

Bacterial survival in Martian conditions

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We present the results of some experiments performed in the Padua simulators of planetary environments, named LISA (Laboratorio Italiano di Simulazione Ambienti) used to study the limit of bacterial life on the planet Mars.

LISA

mini-LISA



Projected in cooperation between: *Dept. Astronomy, Dept. Histology, Microbiology and Medical Biotechnologies, Dept. Mechanical Engineering, University of Padua , Padua Astronomical Observatory - INAF (Italian National Institute for Astronomy) and CISAS “G. Colombo” (Center of Studies and Activities for Space).*

Sponsored by:



Life on Mars?

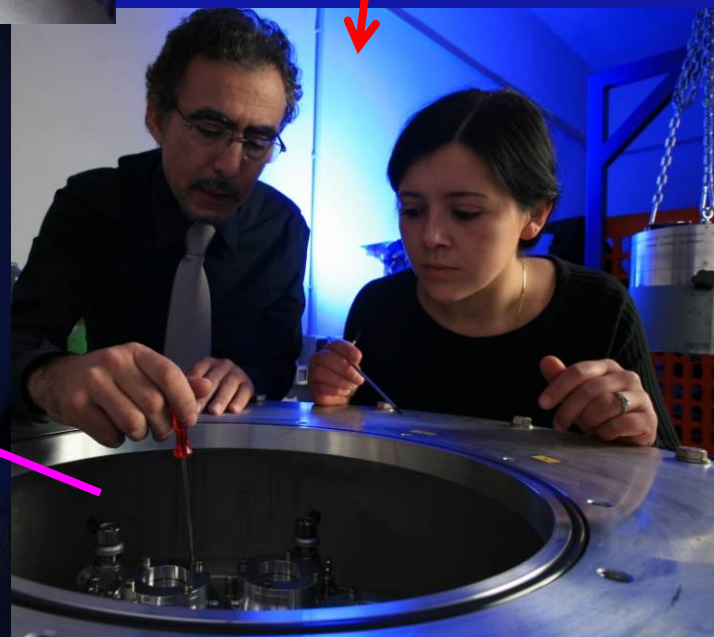
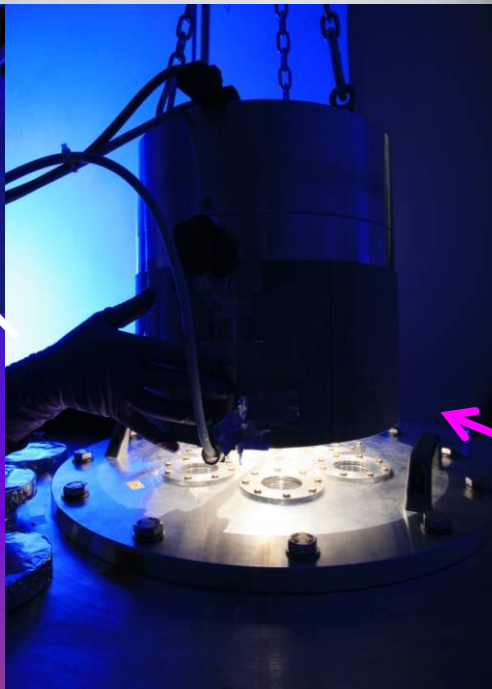
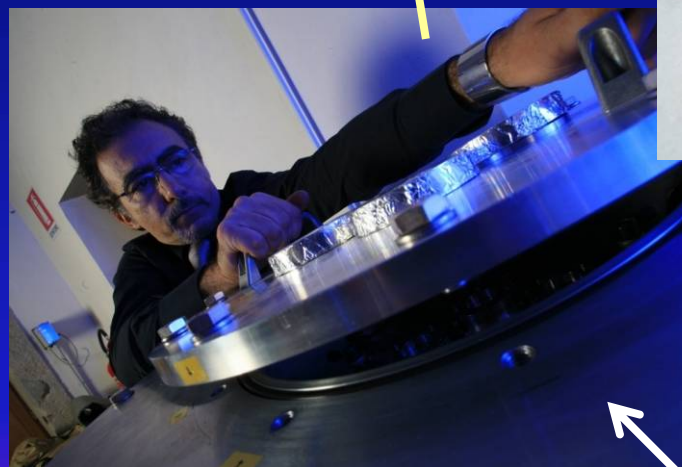
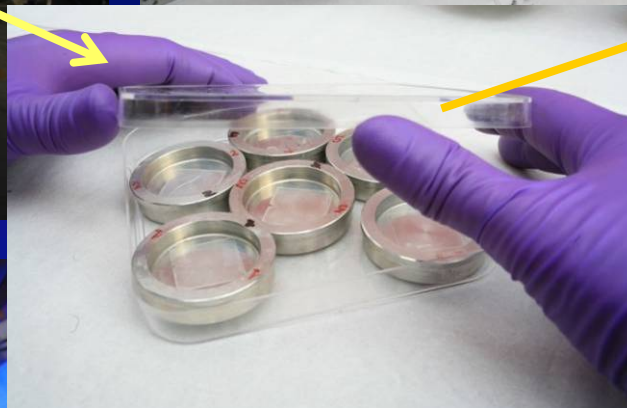
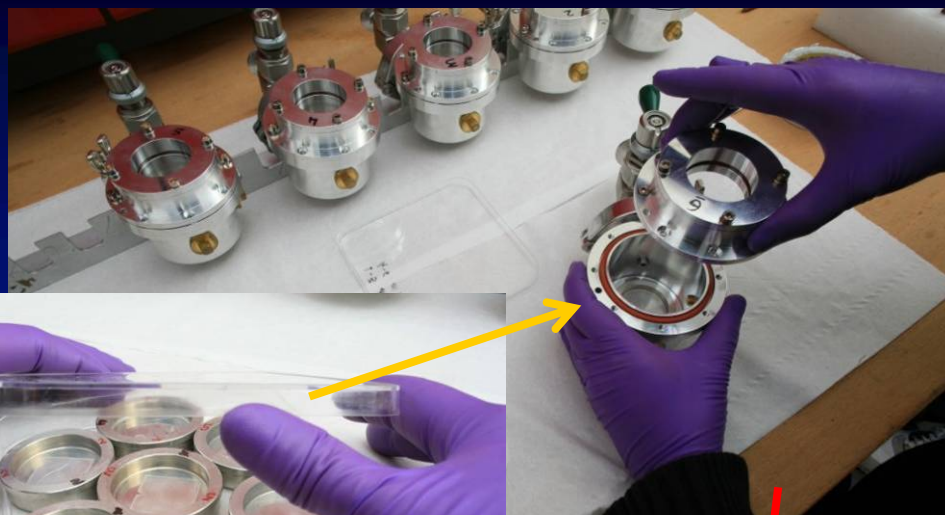
LISA's goal: Before reaching the red planet with manned missions or with bio-packages, we may search in a less expensive way what kind of lifeforms may resist in such an extreme environment.

Caveats:

1 - lifeforms on a different planet may have a fully different combination of nucleic acids and aminoacids (LUCA hypothesis).

We might not be able to recognize it.

2 - we don't have (yet) neither Martian bacteria nor Martian soils to use for the tests. We use terrestrial surrogates! Maybe our conclusions are not applicable to Martian life, but are useful for contamination- or terraforming- studies.



Loading the
samples in the 6
steel reaction cells
of LISA

LISA performances

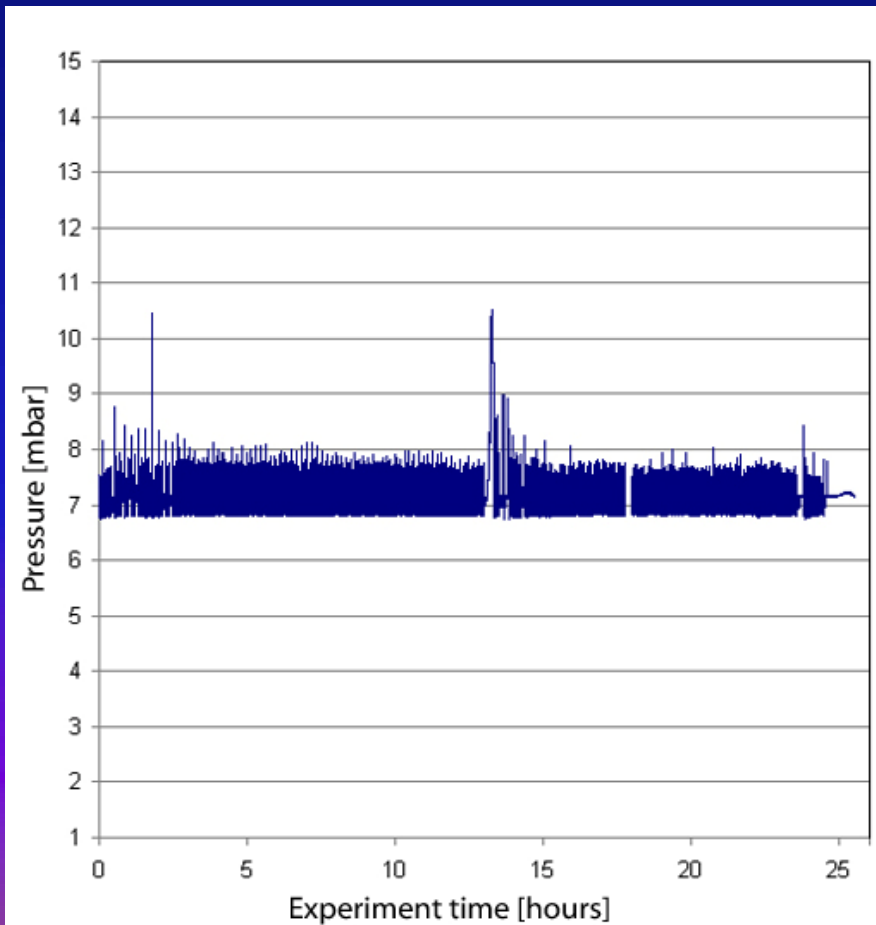
Temperature: $-140 \leq T \leq 50 \text{ }^\circ\text{C}$ (Mars $-136 \leq T \leq +27 \text{ }^\circ\text{C}$)

Pressure: $10^{-4} \leq P \leq 2 \text{ bar}$ (Mars $\sim 7 \text{ mbar}$)

Atmosphere: any (Mars 95% CO_2 , 3% N_2 , etc.)

UVC flux $\sim 3\text{-}6 \text{ W/m}^2$

Length of experiment: ≥ 25 hours LISA, no limit mini-LISA



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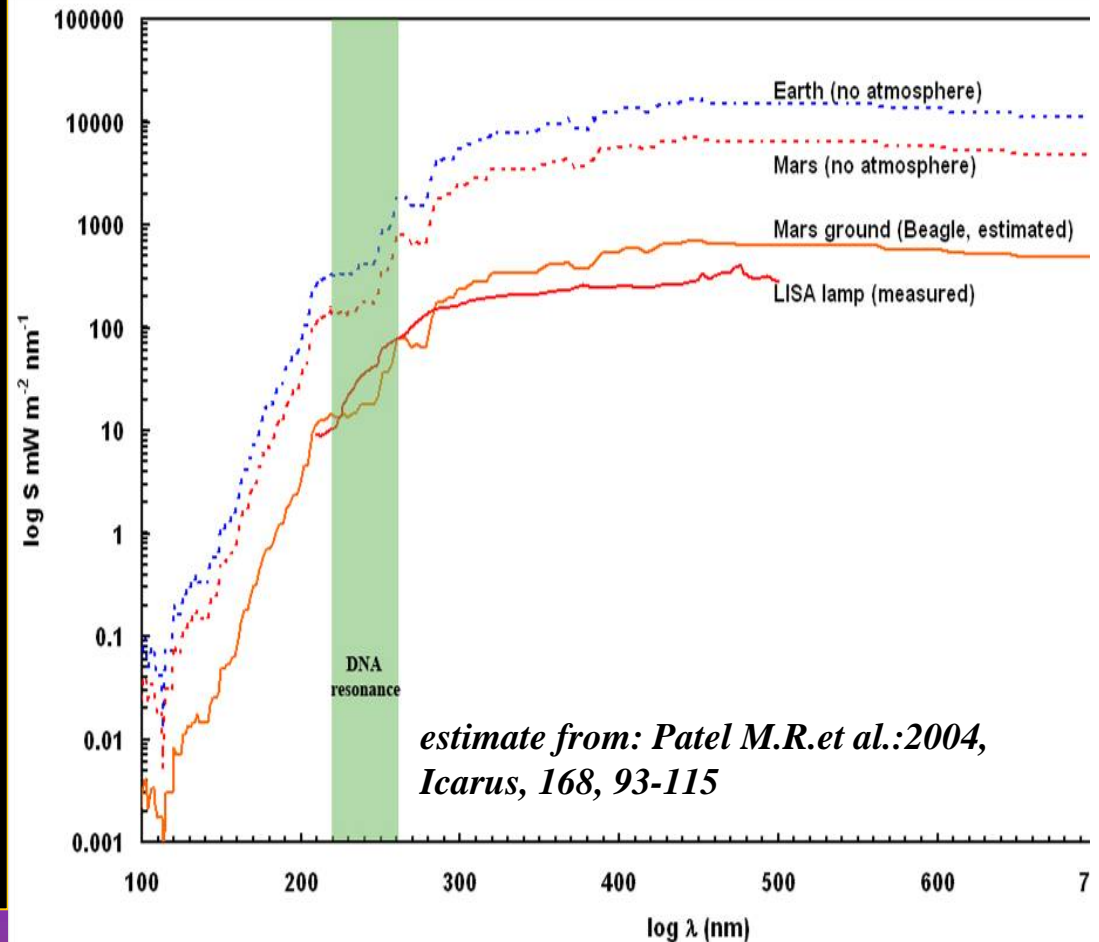
Martian and LISA atmosphere:

Main components:

CO_2	95.32%	95.5%
N_2	2.7%	3%
Ar	1.6-1,7%	1,6%
O_2	0.13-0.2%	0,13%
CO	0.08%	0,07%

Minor components:

H_2O	210 ppm	
NO	100 ppm	
Ne	2.5 ppm	300 ppm
HDO	0.85 ppm	
Kr	0.3 ppm	300 ppm
Xe	0.08 ppm	300 ppm



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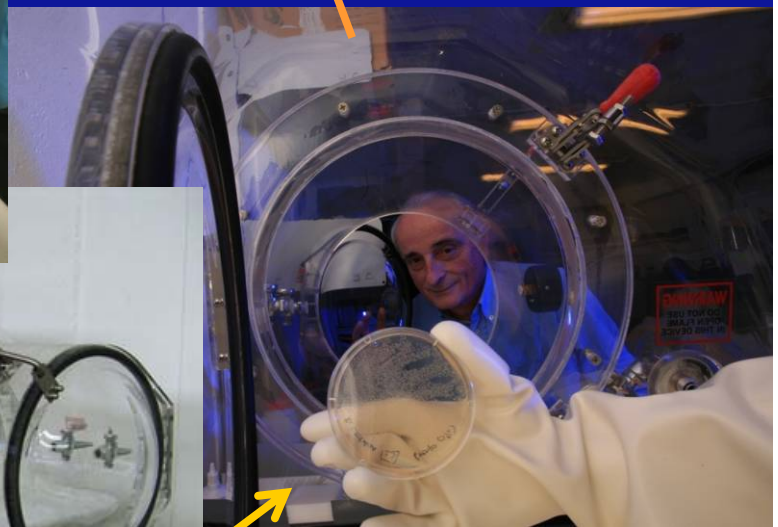
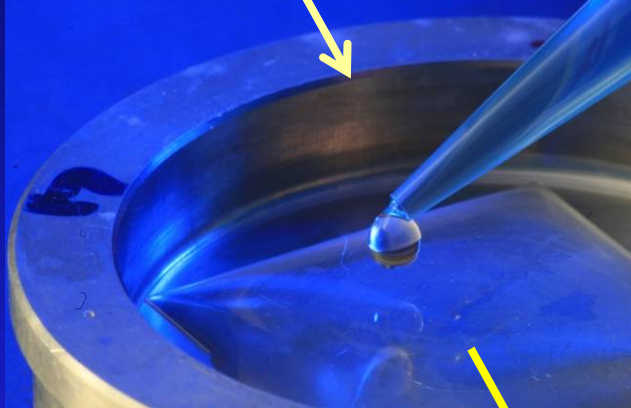
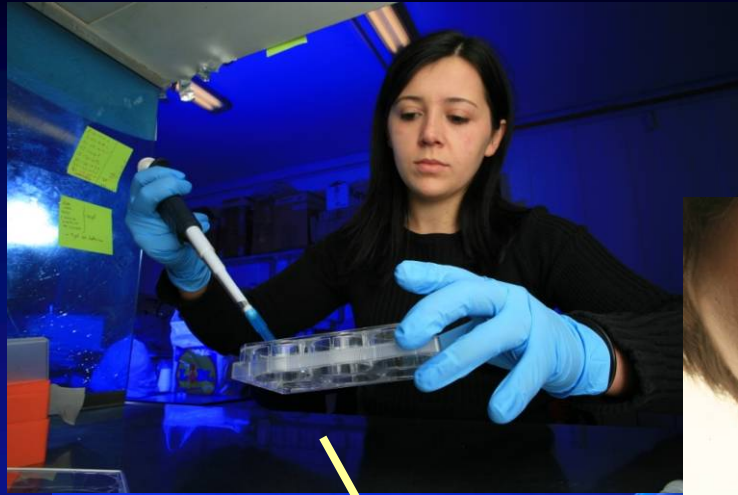
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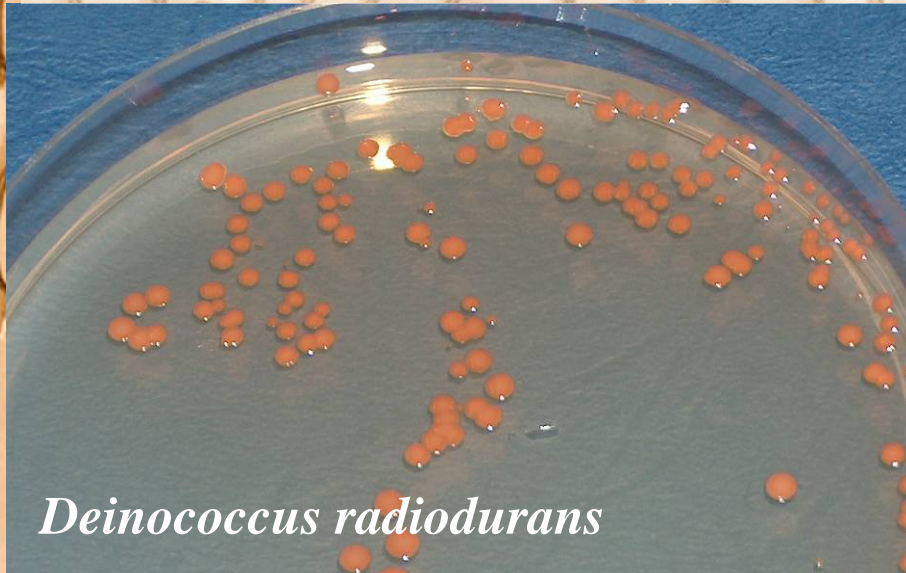
**Length of experiment: ≥ 25 hours LISA, no limit mini-LISA
(500 liter liquid nitrogen, refueling every Monday)**





**Samples
analysis in the
bio lab**

Bacterial colonies grown after the Martian experiments



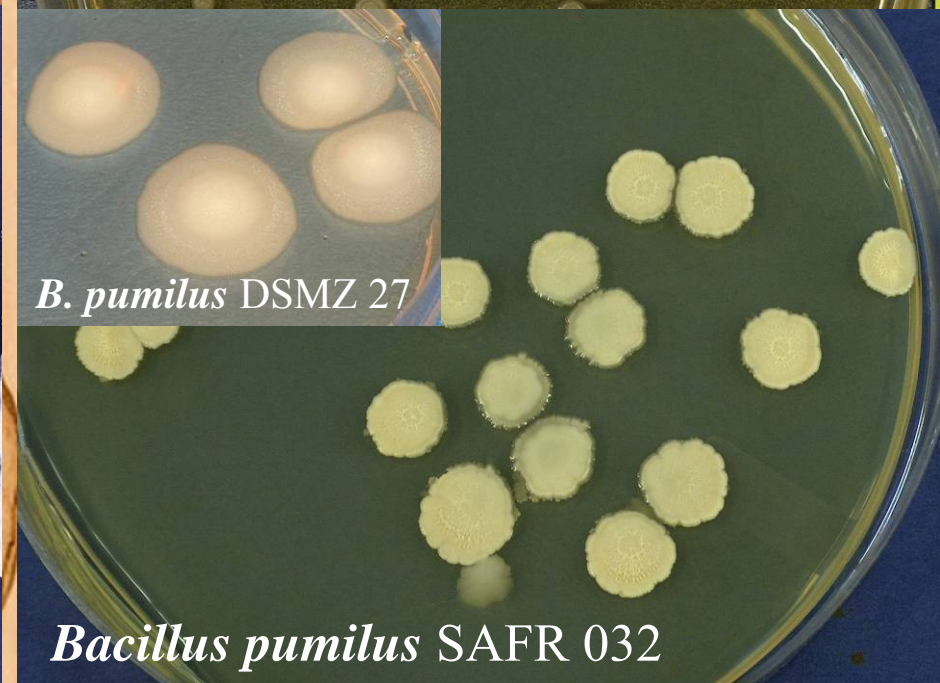
Deinococcus radiodurans



Mycobacterium smegmatis



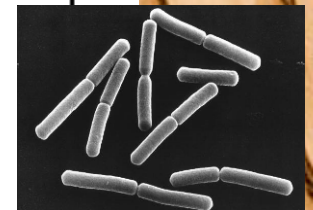
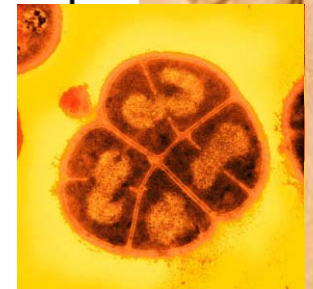
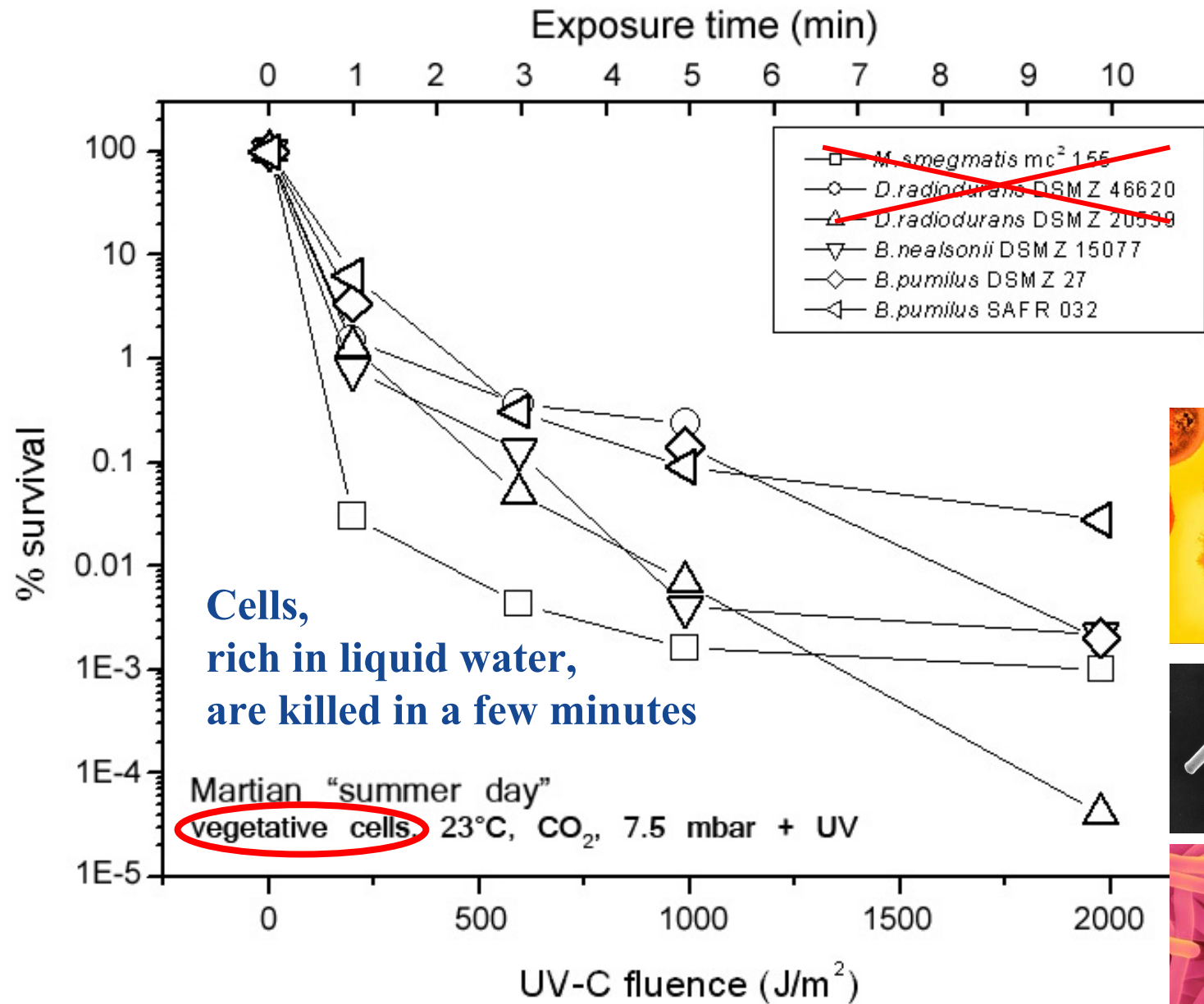
Bacillus nealsonii ATCC 15077



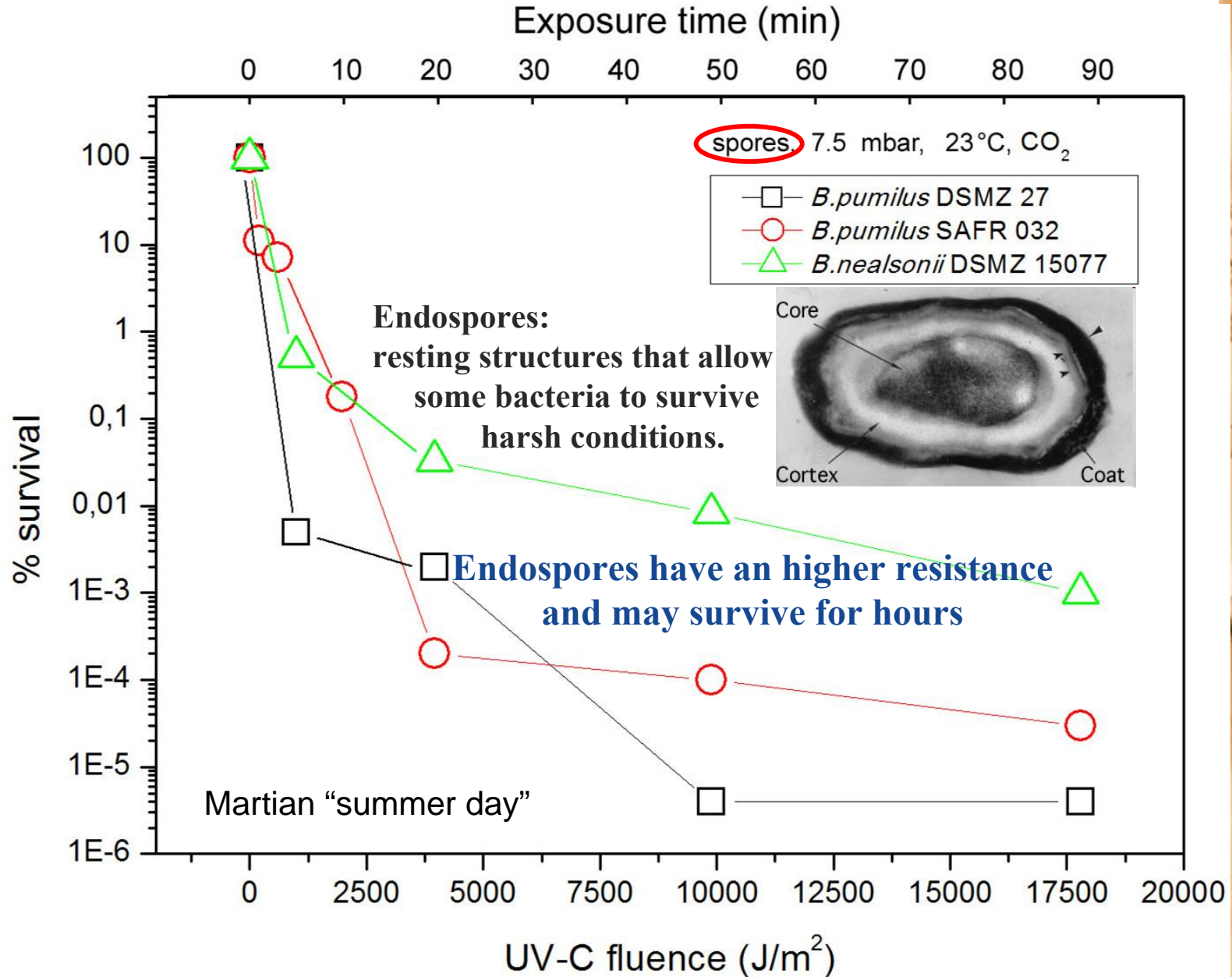
B. pumilus DSMZ 27

Bacillus pumilus SAFR 032

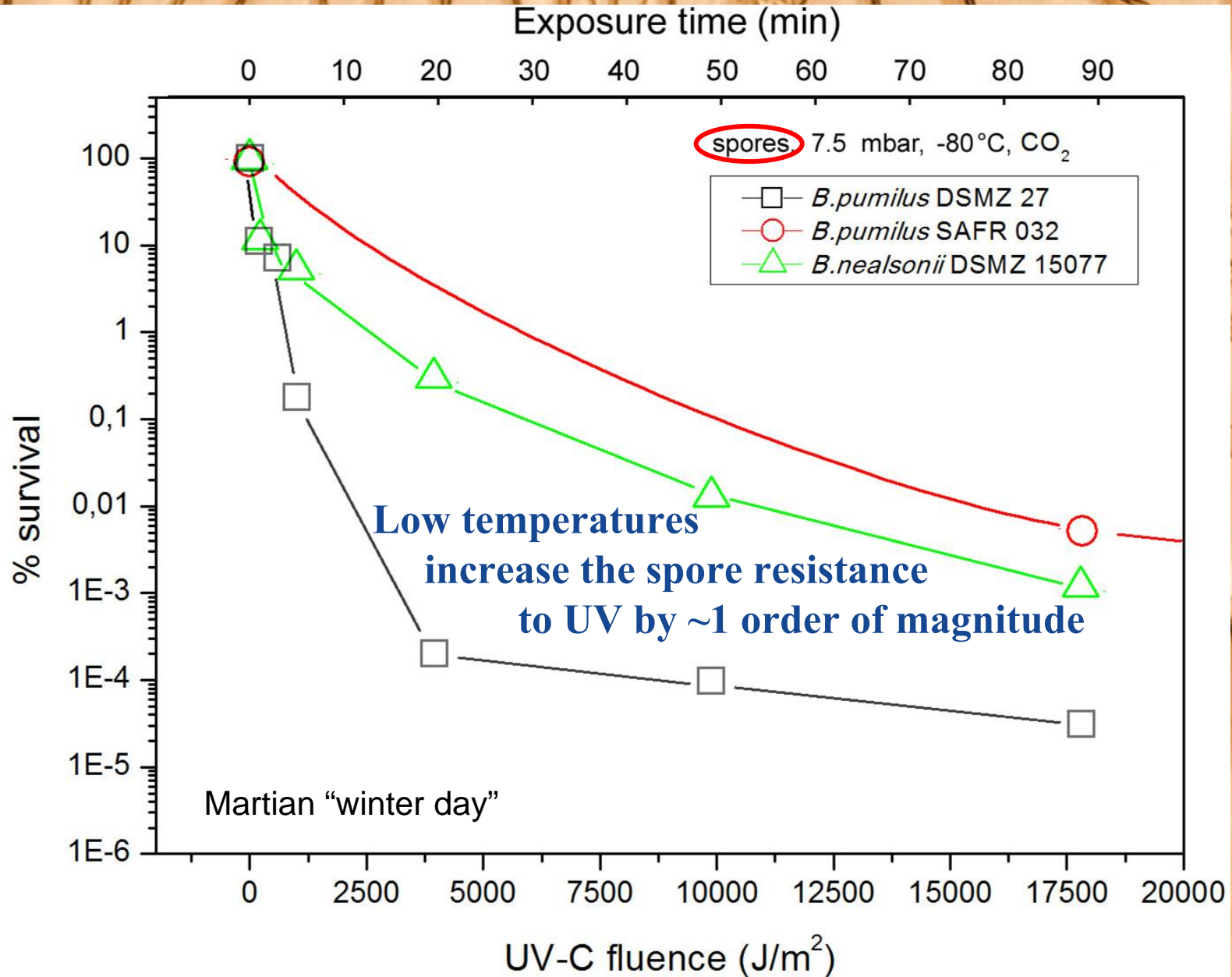
Biological experiments



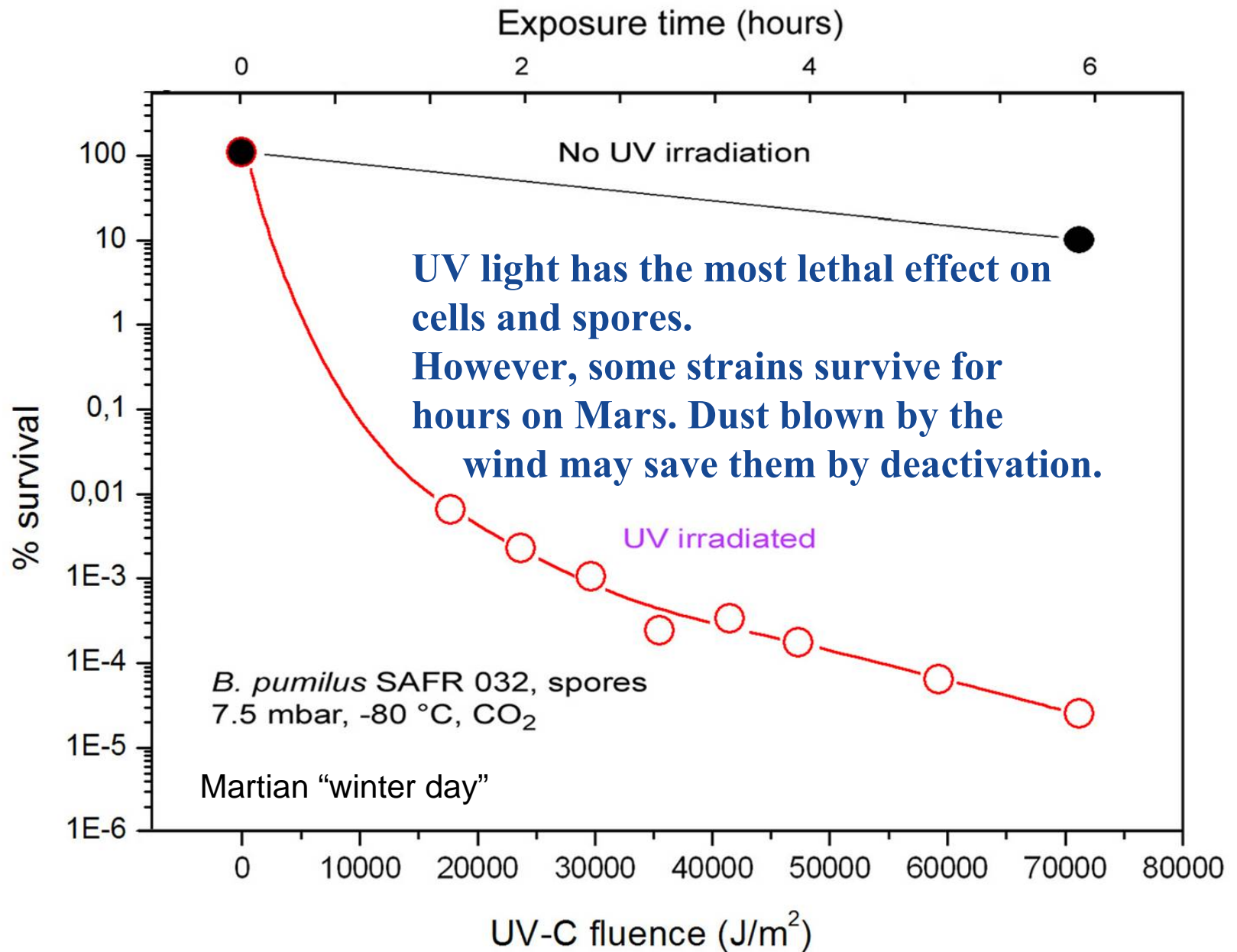
Biological experiments



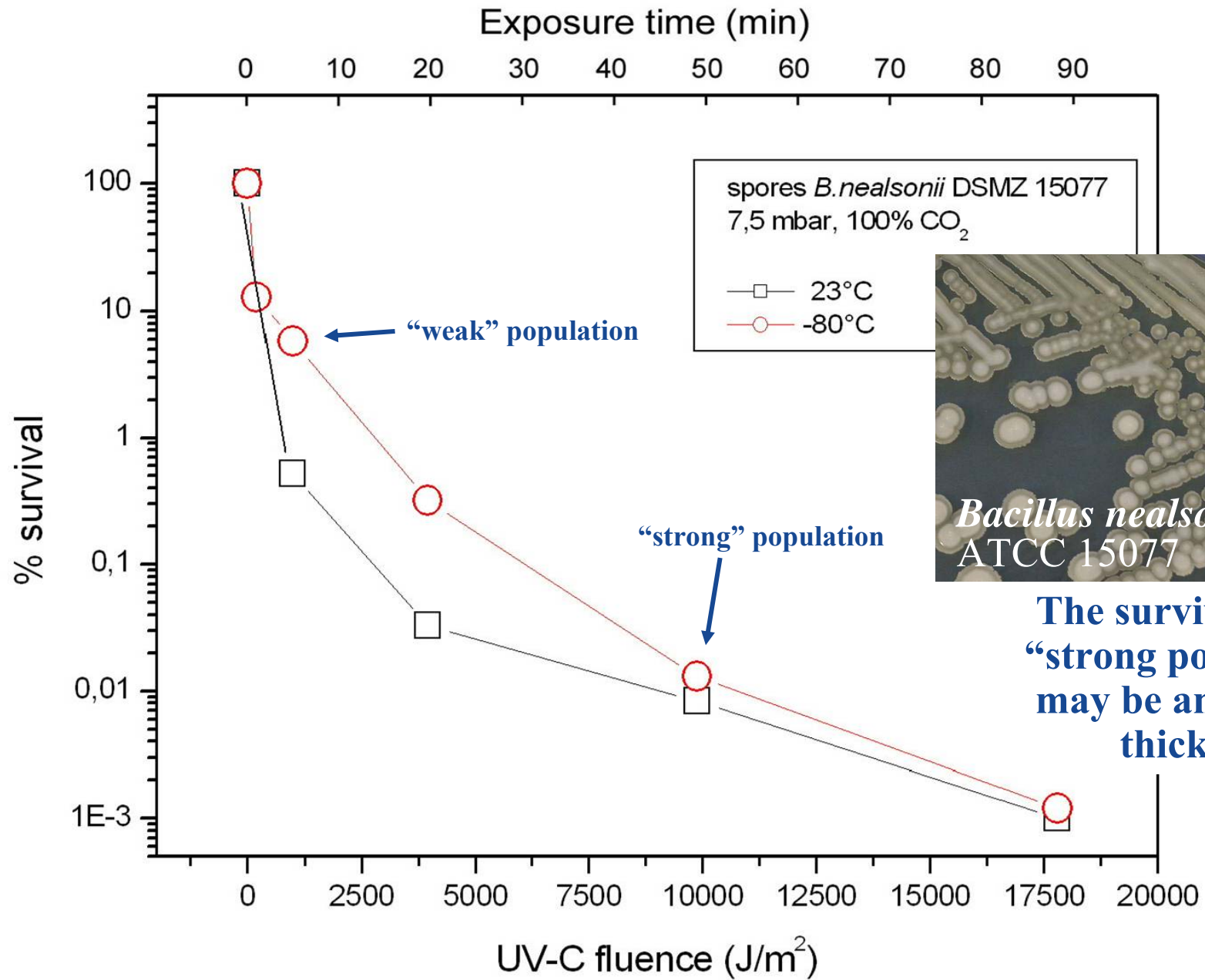
Biological experiments



Biological experiments

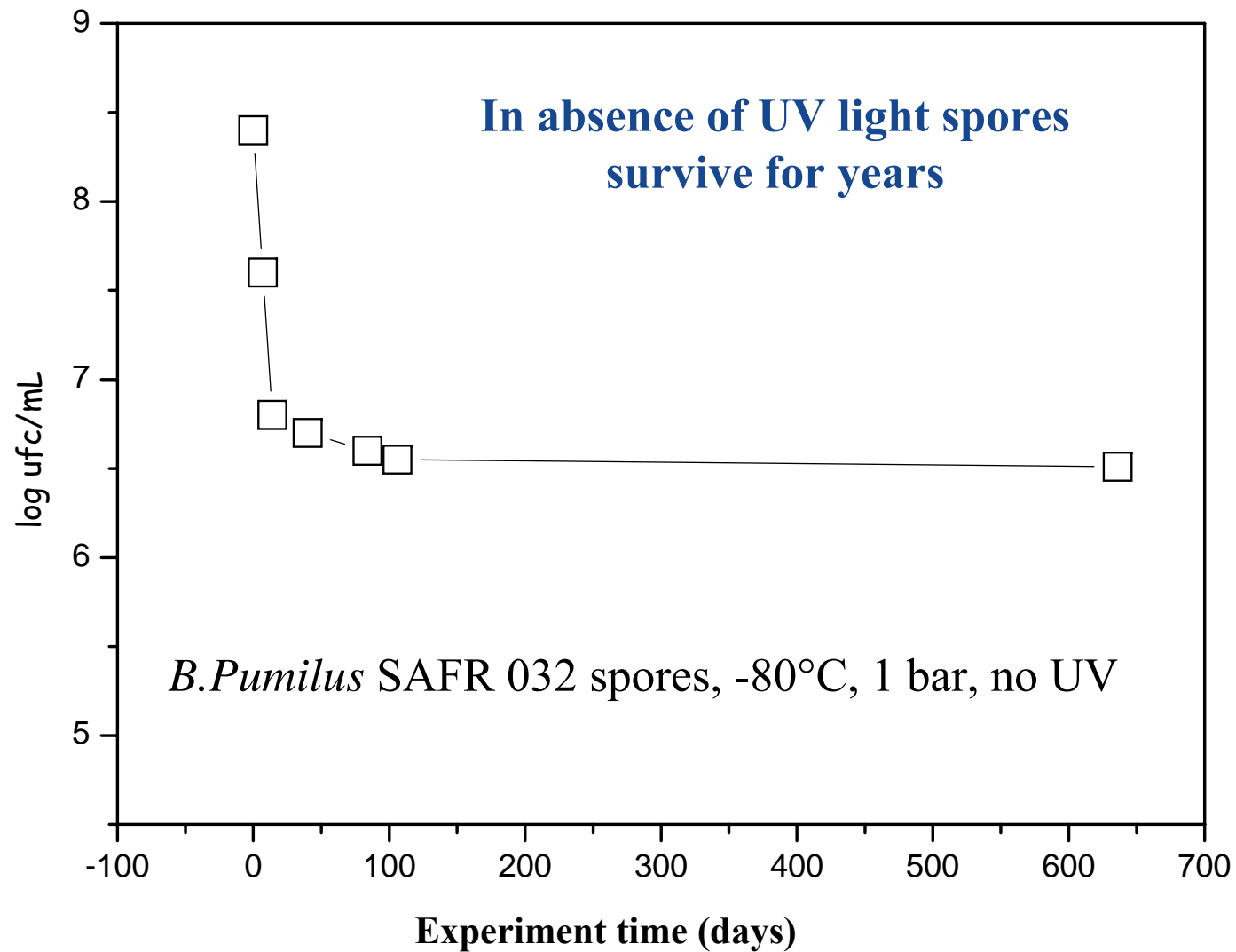


Biological experiments



The survival of the “strong population” may be an effect of thickness

Biological experiments



First results:

- **Desiccation effect (water escape because of low pressure) may strongly decrease the survival of vegetative cells, but not of spores.**
- **In Martian environment, UV light has the most cytocidal effect. Atmospheric composition or temperature are not relevant to their survival.**
- **Vegetative cells are inactivated by UV light in few minutes, spores may survive for hours.**
- **Some bacterial strains, such as *B. pumilus* and *B. Nealsonii* resist for at least 6 hours to Martian conditions. In their sequenced DNA portion no mutations have been detected.**
- **A thin dust cover, or a dead cell layer may be sufficient to warrant the survival of the underlying spores.**

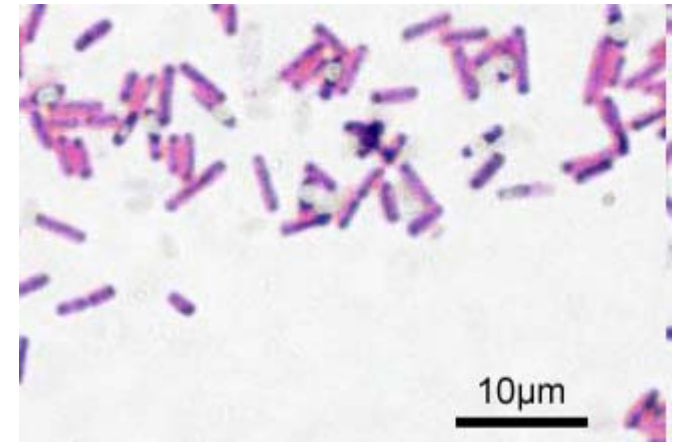
Collaborations:

- **Bacillus studies in space and on Mars:**

R. Möller and co-workers

German Aerospace Center (DLR), Radiation
Biology Division, Institute of Aerospace Medicine

**Bacterial spores covered by dust survived in LISA
up to 25 hours**



- **Tardigrade survival in extreme conditions**

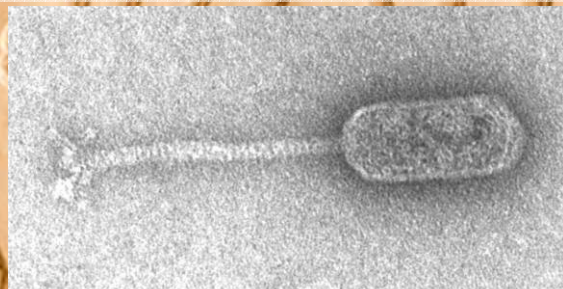
L. Rebecchi, R. Bertolani and co-workers

University of Modena and Reggio Emilia,
Department of Animal Biology, Modena

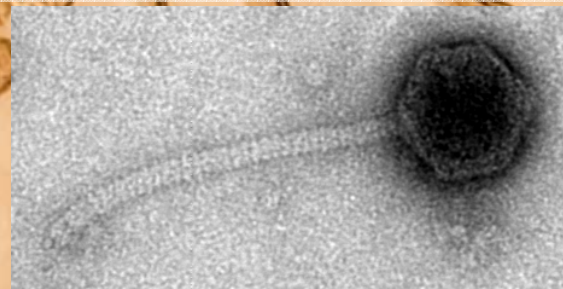
Small animals living in moss survived in mini-LISA



Future works:



Fago PPL1c



Fago 18

The two Fagi infect *Paenibacillus larvae* (gram-positive bacterium, pathogenic for bees)

