



## The nRPC-4D neutron detector: experimental study of its sensitivity to gamma rays

Chloé BOIREL - Luís JANUÁRIO - Malo RUEL

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Supervisors : Luís MARGATO and Andrey MOROZOV

## MOTIVATION

### Motivation

- Find alternative to 3He based neutron detectors with sateof-the-art performance without skyrocketing the costs
- Some of the most important detector requirements are
  - $\circ~$  High detection efficiency
  - $\circ~$  High spatial resolution
  - Discrimination between neutron and gamma
- LIP is working on a new neutron detection technology based on RPCs and 10B converters



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### Goal

### Characterize the nRPC detector **sensitivity to gamma rays**

### Objectives

Establish the experimental procedure and assemble the experimental setup

Conduct the experimental campaign

Develop the signal analysis tools and process the experimental data

## nRPC DETECTOR





## METHOD



### GOAL

### Measure the sensitivity of the nRPC detector to gamma rays at well-defined energies

- **Corelation** of emitted gamma rays

$$^{22}_{11}\mathrm{Na} \longrightarrow ^{22}_{10}\mathrm{Ne}^* + \mathrm{e}^+$$

**Beta+ emission** 

Activity of the source : **78.21 kBq** 

- **GS** = Gamma Sensitivity
- **E** = Gamma ray energy
- **Ndet** = Number of detected gammas
- **Ntot** = Total number of gammas passing through the sensitive area of the detector



## EXPERIMENTAL SETUP



### **Setup for sensitivity to 511 keV** gamma rays



- **Ndet** = N° of coincidence between **PMTs** and **detector**
- Ntot = N° of coincidence between both PMTs



- detector

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### **Setup for sensitivity to 1274.5 keV** gamma rays

----- 511keV -----> 1274.5 keV

• **Ndet** = N° of coincidence between **PMTs** and

• **Ntot** = N° of coincidence between both **PMTs** multiplied by the **fraction of solid angle** covered by the sensitive area of the nRPC detector

## EXPERIMENTAL SETUP



### **Setup for sensitivity to 511 keV** gamma rays



- **Ndet** = N° of coincidence between **PMTs** and **detector**
- Ntot = N° of coincidence between both PMTs



- detector

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### **Setup for sensitivity to 1274.5 keV** gamma rays

----- 511keV -----> 1274.5 keV

Fraction of solid angle computed by simulations with ANTS3

• **Ndet** = N° of coincidence between **PMTs** and

• **Ntot** = N° of coincidence between both **PMTs** multiplied by the **fraction of solid angle** covered by the sensitive area of the nRPC detector

## EXPERIMENTAL SETUP





- **Ndet** = N° of coincidence between **PMTs** and **detector**
- Ntot = N° of coincidence between both PMTs

- detector

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• Ndet = N° of coincidence between **PMTs** and

• **Ntot** = N° of coincidence between both **PMTs** multiplied by the **fraction of solid angle** covered by the sensitive area of the nRPC detector





### **Readout Electronics**

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### **Experimental Setup**







### **Readout Electronics**



### **Readout Electronics**



X RAYS

COMPTON EDGE



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### **Energy window definition**



22Na spectrum from **PMT1** acquired by MCA



22Na spectrum from **PMT2** acquired by MCA



### **Readout Electronics**





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### **Energy window definition**

Energy window settings for**PMT1** acquired by MCA (Setup for sensitivity to 511keV gamma rays)



Energy window settings for **PMT2** acquired by MCA (Setup for sensitivity to 511keV gamma rays)





### **Readout Electronics**





## DATA PROCESSING

### **Selection criteria**

• **AMPLITUDE** 

Pulse spectra at 2.3kV

### Counts Signal Signal Background Background + Gamma Source 10<sup>5</sup> 12000 SATURATION 10<sup>4</sup> 10000 8000 10<sup>3</sup> 6000 10<sup>2</sup> 4000 2000 0 2000 10000 4000 6000 8000 5 0 10 Amplitude (ADU ELECTRONIC NOISE

### • TIME WINDOW



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### Distribution of the position of the rising slope's middle at 2.3 kV



## RESULTS



Average **Ndet/Ntot** per RPC with detector in **front** of the **22Na source** (solid line) and away (dotted line) for the **511keV (blue)** and **1274.5 keV (red)** gamma rays



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### RANDOM COINCIDENCE AMONG THE TOTAL NUMBER OF TRIPLE COINCIDENCES





## RESULTS



# CONCLUSIONS

- Implemented an experimental setup to evaluate the sensitivity of the nRPC detector to 511 keV and 1274.5 keV gamma rays using a gamma correlation method.
- Developed tools for processing the nRPC waveforms recorded with the acquisition system.
- An average Gamma sensitivity per RPC of **~4e-6** and of **~3e-5** for the 511 keV and 1274.5 keV gamma rays, respectively, was measured in the neutron plateau region (@1.9 kV).







# THANK YOU FOR YOUR ATTENTION







### EXTRA SLIDES **GAMMA SENSITIVITY PER RPC**



Note : Values already corrected for random coincidences



gamma rays

# EXTRA SLIDES





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Charge at the input of the pre-amplifiers (PAs) as a function of the amplitude of the pulses (in ADU units) acquired by the DAQ system

### EXTRA SLIDES RPCS TRIGGER SETTINGS



Detector counting rate as a function of the threshold settings on the Comparators for each nRPC cathode channel ( at 2.1 kV)





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