2-3-b
PP activity for return request (status of impact sterilization and radiation sterilization studies)

2026/01/15

MMX PP Team

MMX Planetary Protection Meeting

1. Microbial Transfer Processes from Mars to Phobos

- **At JAXA, the MMX mission to Martian moons has been proposed, and its exploration system has been under development. The spacecraft will explore both Martian moons, such as Phobos and Deimos and collect samples from Phobos to bring back to Earth.**
- **From the view of planetary protection, the assessment of potential microbial contamination of Martian moons is important for the MMX mission.**
- **Transfer processes from Mars to Phobos were classified by Fujita, Kurosawa, *et al*.**
- **Hypervelocity impact sterilization and radiation sterilization processes are crucial.**

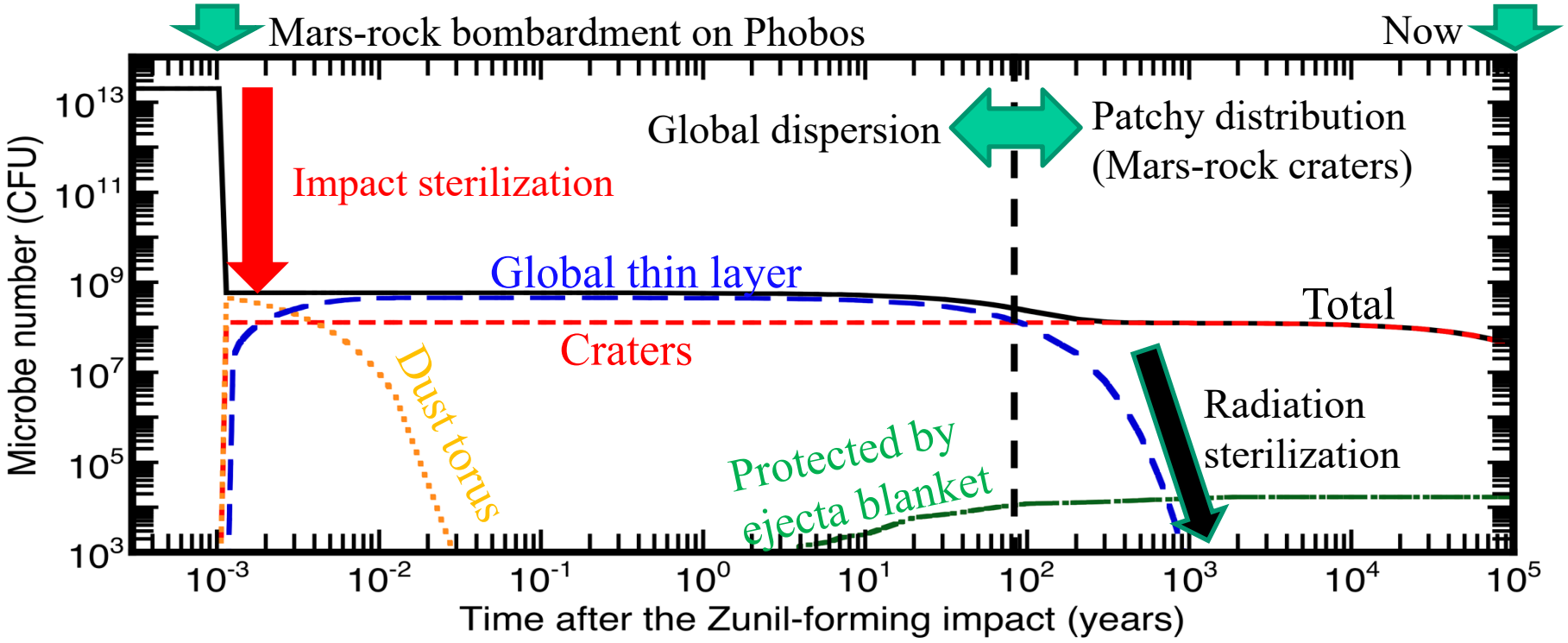


Figure: Estimated microbe number on Phobos

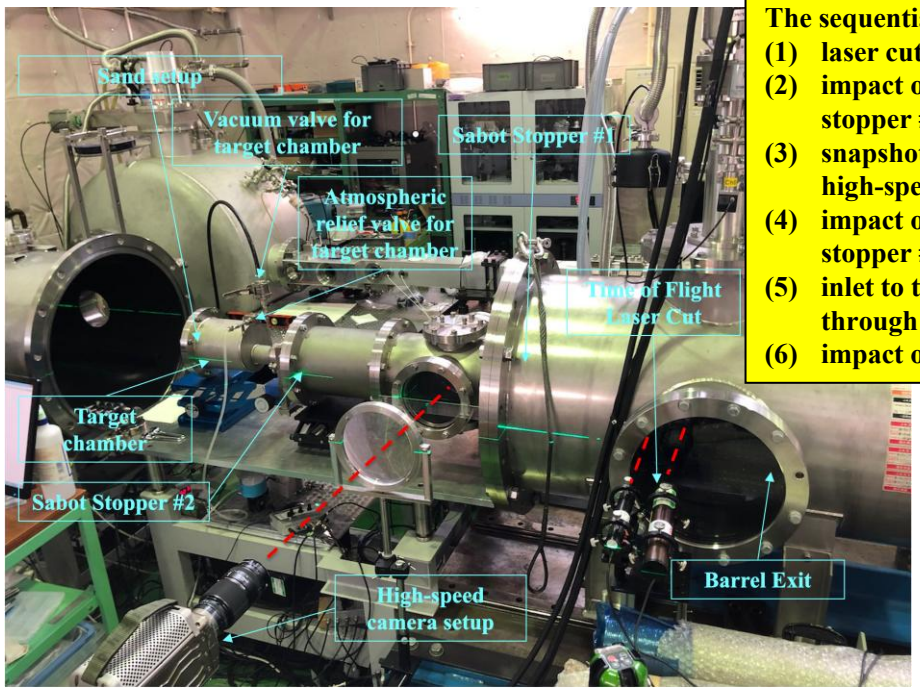
From TR2018-13-04(Assessment of Microbial Contamination Probability)

2. Status of Impact Sterilization Tests, 1/2

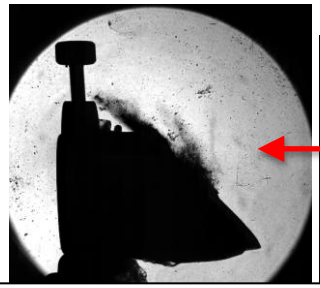
Impact Sterilization Test Procedure

- Culturing and preparation of microbial cells
- Contamination reduction of test facilities
- Placing microorganisms in projectiles
- Light-gas gun test setup
- Light-gas gun implementation
  - Sand uniform stirring → Sand sample recovery → Microorganism -extraction from sand
  - Projectile debris extraction → Debris uniform stirring → Microorganism -extraction from debris
  - Swab assay on chamber surfaces → Swab stirring → Microorganism -extraction from swab
- Serial dilution and microorganism cultivation
- Estimation of the impact sterilization rates

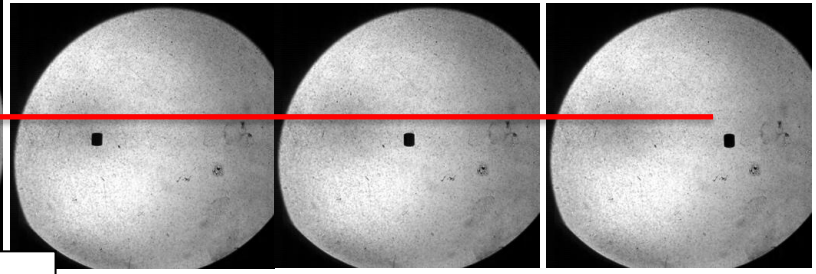
- We improved the light-gas-gun (LGG) equipment at Chofu Aerospace Center Aerodrome Branch (JAXA) to impact sterilization tests.
- Details of the LGG can be found in HVI2024-061



The sequential events
(1) laser cut
(2) impact on sabot stopper #1
(3) snapshots taken by a high-speed camera
(4) impact on sabot stopper #2 (backup)
(5) inlet to target chamber through a gate valve
(6) impact on sand target.



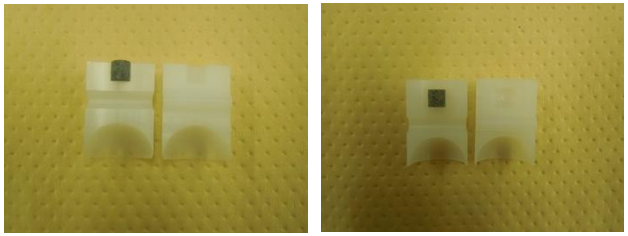
Projectile impact
(not IST, for observation)



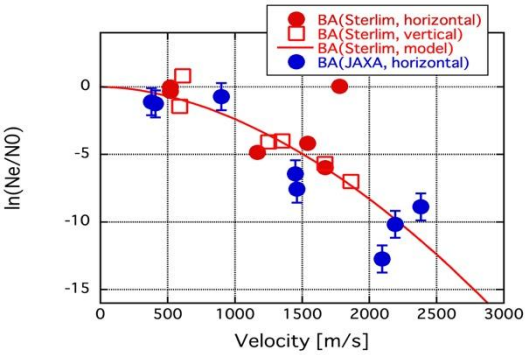
Projectile flight photos after sabot separation

2. Status of Impact Sterilization Tests, 2/2

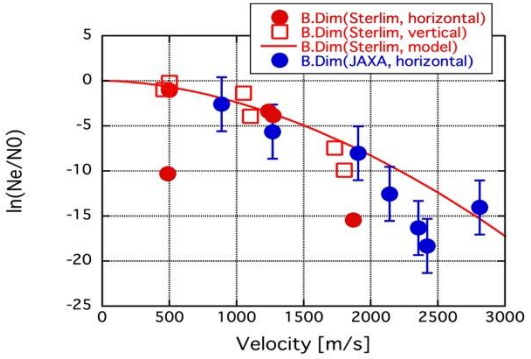
- **Our results (blue symbols) were compared with the Sterlim study (red symbols). For *Ba (*Bacillus atrophaeus) spores, *Bd (Brevundimonas diminuta*) and *MS2 phage*, we obtained data points in the higher-speed range ($2.0 \leq v_{is} \leq 3.0$ km/s). On the other hand, the high impact-speed data is limited for *Dr (Deinococcus radiodurans*) to date.**
- **For all bacterial test species, the impact sterilization rate deceases along with the increase of impact speed.**
- **Basically, our results were similar to or lower than the empirical model.**



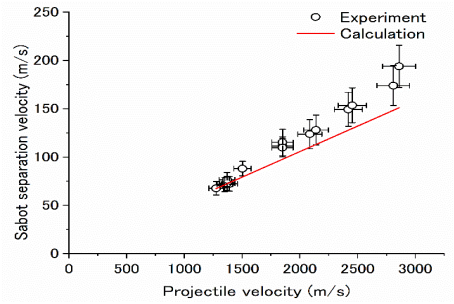
Sabot and projectile photographs



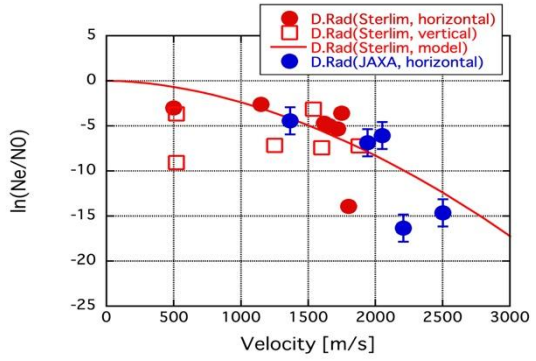
Comparison of impact sterilization rate for *B. A* spores



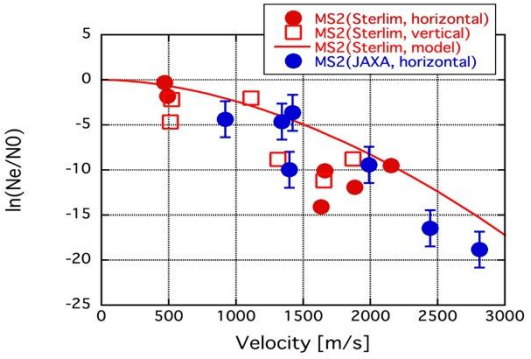
Comparison of impact sterilization rate for *B. Dim*



Sabot separation speed dependence on projectile speed



Comparison of impact sterilization rate for *D. Rad*



Comparison of impact sterilization rate for *MS2Phage*

3. Status of Radiation Sterilization Tests, 1/3

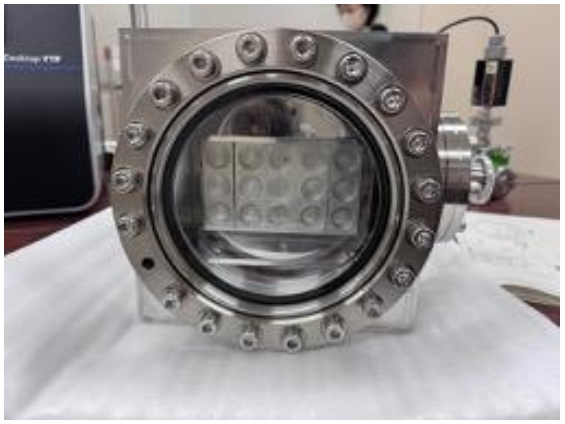
Roadmap of Radiation Sterilization Tests for MMX

- **Develop radiation sterilization test equipment**
  1. **Electron beam data acquisition**
  2. **Gamma ray data acquisition**
  3. **Heavy particle (He) data acquisition**
  4. **Proton data acquisiton**
  5. **Modeling and Report**

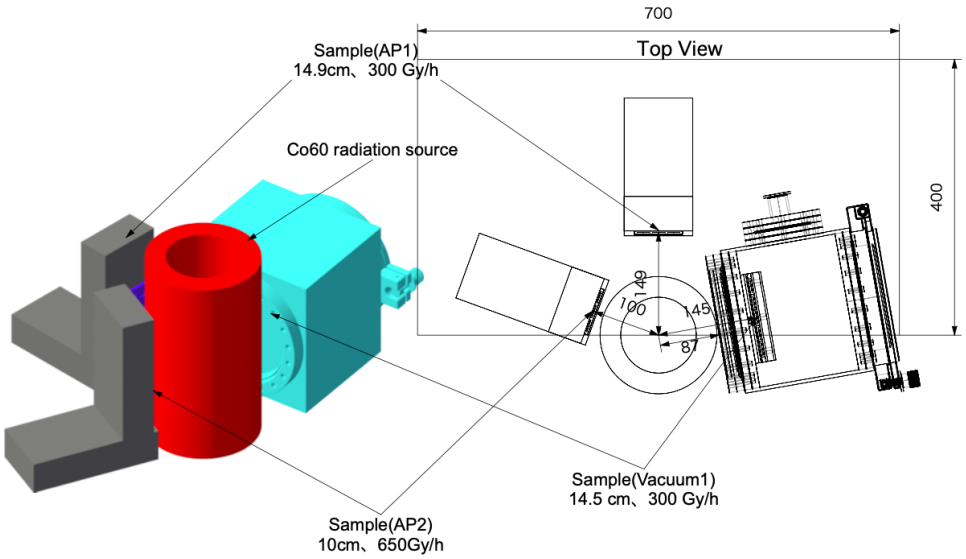
Subject	Annual Plan											
	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030	FY2031
Electron beam・UV・AO (Atomic Oxygen)	BA spores・D.Rad・B.Dim →			Verification →								
Gamma ray @ Science Tokyo		Preparation of equipment →			BA spores・D.Rad →		MS2 →	Verification →				
Heavy particle(He)beam				Preparation of equipment →			BA spores・D.Rad →		MS2 →	Verification →		
Proton						Preparation of equipment →		BA spores・D.Rad・MS2 →		Verification →		
Modeling							Modeling →					
Report					Pre-launch PP report →		△MMX Pre-launch PP review		Pre-returning PP report →		△MMX Pre-returning PP review	

3. Status of Radiation Sterilization Tests, 2/3

- **Gamma-ray irradiation inactivation tests @ Science Tokyo**
  - **Radiation Source: Co60(20TBq、1.17 and 1.33 MeV)**
  - **Two different absorbed dose rate: 650 Gy/h and 300 Gy/h**
  - **Samples are *D.Rad* and *B.A* spores**
  - **Comparison between atmospheric pressure and vacuum (< 1×10^{-3} Pa)**
  - **Total dose: 0 ～ 30 kGy**



Layout of sample holders



Layout of *D.Rad* samples for Gamma-ray