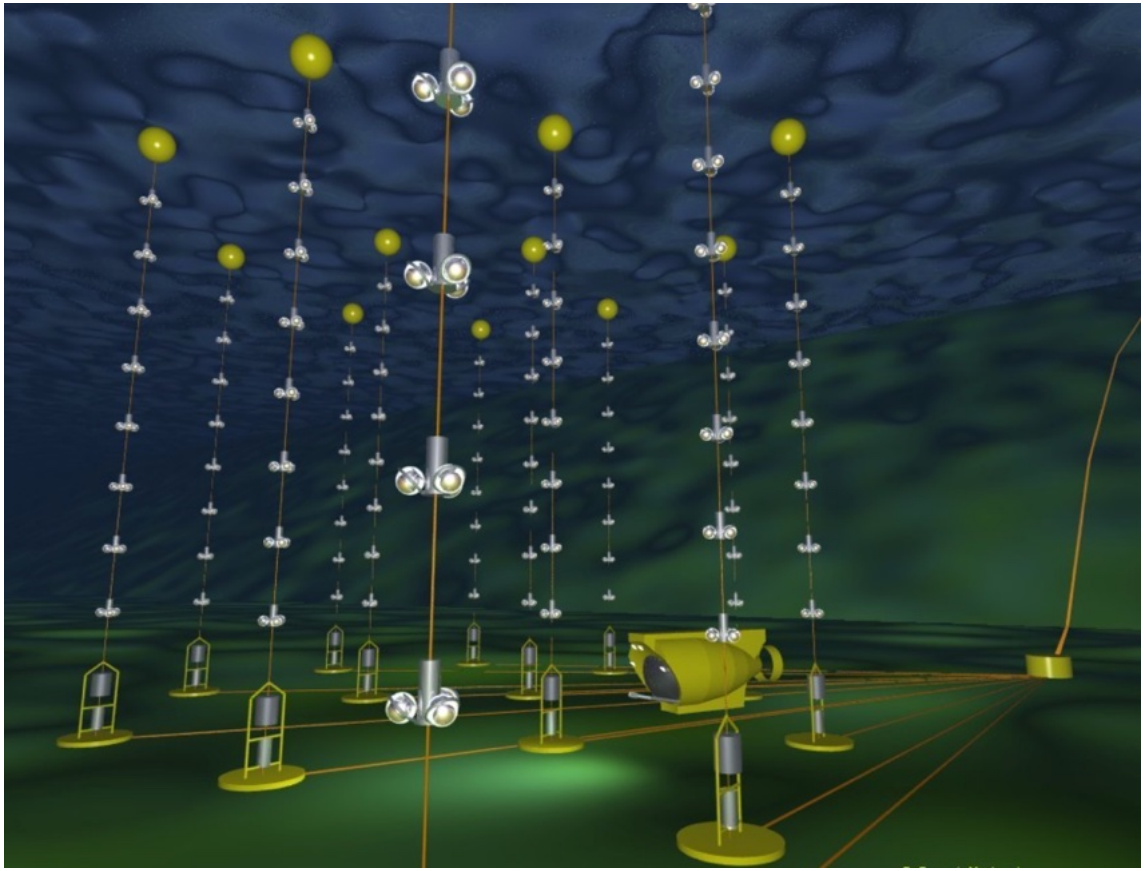
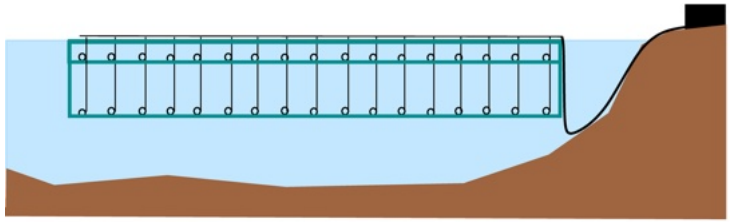
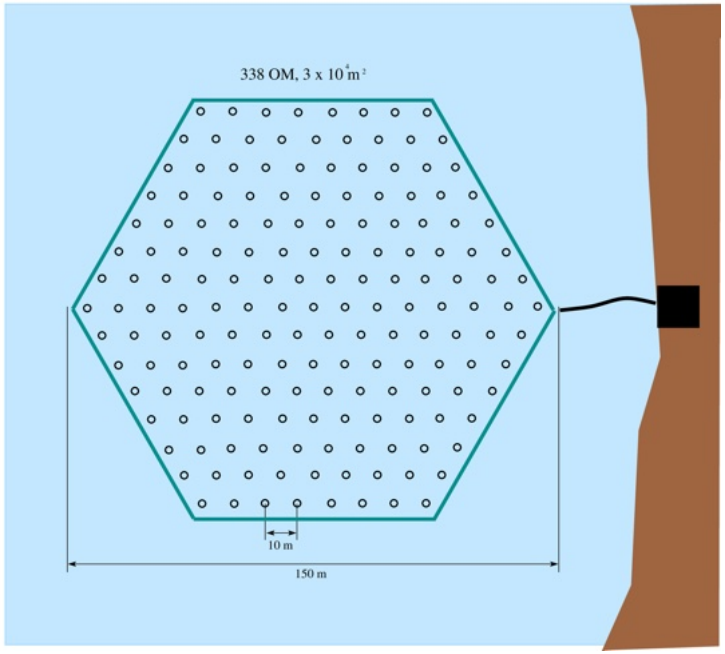
Lake Telescope (Lac-Tel)

Andrii Neronov
APC Paris



ANTARES neutrino telescope





Two-layer Water Cherenkov Detector Array

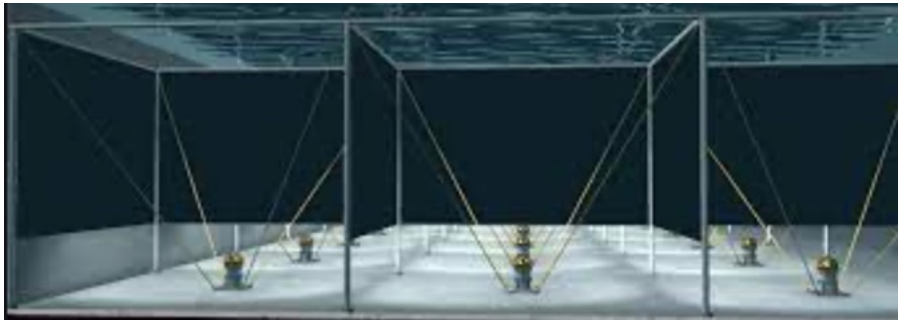
Large High-Altitude Air Shower Observatory (LHAASO)

LHAASO detects cosmic ray and gamma-ray Extensive Air Showers (EAS) with water Cherenkov detectors and scintillator pads. Water Cherenkov detectors (WCDA and muon detector tanks) use large photomultiplier tubes (PMT).

Muon detectors are used for gamma-hadron EAS discrimination: proton and atomic nuclei induced EAS are muon-rich, electron and gamma-ray induced EAS are muon-poor.

Muon detector water tanks (buried under a layer of soil) cover 4% of the area of km2a detector.

Water Cherenkov Detector Array (WCDA)
One-layer water pool 300 m x 300 m



Km2 array
scintillator pads + muon detector water tanks

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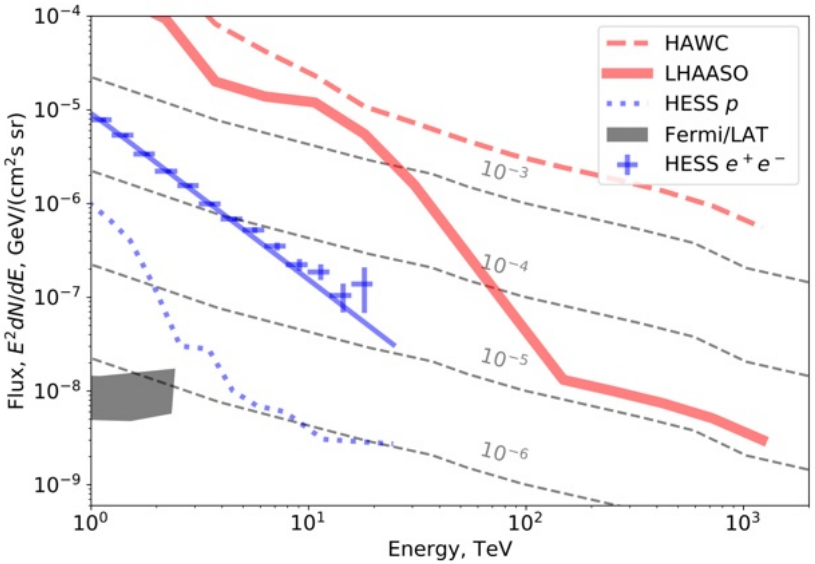

Efficiency of rejection of hadronic EAS background reaches 10^5 at 100 TeV energy, enabling low-background observations of gamma-ray sources.

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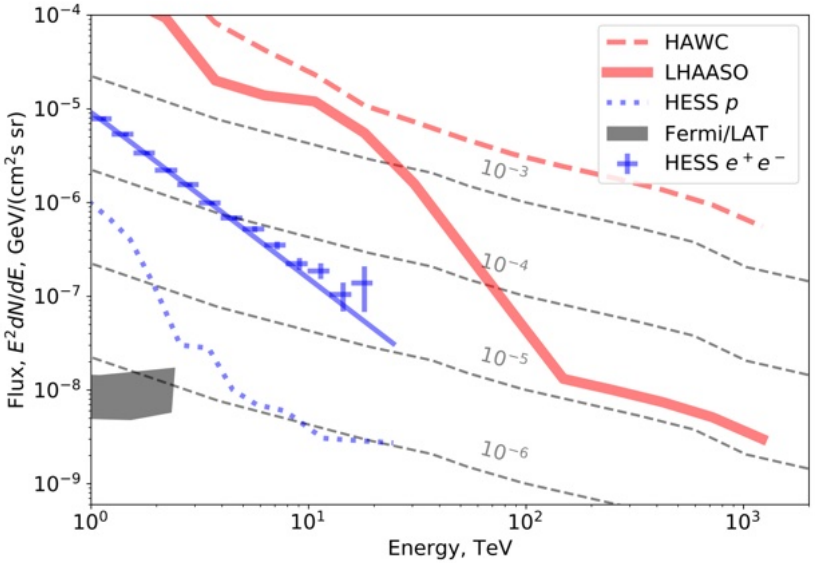
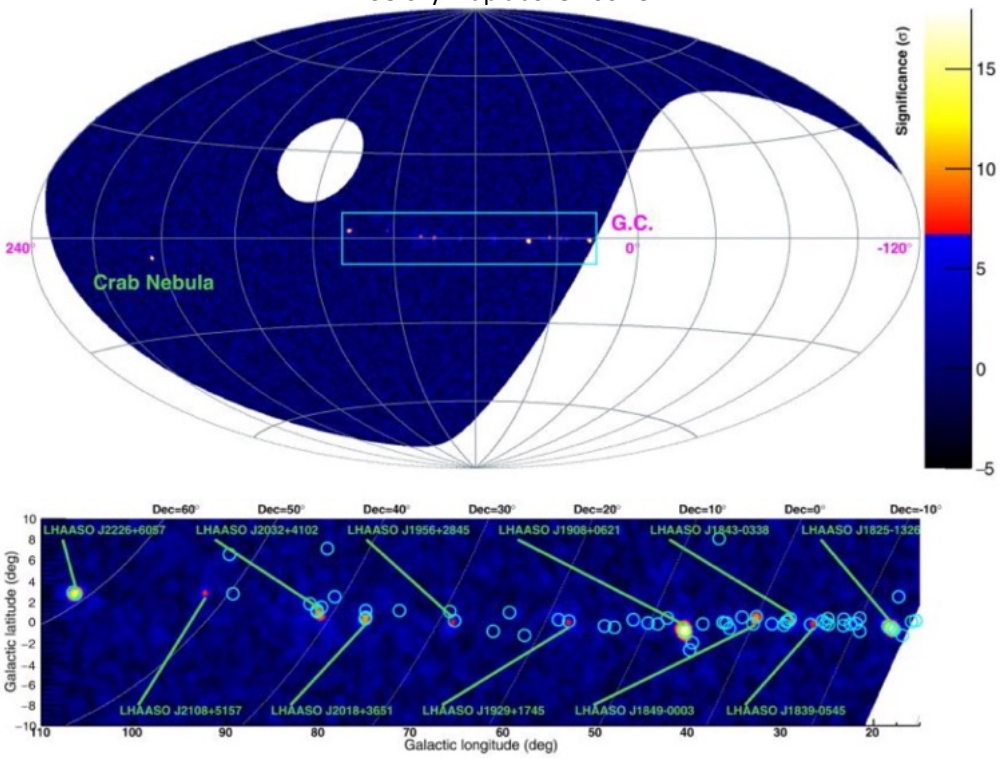
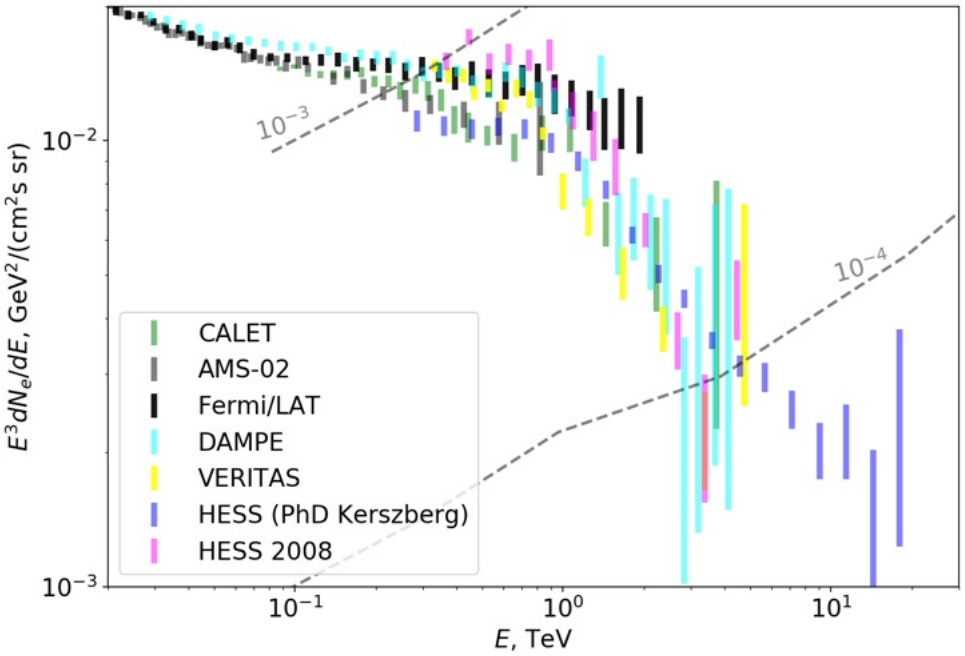


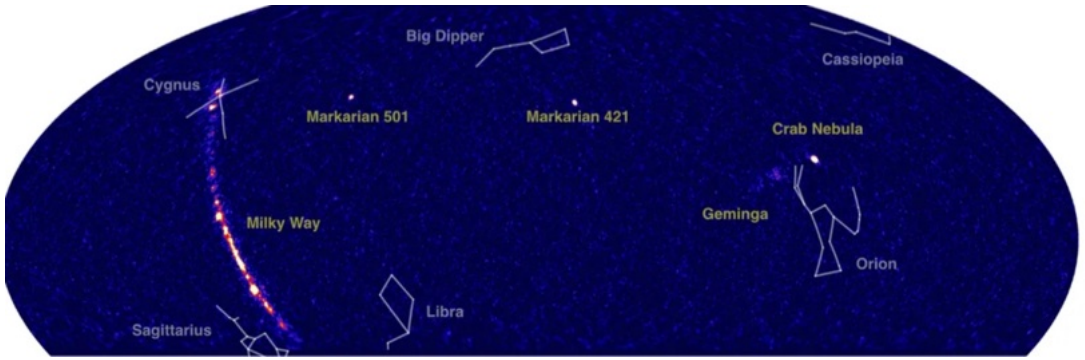
LHAASO sky map above 100 TeV



Efficiency of rejection of hadronic EAS background reaches 10^5 at 100 TeV energy, enabling low-background observations of gamma-ray sources.

Efficient rejection of hadronic EAS down to 10 TeV?



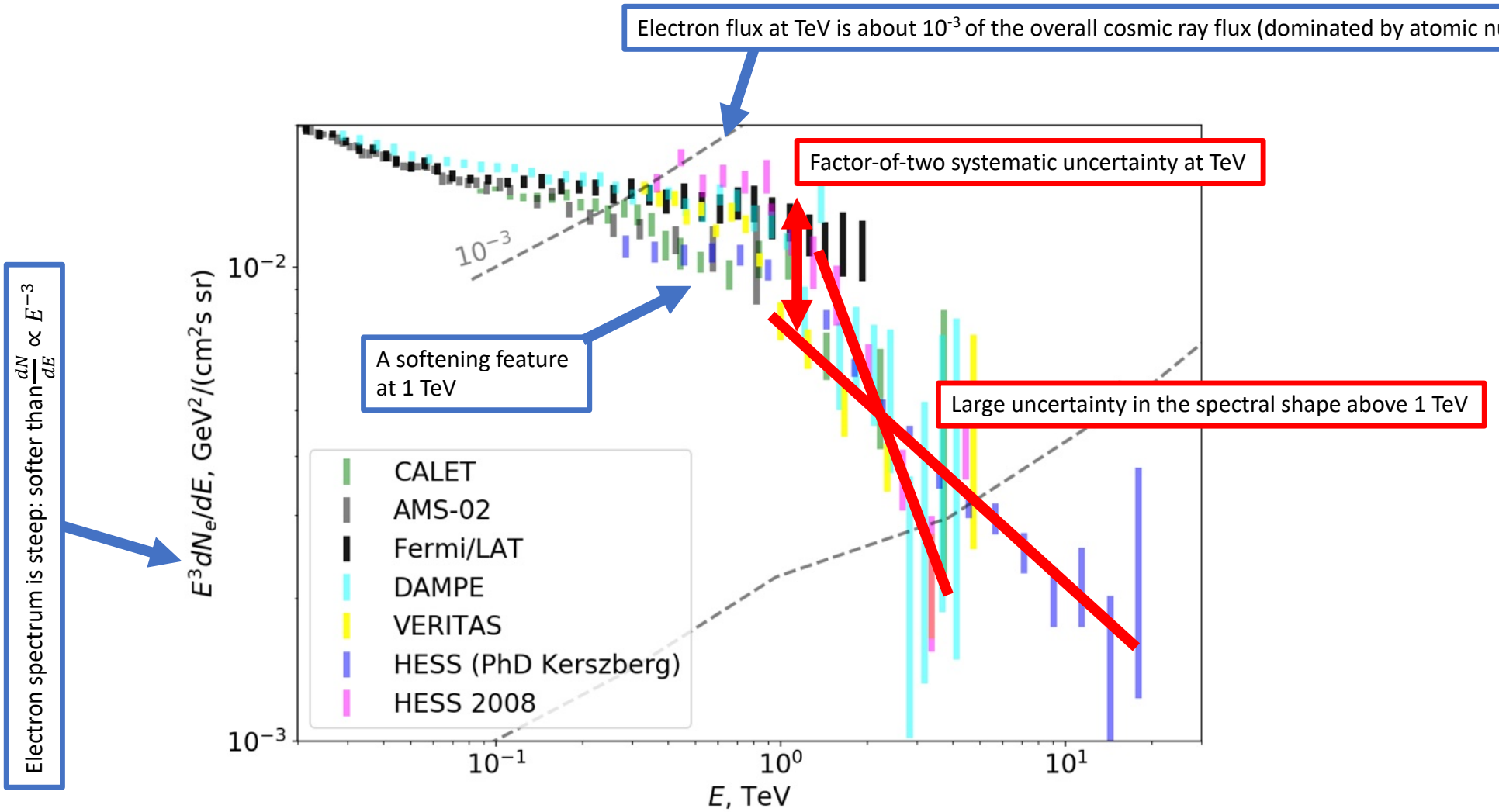


Efficiency of rejection of hadronic EAS background in LHAASO decreases below 100 TeV.

Improving the rejection efficiency can improve sensitivity of gamma-ray observations and enable measurements of electron spectrum.

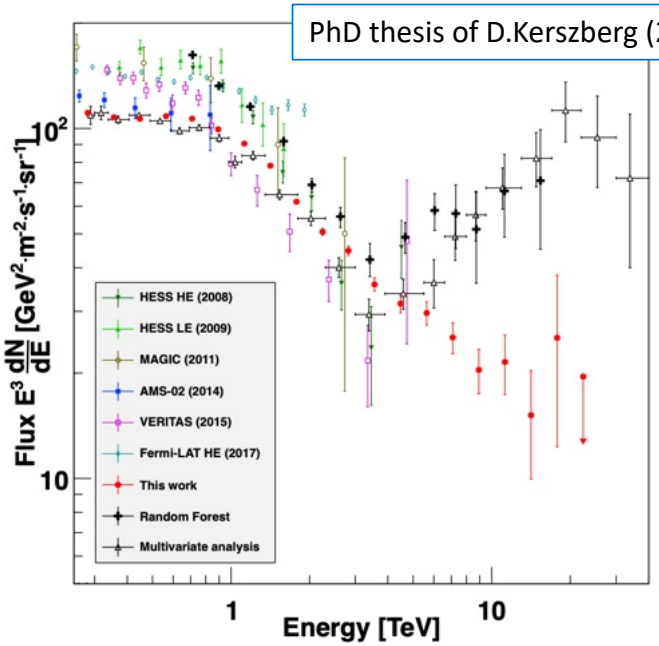
Cosmic ray electrons has been so far detected by space-based detectors in the energy range up to 3 TeV. At higher energies, HESS Cherenkov telescope system has attempted a measurement of the spectrum (up to 20 TeV).

Cosmic ray electron spectrum measurements

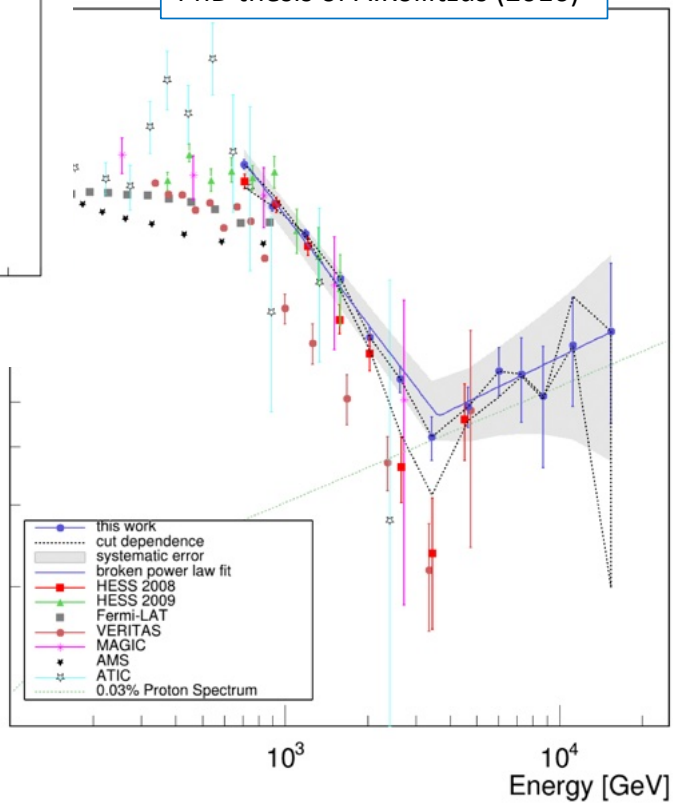


Measurement at 10 TeV ?

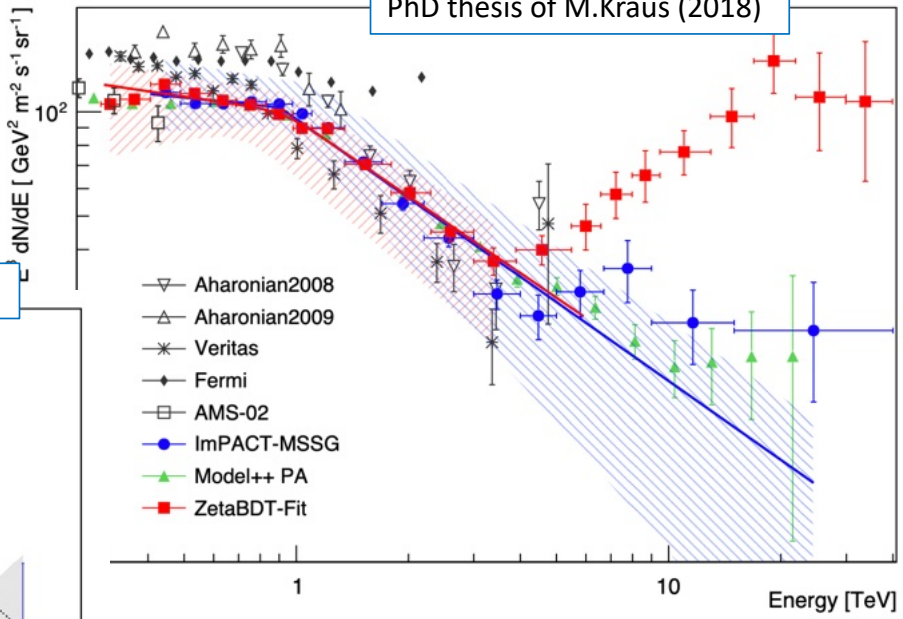
PhD thesis of D.Kerszberg (2017)



PhD thesis of A.Koilitzus (2016)



PhD thesis of M.Kraus (2018)



Different verisions of HESS analysis up to 10 TeV published in different PhD theses illustrate the challenge: different techniques of suppression of hadronic background give different results.

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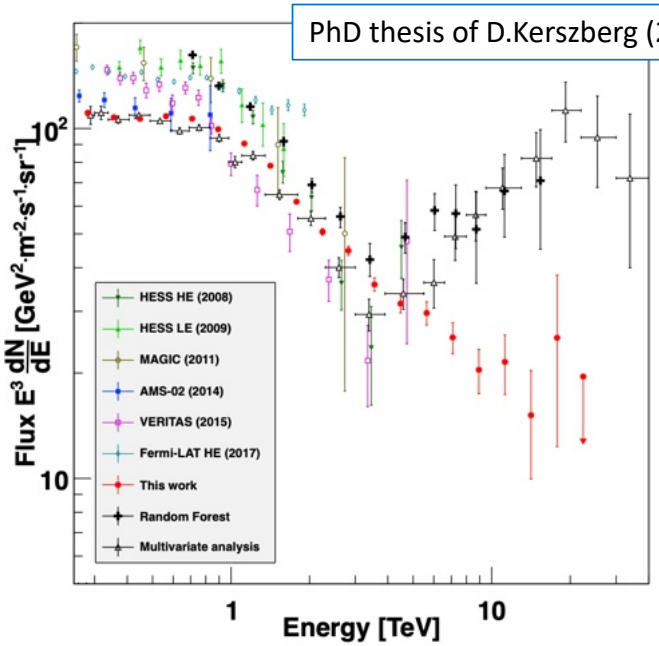

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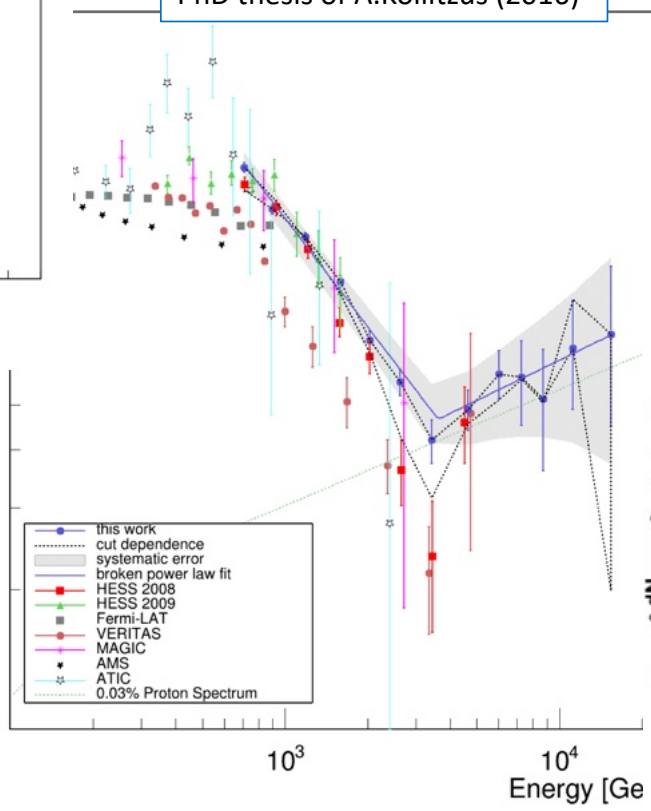

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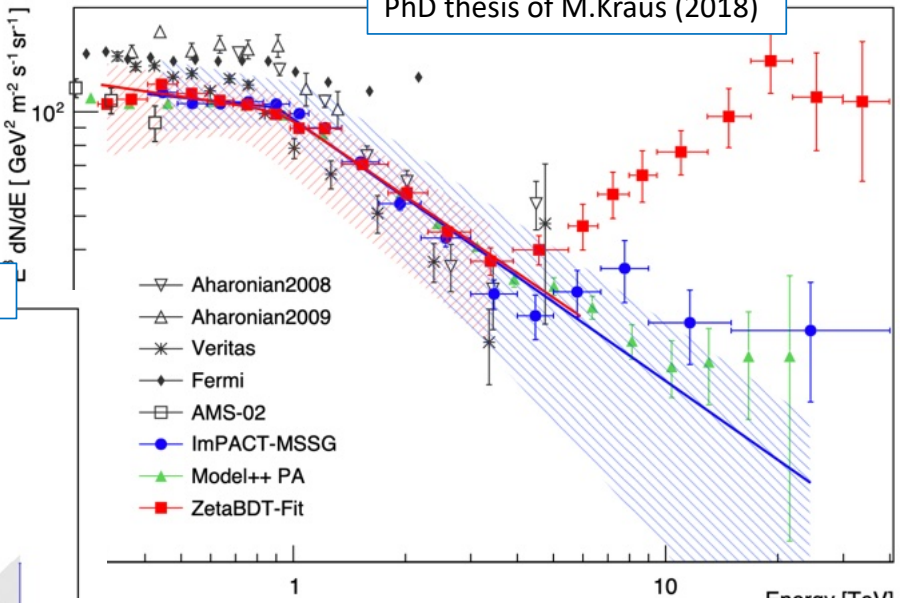
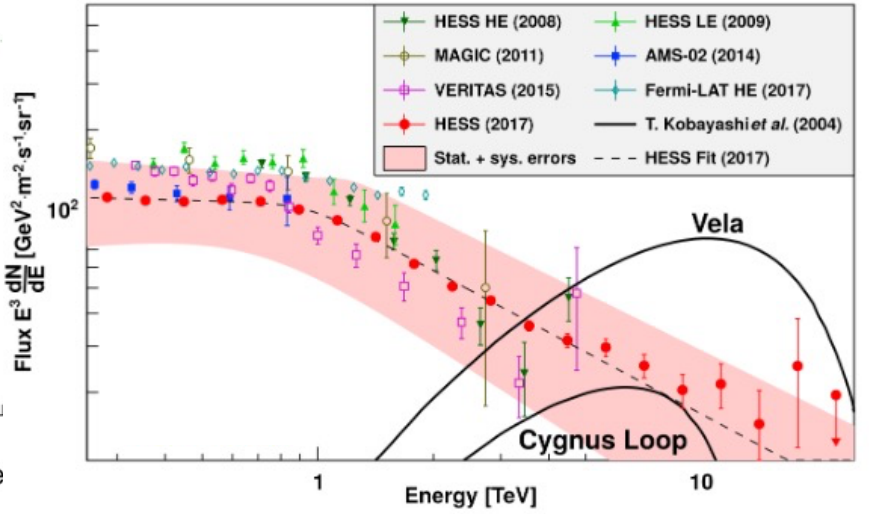
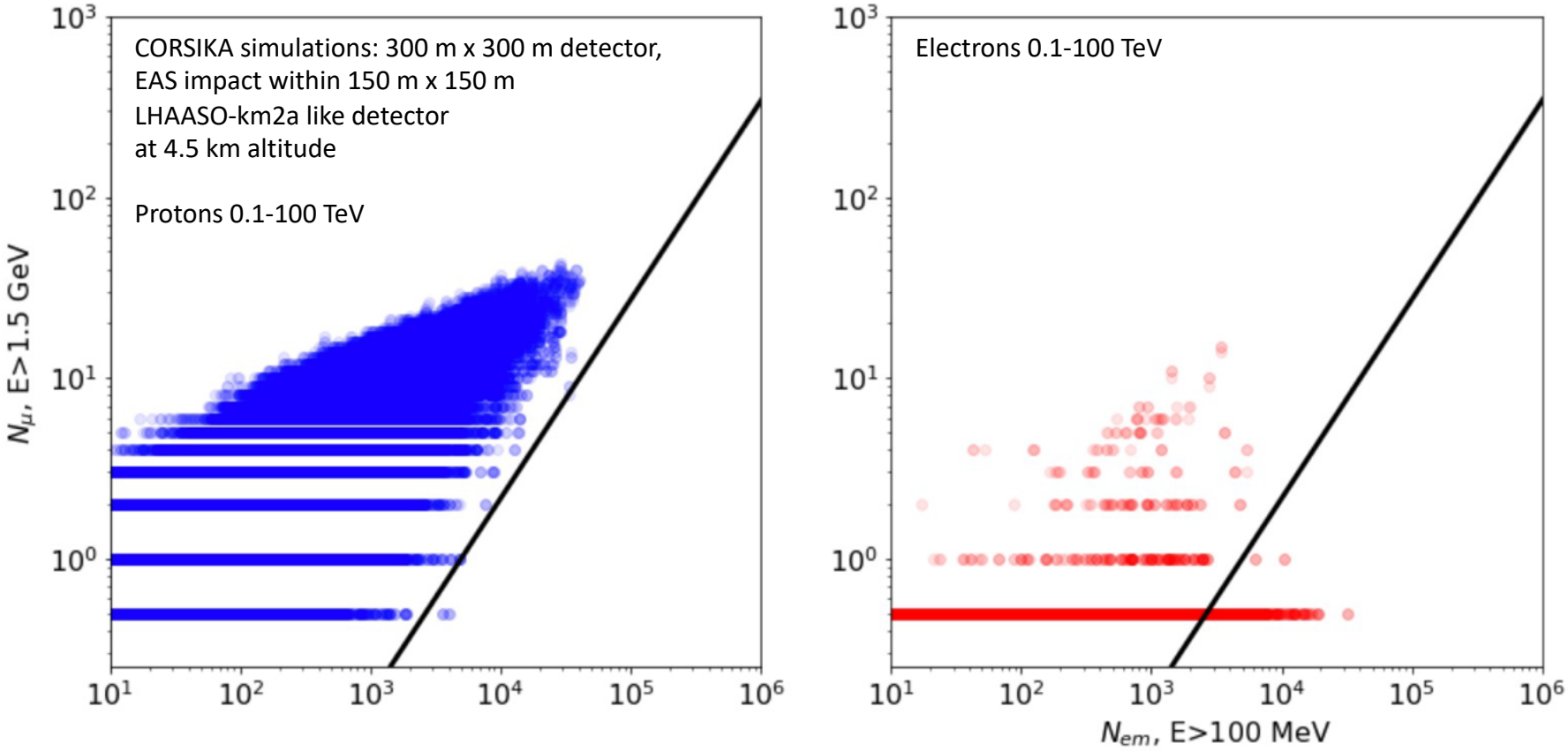




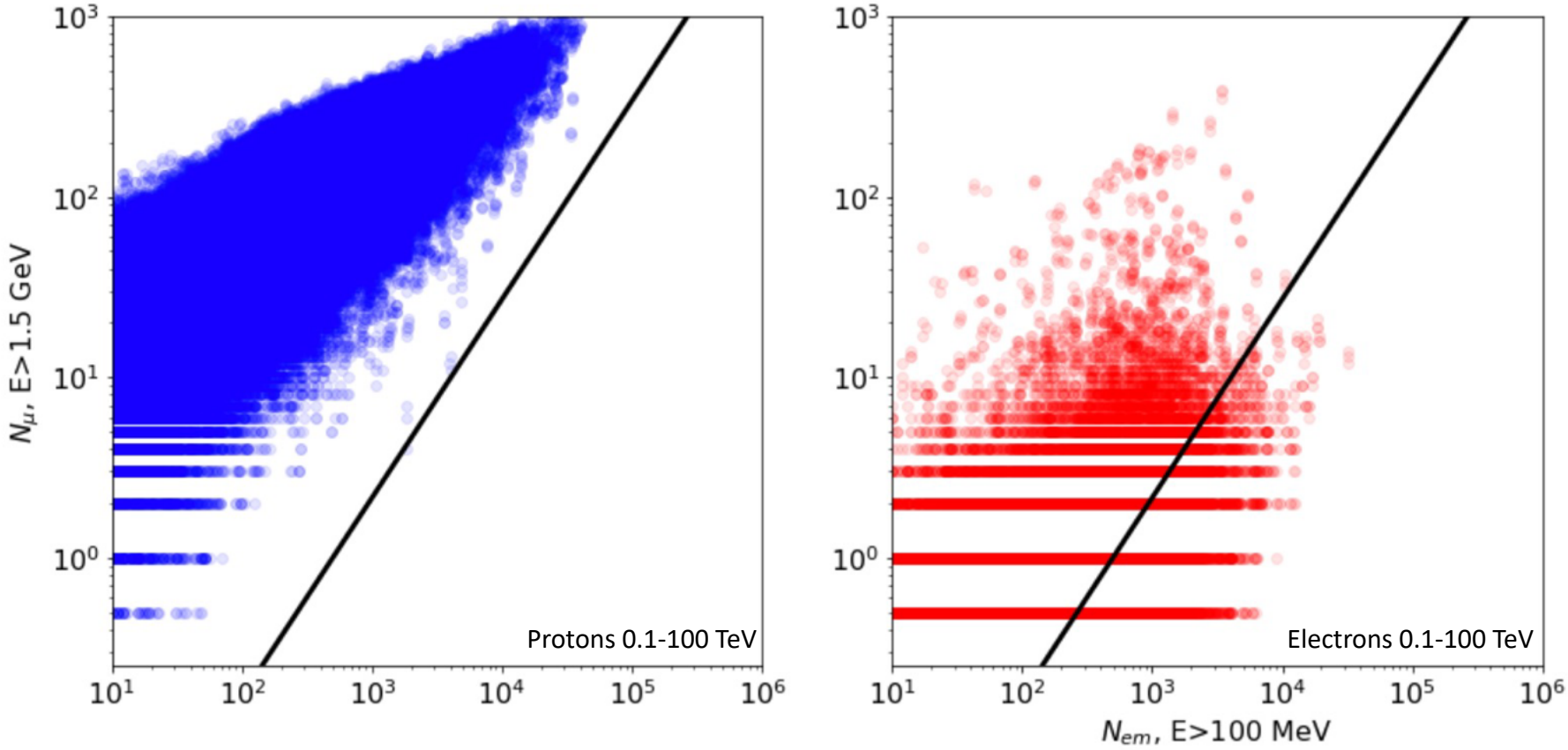
Different verisions of HESS analysis up to 10 TeV published in different PhD theses illustrate the challenge: different techniques of suppression of hadronic background give different results.

Rejection of hadronic background using muon counting



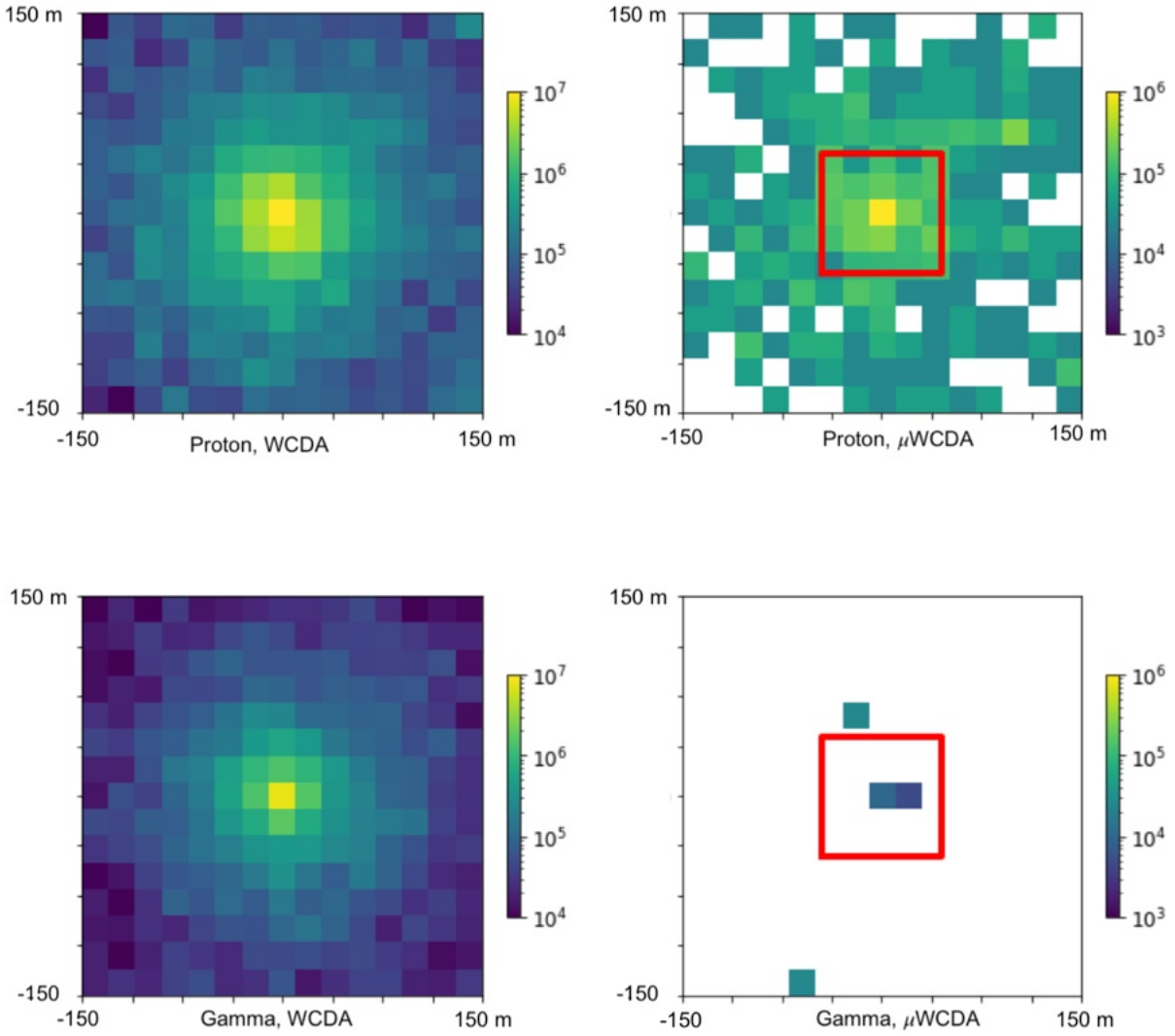
The efficiency of hadronic background rejection in LHAASO-km2a like detector drops at lower energies because of low statistics of muons.

Rejection of hadronic background using muon counting

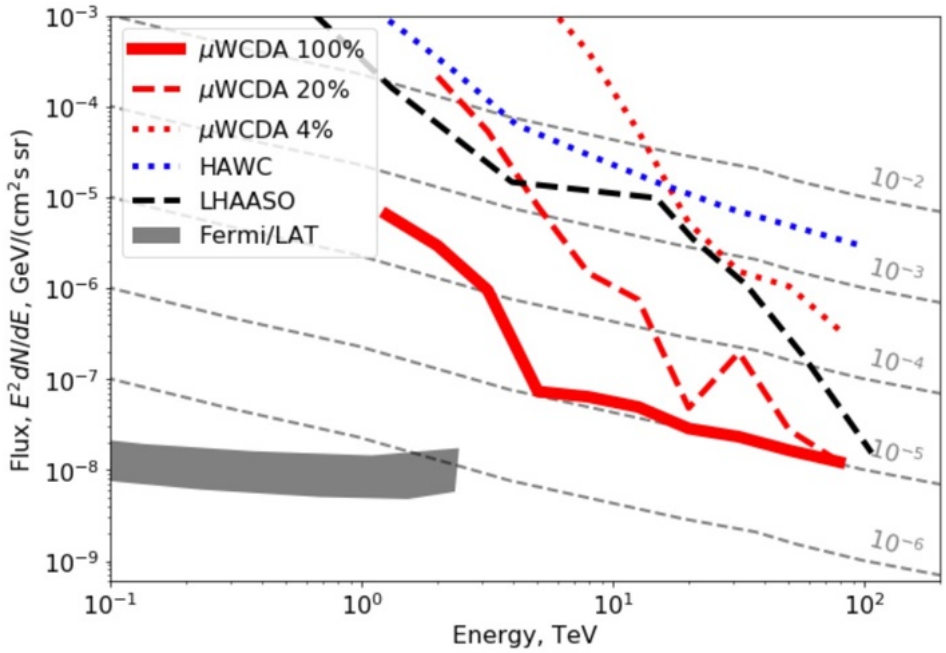


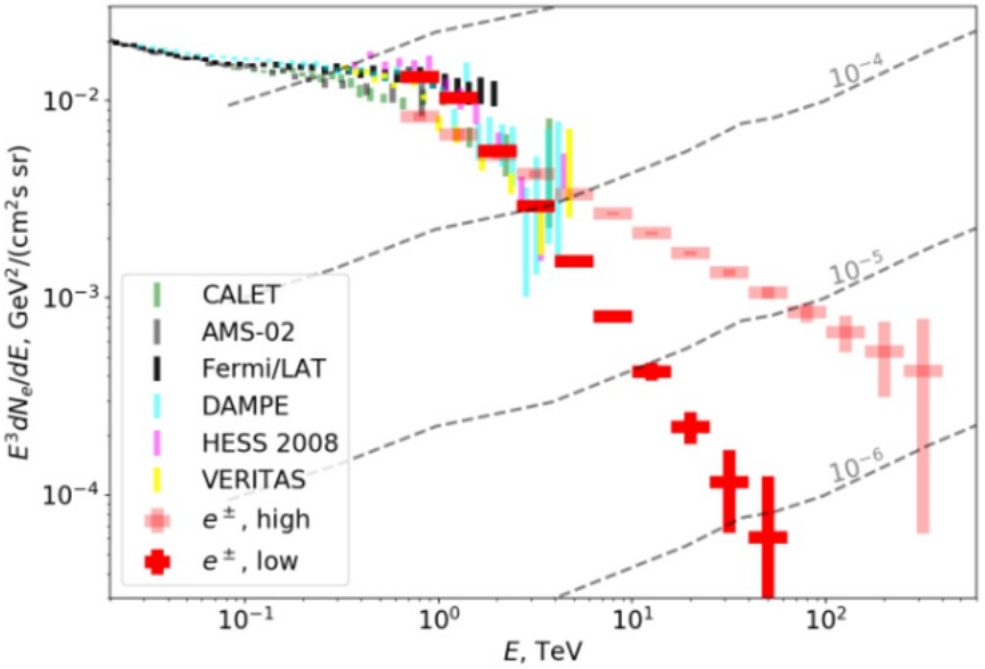
The statistics of muon counts can be improved with muon detector with larger (100%) muon detector filling factor.

Rejection of hadronic background using muon counting



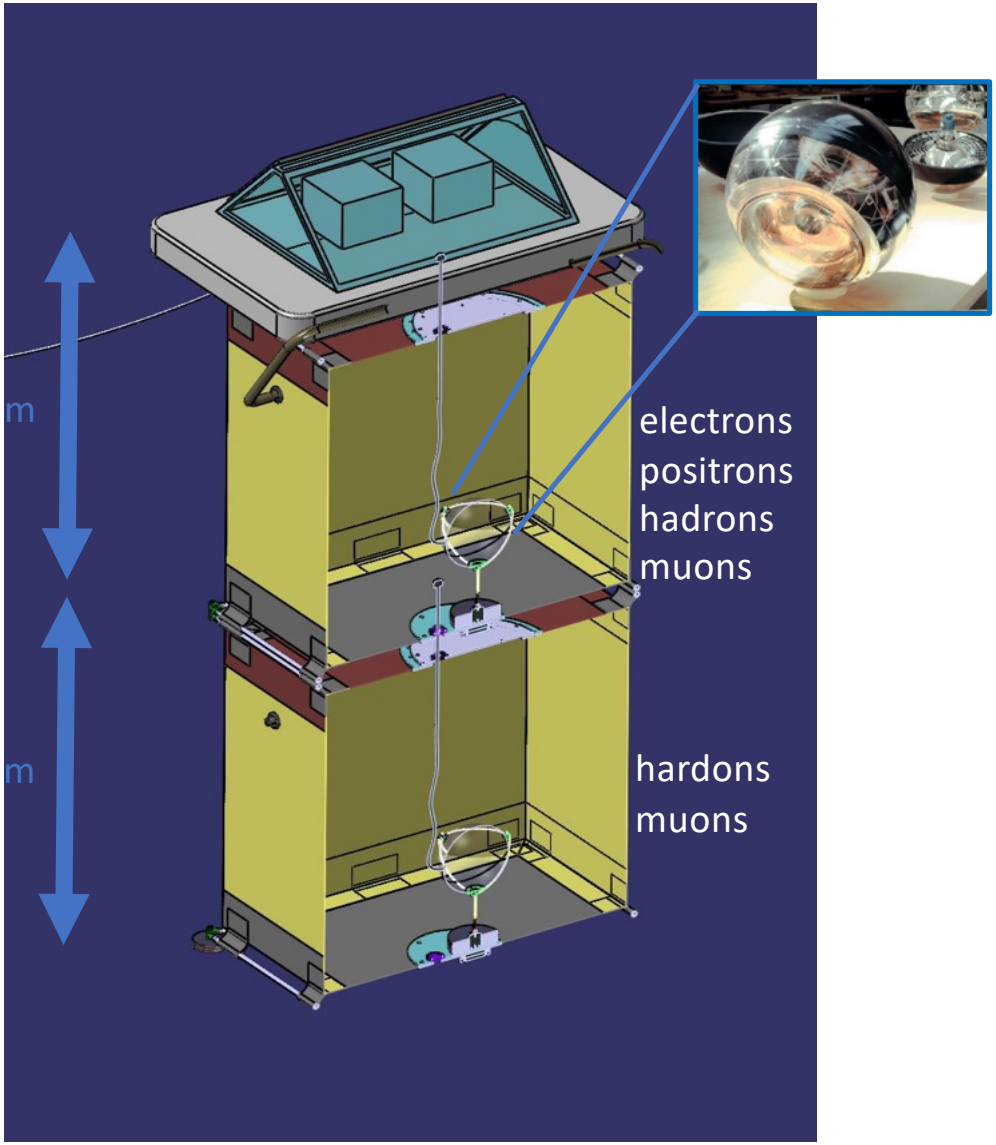
Large 100% efficient muon detector

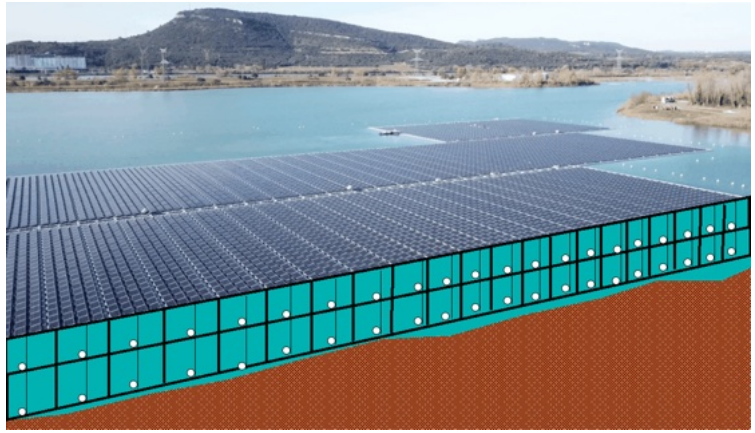




Increase of muon statistics with continuous muon detector of the size comparable to LHAASO allows to achieve suppression of hadronic background down to 10^{-5} already at TeV

”Second life” for ANTARES optical modules



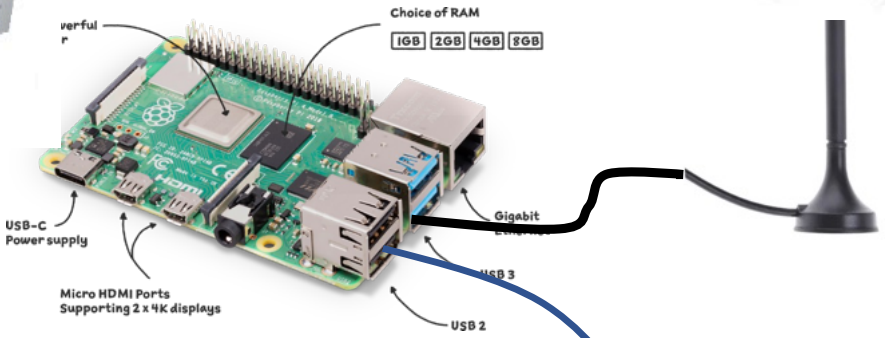


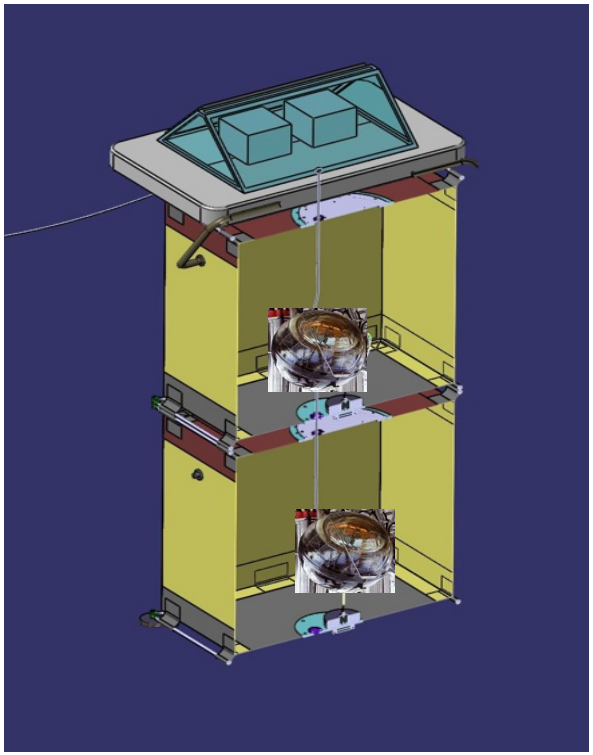
Large two-layer WCDA can be assembled using the optical modules of decommissioned ANTARES neutrino telescope.

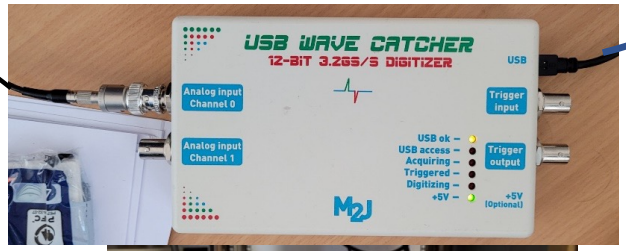
Large detector can be assembled from “Elementary Cells”.

Elementary cells can be autonomous (solar panel powered) so that an arbitrarily large detector is possible, if deployed in a natural lake.

The Elementary Cells

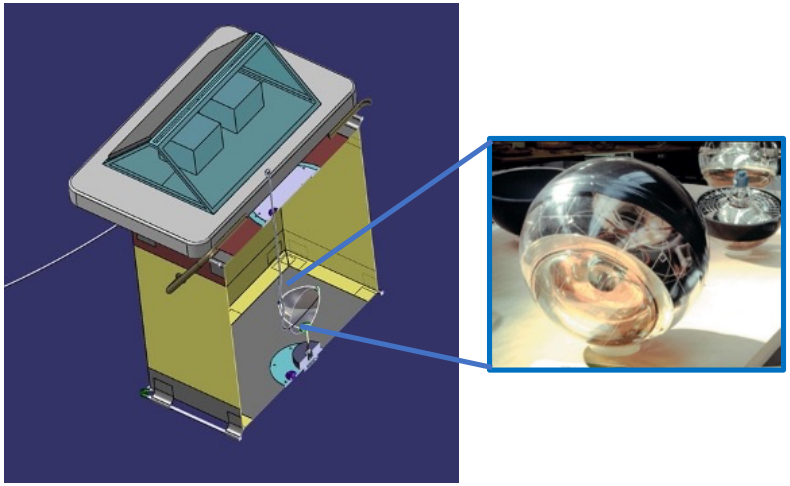






A “strawman” autonomous Elementary Cell, comprising solar panel, battery, a Raspberry Pi controller, readout electronics box, data storage and data transmission link.

LAC-TEL project



Joint 3-year funding by Agence National de Recherche (ANR) and Swiss Fonds National Scientifique (FNS) to deploy a two-layer “mini-WCDA” on Geneva Lake, made of 9 ECs.

Astroparticules et Cosmologie Paris

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