



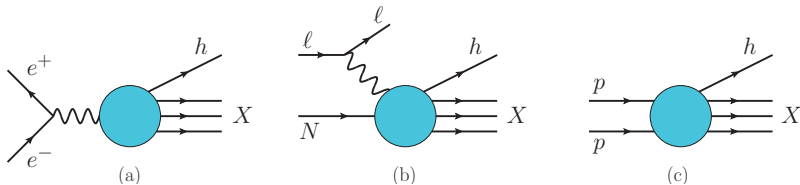
Fragmentation functions and their modification

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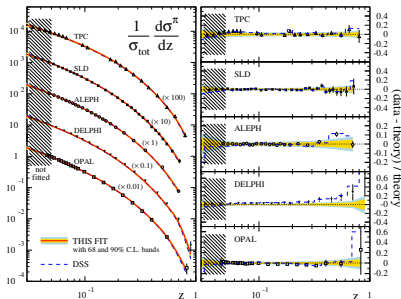
JETSCAPE Workshop 2018

FF in SIA (& SIDIS)



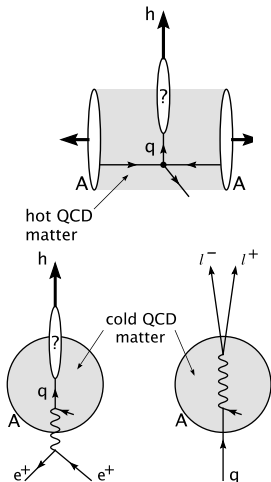
A. Metz, A. Vossen, Prog. Part. Nucl. Phys. 91, 136 (2016)

- SIA: $F_{T,L}(x, s)$ via $e^+e^- \rightarrow \gamma/Z \rightarrow h + X$
- Clean, parton kinematics evident from scattered ℓ^\pm
- $D_i^h(z, \mu^2)$ can be extracted with QCD matrix part known to NNLO
- Flavor tagging possible via b-jets, but not used in global fits



D. de Florian *et al.*, PRD 91, 014035 (2014)

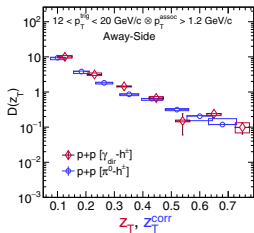
FF/JFF in Heavy Ion



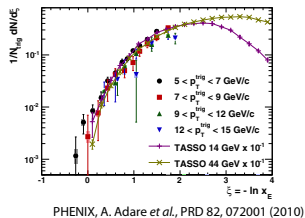
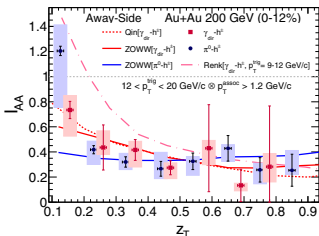
A. Accardi *et al.*, Riv. Nuovo Cim. 32, 439 (2010)

- Measurement of parton interacting with the hot medium
- Contrasted with cold nuclear measurement (nucleus as a probe of the space-time properties of the fragmentation)

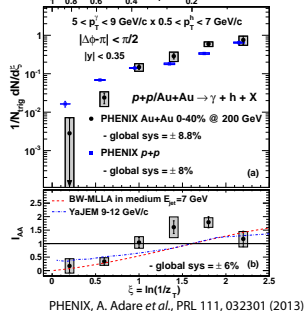
γ +Hadron Correlation at RHIC



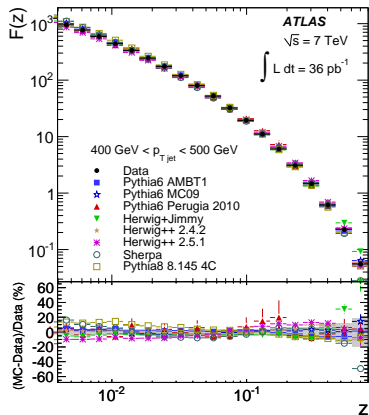
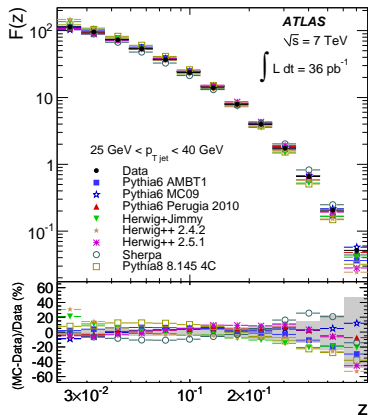
STAR, L. Adamczyk *et al.*, PLB 760, 689 (2016)



- “ γ FF” measurement using backscattering γ , similar to $e^+e^- \rightarrow \gamma/Z$ in SIA
- Possible at RHIC, where NLO γ production is low (vs. e.g. LHC)
- Redistribution of γ FF towards low z_T
- Kinematics of energy-lost parton is folded with its (potentially modified) FF



Jet Fragmentation at LHC

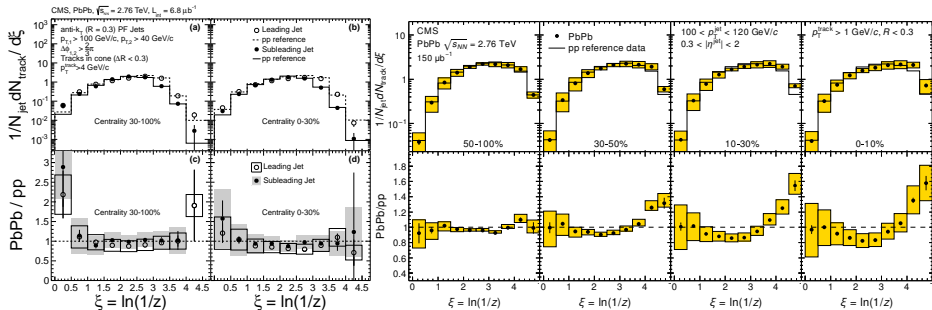


ATLAS, G. Aad *et al.*, Eur. Phys. J. C 71, 1795 (2011)

- Measures a $F(z, p_{T,jet}) = \frac{1}{N_{jet}} \frac{dN_{ch}}{dz}$
- Either $z = \frac{p_{T,ch}}{p_{T,jet}}$ used (boost invariant)

- Or SIA "transplanted" $z = \frac{\mathbf{p}_{jet} \cdot \mathbf{p}_{ch}}{\|\mathbf{p}_{jet}\|^2}$
- Sometimes boosting the dijet system back to $\eta = 0$ to be comparable to SIA

Jet Fragmentation at LHC

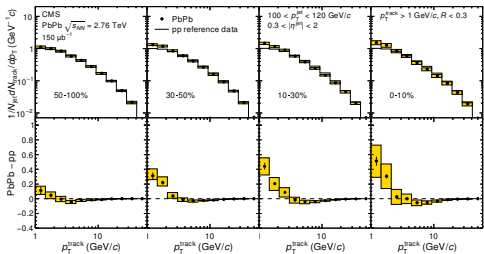


CMS, S. Chatrchyan *et al.*, JHEP 10 (2012) 087 (2011 data)

CMS, S. Chatrchyan *et al.*, PRC 90 024908 (2013 data)

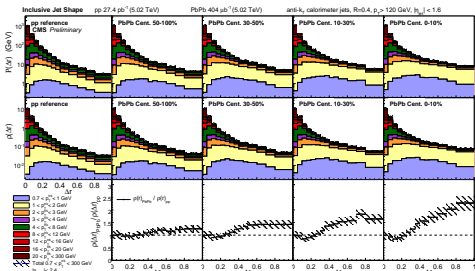
- LHC made the first JFF in PbPb
- Modification is weak, and not immediately visible with limited 2012 pp (low-energy) reference data
- Intra-jet enhancement (extra particle) at low p_T , moderate suppression in intermediate z/ξ , hint of enhancement near $z = 1$, $\xi = 0$

Jet Fragmentation at LHC

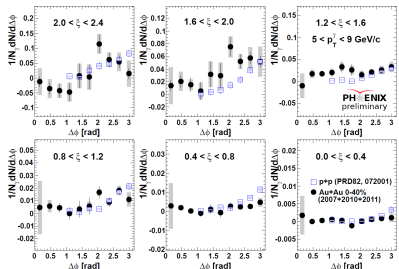


CMS, S. Chatrchyan *et al.*, PRC 90 024908

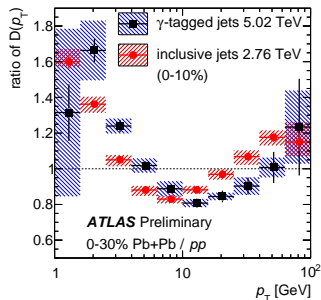
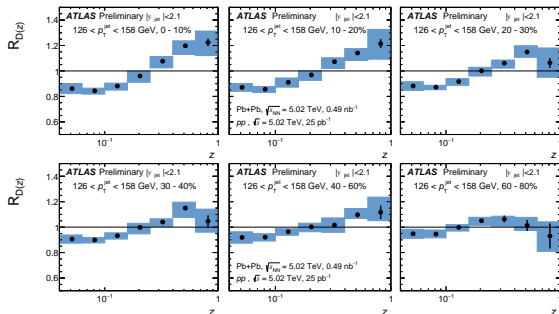
- Plotting as difference shows the low p_T component is really 1–2 additional particles
- Effect needs to be compared to jet shape measurement, the additional soft component is distributed over a wider angle (than the jet)



CMS-PAS-HIN-16-020



Jet Fragmentation at LHC

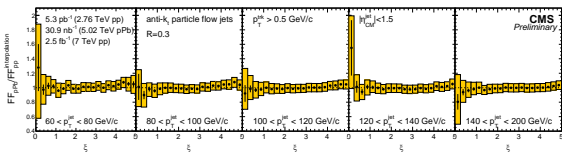


ATLAS-CONF-2017-005

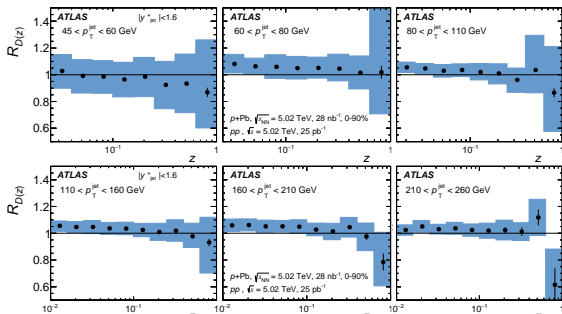
ATLAS-CONF-2017-074

- ATLAS (smaller systematics) sees the $z = 1$ ($\xi = 0$) enhancement significantly
- Recent ATLAS result also shows the γ +jet modification \neq dijet
- Note that neither ATLAS nor CMS are statistics-limited

Jet Fragmentation at LHC

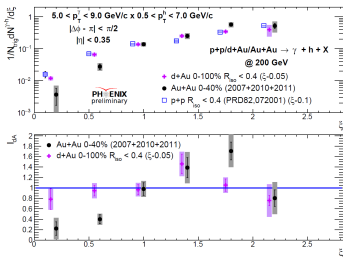


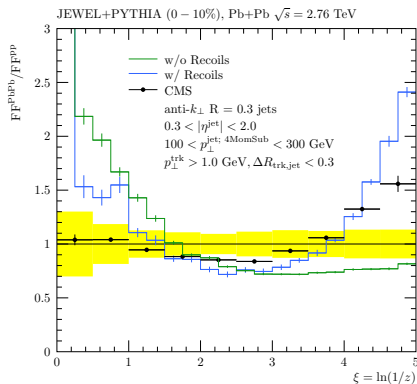
CMS-PAS-HIN-16-020



ATLAS, arXiv:1706.02859

- pPb & dAu FF not modified
- CMS (pre Run-2) with flavor interpolation (similar to global analysis)
- ATLAS (post Run-2), PHENIX reference at the same \sqrt{s}

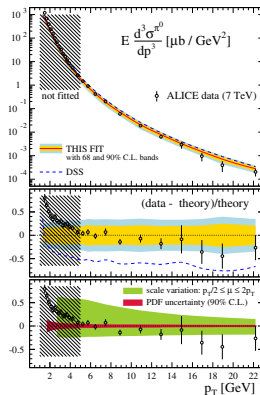
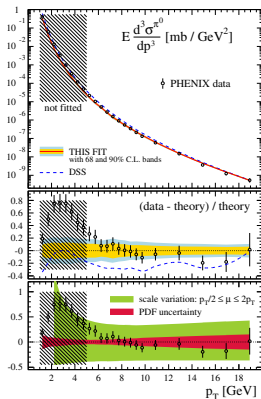




R. K. Elayavalli and K. C. Zapp, arXiv:1707.01539

- Heavy ion MC ability to reproduce JFF modification limited at the moment
- Either ATLAS or CMS ratio + systematics are < 1.3 constrained for $z = 1/\xi = 0$

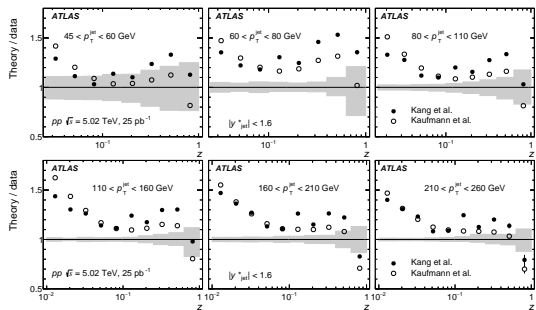
Global Analysis



D. de Florian *et al.*, PRD 91, 014035 (2014)

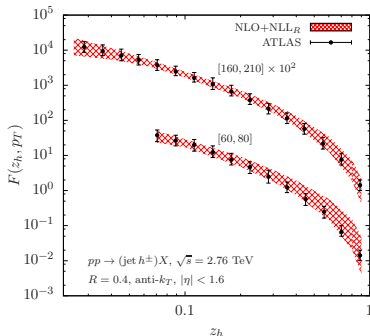
- However, JFF generally do not enter current FF determination
- Gluon FF largely constrained by inclusive spectra
- Parton \neq jets, with differences mainly in resummation and not fixed-order

- SCET with resummation recently used to bridge the gap
- A semi-inclusive FF with jets and hadrons
- It remains to be seen if this can be used to significantly constrain FF global analysis



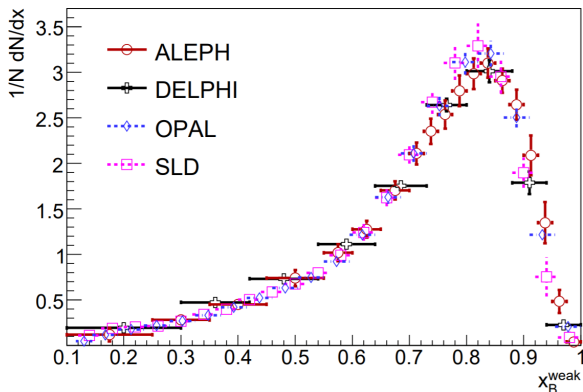
ATLAS, arXiv:1706.02859

- Problem: Detector either good at PID or jet energy resolution/trigging



Z.-b. Kang *et al.*, JHEP 11 (2016) 155

Future: B-FF at (HL-)LHC?

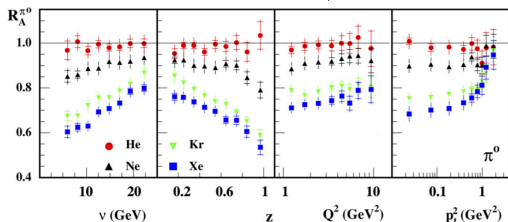
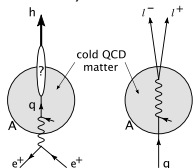


SIA @ LEP at the Z-pole, DELPHI, J. Abdallah *et al.*, Eur. Phys. J. C71, 1557 (2011)

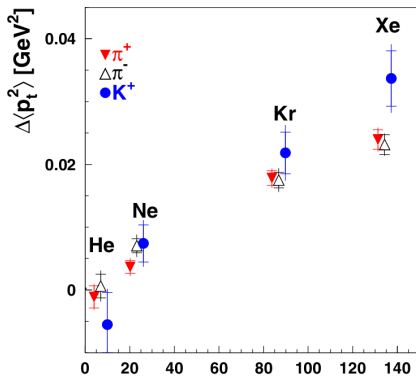
- Either FF wrt. B-meson as potential place-holder for b-jet
- Or with jets: More detail on the b-quark interaction with the medium, than inclusive b-jet and B-meson R_{AA}

Future: EIC with jet k_T broadening

A. Accardi *et al.*, Riv. Nuovo Cim. 32, 439 (2010)



- EIC will be the first nDIS with jets
- Space-time constraint on the fragmentation process



HERMES, A. Airapetian *et al.*, NPB 780, 1 (2007)

Conclusion

- Rich physics with non-perturbative properties of the parton
- Neither ATLAS nor CMS are statistics-limited, how to improve inclusive JFF not clear
- HF FF could be a future expansion for LHC physics
- EIC will open nDIS to jets