

Fully exclusive NNLO/NNLL calculations from



With a focus on UE sensitive observables

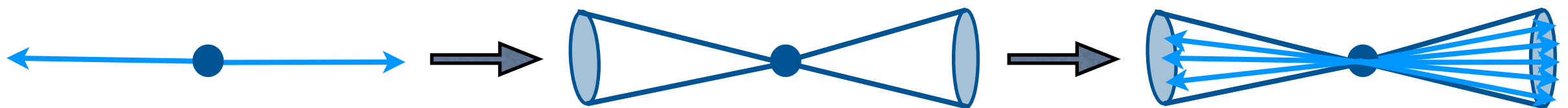
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The main spirit of GENEVA is to calculate physical jet cross-sections

Partonic cross-sections are ill-defined beyond LO in standard perturbation theory

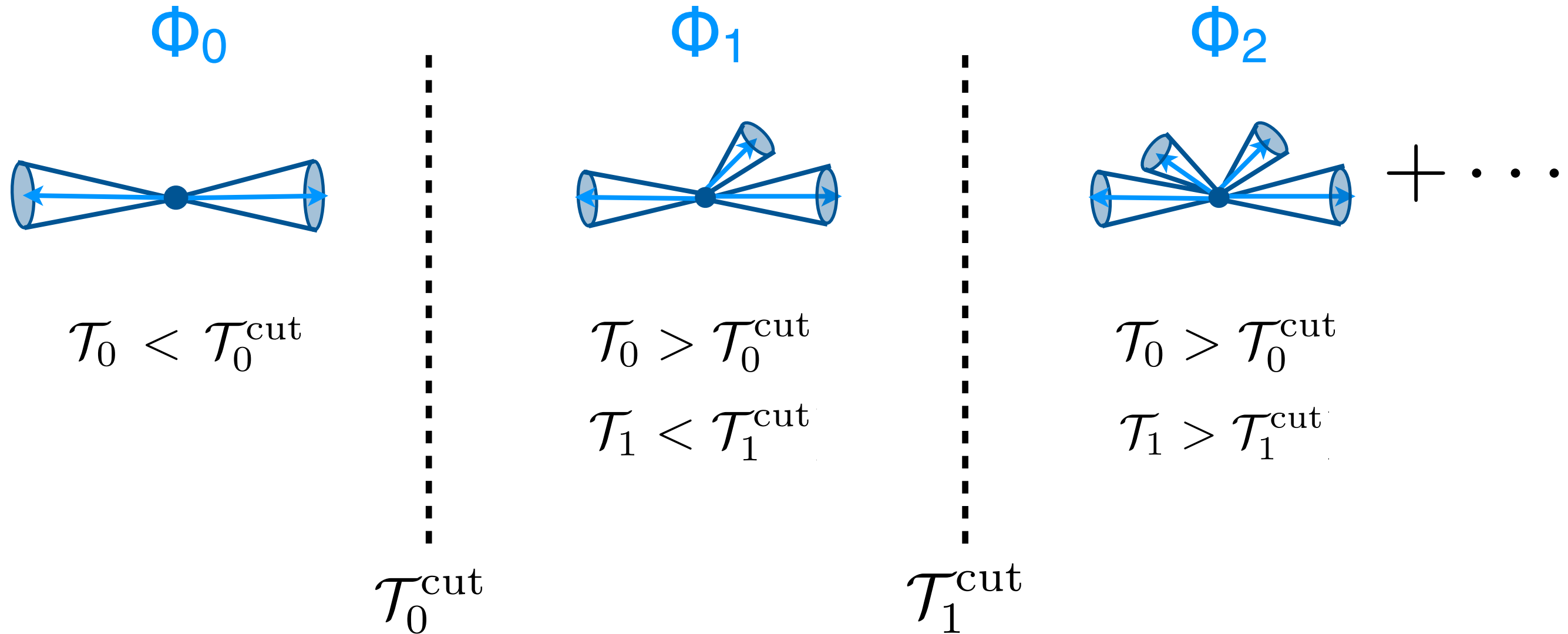
This problem is well known, and always measure and calculate jet cross-sections

Don't count number of partons, count number of jets



Do calculations for jet cross-sections, and use shower to fill out jet

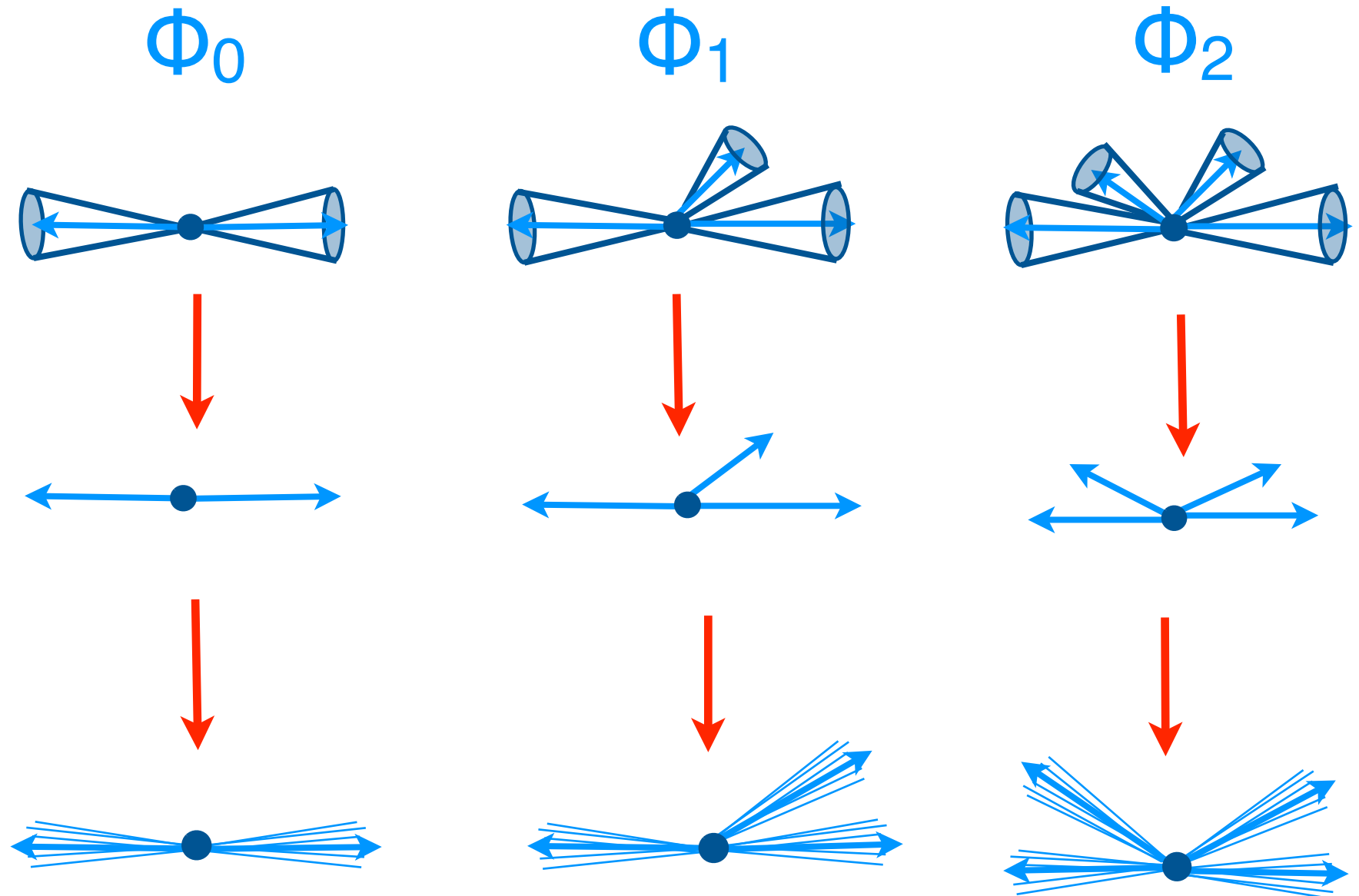
This allows us to separate the total hadronic event into different jet multiplicities



Calculate each jet cross section to desired fixed and resummed accuracy, and use shower to fill out jets with radiation

In contrast to most other Monte-Carlo generators, Geneva calculates physical jet cross-sections

- Create phase space for jet event
- Calculate cross section and assign to partonic event
- Let parton shower fill jets with radiation



The main question is what expression to use for the differential jet cross-section

$$\frac{d\sigma^{\text{MC}}}{d\Phi_N}?$$

In summary, Geneva implements the following results for the fully differential jet cross-sections

Use the full power of SCET to obtain exclusive jet distributions to given FO and resummation accuracy

	Fixed order	\mathcal{T}_0 resummation	\mathcal{T}_1 resummation
σ_0	NNLO	NNLL'	
σ_1	NLO	NNLL'	NLL
$\sigma_{\geq 2}$	LO	NNLL'	NLL

By performing high logarithmic accuracy, can choose very small values for jet separations

To interface with a parton shower, need to make integrations in partonic calculation exclusive again

	Perturbative shower constraint
σ_0	within 0-jet
σ_1	within 1-jet
$\sigma_{\geq 2}$	maintain hardest emission

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	Perturbative shower constraint	Detailed constraints
σ_0	within 0-jet	$\mathcal{T}_0 < \mathcal{T}_0^{\text{cut}}$
σ_1	within 1-jet	$\mathcal{T}_1 < \mathcal{T}_1^{\text{cut}}$ other technical details
$\sigma_{\geq 2}$	maintain hardest emission	$\mathcal{T}_2 < \mathcal{T}_1$

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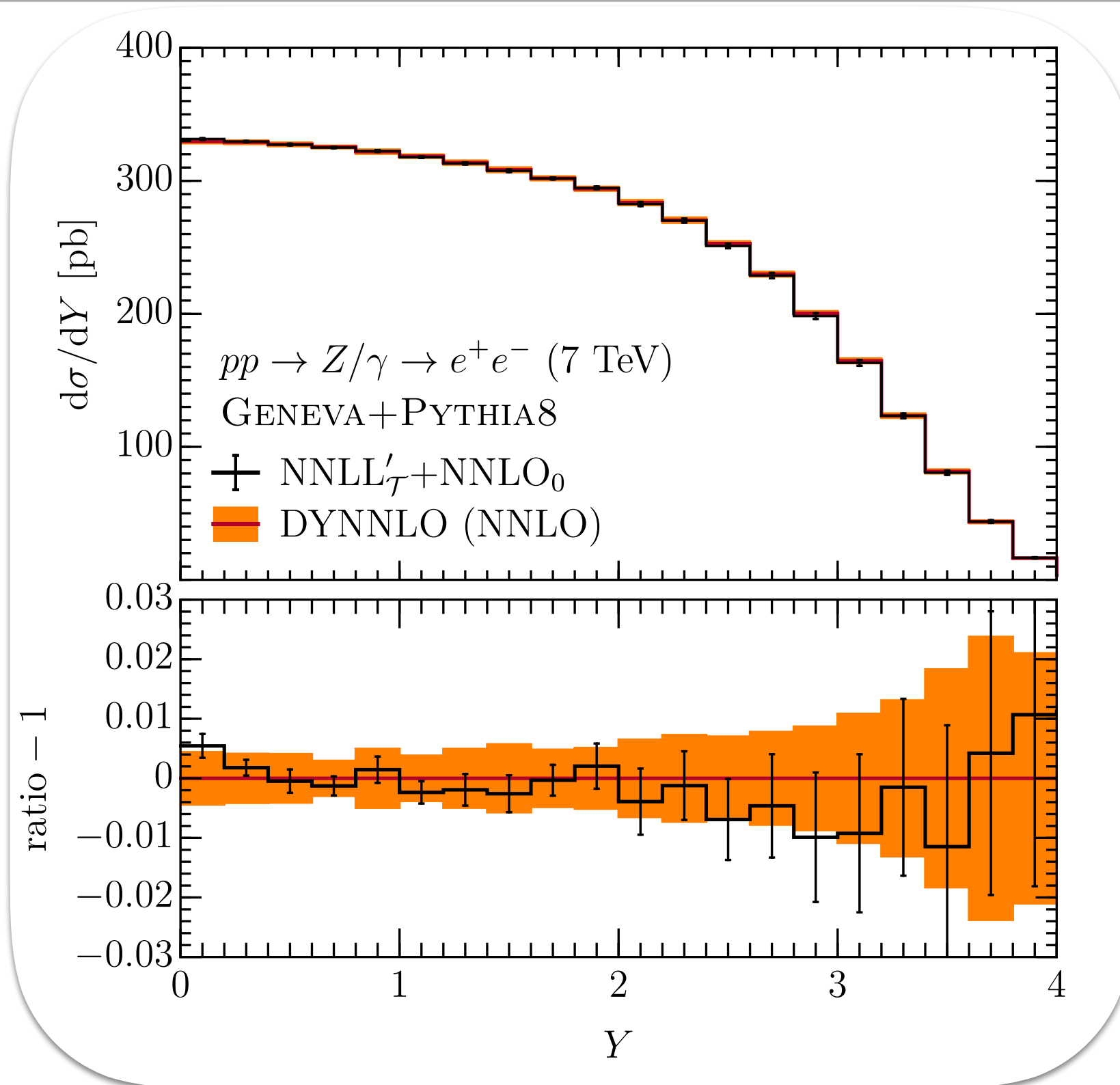
	Perturbative shower constraint	Detailed constraints
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Do first emissions in Geneva and let shower handle higher multiplicities

Before I talk about UE sensitive observables, let's briefly look at UE insensitive observables.

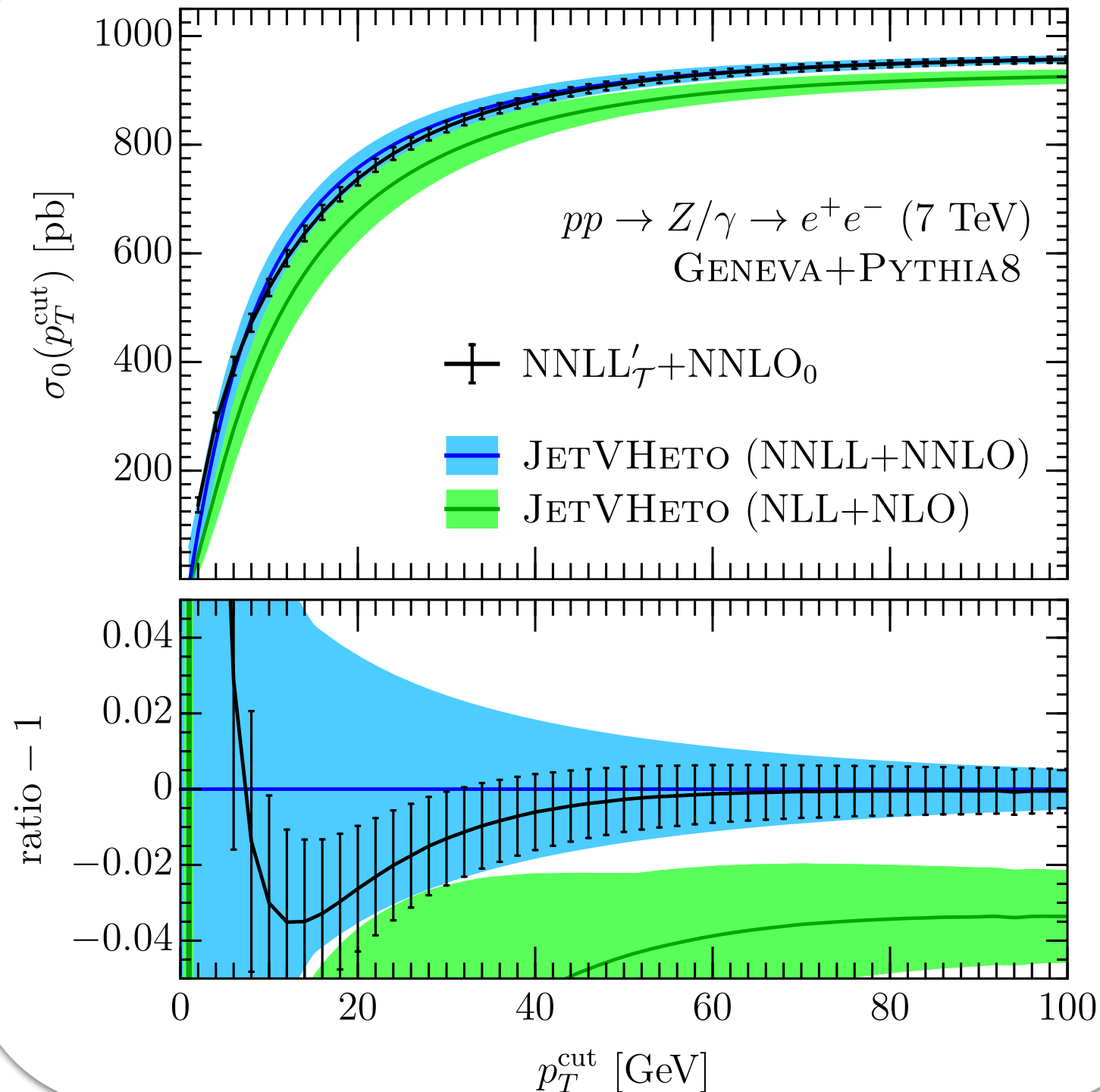
Fully inclusive Z boson spectra agree with NNLO fixed order calculation

DYNNLO: 0903:2120

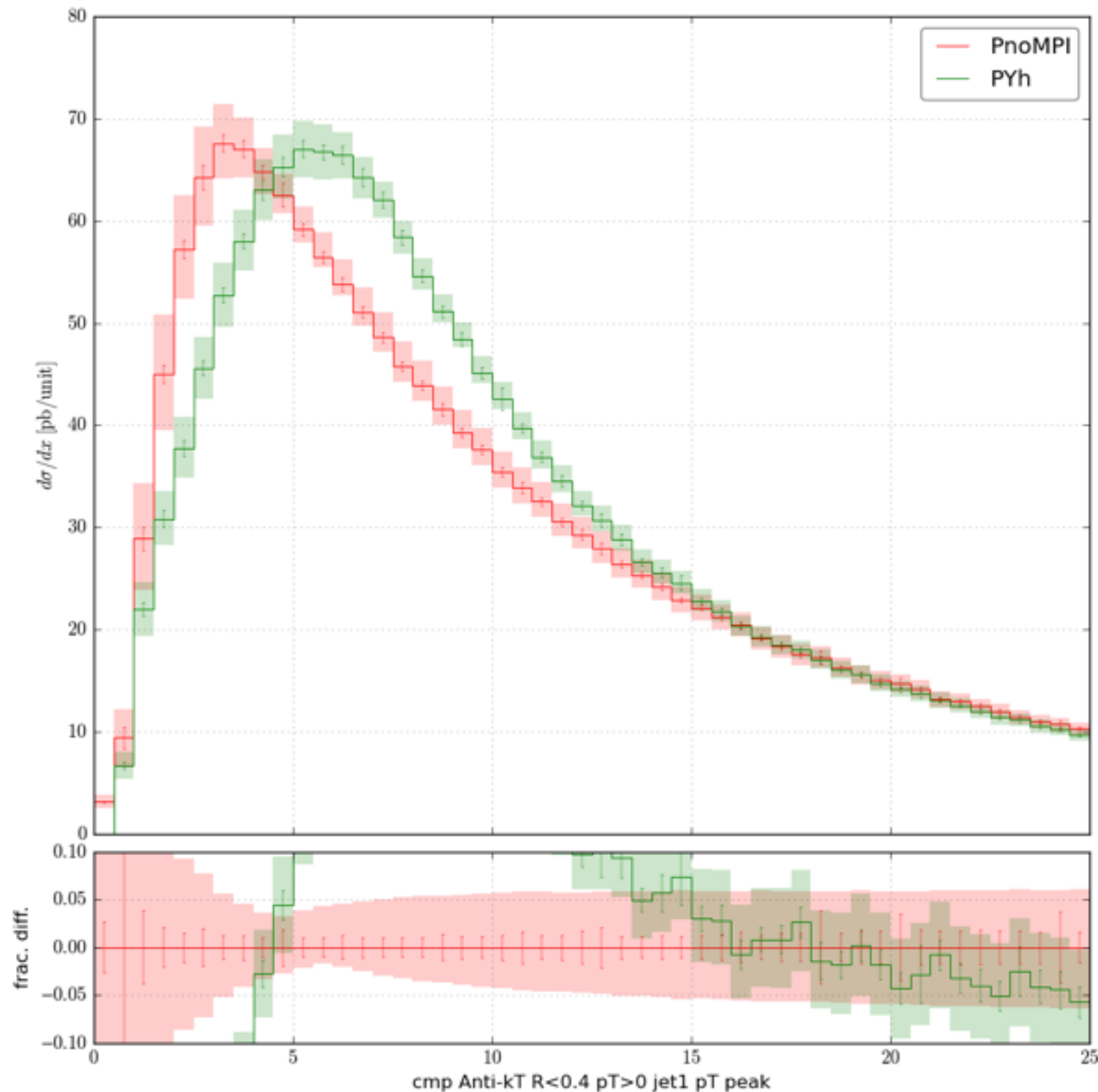


Resummed observables are predicted with accuracies which compare well with dedicated NNLL calculations

JetVHETO: 1206:4998



For jet based observables, MPI is typically a non-negligible effect



Especially at relatively low p_T , jet cross MPI can affect jet cross-section significantly

Need to understand and trust MPI predictions for testing the SM at high accuracy

Care needs to be taken to include MPI effects, since perturbative calculations included no information

The factorization formula that is starting point for the perturbative calculations in Geneva has no information about MPI effects

Geneva therefore has no perturbative information on MPI

Should therefore use the MPI model inside Pythia without any constraints

Care needs to be taken to include MPI effects, since perturbative calculations included no information

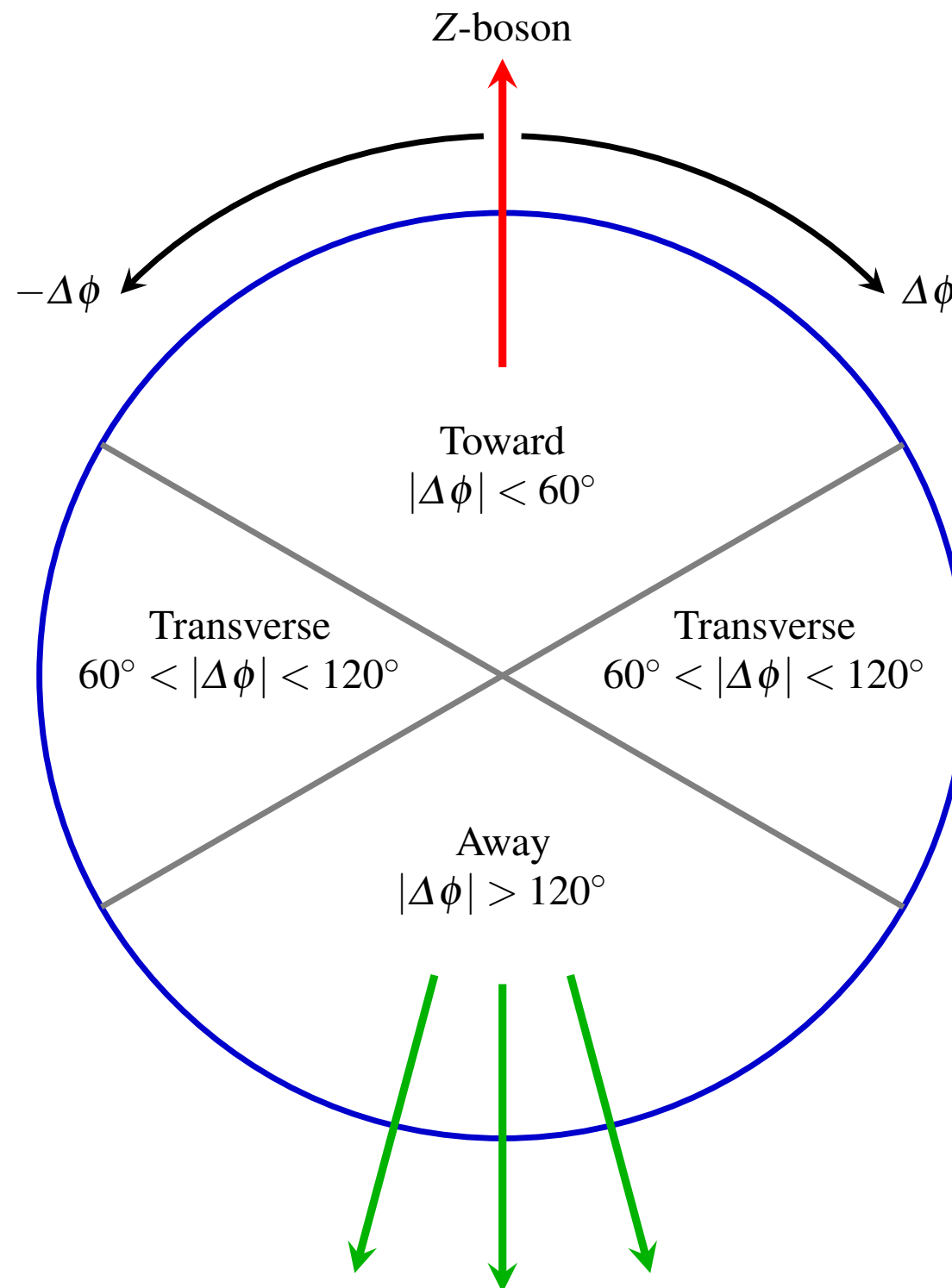
	Perturbative shower constraint	MPI constraints
σ_0	within 0-jet	None
σ_1	within 1-jet	None
$\sigma_{\geq 2}$	maintain hardest emission	None

Technically, needs to take into account that MPI is interleaved with showering of primary event

Results for UE sensitive observables

UE sensitive observables typically measure observables in a region transverse to the primary interaction

Phys. Rev. D65 092002



Several physics effects contribute to the UE sensitive observables

- MPI effects
- Soft radiation of the primary interaction
- Hadronization effects of MPI and primary partons
- ...

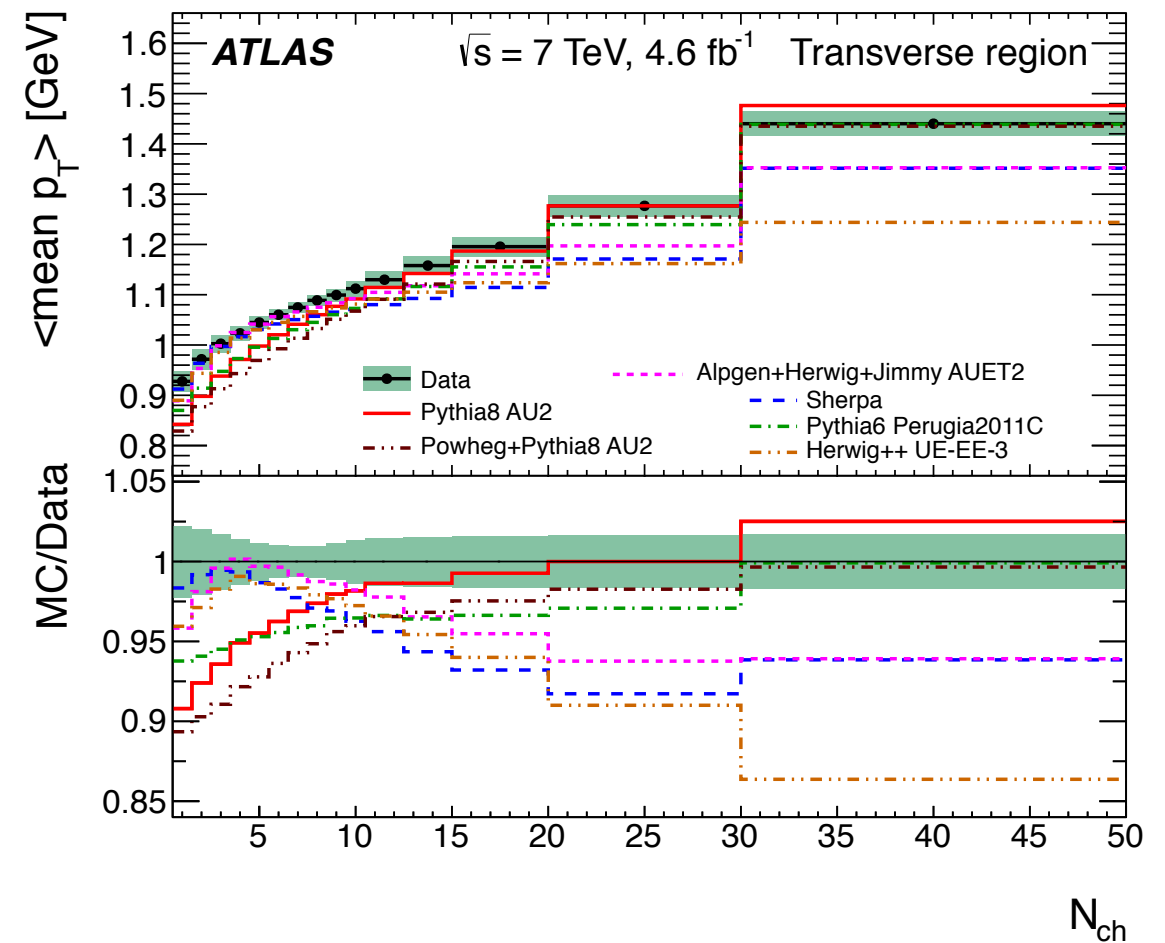
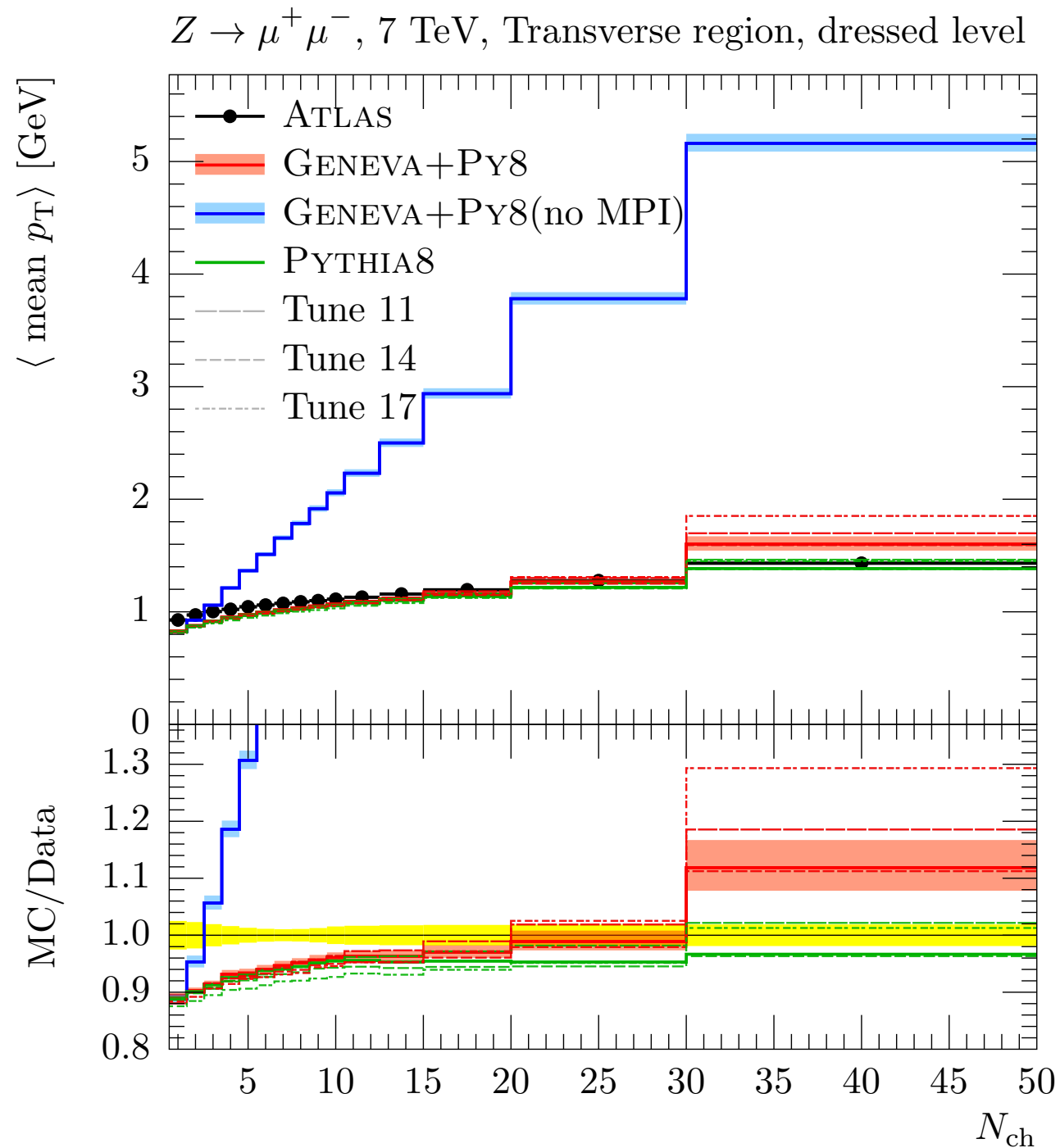
An important question is how to separate these various different effects

Will come back to this later

ATLAS has measured several standard UE sensitive observables

ATLAS arXiv:1409.3433

$\langle p_T \rangle$ vs number of charged tracks

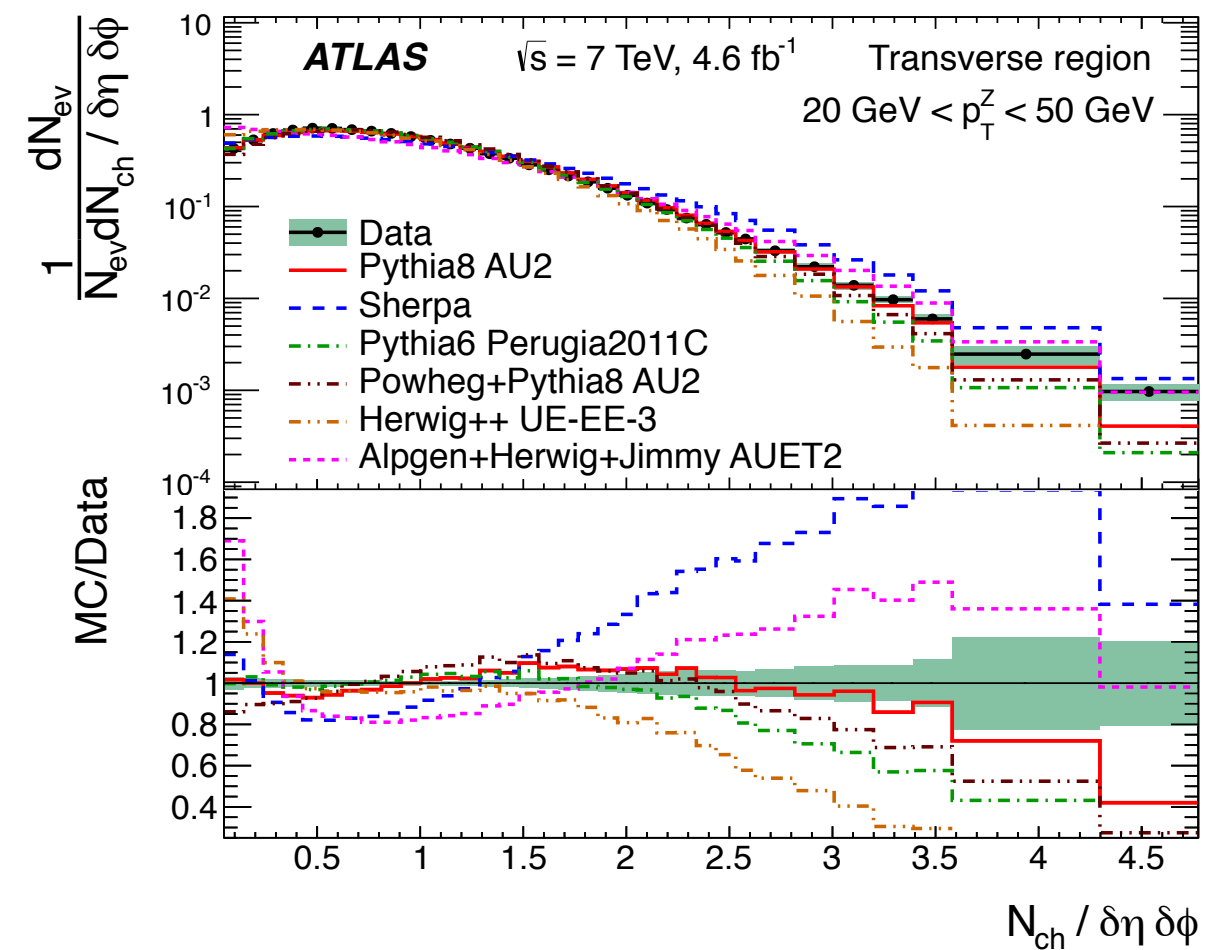
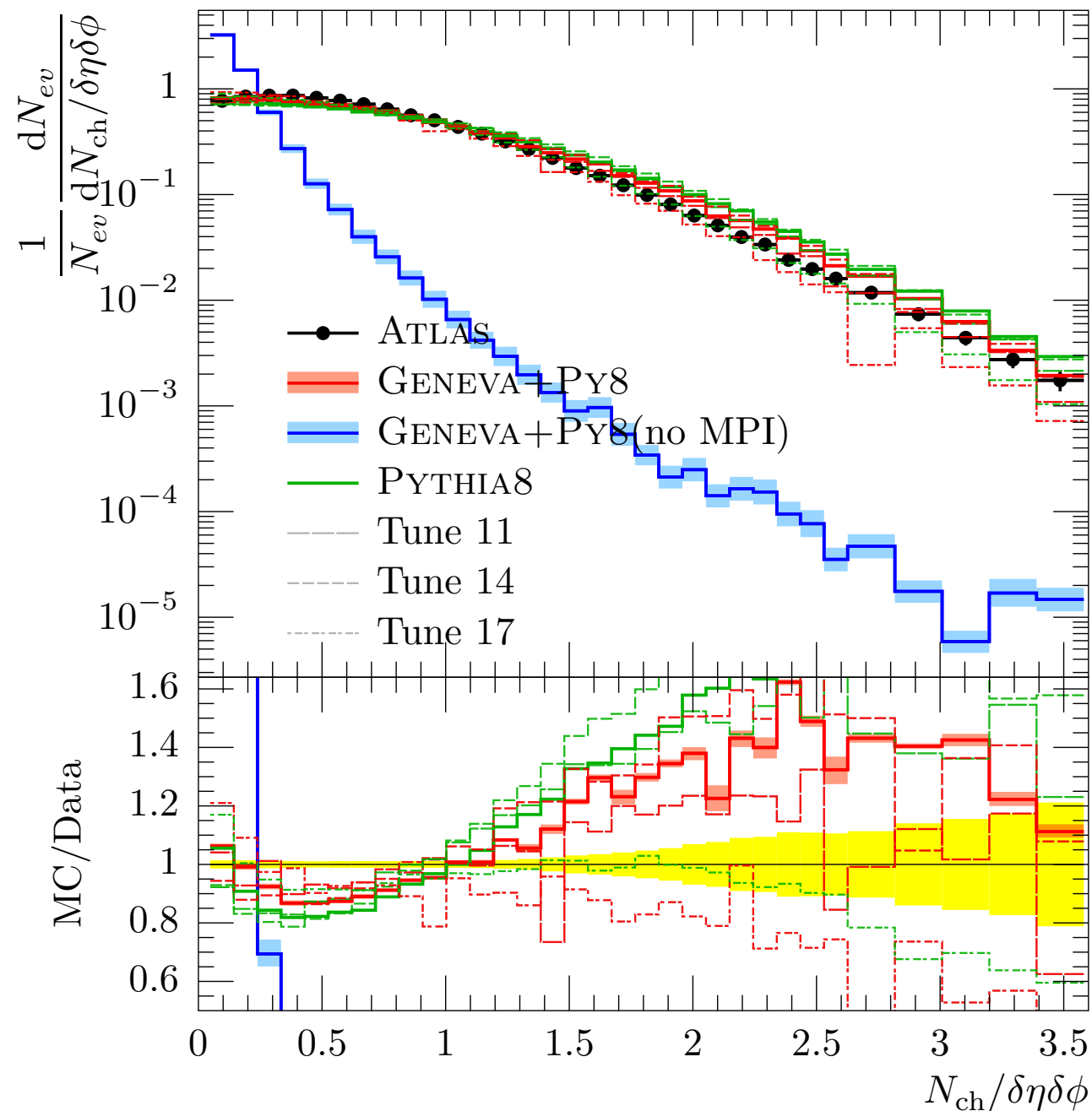


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Number of charged tracks in $\delta\eta$ - $\delta\phi$

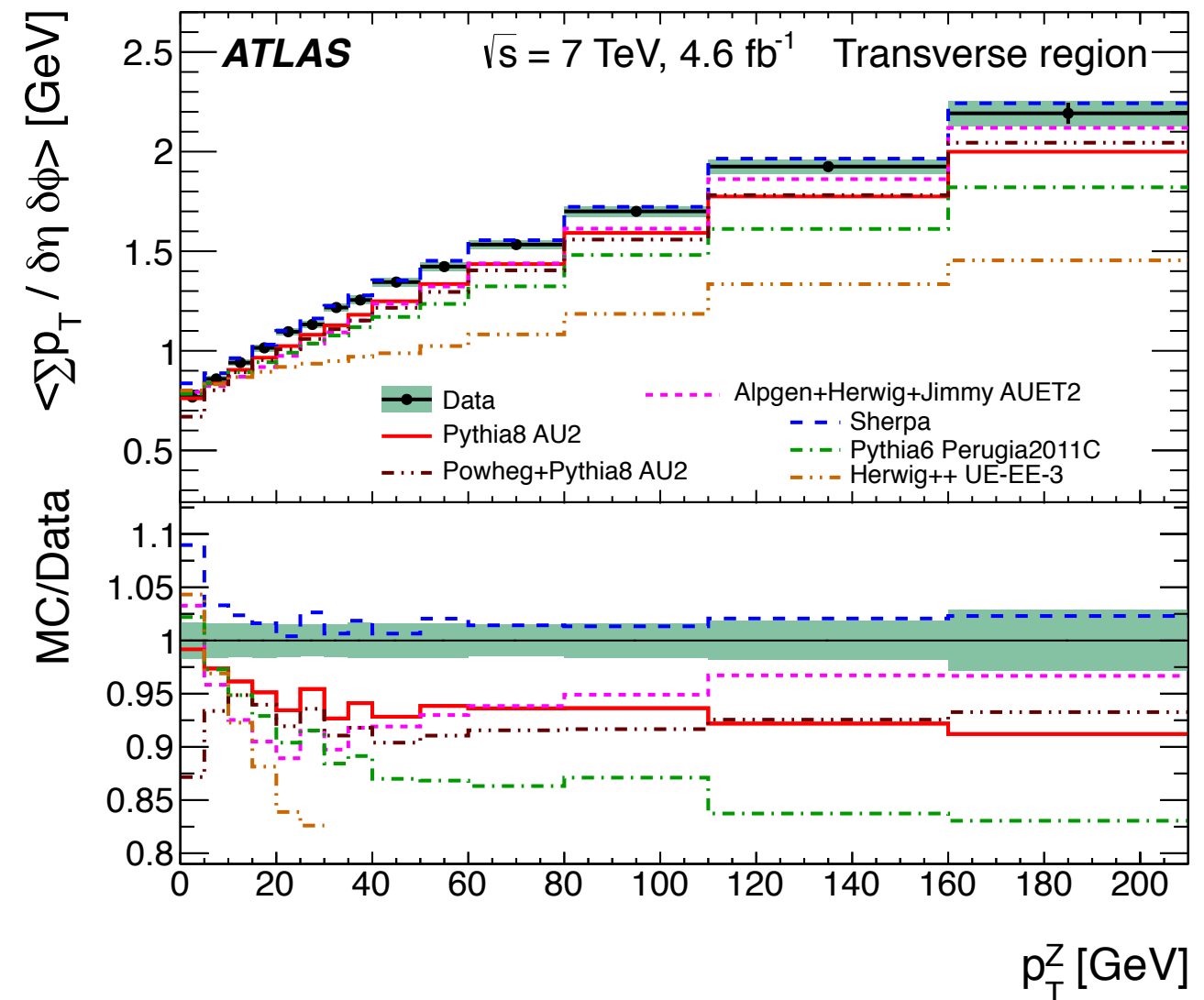
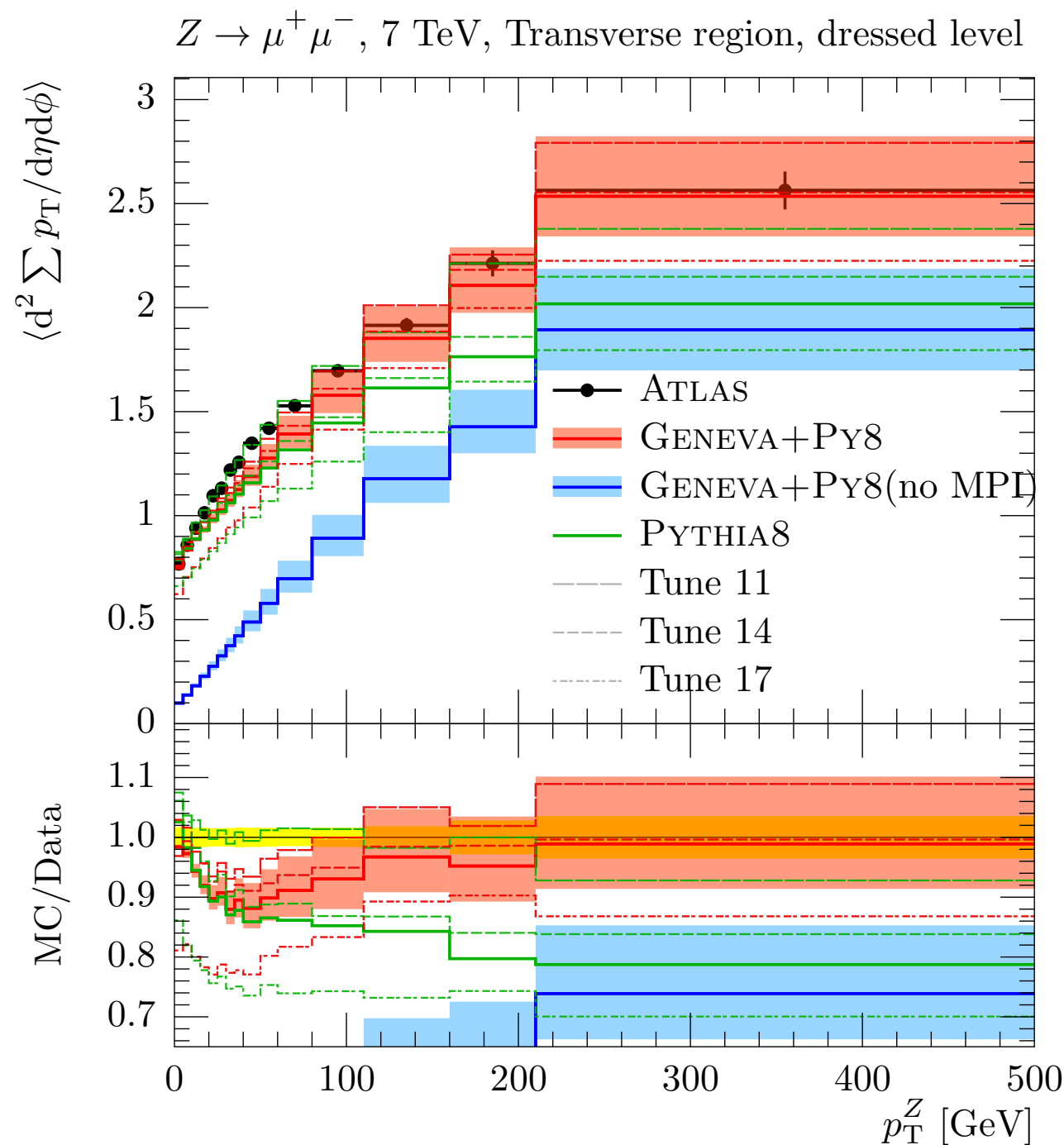
$Z \rightarrow \mu^+ \mu^-$, 7 TeV, Transverse region, $p_T^Z < 5$ GeV



ATLAS has measured several standard UE sensitive observables

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sum p_T vs p_T^Z

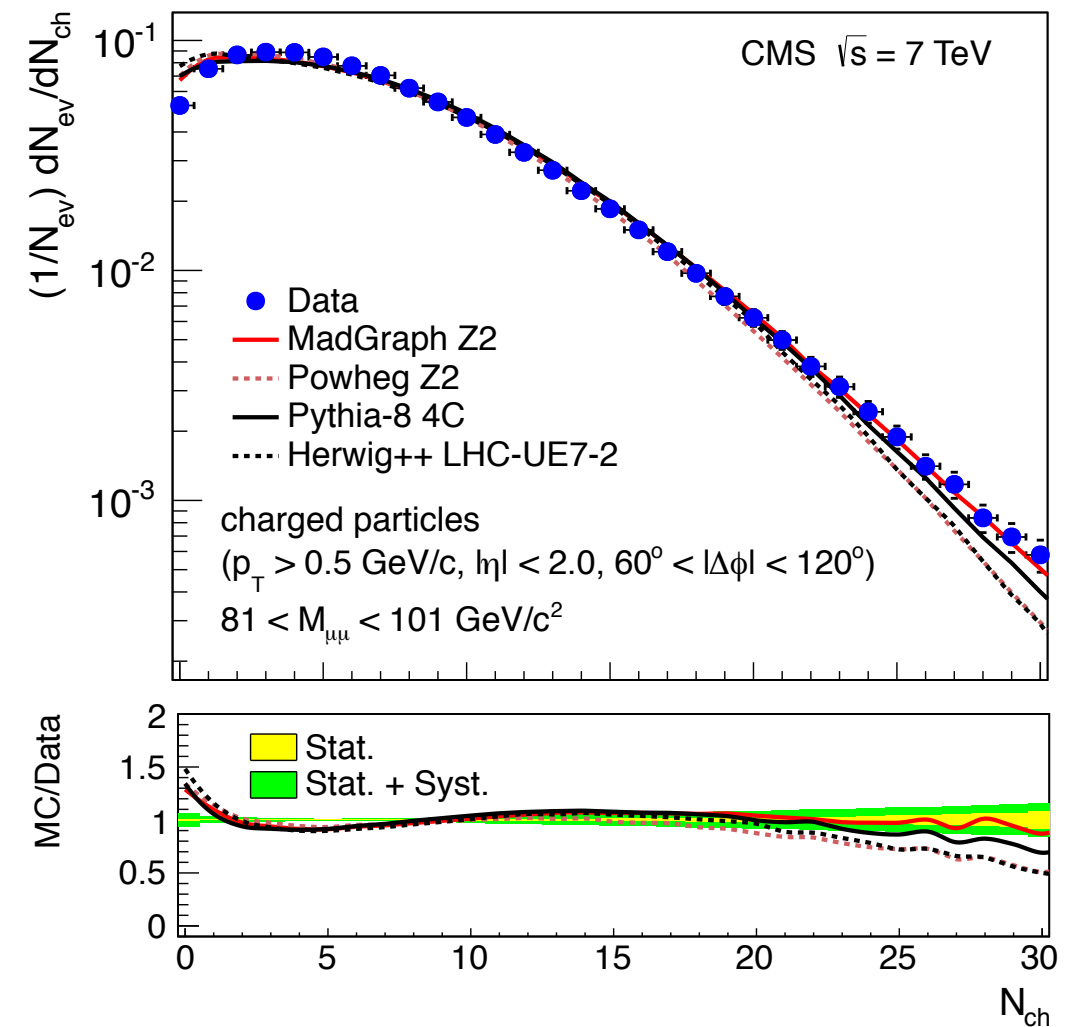
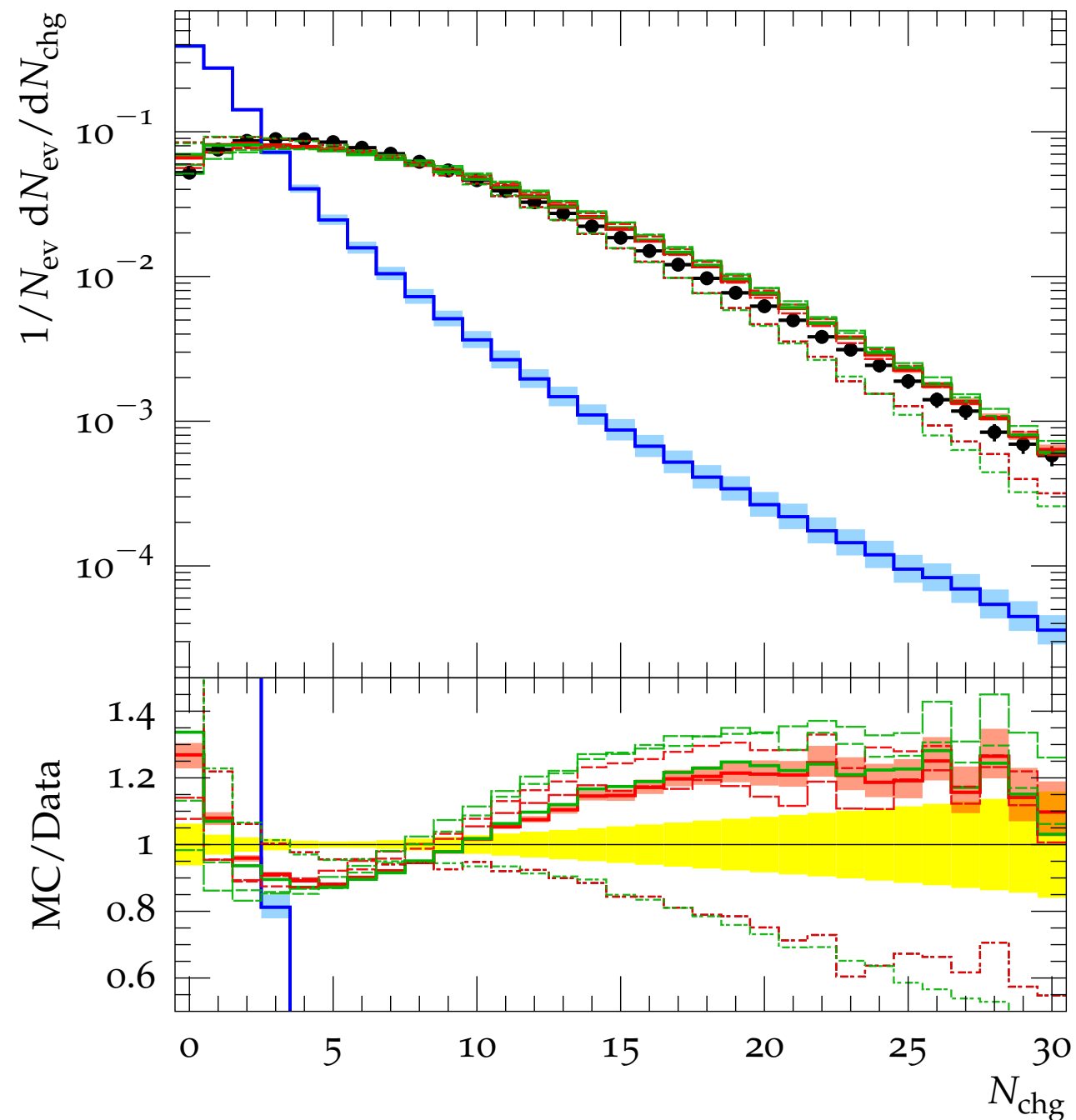


Comparisons to ATLAS and CMS data looks very encouraging

CMS arXiv:1204.1411

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$Z \rightarrow \mu^+ \mu^-$, 7 TeV, Transverse region

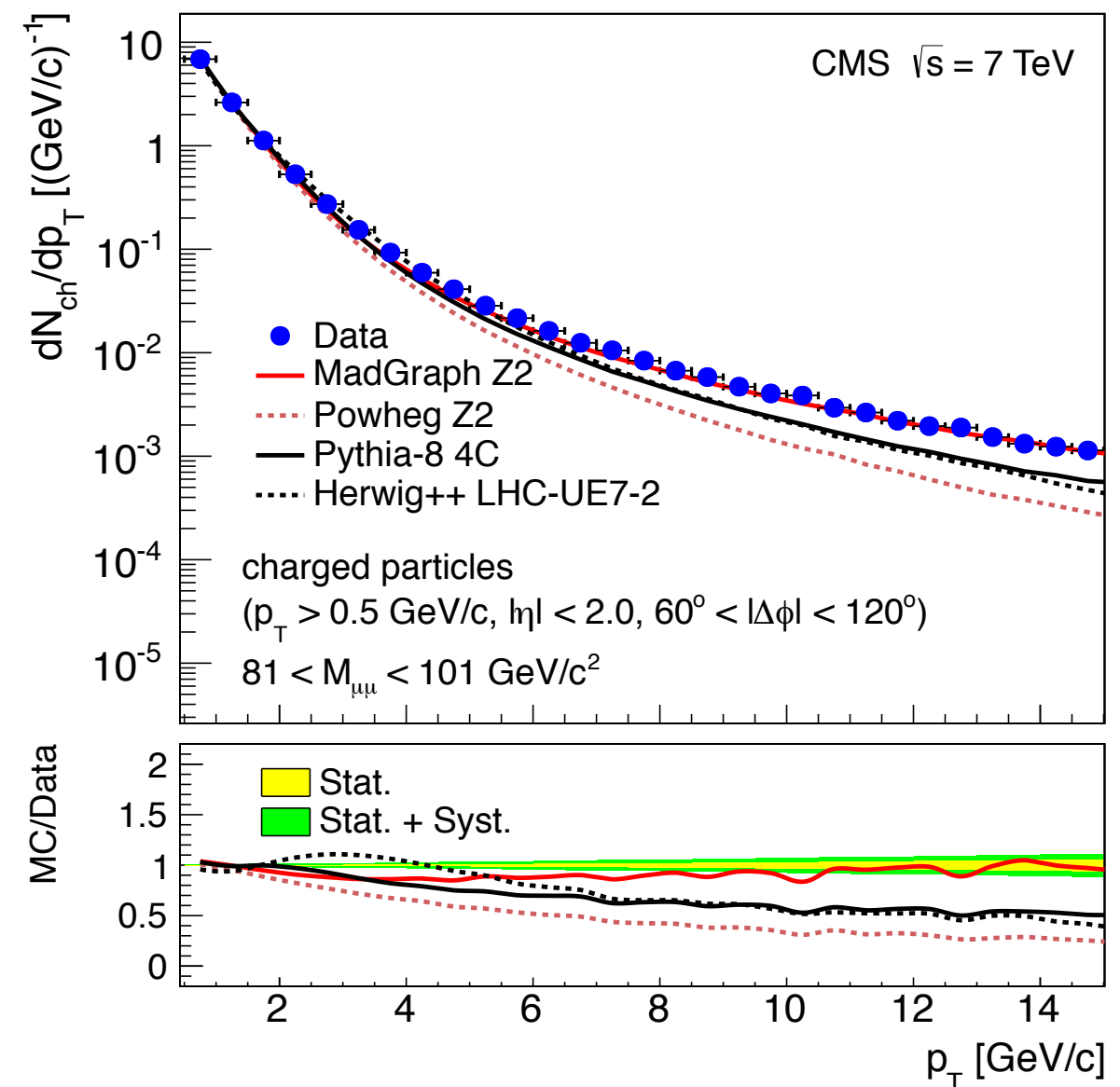
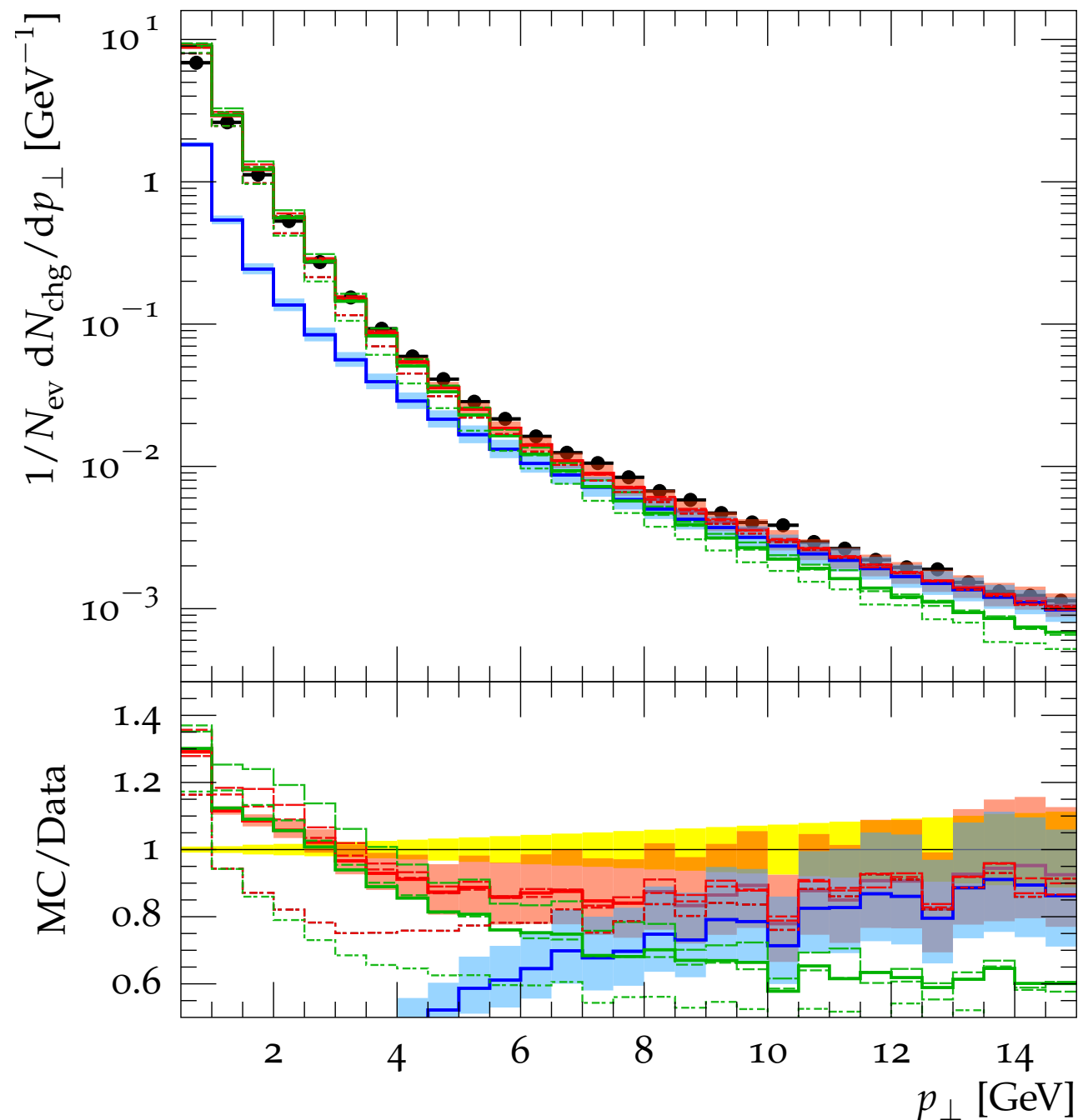


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Number of charged tracks in $\delta\eta$ - $\delta\phi$

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To separate MPI corrections, need to remove the soft perturbative effects from UE sensitive observables

As already mentioned, UE sensitive observables not only probe MPI, but also long distance physics related to primary interaction (i.e. soft radiation ...)

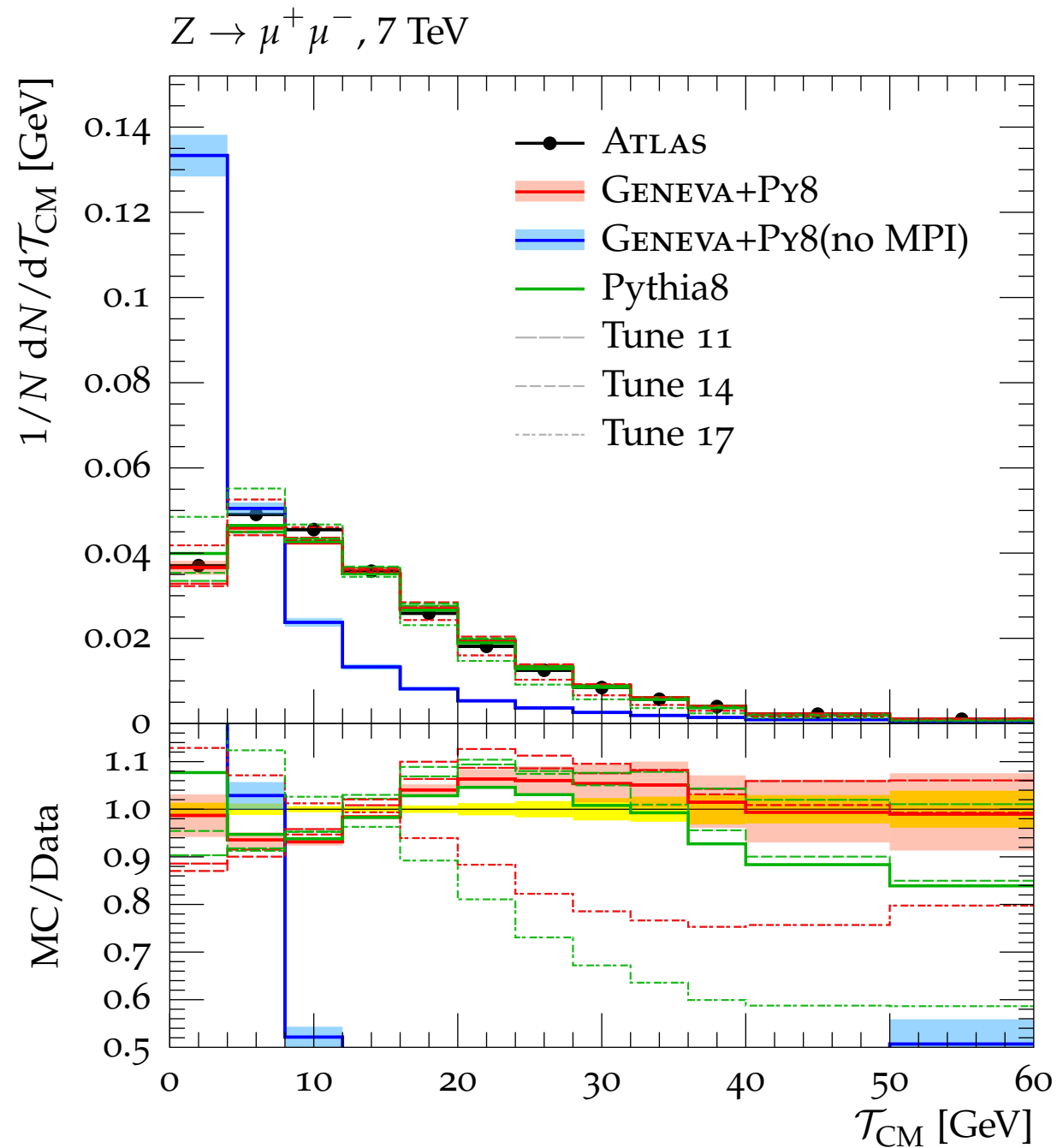
Therefore very difficult to separate MPI effects from primary interaction effects

Best way forward is to choose observable for which primary interaction very well known, including soft radiation effects

Beam thrust distribution calculated precisely in Geneva

Comparisons to ATLAS and CMS data looks very encouraging

ATLAS arXiv:1602.08980



- Seems that current MPI model in PY already doing good job
- This means that MPI extracted from other processes seems to work for 0-jettiness

QUESTIONS?