QuarkNet Cosmic Ray Detector Assembly Instructions for Series 6000

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Read Me First

Document Purpose

How to build a cosmic ray detector (CRD) from components and enable raw data flowing into a capture file.

Not Covered: Configuring CRD, data rate, plateauing individual counters, details of serial communication application ("hyperterm" or "Zterm"). These details are covered in the "QuarkNet/Walta/CROP Cosmic Ray Detectors User's Manual" (http://quarknet.fnal.gov/toolkits/ati/det-user.pdf)

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 plugs completely: **Improperly seated plugs can lead to power shorts.**
- **Avoid over pressure on the PMT window.**
- 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.**

Check Parts

Verify. Contact your QuarkNet mentor if parts are missing.

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

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. **Handle with cotton gloves.**
Heavy Gauge Aluminum Foil	(1) 38"x64" piece for covering scintillator.
Lightproof Black Wrapping Material	(1) 27"x36" 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) Electron Tube Model P30CW5 photodetector packages, including cables for signal, power and control. **Handle with care!**
Optical Couplant	(1) Small film-type canister containing optical grease used to interface the PMT to the light guide "cookie."
Signal Extension Cables for PMTs	(4) 50 ft. cables with male BNC connectors on each end
Power Extension Cables for PMTs	(4) 50 ft. stereo audio cables with one male and one female connector, to extend power and control circuits from PMTs

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

1b) Parts List – Large Components

GPS Receiver Assembly (GPS)	(1) The GPS receiver and interface adapter are in a small grey plastic box to which you will attach three items: A - the 100 ft. CAT-5 coax 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 its 9 ft. cable
Data Acquisition Circuit Board (DAQ)	(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. **Do not change any settings unless specifically asked for in the instructions.** The circuit board has been loaded with the current revision level of QuarkNet firmware.
USB Interface Cable	(1) 9 ft. USB2.0 A to B interface cable for connecting the DAQ to your PC's USB port.
Power Supply	(1) Power supply with 5VDC 1A regulated 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.)

2) Quick Start → Steps leading to a working CRD:
Assemble four counters—section 3.
Plug-in components—section 4.
Power up – section 5.
Commission CRD – section 6.
Take data: Capture data to a file. (See CRD Users Manual.)
Measure geometry and upload to cosmic e-Lab. (See CRD 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 enclosed 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 electrical tape	1/2" Teflon plumber's tape
3" (or 2") wide electrical tape	Scotch tape
Applicator stick	

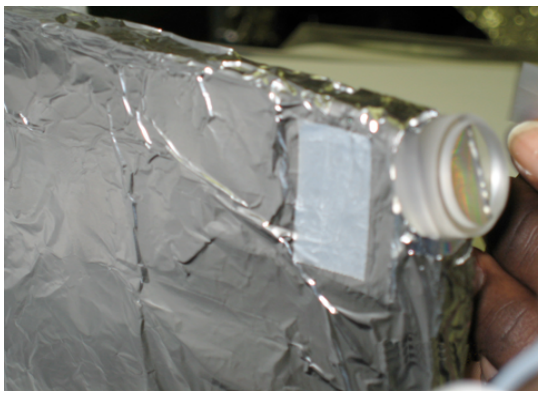
Tools Needed

Scissors	Straight edge
Razor blades	Protractor
Multimeter - VOM	

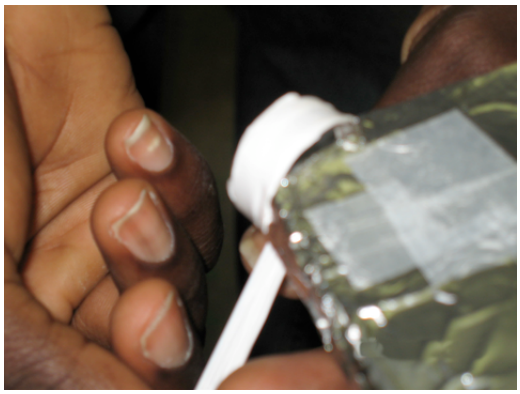
Step 1: Wrap the Scintillator.

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.

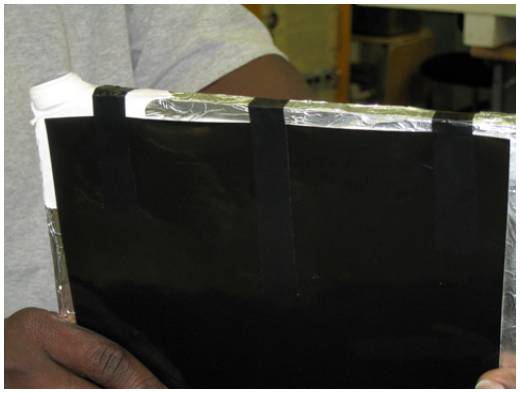
- Cut aluminum foil: four pieces sized 18" X 26" (45.7 cm x 66.0 cm).
- Lay the foil on a workspace with "shiny" side up. Smooth foil.
- Lay the scintillator at one end of the foil. **Use cotton gloves!**
- Fold the foil over one of the long edges.
- Fold foil around the other plate edges and tape.
-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



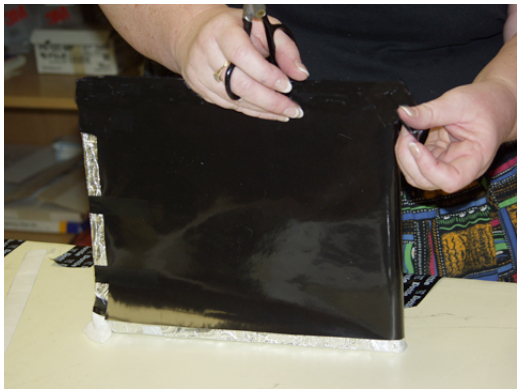
Completely cover the scintillator. While minor wrinkles are acceptable, avoid holes or tears. Add additional "repair" pieces to patch any noticeable tears or holes.



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.

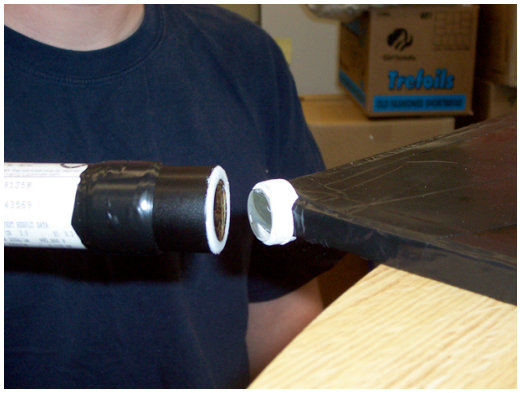


- Cut black wrapping material: four pieces sized 9 1/2” X 23 1/2” (24.1 cm x 59.7 cm).
- Lay the black wrapping material down on a workspace with the white side up.
- Lay scintillator at one end of the material.
- Fold black wrapping material around the short edge opposite the cookie.
- Tape edge with electrical tape to hold the material in place.
- Flip plate, 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 in a later step. 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.

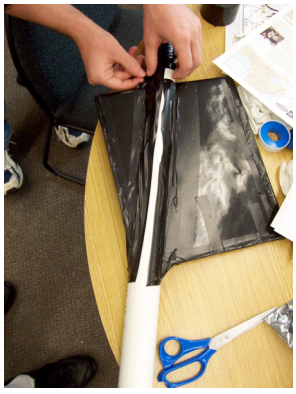


DO NOT force the PMT against the cookie.

- Apply a small amount (about the size of a pea) of optical grease to the PMT.
- Hold the PMT in contact with the cookie face.
- Gently press the two faces together.
- Wrap the joint—use 3” electrical tape.

Step 3: Assemble the PVC support.

- 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 and the long side of the assembly. Adjust the PVC

support until this angle is 18°. This will maintain alignment between the cookie and PMT faces.

- Wrap the outside of the PVC with 3” tape near the PMT-cookie interface.
- Tape the PVC 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

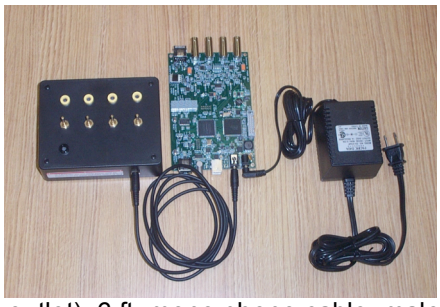
Plan locations for your GPS, counters, DAQ and PDU, and computer.

Preplanning:

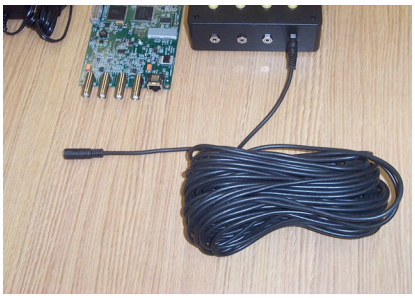
- Place the GPS antenna at a window with at least a partial southern exposure, if possible, where it has a clear view of the vertical sky. The antenna is sensitive enough to acquire satellites from inside the window. The antenna may be placed outside, along with the temperature sensor, but not the gray box containing the GPS module. The GPS module may be located up to 100 feet from the DAQ using the CAT-5 cable 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 CRD Users Manual.)

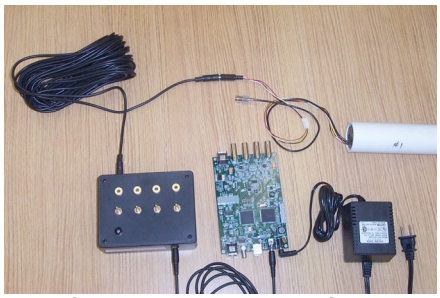
DO NOT POWER UP SYSTEM UNTIL ALL COMPONENTS ARE IN PLACE to avoid overvoltage to the PMT.

1. Power Supply, female connector → DAQ phono jack

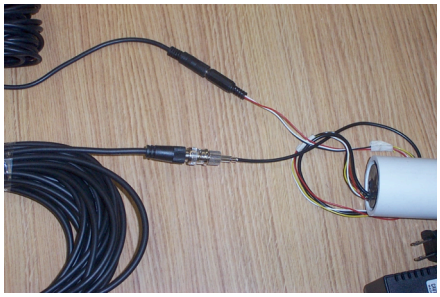


2. DAQ phono jack → PDU (single, side outlet): 6 ft. mono phono cable, male connectors

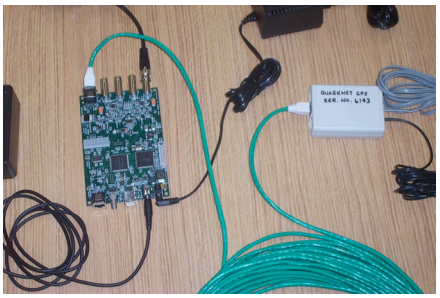




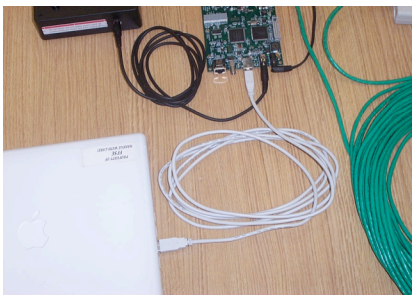
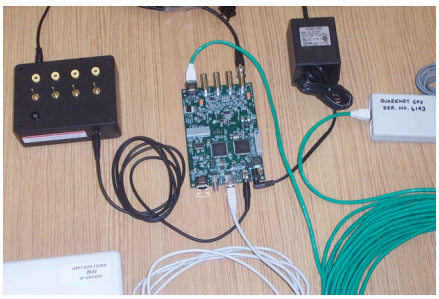
3. PMTs/counters power cables (4) → PDU (four, side outlets): 50 ft. stereo phono cable

4. PMTs/counters signal cables (4) → DAQ BNC connections: 50 ft. BNC cables



5a. temp sensor, GPS attenna → GPS module; 5b. GPS module → DAQ: Cat5 green cable

6. DAQ → PC serial connection: 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/green together: power up condition, no fix
   Red/green together & sequence of green: searching and # of sats
   Green only: long & # of short → # indicates sats
5. Check control voltage on each PDU channel: black socket → ground; yellow socket → positive

6) Commissioning Sequence

1. Install USB driver from "silabs" onto data computer:
http://www.silabs.com/tgwWebApp/public/web_content/products/Microcontrollers/USB/en/mcu_vcp.htm
2. Open USB connection from computer to DAQ; use terminal emulator: “hyperterm” or “Zterm.”
   (See CRD Users Manual - Appendix C: Terminal Emulator Setup.) (default baud: 115200)
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. (See CRD Users Manual – Chapter 6.)
6. Configure DAQ for coincidence, gate width, and delay; run "V1" and "V2" commands. (See CRD Users Manual – Chapter 6.)
7. Take data: begin “Capture Text” with “hyperterm” or “Zterm."

8. Enter list of commands to capture configuration state of DAQ:
   - CD → COUNTER DISABLE
   - H1 → HELP 1
   - H2 → HELP 2
   - DG → GPS
   - DS → SCALAR COUNTS
   - DC → CONTROL REGISTERS
   - DT → TIME CONTROL
   - BA → BAROMETER
   - TH → TEMPERATURE
   - TI → TIME
   - V1 → VIEW REGISTERS
   - V2 → VIEW VOLTAGES
   - CE → COUNTER ENABLE
9. Measure and input CRD geometry
10. Upload data to cosmic e-Lab: quarknet.fnal.gov/e-lab

7) Troubleshooting

- If the DAQ does not respond to 'hyperterm' and 'ZTerm' commands, check the USB cable connection.

- 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.

- Topics found in QuarkNet CRD Users Manual:
  - PC connection
  - DAQ commands
  - Capture data: hyperterm or ZTerm
  - Placement of counters and GPS
  - Plateauing
  - Coincidence
  - Discrimination
  - Pressure/Temp measure
  - CPLD frequency