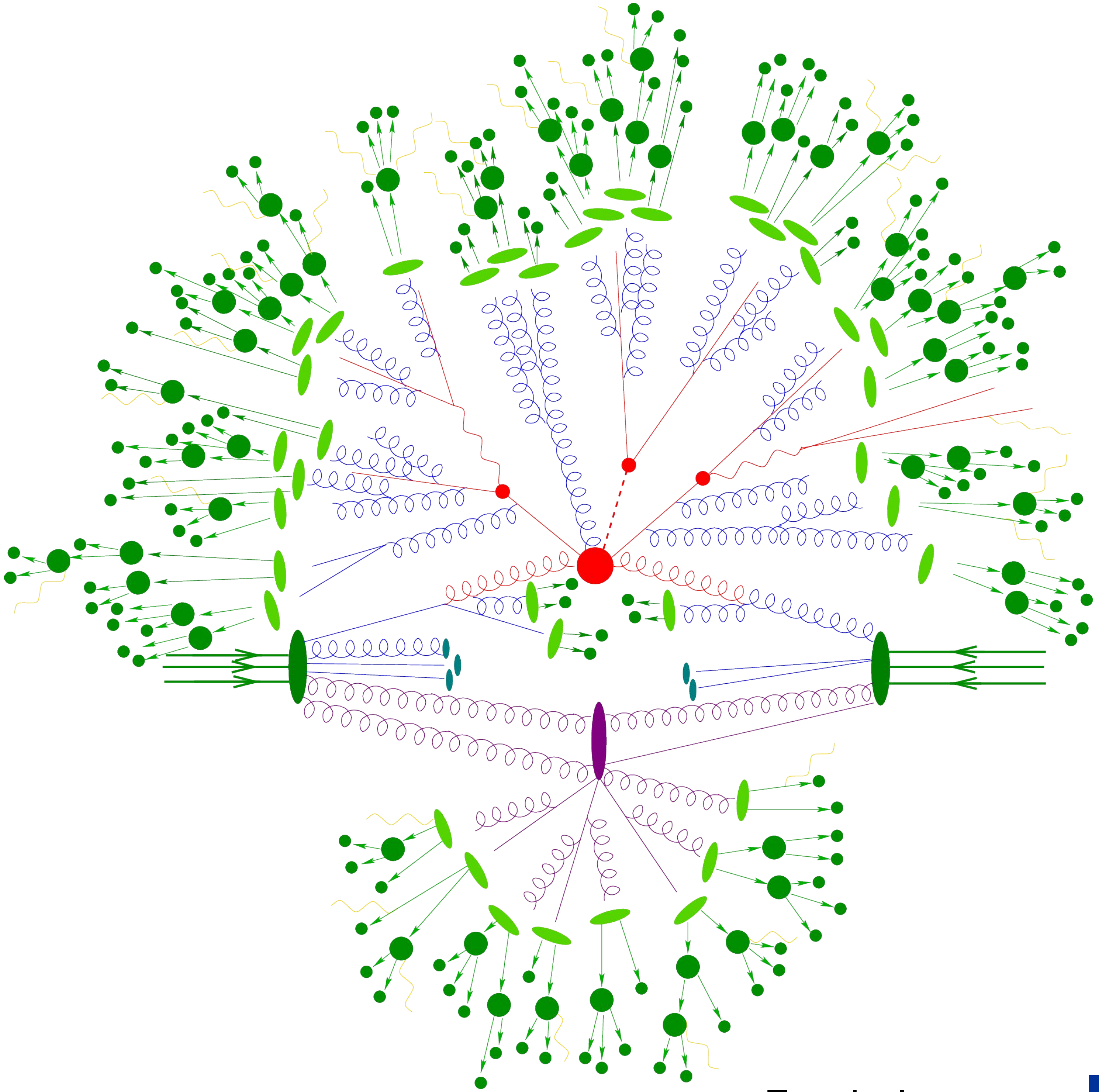
MC & Tools,

Resummation and

Jets WG Summary



PhysTeV 2025 SM Session

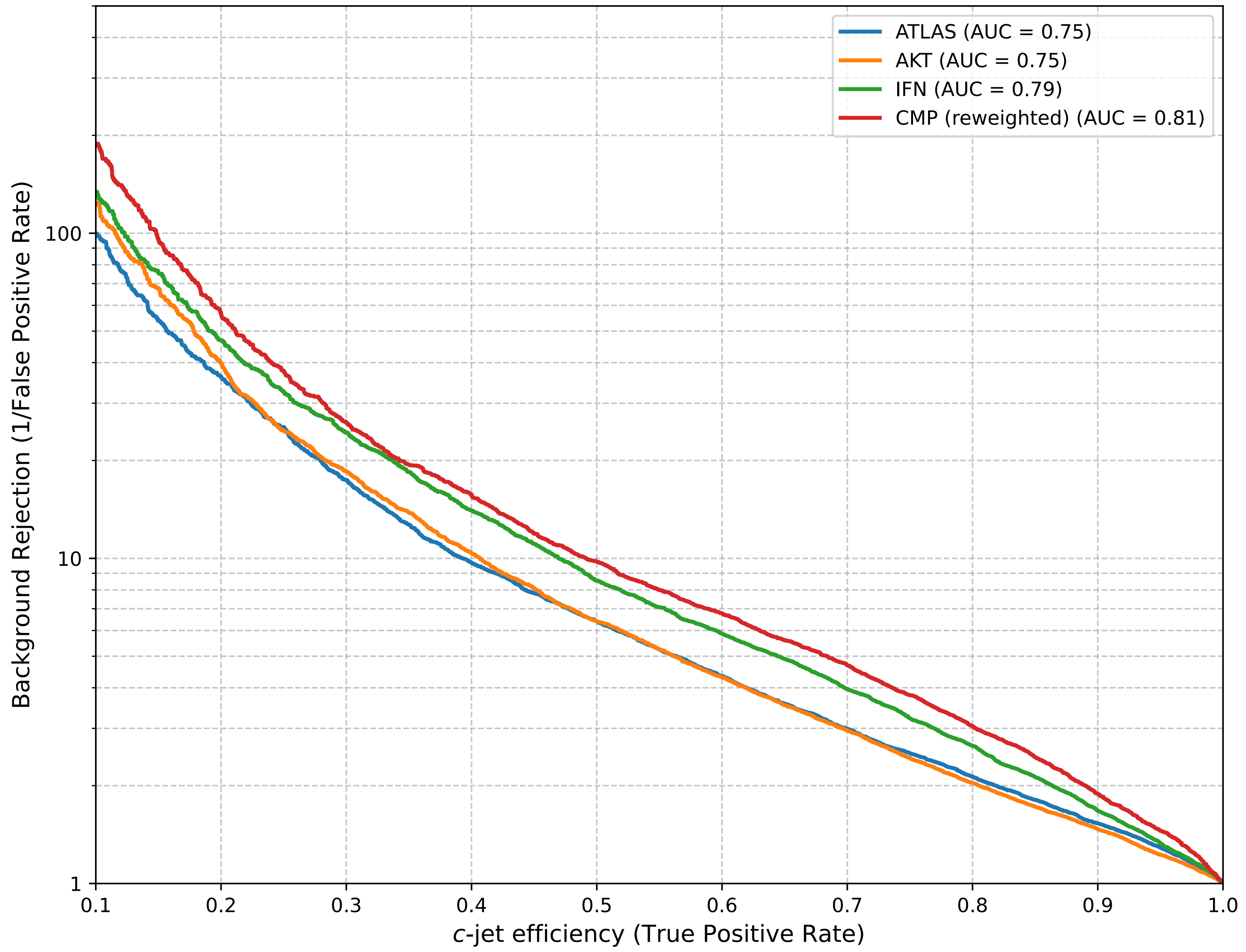
Silvia Ferrario Ravasio,
Daniel Reichelt,
Andrzej Siormok

Funded
by the
European Union

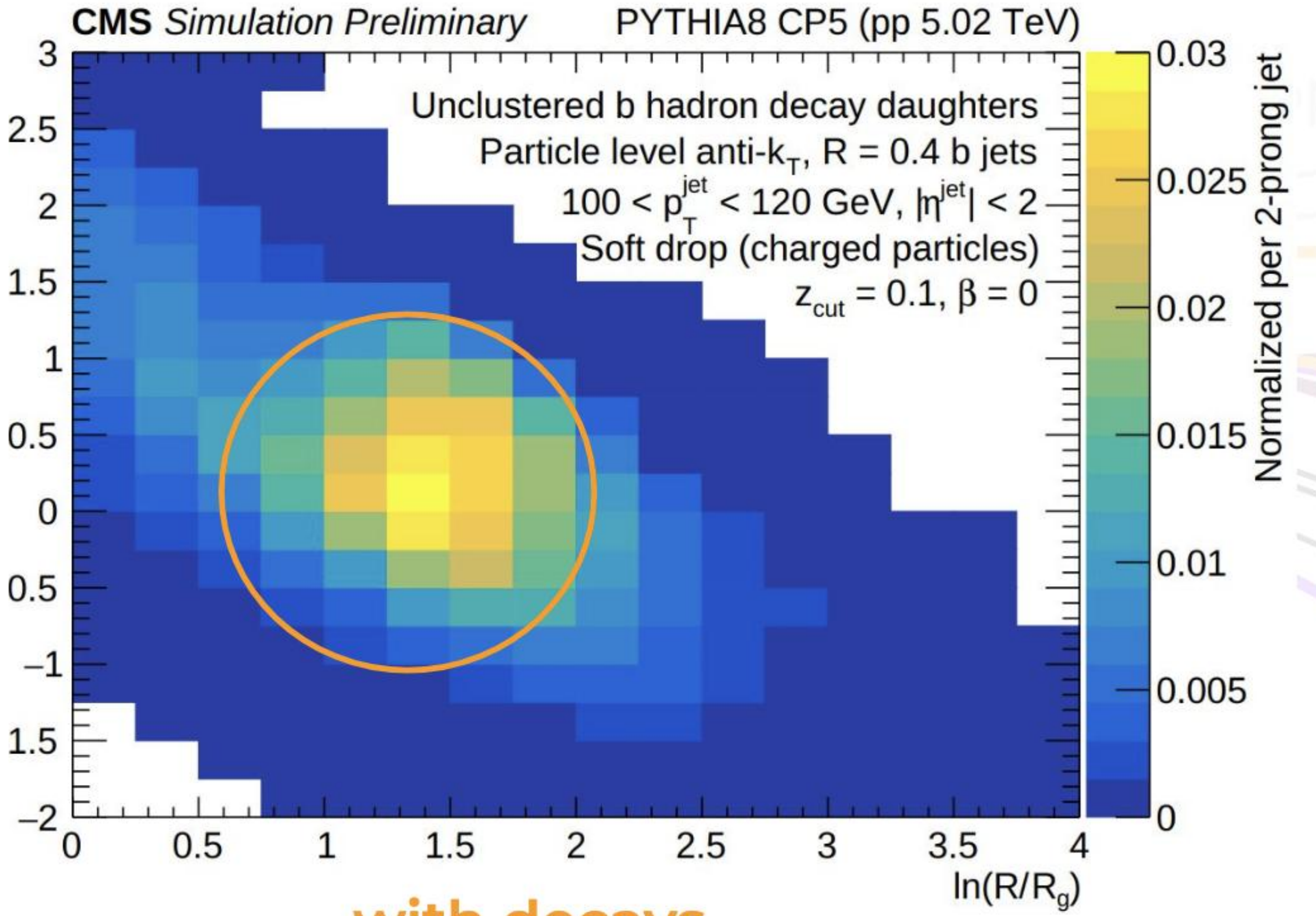
Jet Flavour Labels & JSS

- Continued discussion from LH 23
  - Train taggers with labels from **safe algorithms**

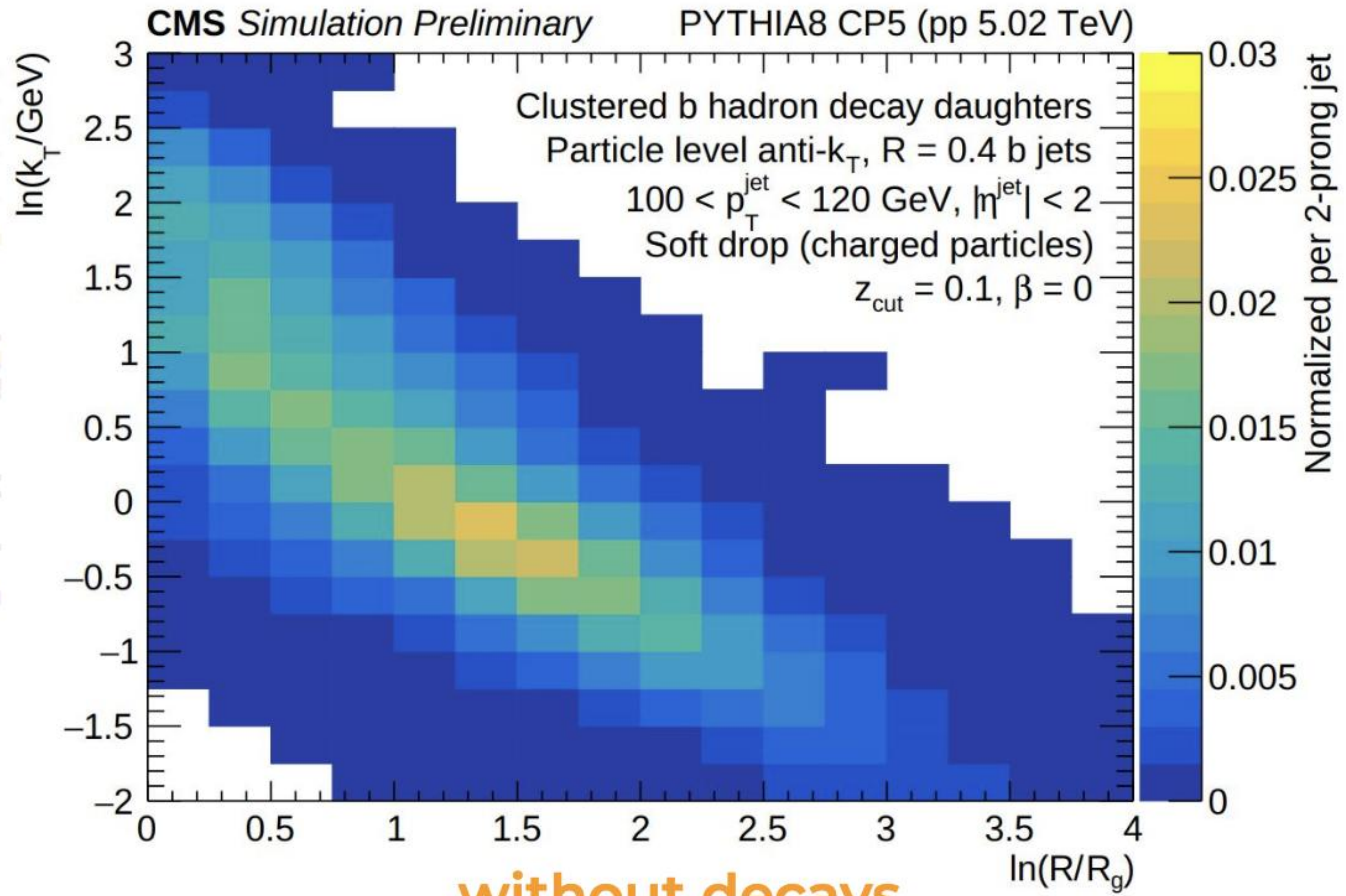
    See Alexander's talk
  - Requirements of EXP and TH for determining $g \to b\bar{b}$ **backgrounds**
  - several project ideas collected
- From MC perspective: need control over mass effects in PS and $g \to b\bar{b}/c\bar{c}$ especially
- Study stability of taggers under model variations
- Several ideas for JSS studies (JSS in ee, Variable Radius Jets, Subjet flavor studies) in various early stages



First results from training, thanks Radek!



with decays

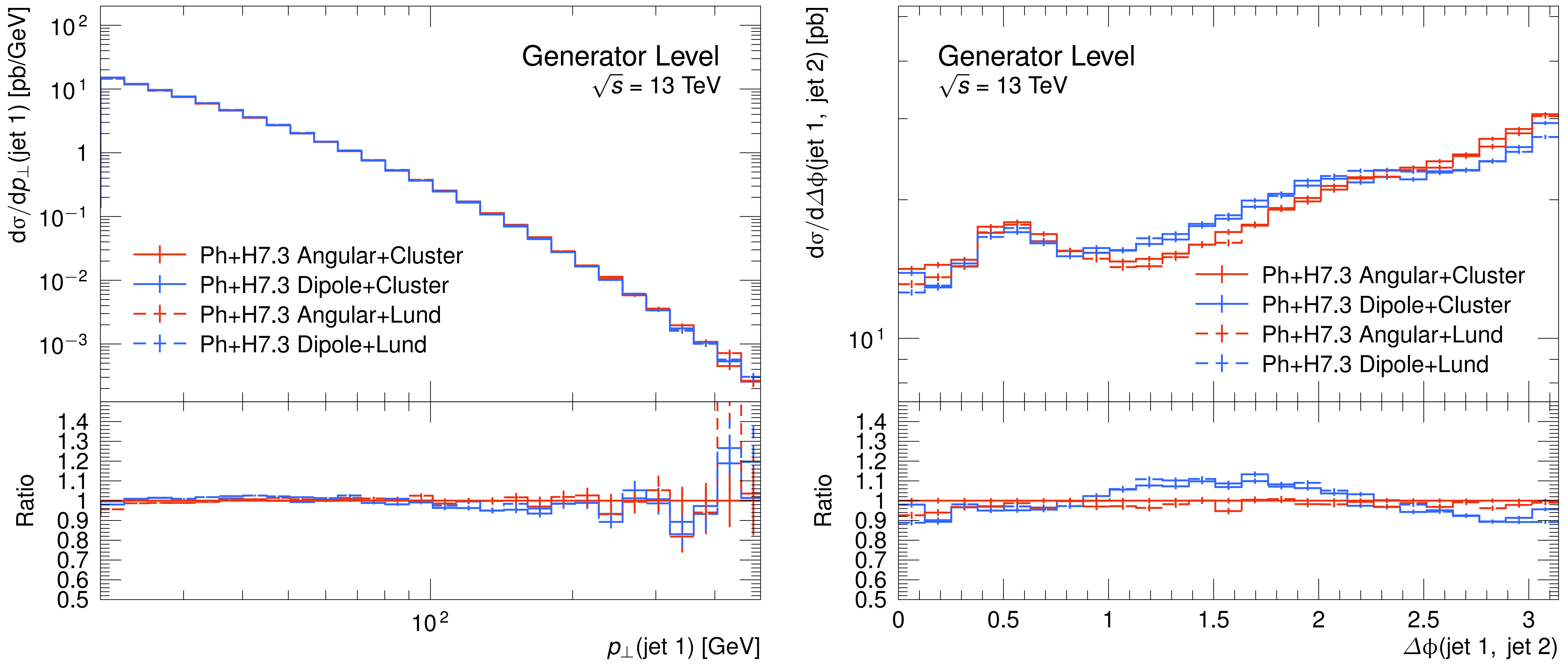


without decays

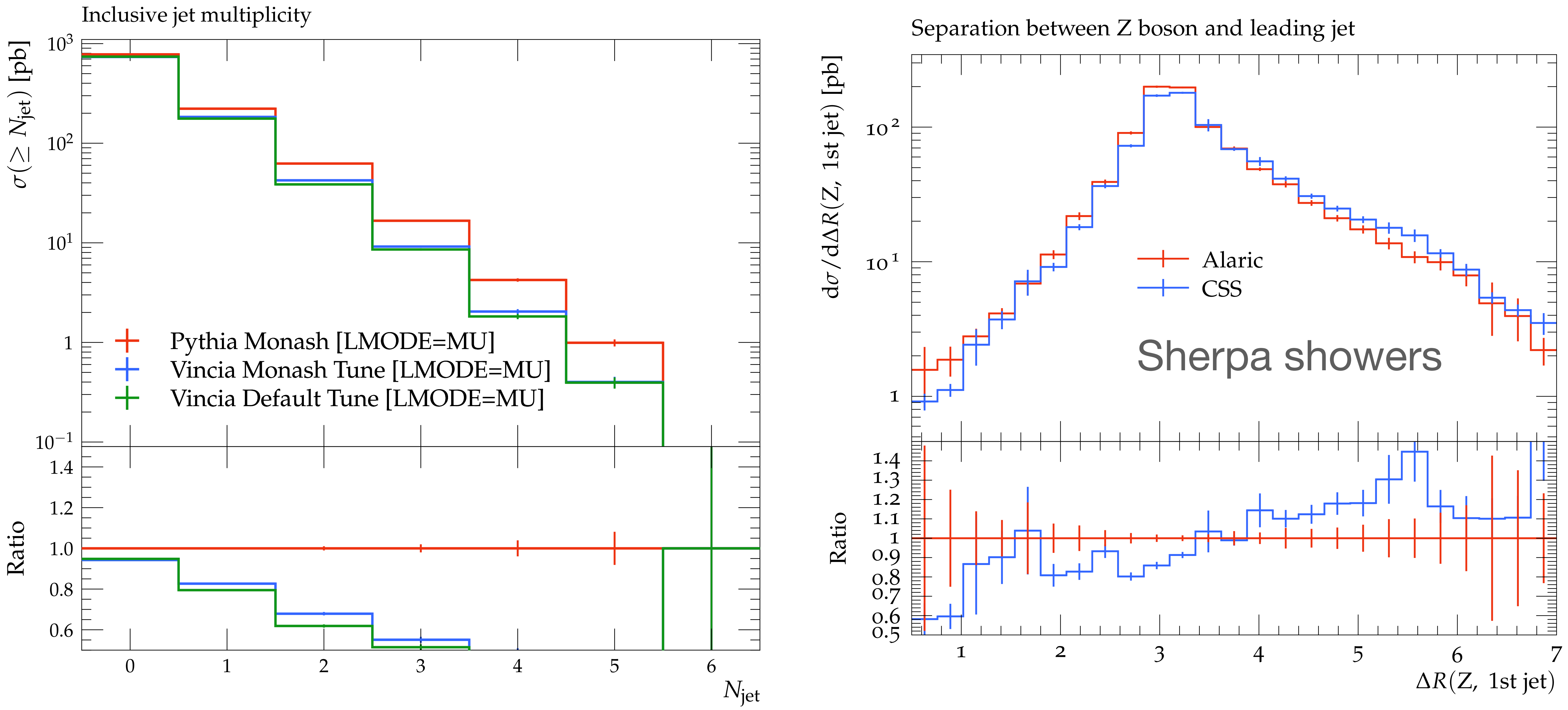
JSS with B tagged jets, from discussion with Mario Campanelli on Monday

PS Uncertainties

- LH23 disucssion: replace Event Generator variation by more systematic variation of components
- Example: Herwig AO with cluster vs. lund hadronisation, Herwig vs. Pythia showers
- LH Update: Additional datapoints from Sherpa CS (current default) and Alaric with string hadronisation, Pythia default shower vs. Vincia



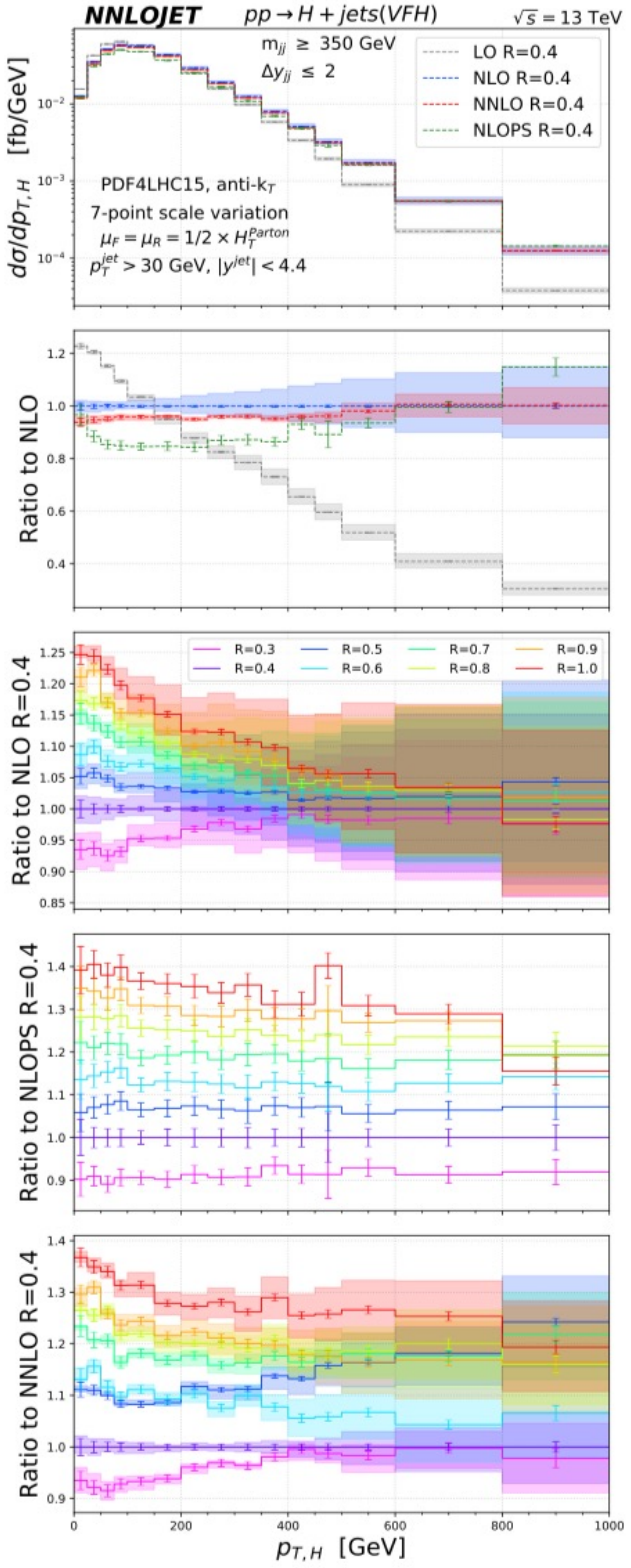
ATLAS update from Betsy



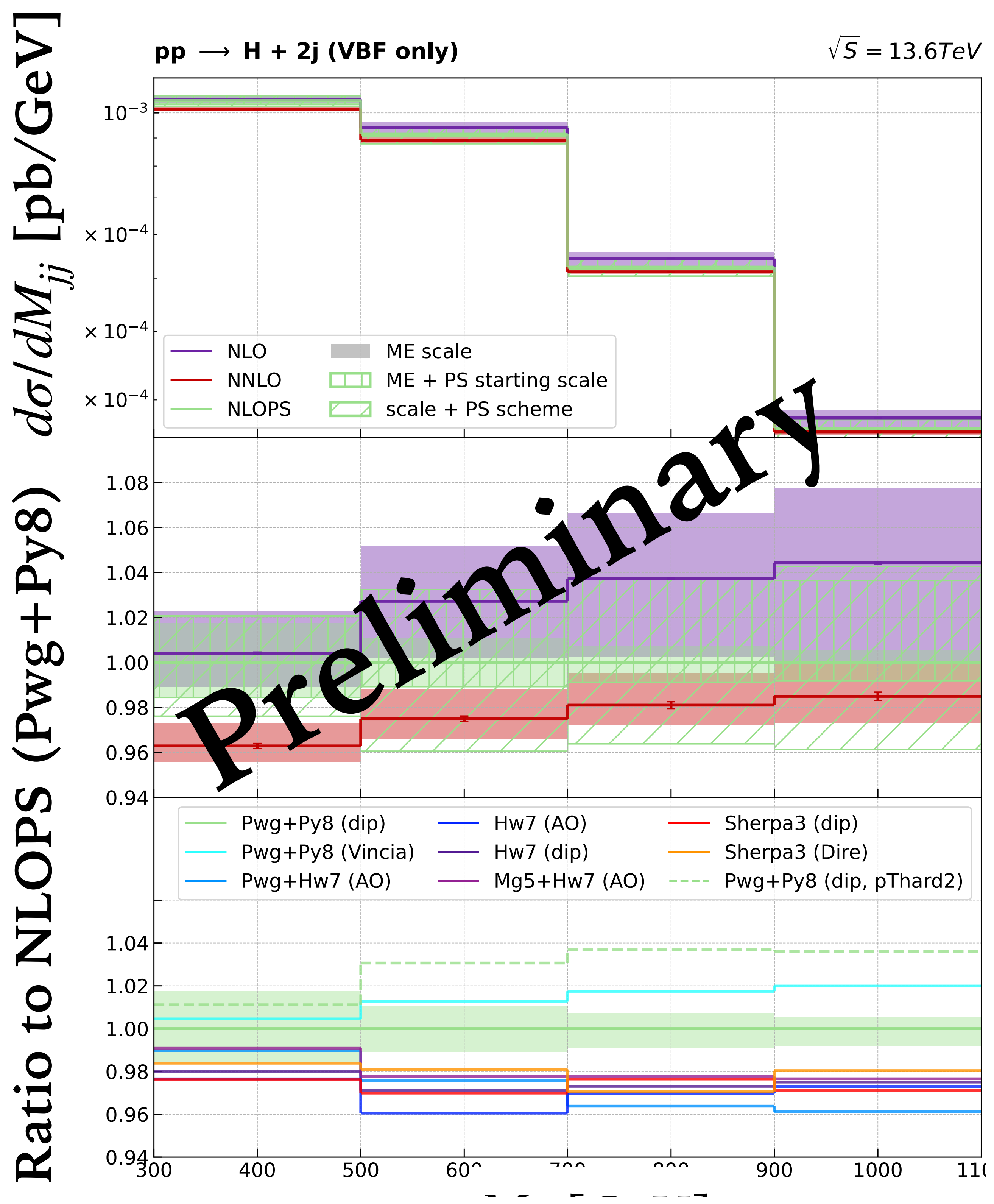
Preliminary runs from last week (thanks Baris!)

PS Uncertainties in Higgs+Jets

- Recurring topic in Les Houches
  - Last year started efforts for **VBF** matching+shower uncertainties, and **ggF study** including NNLO and NLO merging
  - Next step: Systematics with new showers (Alaric, Apollo, PanScales, … others?)
    - not all pieces together yet in any of the frameworks, but can start for example Higgs+jet merged/ME corrected study
    - opportunity to think about regions where different parts of the simulation are important



arXiv:2105.11399



See Silvia’s opening talk

Negative weight suppression

Les Houches updates:

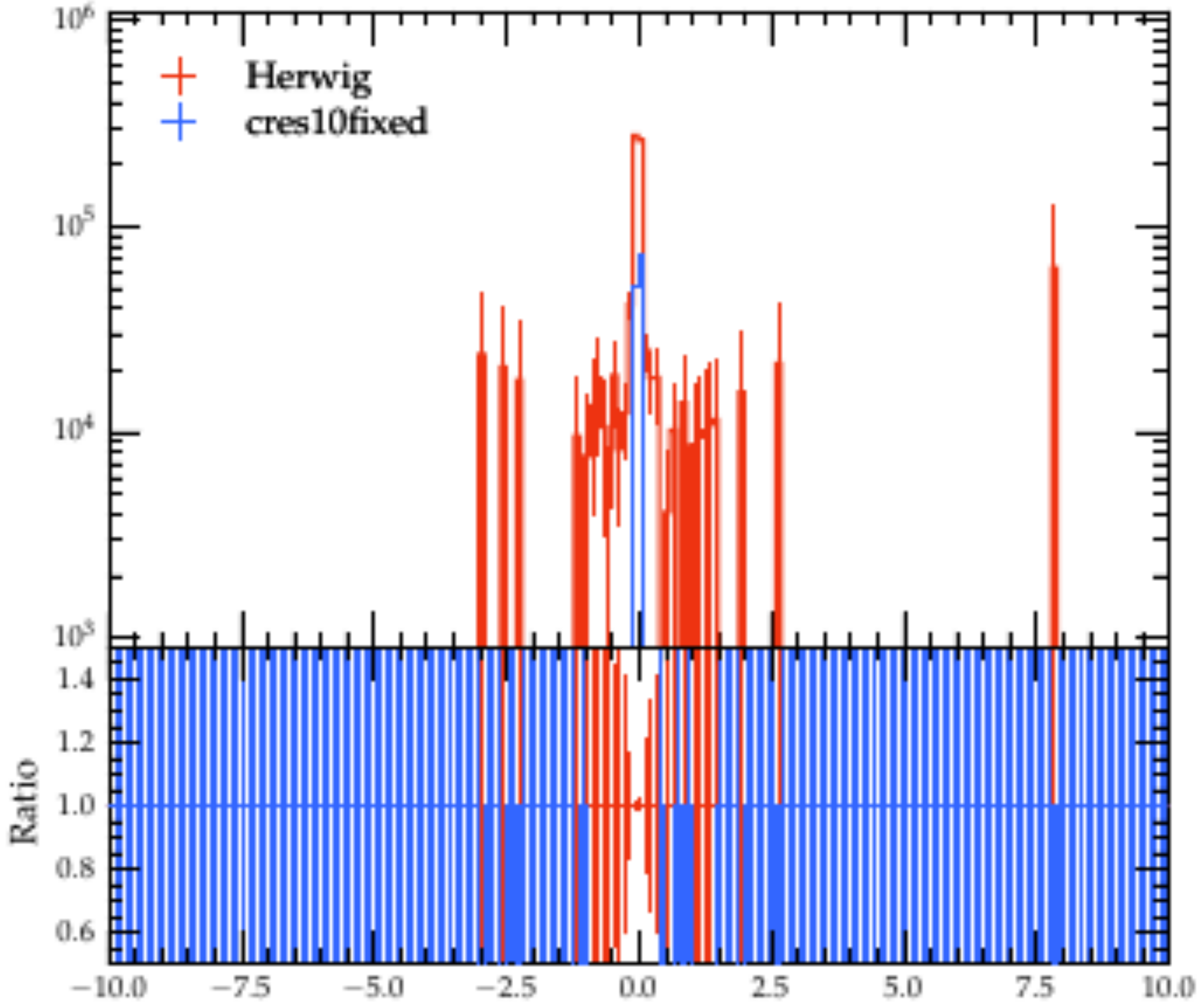
- Rivet analysis written to study negative weights in even samples

  MC_WEIGHTS ↦ LH_WEIGHTS

Example:

- HERWIG NLO correlated event sample for WJJ used for testing (J. Whitehead)

$d|w|/dw$ on the other hand illustrates the problem better.
`MC_WEIGHTS` modified to have several such histograms with varying x-axis.
Variance reduction when using cres clear.



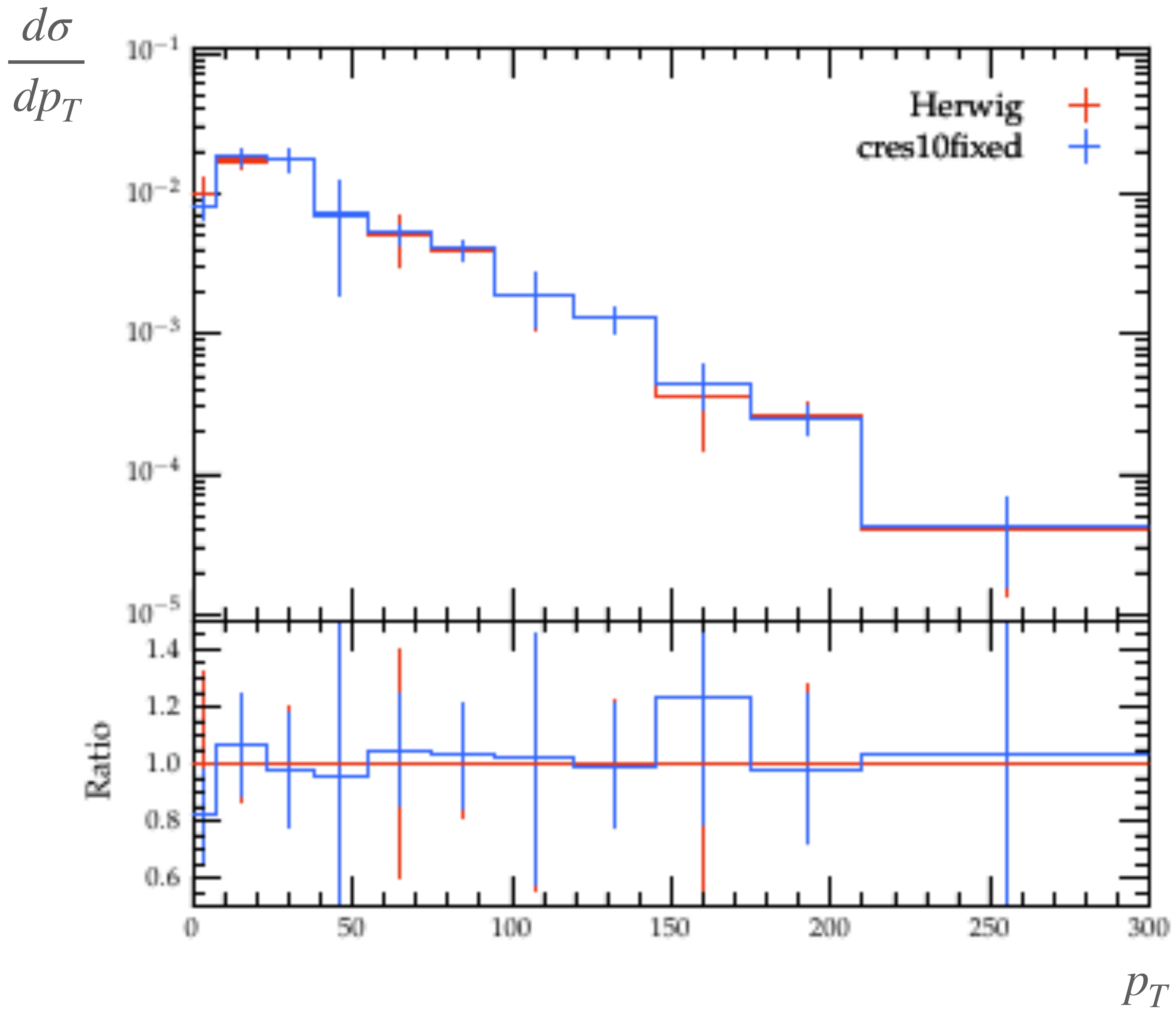
Negative weight suppression

Les Houches updates:

- Rivet analysis written to study negative weights in even samples
  MC_WEIGHTS ↦ LH_WEIGHTS

Example:

- HERWIG NLO correlated event sample for WJJ used for testing (J. Whitehead)
- CRES: Distributions statistically equivalent
- Statistical tests, e.g. two-sample Kolmogorov-Smirnov pT



Negative weight suppression

- Rivet analysis written to study negative weights in even samples

MC_WEIGHTS ↦ LH_WEIGHTS

Plan to apply it on ATLAS MC sample to create new “whish list”

Aside | Negative event weights

- Any development here would be much appreciated…

- We cannot afford to run full simulation on samples with negative weight fraction >25%
  - Starting to become a deal-breaker
- Also has knock-on effects
  - For e.g. huge W/Z samples for high precision analyses we cannot currently use MC@NLO-like matching schemes.

Sample	DSID	Fraction of events with neg. weights [%]
Sherpa (lepton+jets)	364345	20.5
Sherpa (lepton+jets)	364346	20.4
Sherpa (dilepton)	364347	20.4
Sherpa ttbb (lepton+jets, CSSKIN, 4FS)	410329	24.4
Sherpa ttbb (lepton+jets, CMMPS, 4FS)	410335	25.7
aMC@NLO+Py8 (lepton+jets)	410441	23.7
aMC@NLO+Py8 (dilepton)	410442	23.7
aMC@NLO+Py8 (FxFx, 70 GeV)	410452	28.4
aMC@NLO+H++ (4FS, ttbb)	410245	37.2
Powheg+Herwig7 (lepton+jets)	410557	0.4
Powheg+Herwig7 (dilepton)	410558	0.4

9 Josh McFayden | MCnet | 11/4/2018

Reduction of negative weights in Matching PS + NLO

- ESME, Powheg, KrkNLO, …

Non-perturbative physics modeling in Monte Carlo event generators

- Idea: **scrutinise hadronisation models using analytic insights** and not data

- Starting point: extend **2404.09856** (Hoang, Jin, Plätzer, Samitz) to comprise several **parton shower**, **hadronisation** models, and **observables**

Thrust
C-parameter
Energy-energy correlators

Angular-ordered (Herwig7, NLL)
Catani-Seymour dipole (Herwig7, Sherpa3, LL)
PanLocal dipole (PanScales, NLL)
PanGlobal antenna (PanScales, NLL)
Alaric dipole (Sherpa, NLL)

Cluster model
String model

M. Van Beekveld, S. Ferrario Ravasio, A. Hoang, K. Lee, I. Moult, S. Plätzer, D. Reichelt, J. Roloff, A. Siodmok, P. Sarmah, G. Vita, your name???

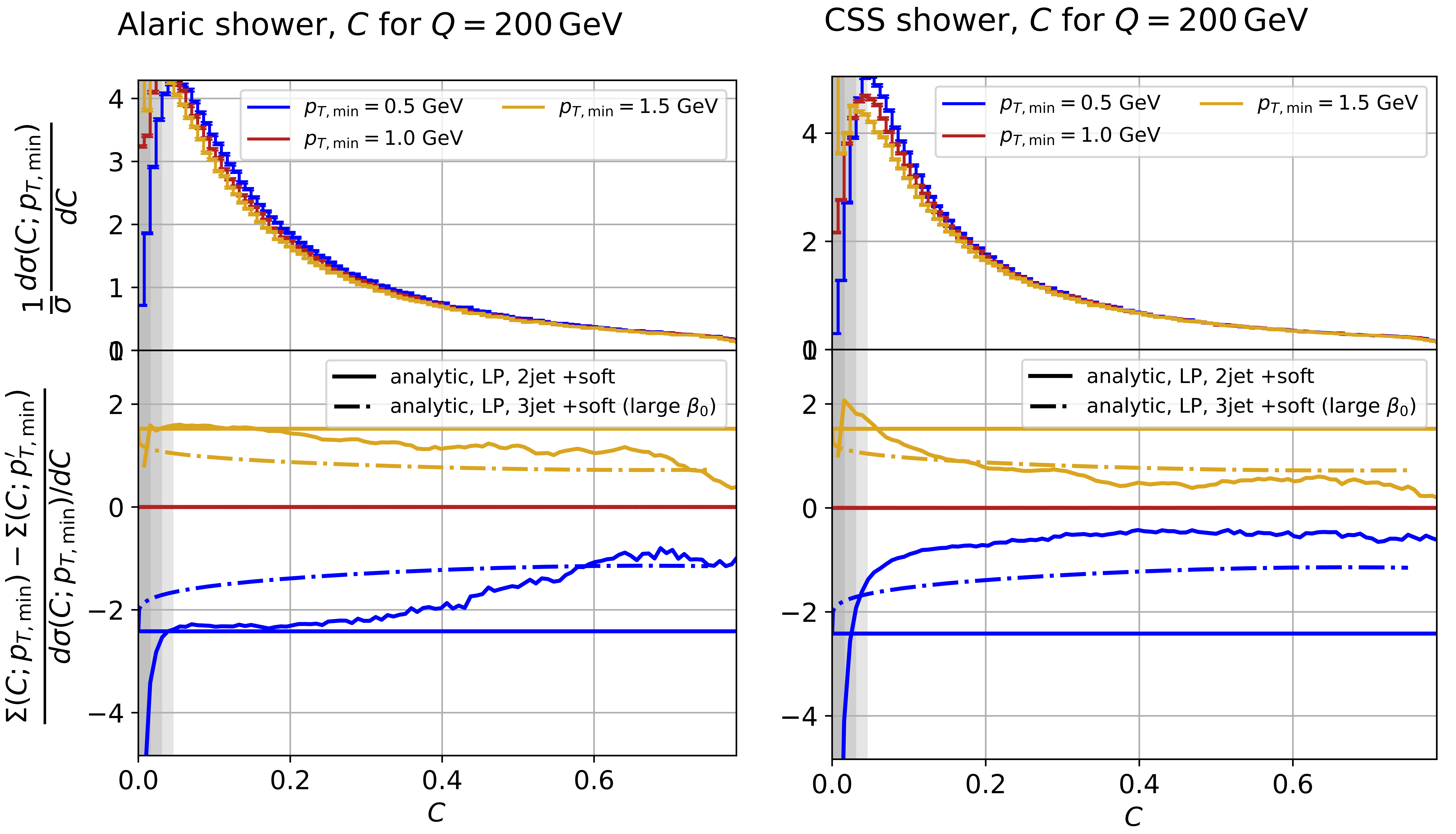
Cutoff dependence

- Warmup: **cutoff** dependence on the distributions.
 The renormalisation scales of parton showers is the $p_\perp$ of the emission: hence, all showers have a $p_{\perp,\,\mathrm{min}}$ cut to terminate the perturbative evolution.

- For **1- Thrust** and **C-Parameter**:

$$\Sigma_{\mathrm{PS}}(v; p_{\perp,\,\mathrm{min}}, \sqrt{s}) - \Sigma_{\mathrm{PS}}(v; p'_{\perp,\,\mathrm{min}}, \sqrt{s}) = \frac{d\Sigma}{dv}\frac{1}{\sqrt{s}}\int_{p'_{\perp,\,\mathrm{min}}}^{p_{\perp,\,\mathrm{min}}} d\mu\, \frac{2C_F}{\pi}\alpha_s(\mu)\,\Delta_{v,\mathrm{soft}}$$

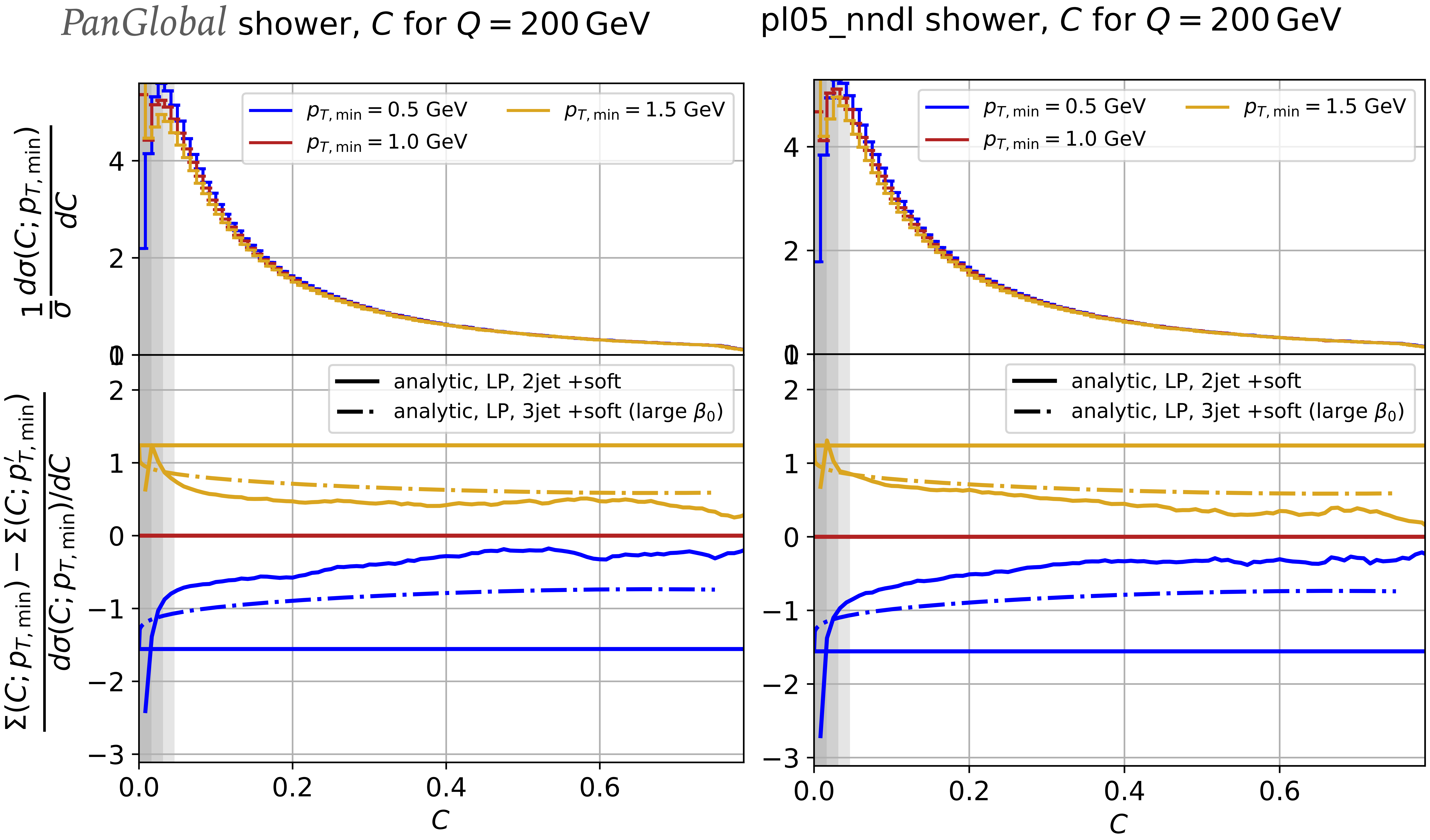
Cutoff dependence for the C-parameter: Sherpa



Solid line:
PLB 339 (1994) 148-150

Dash-dotted:
JHEP12(2022)062

Cutoff dependence for the C-parameter: PanScales



Solid line: PLB 339 (1994) 148-150

Dash-dotted: JHEP12(2022)062

Cutoff dependence

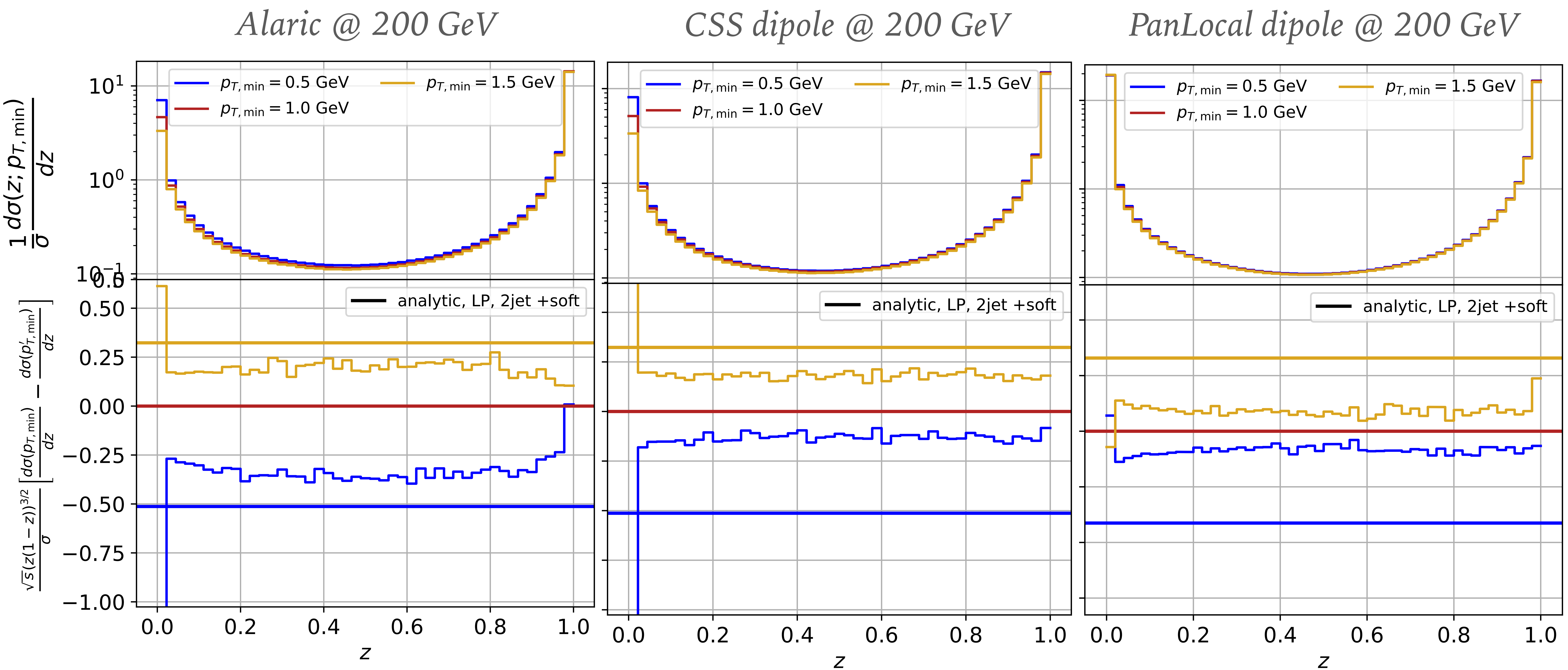
- Warmup: **cutoff** dependence on the distributions.
  The renormalisation scales of parton showers is the $p_\perp$ of the emission: hence, all showers have a $p_{\perp,\,\mathrm{min}}$ cut to terminate the perturbative evolution.

- For EEC:

$$\frac{d\sigma(z, p_{\perp,\,\mathrm{min}}, \sqrt{s})}{dz} - \frac{d\sigma(z, p'_{\perp,\,\mathrm{min}}, \sqrt{s})}{dz} = \frac{1}{2\sqrt{s}(z(1-z))^{3/2}} \int_{p'_{\perp,\,\mathrm{min}}}^{p_{\perp,\,\mathrm{min}}} d\mu\, \frac{2C_F}{\pi} \alpha_s(\mu) \Delta_{\tau,\mathrm{soft}}$$

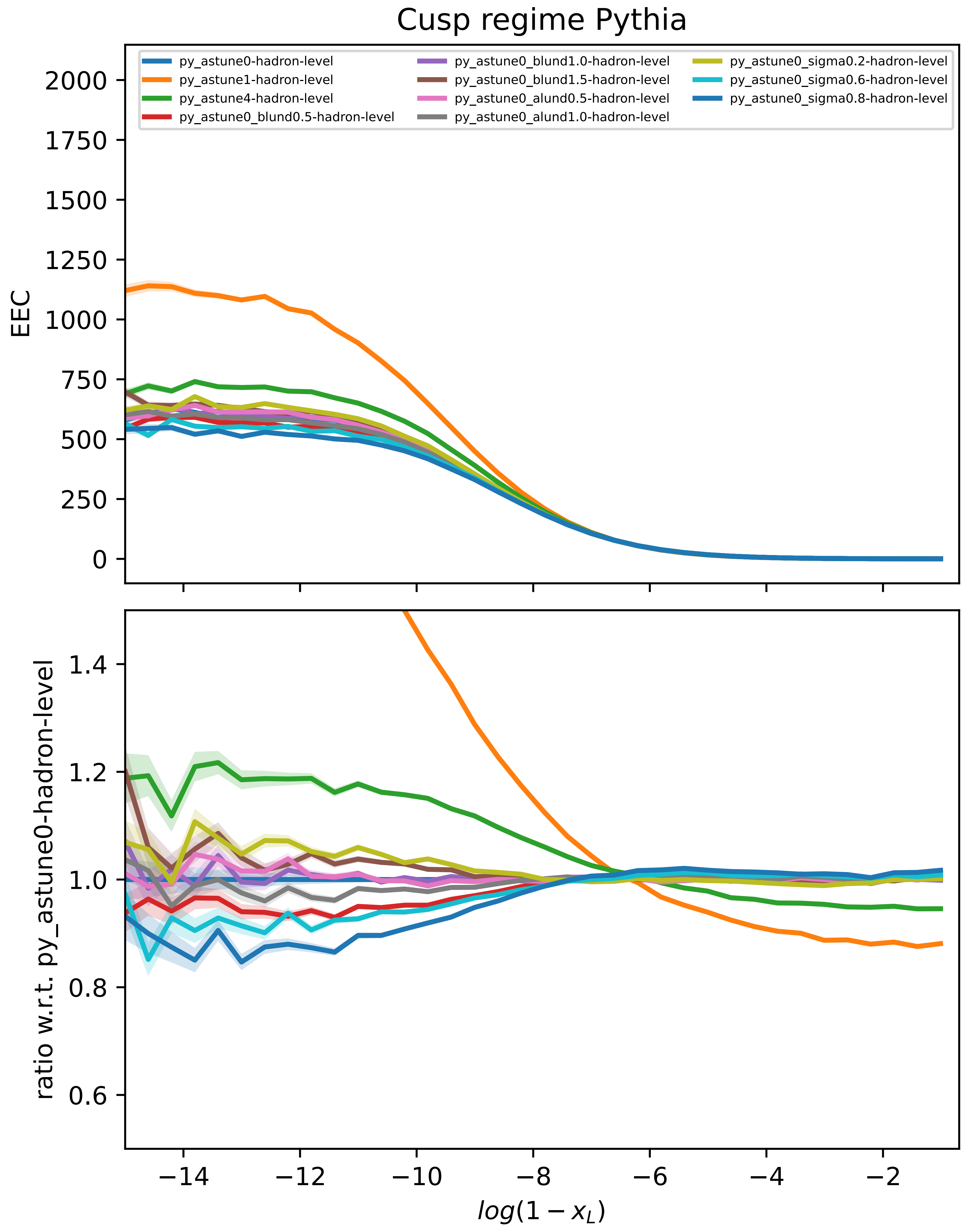
$$\frac{d\sigma}{dz} = \int \frac{d\sigma}{d\Phi} d\Phi \sum_{i,j} \frac{2E_i E_j}{s} \delta\left(z - \frac{1-\cos\theta_{ij}}{2}\right)$$

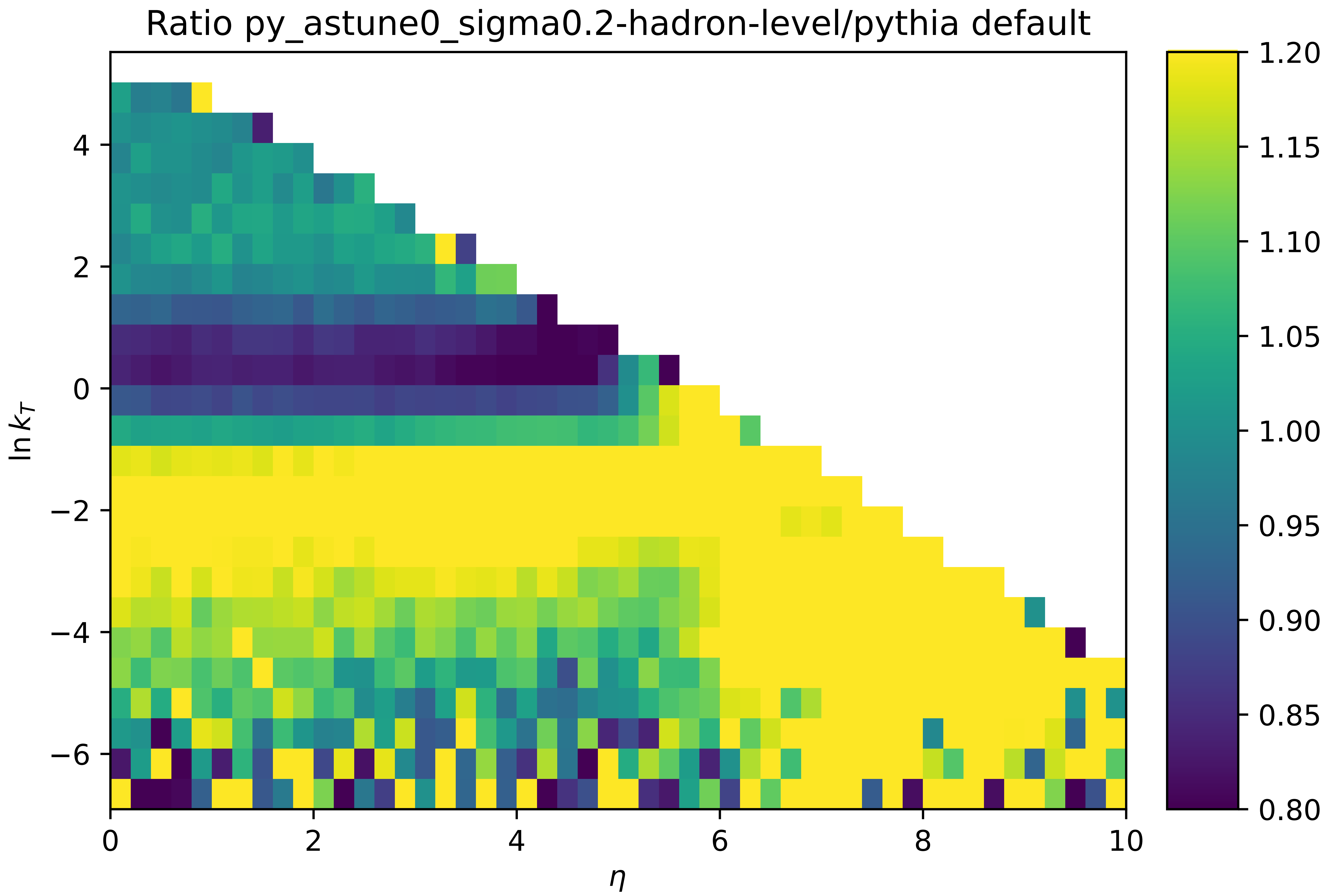
Cutoff dependence for the EEC



Hadronisation Corrections

- Evaluate EECs and Lund Plane in clean $e^+e^- \to \text{jets}$ environment

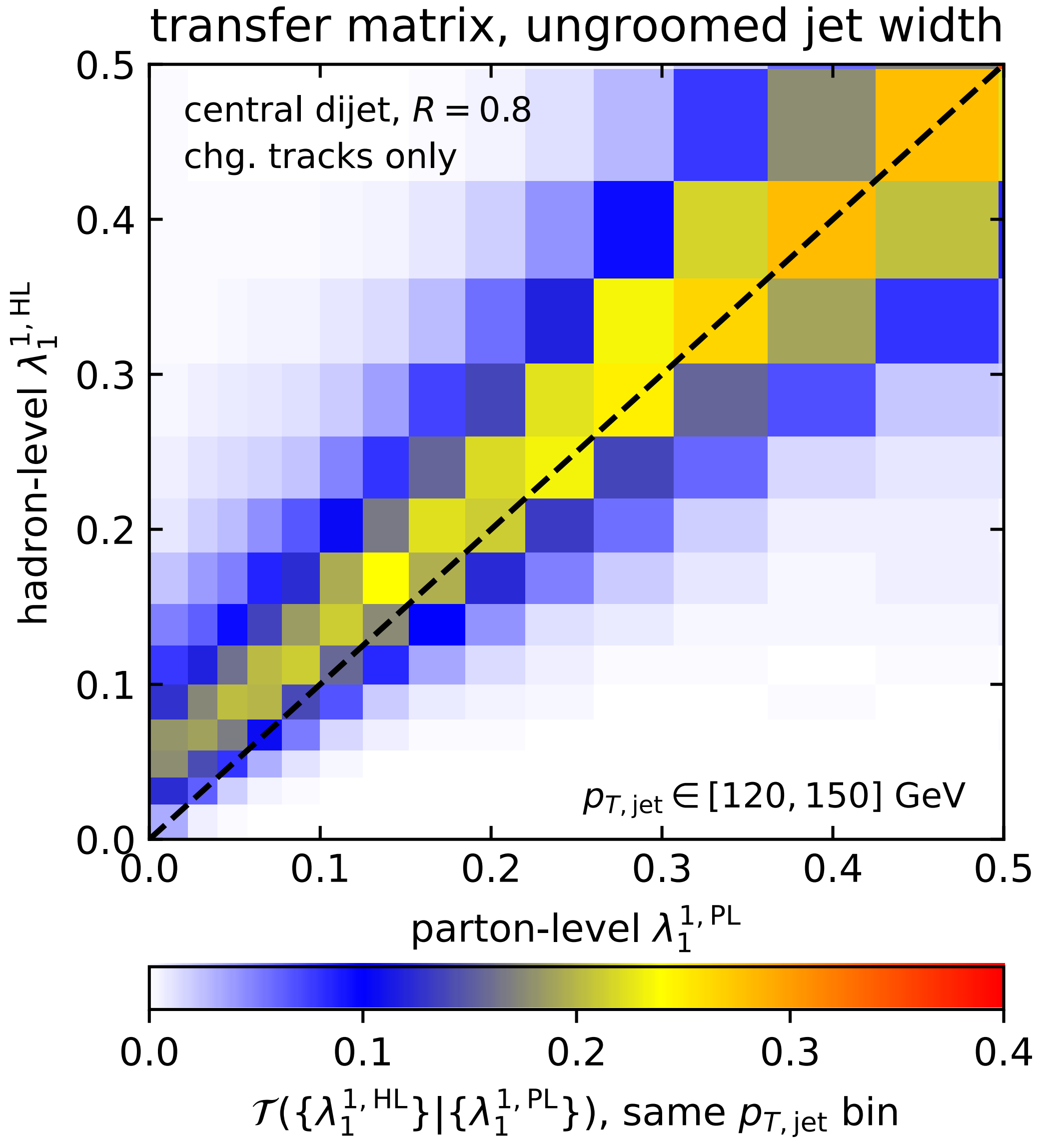




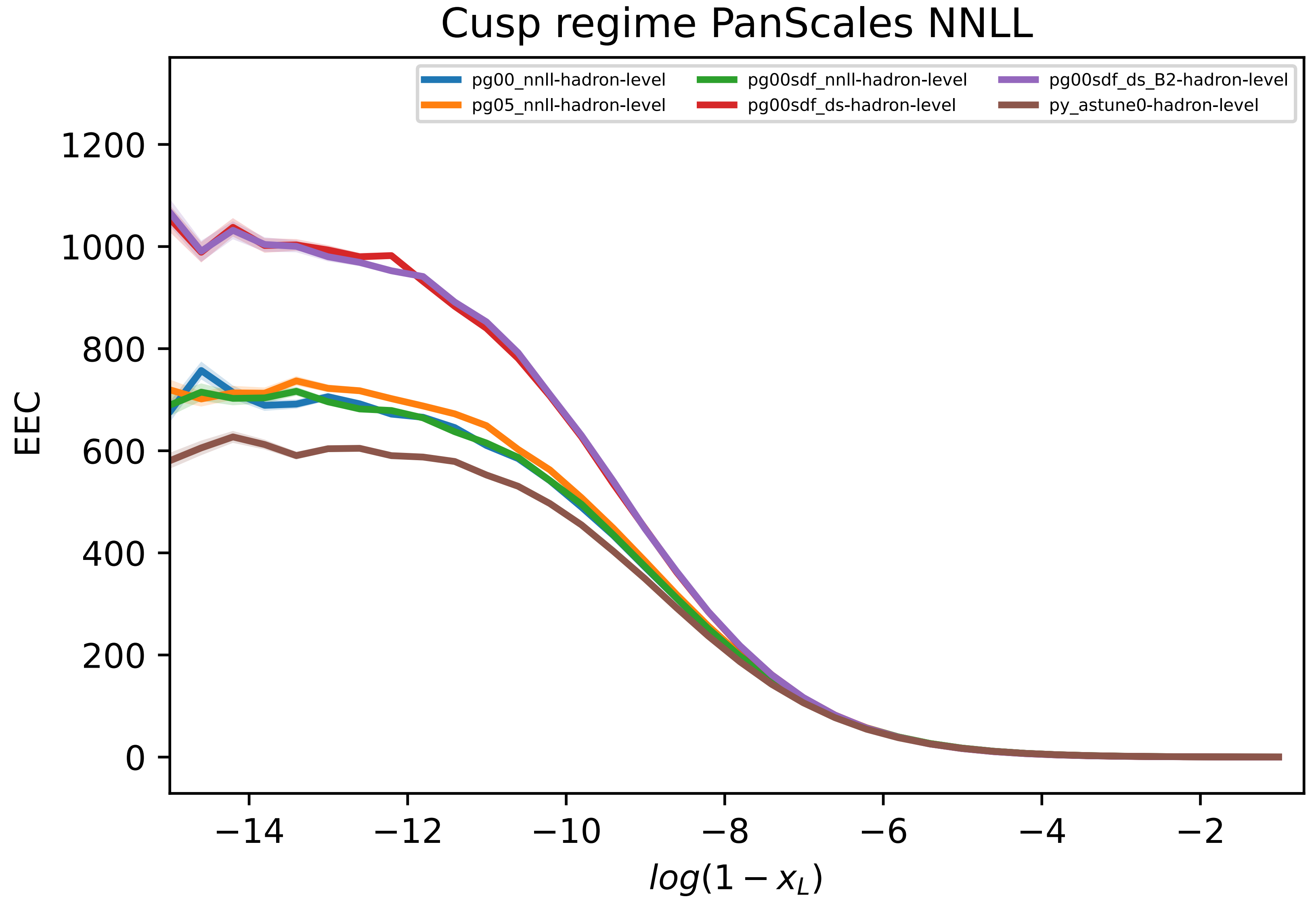
Lund Plane and EEC, thanks Melissa for the plots!

Next Steps and Ideas…

- Study cutoff dependence of corresponding **hadronisation** models and consistency



arXiv:2112.09545



- Study Transfer Matrices and their dependence

$$\mathcal{T}(\vec{v}_h|\vec{v}_p) = \frac{\int d\mathcal{P}\, \frac{d\sigma}{d\mathcal{P}} \delta^{(m)}\left(\vec{v}_p - \vec{V}\left(\mathcal{P}\right)\right) \delta^{(n)}\left(\vec{v}_h - \vec{V}\left(\mathcal{H}\left(\mathcal{P}\right)\right)\right)}{\int d\mathcal{P}\, \frac{d\sigma}{d\mathcal{P}} \delta^{(m)}\left(\vec{v}_p - \vec{V}\left(\mathcal{P}\right)\right)}$$

- Hadronisation differences between models / tunes in EECs and Lund plane / effect of higher log showers