Environmental Effects on the Neutron Monitor Measurements at High Altitudes as Observed at Jungfraujoch

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Cosmic Rays in the Atmosphere
Principle of Neutron Monitor

- Reflector (Paraffin/Polyethylene)
- Producer (Lead)
- Moderator (Paraffin/Polyethylene)
- Counter Tube ($\text{B}^{10}\text{F}_3$)

$$\text{B}^{10} + \text{n} \rightarrow \text{Li}^7 + \alpha$$
Bern Cosmic Ray Group

University of Bern, Switzerland operates 3 NMs:

• 18-IGY NM at Jungfraujoch, 3570 m asl, since 1958
• 3-NM64 NM at Jungfraujoch, 3475 m asl, since 1986
• Special Neutron Monitor at Bern, 570 m asl, since 1977

Main interest of Bern group:

• Analysis of solar cosmic ray events (GLEs)
• Analysis of Forbush decreases
• Space Weather
18-IGY Neutron Monitor Jungfraujoch

Roof of Sphinx building
3-NM64 Neutron Monitor Jungfraujoch

Roof of Research Station
Special Neutron Monitor Bern

Roof of Physics Institute, University of Bern
Environmental Effects

- Atmosphere (mass) over neutron monitor
- Detector environment (housing, rocks, ground)
- Snow accumulations on and around the NM housing
Effect of Atmosphere

- Change in air mass has large effect on count rate
- This change is the only significant meteorological factor
- Barometric pressure is used as a proxy for the air mass
- Barometric pressure coefficient $\sim 1\% / \text{mmHg}$ → pressure must be measured very accurately
Effects of wind on pressure measurements

• Gusty winds cause short-time fluctuations
• Strong winds cause diminished readings of conventional barometers

Bernoulli effect: \( p_{\text{meas}} = p_{\text{eff}} - \rho v^2/2 \)
1-minute pressure data
NM count rate

atmospheric pressure

wind speed
Snow Effect
Precipitation

Meteo station at Interlaken, 18 km NNW from Jungfraujoch

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CEST (UTC+2)
NM Simulation with Monte Carlo

- Simulation of interactions of neutrons with material (detector housing, detector, ground, snow)
- Simulation of detection of slow neutrons in the counter tubes
- Geant4 software package
Detector and material in the environment

- Snow on the roof
- Roof (copper, wood)
- Snow around detector housing
- Ground (concrete)

NM64 neutron monitor
Visualisation of particle interactions
Count rate vs. Snow Accumulation on Roof

First preliminary results

Snow density = 0.05 g/cm³

100 - 0.0875 * x [cm]

~1% / 10 cm snow
$\Delta N_{\text{IGY}}$ vs. Snow Thickness

$\sim 0.5\% / 10 \text{ cm snow}$

$\sim 0.2\% / 10 \text{ cm snow}$
Conclusions

- Effects of atmospheric mass and snow accumulations on and around detector must be known for correct interpretations of NM data
- Accurate pressure measurements
- Correct interpretation of pressure measurements during times with gusty and high speed winds
- Monitoring of snow accumulation (measurements of snow height, web cam)
- Consequences may be different for analysis of short and long time NM data
2006 Jungfraujoch

Tagesmittel Temperatur (degC)

Mittel -6.2  Normwert -7.9