COMPARISON OF SOLAR WIND NOBLE GAS DATA FROM GENESIS WITH APOLLO/SWC – NEW RESULTS FROM IMPLANTATION EXPERIMENTS. A. Grimberg[1], F. Bühler[1], R. Wieler[2] and P. Bochsler[1], [1]Physikalisches Institut, University of Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland, grimberg@space.unibe.ch, [2]Isotope Geology, NW C84, ETH, CH-8092 Zürich, Switzerland.

Introduction: Noble gases are important elements to trace primary mechanisms controlling elemental and isotopic fractionation between the solar wind (SW) and its source reservoirs, e.g. Coulomb drag or the first ionization potential (FIP) effect [1]. The most precise light noble gas SW composition data are available from two trapping experiments in space, the Genesis mission [2] and the Solar Wind Composition (SWC) experiments on the Apollo missions [3].

Recent noble gas analyses from Genesis bulk SW samples [4] reveal some significant differences to data obtained from the SWC experiments, but also to data measured in a special Genesis target originally designated to study contributions of solar energetic particles [5]. The SW ^{3}He/^{4}He ratio of $(4.53\pm0.03)\times10^{-4}$ given by [4] is significantly higher than the average SW ratio of $(4.26\pm0.21)\times10^{-4}$ of all SWC experiments [3]. Also the ^{4}He/^{20}Ne ratio of 656±5 reported by [4] is significantly higher than the SWC average of 570±70.

In order to exclude systematic errors due to poorly known correction factors for backscatter losses of the different target materials exposed on Genesis and SWC, we performed noble gas irradiation experiments using the CASYMS (Calibration System for Mass Spectrometers) facility at the University of Bern [6]. These irradiations are a continuation of former experiments performed for the SWC Al-foils [3,7], the Genesis bulk metallic glass target [5] and Au, Ag, and Ni targets [8]. A further experiment for a Genesis Au target will be presented by Heber et al. at this conference.

Experimental: *Target materials.* Four different materials have been selected for this study which were designated for noble gas analyses on the Genesis mission: aluminum on sapphire (*AloS*), diamond-like carbon on silicon (*DOS*), silicon (*Si*), and bulk metallic glass (*BMG*) consisting of $Zr_{58.5}Cu_{15.6}Ni_{12.8}Al_{10.3}Nb_{2.8}$. We compare these materials with aluminum (*Al*), a target material that has also been used for the SWC experiments. The first four target materials stem from the same production lot as the specimens flown on the Genesis mission. For the Al target we used a commercial 15µm thick foil of 99% purity. For a detailed description of the first four materials see [9].

Irradiation. The targets have been irradiated with He and Ne isotopes in the sequence ^{20}Ne, ^{22}Ne, ^{4}He, and ^{3}He. All ions were accelerated to an energy of 0.75 keV/amu, which corresponds to a typical average SW speed of ~380 km/s. We used 11 *Al*, 5 *AloS*, 5 *DOS*, 4 *Si*, and 4 *BMG* targets to allow for a representative number of samples. All targets were placed on one sample mount, distributed over four columns, with their surfaces in a vertical plane normal to the ion beam axis. Each target was hold by an aluminum frame that also guaranteed an accurately known irradiation area of 6×6mm^2 or 6×4mm^2, respectively. To eliminate the influence of beam inhomogeneities, the sample mount was moved continuously up and down in vertical direction (parallel to the four sample columns) during irradiation, crossing the entire beam in ~72s. A minimum irradiation duration of 5h36min for ^{3}He, and maximum duration of 42h06min for ^{4}He, was chosen to obtain an ion fluence estimated to be a factor of ~100 above the material background.

Noble gas analysis. The implanted ions were released by heating targets at ~1650°C for 21min and were subsequently measured with a noble gas mass spectrometer at ETH Zürich. All results are corrected for interferences of $^{40}Ar^{++}$ and $^{44}CO_2^{++}$ and also for a material blank, using unirradiated target material. Material blank corrections are significant only for ^{4}He in the *DOS* target (<30%) and Ne in the *BMG* (<14%).

Results and Discussion: Up to the date of abstract submission we have analyzed He and Ne isotopes in 5 *Al*, 3 *AloS*, 3 *DOS*, 2 Si, and 2 *BMG* samples. To account for possible beam inhomogeneities in the horizontal direction and to be able to compare samples from different columns, we normalized surface concentrations of each target in one column to averaged results from all *Al* targets in the same column. The surface concentrations in *Al*-targets from a single column

Tab. 1: Trapping probabilities for the different target materials, derived from a normalization to five *Al* targets. All errors represent the 1σ-variation of the respective samples measured for each target material. The trapping probabilities for *Al* are from [3,7]. To eliminate possible systematic uncertainties of the absolute fluences of CASYMS they have been used together with our newly determined Al-values to normalize all other trapping efficiencies given in this table.

	n	^{3}He	^{4}He	^{20}Ne	^{22}Ne
Al	5	≡ 0.87	≡ 0.89	≡ 1.00	≡ 1.00
AloS	3	0.91±0.03	0.92±0.03	1.02±0.01	1.02±0.02
DOS	3	1.02±0.02	1.26±0.37	1.05±0.03	1.04±0.03
Si	2	0.38±0.01	0.48±0.06	1.02±0.01	1.02±0.01
BMG	2	0.77±0.04	0.76±0.04	0.92±0.01	0.92±0.01

are reproducible within 1.36% for ^{3}He, 2.34% for ^{4}He, 0.19% for ^{20}Ne, and 0.84% for ^{22}Ne (1σ). This proves successful homogenization of the ion distribution in the vertical direction. In the following we give values for trapping probabilities, instead of surface concentrations, for He and Ne isotopes in the various target materials, by adopting probabilities of *Al* given by [3,7] for normalization (Tab. 1).

The trapping probabilities of *AloS* are slightly higher, but within uncertainty the same as those of the *Al* targets. However, the reproducibility of three *AloS* analyses is not as good as that of the *Al* measurements, which might be due to some scratches on the *AloS* surface.

The Ne trapping probability of *DOS* is somewhat higher than that of *Al*, but the respective values also agree within uncertainties. Irradiation simulations for Ne isotopes onto pure *C* and *Al* targets, respectively, using the SRIM code [10] predict trapping probabilities of *Al* that are lower by 1 % relative to *DOS*. This is because of the higher atomic weight of *Al* relative to the diamond-like carbon trapping substrate. Also the *DOS* value for ^{3}He of 1.02 is in reasonable agreement with the SRIM prediction of 0.99. However, the high trapping probability of 1.26 for ^{4}He is not predicted by SRIM and seems unreasonable. It is presumably the result of an uncertain material blank correction, which is reflected in the large standard deviation of 30% (three unirradiated DOS samples yielded ^{4}He material blank corrections between 1% to 30%). Nevertheless, even the highest ^{4}He amount measured in these blank targets is too small to possibly account for the differences between the SWC and the Genesis data, because the exposed Genesis targets contain orders of magnitude more ^{4}He than the CASYMS targets [3,4,5]. Additionally, if the trapping probability for ^{4}He predicted by SRIM is adopted (which would be justifiable in view of the good agreement between experimental and modeled value for ^{3}He), a wrong correction for trapping probabilities could also not explain the difference between Genesis and SWC.

The *Si* targets show a trapping probability for Ne that is within uncertainty in good agreement with *Al* and also with SRIM predictions (0.99 for all Ne isotopes). However, as supposed by [11], *Si* seems to lose large amounts of He, possibly due to diffusion. This likely explains the low nominal trapping probability of *Si* for He isotopes of 0.38 and 0.48, respectively, which are much lower than the values of 0.88 and 0.90 predicted by SRIM.

The observed trapping probabilities for *BMG* are lower than those for *Al*, as expected for a target consisting of relatively heavy elements. Within uncertainties they are in good agreement with predictions from SRIM. However, former implantation experiments by [5] revealed higher trapping probabilities for ^{3}He and ^{4}He (0.81 and 0.85). Whether this is due to the different *BMG* specimen used, a flight-like *BMG* in [5] and the flight specimen in this study, is unclear. However, even with the trapping probabilities of *BMG* determined in this study, the corrected ^{3}He/^{4}He and ^{4}He/^{20}Ne ratios reported in [5] would not be as high as those reported in [4].

Conclusion: All targets studied show trapping probabilities for Ne isotopes that are in good agreement with simulations calculated with the SRIM code. Beside *BMG*, all light element targets show quantitative trapping, similar to the proposed trapping probabilities of *Al*. Yet, the He data are less precise. Final correction factors should be available after measurement of the 3rd and 4th set of target materials.

With these experiments we expect to be able to rule out that a wrong correction for trapping probabilities is the reason for the differences between Genesis data reported by [4] and SWC data [3] as well as Genesis data given by [5].

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