# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

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# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

Developed and demonstrated a Standoff Ultracompact micro-Raman (SUCR) sensor for planetary surface exploration under PICASSO program.

Objectives:

- Inspect and identify the minerals, organic, and biomarkers (amino acids) for life detection on the surface of Mars, Europa, Enceladus, and other planetary bodies.
- Characterize lunar regolith (minerals/glasses) and volatiles water-ice at the South pole on the lunar far side.
- Presently, using the micro-Raman sensor for Lunar simulant investigation, for example, NU-LHT-4M, JSC-1A, Feldspar Plagioclase, etc. under Moon to Mars Planetary Autonomous Construction Technology (MMPACT) and In-Situ Resource Utilization (ISRU) programs.

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

**The big pivot is from Planetary Science to Healthcare applications, i.e., potential applications in the healthcare industry.**

Our critical steps are:
*Let customers know about our micro-Raman sensor performances.*

***Investigate the critical unknown, when it will be ready to use in the cancer research lab.***

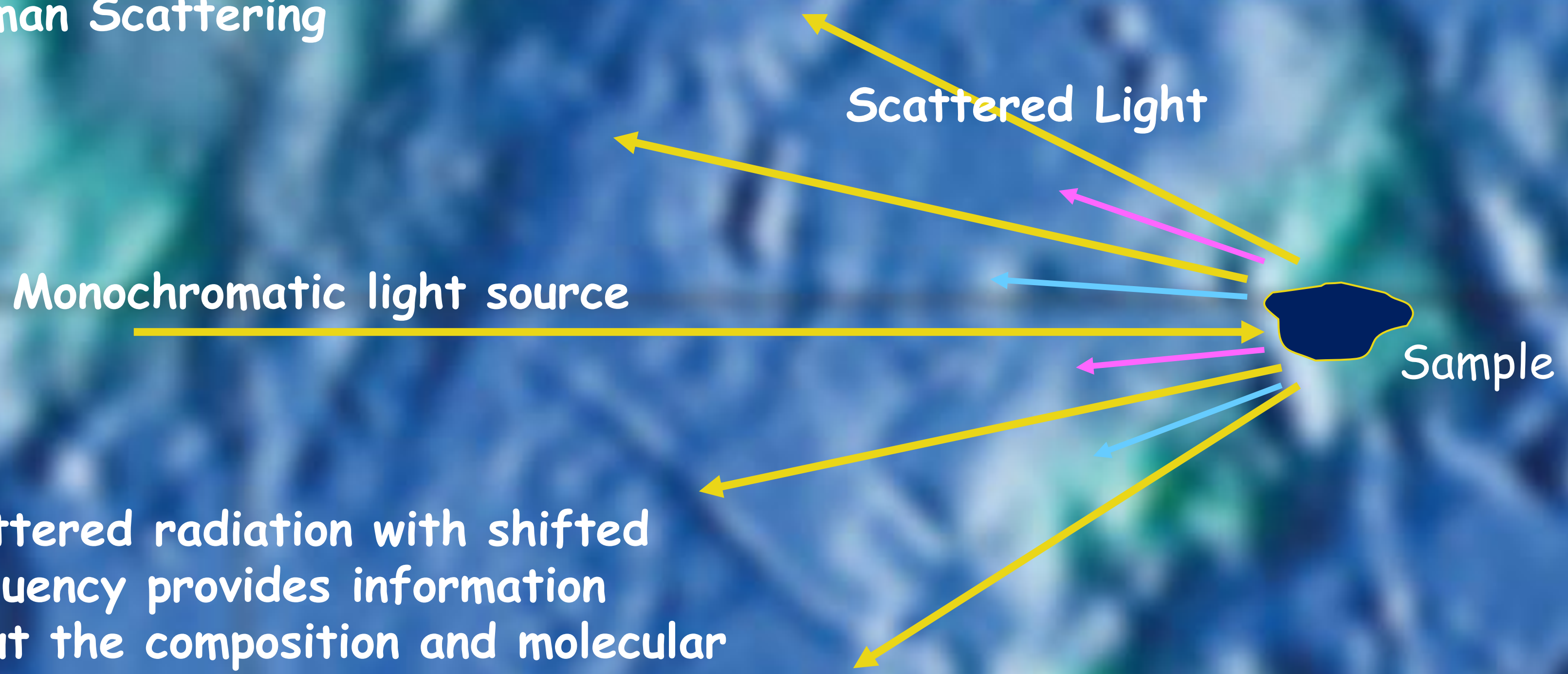
**NASA technology helps** Biological Material Research to monitor patients' health by detecting biomarkers, for example, Human Tissues, Cells, Urine, Saliva, etc. in space and hospital clinic

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Raman Spectroscopy

- Raman spectroscopy is a powerful technique for determining the composition and the structure of a solid, liquid, or gas material based on its vibrational spectra.
- It is an ideal for analyzing rocks and minerals because it produces spectra with very sharp peak, resulting in unambiguous detection.

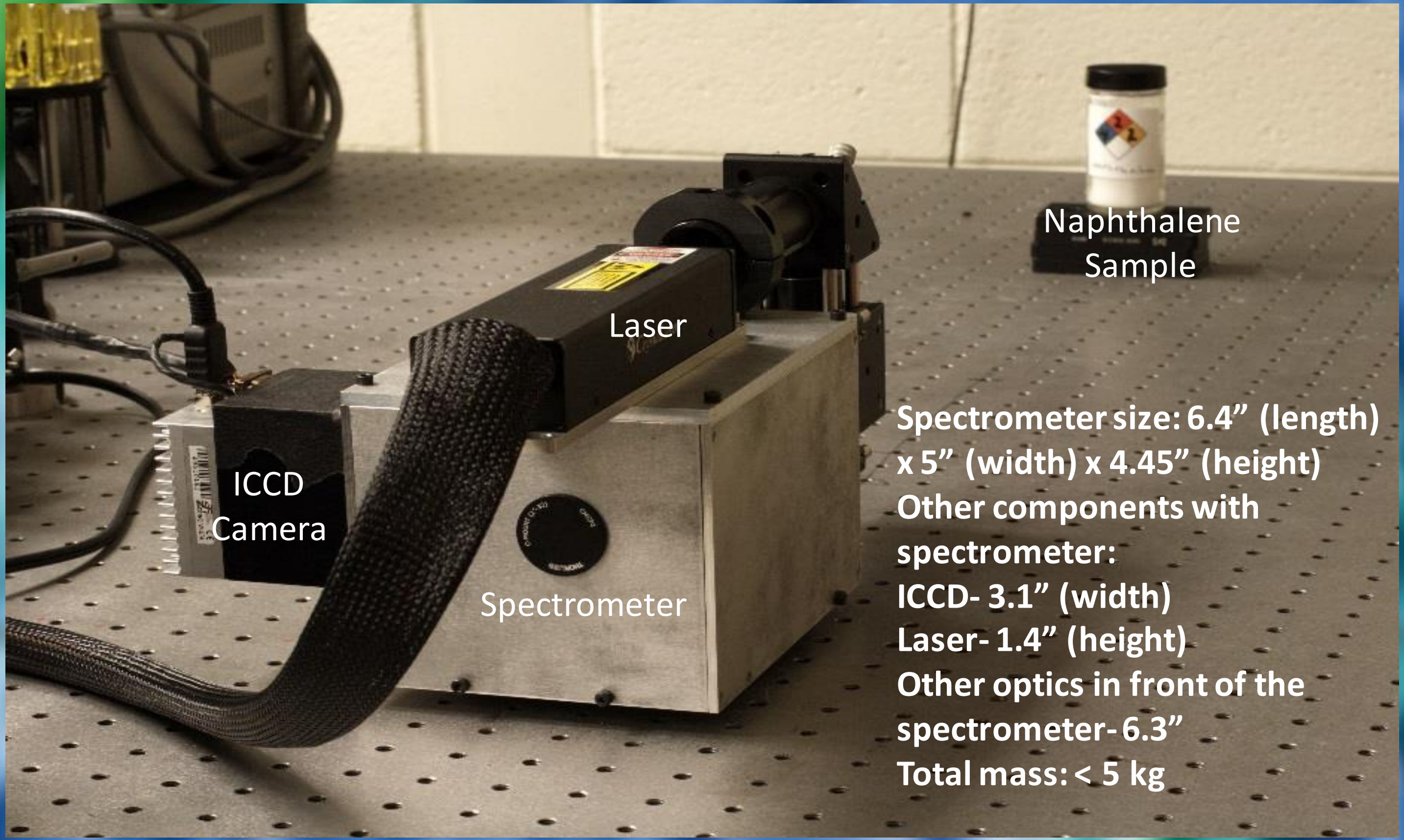
### Raman Scattering




Scattered radiation with shifted frequency provides information about the composition and molecular structure of the sample

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Standoff Ultra-Compact μ-Raman Sensor System



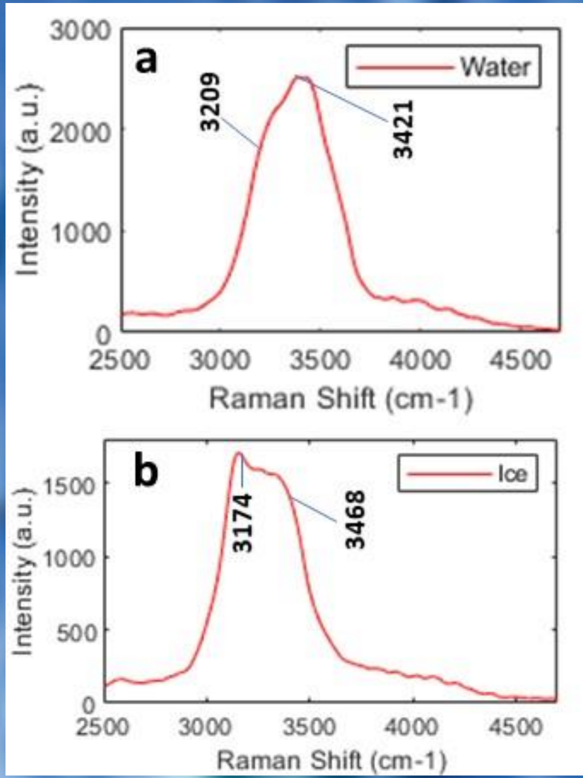

Integrated Stand-off Ultra-Compact Micro-Raman Sensor with a Laser, an ICCD camera, a grating, c-mount lenses and a slit inside spectrograph, and mounting optical components; and a target Naphthalene sample.

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Planetary Bodies

### Water, ice, and biomarkers (amino acids) for life detection

Raman spectra of water and ice




Raman spectra at high frequency region of water and ice obtained using a 532 nm pulsed laser with line shaped laser beam (10 μm width by 5 mm height) at a 6-cm target distance.

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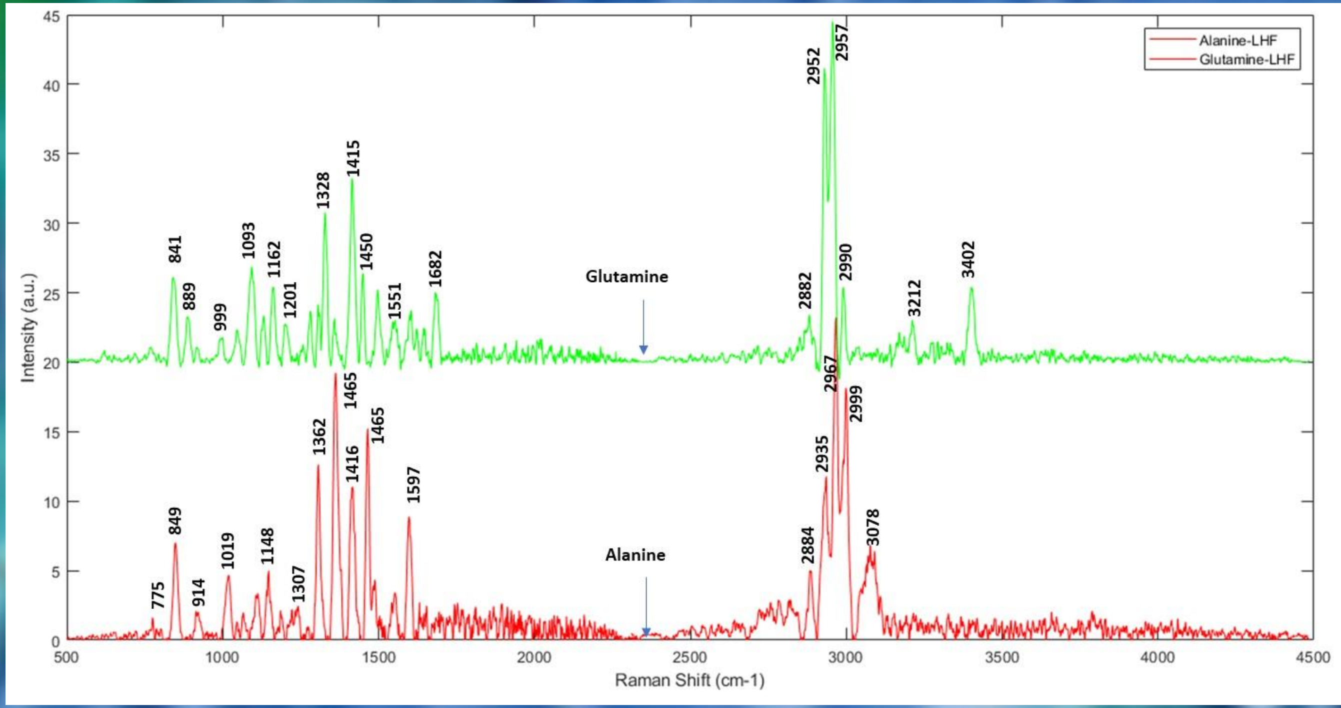
## Planetary Bodies

### Raman Spectrum of biomarkers (Amino Acids, e.g.,L-Glutamine and Alanine) at a 6- cm distance




Sharp Raman peaks at low frequency (left) and high frequency (right) regions of L-glutamine and L-Alanine obtained using a 532 nm pulsed laser with a line shaped laser beam (10 μm width by 5 mm height) at a distance of 6 cm.

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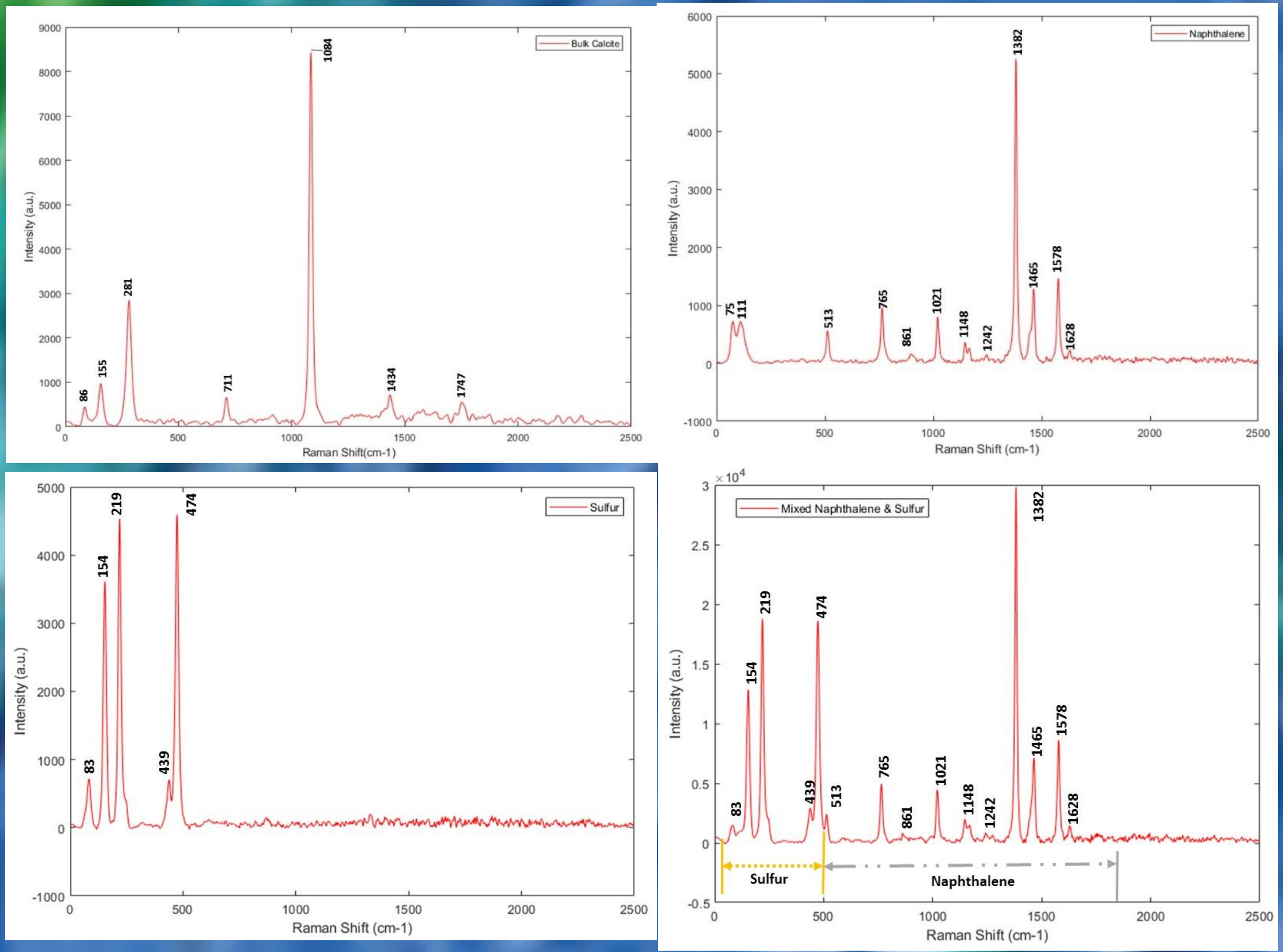
## Planetary Bodies

### Raman Spectra of Calcite, Naphthalene, Sulfur, and Mixed Naphthalene/Sulfur

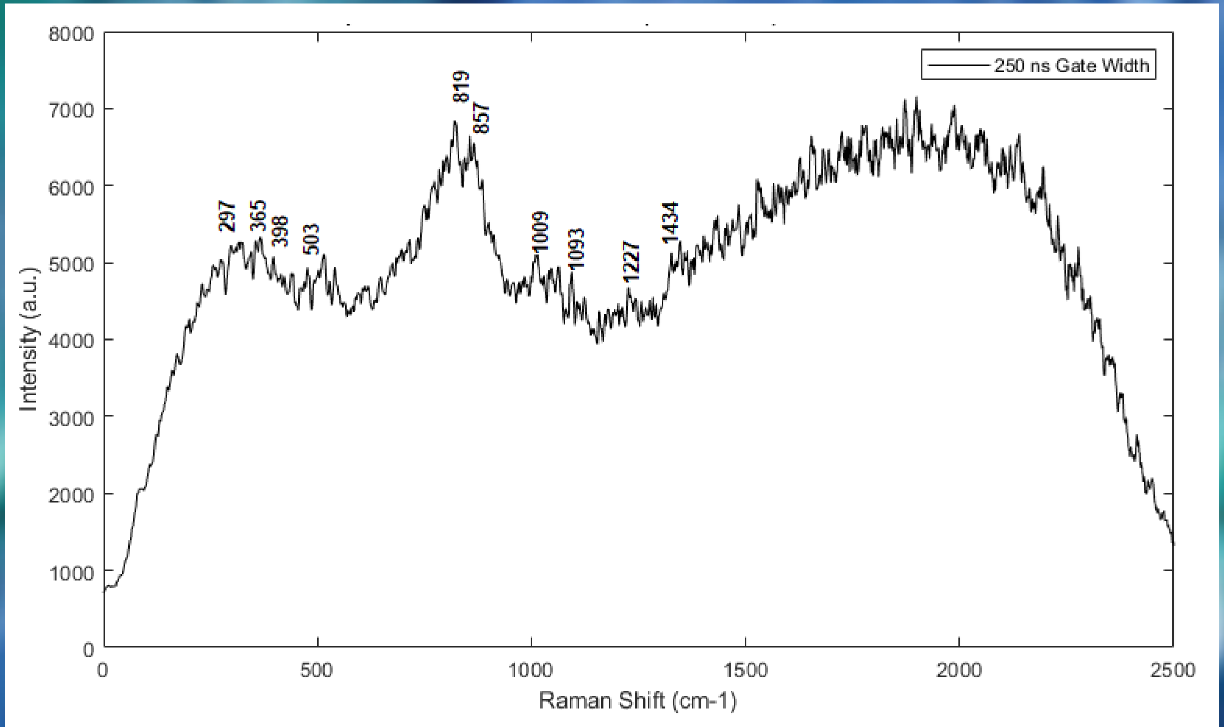



**Sharp Raman peaks at low frequency region of calcite, naphthalene, sulfur, and mixed naphthalene/sulfur obtained using a line shaped laser beam (17.3 μm width by 5 mm height) at a target distance of 10 cm.**

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Planetary Bodies

### Raman spectrum of Lunar Simulant (NU-LHT-4M) on Glass Plate

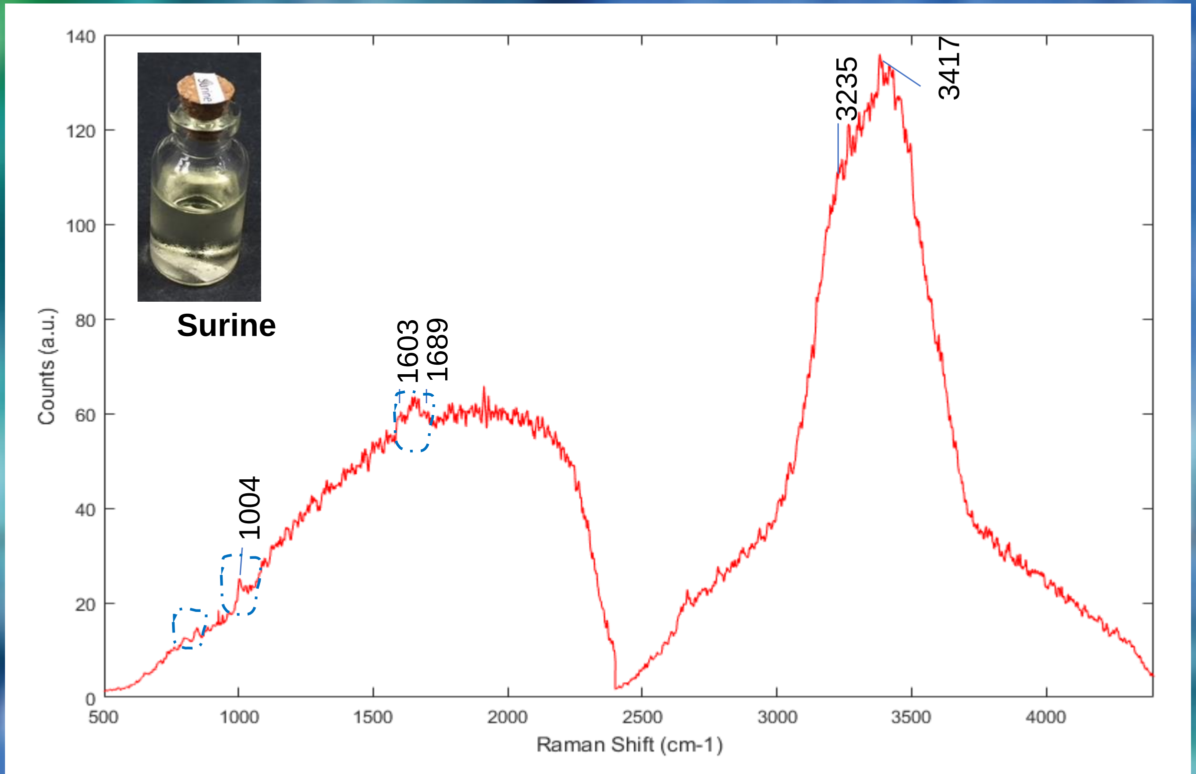



Raman spectra of olivine (819 and 857 cm-1), pyroxene (297, 365, 398, 1009 cm-1), and plagioclase (503 cm-1) from Lunar Simulant (NU-LHT-4M) without baseline correction or smoothing

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Medical Application

### Raman spectrum of Synthetic Urine using a 532 nm pulsed laser at 6 cm distance

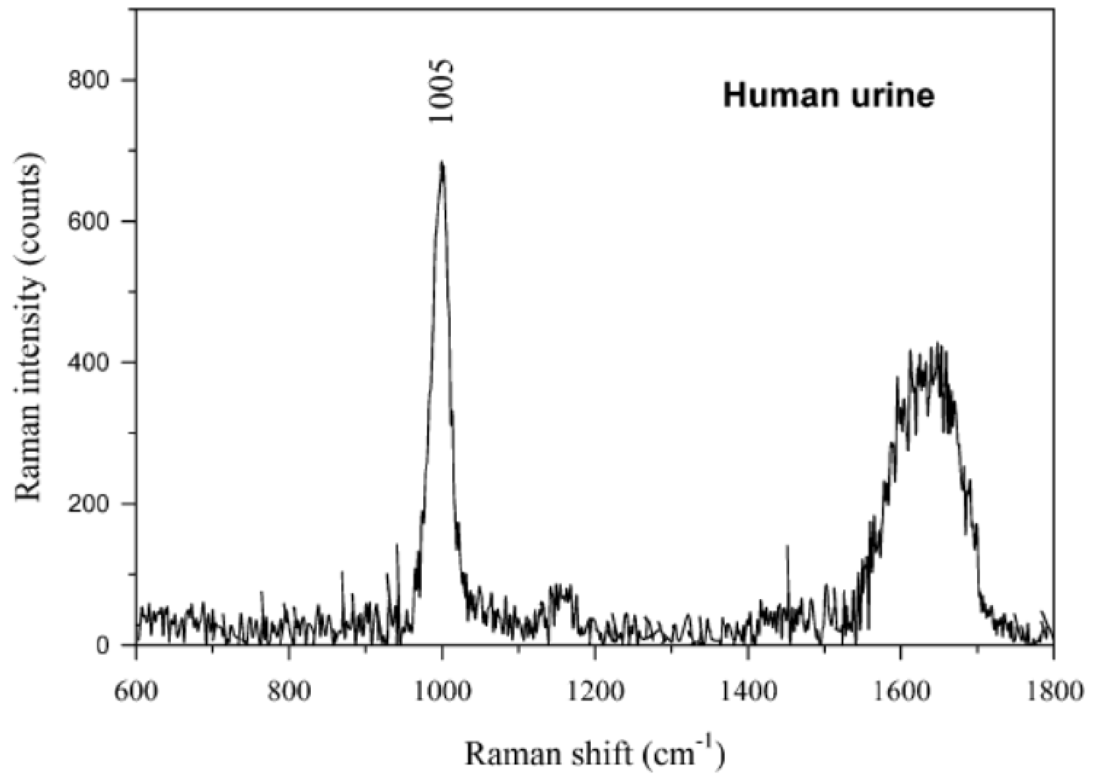



A sharp peak at around 1004 cm-1 and broad peak from 1603 to 1689 cm-1 are due to the non-biological urine spectrum and 3235 to 3417 cm-1 band is due to H2O band.

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Medical Application

### Raman spectrum of Human Urine using a 785 nm CW laser



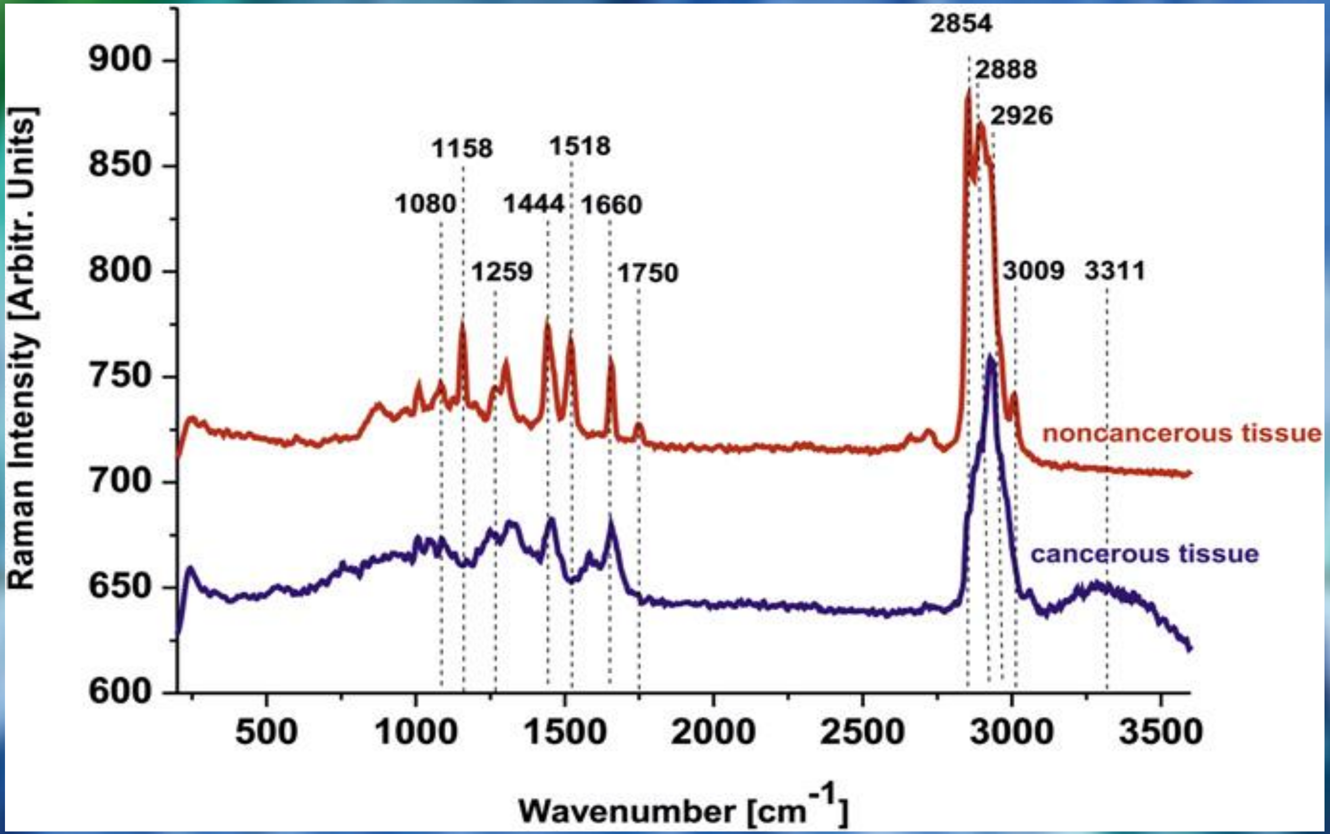

Raman spectrum of human urine.

A peak at 1005 cm-1 and a broadband around 1600 cm-1 are from human urine.
Courtesy: Guimaraes, et al., Near Infrared Raman Spectroscopy (NIRS):
A technique for doping control, Spectroscopy 20 (2006), 185-194, IOS Press.

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Medical Application

### Raman Spectra of normal and abnormal Breast Tissues of a Patient using a 532 nm (CW) laser




The Raman spectra of the noncancerous and cancerous (cancer) bulk breast tissue of a patient. (Courtesy: H. Abramczyk et. al., Raman 'Optical Biopsy' of human breast cancer, Prog. Biophys. and Mol. Biology 108, 74-81 (2012)).

# Micro-Raman Sensor for Planetary Bodies and Healthcare Applications

## Publications

**Journal Publication & News Release (under partial supports from NASA HQ PICASSO & IRAD programs)**

- M.N. Abedin, A.T. Bradley, A.K. Misra, Y. Bai, G.D. Hines, and S.K. Sharma, "Standoff ultra-compact $\mu$-Raman sensor for planetary surface explorations," Applied Optics, 57 (1), 62-68 (2018).

- Based on Applied Optics Paper, editors of The Optical Society of America (OSA) **published a News Release of "Powerful New Tool for Looking for Life Beyond Earth"**, which showed a large public interest in this technology.

**Complimentary Letter:**

- Received a letter from E. Nolan, Deputy Executive Director and Chief Publishing Officer from OSA about our published paper: " Standoff ultra-compact $\mu$-Raman Sensor for Planetary Surface Explorations," in the Journal of Applied Optics (January Issue, 2018) that has **reached a potential audience of at least 12.7 million within three weeks.**

**Patent:**

- **The U.S. Patent & Trademark Office issued a U.S. patent for invention 'Standoff Ultra-Compact Micro-Raman (SUCR) Sensor' on November 16, 2021 with Patent Number 11,175,232.**