



Planet Enterprises

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this incredible opportunity.



NIAC

NASA Innovative Advanced Concepts

Mission Context:

- Drill 50 m into the Mars South Polar Layered Deposits (SPLD)
- Analyze and cache ice cores; analyze and log borehole wall

Extended Mission Goal:

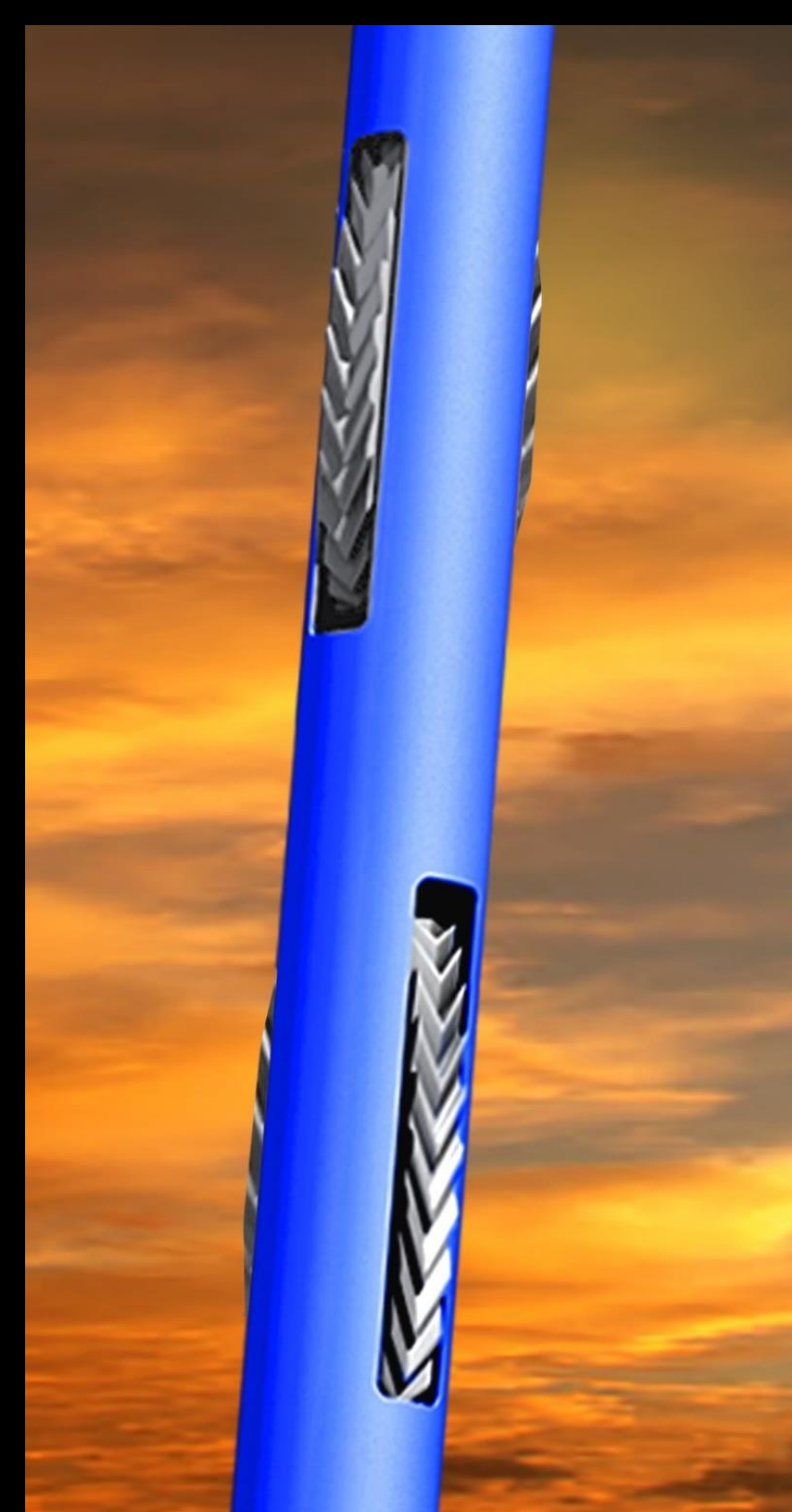
- Drill 1.5 km, access subglacial lake (or basal unit)

Innovation:

- Self-driving robots (borebots) drive up and down the borehole

Autonomous Robotic Demonstrator for Deep Drilling (ARD3)

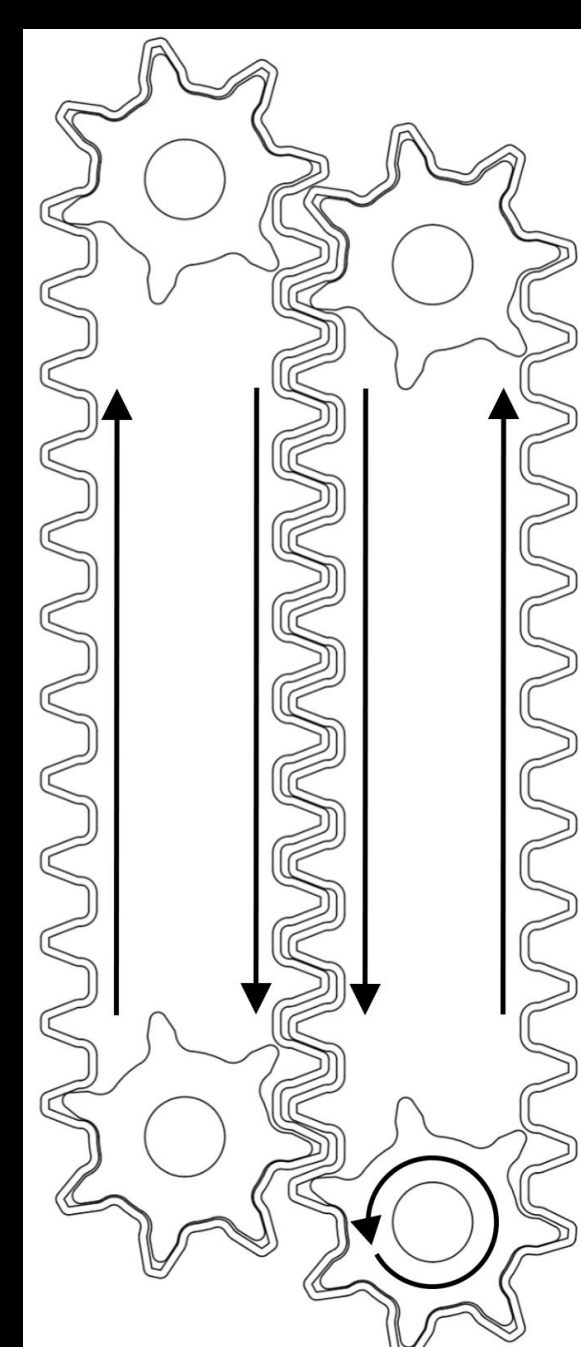
NIAC Phase I Study



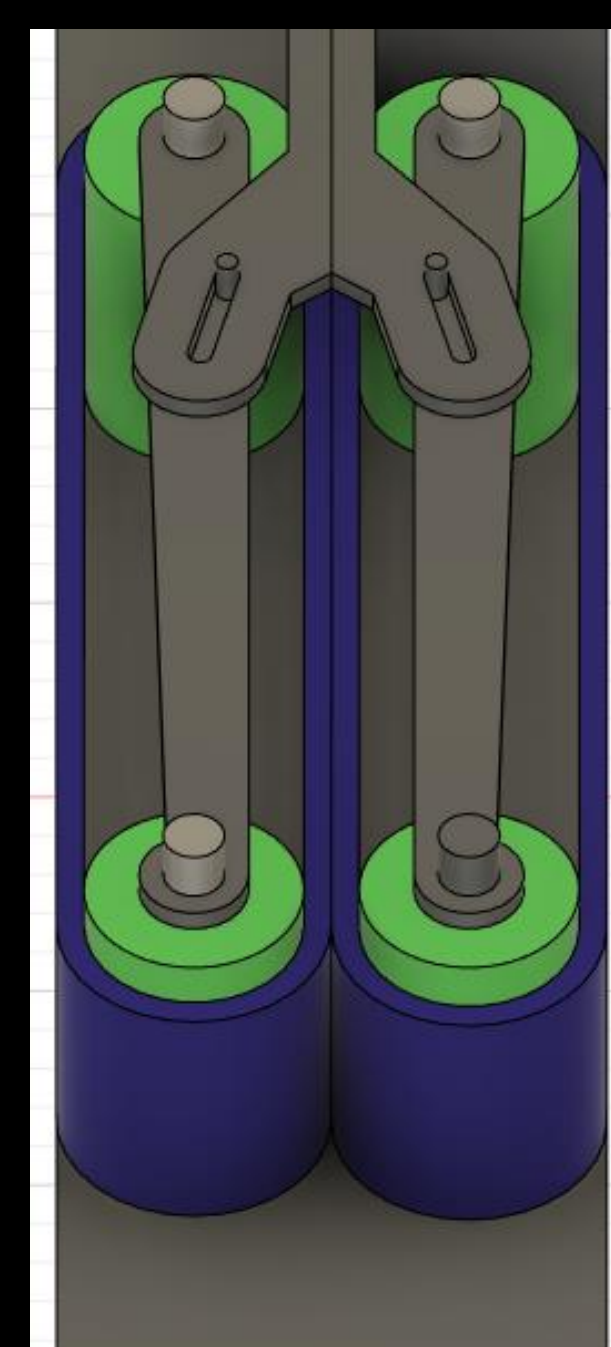
Tracks are flexible ring gears

Drivetrain components remixed from: Lalish, Emmett. 2013. "Gear Bearing." thingiverse.com/thing:53451

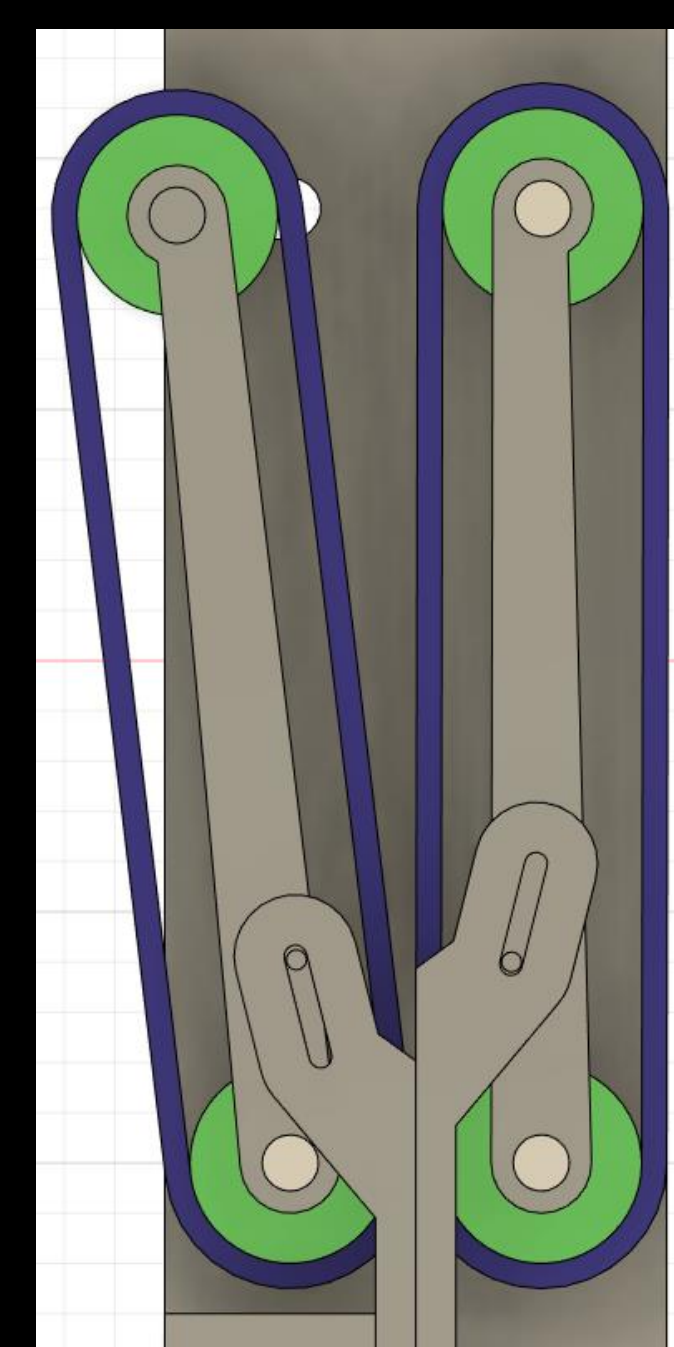
Borebot Drivetrain



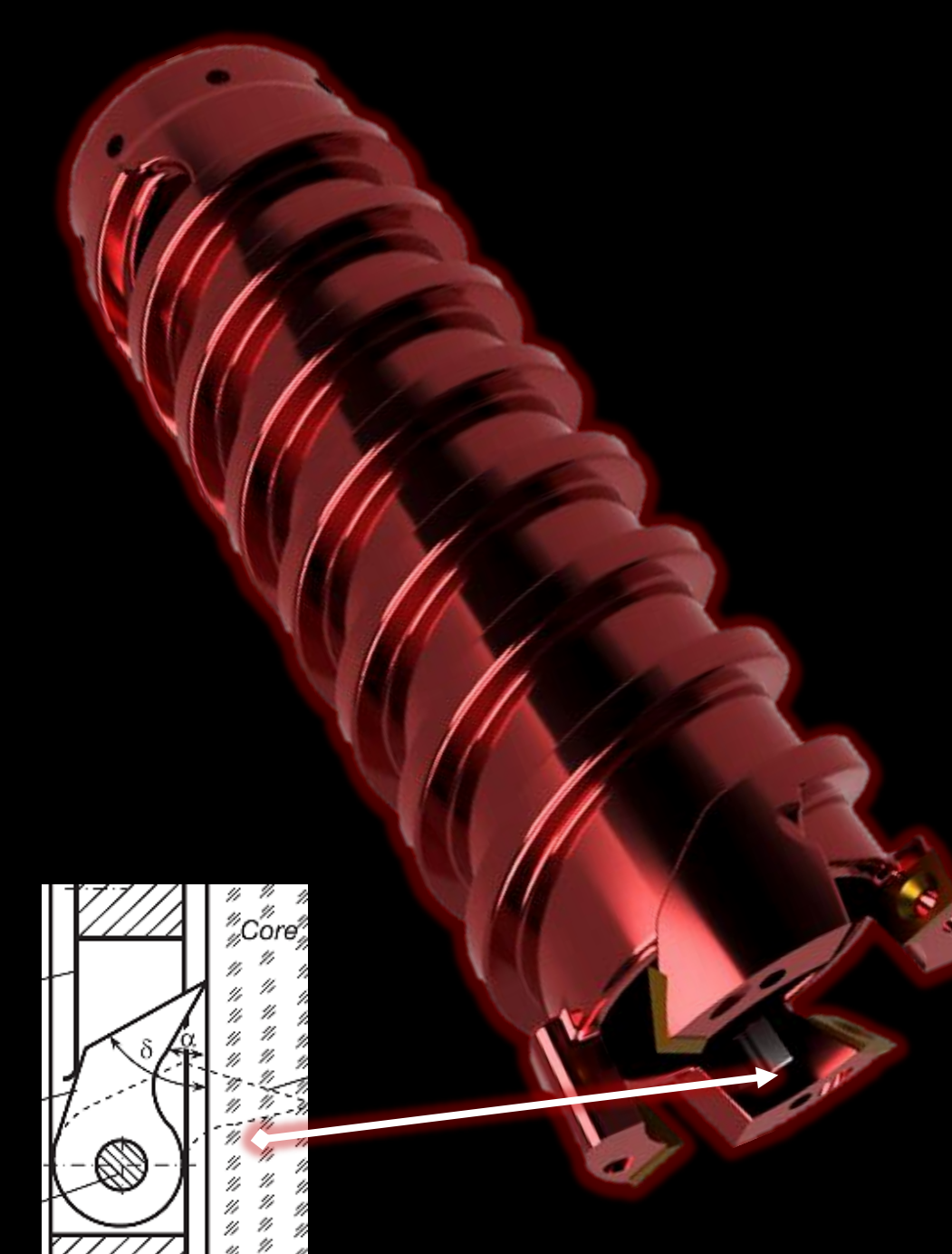
Flexible components for resiliency



Directional drilling innovations



Modular Drill Heads



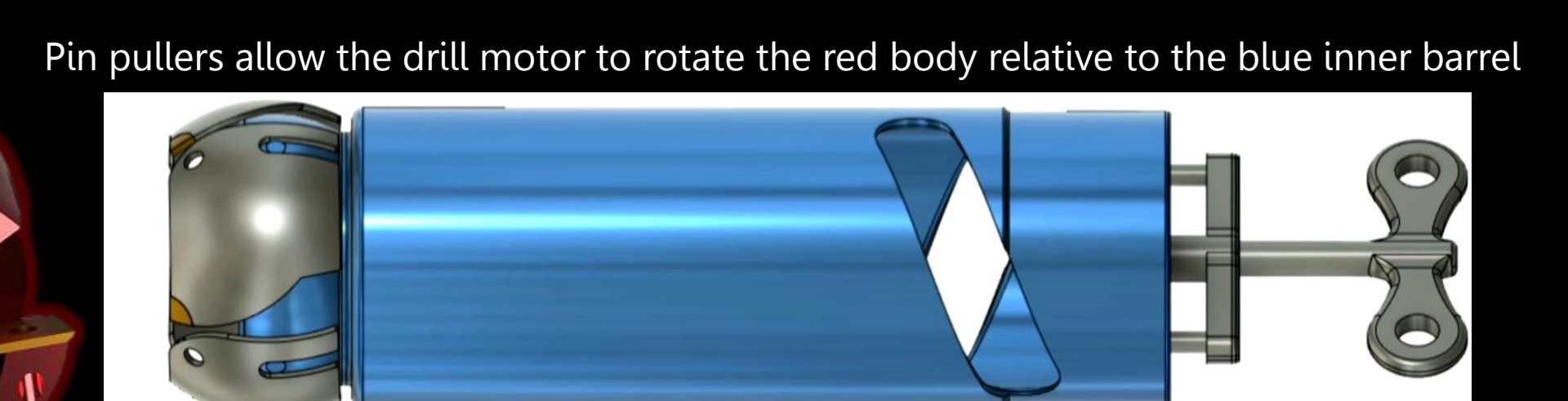
Simple and efficient for clean ice

Talalay PG. 2014. "Drill heads of the deep ice electromechanical drills."
doi:10.1016/j.coldregions.2013.09.009



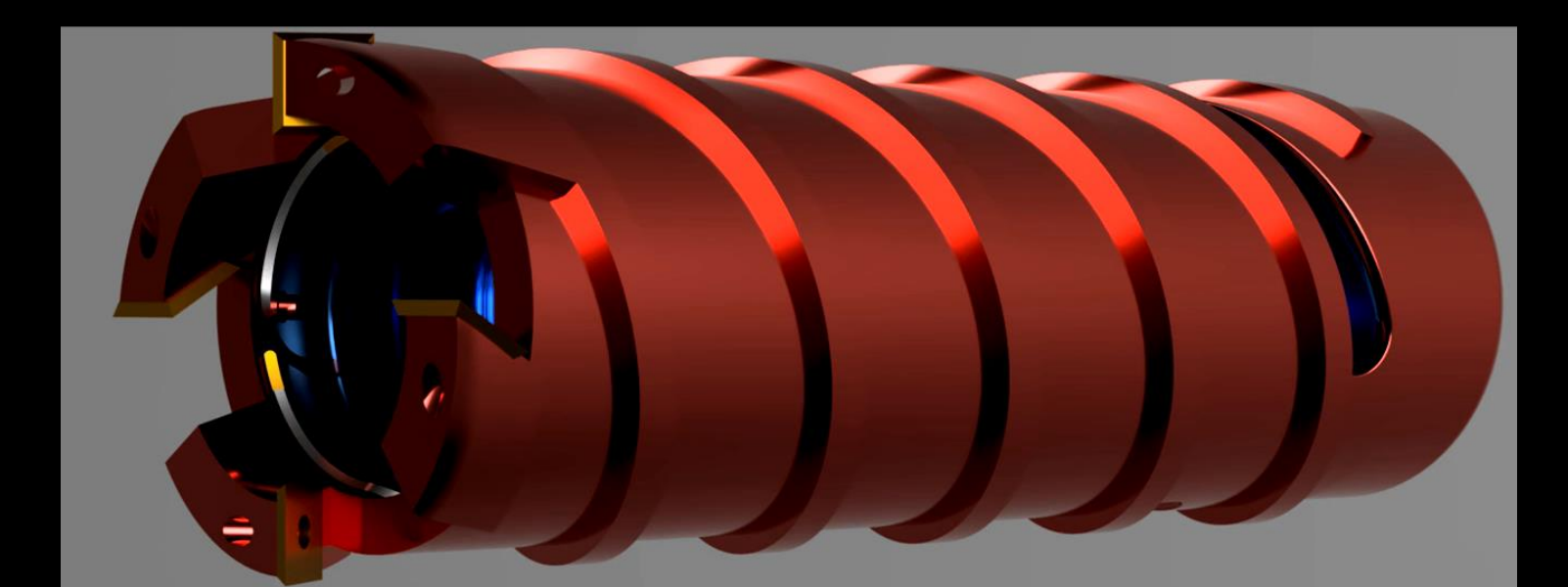
Iris closure innovation for high dust content / crumbly cores

Iris remixed from: Lalish, Emmett. 2016. "Preassembled Iris Box."
thingiverse.com/thing:1811143



Pin pullers allow the drill motor to rotate the red body relative to the blue inner barrel

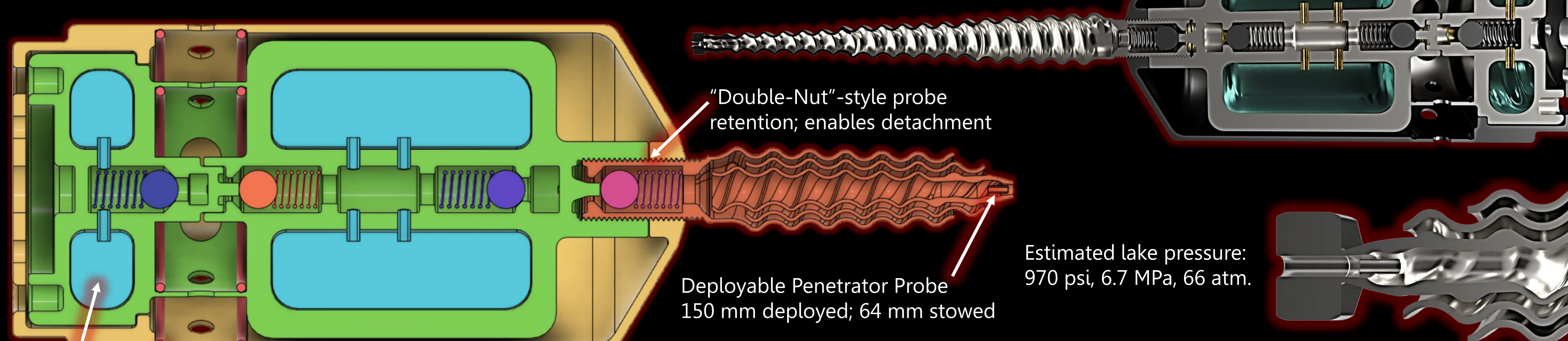
.mp4 video available at <https://git.io/JsPov>



.mp4 video available at <https://git.io/JsKah>

Water Sampler / Penetrator Probe

To simplify the process of breaking through into subglacial liquid environments, we developed a penetrator probe instrument to perform the final subglacial access and extract a liquid water sample. Our calculations show that the ice thickness prior to "normal" breakthrough can be as little as 4 cm.



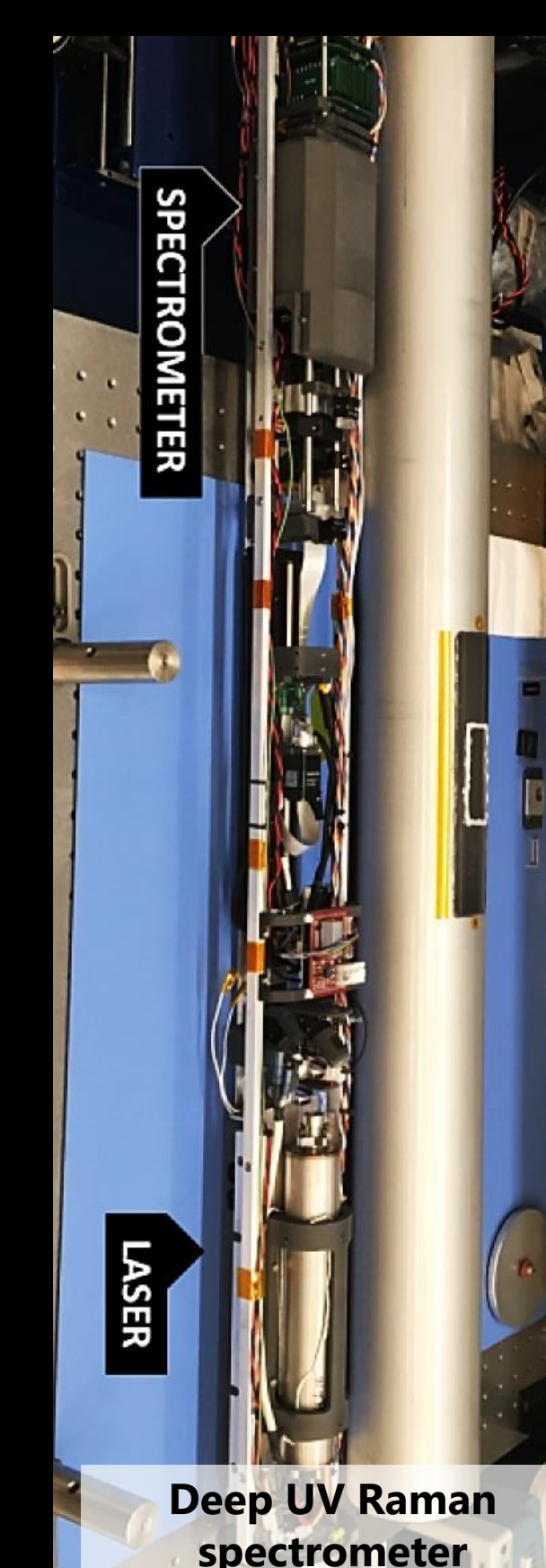
- Penetrator Probe
- Water Bladders
- Inner Barrel
- Outer Barrel
- Sample Access Valve
- Main Bladder Valve
- Separation Valve
- Failsafe Bladder Valve
- Failsafe Sample
- Primer Cord for Failsafe Separation

- The Penetrator Probe deploys in-situ via counter-rotation of the borebot drill motor
- 10 mm shear-nut ensures proper torque for deployment and "setting" of the telescoping sections of the probe (this friction fit is critical), the nut breaks off when torque is reached
- A "nut pocket" on the rover's arm/chassis can hold the nut during deployment

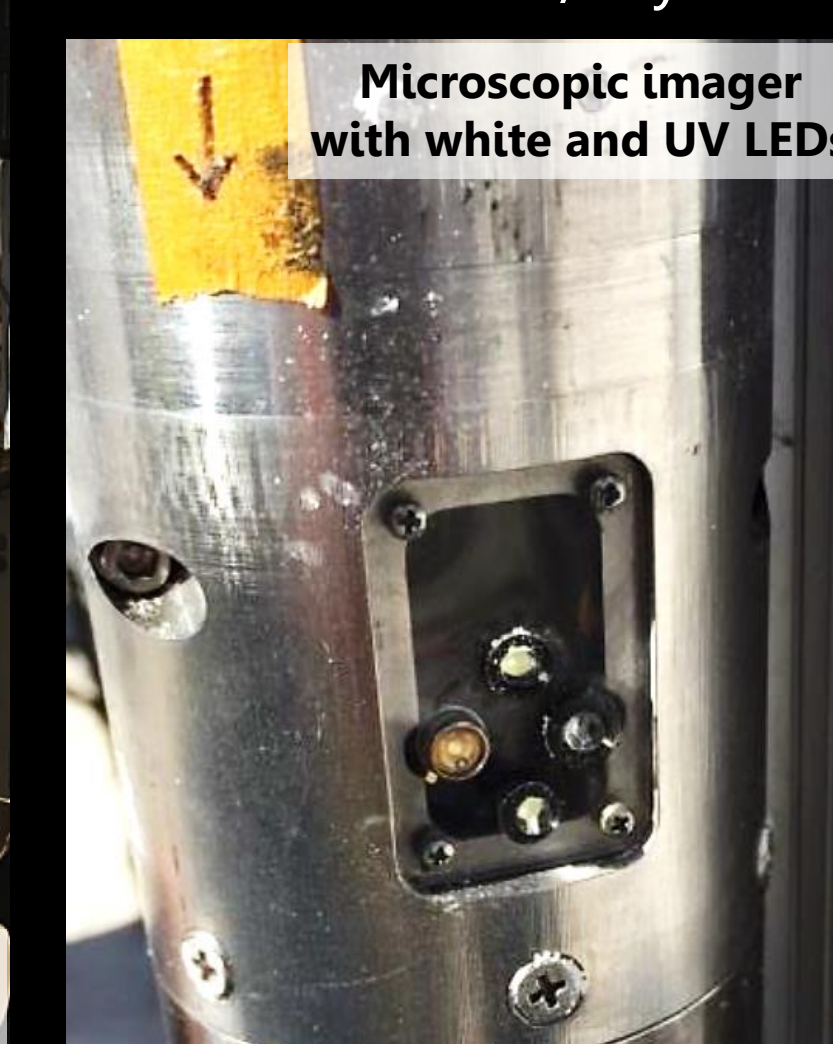
Science Instruments

Downhole Instruments

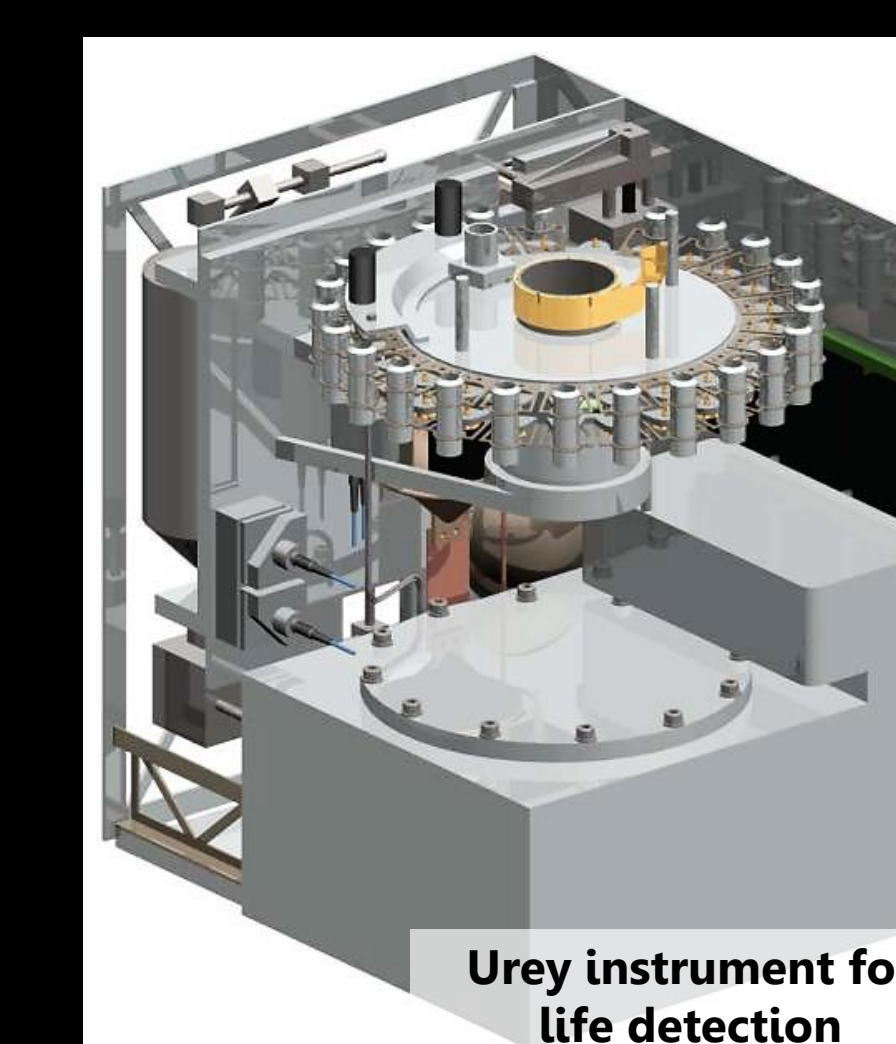
- Microscopic imager (white/UV)
- Spectrometer (deep UV)
- Conductivity/Eddy current
- D/H hydrogen measurement
- Sonar for ice / layer thickness



Eshelman, M. et. al. 2019. "WATSON..."
doi:10.1089/ast.2018.1925



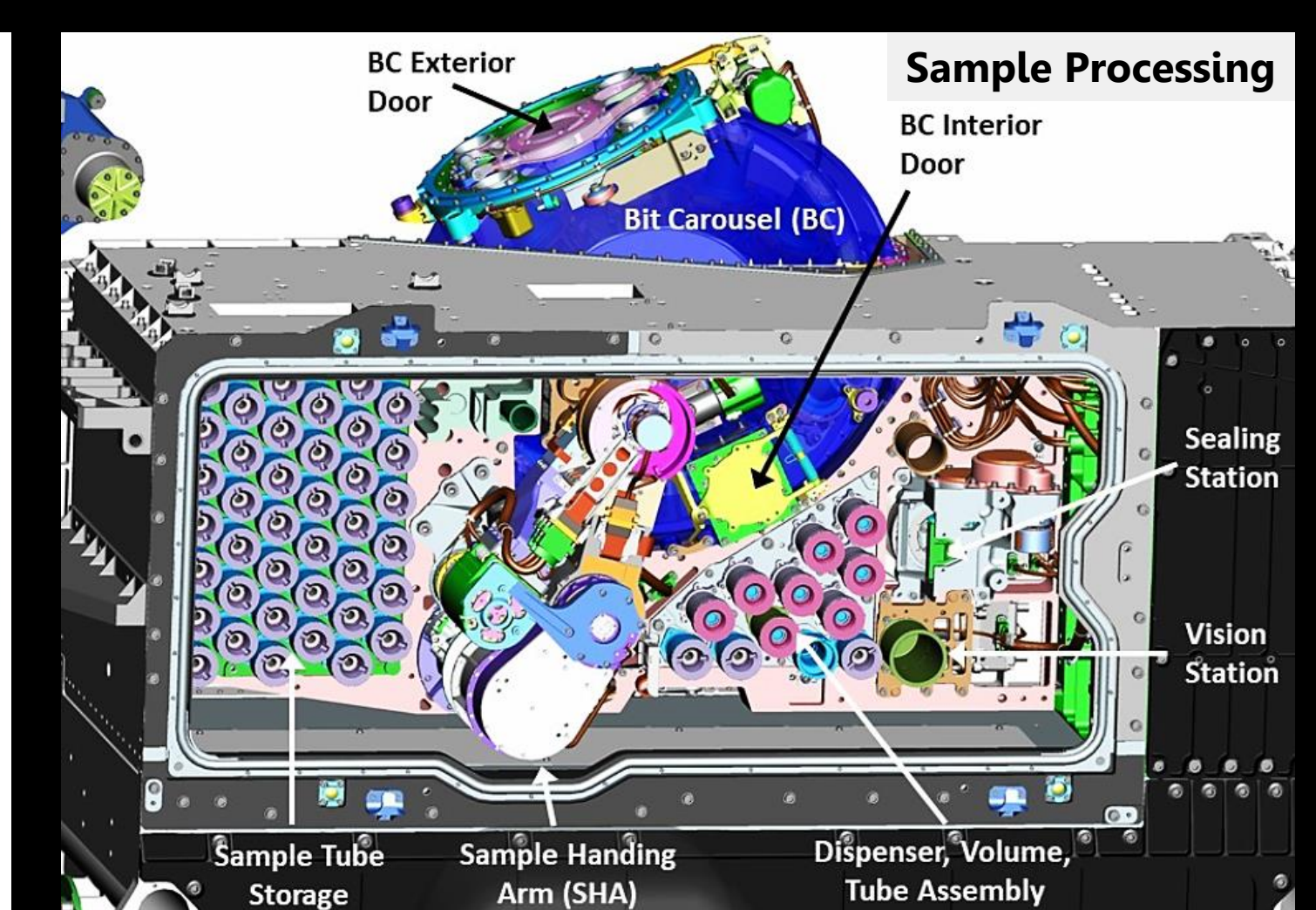
Zacny, K. et. al. 2016. "Development of [PDD]"
doi:10.1061/9780784479971.027



Aubrey, Andrew D., et. al. 2008. "The Urey Instrument..."
doi:10.1089/ast.2007.0169

Rover Instruments

- The Perseverance Adaptive Caching Assembly (ACA) is used
 - ↳ Handoff from ACA to internal rover science instrument payload
- The "Turret Corer" tool is relocated from robot arm to rover chassis
 - ↳ Coring tool "re-cores" ice cores to extract a pristine core center



Boeder & Soares, 2020. "Mars 2020: mission..."
doi:10.1117/12.2569650

