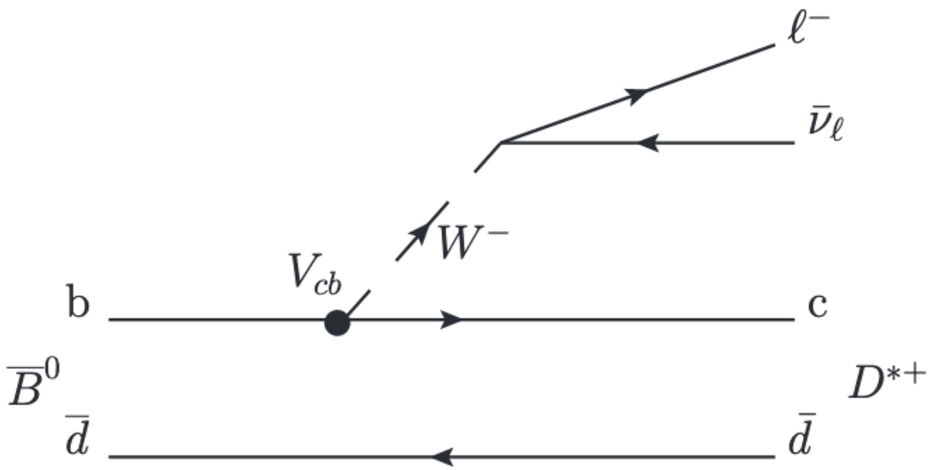
$B^0 \to D^{*-} \mu^+ \nu_\mu$

M. Dorigo, M. Filipige, M. Mantovano
(University and INFN Trieste)

Weekly Meeting
July 29, 2022

Motivation

- Untagged exclusive $B^0 \to D^{*-}\mu^+\nu_\mu$ decays using MC14ri (only mixed) corresponding to 300fb^{-1}.
- Useful to extract the CKM matrix element $|V_{cb}|$.



$|V_{cb}| = (42.2 \pm 0.8) \times 10^{-3}$ (inclusive)

$|V_{cb}| = (39.5 \pm 0.9) \times 10^{-3}$ (exclusive)

The discrepancy underlines that precise measurements of CKM matrix element $|V_{cb}|$ and semi-leptonic form factors in B meson decays are still extremely important.

Motivation

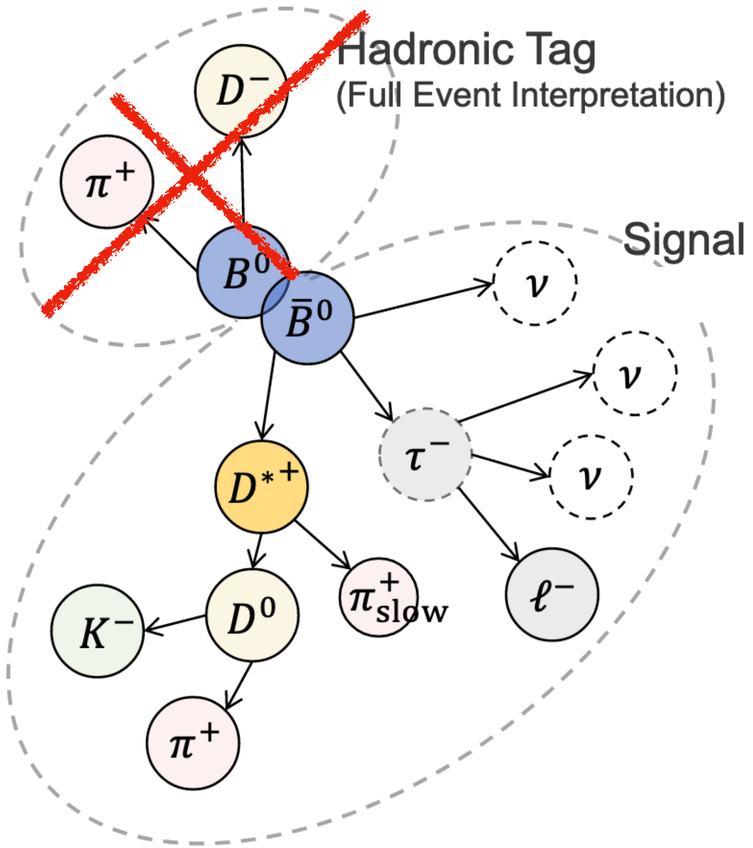
- Possible violation of lepton flavour universality (LFU) related to the $b \to c$ transition.

$$\mathcal{R}(D^{(*)}) = \frac{\mathcal{B}(B \to D^{(*)}\tau\nu)}{\mathcal{B}(B \to D^{(*)}\ell\nu)}, \quad \text{with } \ell = e, \mu,$$

The average of current experimental analyses shows 3σ deviation from the SM predictions.

Untagged analysis

- In an untagged analysis we don't use the information of the other B (FEI approach) to reconstruct the signal.

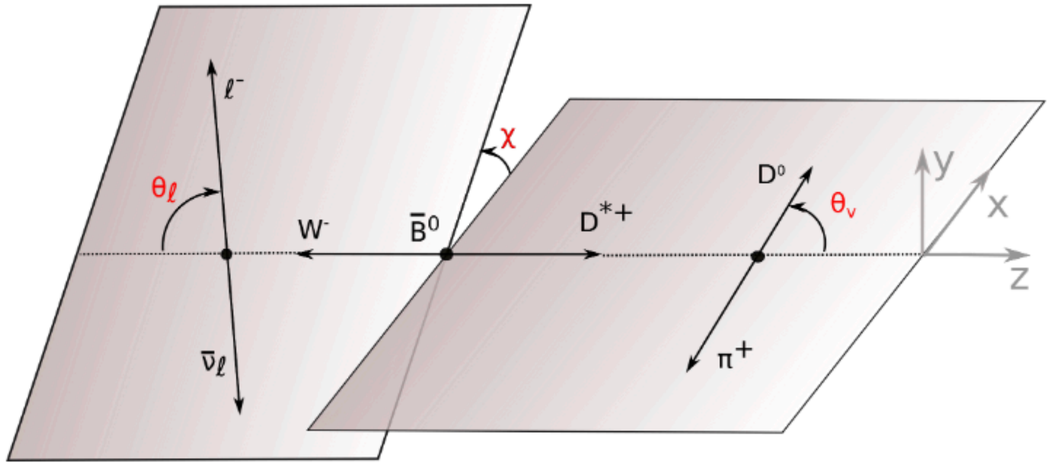


To theoretically describe $B^0 \to D^{*-}\mu^+\nu_\mu$ decays, four kinematics variables are needed:

- w is related to the velocity transfer from the initial state to the final state:

$$w = \frac{p_B \cdot p_{D^*}}{m_B m_{D^*}}$$

- θ_l, θ_V, χ angles:



Methods

There are three possible methods to predict the B direction useful to evaluate these 4 kinematic variables:

- Diamond method: B meson should lie on a cone around the D^*l system.
  Estimate the B direction: select randomly the first vector on this cone with an $\phi \in [0,\pi/5]$, and then choose 9 additional vectors with spacing $\phi_i = \phi_0 + \pi/5 \times i (i = 1,2...9)$.

$$(E^B, p_B^x, p_B^y, p_B^z) = (E_{\text{Beam}}^{\text{CM}}/2, |\vec{p}_B^{\text{CM}}| \sin\theta_{BY} \cos\phi, |\vec{p}_B^{\text{CM}}| \sin\theta_{BY} \sin\phi, |\vec{p}_B^{\text{CM}}| \cos\theta_{BY})$$

  Weighted the 10 B directions where the weight for i-th B direction is given by $w_i = sin^2(\theta_i)$.

- ROE method: reconstruct all the particles that are not associated to the D^*l system.
  In the CM frame: all the tracks and cluster in the rest of event are summed together to obtain $\overrightarrow{p}_{ROE}^{CM}$.
  Obtain the B direction that minimizes the difference to $\overrightarrow{p}_{inclusive}^{CM}$ ($\overrightarrow{p}_{inclusive}^{CM}$= - $\overrightarrow{p}_{ROE}^{CM}$).

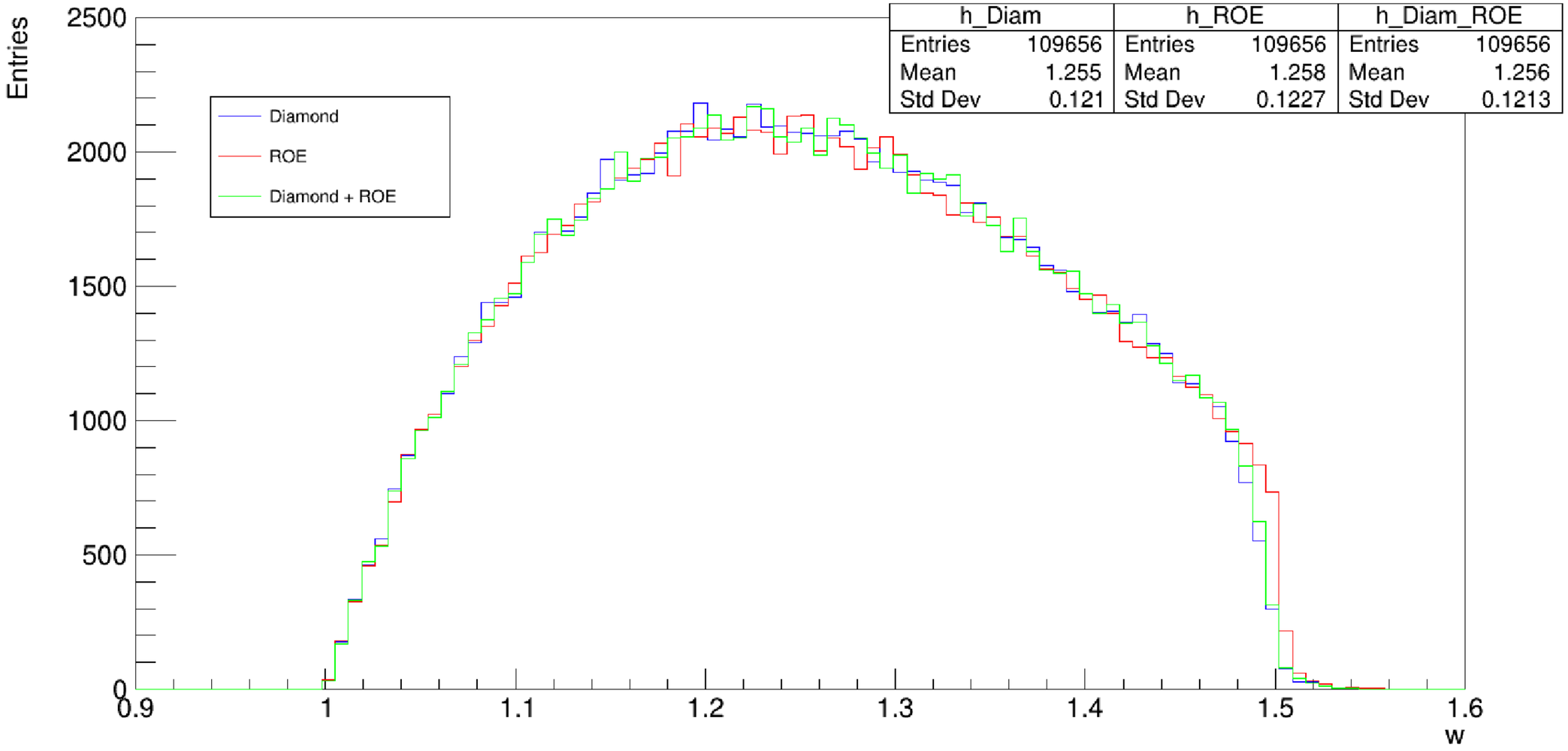
- Diamond + ROE method: combine the two method using $w_i = \frac{1}{2}(1 + \hat{p}_{inclusive} \cdot \hat{p}_B) sin^2(\theta_B)$

The first step of this study is to determine the resolution of these 4 kinematic variables for each methods.

Kinematic variables: Diamond vs ROE vs Diamond+ROE

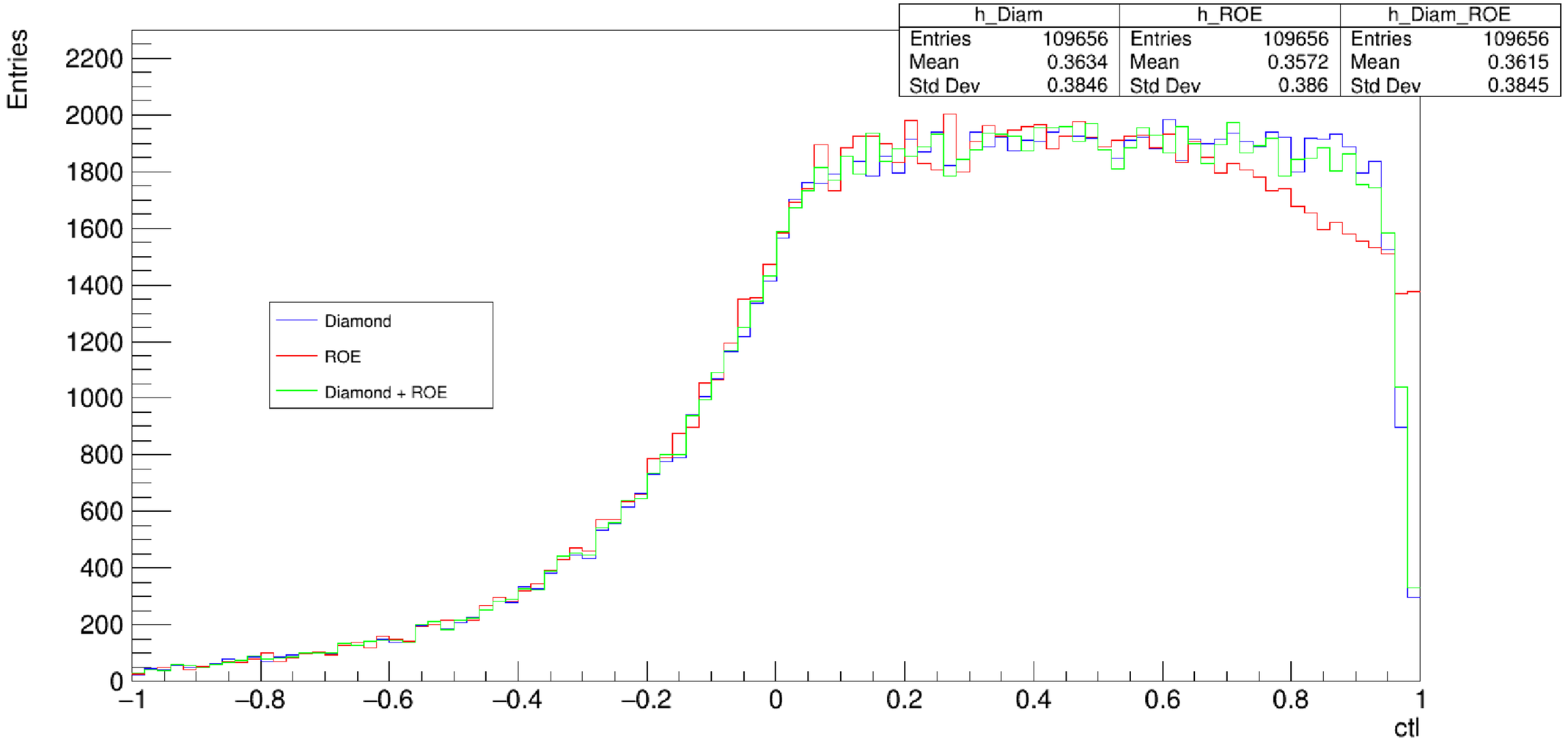
The four kinematic variables obtained for each method:

W



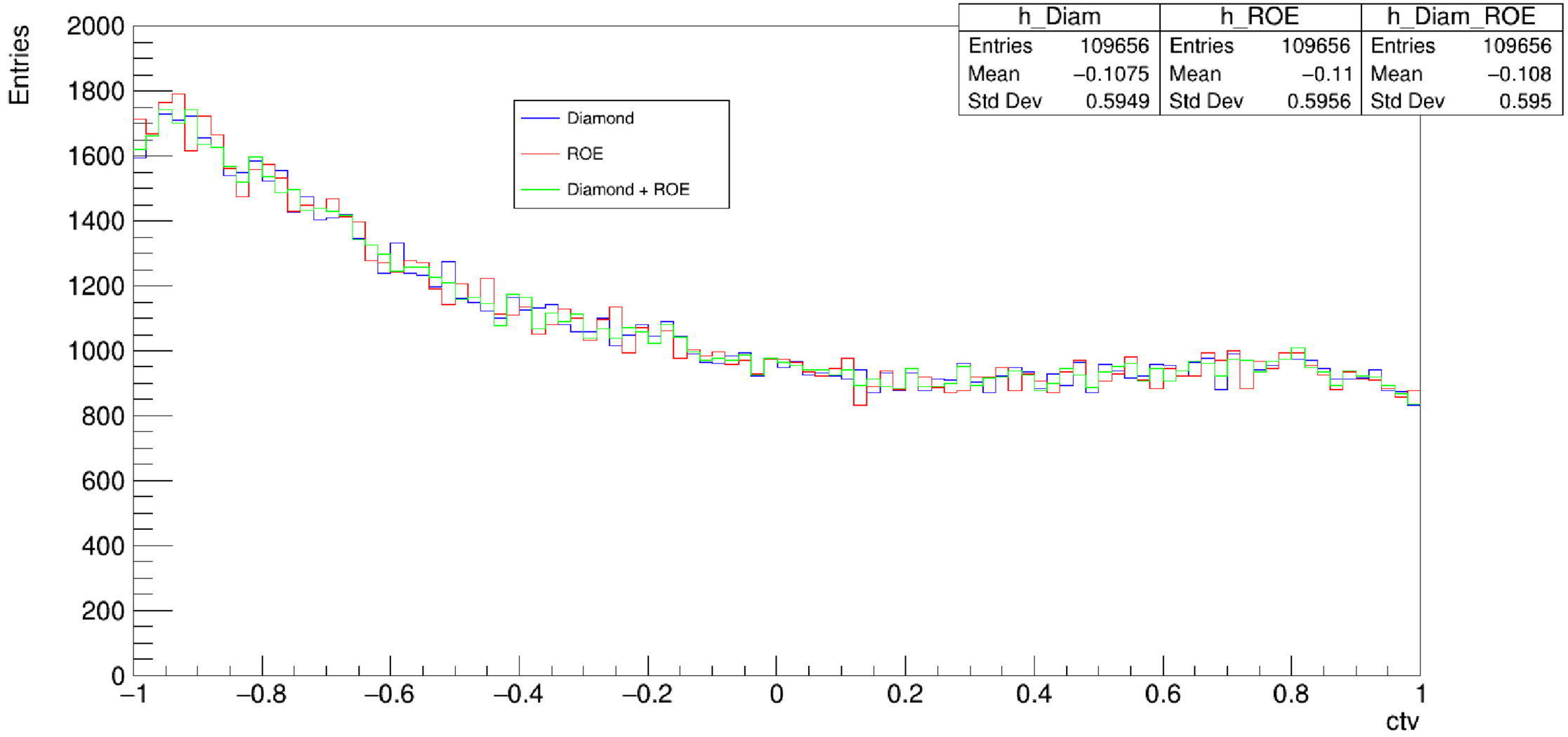
Kinematic variables: Diamond vs ROE vs Diamond+ROE

$cos(\theta_l)$



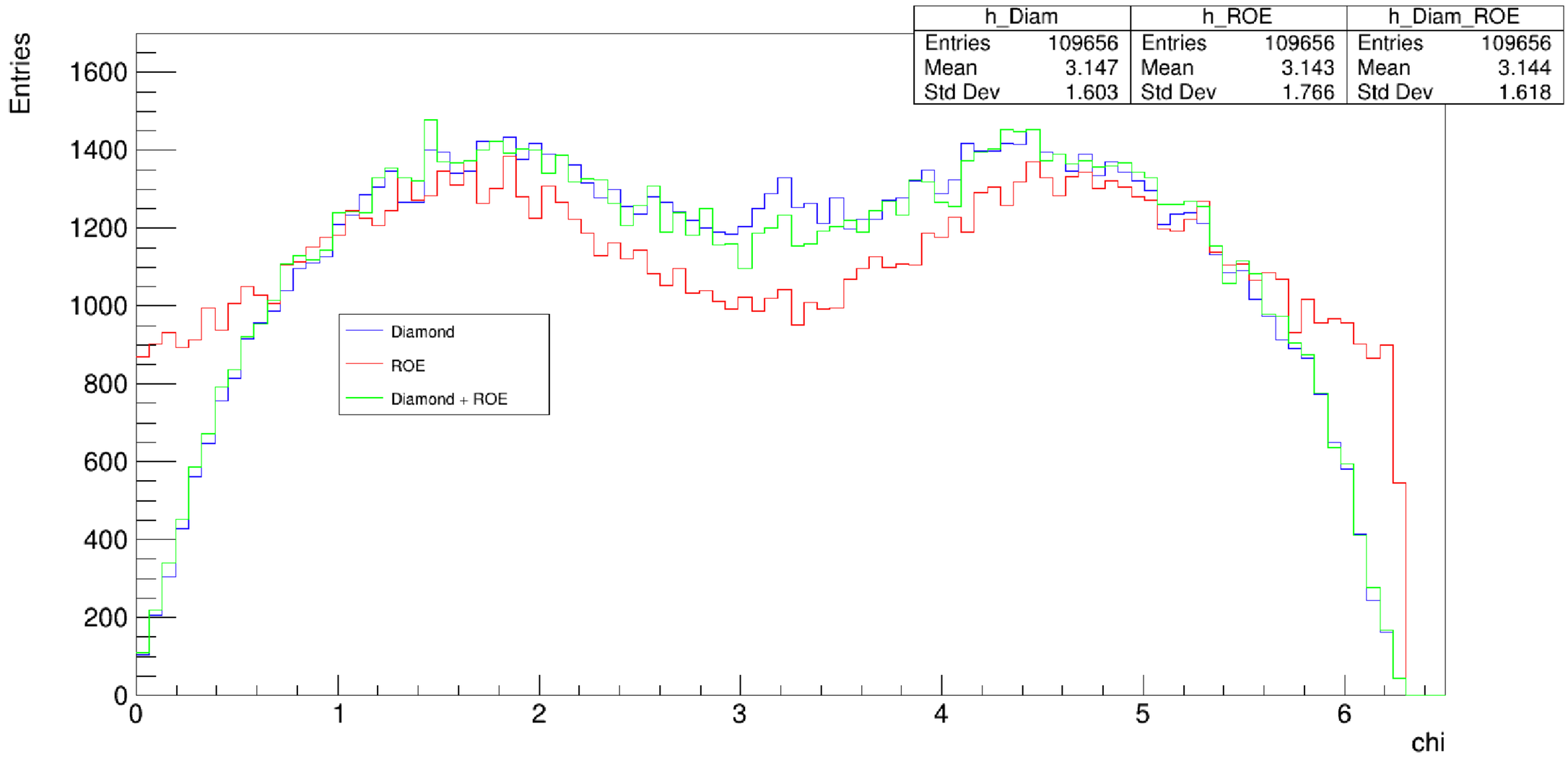
Kinematic variables: Diamond vs ROE vs Diamond+ROE

$cos(\theta_V)$



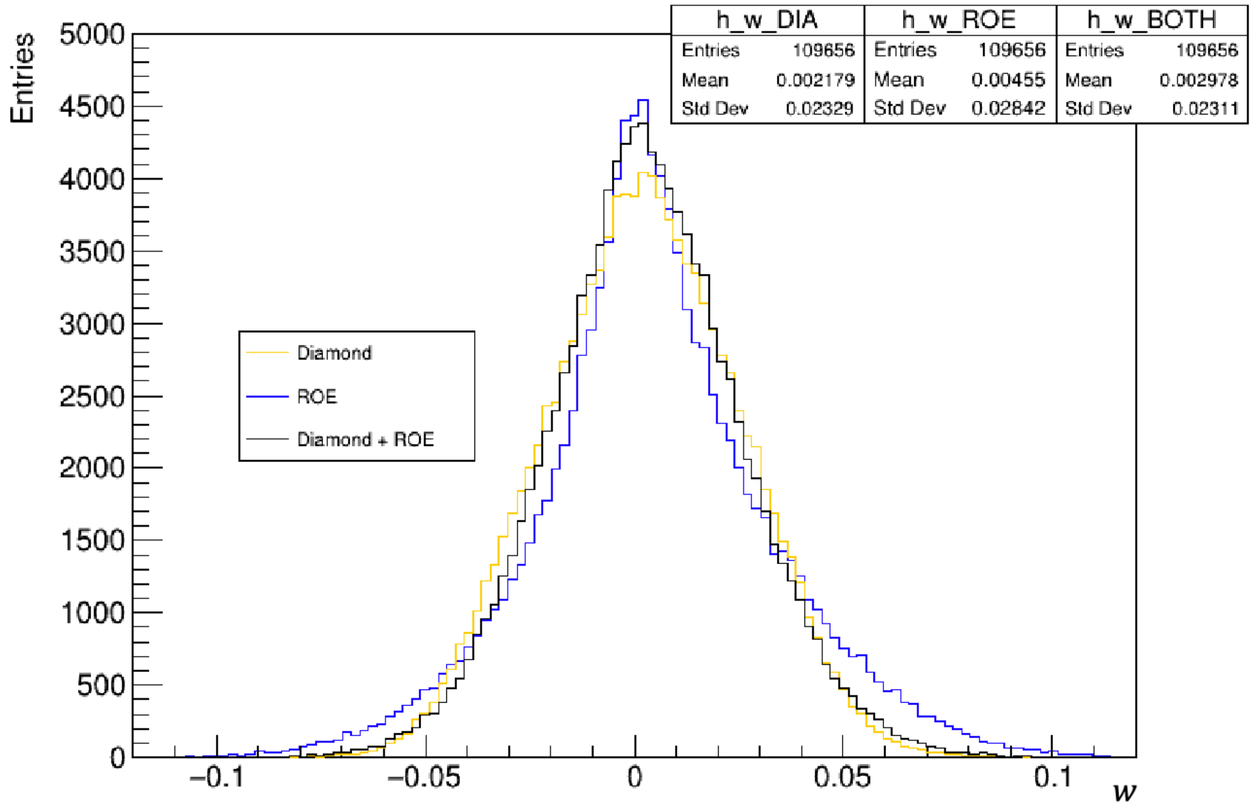
Kinematic variables: Diamond vs ROE vs Diamond+ROE

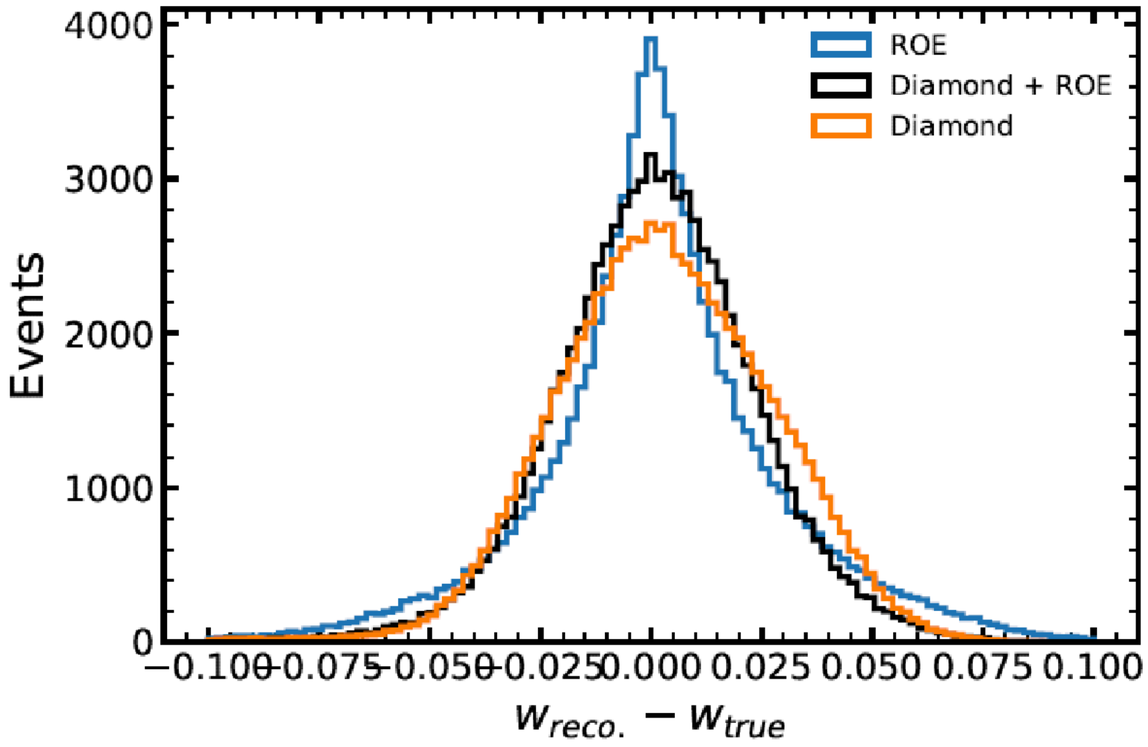
χ



Resolution plots: Diamond vs ROE vs Diamond+ROE

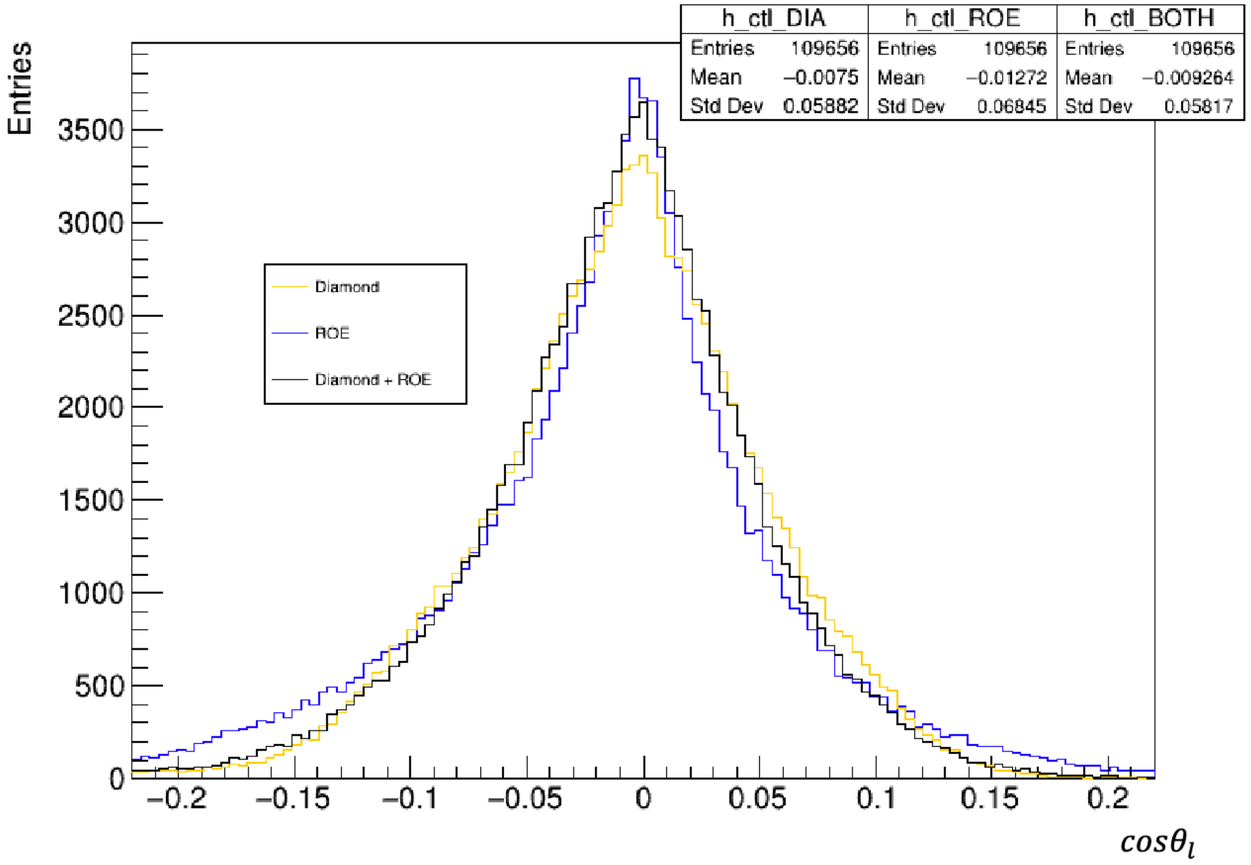
W

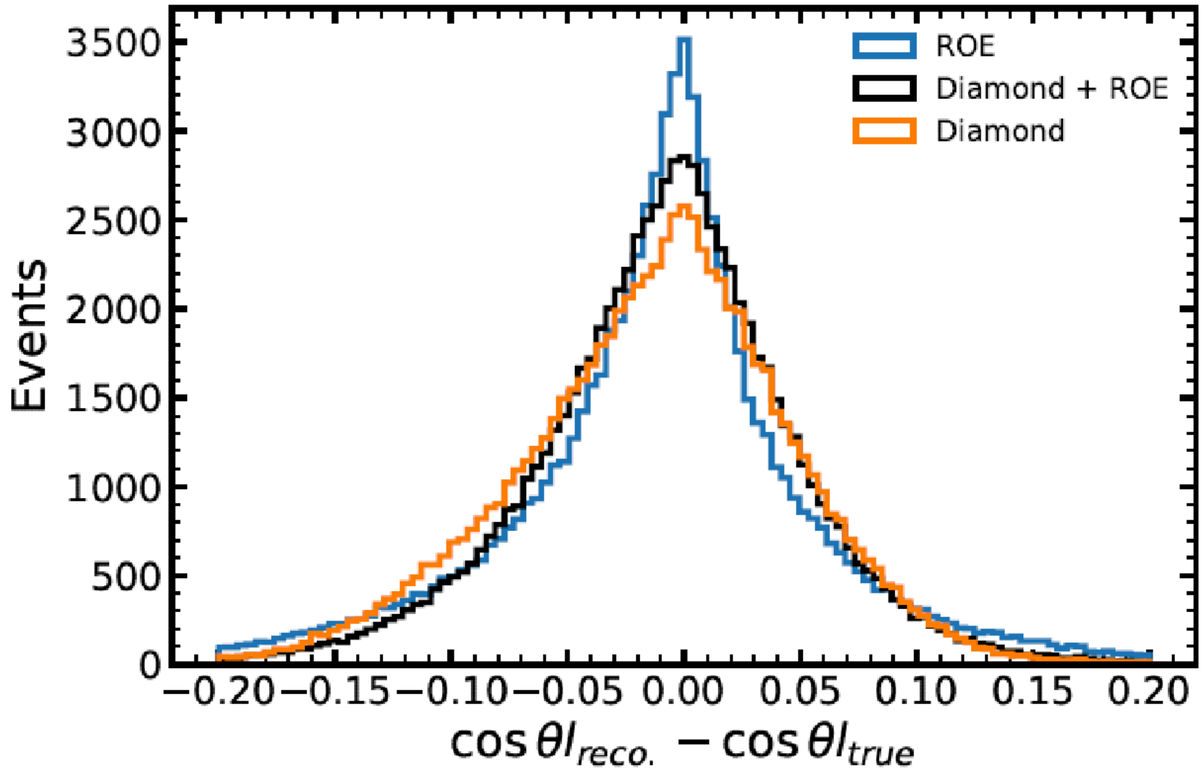




Resolution plots: Diamond vs ROE vs Diamond+ROE

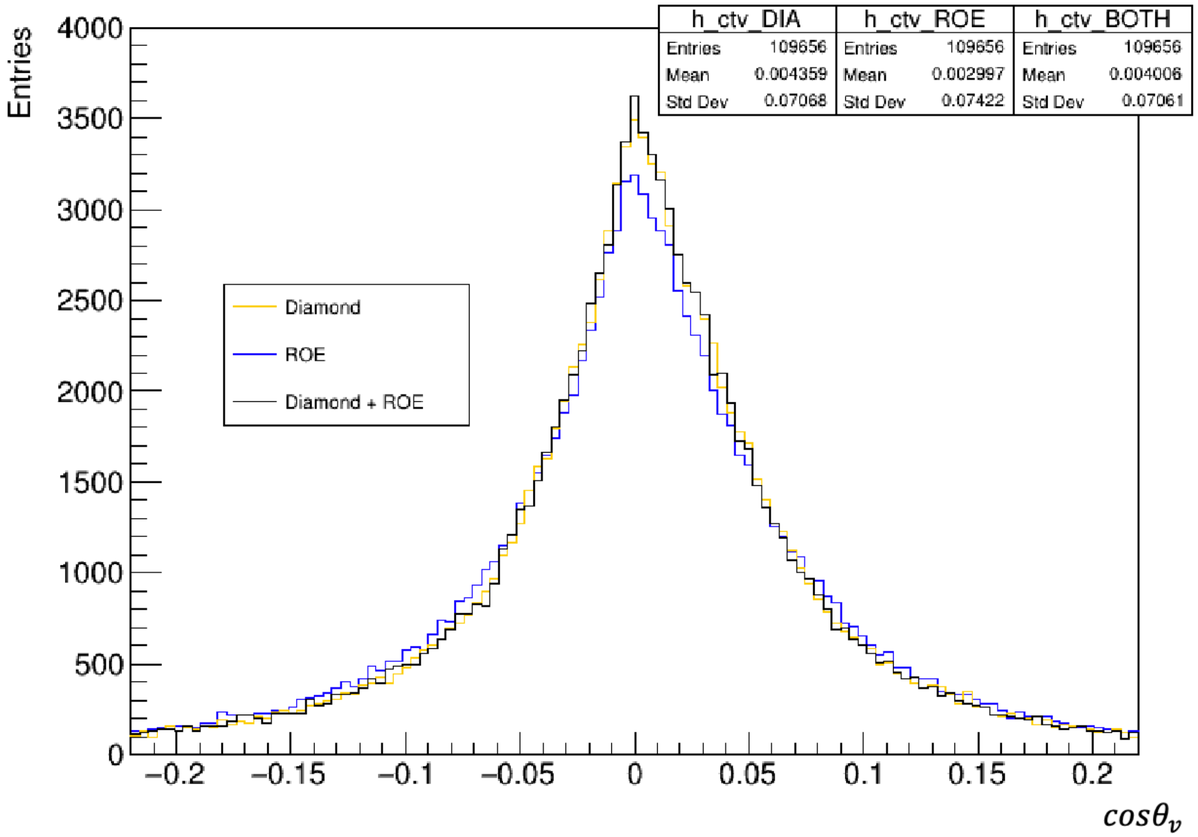
$cos(\theta_l)$

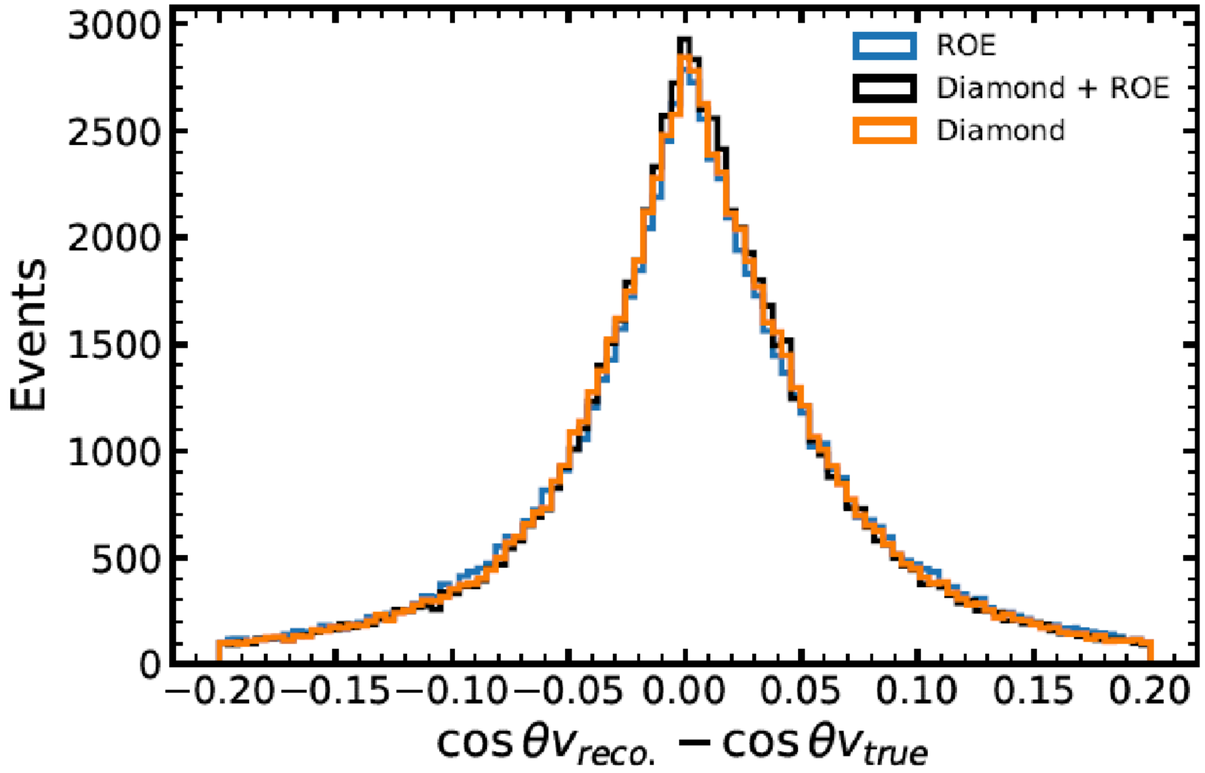




Resolution plots: Diamond vs ROE vs Diamond+ROE

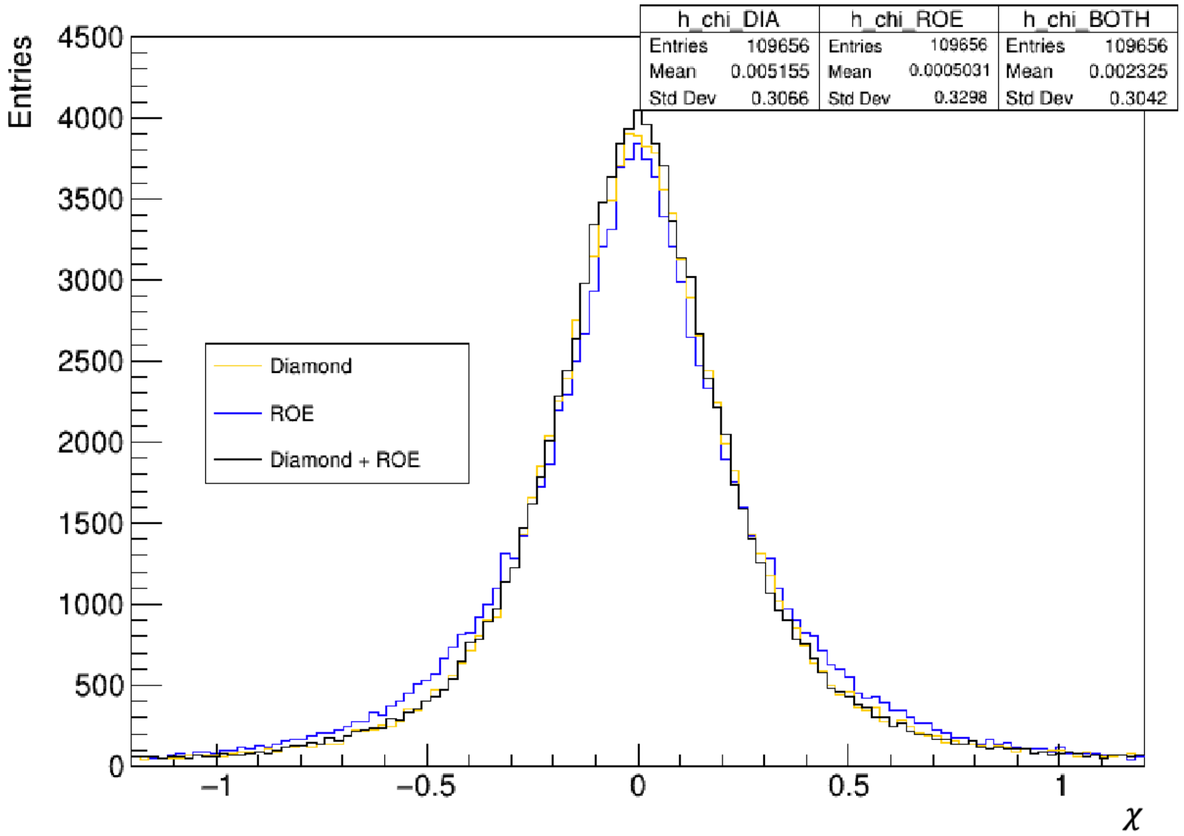
$cos(\theta_V)$

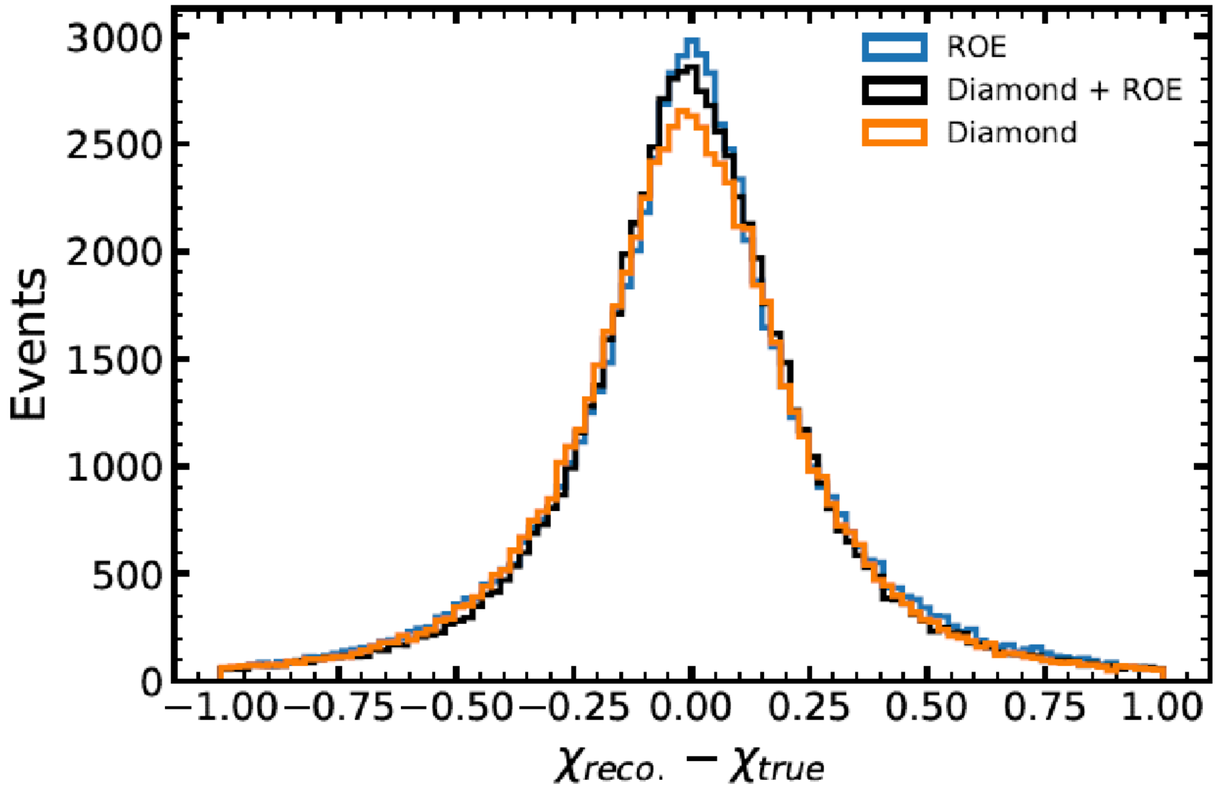




Resolution plots: Diamond vs ROE vs Diamond+ROE

χ





Current status

- Reconstruct $B^0 \to D^{*-} \mu^+ \nu_\mu$ decays ✓
- Apply the same cuts of the ongoing analysis ✓
- Compare same (M_{bc}, ΔE..) distributions with the note ✓
- Measure the reconstruct kinematic variables for each methods ✓
- Measure the truth kinematic variables for each methods ✓
- Do a resolution plots for each method (check again) ✓
- Try to improve the resolution with a new possible method (vertex informations?) ✗