VISTA:
Volatile In Situ Thermogravimetric Analyser

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VISTA goals I

The Volatile In Situ Thermal Analyzer (VISTA) is a micro thermo gravimetry analyzer for the Marco Polo mission

The VISTA main goals are to:

1. measure the volatile (organic, bounded water) and content of the finest fraction of the asteroid regolith.
2. monitor the possible cometary–like activity detecting the volatile, or dust, spontaneously released by the asteroid.
3. asses the contamination produced by the landing/sampling processes

VISTA goals II

VISTA can be fruitfully applied to requirements that are mandatory for the Marco Polo mission. Cited from the SRD

- Other requirements
  - *OR-20: The sampling device shall contain a sensor to ensure that a suitable sample was taken, giving a rough estimate of the volume or mass of the sample*
- Sample requirements, ***Contamination:***
  - *SA-090: During collection and storage (departure from NEO, cruise, Earth re-entry, ground retrieval and transfer to curation facilities) the sample shall be maintained free of organic and particulate contamination. The number of contaminating molecules deposited on the asteroid surface by the propulsion system shall be lower than 10^{14} cm^{-2} (goal 10^{13} cm^{-2}).*
  - *SA-120. The possible contaminants (e.g. propellant, S/C outgassing, etc.) should be tracked in situ (e.g. witness plates).*

Marco Polo Target & VISTA

Asteroid 1999 JU 3

- Cg-type → high abundance of organics
- 0.7 μm feature → hydrated minerals

Hence

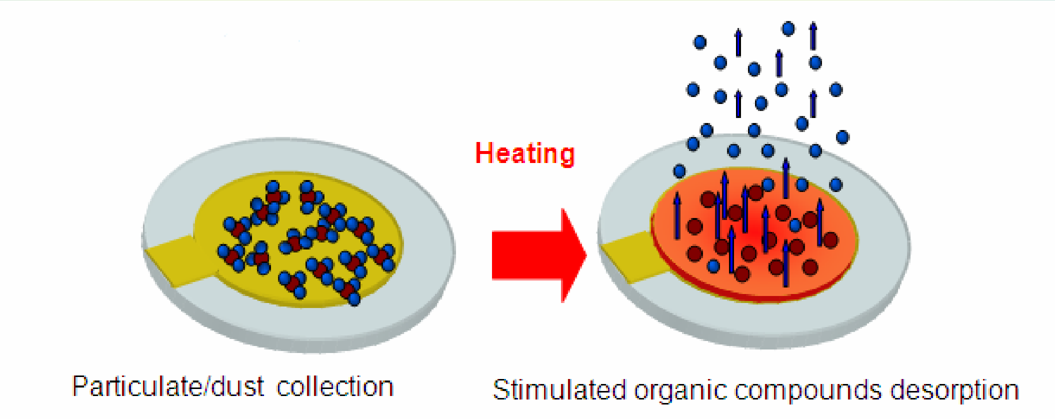
- High-temperature TGA can detect both organics and desorbed water
- Low-temperature TGA can monitor the propellant contamination
- Cometary-like activity

TGA: Basic principles

The instrument is based on the principles of the **Thermo-gravimetric analysis** (TGA). TGA measures the change in mass of a sample as a function of temperature and time. The technique can characterize materials exhibiting weight loss or gain due to kinetic processes, mainly: decomposition, oxidation or dehydration. The TGA can be used in a wide range of temperature intervals, even if in Space it is possible to individuate two former large groups:

-ambient to cryogenic regimes (ACT) (few K<T< 300 K)

-ambient to high temperatures regimes (AHT) (300 K<T< 1000 K)



Desorption of Organics and Water

Combustion Temperature (°C)	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500
Organic Compounds									
Physically Adsorbed Water									
Surface Bound Water *									
Inorganic Sulfur Compounds **									
Carbonates									
Nanodiamonds									

Volatile content in meteorites (I)

Chondrite Class	*Carbon content*	*Organic content*	*Water content*
Carbonaceous	0.1-5 %	0-4%	0-20 %
Ordinary	300-6000 ppm	~ 0.1%	~ 0.3%
Enstatites	1500-7000 ppm	-	~ 1000 ppm

Table 1. Carbon, organic compounds and water abundance in the three families of chondrites (Grady and Wright, 2003; Sephton, 2002; Schaefer and Fegley Jr, 2006; Stalder and Skogby, 2002).

Volatile content in meteorites (II)

CC group	Carbon content	Organic content	Water content
CI	2-5 %	1-4 %	18-22 %
CM, CR	2-5 %	1-4 %	2-16 %
CO	0.1-1.1 %	< 1 %	0.3-3 %
CV	0.1-1.1 %	-	0.3-3 %
CK	0.1-1.1 %	-	-
CH, CB	0.2-1 %	-	0.3-3 %

Table 2. Carbon, organic and water content in carbonaceous chondrites (Grady and Wright, 2003; Rozaud et al, 2008).

Cometary activity

minimum detectable signal and integration time required to detect a NEO cometary-like activity equivalent to the superior limit found for 3200 Phaeton (1 ng cm-2 s-1). (Hsieh and Jewitt et al., 2005)

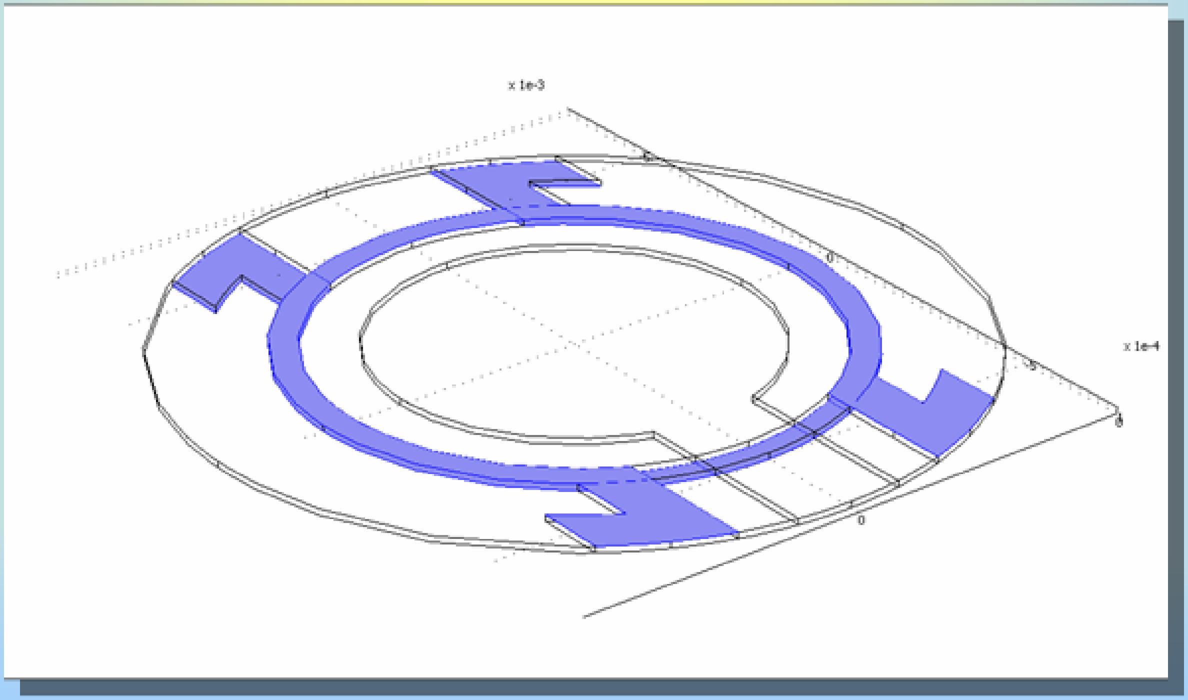
QCM Resonance frequency (MHz)	*Sensitivity ($Hz\ g^{-1}\ cm^2$)*	*Sensitivity^{-1} ($ng\ cm^{-2}$)*	*Integration time (s)*
1	$2.26\ 10^6$	442	*442*
2	$9.05\ 10^6$	110	*110*
5	$5.66\ 10^7$	18	*18*
10	$2.26\ 10^8$	4.4	*4.4*
15	$5.09\ 10^8$	2	*2*
20	$9.05\ 10^8$	1	*1*
25	$1.41\ 10^9$	0.7	*0.7*

VISTA scientific performances

Subsystem 1	**Operating Temperature (K)**	**Mass Flux ($ng\ cm^{-2}\ s^{-1}$)**	**Passive collecting time (s)**
Gas	77	0.01 – 1	100 – 1
Dust	270		
Subsystem 2	**Operating Temperature (K)**	**Sensitivity (ppm)**	**Thermal cycle Behavior**
Adsorbed water	330 – 430	10 – 100	TBD
Organics	470 – 570		

Instrument concept (I)

The core of the instrument is a piezoelectric microbalance equipped with a built-in heater. This special design dramatically reduces the total mass and the power required to perform thermal cycles.



Instrument concept (II)

The instrument will consist in two subsystem detectors (S1, S2) and one electronic box. S1 and S2 are composed by a sensitive element and a proximity electronic and will address different objectives:

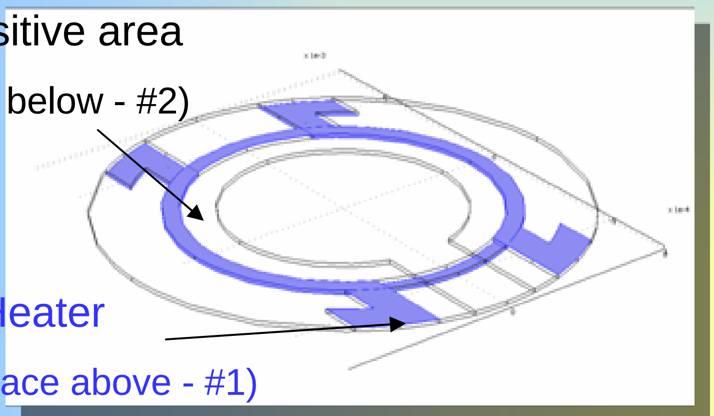
- Subsystem 1 (S1) to monitor cometary-like activity and asteroid organic/volatile abundance
- Subsystem 2 (S2) to asses the contamination produced by the landing/sampling processes

Instrument concept (III)

($I_{supplied}$ = 50 mA, $V_{supplied}$= 1 V, $P_{supplied}$ = 50 mW, in ambient air)

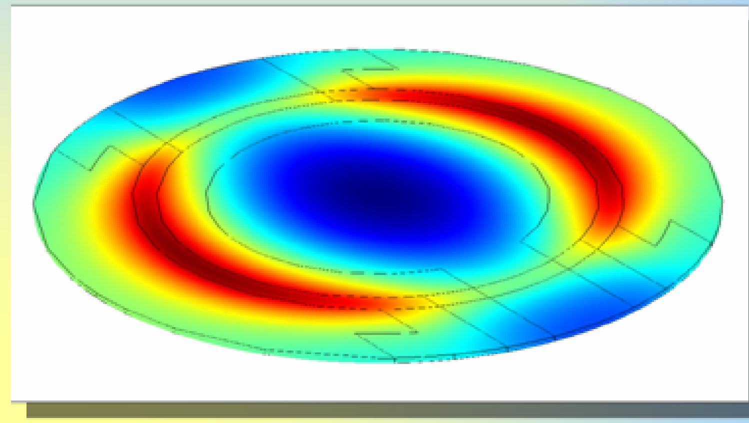
Sensitive area

(face below - #2)

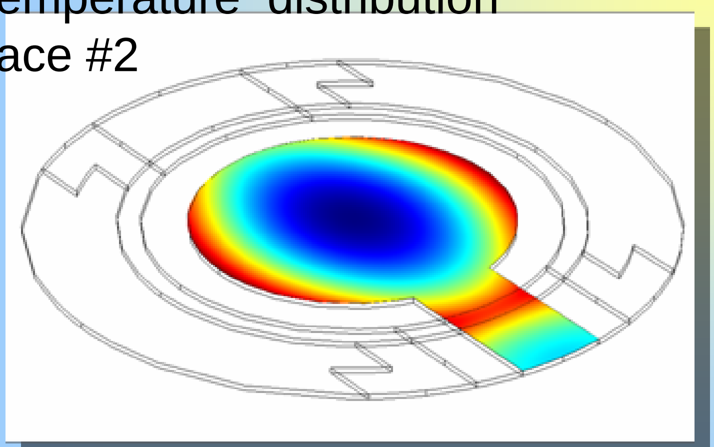


Heater

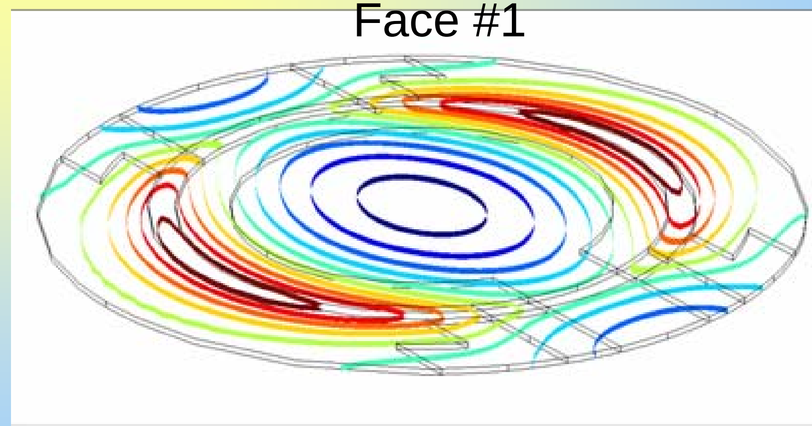
(face above - #1)

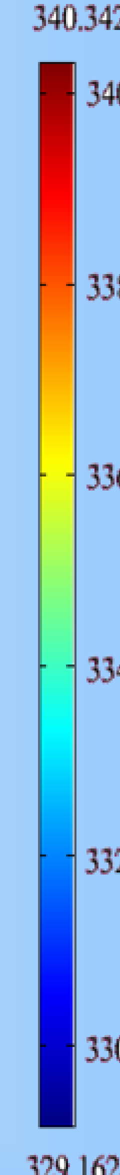


Temperature distribution
Face #2



Temperature distribution
Face #1



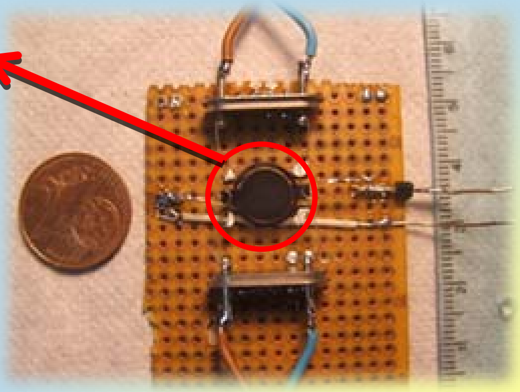


VISTA technical characteristics

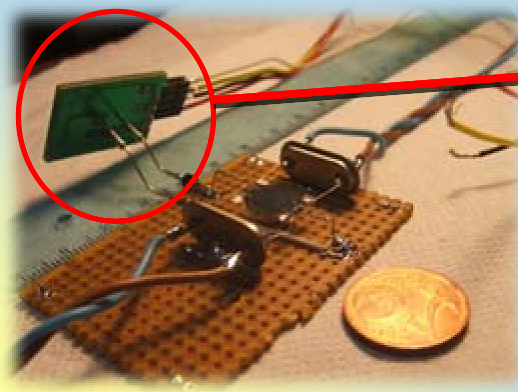
Sensor	Piezoelectric Microbalance
Units	1 electronic box (EB) 2 sensing subsystems (S1 & S2)
Weight [g]	220 (50g {S1+S2} +170g {EB})
Dimensions mm (detector + electronics)	20 x 20 x 30 (per sensing subsystem) 110 x 110 x 25 (main electronics)
Power [W]	Peak = 2 (T~400 K) Mean = 0.5 (T~100 K)
Sensitivity [ppm]	10 – 100
Responsivity [ng/Hz]	100
Operating Temperatures [°C]	
Detectors	-200 → 500
Telemetry data rate and volume	0.02-0.04 bytes/s each measurement, 1 complete thermal cycle 40 Mbit
Technology Readiness Level	3 – 4
Heritage	MBS-GIADA (ESA-Rosetta); Electronic Nose for the ISS Eneide Mission

VISTA New Lab breadboard
Type 1 sensor (Quartz crystal)

QCM

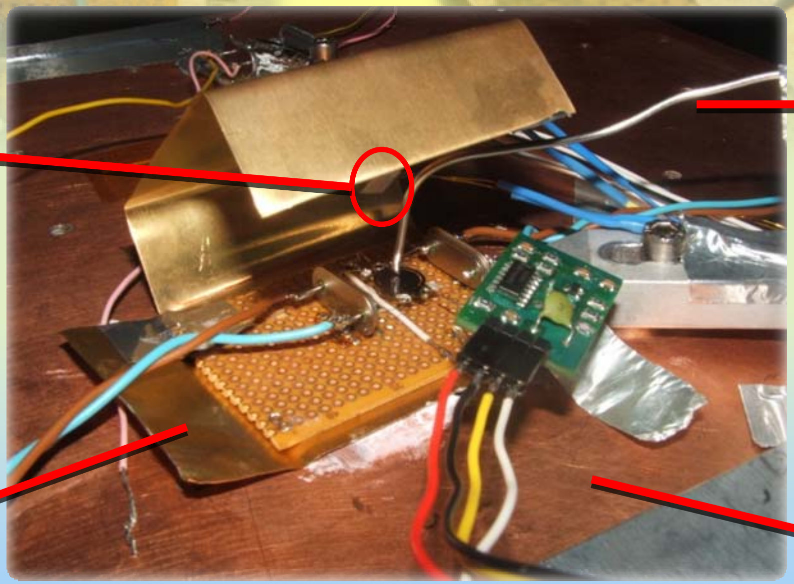


Oscillator



Capillary tube

Temperature sensor



Cold chamber

Cooling plate

VISTA environmental chamber setup

Activity for the Marco Polo Study

- Instrumental and system requirements anaysis
  - Electronic board mass and volume
- VISTA functional & thermal tests in ambient air
- New VISTA breadboard produced
- VISTA under testing in vacuum
  - Gas condensation/desorption (CO_2, NO_2)
  - De-hydration of water rich materials
    - (phyllosilicates, sodium chloride)
  - Volatilization of organics from organic rich materials
    - (carbonaceous chondrites)
- Development of a Thermo-mechanic design
- Production of an improved VISTA breadboard
- TRL analysis