Validating dust flux models with active and passive collectors

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Dust Monitoring Techniques

Remote Sensing

- Using ground and space-based telescopes
- Objects larger than ~few mm can be detected
- Examples HUSIR, MODEST

Active Detectors

- Measure dust impacts in real-time
- Able to measure numbers, velocities and trajectories (and potentially orbit) of particles.
- Rarely have incorporated compositional analysis

Passive Detectors

- Designed for return to Earth
- Surviving residues of the impactor can be studied by high sensitivity analytical instruments
- Can identify of MMs versus OD, based on distinctive chemical signatures

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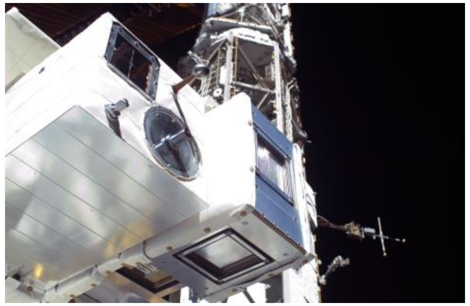
Active Detectors

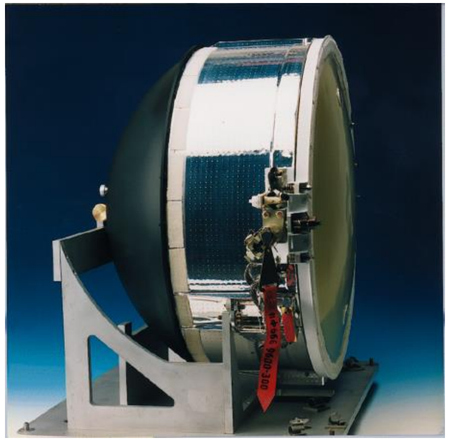
Foils with sensors - DEBIE

- Piezoelectric crystals can give momentum detection
- Electron plasma detector can be used to detect if particle penetrates foil
- Gives impact time and size



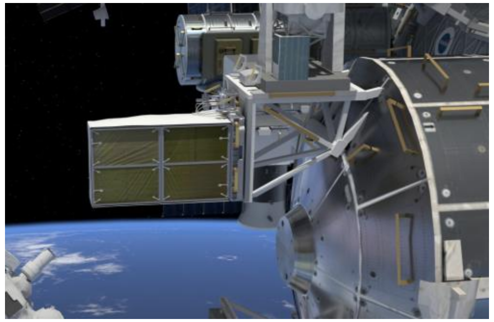
Impact ionisation detectors - GORID

- Ionises the impacting particle
- Gives size, density, composition, speed



Foils with resistive grids - SDS

- Integrated resistive grid
- If there's a breakage an impact is found
- Gives size, time and speed



Measurement Capabilities

- Speed
- Trajectory
- Size
- Rough chemistry

Limitations

- Detailed chemistry
- Added levels of complexity

Image credits: ESA

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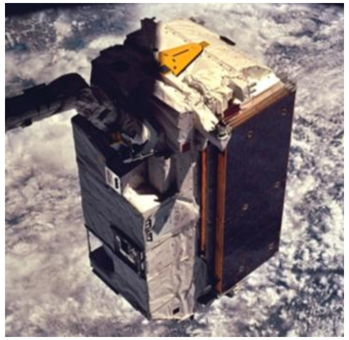
Passive Detectors

Characteristics

- Single layer or multiple layers of foil, metal or aerogel
- Covers a large area for sampling
- Can capture particles or residue in holes and craters
- Analysis back on Earth can identify chemistry of impactors and identify if the particle is orbital debris or micrometeroid in origin

LDEF

Eureca



Potential Measurement Capabilities

- Trajectory upon impact
- Size
- Composition
- Speed
- Can identify MM or OD origin
- Simple and potentially cheap

Limitations

- Requires a sample return mission
- Trajectory/orbit/parent body

Image credits: ESA

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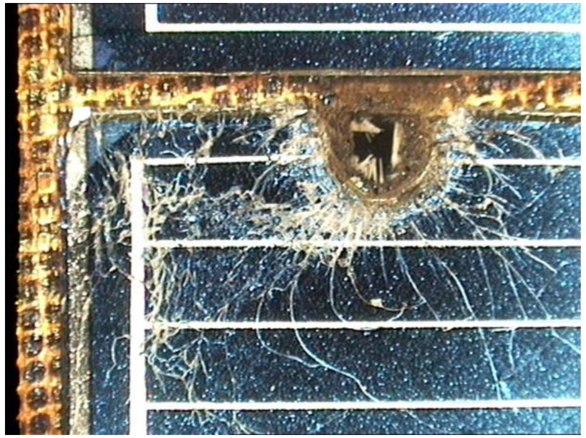
Opportunistic Returns

Anything returned from orbit can be analysed for impact features

- Apollo spacecraft surfaces
- Multi-layer insulation
- Panels from the Space Shuttle
- Clamps and metal experiment trays from LDEF
- Solar panels from Hubble



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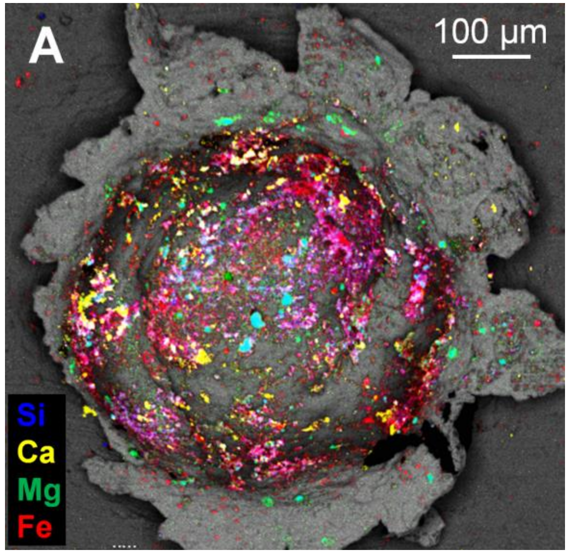

Crater on LDEF Al clamp

Image modified from Graham et al., 2003

Potential Measurement Capabilities

- Trajectory
- Size
- Composition
- Speed
- Can identify MM or OD origin

Limitations

- Requires a sample return mission
- Surfaces are not ideal for analysis

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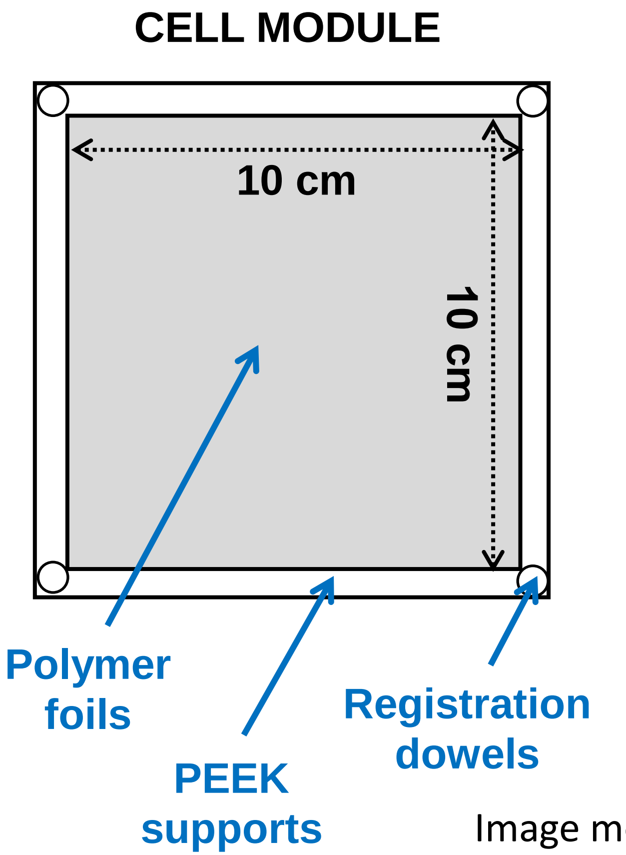
Orbital Dust Impact Experiment (ODIE)

- Retrievable passive detector composed of multiple layers of polymer foil
- Whipple shield-like design
- Able to distinguish between debris and micrometeoroids
- Easy analysis after retrieval (e.g. by SEM, FIB extraction of wafers from crater residue)
- Lightweight design



Multi-layer insulation - SFU

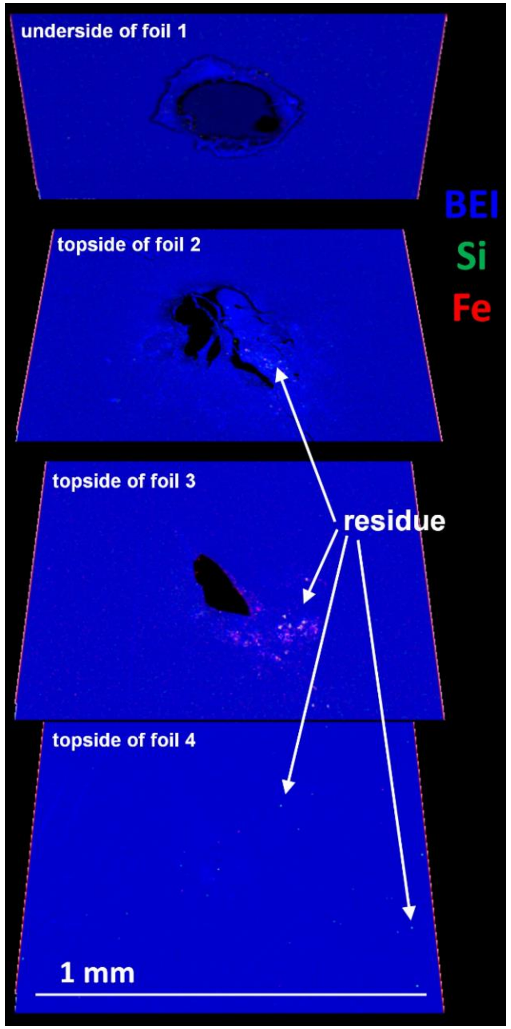
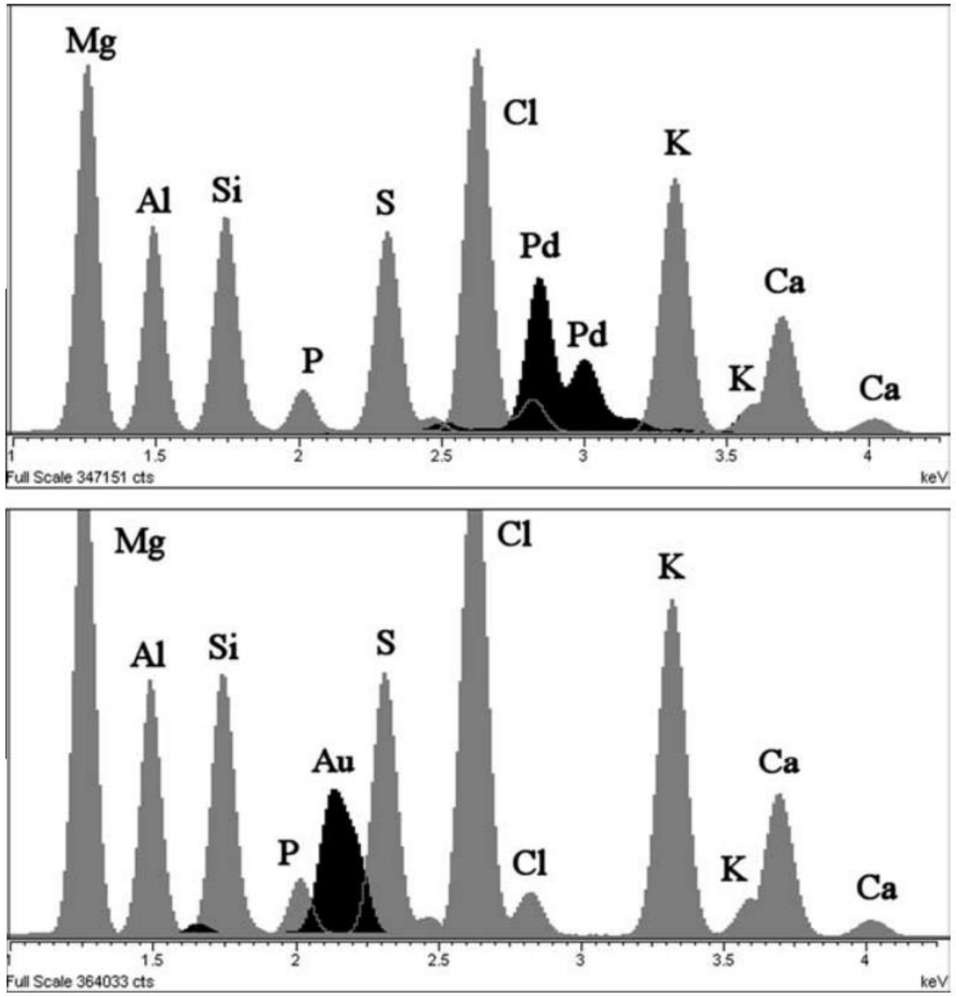


Image modified from Graham et al., 2003

Palladium Coating

- Need to protect against atomic oxygen in LEO
- Sulphur is a key indicator for MM residue, peak overlap if using gold
- Conflict with OD if using aluminium
- Palladium gives very bright background for SEM with no peak overlap or conflicts



Images modified from Graham et al., 2005

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Calibration of Detector/Collector

Simulating LEO impacts using **University of Kent Light Gas Gun Facility**

Speeds between 1 km s^{-1} – 7.5 km s^{-1}

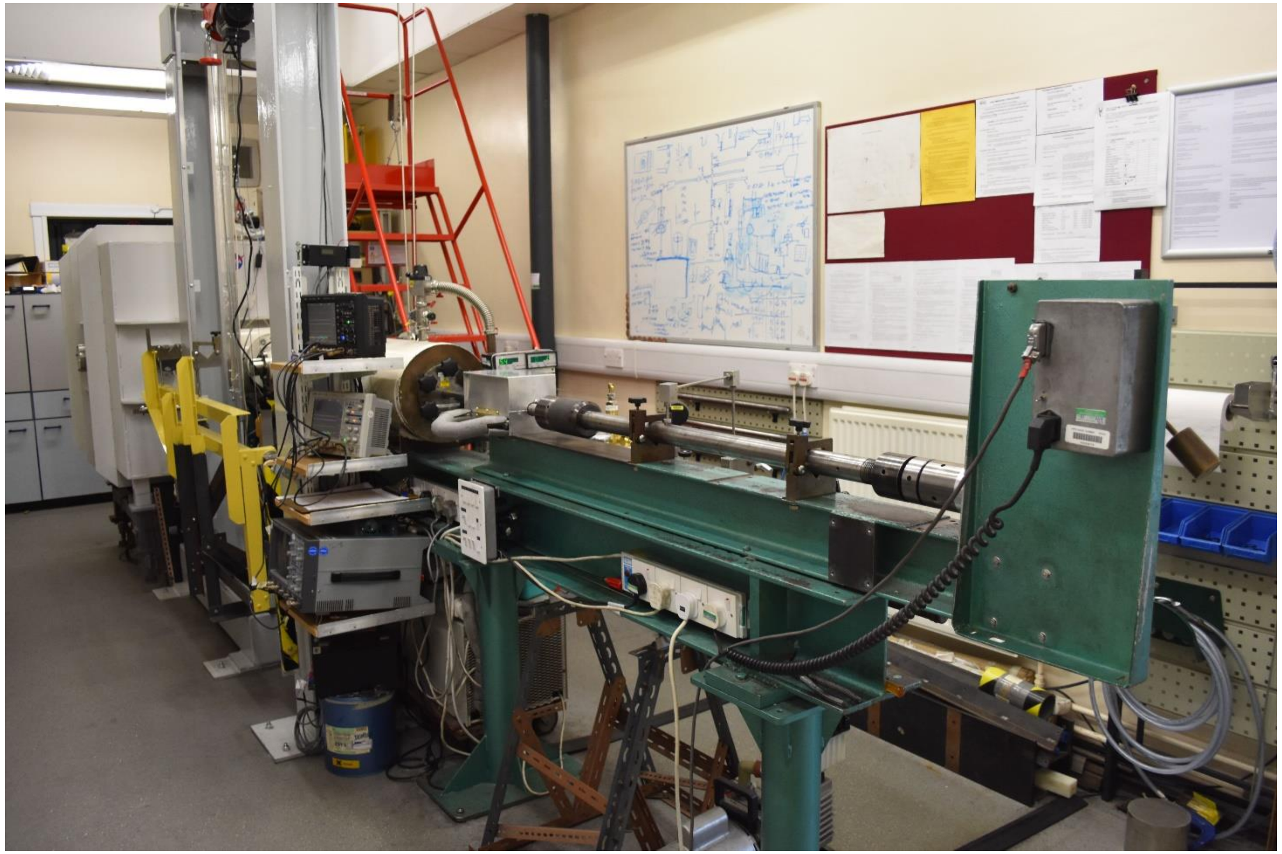
Largest possible target is 1 m^3

Single projectiles between the ranges of 300 μm – 3 mm

Projectiles smaller than 300 μm are shot as a buckshot

Can shoot hot or cold targets

Horizontal and vertical gun capabilities



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Summary

- Remote Sensing can be used to track objects larger than a few cm
- Active and passive in-situ detectors can provide information on the smaller size ranges for MASTER
- For chemical analyses to distinguish between OD and MM, passive detectors, whether opportunistic or dedicated, would be optimal for this purpose
- We are currently developing a passive detector that can be deployed on any spacecraft given that there is a sample return mission
- The data from all these observations and methods can be used in the validation of the MASTER model

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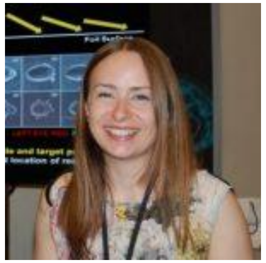

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Coater suppliers: dennis.fitzpatrick@quorumtech.com