A CONSORTIUM INVESTIGATION OF POSSIBLE COMETARY IDPS. K. Kehm[1], G. J. Flynn[2], C. M. Hohenberg[1], R. L. Palma[3], R. Pepin[4], D. J. Schlutter[4], S. R. Sutton[5], R. M. Walker[1] [1]McDonnell Center for Space Sciences, Washington University, St. Louis, MO 63130 charlie@radon.wustl.edu, [2]Dept. of Physics, State University of New York–Plattsburgh, Plattsburgh, NY 12901, [3]Dept. of Physics, Sam Houston State University, Huntsville, TX 77341, [4]School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455, [5]Dept. of Geophysical Sciences, University of Chicago, Chicago, IL 60637.

Background: Messenger and Walker [1] recently advanced the hypothesis that most cluster IDPs collected during June and July of 1991 (JJ-91) on JSC companion collection flags L2009 and L2011 were derived from comet Schwassman-Wachmann-3 (SW-3). A key element in their analysis was the fact that previous measurements by Nier and Schlutter had shown that these particles have unusually low concentrations of solar wind-implanted ^{4}He [2]. Specifically, none of the twelve fragments they measured, each from a different JJ-91 cluster particle, had ^{4}He contents greater than 3.2×10^{-11} ccSTP [2]. In contrast, only ~50% of *similarly sized* cluster fragments from other collectors were as low in ^{4}He [2,3,4]. The JJ-91 particles also had high measured ^{3}He/^{4}He ratios [2], as well as exhibiting anomalously high D/H values [1]. On the basis of He release temperatures [2] and volatile element contents measured in the JJ-91 cluster fragments [5], Messenger and Walker argued that this He-poor nature suggests a limited space exposure time, perhaps due to recent ejection from a parent body. In fact, the collection time, inferred settling rate, and probable atmospheric entry velocities of the JJ-91 cluster particles are all consistent with an origin from comet SW-3.

Consortium Study: Because of the obvious importance of identifying material from a specific comet, we have formed a consortium to attempt to reproduce the original data and provide as many additional analyses as possible on the JJ-91 and related particles.

Phase I of this work, for which we report preliminary results here, involves re-examining, in detail, IDPs from the JJ-91 time period in an attempt to confirm their unusual nature. Since the SW-3 hypothesis implies that the Earth passes through the same dust stream at the same time each year, cosmic dust collected in June/July 1994 (JJ-94) from stratospheric collector L2036 is also included in our study. We note that the amount of SW-3 dust accreted by the earth annually is expected to vary, as is the case for cometary meteor showers. Thus, a lack of similarity between the JJ-94 and JJ-91 cluster particles would not necessarily falsify the SW-3 hypothesis.

Phase II, to be completed later, involves the study of cosmic dust on collectors flown at other times to provide a necessary control for the JJ-91/94 material as well as perhaps identify additional time dependent anomalies in the properties of IDPs.

A variety of techniques, including non-destructive trace element analyses using synchrotron X-ray fluorescence (SXRF), noble gas studies, FTIR analyses, SEM observations, and ion probe isotopic analyses are being used to characterize multiple fragments from each studied cluster IDP. Noble gas measurements on companion fragments are being carried out at both the Univ. of Minnesota and Washington Univ. noble gas labs. Partitioning material between these two laboratories will provide independent tests of the JJ-91 He anomalies and may reveal possible correlated anomalies in Ne and Ar. This consortium approach is of course limited by the fact that cluster particles can be inherently inhomogeneous, with significant compositional variations between different fragments [6]. Large cluster particles are expected to settle more rapidly than smaller individual IDPs and thus are more apt to reflect time variations in the compositions of incoming cosmic material. Indeed, this effect has been invoked to explain the previously observed apparent differences between individual and cluster IDPs [7]. To check this point further, we are also performing measurements on a number of individual IDPs from the JJ-91 time period as well as from other collectors.

Initial Results: Herein we report data from noble gas analyses at the Univ. of Minnesota, the first results of our collaborative analyses. Assisted by Jack Warren at JSC, all samples were hand-selected by members of our team, and sent to Brookhaven for trace element analyses at the National Synchrotron Light Source using the X-ray microprobe [8]. The non-destructive nature of SXRF measurements makes combined trace element and noble gas analyses possible on the same cluster fragments [9]. Following trace element analyses, the samples were mounted in individual Pt boats for noble gas analyses at the Univ. of Minnesota.

The Figure shows the results of the new Univ. of Minnesota He analyses along with the earlier data from Nier and Schlutter. The ^{3}He/^{4}He ratios are plotted versus ^{4}He content. Previous noble gas analyses of IDPs have demonstrated the ubiquity of solar wind- (SW) and solar energetic particle- (SEP) implanted species [e.g. 9], and thus ^{3}He/^{4}He ratios for these reservoirs [10] are shown as dashed horizontal lines. Particle sizes for all data typically range from 20-35 µm in their largest dimension. Large uncertainties in the particle densities, as well as in the surface areas in the case of the previous analyses, make it difficult to compare absolute concentrations. For this reason we simply plot He contents in ccSTP in the Figure. The two data points labeled "11" are both from fragments of L2011 cluster #11. We have assumed that L2009 and L2011, which were flown at the same time, sampled the same stratospheric population of cluster IDPs, thus permitting direct comparison between He data from particles on both flags.

Discussion: There are major differences between the previous and current data sets for the JJ-91 particles. In particular, fragments from the one cluster particle measured in both data sets (cluster #11) display distinctly different He contents. Of the three JJ-91 cluster fragments studied in the current work, none demonstrate the low ^{4}He, high ^{3}He/^{4}He values we had anticipated. The reasons for the differences are not clear. We have reviewed the Nier and Schlutter work carefully, including a thorough re-examination of the original notebooks and can find no reason to doubt the validity of the earlier, low He, high ^{3}He/^{4}He results. Different fragments of the same cluster particle may have very different shielding from the solar wind and thus the difference between the two fragments of L2011 cluster 11 is not, in itself, contradictory. Except for the cluster 11 data, the apparent contradictions rest on statistical arguments. Possibly the original results were a statistical fluke whose *a priori* probability was low. Since about 50%, of "normal" cluster fragments with comparable sizes are low in He (~ 3.2×10^{-11} ccSTP) [2,3,4], the *a priori* probability that Nier and Schlutter would have detected low He in all twelve JJ-91 cluster fragments is one in four thousand. We also note that the four fragments from L2036, each from a different cluster particle, demonstrate no definite similarities with the JJ-91 particles originally measured by Nier and Schlutter. The Figure shows two JJ-94 cluster fragments that are indeed He-poor but which lack the anomalous ^{3}He/^{4}He ratios measured for a majority of the JJ-91 particles. Moreover individual IDPs from JJ-91 are indistinguishable from cluster fragments measured in the current work.

While the limited statistics preclude a definitive resolution of these apparent discrepancies, the new results certainly do not confirm the observation of anomalous He among JJ-91 cluster particles, and thus cast doubt on the SW-3 hypothesis. We hope that additional data from our consortium study, currently in progress, will lead to a clearer understanding of the situation. For one thing it is now apparent that it would be highly desirable to measure other fragments of all of the original clusters studied by Nier and Schlutter. The cross correlation between the Minnesota and St. Louis noble gas labs also takes on additional importance. At the very least, the additional noble gas, ion probe, FTIR and SXRF analyses will add considerably to the existing data base for IDPs, a number of which are certainly derived from comets.

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Fig. Helium in IDPs