Performance of a gamma-ray observatory in a lake with a deep muon layer.

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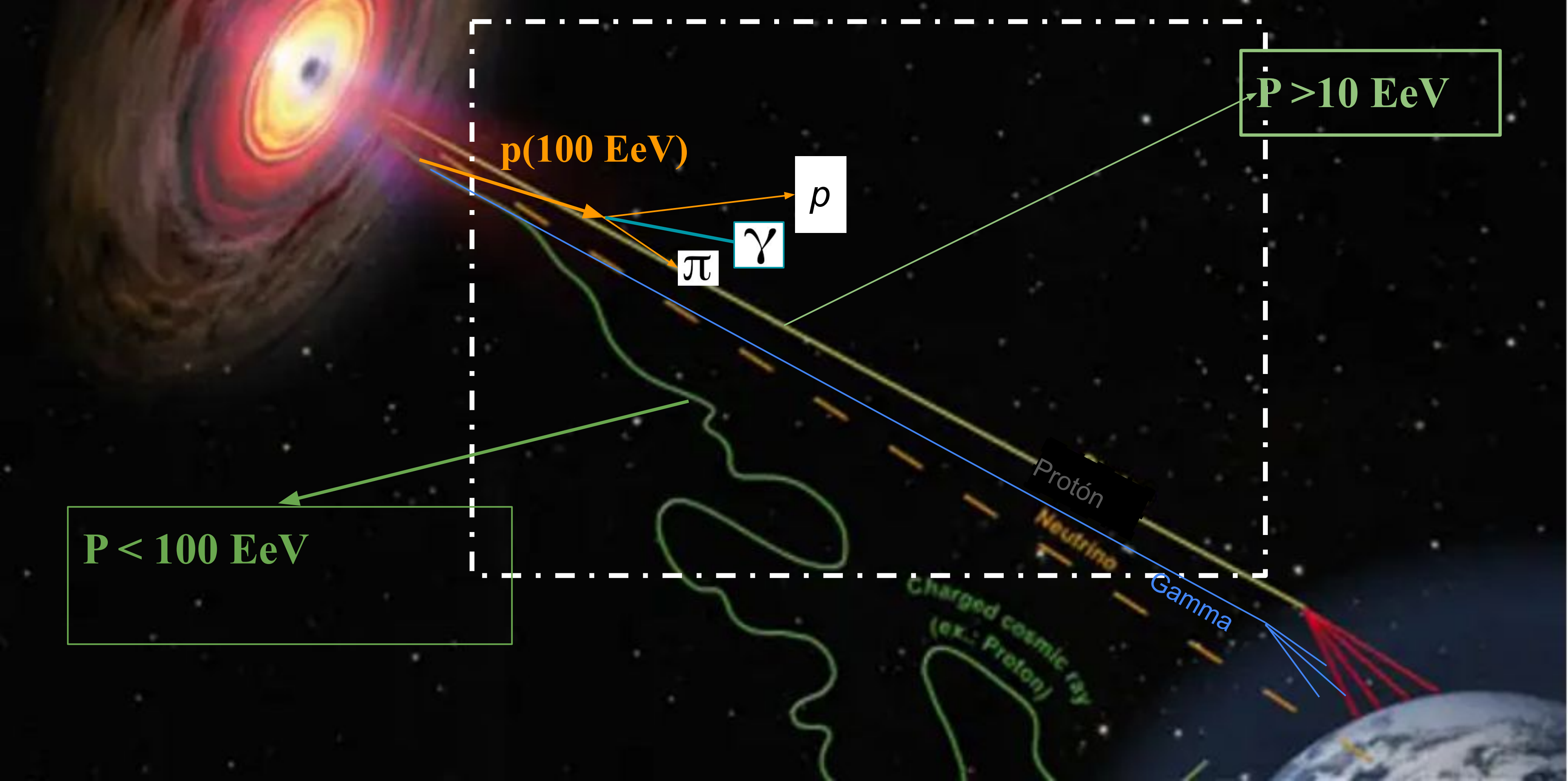
Cosmics Ray


p(100 EeV)
p
γ
π
P >10 EeV
P < 100 EeV
Protón
Neutrino
Gamma
Charged cosmic ray
(ex.: Proton)

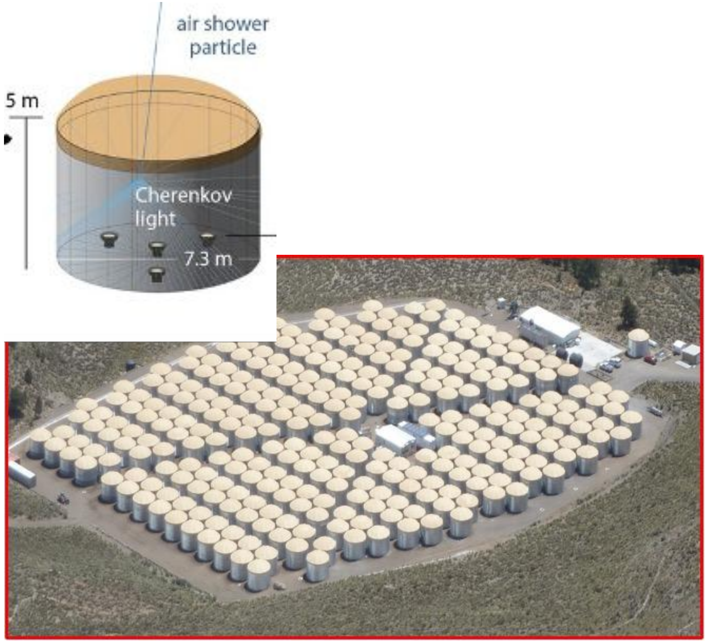
Objectives:

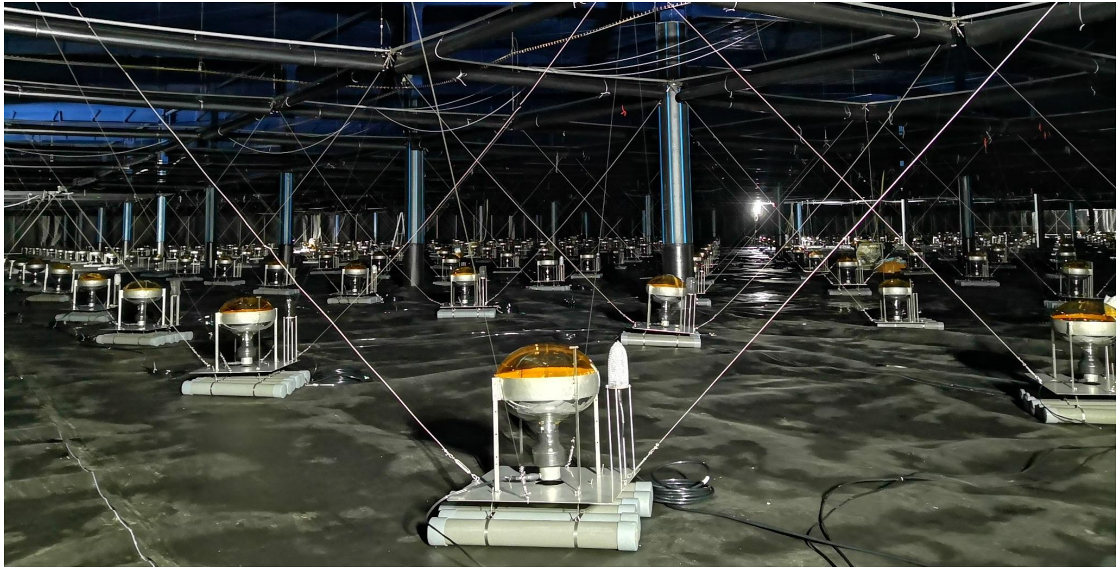
- Assess for a Water Cherenkov observatory with a deep muon layer the capacity to detect and discriminate gamma rays from cosmic ray events.

- Analyze the effectiveness of the deep muon layer in reducing the hadronic noise.

The existing large area WCD observatories HAWC and LHAASO's WCDA

They don't have a dedicated muon layer to do the hadron/gamma discrimination.





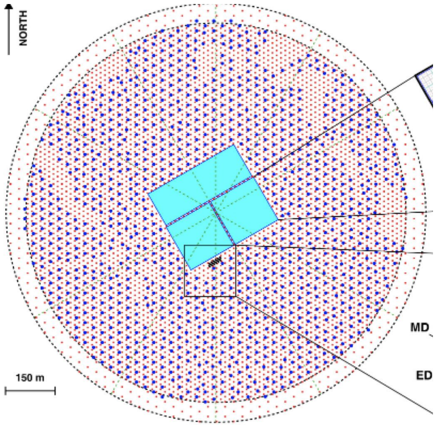
Is it possible to design a detector that has gammas background free at energies from 500 GeV to 20 GeV?

The LHAASO high energy array, KM2A, has shown that it is possible to detect gammas without hadron background above 20 TeV.

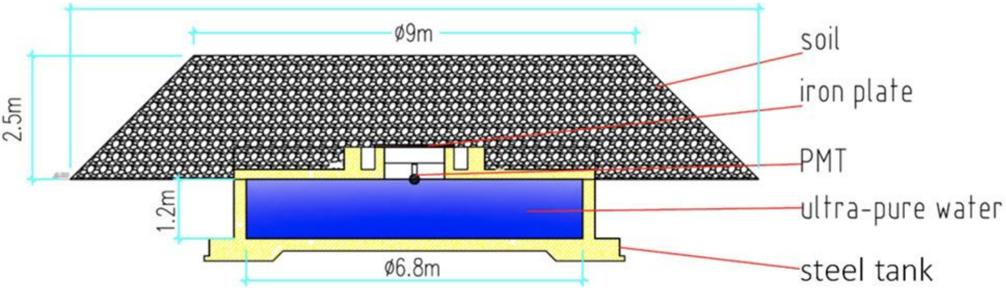
Test with Corsika simulated air showers if it is in principle possible

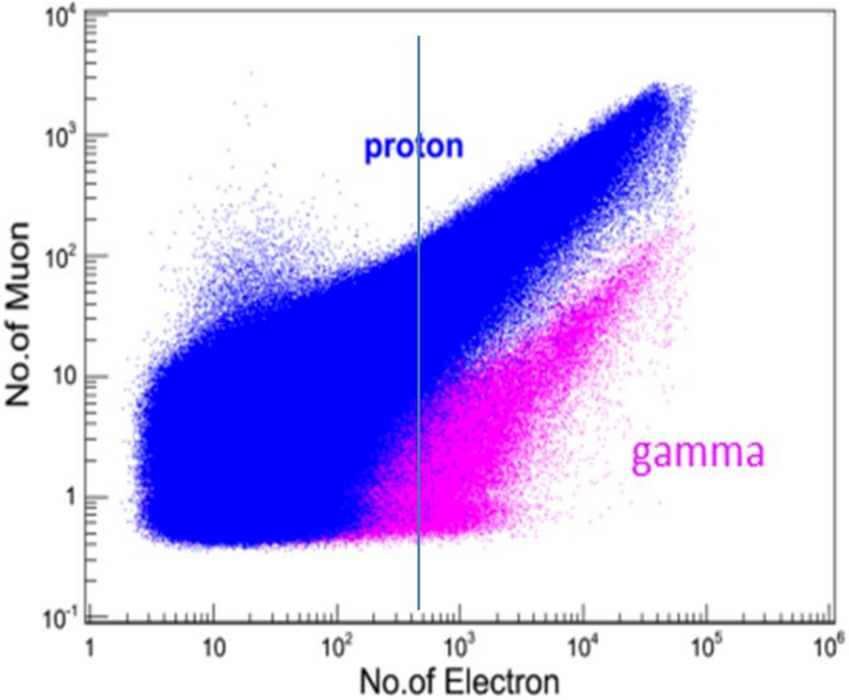
Design and simulate an observatory with an optimized muon detection

The LHAASO KM2A high energy detector utilizes buried muon detectors and is able to get gammas hadron free at high energies > 20 TeV



Deep muon layer





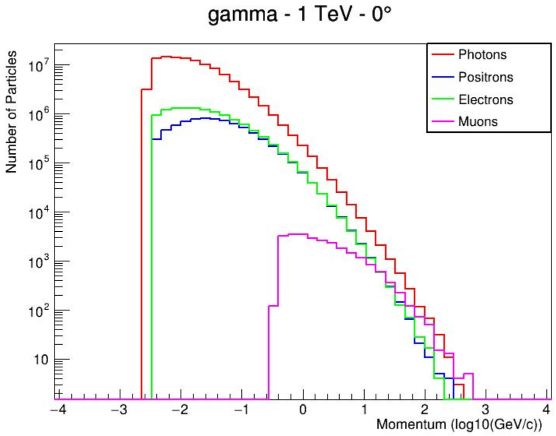
Simulation characteristics in Corsika

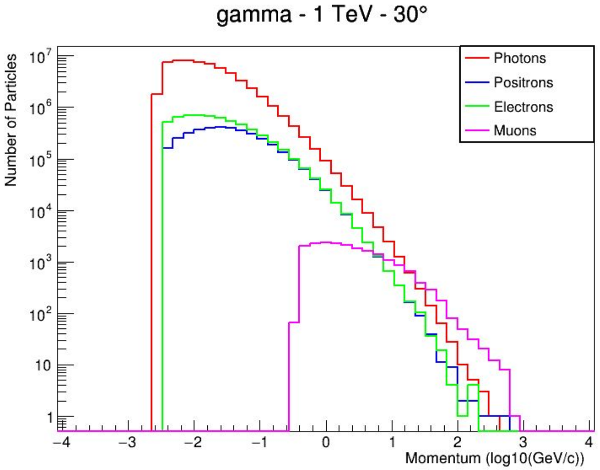
The version of CORSIKA used in this work is V7.7500

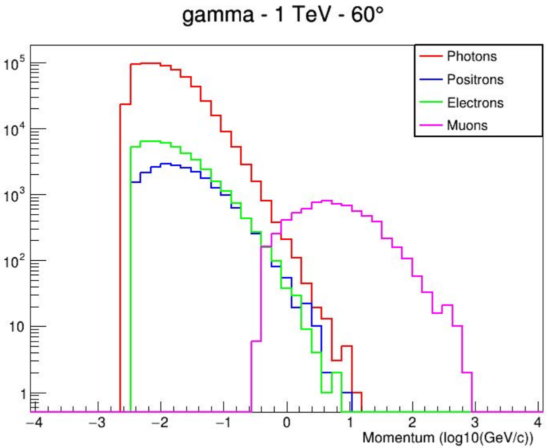
The Lake Sibinacocha is located in the south of Peru, about 85 km southeast of the city of Cusco, it is located at the geographic coordinates 13 ° 51’48 "S 71 ° 01’11" W at an average altitude of 4869 m.a.s.l. and has an area of 30 km^2.
The Earth’s magnetic field in this area has a horizontal component value of 23.174 μT and a vertical component of −2.710 μT.

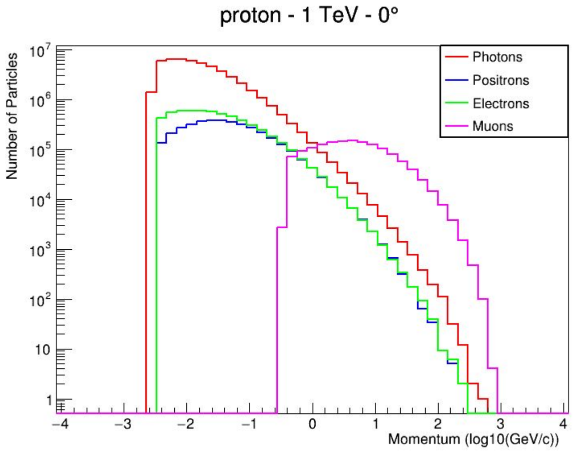
Simulations were performed with SYBILL 2.3d and GHEISHA as high and low energy hadronic interaction models, respectively. 50 000 proton and gamma-ray events were run, with energies of 500 GeV and 1 TeV at incidence angles: 0°, 30° and 60° .

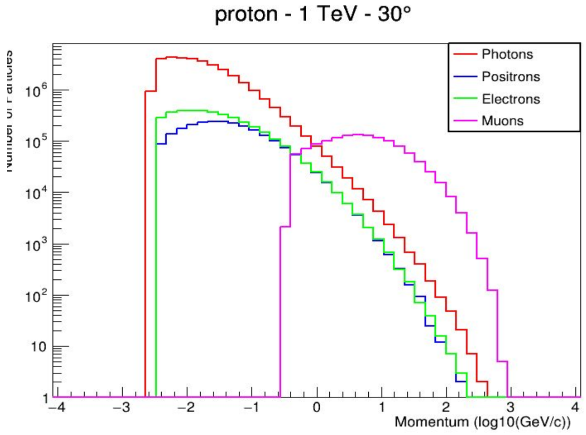
Shower particles at 5,000 m

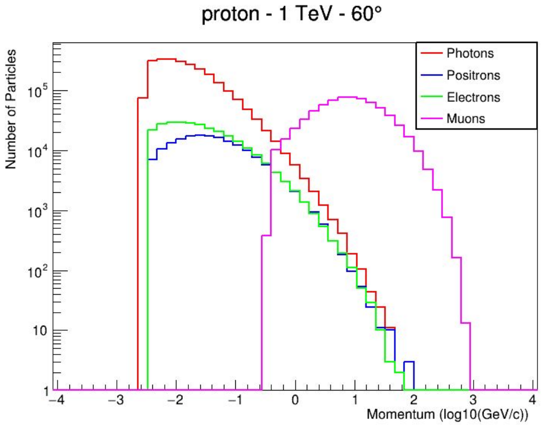




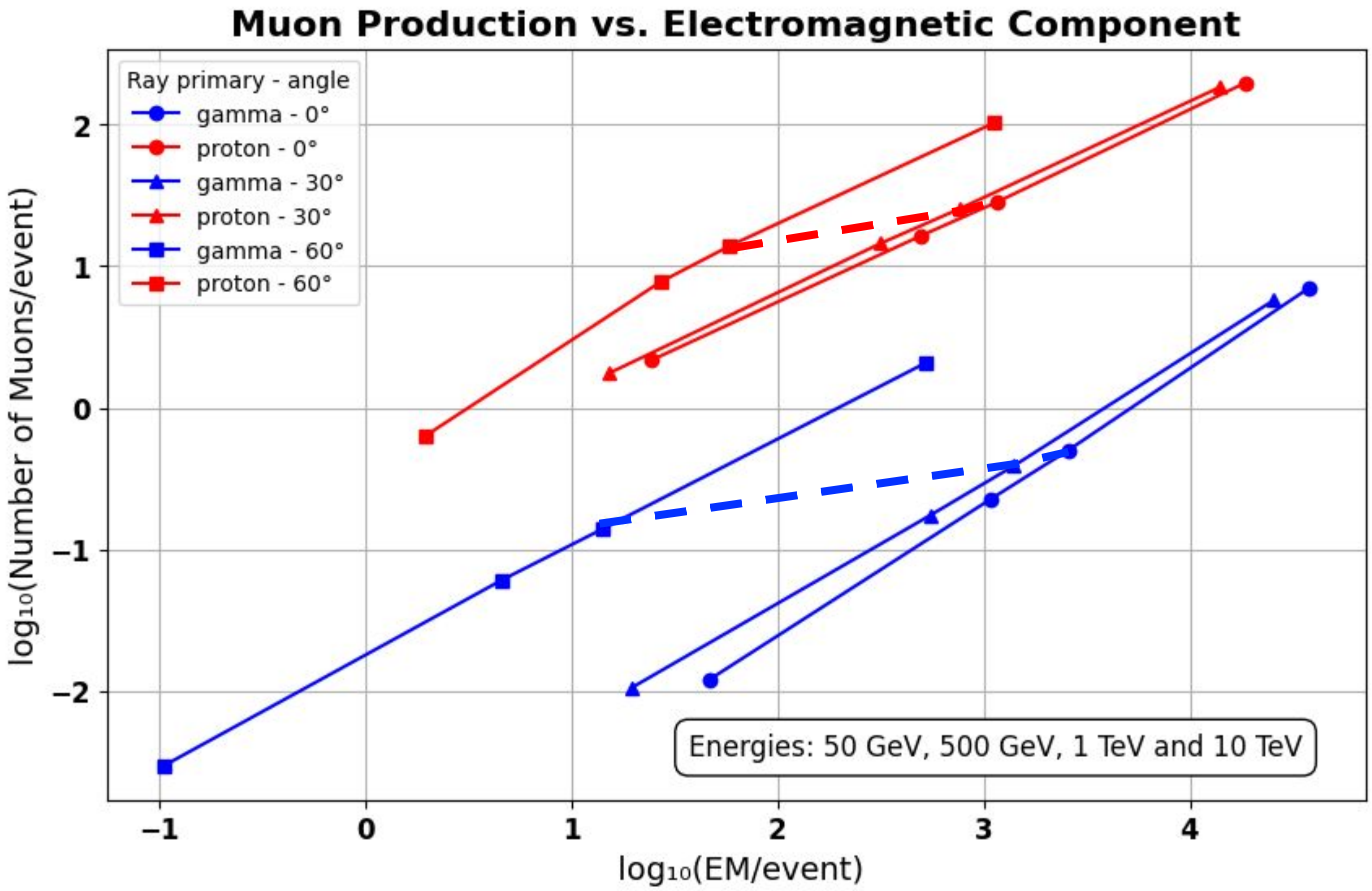




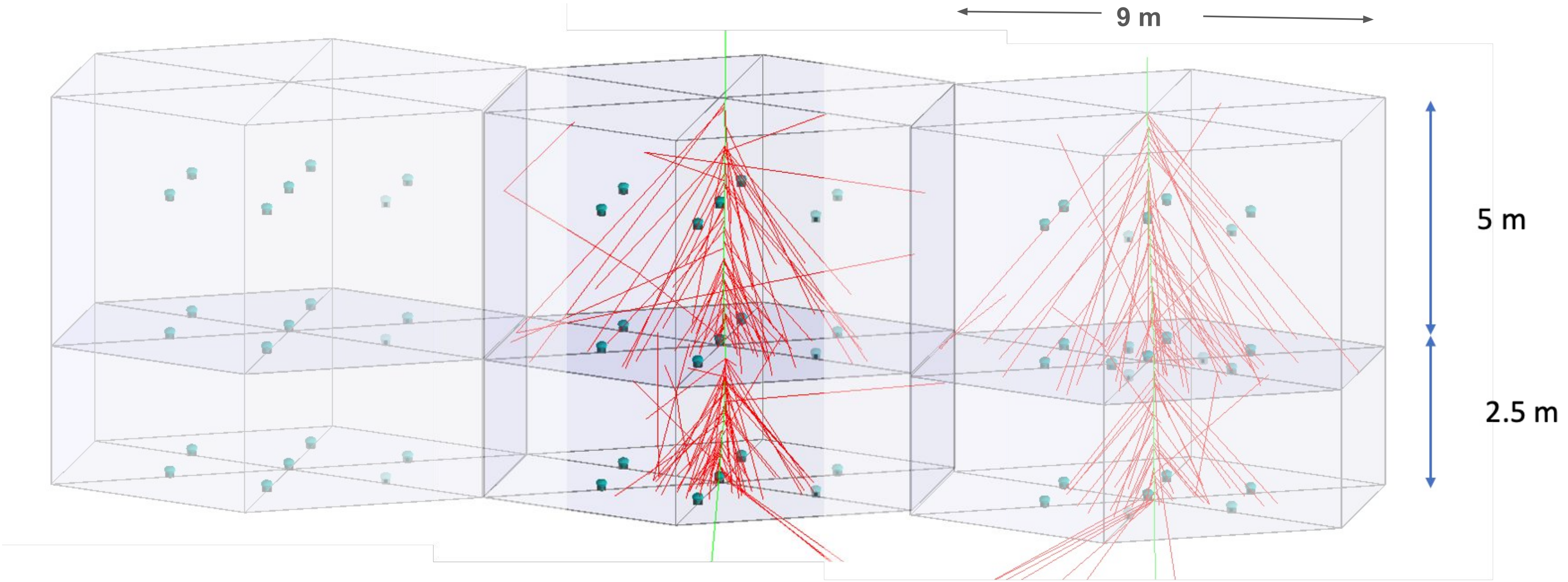




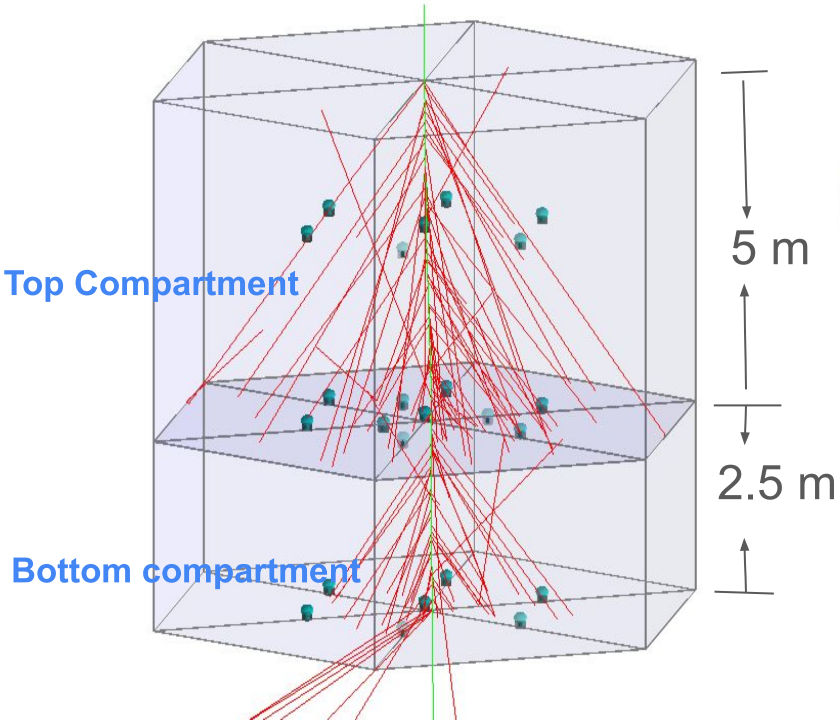
Ideal gamma/hadron discrimination



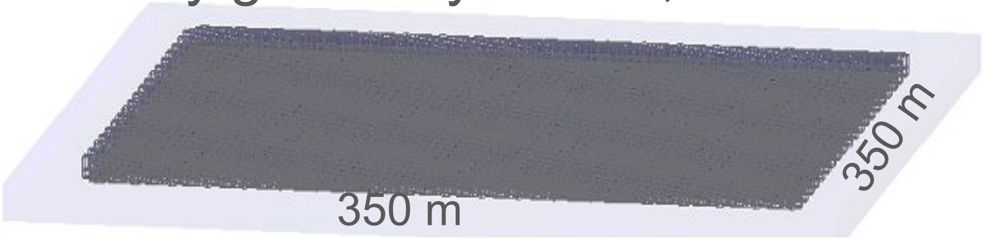
The array has to be very compact with two compartment WCD, the first one deep enough to absorb the EM component, leaving the bottom one for muon detection



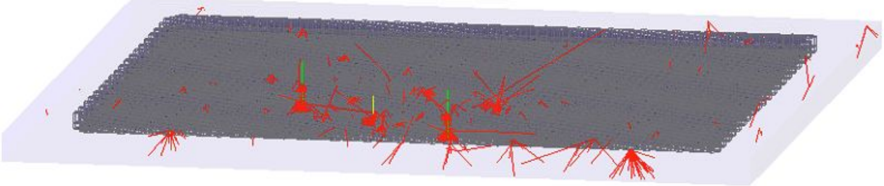
Geant simulation of a two compartment compact WCD array with a deep Muon layer



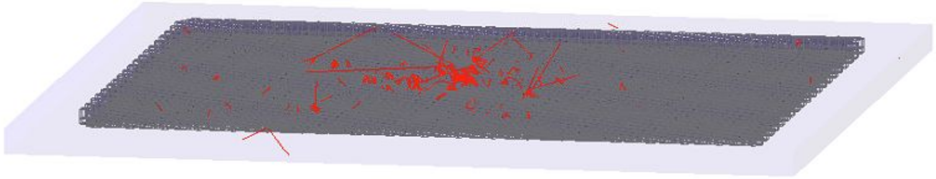
Array geometry with 1,521 WCD



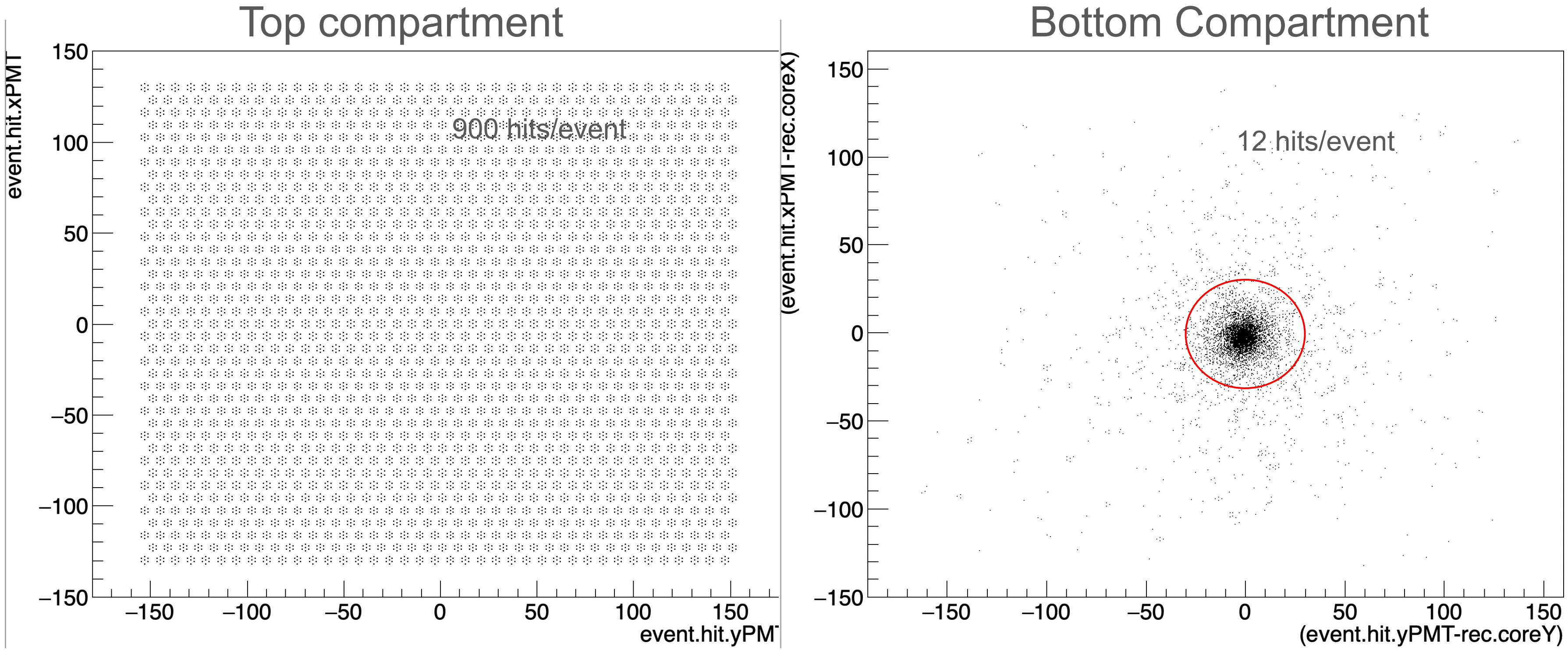
A 1 TeV proton at 0º degrees



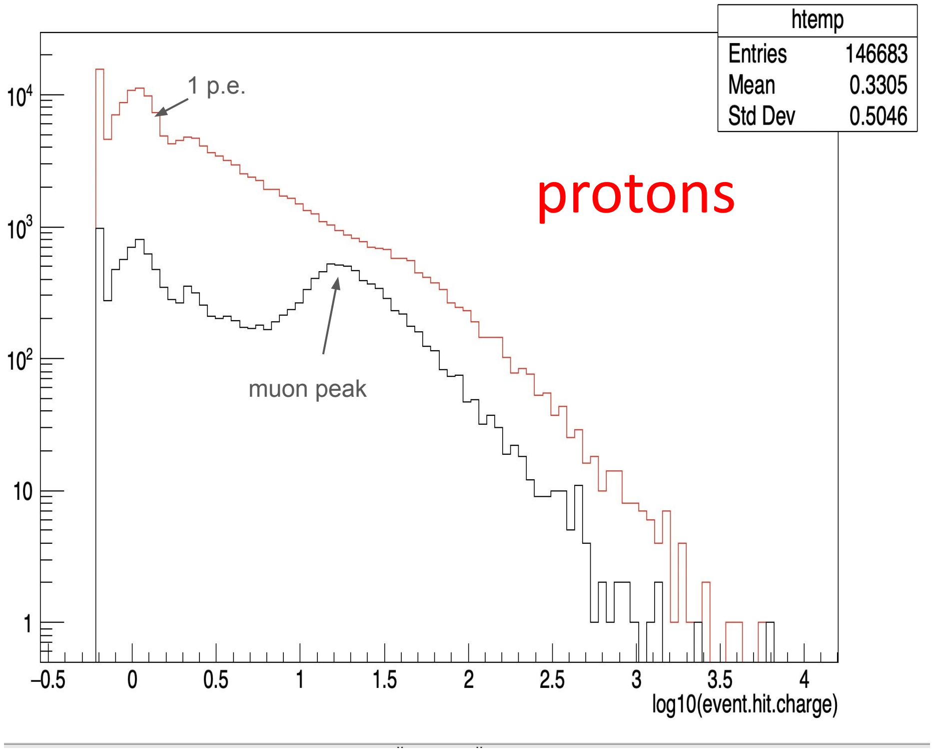
A 1 TeV gamma at 0º degrees

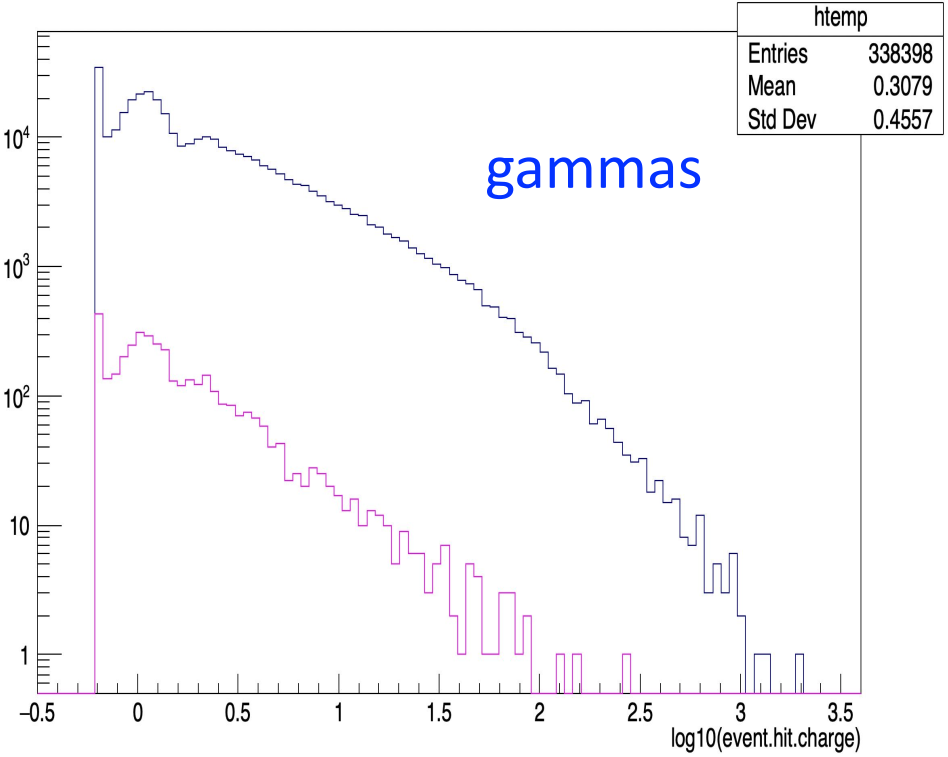


Hits for 500 gamma events at 1 TeV centered on the array, top and bottom compartments

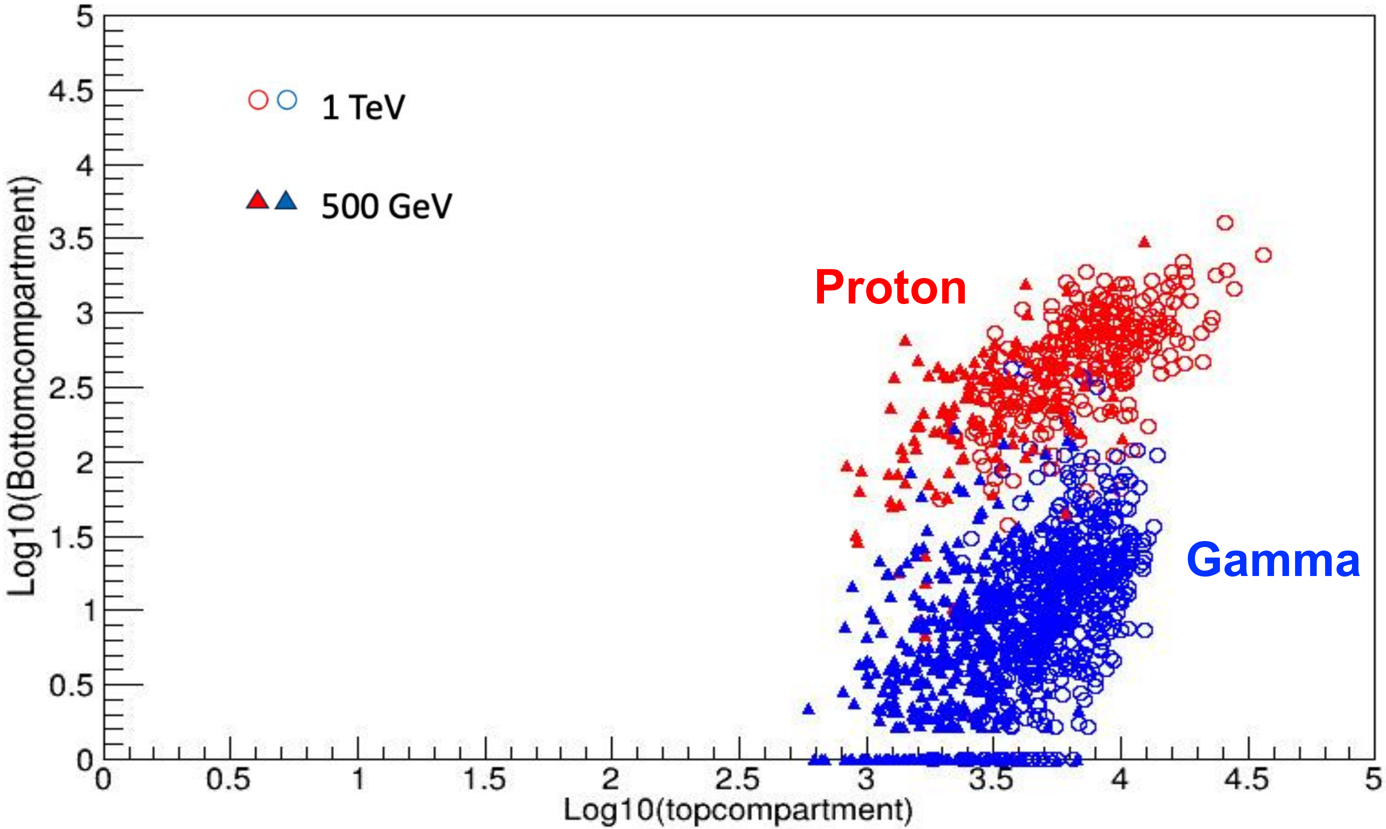


Spectra of the light seen per hit on the top and bottom layers at 1 TeV with a region of 30m diameter around the core excluded





The top vs bottom signals per event for protons and gammas



Summary

It seems possible to have a large aperture compact gamma ray detector with dual compartments, where the bottom one is deep enough to be an efficient muon detector in order to have almost background free gamma ray detection at energies above 500 GeV.

NEXT

Get more statistics, optimize cuts, evaluate performance