Identifying Z and H bosons in di-tau decays

Simonas Draukšas

Vilnius University

2016-12-13

Introduction

- Z and H bosons
- $Z/H \rightarrow \tau\tau$ decay channel
- Visible and total energy ratio $x = \frac{E_{vis}}{E_{tot}}$

τ helicity effect on the decay

$$\lambda = \frac{\vec{J}\cdot\vec{P}}{\left|\vec{P}\right|} = \frac{\vec{S}\cdot\vec{P}}{\left|\vec{P}\right|} \tag{1}$$

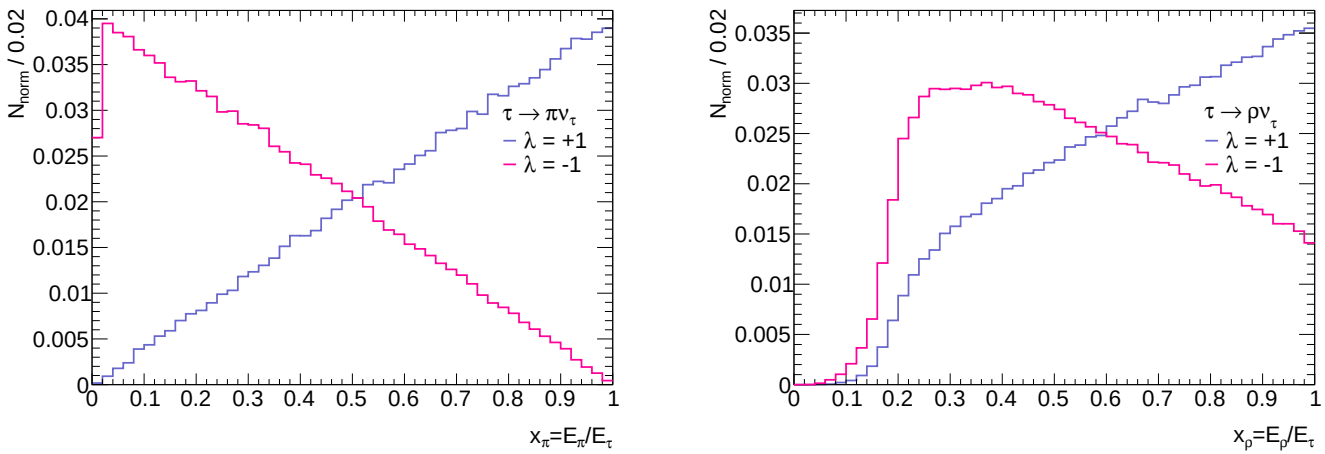

Figure 1: Distribution of fraction of visible energy, x, in pion (a) and rho (b) decays divided into left-handed (pink) and right-handed (blue) samples. [*]

[*] Ingrid Deigaard. "Measurement of the Tau Polarization in Z$\rightarrow \tau\tau$ Decays with the ATLAS Detector". 2012, pp. 21–27, p. 1.

$\tau\tau$ pair correlation by Z and H bosons

- Z-vector boson $\rightarrow$ opposite τ helicities [$*$]
- H-scalar boson $\rightarrow$ same τ helicities [$*$]
- $\tau\tau$ pair helicities are correlated by the mother particle

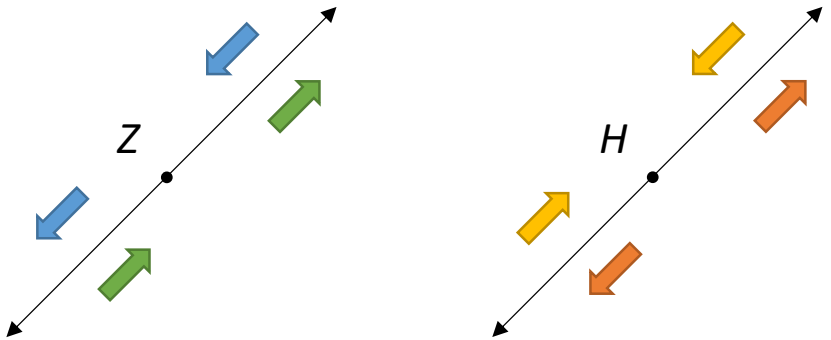

Figure 2: Helicities in Z and H two-body decays

[$*$] K. Hagiwara BK. Bullock and AD. Martin. "Tau pair polarisation correlations as a signal for Higgs bosons". In: *Phys. Lett B* (1991), 273:501

Results in $\pi^-\nu_\tau \times \pi^+\bar{\nu}_\tau$

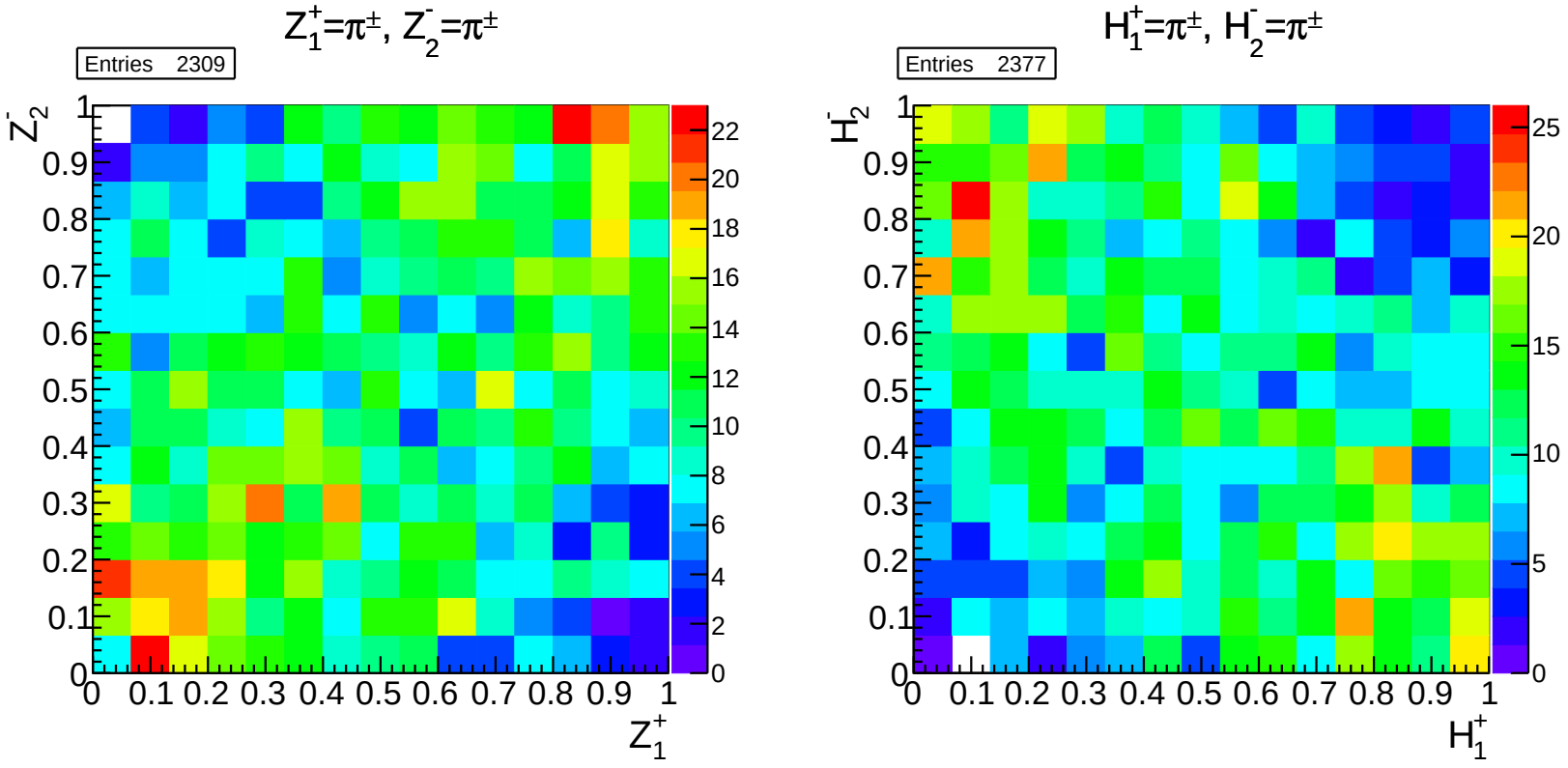

Figure 3: Energy fraction distributions when both tauons decay into single pions

Results in $\pi^-\nu_\tau \times \pi^+\bar{\nu}_\tau$ with a weight function

$$w_R = \sqrt{(x-0.5)^2 + (y-0.5)^2} \tag{2}$$

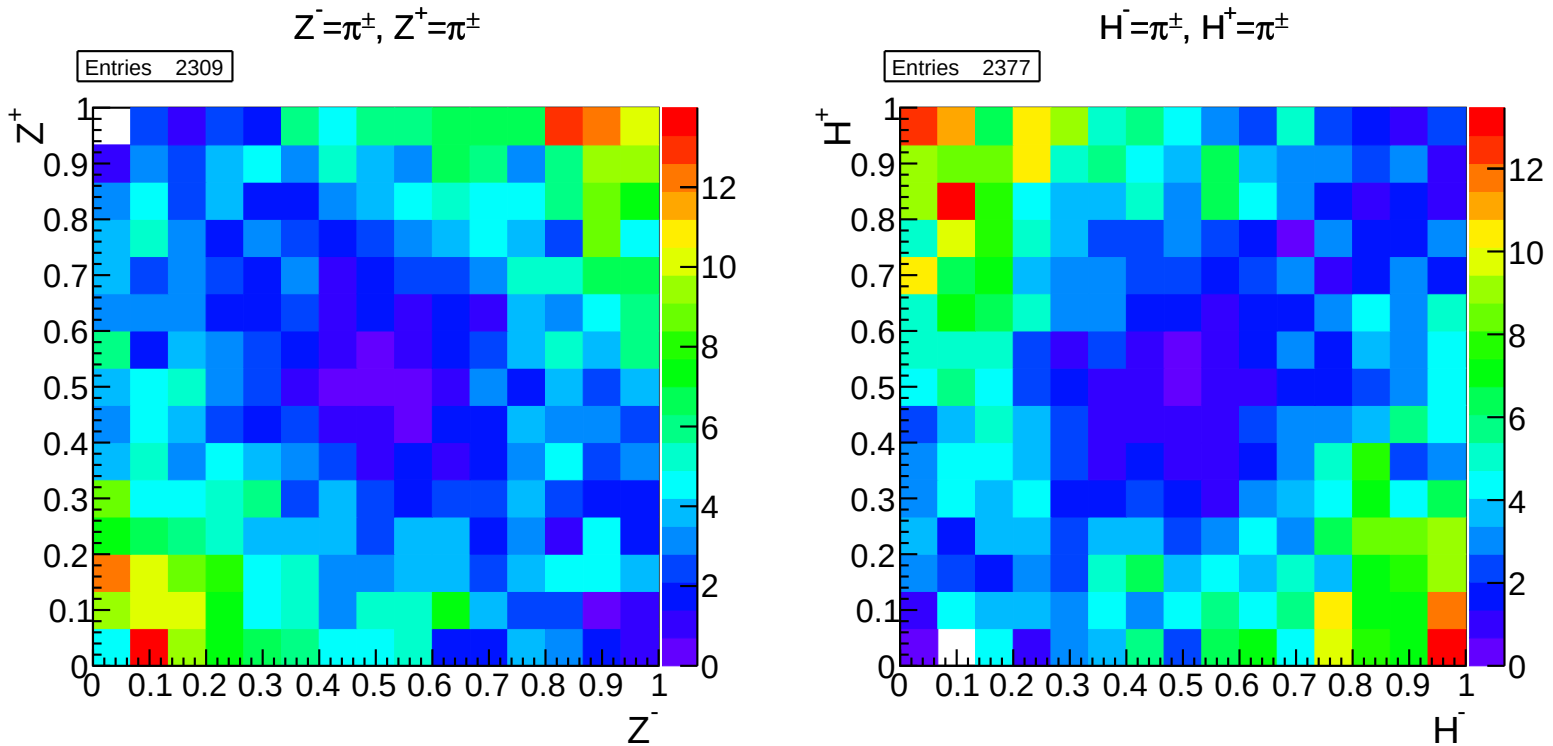

Figure 4: Energy fraction distributions weighted with the w_R function when both tauons decay into single pions

Results in $\pi^-\nu_\tau \times \pi^+\bar{\nu}_\tau$ with a weight function

$$w_R^2 = (x - 0.5)^2 + (y - 0.5)^2 \tag{3}$$

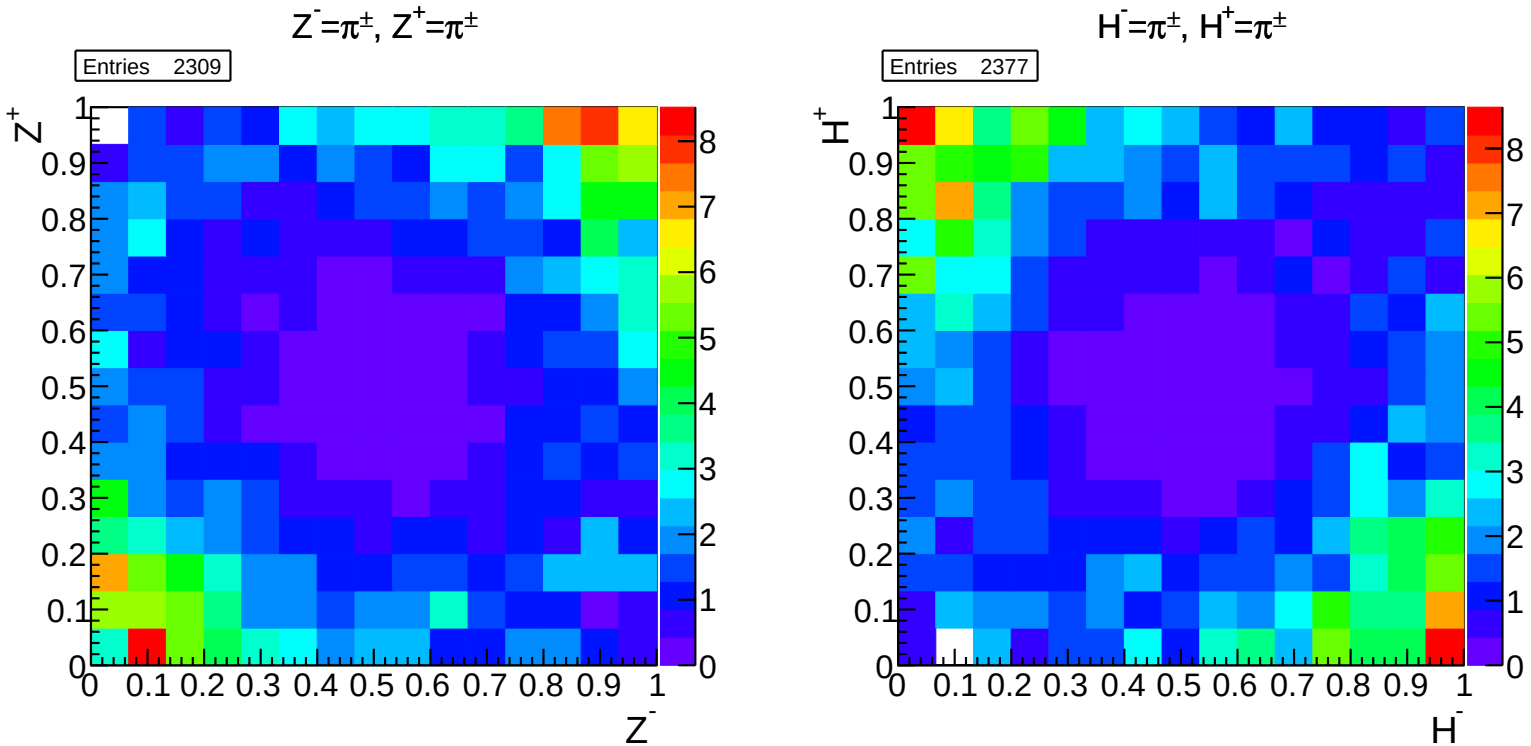

Figure 5: Energy fraction distributions weighted with the w_R^2 function when both tauons decay into single pions

Results in $\pi^-\pi^0\nu_\tau \times \pi^+\pi^0\bar{\nu}_\tau$

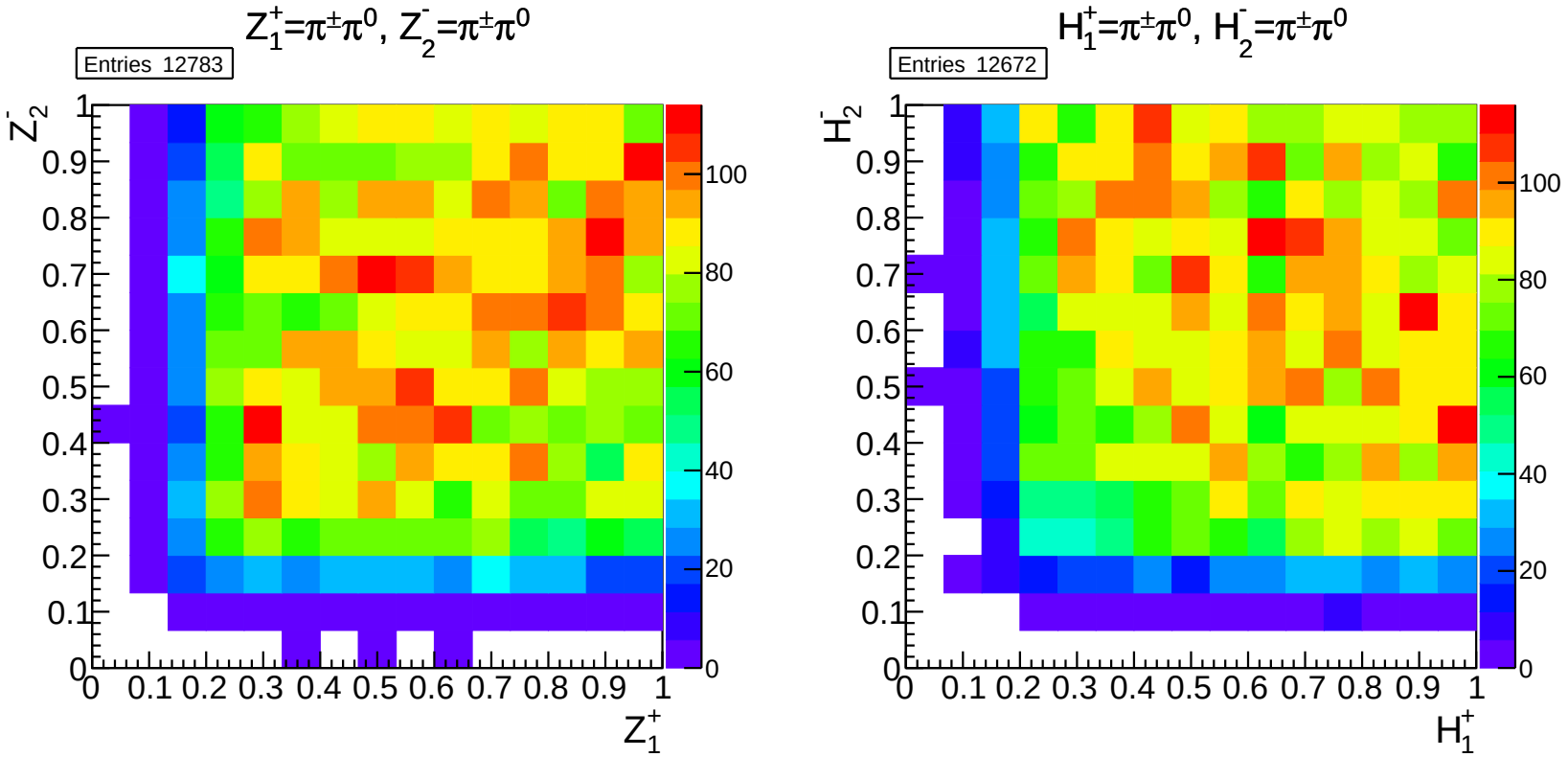

Figure 6: Energy fraction distributions when both tauons decay into two pions

Results in $\pi^-\pi^0\nu_\tau \times \pi^+\pi^0\bar{\nu}_\tau$ with a weight function

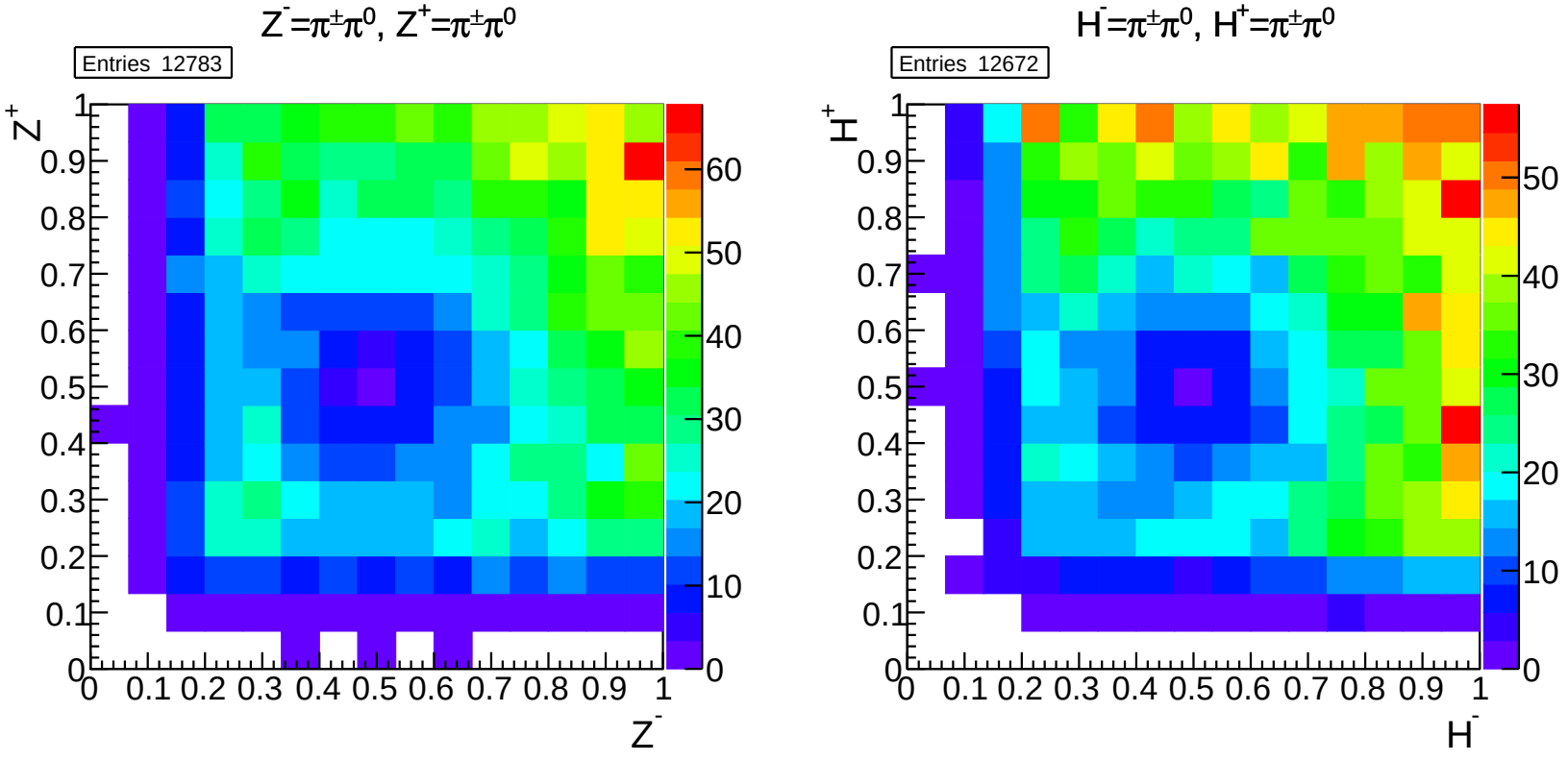

Figure 7: Energy fraction distributions weighted with the w_R (2) function when both tauons decay into two pions

Conclusion

- Z and H bosons can be identified in $\tau\tau$ decays
- $\pi^-\nu_\tau \times \pi^+\bar{\nu}_\tau$ is the most sensitive channel
- Differences can be enhanced with weight functions