The TANGO_RD Project for the development and characterization of Resistive Cylindrical Chambers (RCCs): plans and preliminary results.

D. Piccolo (LNF INFN) for the TANGO_RD project

- ***ToV:*** **B. Liberti (PI)**, M. Vallocchia
- ***LNF:*** D. Piccolo, S. Bianco, A. Paoloni, S. Meola, A. Rocchi, G. Saviano*, C. Vendittozzi*, S. Colafranceschi**
- ***Bari:*** A. Pastore, M. Abbrescia, M. De Serio

* University of materials engineering La Sapienza (RM)

** also James Madison University (JMU)

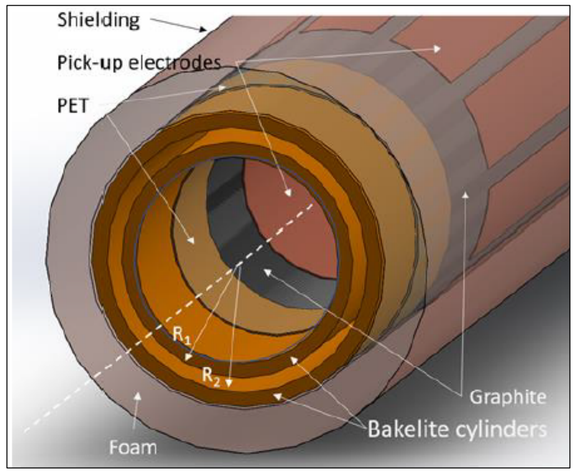
Resistive Cylindrical Chamber: RCC

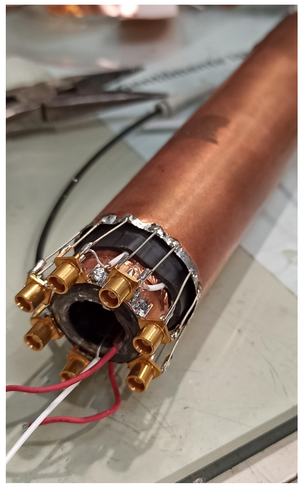
The RCC detector is a new gaseous detector introduced by **R. Cardarelli** in 2021:

R. Cardarelli, Future RPC developments, J. Instrum. 16 (2021) C05004.

R. Cardarelli, A. Rocchi et al, **The Resistive Cylindrical Chamber**. NIM Section A. Volume 1058,2024,168822-ISSN 0168-9002

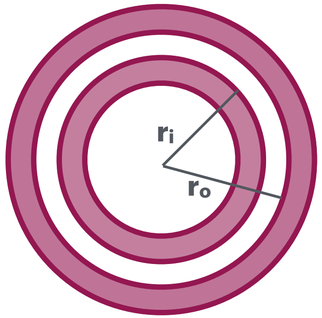
https://doi.org/10.1016/j.nima.2023.168822



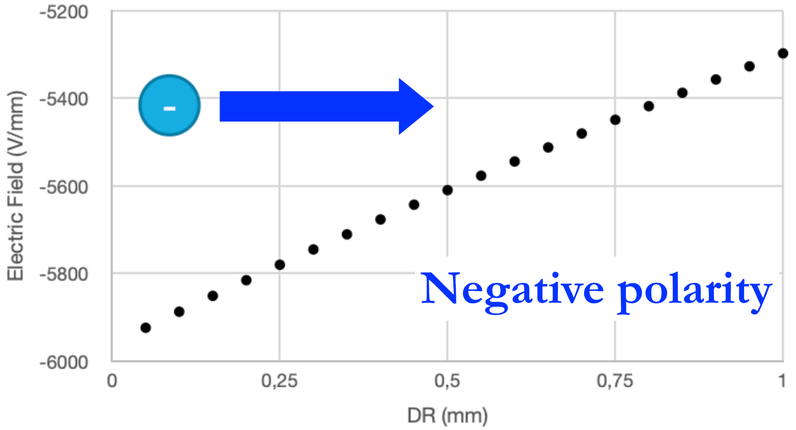


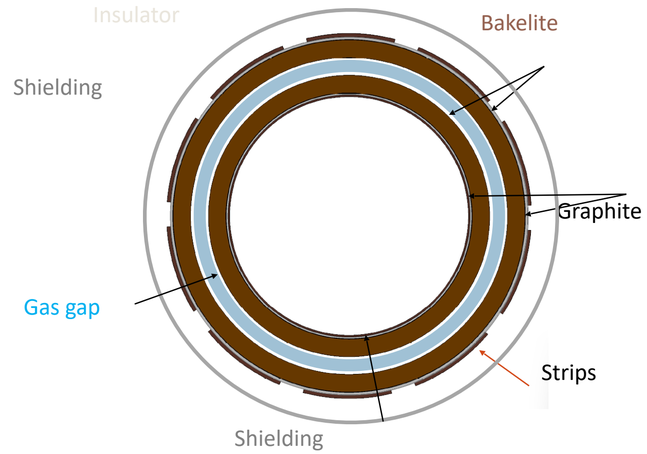
Negative polarity if the inner electrode is at negative voltage vs outer electrode

Positive polarity if the inner electrode is at positive voltage vs outer electrode



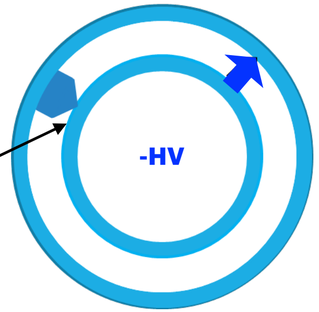
$$E(r) = \frac{V}{r \cdot ln\frac{r_o}{r_i}}$$



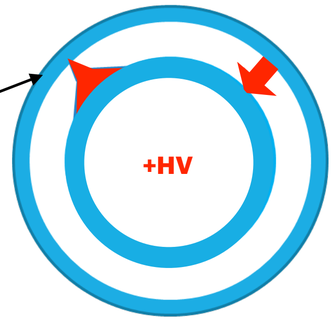


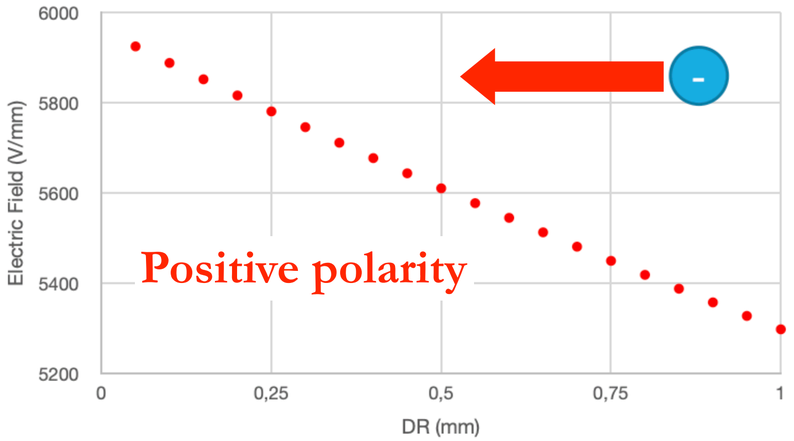
Davide Piccolo (LNF)

Multiplication followed by drift



Drift followed by multiplication



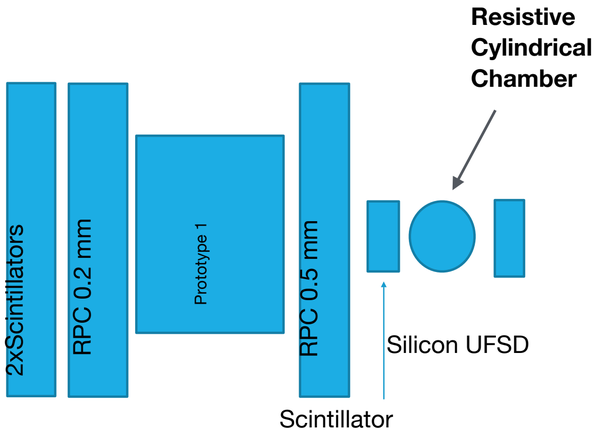


Resistive Cylindrical Chamber: RCC

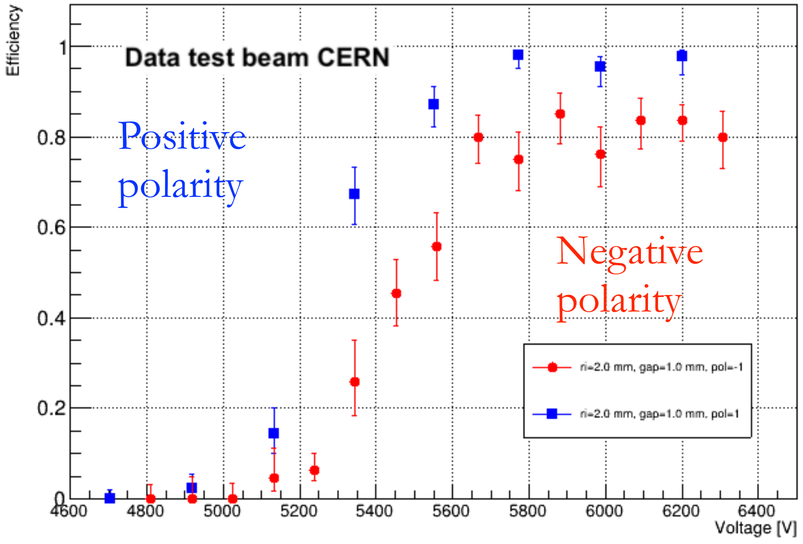
Experimentally characterized: [**A. Rocchi et al**, "**Efficiency and time resolution of a thin gap Resistive Cylindrical Chamber.**"
Contribution to RPC2024 Conference
https://doi.org/10.15161/oar.it/8vsjx-d8c51]

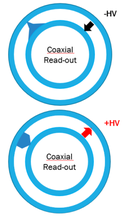
Hybrid RCC r_i=2 mm r_o=3 mm

Test at CERN

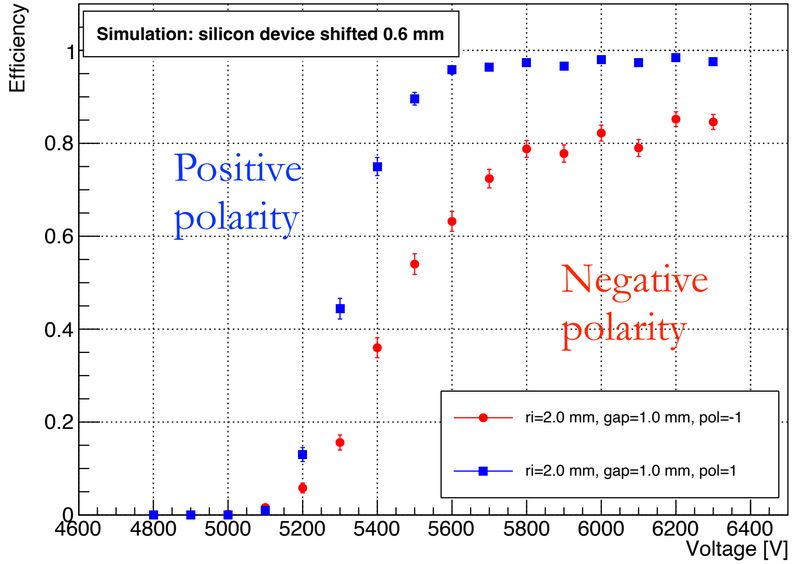


First experimental results from A. Rocchi





Comparison with simulation model



A. Rocchi, "**Moderation of the avalanche gas discharge through a quasi-uniform electric field device: the Resistive Cylindrical Chamber**",
VCI2022 Conference.

Why to study RCC

- **Is a new idea:** The behavior is different from planar RPCs. Lot of detector physics drive the RCC performance.
- **Enhanced Mechanical Resistance**: The cylindrical geometry provides superior structural strength against internal overpressure compared to planar configurations.
  - **Optimized Efficiency & Time Resolution**: High-pressure operation allows for thinner gas gaps while increasing gas density, directly recovering detection efficiency and improving time resolution.
- **Additional Tuning Parameters**: Introduces two new operational degrees of freedom—the ratio between gas gap thickness and inner radius ($\chi = g/R_{in}$) and the voltage polarity—which can be tailored to optimize overall detector performance.
- **Geometrical Avalanche Quenching**: In negative polarity, the electric field topology naturally slows avalanche growth, shifting part of the quenching mechanism from the gas mixture to the geometry itself.
  - **Eco-Friendly Gas Operation**: Geometrical quenching reduces reliance on heavy quenching additives, enabling the use of eco-friendly, pure CO_2 gas mixtures. (To be evaluated)

The **TANGO_RD** project (**T**oward **A** **N**ew **G**eneration **O**f **RPC** **D**etectors)

- **TANGO_RD is a new project recently approved by INFN (2026)**

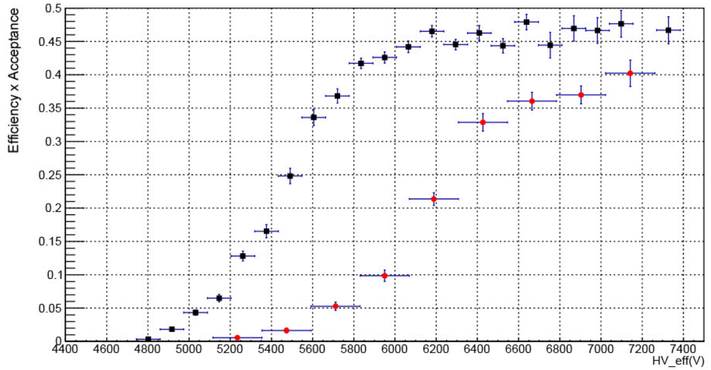
- *ToV:* **B. Liberti (PI)**, E. Vallocchia
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* also James Madison University (JMU)

WP1
Characterization of underlying physical principle and performance as a function of RCC construction parameters

WP2
Development of a Simulation program for RCC and comparison with experimental data

Working principles (polarity asymmetry)



WP5
Production of large size prototypes and test with beam

System scalability
Performance

Toward green detector

WP3
Characterization of performance with ecological gas mixtures and vs overpressure

WP4
Characterization of new electrode materials

Toward high rates

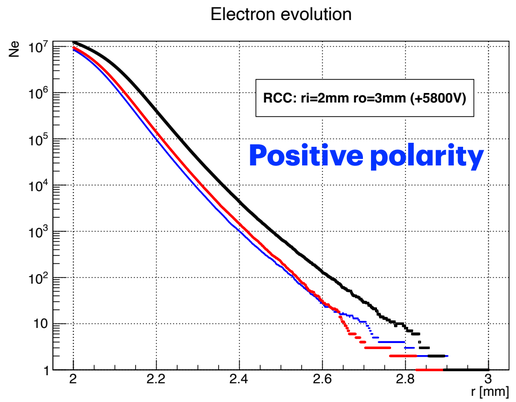
The **TANGO_RD** project (**T**oward **A** **N**ew **G**eneration **O**f **RPC** **D**etectors)

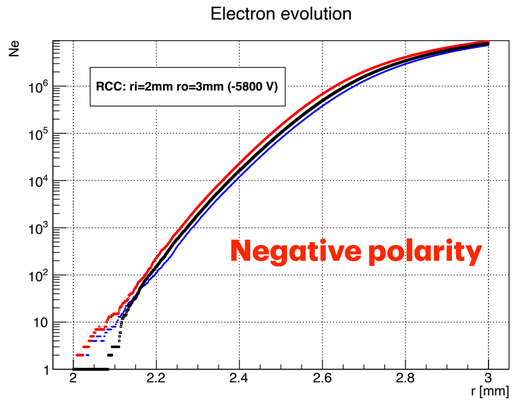
WP2

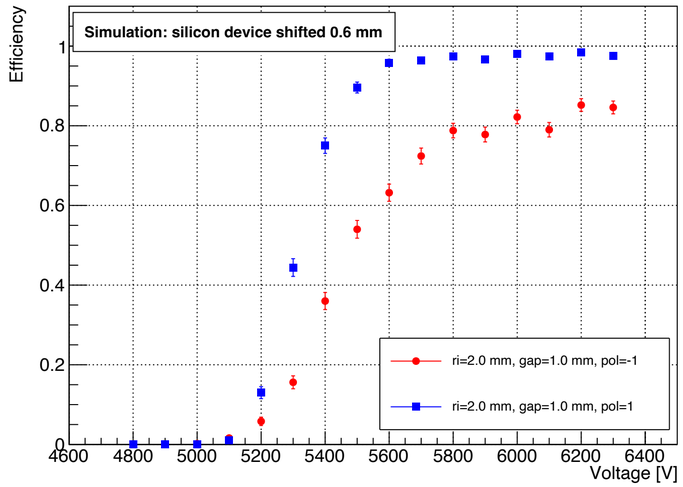
Development of a Simulation program for RCC and comparison with experimental data

Talk @ RPC2026 on Monday:

A Standalone Simulation Framework for the Physical Modeling of Resistive Plate Chambers (RPCs) and Resistive Cylindrical Chambers (RCCs)



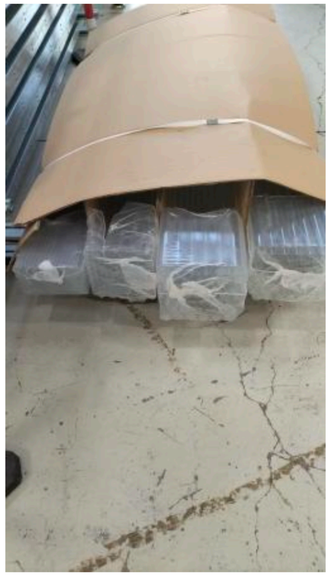




Pubblication

M. Abbrescia, D. Piccolo *et al.* A standalone simulation program for resistive cylindrical chamber (RCC). *Eur. Phys. J. C* 86, 351 (2026). https://doi.org/10.1140/epjc/s10052-026-15576-5

Material procurement





First set of prototypes in soda lime glass:

- for high smoothness to prevent roughness asymmetries between inner and outer surfaces.
- High resistivity O($10^{13}\ \Omega \cdot cm$) see later

4 topologies of tubes procured so far:

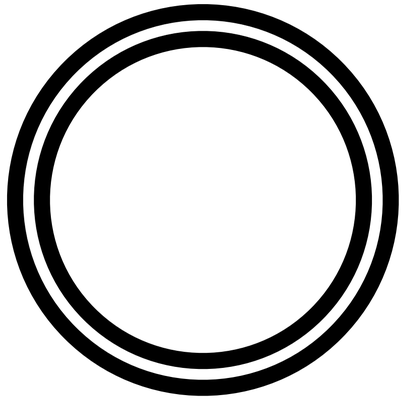
Thickness $1 \pm 0.1\ mm$

External diameters: 28, 24, 14, 10 mm

Accuracy on the diameters 0,14 - 0,19 mm

More topologies ongoing

Prototype 00

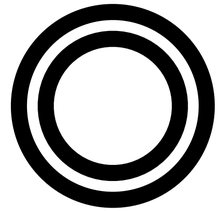


R_i = 12 mm

Gas gap: g = 1 mm

$\chi = \frac{g}{R_i} = 0.08$

Prototype 0



R_i = 5 mm

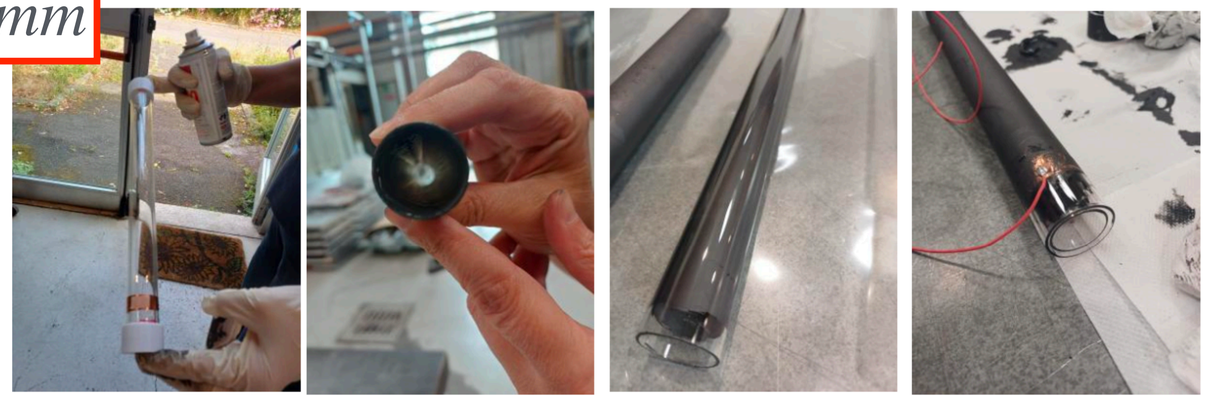
Gas gap: g = 1 mm

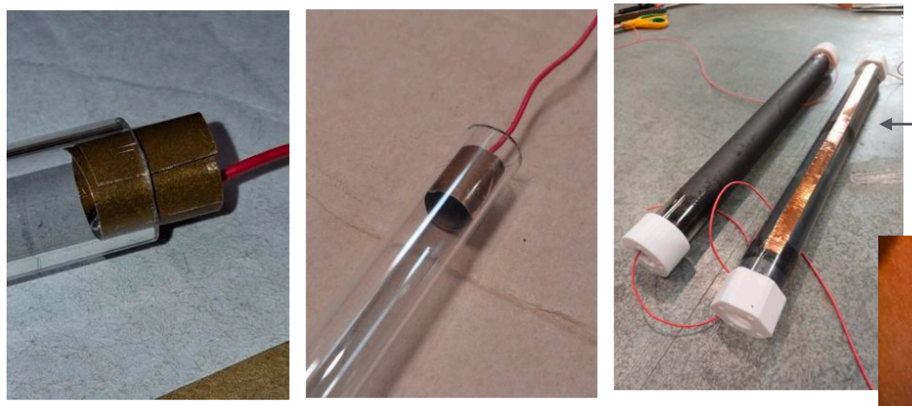
$\chi = \frac{g}{R_i} = 0.2$

Prototype 00 @ Tor Vergata (RM)

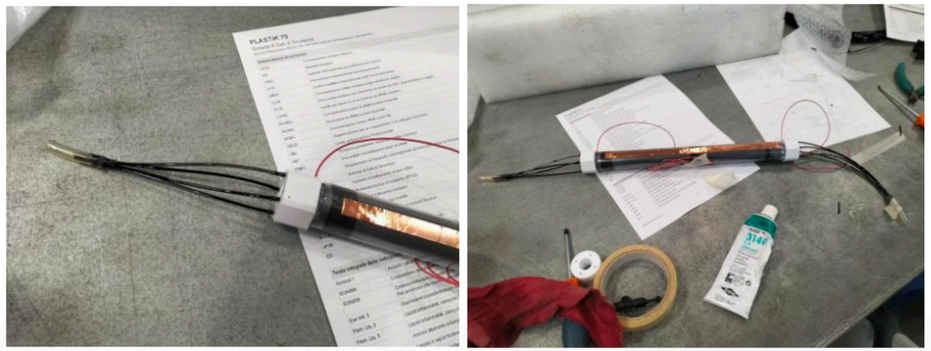
$$gas\ gap\ g = 1\ mm - R_i = 12\ mm$$

- **Glass Tube Cutting**
  - Fragile soda-lime glass tubes.
  - Rotary blade metallographic cutter *(La Sapienza)*.
- **3D-Printed Plastic Endcaps**
  - Low-density plastic components.
  - 3D printed in various shapes and sizes *(La Sapienza)*. Rough precision in terms of gas gap thickness control.
- **Manual graphite Coating / Painting**
  - Low resistivity < 10 $K\Omega/\square$
  - Lack of guaranteed uniformity.
  - Scratchable and removable layer on glass.
- **HV Distribution**
  - Beryllium-Copper (BeCu) spring clips.
  - Manual bending.
- **Adhesive Bonding**
  - Low mechanical strength (sealant-based).
  - Unsuitable for overpressure conditions.





Copper tape for pickup strip

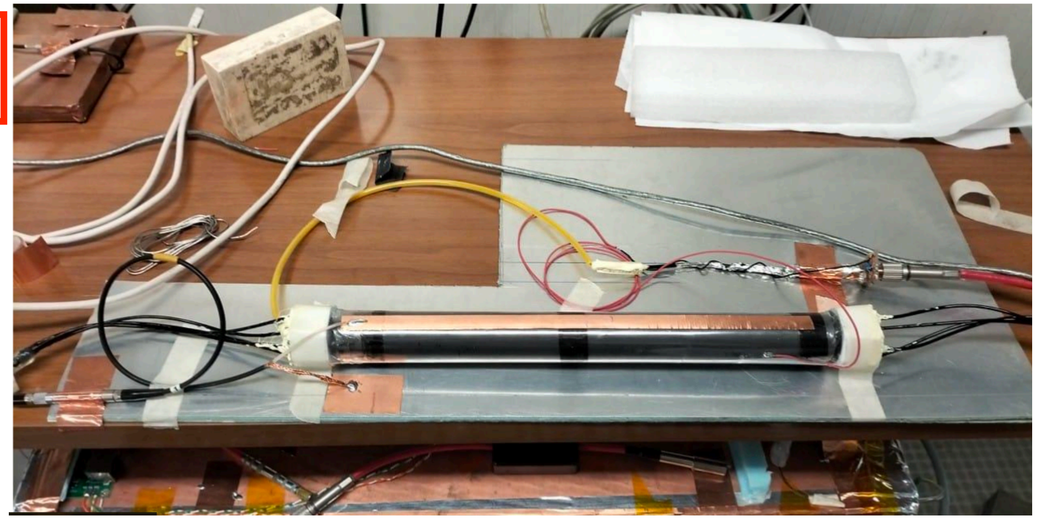


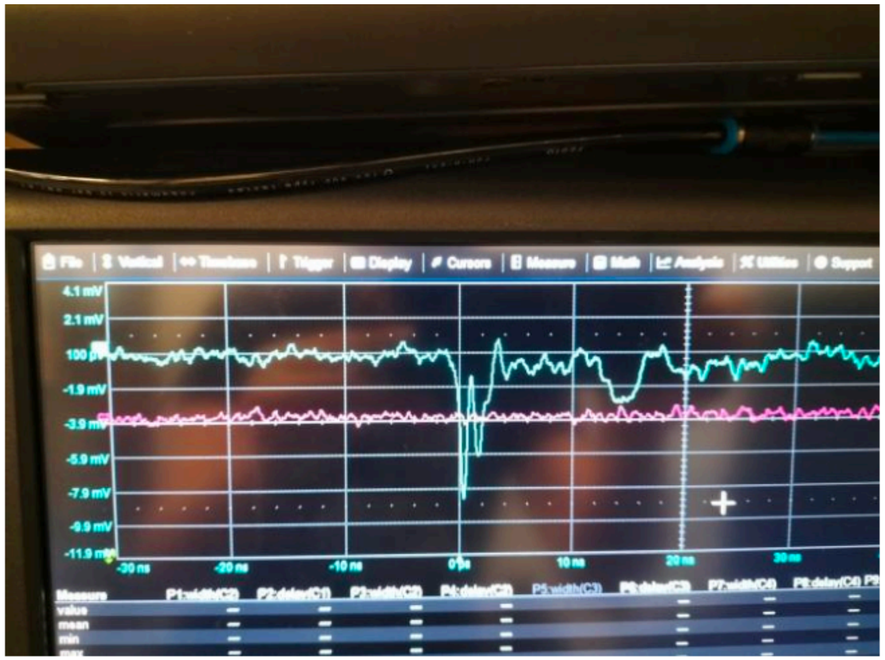


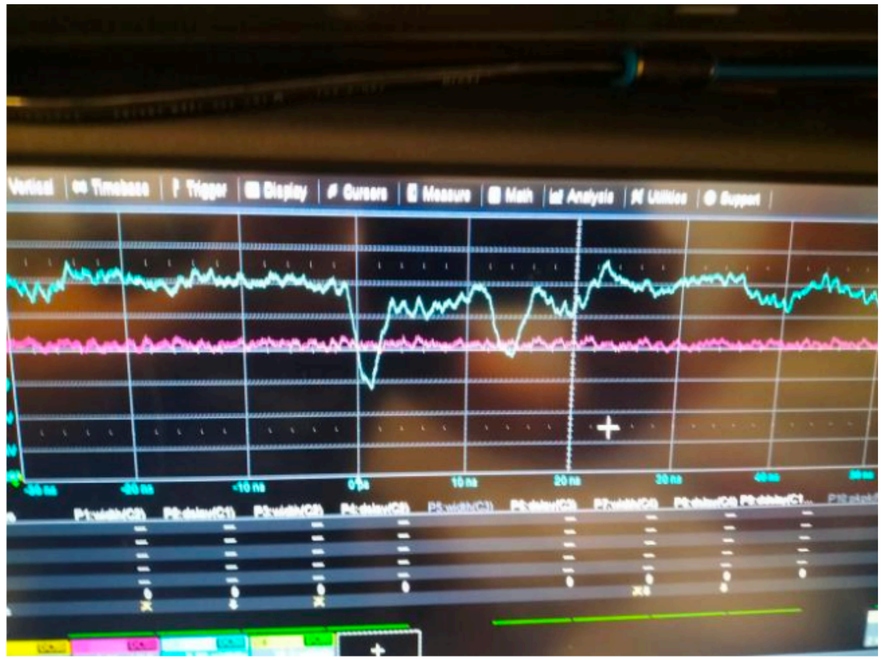
Prototype 00 @ Tor Vergata (RM)

$$gas\ gap\ g = 1\ mm - R_i = 12\ mm$$

- Gas leak issues to poor bonding technique
- Single readout strip (unterminated) on external electrode.
- RCC holds the applied high voltage (HV- on internal electrode).
- Single-channel signals acquired (without cosmic trigger) showing correct polarity (HV-).



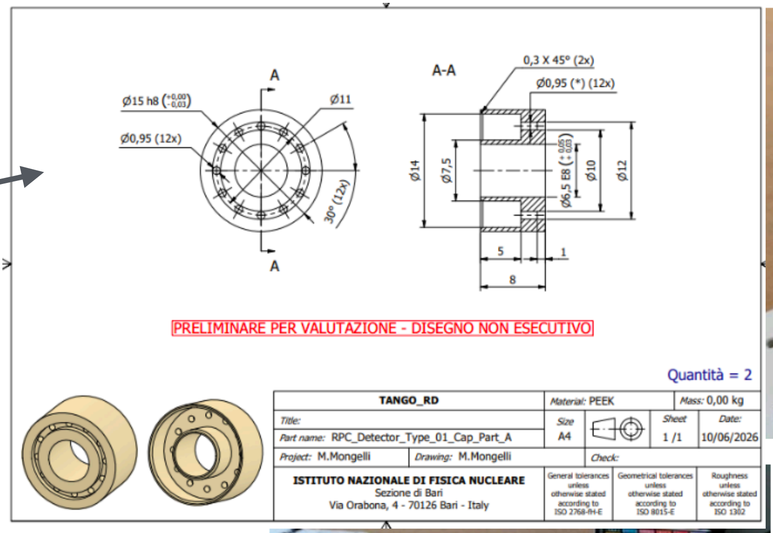


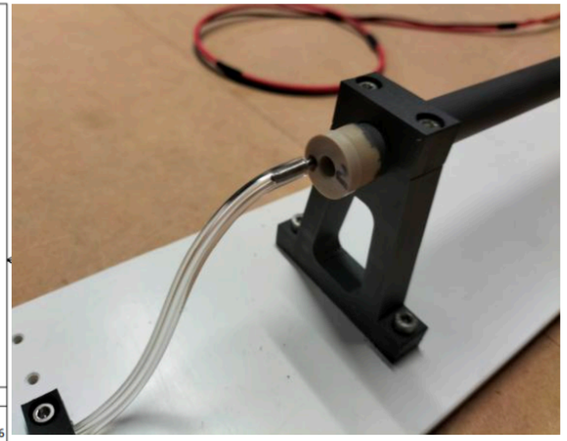


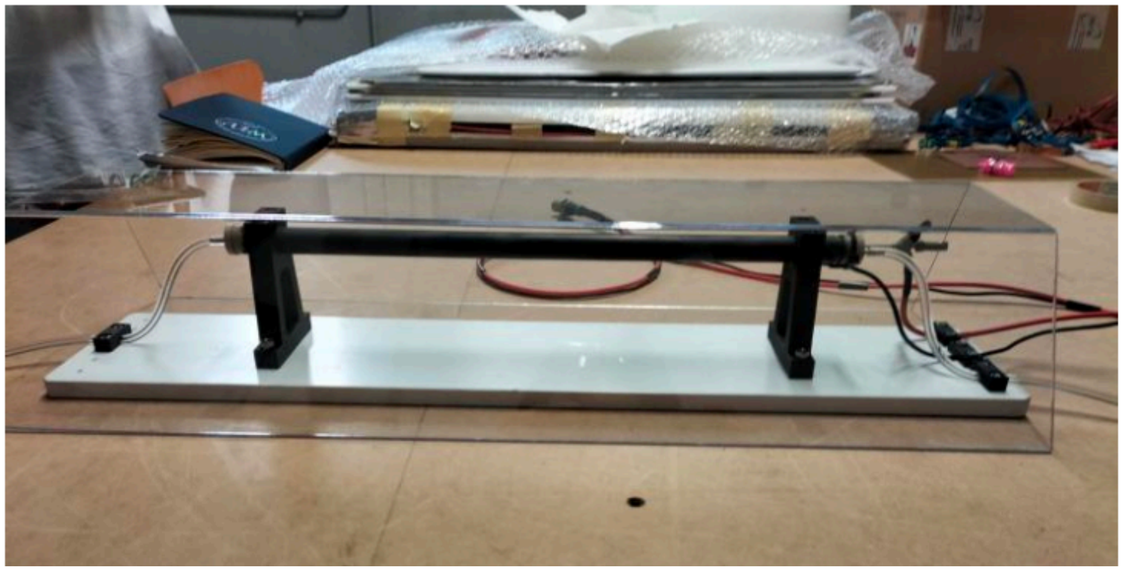
Prototype 0 @ Bari

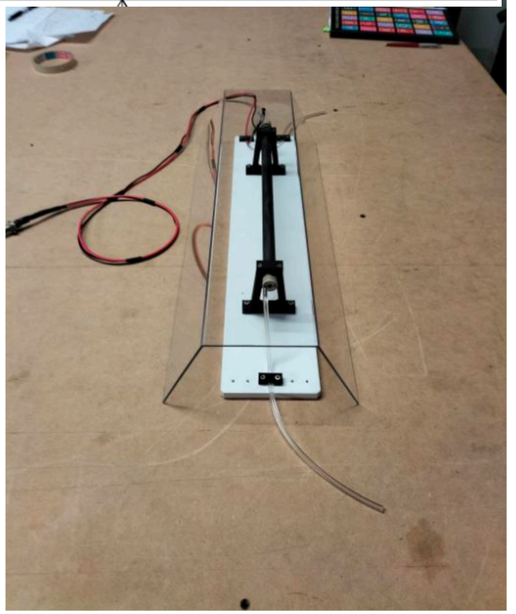
$$gas\ gap\ g = 1\ mm - R_i = 5\ mm$$

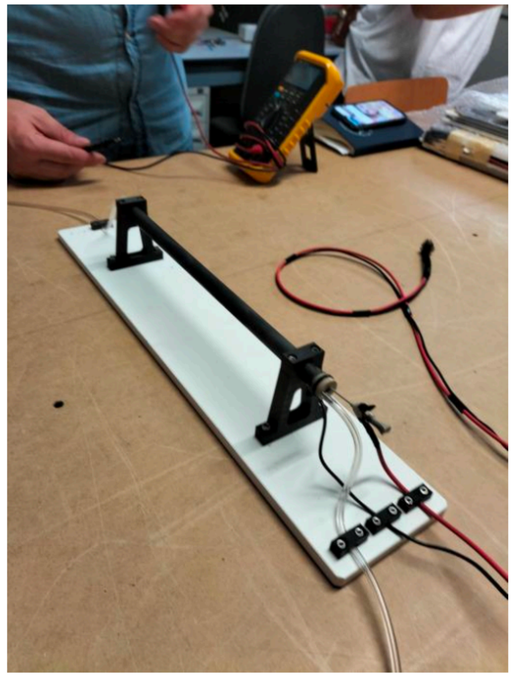
- **PEEK Endcaps:** CAD-designed and lathe-machined.
- **Coating:** Fill-coating technique (pressure/suction) using a rotating roller.
- **HV Distribution:** Commercial off-the-shelf Beryllium-Brass components.
- **Bonding:** Gas-tight and mechanically resistant bonding using Araldite.







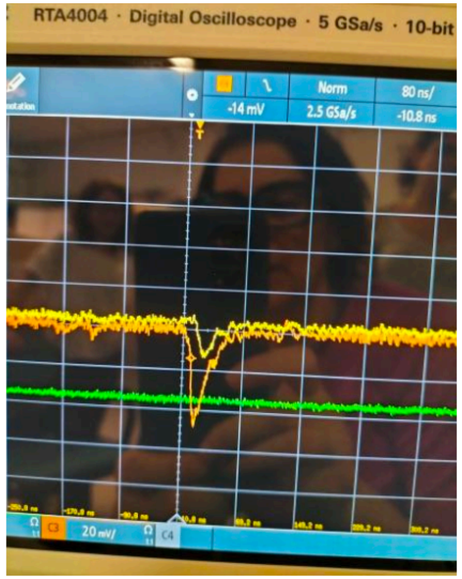




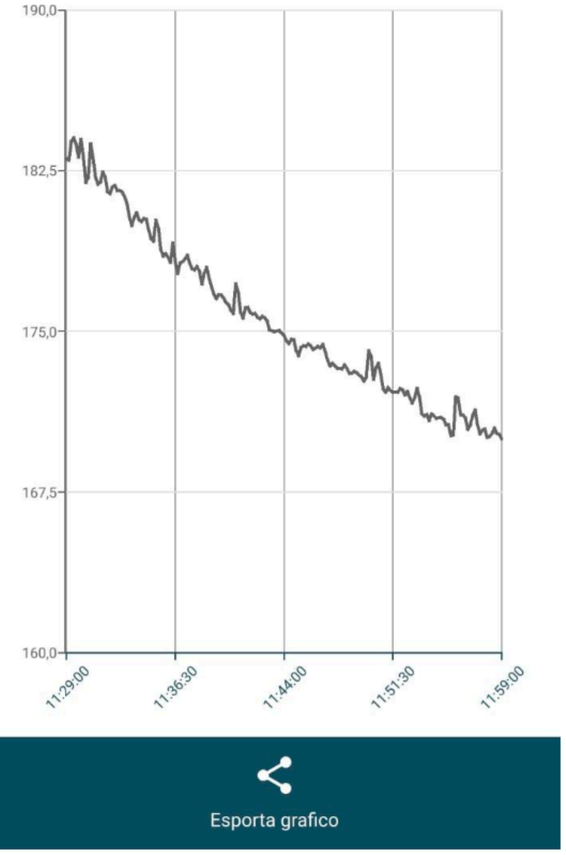
Prototype 0 @ Bari

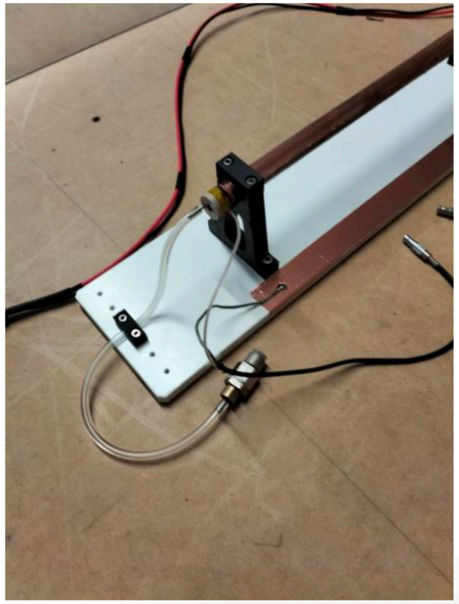
$$gas\ gap\ g = 1\ mm - R_i = 5\ mm$$

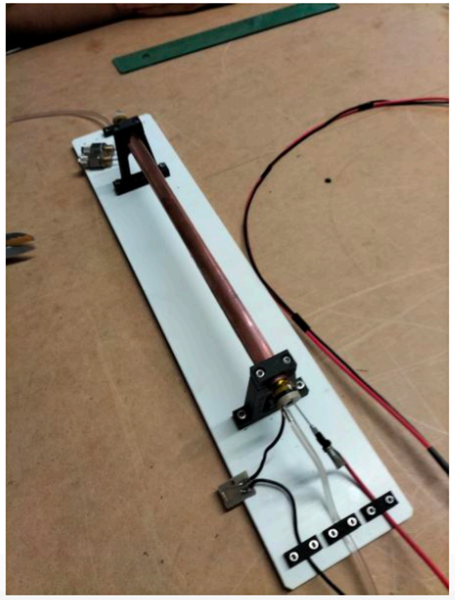
- **Overpressure Sealing:** Gas-tight up to approximately 200 mbar.
  - < 15 mbar lost in 30’
- **Readout:** 2 readout strips (unterminated) on external electrode .
- **High Voltage:** Negative HV applied to internal electrode (without readout electrode).
- **Data Acquisition:** Cosmic ray-triggered signals acquired (geometrical acceptance difficult to estimate).

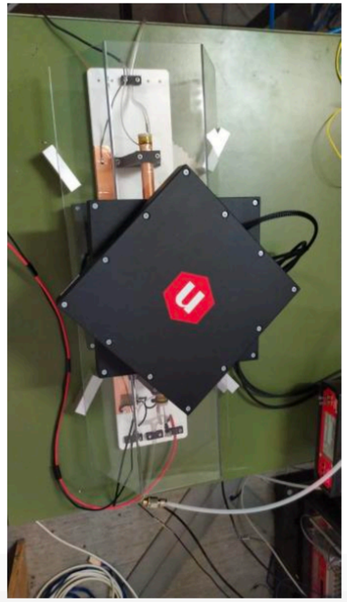


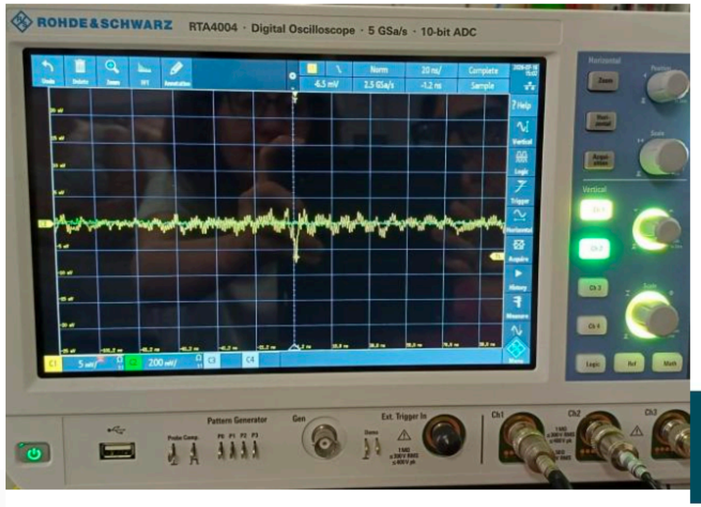








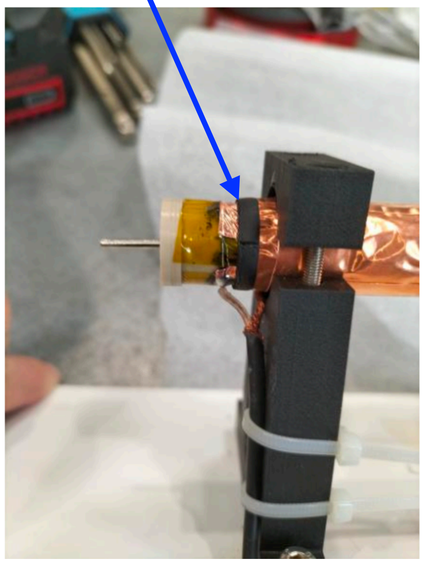


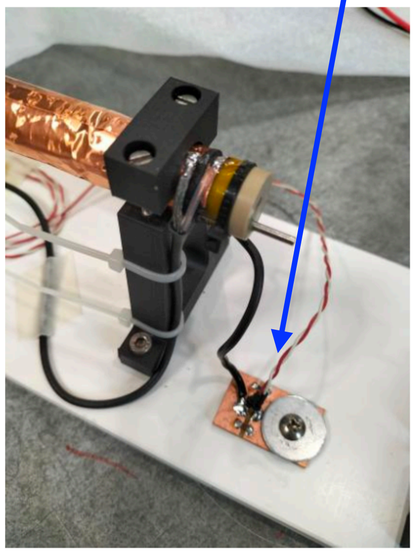


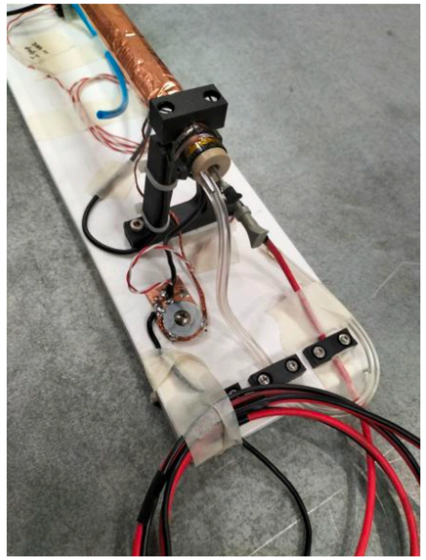
Prototype 0 dressing @ ToV

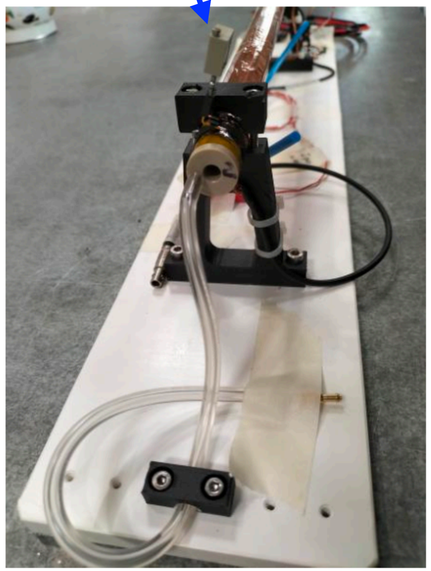
$$gas\ gap\ g = 1\ mm - R_i = 5\ mm$$

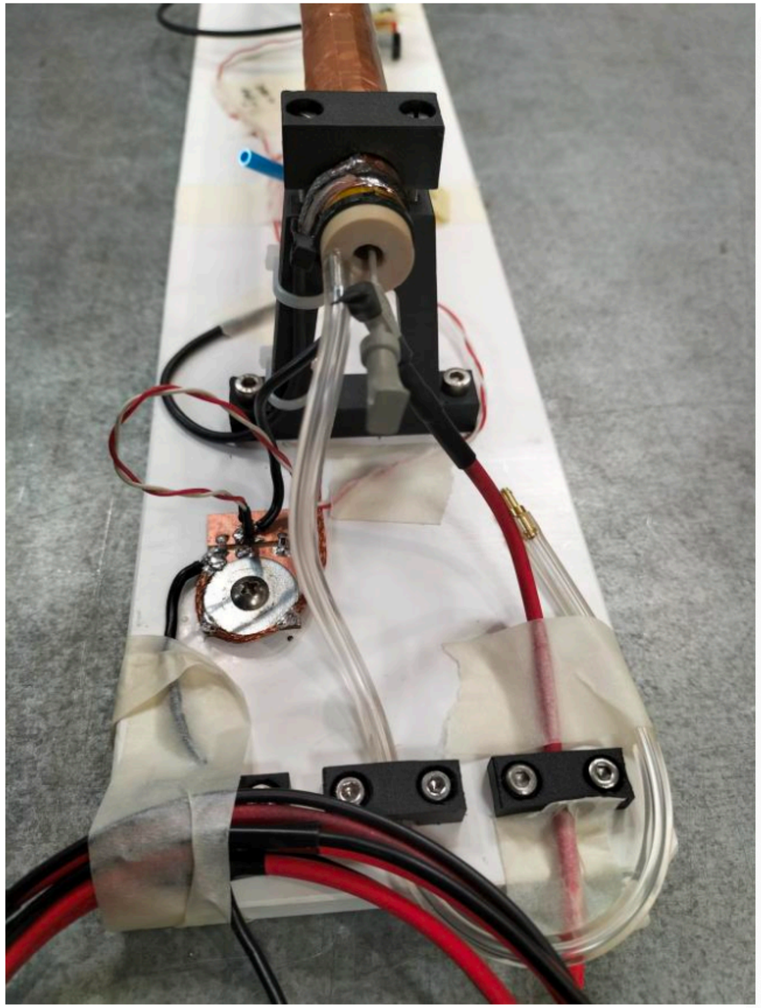
- **Outer Radius Layering:** Mylar layer, copper strip, neoprene layer, and copper ground plane.
- **Impedance Matching:** Variable resistor for strip matching, designed for Z_L =50 Ω.
- **Current Measurement:** Reinforced resistor for Igap readout (110 kΩ).





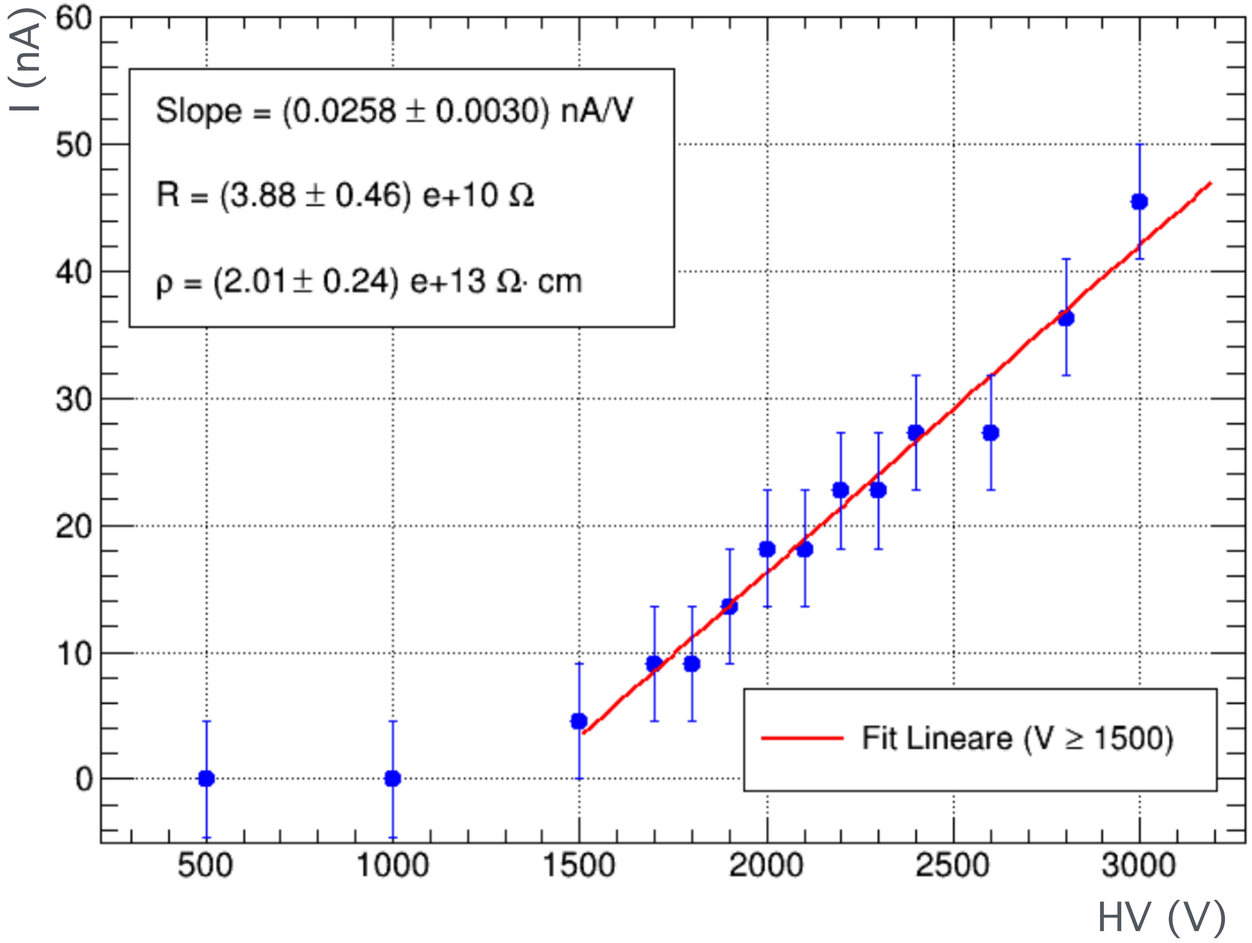






Prototype 0 Argon test @ LNF

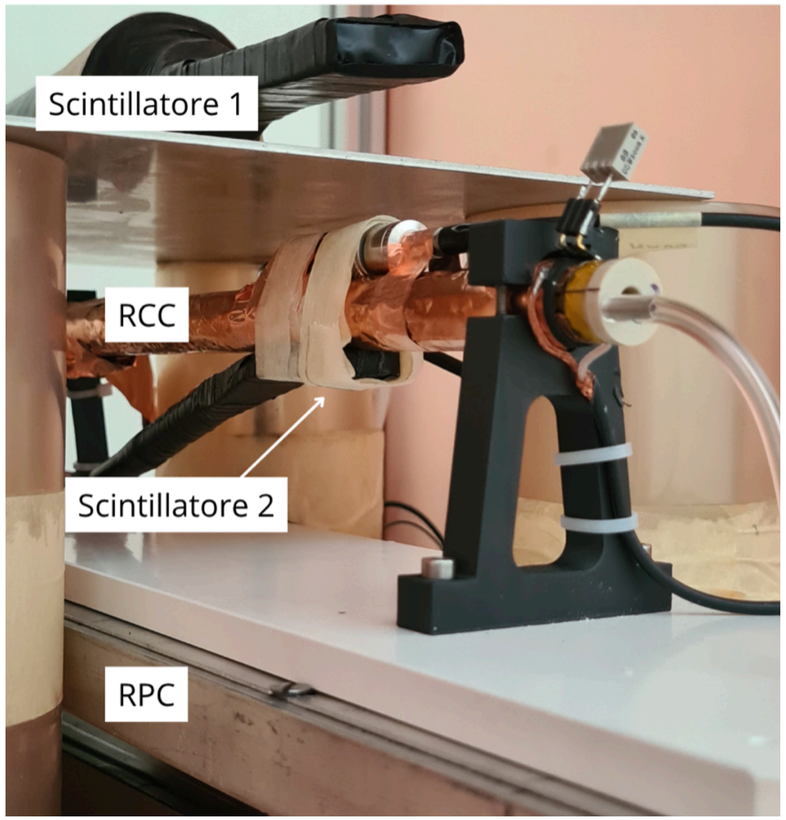
$$gas\ gap\ g = 1\ mm - R_i = 5\ mm$$



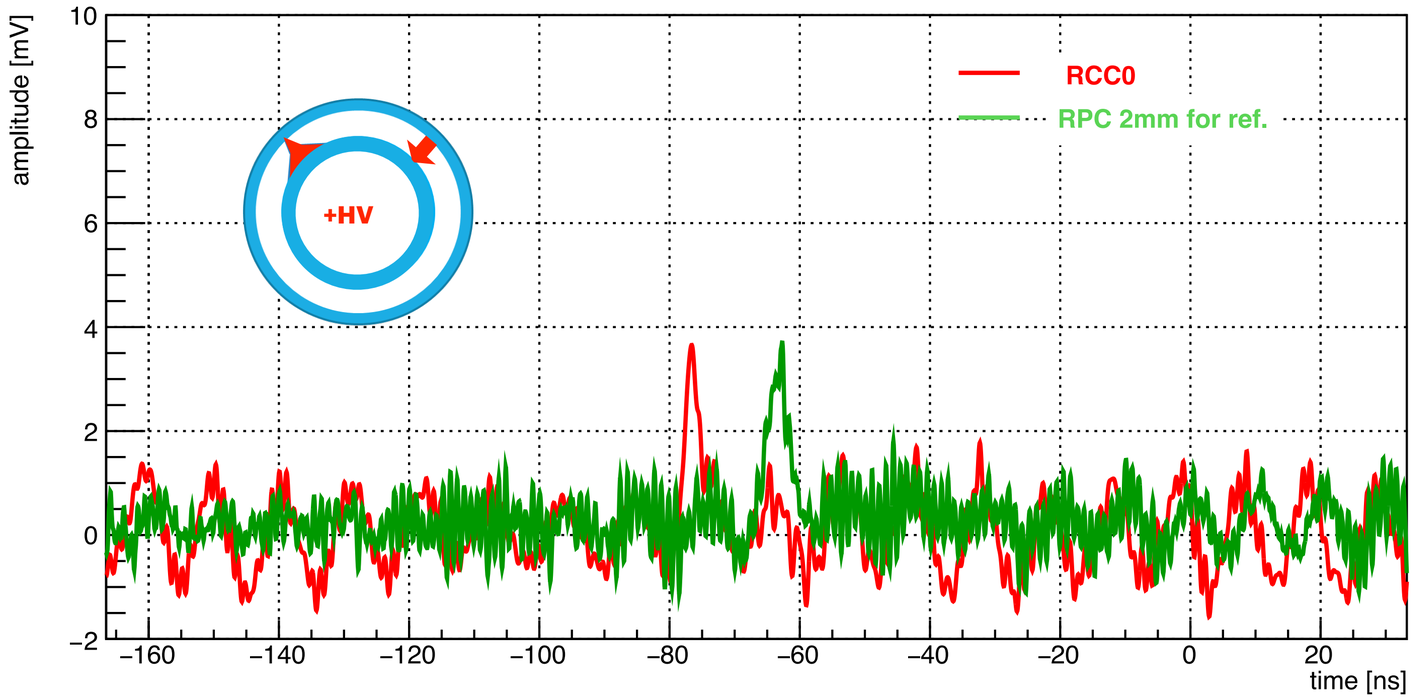
- **Electrode Resistivity Assessment:** Evaluated via Argon scan.
- **Tube Dimensions:** Inner radius (Ri) 4.5 mm, outer radius (Ro) 6.5 mm, length 30 cm.
- **Electrode Thickness:** 1 mm.
- **Extracted Resistivity:** 2×10^{13} Ω·cm.

Prototype 0 Cosmic test @ LNF

$$gas\ gap\ g = 1\ mm\ \text{-}\ R_i = 5\ mm$$



RCC operated in positive polarity



Limited Characterization: A comprehensive characterization was precluded by ambient noise levels and complex cross-talk between the top and bottom strips (S_{up} and S_{down}).

Signal Degradation: Environmental noise combined with inter-strip interference prevented further in-depth performance analysis.

Prototype 00 Cosmic test @ ToV

$$gas\ gap\ g = 1\ mm\ \text{-}\ R_i = 12\ mm$$

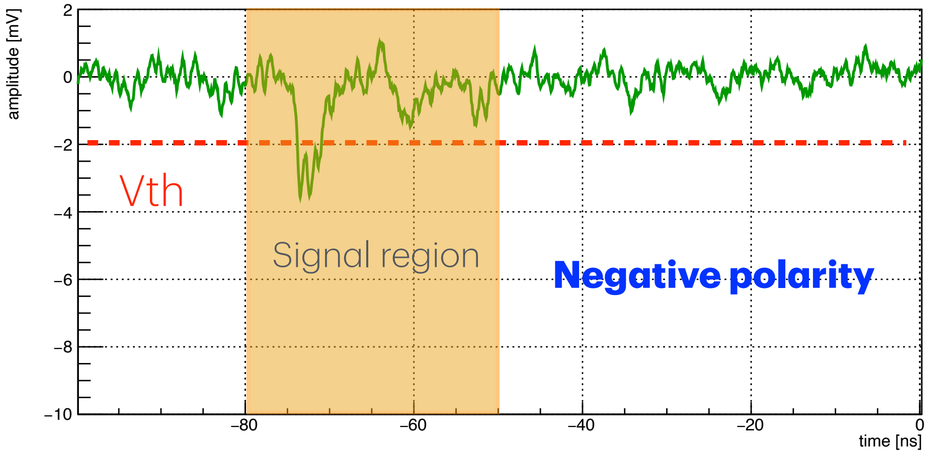
PRELIMINARY

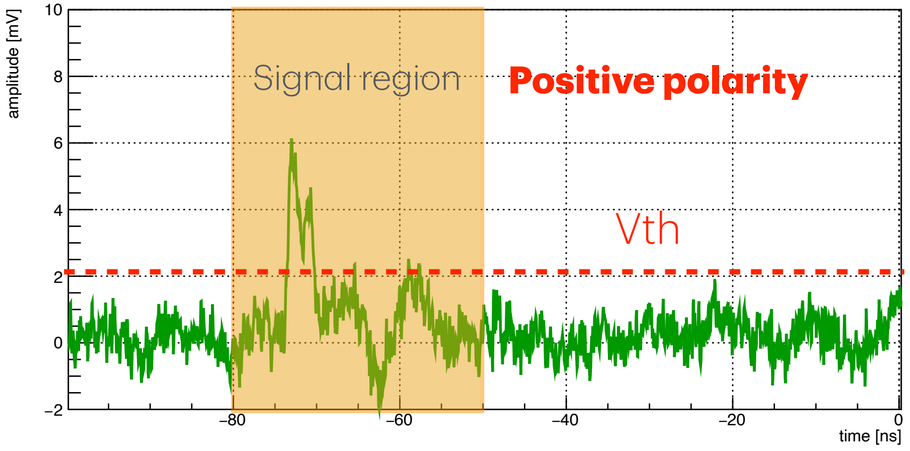
Scint up

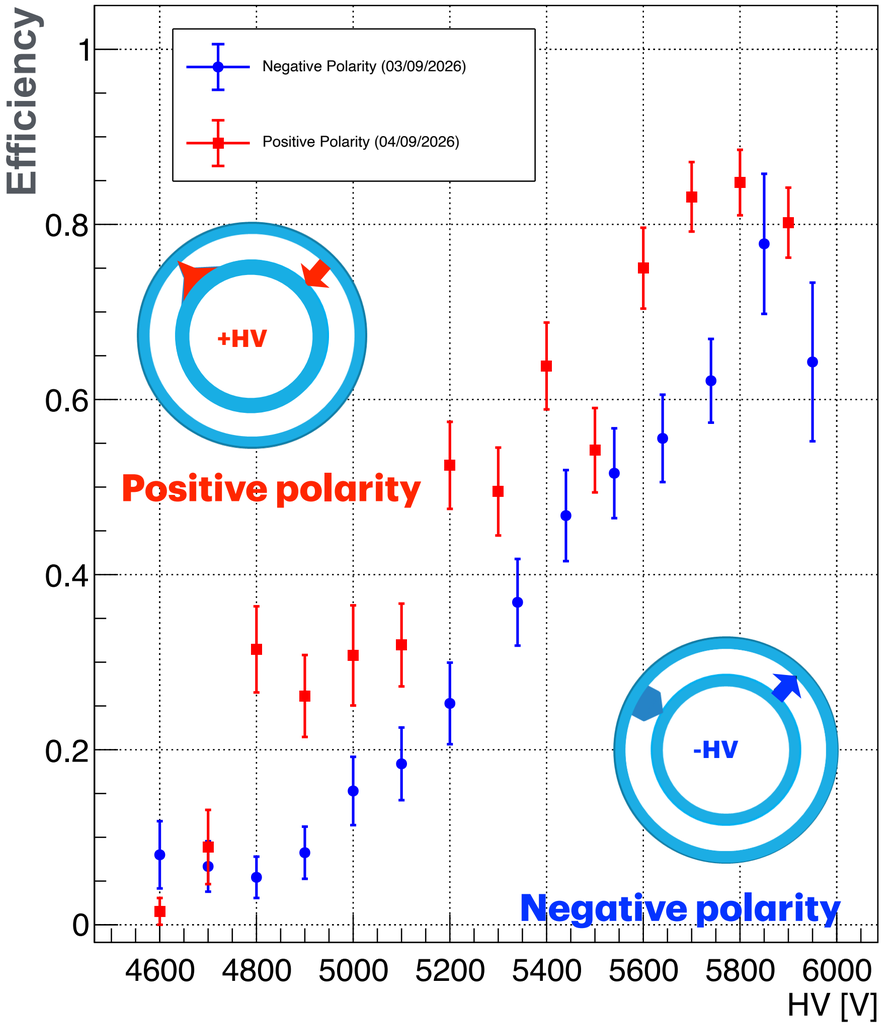
Pickup strip



Scint bottom



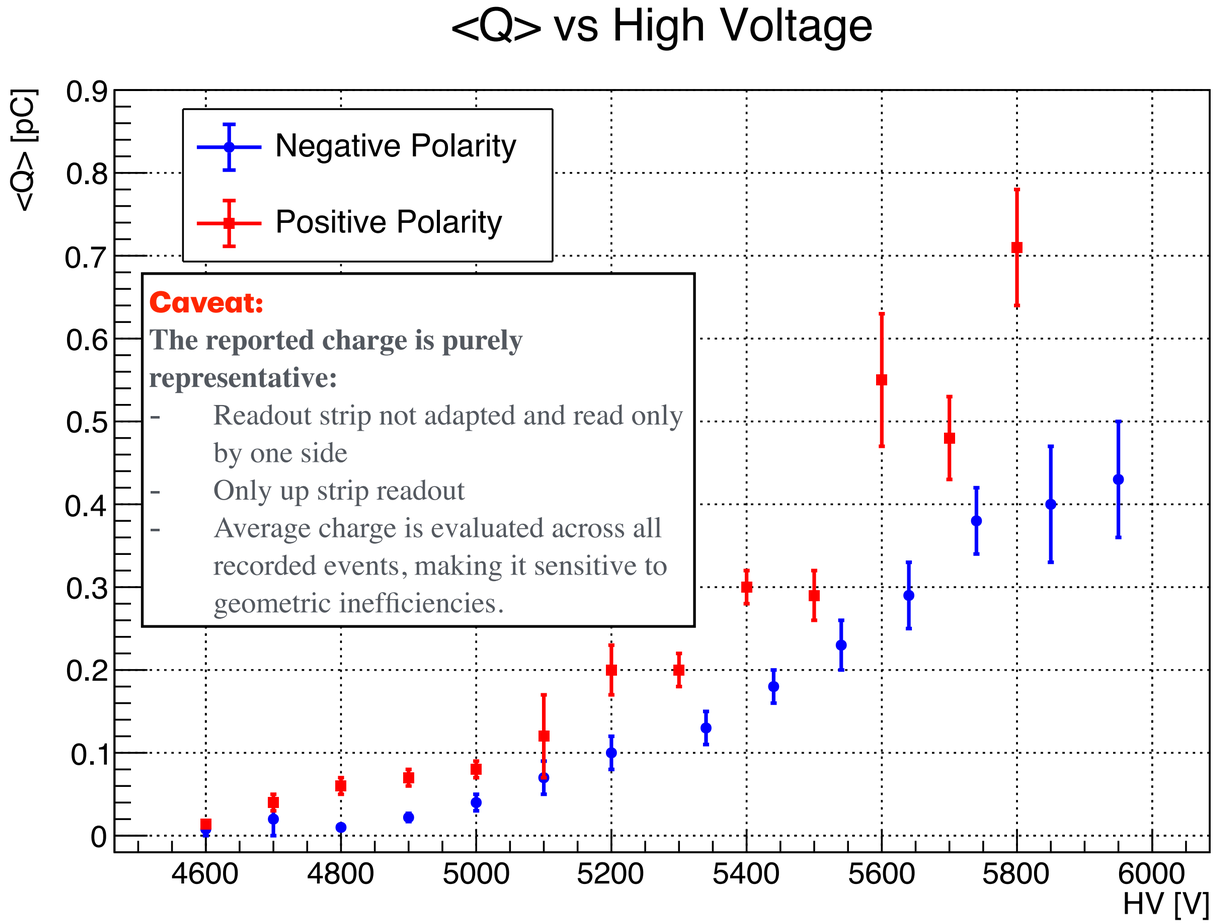


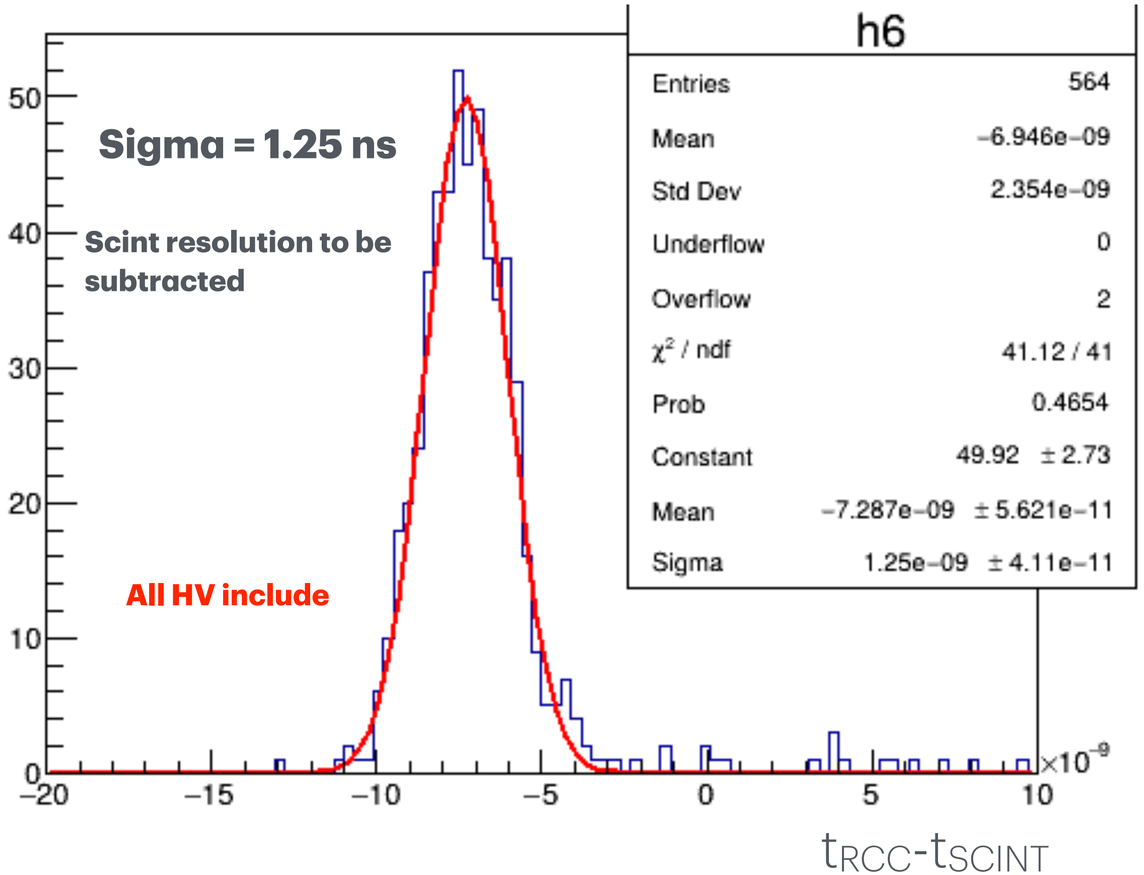


Prototype 00 Cosmic test @ ToV

$$gas\ gap\ g = 1\ mm \text{ - } R_i = 12\ mm$$

PRELIMINARY





Conclusions

- **TANGO_RD:** Is a new INFN project to fully characterize RCC behavior
- **First prototypes**: Two prototypes manufactured in soda lime glass (1 mm gas gap - R_i = 5 and 12 mm) .
  - Several details under study to improve manufacturing .
- **Operations**:
  - prototype RCC-0 tested successfully with OVP up to 200 mbar.
  - HV correctly applied and signals of the correct polarity
- **Preliminary tests:**
  - Few details to improve on the RCC 0 prototype have been understood
  - Preliminary characterization of prototype 00 (limited control on the gas gap thickness uniformity)
  - Asymmetry between positive and negative polarity in both efficiency and charge distribution
- **Simulation:** A standalone simulation model has been developed to underline the main Physics characteristics of the detector
  - Comparison with old experimental data is good.
  - We look forward to extend the comparison to new data