# Jet-Medium Excitation: Hands-on

## [#july29-aug1-jet-physics]

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JETSCAPE

**Online, Augst 1st, 2022**

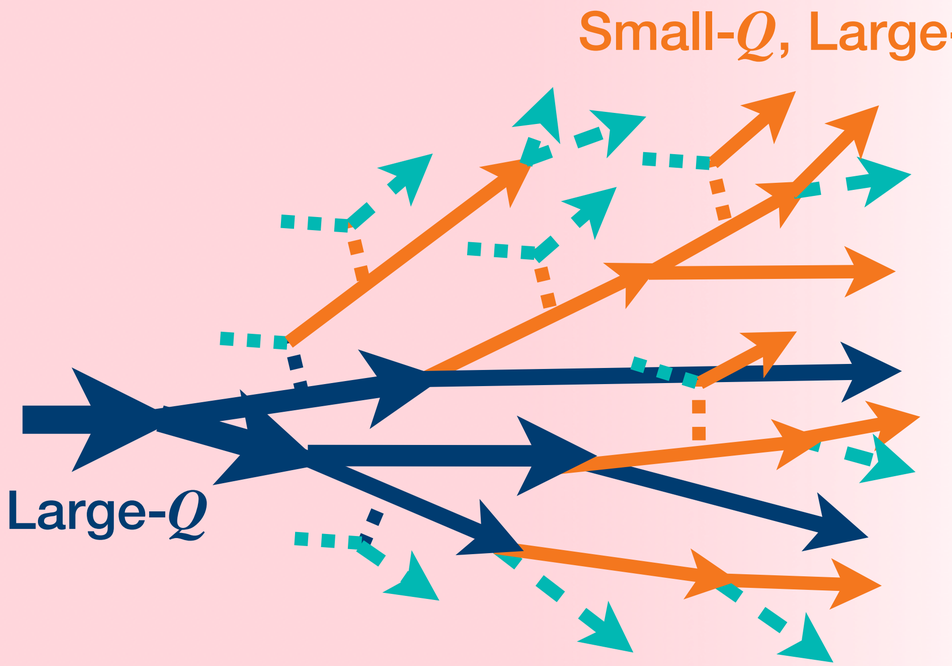
#jul23-jul26-jets

JETSCAPE School 2022

# Two-stage Hydro

# Simulation with JETSCAPE (In-medium Jet Evolution)

In-medium




$Q^2$: virtuality (off-shellness)

**Large-$Q$**

Virtuality ordered splittings with small medium effect

Model: Medium-modified Sudakov (**MATTER**)

**Small-$Q$, Large-$E(>E_{\mathrm{th}})$**

Splittings driven by in-medium scatterings

Models: Kinetic Theory (**LBT, MARTINI**)

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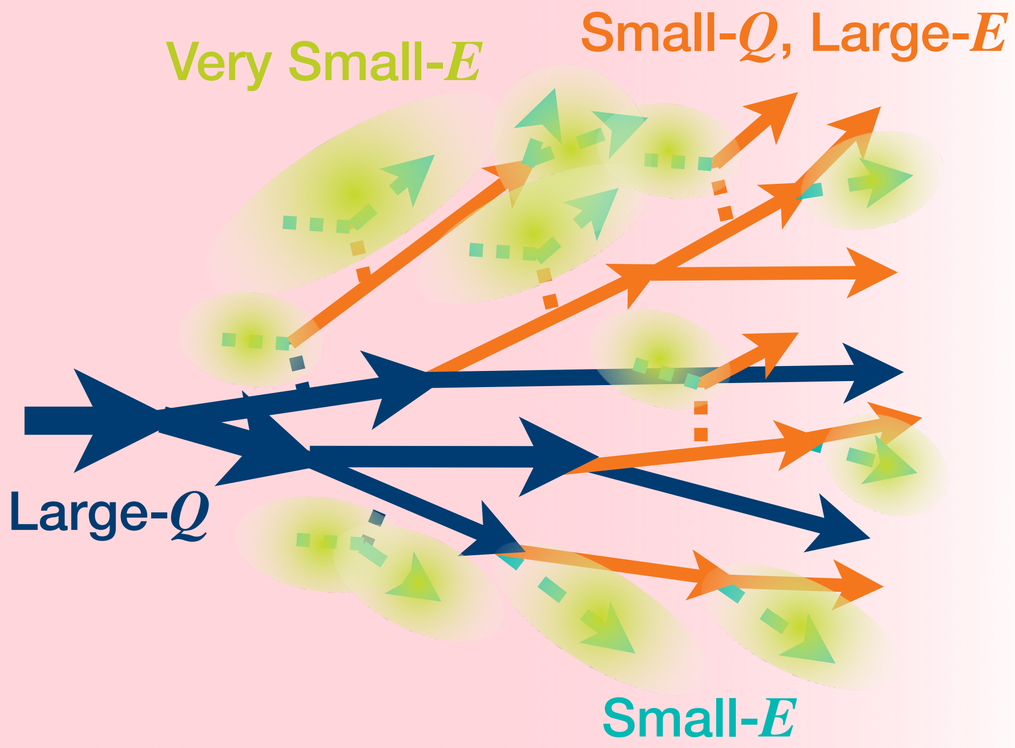


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**Small-$Q$, Large-$E(>E_{\mathrm{th}})$**

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Models: Kinetic Theory (**LBT, MARTINI**)

**Small-$E(\leq E_{\mathrm{th}})$**

Energy-momentum diffusion into medium

Model: Causal Diffusion (**Causal Liquefier**)

**Very Small-$E(\sim E_{\mathrm{med}})$**

Hydrodynamical evolution with bulk medium

Model: Hydrodynamics (**MUSIC**)

# Summary of the Simulation in this session

- **Settings in TwostageHydro for PbPb collisions at 5.02 TeV**

**Jet Shower**

- In-medium shower with ***MATTER*+*LBT*** (Recoil ON, Virtuality separation $Q_{\mathrm{sw}} = 2\,\mathrm{GeV}$)
  Majumder, Cao, Vujanovic,… Luo, Wang, Cao, He,…
- Initial condition from ***PGun*** (single parent jet parton with a fixed-initial $p_{\mathrm{T}} = 200\,\mathrm{GeV}$ and a fixed creation point $(x=0, y=0, z=0)$).
- Hadronization with ***Colorless Hadronization*** (Lund string model of Pythia)
  Pablos, Majumder

**Source Term**

- Source generated by ***Causal Liquefier*** based on relativistic diffusion equation
  YT, Shen, Majumder
- Absorption of partons with energy at LRF of medium $p \cdot u_{\mathrm{fluid}} < E_{\mathrm{th}} = 2\,\mathrm{GeV}$

**Medium Fluid**

- Initial medium profile generated by ***TRENTo*** (PbPb 5020 GeV, 0-10%)
  Moreland, Bernhard, Bass
- (2+1)-D viscous hydro calculation with source term by ***MUSIC***
  Denicol, Gale, Jeon, Luzum, Paquet, Schenke, Shen
- Particle emission at freezeout via Cooper-Frye sampling by ***iSS***
  Shen

# Summary of the Simulation in this session

- **Settings in TwostageHydro for PbPb collisions at 5.02 TeV**

**Jet Shower**

- In-mediu[illegible] shower with ***MATTER+LBT*** (Recoil ON, Virtuality separation $Q_{sw} = 2\,\mathrm{GeV}$)
- Initial co[illegible]dition from ***PGun*** (single parent jet parton with a fixed-initial $p_T = 200\,\mathrm{GeV}$ and a fixed creation point $(x=0, y=0, z=0)$).
- Hadroniz[illegible] with ***Colored Monte Carlo*** (default hadronization model of Pythia)

Pablos, Majumder

**Source Term**

- Source ge[illegible]erated by ***Causal Liquefier*** based on relativistic diffusion equation

YT, Shen, Majumder

- Absorpt[illegible]n of partons with energy at LRF of medium $p \cdot u_{\mathrm{fluid}} < E_{\mathrm{th}} = 2\,\mathrm{GeV}$

**Me[illegible]n Fluid**

- Initi[illegible] medium profile generated by ***TRENTo*** (PbPb 5020 GeV, 0-10%)

Moreland, Bernhard, Bass

(2+1)-D [illegible]iscous hydro calculation with source term by ***MUSIC***

Denicol, Gale, Jeon, Luzum, Paquet, Schenke, Shen

- Particle emission at freezeout via Cooper-Frye sampling by ***iSS***

Shen

**⚠ This setup is NOT realistic at all**

Medium fluid must be simulated in (3+1)-D, since jets and their sources are 3-D objects.
Just to save time, we use (2+1)-D in this session.

# Dialog between Jet Shower and Medium Fluid

- **TwostageHydro in JETSCAPE**

**1) MUSIC1**

Hydro calculation w/o source

$$\nabla_\mu T^{\mu\nu} = 0$$

Medium Infos

$T(x), u^\mu(x), \ldots$

**2) MATTER+LBT with $E_{\rm th}$-cut**

In-medium Jet Evolution

Deposited Parton Infos

Source Term Generation

Source Term $J^\nu(x)$

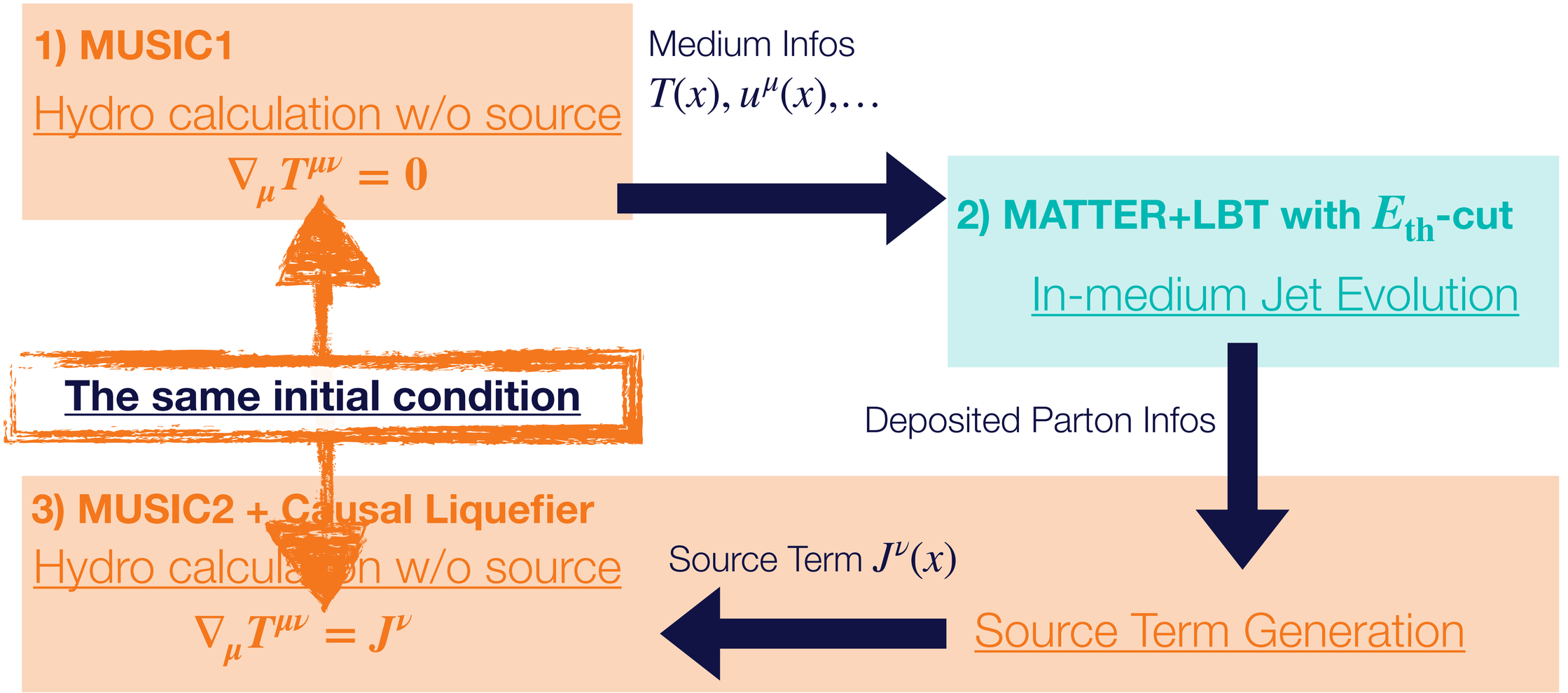
**3) MUSIC2 + Causal Liquefier**

Hydro calculation w/o source

$$\nabla_\mu T^{\mu\nu} = J^\nu$$

# Dialog between Jet Shower and Medium Fluid

- **TwostageHydro in JETSCAPE**



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# XML for TwostageHydro

# XML for TwostageHydro

## Hydro 1st Run

```
<!--Preequilibrium Dynamics Module -->
<Preequilibrium>
  <NullPreDynamics> </NullPreDynamics>
</Preequilibrium>

<!-- Hydro  Module 1 -->
<Hydro>
  <MUSIC>
    <name>MUSIC_1</name>
    <freezeout_temperature>0.150</freezeout_temperature>
  </MUSIC>
</Hydro>

<!-- Create liquifier -->
```

## Hydro 2nd Run

- Add Liquefier

```
      <in_vac> 0 </in_vac>
      <only_leading> 0 </only_leading>
      <hydro_Tc> 0.16 </hydro_Tc>
      <alphas> 0.25 </alphas>
    </Lbt>
  <AddLiquefier> true </AddLiquefier>
</Eloss>

<!-- Hydro  Module 2 -->
<Hydro>
  <MUSIC>
    <name>MUSIC_2</name>
    <freezeout_temperature>0.150</freezeout_temperature>
  </MUSIC>
  <AddLiquefier> true </AddLiquefier>
</Hydro>
```

# XML for TwostageHydro

**Liquefier**

```
56      <freezeout_temperature>0.150</freezeout_temperature>
57    </MUSIC>
58  </Hydro>
59
60  <!-- Create liquifier -->
61  <Liquefier>
62      <!-- CausalLiquefier -->
63      <CausalLiquefier>
64          <name>CausalLiquefier</name>
65          <dtau>0.02</dtau><!-- fluid time step in [fm] -->
66          <dx>0.3</dx><!-- fluid cell size in [fm] -->
67          <dy>0.3</dy><!-- fluid cell size in [fm] -->
68          <deta>5</deta><!-- fluid cell size -->
69          <tau_delay>2.0</tau_delay><!-- in [fm] -->
70          <time_relax>0.1</time_relax><!-- in [fm] -->
71          <d_diff>0.08</d_diff><!-- in [fm] -->
72          <width_delta>0.1</width_delta><!-- in [fm] -->
73      </CausalLiquefier>
74  </Liquefier>
75
76  <!--Eloss Modules -->
```

# XML for TwostageHydro

## Energy Loss Modules

- Add Liquefier

```
74  </Liquefier>
75
76  <!--Eloss Modules -->
77  <Eloss>
78      <deltaT>0.1</deltaT>
79      <formTime> -0.1</formTime>
80      <maxT>250</maxT>
81      <mutex>ON</mutex>
82
83      <Matter>
84        <name>Matter</name>
85        <matter_on> 1 </matter_on>
86        <Q0> 2.0 </Q0>
87        <T0> 0.16 </T0>
88        <vir_factor> 0.25 </vir_factor>
89        <in_vac> 0 </in_vac>
90        <recoil_on> 1 </recoil_on>
91        <broadening_on> 0 </broadening_on>
92        <brick_med> 0 </brick_med>
93        <hydro_Tc> 0.15 </hydro_Tc>
94        <qhat0> -2.0 </qhat0>
95        <alphas> 0.25 </alphas>
96      </Matter>
97
98      <Lbt>
99        <name>Lbt</name>
100       <Q0> 2.0 </Q0>
101       <in_vac> 0 </in_vac>
102       <only_leading> 0 </only_leading>
103       <hydro_Tc> 0.16 </hydro_Tc>
104       <alphas> 0.25 </alphas>
105     </Lbt>
106   <AddLiquefier> true </AddLiquefier>
107 </Eloss>
108
109 <!-- Hydro  Module 2 -->
```