ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

# Humidity calibration of relative humidity devices in Martian conditions

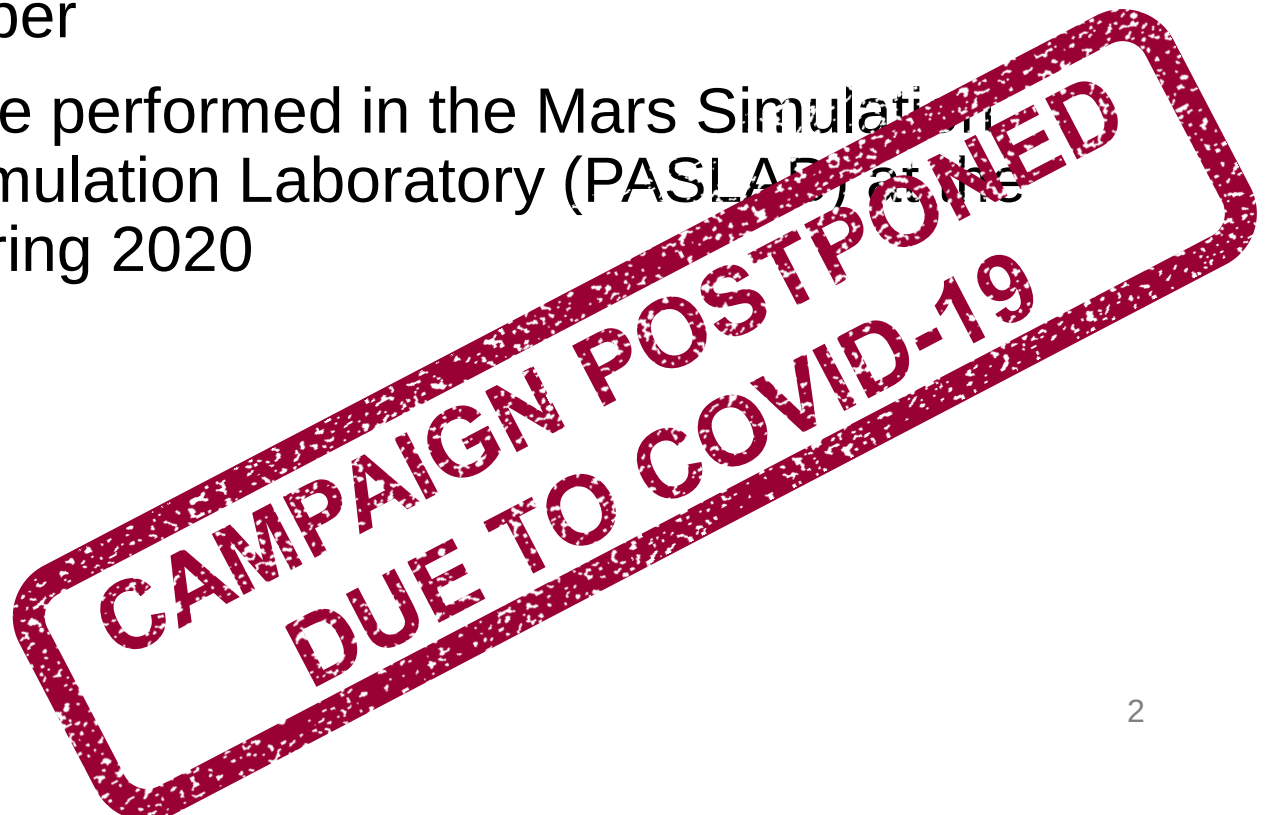
**Maria Hieta**[1], Maria Genzer[1], Jouni Polkko[1], Iina Jaakonaho[1], Andreas Lorek[2], Stephen Garland[2], Jean-Pierre de Vera[2], Erik Fischer[3], and German M. Martinez[3]

[1]Finnish Meteorological Institute, Helsinki, Finland (maria.hieta@fmi.fi),
[2]DLR, Berlin, Germany
[3]University of Michigan, Ann Arbor, USA

28.4.2020 **EGU2020-18057**

# In Brief

- FMI has delivered atmospheric relative humidity instruments for many Mars missions, including MSL Curiosity
- New measurements can be performed with identical ground reference sensors
- Calibration campaings have been performed previously in FMI laboratory and in Michigan Mars Environmental Chamber
- New calibration measurements are to be performed in the Mars Simulation Facility (MSF) and Planetary Analog Simulation Laboratory (PASLAB) at the German Aerospace Center (DLR) in spring 2020



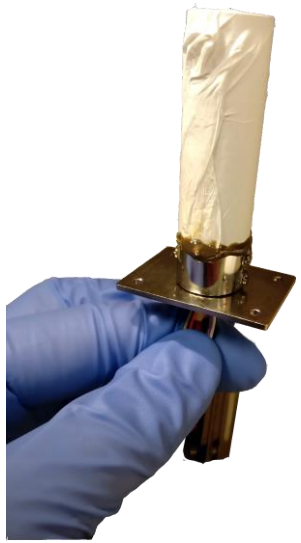
# Background: FMI's instruments

Atmospheric relative humidity (RH) measurement instruments have been delivered for several missions:

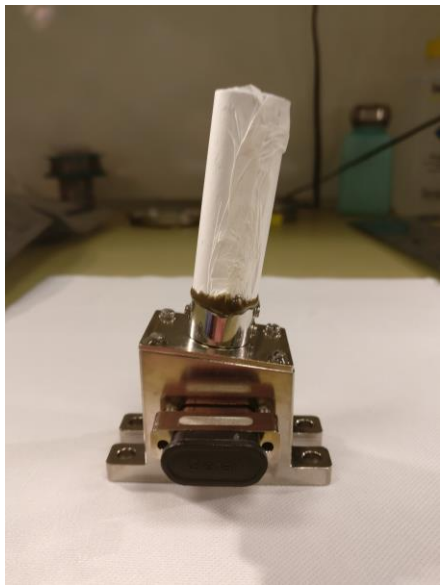
REMS-H in Curiosity

MEDA HS for Mars 2020

METEO-H for ExoMars 2022

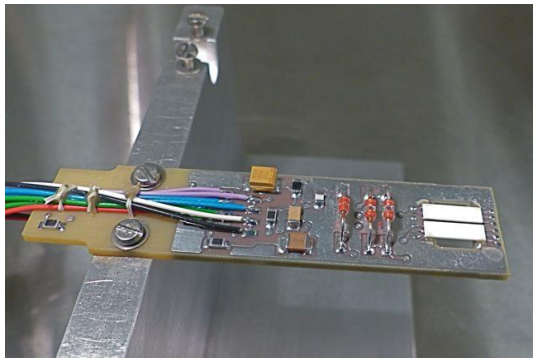


MEDA HS without attachment box

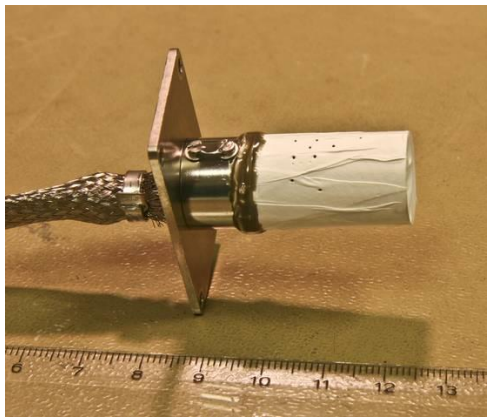


MEDA HS with complete mechanics

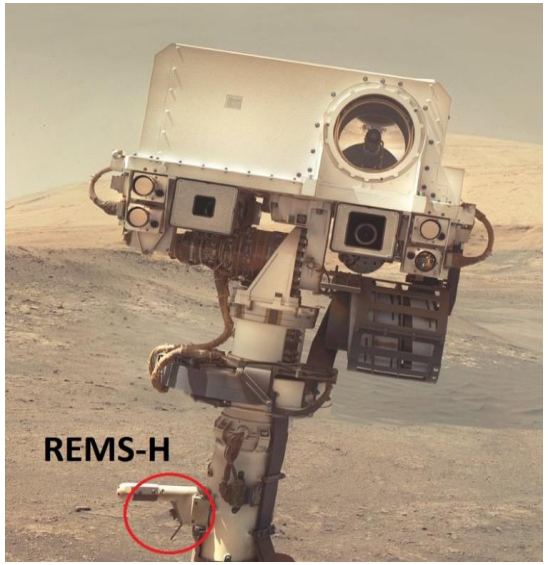
METEO-H



MEDA HS PCB



REMS-H

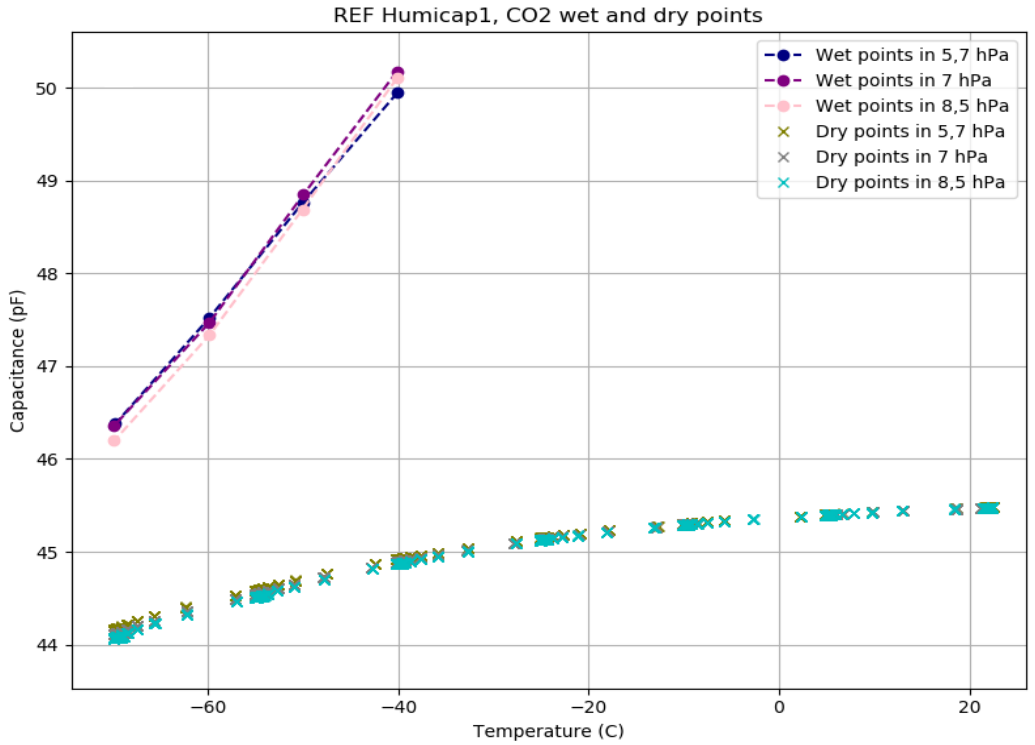



REMS-H in Curiosity (credit: NASA)

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

# Motivation

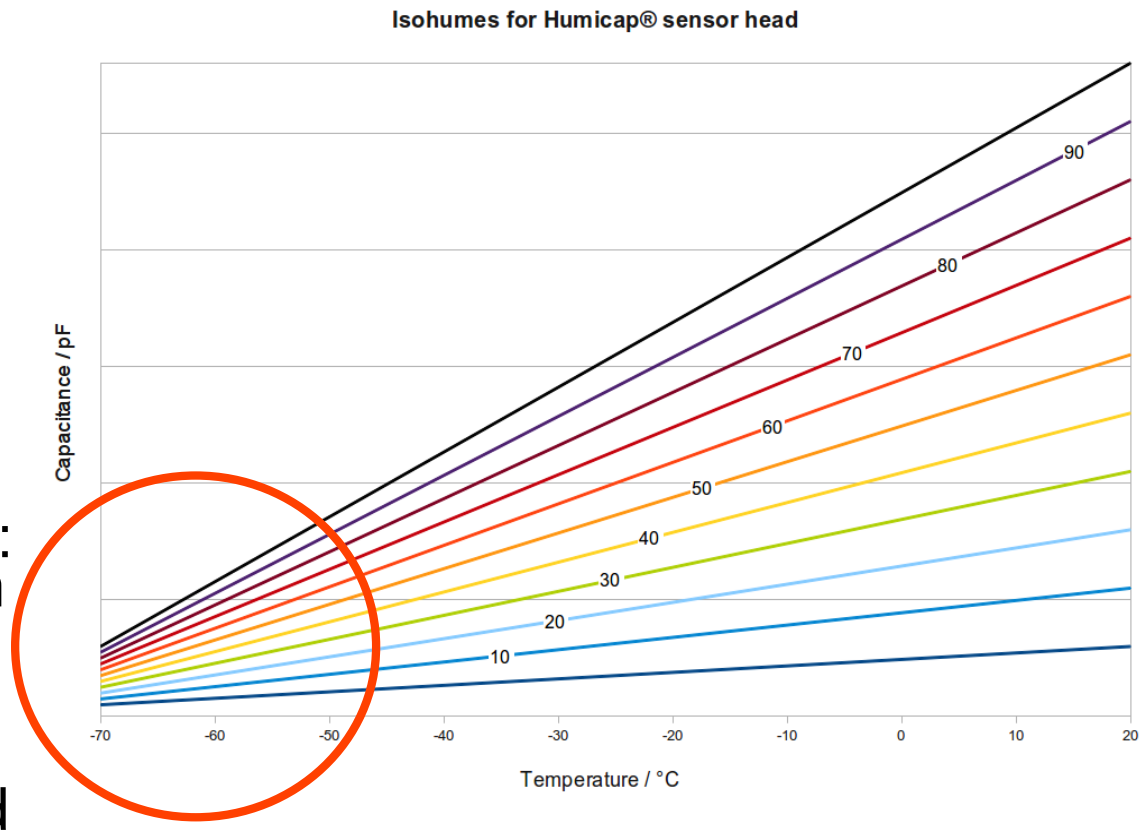
- Martian conditions affect the sensors and calibration done in ambient pressure air can not be directly applied. REMS-H has been calibrated in ambient pressure air and corrected to Martian conditions.
- MEDA and METEO instruments and REMS-H reference model have been calibrated roughly with two-point calibration in Martian conditions: dry $CO_2$ and saturation humidity in $CO_2$
- New measurements with ground reference models of the sensors could improve the calibration and provide more information about instrument characterization




Example of two-point calibration curves: green is wet curve and purple is dry curve

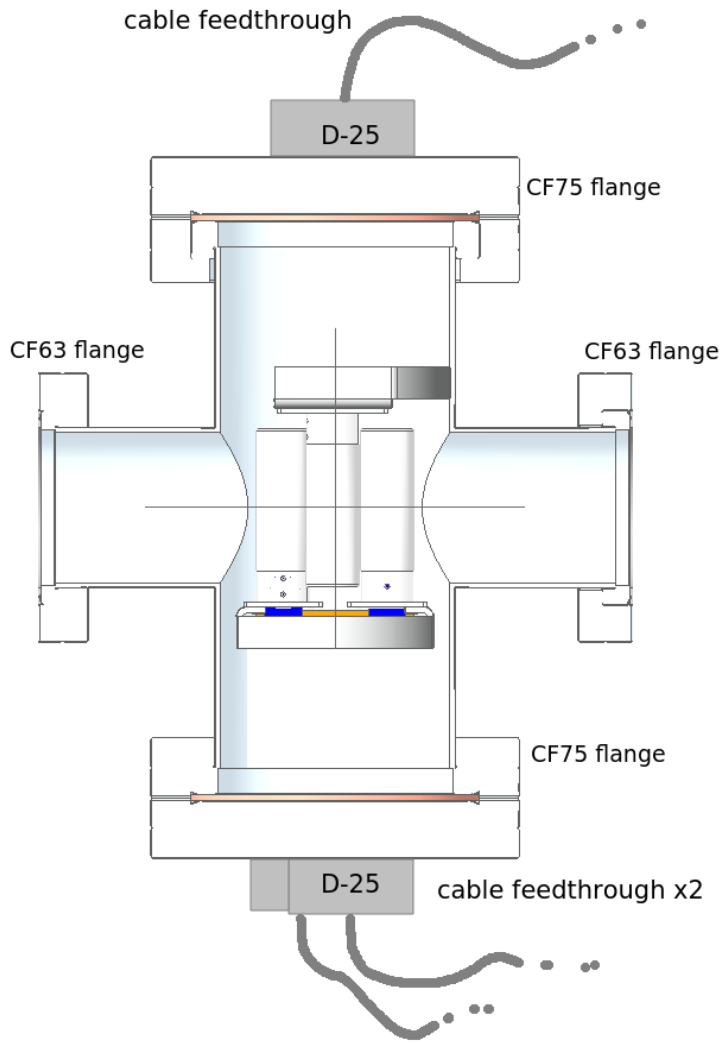
# Relative humidity calibration

- Humicap sensor head reacts to relative humidity, but is also strongly affected by temperature
- Picture on the right demonstrates the temperature effect: each color represents a constant relative humidity value from 0 to 100%RH
- In cold ambient temperature the sensor dynamic range decreases
- Measurement range is still from 0% to 100% but the changes in capacitance are really small: the full range on the Humicap chip is ~2.5 pF in -70°C and ~9 pF in +22°C
- Also Martian conditions affect the capacitance and characterization measurements done in ambient pressure air can not be directly applied



# Test setup

- Mars Simulation Facility (MSF) and Planetary Analog Simulation Laboratory (PASLAB) in DLR Berlin
- The gas mixing system can generate gas compositions and humidity levels corresponding to the atmosphere at the surface of Mars
- In 10 hPa the dew point range of −94 to −46 °C can be reached
- The instruments will be closed in a pressure vessel placed inside a temperature test station. A controlled, continuously humidified carbon dioxide will flow through the vessel and the dew point of the gas is measured with a reference hygrometer.




Calibration vessel with 3 RH sensors inside

# Measurement campaign plan

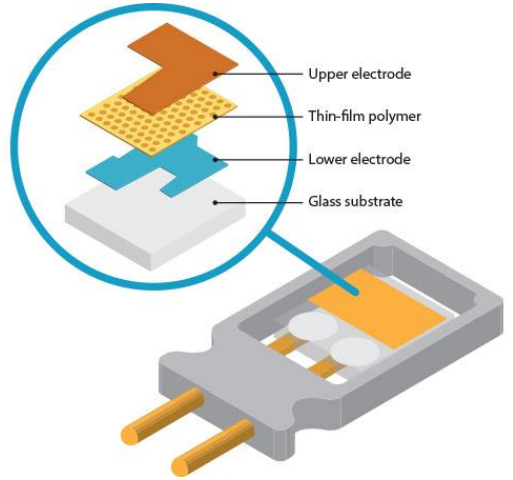
- The goal is to determine the relation between RH% and temperature in Mars conditions (~10 mbar and $CO_2$ gas)
- Measurements are performed with calibration reference models (that are identical to the flight models) of REMS-H, MEDA HS and METEO-H
- At least 3-4 temperature points are measured (inside the operational temperature range on the surface of Mars)
- Multiple RH measurements are taken in each stable temperature against a reference hygrometer
- Cold temperatures < -50°C are the most interesting since in higher temperatures the RH on Mars stays close to 0%

# References

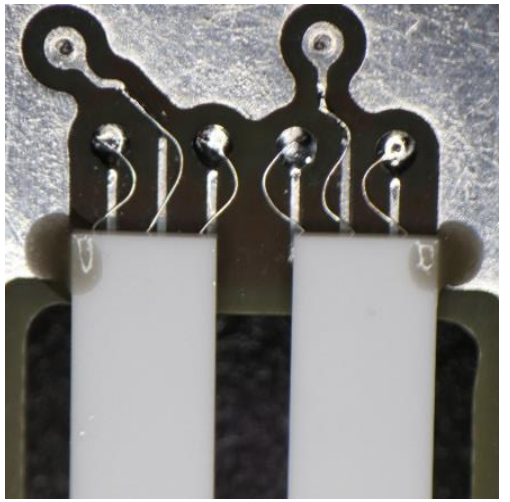

- Harri, A.-M., et al. (2014), “Mars Science Laboratory relative humidity observations: Initial results“, *J. Geophys. Res. Planets*, 119, 2132– 2147, doi:10.1002/2013JE004514.
- Lorek, A. and Jacek M. (2018) “Humidity Measurement in Carbon Dioxide with Capacitive Humidity Sensors at Low Temperature and Pressure.” *Sensors (Basel, Switzerland)* vol. 18,8 2615, doi:10.3390/s18082615
- Hieta, M., et al. (2019), “Relative humidity measurements in Michigan Mars Environmental Chamber*”, Geophysical Research Abstracts Vol. 21*, EGU2019-17273, EGU General Assembly 2019

# Extra: Vaisala's Humicap®

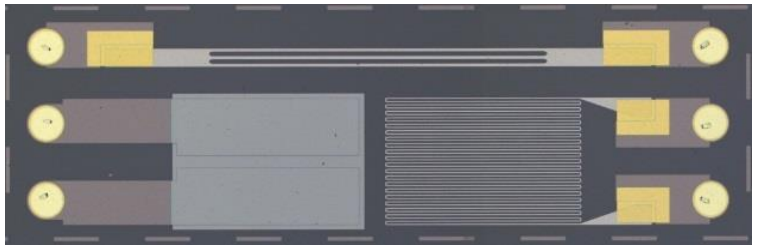
- Vaisala introduced the first HUMICAP® in 1973
- A capacitive thin-film polymer sensor
- Full measurement range 0...100 %RH
- Excellent long-term stability
- Insensitive to dust and most chemicals
- Sensor regeneration heating to remove contaminants or to defrost
- For latest generation: Pt1000 resistor on chip



Structure of the Humicap chip (source: Vaisala)


Humicap chip attachment to PCB

VAISALA


Humicap chip, new generation

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE