My RIVET adventure

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for the ALICE Collaboration

ECT*: Heavy-Flavor Transport in QCD Matter

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Introduction

- 6 months grant after Master thesis (on different topic, not analysis related) from June to November 2019 in Bologna:
  - No previous knowledge of RIVET
  - Basic knowledge of Monte Carlo Generators
  - Good experience with C++

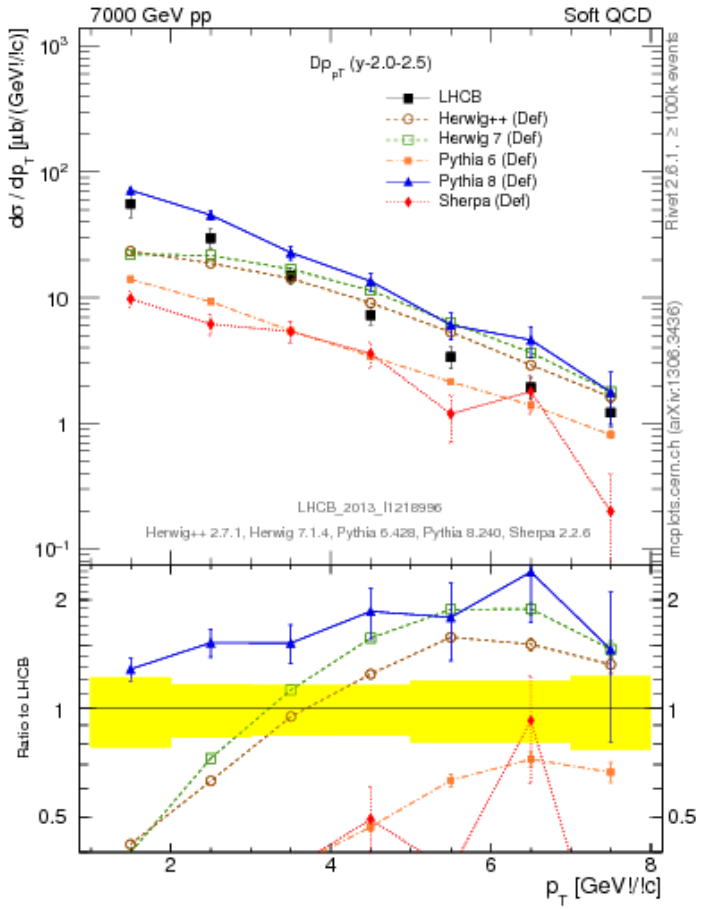
Rivet

- Tasks:
  - Learn to master the framework
  - Create macros and upload them on the RIVET website containing ALICE heavy flavour analyses (none of them were present when I started)
  - Compare obtained results with different MC generators

- Computing Resources:
  - My laptop → 8GB RAM, Intel i5-8250U quad-core, 512 GB SSD
  - ALICE server @INFN-BO → 16GB RAM, Intel XEON X5650 24-cores

The Framework

- RIVET is an *easy* tool that lets users compare MC data (in .hepmc format) to experimental ones → Useful for validating MC generators [arXiv:2001.10737]



Example of result obtained from RIVET (D^+ cross section from LHCb data) [MCPLOTS]

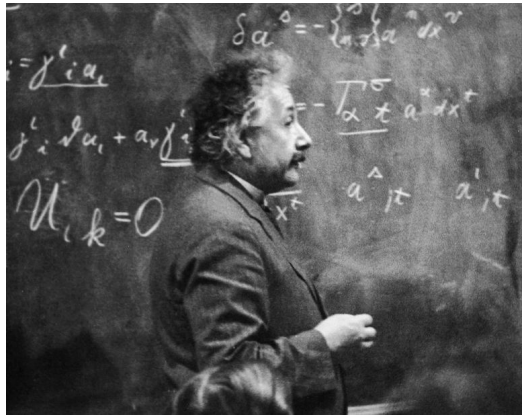
- It's a great educational experience → In a really short time you'll be able to produce a RIVET macro and compare MC results to experimental data

02-04-2021

Key	ALICE	ATLAS	CMS	LHCb	Forward	HERA	$e^+e^-(\geq 12$ GeV)	$e^+e^-(\leq 12$ GeV)	Tevatron	RHIC	SPS	Other
Rivet wanted (total):	236	287	435	202	43	519	733	617	1238	464	61	1
Rivet REALLY wanted:	36	38	79	8	0	13	1	1	6	1	0	0
Rivet provided:	26/262 = 10%	167/454 = 37%	89/524 = 17%	16/218 = 7%	8/51 = 16%	9/528 = 2%	193/926 = 21%	381/998 = 38%	59/1297 = 5%	8/472 = 2%	5/66 = 8%	18/19 = 95%

A lot of analyses from different experiments are in need to be uploaded

Physicists have different points of view



Experimental

Are data coherent with simulation results?

Theoretical

Can this new model describe better the experimental results?

Common Aim → Comparing data (done well by RIVET)

Prerequisite: MC data in .hepmc format

Issues

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- Previously, RIVET documentation (at least up to v. 2.7.2) was not up to date → new features discovered by chance in conference talks and inside the RIVET source code
  - Things have fortunately changed in the past 2 years with the release of RIVET 3 → more interest by the community → more workshops → more tutorials

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- Useful applications related to the framework, like Pythia6/8 interfaces AGILE (=Fortran & C++ interface) and Sacrifice (C++ & Python8 steering code), are old and missing documentation → Had to tweak manually Sacrifice in order to make it produce p-Pb events through Pythia8

See example on next slide →

agile – Hepforge

agile.hepforge.org

agile is hosted by Hepforge, IPPP Durham

Having issues in installing the AGILE application, let's just click on the Documentation link…

- AGILe home
  - Rivet
  - JetWeb
  - HZSteer
- Subversion
- Downloads
- Documentation
  - Getting started
  - Trouble Shooting
  - API documentation
- Project Planning
  - Tickets
  - Timeline
- Contact

AGILe

AGILe is A Generator Interface Library (& executable), i.e. a uniform object oriented C++ interface for a variety of Fortran-based Monte Carlo event generators. The role of AGILe is to provide a standard steering interface for Fortran generator codes which usually do not come with an executable, usually need to be recompiled to change parameter settings, and cannot write output into the C++ HepMC event record: AGILe remedies all of these defects.

The `agile-runmc` executable provides a very powerful yet simple command-line interface for steering a variety of generators: out of the box, AGILe can load generators from the LCG Genser repository as installed on the CERN AFS filesystem. The currently supported generators are:

- PYTHIA, with LHEF reader support for POWHEG etc.
- HERWIG (+ JIMMY), with LHEF reader support for POWHEG etc.
- Charybdis (+ PYTHIA/HERWIG(+JIMMY))
- AlpGen (+ PYTHIA/HERWIG(+JIMMY))
- Cascade
- Rapgap
- PHOJET
- ARIADNE
- (We'd really an MC@NLO interface... can anyone help?)

AGILE webpage

https://agile.hepforge.org/trac/w

agile.hepforge.org/trac/wiki/

```
Error

TracError: [logging] log_level: expected one of ("ALL", "CRITICAL", "DEBUG", "ERROR", "INFO", "WARN", "WARNING"), got u'none'
```

AGILE documentation (self-explanatory)

Well, let’s try to open a support ticket then:

https://agile.hepforge.org/trac/w

agile.hepforge.org/trac/wiki/

```
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AGILE documentation (self-explanatory)

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https://agile.hepforge.org/trac/re

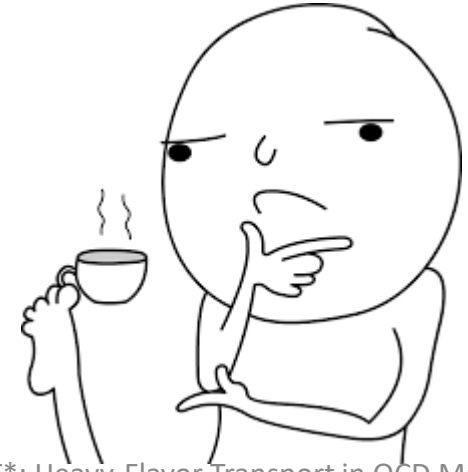
agile.hepforge.org/trac/report/3

```
Error

TracError: [logging] log_level: expected one of ("ALL", "CRITICAL", "DEBUG", "ERROR", "INFO", "WARN", "WARNING"), got u'none'
```

AGILE tickets website (crystal clear)

RIVET developers update often the framework → Older MC generators might have some compatibility issues with the newer versions (support for AGILE ended in 2015 and Sacrifice support will end shortly) → This might cause issues in rivetizing properly older analyses



AGILE webpage was updated few days ago → neither the documentation link nor the ticket requests are available anymore on the website (the screenshots above were taken 3 weeks ago)

Obtained Results

- Worked mostly on pp collisions → 1 analysis using heavy ions (p-Pb) difficult to perform both for the advanced RIVET functions used and for the Sacrifice interface not being updated to include them (Pythia8 Angantyr is also an old model) → extremely time consuming on a laptop

- 3 *rivetizations* were performed:
  - D mesons in pp collisions at 7 TeV:
    - arXiv:1111.1553 Inspire ID: 944757 → The first analysis I uploaded and the easiest one
    - arXiv:1702.00766, Inspire ID: 1511870 → More difficult to handle due to the need of merging multiple simulation jobs (using FIFOs and the newly introduced rivet-merge function released in ~2019)

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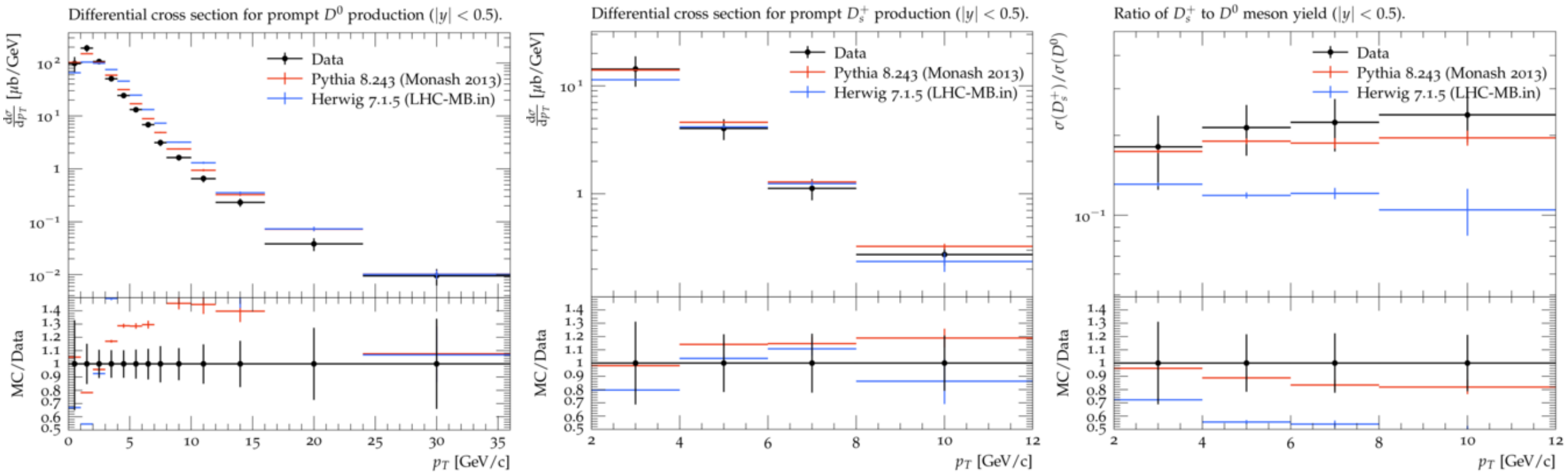
  - Λ_c baryon in pp at 7 TeV + p-Pb at 5.02 TeV:
    - arXiv:1712.09581, Inspire ID: 1645239 → the most difficult and last analysis on which the reentrant finalize (just introduced at that time) had to be used in order to compute the R_{pPb} → rivetization performed before the paper ''Confronting Experimental Data with Heavy-Ion Models, Rivet for Heavy Ions" was released [arXiv:2001.10737]

```
// Book histograms
_h_Lc          = bookHisto1D(1, 1, 1);                          // Lc in pp at 7 TeV
_h_LcPb        = bookHisto1D(2, 1, 1);                          // Lc in p-Pb at 5.02 TeV
_h_LcD0        = bookScatter2D(3, 1, 1);                        // Lc/D0 in pp at 7 TeV
_h_LcD0Pb      = bookScatter2D(4, 1, 1);                        // Lc/D0 in p-Pb at 5.02 TeV
_h_LcD0int     = bookScatter2D(5, 1, 1);                        // "Integrated" Lc/D0 in pp at 7 TeV (1 < pT < 8 GeV/c)
_h_LcD0Pbint   = bookScatter2D(6, 1, 1);                        // "Integrated" Lc/D0 in p-Pb at 5.02 TeV (2 < pT < 12 GeV/c)
_h_RpPb        = bookScatter2D(7, 1, 1);                        // RpPb
_h_Lcdummy     = bookHisto1D("TMP/Lcdummy", refData(3,1,1));    // Lc in pp at 7 TeV with (_h_LcD0) binning
_h_D0          = bookHisto1D("TMP/D0",      refData(3,1,1));    // D0 in pp at 7 TeV with (_h_LcD0) binning
_h_LcPbdummy   = bookHisto1D("TMP/LcPbdummy", refData(4,1,1));  // Lc in p-Pb at 5.02 TeV with (_h_LcD0Pb) binning
_h_D0Pb        = bookHisto1D("TMP/D0Pb",      refData(4,1,1));  // D0 in p-Pb at 5.02 TeV with (_h_LcD0Pb) binning
```

Excerpt of init() function of the Λ_c macro

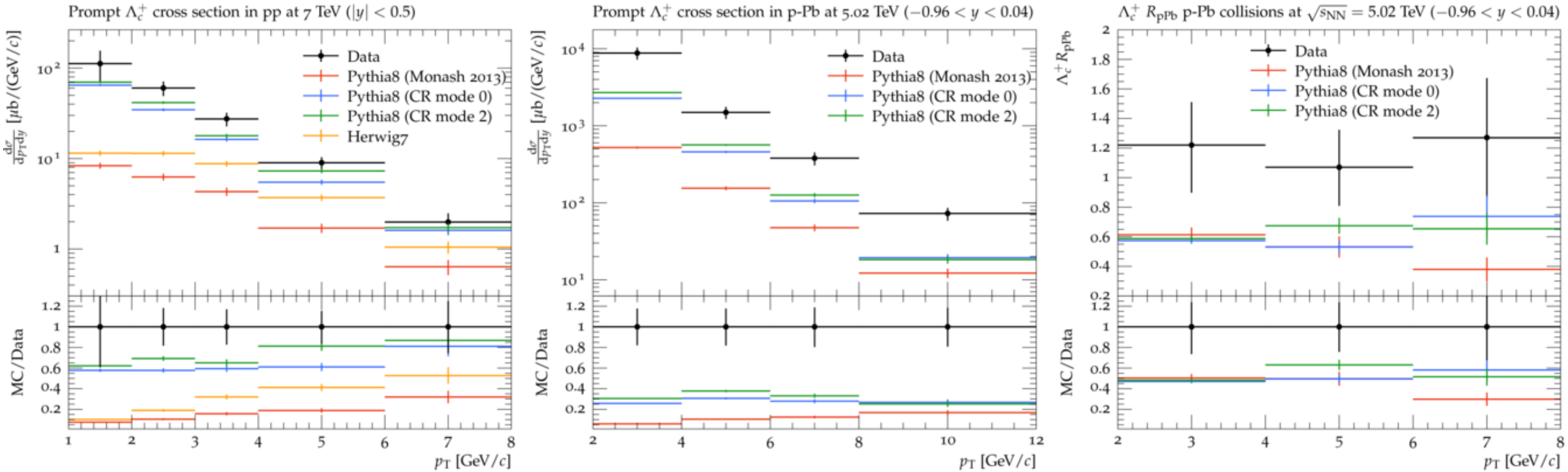
D meson plots in pp collisions



Examples of obtained results with the second *rivetized* paper

- 2 MC generators were used in order to validate the analysis: Pythia8 and HERWIG7 → 10^7 MB events were analyzed in order to have enough statistics
- Merging of multiple jobs without manipulating data

Λ_c plots



Examples of obtained results with the Λ_c rivetization

- 10^6 events analyzed using HERWIG7 for pp collisions and PYTHIA8 for pp and p-Pb collisions → the latter was run using Monash 2013 and enhanced colour reconnection tunes (modes 0 and 2) by Christiansen and Skands [arXiv:1505.01681, JHEP 1508 (2015)] which show a better agreement with exp. data
- Merging of multiple jobs and multiple simulation files in order to obtain all the plots → Difficult to get in touch with the RIVET group at that time in order to solve this issue

Conclusions

- RIVET is an incredibly powerful and educational instrument → it gives the opportunity to get closer to various experimental analyses (ALICE in my case)
- Apart from installation, it's easy to use and can be learned fast
- Results are clear and standardized

- BUT: Most of them are 2019 outdated perceptions, situation may have changed for new developers
  - The validation process for experimental analyses seems to be quite long → RIVET analyses are uploaded once every three months
  - For a common user, not working for a big experiment, it might be difficult to understand from the RIVET website who to contact for clarifications and issues fixing → Might be useful a public communication channel for this purpose (like a Discord server)
  - More efforts should be put on helping new developers:
    - Online support with assigned framework experts
    - More documentation on linked applications (like AGILE and Sacrifice)

Thank you for your attention

Enjoy your journey