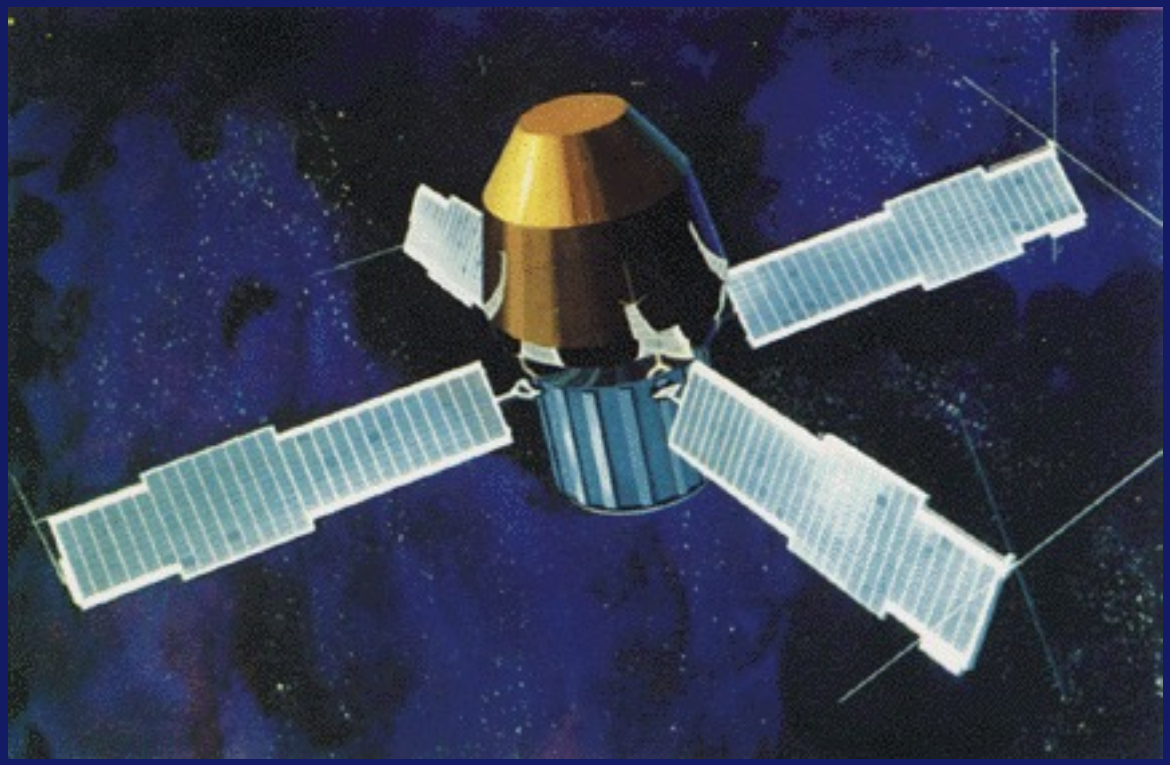


Nanni in the SAS-2 Era

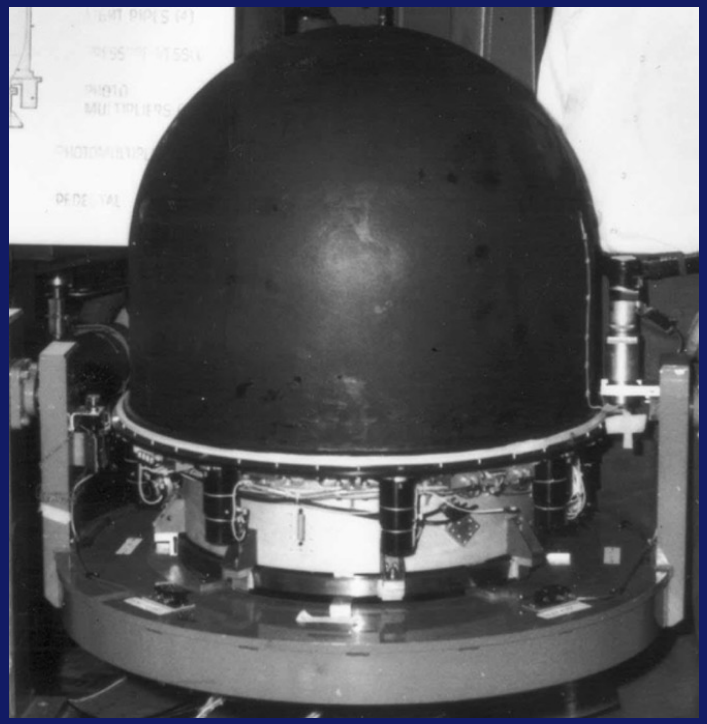
Dave Thompson
NASA Goddard Space Flight Center

Nanni's Day
23 September, 2022



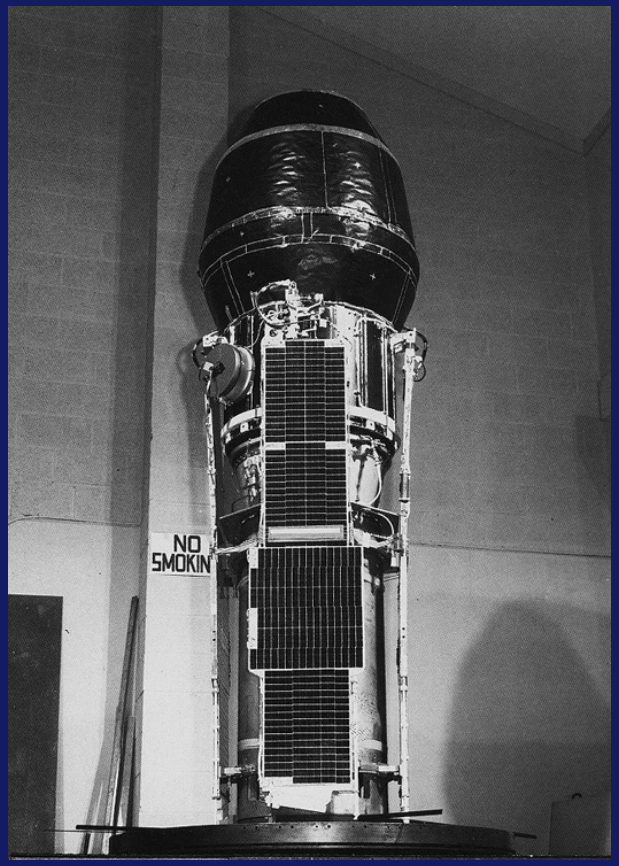


In 1973, Nanni arrived at NASA Goddard Space Flight Center as a post-doc. He spent two years working with the Gamma-ray Astrophysics Branch. We were located in Building 2, which is in the upper right corner of this aerial photo of the Goddard campus.



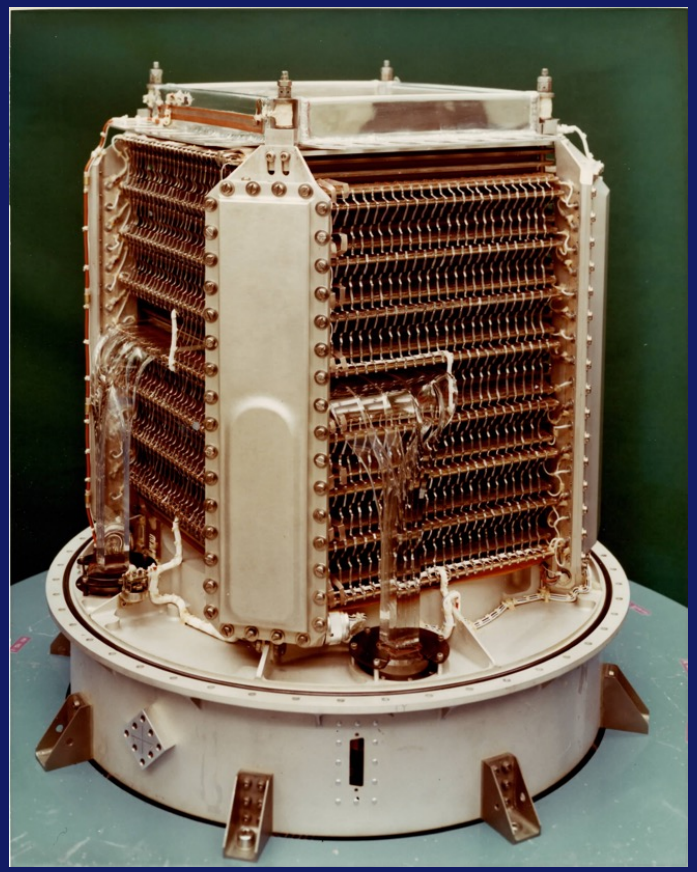
Our primary project was the Second Small Astronomy Satellite (SAS-2, called SAS-B before launch).

The single scientific instrument on SAS-2 was a high-energy gamma-ray telescope, designed to detect gamma rays that interacted by pair production.

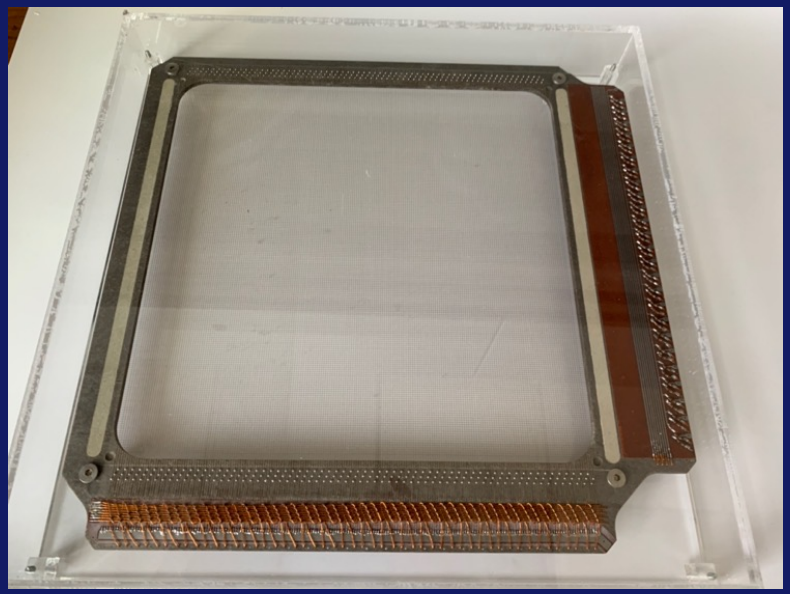




On November 15, 1972, SAS-2 was launched by a Scout rocket from the San Marco platform off the coast of Kenya. On June 8, 1973, an electronic failure ended the operational part of the mission. Much of the data from the mission had not been analyzed when Nanni arrived.

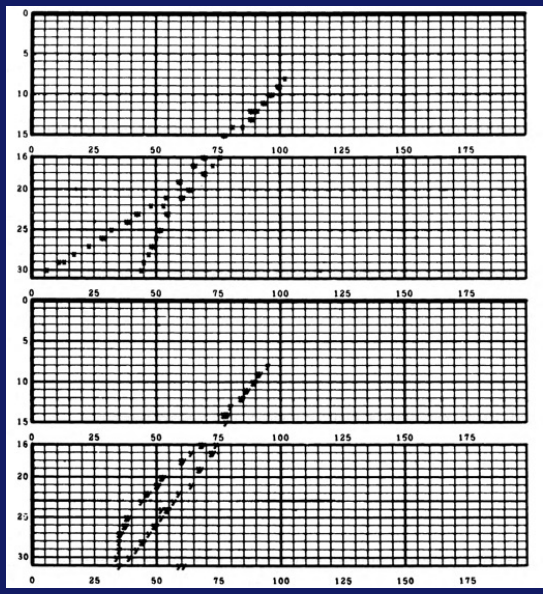


SAS-2 Assembly



Spark chamber module, 200 wires x and y, each threaded a magnetic core.

The SAS-2 data consisted of thousands of pictures of individual gamma-ray interactions like this one. For each one, we derived arrival direction, energy, and arrival time. Total number of non-atmospheric photons: 13,000



SAS-2 Science Team

HIGH-ENERGY GAMMA-RAY RESULTS FROM THE SECOND SMALL ASTRONOMY SATELLITE

C. E. FICHTEL, R. C. HARTMAN, D. A. KNIFFEN, D. J. THOMPSON, AND G. F. BIGNAMI*
NASA/Goddard Space Flight Center, Greenbelt, Maryland

AND

H. ÖGELMAN, M. E. ÖZEL, AND T. TÜMER
Middle East Technical University, Ankara, Turkey

* ESRO Postdoctoral Fellow on leave from LFCTR, Istituto di Fisica dell'Università di Milano, Italy.

Calibrating the SAS-2 Instrument

Although the satellite was in orbit, we had a backup copy of the instrument.

Nanni's arrival at Goddard gave us an opportunity to cross-calibrate the SAS-2 instrument with the COS-B instrument that was being readied for launch.

Nanni helped arrange time at the same gamma-ray beam used by COS-B, at DESY in Hamburg. A small group, including Nanni, spent 6 weeks in Hamburg doing this calibration.

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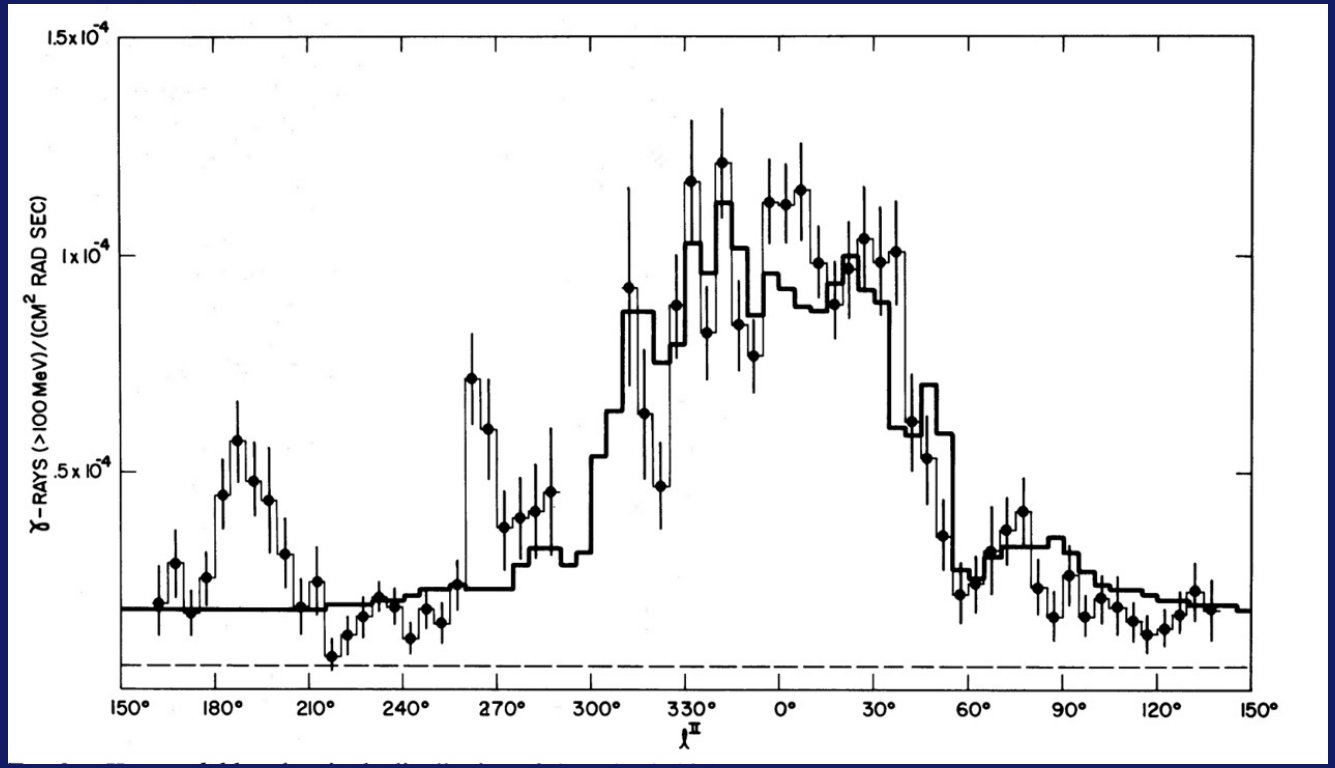
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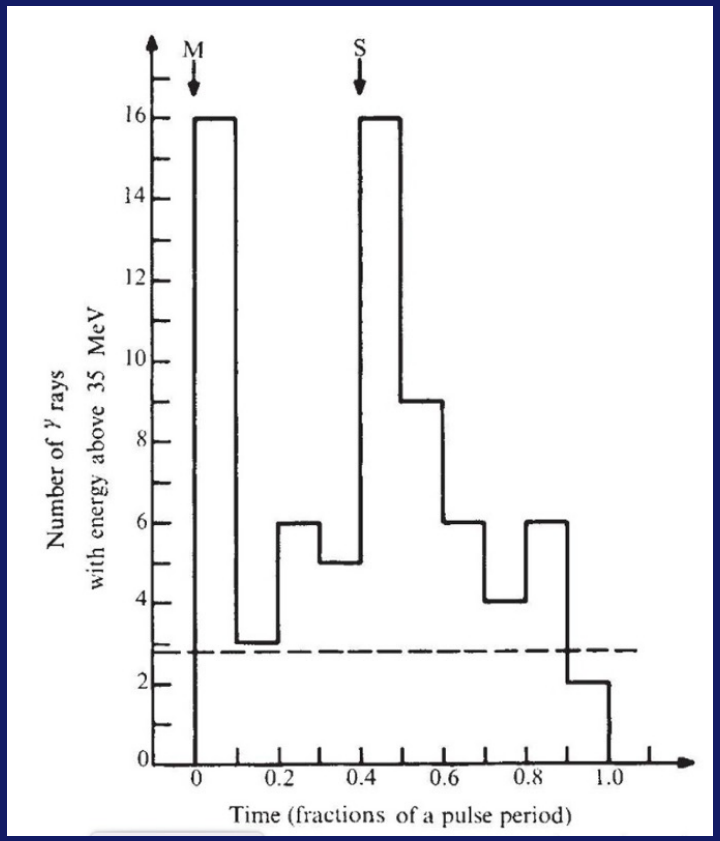
Nanni (on the left) helping load the SAS-2 instrument at DESY.

SAS-2 Science – the Galactic Plane

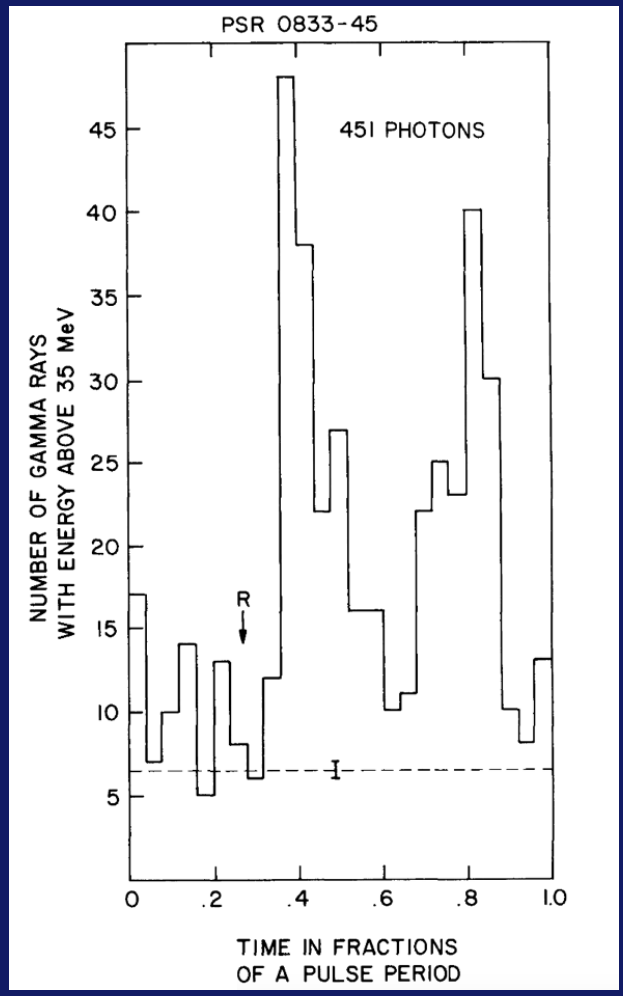


Bignami et al. 1975 – The heavy solid line is one of the first models of the Galactic gamma-ray emission.

SAS-2 Observations – Pulsars

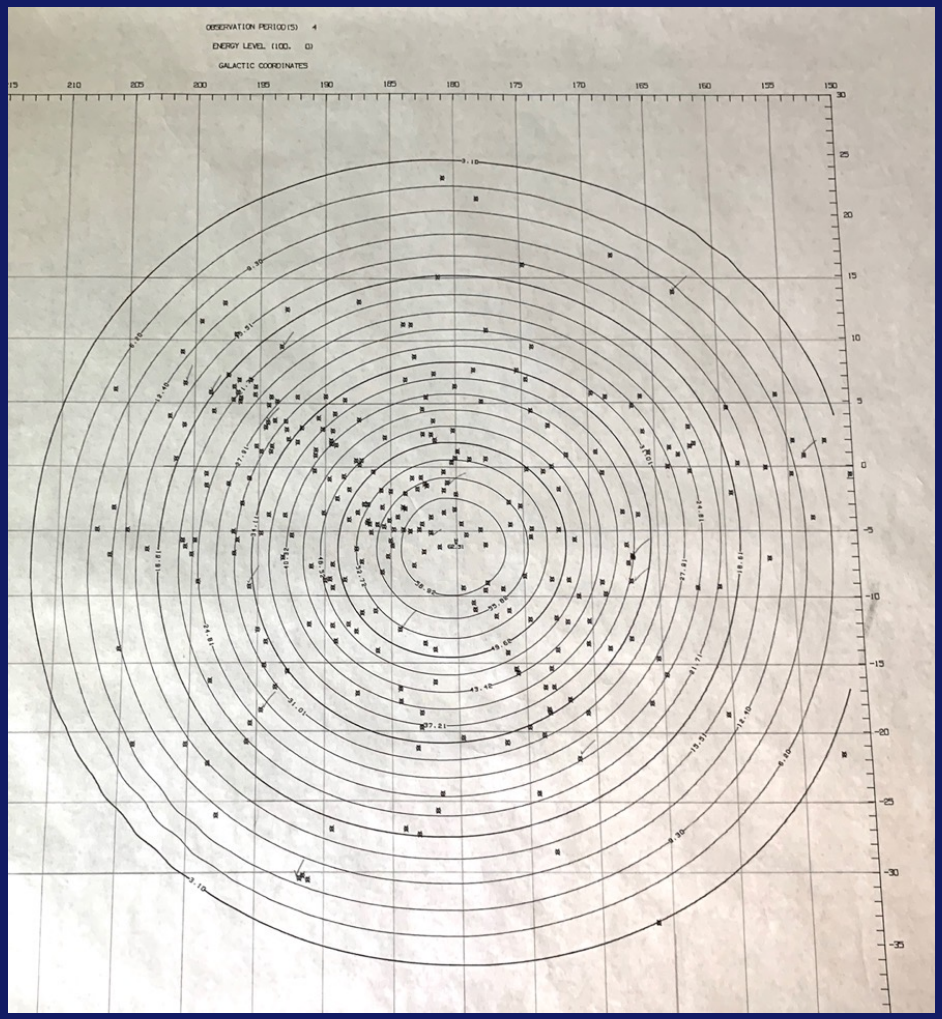


Crab, P = 33 ms. M and S are the radio main and secondary pulse arrival times. Kniffen et al. 1974



Vela, P = 89 ms. R is the arrival time of the single radio pulse. Thompson et al. 1975, 1977

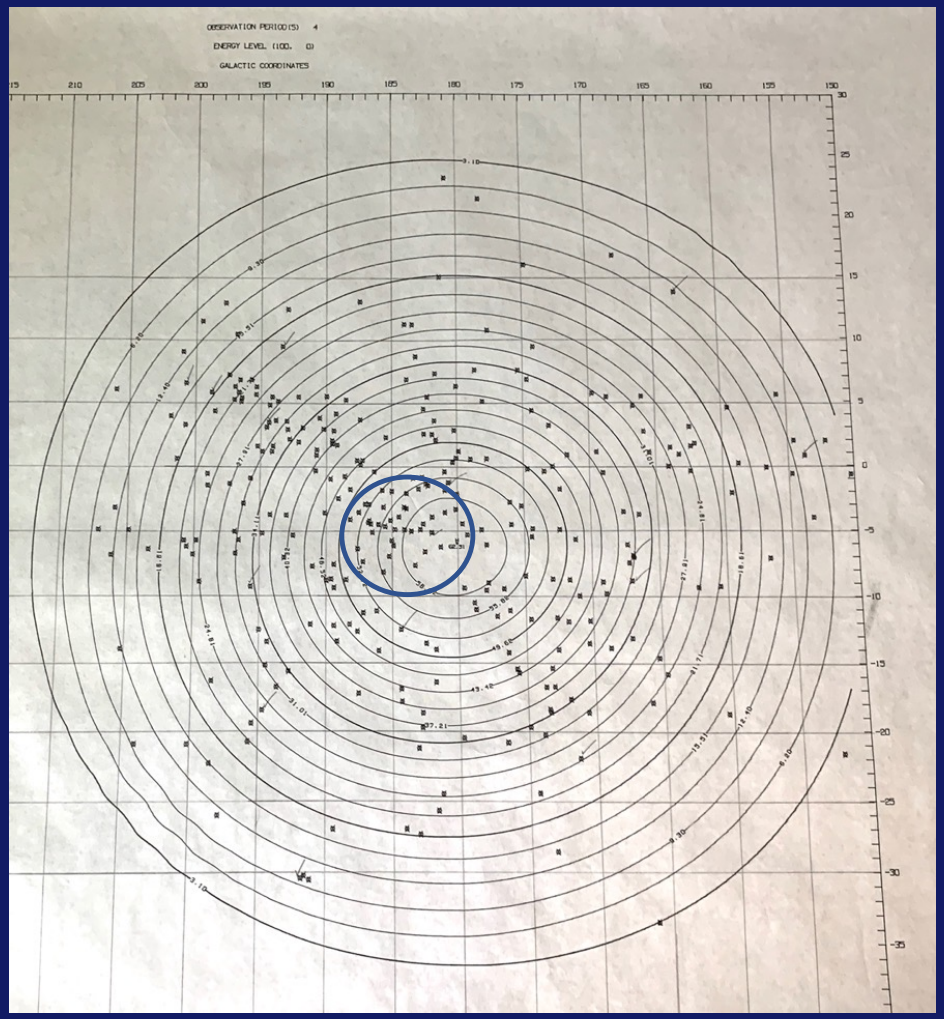
SAS-2 Observations – Unidentified Source



This was a one-week observation. The circles are levels of sensitivity. The spots are arrival directions of individual gamma rays (above 100 MeV).

The distribution of gamma rays is clearly not uniform, but localizing sources is not obvious.

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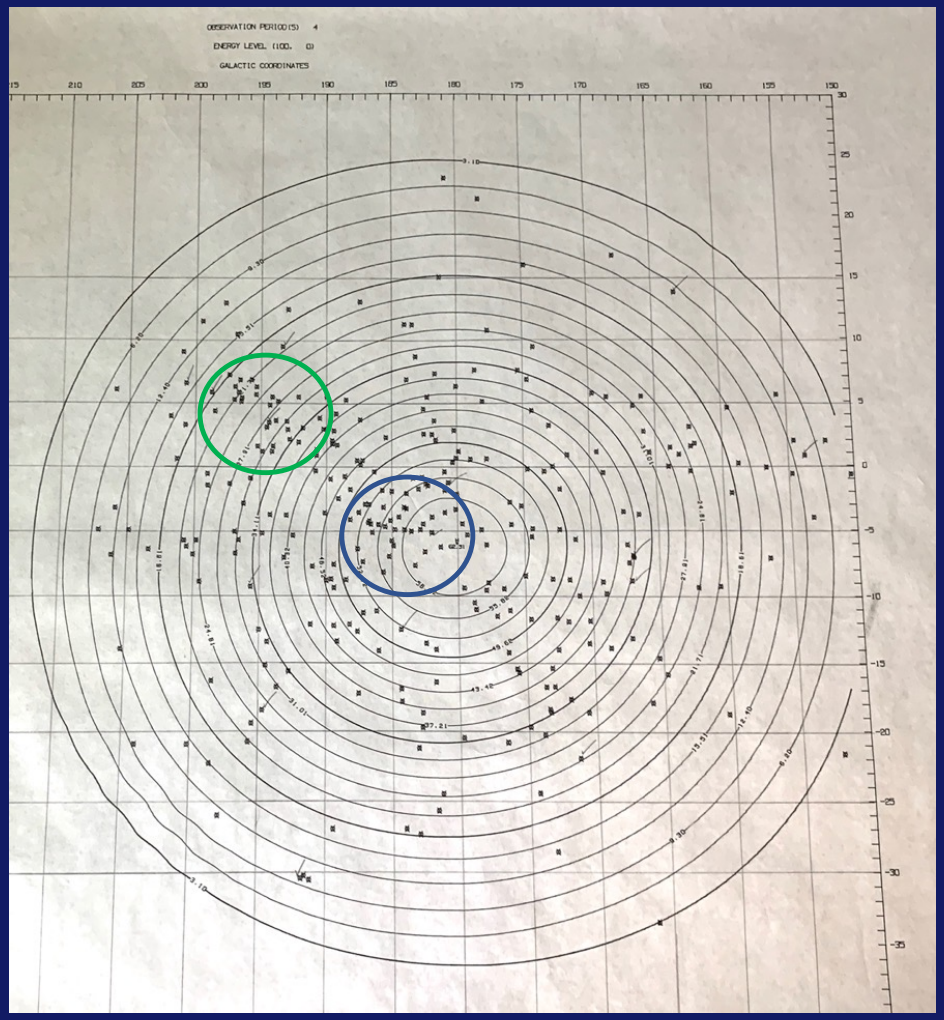


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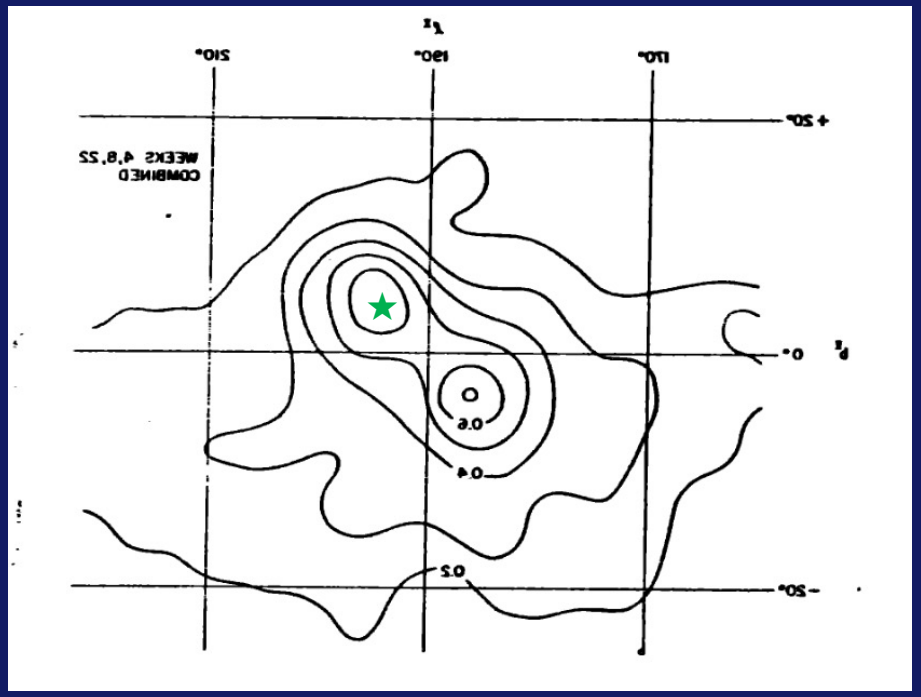
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The distribution of gamma rays is clearly not uniform, but localizing sources is not obvious.

The cluster in the blue circle is the Crab, identified by its pulsations.

The cluster in the green circle we called γ195+5 but is better known as Geminga thanks to Nanni and Patrizia.

SAS-2 Observations – Geminga



Kniffen, Bignami et al. (1975) – The 1975 ICRC meeting was the first publication showing Geminga – the green star is the true position.

The final SAS-2 analysis of Geminga (Thompson et al. 1977) concluded:

> In summary, we regard it highly probable that $\gamma 195+5$ is galactic. A promising possibility is that it is an undiscovered pulsar. If so, then a radio flux

SAS-2 Observations – Modeling the Isotropic Diffuse

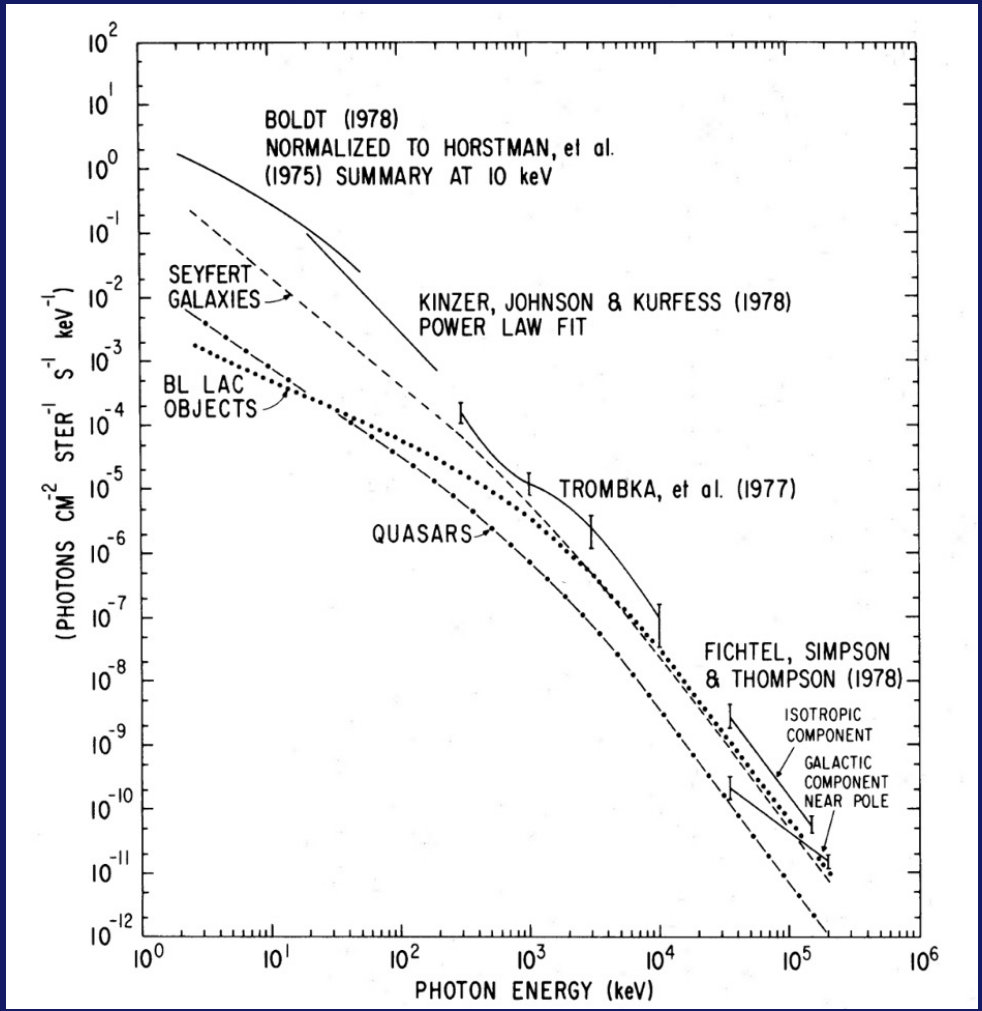
The total contribution of each species of galaxy can then be calculated including cosmological effects. Considering the redshift of the photons, neglecting absorption processes (which is justified in the energy range $E > 1$ MeV), and using the Friedmann world model, the diffuse background intensity is given by

$$j_d(E) = \sum_i \frac{cn_i}{4\pi H_0} \int_0^{z_{\max}} \frac{Q_i(E(1+z), z)}{(1+z)(1+2q_0 z)^{1/2}}\, dz$$

$$\text{photons cm}^{-1}\,\text{s}^{-1}\,\text{sr}^{-1}\,\text{kev}^{-1}, \quad (2)$$

where n_i is the present number density of the ith source class, Q_i is their emissivity, H_0 is the Hubble constant, $z_{\max}$ is the redshift appropriate to the onset time of galaxies, and q_0 is the usual deceleration parameter. For the general background leading to the derivation of the equation, see Stecker (1971),

Bignami et al. 1979



Summary

Nanni was a key part of the SAS-2 team. Although Geminga is the discovery best remembered, Nanni also made important contributions to modeling both the Galactic and isotropic gamma-ray diffuse emissions.

