Cloud Combination Probe (CCP)

Operator Manual

DOC-0226, Rev A

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Trademark Information

Warranty

The seller warrants that the equipment supplied will be free from defects in material and workmanship for a period of one year from the confirmed date of purchase of the original buyer. The probe owner will pay for shipping to DMT, while DMT covers the return shipping expense.

Consumable components, such as tubing, filters, pump diaphragms and Nafion humidifier are not covered by this warranty.

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1.0 Introduction

The CCP is a combination probe incorporating three basic measuring instruments to characterize cloud parameters. These include a Hot-wire Liquid Water Content Sensor (LWC-100), Cloud Droplet Probe (CDP), and a Cloud Imaging Probe (CIP). Full specifications of the CCP are given in section 1.2. The instrument meets the goals of measuring a large range of particle sizes—2 µm to 1.55 mm—with one probe, minimizing the space, cable connections, and data systems necessary for these measurements. The Particle Analysis and Display System (PADS), with an intuitive graphical user interface at the host computer, provides control of measurement parameters while simultaneously displaying real-time size distributions and derived parameters. Data interfaces are done via line drivers meeting the RS-232 or RS-422 electrical specifications.

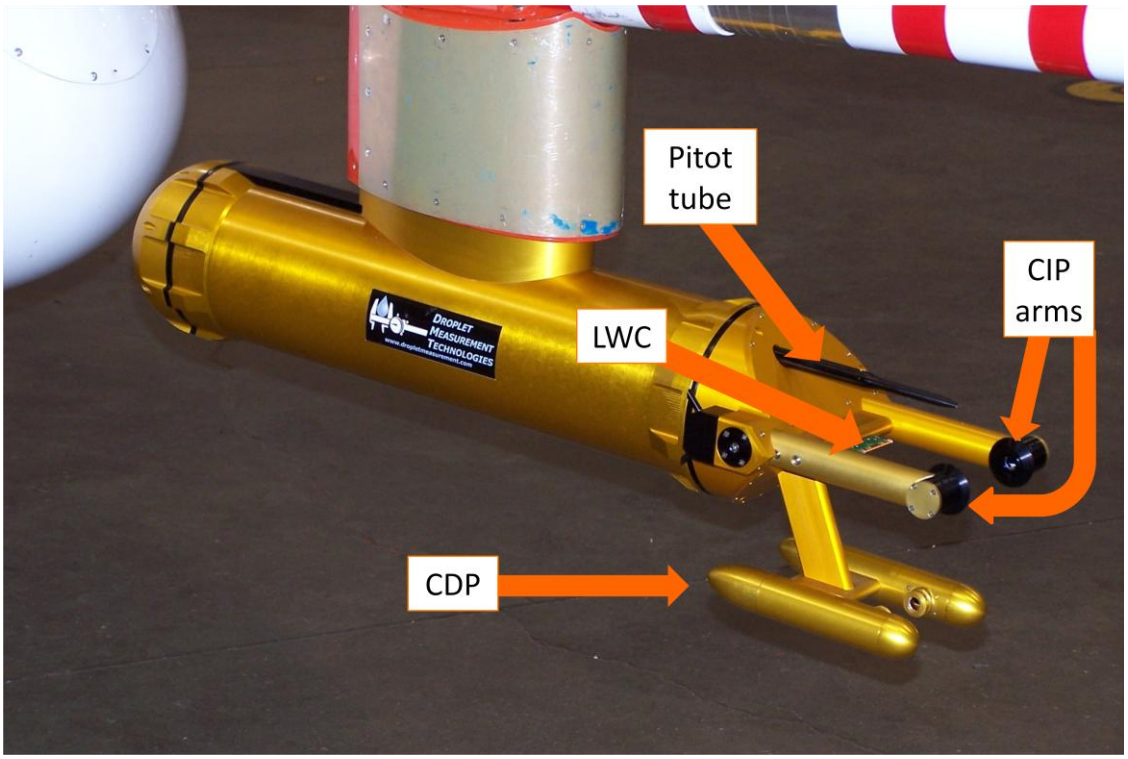

Figure 1: Cloud Combination Probe (CCP) with Important Components Labeled

1.1 Icing Applications

CCPs that are designed for icing conditions are frequently used in aircraft anti-icing certification. These probes provide detailed information about the cloud characteristics and freezing precipitation that aircraft encounter in flight. Moreover, CCPs can accurately assess the presence of supercooled large droplets (SLDs), an acknowledged

aviation hazard that has traditionally been difficult to measure. The CCP is DMT's single-package solution to cover the large particle range that FAA will likely require for aircraft icing certifications in the near future.

CCPs used in icing studies have additional heaters beyond the standard heaters of the CCP component instruments. These additional heaters, which are described in section 3.2, allow the instrument to operate in icing conditions.

1.2 CCP Specifications

1.2.1 Cloud Imaging Probe (CIP)

Technique:	Optical Array Probe with 64 elements: 62 sizing elements, end diodes reject
Measured Particle Size Range:	12.5 µm – 1.55 mm (for 25-µm resolution CIP)[i] 7.5 µm - 9.3 mm (for 15-µm resolution CIP)[i]
Sample Area:	10 cm x 1.55 mm (for 25-µm resolution CIP)[ii] 10 cm x .93 mm (for 15-µm resolution CIP)[ii]
Air Speed Range:	10 – 300 m/sec (for 25-µm resolution CIP)[iii] 10 – 180 m/sec (for 15-µm resolution CIP)[iii]
Number of Size Bins:	62
Sampling Frequency:	1D histogram data: 0.1 to 10 Hz[iv] 2D image data: variable interval, when buffer fills
Laser:	658 nm, 30mW; DMT-manufactured laser with Arima Lasers Corporation diode

[i] The minimum size for detected particles varies based on where on the diode array the particle falls. See the *Data Analysis User's Guide* for details.

[ii] The sample area varies based on the size of detected particles. See the **Sample Volume** entry under *Appendix B: Calculations* in the *PADS Operator Manual (DOC-0116)*. For the CIP, sample volume = sample area • TAS.

[iii] Maximum air speed depends on the CIP's resolution and maximum clock rate, as follows: Maximum TAS = resolution (µm) • clock rate (MHz) • 10^6 (MHz/sec) • 10^{-6} (m/µm). The maximum CIP clock rate is 12 MHz. Note that the 300 m/sec air speed maximum is largely theoretical and reflects only the constraints imposed by the CIP, not those of other instruments or the aircraft itself.

[iv] Versions of the Particle Analysis and Display System (PADS) earlier than 3.5 assume a sampling frequency of 1 sec / 1 Hz. As a result, this frequency is recommended if you are using PADS 2.7 or earlier.

Data System Interface:	1D: RS-232 or RS-422, 56.6 kb/sec Baud Rate 2D: RS-422, High Speed, 4 Mb/sec Baud Rate
Auxiliary Parameters:	Ambient Temperature, Relative Humidity, Static Pressure, Dynamic Pressure
Calibration:	Spinning glass disk with opaque dots of known size

1.2.2 Cloud Droplet Probe (CDP)

Technique:	Light-scattering probe with 10, 20, 30 or 40 size bins
Measured Particle Size Range:	2 µm – 50 µm
Typical Sample Area:	0.24 mm^2
Air Speed Range:	10 - 200 m/sec[v]
Sampling Frequency:	Selectable, 0.1 to 10 Hz[vi]
Refractive Index:	non-absorbing, 1.33[vii]
Light Collection Angles:	4° - 12°
Laser:	658 nm, up to 50 mW; DMT-manufactured laser with Hitachi diode
Data System Interface:	RS-232 or RS-422 serial interface
Calibration:	Precision glass beads

[v] This is the range for which the Pitot is properly calibrated and the electronics can clock appropriately.

[vi] Versions of the Particle Analysis and Display System (PADS) earlier than 3.5 assume a sampling frequency of 1 sec / 1 Hz. As a result, this frequency is recommended if you are using PADS 2.7 or earlier.

[vii] A refractive index of 1.33 is the industry standard. Contact DMT for support for measuring particles with other refractive indexes.

1.2.3 Liquid Water Content Sensor (LWC-100)

Technique:	Temperature-Controlled Hot-wire Sensor
Liquid Water Range:	$0 - 5\ g/m^3$
Air Speed Range:	10 – 200 m/sec
Sampling Frequency:	Selectable, 0.1 to 10 Hz[viii]
Data System Interface:	RS-232 or RS-422, 56.6 kb/sec Baud Rate
Auxiliary Parameters:	Ambient Temperature, Static Pressure, Dynamic Pressure, Airspeed
Calibration:	Not required

1.3 Electrical Specifications

The CCP has four busses:

System Power bus: 28 VDC
Auxiliary bus (formerly "LWC bus"): 28 VDC
CIP Anti-Ice bus: 28 VDC
CDP Anti-Ice bus: 28 VDC

Note: *Standard CCP system power is 28 VDC. However, 115 VAC is optional when specified at time of ordering.*

1.4 Operating Limits

Temp: -40 to +40 C.
Altitude: 50,000 feet.
Humidity: 0 - 100%

[viii] Versions of the Particle Analysis and Display System (PADS) earlier than 3.5 assume a sampling frequency of 1 sec / 1 Hz. As a result, this frequency is recommended if you are using PADS 2.7 or earlier.

2.0 Theory of Operation

See the Theory of Operation sections for the CIP, CDP and LWC-100 hardware manuals.

3.0 Other Instrument Components

3.1 Environmental Measurements

The CCP contains sensors for ambient temperature, static pressure, and dynamic pressure to determine TAS. These environmental measurements are necessary for analysis of the data gathered by the other sensors in the CCP probe. Ambient temperature measurements are made by a semiconductor temperature sensor (AD-590) located at the bottom of the CIP lower arm. The sensor is located at this location to minimize wetting in cloud environments. Static pressure and airspeed are sampled by the Pitot tube shown in Figure 1. The pressure transducers are located on the power supply board of the CIP. The static and dynamic pressure transducers are calibrated at DMT with a pressure standard, and these derived calibration coefficients should be entered into the PADS Configuration Editor Window for the CIP.

3.2 CCP Heaters

For heaters on the CIP Anti-Ice Bus, see the *CIP Hardware Manual (DOC-0028)*. For heaters on the CDP Anti-Ice Bus, see the *CDP Hardware Manual (DOC-0029)*.

As mentioned in section 1.1, CCPs for use in icing studies have several additional heaters to de-ice the instrument. More details about these heaters appear below.

3.2.1 Pitot Cheek Heaters

The Pitot cheek plate is the metal plate from which the Pitot tube emerges. It is shown in Figure 2.

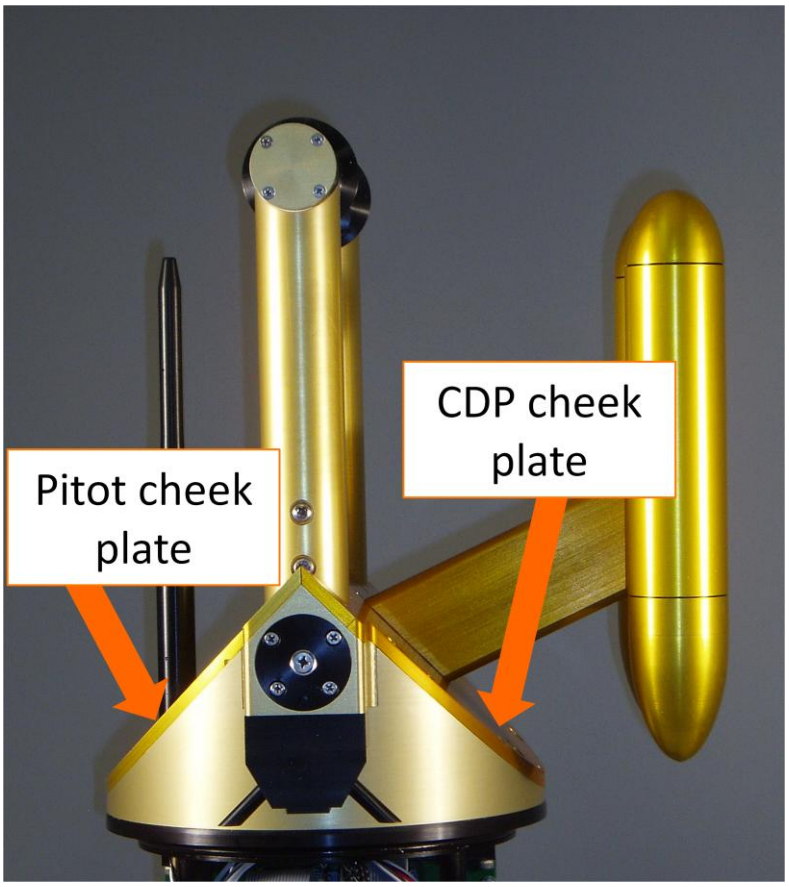

Figure 2: Pitot and CDP Cheek Plates

Pitot cheek heaters' location:	Underside of Pitot cheek plate (see Figure 3). These heaters are only visible when the plate has been unscrewed and removed from the instrument.
Specifications:	***Larger heater:*** 113.6 W at 28 VDC, 4.06A, 6.9 ohms, DMT P/N HTR-0117. ***Smaller heater:*** 37.5 W at 28 VDC, 1.34A, 20.9 ohms, DMT P/N HTR-0099.

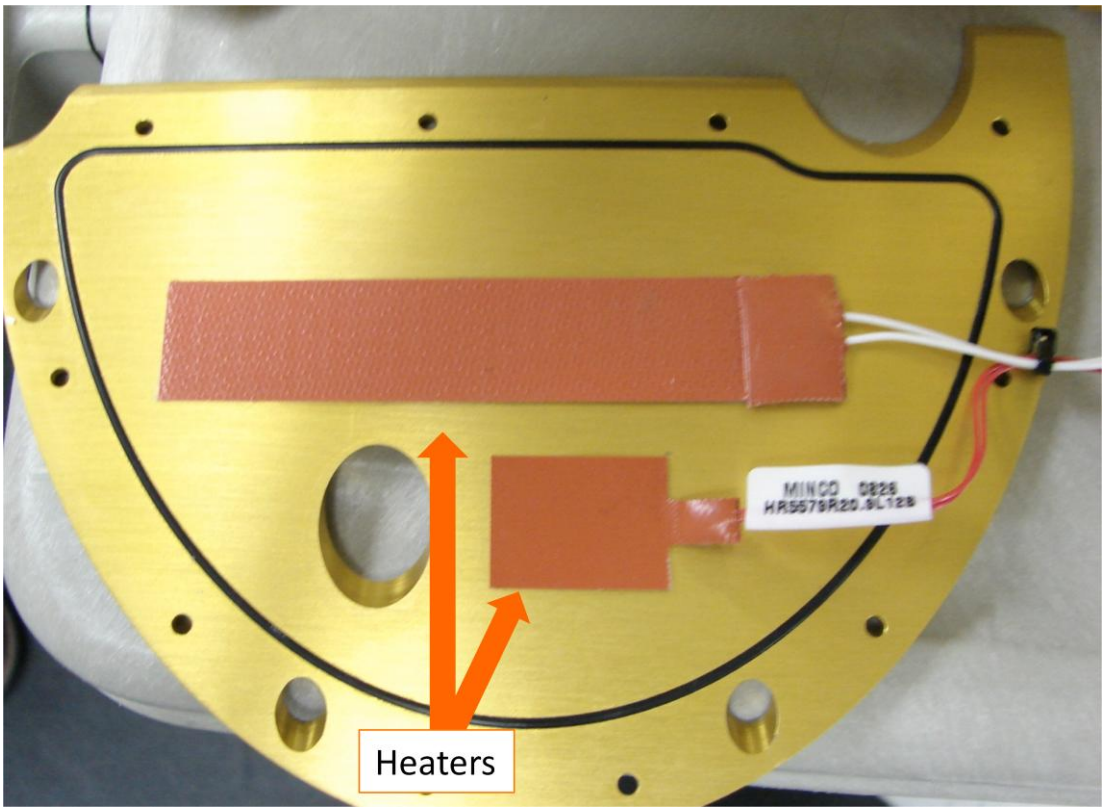

Figure 3: Pitot Cheek Heaters

3.2.2 CDP Cheek Heater

The CDP plate is the metal plate from which the CDP emerges (see Figure 2).

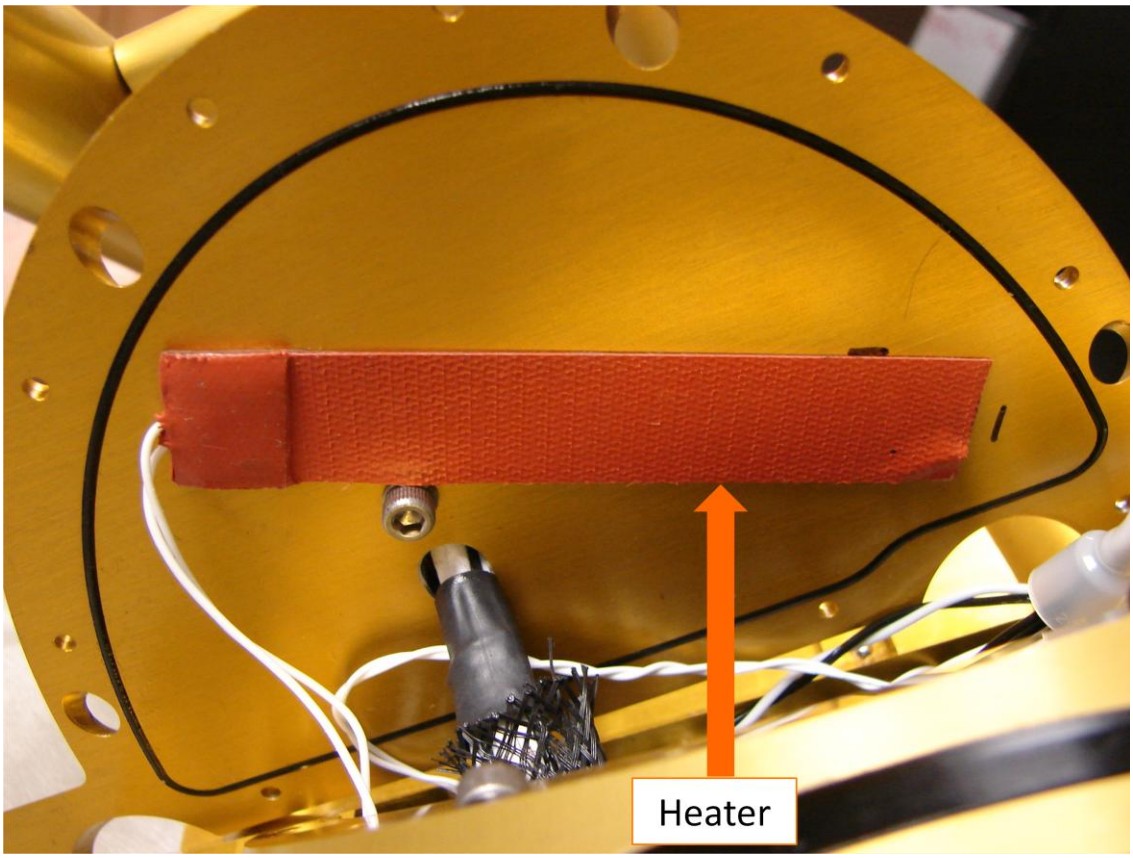

Figure 4: CDP Cheek Heater

CDP cheek heater location:	The heater is mounted on the underside of the plate, as shown in Figure 4.
Specifications:	113.6 W at 28 VDC, 4.06A, 6.9 ohms, DMT P/N HTR-0117.

3.2.3 LWC Sensor Heaters

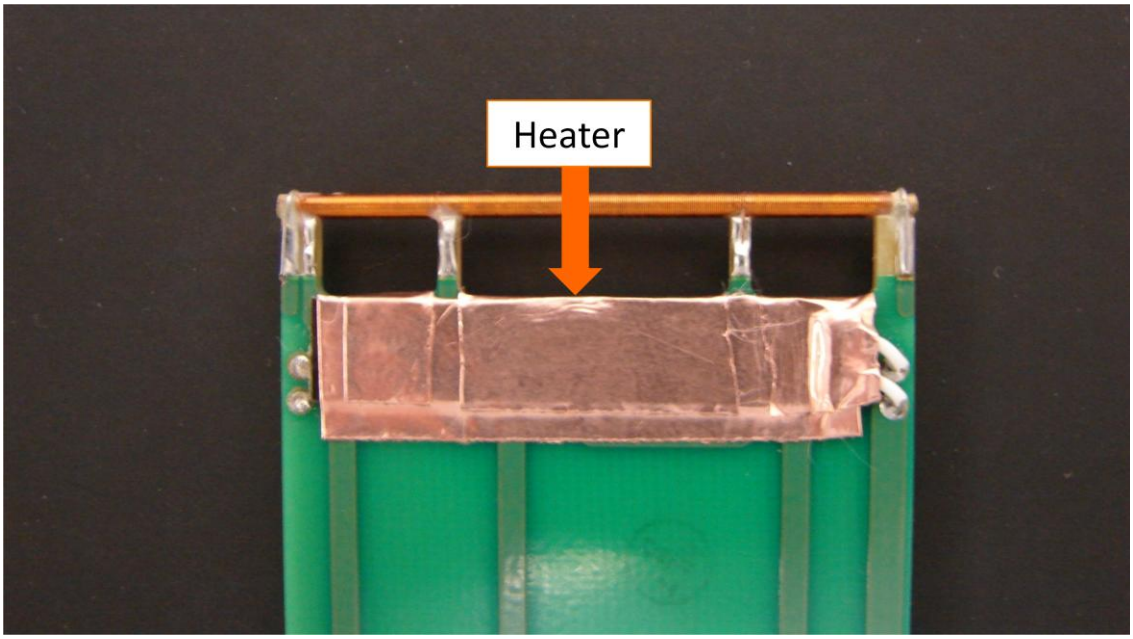

Figure 5: LWC Sensor Heater (One on Each Side of LWC Card)

Location:	Two, one on each side of the LWC card. See Figure 5.
Specifications:	62.7 W each at 28 VDC, 2.24 A each, 12.5 ohms each, DMT P/N HTR-0026.
Total power for both heaters:	125.4 W, 4.48 A.

3.2.4 CDP Strut Leading Edge Heater

Location:	Outside the CDP strut (see Figure 6).
Specifications:	113.62 W at 28 VDC, 4.06 A, 6.9 ohms, DMT P/N HTR-0118.

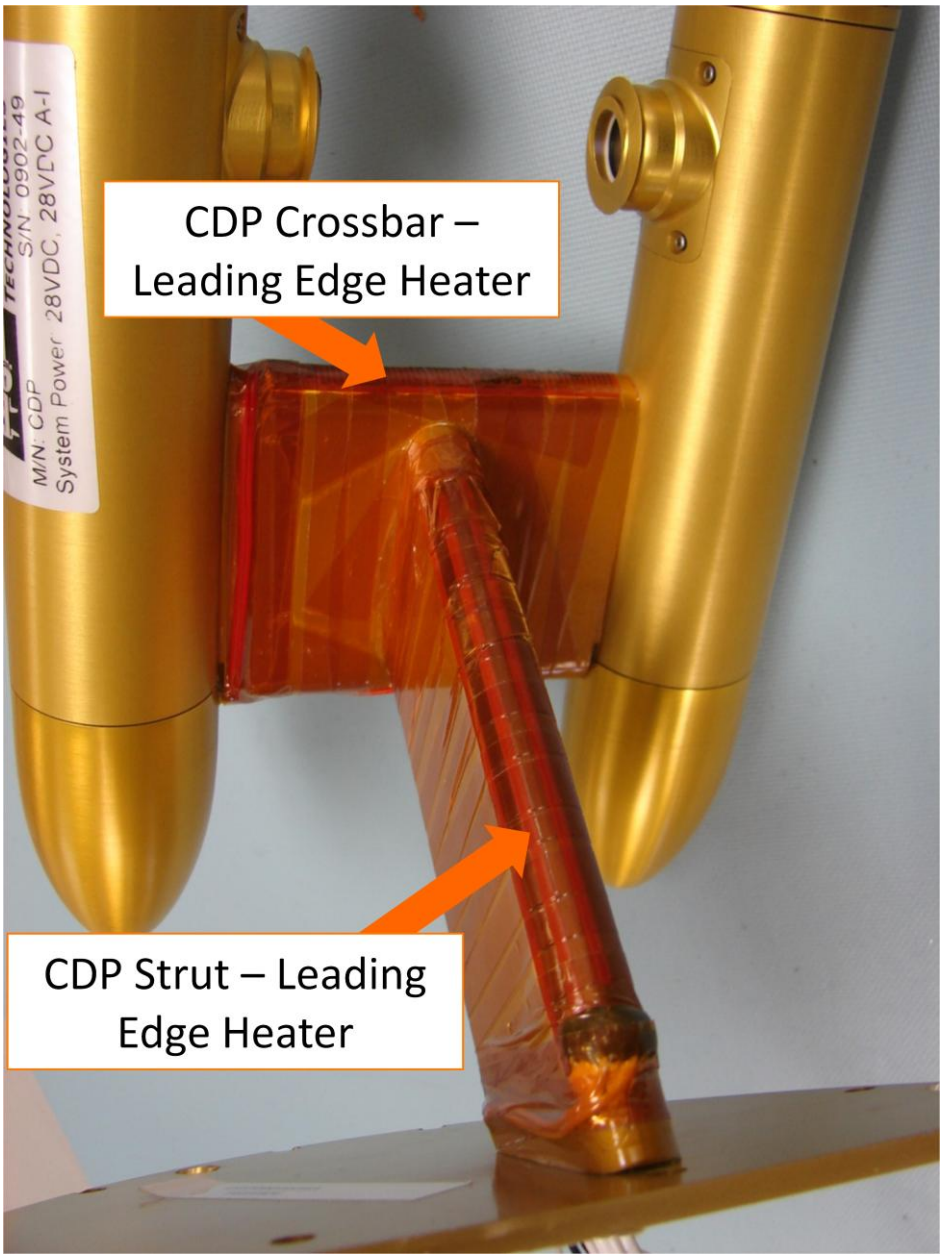

Figure 6: CDP Leading Edge Heaters

3.2.5 CDP Crossbar Leading Edge Heater

Location:	Outside the CDP crossbar (see Figure 6).
Specifications:	76.12 W at 28 VDC, 2.72 A, 10.3 ohms, DMT P/N HTR-0098.

4.0 Particle Analysis and Display System

PADS is a software package that interfaces to CCP and is designed to offer display and analysis features to both novice and advanced users. Figure 7 shows the CCP Summary tab in PADS. This tab combines data gathered by the CCP's component instruments. Note that each instrument also has its own tab; clicking on these tabs will bring up additional information gathered by specific instruments.

Figure 7: CCP Summary Screen in PADS

5.0 Calibration

For information about calibrating the CIP and the CDP, see their respective hardware manuals. The LWC does not require calibration.