Neutron Monitors at Jungfraujoch

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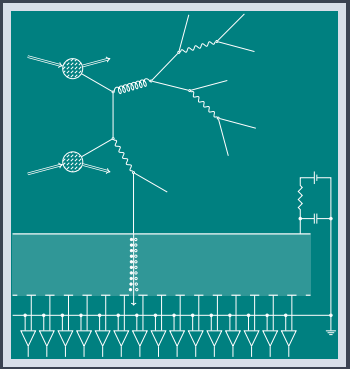
» My personal background

- High energy physics
  - Top quark physics with proton-proton collision data from the CMS detector at the LHC (CERN)
    - Cross section measurements at 7 TeV and 8 TeV
  - Diamond as a material for position sensitive detectors
    - Study of detector characteristics with irradiation
    - Measurement of uniformity of diamond material with irradiation
- Since 2022: employed by research station Jungfraujoch
- Since spring 2024: took over neutron monitor duties from Rolf Bütikofer



» Research Station Jungfraujoch

* Located in Bernese Alps in Switzerland
* Altitude: 3450 m *above sea level*
* Accessible by train (∼2.5 h from Bern)
* Permanently staffed

Wikipedia 2010

» Completion of Jungfrau Railway and Cosmic Ray Research at Jungfraujoch

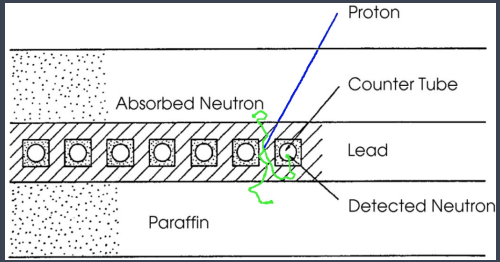
* 1912: completion of Jungfrau Railway to Jungfraujoch
* Cosmic ray research since the opening of the railway
* The construction of the research station and Sphinx observatory made permanent instruments and measurements possible.
  → neutron monitors

» Neutron monitors at Jungfraujoch

» IGY neutron monitor – JUNG

JUNG NM on Sphinx terrace

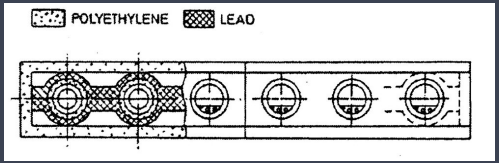
* In operation since 1958
* Built for continuous measurement of cosmic ray intensity
* 18 BF_3 counter tubes (N. Wood) in 3 sections



» NM64 neutron monitor – JUNG1

JUNG1 NM on top of research station

- In operation since 1985
- 3 BF_3 counter tubes (Chalk River)
- JUNG1 has $\sim$3-times higher count rate than JUNG
  $\rightarrow$ better statistics than JUNG



NM64 (Carmichael 1968)

» JUNG and JUNG1 at Jungfraujoch

Housing of JUNG

«Chalet» of JUNG1

Readout electronic (Böttcher et al. 2022)

* Housing of both monitors is designed to withstand the harsh weather conditions
* Precision barometer (±0.2 hPa) at each monitor
* New readout electronics by Uni Kiel introduced in 2020

» Available webcams to monitor environment of JUNG and JUNG1

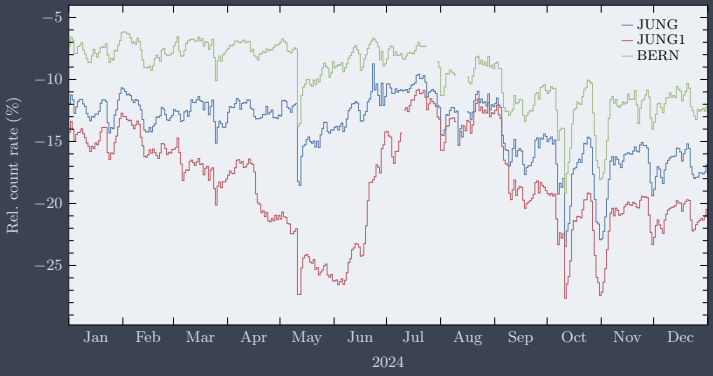
* https://network.switch.ch/pub/cam/
* https://www.jungfrau.ch/webcams/top-of-europe-jungfraujoch/

» Environment of JUNG1

26 Sep 2018

26 Jan 2019

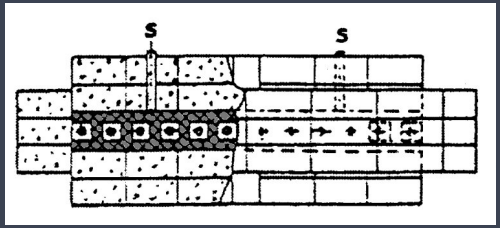
» Relative count rate



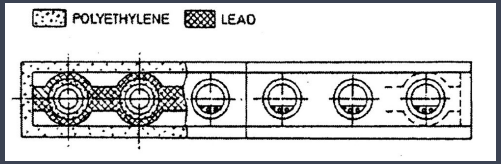
Count rate of JUNG, JUNG1, and BERN

* Comparison of the measurements of the two Jungfraujoch monitors in 2024
* Forbush decreases
* Wind effects
* Seasonal variation of JUNG1 due to snow coverage
  * Snow from JUNG is removed at least once per day
  * On top and behind JUNG1 housing snow accumulated and melts in spring time

» Effects on count rate of IGY vs. NM64 by environmental changes



IGY (Simpson 1957)



NM64 (Carmichael 1968)

- Reflector of the IGY is larger than that of the NM64 (by a factor of ~ 4)
- Therefore, the NM64 is more sensitive to lower energetic neutrons which are produced in the environment of the detector (albedo neutrons) than the IGY.
- As a consequence, changes of material around the detector of the NM64, as snow accumulation or snow melting, have a considerable effect on the count rate of the NM64.

» Summary and outlook

- Longterm data set available (on NMDB) with almost no interruptions
- Jungfraujoch 1-minute data are online in almost real-time
- Monitors at Jungfraujoch are sometimes affected by snow accumulation
  - JUNG1 (NM64) shows clear seasonal variations → not suited for long-term studies
  - JUNG (IGY) housing exposed to wind → snow strongly shifted by wind and only small snow layer
  - Snow from IGY roof is removed at least once per day
- New readout electronics installed at both monitors
- JUNG and JUNG1 will be kept in operation jointly by HFSJG and University of Bern
  Responsible station manager: Lukas Bäni (lukas.baeni@unibe.ch)


Thank you!

» References

[1] S. I. Böttcher, C. T. Steigies and R. Bütikofer, «NMRENA», 23rd Feb. 2022.

[2] H. Carmichael, Cosmic Rays (Instruments), Annals of the IQSY **1**, edited by C. M. Minnis, 178–197 (1968).

[3] J. Simpson, Annals of The International Geophysical Year **4**, 351–373 (1957).

[4] Wikipedia, *Physical location map europe*, (Mar. 2010) `https://commons.wikimedia.org/wiki/File:Europe_relief_laea_location_map.jpg` (visited on 07/10/2024).