Development of small, easy to build and low gas consumming timing RPCs

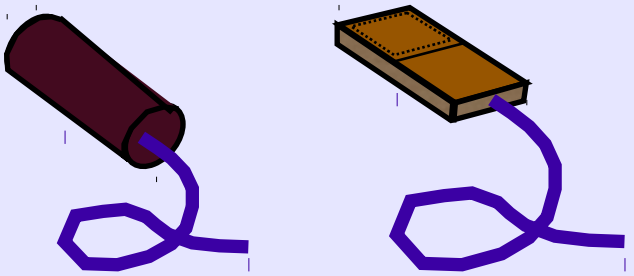
J. Luís Rodríguez[2], **Miguel Morales**[1], N. Teigel[2], D. Ramos[2], J. A. Garzón[1].

1. LabCAF/Univ. de Santiago de Compostela
2. Department of Particle Phisics/Univ. Santiago de Compostela

INFN, Frascati, February 2012, miguel.morales@usc.es

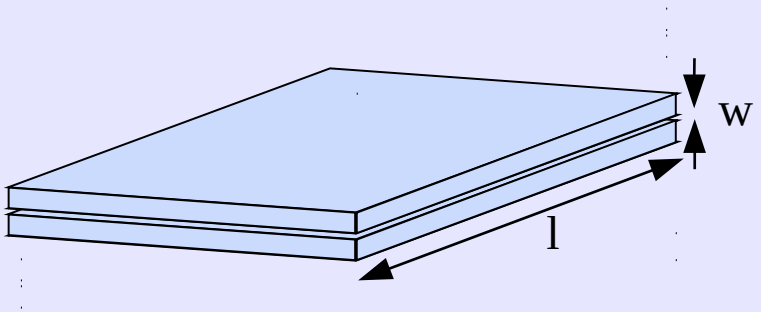
Motivation

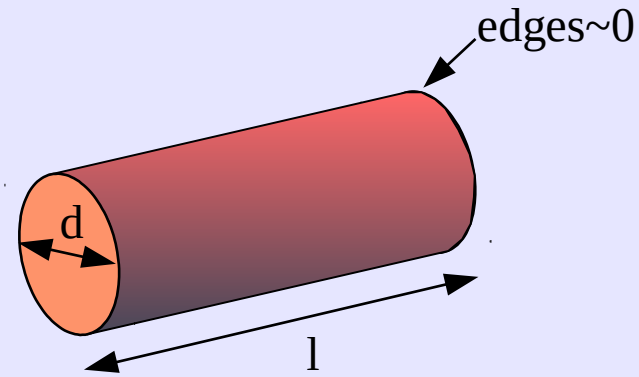
- **Get rid of bulky gas systems to develope a detector with good time resolution in a small shape for**:
  - Planar low-rate alternative to Geiger Müller counters
  - Sub ns-resolution detector for occasional uses
  - Cheap and easy-to-build detector for Educational purposes
  - Others...



- **Apart from the typical gas Issues:**
  - **Economic reasons**. Gas systems and facilities cost money.
  - **Environmental unfriendly**, R134a, SF6 are strong green house effect gases.
  - **Lack of portability**. Gas systems have an important weight and volume.

tRPC vs Geiger Counter





Typical size (mm)	40 (l) · 40 (l) · 0.3 (w)	10(d) · 40(l)
Typical volume: V	$V_{RPC} = 4.8 \cdot 10^2$ mm^3	$V_{GM} = 3.14 \cdot 10^6$ mm^3
Edge surface (mm):S	S_{RPC} = 4 x (l·w) = 48 mm^2	S_{GM} ~ 0 mm^2
S/V ratio	0.1 mm^{-1}	~0
Typical gas mixture	Freon R134a/SF6/iButane (85/10/5)	Neon/Argon + Halogen gas
Working mode	Avalanche	Geiger-Müller
Typical Voltage	~3000V	~1000V
Electric field	~constant	1/r

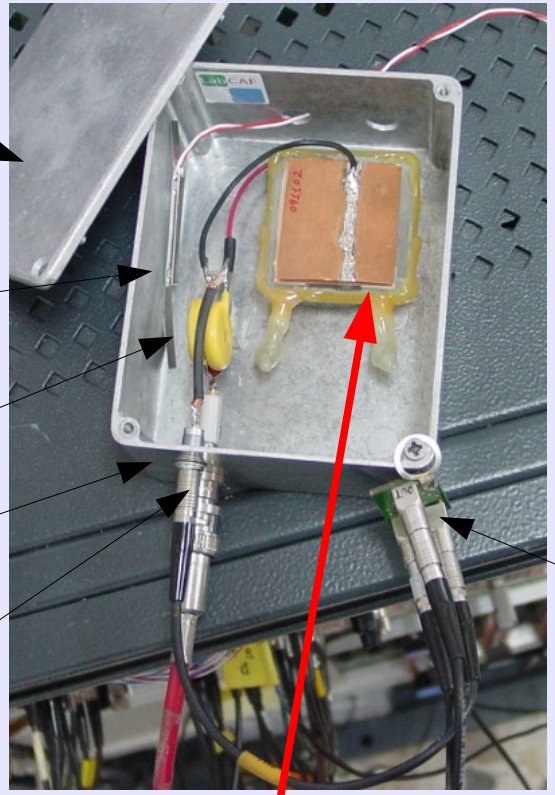
Step 0

The simplest approach

High rate of failure

- **10** sRPCs were made by under-graduate students
- **4** of them have been tested, where:
  - **2** get spoiled at the first day (almost no response to 0.5Mbq Na22 radioactive source)
  - **2** were tested in a month time under radiation:
    - **sRPC1**: Na22 gamma source
    - **sRPC2**: Cosmic Rays

The chamber



Aluminum Box

PT100 Temperature Sensor

Two RC Circuits

Signal Socket

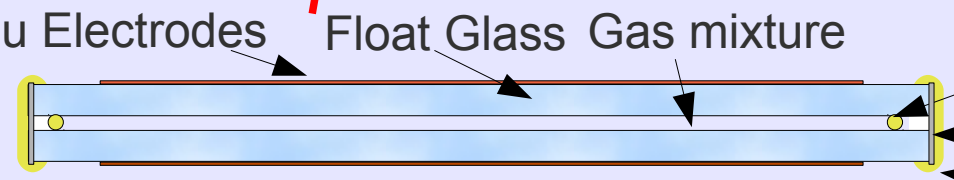
BNC HV Socket

Standard gas mixture
R134a/SF6/Isobutane
85/10/5

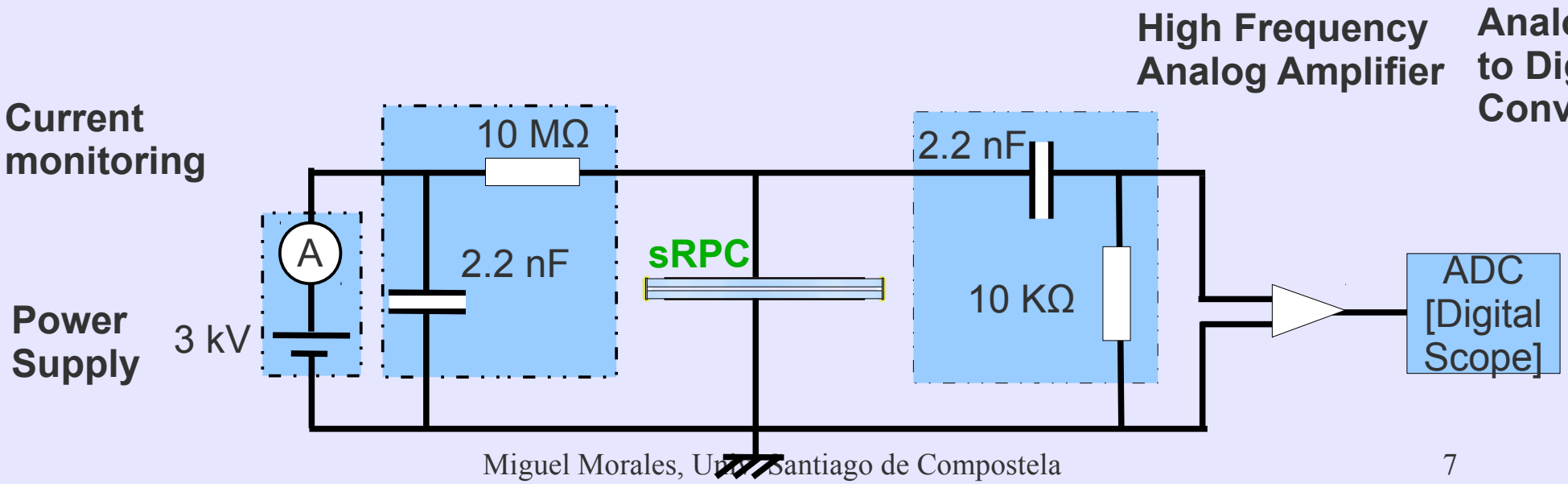
High Frequency Analog Amplifier

Some closing options:

Sealed Chamber



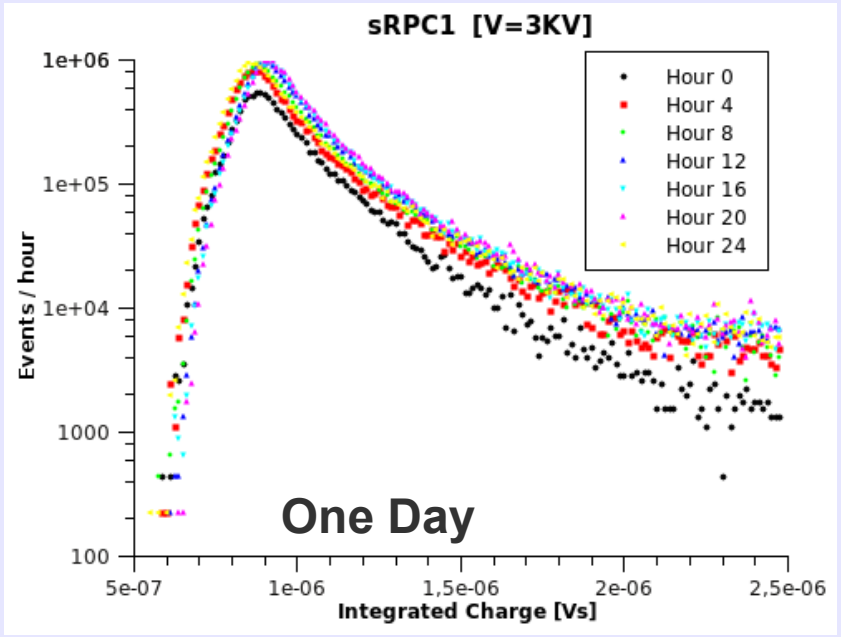
Quite simple setup!!

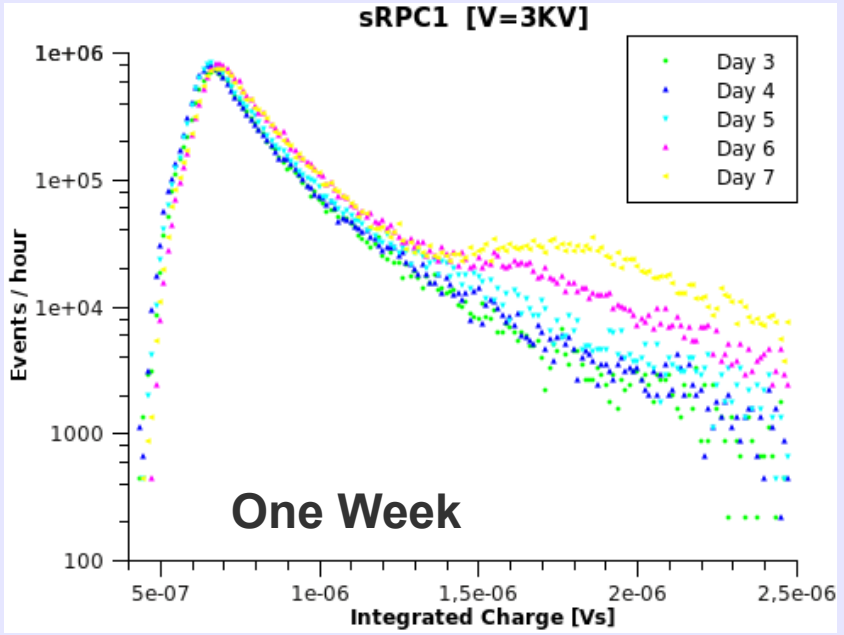


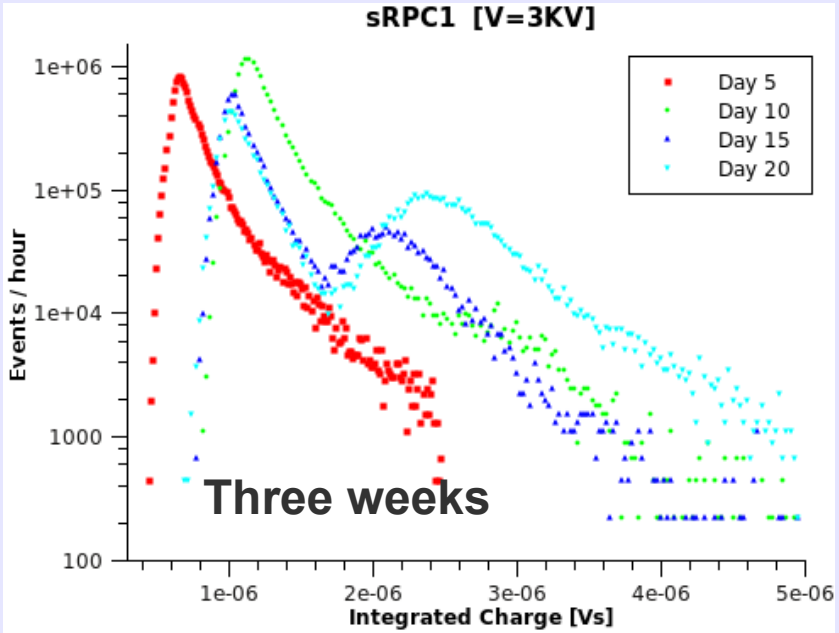
Measurements on sealed RPC (sRPC)

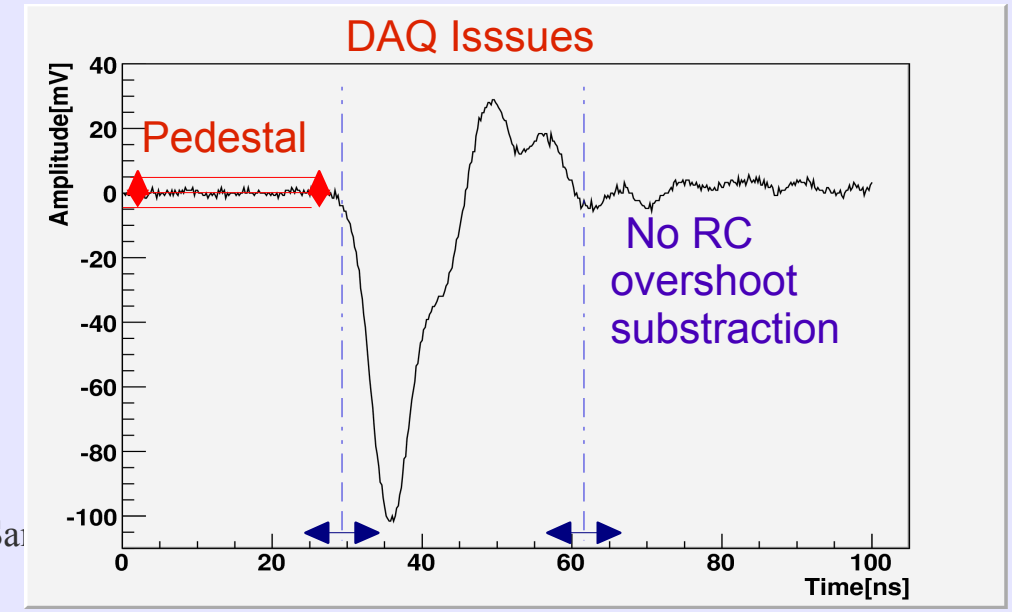
- High Voltage working point evolution
- **Integrated charge**
  - Pulse area calculated by one Scope function
- **Current**
  - Read from the Imon N471a HV source output

“Prompt Charge” distribution

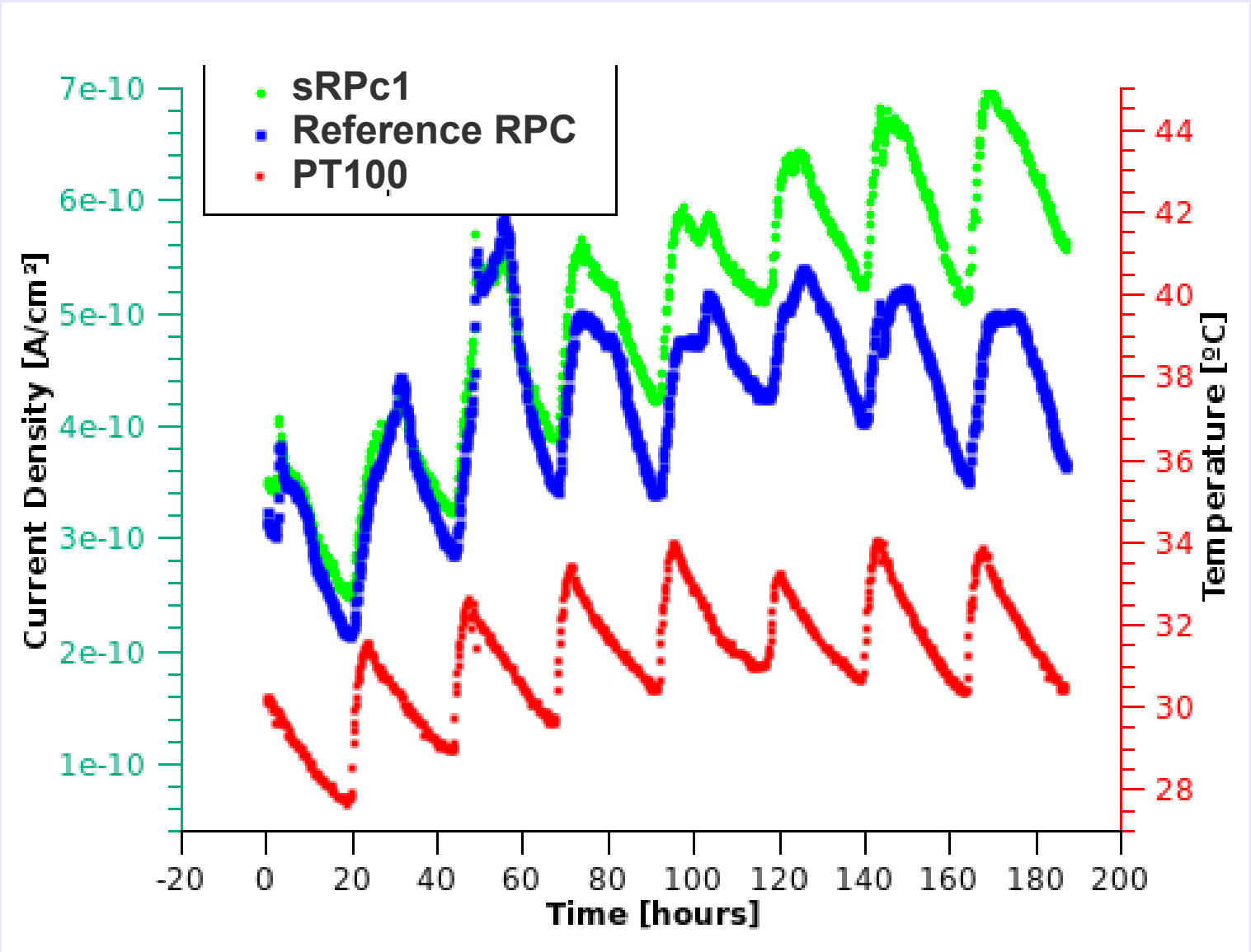








Current Trend



What might start to spoil the chambers in three days?

- Gas ionization
- Gas leaks
- Gas concentration gradient

Gas density (1.013 bar and 15°C)
- R134A: 4.25 kg/m3
- SF6: 6.27 kg/m3
- Isobutane: 2.51 kg/m3

- Glue, thermoplastic or tubes out-gassing
- ???

Step 0: Summary

- First sealed RPCs build and tested in the lab by under-graduate students.
- sRPC current increase with time, different behaviour could see from the third day.
- Rise of sRPCs higher integrated charges.
- We hadn't no idea about the aging source.
- The way of acquiring data it is far too simple, an upgrade is imperative to get a deeper knowledge of the process.

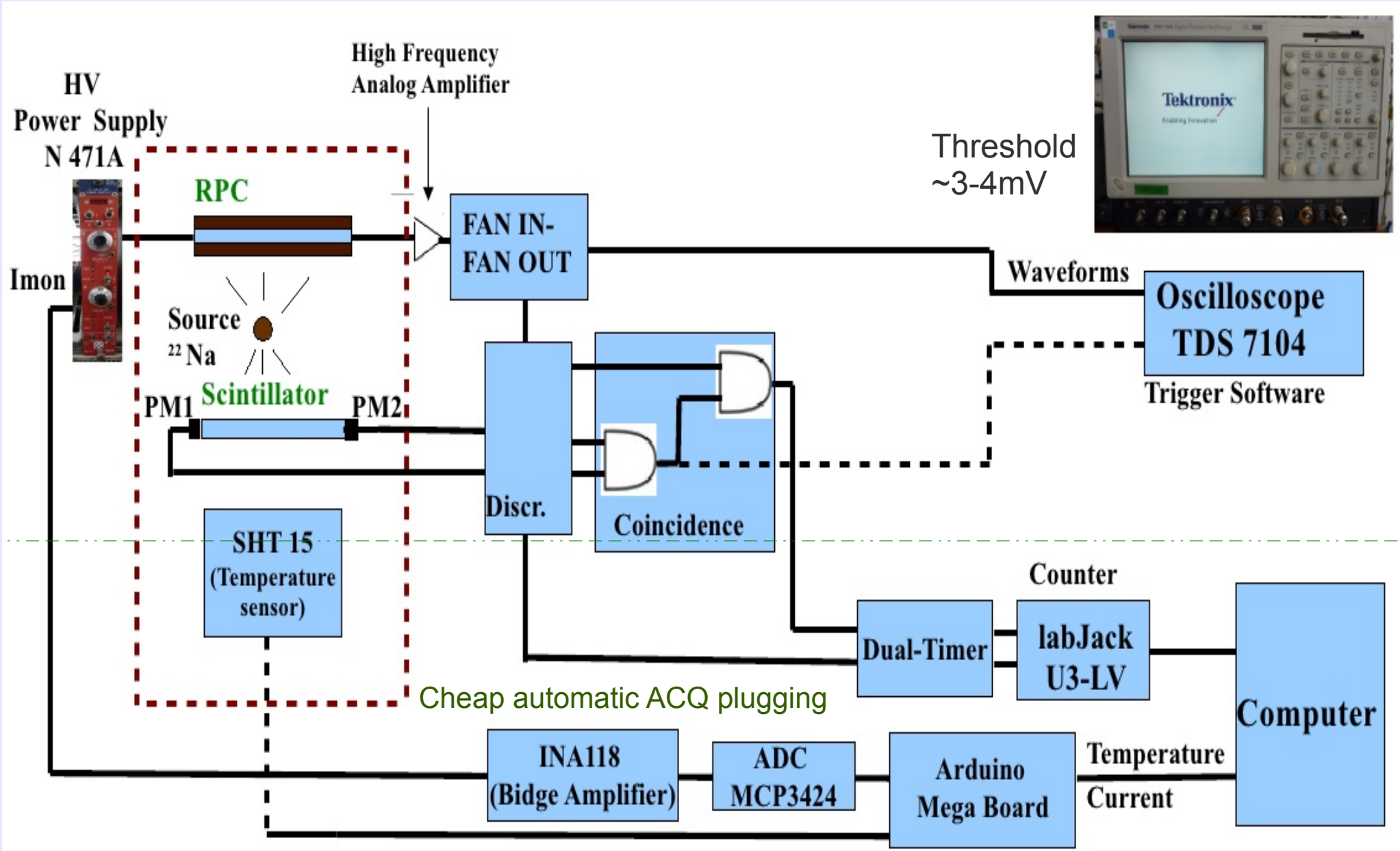
Step 1

A small upgrade

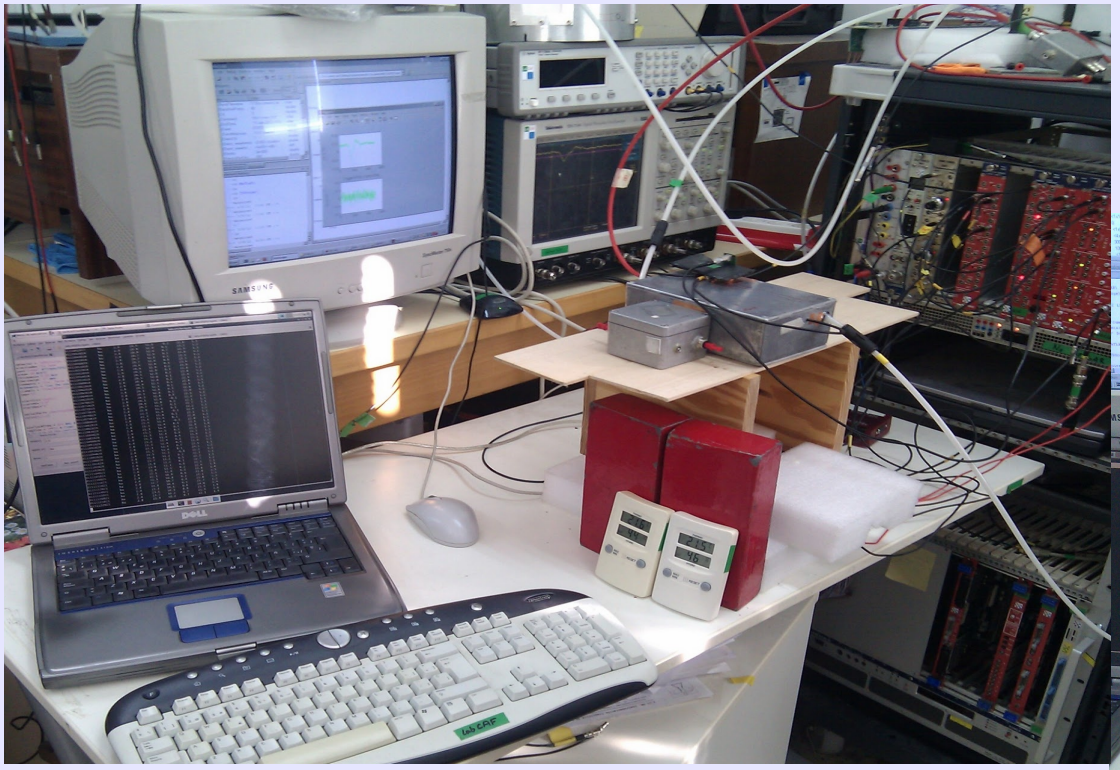
Step 1

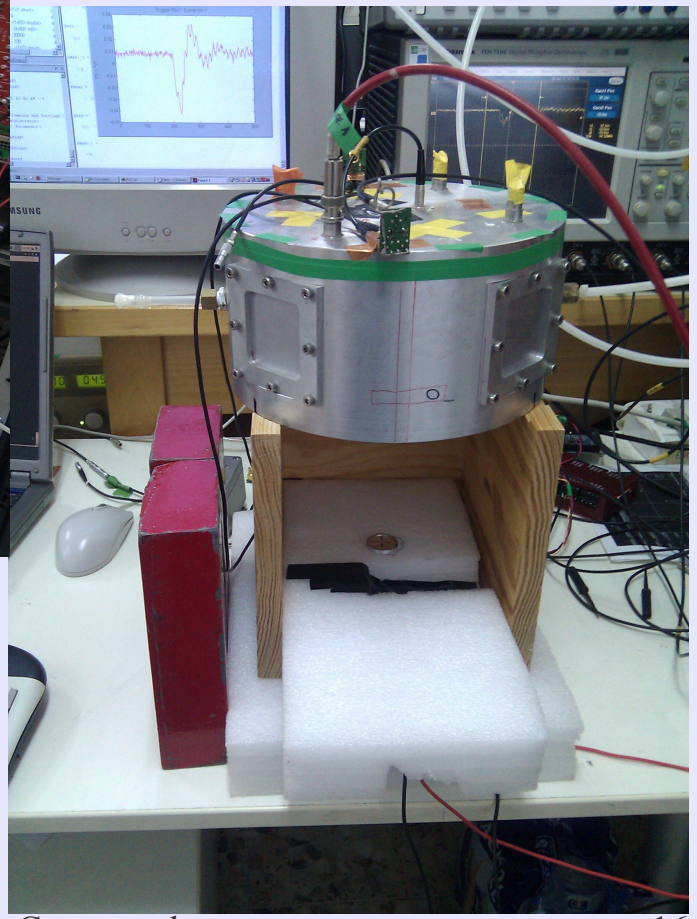
- Slightly more complicated chambers: Two tRPCs of two gaps
- HV plateaus for different gas mixtures, just to test the measurement setup:
  - R134a 100%,
  - R134a/SF6 90/10%
  - R134a/SF6/Isobutane 85/10/5%
- Three configuration used with the simplest “mixture” **R134a**:
  - **Boxed tRPC**: tRPC inside a closed metallic box
    - Gas restriction with less direct out-gassing effect, no glue around the gaps.
  - **sRPC**: tRPC sealed with glue out of the box
  - **Boxed sRPC**: sRPC inside one metallic box with gas flowing.
    - In order to disregard the leakages effects

Step 1: Setup

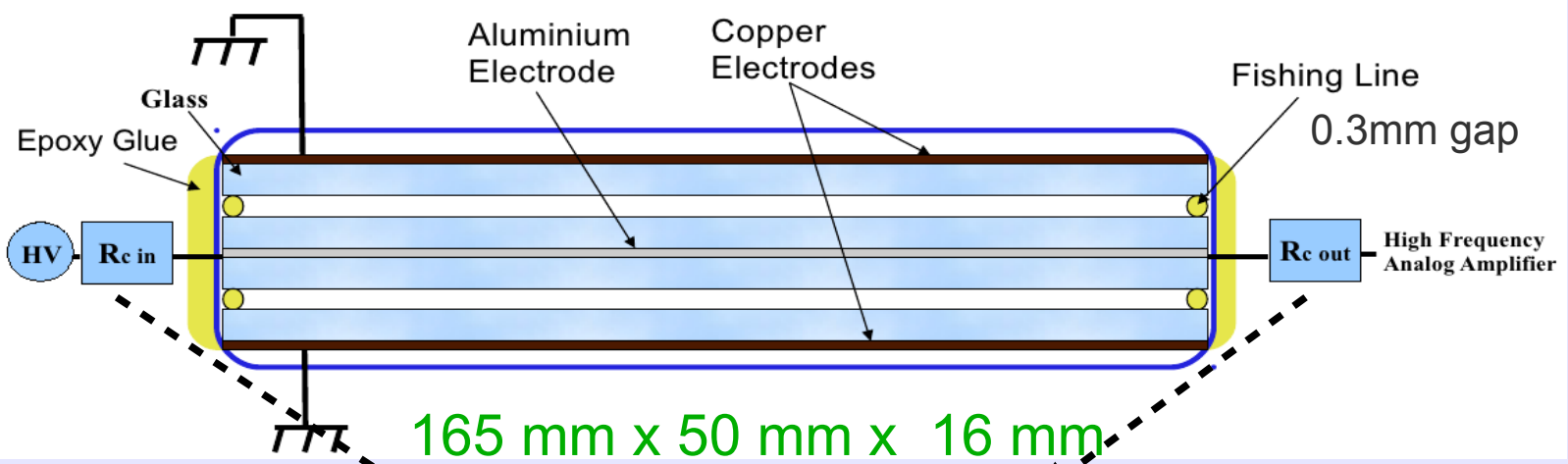

HV
Power Supply
N 471A
High Frequency
Analog Amplifier
RPC
Imon
FAN IN-
FAN OUT
Source
22 Na
Scintillator
PM1
PM2
Discr.
Coincidence
Threshold
~3-4mV
Tektronix
Waveforms
Oscilloscope
TDS 7104
Trigger Software
SHT 15
(Temperature
sensor)
Counter
Dual-Timer
labJack
U3-LV
Computer
Cheap automatic ACQ plugging
INA118
(Bidge Amplifier)
ADC
MCP3424
Arduino
Mega Board
Temperature
Current

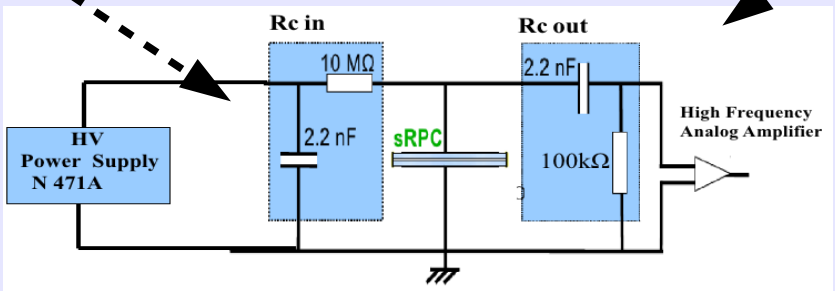
Step 1: Setup



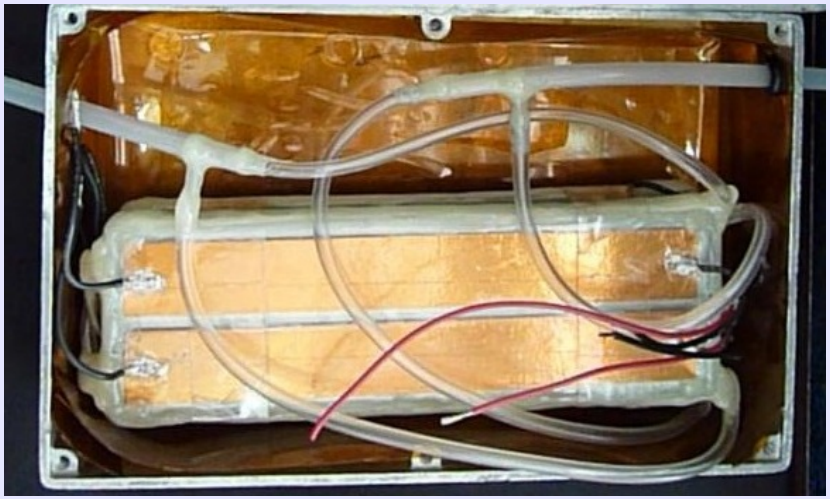


Chamber configuration

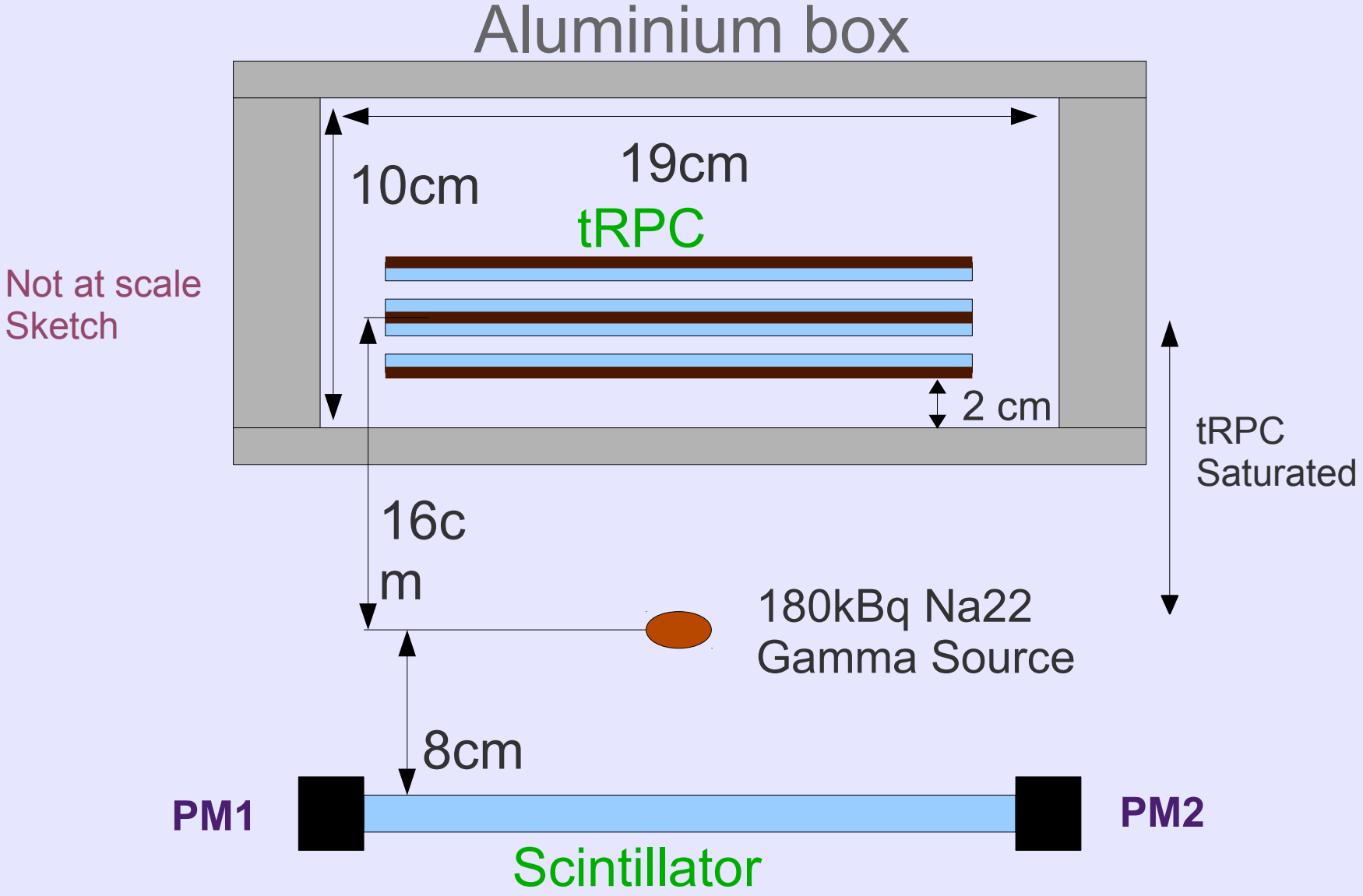




15cm x 2cm Cu electrode
Only one connected



Boxed tRPC

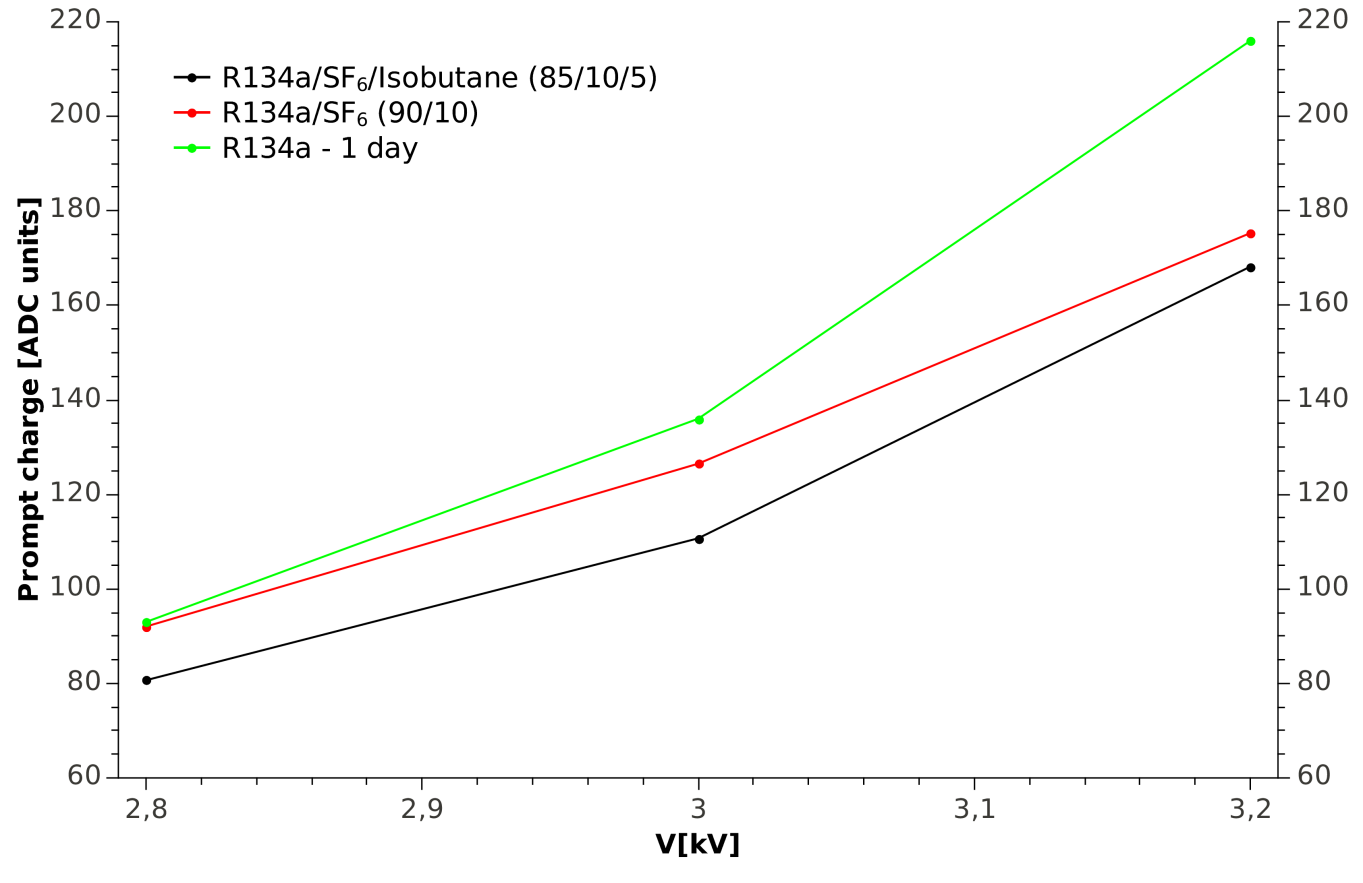

Aluminium box
Not at scale
Sketch
10cm
19cm
tRPC
2 cm
tRPC
Saturated
16c
m
180kBq Na22
Gamma Source
8cm
PM1
PM2
Scintillator

Measurements

- **Pulse amplitudes**
- **Slopes**: amplitude at 90% of rise voltage / time to reach this voltage
- **Prompt charges**
- **RPCs current**
- **Acquired rates:**
  - **tRPC rate**
  - **Coincidence rate: tRPC & PM1 & PM2**
- **Temperature monitoring**

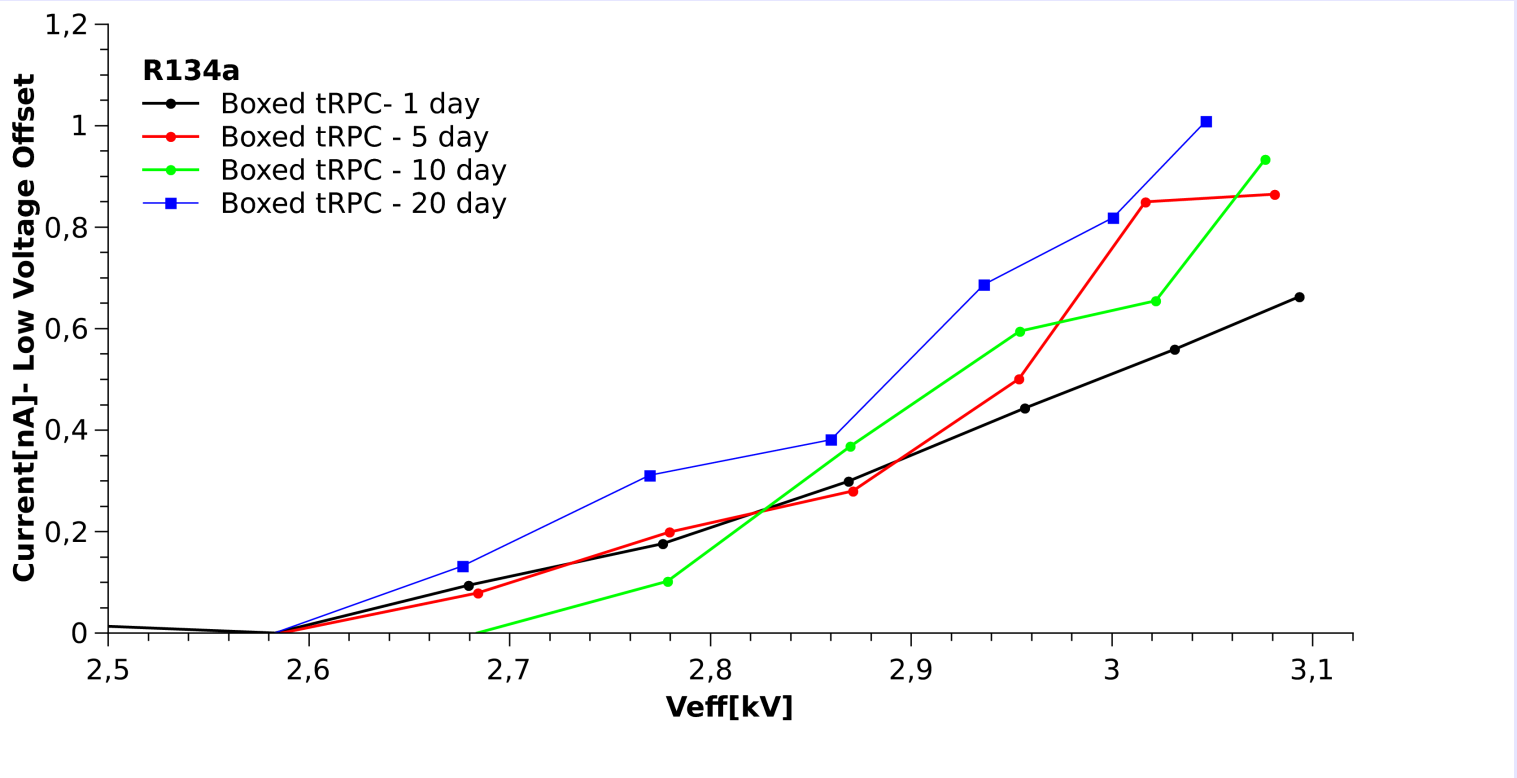
Setup Gas mixture resolution

Prompt charge disregarding large signals, or streamers



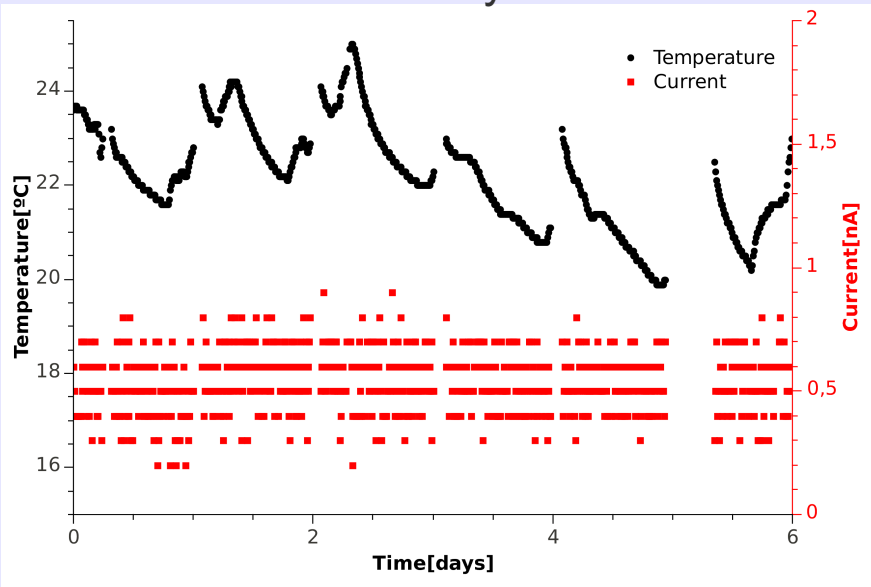
Boxed tRPC

Boxed tRPC: Gamma operation current

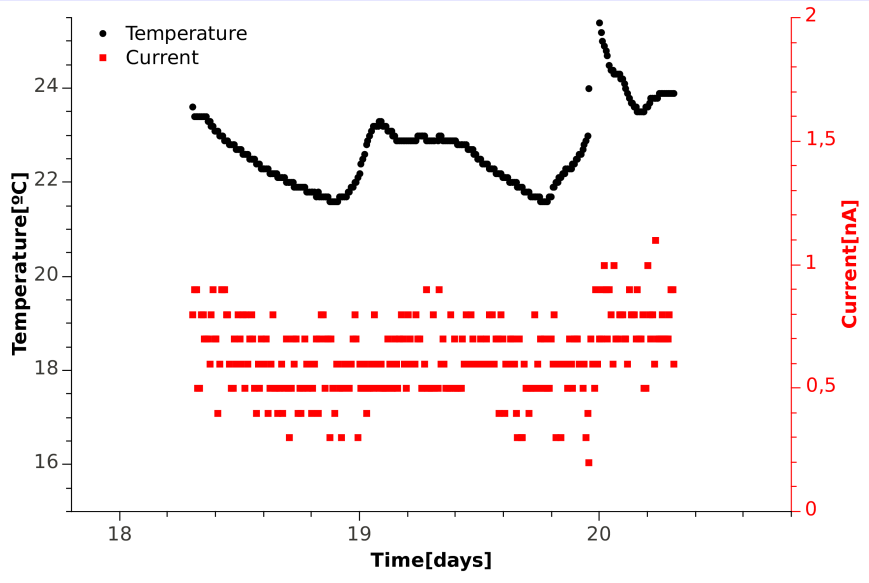


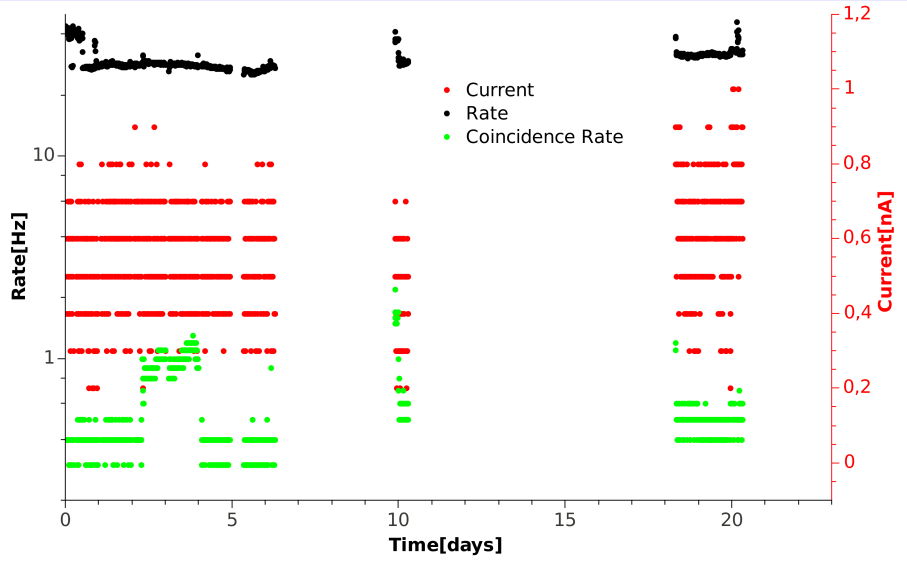
Boxed tRPC: Current

First days

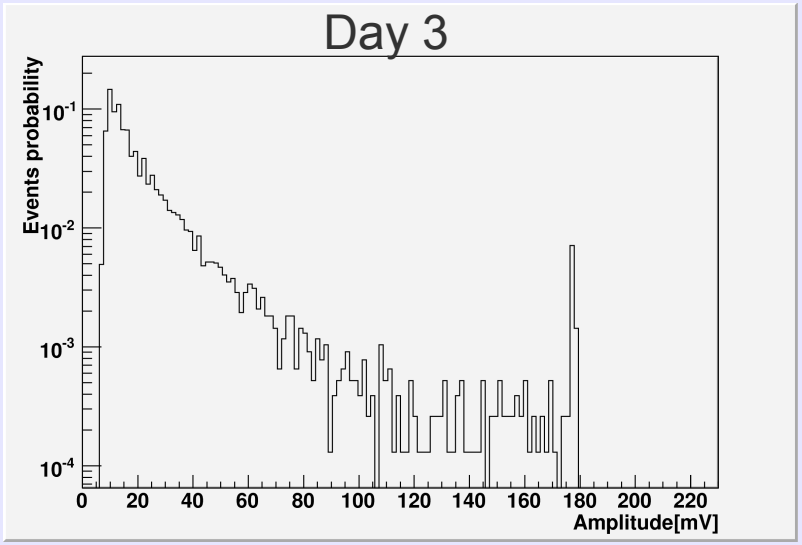


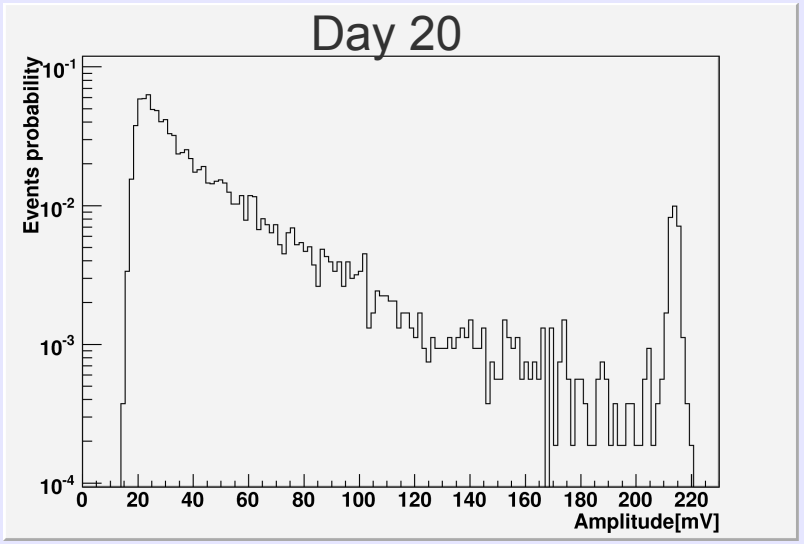
Last days

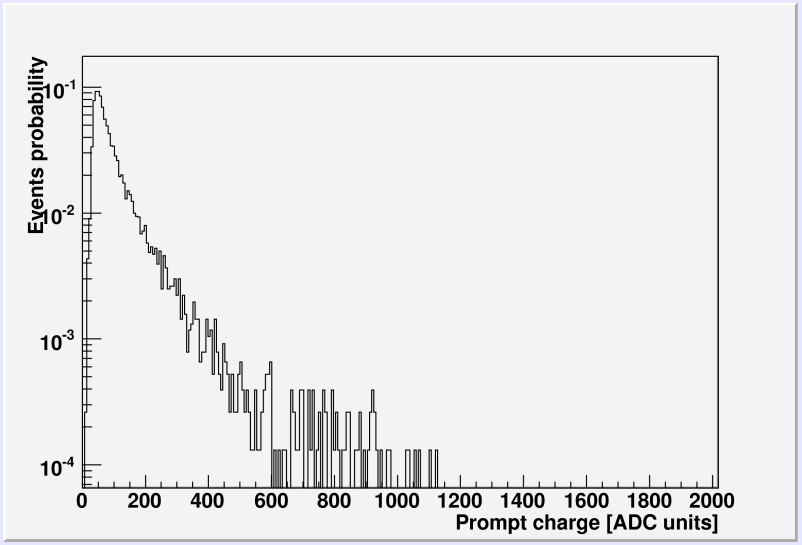


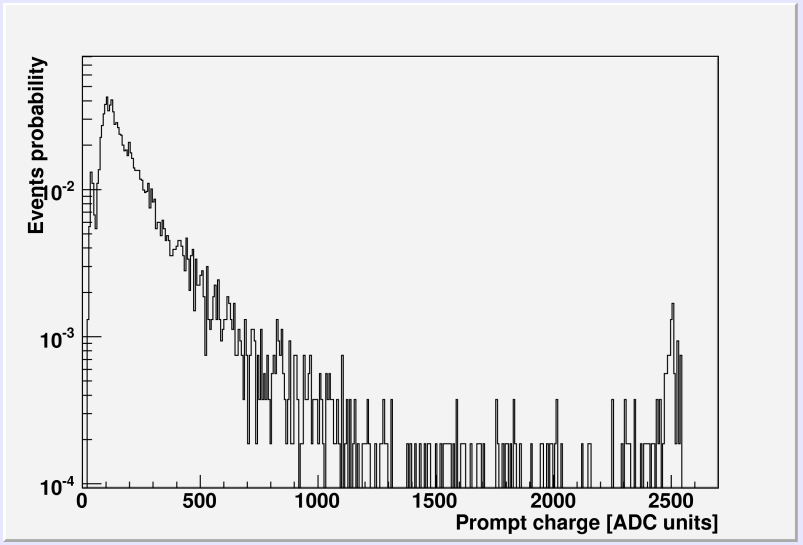


Boxed tRPC: Amplitude and prompt charge



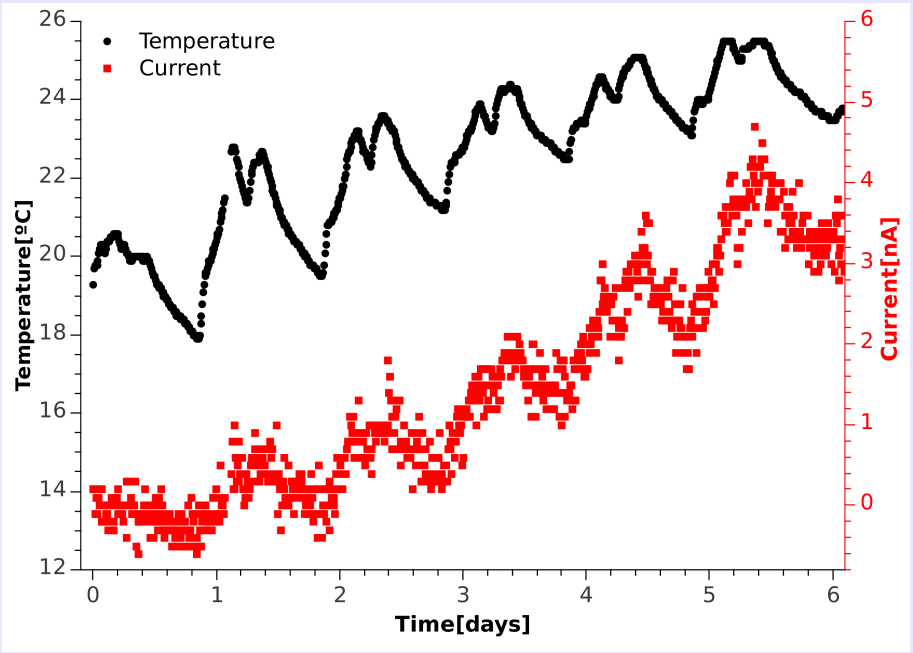


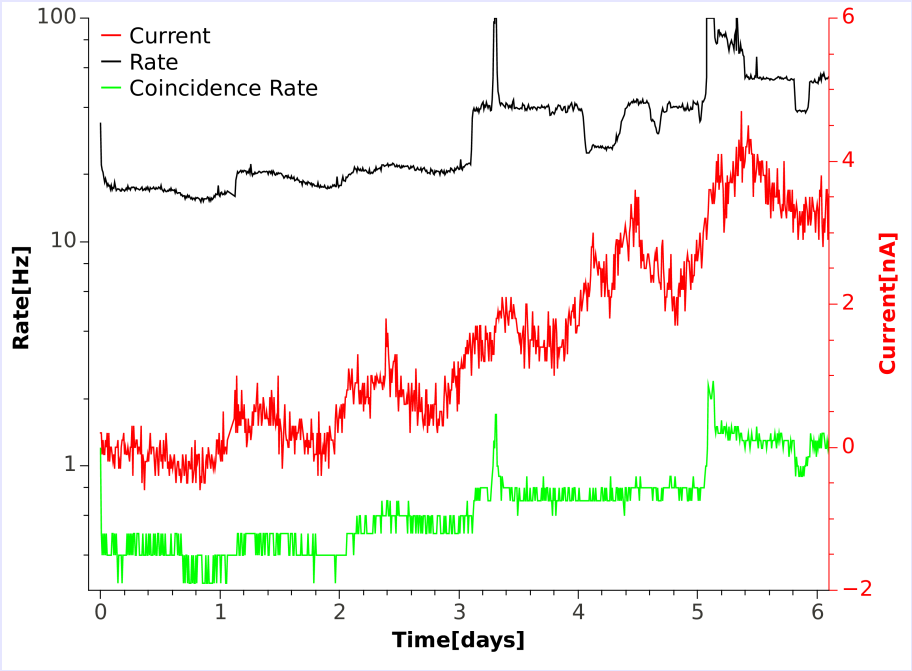




sRPC

sRPC: Current

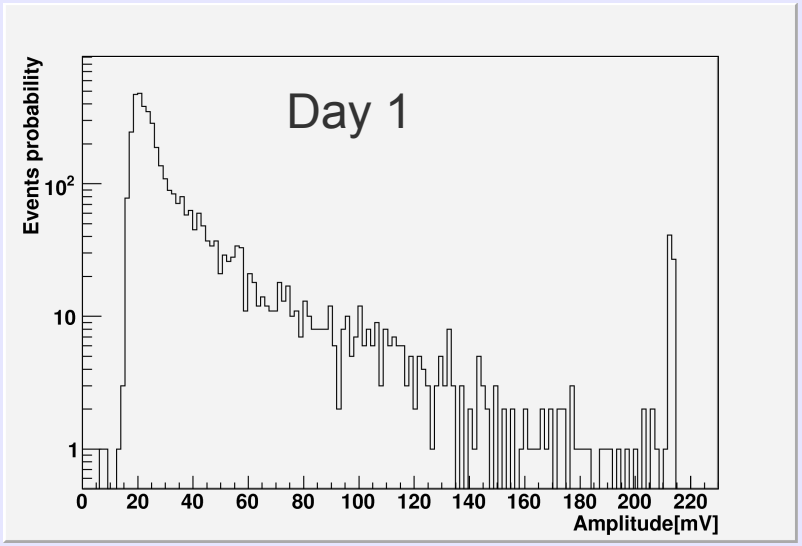


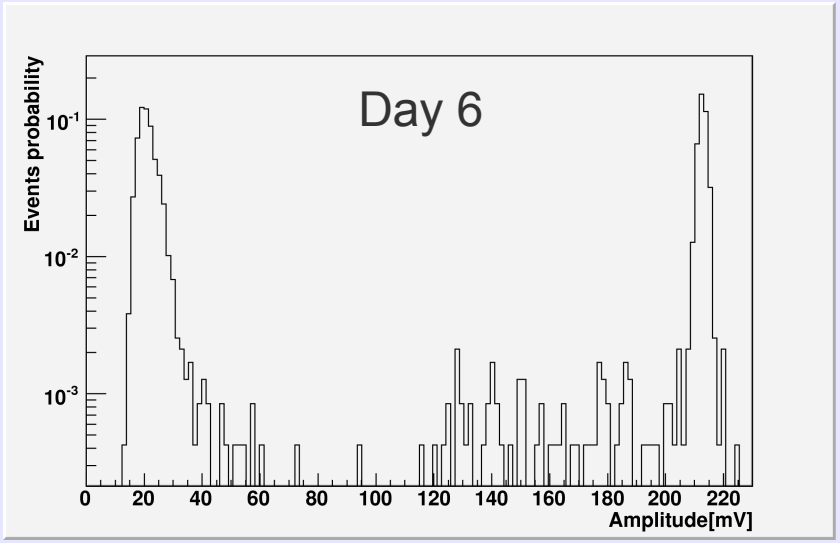


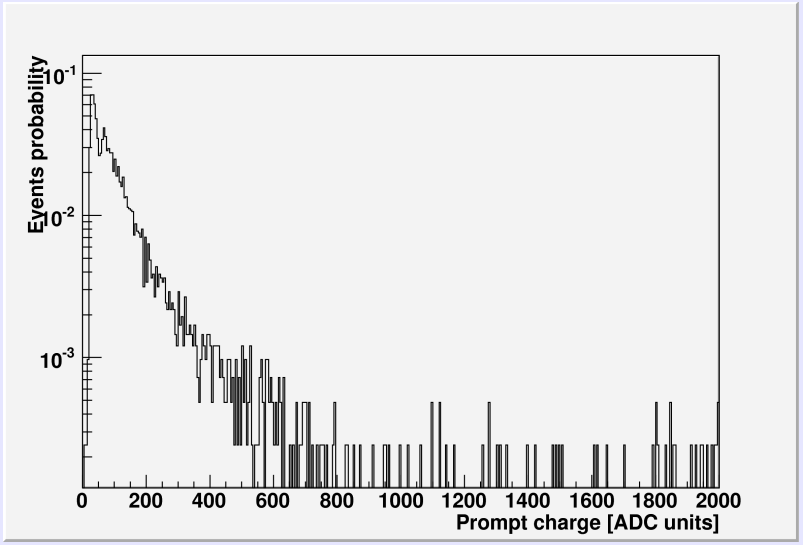
As expected, very strong current, temperature correlation.

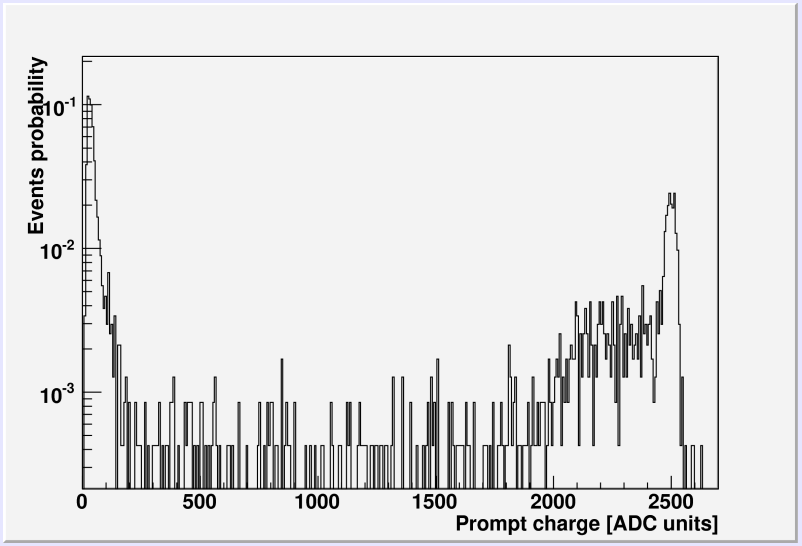
Awfully, it is not easy to put apart the effect of temperature in this case!!

sRPC: Amplitudes and prompt charge evolution

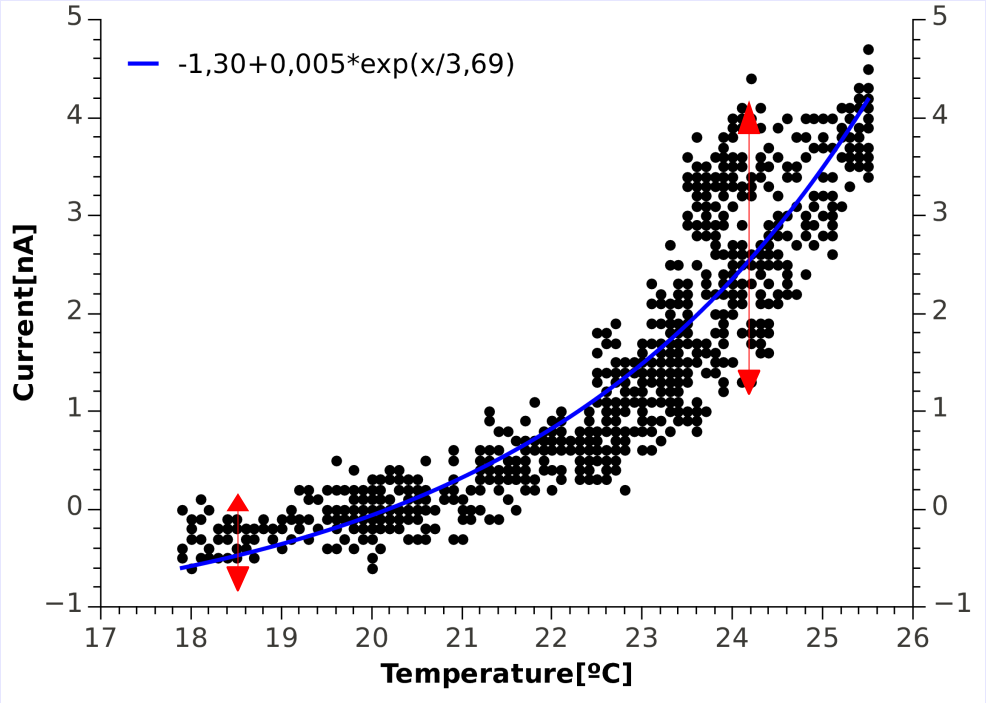








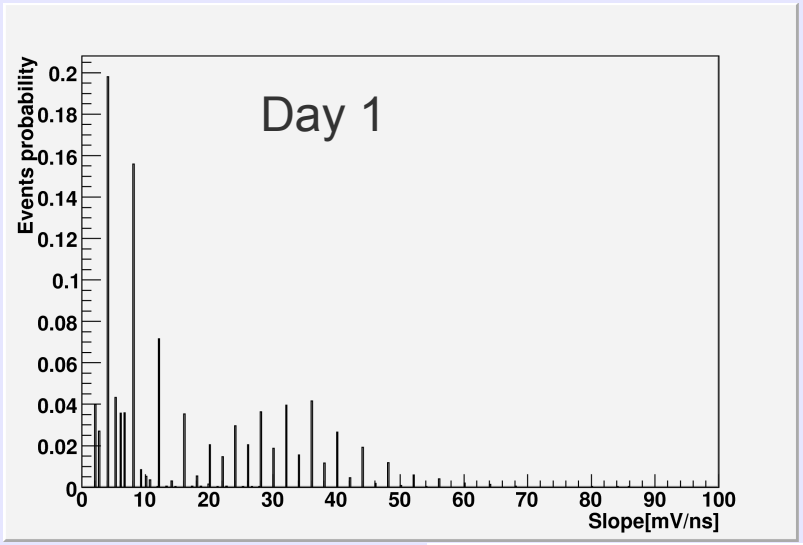
sRPC: Current temperature correlations

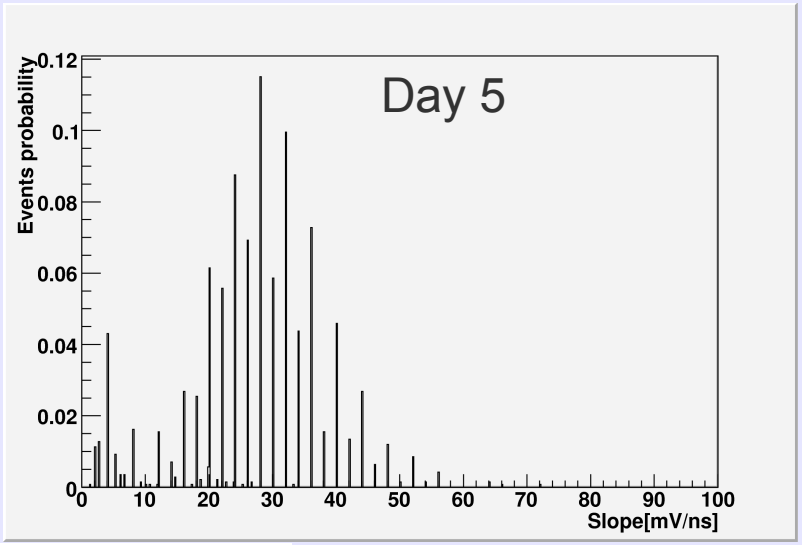


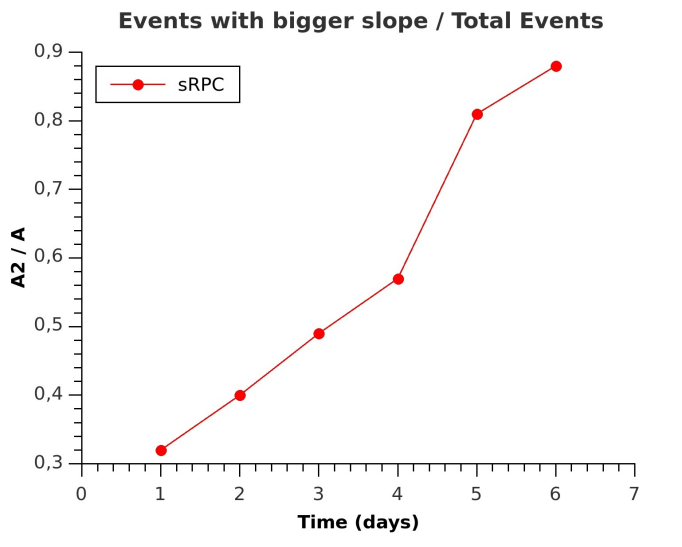
Last days, higher temperatures, other effect than temperature seems to be contributing to the current.

sRPC: Slopes evolution

Slopes at 90% of amplitude.

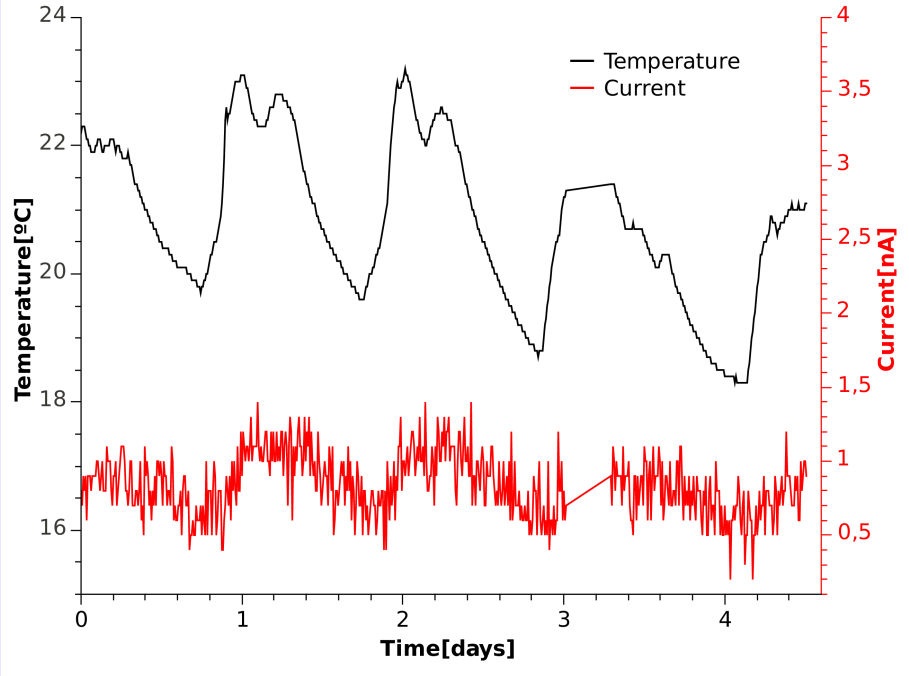


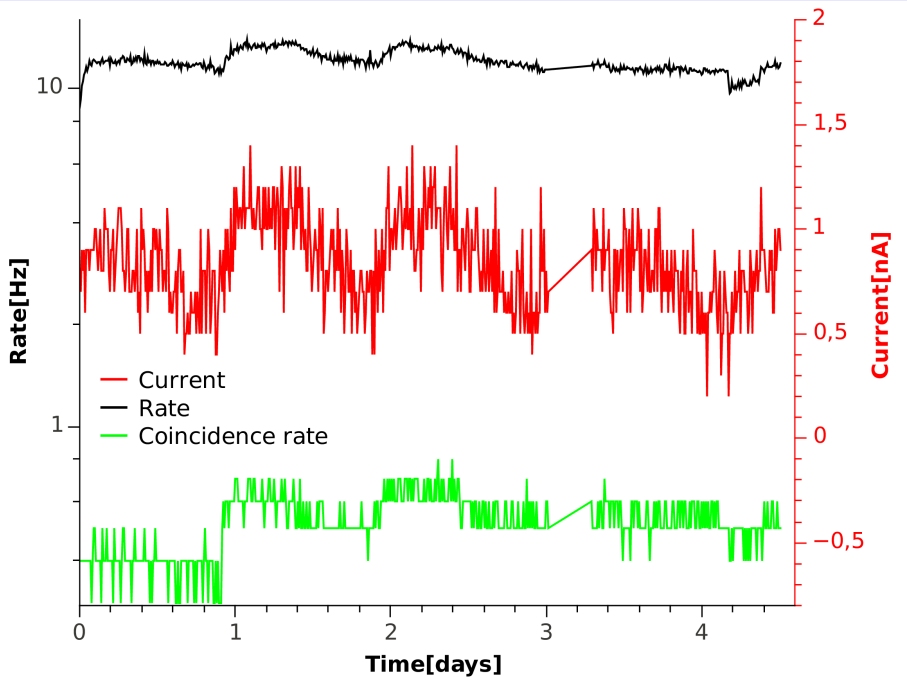




Boxed sRPC

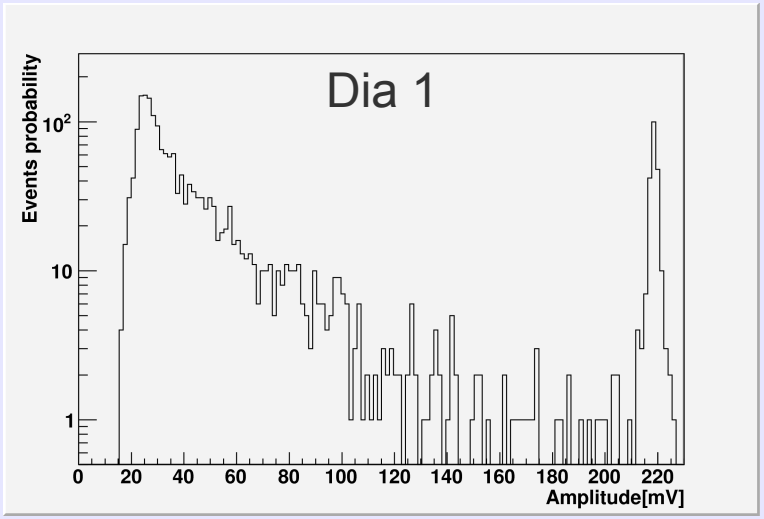
Boxed sRPC: Current

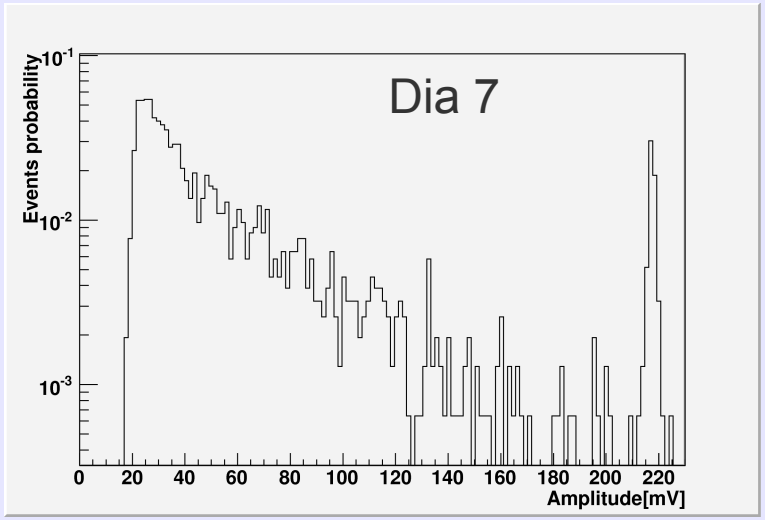


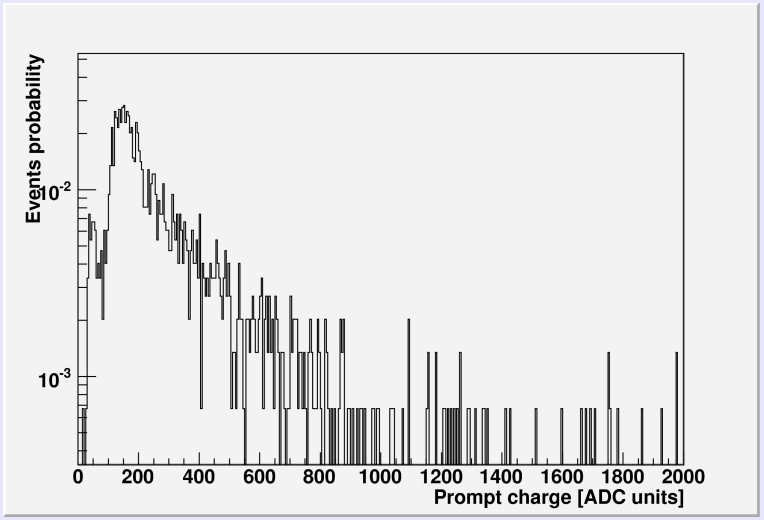


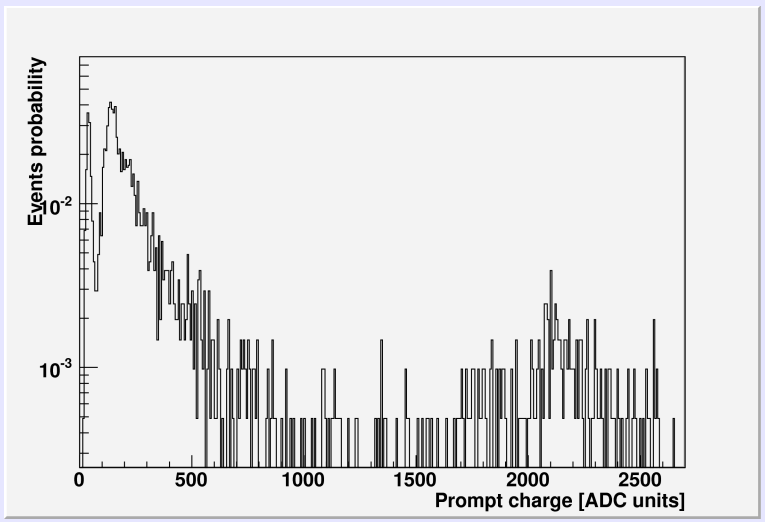
No important degradation in the first week from the current point of view.

Boxed sRPC: Amplitudes and prompt charge



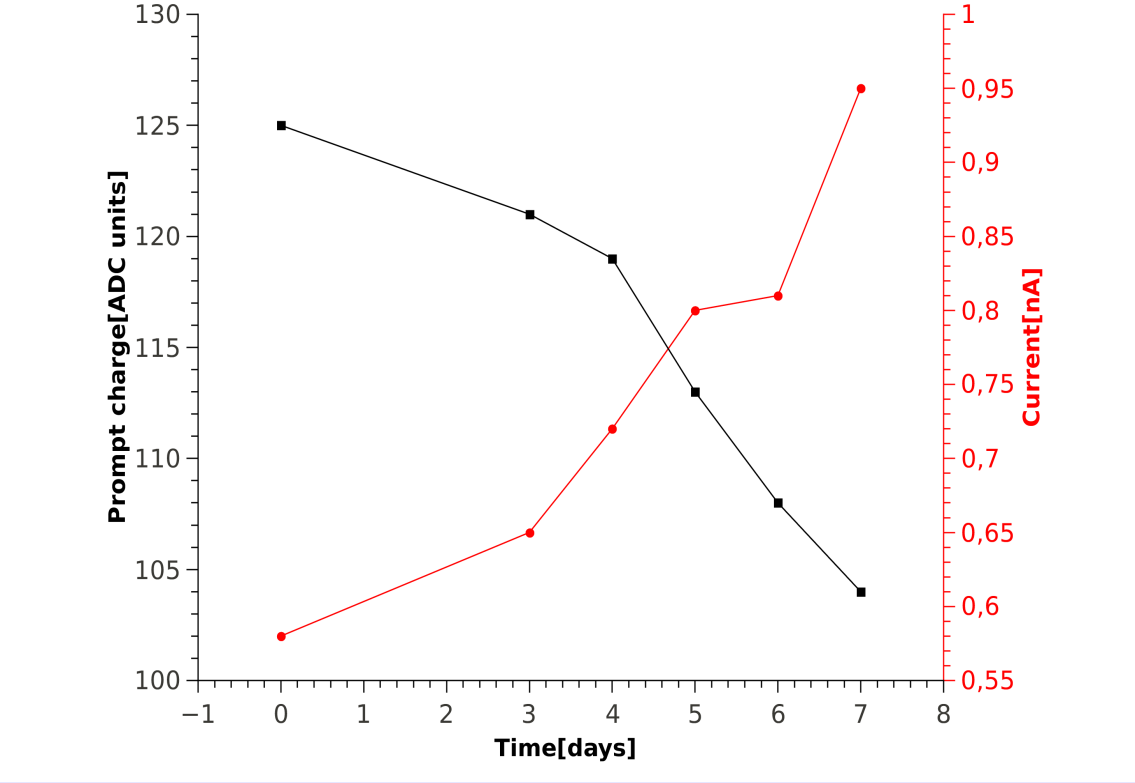






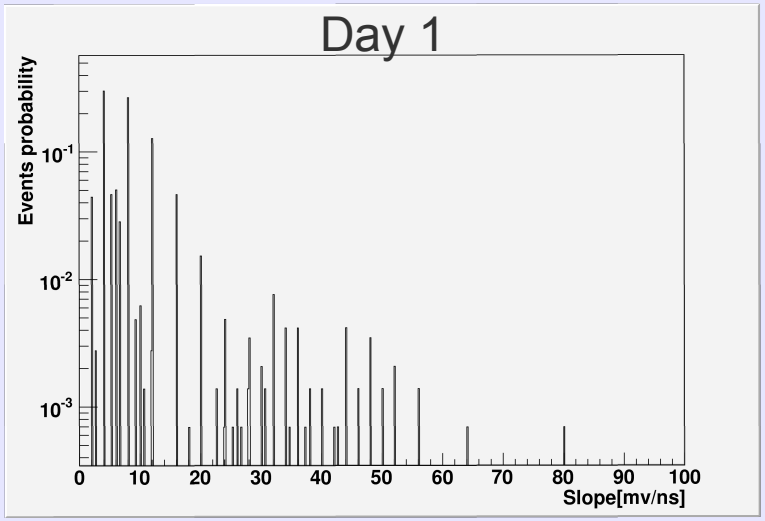
Degradation again, more events with higher charges.

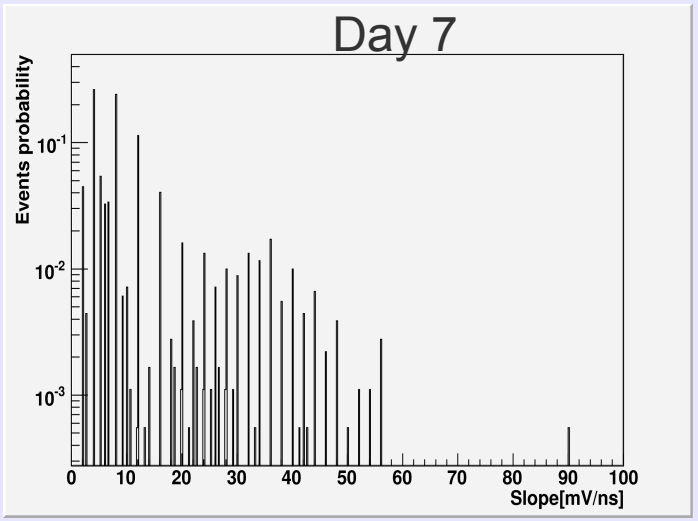
Boxed sRPC: Prompt charge and Current

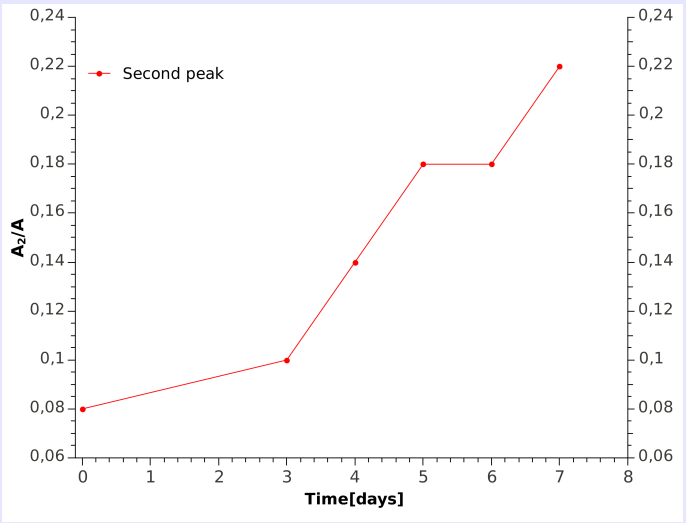


Even it is not clear from the total charge measures, the prompt charge is actually being affected by the increasing current flow.

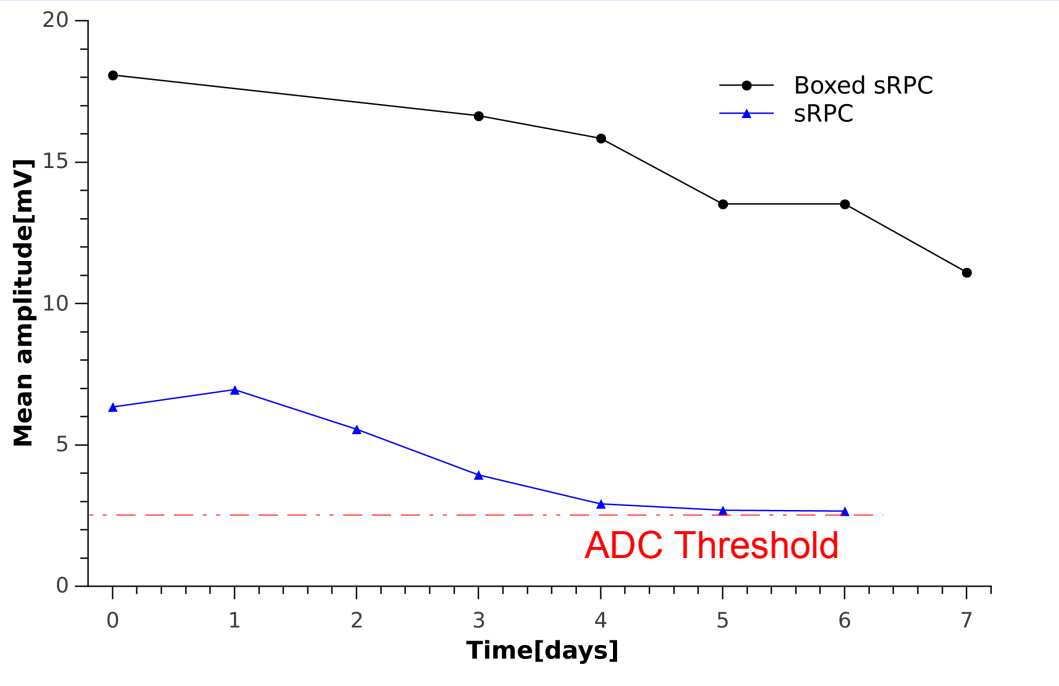
Boxed sRPC slope







sRPC vs Boxed sRPC



Both of them are loosing “efficiency”,
looks like there are other effects than leaks involve.

Summary

- One gap and two gap sealed tRPCs has been build and tested by under-graduated students with a cheap electronic addon.
- Prompt charge distribution, for this setup, shows as a more reliable variable to detect earlier degradation effects.
- **Besides leaks, other effects** seems to be involved in the degradation. Maybe other components out-gassing?.
- Not scalable gluing method, in future, simplified models inside plastic boxes will be tested.
- A controlled temperature environment would help to get faster and reliable results.
- **Work in progress**, efficiency, time and space resolution measurements must be taken in next steps.

Thanks

- Luís Lopes, LIPC.
- Diego Gonzalez, GSI.

Thanks for your attention!!

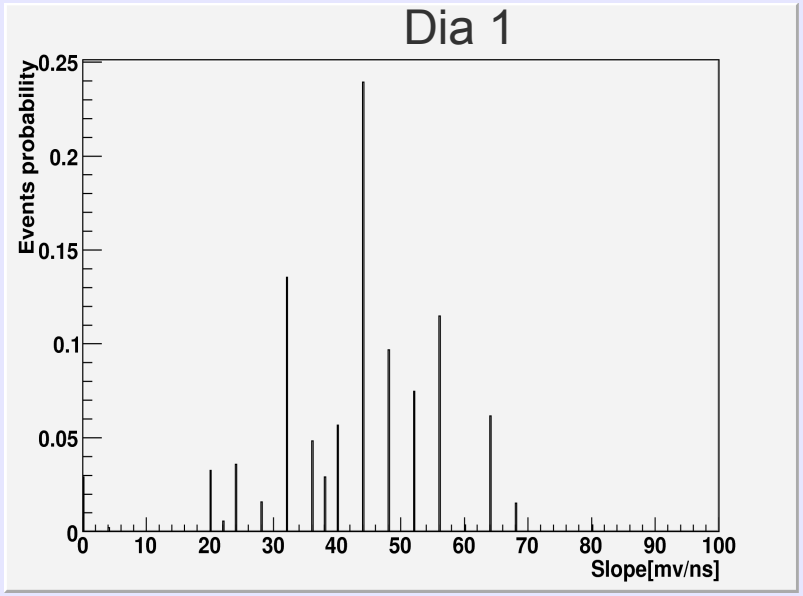
References

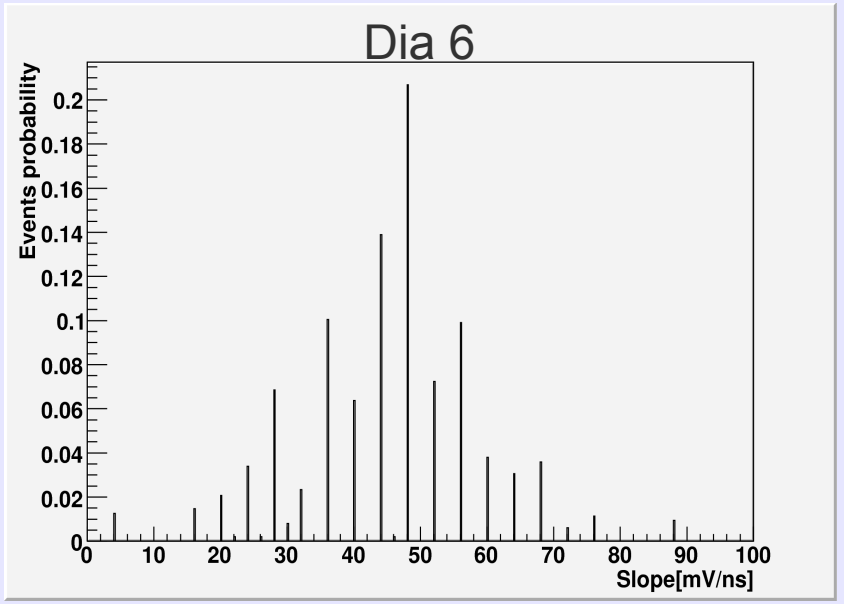
Backup Slides

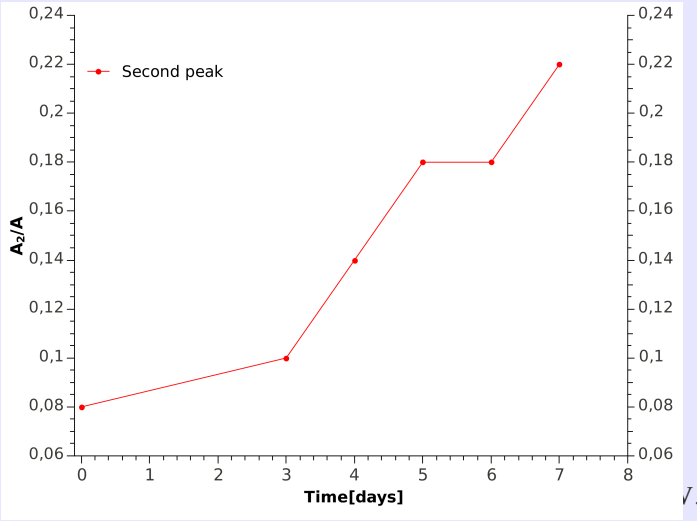
Future work

- Measure sRPC resolution and efficiency, and they evolution.
- Asses gas aging:
  - Study the different aging rates of chambers used and other ones only sealed.
  - More accurate test of materials out-gassing effects.
- Try glasses chemical etching to improve the epoxy stickiness to the glass.
- Try other building ways as keep the rpc inside a pmma enclosure.
- Use Estrela Front End Electronics and TRB acquisition system.
- Scale things up.

Boxed sRPC slope

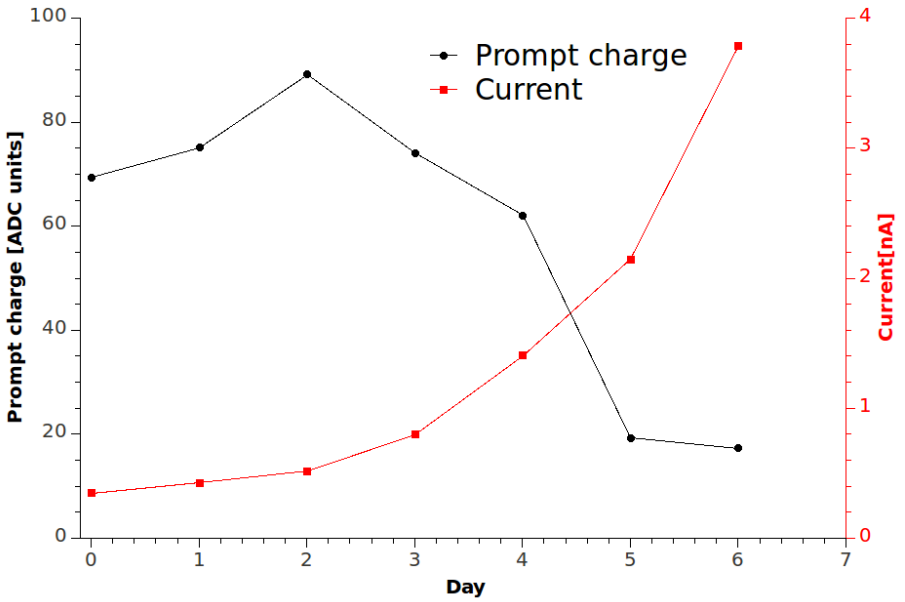






Falta gráfico con evolución das slope medias cos días.

sRPC


Prompt charge
Current
Prompt charge [ADC units]
Current[nA]
Day
0
20
40
60
80
100
0
1
2
3
4
0
1
2
3
4
5
6
7

Eficiencia

A eficiencia xeometrica é do 0,09%, a intrínseca do 0,15%. A xeometrica sacámola de geant4 lanzando geantinos,partículas que non interaccionan con nada e simplemente che dan informacion sobre a xeometría.