Physics Motivation

- In 1964 Dyson and Xuong predicted the existence of a dibaryon multiplet [1]. The ground state of the multiplet was identified with the deuteron and they predicted the existence of a \( \Lambda(1405) \) state with 2350 MeV/c mass.
- This state, named \( d^* \), is formally compatible with an excitation of the deuteron.
- Despite decades of search the existence of non-trivial dibaryon states is still an open question.
- In 2011 the WASA-at-COSY Collaboration reported the observation of a resonance with the predicted \( d^* \) [2] in all relevant two pion decay channels as well as in np scattering.

\( d^* \) properties measured by WASA-at-COSY [3]:
- \( M = 2.380 \text{ GeV}/c^2 \)
- \( \Gamma = 70 \text{ MeV} \)
- \( d^* \rightarrow d + \pi \) branching ratio \( \approx 2(2) \% \)

The purpose of this work is to investigate the possibility to observe \( d^*(2380) \) with the ALICE Experiment.

Thermal Model production

- The expected \( d^*(2380) \) production has been estimated starting from the deuteron yield in p-Pb collisions at 5.02 TeV.
- Assuming thermal production [5,6], average particle yield for an species can be written as:
  \[
  \langle N_i \rangle \propto g_i e^{-\beta m_i}, \quad g_i = 2 J_i + 1
  \]
- The \( d^*d \) yield ratio in p-Pb collisions at 5.02 TeV can be written as:
  \[
  \frac{\langle N_{d^*d} \rangle}{\langle N_{dd} \rangle} = \frac{g_{d^*}}{g_d} e^{-\beta(m_{d^*} - m_d)} = \frac{7}{3} e^{-\beta(m_{d^*} - m_d)}
  \]
- Chemical freeze-out temperature \( T_{fo} = 1.5/3 \) in heavy ion collisions is in the range of 155-170 MeV.
- Considering the measured \( \langle N_{dd} \rangle \), the ratio is \( \approx 0.1 \).

Rate of expected \( d^* \rightarrow 2.46 \times 10^{-1} \) in the \( d^* \rightarrow d + \pi \) decay channel
- \( \approx 14 \% \) of uncertainty due to the \( T_{fo} \) range.
- Is Thermal Model reliable for \( d^* \) production?

Significance of the measurement

Three ingredients used to estimate the significance:
- Expected signal shape from MC.
- Plausible background shape from Like-Sign triplets and normalization.
- \( d^* \) yield from Thermal Model prediction.
- Significance estimated by integrating signal and background in 70 MeV/c\(^2\) region around \( d^* \) peak.
- Significance estimation for the 2 considered PID configurations: significance optimization.
- Low significance for the dataset we have at disposal corresponding to \( \approx 5.5 \times 10^3 \) events.

Two methods to increase the significance:
- Reducing background
  - Optimization of rejection criteria with blind analysis
- Increasing data sample
  - \( \approx 3 \times 10^{11} \) events needed to reach 5\( \sigma \).

Background sources

- Background sources studied in Monte Carlo productions.
- Huge component due to uncorrelated pion pairs.
- Correlated background dominated by neutral mesons.
- Cuts for background reduction are under study → crucial to increase significance.

Conclusions and outlook

- The significance of the \( d^*(2380) \) signal measurement is low due to the huge background and to the low reconstruction efficiency at the production peak.
- We will perform a blind analysis to optimize efficiency and selection criteria.
- How reliable is the \( d^*(2380) \) production given by Thermal Model?
- We will analyze p-Pb datasets to evaluate if we can obtain a better significance.
- Challenging \( d^* \) identification for the experimental conditions at the LHC.
- If thermal model prediction is correct we will be able to set an upper limit to the production cross section of \( d^* \) in the \( d^* \rightarrow d + \pi \) channel.

References

6. G. Torrieri, et al., CPC 167, 229 (2005); CPC 175, 635 (2008); CPC185, 2056 (2014)