Heavy-Ion Jet INteraction Generator -- HIJING

XI SERC School on Experimental High-Energy Physics

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Event Generators Session

Introduction

Heavy Ion Jet INteraction Generator (HIJING)

-- an Event Generator used for High Energy Collisions

-- a Monte-Carlo program to study jets and particle production in in High Energy Hadronic and Nuclear Collisions

-- A QCD inspired model that includes multiple minijets production, soft excitation, nuclear shadowing of partons and final state interaction

X. N. Wang and M. Gyulassy, Phys. Rev. D 44, 3501 (1991)

HIJING Physics Description

- ✓ In high energy hadronic (e.g. pp) collisions, jets and their association with hard parton scatterings play major role – studied through perturbative QCD (pQCD)

- ✓ High energy heavy-ion collisions (HI) involve hard and semi-hard parton scatterings – enormous amount of jet production – pQCD can be used.

- ✓ Minijets (jets having transverse energy < 5 GeV) are responsible to produce 50%-80% of transverse energy in HI collisions at RHIC-LHC
  -- associated parton scattering processes still calculable via pQCD

- ✓ Extension to heavy-ion collisions needs inclusion of nuclear effects such as parton shadowing and final state interactions.

Various Physics Processes in HIJING

- ✓ *Multiple minijets production* -- QCD inspired model
- ✓ *Multiple scattering in Nuclear collisions* -- Binary approximation and Glauber model
- ✓ *Nuclear shadowing* -- Parameterized parton distribution function
- ✓ *Final state interaction (Jet Quenching)* -- assumed energy loss dE/dz of partons traversing the medium
- ✓ *Jet fragmentation or hadronization* -- Lund jet fragmentation (JETSET)

PYTHIA is used to generate kinetic variables of scattered partons for each hard or semihard interaction

HIJING Program Description

✓ Programming Language: FORTRAN 77

-- Uses PYTHIA model to generate kinetic variables for each hard scattering

-- Uses JETSET model for jet fragmentation

-- PYTHIA + JETSET is renamed as HIPYSET for HIJING

✓ Main Subroutines: HIJSET and HIJING

-- First subroutine to call is HIJSET to initialize HIJING for specified event type, collision frame and energy

-- Then subroutine HIJING is called to simulate the event specified by the HIJSET

HIJING Main Subroutines

- ✓ SUBROUTINE HIJSET (EFRM, FRAME, PROJ, TARG, IAP, IZP, IAT, IZT)

  EFRM: Colliding energy (GeV) per nucleon

  FRAME: Frame of the collision "CMS" or LAB"

  PROJ, TARG: Projectile and target particles such as "p", "PBAR", "N", "NBAR", "PI+", "PI-", "A"

  IAP, IAT: Mass number of projectile and target (1 for hadrons)

  IZP, IZT: Charge number of projectile and target

- ✓ SUBROUTINE HIJING (FRAME, BMIN, BMAX)

  FRAME: Frame of the collision as given in the HIJSET

  BMIN, BMAX: Min. (0) and Max. (2R) impact parameters (in fm); 0,0 for hadron-hadron collisions

Common Blocks for Event Information

- COMMON/HIMAIN1/…..

  -- Give overall (following) information of the generates events :

NATT -- Total no. of produced stable and undecayed particles of current event
EATT -- Total energy of produced particles in C.M. frame
JATT -- Total no. of hard scatterings in the current event
NP, NT -- No. of projectile and target nucleons in the current event
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- COMMON/HIMAIN2/…..

  -- Give information of produced stable and undecayed particles :

KATT(I,1): (I=1,..NATT) flavor codes of produced particles
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KATT(I,3): (I=1,..NATT) line no. of parent particle; 0 – if directly produced and not from decay; for others line no. represent parent
[Option to keep this information – IHPR2(21)=1]
KATT(I,4): (I=1,..NATT) status of particle [1 - if finally or directly produced, 11 - if the particle has decayed]
PATT(I,4): (I=1,..NATT) four momentum (p_x,p_y,p_z,E) (GeV/c, GeV) of produced

Common Blocks for Event Information

- COMMON/HIJJET1/…..
  -- Contains information about produced partons connected with valence quarks/diquarks of projectile and target nucleons for forming string systems for fragmentation

  NPJ(I): (I=1,..IAP) number of partons associated with projectile nucleon I
  …..

- COMMON/HIJJET2/…..
  -- Contains information about produced partons to form string systems themselves without being connected with valences quarks/diquarks

  NSG: The total number of such string systems
  …..

- COMMON/HISTRNG/…..
  -- Contains information about the projectile and target nucleons and the corresponding constituent quarks, diquarks.

  NFP(I,1): (I=1,..IAP) flavor code of the valence quark in projectile nucleon I
  …..

Options and Parameters

Input parameters for HIJING for specifying event options and other parameters – Default values are given by "D"

- COMMON/HIPRANT/HIPR1(100),IHPR2(5),HINT1(100), IHNT2(50)

  -- Contains input parameteres (HIPR1, IHPR2) for event options and some extra information (HINT1,IHNT2) of the current event

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HIPR1(34): maximum radial coordinate for projectile nucleons to be given by the initialization program HIJSET

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IHPR2(4): (D=1) switch for jet-quenching in the excited nuclear matter

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IHPR2(6): (D=1) switch for the nuclear effect on the parton distribution function such as shadowing

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IHPR2(12): (D=1) option to turn-off the automatic decay of the following particles: π^0, K^0_S, D^{+-}, Λ, Σ^{+-}

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IHPR2(21): (D=0) option to keep information of all particles including decayed

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HINT1(19): (fm) value of impact parameter of the latest event

Download and Installation

- ✓ Hijing link: ftp://nta0.lbl.gov/pub/xnwang/hijing/
- ✓ Main webpage: http://ntc0.lbl.gov/~xnwang/hijing/
- ✓ Documentation: http://ntc0.lbl.gov/~xnwang/hijing/doc.html
- ✓ Latest version: 1.411 (get from: http://atomfizika.elte.hu/haladolabor/HEP/)
- ✓ Download code: hijing1411.tgz
- ✓ Unzip: tar –xvf hijing1411.tgz
- ✓ Files included: *Makefile* (to compile), *hijing1.411.f* (main program) *hipyset1.35.f* (needed for HIJING), *test.f* (file to include desired simulation), *test.in* (for desired settings)

How to Run

- ✓ Compile: do “make” & get executable file “test.exe”
- ✓ Users’ desired simulation: edit “test.f”
- ✓ Users’ desired input settings: edit “test.in”
- ✓ To run: ./test.exe < test.in > test.out
- ✓ Output file: test.out – ascii file with events and particles’ information

test.in file format:

```
32,32331              // random seed
32,CMS,200            // Coordinate system (Frame), collisions energy
32,A,A                // Colliding particle or nucleus
32,197,79,197,79      // A,Z for target and projectile
32,2                  // Number of events
32,0                  // Print warnings
32,0                  // Print info of decayed particles
```

Exercises

1) Download and install HIJING

2) Generate about 50 events for Au+Au collisions at c.m. energy = 200 GeV for impact parameter 0. to 5. fm.

3) Read the output file and draw following distributions: p_x, p_y, p_z, p_T, η, ϕ, and multiplicity.

Thank You

Back-up