(Groomed) event shape observables in ep at H1

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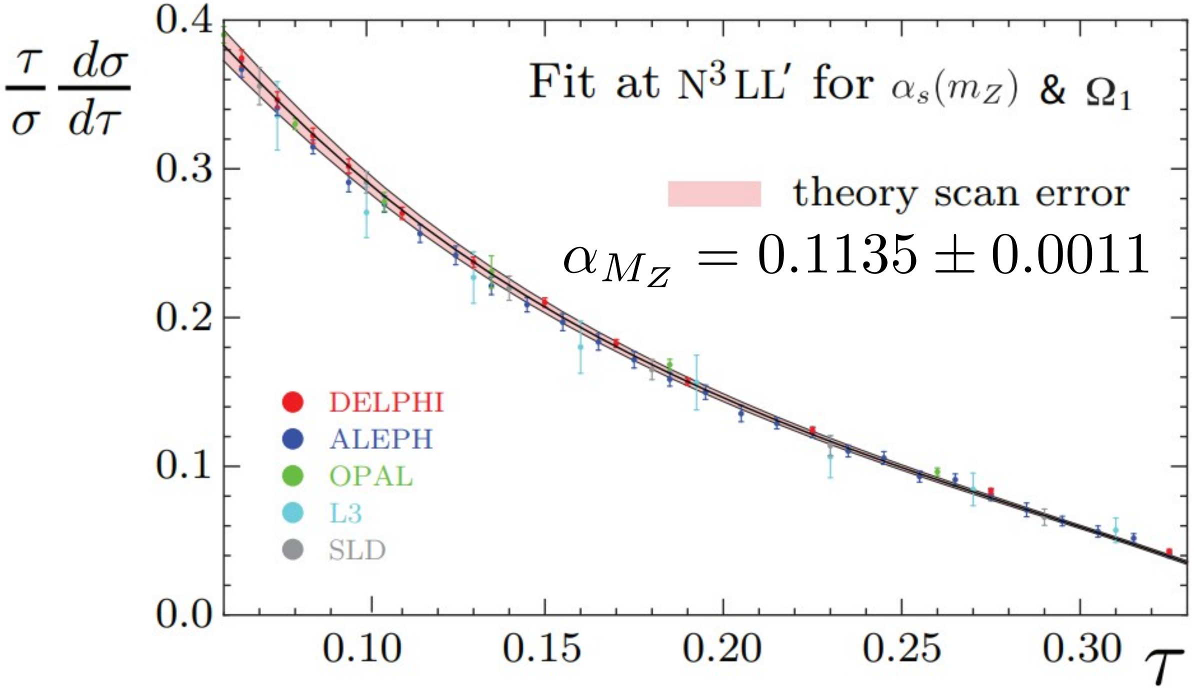
Importance of event shape observables

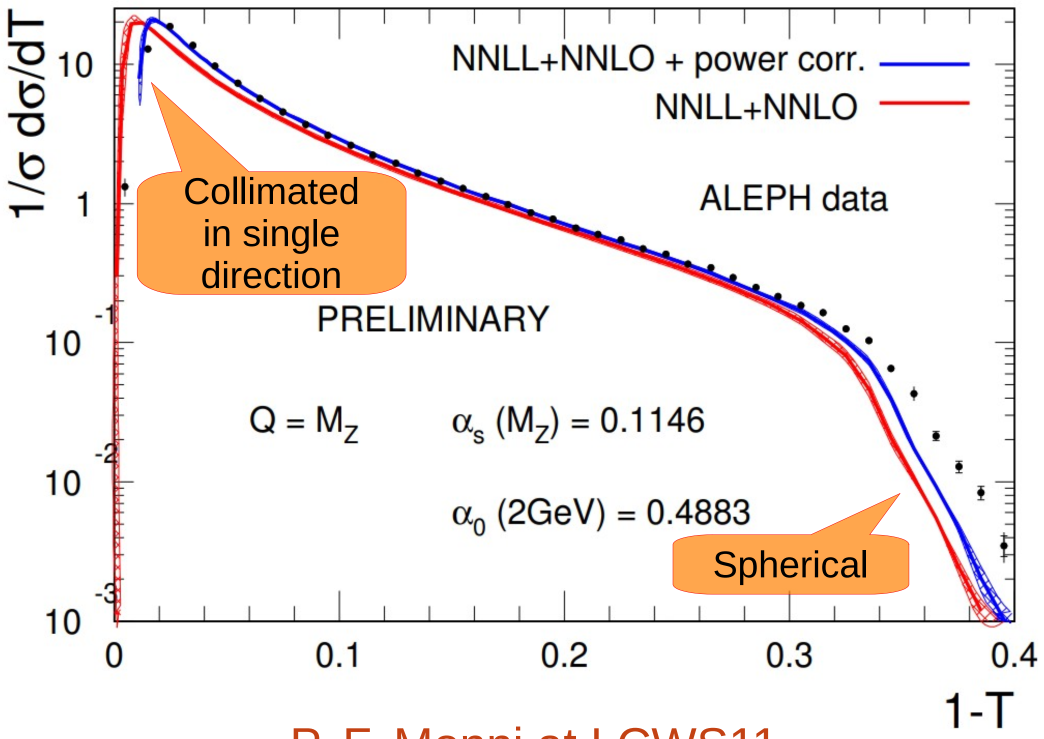
- Extensively studied in ee, pp and ep collisions
- Sensitive to both fixed order calculations and resummation effects

Thrust in ee used in $\alpha_S(M_Z)$ fit



Albbate et al, Phys.Rev.D 83 (2011) 074021

Thrust in ee over wider range



P. F. Monni at LCWS11

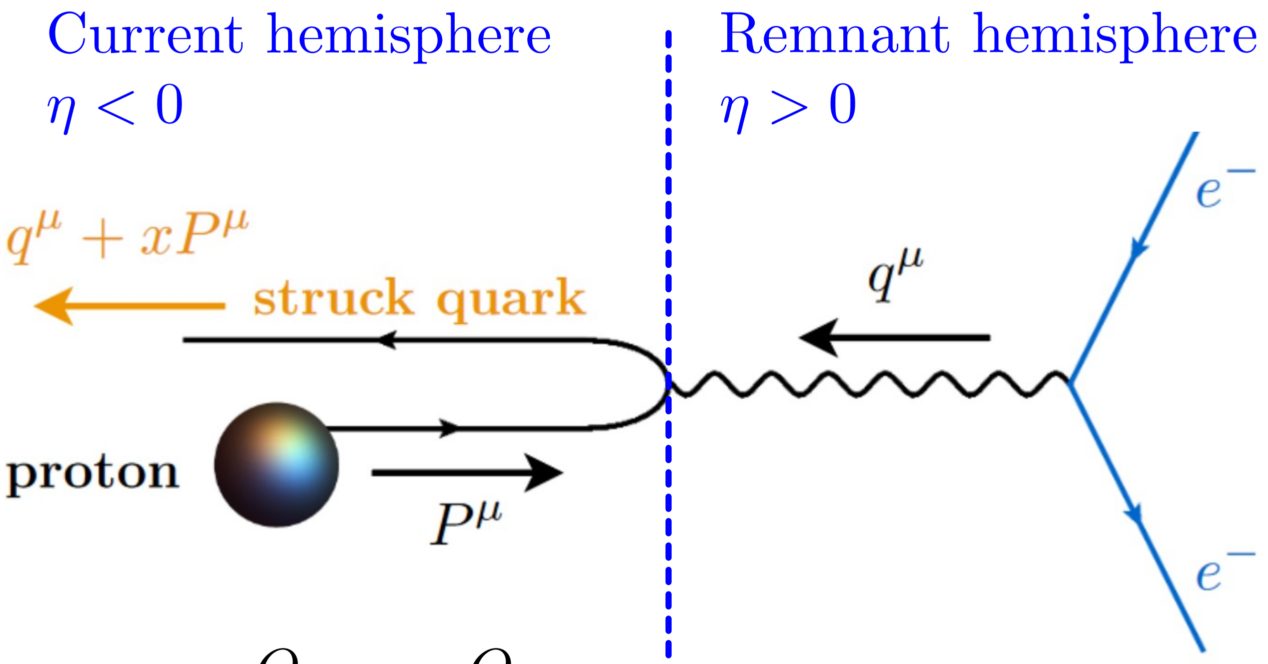
Breit frame in ep scattering

- Intermediate photon has only space component
- Struck quark goes to Current hemisphere
- Spectating partons into Remnant hemisphere

Breit frame condition

$$2x\vec{P} + \vec{q} = 0$$

$$P = (\frac{Q}{2}; 0, 0, -\frac{Q}{2})$$



$$P = (\frac{Q}{2x}; 0, 0, \frac{Q}{2x}) \qquad q = (0; 0, 0, -Q)$$

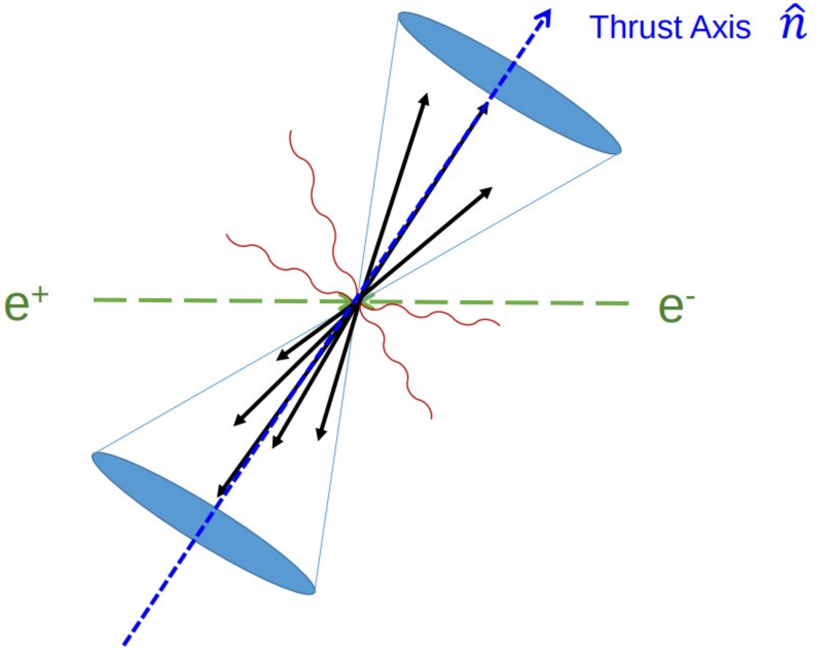
Trust in DIS

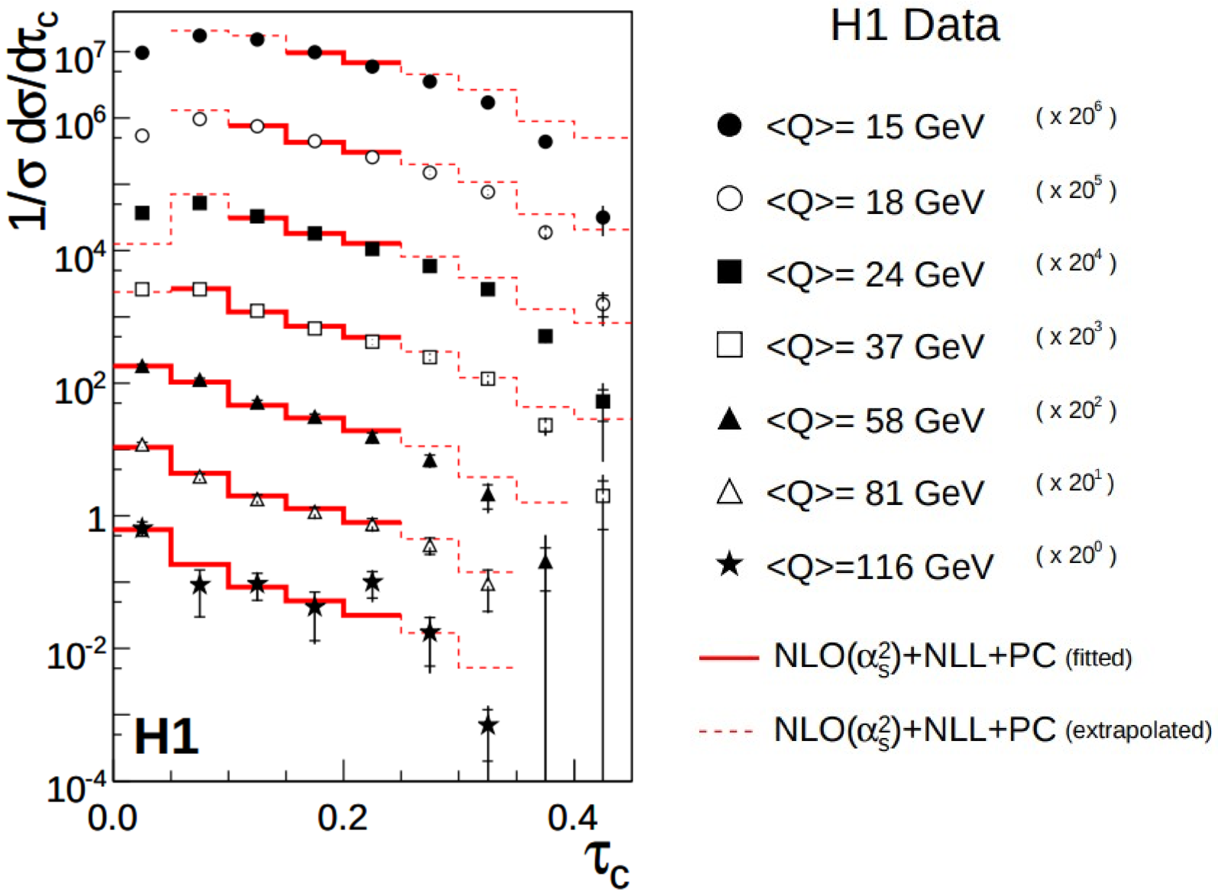
- At HERA measured by both H1 & ZEUS

Eur.Phys.J.C 46 (2006) 343

Calculated in Breit frame from particles in Current hemisphere

$$T_C = \max_{\vec{n}_T} \frac{\sum_h |\vec{p}_h \cdot \vec{n}_T|}{\sum_h |\vec{p}_h|} \qquad \tau_C = 1 - T_C$$





Trust in DIS – revisited

- Suggestion of better observable with only global logarithm in D. Kang et al, Phys.Rev.D 88 (2013) 054004

Yet another variation is τ_{zE} [30, 48] which is like Eq. (47) with the same normalization, but with respect to the **z**-axis in the Breit frame. It is also not global [48]. H1 and ZEUS have measured $\tau_{zE} = \tau_c^{\mathrm{H1}} = 1 - T_\gamma^{\mathrm{ZEUS}}$ and $\tau_{tE} = \tau^{\mathrm{H1}} = 1 - T_T^{\mathrm{ZEUS}}$ [32, 35]. It would be interesting to reanalyze the data to measure the global observables $\tau_1^{a,b,c}$ we predict in this paper at NNLL order.

Thrust

$$\tau_Q = 1 - \frac{2}{Q} \sum_{i \in \mathcal{H}_\mathcal{C}} (-P_{z,i}^{\mathrm{Breit}})$$

Equivalence

1-jettiness

$$\tau_1^b = \frac{2}{Q^2} \sum_{i \in X} \min\{xP \cdot p_i, (q + xP) \cdot p_i\}$$

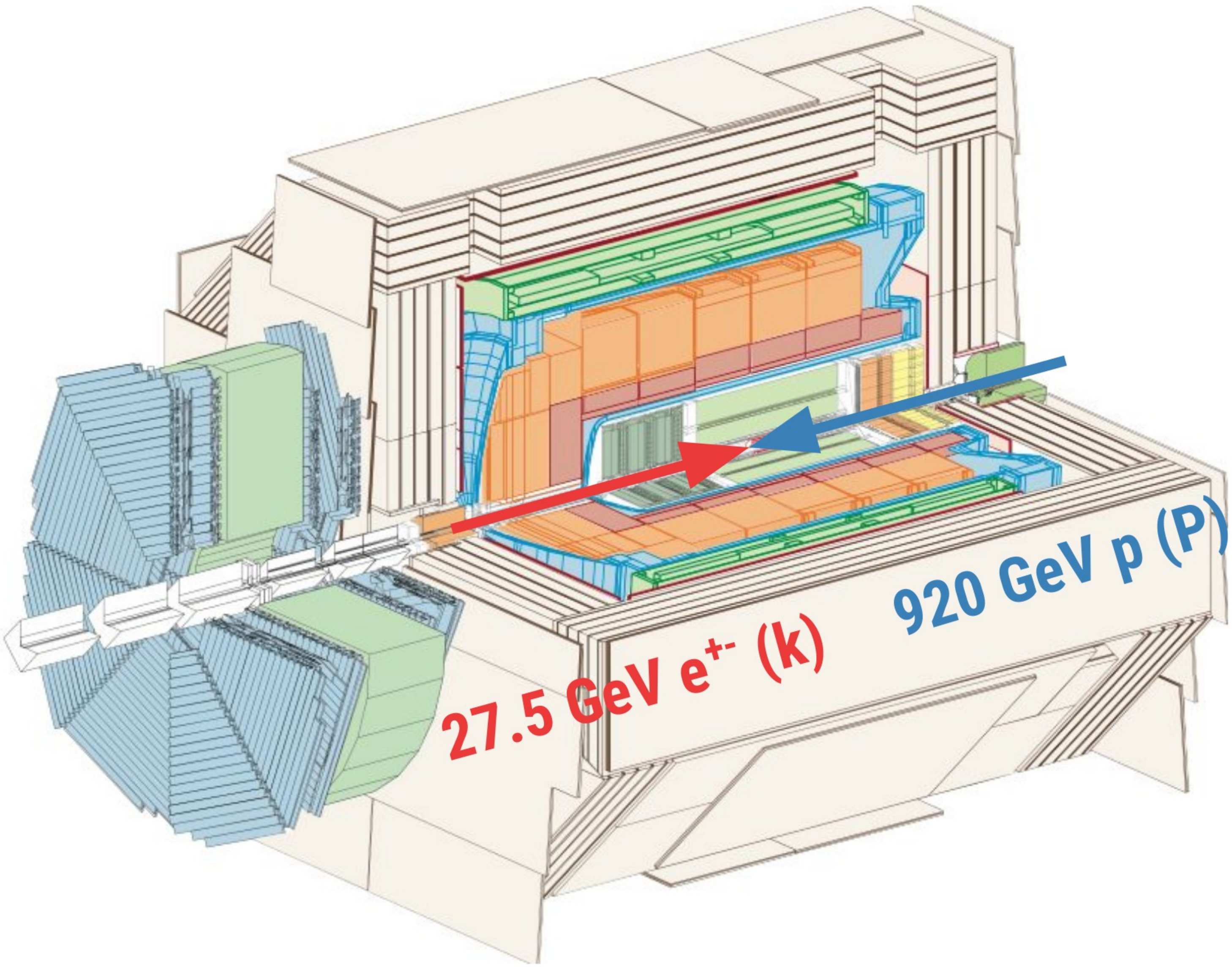
Experimental setup

- 352 pb^{-1} of data collected by H1 in 2003-2007 at $\sqrt{s}$ = 319 GeV
- Phase space definition
  $0.2 < y < 0.7$, $Q^2 > 150$ GeV^2

$$Q^2 = -q^2$$

$$y = Pq / pk$$

P: incoming proton 4-vector
k: incoming electron 4-vector
q=k-k' : 4-momentum transfer

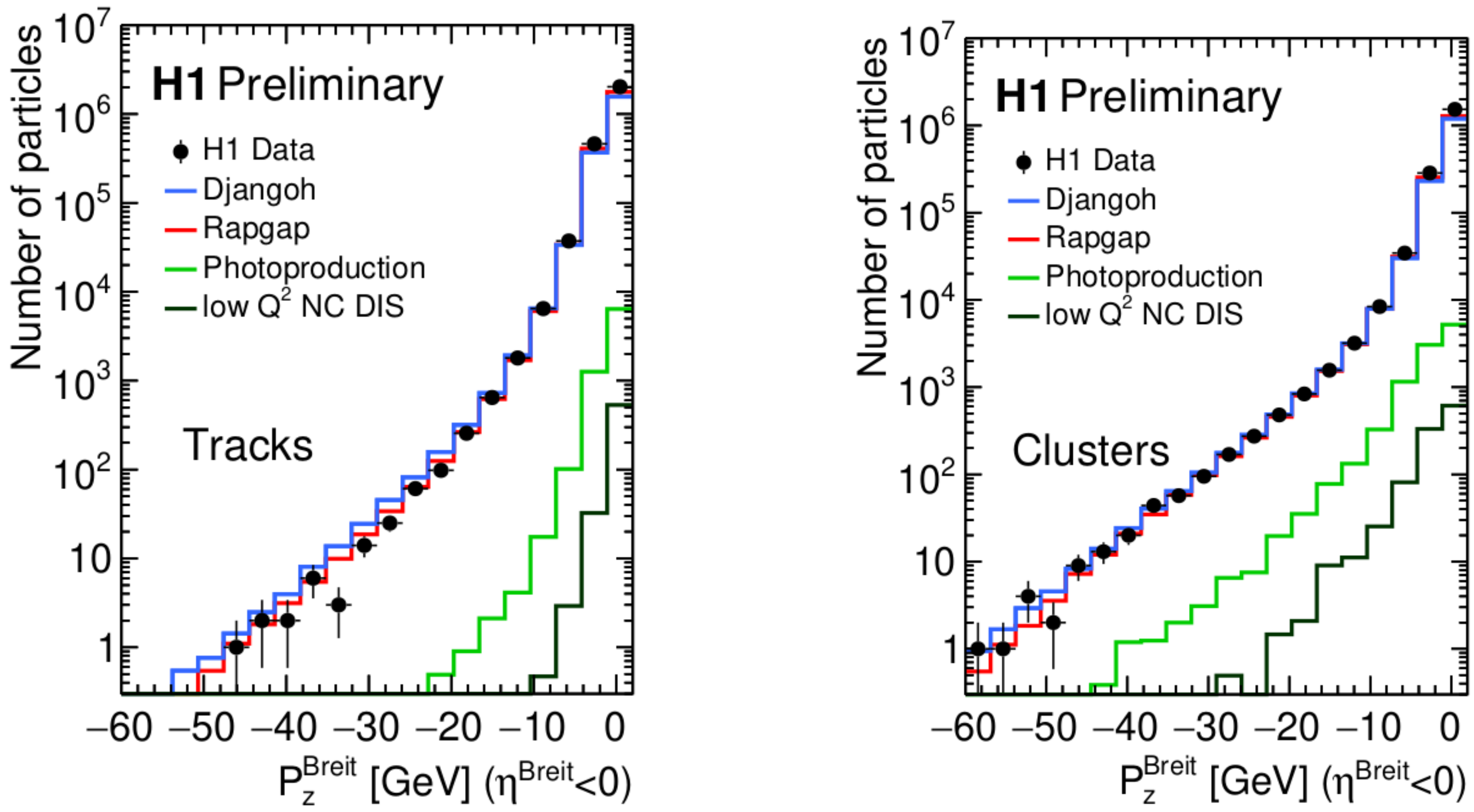


Momenta distribution in Breit frame

$$\tau_Q = 1 - \frac{2}{Q} \sum_{i \in \mathcal{H}_\mathcal{C}} (-P_{z,i}^{\text{Breit}})$$

- Particle-flow algorithm combines momentum information from tracks and clusters

H1prelim-21-032



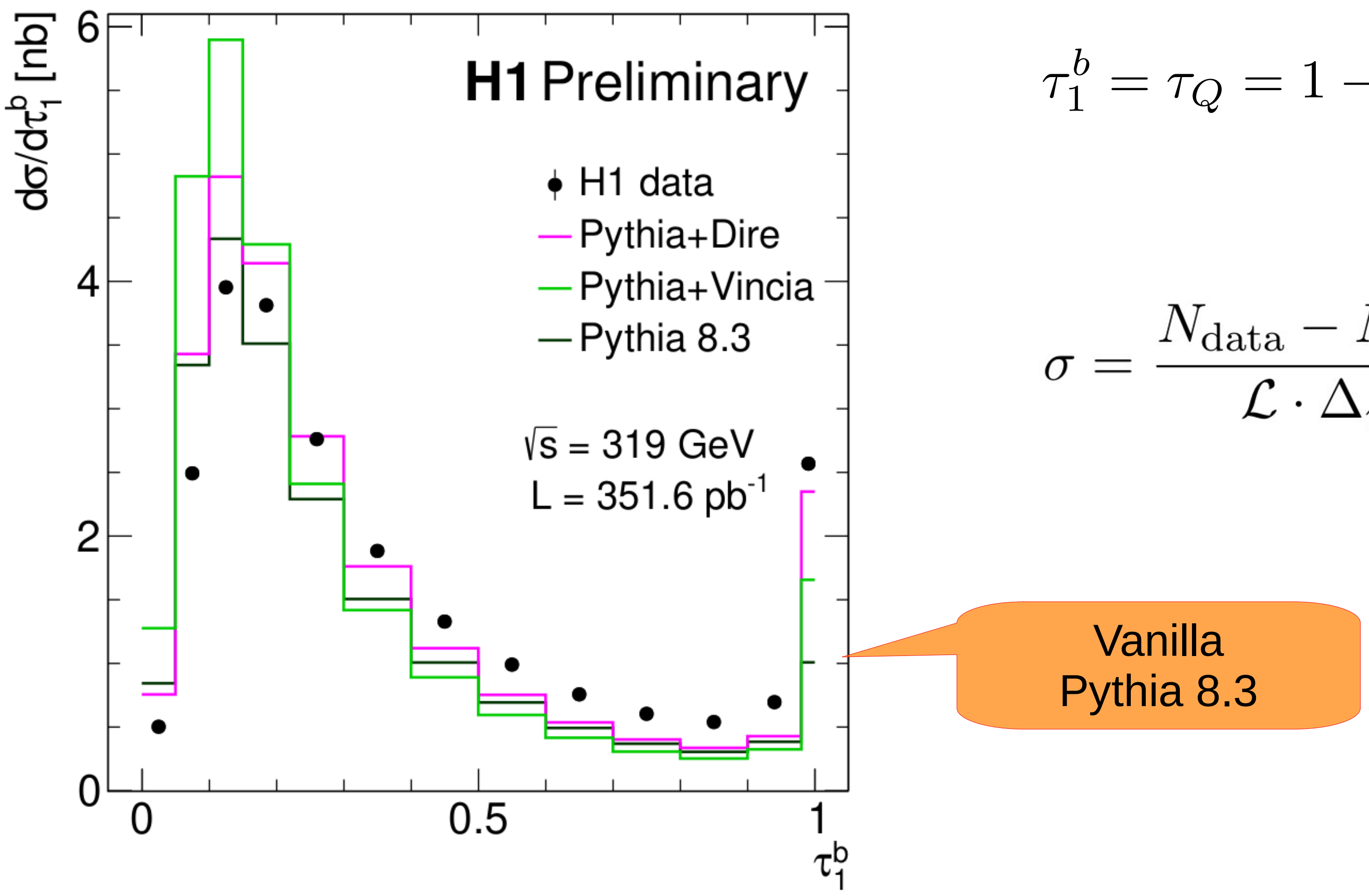
0.2 < y < 0.7
$Q^2 > 150\ \text{GeV}^2$

Current hemisphere

Results of 1-jettiness

0.2 < y < 0.7
$Q^2 > 150$ GeV^2

- Pythia with DIRE showering gives the best description



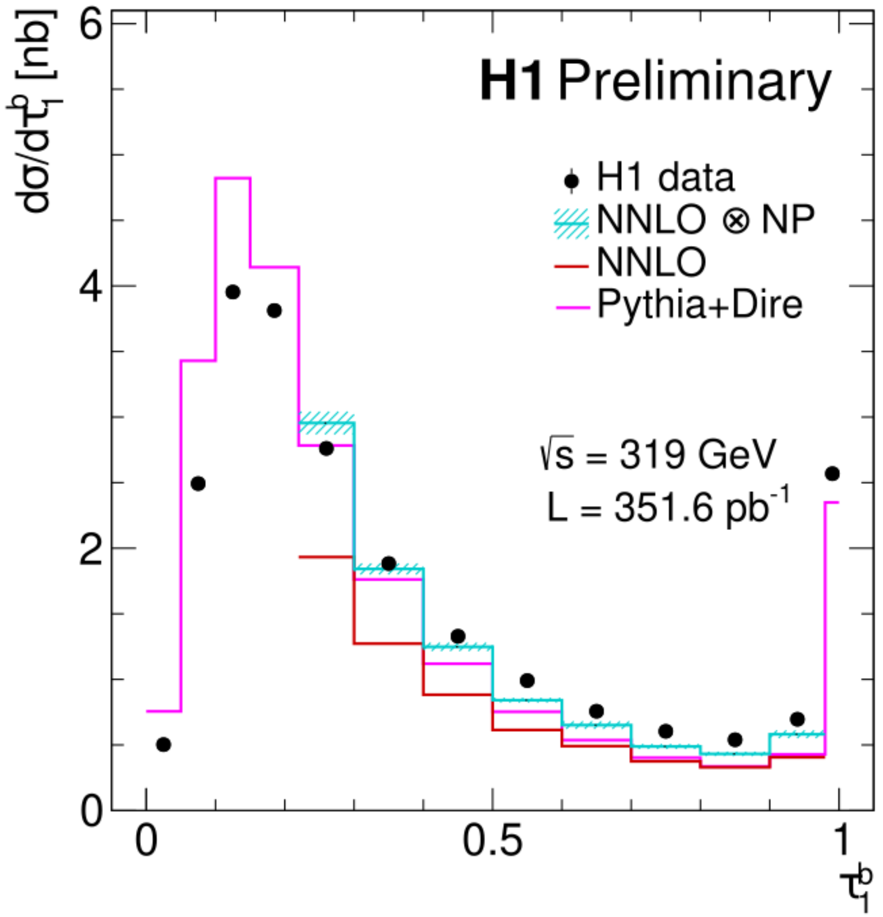
$$\tau_1^b = \tau_Q = 1 - \frac{2}{Q}\sum_{i\in\mathcal{H}_C}(-P_{z,i}^{\mathrm{Breit}})$$

$$\sigma = \frac{N_{\mathrm{data}} - N_{\mathrm{Bkg}}}{\mathcal{L}\cdot\Delta_\tau}\cdot c_{\mathrm{unfold}}\cdot c_{\mathrm{QED}}$$

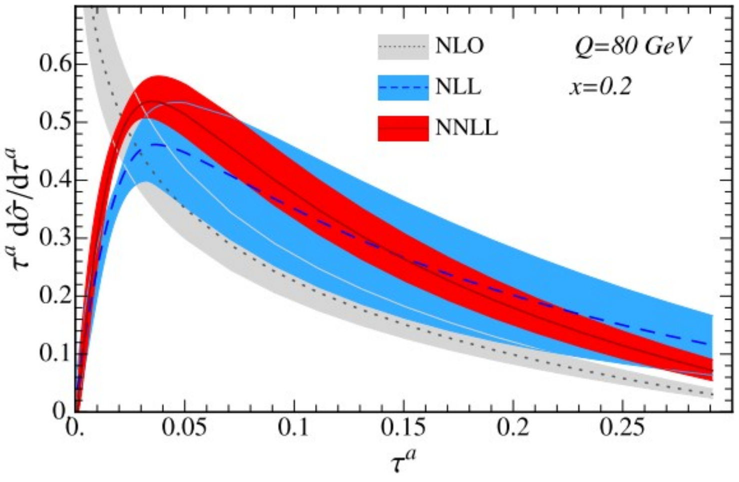
Results of 1-jettiness

0.2 < y < 0.7
$Q^2 > 150\ GeV^2$

- Fixed order calculations at NNLO from NNLOJET



D. Kang et al, Phys.Rev.D 88 (2013) 054004



Calculation including analytical resummation not available yet

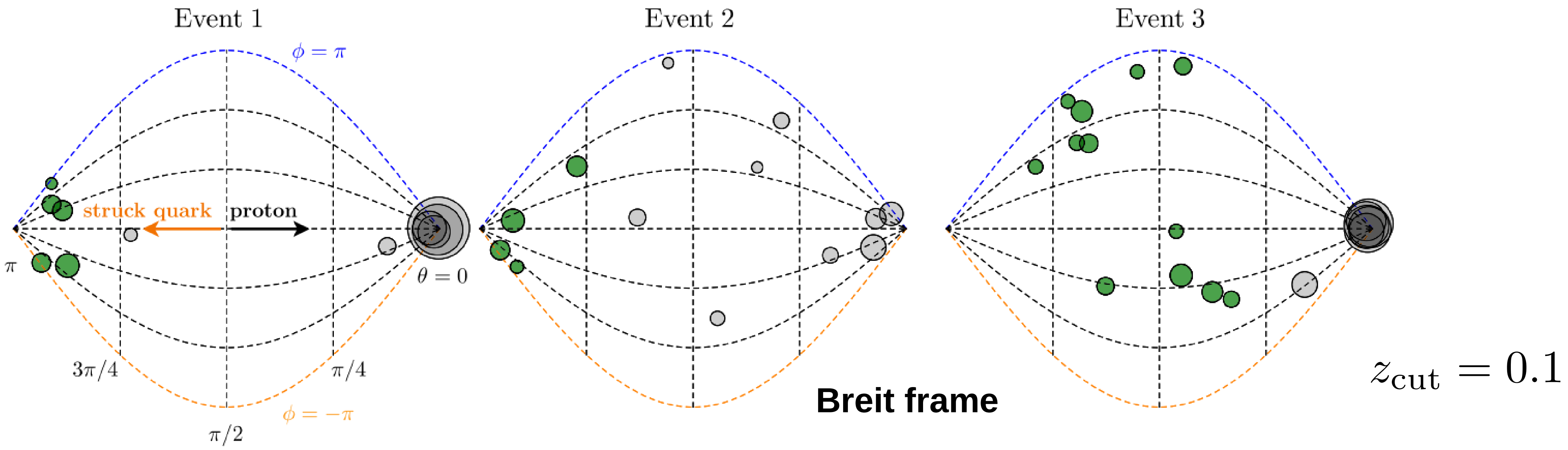
Groomed event shape observables in DIS

Jet Grooming at LHC

- Removing soft (non-perturbative) component of the jet
- See for example:
  Soft Drop JHEP 05 (2014) 146

In ep the Underlying Event is not an issue, why grooming Y. Markis, Phys.Rev.D 103 (2021) ?

1) Constructing observables free from nonglobal-logarithms
2) Mitigation of hadronization corrections
3) Phenomenological handle on soft radiation
4) Dial for nonperturbative contributions

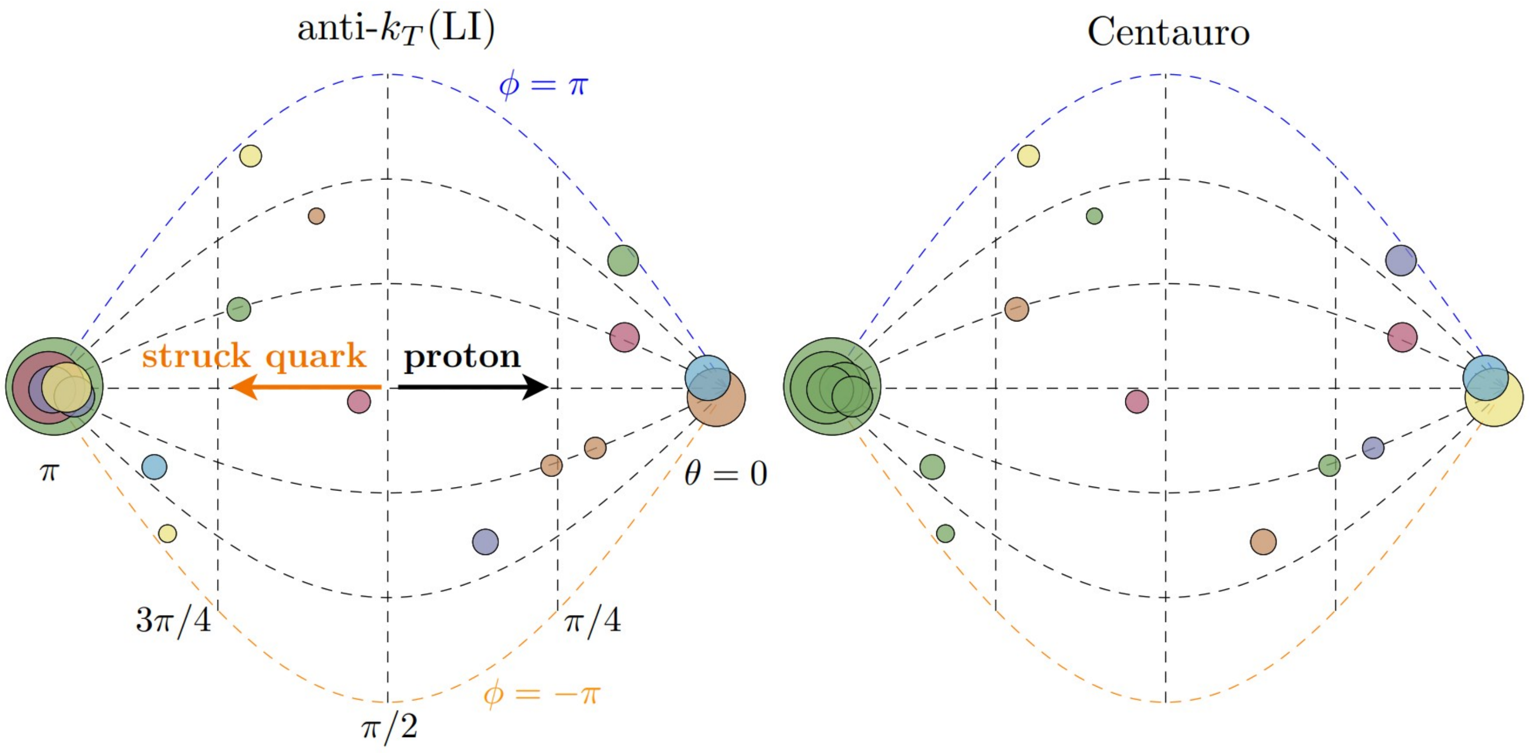


Centauro jet algorithm & Grooming

- Centauro jet algorithm uses asymmetric distance metric such that "Born" jet in the current hemisphere is clustered into single object
- Particles in remnant hemisphere are clustered into "soft" jets

$$d_{ij} = (\Delta\bar{\eta}_{ij})^2 + 2\bar{\eta}_i\bar{\eta}_j(1 - \cos\Delta\phi_{ij})$$

$$\bar{\eta}_i = \frac{p_i^\perp}{p_i^+}$$



$$z_i = \frac{P \cdot p_i}{P \cdot q}$$

Usage of the clustering history applying Grooming condition

$$\frac{min(z_i, z_j)}{z_i + z_j} > z_{cut}$$

Similar to Soft Drop

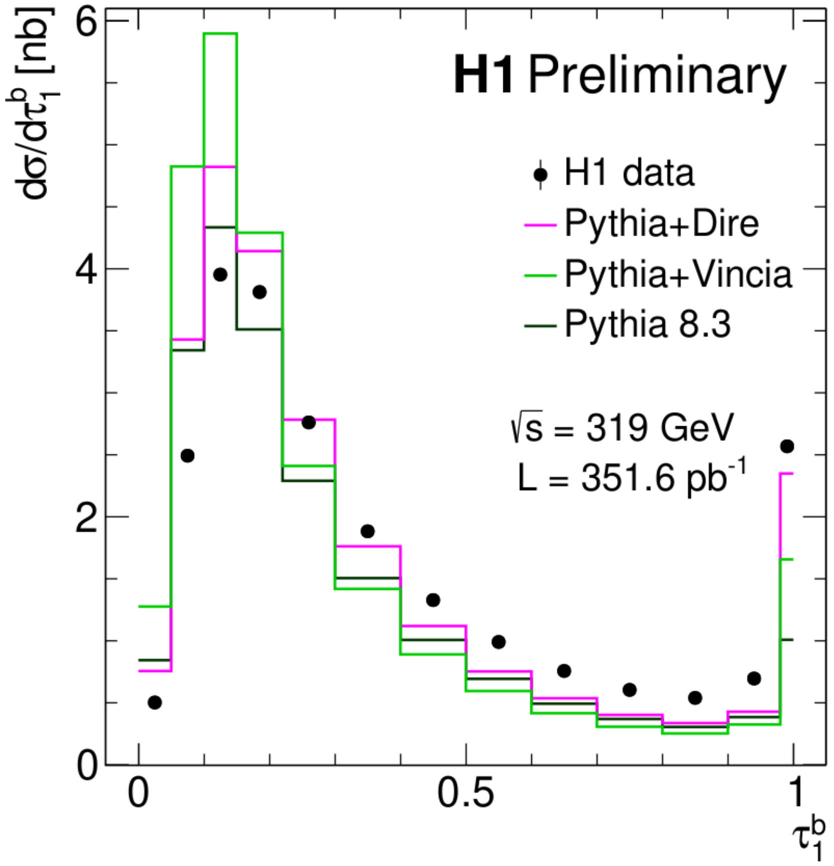
Phys.Rev.D 104 (2021) 3, 034005

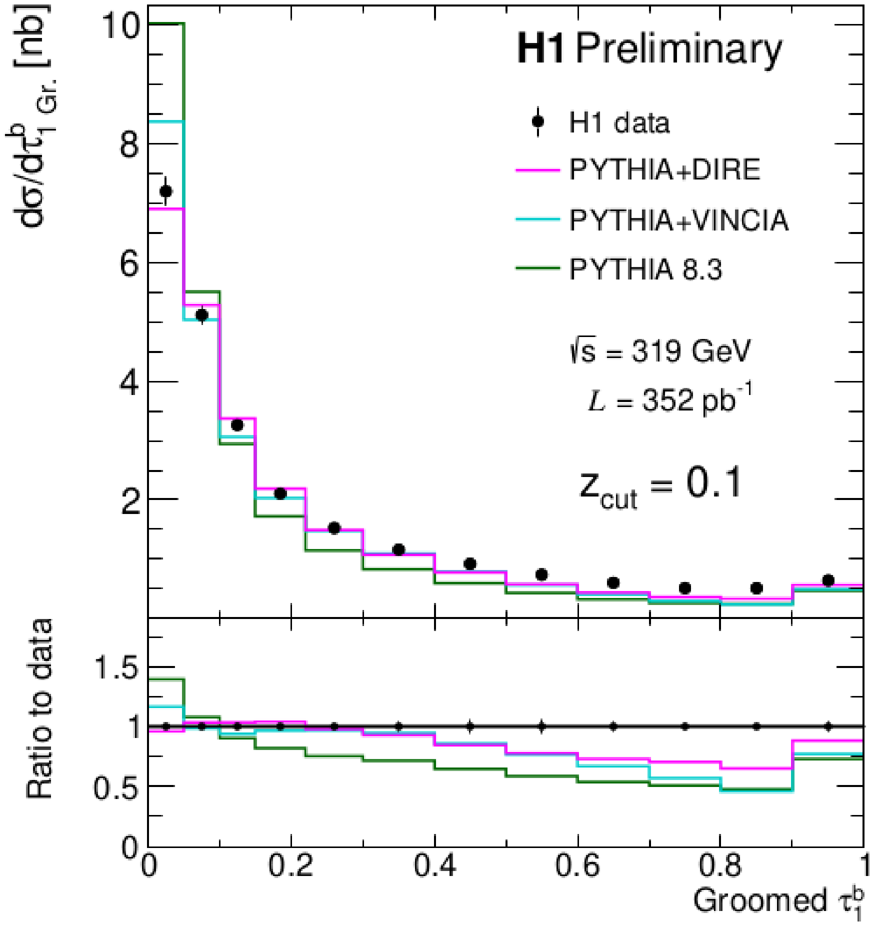
Standard & Groomed 1-jettiness

- The groomed spectrum si better described by the generators
- Pythia+DIRE has consistently the best performance

0.2 < y < 0.7
$Q^2 > 150\ GeV^2$

H1prelim-22-033

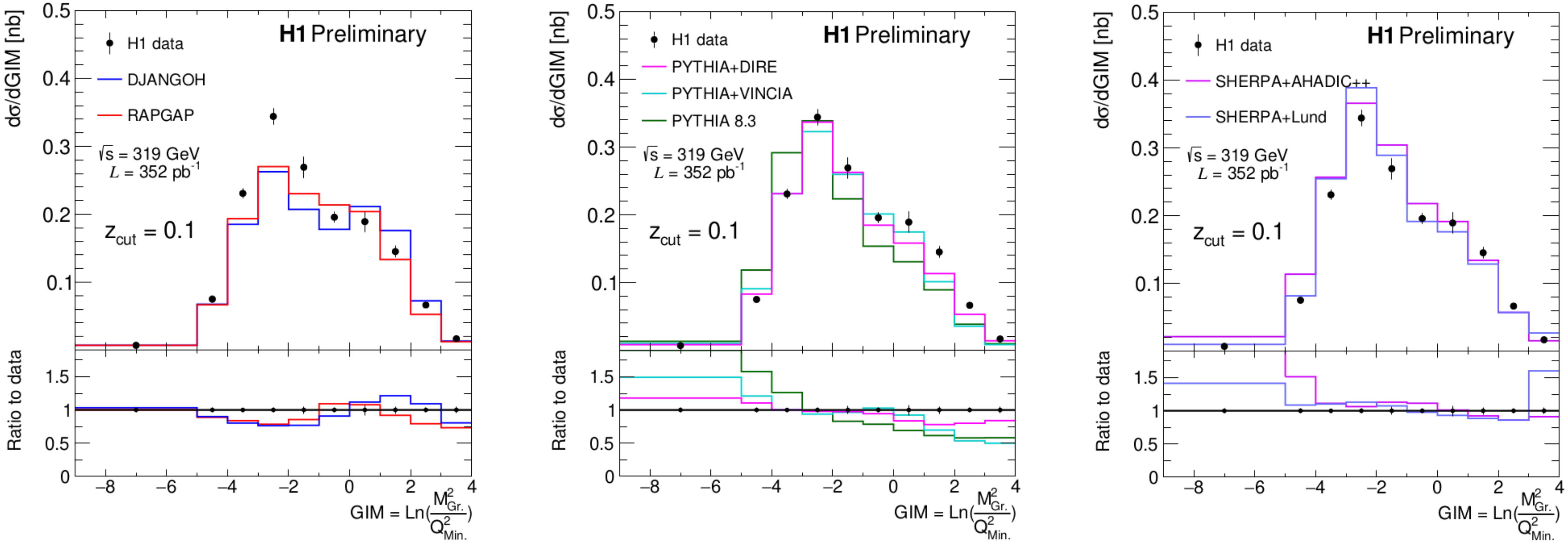




Groomed event mass

0.2 < y < 0.7
$Q^2 > 150\ \mathrm{GeV}^2$

- Good performance of legacy DIS generators
- Pythia+DIRE outperforms classical Pythia's shower
- Sherpa with Lund fragmentation gives slightly better description than AHADIC cluster model



Conclusions

- The Thrust observable remeasured on HERA II data using definition free of non-global logs
  → eqvivalent to 1-jettiness observable
- In addition, grooming technique was applied which also reduced e.g. hadrnonization component
- Measured data ready to be used in MC tunes as well as in analytical calculations