



LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia



Ciências
ULisboa
Faculdade
de Ciências
da Universidade
de Lisboa

RPCs for PAS?

D. Galaviz

R³B Collaboration Meeting

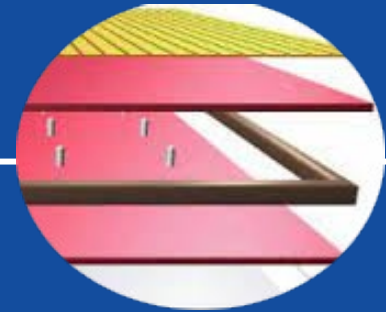
Budapest, May 24th 2023

Overview

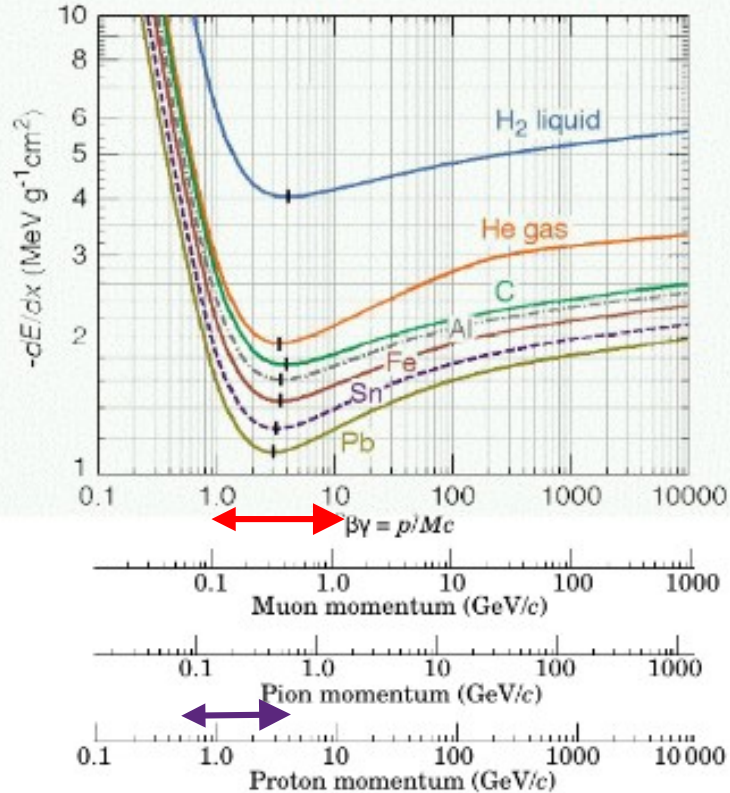
- Resistive Plate Chambers for MIPs detection
- A brief history of RPC at R³B
- Does an RPC meet the PAS requirements?: First studies
- Summary and Next Steps

RPCs

for MIPs detection



Minimum Ionising Particles (MIPs)



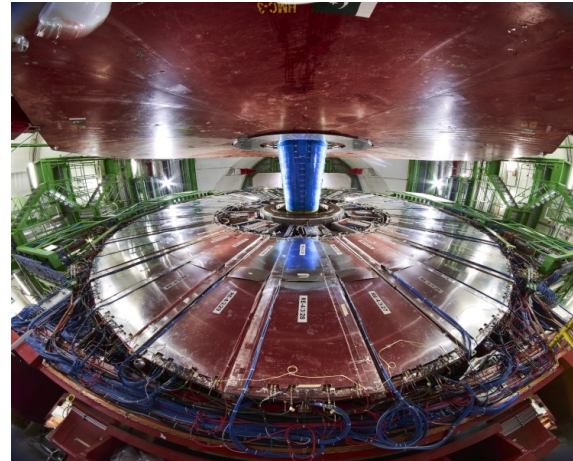
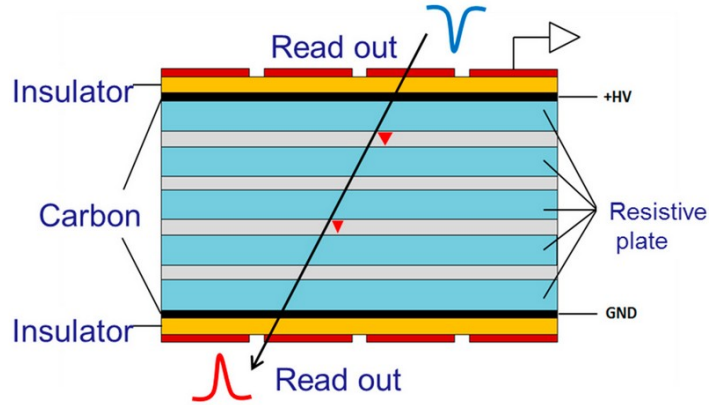
MIPs regime

Protons @ R³B regime

Resistive Plate Chambers (RPCs)

Examples

Schematic



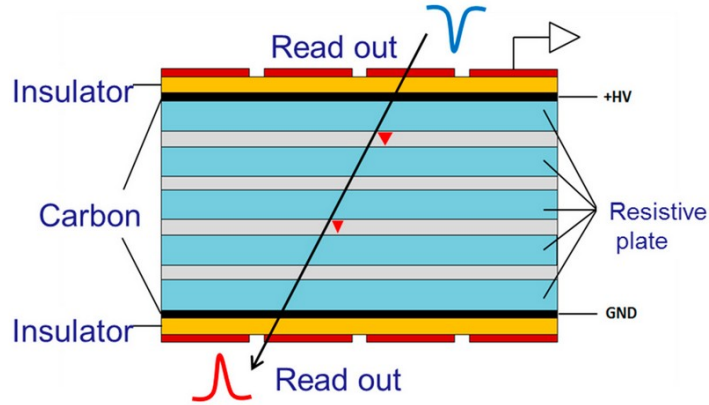
RPCs @ CMS

Y. Wang, Appl. Sci. 2021, 11(1), 111

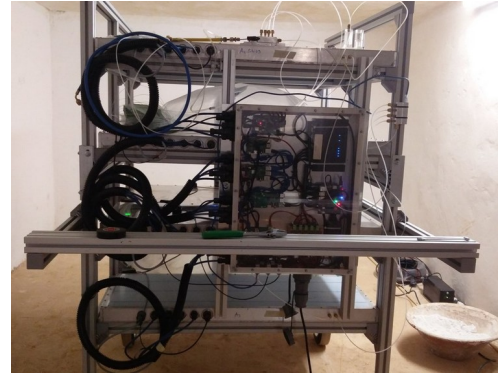
Resistive Plate Chambers (RPCs)

Examples

Schematic



Y. Wang, Appl. Sci. 2021, 11(1), 111

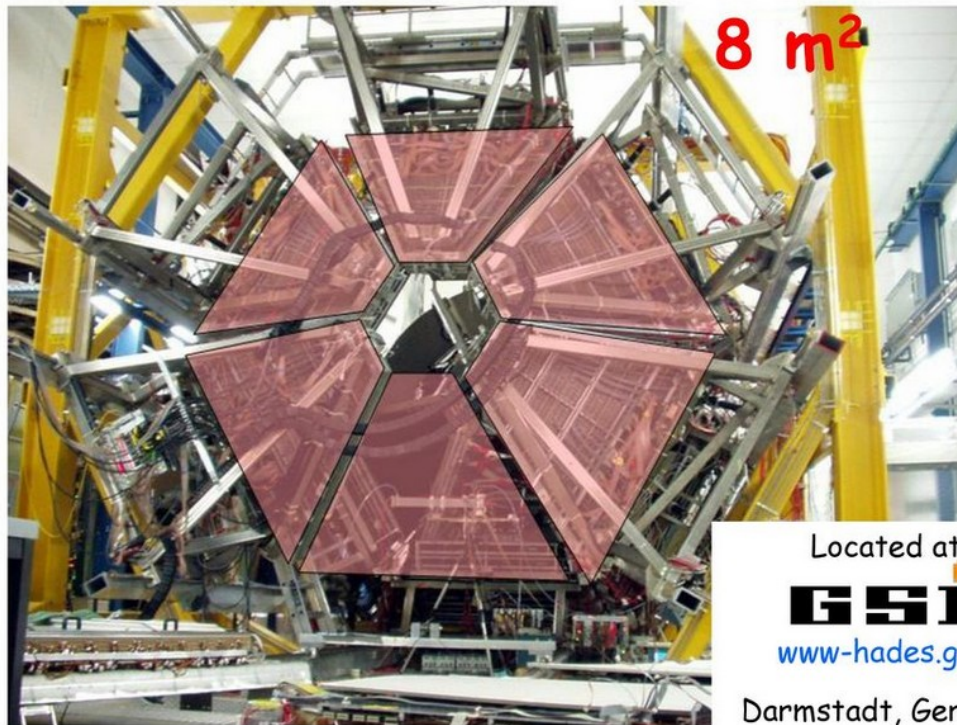


Muon Tomography



Resistive Plate Chambers (RPCs)

HADES spectrometer. RPC-TOF



Located at:

GSI

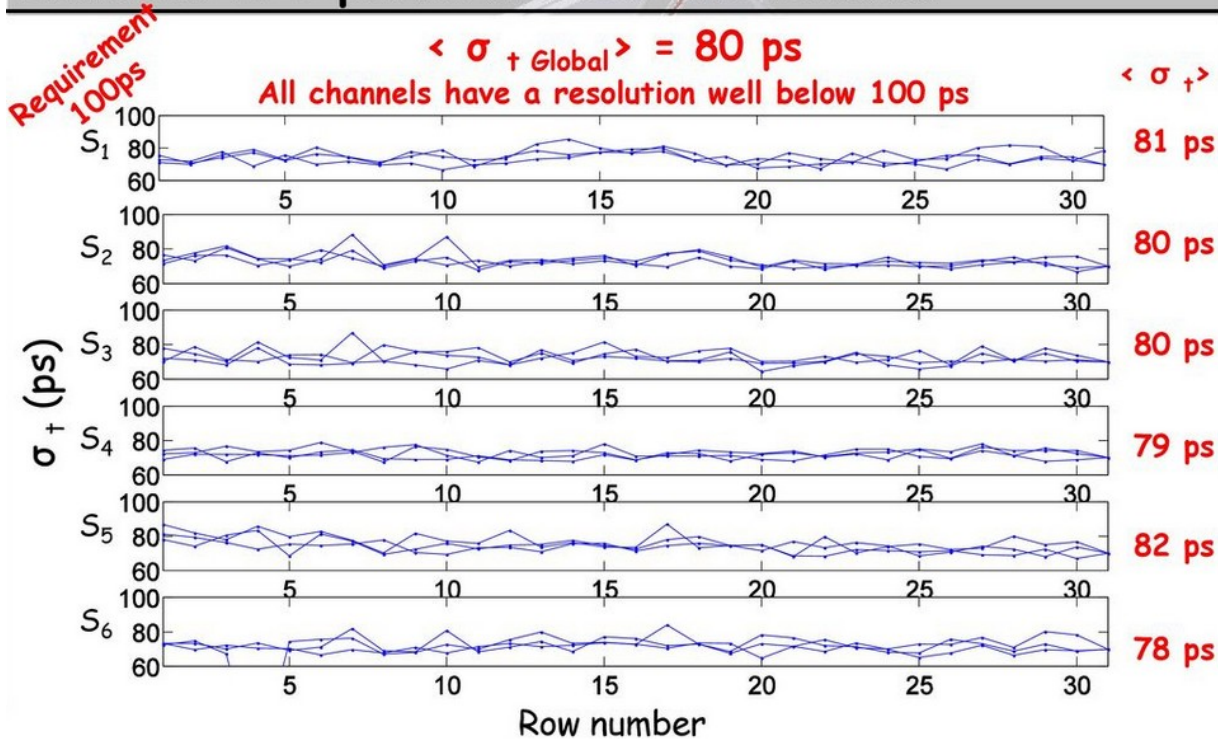
www-hades.gsi.de

Darmstadt, Germany.

Adapted from
A. Blanco

Resistive Plate Chambers (RPCs)

Intrinsic RPC performance. Time resolution



Adapted from
A. Blanco

Out of a total of 1116 cell, 1114 are operative along with 2232 FEE

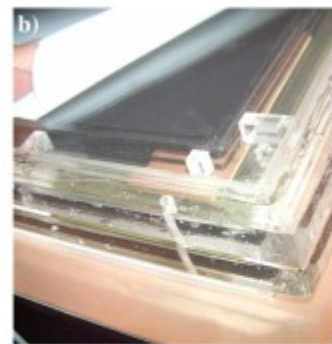
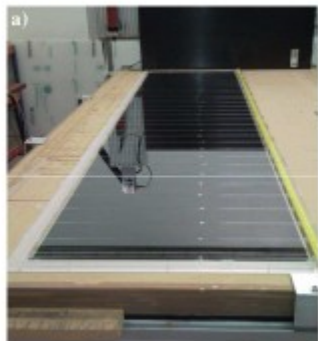
How did we get here?

(Our) brief History of RPCs @ R³B



RPC concept for NeuLAND

(back to 2012)

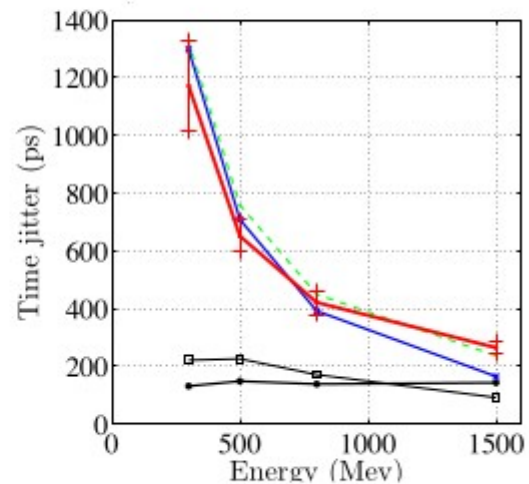


Built in Coimbra



NeuLand
prototype

$\sigma(T_{RPC_{10-0}})$ $\sigma(T_{PDS_2})$ $\sigma(Tn(E, L))$ $\sigma(nTOF_{10-0})_{stat}$ $\sigma(nTOF_{10-0})$ $\sigma(nTOF_{10-0})$ extrapolated



Beam
Direction

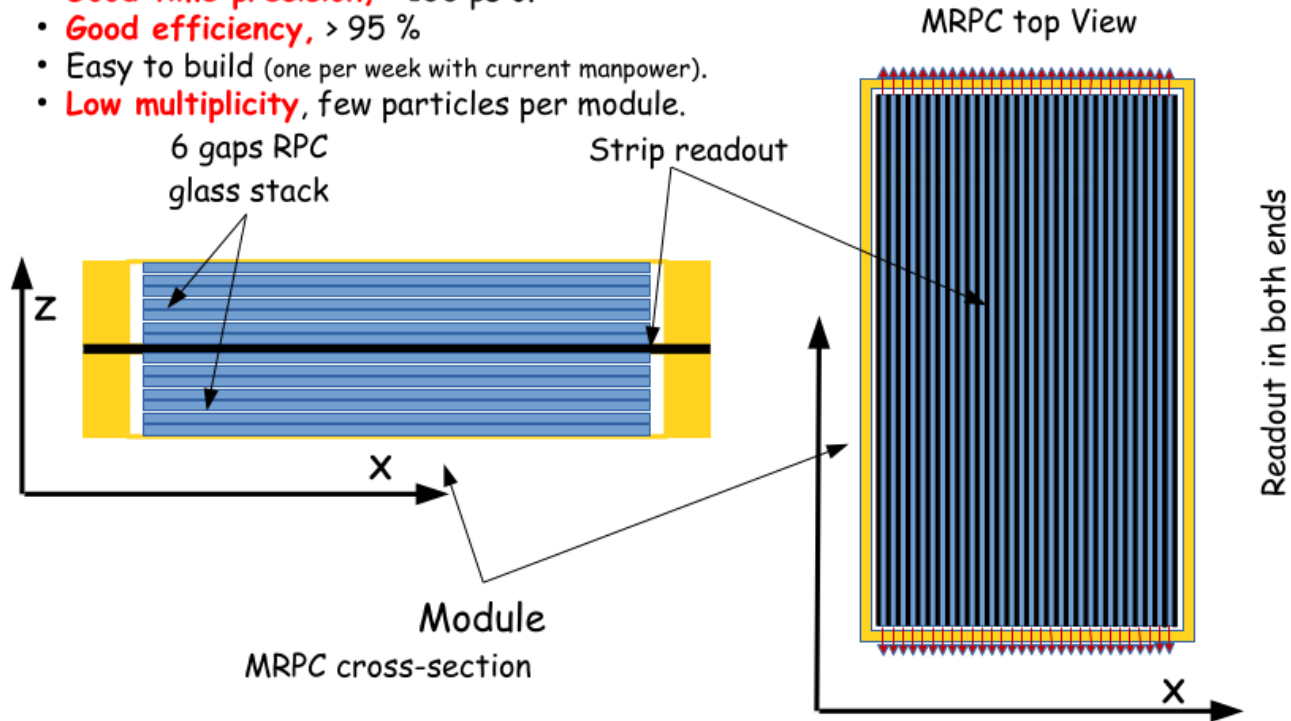
$\sigma(T_{RPC}) \sim 150$ ps

Tested at GSI

A. Blanco *et al.*, JINST 10, C02034 (2015)
J. Machado *et al.*, JINST 10, C01043 (2015)
J. Machado *et al.*, JINST 8, P07020 (2013)

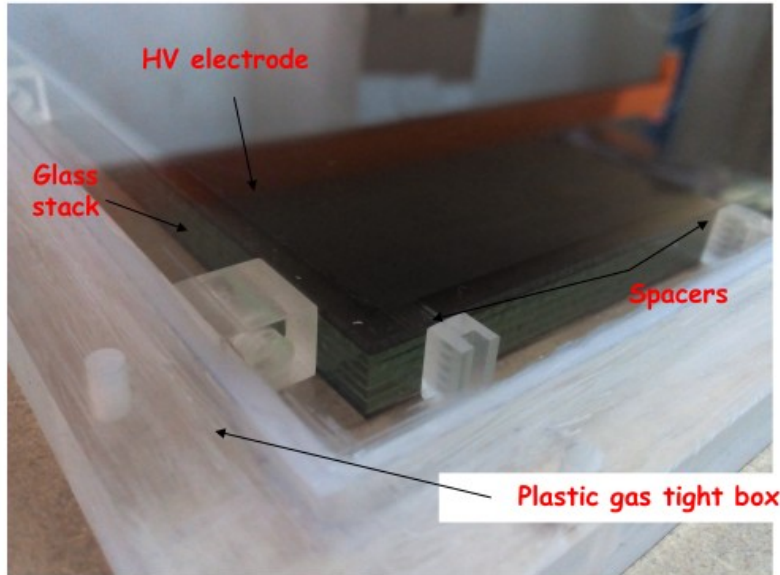
RPC concept for SHiP @ CERN

- **Modules composed of two 6 gaps RPCs** glass stack.
- **Strips 30 mm width** (placed in the middle of two stacks) readout in both sides.
- Active **area of $1500 \times 1200 \text{ mm}^2 = 1,8 \text{ m}^2$**
- **Good time precision**, $< 100 \text{ ps } \sigma$.
- **Good efficiency**, $> 95 \%$
- Easy to build (one per week with current manpower).
- **Low multiplicity**, few particles per module.



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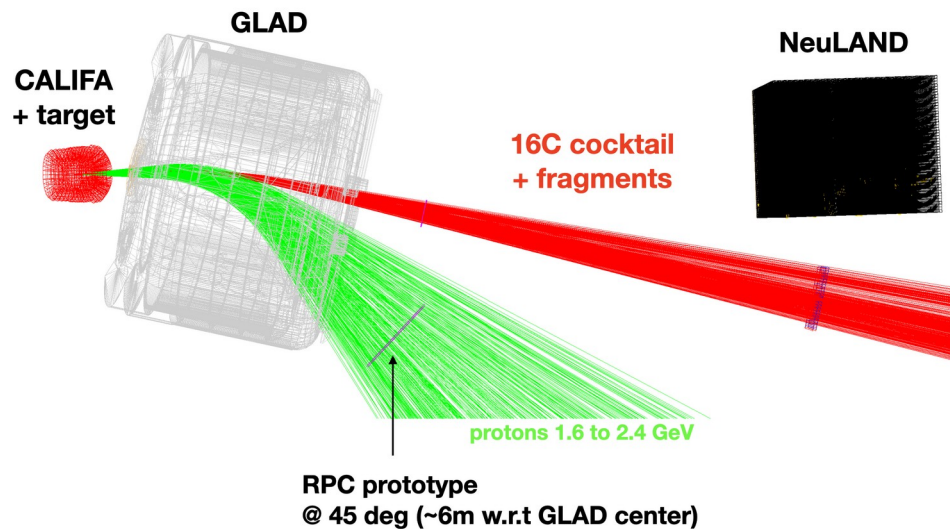
A **glass stack** contains the glass and HV electrodes enclosed in a plastic gas tight box with feed-throughs for gas and High Voltage.

**Easy to build
completely gas tight,
no gas leaks, robust.**

Decouples the gas and HV from the rest.

RPC concept for SHIP @ CERN S522

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

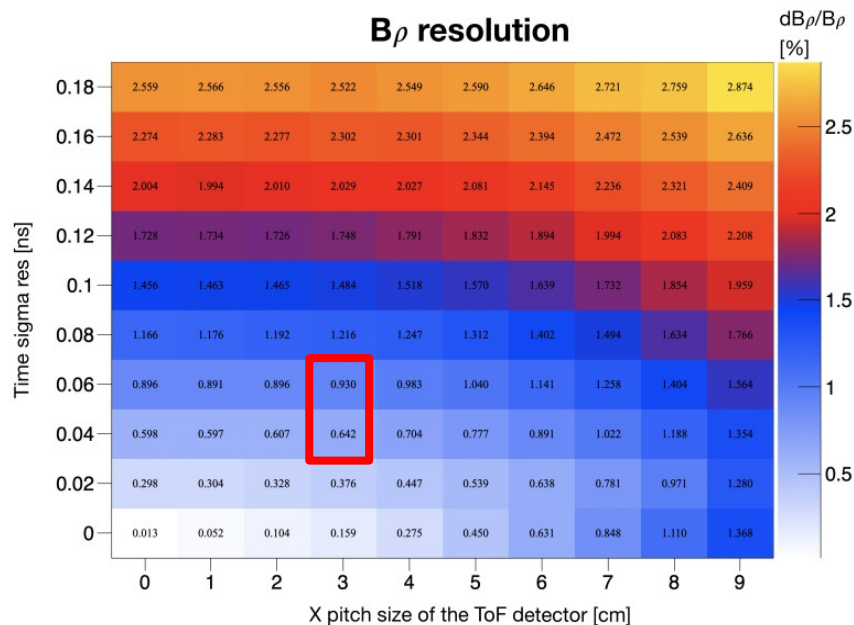
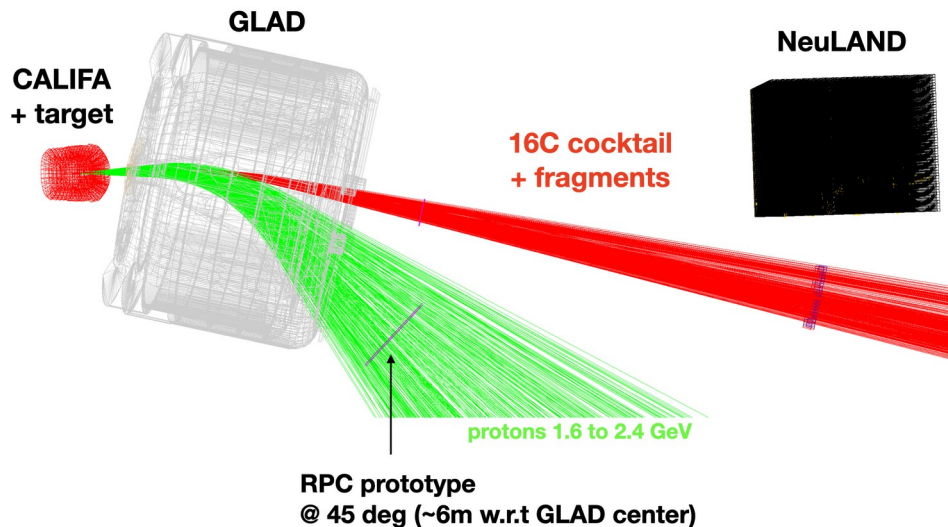


For the RPC detector $\sigma_t \approx 50$ ps and pitch size of 3 cm

Adapted from M. Xarepe

RPC concept for SHIP @ CERN S522

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

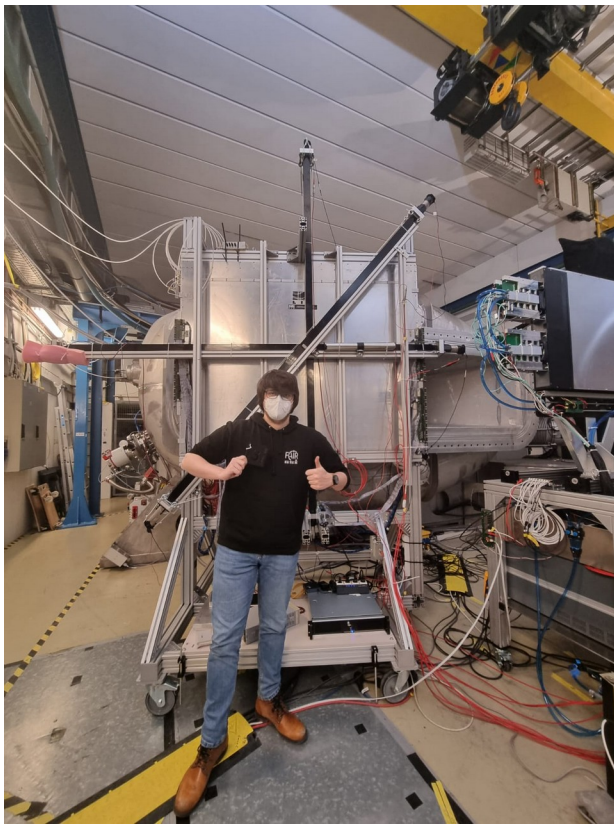


For the RPC detector $\sigma_t \approx 50$ ps and pitch size of 3 cm

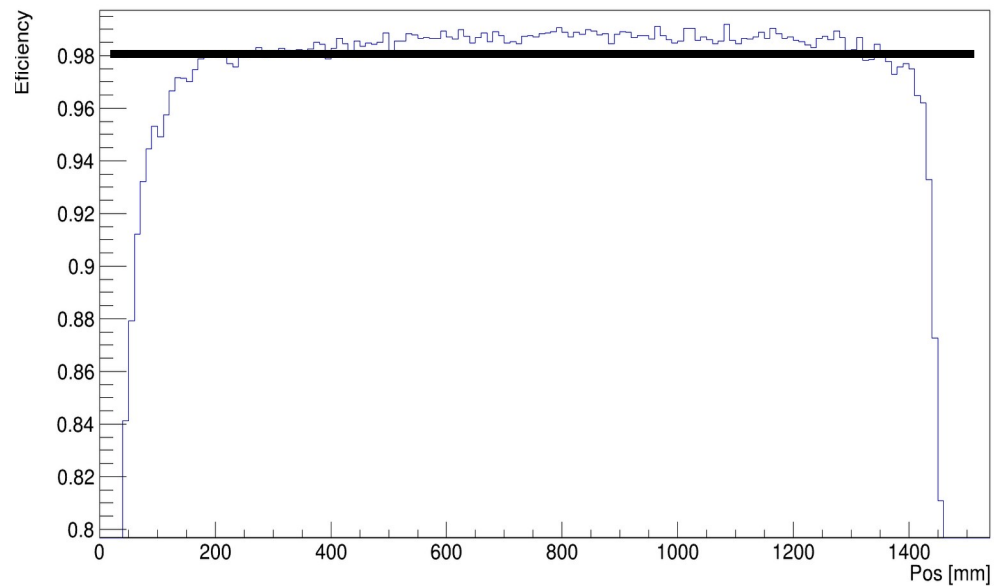
Adapted from M. Xarepe

Expected B ρ resolution < 1%

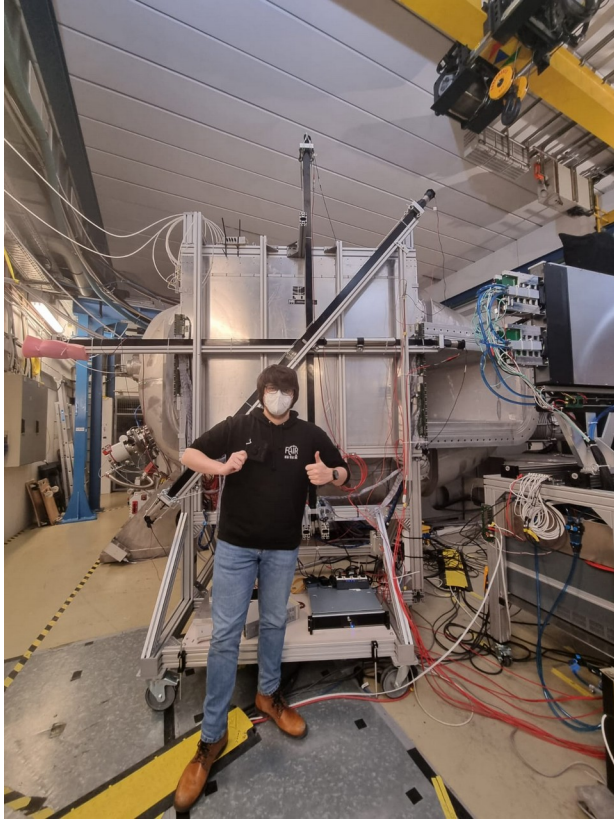
RPC @ S522



Efficiency > 98%



RPC @ S522

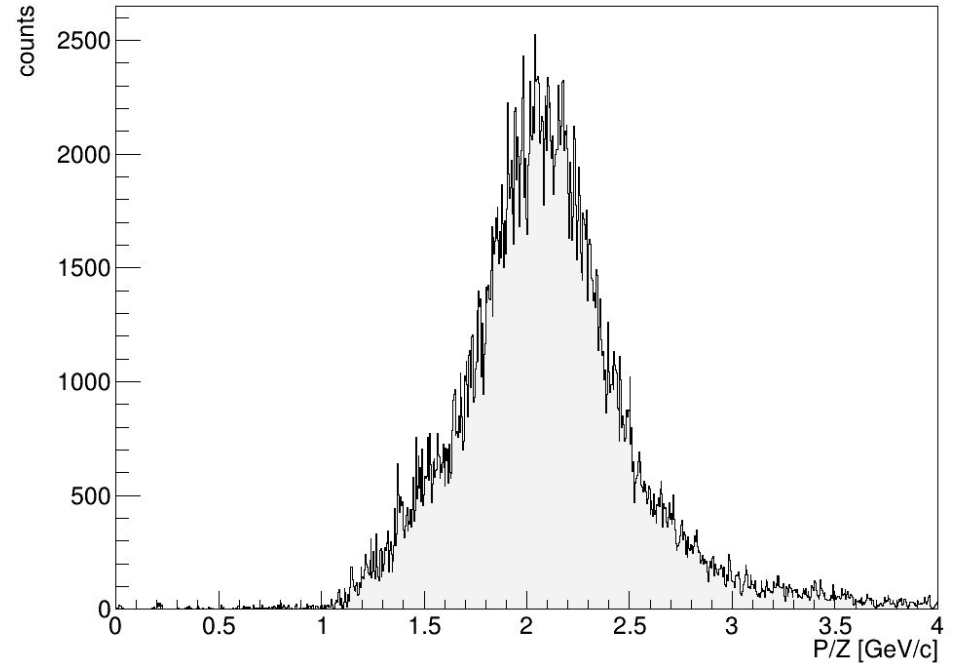


Proton Momentum reconstruction including E-loss

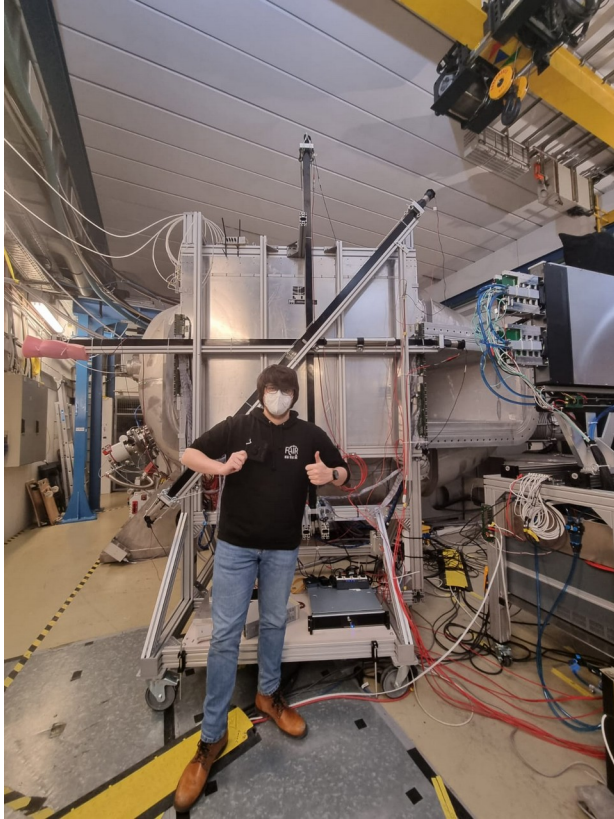
Forward Tracking:

$X_{\text{FOOT1}}, Z_{\text{FOOT1}}, Y_{\text{FOOT2}}, Z_{\text{FOOT2}},$

$X_{\text{RPC}}, Y_{\text{RPC}}, Z_{\text{RPC}}, \text{ToF}_{\text{RPC}}$



RPC @ S522

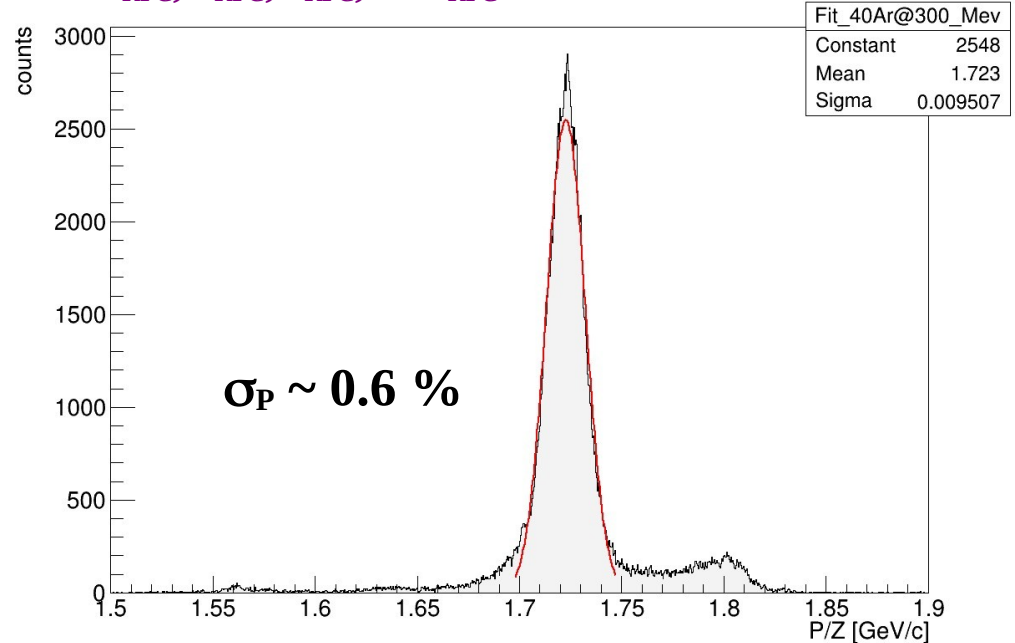


^{40}Ar Momentum reconstruction including E-loss

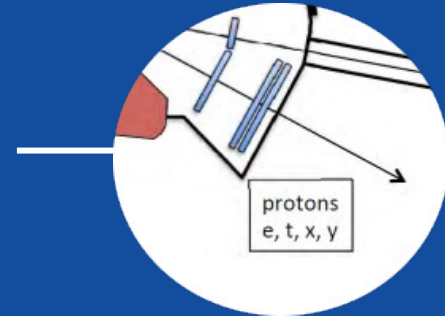
Forward Tracking:

$X_{\text{FOOT1}}, Z_{\text{FOOT1}}, Y_{\text{FOOT2}}, Z_{\text{FOOT2}},$

$X_{\text{RPC}}, Y_{\text{RPC}}, Z_{\text{RPC}}, \text{ToF}_{\text{RPC}}$ ---



An RPC for PAS?



Proton Arm Spectrometer

Design goals

○ $\Delta p < 10^{-3}$

○ $\sigma_x < 150 \mu\text{m}$

○ $\Delta\theta_x < 1 \text{ mrad}$

Current RPC

○ $\Delta p \sim 10^{-2}$

○ $\sigma_x \sim 1 \text{ cm}$

○ $\Delta\theta_x ???$



Current version is **not** an option for PAS

RPC Developments (ongoing efforts)

TOFtracker: gaseous detector with bidimensional tracking and time-of-flight capabilities

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M. Kajetanowicz,^d G. Korcyl,^e M. Traxler^f and R. Marques^g**

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^cInstitut für Kernphysik, Goethe-Universität,
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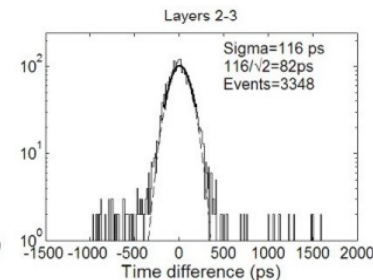
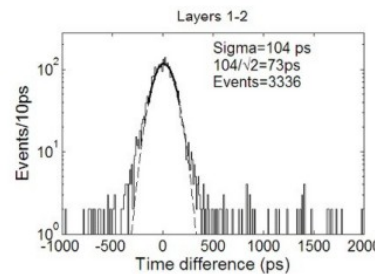
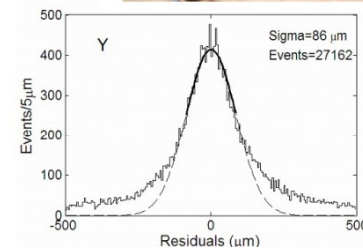
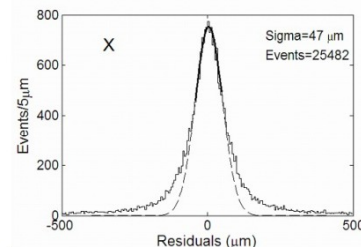
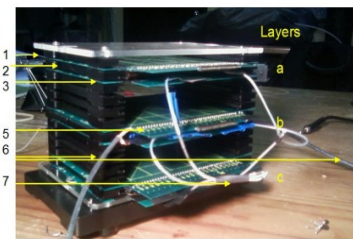
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ABSTRACT: Particle identification by time-of-flight requires the simultaneous measurement of the passing time and the trajectory of particles. It may be useful that each tracking station measures both quantities, providing better timing accuracy by redundancy and independence from an external



$$\sigma_x \sim 50 \text{ um}, \sigma_t \sim 80 \text{ ps over } 100 \text{ cm}^2$$

Recently similar result extended to **1000 cm²**
=> to be published

2012 JINST 7 P11012

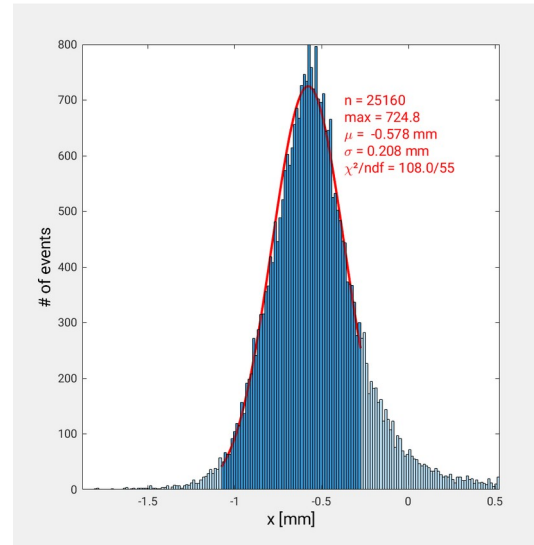
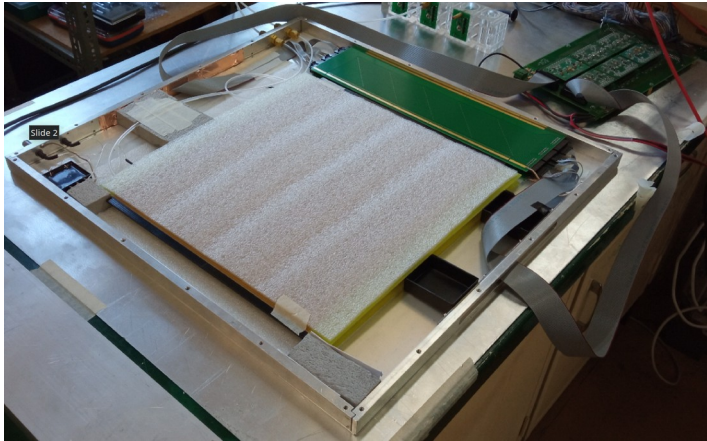
RPC Developments

(ongoing efforts)

Multiplexing the strips to save FEE and DAQ channels

In **1 m² modules** at reasonable cost (with some degradation of resolution).

300x300 mm² small prototype



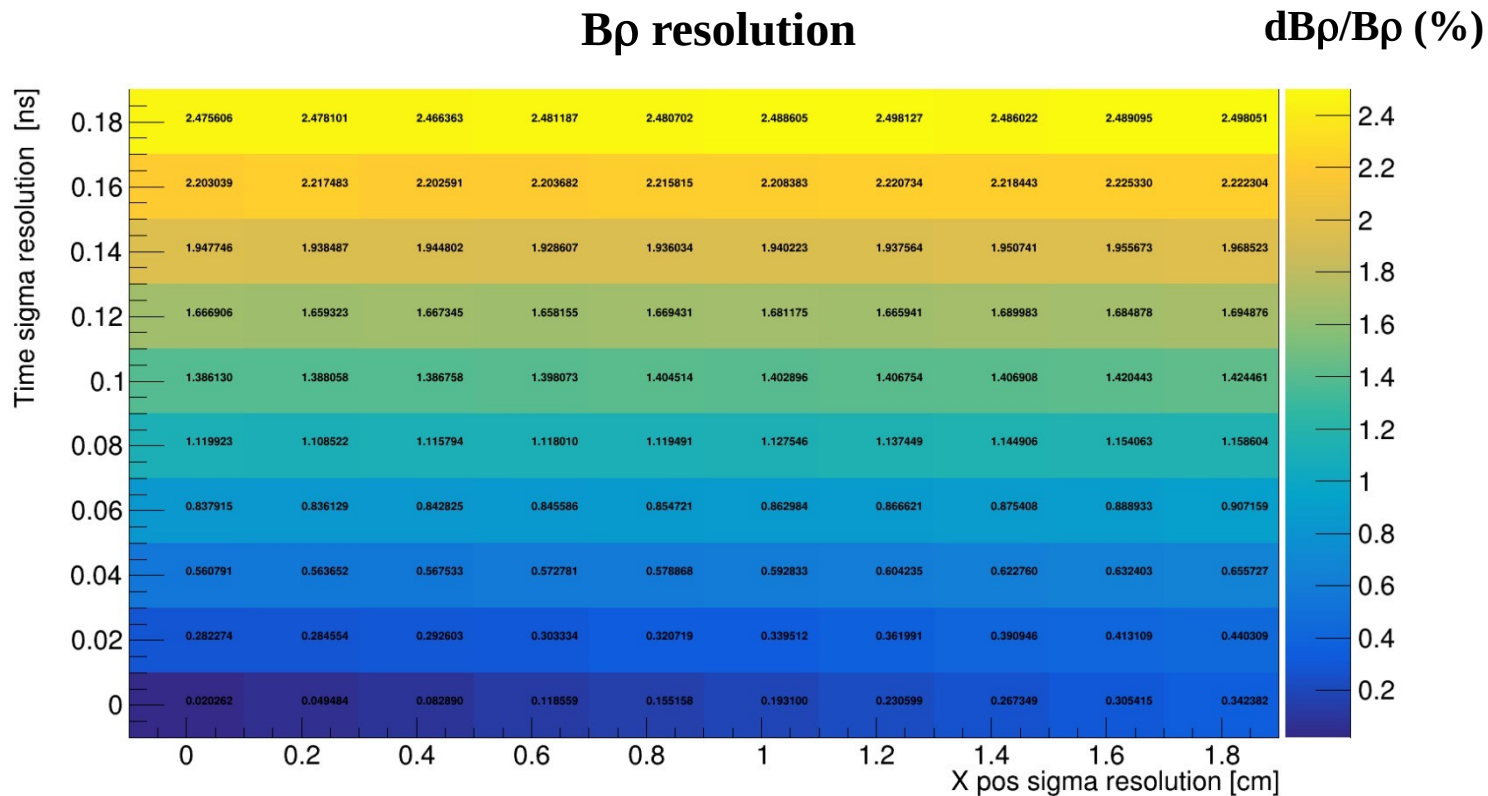
$$\sigma_x \sim 147 \mu\text{m}$$

$$\sigma_t \sim ??$$

Not measured yet

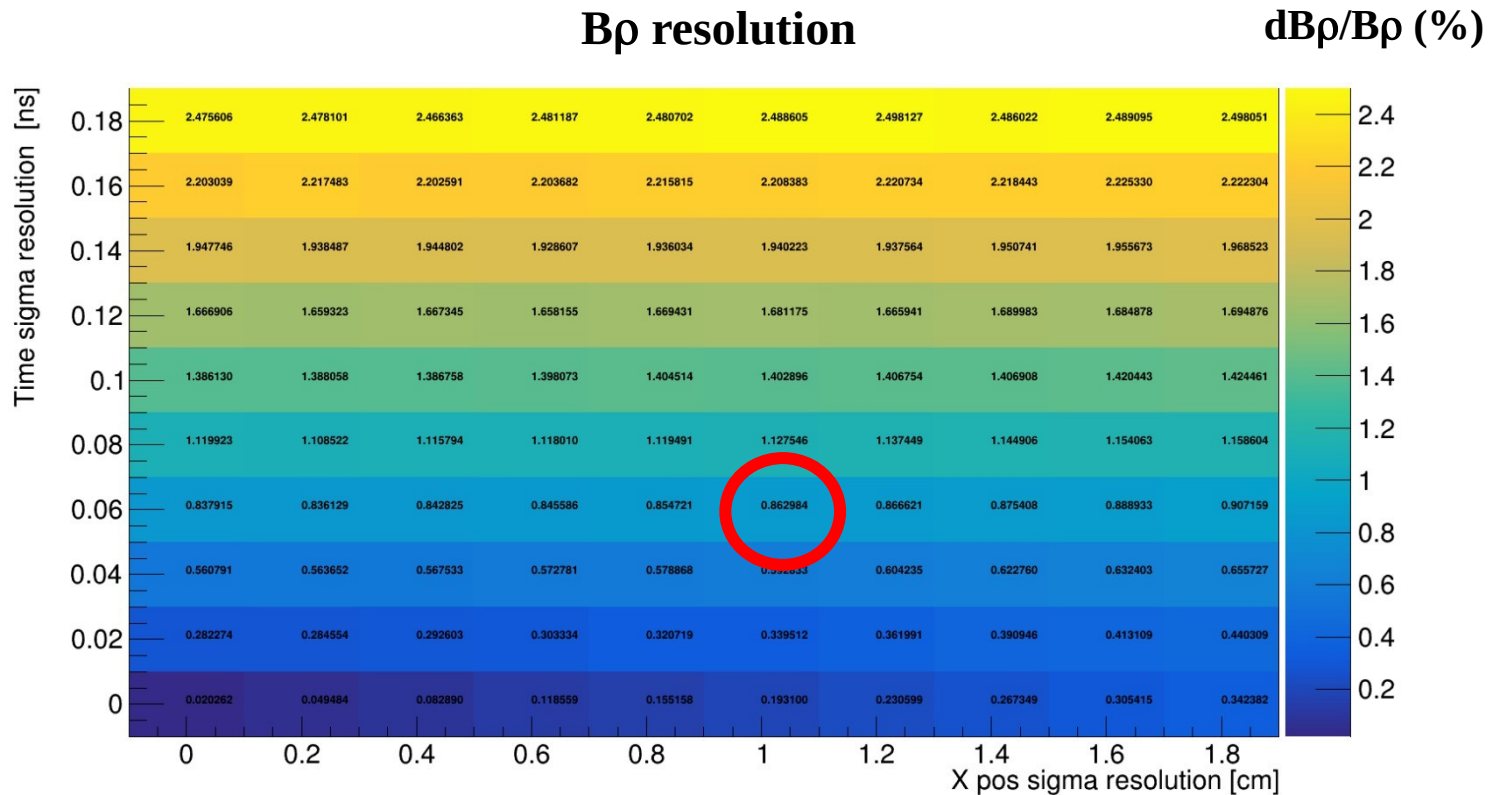
First studies

Forward Tracking:
 $X_0, Y_0, Z_0, X_{RPC}, Y_{RPC}, Z_{RPC}, T_{0F_{RPC}}$



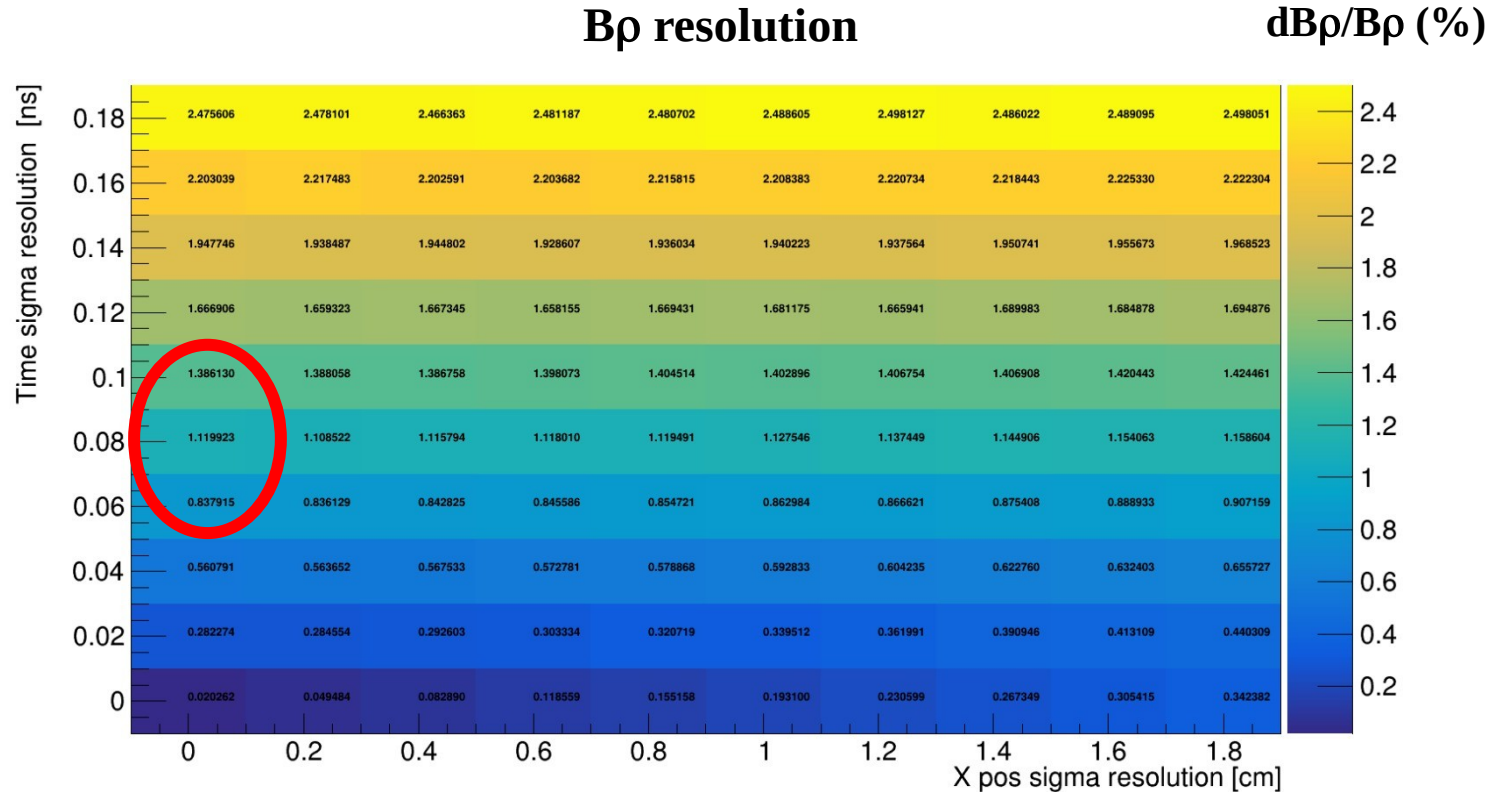
First studies

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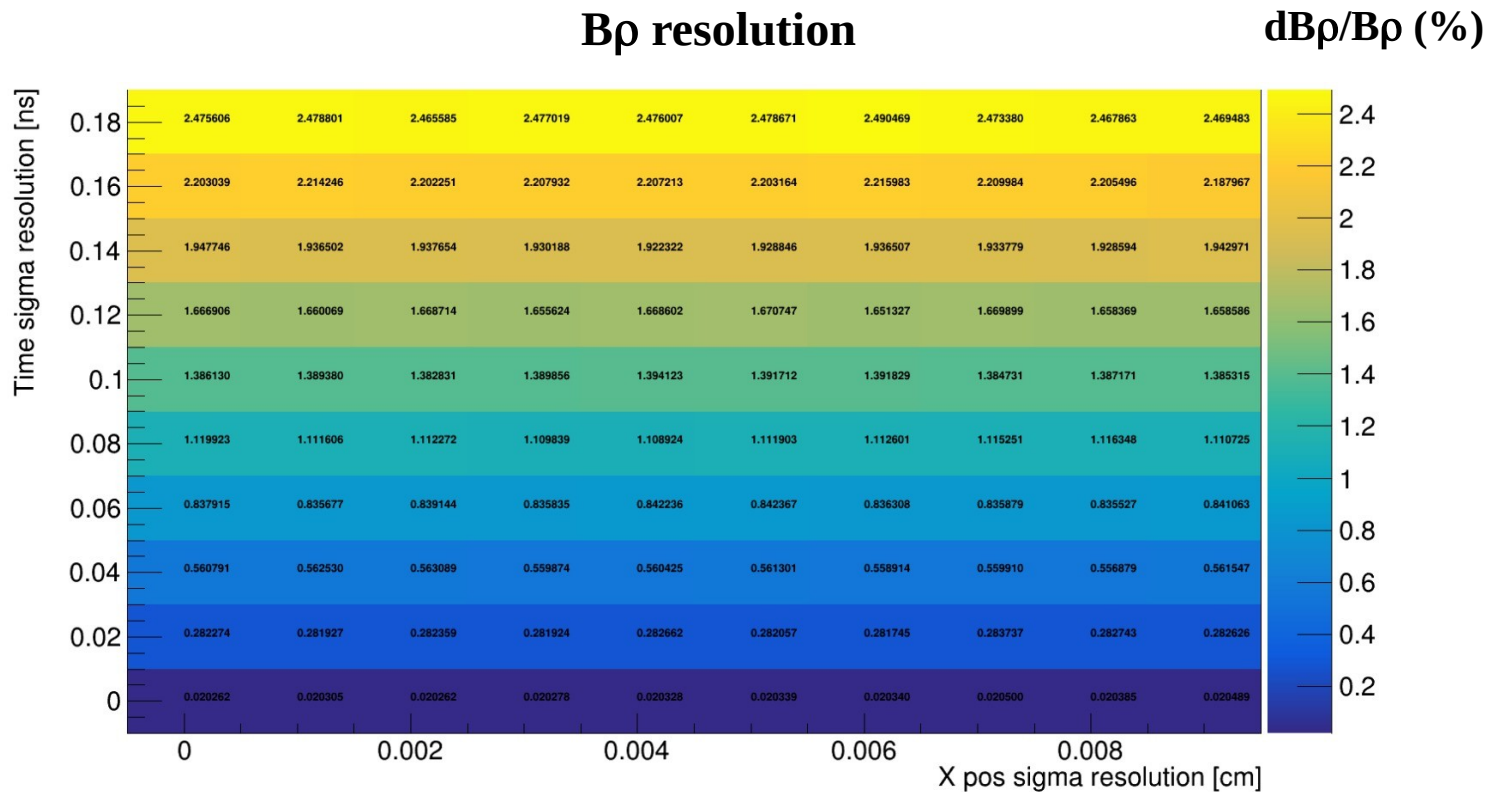
First studies

Forward Tracking:
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First studies

Forward Tracking:
 $X_0, Y_0, Z_0, X_{RPC}, Y_{RPC}, Z_{RPC}, T_{oF_{RPC}}$



Wrapping up...

Summary and Next Steps



Summary



RPC detector successfully installed and used in **S522** and **S509**



RPC available for upcoming **exp. campaigns** (if considered) 2024-25



RPC concept for PAS under investigation

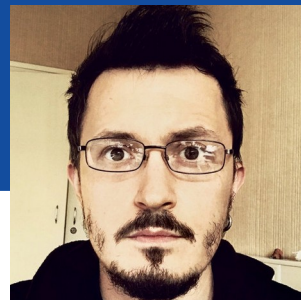
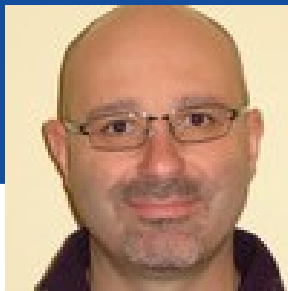


Consider 2 RPCs (distance > 10 cm $\rightarrow \Delta\theta_{x,y} < 1$ mrad) using position, angles and ToF for momentum reconstruction.



RPC option open for **stand alone** or in **combination** with other systems (at reasonable cost)

Thanks!



REPÚBLICA
PORTUGUESA

