# Cosmic Pi

Unit physical assembly & reassembly guide for V1.5 units

*This guide is for anyone who wants to build their own, or rebuild their own Cosmic Pi. A number of our V1.5 units were damaged during shipping, so this is also intended to help the recipients get them back in working order.*

Document Version 1

Released 30/01/18

# Materials:

- One main board V2.5 (see github.com/CosmicPi/MainBoard-hardware for schematics)
- One analogue board V2.5 (see github.com/CosmicPi/ANALOGUE-hardware for schematics)
- Two micro co-ax cables with u.FL connectors
- One Arduino DUE (see Arduino.cc for everything useful)
- Two scintillators (wrapped in foil or an opaque coating)
- Two Hamamatsu SiPMs (S13360-1325CS)
- Two SiPM/u.FL push fit adapter boards
- One Raspberry Pi Zero W + 3 core serial cable  (see www.raspberrypi.org)
- Six M3 nylon screws
- Six M3 nylon washers
- A drilled plastic plate to retain the scintillators in place
- An enclosure (Hammond 1598JBK, modified reference BASMOD2209 – REV2)
- A front sticker

# Tools:

- A flat blade screwdriver (3mm head)
- A cross head/Philips screwdriver (small/medium)
- A pair of fine nosed pliers
- Some sticky tape – masking tape is ideal
- Some superglue or epoxy resin
- A micro-USB cable for the Arduino
- A PC with the Arduino.cc development environment, an internet connection and an SD card slot if you want to flash Raspberry Pi images directly.
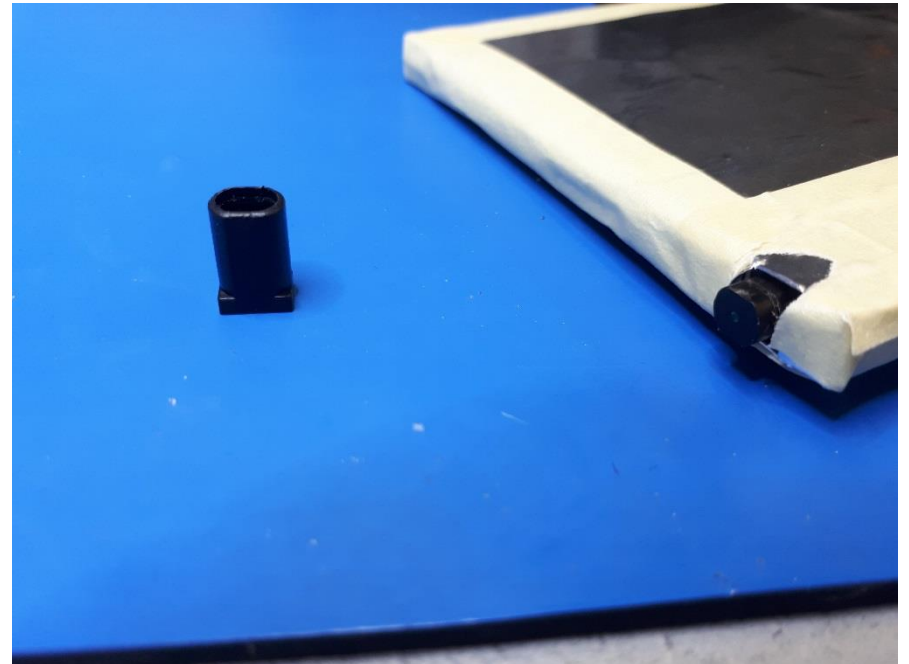
# Step 1: Case

- Open the case and prepare the TOP half.

- Glue 4 M3 nuts to the rear bosses as shown with superglue or epoxy. Ensure they are lined up with the holes.

- Glue 2 M3 nuts to the front (top left, as on the photo) bosses on the BOTTOM half of the case.
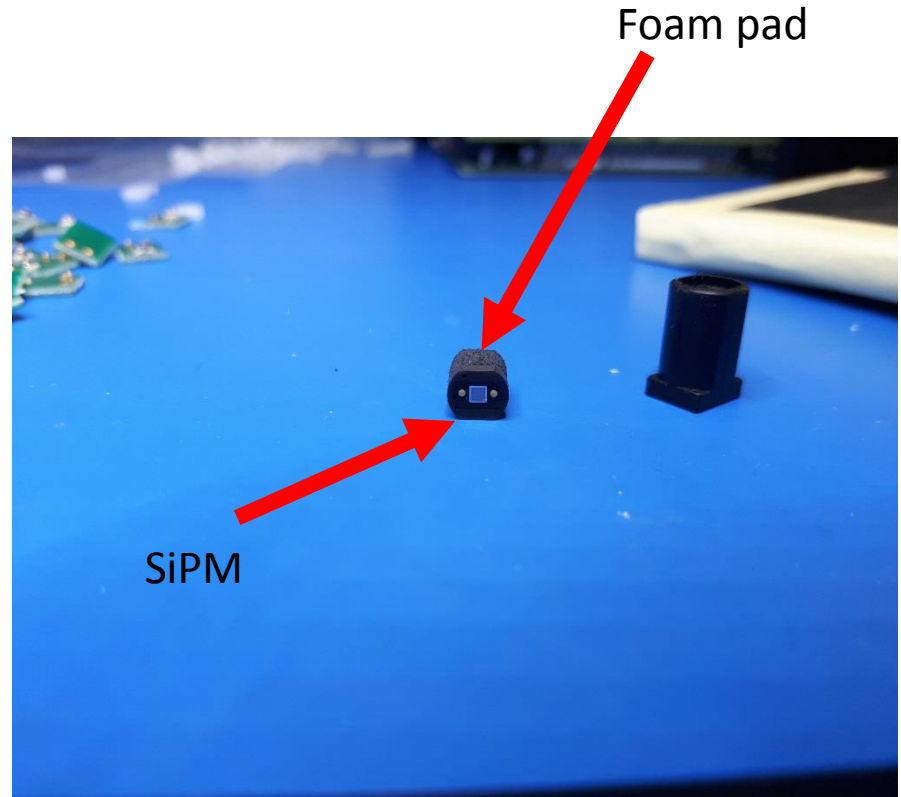


TOP OF CASE



BOTTOM OF CASE

# Step 2: Scintillator prep

- Remove the end cap from the scintillator

# Step 3: Scintillator prep

- Insert the SiPM into the small foam pad. This is required to keep the SiPM pressed up against the scintillators optical fibre.

Foam pad

SiPM

# Step 4: Scintillator prep

- Insert the SiPM and foam pad into the scintillator cap. Ensure that the legs of the SiPM are ligned up with the holes. One side of the SiPM has a dot, indicating polarity. Ensure this is aligned with the curved edge of the cap.

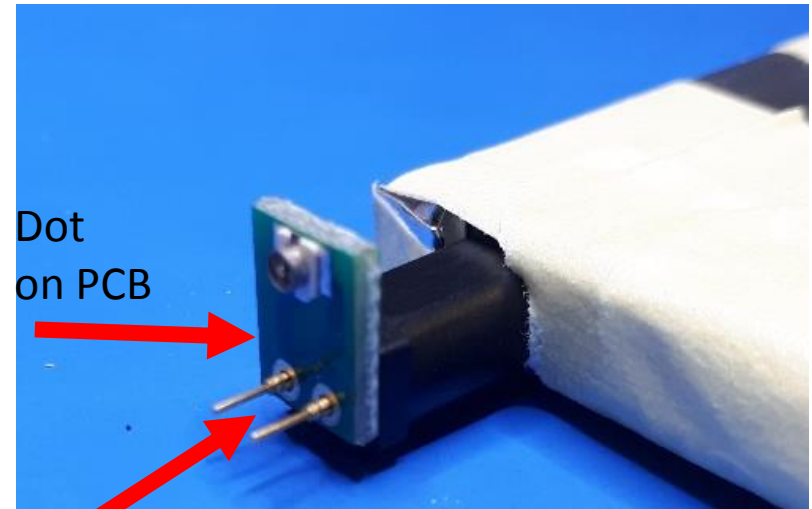Rounded edge of cap

Dot

Rounded edge of cap

Cap
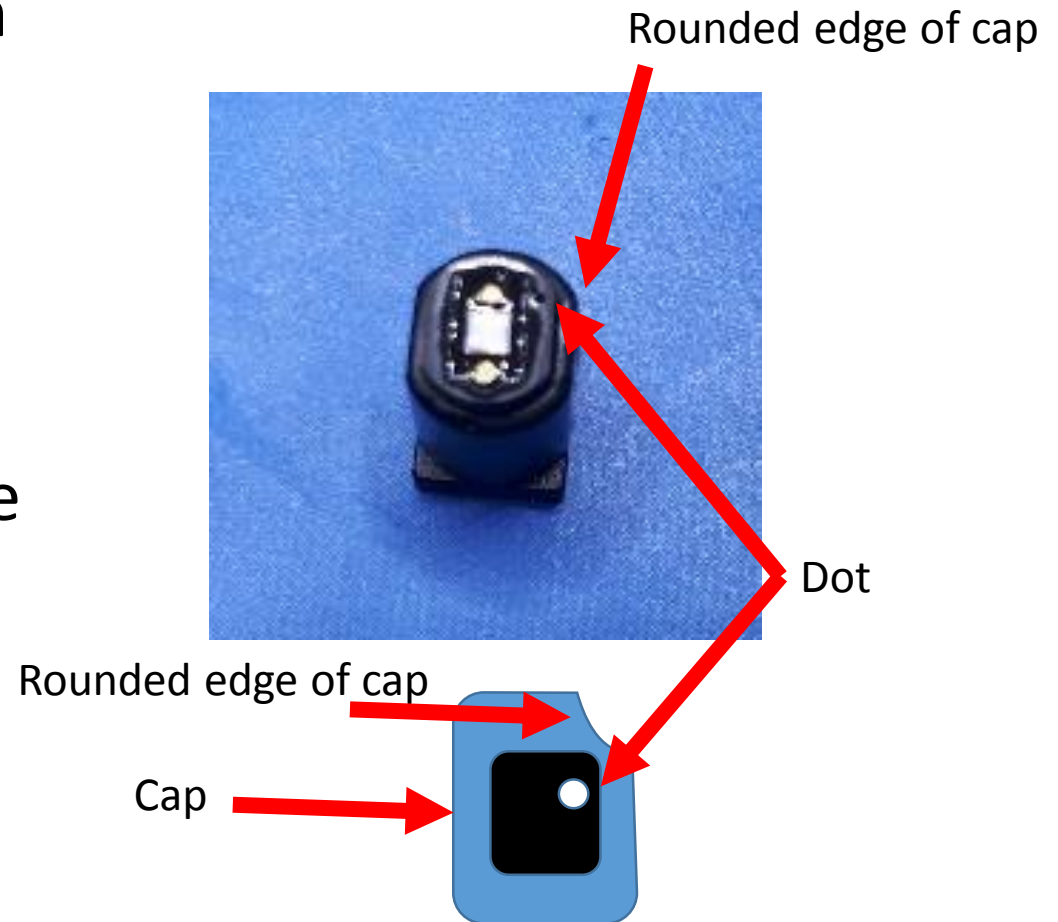
# Step 5: Scintillator prep

- Put the cap back on the scintillator.

- If the legs of the SiPM have become bent, you can straighten them carefully using pliers.
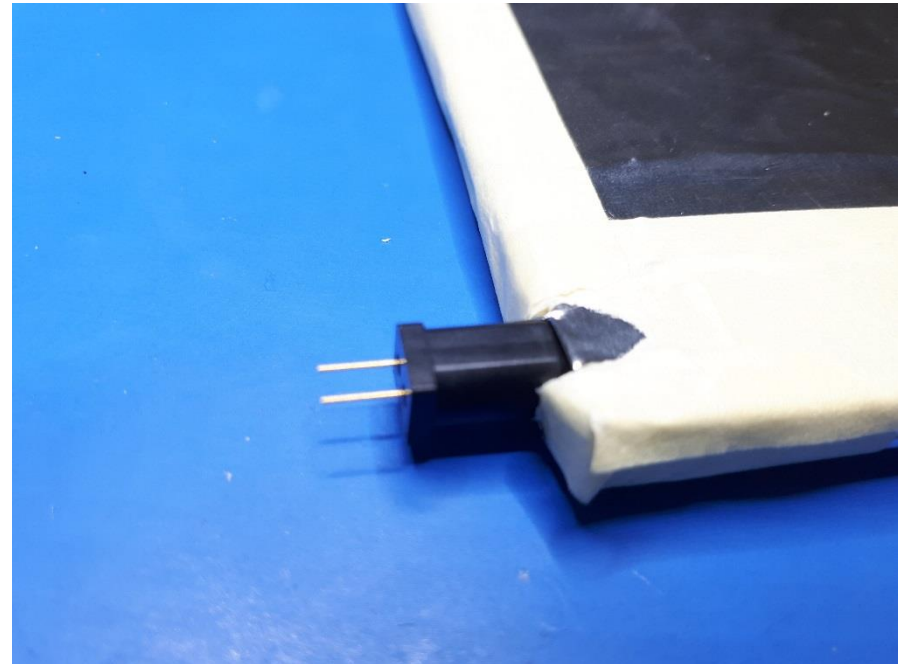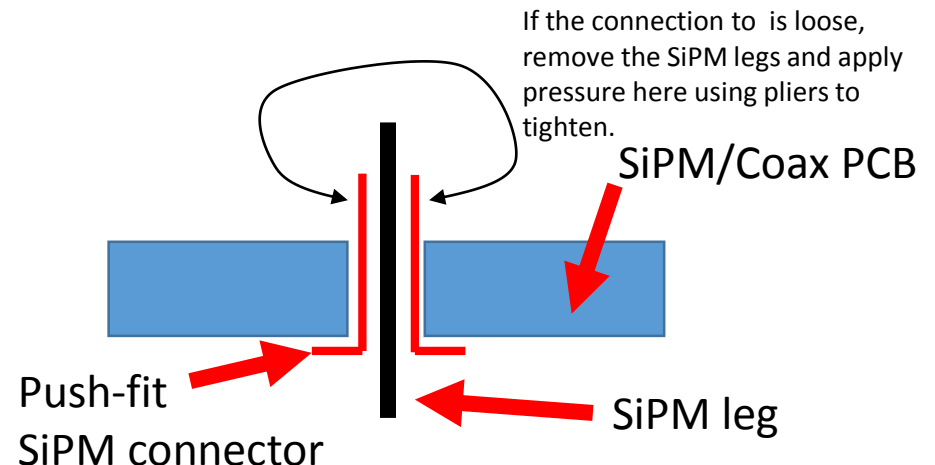
# Step 6: Scintillator prep

- Install the SiPM to Co-ax adapter PCB. Ensure that the side of the PCB with the dot is the same as the side of the cap with the curved edge. This makes sure that the polarity is correct for the SiPM.

- The connector is push fit, you might need to gently tighten the hole connectors with pliers if they have become loose. If they no longer work as push fit connectors due to damage, solder can be applied to make the connection permanent.



Dot on PCB

Rounded edge of cap

If the connection to  is loose, remove the SiPM legs and apply pressure here using pliers to tighten.

SiPM/Coax PCB



Push-fit SiPM connector

SiPM leg

# Step 7: Scintillator prep

- Install the SiPM to Co-ax adapter PCB. Ensure that the side of the PCB with the dot is the same as the side of the cap with the curved edge. This makes sure that the polarity is correct for the SiPM.
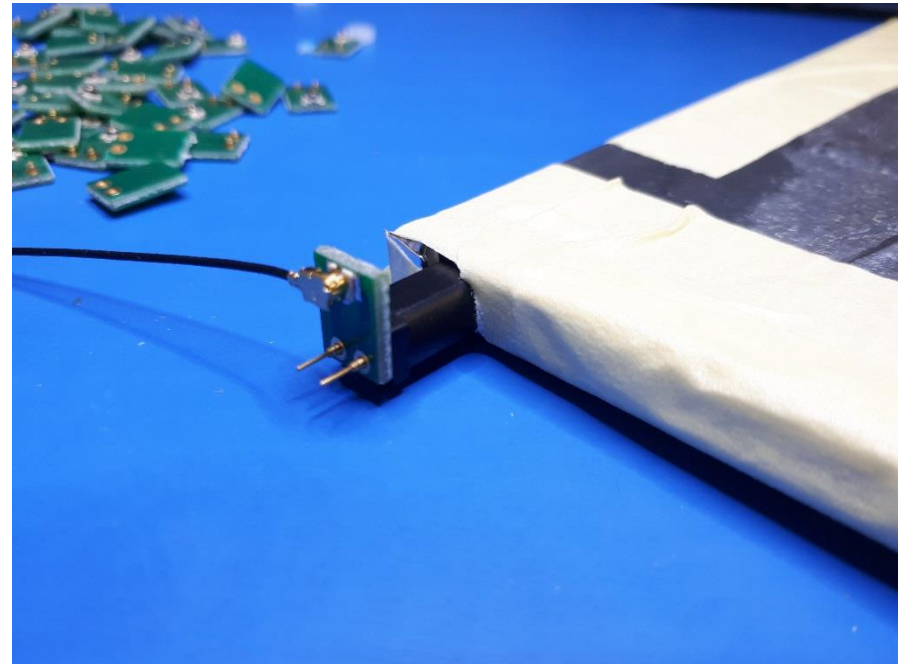
# Step 7: Scintillator prep

- Install the SiPM to Co-ax adapter PCB. Ensure that the side of the PCB with the dot is the same as the side of the cap with the curved edge. This makes sure that the polarity is correct for the SiPM.

- Both scintillators need to be prepared, so repeat steps 2-7 for the other slab.
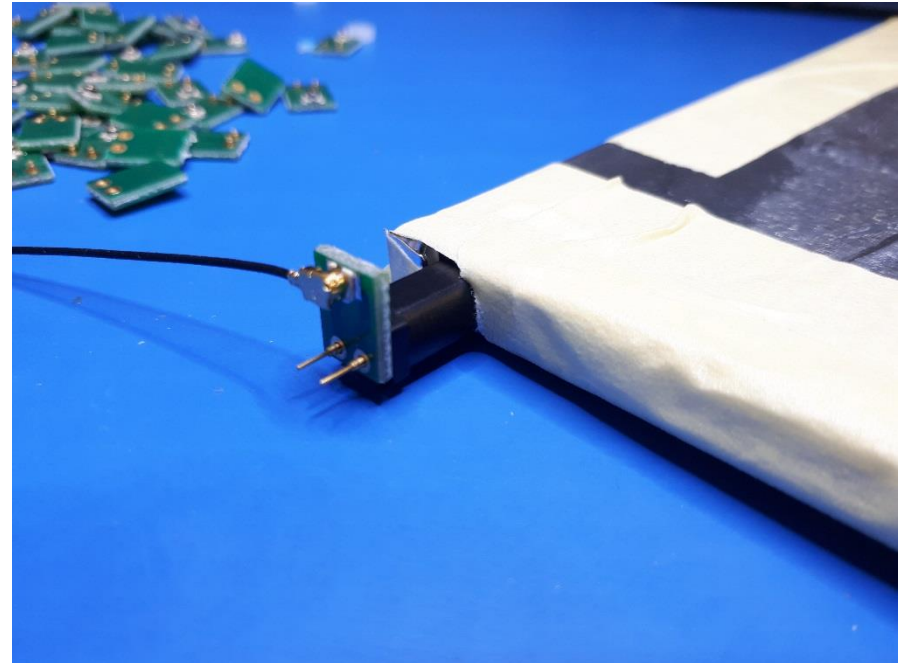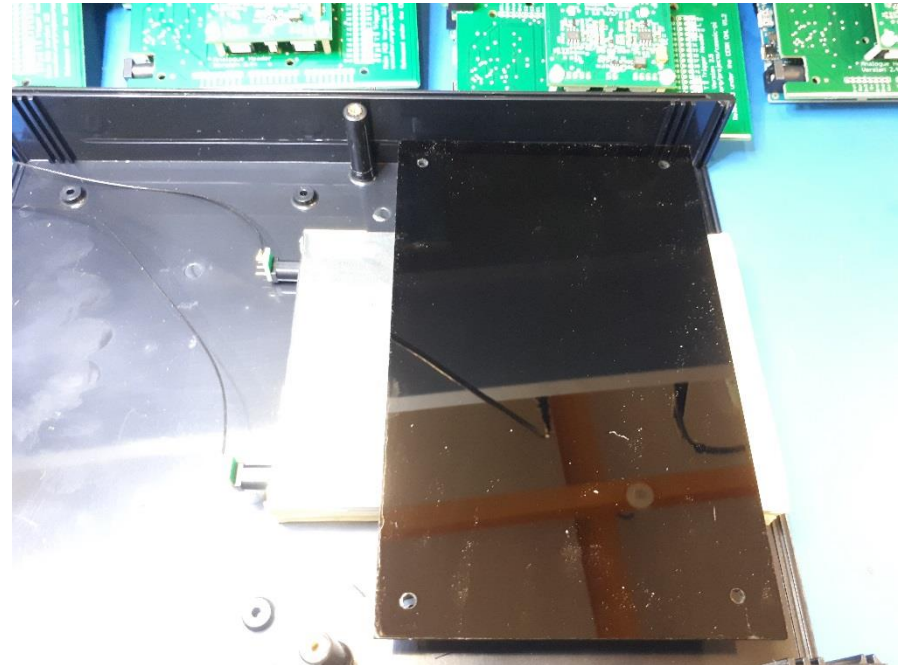
# Step 8: Scintillator installation

- Lay the two slabs on top of each other in the top half of the box, between the 4 bosses. Make sure that the slabs do not protrude from the edge of the box, as it will be closed with the metal plate.

- You may need to flip the slabs such that the SiPM caps don't clash.
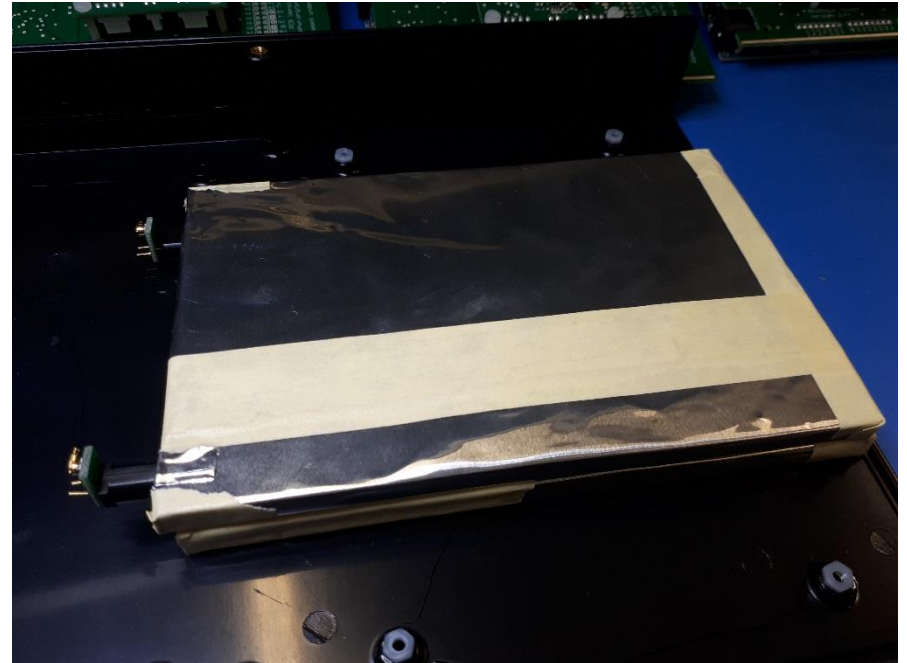
# Step 9: Scintillator installation

- Place the Perspex retainer on top of the slabs such that the holes line up with the 4 nylon nuts which have been superglued to the bosses in the case.

# Step 10: Scintillator installation

- Use 4 x 22mm M3 nylon screws to secure the retaining plate into position. It should curve slightly when under tension.

- Do not overtighten as the nuts will shear from the bosses.
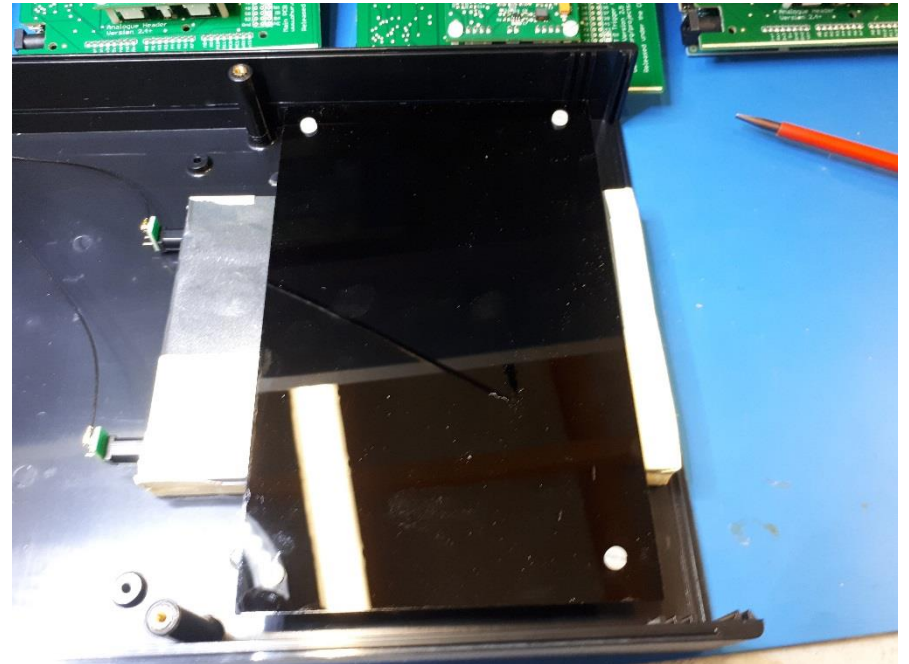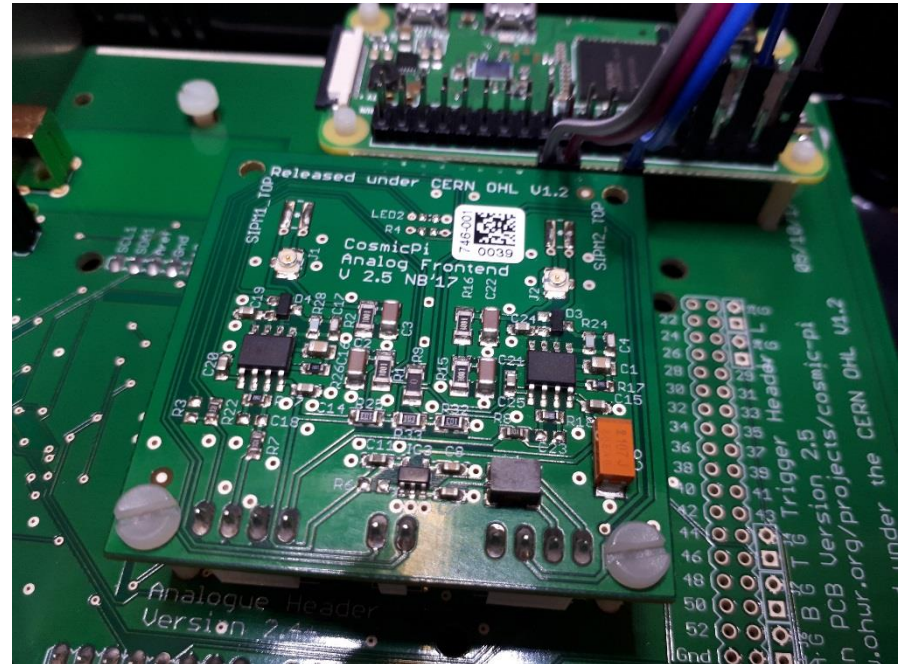
# Step 11: Electronics assembly

- Take the main board (below) and install the Arduino DUE on the pins which protrude from the bottom of the board. Make sure that it's aligned before you start to apply pressure. No mechanical fixing is required

- Be careful if you need to remove the Arduino in future, it's very easy to bend the pins.
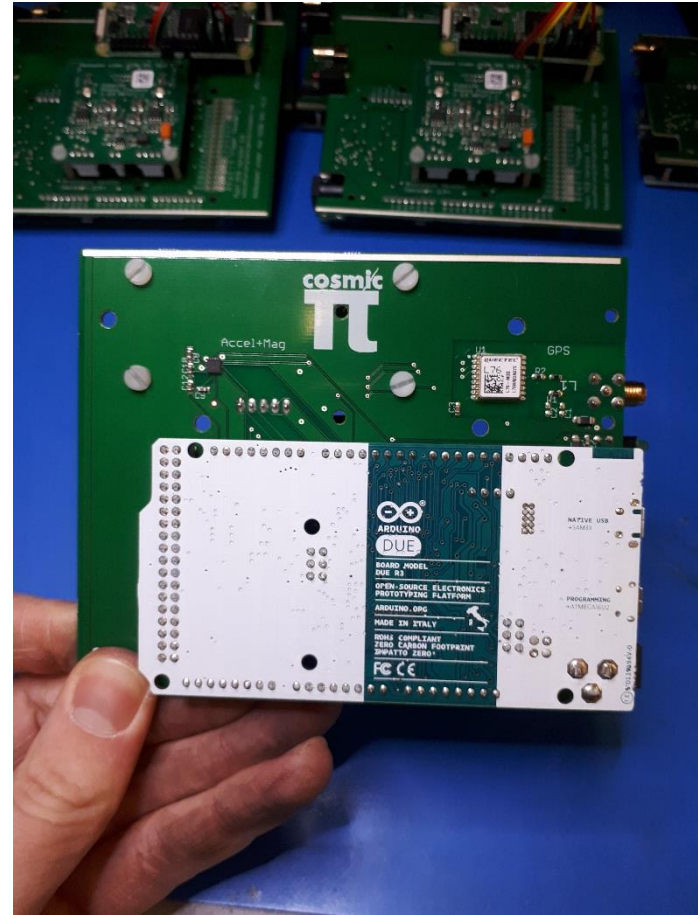
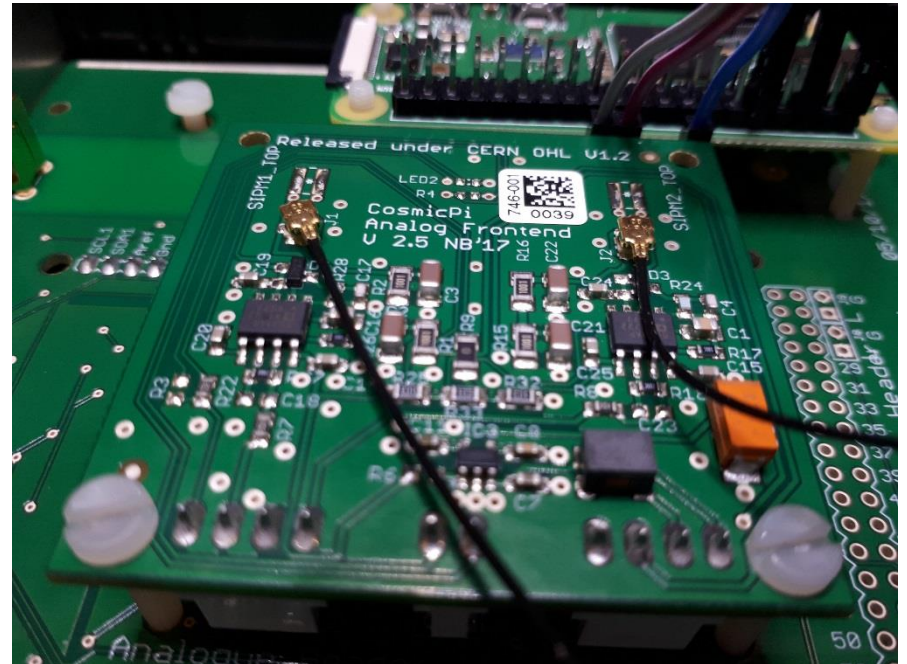# Step 12: Electronics assembly

- Install the analogue amplifier board on top of the main board. It has 10 pins, which will align with the 2 4 pin sockets. The board should not oversail the edges of the main board – see picture for orientation.

- You can push two 22mm M3 bolts into the holes at the edges near the pins to secure it to the main board. They will be a tight fit, nuts are not required.
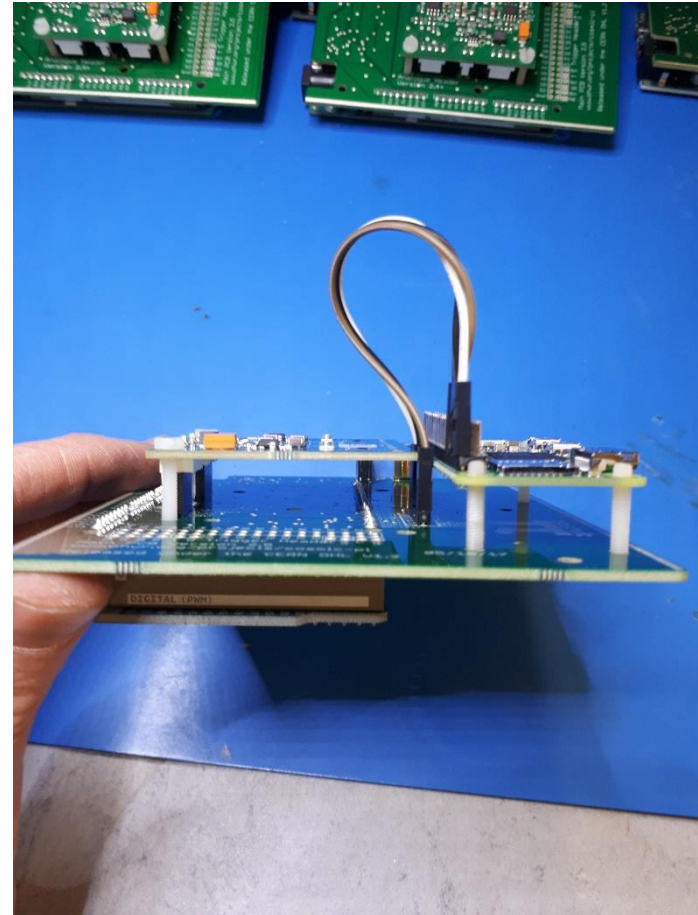
# Step 13: Electronics assembly

- Fit the two u.FL connectors to the analogue board.

- They should pop into place and rotate with a small amount of force once secured.

- The u.FL connectors are only rated for 5 mating cycles, so avoid excessive disconnections and re-connections.

# Step 14: Electronics assembly

- Now insert 4 22mm M3 bolts from the underside of the main board into the four holes for the Raspberry Pi. They will be a snug fit, no nuts are required.

- The Raspberry Pi Zero should push fit on to the end of the M3 bolts, again no nuts are needed.

- You may need to push on the heads of the bolts to ensure they don't slide when attaching the Raspberry Pi.

- Make sure that the SD card is correctly inserted into the Raspberry Pi Zero; it contains the information required to capture, display and send cosmic ray information via Wi-Fi.

# Step 15: Electronics assembly

- Now connect the three core cable from the main board to the Raspberry Pi:
  - 5V – from the 5V pin on the main board to Pin 2 on the Pi.
  - GND – from the GND pin on th emain board to pin 6 on the pi.
  - TX – from the TX pin on the main board to pin 10 on the Pi

- The pins on the main board are labelled with their function.

- Note 1 - TX from the main board goes into RX on the Pi, this is normal for UART communications.

- Note 2 – RX and Reset are exposed on the main board, potentially allowing re-flashing of the Arduino directly from the Raspberry Pi, however this is not implemented in version 1.5.
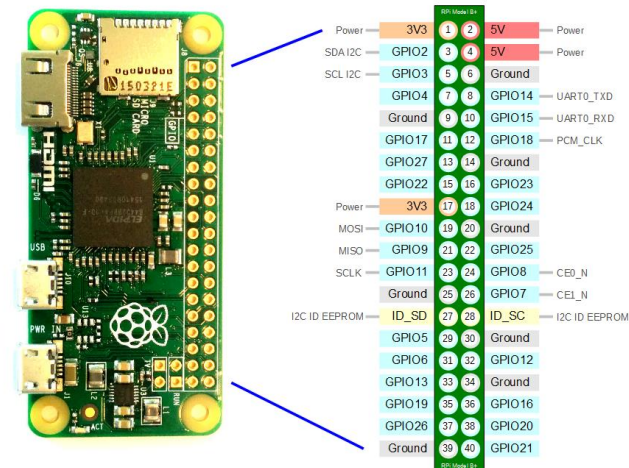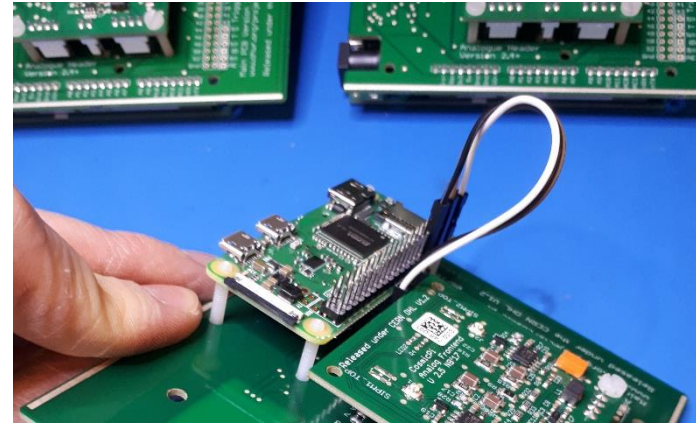
# Step 16: Close the case

- Apply the sticker to the front plate (if it doesn't already have one).

- Mate the electronics with the front plate, it should snap into position with the USB ports accessible.

- Install two 22mm M3 screws through the holes in the main board which connect with the bosses underneath. Do no overtighten as the nut will shear.

- Then lower the electronics and face plate into bottom half of the casing.

Apply tape to secure micro-coax cables

# Step 17: Close the case

- You may wish to tape down the micro co-ax cables before closing the case to ensure that they are not pinched in the case joints – this would break the detector and the cables would need replacement.

- Carefully lower the top case onto the bottom, ensuring that the front and rear face plates are aligned.

- Install the two screws that hold the case together.

Case screws go here

# Step 18: Programming

- When connecting to the Cosmic Pi, always screw the GPS connector in first. This helps to hold the electronics in place.

- Then connect the power jack plug and a micro USB cable from the programming socket of the Cosmic Pi to a computer.

- Download the Arduino software from Arduino.cc and the code from https://github.com/CosmicPi/cosmicpi-arduino_V1.5. Note that you will need the Arduino DUE libraries installed to compile the code, this can be done within the Arduino software menus.

- You can flash the device with firmware by selecting the correct serial port (Arduino DUE Programming) and the correct Arduino type, Arduino DUE Programming port.

# Step 19: Calibration

- Every detector is a bit different, you will need to calibrate the HV and detection threshold settings in lines 4 and 5 of the file detector_settings.ino

- We started with values that work for most units, but you might need to raise/lower the high voltage and thresholds a little (+/- 5 on the HV and +/- 200 on the threshold) to get the best performance – your unit should give about 0.8-1 events/second on average.

- If the unit is unresponsive after flashing, it's because the threshold is set too low and it is overloaded with events. Go back to the default threshold and start adjusting upwards.

- **We will be releasing a more detailed electrical/electronics check out & setup guide in the next week or two, including test points and nominal voltages.**



Use this USB socket

# Step 20: Operation

- Your detector should now be ready to use in USB mode with a computer.

- The web interface update will be released soon, which will enable you to connect via Wi-Fi to the internet and download all your data remotely.

- If you have any questions please contact us via info@cosmicpi.org

**Happy cosmic ray hunting!**