

Rivet and the analysis preservation in heavy-ion collisions experiments

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ALICE

Outline

- **Rivet and analysis preservation**
 - **What is Rivet?**
 - **Analysis preservation**
 - **Rivet in ALICE**

- **Recent developments in Rivet for heavy ions**
 - **What Rivet can already do**
 - **New developments for multiplicity determination in ALICE**
 - **Centrality determination in STAR and PHENIX**

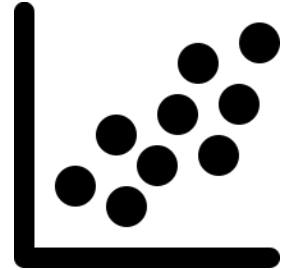
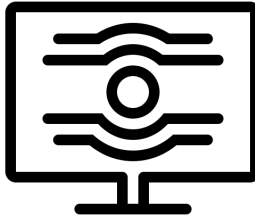
Rivet and analysis preservation

What's Rivet?

Robust Independent Validation of Experiment and Theory (Rivet)



Analysis Code Repository



Comparison between theory and data

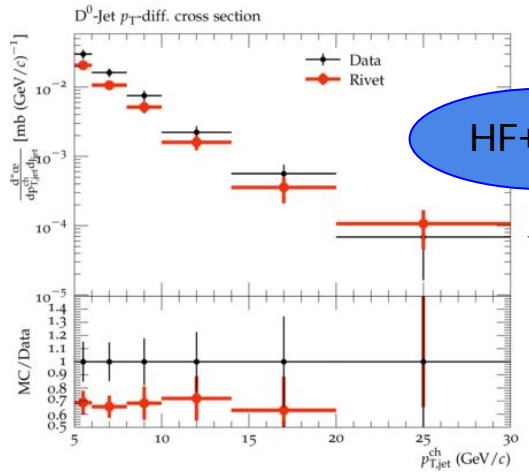


Search for data
EXPERIMENT_YEAR_I<InspireNumber>



Relatively easy to use

What's Rivet?

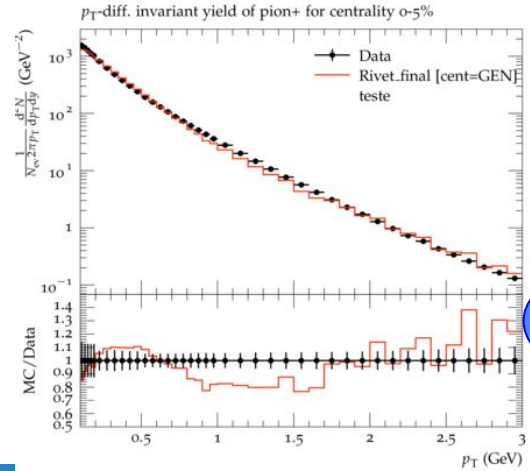


HF+Jets

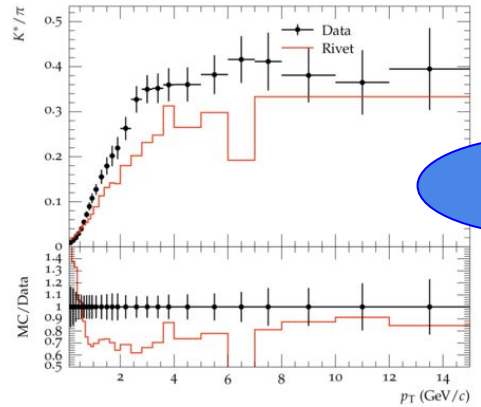
HepMC

HEPData

Rivet



Particle Spectra



Ratios

What's Rivet?



Interface between MC and analysis
arxiv.org/abs/1912.08005

Preservation of scientific results

HepMC



Rivet

Analysis repository
arxiv.org/abs/1003.0694

Analysis preservation

How Rivet can contribute to analysis preservation

- The details related to the methods and analysis uses are not always well described in the article
 - Even internal analysis notes could be incomplete
 - Recover the tiny details of an analysis after many years can be very time consuming!
- For people outside experiments, it is not clear how observables and estimators are defined
 - Ex. multiplicity, centrality, etc
- Convenient for theoreticians interested in testing models
 - Knowledge of the large number of experimental methods is not required

Analysis preservation

What Rivet can offer

- Generator-independent analysis preservation
- Validation/tuning of event generators
- Read outputs generated with HepMC framework (from file or in FIFO mode)
- Multiple analysis can be run over the same simulation at once
- A considerable (~1000) number of analyses already available
- Easy comparison between event generators and experimental data

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):	269	331	446	253	17	496	715	558	1131	460	62	1
Rivet REALLY wanted:	36	38	85	8	0	12	1	0	5	1	0	0
Rivet provided:	26/295 = 9%	181/512 = 35%	94/540 = 17%	16/269 = 6%	8/25 = 32%	17/513 = 3%	180/895 = 20%	305/863 = 35%	58/1189 = 5%	8/468 = 2%	4/66 = 6%	112/113 = 99%

Rivet in ALICE

- Experimental analyses are approved by the experimental collaboration
- ALICE is committed to increase the experimental analyses in the Rivet repository
- The Monte Carlo working group is focused on Rivet
 - Implementation of experimental analysis (plugins)
 - Development of new features and tools (projections)
- There is a established approval processes inside ALICE for Rivet analyses



Recent developments in Rivet for heavy ions

What Rivet can already do

- ALICE primary particles definition (from <https://cds.cern.ch/record/2270008/files/cds.pdf>)

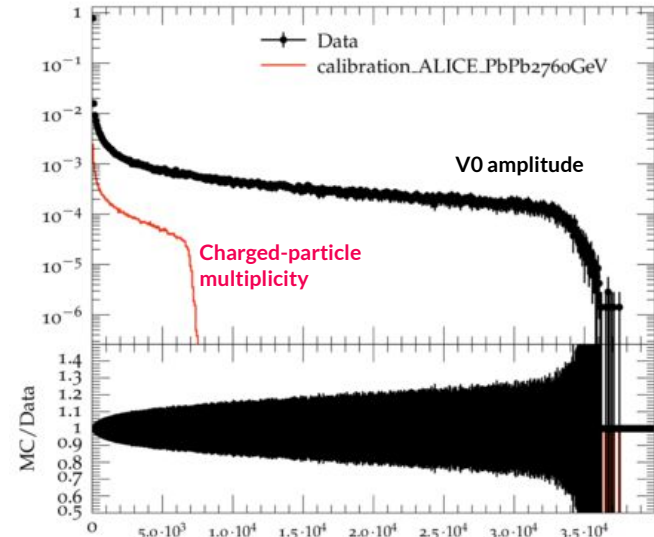
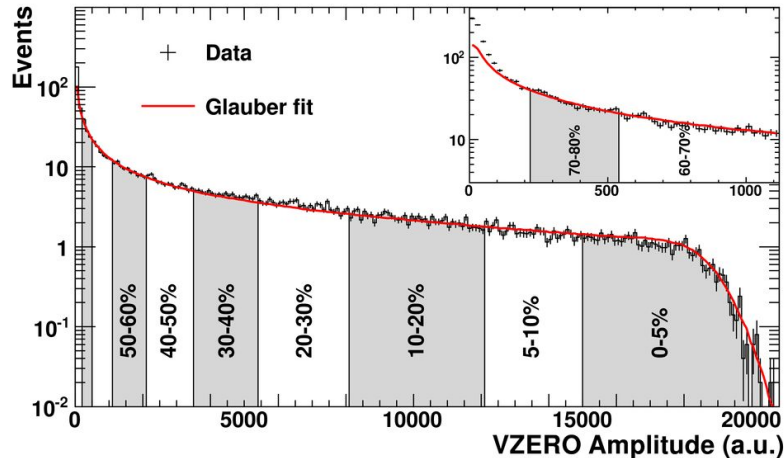
A primary particle is a particle with a mean proper lifetime τ larger than 1 cm/c, which is either a) produced directly in the interaction, or b) from decays of particles with τ smaller than 1 cm/c, restricted to decay chains leading to the interaction.

- The definition of primary particles is experiment-dependent
- Currently, some of the ALICE estimators (forward pseudorapidity) for multiplicity/centrality are already available
 - pp: charged-particle multiplicity in the acceptance of the V0
 - p-Pb: charged-particle multiplicity in the acceptance of the V0A
 - Pb-Pb: charged-particle multiplicity in the acceptance of the V0

What Rivet can already do

Centrality determination in Rivet

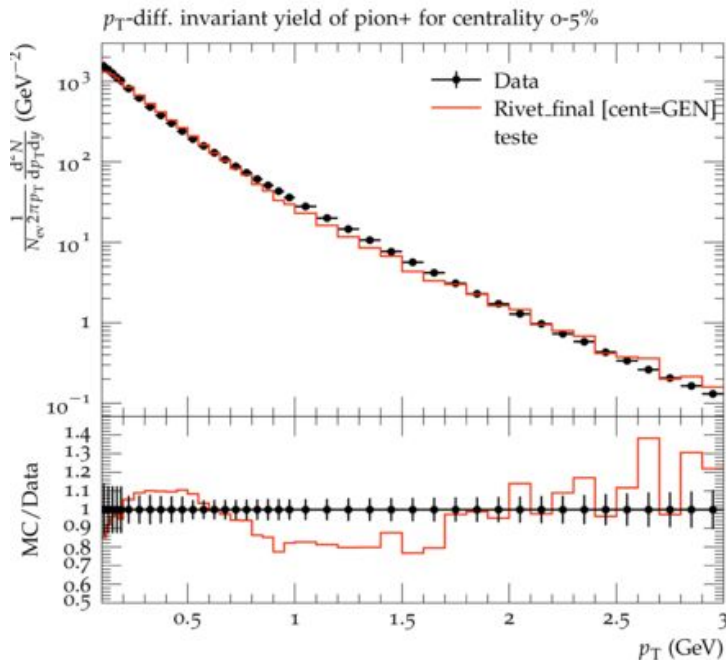
- A calibration file has to be produced before running the analysis
 - Each event generator needs a different calibration
 - A dedicated plugin is used to create the calibration files
- The calibration creates a probability density of number of charged particles per event in the acceptance of the V0 detector
 - $2.8 < \eta_{VOA} < 5.1$ and $-3.7 < \eta_{VOC} < -1.7$



What Rivet can already do

Centrality determination in Rivet

- The calibration file is given to Rivet as a pre-load
- During the analysis run, the centrality is calculated in each event



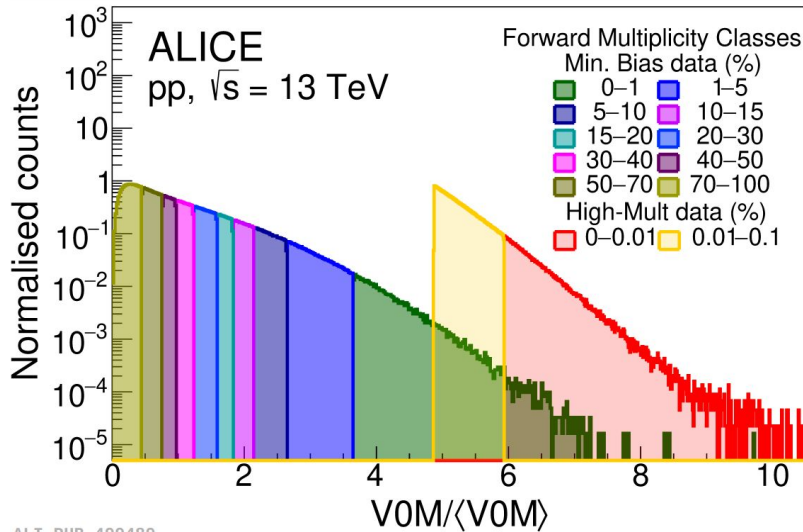
- Centrality is calculated in a way analogous to what is done in the experiment
- Simple implementation
- Previous knowledge of experimental methods is not necessary
- Not a black box! Code is open and methods can be understood

New developments in ALICE

Self normalized estimators

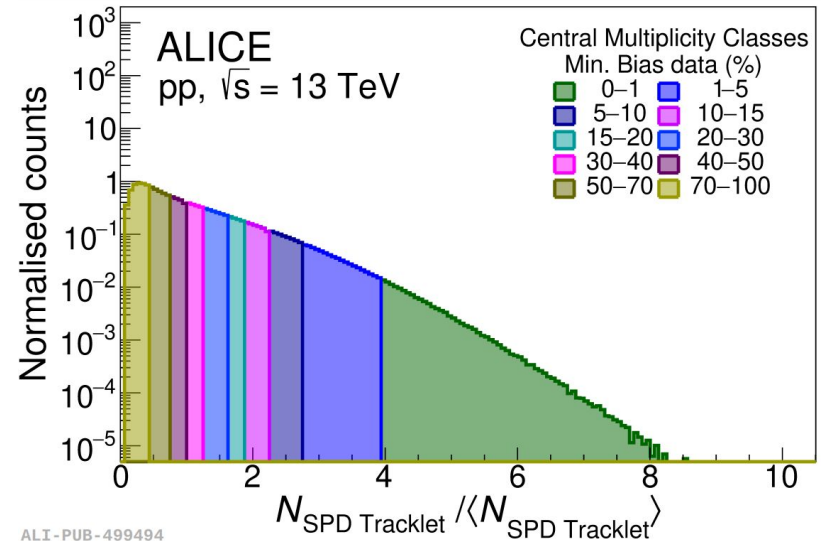
- VOM amplitude over its average ($VOM/\langle VOM \rangle$)
- SPD tracklets over its average ($SPD/\langle SPD \rangle$)

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ALI-PUB-499489

Estimator in forward pseudorapidity



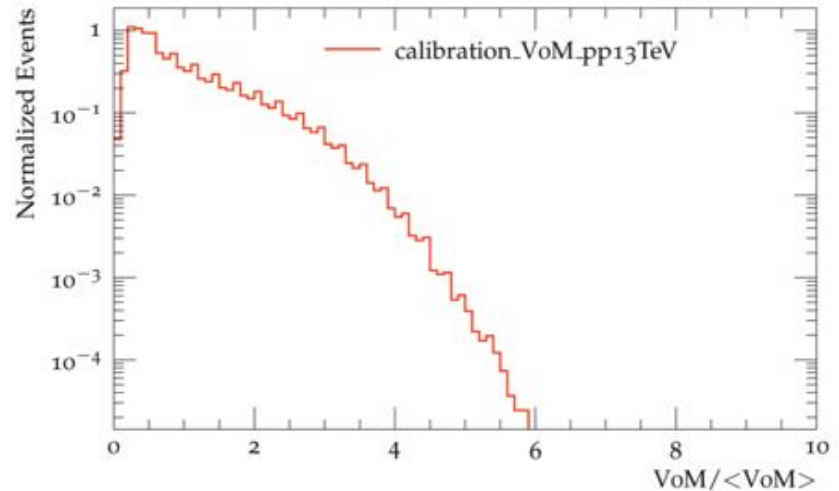
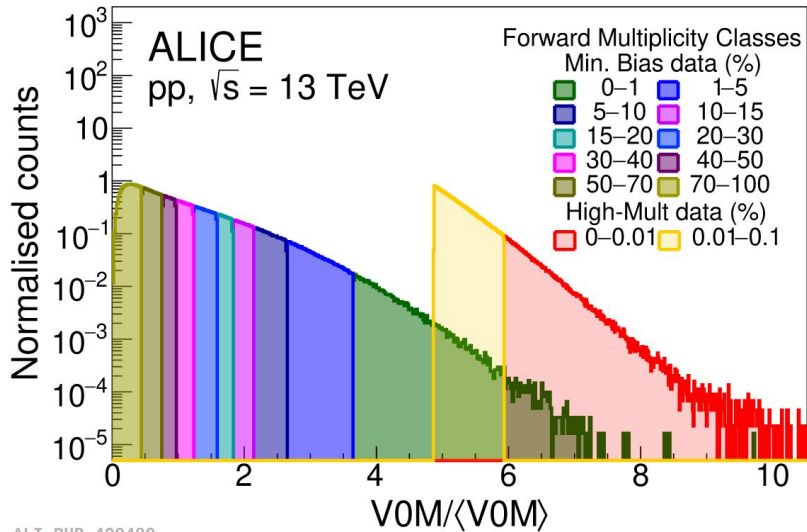
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Estimator in mid pseudorapidity

New developments in ALICE

VOM/<VOM>

- Self-normalized VOM estimator implemented in Rivet
- Calibration file is created the same way as estimators already implemented in the framework

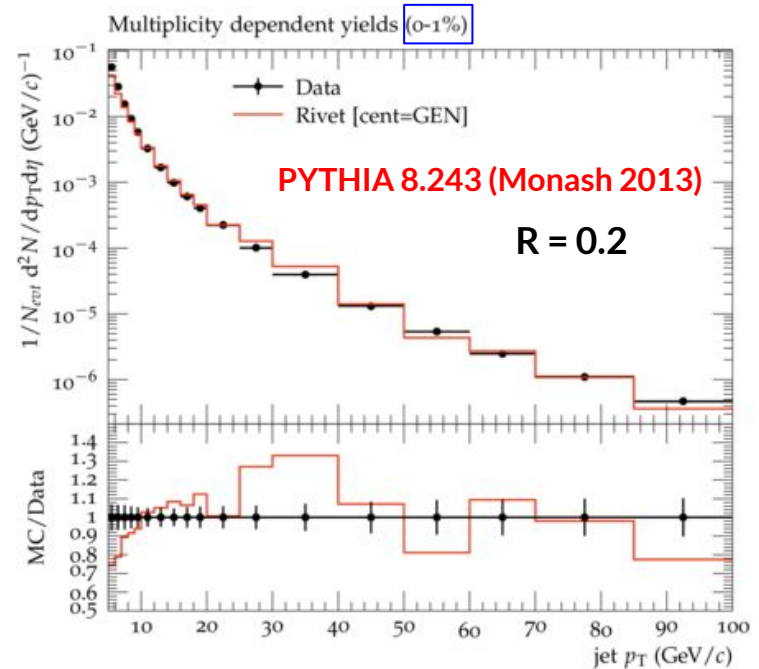
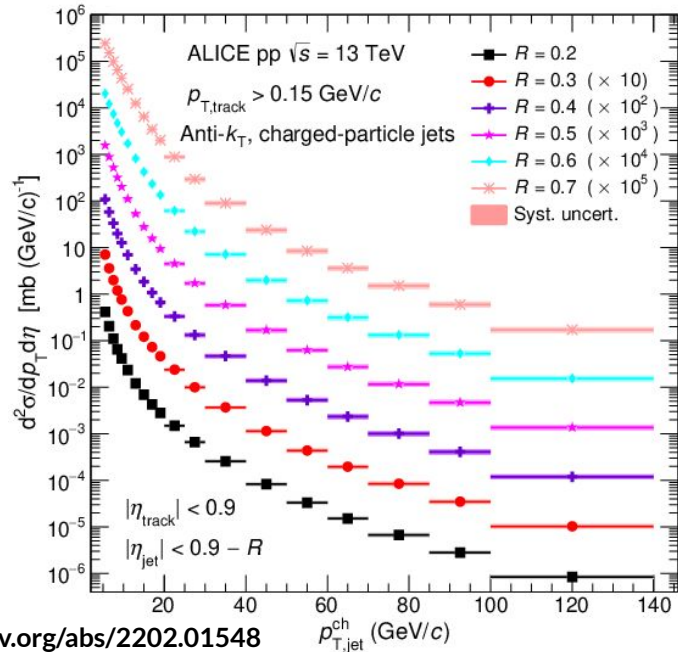


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New developments in ALICE

Analysis using VOM/<VOM>

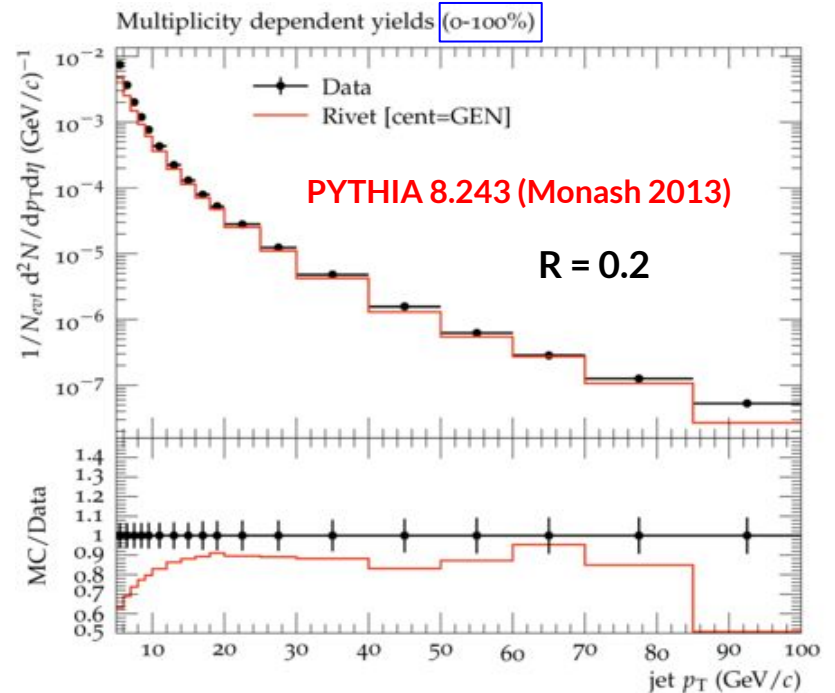
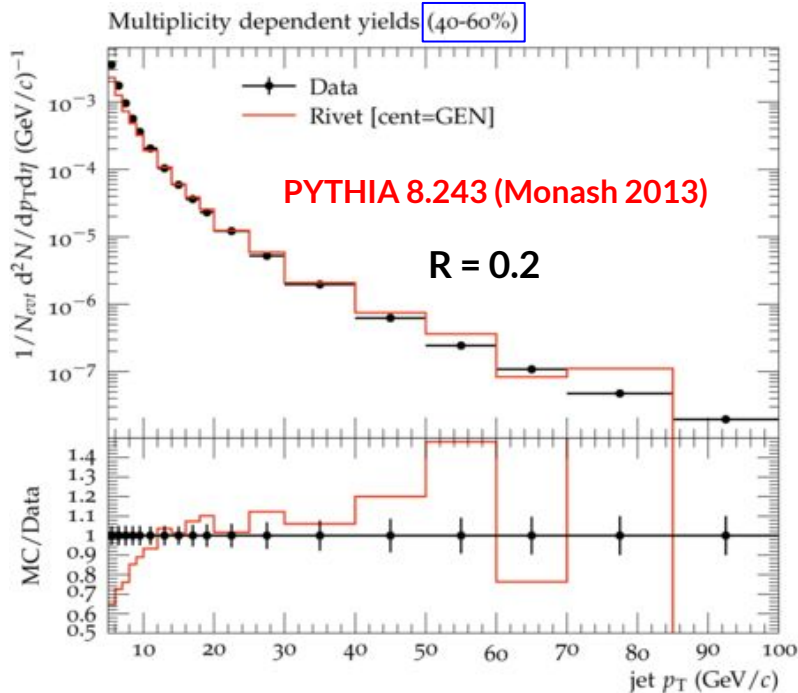
- Multiplicity dependence of charged-particle jet production in pp collisions at 13 TeV
- Rivet plugin for this analysis is under development



New developments in ALICE

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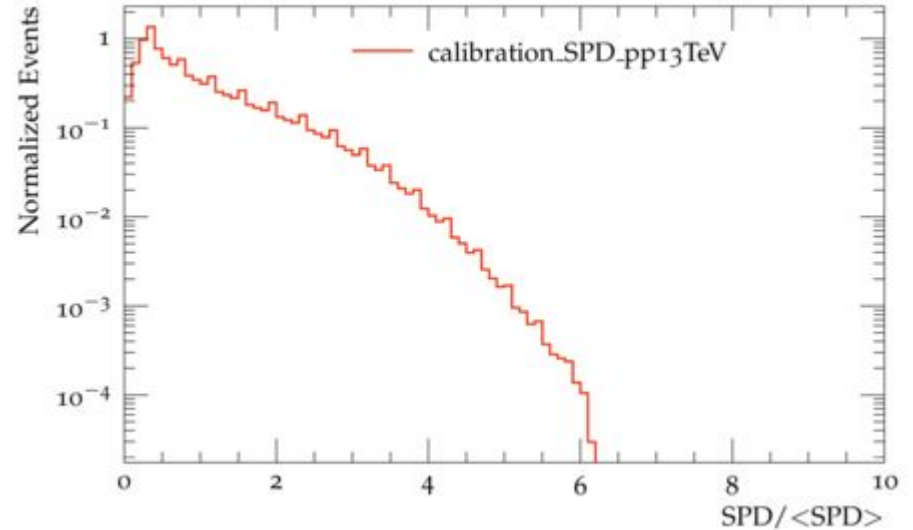
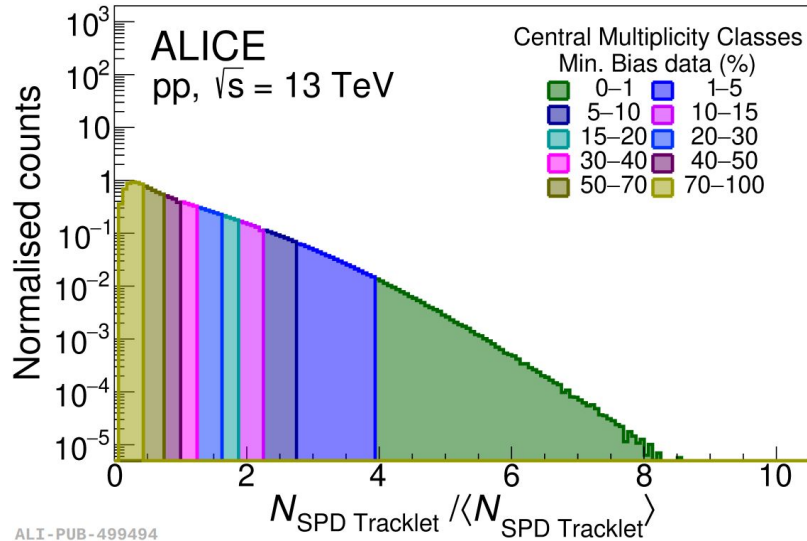
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New developments in ALICE

SPD/ \langle SPD \rangle

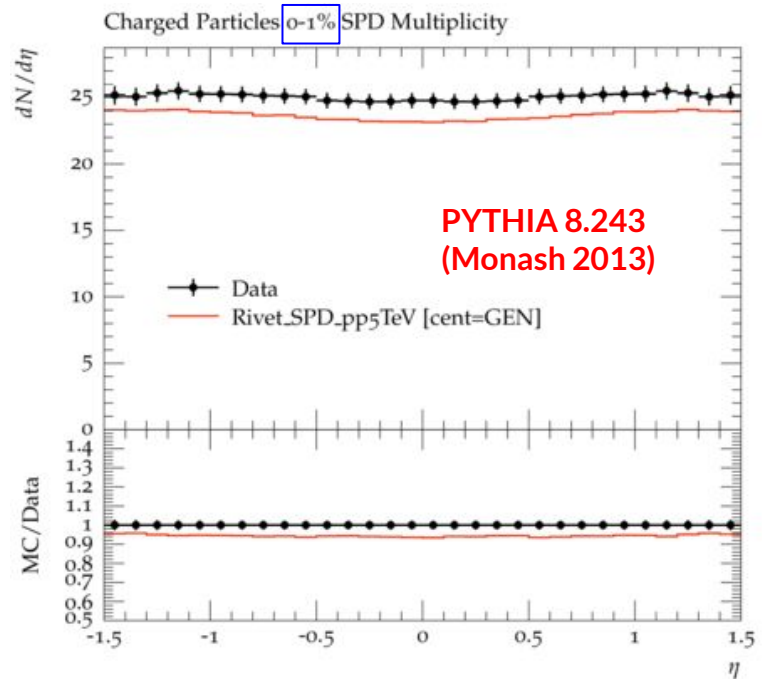
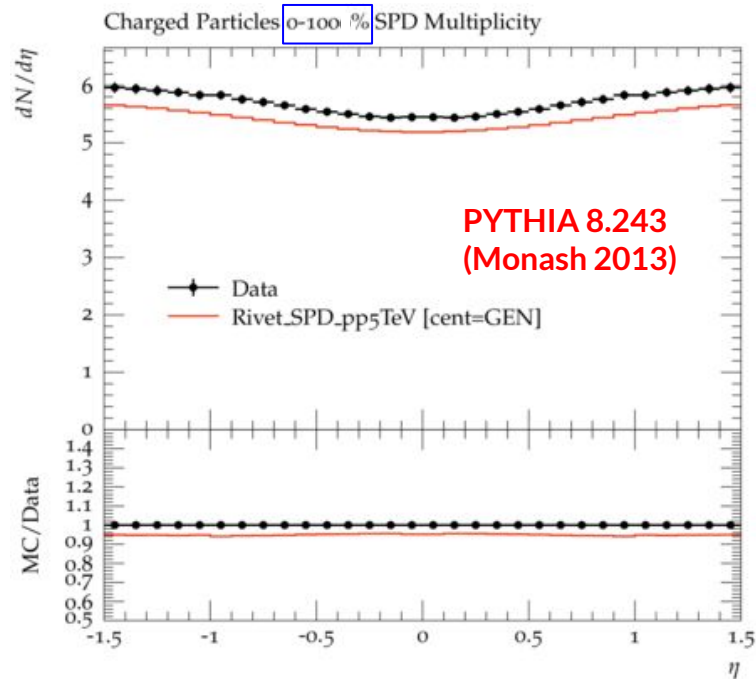
- Self-normalized SPD estimator implemented in Rivet
- Maximum acceptance is $|\eta_{\text{SPD}}| < 2.1$
- Calibration file is created the same way as estimators already implemented in the framework



New developments in ALICE

Analysis using SPD/ \langle SPD \rangle

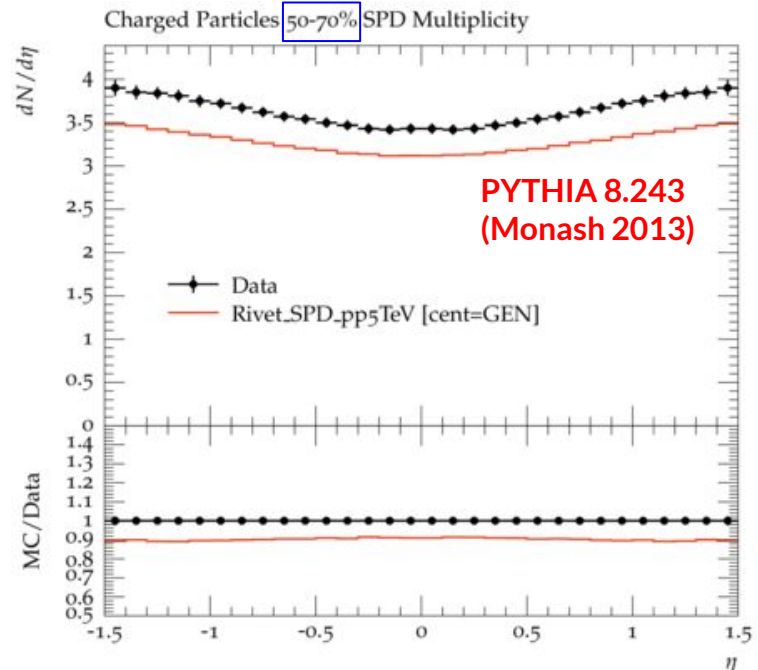
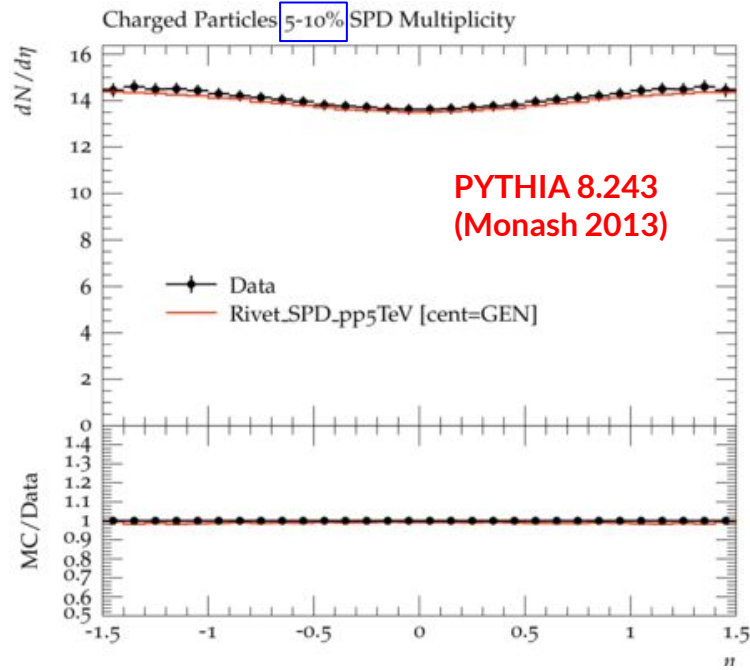
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New developments in ALICE

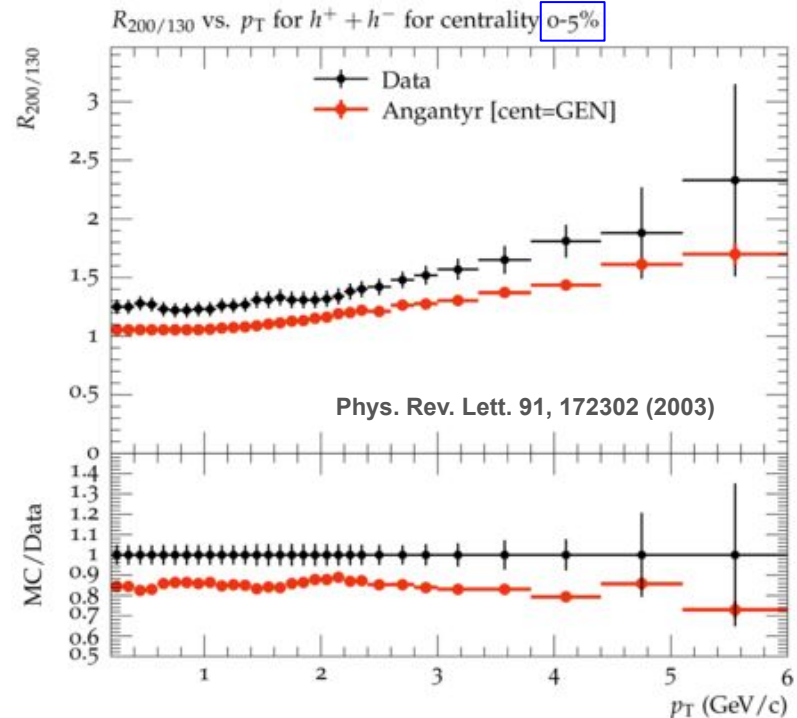
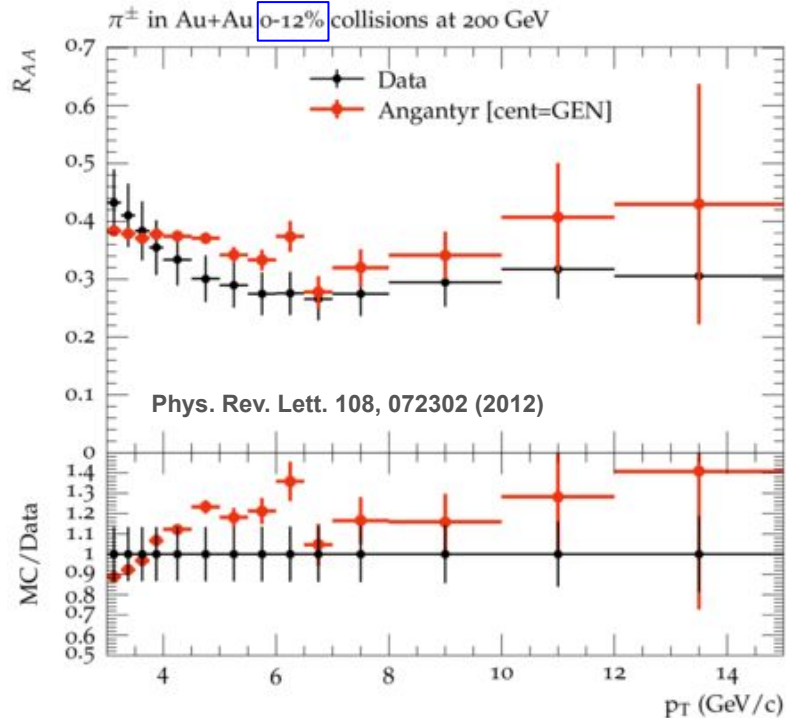
Analysis using SPD/ \langle SPD \rangle

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Centrality for STAR and PHENIX

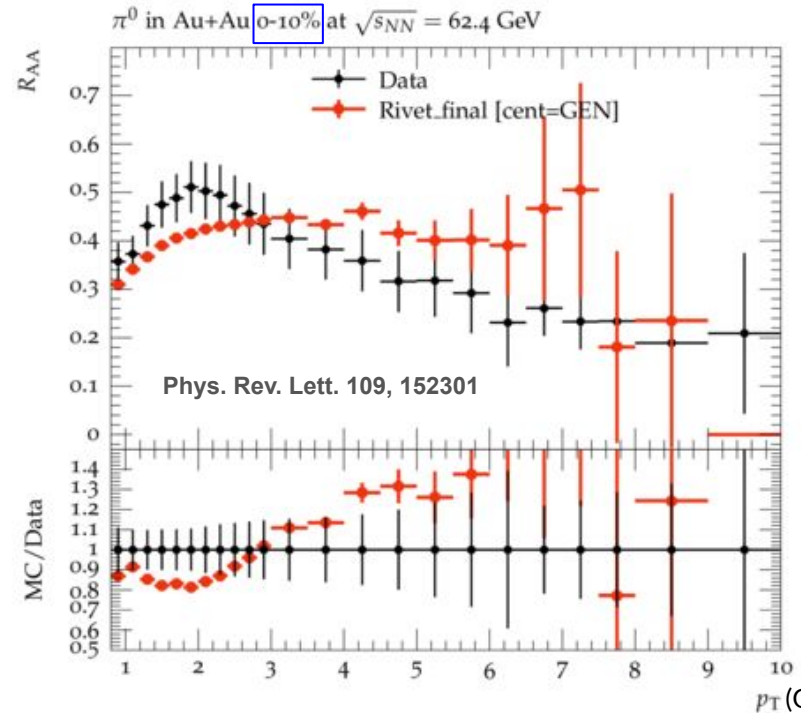
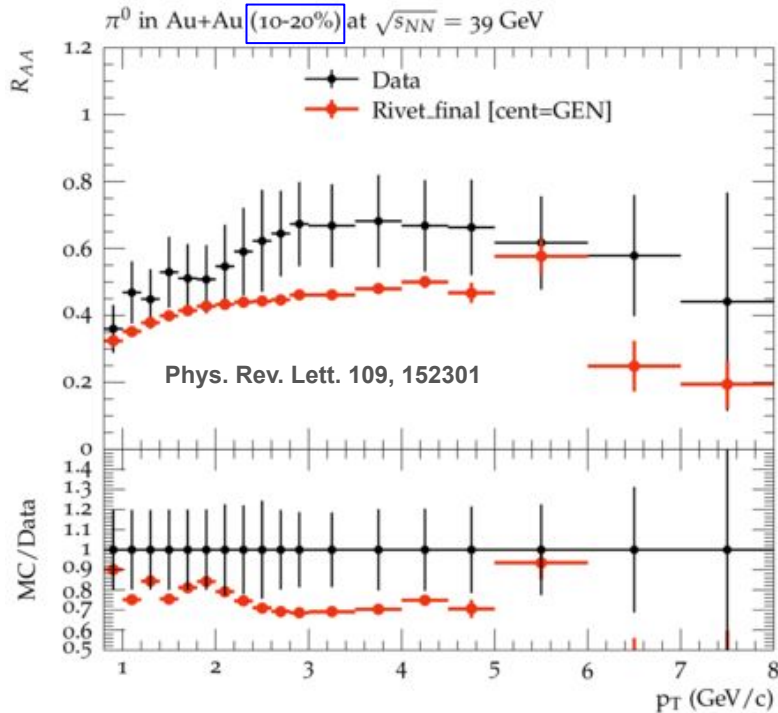
- The centrality determination in Rivet is based on the same methods used by the respective experiments
- Critical feature for the implementation of heavy-ion analyses in Rivet



Centrality for STAR and PHENIX



- The centrality determination in Rivet is based on the same methods used by the respective experiments
- Critical feature for the implementation of heavy-ion analyses in Rivet



Conclusions

- **Rivet** → **Experimental analysis for MC repository**
- **HepData** → **Repository of data**
- **HepMC** → **Interface between MC and analyses**

- **Data and analysis preservation**
- **Easy comparison of data and theory**

- **ALICE is developing tools for heavy-ion analysis**
 - **Many recent developments of the framework for heavy-ions**
 - **Working to increase the number of available analysis**
- **Rivet in STAR and PHENIX**
 - **Centrality determination can be done and heavy-ion analyses are possible!**

“Treat simulation the same way you treat data.”

Thank you!

- Rivet Philosophy



**Simulation
(Solimões River)**

**Data
(Black River)**

**Rivet
(Meeting of Waters)**