

# Evolution of Interstellar Organics to Meteoritic and Cometary Organics: Approaches by Laboratory Simulations

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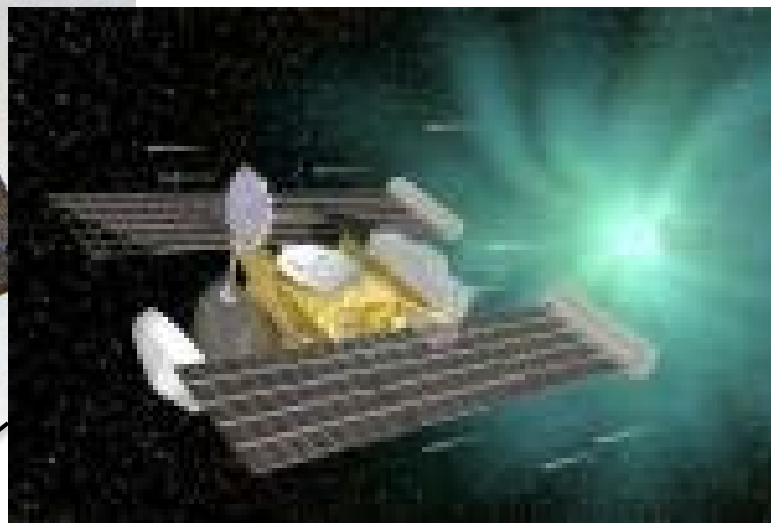
# Outline

- Origins of meteoritic organics and origins of life
- Possible formation and alteration *of interstellar complex amino acid precursors*
- **Cosmic dusts (IDPs)** as carriers of organics to the Earth
- *The Tanpopo Mission*: Capture of cosmic dusts and exposure of organics in space
- Conclusion

# Wide variety of extraterrestrial organics have been detected.

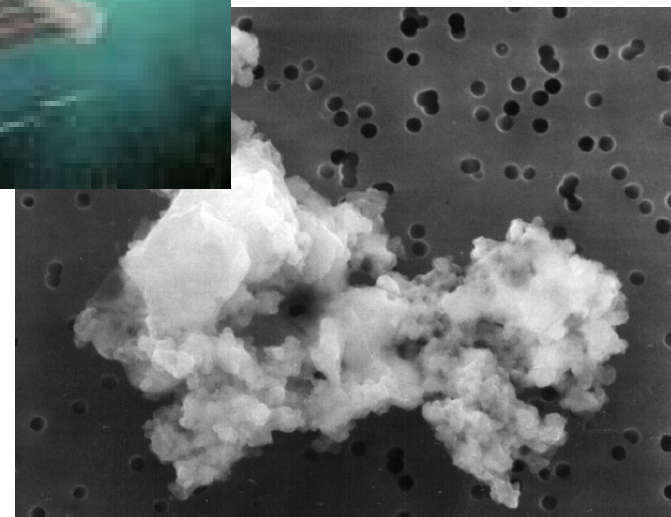


← Meteorites (Yamato791198)



← Comets (Wild 2)

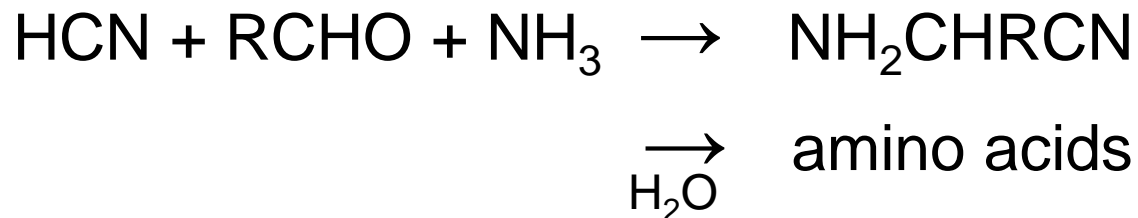
IDPs ↓



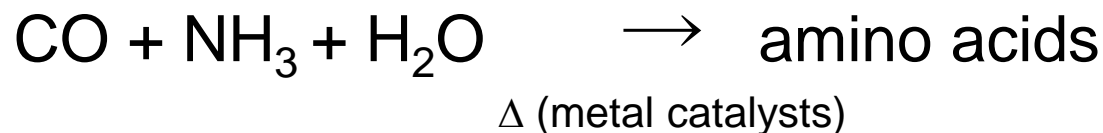
- ✓ Complex organics
- ✓ Amino acids
- ✓ Organics seemed to be formed at low temperature

# Origins of meteoritic amino acids

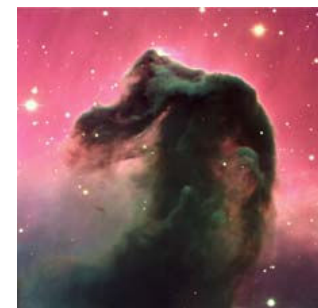
- Strecker synthesis in parent bodies of meteorites



- Fisher-Tropsch-type synthesis in solar nebula



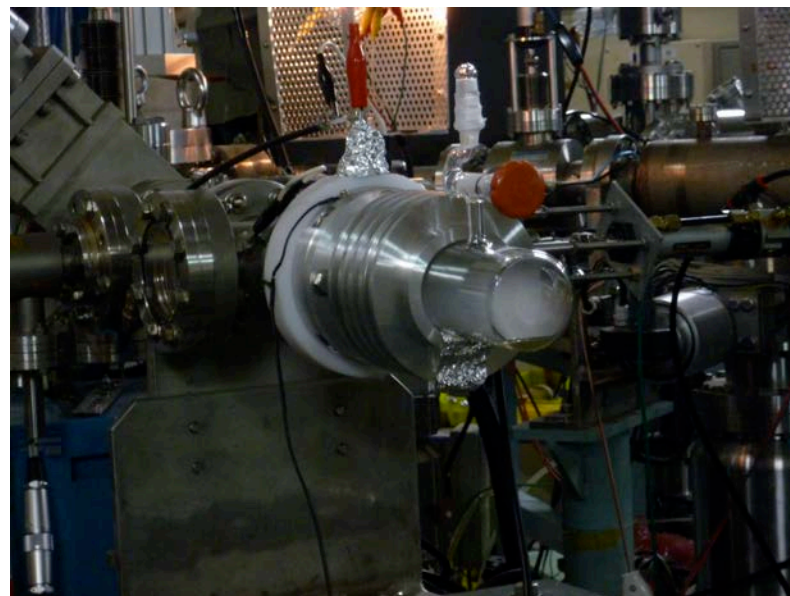
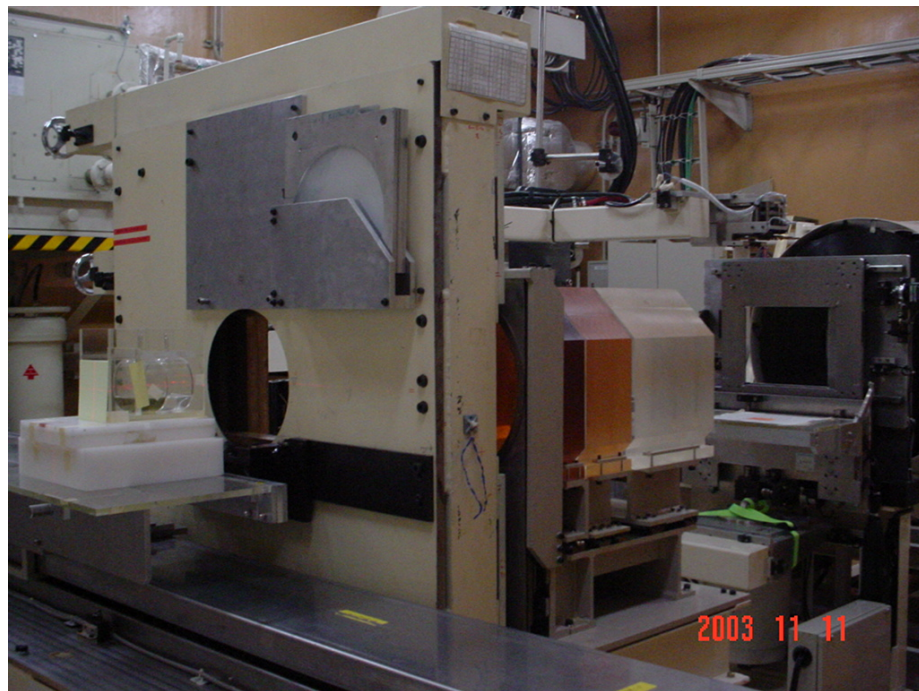
- Alteration of interstellar complex organics



# Particles Irradiation of Simulated Interstellar Media (Ice / Liquid / Gas)

Protons@Tandem  
Accelerator(TIT)→

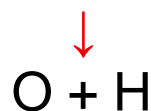
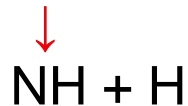
Heavy ions@HIMAC(NIRS) ↓



- ✓ Molecular weights: **Some thousands**
- ✓ **In situ formation** of complex (solid) organics
- ✓ **Amino acids** were yielded after hydrolysis
- ✓ **Nucleic acid bases** were formed



# Formation of amino acids from complex organics (*Garakuta* molecules)

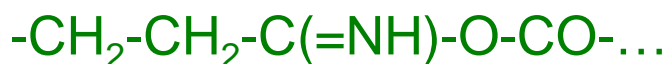
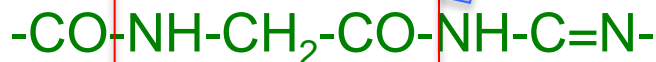


Quench

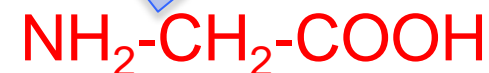


*Garakuta*  
Molecule  
(MW: ca. 1000)

Glycine  
(MW: 75)



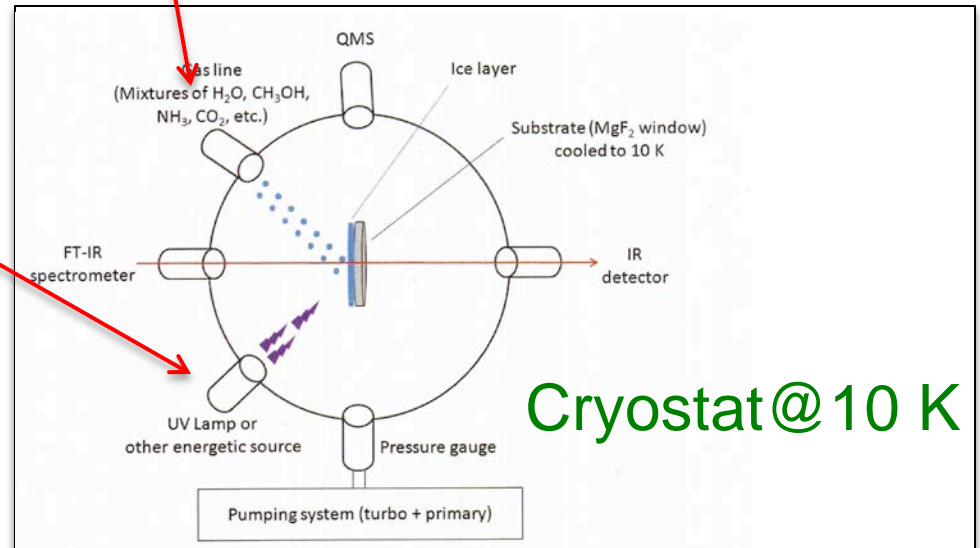
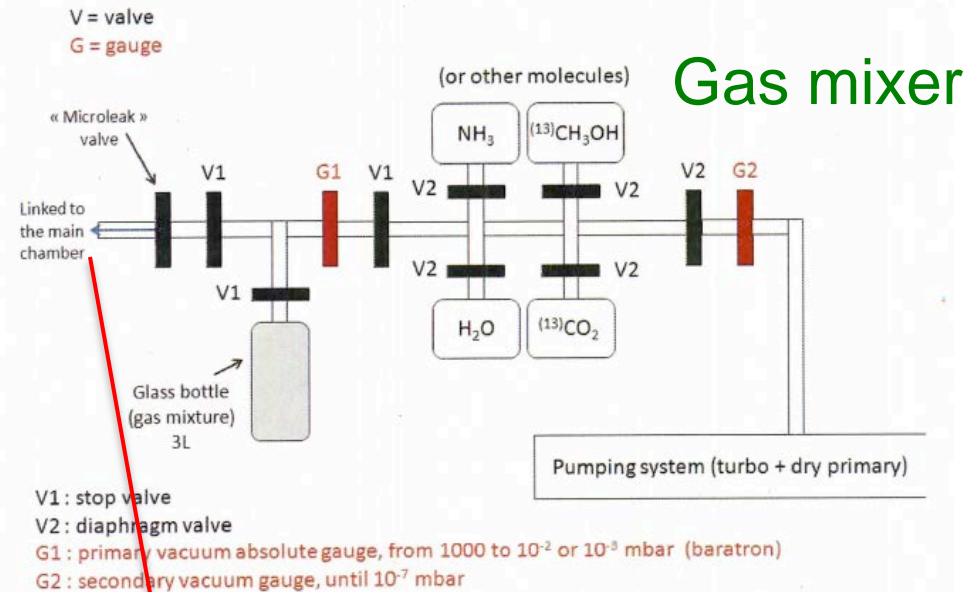
Hydrolysis



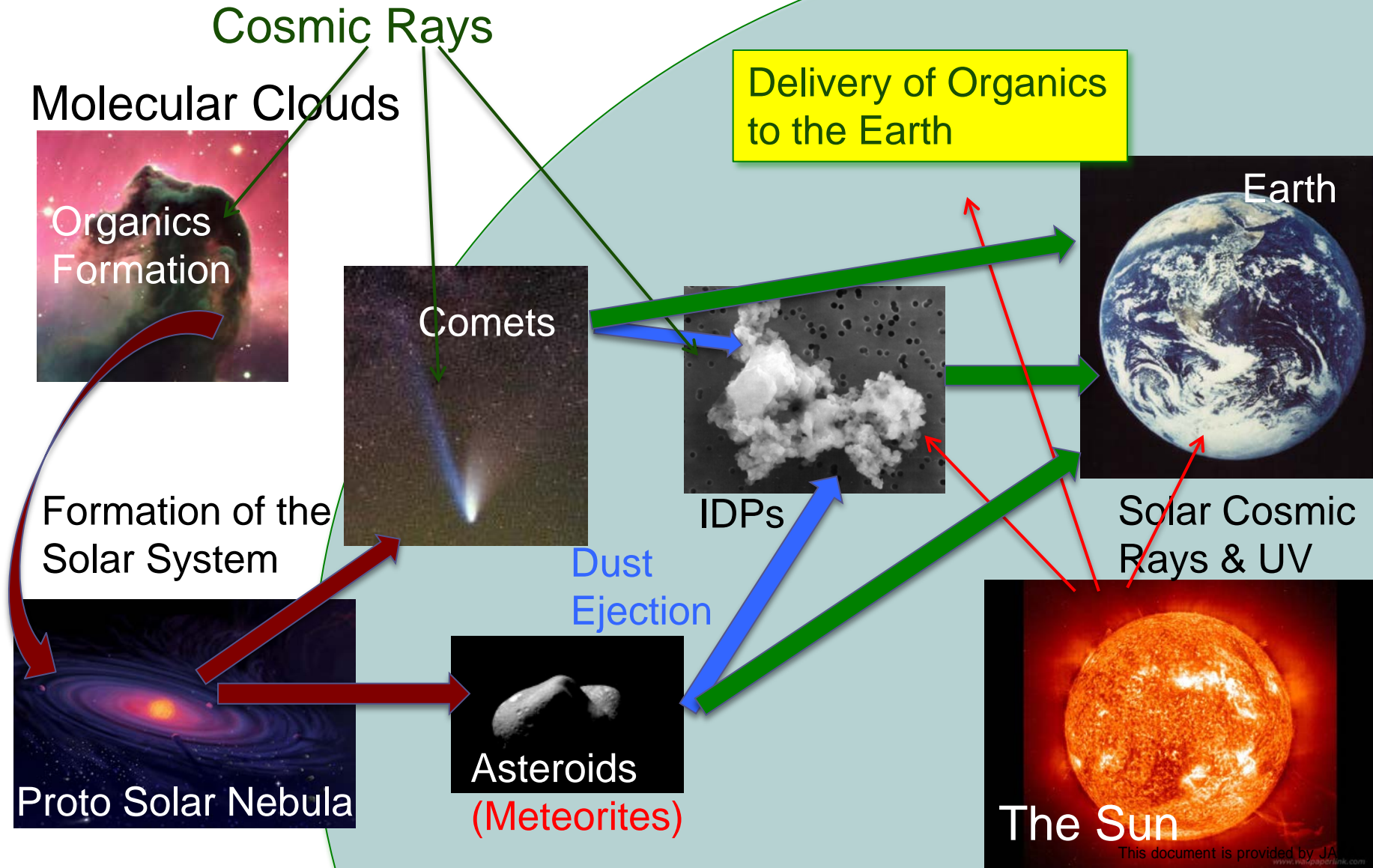
# Heavy ion bombardment of Simulated Interstellar Ices



KEK Digital Accelerator

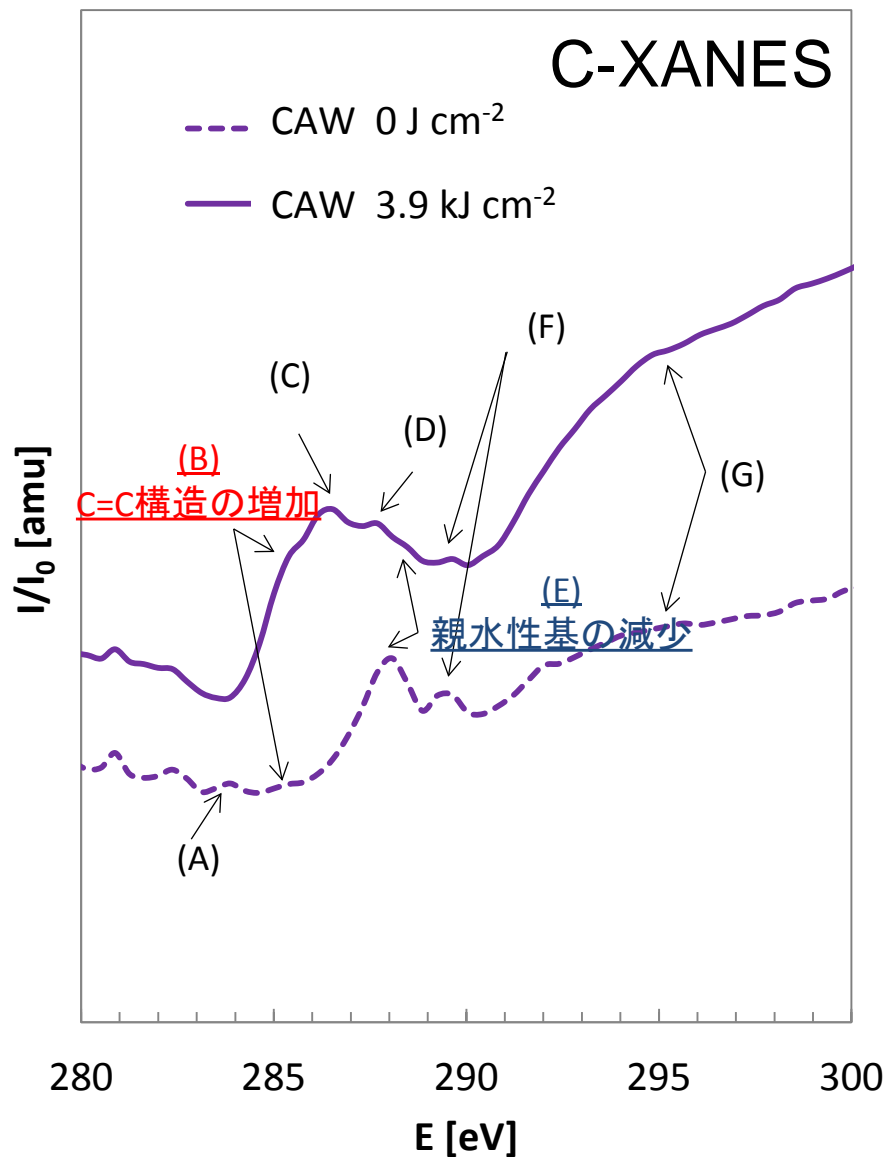


# Alteration and Delivery of Organic Compounds of Interstellar Origins





# Alteration of Interstellar Organics (CAW) in Protosolar Nebula by Soft X-rays



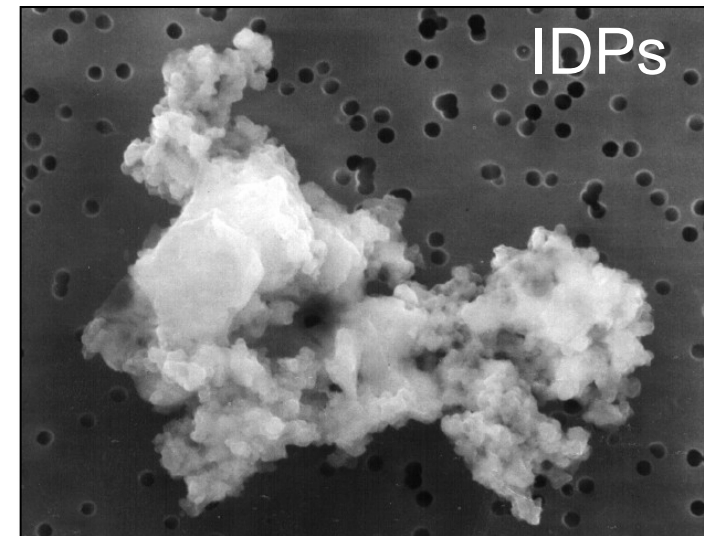
NewSUBARU, Univ. Hyogo

- Decrease of Hydrophilic C=O  
→ (E) Amidyl
  - Increase of Hydrophobic C=C  
→ (B) Aryl, vinyl-keto
- ⇒ **Formation of Insoluble Organics**

## Delivery of Organics to Earth: Meteorites vs. Cosmic Dusts (IDPs)

- ✧ **IDPs** delivered more organics to the Earth than meteorites and comets
- ✧ **IDPs** delivered organics more safely than meteorite and comets.

- ✧ **IDPs** are directly exposed to solar / cosmic radiation.
- ✧ **IDPs** are easily contaminated from terrestrial biosphere.



# UV Irradiation of Amino Acids & Their Precursors

Xe-excimer lamp (172 nm)

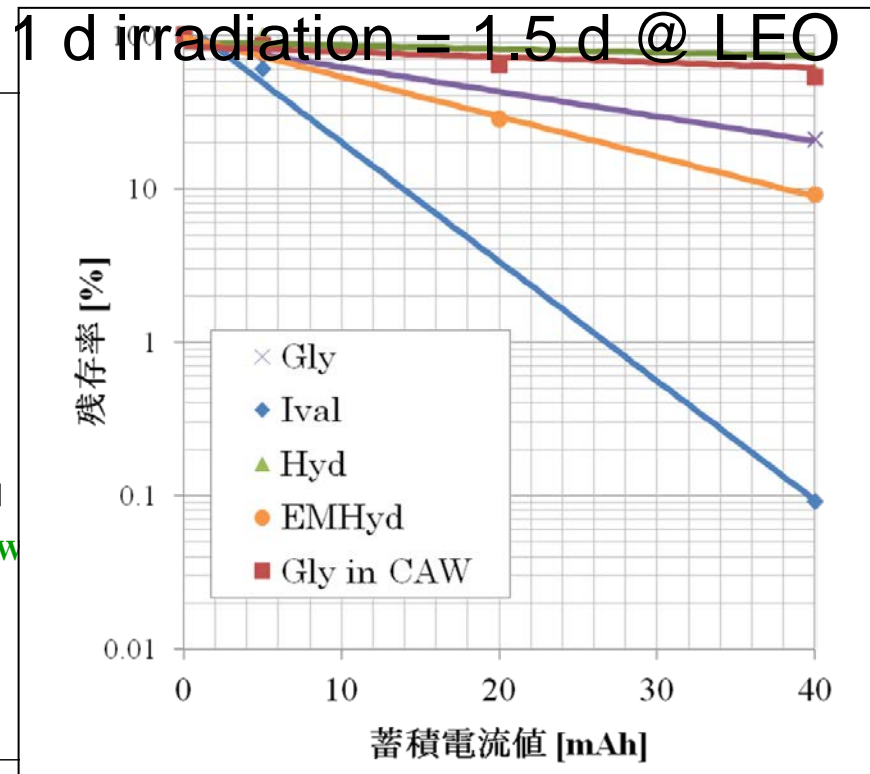
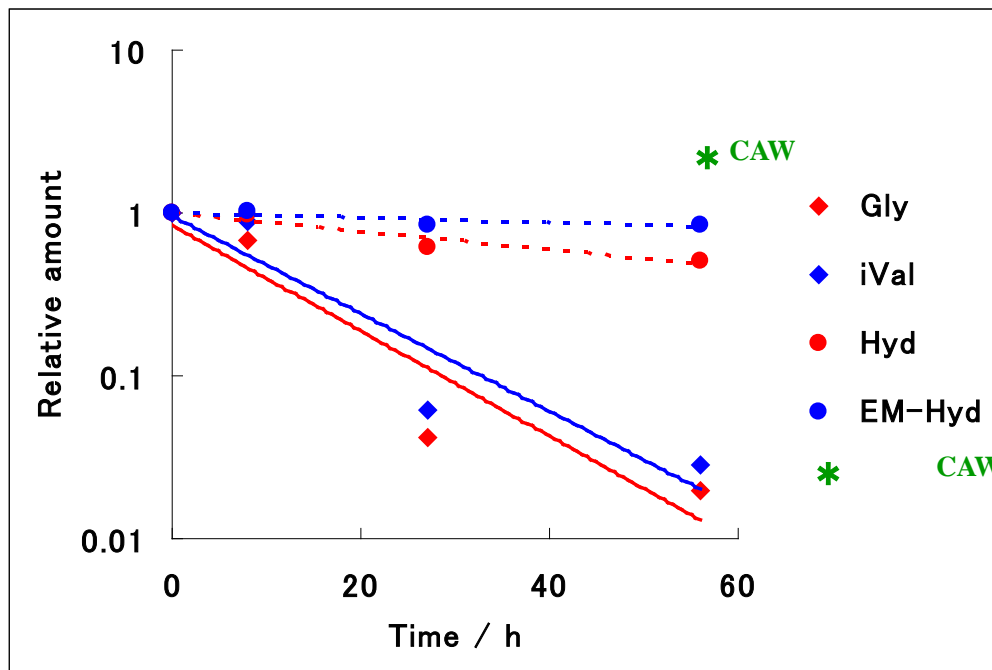
$4 \times 10^{14}$  photon/cm<sup>2</sup>/s

4 d irradiation = ca. 1 yr @ LEO

New SUBARU BL-6

(>130nm)

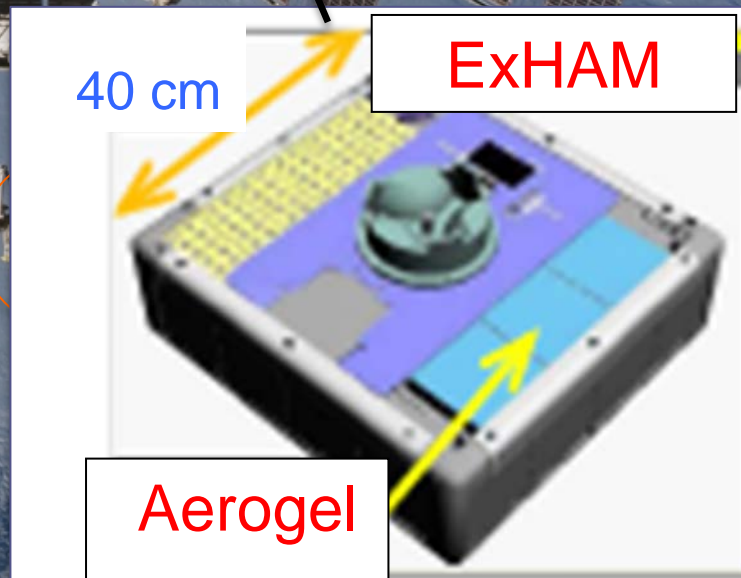
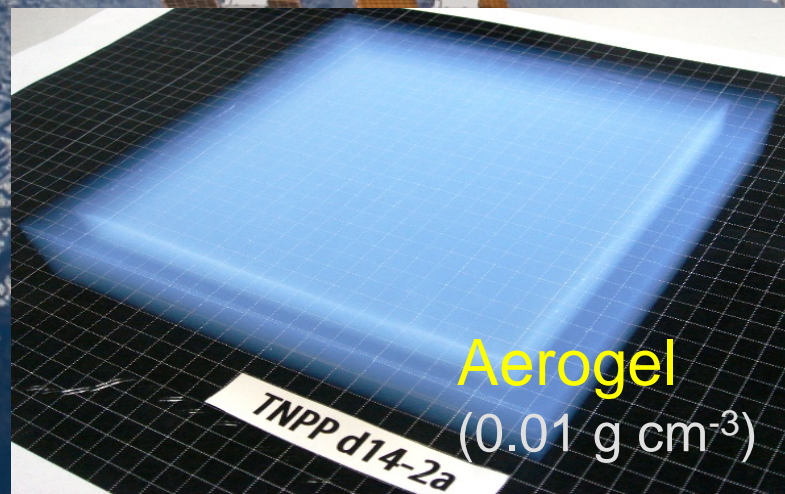
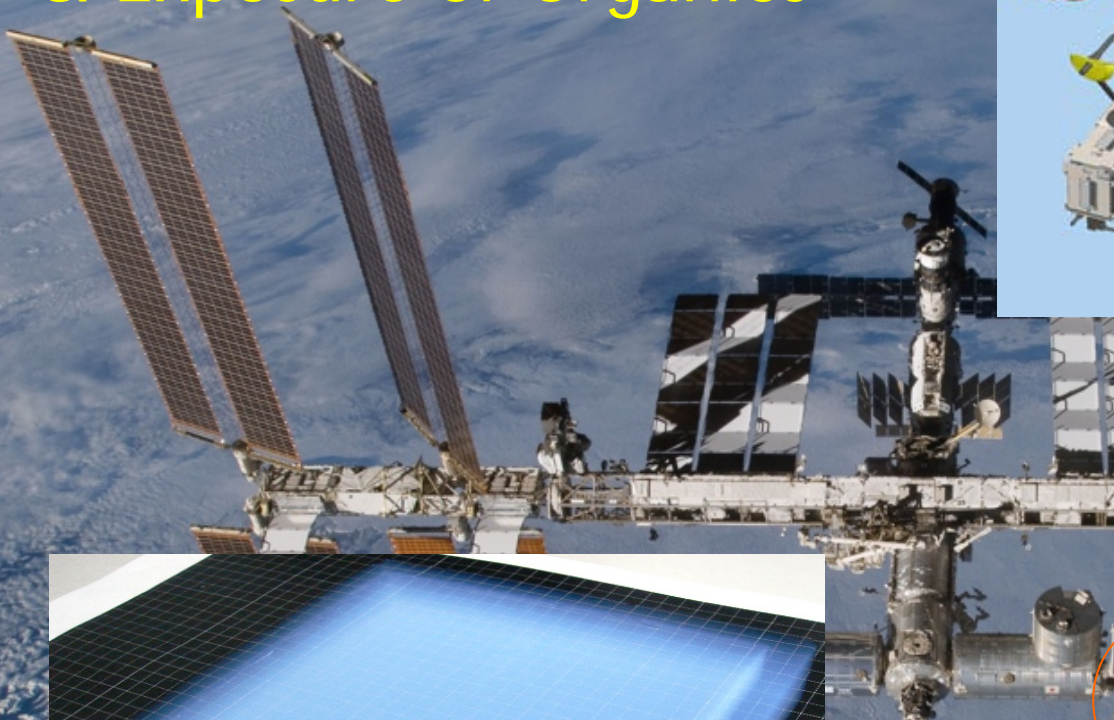
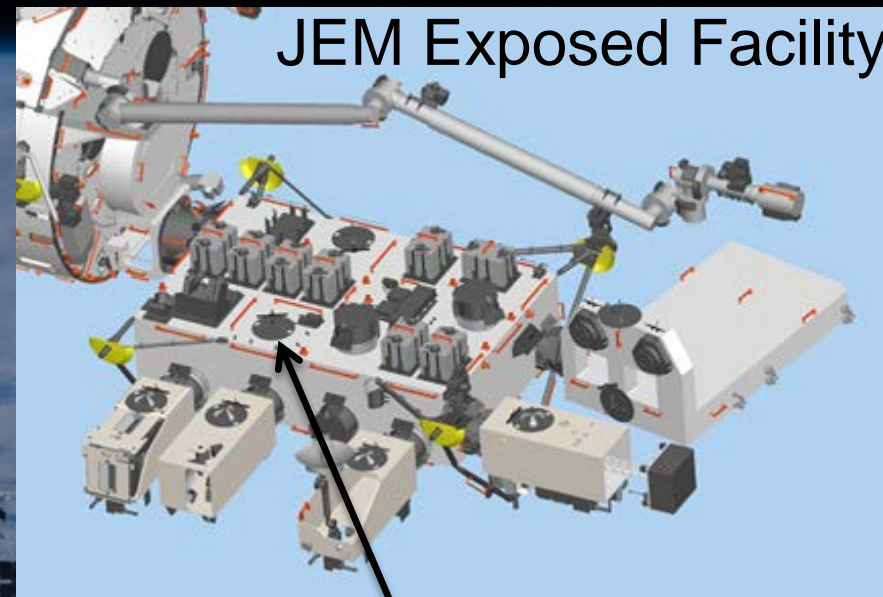
1 d irradiation = 1.5 d @ LEO



**Amino acid precursors** are much more stable than **free amino acids** against UV, X-rays, radiation and heat.

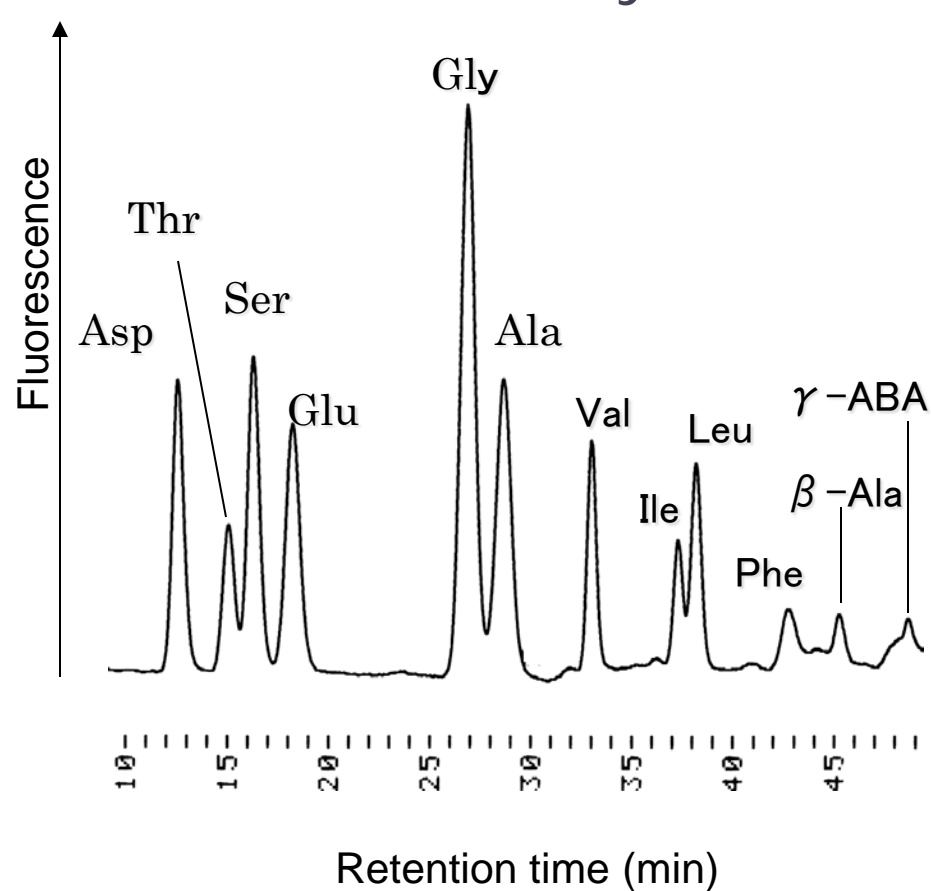


## The Tanpopo Mission: Capture of Cosmic Dusts & Exposure of Organics

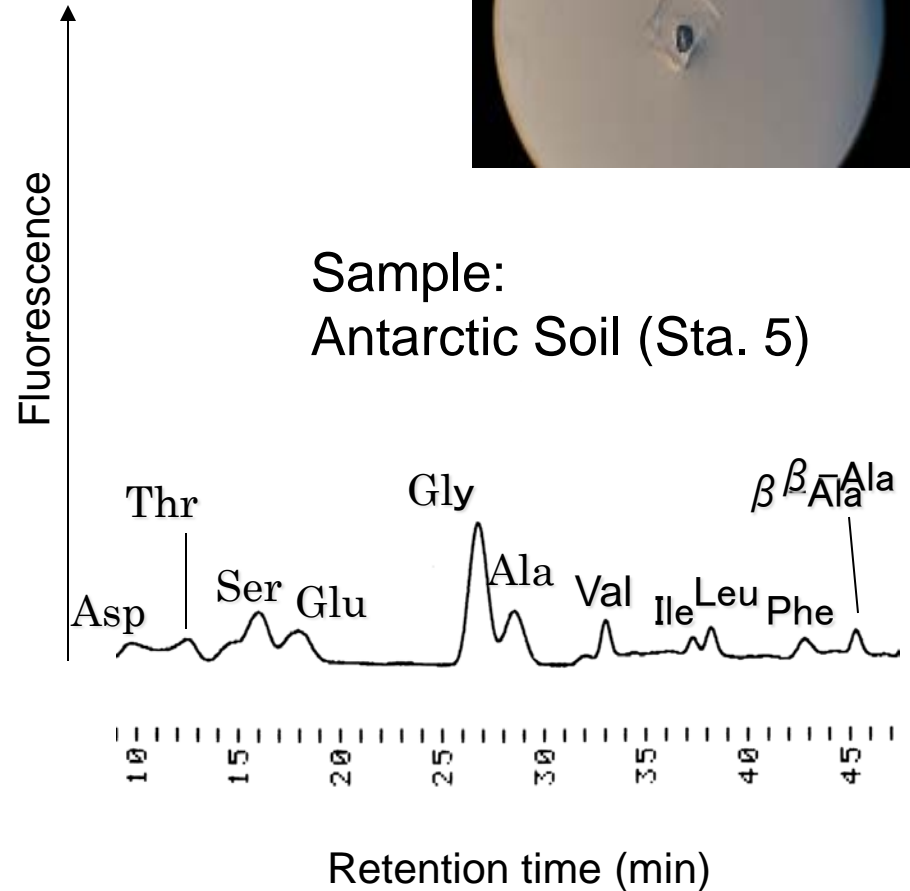




# Amino Acid Analysis in Silicate Matrices



HF-digestion



hot water extraction

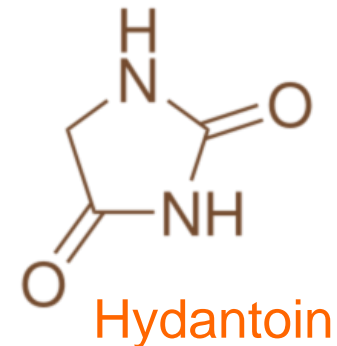
HF digestion gave much more amino acids from samples with mineral matrix

# Exposure of Organic Compounds in the **Tanpopo** Mission

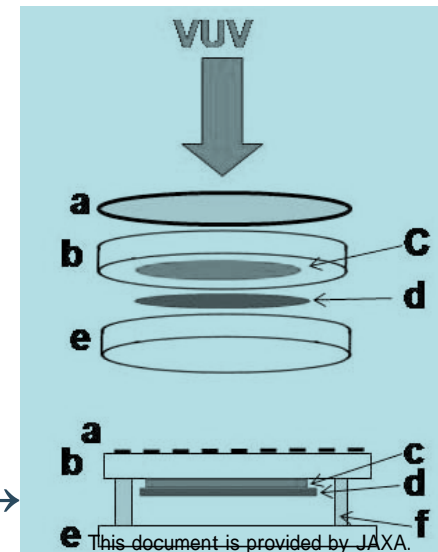


## Amino acids and their **precursors**

- **Glycine**
- **Hydantoin** (A precursor of glycine) →
- **Isovaline** ( $\alpha$ -methyl non-protein amino acid)
- **5-Ethyl-5-methyl hydantoin**  
(A precursor of Isovaline)
- **“CAW”** (Complex amino acid precursors produced by proton irradiation of a mixture of CO, NH<sub>3</sub> and H<sub>2</sub>O)



Alanine Thin Film (as a VUV dosimeter) →



# Summary

- Complex organic compounds with high molecular weights can be formed in simulated interstellar environments by high energy particles bombardment
- Meteoritic organics could have been formed by alteration of interstellar complex organics: Soft X-rays from the young Sun could be important energy source for it, as well as aqueous / hydrothermal alteration in parent bodies of meteorites.
- Major carriers of extraterrestrial organics could have been cosmic dusts (IDPs).
- Cosmic dusts will be collected in space with aerogel in the Tanpopo Mission
- Amino acids in cosmic dusts will be analyzed after HF digestion.

*Thank you for your attention!*

## Acknowledgements

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