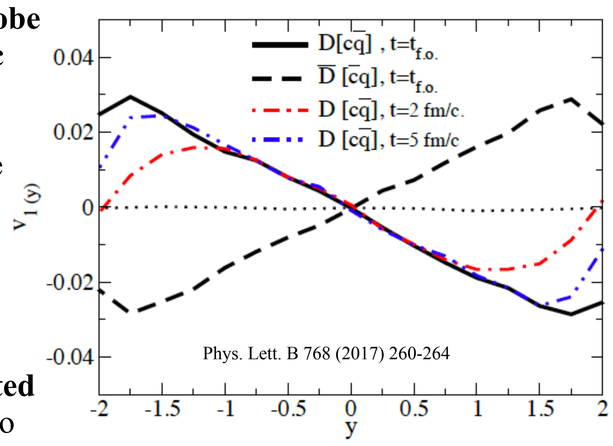
D-meson directed flow in Pb-Pb collisions with the ALICE detector

A. Dubla on behalf of the ALICE Collaboration
University of Heidelberg, Germany
GSI Helmholtz Centre for Heavy Ion Research, Germany
Email : andrea.dubla@cern.ch

Motivation

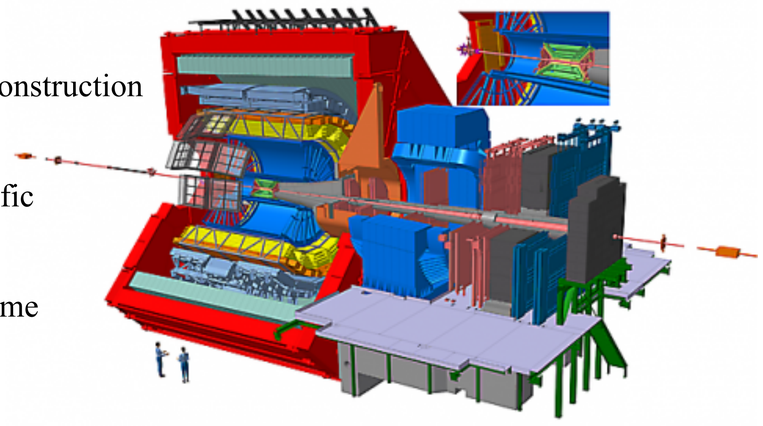
- In non-central heavy-ion collisions a strong **magnetic field** (~10^{18} G) is generated by the movement of the **proton spectators**.
  It quickly decreases (~1 fm/c) as the spectators fly away.
- The varying magnetic field will influence the moving charges and it results in a charge-dependent **directed flow**, asymmetric in rapidity [1]
- The **charm quark** is an **ideal probe** of the properties of this **magnetic field B** [2,3,4].
  - **Formation time ~ 0.1 fm/c** [2]
    → comparable to the time scale when **B is maximum**
  - the kinetic relaxation time of charm is similar to the QGP lifetime



- Theory predictions: **larger directed flow** of charm quarks compared to light quarks

ALICE detector

- **Inner Tracking System**
  - Track reconstruction
  - Primary and decay vertices reconstruction
- **Time Projection Chamber**
  - Track reconstruction
  - Particle identification via specific energy loss
- **Time of Flight**
  - Particle identification via the time of flight measurement
- **V0 detectors**
  - Trigger
  - Centrality estimation
- **ZDC detectors**
  - Spectator-plane (Ψ) estimation



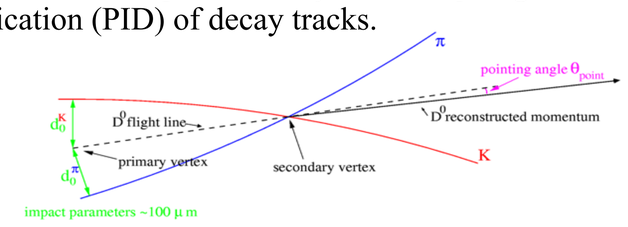
- **Data sample: ~10^8 Pb-Pb MB collisions** $\sqrt{s_{NN}}$ **= 5.02 TeV** $L_{int} \approx 13\ \mu b^{-1}$

Analysis strategy

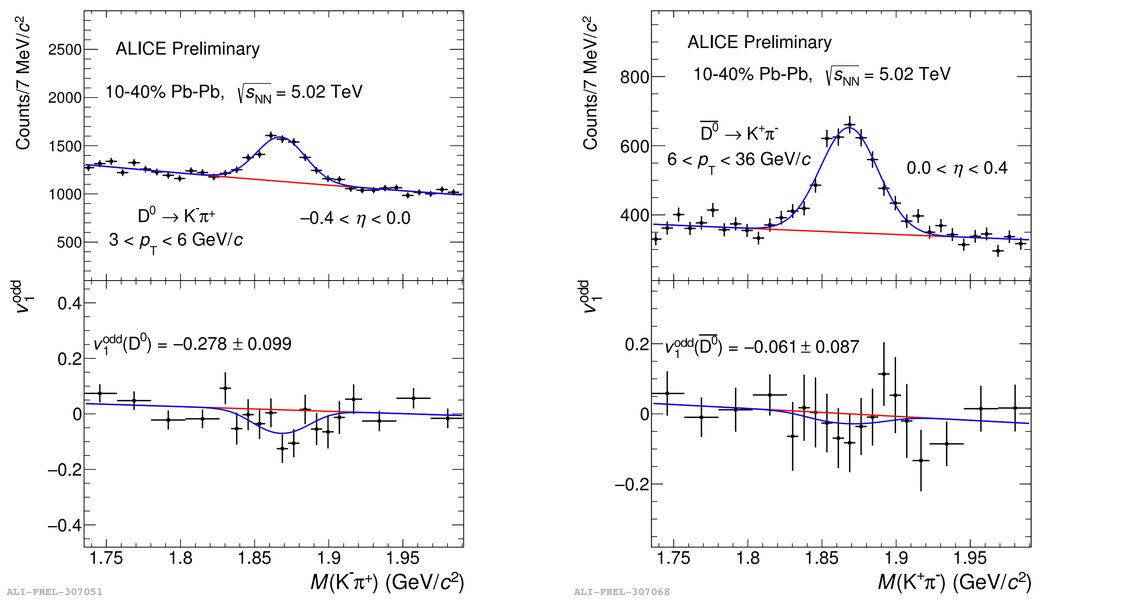
- Directed flow measured with the **scalar-product method** [5]
  - the spectator plane is reconstructed with the $ZDC_{A,C}$ ($|\eta| > 8.8$).
    A, C denote the ZDC side. A: $\eta > 8.8$, C: $\eta < -8.8$
- Analysis is performed as a function of the invariant mass.

$$v_1\{\Psi_{A,C}\} = \frac{\langle \vec{q} \cdot \vec{Q}_{A,C} \rangle}{\sqrt{|\langle \vec{Q}_A \cdot \vec{Q}_C \rangle|}} \qquad v_1(M) = \frac{S(M)}{S(M)+B(M)} \cdot v_1^S + \frac{B(M)}{S(M)+B(M)} \cdot v_1^B(M)$$

- **D-meson reconstruction via decay topologies** displaced few hundred microns from the collision point.
- **Reduction of the combinatorial** background achieved applying:
  - geometrical selection of displaced decay-vertex topologies
  - particle identification (PID) of decay tracks.

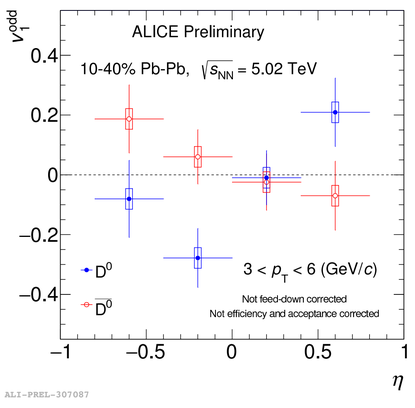


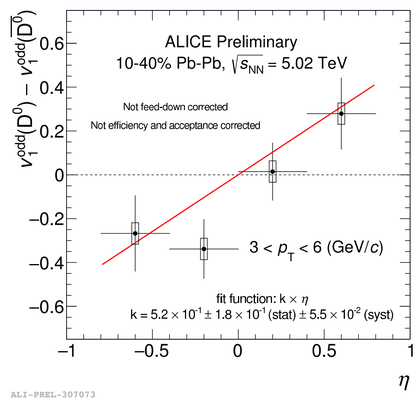
Signal and v_1^{odd} extraction

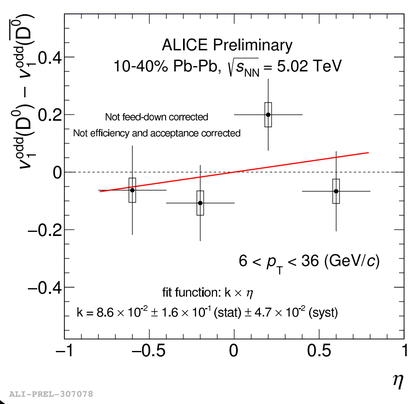


- Computed rapidity-odd component for D^0 and $\bar{D}^0$ separately: $v_1^{odd} = \frac{1}{2}(v_1\{\Psi_A\} - v_1\{\Psi_C\})$
  - sensitive to the asymmetry induced by the magnetic field
- $v_1^{odd}(D^0)$ extracted from a simultaneous fit to the invariant mass and to the $v_1^{odd}(M)$ distributions

Results



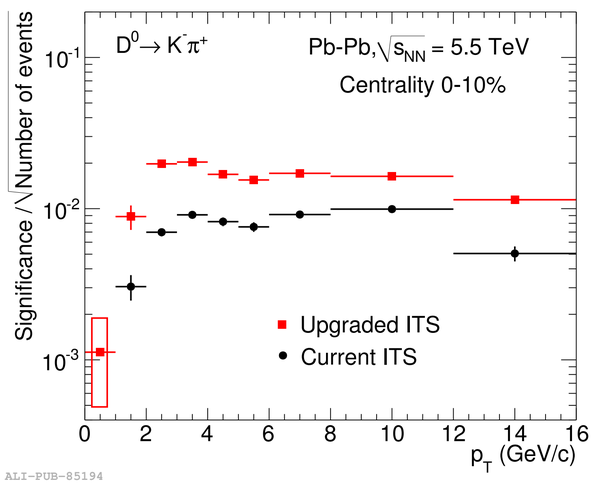


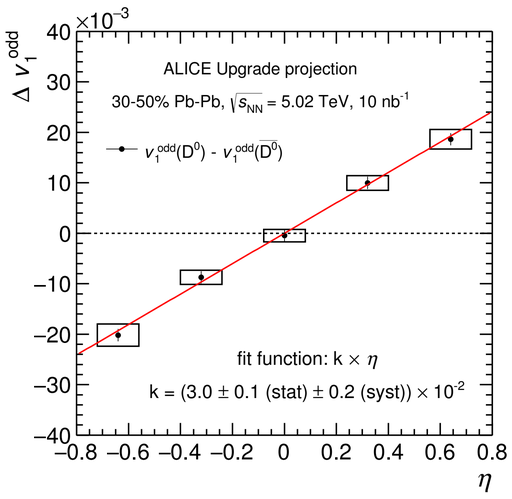


- **Indication of opposite trend** of v_1^{odd} as a function of η for D^0 and $\bar{D}^0$ with $3 < p_T < 6$ GeV/c in the 10-40% centrality class.
  - Hint of a reduction of the v_1^{odd} for $p_T > 6$ GeV/c.
  - Data suggest **larger v_1^{odd} with respect to theoretical calculations.**
  - Larger data samples needed to quantify it.
- $\Delta v_1^{odd} = v_1^{odd}(D^0) - v_1^{odd}(\bar{D}^0)$ fitted with a linear function to quantify the effect.
  - **Indication of positive slope** with a significance of 2.7σ in $3 < p_T < 6$ GeV/c.

Projections with the ALICE upgrade

- Factor two **larger significance** for the D^0 meson with the **upgrade** of the ITS detector [5].
- With the upgraded ITS the **background rejection improves** by a factor of 4-5 for $p_T > 2$ GeV/c and by a factor of about 10 for $p_T < 2$ GeV/c.





- **Performed projections** for the charge-dependence directed flow of D mesons.
- Input of the simulation for the $v_1^{odd}(D^0)$ based on the theoretical predictions [2].
- Based on this simulation, despite the small signal expected from the theory, with the detector upgrade and the statistics that will be collected in **Run3/4**, the measurements will be done with **high significance**.

Conclusions

- The **directed flow v_1^{odd}** has been computed for D^0 and $\bar{D}^0$ separately in the 10-40% centrality class.
- **Indication of opposite trend** of v_1^{odd} as a function of η for D^0 and $\bar{D}^0$ with $3 < p_T < 6$ GeV/c and **indication for a positive slope of Δv_1^{odd}** with a 2.7σ significance
- Data might indicate **larger v_1^{odd}** with respect to theoretical calculations. Larger data samples needed to give constraints to theoretical calculations.
- Projections show that with the **detector upgrade** and with the statistics that will be collected in **Run3/4**, the measurements will be done with **high significance**.

[1] Phys. Rev. C 89, 054905 (2014)
[2] Phys. Lett. B 768 (2017) 260-264
[3] Phys. Rev. Lett. 120, 192301 (2018)
[4] arXiv:1804.04893 [nucl-th]
[5] Phys. Rev. C 66 (Sep, 2002) 034904
[6] J. Phys. G 41 (2014) 087002