CHILI—THE CHICAGO INSTRUMENT FOR LASER IONIZATION—WHERE ARE WE GOING?

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Introduction: CHILI (the Chicago Instrument for Laser Ionization) is a new RIMS (Resonance Ionization Mass Spectrometry) instrument that is about to be completed at the University of Chicago. A detailed technical description of CHILI has been given previously [1]. Technical highlights are ~10 nm lateral resolution and ~40 % useful yield (ratio between detected and consumed atoms). High useful yield is essential, because at high lateral resolution the number of atoms within a sample volume is the ultimate limitation for high precision analysis.

Current Progress: After integration of the liquid metal ion gun (sample sputtering), the field emission electron gun (sample imaging), the Schwarzschild optical microscope (sample imaging and laser ablation), and the time-of-flight mass spectrometer (mass analysis and ion detection), recent technical developments focused on the laser system for resonance ionization. The assembly of six newly designed tunable Ti:sapphire solid state lasers for resonance ionization is nearing completion. They are pumped with three Photonics 527 nm 40 W Nd:YLF lasers. This will allow isotopic analysis of two to three elements simultaneously. First tests of the Ti:sapphire lasers showed that their bandwidth, power levels, and stability match design expectations. A prism beam combiner, which is presently in its final design stage, will be used to introduce all laser beams for resonance ionization into the analysis chamber on a single line. Fast high-voltage electronics for the mass spectrometer is also in its final fabrication and testing stage. A Photonics 351 nm Nd:YLF laser for laser desorption is currently integrated. It will be especially useful for the analysis of trace elements in larger samples,

After approximately four years of building CHILI, the endeavor is nearing completion. Final laser and electronics components should be finished within the next couple of months. Following some testing, optimization, and calibration, CHILI should become operational shortly afterwards.

Outlook: CHILI's strengths will be in isotopic and chemical analysis at lateral resolutions and concentrations beyond the current state of the art. By pushing most technical specifications towards their physical limits, CHILI is setting the stage for addressing a multitude of cosmochemical problems such as: multi-element isotope studies of stardust and sub-grains therein to constrain stellar models and to investigate grain condensation history; absolute dating of presolar grains; isotopic analysis of GEMS (glass with embedded metal and sulfides) in interplanetary dust particles in order to clarify their purported relation to interstellar dust or supernova explosions; ^{26}Al-^{26}Mg chronology of cometary samples from the Stardust mission; search for heavy-element isotope anomalies in hibonite grains; checking SIMS measurements of early solar system ^{60}Fe and ^{41}Ca by eliminating isobaric interferences; isotope analysis of contemporary interstellar dust grains from the Stardust mission; and determining trace element abundances in Genesis targets.

References: [1] Stephan T. et al. 2013. Abstract #2536. 44th Lunar & Planetary Science Conference.