



Herwig 7

- overview -



erc



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17th MCnet Meeting, 11.4.2018

Outline



1. 'This is our detector' slides
2. Recent developments
3. Use cases
4. Perspectives



Herwig(_/++/7) – Brief History

Key features:

- **Angular Ordering**
- **Cluster Model**

HERWIG – Fortran

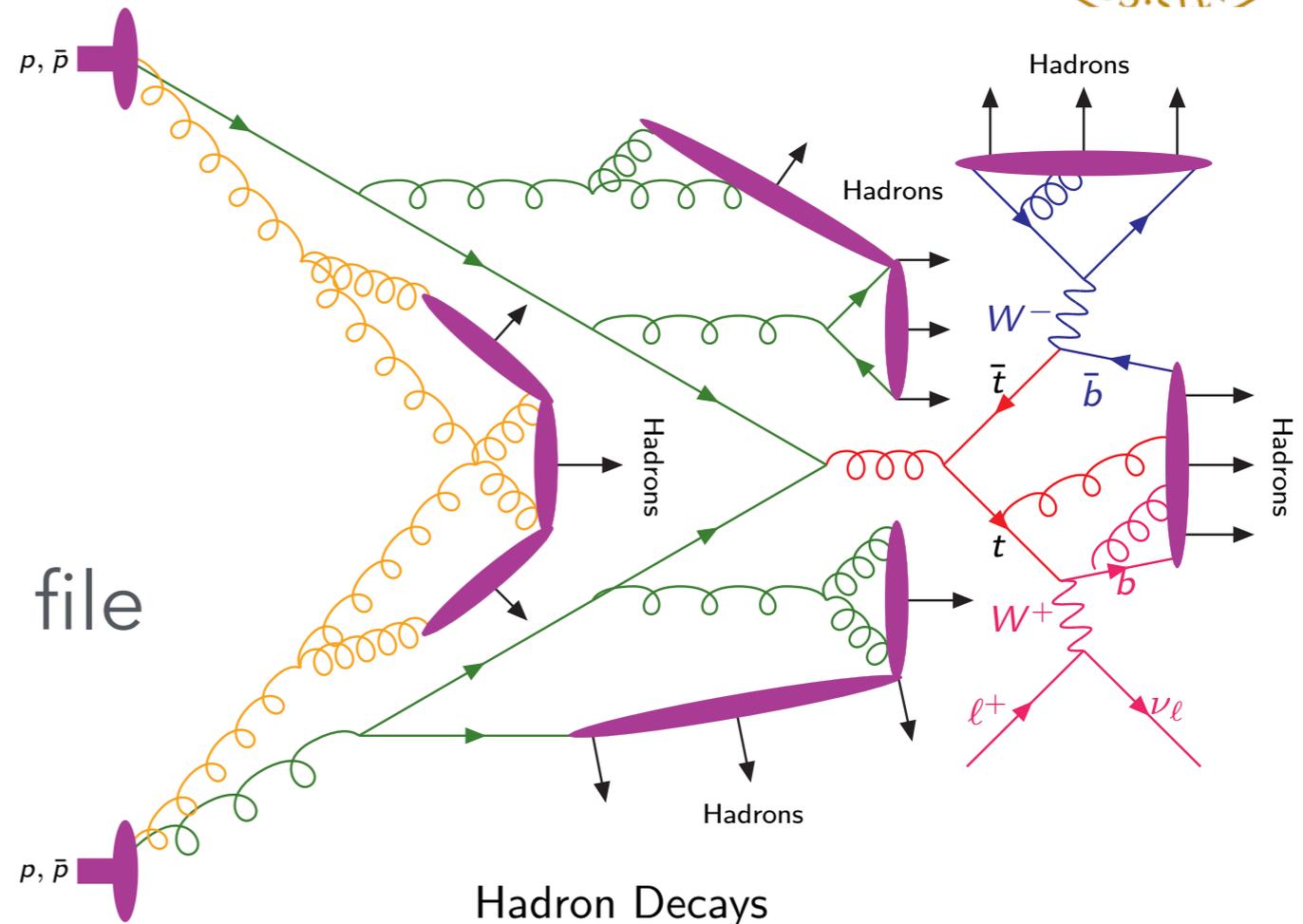
63940 lines ~400 Routines → 1 file

Herwig++ (2000 – 2015)

– new development in C++

Herwig7 (+ ThePEG) (~1200 header)

- 7.0 : overcome HERWIG with automatized NLO Matching and many documented features
- 7.1 : merging, soft model, impr. jet evolution and impr. mass effects



Picture from P. Richardson

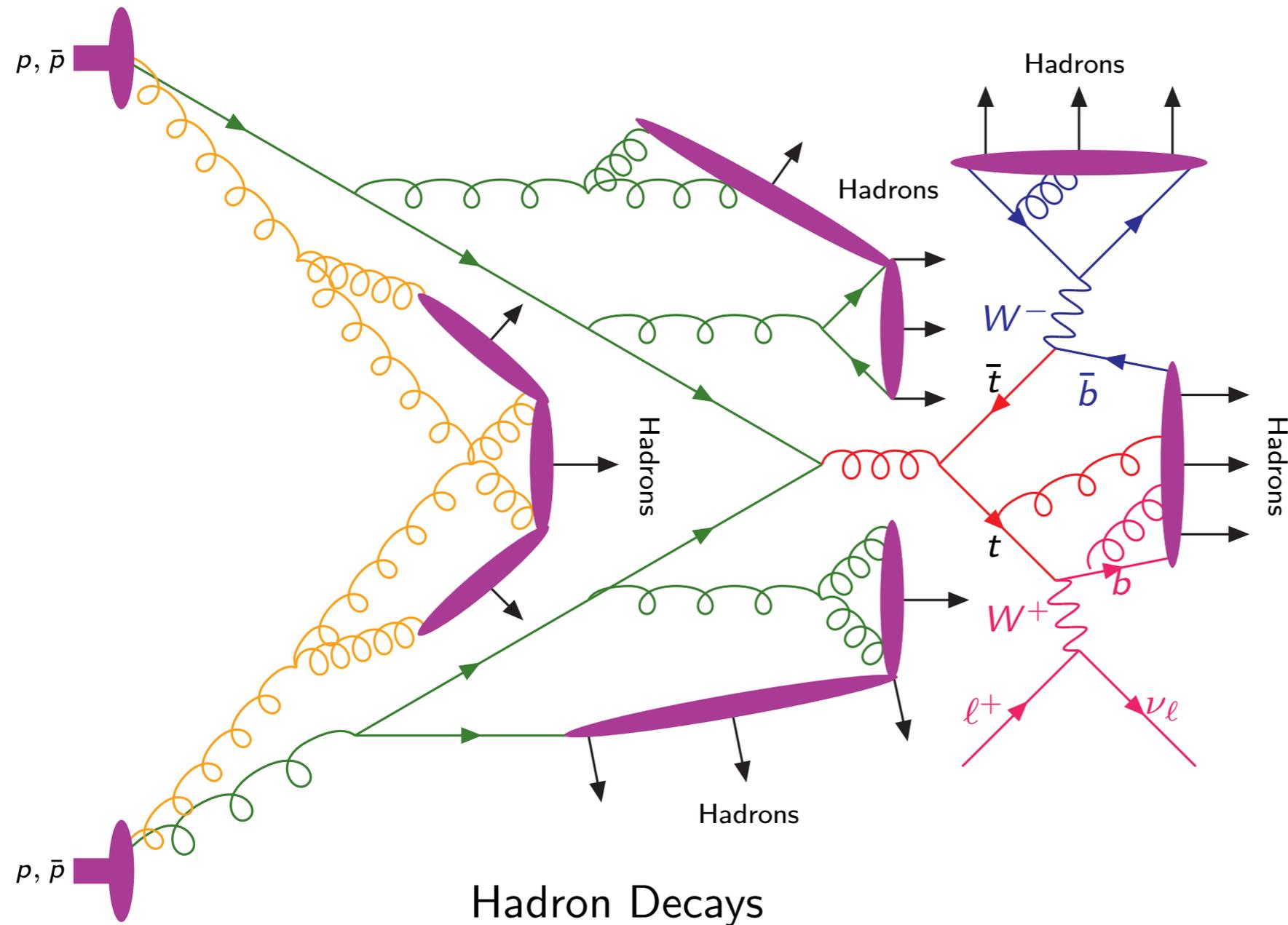


Herwig7 – Brief Features

- Two Showers (Angular Ordered and Dipole shower)
- Two matching schemes to both parton showers
- NLO merging
- Spin correlations
- QED radiation in shower
- Parton shower reweighting for uncertainties
- Developments at the soft front
- Vastly improved documentation and usability
- many more...



Development – Break down to topics



Shower

Hard Process

Underlying Event

Hadronization

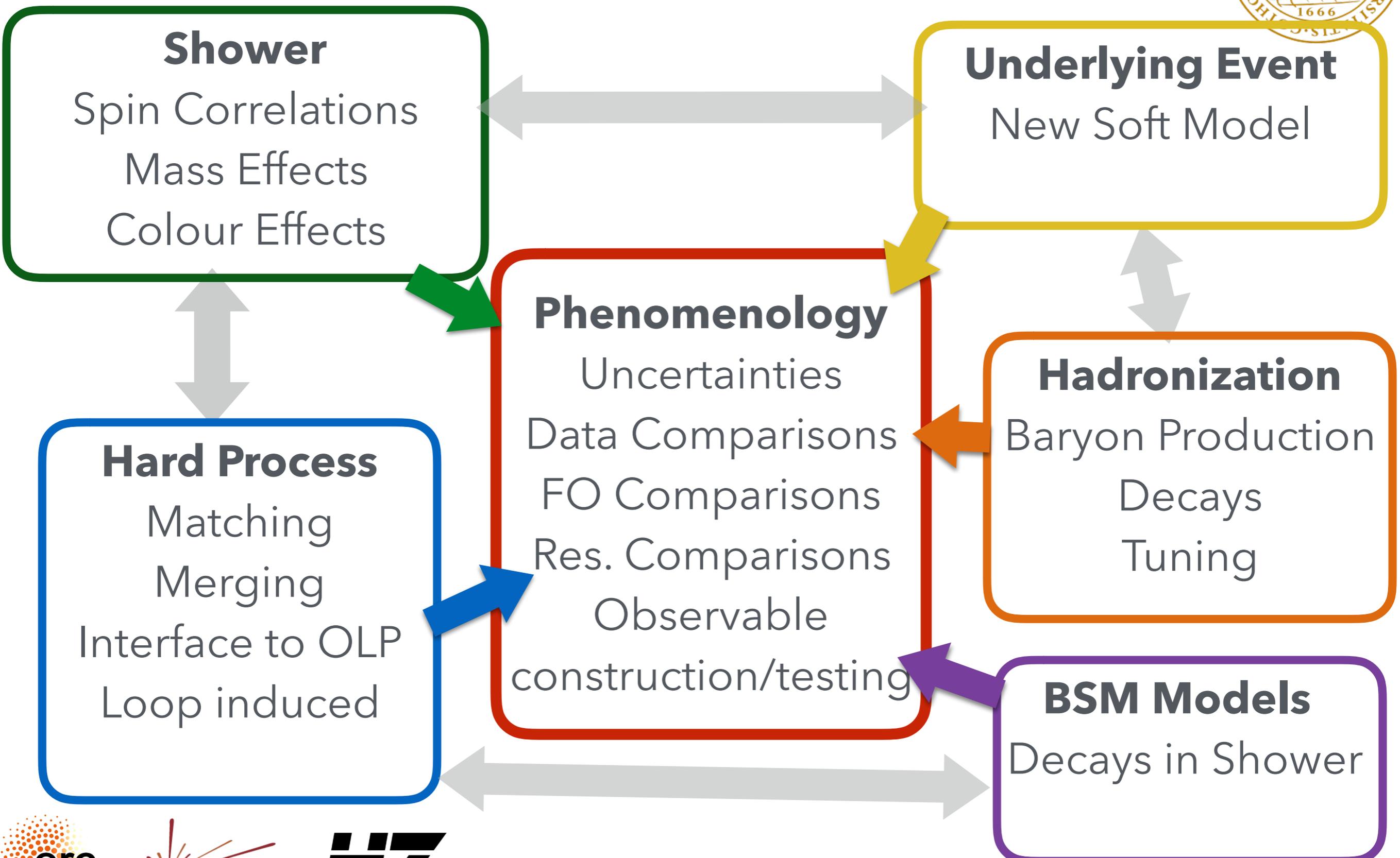
Models

Phenomenology



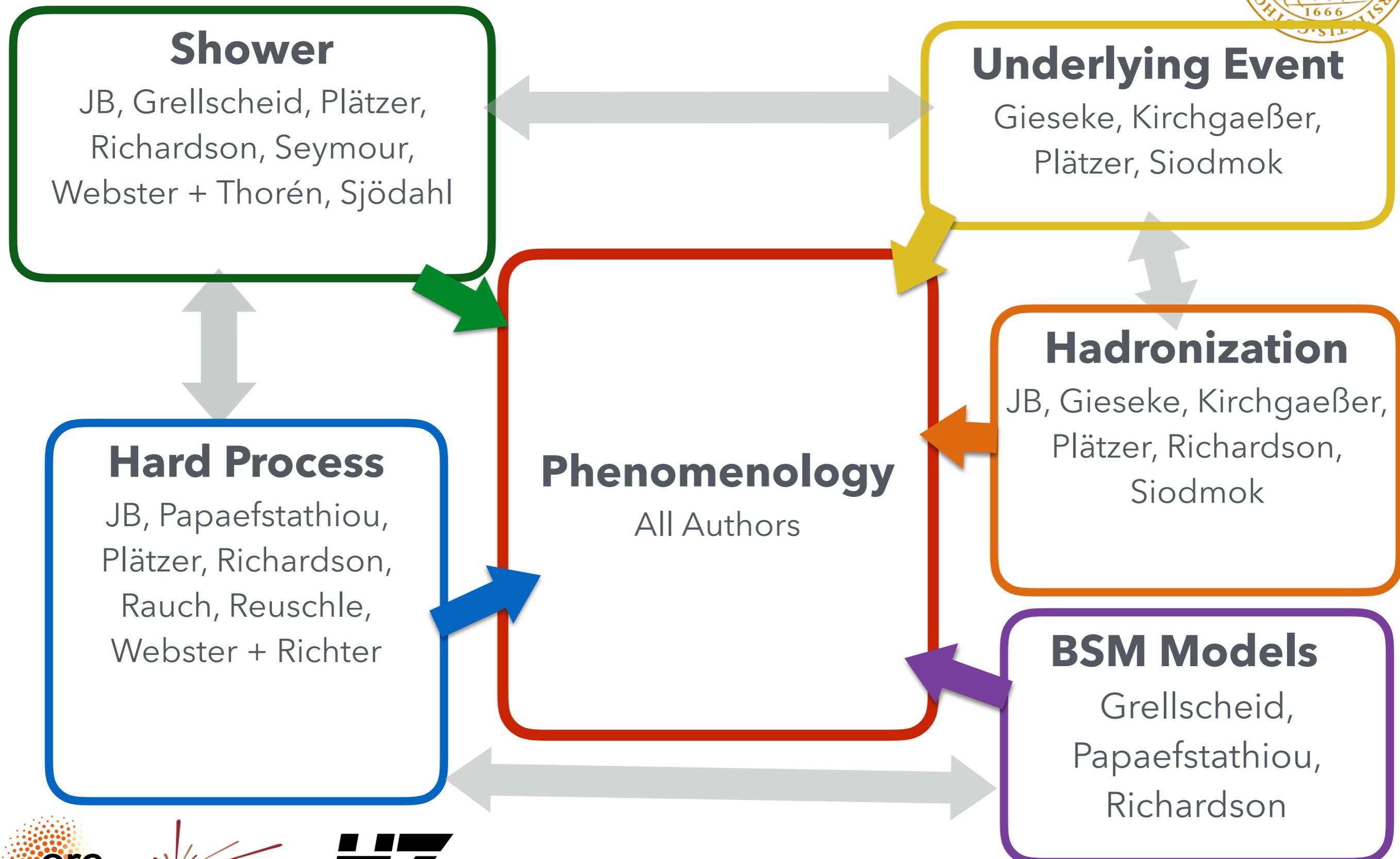


Development – Break down to topics





Recent Development (since 7.1)– Break down to topics



Matching and Merging

Pheno

Hard

Shower

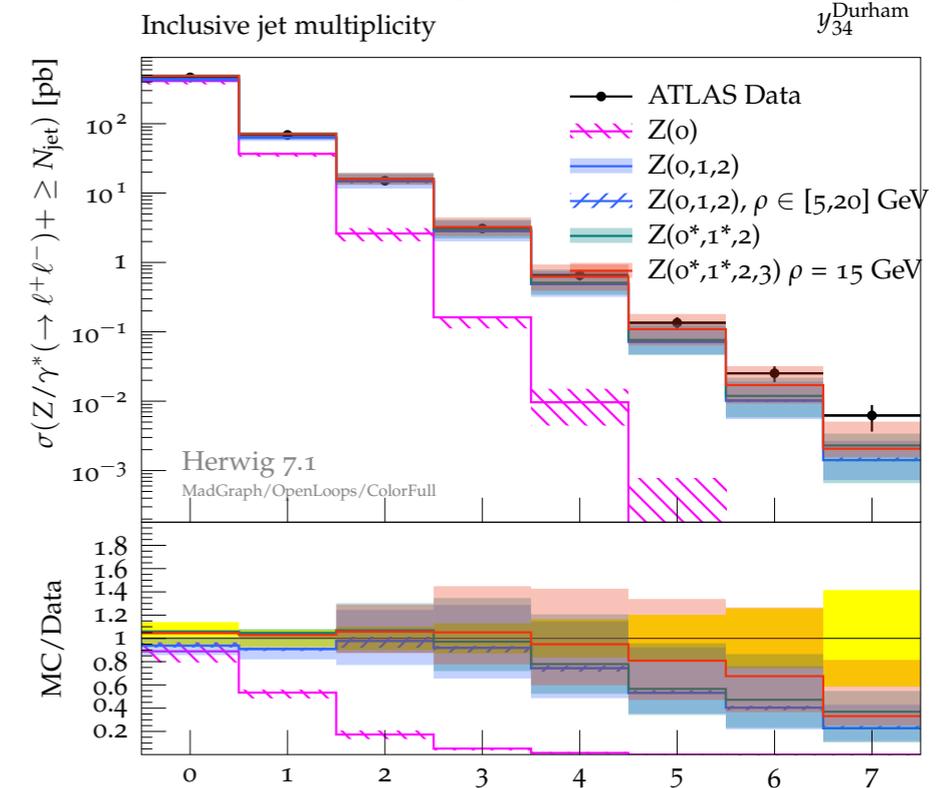
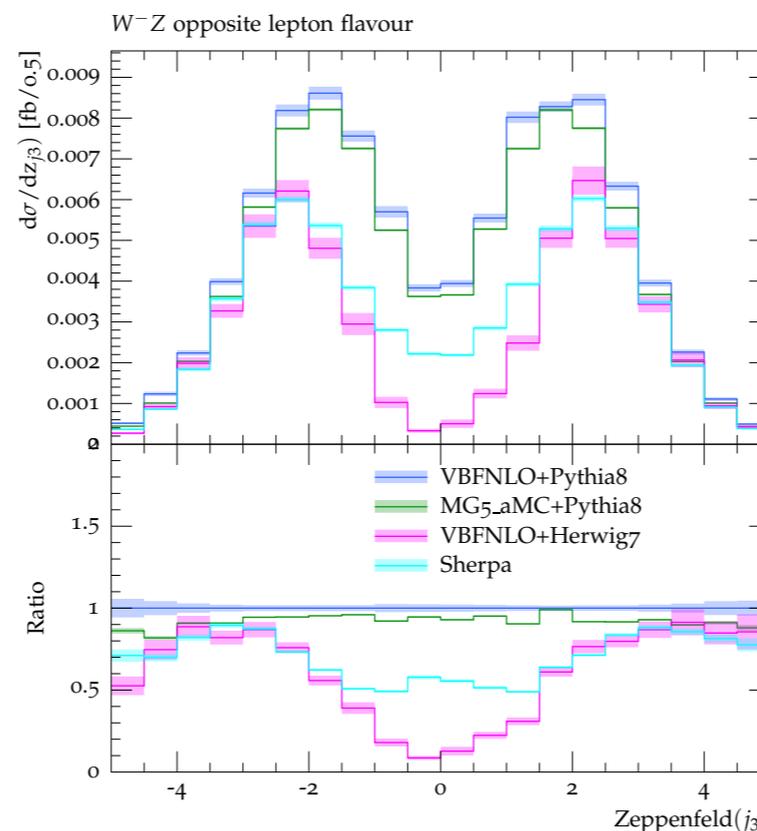
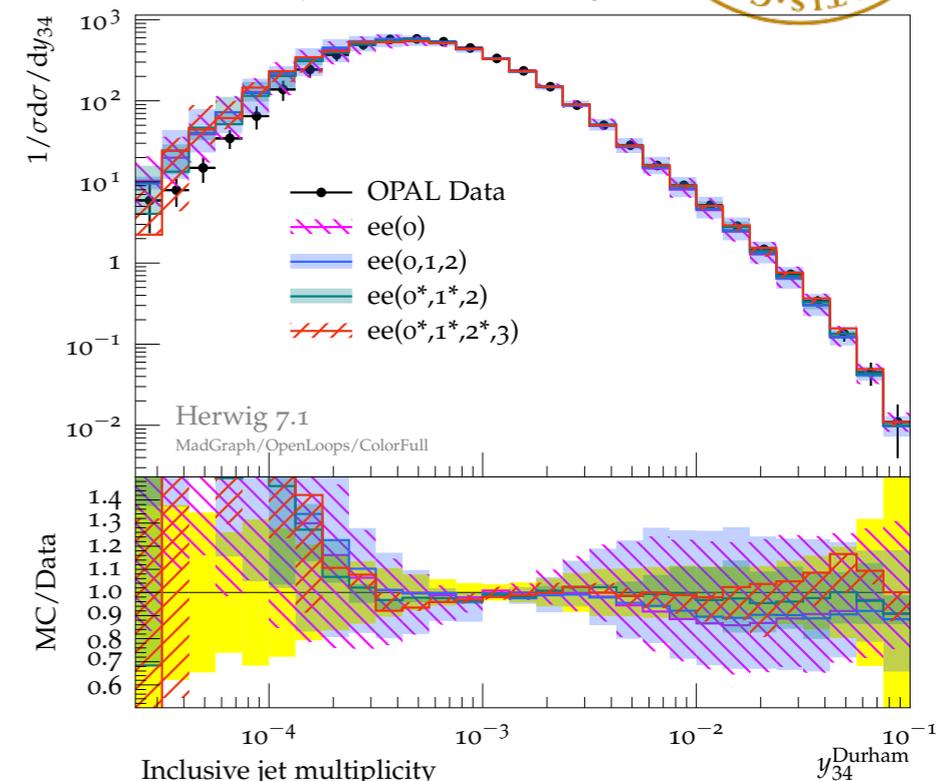


The Herwig Matchbox builds the foundation for Matching and Merging higher orders.

The aim is obviously to understand and describe nature but also estimate the uncertainties introduced.

Stress testing the simulations and data comparisons are mandatory.

Differential 3-jet rate with Durham algorithm (91.2 GeV)



Les Houches 2017

Bellm, Plätzer, Gieseke EPJC 78 (2018) no.3, 244



VBSCAN-Same-Sign WWjj

Ballestrero et al. (VBSCAN) arXiv:1803.07943

Questions:

Where is the VBS approximation valid?

How large can PS effects get for NLO matched results?

While inclusive observables show similar behavior the third jet still shows large deviations between simulations.

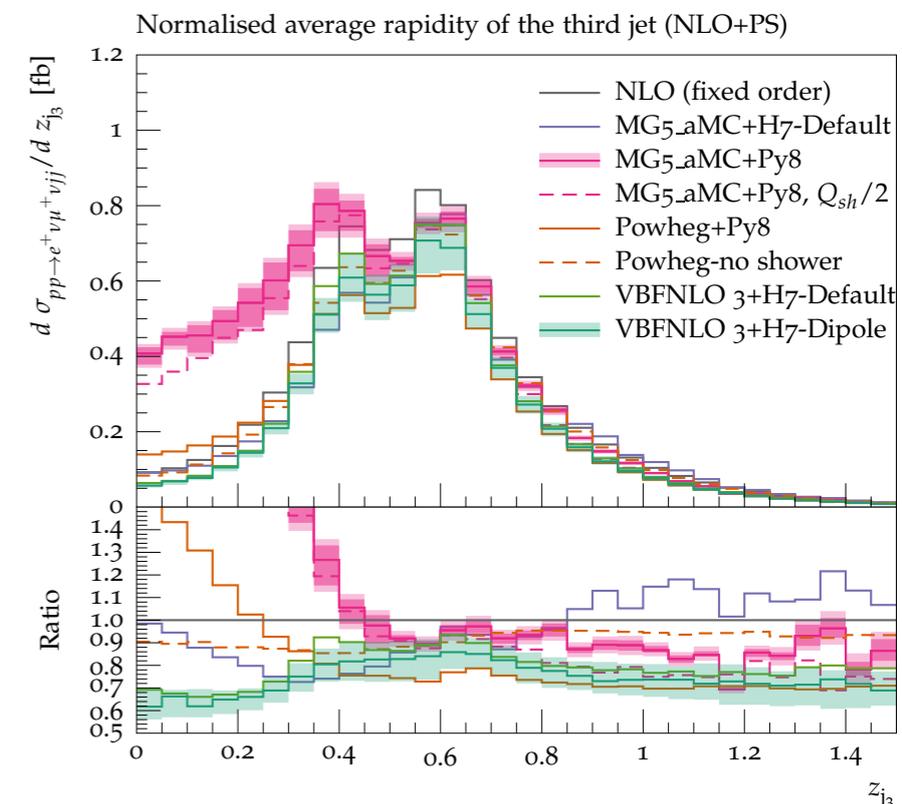
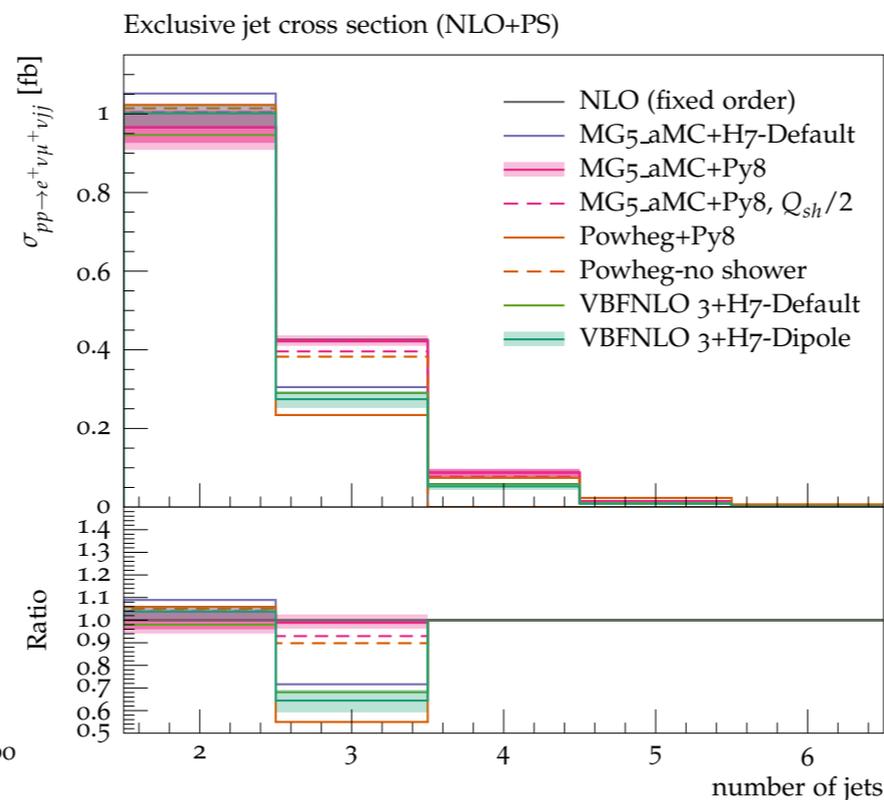
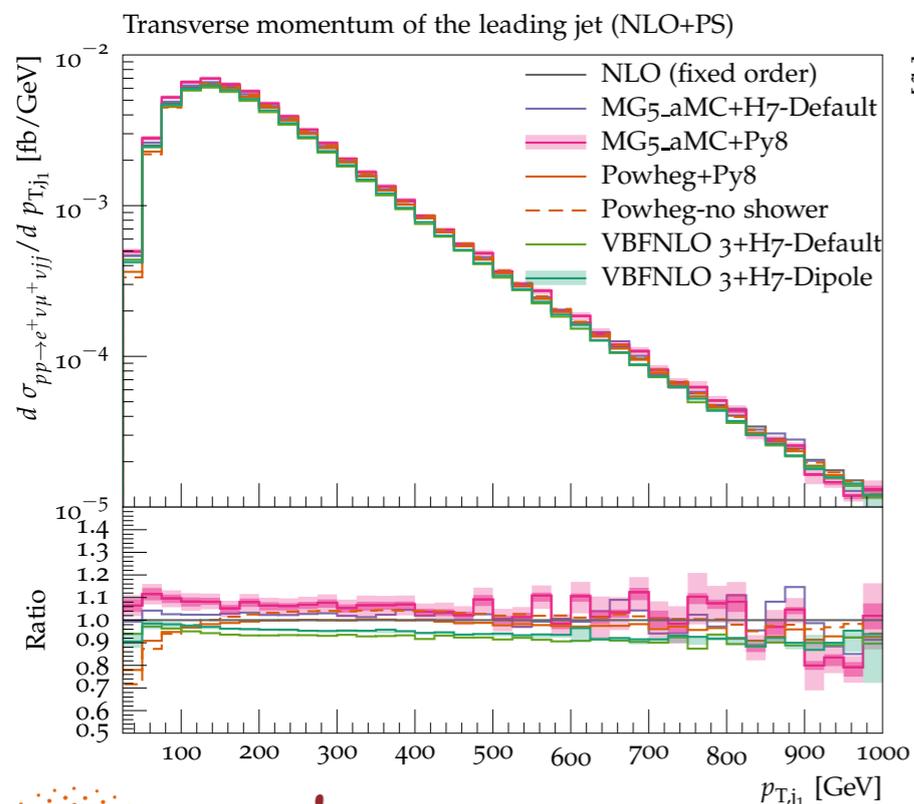
Pheno

Hard

Shower



$$z_{j_3} = \frac{y_{j_3} - \frac{y_{j_1} + y_{j_2}}{2}}{|\Delta y_{jj}|}$$



LH 17 – FO vs. PS

Les Houches 2017

Pheno

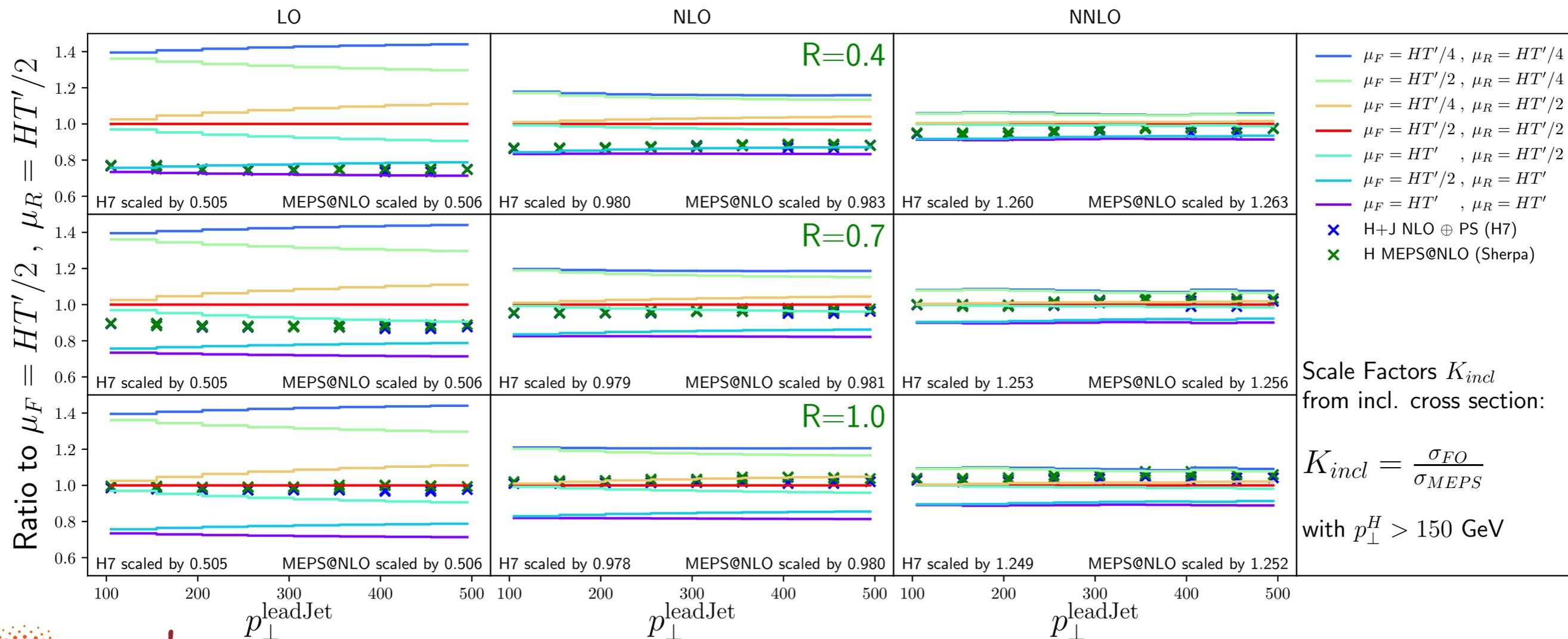
Hard

Shower



Questions: How does the PS jet size compare against FO jet size?

Start of a broader study on jet sizes comparing NNLO to PS+NLO predictions. Observable: leading Jet in Higgs production



Tuning vs. Variations

Les Houches 2017

Pheno

Had

Shower



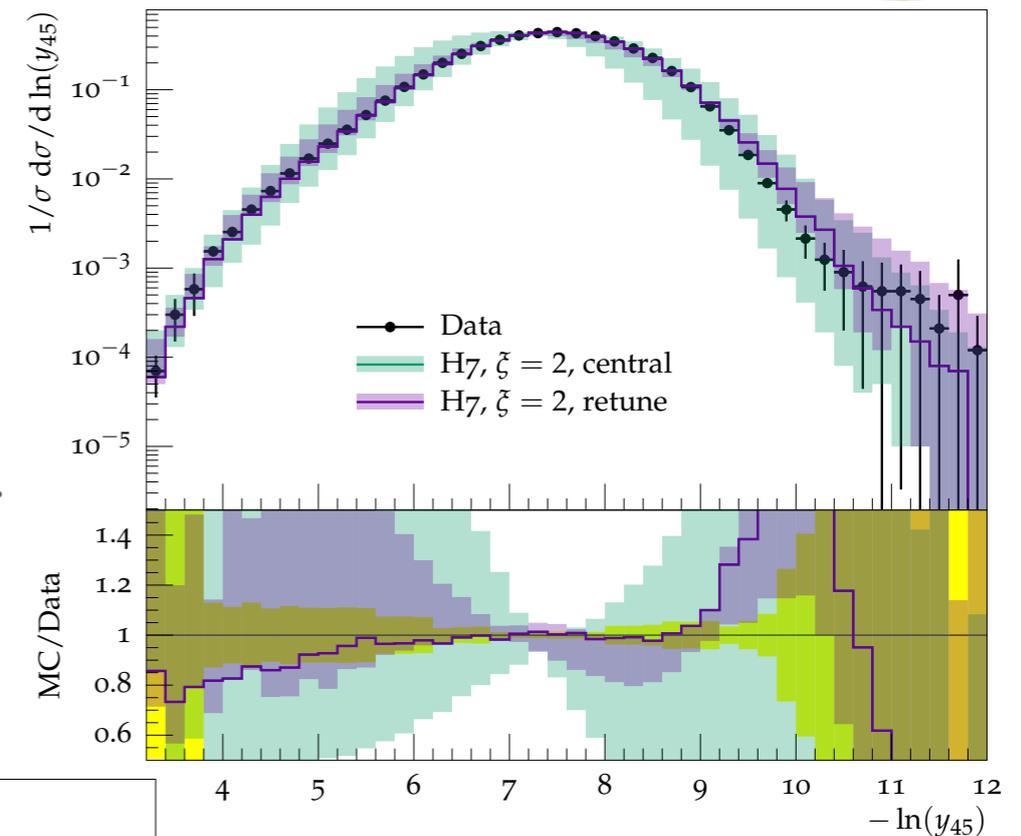
Simplified question: Can PS variations be 'tuned'?

For some observables it seems like the uncertainties shrink dramatically.

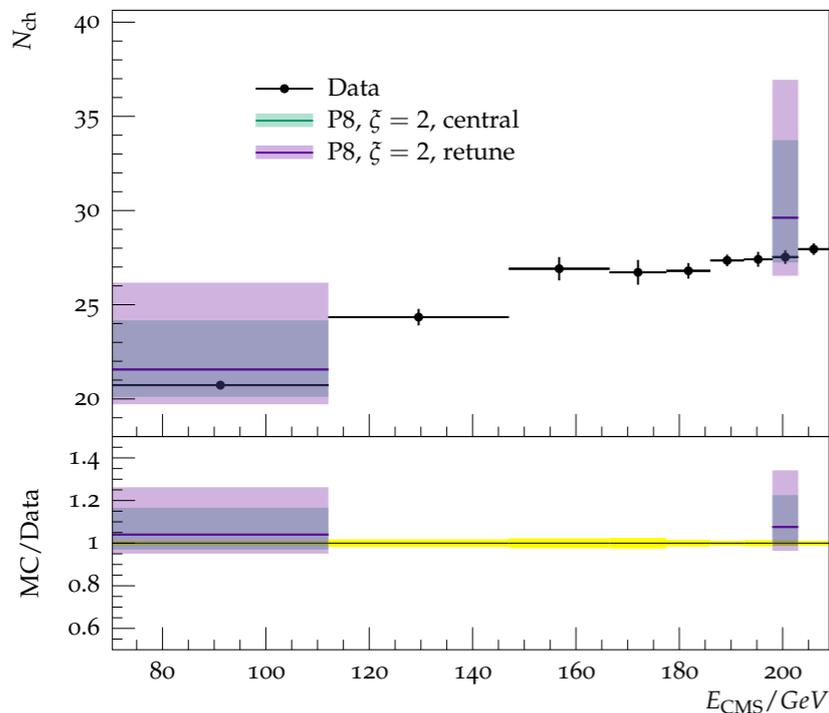
Strongly depends on which observables are tuned to.

More questions produced than answered.

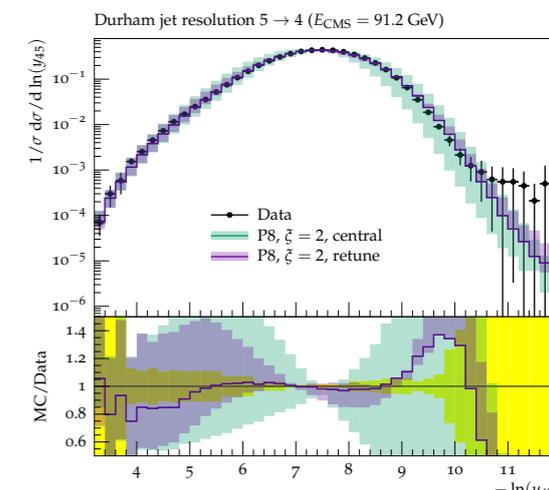
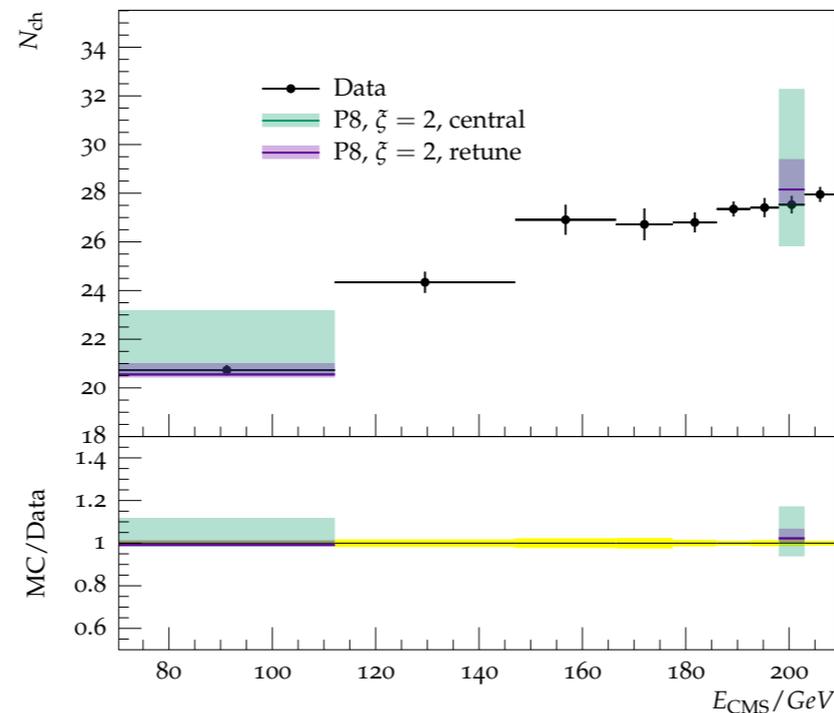
Durham jet resolution $5 \rightarrow 4$ ($E_{\text{CMS}} = 91.2$ GeV)



Charged multiplicity at a function of energy



Charged multiplicity at a function of energy



PDF Fitting and Variations

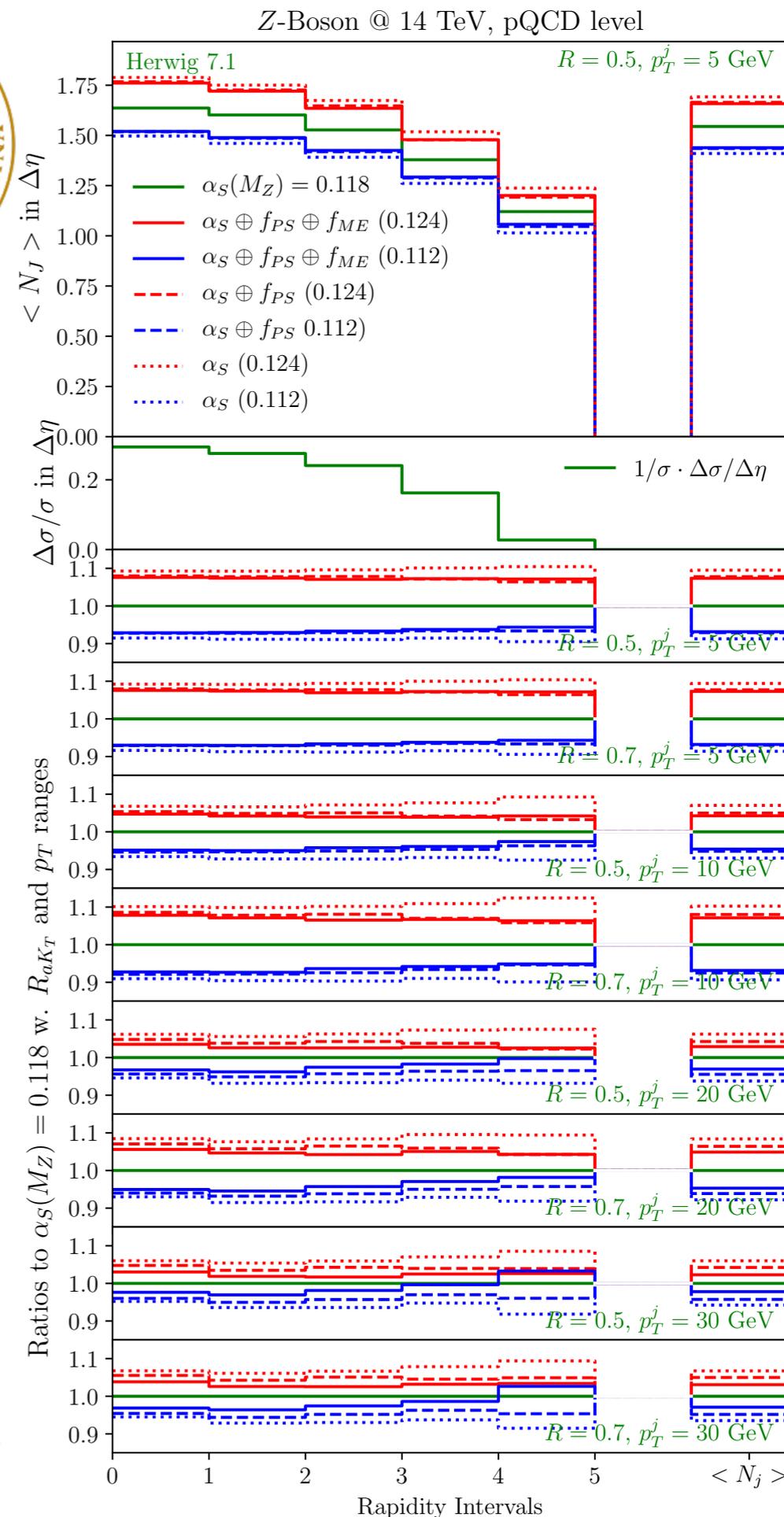
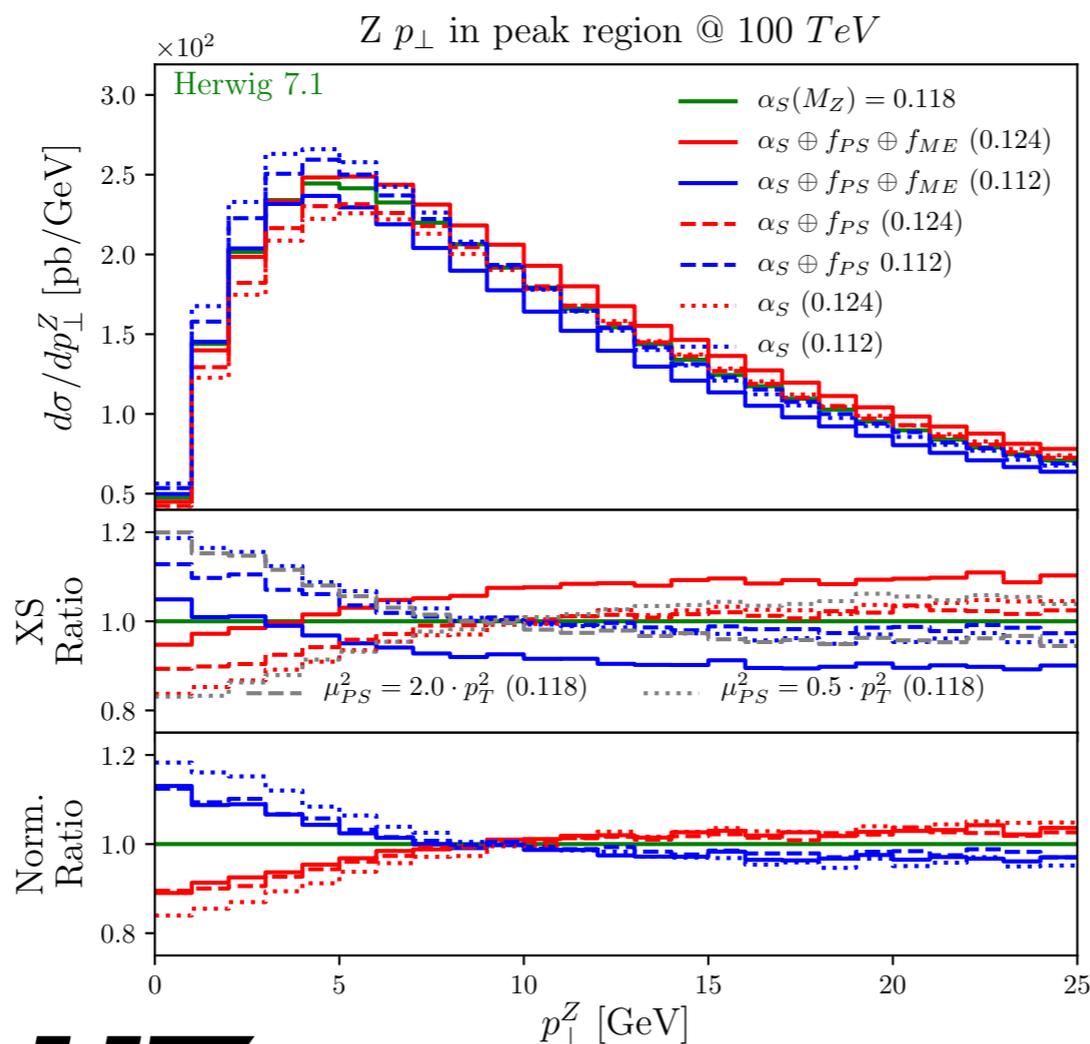
Les Houches 2017

Related question:

How does the fitting of PDFs with multiple strong couplings influence observables?

And are there compensation effects if we use correlated PDFs in the shower process?

Construction of observables that might be sensitive, e.g. $\langle N \rangle$.



Pheno

Shower

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Soft Physics

Gieseke, Loshaj, Kirchgaeßer EPJC 77 (2017) no.3, 156

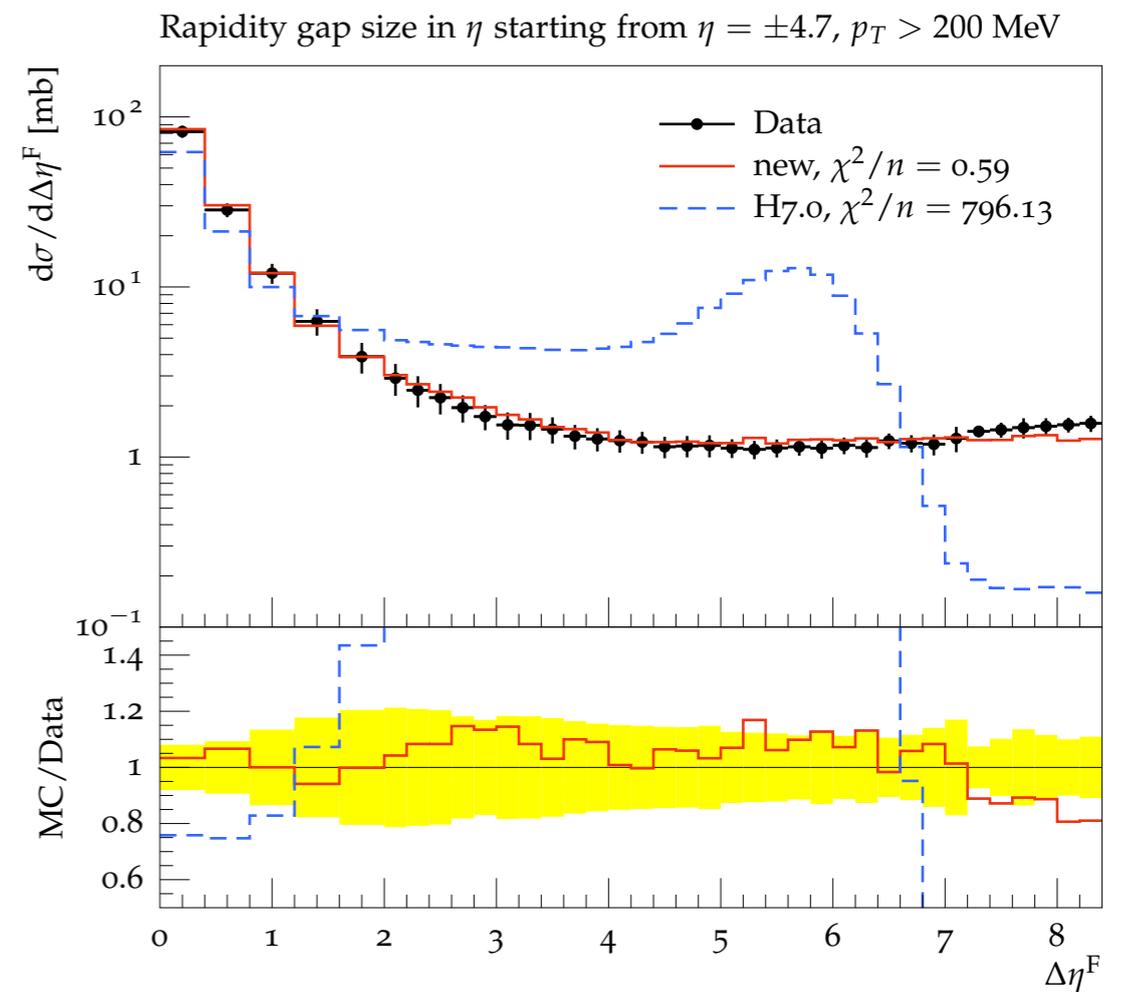
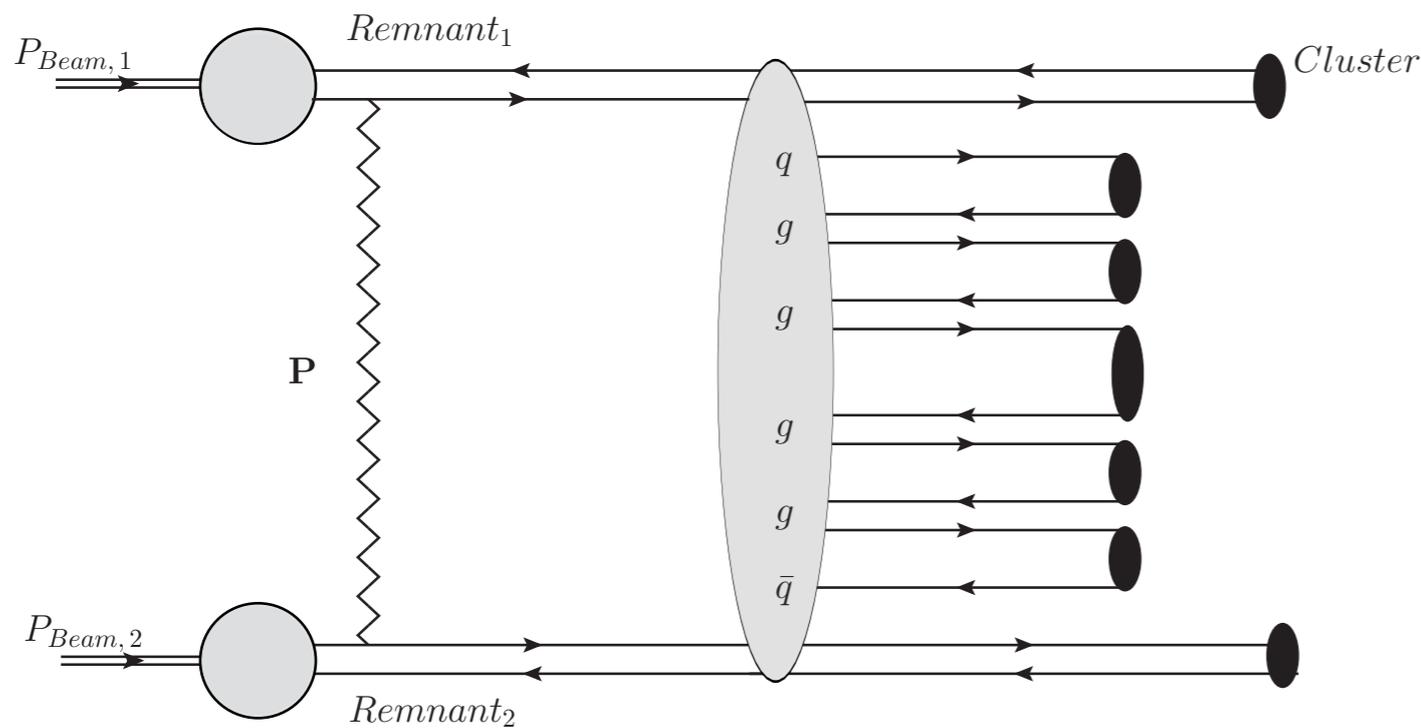
Pheno

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Last Year:

- Inclusion of diffractive topologies
- New soft MPI model
- The bump disappears



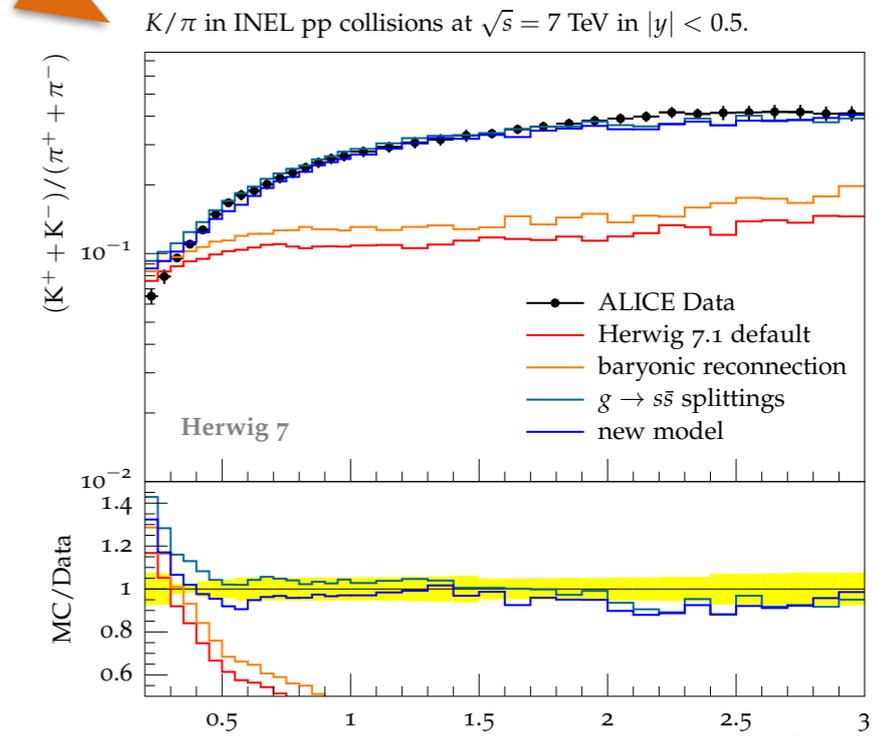
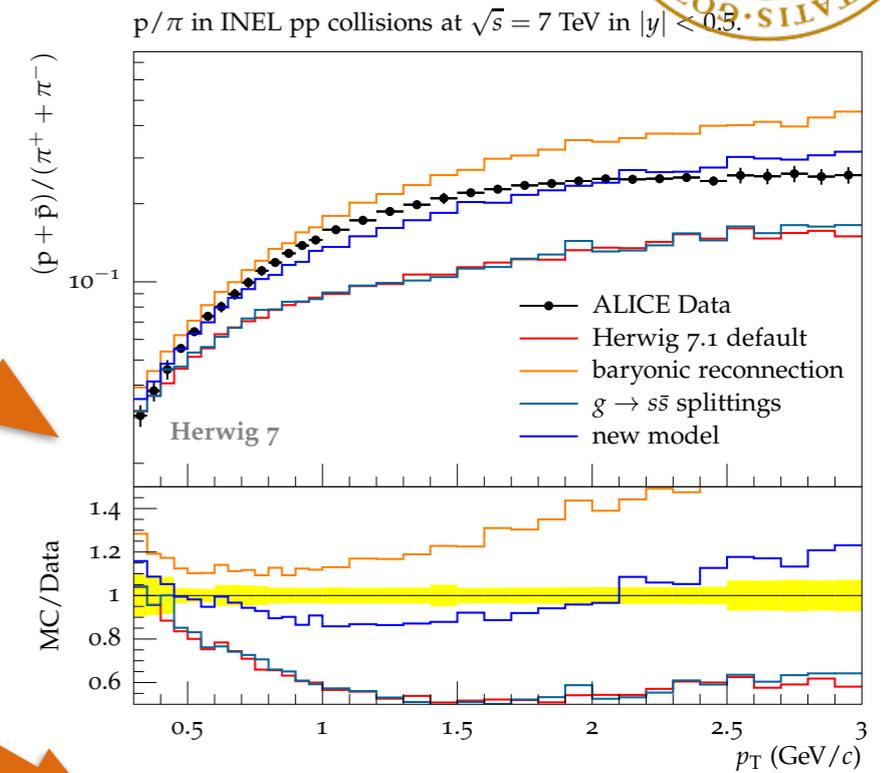
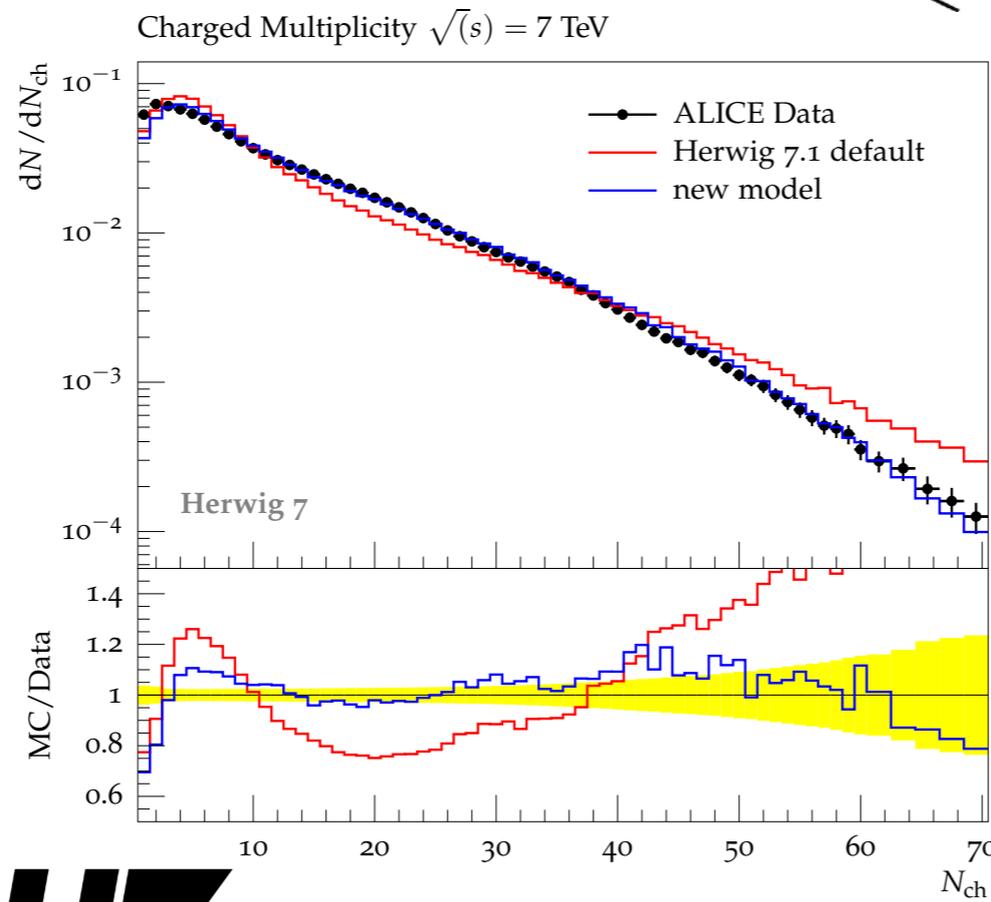
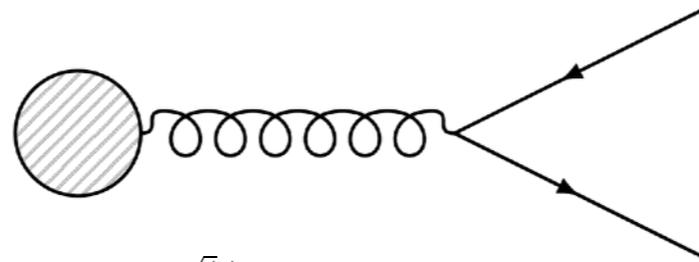
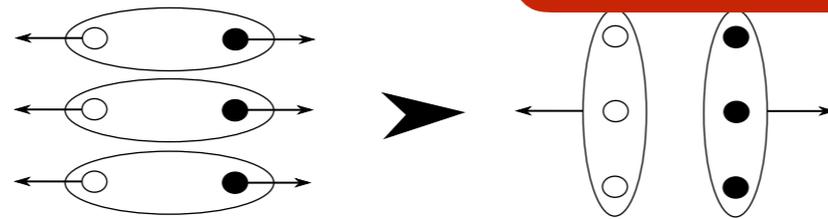
Baryonic Reconnection

Gieseke, Kirchgaeßer, Plätzer EPJC 78 (2018) no.2, 99



Idea:

- Allow recombination of mesonic to baryonic clusters.
- Based on proximity in momentum space
- Allow gluon to strange-pairs



Outlook



Perspective:

- Many questions raised.
- We are in a position to technically tackle these questions.
- Further developments in all parts of the event generator needed.
 - subleading N
 - colour reconnection/rearrangement
 - EW + QCD combination
 - further BSM studies
 - improving MPI and Hadronisation
- Studies on the crosstalk between perturbative and non-perturbative modeling needed



Thank you!

