RAL
DESIGN & DISCOVERY
Open Days July 1990
RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

X-ray Astronomy and the Ginga Satellite

RAL and Ginga

Launched on February 5^{th}, 1987, Ginga is the third Japanese X-ray astronomy satellite. It was launched from Kagoshima Space Centre, Japan, on a rocket designed and built in Japan. The main instrument on Ginga is the Large Area Counter (LAC), which was conceived and manufactured by a single scientific team, involving the Space Science Department at RAL, the X-ray Astronomy Group at Leicester, and groups from ISAS (one of Japan's two national Space centres), and the universities of Tokyo and Nagoya in Japan. Rutherford Appleton Laboratory had major responsibility for several of the detector sub-systems, and also for the vibration testing of the detectors. The LAC is the most sensitive medium energy instrument yet placed in orbit. This makes Ginga ideally suited to the study of Active Galactic Nuclei, time variability in galactic sources, and spectral surveys of various classes of faint X-ray sources from stars to galaxies. Most of the research work done at RAL with Ginga data is in collaboration with other university groups in the UK and also Japanese scientists. The UK groups include the universities of Leicester, Oxford, and Cambridge, along with scientists from the Armagh Observatory, Northern Ireland.

Some Examples of Ginga X-ray Observations

Ginga has made significant contributions to our understanding of many types of X-ray sources. Some of the highlights from the first three years are described below.

(1) Large Scale Extended X-ray Emission from the Virgo Cluster of Galaxies

It appears that most galaxies occur in distinct groups, or clusters. One of the closest of these is in the constellation Virgo. The Virgo cluster is 62 million light years away (a light year is 9.5 million million Km!), and 10 million lt. yr in diameter. Clusters, like galaxies, are gravitationally bound structures. Up to a 1000 galaxies may be found in a cluster. The space between them is not empty either, but is filled with a tenuous gas at a temperature of 100 million Kelvin, and this gas is observable with sensitive X-ray detectors. Previous X-ray observations of clusters revealed that the hot, diffuse gas exists in the centre of the cluster, where the largest galaxies are normally found (in the case of Virgo this galaxy is called M87), but *NOT* detected towards the edge of the cluster.

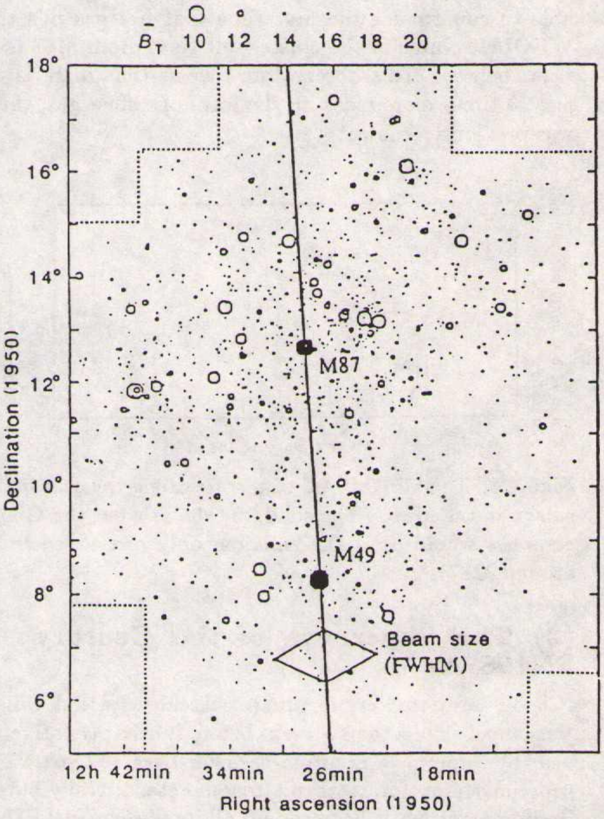

Figure 1: Ginga scan path across the Virgo cluster of galaxies superimposed on the optical map of the area (the size of the circles represents the apparent brightness of the various galaxies).

Astronomers from Nagoya and Tokyo universities used Ginga to observe the Virgo cluster in June, 1988. Optical observations (as shown in the map, figure 1) show that the Virgo cluster is $\sim 14°$ in diameter. (**NB:** 14° is about 28 times the angular diameter of the Moon; so here we have a gravitationally-bound structure in the universe that covers an area of sky nearly 800 times the size of the full Moon, and 4 million million times further away than

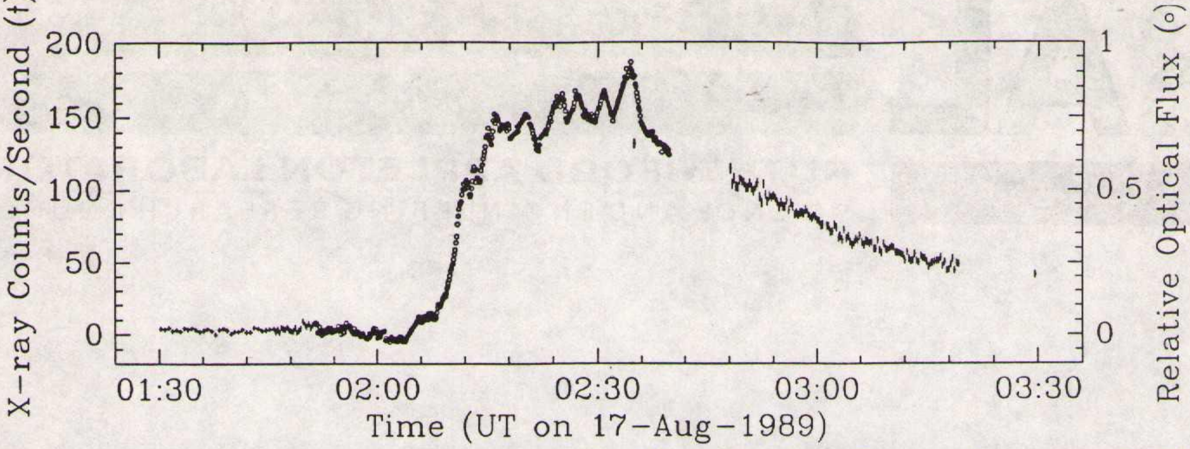

Figure 4: The simultaneous optical and X-ray data of the II Pegasi large flare. The optical data (taken in Greece, ended with the start of twilight, while the X-ray data ended when Ginga automatically started to move to the next target.

the Sun!). Ginga performed a scan across the centre of the cluster, passing through M87 (see figure 1), and was able to confirm for the first time that hot gas fills the WHOLE volume of the cluster out to 6° from M87 (see scan, below). This observation reveals that there is at least 3 times more mass, in the form of diffuse gas, than was previously known!

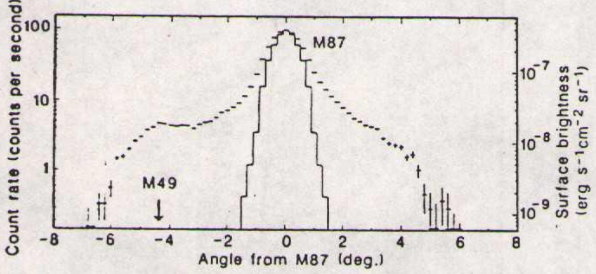

Figure 2: The Ginga LAC countrate along the scan-path shown in the Map. (The solid line shows what the Ginga response would be if the emission only originated from around M87).

(2) The Supernova of the Century — SN1987A

It is one of those very fortunate coincidences that Ginga was launched less than 3 weeks before the first (relatively) near-by Supernova eruption seen for over 300 years! A supernova eruption is when a massive star literally blows itself apart when it has used up all its nuclear fuel. This explosion releases in a few milliseconds the same amount of energy as a normal star (such as the Sun) emits in its entire life time ($\sim 10^{10}$ years!).

SN1987A lies in the Large Magellanic Cloud, and, unfortunately for Ginga, is close to several other X-ray sources. This means that all these sources are in the field-of-view of the LAC at the same time (Particularly a source called LMC X−1). However, by performing a similar observation to that described above for the Virgo cluster, namely a scan across the supernova, its unique positional signature can be revealed. The scan is shown in figure 2 for various energy bands, and it can clearly be seen that another source is present at higher energies (bottom panel). The angular offset from LMC X−1 agrees very well with the position of SN1987A determined from optical photographs.

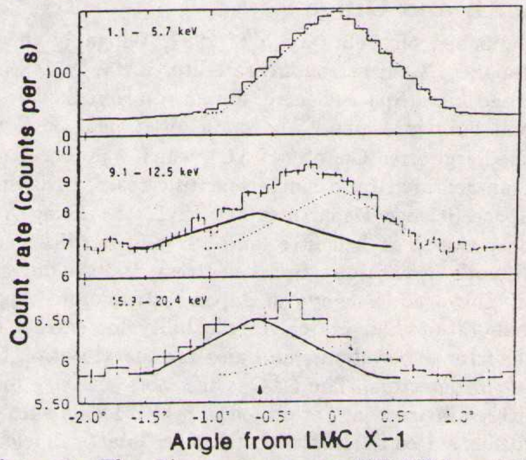

Figure 3: The Ginga scan across SN1987A and LMC X−1. The dotted line is the Ginga response to LMC X−1, and the solid line is the supernova. (Note that the supernova response is much stronger at higher energies).

(3) A Very Large Flare on the Star II Pegasi

II Pegasi is a member of a binary star system (two stars orbiting around each other), with the principle star being a red sub-giant, somewhat cooler than the Sun, but about three-times larger. The orbital period is approximately 6.7 days. Previous studies have shown that II Peg is an "active" star, with flares and star-spots having been observed, making it a likely member of the RS CVn class of binary stars. RS CVn-type stars are also seen to flare in the radio and X-ray regimes, but there have been very few reports of optical flares.

It was for this last reason that a large, multi-wavelength observing campaign of II Peg was set up for August, 1989. This campaign detected an enormous optical/X-ray flare, shown in the top panel. This event released $\sim 10^{35}$ ergs in both the X-ray and optical bands, so the total energy released in this flare in all energy bands was at least $\sim$ 2–3$\times 10^{35}$ ergs. This is a factor of at least 1000 more than is observed in large solar flares.

RAL Contact: Barry J. Kellett (Extn: 6361)