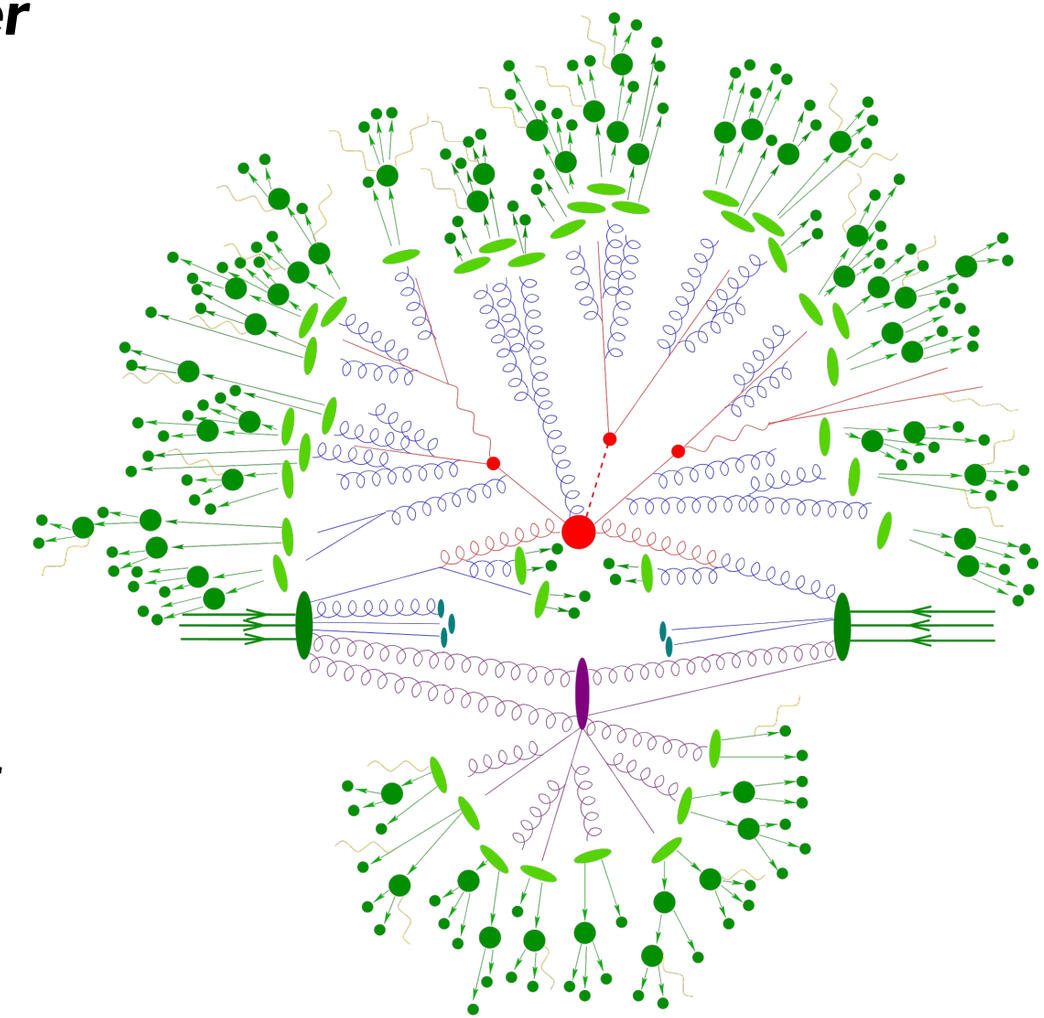
Monte-Carlo Event Generators

Stefan Hoeche

Theory Frontier Kick-Off Town Hall Meeting
July 30, 2020

General-purpose simulation tools

- ***Hard scattering processes at fixed order***
  - ***Automated frameworks***
  - ***Dedicated codes***
- ***Parton Showers / Resummation***
  - ***General-purpose showers***
  - ***Proof-of-concept codes***
- ***Matching and Merging of fixed order and parton shower at (N)LO & NNLO***
- ***Electroweak Sudakov resummation***
- ***Soft photon resummation via YFS***
- ***Underlying event models***
  - ***Multiple scattering and rescattering***
  - ***Soft underlying event models***
- ***Hadronization models***
  - ***String or Cluster fragmentation***
- ***Hadron decays***



Hard cross section computation

- ***Near fully automated process from Lagrangian to parton-level events, both LO and NLO, including spin-correlated decay chain simulation*** *[FeynRules,MadGraph,Herwig,Sherpa,Whizard,...]*
- ***Some processes available at NNLO*** *[POWHEG Box,Sherpa]*

Parton Showers and Resummation

- ***NLL accurate shower for e+e-*** *[Dasgupta,Dreyer,Hamilton,Monni,Salam,Soyez]*
- ***NLO corrections to splitting kernels*** *[Skands,Li], [Prestel,SH], [Dulat,Prestel,SH]*
- ***Sub-leading color, non-global and super-leading logarithms***
  - ***Color ME corrections*** *[Platzer,Sjodahl,Thoren], [Isaacson,Prestel], [Reichelt,SH]*
  - ***Evolution at amplitude level*** *[Nagy,Soper], [Forshaw,Holguin,Platzer]*
- ***Comparison to analytic resummation***
  - ***Fixed-order & resum benchmarks*** *[Dasgupta,Dreyer,Hamilton,Monni,Salam]*
  - ***Non-logarithmic effects*** *[Reichelt,Siegert,SH]*

Non-perturbative physics & Heavy Ions

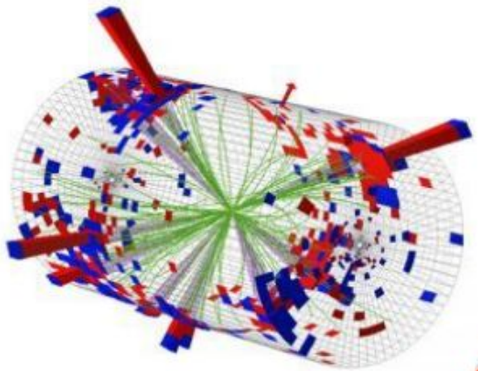
- ***Overlapping strings / Shoving model*** *[Bierlich,Gustafsson,Lonnblad,Tarasov]*
- ***Angantyr model for heavy ion collisions*** *[Bierlich,Gustafsson,Lonnblad,Shah]*
- ***Hadronic Rescattering in pp collisions*** *[Sjostrand,Utheim]*

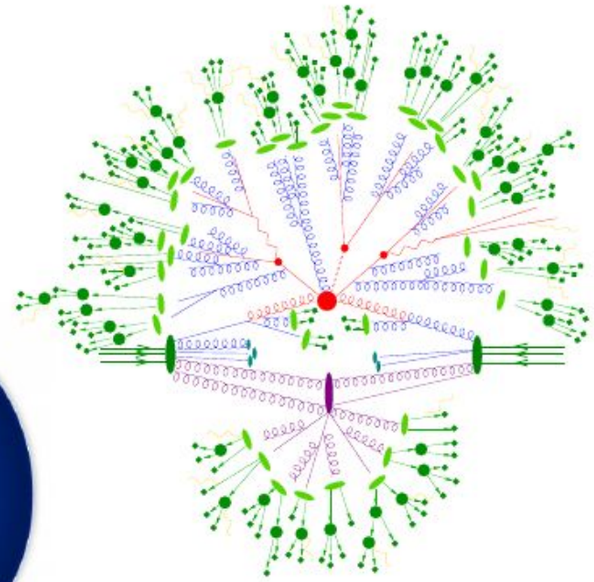
Computational Aspects

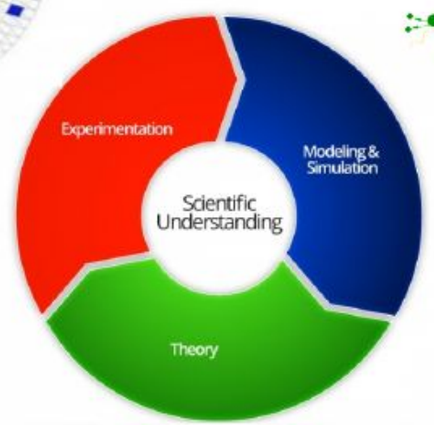
- ***On-the fly variation of generator parameters*** *[all MC frameworks]*
- ***Matrix element generators***
  - ***Parallelization*** *[Childers,LeCompte,Uram], [Prestel,Schulz,SH]*
  - ***AI/ML assisted evgen*** *[Danziger,Siegert], [Bothmann et al.], [Gao et al.]*
- ***Parton showers and matching***
  - ***Negative weight reduction in matching*** *[Frederix,Frixione,Prestel,Torrielli]*
  - ***Resampling*** *[Olsson,Platzer,Sjodahl], [Andersen,Gutschow,Maier,Prestel]*

Where do we stand, and what comes next?

- ***MCEGs perform challenging perturbative calculations***
- ***They complement analytic resummation techniques***
- ***They provide practical models for non-perturbative QCD effects***







$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i\bar{\psi}\not{D}\psi + h.c.$$