FNAL Generator Tools Workshop: Goals

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8 January 2020

Brief Recent History of this Effort

- Needs for increasing sophistication in generators have been clear for a long time, but increasingly urgent with T2K and NOvA data, and design studies for DUNE and Hyper-K.
- Series of generator workshops, organized at ECT* in Trento in 2018 and 2019, to discussed collaborations to improve generator models.
  - The second of these in 2019 focused increasingly on technical work and tools to increase efficiency of collaborations.
- Plan for this workshop, to move forward on some of the conclusions from ECT* 2019, began shortly after the workshop.
- Welcome, and thank you for continuing this work with us!

Needs and "Pain Points"

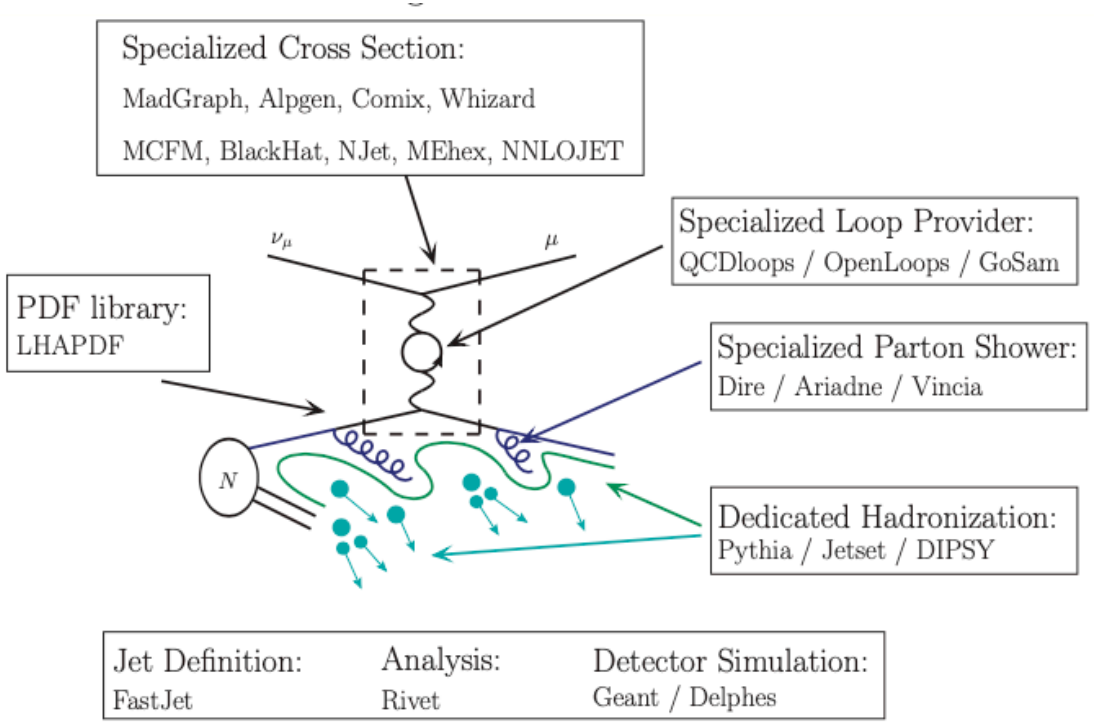
- Generators encode theoretical and experimental work for neutrino experiments.
- Experiments would benefit from faster access to new theoretical models.
- Experiments would benefit from using a generator framework to more effectively "share" each other's work.

"**Pain Points**" from Gabe Perdue, Laura Fields (ECT* 2018-2019)

- The **time between model development and incorporation into experimental simulations** is quite long
- It is **difficult for theorists to engage**, and they are generally underserved in terms of citations when they do
- We **duplicate effort** in re-implementing models many time
- **Release schedules are slow, and lots of bugs** are unearthed once code gets to large users, leading to lots of headaches in neutrino software and missed production deadlines
- In general the current structure of generator collaborations puts **bottlenecks on model development** and makes it hard to leverage a large community (not because the generator authors are bad people, but because they need to be deeply involved in putting models into the generators and there are only so many generator folks)
- Some of **our best physics models are very hard to use** because they don't have geometry and flux support (and it is hard to ask developers to add that sort of stuff - that isn't their expertise)

Generators @ Hadron Colliders

- The model at hadron colliders uses factorization of components to allow many groups to develop independently, but still results in an integrated product.
- This model is not perfect, but it has some advantages over ours.
- We have different “factorization” in neutrino interaction models, but can we still use the concept?



More factorized – i.e. more codes contributing – where it matters most (precision hard scattering)

Figure courtesy of Stefan Prestel

One Trento conclusion: pursue separation of components of generators ("ratings")

1. An accord on a common format for all generators ("easy")
   - Event history: initial state, hard scattering before application of FSI cascade
     - Currently several collaborations (NUISANCE, T2K, NOvA, MINERvA, etc.) develop their own solutions (mostly translators) for this independently.
   - Common descriptions of flux and detector geometry would also be beneficial
2. Support FSI in a "second stage", separate from hard scattering, in generators ("doable")
   - Would allow cross-fertilization of FSI models.
     - At a minimum, easier to compare results.
     - Could accelerate adaptation of best practices/models into different generators.
   - There exist complications: consistency with initial state nuclear model, for example.
3. Common flux and geometry driver ("harder" to "impossible")
   - How difficult is something to debate. Everyone agrees there are many details to work out.
   - If the first three factorizations could be accomplished, then any theorist could put their model into a "mini-generator" using those common components, and experiments could easily run them.
     - Huge benefit to both experiment and theory communities if this were used widely.

Separation of components (“ratings”)

4. Universal theory “API” in generators (“difficult” to “very difficult”)
   - Limited case, hadronic tensor stored in tables, has already been used for several models.
   - What are the limitations of this approach? Are there other approaches?
5. Separation of initial state and hard scattering (“conceptually impossible?”)
   - Clear benefit to this, but…
   - Many models using data inherently integrate those together in their approach, and there is no clear universal scheme for separation. There is a big price for excluding such models.
6. More speculative ideas (“difficult” to “fantasy”)
   - Common reweighting engines, or at least a standard interface for such. T2K work for NuWro and the DUNE reweighting interface suggests possible approaches.
   - Common tuning infrastructure or project for models. (Already discussed this morning in generalities.) This would address some stated needs from the collaborations.

- The focus of this workshop is on the first four of these components.

Structure of the Workshop

- Introduction (you are here)
- Reports from GENIE, NEUT, NuWro, GiBUU on the topics below
- Topics
  - Flux and geometry
  - Event format
  - Factorizing FSI from hard scattering
  - Theory API
- Summary and development of a work plan

- There is plenty of time in the agenda for discussion, and for working out details. We are not presenting (only) polished products.

Next steps

- Documentation
  - We will use the discussions and summaries at the meeting as a springboard for writing an outcomes document from this workshop.
  - That document will include a first draft of a work plan based on discussions here.
    - That plan can be refined (offline) in the document when it is circulated for review. Don’t be shy in helping to improve the output of this meeting.
- First work towards realizing the plan
  - We hope to leave with a set of action items for interested individuals and generators developers.
- Collaboration
  - As that work progresses, we will want to stay in touch. Remote, periodic meetings on focused topics seem desirable.
  - When ready and needed, another global meeting like this one.