

# QuarkNet Cosmic Ray Muon Detector (CRMD) Assembly Instructions for Series 6000 DAQ

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## Read Me First

### Document Purpose

How to build a cosmic ray muon detector (CRMD) from components and enable raw data to flow into a "capture" file on the users data computer.

Not Covered: Configuring CRMD, data rate, plateauing individual counters, details of serial communication application ("hyperterm" or "ZTerm"). These details are covered in the "QuarkNet Cosmic Ray Muon Detector User's Manual"; see <http://www.i2u2.org/elab/cosmic/library/resources.jsp>

### Assembly Required

User must assemble some components: PMT, scintillator, wrapping materials, support tube → counter  
(Previously assembled components: GPS, DAQ, PDU)

### Warnings

- Do not handle the scintillator material with bare hands.
- Read Material Safety Data Sheet (MSDS) for optical couplant.
- Seat all electrical plugs completely: **Improperly seated plugs can lead to power shorts.**
- **Avoid excess pressure on the PMT window. Fragile!**
- PMT power up: Make sure that voltage levels are set to minimum for power up (control stems on the PDU potentiometers, rotated counterclockwise).
- **Do not power up until all components are plugged into their proper connections.**
- GPS Module (gray box) must remain indoors; it is not weather proof.

### Check Parts

Verify. If parts are missing, contact your QuarkNet mentor or Cosmic Ray e-Lab HelpDesk:  
(<https://www.i2u2.org/elab/cosmic/teacher/forum/HelpDeskRequest.php>)

### Instruction Sections

1. Parts List
2. Quick Start
3. Counter Assembly Instructions
4. Detailed PLUG-IN Sequence
5. POWER-UP Sequence
6. Commissioning Sequence
7. Troubleshooting
8. FAQs
9. Addendum

### 1a) Parts List – Subcomponents

Counters	(4) To be assembled from the following pieces:
Scintillators	(4) 10"x12"x1/2" scintillator plastic blocks with polished edges and light guide "cookie" glued to one corner. <b>Handle with cotton gloves.</b>
Heavy Gauge Aluminum Foil	(1) 38"x64" (approx) piece for covering scintillator.
Lightproof Black Wrapping Material	(1) 27"x40" (approx) piece for covering scintillator.
Support Tubes	(4) 24" lengths of PVC pipe slotted to accept wrapped scintillator and to align photomultiplier tube (PMT) with optical cookie.
Photomultiplier Tubes (PMTs)	(4) SensTech Model P30CW5 photodetector packages, including cables for signal, power and control. <b>Handle with care!</b>
Optical Couplant	(1) Small film-type canister containing optical grease used to interface the PMT to the light guide "cookie."

<b>Signal Extension Cables for PMTs</b>	(4) 50 ft. cables with male BNC connectors on each end
<b>Power Extension Cables for PMTs</b>	(4) 50 ft. stereo audio cables with one male and one female connector, to extend power and control circuits from PMTs
<b>Power Distribution Unit (PDU)</b>	(1) Box with 5VDC power input and 4 outputs including potentiometer controls for each control circuit
<b>PDU Power Cable</b>	(1) 6 ft. mono audio cable, male connectors on both ends, to get power for the PDU from the connection provided on the DAQ circuit board
<b>Cloth Gloves</b>	(2) Pair clean soft cotton gloves used for handling scintillator materials to avoid dirt, scratches and fingerprints
<b>Specification Sheets</b>	(4) Spec sheets for PMT, scintillator plastic, optical couplant, GPS antenna
<b>Safety Data Sheet</b>	(1) Material Safety Data Sheet (MSDS) for optical couplant

### 1b) Parts List – Large Components

<b>GPS Receiver Assembly (GPS)</b>	(1) The GPS receiver and interface adapter (GPS module) are in a small gray plastic box to which you will attach three items: a) - the 100 ft. CAT-5 standard network cable which connects the GPS to the DAQ b) - the temperature sensor cable with the red weatherproof coating on the sensing end c) - the GPS antenna with 9 ft. MCX cable; antenna has magnetic base
<b>Data Acquisition Circuit Board (DAQ)</b>	(1) This circuit board contains the logic, timing, multipliers, and discriminators for processing the input signals from the counters and creating the output data stream. It has interfaces to the counters, the GPS and your PC. Many of the devices on this circuit board have been preset. <b>Do not change any settings unless specifically asked for in the instructions.</b> The circuit board has been loaded with the current revision level of QuarkNet firmware.
<b>USB Interface Cable</b>	(1) 9 ft. USB2.0 A to B interface cable for connecting the DAQ to your PC's USB port.
<b>Power Supply</b>	(1) Power supply with 5VDC 1A output, female connector, to provide power to the DAQ.

**(Note:** You must provide a PC or Mac with a terminal emulator program such as "hyperterm" or "ZTerm" to display data and send keyboard commands to the DAQ.) (Connections with a Linux OS are possible. Contact: Cosmic Ray e-Lab HelpDesk.)

### 2) Quick Start → Steps leading to a working CRMD:

Assemble four counters—section 3.

Plug-in components—section 4.

Power up – section 5.

Commission CRMD – section 6.

Take data: Capture data to a file. (See CRMD Users Manual.)

Measure geometry and upload to cosmic e-Lab. (See CRMD Users Manual.)

### 3) Counter Assembly (Read entire section before starting)

#### General Tips

- When working with electrical tape, pull tape off roll, then let it "relax" by hanging it vertically and letting it rest for 3-5 minutes.
- Handle scintillator with the provided cotton gloves.
- The PMTs are expensive electronic devices. The windows are easily damaged by excessive pressure. **DO NOT force the PMT against the scintillator cookie.**

#### Assembly Steps

- Wrap the scintillator.
- Attach the photomultiplier tube.
- Assemble the PVC support.

#### Parts Provided

Plastic scintillator with cookie	Photomultiplier Tube (PMT)
Aluminum foil	PVC support
Lightproof black wrapping material	Optical grease

#### User Provided Materials

3/4" wide black vinyl electrical tape	1/2" Teflon plumber's tape
3" (or 2") wide black vinyl electrical tape	Scotch tape

#### Tools Needed

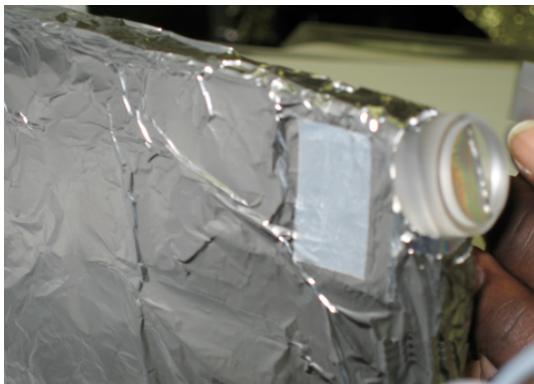
Scissors	Straight edge
Razor blades	Protractor
Multimeter - VOM	

#### Step 1: Wrap the Scintillator.

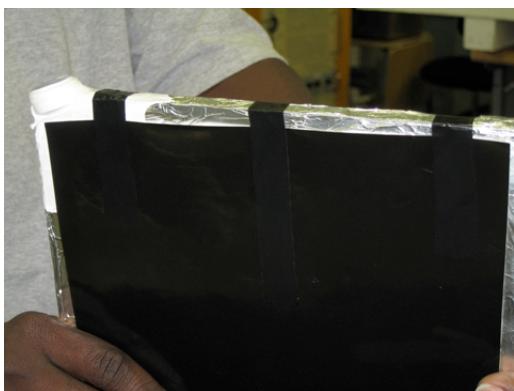
The scintillator must be wrapped to block transmission of ambient light. Aluminum foil and black wrapping material are provided. The wrapping and taping are much like wrapping a present. Lay out the material, lay the scintillator down, fold and tape.



- Cut aluminum foil: four pieces sized 18" X 26" (45.7 cm x 66.0 cm).
- Lay the foil on a workspace with "shiny" side up. Smooth foil.
- Lay the scintillator at one end of the foil. **Use cotton gloves!**
- Fold the foil over one of the long edges.
- Fold foil around the other plate edges and tape.
- Trim foil to cover just behind the counter cookie using a razor blade.



Completely cover the scintillator. While minor wrinkles are acceptable, avoid holes or tears. Add additional “repair” pieces to patch any noticeable tears or holes.



Use Teflon plumber’s tape to wrap the edges of the cookie to block light; do not cover the face. Avoid scratching the face of the cookie. This is the transmission window for the light pulses.

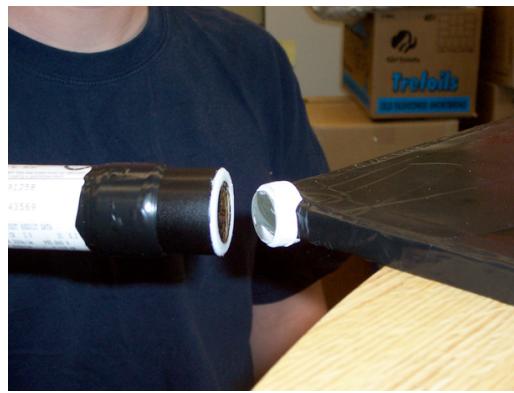
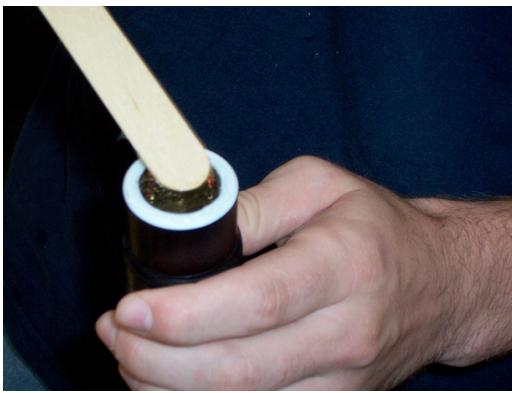


- Cut black wrapping material: four pieces sized 9 1/2" X 23 1/2" (24.1 cm x 59.7 cm).
- Lay the black wrapping material down on a workspace with the reflective side up, black side down.
- Lay scintillator at one end of the material.
- Fold black wrapping material around the short edge opposite the cookie.
- Tape edge with electrical tape to hold the material in place.
- Flip scintillator, pull material tight and tape other edge.
- Completely cover remaining exposed foil using 1" and 3" electrical tape.



- Reinforce each corner with extra tape using “gift-wrap” folds. Be creative but avoid bulk.
- Trim the material behind the cookie and secure with electrical tape.
- Apply a piece of 3" electrical tape to protect the black material from damage due to sharp edges of the PVC support tube. Start at the cookie and run the tape across the face at an 18° angle measured from the long side. Do this on both sides of the scintillator.

## Step 2: Attach the photomultiplier tube.



**DO NOT force the PMT against the cookie.**

- Remove the PMT cap; save for PVC pipe plug
- Apply a small amount (about the size of a pea) of optical couplant to the PMT window.
- Hold the PMT in contact with the cookie face.
- Gently press the two faces together. Gently!
- Wrap the joint—use 3" electrical tape.



**Step 3: Assemble the PVC support tube.**



- Carefully slide the assembly into the PVC support tube; be sure to not crimp the wires. Stop if there is excessive resistance.
- Guide the assembly until the PMT is 1-2 inches from the end of the slot; the PVC will extend beyond the assembly.



- Measure the angle between the PVC support tube and the long side of the assembly. Adjust the PVC support until this angle is 18°. This will maintain alignment between the cookie face and PMT window.
- Wrap the outside of the PVC tube with 3" tape near the PMT-cookie interface.
- Tape the PVC tube to the face of the scintillator assembly with 3" electrical tape.
- Slide the PMT cap into the end that extends beyond the scintillator assembly and circle tube with tape; this provides pressure point to clamp the assembly inside the PVC slot.

#### 4) Detailed PLUG-IN Sequence

Plan locations and layout for your GPS, counters, DAQ and PDU, and computer.

##### Preplanning:

- Place the GPS antenna at a window with at least a partial southern exposure, if possible, where it has a clear view of the vertical sky. The antenna is sensitive enough to acquire satellites from inside the window. The antenna may be placed outside, along with the temperature sensor, but not the gray box containing the GPS module. The gray GPS module box MUST remain inside. The GPS module may be located up to 100 feet from the DAQ using the CAT-5 cable provided. The GPS antenna has a magnetic base. Alternate CAT-5 cable may be used especially to reach an outside window in another room; user provided.
- DAQ lives near the data computer.
- PDU enables control of voltage levels and power supply to PMTs. Must be within 50 ft. of counters. Extensions are possible; user-supplied.
- Counter placement driven by experiment type: array or stacked (See CRMD Users Manual.)

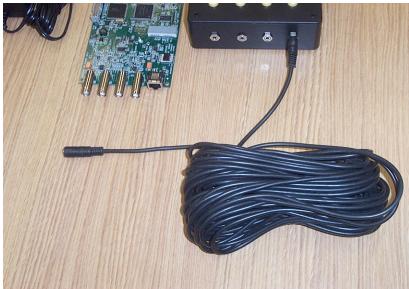
***DO NOT POWER UP SYSTEM UNTIL ALL COMPONENTS ARE IN PLACE to avoid overvoltage to the PMT. Make sure all cable connections are completely seated.***



1. Power Supply, female connector → DAQ male jack (power supply may differ from photo)  
Note: Do not plug into wall outlet at this step.

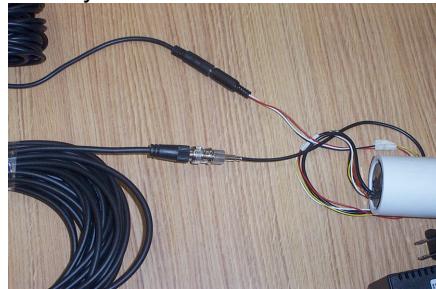


2. DAQ female jack  $\leftrightarrow$  PDU (single, side outlet): 6 ft. PDU power cable, male mono connectors

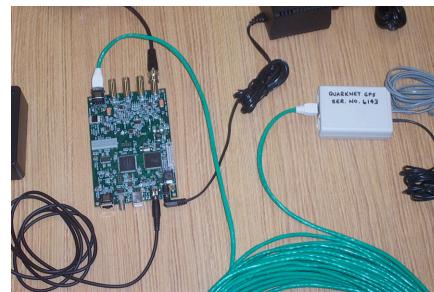


3. PMTs/counters (4)  $\leftrightarrow$  PDU (four, side outlets): 50 ft. power extension cable, stereo connectors

Note: check all power connections; must be fully seated.



4. PMTs/counters BNC connections (4)  $\leftrightarrow$  DAQ BNC connections: 50 ft. BNC signal ext cables

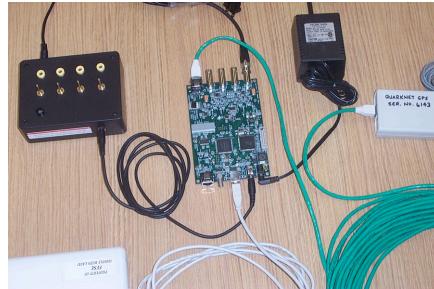
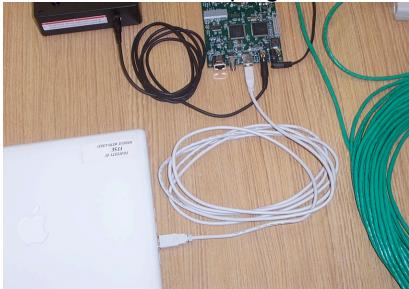


5a. GPS antenna  $\rightarrow$  GPS Receiver Assembly: black MCX cable

5b. temp sensor  $\rightarrow$  GPS Receiver Assembly: gray phone cable, red sensor end

5c. GPS Receiver Assembly  $\rightarrow$  DAQ: CAT-5 green network cable

Note: CAT-5 cable plugs into DAQ "GPS IN", not "GPS FANOUT".



6. DAQ  $\rightarrow$  computer USB port: USB 2.0 A to B cable

## **5) POWER-UP Sequence (after plugging in all components)**

1. Set potentiometers on the PDU to minimum (fully rotate counterclockwise).
2. Plug 5V DC power supply into 110V wall outlet.
3. Check DAQ: two yellow LEDs next to USB for power → 3V, 5V
4. Verify power to GPS module: red/green LED on module box
  - Red blinking: power up condition, initializing
  - Red/green combination: searching and # of sats
  - Green only: long & # of short → # indicates "healthy" sats
5. Check control voltage on each PDU channel: black socket → ground; yellow socket → positive

## **6) Commissioning Sequence**

1. Install USB appropriate driver from "SiLabs" vendor onto data computer: See Addendum below.  
Note: URL has changed.
2. Open USB connection from computer to DAQ; use terminal emulator: "hyperterm" or "Zterm."  
(See CRMD Users Manual - Appendix C: Terminal Emulator Setup.) (default baud: 115200; flow control: Xon/Xoff)
3. Verify GPS signal on DAQ; white LED (marked 1PPS) should be blinking next to GPS jack (GPS IN). (may take 1 hour to lock signal)
4. Check number GPS satellites; run 'DG' command.
5. Plateau and test counters. (for plateauing instructions see CRMD Users Manual – Chapter 6 or Cosmic Ray e-Lab: <http://www.i2u2.org/elab/cosmic/library/resources.jsp> → PowerPoint and Spreadsheet)
6. Configure DAQ for coincidence, gate width, and delay; run "V1" and "V2" commands. (See CRMD Users Manual – Chapter 6.) (defaults: gate = 100ns; delay = 40ns. Set to defaults: DAQ command 'SA 2'.)
7. Take data: begin "Capture Text" with "hyperterm" or "Zterm."
8. Enter list of commands to capture configuration state of DAQ:  
CD → COUNTER DISABLE (stop data flow)  
H1 → HELP 1  
H2 → HELP 2  
DG → GPS  
DS → SCALAR COUNTS  
DC → CONTROL REGISTERS  
DT → TIME CONTROL  
BA → BAROMETER  
TH → TEMPERATURE  
TI → TIME  
TL → THRESHOLD VOLTAGES  
SN → DAQ SERIAL NUMBER (DAQ ID NUMBER)  
V1 → VIEW REGISTERS  
V2 → VIEW VOLTAGES  
ST 3 5 → PRINT STATUS LINES EVERY 5 MINS  
SA 1 → SAVE CONFIGURATION  
CE → COUNTER ENABLE (start data flow)
9. Upload data to Cosmic e-Lab:  
<https://www.i2u2.org/elab/cosmic/data/upload.jsp> → UPLOAD
10. Measure and input CRMD geometry to Cosmic e-Lab:  
<https://www.i2u2.org/elab/cosmic/geometry/> → GEOMETRY

## **7) Troubleshooting**

- If the DAQ does not respond to 'hyperterm' and 'ZTerm' commands, check the USB cable connection, unplug the USB cable, reboot, replug cable, and open fresh 'hyperterm'.
- If the Terminal Emulator is not responding, push the DAQ "Board Reset" button.

## **8) FAQs**

- How do I reset DAQ?  
Pushing the "BOARD RESET" button next to the "GPS FANOUT" will do a TOTAL reset.  
Pushing the button "COUNTER RESET" next to the "count" display will only reset the display.

- I have Vista or Win7 OS and 'hyperterm' is missing. What to do?
  - a) MicroSoft has given permission to move 'hyperterm' from an older Windows OS. On WinXP or Win2000 find:
    - hypertrm.exe (in Program Files\Windows NT)
    - hypertrm.dll (in Windows\System32).
  - Copy them to a common folder on Vista or 7. Double click 'hypertrm.exe' to launch.
  - b) Try open source application: PuTTY → <http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html>
- User configuration required.
- Topics found in QuarkNet CRMD Users Manual:
  - PC connection
  - DAQ commands
  - Capture data: hyperterm or ZTerm
  - Placement of counters and GPS
  - Plateauing
  - Coincidence
  - Discrimination
  - Pressure/Temp measure
  - CPLD frequency

## Addendum

### **QNET 2.5 (6000 Series DAQ) USB DRIVER INSTALLATION Fermilab, July 22, 2008**

The following are instructions for installing QNET USB drivers on a personal computer. Most of this document is for Windows PC users. *Note: Install the drivers before making the first USB connection to the DAQ.*

To get the most recent version of the drivers go to (<http://www.silabs.com>). Search for ‘VCP Drivers’ or ‘CP210X’. Below is an example listing of the driver packages for Mac, Win, and Linux.

**Download the driver package you need. Go here:**

<https://www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx>

→ VCP Driver Kit for your OS

**Windows OS** → CP210x\_VCP\_Win2K\_XP\_S2K3.zip

**Mac OS** → Mac OSX\_VCP\_Driver.zip

**Linux OS** → cp210x-3.0.0.tar.gz

Note: some older DAQs have an outdated URL printed on the back of the card. Use the above.

#### **Installing the driver on a Windows PC.**

- Install CP210x driver.
- Now connect the USB port on the PC to the Qnet DAQ board.
- New hardware found wizard will open. The wizard should find the drivers and complete the install.
- HyperTerminal can now be used to connect to the DAQ. Connect using the assigned port. This is usually the highest port number that is selectable on the Properties menu under File option for HyperTerminal.
  1. Connect using : usually COM3 (for additional help, see **will not connect to DAQ**)
  2. click on configure button and make the following Port Settings
  3. Bits per second: 115200 (BAUD)
  4. Data bits : 8
  5. Parity : None
  6. Stop bits : 1
  7. Flow control : None

The following is for Windows users if HyperTerminal **will not connect to DAQ**.

After installing driver do the following to find the COM port assigned to CP210x USB.

- Note: The Cp210x drivers have been installed.
- Connect Qnet to the PC using a USB cable.
- Right click on 'My Computer" (WinXP example)
- click on Properties
- click Hardware
- click Device Manager
- click Ports (COM & LPT)
- CP210x USB to UART Bridge Controller COM (n). COM (n) is the port number for HyperTerminal.