The next Heavy Ion Jet INteraction Generator

HIJING++

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Introduction

- HIJING(Heavy-Ion Jet INteraction Generator)

易經

Bagua (eight simbols)

fundamental principles of reality

adjoint representation 8 of *SU(3)*

Introduction

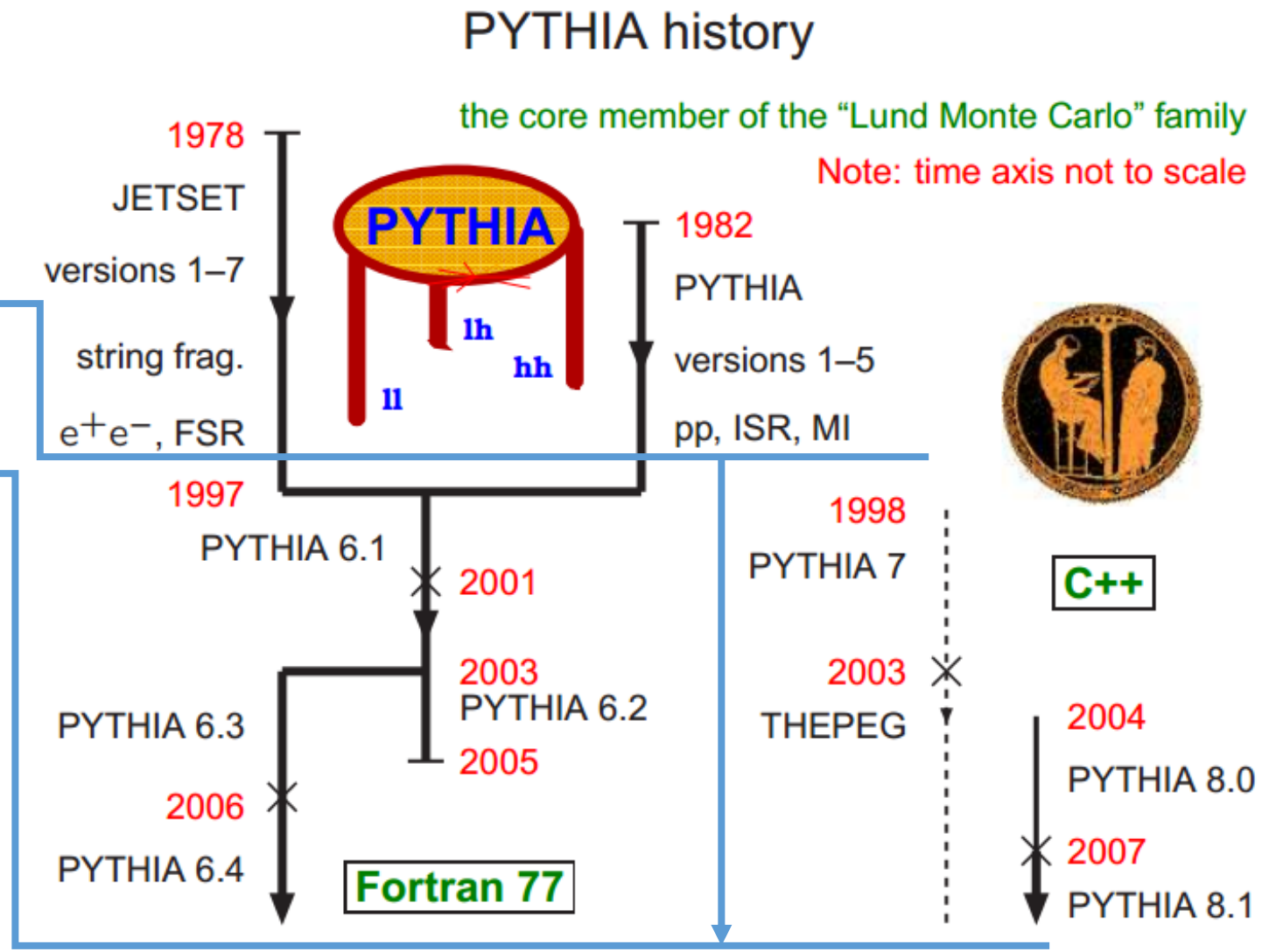
- HIJING(Heavy-Ion Jet INteraction Generator)

- HIJING versions
  - FORTRAN v1.36, v2.553
  - C++ v3.0

Reasons to use C++

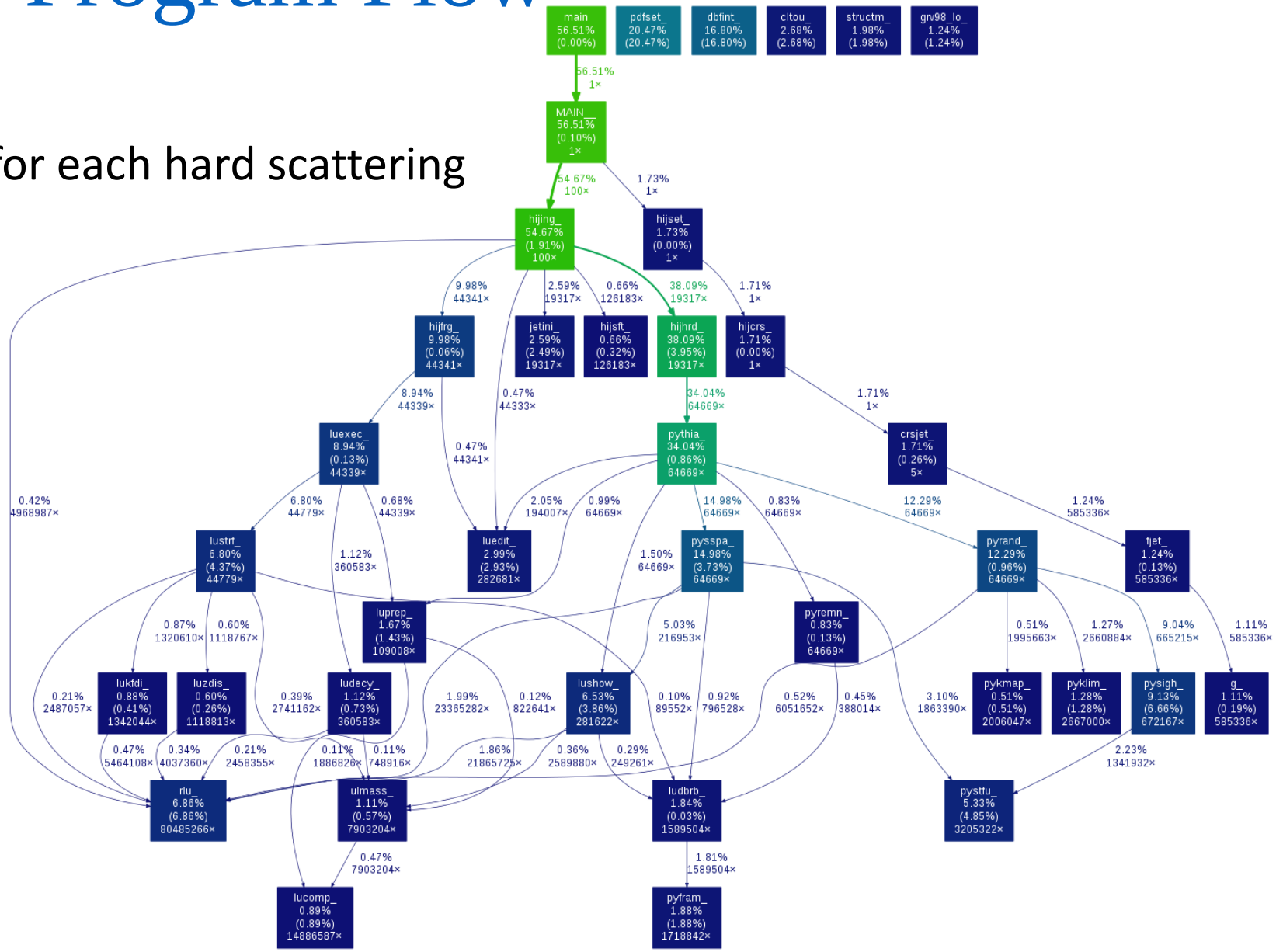
Object oriented language: Hierarchy, Modularity

C++11/14 has thread support
and compatibility with OpenCL



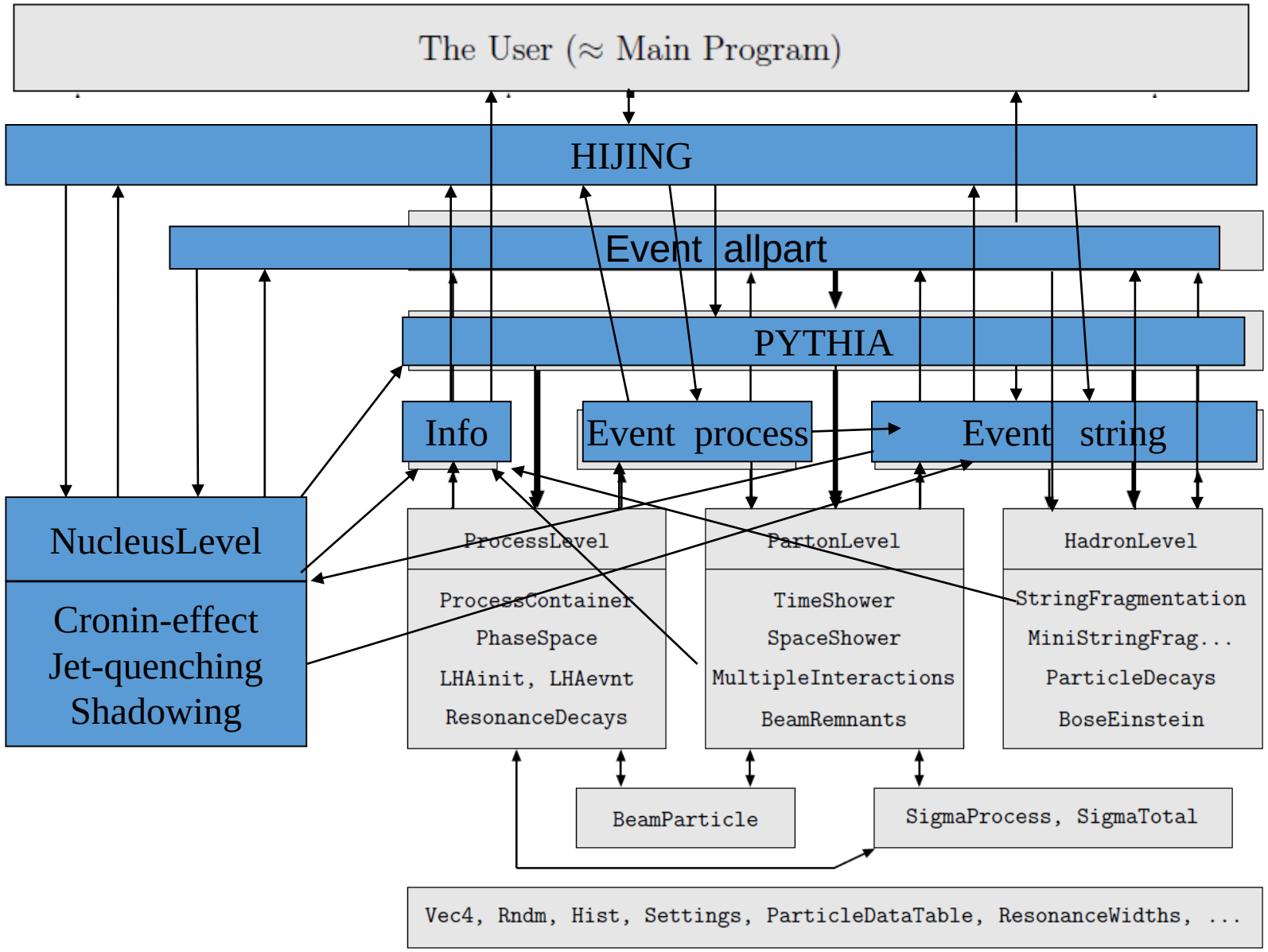
(Old) Program Flow

- Generation of kinetic variables for each hard scattering with Pythia 5.3
- Multiple soft gluon exchanges between valence- and diquarks
- String hadronization according to Lund fragmentation scheme



(New) Program Structure

- Pythia8 namespace containers
- Structure similarities
- Actual program flow is more complicated



Program Structure
Hijing class

```
namespace Pythia8 {

    class Hijing {

    public:

        Info            info;
        Rndm            rndm;
        Settings        settings;
        ...

    private:

        HardCollision   hijhard;

        SoftScatter     hijsoft;

        Fragmentation   fragmentation;

        NucleonLevel    nucleonlevel;

        ...
    }
}
```

- Processes ordered in class hierarchy
- Former common blocks → class variables
- Processes called through object functions

// Class for handling the hard collisions

// Class for handling the soft interactions

// Class for handling the Lund string fragmentation

// Class for the nuclear effects

Dependencies & External packages

- Boost

  sudo apt-get install libboost-all-dev

- LHAPDF 6

  ./configure –prefix=$HOME/.../share/LHAPDF

  make all

  insert downloaded PDF library to $HOME/.../share/LHAPDF

  optionally modify **pdfsets.index**, add set if needed

  export LD LIBRARY PATH=<library path>

- Pythia 8

  *./configure --with-lhapdf6-lib=$HOME/.../lib *
  --with-boost-lib=/usr/lib/x86_64-linux-gnu
  make –j4

- GSL (optional)

  HIJING **make** option

Main example

Usual form kept for regular users

FORTRAN

```
PROGRAM TEST
...
PARM(1) = 'DEFAULT'
VALUE(1) = 80060
CALL PDFSET(PARM, VALUE)
CALL GetDesc()
...

CALL HIJSET(EFRM, FRAME, PROJ, TARG, IAP, IZP, IAT, IZT)

N_EVENT=1E6
DO 200 IE = 1, N_EVENT
    CALL HIJING(FRAME, BMIN, BMAX)
200 CONTINUE

STOP
END
```

Form also similar to Pythia 8.x

C++

```
#include "Hijing.h"

using namespace Pythia8;

int main() {
    Hijing hijing("../xmldoc", true);
    hijing.readString("PDF:pSet = LHAPDF6:GRV98lo");

    bool okay = hijing.init(200.0, frame,
                "A", "A", 197, 79, 197, 79);
    if (!okay) return 1;

    int MaxEvent = 1e6;
    for (int iEvent = 0; iEvent < MaxEvent; ++iEvent)
        hijing.next(frame, 0.0, 0.0);
}
```

Program Features

- Calculation by improved models
- Pythia like prompt Histogram creation
- CPU level Parallel computing


```
const std::size_t num_threads = std::thread::hardware_concurrency();
for (std::size_t i = 0u; i < num_threads; ++i){
    async_hijing.at(i) = std::unique_ptr<Hijing>(new Hijing);
}
for (std::size_t I = 0; I < num_threads; ++I){
    ...async run...
    okay[I] = async_hijing[I]->init(...);
    for (int iEvent = 0; iEvent < numEvent; ++iEvent)
        async_hijing[I]->next(...);
    for (int i = 0; i < async_hijing[I]->event.size(); ++i)
        if(...) hist[I]->fill(...);
}
```

- AliRoot compatibility (planned)

Model Improvements

- Shadowing

  HIJING 2.0 fits RHIC data well
  Improvements are needed for LHC energy

  $R_i(x, b) \rightarrow R_i(Q, x, b)$

- Jet-Quenching

  Various models: accuracy ←→ speed

- Soft QCD radiation

  updated ARIADNE calls

- (already implemented improvements since v1.36)

Data Analysis

```
#include "Hijing.h"
using namespace Pythia8;

int main() {
    Hist dndpT("dn/dpT for charged particles", 100, 0., 10.);
    ofstream ch_file("ch_hist.dat");
    ...
    bool okay = hijing.init(efrm, frame, proj, targ,
                            aproj, zproj, atarg, ztarg);
    if (!okay) return 1;
    int MaxEvent = 1e6;
    for (int iEvent = 0; iEvent < MaxEvent; ++iEvent) {
        hijing.next(frame, bmin, bmax);
    for (int i = 0; i < hijing.event.size(); ++i)
    if (hijing.event[i].isFinal() && hijing.event[i].isCharged())
        dndpT.fill(hijing.event[i].pT());
    }
    dndpT *= 1.0 / MaxEvent;
    cout << dndpT;
    dndpT.table(ch_file);
    ...
    return 0;
}
```

Pythia 8 Histogram class available

Selection has to be made for every particle

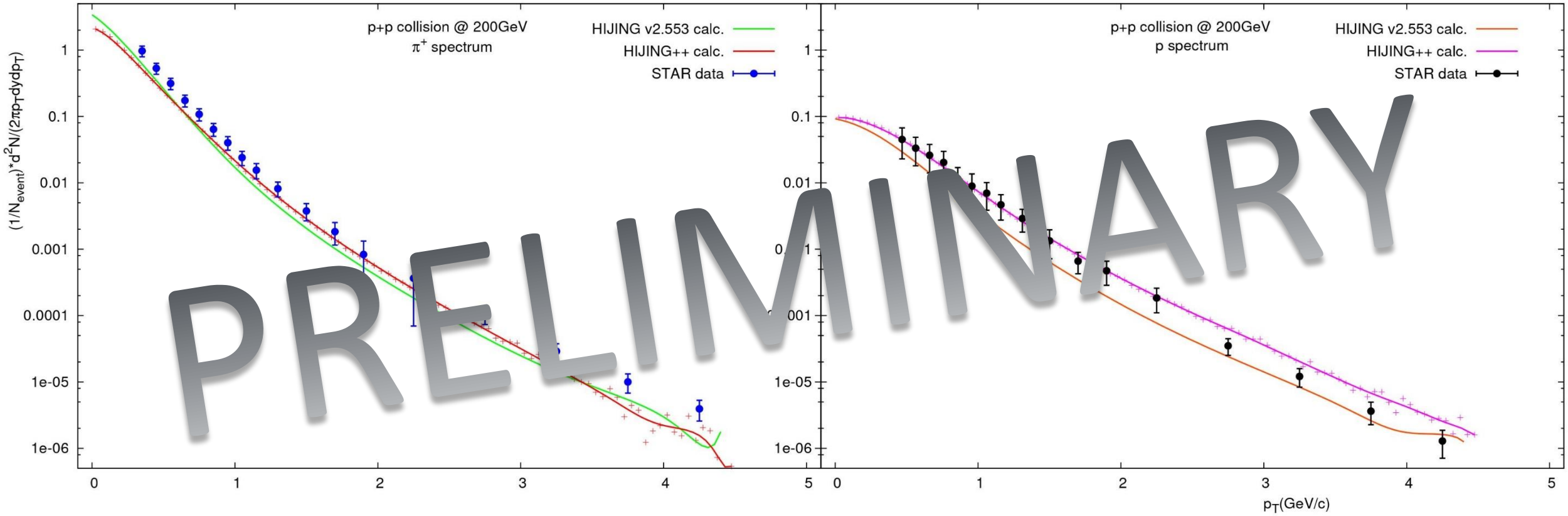
Hist::fill(double Input);

Normalization

standard output and file output both provided

Result Comparison

Code validation with „old” version and data



STAR Collaboration, Phys.Lett. B637 page 161-169 (2006)

Runtime comparison

For 1e5 Events.

```
integer::beg, end, rate
call system_clock(beg,rate)

(end - beg)/real(rate)
```

```
#include <chrono>

auto start = std::chrono::high_resolution_clock::now();

double runtime = std::chrono::duration_cast<std::chrono::milliseconds>
(end.time_since_epoch() - start.time_since_epoch()).count();
```

(gain)	FORTRAN	C++ single core		C++ parallel	
pp	0.2640s	0.5055s	-91.5%	0.1980s	25.0%
pA	3.5090s	19.874s	-466.4%	10.178s	-190.1%
AA	397.96s	482.28s	-21.2%	224.42s	43.6%

Future plans

- Online Access - Documentation
- AliRoot compatibility
- Multi thread and GPU support
- GUI

Thank you!

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