

国際宇宙ステーション(ISS)「きぼう」日本実験棟
汎用宇宙曝露実験用ハンドレール取付機構(ExHAM)
を利用したダストの宇宙曝露実験計画

「炭素質ナノ粒子の宇宙風化と星間有機物進化の実証研究」

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宇宙空間の固体微粒子(ダスト)

水素とヘリウムしかなかった初期宇宙は、恒星核の元素合成によって、それらの原材料から重元素(炭素、窒素、酸素、シリコン、マグネシウム、鉄など)を有するに至った。

恒星進化の終盤には、恒星内核反応で合成した重元素を星周空間に恒星風として、時には、爆発的な現象を伴って放出し、そうした放出ガスを原材料に、炭素質ダストや珪酸塩ダストが合成される。

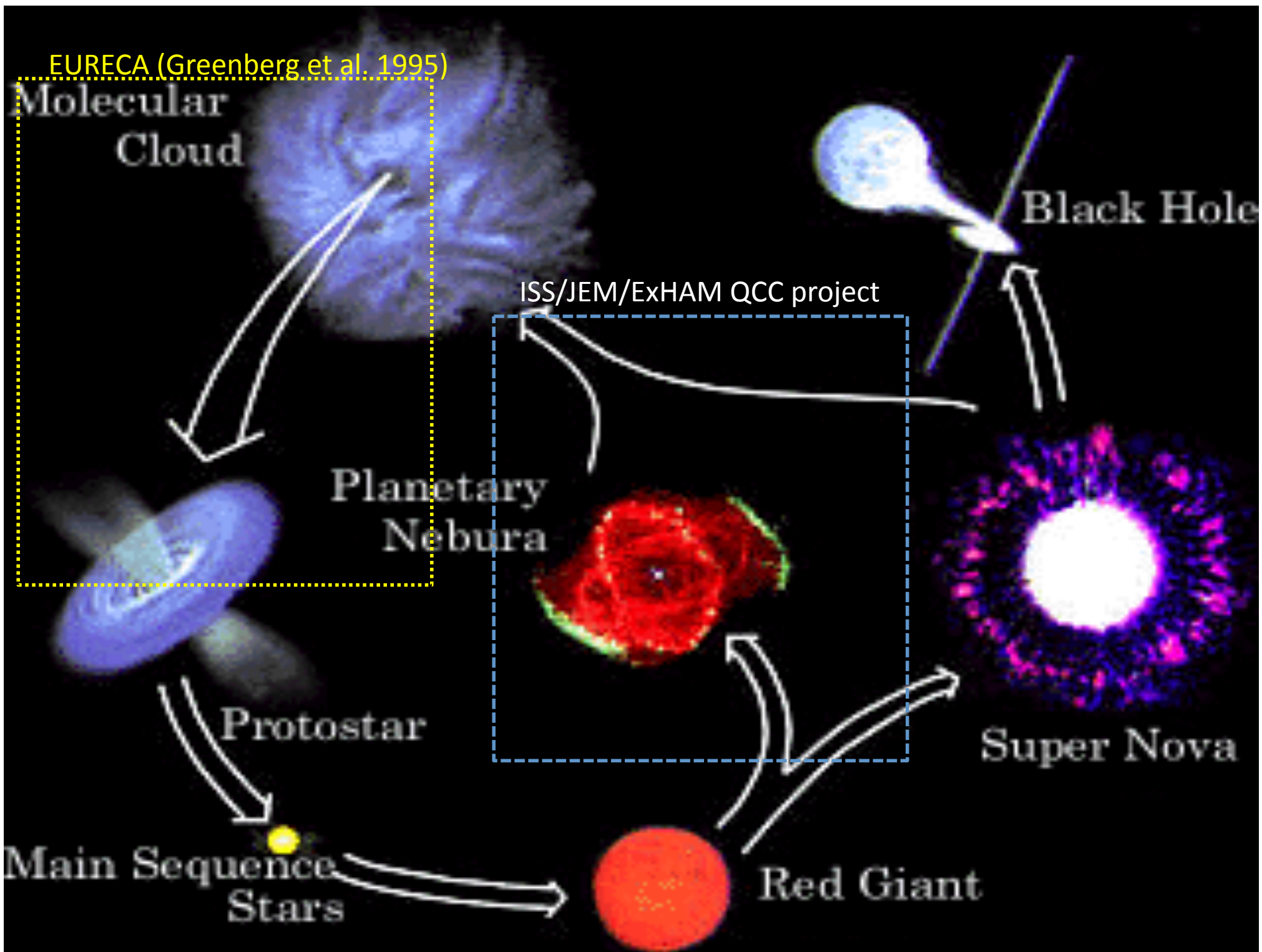
こうしたダストの組成や物質状態を判断する上で、赤外線／紫外線分光観測が有効である。

1973年に初めて捉えられた**未同定赤外バンド**は、日本のIRTS, 欧州天文台ISOによる赤外衛星観測で初めてその赤外波長域での姿が捉えられ、年老いた中小質量星周をはじめ、豊富な紫外線の熱源を有する星形成活動領域、星間物質、さらには遠方の系外銀河において、普遍的に観測される事が明らかになった。我が国の「あかり」衛星やSpitzer宇宙望遠鏡を始め、この顕著な赤外バンド構造は、観測対象の物理状態を探る為の重要な情報として利用されている。

この未同定赤外バンドの担い手は、炭素質ダスト、特に多環式芳香族炭化水素などの大型の有機物分子や、水素化アモルファスカーボンダストとの関連性が指摘されるものの、依然として物質同定はできていない。

同様に、**2175Åの星間減光曲線バンプ構造**も、多環式芳香族炭化水素との関連性が指摘されるものの、明確な物質同定には至っていない。

本研究では、恒星周囲で合成される最も始源的な炭素質物質を模擬する試料を実験室で合成し、きぼう実験棟ExHAMを利用したISS軌道上での曝露実験を行う事で、未同定赤外バンドおよび2175Åの星間減光バンプの担い手の同定を図る。



EURECA (Greenberg et al. 1995)

Molecular Cloud

Black Hole

ISS/JEM/ExHAM QCC project

Planetary Nebula

Super Nova

Protostar

Main Sequence Stars

Red Giant

Environment expected at ISS/JEM/ExHAM Site

Altitude; 400km

Micro gravity of $\sim 10^{-6}G$

Atmospheric Condition; $\sim 10^{-5}Pa$

Radiation Belt Particle; dominated by electron (with several tens keV)
and proton (with a few MeV)

Galactic Cosmic Ray; proton, He, C, O, Fe etc.

with wide energy range from $10-10^{16}MeV$

Solar Flare Particle; proton with a few – a few hundreds MeV

Solar Radiation; X-ray, UV

Meteoroid; particles with $a=0.1mm$, colliding with $v=20km/s$

Space Debris; mostly $<1cm$, colliding with $v=10km/s$

実験供試体の設計及びExHAM2号機とのインターフェース

Number of Experiment Equipments: 2 (EE64-I, EE64-II)

Size : 100mm x 100mm x 20mm

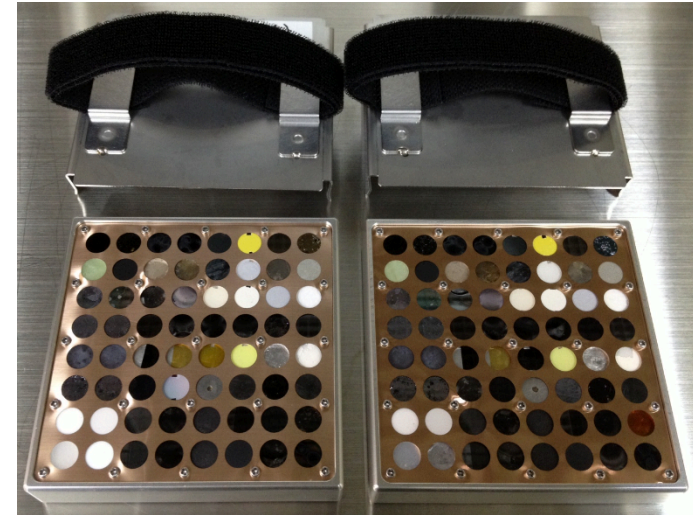
Weight: ~200g

Size of samples; $\Phi 10$ mm, t0.8-1.5mm

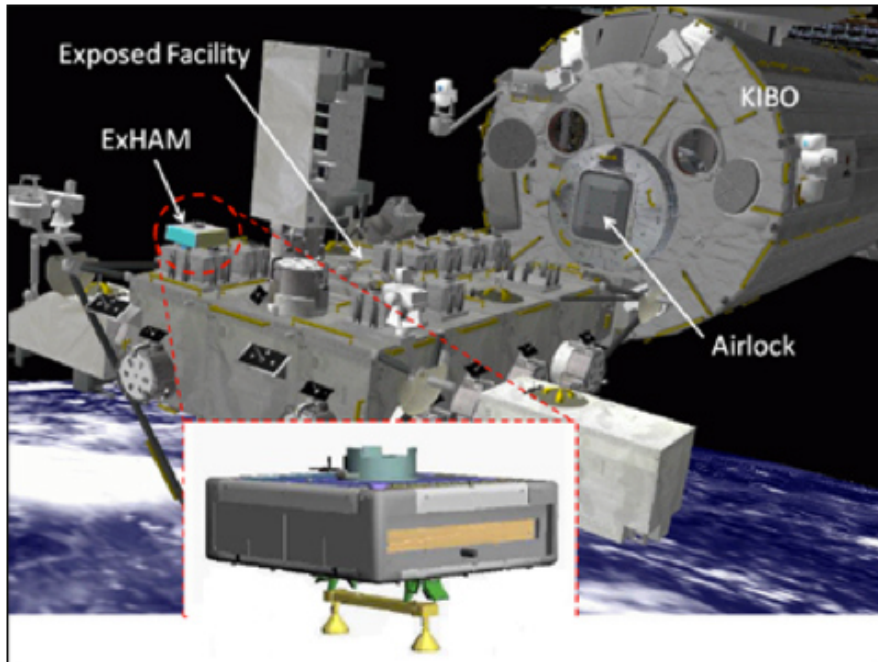
Number of Slots; 128 (64 for EE64-I and 64 for EE64-II)

Duration of Exposure; 12^{+2}_{-6} months

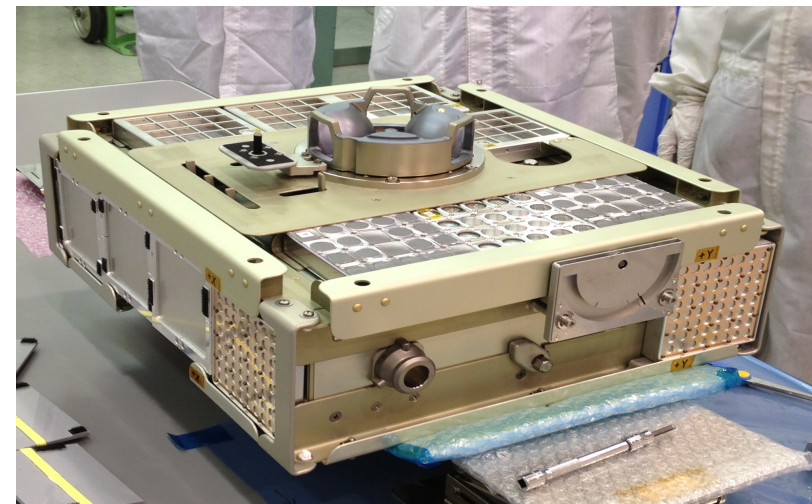
Expected location on JEM/ExHAM; U and V



EE64-I and EE64-II (FM)



(Credit; JAXA, <http://iss.jaxa.jp/kiboexp/equipment/ef/exham/>)



Experiment equipments (FM) attached to ExHAM-2 @KHI, fitcheck (06Nov2014)

フライト実験準備移行審査後のスケジュール

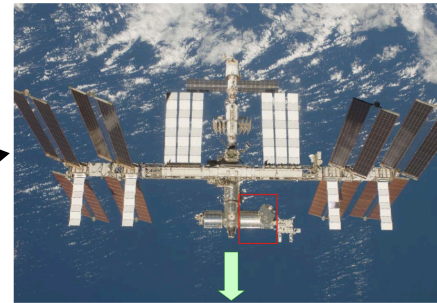
項目	2014				2015		
	11月	12月	1月	2月	3月		
フライト実験準備移行審査 該非判定	▲				↔		
品質認定試験後審査(PQR)/ 出荷前審査(PSR)							▲
フライト品出荷							▲
フライト品試料合成	←————→						
フライト品試料事前物性測定	←————→						
地上対照試験(AO照射試験、 UV照射試験、EB照射試験)	↔						
ExHAM2号機との適合性試験	▲						
耐荷重圧縮試験(2014年9月 26日に実施)							
真空低温熱晒し試験					▲		
真空高温熱晒し試験						▲	
振動試験(QT) (2014年9月29 日に実施)							
振動試験(AT)						▲	



Delivery of samples to Tsukuba Space Center, JAXA (9Mar., 2015)
Shipped to NASA (10 Mar., 2015)



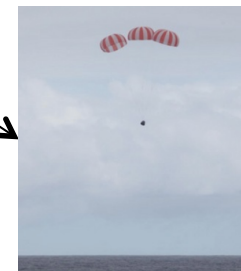
Launch via Space-X 6 (10 Apr. 2015 TBD)



Exposure experiment by using ExHAM (starting in JFY2015)

Ground-based Comparison Experiments
 • AO, UV, EB irradiation (TSC, JAXA)
 • gamma-ray, proton irradiation (JAEA) (JFY 2015 – JFY2016)

Samples returning (in JFY2016)



Analyses in JFY2016

Experiment Equipments (Flight Model)



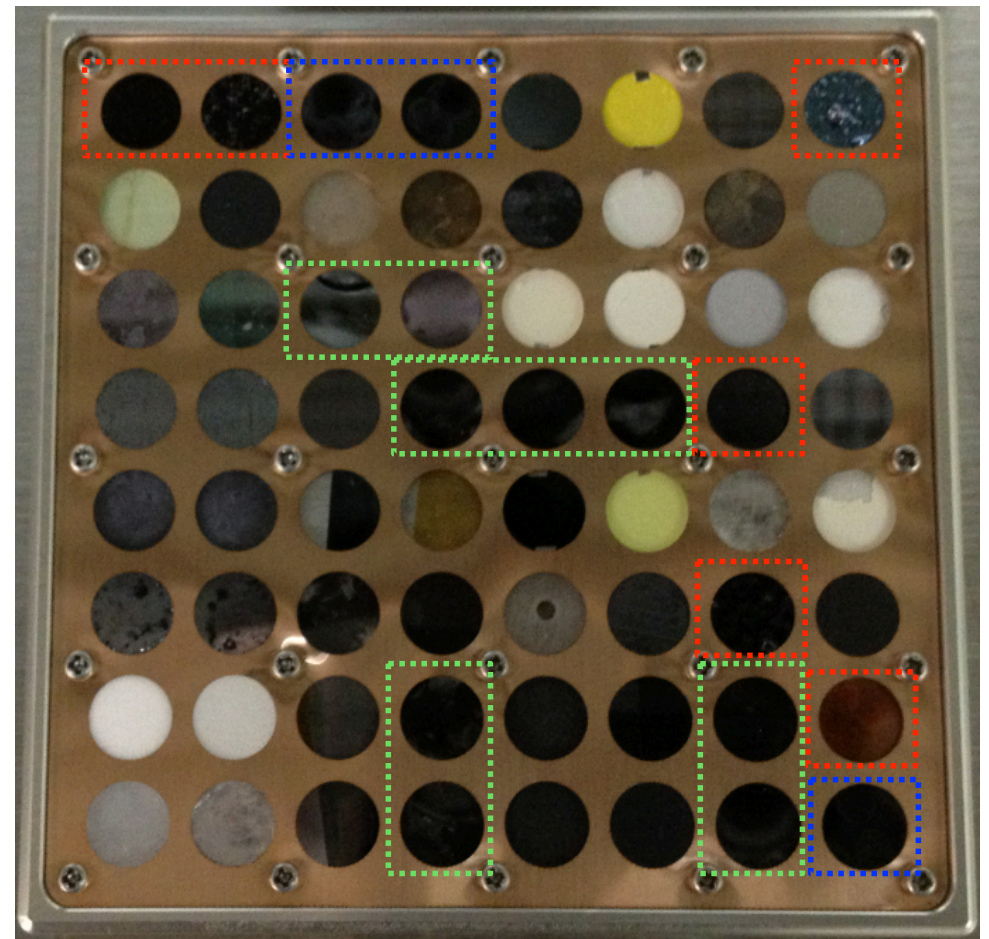
搭載サンプル

- | Sample ID | Samples |
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| (1) | Filmy Quenched Carbonaceous Composite |
| (2) | Deuterated Filmy Quenched Carbonaceous Composite |
| (3) | Dark Quenched Carbonaceous Composite |
| (4) | Nitrogen-Containing Carbonaceous Compounds |
| (5) | Organic Globule |
| (6) | Organics on silicate by FT reaction |
| (7) | Onion-like Carbon |
| (8) | Giant Fullerene |
| (9) | Hydrogenated Amorphous Carbon |
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| (19) | Polycyclic Aromatic Hydrocarbons |
| (20) | Glycolaldehyde dimer |
| (21) | Amorphous Alumina |
| (22) | Calcium Aluminate Hydrate |
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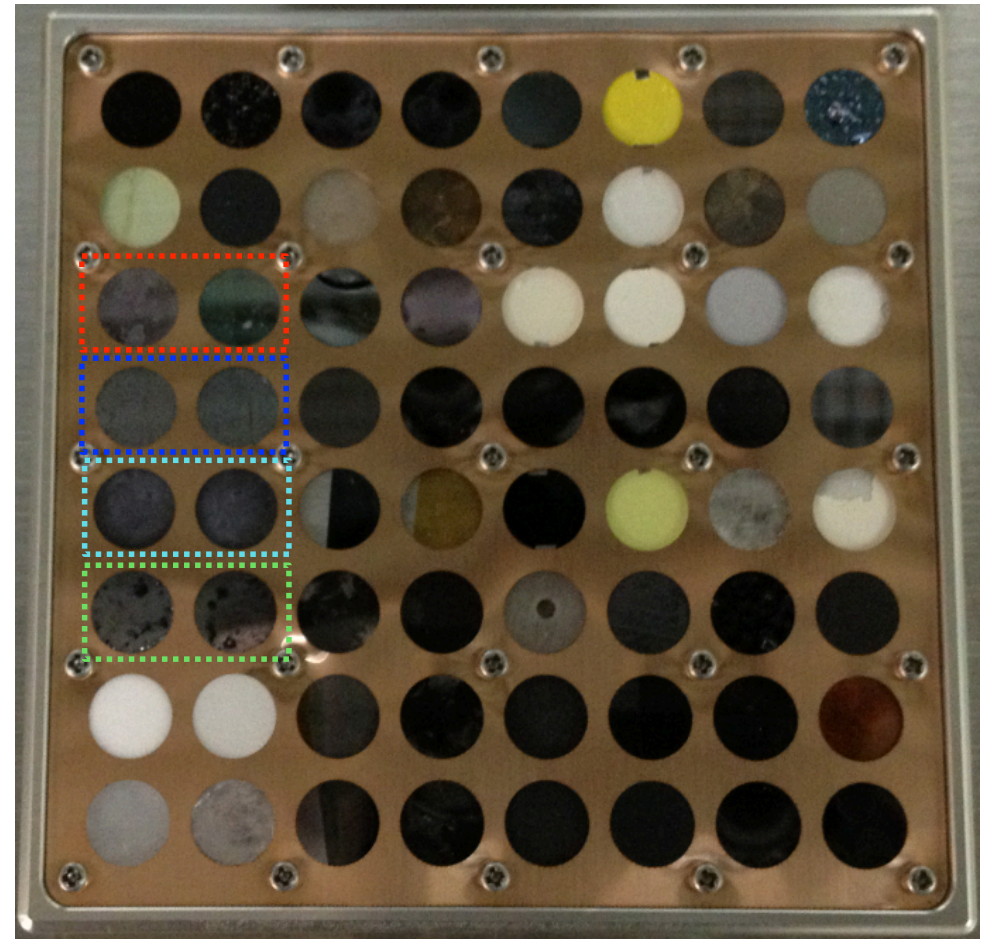
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重水素含有Filmy急冷炭素質物質
→ 該非判定の過程で搭載先送り

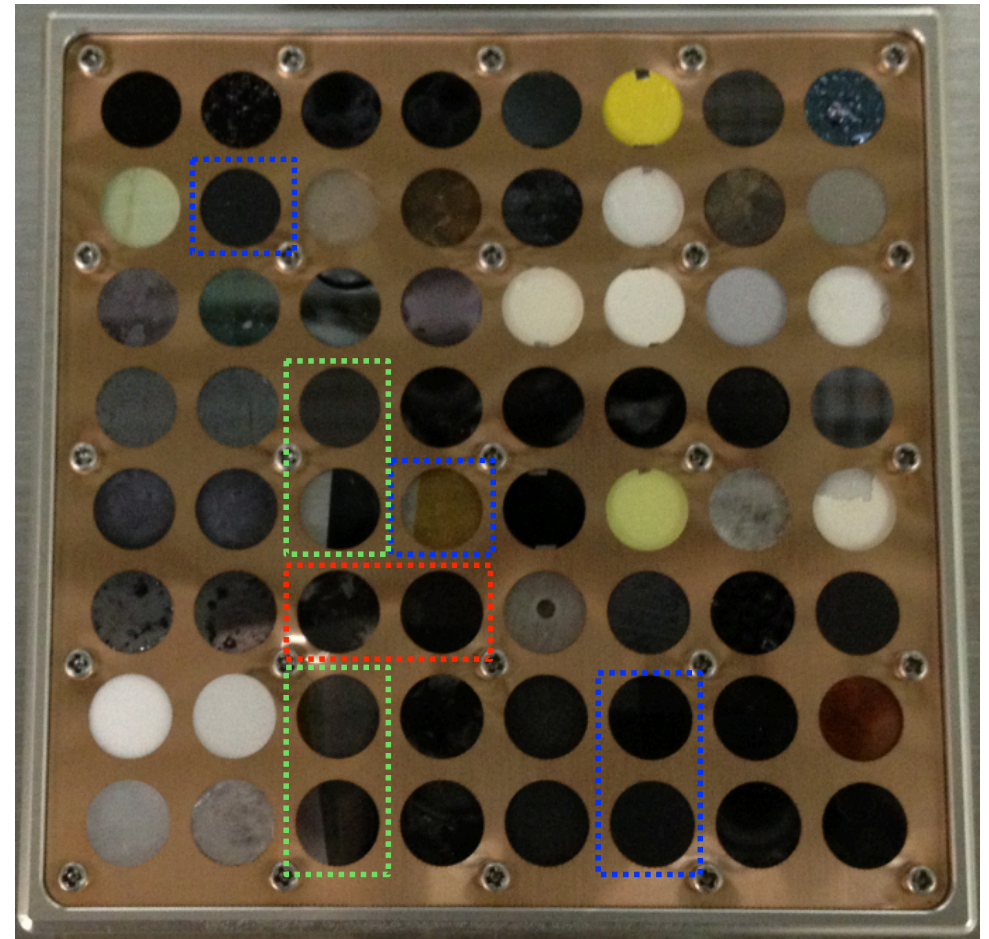
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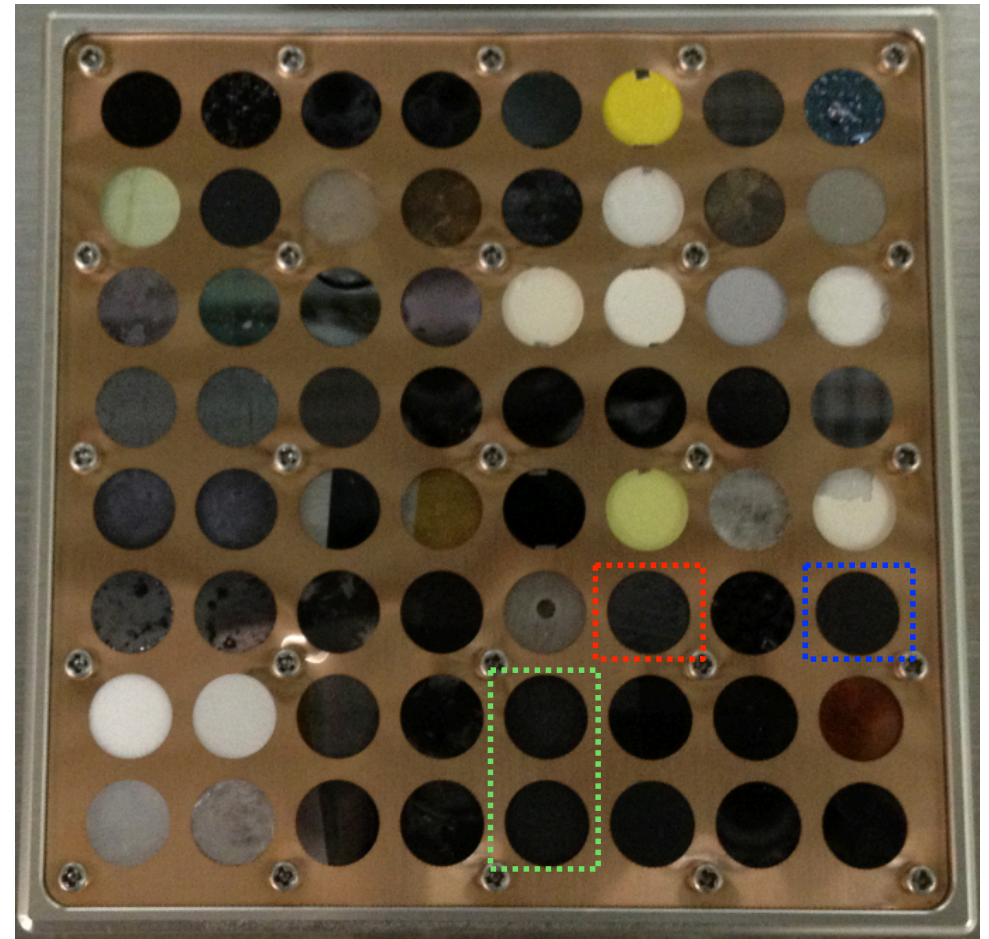
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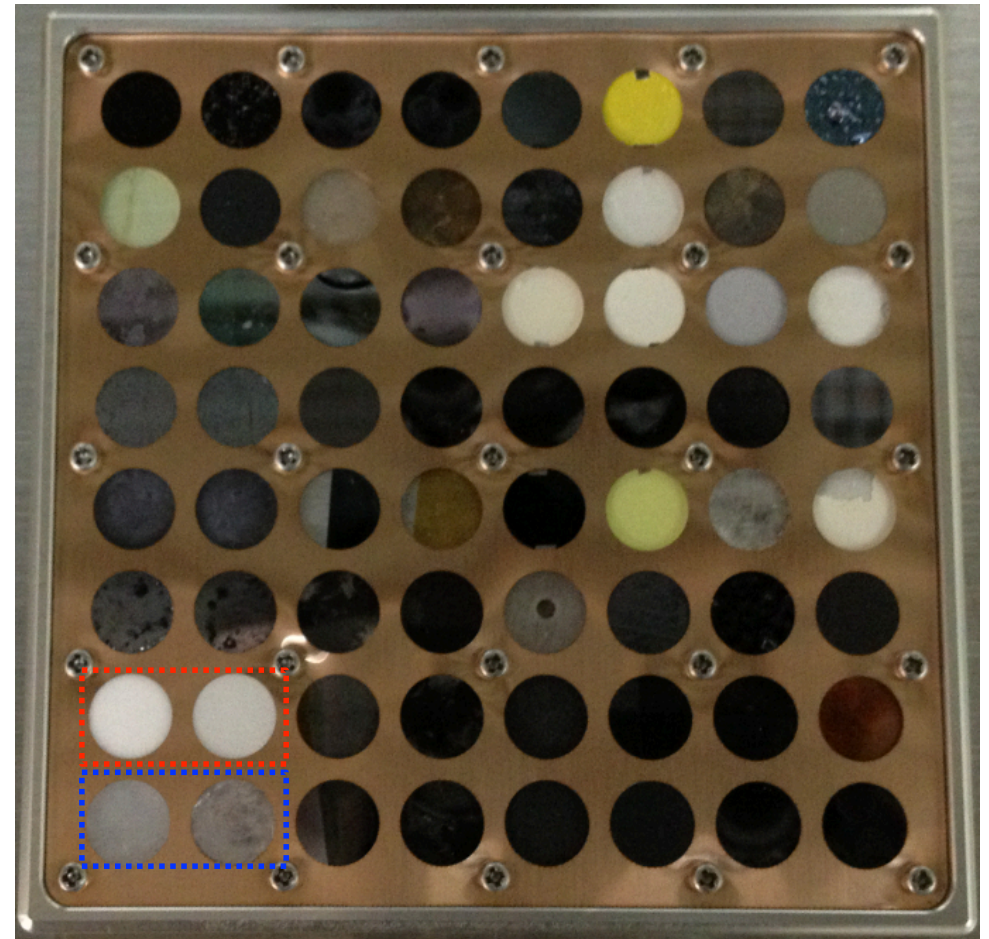
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Synthetic Graphite, Pyrolytic Graphite C/A
→ 該非判定の過程で搭載先送り

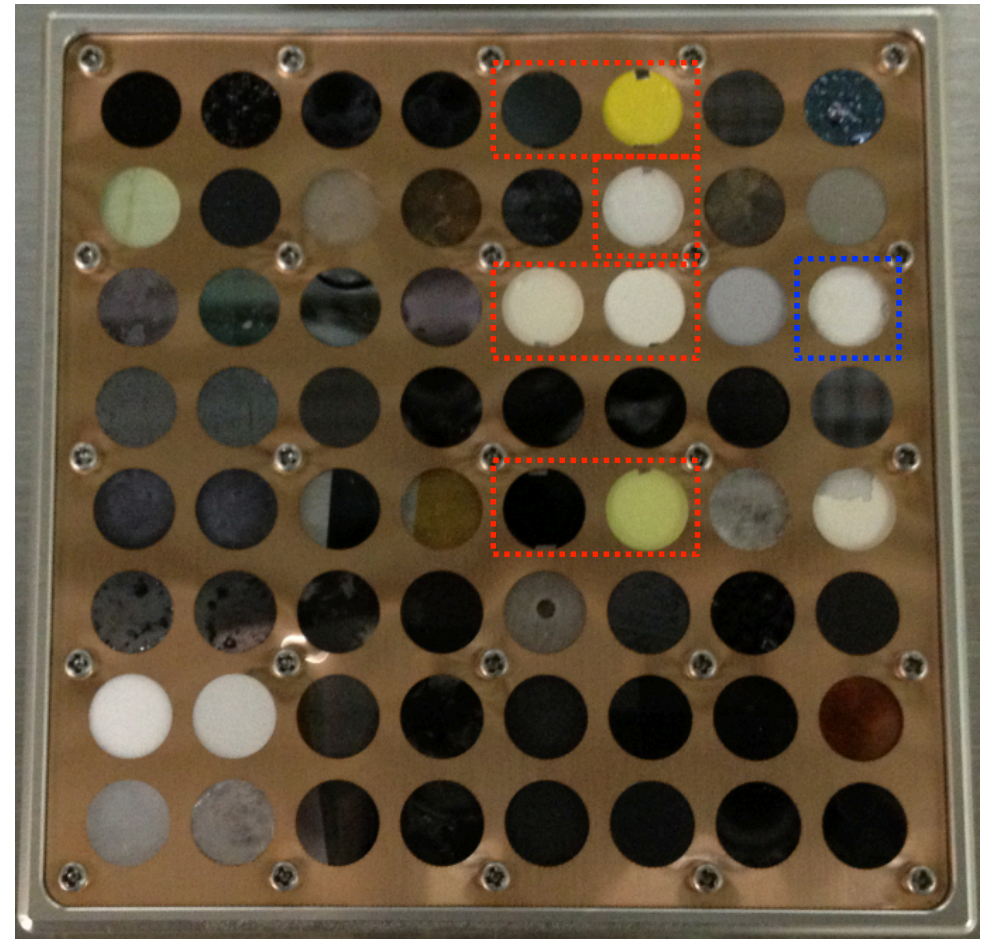
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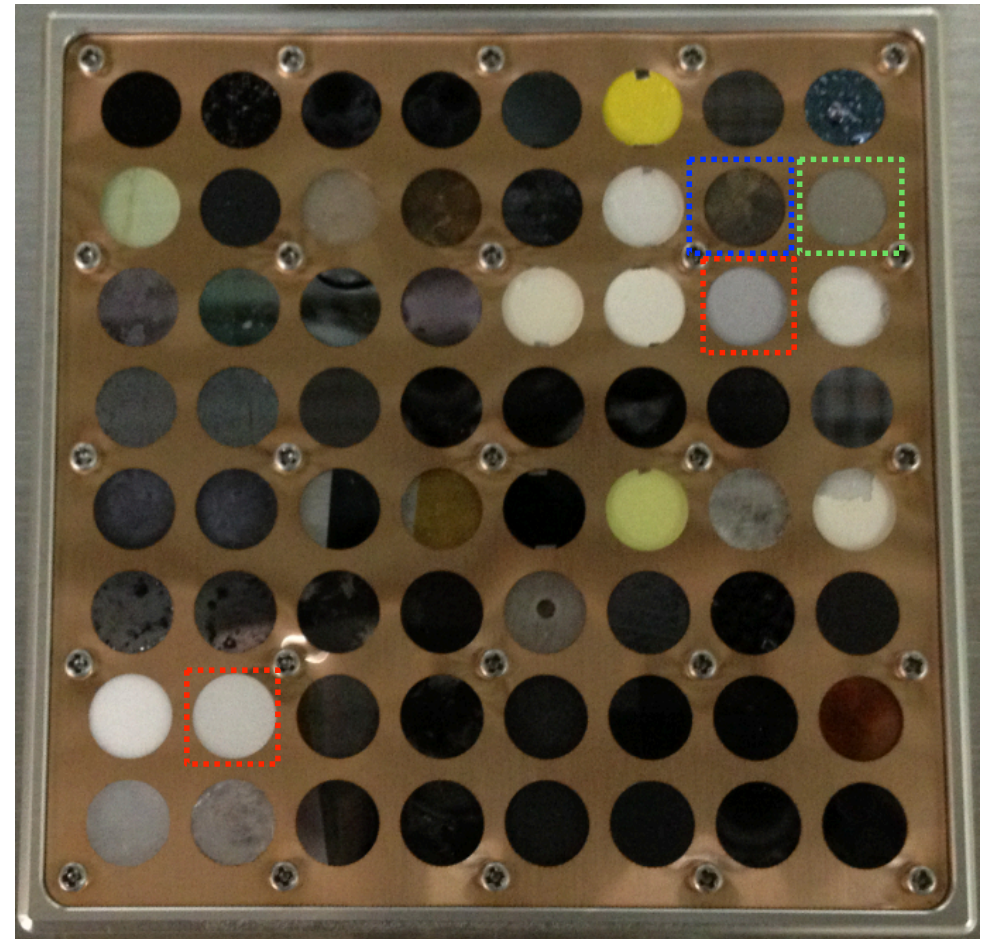
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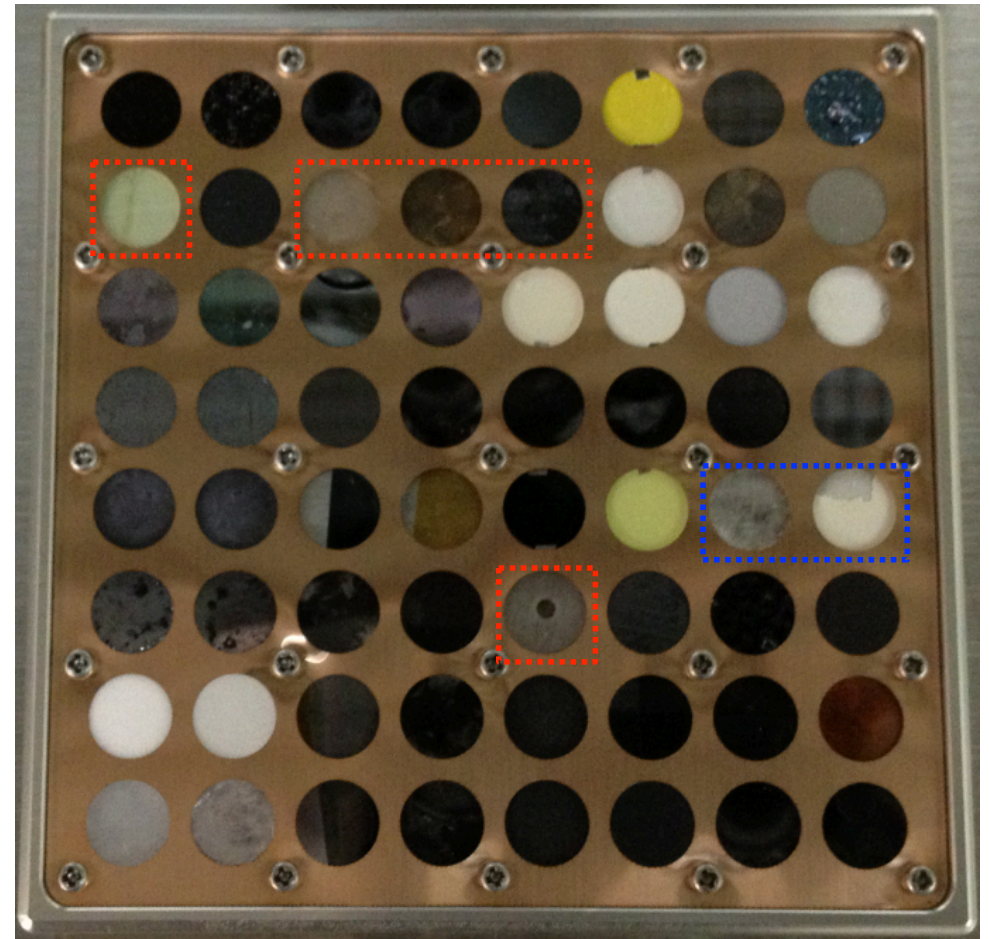
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Summary

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- ・ExHAMg2号機の曝露部UおよびVに、約40種合計128個のサンプルを搭載した実験供試体を設置し、2015年度から約1年間の宇宙環境に曝露予定
- ・フライト実験準備移行審査、安全審査等を経て、2015年3月6日に品質認定試験後審査(PQR)および出荷前審査(PSR)に合格
- ・2015年3月9日にフライト品をJAXAに納品完了
- ・2015年4月にSpX-6で打ち上げ予定
- ・約1年間の曝露後、2016年度に回収し各種分析を実施
 - 赤外線顕微分光測定(透過/ATR)
 - X線光電子分光測定(XPS)
 - 透過型電子顕微鏡(TEM)観察
 - 紫外線分光測定
- ・分析の結果を、地上対照実験で得られたサンプルと、非曝露／曝露回収サンプルとの間で比較し、炭素質ダストが実宇宙環境で経験する物質変性の実証データを得る。