Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

A New Generation of In Situ Instruments for Stratospheric Aerosol and CN Measurements

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Background

- In situ measurements of stratospheric aerosol have been made from Laramie Wyoming, since 1971
- There have been both personnel and instrument changes made over the past ~~45~~ 46 years
- The current instrumentation and PI are nearing retirement
- Designing a new generation of smaller/lighter/cheaper instruments and moving operations to Boulder

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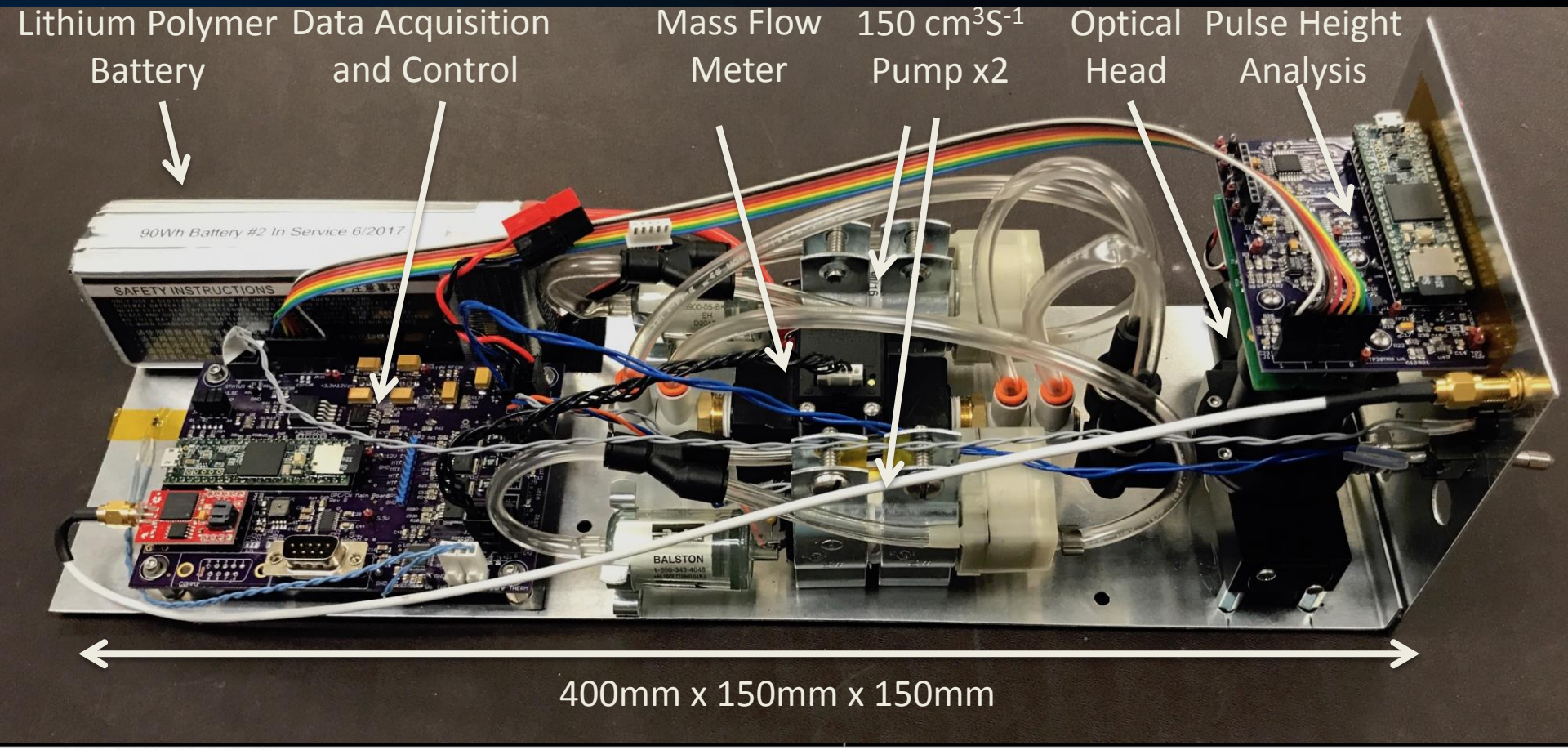
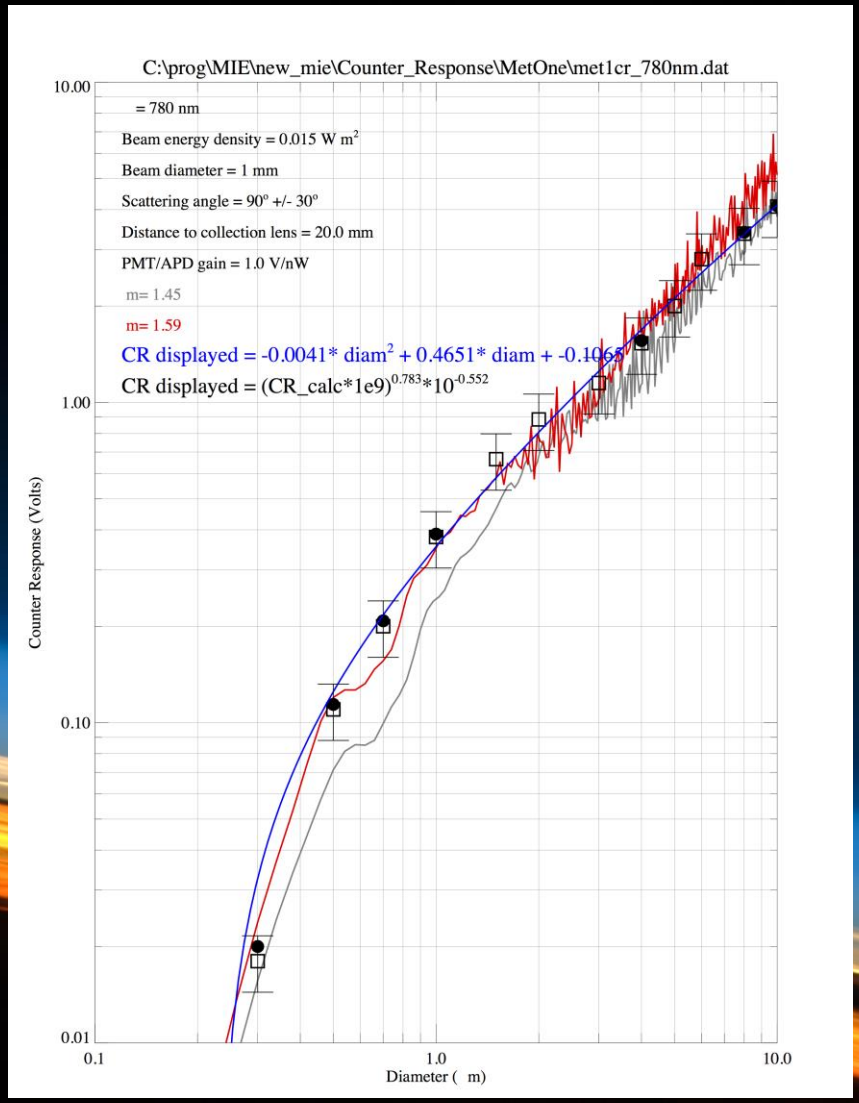
Instrument Status

- Since the last meeting in Potsdam (2016):
  - NSF has provided funding for the development and test of a new Condensation Nuclei Counter (CNC) and the LASP Optical Particle Counter (LOPC)
  - Both instrument designs are complete
  - Final prototypes of both instruments have been built
  - Prototypes have undergone lab testing and calibration
  - Two test flights with legacy Wyoming instruments have been performed, both partially successful
  - Minor design revisions for serial production are underway

LASP Optical Particle Counter Prototype



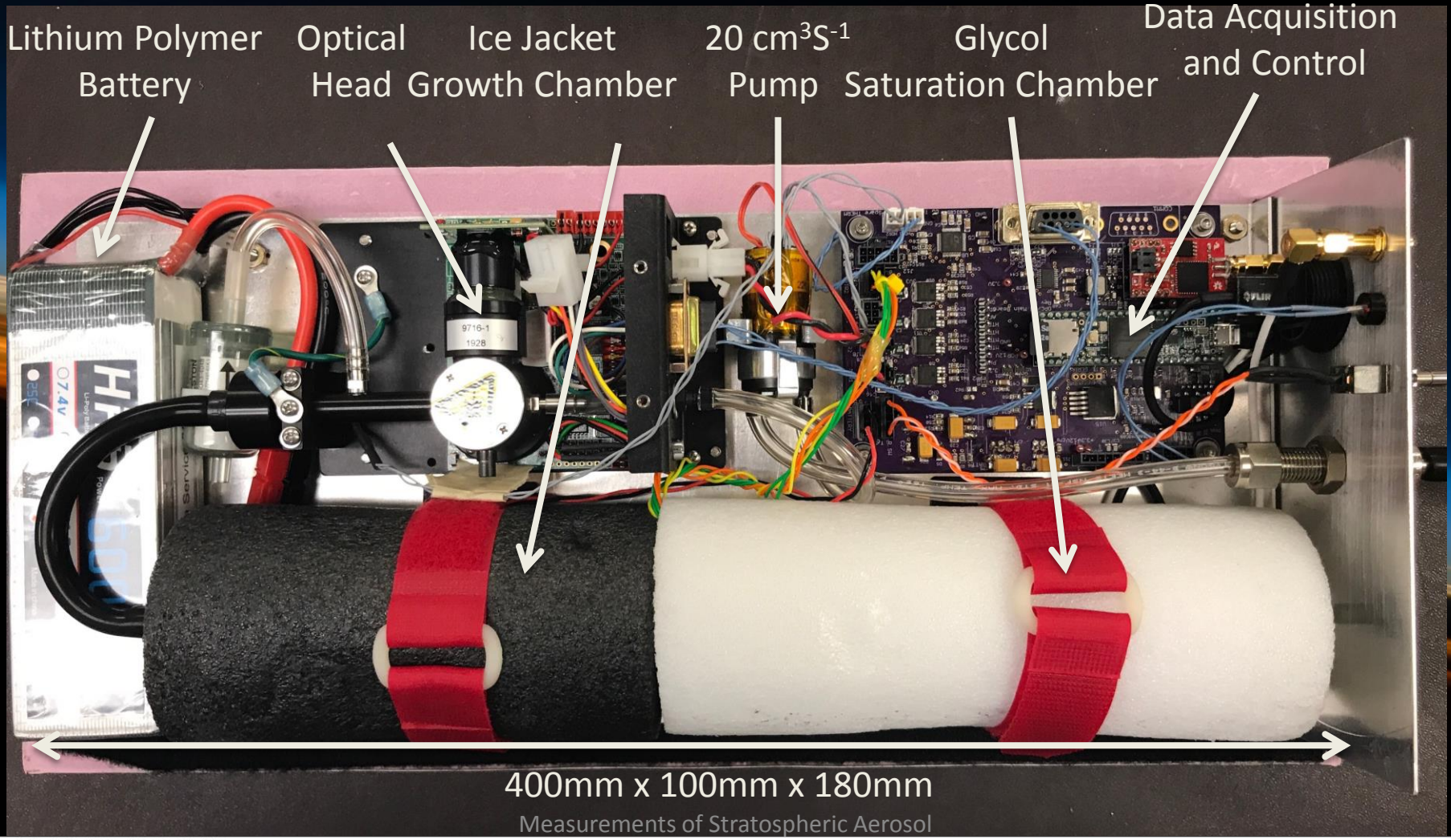


LOPC Counter Response Function. Red/Grey curves theoretical Response for refractive index of m = 1.59 and m = 1.45. Black points – laboratory measured response . Blue curve – quadratic fit to response function for online instrument transfer function

LOPC Specifications

Size Range (diameter)	0.25 – 15µm
Size Bins	2048 Raw, 1200 Effective, log spaced
Flow Rate	15 LPM (250 cm^3 per sample at 0.5Hz)
Concentration Range	10^{-3} – 10^3 cm^{-3} (at 0.1Hz)
Dimensions	40cm x 15cm x 15cm
Mass	2.4Kg (including battery)
Cost	~$5K (component cost)
Light Source	90mW 780nm Laser Diode
Detector geometry	90° Scattering angle, 60° Acceptance
Detector	APD, non linear gain, 2 gain stages

LASP Condensation Nuclei Counter Prototype



CNC Specifications

Minimum Detectable Size (diameter)	**> 0.015µm**
Flow Rate	**1 LPM (33 cm^3 per sample at 0.5Hz)**
Sensitivity	**10^{-2} – 10^3 cm^{-3} (at 0.1Hz)**
Dimensions	**40cm x 10cm x 18cm**
Operation Time	**4 hours**
Mass	**2.6Kg (including battery)**
Cost	**~$4K (component cost)**

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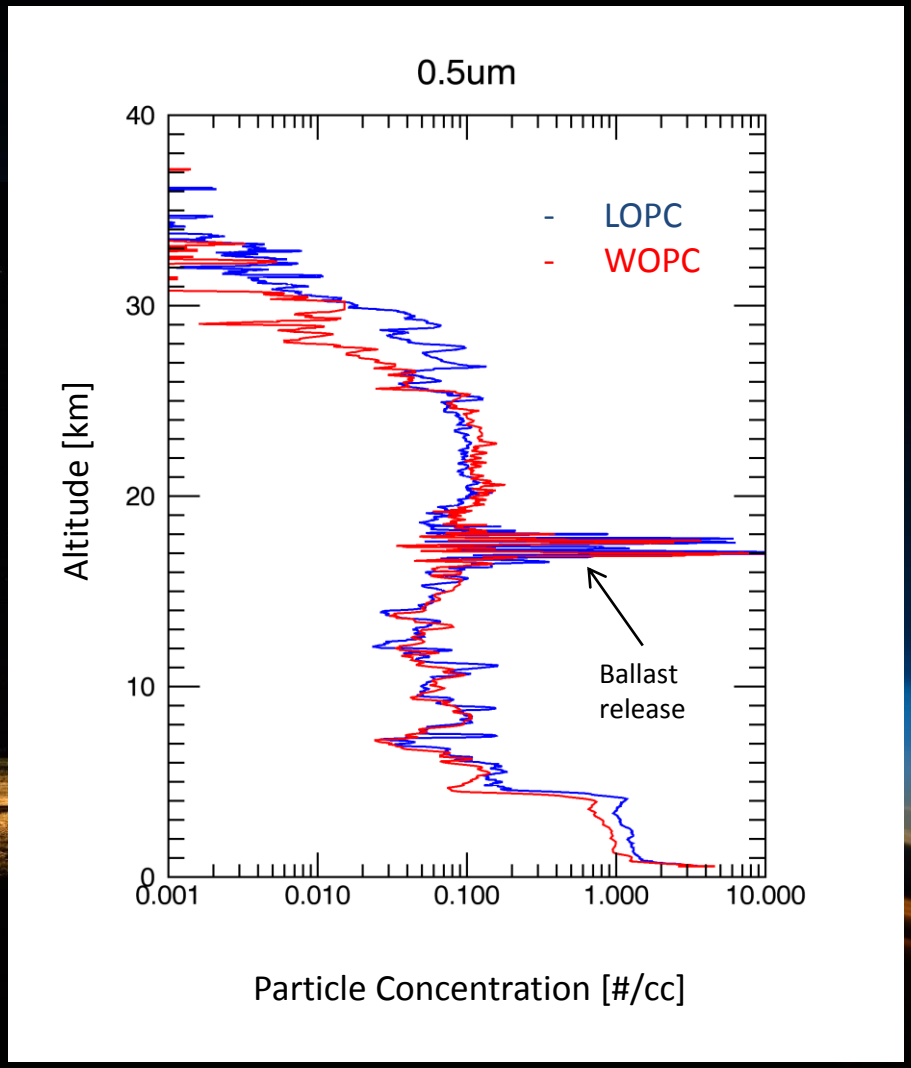
Results from test flights

AUSTRAL 2017 – April 2017, Alice Springs, Australia

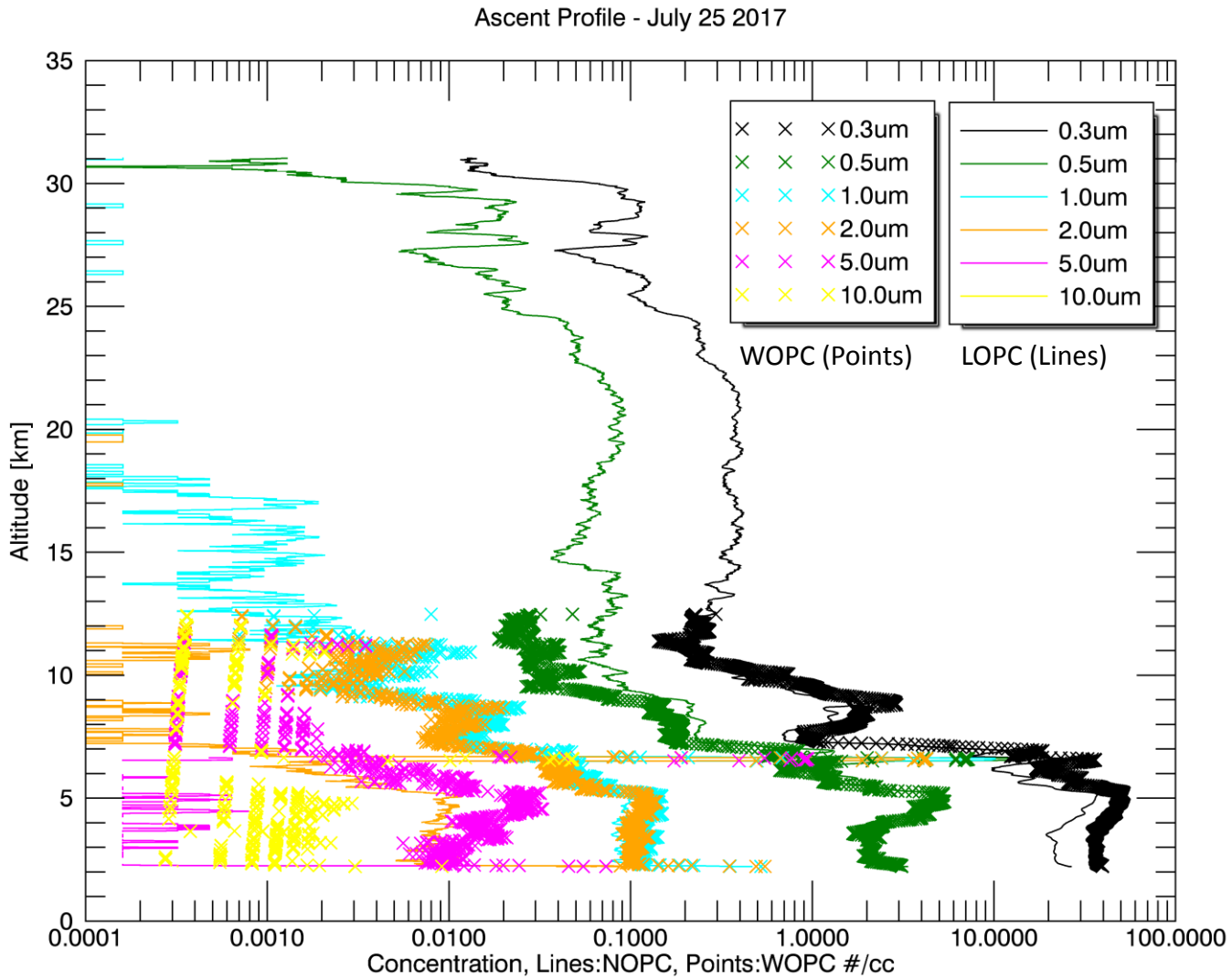
- WOPC/LOPC/CNC flight of opportunity as secondary payload on a joint CNES/CSA flight
- WOPC measured ascent profile
- LOPC functioned for entire 12 hour flight, issue identified in bandwidth of second stage amplification - biasing sizing
- CNC functioned for 5 hours of flight – flow rate (3lpm) too high for growth chamber



Results from test flights

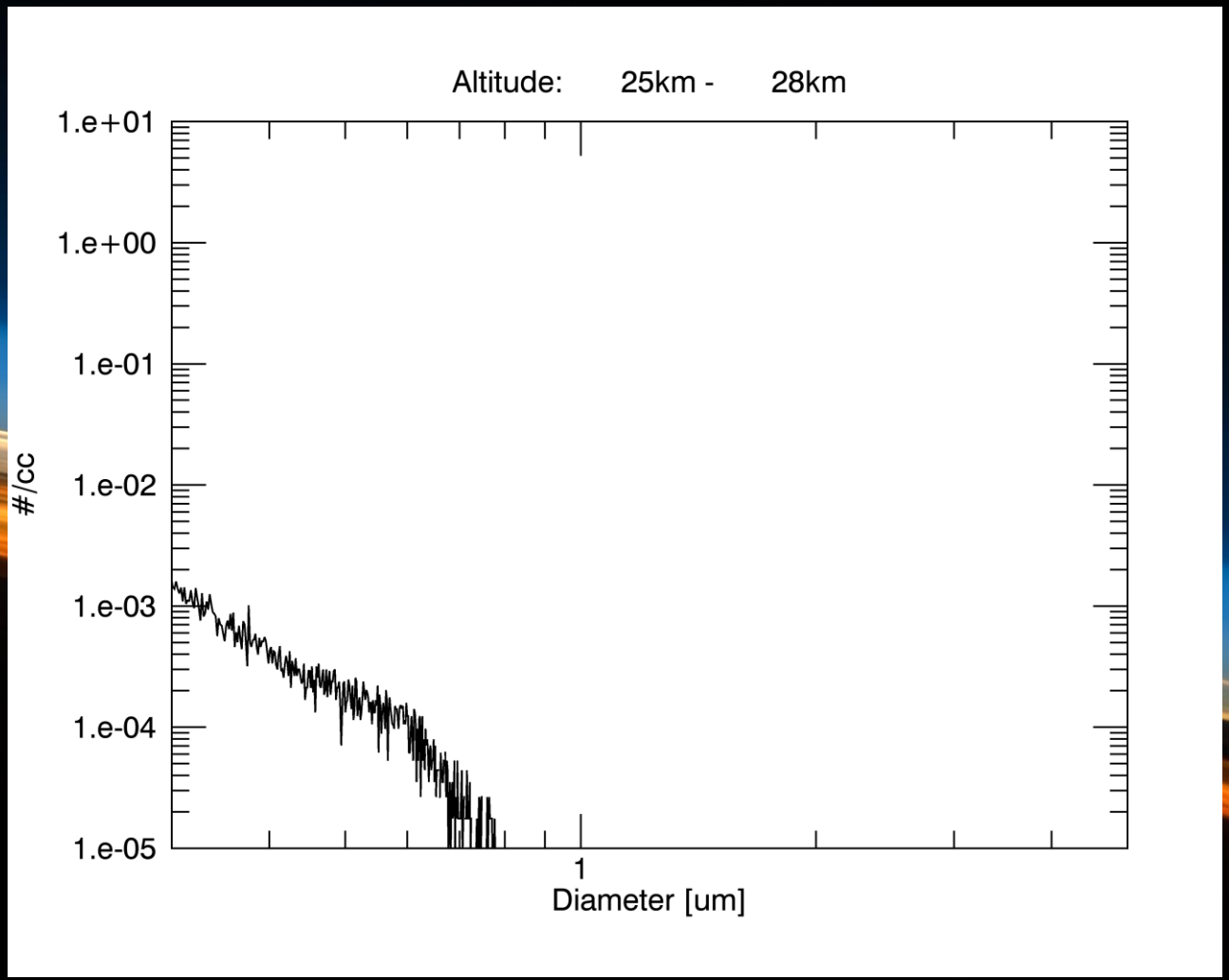
WY926 – July 2017, Laramie WY

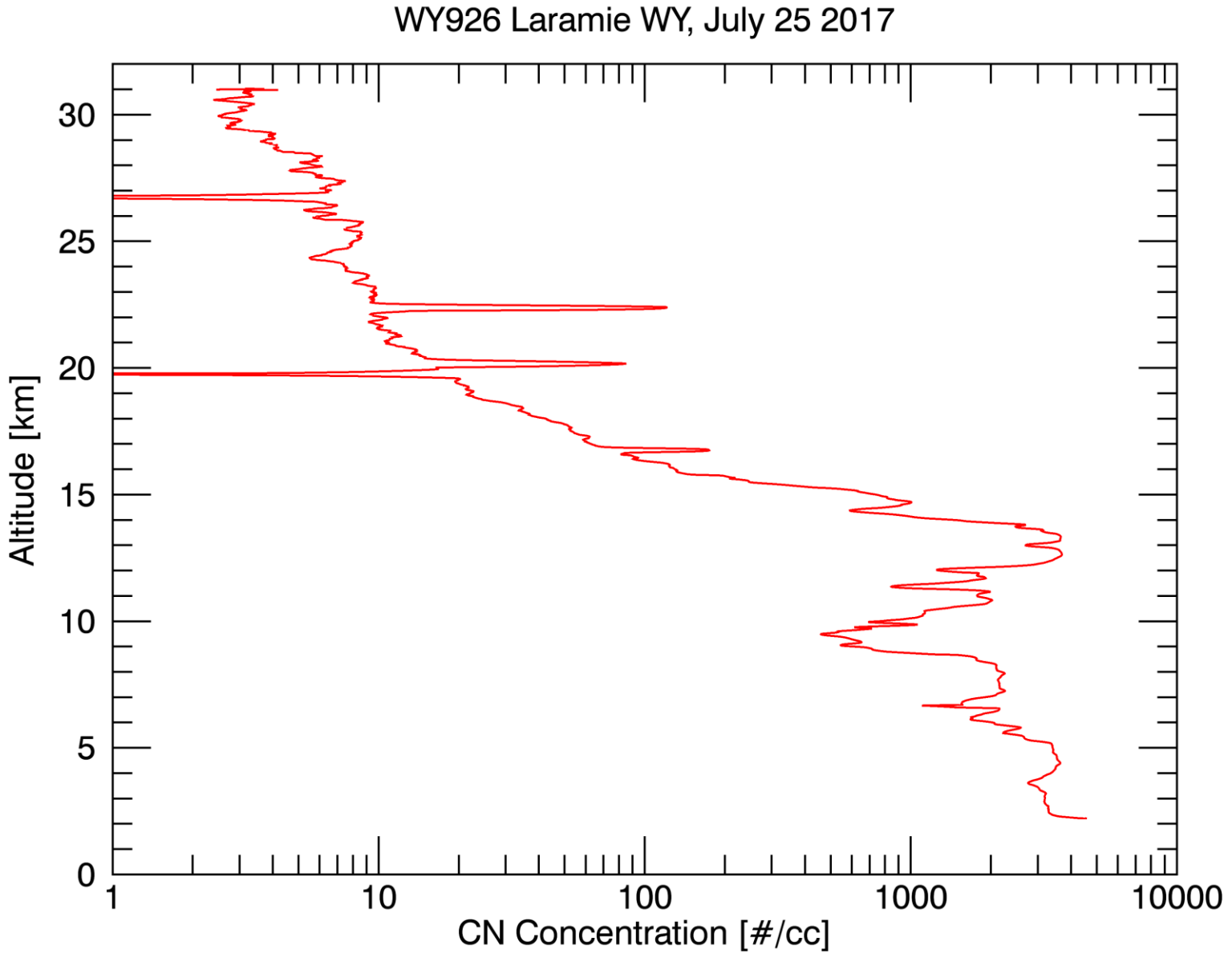
- WOPC/LOPC/CNC comparison flight
- LOPC and CNC performed well
- WOPC stopped reporting data at 12km

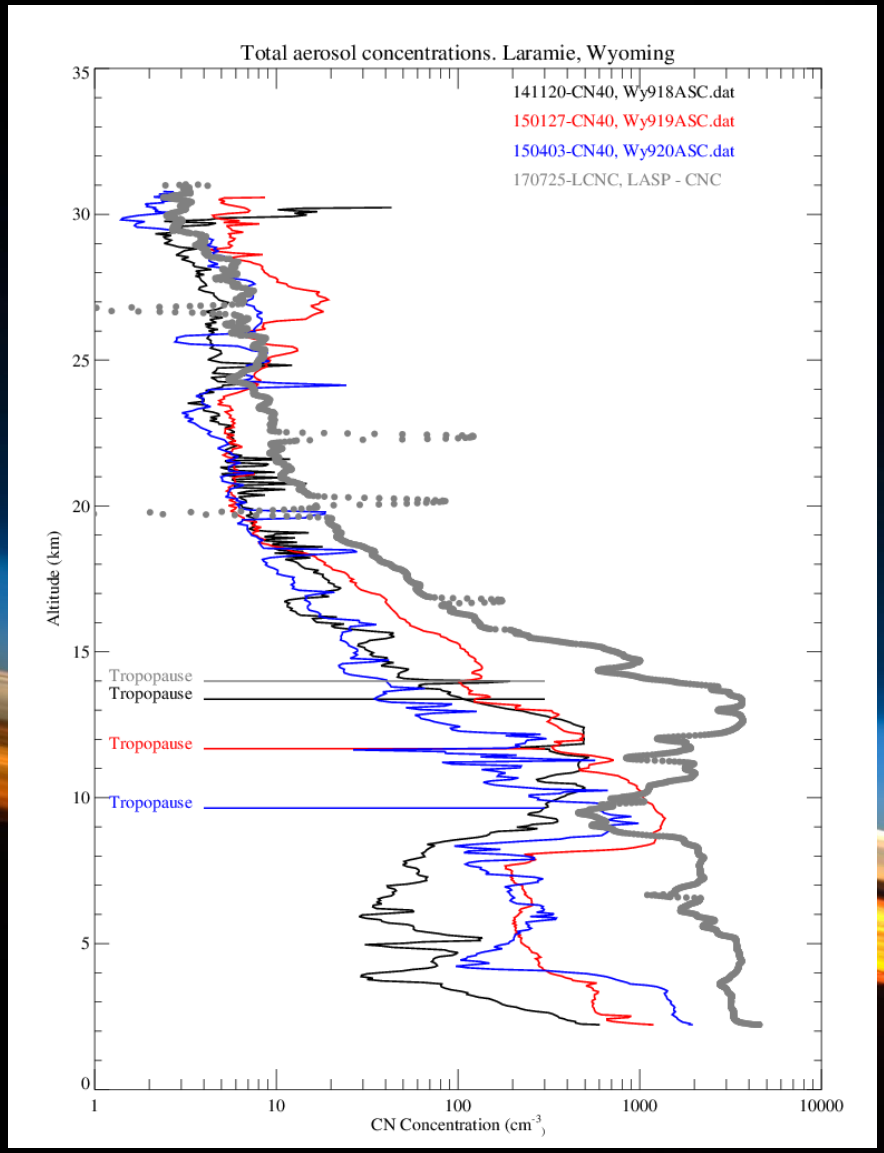


LOPC data (lines) down-sampled to WOPC channels (points). Cumulative distributions shown.

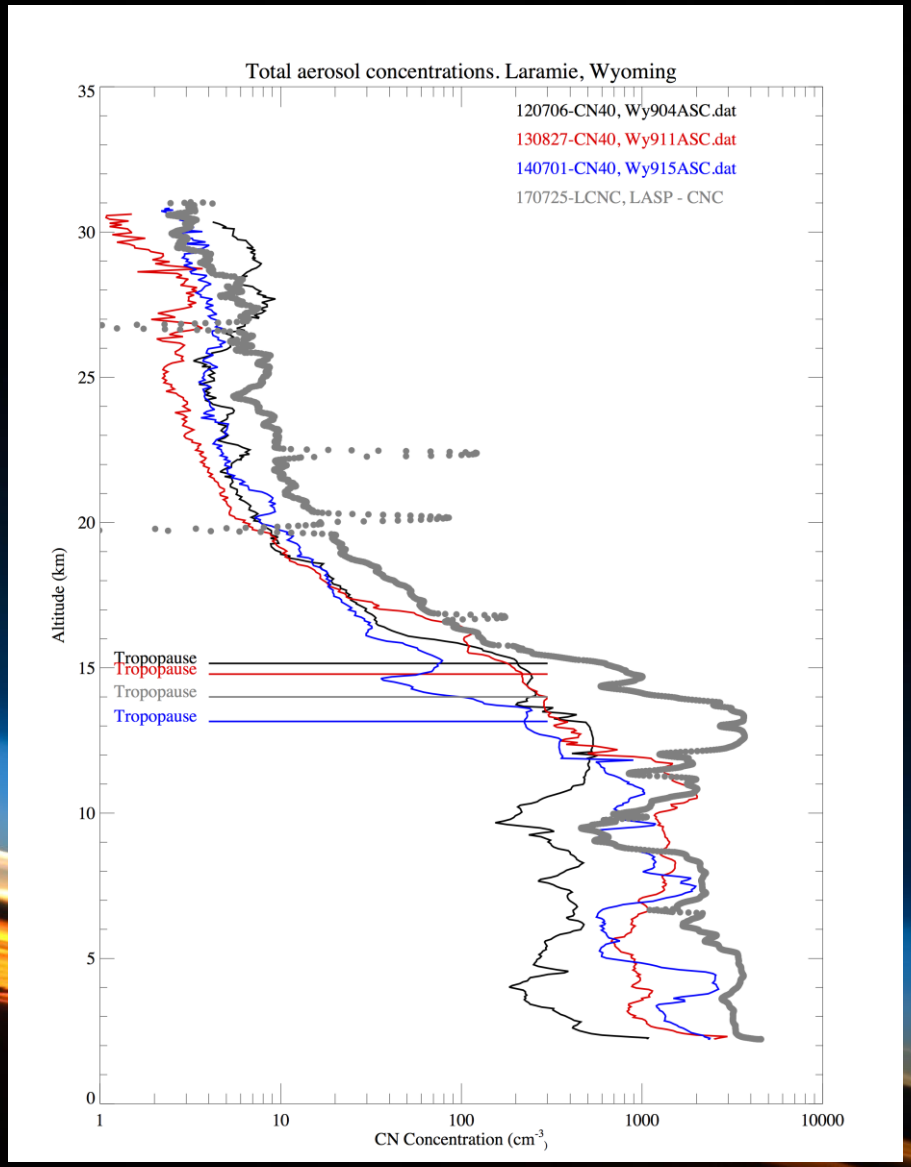
Size distributions as function of altitude



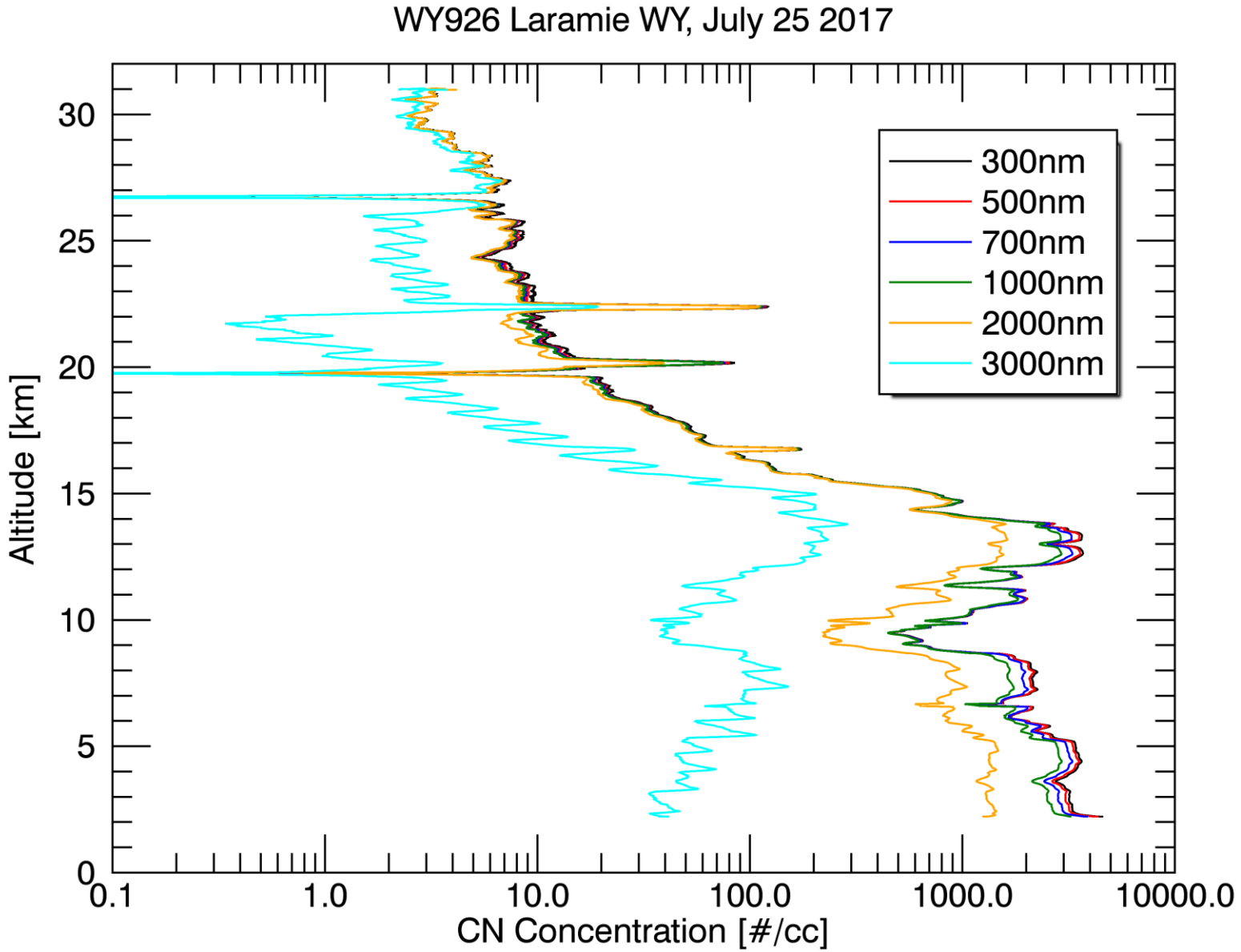

WY926 Laramie WY, July 25 2017
Altitude [km]
0
5
10
15
20
25
30
1
10
100
1000
10000
CN Concentration [#/cc]



CNC Compared to 3 most recent Wyoming CN profiles



CNC Compared to 3 recent Wyoming Summer CN profiles


WY926 Laramie WY, July 25 2017
Altitude [km]
0
5
10
15
20
25
30
0.1
1.0
10.0
100.0
1000.0
10000.0
CN Concentration [#/cc]
300nm
500nm
700nm
1000nm
2000nm
3000nm

Summary

- LOPC is in final prototype stage – minor revisions required for production instrument
- CNC final prototype is complete and ready for production
- 3-6 months to operational status
- High resolution size channels will provide more detailed size distributions with lower uncertainty
- Final instrument weights are lighter than expected, allowing FAA small balloon exemption and rubber balloon launches

Looking forward

- Two more test/validation flights scheduled for this autumn/winter
- Exploring avenues to fund continuation of 45 years of regular profiles.
- Looking for collaborations (validations, measurements of opportunity) to push instrument design forward and help support routine operations
- Developing satellite based telemetry, combined with small balloons and ‘disposable’ instruments for rapid deployment anywhere in the world
- Volcanoes, forest fires, overshooting convection etc.