

Electron Identification using Deep Neural Networks



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**Exclusive, Diffractive & Tagging
PWG meeting**

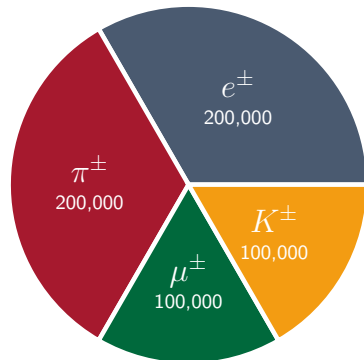
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Training Dataset

The training dataset consists of [single-particle](#) Monte Carlo samples simulated with [DDSim](#) using the ePIC detector geometry (epic_craterlake_10x275.xml).

- particles: $e^{\pm}$, $\pi^{\pm}$, $\mu^{\pm}$, $K^{\pm}$
- momentum: $0.3 < p < 5$ GeV
- polar angle: $2^{\circ} < \theta < 178^{\circ}$ (η flat)



Features

Requirements

- Associated reconstructed track

DNN Input

- **Kinematics:** p , p_T , η
- **Calorimetry:** E_{calo} , E_{hcal} , E/p , N_{hits} , E/hit
- **PID:** L_{total}
- **Shape Parameters:** radius, dispersion, x , y , z , θ and ϕ widths

Likelihood (L_{total})

- rely on `edm4hep::ParticleID`
- detectors included:
pfRICH, DIRC, TOF, dRICH

$$L_{\text{total}} = \sum \log_{10} P(e^{\pm}) - \sum \log_{10} P(\pi^{\pm})$$

Global Feature Importance (SHAP)

- SHAP analysis reveals that the two most critical discriminatory features are L_{total} and E/p .

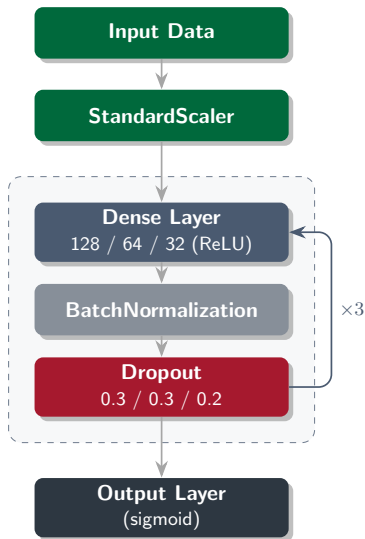
DNN Architecture

Dataset

- **Training:** 60%
- **Validation:** 20%
- **Test:** 20%

Training Setup

- **Optimizer:** Adam
- **Loss:** Binary Crossentropy
- **Metrics:** Accuracy
- **Early Stopping:**
patience = 10



- **Threshold** is optimized by maximizing the F1-score:

$$F_1 = 2 \cdot \frac{\text{Purity} \cdot \text{Efficiency}}{\text{Purity} + \text{Efficiency}}$$

$$\text{Efficiency} = \frac{N_{TP}}{N_{TP} + N_{FN}}$$

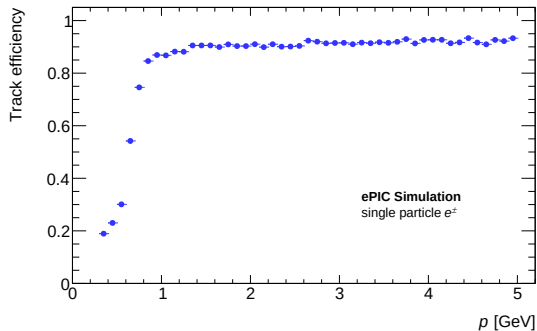
$$\text{Purity} = \frac{N_{TP}}{N_{TP} + N_{FP}}$$

Predicted

		Pos	Neg
True	Pos	TP	FN
	Neg	FP	TN

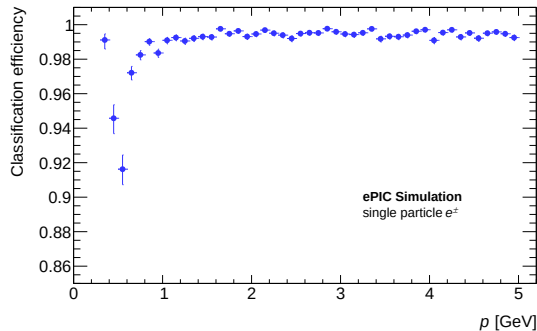
Performance

- Low- p (< 1 GeV) efficiency is limited by track reconstruction

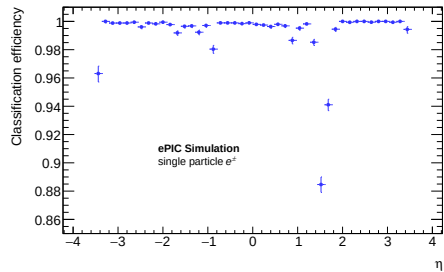
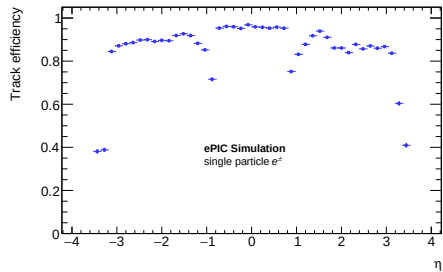
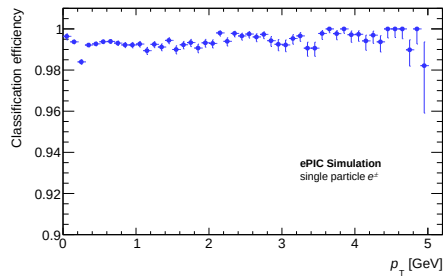
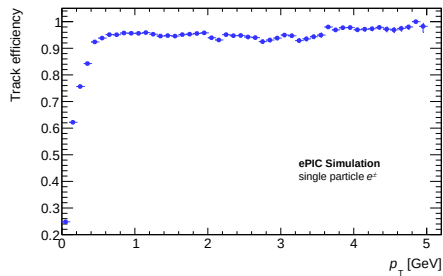


- Classification results (if particle has a track)

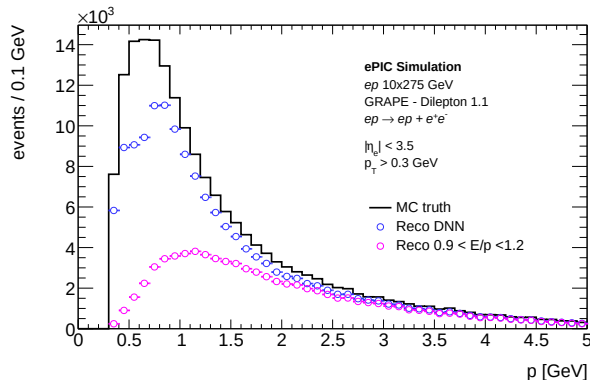
- Efficiency $\approx 98.78\% \pm 0.13\%$
- Purity $\approx 98.74\% \pm 0.12\%$



Performance



Results



- Results for classifier used on exclusive e^+e^- production events from GRAPE
- Efficiency (total): 80.67%
- ML approach overcome the limitations of classical cuts and maximize pion rejection, particularly in the challenging low-momentum kinematic regime.
- [Link to GitHub repository](#)

Thank you!