PRODUCTION OF ANTINEUTRONS IN HEAVY ION AND pp COLLISIONS IN THE ALICE EXPERIMENT AT THE LHC

Fabiola Lugo, Arturo Menchaca

IF UNAM

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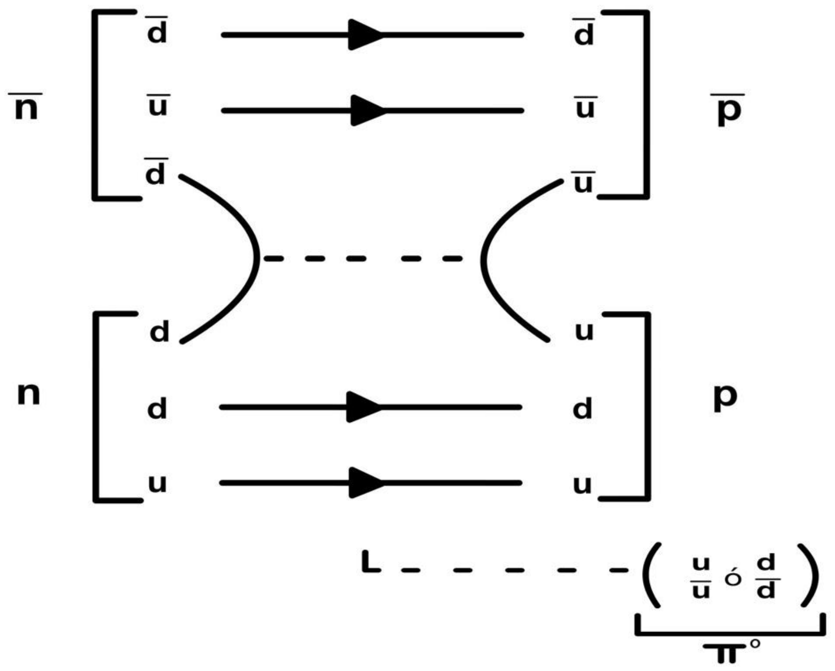
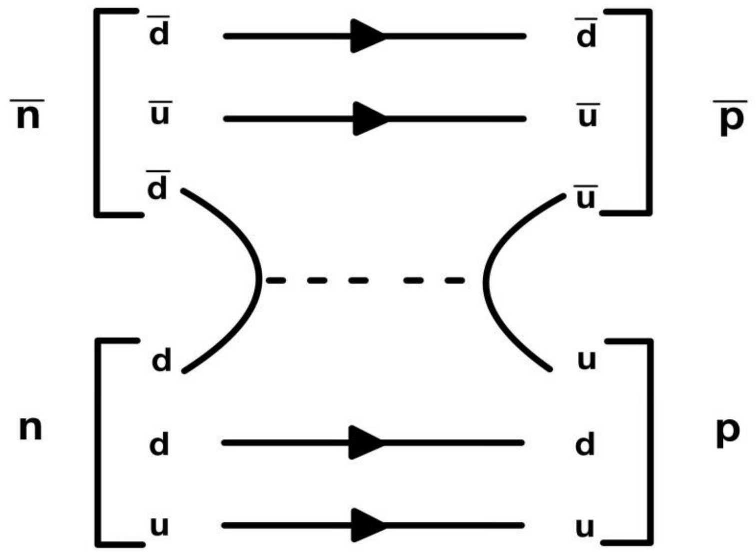
Introduction

- Identify $\bar{n}$ ‘s and reconstruct their kinematic properties through the momentum correlations between the $\bar{n}$‘s and the $p\bar{p}$ pairs produced in charge exchange reactions.
- Use ITS silicon n’s as targets in which these reactions can be carried out.

$$n + \bar{n} \rightarrow p + \bar{p} + \pi^0$$



$$n + \bar{n} \rightarrow p + \bar{p}$$

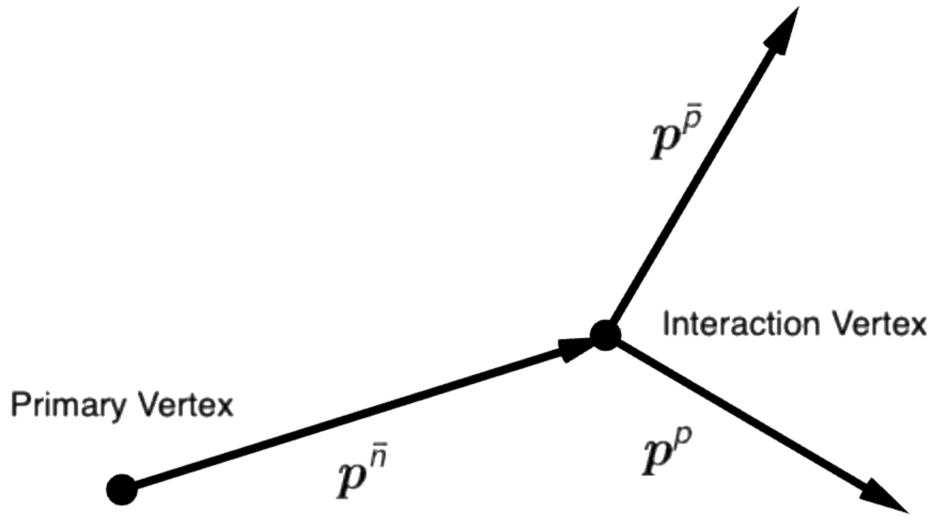


Introduction

Previous study

- When the reaction occurs, the nucleus breaks apart, and a certain amount of energy is transferred to the nucleus fragments.
- The $\bar{n}$ momentum can only be recovered from a CEX-based kinematic analysis within this limitation.
- In a CEX event a unique $\bar{p}$ is produced.
- This is not the case for the p. The best one can do is to identify as the p CEX-partner the one that satifies the following conditions:

➢ The most likely p should be that for which the distance from the primary vertex to the plane defined by the interaction vertex and the $\bar{p}$ and p momenta, is minimal.



To reduce the uncertainty in kinematic reconstruction, events characterized by a large loss of $\bar{n}$ energy were discarded:

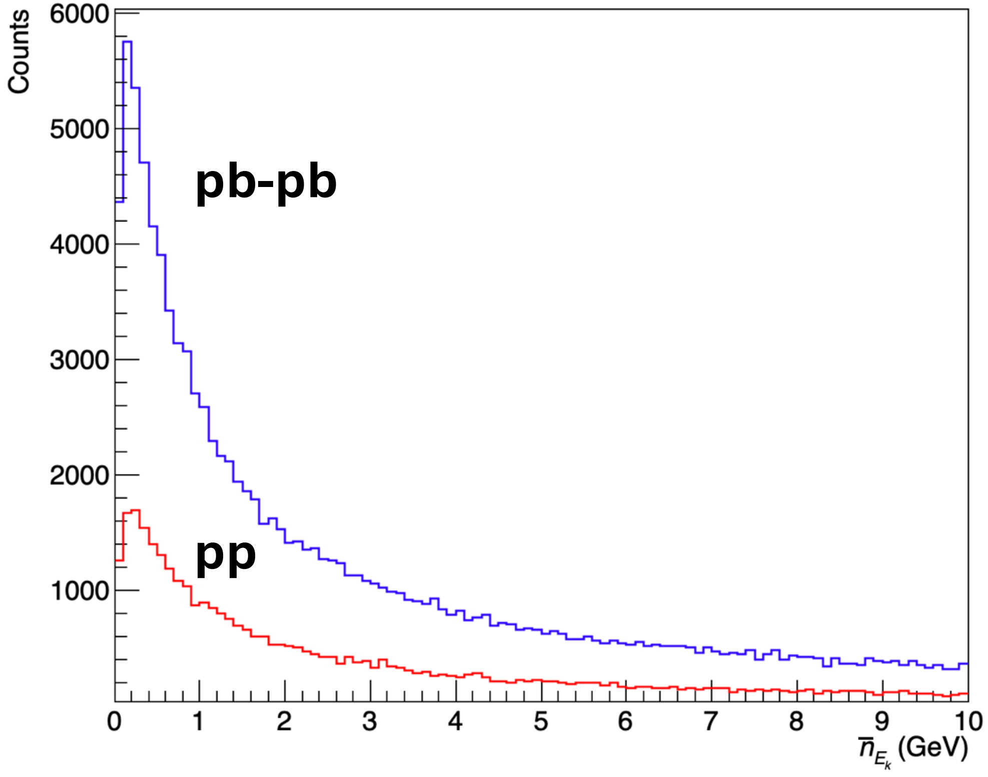
➢ $E_k^{\bar{p}} + E_k^{p}$

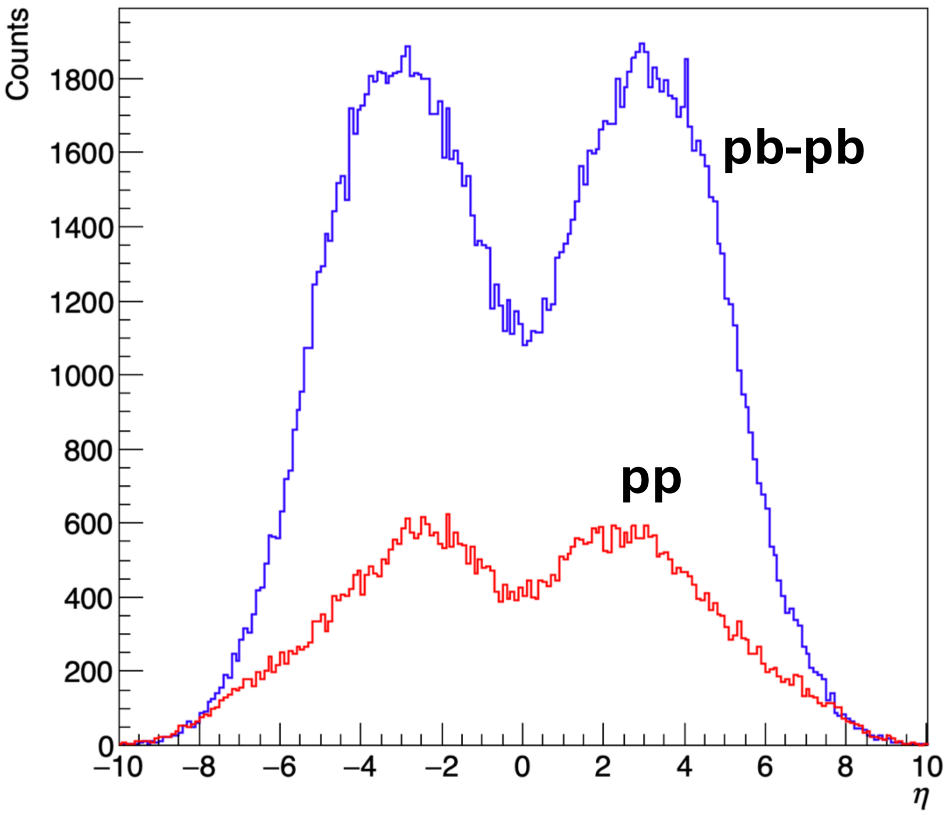
➢ $\left|c(\boldsymbol{p}^{\bar{p}} + \boldsymbol{p}^{p})\right|$

F Lugo-Porras *et al,* Feasibility study to characterize the production of antineutrons in high energy *pp* collisions through charge exchange interactions, 2024 *J. Phys. G: Nucl. Part. Phys.* **51** 035005, doi: 10.1088/1361-6471/ad1dc1

Antineutrons production

- The protocol proposed for selecting CEX $p\bar{p}$ pairs was applied to the ALICE Monte Carlo simulations:
  - pb-pb (HIJING) : LHC16g1 Ecm = 5022.00 GeV/n 1000 events 187631 primary $\bar{n}$
  - pp (PYTHIA): LHC15a2a Ecm = 7000 GeV 40000 events 61482 primary $\bar{n}$
- ITS coverture: $|\eta| < 1.5$ and $|V_z| < 5.3$ cm
  - 13% for pbpb
  - 19% for pp

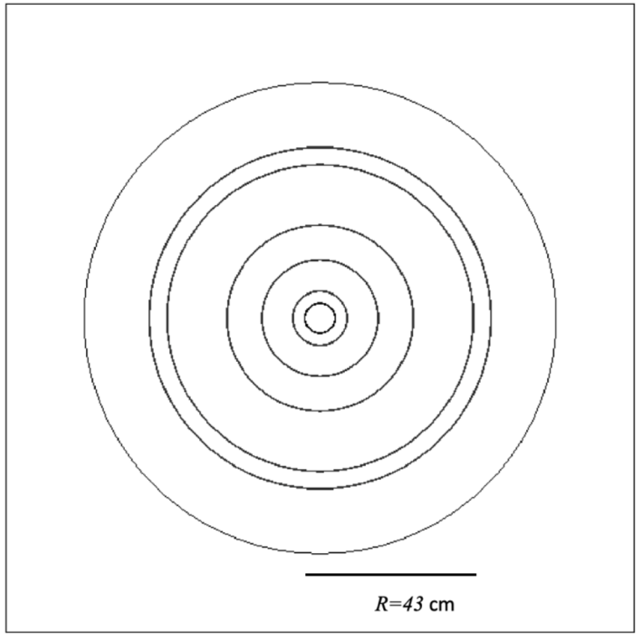




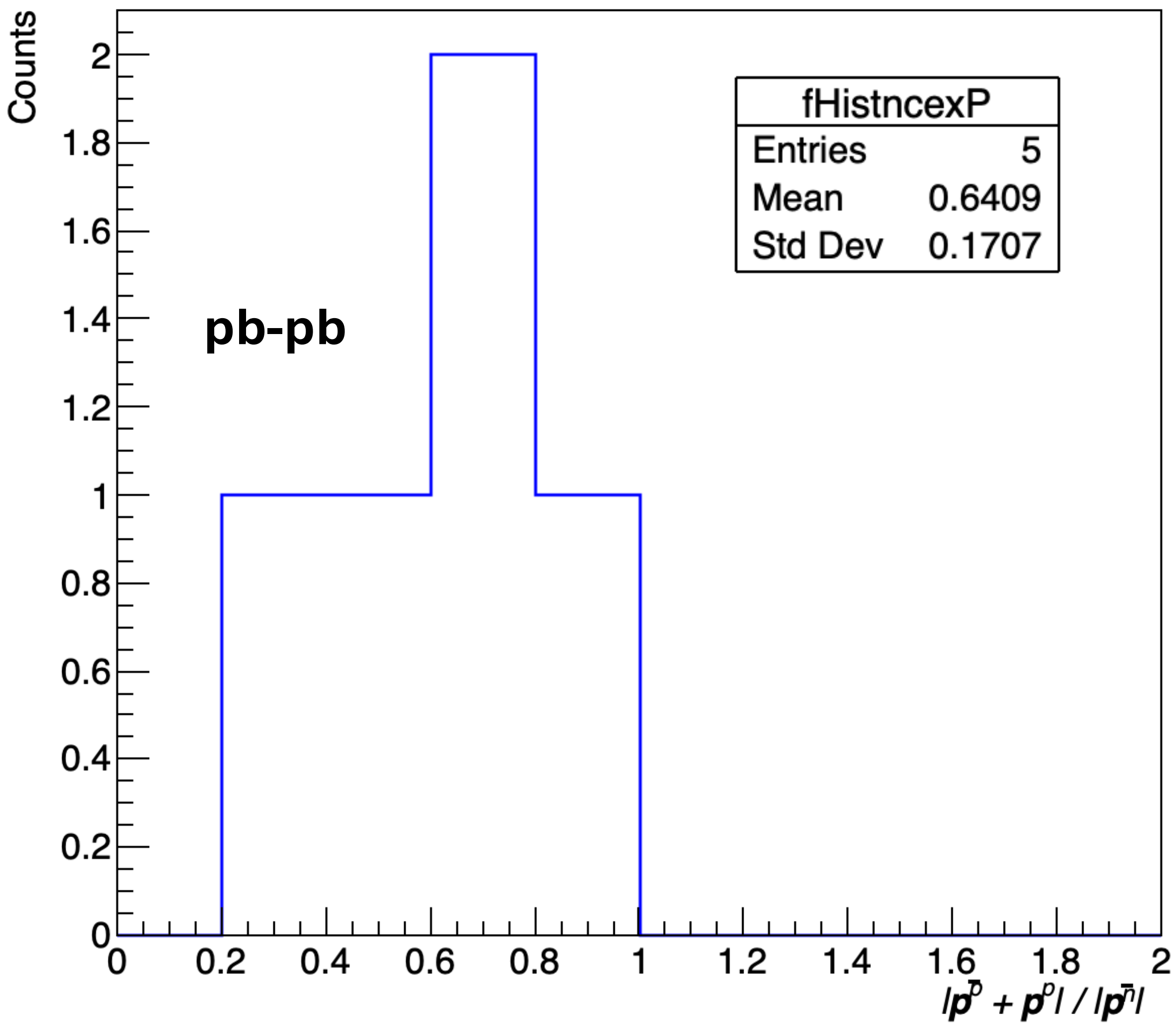
Verification of previous results

We select:

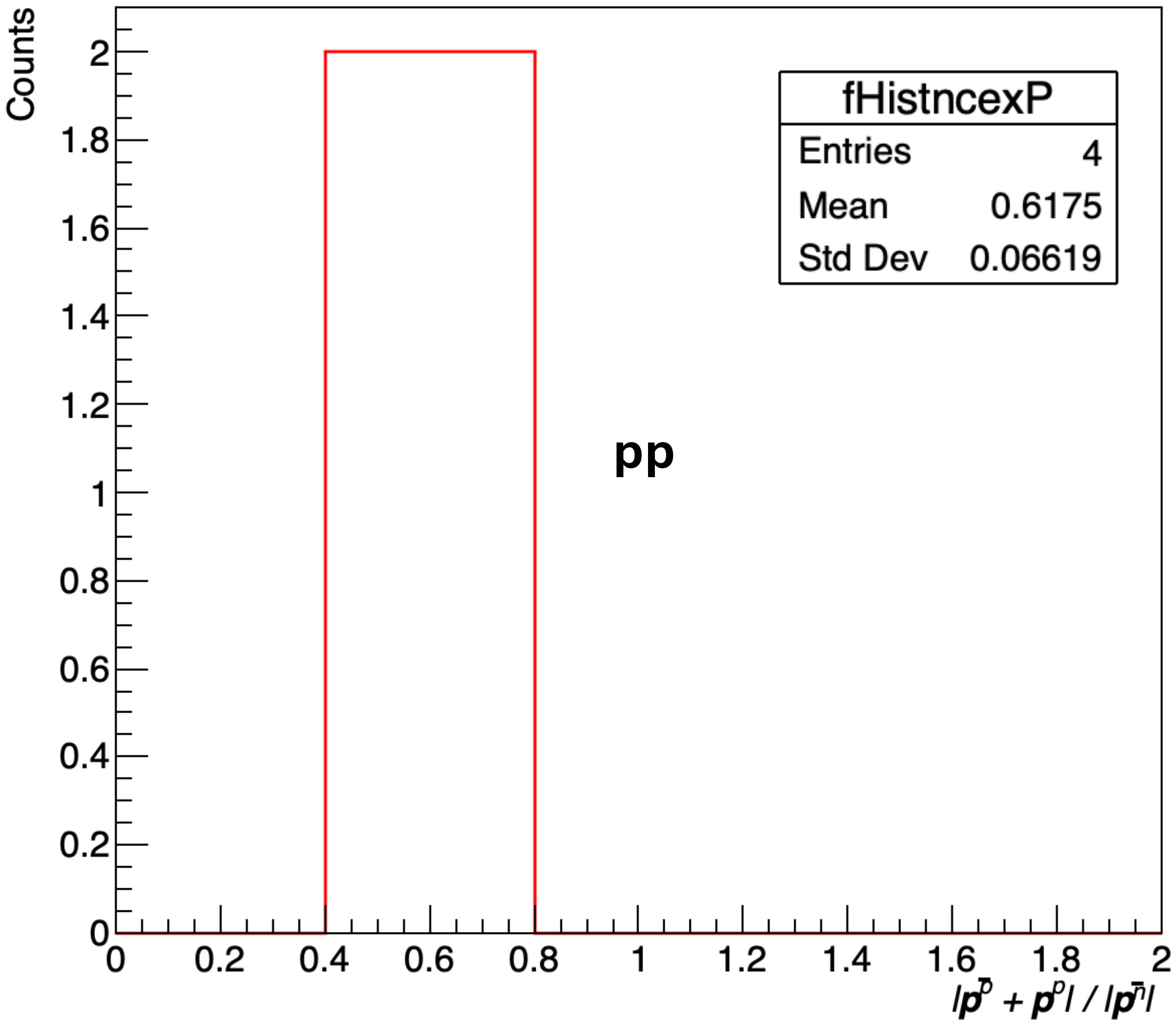
- Secondary $\bar{p}$'s generated by the interaction of a primary $\bar{n}$ with the material
- Secondary vertex inside the ITS
  - 3.9 cm <|Vx|< 43.6 cm   3.9 cm <|Vy|< 43.6 cm. |Vz|< 48.9 cm
- Charged pion veto
- p's fulfilling the same conditions as the $\bar{p}$ and produced in the same vertex
- CEX $p\bar{p}$ pair through the protocol developed previously.
- Events for which the $\bar{n}$ mother is covered by the ITS:
  - $|\eta| < 1.5$ and $|V_z|$< 5.3 cm
- We recover the efficiencies obtained in the feasibility study
  - pp: 7 events $\longrightarrow$ 0.007%
  - pbpb: 11 events $\longrightarrow$ 0.003%
- The reconstructed momentum is ~60% of the $\bar{n}$ momentum.



Layer	R (cm)	$\pm Z$ (cm)	Area (m^2)
1	3.9	14.1	0.07
2	7.6	14.1	0.14
3	15.0	22.1	0.42
4	23.9	29.7	0.89
5	38.0	43.1	2.20
6	43.0	48.9	2.80
7	60.0	60.0	—



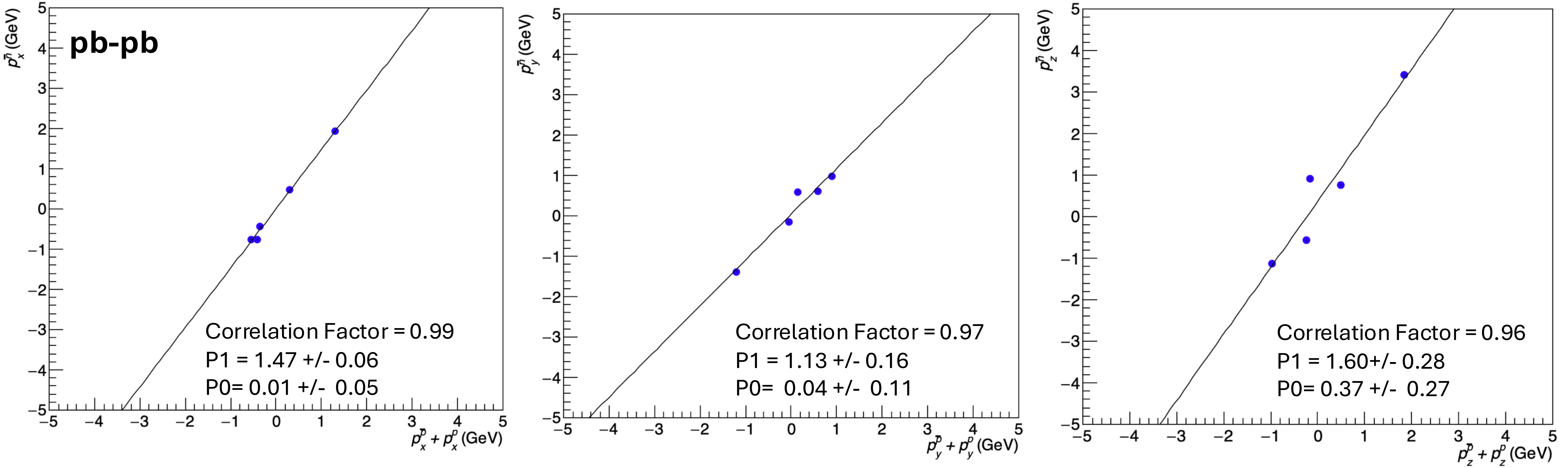
fHistncexP
Entries 5
Mean 0.6409
Std Dev 0.1707
pb-pb
Counts
$|\mathbf{p}^{\bar{p}} + \mathbf{p}^{p}| / |\mathbf{p}^{\bar{n}}|$

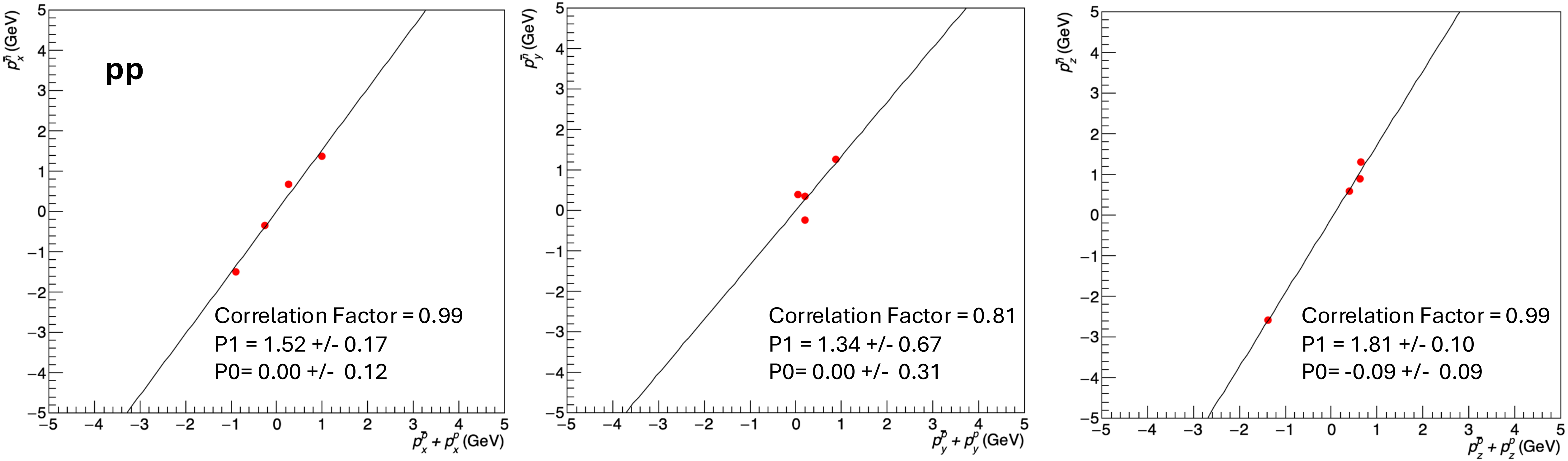


fHistncexP
Entries 4
Mean 0.6175
Std Dev 0.06619
pp
Counts
$|\mathbf{p}^{\bar{p}} + \mathbf{p}^{p}| / |\mathbf{p}^{\bar{n}}|$

Verification of previous results

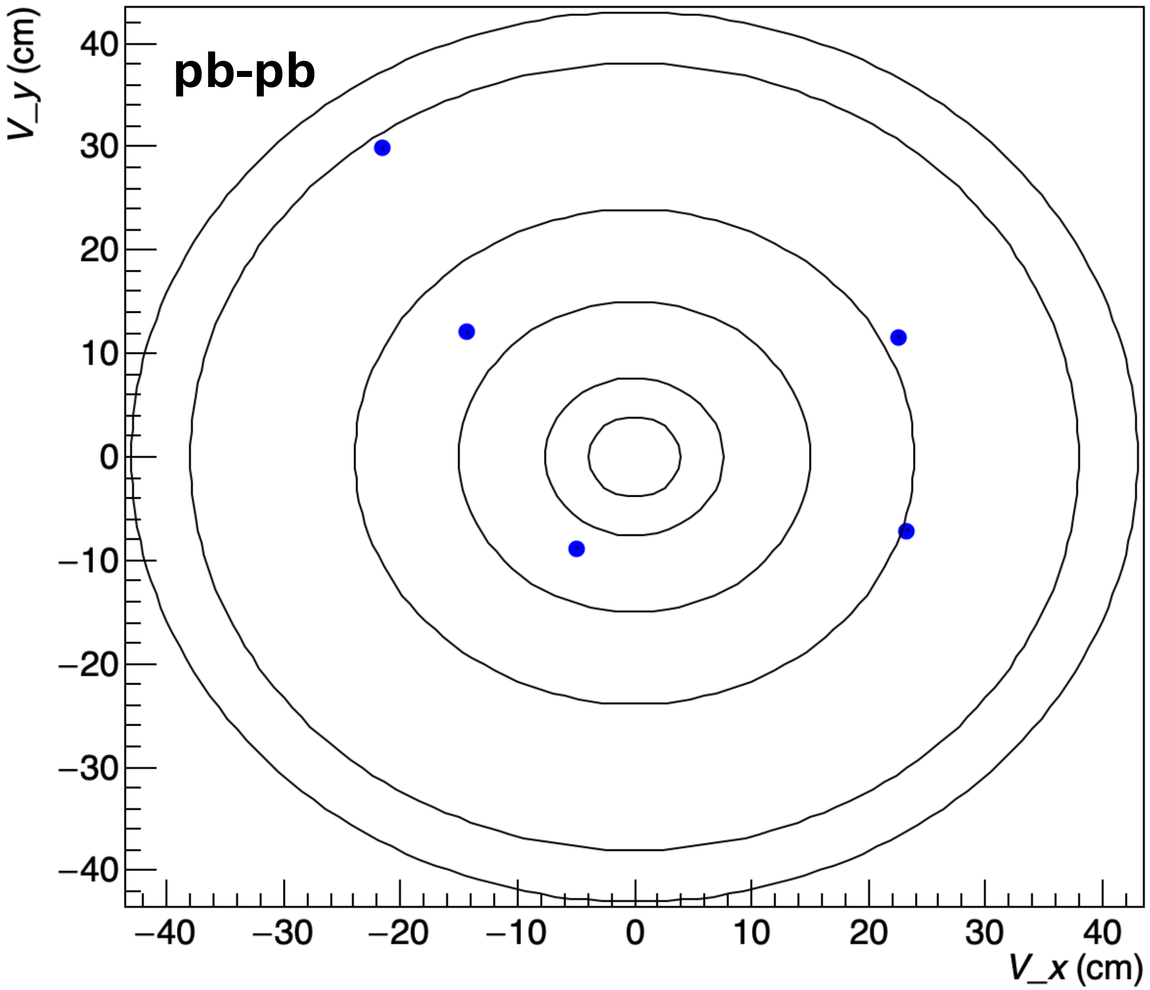
- The $\bar{n}$ momentum and CEX-reconstructed momentum components are correlated.
- A linear function of the form P0 + P1x is fitted.

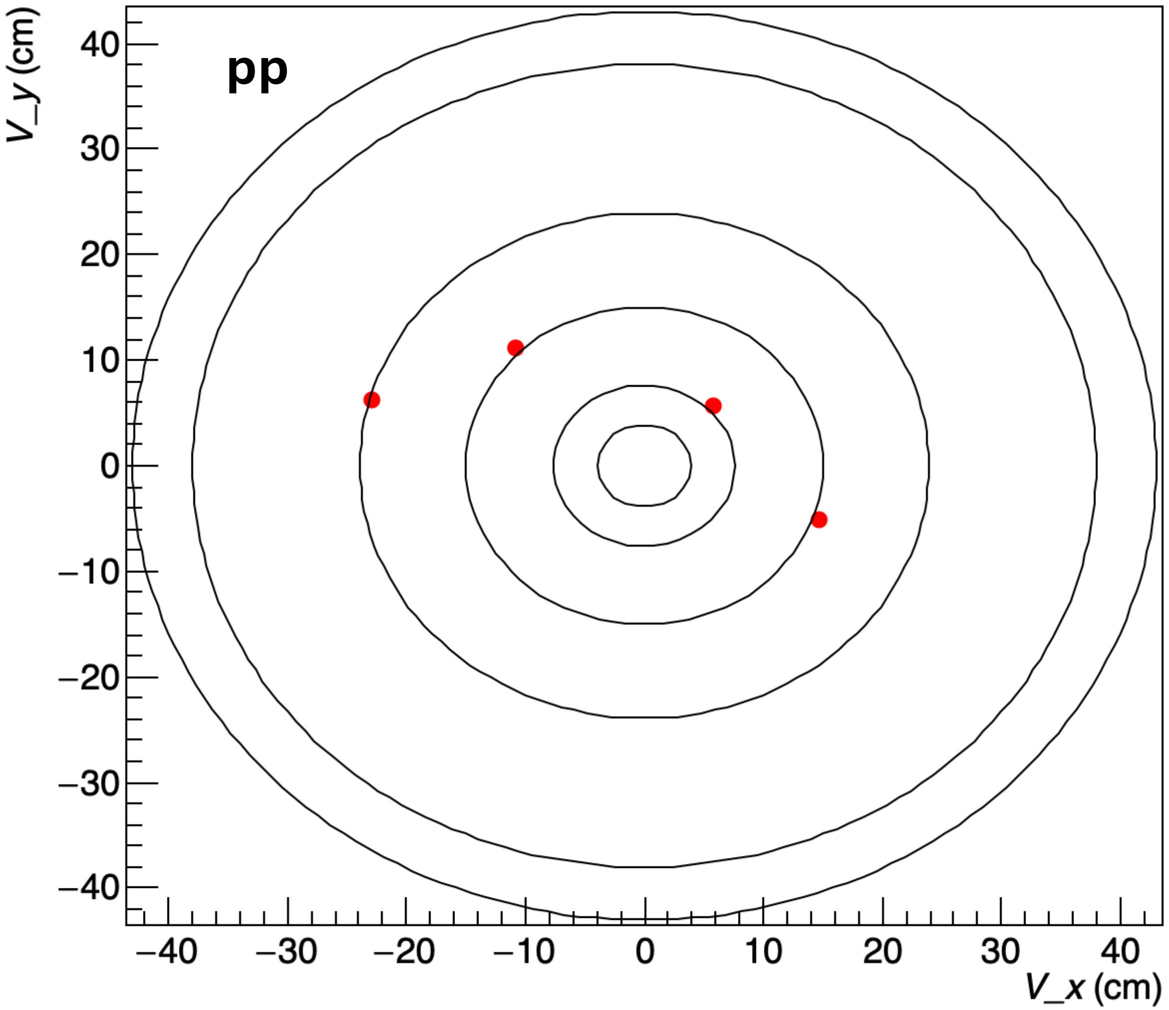



pp
Correlation Factor = 0.99
P1 = 1.52 +/- 0.17
P0= 0.00 +/- 0.12
Correlation Factor = 0.81
P1 = 1.34 +/- 0.67
P0= 0.00 +/- 0.31
Correlation Factor = 0.99
P1 = 1.81 +/- 0.10
P0= -0.09 +/- 0.09

Verification of previous results

- The ITS can be considered as a continuous target.
- CEX interactions occur in the ITS layers.





Background study

- We select secondary $\bar{p}$ generated by the interaction of a primary particle with the material.
- Events where a charged pion is produced are discarded.
- 90% of the $\bar{p}$'s originate from primary $\bar{n}$'s and $\bar{p}$'s.
- We expect to reject background from charged particles using the ITS and the TPC, since the parent particle must produce signals in the first layers of the ITS.
- Background from neutral particles is less than 1%.

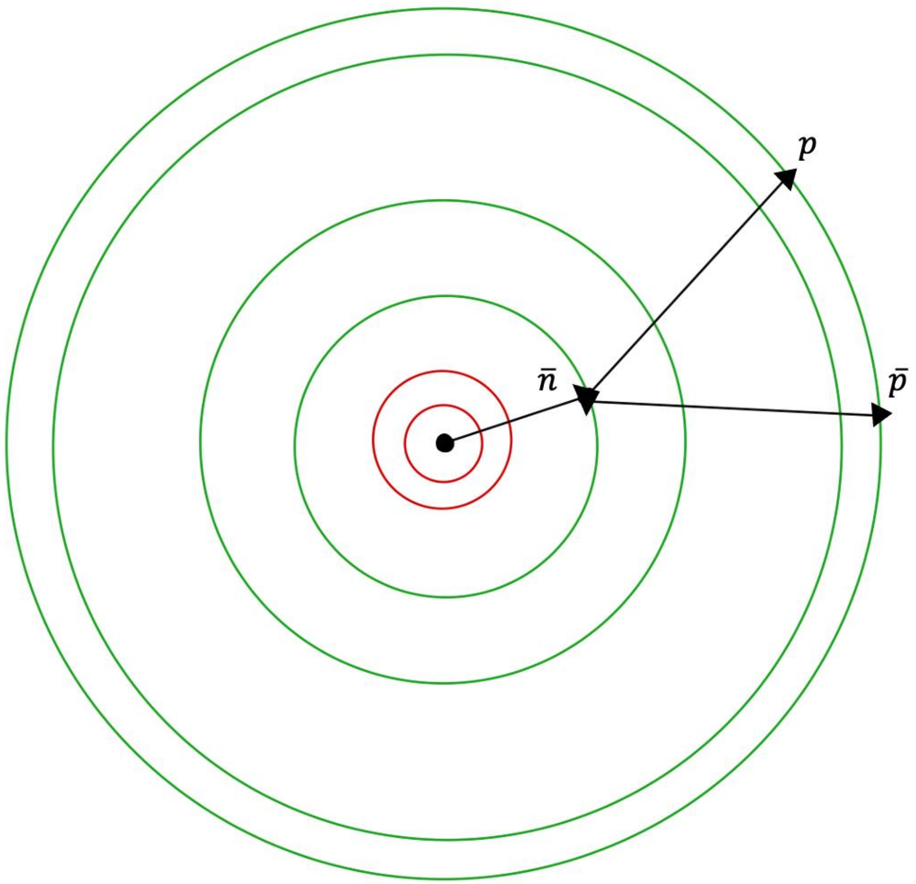
Mother particle	pbpb (%)	pp (%)
n	0.54	0.30
$\bar{n}$	31.46	28.68
p	0.56	0.38
$\bar{p}$	63.77	64.29
π^+	1.26	2.20
π^-	1.24	2.17
K^+	0.36	0.90
K^-	0.31	0.62
K_S^0	0.15	0.13
K_L^0	0.34	0.34

Next steps

Task to analyze data

To select CEX events in data, the following steps are proposed:

- Use TPC signals to select $\bar{p}$'s and p's
  - Produced in the same vertex.
  - Do not register a signal in the first 2 layers of the ITS (preliminary)
- Implement a charged pion veto.
- CEX p selection using the previous protocol.
- Convert the task to O2 to apply the analysis to RUN 3 data.



THANKS

Fabiola Lugo
fabiola.viridiana.lugo@cern.ch