Estimation of neutral pileup particle multiplicity in high-luminosity hadron collider environments

Federico Colecchia
federico.colecchia@brunel.ac.uk

BACKGROUND

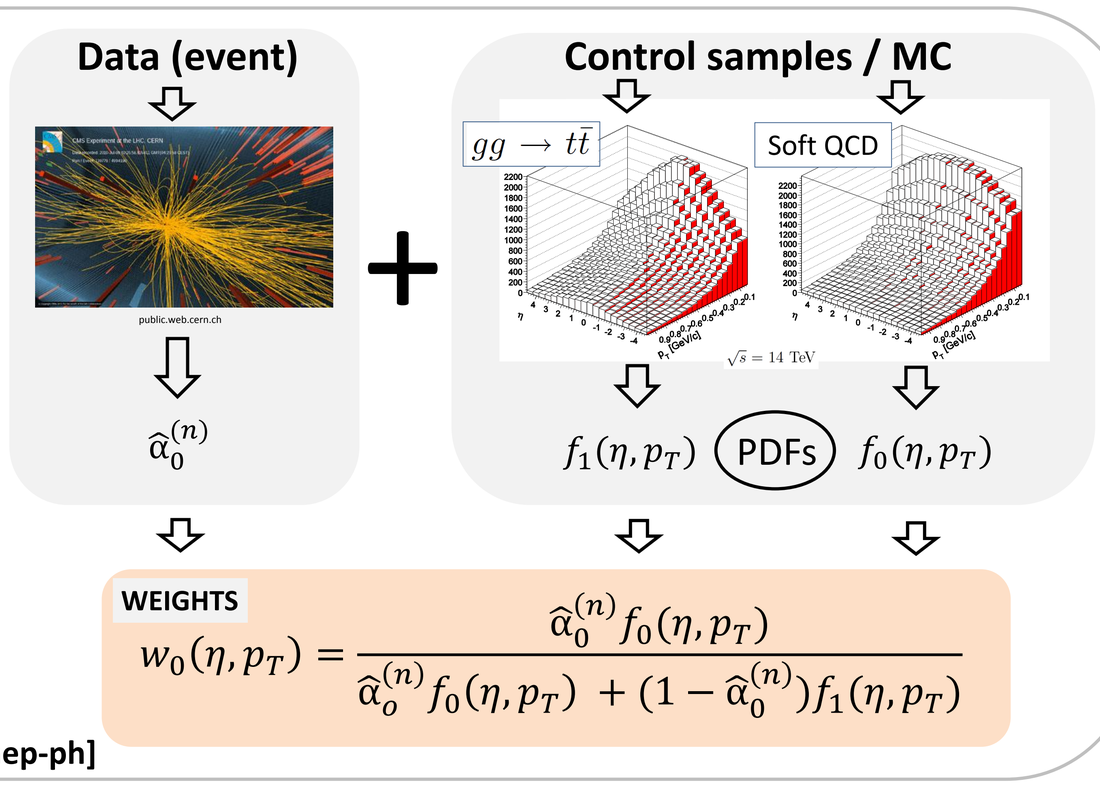
- ***Pileup (PU) at the Large Hadron Collider (LHC)***: Uninteresting low-energy interactions between other protons described by Quantum Chromodynamics (QCD)
- Estimate the probability of ***individual particles*** originating from PU, particularly neutrals [1 – 5]
- ***Particle weighting methods*** for PU subtraction at higher luminosity

MOTIVATION

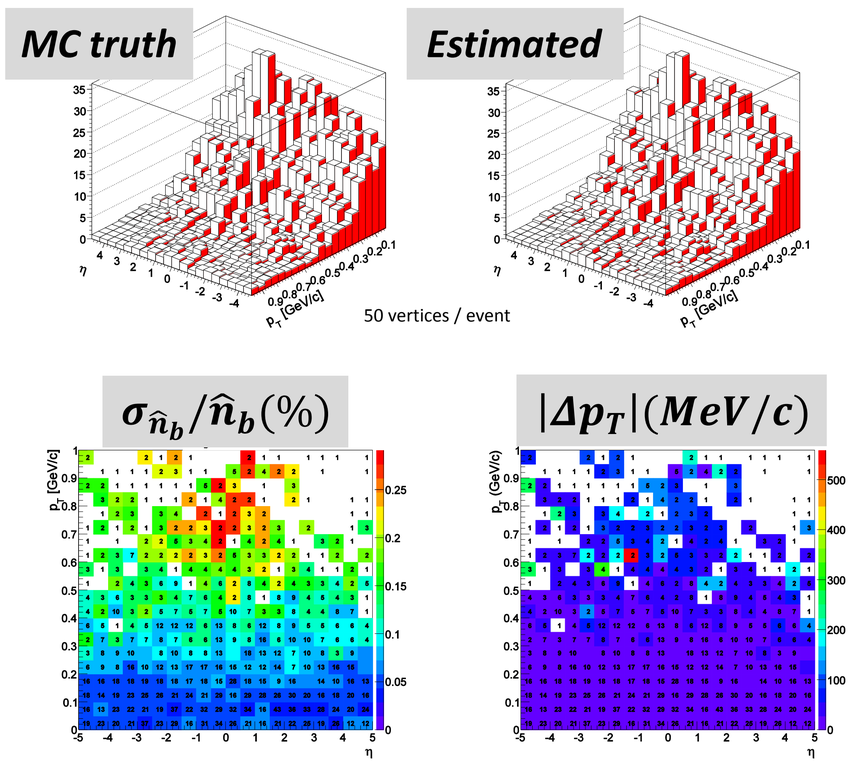
- A ***different approach*** to calculating the weights
  - ✓ *Particle-level kinematic signatures*
  - ✓ *Fraction of neutral PU particles in each event*
- Use the weights to ***rescale the data***

PARTICLE WEIGHTS

1. In each event, consider bins of widths $\Delta\eta$=0.5 and Δp_T = 0.05 GeV/c
2. Overall fraction of neutral PU particles in each collision event: $\hat{\alpha}_0^{(n)}$
3. Shapes of the particle-level (η, p_T)probability density functions (PDFs) for soft QCD and for the hard scattering: $f_0(\eta, p_T), f_1(\eta, p_T)$



arXiv:1412.1989 [hep-ph]



RESCALING THE DATA

- Expected number of neutral pileup particles in each (η, p_T) bin: $\hat{n}_b(\eta, p_T) = w_0(\eta, p_T)\, n(\eta, p_T)$
- Statistical uncertainty: $\sigma_{\hat{n}_b} = \sqrt{n w_0 (1 - w_0)}$
- Effect on particle p_T: $\Delta p_T(\eta, p_T) = p_T[w_0(\eta, p_T) - w_0^*(\eta, p_T)]$
- Impact on missing transverse energy (MET) resolution: $\sigma_{\mathrm{MET}}^{PU} \simeq 0.3$ GeV

arXiv:1412.1989 [hep-ph]

CONCLUSIONS

1. We have calculated the particle weights using information ***not employed*** by existing methods
2. We expect that combining algorithms using different phenomenological handles will result in improved pileup subtraction at higher luminosity

SPECULATIONS

- ***LHC post-shutdown (LS1)****:*
  - ✓ *Multiple particle weighting algorithms upstream of jet reconstruction?*
- ***High Luminosity LHC****:*
  - ✓ *Multivariate particle weighting?*

References

1. F. Colecchia , “A population-based approach to background discrimination in particle physics” *J. Phys.: Conf. Ser.* 368 012031 , 2012
2. F. Colecchia , “Toward particle-level filtering of individual collision events at the Large Hadron Collider and beyond” *J. Phys.: Conf. Ser.* 490 012226, 2014
3. D. Bertolini D, P. Harris, M. Low and N. Tran, “Pileup Per Particle Identification” *J. High Energy Phys.* 1410 (2014) 59
4. M. Cacciari, G. P. Salam and G. Soyez, “SoftKiller, a particle-level pileup removal method” CERN-PH-TH/2014-116
5. P. Berta, M. Spousta, D. W. Miller and R. Leitner , “Particle-level pileup subtraction for jets and jet shapes” *J. High Energy Phys.* 1406 (2014) 092