



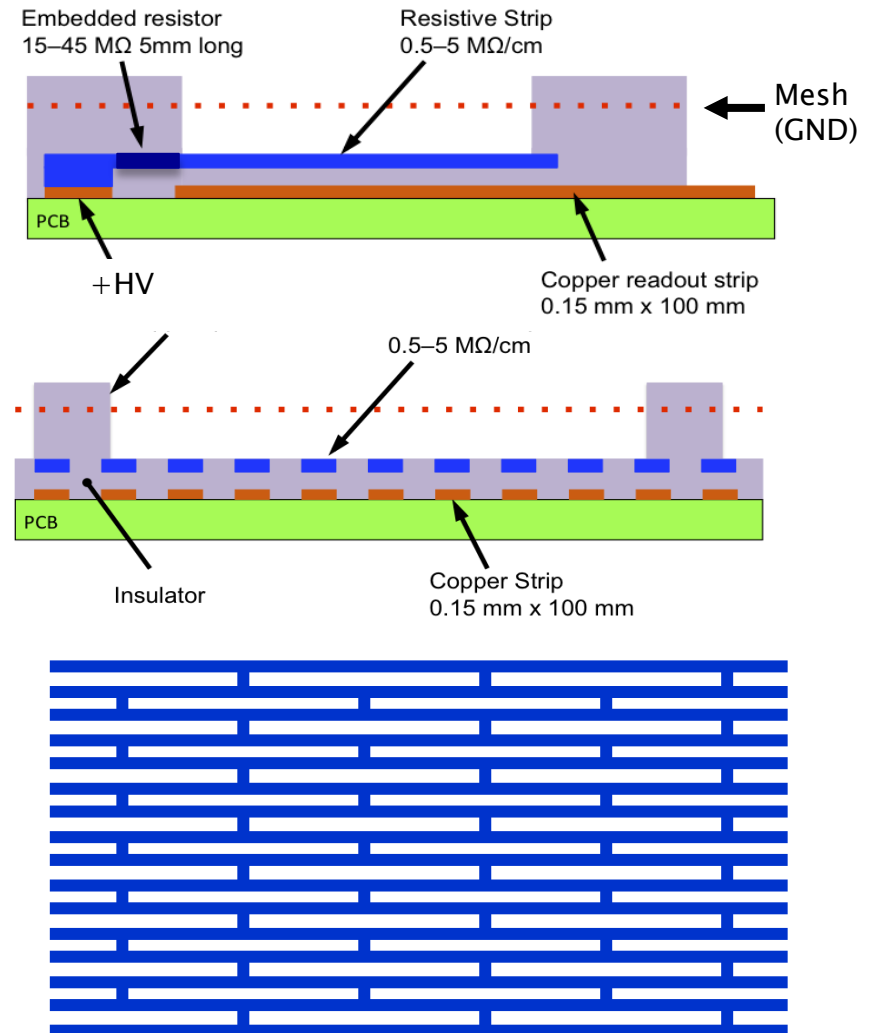
Resistive Strips foils production
for ATLAS NSW MicroMEGAS

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Kobe University

18/03/2015 RD51 WG6 @ CERN

Requirements for ATLAS NSW MM

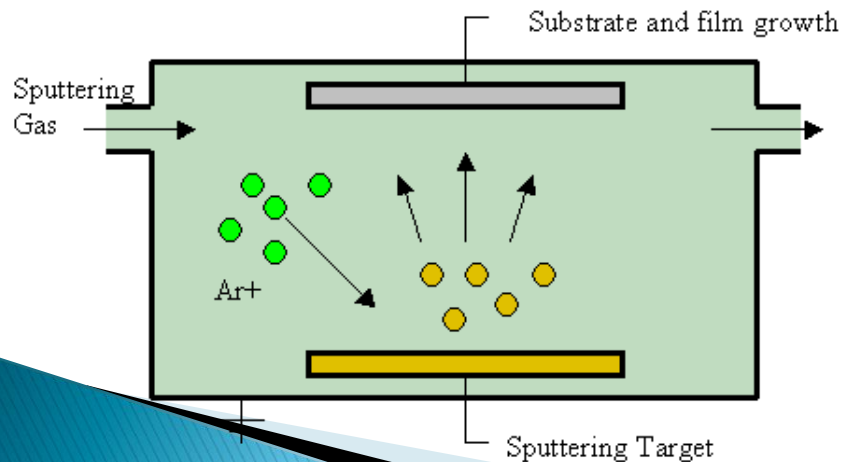
- ▶ High position resolution for one dimension
 - $< 100 \mu\text{m}$ for eta direction.
(Resolution of a few cm is allowed for second coordinate.)
- ▶ Tolerant for high rate HIP particles
 - $\sim 5\text{kHz}/\text{cm}^2$
- ▶ **Resistive layer should be formed as strips**
- ▶ Resistivity: $\sim 20\text{M}\Omega/\text{cm}$
 - To protect from spark
- ▶ Mass production should be available, with large size (1m)
 - ~ 2000 board should be produced in half year.
- ▶ Low cost



Candidates for production

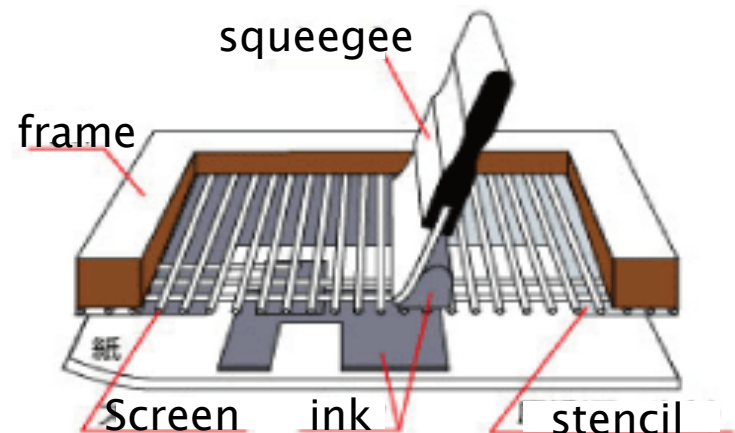
▶ Sputtering+liftoff

- Pros.
 - Large area ($>2\text{m}$)
 - Fine pattern ($<100\mu\text{m}$)
 - Uniform resistivity
 - Strong attachment on substrate
- Cons.
 - Production speed (Now, it will be OK, next slide)
 - High cost



▶ Screen printing

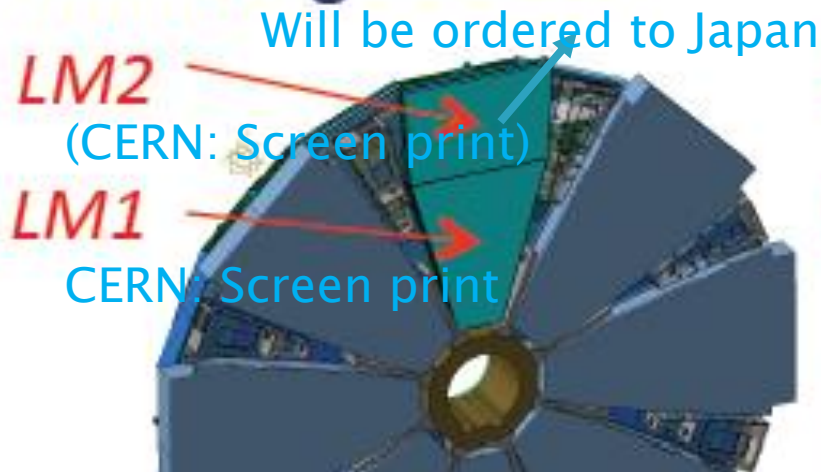
- Pros.
 - Large area ($>2\text{m}$)
 - Fast production speed
 - Low cost for mass production
- Cons.
 - Stability of resistivity
 - Thick pattern ($\sim 20\mu\text{m}$)
 - Lower tolerance for breakdown for high voltage



Share of module-0 (prototype for mass production) resistive foils

- ▶ Japanese group has made SM1 / 2 foils for module-0
- ▶ We will use two different technologies for making resistive strips
 - SM1: Screen Printing
 - SM2: Carbon sputtering

MM Large Sector

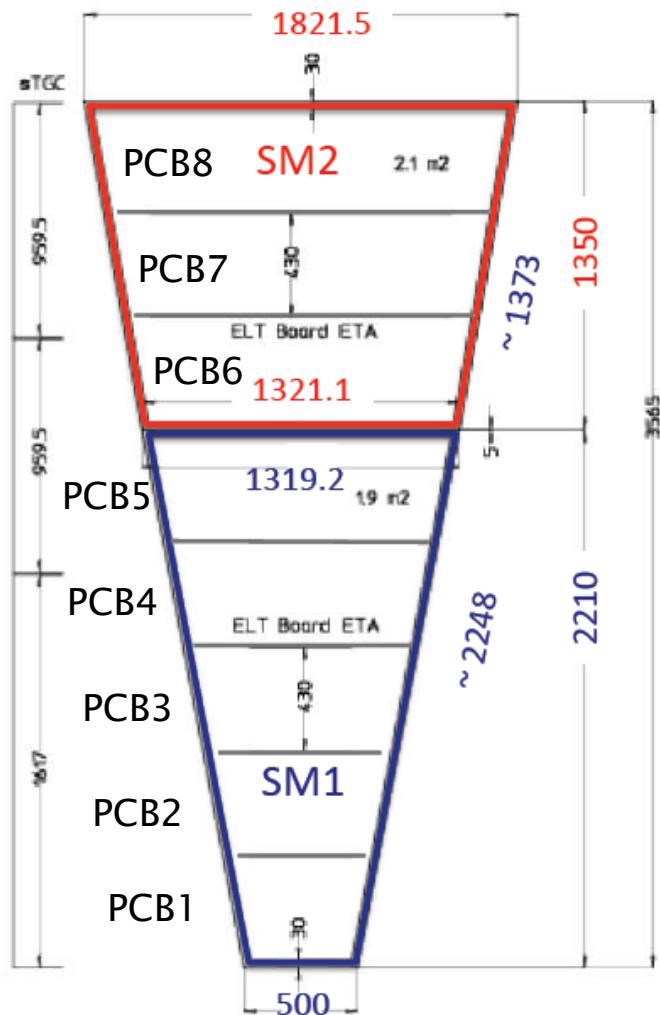


MM Small Sector



Size of foils

Small sector modules



Type	Max. Length	Mod.0	Prod.
PCB1 + 5	1700mm	6 + 6	64 + 64
PCB2 + 4	1700mm	6 + 6	64 + 64
PCB3 + 3	1700mm	3 + 3	32 + 32
PCB6	1770mm	6 + 6	64 + 64
PCB7	1600mm	6 + 6	64 + 64
PCB8	1400mm	6 + 6	64 + 64

Screen printing

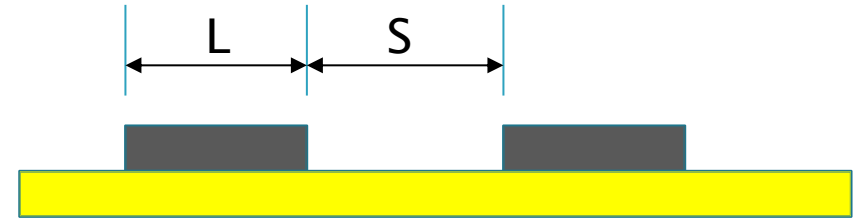


Two candidates of resistive ink

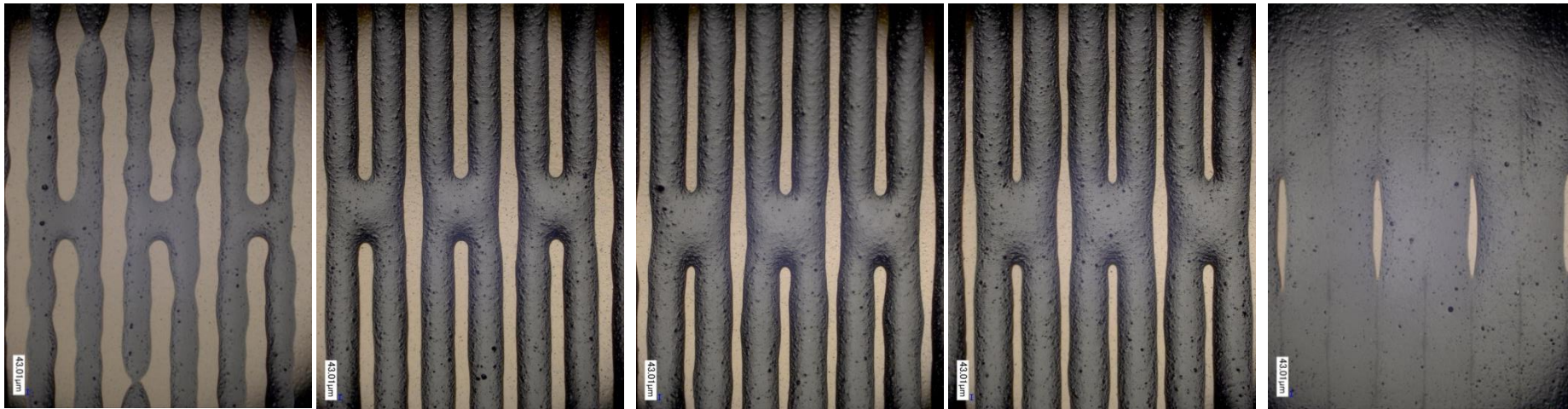
- ▶ Resistive ink from Jujo chemical:
 - Jujo JELCON CH-8 + Medium + Silica additive
 - About 100CHF/kg
 - The material is not validated yet.
- ▶ Resistive ink from ESL:
 - RS12100 Series
 - About 1kCHF/kg
 - The material is well tested as MM electrodes.

Printing quality

Line/Space (on the printing proof)



- ▶ 150 μ /250 μ
 - No good
 - Some lines are broken
- ▶ 180 μ /220 μ
 - Good
 - No break found
- ▶ 200 μ /200 μ
 - Good
 - No break found
- ▶ 220 μ /180 μ
 - Good
 - No break found
- ▶ 250 μ /150 μ
 - No good
 - The lines are attached to next ones



New samples ... **Good quality**

Resistivity of the foils

- ▶ Typical resistivity of the foil
 - 1 cm length with 1 cm width
 - (25lines included in this width)

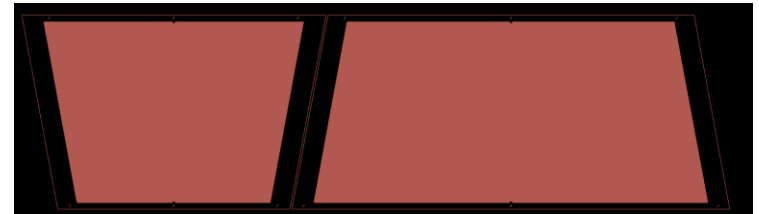
Line width on proof	150 μ m	180 μ m	200 μ m	220 μ m
Resistivity	>2M Ω	570k Ω	360k Ω	270k Ω
Resistivity / line	>50M Ω	14M Ω	9.1M Ω	6.9M Ω



This condition is most close to our requirements (20M Ω /cm).

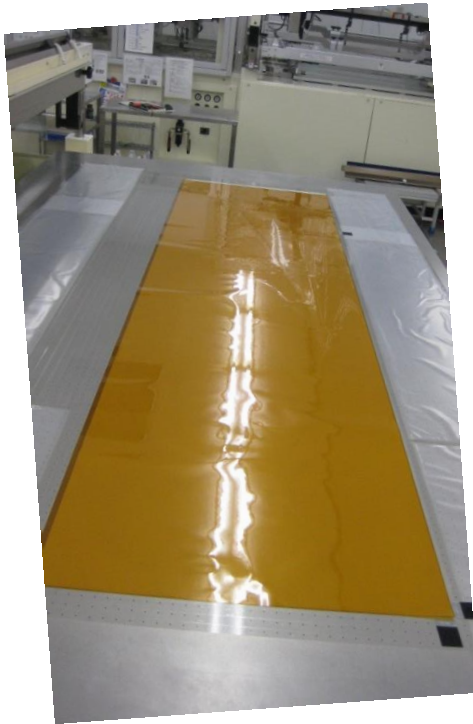
Production of SM1 foils

- ▶ The resistive foils for SM1 are printed by Matsuda Screen (Osaka, Japan)
 - 6 type of patterns
 - PCB1 + PCB5 Eta
 - PCB1 + PCB5 Stereo
 - PCB2 + PCB4 Eta
 - PCB2 + PCB4 Stereo
 - PCB3 + PCB3 Eta
 - PCB3 + PCB3 Stereo
 - 6 foils are printed for each type
 - 26th Jan. 2015, Printings were done.
(36 foils are printed in one day.)

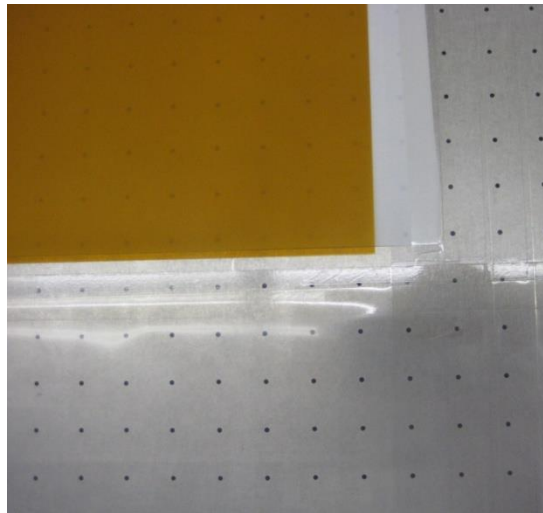


Printing procedure (Matsuda Screen)

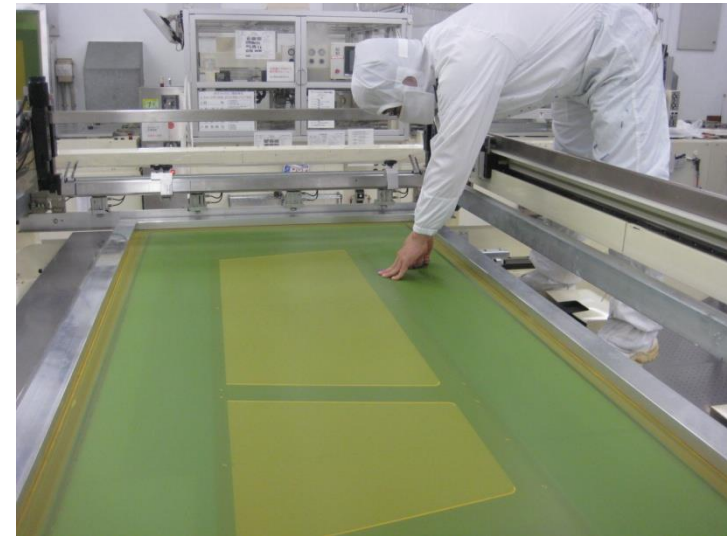
Film is prepared



Polyimide film is attached to vacuum table with porous sheet



Screen mask is set on printing machine

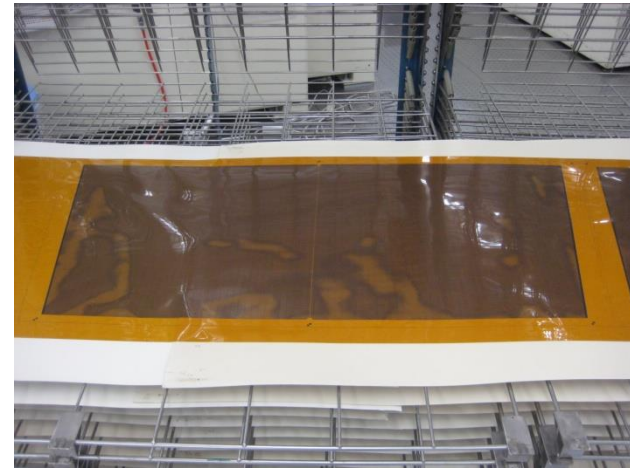


Printing procedure (Matsuda Screen)

Resistive paste is put on



Printing is done



Squeegee is controlled automatically



Drying with 170 degree, 2H.

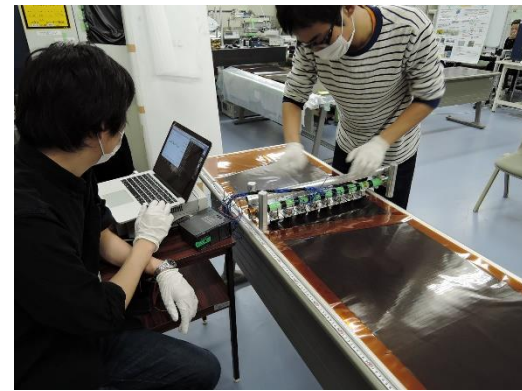


Mass production feasibility

- ▶ Screen print @ Matsuda Screen Inc.
- ▶ Maximum size for printing
 - 2600mm x 1300mm
 - We need 2200mm x 500mm maximum.
- ▶ Production rate
 - 50 foils / day
 - It is limited by ovens.
- ▶ Production cost
 - Reasonable

Delivering and QA check (screen print)

- ▶ Screen printed foils are delivered (to KEK) at 30th Jan.
- ▶ Qualities of the foils (resistivity only) were checked at KEK large clean room (3rd Feb.)
 - Almost all foils are fine
- ▶ Foils were shipped to CERN at 5th Feb.



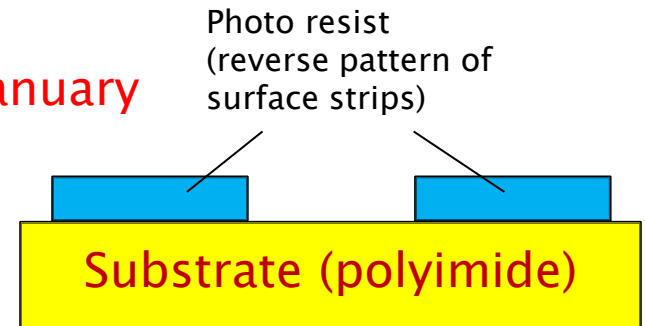
Carbon Sputtering



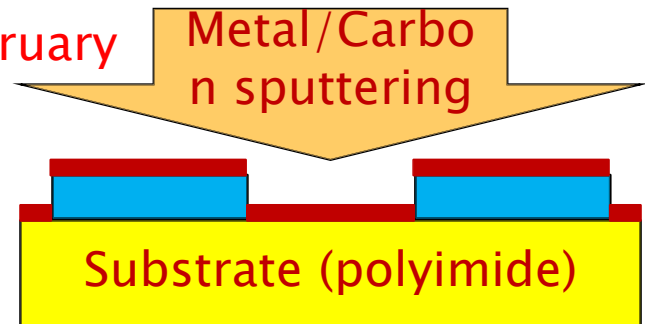
Production of SM2 foils

- ▶ The resistive foils for SM2 are made by Raytech Inc. (Saitama, Japan) and Be-Sputter Inc. (Kyoto, Japan)
 - 6 types of pattern
 - PCB{6, 7, 8} x {eta, stereo}
 - 5 foils are produced for each type.

Mid-end of January
(Raytech)



5th – 13th February
(Be-Sputter)

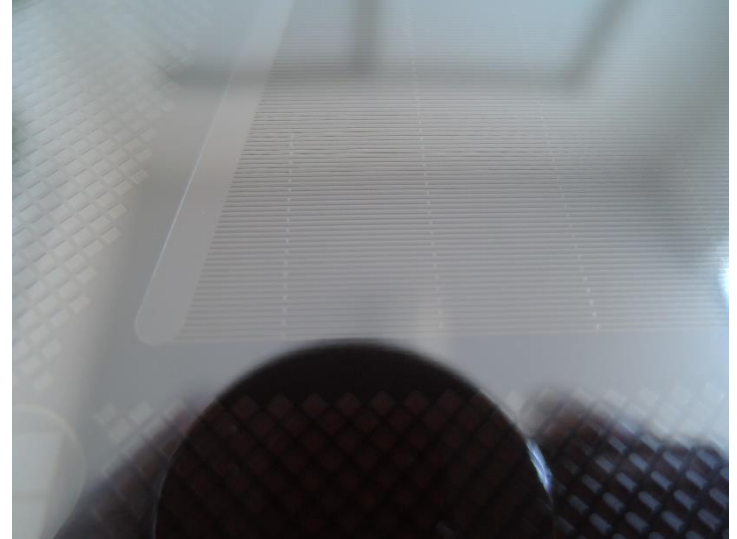
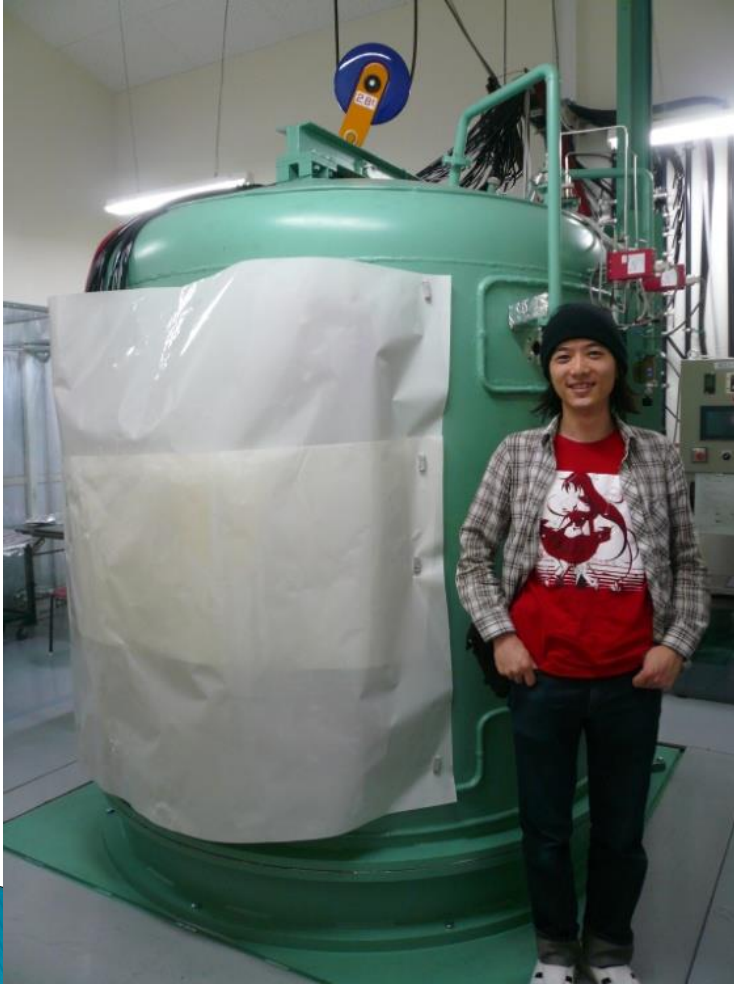


9th – 20th February
(Raytech)

Developing the resists

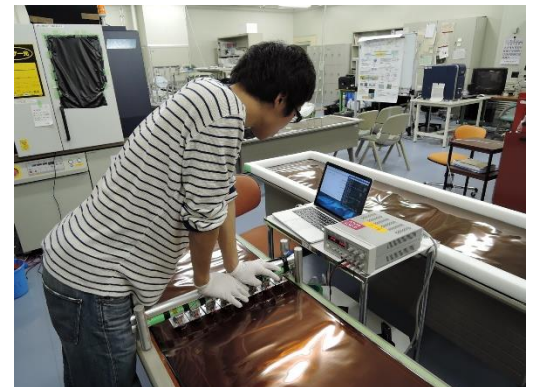
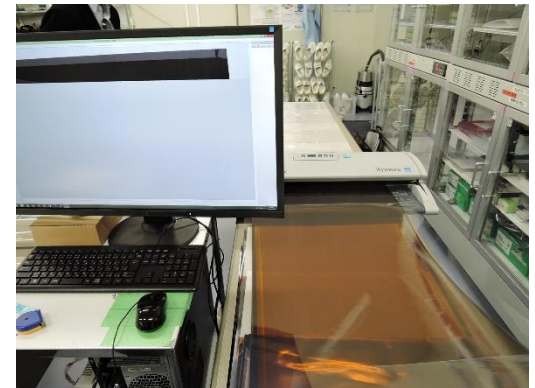
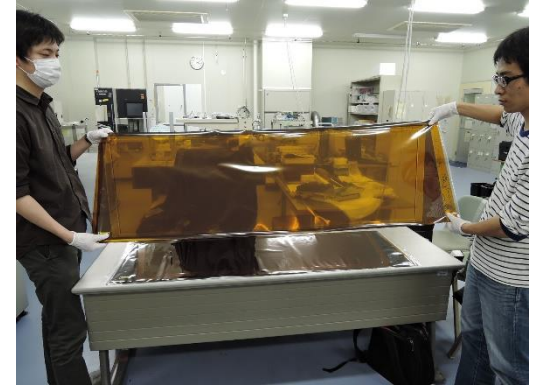


Sputtering procedure



Delivering and QA check (Sputtering)

- ▶ Sputtered foils are delivered (to Kobe Univ) at 27th Feb.
- ▶ Resistivity and patterns of the foils were scanned at KEK large clean room (4th–5th Mar.)
 - Almost all foils are fine
- ▶ Foils were shipped to CERN at 6th Mar.



QA/QC



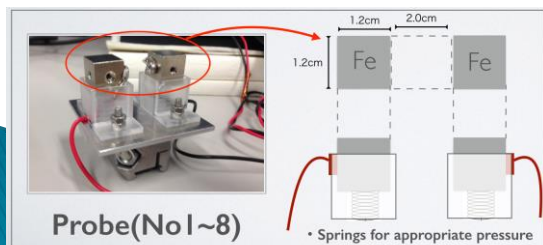
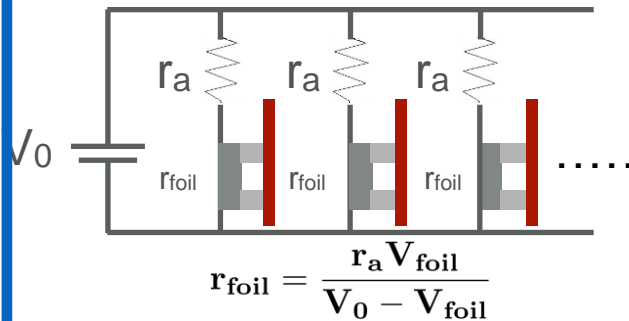
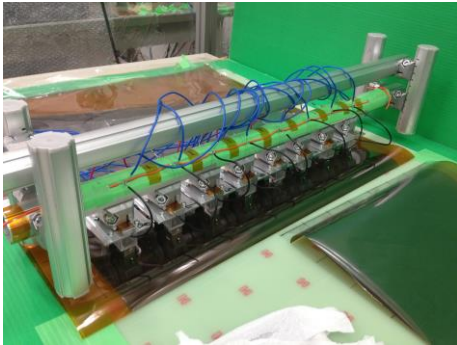
Studies for QA/QC

- ▶ QA/QC for resistive foils are studied at Kobe
 - With inviting Rui and Paolo, 23rd – 27th February
- ▶ Extra sheets are used for these studies
 - The foils for chambers should be checked in clean room, however it is not constructed in Kobe yet.

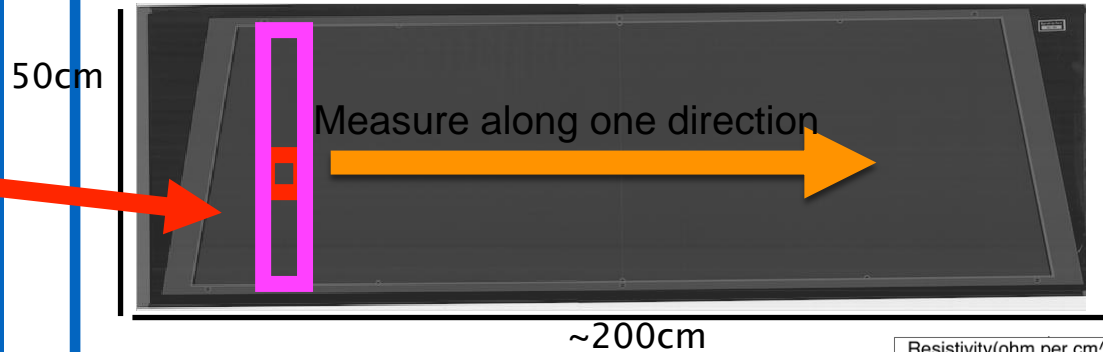


Surface resistivity measurement

Ohm meter



Measured Resistivity for each 5cmx5cm block.



Example of Resistivity 2D plot

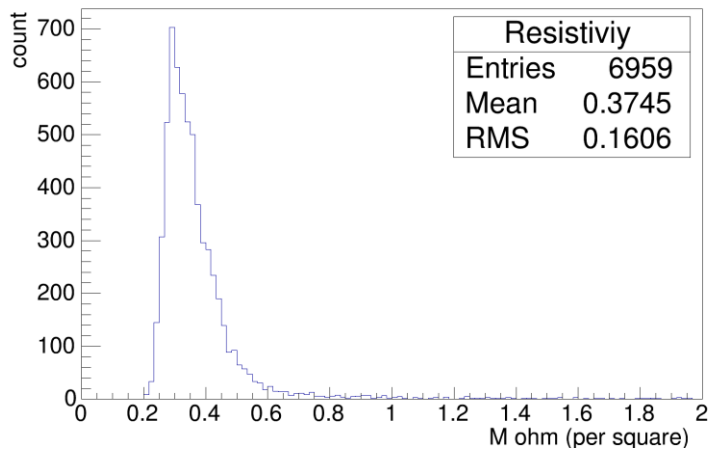


✓ Target Resistivity: 20MΩ(per strip per cm) → ~0.8MΩ/□

[M. Yamatani, 12th Mar 2015, NSW week]

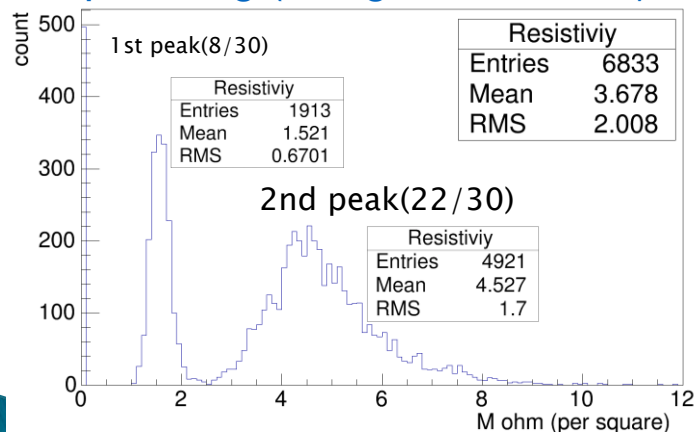
Results of Resistivity Measurement

□ Screen print (using 36 foils data)



- ✓ Mean resistivity = 376k Ω /□□
- ✓ Under good control.
- ✓ We expect resistivity increase during PCB production process (glue melting).
✗ about 2 times \rightarrow \sim 0.8M Ω /□□

□ Sputtering (using 30 foils data)



- ✓ Large variation. (Mainly 2 peaks)
- ✓ We expect resistivity decrease during PCB production process (glue melting).
✗ about 1/2 times \rightarrow \sim 0.8M Ω /□□. (only 1st peak)
 \rightarrow 2nd peak seems to be high

Toughness test of the foils

- ▶ Resistive patterns (both screen printed and sputtered) are exposed to alcohols, acetone.
 - Those liquid will be used for PCB washing.
 - The resistivity of the foils were checked both before and after exposure and washing.
- ▶ **No resistivity changes are found after washing.**



Summary of foil preparation for module-0 (small modules)

Module type	SM1 (PCB1 – 5)	SM2 (PCB6 – 8)
Technology	Screen print (ESL paste)	Carbon sputter (N doped)
# of type and foils	6 types 36 foils	6 types 30 foils
Production site	Matsuda Screen	Raytech, Be-Sputter
Production date	26 th January	20 th February
Resistivity check	3 rd February	5 th March
Image check	(machine not ready)	4 th March
Shipped from Japan	6 th February	6 th March
Delivered to CERN	Around 13th February	Expected in this week

The resistive foils for small modules are now ready for module-0 production

Conclusion

- ▶ Large area resistive strip foils (1800 x 500) have been produced for ATLAS NSW MM module-0.
- ▶ Two different technologies are used for those production.
 - Screen Print
 - Carbon Sputtering
- ▶ Both of them are successfully produced.
 - We can keep two option for resistive foil production.
 - The cost for screen print is much lower.