



sRPC: an RPC based on resistive MPGD technology



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SRPC vs RPC

Classical RPC

- bulk resistivity electrodes (bakelite or float-glass)
- recovery time proportional to volume resistivity and electrode thickness
- low volume resistivity and thin electrodes, together with the reduction of the gas gain is the standard recipe to increase the detector rate capability

Surface - RPC

- surface resistivity electrodes manufactured with industrial sputtering techniques of DLC on flexible supports (scalable and cost-effective technology)
- the technology allows to realize electrodes with a surface resistivity in a very wide range, $0.001 \div 10 \text{ G}\Omega/\square$
- high density current evacuation schemes, similar to those used for resistive MPGD (i.e. μ -RWELL) can be implemented to improve the rate capability of the detector

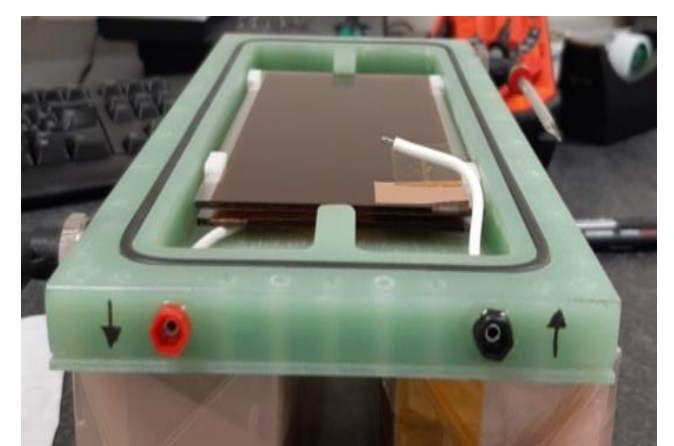
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INFN – "ELETTRODO PIANO A RESISTIVITÀ SUPERFICIALE MODULABILE E RIVELATORI BASATI SU DI ESSO."

Prototype layouts

Two layouts

- 1) a symmetrical version with both electrodes made of patterned DLC sputtered on kapton foil then glued on float-glass substrates
- 2) a hybrid version in which one electrode is realized with DLC kapton foil on glass and the second one made of float-glass powered by means a copper tape on the external side

The 2 mm gas gap between the two electrodes is ensured by E-shaped spacers made of Delrin. The electrodes stack is inserted in a FR4 box that acts as gas volume container.



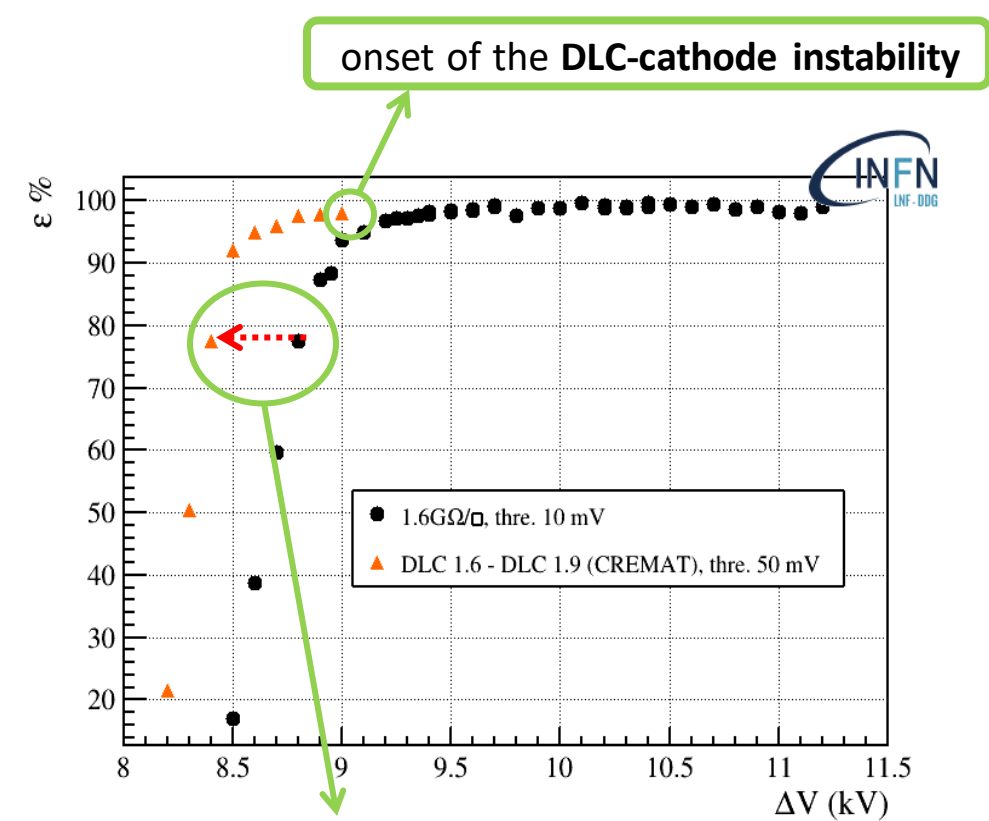
Symmetrical vs Hybrid layout

Symmetrical

- DLC (anode) – DLC (cathode) electrodes show instability at high voltage
- possible photon-feedback or/and field emission effects on the DLC surface of the cathode
- with more sensitive electronics few hundreds of Volts of stable operation can be found

Hybrid

- DLC (anode) – float glass (cathode) electrodes shows high stability (plateau larger than to 2 kV)
- glass cathode does not suffer of photon-feedback or field emission effects
- not a solution for high-rate because limited by the relatively high resistivity of the float-glass



Exploited as a lock-pick for the study of the DLC as SRPC electrodes

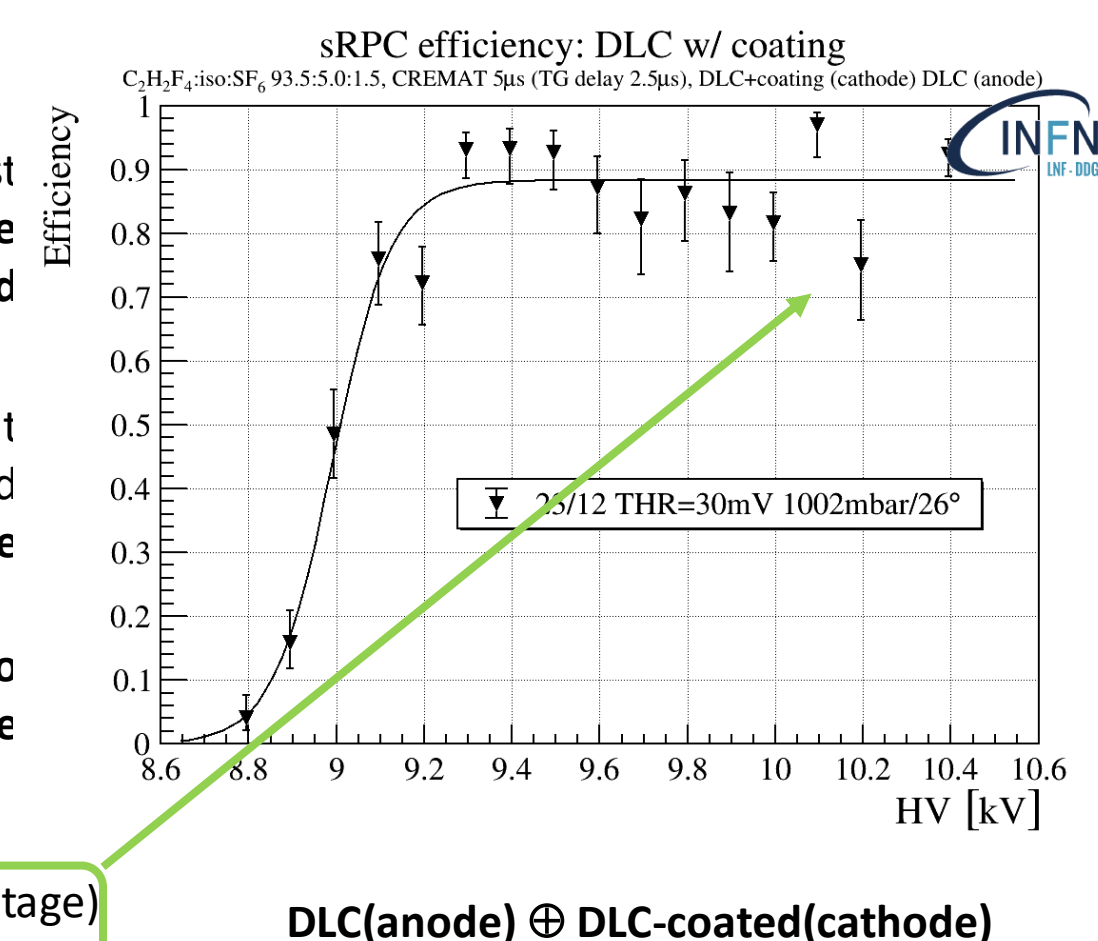
Symmetrical layout: the cathode puzzle

Tests indicate that the instability at highest voltages is due to some physics occurring at the cathode surface (photon-feedback or/and field emission effects on the DLC).

Besides replacing the DLC cathode with the float glass electrode (Hybrid layout), we tested several cathode configurations, leaving the anode unchanged.

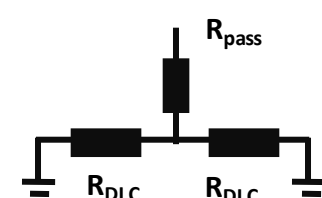
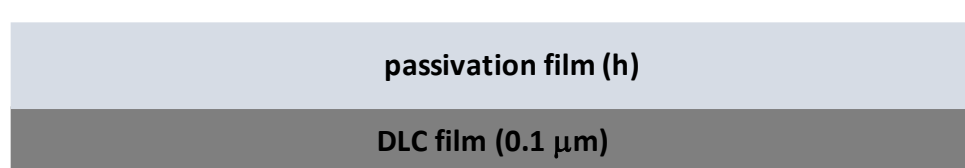
The idea is to create a barrier in order to suppress the electron extraction from the cathode DLC surface (cathode passivation).

High stability (>1kV wide operating voltage) achieved with suitable cathode passivation



The cathode passivation

Cathode passivation with different features (resistivity/film thickness) have been considered. Simple arguments based on Ohm's law can be used in order to understand the characteristics of possible coatings. Stability tests are clearly required.



$$R_{\text{pass}} < R_{\text{DLC}} \approx 1 \text{ G}\Omega$$

$$R_{\text{pass}} = (\rho_{\text{pass}} \times h) / S < 1 \times 10^9 \text{ Ohm}$$

$$S \sim O(1 \text{ mm}^2) \rightarrow \rho_{\text{pass}} < 10^7 / h(\text{cm}) \text{ Ohm.cm}$$

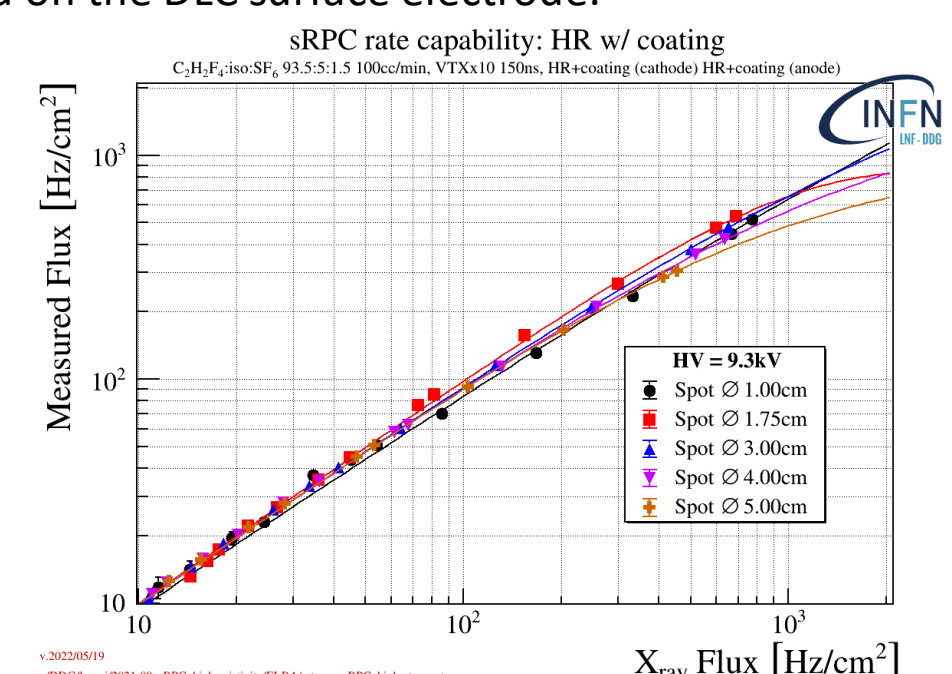
$$h = 1 \text{ }\mu\text{m} \rightarrow \rho_{\text{pass}} < 10^{11} \text{ Ohm.cm}$$

$$h = 0.1 \text{ }\mu\text{m} \rightarrow \rho_{\text{pass}} < 10^{12} \text{ Ohm.cm}$$

$$h = 0.01 \text{ }\mu\text{m} \rightarrow \rho_{\text{pass}} < 10^{13} \text{ Ohm.cm}$$

High-rate layout : rate capability

The rate capability of a symmetric high-rate layout has been measured irradiating the detector with a high intensity 5.9 keV X-ray gun with different spot size (1÷5 cm diameter) larger than the pitch (1 cm) of the current evacuation conductive grid realized on the DLC surface electrode.



High-rate layout with conductive grid acting as fast current evacuation scheme. Grid-pitch ~1 cm, DLC resistivity ~ 7GΩ/□

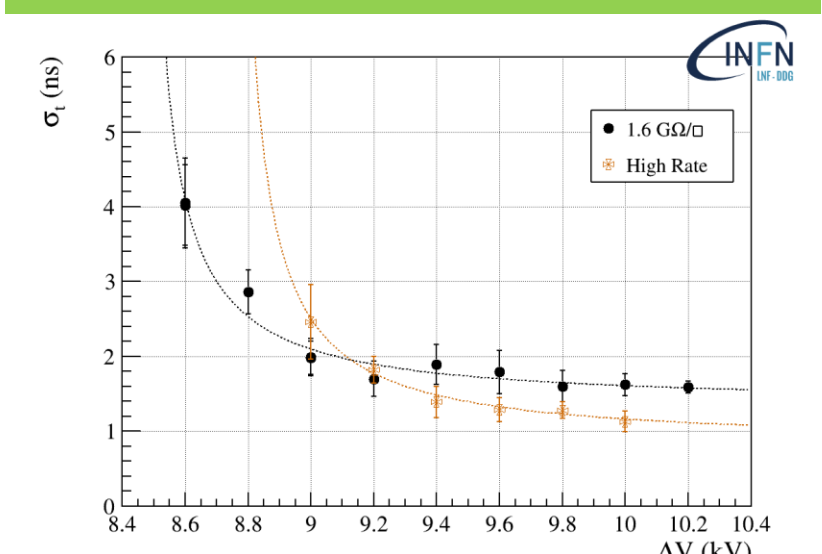
Rate capability of ~1 kHz/cm² with X-ray, corresponding to ~ 3 kHz/cm² m.i.p.

Summary and Outlook

By exploiting the DLC sputtering technology developed for resistive MPGDs we realized surface resistive electrodes for a new generation of RPCs

- Detector layouts with electrode resistivity $\rho_s > 1 \text{ G}\Omega/\square$ have been tested, exhibiting good performance in terms of efficiency ~95% and time resolution ~1 ns
- A high-rate layout with $\rho_s \sim 7 \text{ G}\Omega/\square$ & ground-pitch 1 cm showed a rate capability of ~3 kHz/cm² with m.i.p
- Optimizing the ground-pitch and reducing the surface resistivity a rate capability of the detector > 20kHz/cm² with m.i.p is expected
- The DLC technology allows to realize large area electrodes: the CERN-INFN DLC sputtering facility can easily produce 2x0.5 m DLC foils
- Cost-effective technology suitable for applications in large HEP experiments for future high luminosity colliders (FCC-ee, CepC)

Time resolution



O(1 ns) time resolution obtained with different sRPC prototypes