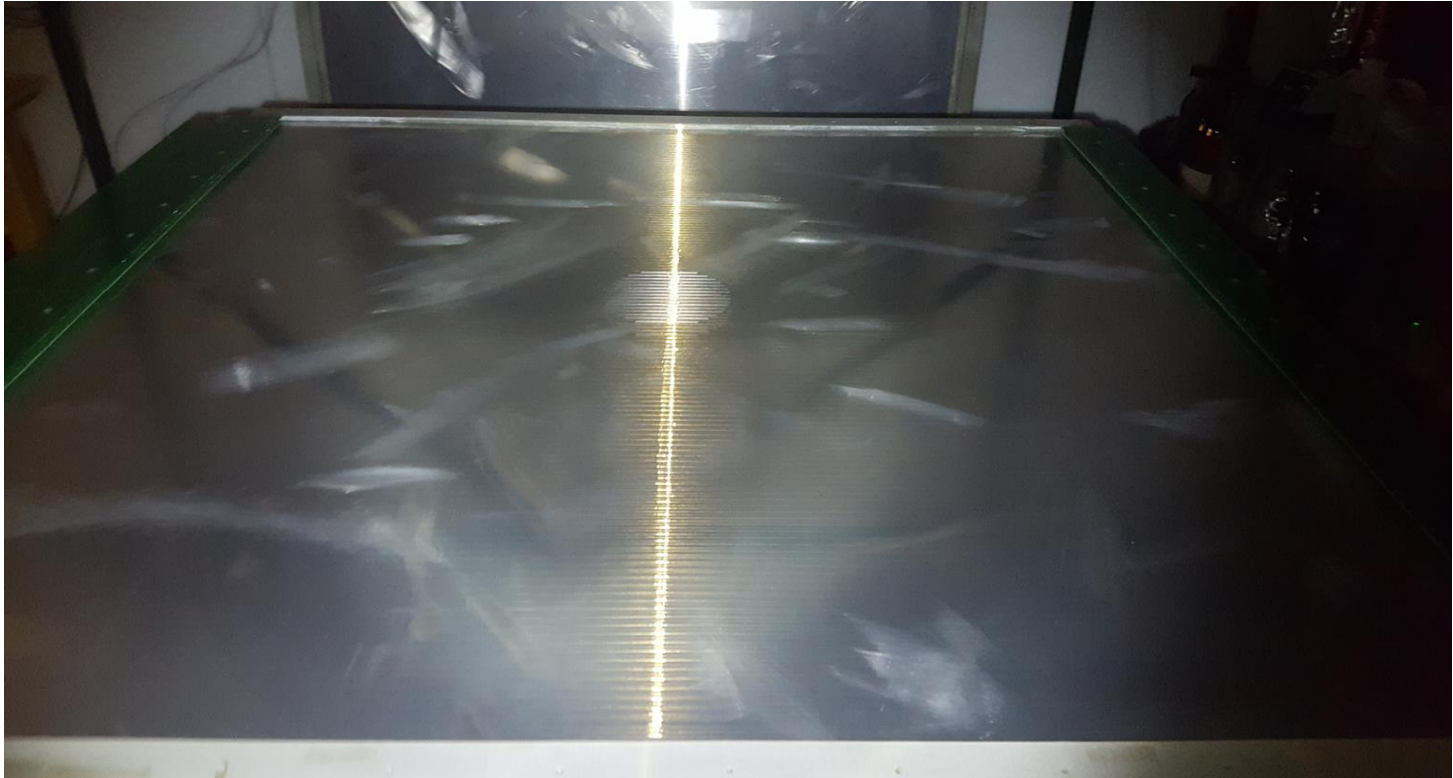


# Stringing the Large MWPCs

This is a guide to stringing the large sized MWPCs for the JLab CPP Experiment.



# Purpose of these slides

The purpose of this guide is to:

1. Describe how to string a large detector thoroughly. It took ~ 3 months to string without a guide due to all the unknowns, in the future this time should be greatly lowered by avoiding these unclear areas
2. Act as a logbook for all materials used in the construction of the MWPC. As such, pictures of materials used are also included.



# Outline

- ❖ General Stringing Information
- ❖ General Stringing Procedure
- ❖ Stringing with Carbon Tubes
- ❖ Single Person Stringing
- ❖ Conclusion



# General Stringing Information

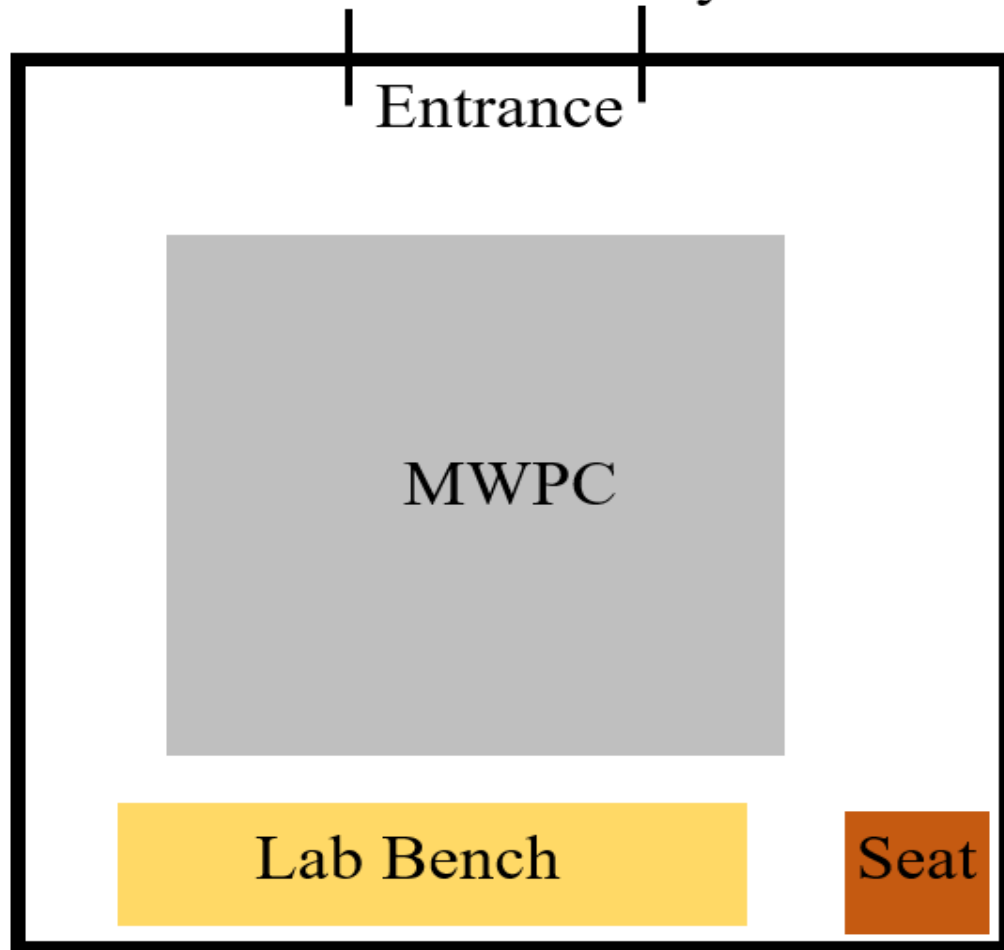
## Overview

The general structure of stringing wires is to pull them out over the detector, tension them between 25 – 50 grams depending on the wire and location, and solder them in place on the circuit boards. There are a number of nuances to this procedure and many of them are captured in these slides, but inevitably some things have likely been missed.

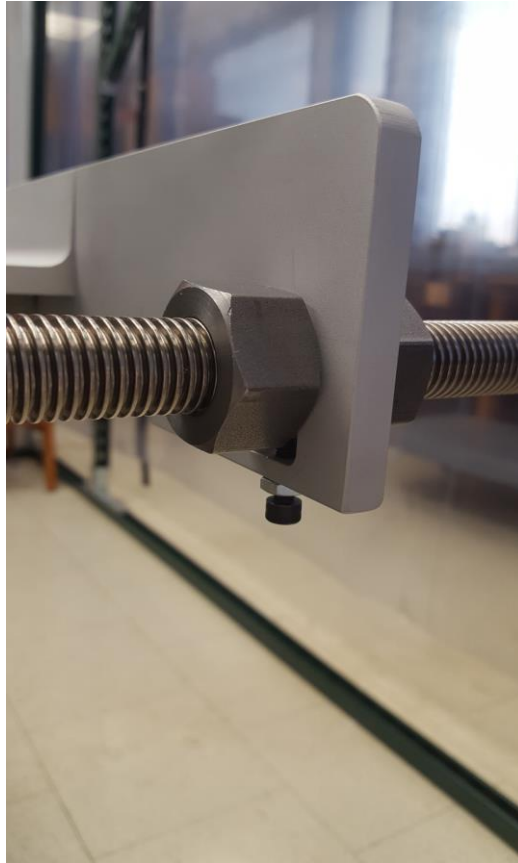
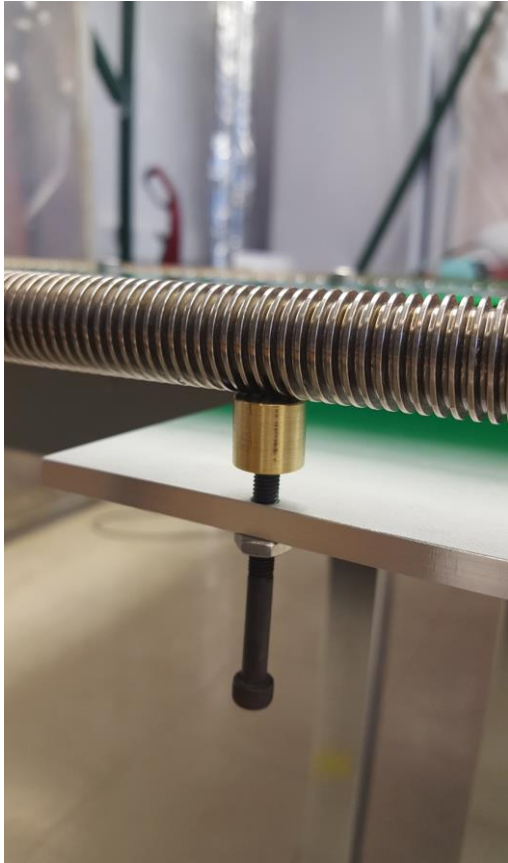
Before stringing, the clean room and detector must be prepared properly. Not included in this guide is how to do this, specifically how to lock in the guiding ACME rod which is used to position the wires for the detector. For more details on this, reference the honors theses written by Jordan Kornfield (2017) and Bobby Johnston (2017). These documents should be read before examining these slides for a better idea of the purpose and scope of the project.



# Clean Room Layout



# Aligning the ACME Rod

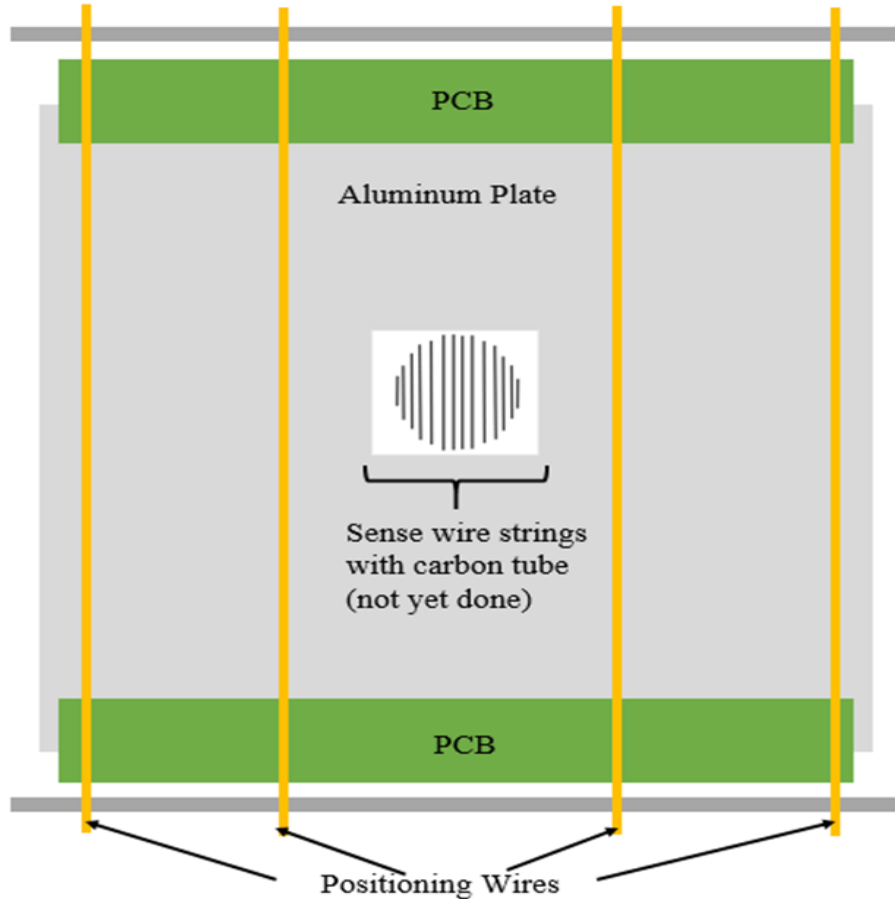


There are several screws around the detector frame to adjust the ACME rod.

As mentioned, aligning the rod will not be described in detail here, but it is important to note that this must be completed before stringing can begin.



# General Stringing Information



When the detector is ready to string, the ACME rod should be aligned, and 4 positional wires should be on the detector to monitor rod location for the duration of the stringing.

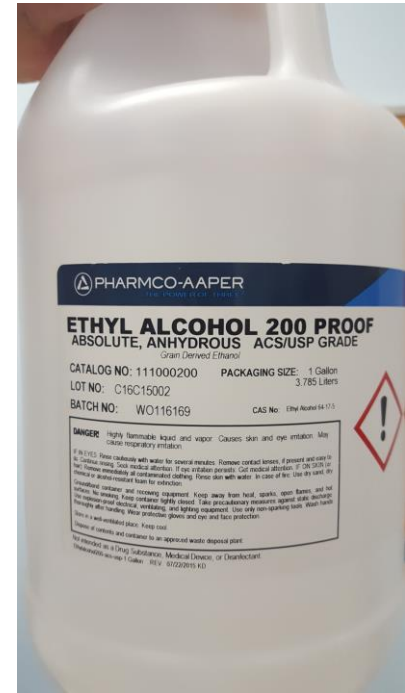
The central region is shown here, and is the area that should be completed first for ease of access.



# Clean room materials

Wire stringing is done in a clean room.  
When in clean room, always wear bunny suits and appropriate gloves

Acetone and Alcohol for general purpose cleaning - wipe down all materials with alcohol before bringing into clean room





# Clean room materials

Polyester rags are used in the clean room as they are non-fibrous



Additionally, if people have facial hair they should wear appropriate covering when in the clean room



# Soldering Materials

## Soldering iron & Solder wick



## Low-flux Solder



# Stringing Materials

Knife to cut wires



Clamps of different weights

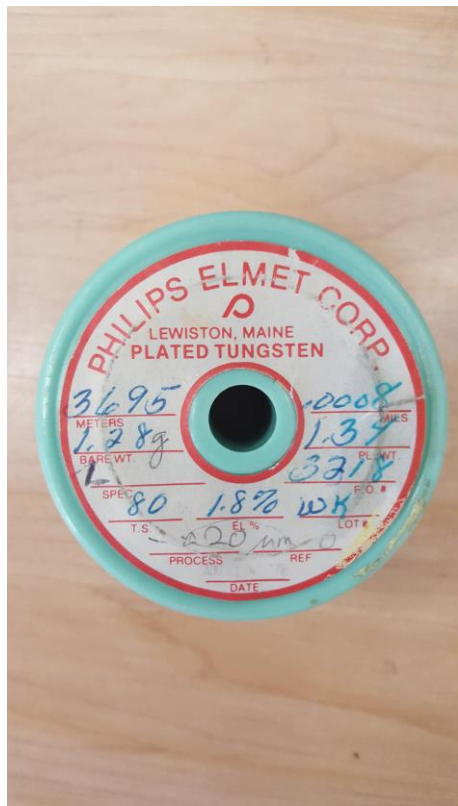


Bolts to facilitate in transferring wires



# Stringing Materials

## Sense Wire



## Field Wire



## Ringstand and spool pin



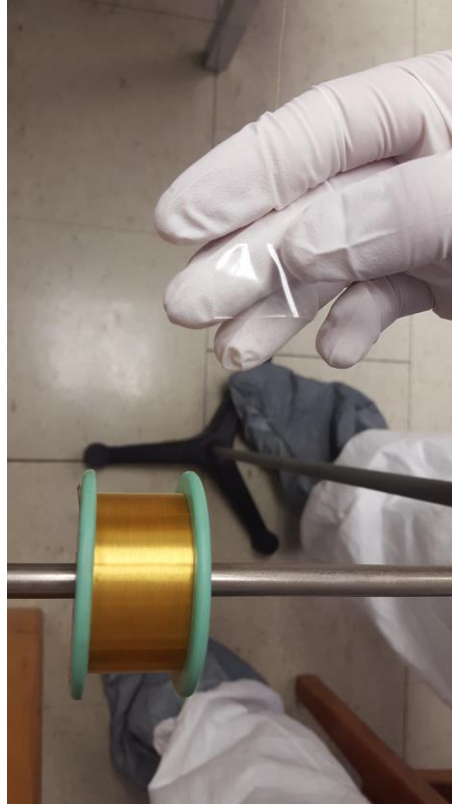
# General Stringing Procedure

## Overview

This section breaks down the steps to string wires across the detector. This details the wires in general, with another section devoted to stringing with carbon tubes in the central region.



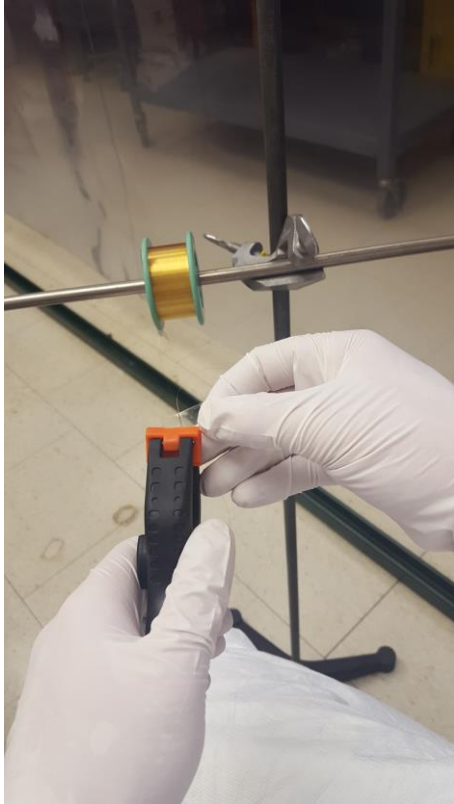
# 1) Tape Wire



Tape end of wire so it does not slip. This is only necessary for the smaller diameter sense wire. Yellow tape might have to be used to ensure adherence.



## 2) Clamp Wire



Clamp wire with a clamp of an appropriate weight.

Reference tensioning map to see what weight is appropriate.



## 2) Clamp Wire





### 3) Pull Out Wire

Begin pulling out wire from spool. Hand clamp off to group member.



### 3) Pull Out Wire



Pull wire out to length about 3 feet longer than length of detector



## 4) Tape Other Wire End & Clamp



When at appropriate length, tape & clamp wire end near spool



## 5) Cut Wire from Spool



Cut the wire  
free from the  
spool



## 6) Drape Wire over Cylinders



Using bolts, or similar cylindrical rods, drape wire over rods. This allows for constant tension in the wires and prevents snapping



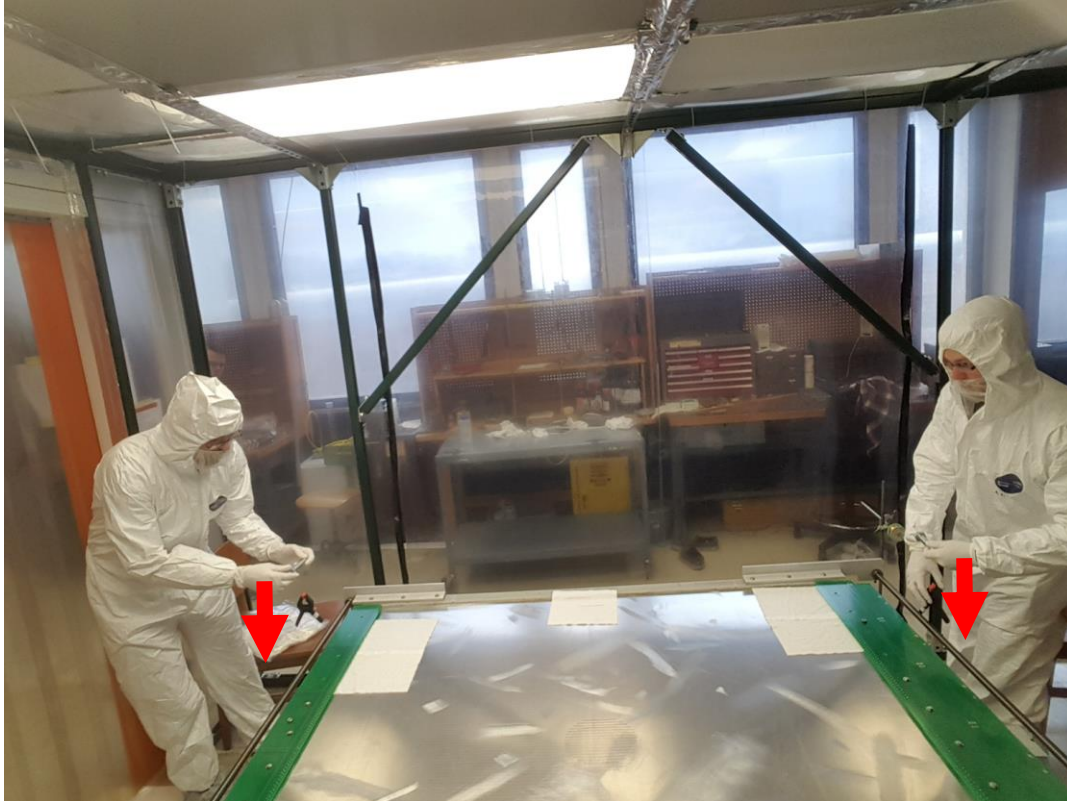
## 7) Transfer Wire to MWPC



Gently walk wire  
over to  
destination on  
MWPC



## 8) Lower Wire to Location



As a team, gently lower the wire down to the circuit boards.

When completely lowered (wires resting on circuit boards) carefully remove the cylinders from behind the wires



# Positioning Wires on Pads



The ACME rod has a spacing of 0.1" between slots. It is very clear to see if the wire is in the proper slot.

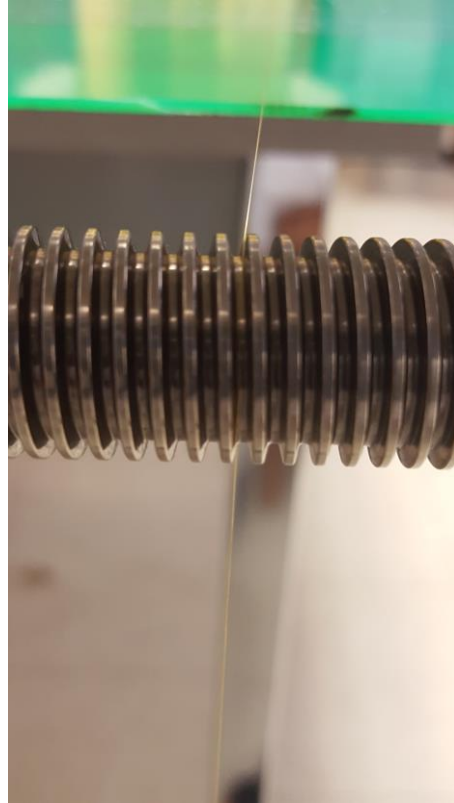
Image on left: wire in slot 1 removed from proper screw thread

Image on right: wire in proper thread





# Pushing Wire to Side of Rod



The ACME rod has a square bottom, rather than a sharp slot.

For higher accuracy, the wires must be pushed to one side of the room on both rods throughout the entire detector. Otherwise the wires might lie somewhat diagonally across the detector



# Pushing Wire to Side of Rod



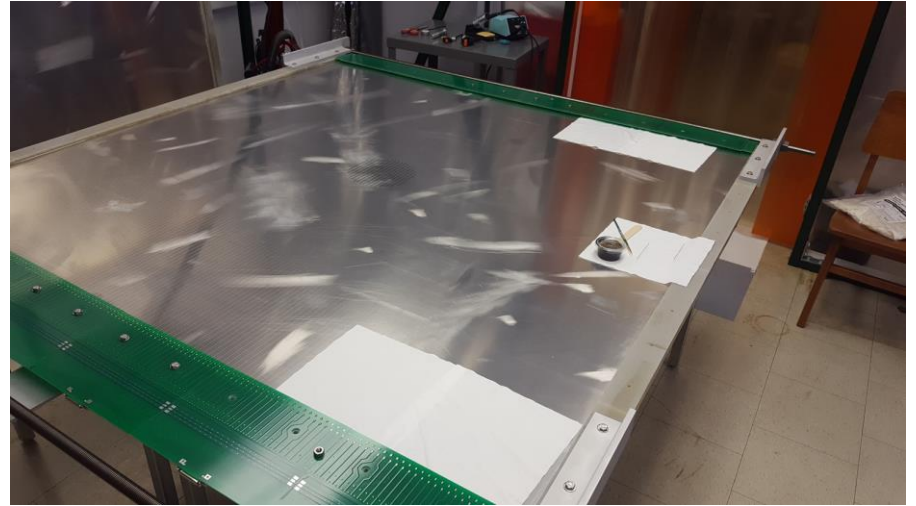
Image on left: Wire pushed to left of square bottom on rod

Image on right: Wire pushed to right of square bottom on rod. The difference is noticeable.

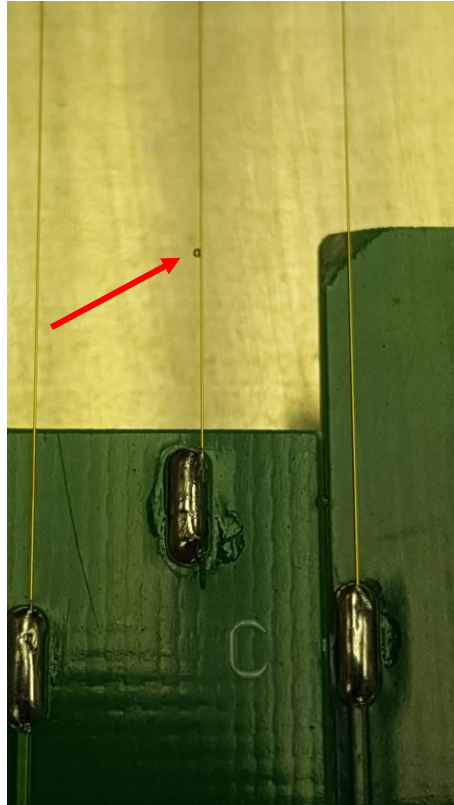
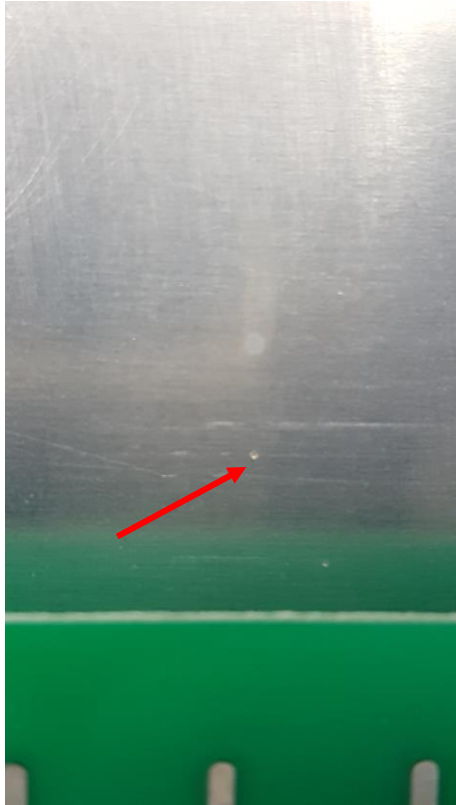


# Place rag beneath soldering area

When the wire is in proper position, before soldering it in place, make sure there is a polyester rag on the metal plate next to the soldering pad that will be worked on. This is to prevent flux from splattering onto the aluminum plate.



# Prevent Flux Splatter from hitting plate



Without the polyester rag, the flux will jump out and land on the metal plate and form small dots, as shown on image on left.

A small percentage of the time, flux will stick to the wires themselves, these must be removed from the wires or the wire re-strung



# How to Clean up Stray Flux Dots

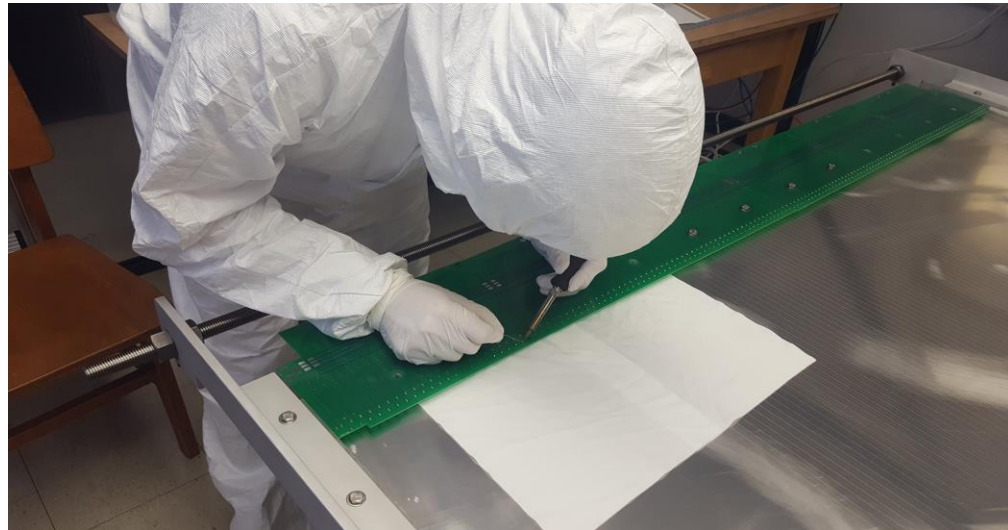


To clean up flux that splattered onto plate or wires, use a small straw taped to the clean room vacuum hose and gently nudge until dot is removed.



# Soldering Wires into Place

When wire is positioned properly, solder into place.



# Good, Bad, & Ugly Soldering Jobs

Good, shiny,  
smooth, round



Bad, dull, wrinkly



Mostly good but  
large bulge of solder

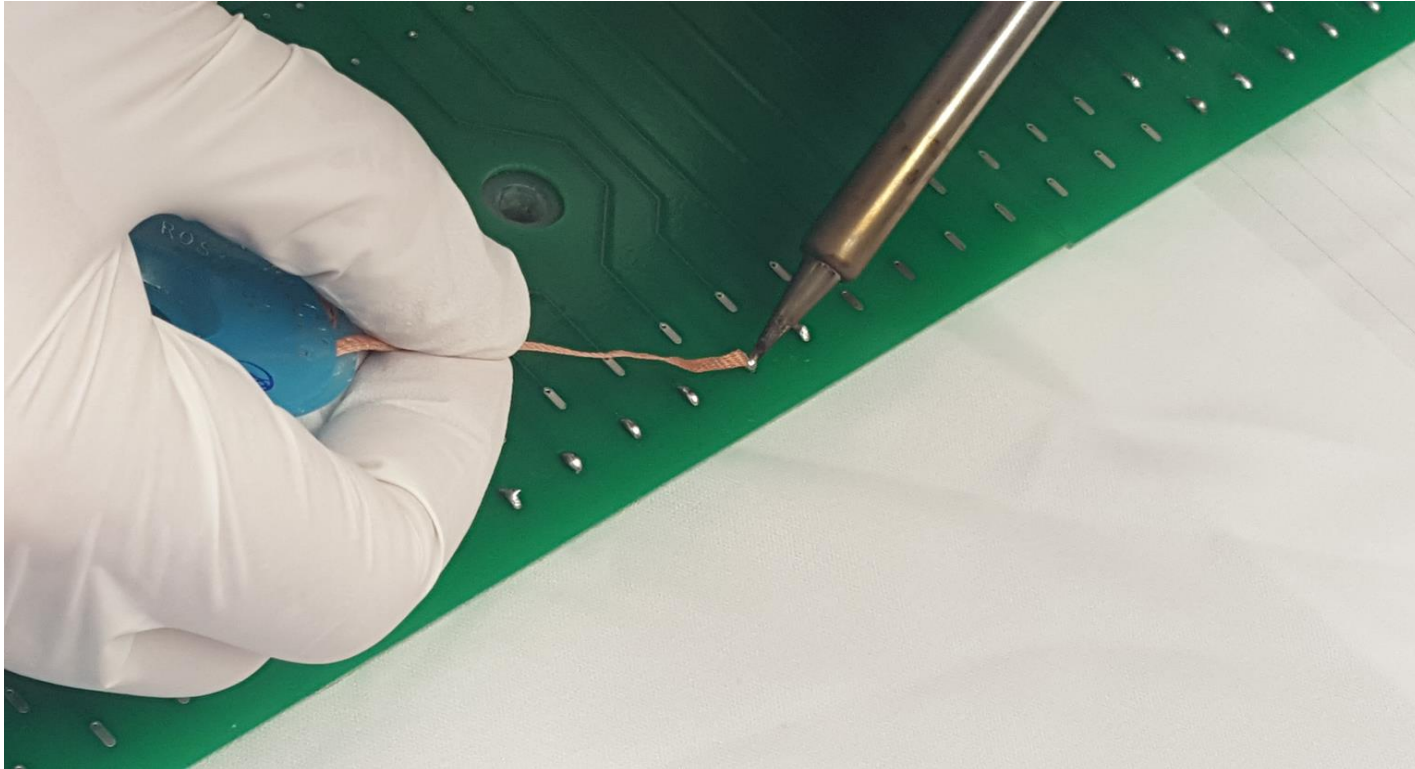


Spikey and dull



# Removing Solder from Pads

To redo a solder joint, use copper braid to remove solder from pad





# Cleaning Flux from PCBs



After removing solder with copper braid, there will be residue left behind from flux. Use acetone and a polyester rag to clean pad.



# Cutting Wire from Solder Pad



When wire is soldered to both circuit boards, use a sharp knife to cut remaining portion of wire from solder joint. Cut as close as possible to solder bead to prevent spiked points.

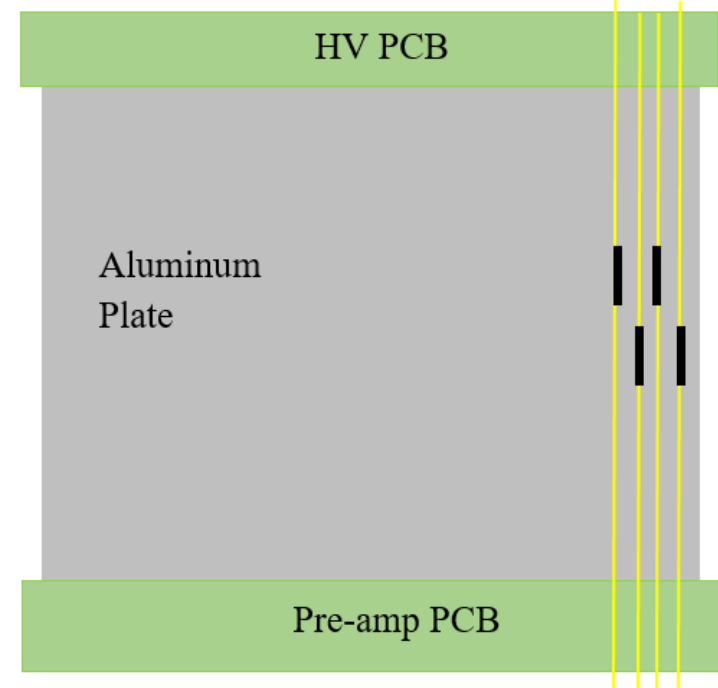


# Stringing wires with carbon tubes

## Overview

The purpose of the carbon tubes is to create a dead region in the central region of the detector. The procedure for preparing carbon tubes is described in other MENP PowerPoints and will not be covered here.

This section covers taking the carbon tubes and stringing them to create a dead region. The first phase of this procedure is to string the carbon tubes with sense wires and suspend them on the MWPC, as shown in the image on right.

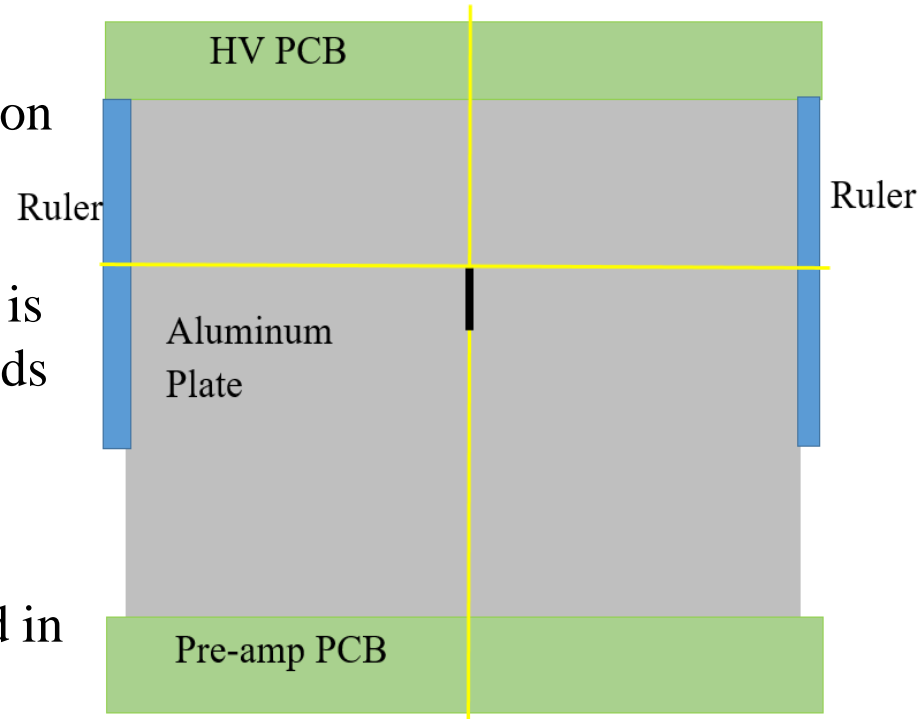


# Stringing wires with carbon tubes

## Overview Continued

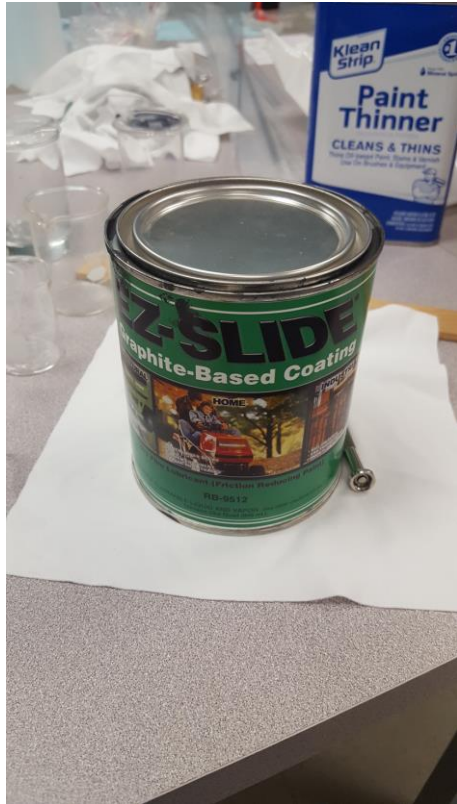
Once the sense wires with carbon tubes are on the MWPC, the carbon tubes must be connected permanently to the sense wire so that it cannot slide around on the wire. This is done by painting conductive paint on the ends of the tube, which acts as a firm connection once dry.

Finally, the carbon tubes must be positioned in the central region of the detector. This is accomplished by using two rulers and a guide wire to locate where the tubes should be aligned to, as illustrated in the image on right.



# Paint Materials

Conductive paint



Paint Thinner



Very thin paintbrush



# Preparing Conductive Paint

Unstirred paint



Stirred paint. Note change in color



Place in small container

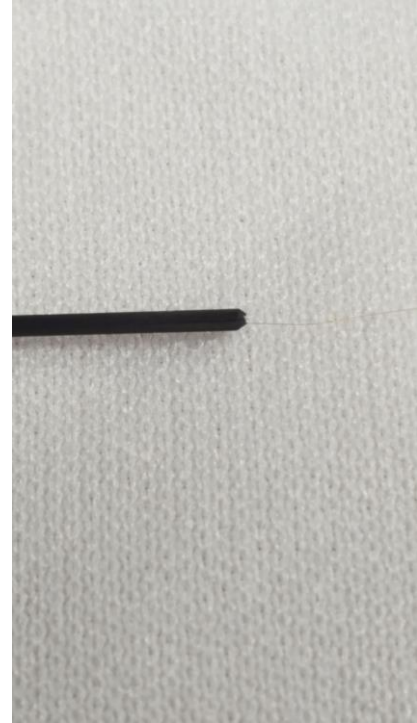
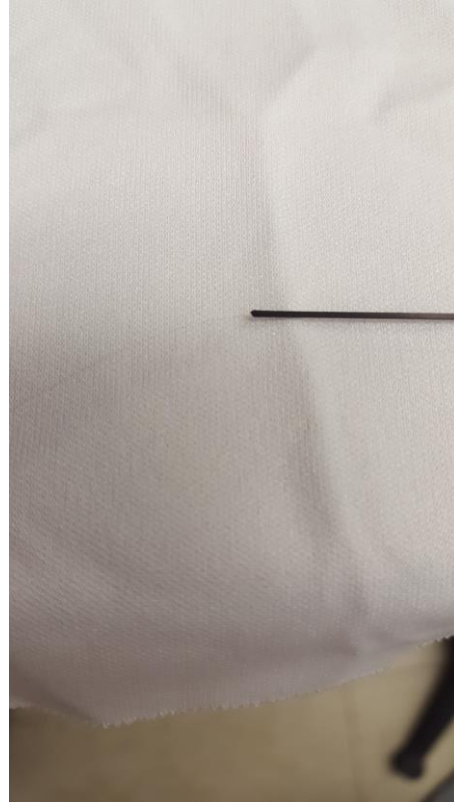
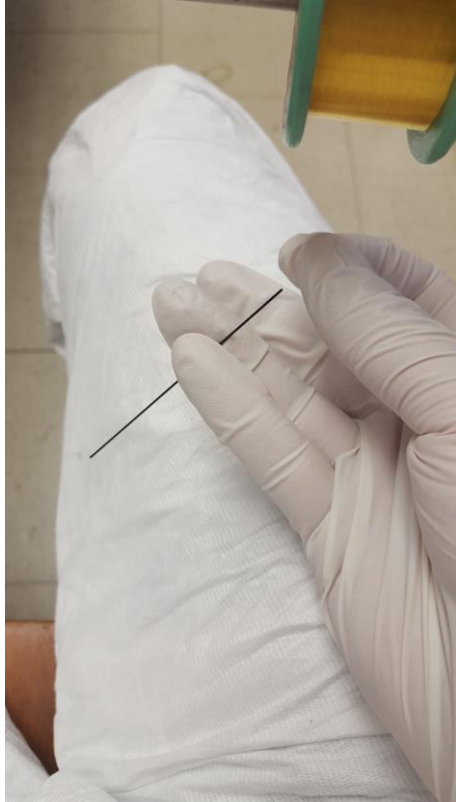


Stir with stick until completely mixed, usually takes ~5 minutes. Be sure to scrape bottom of paint can as it settles over time. Take plastic container of paint and brushes to clean room



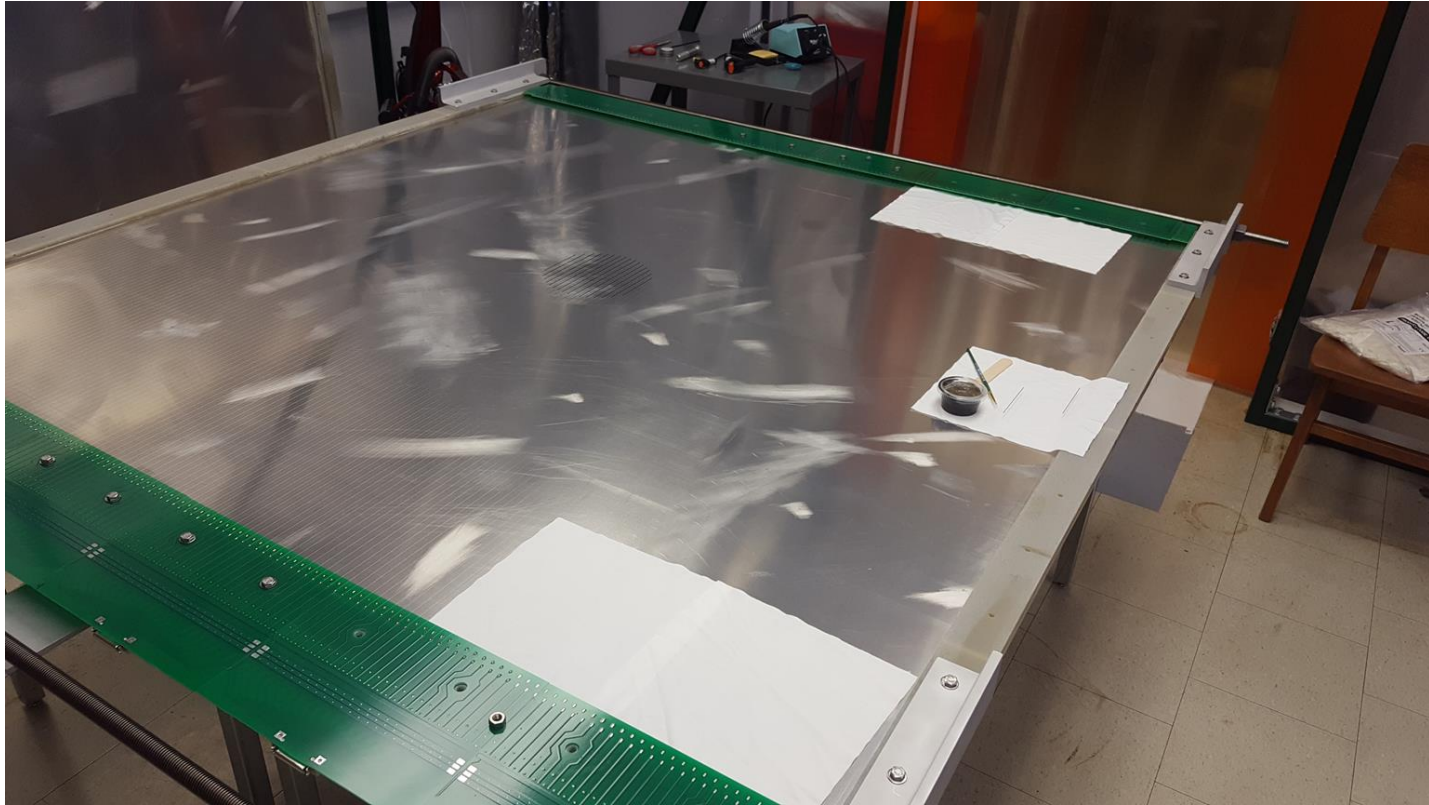
# 1) Thread Wire through Tube

Thread wire through carbon tube. This is a bit difficult but after some practice can be done in about 1 minute or less.



## 2) String wire as previously described

Refer to slides 14 to 23 for wire stringing procedure. Place wire near end of MWPC for easy access for painting tubes.





### 3) Prepare to Paint Carbon Tubes



To paint carbon tubes, place a polyester rag under painting region. Have carbon paint, stirrer, and paint brush ready.



## 4) Quickly Paint Carbon Tubes

When ready to paint:

- 1.) Remove cover from paint container and briefly stir it
- 2.) Take paint brush, dip the tip into the paint, and touch the brush to the top and bottom of one end of the carbon tube. The time span from dipping in paint to touching the carbon tube must be less than about 5 seconds. The paint develops a dry film extremely quickly otherwise and makes it very difficult to adhere to carbon tube and makes the result spikey and irregular. Use g10 slat as a rest to help steady the hand.
- 3.) Repeat for all other carbon tube ends
- 4.) Clean brush with paint thinner



# Results from Painting

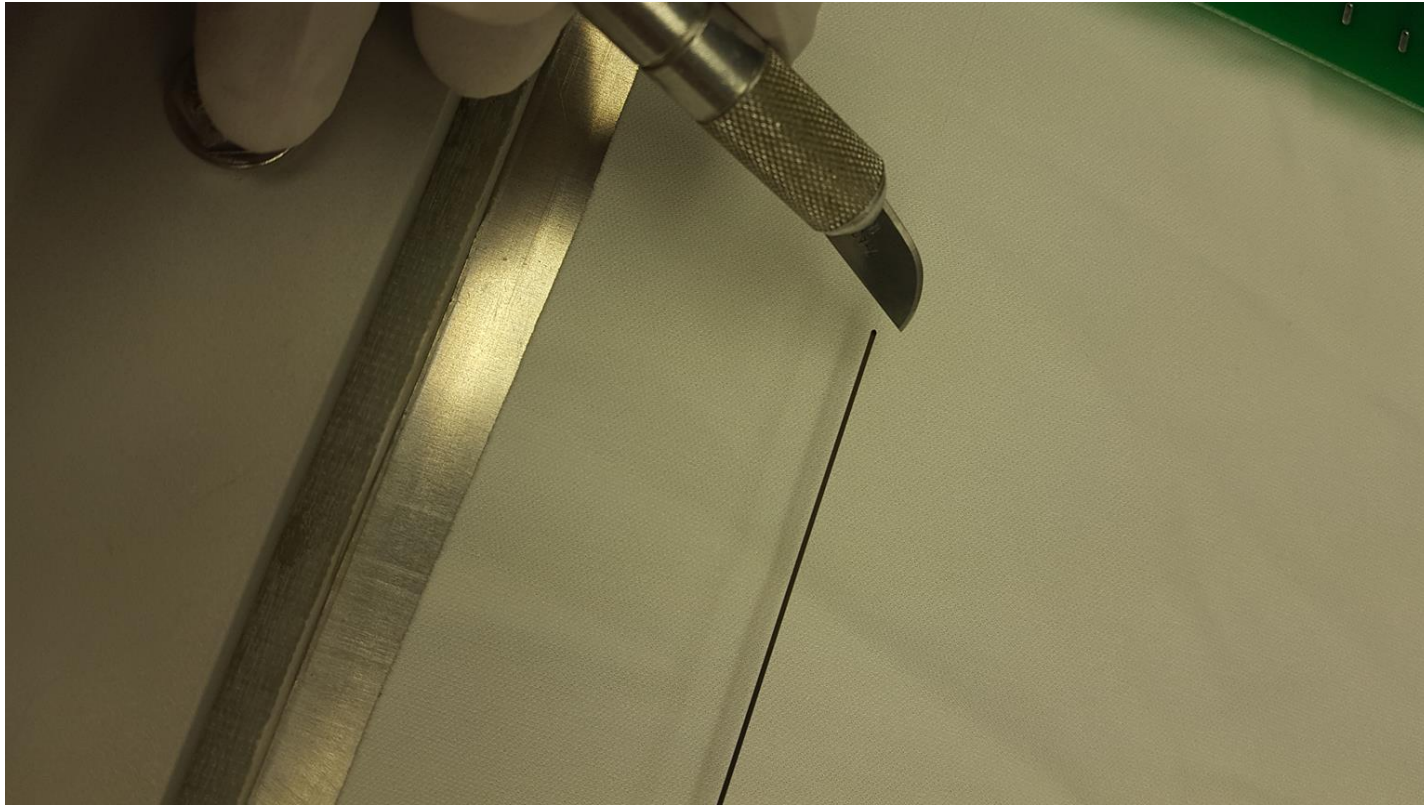


Allow paint to dry for 24 hours. This might be longer than necessary, but is a convenient time interval to ensure drying. The paint should be a round droplet on the end of the tube, as small as possible.

Poor jobs will be spikey, irregular, or have the tube not be adhered to the wire at all.



## 5) Test Connectivity of Tube



To test connectivity of carbon tube to wire, take the back of a blade and gently nudge the carbon tube along the wire. If it is adhered properly it will not move. Be gently about this or else it will be knocked free.



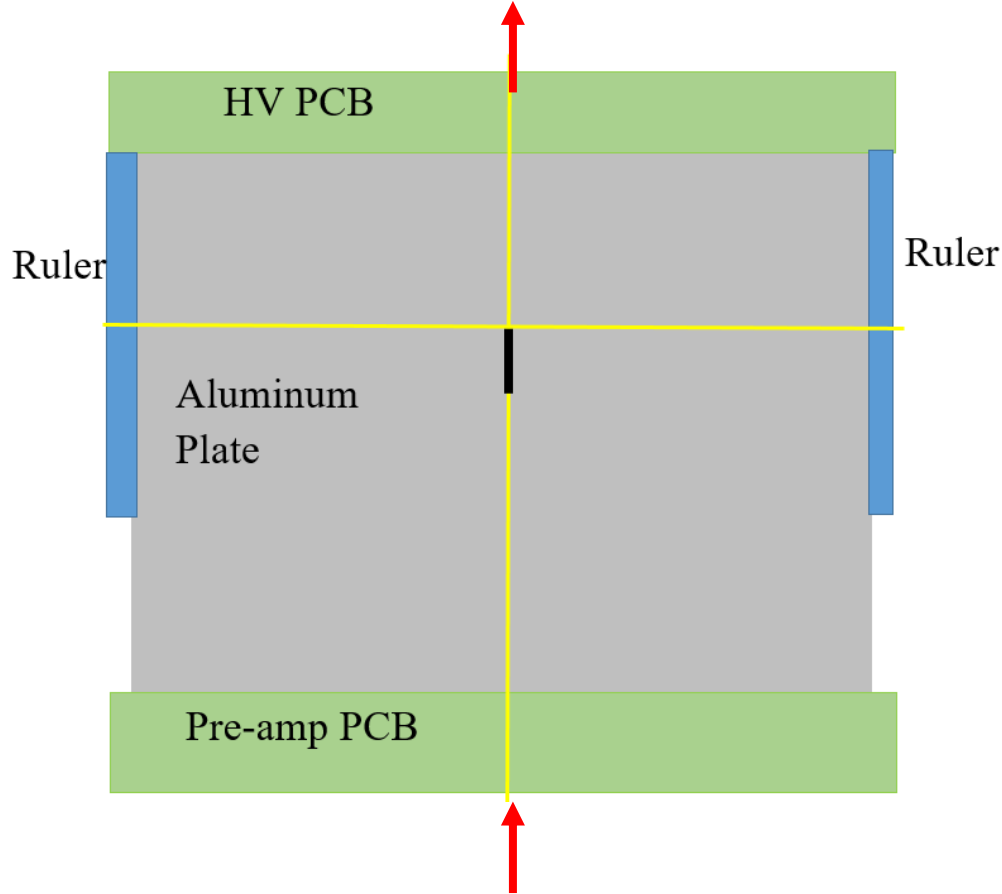
## 6) Transfer Wires to Final Location



When carbon tubes are adhered to wires, the wires can be transferred to their desired location in the central region of the detector.



# 7) Position Carbon Tube Using Rulers



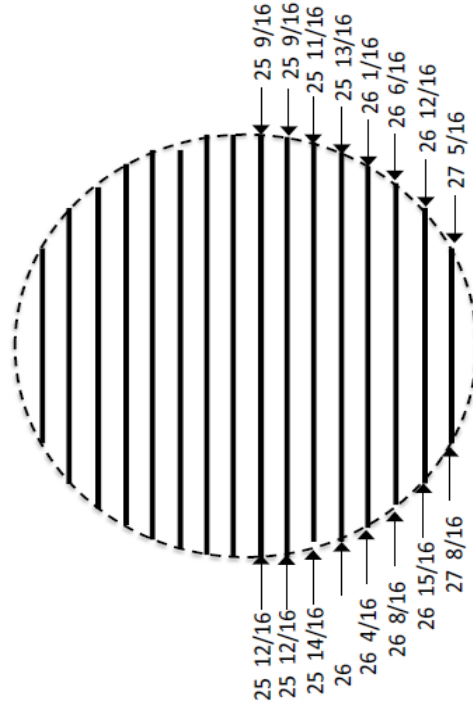
To position the carbon tubes in the central region of the detector, use two rulers on the edge of the detector and a wire strung perpendicularly across them to act as a guide line for the carbon tube.

The idea is to line the carbon tube end up with this guide wire by sliding the sense wire as indicated by the red arrows.



# Wire Positioning Map

Preamp Board

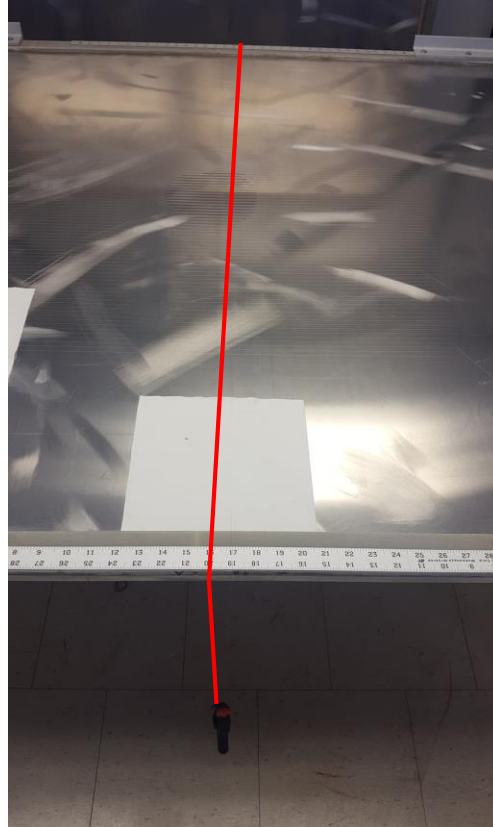


HV Board

This map (can be found in the clean room) shows lengths between the end of the carbon tubes and the ends of the circuit boards.



# 7) Position Carbon Tube Using Rulers

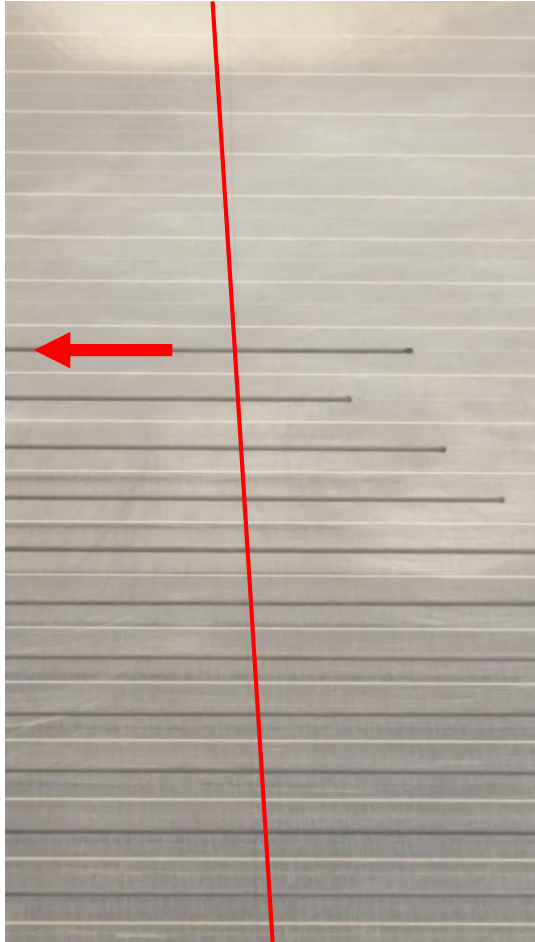


Using a field wire with clamps attached, string the field wire across the detector and align on the rulers at the spacing indicated on the wire positioning map.





# 7) Position Carbon Tube Using Rulers



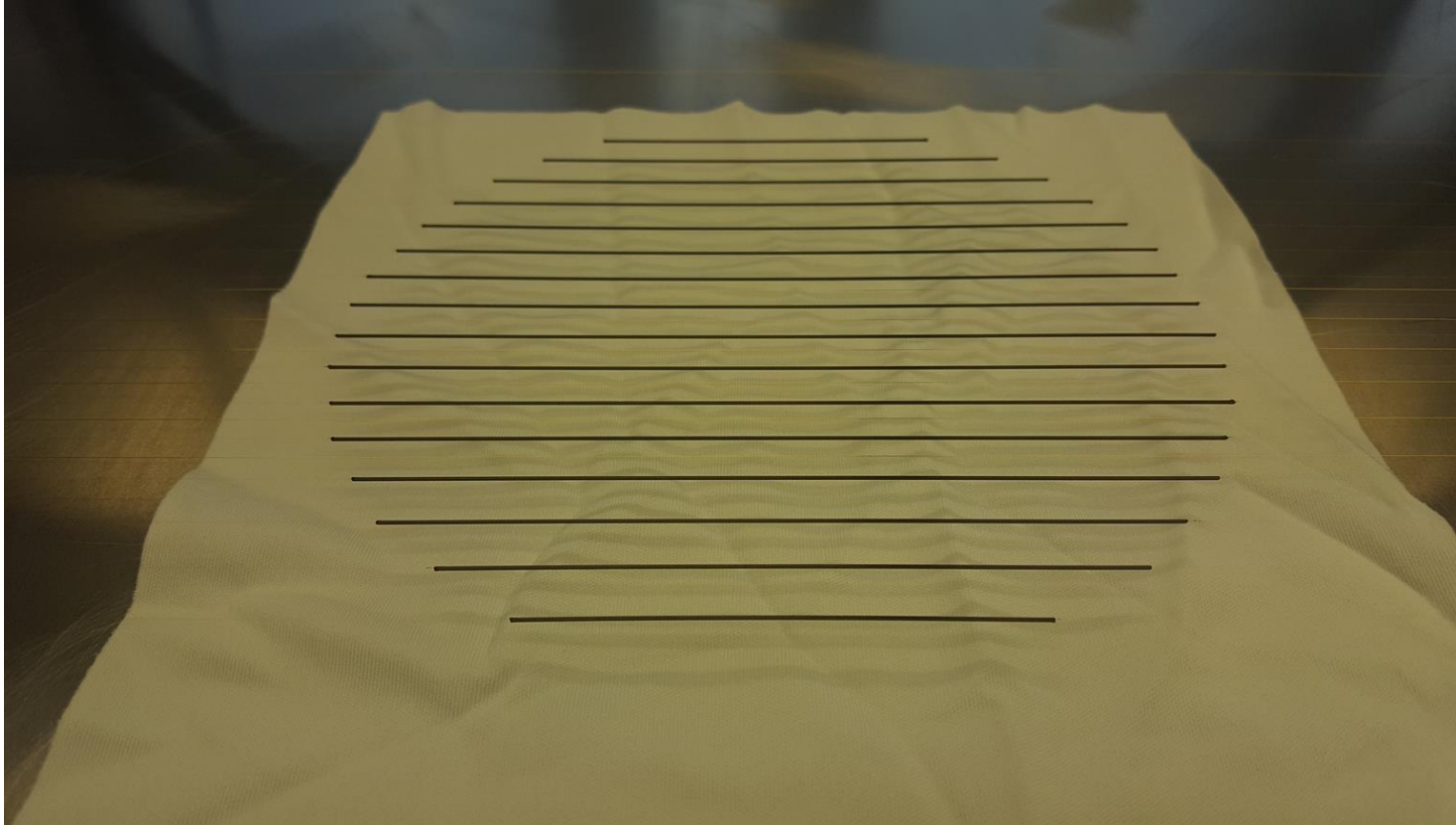
Slide the sense wire such that the carbon tube lines up with the guide wire as shown in image on right.

The guide wire is shown as a red line here as it is too difficult to see on camera.



# Completed Central Region

Included for reference



# How to String with Only One Person

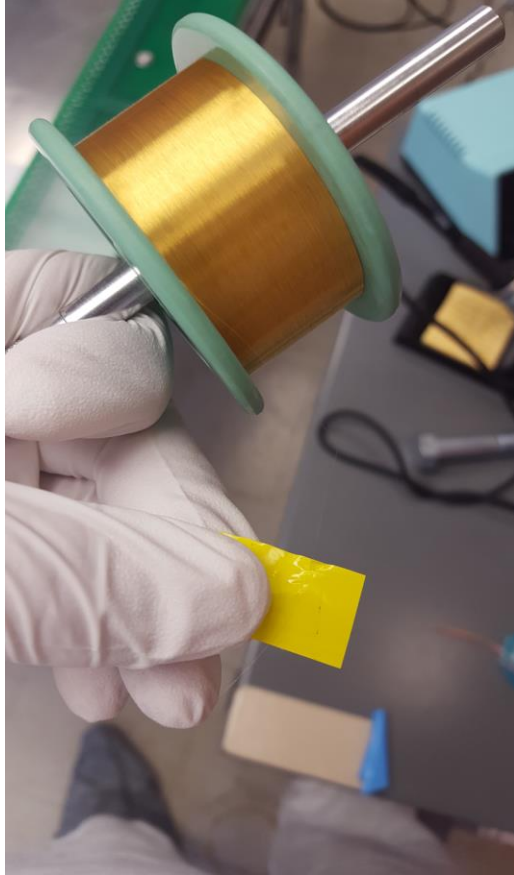
## Overview

Stringing wires with two people is most convenient, but in the case that only one person is available it can still be done. The only complication is to make sure the wire is under constant tension and that the spool does not unwind on its own.

The time per wire for single person stringing is slightly more than double that of two person stringing, an average of about 3 minutes per wire for 2 people was recorded for the large MWPC prototype stringing, and about 7-8 minutes for single person stringing.



# 1) Tape End of Wire & Clamp



Take wire from spool, tape, and clamp with an appropriately weighted clamp.



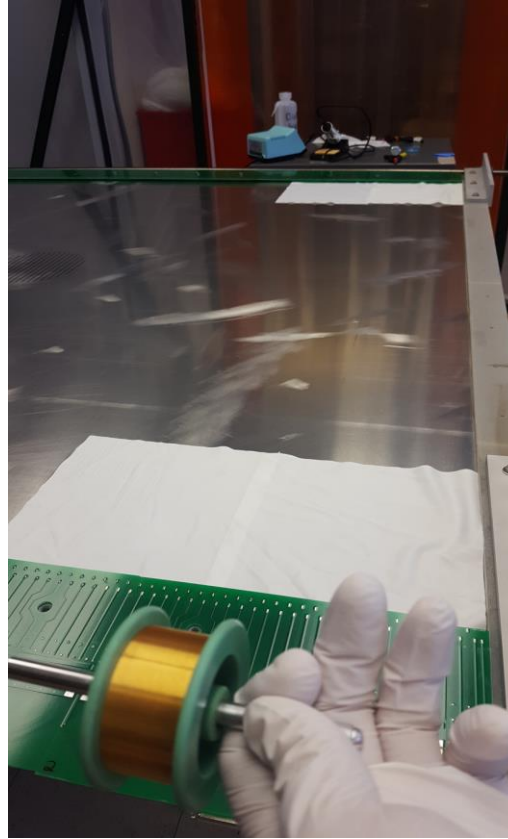
## 2) Secure Clamp to Table



Secure clamp to table so that the wire can be unspooled. This can be done using any heavy item, here it is done using a bolt.



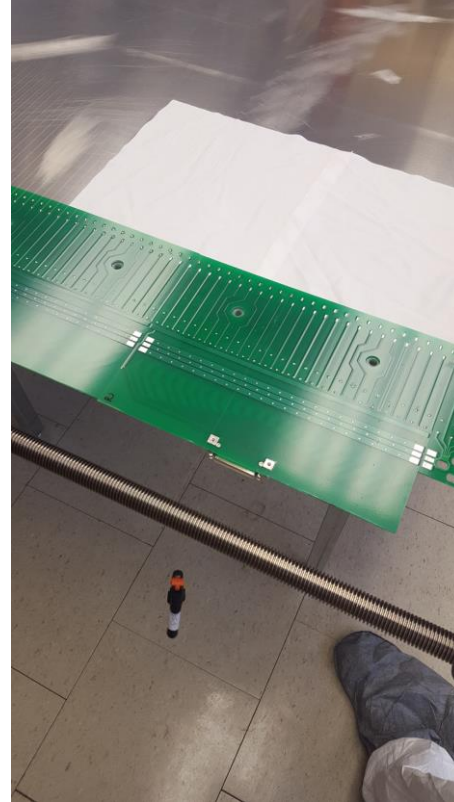
### 3) Pull Spool Across Detector



Gently pull spool back across detector. Pull at a constant, non-jerking rate.



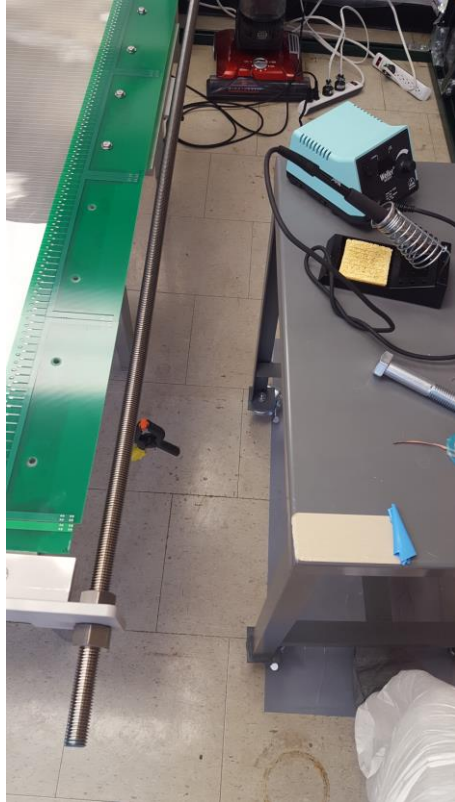
## 4) Tape Other End, Clamp & Cut



Tape, clamp, and cut end of wire. Gently allow clamped wire to hang free from detector.



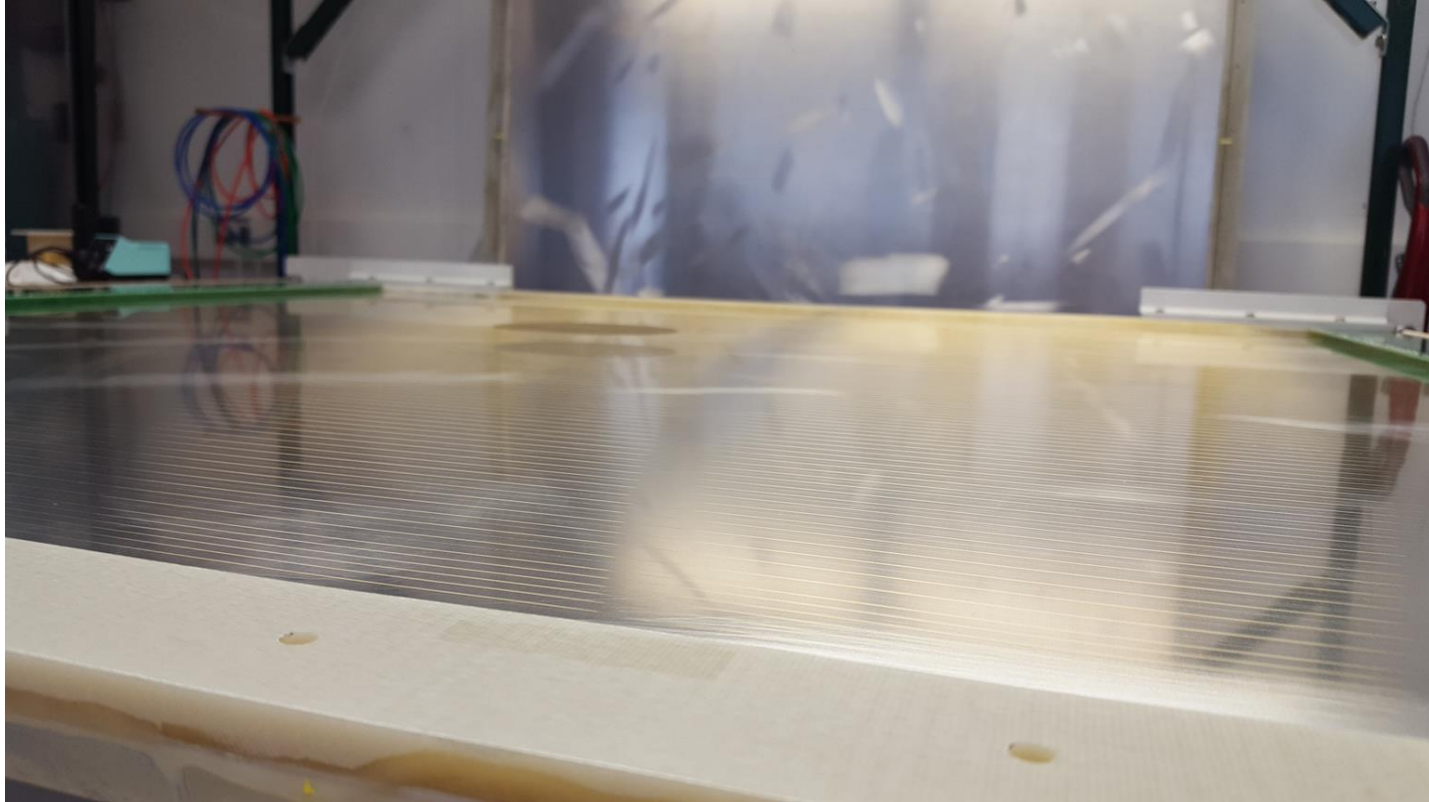
# 5) Allow Clamp to Hang Free



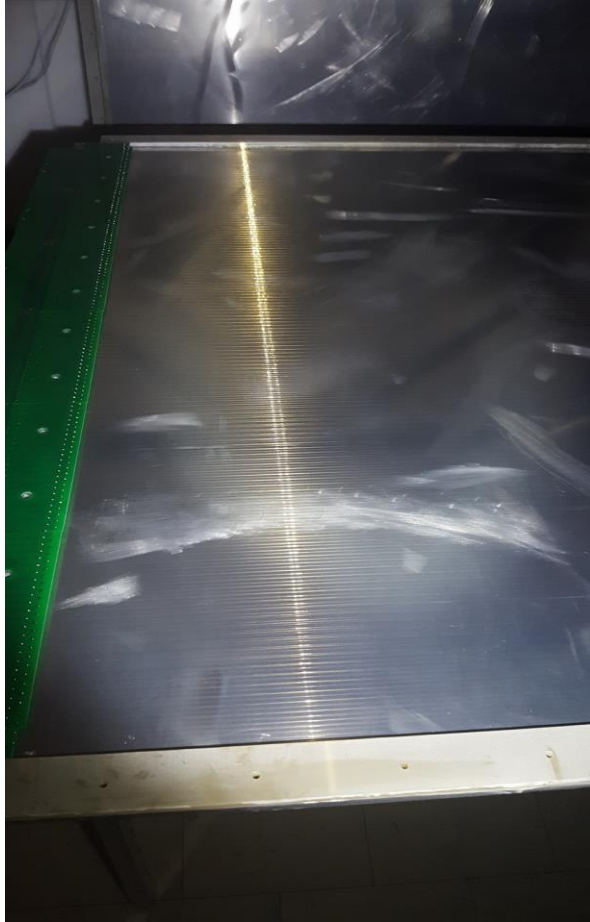


# Pictures of Finished Stringing

Side-view of detector with all wire stringing complete



# Pictures of Finished Stringing



A flashlight can be used to see all wires on the detector. This doesn't help in a practical way, but allows for final pictures to be taken, otherwise wires are rather invisible from this angle.

