Characteristics of muons in EAS

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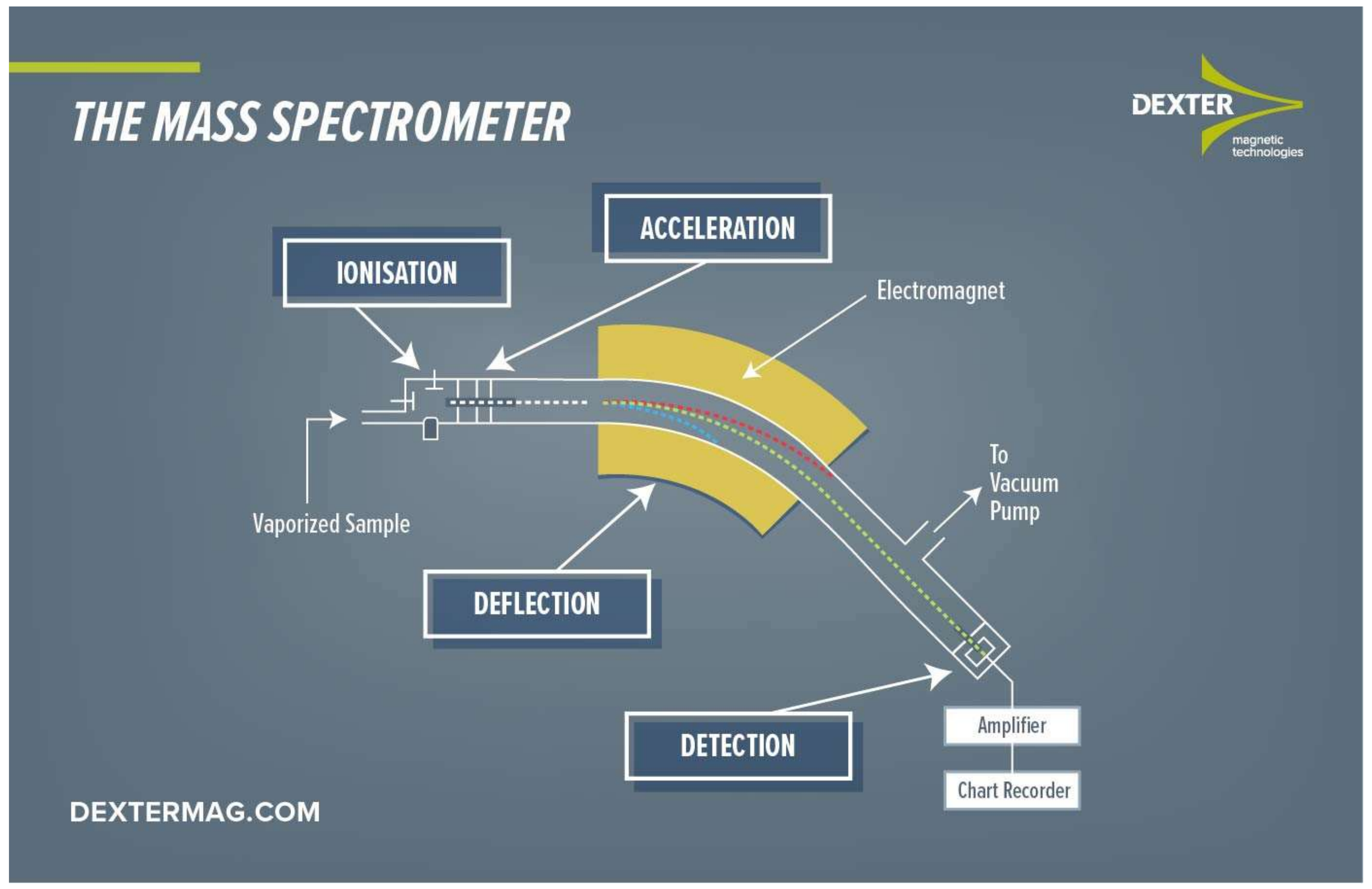
INTRODUCTION

- Muons play one of the key roles in cosmic ray physics. The muon flux is formed as a result of the decays of charged mesons (mostly pions and kaons), formed during the interaction of particles of primary cosmic rays with the nuclei of air atoms and the subsequent development of nuclear-electromagnetic cascades (extensive air showers). Studies of the energy, spatial, and angular characteristics of the muon component provide unique information on the spectrum and mass composition of primary cosmic radiation, as well as on the characteristics of hadronic interactions at very high energies (so far inaccessible to accelerators). Interest in high-energy muons is also due to the rapid progress of neutrino astronomy, since for the interpretation of data from large-scale deep-sea (under-ice) detectors: NT-200 + (Lake Baikal), IceCube (Antarctica), ANTARES, NEMO, NESTOR (Mediterranean Sea), recording space neutrinos, reliable knowledge of the background fluxes of atmospheric muons and neutrinos is required.

MAGNETIC SPECTROMETERS

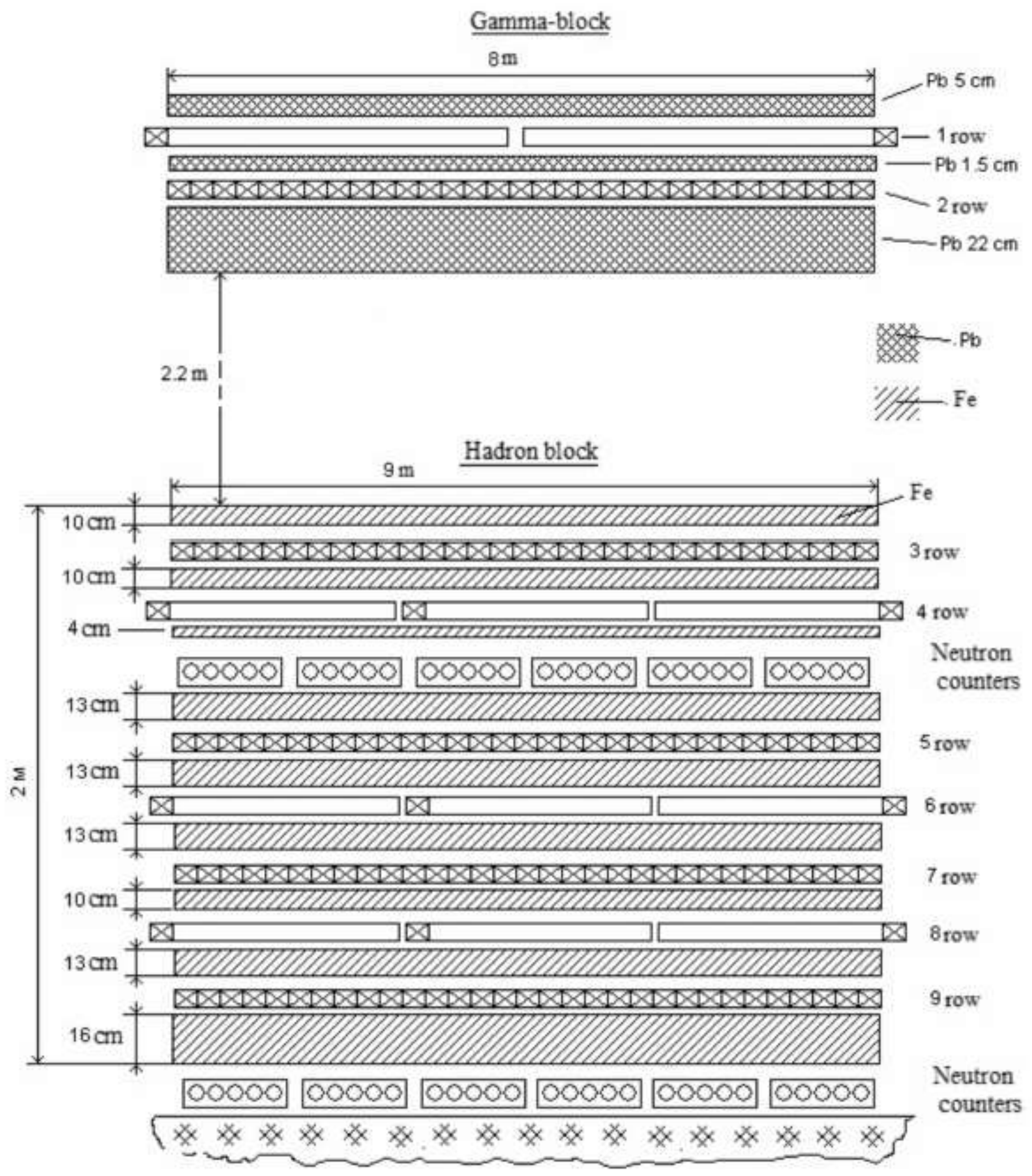
- Magnetic spectrometers are used to measure the momentum of each muon by the deviation of its trajectory in a magnetic field. Spectrometers differ from each other in the type of magnets and particle deflection detectors. The use of solid magnets makes it possible to create a sufficiently strong and uniform magnetic field, as well as to identify muons, since electrons and hadrons are absorbed in the magnet material. The accuracy of pulse measurement in such spectrometers is limited by the effect of multiple scattering and electromagnetic tracking, but by increasing the thickness of the magnet, it is possible to reduce the relative contribution of errors to an acceptable value. The most important characteristic of magnetic spectrometers is the "maximum measurable momentum" (mdm), i.e. the value of the pulse at which the magnetic deflection is equal to the error of its measurement.



Magnetic mass spectrometer

CALORIMETRIC METHOD

- The idea of the calorimetric method for estimating the muon energy is to measure the spectrum of high-energy cascades formed mainly as a result of bremsstrahlung of muons with energy transfers s close to the muon energy from which the muon spectrum is reconstructed using calculations.The spectrum of muons in the energy region above 10 TeV was studied by the indicated method on the scintillation detector of the Artyomovsk scientific station of the Institute of Nuclear Research of the USSR Academy of Sciences, located in a salt mine; at the Baksan underground scintillation telescope; at the MSU installation from deep lead X-ray emulsion chambers (REC) located in the underground room of the Moscow Metro. In addition, based on the results of the operation of the NT-200 Baikal Cherenkov neutrino telescope, restrictions on ultrahigh-energy muon fluxes were obtained.The limiting case of a calorimeter is a jogging installation, when cascade showers are recorded in only one layer. This approach is used to register wide air showers (EAS) at large zenith angles - horizontal air showers (HAL), which can be generated by high-energy muons or neutrinos. Upper limits on the flux of high-energy muons by this method were set at the Akeno and EAS-TOP facilities.



Installation "Hadron 55"

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