GEOTAIL Observations of SGR Giant Flares

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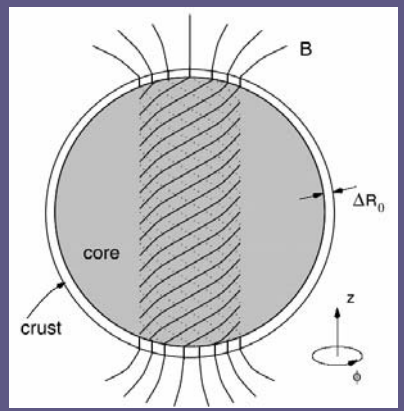
1. Abstract

We report the first 300 ms unsaturated peak profile of SGR 1900+14 giant flare on 27 Aug. 1998. It was obtained using a plasma particle detector onboard a magnetospheric satellite GEOTAIL. Physical quantities such as a total emitted energy are also shown. Its calibrations as a gamma-ray detector were performed by means of the Monte Carlo simulations and laboratory experiments.

The observed light curve was more complicated than that of SGR 1806-20 on 2004: it reached a sharp peak, decayed rapidly, and again increased to flat-top subpeak, then decayed exponentially. It naturally fills in gaps of the profile observed with Konus-Wind (Mazets et al., 1999). Assuming that the distance to the SGR 1900+14 is 10 kpc, the total emitted energy is $(5.5 \pm 1.6) \times 10^{44}$ erg, which is about a hundredth of energy emitted from SGR 1806-20 giant flare on 2004.

SGR Giant Flare model

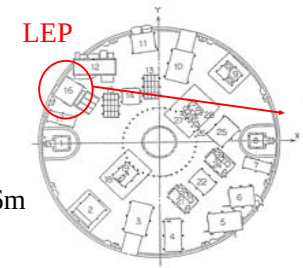


Global energy release due to entire crust-core magnetic instability (Thompson and Duncan, 2001)

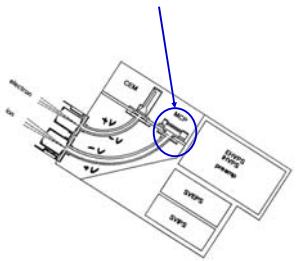
2. GEOTAIL spacecraft

GEOTAIL, which is a magnetospheric satellite, was launched on July 1992 and contributed to the understanding of such as shock acceleration and magnetic reconnection via in-situ observations of space plasma.

Microchannel plates (MCPs) are compact electron multipliers of high gain and used as a ion detector. They have **very low sensitivities for gamma-rays and their quantum efficiencies are reported as 1~2 %** (e.g. Fraser et al., 1984).



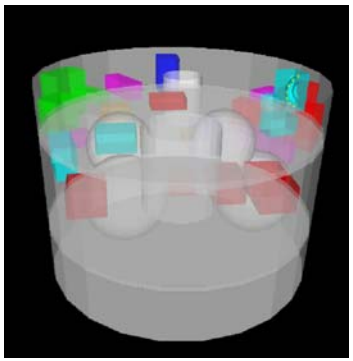
Inner Structure of GEOTAIL

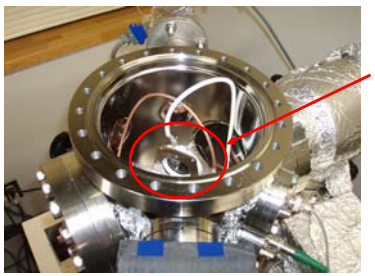


Low Energy Particle experiment (LEP) (Mukai et al. 1994)

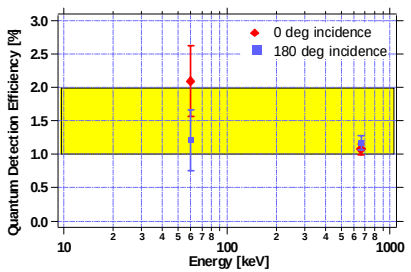
3. Monte Carlo Simulations and Laboratory Experiments

We construct a mass model of GEOTAIL (shown below left) and irradiate numerous gamma-rays, whose spectrum was obtained from Ulysses observation (Hurley et al. 1999). From this simulation, we confirm that **the contaminations of compton-, photo-electrons and characteristic X-rays are negligible.**





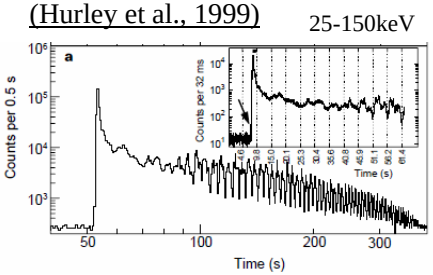
preliminary



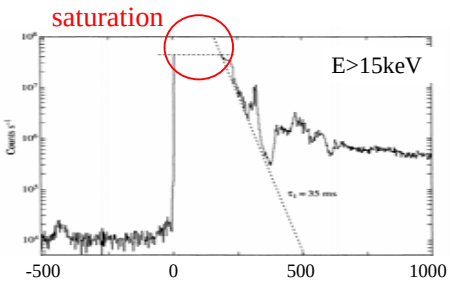
Left panel shows the measured quantum detection efficiency of the same MCP equipped with GEOTAIL, using Am241(60keV) and Cs137(662keV) from normal incidence and 180 deg incidence (preliminary results).

4. SGR 1900+14 Giant Flare on 27 August 1998

4-1. Ulysses observation (Hurley et al., 1999)



4-2. Konus-Wind observation (Mazets et al., 1999)

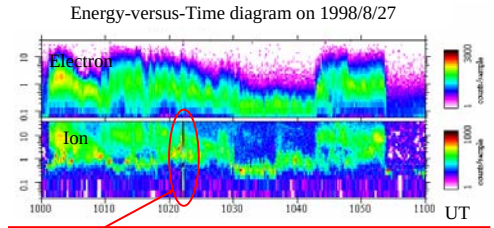


.The peak flux of SGR 1900+14 giant flare was so intense that professional gamma-ray detectors cannot observe the peak profile of SGR 1900+14 giant flare, because of the saturation effect and pulse pileup. And only the lower limits of physical quantities are obtained (shown below).

	Ulysses (E>25keV)	Konus-Wind (E>15keV)
Peak flux [erg/cm^2/sec]	$>3.4\times10^{-3}$	$>3.1\times10^{-2}$
Peak luminosity [erg/sec]	$>2.0\times10^{43}$	$>3.7\times10^{44}$
Fluence [erg/cm^2]	$>7.0\times10^{-3}$	$>5.5\times10^{-3}$

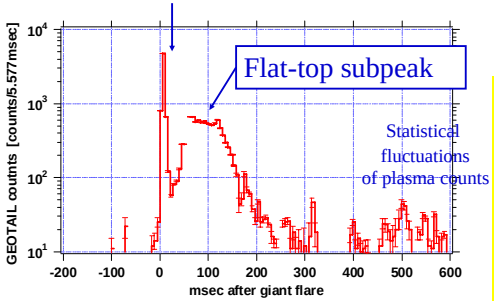
.However the sensitivity for gamma-rays of the plasma particle detector onboard GEOTAIL is **much less than those of professional gamma-ray detectors, we can determine the peak profile and total energy**!

4-3. GEOTAIL observation



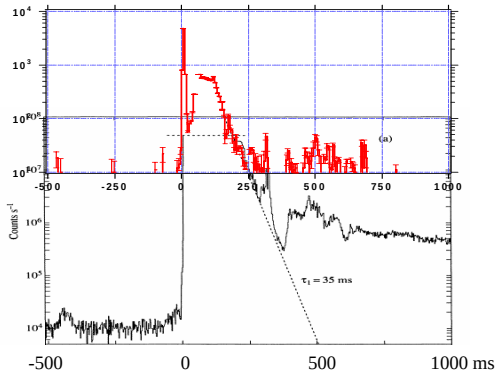
Rapid increase of backgroud counts
Due to gamma-rays from SGR 1900+14

Sharp peak and rapid decay



The first 600 ms light curve observed with GEOTAIL

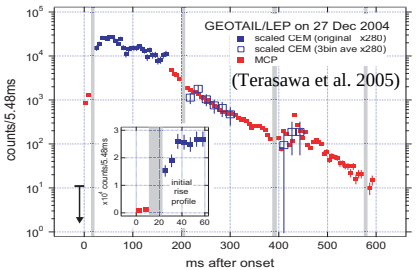
GEOTAIL determined the unsaturated peak profile !!

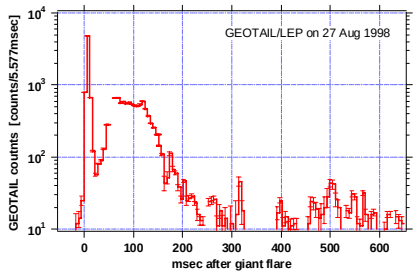


Preliminary Results based on the Monte Carlo simulations and laboratory experiments (assuming the distance is 10 kpc)

Peak flux 2.4 ± 0.7 [erg/s/cm^2]
Fluence $(4.6\pm1.3)\times10^{-2}$ [erg/cm^2]
Peak luminosity $(2.8\pm0.8)\times10^{46}$ [erg/s]
Total energy $(5.5\pm1.6)\times10^{44}$ [erg]

5. Comparison of the Initial Spike of SGR 1900+14 Giant Flare with SGR 1806-20 Giant Flare on 27 Dec. 2004





Left upper panel shows the peak profile of the initial spike of SGR 1806-20 giant flare in 2004 (Terasawa et al, 2005), while left lower panel shows that of SGR 1900+14 in 1998.

	SGR 1806-20*	SGR 1900+14**
Peak flux [erg/cm^2/sec]	19^{+9}_{-4}	2.4 ± 0.7
Peak luminosity [erg/sec]	$(5.1^{+2.3}_{-1.2})\times10^{47}$	$(2.8\pm0.8)\times10^{46}$
Fluence [erg/cm^2]	$2.0^{+0.9}_{-0.5}$	$(4.6\pm1.3)\times10^{-2}$
Total Energy [erg]	$(5.4^{+2.4}_{-1.3})\times10^{46}$	$(5.5\pm1.6)\times10^{44}$

*The spectrum is from Hurley et al. (2005) and **Hurley et al. (1999)

As shown in upper tables, **the total energy of SGR 1900+14 is about one hundredth of that of SGR 1806-20.** This is consistent with radio observations, which report that the isotropic spectral luminosity of the afterglow of SGR 1900+14 giant flare is approximately five hundred times smaller than that of SGR 1806-20 (Gaensler et al., 2005).

6. Summary

GEOTAIL observed two SGR giant flares and determined their peak profiles without the saturation effect. The time profile of SGR 1900+14 giant flare showed the complicated features compared to that of SGR 1806-20 giant flare, which showed clear energy injections. The physical meanings of these features are unknown. GEOTAIL observations also enabled us to obtain the total energy of SGR 1900+14 giant flare as 5.5×10^{44} erg, which is about one hundredth of that of SGR 1806-20 on 2004. This is consistent with the radio observations.