REFINEMENT OF NASA’S MARS XRD INSTRUMENT USING RAY TRACING AND COMBINATORIAL OPTIMIZATION.

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CheMin is a compact XRD/XRF instrument being developed for the onboard science payload of “Mars Science Laboratory” (MSL), the landed mission to Mars planned by NASA for the 2009 launch opportunity. CheMin will perform mineralogical and elemental analyses of rocks, sediments and soils collected by the rover over a two-year period of planned operation on the surface of Mars.

The instrument operates in transmission geometry and uses a two-dimensional CCD detector for simultaneous spatial and energy resolution of X-ray photons. A number of proof-of-concept prototypes have been built; the recent versions are portable and have been deployed in the field for demonstration of in-situ analysis capabilities. These prototypes produce quality diffraction data enabling mineral identification, quantitative analysis of mixtures, and refinement of some structural parameters.

Although the flight version will use a lower X-ray tube power than the field prototypes, MSL requirements demand a reduced data acquisition time. These requirements lead to a major instrument redesign for which an innovative approach was taken. The performance of individual design configurations was evaluated using ray tracing computation. The ray tracing analysis was implemented in systematic exploration of a few instrument parameter grids as well as combinatorial optimization of several parameters using an evolutionary algorithm. This work pointed towards a number of design improvement directions with regard to the collimation assembly and the angular positions of the detector and the sample. The configuration chosen for the flight system features diffracted intensities an order of magnitude greater than present prototypes, while preserving resolution.

The results of this instrument optimization will be compared with experimental measurements obtained with a flexible XRD - CCD setup.