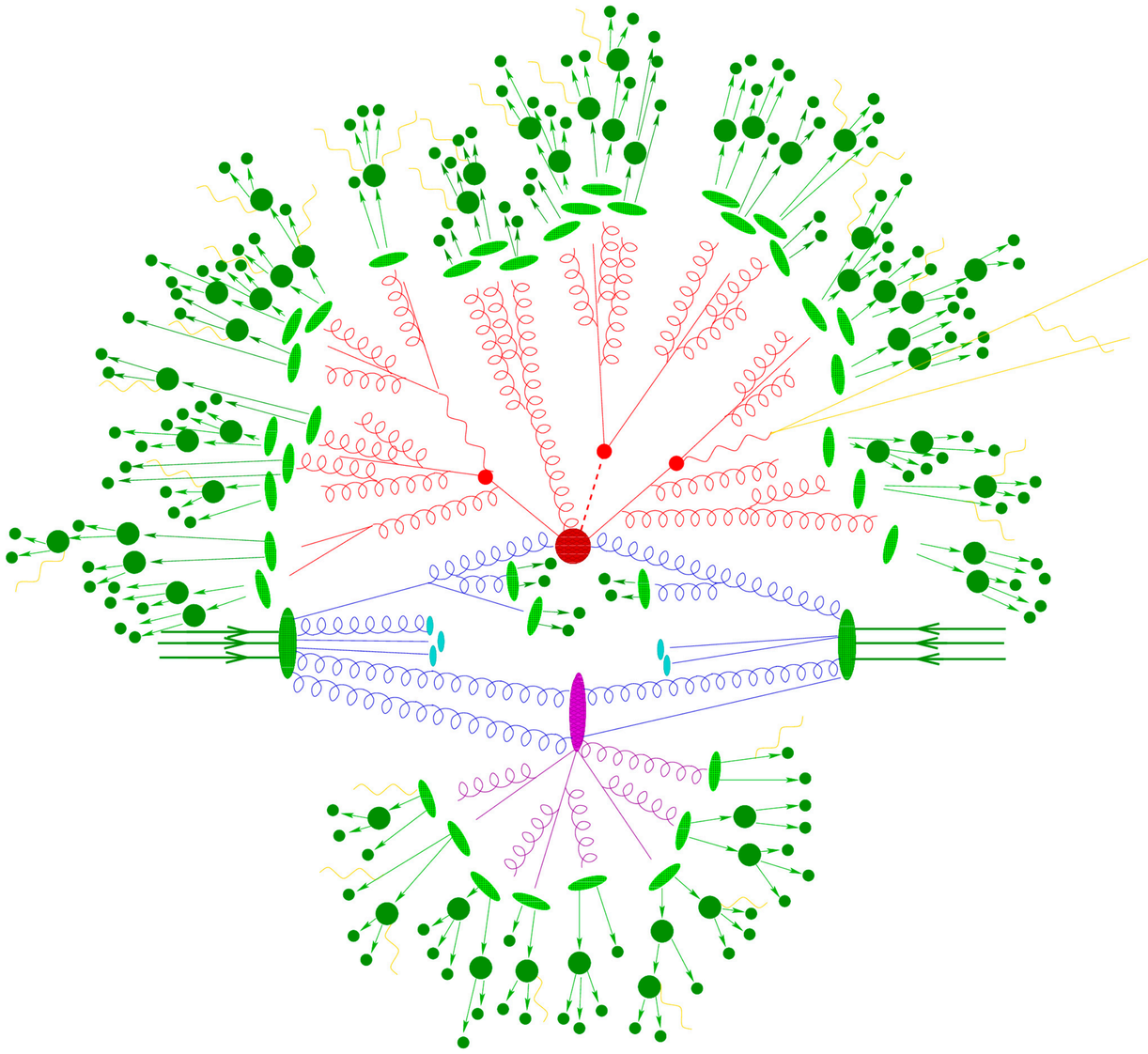
Future Challenges For Event Generators

Davide Napoletano, Lepton Photon ’23, Melbourne

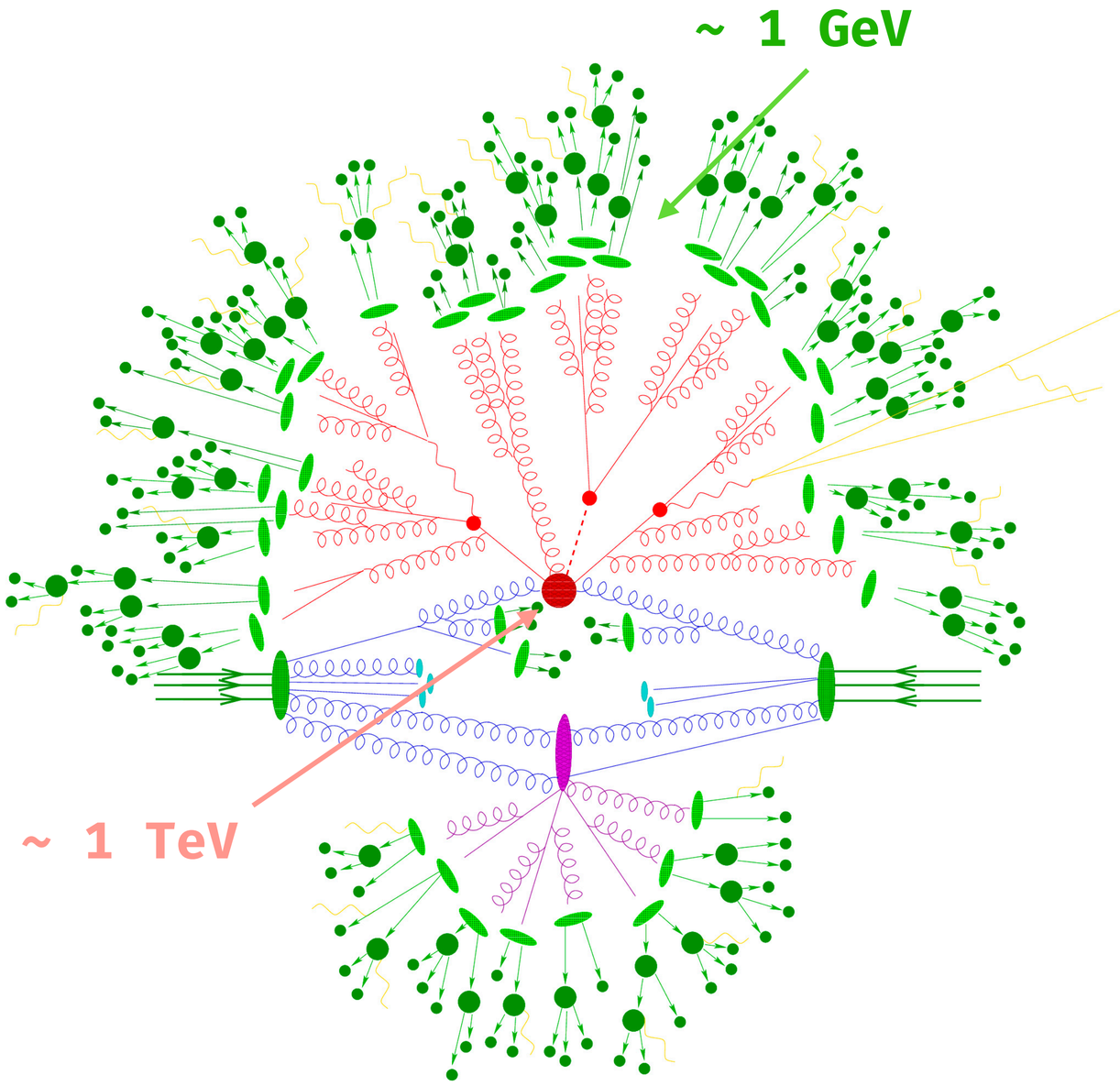
Introduction

- MC community devoted to describe



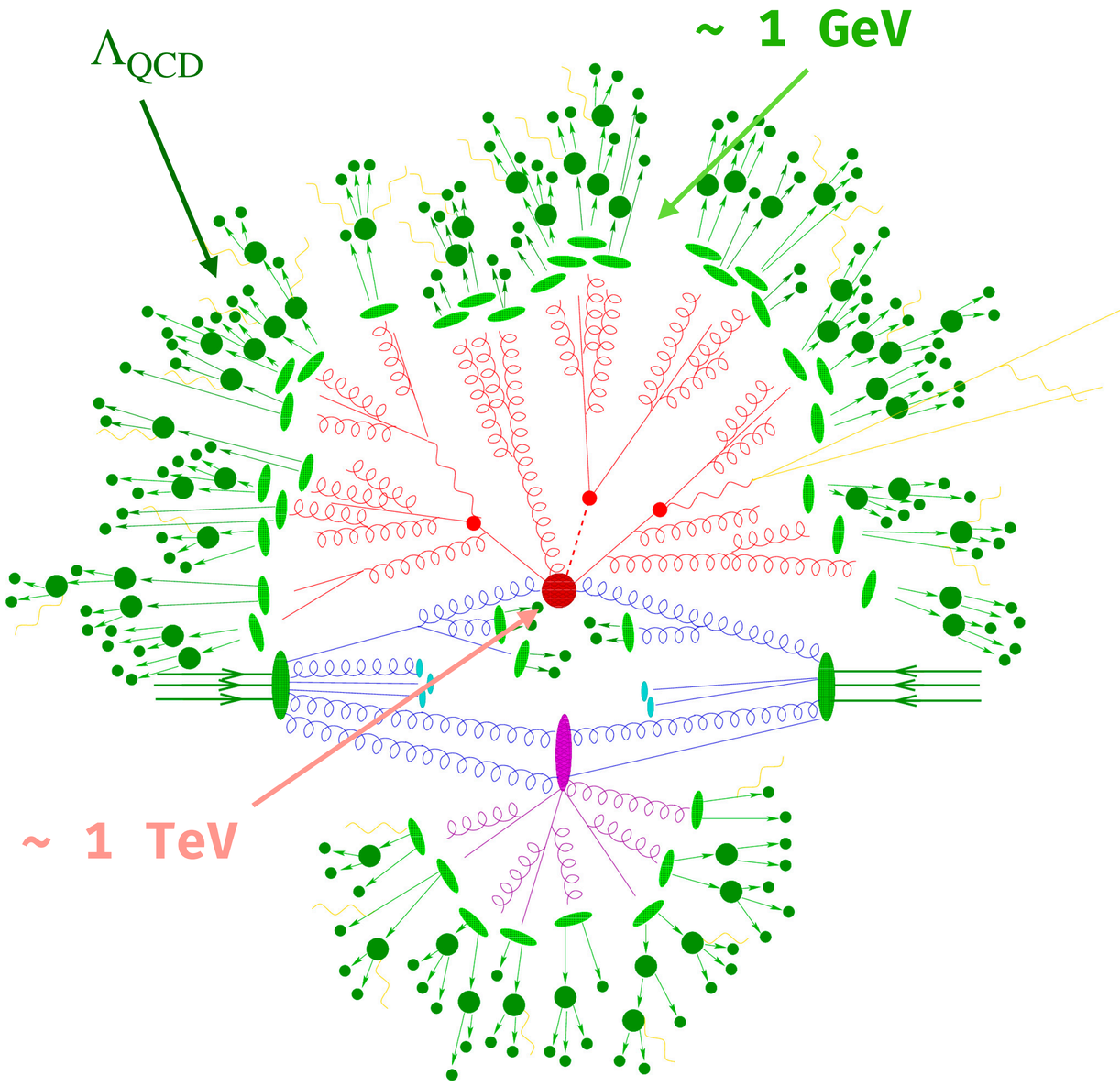
Introduction

- The strength of MC generators lies in factorisation of energy regimes!



Introduction

- This makes it possible to separately improve each of the “components”!



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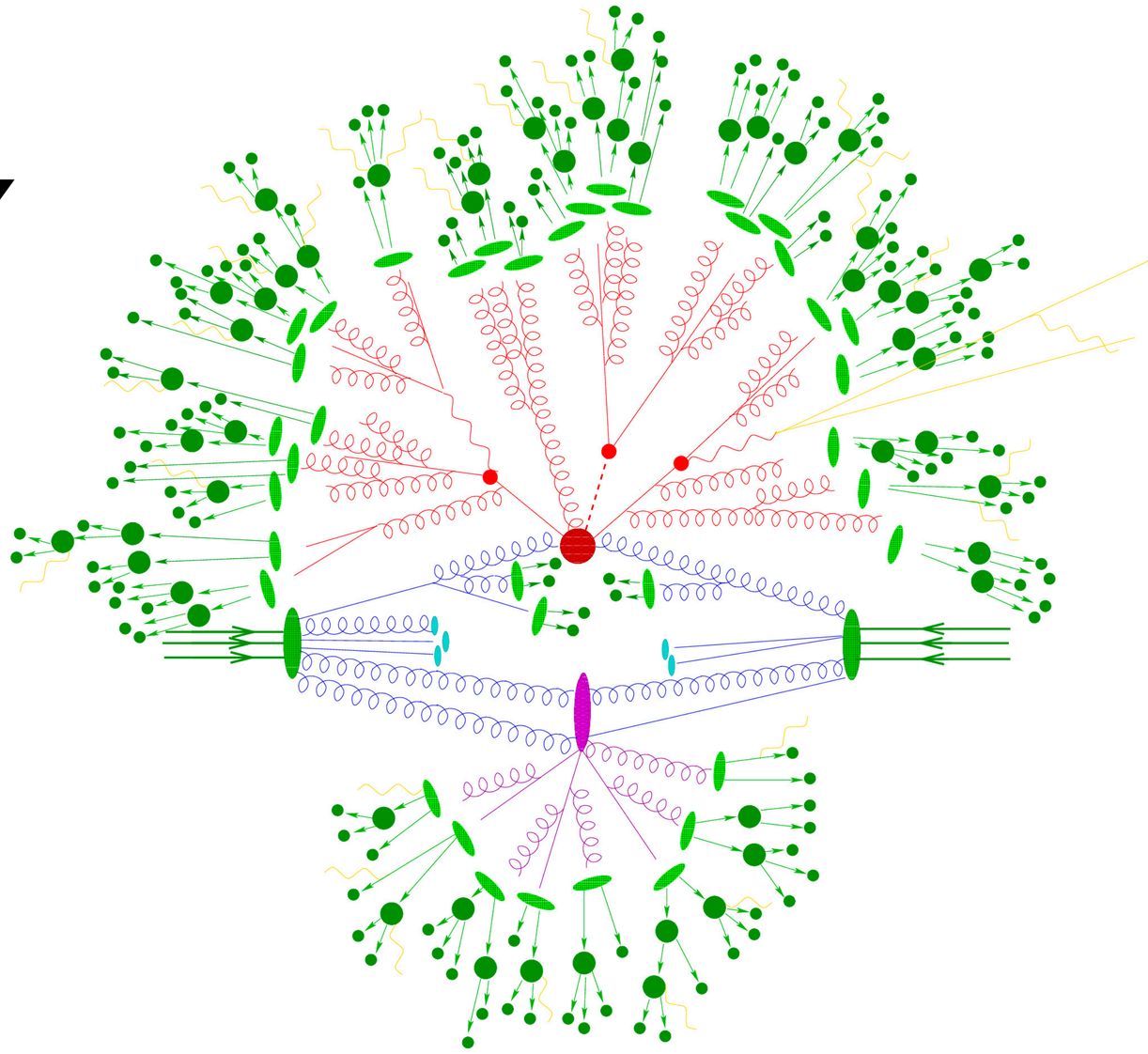
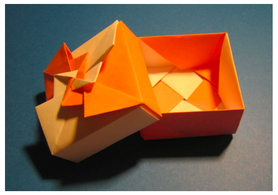
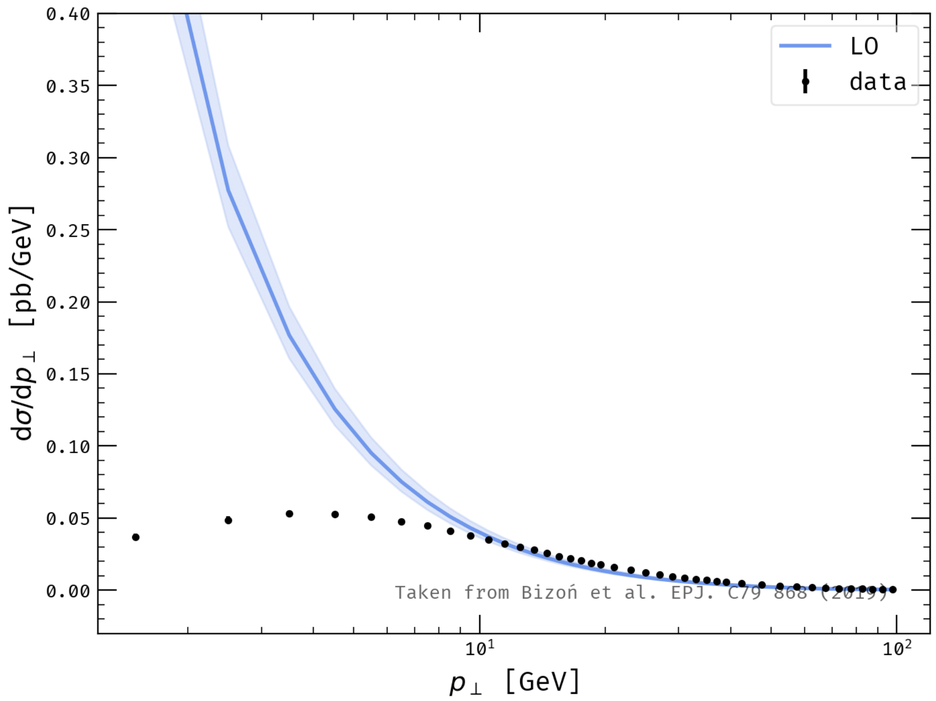
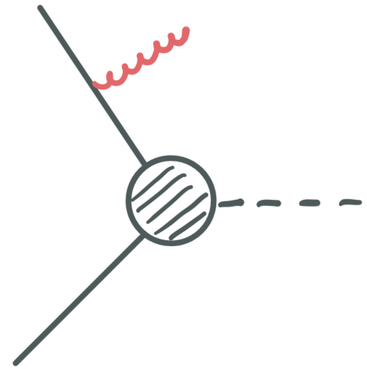




Hard Scattering





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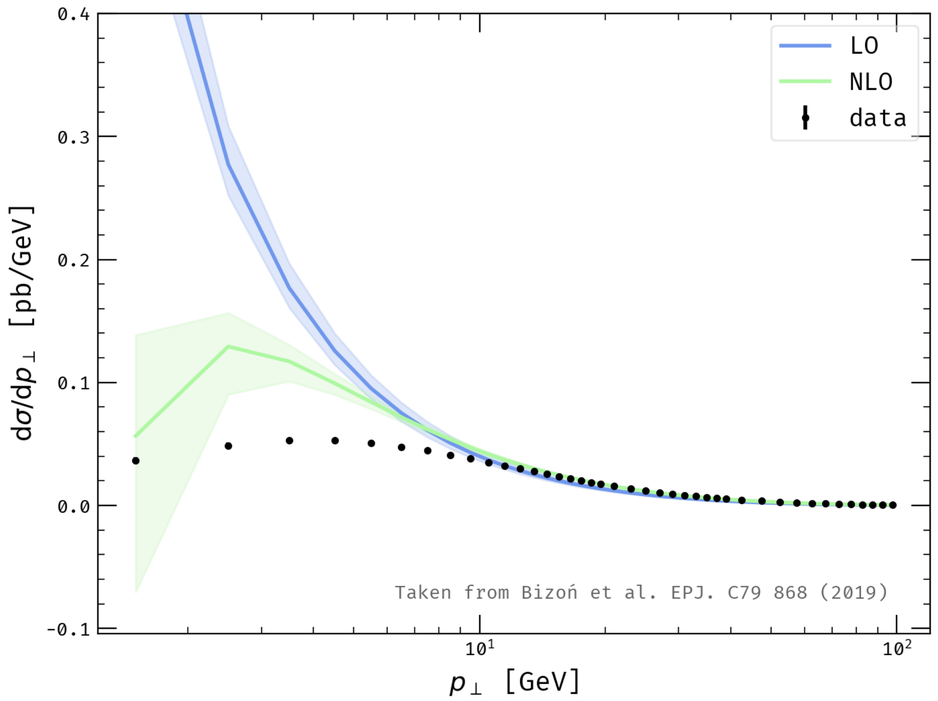
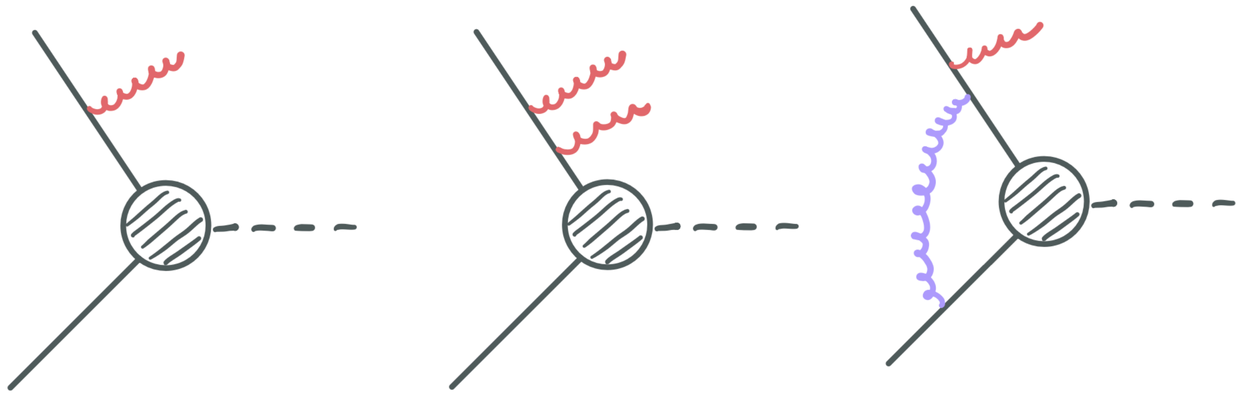
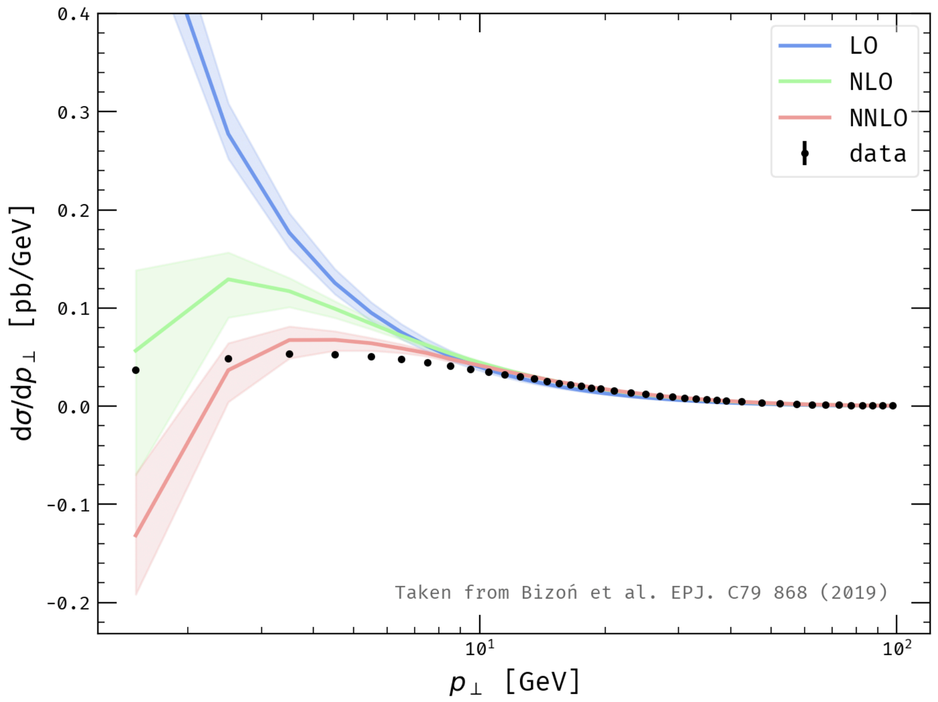


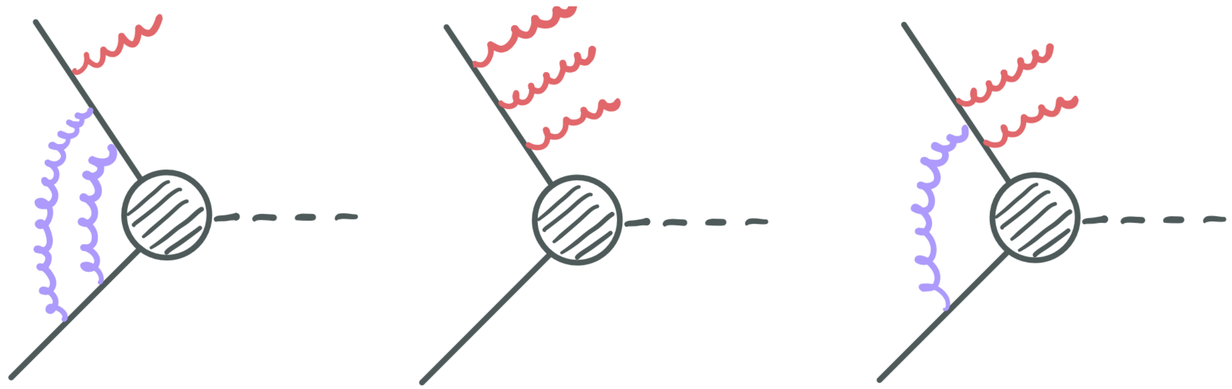


- To do this at NLO need subtraction of IR divergences!

[Catani-Seymour, FKS,…]

Hard Scattering

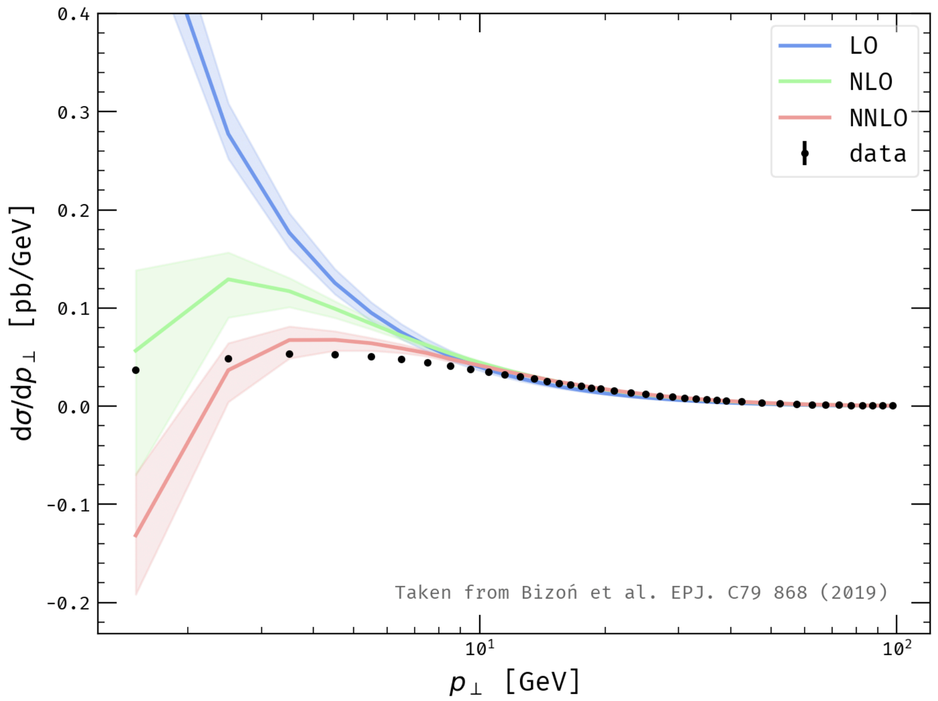




- At NNLO many methods, none implemented in general purpose tools…

[Antenna, ColorFull, Slicing, Analitic…]

Hard Scattering

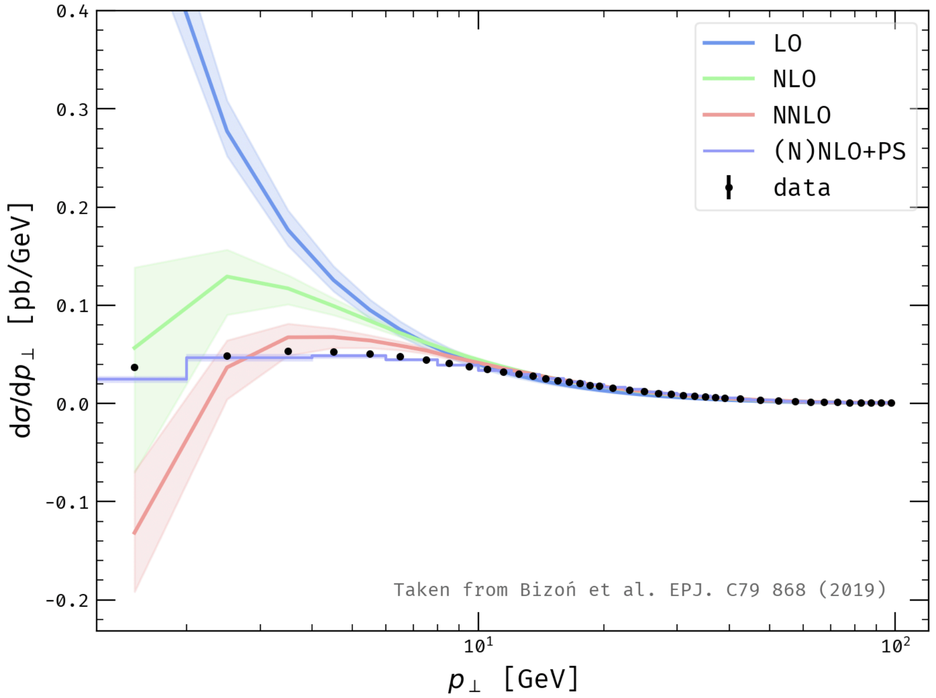


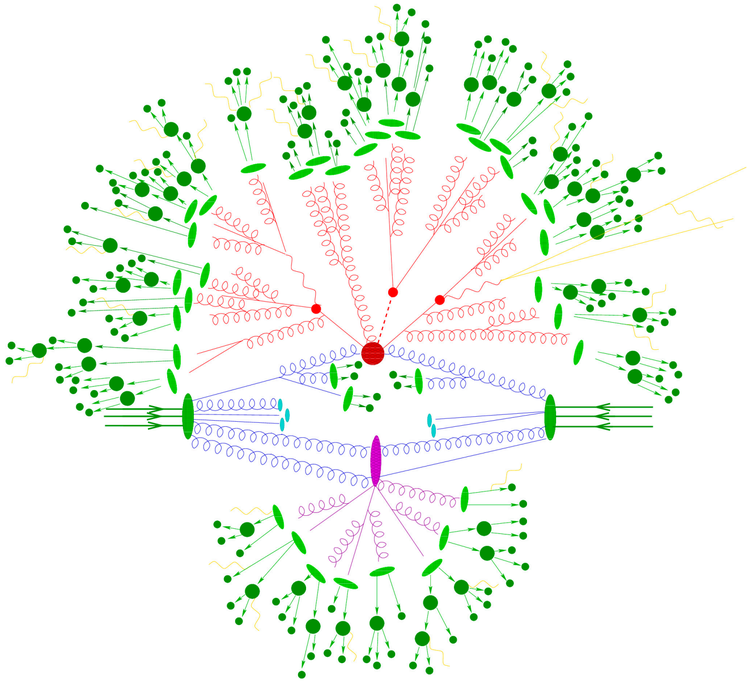
- This has been the core focus of developments in MC over the last ~ years i.e. how to include higher fixed order correction!

- Still, fixed order description misses something…

Parton Shower

- Still need to run down to the GeV scale





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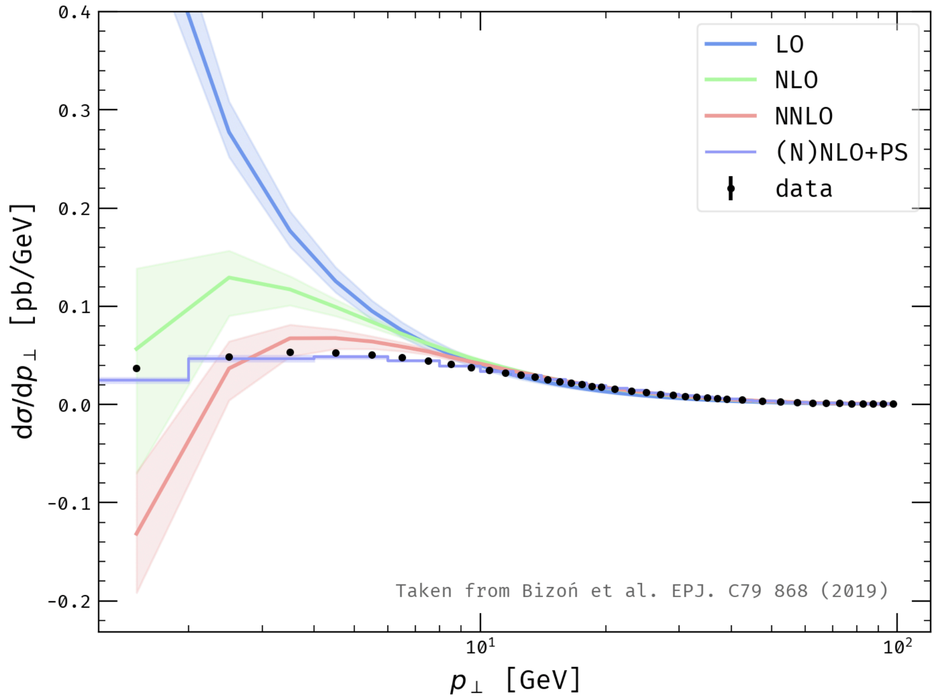


A MODEL FOR PARTON SHOWERS IN QCD*

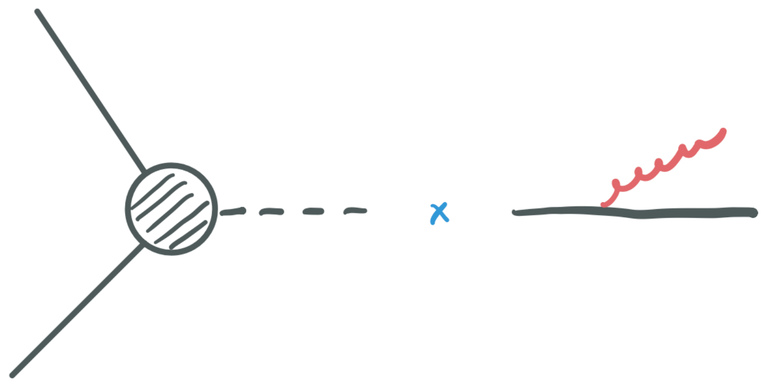
Geoffrey C. FOX and Stephen WOLFRAM[1]
California Institute of Technology, Pasadena, California 91125, USA

Received 27 December 1979

A Monte Carlo model for the development of parton jets in QCD is described. Explicit low-order calculations are supplemented by leading logarithmic approximations for higher orders.

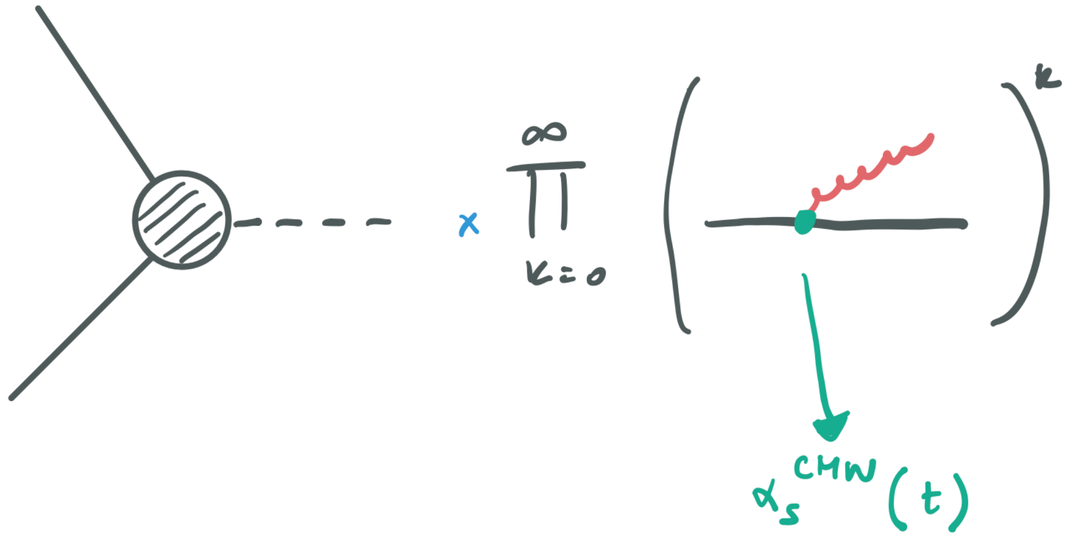
Parton Showers

- Various implementation with various degrees of technical details
- Accuracy of perturbative ingredients unchanged since the 90s



Parton Showers

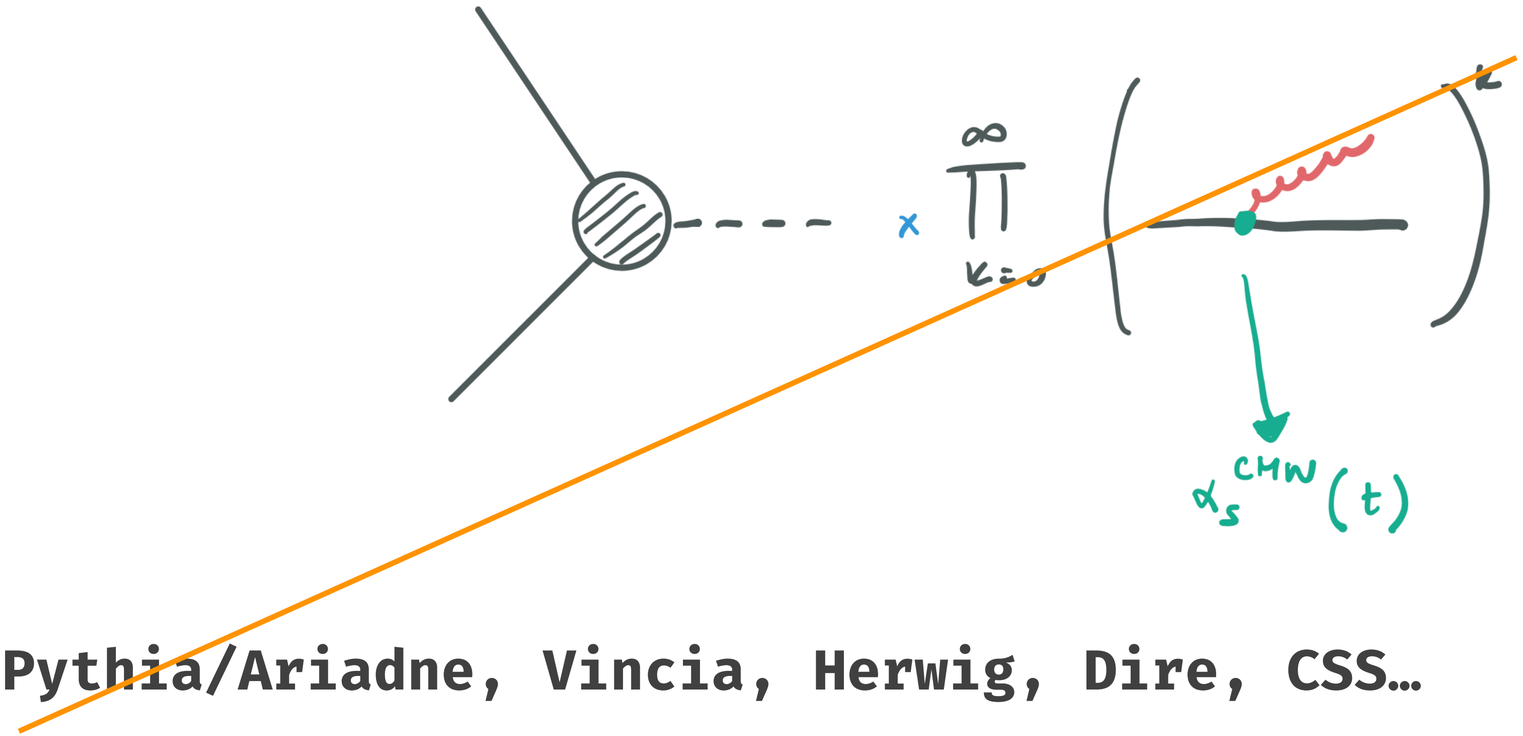
- Various implementation with various degrees of technical details
- Accuracy of perturbative ingredients unchanged for 20 or so years



- Pythia/Ariadne, Vincia, Herwig, Dire, CSS…

New generation showers

- LO splittings and CMW scheme not enough, be careful of t or recoil (PanScales, Alaric, Deductor, Herwig, Amplitude Evolution)



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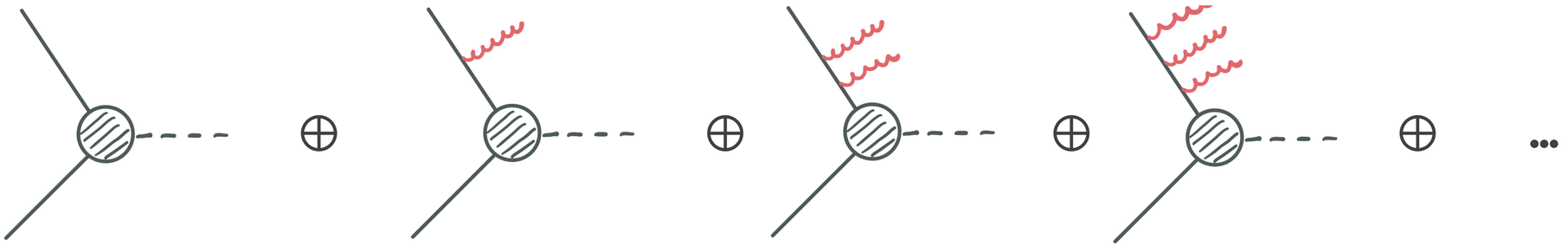
Matching & Merging

- Merging multiple multiplicities with Sudakov vetoes [CKKW-L, FxFx]



- Matching higher order calculations with standard showers already non-trivial (NN(N)LO + PS) –> what about even higher order showers?

Matching & Merging

- Merging multiple multiplicities with Sudakov vetoes [CKKW-L, FxFx]

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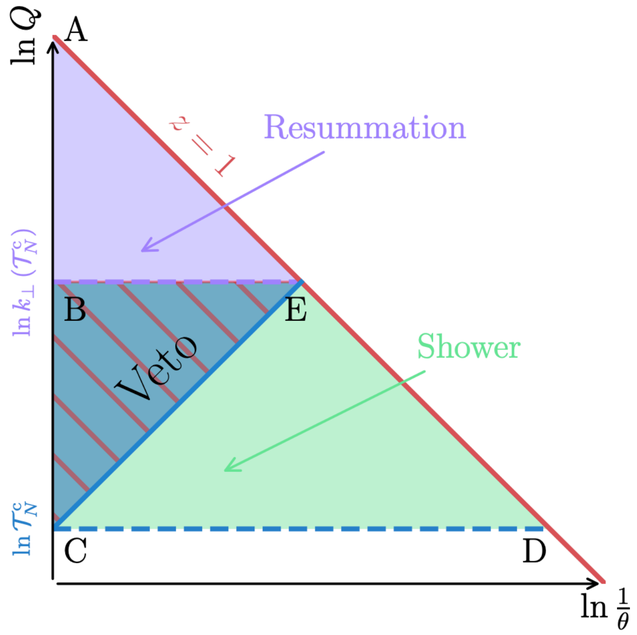
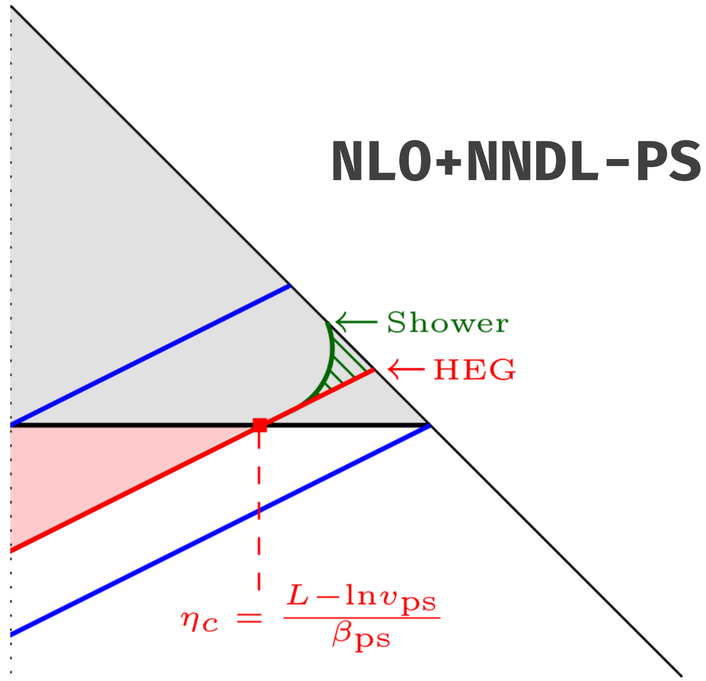
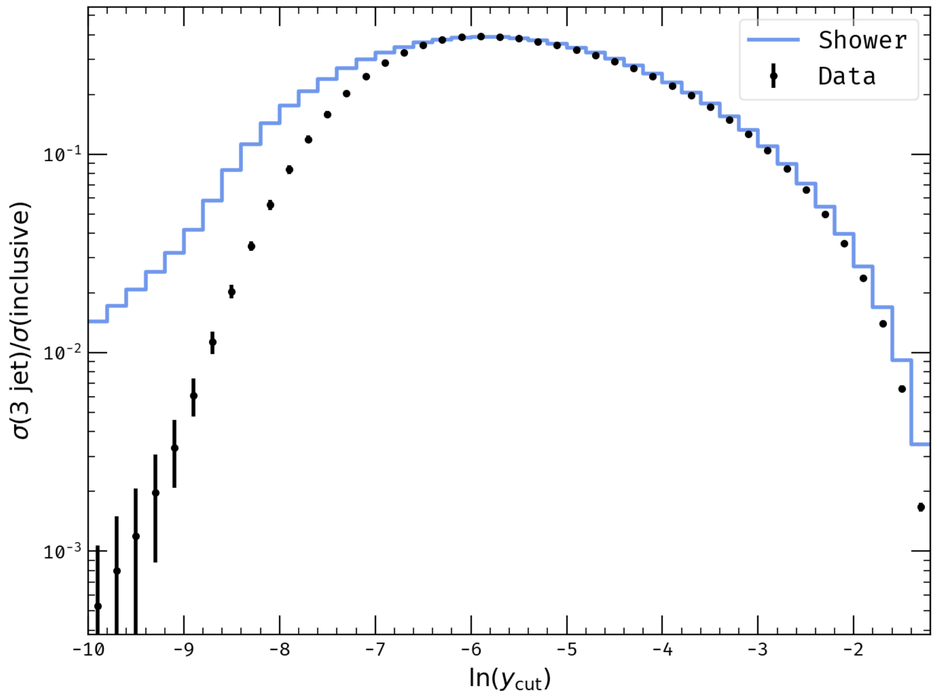
NNLO+PS



NLO+NNDL-PS

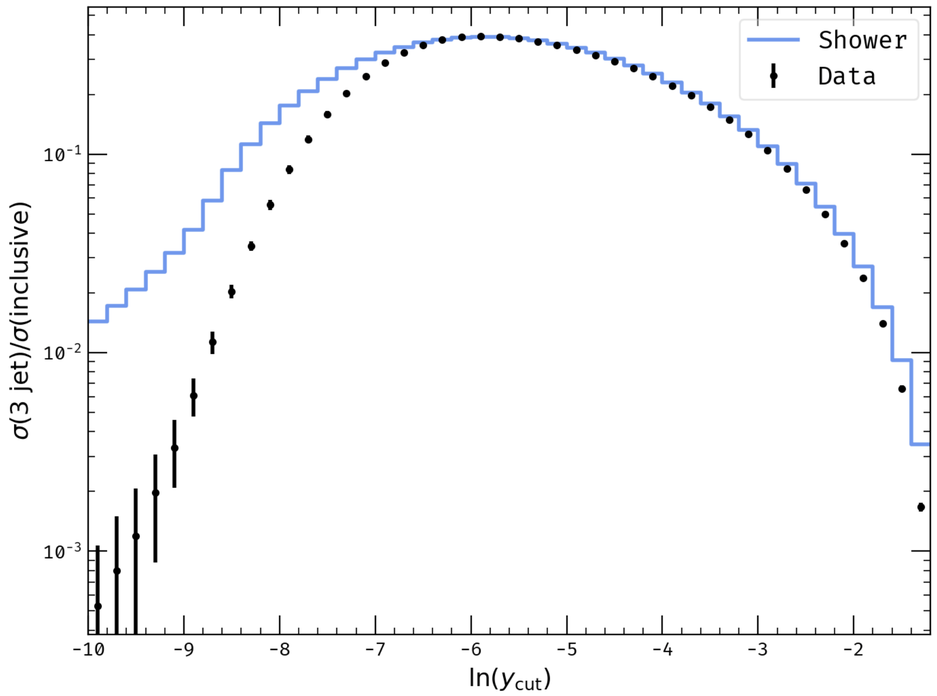


NP Corrections



- Take e^+e^-, look at a global observable

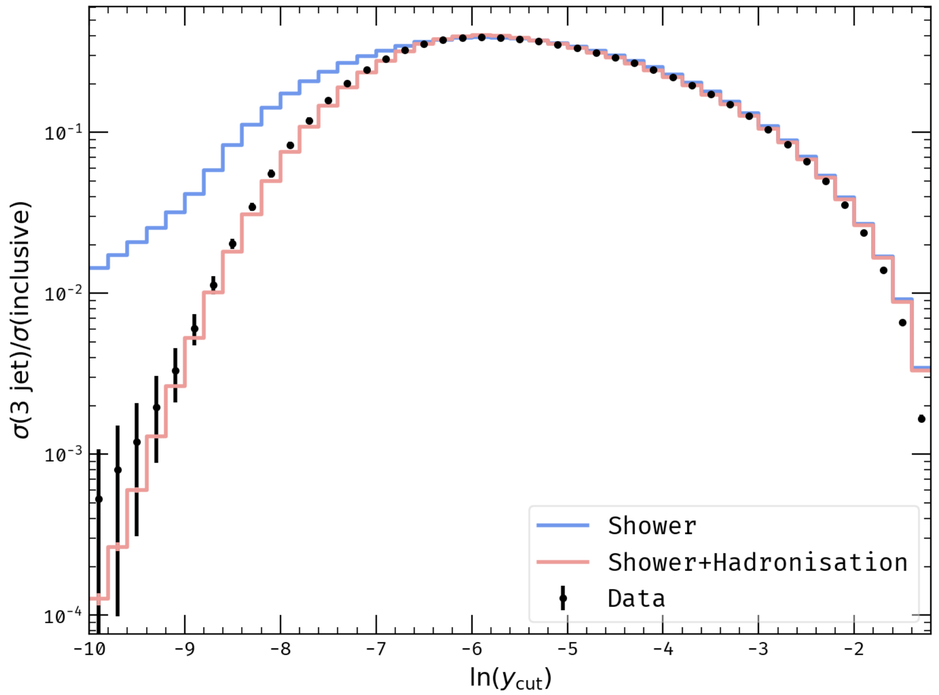
NP Corrections



- Take e^+e^-, look at a global observable

- The shower description is still not enough…

NP Corrections

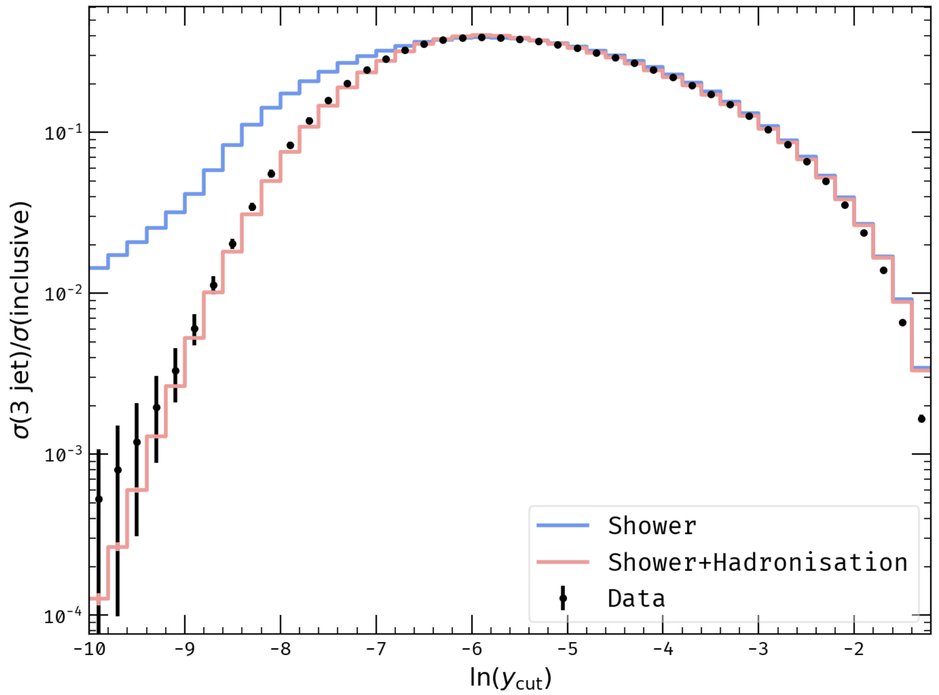


- We still need to parametrise what happens between 1GeV -> Λ_{QCD}

Tuning!

[Strings, Clusters…]

NP Corrections



- We still need to parametrise what happens between 1GeV -> Λ_{QCD}

Tuning!

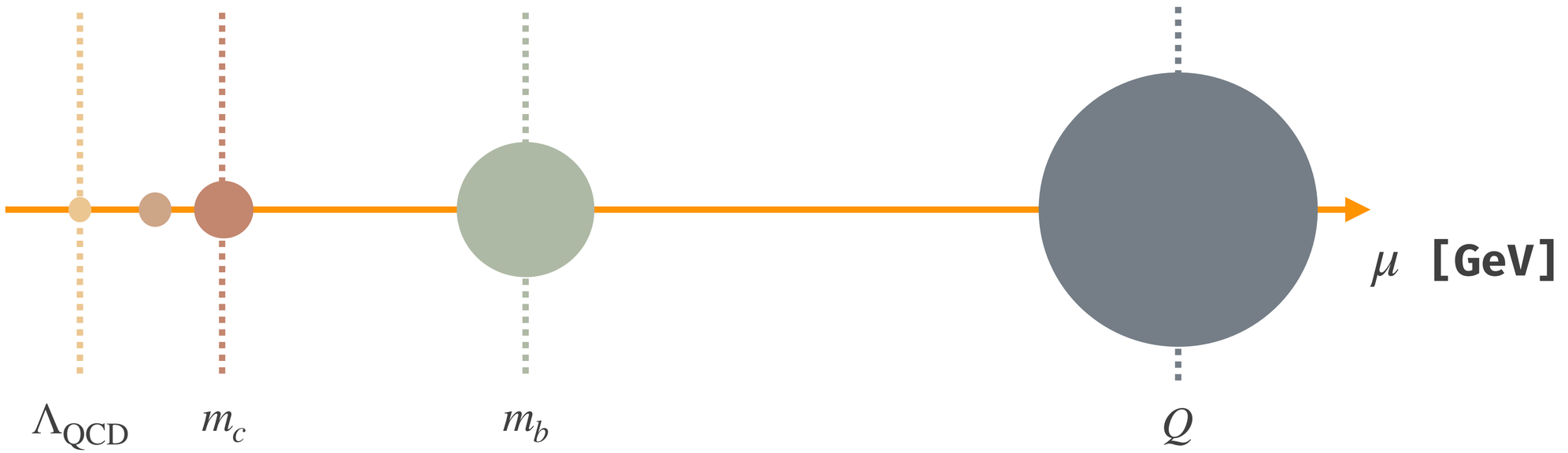
- Really universal? Perturbative/NP?

[Strings, Clusters…]

Quark Masses

- So far only replacing this amounts to replacing splitting functions and Kinematics

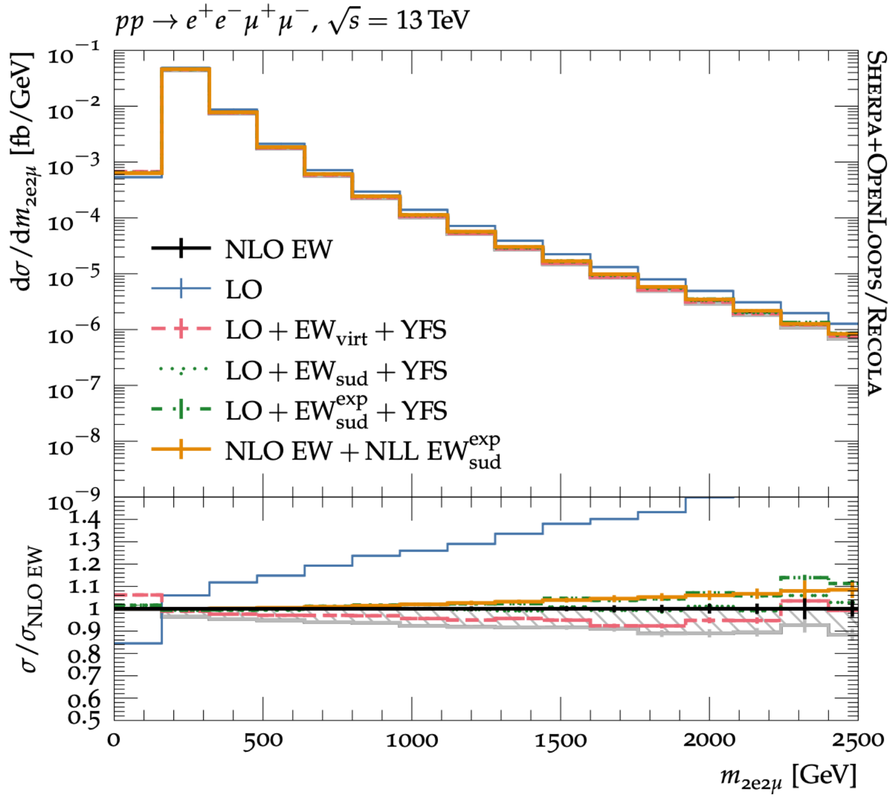
- Clear interplay of scales…



ElectroWeak Corrections/Photons

- Most GPMCG come equipped with some form of EW corrections, fixed order, or in the Sudakov approximation

- Still some work to do on fully fledged EW showers, EW final states?

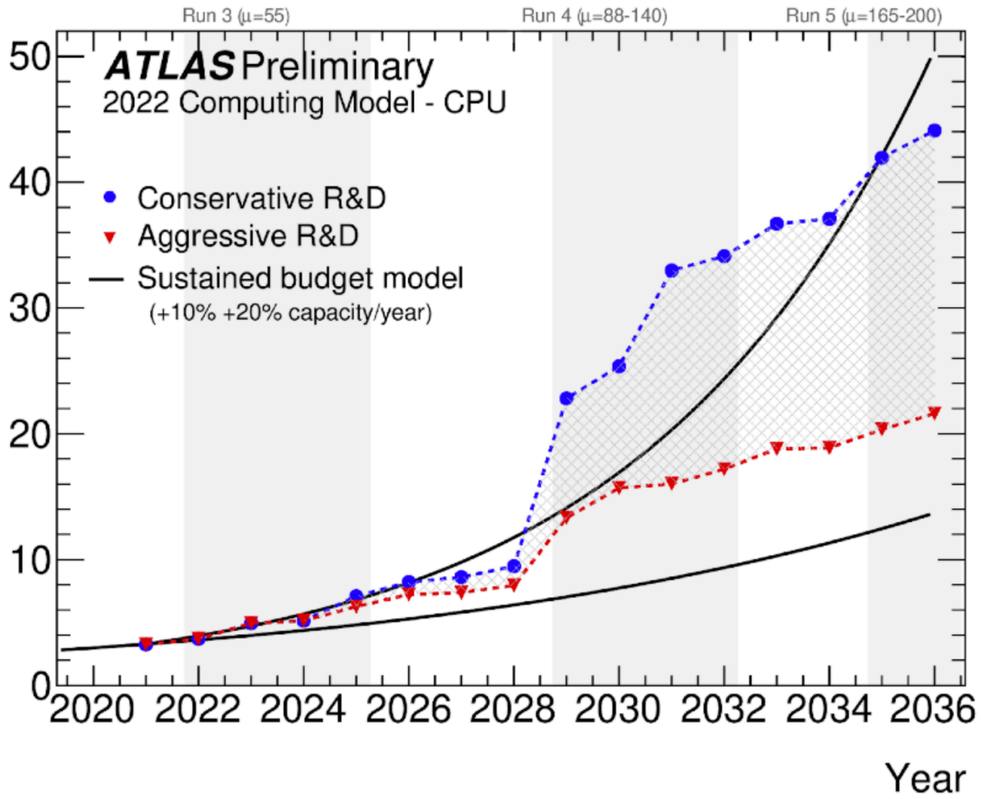


More Colliders/Heavy Ions

- Pythia is virtually the only option! But all other MCs need to catch up, as competition drives excellence!

Code Speed/Data sharing

- Running these tools at their highest accuracy is costly
- Codebases often contain inefficiencies (as we are physicists after all!)
- Results of running can occupy an extremely large amount of space



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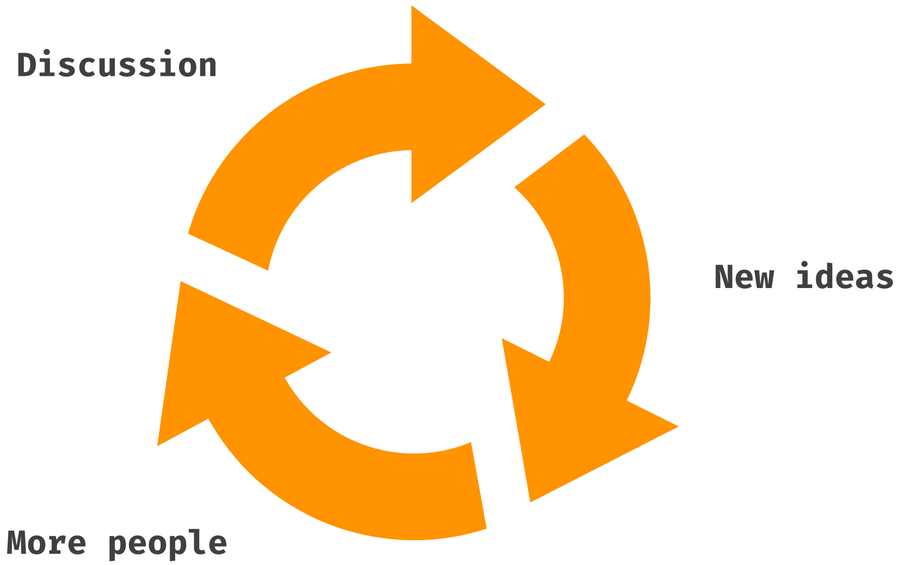
  - How far in the future is this?

Work Recognition & Man Power

- Increasingly harder to attract good physicist to do MC
- Codebases are often so large that require years of experience to significantly contribute to
- And the recognition for working behind the scenes is virtually zero



Conclusions

- Successes!

- Incredible development on higher order corrections/pQCD aspects
- Calculation of BSM effects through UFO or coded models
- Recent development of Parton Showers -> higher accuracy

Conclusions

- **Challenges for the future!**

- Dedicated study of power-corrections (mass, etc)
- Dedicated study of NP effects, in how far are they universal
- Need to discuss work recognition: (more papers == better)
- Expand to other colliders
- Code speed, generation management/sharing…