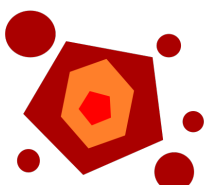
OSCAR to HepMC

(should we?)



V. Kireyeu[1,2]

[1]JINR, Dubna
[2]HFHF, Frankfurt am Main

HEPMC in Heavy Ion Collisions

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Introduction

A converter from the PHSD OSCAR format to HepMC has been developed with the aim of the future use of the PHSD (and PHQMD) model predictions within Rivet.

This converter was created in the October-November of 2019 with the support from **Andy Buckley** and **Andrii Verbytskyi** on the HepMC format and **Christian Bierlich** from the Rivet side.

The 'phsd2hepmc' converter can work with **elementary** (e.g. $p + p$) and **Heavy-Ion Collisions** (both symmetric and asymmetric, e.g. $Pb + Pb$, $d + Au$, $p + C$ etc).

Converter: HepMC

Main problem: HepMC format. Very many fields which should be filled (model-depended!):

- flavour code of first parton
- flavour code of second parton
- fraction of beam momentum carried by first parton ("beam side")
- fraction of beam momentum carried by second parton ("targetside")

etc and so on.

But we need only 4-momenta and particle ID.

Solution:

- Almost all fields can be set to 0.
- Only one main vertex can be used instead of the multitude of secondaries.

Converter: use with Rivet

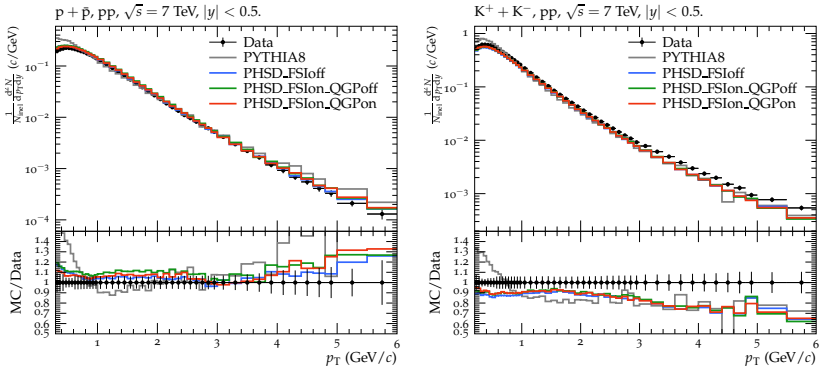

Figure 1: Rivet analysis. p_T-spectra of protons and kaons in $p + p$ collisions (Eur.Phys.J.A 56 (2020) 9, 223).

Converter: use with Rivet

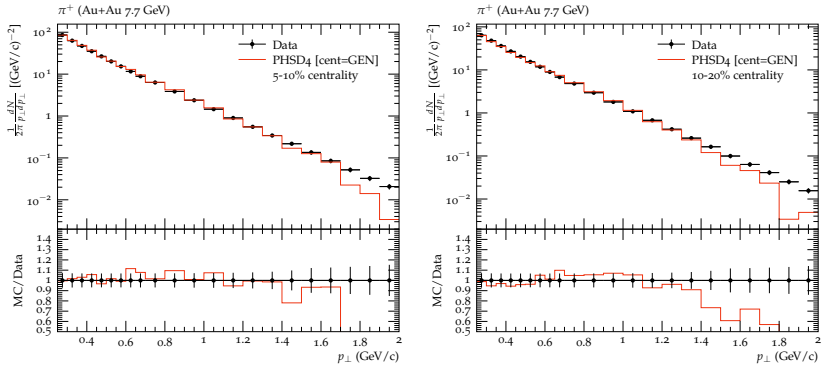

Figure 2: Rivet analysis. p_T-spectra of pions in $Au + Au$ collisions ("STAR_2017_I1510593").

Acknowledgements: Johannes Jahan and Christian Bierlich.

Rivet: writing an analysis

4 files should be filled to describe each analysis. If the HepData ROOT file exists – why not to use it?

Elementary $p + p$ analyses: NA49_2006_I694016 and NA49_2009_I818217.

Experiment: interaction trigger of 2 cm diameter was placed on the beam trajectory 380 cm downstream of the target to select elastic events.

Rivet analysis assumption: only 2 final state particles $\Longrightarrow$ event was elastic.
Experimental data from the HepData was copied by hand into Rivet analysis files.

Rivet: writing an analysis

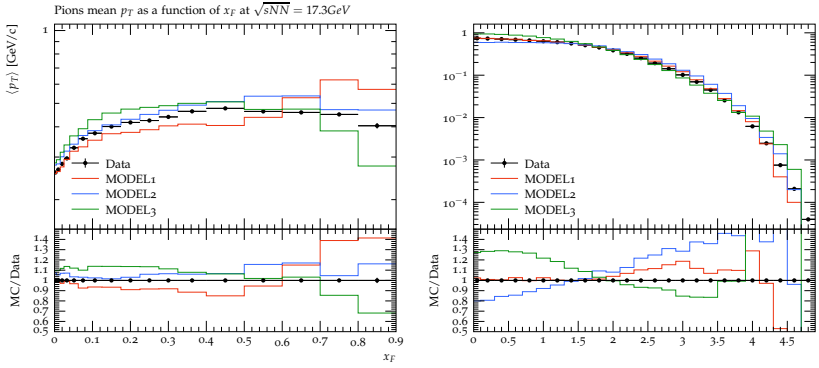

Figure 3: Rivet analysis: "NA49_2006_I694016"

Acknowledgements: Christian Bierlich.

HepMC & Rivet: the main problem

Enterprise-level standard of the HIC physics: ROOT.

Everything should be done within ROOT.

HepMC & Rivet: the main problem

Rivet does not understand ROOT:

```
"Could not read from 'hepmc.root' (error=basic_string::_M_replace_aux)"
```

HepMC and other formats

Settings for ASCII files: "-9" for the best compression level.
Settings for ROOT: compression level 6 out of 9, ZLIB compressor.
Both use the "Deflate" algorithm.
HepMC trick: only one vertex.

50 events		
phsd.dat.gz	1,1M	**100%**
phsd.hepmc.gz	1,4M	**+27%**
phsd.root	652K	**-40%**

25.000 events		
phsd.dat.gz	462M	**100%**
phsd.hepmc.gz	612M	**+32%**
phsd.root	266M	**-42%**

But this is only beginning as ROOT provides several compression algorithms: LZ4, LZMA, ZSTD.

HepMC and other formats

For the flow analysis one needs about 20-30 millions of events. Some types of the femtoscopy analyses require even more.

Possible solution: make a new ROOT-format or to teach Rivet to understand one of existing in addition to the HepMC.

KISS principle – keep it short and simple.

HepMC and other formats

Examples of ROOT formats already used by many experimental groups:

- **United Generators (UniGen)** – has build-in converters for many models.
- **mcini** – based on UniGen, has converters for even more models.
- **McDST** – created to be as small as possible: tuned data types, storage organization etc.
- **mcpico** – stores only necessary information.
- and very many others.

Another point: experimental analysis

Centrality selection by the particles multiplicities in BBC or TPC is not the only one method. Experiments with many unique interesting results in the HIC field of physics use the **energy deposition in calorimeters** and this cannot be ignored.

One needs to use corresponding **acceptance maps** (e.g. 3D kinematic region: rigidity, transverse rigidity, azimuthal angle) **to compare model and experiment**.

These maps are different for each system, energy and particle charge.

Another point: experimental analysis

(not so) Small example for only one system and one energy:

map_negative.txt	187.8 MB
map_neutral.txt	187.8 MB
map_positive.txt	187.8 MB
total:	**563.4 MB**

map_all_types.root	594.9 KB
total:	**594.9 KB**

It's not so funny anymore.

Summary

- Rivet can be interesting for theoreticians but is not user-friendly for experimentalists: 4 different files should be filled to make an analysis, **ROOT is not supported**.
- HepMC can be good a format for some models but it contains very many unneeded or model-dependent information which can be ommited.
- ROOT is an enterprise-level standard in the high energy physics, so it should be used everywhere.
- **ROOT support**: **evolution, not revolution** $\Longrightarrow$ do not re-implement the whole Rivet, but just add this support as an option.