Running Chain Wrapper

1. Prepare the folder where you will run

1. Copy the clean_run_dir somewhere else
2. Make sure the symbolic links are ok
   - EKT -> hadrex-workshop-2021/sources/KoMPoST/EKT
   - EOS -> hadrex-workshop-2021/sources/MUSIC/EOS
   - tables -> hadrex-workshop-2021/sources/MUSIC/tables
   - iSS_tables -> hadrex-workshop-2021/sources/iSS/iSS_tables
   - tables_urqmd -> hadrex-workshop-2021 /.local/urqmd/tables.dat
   - scripts -> hadrex-workshop-2021/generators/hydro_chain/chain/scripts

2. Choose your run parameters

```
<general>
   <start_event_index>0</start_event_index>
   <end_event_index>11</end_event_index>
   <num_processes>4</num_processes>
   <dynamical_num_proc>enabled</dynamical_num_proc>
   <hadrex_conversion>enabled</hadrex_conversion>
   <oversampling_factor>1</oversampling_factor>
</general>
```

2. Choose your run parameters

```
<general>
    <start_event_index>0</start_event_index>
    <end_event_index>11</end_event_index>
    <num_processes>4</num_processes>
    <dynamical_num_proc>enabled</dynamical_num_proc>
    <hadrex_conversion>enabled</hadrex_conversion>
    <oversampling_factor>1</oversampling_factor>
</general>
```

- Event indexing
- Number events to generate

2. Choose your run parameters

```
<general>
   <start_event_index>0</start_event_index>
   <end_event_index>11</end_event_index>
   <num_processes>4</num_processes>
   <dynamical_num_proc>enabled</dynamical_num_proc>
   <hadrex_conversion>enabled</hadrex_conversion>
   <oversampling_factor>1</oversampling_factor>
  </general>
```

- Number of processes to spawn

2. Choose your run parameters

```
<general>
   <start_event_index>0</start_event_index>
   <end_event_index>10</end_event_index>
   <num_processes>4</num_processes>
   <dynamical_num_proc>enabled</dynamical_num_proc>
   <hadrex_conversion>enabled</hadrex_conversion>
   <oversampling_factor>1</oversampling_factor>
  </general>
```

- Enables modification of num_processes on the fly

2. Choose your run parameters

```
<general>
   <start_event_index>0</start_event_index>
   <end_event_index>10</end_event_index>
   <num_processes>4</num_processes>
   <dynamical_num_proc>enabled</dynamical_num_proc>
   <hadrex_conversion>enabled</hadrex_conversion>
   <oversampling_factor>1</oversampling_factor>
  </general>
```

- DO NOT CHANGE
- Disable conversion on the end of the chain

2. Choose your run parameters

```
<general>
   <start_event_index>0</start_event_index>
   <end_event_index>10</end_event_index>
   <num_processes>4</num_processes>
   <dynamical_num_proc>enabled</dynamical_num_proc>
   <hadrex_conversion>enabled</hadrex_conversion>
   <oversampling_factor>1</oversampling_factor>
</general>
```

- DO NOT CHANGE
- Number of times to run iSS

2. Choose your run parameters

```
<trento>
   <enabled>true</enabled>
   <basic>
      <projectile>Pb</projectile>
      <projectile>Pb</projectile>
   </basic>
   <output>
      <hdf5>disabled</hdf5>
      <quiet>enabled</quiet>
      <header>enabled</header>
      <ncoll>disabled</ncoll>
   </output>
   <physics>
      <reduced-thickness>0.007</reduced-thickness>
      <fluctuation>1.187</fluctuation>
      <nucleon-width>0.956</nucleon-width>
      <nucleon-min-dist>1.27</nucleon-min-dist>
      <cross-section>6.28</cross-section>
      <normalization>286.23</normalization>
      <b-min>default</b-min>
      <b-max>default</b-max>
   </physics>
   <grid>
      <grid-max>14</grid-max>
      <grid-step>0.1</grid-step>
   </grid>
</trento>
```

Change to false to disable trento.

For details, see
TRENTo — trento 2http://qcd.phy.duke.edu/trento/.o documentation (duke.edu)

Tunned to descibe $\left\langle \frac{dN}{d\eta} \right\rangle_{|\eta|<0.5}$

2. Choose your run parameters

- Impact parameter vs Centrality

Centrality	b-min (fm)	b-max (fm)
0-5%	0	3.74
5-10%	3.74	5.28
10-20%	5.28	7.46
20-30%	7.46	9.13
30-40%	9.13	10.55
40-50%	10.55	11.79
50-60%	11.79	12.91
60-70%	12.91	13.94
70-80%	13.94	14.91
80-90%	14.91	15.94
90-100%	15.94	default

2. Choose your run parameters

- Impact parameter vs Centrality

Centrality	b-min (fm)	b-max (fm)
0-5%	0	3.74
5-10%	3.74	5.28
10-20%	5.28	7.46
20-30%	7.46	9.13
30-40%	9.13	10.55
40-50%	10.55	11.79
50-60%	11.79	12.91
60-70%	12.91	13.94
70-80%	13.94	14.91
80-90%	14.91	15.94
90-100%	15.94	default

Performance estimation:

10-20% centrality, WSL box, 4 GHz

- 10-20%: ~ 1 hour to run up to iSS
- 10-20%: ~ 2 hours to run only UrQMD
- ~ 1-2 GB of scratch per event
- ~ 1GB of RAM per event
- ~1 GB of final storage per event

2. Choose your run parameters

```
<kompost>
  <enabled>true</enabled>
  <renormalization_factor>0.86</renormalization_factor>
  <trento2kompost>enabled</trento2kompost>
  <eos>s95p-v1.2_eos</eos>
  <num_threads>2</num_threads>
  <physics>
    <start_time>0.2</start_time>
    <end_time>1.2</end_time>
    <EtaOverS>0.16</EtaOverS>
    <EtaOverS_TemperatureScale>0.1</EtaOverS_TemperatureScale>
    <enable_ekt>false</enable_ekt>
    <enable_energy_perturbations>true</enable_energy_perturbations>
    <enable_momentum_perturbations>true</enable_momentum_perturbations>
  </physics>
  <input_grid>
    <lattice_spacing>0.1</lattice_spacing><!--lattice spacing in fm-->
    <number_points>280</number_points><!--number of grid points on a square lattice-->
    <x_start_point>0</x_start_point>
    <x_end_point>279</x_end_point>
    <y_start_point>0</y_start_point>
    <y_end_point>279</y_end_point>
  </input_grid>
</kompost>
```

Change to false to disable kompost.

2. Choose your run parameters

```
<kompost>
   <enabled>true</enabled>
   <renormalization_factor>0.86</renormalization_factor>
   <trento2kompost>enabled</trento2kompost>
   <eos>s95p-v1.2_eos</eos>
   <num_threads>2</num_threads>
   <physics>
      <start_time>0.2</start_time>
      <end_time>1.2</end_time>
      <EtaOverS>0.16</EtaOverS>
      <EtaOverS_TemperatureScale>0.1</EtaOverS_TemperatureScale>
      <enable_ekt>false</enable_ekt>
      <enable_energy_perturbations>true</enable_energy_perturbations>
      <enable_momentum_perturbations>true</enable_momentum_perturbations>
   </physics>
   <input_grid>
      <lattice_spacing>0.1</lattice_spacing><!--lattice spacing in fm-->
      <number_points>280</number_points><!--number of grid points on a square lattice-->
      <x_start_point>0</x_start_point>
      <x_end_point>279</x_end_point>
      <y_start_point>0</y_start_point>
      <y_end_point>279</y_end_point>
   </input_grid>
</kompost>
```

Kompost affects multiplicty. This number corrects it.

Uses FS (false) or EKT (true)

2. Choose your run parameters

```
<music>
   <enabled>true</enabled>
   <IC_mode>kompost</IC_mode>
   <physics>
      <EOS_to_use>s95p-v1.2</EOS_to_use>
      <Viscosity_Flag>True</Viscosity_Flag>
      <Include_Shear_Viscosity>True</Include_Shear_Viscosity>
      <Include_Bulk_Viscosity>True</Include_Bulk_Viscosity>
      <Include_deltaf_bulk>True</Include_deltaf_bulk>
      <Include_second_order_terms>True</Include_second_order_terms>
      <T_dependent_Shear_to_S_ratio>True</T_dependent_Shear_to_S_ratio>
      <Include_Rhob>False</Include_Rhob>
      <use_eps_for_freeze_out>False</use_eps_for_freeze_out>
      <T_freeze>0.151</T_freeze>
   </physics>
   <discretization>
      <boost_invariant>true</boost_invariant>
      <Delta_Tau>0.005</Delta_Tau>
      <Y_grid_size_in_fm>28.0</Y_grid_size_in_fm>
      <X_grid_size_in_fm>28.0</X_grid_size_in_fm>
      <Grid_size_in_y>280</Grid_size_in_y>
      <Grid_size_in_x>280</Grid_size_in_x>
   </discretization>
   <output>
      <output_evolution_data>False</output_evolution_data>
      <output_evolution_every_N_timesteps>10</output_evolution_every_N_timesteps>
      <outputBinaryEvolution>True</outputBinaryEvolution>
   </output>
   <misc>
      <Initial_time_tau_0>1.2</Initial_time_tau_0>
   </misc>
</music>
```

Enable/disable MUSIC

2. Choose your run parameters

```
<music>
   <enabled>true</enabled>
   <IC_mode>kompost</IC_mode>
   <physics>
      <EOS_to_use>s95p-v1.2</EOS_to_use>
      <Viscosity_Flag>True</Viscosity_Flag>
      <Include_Shear_Viscosity>True</Include_Shear_Viscosity>
      <Include_Bulk_Viscosity>True</Include_Bulk_Viscosity>
      <Include_deltaf_bulk>True</Include_deltaf_bulk>
      <Include_second_order_terms>True</Include_second_order_terms>
      <T_dependent_Shear_to_S_ratio>True</T_dependent_Shear_to_S_ratio>
      <Include_Rhob>False</Include_Rhob>
      <use_eps_for_freeze_out>False</use_eps_for_freeze_out>
      <T_freeze>0.151</T_freeze>
   </physics>
   <discretization>
      <boost_invariant>true</boost_invariant>
      <Delta_Tau>0.005</Delta_Tau>
      <Y_grid_size_in_fm>28.0</Y_grid_size_in_fm>
      <X_grid_size_in_fm>28.0</X_grid_size_in_fm>
      <Grid_size_in_y>280</Grid_size_in_y>
      <Grid_size_in_x>280</Grid_size_in_x>
   </discretization>
   <output>
      <output_evolution_data>False</output_evolution_data>
      <output_evolution_every_N_timesteps>10</output_evolution_every_N_timesteps>
      <outputBinaryEvolution>True</outputBinaryEvolution>
   </output>
   <misc>
      <Initial_time_tau_0>1.2</Initial_time_tau_0>
   </misc>
</music>
```

IC format

2. Choose your run parameters

```
<music>
   <enabled>true</enabled>
   <IC_mode>kompost</IC_mode>
   <physics>
      <EOS_to_use>s95p-v1.2</EOS_to_use>
      <Viscosity_Flag>True</Viscosity_Flag>
      <Include_Shear_Viscosity>True</Include_Shear_Viscosity>
      <Include_Bulk_Viscosity>True</Include_Bulk_Viscosity>
      <Include_deltaf_bulk>True</Include_deltaf_bulk>
      <Include_second_order_terms>True</Include_second_order_terms>
      <T_dependent_Shear_to_S_ratio>True</T_dependent_Shear_to_S_ratio>
      <Include_Rhob>False</Include_Rhob>
      <use_eps_for_freeze_out>False</use_eps_for_freeze_out>
      <T_freeze>0.151</T_freeze>
   </physics>
   <discretization>
      <boost_invariant>true</boost_invariant>
      <Delta_Tau>0.005</Delta_Tau>
      <Y_grid_size_in_fm>28.0</Y_grid_size_in_fm>
      <X_grid_size_in_fm>28.0</X_grid_size_in_fm>
      <Grid_size_in_y>280</Grid_size_in_y>
      <Grid_size_in_x>280</Grid_size_in_x>
   </discretization>
   <output>
      <output_evolution_data>False</output_evolution_data>
      <output_evolution_every_N_timesteps>10</output_evolution_every_N_timesteps>
      <outputBinaryEvolution>True</outputBinaryEvolution>
   </output>
   <misc>
      <Initial_time_tau_0>1.2</Initial_time_tau_0>
   </misc>
</music>
```

Time of start of hydro

$\tau_0 = 1.2$ fm/c for EKT/FS

$\tau_0 = 0.2$ fm/c for Trento only

2. Choose your run parameters

```
<music>
   <enabled>true</enabled>
   <IC_mode>kompost</IC_mode>
   <physics>
      <EOS_to_use>s95p-v1.2</EOS_to_use>
      <Viscosity_Flag>True</Viscosity_Flag>
      <Include_Shear_Viscosity>True</Include_Shear_Viscosity>
      <Include_Bulk_Viscosity>True</Include_Bulk_Viscosity>
      <Include_deltaf_bulk>True</Include_deltaf_bulk>
      <Include_second_order_terms>True</Include_second_order_terms>
      <T_dependent_Shear_to_S_ratio>True</T_dependent_Shear_to_S_ratio>
      <Include_Rhob>False</Include_Rhob>
      <use_eps_for_freeze_out>False</use_eps_for_freeze_out>
      <T_freeze>0.151</T_freeze>
   </physics>
   <discretization>
      <boost_invariant>true</boost_invariant>
      <Delta_Tau>0.005</Delta_Tau>
      <Y_grid_size_in_fm>28.0</Y_grid_size_in_fm>
      <X_grid_size_in_fm>28.0</X_grid_size_in_fm>
      <Grid_size_in_y>280</Grid_size_in_y>
      <Grid_size_in_x>280</Grid_size_in_x>
   </discretization>
   <output>
      <output_evolution_data>False</output_evolution_data>
      <output_evolution_every_N_timesteps>10</output_evolution_every_N_timesteps>
      <outputBinaryEvolution>True</outputBinaryEvolution>
   </output>
   <misc>
      <Initial_time_tau_0>1.2</Initial_time_tau_0>
   </misc>
</music>
```

BEWARE:

- Not all hydro parameters are included in this file
- Look at `sources/MUSIC/src/read_in_parameters.cpp` for complete list
- New parameters can be implemented in `scripts/parse_input_music.py`

2. Choose your run parameters

```
<iss>
   <enabled>true</enabled>
   <hydro>
      <hydro_mode>1</hydro_mode>
      <turn_on_shear>1</turn_on_shear>
      <turn_on_bulk>1</turn_on_bulk>
      <turn_on_rhob>0</turn_on_rhob>
      <turn_on_diff>0</turn_on_diff>
      <include_deltaf_shear>1</include_deltaf_shear>
      <include_deltaf_bulk>1</include_deltaf_bulk>
      <include_deltaf_diffusion>0</include_deltaf_diffusion>
      <bulk_deltaf_kind>1</bulk_deltaf_kind>
      <restrict_deltaf>0</restrict_deltaf>
      <deltaf_max_ratio>1.0</deltaf_max_ratio>
      <f0_is_not_small>1</f0_is_not_small>
   </hydro>
   <output>
     . . .
   </output>
   <sampling>
      <perform_decays>0</perform_decays>
      . . .
      <y_LB>-2.5</y_LB>
      <y_RB>2.5</y_RB>
      . . .
      <sample_upto_desired_particle_number>1</sample_upto_desired_particle_number>
      <number_of_particles_needed>100000</number_of_particles_needed>
      <number_of_repeated_sampling>10</number_of_repeated_sampling>
      <sample_pT_up_to>4.5</sample_pT_up_to>
      . . .
   </sampling>
   <randomSeed>-1</randomSeed>
</iss>
```

False will disable iSS

Decays disabled by default

Rapidity range to sample

Oversample up to desired particle number

Maximum p_T to be sampled

2. Choose your run parameters

```
<iss>
   <enabled>true</enabled>
   <hydro>
      <hydro_mode>1</hydro_mode>
      <turn_on_shear>1</turn_on_shear>
      <turn_on_bulk>1</turn_on_bulk>
      <turn_on_rhob>0</turn_on_rhob>
      <turn_on_diff>0</turn_on_diff>
      <include_deltaf_shear>1</include_deltaf_shear>
      <include_deltaf_bulk>1</include_deltaf_bulk>
      <include_deltaf_diffusion>0</include_deltaf_diffusion>
      <bulk_deltaf_kind>1</bulk_deltaf_kind>
      <restrict_deltaf>0</restrict_deltaf>
      <deltaf_max_ratio>1.0</deltaf_max_ratio>
      <f0_is_not_small>1</f0_is_not_small>
   </hydro>
   <output>
     . . .
   </output>
   <sampling>
      <perform_decays>0</perform_decays>
      . . .
      <y_LB>-2.5</y_LB>
      <y_RB>2.5</y_RB>
      . . .
      <sample_upto_desired_particle_number>1</sample_upto_desired_particle_number>
      <number_of_particles_needed>100000</number_of_particles_needed>
      <number_of_repeated_sampling>10</number_of_repeated_sampling>
      <sample_pT_up_to>4.5</sample_pT_up_to>
      . . .
   </sampling>
   <randomSeed>-1</randomSeed>
</iss>
```

Number of particles to sample per rapidity unit
(if sampling up to desired particle numbers)

Number of particles to sample
(if NOT sampling up to desired particle numbers)

2. Choose your run parameters

```
<urqmd>
   <enabled>true</enabled>
   <calculation>
      <decays_only>false</decays_only>
      <list_output_time>80000</list_output_time>
      <calc_stop_time>80000</calc_stop_time>
   </calculation>
   <disable-output>
      <f13>false</f13>
      <f14>true</f14>
      <f15>true</f15>
      <f16>true</f16>
      <f19>true</f19>
      <f20>true</f20>
   </disable-output>
</urqmd>
```

False will Disable UrQMD

`true` makes UrQMD only consider decays

`false` outputs collision history

3. Run and monitor chain

- Run the script `scripts/run_chain.sh`
- Folder `log` gives an overview of what of the progress of each event
- `ls jobs_status/running` will show which events are running
- `ls jobs_status/completed` will show which events are completed
- You may edit `NUM_PROCESSES` inside `GENERAL_VARS.sh` to increase/decrease number of cores used.
- Each step keeps its respective log inside its folder

4. Outputs

- Outputs are on the `HadrEx` folder
  - Output1: Particles sampled by iSS
  - Output2: Particles decayed by UrQMD (no hadron gas simulation)
  - Output3: Full hadron gas simulation by UrQMD