



# **Long-Term Demonstration of an Optical Multi-Gas Monitor on International Space Station**

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# Background & Objectives

- Low Power Tunable Diode Laser Spectroscopy for gases
  - ✓ Focus on portable equipment
  - ✓ Major constituents
  - ✓ Minor contaminants like ammonia, CO, acid gases, methane, formaldehyde
  - ✓ Replace obsolete equipment
- Past NASA talks at SAMAP covered plans/prototypes
- Requested & received funding for a flight exp't in Nov 2012
- Objective of the ISS Tech Demo was to prove long term reliability of the sensor for multiple gases

Gas	Range
Ammonia	5 – 20,000 ppm
Carbon Dioxide	250 – 30,000 ppm
Oxygen	4 – 36%
Water vapor	5 – 90% RH

# Multi-Gas Monitor Tech Demo Hardware for ISS



Mass: 2.6 Kg

Volume: 4.4 L

Power: 2.5 W

- USB (5VDC) or
- 28VDC or
- Internal batteries

Memory: 16 GB

Data log: 30sec avg's

Large readable LCD

*No means to zero or calibrate on board*

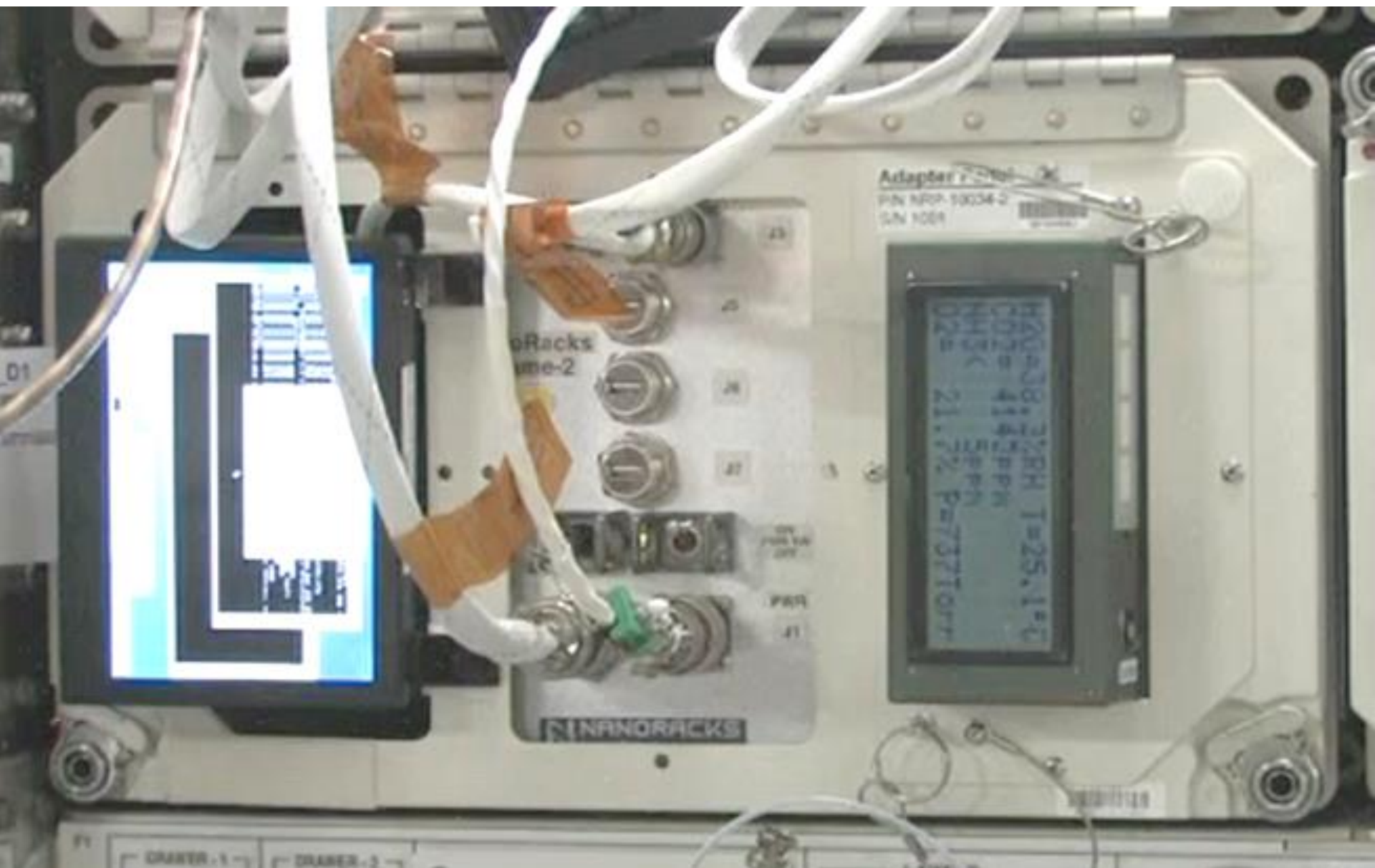


# Multi-Gas Monitor Tech Demo Timeline

Date	Event
July 22-30, 2013	MGM calibrated at NASA-JSC
Nov 7, 2013	MGM launched on 37 Soyuz
Feb 3, 2014	Activation and check out
Feb 11, 2014	SPHERES CO2 unplanned “challenge”
July 25, 2014	Ammonia inhalant test
Dec 15, 2014	Crew manual reset
Jan 14, 2015	Thermal control ammonia false alarm
Jan 16-17, 2015	SPHERES CO2 unplanned “challenge”
Aug 25-26, 2015	Deployed on battery power to Node 3
Aug 28-Sep 28, 2015	Deployed on 28V power to US Lab
Sep 28 - present	Back in JEM Nanoracks; stopgap for NH <sub>3</sub>

*20 months and counting!*

# MGM installed in a Nanoracks Frame in JEM



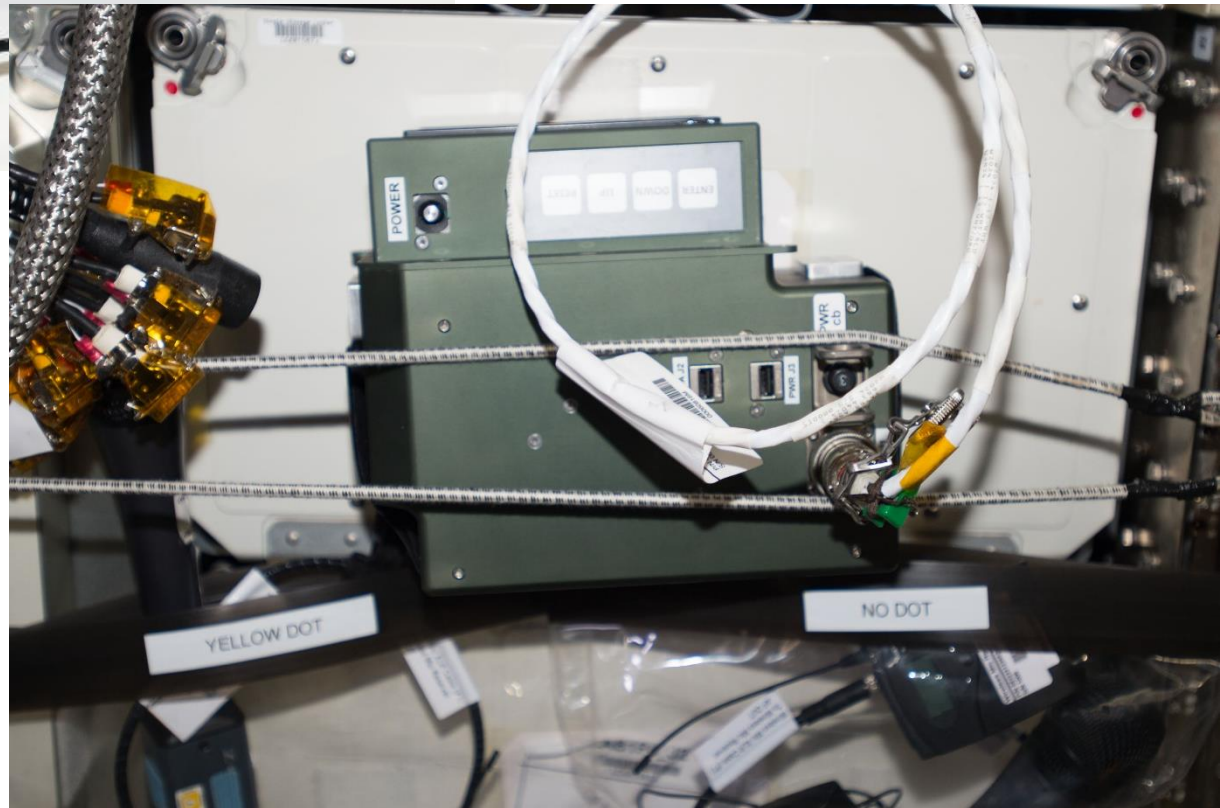
# Crew Member holding MGM





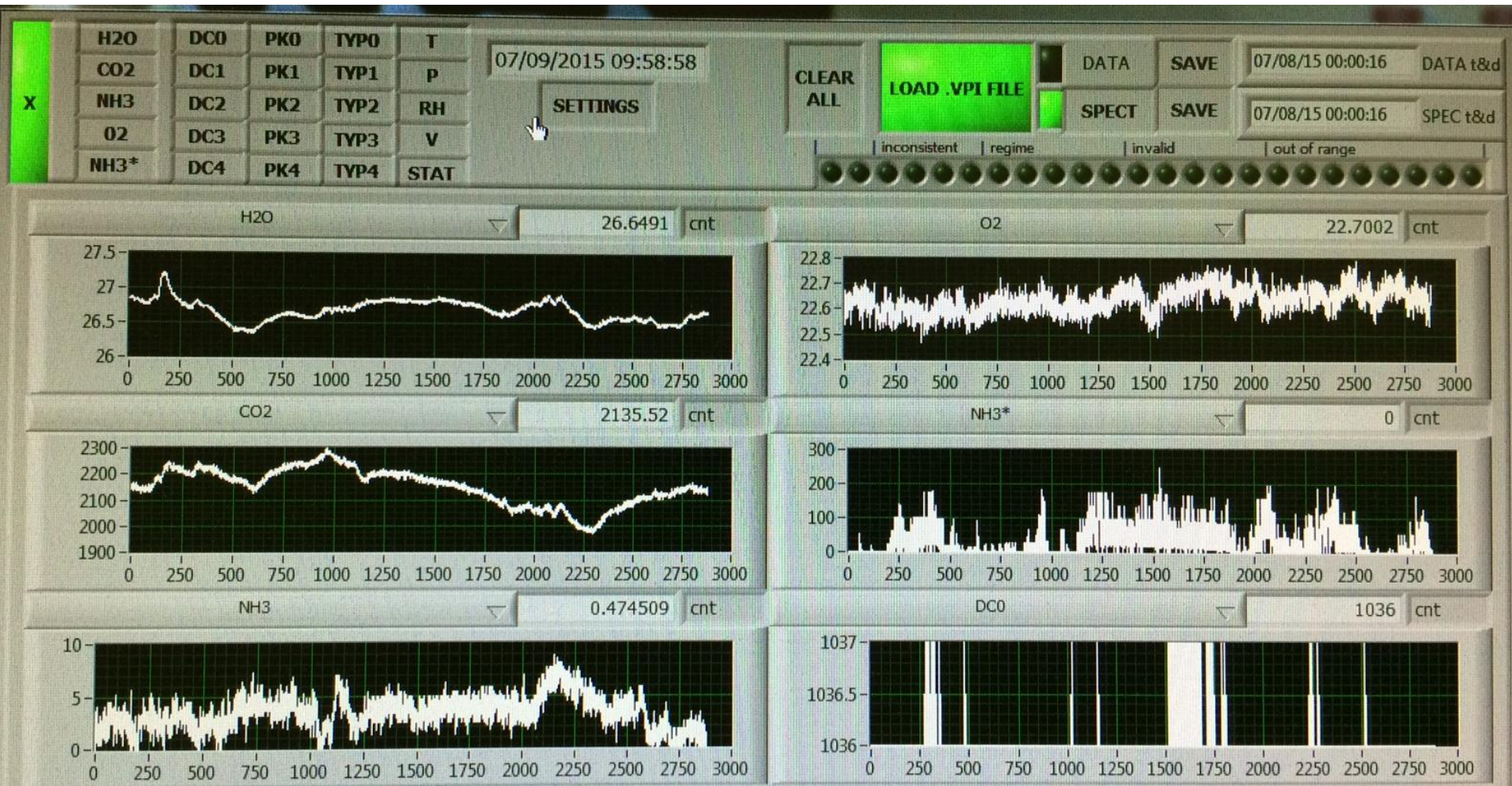
Deployed on batteries  
in Node 3

Plugged into 28VDC  
in the US Lab Module



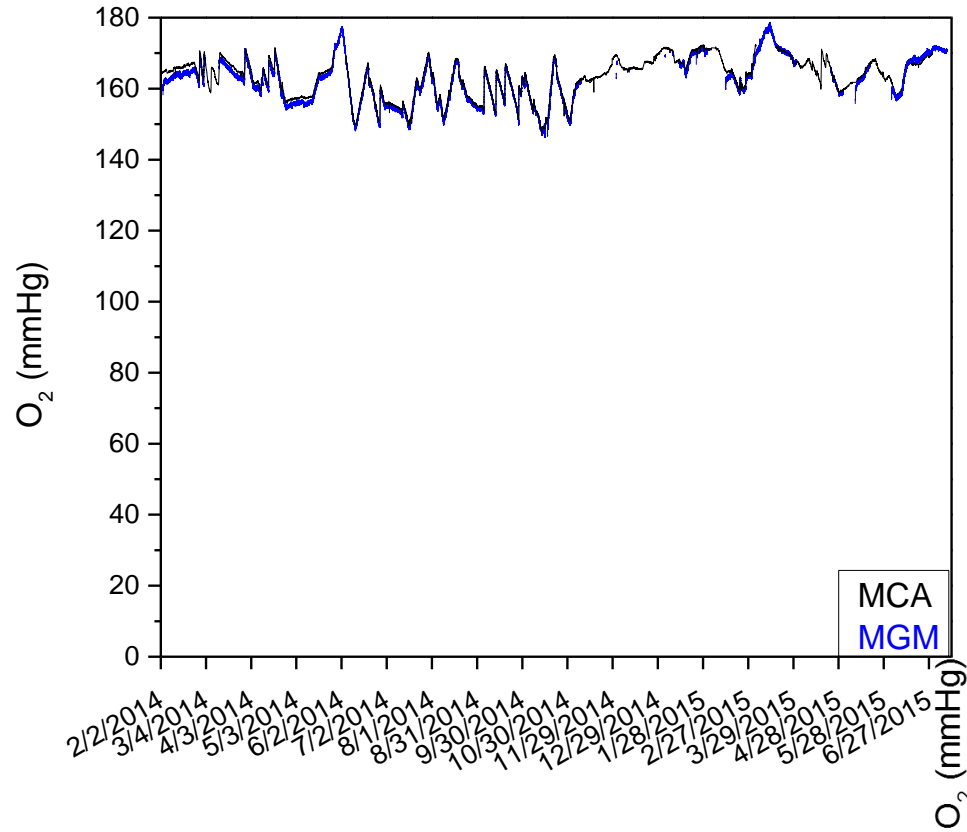
# MGM Data Downlink & Ground Display GUI

- New data file created daily within MGM
- Data files zipped and downlinked weekly
- Labview GUI (below) used to check data quickly on the ground

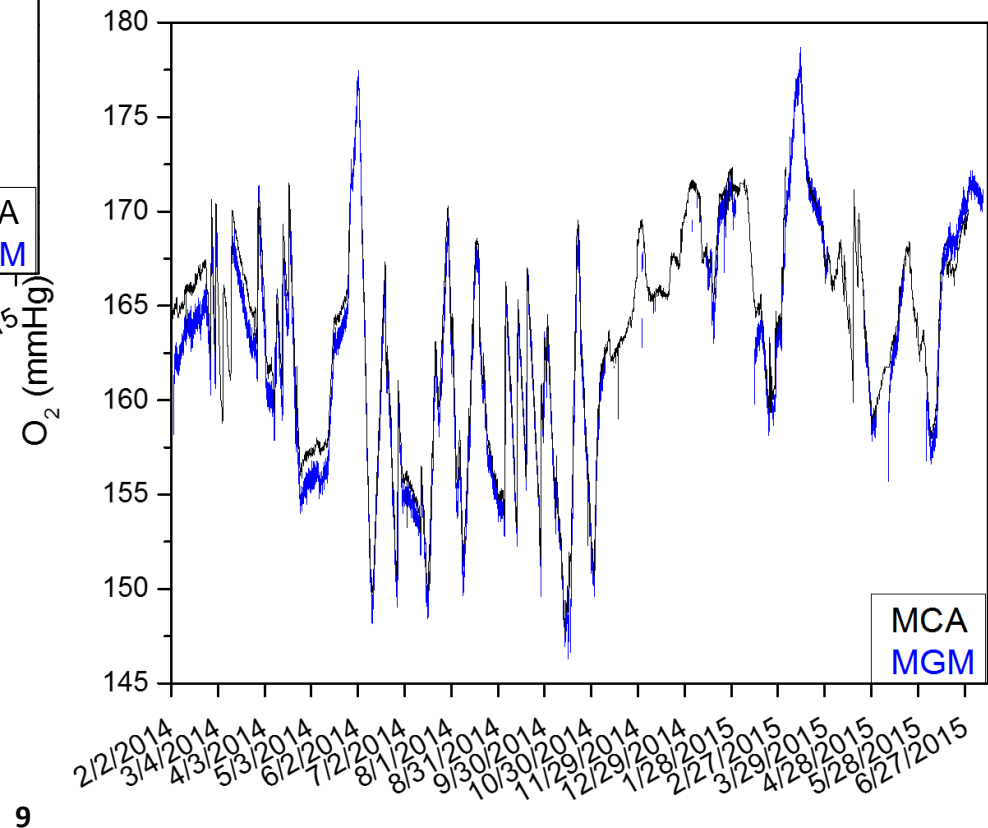




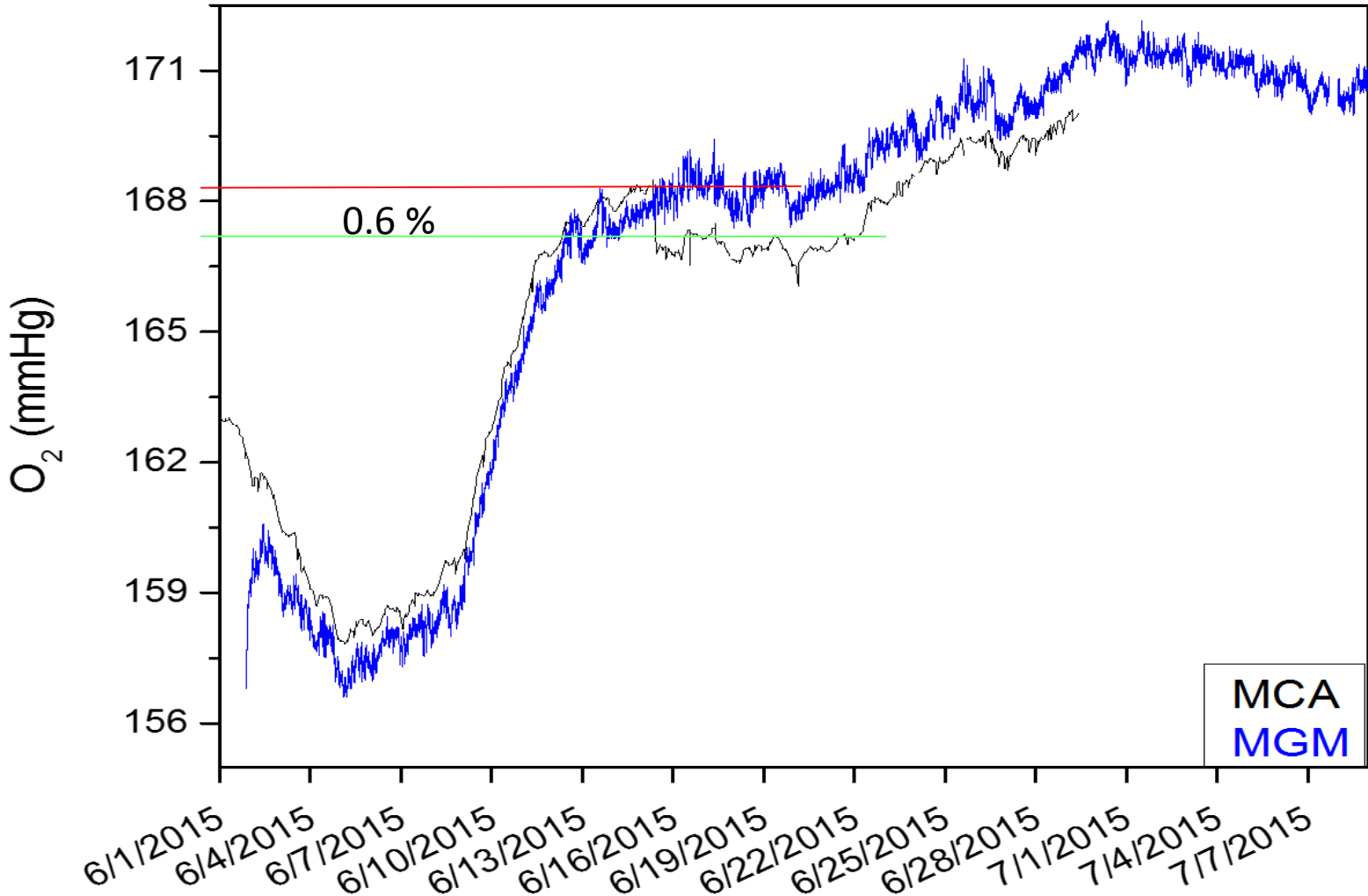
# All MGM Oxygen Data vs. MCA for JEM



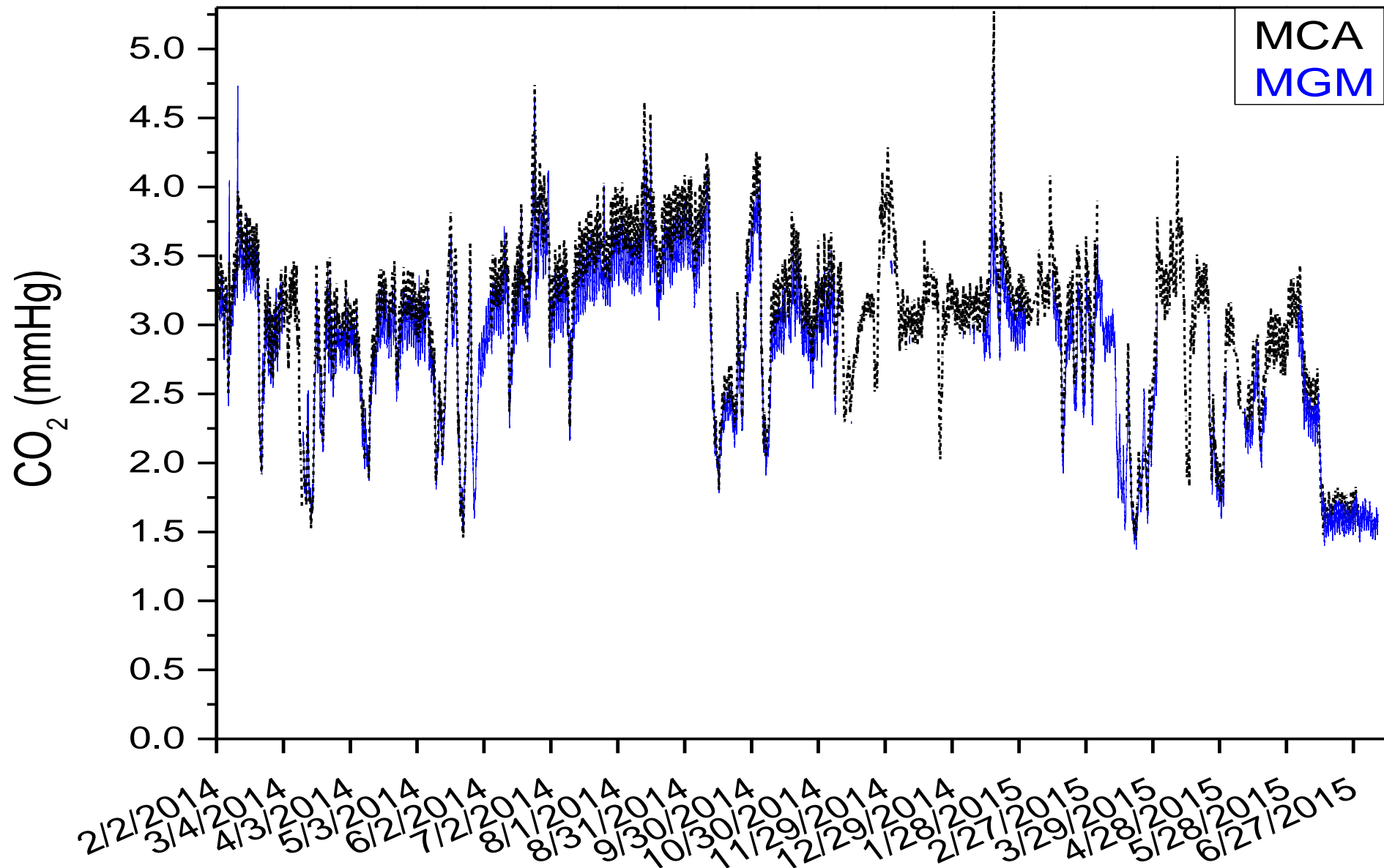
ppO<sub>2</sub> in mmHg



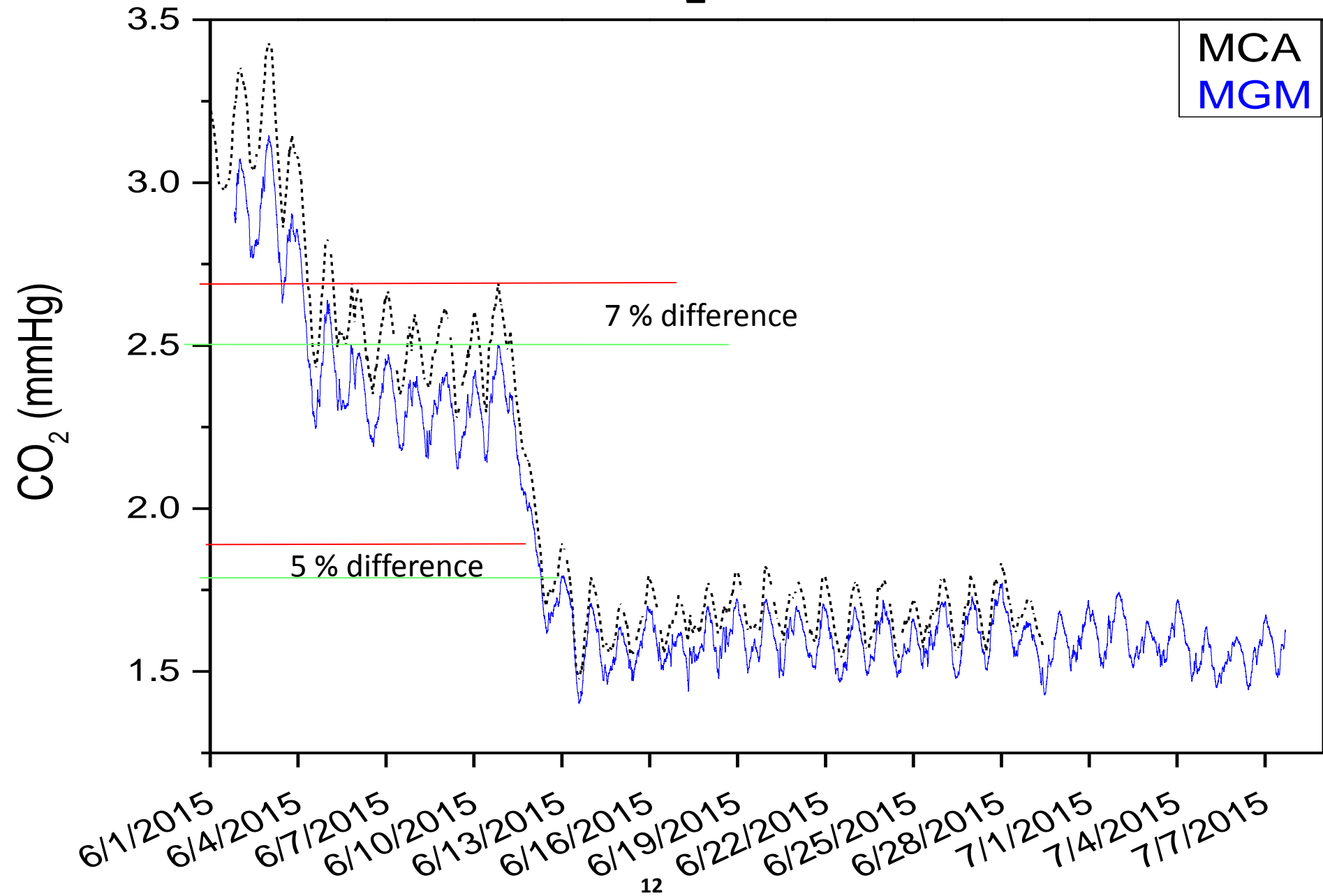
# Recent MGM Oxygen Detail vs. MCA



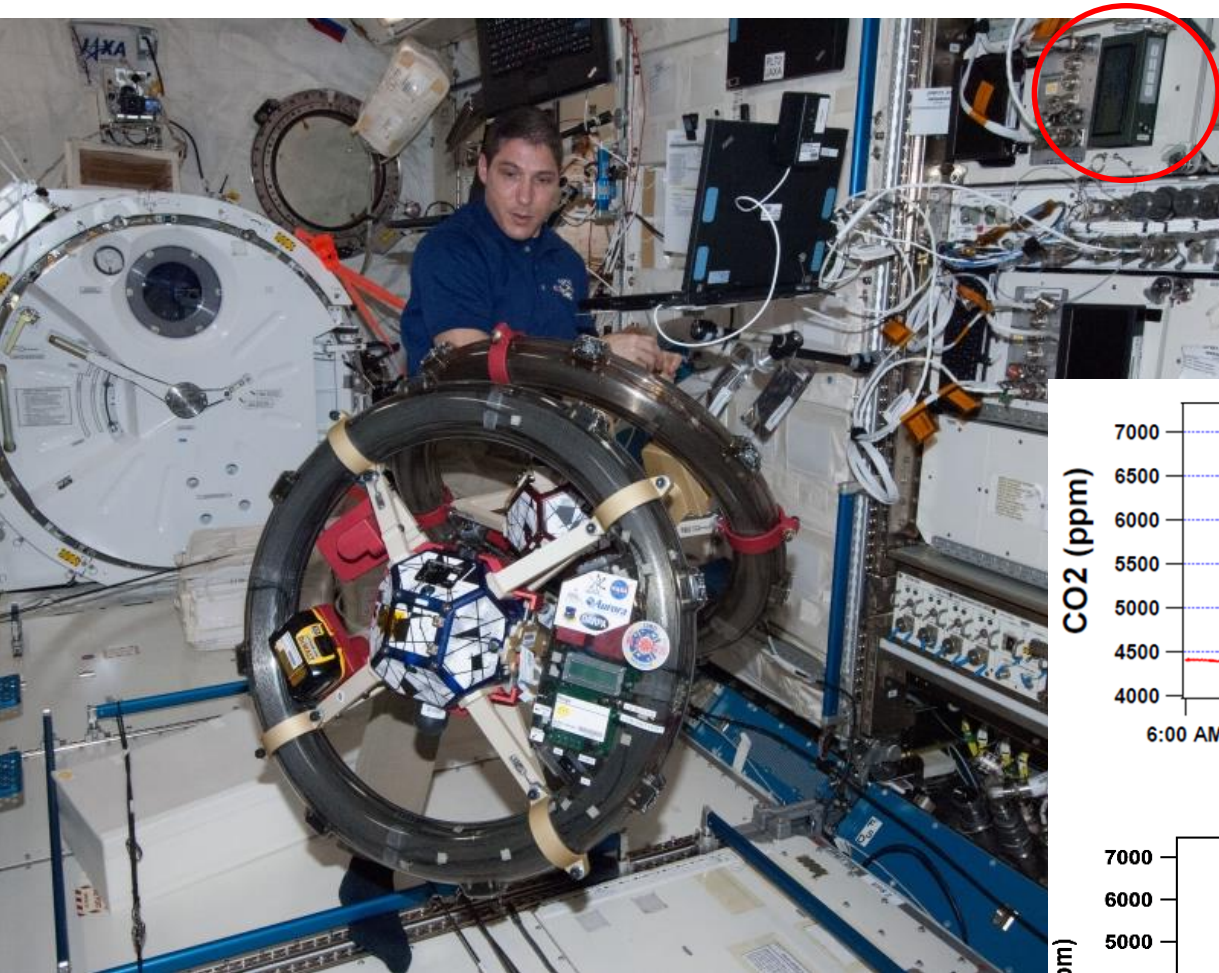
# All MGM Carbon Dioxide Data vs. MCA (JEM)



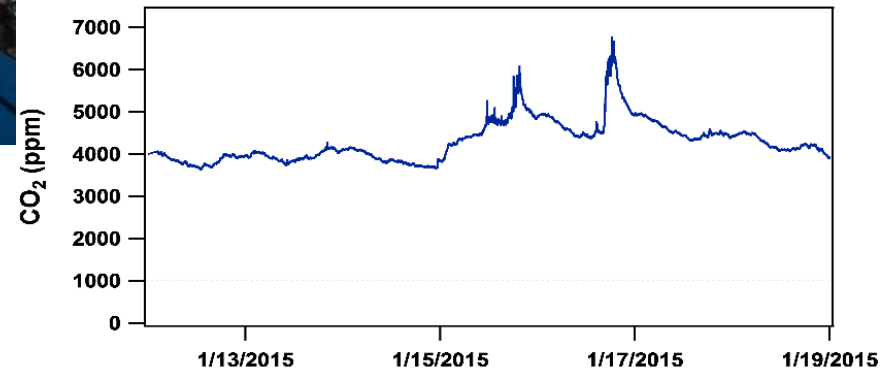
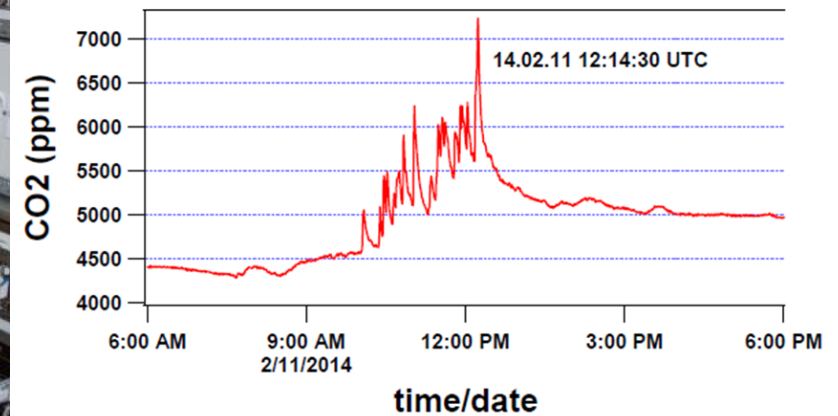
# Recent MGM CO<sub>2</sub> vs. MCA (JEM)



# MGM operating near SPHERES/RINGS payload



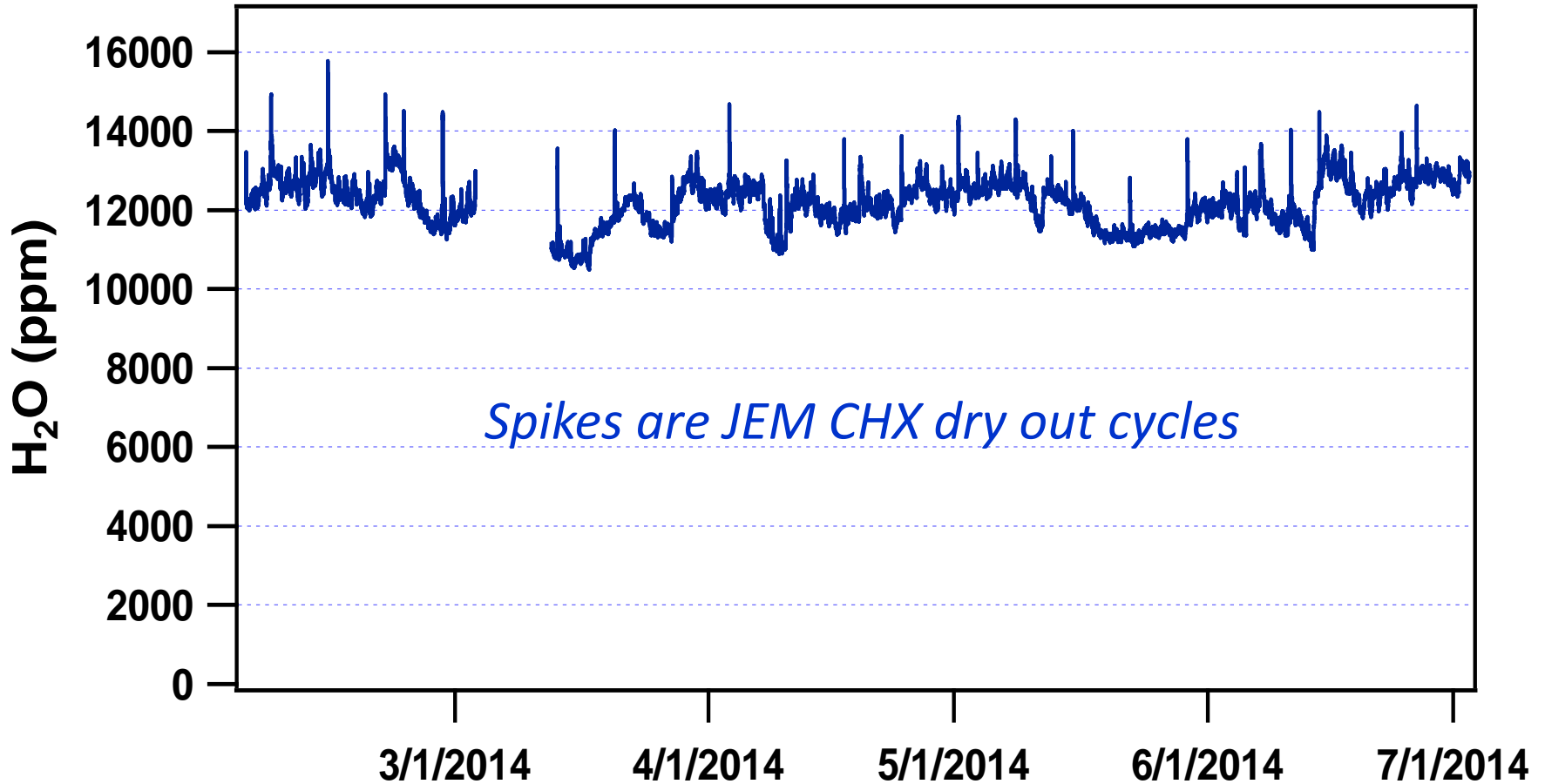
MGM



# Regarding Health Impact of CO<sub>2</sub>

- ISS CO<sub>2</sub> up to 10X terrestrial outdoor concentrations
  - ✓ 3X to 5X higher than typical indoor concentrations
- High CO<sub>2</sub> exposure may affect vision, cause headaches, affect decision making
- NASA operational CO<sub>2</sub> limits are under review
- ISS CO<sub>2</sub> currently governed by operational “chits”
  - ✓ 24 hr average limited to 3 mmHg (4000 ppm)
  - ✓ US and Russian life support system controllers cooperate to manage CO<sub>2</sub>
- Short-term manned chamber testing planned to assess cognitive effects

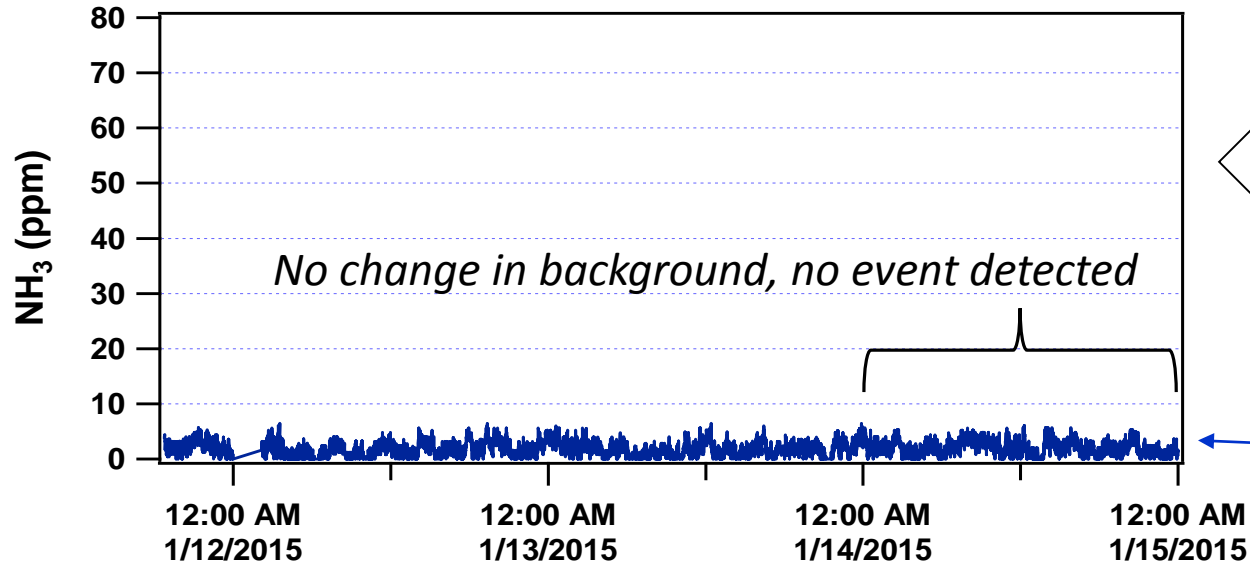
# Water Vapor



12,000 ppm H<sub>2</sub>O corresponds to 38% RH at 25C/1atm.

Dewpoint in Columbus Module in 2014 averaged 48F (36% RH at 25C/1atm).

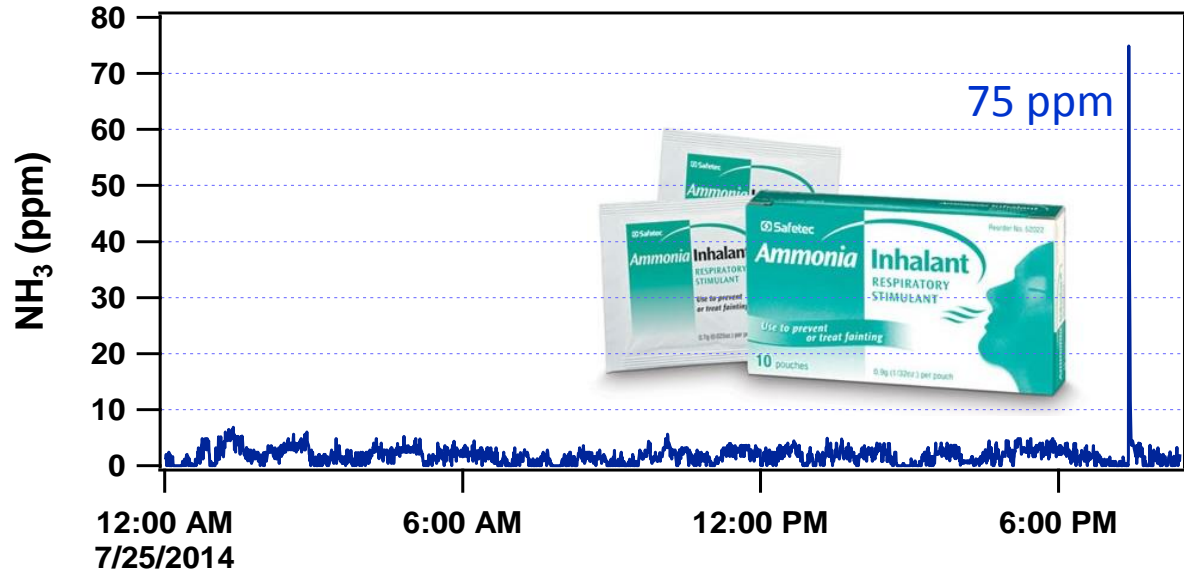
# Ammonia



$\text{NH}_3$  alarm on ISS on Jan 14, 2015

LOD ~ 5 ppm

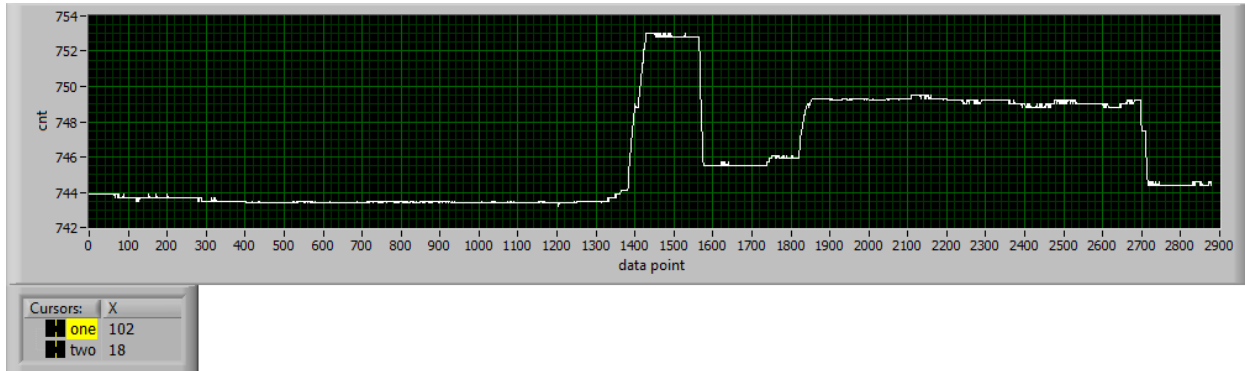
Inhalant challenge on July 25, 2014



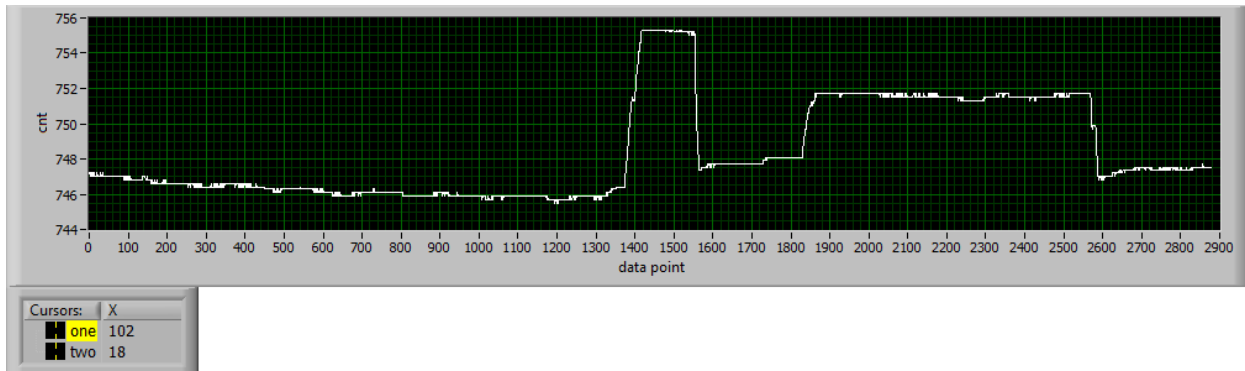


# MGM Pressure Sensor Data

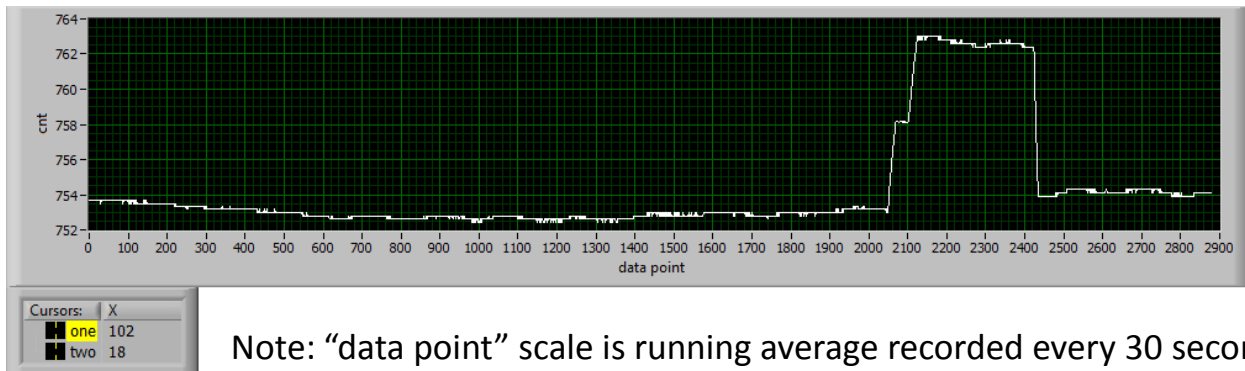
Feb 25, 2015  
US EVA  
6 hr 43 min



March 1, 2015  
US EVA  
5 hr 38 min



March 6, 2015  
Airway  
Monitoring  
investigation in  
US Airlock



Note: "data point" scale is running average recorded every 30 seconds

# Summary and Future Work

- Stable operation of the TDLS sensor over 20 months, no drift or degradation
- MGM results closely match MCA results for O<sub>2</sub> and CO<sub>2</sub>
- Ammonia channel tested on orbit using an inhalant
- Water channel consistent with humidity readings in COL and JEM
- Occasional data logger hiccups lost several weeks of data
  - ✓ Sensor unaffected
  - ✓ Remote power cycling recovers the data logger
- Overall a very successful tech demo
- Working to expand TDLS to monitor combustion products, formaldehyde and hydrazine for ISS, Orion and Mars vehicles
- *Mars or bust!*

# MGM Team Photo



# SUBS IN SPACE

Air Quality in Spacecraft and Submarines,  
January 26-28, 2015, NASA-JSC, Houston, TX



***BLOW THE BALLAST!***

# Sea Trial version of MGM



**Mass: 2 Kg Vol: 3.1 L Power (120VAC/6VDC): 2.6W Data Log: 1 min averages**