**Introduction:** Presolar grains are small, up to µm-sized particles that formed in the vicinity of dying stars and were incorporated into Solar System material at its formation. These grains still carry the isotopic signature of their parent stars. While certain elements in SiC grains from asymptotic giant branch (AGB) can be used to study the $s$-process in detail, other elements, like Fe and Ni, are expected to show minimal effects from nucleosynthesis in the star. These elements are therefore good proxies to study galactic chemical evolution (GCE). Model calculations [e.g., 1] predict that the neutron-rich isotopes $^{58}$Fe and $^{64}$Ni in AGB stars show some effects from the $s$-process, up to ~100‰ excess in $^{58}$Fe and up to ~500‰ excess in $^{64}$Ni. These excesses can be used to determine the type of parent star and thus to correct the minor isotopes for $s$-process contributions. The actual isotopic composition that went into the star in the first place can be inferred from this. In the present study, we measured 11 presolar SiC grains simultaneously for their Fe and Ni isotopic composition. All of these grains are at this point unclassified, however, all of the measured Fe and Ni analyses agree with expectations from nucleosynthesis models of low-mass stars.

**Methods:** We used the CHicago Instrument for Laser Ionization (CHILI) [2, 3] to determine the Fe and Ni isotopic composition of the given samples. Acid-cleaned presolar grains [4] were mounted and pressed into gold foil. Sample material was subsequently desorbed using a 351 nm UV laser. After ejecting secondary ions from the system, the neutral particles were resonantly ionized using six tunable Ti:sapphire lasers. Three lasers were used for each element. Details about the resonance ionization are given in [5]. The photoions were then extracted into a time-of-flight mass spectrometer and detected with a microchannel plate with a single anode. The measurements are done with a repetition rate of 1 kHz, and each shot is recorded separately [5]. Since the mass resolution of CHILI cannot resolve $^{58}$Fe from $^{58}$Ni, we delayed the Ni ionization event by 200 ns with respect to the Fe ionization event [5]. Therefore, the two peaks shift apart from each other by half a mass unit – a shift that can be easily resolved in CHILI. This allows the simultaneous analysis of Fe and Ni without isobaric interferences. This is the first time that such a time discrimination scheme is used in RIMS for measuring the isotopic compositions of elements that have direct isobars. To standardize our measurements, we used stainless steel with an Fe/Ni ratio of ~7 and a NIST SRM 610 glass with an Fe/Ni ratio of ~1. Both standards showed the same isotope ratios, except for interferences with TiO on $^{62}$Ni and $^{64}$Ni in the glass. We also measured the gold substrate itself. Aside from the surface layer in which we detected a few counts for usually less than a second of measurement time, we did not see any contamination in the gold.

**Results and Discussion:** The Fe isotopic composition (see Figure 1) in the 11 measured grains shows some excesses in $\delta^{57}$Fe and a hint of excess in $\delta^{58}$Fe. The isotope ratio of $^{54}$Fe/$^{56}$Fe is close to the Solar System value. Figure 1 also shows our previous measurements of Fe isotopic composition [6] using the CHARISMA instrument at Argonne National Laboratory as well as data measured by secondary ion mass spectrometry (SIMS) [7]. The uncertainties of the measurements performed with CHILI are up to a factor of 2 smaller than for previous measurements with CHARISMA [6] and about a factor of 4 smaller than for measurements by SIMS [7], allowing the detection of small GCE effects. The Ni isotopes show Solar System composition in $\delta^{61}$Ni. The values for $\delta^{60}$Ni, $\delta^{62}$Ni, and $\delta^{63}$Ni, and $\delta^{64}$Ni are

![Figure 1. Iron isotopic ratios in comparison with literature values [6, 7]. Uncertainties are 1σ.](https://example.com/figure1.png)
δ64Ni show hints of excesses in these isotopes. The Ni data however have uncertainties comparable to data from SIMS measurements [7]. This is due to the fact that our detected Ni abundance is much lower than the Ni abundance found previously [7], resulting in larger uncertainties.

Elemental Fe/Ni ratio. On average, the measured elemental fractionation between Ni and Fe is 0.59 in the stainless steel and 0.56 in the NIST SRM 610 glass. The reason why our detection of Fe is better than the detection of Ni by almost a factor of two is explained by the laser ionization scheme. As described in [5], about half the Ni neutrals are in the ground state after the desorption event, our first ionization laser however starts at a low-lying excited state and the ground state is thus not used in our ionization scheme. This results in a loss of about 50% of the Ni isotopes. The two fractionation factors for steel and glass are very similar, even though they were determined on two very different matrices. It is reasonable to assume that the fractionation factor for a SiC matrix is similar as well. Figure 2 shows the estimated Fe/Ni elemental ratios that we calculated for our samples. Uncertainties from the fractionation factor and the count rates are smaller than the symbols. The blue shaded area shows the Fe/Ni elemental range measured by SIMS [7]. The Ni abundance in these measurements was much higher than in our case. It is unclear if and how these samples could have been contaminated with extra Ni. One possible source of contamination could be the gold the presolar grains were mounted on. We previously discovered that even high-purity gold can be contaminated with Ni, even if no Fe contamination is detected. Another possibility could be that meteoritic Ni was incompletely removed during grain separation. Taken at face value, our results suggest that ~90% of the Ni signal measured by [7] may have been extraneous to the SiC. Our measurements were performed on acid-cleaned presolar grains [4], and we analyzed the gold substrate our grains were mounted on and detected neither Fe nor Ni contamination.

Comparison of presolar grain data with nucleosynthesis and GCE models. All of the measured presolar grains show close to Solar System composition in their Fe and Ni isotopes. We can thus conclude that these grains come from low-mass stars. We see a slight enhancement in 58Fe and 64Ni; however, due to the large uncertainties, we cannot determine a unique type of star that would produce this excess. GCE calculations predict that all minor Fe isotopes are depleted by >100% compared to 56Fe and that all minor Ni isotopes are enhanced by >200% compared to 58Ni [8]. Our results show that δ60Ni and δ62Ni might show a slight enhancement compared to the Solar System; also δ57Fe shows a slight enhancement. We do not see, however, the high depletion and enhancement for Fe and Ni isotopes predicted by [8]. GCE models have similar problems explaining Si isotopes, which should also show only minor s-process contributions. Correlating multiple GCE dominated elements can help in the future to better understand the processes that contributed to the chemical composition of the galaxy.

Summary and Outlook: We present Fe and Ni isotopic compositions of 11 presolar SiC grains including interference free, simultaneous analyses of 58Fe and 64Ni. We see a slight enhancement in several isotopes. Uncertainties in the neutron rich isotopes are at this point too high to clearly determine the type of parent star for these grains. These are preliminary results, and more Fe and Ni measurements in presolar grains will soon be performed. We will subsequently measure the Si and C isotopic abundance in these presolar grains to classify them. Since Si isotopes are also mostly dominated by GCE, it remains to be seen if correlations between Si, Fe, and Ni isotopes exist.