

# Quality Control and Quality Assurance for PCB production

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on behalf of the MAMMA Collaboration

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- Philosophy of QC/QA
- QC/QA steps during PCB production
- Proposal on QC setups
  - PCB + readout strips
  - resistive foils
  - glued PCB + foil
  - finished PCB incl. pillar structure
- Open questions (Summary)

## *Conduct QC tests as fine-meshed as possible*

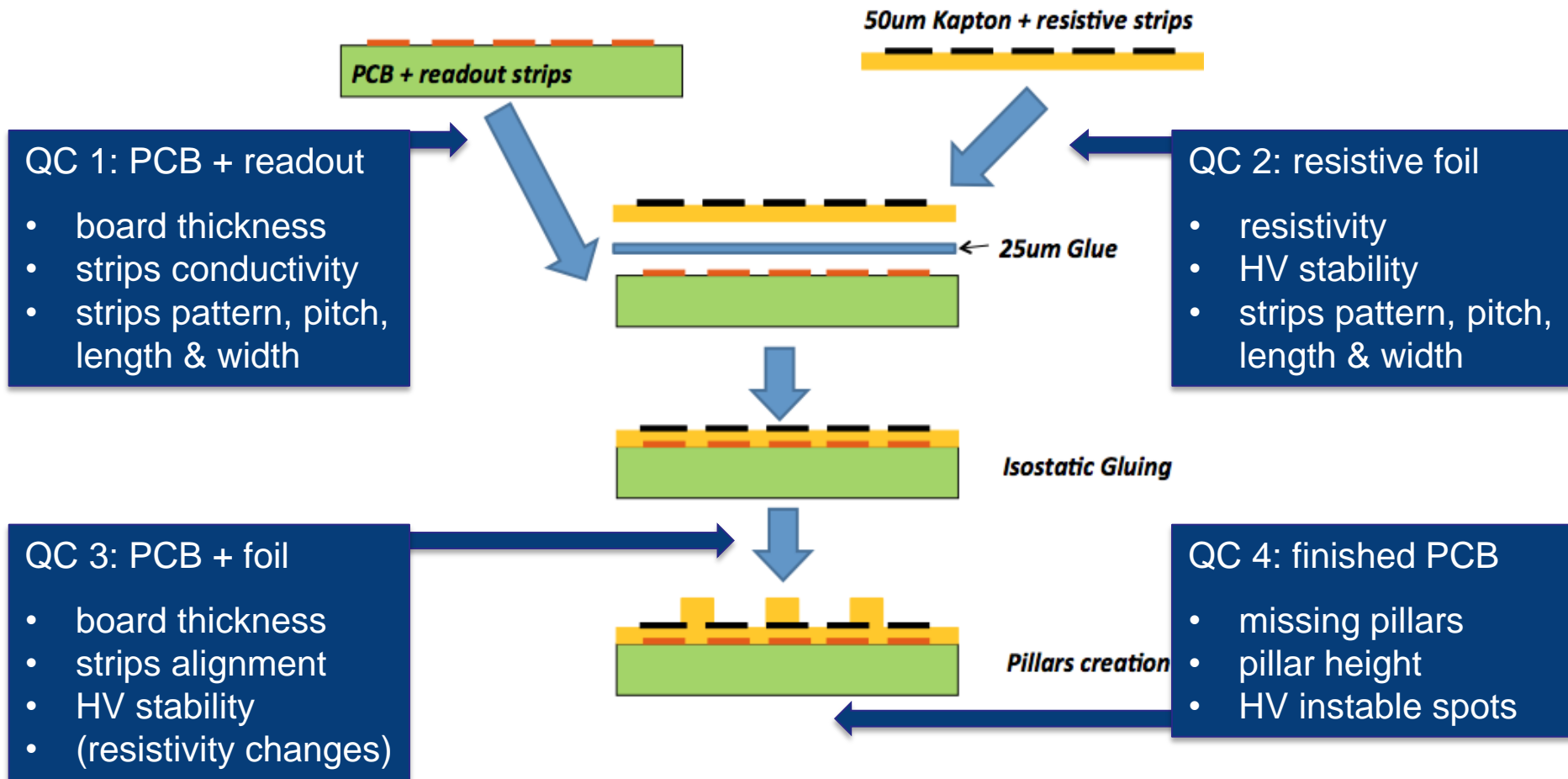
- QC should be done after many steps during PCB production
  - all parts should be qualified before further processing, especially before shipping to another company

## *Shifting QC as close to industries as possible*

- QC should be done at the industries whenever possible
  - requires exportable setups
- QC should be done by industry employees
  - requires automatized setups & strict criteria

## *Maintaining QC pressure on the industries*

- retest qualified products before delivery whenever we like



from: Rui de Oliveira: 'Situation with industries', RD51 collaboration Meeting, 16-18.10. 2013 - CERN

## Raw material parameters:

- Thickness of FR4  $500 \pm 50\mu\text{m}$  (industrial standard)
- lower deviation of 5% maybe possible
- Copper thickness quiet accurate  $18\mu\text{m}$ , variation negligible

## QC 1: PCB + readout

- board thickness
- strips conductivity
- strips pattern, pitch, length & width

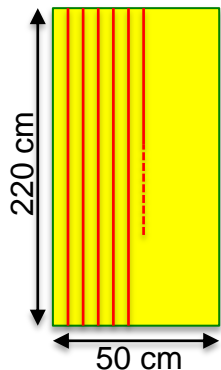
## Mean thickness control by weight:

- easily accurate < %-level, possible fast rejection criterion

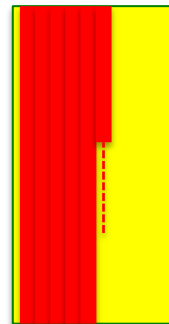
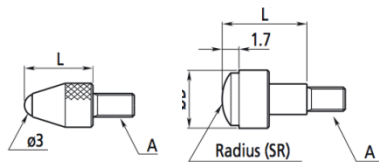
## PCB + readout strips

## Local thickness measurement (automated test):

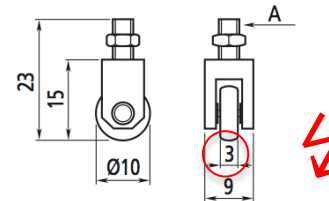
- 2D Gantry system scanning PCB (sucked on flat desk) with a length gauge → Accuracy on <  $5\mu\text{m}$ -level
- 2 different approaches:



Scanning lines with a punctual sensor:



Area wide scan with a 'wheel-like' sensor:



## Open questions/tasks

- Preselecting by weigh necessary or even sufficient?
- Local /area wide scan practicable and affordable?
- Rejection criteria to be discussed / defined (depending on panel construction technique)

*Proving conductivity (record resistance) of each strip*

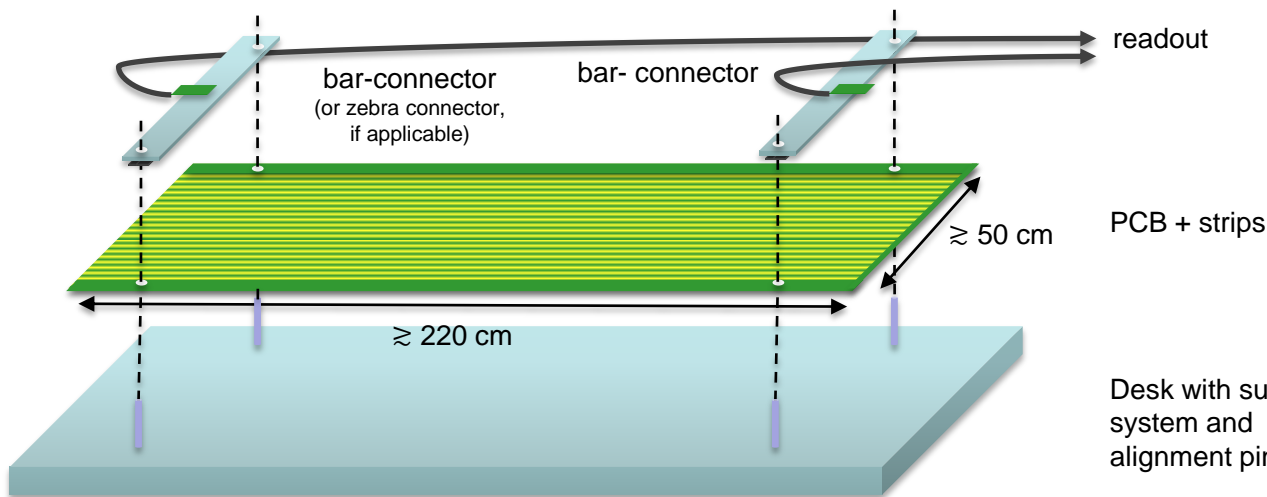
*Tagging shortcuts between neighboring strips*

QC 1: PCB + readout

- board thickness
- strips conductivity
- strips pattern, pitch, length & width

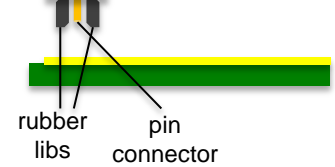
**PCB + readout strips**

setup sketch  
(not to scale)

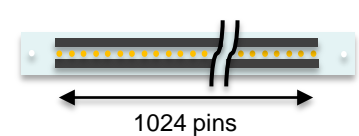


connector

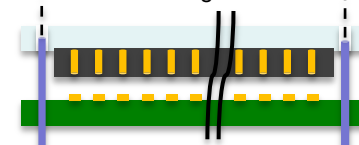
Side view



Bottom view

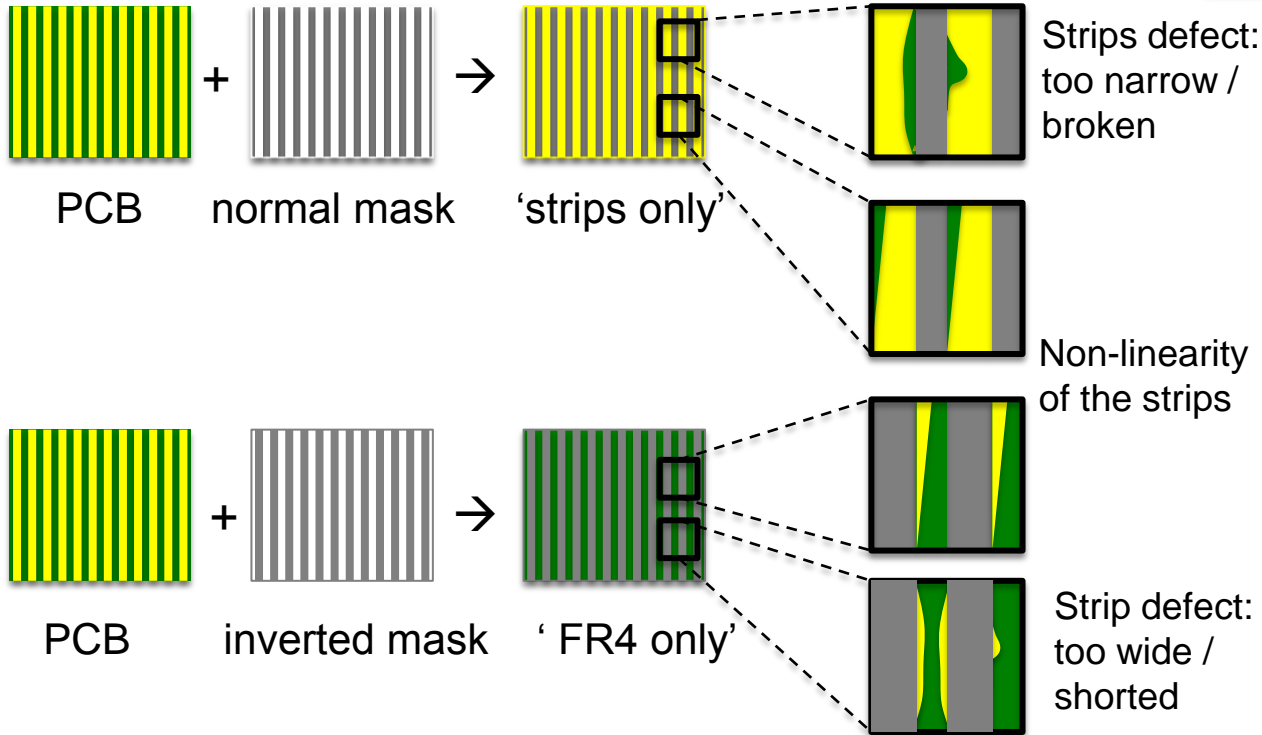


Longitudinal cut



## Optical evaluation of the mask-PCB agreement

(human based QC)



QC 1: PCB + readout

- board thickness
- strips conductivity
- strips pattern, pitch, length & width

PCB + readout strips

Open questions/tasks

- Human or PC based measurement?
- Distinct criteria to be defined!

Alternative: Taking high resolution image + digital pattern recognition program

(PC based QC)

## Optical evaluation of the mask-PCB agreement

(human based QC)



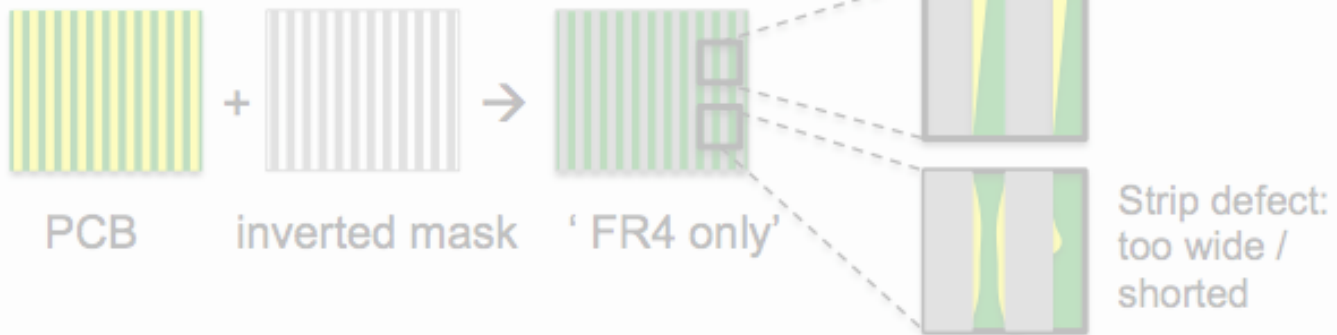
QC 2: resistive foil

- resistivity
- HV stability
- strips pattern, pitch, length & width

50um Kapton + resistive strips



## Same possibilities as proposed for PCB inspection



### Open questions/tasks

- Human or PC based measurement?
- Do we care about single/ local defects in the pattern?
- Rejection criteria to be defined.

*Alternative: Taking high resolution image + digital pattern recognition program (PC based QC)*



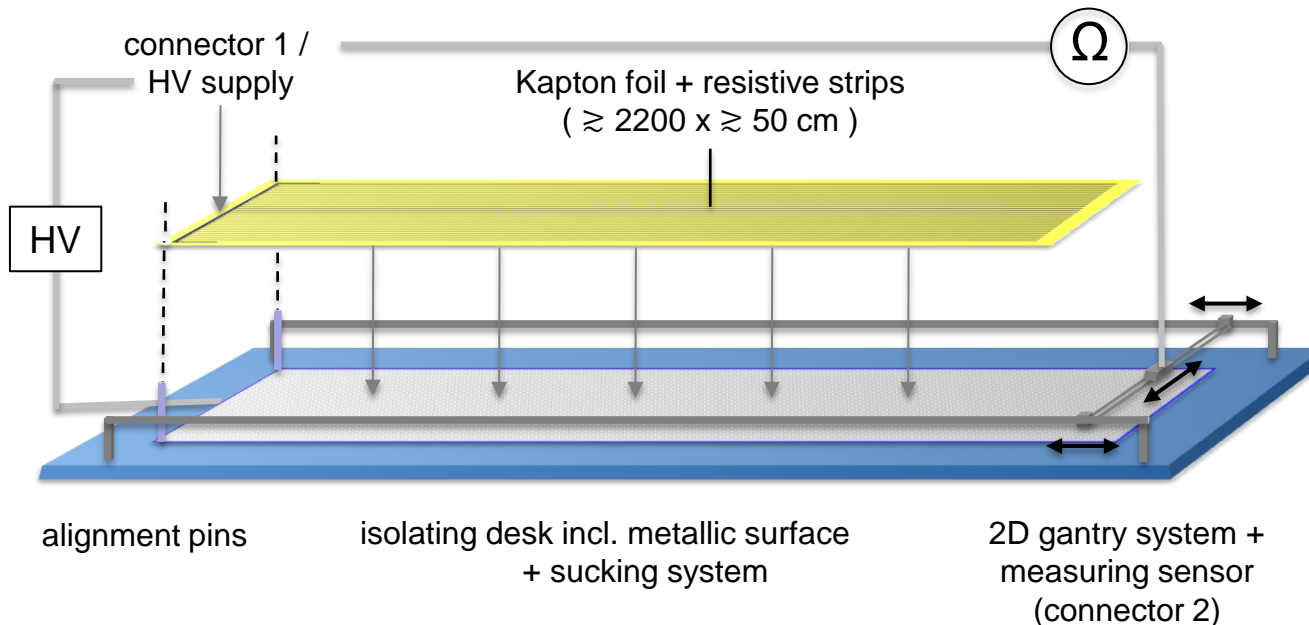
## Resistivity & HV stability QC (automated test)

- Combined setup to minimize installation time
- Sequential steps for resistivity measurement and HV - QA

QC 2: resistive foil

- ⇒ resistivity
- ⇒ HV stability
- strips pattern, pitch, length & width

**50um Kapton + resistive strips**



### Open questions/tasks

- Limits on resistivity variation?
- Requirements on HV stability?
- Rejection criteria to be defined.

## Gluing process might lead to:

- Long-scale thickness fluctuations
- Severity? (depending on panel construction technique)
- Local surface defects ('pits' or 'bumps')



- 'pits' should cause no trouble → no need for sensitive QC
- 'bumps' could lead to localized sparking → QC necessary

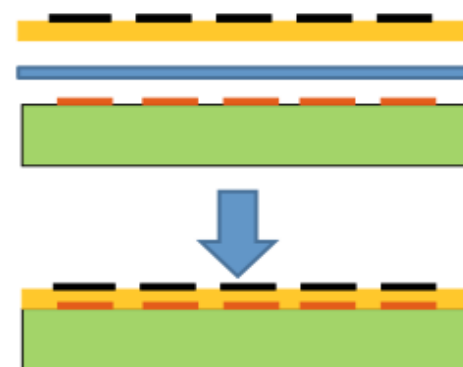
## Checking 'by-hand' (human based)

- Human hand is a very sensitive tool
- ⚡ Objective test criteria (Quantity and Severity)
- ⚡ 'Storing test results'

Or: Automated area wide scan (as for PCB) (PC based)

## QC 3: PCB + foil

- board thickness
- strips alignment
- HV stability
- (resistivity changes)



## Open questions/tasks

- Decision on method
- Definition of rejection criteria

## *Test on strip alignment with mask*

- same alignment holes on PCB and resistive foils
- attaching PCB mask over the cured PCB + foil yields disalignment between resistive pattern & strips

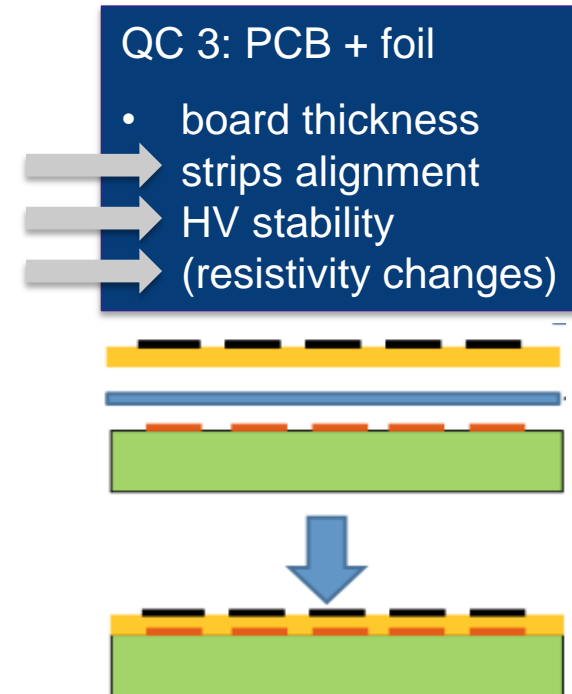
## *Retest HV stability*

- enclosed dirt could pierce trough the kapton foils

## *Repeat resistivity measurement*

- heat and pressure may influence the resistive layer
- has to be studied in advance, maybe not necessary for each single PCB

→ *Setup as proposed for resistive foil QC*



### Open questions/tasks

- Criteria on alignment to be defined.
- Requirements on HV stability?
- Study influence of gluing / curing process

## *Influence of missing / broken pillars*

- a single missing pillar seems barely to influence the MM
- but: region or pattern of missing pillars will
- ‘Threshold’ of missing pillars is not really known

## *Visual & tactile test on missing pillars* (human based)

- Hand & eyes are very sensitive tools
- Missing pillars are easy to identify
- ⚡ ‘Storing test results’

## *Or: Automated surface scan (similar as for PCB)*

(PC based)

- ⚡ Difficult to ensure ‘damage free’ measurement

## *Or: Trust on capacity measurement*

- As soon as missing pillars influence the mesh position, this should be visible in the capacity measurement ...

QC 4: finished PCB

- missing pillars
- pillar height
  - HV stability



### Open questions/tasks

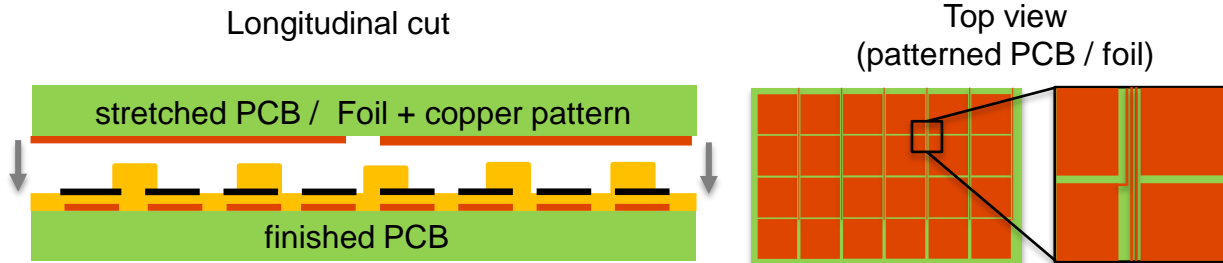
- Study the influence of missing pillars
- Decide if / how to identify missing pillars
- Define rejection criteria

## Pillar height by capacity measurement

- Capacity is very sensitive to height deviation
- Attaching a segmented anode on the pillars  
(segmented PCB or foil, applied similar to a floating mesh)
- Capacity mapping → 'mean' pillar height map

QC 4: finished PCB

- missing pillars
- pillar height
- HV stability



⚡ Stretching of PCB / foil not jet tested

## Same Setup can be used to identify HV instable spots

- If dust filaments are partly encapsulated in the pillars they can act as a current bridge
- Localization allows systematic cleaning
- ⚡ Setup requires clean environment

### Open questions/tasks

- Study on operability
- Decision on layout / size of segments
- Define rejection criteria

- *QC/QA plans for PCB production are in progress, proposals to address all QC items are under discussion.*
- *Technical realization of these proposals will be driven forward.*
- *To conclude on QC/QA plans **open questions** have to be discussed and answered:*
  - **Final decisions** on production have to be taken before finalization of QC/QA plans.
  - QC-testing proposals / alternatives should be discussed and agreed on.
  - Technical details of proposed setups have to be fixed.
  - Requirements for QC tests (alignment holes, connections etc.) must be included in PCB and resistive pattern layouts.
  - **Rejection criteria** in every step of PCB production have to be defined.

*Thank you for your attention!*

*Questions, comments and remarks are highly welcome.*