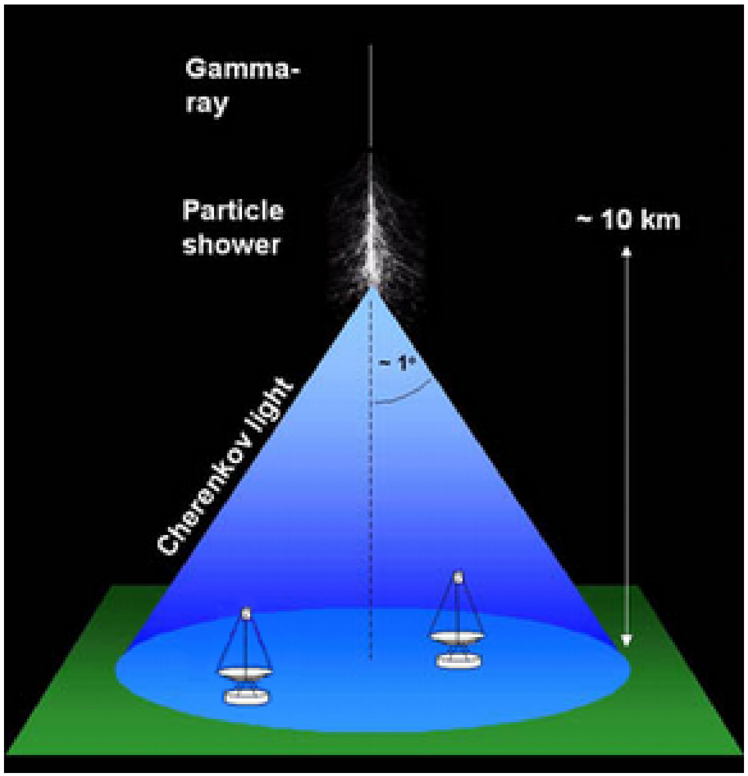
University of Insubria
Astronomical Observatory of Milano-Brera

Contribution to the MEC project

Muon imaging of the Etna volcano using Cherenkov technique

Luca Perri

Imaging Air Cherenkov Telescopes



γ above few GeV in atmosphere

⇩

EM air showers (10-12 km a.m.s.l.)

⇩

e^+e^- production and secondary photons (bremsstrahlung)

⇩

e^+e^- above 40 MeV pass through a dielectric and electrically polarizable medium at $v_e > v_{ph}$ of light in that medium

⇩

Cherenkov light emission in optical-UV. Cone angle about 1° that illuminates 10^5 m^2 in few nanoseconds

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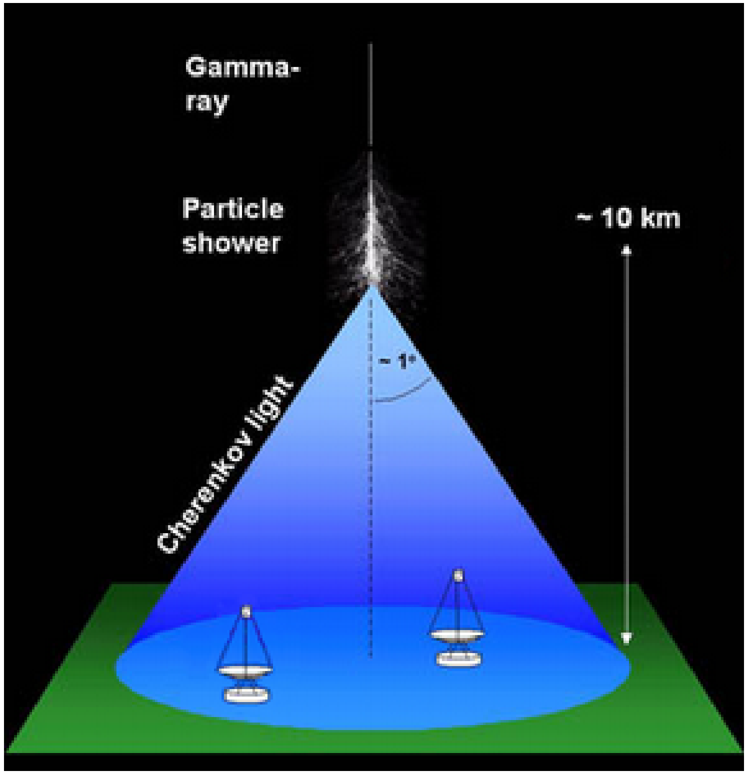
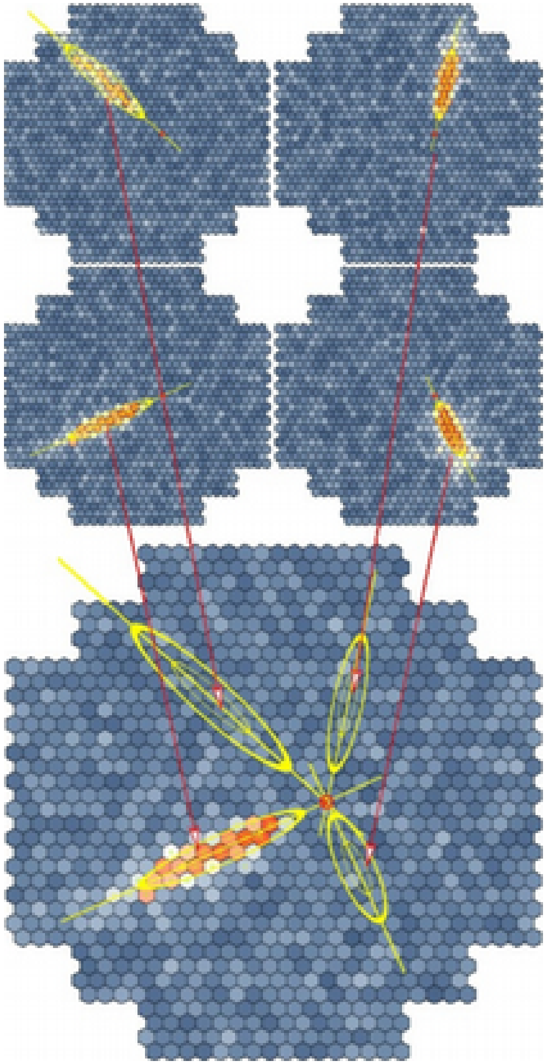
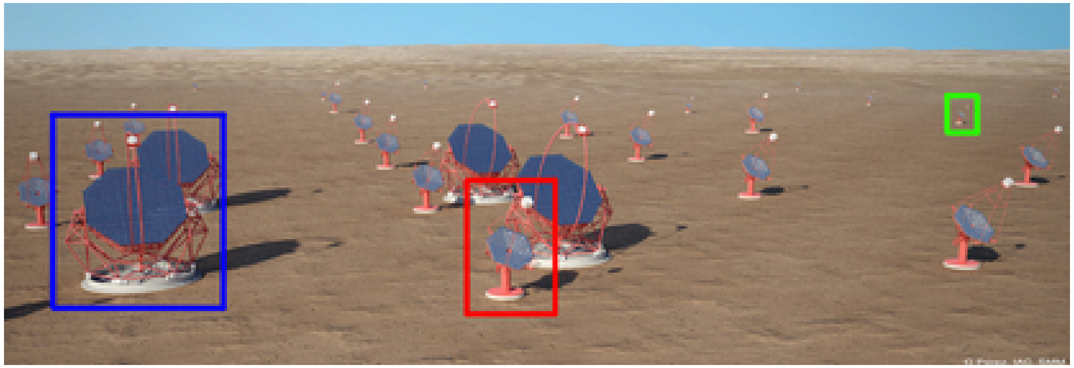




CTA and ASTRI

CTA
Collaboration of 27 countries.
About 120 telescopes in two sites (North/South).
Mixed arrays of three different types of telescopes of different sizes.
- 10x sensitivity of current telescopes
- 10x energy range
- improved angular resolution



ASTRI SST-2M
Prototype of Small-Size Telescope for CTA:
- dual mirror Schwarzschild-Couder optical design
- compact camera based on SiPM

It was installed at the INAF Observatory in Serra La Nave (1735 m a.s.l., Mt. Etna, Sicily).
It uses the detection of cosmic ray muons as a calibration and to measure the PSF.

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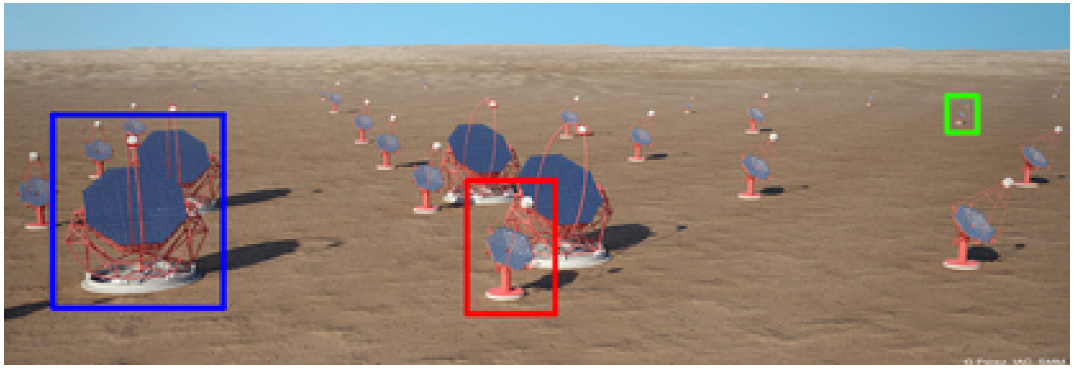
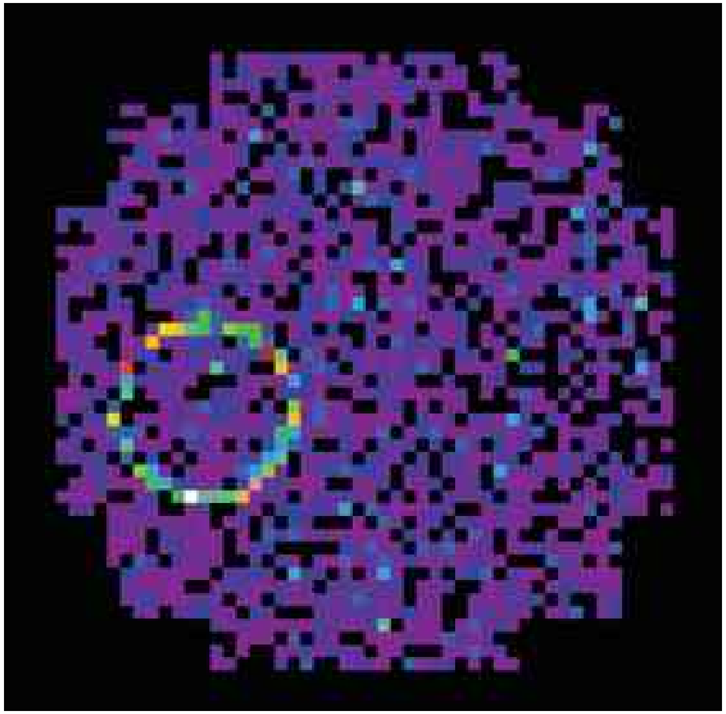




Muon tomography and volcanoes

It uses cosmic-ray muons to generate 3D images of volumes (Coulomb scattering or absorption).
Muons more deeply penetrating than X rays ⇨ MT used to image through thicker materials.
Developed in the 1950s, used for many purposes.

By measuring the differential attenuation of the muon flux as a function of the amount of rock crossed along different directions, it is possible to determine the density distribution of the interior of a volcano.

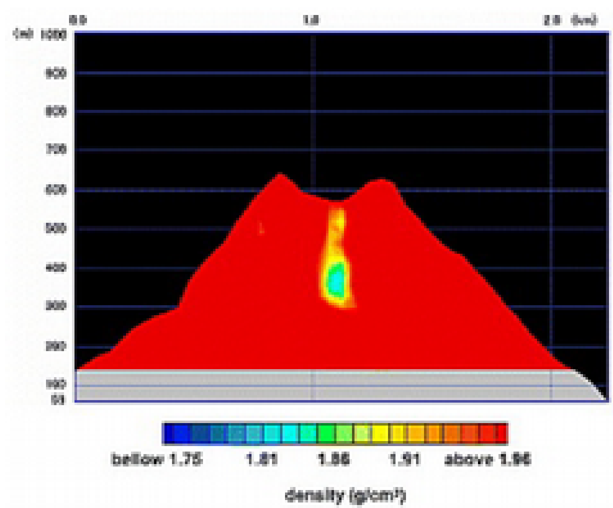
A number of experiments (hodoscopes, scintillators or nuclear emulsion planes):

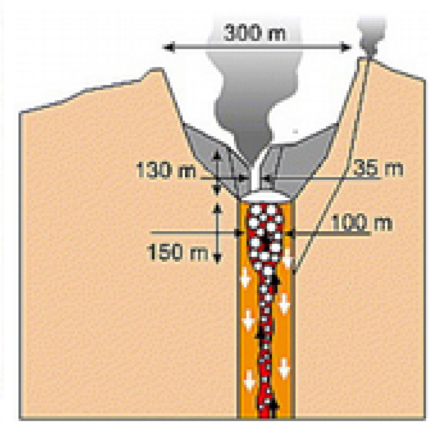
- since 2007, Mt Asama, Mt Usu, Mt Iwodake, Satsuma-Iwojima, (Japan)

- in 2012, hydrothermal reservoirs in the Grande Soufrière volcano (Guadeloupe)

- Mu-Ray project, Mt Vesuvius (Italy)

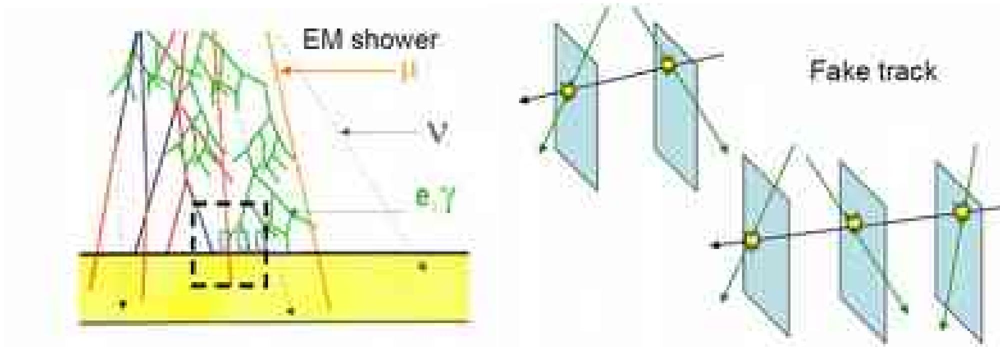
- in summer 2010, Etna (Italy)





Hodoscopes vs. telescopes

e^+ and e^- of the shower constantly hit the matrices of the hodoscope.
If the matrices are simultaneously hit, the instrument will trigger the occurrence of an event.
False events are reduced by using three or more aligned matrices ⇨ expensive and not very transportable.



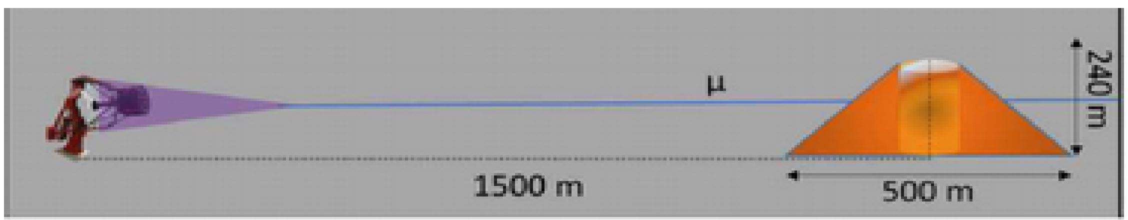
Flux of upward going particles detected when the rear side of the instrument is exposed to a wide volume of atmosphere located below the altitude of the installation site ⇨ noise.

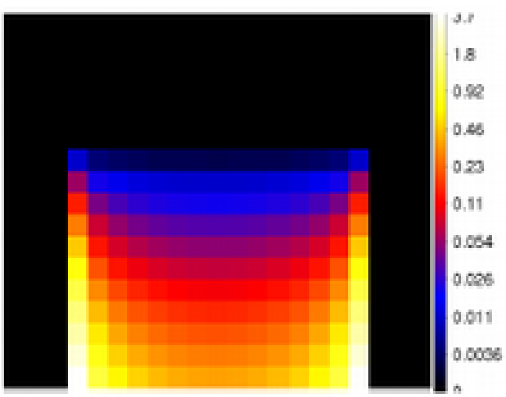
An array of mobile telescope similar to ASTRI SST-2M (MEC project) could allow:
- determination of the differential muon flux
- higher acceptance
- improved spatial resolution
- fake muon tracks and upward going particles noises are dramatically suppressed
- relatively low cost.

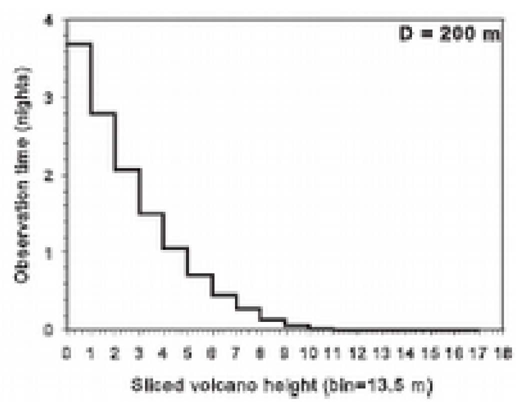
The MEC project

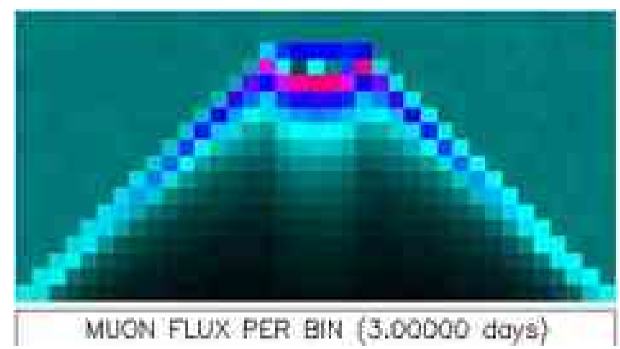
Preliminary simulations by using the ASTRI SST-2M geometrical parameters and simplified shapes for both the Etna volcano and its conduit. The distance between telescope and volcano has been set at 1500 m (instead of the actual 6500 m).

A magma conduit was simulated, so as to assess the minimum number of observational night necessary to resolve it.
200 m diameter, H=135 m: **3.7 nights**
⇨ av. velocity of magma **<v>≃5 m/h** (for the Satsuma-Iwojima is 10-30 m/day).









Thank you

If you want more detailed informations, there is a pedantic poster downstairs…

Enjoy!