Introduction
The surfaces of solar system bodies that do not possess a significant atmosphere are slowly but inexorably altered by the action of the solar wind. This includes our Moon as well as the majority of objects in the solar systems such as small moons, asteroids and inactive comets. The solar wind breaks chemical bonds, sputters material and stimulates chemical reactions. The reducing nature of the hydrogen dominated solar wind drives the formation of nanophase iron and may enable if not directly cause the formation of water and other volatiles.

Here, we report our experimental work that demonstrates the increased sputtering yield of O, OH after solar wind energy proton irradiation of lunar samples. These observations provide important clues on space weathering by the action of the solar wind. This includes our Moon as a small moon, asteroids and inactive comets. The solar wind energy proton irradiation of lunar samples. These observations provide important clues on space weathering by the action of the solar wind.

Outcomes from this work
By subjecting Apollo samples and silicon dioxide (for comparison) to solar wind energy hydrogen we found evidence for:

1. Hydrogen implantation to form hydroxyl bonds in the form M-OH (M = Si, Al, Fe etc.)
2. These surface moieties are not entirely stable with significant reduction in the OH yield after several days at room temperature.

Methods
• We constructed a secondary ion/neural sputtering apparatus using ions and energies found in the solar wind (SW).
• Ions at SW energy are pulsed allowing measurements on the evolving plume of sputtered ions and neutrals.
• Sputtered negative ions pass in and through the extraction region of a Reflectron-Time-of-Flight mass analyzer and after a set delay from the ion sputtering pulse, the RTOF extraction pulse is triggered.

Sample Preparation
Samples of Apollo soil 72501 were placed into a gold cup. In vacuum the samples were heated for several hours at ~580°C inside a tube furnace. After cooling and without breaking vacuum (<10^-8 torr), the sample was positioned below the RTOF apparatus below the pulsed ion source. The sample was irradiated with a 4 keV argon ion beam for several hours to remove surface contaminants prior to hydrogen implantation. For comparison, we tested a silicon dioxide sample with identical procedures.

Results
After baking and irradiating overnight with a continuous argon ion beam at 4 keV to remove surface contaminants, we took RTOF spectra of argon ion sputtered sample prior to proton implantation. During argon ion irradiation and subsequent proton implantation, a nearby filament was heated in order to provide electrons to prevent charge imbalance on the surface. By use of a pulsed ion source to take RTOF spectra the sample is minimally disturbed, enabling additional proton implantation and a measurement of changes taking place as the proton fluence is increased.

While exposing the sample to a 2 keV H_2 beam the current on the sample was monitored with a picoammeter. The measured current is proportional to the ion current since electrons are sputtered from the sample leading to an anomalously high current. We have not corrected the measured current in the charts below, but this does not affect our conclusions on the trends of changes to the surface as a result of proton implantation. Initial tests to suppress scattered electrons by floating the sample to a nearby filament were unsuccessful. Initial tests to suppress scattered electrons by floating the sample to a nearby filament were unsuccessful. We have observed clear evidence of the formation of bonded hydroxyl that are formed by proton irradiation induced by hydrogen implantation does not greatly affect the fluorine yields. Furthermore, since hydrogen is an inefficient sputterer, very little material is removed during the implantation process and so the fluorine concentration in the sample will not change substantially. Other normalization (such as total carbon or gold from the holder) lead to the same conclusions.

Conclusions and Next Steps
We observed evidence for the formation of hydroxyl groups on the surface of lunar regolith as a result of implantation of solar wind energy hydrogen. This accomplished by probing the surface with a pulsed argon ion beam at 4 keV and observing sputtered ions using an RTOF mass analyzer. Subsequent tests on silicon dioxide suggest the possibility that the hydroxyl may not be stable, at least at the top surface which the argon beam probes. We will refine this work to refine our total fluence measurements, extend to deposition in search of a plateau and determine the stability of formed hydroxyl groups in Apollo soils.