Practical Considerations for Citizen Science Studies In the Field

Lessons Learned in implementing the 2015 Ironbound citizen science study

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Ironbound Citizen Science Air Monitoring Project

First project of its kind

- Instruments developed by addressing concerns and needs expressed by local organizations
  - PM & NOx
  - One week unattended operation
- Instruments released to Citizen Monitoring Groups
  - Citizen groups have custody of instruments
  - Citizen group determine sampling locations
  - Training given to Citizen Science groups in basic maintenance and operation of samplers
- Data analysis done by EPA-ORD

Ironbound Citizen Science Air Monitors (CSAM) Project

- Developed and designed by EPA-ORD
- Built by ORD's Contractor
- Supported by EPA R2 DESA
- Data Analysis by EPA-ORD

4 CSAM samplers assembled

Practical Considerations

- Safety
- Getting samplers/monitors “from here to there”
- Ease of assembly & operation
- Stability
- Durability/Ruggedness – “field ready”
- Size and weight
- Instrument Design
- Reliability
- Comparison w/ established reference analyzers
- Level of support (Federal/State/Local)

Safety

Safety of the operator

- Time of sampling (day/night)
- Location of sampling (traffic, loading/unloading)
- Size, weight, & complexity of instrument to be deployed

Safety of the public

- Tripping hazards
- Falling hazards
- Electrical or moving parts hazards

Safety of the monitor/sensor

- Theft/vandalism
- Rain/Snow/Cold/Heat
- Field ruggedness

Getting Samplers/Monitors "From Here To There"

CSAM Arrival
@ Edison, NJ

Getting Samplers/Monitors "From Here To There"

Boxes unpacked.

4 complete CSAM units.

Note lack of boxes/containers to transfer samplers to contractors (ICC) or to ship samplers from site to site

Ease of Assembly

4 CSAM samplers assembled.

Stability

Video of Lack of Tripod Stability. Mouse Over the Picture and Press Play

R2 DESA Solution Addressing Sampler Transport & Stability

Pelican 1660 cases

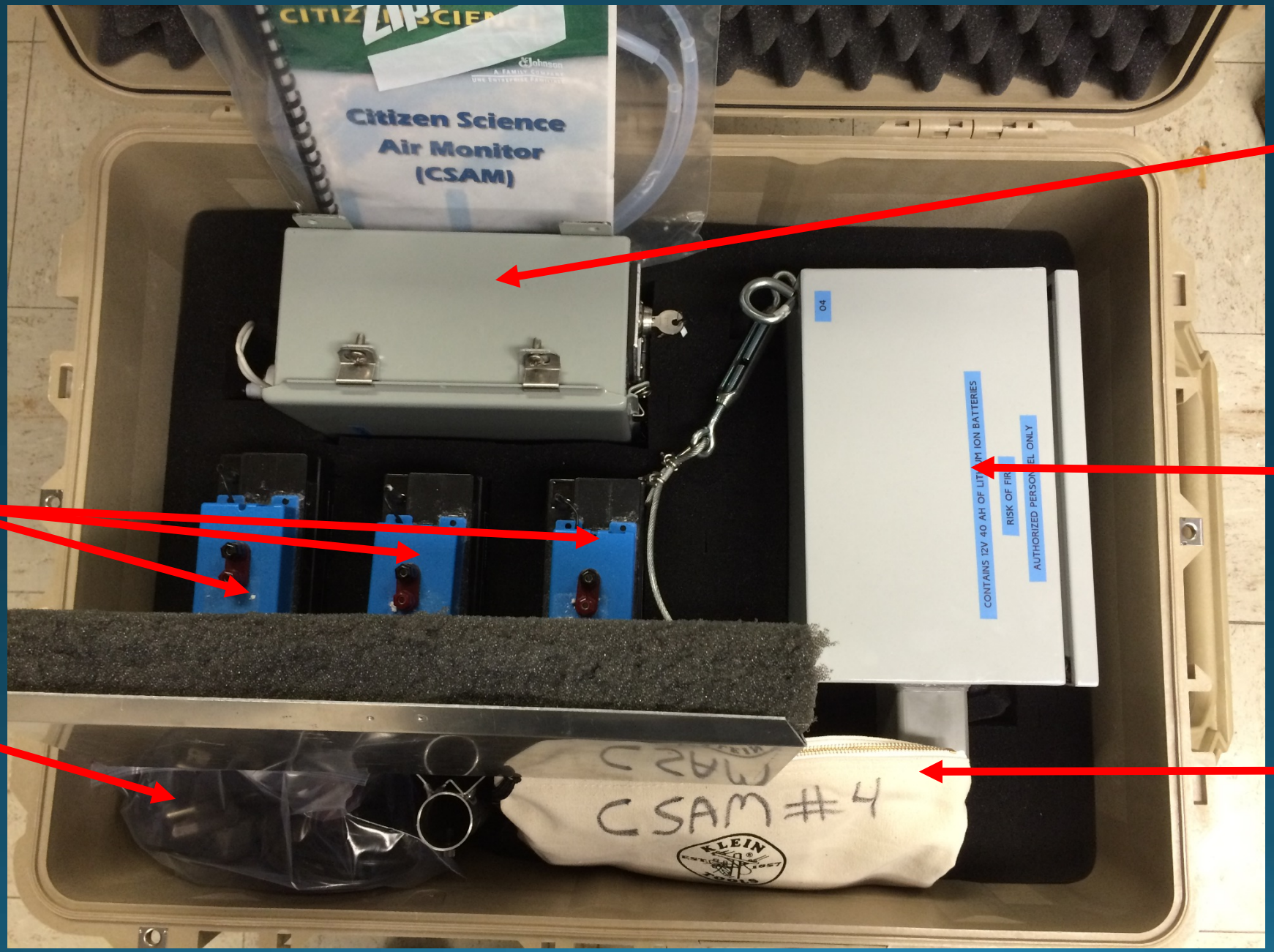
5/8" marine plywood, sanded, painted, with added mounting hardware and handhold cutouts (4 units)

R2 DESA Solution Addressing Sampler Transport & Stability

Inside view of Pelican 1660 cases

R2 DESA Solution Addressing Sampler Transport & Stability

Inside view of one Pelican 1660 cases



Sampler Case

Battery Case

Batteries

Tripod mounting hardware

Tool kit

R2 DESA Solution Addressing Sampler Transport & Stability

Tool kit contents

R2 DESA Solution Addressing Sampler Transport & Stability

4 CSAM samplers in van, out for delivery

Size & Weight

CSAM + Case = 90+ pounds

Bulky tripod – poor materials and workmanship

2nd story work or stair climbs would be dangerous with one person operation

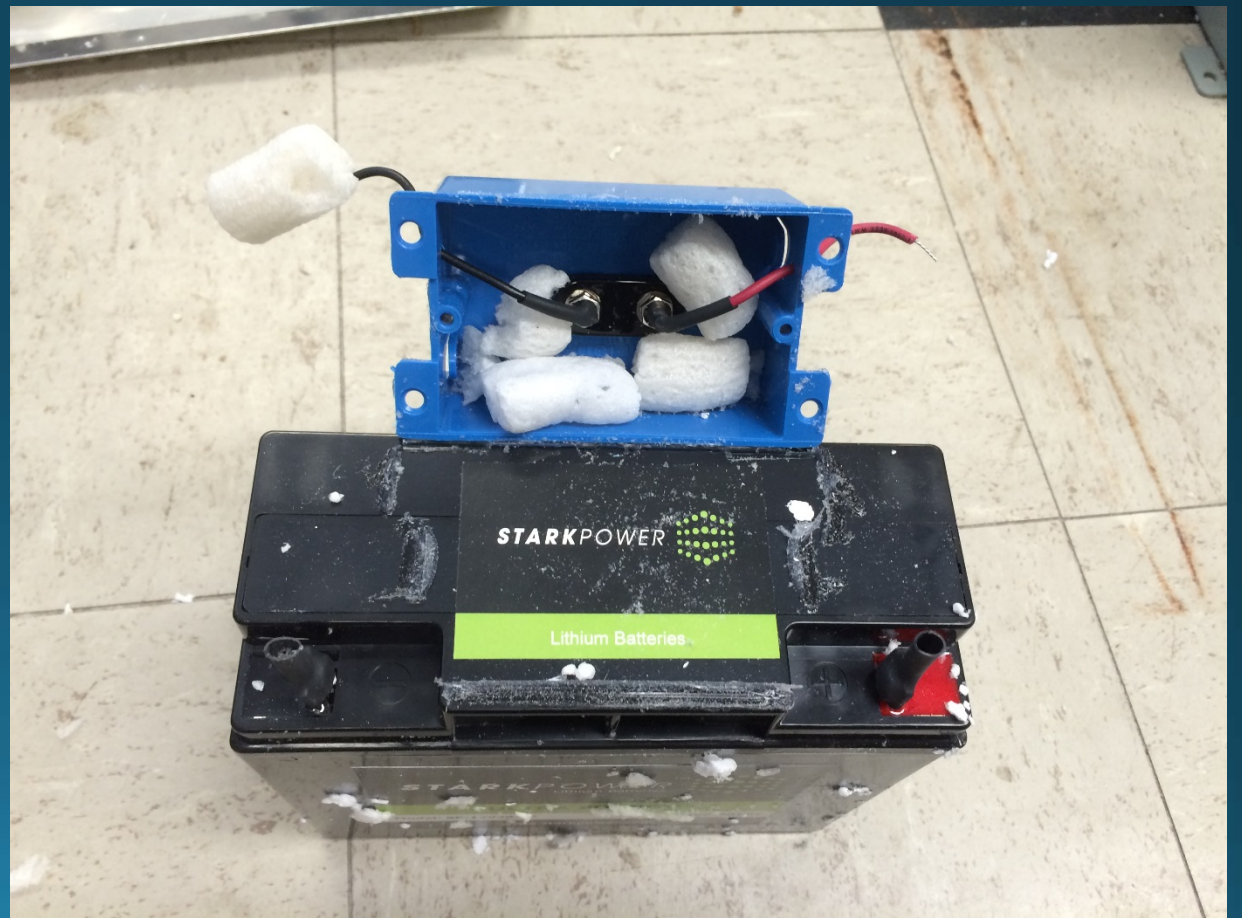
Durability/Ruggedness

CSAM sensors arrived with:

- broken parts,
- bent electronic pins,
- loose screws,
- missing/loose standoffs

Durability/Ruggedness

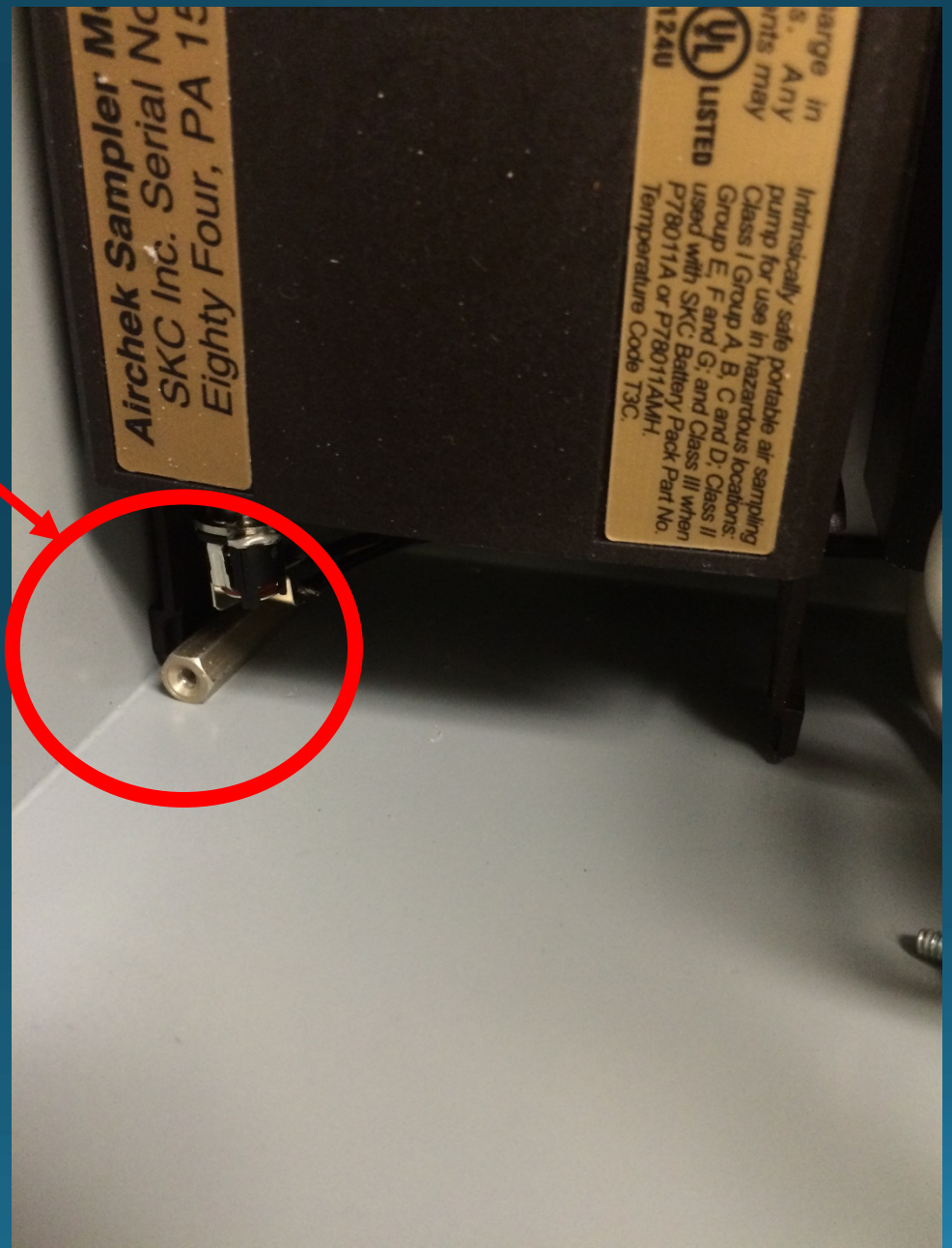
Broken Parts



Durability/Ruggedness

Durability/Ruggedness

Loose standoff

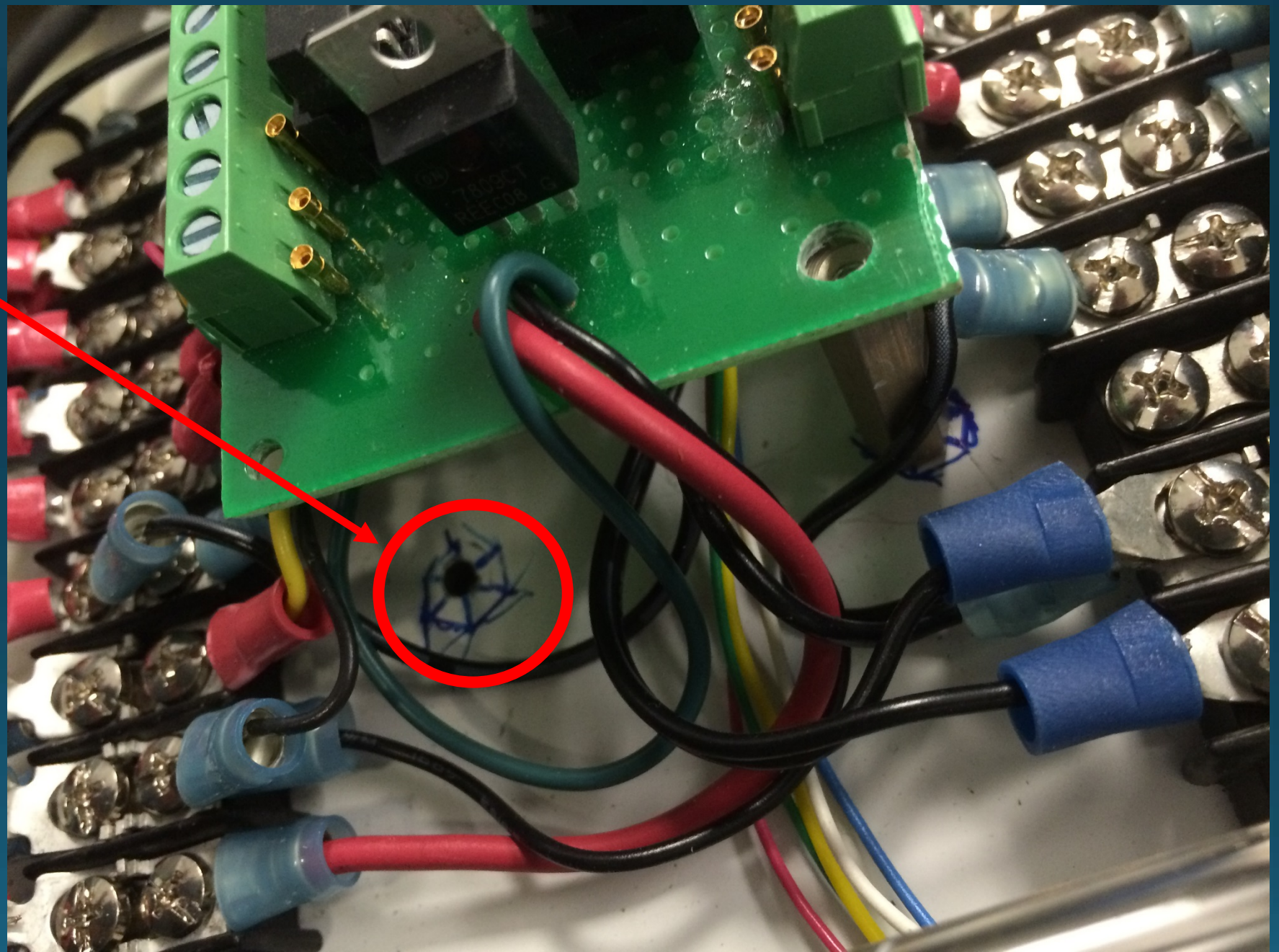


Durability/Ruggedness

Loose pump cutoff switch

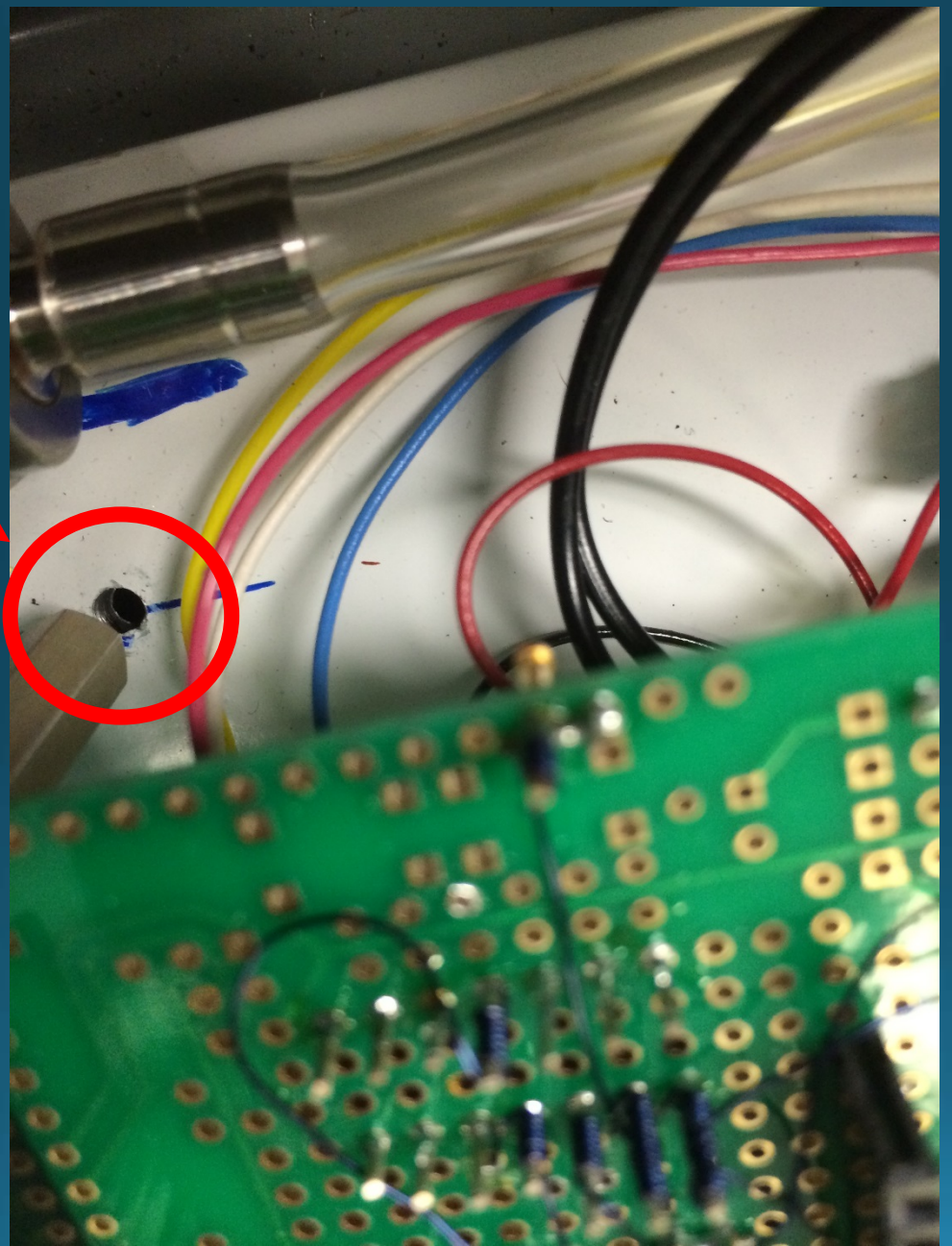
Durability/Ruggedness

Missing Standoff



Durability/Ruggedness

Missing standoff screw



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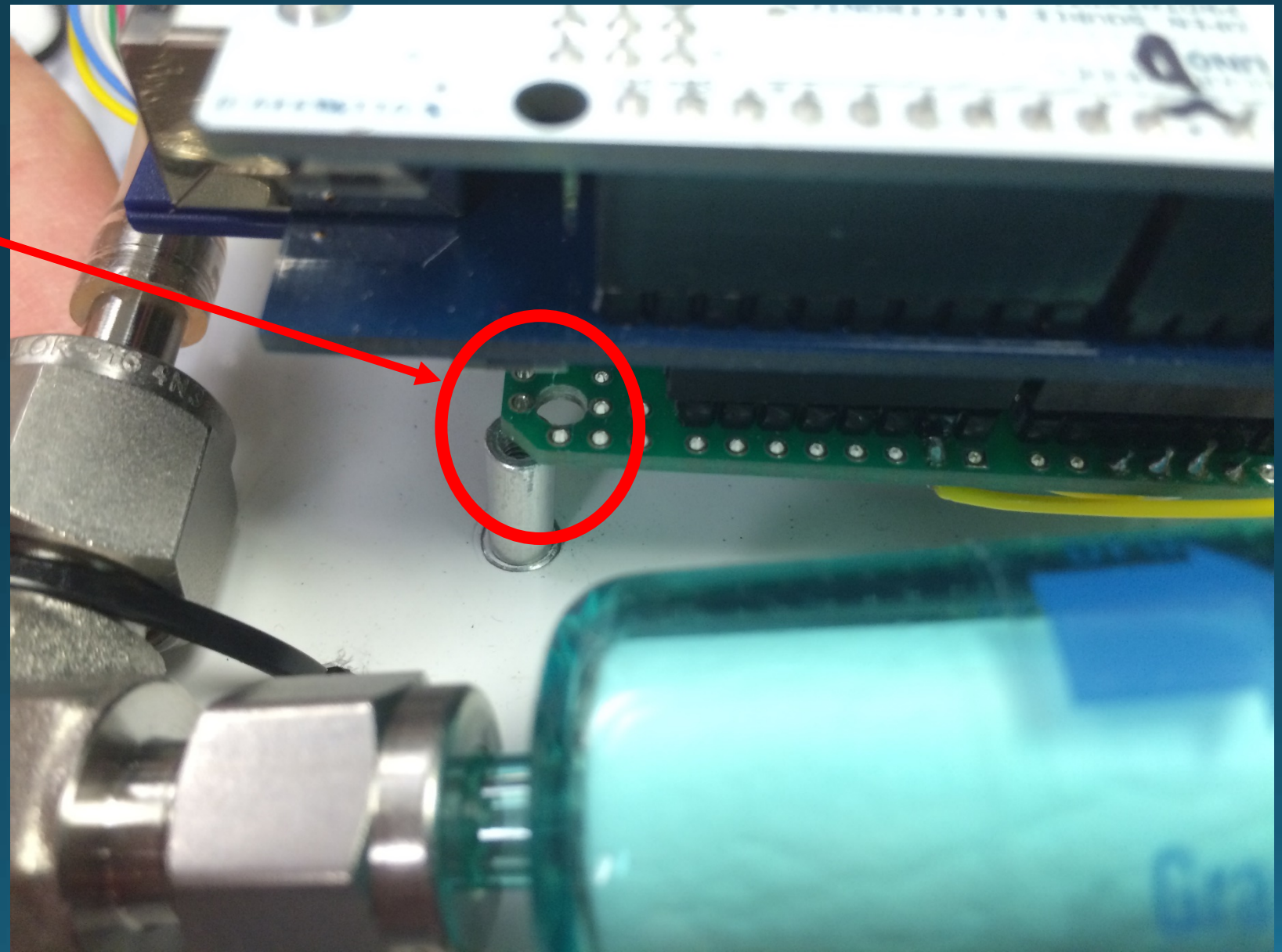
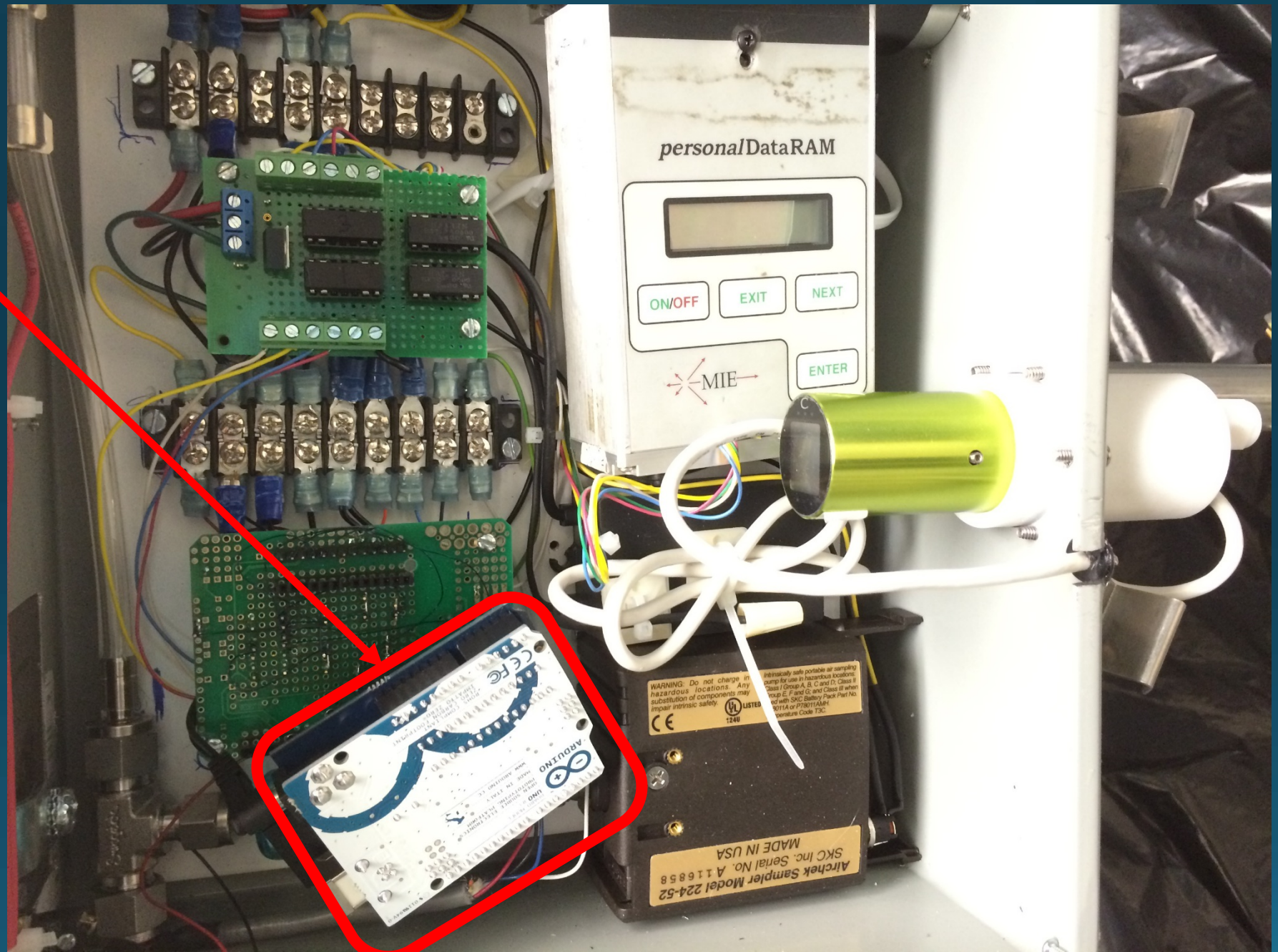


Durability/Ruggedness

Arduino board loose & bouncing around sampler



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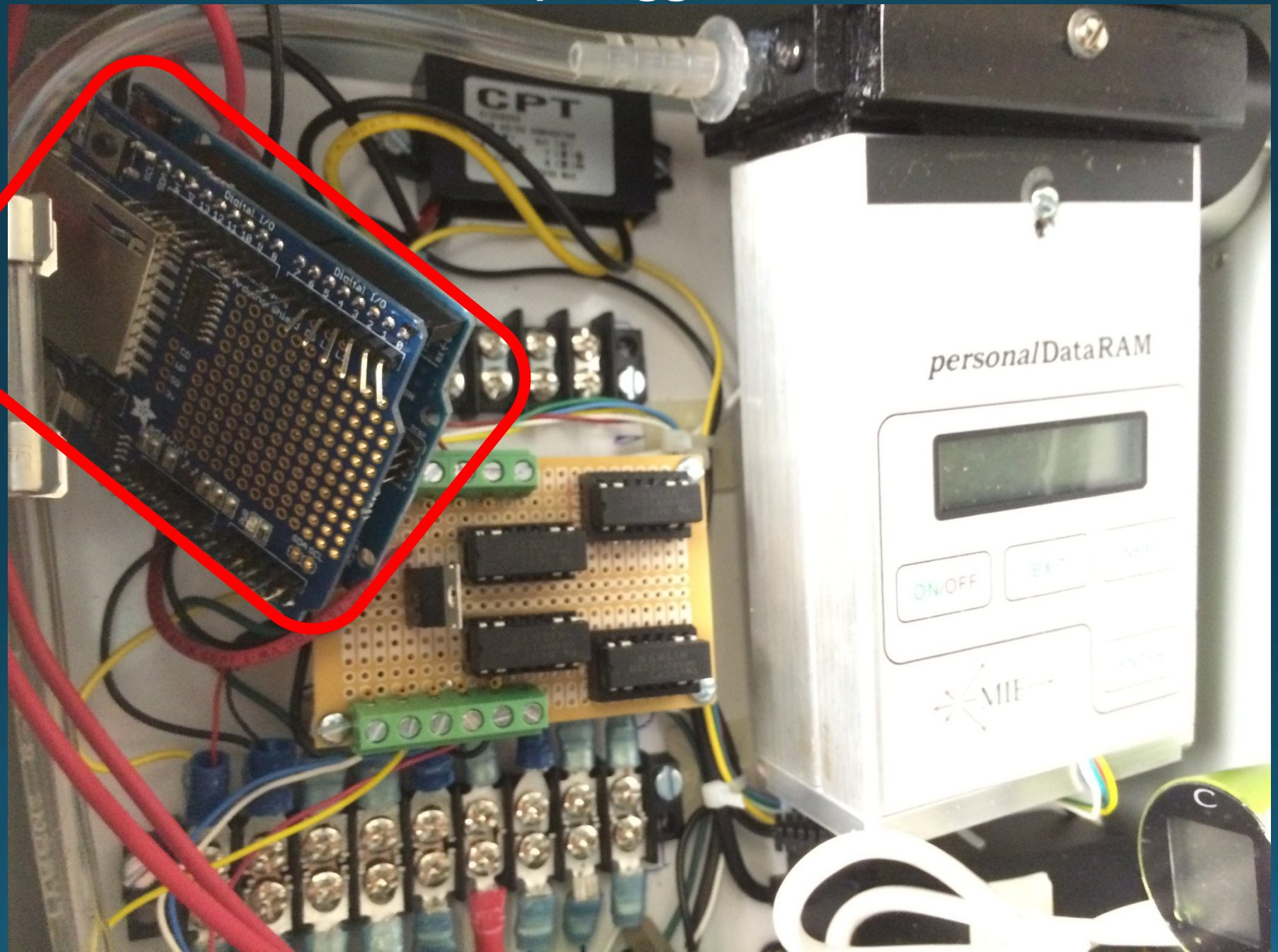
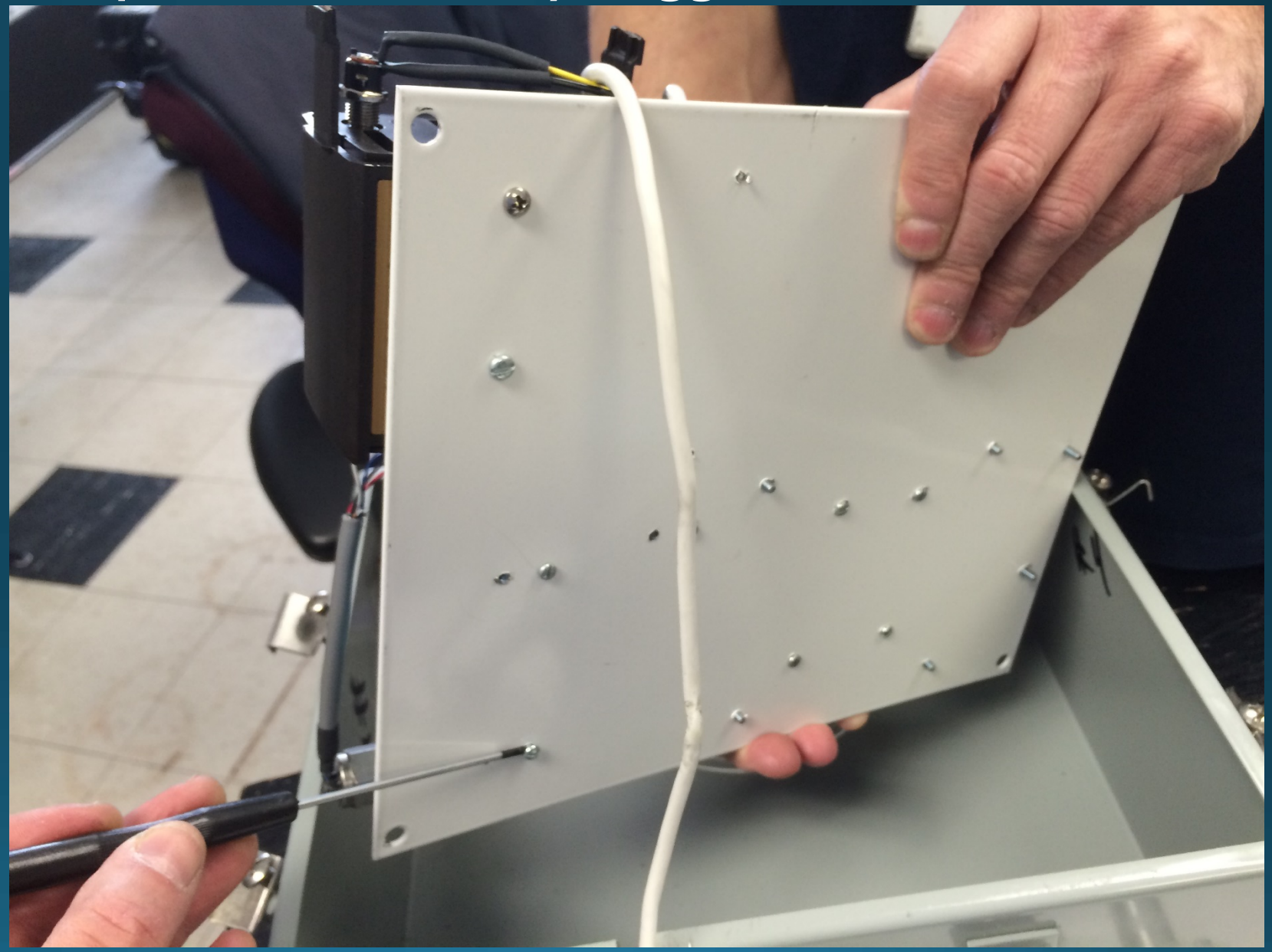
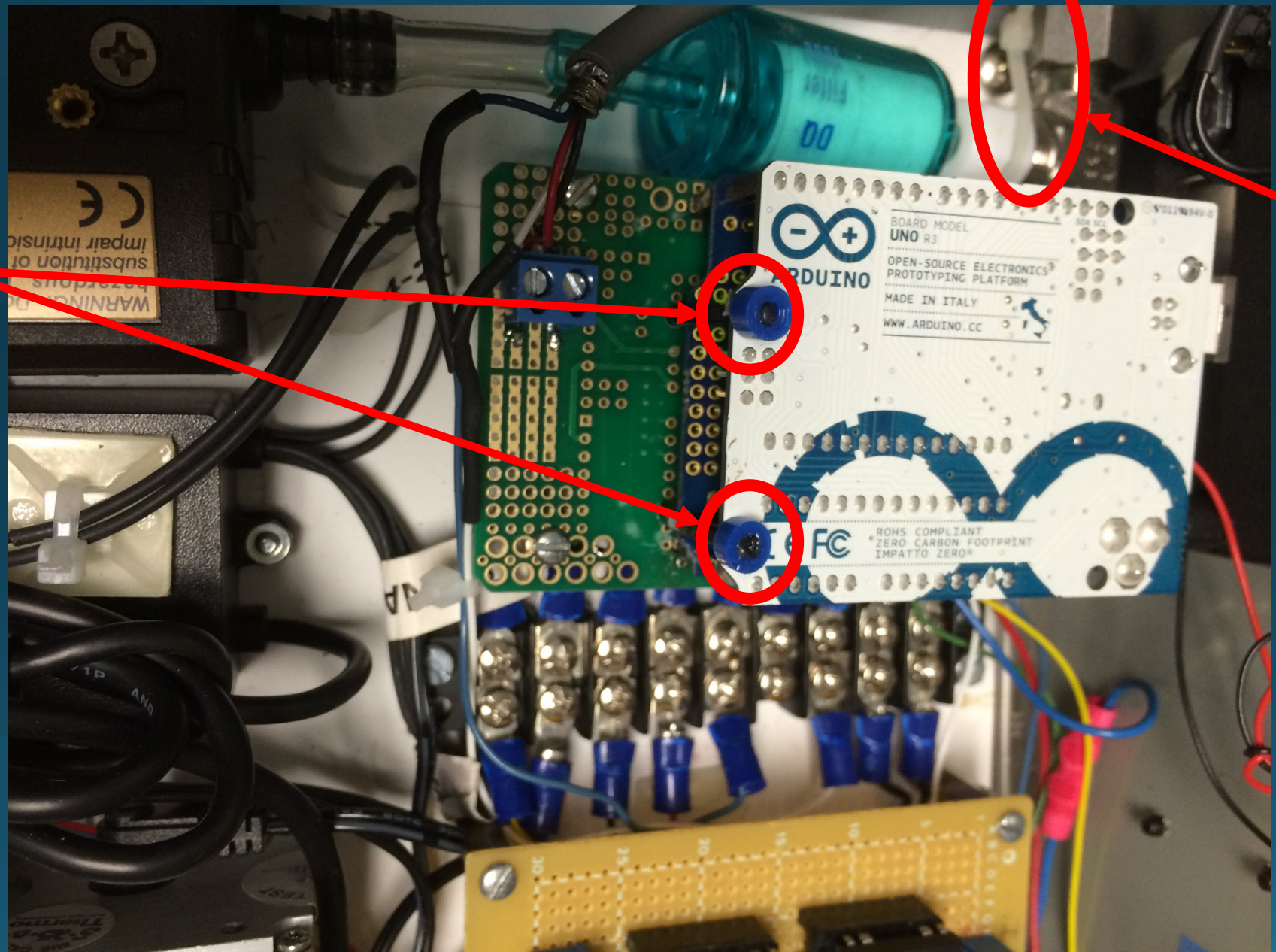


R2 DESA Repairs for Durability/Ruggedness



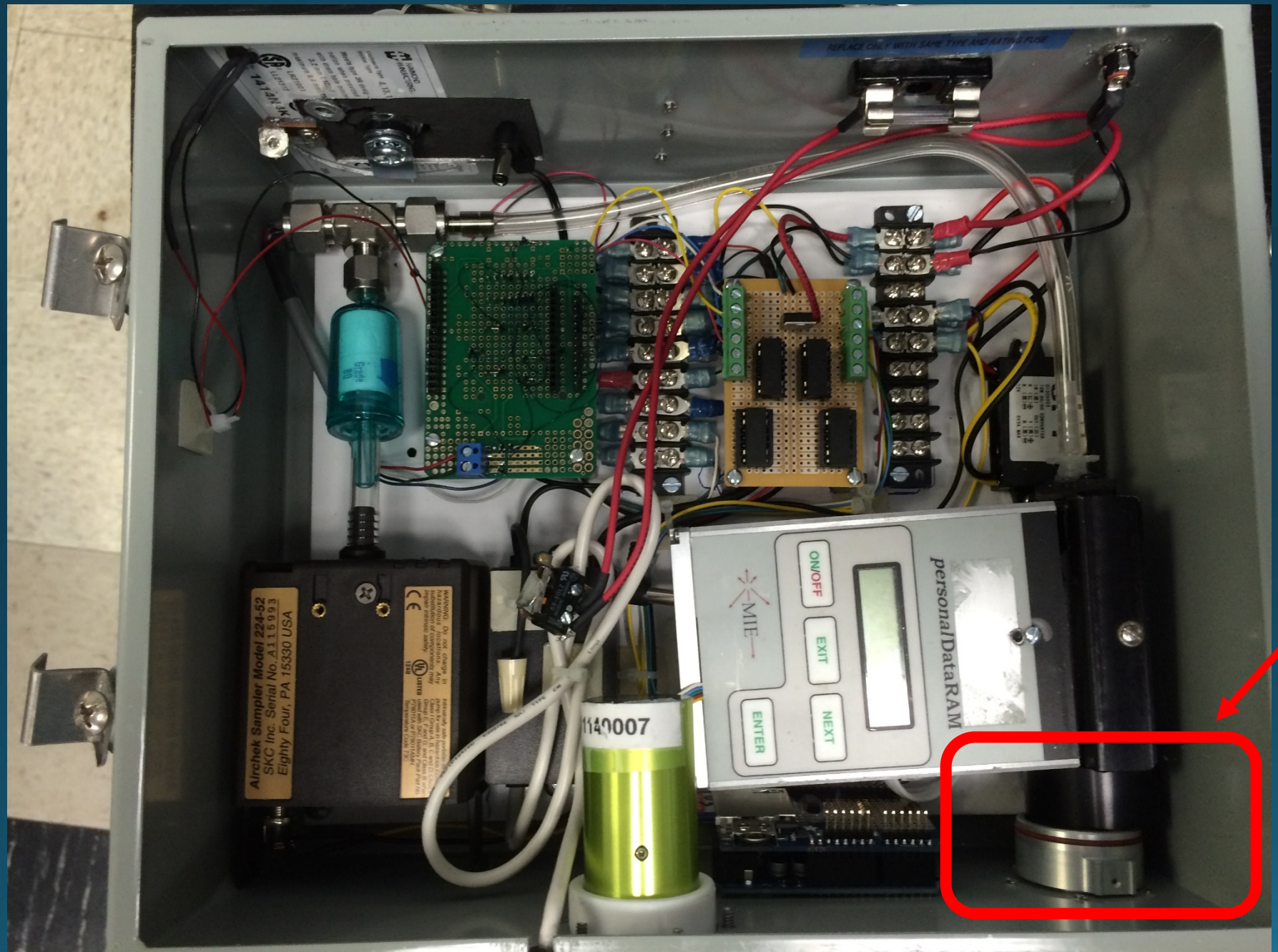
R2 DESA Repairs for Durability/Ruggedness

Installation of retaining rings to secure Arduino board



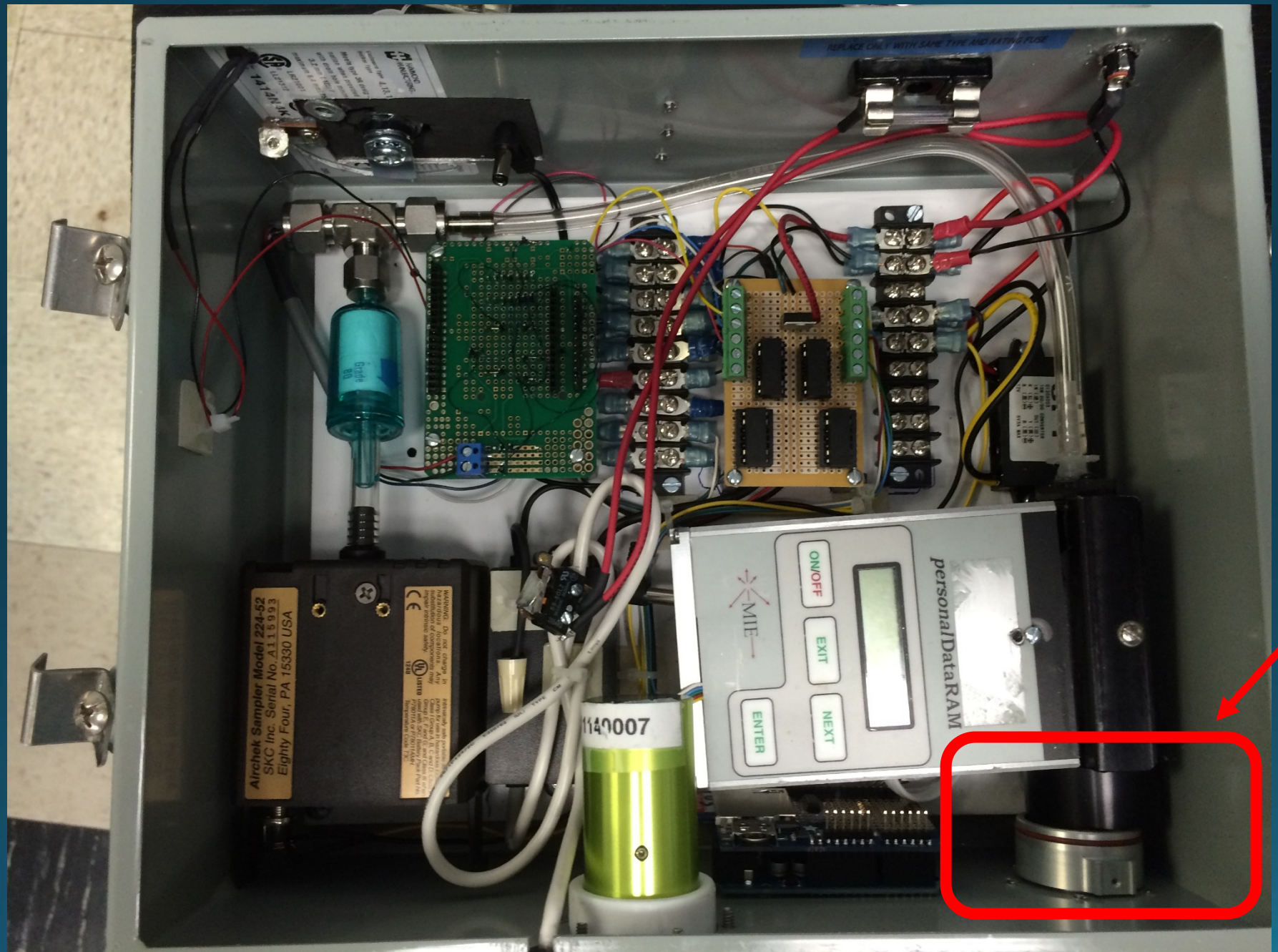
Cable tie to secure SS tee that was knocking Arduino board off its mounting pins

Instrument Design



Note misaligned particulate sampler/sharp cut cyclone head for particulate monitoring

Instrument Design

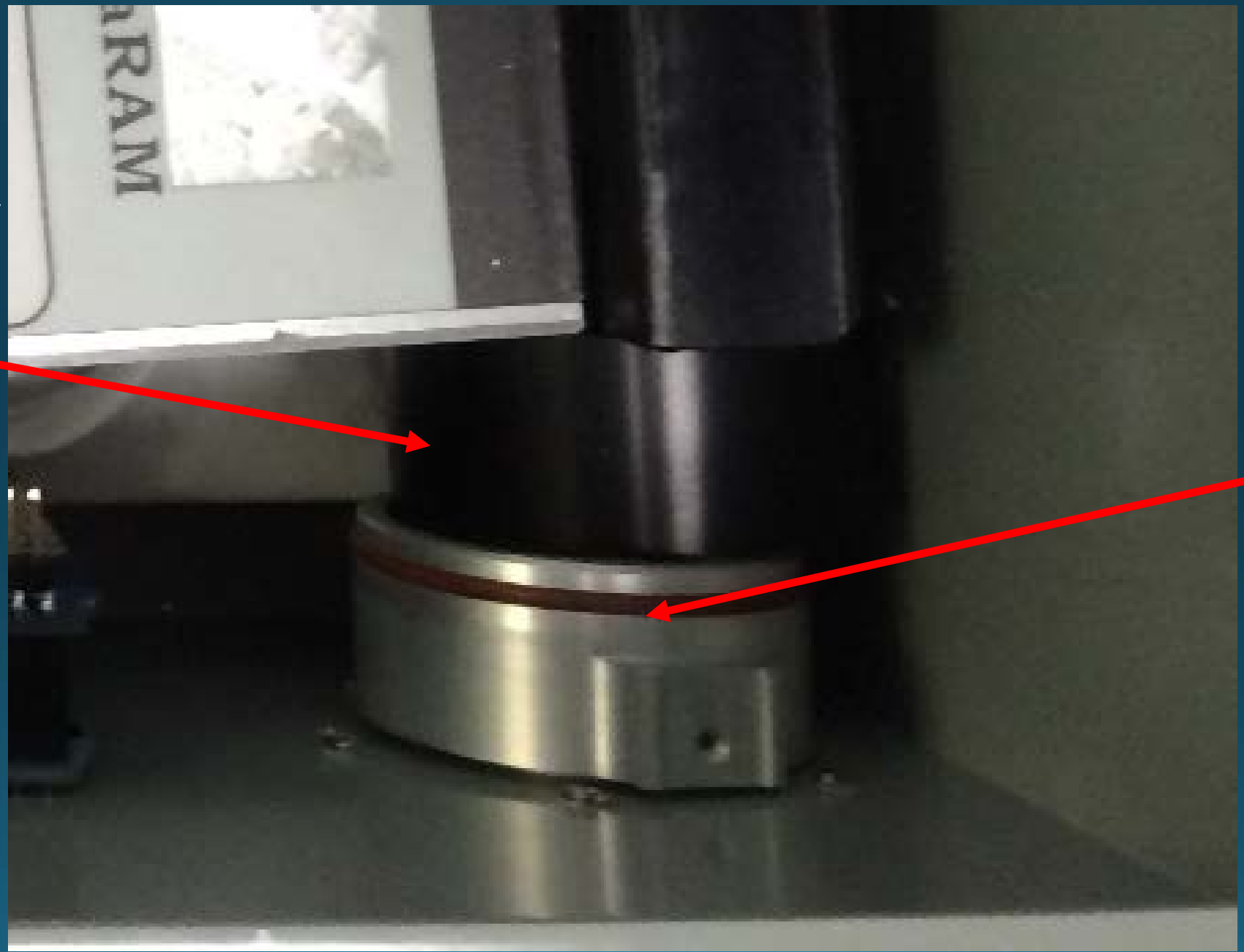


Note misaligned particulate sampler/sharp cut cyclone head for particulate monitoring

Instrument Design

Closeup of misaligned particulate counter/sharp cut cyclone head for particulate monitoring.

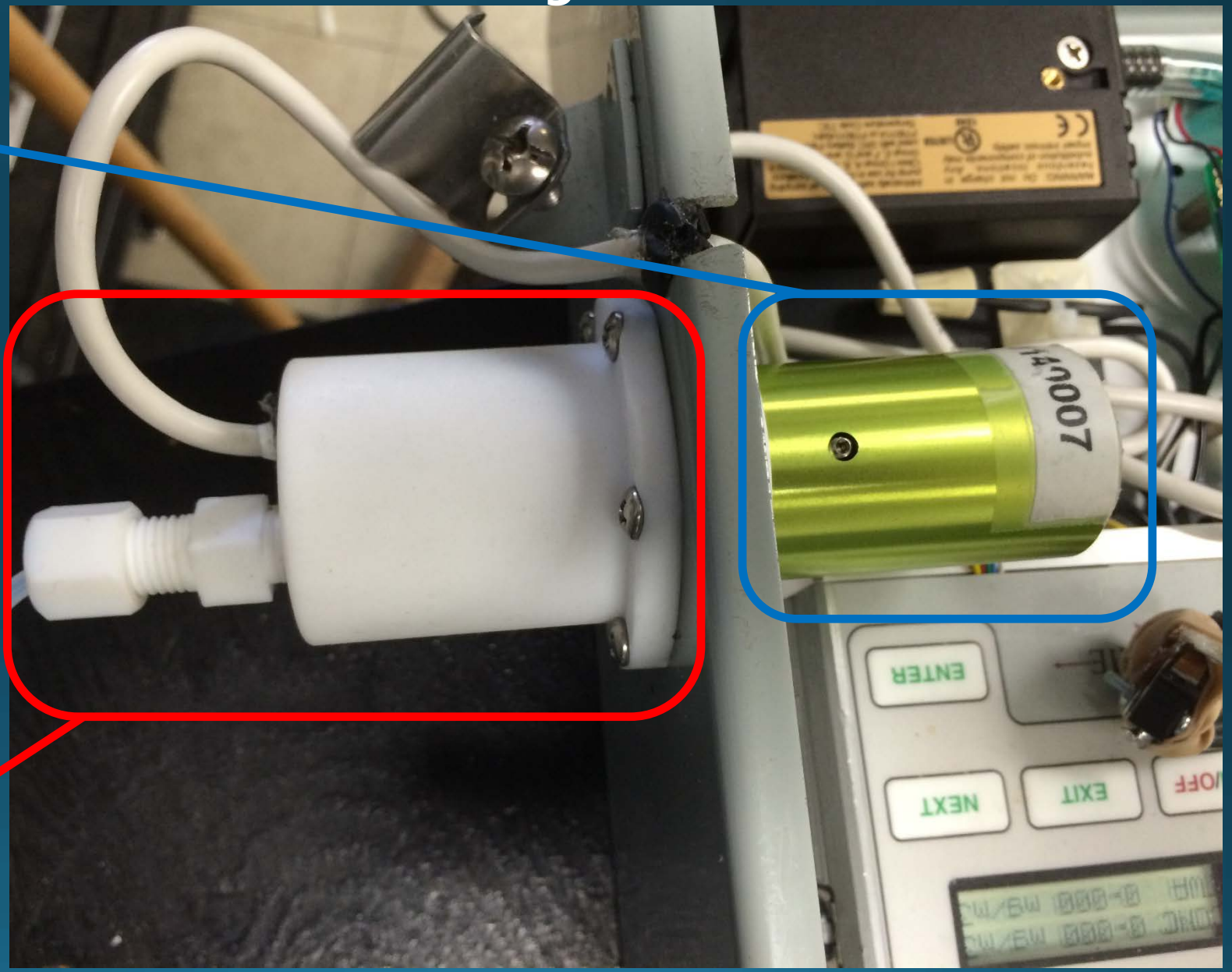
All 4 samplers arrived misaligned and would not stay aligned with even small amounts of movement or transport.



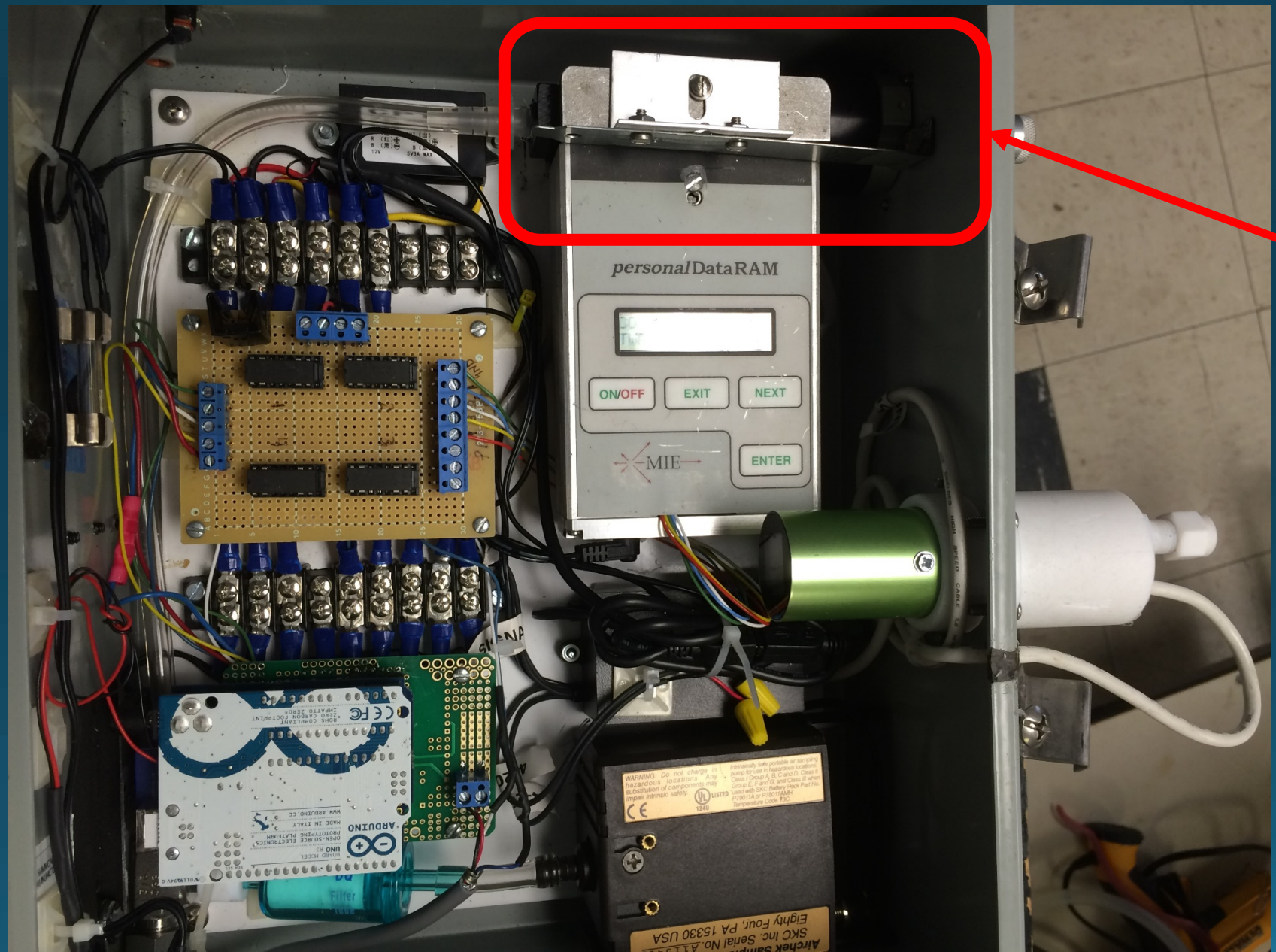
Instrument Design

NO_2 Sensor

Dead Volume



R2 DESA Repair of Instrument Design Flaws



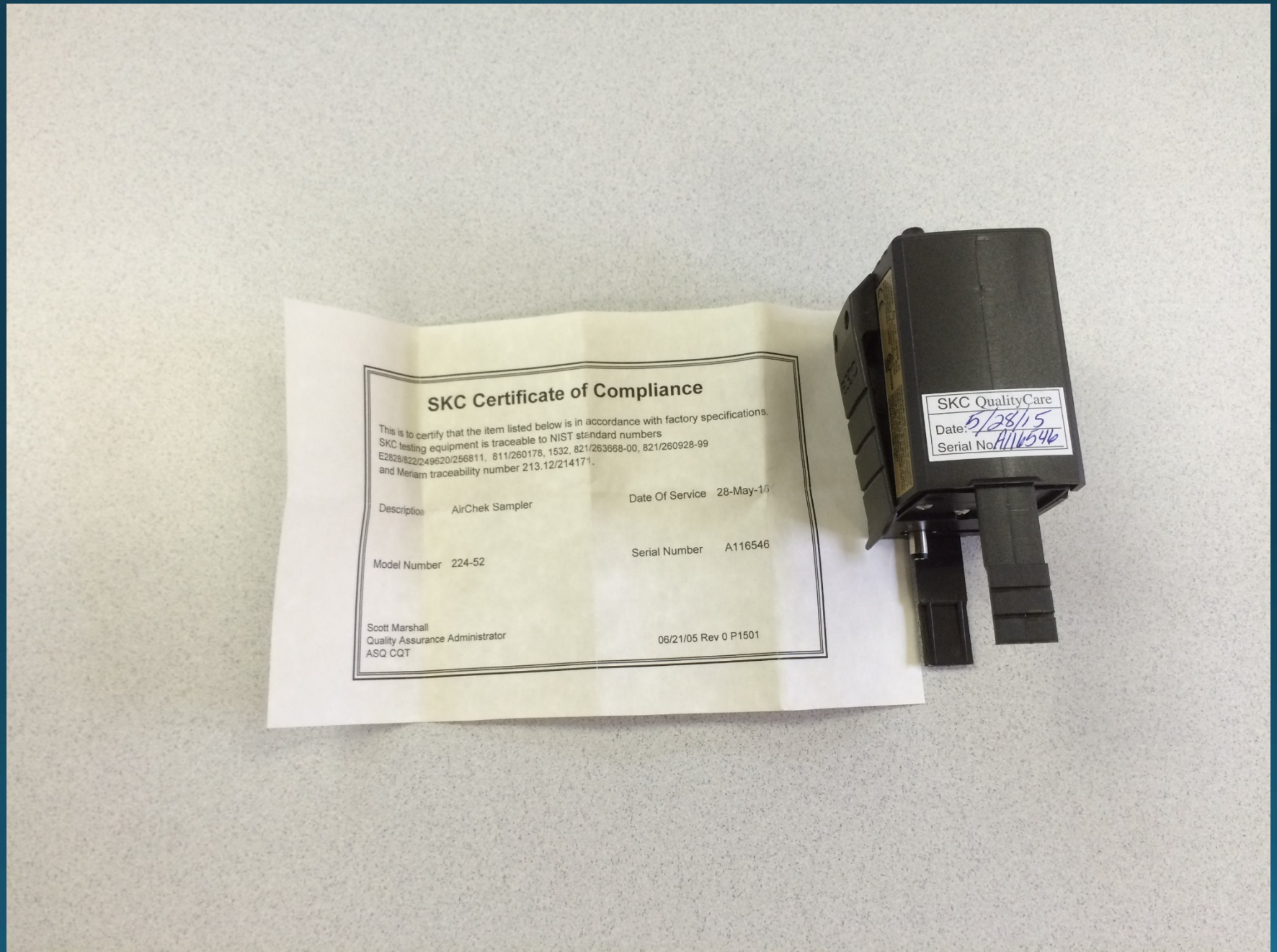
Installation of mounting bracket to ensure stable coupling of the particulate counter and the sharp cut cyclone.

R2 DESA Repair of Instrument Design Flaws

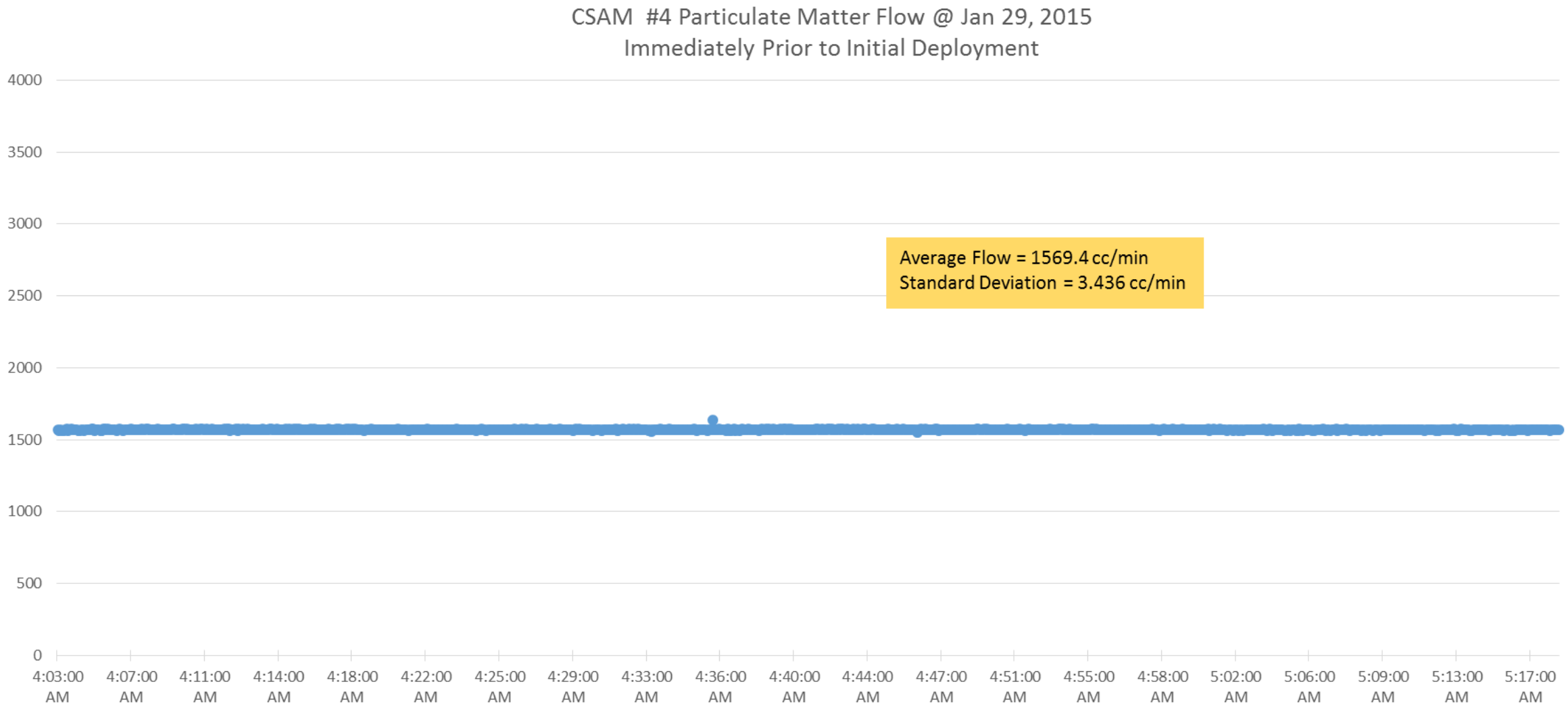
Detail of installed mounting bracket.

Reliability

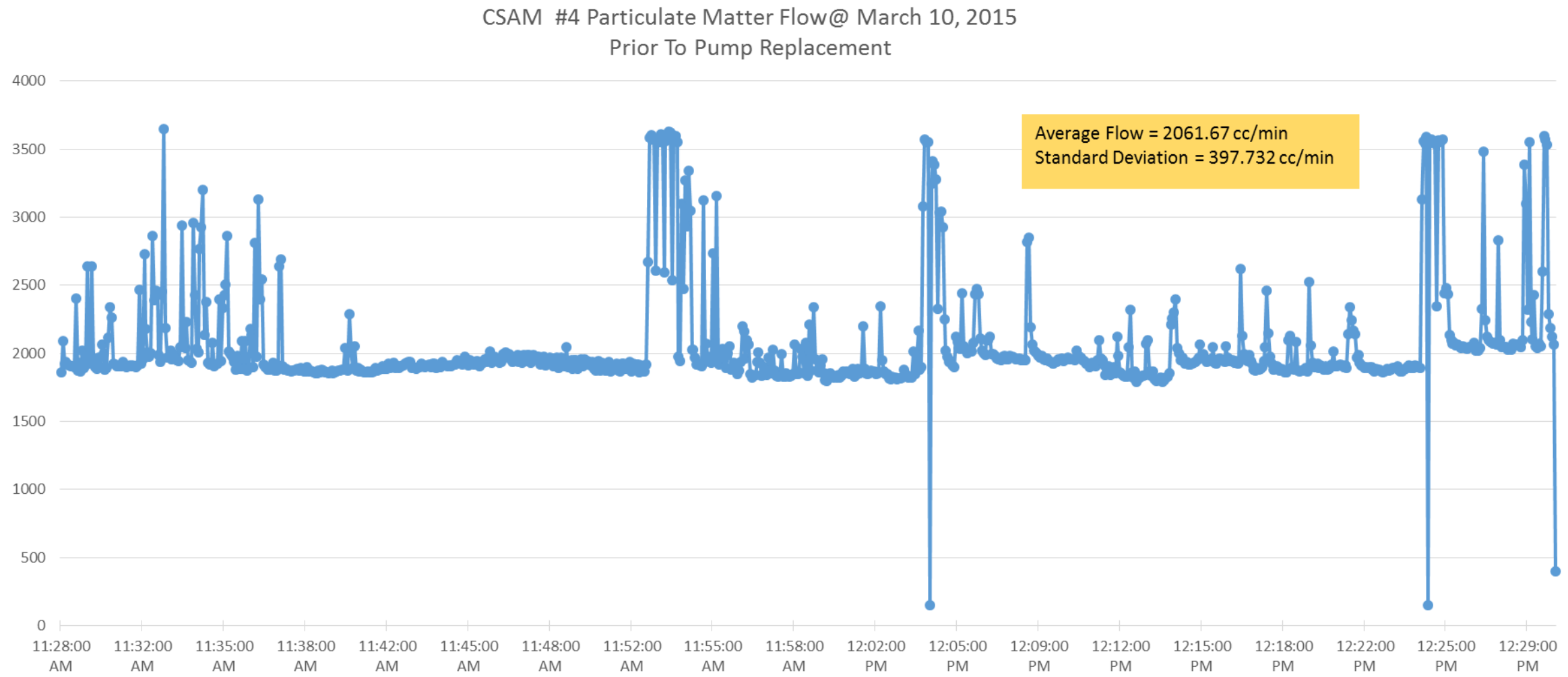
Reliability



Reliability



Reliability



Reliability

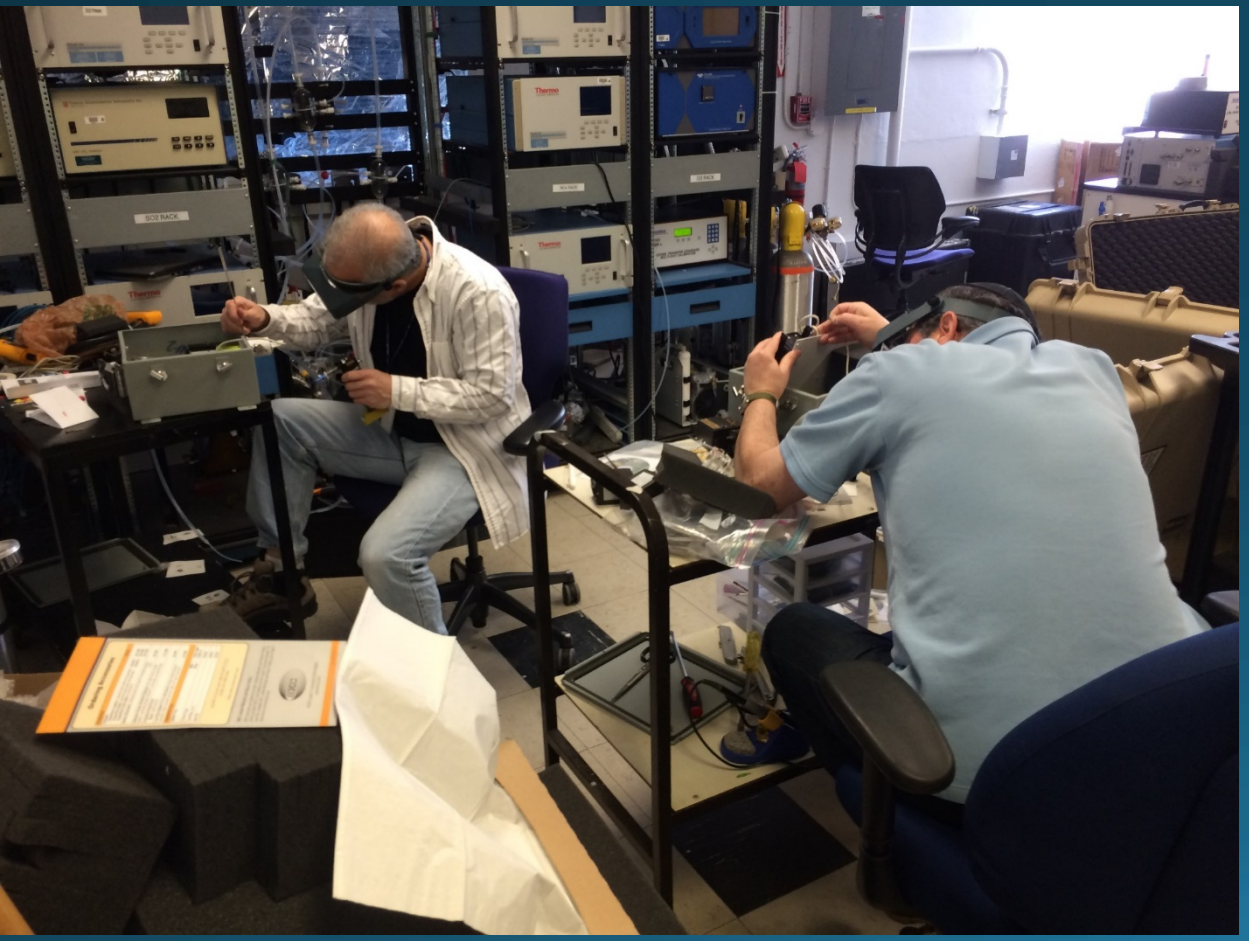
During the course of the study, pumps were replaced 7 times.

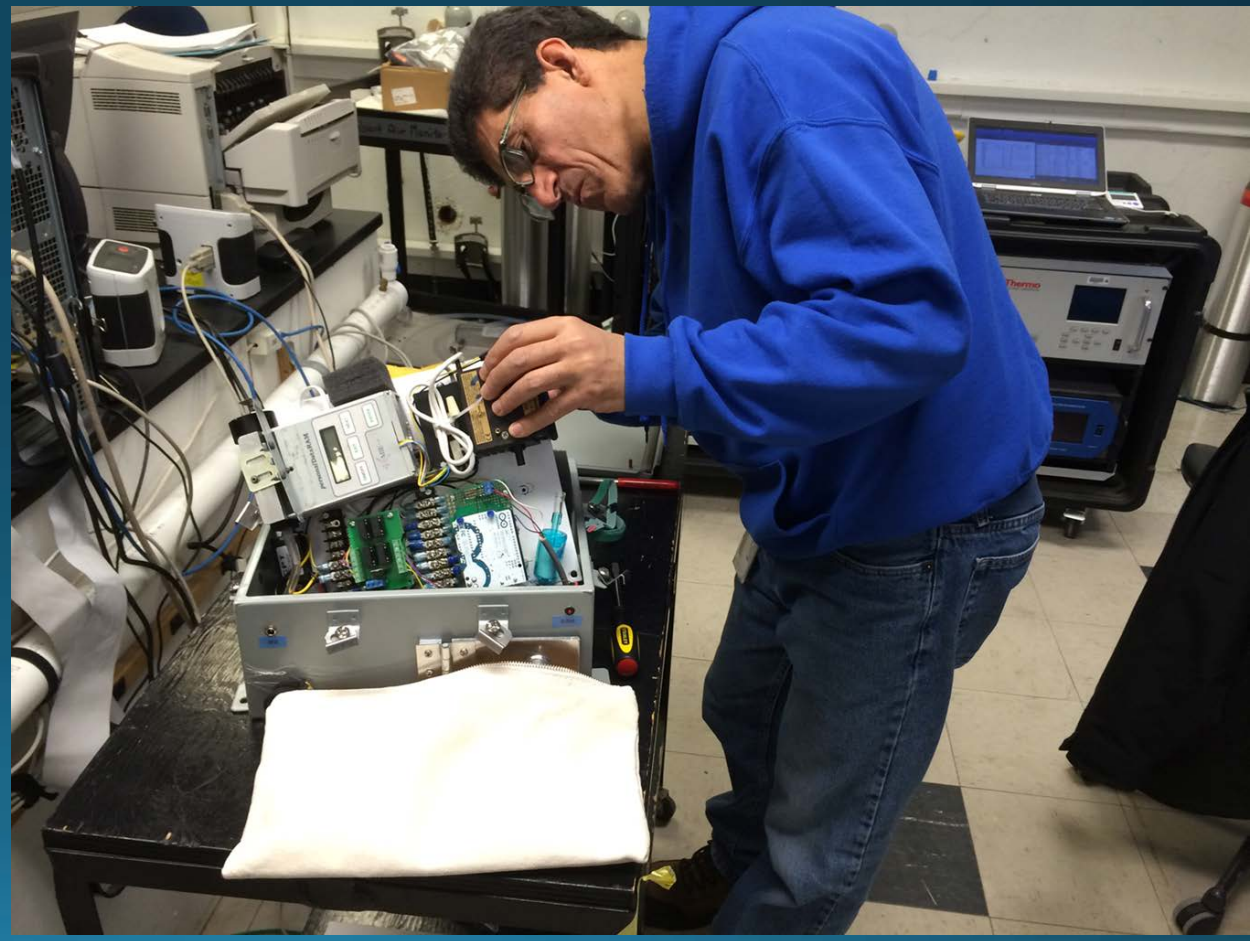
There were only 4 samplers in the study.

Pumps either had unreliable flow, intermittent flow, or stopped altogether.

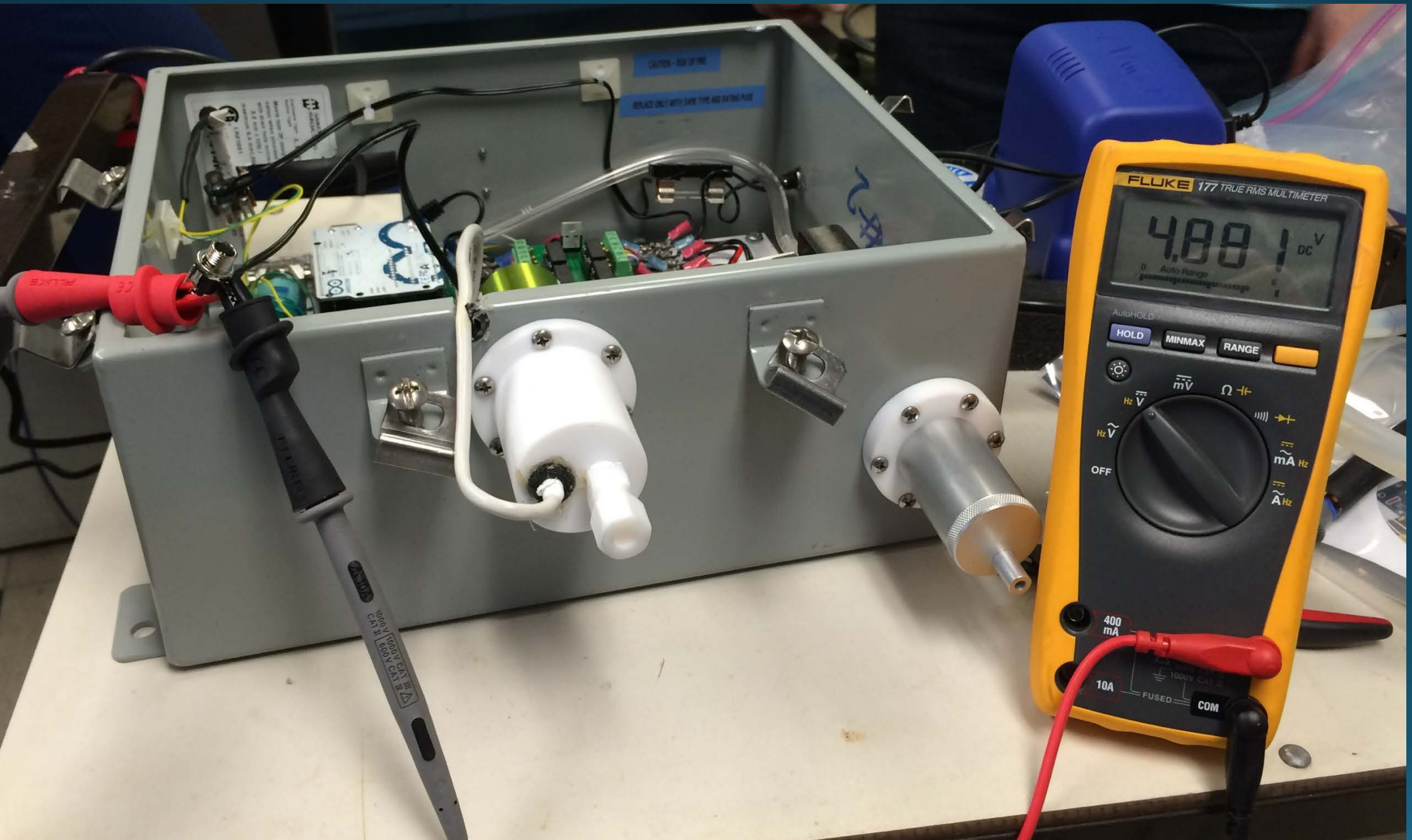
DNU =
Do Not Use

R2 DESA Staff Replacing Pumps @ Edison Lab





R2 DESA Reliability Repair



Checking voltages after a pump failed to start. Problem linked to poor connector contact at pump.

R2 DESA Reliability Repair

Bench testing CSAM samplers overnight.

Comparison w/ Established Reference Analyzers & Standards

Flow Measurements

NO_2 measurements

R2 DESA conducted Reference and Equivalent Methods Comparison at NJDEP Ncore station

R2 DESA Comparison w/ Established Reference Analyzers & Standards – Flow Measurements

R2 DESA Comparison w/ Established Reference Analyzers & Standards
NO_2 Measurements

R2 DESA Comparison w/ Established Reference Analyzers & Standards
NO_2 Measurements

Note difference in span voltages between the contractor determined vs. EPA determined NO_2 sensor voltages

	Contractor Determined Zero & Span Points			EPA R2 Determined Zero & Span Points		
CSAM UNIT #1	**NO2**			**NO2**		
	Zero/Low Voltage	39.42	mV	Zero/Low Voltage	252.34	mV
	Zero/ Low Setpoint	0	ppb	Zero/ Low Setpoint	0	ppb
	Span Voltage	2909	mV	Span Voltage	4743.36	mV
	Span Set Point	231	ppb	Span Set Point	188	ppb
CSAM UNIT #2	**NO2**			**NO2**		
	Zero/Low Voltage	42.31	mV	Zero/Low Voltage	117.02	mV
	Zero/ Low Setpoint	0	ppb	Zero/ Low Setpoint	0	ppb
	Span Voltage	2711	mV	Span Voltage	4796.28	mV
	Span Set Point	231	ppb	Span Set Point	188	ppb
CSAM UNIT #3	**NO2**			**NO2**		
	Zero/Low Voltage	67.44	mV	Zero/Low Voltage	138.35	mV
	Zero/ Low Setpoint	0	ppb	Zero/ Low Setpoint	0	ppb
	Span Voltage	1307	mV	Span Voltage	4861.71	mV
	Span Set Point	231	ppb	Span Set Point	188	ppb
CSAM UNIT #4	**NO2**			**NO2**		
	Zero/Low Voltage	36.75	mV	Zero/Low Voltage	33.81	mV
	Zero/ Low Setpoint	0	ppb	Zero/ Low Setpoint	0	ppb
	Span Voltage	2923	mV	Span Voltage	4714.54	mV
	Span Set Point	231	ppb	Span Set Point	188	ppb

R2 DESA Comparison @ NJDEP Ncore Station in Newark

4 CSAM samplers were deployed on the roof of NJDEP's Ncore station at the Clinton Avenue Firehouse in Newark, NJ.

CSAM Flow failures at Collocation Study @ Ncore Station

CSAM Flow Rates During Ncore Collocation Study

(4/7 - 4/14, 2015)

Date	CSAM #1		CSAM #2		CSAM #3		CSAM #4	
	Flow on Arrival @ Newark Ncore Station (L/min)	Flow on Departure @ Newark Ncore Station (L/min)	Flow on Arrival @ Newark Ncore Station (L/min)	Flow on Departure @ Newark Ncore Station (L/min)	Flow on Arrival @ Newark Ncore Station (L/min)	Flow on Departure @ Newark Ncore Station (L/min)	Flow on Arrival @ Newark Ncore Station (L/min)	Flow on Departure @ Newark Ncore Station (L/min)
4/7/2015	1.5	1.5	3.3	1.5	1.5	1.5	2.0	1.5
4/8/2015	1.5	1.5	**0.0**	1.5	1.5	1.5	**0.0**	1.5
4/9/2015	1.5	1.5	**0.0**	1.5	1.5	1.5	**0.0**	1.5
4/13/2015	1.5	1.5	**0.0**	1.3	1.6	1.6	**0.0**	1.5
4/14/2015	1.5		**0.0**		1.5		**0.0**	

CSAM Units 2 & 4 consistently showed zero flow when we arrived at the station. Resetting and/or adjusting the pump set screw would result in an acceptable flow rate. We would then depart the station. The next time we would arrive at the station, the flow would again be zero for CSAM 2 & 4.

Level of Support

R2 DESA dedicated hundreds of staff hours to make this study succeed.

This was partially due to:

- Citizen Science organization sampler requirements (Particulates, NOx, 1 week unattended operation)
- Custom designed samplers
- Contractor assembly

Lessons Learned

Practical considerations are critical in the success or failure of any citizen science study.

If possible, use off the shelf and established instruments/sensors with proven track records . This will eliminate “teething pains” with unique instrumentation from vendors/contractors with limited or costly manufacturing and support capabilities.

Comparison with reference sensors/analyzers is critical for drawing conclusions from the ambient data collected. If possible collocate with reference instruments at monitoring stations operated by State/Local agencies.

A successful project requires dedicated resources. Resources for maintenance and operational support need to be built into project planning considerations.