The ASCA Slew Survey*

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Abstract

We have been systematically analyzing ASCA GIS data taken during the satellite attitude maneuver/slew operation. We report the current status of this project. Our motivation is to search for serendipitous hard X-ray sources and make the ASCA Slew Survey catalog. We have developed a new technique to improve the satellite attitude during the maneuver, and determine the source position accurately. A quick look analysis found a new hard X-ray source in the north of SS433, at $(\alpha, \delta) = (287.6, 7.7)$ (J2000).

Key words: ASCA: GIS — All Sky Survey

1. ASCA Slew Data

Although ASCA is not designed to carry out observations while attitude maneuver/slew operation, the GIS instrument was operational and collecting X-ray events during most attitude maneuvers. GIS has a high time resolution ($\sim$ 60 msec) so that it may determine the photon arrival direction while the satellite is moving (maximum maneuver velocity is $\sim$ 0.2 deg/sec). SIS is not usable because of the long exposure time ($\geq$ 4 sec).

During its operational life from 1993 February to 2000 July, ASCA carried out more than 2,500 maneuver operations, and total exposure time during the maneuver was $\sim$ 415 ksec after proper GIS data screening.

In total, $\sim$ 60 % of the sky (7.6 str) was scanned at least once, and the total exposure time $\times$ area is $\sim$ 60 str $\cdot$ sec. Therefore, average exposure time of the scanned region is $\sim$ 7.9 sec. See Figure 1 for the exposure map.

2. Attitude Determination

We found the most technically challenging part in this project is to determine the satellite attitude during the attitude maneuver accurately, since this is beyond specification of the ASCA attitude control and determination system which is designed for pointing observations.

We have been working with NEC engineers who have designed and built the ASCA attitude control and determination system. As a result, we have learned the following:

- During attitude maneuver, the attitude was determined only using the on-board gyroscope signals (the star tracker was not used).
- Just before and after the attitude maneuver operations, attitude is determined pretty accurately ($\sim 10''$) by using the star tracker data.
- The on-board gyroscope integrates the attitude forwardly during the maneuver since the last star-tracker data, while the ground attitude determination calculates the attitude backwardly from the first star-tracker data after the maneuver completion. These two attitudes may have discrepancies, typically $\sim 0.2^\circ$ degree.
- Averaging the on-board attitude (to be calculated from the housekeeping information in the telemetry) and the ground attitude (already calculated and provided by NEC), we can achieve the most precise attitude during the maneuver with systematic error less than $\leq 0.2^\circ$. (We may call it the *hybrid* attitude.)

Note, in the course of working on this project, we have found the leap second is not taken into account in the ground attitude determination. As a result, current ASCA attitude files have the elapsed time since the beginning of 1993 (definition of the ASCA time) *as if there had not been leap seconds since 1993.* We have corrected this error, since a difference of up to 5 sec is crucial to determine the attitude during the maneuver (while this is completely negligible for pointing observations).

3. Feasibility and Preliminary Results

Using the "hybrid" attitude, we have processed all the maneuver data, and determined positions of GIS events

** The original manuscript is in color and available at `http://lheawww.gsfc.nasa.gov/users/ebisawa/nikko_proceeding.ps.gz`.

(Figure 2). Average exposure time is $\sim$ 8 sec for a scanned region. So we may collect $\sim$ 10 events for a 0.625 cts/GIS source, which corresponds to $\sim$ 0.6 mCrab. This is considered to be 3 σ sensitivity of our dataset.

In Figure 3, we show examples of our slew dataset in the Galactic center region, LMC, and the GRS1915-105 – SS433 region (exposure not corrected). Photon energies are differentiated by different colors. Although these results are preliminary, we can easily recognized many sources.

Note that GIS energy range is 0.7 – 10 keV. Our dataset is a unique large sky survey above 2 keV with a focusing instrument, while ROSAT all sky survey extensively studied the soft X-ray sky below 2 keV and HEAO-1 carried out all sky survey above 2 keV with modulation collimator.

In Figure 3, different source spectra are clearly seen as difference of colors. For example, note the softness of most LMC sources, as opposed to many Galactic center sources (in particular GX1+4 and 2E1740.7–2943) and GRS1915+105 which have relatively hard spectra.

We expect to discover new hard X-ray sources which may be bright only above 2 keV and thus not be detected by the ROSAT all sky survey. Actually, we did discover a new hard X-ray source at (α, δ) =(287.6, 7.7) in the north of SS433. Find the contrast in color with the nearby ROSAT all sky survey source (1RXS J190732.6+070817).

4. Future Works

- Sophisticate the attitude determination algorithm, and estimate systematic error in source positions due to attitude determination error.
- Carry out systematic source search.
- Carry out exposure correction and determine the source flux.
- Create the ASCA Slew Source Catalog. Make the processed data public.
- Propose Chandra and/or XMM follow-up observations of the newly discovered sources to improve the source positions and study nature of these X-ray sources.

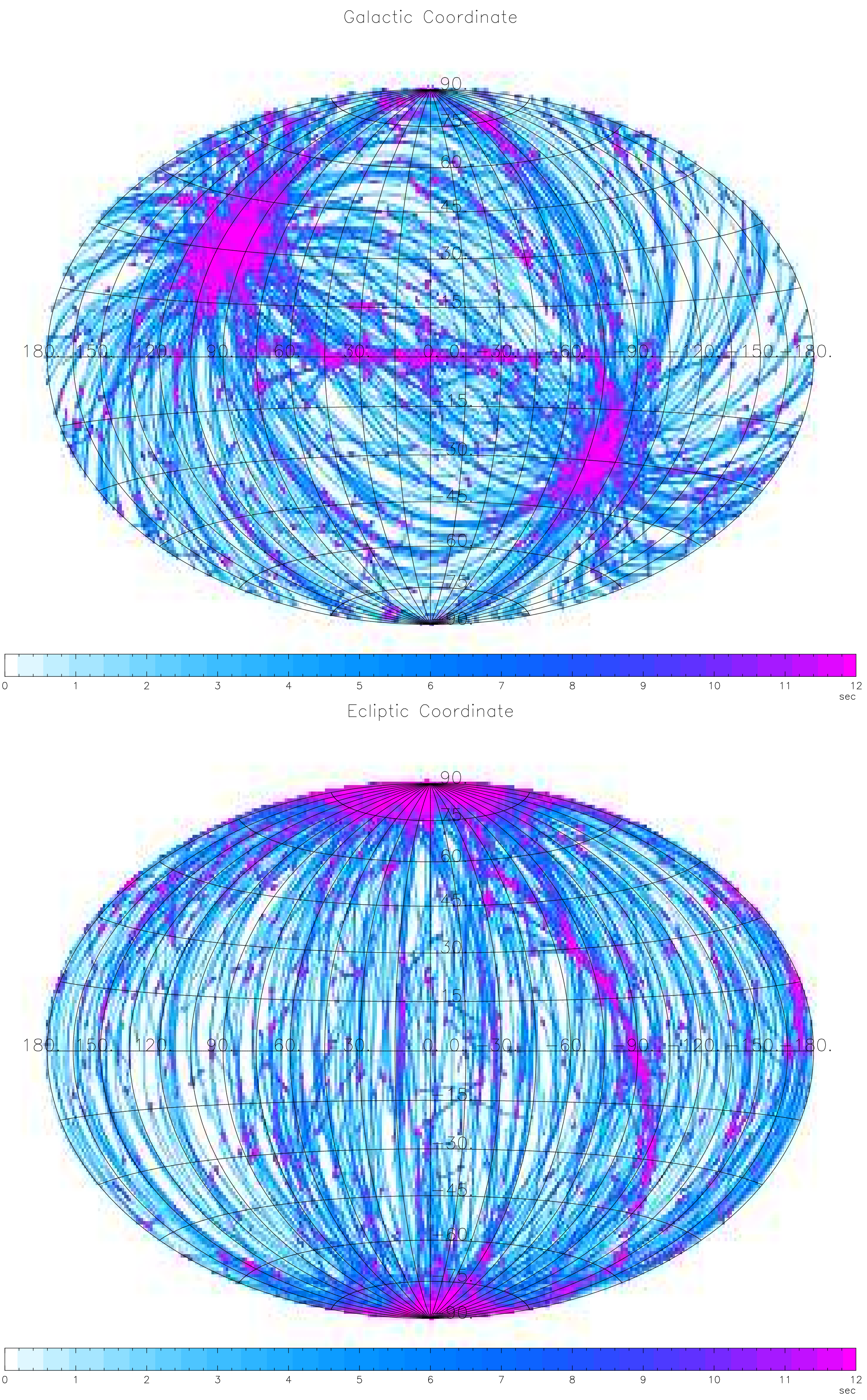

Fig. 1. Exposure map of the ASCA GIS slew data in Galactic coordinate (top) and ecliptic coordinate (map). Different color indicate the exposure time for each bin. Note that most scans are along the ecliptic meridian because of the ASCA operational constraint. Consequently, we have good coverage in the north and south ecliptic regions.

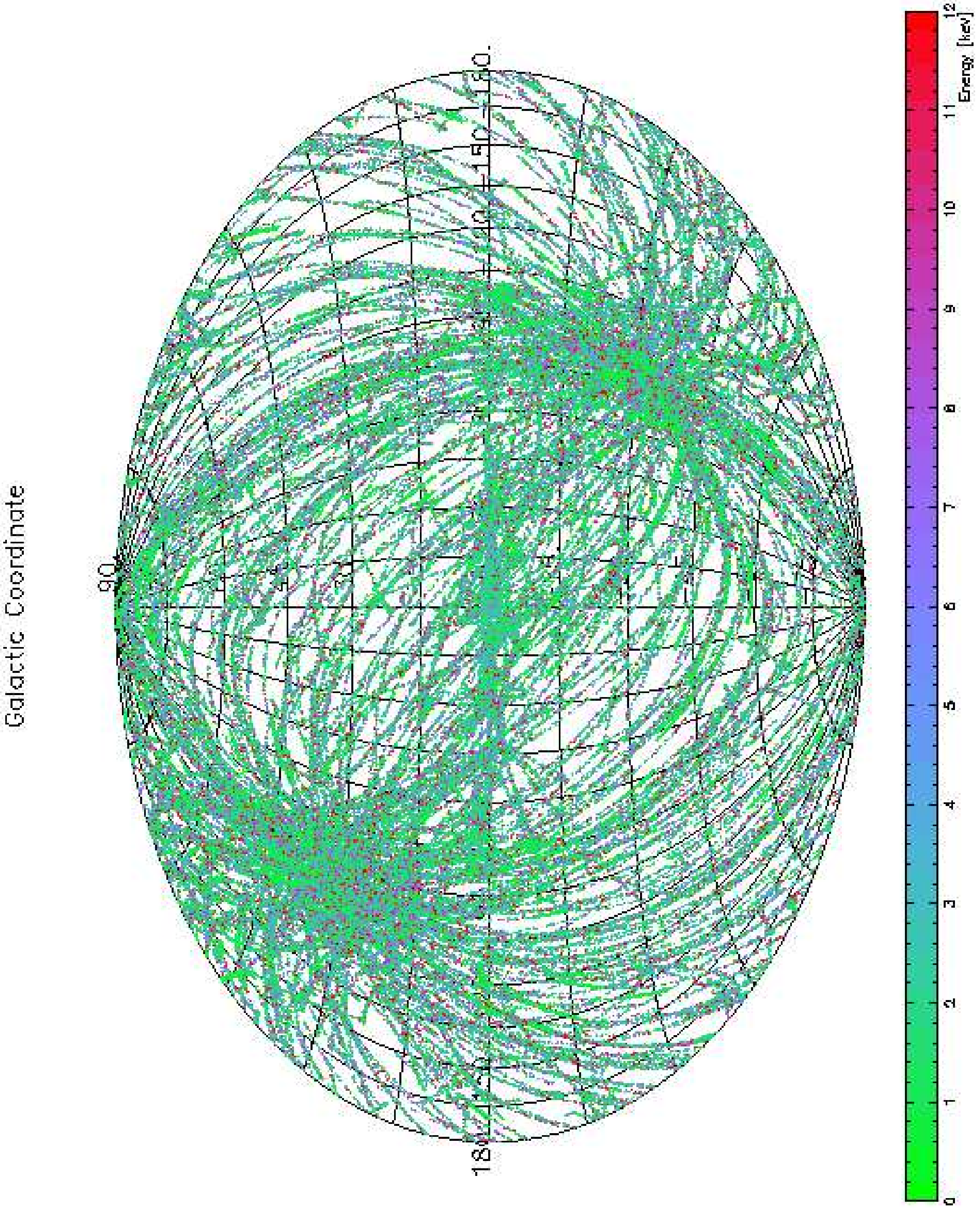

Fig. 2. All the GIS events during the slew in the Galactic coordinate. GIS2 and GIS3 are combined. Different color indicate the photon energies. Exposure is not corrected.

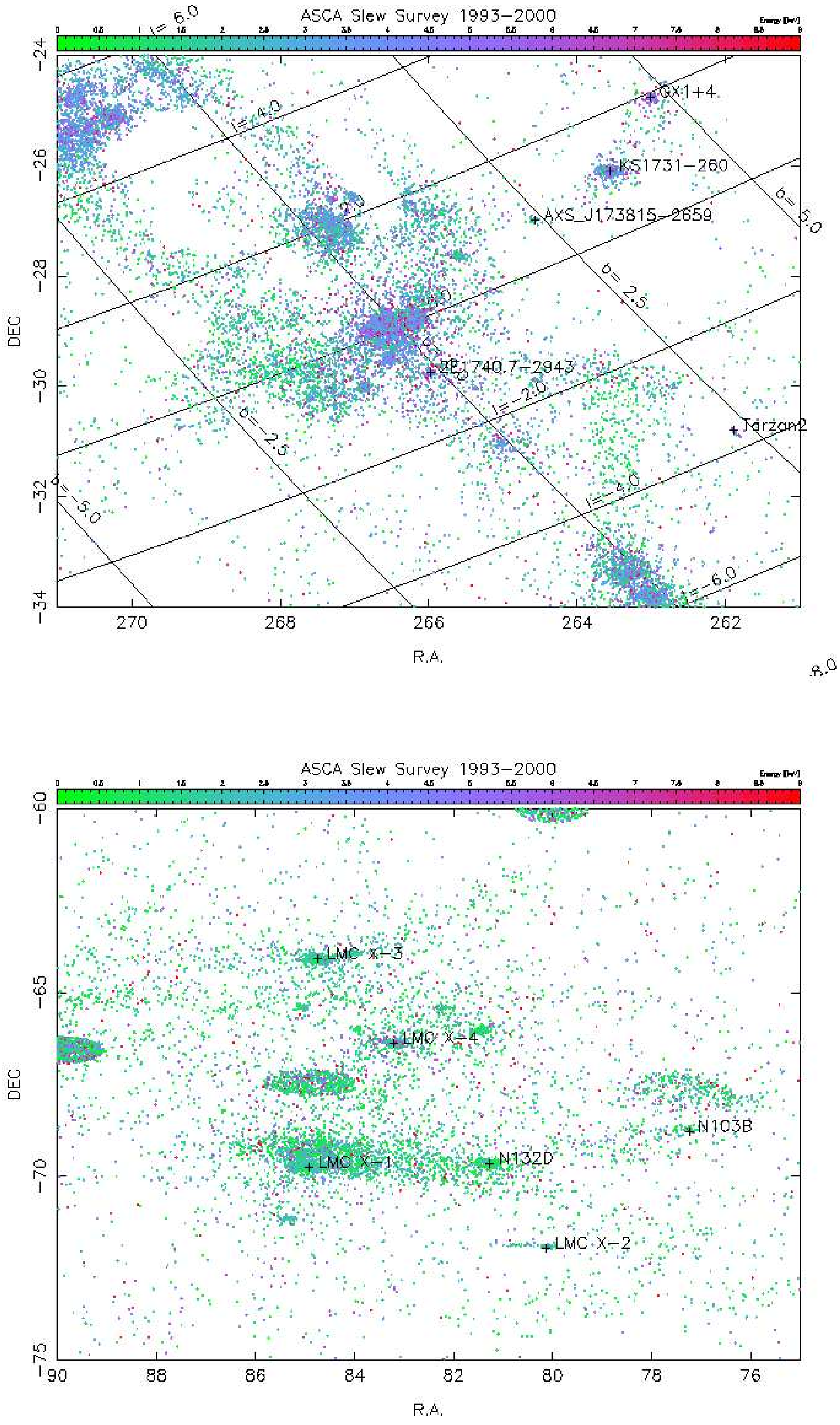

Fig. 3. Close-up of the slew data in the Galactic Center region (top) and LMC region (bottom). GIS2 and GIS3 are combined. Different color indicate the photon energies. Exposure is not corrected.

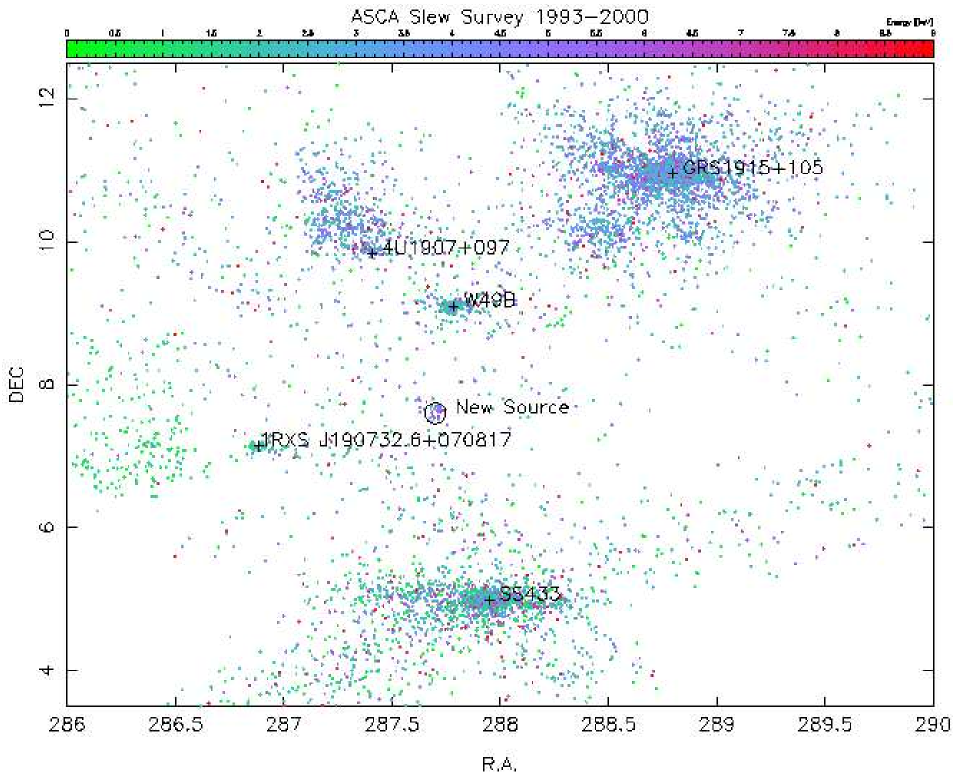

Fig. 3. Continued: Close-up of the slew data in the GRS1915-105 – SS433 region. A new hard source is discovered at (α, δ) =(287.6, 7.7) in the north of SS433.