Gas Detectors for μ systems

Marcello Piccolo

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μ system requirements for gaseous detectors

- Given the design we have seen up to now, a muon system should comprise a detector that;
  - Is efficient at detecting minimum ionizing particles.
  - Can cover very large areas with relatively low cost
  - Can afford long pick-up strips, or in general large capacitance electrodes.
  - Offers a good reliability.
  - Is mechanically sturdy so that installation would not require enormous care and time.
- Peculiarity of gas detectors is the very high granularity, they can offer.

μ system requirements for gaseous detectors (cont.)

- Different parts of the detector might experience different background condition:
  - e.g. the end-caps might have a much higher counting rate from beam associated e.m. stuff (traveling WITH the beam itself)
- This might warrant using different devices if performances required go beyond what a detector can yield.
- If possible, uniformity should be, in my opinion a guiding principle in design.

Which devices

- Either wire or parallel plates detector can fulfill the requirements mentioned above.
  - In the wire device compartment I will just mention the Plastic Streamer Tubes.
- As for what parallel plates detectors are concerned both plastics (various types) and glass have been used: both material have their pros and cons.

Rate capability for gas detectors

Detector	Hits/cm^2*sec	Typical p.h.
Plastic Streamer Tubes	$>10^4$	30 mV
Bak. RPC stream. Bak. RPC aval.	10 10^3	300 mV 3-5 mV
Glass RPC stream. Glass RPC aval.	1 10^2	300 mV 3-5 mV

Plastic Streamer Tubes

- This is a very mature technique:
  - More that 10^6 wires built in various experiments
  - The coverless design allows (strips) read-out transverse to the wires or pads.
  - The coordinate transverse to the wire can be obtained from the wire itself:
    - With this design one could have a very low cathodic resistivity, which, in turn, yields a good painting efficiency.
- Pulses are smaller that parallel plates detectors, (30 mV on the wires), but long electrodes have been successfully used. (up to 8 m. in length)
- Lately used in the BaBar muon identifier to replace an ageing bakelite RPC system.
- Not much R&D needed on the detector itself; might require some R&D on specific implementations (cabling, pickup, H.V. …)
- Not really a bidimensional device

What about RPC's

- Parallel plate counters are in principle devices that should be extremely easy to use and reliable.
- In practice things did not go the way one would expected with streamer devices when used on a large detector scale.
- In BaBar bakelite showed problems, that were connected also with operational misuse.
- For BELLE there was a big scare at the beginning, which faded away, as water content of the gas mix was controlled better. (The double gap design is also more robust)
- As of now, expectations for the Mylar lined bakelite advocated by a Chinese groups are very high.
- Still some concerns on long term reliability.
- Truly bidimensional devices

The RPC working environment

- Given the field shape of a parallel plate chamber, one is forced to use very electronegative (and thus chemically aggressive) gases.
- This in turn might harm the electrode surfaces and cause loss of performances.
- The way glass (e.g.) RPCs lose efficiency is typically due to an increase of dark current/singles rate, which, in turn, reduces the effective gap voltage because of the electrode bulk resistivity.

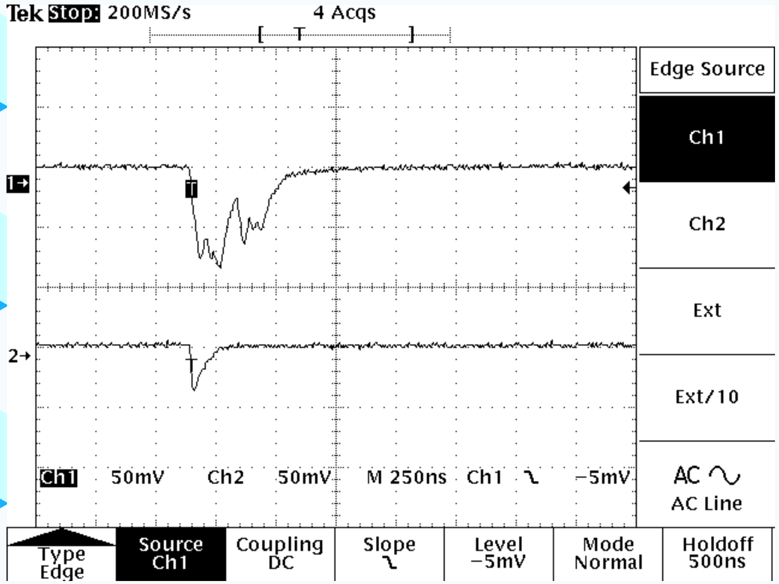
RPC R&D

- Many groups have developed both glass and bakelite parallel plate detectors.
- I will not present here, for once, the traditional R&D work on RPC
  - Many large systems are coming on line (LHC)
  - Many effort also present in the ILC community
- I will describe instead a different R&D effort which would eventually lead to a device that will offer stable performances because of the way it is built and operated

Quenching the streamers

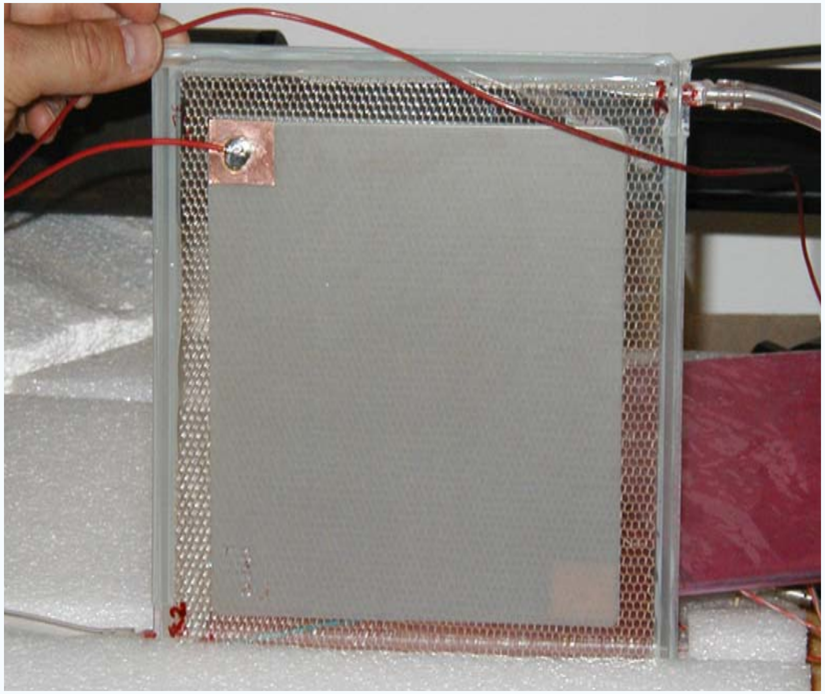
- As mentioned before, streamer confinement is usually obtained by the electrode resistivity (voltage drop upon discharge) and by using gases that eat-up electrons.
- We believe that the second function can be achieved mechanically using a mesh that would divide the gas volumes into cells, the division being impervious to discharge electrons.
- We tested this idea and I will show the data we obtained in the following.

Quenching the streamer (cont.)



- Here we can see the pulses of a 2mm gas gap filled with Argon/Isobutane 95-5 (%) mix @ 6000 V.
- The upper trace refers to a normal glass RPC.
- The lower trace refers to a glass RPC in which a mechanical quencher was at work.

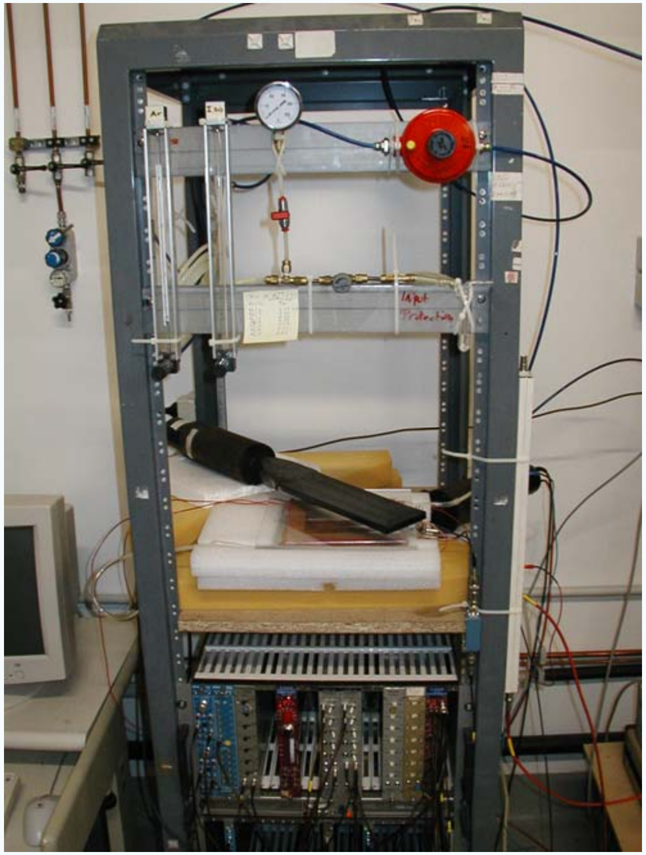
Mechanically Quenched RPC the ADHOQ detector



- A. Calcaterra, R. de Sangro, G. Mannocchi, P. Patteri, P. Picchi, M. Piccolo, N. Redaelli, T. Tabarelli de Fatis, G. Trinchero

- The material needed to quench must be a very good electrical insulator.
- It has to be mechanically sturdy
- It has to be resistant to chemicals and possibly non flammable.
- A material like that does exist and is routinely produced : it is used as a filler material in plane wings: ECA-I.
- Mesh size used up to now 3mm diameter.

Test Setup

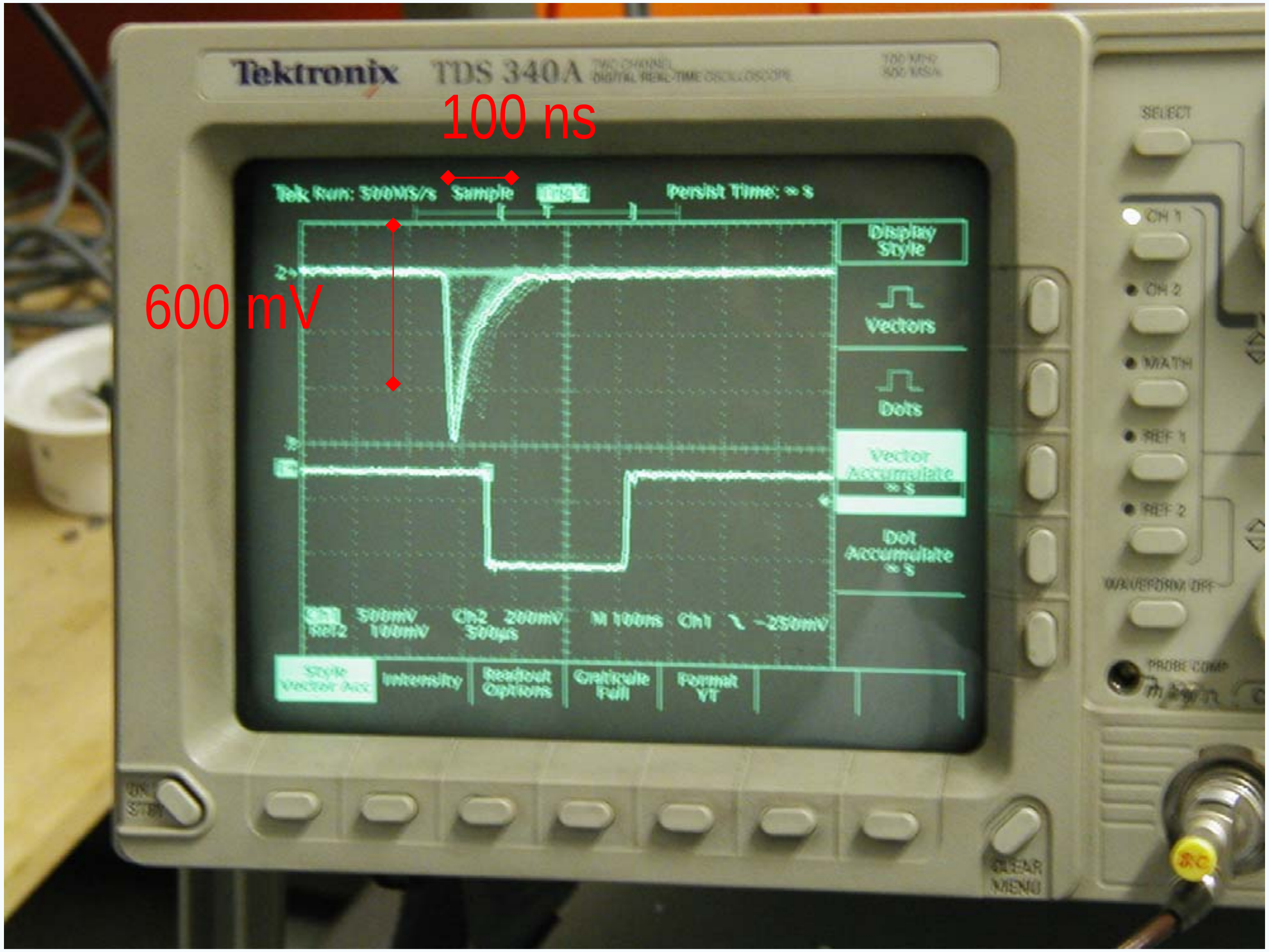


- Test 8x8 cm^2 area defined by two scintillator trigger counters.

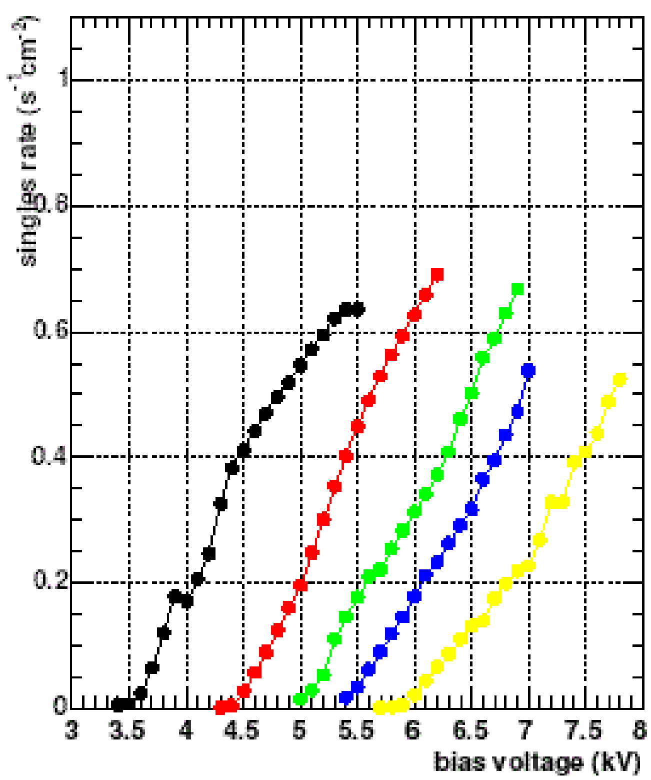
  One 18x18 cm^2 single pad for digital (30 mV threshold) and analog readout

- Gas Mixes Ar/Iso flowing at about 5 l/h
- Two chambers:
  - 2 mm glasses

2 mm glass chamber: preliminary results

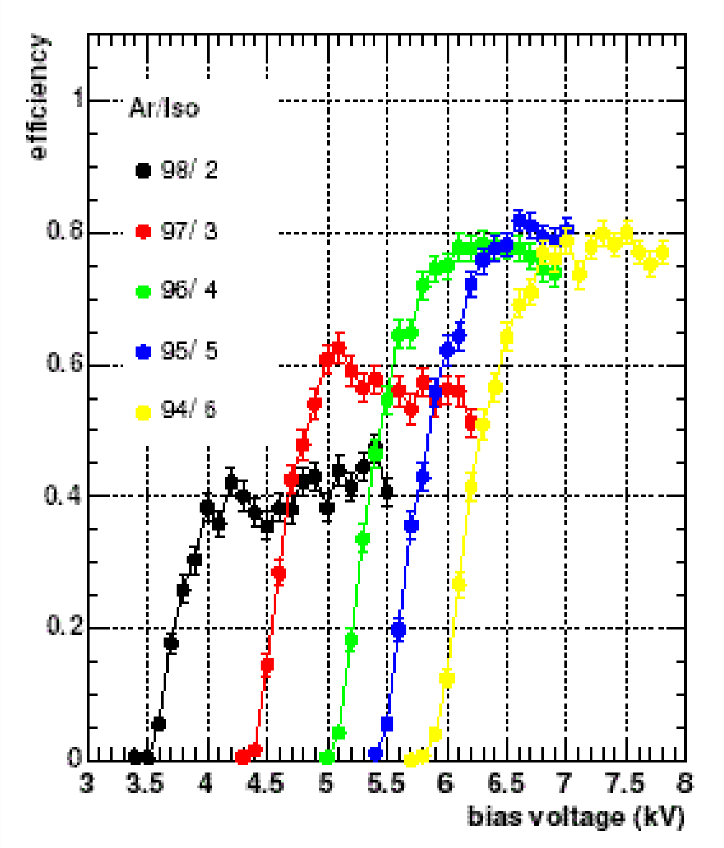


2 mm glass chamber: preliminary results



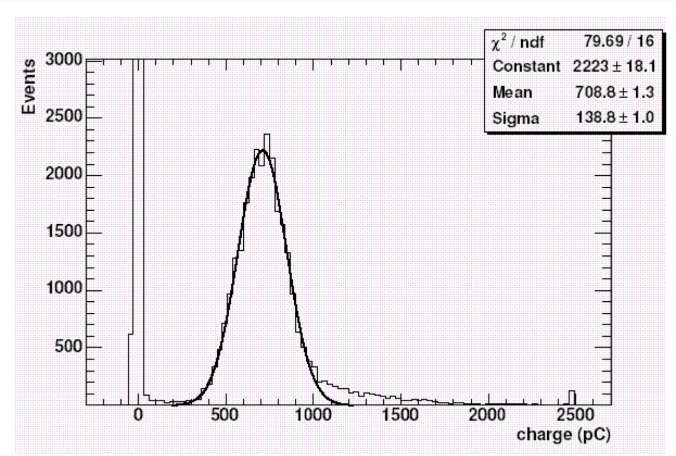
- The results obtained measuring the single rates were reasonable.
- As a matter of fact singles rate were a factor of three higher than traditional RPC, but still about few KHz/m^2
- Yet, one has to stress that , in case of a very resistive electrode material this would mean a loss of effective gap voltage.

2 mm glass chamber: preliminary results



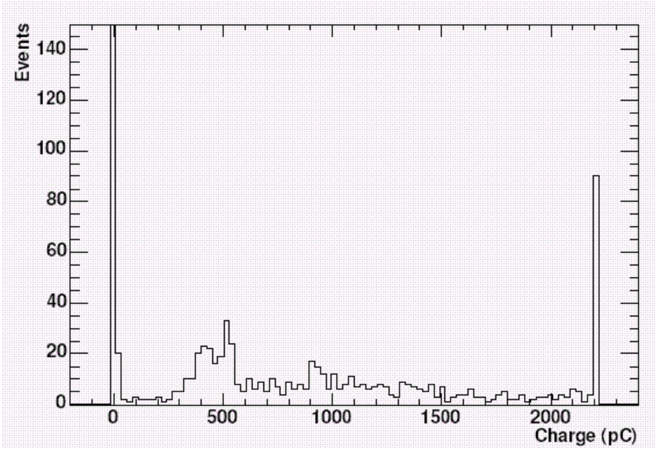
- Here are few efficiency plateaux for different gas mixtures.
- The ADHOQ devices start working with a minimum amount of quencher of 2-3%.
- The top efficiency is about 80% and comes about with more than 4% quenching gas (Isobutane)

2 mm glass chamber: preliminary results

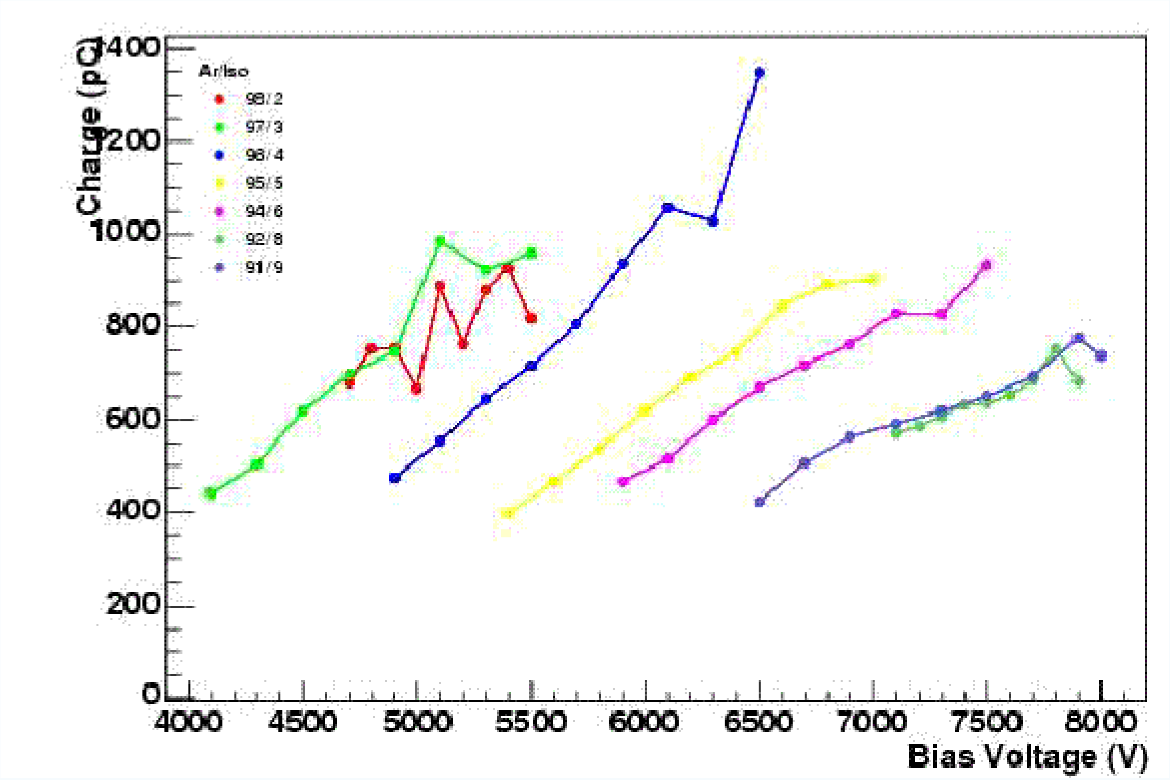


- Here is pulse height for the ADHOQ device at 95-5 % Argon-Isobutane mix.
- The limiting effect on the on the streamer is clear.

- Here is the amplitude for a normal RPC with the same mix:
- The Geiger effect is clear: many times the chamber is completely illuminated by the discharge.

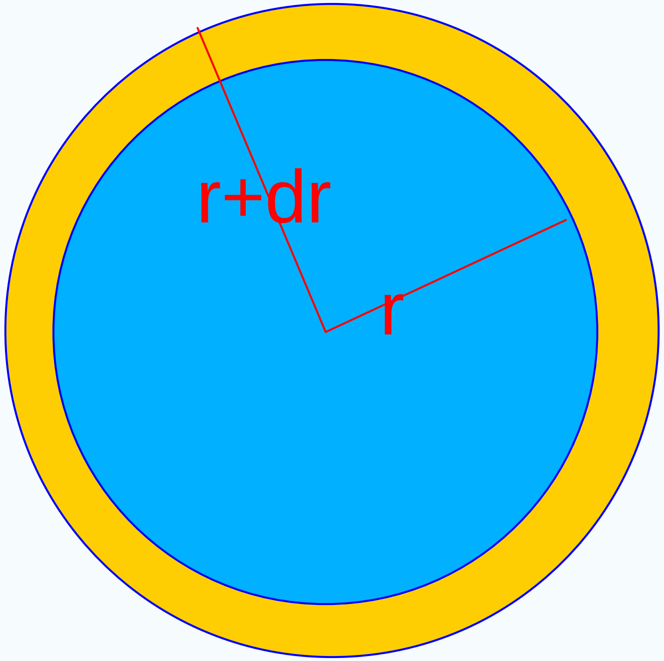


Collected charge vs. H.V.



- Here too, the typical behavior of a saturated regime is clear
- The collected charge is linear vs. the bias voltage.

2 mm glass chamber: preliminary results



- **Approximation of a single hexagonal cell:**
- **$1-\varepsilon = 2\pi r dr / \pi r^2 = 2dr / r$**
- **20% inefficiency**
  → $dr = 0.1\ r \approx 0.15$ mm

of the order of the honeycomb thickness

Where do we stand

- Both Plastic Streamer Tubes and Parallel Plate Counters could be effectively used as active part of a μ-detector.
- PST have been around for long time and they have well known pros and cons.
- RPCs work well: the only concern has to do with their long term stability.
- R&D to this purpose has been and is being carried on.
- Results from LHC will soon be available.

Where do we stand (cont.)

- The question of reliability could also be addressed trying to built a device that doesn't need aggressive chemicals to function.
- In this line of thought, the idea of mechanically quenching streamers is intriguing.
- To a very preliminary look it works….
- We have, however, a quite big phase space to explore:
  - Mesh size
  - Gas Mixtures
  - Electrode materials
  - ……
- The stability of the detector in principle should be checked, but I would not anticipate troubles , giving that the device operate mainly out of a noble gas.

Conclusions

- Both PST and RPC could be the active part of a high efficiency μ-detector.
- The former does not need much of R&D as is a very well known device.
- The latter works fine: few concerns are still there for long term reliability, but they will fade soon . .
- The idea of mechanically quenching the streamer in a parallel plate counter seems worth a try.
- The very first results are, in my opinion, encouraging.
- The honeycomb structure might proven a big simplification in the construction/assembly phase of the detectors.
- The R&D work on this device has just started: reliability, construction of large area detectors, test of different electrode material have to be carried out. The basic idea seems to hold the promise of a reliable, easy to build and operate detector.