# Resistivity change of printed foils for ATLAS Micromegas production

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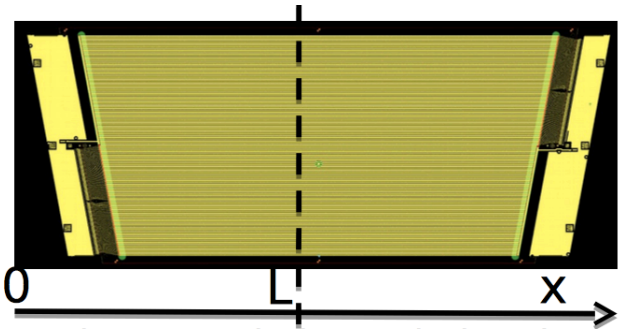
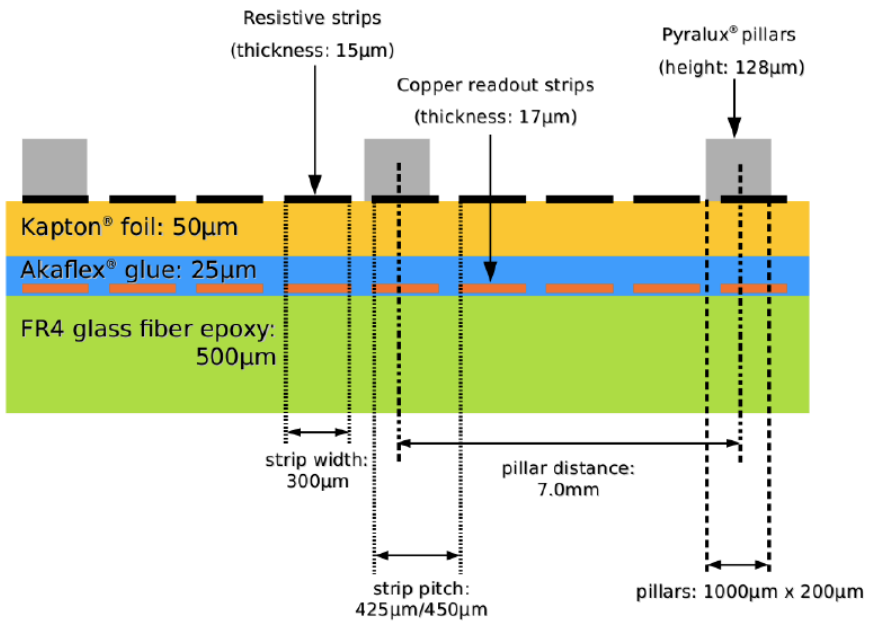
# Outline

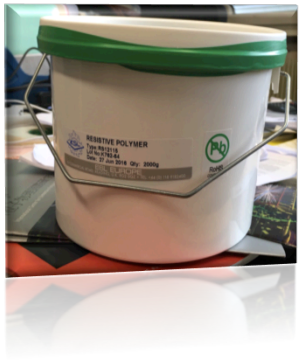
- resistive foils production
- resistive foils quality control (QC)
- gluing procedure
- observations about the resistivity change

Schematic view of an ATLAS Micromegas readout board



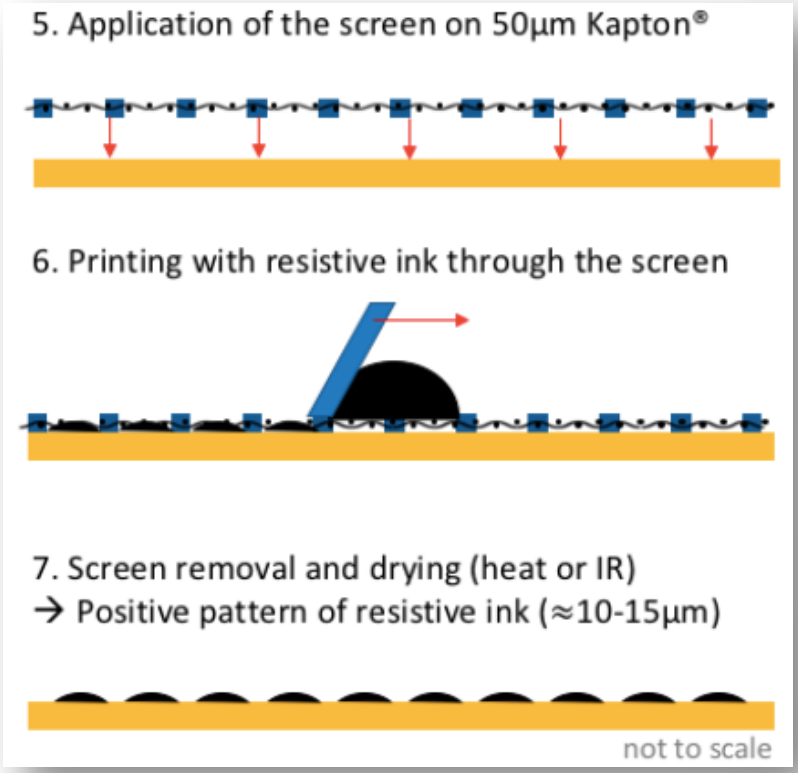
# Resistive foils production



Product:
ESL Electroscience®
RS 12115

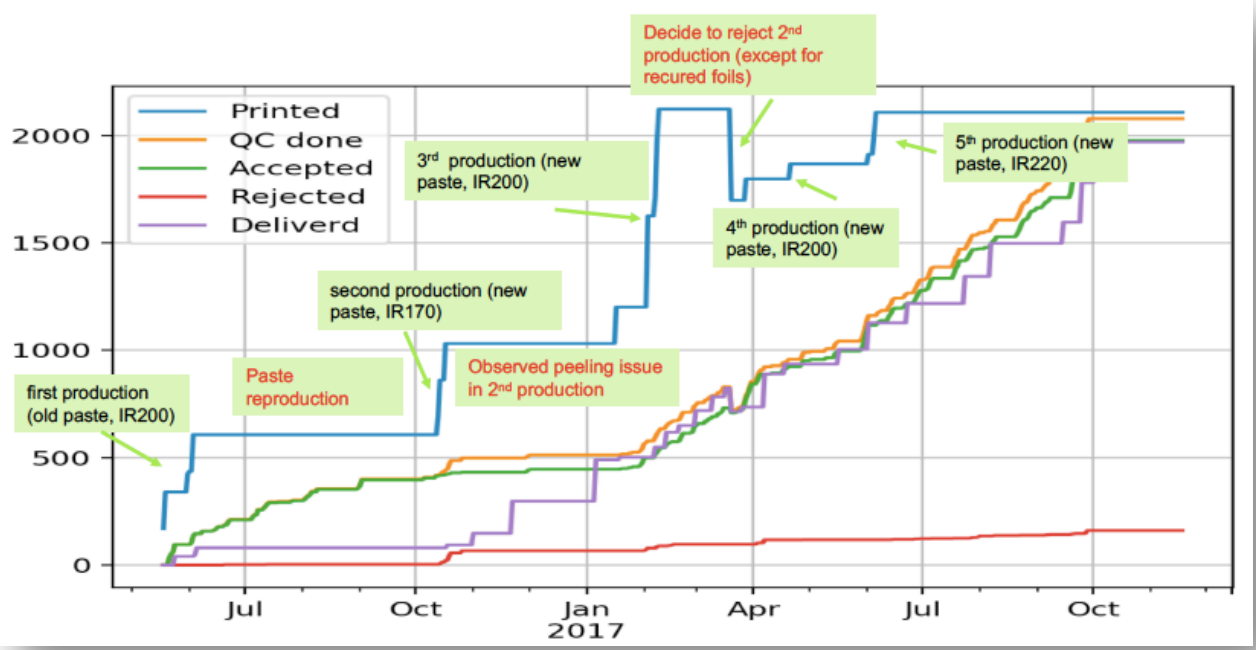
- *old* paste
  - resistivity (ρ)≈1 MΩ/sq
  - mostly used for pre-series and some mass production foils
- *new* paste
  - resistivity (ρ)≈0.4-0.5 MΩ/sq
  - used for mass production foils

Foils production @ Matsuda




Curing: initially done in oven at 170°C for 2h following the company specifications (mostly for pre-series), then moved to IR curing to save time (11.5 min) and guarantee a more uniform warming

# Resistive foils production




Nomenclature:

- 1st batch: old paste, IR at 200°C
- 2nd batch: new paste, IR at 170°C; peeling issue observed -> necessity of an additional step of curing (170°C for 2h in the oven)
- 3rd batch: new paste, IR at 200°C
- 4th batch: new paste, IR at 200°C
- 5th batch: new paste, IR at 220°C

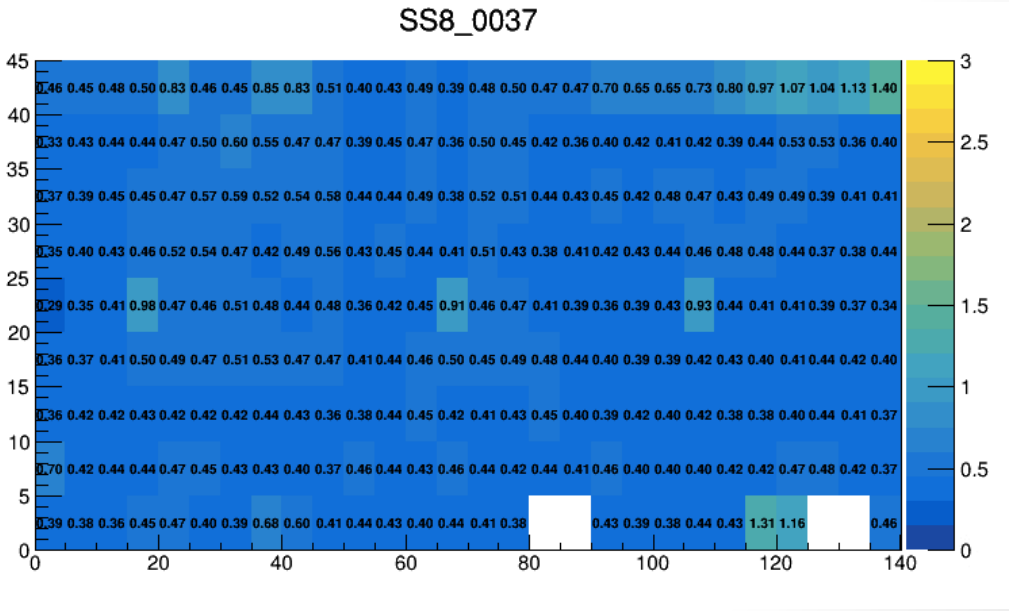
# Resistive foils QC

Several checks on the quality of the foils are performed in Kobe focusing on:

- strip pitch
- strip width
- dimensions
- possible printing defects
- **resistivity** ←

For each foil a resistivity map is performed:

- device with ~100 probes
- depending of type boards, we could measure from ~100 up to more than 300 points

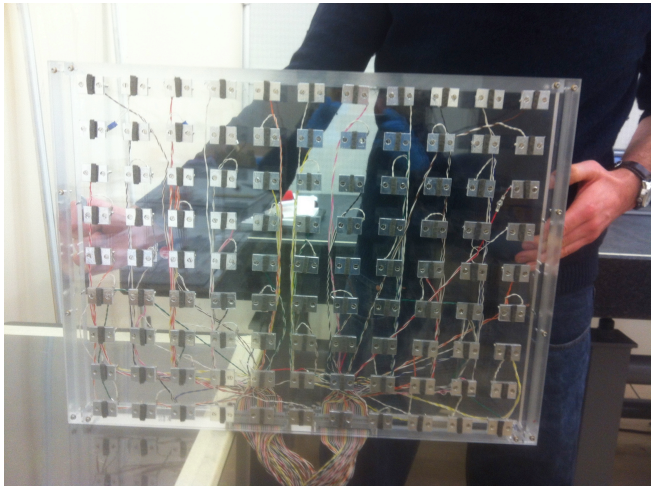


# Resistivity foils QC

**Resistivity**

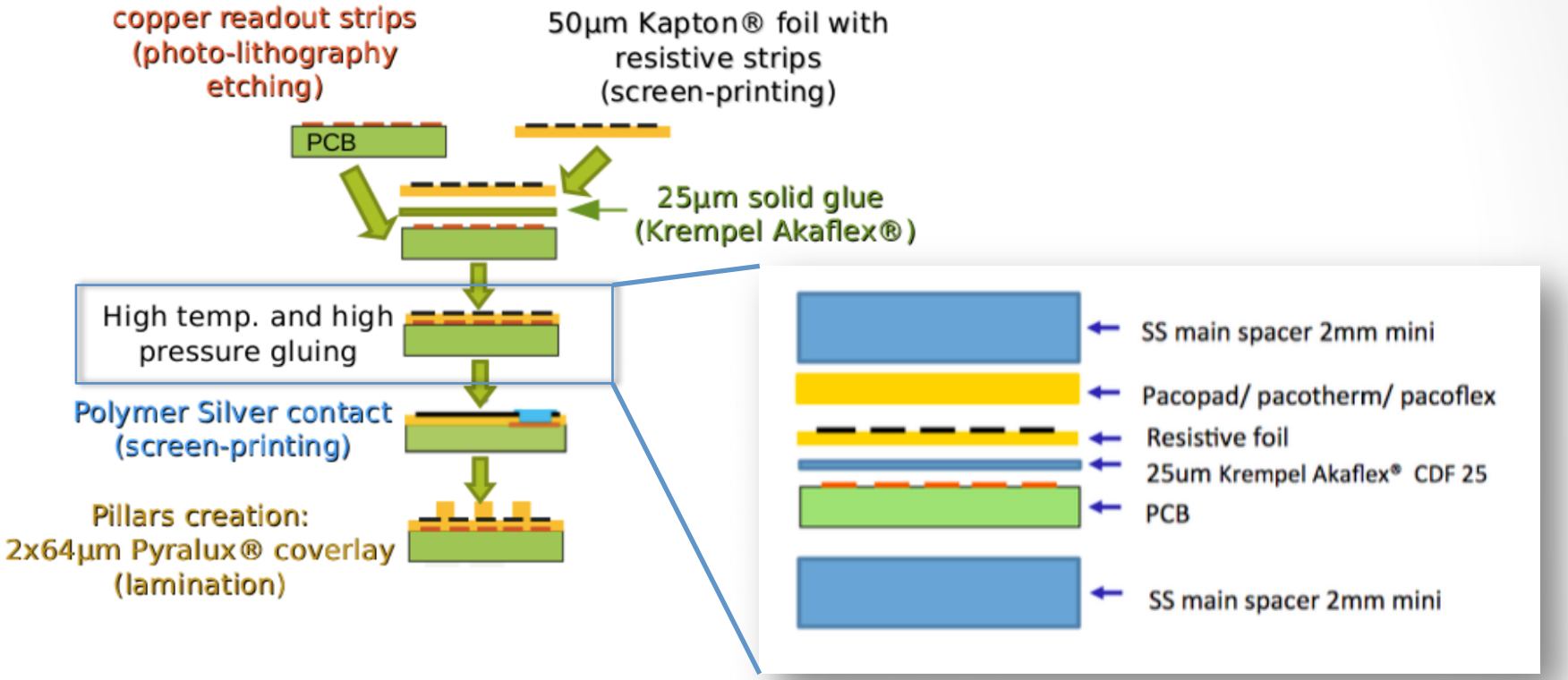
target resistivity = 0.85 MΩ/sq

- **Average criteria**
  - ✧ Average Resistivity (per foil) 0.43MΩ/sq < R < 1.7MΩ/sq
- **Outlier criteria**
  - ✧ 95% of measured points within 0.28MΩ/sq < R < 2.6MΩ/sq : **Grade B**
  - ✧ 99% of measured points within 0.28MΩ/sq < R < 2.6MΩ/sq : **Grade A**
  - ✧ 95% of measured points within 0.21MΩ/sq < R < 3.4MΩ/sq : Grade $B^-$



Same system used for the foil measurements performed in Kobe is also used at CERN

# Readout board




Resistive foil polishing before pillars creation:

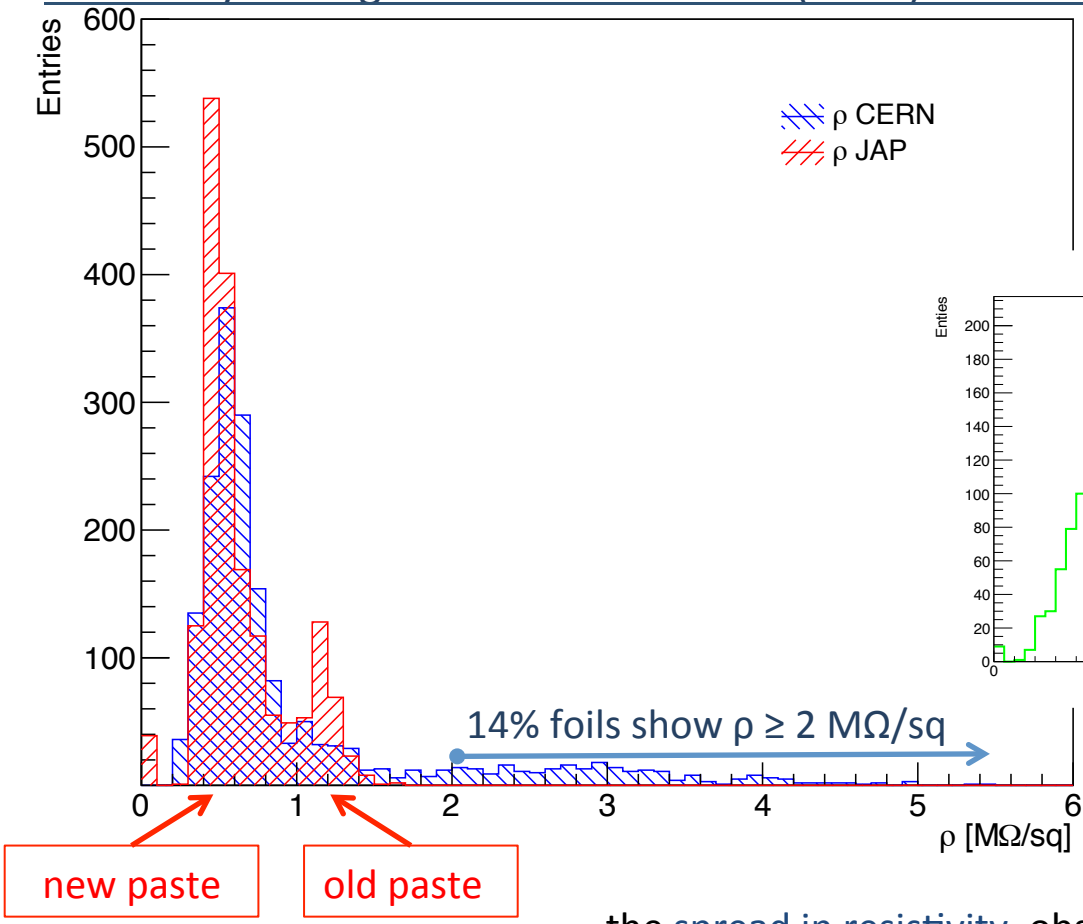
- ELTOS: polishing machine
- ELVIA: manual polishing

Pressing procedure:

- pressure (P) > 5 Kg/cm$^2$
  - ELTOS: P > 14 Kg/cm$^2$
  - ELVIA: P > 11 Kg/cm$^2$
- temperature = 170°C
- waiting time of 45 min

# Resistivity

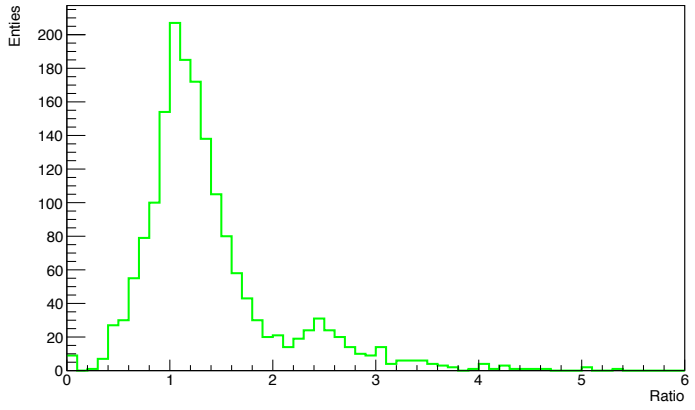
Resistivity average distribution before (Kobe) and after (CERN) gluing




Ratio distribution:

long tail overcoming 3 (current rejection threshold)

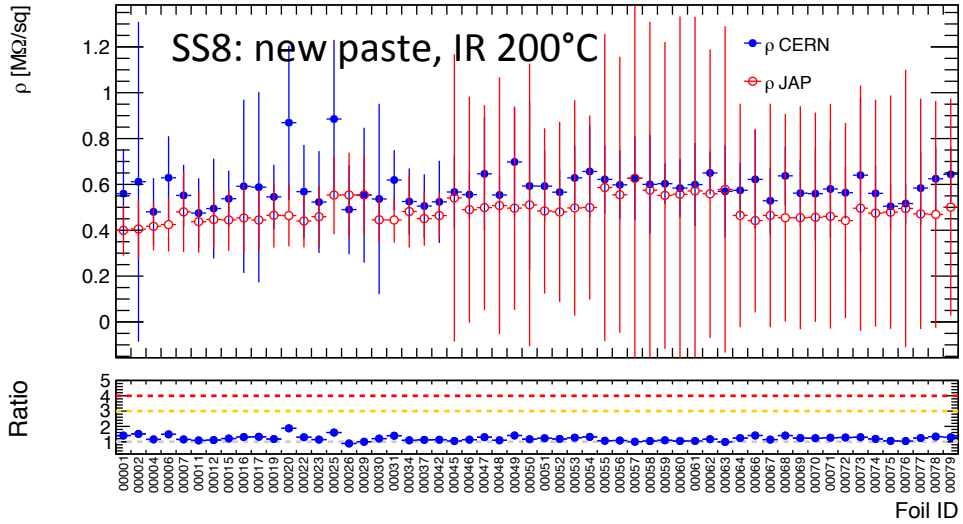
✧ <Ratio> ≈ 1.38



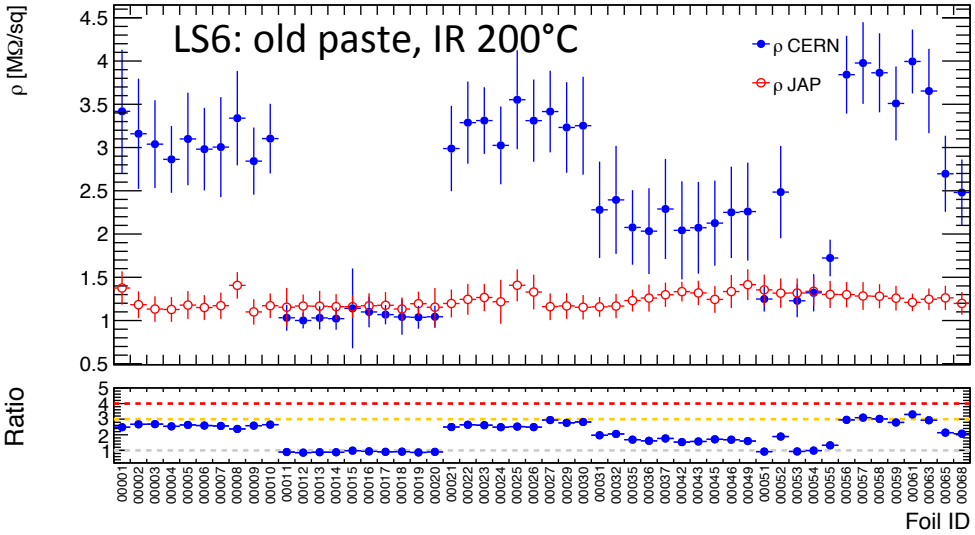

the spread in resistivity, observed after the gluing procedure, found to be related to the paste type and NOT to the production process

# Resistivity

Foils produced with the new paste show roughly the same average resistivity



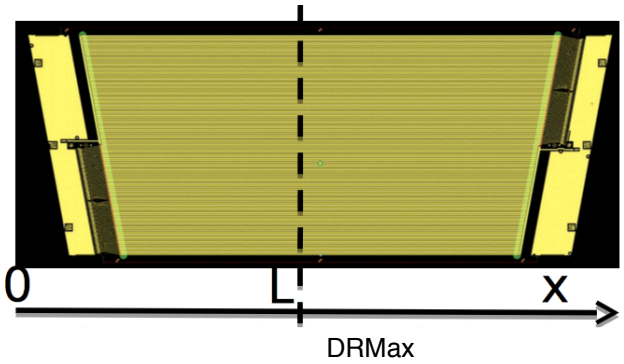

Deviations from the initial value observed when old paste is used

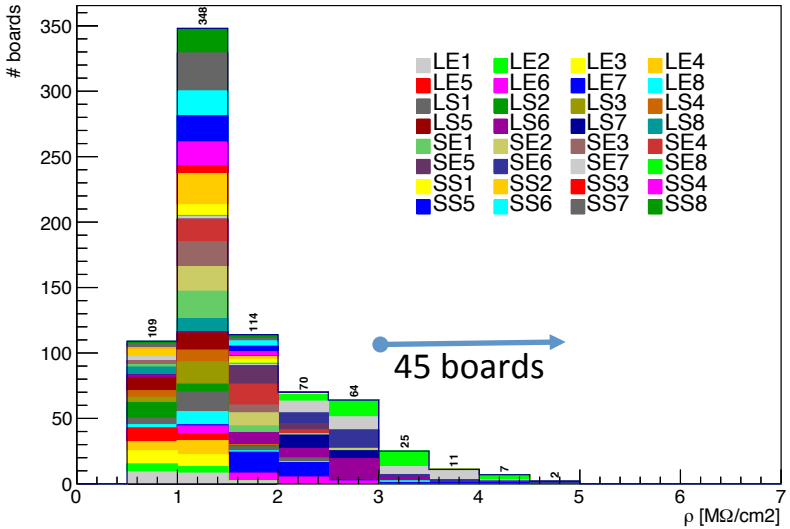


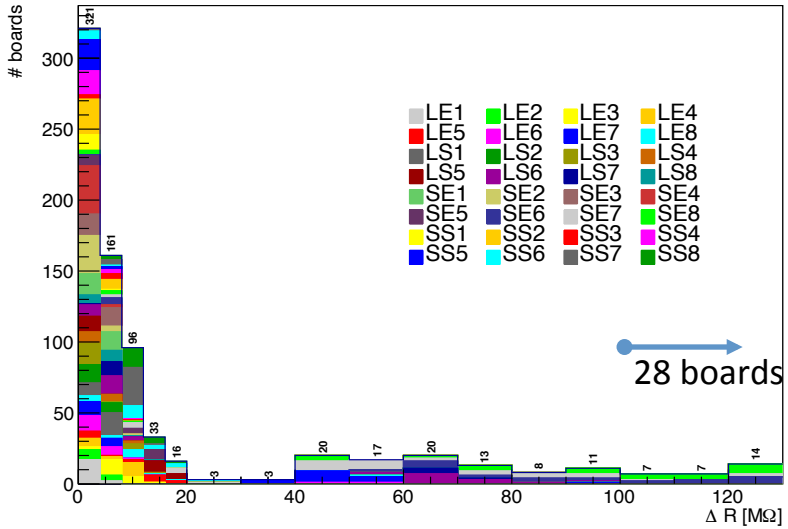

Most of these foils can be still used, even if showing a ratio higher than 3

# Resistivity

**CRITERIA:** trying to avoid a drop of 5 V in operation condition; assuming $I_{max}$=5μA, still possible if the difference in resistance (ΔR) between the middle of the board and near the coverlay rim is less than 100 MΩ

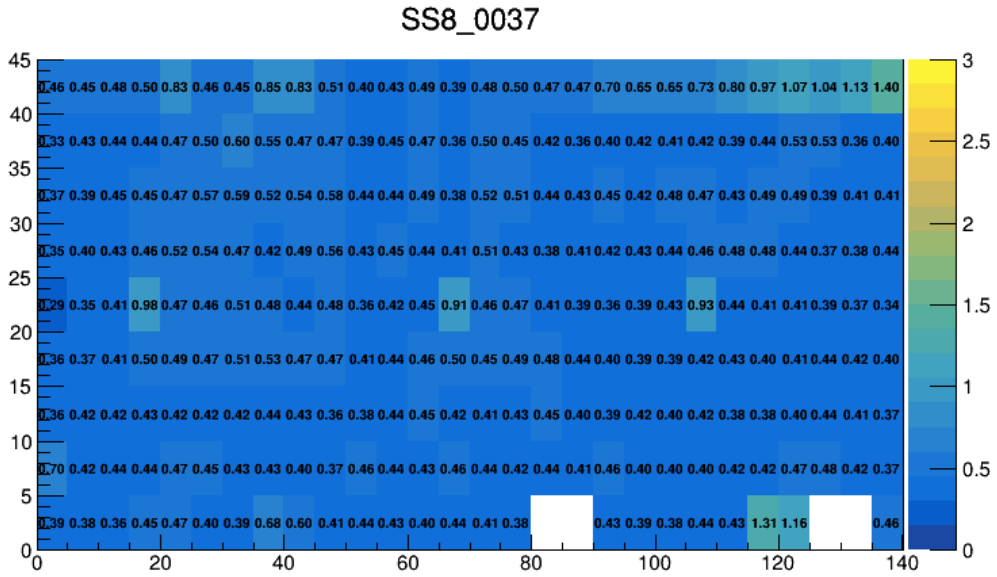


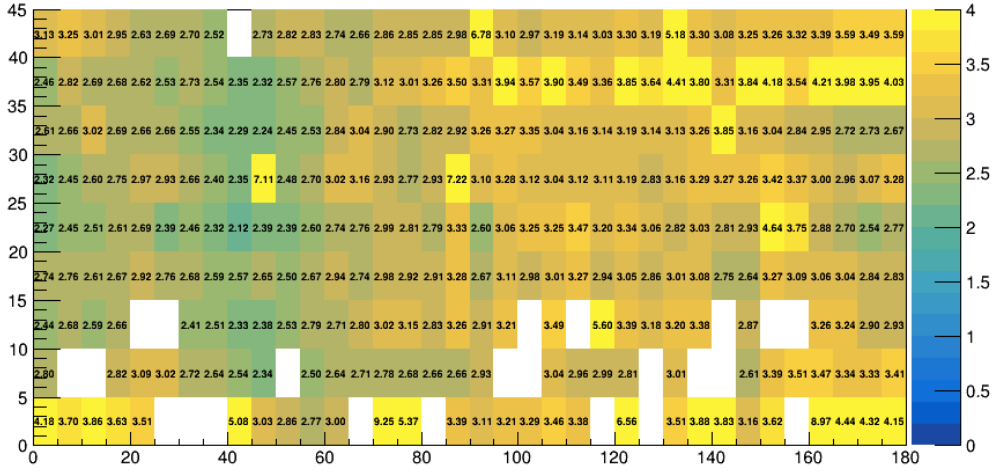




Assuming boards with Ratio < 4 and ΔR<100MΩ as good, up to now acceptable boards are 96% instead of 94%

# Resistivity




Resistivity more homogenous for the foils made with new paste

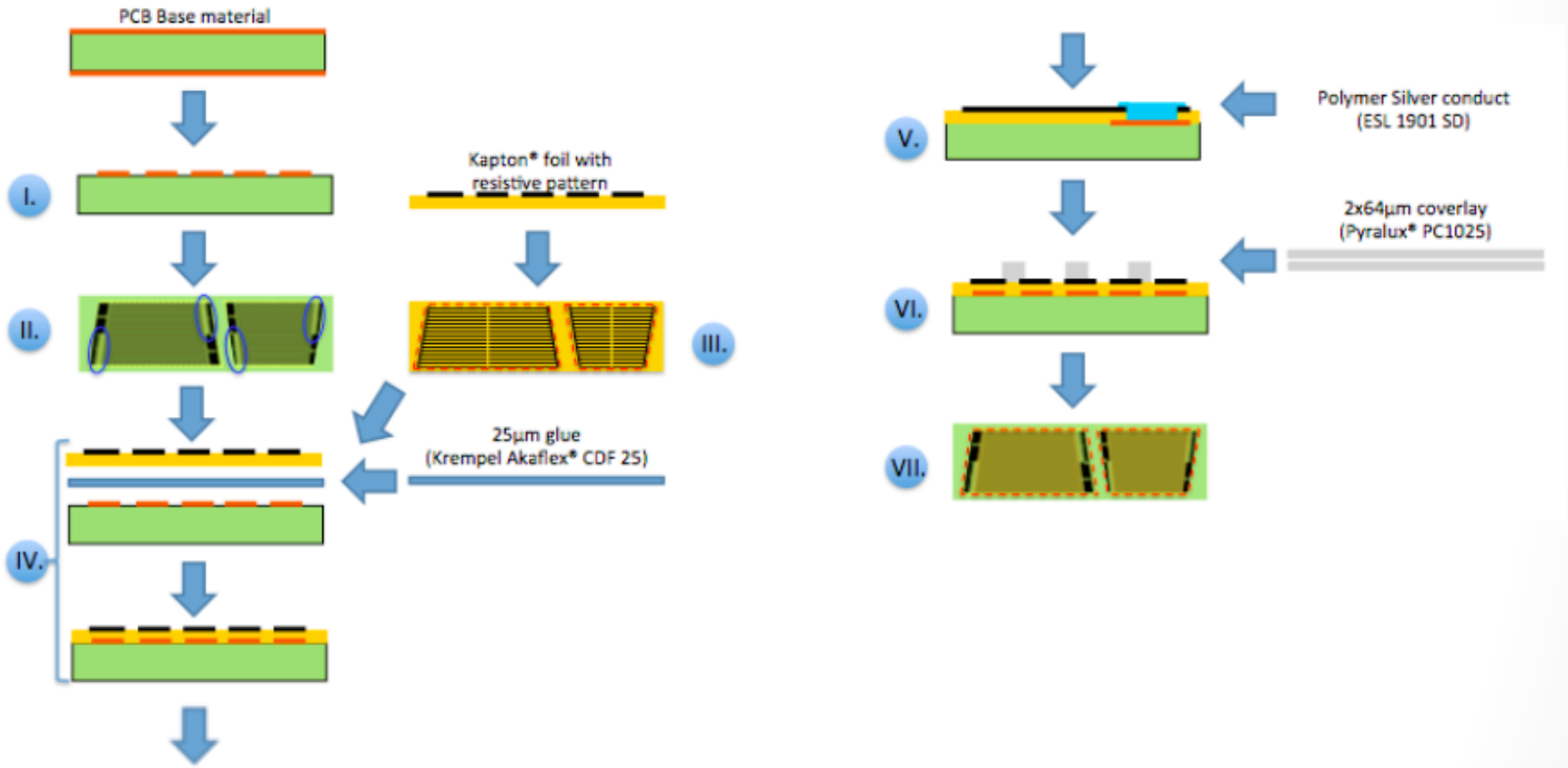
# Conclusion

- good technology transfer
- foils production well under control
- carefully quality check is performed in Japan
- additional checks performed at CERN
- 96% of the produced boards are acceptable from resistive foils point of view
- main issue is ONLY related to the paste type

Thanks to R. De Oliveira

# Backup

# Readout production schema



# Resistive foils QC

**CRITERIA 1**

**Performed in Kobe**

**Resistivity**

target resistivity = 0.85 MΩ/sq

- **Average criteria**
  - ✧ Average Resistivity (per foil) 0.43MΩ/sq < R < 1.7MΩ/sq
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  - ✧ 95% of measured points within 0.21MΩ/sq < R < 3.4MΩ/sq : Grade B$^{-}$

**Strip pitch**

- Average : Small module : 425um±10%, Large module : 450um±10%
- Average±RMS : 425um±20%, 450um±20%
  - ✧ Fulfilled : **Grade A** Not fulfilled : **Grade B**

**Strip width**

- Average 300um±10%, Average±RMS : 300±20%
  - ✧ Fullfilled : **Grade A** Not fulfilled : **Grade B**

# Resistive foils QC

**CRITERIA 2**

**Performed in Kobe**

**Dimension**

- Absolute dimension (from gerber file) within ±1mm
  - ✧ Fulfilled : **Grade A** Not fulfilled : **Grade B**

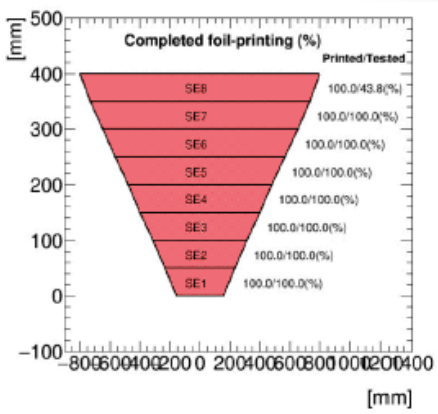
**Visual check (+ double check with scanned image)**

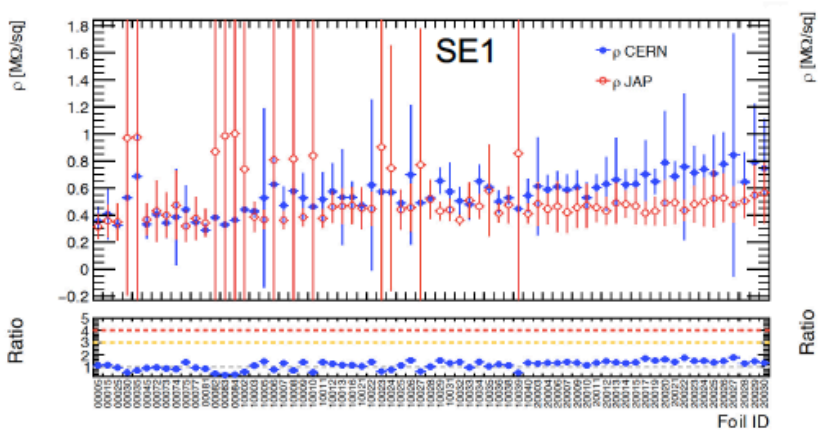
- Printing defects (Cut, mis-interconnection, dust):
  - ➔ Minor defect: <5×5mm$^2$
  - ➔ Major defect: 5×5mm$^2$ <defect size<10×10mm$^2$
  - ➔ Critical defect: >10×10mm$^2$
- ✧ Minor <= 10 && Major defect <= 1 : **Grade A**
- ✧ !Grade A && (Minor <= 20 || Major <= 2) : **Grade B**
- ✧ Failed Grade B in criteria 2 : **Reject**

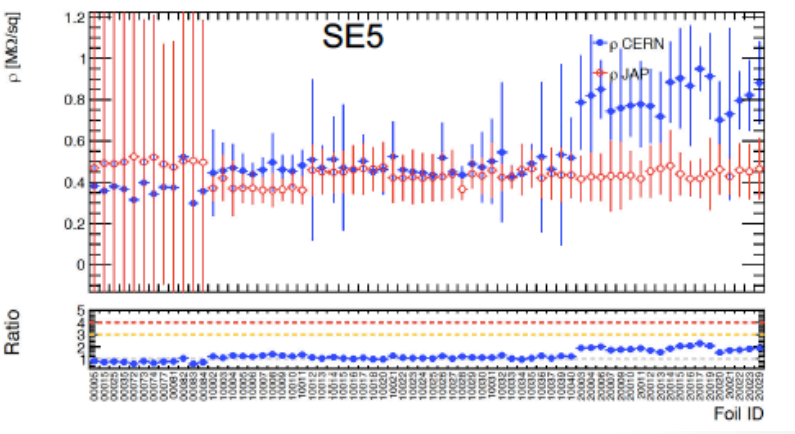
!!! Ink squeeze-out may not be counted as defect

# SE15

- **SE1(5)_0XXXX** : New paste, cure 170 degree IR
  - Produced in Oct 2016 ➔ Peeling issue appeared
  - Recured at CERN to fix peeling issue ➔ **Used in urgent cases**
- **SE1(5)_1XXXX** : New paste, cure 200 degree IR
  - Produced in Mar 2017 (~40 foils)
- **SE1(5)_2XXXX** : New paste, cure 220 degree IR
  - produced in June 2017 (~40 foils)

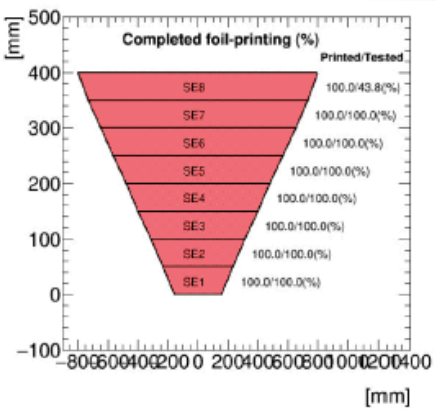


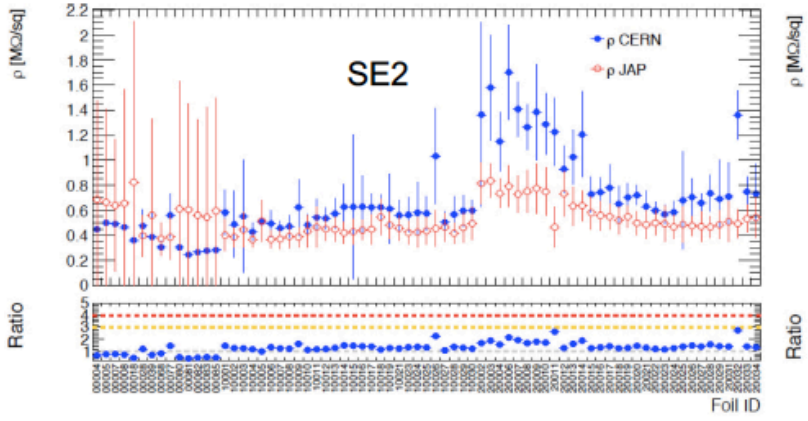



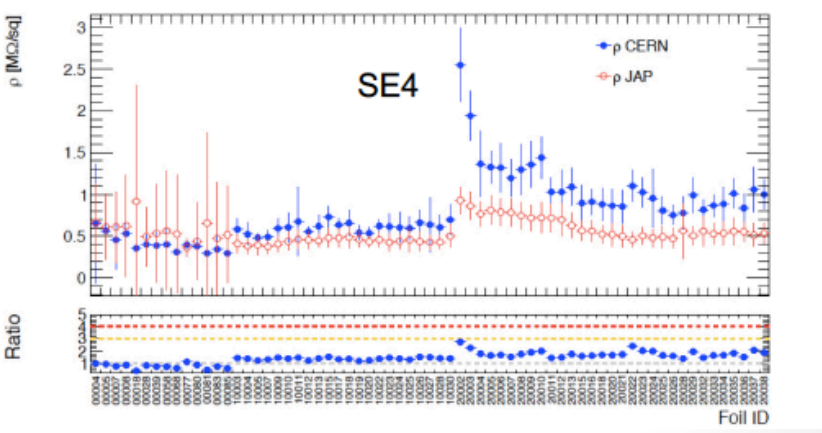



# SE24

- **SE2(4)_0XXXX** : New paste, cure 170 degree IR
  - Produced in Oct 2016 ➔ Peeling issue appeared
  - Recured at CERN to fix peeling issue ➔ **Used in urgent cases**
- **SE2(4)_1XXXX** : New paste, cure 200 degree IR
  - Produced in Apr 2017 (~30 foils)
- **SE2(4)_2XXXX** : New paste, cure 220 degree IR
  - produced in June 2017 (~50 foils)

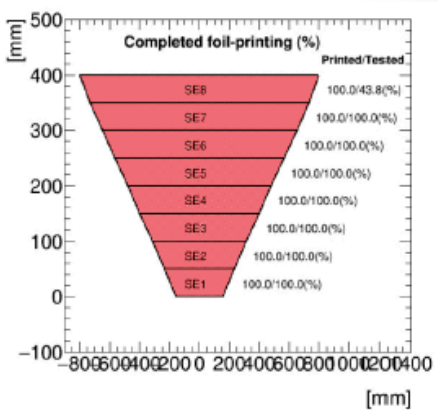


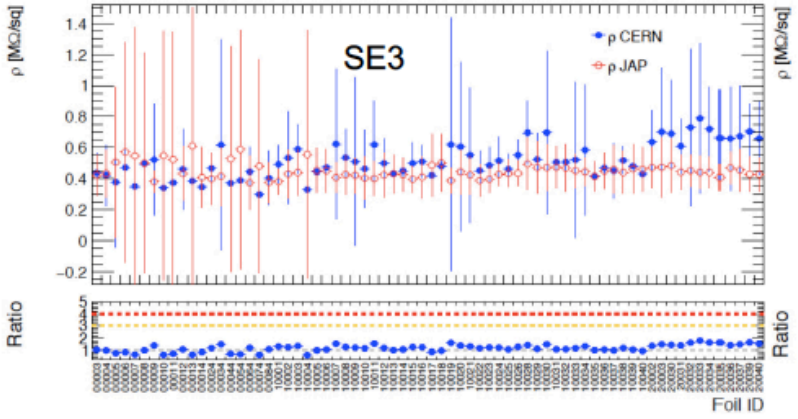



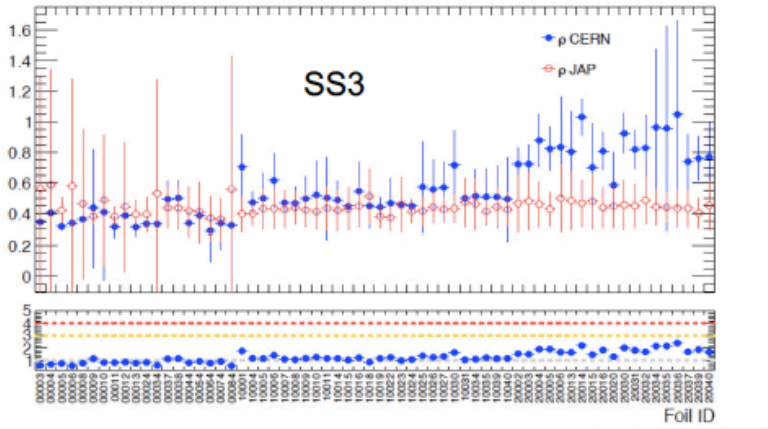



# SES3

- **SES3_0XXXX** : New paste, cure 170 degree IR
  - Produced in Oct 2016 ➔ Peeling issue appeared
  - Recured at CERN to fix peeling issue ➔ **Used in urgent cases**
- **SES3_1XXXX** : New paste, cure 200 degree IR
  - Produced in Apr 2018 (~40 foils)
- **SES3_2XXXX** : New paste, cure 220 degree IR
  - produced in June 2017 (~40 foils)

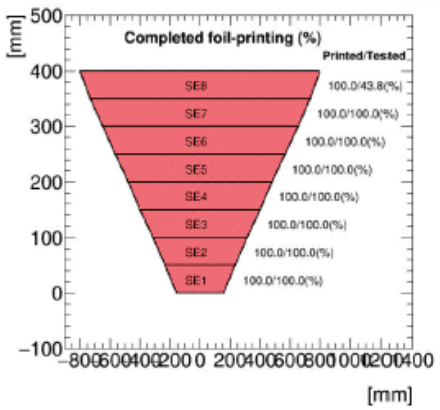


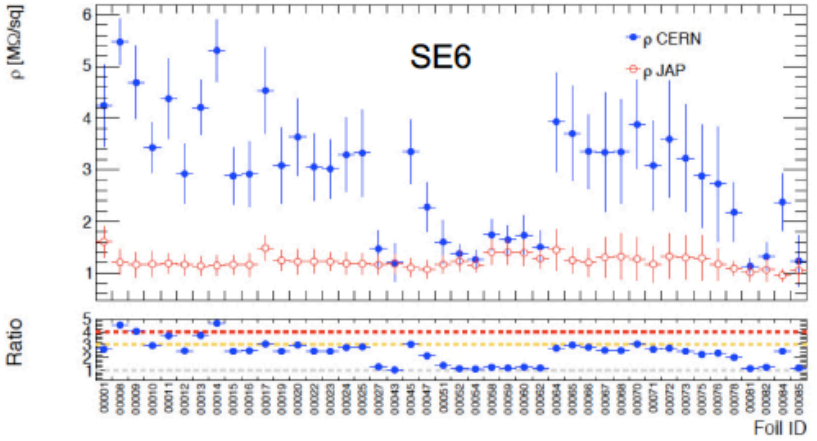



# SE6

- **SE6_0XXXX** : old paste, cure 200 degree IR
  - Produced in May 2016 (~80 foils)



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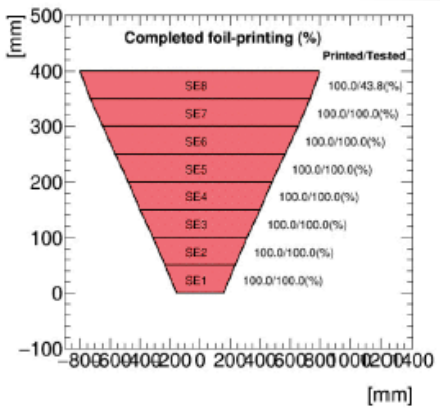
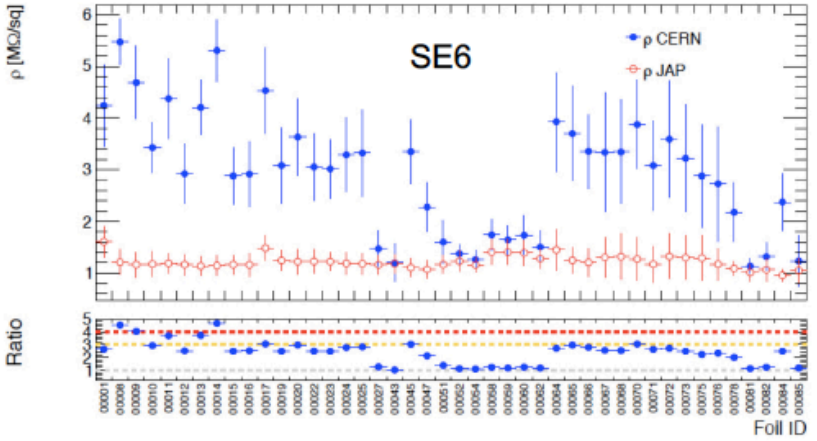
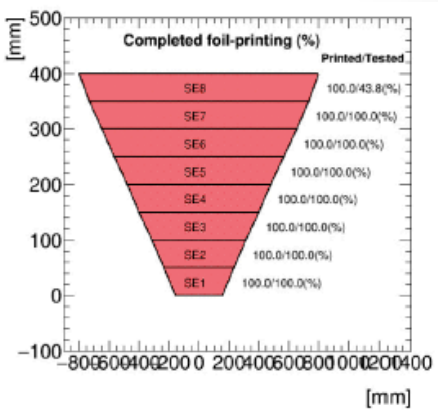
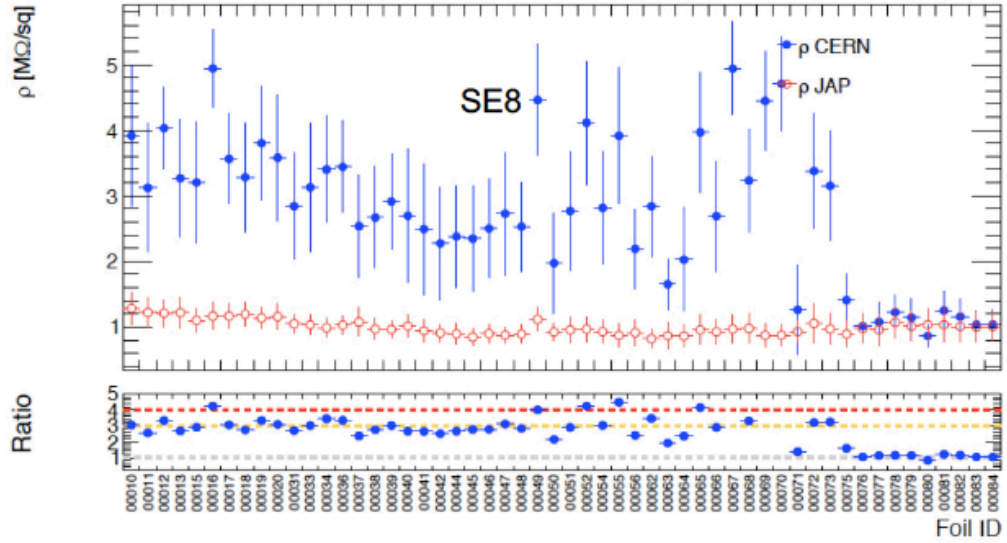


# SE8

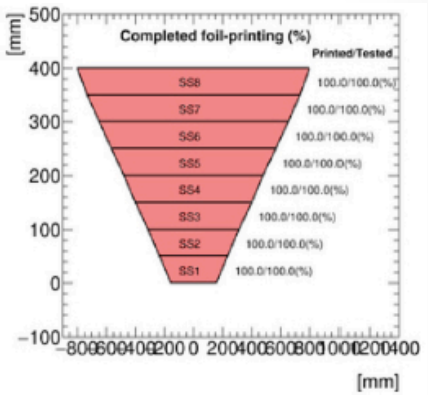
- **SE8_0XXXX** : old paste, cure 200 degree IR
  - Produced in June 2016 (~80 foils)

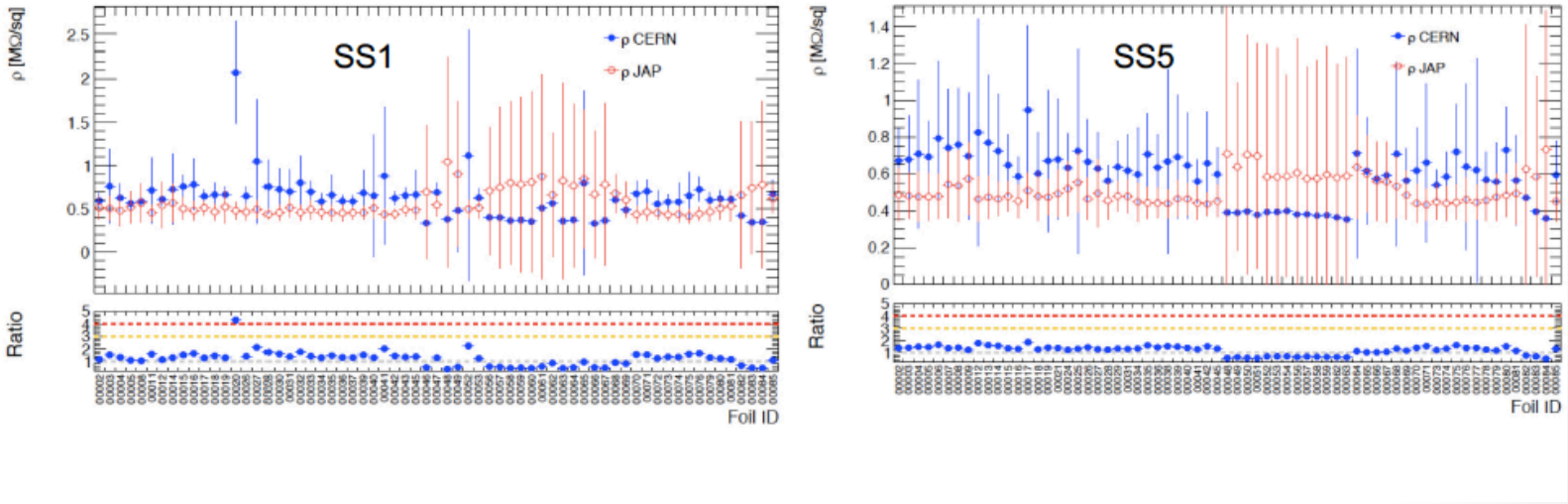


# SS15

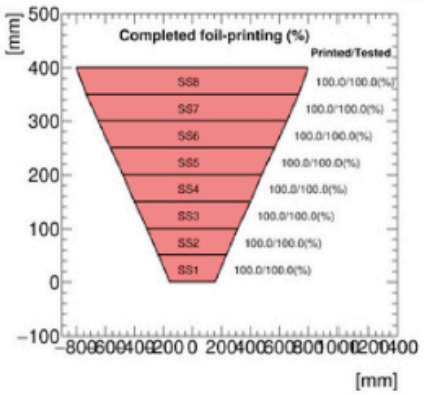
- **SS1(5)_0XXXX** : New paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

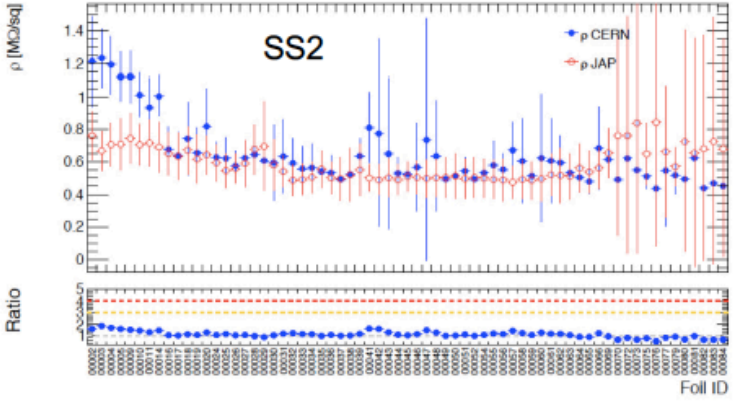


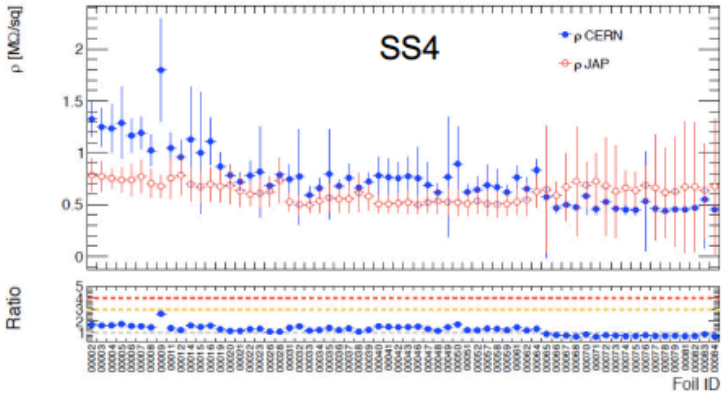



# SS24

- **SS2(4)_0XXXX** : New paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

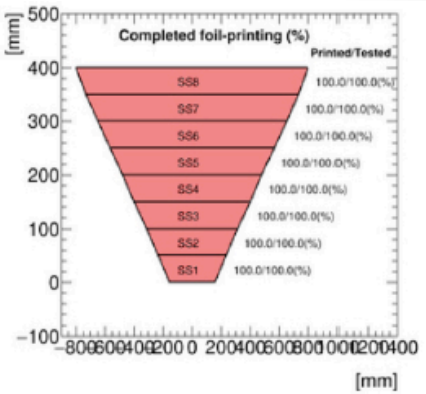


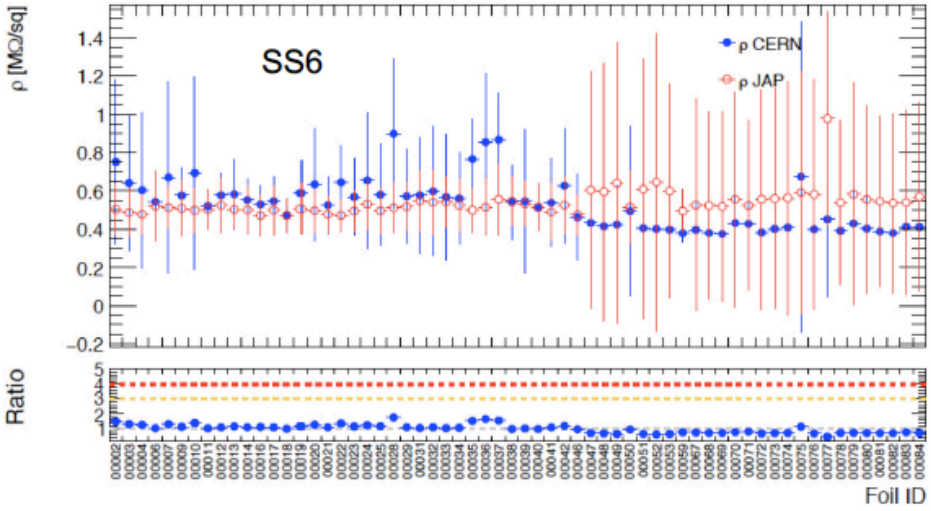



# SS6

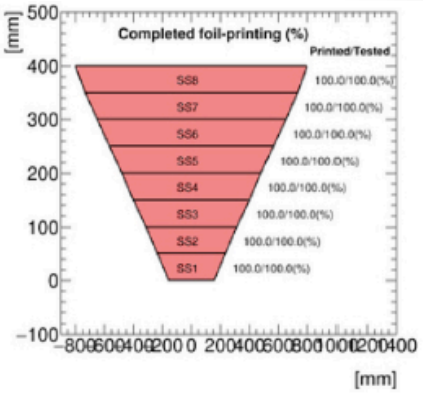
- **SS6_0XXXX** : New paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

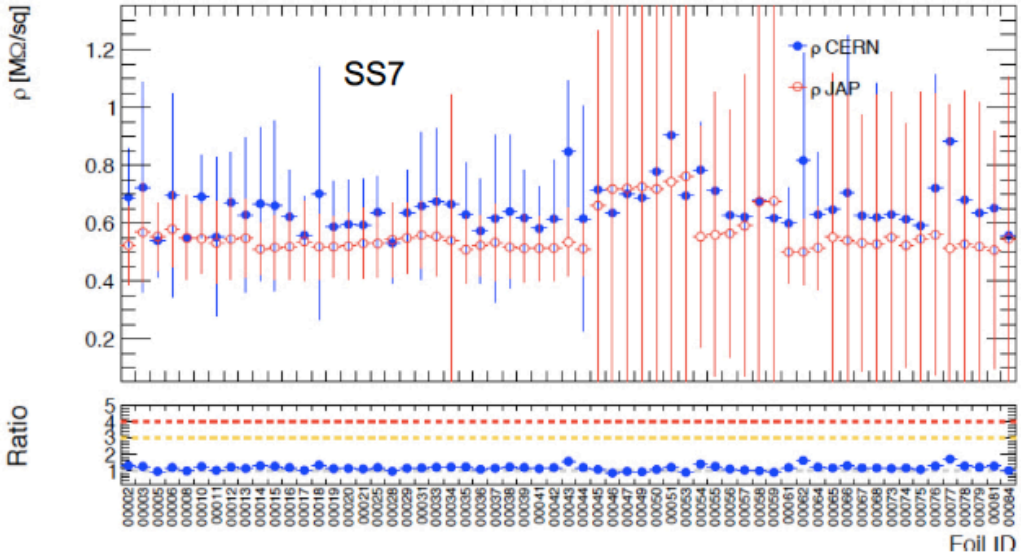


# SS7

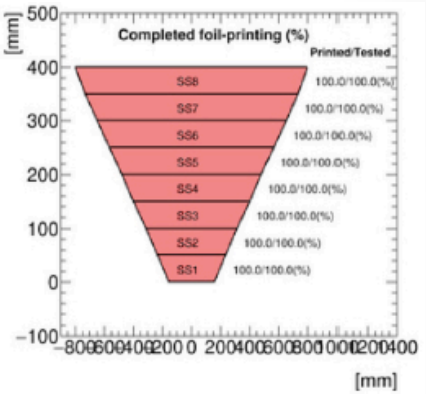
- **SS7_0XXXX** : New paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

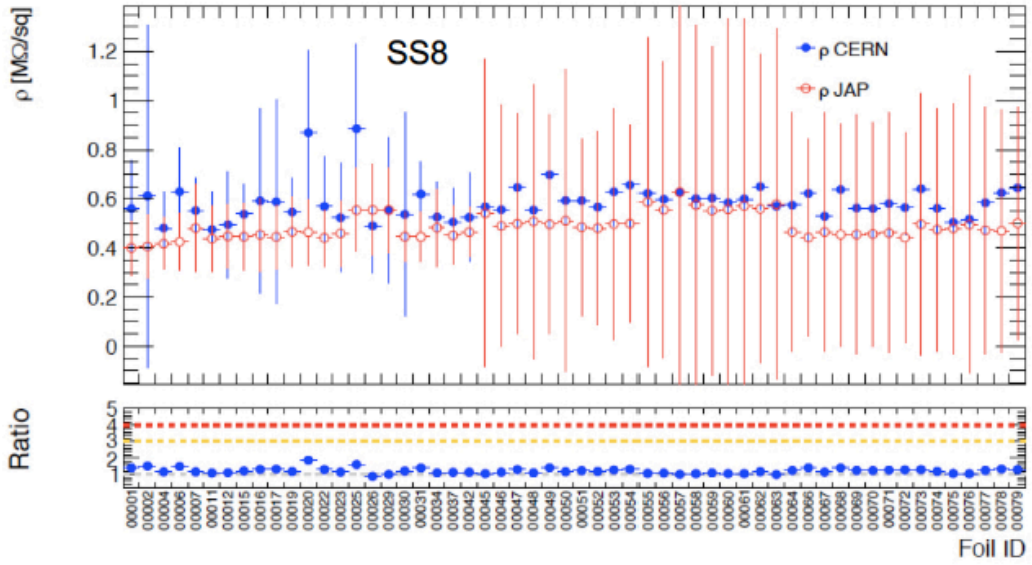


# SS8

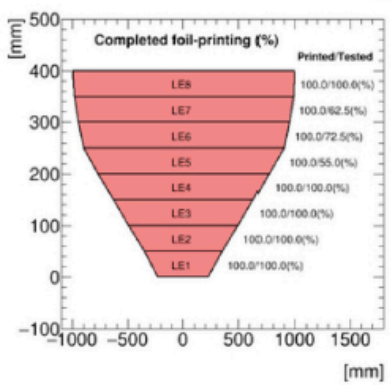
- **SS8_0XXXX** : New paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

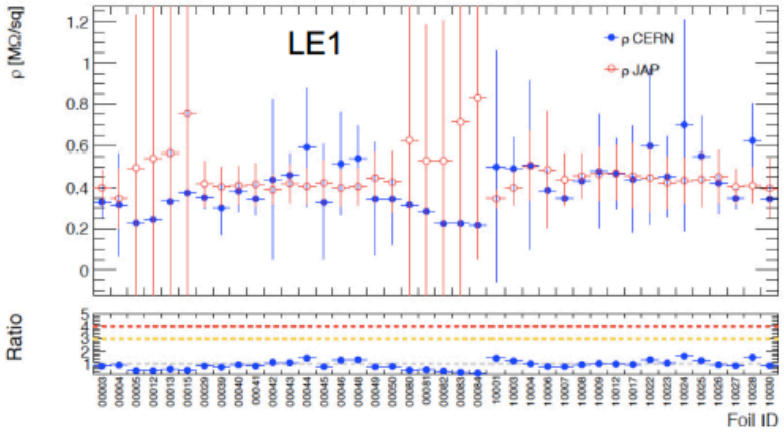


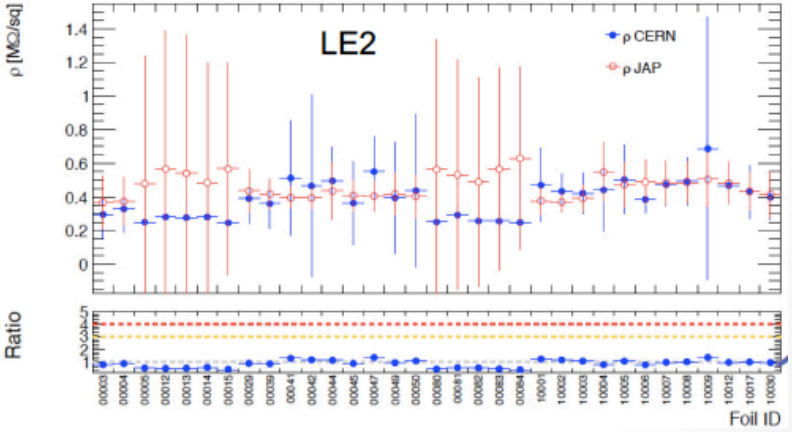



# LE12

- **LE1(2)_0XXXX** : New paste, cure 170 degree IR
  - Produced in Oct 2016 ➔ Peeling issue appeared
  - Recured at Matsuda to fix peeling issue ➔ **Used in urgent cases**
- **LE1(2)_1XXXX** : New paste, cure 200 degree IR
  - Produced in Mar 2017 (~30 foils)
- **LE1(2)_2XXXX** : New paste, cure 220 degree IR
  - Produced in June 2017 (~40 foils)

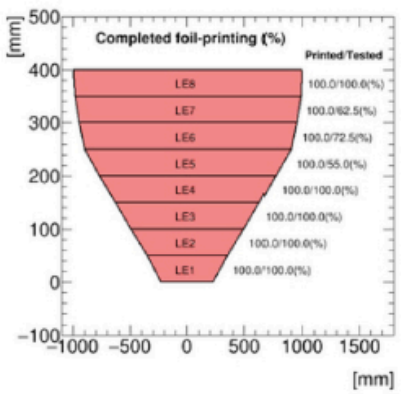


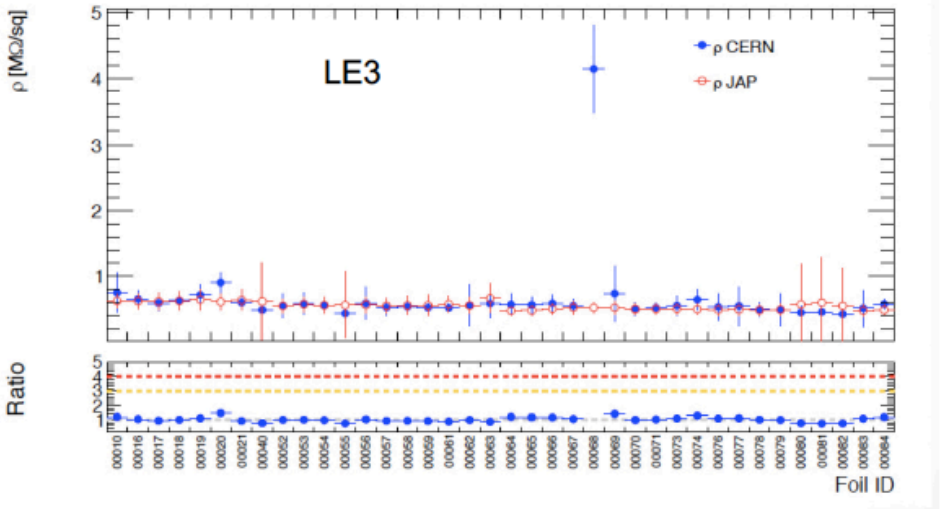



# LE3

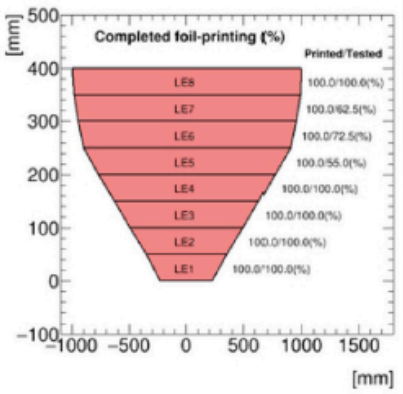
- **LE3_0XXXX** : New paste, cure 200 degree IR
  - Produced in Jan 2017 (~80 foils)

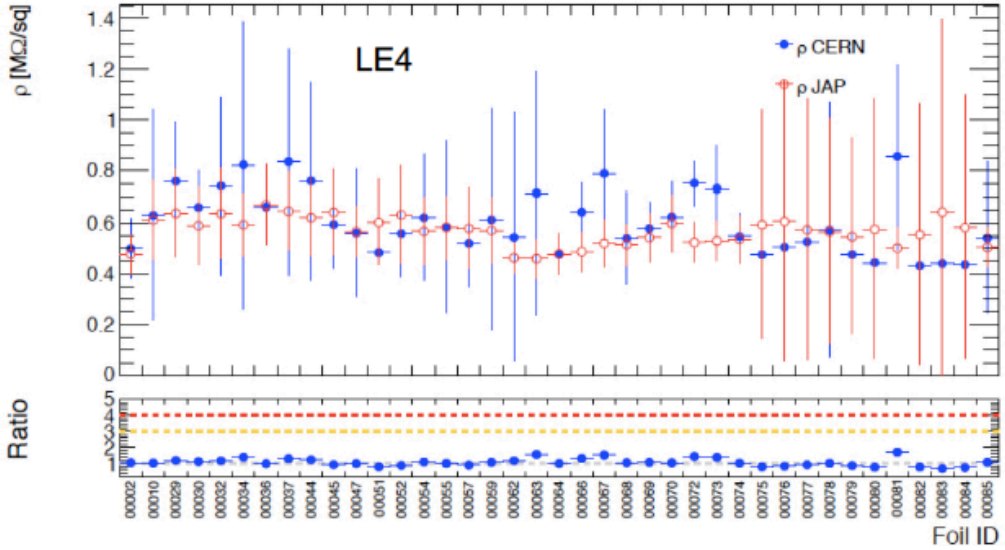


# LE4

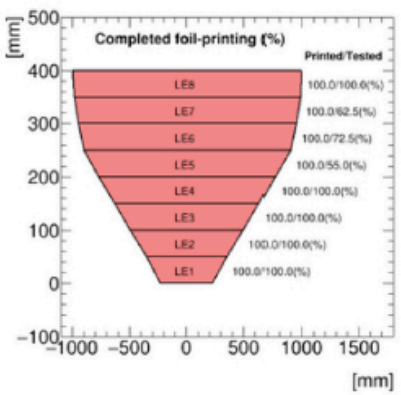
- **LE4_0XXXX** : New paste, cure 200 degree IR
  - Produced in Jan 2017 (~80 foils)

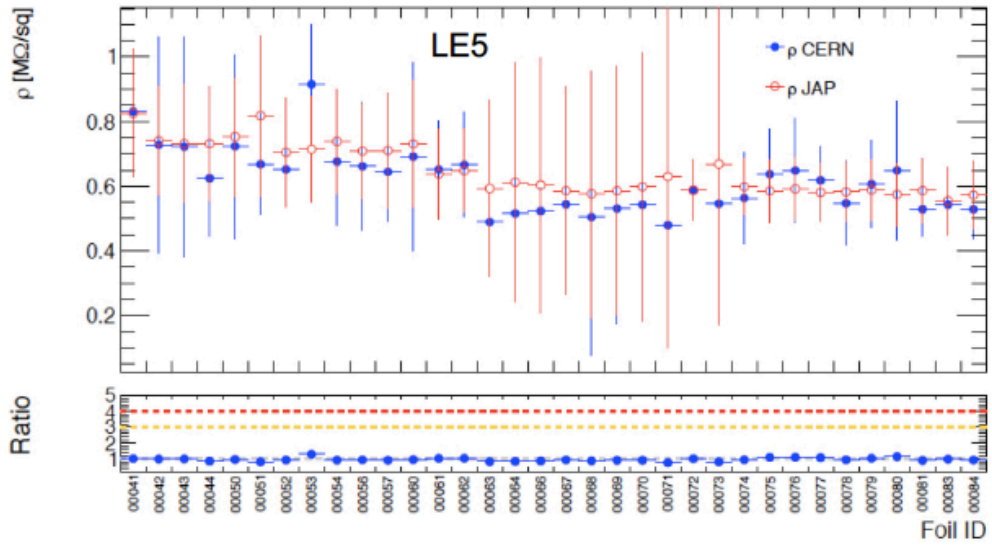


# LE5

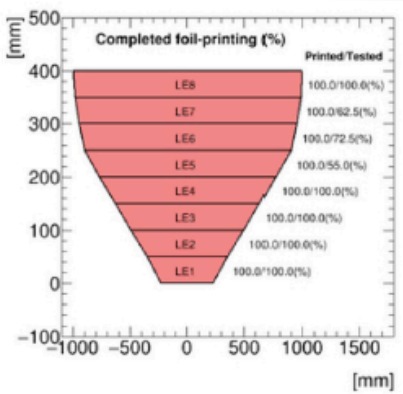
- **LE5_0XXXX** : New paste, cure 200 degree IR
  - Produced in Jan 2017 (~80 foils)

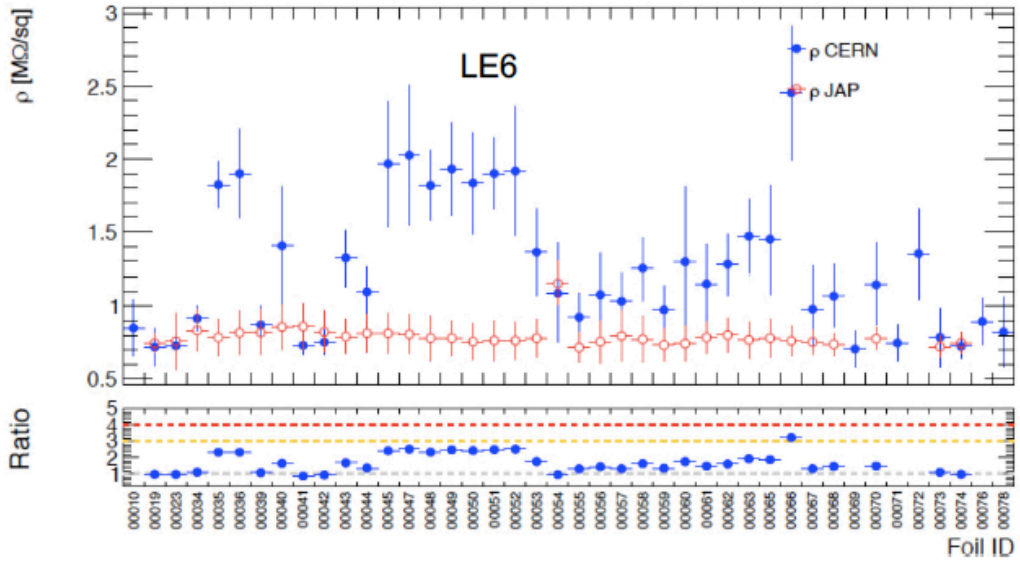


# LE6

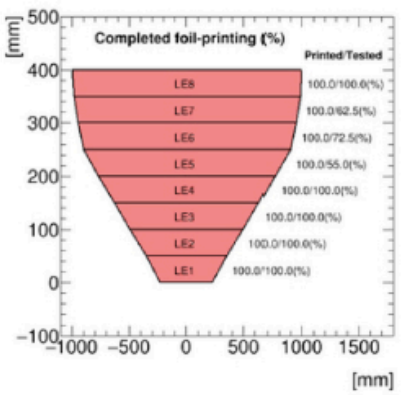
- **LE6_0XXXX** : old paste, cure 200 degree IR
  - Produced in May 2016 (~80 foils)

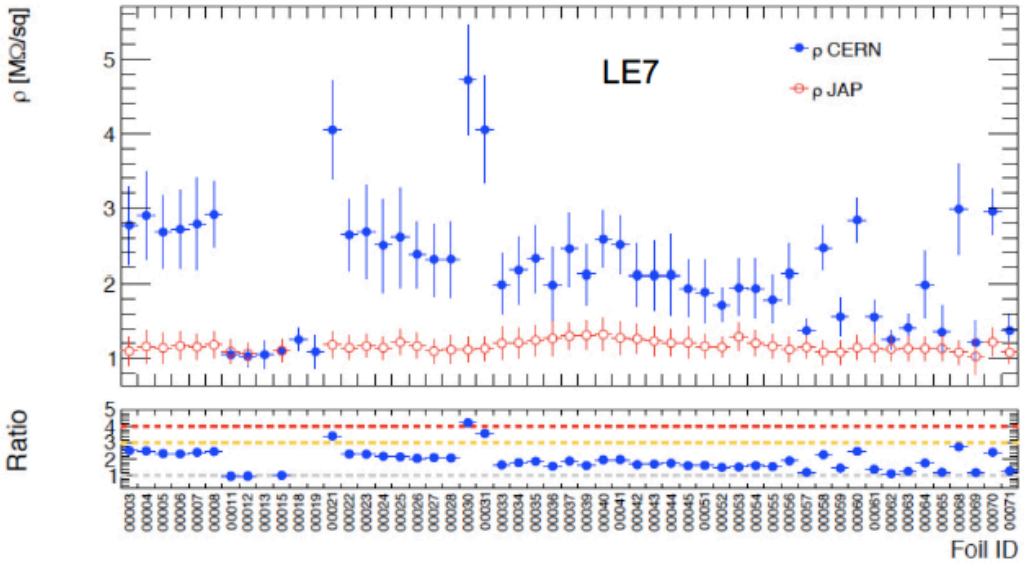


# LE7

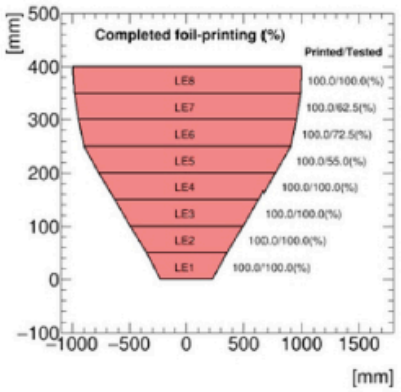
- **LE7_0XXXX** : old paste, cure 200 degree IR
  - Produced in May 2016 (~80 foils)

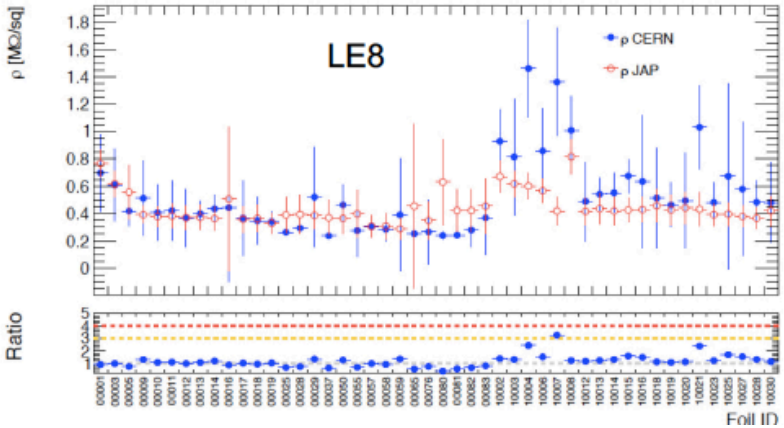


# LE8

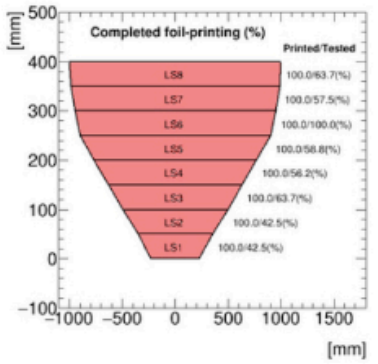
- **LE8_0XXXX** : new paste, cure 170 degree IR
  - Produced in Oct 2016 ➔ Peeling issue appeared
  - Recured at ELVIA/Matsuda to fix peeling issue ➔ **Used in urgent cases**
- **LE8_1XXXX** : new paste, cure 200 degree IR
  - Produced in Mar 2017 (~30 foils)
- **LE8_2XXXX** : new paste, cure 220 degree IR
  - Produced in June 2017 (~50 foils)

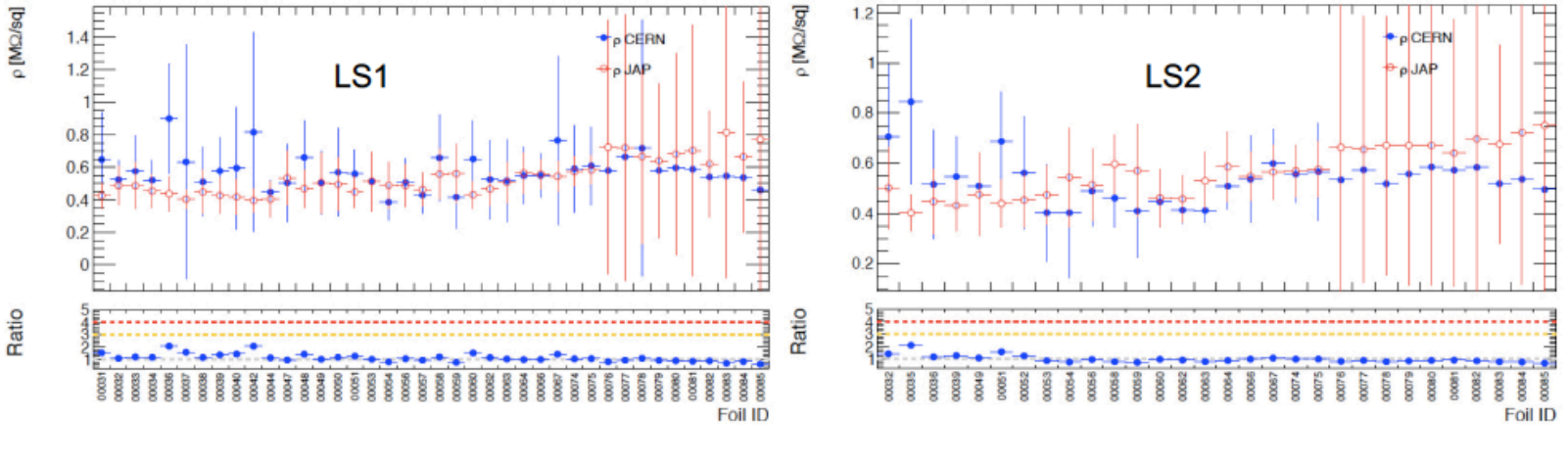


# LS12

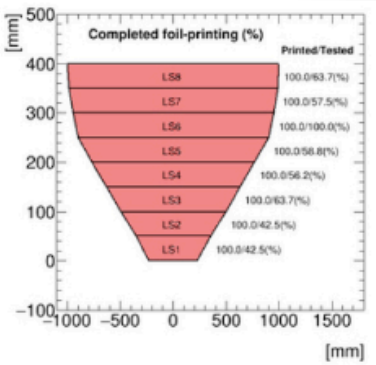
- **LS12_0XXXX** : new paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

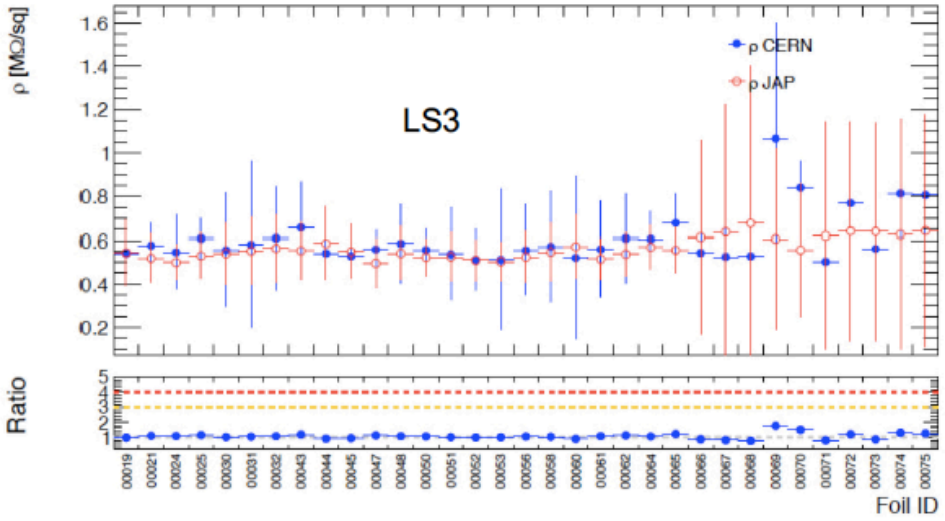


# LS3

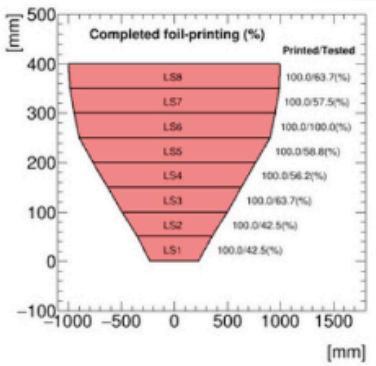
- **LS3_0XXXX** : new paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

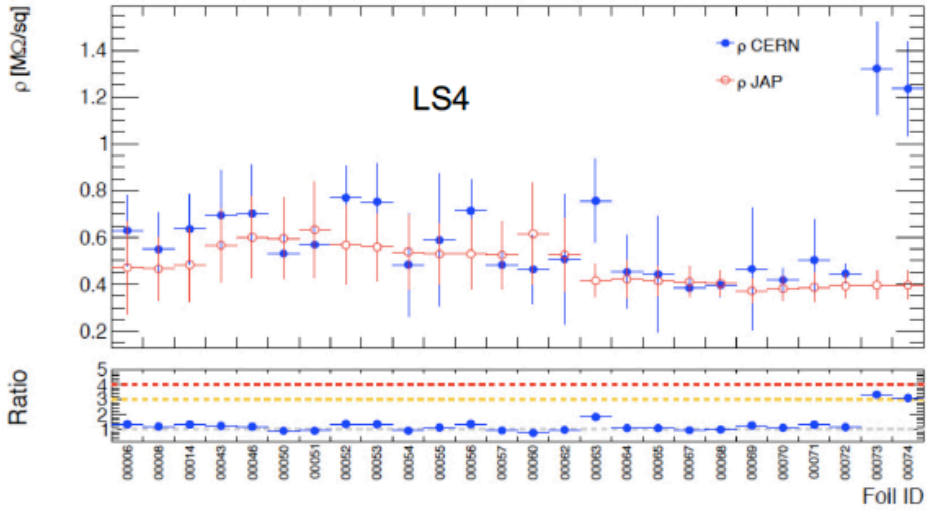


# LS4

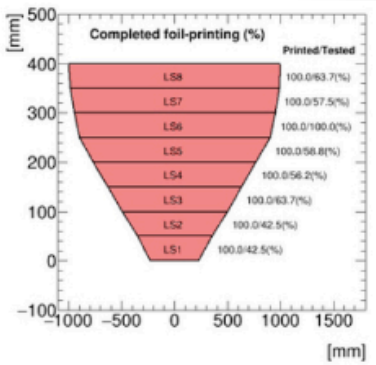
- **LS4_0XXXX** : new paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

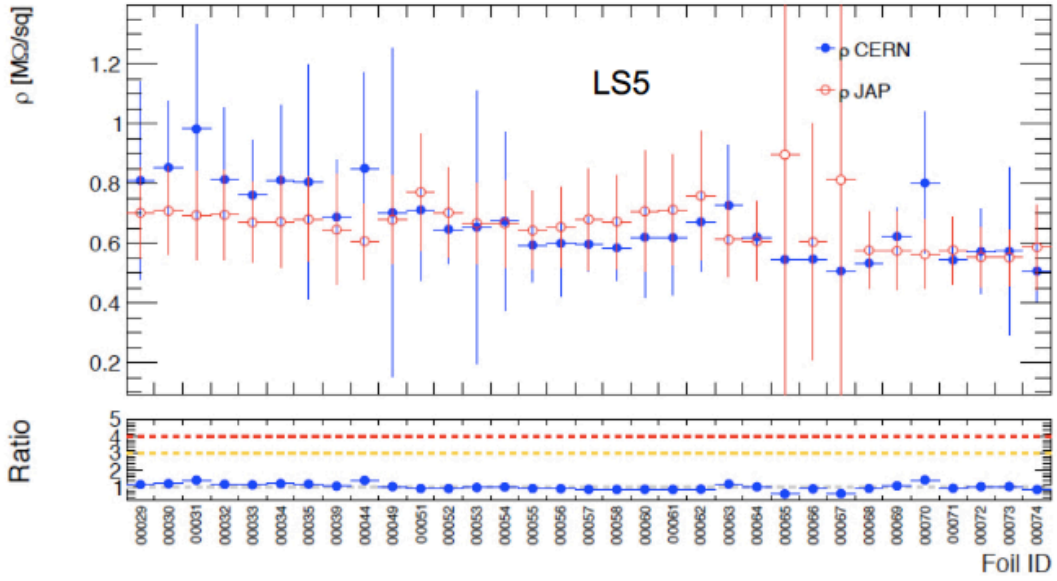


# LS5

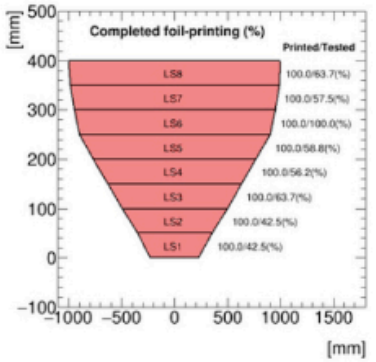
- **LS5_0XXXX** : new paste, cure 200 degree IR
  - Produced in Feb 2017 (~80 foils)

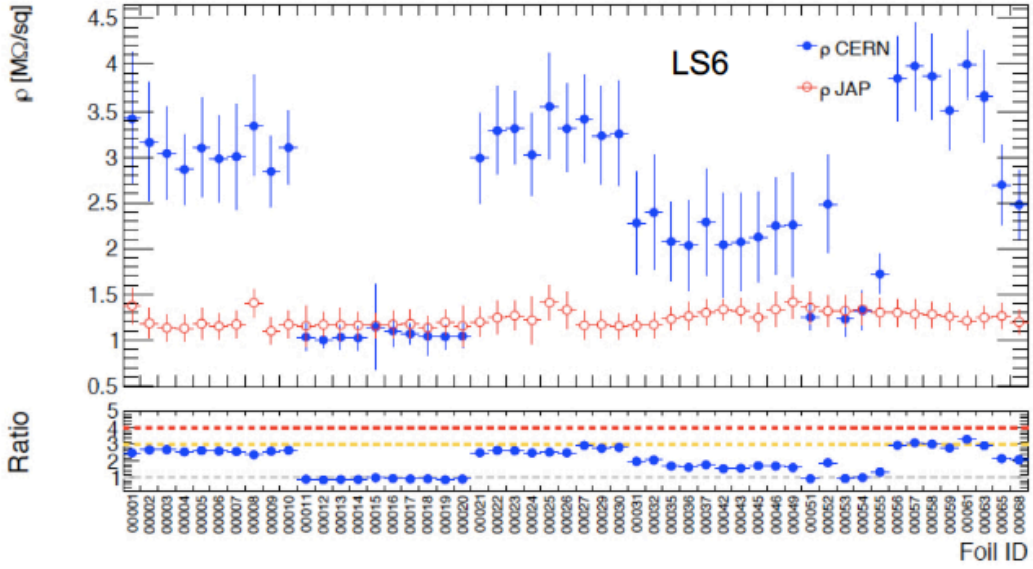


# LS6

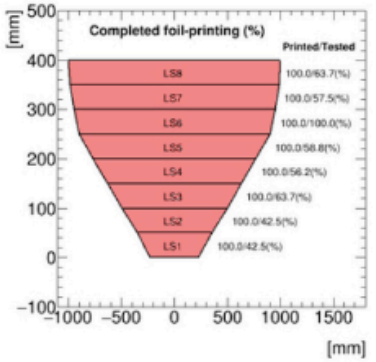
- **LS6_0XXXX** : old paste, cure 200 degree IR
  - Produced in May 2016 (~80 foils)

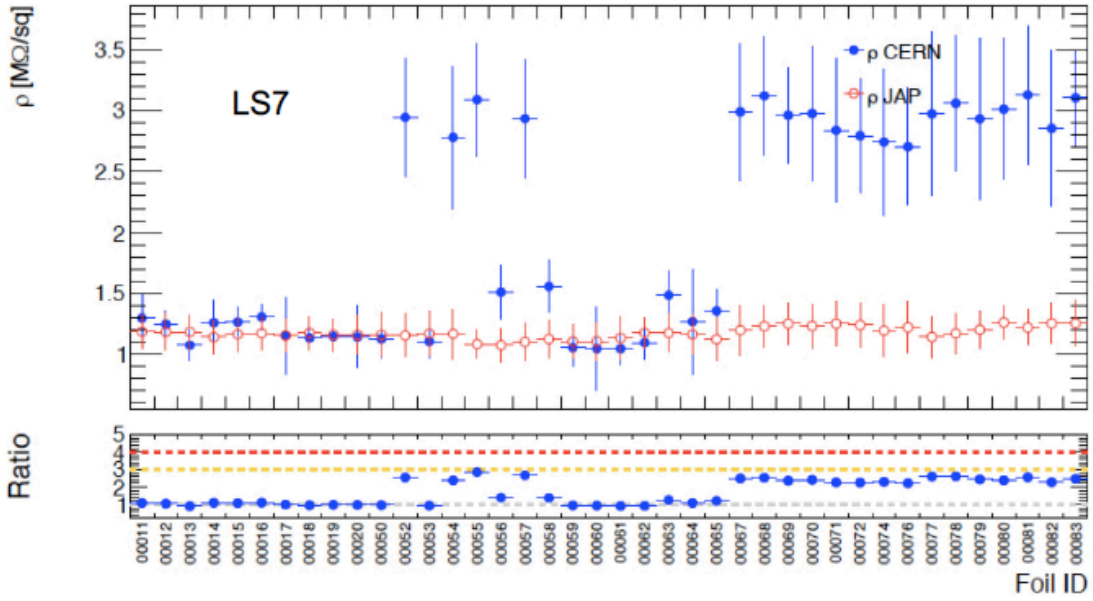


# LS7

- **LS7_0XXXX** : old paste, cure 200 degree IR
  - Produced in May 2016 (~80 foils)



# LS8

- **LS8_0XXXX** :
  - old paste, cure 200 degree IR ➔ Produced in May 2016 (~12 foils)

  **We fully consumed old paste during this production, then use new paste after LS8_00013

  - new paste, cure 200 degree IR ➔ Produced in Feb 2017 (~70 foils)