

# A brief introduction to RIVET for the EIC

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## Day 2: RIVET

- Yesterday: went through PYTHIA8, and ran a RIVET analysis.
- Today: a more detailed introduction to RIVET.
- Prerequisites:
  - A working installation of the tutorial image.
  - A HEPMC ep sample (generated yesterday, or download later).
- Program:
  - 25'** Introduction to RIVET.
  - 10'** Questions and start group work.
  - 35'** Groups: Write your own analysis (including small break).
  - 10'** Follow-up on exercise & start next one (in plenary room).
  - 35'** Groups: Advanced analysis features.
  - 5'** End of day (in plenary room).
- This tutorial is also available as a lecture note, attached on [Indico](#)

- Analysis system allowing for easy extraction of observables and plots from *any* Monte Carlo event generator.
- Requires only HEPMC event output – no access to “unphysical” observables.
- Well suited for MC/data comparisons, with *many* analyses implemented.

## Rivet analysis coverage

Rivet analyses exist for 917/5952 papers = 15%. 196 priority analyses required.

Total number of Inspire papers scanned = 10604, at 2020-07-02

Breakdown by identified experiment (in development):

Key	ALICE	ATLAS	CMS	LHCb	Forward	HERA	$e^+e^- (\geq 12 \text{ GeV})$	$e^+e^- (\leq 12 \text{ GeV})$	Tevatron	RHIC	SPS	Other
Rivet wanted (total):	259	311	411	222	44	520	800	690	1238	476	63	1
Rivet REALLY wanted:	36	45	82	9	0	13	1	3	6	1	0	0
Rivet provided:	26/285 = 9%	165/476 = 35%	86/497 = 17%	13/235 = 6%	8/52 = 15%	9/529 = 2%	176/976 = 18%	348/1038 = 34%	59/1297 = 5%	9/485 = 2%	5/68 = 7%	16/17 = 94%

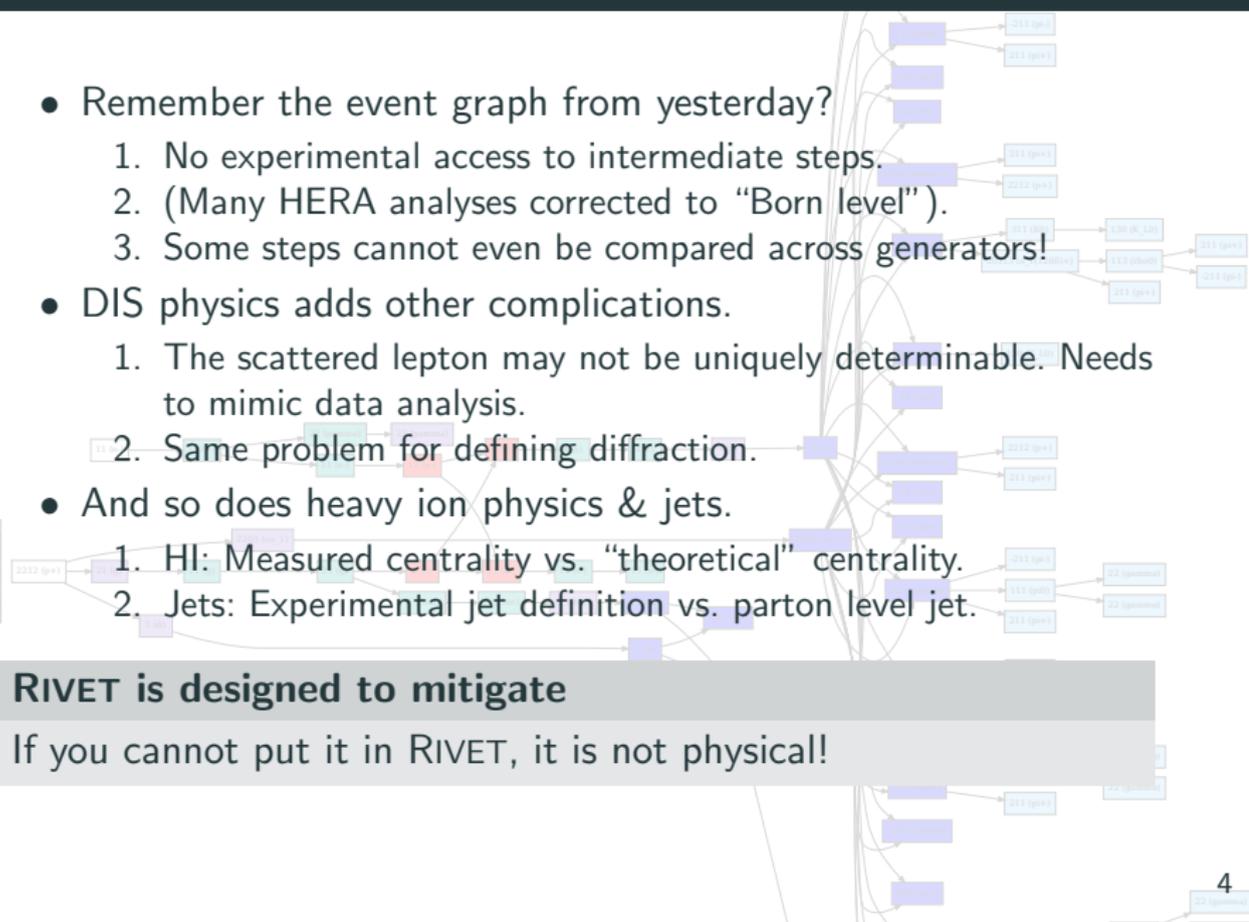
- ...but also the tool of choice for communication between MC developers internally & to experiments.

# Unphysical observables? What?

- Remember the event graph from yesterday?
  - No experimental access to intermediate steps.
  - (Many HERA analyses corrected to “Born level”).
  - Some steps cannot even be compared across generators!
- DIS physics adds other complications.
  - The scattered lepton may not be uniquely determinable. Needs to mimic data analysis.
  - Same problem for defining diffraction.
- And so does heavy ion physics & jets.
  - HI: Measured centrality vs. “theoretical” centrality.
  - Jets: Experimental jet definition vs. parton level jet.

**RIVET is designed to mitigate**

If you cannot put it in RIVET, it is not physical!



# Tool of communication

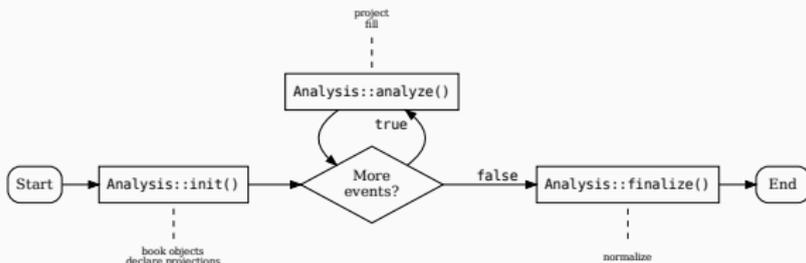
- For MC authors RIVET is also an invaluable tool of communication.
- Frequent use case: Compare observable across generators for prediction/validation.
- Two key features:
  1. Generator-agnostic analysis means rapid turn-around.
  2. Observables are physical *by design*.
- Also useful for MC/exp communication.
  1. Acceptances and trigger definitions encoded directly.
  2. EASY! No need for MC developers to install large exp. code frameworks.
  3. No ambiguity in definitions of observables.

## Communication with the EICUG

MC authors prefer to communicate analyses with RIVET.  
If you don't use it, expect long answer times!

# Analysis structure

- You already ran an analysis yesterday.
- Let's take a look at the general structure.



**Initialization:** `init()` is called once per analysis, used to declare ("book") histograms and projections.

**Analysis:** `analyze(const Event&)` is called once per event, analyze events and fill histograms.

**Finalization:** `finalize()` is called once, at the end of each analysis, apply normalizations, fill histograms with all-event averages, construct ratios.

# A closer look

- We'll take a closer look at the analysis [MC\\_DIS\\_Check](#).
- All analyses can be studied in the online documentation.
- Keywords: class structure, projections: booking, projections: using, histograms: booking, filling and scaling.

- Rivet home
  - Cantur
  - Professor
  - YODA
  - MCplots
  - AGILE
- Downloads
- Analyses
  - Standard analyses
  - Analysis changelog
  - Writing an analysis
- Analysis coverage & wishlists
  - General
  - No searches/MI
  - Searches
  - Heavy ion
- Documentation
  - Getting started
  - Rivet via Docker
  - Manuals & tutorials
  - Changelog
  - Daxxygen code/API docs
- Source code
- Contact

## Rivet analyses reference

### MC\_DIS\_Check

**A simple analysis using the DISKinematics projection.**

**Experiment:** (HERA)

**Status:** UNVALIDATED REENRANT

**Authors:**

- Hannes Jung
- Leif Lönnblad

**No references listed**

**Beams:** p+ e-, p+ e+

**Beam energies:** ANY

No run details listed

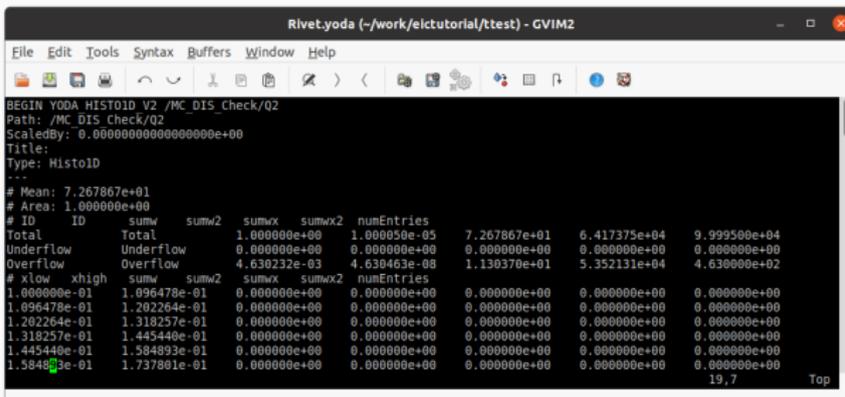
A simple analysis to illustrate how to use the DISKinematics projection together with different options, and to histogram the obtained x, y and Q2 variables.

**Source code:** [MC\\_DIS\\_Check.cc](#)

```
1 // -*- C++ -*-
2 #include "Rivet/Analysis.hh"
3 #include "Rivet/Projections/FinalState.hh"
4 #include "Rivet/Projections/FatJets.hh"
5 #include "Rivet/Projections/DISKinematics.hh"
6
7 namespace Rivet {
8
9
10
11 // @brief A simple analysis to illustrate how to use the
12 // DISKinematics projection together with different options.
13 class MC_DIS_Check : public Analysis {
14 public:
15
16 // Constructor
17 DEFAULT_RIVET_ANALYSIS_CTOR(MC_DIS_Check);
18
19 // @name Analysis methods
20 //@
21
22 // Book histograms and initialise projections before the run
23 void Init() {
24
```

# Analysis output

- You will run the analysis from command line in a minute.
- The output file is in the [YODA](#) format.
- YODA is light-weight, and optimized for hep usage.



```
Rivet.yoda (~/.work/elc/tutorial/ttest) - GVIM2
File Edit Tools Syntax Buffers Window Help
BEGIN YODA HISTO1D_V2 /MC_DIS_Check/Q2
Path: /MC_DIS_Check/Q2
ScaledBy: 0.0000000000000000e+00
Title:
Type: Histo1D
---
# Mean: 7.267867e+01
# Area: 1.000000e+00
# ID   ID      sumw  sumw2  sumwx  sumwx2  numEntries
Total   Total   1.000000e+00  1.000000e-05  7.267867e+01  6.417375e+04  9.999500e+04
Underflow Underflow 0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
Overflow  Overflow 4.630232e-03  4.630463e-08  1.130370e+01  5.352131e+04  4.630000e+02
# xlow  xhigh  sumw  sumw2  sumwx  sumwx2  numEntries
1.000000e-01  1.096478e-01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
1.096478e-01  1.202264e-01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
1.202264e-01  1.318257e-01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
1.318257e-01  1.445440e-01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
1.445440e-01  1.584893e-01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
1.584893e-01  1.737801e-01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
19,7 Top
```

## But... ROOT?

ROOT is too heavy weight to include as a dependency for MC developers. You can convert YODA histograms to ROOT with `yoda2root` (see online docs).

# Setting up RIVET

- Installation instructions and standard tutorials can be found on [gitlab](#).

## Local installation

Mostly harmless to install, using the [installation script](#).  
Requires C++14.

- For this tutorial, we use the same docker image as yesterday (with RIVET 3.1.2 installed).

## Docker setup

```
docker pull electroncollider/pythia-eic-tutorial
```

- See next page for further setup.

## Further setup

- Navigate to the working directory from yesterday.
- Expose relevant RIVET commands from the container.

```
$> alias rivet='docker run -i --rm -u `id -u $USER`:`id -g` \  
-v $PWD:$PWD -w $PWD electronioncollider/pythia-eic-tutorial rivet'  
$> alias rivet-mkanalysis='docker run -i --rm -u `id -u $USER`:`id -g` \  
-v $PWD:$PWD -w $PWD electronioncollider/pythia-eic-tutorial \  
rivet-mkanalysis'  
$> alias rivet-build='docker run -i --rm -u `id -u $USER`:`id -g` \  
-v $PWD:$PWD -w $PWD electronioncollider/pythia-eic-tutorial \  
rivet-build'  
$> alias rivet-mkhtml='docker run -i --rm -u `id -u $USER`:`id -g` \  
-v $PWD:$PWD -w $PWD electronioncollider/pythia-eic-tutorial \  
rivet-mkhtml'
```

- You can now run RIVET from the command line, as if it was installed on your own machine.

### Try this:

```
$> rivet --help # Display the Rivet help menu  
$> rivet --list-analyses # List available analyses on your system
```

## Exercises: Run analyses & writing your first analysis

- It is time to get to work!
- I will first show you how to run analyses on the command line, using your pre-generated HEPMC file, following the tutorial sheet.
- You will then be divided into smaller groups, and should follow the attached tutorial sheet, where you will:
  1. Study the analyses.
  2. Write your own analysis, which adds more observables.
- Start from section 4 in the tutorial sheet, and work through until section 7 (More advanced analysis techniques), or however far you get.
- I will visit all the breakout rooms, and answer questions.
- We reconvene in 35 minutes (including a short break).

Have fun!

## Follow-up on first exercise

- The tutorial sheet includes a possible solution to the exercise.

## Advanced analysis features

- For the next exercise, you can choose between three features.
  1. Interact with an analysis using `options`.
  2. Percentile binning of observables.
  3. Jet finding with FASTJET.
- The instructions in the sheet are a bit more fast paced.
- Make sure you have a working ex. 1 analysis before moving on!
- We reconvene in 35 minutes.

# The end

- You can now write a RIVET analysis, run it and produce figures.
- Most useful to preserve existing analyses and communication with MC authors.
- More functionality: detector simulation, multi-weights, NLO counter-events, multi-particle cumulants, event mixing...
- Need more?

**Documentation:** [rivet.hepforge.org](http://rivet.hepforge.org).

**Mailing list:** rivet-developers@cern.ch.

**Contribute?** exp: Implement your analysis,  
ph: Make your generator HEPMC compatible.

**Tutorial at \$MY\_LAB:** Get in touch. Also with different focus.

- Feedback and questions always welcome!

Thank you!