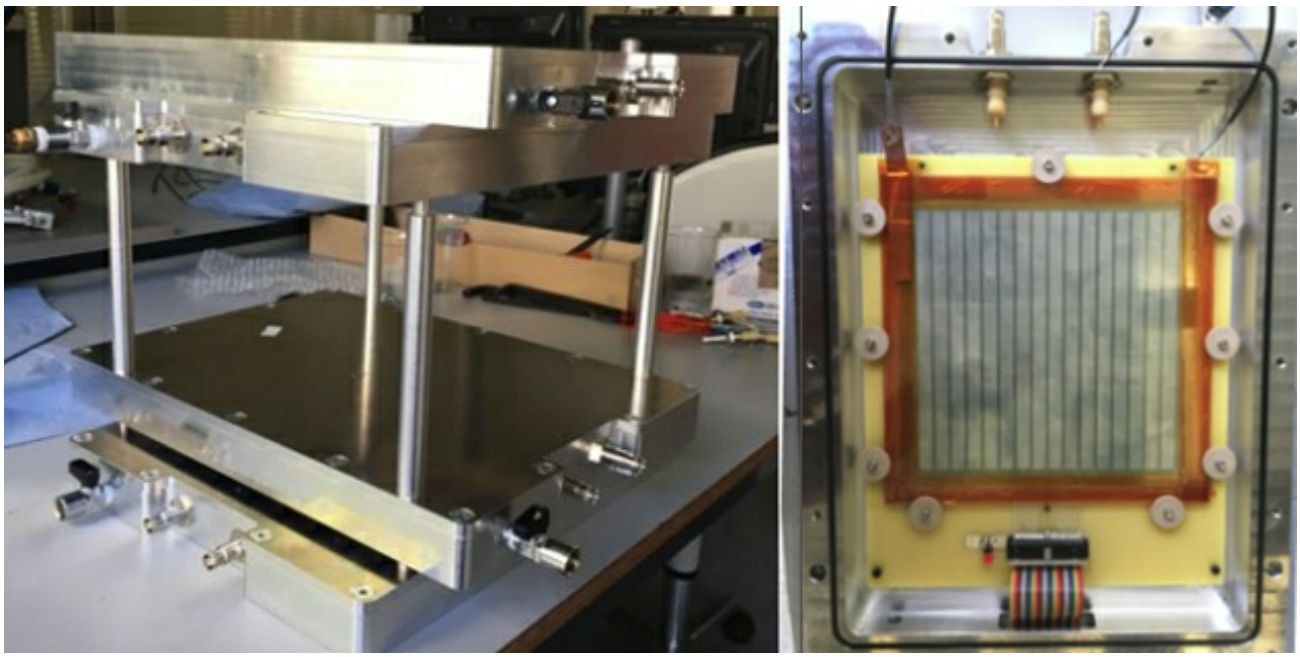

The muon telescope developed by the CMS Collaborators from Ghent University and the Catholic University of Louvain in Belgium (Republished with permission of The Royal Society Publishing, from A portable muon telescope based on small and gas-tight resistive plate chambers, S. Wuyckens, A. Giammanco, E. Cortina Gil and P. Demin, Phil. Trans. R. Soc. A, Volume 377, Issue 2137, 2018; permission conveyed through Copyright Clearance Center, Inc.)

With cosmic-ray muons you can do almost anything. They can penetrate tens of metres of material, in some cases hundreds, and tell us what is inside producing a muograph, just like radiography or tomography are done with less exotic particles such as X-rays, gamma rays and positrons. They are used in a variety of applications, from detecting nuclear contraband, hidden chambers in ancient pyramids, inner structure of volcanoes, and bedrock profile under the Aletsch glacier, to the quite recent measurement of the huge potential differences, exceeding one billion volts, present in some clouds during thunderstorms.

Cosmic-ray muons are there for you at no cost 24/7, all you need is a suitable detector, and spin-offs from high-energy particle physics can help you. For many applications the size of the detecting surface is at a premium, e.g. if you have to investigate large distant structures. However in some cases detectors have to be located in small cavities accessible by narrow tunnels and in remote places without any infrastructure, where a small, portable, robust and as autonomous as possible

detector would be required.

All large high-energy physics experiments at accelerators have powerful muon detectors ready to open a window on new phenomena, beyond the expectations of the Standard Model of particle physics. During the R&D for the Phase-2 upgrade of the Compact Muon Solenoid (CMS) experiment at the CERN Large Hadron Collider, small size prototypes of Resistive Plate Chambers (RPC), one of the four types of muon detectors present in CMS, were produced at the Université Catholique de Louvain (UCL) and Universiteit Gent. Researchers at UCL soon realized that they had at hand an ideal small-size detector to be used in difficult situations with cosmic-ray muons. This new CMS project, after Drift Tubes (DT) and Gas Electron Multipliers (GEM), is the third spin-off of CMS technology in applied muon-detection. RPCs can easily provide a space resolution better than 1 mm (hard to obtain with a detector based on plastic scintillators) and a time resolution better than 1 ns. This novel detector is small, but it is easy to construct, with low construction costs, and able at the same time to provide good tracking precision.

The so-called Muoscope prototype consists of four planes of RPCs made with high-resistivity glass plates (gRPC), with 16x16 cm^2 read out by 0.9 cm wide pick-up metal strips. Two pairs of gRPCs are located at a distance of about 15 cm. The electronics used for the first tests is the same as for the CMS RPCs. One peculiar characteristic in view of the applications is the absence of gas flow: the RPC elements are sealed, which demanded a strenuous fight against gas leaks. By design this detector is compact, with a modest weight of about 50 kg (including electronics and supplies), gas-tight, robust and easy to transport. The last two features were tested by shipping the detector to the Mars Desert Research Station in the Utah desert, as part of the UCLtoMars project, operating it there for a month with a single person, and getting it back in perfect operating conditions. Given that there are ideas for muography on Mars in search of water/life in hidden cavities, the Muoscope could well be the perfect detector for the job.

Homepage: A view of the Mars Desert Research Station where the UCL researcher operated the Muoscope prototype. Copyright: The Mars Society.