# INSPIRE

## *Interplanetary NanoSpacecraft Pathfinder In a Relevant Environment*

*Low-cost mission leadership with the world's first CubeSat beyond Earth-orbit*

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*University Partners:*
- *U. Michigan – Ann Arbor*
- *Cal Poly - San Luis Obispo*
- *U. Texas – Austin*

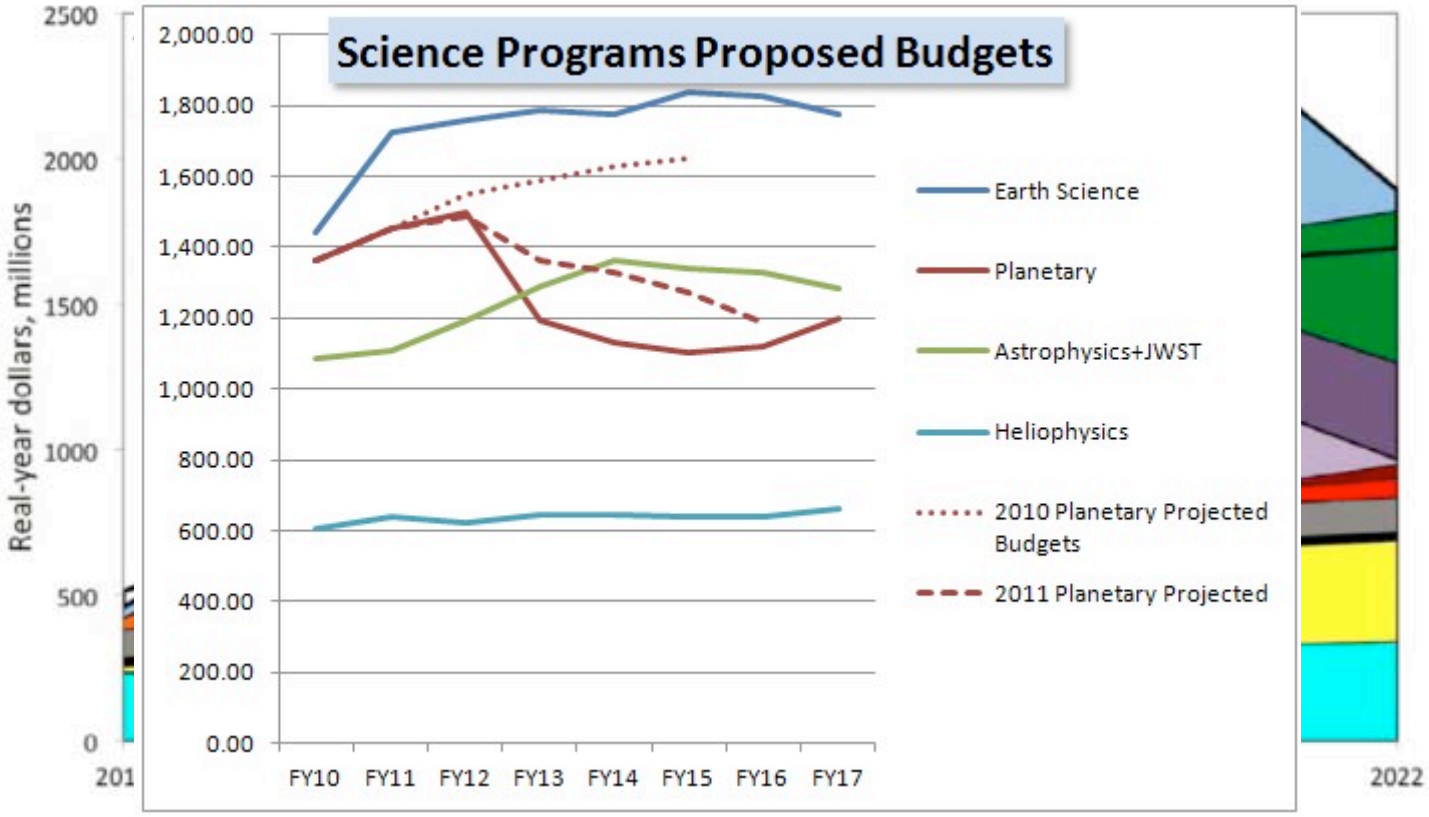
*Collaborator:*
- *Goldstone-Apple Valley Radio Telescope (GAVRT)*

Jet Propulsion Laboratory
California Institute of Technology
CAL POLY GAVRT MICHIGAN THE UNIVERSITY OF TEXAS AT AUSTIN

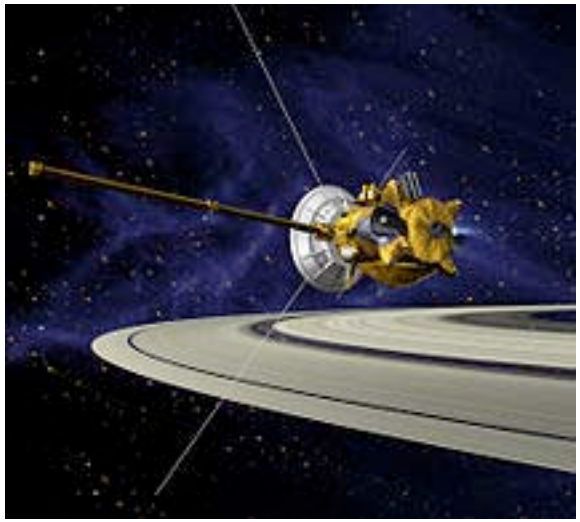
# Currently Flying Overhead…

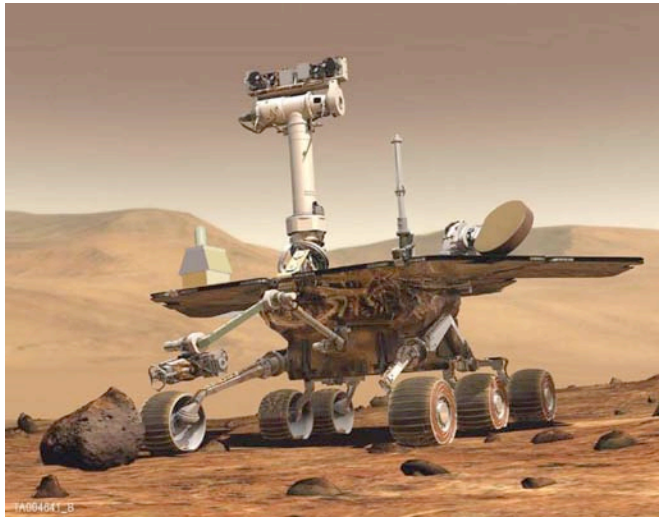
- MSL, Cassini, Dawn – Worth many CubeSats!

  + more than 25 other missions JPL is involved in (Voyager is still performing science!)

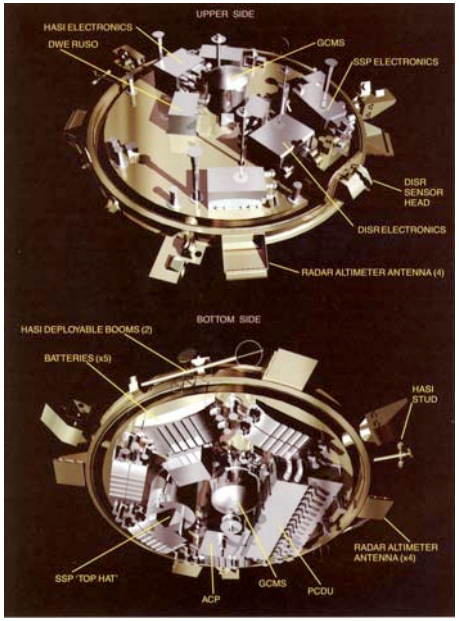


# But JPL does BIG things!





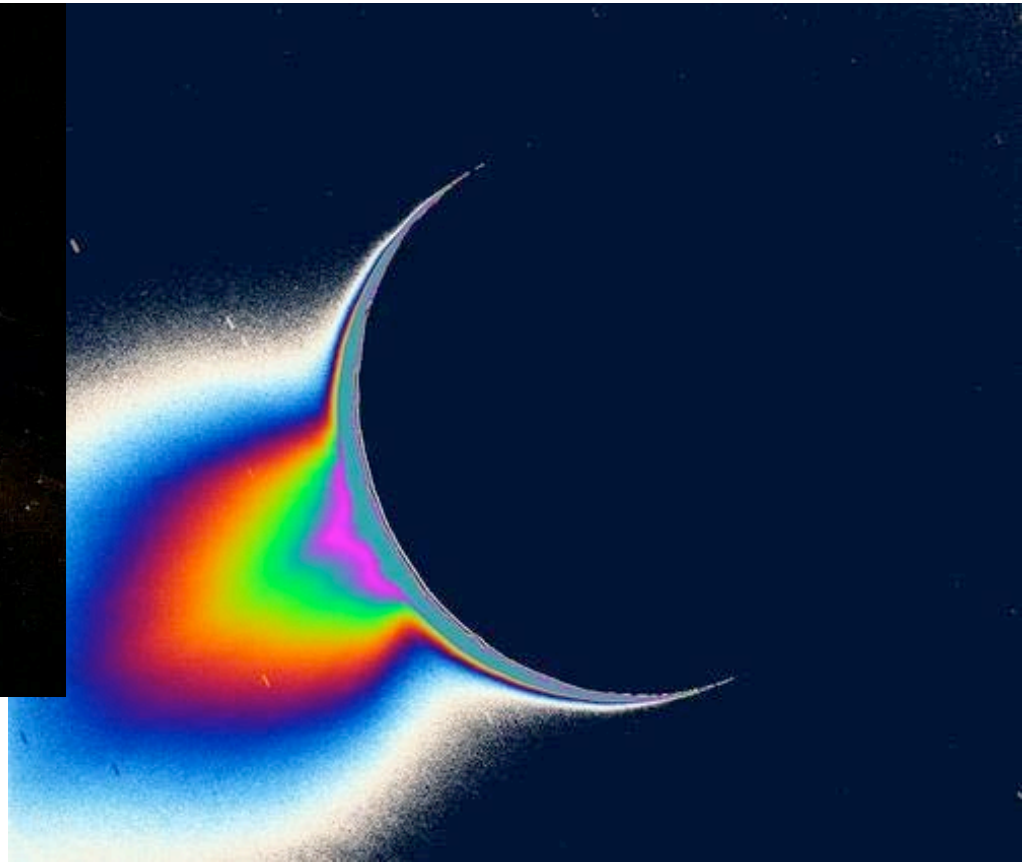
…. Except for these:



# It's a Scary Solar System

- NanoSatellites may be useful at other places in the solar system

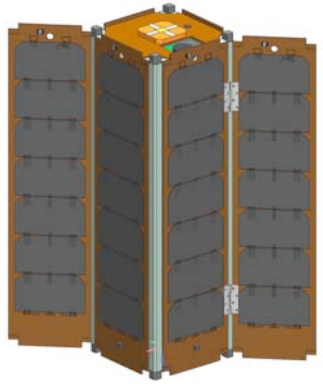
- Is there compelling science enabled by this platform?



# Fact Sheet

**INSPIRE would enable a new class of interplanetary explorer, while providing components to reduce the size and cost of traditional missions**

## Mission Objectives

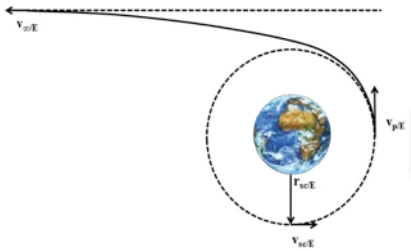


- Demonstrate and characterize key nano-spacecraft telecommunications, navigation, command & data handling, and relay communications for mother-daughter
- Demonstrate science utility with compact science payload (1/2U Helium Magnetometer and combination Star-Tracker/Imager)
- Demonstrate ability to monitor and power cycle COTS/university processing systems

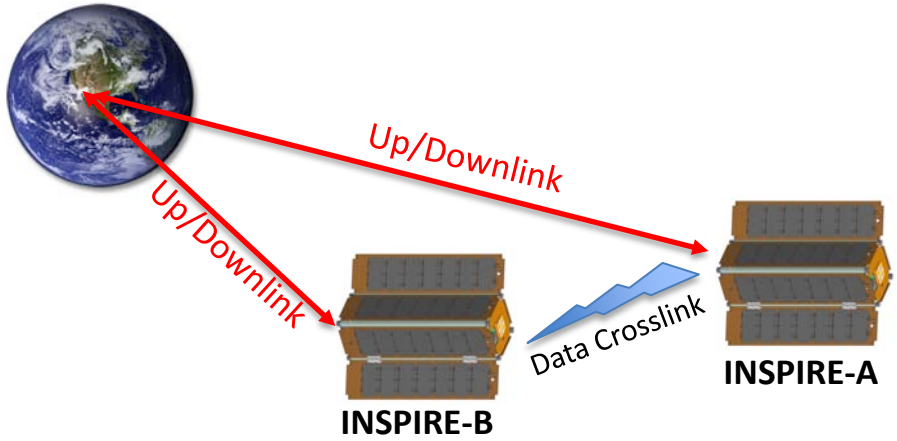
## Mission Concept

- JPL-built spacecraft; collaborative partnerships with Michigan, Texas, and CalPoly/Tyvak for COTS processing systems. Ground stations at U. Michigan and Goldstone with DSN compatibility

**Nominal:**
CLI Launch:
Ready by
Summer 2014

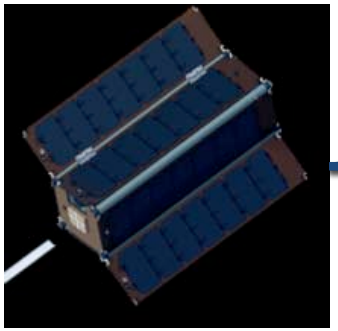


**Nominal:**
Deploy to Escape

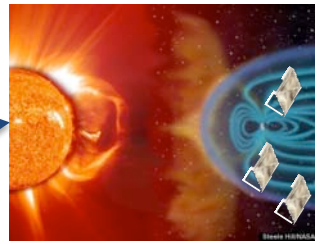


# Opportunities

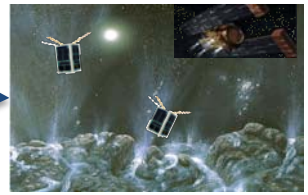
**Why do this?** NASA and JPL have identified high-value science applications using Nano s/c



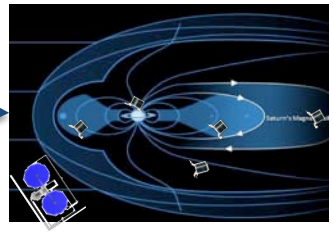
**INSPIRE Mission**



**Low-Cost Heliophysics:** Constellation of 50 standalone 10 kg spacecraft to monitor the solar wind 3D structure at Sun-Earth L1.



**Supplemental Science:** Sacrificial probes used to scout plume passage or descend into high magnetic fields.



**Enabling Novel Science:** Use multiple nano s/c to allow for distributed flybys, capturing multiple vantage points simultaneously.

**These innovative science applications can only be enabled through the development and demonstration of critical gap-filling nano-s/c technologies.**

# Design Overview

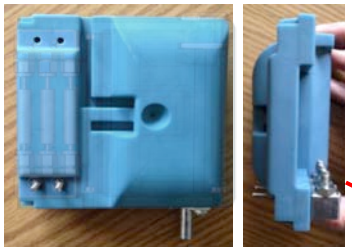
**CubeSat Overview:**
**Volume:** 3U (10x10x30cm)
**Mass:** 3.8 kg
**Power Generation:** 20 W
**Data Rate:** 62-64000 bps

**Software:**
Developed in-house

**I&T:**
In-house S/C I&T, CalPoly P-Pod/Launch Integration

**Operations:**
DSN, DSS-13 (JPL), & Peach Mountain (U. Michigan)

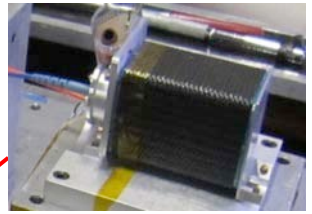
S/C components would provide ***the basis for future high-capability, lower-cost-risk missions*** beyond Earth expanding and ***providing JPL leadership in an emergent domain***



**Cold-Gas ACS** (U. Texas)

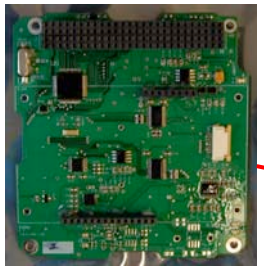
**UHF Antenna**

**X-Band Patch Antennas** (JPL) [two sets]

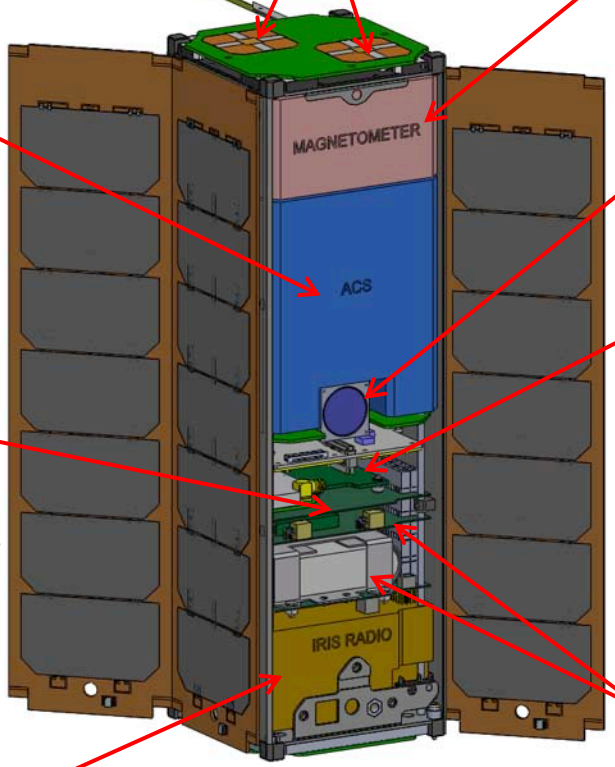


**Magnetometer** (JPL)

**Star Tracker** (Blue Canyon)

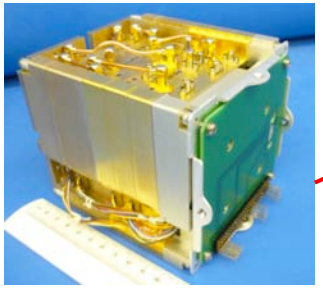


**C&DH + Watchdog Board + Lithium UHF** (U. Michigan)

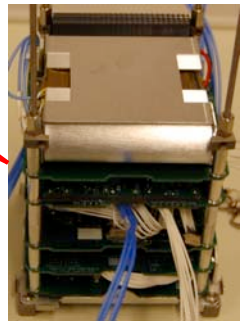



**Deployable Solar Panels + Structure** (Pumpkin)

**Processing Board** (CalPoly)

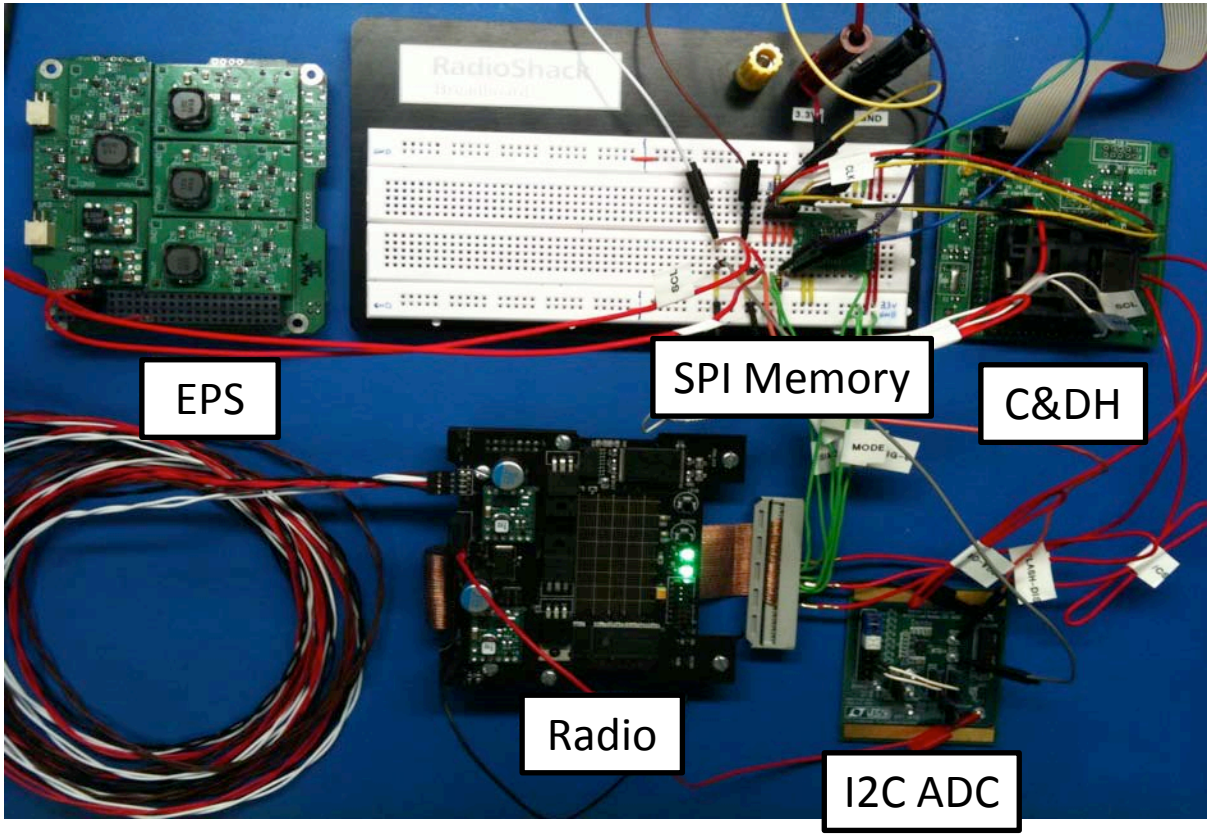


**Nav/Comm X-Band Radio** (JPL)



**Electrical Power System + Battery Board** (U. Michigan)

# Current Flat-Sat Development

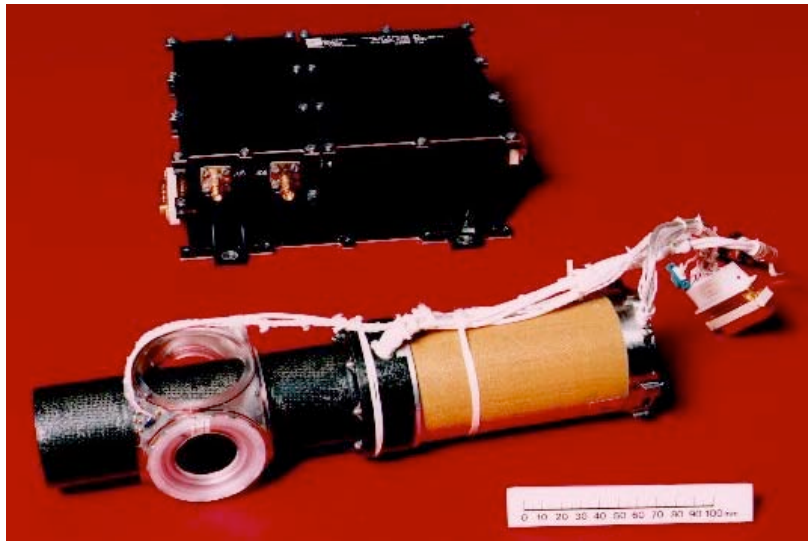



**Current Status:**

- Selected by the CubeSat Launch Initiative
- Flight Software interfaces to development components and external computer via CCSDS (DSN compliant & utilizes existing NASA Advanced Multi-Mission Operations Software)
- Partners are preparing prototype units to be integrated this summer. Interns from partner schools will be on site at JPL and involved in prototype I&T.
- Currently designing mechanical and electrical interfaces between subsystems.

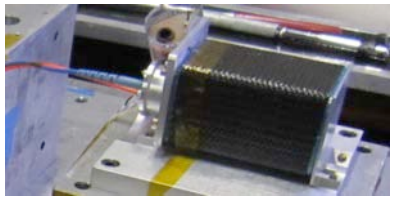
# JPL Helium Magnetometers

- Derived from a long heritage of Helium magnetometers at JPL
  - Stable and accurate
  - Vector and scalar mode
  - Traditionally heavier than fluxgate systems

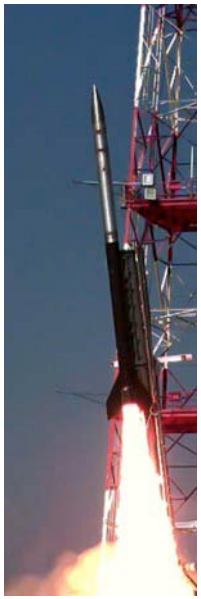


Cassini S/VHM (0.8kg sensor, 3kg electronics)

- Recent developments aimed at an instrument for high-radiation environment
  - Laser-pumped helium magnetometer, compact sensor, new digital electronics (in partnership with UCLA)
  - Achieved significant mass reduction (sensor 300g, electronics 1 board)
  - Tested on the Dynamo sounding rocket mission in June 2011 – next flight June 2013
  - Compact system retains the stability and accuracy of the heritage systems
  - ½ U formfactor at ~0.5kg



CVHM sensor during vibration testing



# Lessons Learned

- NASA's Deep Space Network is interested in supporting NanoSpacecraft missions and the CubeSat community
  - Investing in a low-cost "CubeSat" version of NASA Advanced Multi-Mission Operations System.
- Everyone is learning in the CubeSat community
  - Collaboration is key. JPL has deep expertise in certain areas, but the CubeSat community has developed (and flown) incredible capability.
- Interplanetary missions are not Earth-orbiting
  - 8-hour passes, position is not provided, no magnetic field, more high energy particles, no eclipse,
- Heliophysics and planetary scientists are excited about mission possibilities with NanoSpacecraft
  - INSPIRE would examine solar wind turbulence, as two spacecraft would be located close together.

# Conclusions

- Deep space NanoSpacecraft are scientifically compelling – but they must be proven before PI / reviewer acceptance
- INSPIRE would demonstrate survivability, navigation and communication utilizing the CubeSat platform, and in partnership with the CubeSat community
- INSPIRE is partnering with the CubeSat community to extend capabilities to deep space
  - Peach Mountain and DSS-13 receive stations
  - Robust low-power C&DH
  - Monitored high-power processing
  - 3-axis cold-gas system
- JPL is developing novel technologies to support these and future missions
  - X-band Nav/Comm radio
  - Vector-Helium Magnetometer
  - DSN Compatible Ground Data System and Flight Software