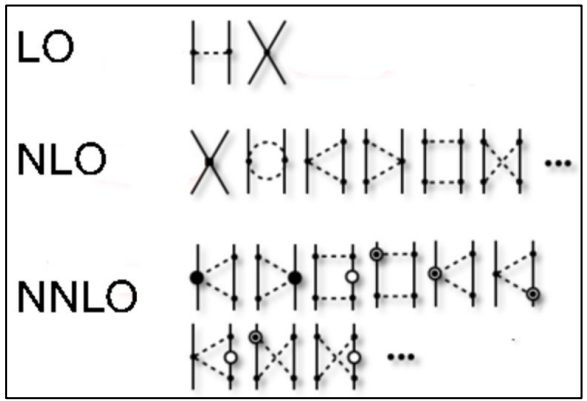
WG Name, Charge and Scope

Generators & Theory WG

- Scope:
  - Event generators and their components, i.e., MC integrators, matrix element generator, event production, showering,
  - Theory calculations
- Charge:
  - Work toward NNLO calculations in generators for the HL-LHC
  - Investigate new algorithms leading to possible precision or performance improvements
  - Develop repository for common tools with standard formats and interfaces
  - Define performance measurements and improve algorithm performance

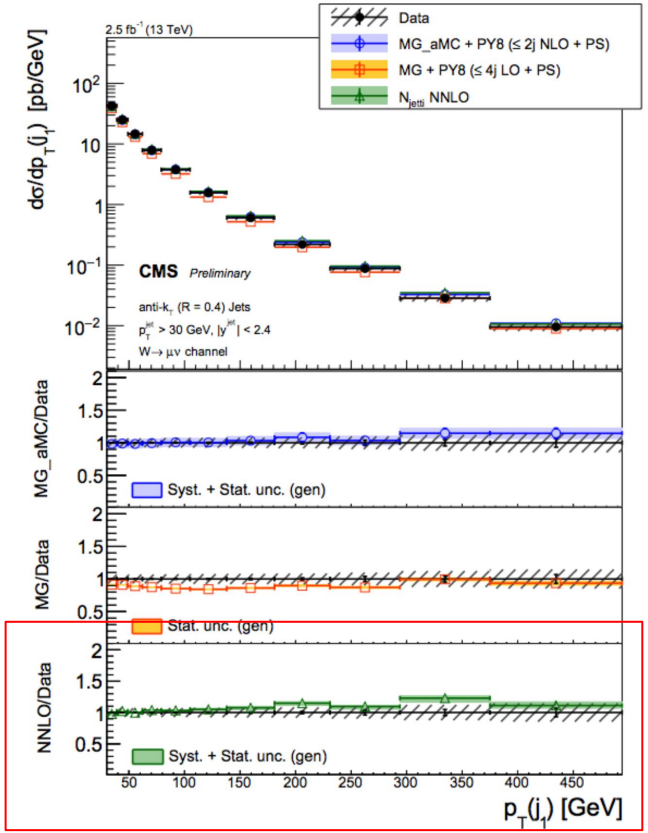
Key challenges and opportunities

- Developing NNLO generators still requires **significant theoretical development**
- Developing repository of tools for common, well-established algorithms as a community
- Improve scalability and performance making use of advances in CPU, storage, and network technologies
- Maintain the memory footprint of event generators below 1GB/thread at the scale of 64 threads
- Reduce the computing resources to achieve a result by improving/switching algorithms



Integrating NNLO processes into Generators

- Integrating NNLO matrix elements into generators (already included in some theory calculations) is required for a robust physics program at the HL-LHC.
- Figure shows analysis uncertainty is already competitive with NNLO theory calculations.
- Going from LO to NLO generation was already a challenge increasing both memory and computational requirements
- Moreover, we don't even have the theoretical tools to calculate NNLO for color-full processes:
- The number of Matrix Elements explodes with each additional order in pQCD leading to more integrals to calculate
- Different solutions have been developed and employed by different collaborations for integration and generation



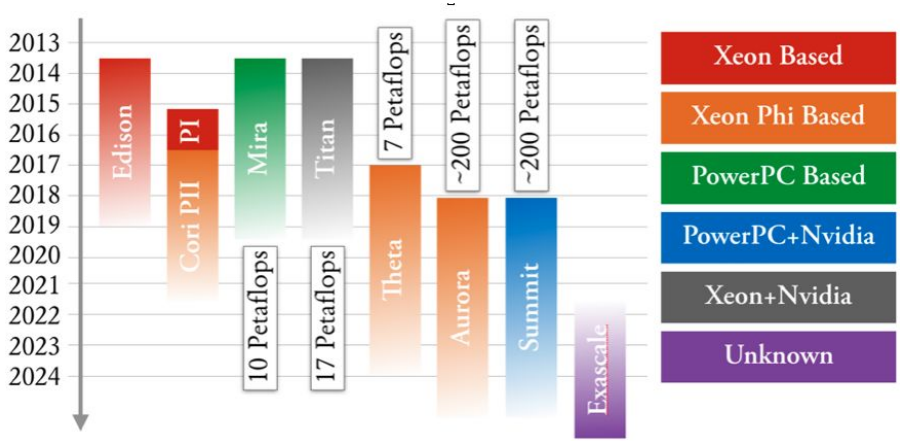
https://cds.cern.ch/record/2204927/files/SMP-16-005-pas.pdf

Repository of Common Tools

- Different solutions have been developed and employed by different collaborations for integration and generation
- Consolidating tools, e.g. matrix element generators, monte carlo integrators, into a single repository would improve maintainability
- To get the most of such a repo, a common interface and data format will need to be defined to enable plug-and-play style usage
- However, it is important to have a range of generators which depend on different theoretical methods to ensure a robust testing ground
- No code is ever bug free, and having many generators provides checks to test for errors

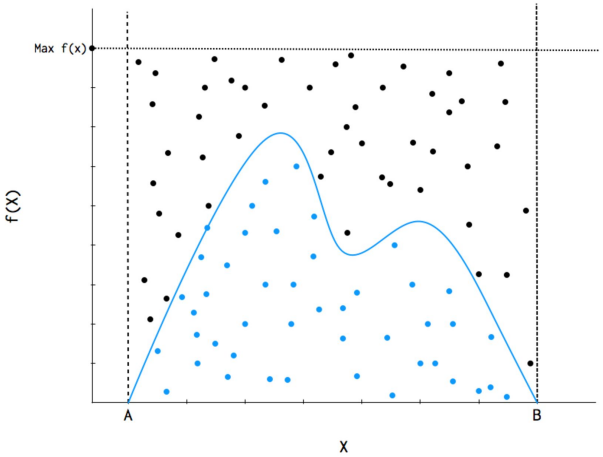
Targeting Scientific Supercomputers

- Our group is responsible for some of the most computationally intensive codes within the LHC scope.
- The US & China are investing O($1T) in scientific computing resources in the form of supercomputers over the next decade, providing a 100x increase in cpu cycles.
- Next generation integration and generation software will be designed to be performant and scalable.



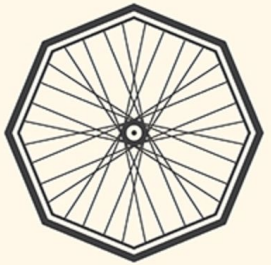
Practical Consideration for Progress in the WG Area

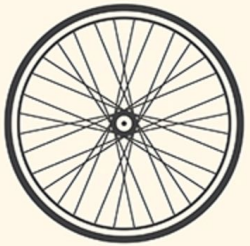
- To achieve these goals in time for the HL-LHC the follow plan has been proposed
- In the next 1-2 years:
  - Continue theoretical development for generating NNLO parton interactions
  - Investigate new integration techniques with an eye on performance and scalability
  - Identify common algorithms for common repo and begin defining common interfaces/formats
- On the 3-5 year time scale:
  - Continue theoretical development for generating NNLO parton interactions, and hopefully vetting some of these calculations during this time period
  - Implementing/porting common algorithms in repo

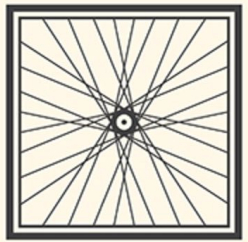


Commonality and Leveraging S&C beyond HEP domain

- There are clear benefits to consolidating effort in this area as all LHC experiments use essentially the same generators
- Having common tools in some cases is advantageous
- However it is also important to have competing methods for robust results as no code is ever bug free







Cross-cutting Elements

Not Obvious

CWP Chapter Status and Plans

- Our chapter is being drafted in Overleaf.
- The outline is in place with plans & big ideas
- Writing the meat of the text, plots, etc, is beginning to be written
- Given the current effort, a first draft could be ready in September
- Then iterate with comments from the community

Auxiliary Material

Primary Activities

- Beyond Leading Order Calculations on HPCs
  - Sept 2016 @Fermilab
  - https://indico.cern.ch/event/557731/timetable/
- January 13th first phone meeting
- June 9th latest phone meeting

Generators & Theory WG

Working Group Members:

- Taylor Childers (ANL) (primary organizer)
- Stefan Hoeche (SLAC)
- Steven Mrenna (FNAL)
- Frank Pertriello (Northwestern)
- Radja Boughezal (ANL)
- Josh Bendavid (Caltech)
- Josh McFayden (CERN)
- Christian Reuschle (FSU)
- Olivier Mattelaer (UCL/CERN)