

# Mars

## Radiation field and Habitability evolution through time

A. Keating<sup>(1,2)</sup>, P. Gonçalves<sup>(1)</sup>

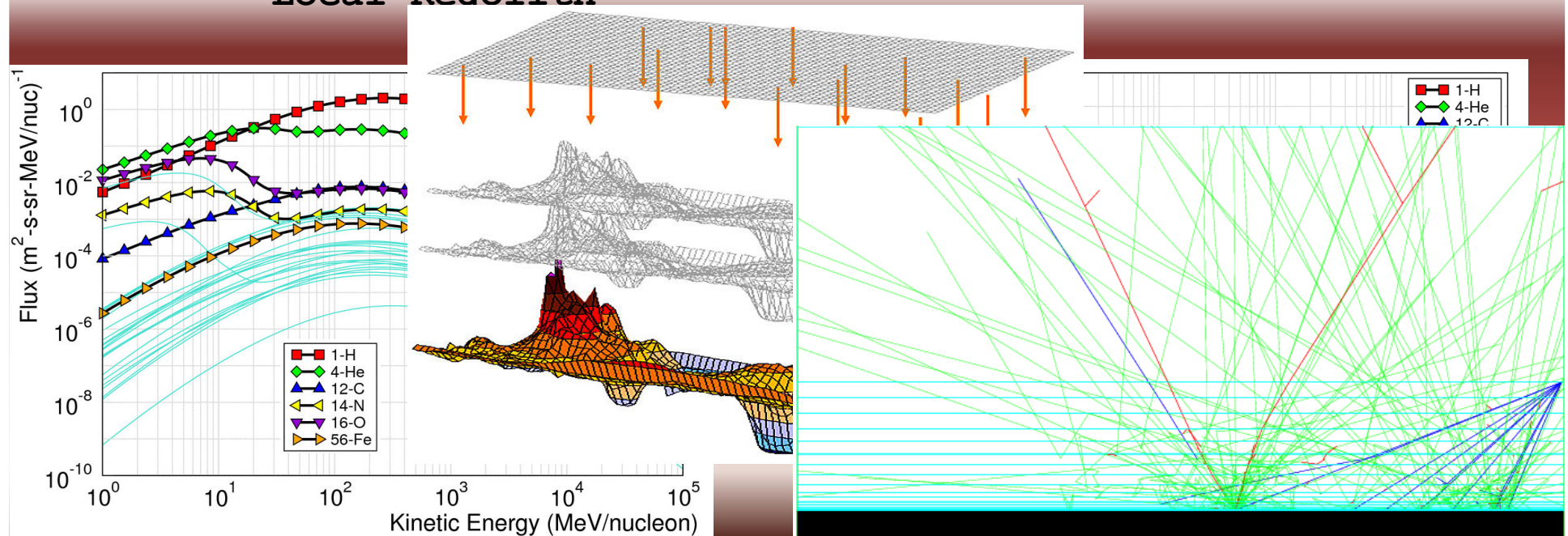
(1) LIP- Portugal,

(2) ESA- ESTEC

keating@lip.pt

# Characterization of ionizing radiation field

- MarsREC[4] and dMEREM[5], are ESA GEANT4[6] models taking into account:
  - Solar cycle modulation,
  - Galactic cosmic rays and solar particles
  - Seasonal effects, atmospheric depth
  - Local Regolith



# Geophysical Evolution

From the point of view of ionizing radiation, the parameters to consider are:

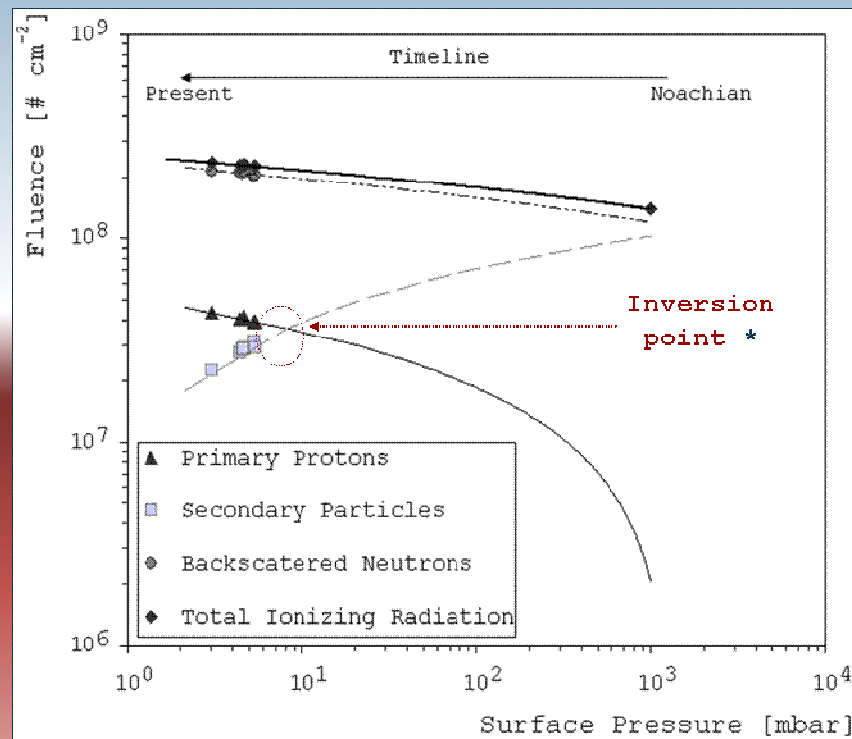
1. atmospheric evolution
2. existence of water at the surface (Ocean/hydrated minerals)
3. presence of subsurface water
4. mineral alteration

## Atmosphere:

Dependences of the modern Martian radiation environment on soil composition (after Keating et al., 2009).

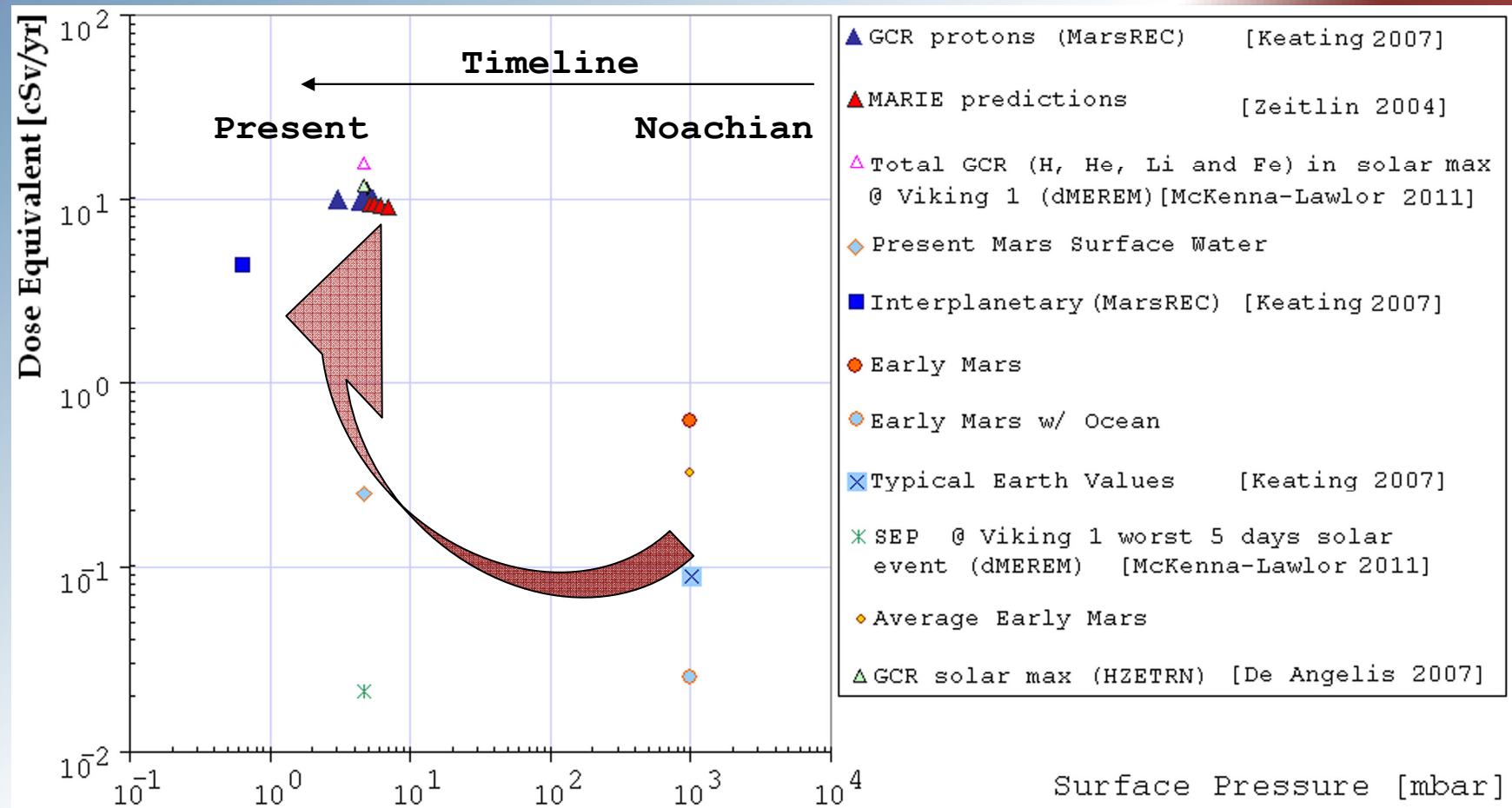
Parameter	Description	Radiation environment	Ambient dose equivalent
H <sub>2</sub> O	Water at the surface	Reduction of 30%	Reduction of 99%
Soil density	10–20% increase in soil density in the range 1 g/cm <sup>3</sup>	60% percent in neutron backscattering, 30% in general backscattering radiation	10–20% reduction
Fe <sub>x</sub> O <sub>y</sub>	Increase of Fe <sub>2</sub> O <sub>3</sub> equivalent weight percentage	10% reduction in backscattered neutrons	10% reduction
Dry ice	CO <sub>2</sub> ice layer at the surface	10% increase in backscattered neutrons	Increase of 10%

# Inversion Point



- The inversion point was identified to be the turn over point in time from which the Martian atmosphere evolved from shielding to a soft attenuator. It is expected to have happened sometime between Hesperian and early Amazonian.

# Evolution of Martian Ambient Dose Equivalent



# Conclusions

LHB—erosion of Martian  
Atmosphere



Radiation and Habitability  
Degradation

Martian evolution  
(wet and warm) → (cold and dry)



Loss of Radiation Protection

Noachian/Hesperian Earth-like  
Magnetosphere



Habitability conditions

Inversion point accurate deter-  
mination shall improve



Understanding of the Habitability  
evolution.