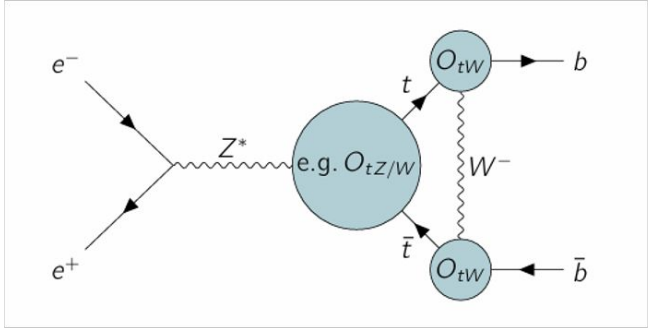
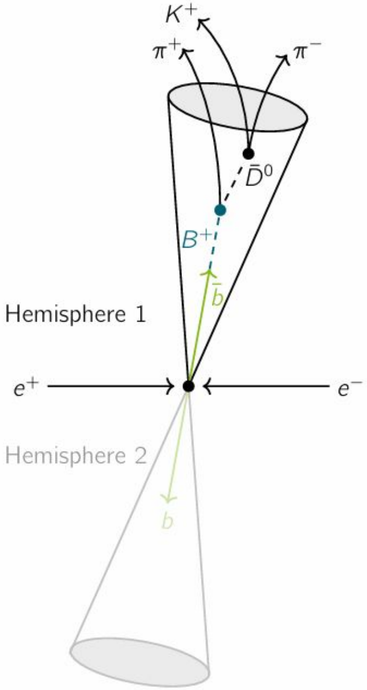
Rb measurement in CEPC

Current method



- Event topology: two back to back particle sprays
- Produce Z to qqbar events at Z pole
- Training the JOI model
- With total 1e12 events (1e11 for low Z), estimate the mean value of Rb and the error σ
- Flavor tagging
- Get Ri and σi (i = b, c, q) by solving the overdetermined simultaneous system of equations using LSM



Single tag: $N_1 = 2N_Z \cdot (R_b\,\varepsilon_b + R_c\,\varepsilon_c + R_{uds}\,\varepsilon_{uds})$

Double tag: $N_2 = N_Z \cdot (R_b\,\varepsilon_b^2\,C_b + R_c\,\varepsilon_c^2\,C_c + R_{uds}\,\varepsilon_{uds}^2\,C_{uds})$

Hemisphere correlation

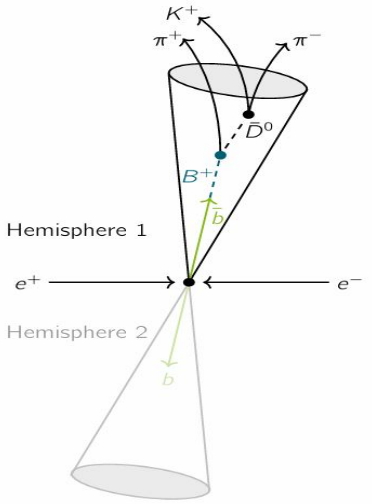
- Key parameter in double tag equation

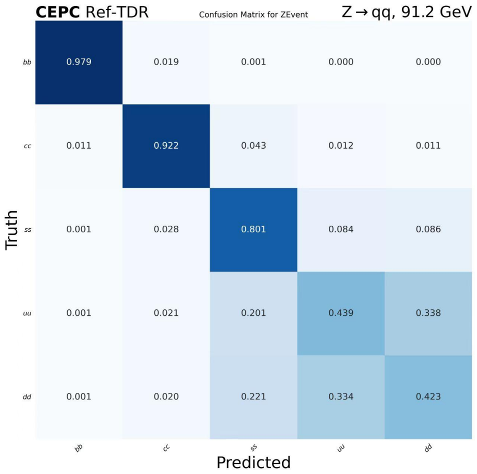
Single tag: $N_1 = 2N_Z \cdot (R_b\,\varepsilon_b + R_c\,\varepsilon_c + R_{uds}\,\varepsilon_{uds})$

Double tag: $N_2 = N_Z \cdot (R_b\,\varepsilon_b^2\,C_b + R_c\,\varepsilon_c^2\,C_c + R_{uds}\,\varepsilon_{uds}^2\,C_{uds})$

- Need to be study with MC samples and a fixed tagging working point
- Since JOI can distinguish b and bbar, probably the correlation can be different.
- Using Z→bb/cc/qq tagger may get rid of this correlation

$$C_i = \frac{\varepsilon_{i_1}\varepsilon_{i_2}}{\varepsilon_{i_{1,2}}^2}$$





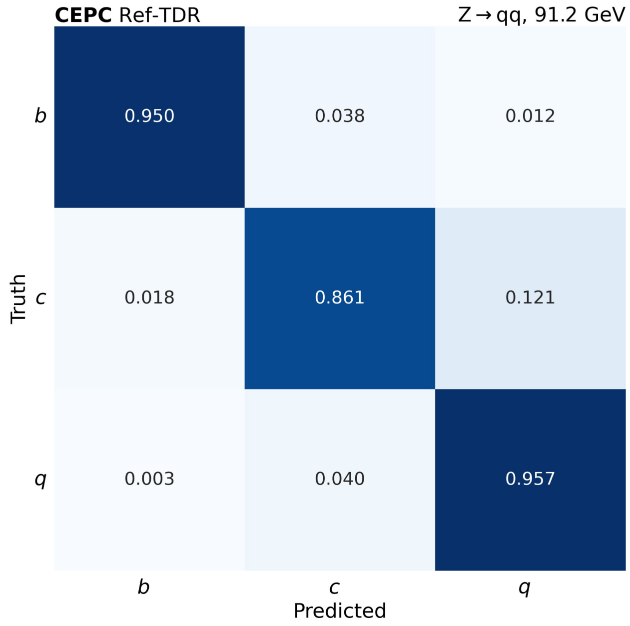
How to get efficiency

- Tag result is assigned by selecting highest score among p_b, p_c, p_q,

b-tagged ← max(p_b, p_c, p_q)= p_b

- Imply a selection applied, not straight forward and stable, need to evaluate how large impact with systematic uncertainty to efficiency
- Another possibility to get efficiency (weight event with probability)

$$\begin{bmatrix} \sum_{n_b} p(b|b)/n_b & \sum_{n_b} p(c|b)/n_b & \sum_{n_b} p(q|b)/n_b \\ \sum_{n_c} p(b|c)/n_c & \sum_{n_c} p(c|c)/n_c & \sum_{n_c} p(q|c)/n_c \\ \sum_{n_q} p(b|q)/n_q & \sum_{n_q} p(c|q)/n_q & \sum_{n_q} p(q|q)/n_q \end{bmatrix}$$



- We can also try to define fixed cut
- Tag b/c at the same time

Sytematic uncertainty

- Experiment uncertainty could be obtained by varying input variable values and propagate to JOI output
- Re-do the evaluation, model should keep the same as the nominal.
- Impact on efficiency will be counted
- Theoretical uncertainty need to tune generators.

Variable	Definition
p_x, p_y, p_z, E	particle 4-momentum, with energy E derived from PID.
$\Delta\eta$	difference in pseudorapidity between the particle and the jet axis
$\Delta\phi$	difference in azimuthal angle between the particle and the jet axis
$\log p_{\mathrm{T}}$	logarithm of the particle's p_{T}
$\log E$	logarithm of the particle's energy
$\log \frac{p_{\mathrm{T}}}{p_{\mathrm{T}}(\mathrm{jet})}$	logarithm of the particle's p_{T} relative to the jet p_{T}
$\log \frac{E}{E(\mathrm{jet})}$	logarithm of the particle's energy relative to the jet energy
ΔR	angular separation between the particle and the jet axis
d_0	transverse impact parameter of the track
$d_0$err	uncertainty associated with the measurement of the d_0
z_0	longitudinal impact parameter of the track
$z_0$err	uncertainty associated with the measurement of the z_0
charge	electric charge of the particle
PID	Reconstructed particle type of $e, \mu, \pi, k, p, \gamma$ and neutral hadron

Should not have extra variation on PID. Not sure

Statistical Treatment

- With systematic uncertainty, the binned likelihood could be performed

$$\mathcal{L}(N_{\text{obs}}^{ii}|R_b, R_c, \vec{\theta}) = \prod_{i=b,c,q} \text{Pois}(N_{\text{obs}}^{ii}|\nu^{ii}) \times \prod_{\theta} \text{Gaus}(0|\theta)$$

$$\nu^{bb} = N_Z(R_b\epsilon_{b,b}^2(\vec{\theta})C_b^{bb}(\vec{\theta}) + R_c\epsilon_{b,c}^2(\vec{\theta})C_c^{bb}(\vec{\theta}) + R_q\epsilon_{b,q}^2(\vec{\theta})C_q^{bb}(\vec{\theta}))$$

- If using Z→bb/cc/qq tagger, replace $\epsilon_{b,j}^2(\vec{\theta})C_j^{bb}(\vec{\theta}) \Rightarrow \epsilon_{bb,j}(\vec{\theta})$

- Study is ongoing, will report in coming days