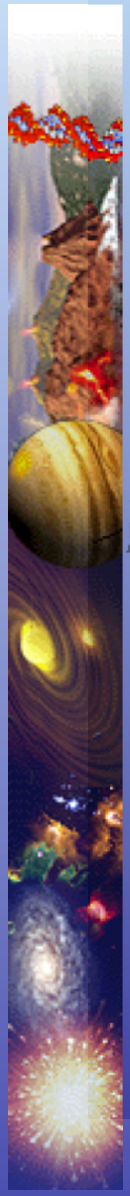
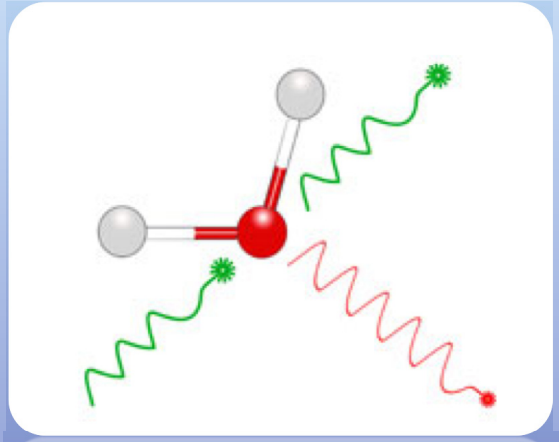


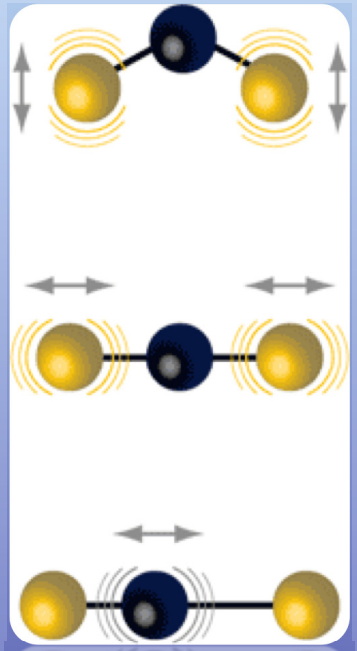
Raman spectrometer for *in-situ* measurements on Europa's surface

J.A. Rodriguez-Manfredi, O. Prieto-Ballesteros, F. Gomez, A. Sansano

Centro de Astrobiología. CSIC-INTA (Madrid, Spain)

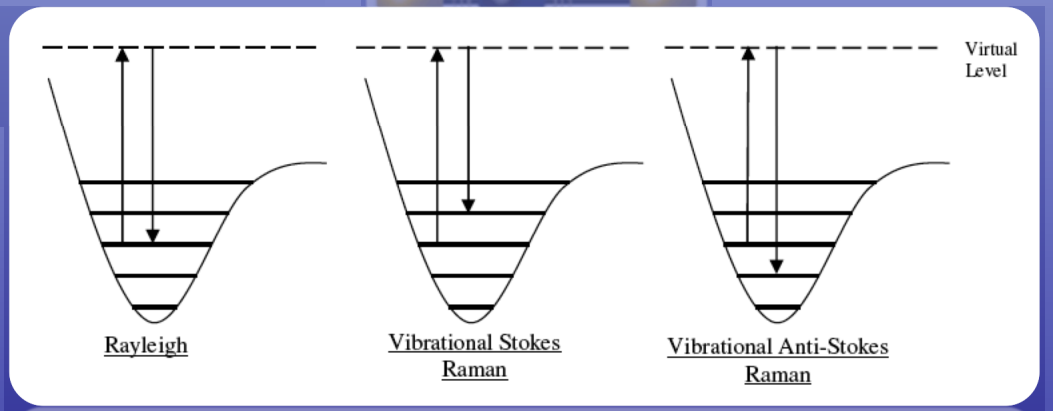
What is Raman spectroscopy



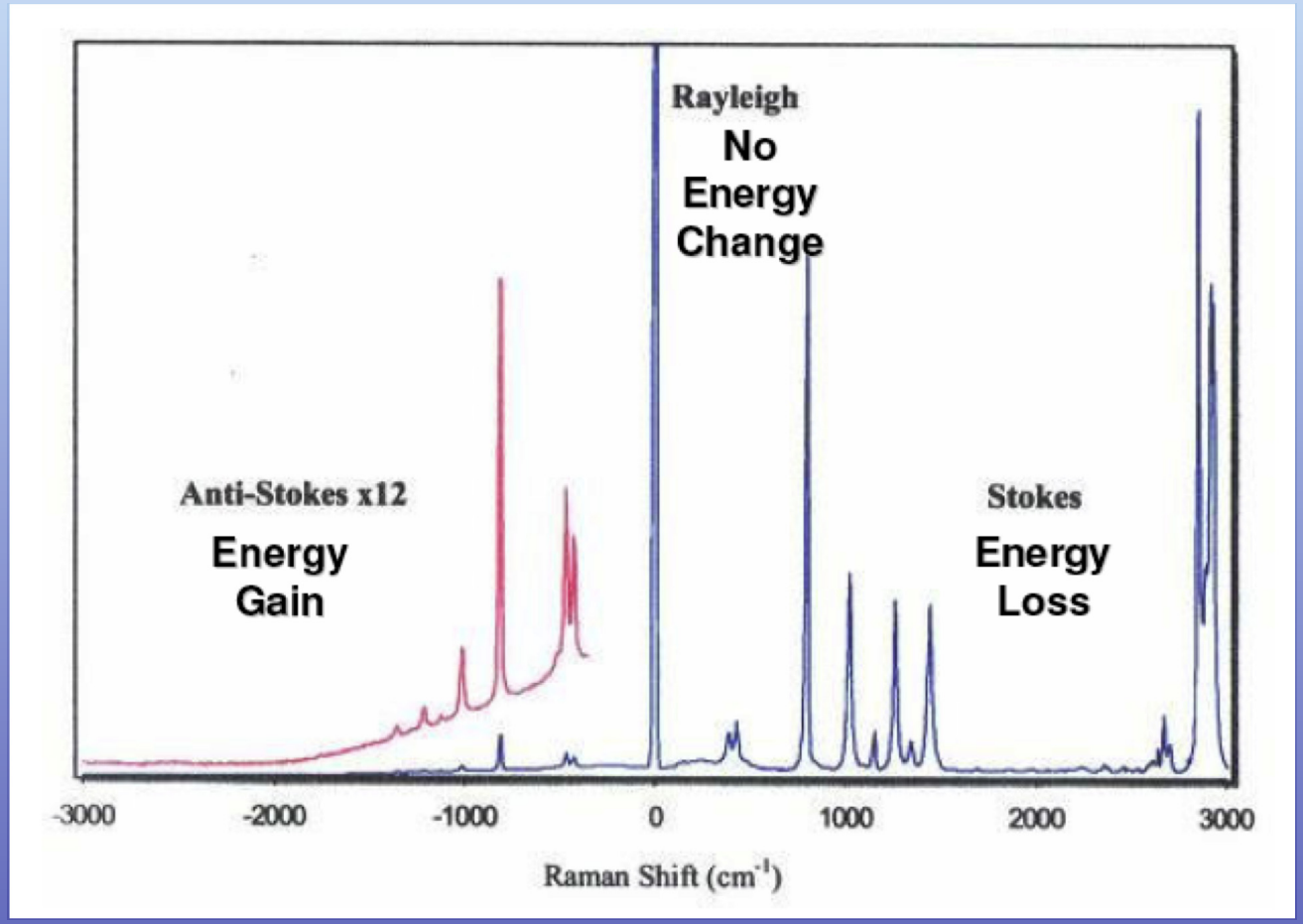


Vibrational modes:
- Bending mode
- Symmetric stretching mode,
  Antisymmetric stretching mode

Rotational modes

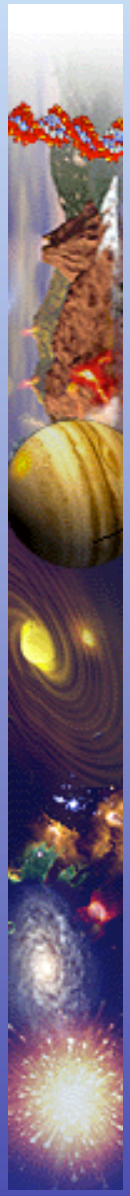


What is Raman spectroscopy



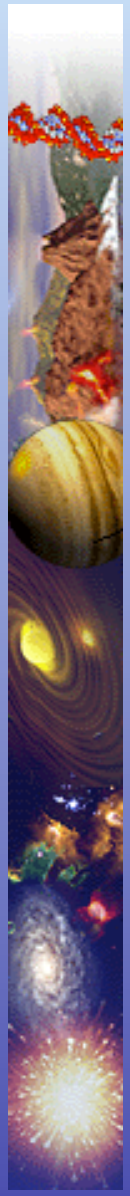
Stokes and anti-stokes
Example of Raman cyclohexane spectra

Advantages of Raman



- Raman scattering is specific of each chemical bond (it is a fingerprint)
- Can be used with solids, liquids or gases.
- No sample preparation needed.
- Small samples / volumes are needed.
- Non-destructive.
- Short time scale: spectra can be acquired quickly.
- Can use down fibre optic cables for remote sampling.
- Very populated databases.

Disadvantages of Raman

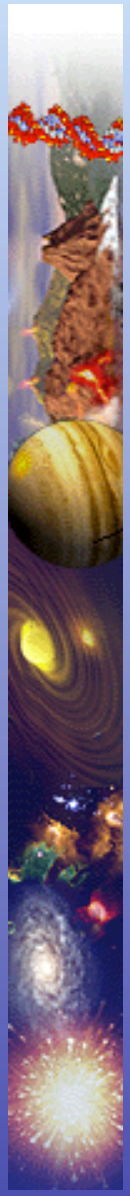


-The Raman effect is very weak, which leads to low sensitivity, making it difficult to measure low concentrations of a substance (excitation power, acquisition time and suitable optical designs –gratings,…- mitigate this effect).

- Precise focus on the sample is needed (fixed geometry by using analysis chambers).

- Can be swamped by fluorescence from some materials (further data processing substracts this effect).

Besides those aspects…



- Vibrational modes are specific of each molecule: unambiguous identification of species.

  Organic molecules are in the range of 500-2000 cm^{-1}.

- Characterization of present elements in any phase as well as the identification of the phase.

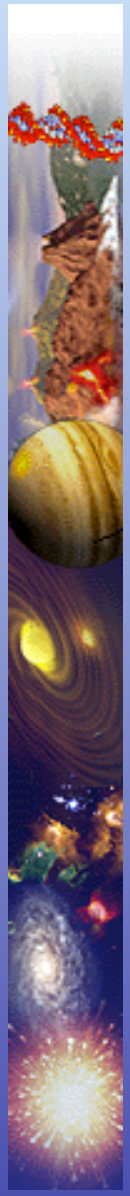
- Temperature measurements.

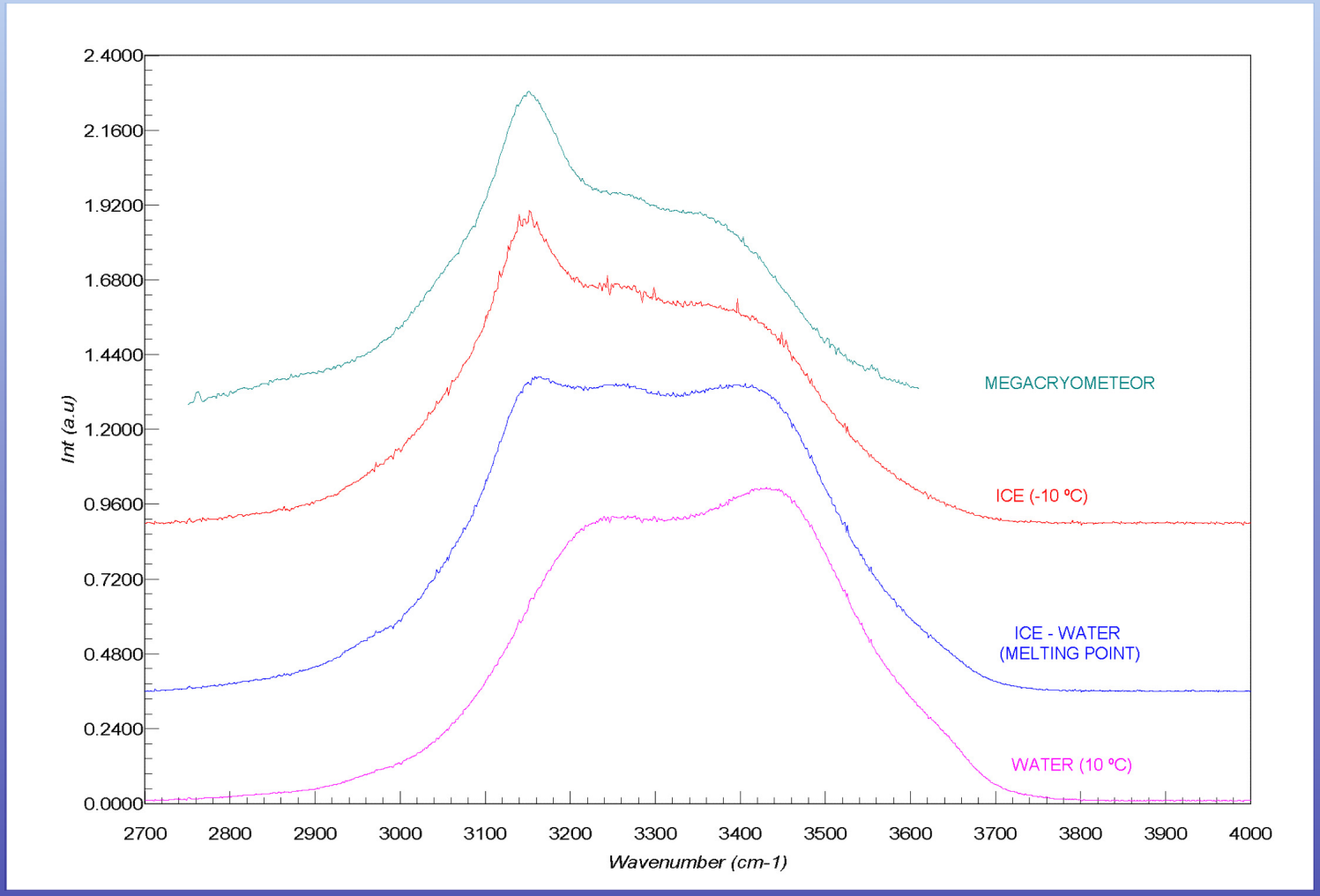
- Crystalographic orientation of sample.

- High spatial resolution: spatial distribution (depth profiles) and analysis of inclusions (resolves morphology controversies).

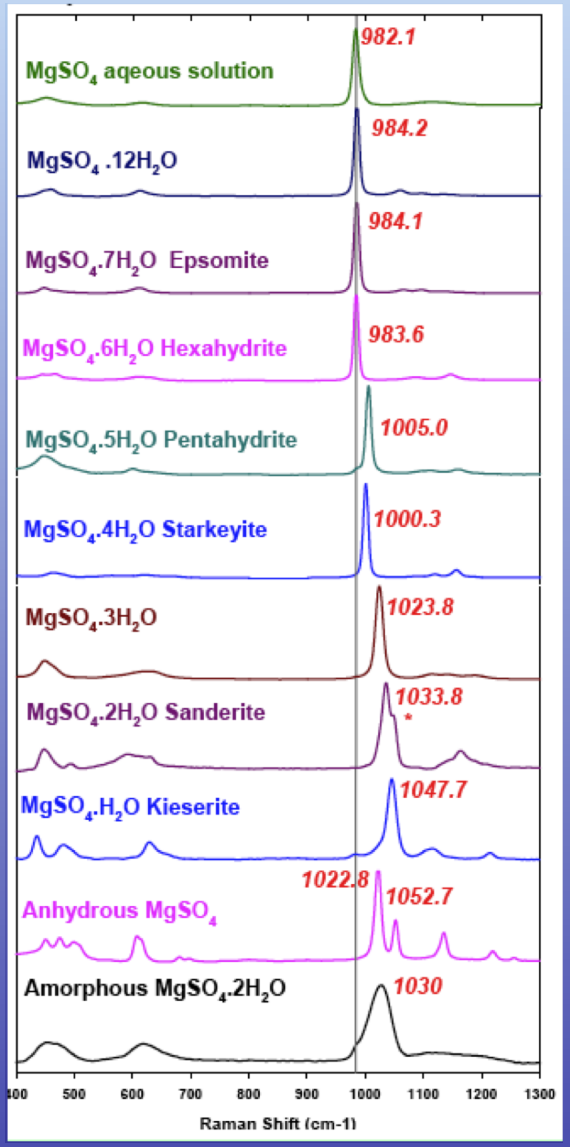
- Quick acquisitions: *Evolution* in time of the sample.

Raman as a tool to characterize phases of water



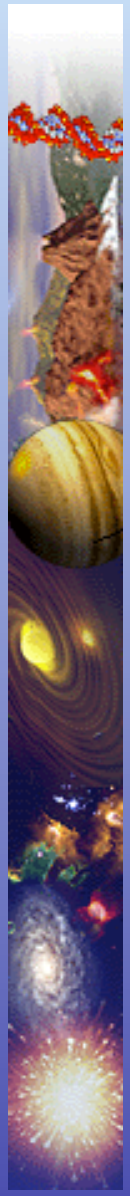


Detection / identification capabilities of Raman



Identification of hydration state of magnesium sulfates by Raman spectrometry.
(Wang 2006)

Technical handicaps



Space mission:
BIG CONSTRAINTS
- Volume
- Mass
- Power consumption
- Data volume

+

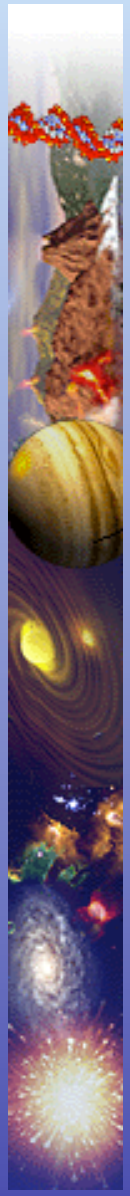
Europa environment:
- RADIATION
- TEMPERATURE
- ...

Possible mitigation scenario:
Opto-electro-mechanical design: as simple as possible

Spectral resolution
Spectral range
Laser excitation power → Poor Science???

It is not the case of the potential minerals and potential simple organic compounds susceptible of being found on Europa. → Valuable contribution to definition of **habitability parameters**

Tri-spec concept

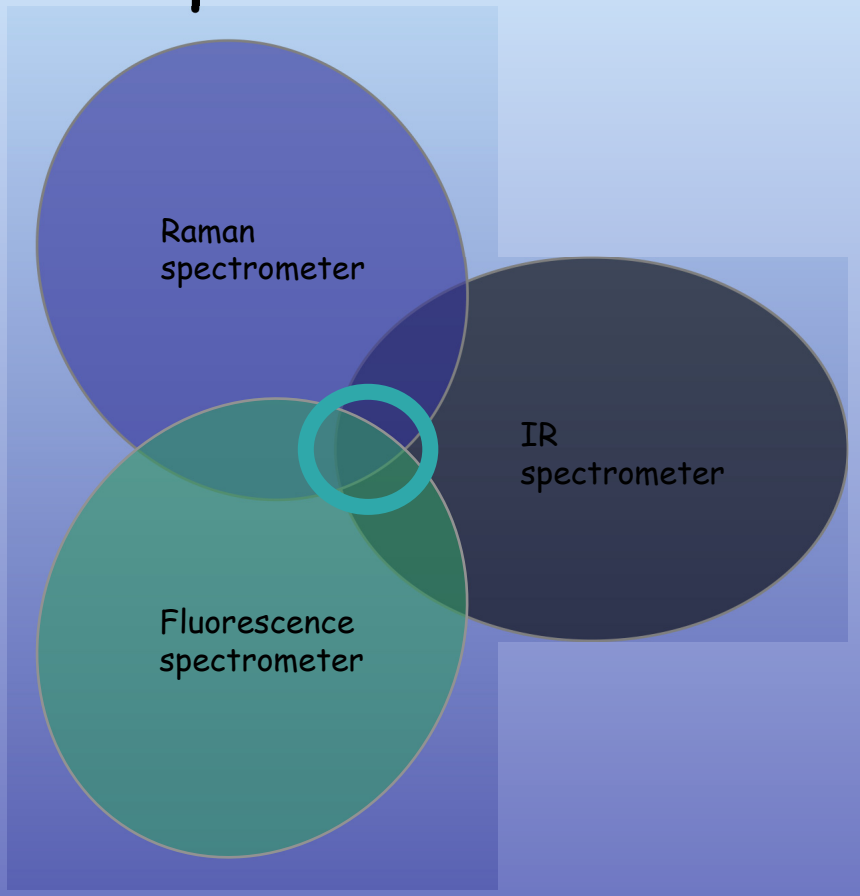


What is a that?

Combination of techniques:

- Raman spectrometer
- IR spectrometer
- Fluorescence spectrometer

taking advantage of the **synergy** of these individuals and well-known techniques to reduce uncertainties due to **low resolution** and **simple designs**.



How does it work?

It takes measurements

- of the same sample
- at the same spot
- at the same time

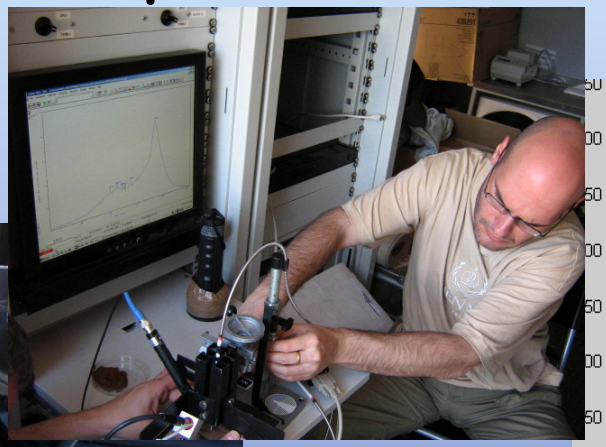
Advantages

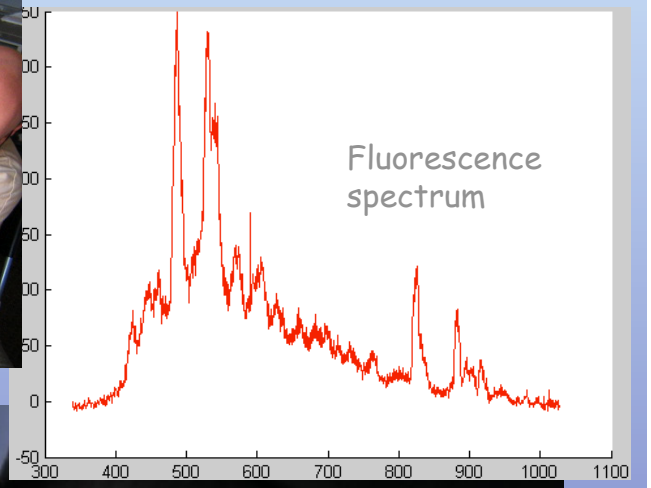
- Well-known techniques (use)
- Mature techniques (devices)
- Full catalog of materials
- To be easily miniaturized
- Robust

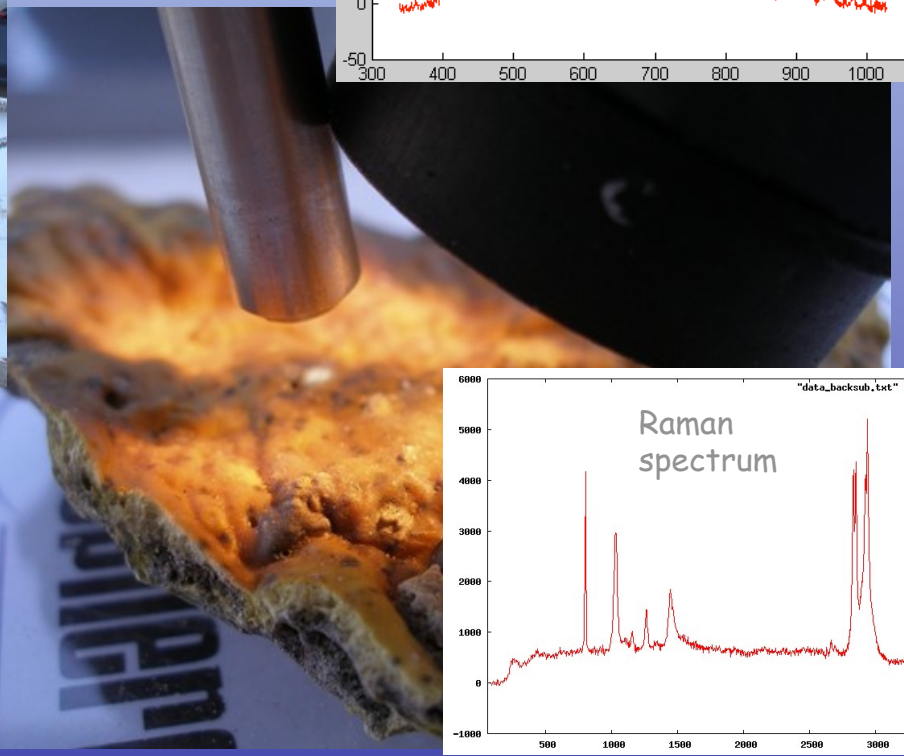
Disadvantages

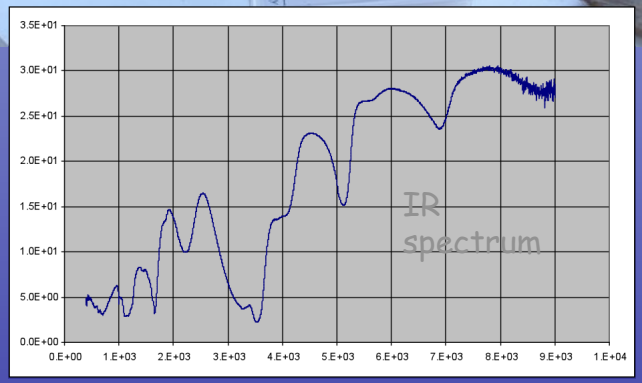
- High software capability is needed: needs to run a software to correlate each spectra. This processing might be done on Earth.

Tri-spec concept & field campaings

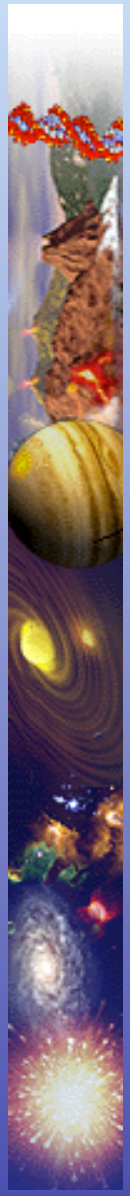








Technical aspects



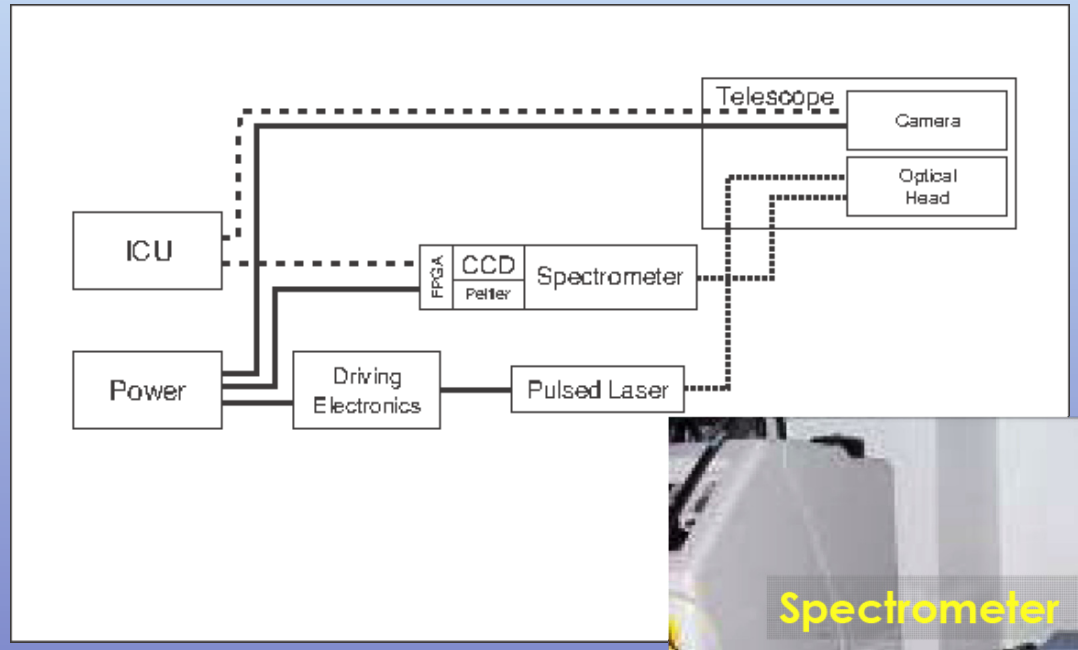
Major issues:

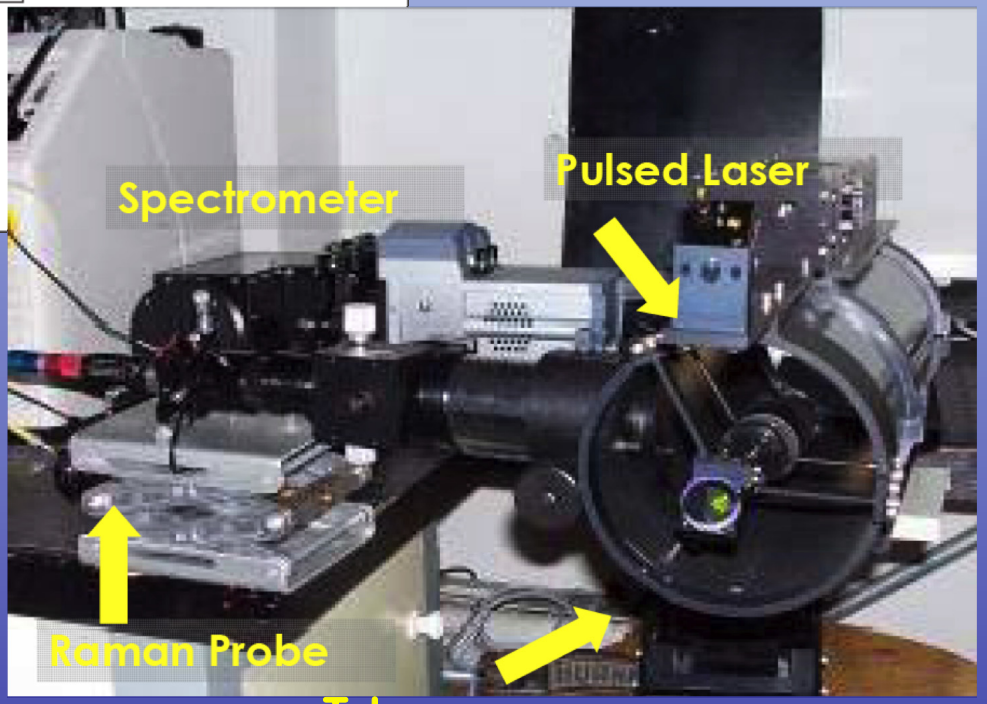
- The system would see high *g forces* (other impactors sent to Mars were designed for higher g impacts).
- Most of the elements are tiny and very rugged with no large masses.
- Optical elements have simple design involving fiber optic cables.
- Some designs include crushable materials to absorb some of the impact forces.
- Similarities with some military applications.

Concerns:

- There are a lot of uncertainties.
- Sterilization (PP).
- Radiation-hardness of the systems.
- Possible contamination of the landing site by thruster plume impingement.

Another concept: Raman for remote sensing

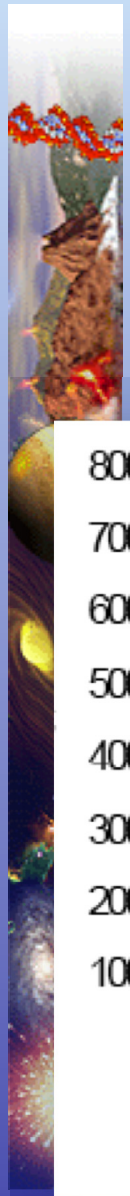


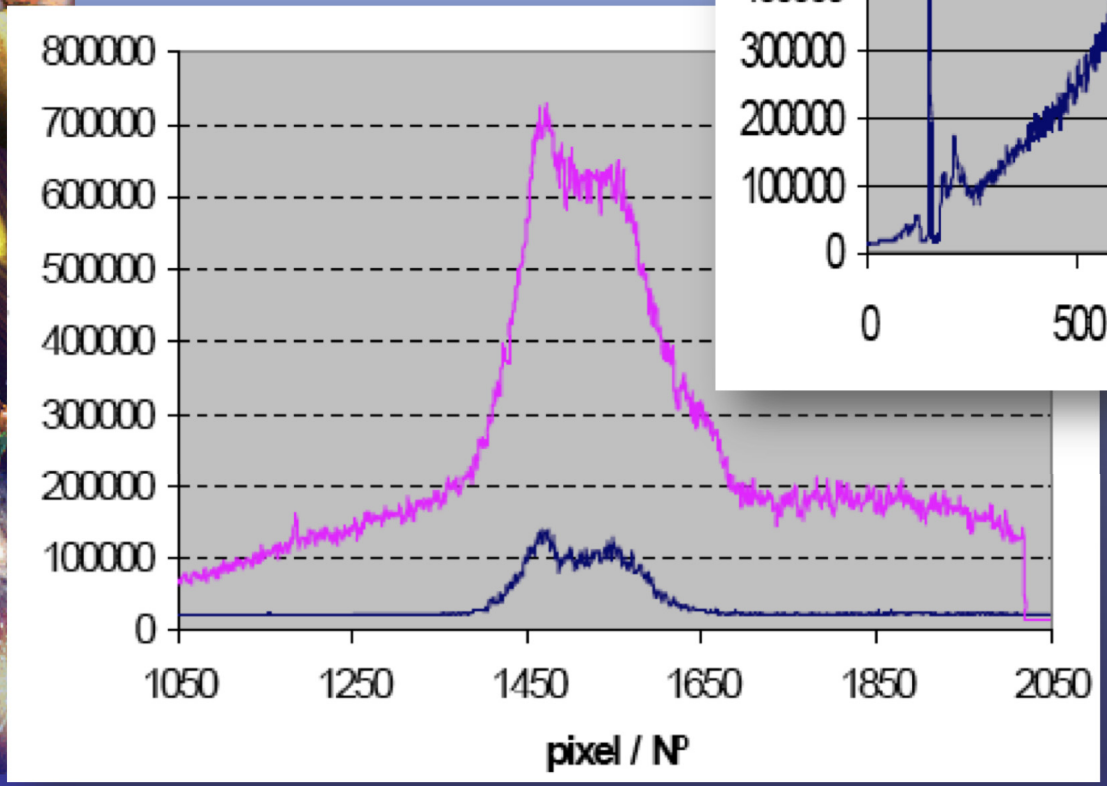


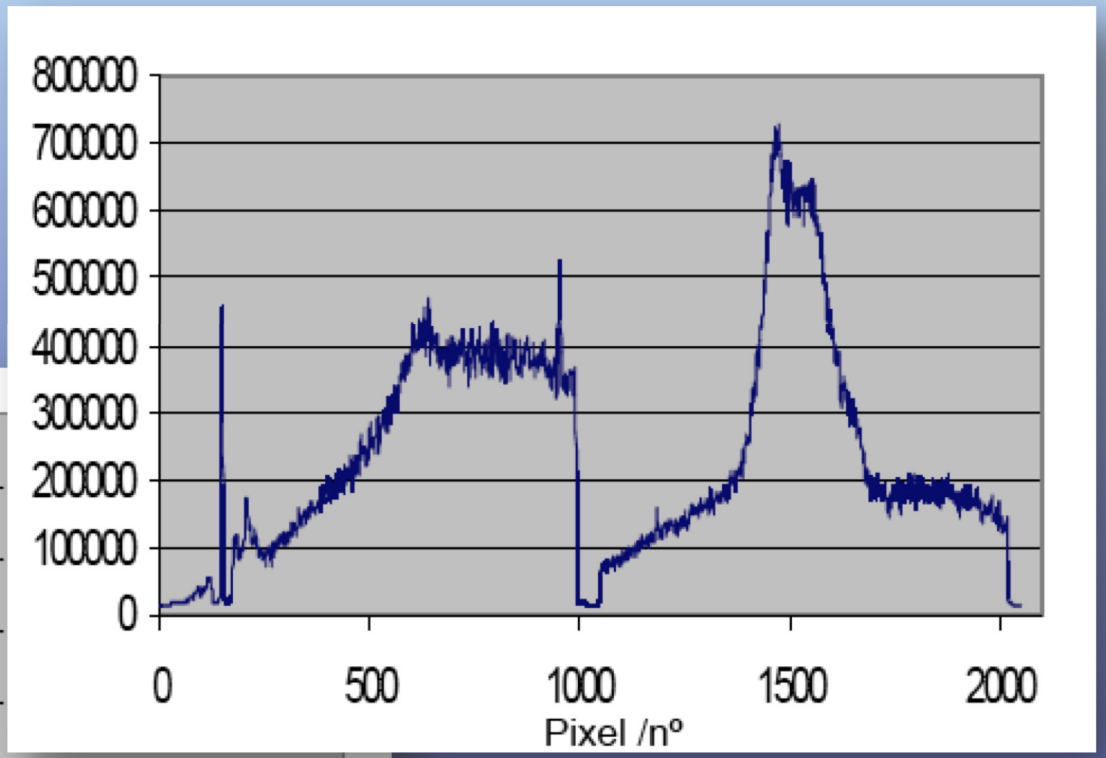
Another concept: Raman for remote sensing

Getting spectra on icebergs from a 20-25 m distance
(NASA-ESA AMASE Artic Expedition. 2007 & 2008)

Raman spectra of icebergs from a distance

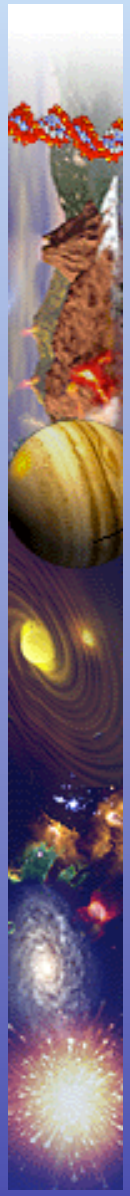






(Rull 2008)

Main conclusions



Raman spectroscopy: vibrational, rotational, and other low-frequency modes.

- Powerful technique for mineral and organics analysis.
- Potential tool for surface planetary exploration onboard rovers or landers.

Complementary information with Infrared and Fluorescence spectroscopy.

Specially interesting for detecting:

- Organics in any phase, even as inclusions
- Clathrate hydrates

  Characterization of the hydrates (guest gas, mixtures, crystalline structure)
- Phases of ice

Two compact **instruments** have been presented.

Special thanks to Prof. F. Rull and Dr. P. Sobron