Experimental updates on quantum observables in $t\bar{t}$ production

Quantum Decoherence Meeting

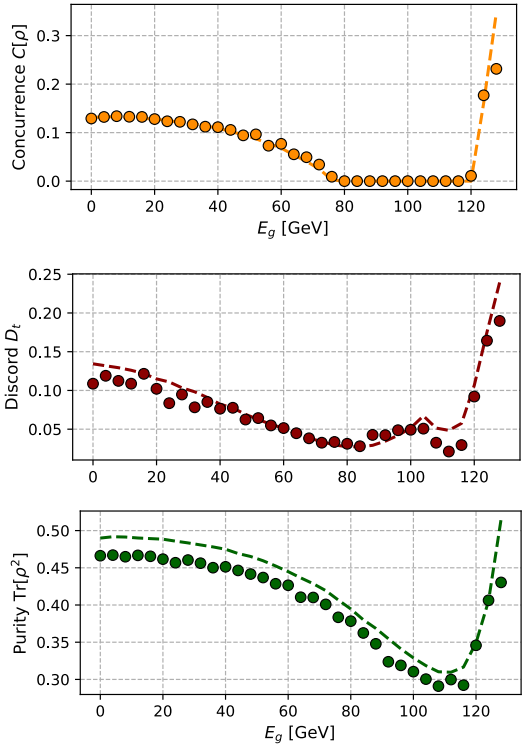
Date: 02th of June, 2026

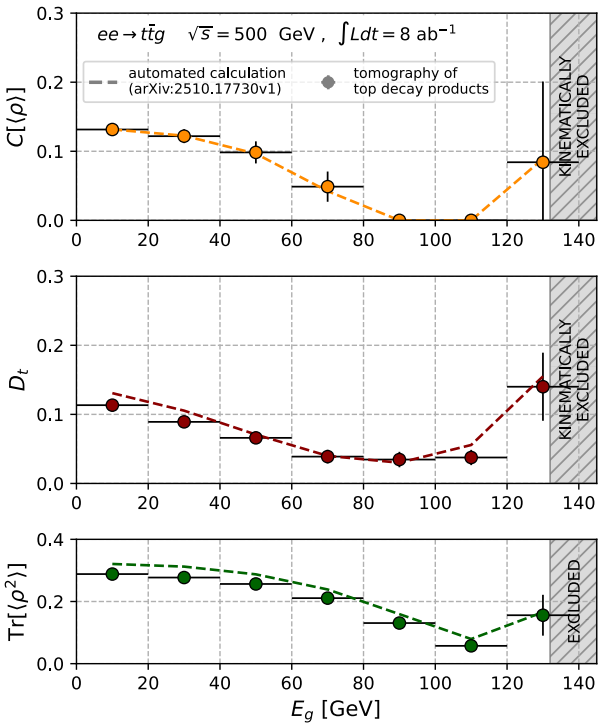
Guillermo García-Mir, José Manuel Camacho, Marcel Vos, María Moreno Llácer

NEW COMBINATION RESULTS ON $e^+e^- \rightarrow Z^*/\gamma^* \rightarrow t\bar{t}g, \sqrt{s} = 500$ GeV

A new rebinning for the presentation of the quantum observable results, now including quantum discord, is purposed here.

The objective of this new rebinning is to hide the unexplained features and improve the agreement across the multiple techniques.





NEW COMBINATION RESULTS ON $e^+e^- \to Z^*/\gamma^* \to t\bar{t}g, \sqrt{s} = 500$ GeV

For reference, the expression for the quantum discord for the top quark (antiquark) [arXiv:2602.15115] is:

$$\mathcal{D}_{t(\bar{t})} = \mathcal{S}(\rho_{\bar{t}(t)}) - \mathcal{S}(\rho_{t\bar{t}}) + \min_{\hat{u}} \left[p_{t(\bar{t})\hat{u}} \mathcal{S}(\rho_{t(\bar{t}),\hat{u}}) + p_{t(\bar{t})-\hat{u}} \mathcal{S}(\rho_{t(\bar{t}),-\hat{u}}) \right]$$

$$S(\rho) = -\mathrm{Tr}(\rho \log_2 \rho) \qquad \rho_{\bar{t}(t)} = \mathrm{Tr}_{t(\bar{t})}(\rho_{t\bar{t}})$$

$$\rho_{t\bar{t}} = \frac{1}{4}\left(\mathcal{I}_2 \otimes \mathcal{I}_2 + B_i^1 \sigma^i \otimes \mathcal{I}_2 + B_i^2 \mathcal{I}_2 \otimes \sigma^i + C_{ij}\sigma^i \otimes \sigma^j\right)$$

$$\rho_{\bar{t}(t)} = \frac{1}{2}\left[\mathcal{I}_2 + B_i^{2(1)}\sigma^i\right]$$

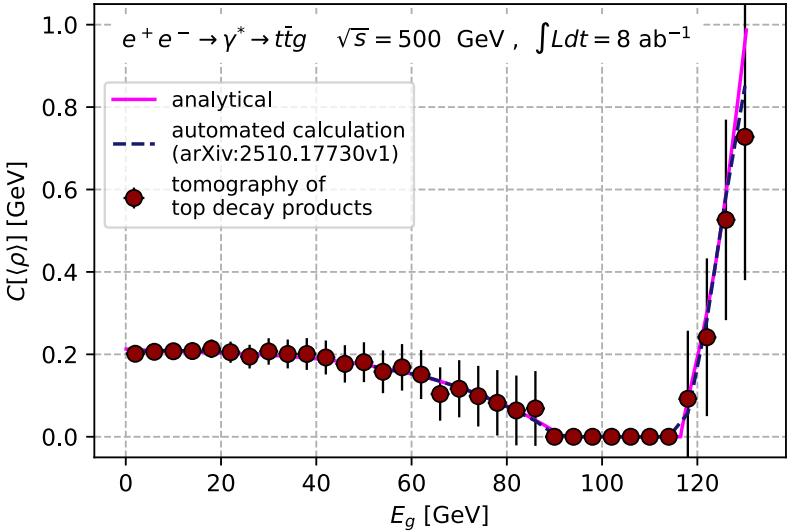
$$\rho_{t,\pm\hat{u}} = \frac{1}{\mathrm{p}_{t,\pm\hat{u}}} \mathrm{Tr}_t \left[(\mathcal{I}_2 \otimes \Pi_{\pm\hat{u}}) \rho_{t\bar{t}} (\mathcal{I}_2 \otimes \Pi_{\pm\hat{u}}) \right] = \frac{1}{2}\mathcal{I}_2 + \frac{1}{2}\frac{C_{ij}n^j + B_i^1}{1 + B_j^2 n^j}\sigma^i$$

$$p_{t,\pm\hat{u}} = \frac{1}{2}\left(1 + B_j^2 n^j\right)$$

Concurrence $C[\langle\rho\rangle] = \max(0, \lambda_1 - \lambda_2 - \lambda_3 - \lambda_4)$ λ_i eigenstates of $R = \sqrt{\sqrt{\rho}\sigma_2 \otimes \sigma_2 \rho^* \sigma_2 \otimes \sigma_2 \sqrt{\rho}}$ **Purity:** $Tr\left[\langle\rho\rangle^2\right]$

COMBINATION OF RESULTS ON $e^+e^- \to \gamma^* \to t\bar{t}g, \sqrt{s} = 500$ GeV

Gamma channel



Gamma + Z channel