HIJING++, a Heavy Ion Jet INteraction Generator for the High-luminosity Era of the LHC and Beyond

HOTQUARKS2018

GÁBOR BÍRÓ

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- ÚNKP-17-3 New National Excellence Program of the Ministry of Human Capacities

Release

Download from here:

Release

~~Download from here:~~ Not now, but soon...

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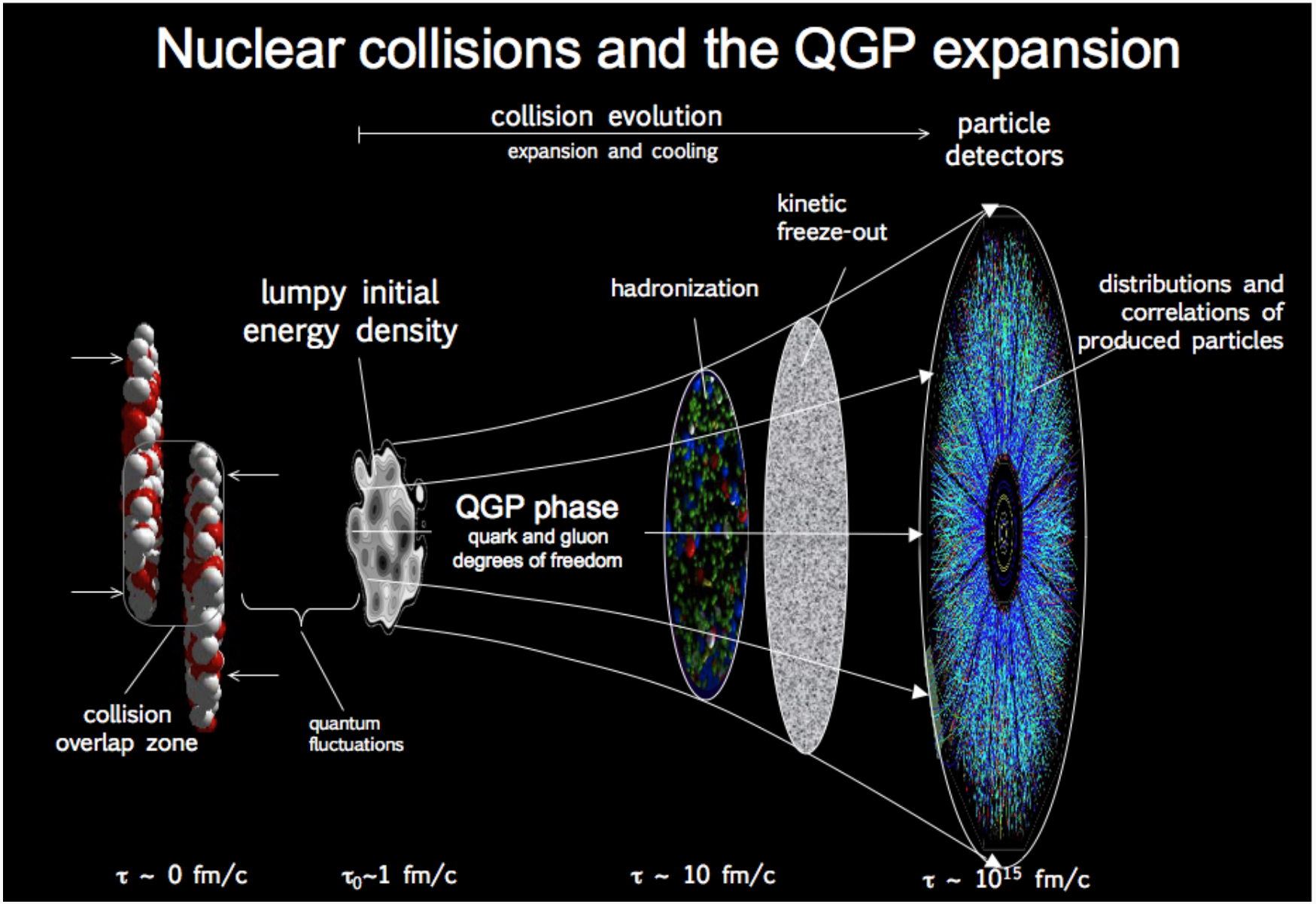
Motivation

Hadronization



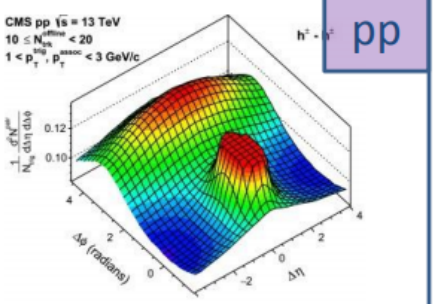
Source: http://icc.ub.edu/

QGP EVERYWHERE…?

The ridge: collectivity in a hazelnutshell

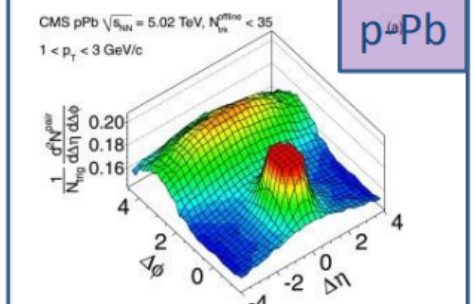
PLB 765 (2017) 193

pp



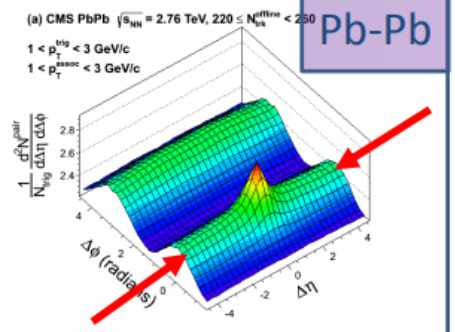
PLB 718 (2013) 795

p-Pb



JHEP 07 (2011) 076

Pb-Pb



2-particle correlations.

Ridge at $\Delta\phi=0$ in a wide range of $\Delta\eta$.

Attributed to hydrodynamic collective flow of a strongly interacting expanding medium (QGP)

What is the reason for observing a ridge structure in small systems? QGP? Strong initial state momentum correlations?

Need to be more quantitative and study radial and anisotropic flow in small systems!

↓

HIJING Monte Carlo event generator

Heavy
Ion
Jet
INteraction
Generator

核易经

Hé – yì – jīng

”Nuclear change theory”; Book of Changes, ”Originally a divination manual in the Western Zhou period (1000–750 BC)”

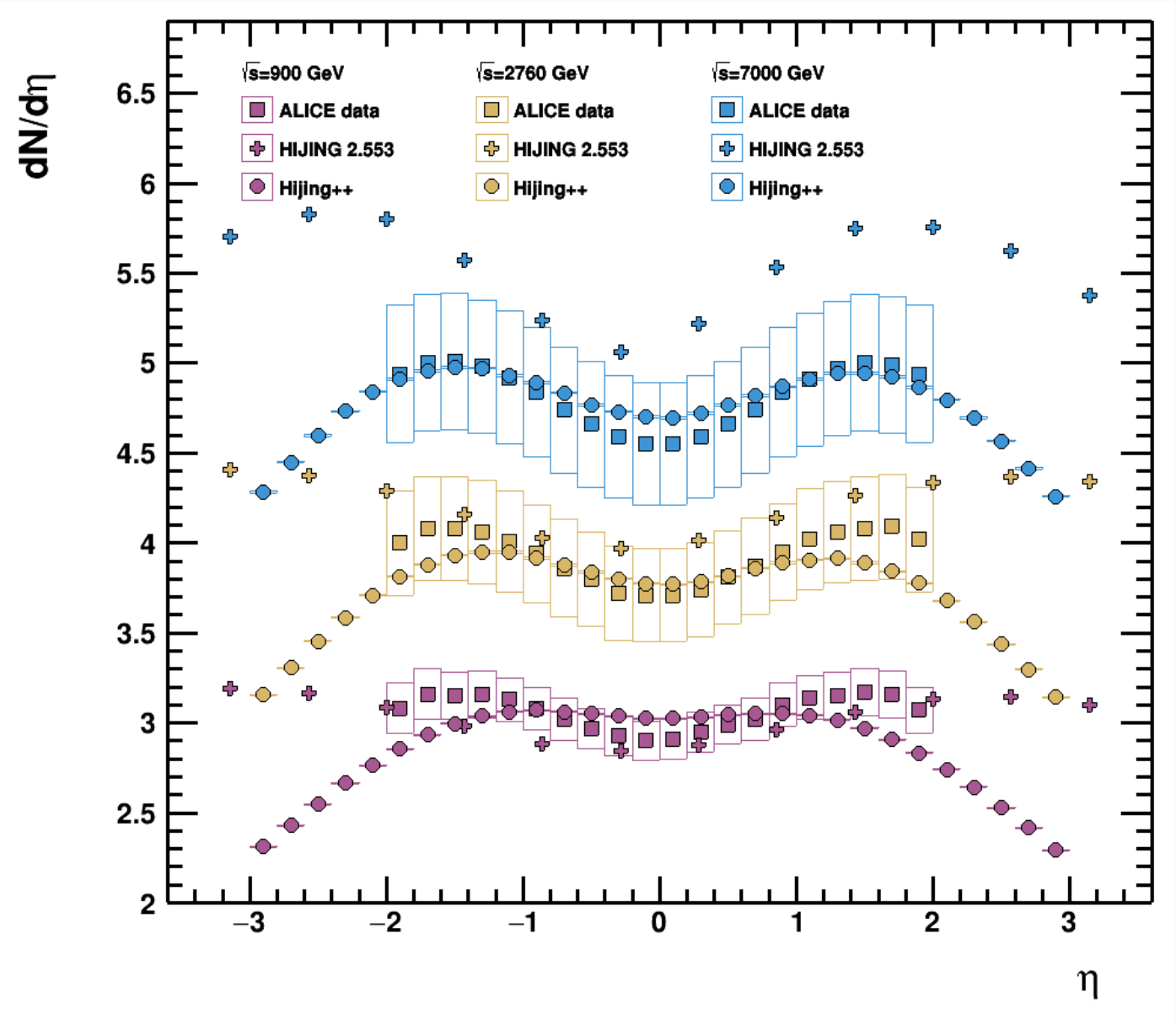
First, FORTRAN version: 1991, X.N. Wang, M. Gyulassy, *Phys. Rev. D***44**, 3501 (1991).

HIJING++ Monte Carlo event generator

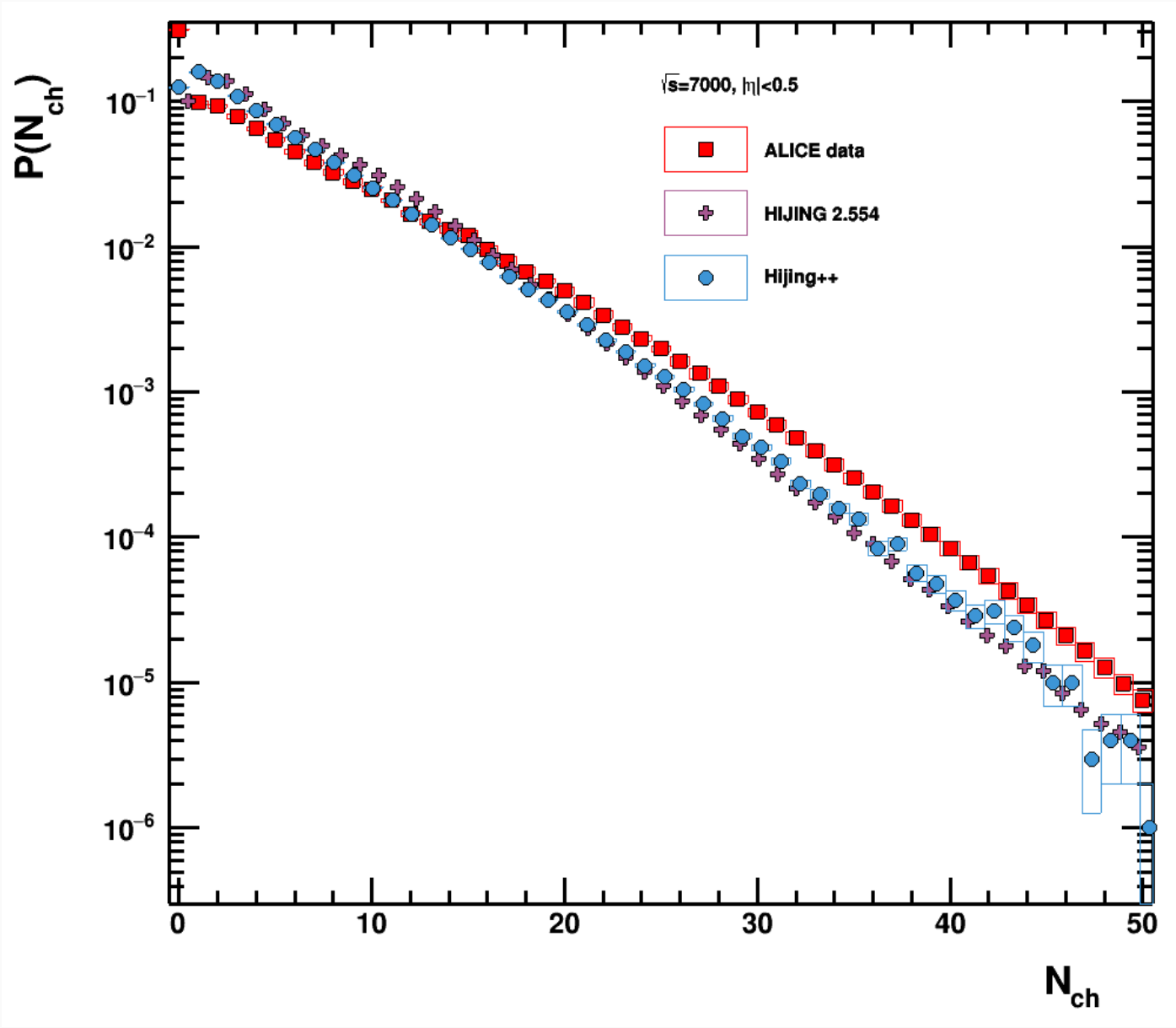
- Pairwise nucleon interactions ((in)elastic scattering (Pythia), diffraction, gluon radiation, Lund fragmentation...)
- Key importance for detector design and validation, testing new physics
- Up to date, the community still uses the (more-or-less) original FORTRAN code
- Challenge: software simulation of 600 million real collision in each second (HiLumiLHC: multiple of this)
- Target audience: the whole heavy ion community (large collaborations and BSc students as well)
- Gergely Gábor Barnaföldi, Gábor Papp, Péter Lévai, Szilveszter Harangozó, Miklós Gyulassy, Xin-Nian Wang, Ben-Wei Zhang, Guoyang Ma

Current status results

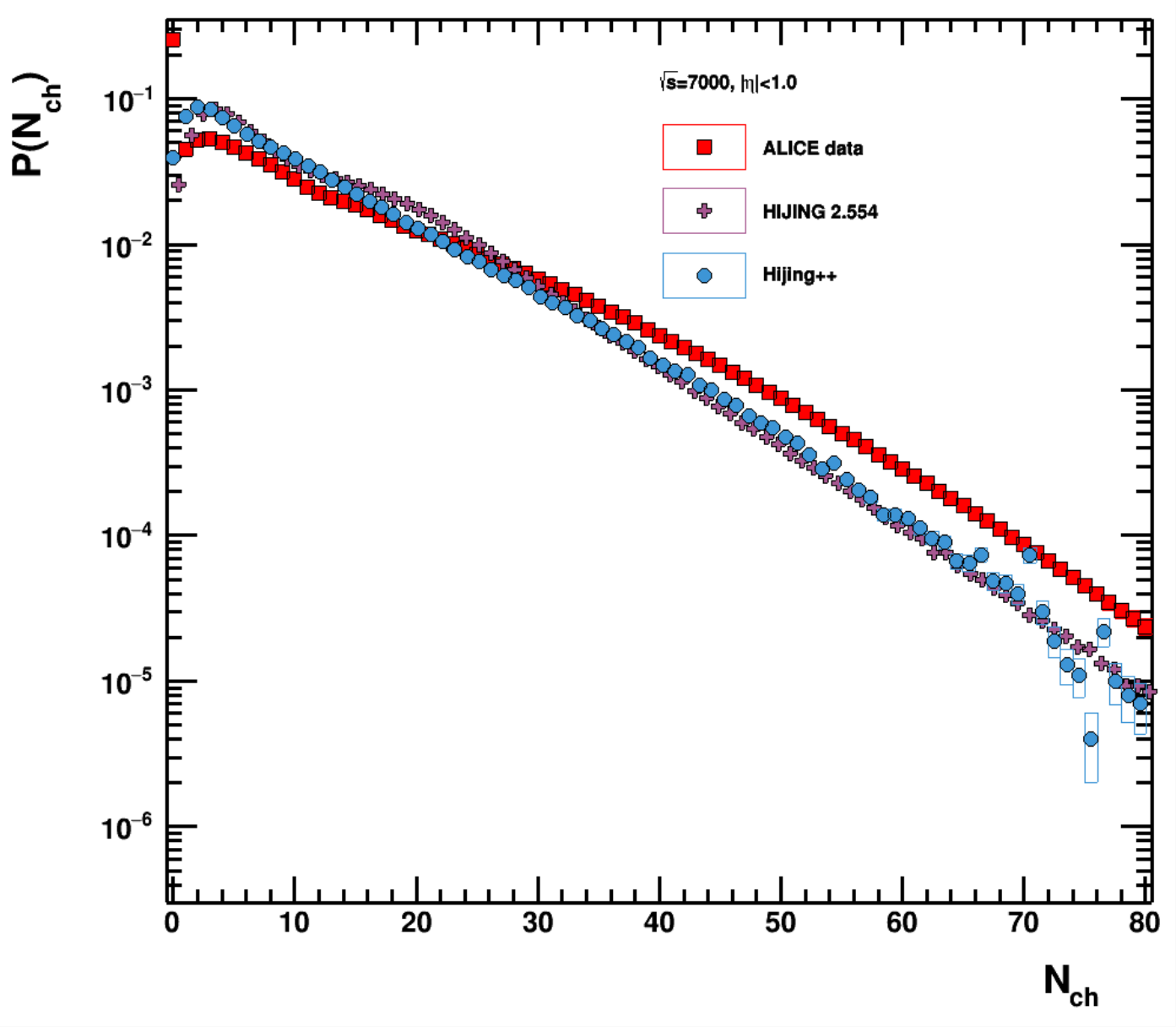
HIJING++ RESULTS



HIJING++ RESULTS



HIJING++ RESULTS



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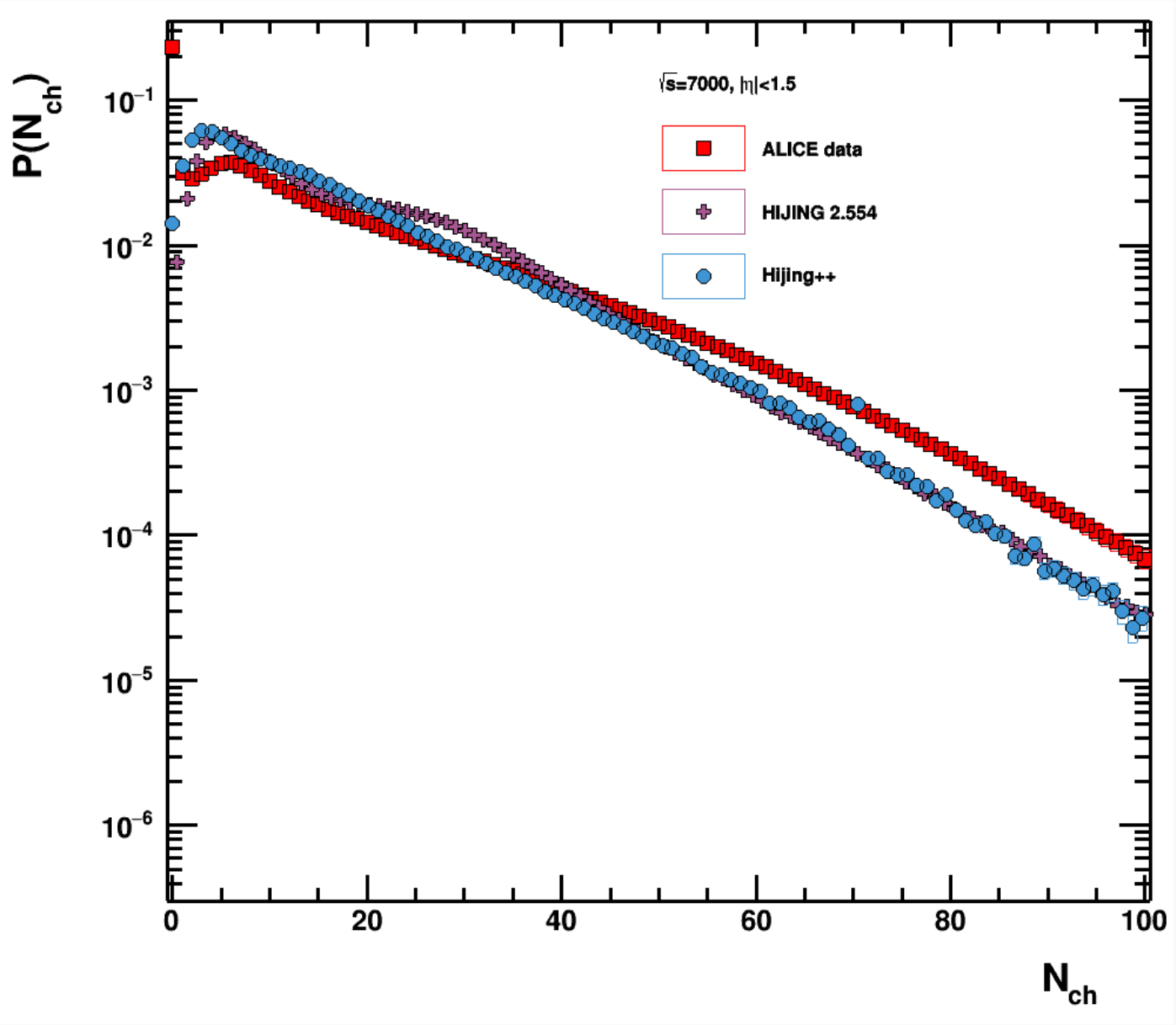

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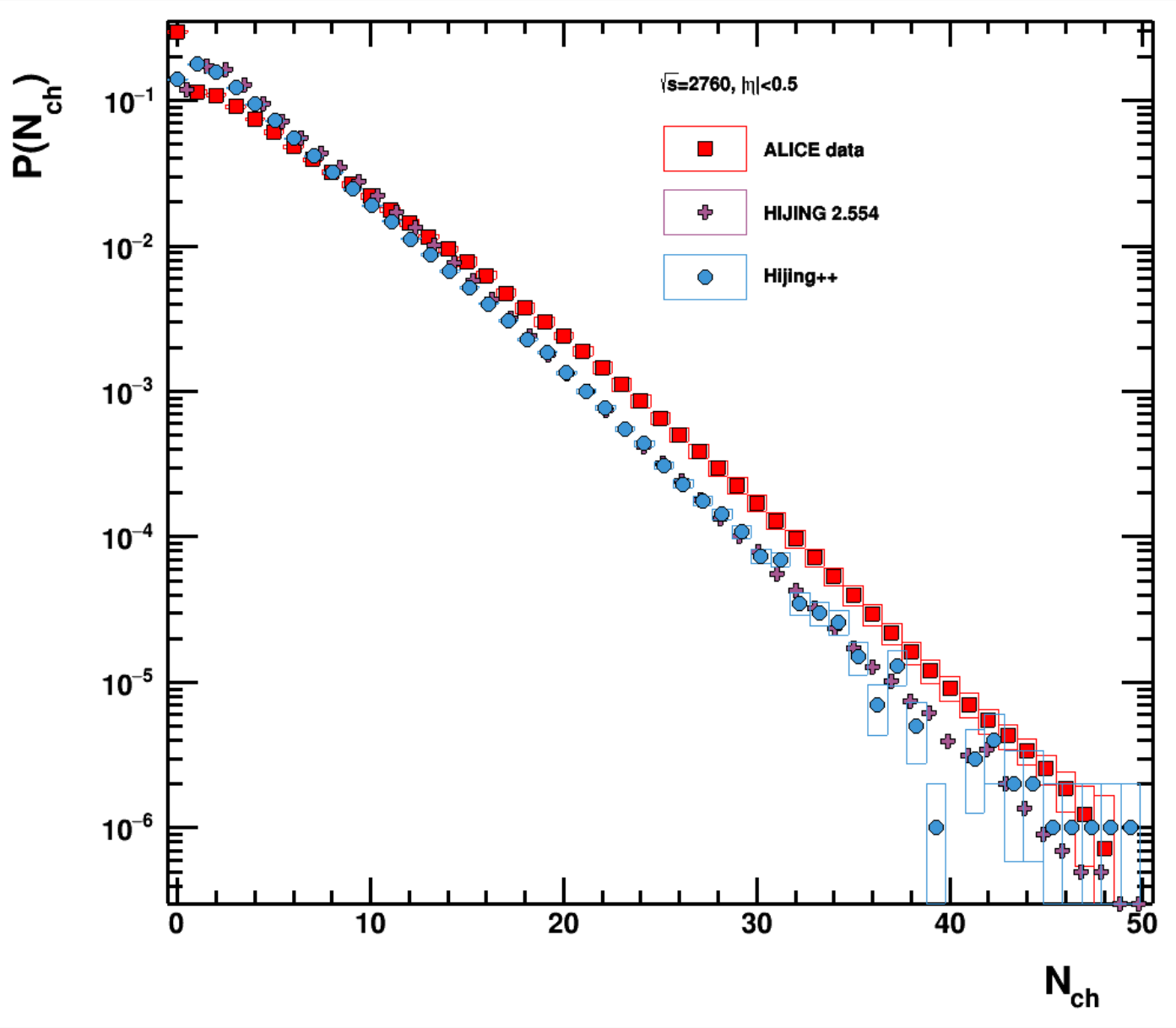

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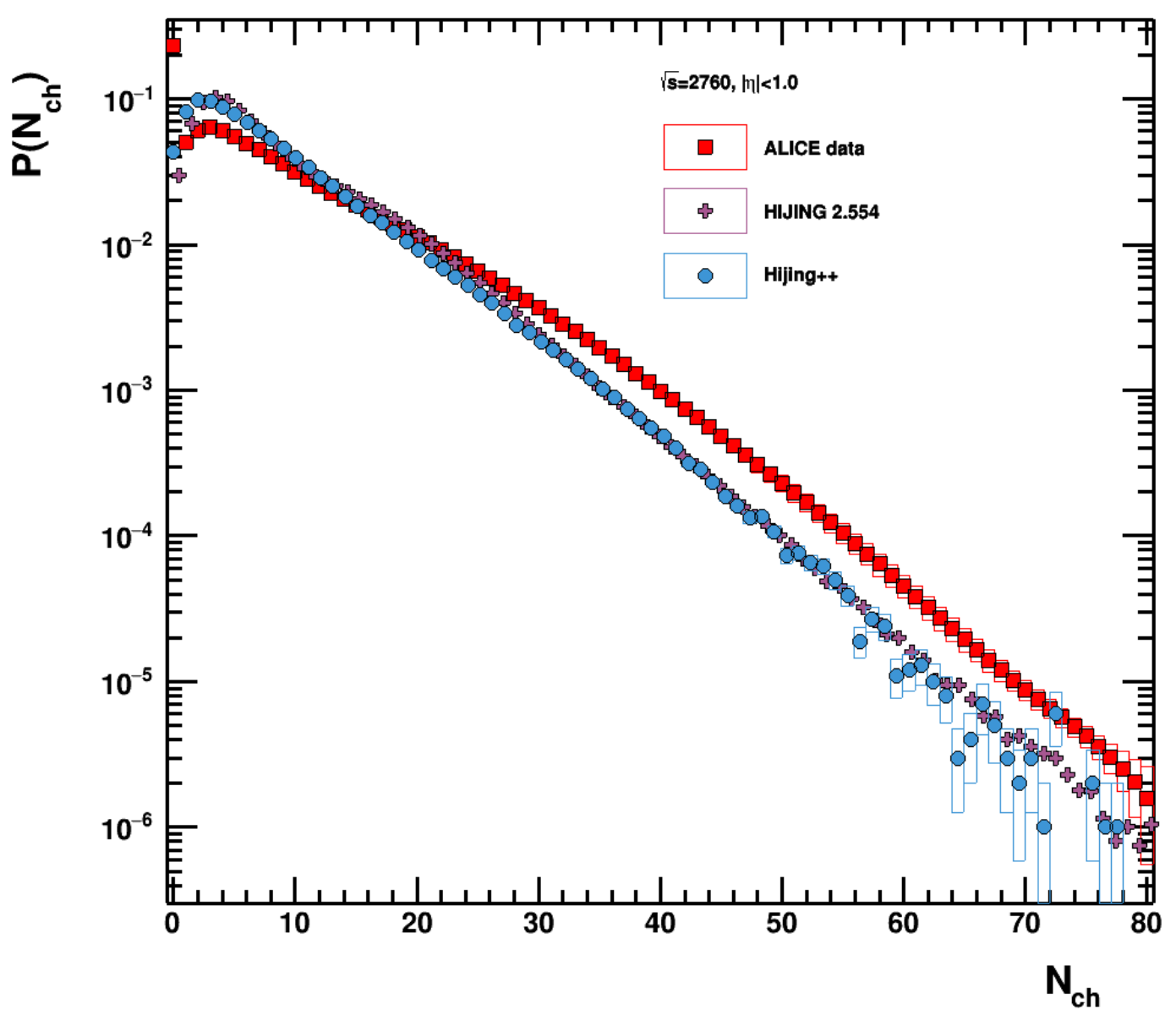

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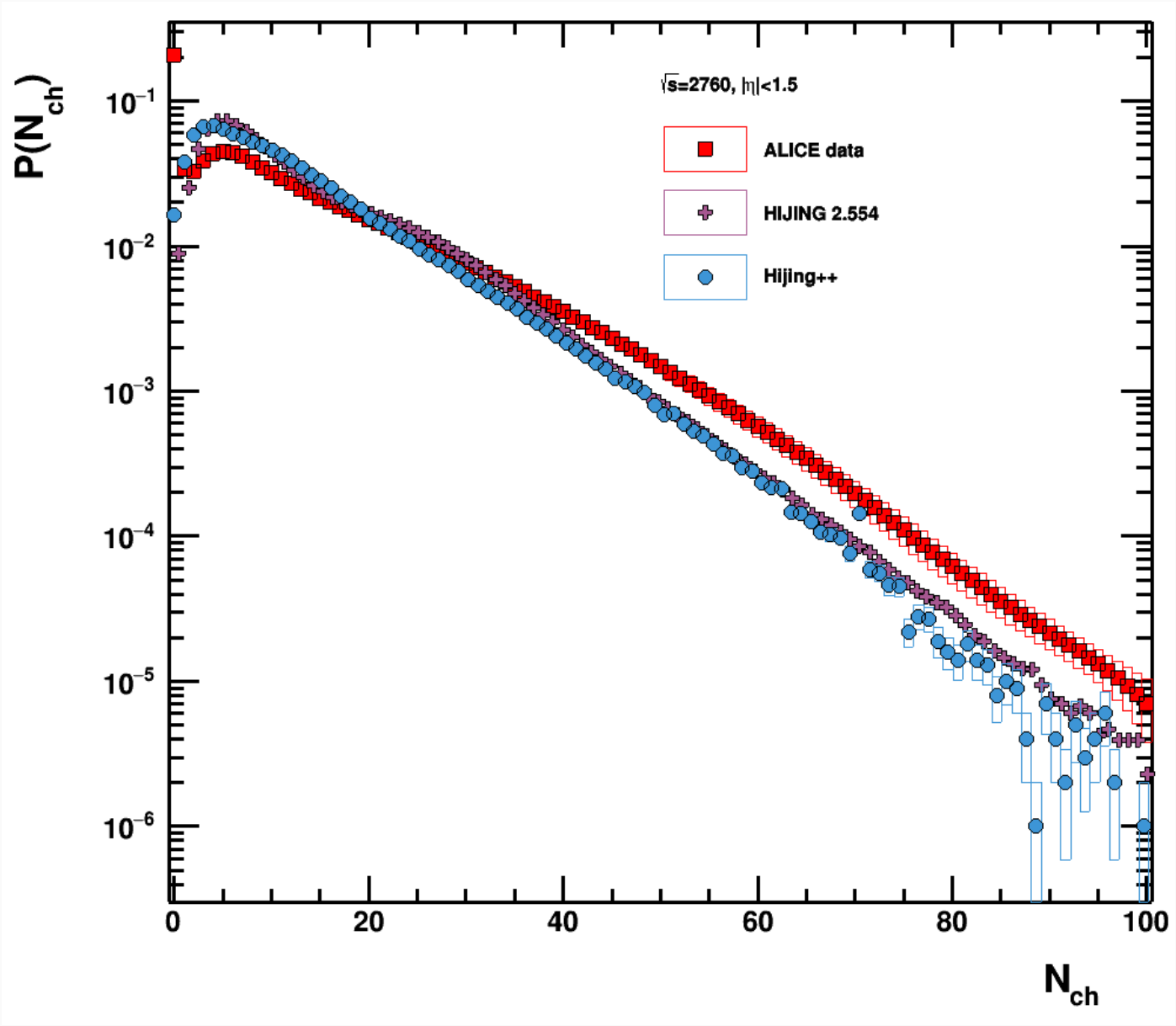

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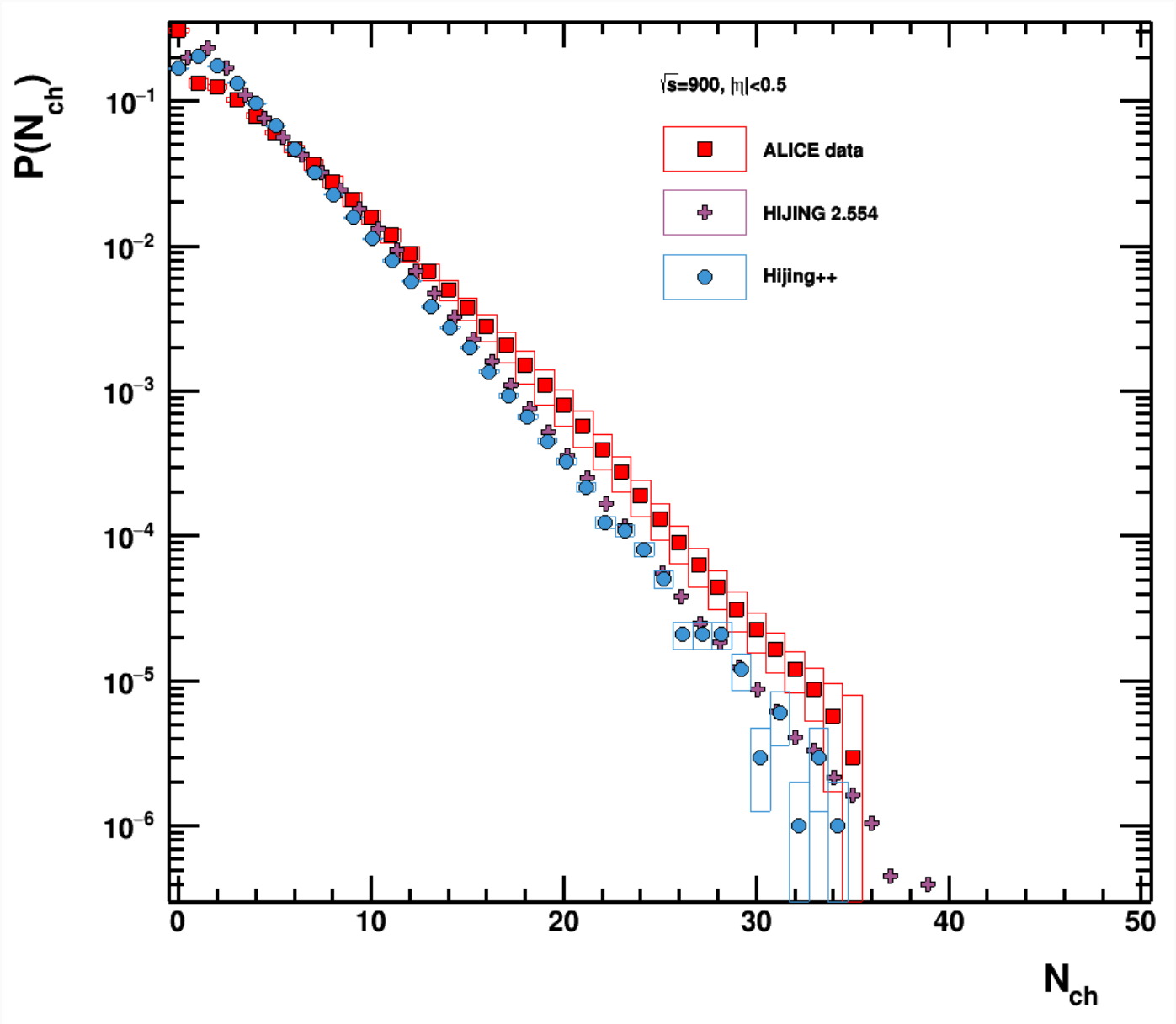

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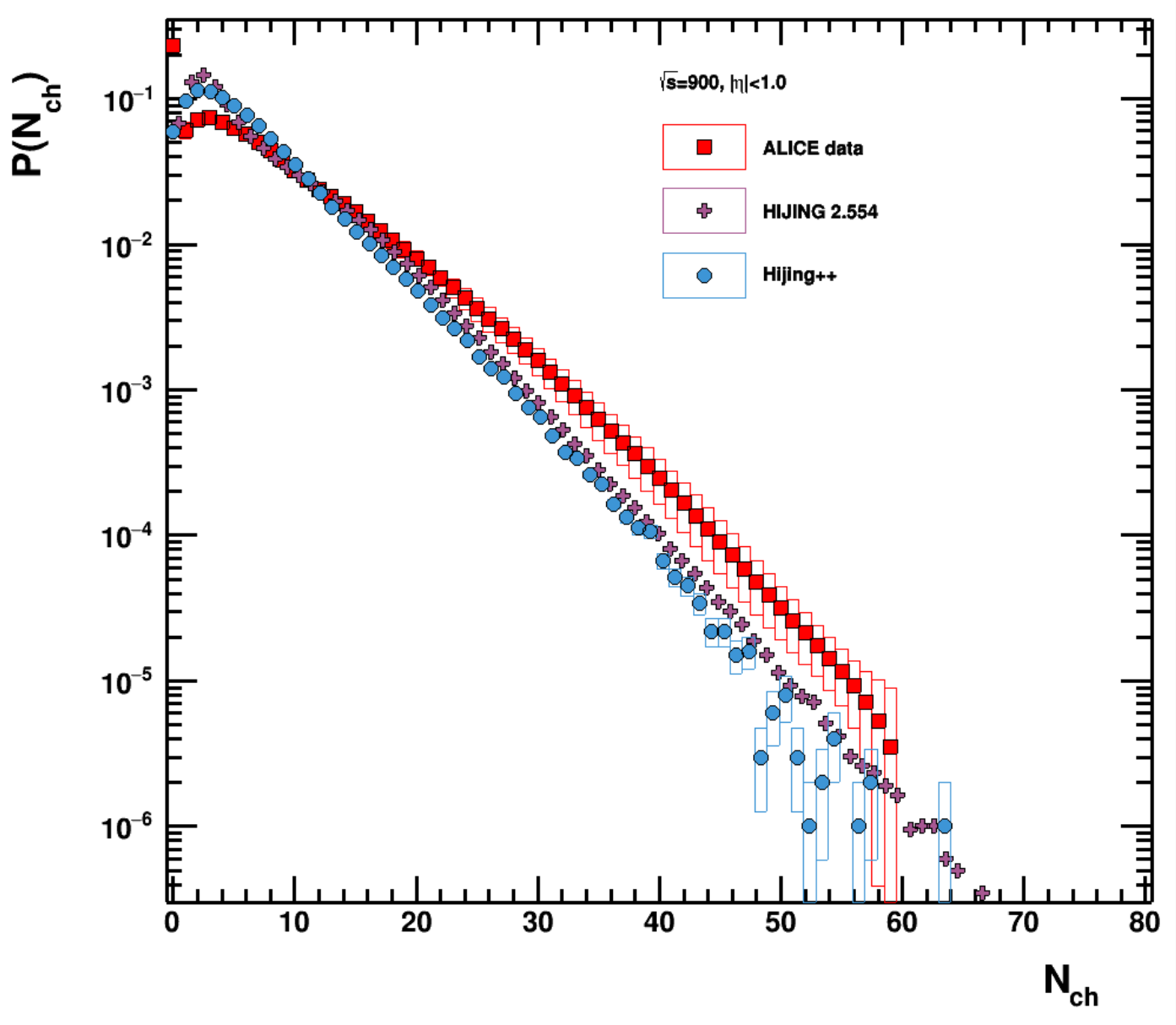

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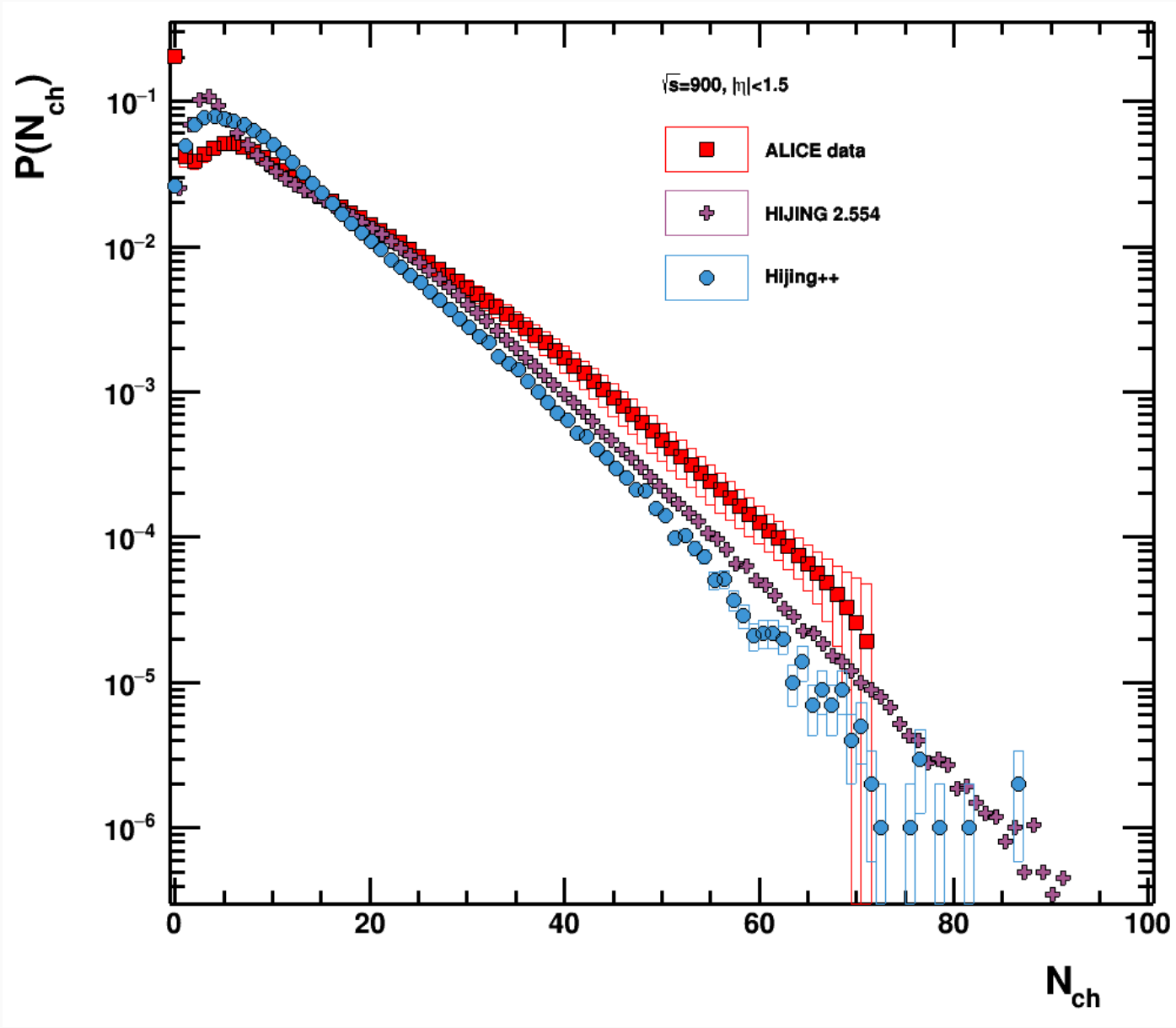

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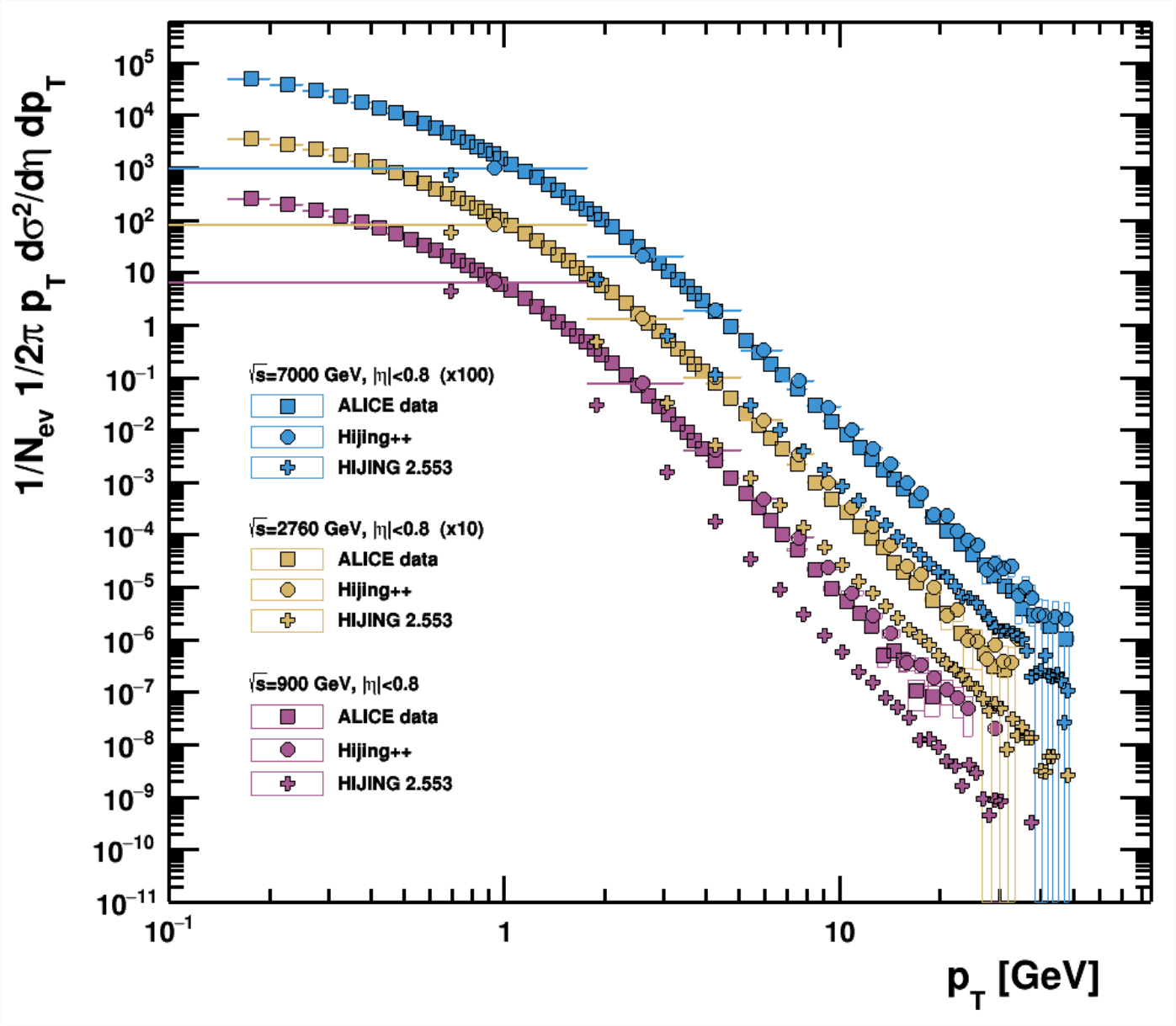

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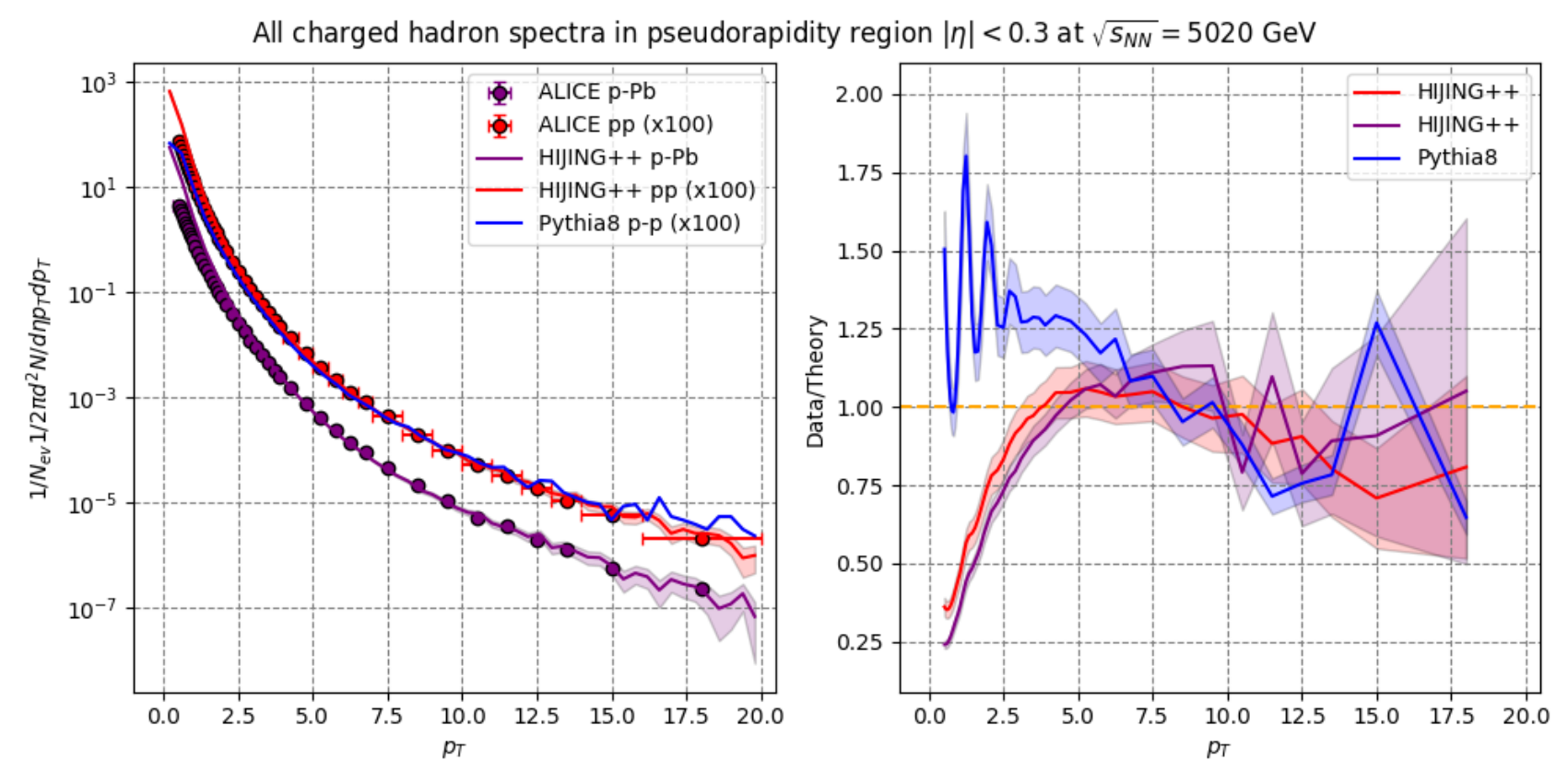

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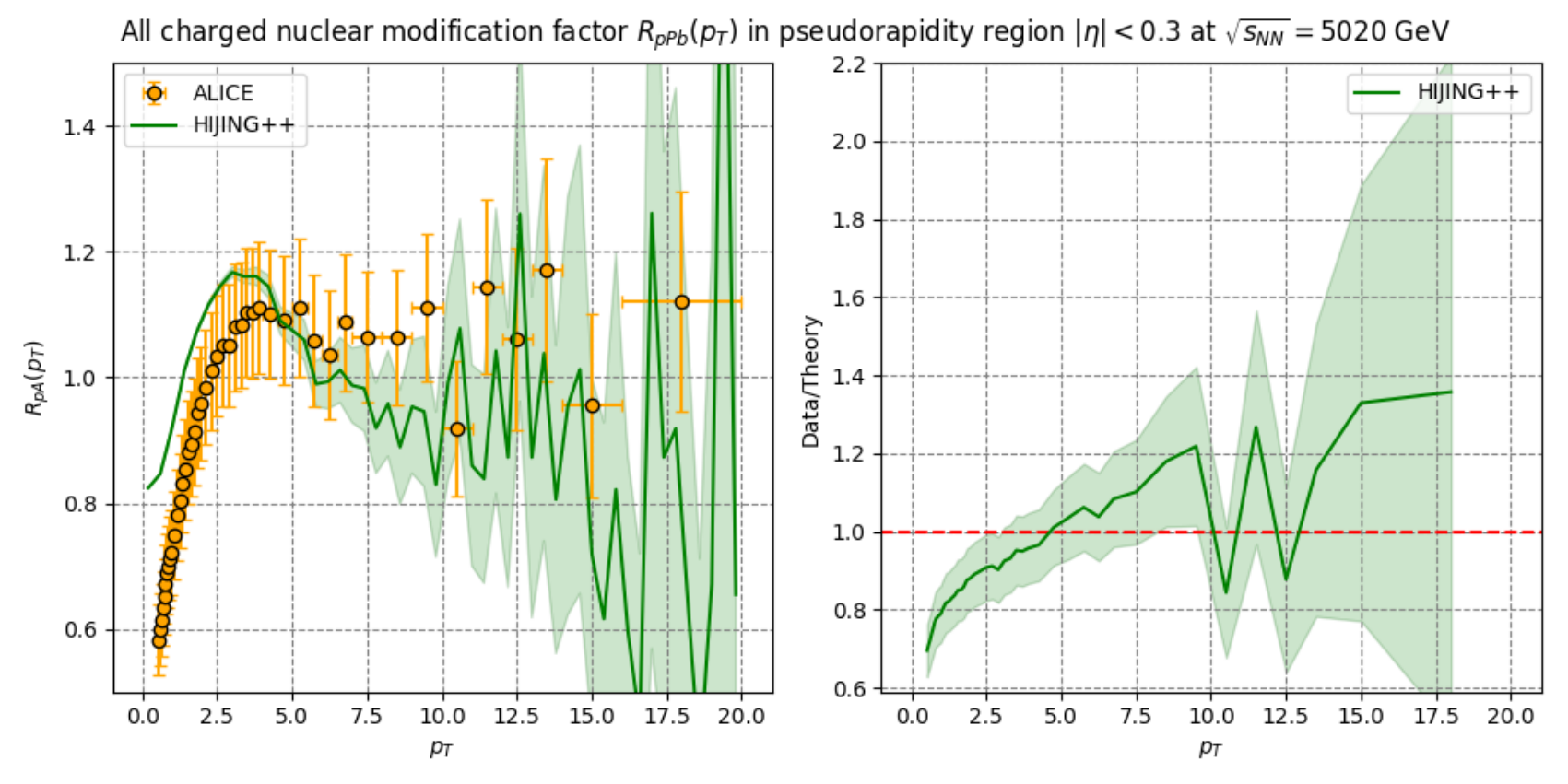
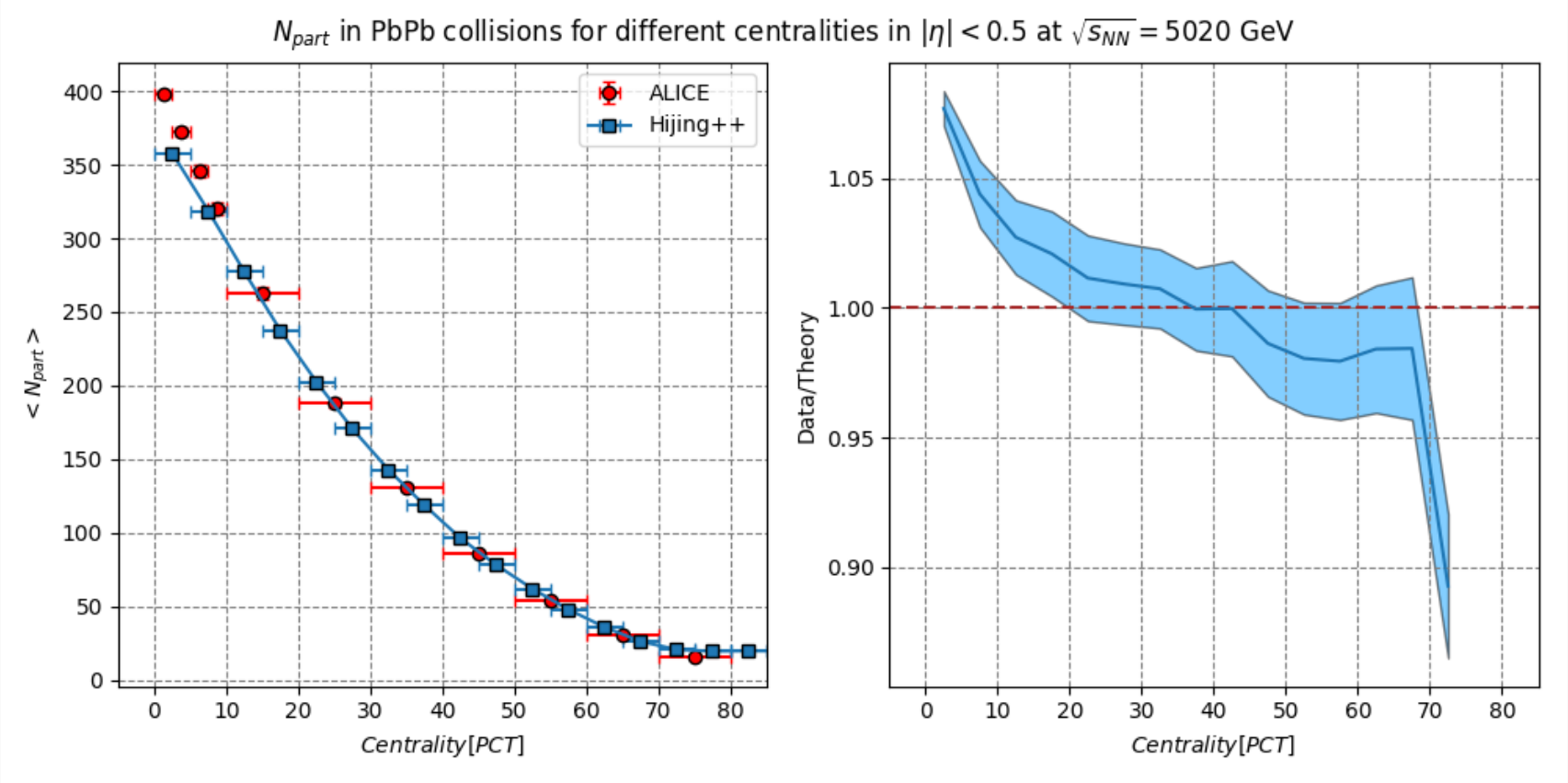


HIJING++ RESULTS



Features

HIJING++ Monte Carlo event generator

Solid C++ foundations

- User friendly usage (C++14 compiler, cmake, LHAPDF6, Pythia8)
- Many optional extension (ROOT, FastJet, Rivet, ...)
- Easily parallelizable

main.cc:

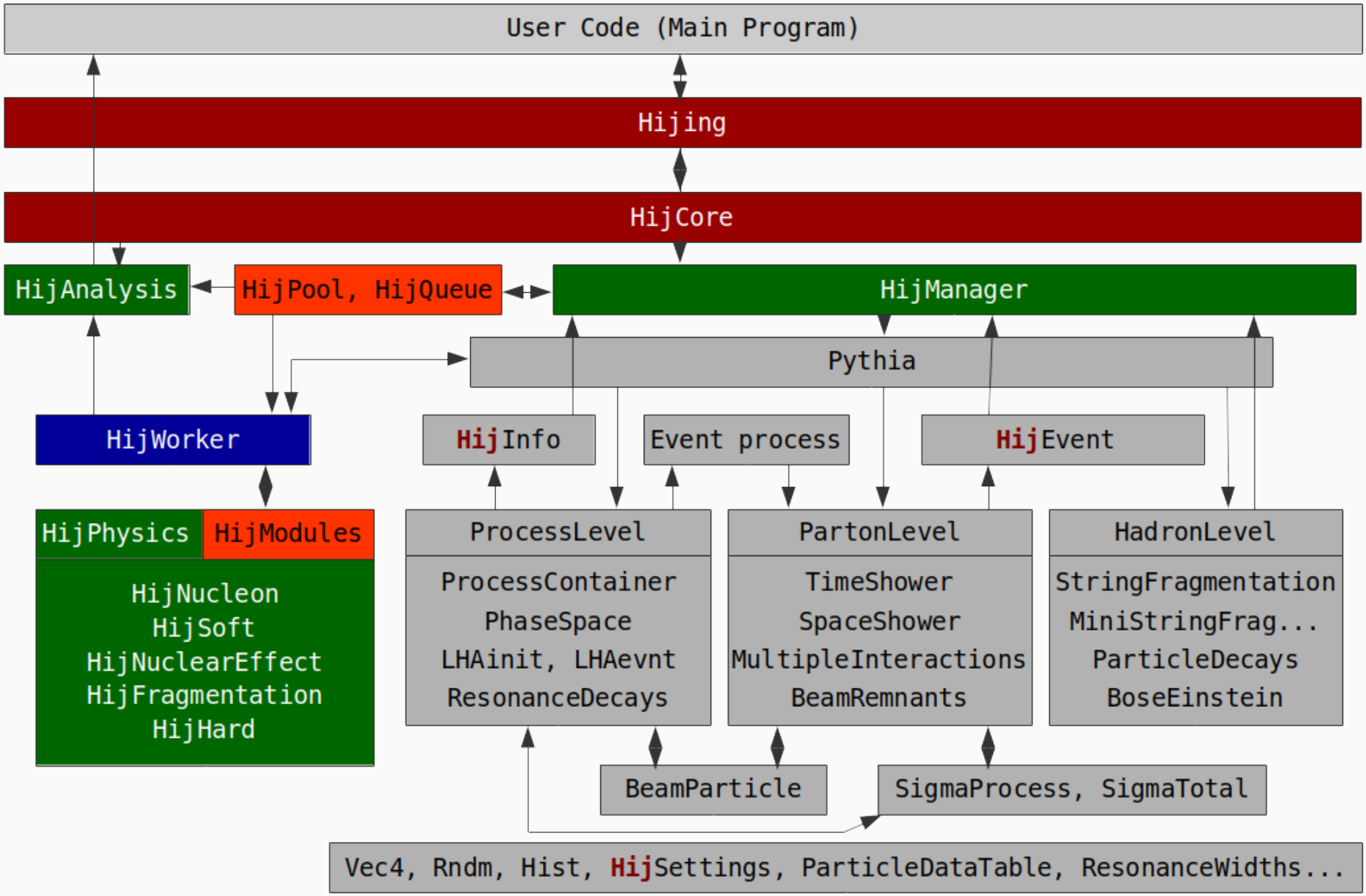
```
#include "Hijing.hpp"

using namespace Hijing3;

int main(int argc, char* argv[])
{
  Hijing hijing;
  if(argc==1)
    hijing.readFile("testSettings.cmnd");
  else
    hijing.readFile(argv[1]);

  hijing.init();
  hijing.start();
}
```

testSettings.cmnd:

```
PDF:pSet = GRV98lo
! PDF:pSet = nCTEQ15

Hijing:threads = 3
Beams:eCM    = 8160
Hijing:NuclearEffects = on

Main:numberOfEvents = 50000
Hijing:idA = P
Hijing:aproj = 1
Hijing:zproj = 1
Hijing:idB = A
Hijing:atarg = 208
Hijing:ztarg = 82
(...)
```

Highly customizable through run parameters stored in xml files

HIJING++ STRUCTURE



HIJING++ MODULARITY

In the xml:

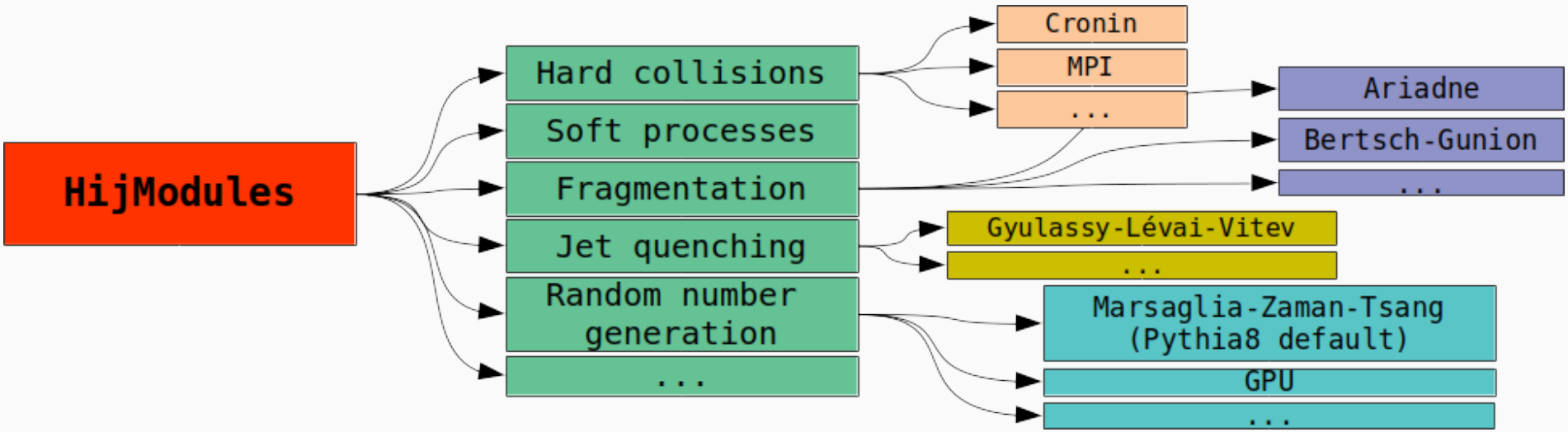
```
<word name="Hijing:Quenching" default="HijQuenching_GLV0">
Select the jet quenching definition: GLV model version 0.
</word>
```

Building the HijModules:

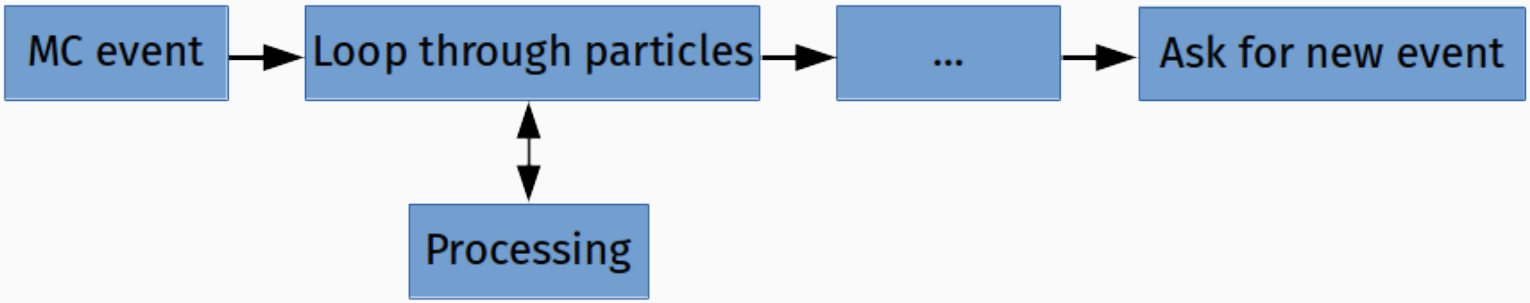
```
unique_ptr<IHijQuenching> ModuleFactory::makeQuenching(const string &name) {
    if (name == "HijQuenching_GLV0")
      return move(make_unique<HijQuenching_GLV0>());
    if (name == "HijQuenching_GLV1")
      return move(make_unique<HijQuenching_GLV1>());
}
```

At user level, in testSettings.cmnd:

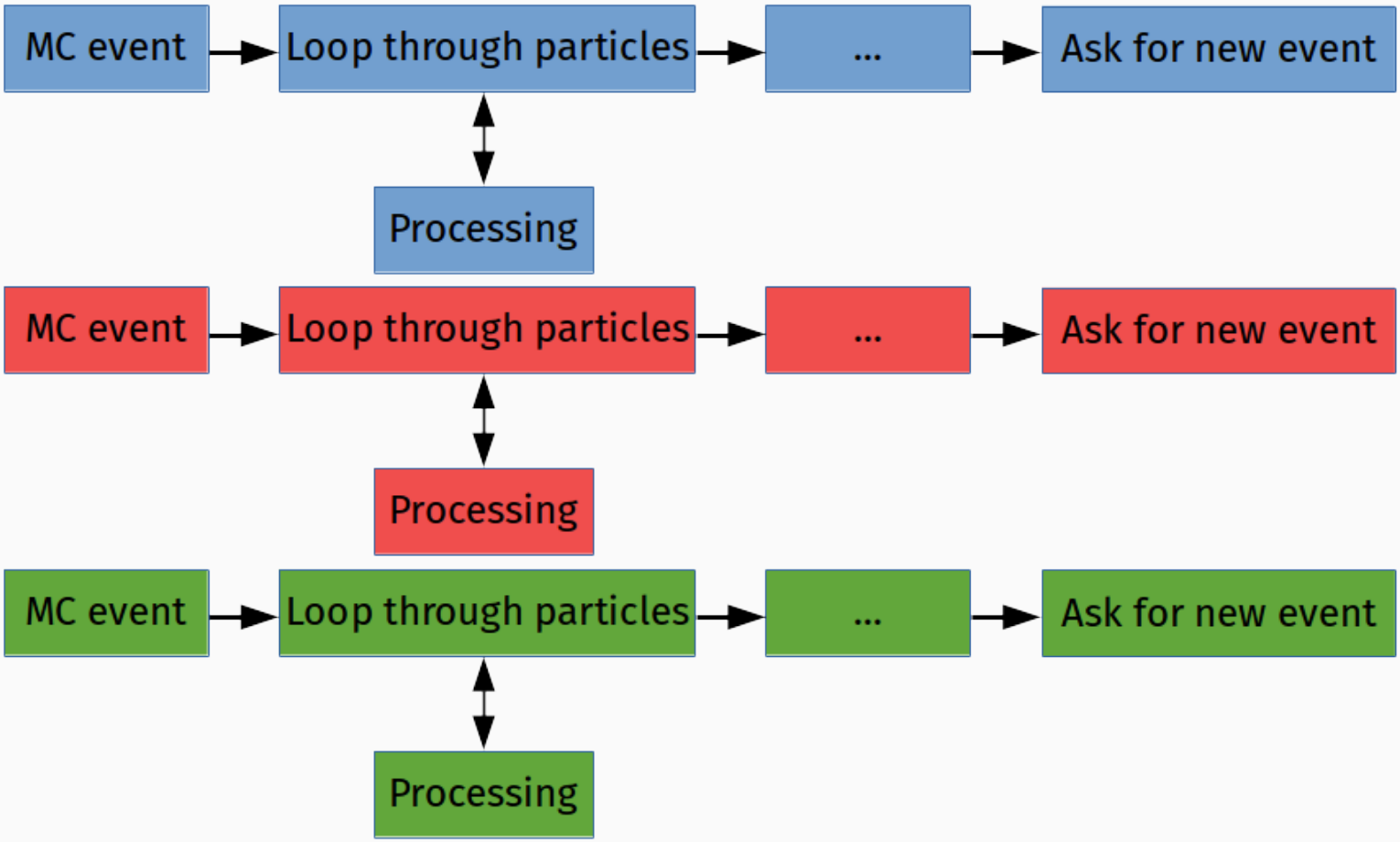
```
Hijing:Quenching = HijQuenching_GLV0
```

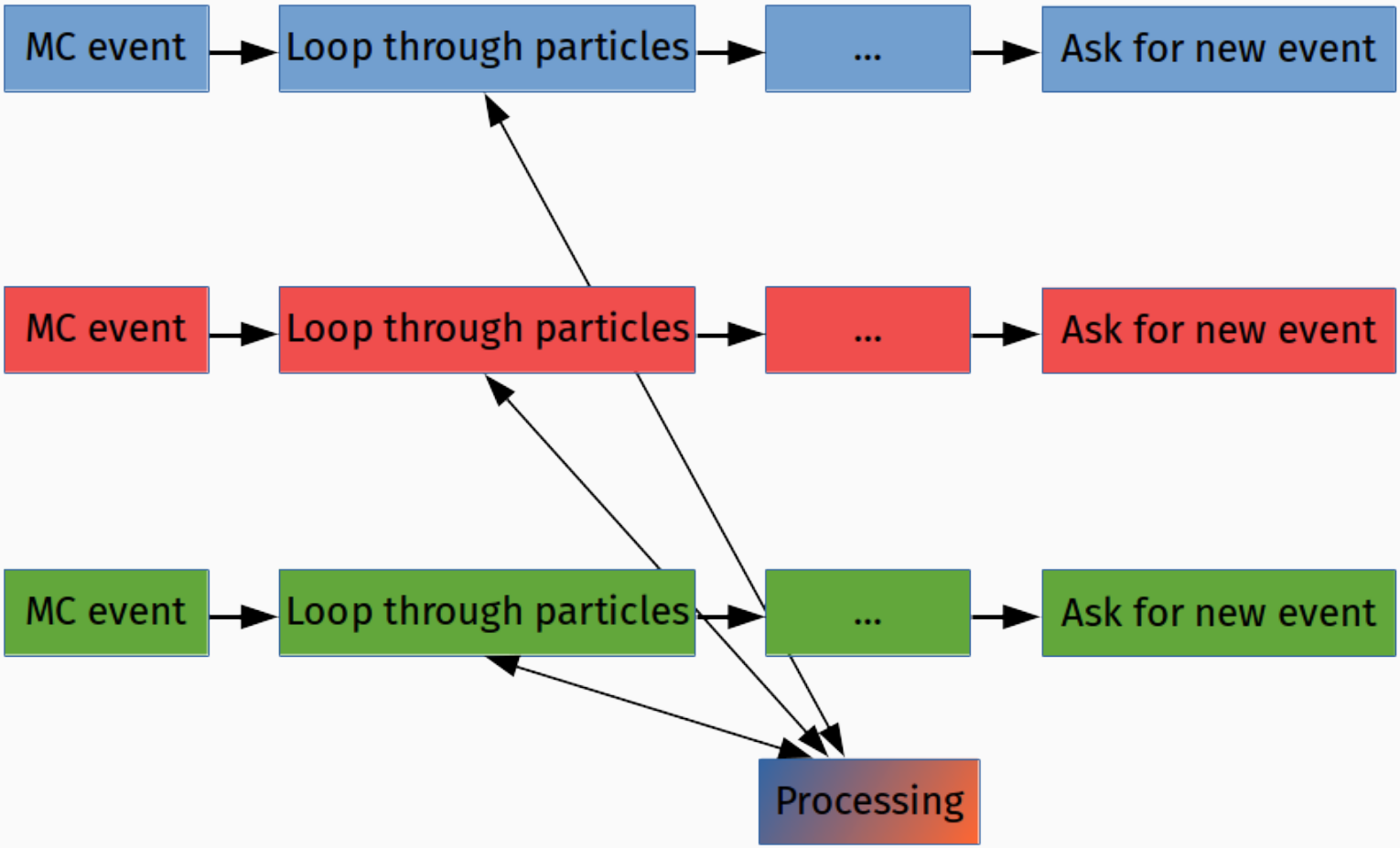


HIJING++ MULTITHREADING

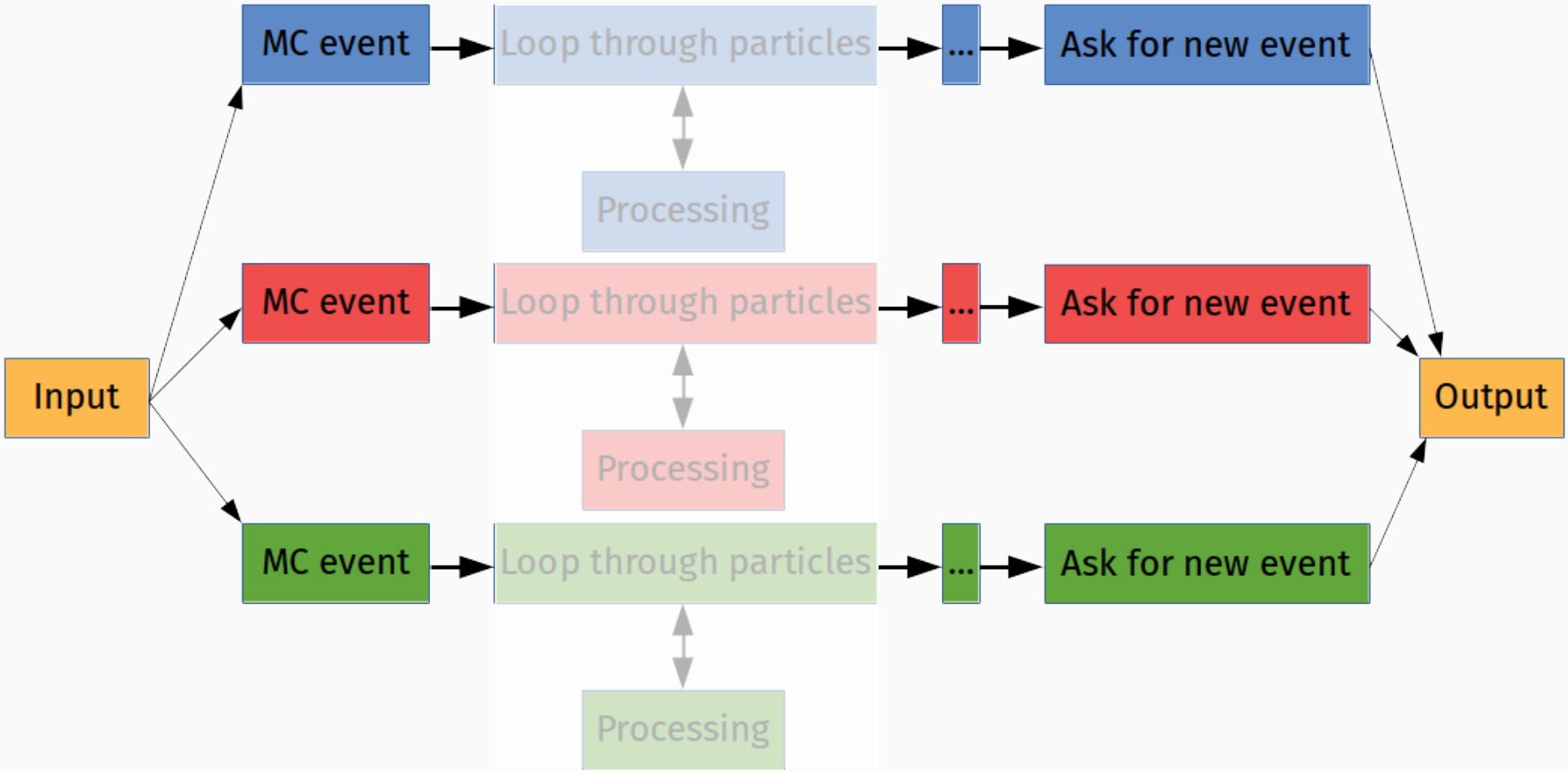


HIJING++ MULTITHREADING

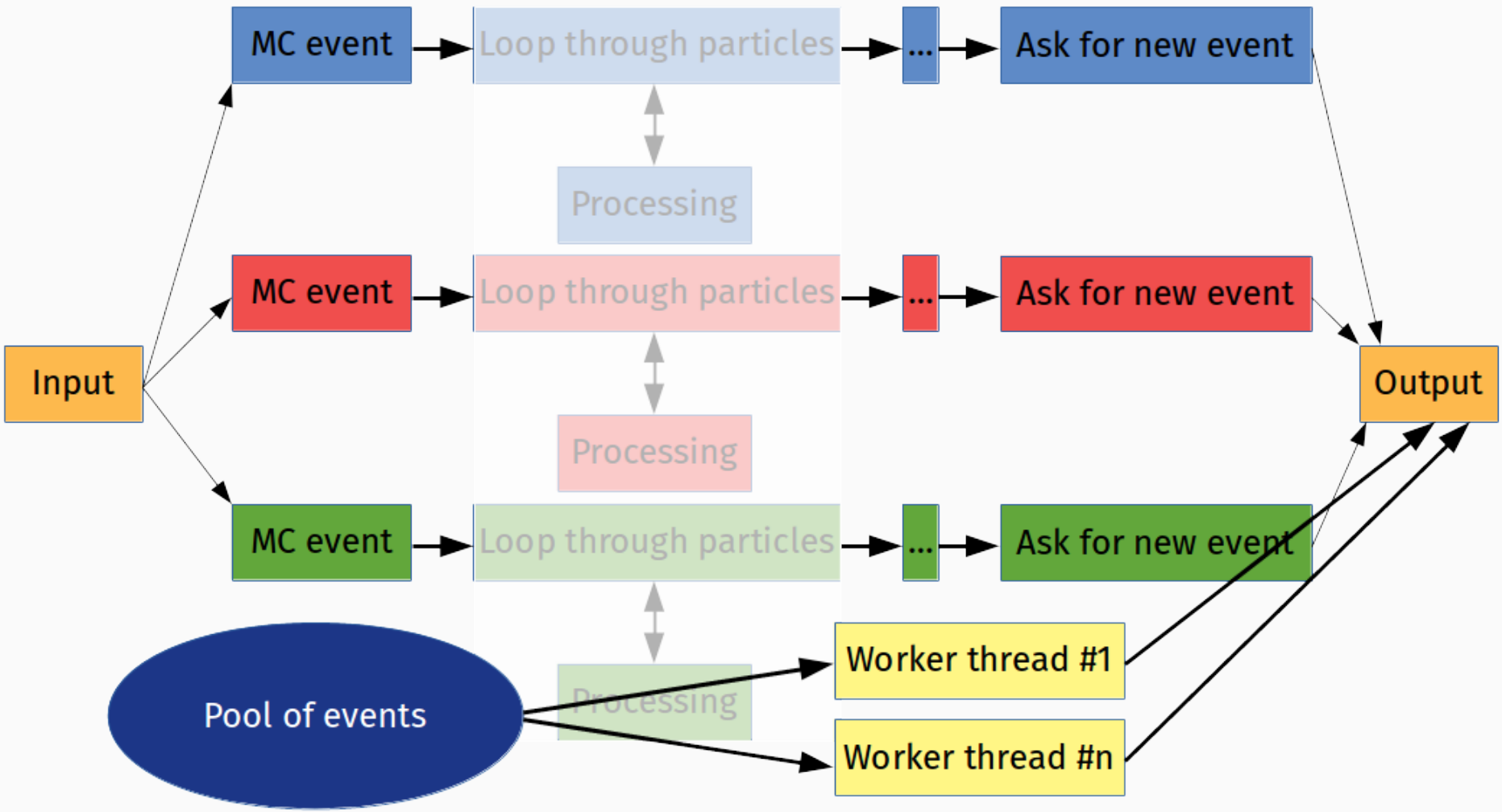



MC event
Loop through particles
...
Ask for new event
MC event
Loop through particles
...
Ask for new event
MC event
Loop through particles
...
Ask for new event
Processing

HIJING++ MULTITHREADING



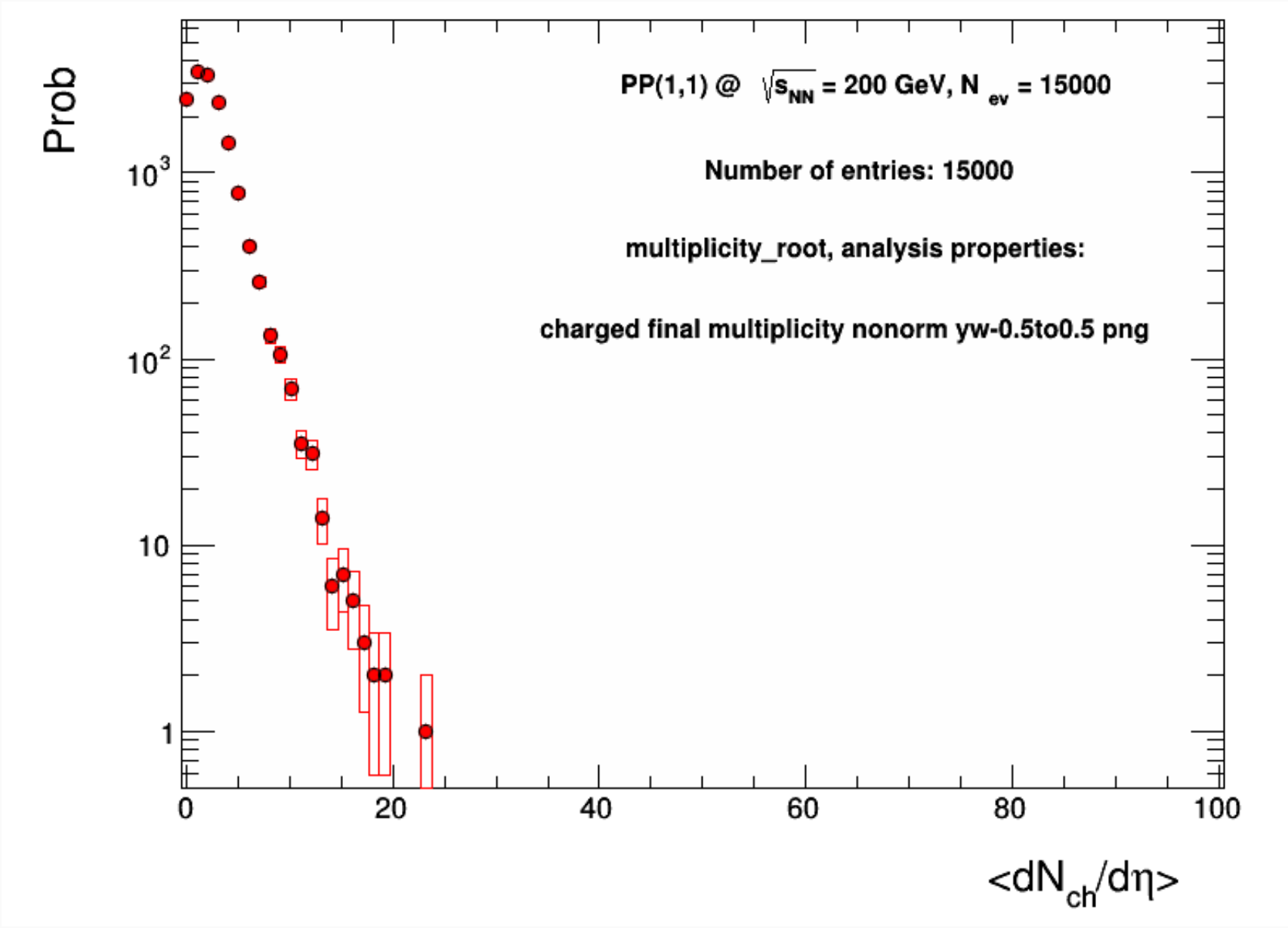
HIJING++ MULTITHREADING



HIJING++ BUILT-IN ANALYSIS

```
hijing.newAnalysis("root", "EventEnd", "multiplicity_root", 100, 0.0, 100.0, "<dN_{ch}/d#eta>", "Prob");

hijing.newAnalysis("ascii","EventEnd", "eta_charged_ascii", 20, -5.0, 5.0);

hijing.newAnalysis("root", "raw","EventEnd","raw data");

auto myEventFilter = [&](const Event &event) {
    return true;
};

auto myHadronFilter = [&](const Particle &particle, const Event &event) {
    return particle.isFinal() && abs(particle.id()) == 211;
};

hijing.analysisBranches("raw data", "eta", "pT");

hijing.analysisFilter("raw data", myEventFilter, myParticleAccept);

hijing.analysisProperties("multiplicity_root", "charged", "final", "multiplicity", "nonorm",
                          "yw-0.5to0.5", "png");

hijing.analysisProperties("eta_charged_ascii","final","eta", "charged");
```

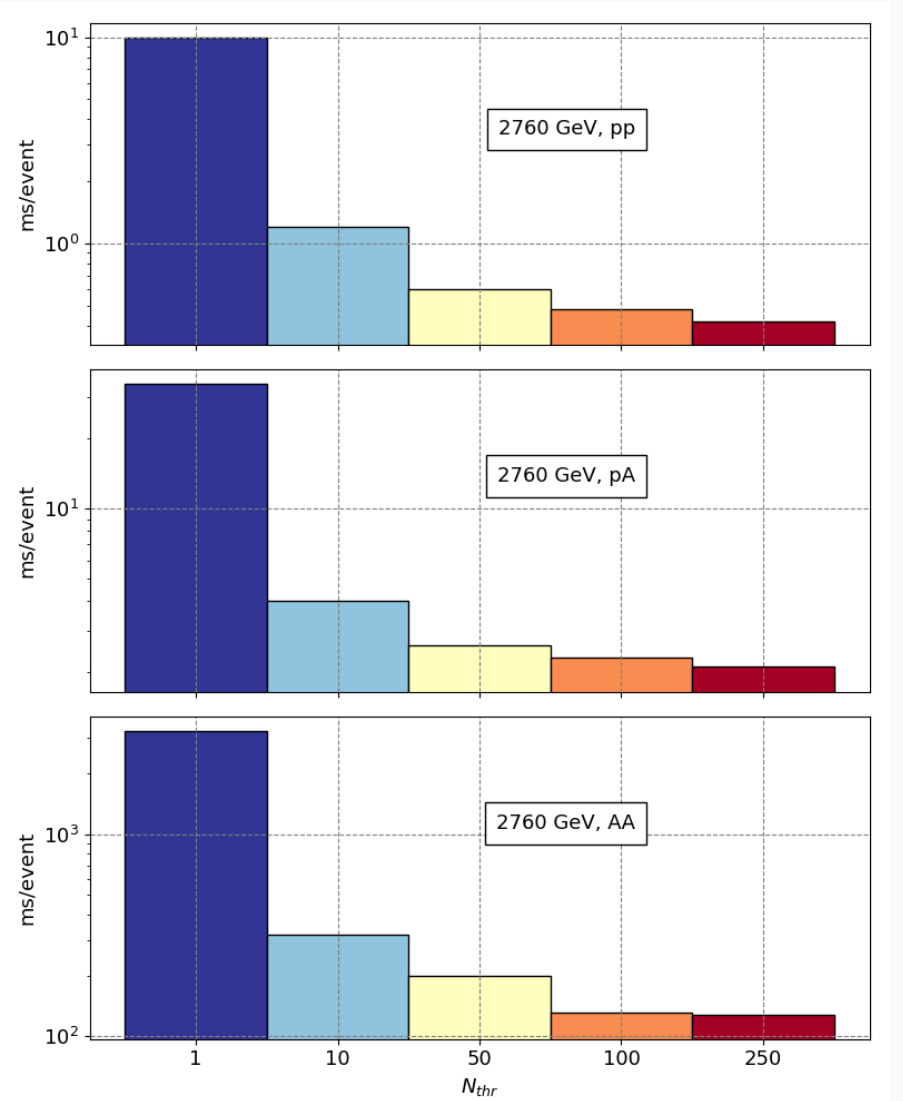
HIJING++ ANALYSIS EXAMPLE OUTPUTS

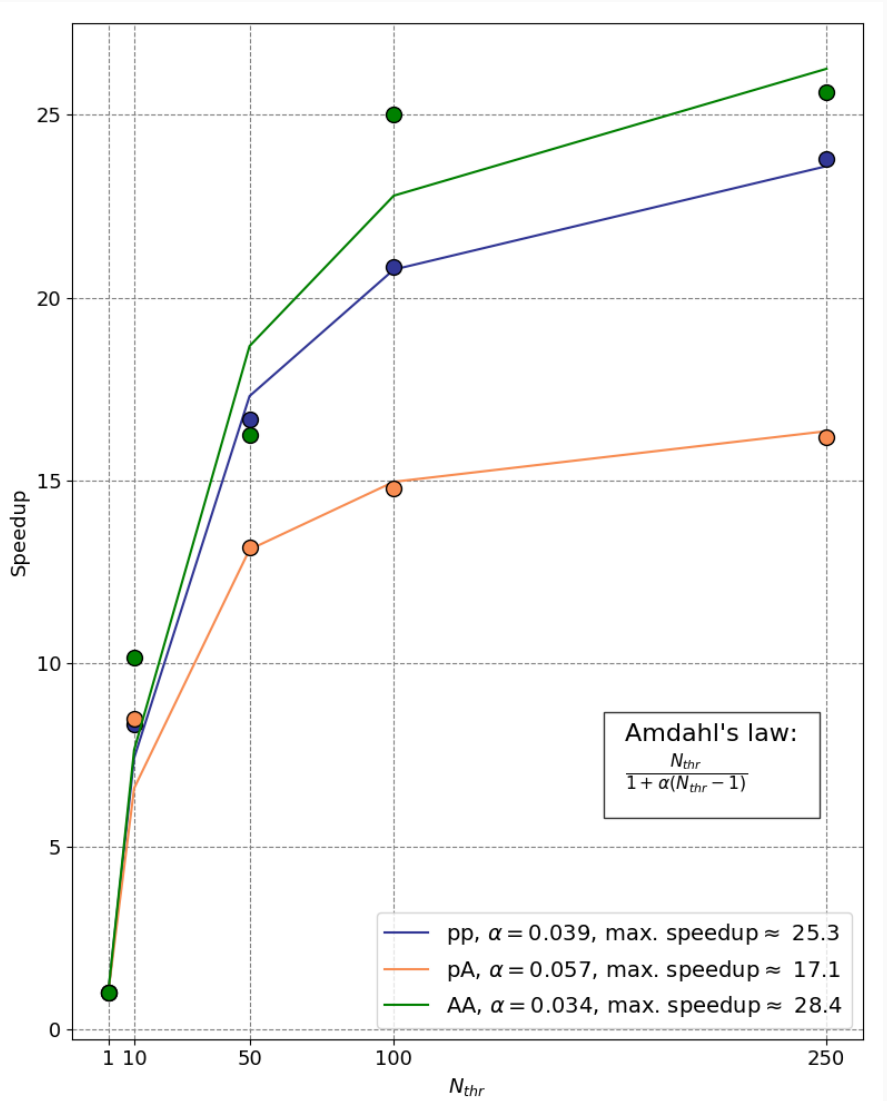


HIJING++ ANALYSIS EXAMPLE OUTPUTS

```
# Name: eta_charged_ascii
# System: PP(1,1) @ #sqrt{s_{NN}} = 200 GeV
# Event number: 15000
# Entries: 251506
# Analysis properties: final eta charged
# bincenter  binwidth  value stat.error
-4.9   0.1   0.20273   0.0036764
-4.7   0.1   0.23273   0.003939
-4.5   0.1   0.25573   0.004129
-4.3   0.1   0.26953   0.004239
-4.1   0.1   0.28187   0.0043349
-3.9   0.1   0.29753   0.0044537
-3.7   0.1   0.3106    0.0045505
-3.5   0.1   0.30907   0.0045392
-3.3   0.1   0.32467   0.0046524
-3.1   0.1   0.328   0.0046762
-2.9   0.1   0.3472    0.0048111
-2.7   0.1   0.35693   0.0048781
-2.5   0.1   0.36413   0.004927
-2.3   0.1   0.37133   0.0049755
-2.1   0.1   0.3744    0.004996
-1.9   0.1   0.3822    0.0050478
-1.7   0.1   0.3864    0.0050754
-1.5   0.1   0.38933   0.0050947
-1.3   0.1   0.3928    0.0051173
-1.1   0.1   0.39893   0.0051571
-0.9   0.1   0.38507   0.0050667
```

HIJING++ PERFORMANCE TESTS





Wigner GPU Laboratory, Intel(R) Xeon Phi(TM) CPU 7250 (272 CPU threads)

1 event, 1 thread, Pythia 8.2: ∼**200%**

1 event, 1 thread, FORTRAN HIJING: ∼**70%***

HIJING++ DOCUMENTATION (BASED ON THE XML FILES)

核易经 HIJING++

Hijing++ RC 3.0-1

A Heavy Ion Jet INteraction Generator, C++ version

Home | Installation | Downloads | Documentation | Classes | Files | List of example mains

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  - Downloads
  - Documentation
  - Examples
  - Glossary
  - Update history
  - Bibliography
  - Example results
- Classes
- Files
- List of example mains

Installation

Introduction

These are the setup instructions.

Prerequisites

- git
- cmake (min. v3.2)
- LHAPDF6 (v6.2.0 or newer)
- Pythia8 (v8219 or newer)
- c++ compiler with c++14 support (gcc 5 or later)

LHAPDF6

```
wget http://www.hepforge.org/archive/lhapdf/LHAPDF-6.X.Y.tar.gz
tar -xvf LHAPDF-6.X.Y.tar.gz
cd LHAPDF-6.X.Y
./configure --prefix=/where/to/install
make -jN
sudo make install
```

Install (nuclear) pdf sets

The pdf set *GRV98lo* is included in the downloaded package. It is mainly used during the development, since it is an unvalidated, "unofficial" set. However, if you wish

1. copy the *GRV98lo* folder (you can found it in `misc`) into `/path/to/install/LHAPDF6/share/LHAPDF`
2. insert into the file `pdfsets.index` at the correct line number (i.e. between 80000 and 80111) the following: *80060 GRV98lo 1*:

```
sed -i '/80000\ METAv10LHC\ 2/a 80060 GRV98lo 1' /path/to/install/LHAPDF6/share/LHAPDF/pdfsets.index
```

If you wish to use other npdf sets, visit http://lhapdf.hepforge.org/pdfsets.html and repeat the first step.

Pythia8

Download and install the latest version from the official webpage:

Summary

Summary

- Brand new framework in **C++**
- CPU parallelization and analysis is included in the standard accessory
- Modules: room for any new model
- Only a little polishing is needed, release soon...

STAY TUNED!

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or

hijing@wigner.mta.hu

wigner.mta.hu/∼hijing (Soon!)

Thank you for your attention!