Measurement of Short Range Correlations on Exotic Nuclei at R^{3}B using tRPCs

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Ciências ULisboa

R^{3}B

LIP

RPC 2022

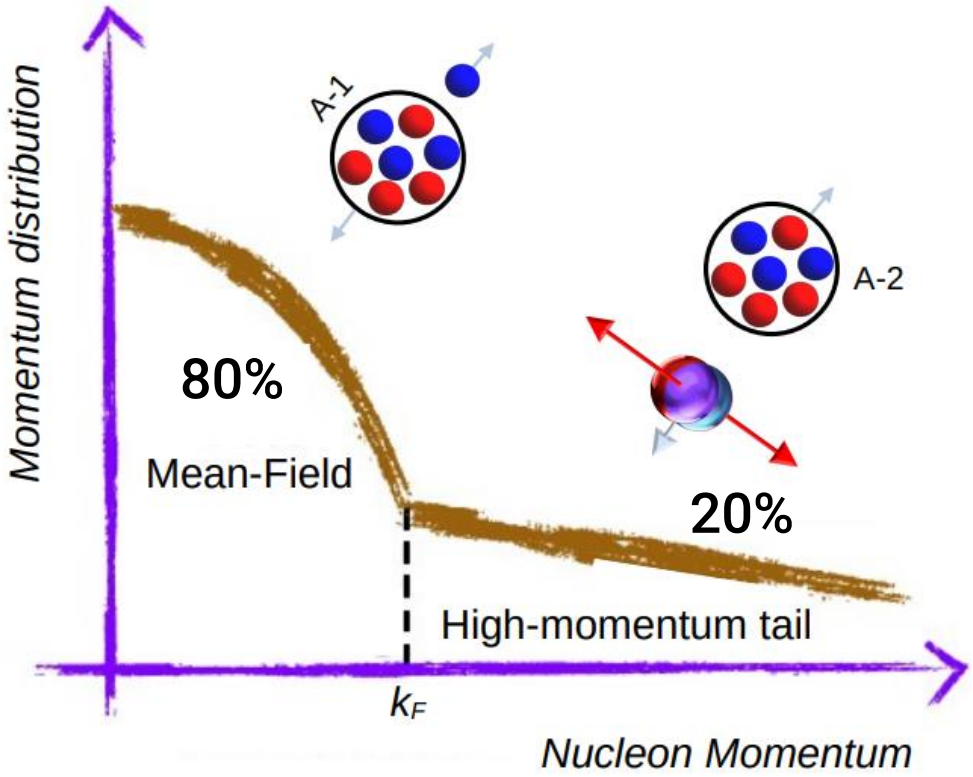
Overview

RPC 2022

- Motivation
  - Small introduction on SRC
  - R^3B Collaboration
  - S522 experiment
- Resistive Plate Chamber Detectors
  - RPC integration in R^3B environment
  - RPC calibration
  - Beam time performance
  - Ongoing analysis
- Summary and Outlook

(SRC) Short Range Correlations

RPC 2022



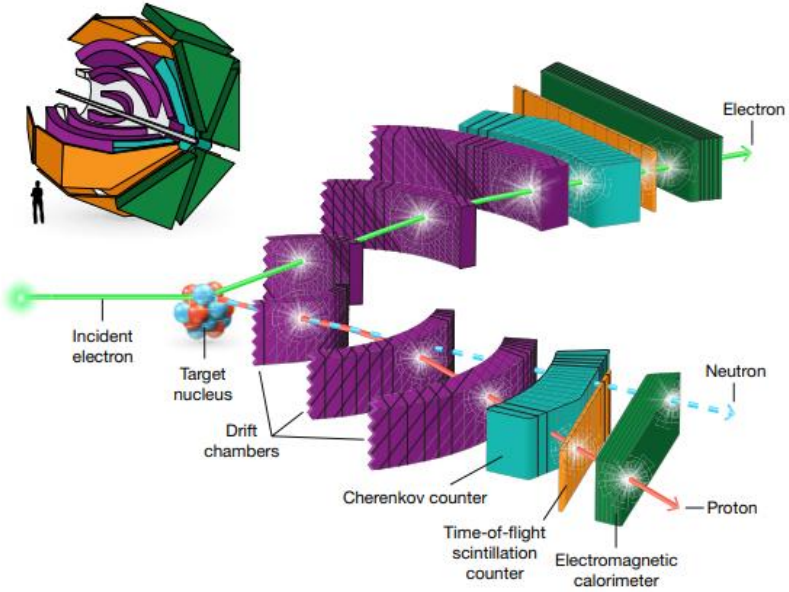
Brief fluctuations of nucleon pairs, characterized by:

- High relative momentum*
- Low center-of-mass momentum*
- SRC pair can be pp, pn and nn, where the pn are dominant
- Fraction of high momentum nucleon in nuclei is about 20%

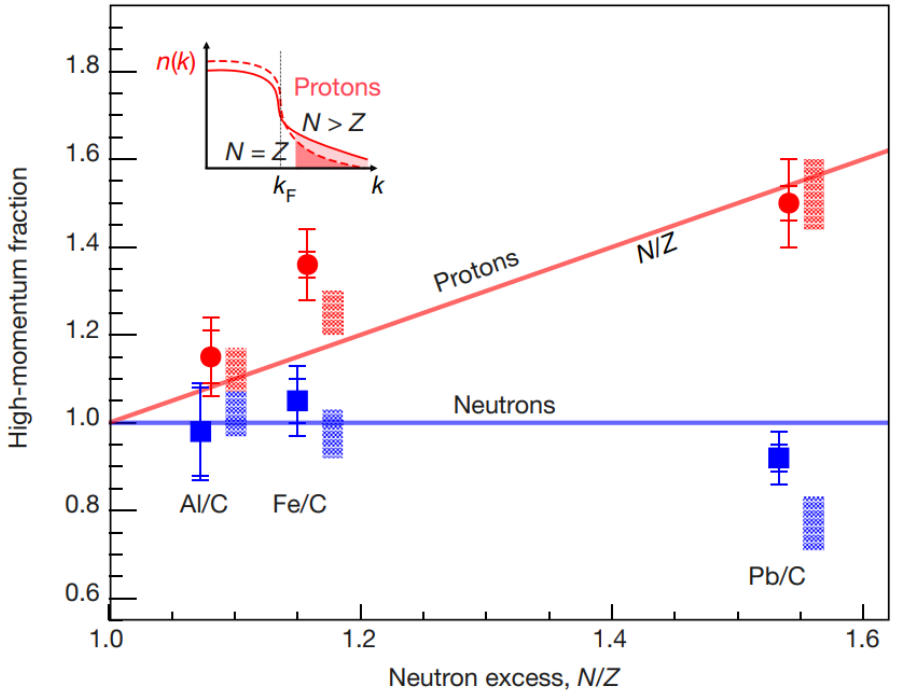
*in reference to Fermi Momentum (k_f)

Measuring SRC with High energy probes

RPC 2022



CLAS spectrometer



The CLAS Collaboration. Probing high-momentum protons and neutrons in neutron-rich nuclei. *Nature* 560, 617–621 (2018)

Measuring SRC in Inverse Kinematics

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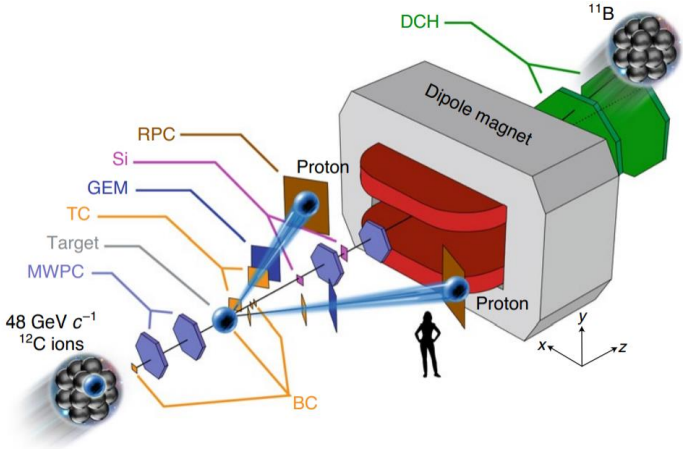
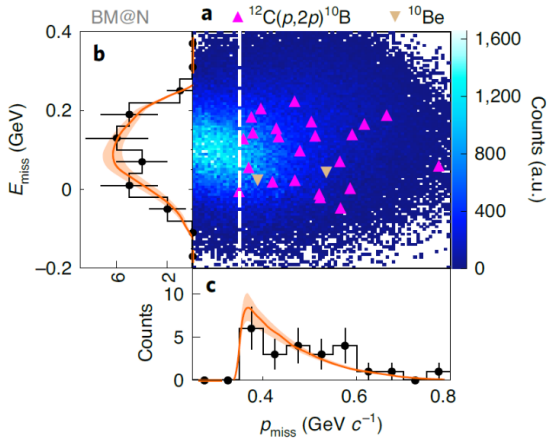
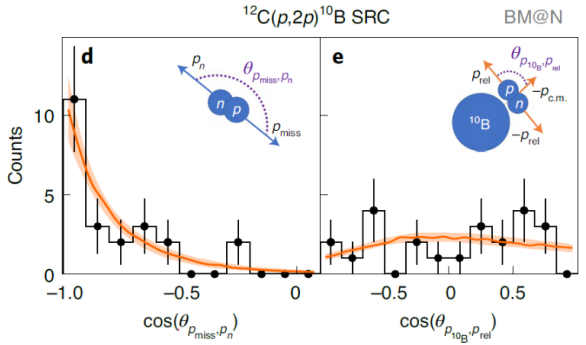






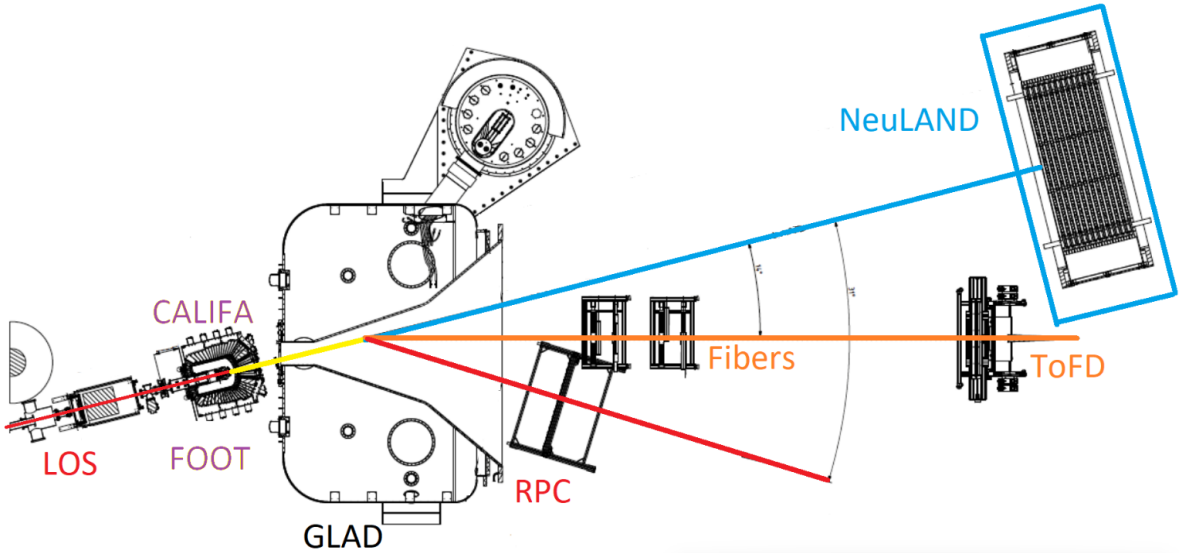
Patsyuk, M., et al. "Unperturbed inverse kinematics nucleon knockout measurements with a carbon beam." *Nature Physics* 17.6 (2021): 693-699

(R³B) Reaction with Relativistic Radioactive Beams

RPC 2022

GSI FAIR

R³B



S522 Experiment and why an RPC?

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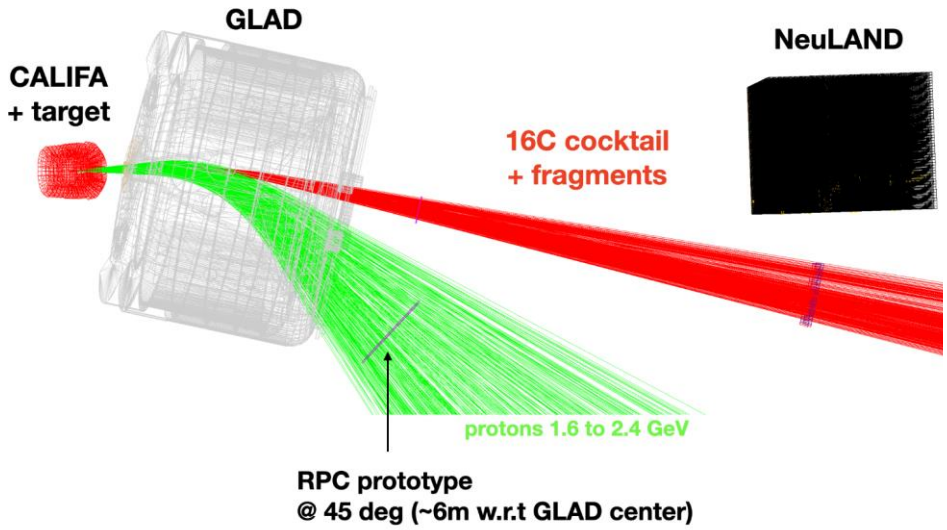
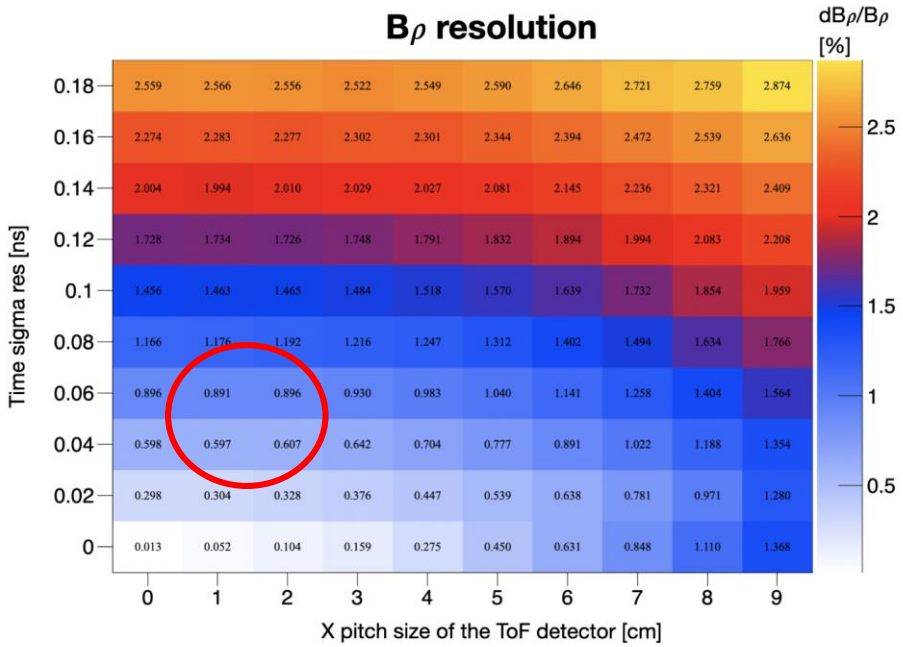
First characterization of Short-Range Correlations in exotic nuclei at R³B - Spokesperson: Anna Corsi and Or Hen





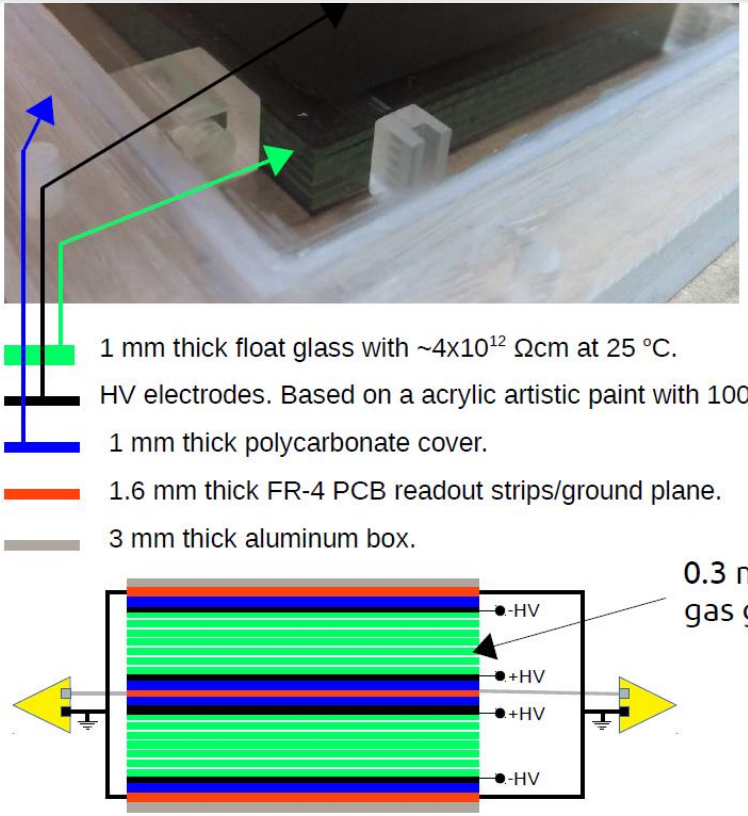
For the RPC detector Δσ ≈ 50 ps and ΔX ≈ 1cm

Courtesy of Valerii Panin

(RPC) Resistive Plate Chamber Detector

RPC 2022

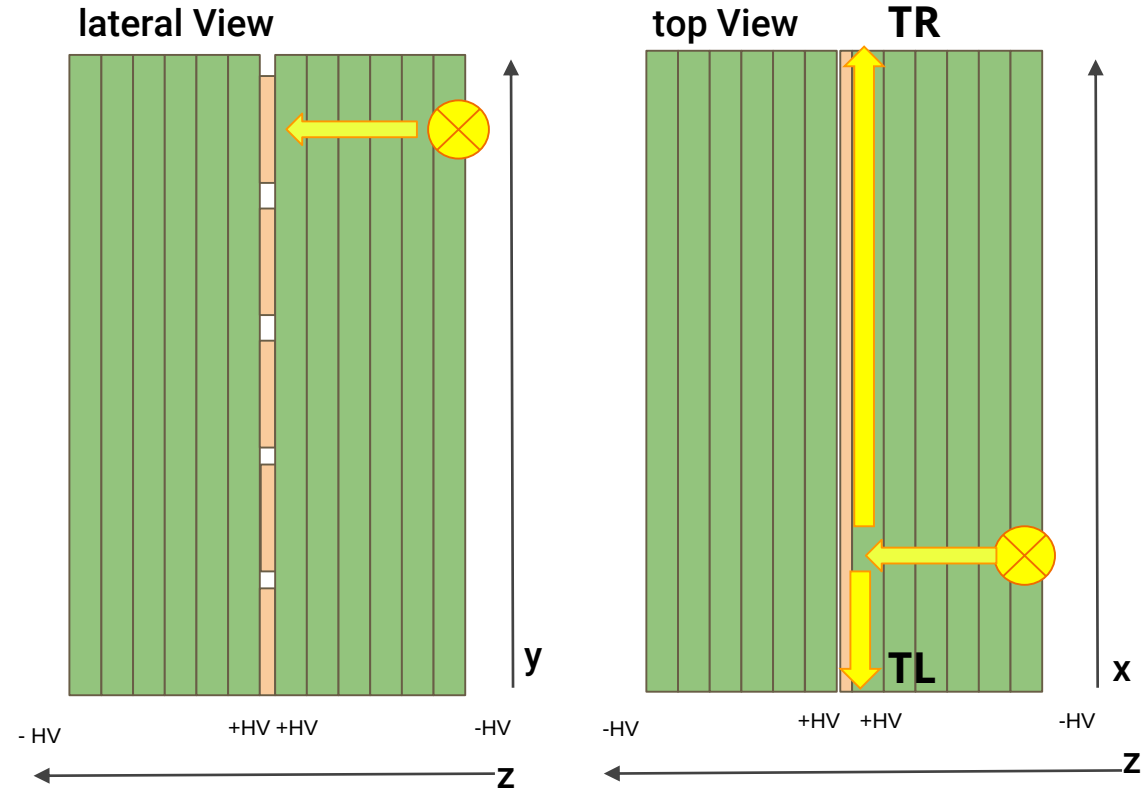
- Active area of 1500x1200 mm² = 1,8 m²
- Two modules composed 6 gap RPC glass stacks
- Gas mixture of $C_2H_2F_4$ (98%) and SF_6 (2%)
- Readout strips 3 cm width (placed in the middle of the two modules)
- Readout in both sides of the strips



The SHiP timing detector based on MRPC - A. Blanco et al.

RPC readout and data structure

RPC 2022

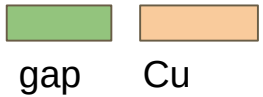


From the readout we can obtain:

- #Strip
- Time Leading and trailing
- Side (L, R)

From this we can calculate:

- Y position from #Strip
- X position from (TR-TL)/2
- Time over Threshold (ToT) values that will be used to select the hit



Characterization at CERN

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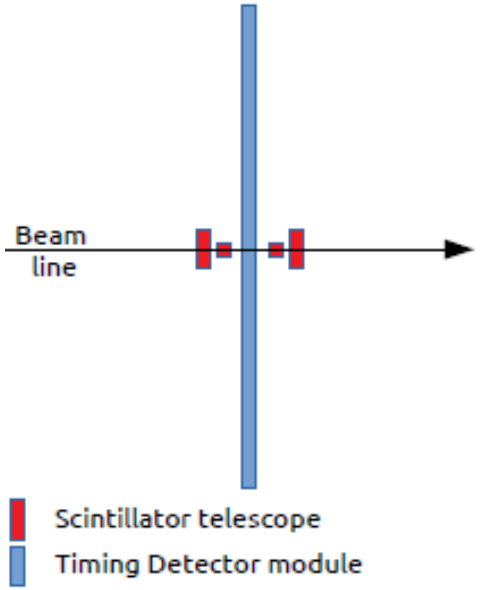
RPC characterized at CERN with a beam of negative pions with and energy of 8 GeV/c



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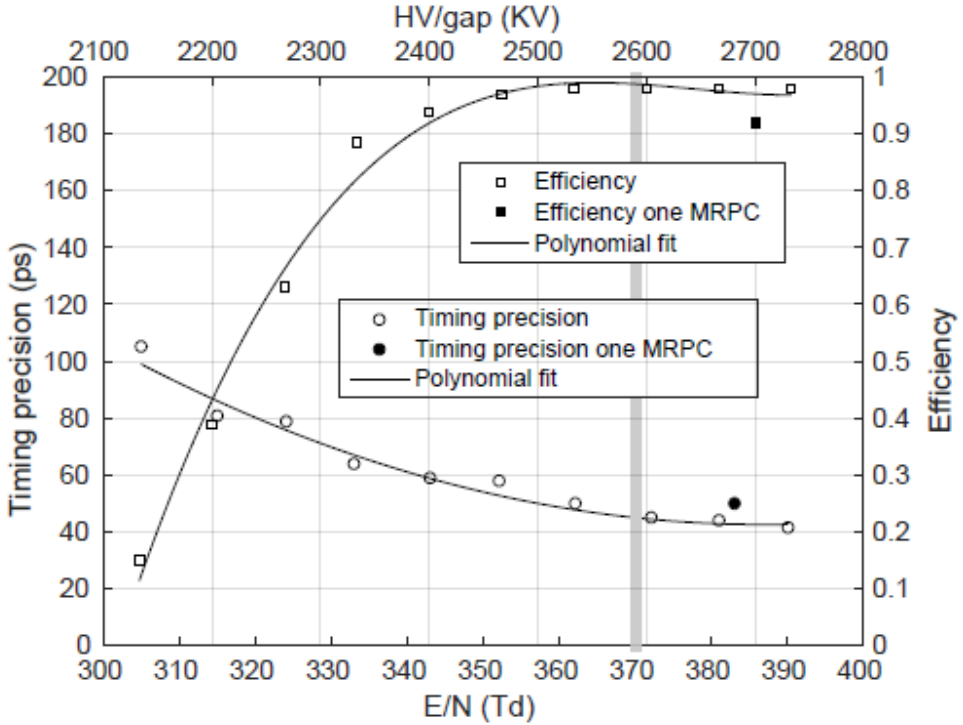

R^3B integration

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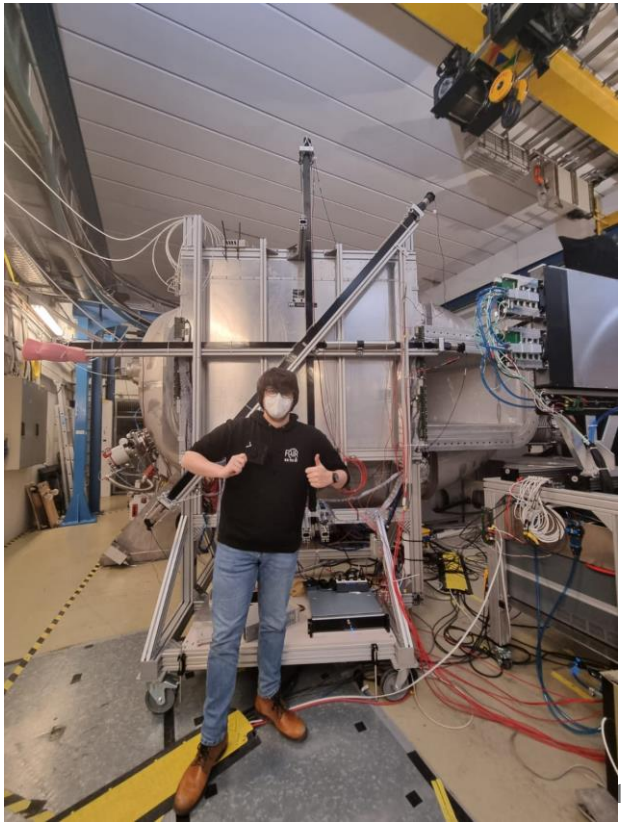
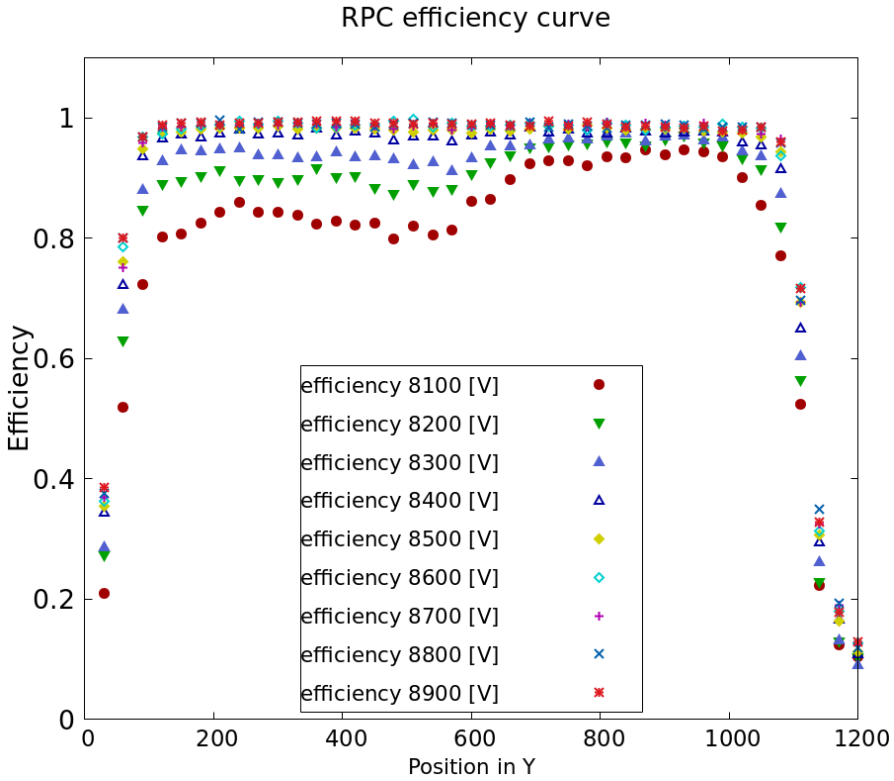
The RPC arrived on the 29/11/2021

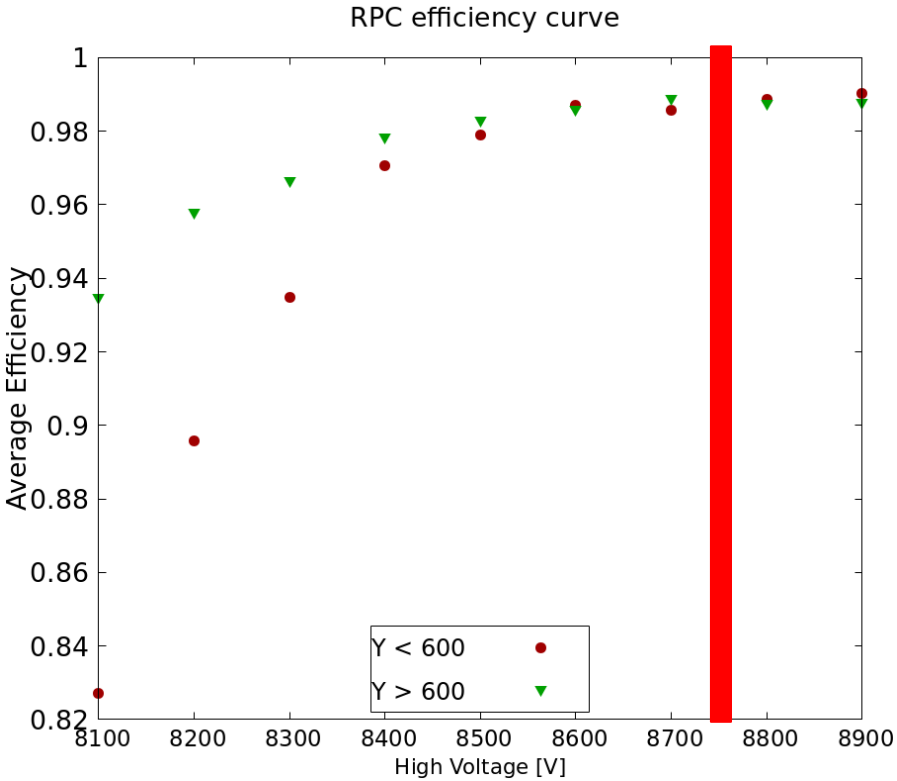
- Positioning the Detector inside Cave C
- Integrating the Detector into the R^3B DAQ
- Implementing R^3B analysis tools (online and offline)



Finding HV working point at R³B

RPC 2022





Calibrating the RPC

RPC 2022

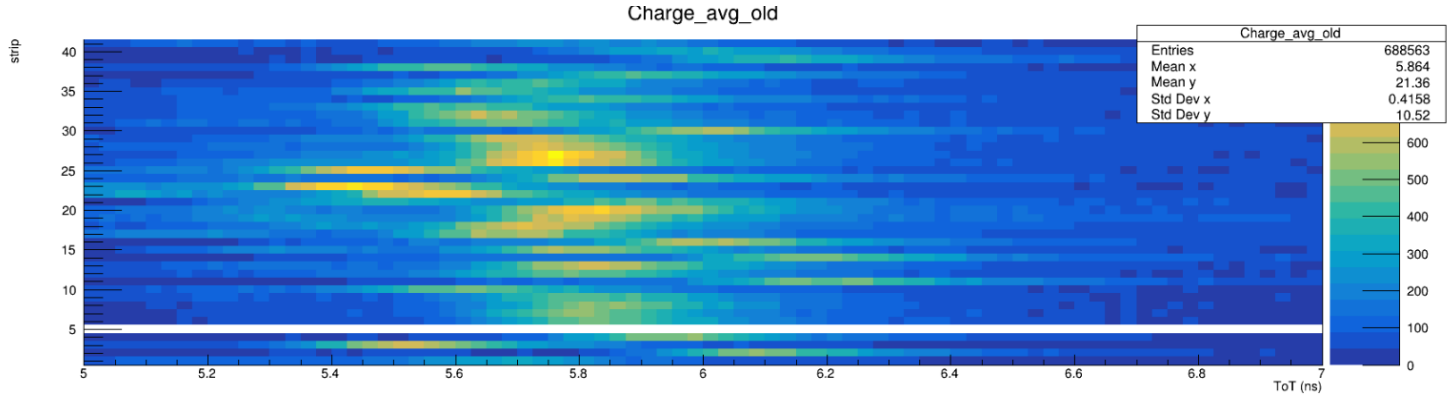
Several calibration need to be implemented:

- Time over threshold alignment (ToT) - > Using derivative to find offset;
  - Very important for Hit selection
- Position alignment of the Strips -> Uses the integrated histogram of the hits;
  - Very good alignment
- Time Calibration
  - Calibrate time intra/inter-strip
  - Final objective, a isochron surface placed in the R3B environment
- Position the RPC into the R^3B environment
  - Measurements with laser and radioactive source
  - Sweep Run with ^{40}Ar at 300 MeV/u

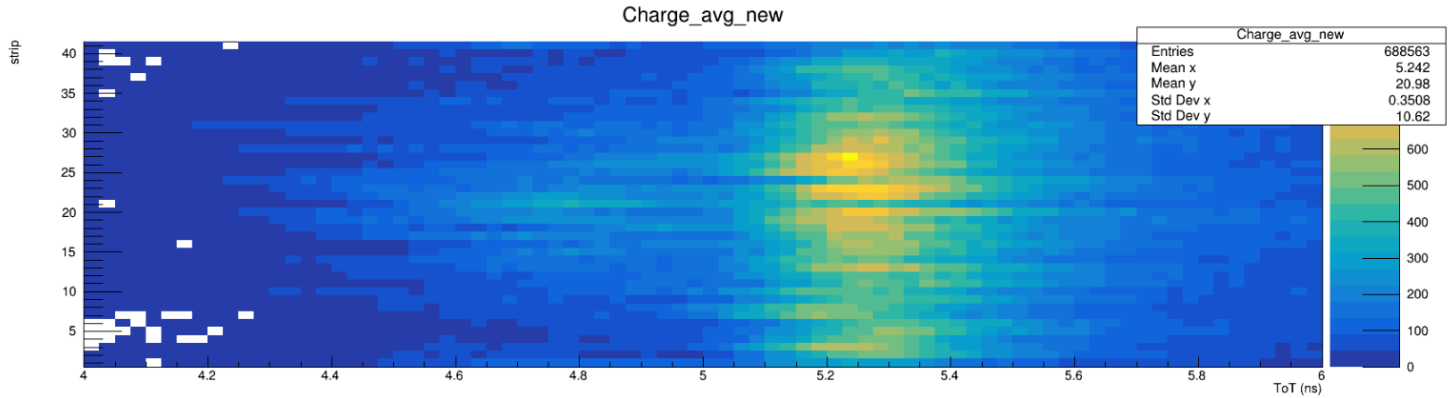
ToT alignment

RPC 2022

10% of events mismatched events



2% of events mismatched events



Calibration

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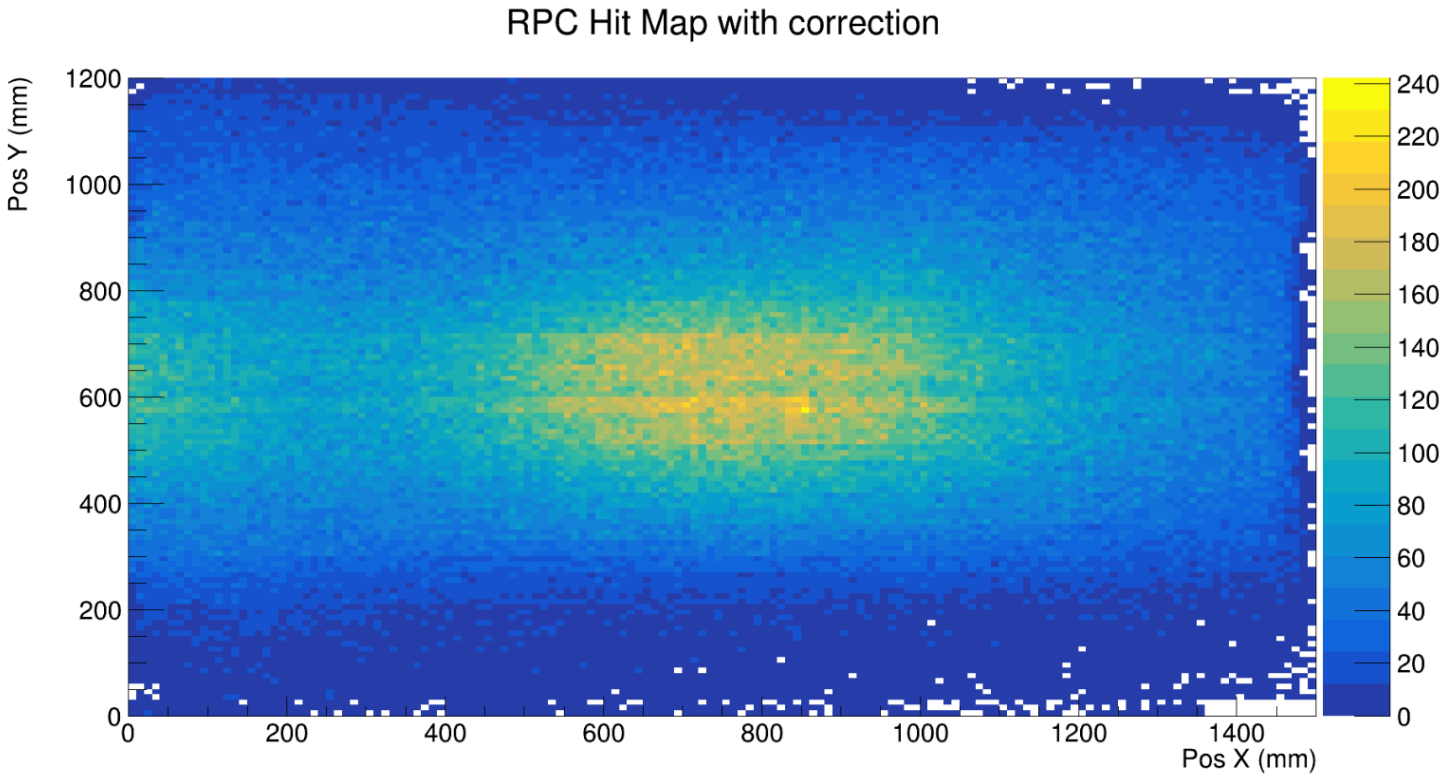
RPC Hit Map alignment

RPC 2022



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RPC Time Calibration

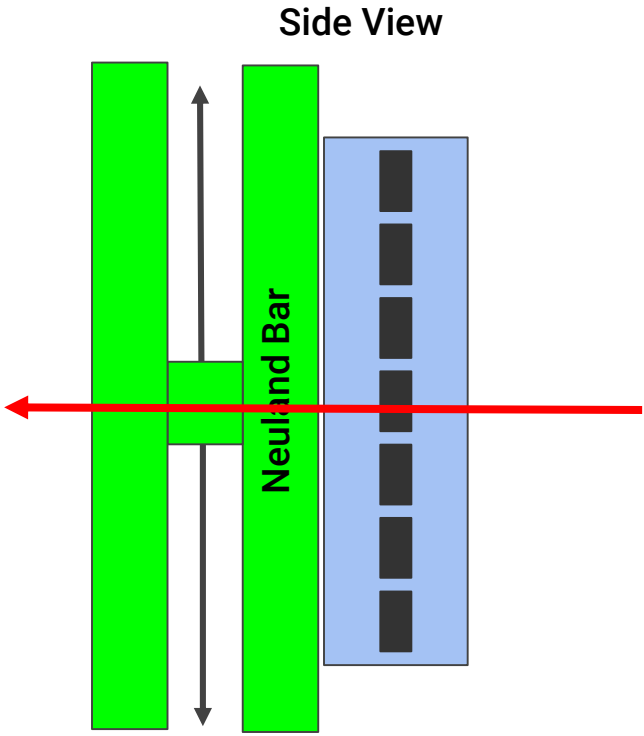
RPC 2022

Work in progress, there are 2 approaches:

- Using cosmic coincidences
- Using protons from the reaction

Crucial for the analysis as the RPC needs to be an isochron surface.

Work in progress!



Calibration

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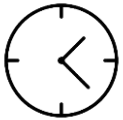
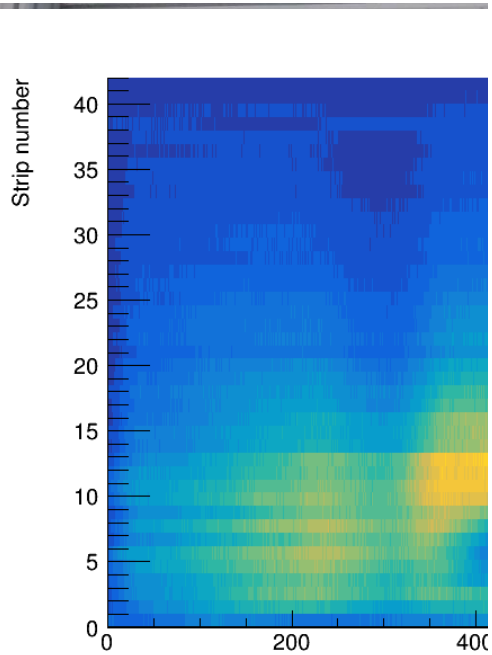
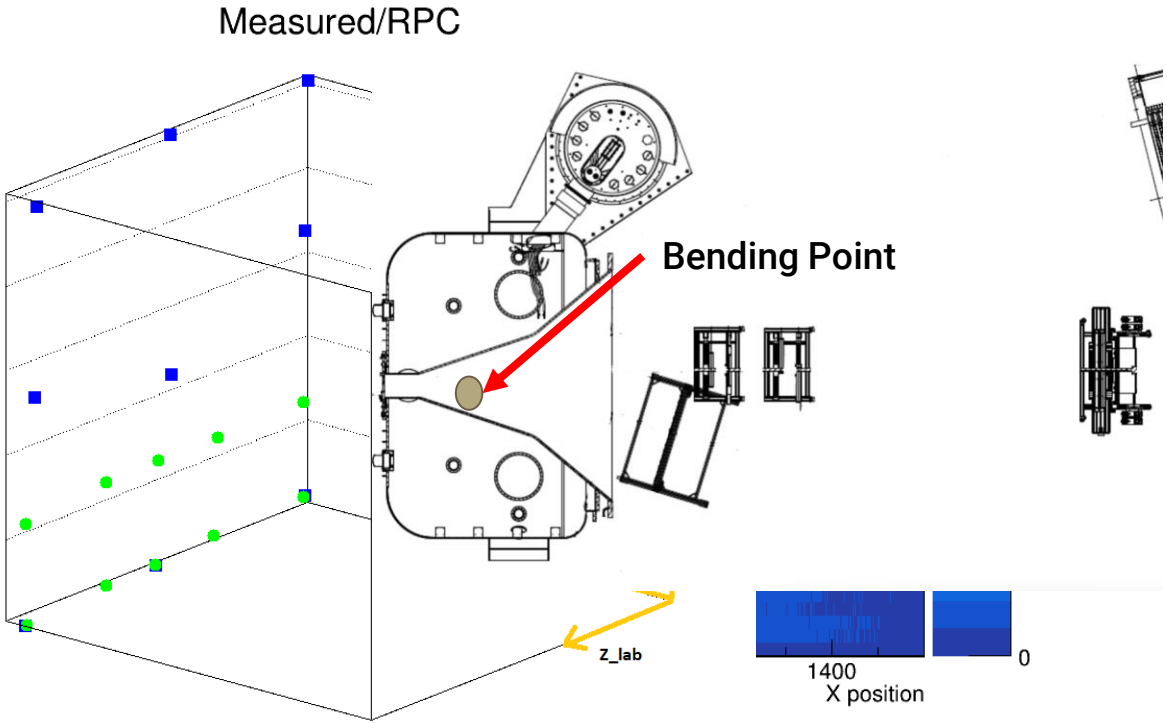


- Position the RPC into the R^3B environment
  - Measurements with laser and radioactive source
  - Sweep Run with ^{40}Ar at 300 MeV/u

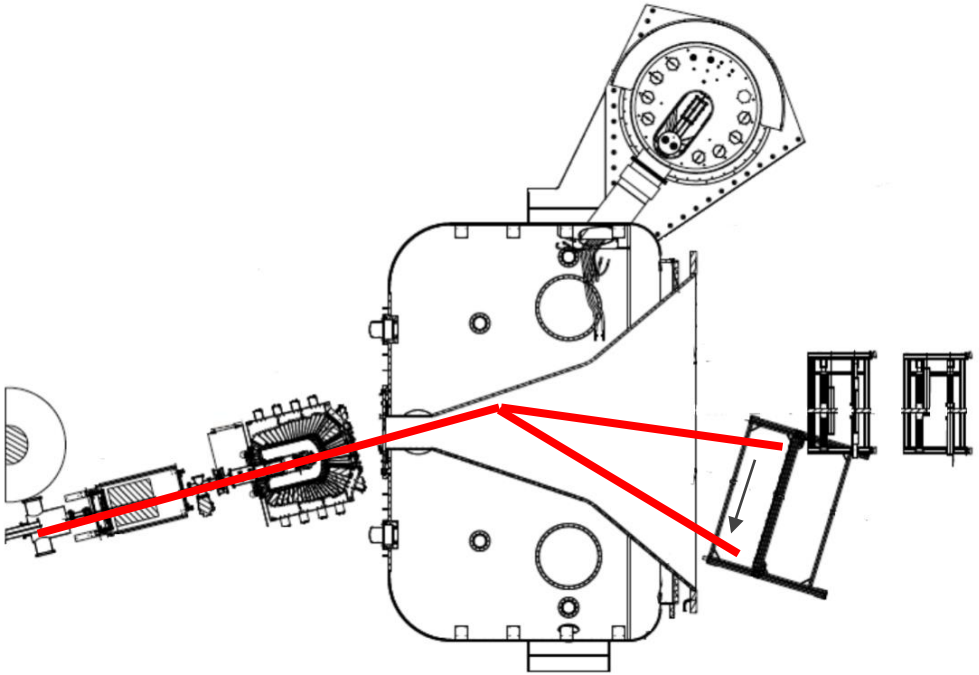
Correlate Strip Position with RPC box

RPC 2022





Sweep run with ^{40}Ar

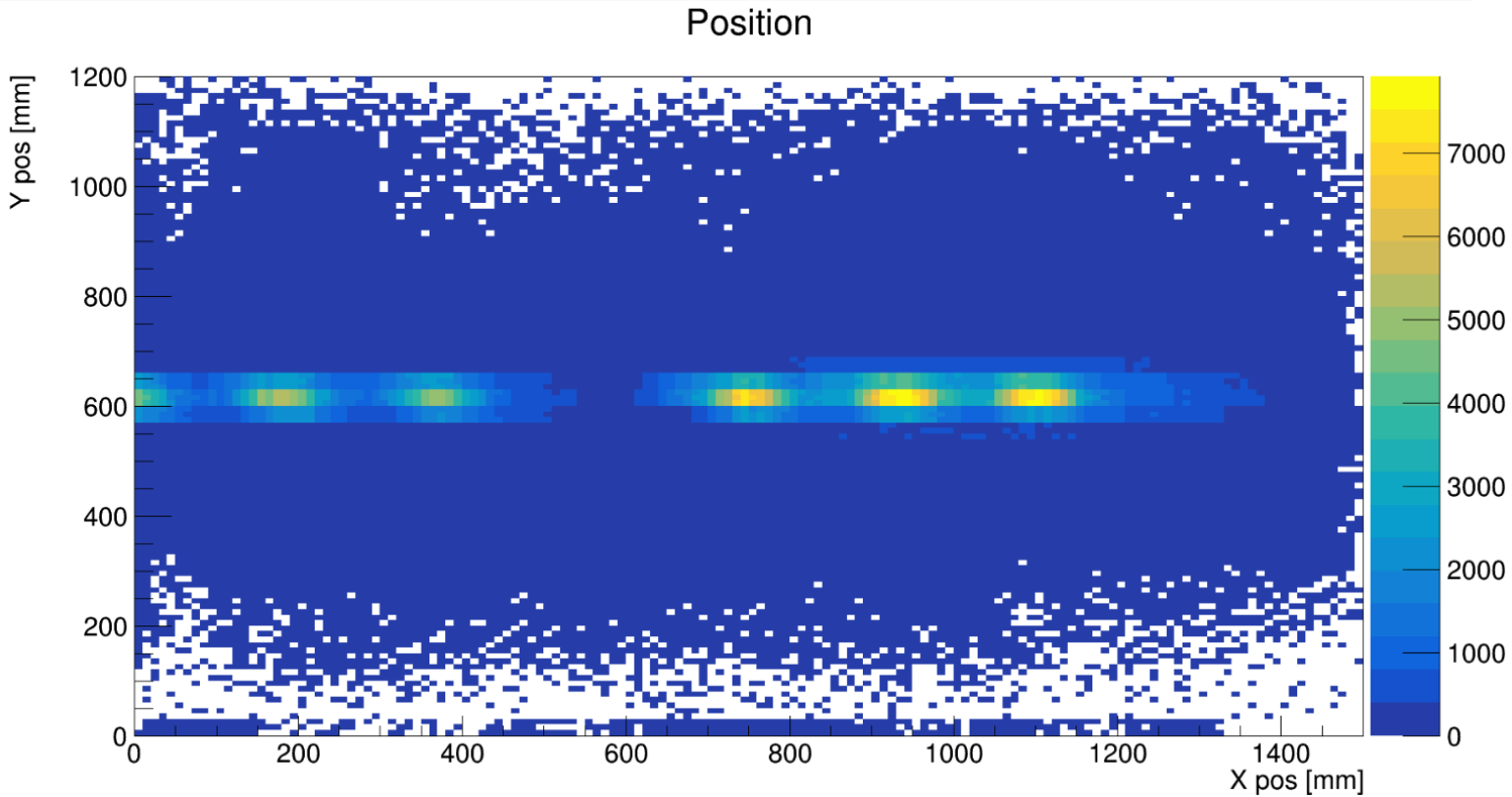


Calibrate the RPC Position:

- 300 MeV/u 40Ar beam sent through GLAD;
- Sweep the RPC by changing the Magnetic field of GLAD;
- Compare the results with simulation;

Sweep run with ^{40}Ar

RPC 2022



RPC Resolution for ^{40}Ar

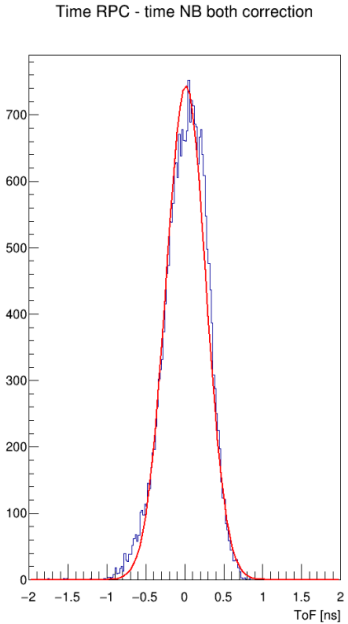
RPC 2022

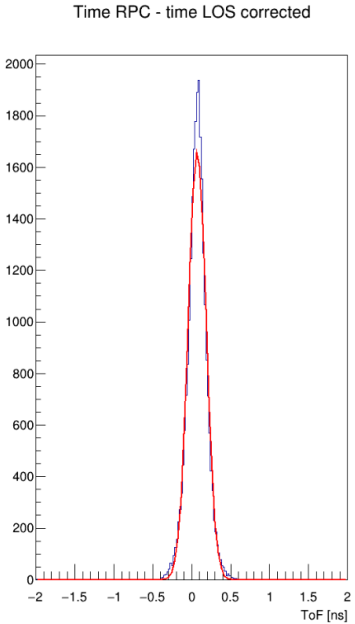
$$\begin{pmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{pmatrix} \begin{pmatrix} \sigma^2_{RPC} \\ \sigma^2_{SC_1} \\ \sigma^2_{SC_2} \end{pmatrix} = \begin{pmatrix} \sigma^2_{\Delta_{RPC-SC_1}} \\ \sigma^2_{\Delta_{RPC-SC_2}} \\ \sigma^2_{\Delta_{SC_1-SC_2}} \end{pmatrix}$$

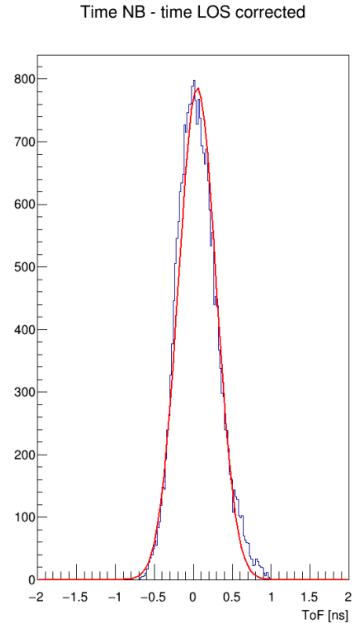
where:

- Sc1 is Start detector (LOS)
- Sc2 is Neuland Bar

σ_{RPC} = 0.098 ps
σ_{Sc1} = 0.059 ps
σ_{Sc2} = 0.235 ps





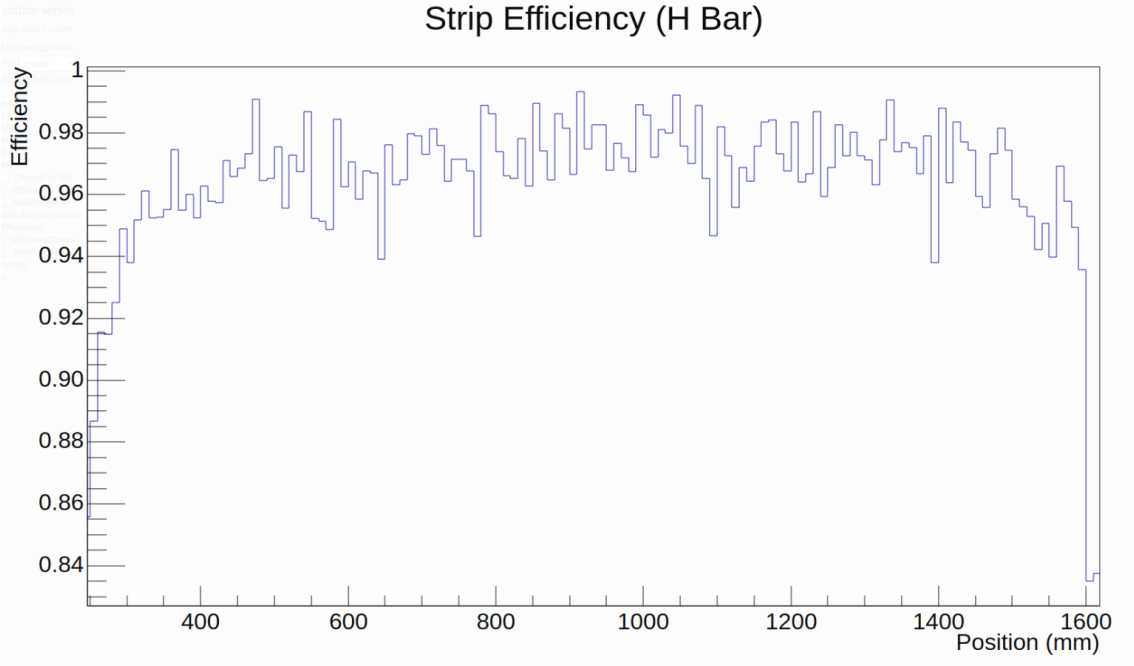


Beam time performance

RPC 2022

First Beam time at R^3B:

- RPC efficiency higher than 95%;
- Good synchrony between RPC and the other detectors
- Detector and DAQ were stable during the two weeks of beam time

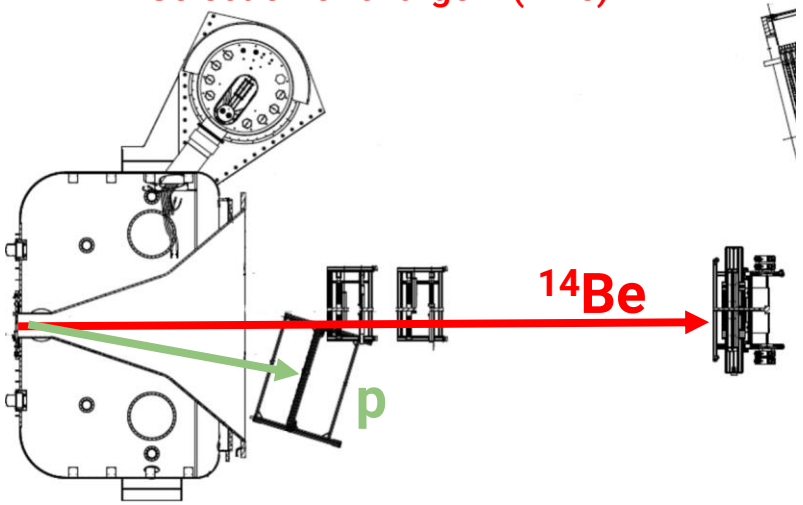


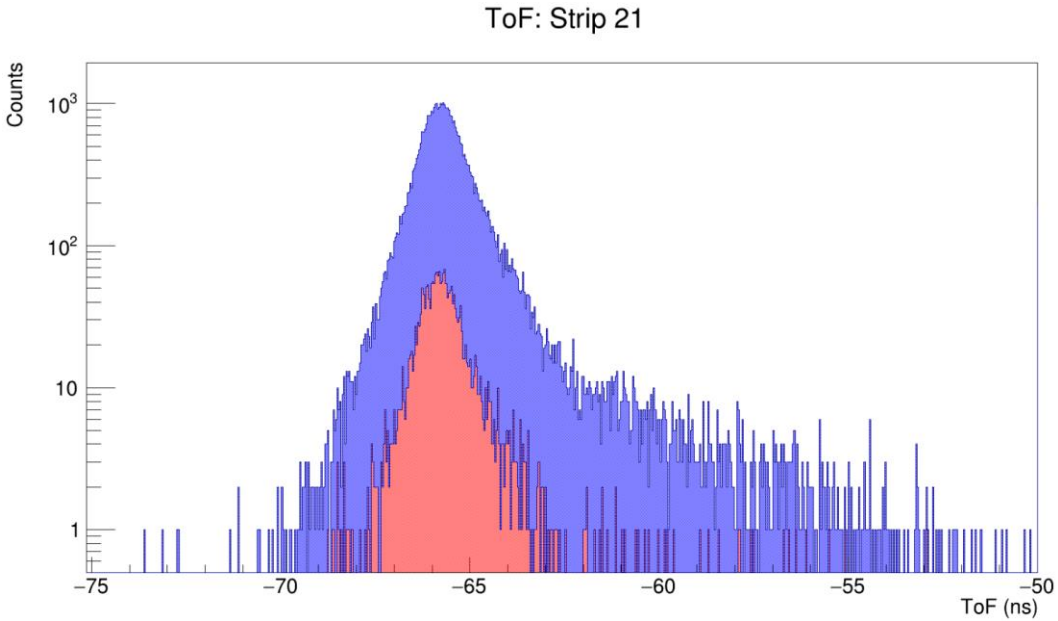
Beam time performance

RPC 2022

ToF between RPC and LOS for ^{16}C Beam at 1.25 GeV:

- reaction of interest $^{16}C(p,2pp)^{14}Be$
- All events
- Selection of charge 4 (^{14}Be)





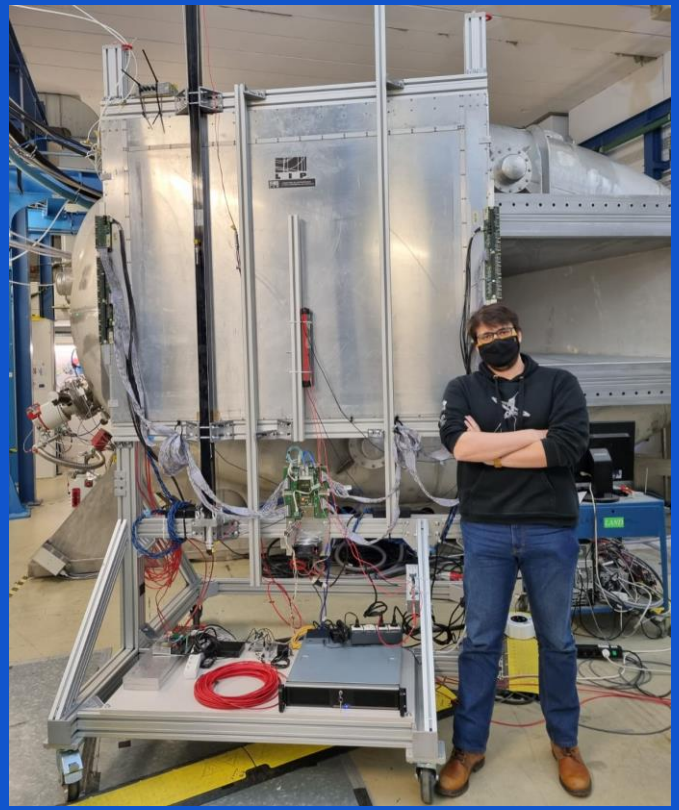
Around 1% of all data

Summary and Outlook

RPC 2022

- RPC detector fully implemented into R^3B environment
  - Daq integration of a completely new system
  - Working point found (8750 V)
  - Software for online analysis and calibration was developed
- Calibration still in development:
  - Good ToT calibration
  - Good alignment of the strip position
- Outlook
  - Time calibration
  - Data analysis!

Thank you for your attention!



Supported by Portuguese FCT, Project Refs: 2021.05736.BD and EXPL/FIS-NUC/0364/2021

RPC Position in the cave

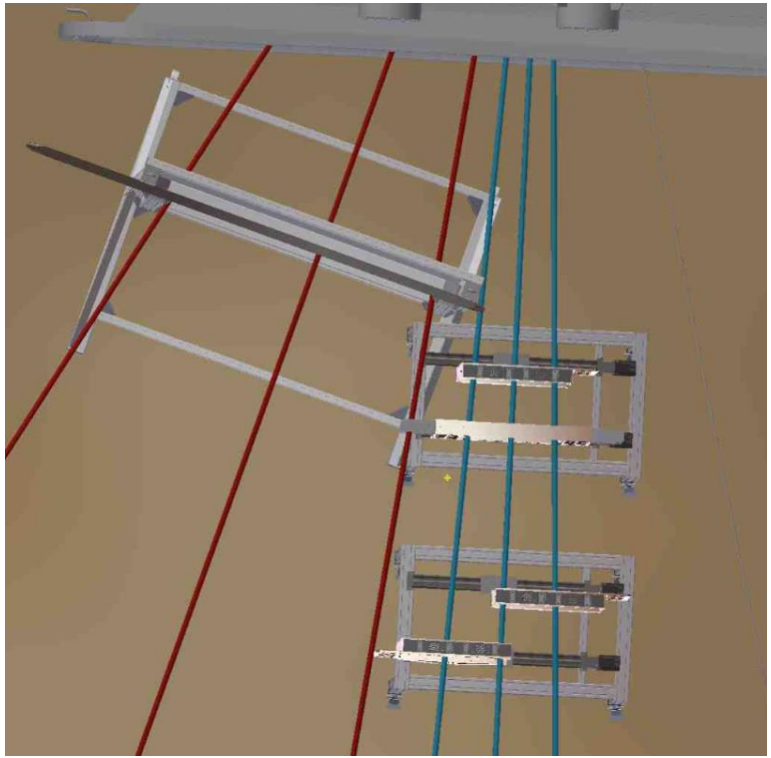
RPC 2022

The RPC center will be position at 3.70 m from the bending point of GLAD.

It will cover the forward emitted proton from:

- 21º-44º for the ^{12}C beam;
- 27º-51º for the ^{16}C beam;

Angles with respect to the bending point of GLAD;



Daniel Koerper CAD design

Pulser Test

RPC 2022