1. Introduction

• Machine learning is being used in various classification and regression problems
• ML gives ability to the machine to predict an outcome without being explicitly programmed
• A multi-phase transport (AMPT) model is used for data generation
• Impact parameter is a crucial observable in heavy-ion collisions yet almost impossible to predict in experiments
• Transverse spherocity, an event shape observable, has recently been introduced in heavy-ion collisions to study azimuthal anisotropy [1]
• In the absence of any experimental exploration, ML could be used to estimate spherocity

2. Observables

• Final state observables such as charged particle multiplicity, charged particle multiplicity in the transverse region and mean transverse momentum are chosen as the input
• Pearson correlation coefficient indicates strong linear correlation among the chosen input and target observables

2. Method

- **Gradient boosting decision trees (GBDTs)** for regression [2,3]
- Loss function: Least squares, Least absolute deviation and Huber function
- Maximum number of trees: 100
- Learning rate: 0.1, Maximum depth: 40
- Training sample size: 60,000 events
- The least difference in $\Delta b$ and $\Delta S_0$ among the different loss functions are taken as the systematic uncertainty

<table>
<thead>
<tr>
<th>Size of training data</th>
<th>2K</th>
<th>10K</th>
<th>20K</th>
<th>40K</th>
<th>50K</th>
<th>60K</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta b$ [fm]</td>
<td>0.71</td>
<td>0.62</td>
<td>0.58</td>
<td>0.53</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td>$\Delta S_0$</td>
<td>0.079</td>
<td>0.068</td>
<td>0.062</td>
<td>0.058</td>
<td>0.056</td>
<td>0.055</td>
</tr>
</tbody>
</table>

- Least squares loss function gives minimum $\Delta b$ and $\Delta S_0$
- Training error saturates at 60K events
- Prediction error for $\Delta b = 0.52$ fm and $\Delta S_0 = 0.055$
- Prediction vs. true plot shows a straight line with slope = 1

3. Results and discussions

- Training for impact parameter and transverse spherocity is done on Pb-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV (min. bias) data from AMPT.
- Black band denotes statistical uncertainty in simulated (true) values.
- Red band denotes the quadratic sum of statistical and systematic uncertainty in the predicted values from the ML-model.
- The predictions for impact parameter and transverse spherocity in Pb-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV (min. bias) are in good agreement with the true values.
- ML-model trained on Pb-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV (min. bias) data successfully predicts transverse spherocity distribution for Pb-Pb collisions, $\sqrt{s_{NN}} = 2.76$ TeV (min. bias).

- Training for transverse spherocity is done on Pb-Pb collisions, \( \sqrt{s_{NN}} = 5.02 \text{ TeV (min. bias)} \) data from AMPT
- Black band denotes statistical uncertainty in simulated (true) values
- Red band denotes the quadratic sum of statistical and systematic uncertainty in the predicted values from the ML-model
- ML-model trained on Pb-Pb collisions, \( \sqrt{s_{NN}} = 5.02 \text{ TeV (min. bias)} \) data successfully predicts the transverse spherocity distributions at various centralities such as (0-10)%, (40-50)% and (60-70)%