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58<sup>th</sup> Karpacz Winter School of Theoretical Physics "Heavy Ion  
Collision: From First to Last Scattering"



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# Study of the production of antimatter in heavy-ion collisions at NICA energies

## Antiprotons production analysis

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# Outline



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- ✓ Motivation
  - ✓ NICA Complex: *parameters*
  - ✓ MPD detector
  - ✓ Antiproton analysis: *efficiency, contamination,  $p_T$  -spectra*
  - ✓ Summary

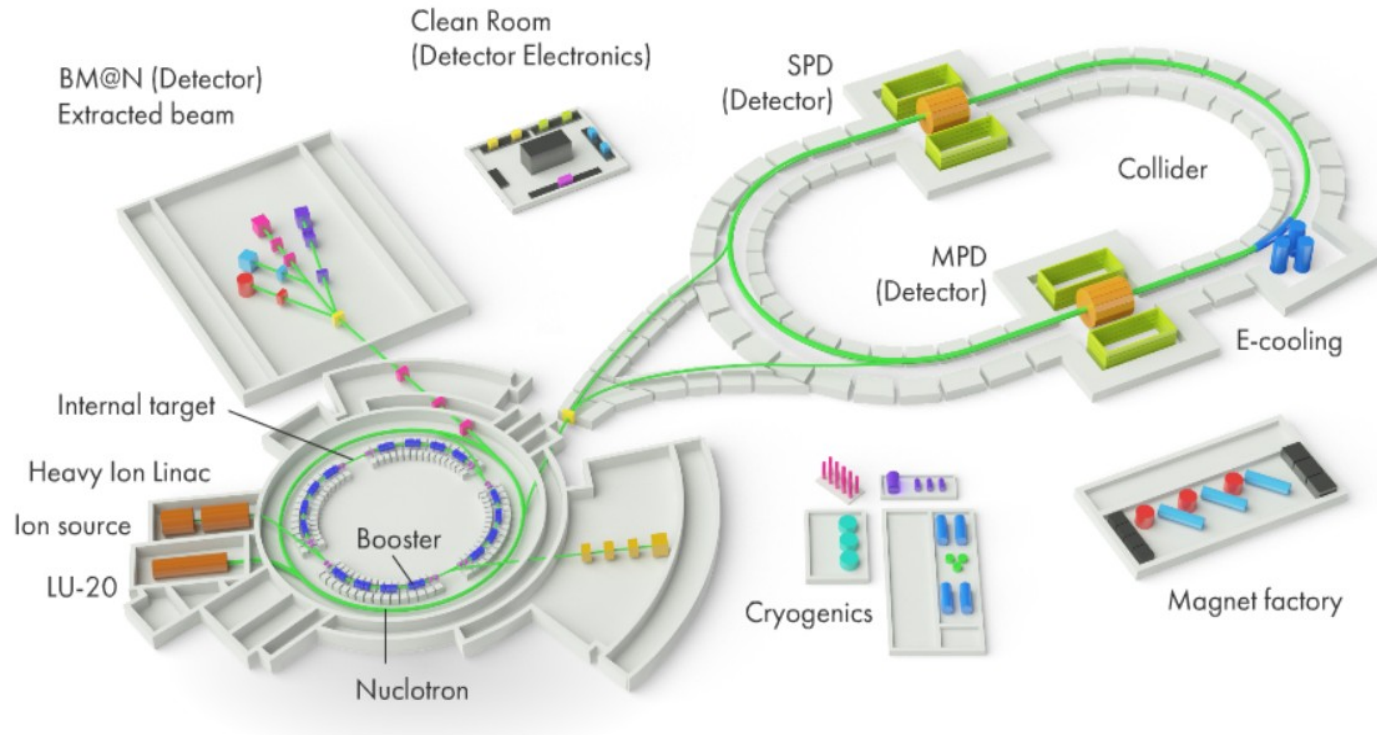
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- The measurement of the anti-proton, proton can shed light on the properties of dense nuclear matter
  - Anti-baryon production and anti-baryon to baryon ratios should help elucidate the possible role of annihilation processes in anti-hyperon production in collisions of heavy nuclei.
  - NICA plans to investigate baryon-rich regions from QCD phase diagram, representing the means for investigating observables related to its structures, such as a first-order phase transition or a critical end point.

# Nuclotron-based Ion Collider fAcility



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## NICA Complex



### NICA nominal parameters (first stage):

*Beams:* p, d, ...Au<sup>79+</sup>,

*Collision energy:* 4-11 GeV (nuclei)

4-20 GeV (protons)

*Luminosity:* 10<sup>27</sup> cm<sup>-2</sup>s<sup>-1</sup> (Au), 10<sup>32</sup> cm<sup>-2</sup>s<sup>-1</sup> (p)

# Multi-Purpose Detector @ NICA

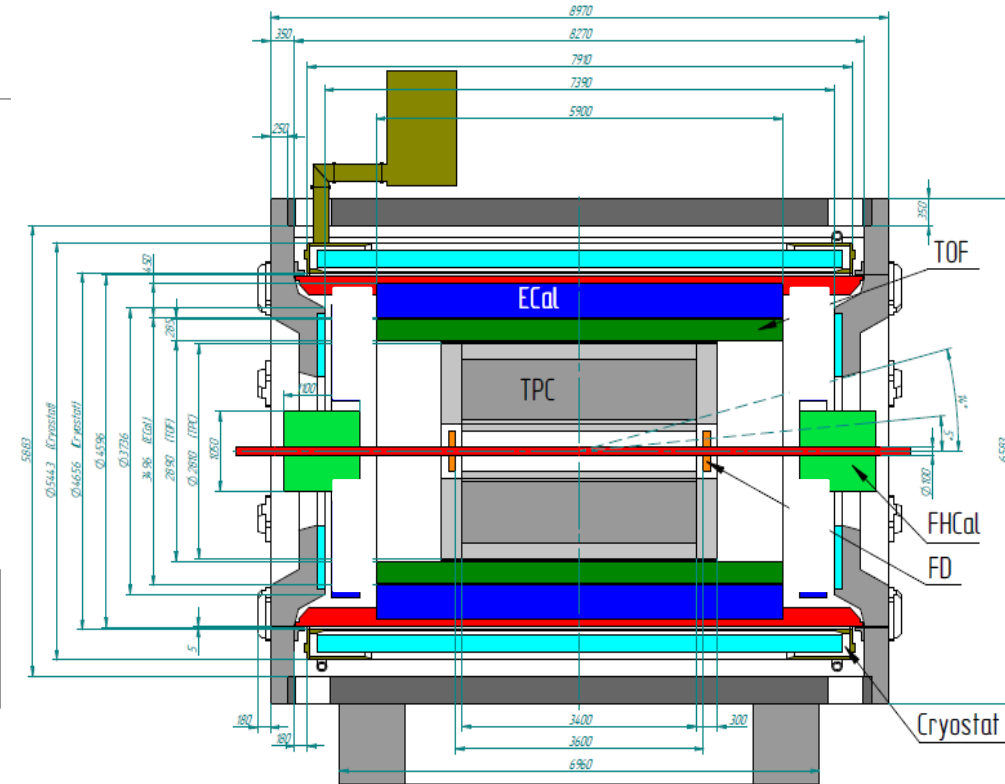


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- ✓ Designed as a  $4\pi$  spectrometer detecting charged hadrons, electrons and photons at high luminosity
  - ✓ Installed in two stages, first one will be completed by the end of 2023
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- **Magnet** 0.5 T Superconductor
  - **TPC+TOF** = precise momentum measurements and particle identification
  - **FFD** wake-up trigger
  - **ECal** detection of electromagnetic showers
  - **FHCAL** collision centrality, orientation of the reaction plane

**Data Set:** Bi+Bi @ 9.2 GeV (min bias), PHQMD event generator

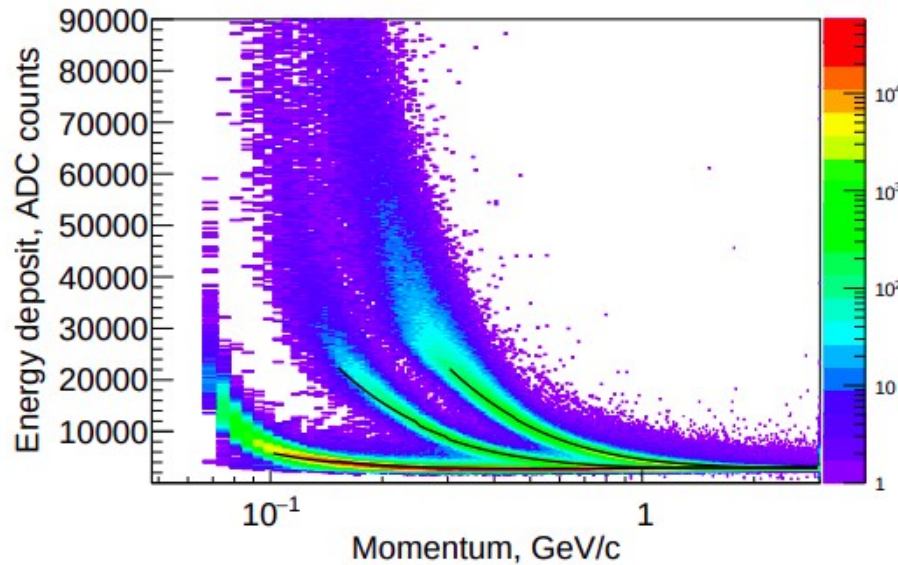
**Track selection:**  $N_{\text{hits}} \geq 28$ ,  $\eta \leq 0.5$ , primary particles



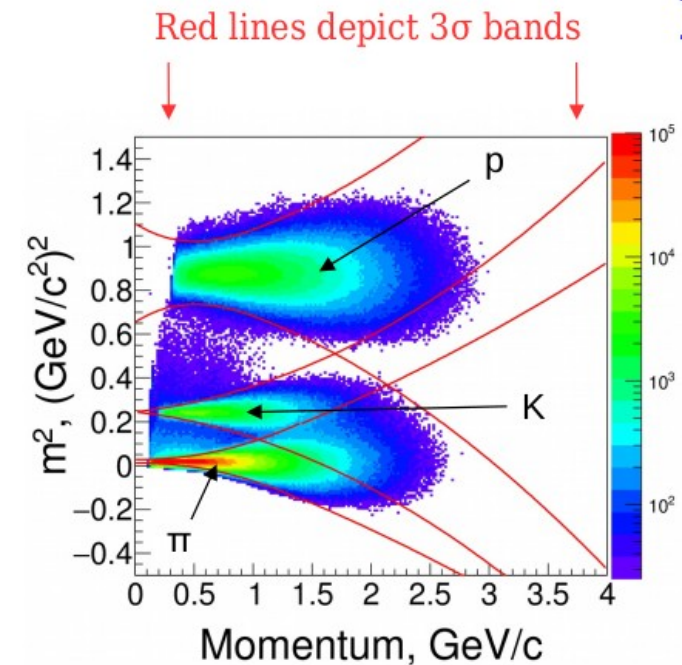
# Particle Identification (PID) @ MPD



- Identification of charged hadrons at momenta is achieved by the time-of-flight (TOF) measurements which are complemented by the energy loss ( $dE/dx$ ) information from the TPC.
- PID provides vector of probabilities for each identified particle.
- It can be based on  $dE/dx$  and  $m^2$  values information (combined probability vector)

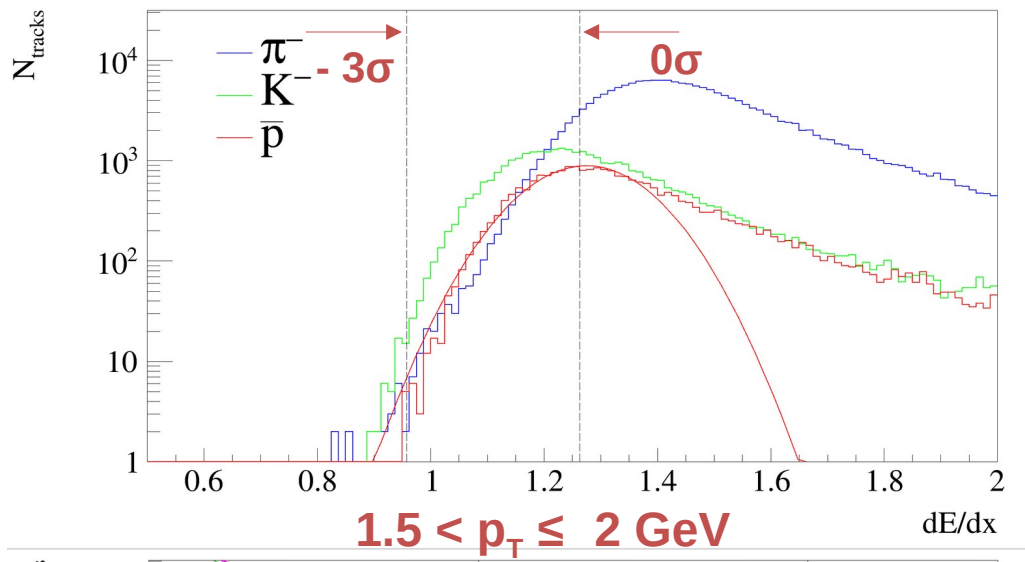


10.5506/APhysPolBSupp.11.657

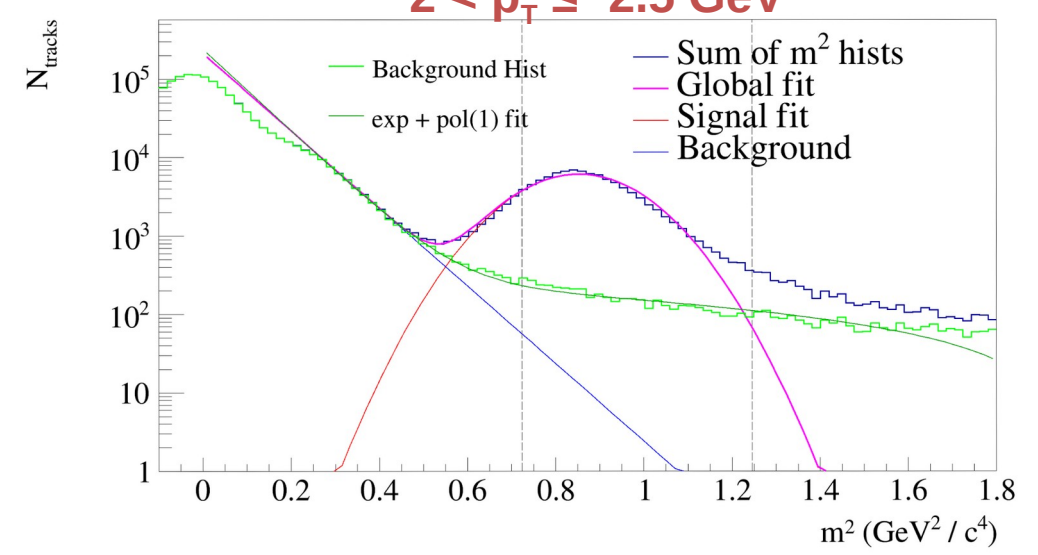
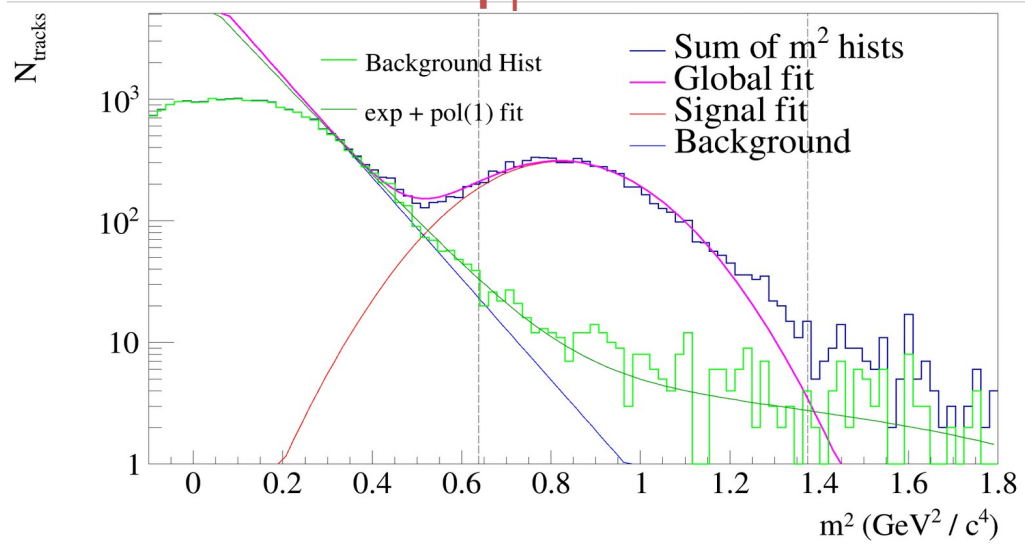
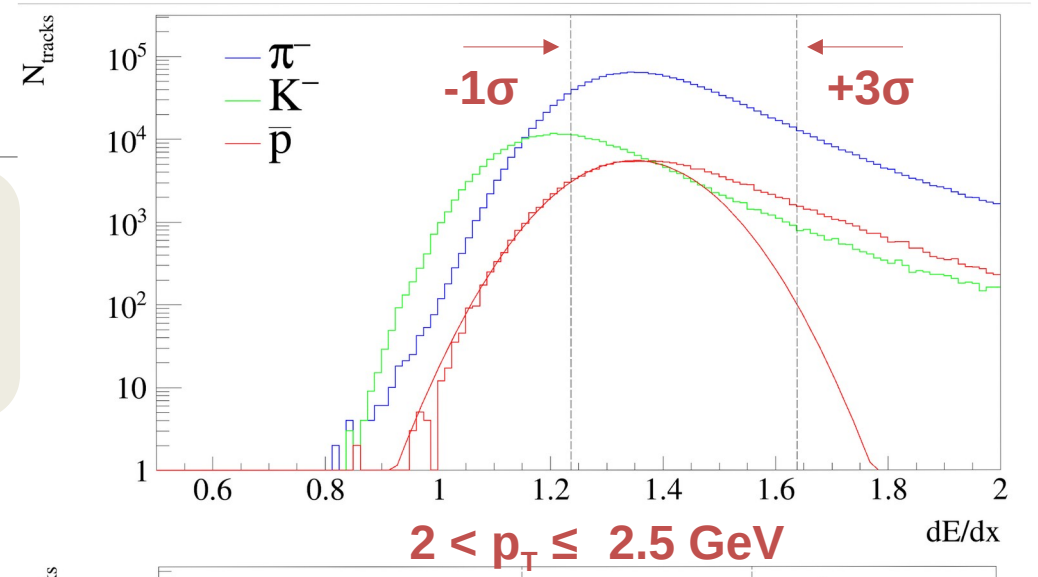


# Antiprotons production analysis

## dE/dX & m<sup>2</sup> distribution for selected p<sub>T</sub> regions



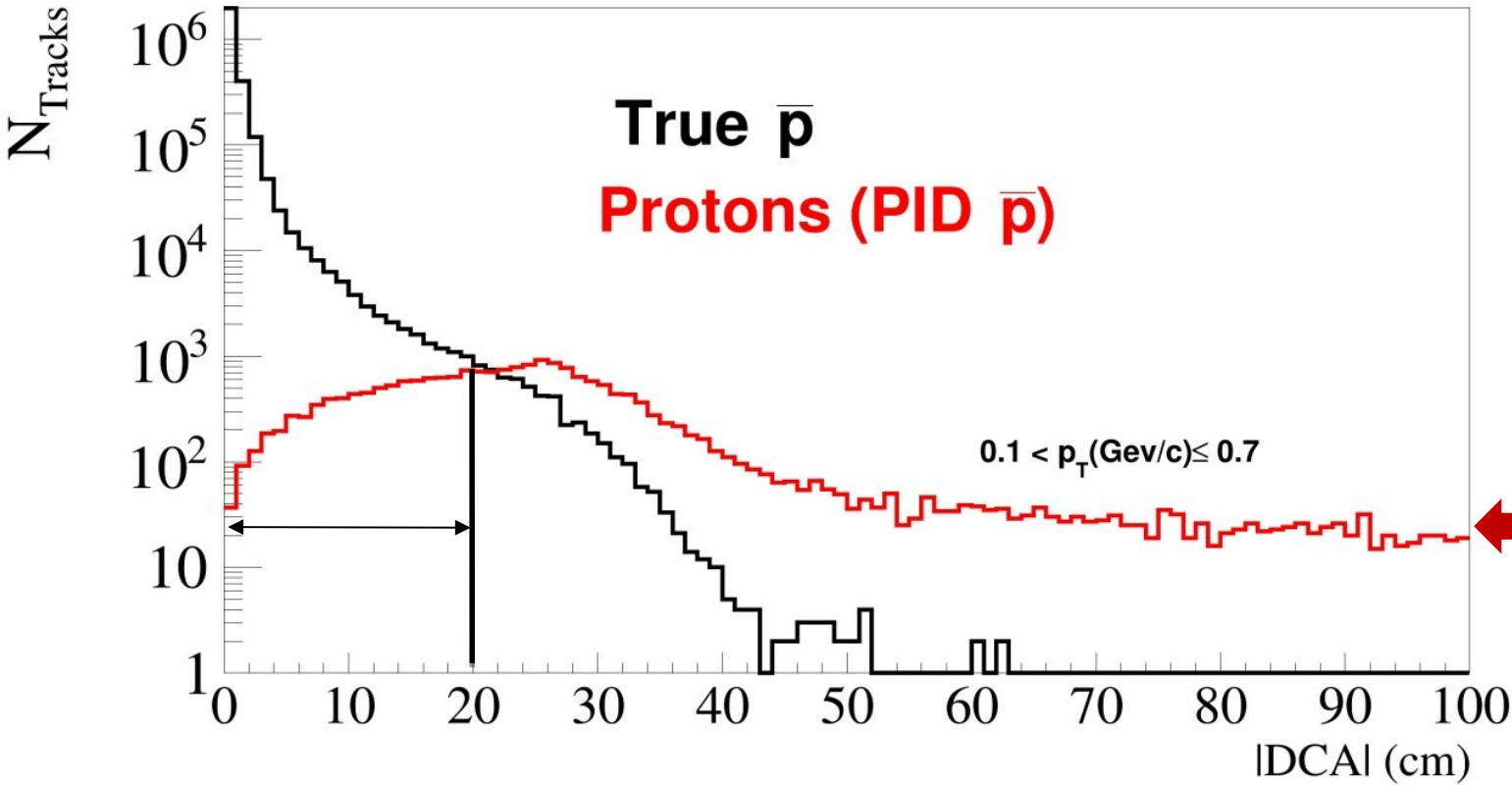
Select anti-protons, rejecting other species





# Antiprotons production analysis

## DCA distribution for identified anti-protons



| Contribution of wrongly identified particles |        |             |           |       |       |
|--|--------|-------------|-----------|-------|-------|
| $p_T(\text{Gev}/C)$                          | p      | $\bar{\pi}$ | $\bar{K}$ | other | all   |
| 0.1-0.2                                      | 100%   | 0%          | 0%        | 0%    | 485   |
| 0.2-0.3                                      | 99.95% | 0%          | 0.04%     | 0%    | 4656  |
| 0.3-0.4                                      | 99.97% | 0%          | 0.03%     | 0%    | 12373 |
| 0.4-0.5                                      | 99.16% | 0.25%       | 0.45%     | 0.12% | 2392  |
| 0.5-0.6                                      | 88%    | 4.5%        | 6%        | 1%    | 861   |
| 0.6-0.7                                      | 63%    | 16%         | 16%       | 4%    | 820   |
| 0.7-0.8                                      | 35%    | 29%         | 16%       | 9%    | 1035  |
| 0.8-0.9                                      | 18%    | 41%         | 35%       | 5%    | 1251  |
| 0.9-1  | 15%    | 58%         | 34%       | 3%    | 2104  |

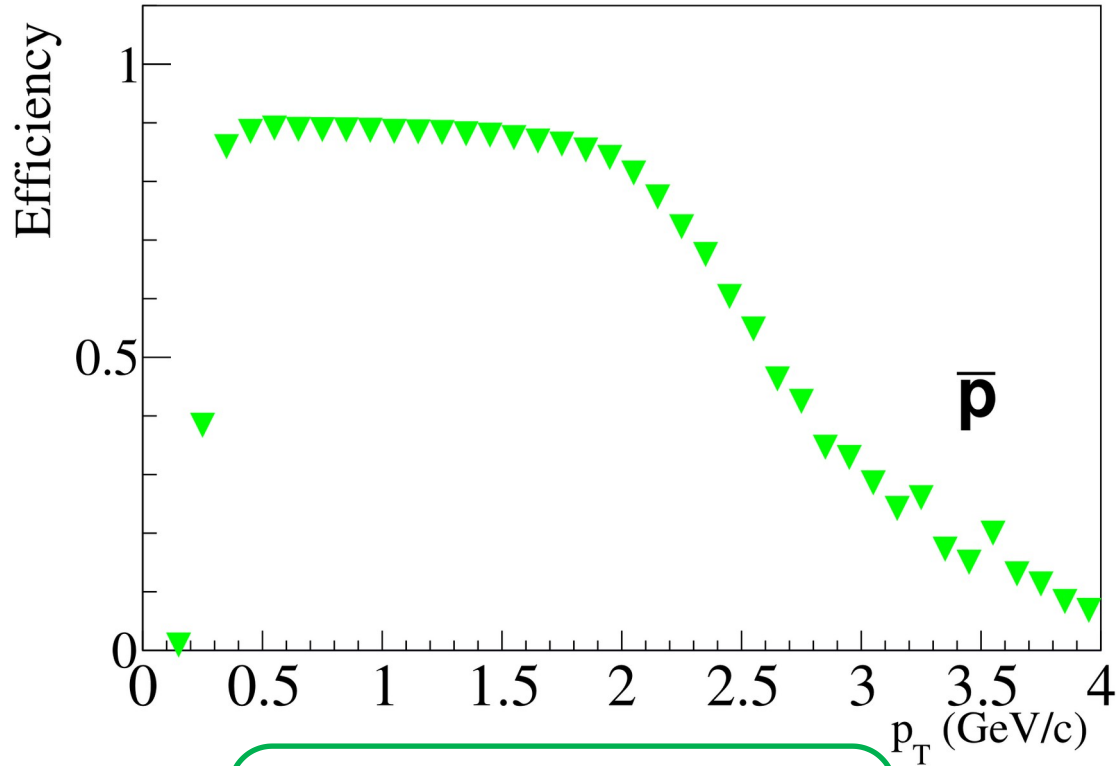


# Antiprotons production analysis

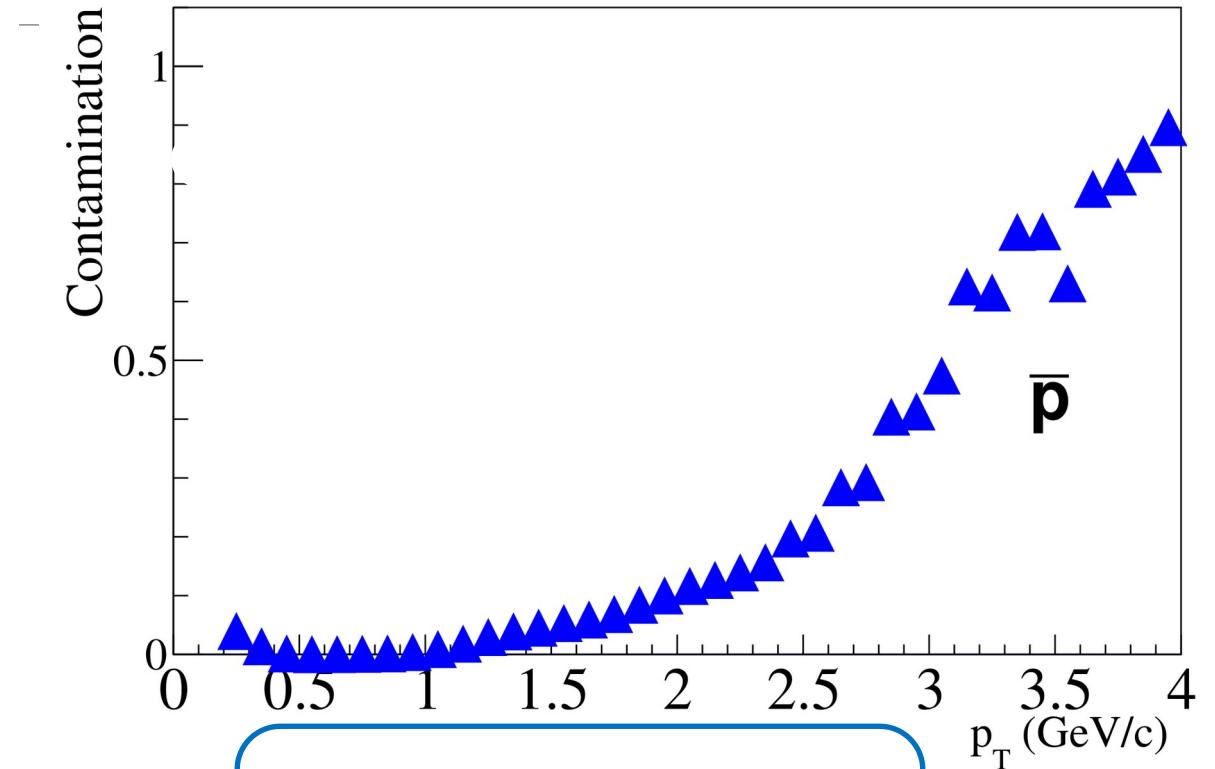
PID Efficiency-contamination distribution after all selection



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**efficiency** = right identified tracks/identified tracks



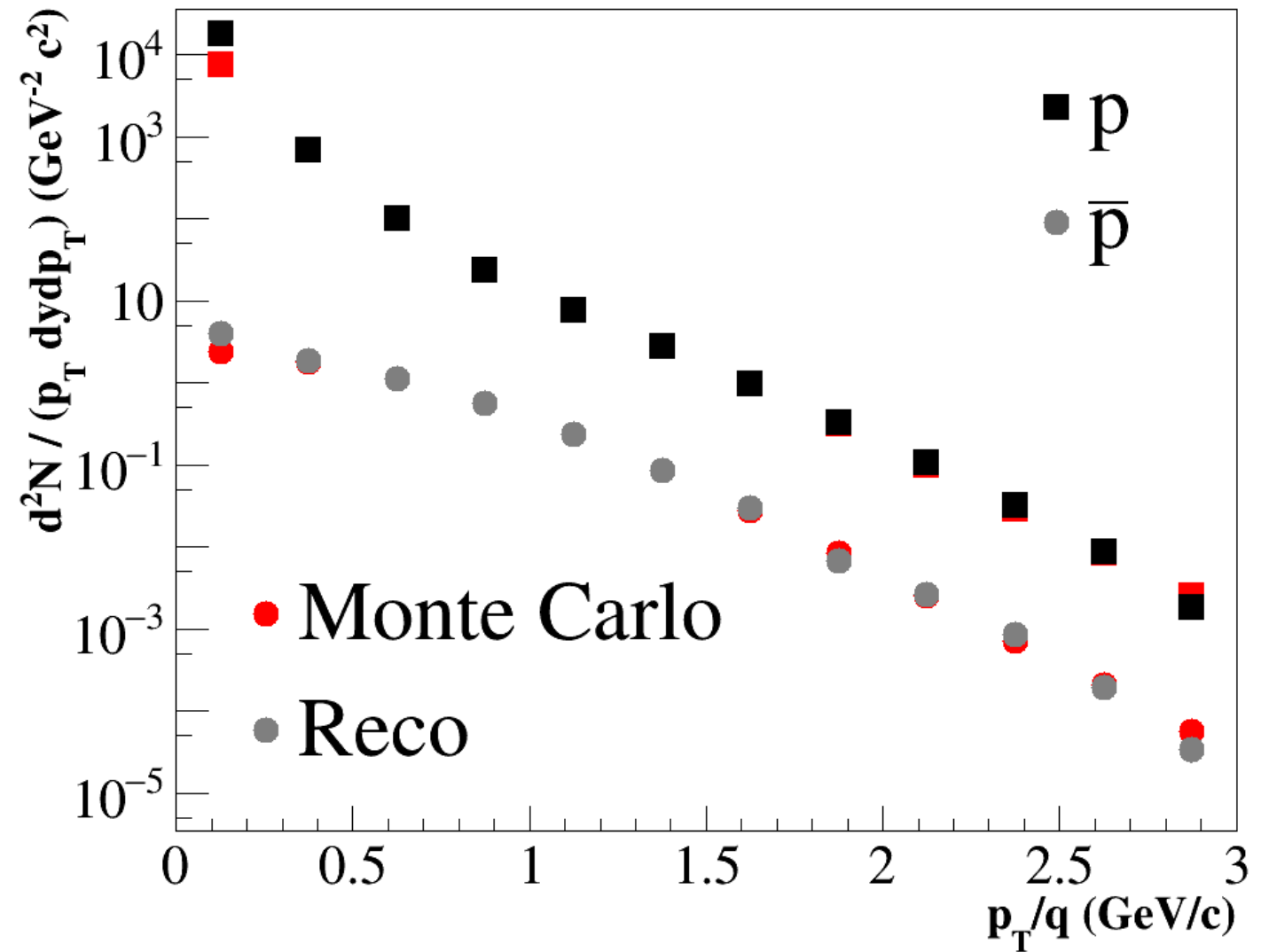
**contamination** = wrong identified tracks/ identified tracks

# Efficiency corrected $p_T$ spectra



Spectra includes :

- 1) corrected PID efficiency/contamination
- 2) correction over the losses in TPC due to reconstruction procedure
- 3) TPC/TOF (mis)matching
- 4) correction over the losses due to the track selection criteria



# Summary



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- Preliminary invariant  $p_T$  spectra of anti-protons *was produced with the correction for all the methods used in the analysis : PID, TPC reconstruction procedure, TPC/TOF (mis)matching, losses originated from track selection criteria*
  - Additional efforts are needed to unveil the remaining discrepancy of first  $p_T$  points



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# THANK YOU!