

$$\mathcal{L}(\vec{\mu}, \vec{\theta}) = \prod_{c=1}^{N_C} \prod_{b=1}^{N_B^c} \text{Pois}(n_{cb} | n_{cb}^{\text{exp}}(\vec{\mu}, \vec{\theta})) \prod_{e=1}^{N_E} p_e(\tilde{\theta}_e | \theta_e) \quad \text{NP constraints}$$

$$n_{cb}^{\text{exp}} = \max(0, \sum_p M_{cp}(\vec{\mu}) N_{cp}(\vec{\theta}_L, \vec{\theta}_S, \vec{\theta}_G, \vec{\theta}_\rho) y_{cbp}(\vec{\theta}_S) + E_{cb}(\vec{\theta}_B))$$

Physics model scaling Process norm. Process templates MC stats

$$p_{L,S} = \mathcal{N}(\theta_{L,S} | \tilde{\theta}_{L,S})$$

$$p_G = \text{Pois}(\theta_G | \tilde{\theta}_G)$$

$$p_B = \begin{cases} \mathcal{N}(\theta_B | \tilde{\theta}_B, 1) & \theta_B \in \text{Gaussian} \\ \text{Pois}(\theta_B | \tilde{\theta}_B) & \theta_B \in \text{Poisson} \end{cases}$$

$$p_\rho = \begin{cases} \mathcal{N}(\theta_\rho | a, b) \\ \text{constant} \end{cases}$$

Barlow-Beeston

"lite"

$$E_{cb}(\theta) = \theta \left(\sum_p (e_{cpb} N_{cp} M_{cp}(\vec{\alpha}))^2 \right)^{\frac{1}{2}}$$

full

$$E_{cb}(\vec{\theta}) = \sum_i^{\text{Poisson}} \left(\frac{\theta_i}{\tilde{\theta}_i} - 1 \right) y_{cib} N_{ci} M_{ci}(\vec{\alpha}) + \sum_j^{\text{Gaussian}} \theta_j e_{cjb} N_{cj} M_{cj}(\vec{\alpha}),$$

$$N = N_0(\theta_G) \prod_n \kappa_n^{\theta_{L,n}} \prod_a \kappa_a^A(\theta_{L(S)}^a, \kappa_a^+, \kappa_a^-)^{\theta_{L(S)}^a} \prod_r F_r(\theta_{\rho,r})$$

Gamma Log-normal Asymmetric log-normal rateParams

$$\theta_G / \tilde{\theta}_G$$

$$\kappa^A(\theta, \kappa^+, \kappa^-) = \begin{cases} \kappa^+, & \text{for } \theta \geq 0.5 \\ \kappa^-, & \text{for } \theta \leq -0.5 \\ \exp\left(\frac{1}{2}((\ln \kappa^+ + \ln \kappa^-) + \frac{1}{4}(\ln \kappa^+ - \ln \kappa^-) I(\theta))\right), & \text{otherwise} \end{cases}$$

Interpolation between up and down variations (norm)

$$I(\theta) = 48\theta^5 - 40\theta^3 + 15\theta$$

$$\kappa_s^\pm = \frac{\sum_b y_b^{s,\pm}}{\sum_b y_b^0}$$

Shape uncert. norm.
change factored out

$$y_b(\vec{\theta}_S) = \begin{cases} \max(0, y^0 (f_b^0 + \sum_s F(\theta_s, \delta_b^{s,+}, \delta_b^{s,-}), \epsilon_s)) & \text{(direct),} \\ \max(0, y^0 \exp(\ln(f_b^0) + \sum_s F(\theta_s, \Delta_b^{s,+}, \Delta_b^{s,-}, \epsilon_s))) & \text{(logarithmic),} \end{cases}$$

Vertical morphing

$$f_b = y_b / \sum y_b$$

$$y^0 = \sum y_b^0, \delta^\pm = f_i^\pm - f_i^0, \text{ and } \Delta^\pm = \ln(f_i^\pm) - \ln(f_i^0).$$

$$F(\theta, \delta^+, \delta^-) = \begin{cases} \frac{1}{2}\theta'((\delta^+ - \delta^-) + \frac{1}{8}(\delta^+ + \delta^-)(3\bar{\theta}^5 - 10\bar{\theta}^3 + 15\bar{\theta})), & \text{for } -q < \theta < q; \\ \theta' \delta^+, & \text{for } \theta \geq q; \\ -\theta' \delta^-, & \text{for } \theta \leq -q; \end{cases}$$

Interpolation between up and down variations (shape)