SOLAR COSMIC RAY PRODUCTION RATE ON GENESIS QUARTZ TARGET. K. Nishiizumi[1], R. C. Reedy[2], D. S. Burnett[3], K. Komura[4], and K. C. Welten[1], [1]Space Sciences Laboratory, Univ. of California, Berkeley, CA 94720-7450 USA (kuni@ssl.berkeley.edu), [2]Institute of Meteoritics, Univ. of New Mexico, Albuquerque, NM 87131-1126 USA (rreedy@unm.edu), [3]California Institute of Technology, Pasadena, CA 91125 USA, [4]Low Level Radioactivity Lab., Kanazawa Univ., Ishikawa, Japan.

Summary: Radionuclides made in a SiO_2 slab flown on Genesis have been measured. The $^{7}Be/^{10}Be$ ratio is that for galactic cosmic rays. Excess activities of ^{26}Al and ^{22}Na are consistent with production by independently-measured solar-proton fluxes.

Introduction: A total of 8,000 cm^2 of Mo-coated Pt foils was exposed to solar wind for 887 days by the Genesis mission. Solar wind (SW) ions were captured in the surface of the Mo. The Mo-Pt foils as well as all spacecraft materials were also exposed to solar cosmic rays (SCR) and galactic cosmic rays (GCR) for 1,125 days in space. The spacecraft was in space from August 8, 2001 to September 8, 2004, during later half of solar maximum, cycle 23, and was irradiated by large solar particle events. Although the exposure geometry was somewhat complicated, we compared cosmogenic radionuclides in an exposed SiO_2 plate to calculated production rates based on known cross sections and newly compiled solar proton fluences.

SiO_2 Target and Experimental Procedures: In order to correct for the contribution of cosmogenic radionuclides in the Mo-Pt solar wind collectors, we exposed a synthetic SiO_2 (Spectrosil quartz) disk (5.0x5.0x0.5 cm, density = 2.3 g/cm^3) at the side of the Mo-Pt foils deployed on the Sample Return Capsule (SRC) Lid blanket (Fig. 1). Although the disk was broken by the hard landing, we recovered all of the pieces since it was covered by a plastic sheet (0.010 g/cm^2 thickness) and glued on backside of the Mo-Pt foils (Fig. 2). Most of the broken pieces were reassembled to an original block shape. Cosmogenic ^{7}Be (half-life = 53 d) and ^{22}Na (2.60 yr) in the 23.6 g of SiO_2 block were non-destructively measured by a high-sensitivity Ge detector at the Low Level Radioactivity Laboratory, Kanazawa University. Long-lived ^{10}Be and ^{26}Al were extracted from the small broken pieces (2.49 g) and measured by accelerator mass spectrometry (AMS).

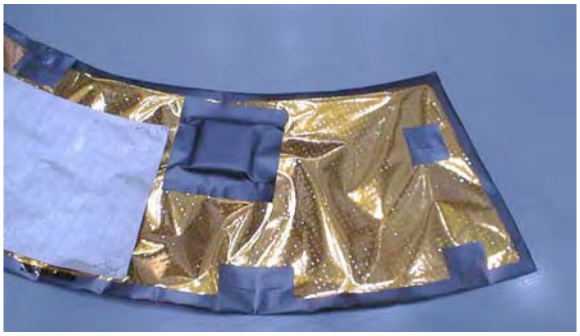

Fig. 1. 5x5 cm of SiO_2 target (covered by dark plastic sheet) and Mo-Pt SW collector foil were placed over thermal blanket.

Fig. 2. Broken recovered SiO_2 plate.

Cosmic Ray Exposure: The SiO_2 and Mo-Pt foils were placed inside of the backshell of the SRC. The SiO_2 target was exposed to SCR and GCR during entire flight period but experienced different shielding geometry when the backshell was closed or opened.

Backshell closed. When the backshell was closed, the front side of SiO_2 plate was facing the science canister, SRC heatshield and spacecraft. The shielding geometry was complicated but was a few g/cm^2. The backside of SiO_2 was shielded by multi-layer thermal blanket insulation (Kapton, Mylar, and Dacron mesh layer), SRC structural sandwich (mainly carbon fiber cloth), and ablator (silicone). The thicknesses of those materials were about 0.03 g/cm^2, 0.25 g/cm^2, and 0.22 g/cm^2, respectively (P. Doukas, pers. comm).

Backshell opened. The backshell was opened from August 17 to September 15, 2001, and from November 26, 2001 to April 2, 2004, for a total of 887 days. During these periods, the Mo-Pt foils were exposed to SW. The exposed period was different from that for SW collector arrays. The front side of the SiO_2 target was fully exposed to space through 10 mg/cm^2 of plastic cover sheet. The backside of SiO_2 was shielded by the backshell materials (see above) and partially shielded by spacecraft. The shielding depths for the SiO_2 target were thin, and the target was exposed to SCR during entire flight period.

Results and Discussion: The results are shown in Table 1. Concentrations of short-lived nuclides were corrected to the date of return, September 8, 2004. The last column indicates apparent saturation values based on total flight period of 1,125 days. The $^{10}Be/^{7}Be$ saturation ratio of 0.36±0.10 is in the same range as that found in meteorite falls. The high ^{26}Al activity clearly shows SCR production.

Effective SCR fluences and SCR production rates. Fig. 3 shows compilation of solar proton event fluences for solar cycle 23 [1]. Large solar particle events occurred during the Genesis flight period. We integrated solar proton fluences at proton energies of >10 MeV, >30 MeV, >50 MeV, >60 MeV, and >100 MeV, during periods when the SRC Lid was opened and closed. We obtained solar proton parameters [2], rigidity R_0 = 56 MV and fluence J(>10 MeV) = 3.21×10^{10} proton/cm^2-4π for the SRC Lid closed and R_0=66 MV, J(>10 MeV) = 2.06×10^{10} proton/cm^2-4π for the Lid opened. For the cases of ^{7}Be and ^{22}Na, the effective fluences were calculated using decay corrections for these short-lived nuclides.

We assumed SCR shielding depth of 0.55 g/cm^2 (SiO_2 equivalent) from backside of SiO_2 and infinite from front side (because of canister and spacecraft) for the Lid closed and 0.55 g/cm^2 from backside and 0.015 g/cm^2 from front side for the Lid opened.

The SCR production rates of 4 nuclides were calculated [2] and shown in Table 1 for the two different exposure periods and total. Calculated SCR produced ^{26}Al is in good agreement with observed activity. Rough estimation of GCR produced ^{26}Al was ~10% of observed value. However, SCR production rate of ^{22}Na is overestimated. We need better shielding correction for backside of SiO_2 target when the Lid was opened. Although ^{7}Be has already decayed, measuring depth profiles of ^{22}Na and ^{26}Al in the SiO_2 target may improve our understanding of SCR production.

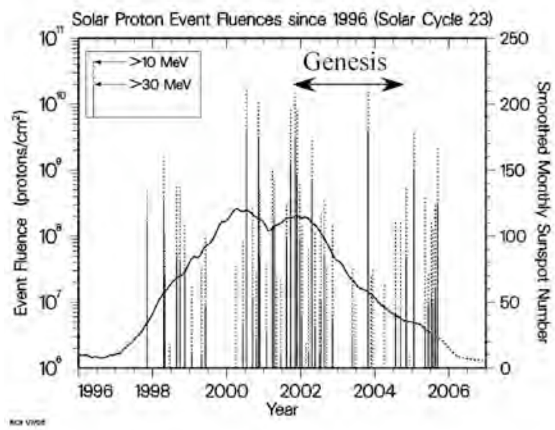

Fig. 3. Solar proton event-integrated fluences of solar cycle 23 [1] and Genesis flight period (bars) and smoothed sunspot number (curve).

Acknowledgement. We thank Peter Doukas and Benton Clark for providing information of spacecraft shielding condition. This work was supported by NASA's Genesis program through JSC and by NASA's Cosmochemistry program.

References: [1] Reedy R. C. (2006) *Lunar Planet. Sci. XXXVII*, submitted. [2] Reedy R. C. and Arnold J. R. (1972) *J. Geophys. Res.*, *77*, 537-555.

Table 1. Observed and calculated cosmogenic radionuclides in SiO_2 plate.

	Observed			Calculated SCR production		
	atom/g#	dpm/kg#	dpm/kg*	dpm/kg(close)	dpm/kg (open)	dpm/kg(total)
^{7}Be	$(8.6\pm2.1)\times10^{3}$	78±19	78±19	0.25	1.3	1.5
^{10}Be	$(4.5\pm0.7)\times10^{4}$	$(4.0\pm0.6)\times10^{-5}$	28±4	1.4×10^{-6}	4.3×10^{-6}	5.7×10^{-6}
^{22}Na	$(9.5\pm0.5)\times10^{4}$	48±2	86±4	11	56	67
^{26}Al	$(1.2\pm0.1)\times10^{6}$	$(2.2\pm0.3)\times10^{-3}$	735±85	5.1×10^{-4}	1.4×10^{-3}	1.9×10^{-3}

#: at September 8, 2004; *: at saturation