Hyperon global polarization studies at MPD

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October 30^{th}, 2020

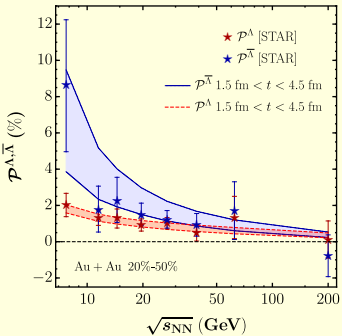
VI-th Collaboration Meeting of the MPD Experiment at the NICA Facility

Outline

Section 1

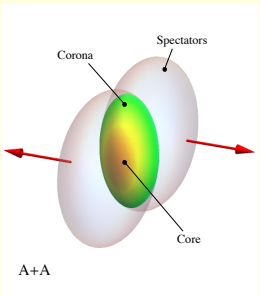
Motivation

Motivation: Core meets Corona



Polarization of Λ and $\bar{\Lambda}$ compared with data from the BES[Nature 548,62-65(2017)]

A two component source to explain Λ and $\bar{\Lambda}$ global polarization in semi-central heavy-ion collisions.
J.Phys.Conf.Ser. 1602, 012032 (2020), Phys.Lett.B 810, 135818 (2020)



$$\mathcal{P}^{\Lambda} = \frac{z\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}}{\left(1+\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}\right)}$$

$$\mathcal{P}^{\bar{\Lambda}} = \frac{(\frac{\bar{z}}{w})\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}}{\left(1+(\frac{1}{w})\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}\right)}$$

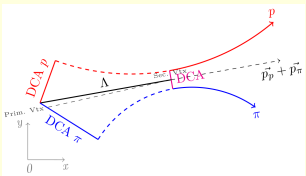
- $z(\bar{z})$ intrinsic polarization
- $w \to \bar{\Lambda}/\Lambda$ ratio in periphery;
- `QGP` $\to$ central region
- `REC` $\to$ periphery region

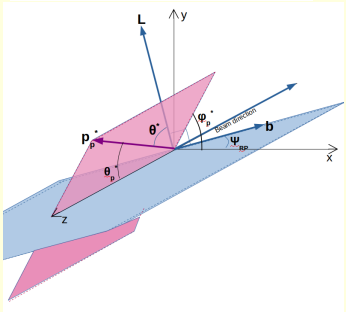
Section 2

Measurement procedure

Measurement procedure of Hyperon Global Polarization

1. Λ and $\bar{\Lambda}$ identification through their decay products and measurement of the azimuthal angle of the decay baryon ϕ_p^*
2. Measurement of the Event Plane angle Ψ_{EP} and its Resolution R_{EP}
3. Polarization as a function of the difference of these angles





Polarization

$$\mathcal{P}_H = \frac{8}{\pi \alpha_H} \frac{\left\langle \sin\left(\phi_p^* - \Psi_{EP}^{(1)}\right) \right\rangle}{R_{EP}}$$

$\alpha_H = 0.642 \pm 0.013$ - hyperon decay parameter

Section 3

Analyzed data

Analyzed data: Bi+Bi at $\sqrt{s_{NN}} = 11\text{GeV/c}$

- Generation of $\approx 100,000$ events of Bi+Bi for each different centrality sets of data
  - Minimum Bias,
  - Central collisions $b < 4$ fm,
  - Semi-Central collisions 6 fm $< b < 8$ fm
  - Peripheral collisions $b > 10$ fm
- Generator $\rightarrow$ UrQMD
- Transport $\rightarrow$ GEANT3
  - TPC, TOF, EMC, ZDC
- Reconstruction analysis $\rightarrow$ Only TPCKalmanTracks

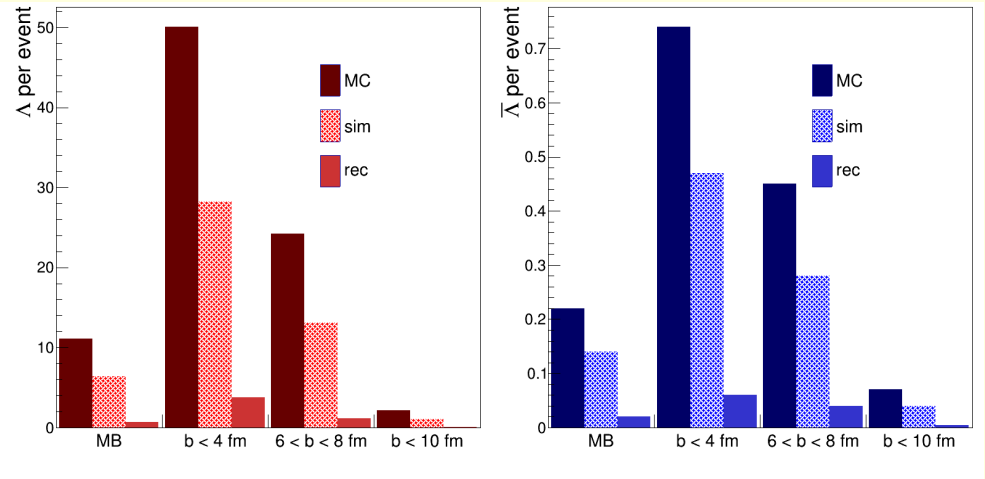
Data type: MC/Sim/Rec

Number of Λ and $\bar{\Lambda}$ per event in each data set

- MC data $\rightarrow$ Λ and $\bar{\Lambda}$ generated by UrQMD + particle decays, secondary interactions by GEANT3 transport package
- Sim data $\rightarrow$ Findable Λ and $\bar{\Lambda}$, identified by the products of its charged decay and with $p_{T>0.001}$(GeV/c) and $|\eta| < 1.3$
- Rec data $\rightarrow$ Reconstructed Λ and $\bar{\Lambda}$, identified by combination of secondary tracks of opposite charge.

Data	Generated		Simulated		Reconstructed	
Sample	Λ	$\bar{\Lambda}$	Λ	$\bar{\Lambda}$	Λ	$\bar{\Lambda}$
MB	11.8	0.22	6.36	0.14	0.66	0.02
$b < 4$ fm	50.6	0.74	28.2	0.47	3.78	0.06
6 fm $< b <$ 8 fm	24.0	0.45	13.1	0.28	1.16	0.04
$b > 10$ fm	2.12	0.07	1.10	0.04	0.05	0.004

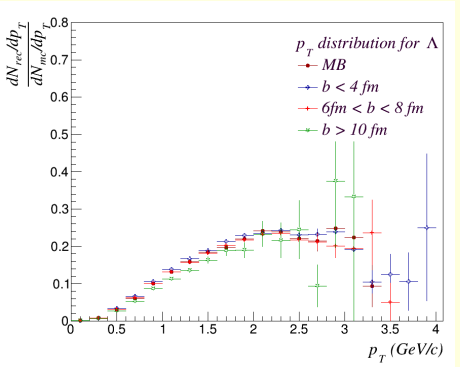
Comparison: MC/Sim/Rec

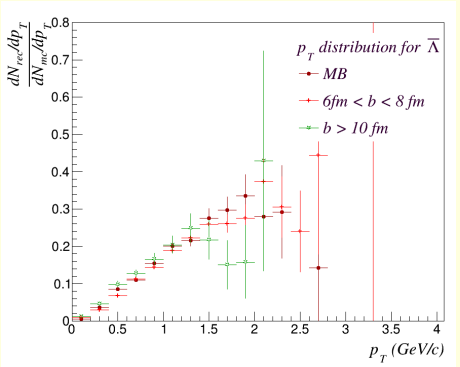


Number of Λ and $\bar{\Lambda}$ per event at each level of analysis and impact parameters

Maximum efficiency for reconstruction in p_T

The efficiency for Λ and $\bar{\Lambda}$ for each data set is similar



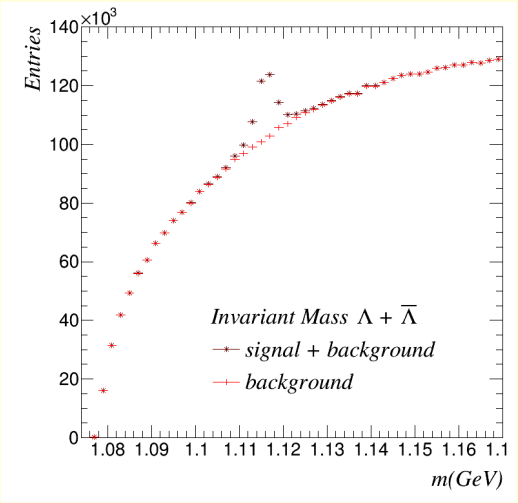


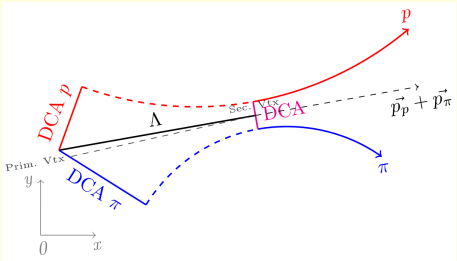
Maximum efficiency with MC association

Section 4

Reconstruction

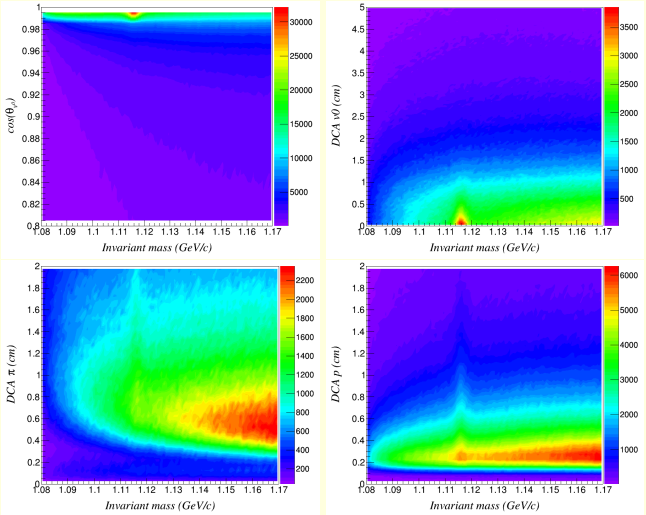
Reconstruction: Kinematical and topological variables





Variable	Cut
Cos of Angle	?
DCA V^0	? cm
DCA $p-$track	? cm
DCA $\pi-$track	? cm

Cuts for selection



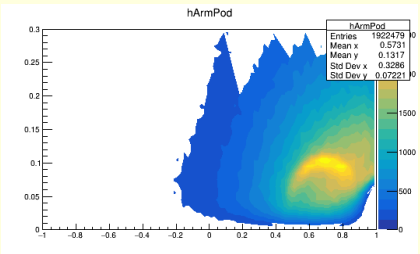
Most of Λ and $\bar{\Lambda}$ are in:

- $\cos(\theta) > 0.98$
- DCA $V^o < 0.5$ cm
- DCA $p - track > 0.1$ cm
- DCA $\pi - track > 0.3cm$

Some cuts distinguish Λ from $\bar{\Lambda}$

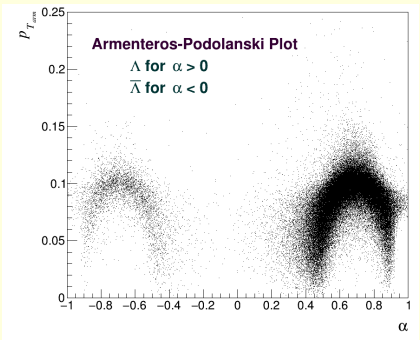
Distinguish between Λ and $\bar{\Lambda}$

$$\alpha = \frac{p_L^+ - p_L^-}{p_L^+ + p_L^-}$$



We use:

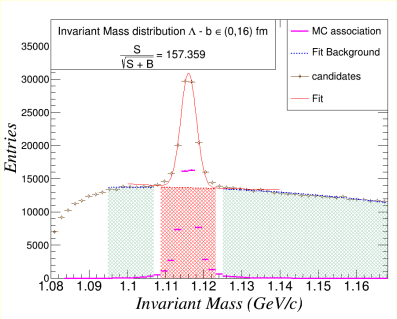
- $\alpha > 0$ for Λ
- $\alpha < 0$ for $\bar{\Lambda}$



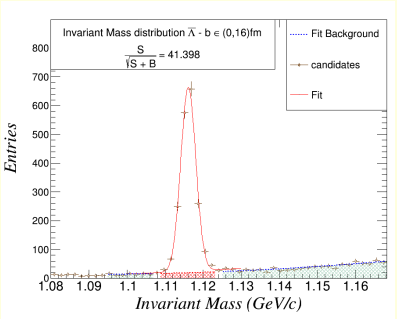
Even with cuts the background is difficult to visualize $\bar{\Lambda} \rightarrow$ we use MC association

Invariant mass with preliminary cuts

Λ - in MB data set



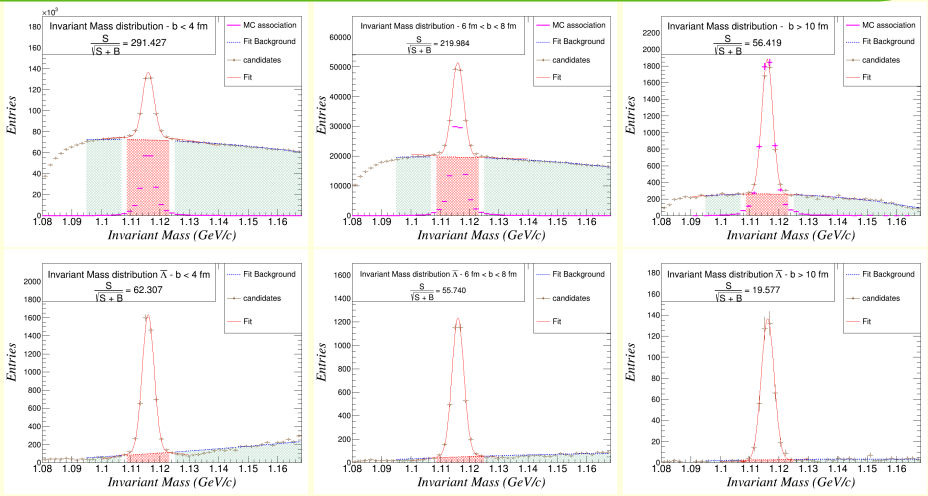
$\bar{\Lambda}$ - in MB data set



Variable	Cut
Cos of Angle	< 0.98
DCA V^0	< 0.5 cm
DCA $p-$track	> 0.1 cm
DCA $\pi-$track	> 0.3 cm

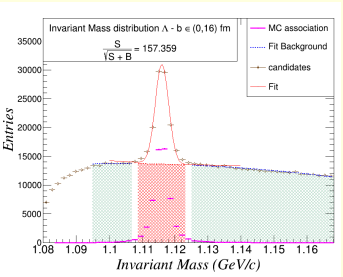
Significance measured in 3.5σ from the peak.

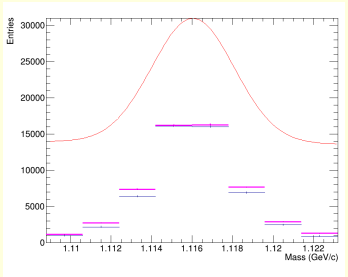
Invariant Mass at different b

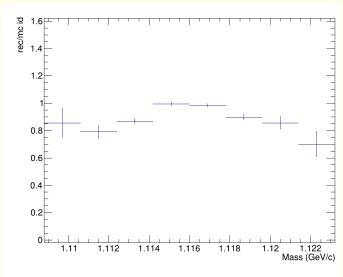


Signal decreases with impact parameter

Invariant Mass ratio for Λ

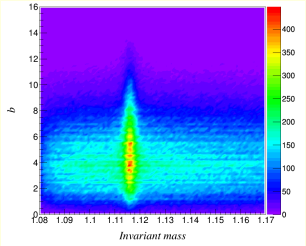




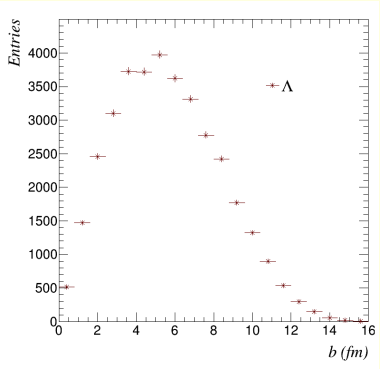


Background subtraction and comparison with MC association of V^o candidates

Λ and $\bar{\Lambda}$ vs Impact Parameter

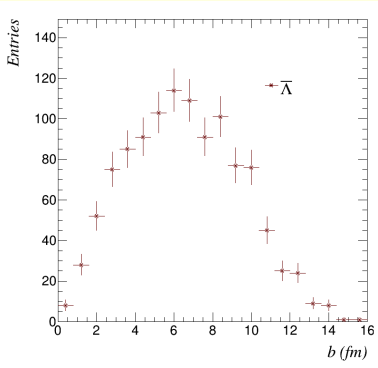


To do:
With the bin counting background subtraction method, we can clean the signal to get the impact parameter distributions



Code:
$b = (\text{FairMCEventHeader}*) \rightarrow \text{GetB}();$

For these two distributions we get the MC identification of the reconstructed tracks after kinematical cuts

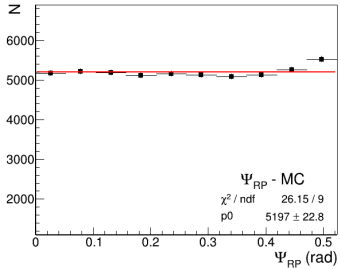


Section 5

Event Plane Angle

Measurement of Ψ_{EP} and R_{EP}

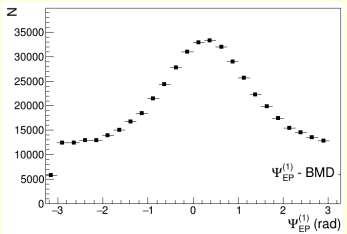
MC $\rightarrow \Psi_{RP}$ randomly in $(0, 30^o)$ isotropic distribution



Reconstruction requires $\Psi_{EP}^{(1)}$ and R_{EP}.
Example with **BeBe** $\longrightarrow$

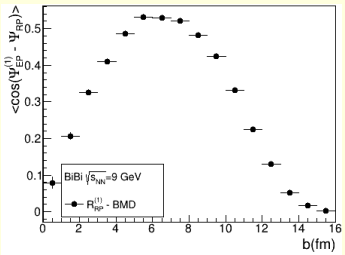
Event Plane Angle

$$\Psi_{EP}^{(n)} = \frac{1}{n}\frac{\sum_i w_i sin(n\phi_i)}{\sum_i w_i cos(n\phi_i)}$$



Resolution

$$R_{EP} = \left\langle cos(\Psi_{EP}^{(1)} - \Psi_{RP}) \right\rangle$$



Section 6

Polarized Hyperons

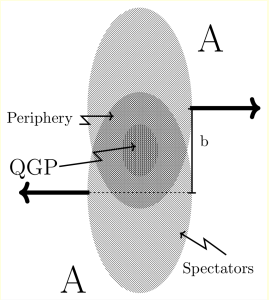
How to introduce a Polarization?

Selecting a subset of tracks in the simulated and reconstructed data that follows the characteristics described in the model.

$$\mathcal{P}^{\Lambda} = \frac{z\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}}{\left(1+\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}\right)}$$

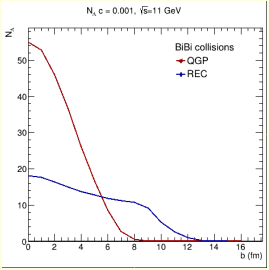
$$\mathcal{P}^{\bar{\Lambda}} = \frac{(\frac{\bar{z}}{w})\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}}{\left(1+(\frac{1}{w})\frac{N_{\Lambda_{QGP}}}{N_{\Lambda_{REC}}}\right)}$$

- $z(\bar{z})$ - Intrinsic polarization
- w - $\bar{\Lambda}/\Lambda$ ratio in periphery
- QGP - Central region
- REC - periphery



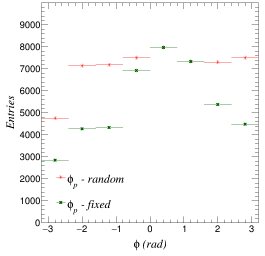
Consider that $\mathcal{P}^{\Lambda}_{REC} = \mathcal{P}^{\bar{\Lambda}}_{REC} = 0$

Number of Λ and $\bar{\Lambda}$ estimated with Glauber Model



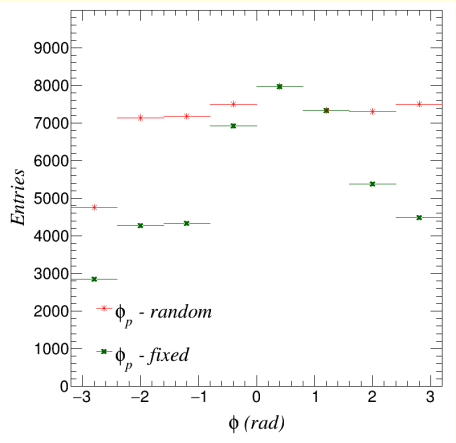
Add a polarization proportional to $N_{\Lambda\,QGP}$

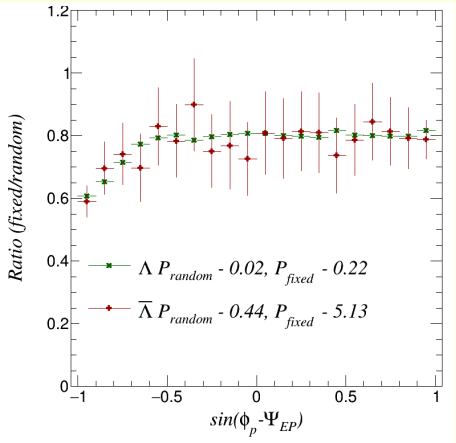
Proton azimuthal distribution



Fix an azimuthal distribution for baryon decay according to $N_{\Lambda\,QGP}$

Preliminary - $\sin(\phi_p - \Psi_{EP})$





inhomogeneous azimuthal baryon decay distribution leads to different estimations of polarization.

Section 7

Summary

Summary

- We have presented a general overview of Λ and $\bar{\Lambda}$ reconstruction using the MPD, aimed at measuring the hyperon global polarization for NICA energies.
- We plan to get the polarization with the measured event plane and to improve the selection of Λ and $\bar{\Lambda}$ considering the particle identification for the decay product tracks and improving the topological cuts to increase the significance.
- We plan to model the azimuthal angular distributions of the decay baryons to simulate polarization of particles coming from the different density regions, and compare with results obtained with other generators such as DCM-SMM and DCM-QGSM.

¡GRACIAS!