ISOTOPIC COMPOSITION OF SOLAR WIND NITROGEN IN A GENESIS BULK SOLAR WIND COLLECTOR. G. R. Huss[1], K. Nagashima[1], A. J. G. Jurewicz[2], D. S. Burnett[3], and C. T. Olinger[4], [1]HIGP, Univ. of Hawai'i at Mānoa, 1680 East-West Road, Honolulu, HI 96822 (ghuss@higp.hawaii.edu), [2]SESE, Arizona State Univ., Tempe, AZ 85287-1404, [3]Div. of Geological and Planetary Sciences, MC 100-23, Caltech, Pasadena, CA 91125, [4]Applied Modern Physics, Los Alamos National Laboratory (MS H803), Los Alamos, NM 98544.

Introduction: Determining the isotopic composition of solar wind nitrogen was a high priority of the Genesis Mission [1]. Initial results have been confusing. The Nancy group analyzed the "gold cross" from the target of the electrostatic concentrator using defocused UV laser extraction and static mass spectrometry. Extraction efficiency was high, but the electroplated gold was not intended to be a solar-wind collector, and a large background of terrestrial nitrogen gave low signal-to-noise. Their best estimate for $(^{15}N/^{14}N)_{SW}$ is $(2.26\pm0.67)\times10^{-3}$ ($\delta^{15}N$ = -385±182‰ relative to Earth's atmosphere) [2]. In contrast, the Minnesota group measured an array collector consisting of gold film deposited on sapphire (AuOS). Nitrogen was released for static mass spectrometry by mercury amalgamation. This technique discriminated against some background, but the yield of solar wind nitrogen was low. Their best estimate for $(^{15}N/^{14}N)_{SW}$ is $\sim4.9\times10^{-3}$ ($\delta^{15}N$ = +330‰) [3]. To resolve this disagreement, the UCLA group carried out MegaSIMS measurements of the silicon carbide target from the electrostatic concentrator. Their preliminary results gave $(^{15}N/^{14}N)_{SW}$ of $1.85\text{-}2.05\times10^{-3}$ ($\delta^{15}N \approx$ -440 – -495‰) [4], supporting the Nancy value but with larger errors.

Two out of three analytical results indicate that the solar wind is isotopically lighter than Earth's atmosphere. However, both of these measurements came from the concentrator, which is known to fractionate isotopes [2]. The isotopically heavy measurement was from a passive, bulk-solar-wind collector, leaving open the possibility of unrecognized mass fractionation of nitrogen isotopes. To investigate whether the result was influenced by the collection technique, we measured nitrogen isotopes and fluences in amorphous diamond-on-silicon (DOS) from the B/C bulk solar wind array using the UH Cameca ims 1280 ion microprobe.

Experimental: The amount of solar wind nitrogen in B/C array collectors is ~20× lower than in the concentrator targets, so instrumental background is a problem. We mounted sample 60628 of the B/C array along with a ^{15}N implant (H-^{18}O-^{15}N implanted into flight-spare DOS) and a silicon wafer in the same sample holder. To reduce instrumental background, we (1) pumped the sample in the airlock for several days, (2) used the Ti sublimation pump, and (3) sputtered the silicon wafer with a 20 nA beam for 14 hours to "getter" residual gases from the vacuum system. These procedures reduced the pressure in the sample chamber to $\sim6.3\times10^{-10}$. The LN_2 trap was used during measurements to further reduce sample-chamber pressure.

Nitrogen isotopes were measured as CN^- using a 0.75 nA Cs^+ primary-ion beam with 20 keV impact energy. The mass resolving power was ~7500. Measurements were made by depth profiling using a 50×50 μm raster. Ions were counted on the mono-collector electron multiplier. To minimize the contribution of gaseous nitrogen from the sample chamber, we used a field aperture in combination with the dynamic transfer system (DTOS). DTOS deflects ions produced by the primary beam in the rastered area so that they enter the mass spectrometer with the same trajectory. Because ions generated in the gas phase do not correlate with the position of the primary beam and are not focused by DTOS, they are cut effectively by the field aperture. To further reduce unwanted nitrogen signals, we used the electronic gate to exclude ions from the outer 50% of the sputtered area, eliminating contributions from the edge of the rastered crater. To remove nitrogen bound to the surface of the sample, we pre-sputtered the surface with a 7 keV primary ion beam. Low energy sputtering minimizes "knock-on", which implants surface nitrogen deeper into the sample, and was successfully applied during the oxygen-isotope measurement of the concentrator sample by MegaSIMS [5].

Still, the initial signal was overwhelmingly dominated by surface nitrogen, which declined exponentially until a depth of ~400 Å, below which a constant background signal of ~500 cps was present. This compares with an implant signal at the peak of the profile of ~550 cps. The nitrogen in the constant background is probably primarily from the collector material, which was not tailored for nitrogen measurements.

Nine separate profiles on 60628 were used in the data analysis. Data were corrected for detector dead time and for time-dependent variation in the ion signal. Profiles were converted to depth by measuring crater depths with an Alpha-step 200 profilometer at ASU.

The $^{15}N/^{14}N$ ratio of the solar wind was extracted from the data using two different methods. Method 1 ignores the data above 300 Å. A constant background based on nitrogen measured below the solar wind profile (>1000 Å) was then subtracted from the remaining profile. The corrected profile between 300 Å and 1000 Å was integrated to get the $^{15}N/^{14}N$ ratio. In Method 2, a model profile of solar wind ^{14}N implanted into DOS (created by C. Olinger using SRIM) was iteratively subtracted from the measured ^{14}N profile until the region below 300-400 Å was flat. The amount of the profile was estimated independently for each of the nine measurements, although inferred amounts were very similar. The ^{14}N signal remaining after subtracting the SRIM profile was assumed to be background. Using the average $^{15}N/^{14}N$ ratio measured in the first few cycles and below the solar wind implant, the background profile of ^{15}N was estimated. The ^{14}N and ^{15}N backgrounds were then subtracted from the total measurements and the resulting implant profiles were integrated to give $(^{15}N/^{14}N)_{SW}$.

Results and Discussion: Table 1 gives our results. The two methods for determining $(^{15}N/^{14}N)_{SW}$ give the same result; the solar wind is ~30% depleted in ^{15}N relative to the Earth's atmosphere, consistent with the results from the concentrator [2,4]. The Sun has essentially the same composition as Jupiter [6], a TiN grain thought to have condensed from the solar nebula [7], and the local interstellar medium [8]. All other solar system objects are enriched in ^{15}N, and their compositions must be understood in terms of fractionation of this original ^{15}N-depleted composition [e.g., 2].

Our determination of the nitrogen fluence (Table 1) is consistent with expectations based on fluence determinations for C, N, O, light noble gases, and Mg in Genesis collectors (Fig. 1). Our estimate also agrees well with the nitrogen fluence estimated for the same period of exposure to the solar wind from the data of the Solar Wind Ion Composition Spectrometer (SWICS) on the Advanced Composition Explorer (ACE) spacecraft [9]. The fluence estimates, which use the same calibrated SRIM profile as the isotopic determinations, support our inferred $(^{15}N/^{14}N)_{SW}$.

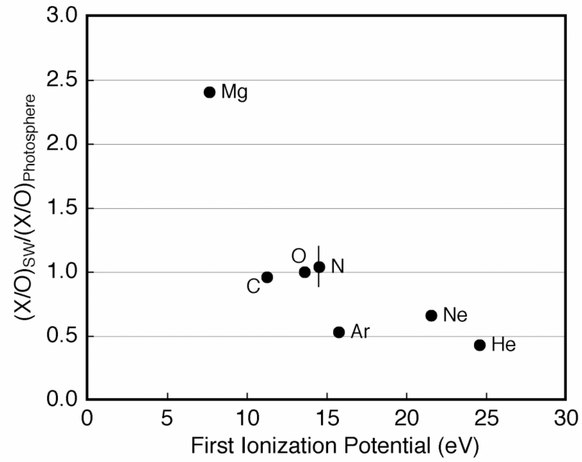

Fig. 1: Relative abundances of elements in the solar wind as determined from fluences in Genesis collectors [10-12]. Photospheric abundances from [13].

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Table 1: Estimated $^{15}N/^{14}N$, $\delta^{15}N$*, and nitrogen fluence for nine measurements of the Genesis B/C array

Measurement	Background subtraction		SRIM modeling		Nitrogen
Number	$^{15}N/^{14}N$	$\delta^{15}N$	$^{15}N/^{14}N$	$\delta^{15}N$	Fluence
1**	0.00270	-265	0.00204	-446	1.68×10^{12}
2**	0.00264	-283	0.00196	-466	1.61×10^{12}
3	0.00283	-229	0.00292	-205	1.52×10^{12}
4	0.00304	-173	0.00318	-135	1.52×10^{12}
5	0.00266	-275	0.00266	-277	1.51×10^{12}
6	0.00248	-325	0.00226	-386	1.59×10^{12}
7	0.00260	-294	0.00283	-232	1.59×10^{12}
9	0.00272	-259	0.00268	-270	1.59×10^{12}
11	0.00241	-345	0.00237	-354	1.59×10^{12}
Ave. ± 2σ Stdev	0.00268±0.00037	-272±101	0.00254±0.00083	-308±225	$(1.58\pm0.24)\times10^{12}$***

* Delta ^{15}N values calculated relative to a terrestrial $^{15}N/^{14}N$ value of 0.003676.

** First two measurements were made with 60 minutes of low-energy pre-sputtering compared to 15 minutes for the other measurements.

***Error for fluence is dominated by systematic uncertainties totaling ~15%.

Measurement 8 was not used because magnetic field position was lost during the run.

Measurement 10 was not used because liquid nitrogen trap warmed up during the run.