Martian Moon Sample Return (MMSR)
An ESA mission study

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and the MMSR Science Definition Team:

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Programmatic framework

Mars Robotic Exploration Programme (MREP) – part of the ESA/NASA Joint Mars Exploration Programme (JPEP)

- Aim: return samples from Mars in the 2020s
- Initially spanned several launch opportunities including rovers and orbiters
  - ☞ 2016 ExoMars Trace Gas Orbiter (TGO) + ESA Entry, Descent, and Landing Demonstrator Module
  - ☞ 2018 ESA/NASA rover sample caching mission
- 2018 mission currently under feasibility assessment
- To be prepared for >2018: ESA initiated further mission studies
  - ☞ Martian Moon Sample Return (MMSR): upcoming CDF study + past studies
  - ☞ Network Lander: upcoming CDF study + past studies
  - ☞ Mars precision landing: ongoing industry studies
  - ☞ Mars Sample Return orbiter: ongoing industry studies

  And previously studied:
  - ☞ Atmospheric sample return: CDF study

CDF = Concurrent Design Facility

Goal of current study

- Bring the candidate missions to a level of definition enabling their programmatic evaluation, including development schedule and Cost at Completion to ESA.

Programmatic framework

The Science Definition Team was asked to

- (a) Describe the science case for such a mission
- (b) Propose a baseline mission scenario or concept
- (c) Propose the baseline science instrumentation

Constraints:

- Sample return mission to either Phobos or Deimos
- Launch with Soyuz
- 'ESA affordable' (but can have collaboration), Cost at Completion <~750 – 800 MEuro
- Extensive reuse of existing studies

Timetable

Mars future missions: 2011/2012 timetable and key events	
Event	**Date**
Setting of Science Definition Teams for supporting the Mission definition for the Mars network mission and Mars moon sample return missions	April 2011
SDTs reports on Mars network and Martian Moon Sample Return missions	July 2011
Completion of ESA internal studies (CDF) for the mission definition	November 2011
Completion of industrial studies on MSR Orbiter and Mars Precision Lander missions	December 2011
Programmatic consolidation	December 2011 - January 2012
Presentation to PB-HME (Programme Board)	February 2012
Elaboration of international collaboration schemes	January – June 2012
PB-HME decision on way forward for C-Min(2012)	June 2012

Science goals - 1

Top-level science goal:

Understand the formation of the Martian moons Phobos and Deimos and put constraints on the evolution of the solar system.

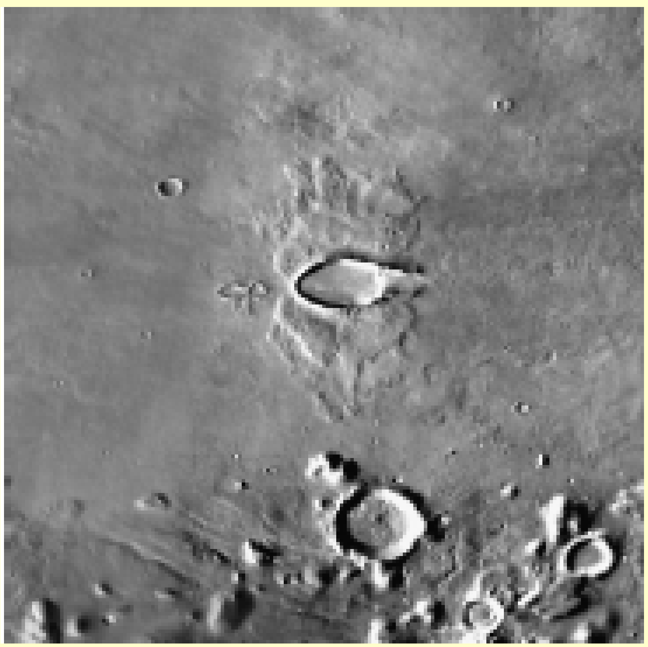
- ***Constrain the moon formation scenario by analysing returned samples***
- ***Constrain dynamical models of the early solar system by showing how often a large impact occurs***

Science goals - 2

(a) co-formation with Mars (see *e.g.* Burns 1992 and references therein);

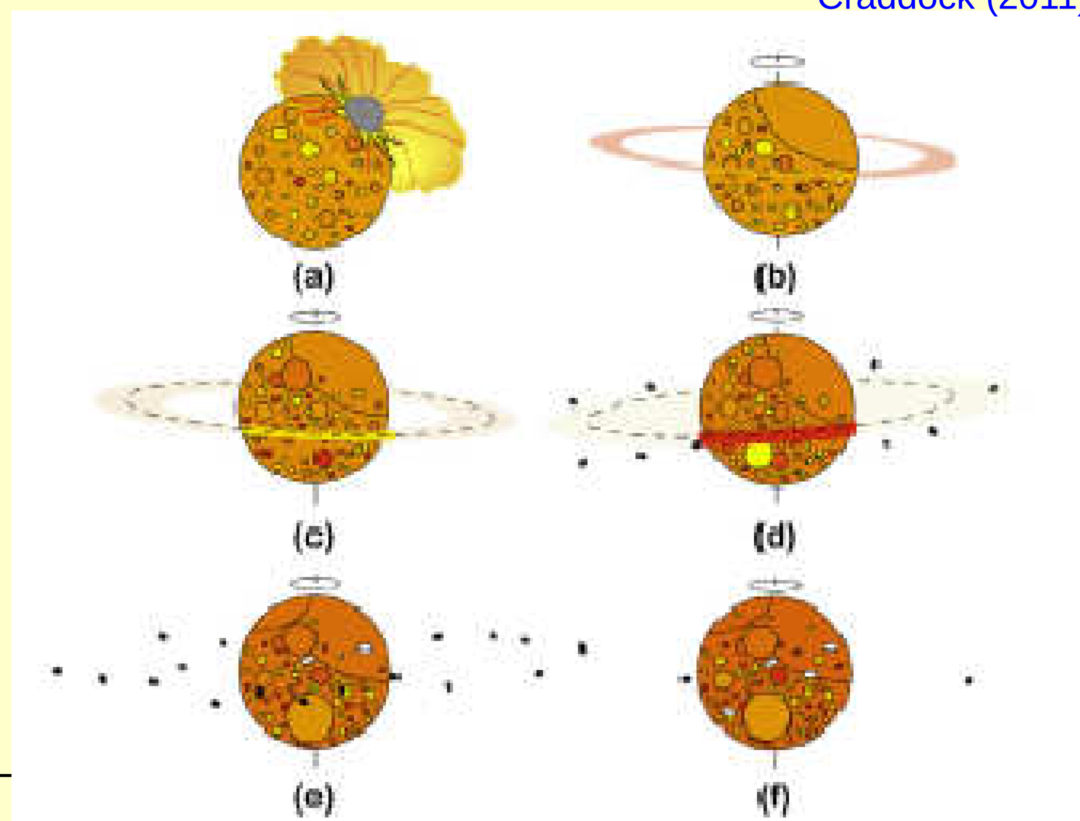
(b) capture of objects coming close to Mars (Bursa et al., 1990);

(c) Impact of a large body onto Mars and formation from the impact ejecta (Singer 2007, Craddock 2011).



Chappelow and Herrick (2008)

Craddock (2011)



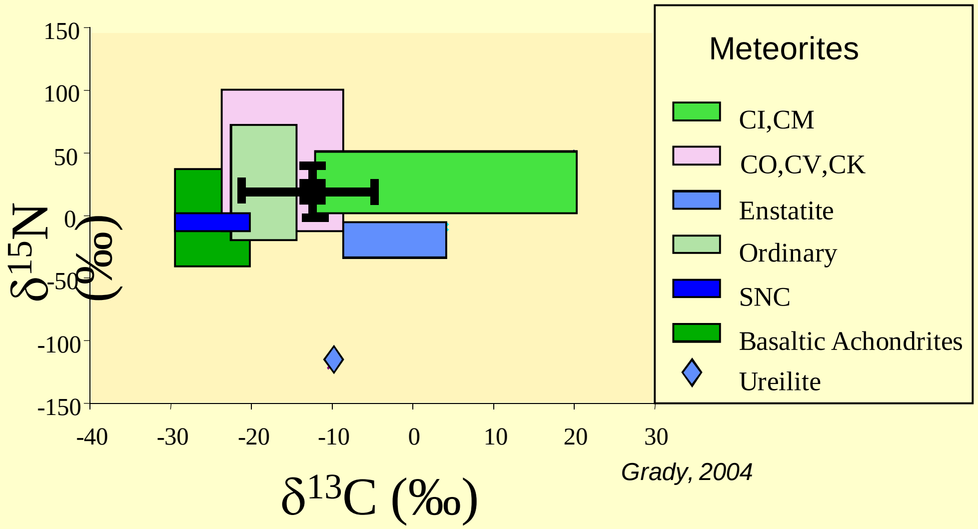
Science goals – 3

Returned sample will allow:

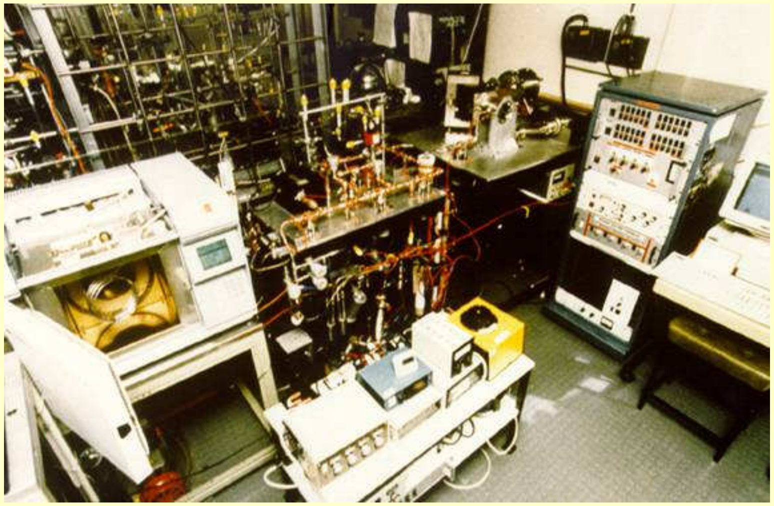
- Detailed chemical analysis (much more than in-situ), mineralogy, texture…
- Dating

⇒ Better constrain formation mechanism

e.g.: Martian material? Asteroidal material?



Grady, 2004



Phobos or Deimos?

Phobos-Grunt => go to Deimos?

⇩

Thomas et al. (1996): 200 m regolith, "…from the ejecta being accreted … long after the impact…"

⇩

Sample a boulder!

⇩

Go to Phobos, but to a different geological unit (still to be discussed)

Preliminary mission analysis result: Deimos would allow 60 – 100 kg more s/c mass

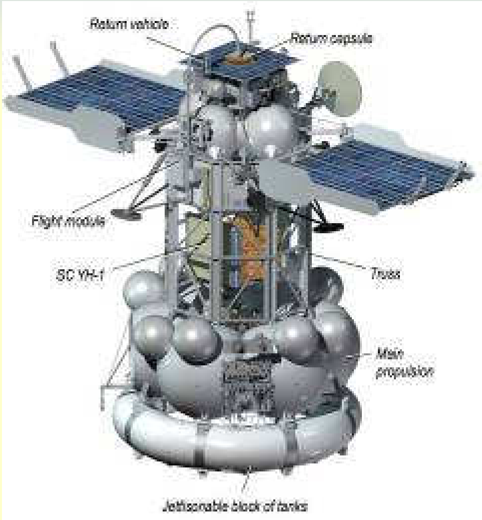
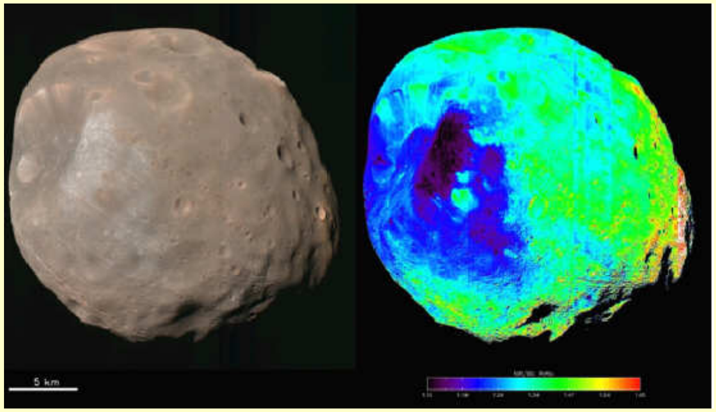


Image credit: NPO Lavochkin

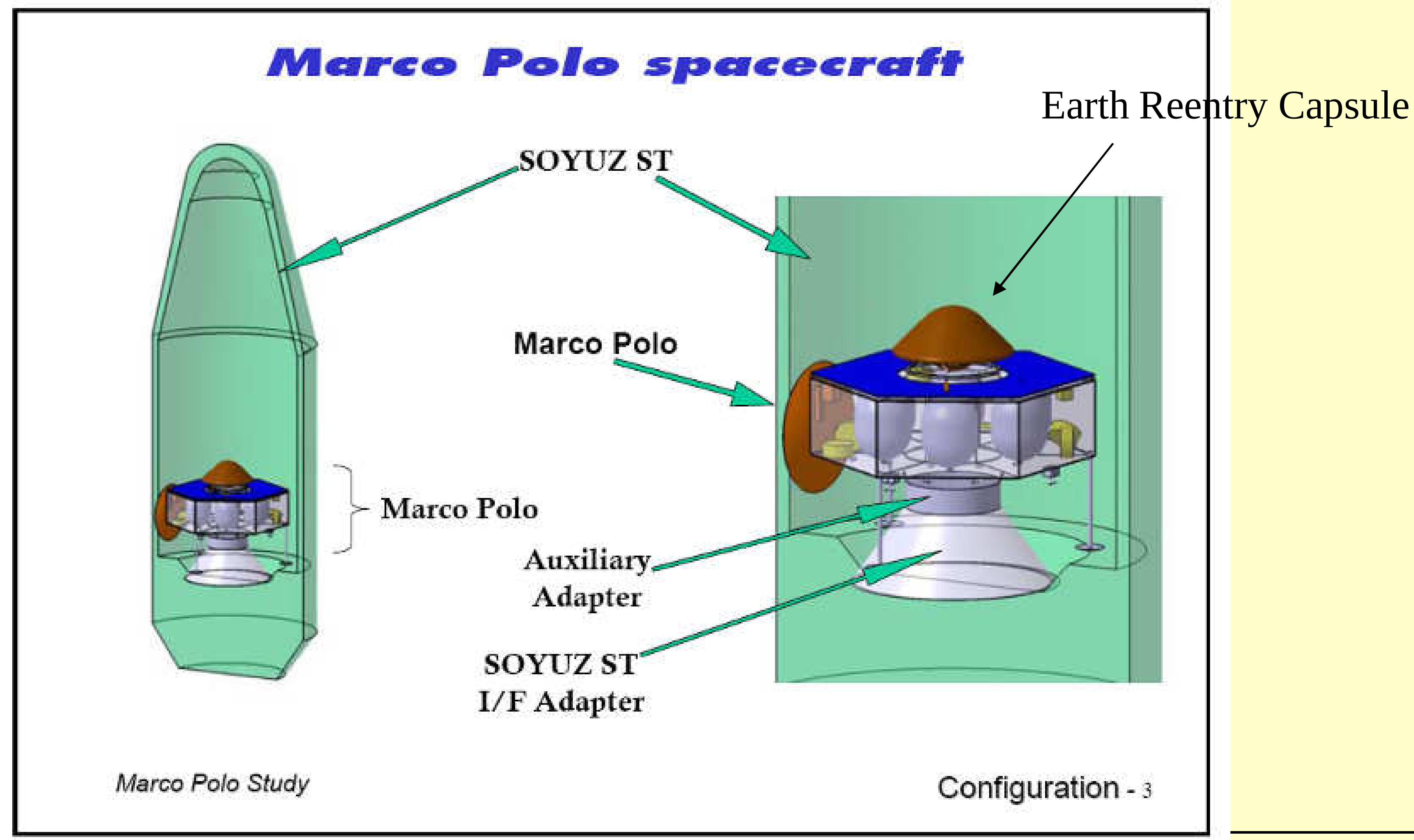


From Thomas 2011

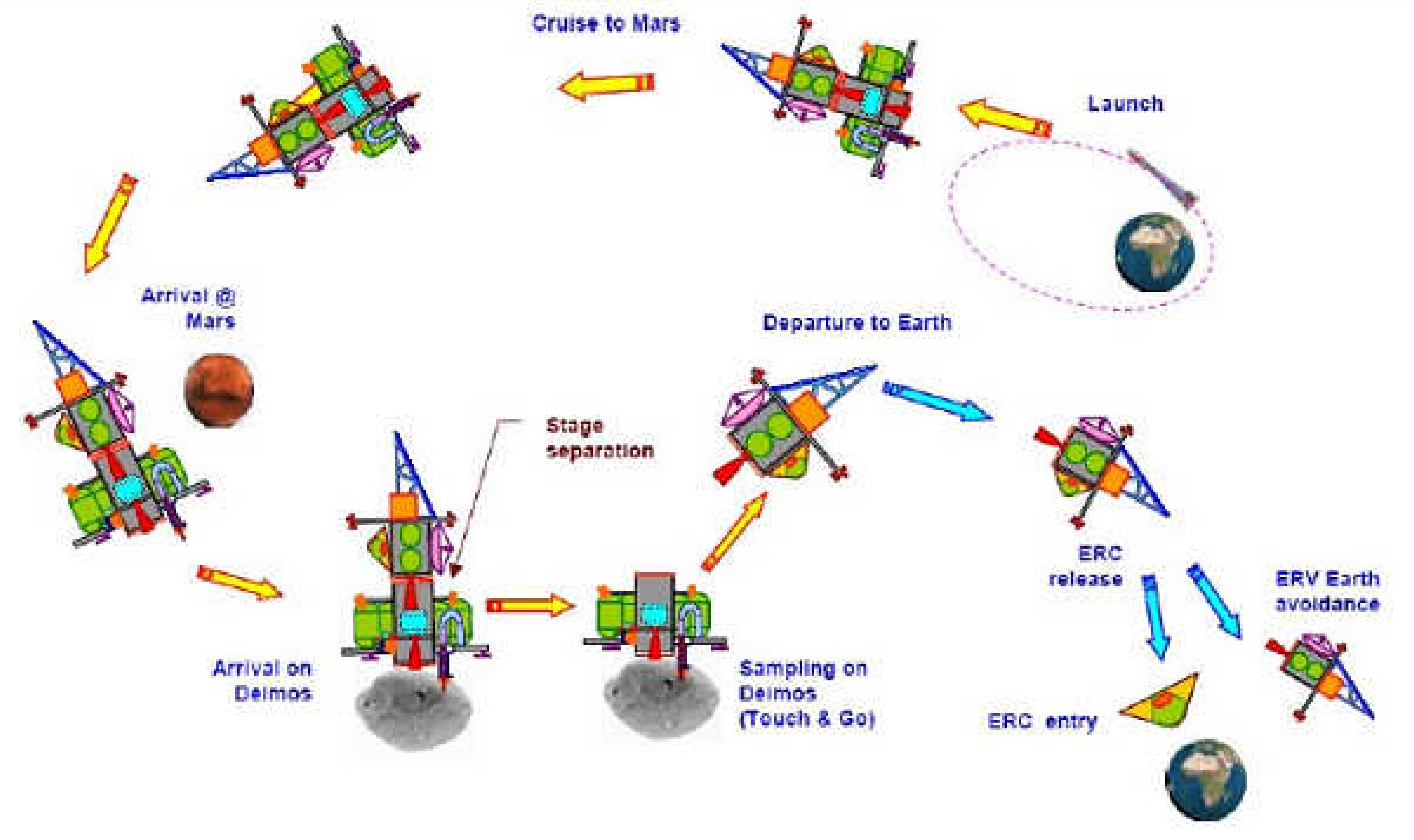
HiRISE image PSP_007769_0910,
unsharp masked (Thomas 2011)

Mission building blocks

Could build on Marco Polo's design…



Deimos Sample Return



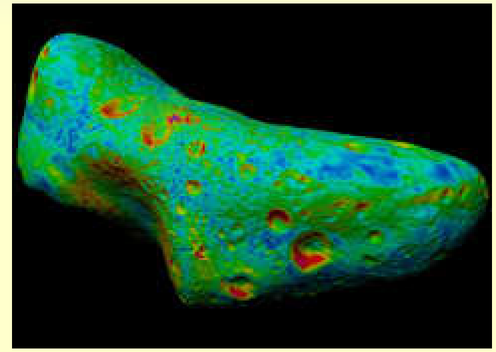
Baseline payload

Again we use the Marco Polo study as a starting point:

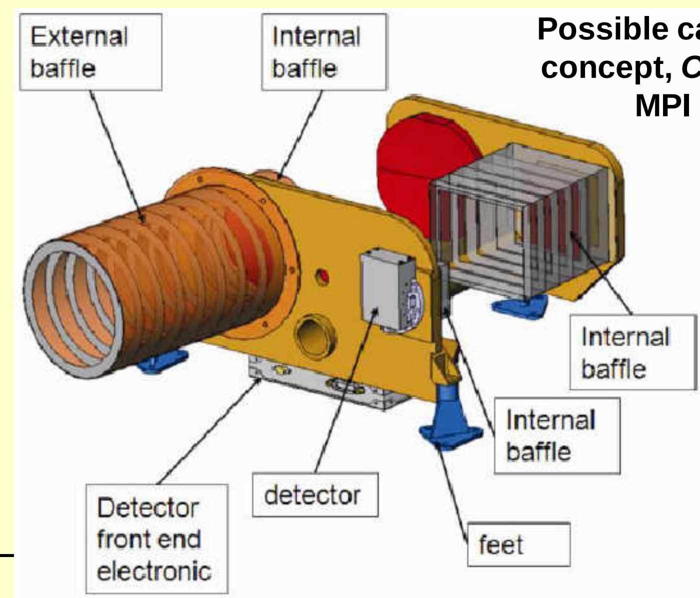
- Wide angle camera
- Narrow angle camera
- Close-up camera
- Vis/NIR imaging spectrometer (0.4–3.3 µm)
- MIR spectrometer (5–25 µm)
- Radio science

More to be discussed, depends on available mass

	Total
Mass [kg]	25
Power [W]	50
Data volume [Gbit]	280



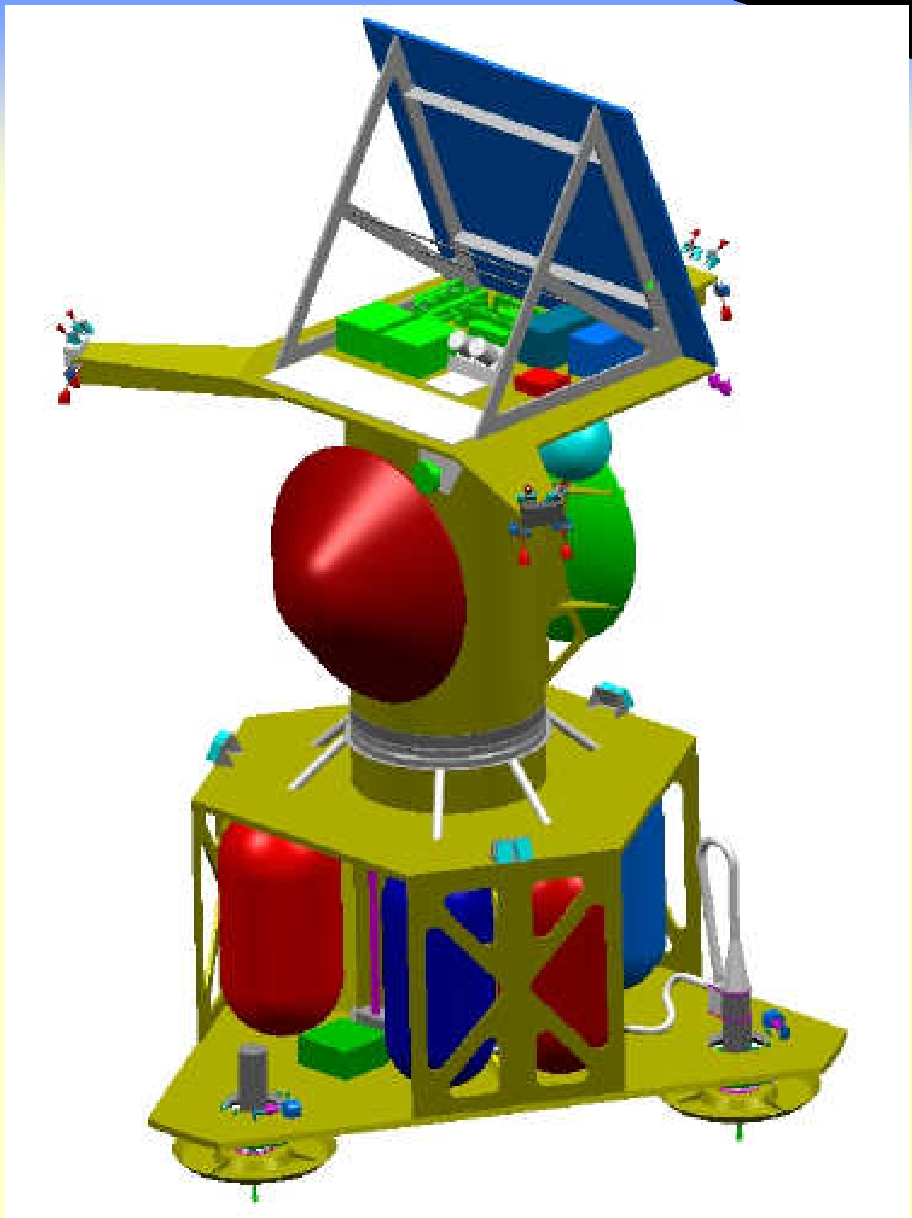
Coloured image of Eros, *Credit:* NASA



Possible camera concept, *Credit:* MPI

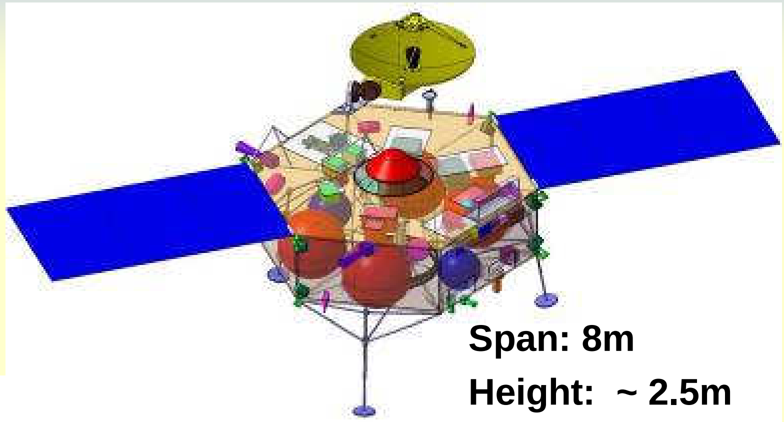
Spacecraft configuration

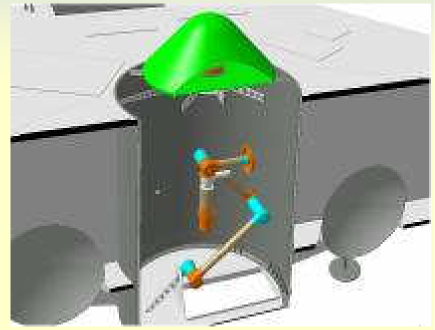
Deimos sample return s/c (2005)

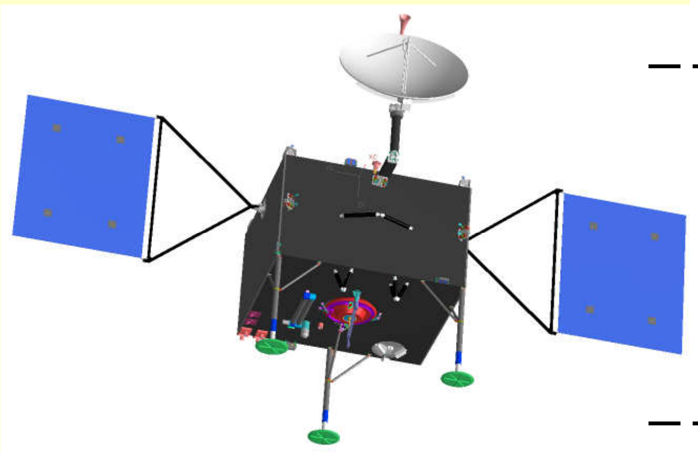


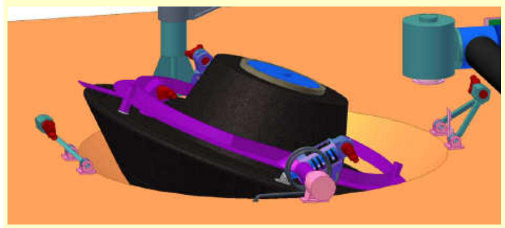
Marco Polo - Main spacecraft

Contractor 1**: Corer, top-mounted capsule, one articulated arm inside central cylinder**



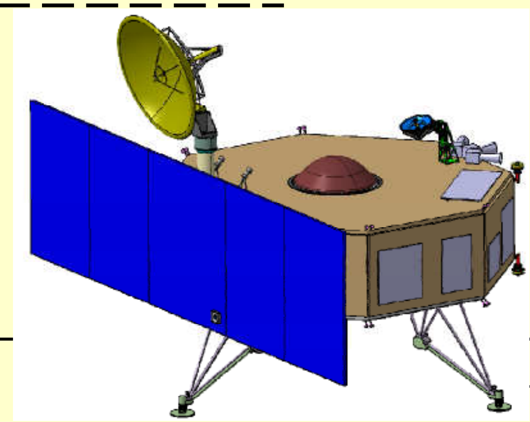


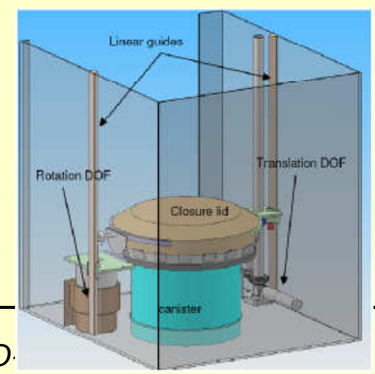




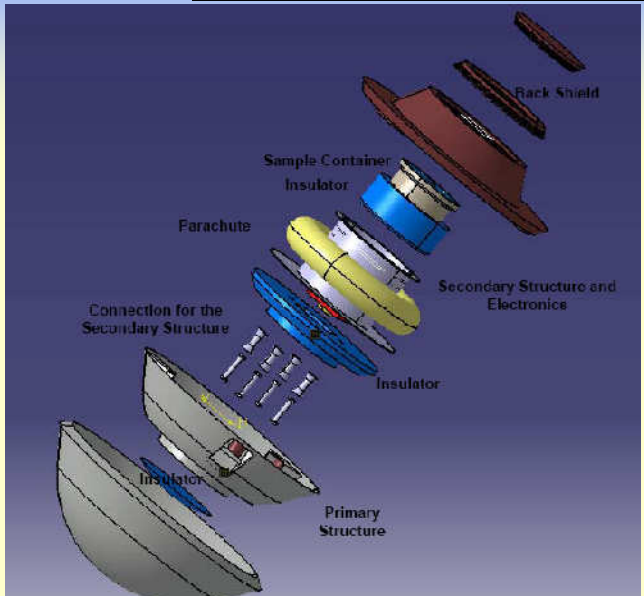
Contractor 2: Corer, bottom-mounted capsule, two articulated arms

Contractor 3: Fast sampler, top-mounted capsule, transfer via landing pads/legs + elevator in central cone





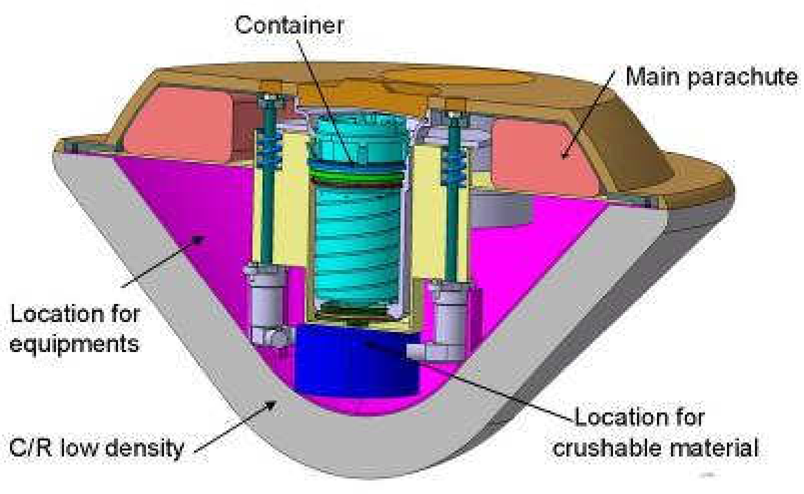
Marco Polo Earth Re-entry Capsule

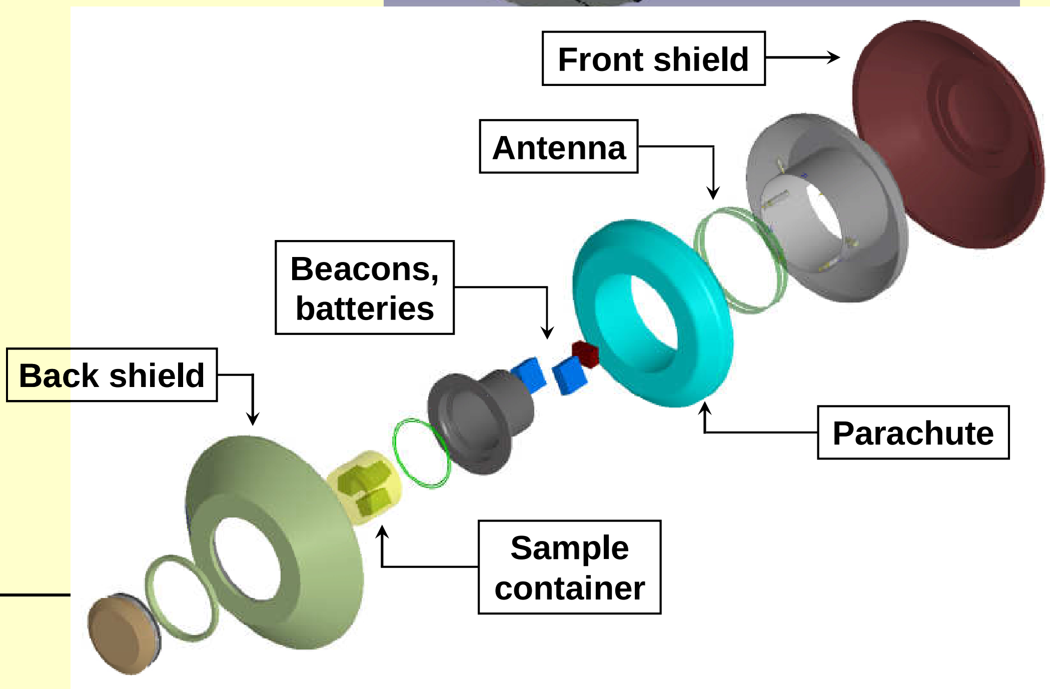


45º half-cone angle front shield

In-development lightweight ablative material or classical carbon phenolic

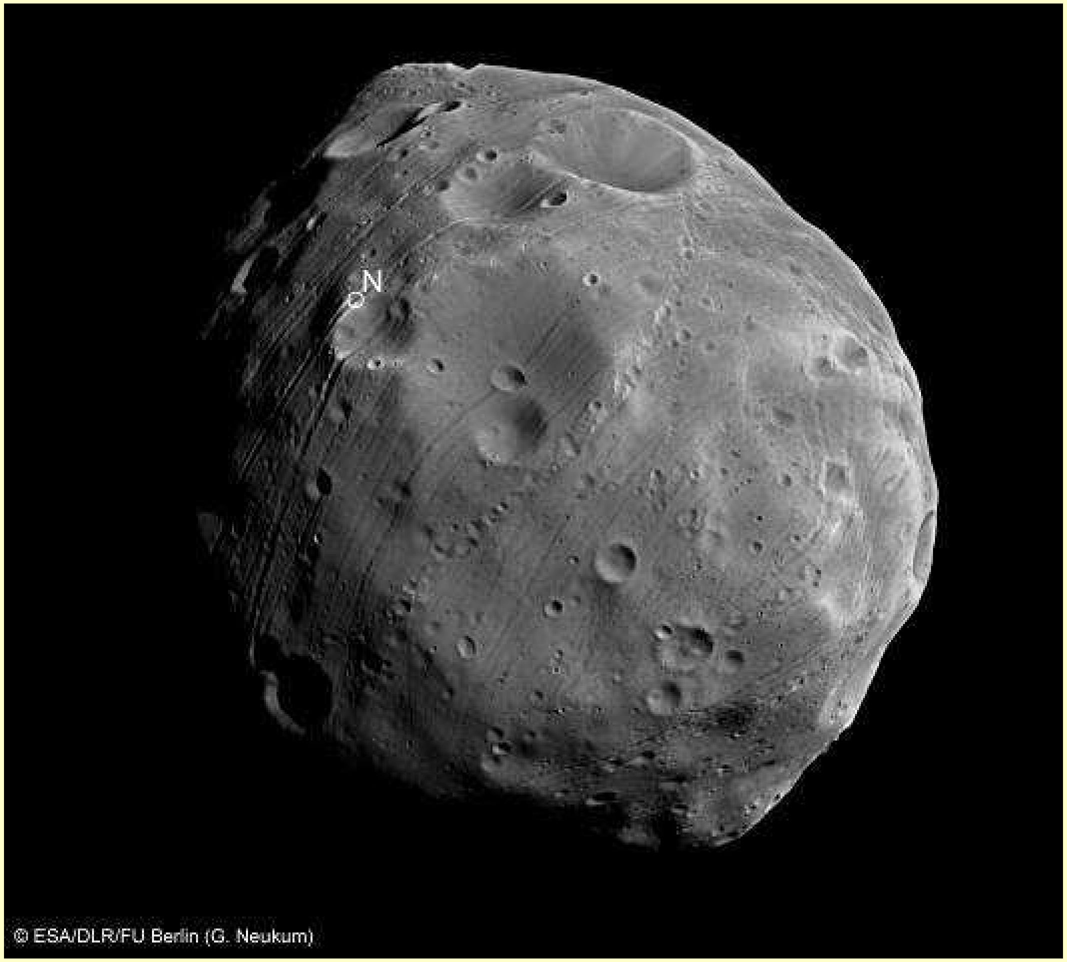
Capsule mass: 25 – 69 kg





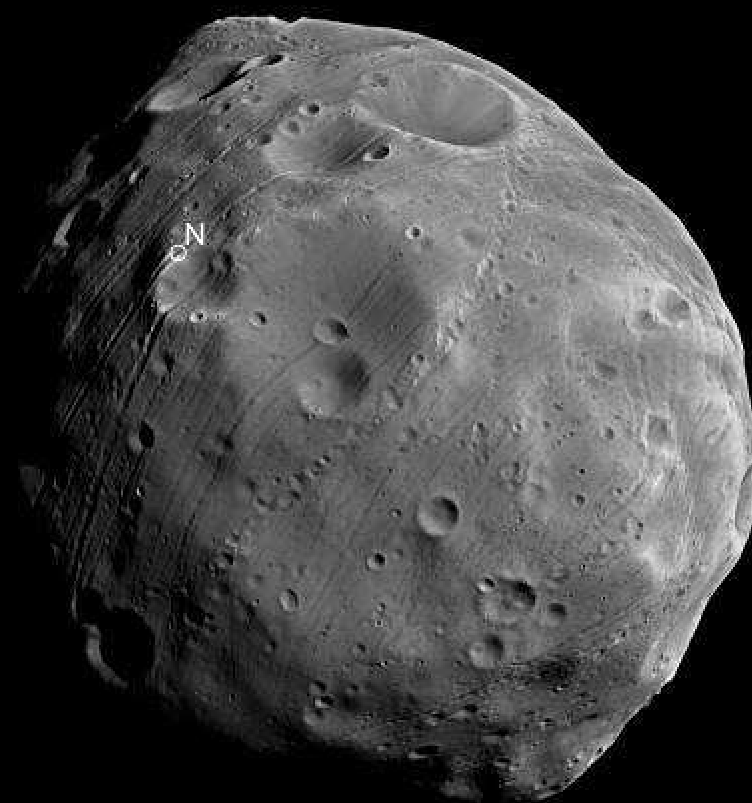
Conclusion

- ESA is studying a Martian Moon Sample Return mission
- Phobos or Deimos?
- Science case has been defined
- Detailed science requirements are being iterated
- Mission scenario is being developed
- ESA-internal 'CDF' study before end 2011
- Decision on further activities envisaged by PB-HME in Jun 2012



PB = Programme Board

Credit: HiRISE, MRO, LPL (U. Arizona), NASA

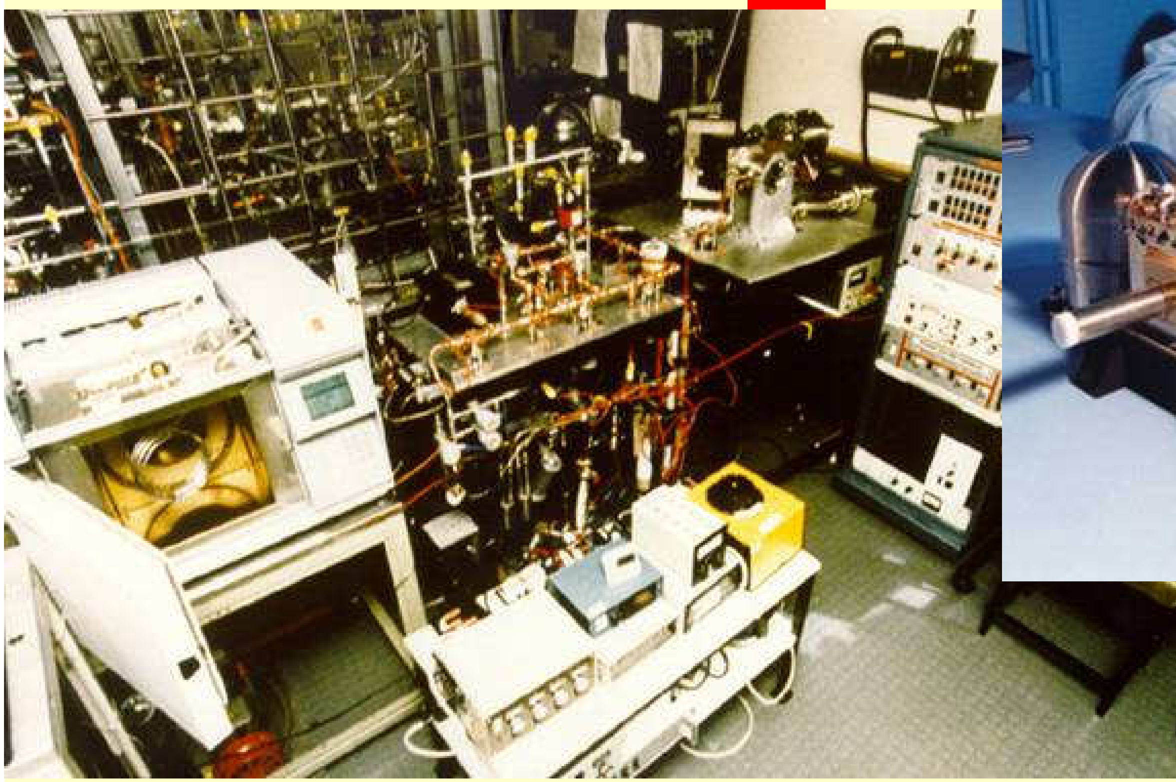


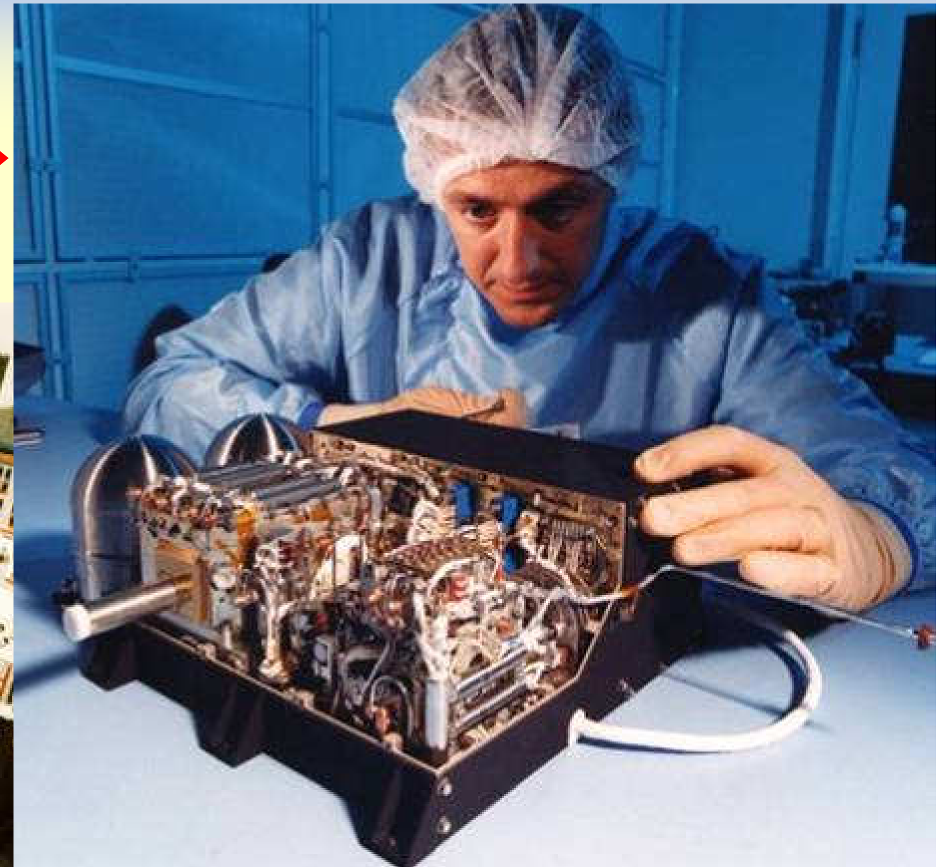
Additional slides

Why do we need to return samples?

Superior instruments…

“Miranda” GC-IRMS
Laboratory
Isotope ratio ± 0.01%





Rosetta Ptolemy
In situ
Isotope ratio ± 1%

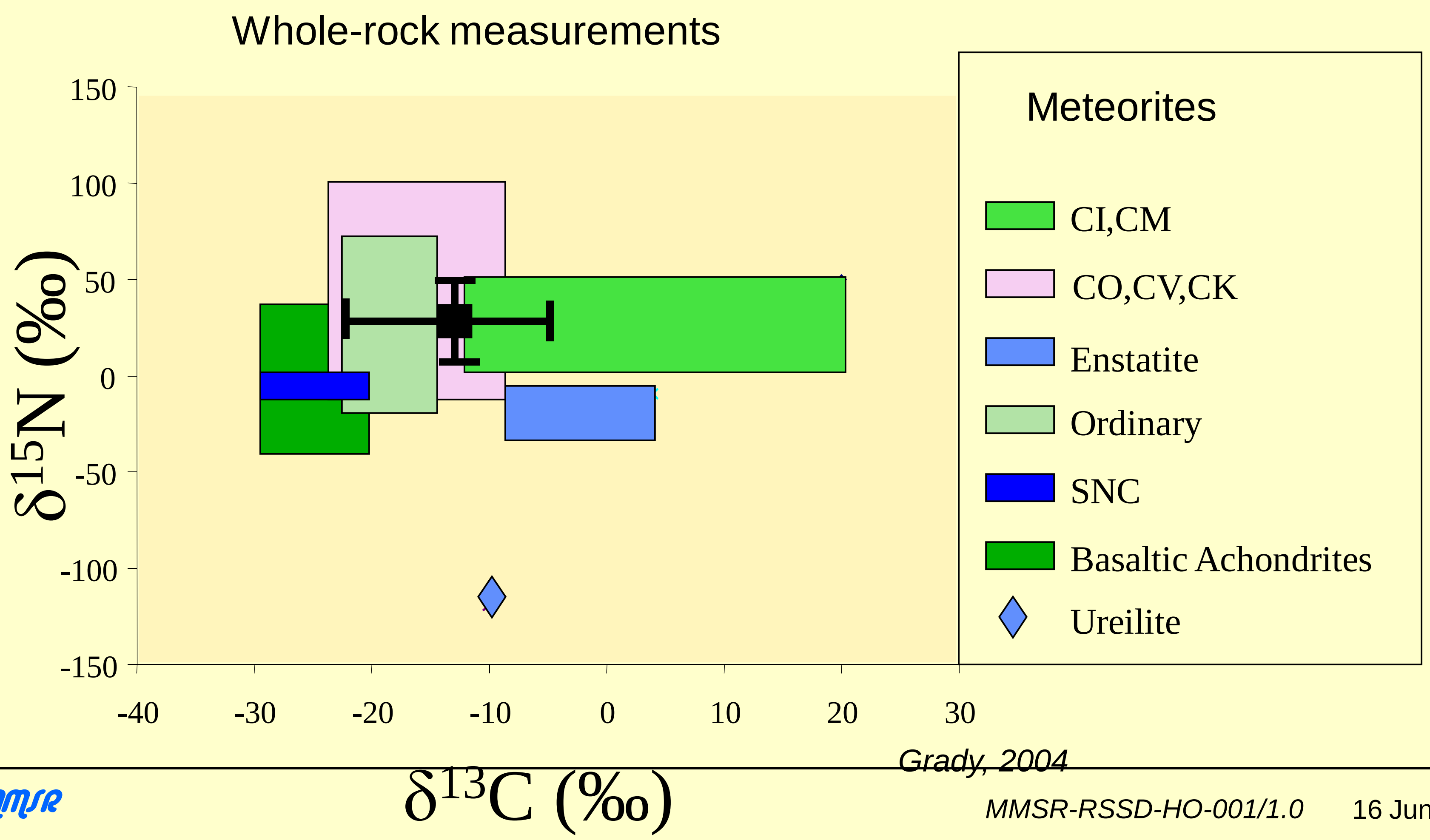
In-situ instruments limited (mass/volume/power/reliability)

Superior instruments…

Diamond synchrotron source

Superior instruments…

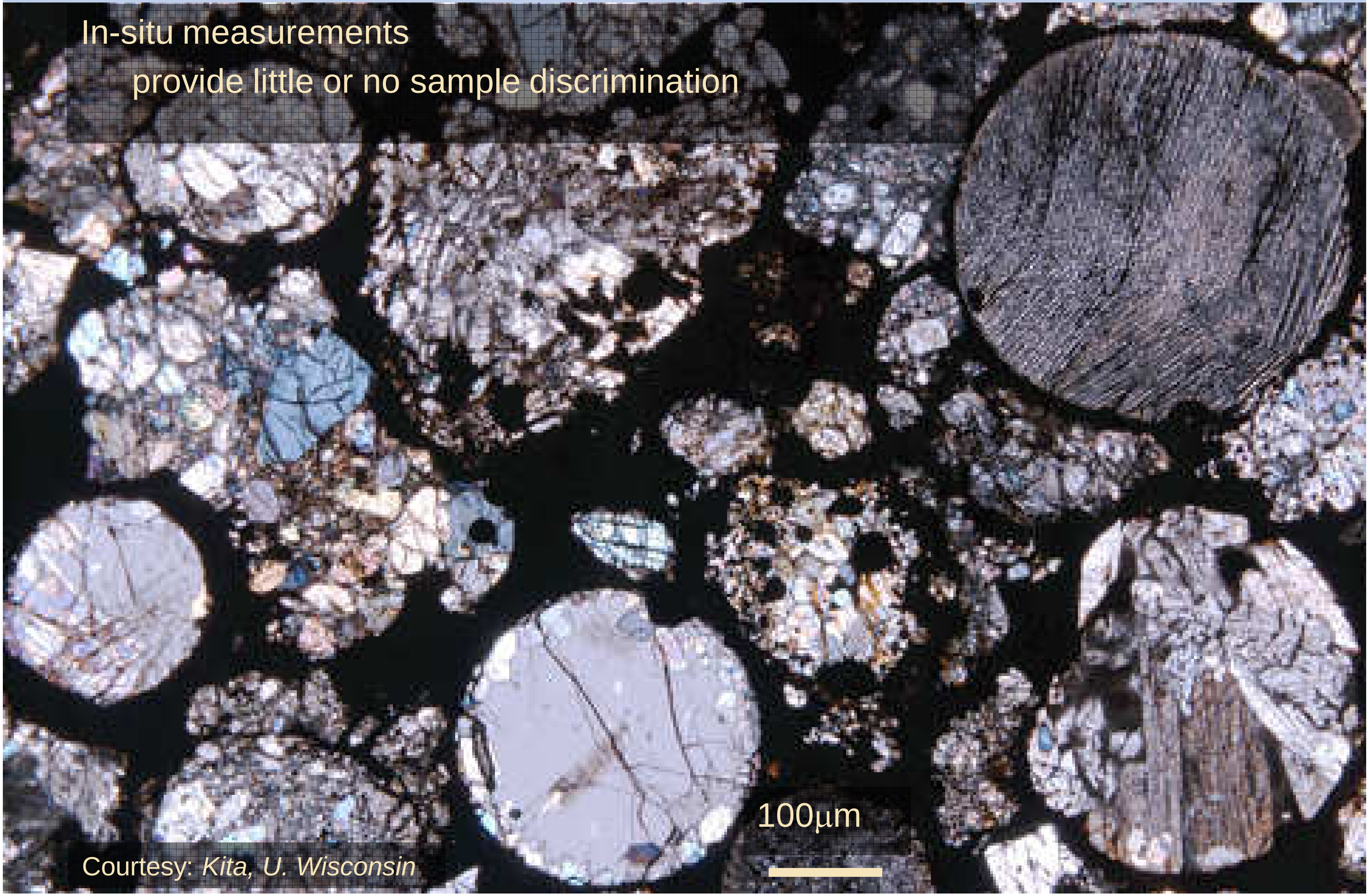
In-situ measurements provide insufficient precision



Grady, 2004

In-situ measurements

provide little or no sample discrimination



Courtesy: *Kita, U. Wisconsin*

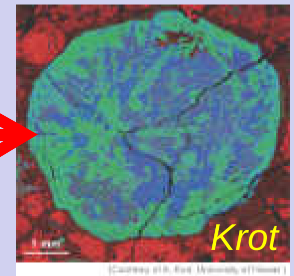
Complexity...

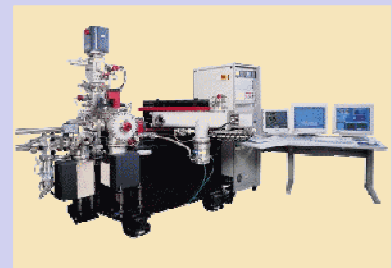
- Same sample analysed by many instruments
- Complex sample selection and preparation

Initial selection

Split

Process characterisation





Example: isotope dating of chondritic components

Isotope dating

- Dissolution
- Purification
- Analysis
- Calibration

Context (mm–µm) – check secondary effects