Cryogenic Sample Acquisition and Delivery System (CryoSADS) for Titan and Europa

K. Zacny[1], R. Lorenz[2], F. Rehnmark[1], T. Costa[1], J. Bailey[1], N. Traeden[1], Z. Mank[1], J. Sparta[1]
[1]Honeybee Robotics, Pasadena, CA, zacny@honeybeerobotics.com
[2]APL-JHU, Ralph.Lorenz@jhuapl.edu

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Background

To date, a limited number of sampling systems have been developed for Europa and Titan. The optimal system would need to deal with a range of Europa's cryogenic materials: ice and salty ice, and Titan's cryogenic materials: ice, organic solids and liquids, and mixtures thereof. The other environmental constraints include hard vacuum, cryogenic temperature and significant radiation on Europa, and 1.5 bar atmospheric pressure and cryogenic temperature on Titan.
Most science instruments such as GC/MS, Raman, LDMS require subsurface samples in powdered form. CryoSADS is designed to reach samples 10-20 cm below the surface. Greater depths are possible with the addition of a longer drill bit.

CryoSADS consists of a deployment system, rotary-percussive drill, and pneumatic sample transfer and drop-off system. The Weight on Bit will be limited because of the low gravity and low spacecraft mass. To enable penetration into cryogenic material the hammer system will deliver ~2 J/blow at ~30 Hz.

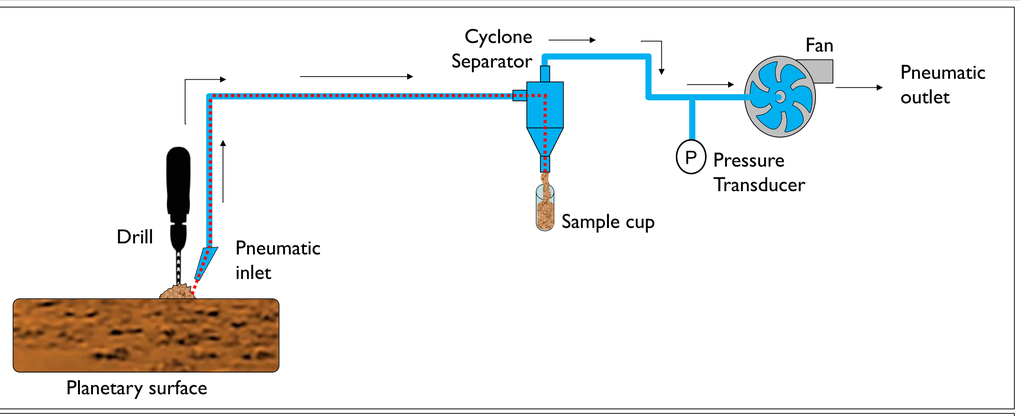
The game changer of the CrySADS is a pneumatic sample delivery. It allows extremely fast sample transfer to an instrument while minimizing heating of the sample itself and never relying on gravity. The instrument can be placed at some distance from the sampling system since the connecting transfer tube can be routed around the other hardware elements.

The gas options include compressed gas from a dedicated tank for Europa's probe and a suction blower for Titan's probe. On Europa the sample is 'blown' into an instrument by compressed air ("air gun" approach) while on Titan the sample is 'sucked' because of lower pressure generated by an impeller ("vacuum cleaner" approach).

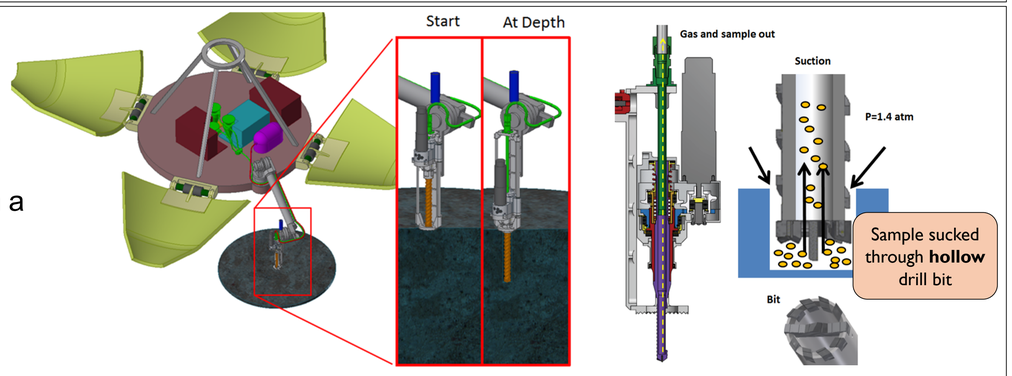
Pneumatic Sample Acquisition

Pneumatic: Suction (Titan)

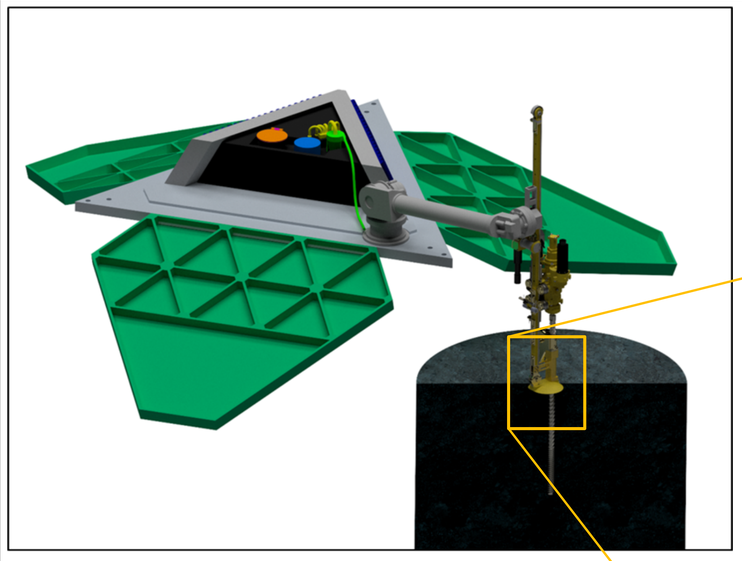
Pneumatic decoupled from drilling

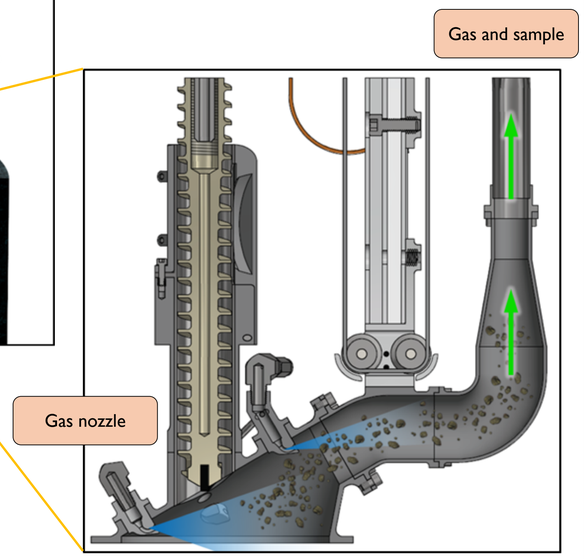


Pneumatic coupled with a drill



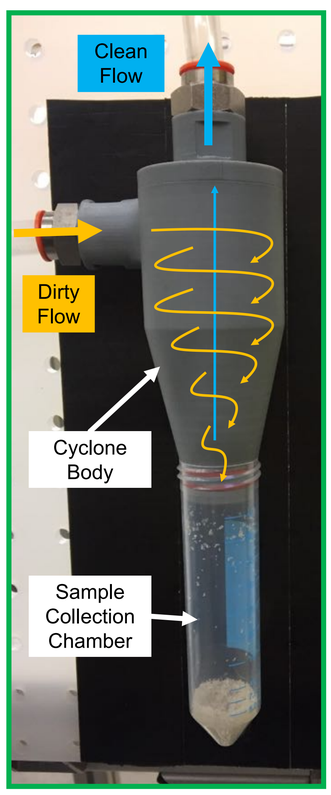
Pneumatic: Compressed Gas (Europa)



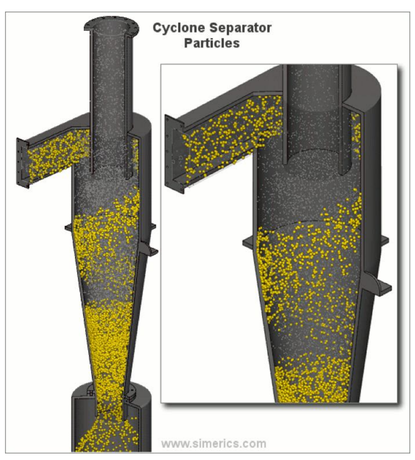


Pneumatic Sample Delivery

Cyclone Separator



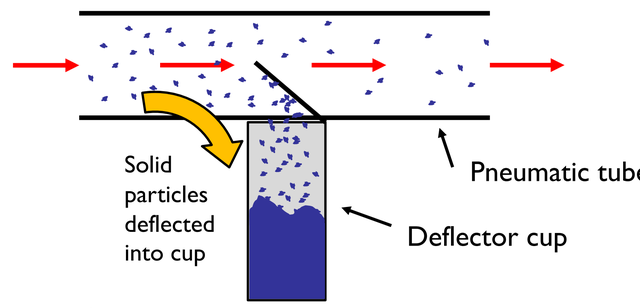
- Creates gas vortex or "cyclone" which separates particles from gas
- Depends on gravity for final delivery into cup
- Bulk collection – widely used in industrial conveying
- Requires metering for some instruments
- More efficient with DRY material
- **Uncollected mass is stuck inside system**



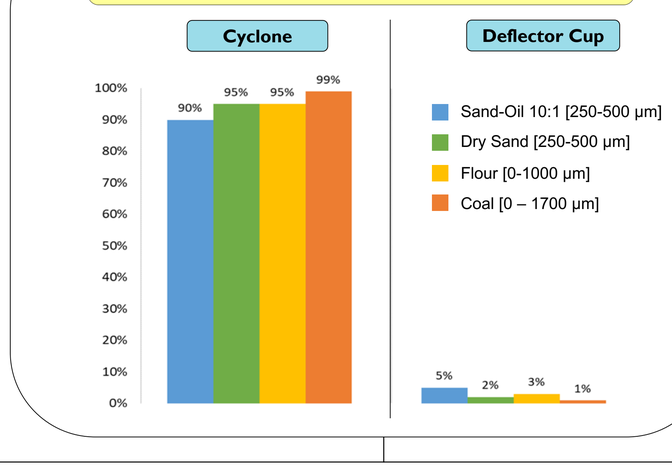
Deflector Cup

Key Differences:

- Deflects particles into cup using mesh
- **Gravity independent**
- Clean / minimal cross-talk between samples
- Sample metering – fills the cup with set volume
- More efficient with STICKY material
- **Uncollected mass is expelled to the outside**



$$\text{Collection Efficiency} = \frac{\text{mass collected in sample cup}}{\text{mass of sample ingested by pneumatic system}}$$



Looking from above:

Looking down the tube: