Desvendando o mundo das biomoléculas através de técnicas avançadas baseadas em fontes de raio-X de alta intensidade

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Group and colaborations

1. *Universidade de Brasília, Instituto de Física- Brasília DF*
2. *Laboratório Nacional de Luz Síncrotron (LNLS) Campinas-SP*
3. *Universidade Federal do ABC, Santo André-SP*
4. *Universidade Federal da Bahia, Barreiras-BA*

More Colaborations

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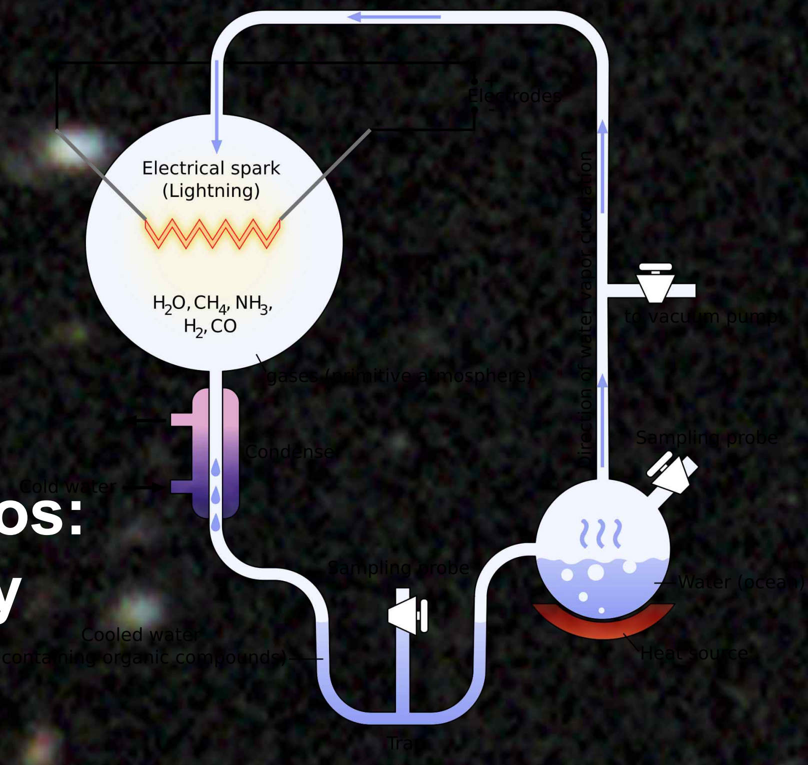
Cenários da evolução pré-biótica

A comunidade científica concorda em geral: Os aminoácidos, e bases nitrogenadas (nucleotídieos e nucleocídeos) foram os precursores formando pepitídeos, proteínas e os polímeros RNA e DNA.



Experimentos:
Miller e Urey
1953
Crédito: NASA

Em 1969 um meteoro "aterrisou" em Murchison, Austrália. Foi mostrado que o mesmo continha os mesmos compostos orgânicos e amoniácidos e nas MESMAS proporções daquelas originadas no experimento de Miller!

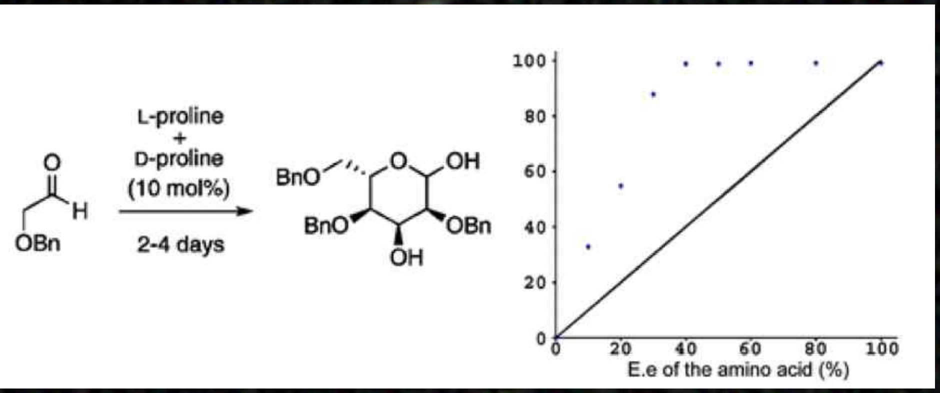
Compound class[9]	Concentration (ppm)
Amino acids	17-60
Aliphatic hydrocarbons	>35
Aromatic hydrocarbons	3319
Fullerenes	>100
Carboxylic acids	>300
Hydrocarboxylic acids	15
Purines and Pyrimidines	1.3
Alcohols	11
Sulphonic acids	68
Phosphonic acids	2

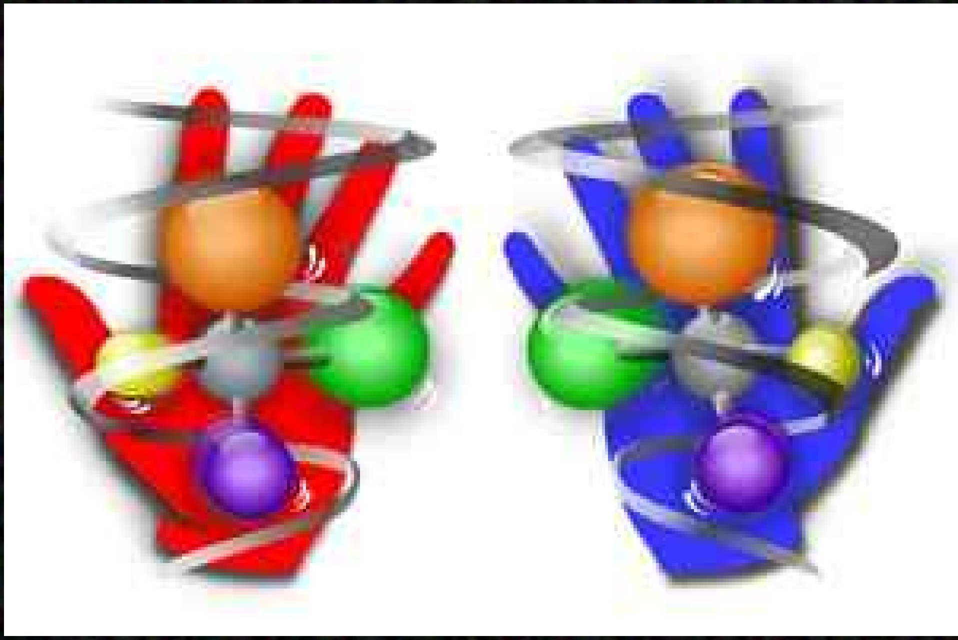
Problema:

Misturas racêmicas de DNAs e RNAs não conseguem se replicar

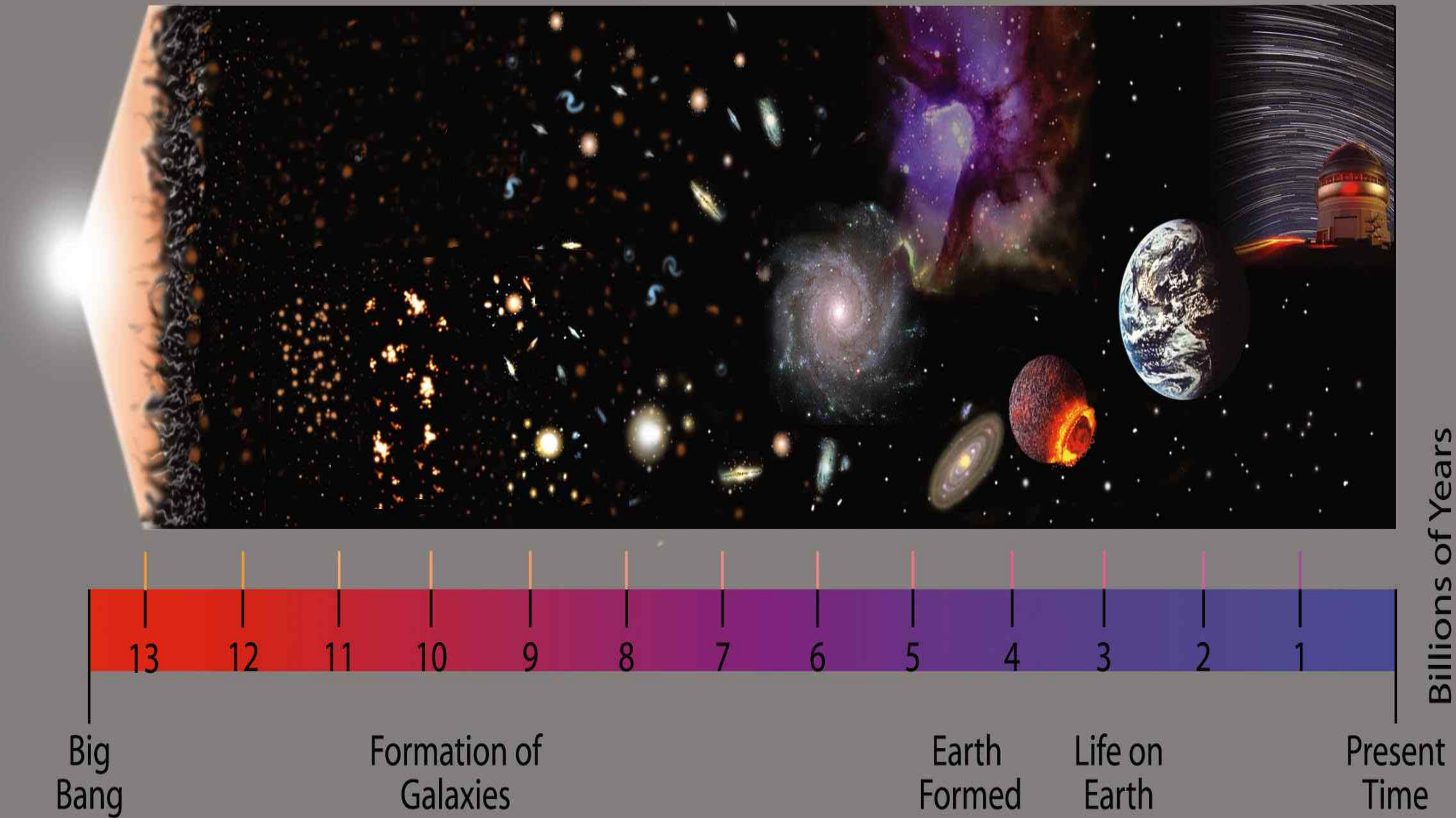
Aminoácidos podem servir de catalizadores para produção assimétrica de carboidratos

A homoquiralidade e fundamental para que exista a vida!



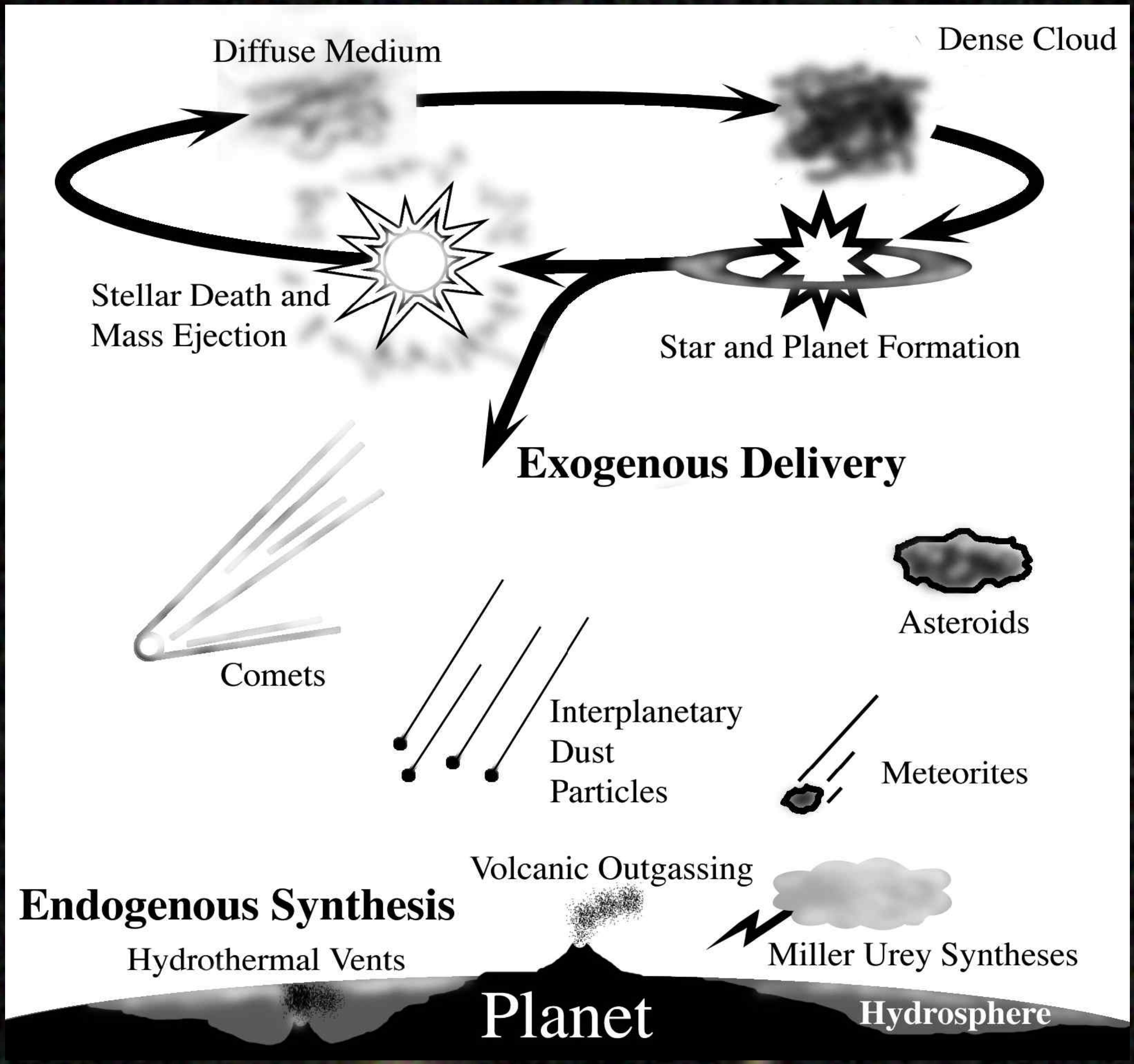


Depois de 4.5 Giga-years – O Nosso sistema solar nasceu num universo que tinha 10 Gyears!
Muito da química pré-biotica já poderia estar lá.

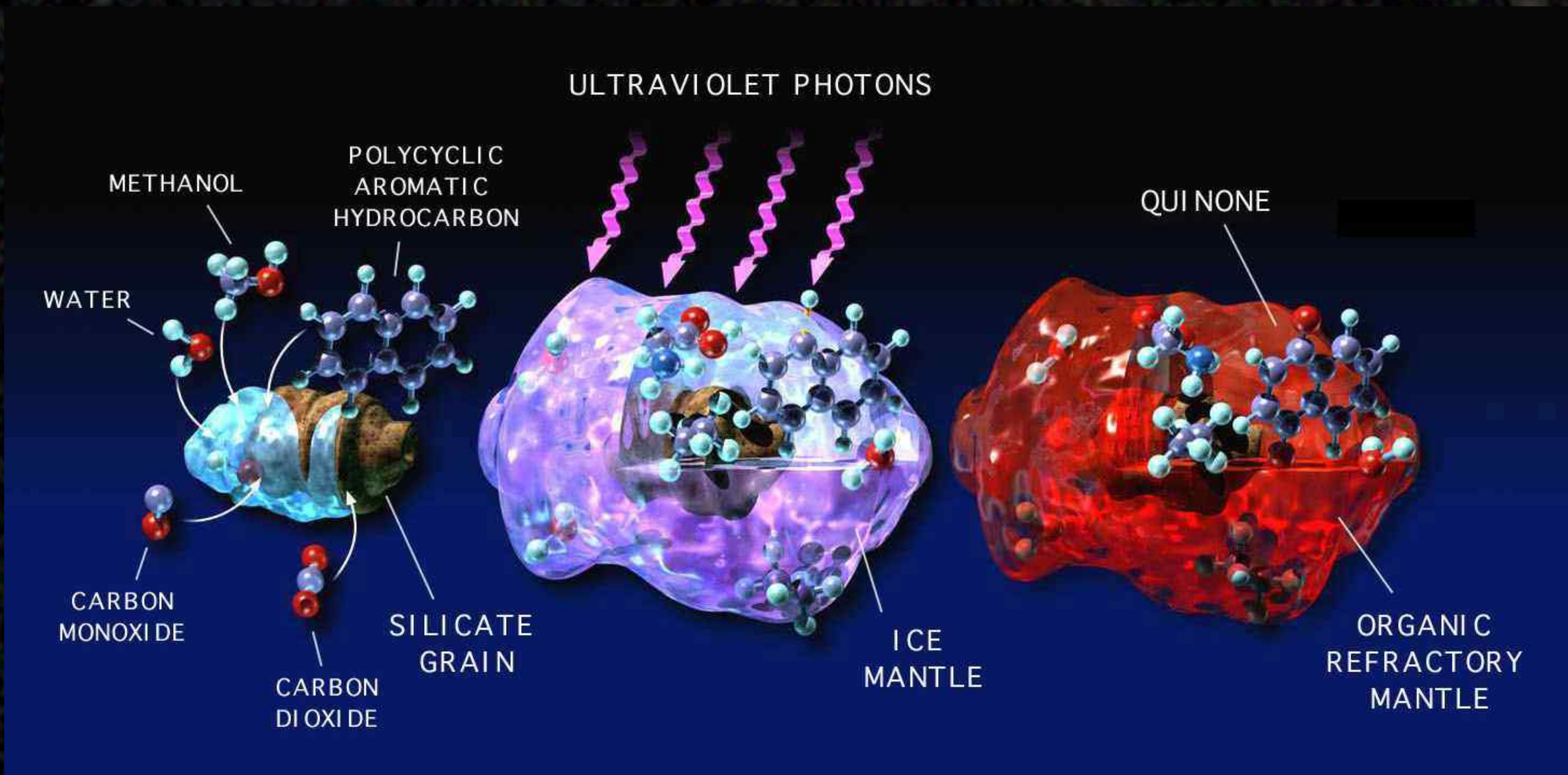



100.000.000.000.000.000.000.000.000
STARS
Hubble ULTRA deep field

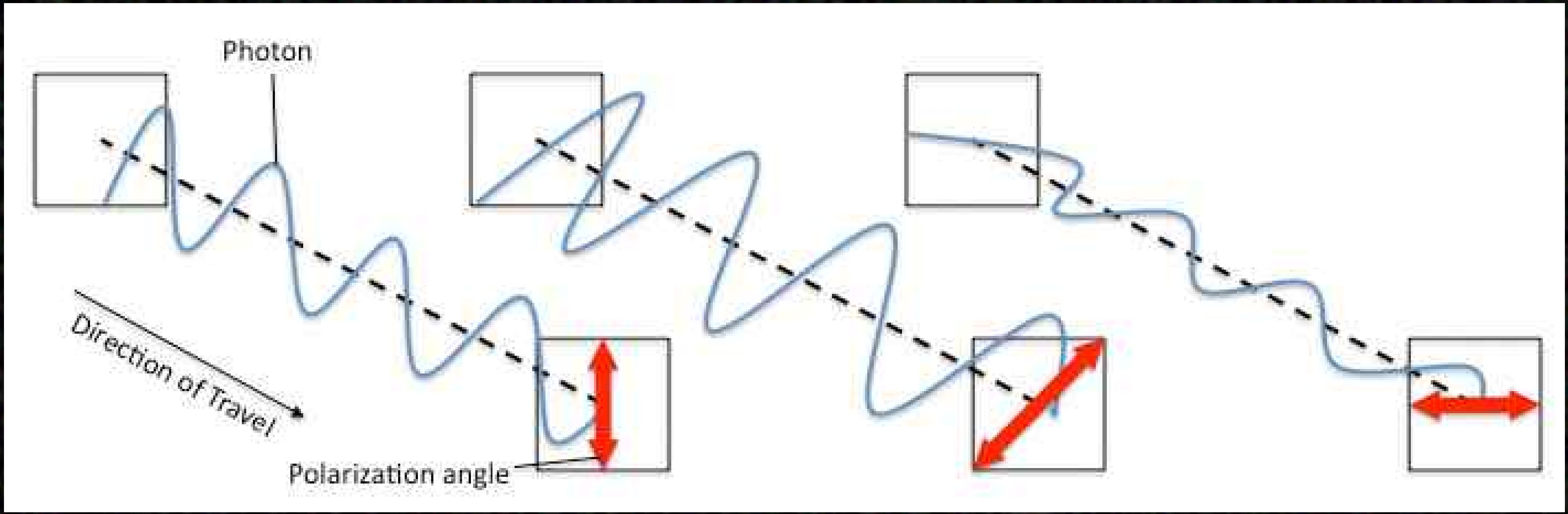
Possíveis caminhos para a química pré-biótica



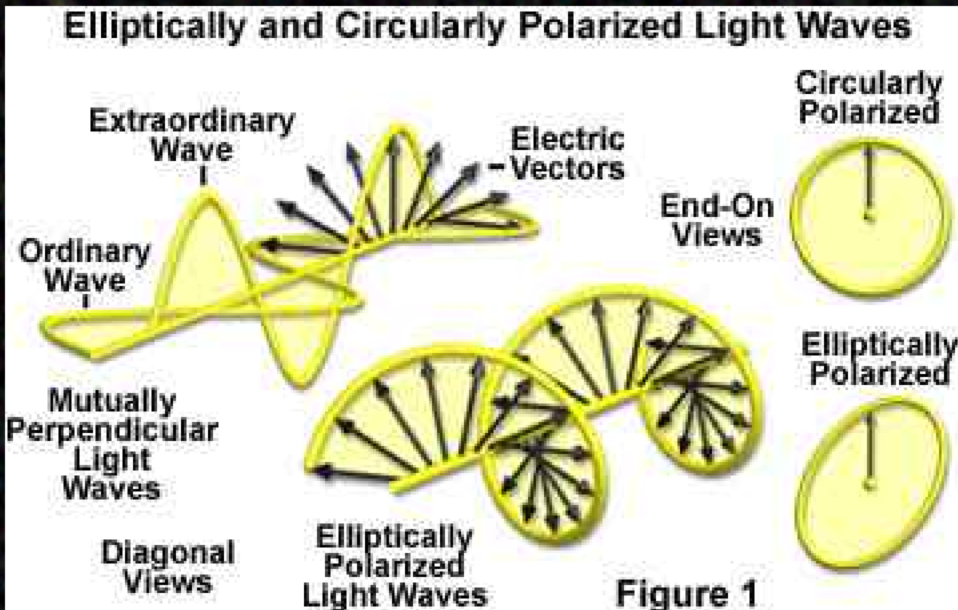
Vamos nos concentrar na produção abiótica no espaço!

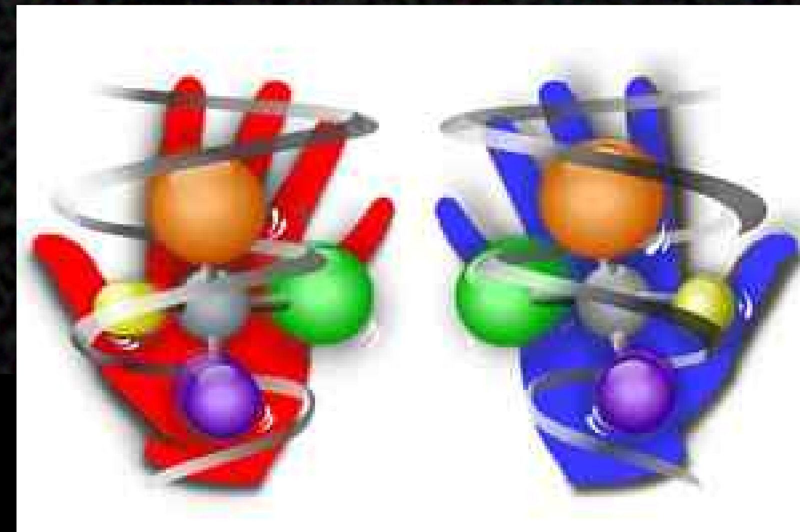


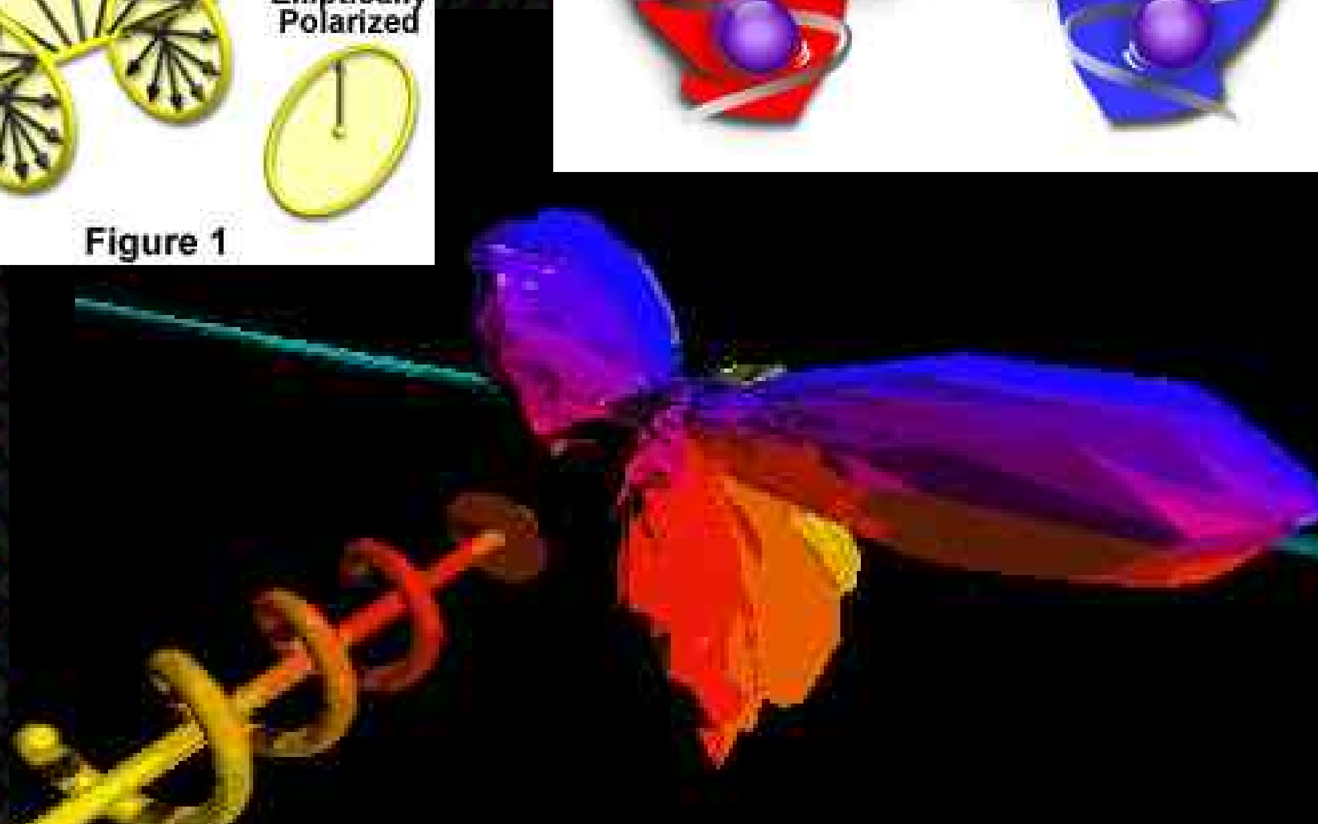
Raios–X ou qualquer outro fóton possui uma propriedade importante: POLARIZAÇÃO



POLARIZAÇÃO Circular de fótons:



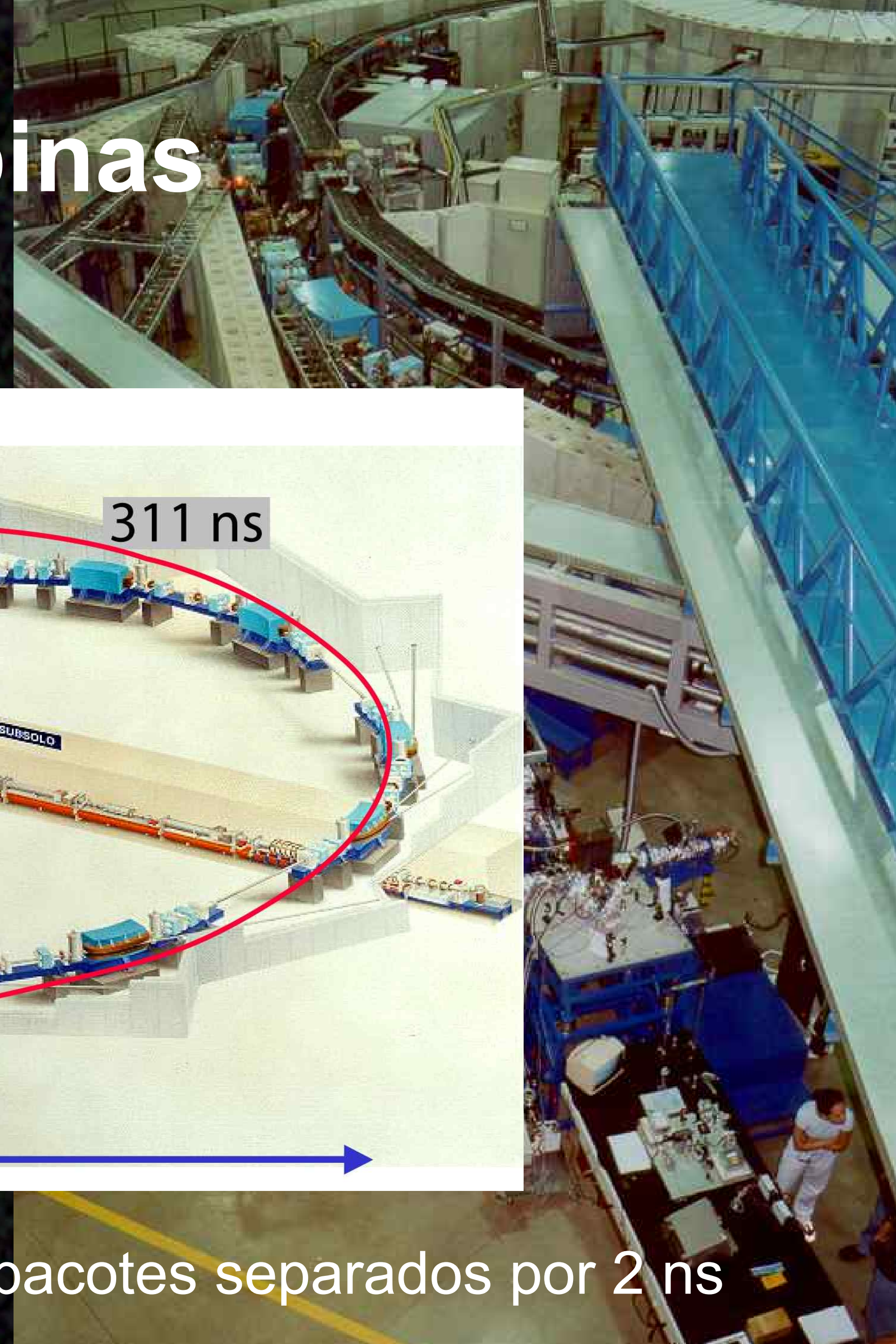


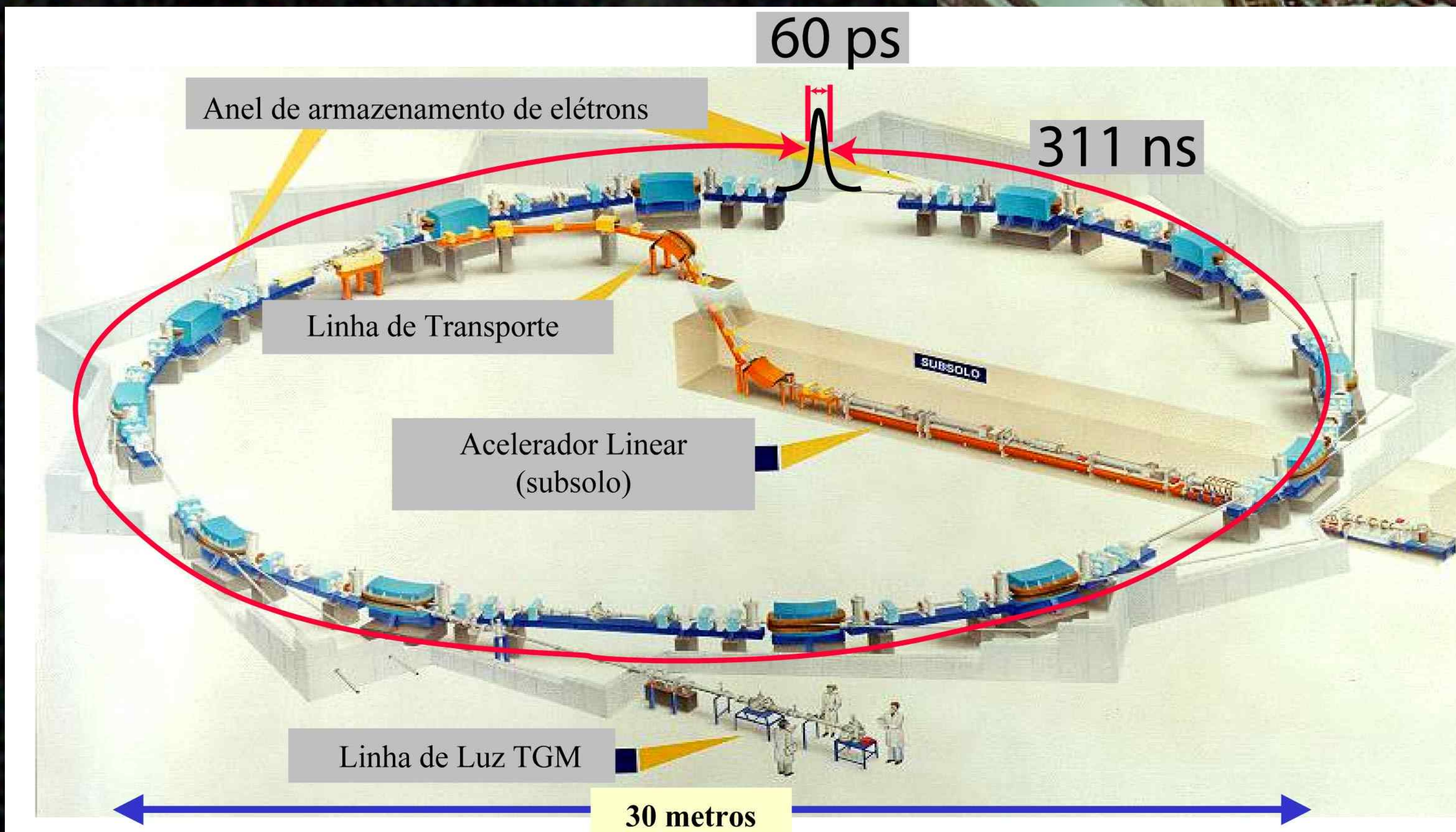


Usaremos como fonte de raios-x vindo de um acelerador síncrotron

Fonte muito poderosa (alto brilho): milhões de anos acumulados de dose no espaço são equivalentes a somente dezenas de horas no síncrotron.

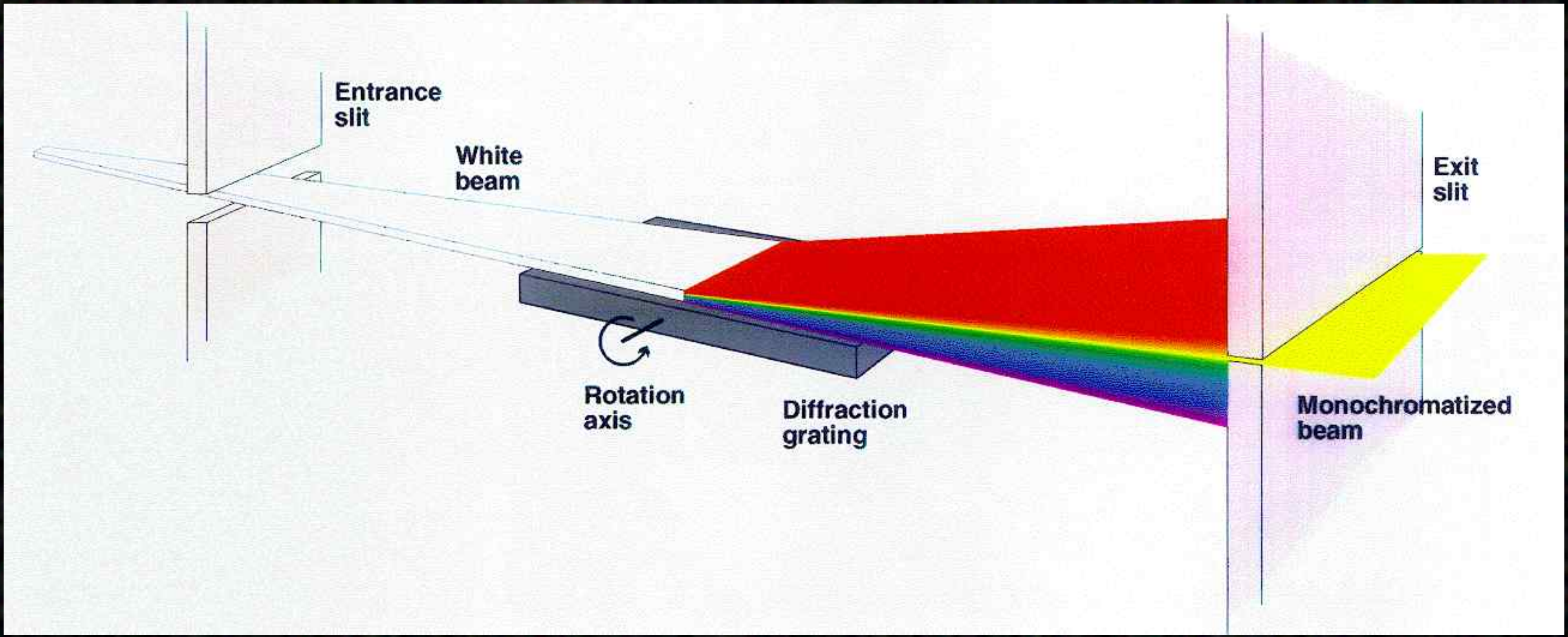
O LNLS-Campinas





Usualmente termos 147 pacotes separados por 2 ns

Precisamos de um monocromador



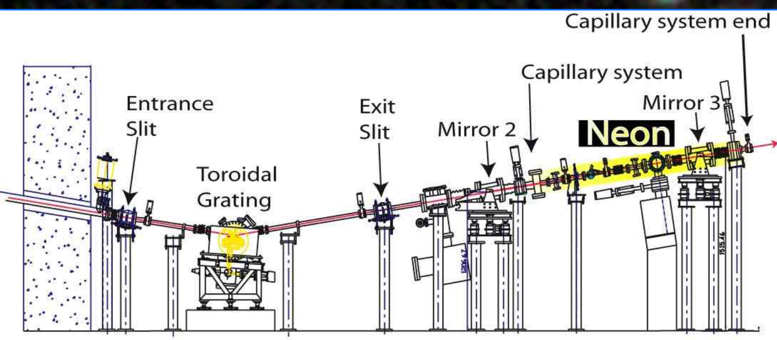
Linha de Luz TGM

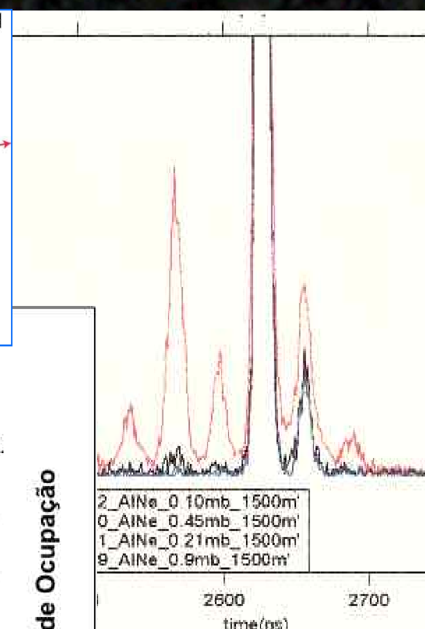
Open Facility (2002- ; 8 years)
TGM: ~40 Projects or 30 group/year
Trained~16 (18) Groups 50 users
trained for TGM al. us. SXS&SGM

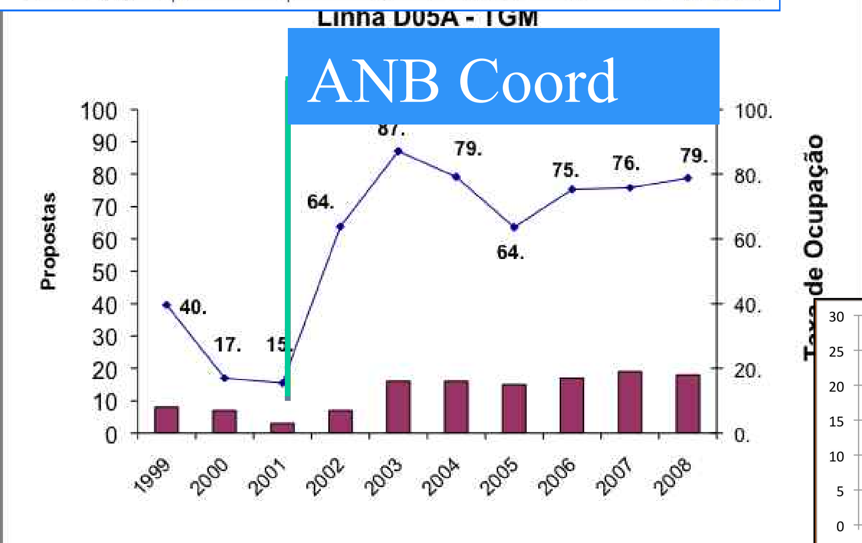
Mirhaclle

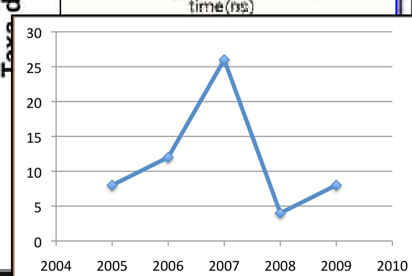
MIRror-inserted Harmonic Attenuator
Calibrator-device with a Long LEgth

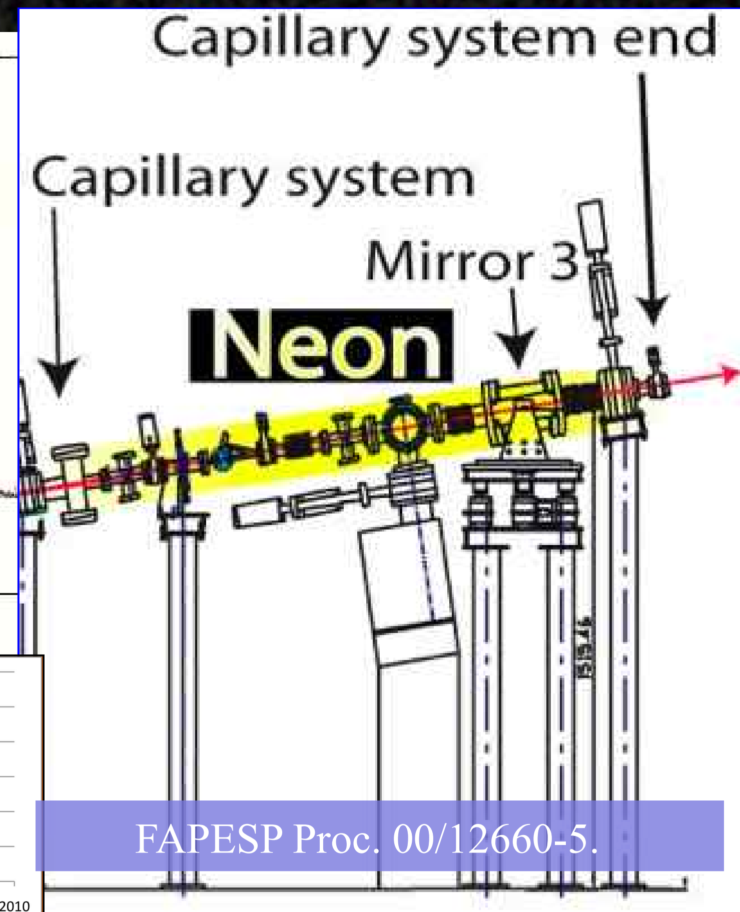
Cavasso-Fillho. RL…de Brito AN, Rev Scien. Instrum. **78**,115104, (2007)



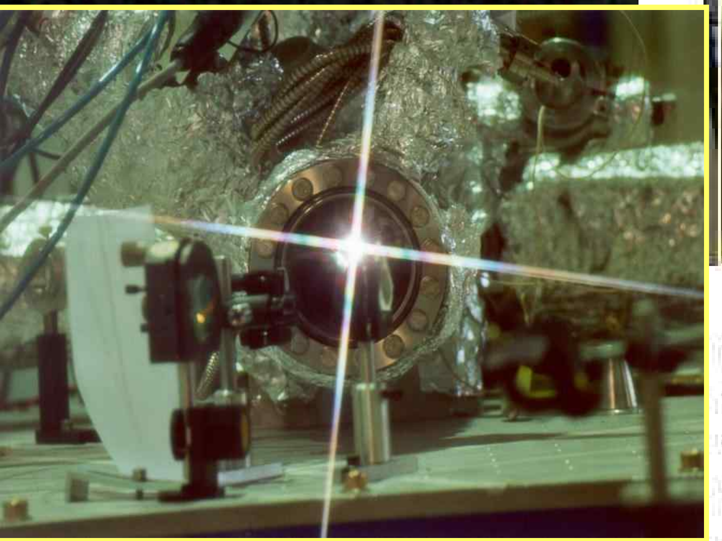


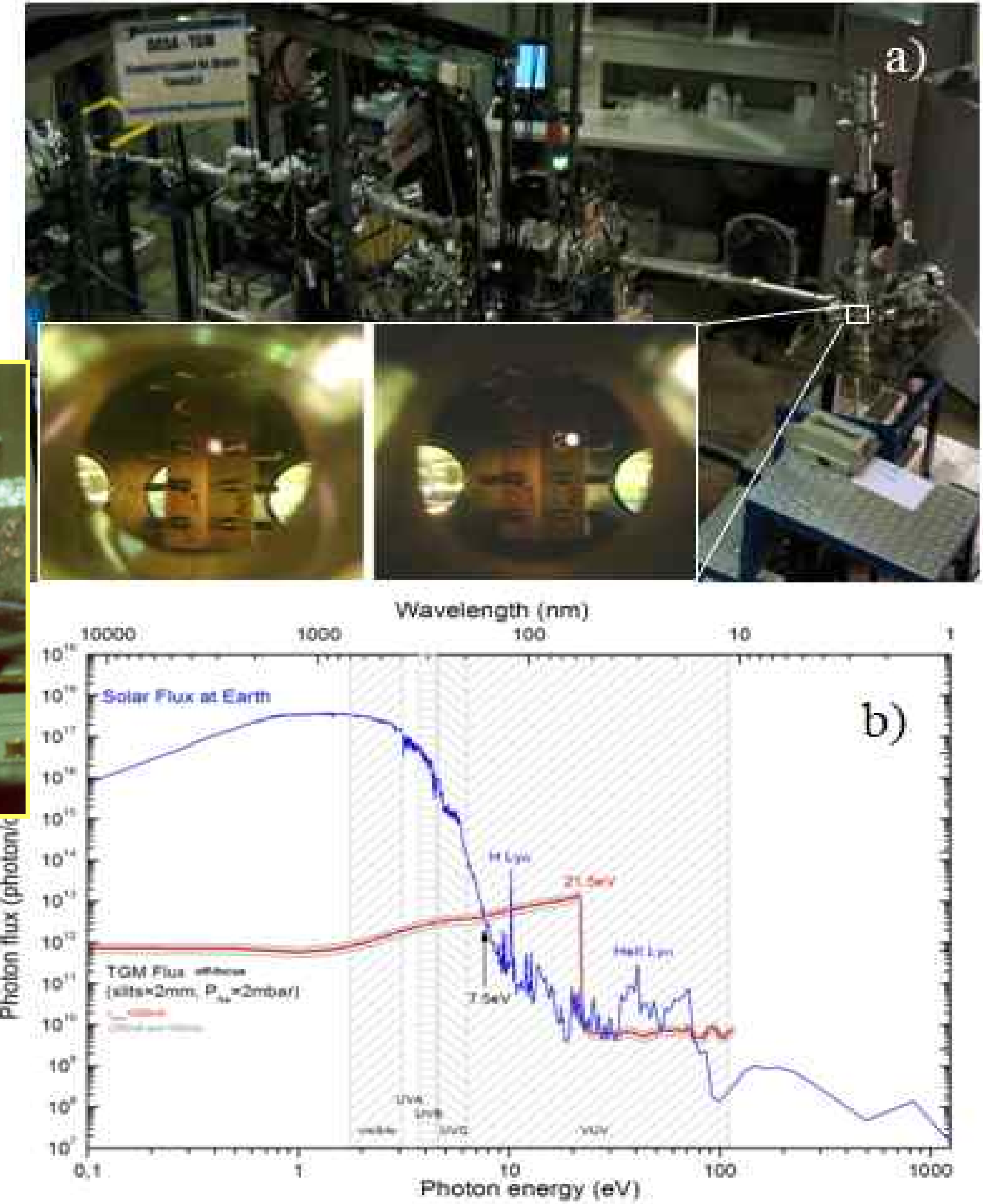






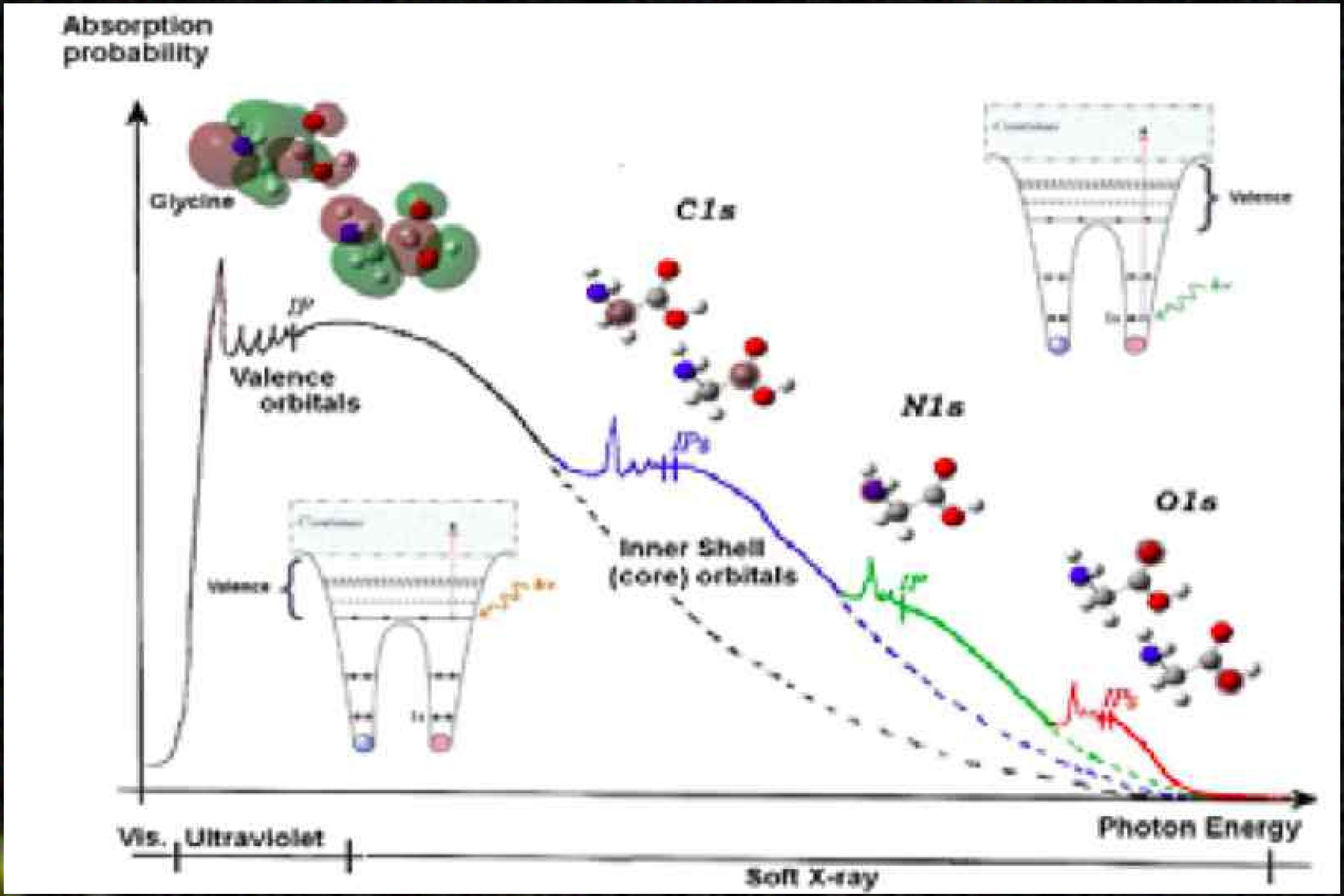
FAPESP Proc. 00/12660-5.





VUV SOLAR RADIATION

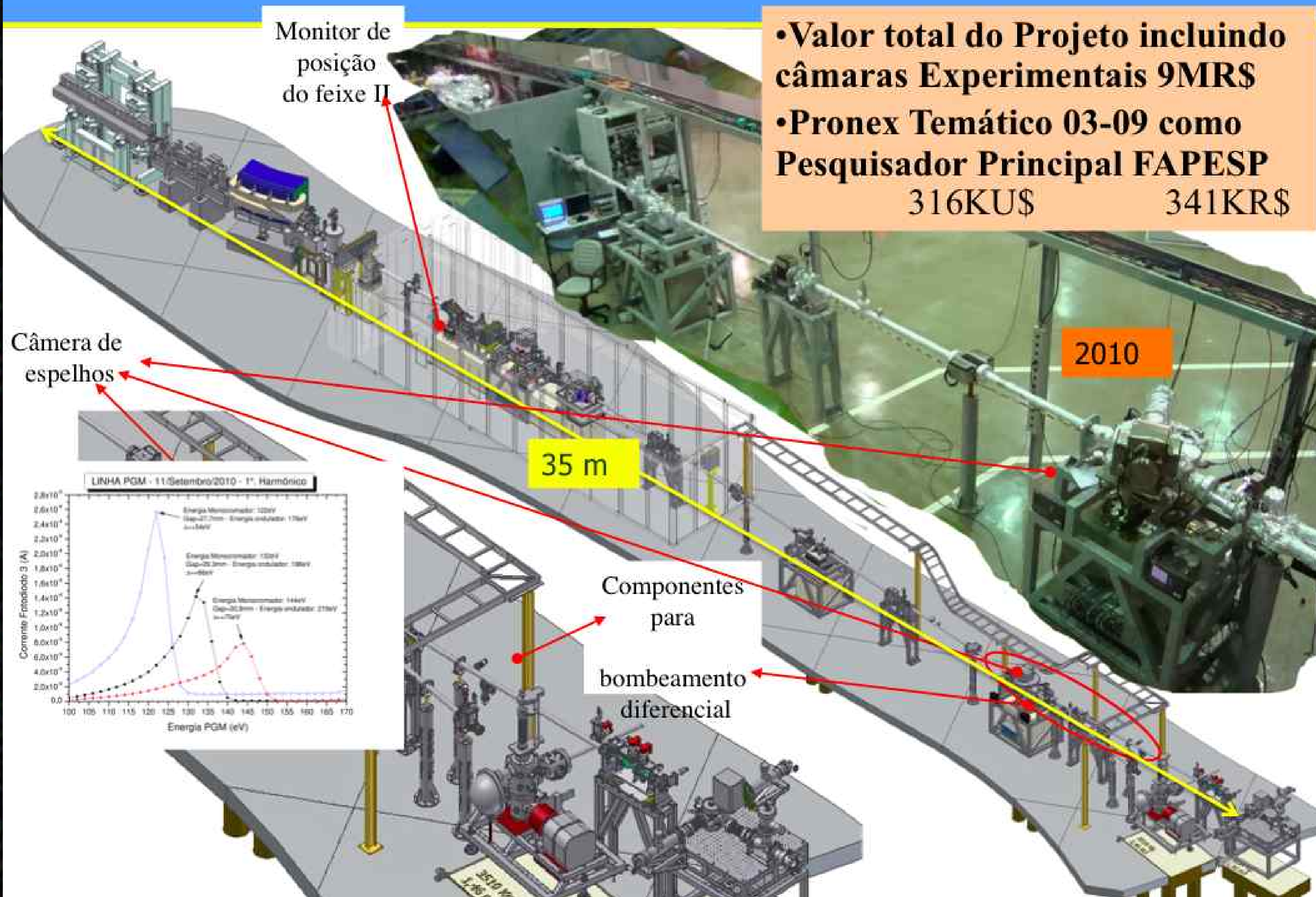
VUV não basta raio-x é muito importante



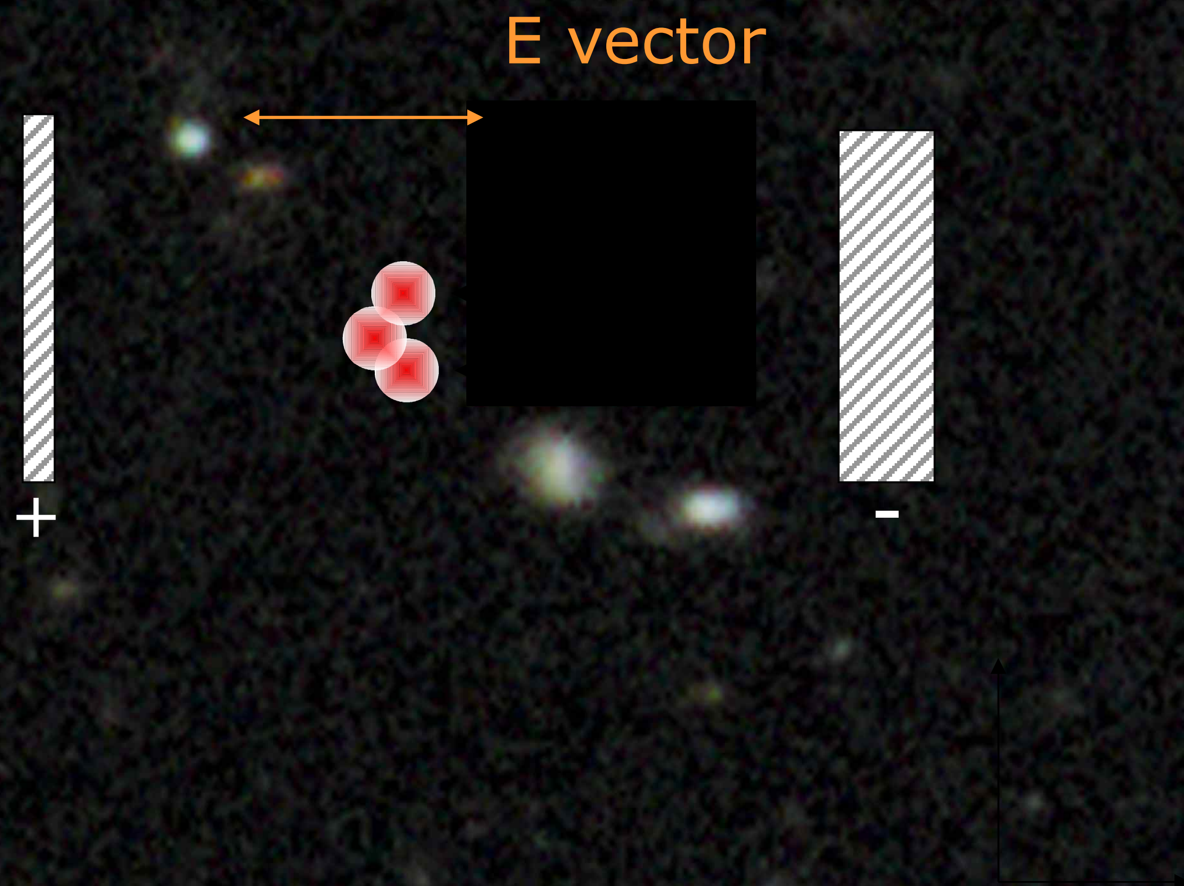
Linha PGM

- •Valor total do Projeto incluindo câmaras Experimentais 9MR$
- •Pronex Temático 03-09 como Pesquisador Principal FAPESP

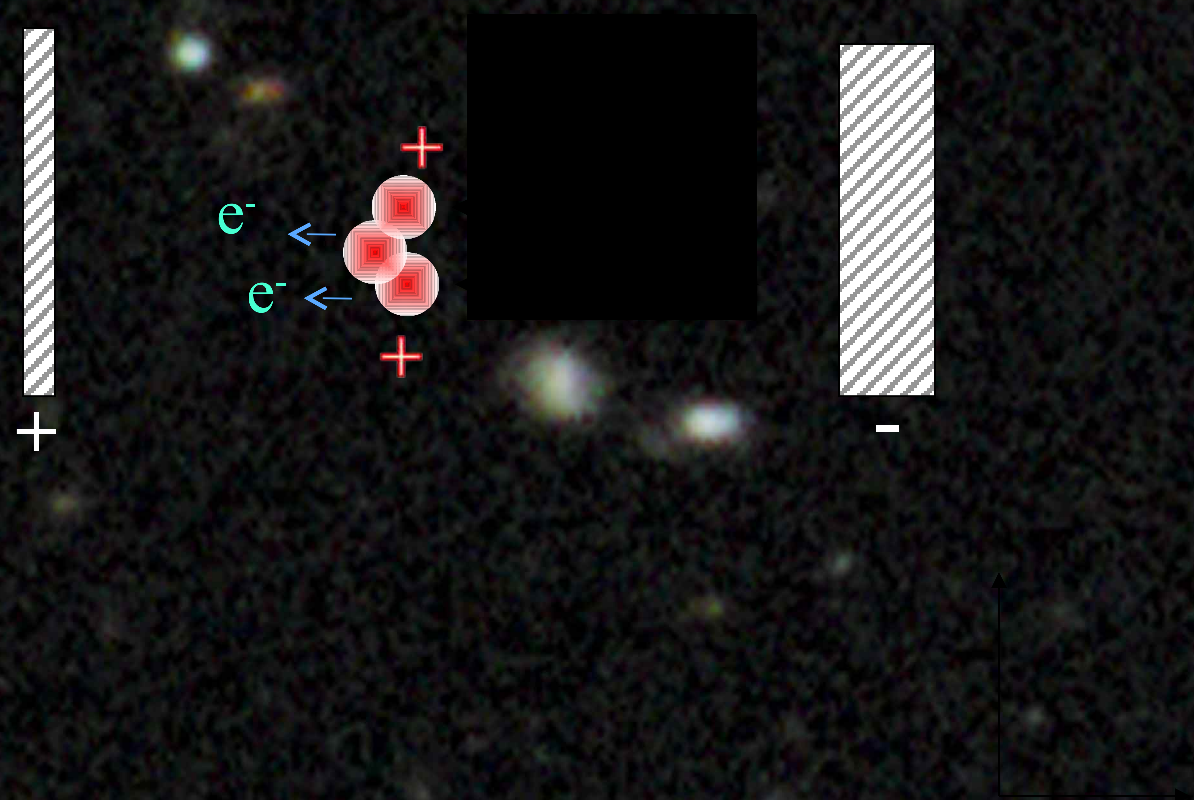
316KU$ 341KR$



Espectrômetro por Tempo de Vôo

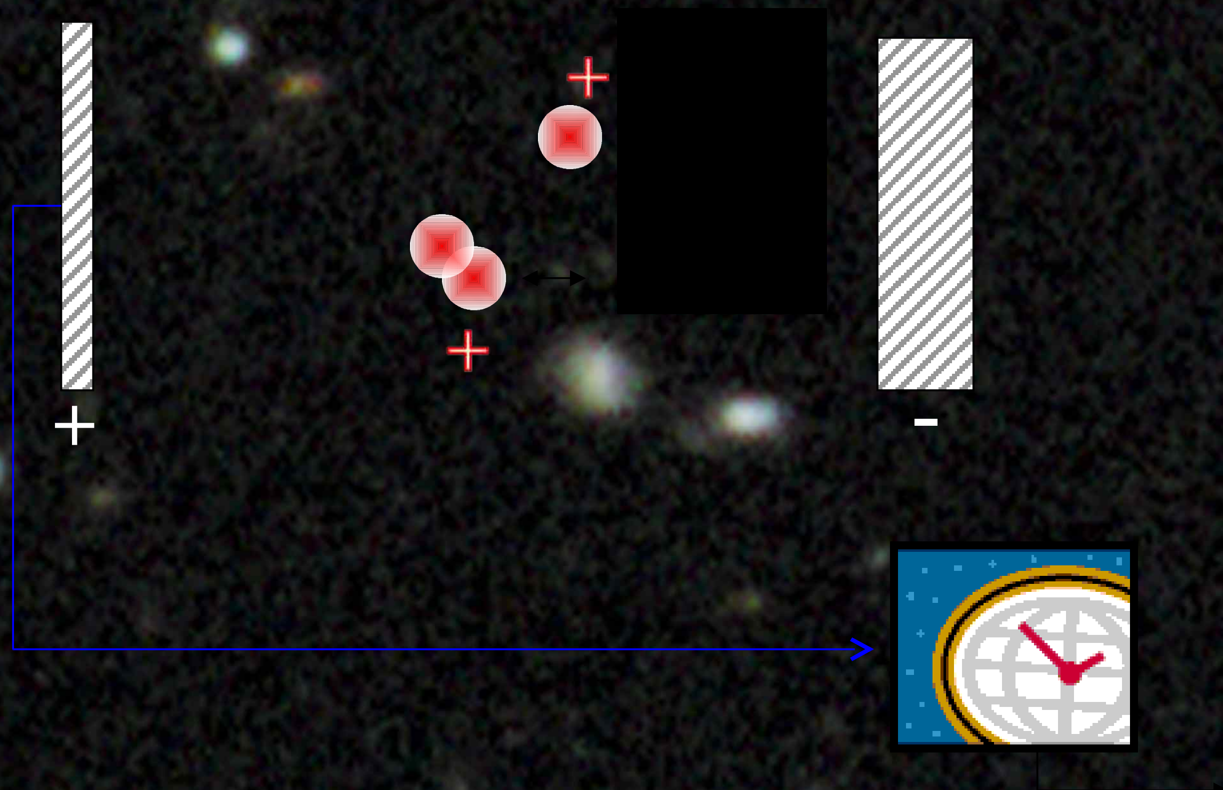


Espectrômetro por Tempo de Vôo



Espectrômetro por Tempo de Vôo

Espectrômetro por Tempo de Vôo



Espectrômetro por Tempo de Vôo

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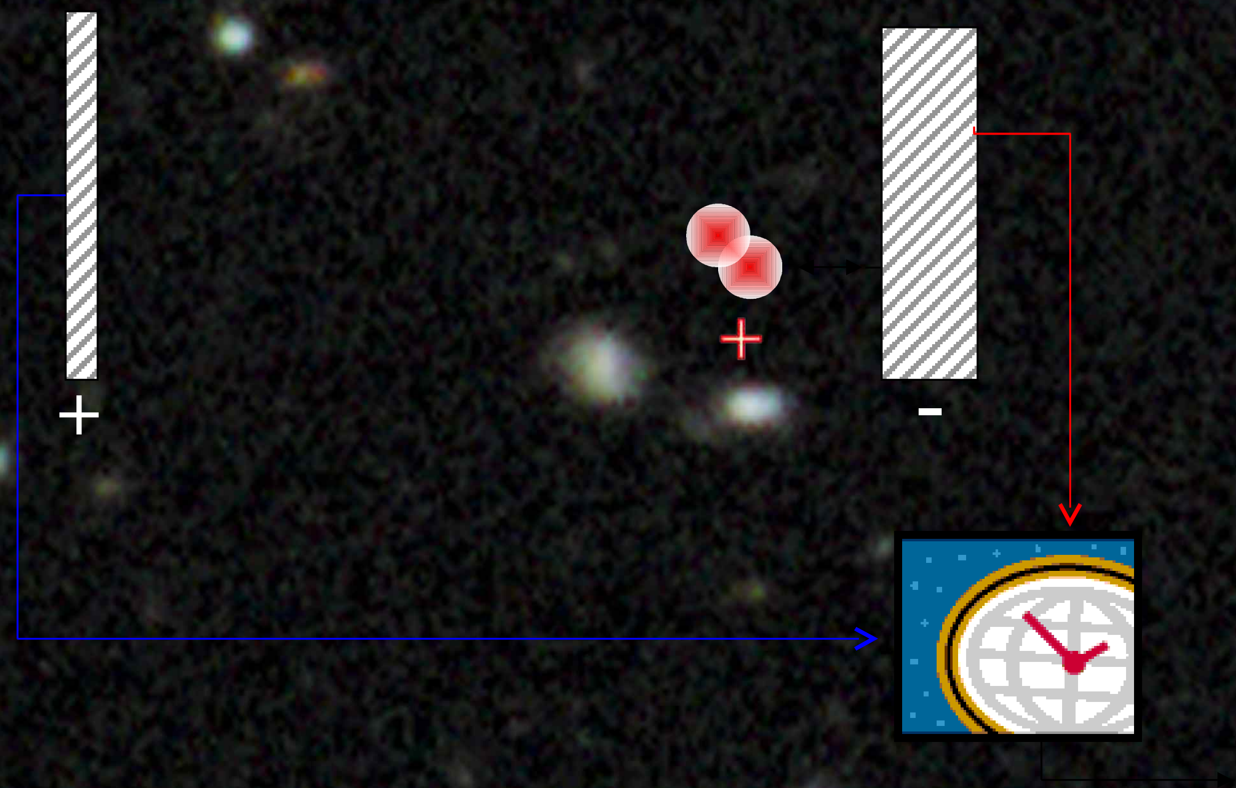
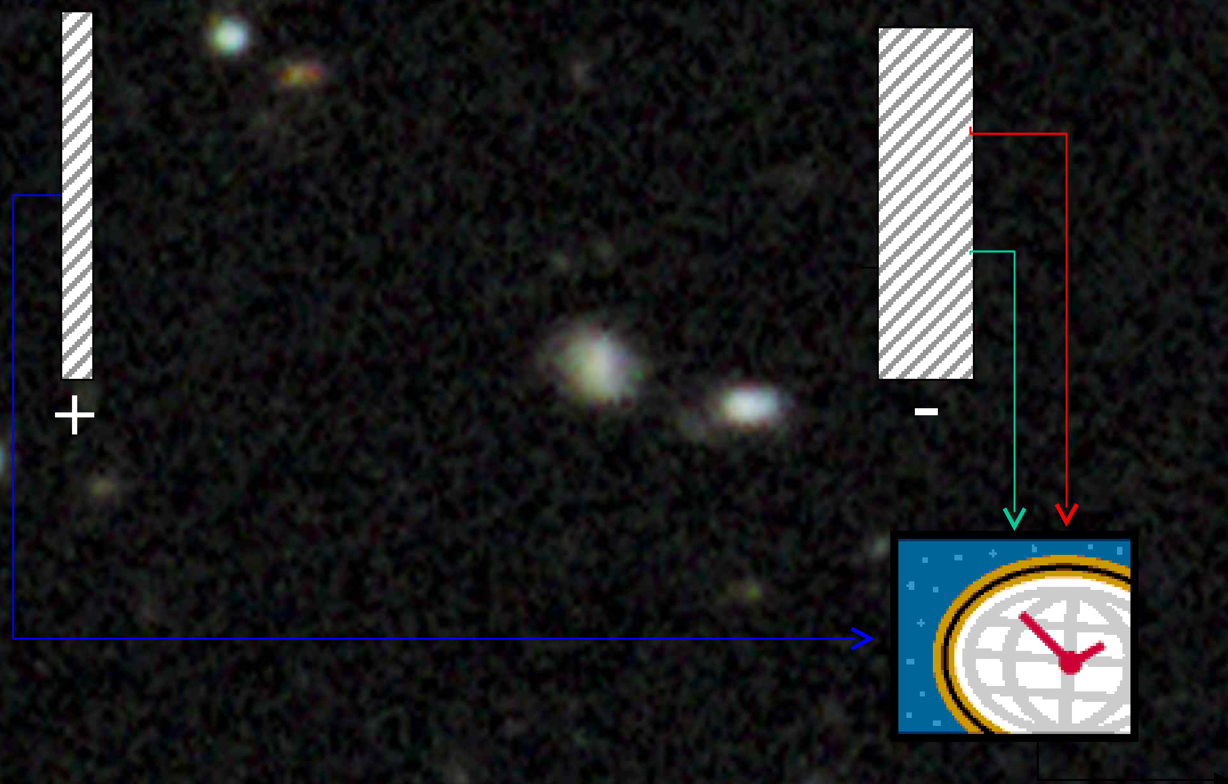
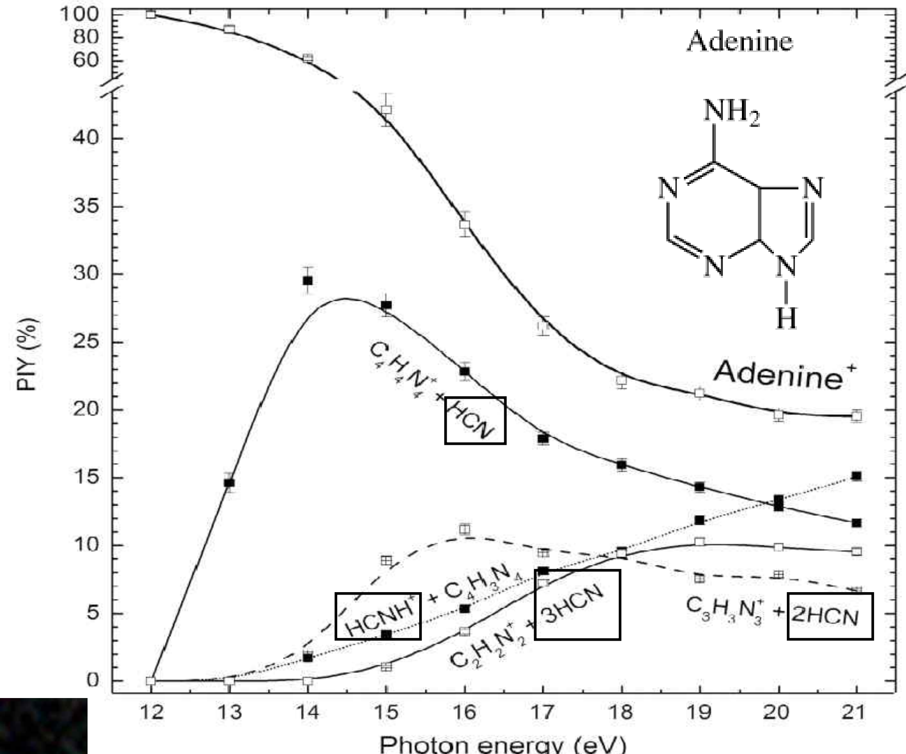
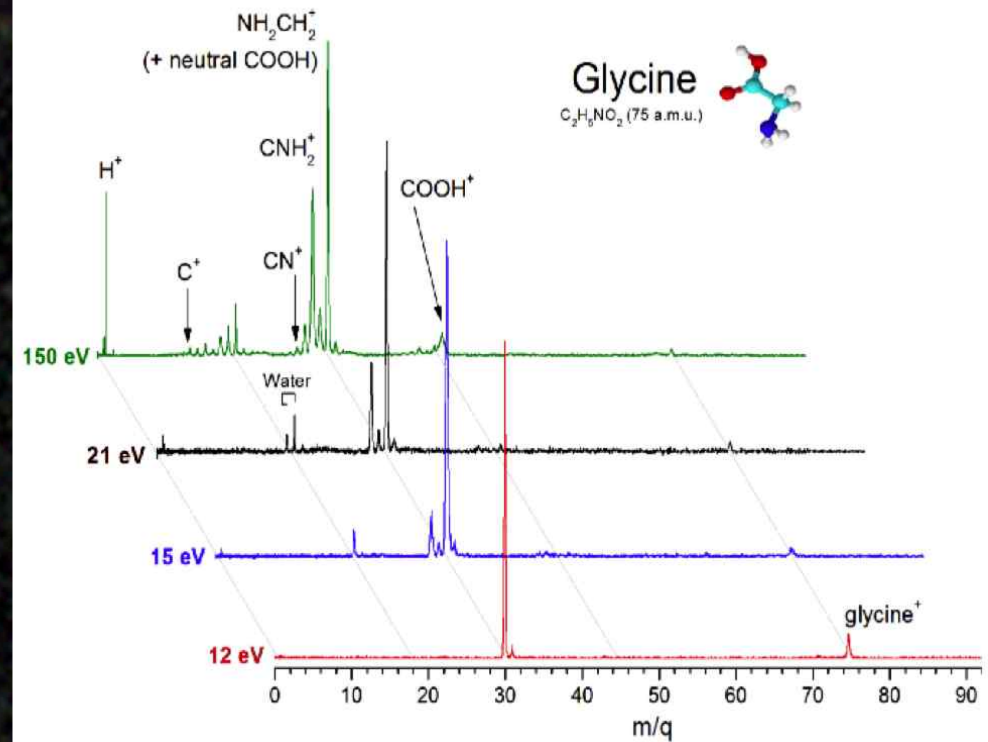


Espectrômetro por Tempo de Vôo



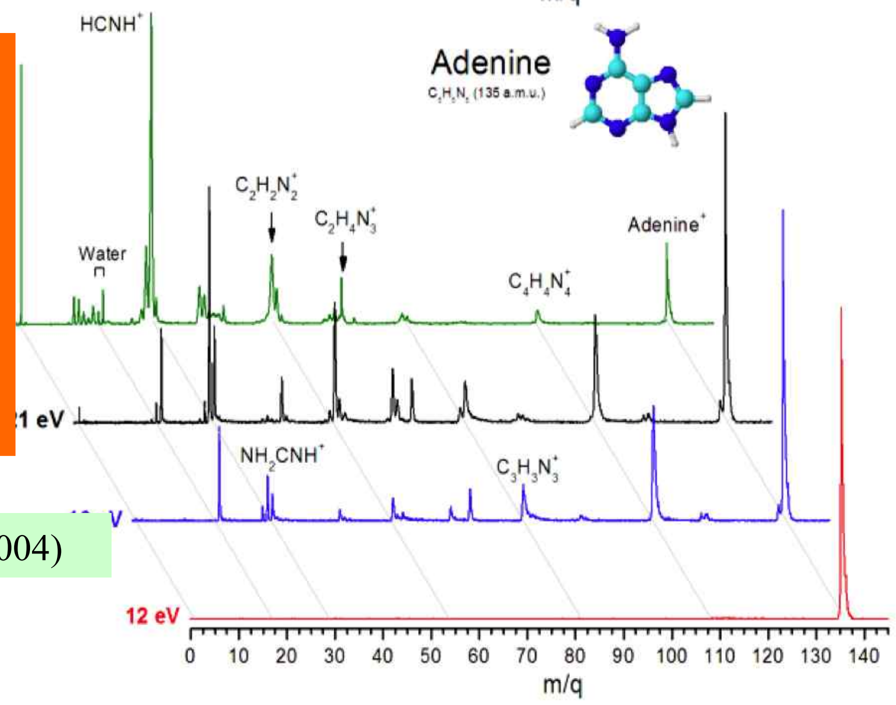
Espectrômetro por Tempo de Vôo

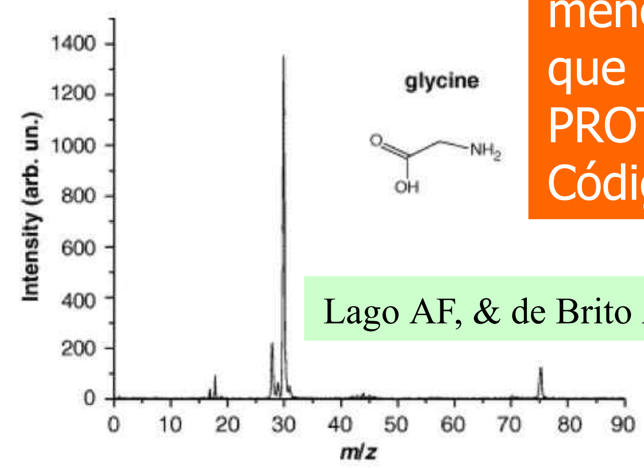




Serg. Pilling&**de Brito AN** Rapid Comm. Mass Spec. **21**, 3646-3652 (2007)

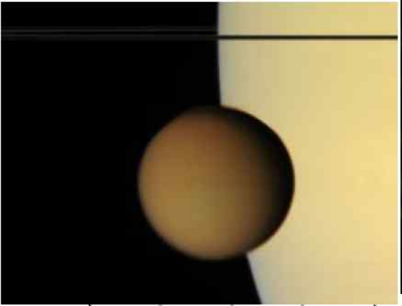
-Aminoácidos fotodegradam em energias muito menores do que do que bases de DNA!! PROTEÇÂO extra ao Código Genético?

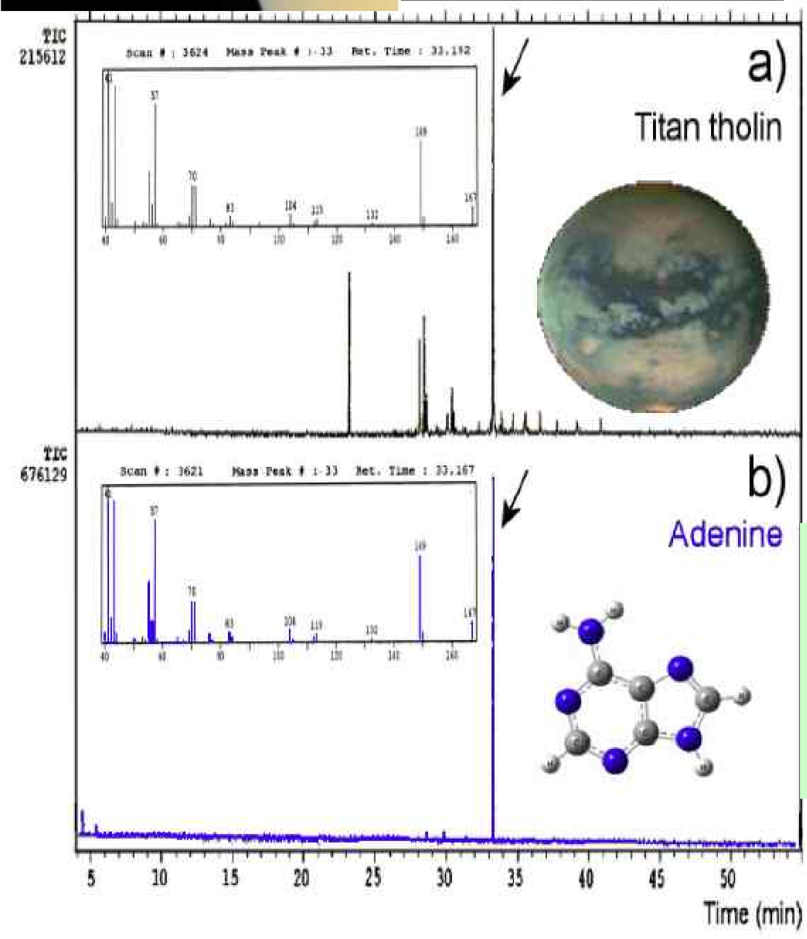


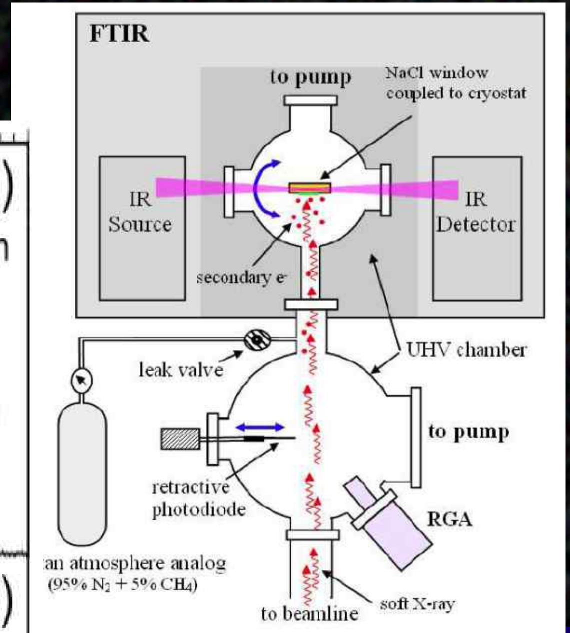


Lago AF, & de Brito ANChem Phys. **307**, 9 (2004)

Foto-produção de base de DNA na atmosfera de Titã







Pilling S …Rittner R (UNICAMP)&de Brito AN, JPC A, **113**, 11161 (2009),

- 73 hs de irradiação com luz sincrotron!
- ~ 7 milhões de anos de raios X solares em Titã
- Adenina: formação promovida por elétrons secundários produzido a partir da dissociação de moléculas por fótons de raios X.

- Produção de base de DNA em simulação de lua de Saturno:

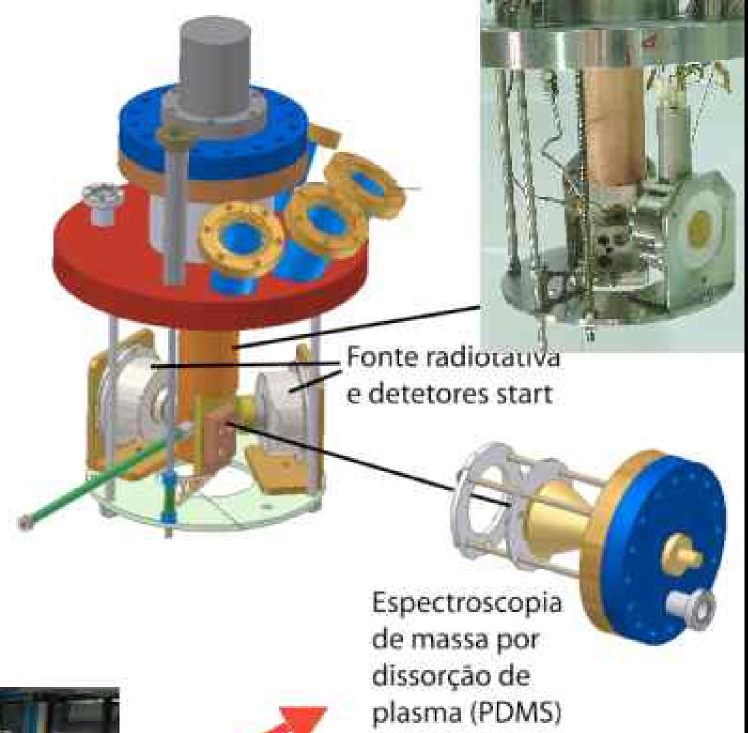
THE JOURNAL OF PHYSICAL CHEMISTRY A
O DIA
FAPERJ
FAPESP
NewScientist
FOLHAONLINE www.folha.com.br
Inovação tecnológica
LNLS
Ciência e Tecnologia Ministério da Ciência e Tecnologia

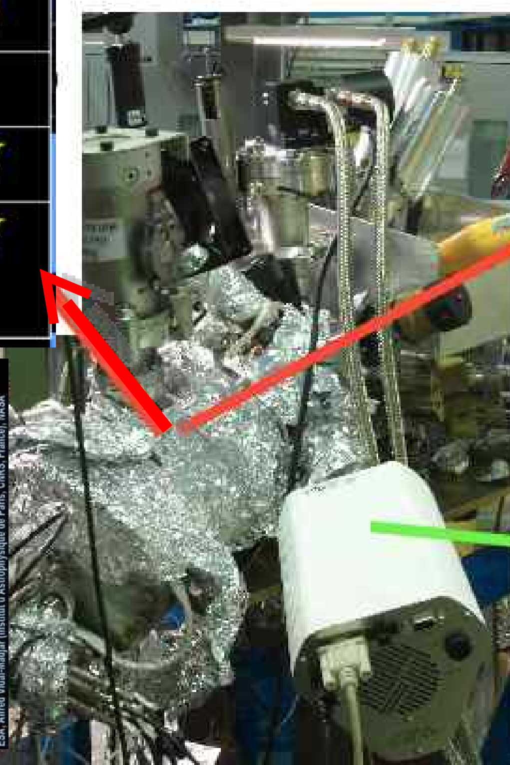
Comet "simulator" at LNLS

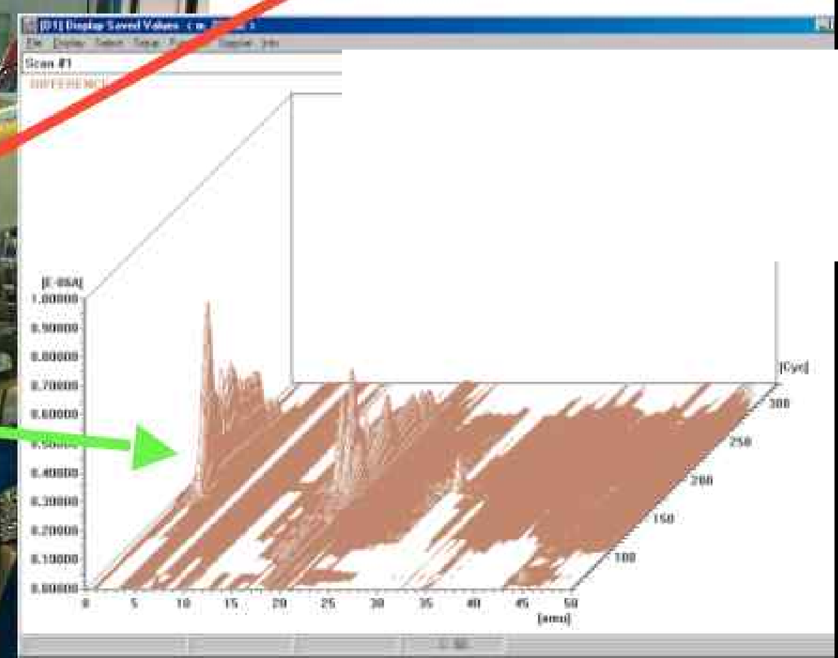
Sample	ions	LS
H_2O	√	√
	√	√
CO_2		
H_2O +	√	
CO_2		
CO	√	√
NH_3	√	
NH_3 + CO	√	√
NH_3 + CO + H_2O	√	√

In-situ probing of the formation of amino acid precursors

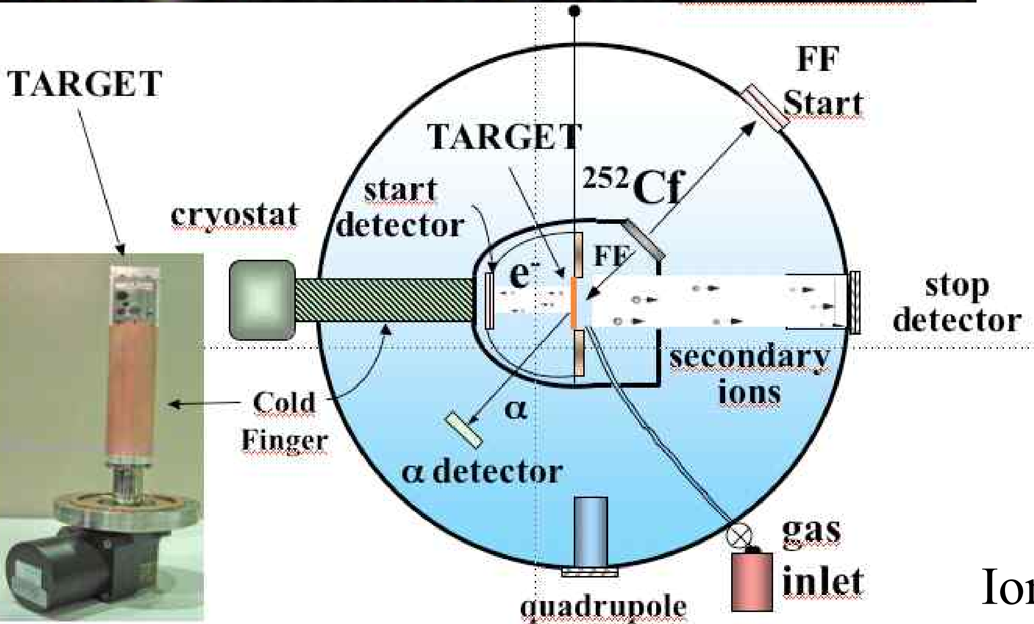
molecules

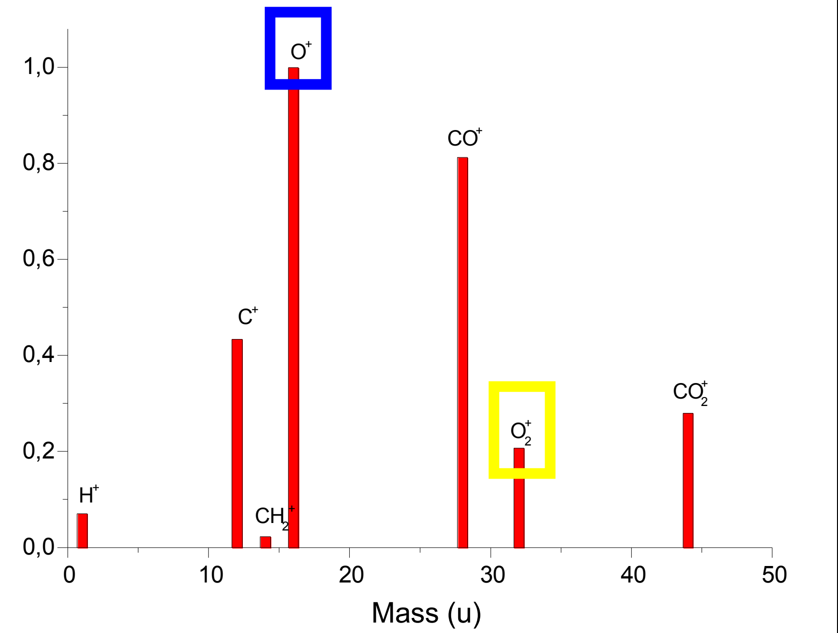






PDMS Chamber OfL

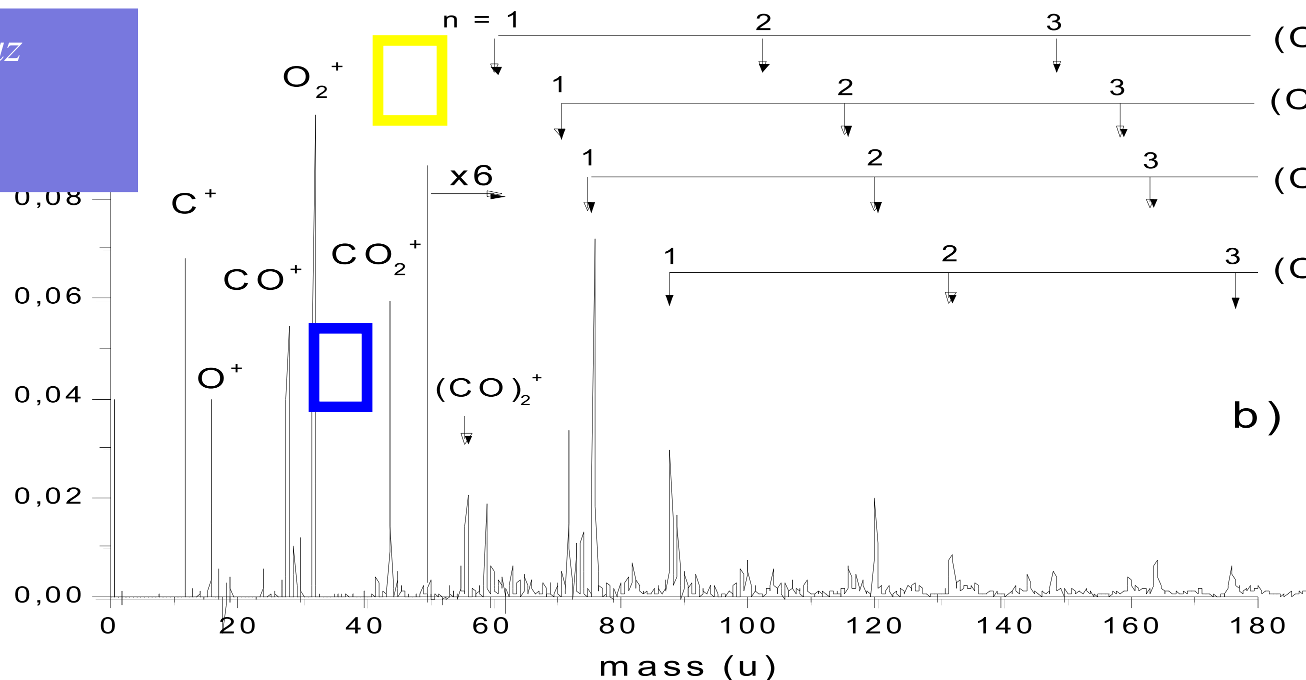




Ions impact O_2 LARGEST INTENSITY

•Projeto *"Origem da vida e Luz síncrotron: Simulação……*

•FAPESP Proc. 00/12660-5.)



Panspermia hypothesis

Ejection

Transport in space

Density: 1 - 10^6 molecules.cm^{-3}

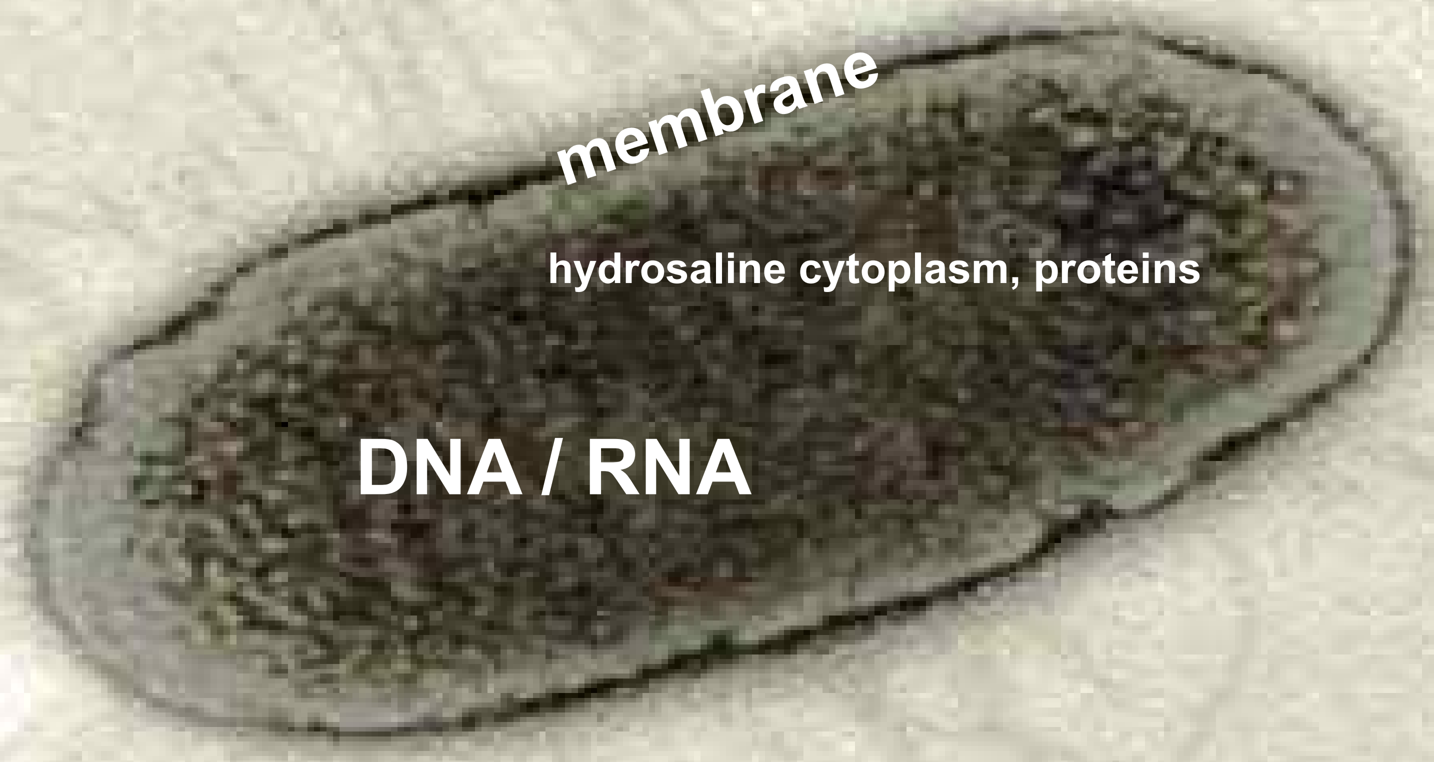
Pressure 10^{-17} atm

Temperature = 0 - 10^2 K

UV Radiation: 122.3 $J.m^{-2}.s^{-1}$

Reentry

Basic structure of a bacterial cell



Apollo Programme (*Streptomyces, Bacillus subtilis)*

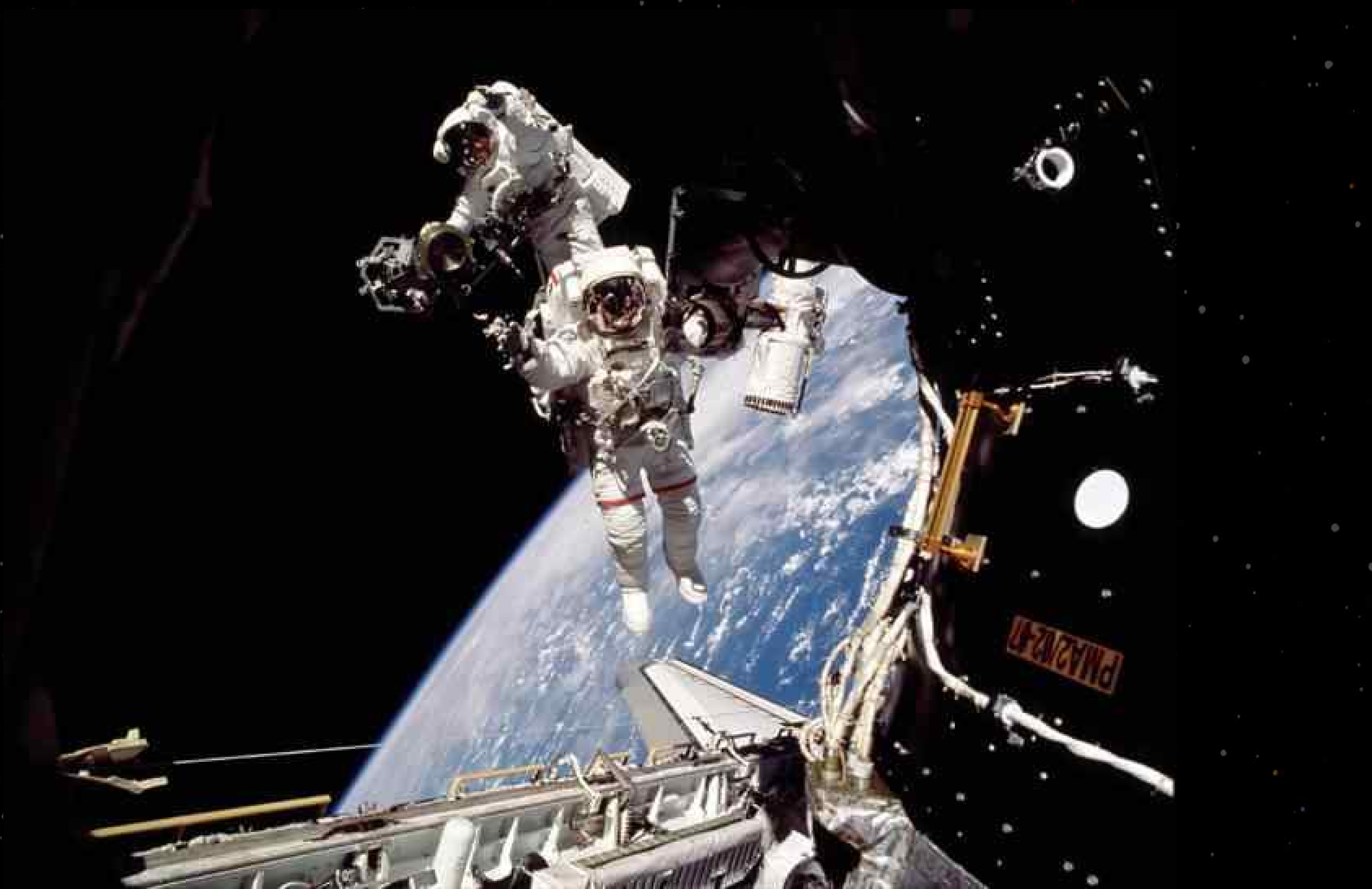


Table 1 Classification and examples of extremophiles

Environmental parameter	Type	Definition	Examples
Temperature	Hyperthermophile	Growth >80 °C	*Pyrolobus fumarii*, 113 °C
	Thermophile	Growth 60–80 °C	*Synechococcus lividis*
	Mesophile	15–60 °C	*Homo sapiens*
	Psychrophile	<15 °C	*Psychrobacter*, some insects
Radiation			*Deinococcus radiodurans*
Pressure	Barophile	Weight-loving	Unknown
	Piezophile	Pressure-loving	For microbe, 130 MPa
Gravity	Hypergravity	>1*g*	None known
	Hypogravity	<1*g*	None known
Vacuum		Tolerates vacuum (space devoid of matter)	Tardigrades, insects, microbes, seeds
Desiccation	Xerophiles	Anhydrobiotic	*Artemia salina*; nematodes, microbes, fungi, lichens
Salinity	Halophile	Salt-loving (2–5 M NaCl)	Halobacteriaceae, *Dunaliella salina*
pH	Alkaliphile	pH > 9	*Natronobacterium*, *Bacillus firmus* OF4, *Spirulina* spp. (all pH 10.5)
	Acidophile	low pH-loving	*Cyanidium caldarium*, *Ferroplasma* sp. (both pH 0)
Oxygen tension	Anaerobe	Cannot tolerate O_2	*Methanococcus jannaschii*
	Microaerophile	Tolerates some O_2	*Clostridium*
	Aerobe	Requires O_2	*H. sapiens*
Chemical extremes	Gases		*C. caldarium* (pure CO_2)
	Metals	Can tolerate high concentrations of metal (metalotolerant)	*Ferroplasma acidarmanus* (Cu, As, Cd, Zn); *Ralstonia* sp. CH34 (Zn, Co, Cd, Hg, Pb)

Deinococcus radiodurans:

AN EXTREME EXTREMOPHILE

NON-SPORE forming species (always viable)

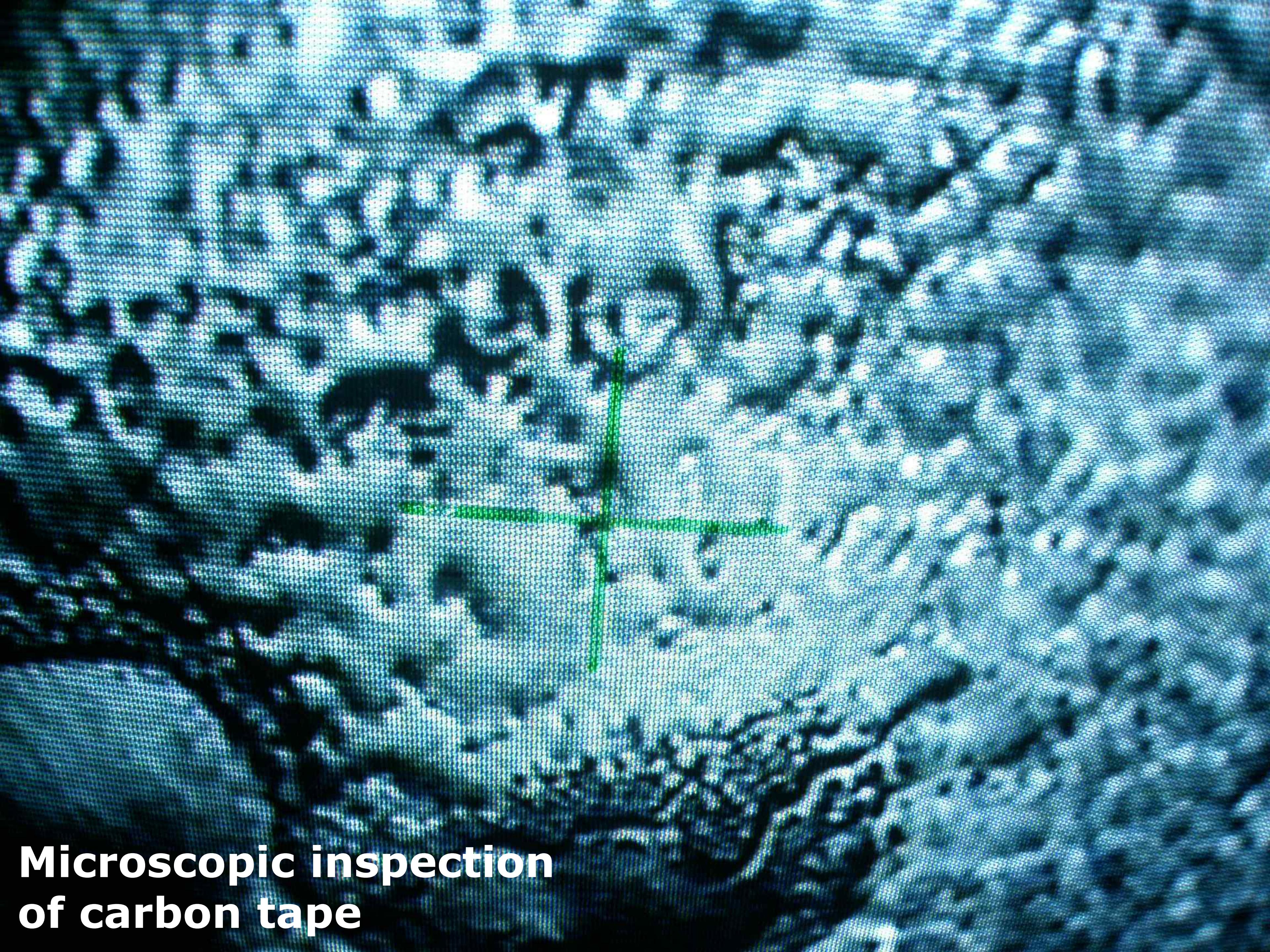
High content of anti-oxidant compounds (carotene and Mn^{++})

Impressive mechanisms to repair DNA damage !!

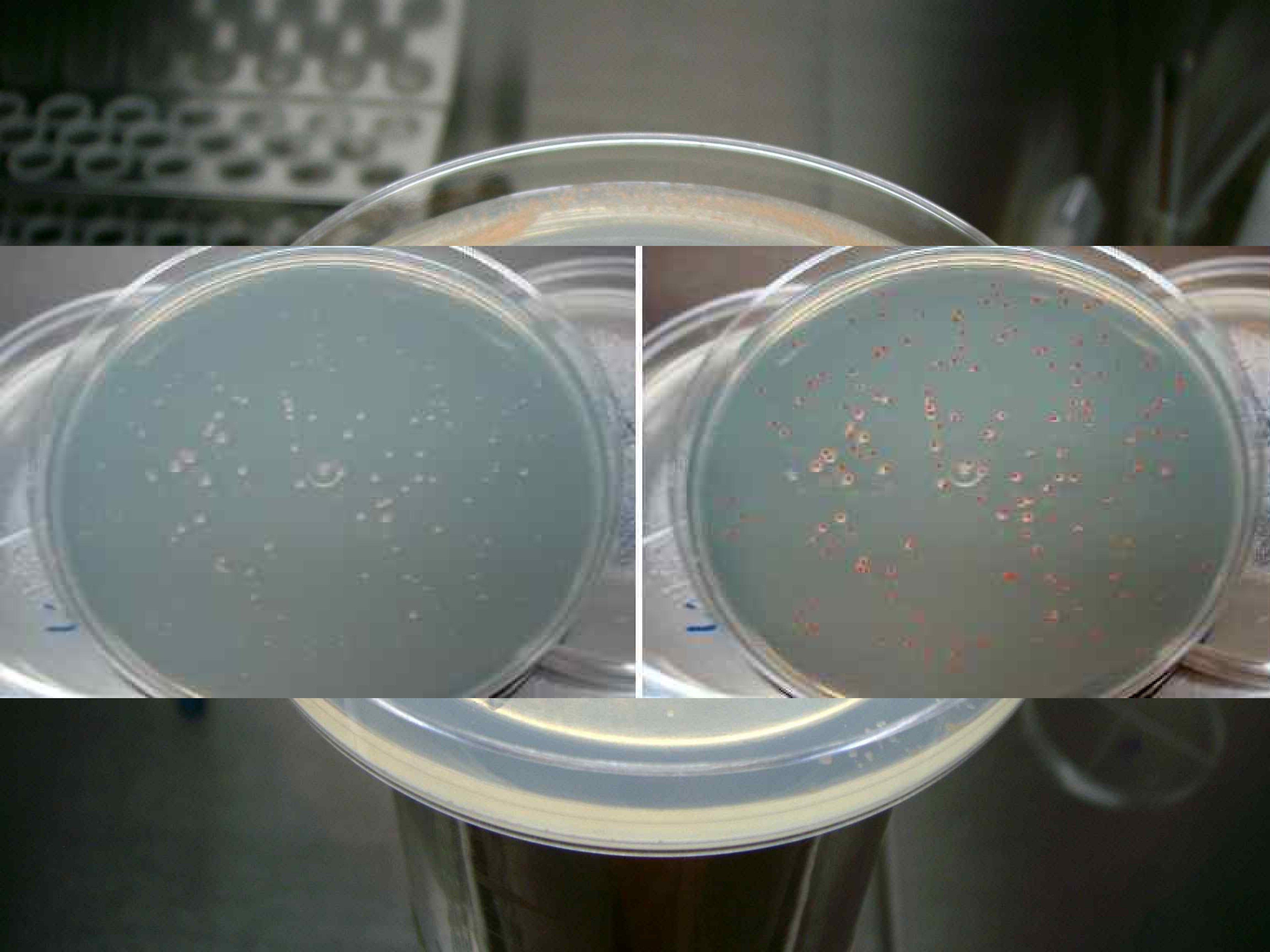
still under division after 15,000 Gy ☺

Humans = 4 Gy !!!!! ☠ **1 Gray = 1 J/kg.**

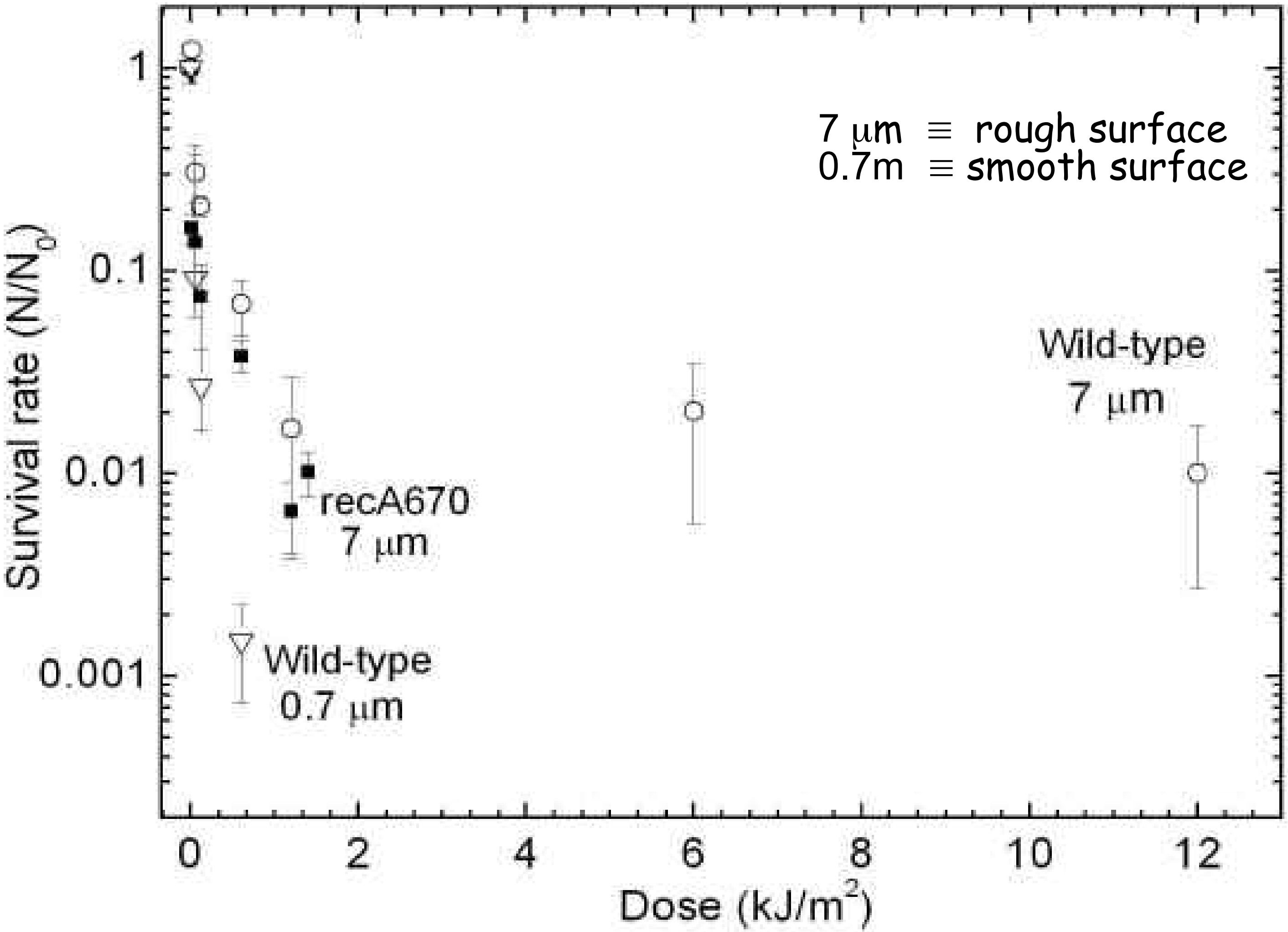
- **“minimal” biological organization inoculated among different planets ??**
- **(if it ever could survive outer space conditions)**



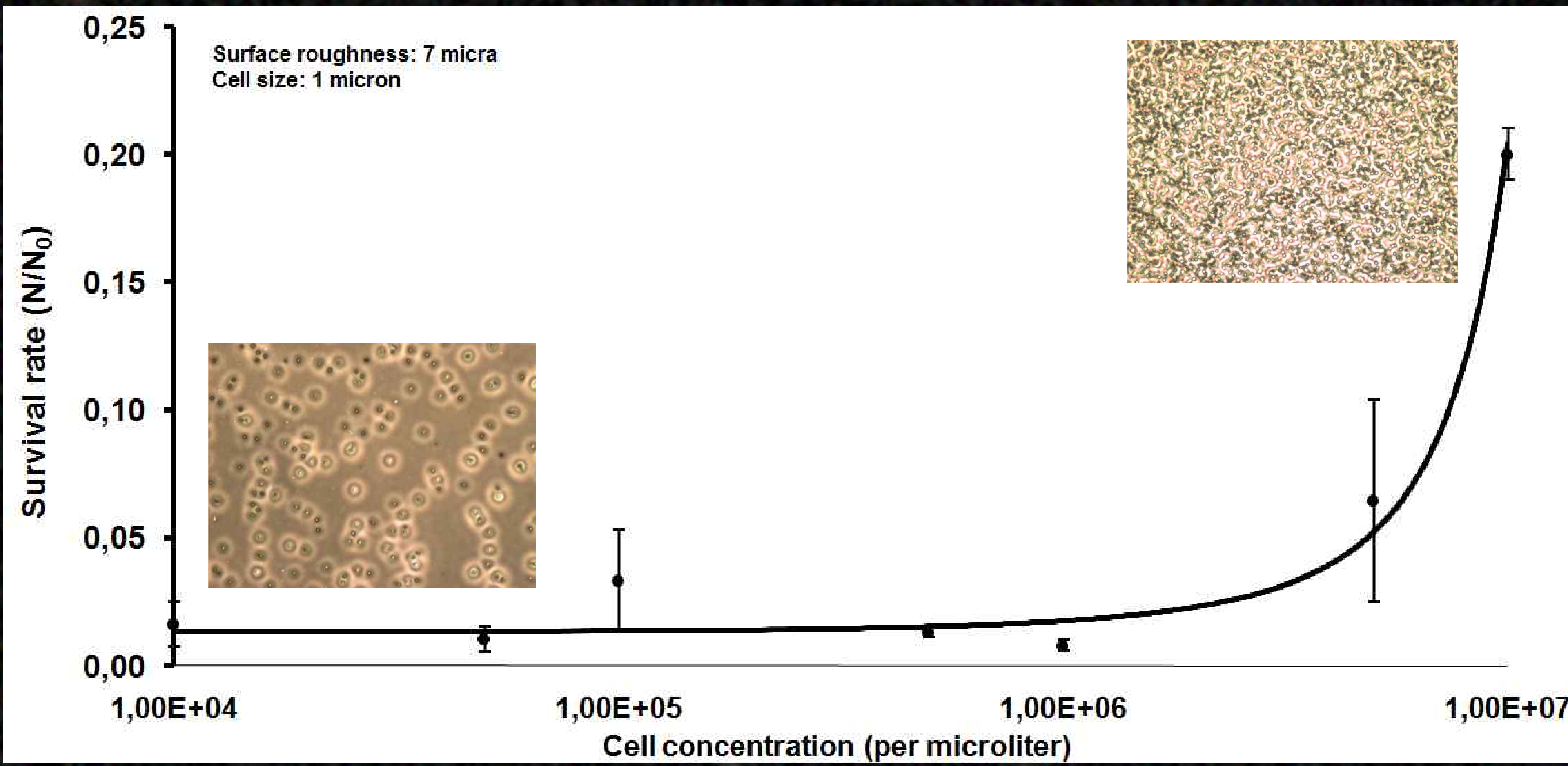
Microscopic inspection of carbon tape



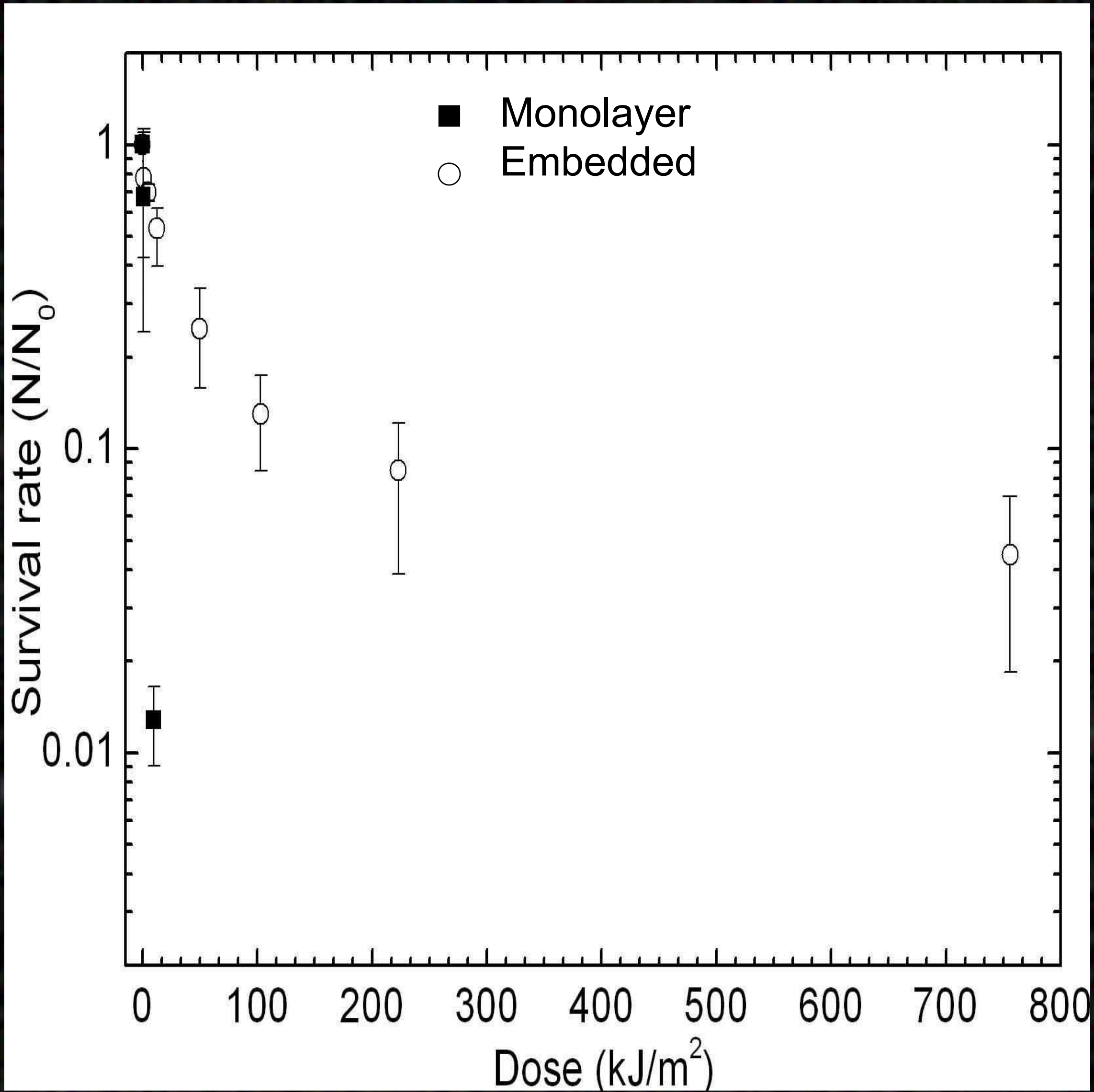
Survival of *D. radiodurans* after exposure to VUV beamlight. Samples were deposited on surfaces with two different levels of roughness (~0.7 and ~7 μm)



up to
420d
at 1AU

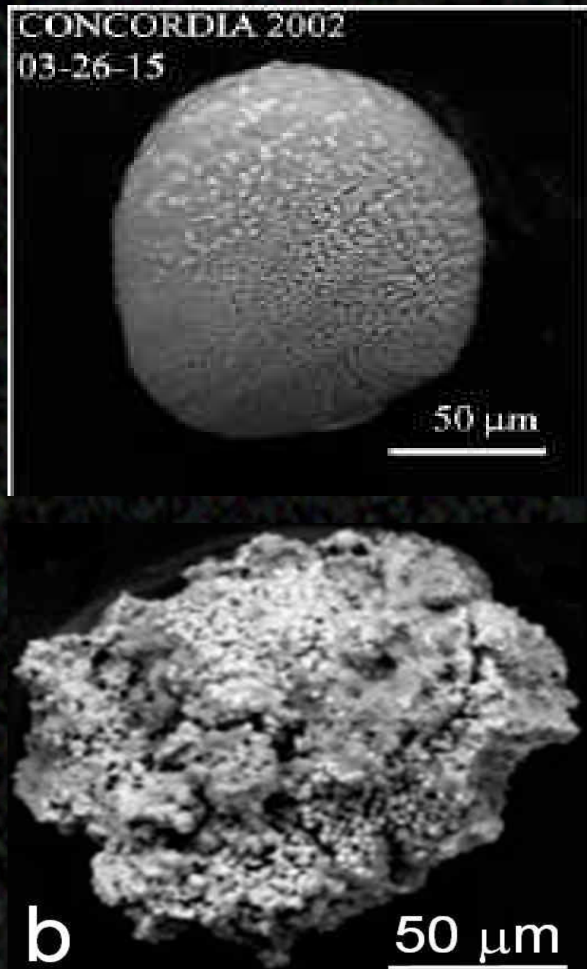

0,25
0,20
0,15
0,10
0,05
0,00
Surface roughness: 7 micra
Cell size: 1 micron
Survival rate (N/N_0)
1,00E+04
1,00E+05
1,00E+06
1,00E+07
Cell concentration (per microliter)

Survival of *D. radiodurans* to irradiation with hidrogen lamp λ=121.6nm (10.2eV)

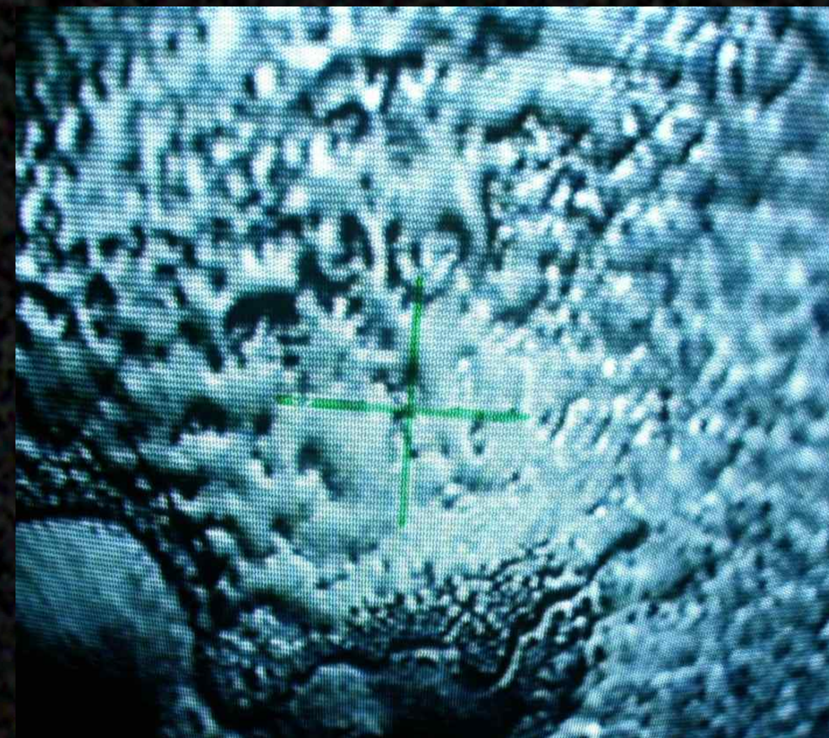


~ 45d of continuous solar radiation

CONCORDIA MICROMETEORITES



CARBON TAPE



Morphologic comparison between **surfaces** of Concordia 2002 micrometeorite (Antartica) and that of the carbon tape on which bacterial powder was layered for irradiation (with permission of M. Maurette).


ALIENS ARE
MICROBES !!

Planetary and Space Science 58 (2010) 1180–1187

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/pss

Laboratory simulation of interplanetary ultraviolet radiation (broad spectrum) and its effects on *Deinococcus radiodurans*

Ivan Gláucio Paulino-Lima [a,*], Sérgio Pilling [b,1], Eduardo Janot-Pacheco [c], Arnaldo Naves de Brito [b,2], João Alexandre Ribeiro Gonçalves Barbosa [b,3], Alvaro Costa Leitão [a], Claudia de Alencar Santos Lage [a]

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A R T I C L E I N F O

Article history:
Received 27 December 2009
Received in revised form
11 April 2010
Accepted 13 April 2010
Available online 18 April 2010

Keywords:
Panspermia
Micro-shielding
Vacuum ultraviolet
Extremophile microorganisms

A B S T R A C T

The radiation-resistant bacterium *Deinococcus radiodurans* was exposed to a simulated interplanetary UV radiation at the Brazilian Synchrotron Light Laboratory (LNLS). Bacterial samples were irradiated on different substrates to investigate the influence of surface relief on cell survival. The effects of cell multi-layers were also investigated. The ratio of viable microorganisms remained virtually the same (average 2%) for integrated doses from 1.2 to 12 kJ m^{-2}, corresponding to 16 h of irradiation at most. The asymptotic profiles of the curves, clearly connected to a shielding effect provided by multi-layering cells on a cavitary substrate (carbon tape), means that the inactivation rate may not change significantly along extended periods of exposure to radiation. Such high survival rates reinforce the possibility of an interplanetary transfer of viable microbes.