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Study of the HV stability in the ATLAS New Small Wheel upgrade Micromegas detectors

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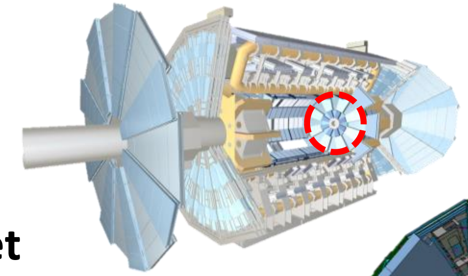
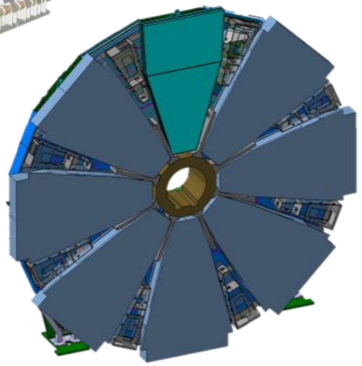
ATLAS Micromegas detector

- The innermost stations of the forward muon spectrometer of **ATLAS detector** upgrade (New Small Wheels) are made of micromegas (MM) detectors and small strip TGC (sTGC)
- There are 4 different **MM 4-plet**: SM1 (Italy), SM2 (Germany), LM1 (France), LM2 (Russia and Greece)
- The **MM**s are planar gaseous detector where a conductive mesh divide the gas gap in two regions: drift (5mm thick) and avalanche (0.12 mm thick)
- To mitigate discharges between mesh and strips, in particular with high flux of ionizing particles, a layer of carbon resistive strips are glued on top to the pickup strips and used as anode.

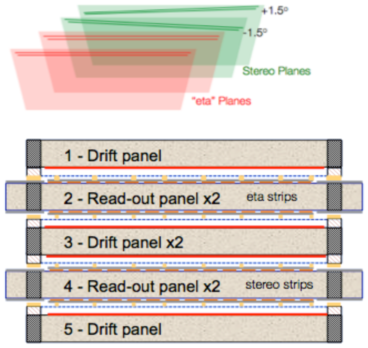
ATLAS



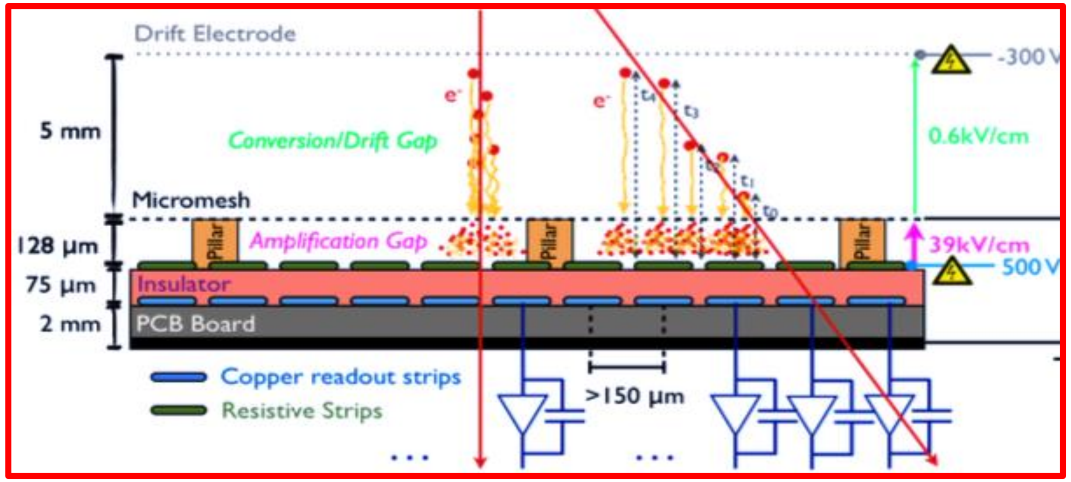
NSW



MM 4-plet

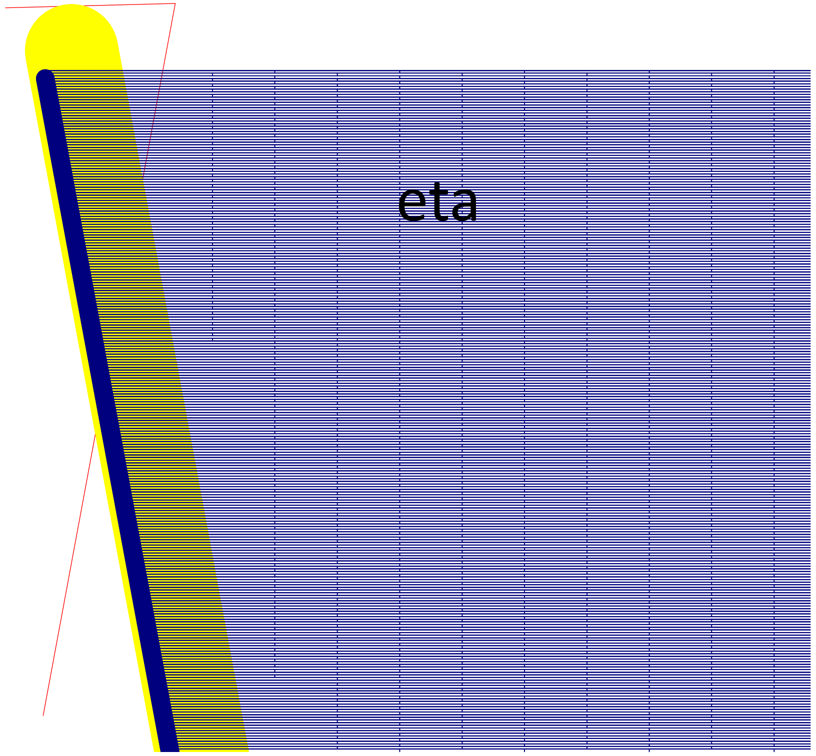


MM



MM Resistive strips

- The anode is formed by resistive strips 300μm wide and 15 μm thin, 1MΩ/mm electric resistance, parallel to the pickup strips with the same pitch (450 μm)
- The resistive strips are interrupted at the middle of the PCB in order to increase the HV distribution granularity and to get electric resistance in the range 5-15 MΩ
- Each resistive strip is connected to the two neighbouring strips every 2 cm in order to realize a resistance network
- The network is necessary to reduce the electric resistance seen by the avalanche
- Each MM panel is made of 5 (3) PCBs, both for the eta strips and for the stereo strips. Each PCB has its resistive strip layout



- Horizontal lines are the resistive strips
- Vertical dashed lines are strip-strip interconnections

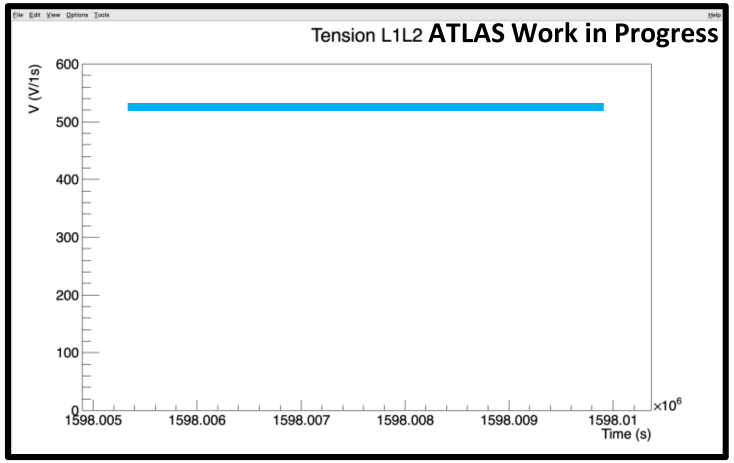
MM HV stability

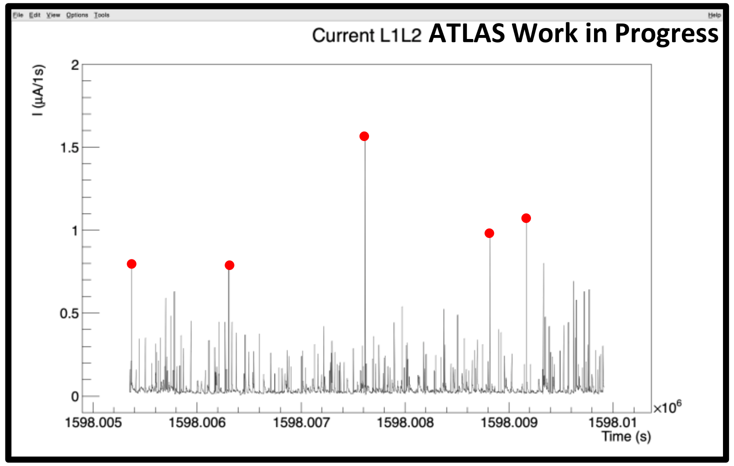
The MM base line gas mixture is $ArCO_2$ (93:7, @ 2 mbar overpressure). The working point is 570V in the amplification region and 300 V in the drift one.

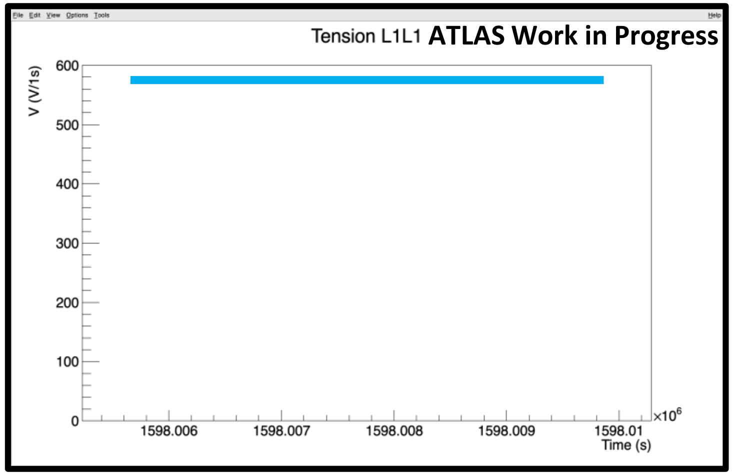
Causes of discharges:

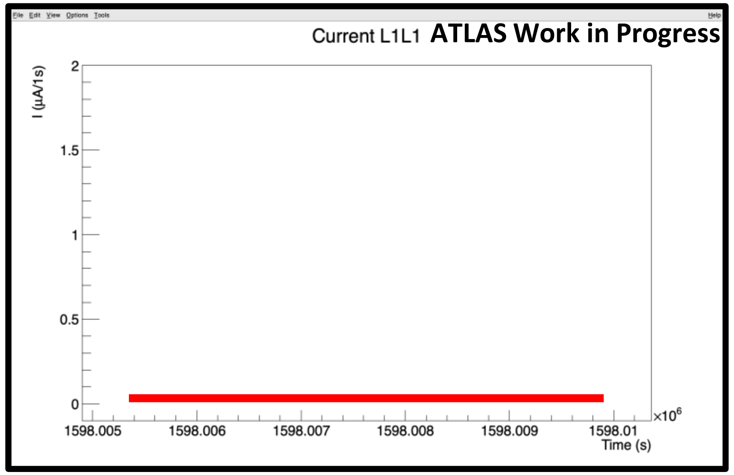
- Dirt
- Defects in resistive strips layer and in the mesh
- Resistive strip layout. In some PCB the interconnections are close to the HV distribution line and cause a reduction of the electrical resistance seen by the avalanches

Good sector: 7 discharges/min @ 570 V





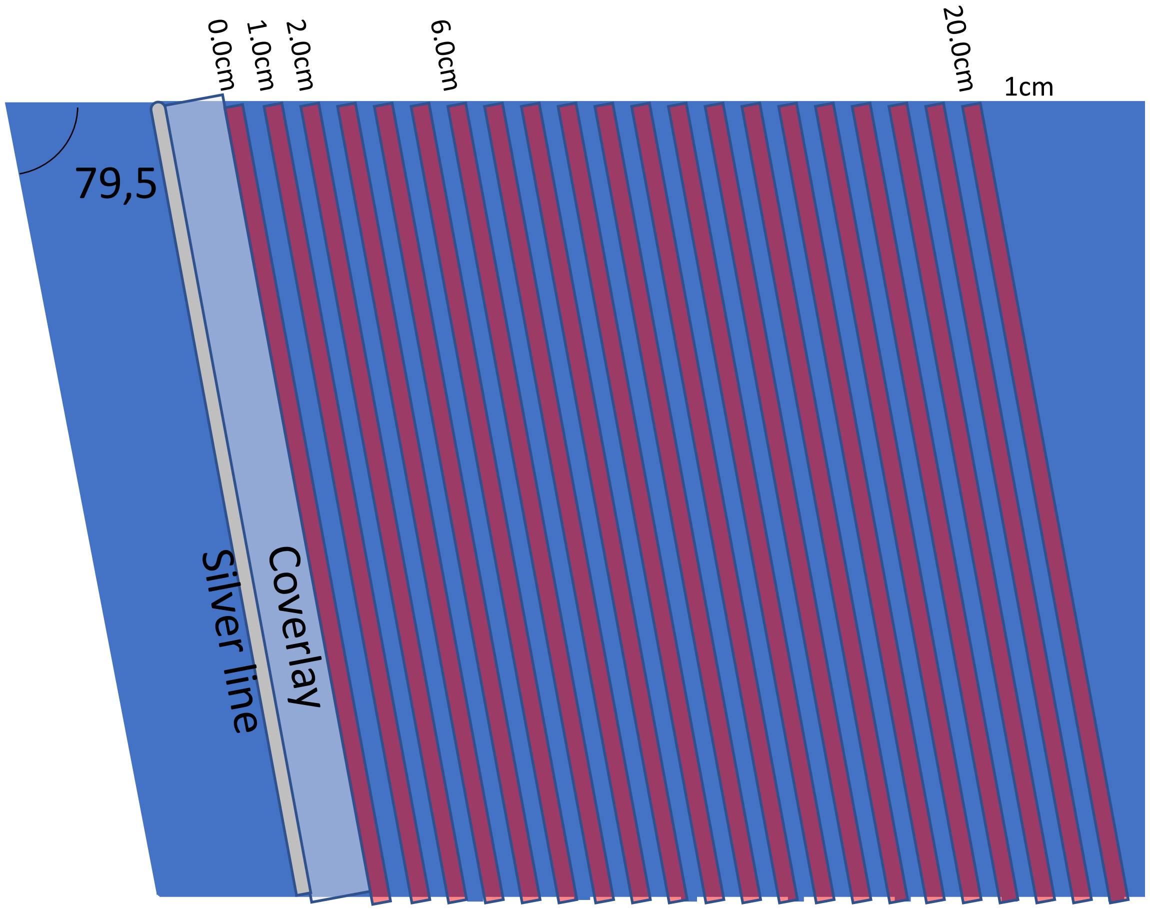




Single strip electric resistance measurements

The electrical resistance of the resistive strips has been measured on single strips at different distance from the HV distribution line

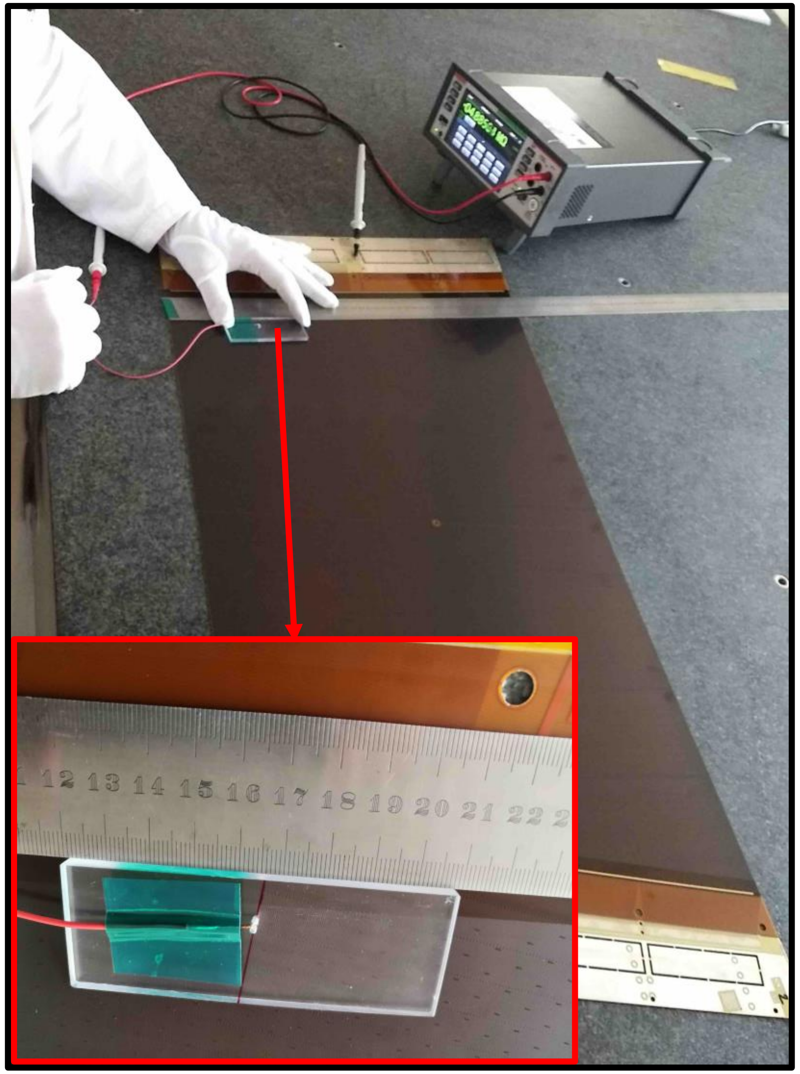
- Only along the line 0.0 cm the resistance has been measured for the whole set of strips (about 1100)
- All lines are parallel to the HV distribution line and separated from each other by a distance of 1 cm
- Along the other lines the resistance has been measured at step of 1 cm, remaining always on the same strip (±2)
- A special probe has been built to speed up the measurement and to avoid damage to the strip



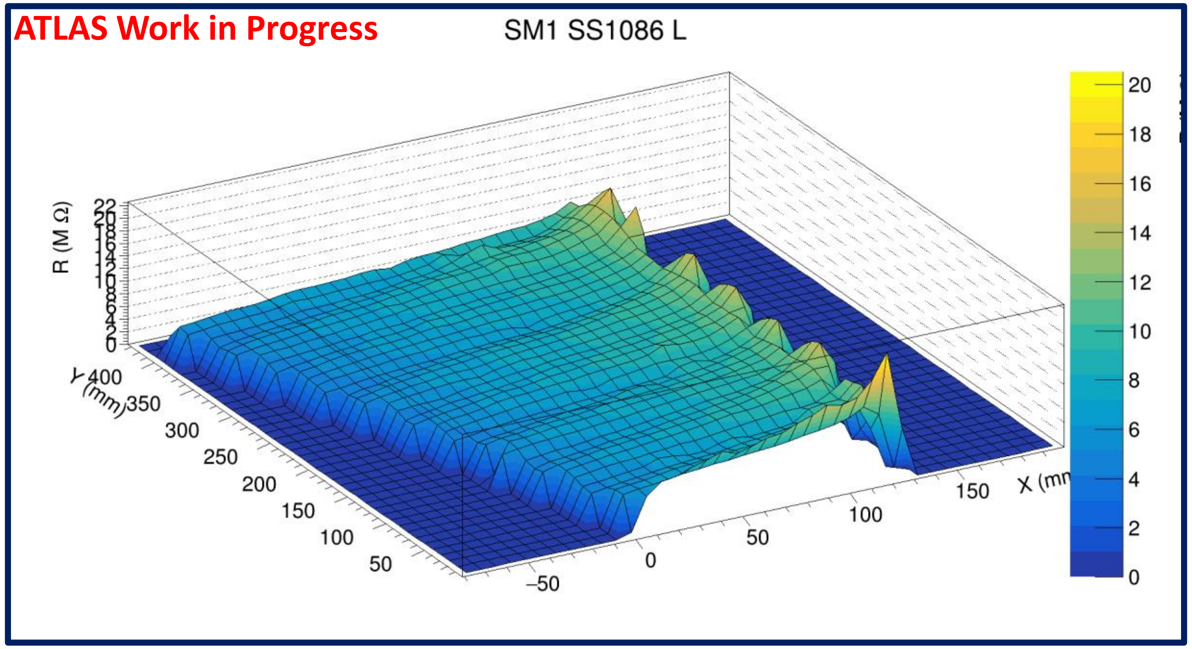
Red lines along which the resistance measurement was done

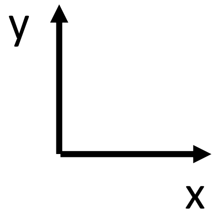
Single strip electric resistance measurements

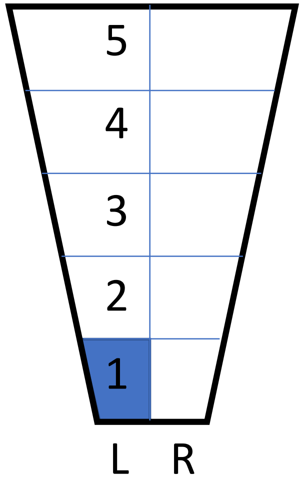
- The probe is slided along the ruler, positioned on the strip whose electrical resistance is to be measured
- The measurement of the resistive strip electrical resistance has been done for each type of PCB
- The resistance measurement has been made for 4 stereo PCBs and 4 eta PCB of the SM1 4-plets. Two examples are reported in the following slides

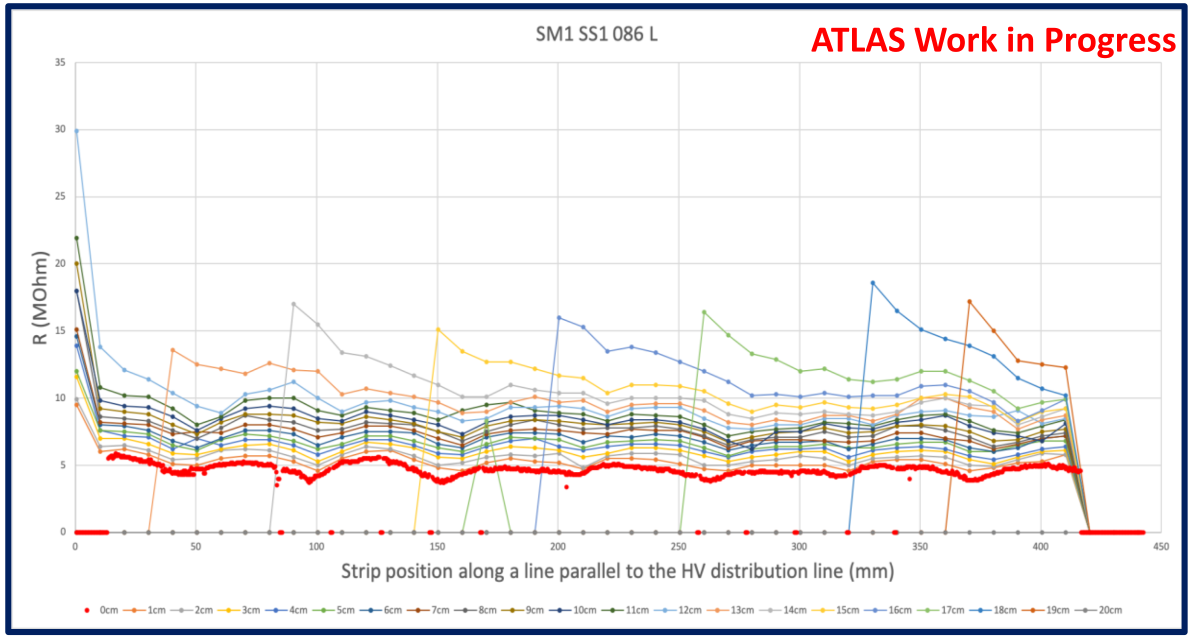


SM1 stereo strips, PCB type 1, left side



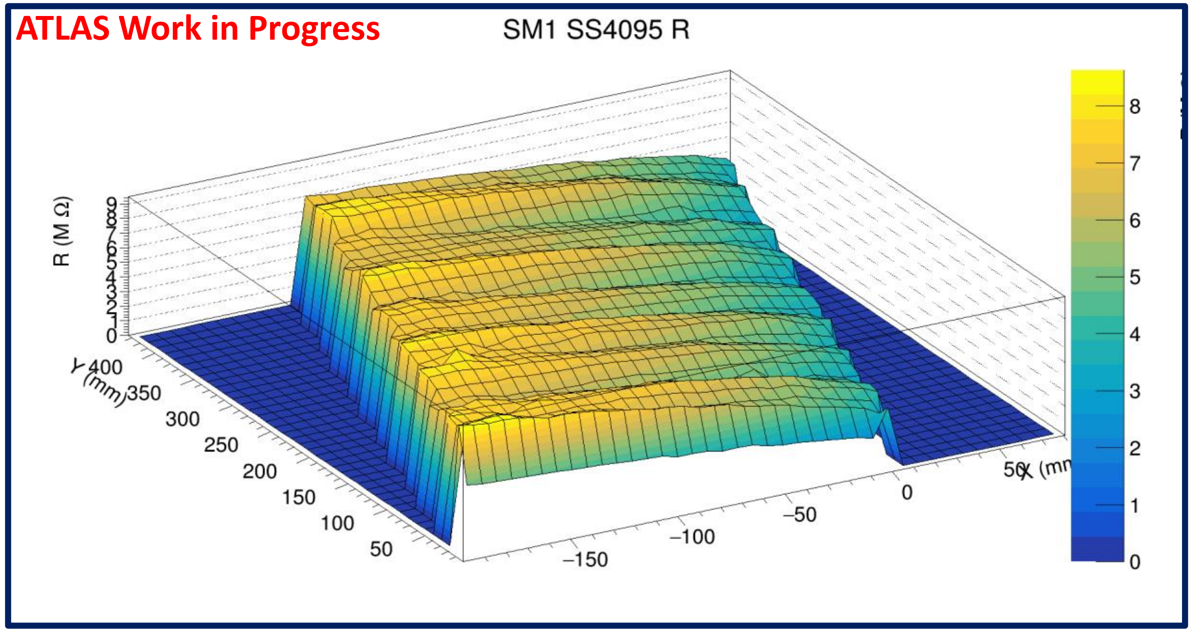


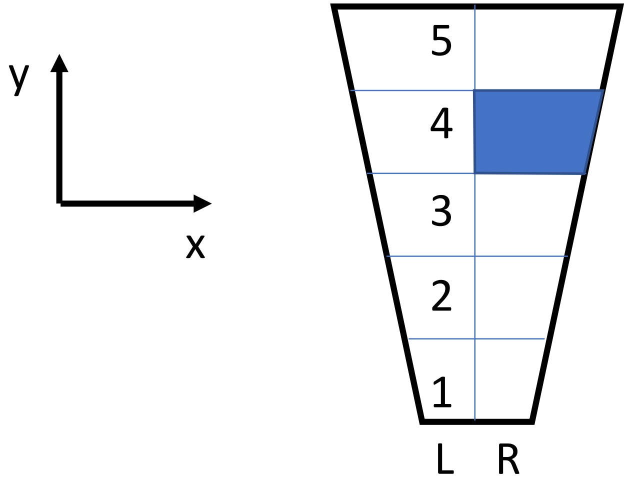




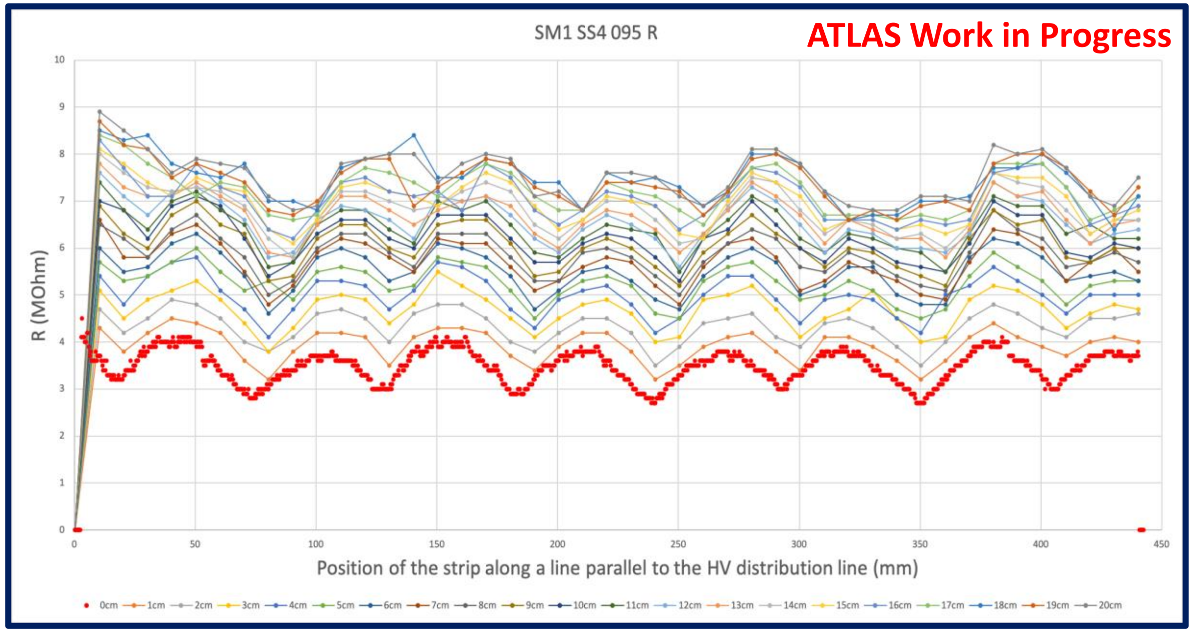
The resistance increase moving away the HV distribution line as expected

SM1 stereo strips, PCB type 4, right side





The observed resistance trend (arcs) is due to the particular disposition of the strip interconnections



Results

- Poor uniformity in resistance values inside a PCB and between different types of PCBs
- In many cases the resistance of the resistive strip is lower than the minimum value of 5 MΩ which, from previous studies, should guarantee good HV stability
- The first 10 assembled SM1 4-plets have shown about 18% HV sectors unable to reach the operative voltage (570 V). In many cases the problem was caused by the low resistance of the strips close to the HV distribution line
- To mitigate this problem the first few centimeters of resistive strip, close to the HV distribution line, have been covered by a layer of insulator (in the following this layer is named passivation). The SM1 modules treated with this technique have shown only 7% of HV sectors unable to reach the operative voltage
- The presented study is useful for indicating where to measure the resistance in the PCB (weak points) and, if necessary, to determine the extend of the passivation

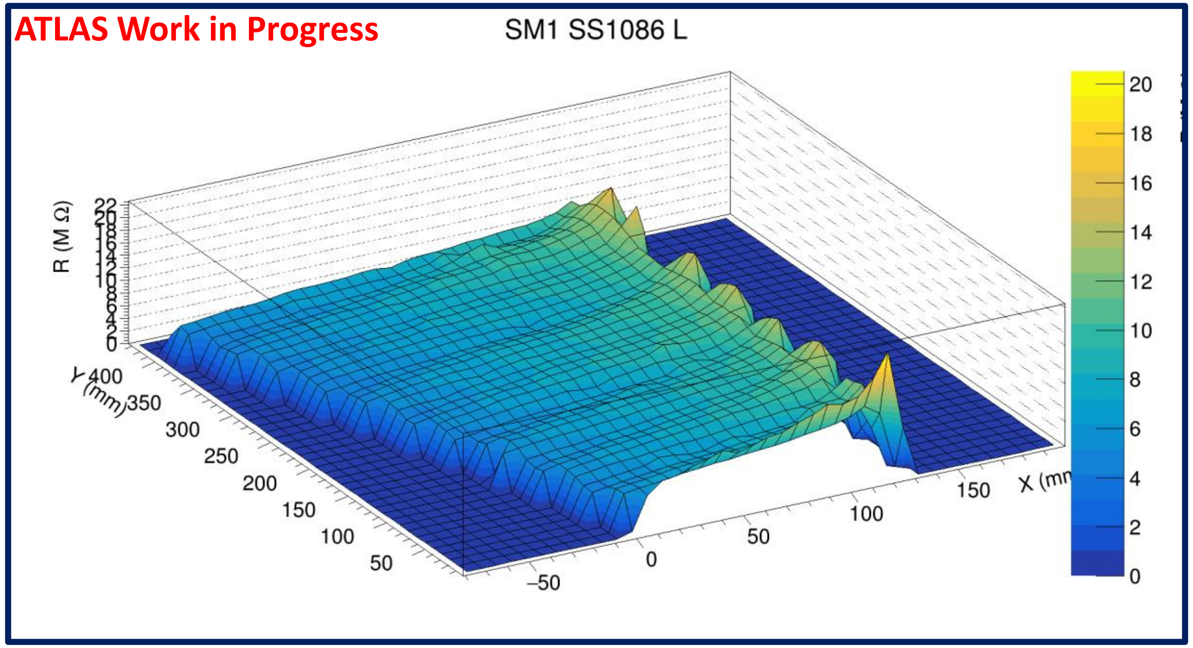
Conclusions

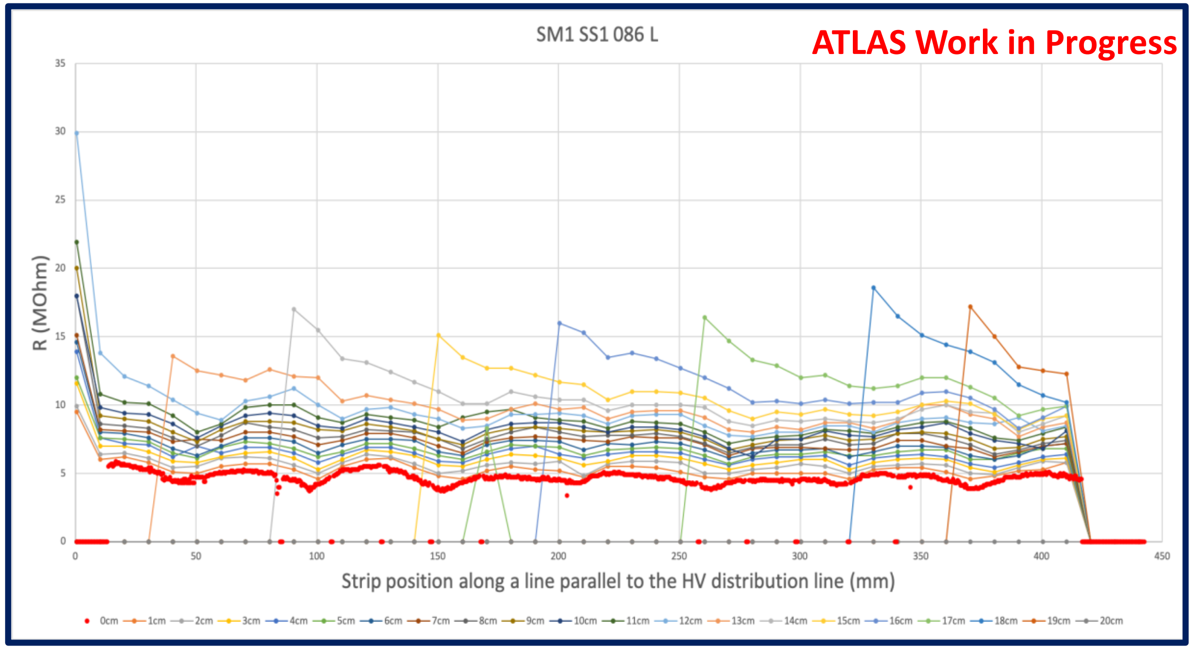
- The electric resistance of the resistive strips has been measured for many types of SM1 PCBs, showing a large non uniformity and trends that depends from the position of the strip interconnections
- The passivation solve only in part the problem
- Under study new gaseous mixtures with lower operative voltage and more efficient quenching. The Ar - CO_2 - C_4H_{10} (93:5:2) is very promising but other gas mixture are under study.

THANKS FOR YOUR ATTENTION

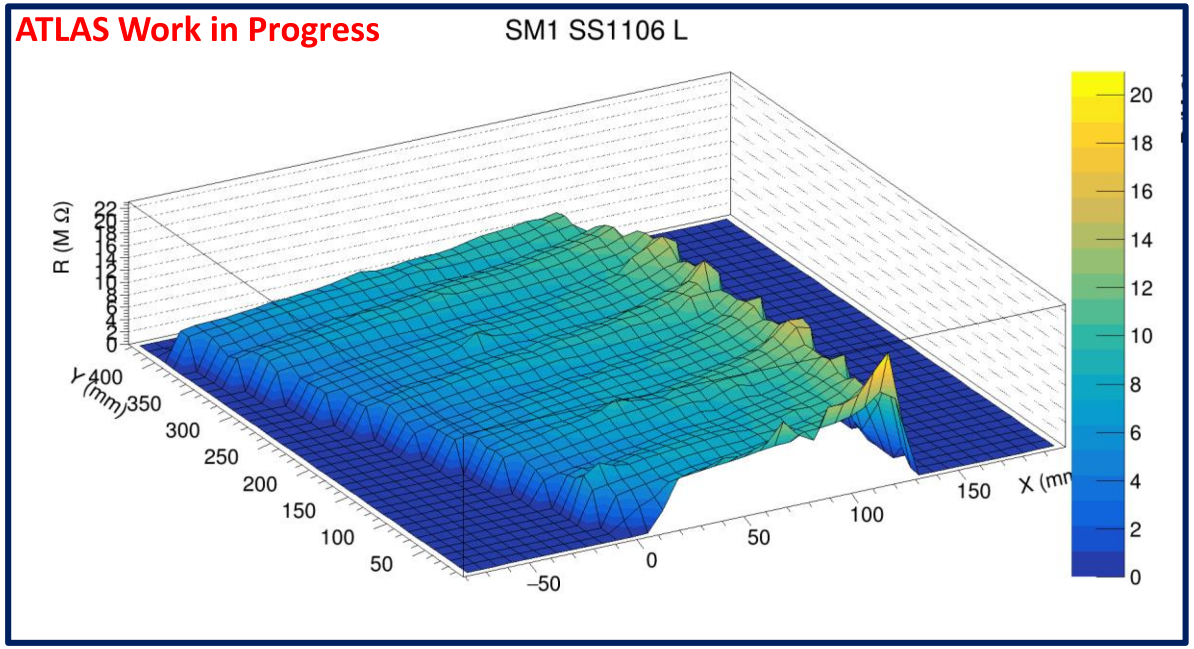
BACKUP SLIDES

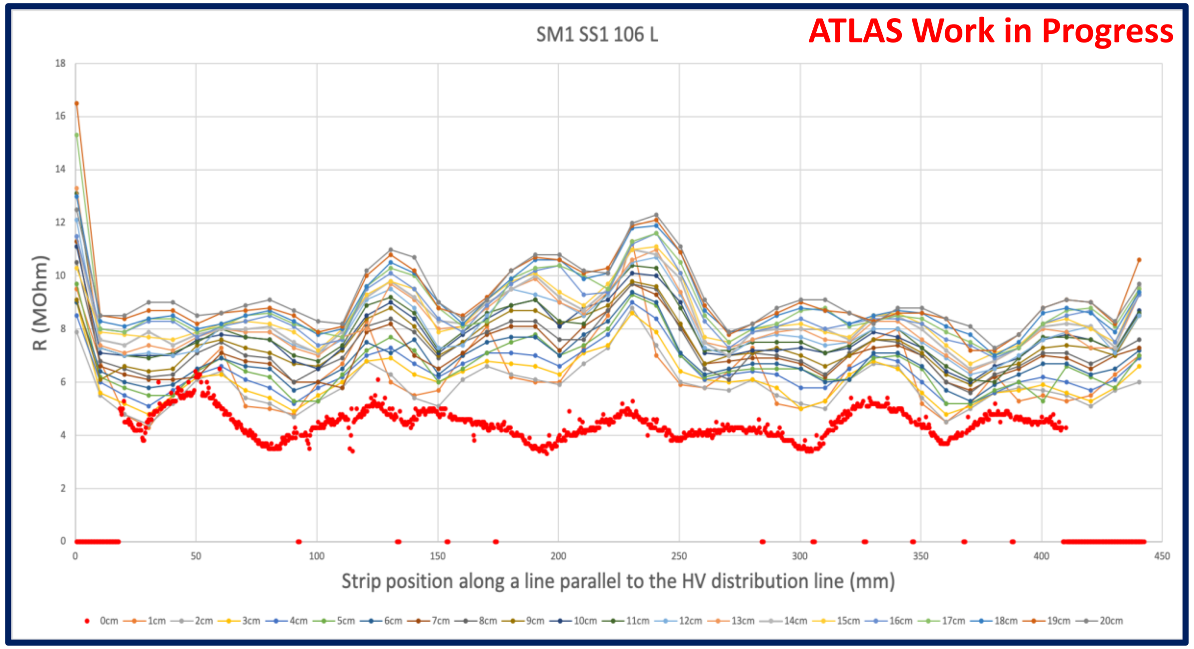
SM1 stereo strips, PCB type 1, left side



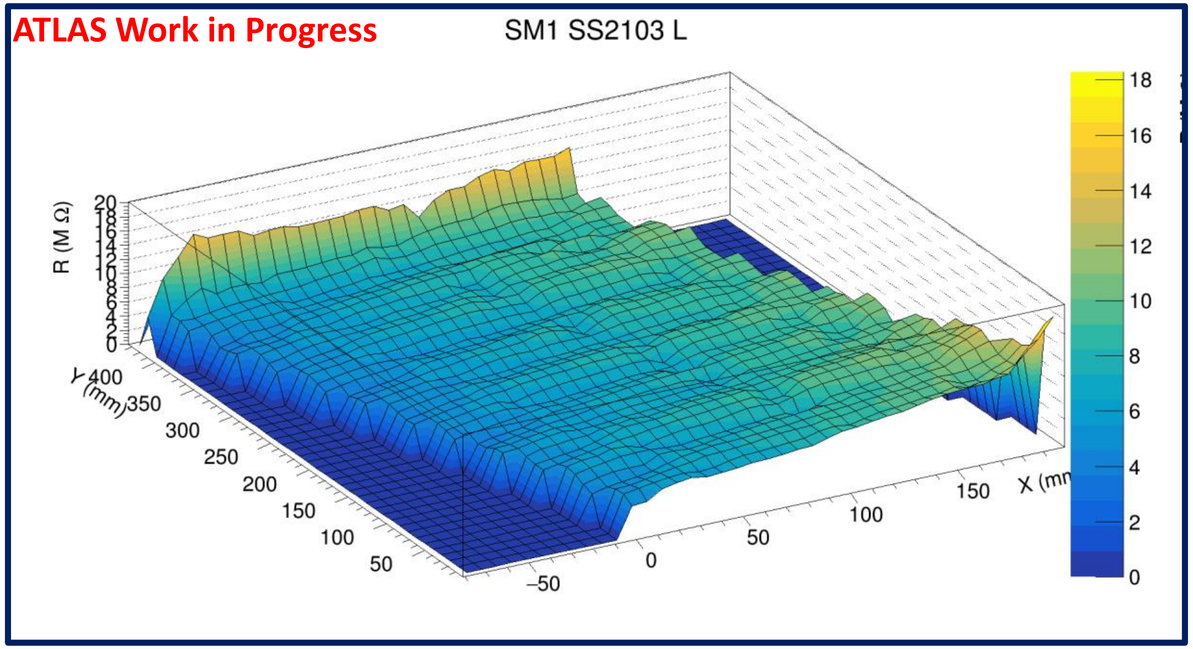


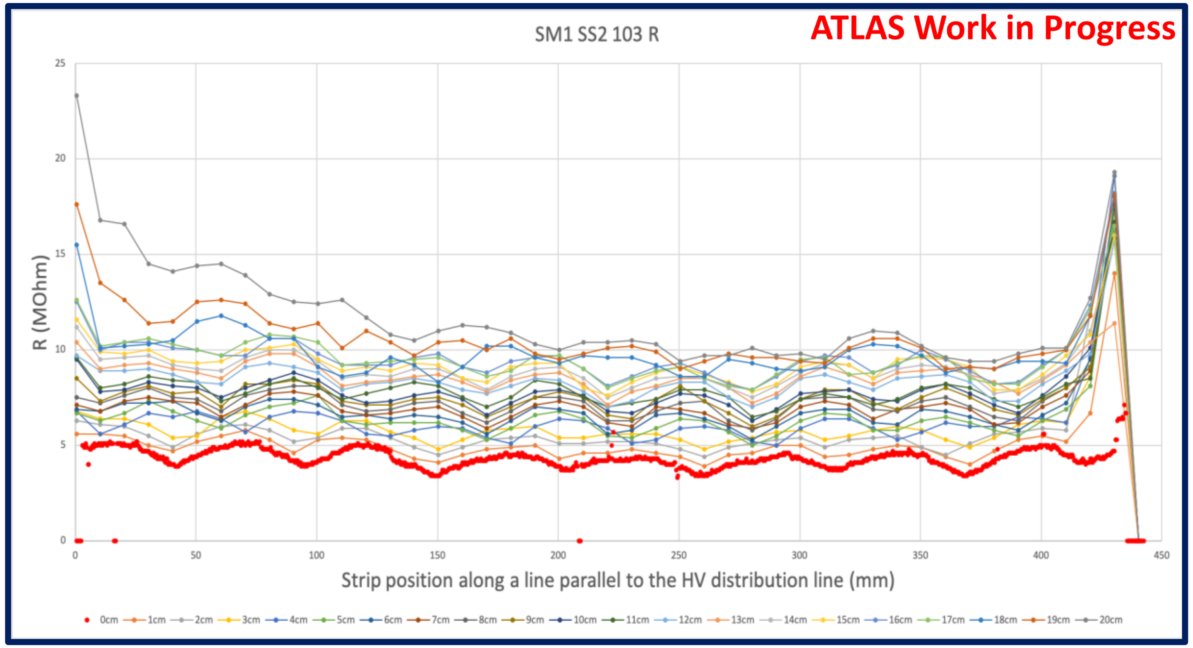
SM1 stereo strips, PCB type 1, left side



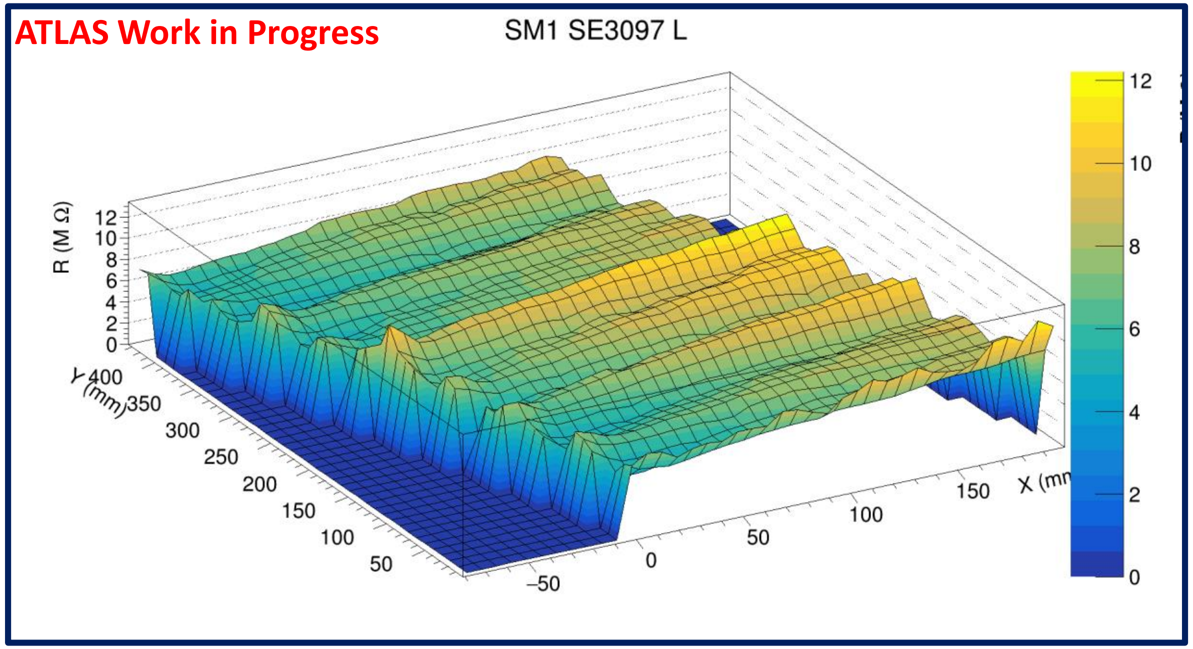


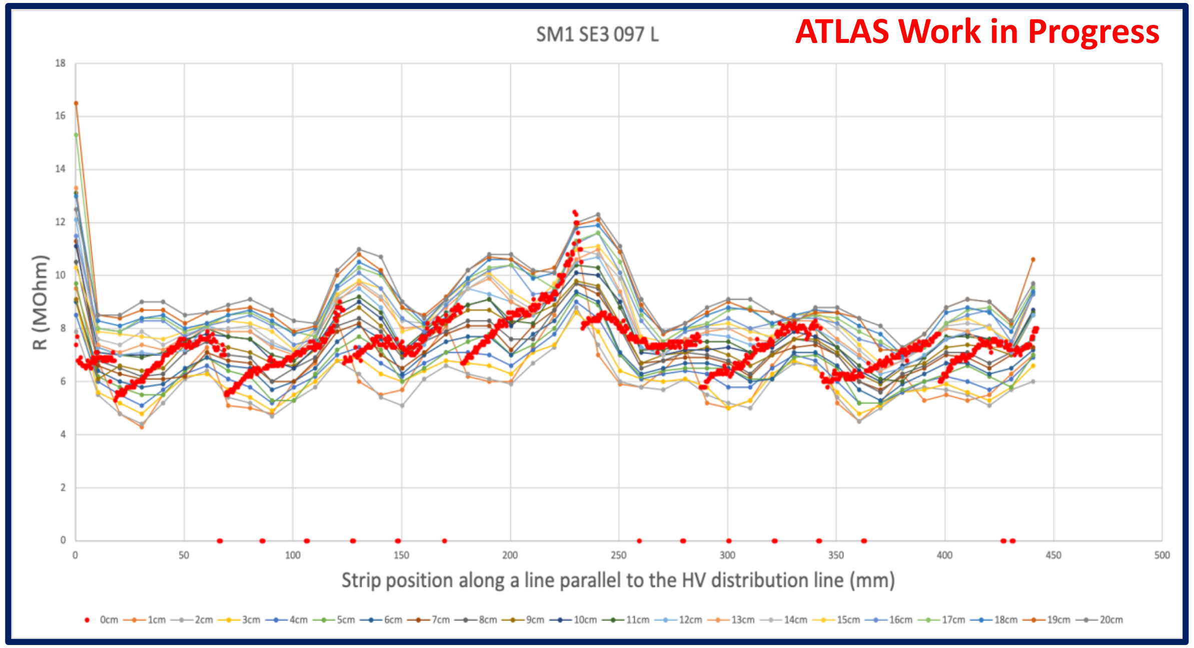
SM1 stereo strips, PCB type 2, right side



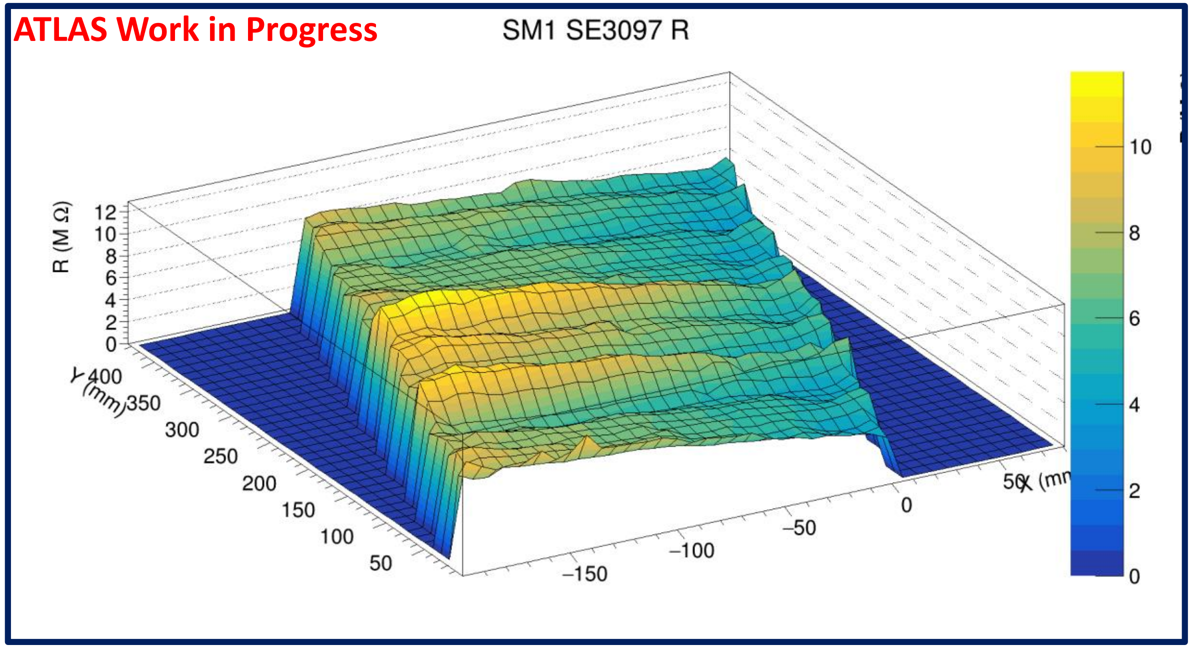


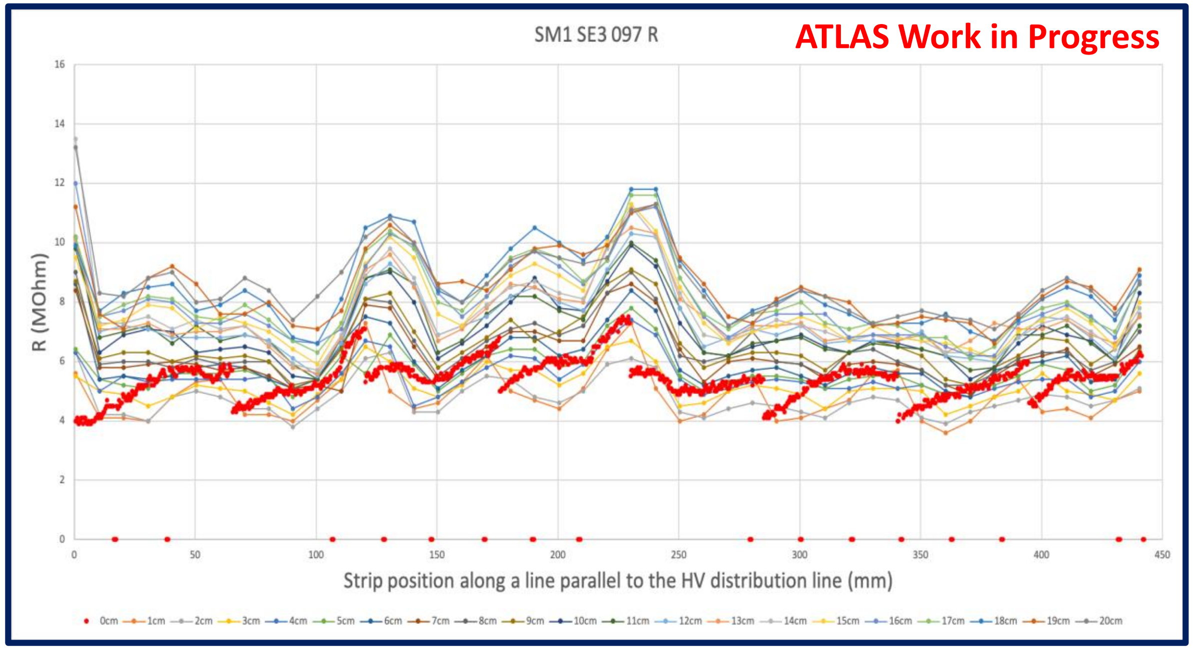
SM1 eta strips, PCB type 3, left side



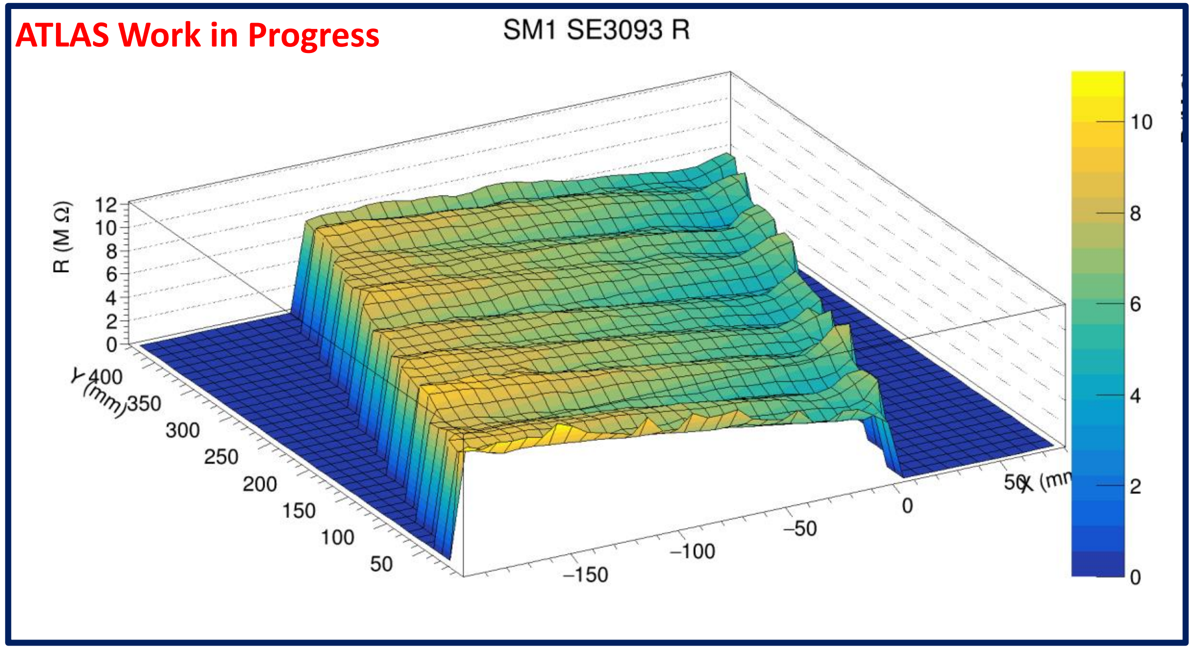


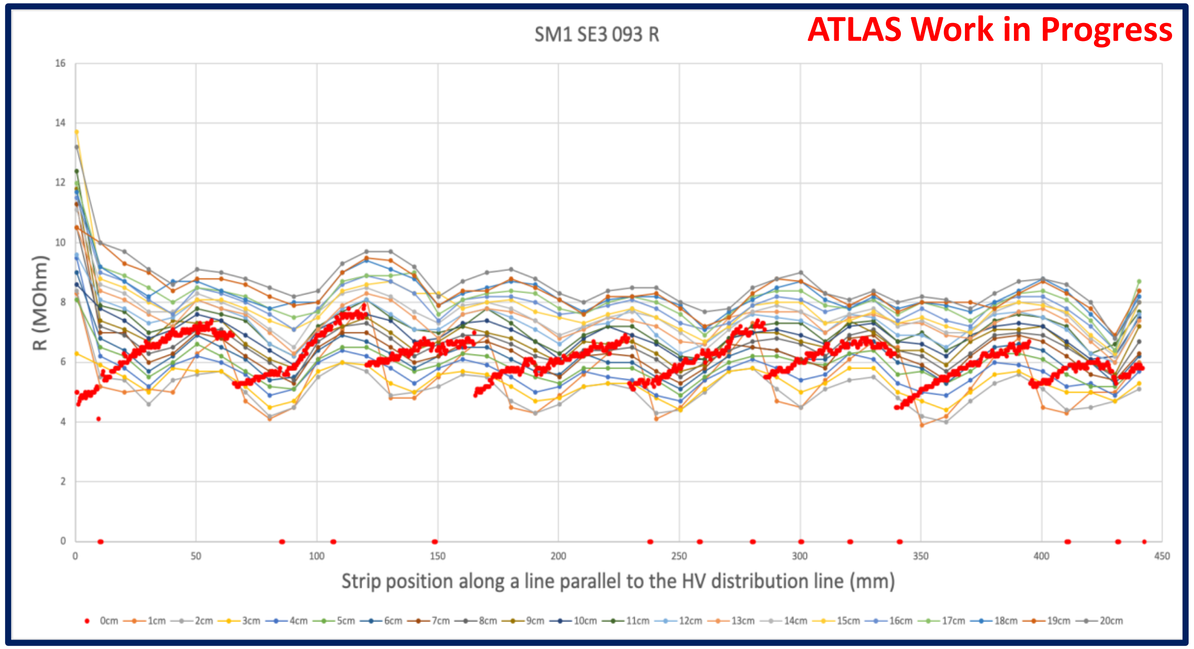
SM1 eta strips, PCB type 3, right side



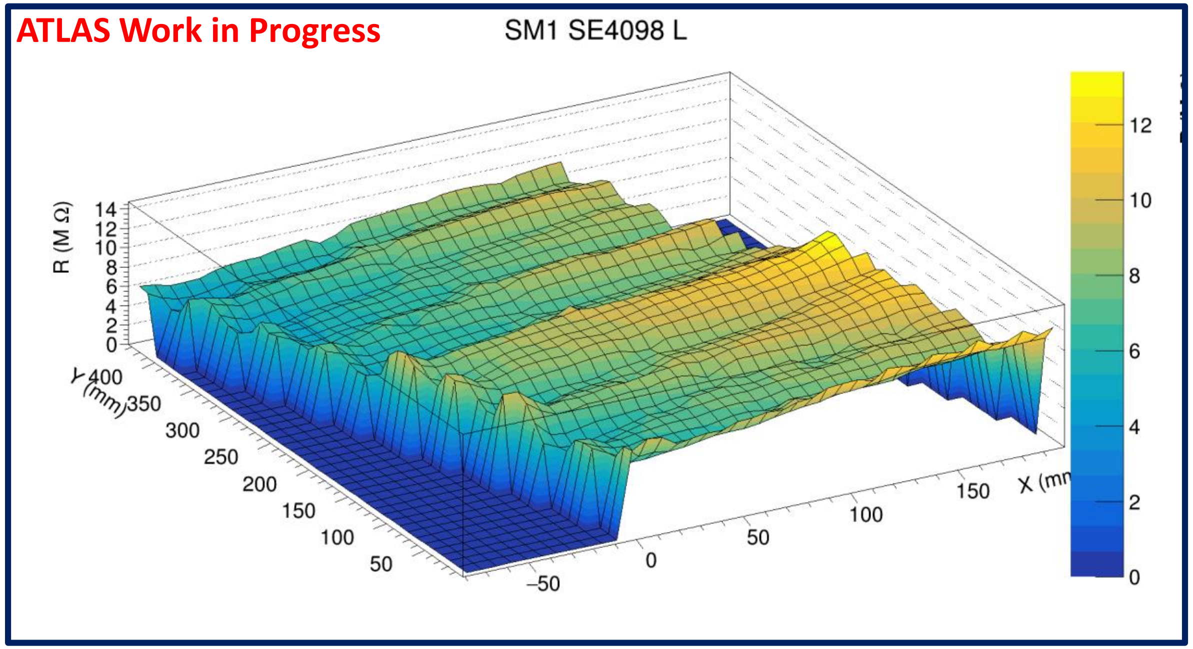


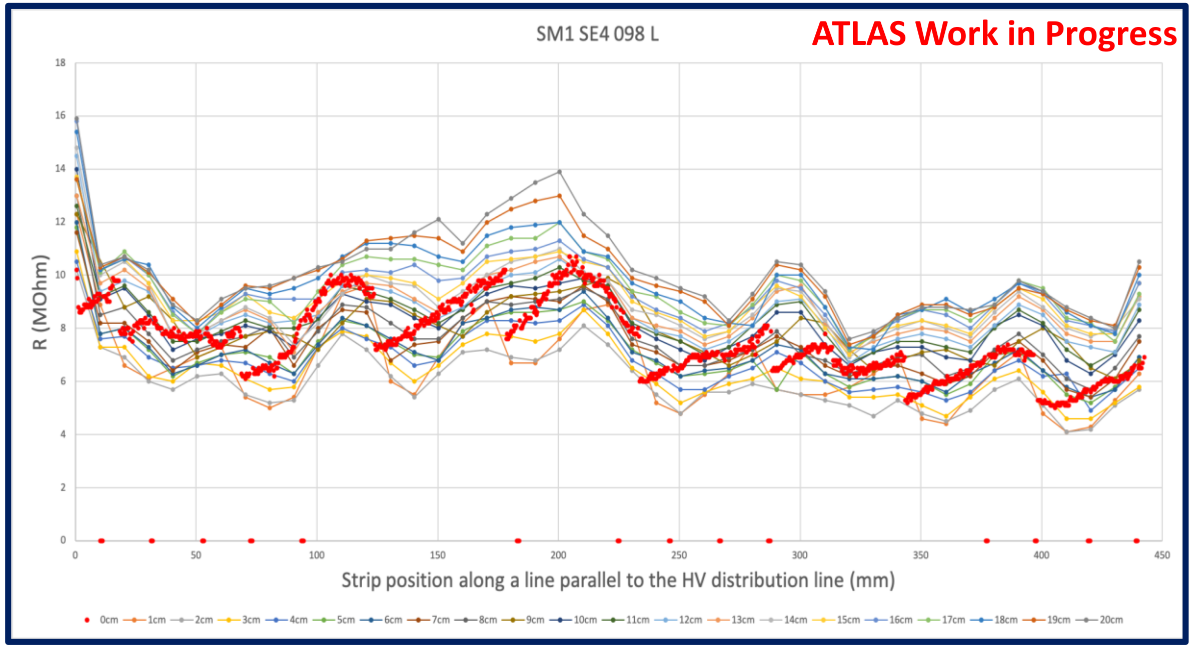
SM1 eta strips, PCB type 3, right side



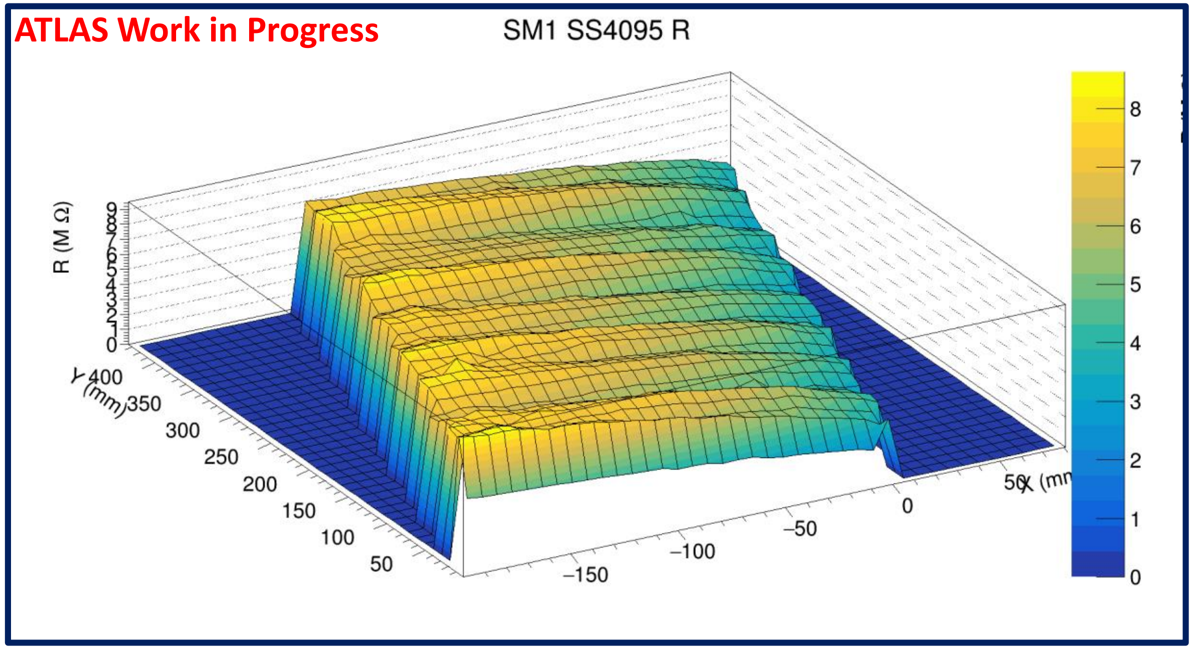


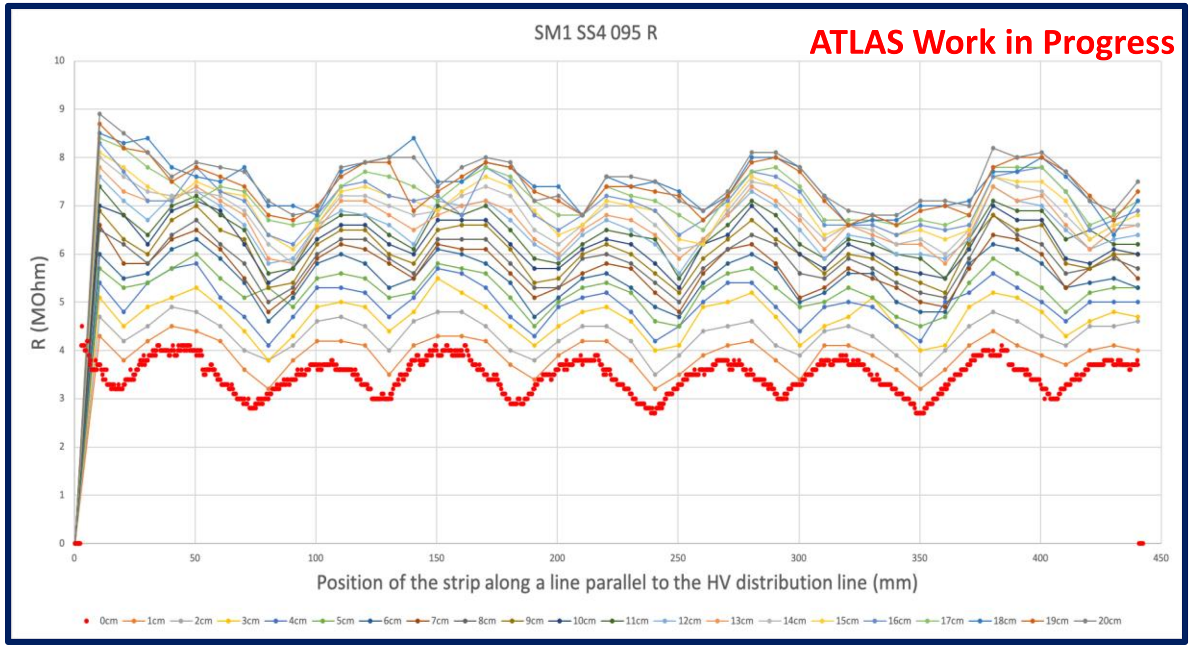
SM1 eta strips, PCB type 4, left side



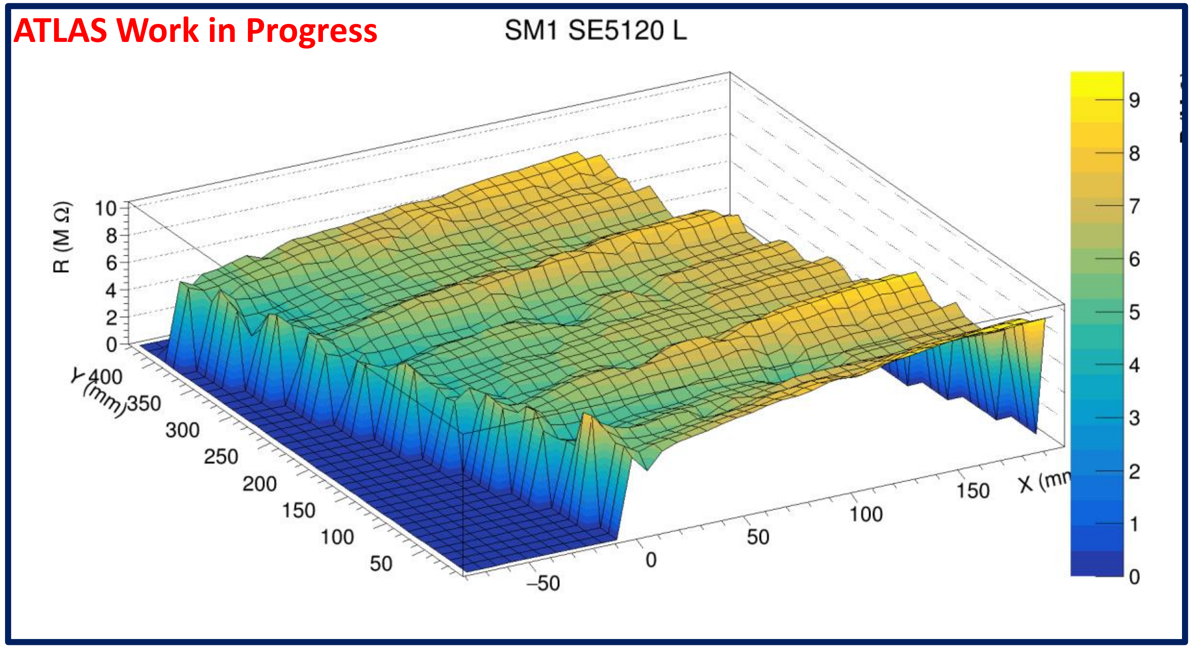


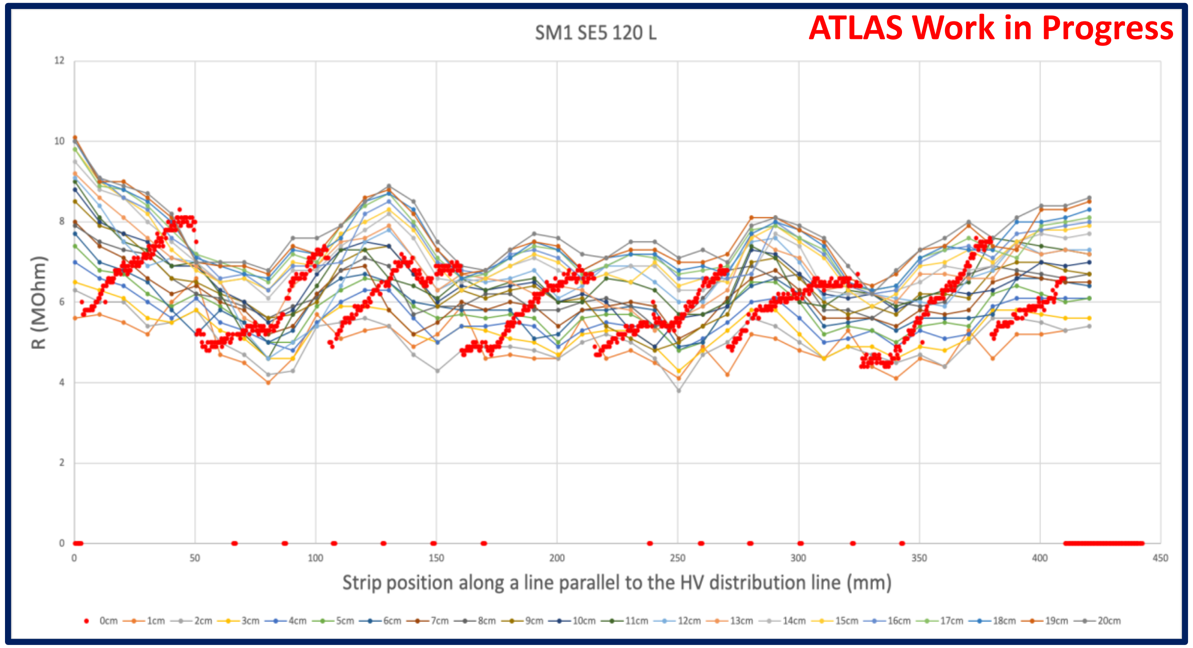
SM1 stereo strips, PCB type 4, right side



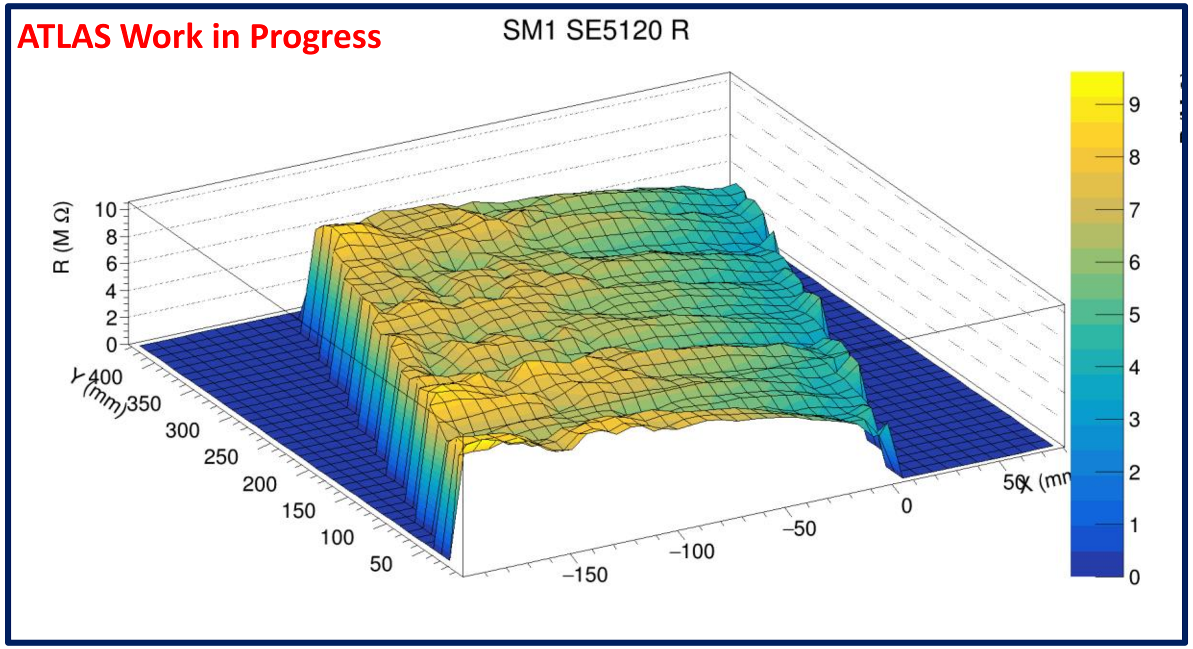


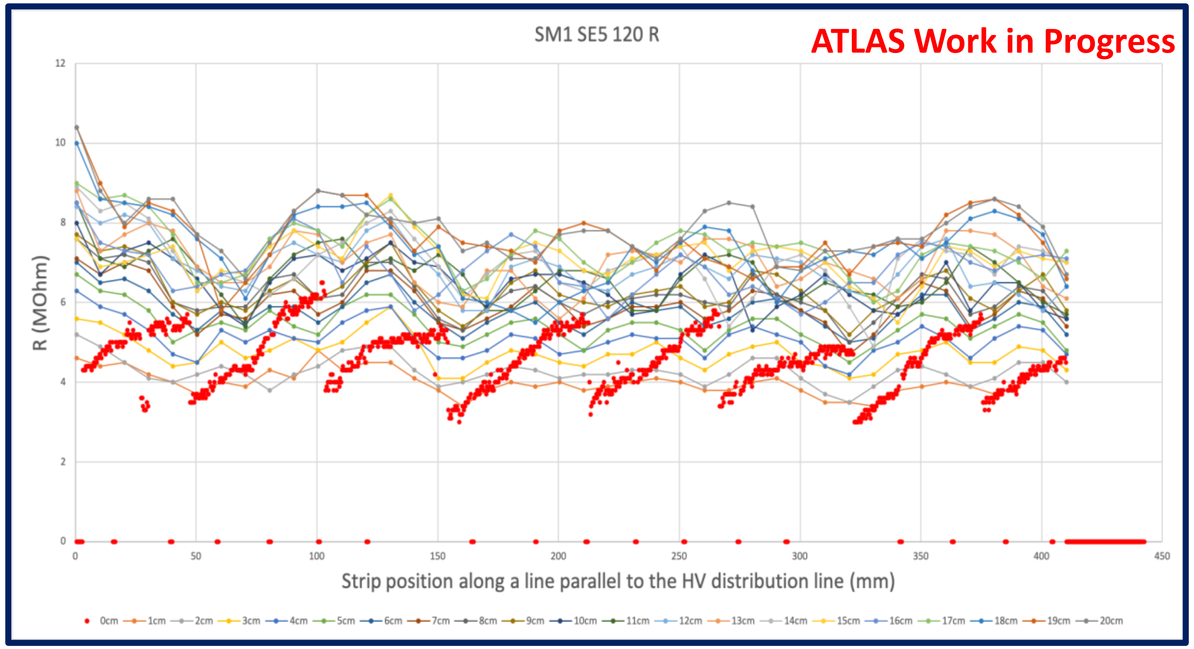
SM1 eta strips, PCB type 5, left side



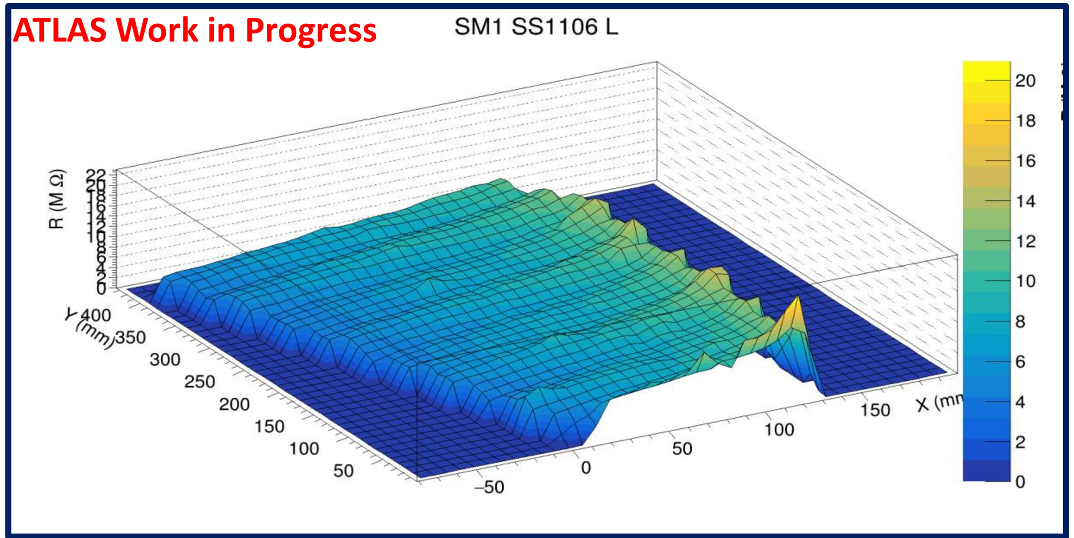


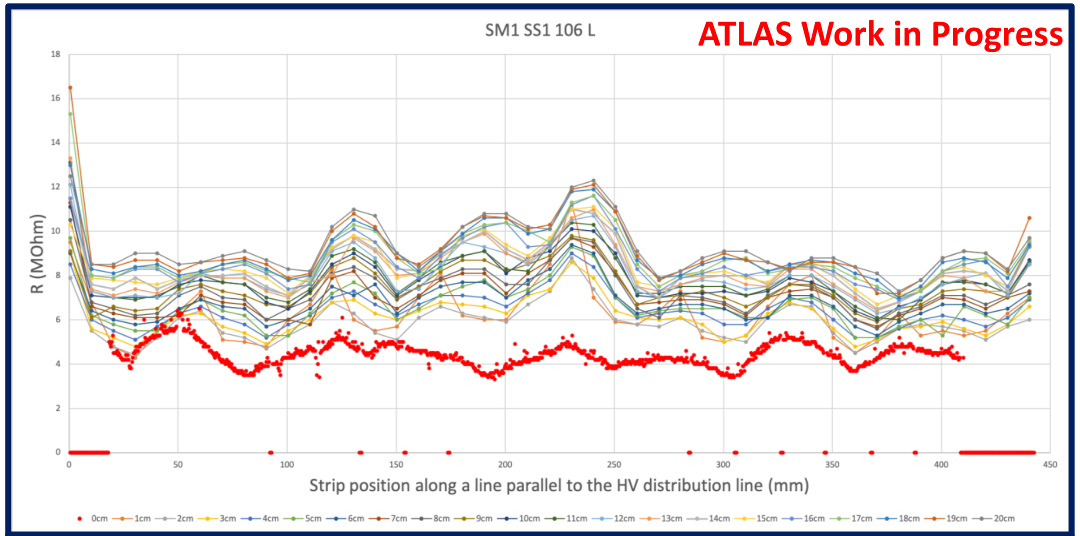
SM1 eta strips, PCB type 5, right side

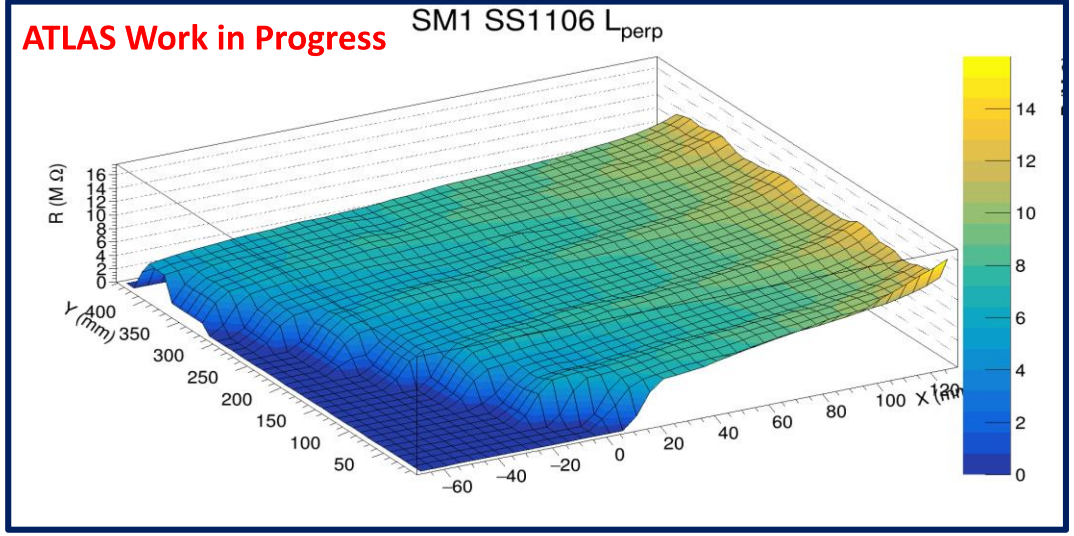


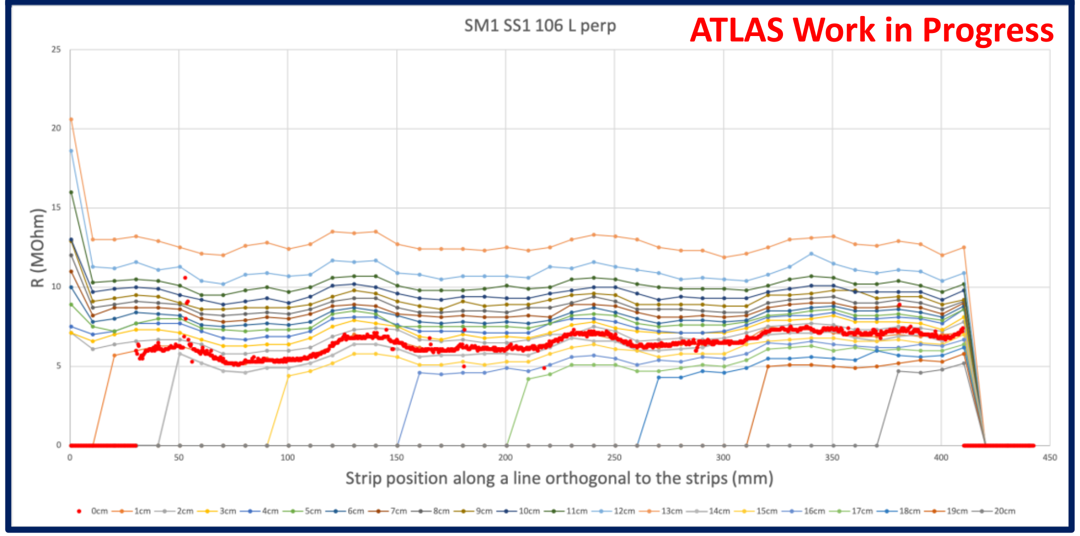


Comparison between resistance measurements: parallel to HV distribution line and orthogonal to the strips









Comparison between resistance measurements: parallel to HV distribution line and orthogonal to the strips