Application of MVA methods to the analysis of inclusive J/ψ in Pb-Pb collisions with ALICE at the LHC

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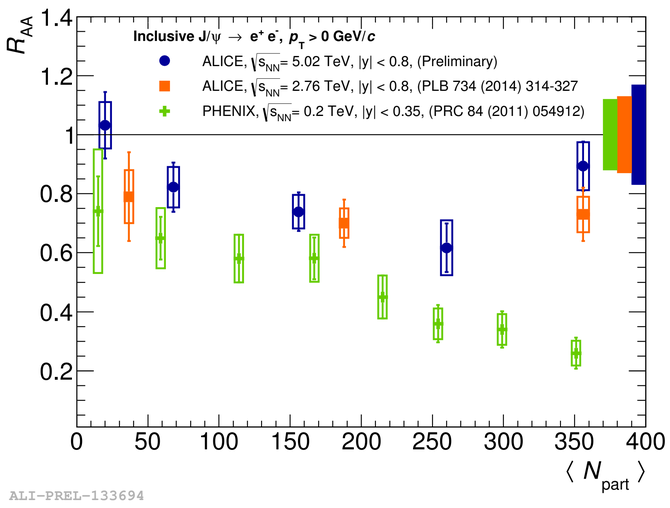
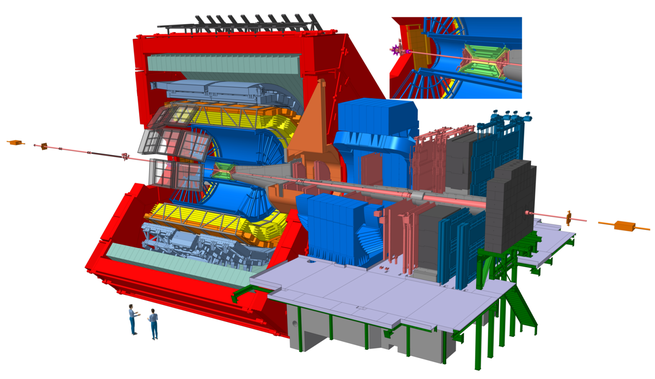
PHYSICS MOTIVATION

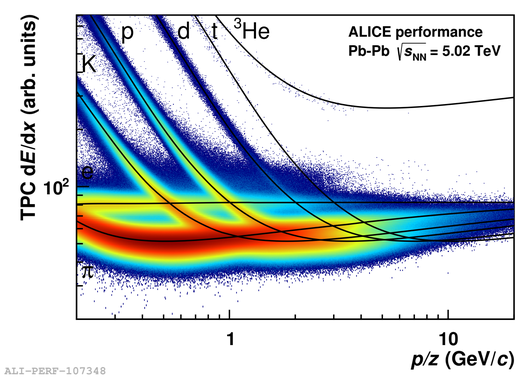
The **suppression of charmonium** production induced by color screening of quarks was proposed as a probe of the formation of the QGP [1]. At LHC collision energies new production mechanisms are expected to lead to a **charmonium enhancement** in most central collisions [2, 3]. The inclusive J/ψ nuclear modification factor R_{AA} measured by ALICE [4, 5] at $\sqrt{s_{NN}}$ = 2.76 TeV and at $\sqrt{s_{NN}}$ = 5.02 TeV in the dielectron channel, shows a striking **enhancement in central collisions** compared to the measurements at lower energies [6, 7], supporting models including (re)generation. The measurement is **limited by the low signal to background**. This motivates the application of **Multivariate Analysis (MVA) methods to increase the sensitivity**.



THE ALICE DETECTOR

The **ALICE experiment** [8] is designed to examine strongly interacting matter under extreme energy densities.





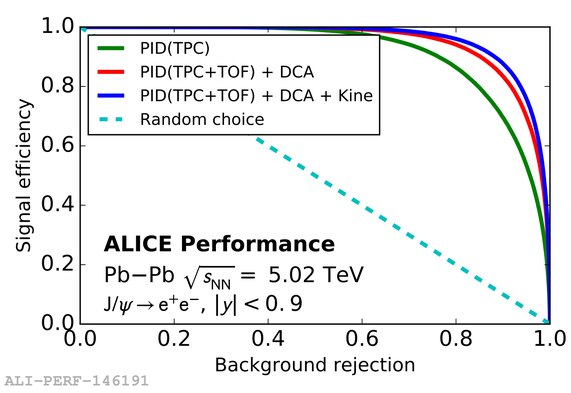
The main **tracking devices** for charged particles are the Time Projection Chamber **TPC** and the Inner Tracking System **ITS**. **Particle identification (PID)** relevant for the identification of electrons is provided by the TPC via a measurement of the **energy loss**, the Time of Flight detector **TOF** and the Transition Radiation Detector **TRD**.

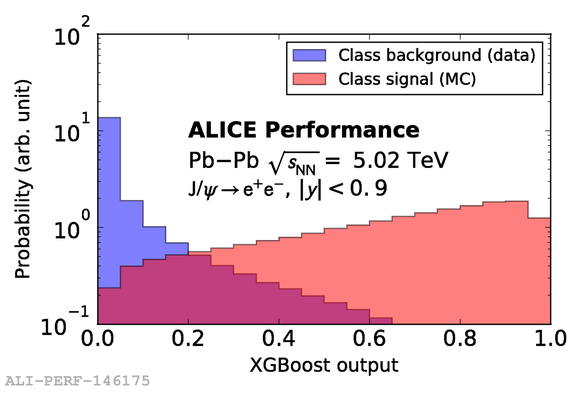
ANALYSIS WITH MACHINE LEARNING

- **Classical**: high quality electron selection with rectangular cuts on PID and tracking variables
- **MVA**: combine PID variables and tracking variables in one classifier to select J/ψ candidates

Classifier training

- **Three** different variable combinations are evaluated based on the **particle identification** of the **TPC** and **TOF**, the impact parameter (**DCA**), and the transverse momentum p_T
- Use **MC** simulated events as **signal** and real **data** as **background**
- Used algorithm: Extreme Gradient Boost **XGBoost** [9]
- Training in p_T bin 3-5 GeV/c



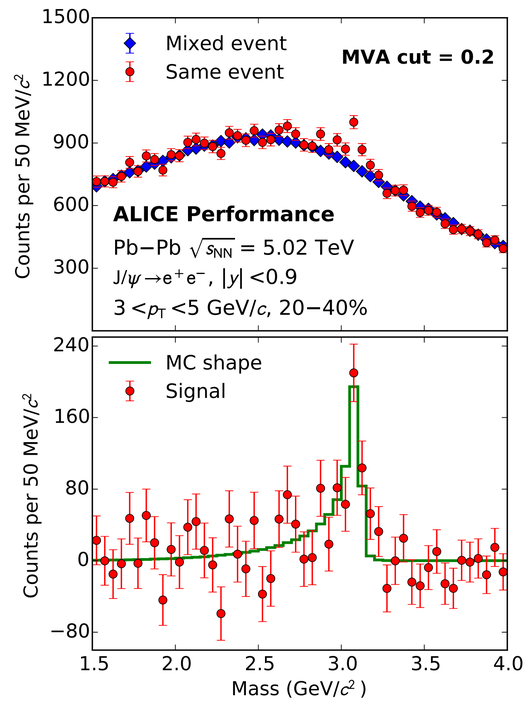


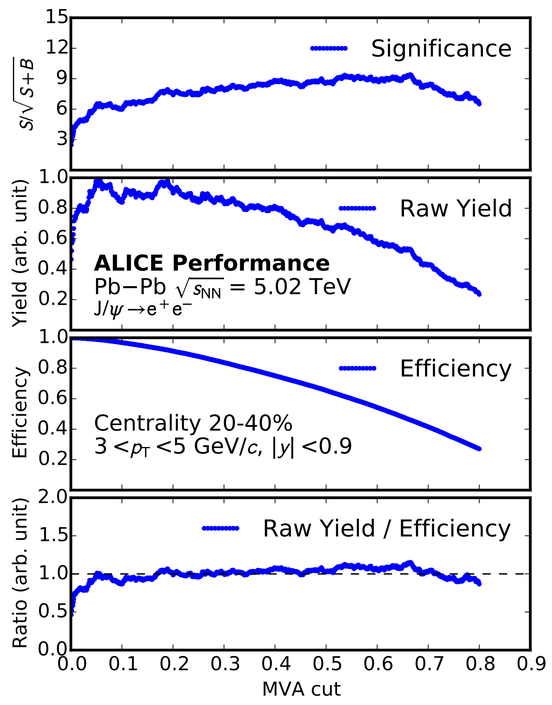
→ **Strong background rejection at high signal efficiency**

SIGNAL EXTRACTION + EFFICIENCY

Signal extraction

- Invariant mass spectrum from combination of **unlike-sign tracks**
- Background description with the **mixed event technique**
- Cut on the **MVA classifier** to select signal-like e^+e^- pairs
- Signal extraction after **background subtraction** by bin counting in the p_T bin 3–5 GeV/c and 20-40% centrality class



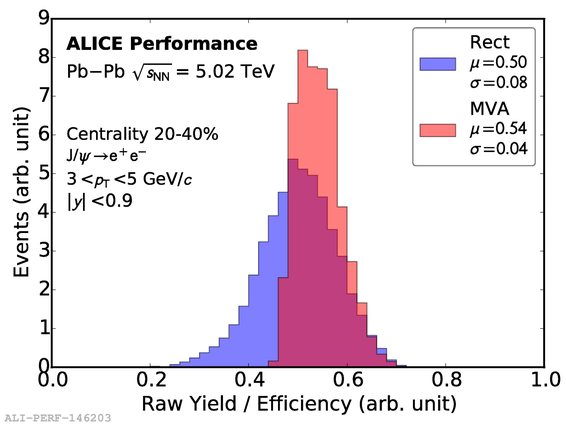


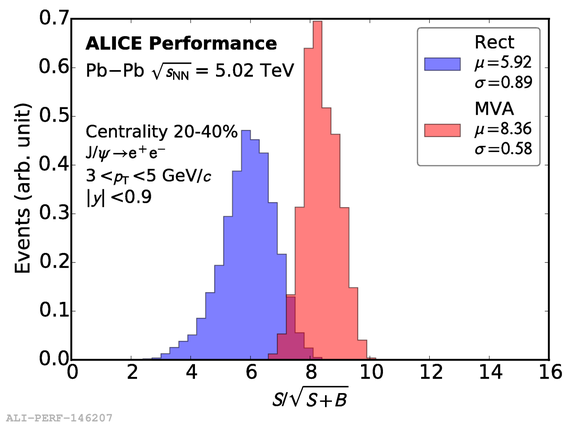
Stability of the efficiency corrections

- Signal, efficiency and significance ($S/\sqrt{S+B}$) are extracted as a function of the MVA cut
- Ratio of signal and efficiency is stable → MVA cut well described in simulation

COMPARISON TO CLASSICAL APPROACH

For both, the classical (rectangular cuts), and the MVA approach a **variation of all cuts** is performed to investigate the distribution of the **signal divided by efficiency** and the **significance** ($S/\sqrt{S+B}$).





Results

- **Agreement between classical and MVA approach**
- **Better statistical significance**

Outlook

- Improvement of data-MC agreement
- Preparation to apply MVA methods in the standard analysis

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