Designing your parton shower simulation

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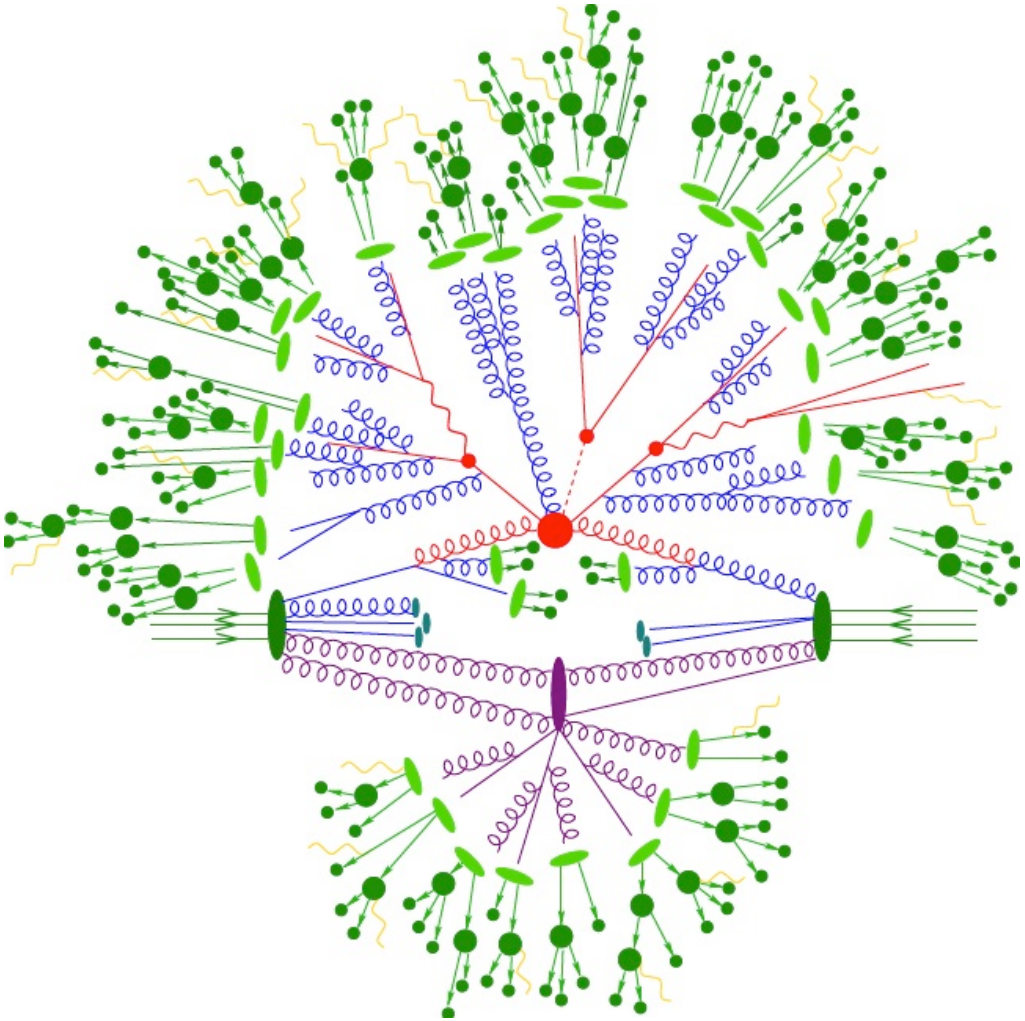
Event generation for high-energy physics

All physics relying on high-energy scattering events rely on scattering event simulations, featuring many different phenomena:



High-energy reaction

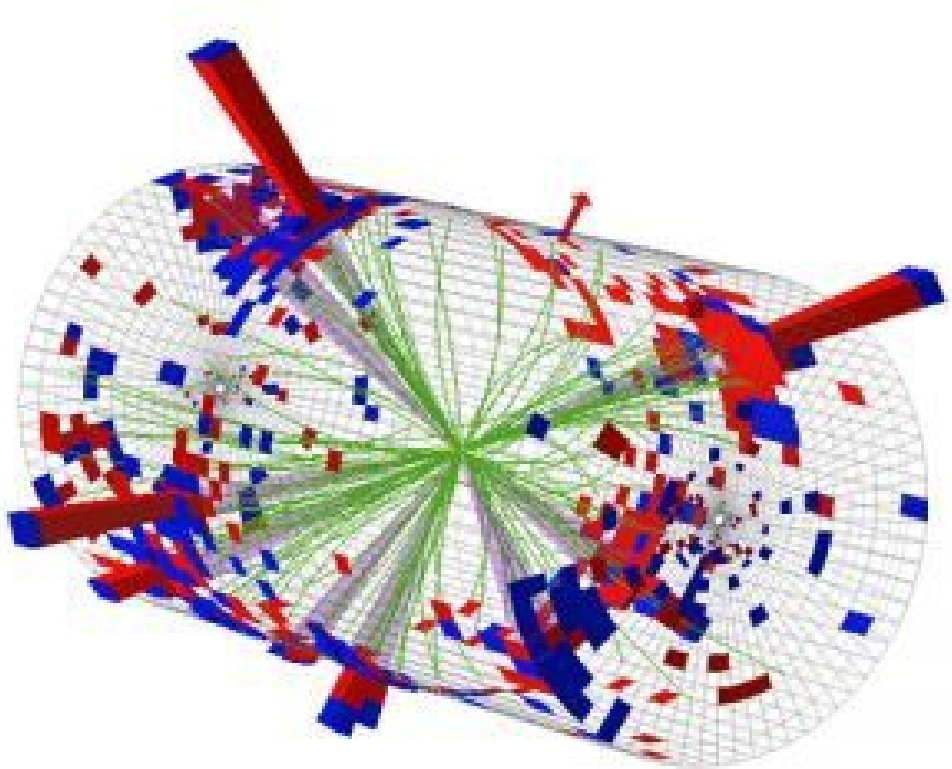
Radiation cascade

Secondary scatterings

Hadronization

Parton showers

Parton shower radiation cascades describe how jets are formed in particle collisions. Jets are an essential tool in collider physics.



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$\Rightarrow$ Good jet modelling necessary!

Project description

Construct and test your own parton shower for one (or more) high energy scattering processes!

...and improve it with a next-to-leading order QCD calculation.
...and apply it to a future lepton collider.

You will

- Learn about QCD calculations, phase space integration, and apply your knowledge of (fixed- and all-order) perturbation theory.
- Improve your Python programming skills.
- Go home with your very own parton shower generator.

Be creative with your tool!

Check out the "PS tutorial" at
`www.slac.stanford.edu/~shoeche/mcnet16/ws`

Once you have mastered your tool, be creative with your own improvement ideas, and test your understanding!

Possible challenges for you and your group are:

- Study your improvements at a high-energy lepton collider.
- Parton showers resum large logarithms of their ordering variable to all orders in perturbation theory. If you use a different ordering variable, you perform a different all-order calculation! Use another ordering variable (e.g. the virtuality of a branching) and compare!
- Include the calculations for $e^+e^- \to Z^0Z^0 \to$ jets and $e^+e^- \to W^+W^- \to$ jets. When will these more complicated electro-weak processes become important?
- Calculate tree-level MEs for $e^+e^- \to n$ gluons/partons and combine with your PS by "matrix-element + parton shower merging".

References/hints

1. The introductory tutorial sheet can be found on
   `www.slac.stanford.edu/~shoeche/mcnet16/ws`
   under the "PS tutorial" link.
2. You will need a Python installation, and the YODA histogramming tool if you want to produce plots. The best way to get a full-fledged software setup is to use a virtual machine (VM). The VM and instructions on how to get started can be found at
   `www.slac.stanford.edu/~shoeche/mcnet16/`
3. You can get a "raw" version of the supplementary Python code with
   ```
   svn co --username=mcnet16 --password=school \
       svn://svn.slac.stanford.edu/mc/tutorials/mcnet16/ps
   ```
4. Follow Keith Ellis' lecture closely!
5. Helpful background material: MCnet event generator review:
   `https://arxiv.org/abs/1101.2599`
   TASI lectures by Stefan Hoeche (very detailed!):
   `https://arxiv.org/abs/1411.4085`
   ICTP lectures by Stefan Prestel (with videos!):
   `http://www.slac.stanford.edu/~prestel/schools/2015-sao-paulo`