

# SOLAR NEUTRON EVENTS IN ASSOCIATION WITH LARGE SOLAR FLARES IN NOVEMBER 2003

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The Sun was intensely active from the late October to the beginning of November 2003. A series of eleven X-class solar flares were observed during October 19 and November 5, 2003, in NOAA regions 484, 486 and 488. Among them, in the flares on November 2, 3 and 4, solar neutrons were observed by the ground based neutron monitors and the solar neutron telescopes located around the world.

At 17:03 UT on November 2, 2003, an X8.3 class solar flare was occurred in NOAA active region 486. Solar neutrons in association with this flare were detected by the neutron monitor located at Mt. Chacaltaya, Bolivia (292.0°E, 16.2°S, 5250 m a.s.l.). The statistical significance of this event was  $4.5\sigma$ .

The solar neutron event of November 3, 2003, was detected by the Hawaii solar neutron telescope located at Mauna Kea (203.7°E, 19.8°N, 4200 m a.s.l.), in association with an X2.7 class flare occurred at 1:09 UT. The statistical significance of this event was  $4.7\sigma$ . Excesses for this event were detected from the direction of the sun.

On November 4, 2003, an X28 class solar flare, which is the largest flare on record, was detected at 19:29 UT. Solar neutrons were also observed by the neutron monitor at Mt. Haleakala, Hawaii (20.7°N, 203.7°E, 3030 m a.s.l.). The statistical significance of this event was  $5.3\sigma$ .

In these flares, intense emission of hard X-rays and  $\gamma$ -rays have been observed by the RHESSI satellite.

At the solar neutron event of November 2, 2003, the 800 – 7000 keV high energy channel of the RHESSI satellite observed clear excesses. And in particular, a large amount of 2.223 MeV neutron capture line  $\gamma$ -rays was observed.

On November 3, 2003, there was no significant enhancement of 2.223 MeV  $\gamma$ -rays, however, the intense emission of 300 – 800 keV  $\gamma$ -rays has been observed.

During the solar flare occurred on November 4, 2003, RHESSI satellite could not observe the solar flare because it was the night side of the Earth. However, GOES satellite observed rapid increase of soft X-rays at 19:42 UT.

It seems that solar neutrons were produced at the same time as the production time of these hard electromagnetic radiations.

In this paper, we report these solar neutron events and describe analysis results.