A RE-EXAMINATION OF THE U-Pb SYSTEMATICS OF THE ACHONDRITE ASUKA 881394. P. Koefoed1, Y. Amelin1, Q-Z. Yin2, M. E. Sanborn2 and M. Huyskens2 1Research School of Earth Sciences, The Australian National University, Canberra ACT 2601, Australia (piers.koefoed@anu.edu.au), 2Department of Earth and Planetary Sciences, University of California at Davis, One Shields Avenue, Davis, CA 95616, USA.

Introduction: Asuka 881394 is a unique basaltic achondrite composed of mostly calcic plagioclase and pyroxene [1]. Although it shares many similarities to coarse-grained cumulate eucrites, differences in Mn-Cr systematics [2], stable Cr isotopic anomalies [3] and oxygen isotope data [4] indicate Asuka 881394 was formed on a separate body to eucrites and other HED meteorites.

The current reported Pb-Pb age for Asuka 881394 (4566.51±0.21 Ma) makes it the oldest achondrite studied so far [2]. However, there is a discrepancy in age difference between Asuka 881394 and D’Orbigny for different chronometer systems (Pb-Pb: 2.1±0.3 Ma, $^{26}$Al/$^{26}$Mg = 1.0±0.2 Ma, $^{51}$Mn/$^{53}$Cr=0.90±0.4 Ma) [2, 5]. As a result, it is currently difficult to advocate the use of Asuka 881394 as a reference “milestone” for early Solar System chronology. Possible causes of this age discrepancy, such as varying closure temperatures, heterogeneous distribution of isotopes in the early Solar System and the possible disturbance of isotopic systems, have been previously investigated [2, 5]. Despite this, the exact reason for this discrepancy is yet to be identified. Here we re-investigate the U-Pb systematics of Asuka 881394 via a different approach, in order to better understand this age discrepancy.

Methods: Analyses were conducted on five mineral fractions that were purified by magnetic separation and hand picking. These fractions consisted of one 2.56 mg silicon oxide (tridymite) fraction, two large (pure: 28.03 mg and impure: 39.66 mg) plagioclase fractions, one 30.03 mg pyroxene fraction and one 25.86 mg whole rock fraction. Each fraction underwent five leaching steps followed by complete dissolution in concentrated HF. The first three steps comprised dilute HBr and HNO$_3$, 7M HNO$_3$ and 6M HCl. The final two steps involved two dilute (0.2M and 1M) HF washes. All fractions were spiked with a $^{208}$Pb-$^{208}$Pb-$^{228}$Th-$^{233}$U-$^{230}$U tracer. Pb fractions were analysed at the Australian National University (ANU) on a modified MAT-261 thermal ionization mass spectrometer (TIMS) using the secondary electron multiplier. Analysis of U-Th fractions was conducted using a Thermo Neptune Plus MC-ICP-MS at both University of California at Davis and the ANU.

Preliminary U-Th data will be expanded upon at the time of presentation.

Results: As shown in Fig. 1, all the Pb-Pb isotope analyses lie (within error) between primordial Pb, modern crustal Pb and the most radiogenic data point. This suggests that the Pb contained within Asuka 881394 is a mixture between these three components. The different mineral phases also show significant variation in their Pb components. The analyses of bulk rock and impure plagioclase are scattered indicating a strong “terrestrial” Pb component. In contrast, tridymite and pure plagioclase plot along a straight line between radiogenic and primordial Pb, suggesting a complete lack of “terrestrial” Pb. The pyroxene array plots between the two extremes indicating a small “terrestrial” component.

During leaching, non-radiogenic Pb was preferentially removed, resulting in more radiogenic W4 and residue fractions relative to the earlier leaching steps. However, the W4 (1M HF washes) and residues from the plagioclase and tridymite fractions were still relatively unradiogenic with measured $^{206}$Pb/$^{238}$Pb between 40-170. In contrast, the pyroxene and bulk fractions contained highly radiogenic Pb with $^{206}$Pb/$^{238}$Pb between 900-1500. Also, the distinct lack of radiogenic Pb in the early washes indicates an absence of U-rich phosphate minerals which can be present in certain achondrites (e.g. [6]).
Fig. 2. Pb isotope data for all pyroxene and bulk rock residue fractions. Grey ellipses – fractions from [2]. Blue ellipses – this study.

A combination of the previous Pb-Pb isochron by Wadhwa et al. (2009) with the addition of new precise pyroxene and bulk rock residue fractions can be seen in Fig. 2 (both ages are calculated using $^{238}\text{U}/^{235}\text{U}=137.88$). As shown, the addition of residue fractions from this study increases the age from 4566.51±0.21 Ma to 4566.75±0.31 Ma.

**Discussion:** The initial U-Pb study on Asuka 881394 by Wadhwa et al. (2009) yielded a precise Pb-Pb isochron age of 4566.51±0.21 Ma ($^{238}\text{U}/^{235}\text{U}=137.88$) from the analysis of 16 pyroxene and two bulk rock fractions (Fig. 2). However as a result of small fraction sizes, the more radiogenic analyses had larger uncertainties [2]. This resulted in the data effectively becoming a three point plot with the slope and intercept controlled by the two least radiogenic fractions (Fig. 2). If the two lesser radiogenic fractions suffer from the presence of multiple Pb components, then the isochron age could be compromised.

With the addition of two new high precision pyroxene and bulk rock analyses (which overlap the previous set), the results from the earlier study can now be further confirmed (Fig. 2). Additionally, the new age of 4566.75±0.31 Ma slightly increases the age discrepancy between isotopic systems. Using the measured $^{238}\text{U}/^{235}\text{U}=137.768±0.038$ [5], the new Pb age for Asuka 881394 becomes 4565.57±0.55 Ma. However as the $^{238}\text{U}/^{235}\text{U}$ measured for D’Orbigny is the same within uncertainty [7], this has no effect on the apparent age discrepancy.

Interestingly, 1M HF washes of the pyroxene and bulk rock fractions display higher $^{207}\text{Pb}/^{206}\text{Pb}$ relative to the equally radiogenic residues (Fig. 3). This phenomenon has previously been observed, although only when leaching with concentrated HBr [8]. However as they also reported, we attribute this observation to be the result of leaching induced fractionation between $^{207}\text{Pb}$ and $^{206}\text{Pb}$. Therefore, until leaching induced isotopic fractionation is further understood, caution should be used when applying multi-stage HF leaching to achondrites.