A new graphene-based RPC fully built with additive manufacturing

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Additive manufacturing is a popular technique currently providing new opportunities in several domains. We applied the AM to detector construction. We had hypothesized that a fully automated 3D printing of a detector would reduce drastically:

1) detector construction cost and assembly time

2) the probability of mistakes during construction

We introduced and optimized a new electrode material to match the properties of the existing Bakelite featured in RPC detectors for LHC experiments. The new material is extruded in a filament form, readily usable by any general-purpose desktop 3D printers.

With custom-made filament, we developed and printed several detector prototypes. Preliminary results, under cosmic rays regime, are going to be presented to demonstrate the proof-of-concept of this new RPC fully built with additive manufacturing.

Motivation

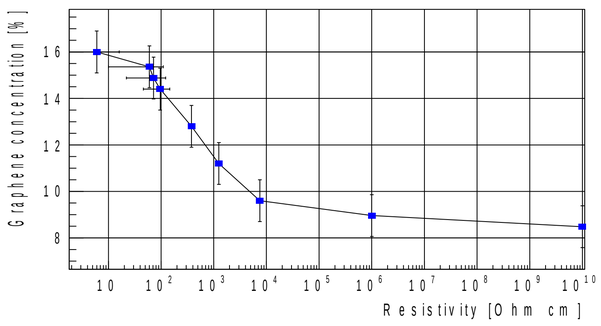
Adopting additive manufacturing as a breakthrough technology for the field of particle detection

- Fine tuning and control of the detector resistivity
- Detector manufacturing totally automatic via 3D printed, (no limitation in shape), well-controlled procedure (no hygroscopy)
- Standardized materials and and high integration of components/parts (improved mechanical and electrical stability)
- Cost-effective for small and/or large scale production
- High customization for very different applications (high rate vs neutrinos, large vs small projects, active surface area dimensions)

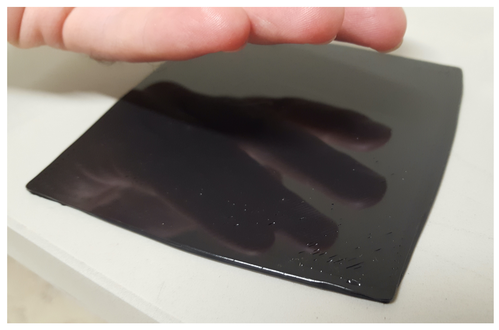
Detector Design and manufacturing

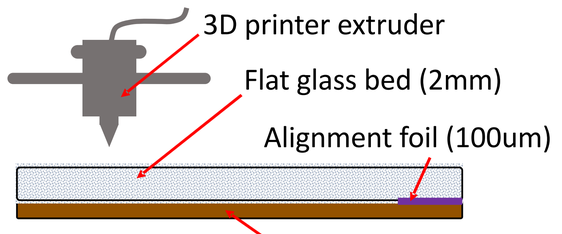
The proposed detector is being designed following a simple, effective and flexible design methodology

- The detector resistivity can be controlled by doping PLA plastics with graphene
  - Very large variety of resistivity can be obtained, measured by a Trek-152 (compliant to ANSI/ESD Standards)

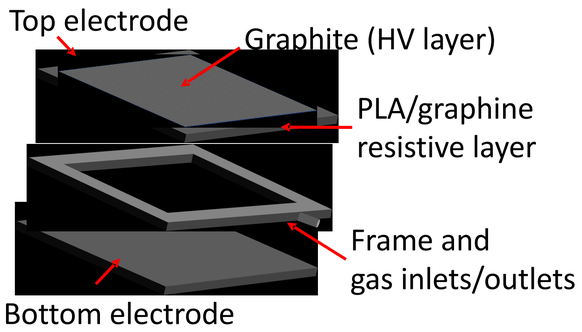


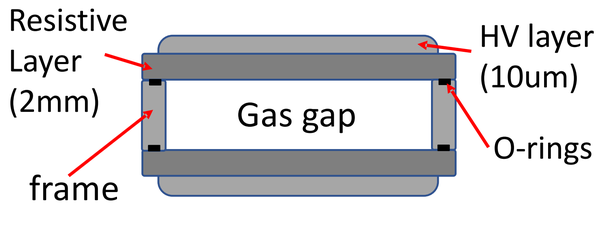
- Variable graphene content in the PLA-based filament, with resistivity of the electrode easily adjusted
  - Suitable for low/high rate cosmic experiments



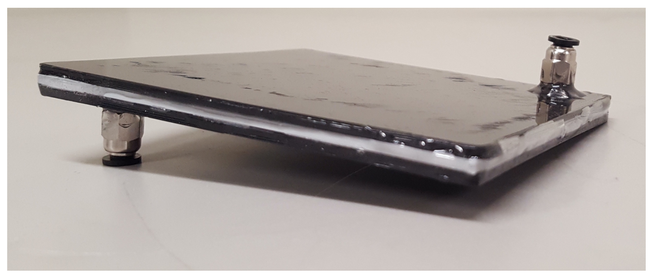


- The mixed graphene+PLA pellet is extruded to generate a plastics filament to be used in the 3D printer
- Printing on glass ensures a mirror-like surface





- Two resistive electrode and one pure PLA frame are printed and glued to form the detector stack
- A 500 Ω squared HV distribution layer is then glued on both electrodes to apply HV
- 10 detectors are being printed and assembled to assess consistency and reproducibility of this technique



Current status and future plans

Promising R&D for a cost-effective detector design for general purpose uses
Aiming at a broader impact, delivering affordable detectors for educational purposes and potential small experiments

- Additive manufacturing dramatically reduces **prototyping costs** and the need for an industrial partner
- In-house design and fabrication allows **complete control** of the **costs, timeline** and **design** optimization
- Prototyping and testing is a formative learning **educational tool** that shapes young students
- We will continue to **explore RPC prototypes and test** them with cosmic ray and/or radiation sources.
- Upon success, we would **explore all various detector** concepts with additive manufacturing, such as **THGEM, Micro dot detectors**.

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