

Phenolic glass based materials for the RPC electrodes

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R. Santonico

INFN and University of Tor Vergata, Rome, Italy

On behalf of the Rome2 RPC group

Abstract

- Pure phenolic glass and melamine coated phenolic glass. Optimal combination of electrical and mechanical properties
- Electrode thickness: the advantages of thin/very-thin electrodes
- Flexibility coupled to high mechanical performance

The phenolic glass

- The «phenolic glass» is a material made of glass fibers embedded inside the phenolic resin. This gives the advantage of coupling the low and well tunable electrical resistivity of the phenolic polymers with the high mechanical performance of the glass. Two types of materials suitable for the RPC electrodes have been studied so far:
 - Pure phenolic glass plates
 - Melamine coated phenolic glass plates, made with a phenolic glass core sandwiched between 20 micron thick melamine foils
- The mechanical performance of the phenolic glass offers the possibility of building RPCs with very thin electrodes that would be impossible, e.g. with the standard laminate where the phenolic resin impregnates a cellulose substrate
- The importance of thin electrodes has been already stressed and is one of the main points focused in this talk
- Thin phenolic glass electrodes show a good flexibility while keeping a high level of mechanical stability. This offers also the unprecedented possibility to fit cylindrical geometries

Thin electrodes vs the induced read out charge

- The electrode thickness is related to the charge induced on the read out electrodes by the well known relationship...

$$q_{\text{ind}}/Q = 1/(1+2t/\epsilon_r g)$$

- Here q_{ind} is the charge induced on the read out electrodes, Q the total charge delivered in the gas, ϵ_r the relative dielectric constant and g the gas gap
- The signal is therefore attenuated by a factor $A=1+2t/\epsilon_r g$
- Scheme of the charge induction circuit: prompt and ionic signals
 - Each kind of signal follows a time scale depending on its drift velocity
 - Two drift velocities observed in the gas: electron and ion velocities, producing the prompt and ion signals, in the nanosecond and several microsecond scale respectively
 - Electrons and ions have to continue their drift motion even inside the electrode material in order to definitely close the power supply-detector circuit. The corresponding drift motion however is so slow as to require several milliseconds. As a consequence, if your device detects a rate as modest as a few hundreds per second, this drift current takes a continuous structure where no signal is any more detectable inside. The corresponding charge is a «dark» charge that cannot be measured on a event by event basis but that can only be evaluated from the overall current absorbed in a heavily irradiated RPC
- This shows that the thinner is the electrode the smaller is the «dark charge» and the visible signal is correspondingly amplified

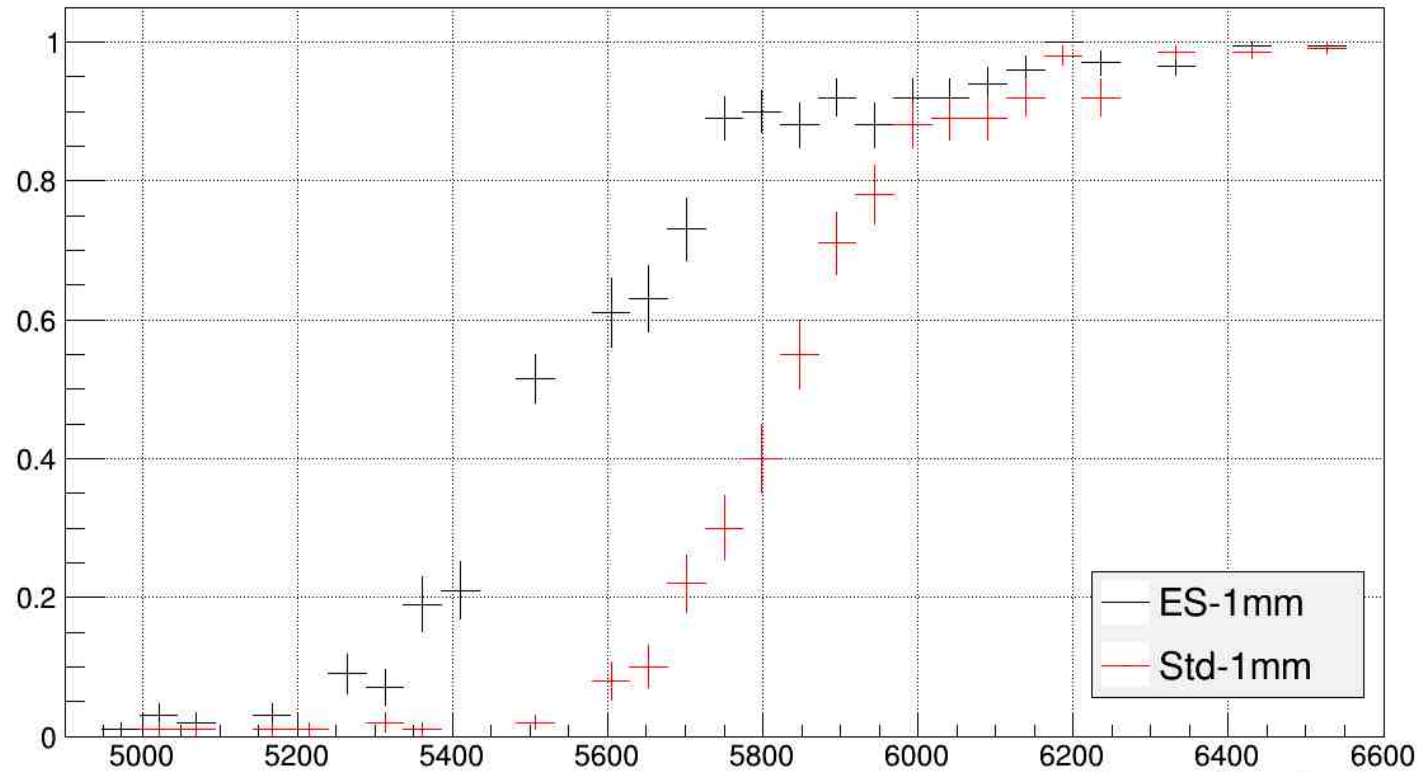
Test of different phenolic materials

The following tests were performed, at CR rates, on a few RPCs of sensitive area 10x50 cm².

- Melamine coated phenolic glass RPCs
 - .8 mm thick electrodes of high resistivity and 1 mm gap
- Pure phenolic glass RPCs
 - .5 mm electrodes of both high...and low...resistivity with 0.5 mm gap
- Pure phenolic glass bigap RPC
 - 2x1 mm gas gaps
 - 0.5 mm external electrodes
 - 0.17 mm inner floating electrode

Melamine coated 0.8 mm phenolic glass electrodes vs standard 2 mm electrodes

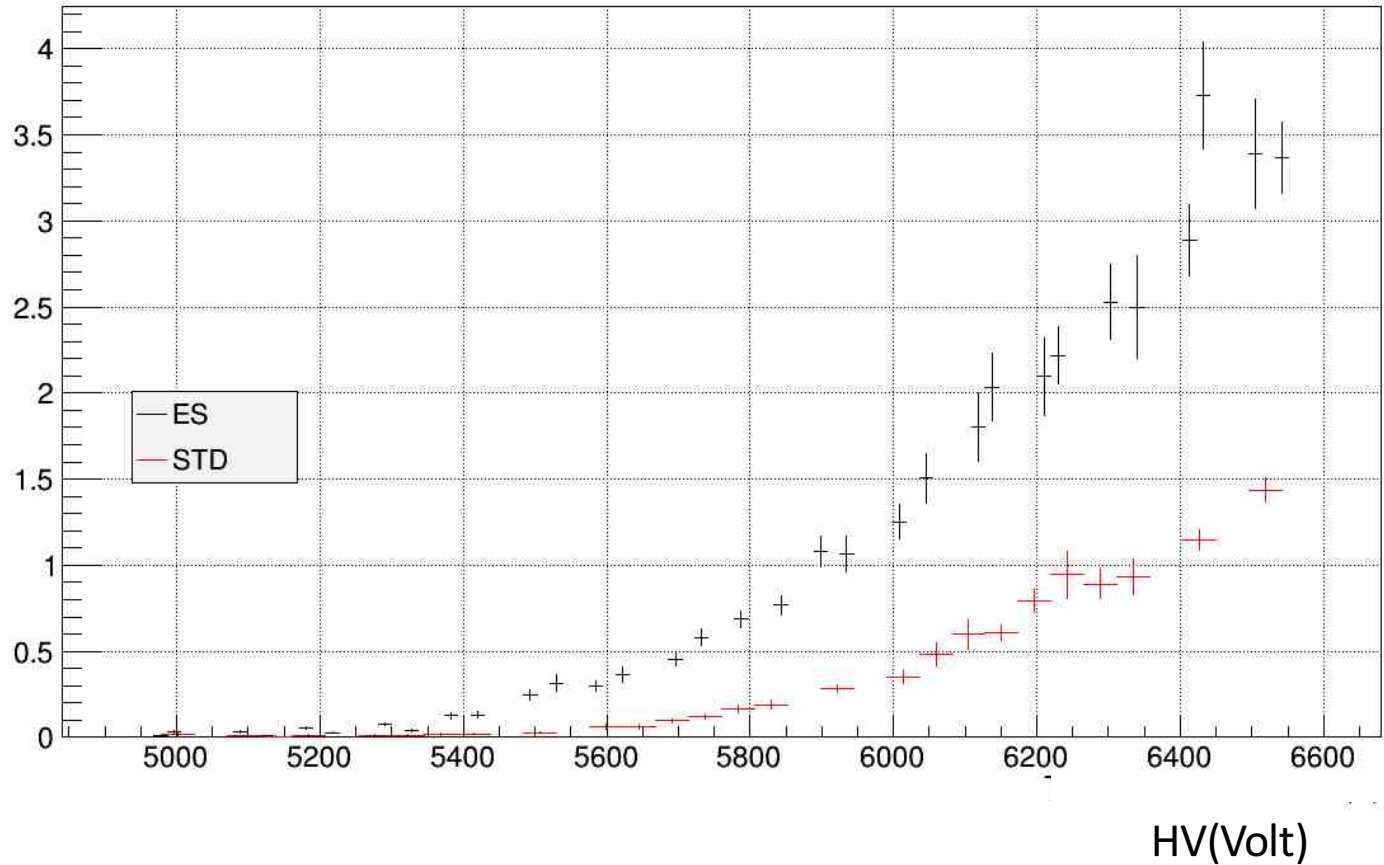
Efficiency vs voltage comparison



Melamine coated 0.8 mm phenolic glass electrodes vs standard 2 mm electrodes

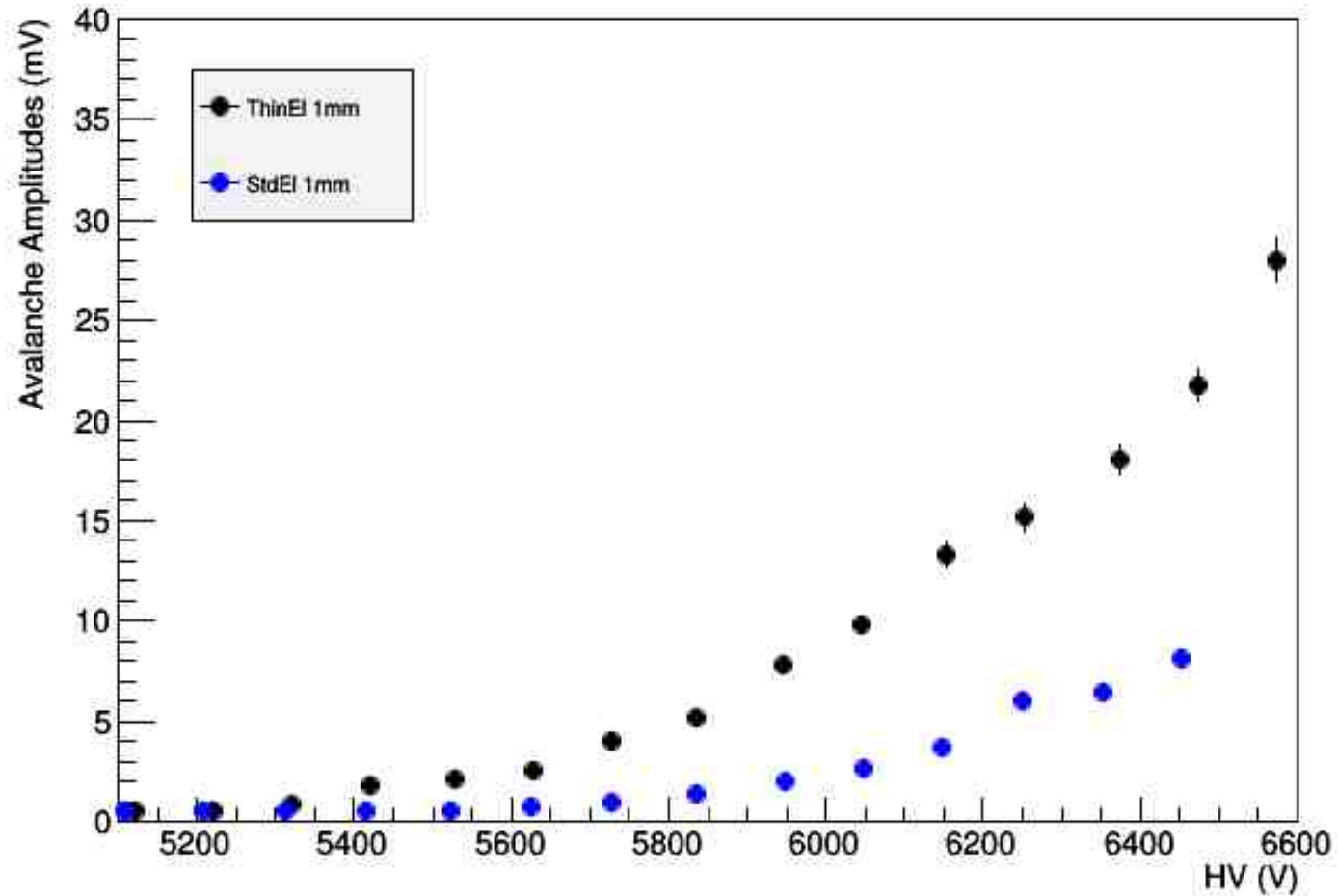
Prompt charge comparison

Prompt charge (pC)



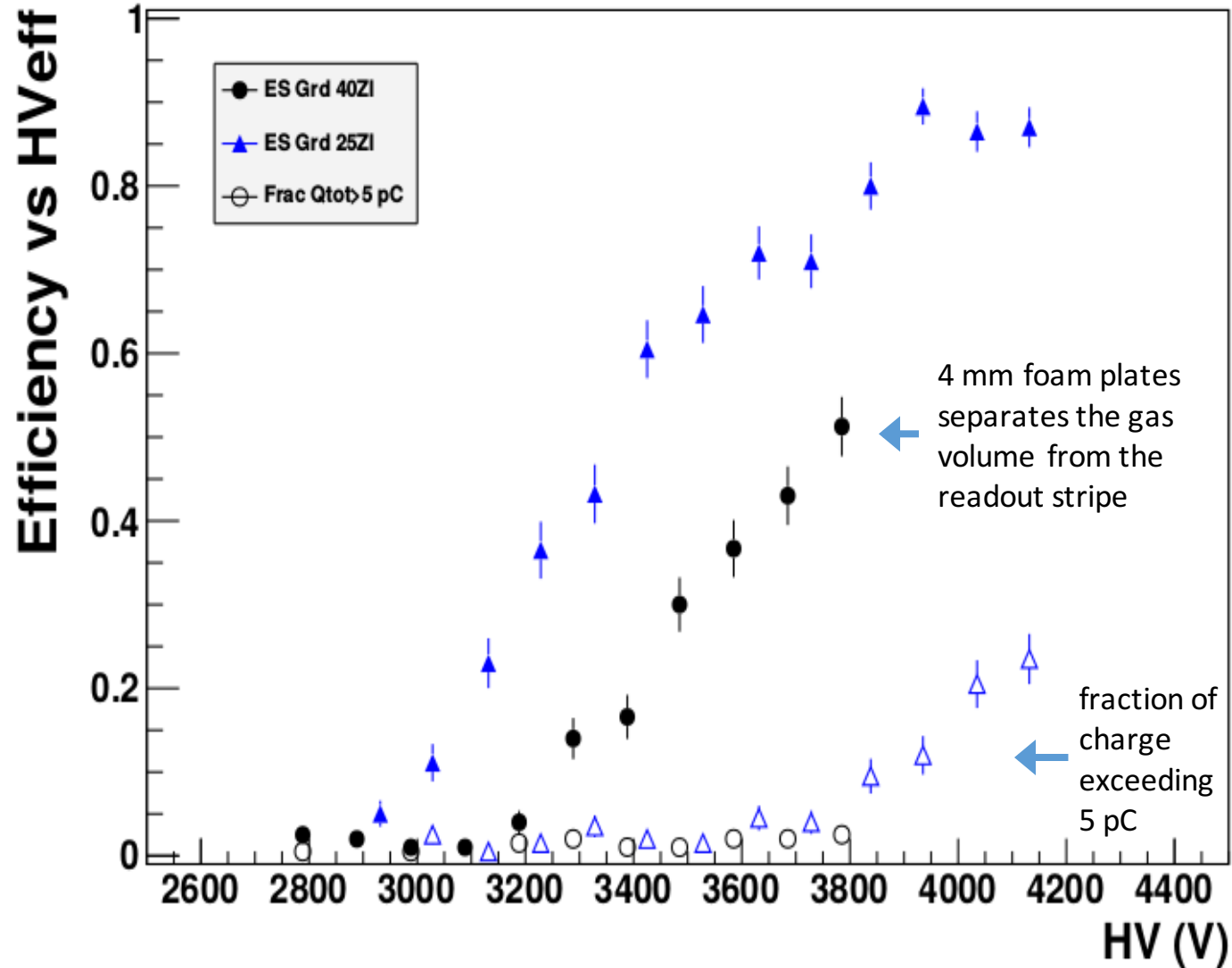
Prompt signal amplitude comparison

1 mm Gas Gaps ThinElectrodes vs Standard



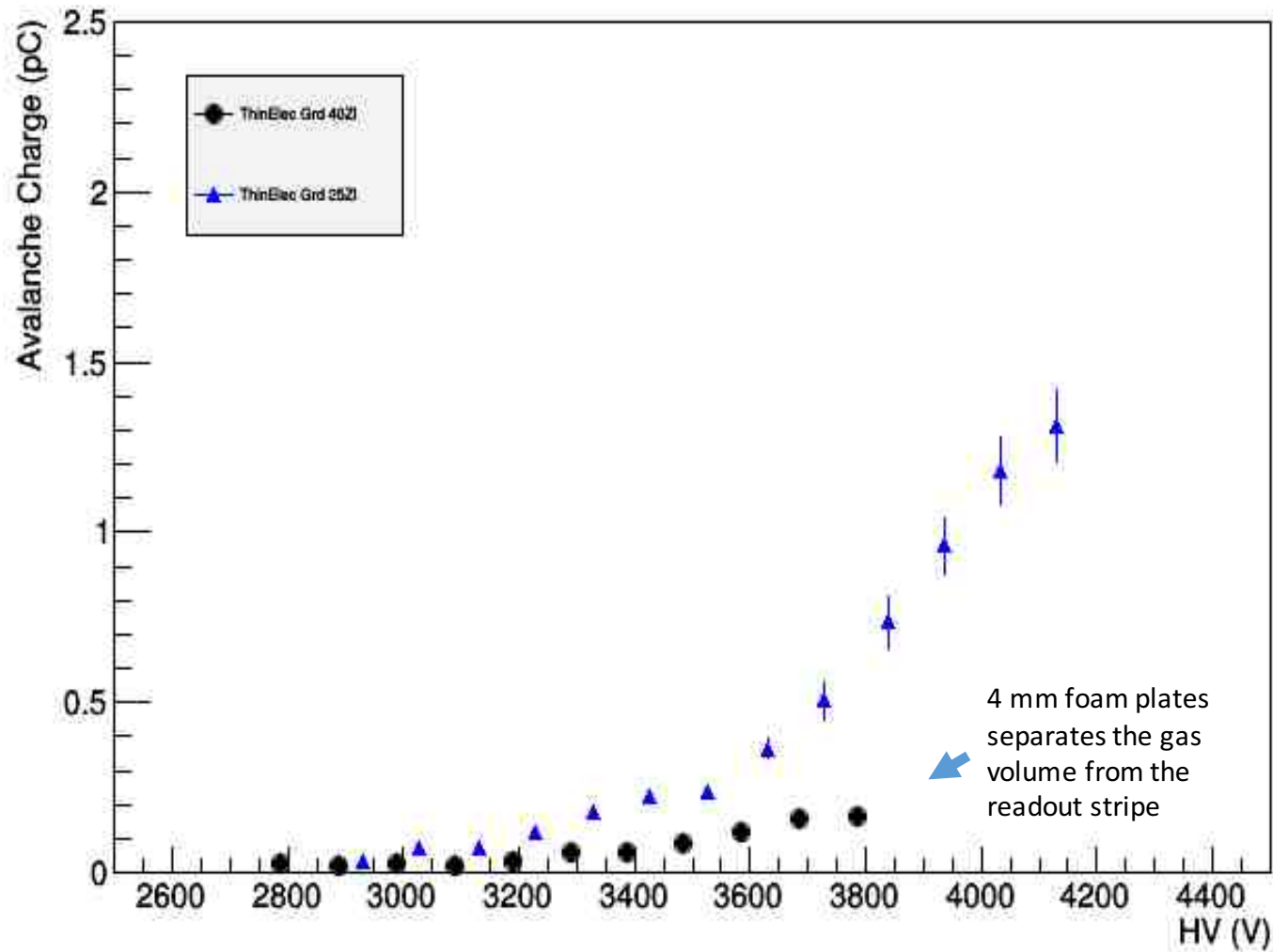
Pure phenolic glass Efficiency vs HV

0.5 mm Gap with 0.5 mm ThinElectrodes



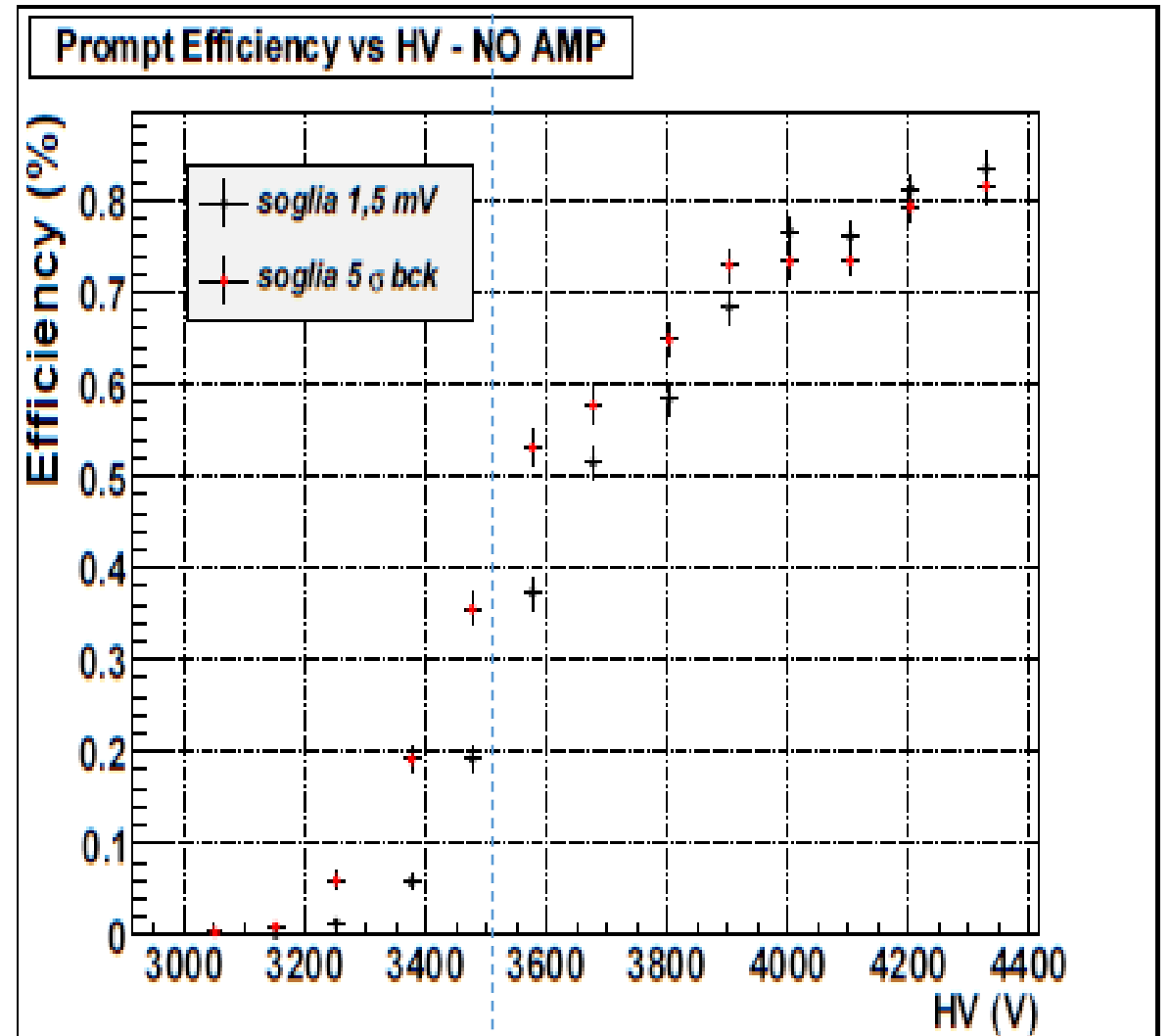
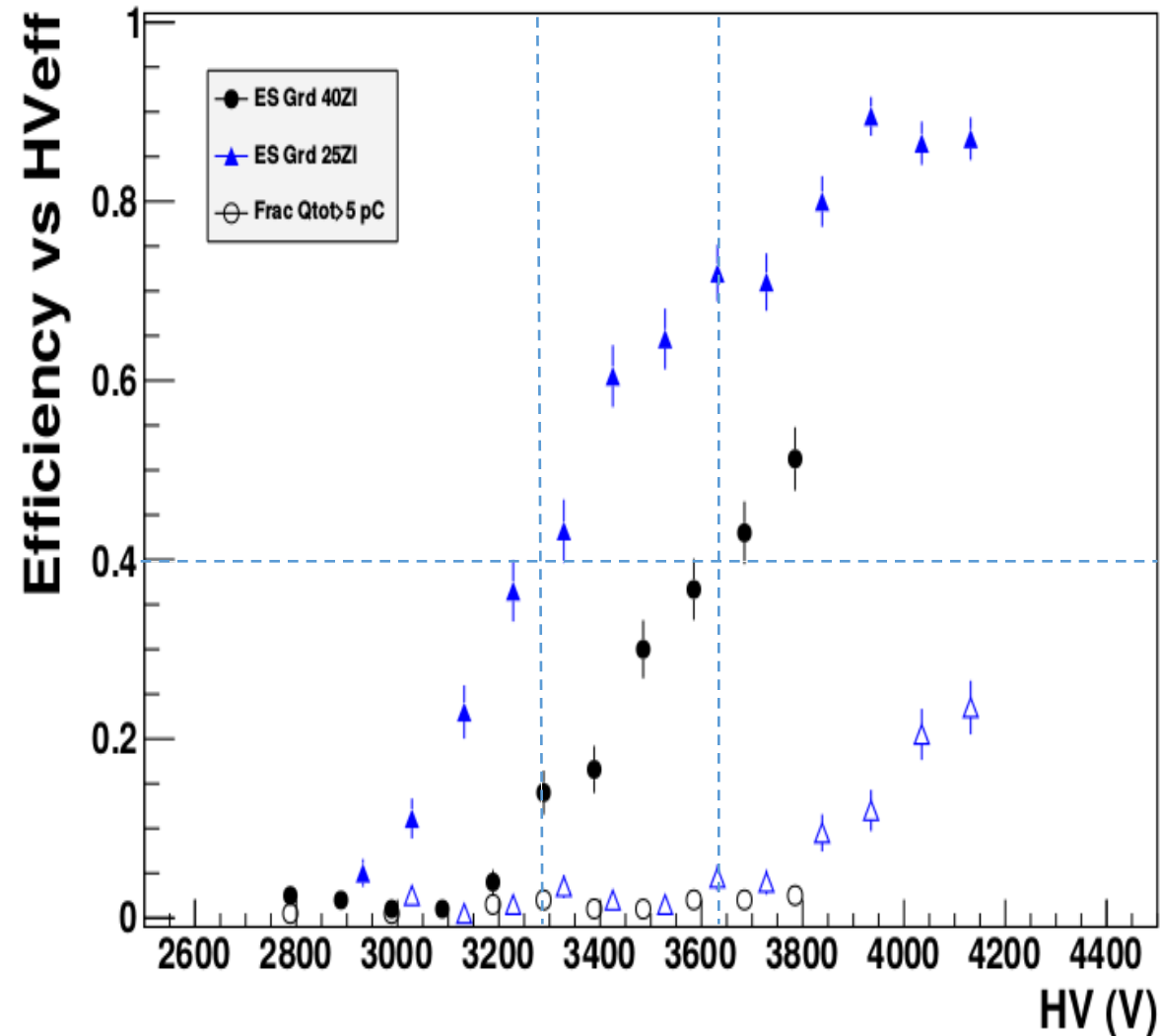
Prompt charge comparison vs HV

0.5 mm Gap with 0.5 mm ThinElectrodes

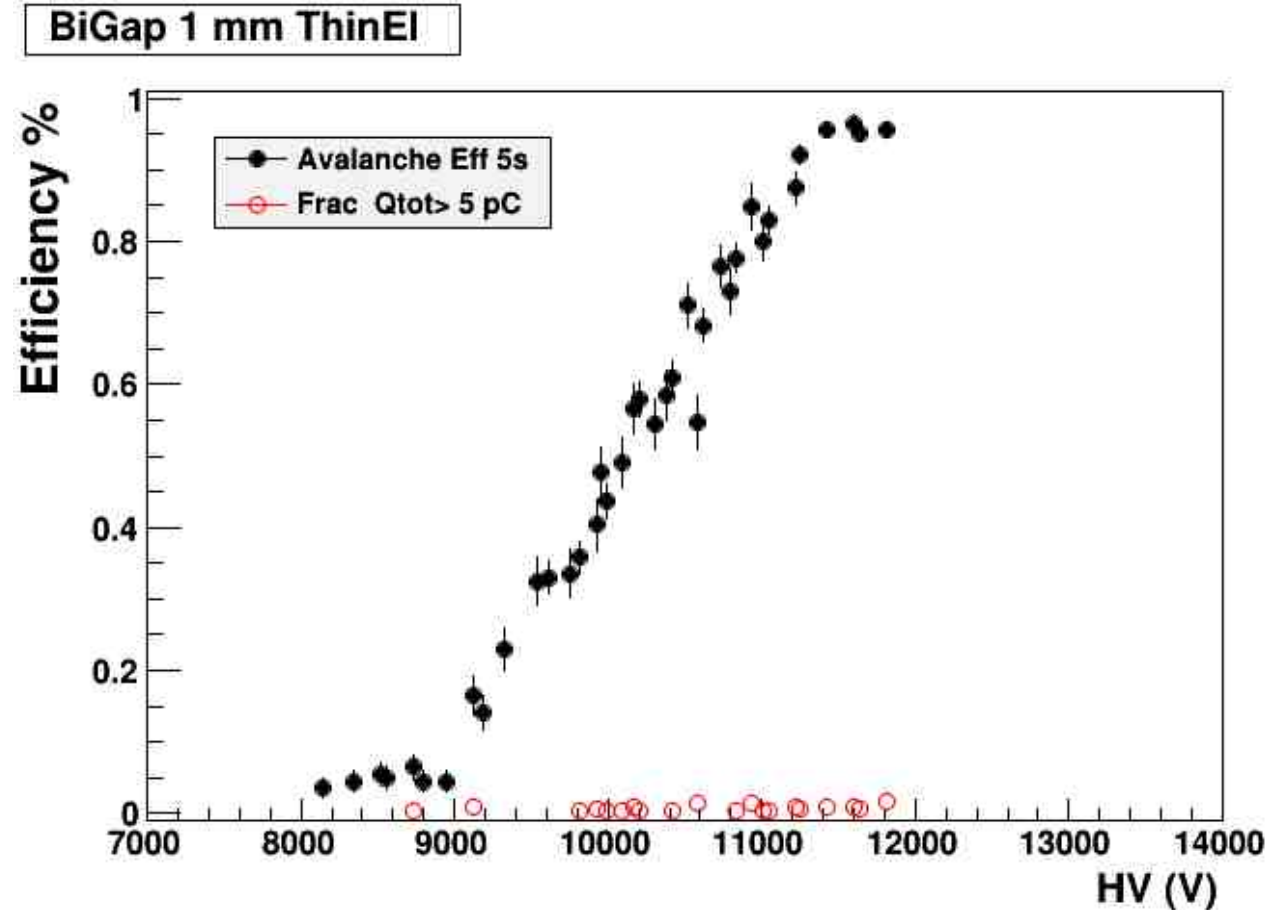


0.5 gap – 0.5 electrode vs standard electrodes

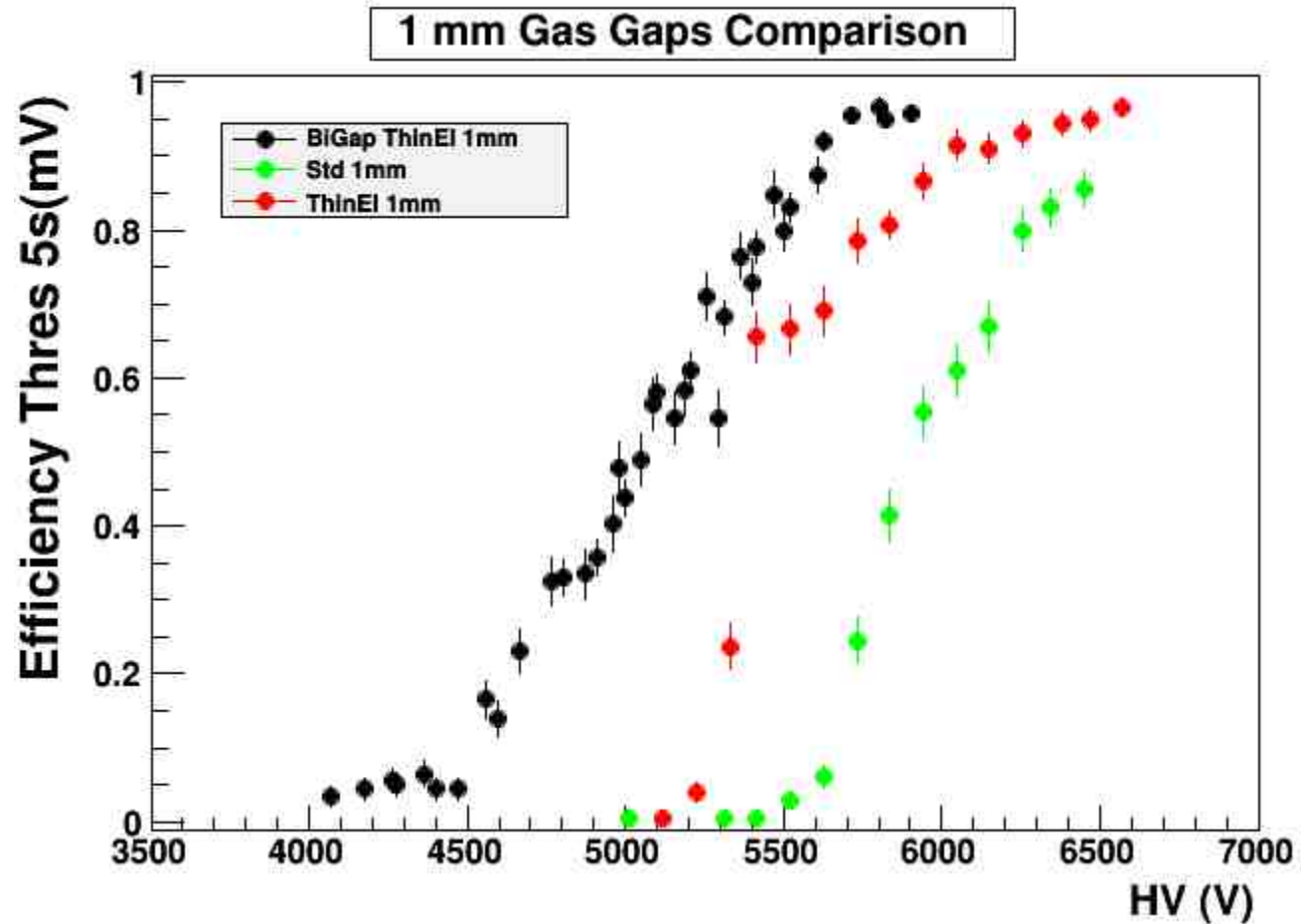
0.5 mm Gap with 0.5 mm Thin Electrodes



Pure phenolic glass 1+1mm bigap 0.5mm external electrodes 0.17mm floating inner electrode



Single vs bigap comparison



Comments on the multigap RPCs with floating inner electrodes

- An important achievement and the simplest RPC configuration to reach timing accuracies in the tens of picosecond range
- Based on the principle of the **self-equipartition of the electric field** among different gas gaps
- This principle makes the simplicity and the competitiveness of multigap RPCs
- This principle can work only when the current flowing in the gas prevails over any Ohmic term

Prompt charge vs voltage

