Measurement of the muon flux in the bunker of Monte Soratte with the CRC detector

**What is CRC?**

The Cosmic Ray Cube (CRC) is a portable tracking device conceived for outreach activities allowing a direct scientific experience for secondary school students.
- 48 channels
- 4x1x24 cm² scintillating bars with TiO₂ reflector
- WLS fibres Y-11 coupled to SiPMs
- LEDs placed on SiPMs for real-time visualisation of cosmic rays
  - its operation requires only the standard electrical power

**Measurements**

- In the bunker of Monte Soratte, ~50 km north of Rome
  - candidate site to host the Ptolemy experiment.
- Integrated data taking time of about 2 months during Covid-19 lockdown.
- Technical rotating support to scan in azimuth and zenith bins of $\Delta \phi = 15^\circ$ and $\Delta \theta = 15^\circ$.
  - measure differential muon flux in the whole upper hemisphere.

**Event selection**

3D trajectory of muon crossing CRC reconstructed from 2D projections.
- each of the 4 planes of a lateral view with $\geq 1$ turned on LED
- if 2 LEDs are turned on in a plane, they must be contiguous
- $\chi^2 < 1.5$ from linear regression
- all previous conditions must be valid for both $x$ and $y$ views

Efficiency measured in 9x9 bins of 10° width with $\sim 10^6$ cosmic muons. Efficiency of a single plane is $\epsilon_{\text{plane}} \sim 93\%$.

**Analysis & Results**

Differential muon flux

$$\Phi_\mu = \frac{R}{\omega \cdot S \cdot A \cdot \epsilon}$$

- $R =$ cosmic muon rate
- $\omega =$ solid angle defined in a bin $\Delta \theta, \Delta \phi$
- $S =$ surface of a CRC plane

The $\Phi_\mu$ scan highlights the details of the mountain above the bunker
  - providing a map of the rock thickness that surrounds the detector.

A the Soratte hypogeeum $\Phi_\mu$ is more than O(10³) lower than on surface:

$$\Phi_\mu = 0.3 \text{ m}^{-2}\text{s}^{-1}\text{sr}^{-1}$$

compatible with the requirements of astroparticle physics experiments requiring a low cosmic ray induced background.

We plan to add the Soratte bunker to the educational CRC network at the disposal of high school students.

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