Production of charged-particles in proton-proton and heavy-ion collisions using RIVET analysis

Md Samsul Islam

Tinku Sarkar - Sinha

Saha Institute of Nuclear Physics, India

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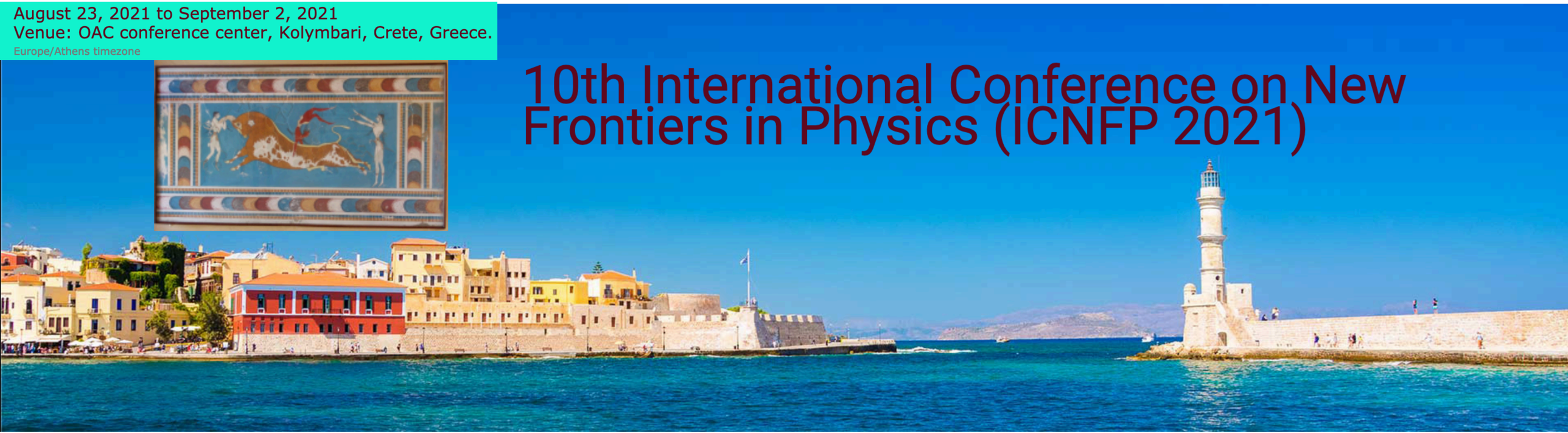


Why RIVET
(Robust Independent Validation of Experiment and Theory)??

- Study of phenomenology of the strong nuclear force (QCD) in High energy collisions of hadrons: Different phenomenological models along with the event generators are used to reproduce experimental data.
- There is a contest between such model components and experimental data during its validation in a systematic way though these event generators are very useful.
- RIVET platform has started to overcome these challenges during last one decade.
- Applied to final state particle describing soft processes such as hadronisations and underlying events (UE).
- RIVET provides a direct comparison between Monte-Carlo event generators (PYTHIA8, EPOS-LHC, Herwig, JEWEL, ThePEG) and experimental data.
- Very useful for validation and tunings of event generators for Standard Model processes.
- Part of analysis and interpretation toolkit within LHC experiment.

Outline

Event generator used PYTHIA8!!

- **Standard RIVET Analysis**

a) Study of charged particle multiplicity density and mean collision centrality (N_{part}) as a function of centrality (%) intervals in Pb-Pb collisions

b) Charged multiplicity distribution in p-p collisions.

- Own developed RIVET analysis

a) p_T -distribution of charged particles in p-p collisions.

b) Differential p_T -spectra of charged-particles in nine centrality classes (from most central to peripheral) for Pb-Pb collisions.

RIVET design

- A set of computational tool with robust and standard definitions of physics object.
- Definition of analysis routines based on common experimental data analyses.
- Equipped to direct compare of model predictions for particles at final state with experimental data.
- Facility to synced experimental data points available on HepData (https://www.hepdata.net/).
- Allows histogram booking based on HepData records.

Will Live on !!
significant contribution by HEP community & MCEG group

Heavy Ion (HI) in RIVET

- Plugin of HI routine based on data from heavy ion experiments.

- Provide
  a) calibration framework for centrality selection.
  b) framework for calculating flow observables.

- Postprocessing of analysis to allow HI to pp (proton-proton) ratio, such as nuclear modification factor (R_{AA}).

RIVET analysis

Default PYTHIA8 event generators for pp analysis, soft QCD processes, primary charged particles ($c\tau \sim 10$ mm)

Compare ALICE results for Pb-Pb collisions with RIVET using PYTHIA8 Heavy-ion model (**Angantyr**).

1) **ALICE_2010_I880049 :** Pb-Pb collisions at $\sqrt{s}$ = 2.76 TeV => **RIVET analyses reference** (validated),
=> centrality dependence of the charged-particle multiplicity density at mid-rapidity (**https://www.hepdata.net/record/ins880049**)

2) **ALICE_2018_I1657384 :** Pb-Pb collisions at $\sqrt{s}$ = 2.76 TeV & 5.02 TeV => own script (unvalidated)
=> charged particle p_T -spectra for nine centrality classes (**https://www.hepdata.net/record/ins1657384**)

3) **ALICE_2010_S8625980 :** p-p collisions at $\sqrt{s}$ = 7 TeV => **RIVET analyses reference** (validated).
=>charged multiplicity (**https://www.hepdata.net/record/ins852264**)

4) **ALICE_2018_I1657384 :** p-p collisions at $\sqrt{s}$ = 2.76 TeV & 5.02 TeV => own script (unvalidated)
=> charged particle p_T -spectra (**https://www.hepdata.net/record/ins1657384**).

Ref:

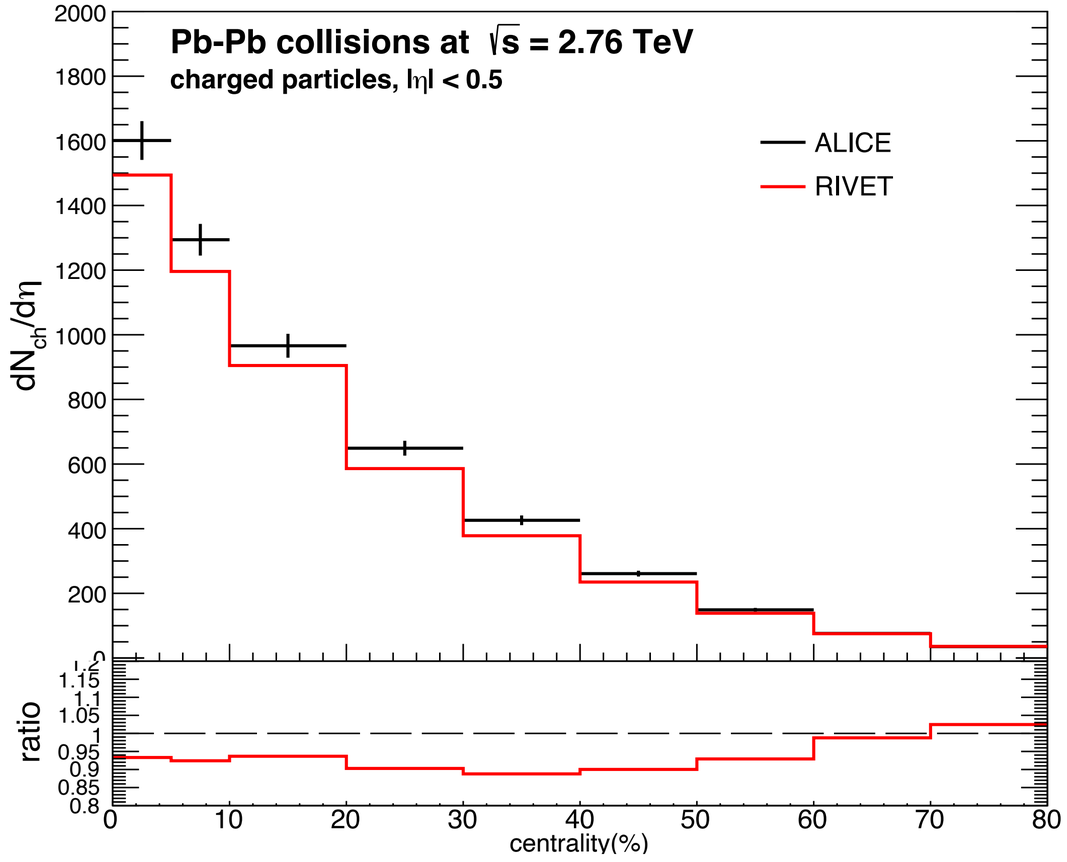
1) **RIVET:** https://rivet.hepforge.org/

2) **RIVET in ALICE:** https://alice-doc.github.io/alice-analysis-tutorial/rivet/rivet-tutorial.html

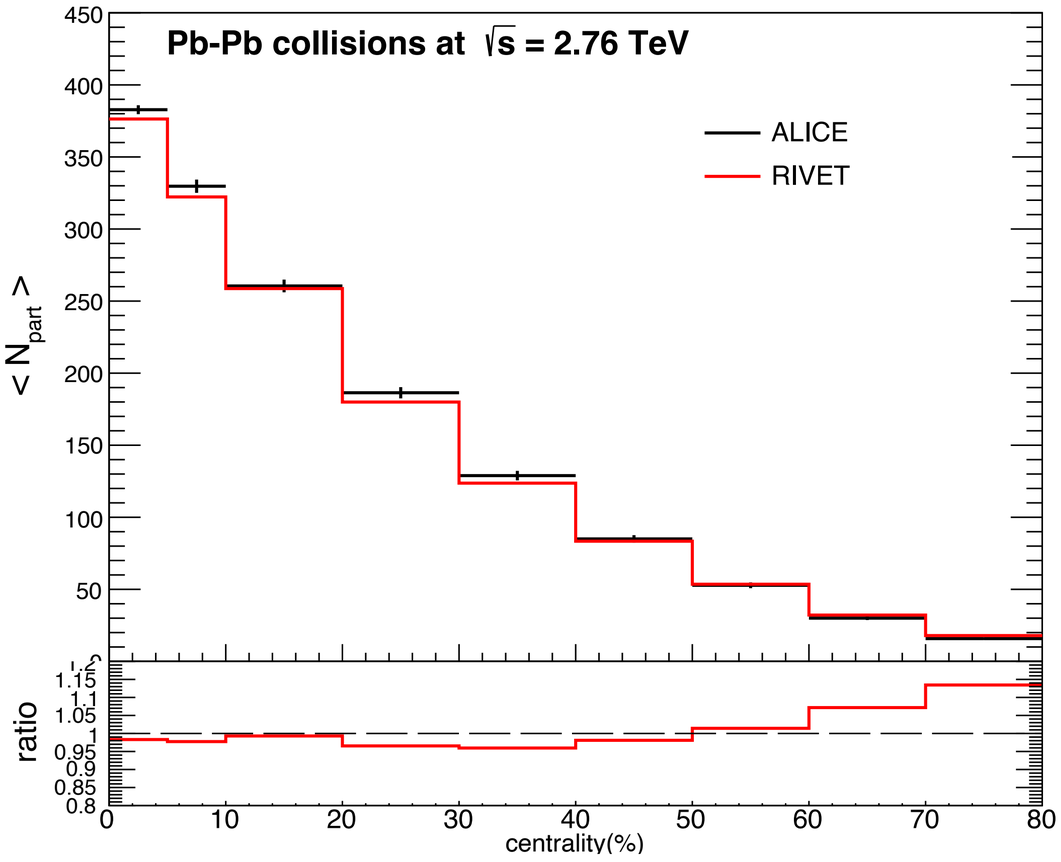
3) **PYTHIA8 online manual:** https://pythia.org/latest-manual/Welcome.html

Pb-Pb collisions at $\sqrt{s}$ = 2.76 TeV
(ALICE_2010_I880049 : RIVET analyses reference)

centrality dependence of the charged-particle multiplicity density at mid-rapidity

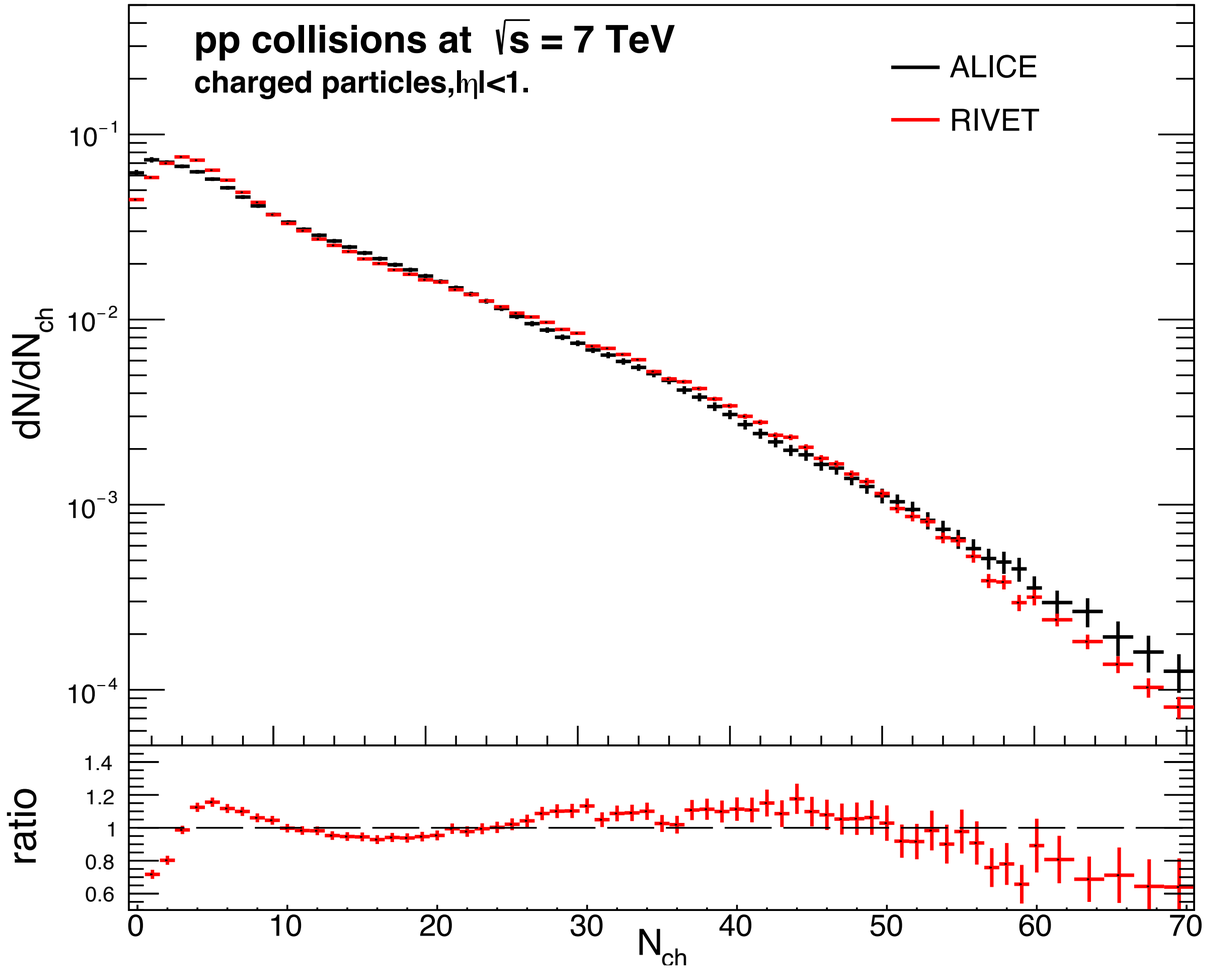


Number of participants (N_{part}) as a function of collision centrality

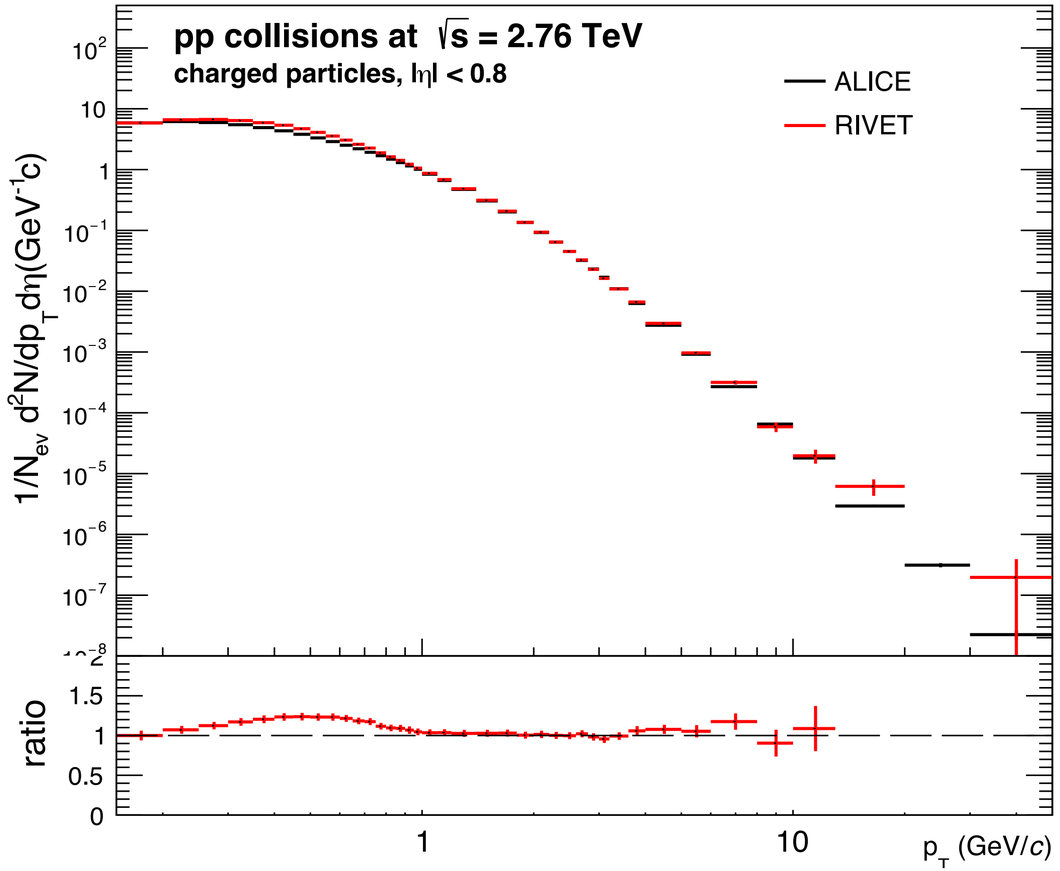


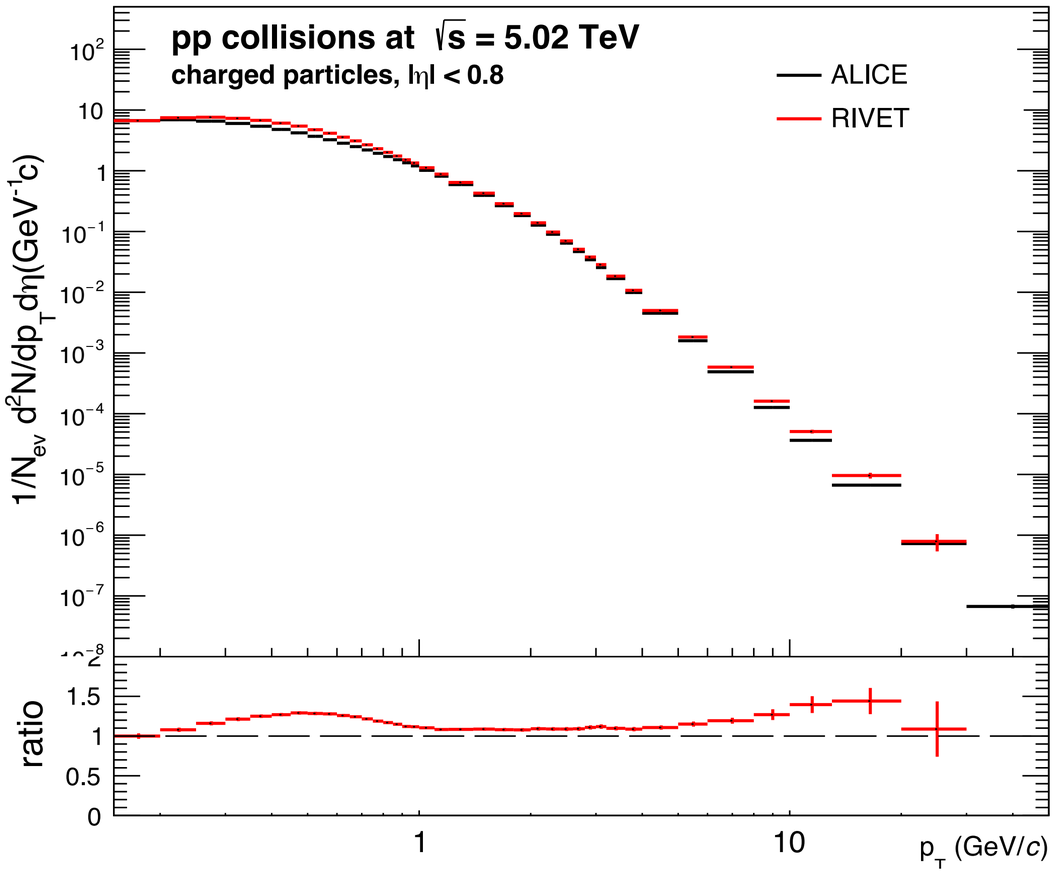
charged particle multiplicity distribution in p-p collisions at $\sqrt{s}$ = 7 TeV.

(ALICE_2010_S8625980 : RIVET analyses reference)



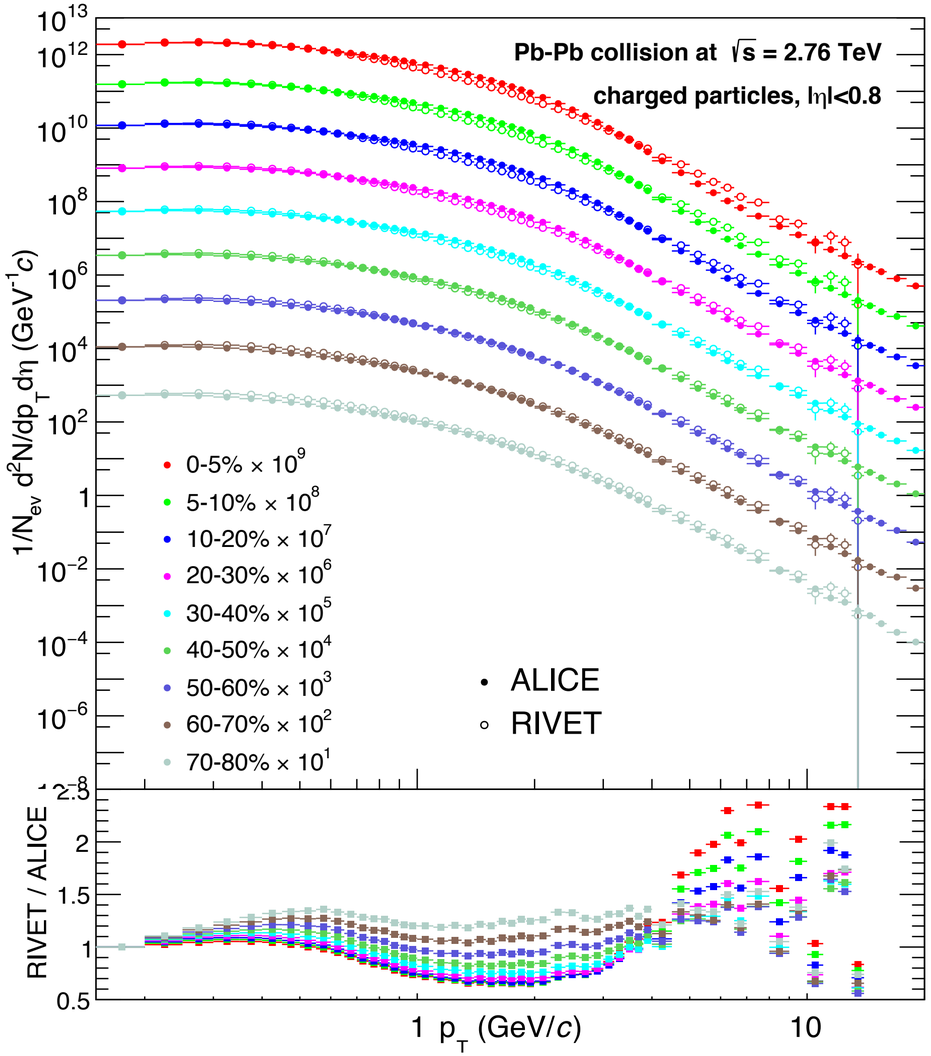
Differential p_T -spectra of charged particle at mid-rapidity ($|\eta| < 0.8$) in pp collisions (ALICE_2018_I1657384)

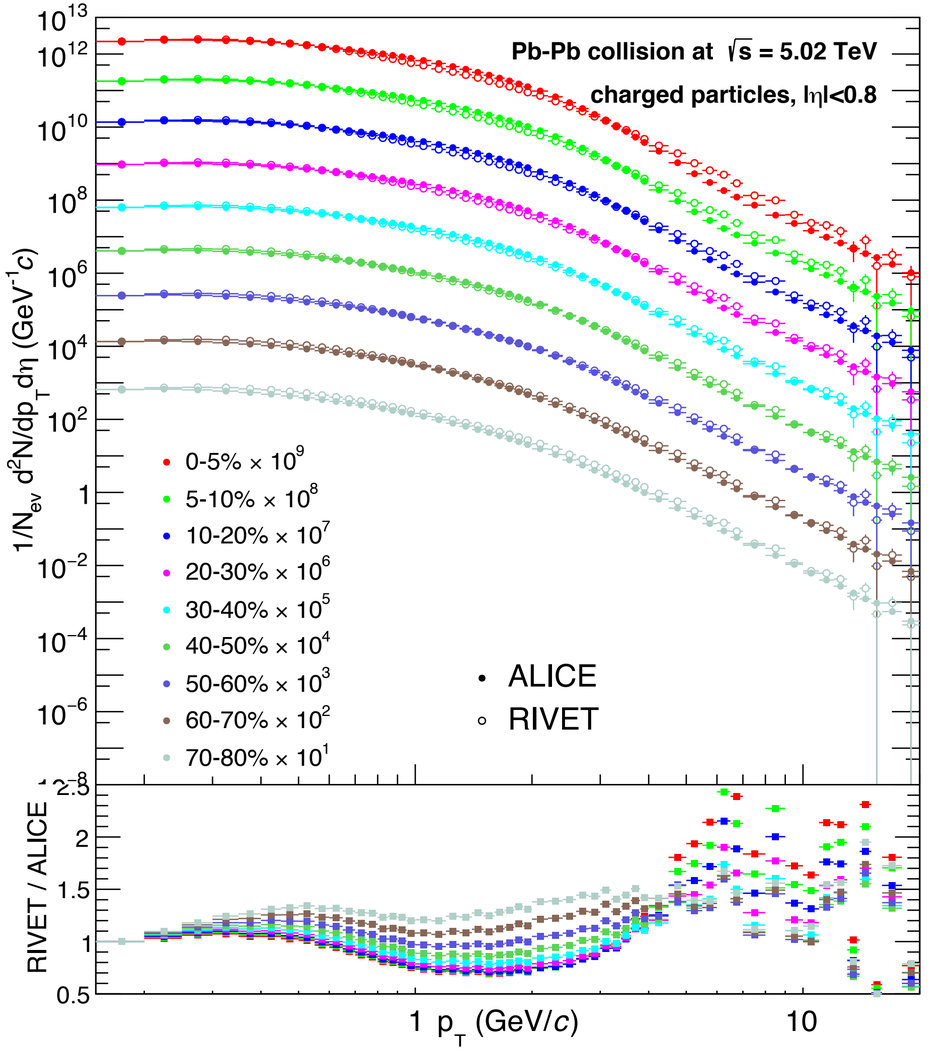




Differential p_T -spectra of charged particle at mid-rapidity ($|\eta| < 0.8$) in PbPb collisions (ALICE_2018_I1657384)

from most central (0-5%) to peripheral (70-80%)





Summary and Future Plan

- Charged particles production in both p-p and Pb-Pb collisions reproduced ALICE data well.
- The charged particle production carried out over wide scale of LHC energies.
- RIVET platform found very robust and efficient for a direct comparison of MC generator (PYTHIA8) with experimental data (ALICE).
- Wish to study the rivet analyses for other heavy-ion (i.e, Xe-Xe) collisions.
- Plan to study the Heavy Flavor production (charm and beauty) in both p-p and heavy-ions using RIVET analysis in near future.

Thank you