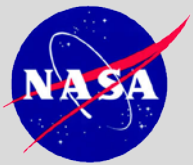




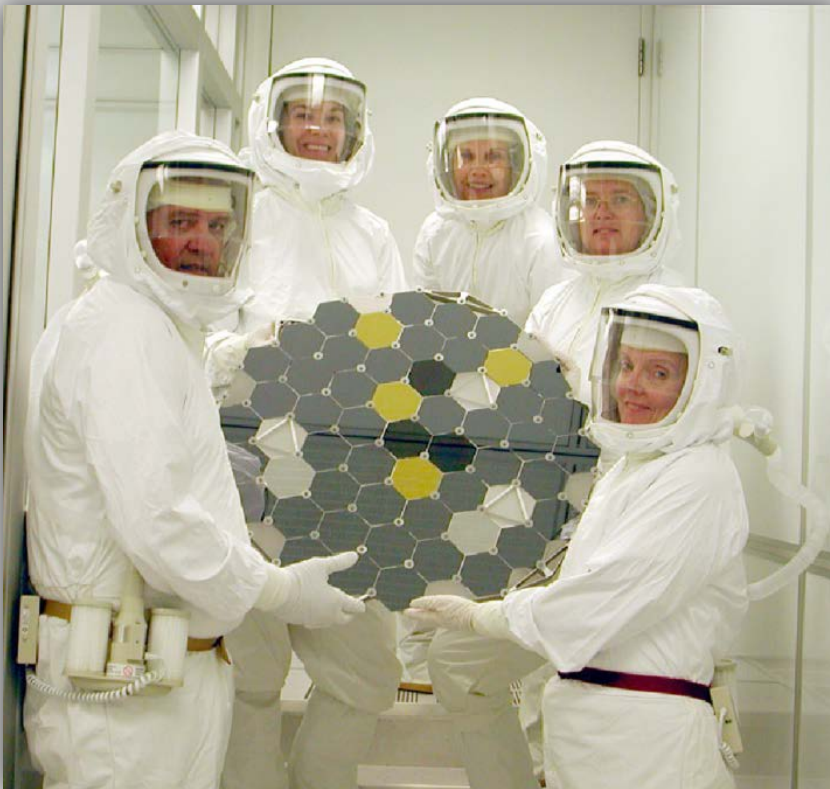
# Overview Genesis Contamination Control and Curation

Judy Allton, Eileen Stansbery, Kim Cyr, Jack Warren, Carol  
Schwarz, Jerome Hittle, Karen McNamara, Mike Calaway,  
Melissa Rodriguez, P. J. Burkett, Vern Lauer, Carla Gonzalez,  
Kimberly Allums



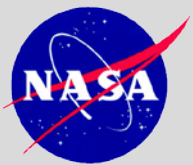
# ASTROMATERIAL CURATION

JSC



- **Preservation of scientific integrity**
  - Controlled environment storage and handling
  - Controlled documentation and sample accountability
- **Characterizing the collection**
- **Dissemination of information about the collection**
- **Allocation of samples for research and education**
- **Reserve portion for future studies**

**Responsibility assigned to Director of the Johnson Space Center per NASA Policy Directive 7100.10E**

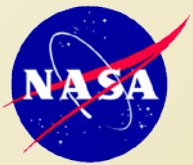


# ASTROMATERIAL CURATION

JSC



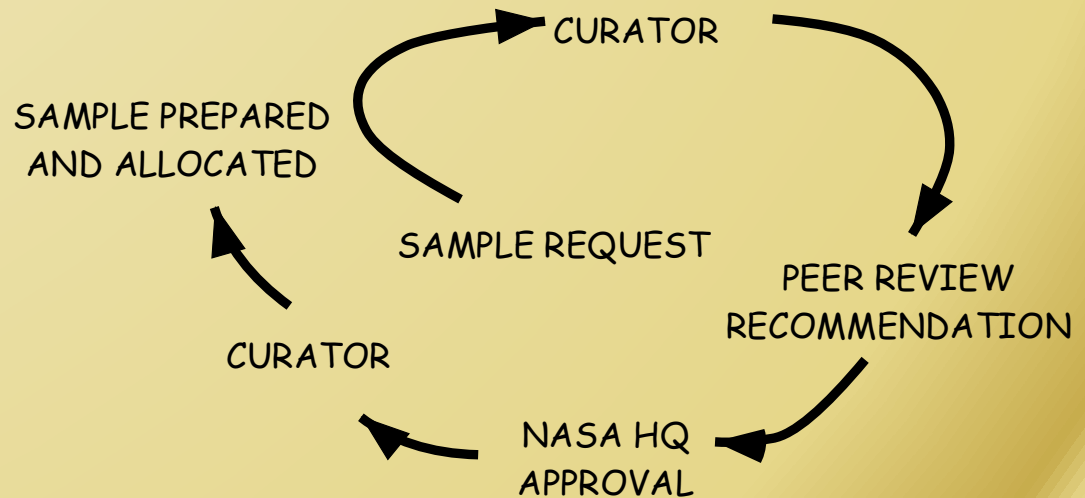
- **Begins with mission design and hardware design**
  - Set requirements for contamination control based on science requirements
  - Active participation in mission planning
- **Continues through fabrication, cleaning and assembly**
  - Attention to detail of fabrication and assembly process is critical
  - Active participation and contamination control oversight
- **Continues through launch, flight and return phases**
  - Active participation
- **Recovery operations optimized for scientific integrity**
- **Curatorial facility operation for preservation of scientific integrity**

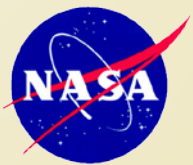


## CURATION – SCIENCE FROM THE SAMPLES

JSC

- Sample Characterization and documentation
- Dissemination of information about the collection
- Facilitating peer review and implementing allocation decisions



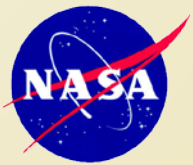


## CURATION – SAMPLE ACCOUNTABILITY

JSC

- **Accurate tracking :  
collection inventories,  
investigator  
inventories**



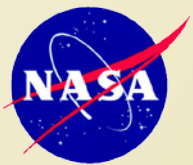


# GENESIS DID IT RIGHT!

JSC



- **Mission plan and budget included contamination control and curation from the beginning**
- **Excellent team work among Principal Investigator, science team, mission design, engineering and curation**
- **“START CLEAN, STAY CLEAN”**
- **Post-landing intense collaboration between curation and science team on cleaning methods and cleanliness assessment**

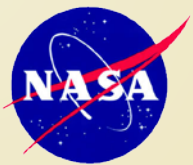


# PRE-LAUNCH CURATION

JSC

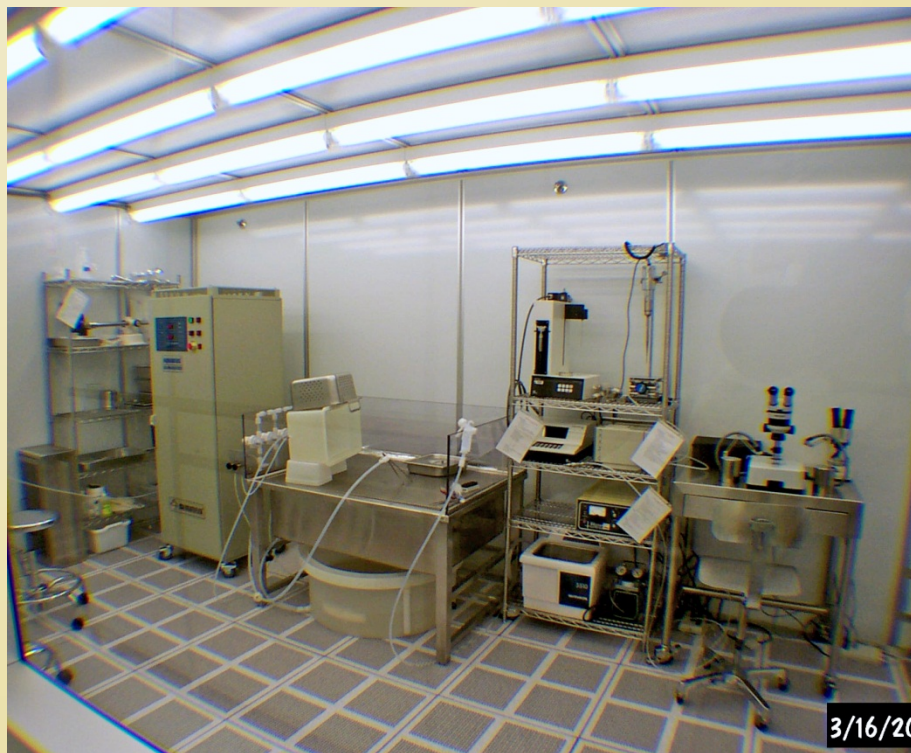


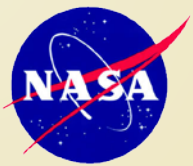
- **Assessment of contamination mitigation during flight operations**
  - Sealed payload open only during collection
  - Minimization of thruster plume effects
  - Re-entry pressure equalization and ablation gas mitigation
- **Choice of clean and cleanable materials for payload fabrication**
  - Bare aluminum, minimum lubricants and adhesives
- **Construction of ISO Class 4 cleanroom for payload cleaning & assembly**
  - Cleaning with megasonically energized ultrapure water: 18 meg-Ohm-cm
  - Assembly and sealing of payload
- **Archiving of flight reference coupons and environmental monitoring witness plates**
- **Clean sample storage under nitrogen**



## PRE-LAUNCH CURATION: ISO 4 laminar flow cleanrooms

JSC



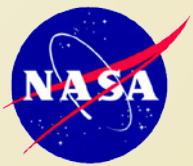


## PRE-LAUNCH CURATION: Cleaning with UPW

JSC

- 18 M $\Omega$ -cm resistivity
- <5 ppb TOC
- Ultrasonic or megasonic energy
- Ionic concentration low parts per trillion = “hungry water”





## PRE-LAUNCH CURATION: Clean assembly, HEPA-filtered people

JSC



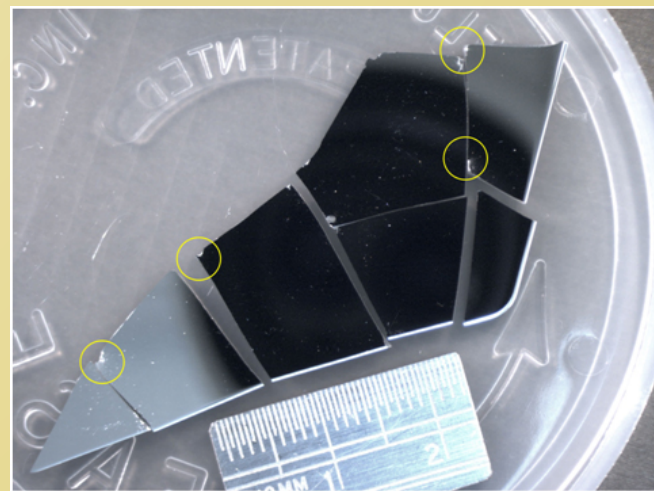
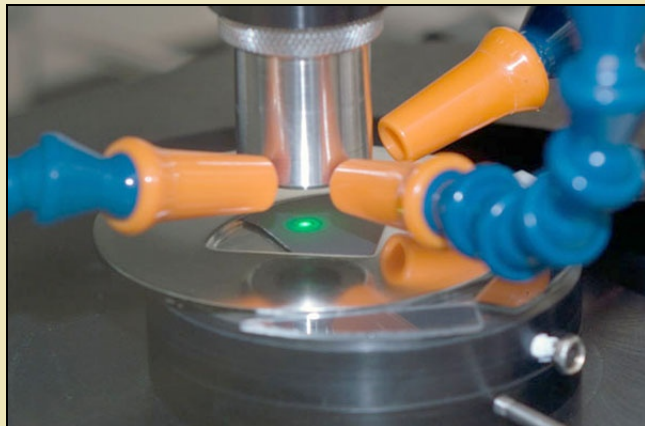


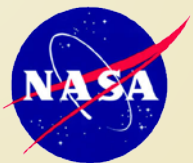
- **Instrumentation for surface cleanliness assessment**
  - High resolution optical scanning for particulates
  - Ellipsometry mapping for molecular films



## PRE-RECOVERY CURATION

- **Capability for clean subdivision of collectors**
  - Laser scribing backside
  - Manual cleaving



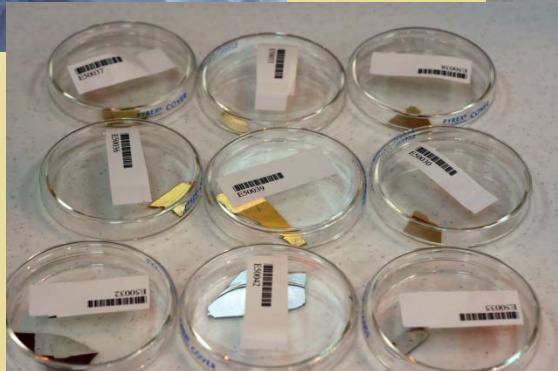


# POST-LANDING CURATION

JSC

- **Landing site recovery**

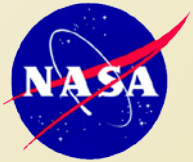
- Field recovery to UTTR cleanroom before sunset
- Removal of collector fragments from canister
- Imaging and packaging of >10,000 fragments
- Transport to JSC in less than a month



Oct. 7-9, 2014

GENESIS EARTH RETURN - 10th

14



## JSC CURATION

JSC



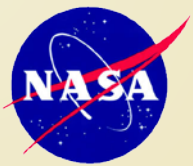
- Secure nitrogen storage
- ISO Class 4 handling
- Sample characterization
- Sample information dissemination
- Sample allocation



Oct. 7-9, 2014

GENESIS EARTH RETURN - 10th

15



## JSC CURATION: Secure nitrogen storage

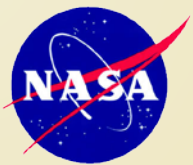
JSC



Oct. 7-9, 2014

GENESIS EARTH RETURN - 10th

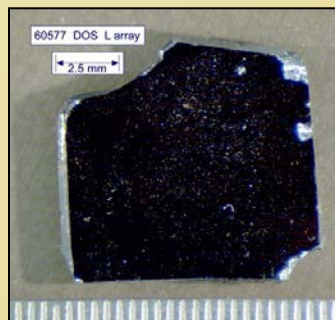
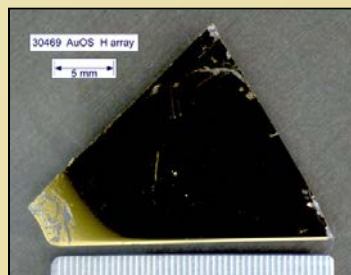
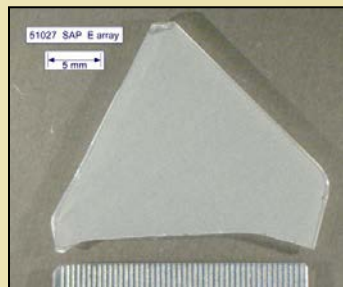
16



# JSC CURATION: Sample characterization

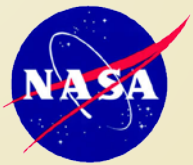
JSC

- Material
- Solar wind regime
- Imaging
- Size and surface quality



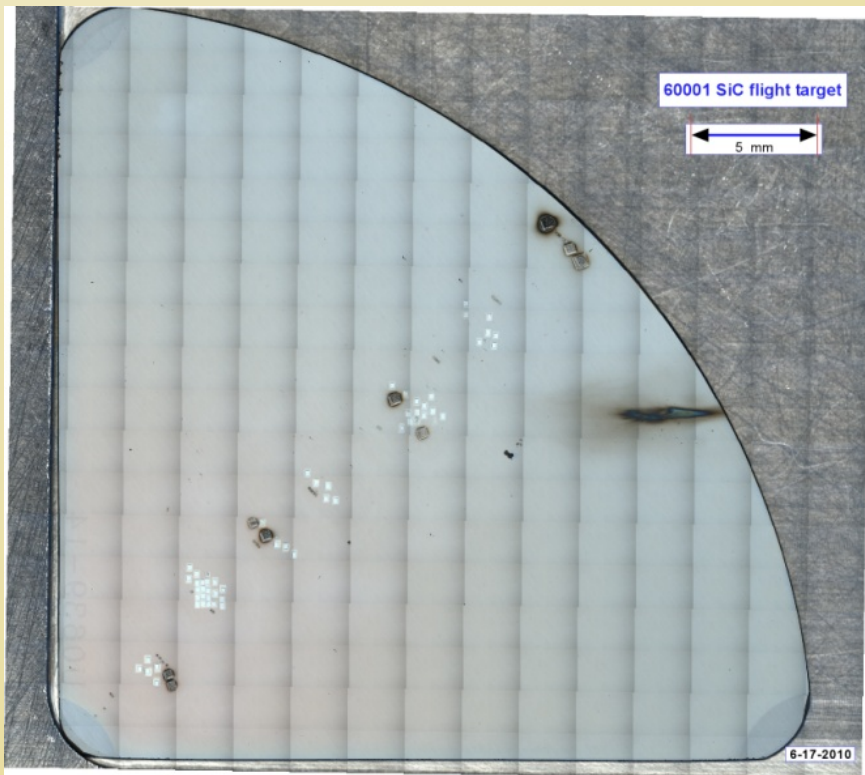
Oct. 7-9, 2014

GENESIS EARTH RETURN -

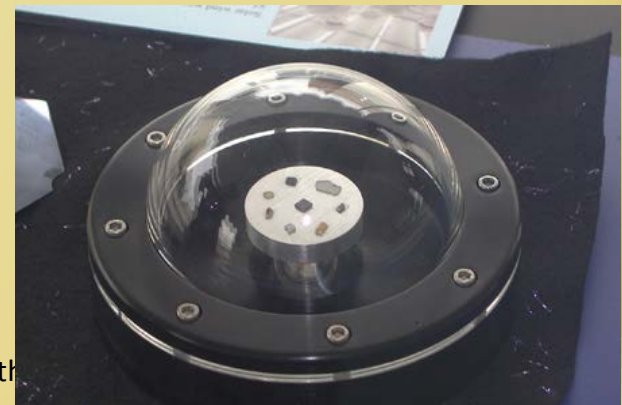


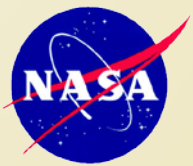
# JSC CURATION: Dissemination of sample information, facilitation of peer review, allocation

JSC



- Online catalog updated monthly
- Newsletter
- Investigator Guidebook
- Genesis Oversight Subcommittee of CAPTEM reviews sample requests and recommendations to Discipline Scientist at NASA HQ
- Public display samples





# JSC CURATION:

## Collaboration with science team, cleaning samples

JSC



- JSC optical imaging between cleaning steps
- JSC cleaning with ultrapure water (UPW)
- JSC use of UV ozone to remove molecular film



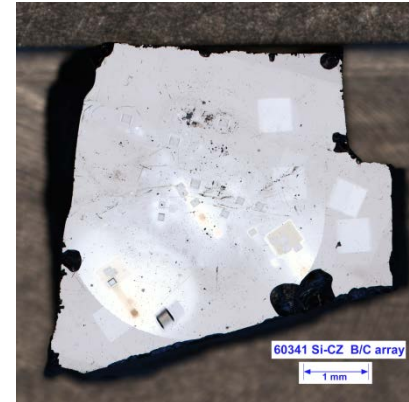
# Sample History



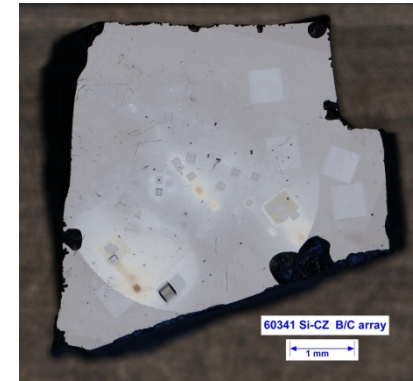
After UPW cleaning  
(Step 1)



After UV ozone cleaning  
(Step 4)



After ToF-SIMS analysis  
(Step 5)



After UPW cleaning  
(Step 8)

1. UPW cleaned (2/21/2007) \*
2. 25Mg implant, SIMS analysis (6/12/2007)
3. 54Fe implant, SIMS analysis (5/1/2011)
4. UV ozone (6/22/2011) \*
5. ToF-SIMS (3/11/2013) \*
6. UPW cleaned (8/21/2013) \*
7. HCl, hot xylene (8/28/2013) \*
8. UPW cleaned (9/4/2013) \*
9. ToF-SIMS (3/14/2014)

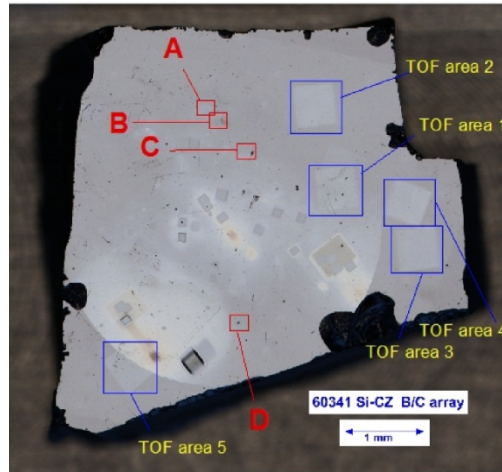
UPW= Ultra Pure Water

\* Followed by optical imaging

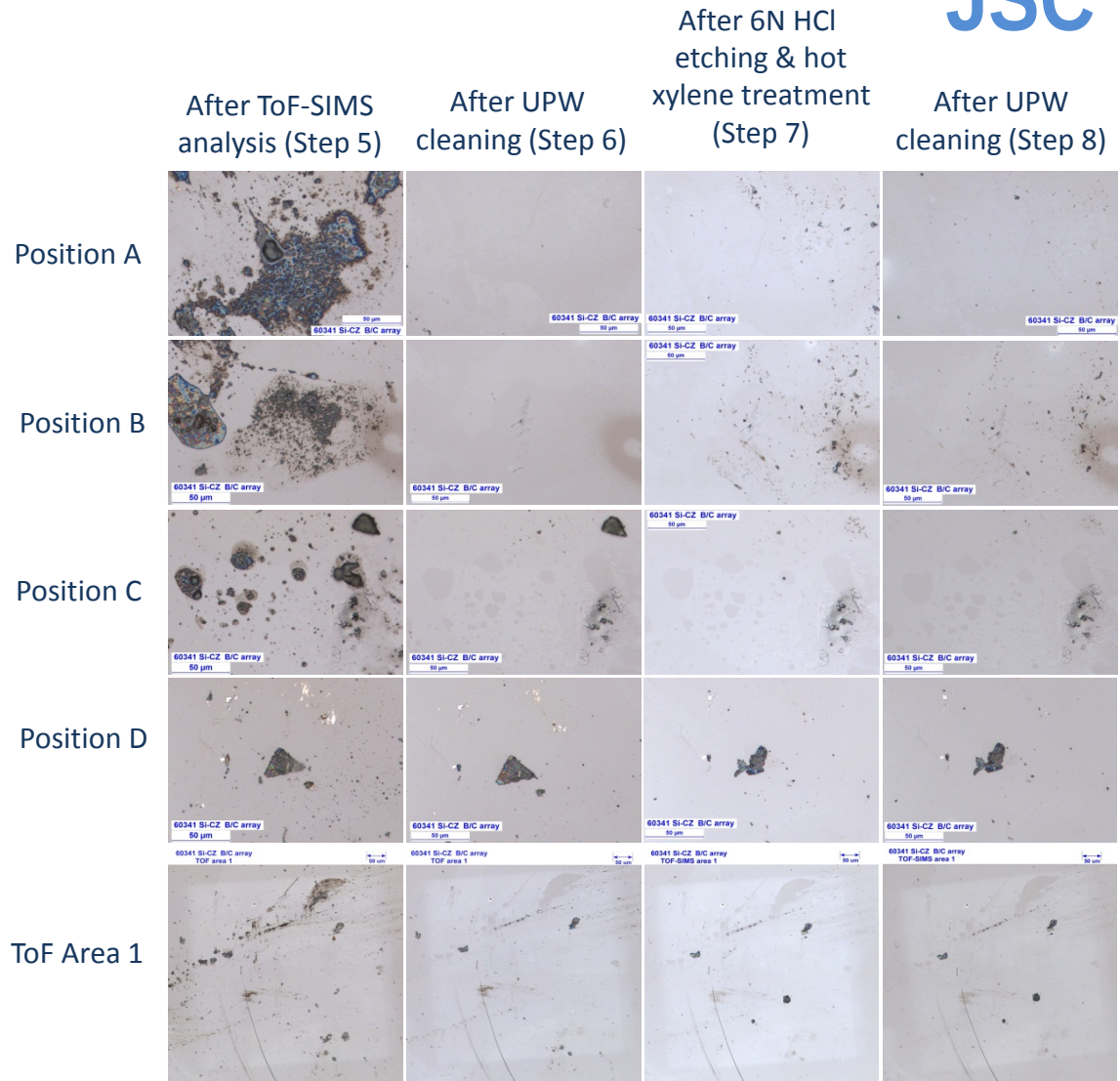


# Optical Images of 60341

JSC



Location of high magnification optical images and ToF-SIMS scans. Overall image taken after 3rd UPW cleaning-Step 8. The bright areas are oxidation introduced during SIMS analysis.



1. Step 6 shows UPW cleaning effectively removed handling debris documented in step 5 (ToF-SIMS);
2. Acid cleaning, hot xylene treatment, and ultrasonic cleaning (step 7) added contamination to positions A and B, but removed in C and D;
3. Images from step 8 show contamination from step 7 handling was partially mitigated in A and B, but there were few visible changes in C and D.



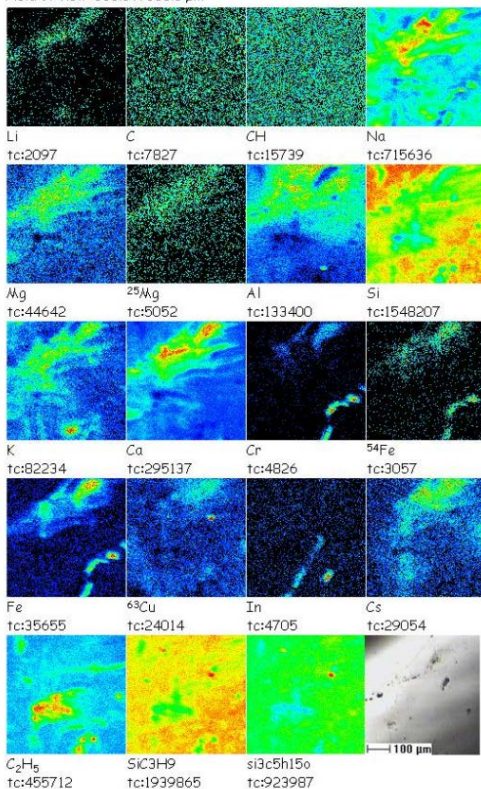
# ToF-SIMS Results

JSC

60341 TOF area 1 before Ar sputtering

Positive ion imaging

Field of view: 500.0 x 500.0  $\mu\text{m}^2$

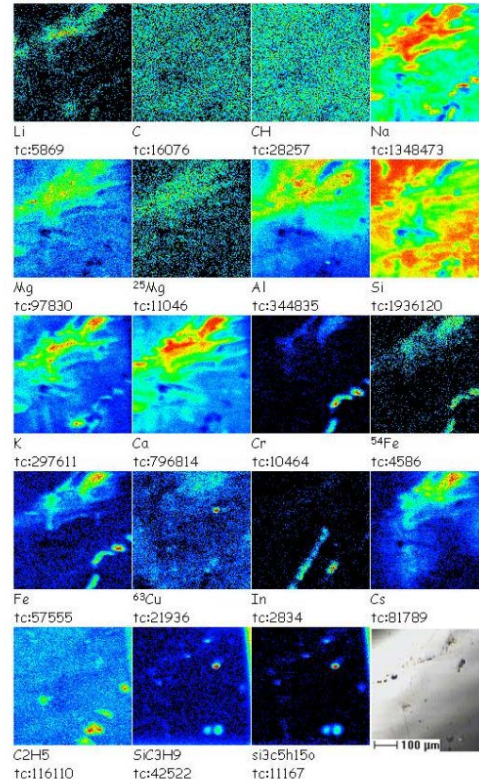


A) ToF-SIMS Area 1 after Step 4  
Before Ar sputtering

60341 TOF area 1 after Ar sputtering

Positive ion imaging

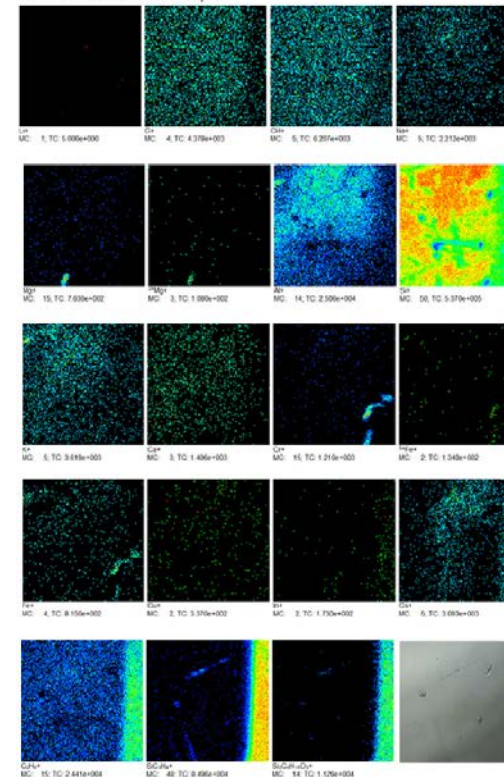
Field of view: 500.0 x 500.0  $\mu\text{m}^2$



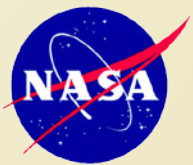
B) ToF-SIMS Area 1 after Step 4  
After Ar sputtering

Positive ion imaging

Field of view: 500.0 x 500.0  $\mu\text{m}^2$



C) ToF-SIMS after Step 8 (last UPW)



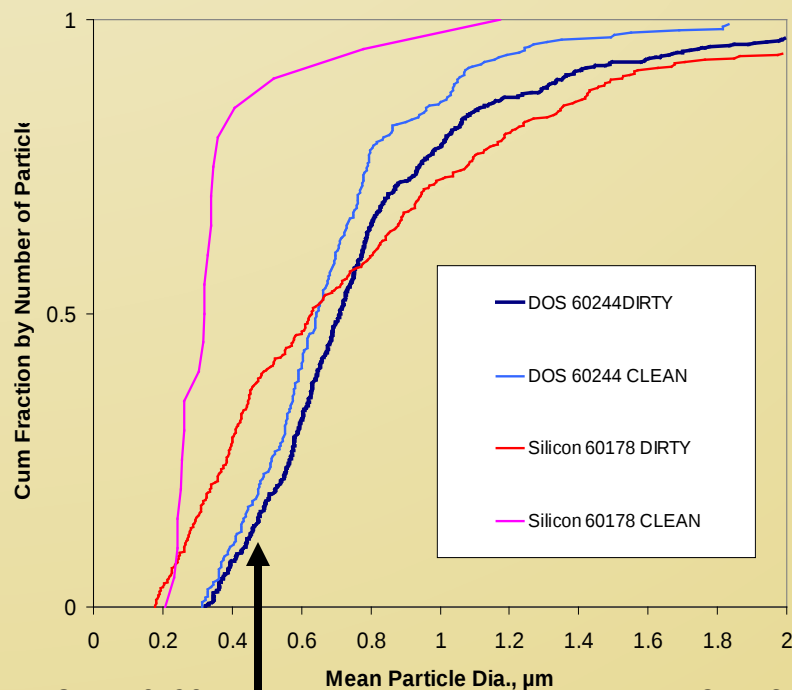
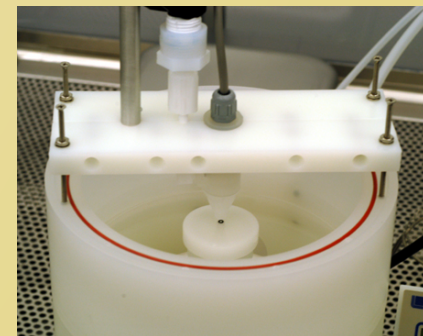
# GENESIS SAMPLE CLEANING

JSC

- Brown stain removal - UV ozone cleaner



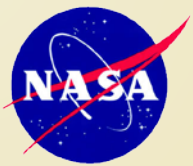
- Particle removal - UPW megasonic



0.5  $\mu\text{m}$

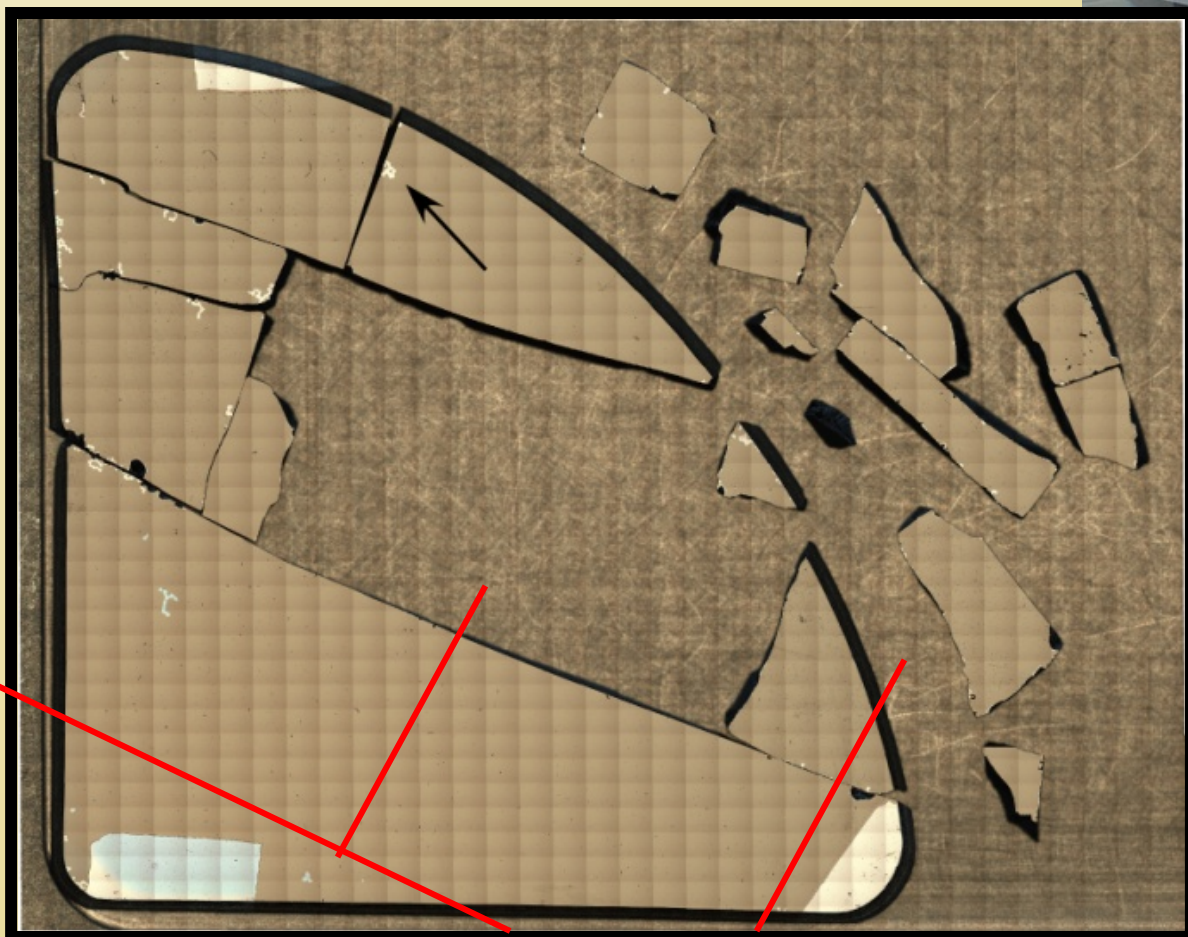
Oct. 7-9, 2014

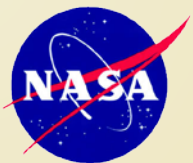
GENESIS EARTH RETURN - 10th



## JSC CURATION: precise sample subdivision

JSC





## JSC CURATION: clean sample subdivision

JSC

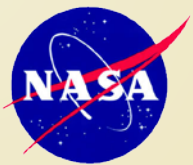


- Subdivision of polished aluminum –
- Yield material for noble gas analysis and two craters



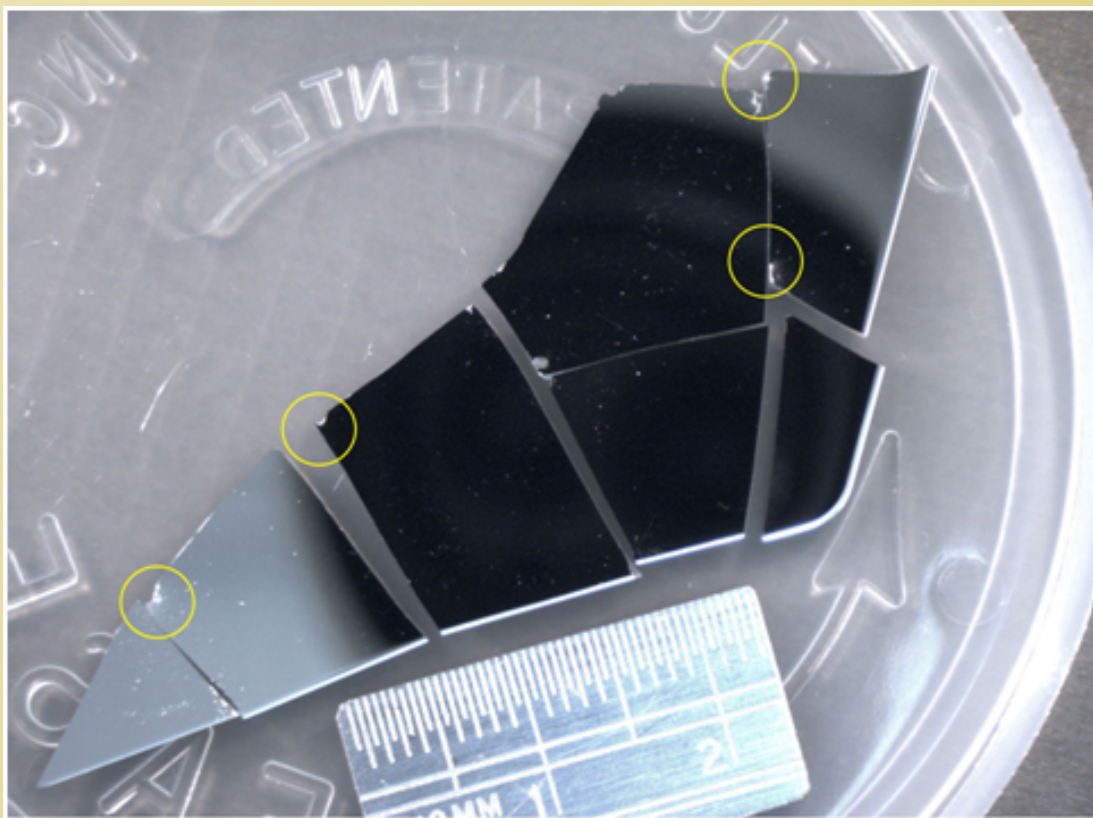
Oct. 7-9, 2014

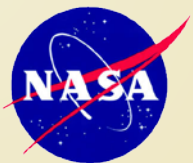
GENESIS EARTH RETURN - 10th



## JSC CURATION: clean sample subdivision

JSC





# JSC CURATION 10 YEARS: Samples characterized

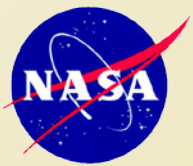
JSC

| MATERIAL | ARRAY | FLOWN AREA<br>(mm <sup>2</sup> ) | AREA<br>CATALOGED<br>(mm <sup>2</sup> ) | TOTAL<br>CATALOGED<br>(%) |
|----------|-------|----------------------------------|-----------------------------------------|---------------------------|
| CZ Si    | B     | 56493                            | 3123.2                                  | 1.8                       |
|          | C     | 112986                           |                                         |                           |
|          | H     | 43939                            | 2219.0                                  | 5.1                       |
|          | E     | 56493                            | 2415.7                                  | 4.3                       |
|          | L     | 56493                            | 2426.7                                  | 4.3                       |
| FZ Si    | B     | 125540                           | 4580.7                                  | 2.0                       |
|          | C     | 100432                           |                                         |                           |
|          | H     | 106709                           | 1846.8                                  | 1.7                       |
|          | E     | 106709                           | 2412.8                                  | 2.3                       |
|          | L     | 138094                           | 1192.9                                  | 0.9                       |
| DOS      | B     | 18831                            | 1502.9                                  | 4.0                       |
|          | C     | 18831                            |                                         |                           |
|          | H     | 25108                            | 523.7                                   | 2.1                       |
|          | E     | 25108                            | 985.8                                   | 3.9                       |
|          | L     | 25108                            | 730.4                                   | 2.9                       |

Data as of January 2009

| MATERIAL | ARRAY | FLOWN AREA<br>(mm <sup>2</sup> ) | AREA<br>CATALOGED<br>(mm <sup>2</sup> ) | TOTAL<br>CATALOGED<br>(%) |
|----------|-------|----------------------------------|-----------------------------------------|---------------------------|
| SAP      | B     | 25108                            | 10976.0                                 | 21.9                      |
|          | C     | 25108                            |                                         |                           |
|          | H     | 25108                            | 12147.4                                 | 48.4                      |
|          | E     | 31184                            | 15096.6                                 | 48.4                      |
|          | L     | 25108                            | 2796.6                                  | 11.1                      |
| SOS      | B     | 31385                            | 33690.2                                 | 59.6                      |
|          | C     | 25108                            |                                         |                           |
|          | H     | 25108                            | 14878.5                                 | 59.3                      |
|          | E     | 25108                            | 16078.6                                 | 64.0                      |
|          | L     | 25108                            | 9542.6                                  | 38.0                      |
| AIOS     | B     | 31184                            | 30110.4                                 | 42.0                      |
|          | C     | 40499                            |                                         |                           |
|          | H     | 31385                            | 14747.8                                 | 47.0                      |
|          | E     | 37461                            | 16488.8                                 | 44.0                      |
|          | L     | 25108                            | 7992.7                                  | 31.8                      |
| AuOS     | B     | 24907                            | 31952.1                                 | 48.9                      |
|          | C     | 40499                            |                                         |                           |
|          | H     | 62167                            | 19060.8                                 | 30.7                      |
|          | E     | 43738                            | 29398.4                                 | 67.2                      |
|          | L     | 43336                            | 6744.4                                  | 15.6                      |
| CCo-AuOS | B     | 12353                            | 6068.3                                  | 49.1                      |
|          | C     | 0                                | 0.0                                     | 0.0                       |
|          | H     | 0                                | 0.0                                     | 0.0                       |
|          | E     | 0                                | 0.0                                     | 0.0                       |
|          | L     | 0                                | 0.0                                     | 0.0                       |

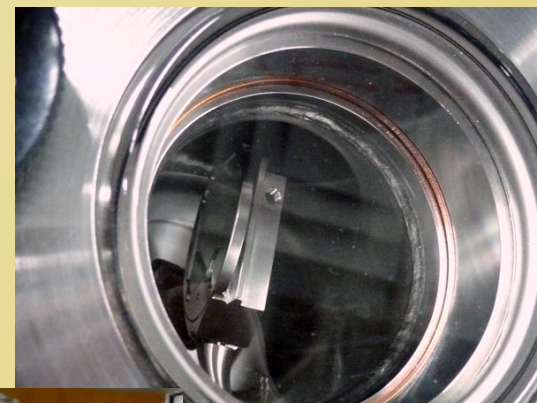
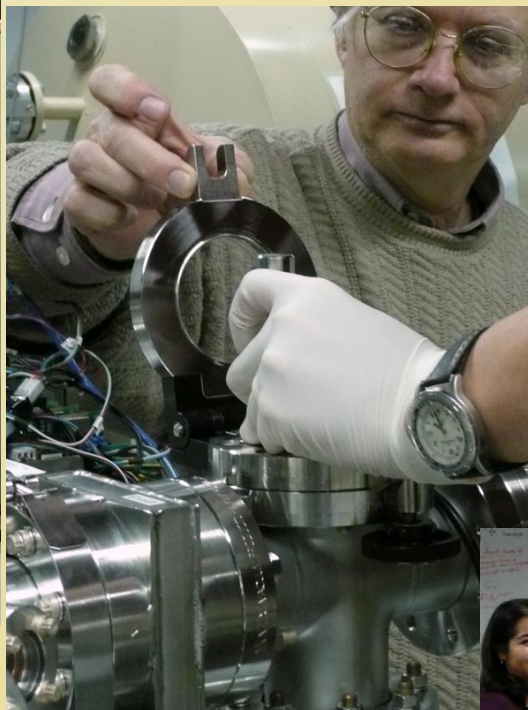
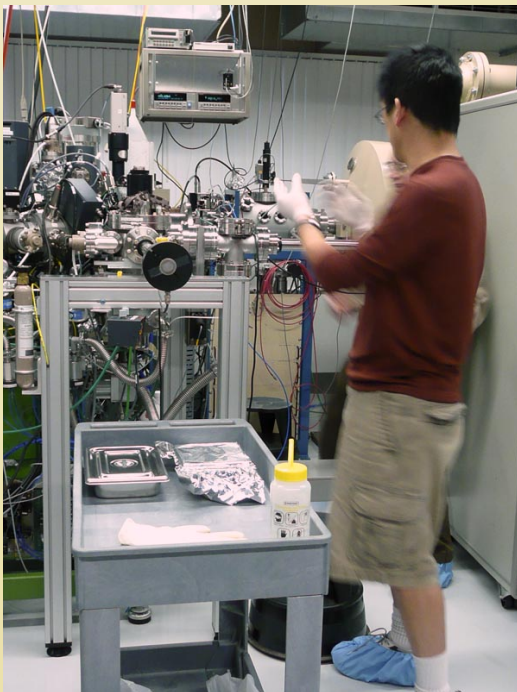
- Sapphire based: 15-49% cataloged
- Silicon based: 1-5% cataloged

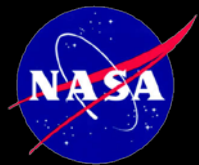


# JSC CURATION 10 YEARS: Samples allocated

JSC

- 653 Genesis-flown samples
- 327 reference collectors
- 28 research groups in 6 countries





JSC