A Multi-Phase Transport (AMPT) Model

XI SERC School on Experimental High-Energy Physics
NISER Bhubaneswar
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Event Generators Session

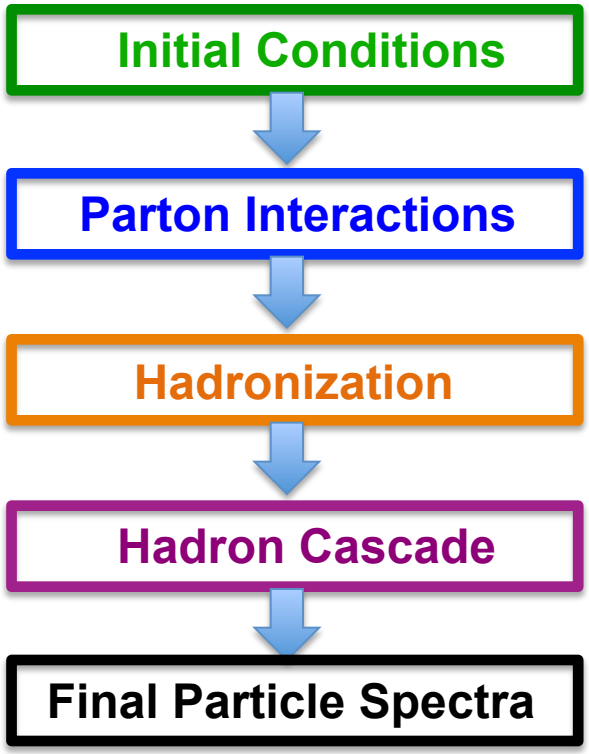
Introduction

- ✓ A Multi-Phase Transport (AMPT) is a Monte Carlo transport model for heavy ion collisions at relativistic energies.
- ✓ Includes both initial partonic and final hadronic interactions, and the transition between these two phases of matter.
- ✓ Aims to provide a kinetic description of all essential stages of heavy ion collisions:

A+B

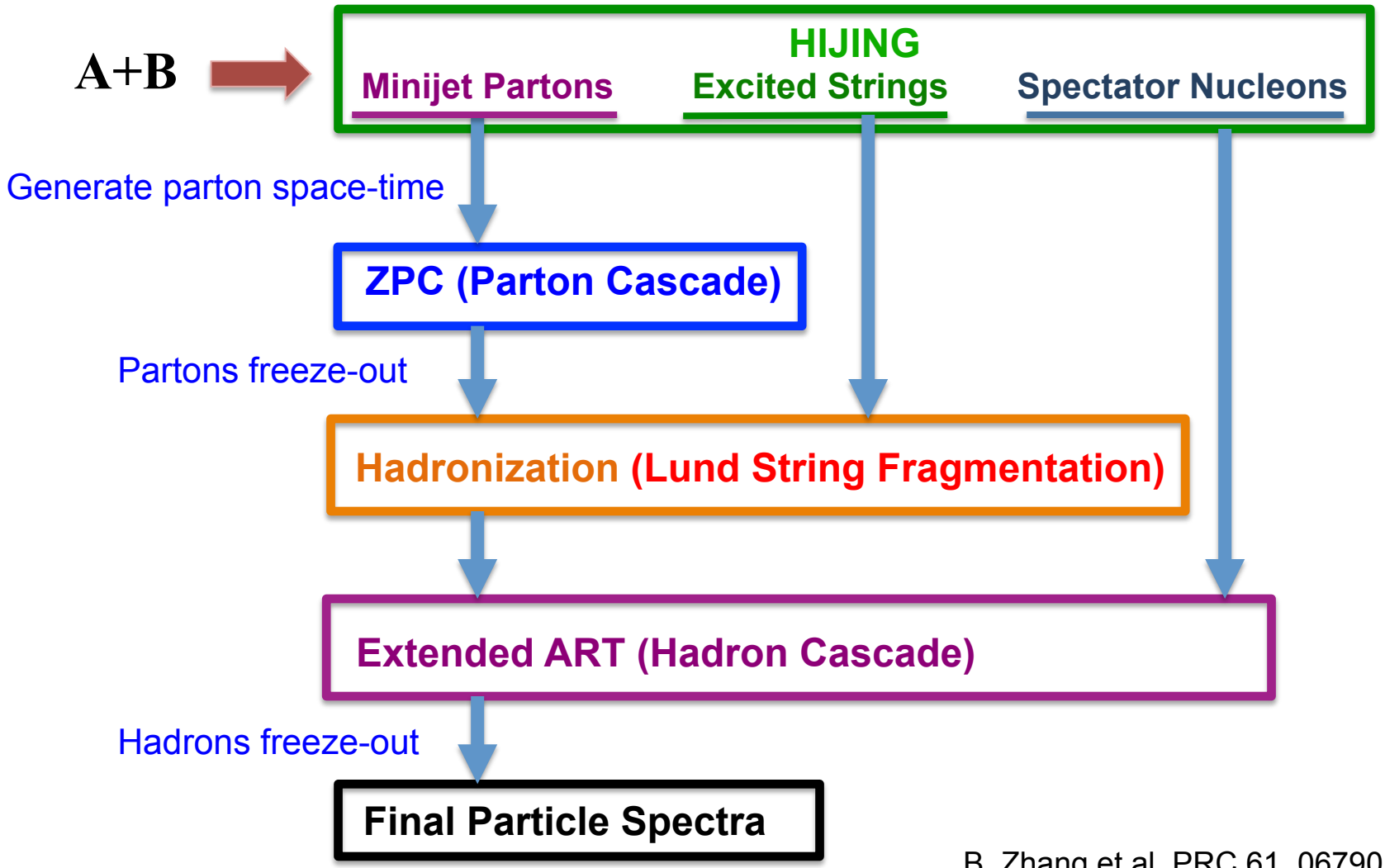
Collision Systems:
p+A, A+A

Collision Energies:
$\sqrt{s_{NN}}$ = 5 - 5500 GeV



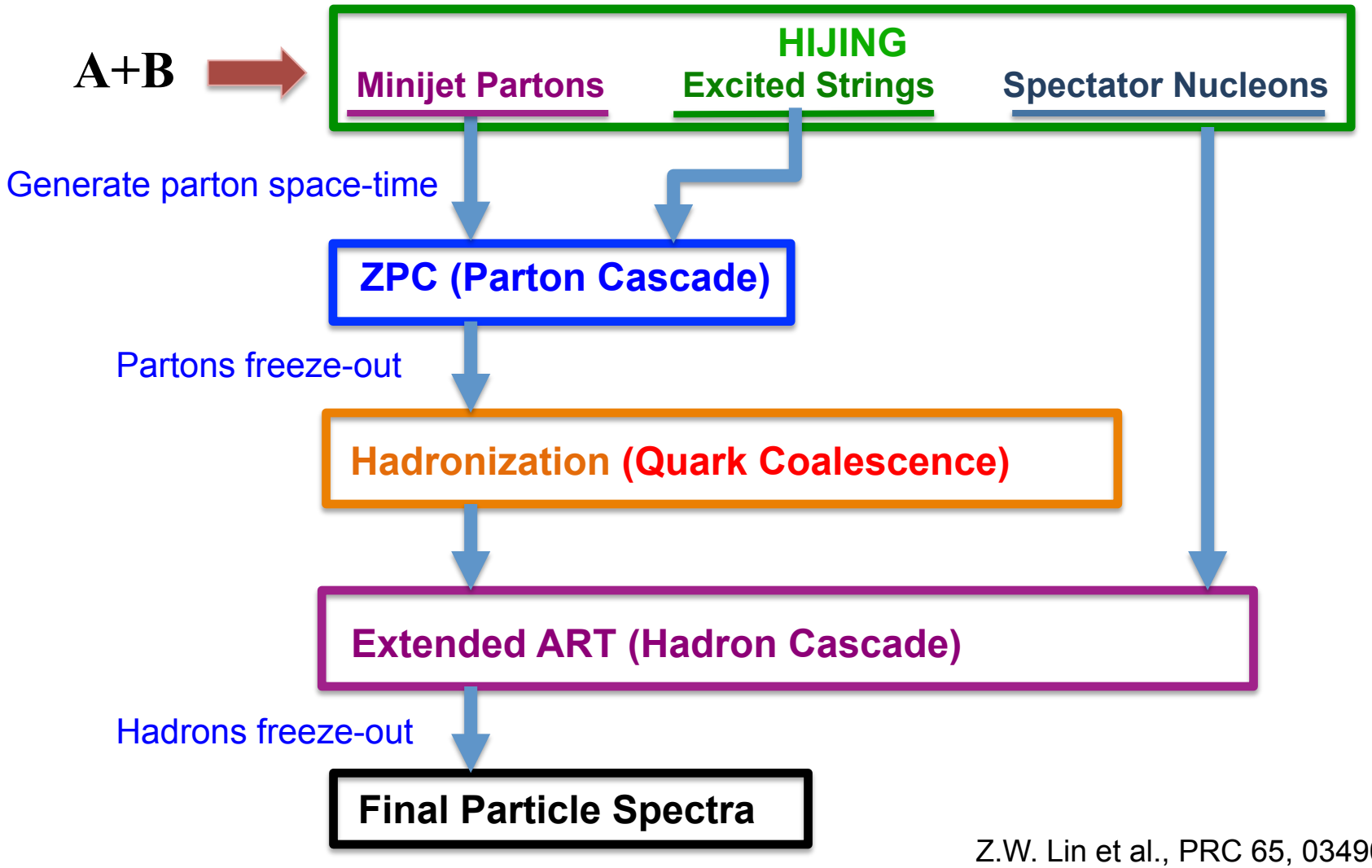
- ✓ Two versions of AMPT model are available: **Default and String Melting**

Structure of AMPT v1.xx (Default version)



B. Zhang et al. PRC 61, 067901 (2000)
Z.W. Lin et al. PRC 61, 067901 (2001)

Structure of AMPT v2.xx (String Melting version)



Z.W. Lin et al., PRC 65, 034904 (2002)
Z.W. Lin et al., PRL 89, 152301 (2002)

Individual Components of AMPT

HIJING Two component model (soft strings + hard minijets)

ZPC Zhang's Parton Cascade (elastic collisions only)

Hadronization Lund string fragmentation **(Default AMPT)**
or
Quark coalescence **(String Melting AMPT)**

Extended ART Hadron cascade,
including secondary interactions for
π, ρ, ω, η, K, K*, ϕ
n, p, Δ, N*(1440), N*(1535), Λ, Ω, Ξ, Σ, d

All other particles with PYTHIA flavor codes have no secondary interactions
e.g. D, D_s, J /ψ, B, Υ

Installation

A Multi-Phase Transport (AMPT) Model

Authors: Che-Ming Ko, Bao-An Li, Zi-Wei Lin, Subrata Pal, and Bin Zhang

"Official" versions v1.11/v2.11 (2004) and v1.21/v2.21 (2008) are available at:
http://myweb.ecu.edu/linz/ampt/
https://karman.physics.purdue.edu/OSCAR

More versions, including later test (t) versions, are available at:
http://myweb.ecu.edu/linz/ampt/

Detailed physics descriptions:
Z.W. Lin et al., PRC 72, 064901 (2005)

- Download zip file of the source code (e.g. ampt-v1.26t7-v2.26t7.zip) from the above link
- Unzip the source code in your working directory
- Package of each AMPT version contains:
  the source codes, an example input file, a Makefile, a readme, a required subdirectory for storing output files, and a script to run the code

Installation

Fortran Source Routines:

amptsub.f
art1f.f
hijing1.383_ampt.f
hipyset1.35.f
linana.f
main.f
zpc.f

readme	Users' Guide (including summary of changes)
Makefile	To compile the code
exec	To execute the code
input.ampt	Input parameter settings
ana/	Directory for output data and diagnostics files

- set the initial parameters in `input.ampt'
- Type 'make' to compile
- Type 'sh exec &' or './exec' to execute

Input File: input.ampt

Collision parameters / HIJING / Fragmentation

```
200          ! EFRM (sqrt(S_NN) in GeV if FRAME is CMS)
CMS          ! FRAME
A            ! PROJ
A            ! TARG
197          ! IAP (projectile A number)
79           ! IZP (projectile Z number)
197          ! IAT (target A number)
79           ! IZT (target Z number)
1            ! NEVNT (total number of events)
0.           ! BMIN (mininum impact parameter in fm)
3.           ! BMAX (maximum impact parameter in fm, also see below)
4            ! ISOFT (D=1): select Default AMPT or String Melting(see below)
```

Hadron Cascade

```
150          ! NTMAX: number of timesteps (D=150), see below
0.2          ! DT: timestep in fm (hadron cascade time= DT*NTMAX) (D=0.2)
0.55         ! PARJ(41): parameter a in Lund symmetric splitting function
0.15         ! PARJ(42): parameter b in Lund symmetric splitting function
.....
1            ! shadowing flag (Default=1,yes; 0,no)
0            ! quenching flag (D=0,no; 1,yes)
2.0          ! quenching parameter -dE/dx (GeV/fm) in case quenching flag=1
```

Parton Cascade

```
2.265d0      ! parton screening mass in fm^(-1) (D=2.265d0), see below
0            ! IZPC: (D=0 forward-angle parton scatterings; 100,isotropic)
0.33d0       ! alpha in parton cascade (D=0.33d0), see parton screening mass
```

Coalescence radii

```
1d6          ! dpcoal in GeV
1d6          ! drcoal in fm
```

Shadowing Option

```
......
0            ! Flag to enable users to modify shadowing (D=0,no; 1,yes)
1.d0         ! Factor used to modify nuclear shadowing
```

Reaction Plane

```
0            ! Flag for random orientation of reaction plane (D=0,no; 1,yes)
```

Input File: input.ampt

EFRM : $\sqrt{s_{NN}}$ in GeV per nucleon if FRAME is CMS
projectile energy per nucleon if FRAME is LAB

ISOFT : choice of parton-hadron conversion scenario
=1: default AMPT model (version 1.x)
=4: the AMPT model with string melting (version 2.y)

NTMAX : the number of time-steps for hadron cascade, D=150
DT : value of the time-step (in fm/c) for hadron cascade, D=0.2
Termination time of hadron cascade (t_cut) = NTMAX*DT

parton screening mass : Its square is inversely proportional to the parton cross section
D=2.265d0 for 3mb cross section when alpha in parton cascade is set to 0.33
D=3.2264d0 for 3mb cross section when alpha in parton cascade is set to 0.47
D=2.2814d0 for 6mb
D=1d4 effectively turns off parton cascade.

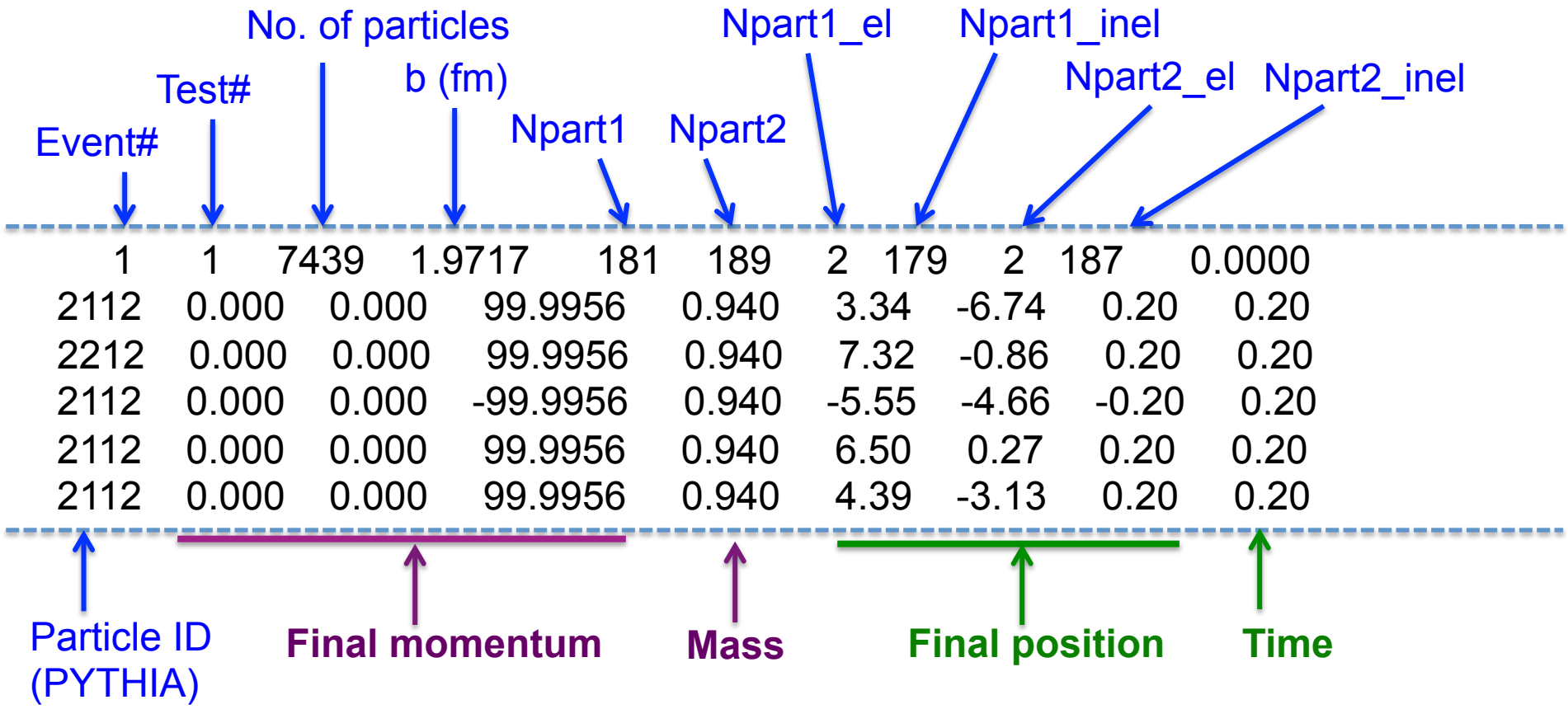
dpcoal : parton coalescence distance in momentum space (in GeV/c), D=1d6
drcoal : parton coalescence distance in coordinate space (in fm), D=1d6

ishadow : set to 1 to enable users to adjust nuclear shadowing
dshadow : valid when ishadow=1; this parameter modifies the HIJING shadowing
D = 0.d0 turns off shadowing
D = 1.d0 uses the default HIJING shadowing

iphirp : set to 1 to turn on random orientation of reaction plane (D=0)

Output File: ampt.dat

ana/ampt.dat: Contains particle records at hadron kinetic freeze-out



Units: E, p, m in GeV; x, t in fm

Exercises

- Make necessary changes in input.ampt file
- Generate about 50 events for Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV with impact parameter 0 to 5 fm.
- Read the output file and draw following distributions:
  p_x, p_y, p_z, p_T, η, φ, and multiplicity of charged particles.

Back-up