Search for the d*(2380) in p-Pb collisions at 5 TeV with ALICE at the LHC

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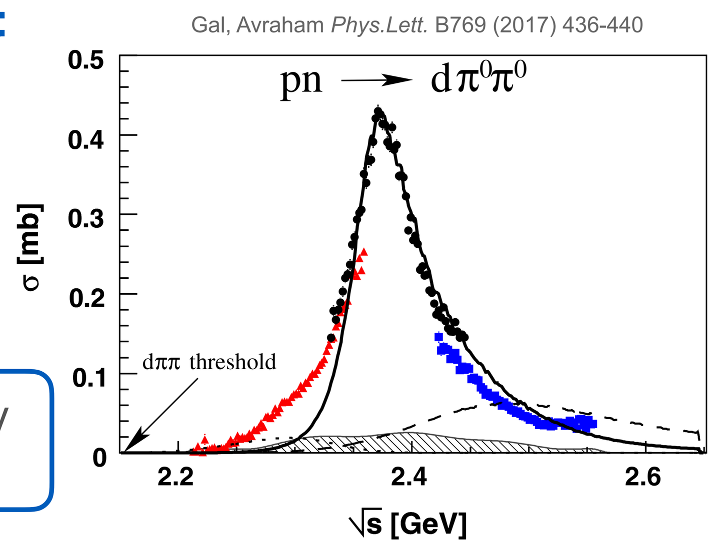
Physics Motivation

- 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 $I(J^P)=0(3^+)$ state with 2350 MeV/c^2 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 compatible 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]:

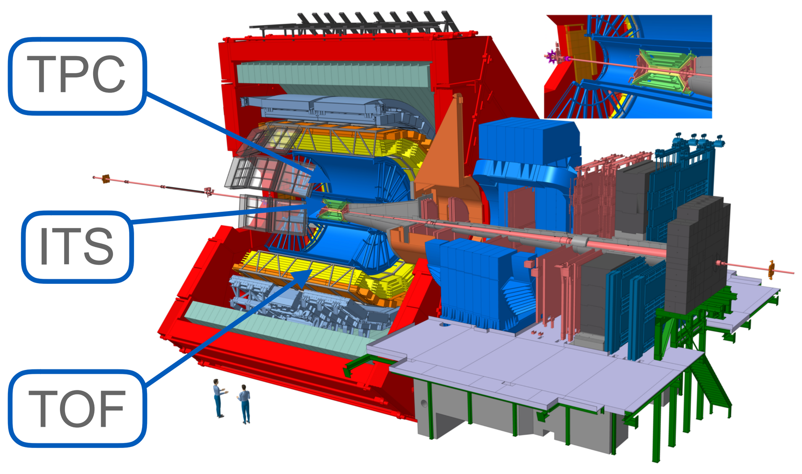
- **M = 2.380 GeV/c^2**
- **Γ = 70 MeV/c^2**
- **$d\pi^+\pi^-$ branching ratio → 23(2) %**



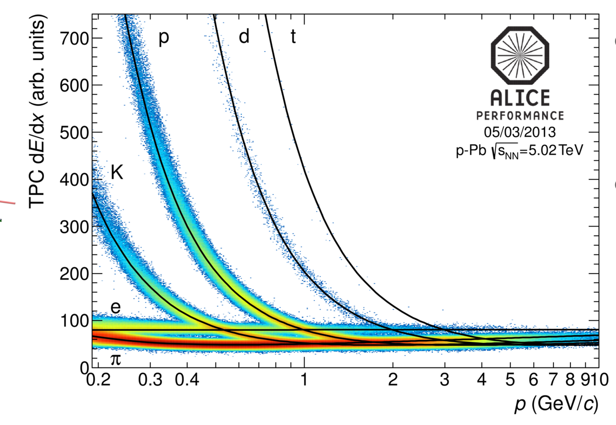
The purpose of this work is to investigate the possibility to **observe *d**(2380) with the ALICE Experiment**.

ALICE Detector

Thanks to its **excellent tracking** and **particle identification (PID)** capabilities, the ALICE apparatus [4] allows for an efficient detection of deuterons and pions produced in the *d** decay.



Time Projection Chamber

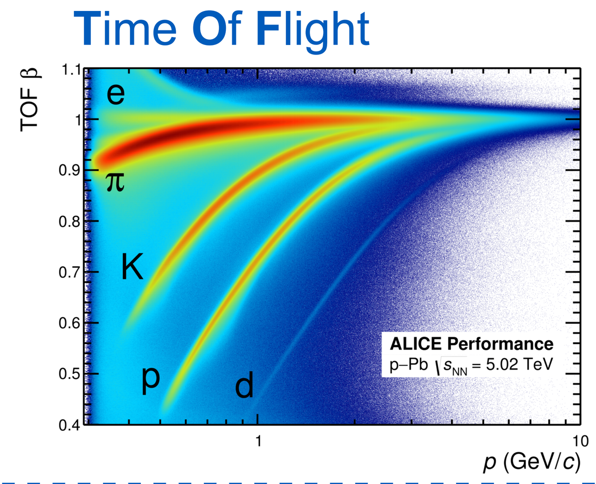


- Particles are identified via their **specific energy loss** (dE/dx).
- Clear deuteron identification with the TPC alone is possible up to ***p* ~ 1.2 GeV/*c*.**

Inner Tracking System

- Silicon detector used in this analysis for **tracking** and **vertexing.**
- DCA_{xy} and DCA_z measurements used to select tracks from primary vertex and reject secondary nuclei produced in material knock-out.

Time Of Flight



- Particles are identified by measuring their **time of flight**
- Unambiguous identification of deuterons up to ***p* ~ 2 GeV/*c*.**
- Good deuterons identification up to ***p* ~ 6 GeV/*c*.**

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 *i*-species can be written as:

$$\langle N_i \rangle \propto g_i e^{-\beta m_i}, \quad g_i = 2J_i + 1$$

- The d*/d yield ratio in p-Pb collisions at 5.02 TeV can be written as:

$$\frac{\langle N_{d^*} \rangle}{\langle N_d \rangle} = \frac{g_{d^*}}{g_d} e^{-\beta(m_{d^*} - m_d)} = \frac{7}{3} e^{-\beta(m_{d^*} - m_d)}$$

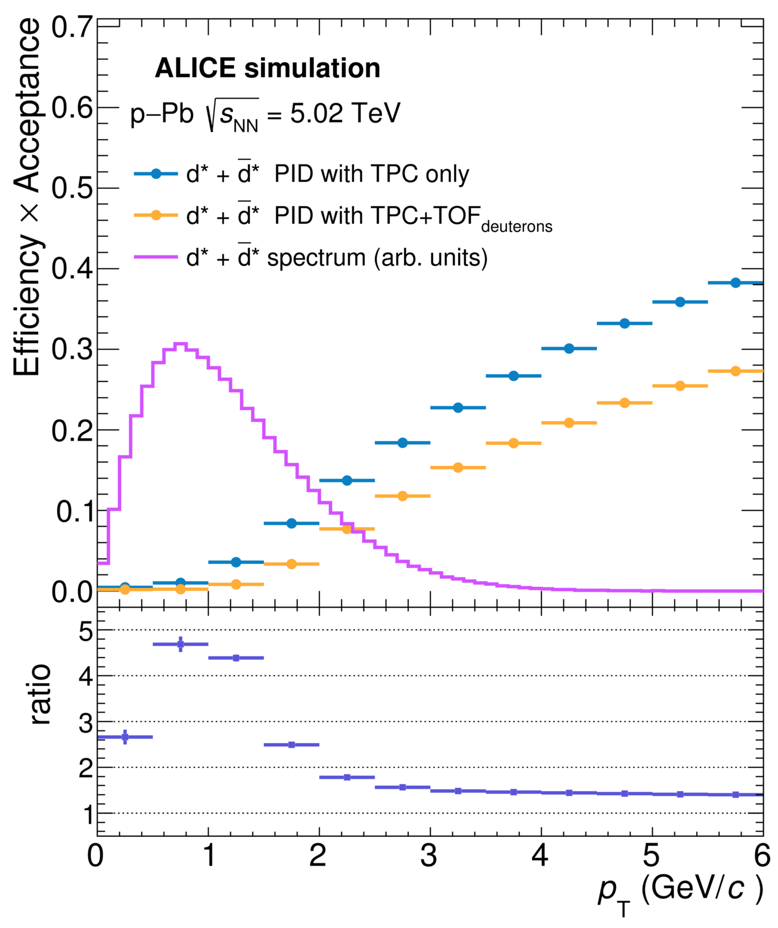
- Chemical freeze-out temperature $T_{ch} = 1/\beta$ in heavy ion collisions is in the range of **155-170 MeV.**
- Considering the measured $\langle N_d \rangle$, the **ratio is ~ 0.1.**

Rate of expected d* ⟶ 2.46 × 10⁻⁵ in the $d\pi^+\pi^-$ decay channel

- ~14 % of uncertainty due to the T_{ch} range.
- Is Thermal Model reliable for *d** production?

Reconstruction efficiency

The reconstruction efficiency has been studied in a dedicated MC production with **injected *d****.

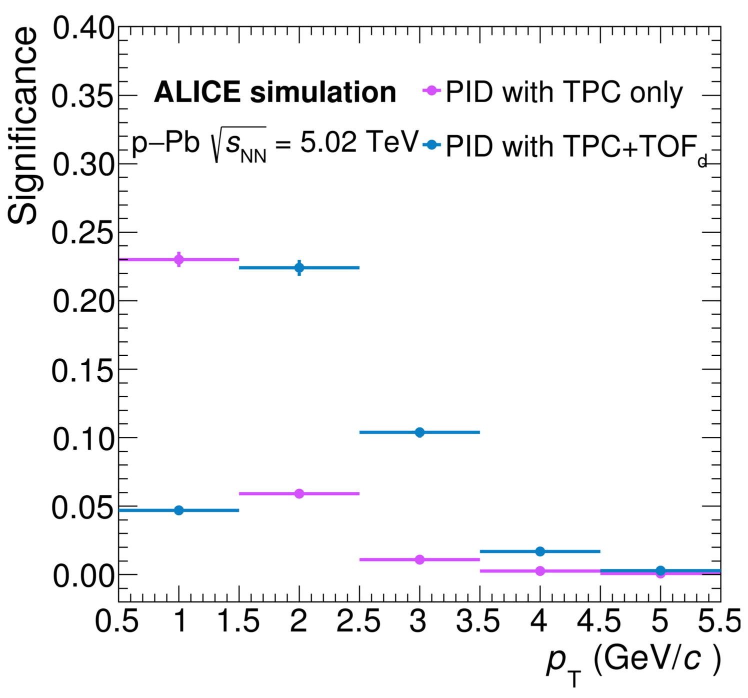


- Expected *d** spectrum obtained assuming the same Blast Wave distribution of the deuteron.
- 2 different PID configurations considered:
  - **PID based on TPC alone (TPC only).**
  - **PID with TPC and TOF for deuterons.**
- TPC only guarantees higher efficiency but deuteron sample for p_T > 1.5 GeV/*c* is too contaminated.
- Using TOF reduce significantly contamination but also efficiency.
- PID configuration choice based on the significance optimization in each p_T bin.

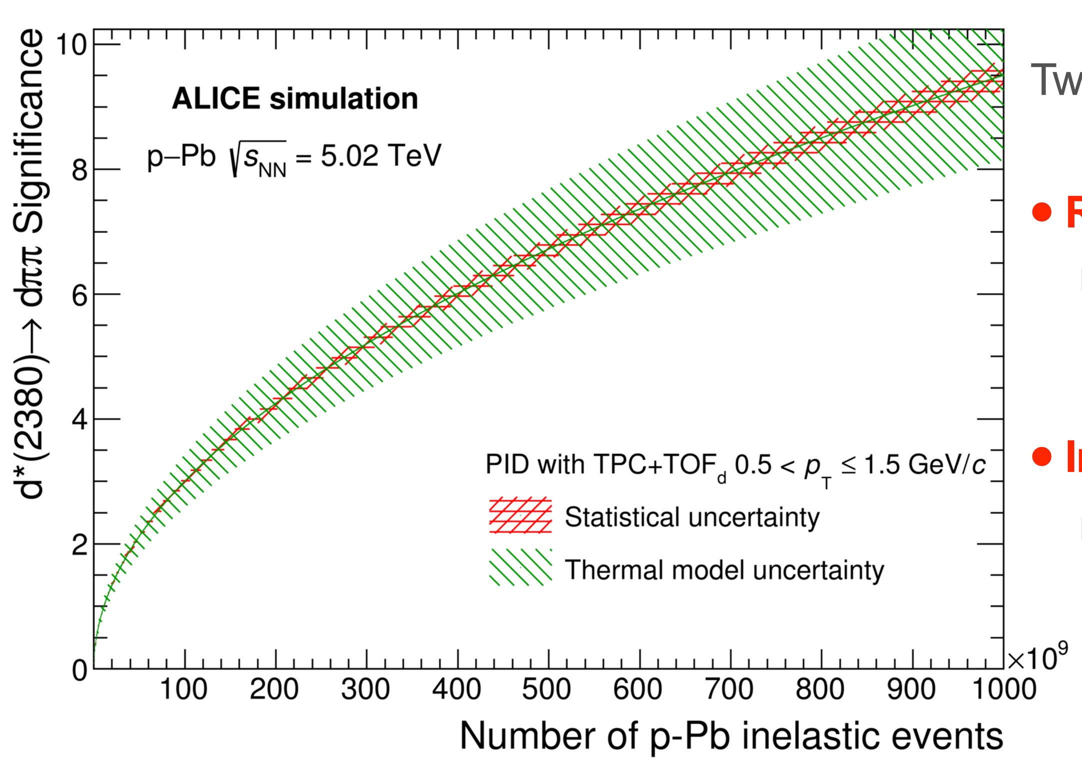
Significance of the measurement

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 **~ 5.5 10⁸ events**.



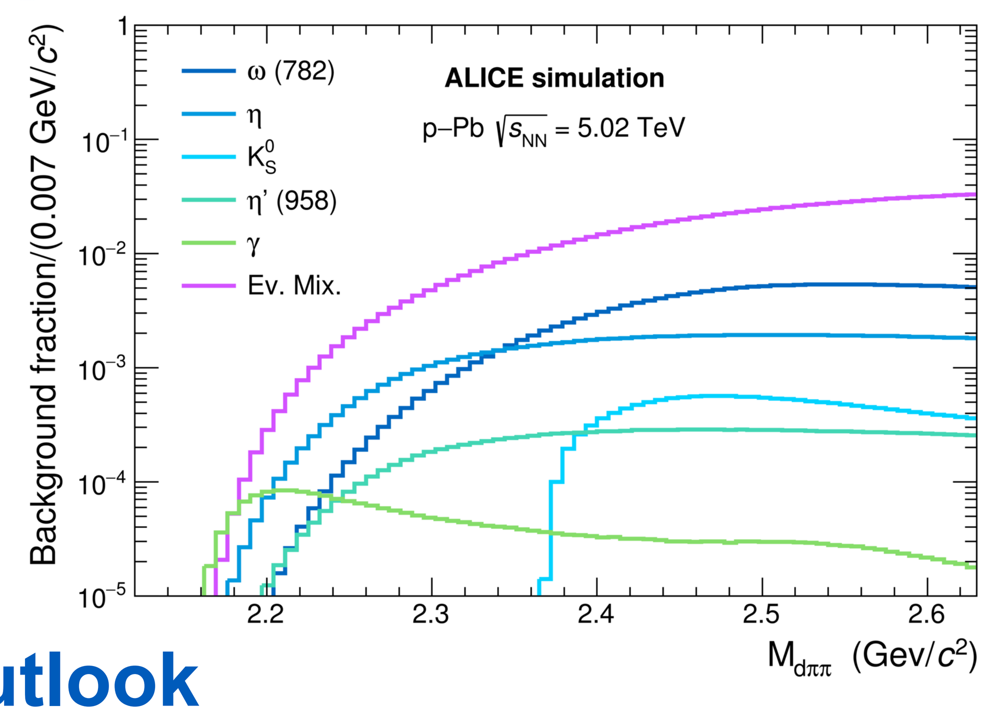
Two methods to increase the significance:

- **Reducing background**
  - Optimization of rejection criteria with blind analysis
- **Increasing data sample**
  - ~ 3 × 10¹¹ events needed to reach 5σ

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-p 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 $d\pi^+\pi^-$ channel.

References

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[2] P. Adlarson, et al., *Phys. Rev. Lett.* 106 (2011) 242302
[3] Bashkanov, M., Clement, H. & Skorodko, *T. Eur. Phys. J.* A (2015) 51: 87
[4] ALICE Collaboration *Int. J. Mod. Pays.* A29 (2014) 1430044
[5] S. Wheaton, et al., CPC180, 84 (2009)
[6] G. Torrieri, et al., CPC 167, 229 (2005); CPC 175, 635 (2006); CPC185, 2056 (2014)