

Industrialization of the Production of Thin-Gap Resistive Plate Chambers

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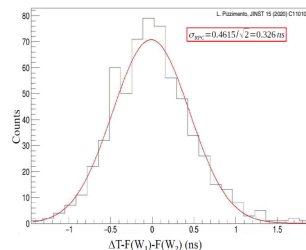
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Thin-gap RPCs in particle physics

Strengths of resistive plate chambers with phenolic high-pressure laminate electrodes as introduced by Cardarelli and Santonico in 1981:

- Low production cost.
- Large active area $\sim 2 \text{ m}^2$.
- Fast response time.
- Time resolution $< 400 \text{ ps}$.
- Spatial resolution $\sim 1 \text{ mm}$.
- Rate capability up to 10 kHz/cm^2 with modern low-noise electronics.



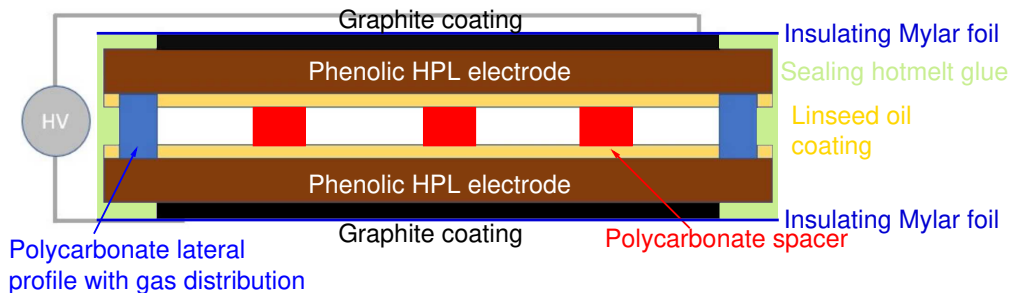
Examples of experiments using RPCs

- ATLAS and CSM muon systems.
- Thin-gap RPCs used for the phase-II upgrade of the ATLAS muon spectrometer.
- ANUBIS.
- ...

Problem

- Currently only a single company producing thin-gap RPCs, demand for RPCs exceeds the manufacturers capacities.
- ⇒ **Need to establish additional manufacturers.**

Structure of a thin RPC gas gap

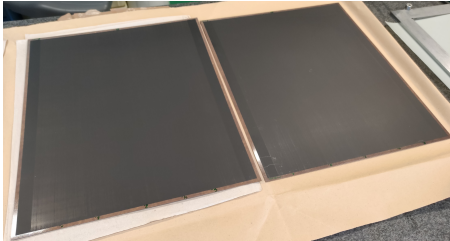


Critical points

- Reproducible resistivity of the graphite coating: $350 \text{ k}\Omega \square (\pm 30\%)$.
- Variation of the size of the gas gap must be $< 15 \mu\text{m}$.
- Gluing of the lateral profiles and of ~ 500 spacers for a 2 m^2 RPC within the ~ 60 minutes curing time limit of the DP460 glue.

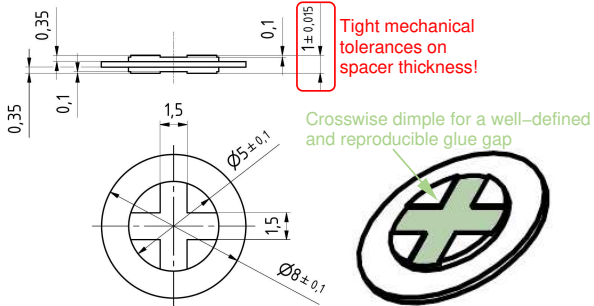
How to ensure surface resistivity and gap size

Surface resistivity of graphite coating



- Silk screen printing of graphite coating

Gap size

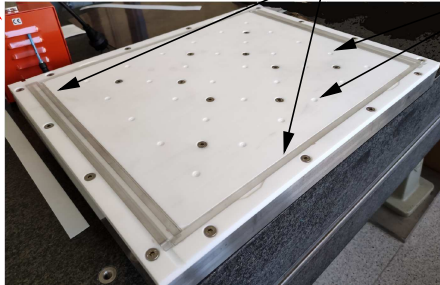


- Injection molded spacer with 15 μm tolerance on the thickness.
- Crosswise dimples on the top and bottom of the spacers for a well-defined and reproducible glue gap.

How to ensure gluing within the curing time limit

Vacuum pump to suck the spacers and lateral profiles onto template

Template with grooves for the lateral profiles and the spacers



Test template for a 50x30 cm² RPC

Section of an image of a gluing test



Procedure

- Lateral profiles and spacers are put into a template out of teflon.
- Teflon was chosen to avoid that glue sticks on the template.
- Glue is put onto the lateral profiles and spacers.
- A HPL electrode plate is put onto the profiles and spacers and push down with a vacuum bag.

1. Silk screen printing of graphite.
2. Fixation of the HV contacts with conducting silver glue.
3. Laminating of the insulating Mylar foil with EVA hotmelt onto the HPL electrodes.
4. Gluing of the lateral profiles and spacers onto the first HPL electrode.
5. Insertion of gas pipes.
6. Gluing of the second HPL electrode onto the first one with lateral profiles and spacers.
7. Sealing of the edges of the RPC with hotmelt.
8. Coating of the insides of the electrodes with linseed oil.
Polymerization of the linseed oil coating.

New companies interested in the RPC production

4 companies from Germany which have the technical prerequisites for a large scale RPC gas gap production have been chosen for the qualification processes.





- Specialized in plastic processing including polycarbonate and HPL.
- Company uses a machine for laser cleaning of the plastic surfaces of the components to be glued together.
- Website: <https://www.hokun.de/>



- Large fair construction company, all in-house production.
- Large production area and capacity.
- A lot experience in processing of plastics and HPL plates.
- Website: <https://www.metron-eging.com/>



- Specialized in radiation monitoring system.
- R&D department lead by former high-energy physicists.
- QA/QC for their products compliant with high medical standards.
- Website: <https://www.mirion.com/>

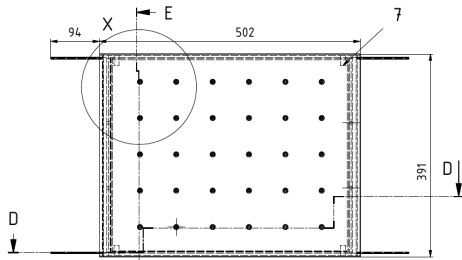


- Specialized in mechanical engineering.
- Expertise in machining large objects, surface treatments (coating).
- Large production area.
- Website: <https://www.ptsmaschinenbau.com/>

Qualification procedure

Step 1: Production of small-size RPC gas gaps

- Each of the 4 companies have produced 3 RPC gas gaps of $50 \times 30 \text{ cm}^2$ size to practice the production procedure.



- Mechanical and basic functional tests of the small-size gas gaps ongoing.

Step 2: Production of large RPC gas gaps

- Each of the 4 companies will produce large RPC gas gaps of $2 \times 1.2 \text{ m}^2$ size in May 2022.
- Mechanical and basic functional tests planned for June 2022.
- Final certification: 1 year aging test in CERN's GIF++ from July 2022 to June 2023.

- Resistive plate chambers with phenolic high-pressure laminate electrodes are ideal for the instrumentation of large area muon systems offering excellent time resolution and decent spatial resolution.
 - Large demand by several high-energy physics experiments in the following years will exceed the production capacity of the singleton manufacturer of RPC gas gaps.
- ⇒ Need to qualify additional manufacturers for RPC gas gaps.
- 4 companies from Germany are in the process of qualification of the production of thin-gap RPCs.