

# Pulsars and Pulsar Wind Nebula Detected with IBIS

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# Galactic Plane Pulsar Survey

We have search for hard x-ray flux from rotation powered pulsars in the galactic plane using images constructed from ISGRI data.

- This search used core-program survey data and public data from pointing within 22 degrees of the galactic plane.
- The science windows were divided into 8 regions and and then subdivided into time intervals. A mosaic image was made for each subdivision (34 mosaic images in all).
- Fluxes in the 20-60 keV band were extracted from the mosaic images for a catalog of known sources. The fluxes for each source were then averaged.
- Candidate detections were then screen for source confusion, variability or other problems.
- Six sources, all associated with pulsar wind nebula were detected.

# Imaging

- The analysis used the OSA 4.1 software, with version 1 data.
- Galactic Center Deep Exposure and Galactic Plane Survey data up to revolution 229, and public data were analyzed.
- A step to screen out additional hot pixels was added to the standard analysis before science window level images were made. This was found to reduce systematic image structure at lower energies.
- The SPI Bright Source Catalog was used as the cleaning catalog.
- The science window level images used for mosaicing were screened based on the rms of the significance and the 90% width of the significance distribution in the 15-20 keV band.
- Groups of science windows with nearly identical pointing directions were removed before making the mosaic images.

# The Pulsar Catalog

The catalog of sources searched for in the mosaic images came from the following sources:

- Sources in the Australia National Telescope Facility Pulsar Catalog with spin-down flux  $\dot{E}/4\pi d^2 > 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$  which were within  $30^\circ$  of the galactic plane (128 sources).
- X-ray detected rotation powered pulsars from Kaspi, Mallory and Harding (2004).
- Nebula from Mallory Roberts' Pulsar Wind Nebula Catalog (<http://www.physics.mcgill.ca/~pulsar/pwncat.html>).

# Flux Extraction

- For each catalog source rates and errors, in four 10 keV wide bands between 20 and 60 keV, were obtained from the mosaic images they were in. The rates and errors were interpolated between pixels.
- Fluxes in these bands were found by scaling the rates using the Crab rate and flux. These fluxes were added to obtain a 20-60 keV flux for all sources in each image.
- Average 20-60 keV fluxes and their errors were then found for each source.

# Source Screening

Of the 154 catalog sources, 10 had average 20-60 keV fluxes more significant than  $10 \sigma$ , and 7 had significances in the 4-10  $\sigma$  range. The following checks were made for each of these sources:

- The fluxes were checked for variability between mosaic images.
- $1^\circ \times 1^\circ$  images centered on the source location were made using all the data, and checked for evidence of source confusion or other problems.
- Catalogs were searched for nearby known x-ray and gamma-ray sources.

Four of the  $> 10 \sigma$  and five of the 4-10  $\sigma$  sources were found to be confused with other sources.

# PWN and Pulsar Detections

*Significance > 10  $\sigma$*

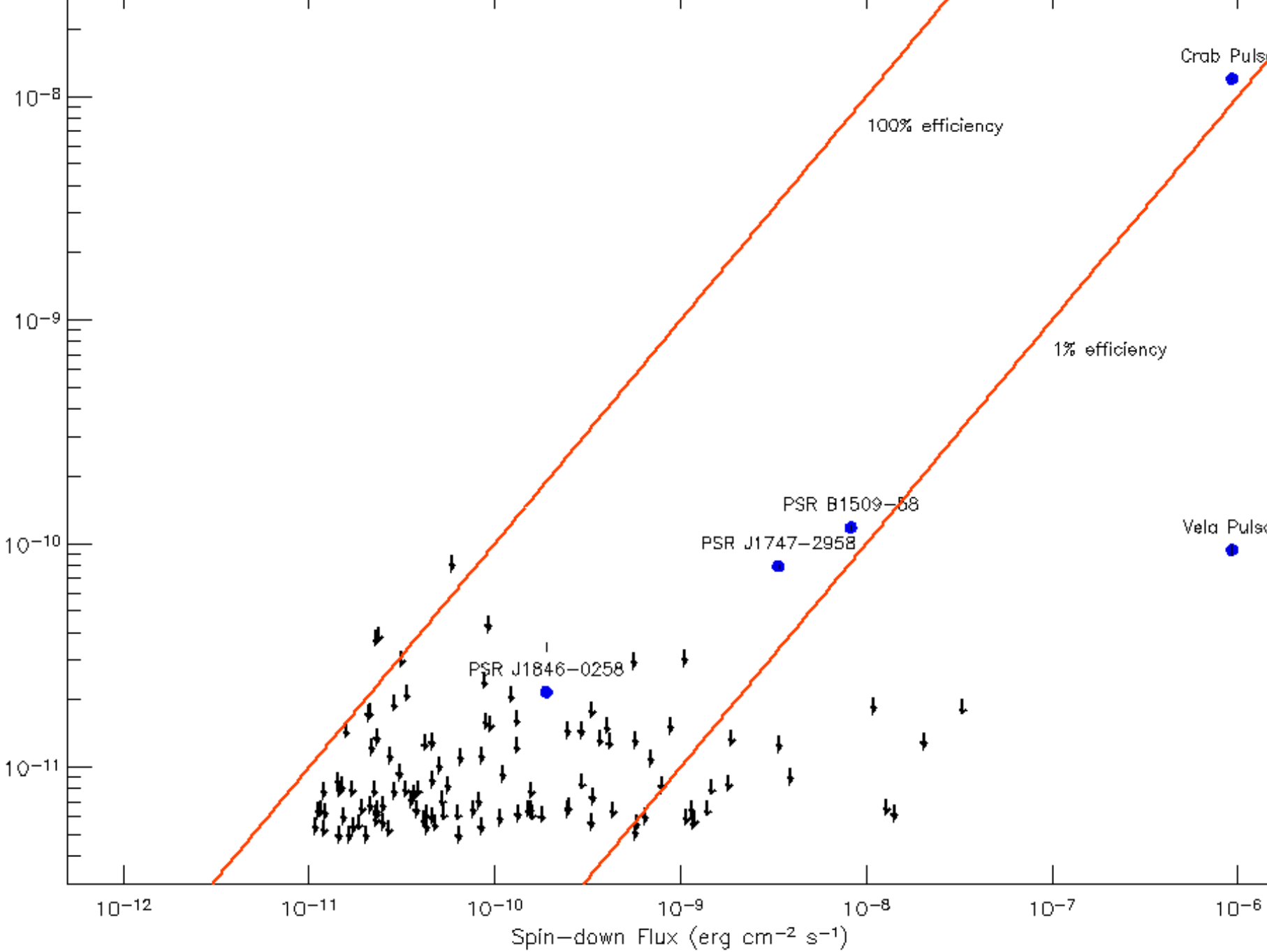
Nebula	Pulsar	Flux (20-60 keV)
Crab	Crab Pulsar	$1.2 \times 10^{-8}$
G320.4-1.2	PSR B1509-58	$1.2 \times 10^{-10}$
Vela X	Vela Pulsar	$9.3 \times 10^{-11}$
Mouse	PSR J1747-2958	$7.9 \times 10^{-11}$
G21.5-0.9	unknown	$3.4 \times 10^{-11}$
Kes 75	PSR J1846-0258	$2.2 \times 10^{-11}$

# Spectral Fits

Fits 20-140 keV of 7 channel rates from images.

PSR/Nebula	Power-law index	Flux (20-60 keV)
Crab	2.247	$1.063 \times 10^{-8}$
PSR 1509-58	1.876(4)	$1.02(2) \times 10^{-10}$
Vela	2.1(1)	$8.0(3) \times 10^{-11}$
PSR J1747-2958	2.81(5)	$7.2(1) \times 10^{-11}$
G21.5-0.9	2.00(1)	$3.0(1) \times 10^{-11}$
PSR J1846-0258	1.69(2)	$1.9(2) \times 10^{-11}$





# Future Plans

This is an ongoing project. In the future we plan to:

- Improve flux extraction and spectral analysis.
- Perform epoch-folding analysis of PSR J1747-2958.
- Add more data to the search, including that from high latitudes.