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Fast Cloud Droplet Probe Technical Manual Rev. 1.0

PRELIMINARY

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1.0 FCDP General Description

The Fast Cloud Droplet Probe (FCDP) measures particle size and concentration. FCDP sizes particles by measuring the amount of light scattered into the collecting optics aperture during particle interaction through a focused laser beam. The instrument can size particles from 1 -50 μm with a resolution of about 3 μm . The system resolves particles into twenty equally spaced bins. It is capable of sizing particles having velocities from 10-200 m/s. The FCDP is a stand-alone system with an onboard data acquisition system which stores data on a Compact Flash card. The instrument can be controlled by a computer inside the aircraft cabin or can be configured to turn on and store data automatically at power ON.

1.1 Main Sections of the FCDP

The FCDP can be divided into three main sections: Transmit and Receive Arms, Main Body and Strut. The transmit arm contains the laser and transmit optics.

The Receive Arm encloses the receive optics, detector and detector amplifier board. The outputs of the detector amplifier board are fed in to the data acquisition system in the main body.

The Main Body consists of the data acquisition system, which contains the electronics board, and the 400 MHz Intel PXA255 microprocessor based System on Module (SOM). The electronics board converts the analog voltages to digital form and this data is stored in FIFOs on the Field Programmable Gated Array (FPGA). The FPGA interfaces with the Signal, Qualifier, Housekeeping ADCs and the SOM. The SOM analyzes and processes the voltages corresponding to scattered light and classifies it in different particle size bins. This data along with the housekeeping data are saved in the form of 5 different files on the Compact Flash Card by the SOM. The SOM also provides Ethernet and RS232/422 interfaces for real time display and control by a remote computer.

The Strut contains the Power, Laser and Heater control board. The 28 VDC and 110 VAC inputs from the aircraft are distributed to the various components of the FCDP: laser, detector, detector amplifier board, data acquisition system and heaters, by the Power-laser-heater board. The board also controls the temperatures of the heaters.

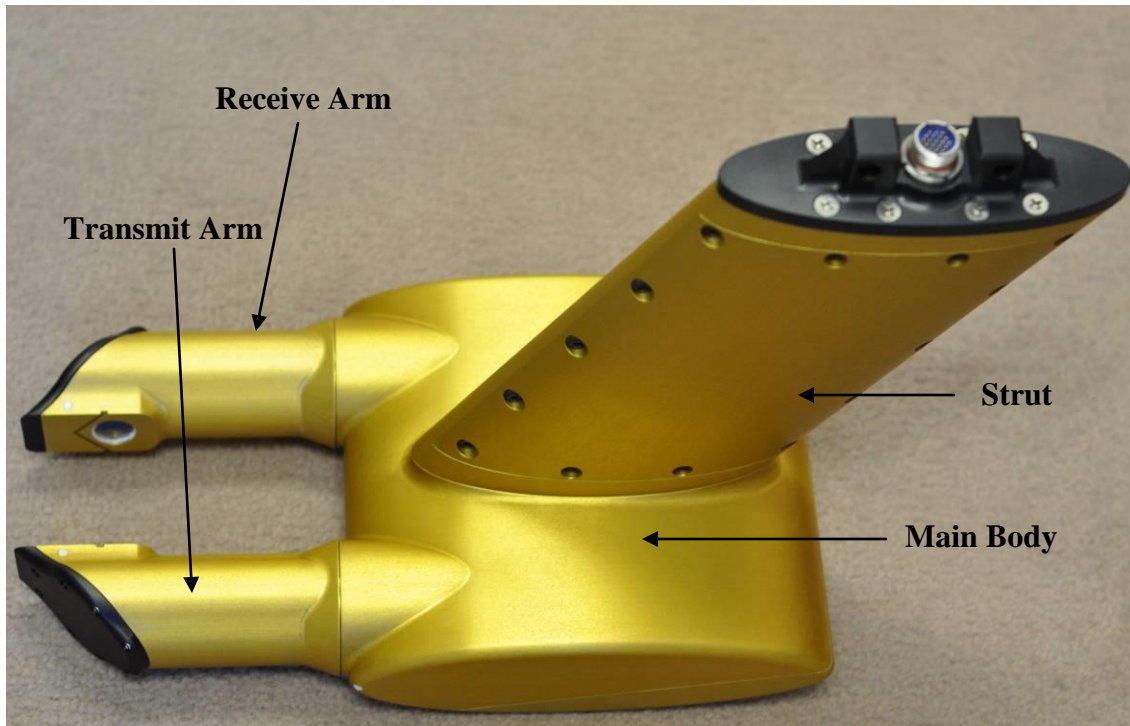


Figure 2.1.1 FCDP Main Physical Sections

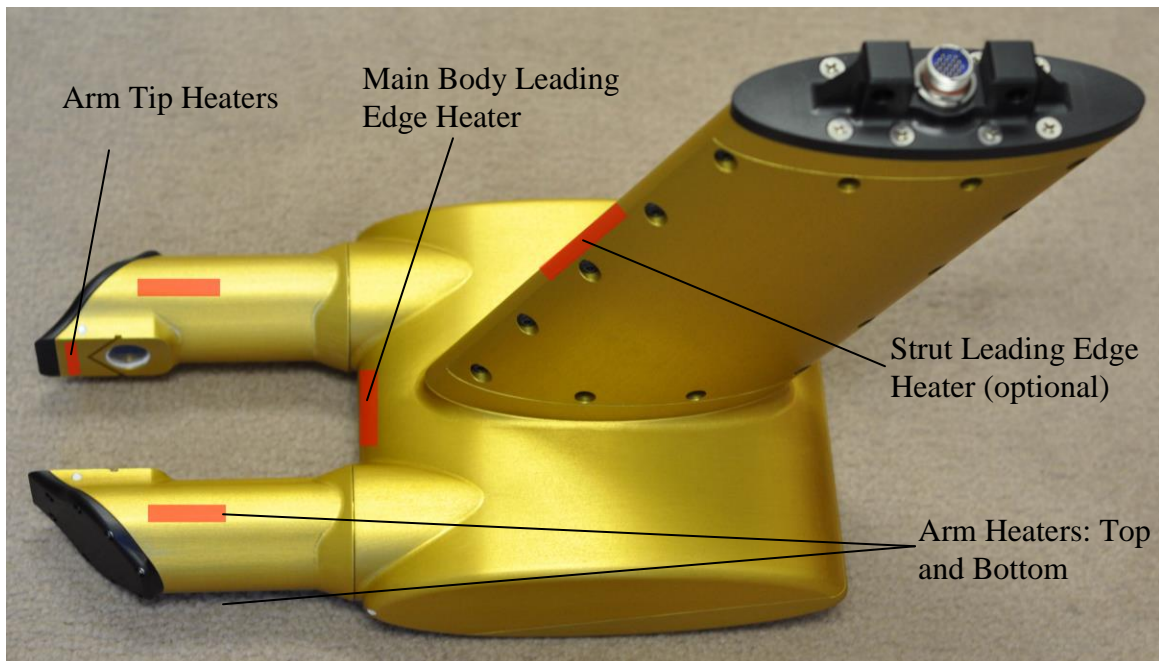


Figure 2.1.2 FCDP Heater Locations

1.2 FCDP Principles of Operation

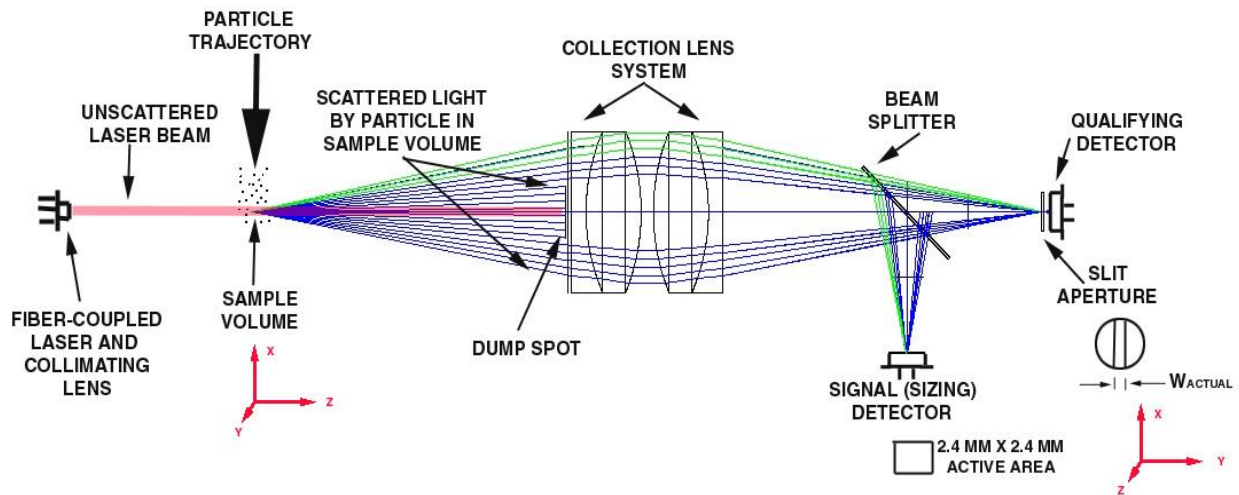


Figure 1.2.1 Diagrammatic representation of the principle of operation

A collimated, fiber-coupled laser is projected on the sample volume between the transmit and receive arms of the FCDP. Cloud particles in the sample volume scatter the laser beam. The light scattered by the cloud particles is collected at a dump spot on the receive arm. This beam is splitted to two detectors: qualifying and signal detectors. **Figure 1.2.1** is a diagrammatic representation of the principle of operation of the FCDP.

When a particle is in focus for both detectors, the slit based qualifier sees a high peak. Since a 70:30 splitter is used, for a particle to be qualified the qualifier peak should be higher than the signal peak, as shown in **Figure 1.2.2**.

Characteristics such as run time, transit time, signal voltage, qualifier voltage, area(sum of volts) and time to peak are recorded for each particle by the data acquisition system.

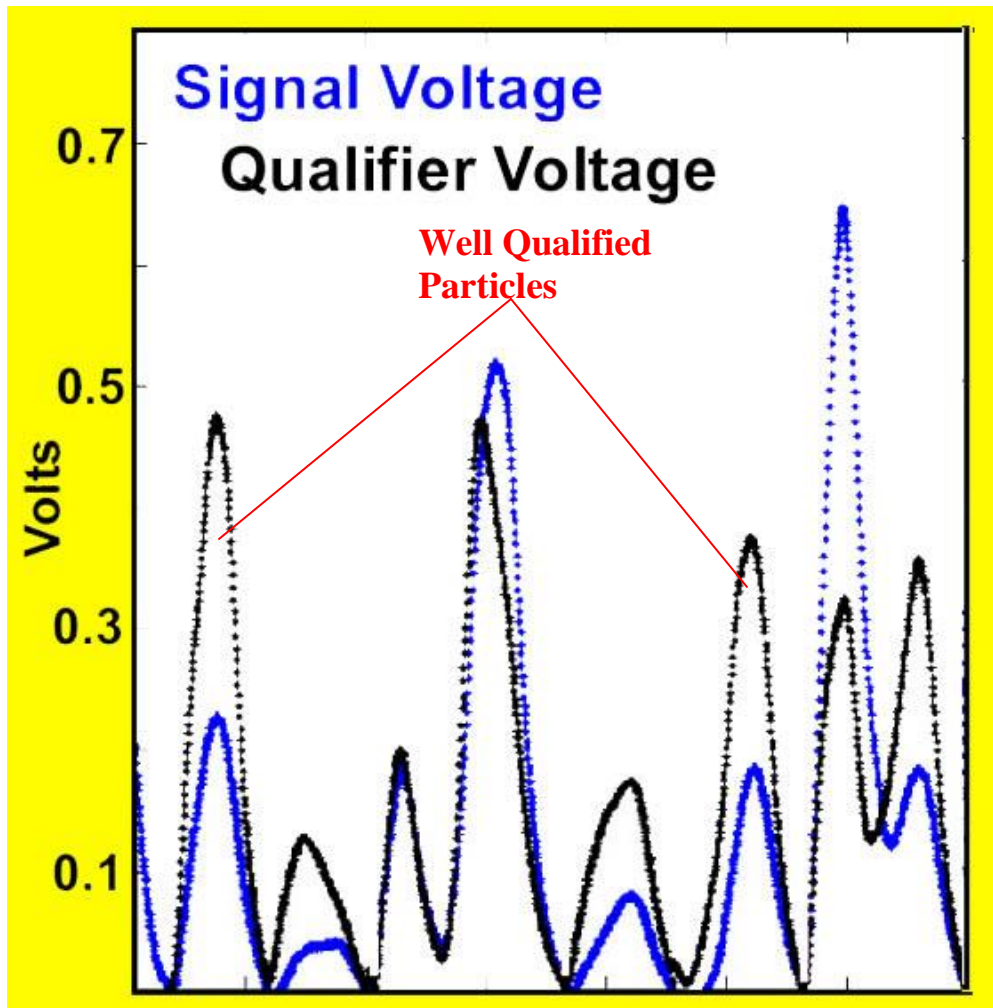


Figure 1.2.2 Examples of Qualified Particles

2. FCDP Electronics Description

The Electronics section consists of four main boards: 2 detector boards, an electronics boards and a laser/power board.

Detector Boards:

Detector boards are small boards placed close to the detectors. They detect and amplify the signal and qualifier voltages over two stages. The output of these amplifiers is fed in to the Electronics Board.

Electronics Board:

The Electronics board consists of the main electronics, which sample and process the detector voltages. The amplified signal and qualifier voltages are digitized by dual, 14 bit ADCs. These voltages along with the House Keeping voltages from an ADC-MUX are fed in to a Field Programmable Gated Array (FPGA). Housekeeping parameters such as air temperature, voltages, relative humidity and pressure are sampled.

The FPGA interfaces with a PXA255 processor based System on Module (SOM). The FPGA and the SOM together form the data acquisition system. When the FCDP is turned ON, the SOM powers up and implements a code which programs the FPGA to acquire and store data from the ADCs in FIFOs. The SOM then implements a real time control loop (see **Figure 2.2**) to retrieve data from the FIFOs on the FPGA, perform basic processing and store it on 5 different raw data files on the Compact Flash card. The 5 raw data files are:

- ‘YYMMDDHHMMSSlog.txt’: Log file
- ‘YYMMDDHHMMSShk.txt’: Housekeeping data file
- ‘YYMMDDHHMMSSscat.bin’: Scattering data file
- ‘YYMMDDHHMMSSsig.bin’: Signal detector data file
- ‘YYMMDDHHMMSSqual.bin’: Qualifier detector data file

The above files can be post-processed to yield more accurate particle characteristics such as concentration and sizes.

Data that is processed using a preliminary real time code is also sent over the Ethernet and/or RS232/422. This data can be viewed in real time using the *FCDP.exe* software. It can also be used by simple Secure Shell Clients such as Putty.

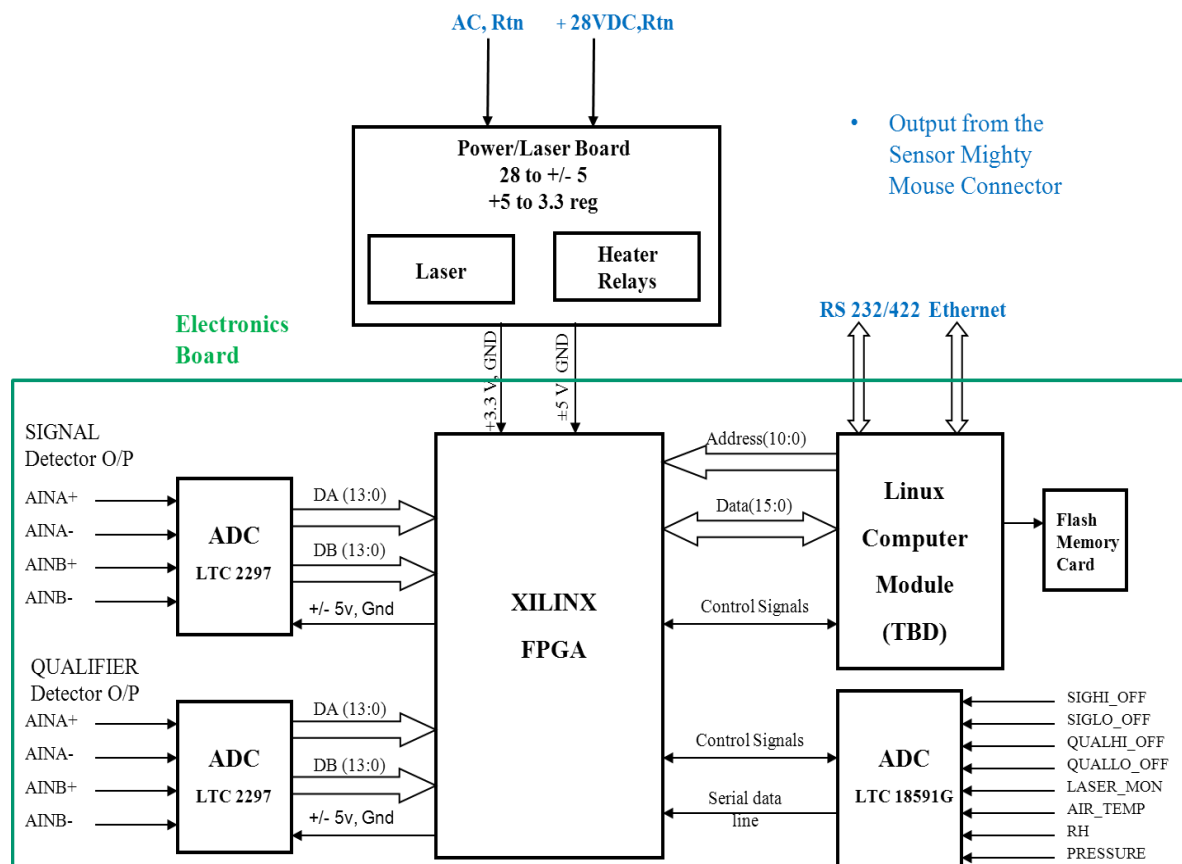


Figure 2.1 Electronics System Level Block Diagram

Laser/Power Board:

The laser/power board obtains the AC and 28VDC power input to the FCDP sensor and converts it to appropriate voltages ($\pm 5\text{VDC}$, $+3.3\text{VDC}$) which power up the heater relays and the electronics board. The power and control circuitry for the laser is also placed on this board. The heater relays are controlled by the real time software running on the SOM.

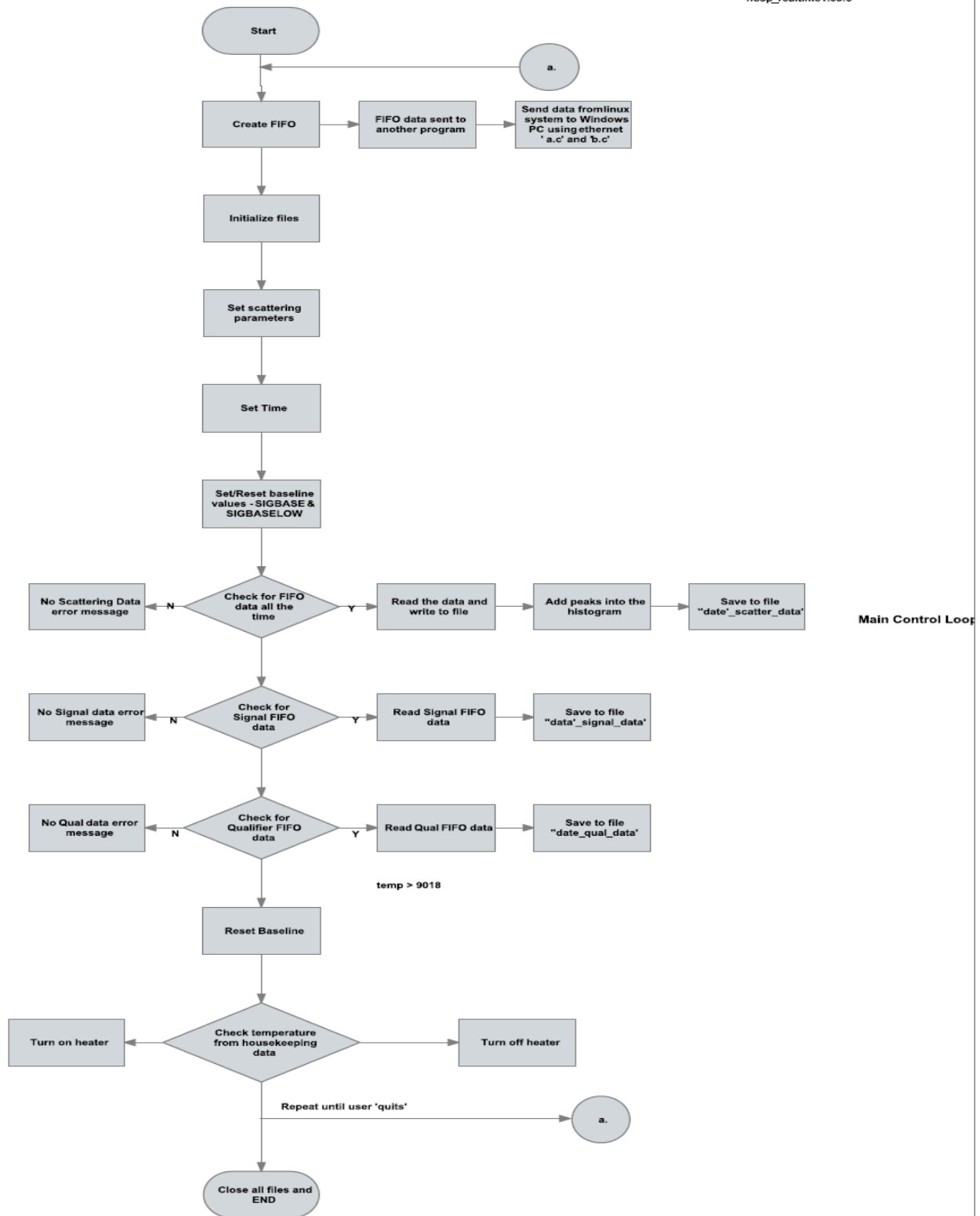


Figure 2.2 Real time control loop flowchart

3. FCDP Start Up Procedure

A low noise 28VDC and AC power sources are required to start up the FCDP

3.1 Connecting FCDP Sensor to Remote Computer

A bench test cable is supplied with FCDP. It connects to the 19 pin connector at the FCDP sensor head chassis. The bench test cable mates to this connector and branches to 28 VDC power, AC power, Ethernet and RS242/232 on the other end. Recommended aircraft cabling is TBD.

Connect the AC and DC power connectors to appropriate power supplies. Connect the Ethernet cable directly to a Windows OS computer. Connect the RS 232/422 connector to the same computer as well. Configure the computer to a static IP address of 192.168.1.211.

3.2 FCDP Real time Graphical User Interface (GUI)

Connecting to the FCDP

1. To initialize the connection between the FCDP GUI and the probe, click the green “Connect to Probe” button shown in Figure 3.2.1. This will connect and time sync the probe.
2. Once the network connection has been established, type `df -h /mnt/hda` in the “SSH Command Field”, then click the “Send String” button to check the amount of available flash disk space and ensure there is sufficient memory available.
3. Click the green “Start” button (may take around 60 seconds before the display updates).
4. The system is now ready for Real-Time Operation and will begin collecting data.

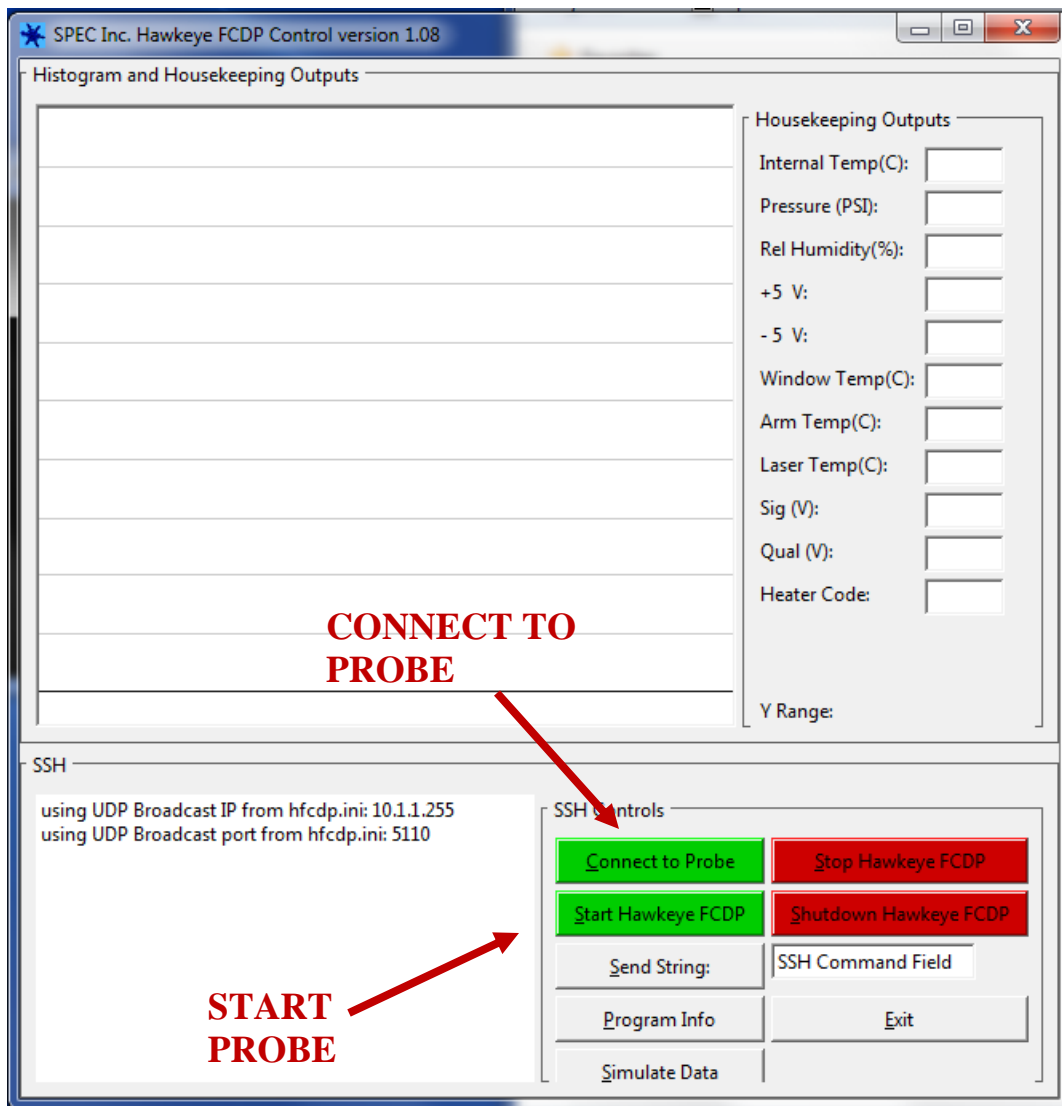


Figure 3.2.1. Startup screen for the FCDP GUI.

Disconnecting from the FCDP

1. To disconnect from the FCDP, click the “Stop FCDP” button (see **Figure 3.2.1**).
4. Once the FCDP has stopped collecting data, click the “Shutdown FCDP” button. Once stopped, the FCDP GUI window may be closed.

4. FCDP Maintenance Procedure

Cleaning the FCDP windows is the only regular maintenance required. Items required to clean to windows are shown in **Figure 4.1**.



Figure 4.1 Items required for window cleaning

1. Visually inspect both windows. Shine the bright LED on each window and look for contamination on the windows.
2. The first step to cleaning is to blow off any particles off the windows using the compressed air. Particles pose the greatest threat to the windows because they can scratch the coatings. (See **Figure 4.2**)
Keep the compressed air at a distance and speed such that no liquid refrigerant gets on the windows.
3. Use an optical quality cleaning tissue, wetted with methanol to clean the window surface. A good way to clean the windows is to fold the tissue over the end of a lab-grade cotton swab (See **Figure 4.3**). Do not wipe the windows without wetting the swab or tissue.
4. Apply a few drops of reagent grade Methanol to the tissue (See **Figure 4.4**).
5. Lightly swirl the tissues around the window to clean. Methanol evaporates quickly and tends not to leave a residue unless there are still impurities on the glass.
Do not rub the windows too forcefully, the window anti-reflection coating is delicate and pressure on the windows could damage the coating. Never dry scrub the windows. If the coating is damaged, the laser intensity profile will be adversely affected, affecting the instrument response. Replacing a scratched window is extremely labor intensive, as it requires disassembly of epoxied components. This is not covered under warranty.
6. Repeat until each window is clean on visual inspection with LED light. Start HVPS system again and check to see that element voltages are improved. If voltages have

increased, the cleaning was successful. If the voltage decreases, repeat the procedure as cleaning residue might attenuate the laser.

SPECIAL CLEANING NOTES

In maritime conditions, salt residue on the windows is likely. In addition to using compressed air, use distilled water on the windows to dissolve and remove any salts off the windows. Then move to Methanol.

In non-maritime cases where the windows are extremely dirty (e.g. smoke plume) you can use reagent Acetone to clean the windows. Acetone will leave a residue and must be followed by a cleaning with Methanol.

If you are cleaning the windows for a flight that is to take place in the future, a large electrostatic bag can cover the tips and be taped to the PMS can to seal it off from particulates that could accumulate on the windows. If the aircraft is outdoors, doing this will prevent rain from contaminating the windows.

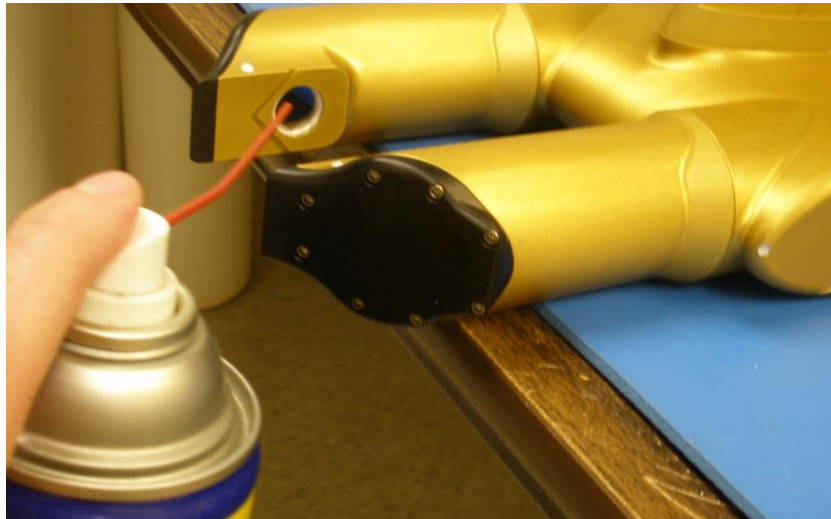


Figure 4.2 Blowing particles off windows with compress air



Figure 4.3 Optical quality cleaning tissue and cotton swab to lightly clean windows

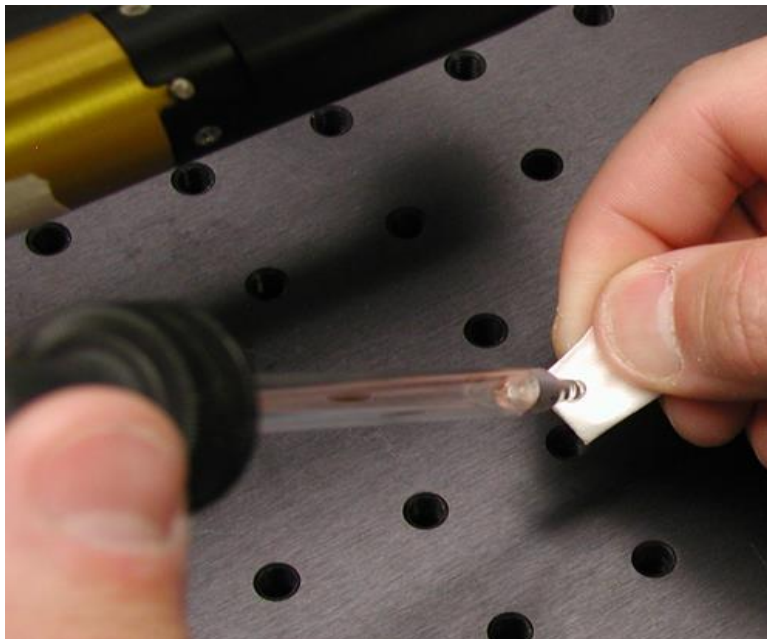


Figure 4.4 Methanol wetted tissue for dirtier windows

5. FCDP Collar Installation

The collar designed to mount the FCDP is specific for SPEC hermetic canisters. In order to mount the collar to a SPEC canister, it must be slightly modified. The modification is simple and if it is decided the collar is wanted existing canisters can be returned to SPEC. If the collar is purchased as part of a SPEC package the modification is included to the can with the collar and FCDP.

The FCDP is designed to hang vertically from its mounting point. The collar is designed so that the canister can be mounted in 3 different rotational patterns and allow for the FCDP to remain in its proper orientation. **Figure 5.1** shows the final FCDP orientation on the collar with a 2D-S installed in the hermetic can.

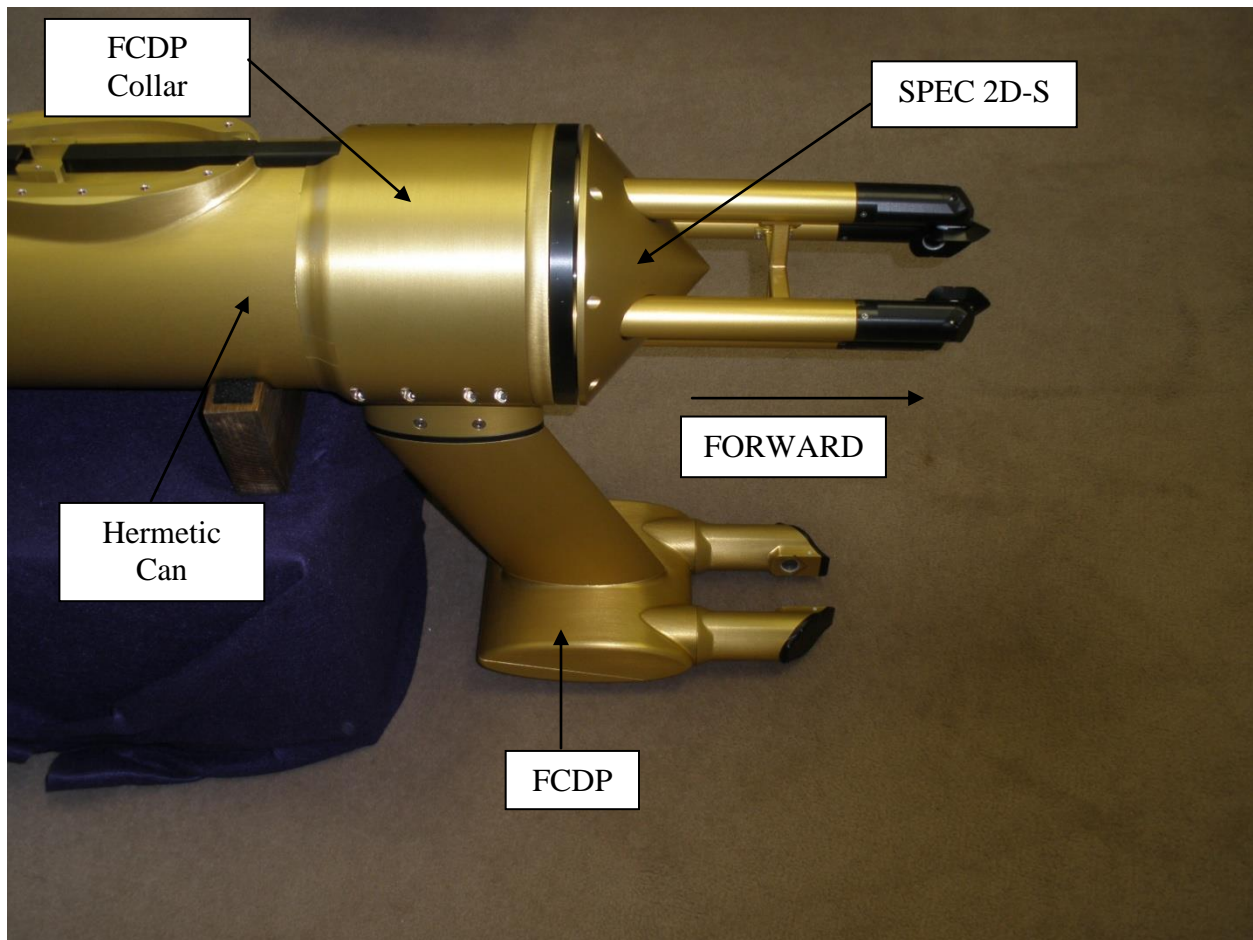


Figure 5.1: FCDP/Collar/2-DS

The collar comes apart into two pieces, the mounting base half and the top clamping half. Eight #8-32 screws hold the two halves together. **Figure 5.2** shows the top half; **Figure 5.3** shows the bottom half.

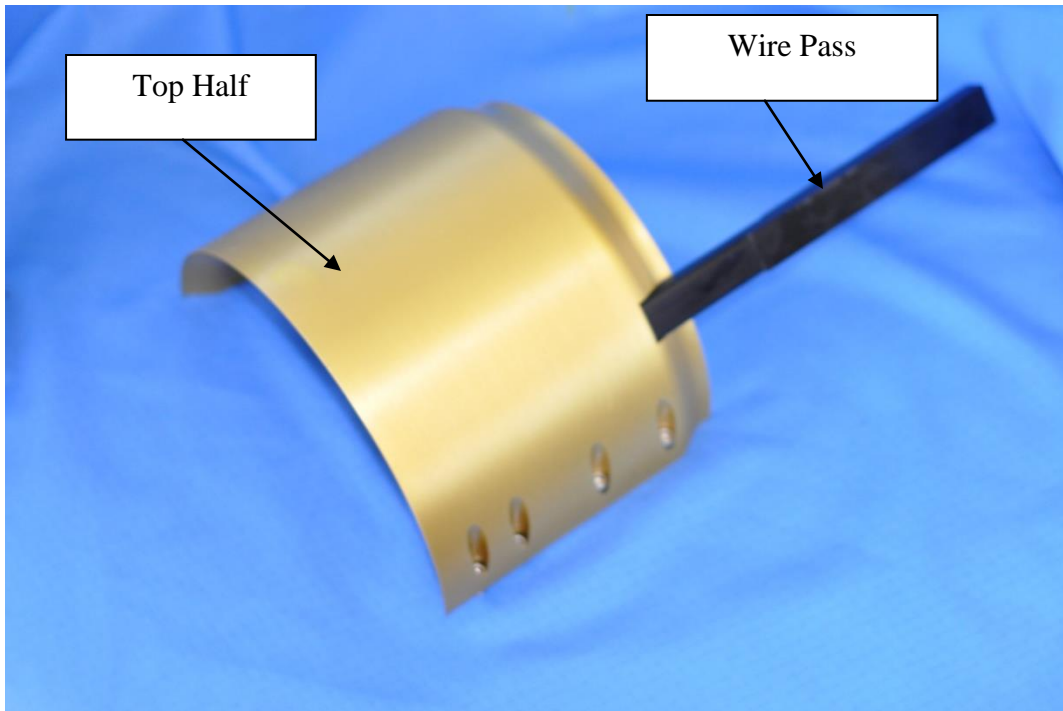


Figure 6.2: Top Clamping Half

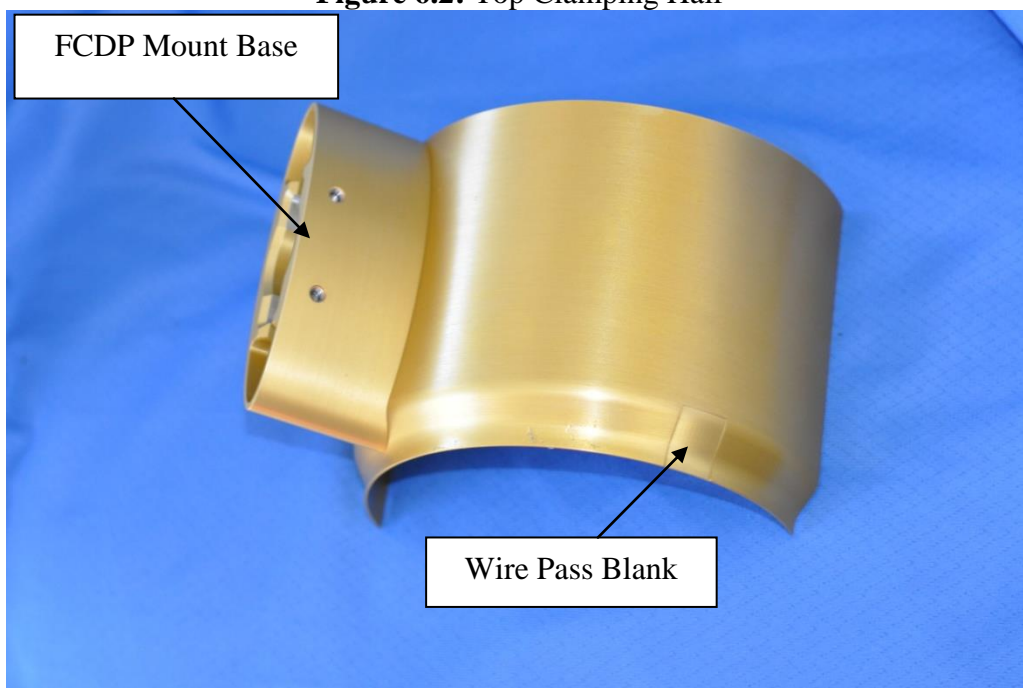


Figure 5.3: FCDP Mounting Base

Figure 5.4 shows the three components of the collar that are acceptable to remove in order to rotate the FCDP collar. The parts are also pointed out in **Figure 5.2** and **Figure 5.3**, to show them in the assembly.

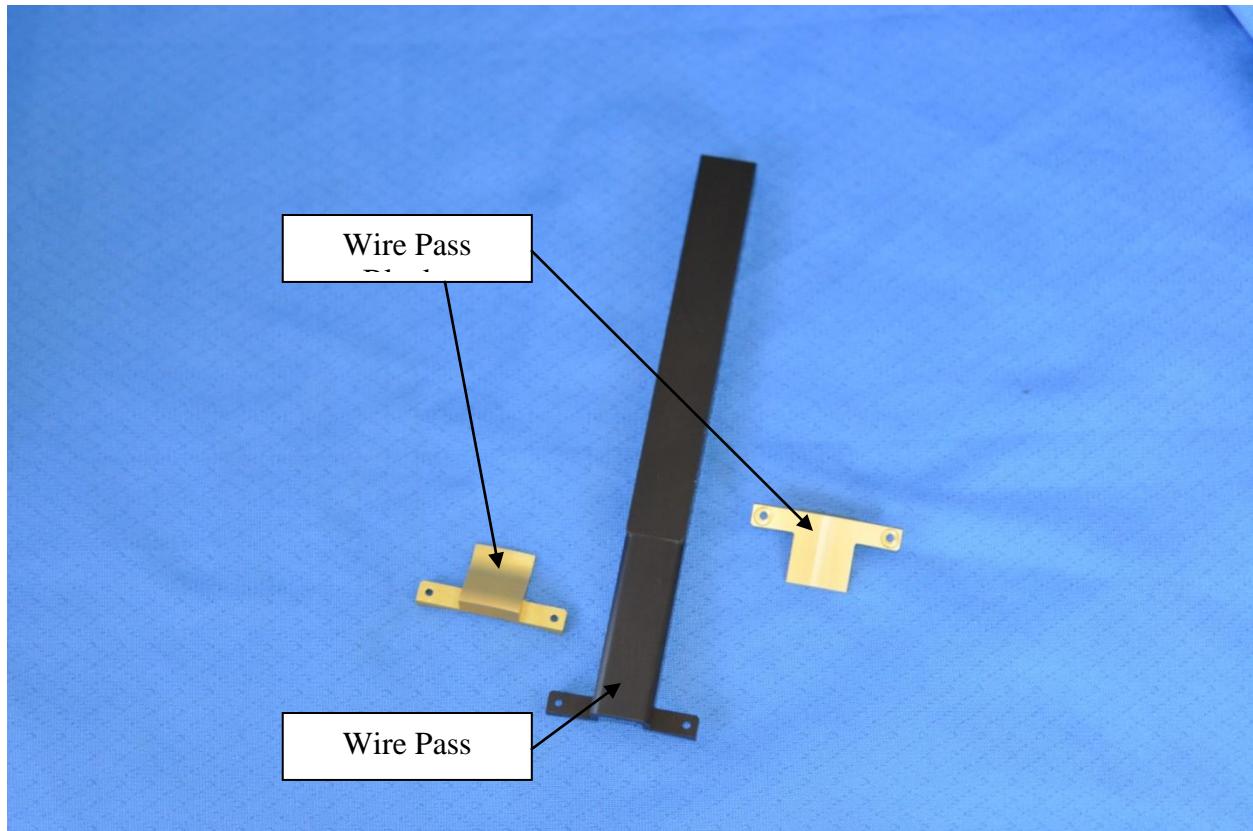


Figure 5.4: Collar Interchangeable Parts

If the FCDP collar is removed there is an additional part included in the shipment to cover the canister modification. **Figure 5.5** shows the extra part, **Figure 5.6** shows how the part looks when installed.



Figure 5.5: Canister Blank

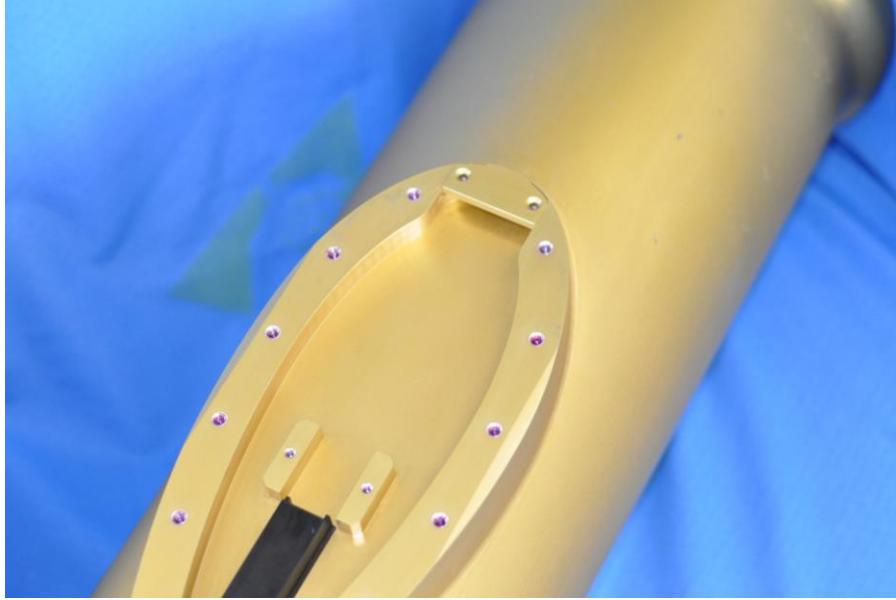


Figure 5.6: Canister Blank with Canister

Installing the FCDP collar:

- 1.) Orient the wire pass so the FCDP hang vertically when installed. To remove/replace interchangeable parts remove the two # 2-56 using a 5/64" hex driver holding the parts (inner radius).
- 2.) Align the wire pass with the slot on the modified canister.
- 3.) Align opposite half with the half containing the wire pass. Get the eight #8-32 screws turned so the collar is tight enough to stay together but can still be slid forward.
- 4.) Slide the collar until it stops on the hermetic canister.
- 5.) Tighten the screw so the collar is no longer able to move.

Mounting the FCDP to the Collar:

The FCDP is mounted to the collar using two custom bolts shown in **Figure 5.7**. The bolts are driven by a flathead screwdriver.



Figure 5.7: FCDP Custom Bolts

To Install the FCDP follow these steps:

- 1.) Connect the electrical connector (**Figure 5.8**)

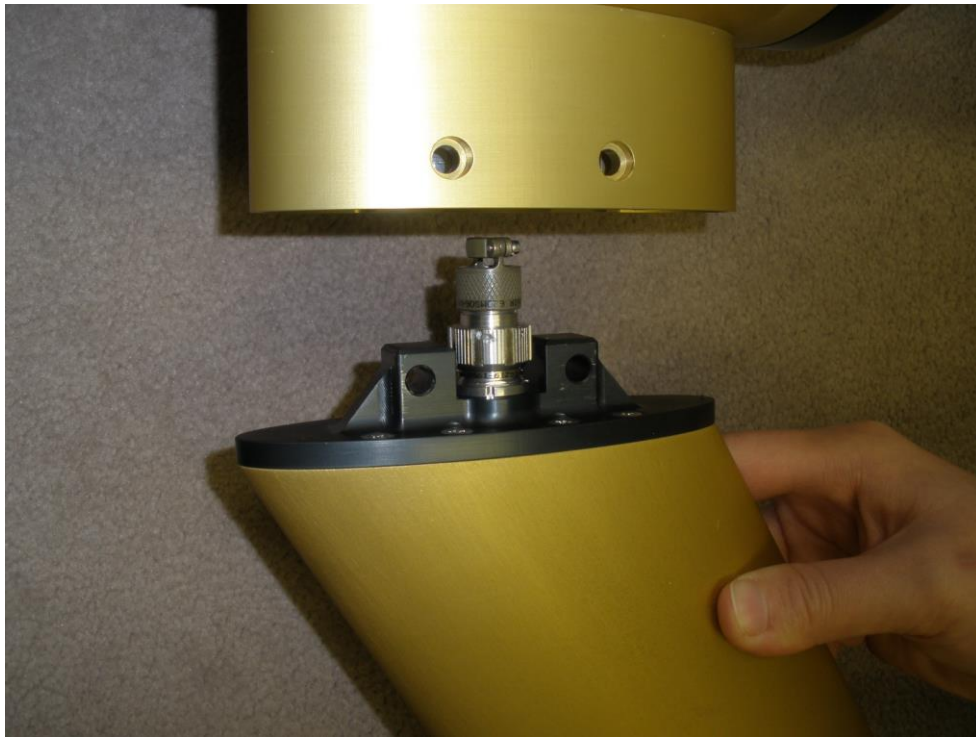


Figure 5.8: FCDP Connectors' engaged

- 2.) Align the holes of the FCDP so it appears as pictured in **Figure 5.1**.
- 3.) Insert custom bolts and tighten (**Figure 5.9**).



Figure 5.9: Mounted FCDP with Custom Bolts