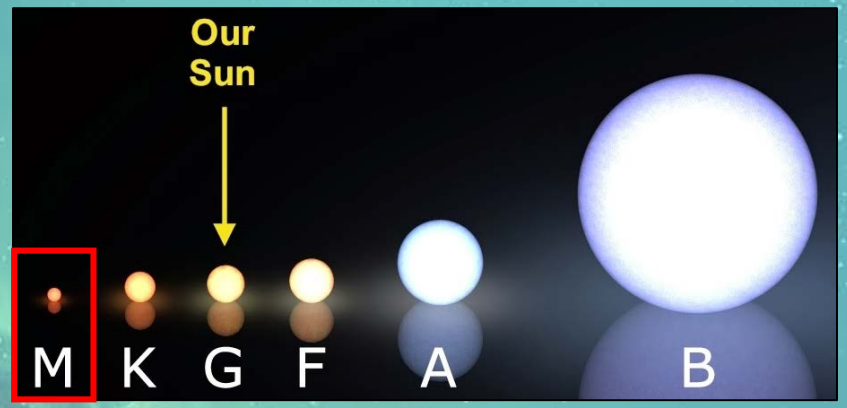
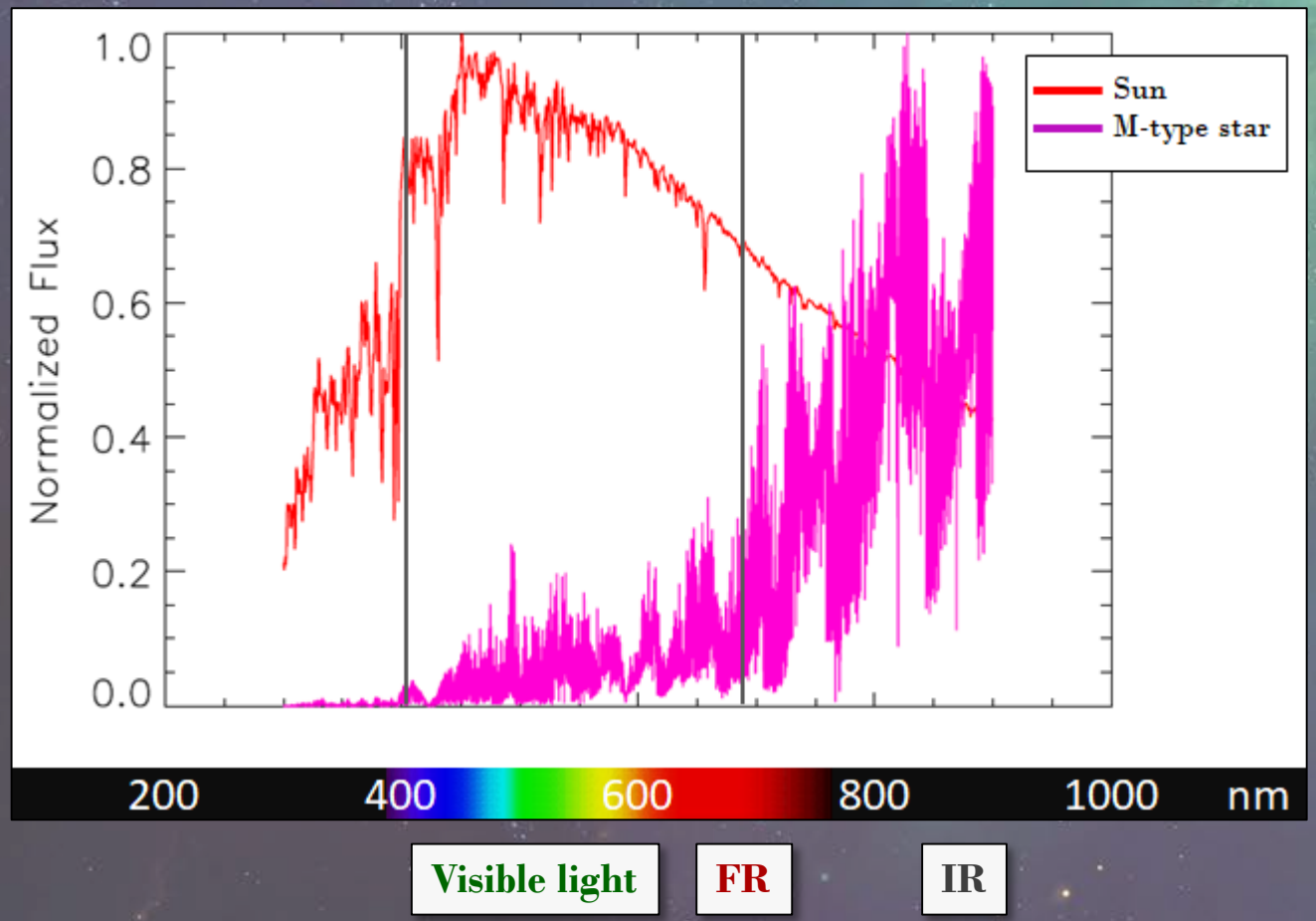
Studies on photosynthetic organisms as a tool for improving the success of future space missions

Mariano Battistuzzi, 13_14/09/2018

Many of them in the Habitable Zone (HZ) of M-Type Stars





Most common stars in the Milky Way (76% of total stars)

Live long enough to sustain life evolution

Gale and Wandel, 2017
Ritchie, Larkum and Ribas, 2017
Takizawa et al, 2017
Wandel, 2018

Aim of the Project

Biological Questions:

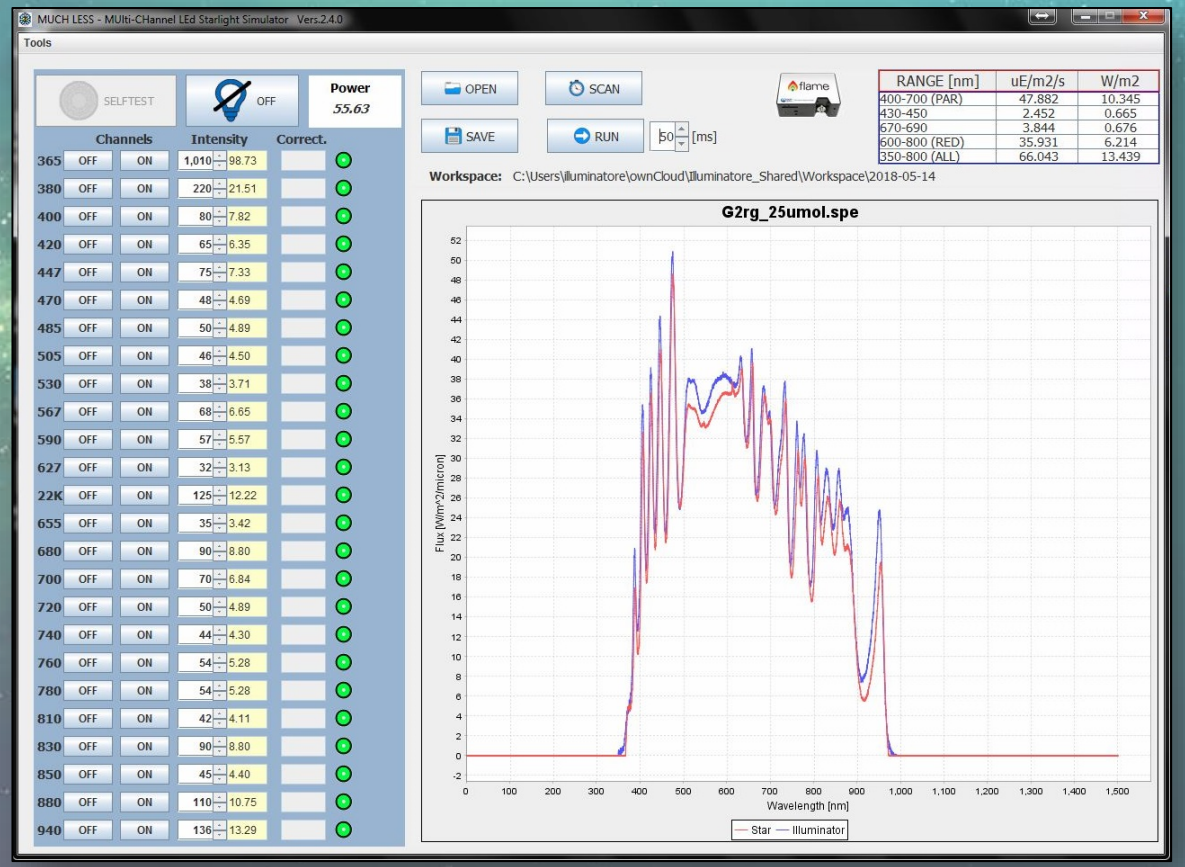
1. Could Oxygenic Photosynthetic organisms survive/grow under M-type star light spectra?

2. Could Oxygenic photosynthesis be performed and which impact would it have on a primeval atmosphere?

3. Atmospheric biosignatures could be generated by the activity of these organisms?

Star Light Simulator (SLS)

- 25 channels, 365-940 nm
- 273 air cooled diodes
- custom-made software
- Emission spectra of F/G/K/M - type stars

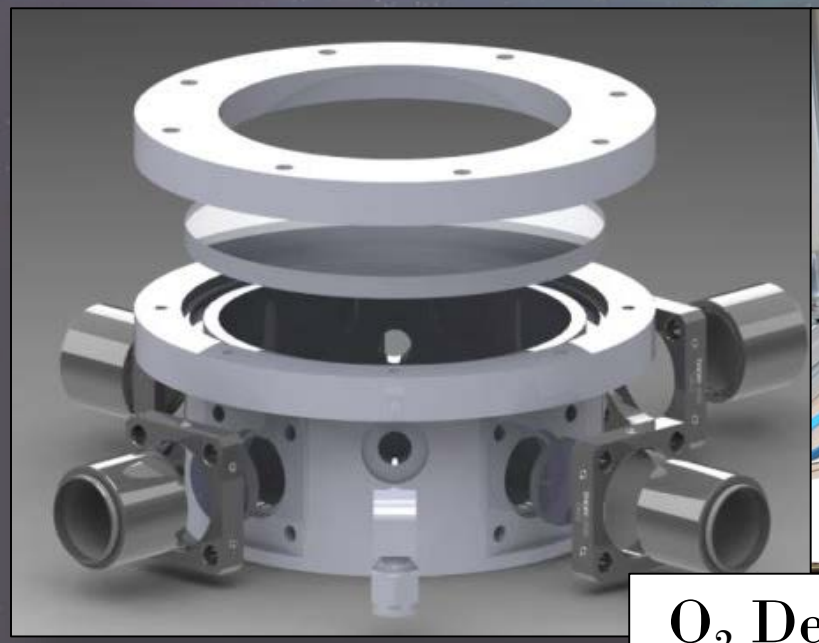


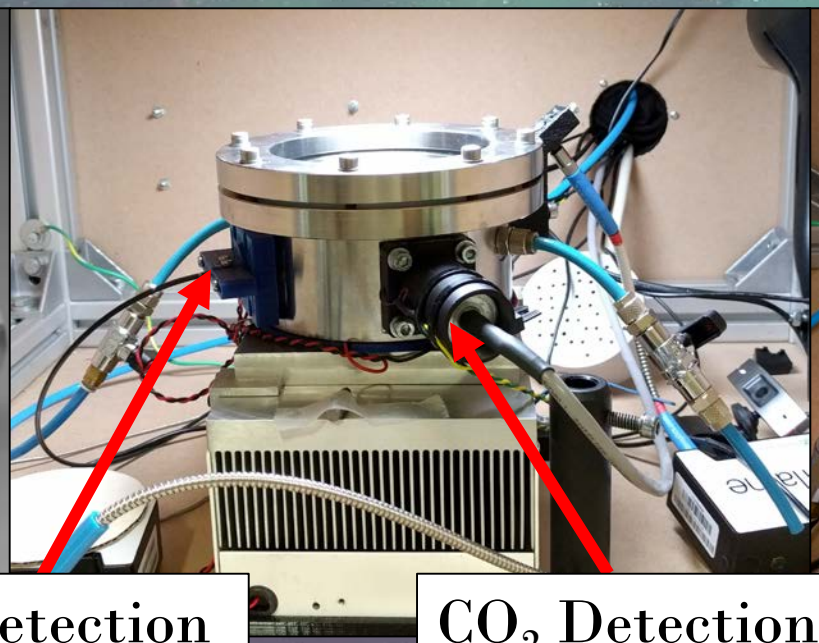
(Salasnich et al, 2018; DOI: 10.1117/12.2311436)

Atmosphere Simulator Chamber (ASC)

- 0,5 L sealed stainless steel growth chamber
- Borofloat window (SLS approved!)
- Temperature, Pressure and Atmospheric Composition tunable
- Equipped to measure O_2 and CO_2 Concentration

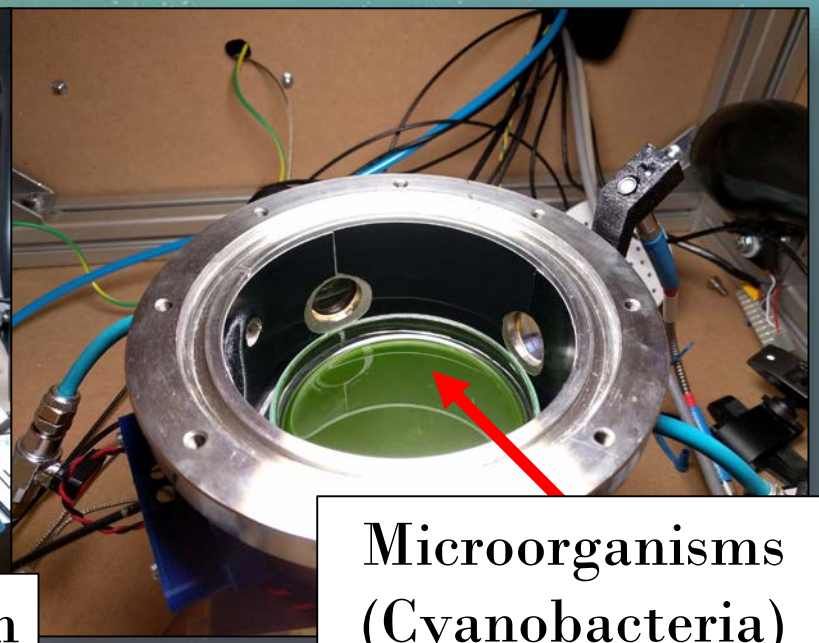
(Erculiani et al, 2016; Memorie della Società Astronomica Italiana 87;112)





O_2 Detection

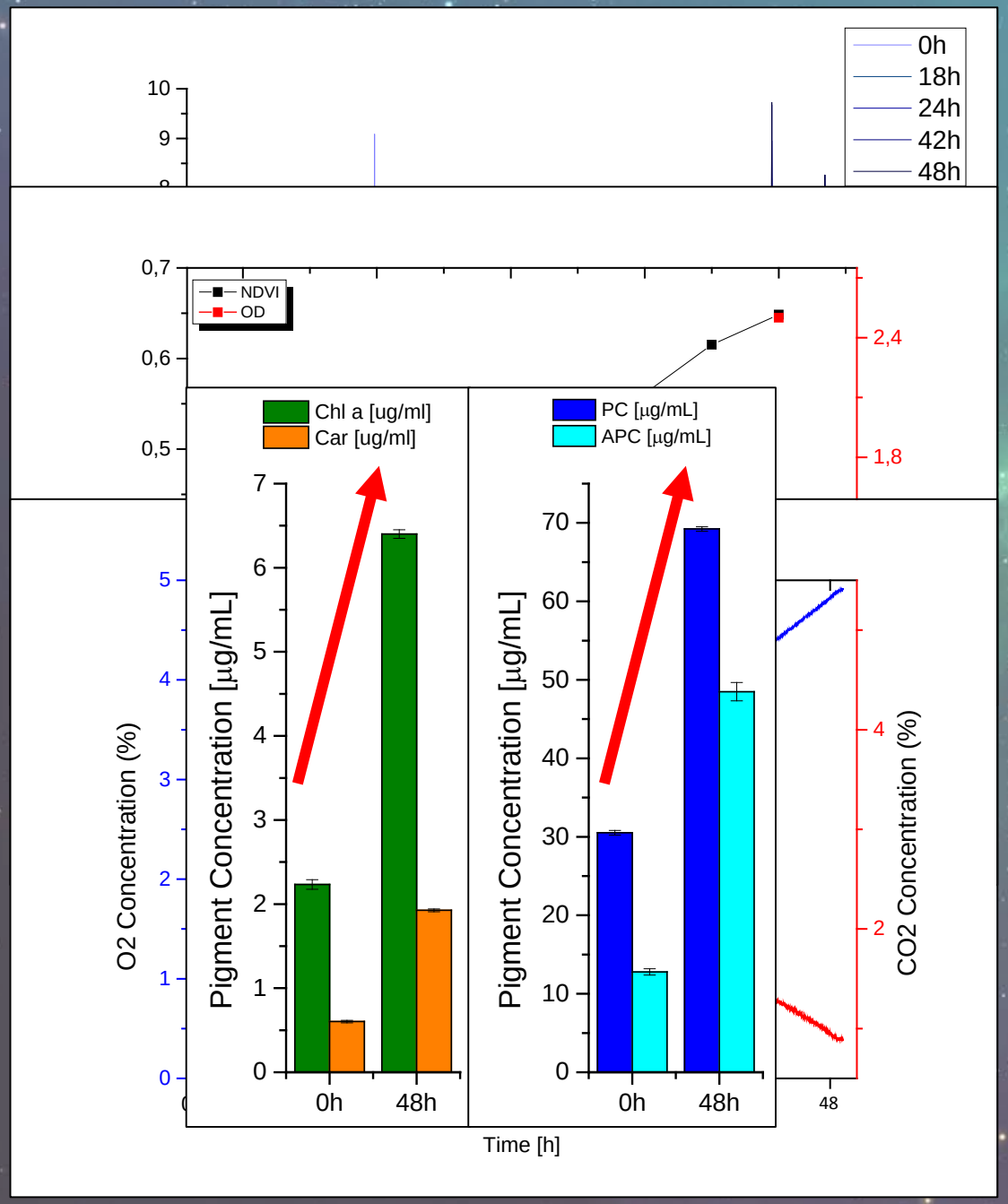
CO_2 Detection



Microorganisms (Cyanobacteria)

Validation Experiments with Photosynthetic Microorganisms

Validation Experiments



Reflectance Spectra

NDVI/Time vs. OD/Time

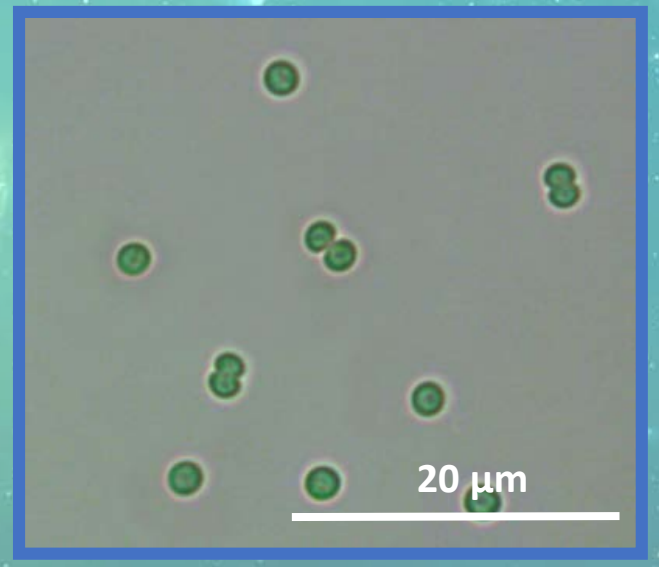
Pigment Content

O_2 Evolution and CO_2 Consumption

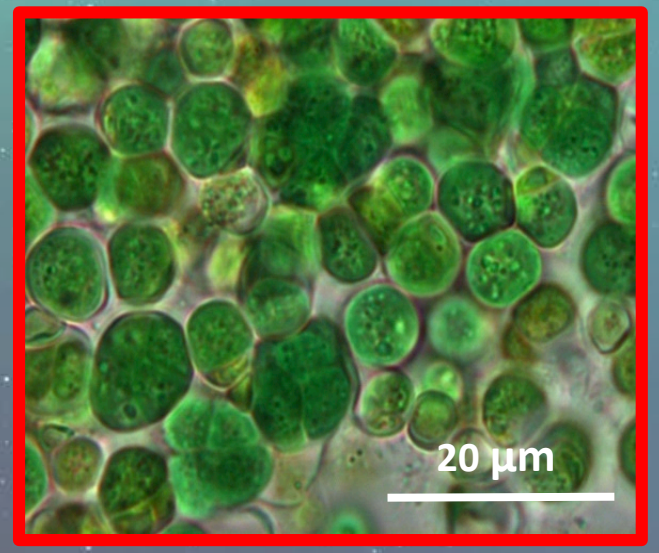
Short-Term Experiments

2 Target cyanobacteria species:

- ***Synechocystis sp.* PCC 6803**



- ***Chlorogloeopsis fritschii sp.* PCC 6912**
  Able to grow under far-red light (720 nm)
  Gan and Bryant, 2015



Short-Term Experiments

Environmental Conditions

Exp n°	Light		Atmosphere Composition	
	G2	M7	Atm Ter	Atm Mod
1	X		X	
2	X			X
3		X	X	
4		X		X

Light Intensity = 30 µmol $m^{-2}s^{-1}$ (VIS)

T = 30 °C

P = 1 Atm

***G2**: Simulated Solar light*
***M7**: Simulated Red Dwarf light*
***Atm Ter**: Simulated terrestrial-like atmospheric composition enriched in CO_2 (20% O_2, 75% CO_2, 5% CO_2)*
***Atm Mod**: Modified atmospheric composition depleted in O_2 (95% N_2, 5% CO_2)*

Aim of the Project

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Could Oxygenic Photosynthetic organisms survive/grow under M-type star light spectra?

Could Oxygenic photosynthesis be performed and which impact would it have on primeval atmospheres?

Atmospheric biosignature could be generated by the activity of these organisms?

Future Plans

- Short-Term experiments with different atmospheric pressures
- Long -Term experiments with increasing CO_2 concentrations (10 up to 100%)
- Molecular analyses on cyanobacteria grown under Short-Term experiments environmental conditions

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