Small-Strip Thin Gap Chambers for the Muon Spectrometer Upgrade of the ATLAS Experiment

Rimsky Rojas (Universidad Tecnica Federico Santa Maria, Chile)

on behalf of the Atlas Muon Collaboration

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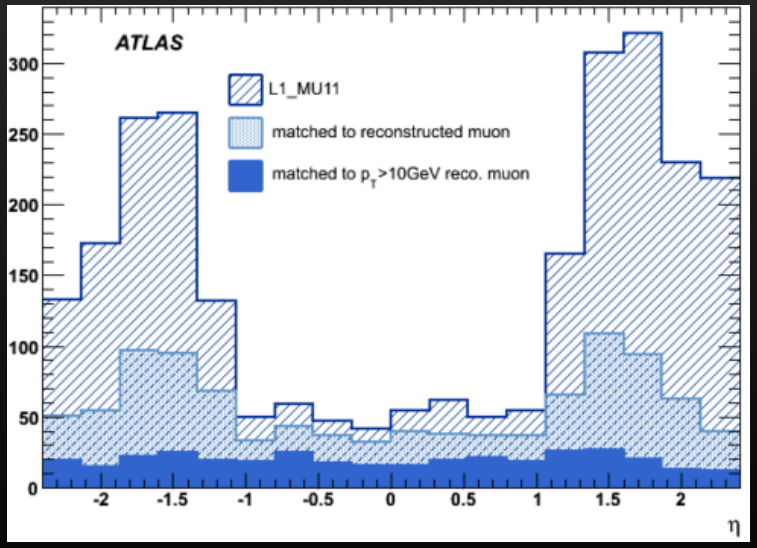
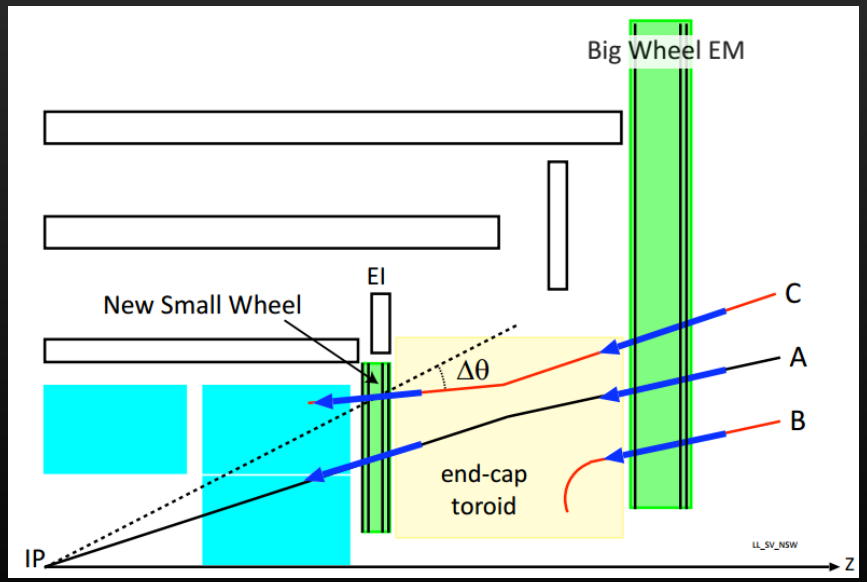
Motivation

- The instantaneous luminosity of the Large Hadron Collider at CERN will be increased up to a factor of five with respect to the design value by undergoing an extensive upgrade program over the coming decade.
- The largest phase-1 upgrade project for the ATLAS Muon System is the replacement of the present first station in the forward regions with the so-called New Small Wheels (NSWs) during the long-LHC shutdown in 2019/20

Principal reasons to change the Small Wheel

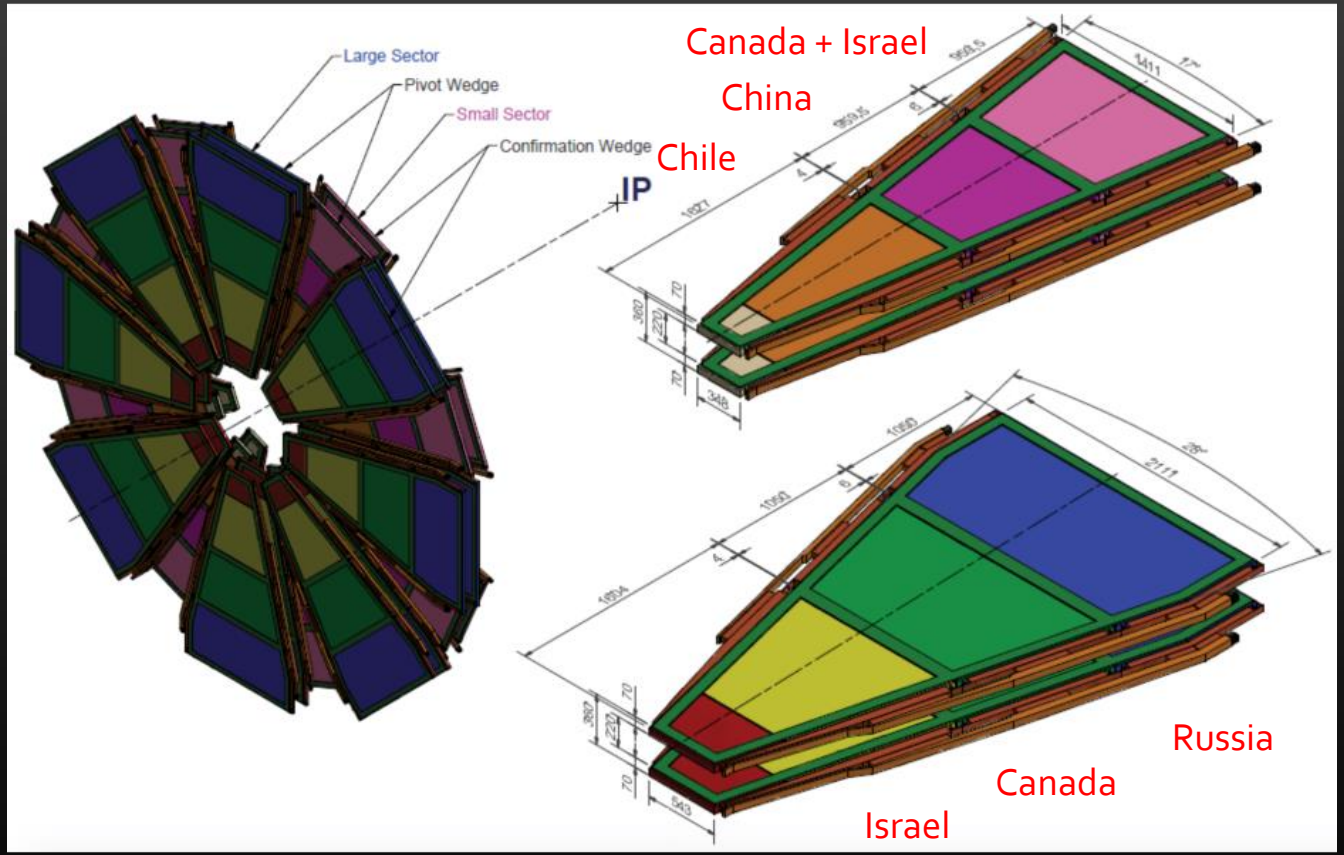
- Precise position measurement in front of the end-cap magnet is crucial for the momentum determination of the muon.
- Low energy particles produce fake triggers by hitting the end-cap trigger chambers at an angle similar to that of real high *p*T muons. An analysis of 2012 data demonstrates that approximately 90% of the muon triggers in the end-caps are fake.





New Small Wheel

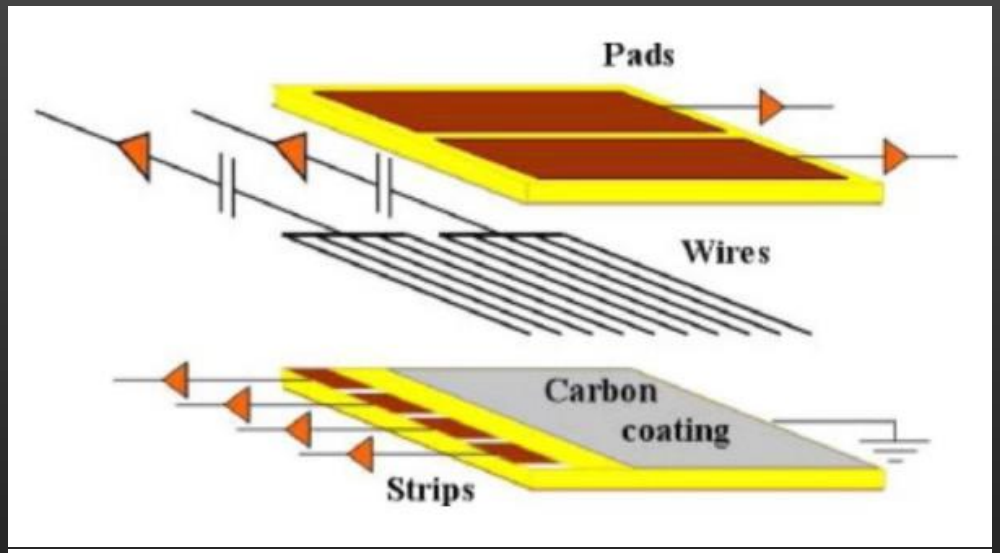
- The NSW is a set of precision tracking and trigger detectors able to work at high rates with excellent real-time spatial and time resolution.
- These detectors forms an integral part of the muon Level-1 trigger system with online track segments of good angular resolution (<1mrad) to improve the momentum measurement
- two sTGC wedges (made by 3 sTGC quadruplets), pivot and confirm sandwiched the MicroMegas detector in small and large sectors.

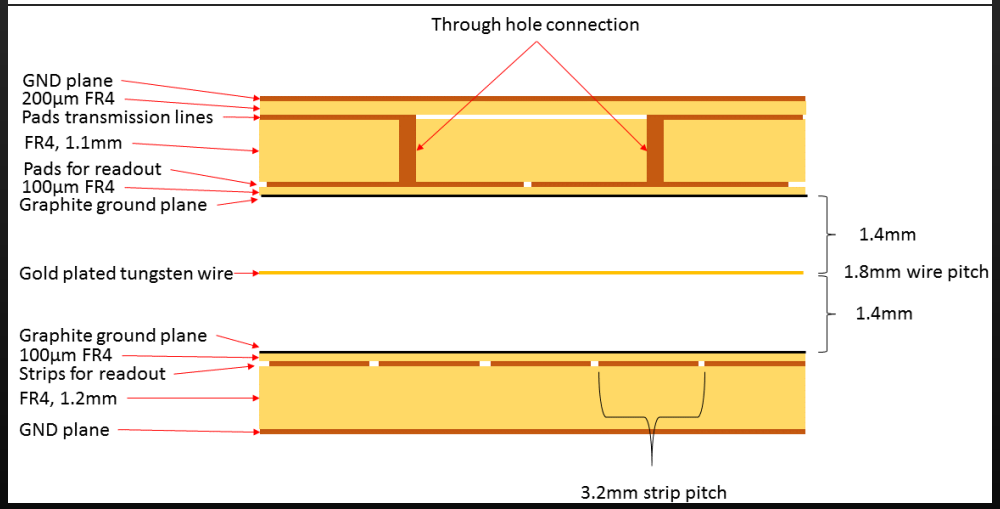


See Mauro's talk: http://indico.cern.ch/event/432527/contributions/1071669/

sTGC structure

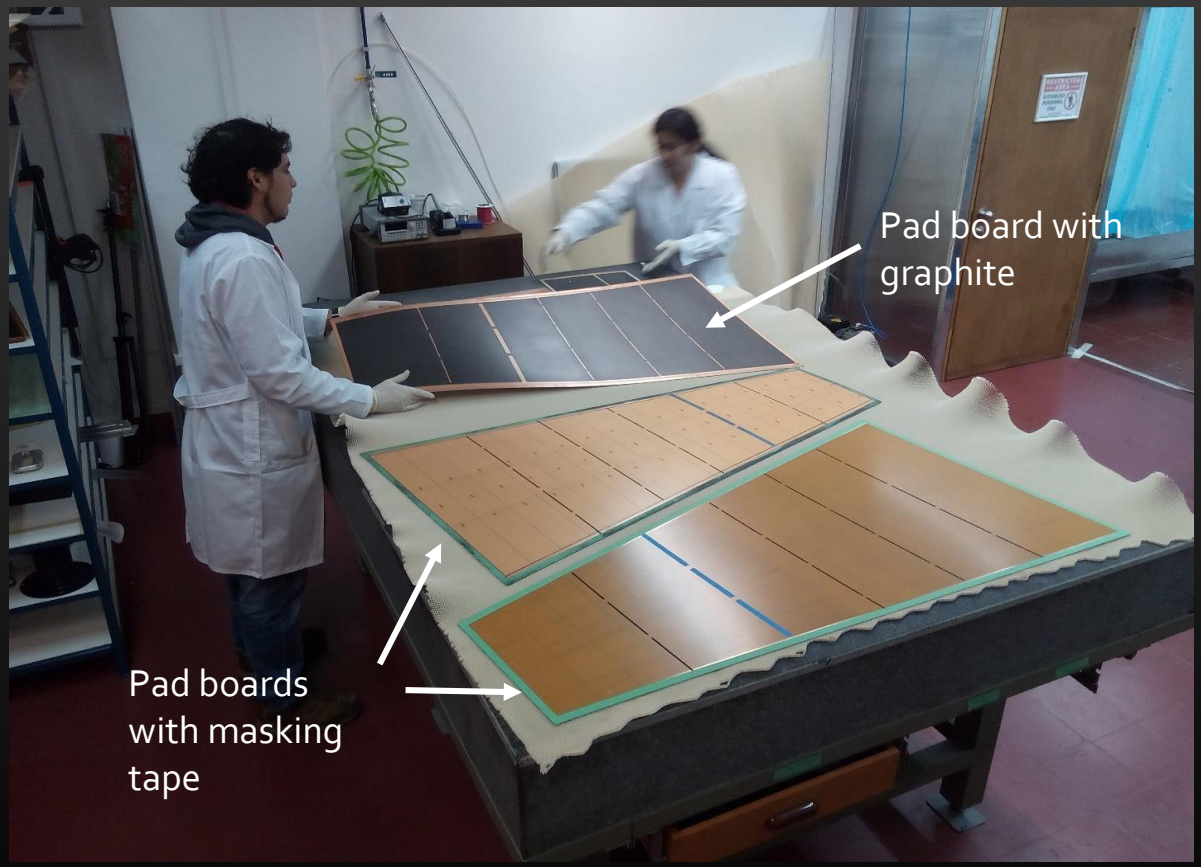
- The basic sTGC structure consists of a grid of gold-plated tungsten wires sandwiched between two resistive cathode planes at a distance of 1.4mm from the wire plane.
- The precision cathode plane has strips with a 3.2mm pitch for precision readout relative to a precision brass insert outside the chamber, and the cathode plane on the other side has pads for triggering .
- The gap is provided using precision frames machined and sanded to 1.4mm ±20µm and glued to the cathode boards





small-strip Thin Gap Chamber

- Pads readout provide fast pre-trigger to determine which strips to read.
- Precision strips for precision muon tracking reconstruction at level of 100μm
- High efficiency at high background rate.

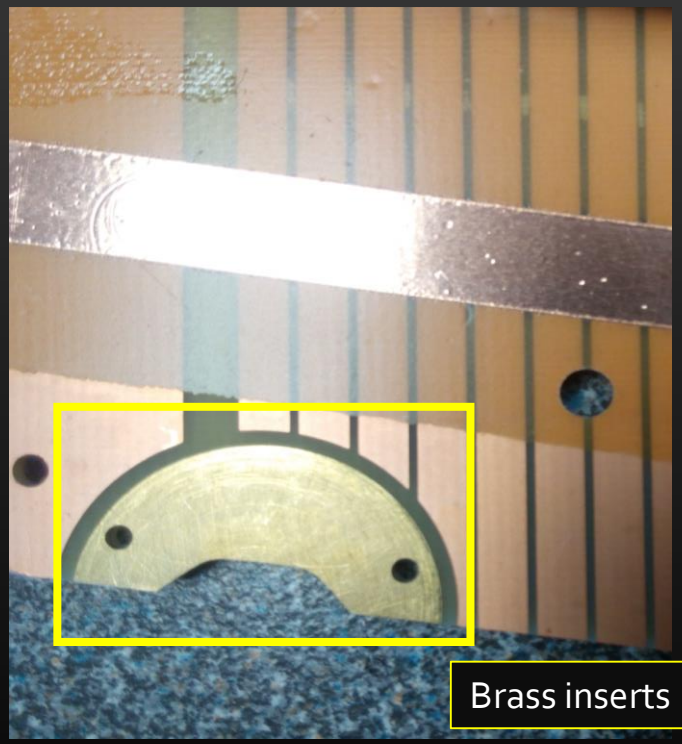


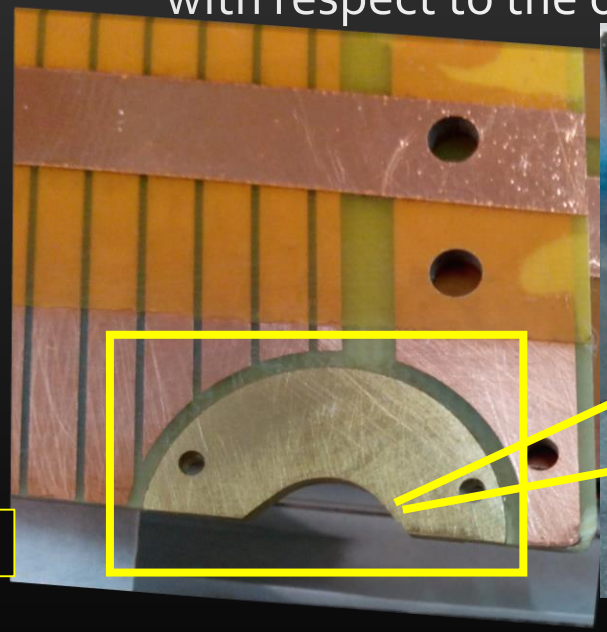
More information about sTGC

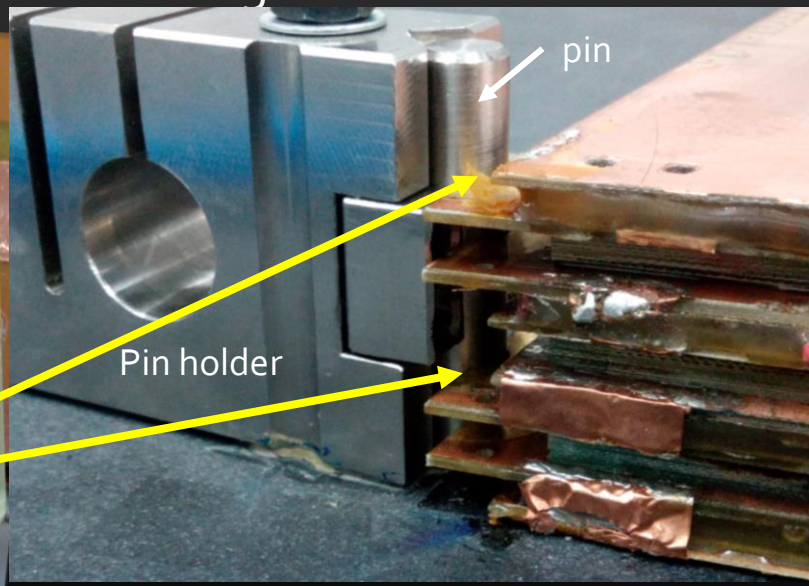
- The gas used is a mixture of n-pentane/CO2, 45%/55%.
- The selected gas mixture has three properties: high gain, quenching of photons and clean the chamber.
- The chamber operate at a nominal voltage of 2.8kV
- The cathode plane is made by a resistive layer of graphite with a surface resistivity of 100kΩ/square.
- All quadruplets have trapezoidal shapes with surface areas up to 2 m2

Precision brass insert and alignment pin

- Brass insert manufacture together with the strips, to 40μm precision.
- A precision alignment pin is used to align each plane with respect to the others using the brass insert.







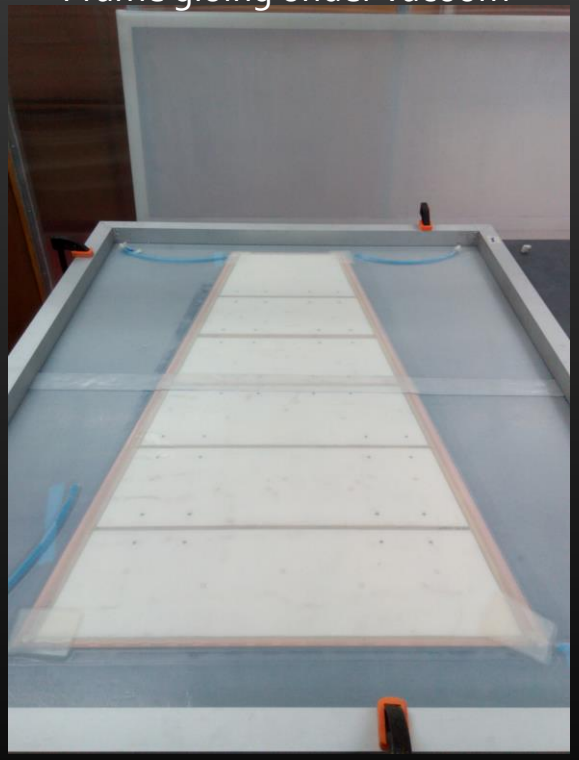
Construction steps

- Cathode boards check QA/QC
- Resistive layer spraying
- Polishing to get 100kohm/sqr. Surface resistivity
- Gluing of precision frames, QA/QC
- Winding of pad cathodes boards
- Soldering of wires, wash, solder resistors and cables, QA/QC
- Closing of single chambers, QA/QC flatness and thickness
- Test with HV during 7 days and gain uniformity with xrays, QA/QC
- Assembly of doublet/quadruplet, QA/QC

Spraying and frame gluing

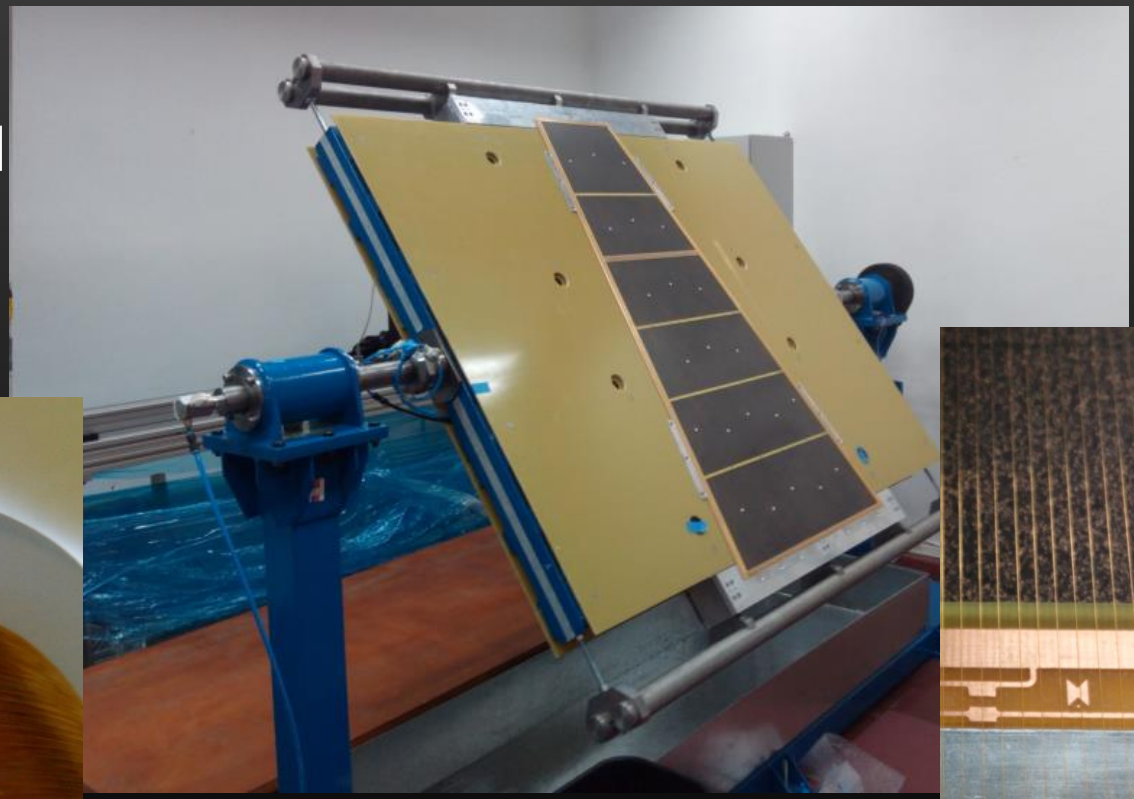
Horizontal spraying machine

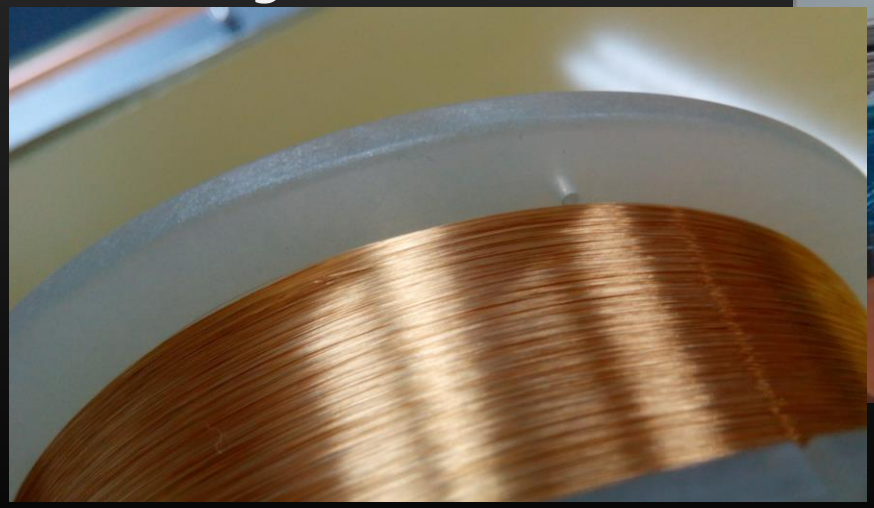
Frame gluing under vacuum

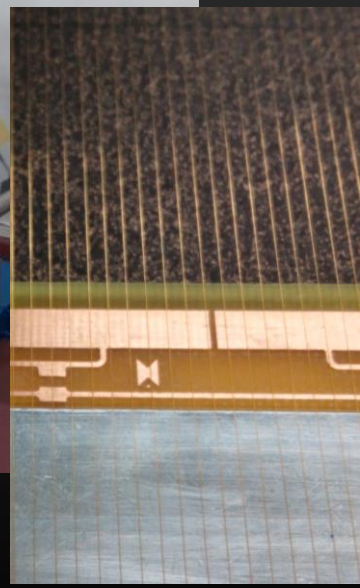


Winding of pad cathodes boards

- Two pad boards with frames glued are placed in a rotary table in which a gold plated tungsten wire is winded

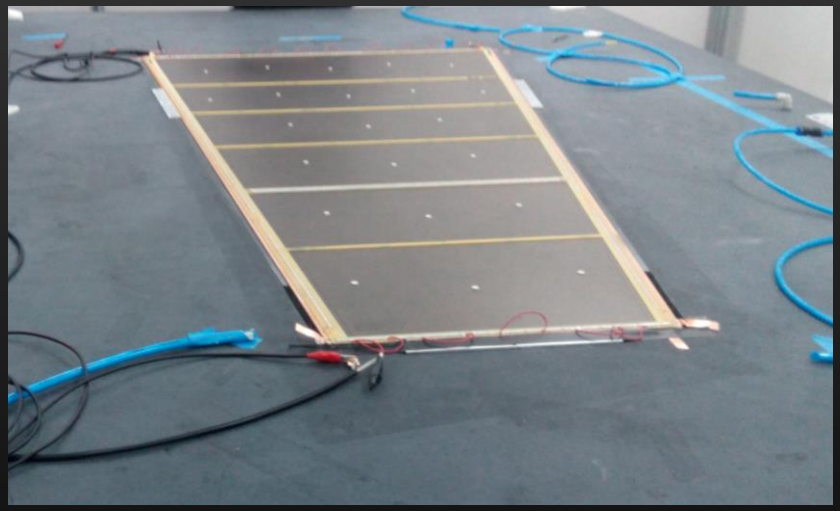




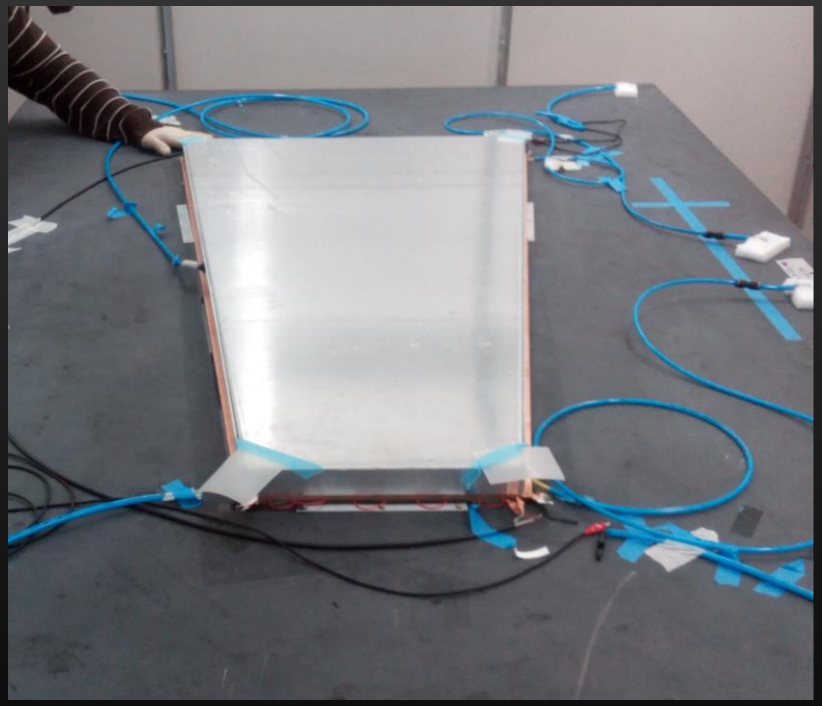


Chamber closing

Pad cathode under high voltage

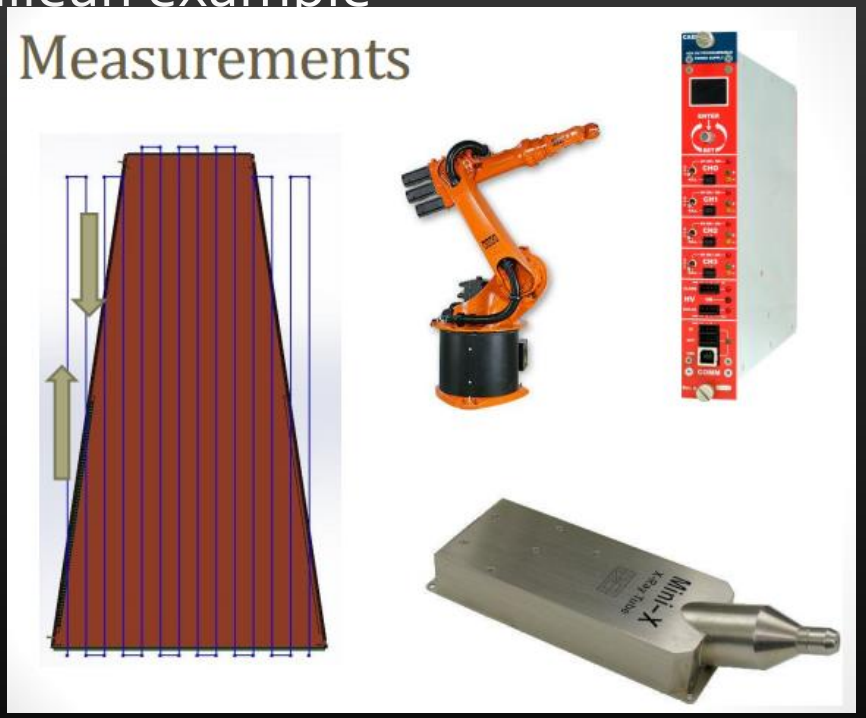


Chamber with aluminum honeycomb strong-back



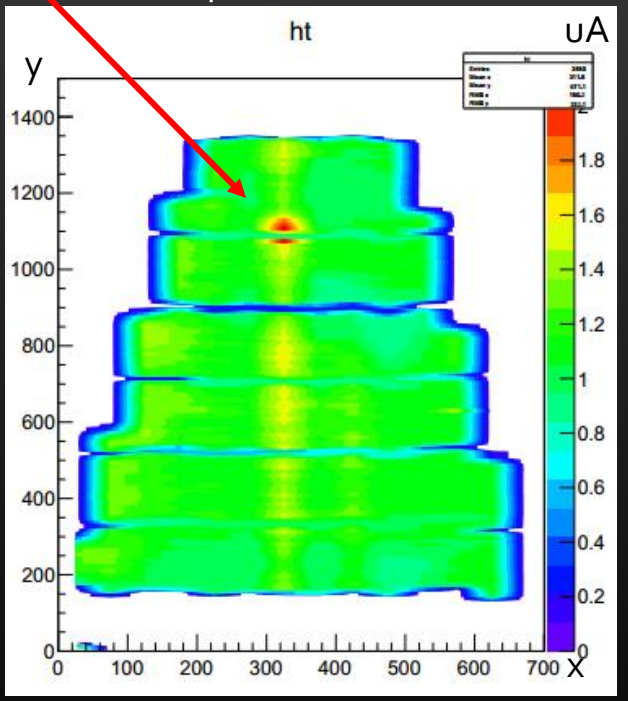
Gain uniformity test using x-ray

- Chilean example



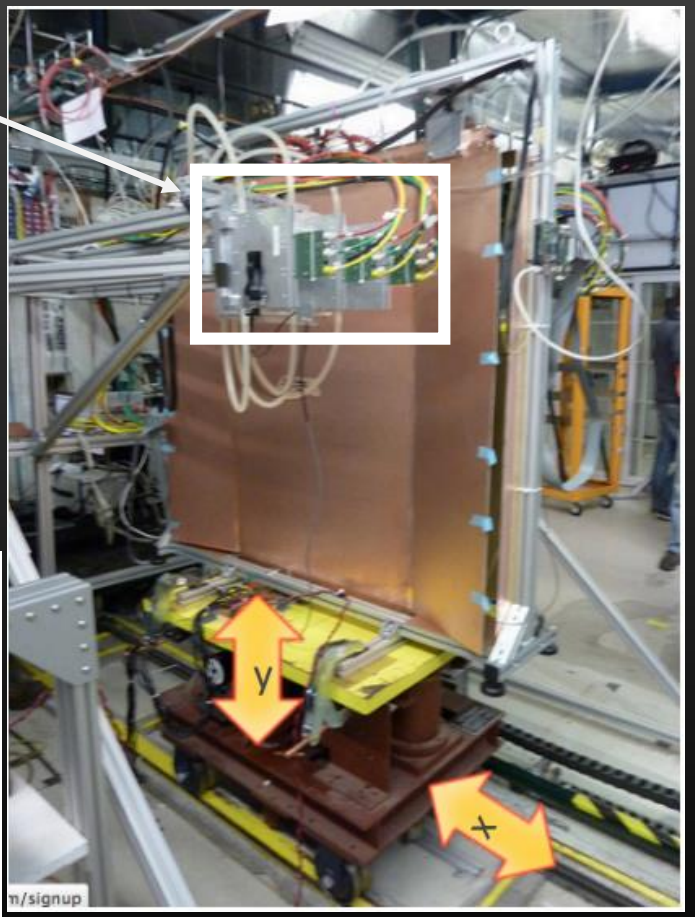
Problematic point

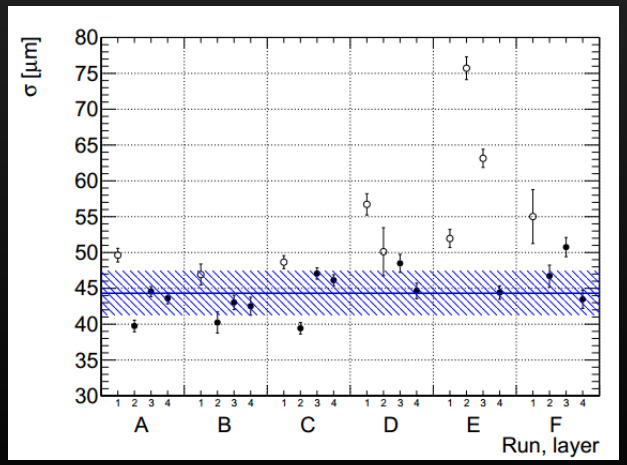
Interpolation of data

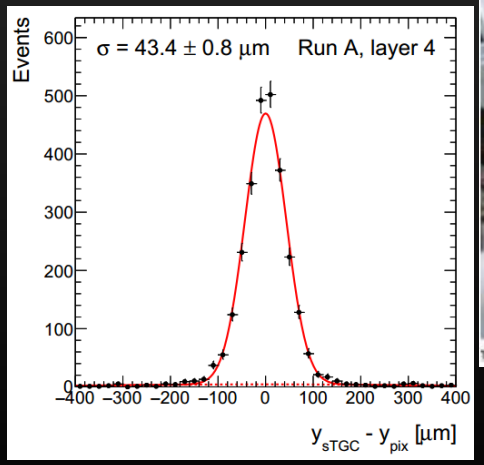


Position resolution measurement at fermilab

- Position resolution was measured using a 32GeV pion beam at Fermilab, arXiv:1509.06329v1
- The results shown a position resolution to be better than 50μm comparing to an external pixel telescope for different position scan in x-y (A,B,C,D,E,F) in different layers (1,2,3,4).

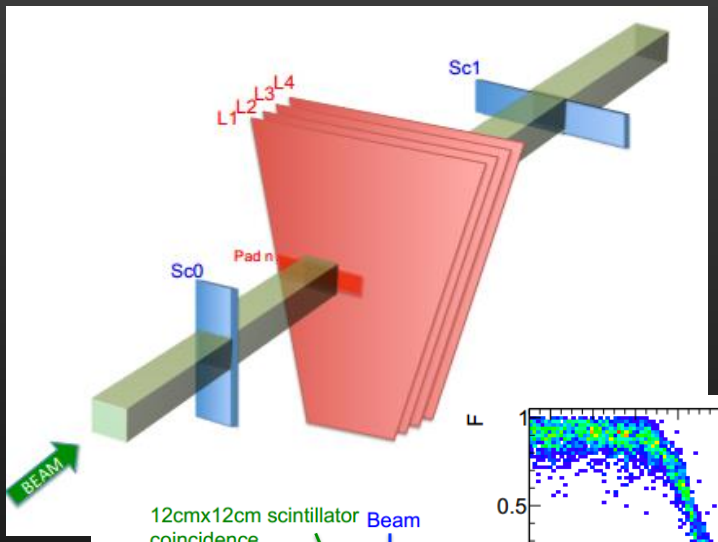


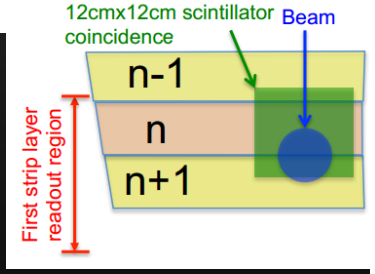




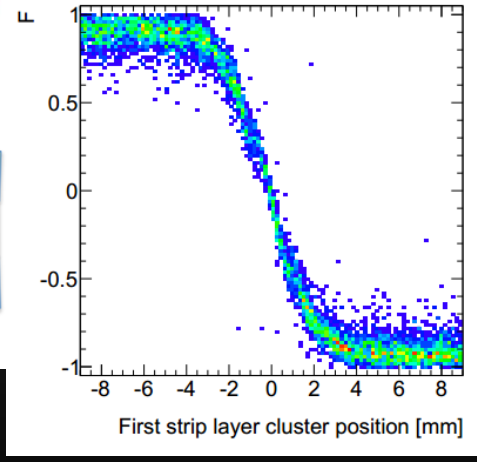
Test beam results at CERN

- Efficiency was measured at CERN using a 130GeV muon beam of about 4cm radius. arXiv:1509.06329v1
- It was determined that the detector efficiency is 100%.
- When particle cross in between two adjacent pads, the charge is shared between them.

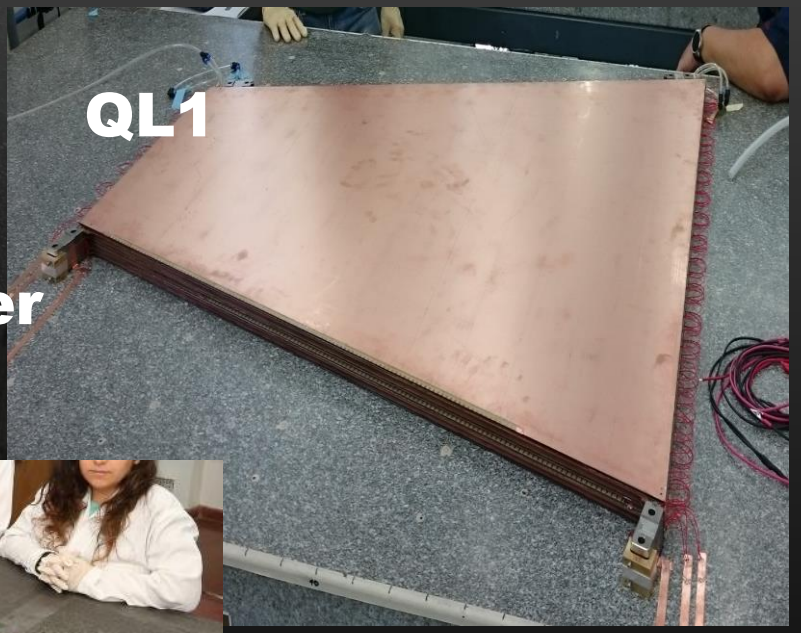




$$F = Q_n - Q_{n+1}$$

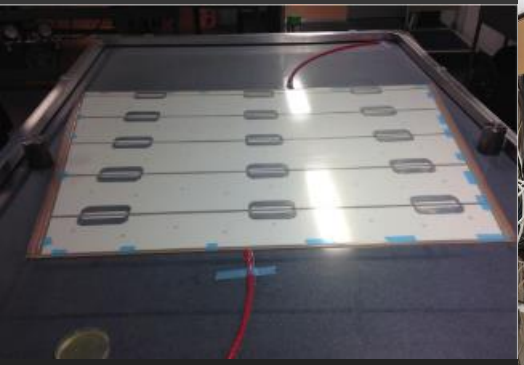


The module#0s



Conclusions: Project is advancing well in all construction sites

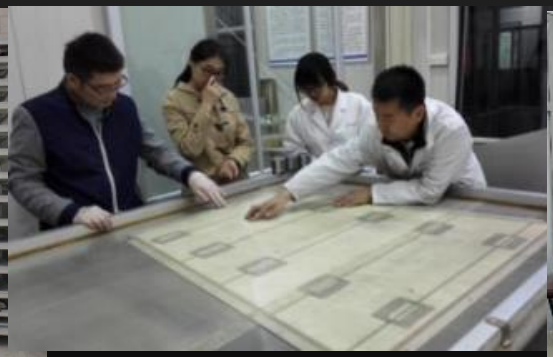
Canada



Chile

Russia

China

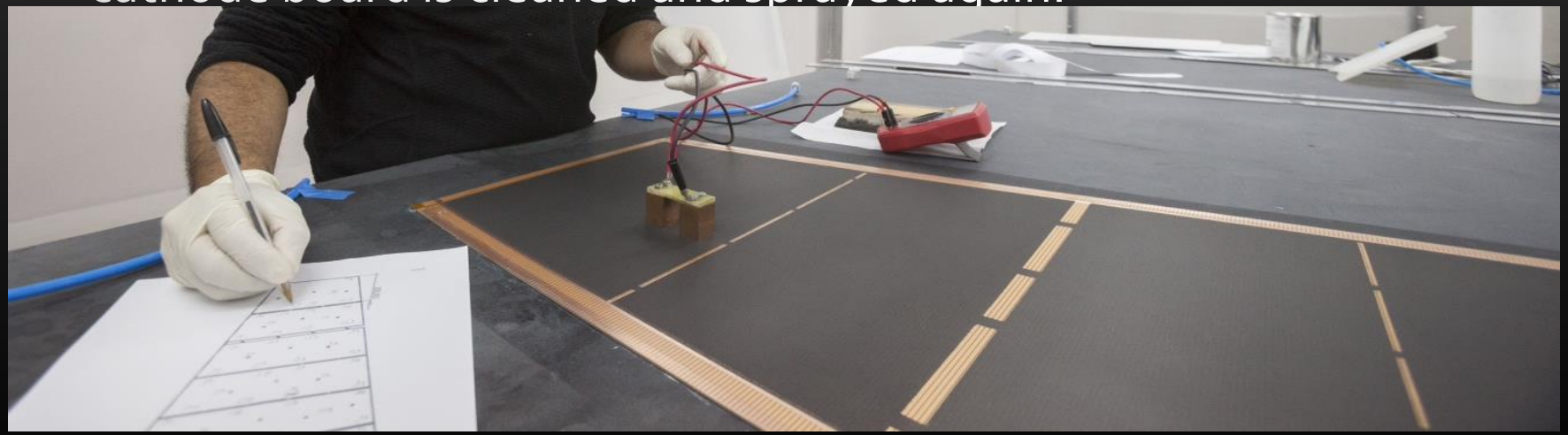


Israel

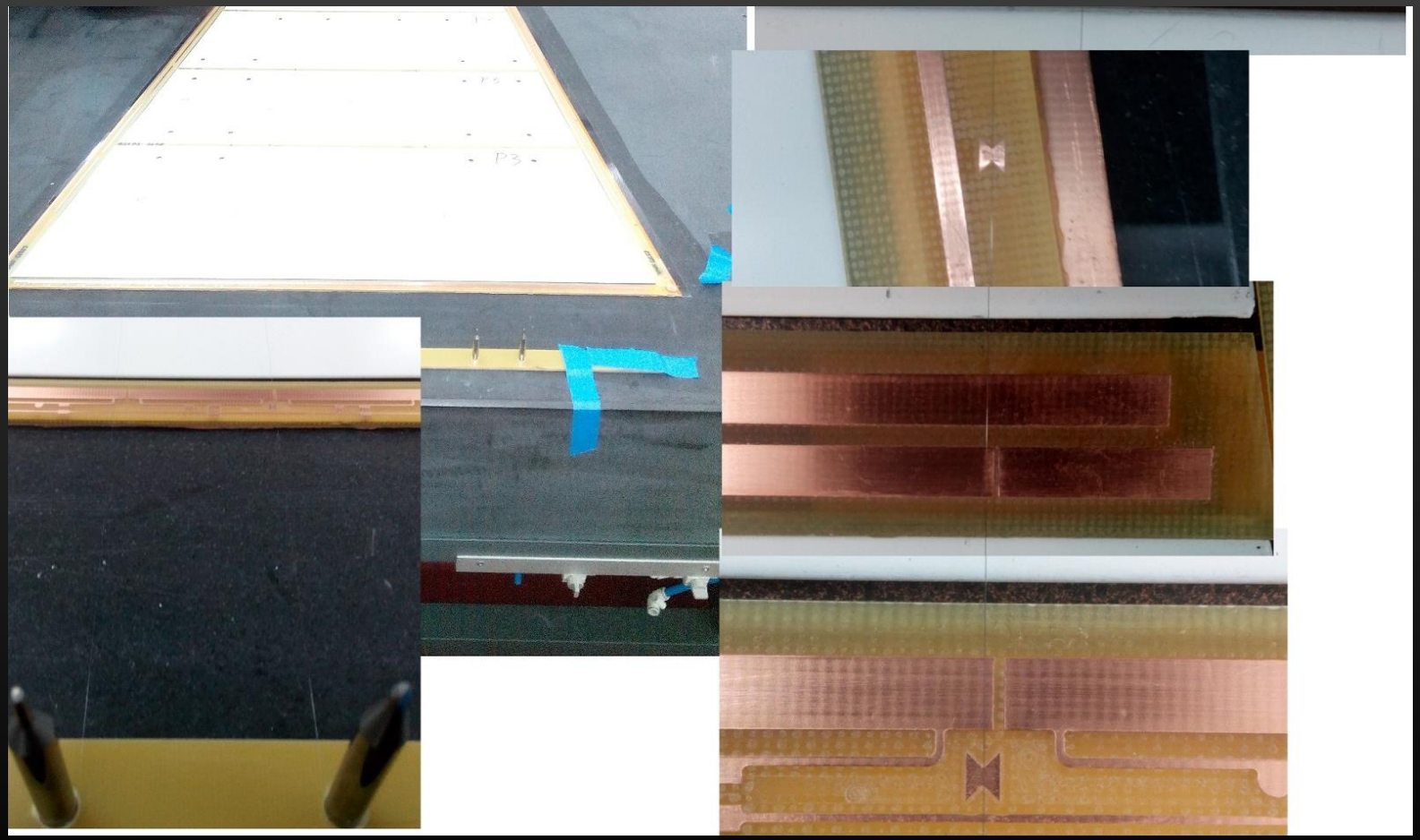
backup

Polishing to get 100kohm/sqr. Surface resistivity

- Board is polished to get down the resistivity to 100kΩ/square ±20%
- Surface resistivity is recorded to DB
- If surface resistivity does not meet the requirement, cathode board is cleaned and sprayed again.



Gluing of precision rulers, QA/QC



Soldering of wires, cut excess of wires, wash, solder resistors and cables, QA/QC

- Check soldering quality, check for wire cuts, check no wire crossing to neighbors pads