Cosmic Ray / Solar Activity Induced Earthquakes and Volcanoes - Societal Impacts

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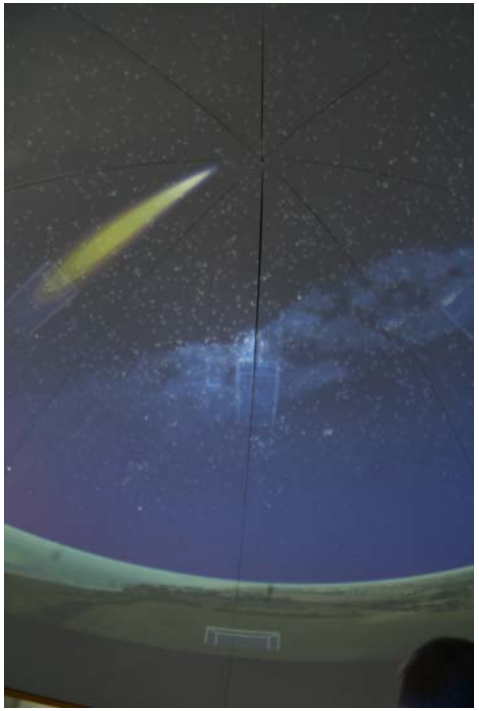
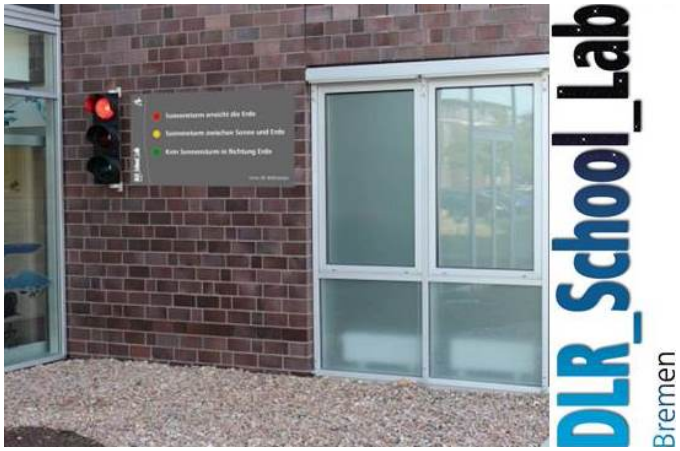
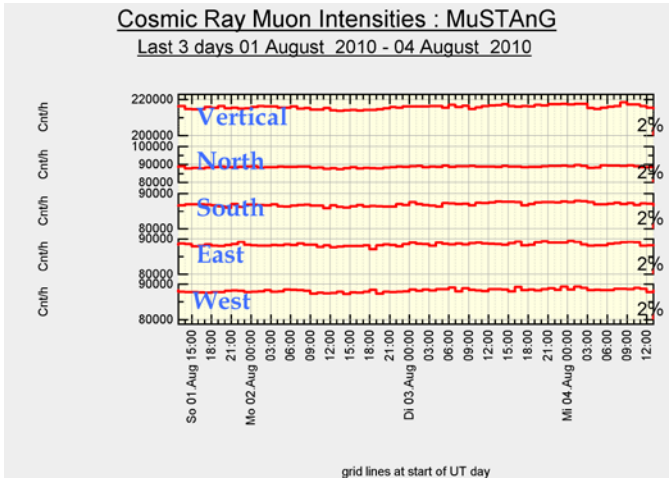
Earthquakes, Volcanoes and Cosmic Rays / Solar Activity

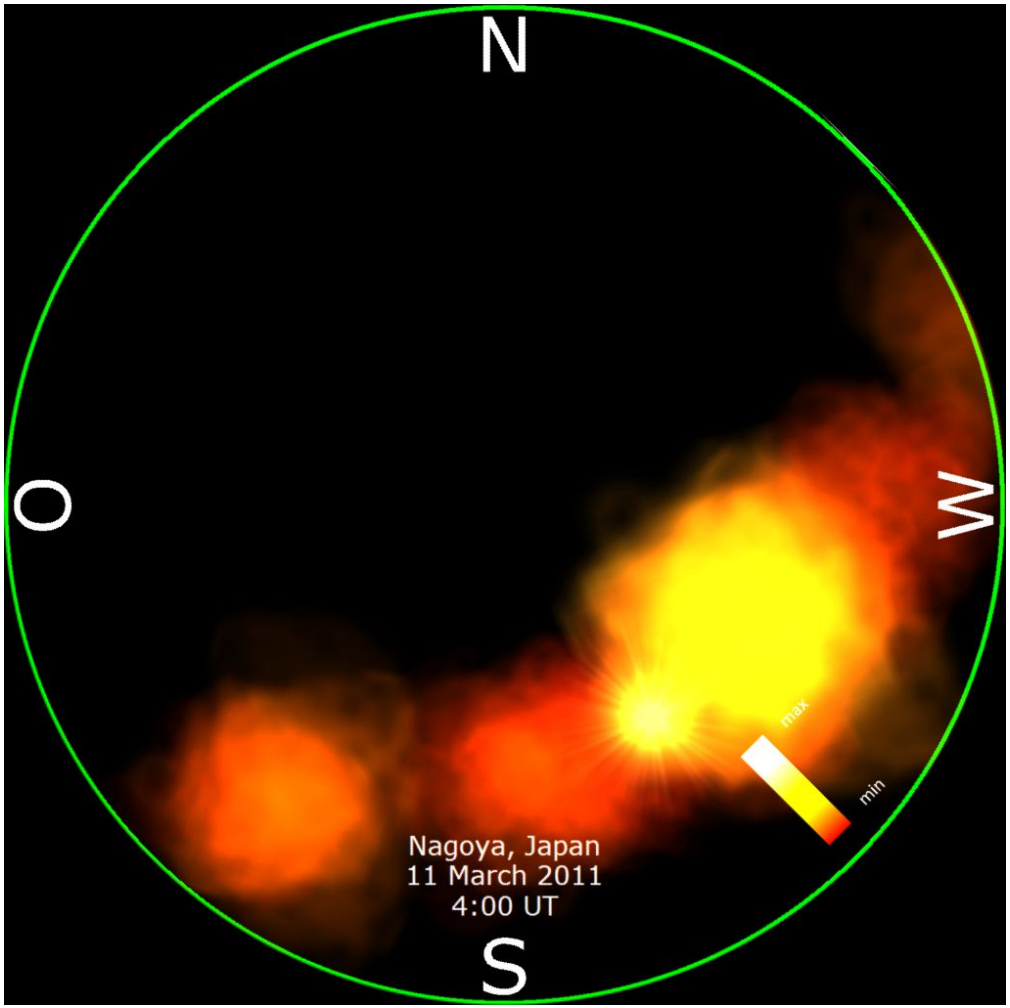
1) three most disastrous earthquakes (1923, 1964, 1995) in the 20th century in Japan occurred in cosmic ray maximum conditions (respectively solar minimum period, T. Ebisuzaki et al. 2011),
2) 2% cosmic ray neutron intensity increase exact with the begin of the Tien Shan earthquake on 25 December 2006 (V.P. Antonova *et al.* 2009),
3) Tohuku earthquake 11 March 2011 (Fukushima Dai-ichi nuclear power plant failure): CR neutron?, TEC? but CR muon? => GMDN telescopes (DLR Bremen)



Cosmic Ray Sky (GMDN data) above Nagoya just before M9 Earthquake

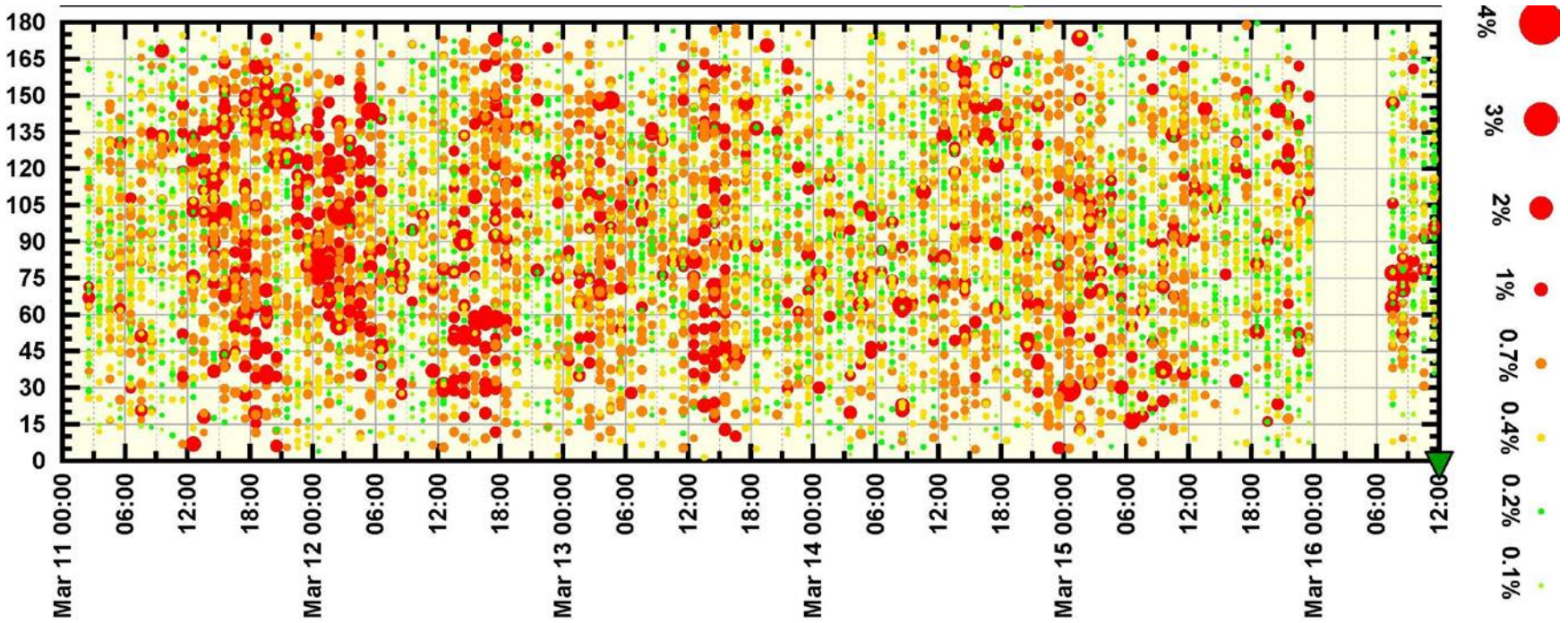






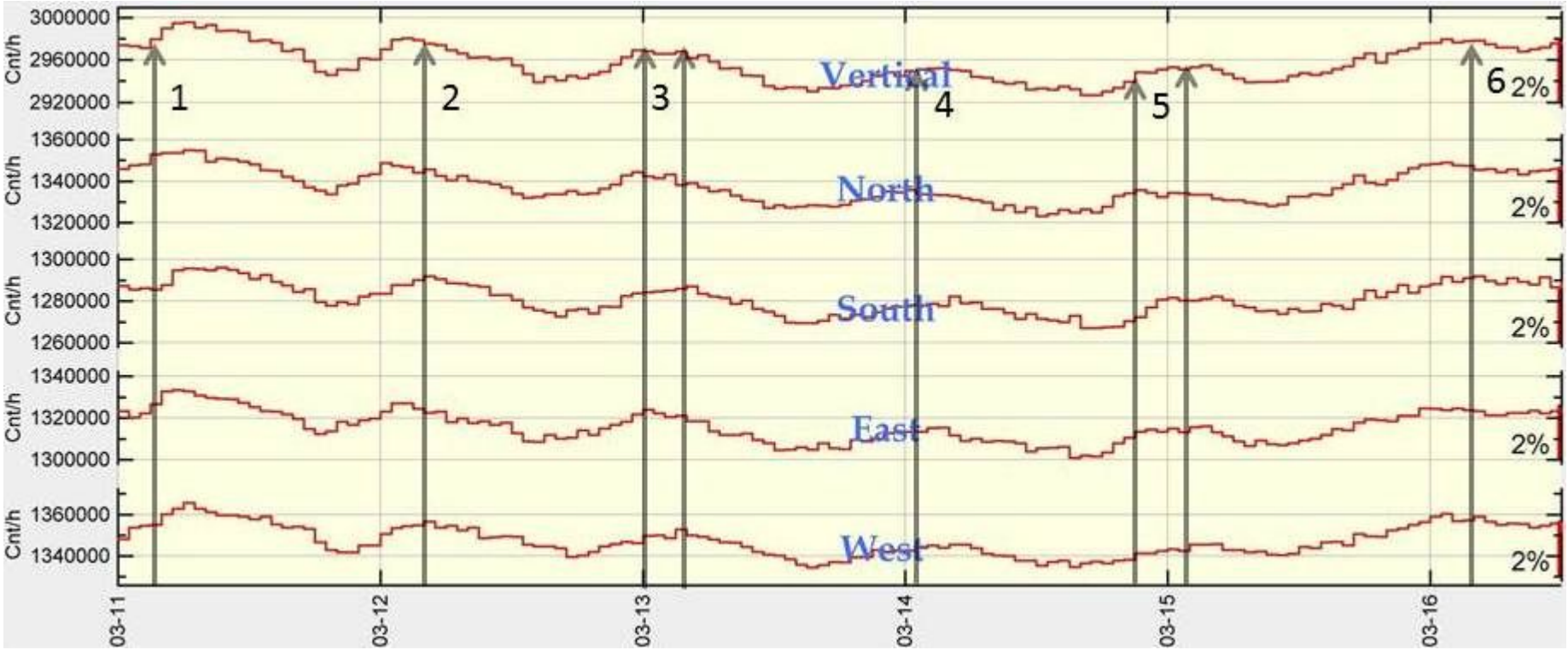
cosmic ray muon sky from all five GMDN telescopes above Nagoya about 1h 46 min before Tohuku earthquake in Japan (the horizon is green)

GMDN / CR Muon Anistropies during March 2011



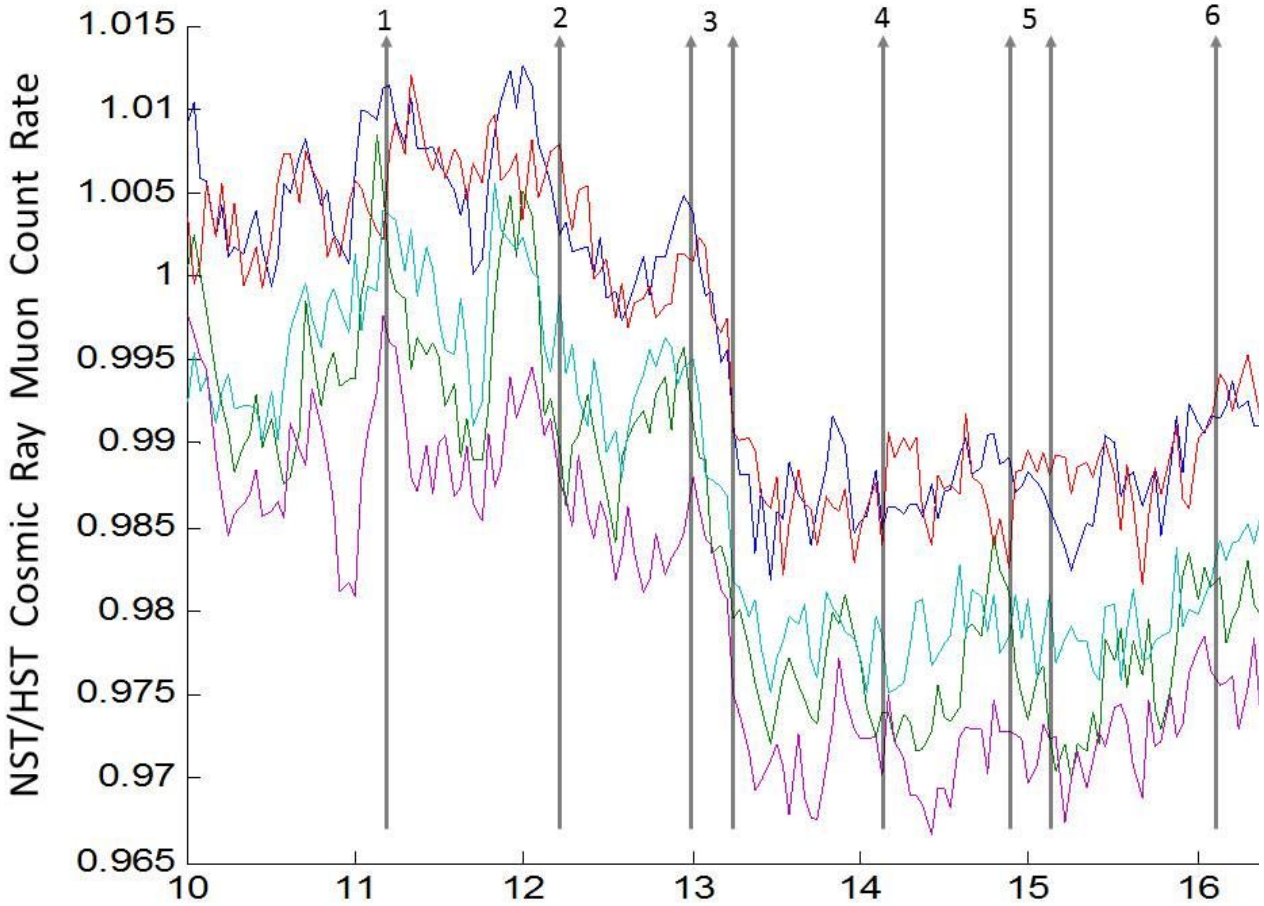
- ordinate is the pitch angle distribution (45° Parker spiral field at Earth orbit, 0° Earth motion direction in interplanetary space around the Sun),
- enhanced anisotropies correlates with the time of the earthquake, explosions and ventings (see vertical lines next figure),
- enhancements are only caused by the NST data - not measured in the four other GMDN telescopes

NST during March 2011



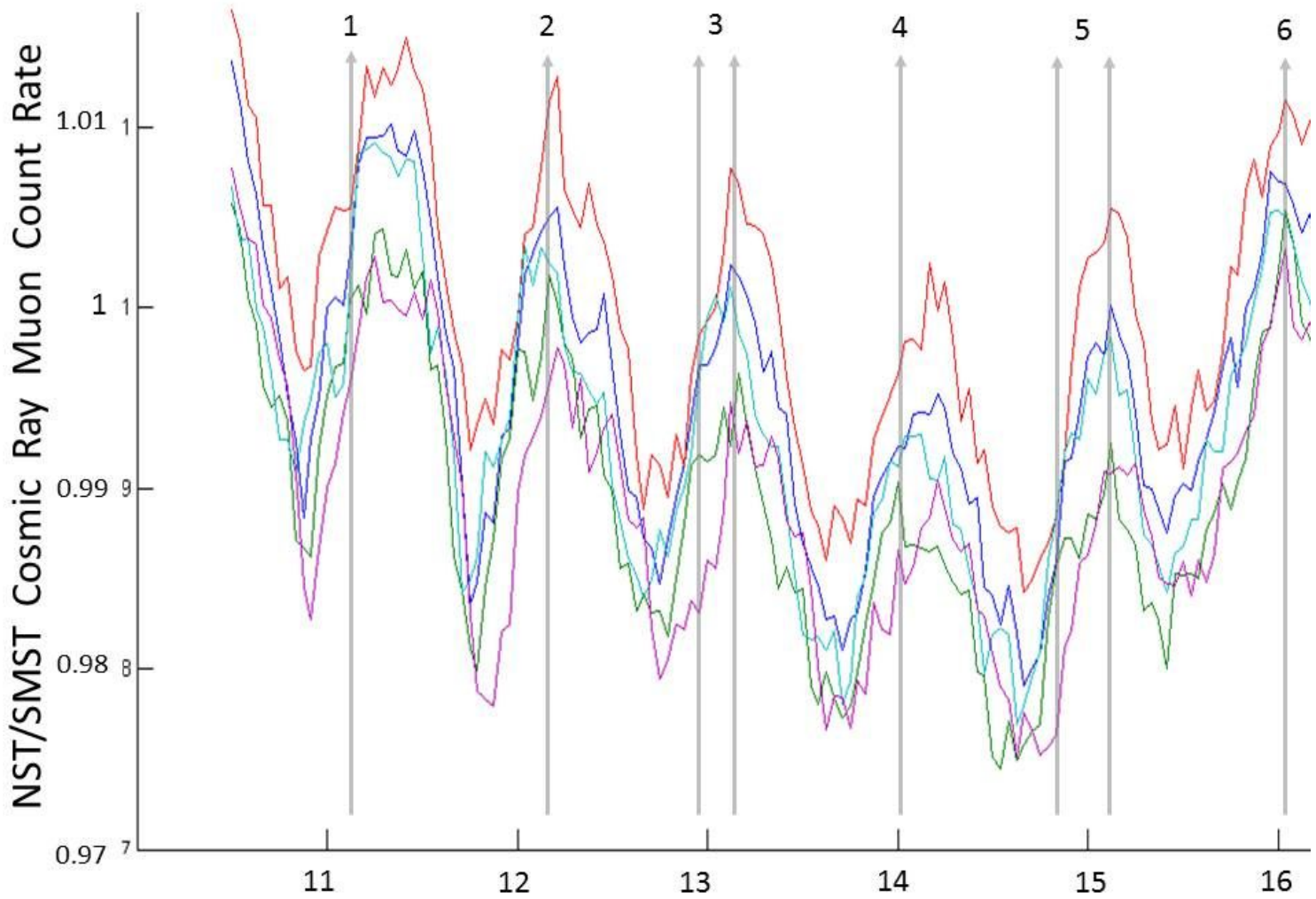
- NST hourly cosmic ray muon intensity measured 11 March to 16 March 2011 (500 km southward from Fukushima Dai-ichi nuclear power plant),
- explosion and ventings at Fukushima Dai-ichi nuclear power plan (1 Earthquake 05:46 am UT; 2 explosion Unit1 06:36 am UT, venting Unit1 10:25 am UT, detection ^{137}Cs and ^{131}I; 3 venting Unit3 and 2 00:20 am UT and 04:50 am UT; 4 H explosion Unit3 02:01 am UT; 5 explosion Unit2 9:10 pm UT 30…400mSv/h, explosion and fire Unit4 9pm to 2am; 6 venting Unit2 and 3 about 03:00 am UT)

NST/HST CR Enhancement during March 2011



- normalized Nagoya to Hobart CR muon data ,
- 1% enhancement of NST muon counts are visible (until about the end of 12 March 2011) in all muon incoming directions (V, N, S, E, W),
- daily cosmic ray variation: not the reason, NST was operating normally/no malfunctions during these days

CR Muon Daily Variation during March 2011



- normalized Nagoya to Sao Martinho CR muon data ,
- daily variation

Physics?

muon production

- $^{222}Rn(\alpha,n)^{218}Po$ (^{222}Rn was observed via TEC anomalies by D. Ouzounov *et al.* 2011),
- free neutrons decay into additional electrons, which collided with secondary cosmic ray positrons and produces via Z^0 additional $\mu^- \mu^+$,
- during the power plant failures occurs $^{239}Pu \rightarrow ^{235}U \rightarrow ^{131}I$ respectively and $^{239}Pu \rightarrow ^{235}U \rightarrow ^{236}U \rightarrow ^{137}Cs$,
- β^- decays of ^{131}I and ^{137}Cs produced additional electrons, which produced via secondary cosmic ray positrons and Z^0 additional $\mu^- \mu^+$,
- but very low decay cross section $Z^0 \rightarrow \mu^-\mu^+ \sim 0.92$ nb both processes results into magnitudes to low additional muon production…

but CR muon and volcanoes (plus CR muon tomography of volcanoes)…

Outline: Statistics from 2006 to 2014