

“Don’t slam the door!”



Micro-Manipulation of Extra-Terrestrial Dust

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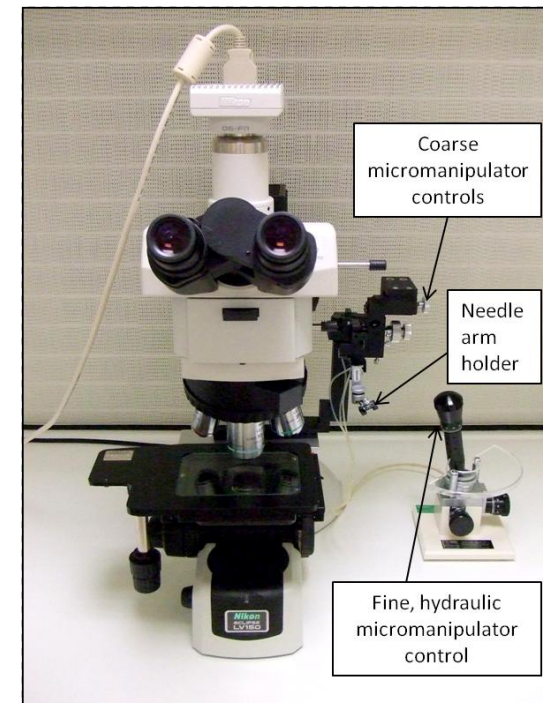


Clean Room Facility at the University of Manchester

The class 1000 clean dust laboratory is equipped with:

- Mach-Aire laminar flow cabinet
- High-performance microscope (Nikon Eclipse LV150, purchased in 2010)
- Hydraulic micro-manipulation system (Narishige MMO-202ND/MMN-1)
- Custom-made glove box (designed and constructed by J. Cowpe) - evacuated by diaphragm vacuum pump (down to ~ 0.1 mbar) - filled with purified N₂

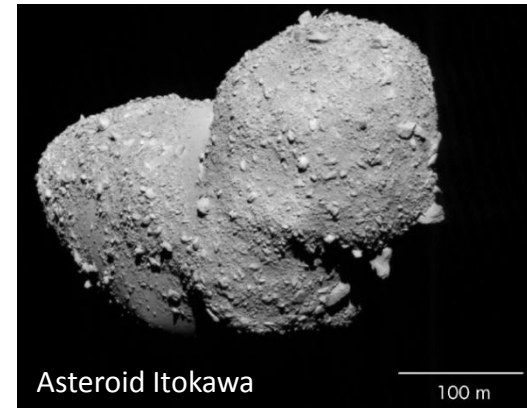
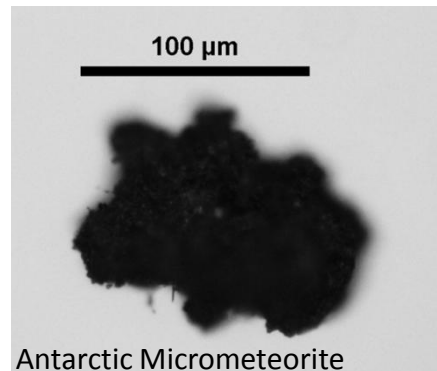
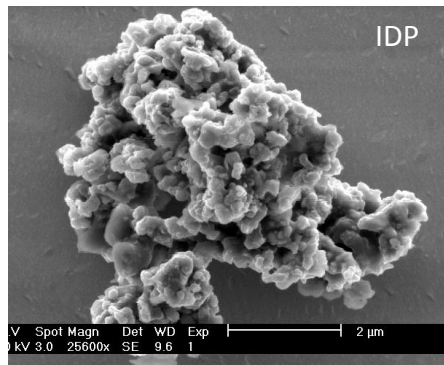
The trinocular eyepiece tube on the microscope with 45:55/0:100 split facilitates simultaneous optical examination of samples through eyepiece and camera/computer.





Samples

- IDPs and micrometeorites (2 – 150 μm)
- Insoluble Organic Residue from Chondrites
- Itokawa regolith (50 – 150 μm)
- Olivine grains from Khatyrka meteorite (40 μm)



Other samples prepared by IGC members...

- Comet Wild 2 dust in aerogel, returned with the Stardust mission.
- The Genesis mission's collector foils exposed to the solar wind
- Lunar Apollo samples
- Meteorite slabs, minerals, sections, separates



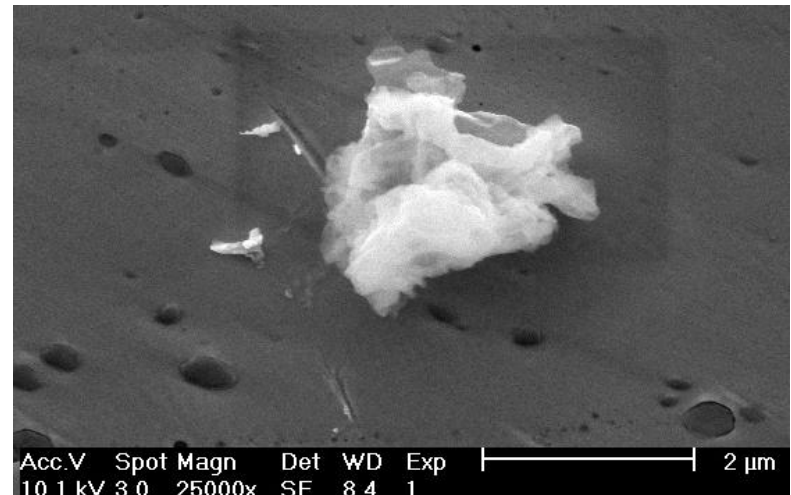
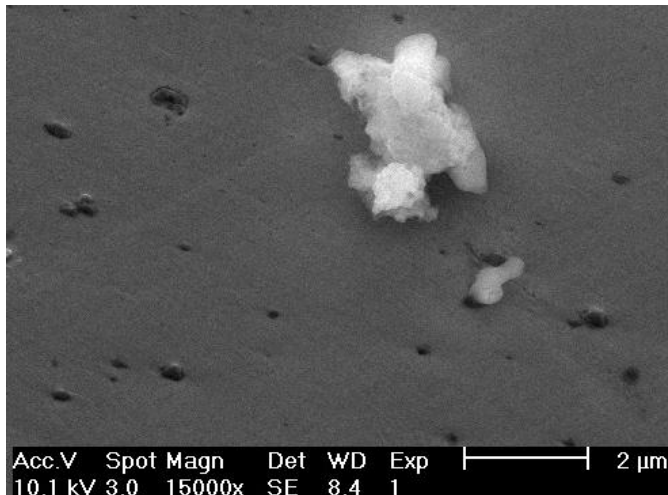
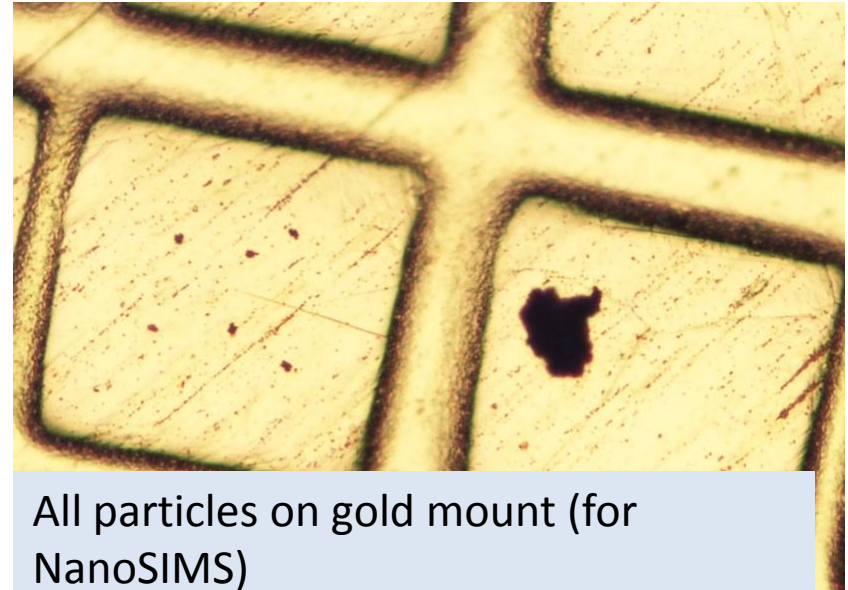
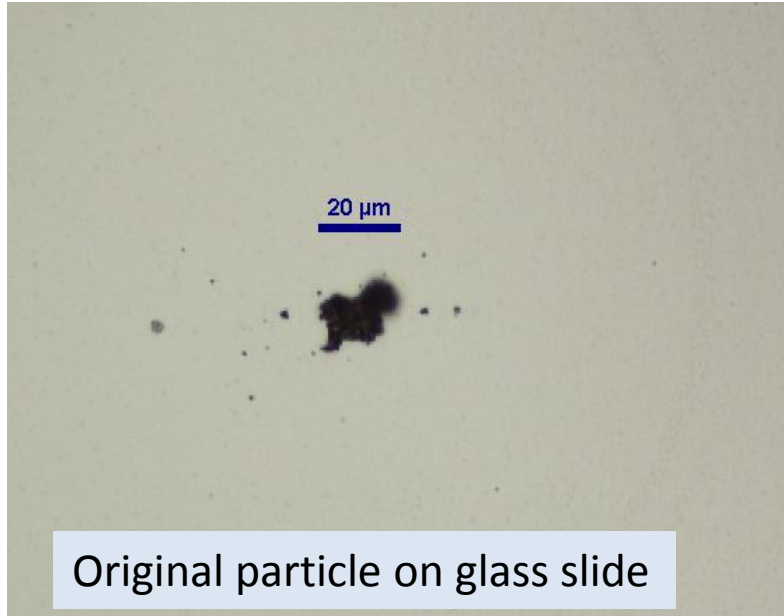
General procedure for micro-manipulation (in Manchester)

- Sharpen tungsten needle in electrolyte bath (NaOH)
- Clean needle
- Test transfer configuration – will needle hit anything? Reduce time and distance from sample to sample holder – no large chasms.
- Get in 'the zone' – hunger, tiredness, irritability, time constraints → nope.
- Put signs up warning others - concerning the doors
- Before/during/after transfer documentation
- Clean needle after each transfer





2 μm-sized particles





Main causes of lost particles

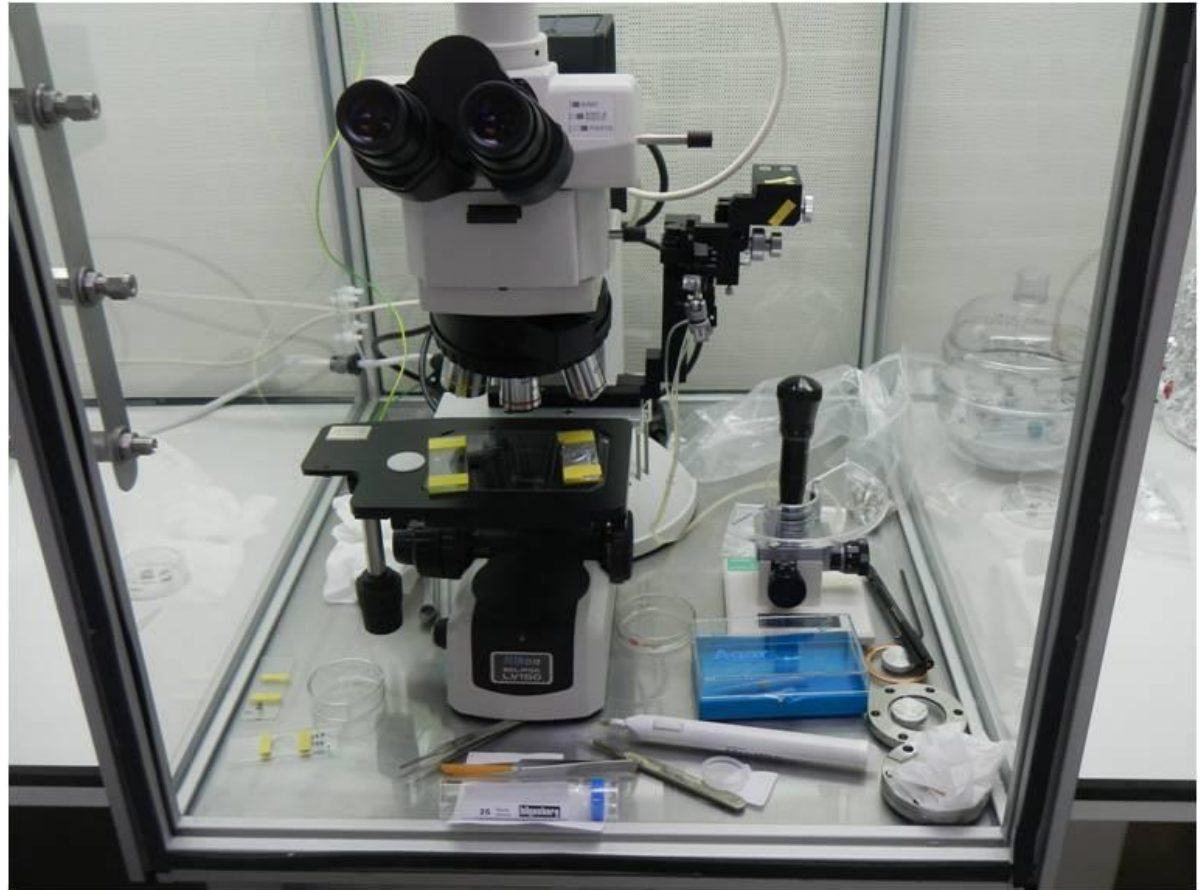
1. Vibrations – Doors
2. Static
3. Terrestrial dust hampering a rescue mission
4. Rescue search area too large
5. Lack of documentation
6. Lapse in concentration – accidentally knocking needle holder...

However, the loss rate is extremely low.
(maybe 5%) - depends on type of sample.



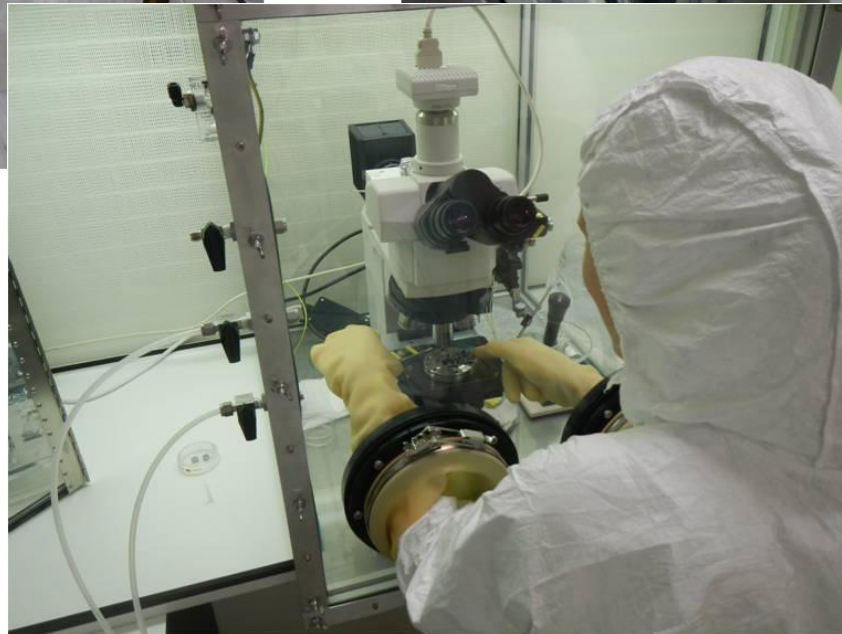
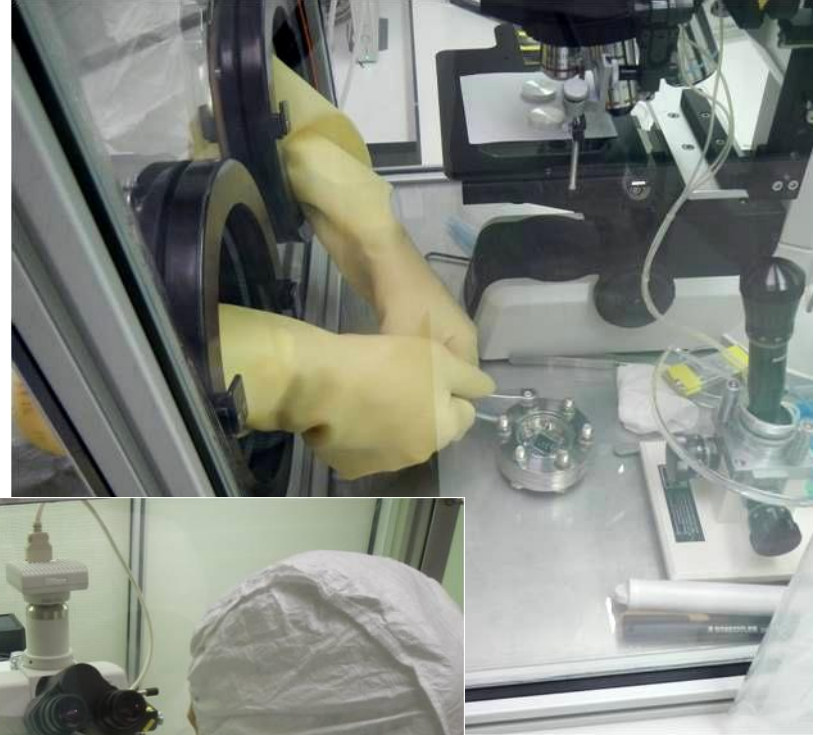
Micro-manipulation in a glove box

- The glove box consists of acrylic glass covered with antistatic coating
- Over pressure valve, feed throughs for power and camera signal
- Can be equipped with an additional static eliminator.
- Built for handling Itokawa samples in N_2



Preparing for transferring Itokawa samples in N_2 atmosphere.

Micro-manipulation in a glove box



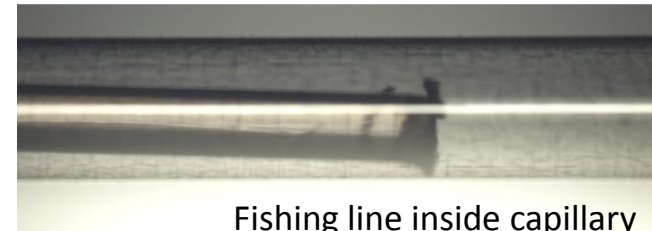
Team effort with
Henner Busemann and Matthias
Meier (ETH, Zürich) - one to
document via laptop, one as
second pair of eyes from
different perspective.



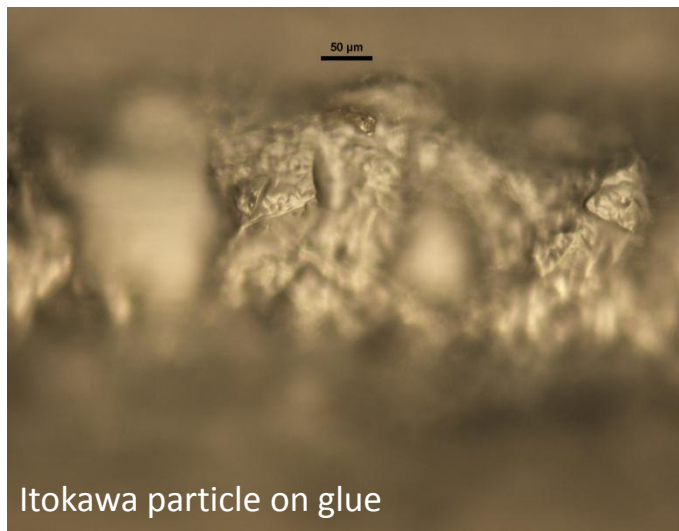
The things we do for noble gases...



- Need accurate estimate of mass to reduce error in measurement of noble gas isotopes.
- 3D synchrotron radiation X-ray tomograph microscopy
- Particles placed onto glue sprayed fluorocarbon thread
- Boron glass capillaries ($\varnothing \sim 700 \mu\text{m}$)
- Mass of six grains precisely determined with SRXTM: 0.07 to 1.66 μg (with 3-6% uncertainty)



Fishing line inside capillary



SRXTM image – Meier et al. (2013)

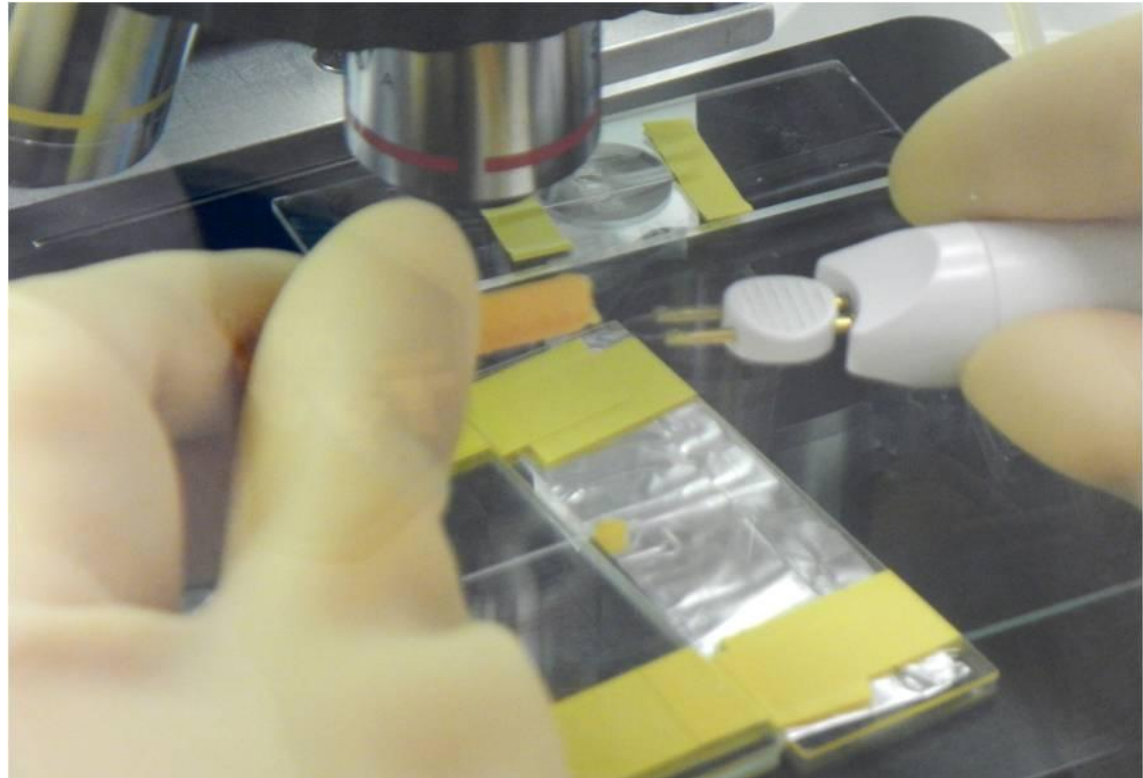
Itokawa particle on glue



X-ray tomography sample prep



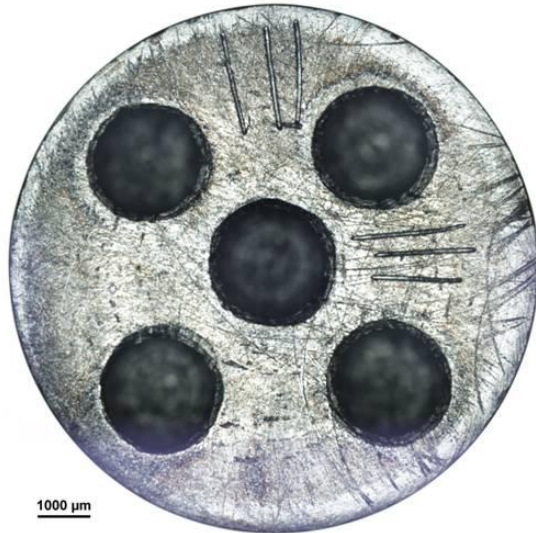
Fishing line's set up for grain transfer from JAXA sample container



Sealing capillaries with wax after fishing lines inserted.

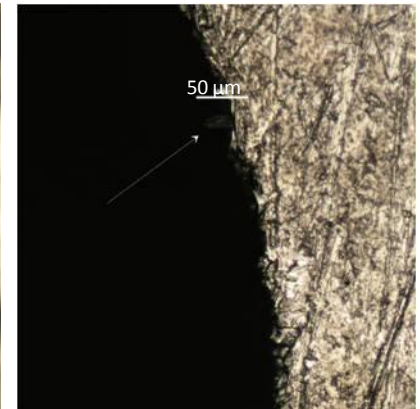
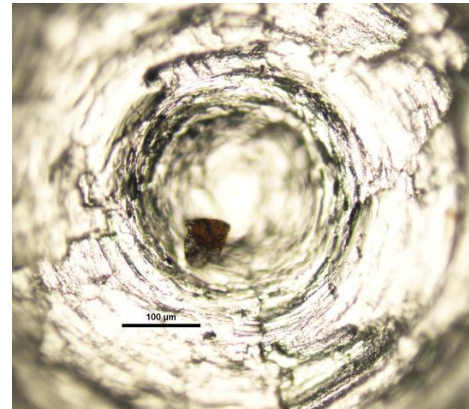
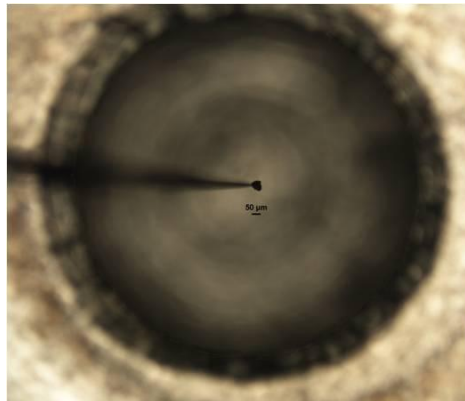
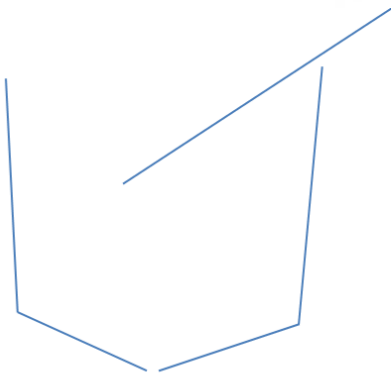


Sample holder design to aid transfer



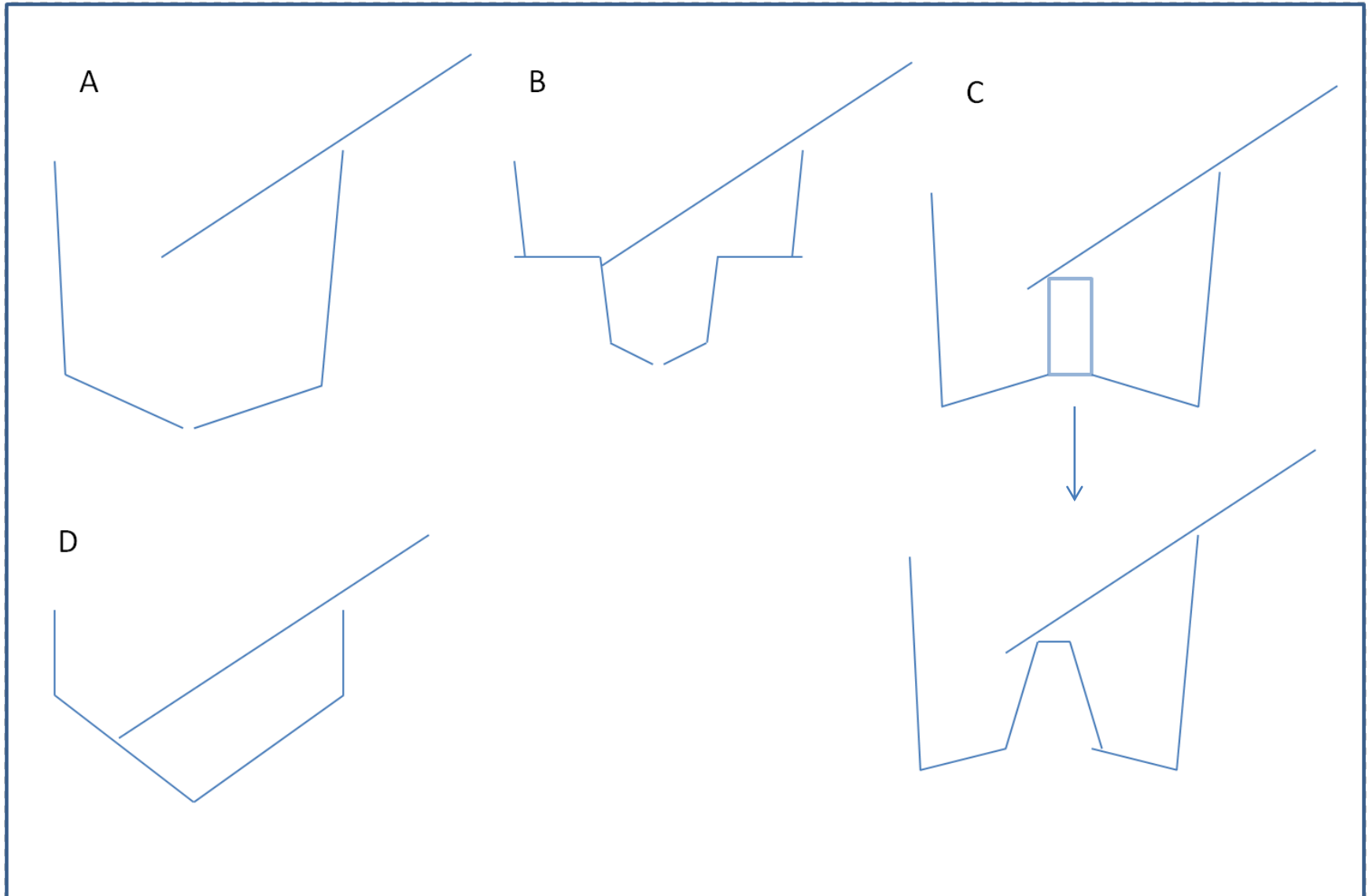
Sample holders for noble gas analyses in Manchester

- Good for large (100 µm) particles that easily drop off needle into centre of hole
- Tricky for smaller and/or sticky particles that need to be scraped off the needle





Sample holder design to aid transfer



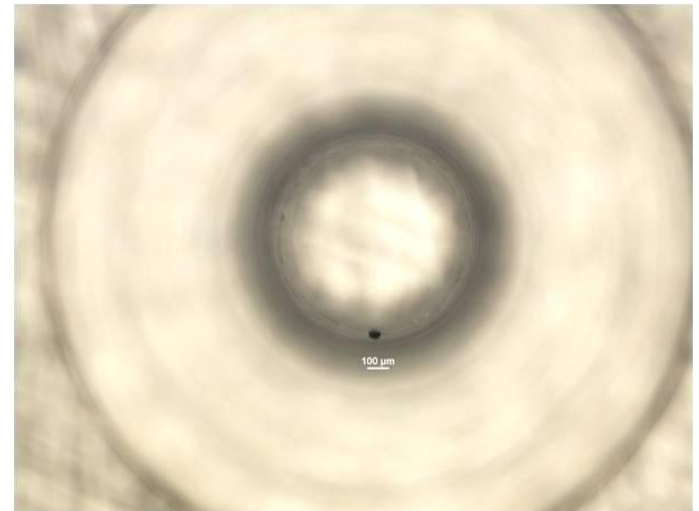


Sample holder design to aid transfer



Khatyrka particle sample holder for noble gas analyses

Particles slightly sticky after being on C-tape





Summary

- Micro-manipulation is a vital tool for preparing many extra-terrestrial samples
- With the right equipment, enough preparation and perseverance, particles as small as 2 microns and even particles stuck in glue can be transferred to and from a variety of sample holders.
- Particle loss can be nearly completely prevented – simple design fixes, preparation and practice.
- Key features:
 - Good microscope
 - Vibration isolation table
 - Custom-made mounts with effective particle transfer in mind
- Glass needles instead of tungsten? No need for cleaning.