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The Method of the HXD-PIN Non X-ray Background Modeling

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This memo describes the modeling method of the PIN non X-ray background. This modeling method is refered as "bgd_a" in the Suzaku SWG team. The event FITS files generated with the modeling method are identified by the keyword of "PINUDLC" in the "METHOD" record of the FITS file header.

The non X-ray background (NXB) model of HXD-PIN is constructed on the database of earth occultation data. In the modeling, the counter of upper discriminator of the PIN diodes (PIN-UD) is used as a monitor of real-time particle flux. The level of PIN-UD corresponds to $\sim$ 90 keV, and the counting rate of PIN-UD can be regarded as the number of cosmic-ray charged particle penetrating the device. Actually, since the PIN diodes are embedded in the thick BGO shields, protons above $\sim$ 100 MeV can be counted with PIN-UD. Figure 1 show typical lightcurves of the total PIN-UD count rate, the event rate of PIN and GSO, and the time variation of COR during a blank sky observation. The sharp peaks of $\sim$ 10000 counts s^{-1} in the PIN-UD lightcurve indicate SAA passages.

The real time PIN-UD count rate can be used as a good indicator of the NXB component which directly correlate with COR. As shown in Figure 1 and Figure 2, the count rate of the PIN NXB is strongly correlated with COR and PIN-UD count rate.

Another NXB component correlated with T_SAA cannot be modeled by simply using PIN-UD. This component is weaker than that correlated with COR. However, it is clearly seen in the lightcurve of event rate as shown in Figure 1 and Figure 3. In order to take this component into account, we

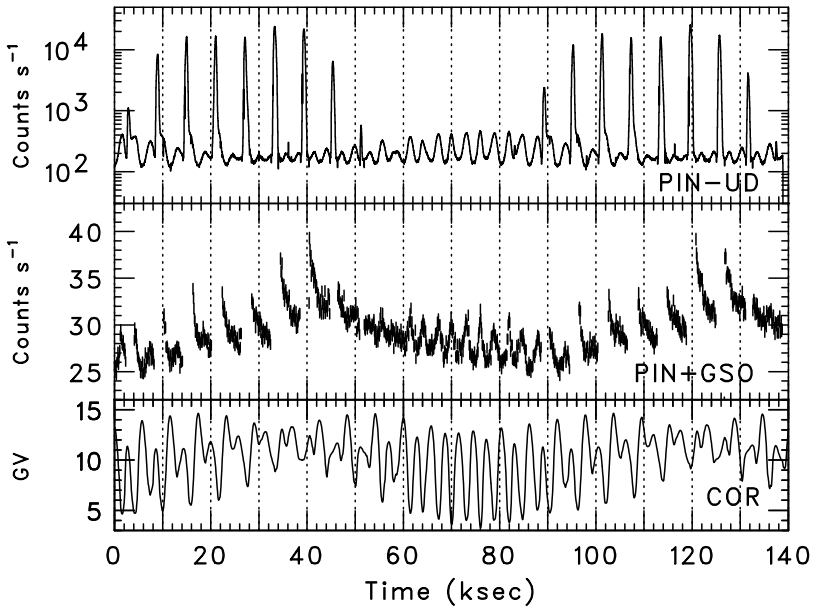

Figure 1: A typical lightcurve of the PIN-UD summed over the 16 units together with that of events from PIN and GSO, and the COR, obtained from $\sim$ 1.5 days observation of a blank sky field.

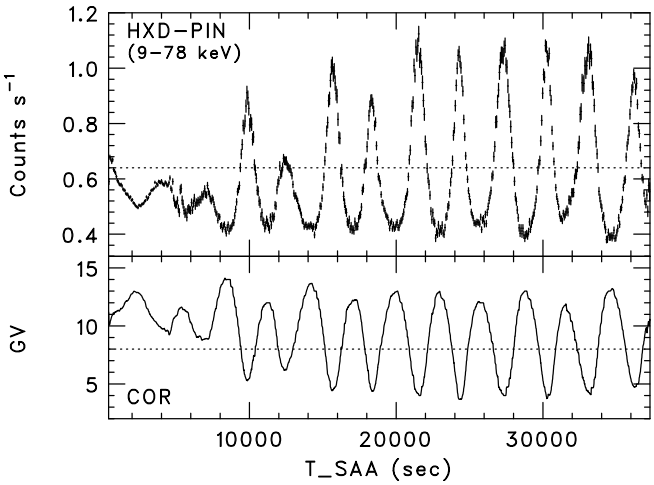

Figure 2: Count rate of PIN NXB folded with T-SAA and cut-off rigidity (COR). (from (1))

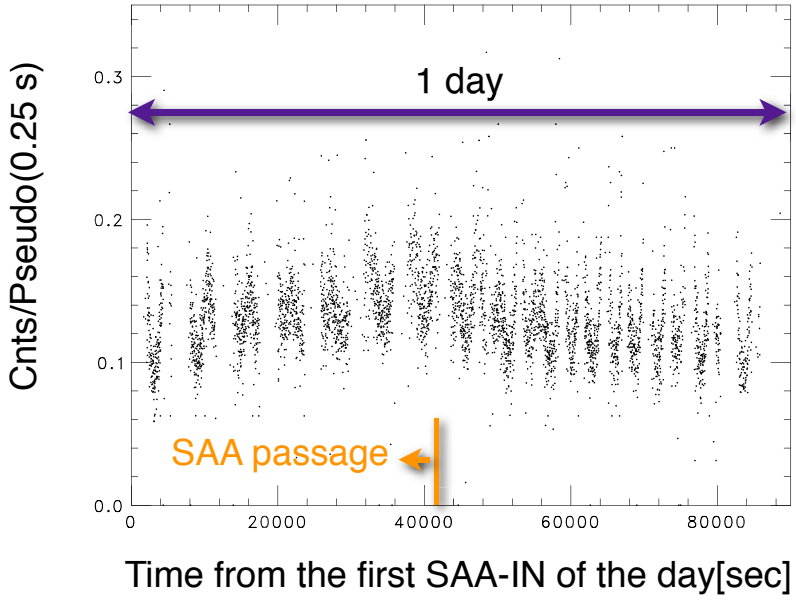

Figure 3: Count rate of PIN events during earth occultation, folded with a time from the first SAA-IN of the day.

have introduced a parameter "PIN-UD build-up", represented by

$$\text{PIN-UD}_{\text{buildup}}(t) = \int_{-\infty}^{t} \text{PIN-UD}(t_0)\, \exp\left(\frac{t_0 - t}{\tau}\right) dt_0. \quad (1)$$

Various values of time constant τ was tried between 5000–10000 s and $\tau = 8000$ s was selected in the latest BGD model. A typical lightcurve of PIN-UD and PIN-UD$_{\text{buildup}}$ are shown in Figure 4.

The NXB database was constructed by accumulating and sorting the earth occultation data by the two parameters, PIN-UD and PIN-UD$_{\text{buildup}}$. We accumulated PIN event data and pseudo event data under the conditions that the target elevation angle should be $< -5°$ and the COR should be > 6 GV. In Table 1, the conditions of the NXB database are summarized for each version of the PIN NXB event FITS ("METHODV").

The database consists of 100 $\times$ 100 PIN-NXB spectra constructed with the PIN events and the pseudo events. The range of the PIN-UD in the database is from 100 counts/s to 400 counts/s, and, that of the PIN-UD$_{\text{buildup}}$ is from 1.0×10^6 counts to 2.5×10^7 counts. Figure 5 presents a NXB database divided into four energy bands for the visualization.

The PIN NXB for each observation is estimated by picking up a spectrum from the database based on the two parameters. From PIN-UD and PIN-UD$_{\text{buildup}}$ during observation, we can pick up a PIN NXB spectrum in the database. A time to the next event and a pulse height are obtained by generating random numbers following probability distributions based on the PIN NXB spectrum. And then, by repeating these processes from the beginning of the observation to the end, the PIN NXB event file can be obtained.

Table 1: Summary of PIN NXB versions (as of 10 Jan. 2007)

METHODV	Objects	PIN H.V.	database accumulating period	database exp.
"1.2"	All 64 PINs	500 V	16 Sep.2005–16 Apr.2006 (only SWG obs.)	2.3 Msec
"1.2w123"	48 PINs in WPU1,2,3	500 V	16 Sep.2005–16 Apr.2006 (only SWG obs.)	2.3 Msec
"1.2w23"	32 PINs in WPU2,3	500 V	16 Sep.2005–16 Apr.2006 (only SWG obs.)	2.3 Msec

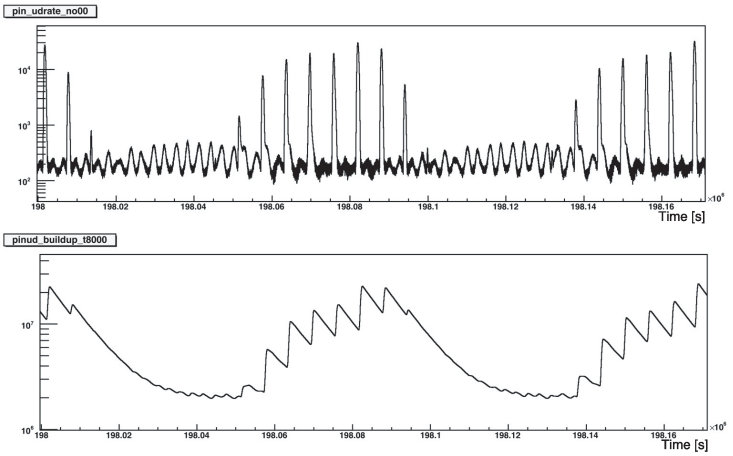

Figure 4: Lightcurves of PIN-UD (top) and PIN-$UD_{buildup}$ (bottom).

The reproducibility of the PIN NXB model is reported in Suzaku Memo 2006-42.

References

[1] Kokubun, M., et al., "In-Orbit Performance of the Hard X-ray Detector on board Suzaku", PASJ, 2006, in press

[Suzaku Memo-2006-42] Mizuno, T., et al, "Reproducibility of the HXD-PIN Non X-ray Background", Suzaku Memo 2006-42, http://www.astro.isas.jaxa.jp/suzaku/doc/suzakumemo/suzakumemo-2006-42.pdf

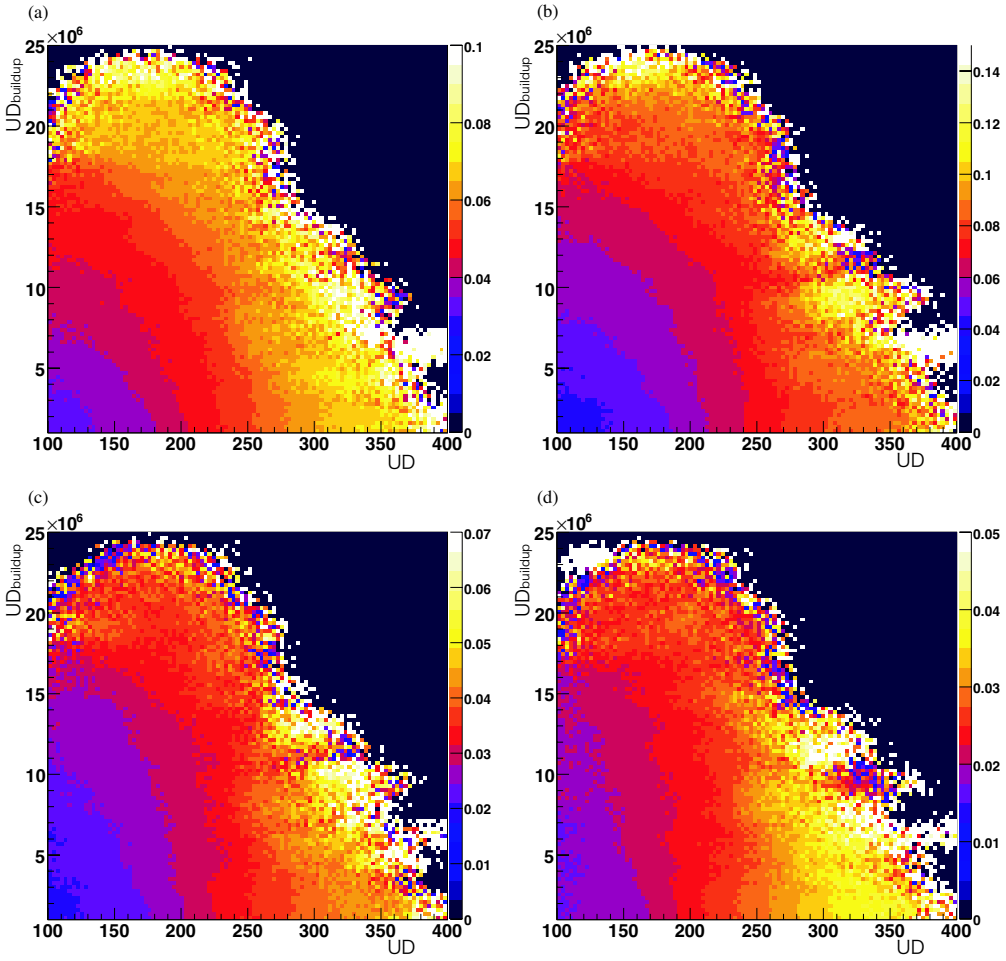

Figure 5: A NXB database of HXD-PIN of (a) 12–15 keV, (b) 15–25 keV, (c) 25–40 keV, and (d) > 40 keV. This database is used in the PIN NXB estimation of "METHODV = 1.2". The unit of the color scale is counts/(pseudo event[4 Hz]).