Measurement of Transverse Energy-Energy Correlations and heavy-flavour jet fragmentation with the ATLAS detector

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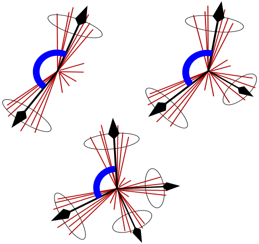
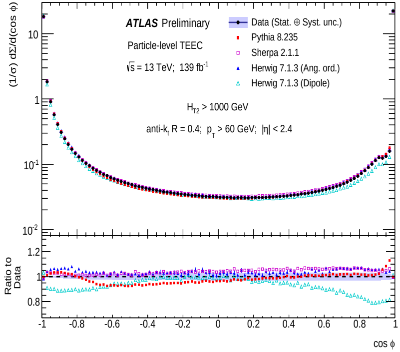
TEEC: The x_{T}-weighted distribution of differences in azimuth between jets i and j, with $x_{\mathrm{T}i} = \frac{E_{\mathrm{T}i}}{\sum_k E_{\mathrm{T}k}}$

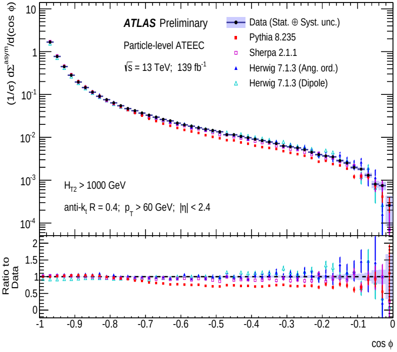
$$\frac{1}{\sigma}\frac{d\Sigma}{d(\cos\phi)} = \frac{1}{\sigma}\sum_{ij}\int\frac{d\sigma}{dx_{\mathrm{T}i}dx_{\mathrm{T}j}d(\cos\phi)}x_{\mathrm{T}i}x_{\mathrm{T}j}dx_{\mathrm{T}i}dx_{\mathrm{T}j}$$



And the azimuthal asymmetry ATEEC is defined as

$$\frac{1}{\sigma}\frac{d\Sigma^{\mathrm{asym}}}{d(\cos\phi)} \equiv \frac{1}{\sigma}\frac{d\Sigma}{d(\cos\phi)}\bigg|_{\phi} - \frac{1}{\sigma}\frac{d\Sigma}{d(\cos\phi)}\bigg|_{\pi-\phi}$$



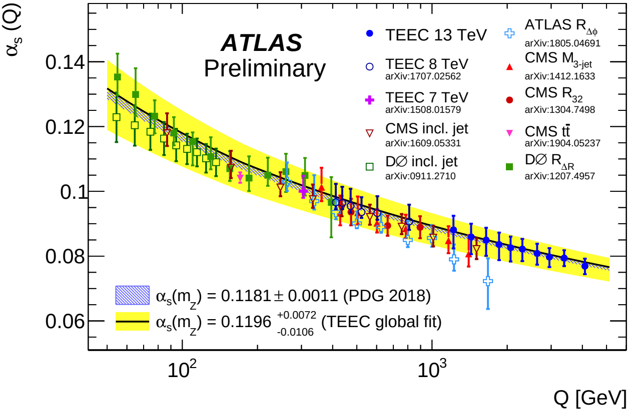


Measurement of TEEC at $\sqrt{s} = 13$ TeV [ATLAS-CONF-2020-025]

- Determination of $\alpha_s(Q)$ for each H_{T2} bin from NLO pQCD predictions.
- A χ^2 function with correlations between uncertainties is minimized.

$$\chi^2(\alpha_s, \vec{\lambda}) = \sum_i \frac{[x_i - F_i(\alpha_s, \vec{\lambda})]^2}{\Delta x_i^2 + \Delta \xi_i^2} + \sum_k \lambda_k^2; \quad F_i(\alpha_s, \vec{\lambda}) = \psi_i(\alpha_s)\left(1 + \sum_k \lambda_k \sigma_k^{(i)}\right)$$

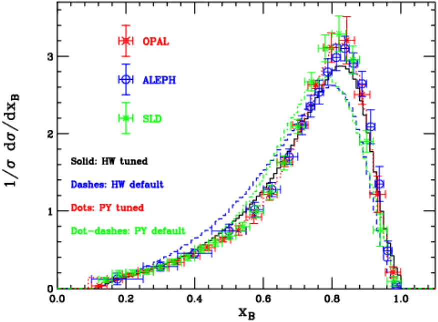
- Highest Q^2 determination of α_s to date at $Q \simeq 4.1$ TeV.



Measurement of b fragmentation using $B^{\pm} \to J/\psi K^{\pm} \to \mu^{+}\mu^{-}K^{\pm}$

- Important uncertainty in final states with b-quarks ($H \to b\bar{b}$, $t\bar{t}$, ...).
- Inputs to MC tuning on HF fragmentation use LEP / SLD data.
- Reconstruction of the B hadron momentum in the decay $B^{\pm} \to J/\psi K^{\pm}$.
- Measurement of longitudinal and transverse profiles of $B^{\pm}$ mesons

$$z = \frac{\vec{p}_J \cdot \vec{p}_B}{|\vec{p}_J|^2}; \qquad p_T^{\mathrm{rel}} = \frac{|\vec{p}_J \times \vec{p}_B|}{|\vec{p}_J|}$$



G. Corcella, F. Mescia [Eur. Phys. J. C 65, 171 (2010)]

Measurement of b fragmentation using $B^{\pm} \to J/\psi K^{\pm} \to \mu^{+}\mu^{-}K^{\pm}$

Sample composition versus (p_T, z) and (p_T, p_T^{rel}) estimated from mass fits

$$\mathcal{F}(m) = \lambda_s \mathcal{F}_s(m) + \lambda_{B_x}\mathcal{F}_{B_x}(m) + \lambda_{B_\pi}\mathcal{F}_{B_\pi}(m) + \lambda_c \mathcal{F}_c(m)$$

- Signal model: Double Gaussian

$$\mathcal{F}_s(m|\mu,\sigma_1,\sigma_2,\beta) = \frac{1}{\sqrt{2\pi}}\left\{\frac{\beta}{\sigma_1}\exp\left[-\frac{(m-\mu)^2}{2\sigma_1^2}\right] + \frac{1-\beta}{\sigma_2}\exp\left[-\frac{(m-\mu)^2}{2\sigma_2^2}\right]\right\}$$

- Misreconstructed background $B \to J/\psi X$

$$\mathcal{F}_{B_x}(m|b,s) = 1 - \tanh\left(\frac{m-s}{b}\right)$$

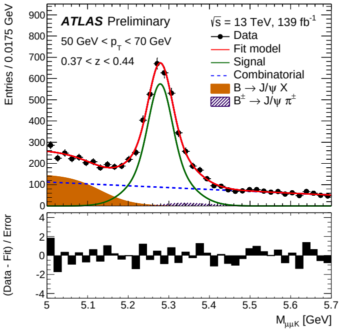
- Resonant background $B^{\pm} \to J/\psi\pi^{\pm}$

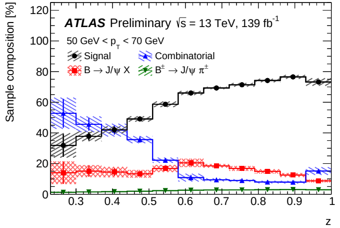
$$\mathcal{F}_{B_\pi}(m,\vec{\mu},\vec{\sigma},\gamma) = \frac{1}{\sqrt{2\pi}}\left\{\frac{\gamma}{\hat{\sigma}_1}\exp\left[-\frac{(m-\mu_1)^2}{2\hat{\sigma}_1^2}\right] + (1-\gamma)\mathcal{G}_{\text{asym}}(m|\mu_2,\hat{\sigma}_2,\hat{\sigma}_3)\right\}$$

- Combinatorial background $J/\psi + X$

$$\mathcal{F}_c(m|p_0,p_1) = p_0 + p_1 m.$$

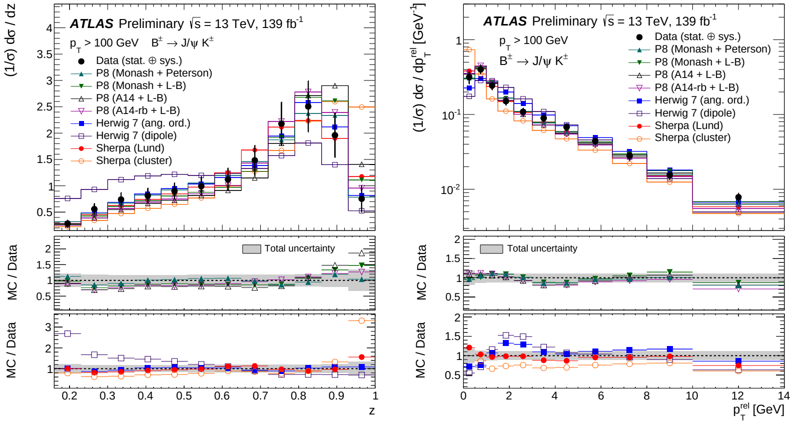
Systematic estimated by changing this choice.





Measurement of b fragmentation using $B^{\pm} \to J/\psi K^{\pm} \to \mu^{+}\mu^{-}K^{\pm}$

Results for z and p_T^{rel} distributions for $p_T > 100$ GeV



- Important contribution from gluon splitting $g \to b\bar{b}$ at high p_T.
- All Pythia fragmentation models give a decent description. A14-rb is best.
- Sherpa (cluster) and H7 (dipole) are visibly off in different regions.

Summary and conclusions

- Two tests of QCD have been presented, covering different aspects
  - Global event geometry using Transverse Energy-Energy Correlations.
  - Fragmentation of b-quark jets using $B^{\pm} \to J/\psi K^{\pm}$ decays.
- Measurements are compared to state-of-the-art MC predictions.
- TEEC compared to NLO pQCD, corrected for non-perturbative effects.
- High-Q^2 determination of α_s. Good agreement with 2018 world average and previous measurements.
- Test of different fragmentation models for b quarks:
  - Lund-Bowler (including r_b variations) vs Peterson.
  - Lund string model vs cluster model.
- Sensitivity of $B^{\pm}$ production to $g \to b\bar{b}$ is explored.