Hands-on Session: Medium Excitation by Jets

[#jet-tachibana]

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JETSCAPE

Online, July 17th, 2020

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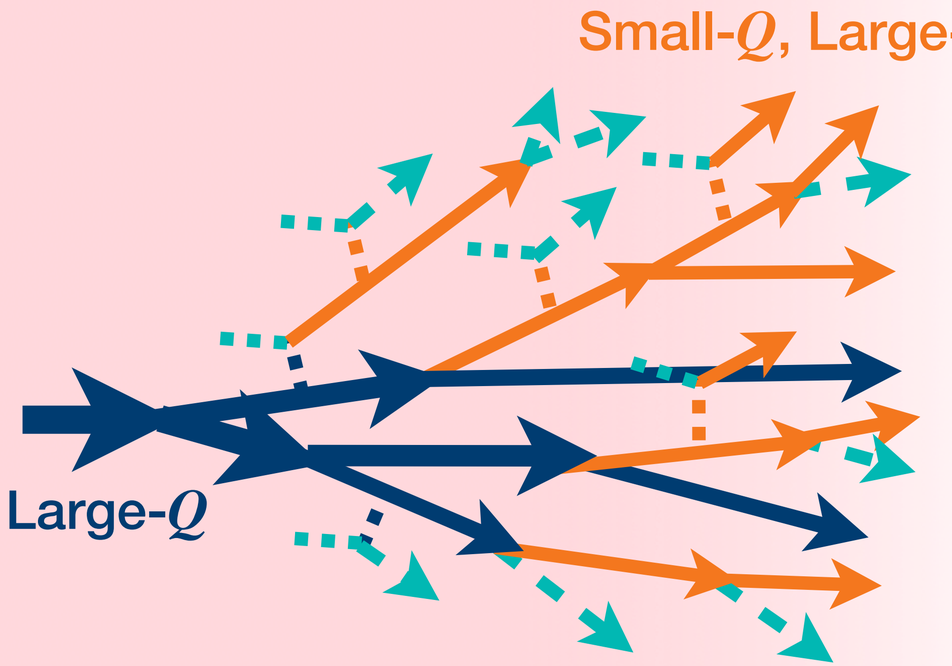
JETSCAPE School 2020

Simulation Setup

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**)

Simulation with JETSCAPE (In-medium Jet Evolution)

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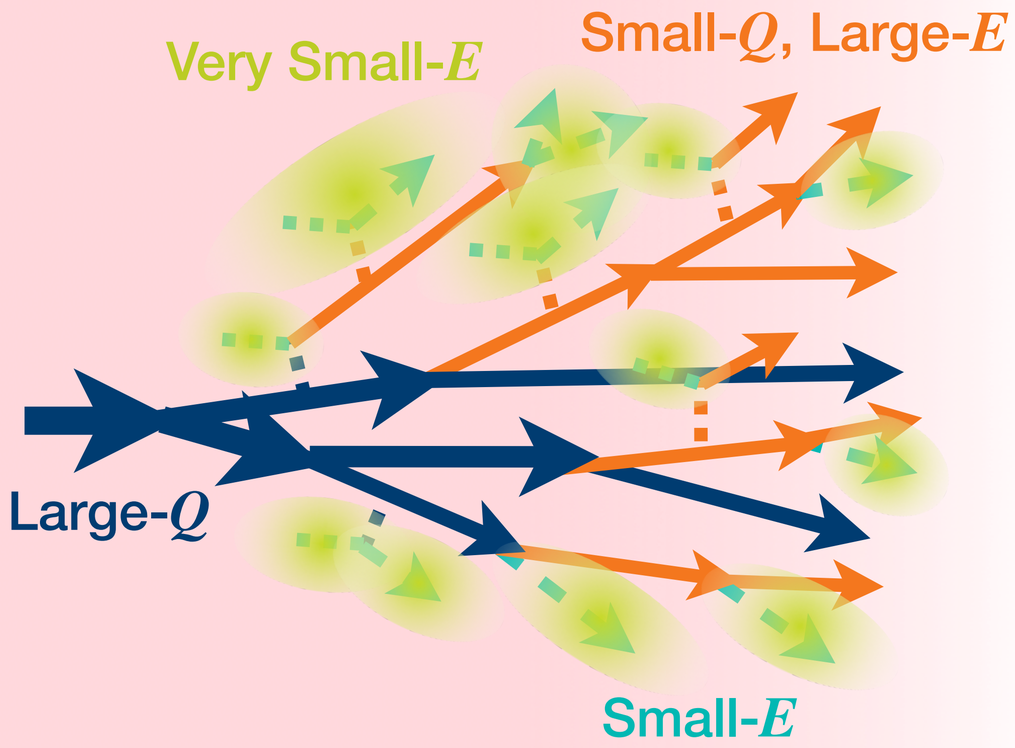

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Splittings driven by in-medium scatterings

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
- 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
- Initial co
  and a fixed creation point ($x=0, y=0, z=0$)).
- Hadroniz

⚠ 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.

Source Term

- Source ge erated by ***Causal Liquefier*** based on relativistic diffusion equation
  YT, Shen
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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

Im-medium Jet Evolution

Deposited Parton Infos

Source Term Generation

Source Term $J^\nu(x)$

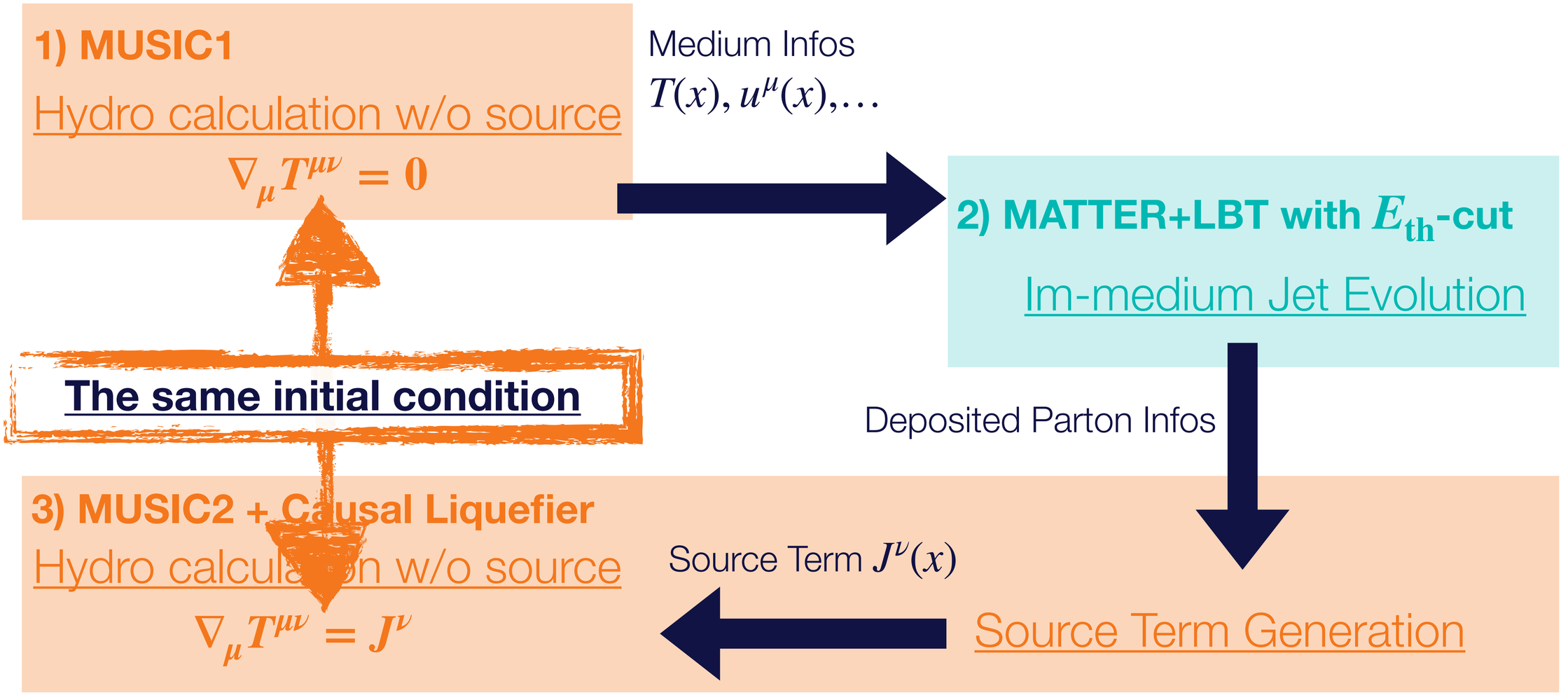
3) MUSIC2 + Causal Liquefier

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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Simulation with JETSCAPE

Run JETSCAPE Docker

- If you use ssh, please do as follows:

```
ssh -L 8888:127.0.0.1:8888 user@server
```

Run JETSCAPE Docker

- **Start the docker container you have just used (if you stopped it),**
  - For macOS

```
docker run -it -v ~/MATTER_LBT_results:/home/jetscape-user/JETSCAPE/
MATTER_LBT_results -p 8888:8888 gvujan/jetscape-school:latest
```

  - For Linux

```
docker pull gvujan/jetscape-school:latest
docker run -it -v ~/MATTER_LBT_results:/home/jetscape-user/JETSCAPE/
MATTER_LBT_results -p 8888:8888 --user $(id -u):$(id -g) gvujan/jetscape-
school:latest
```

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```

Don’t Foget this option

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```

Prepare Materials

- **Get materials from git**

```
cd ~
git clone https://github.com/JETSCAPE/SummerSchool2020.git
```

- **Go to the build folder**

```
cd ~/JETSCAPE/build
```

- **Copy the material**

```
cp -r ../../SummerSchool2020/med_res_session .
```

Run JETSCAPE

- **Run JETSCAPE with XML in the material**

```
./runJetscape med_res_session/jetscape_user_twostagehydro_summer_school_2020.xml
```

- **Confirm the end of the JETSCAPE code**

```
Sampling finished in 4e-06 seconds.

sample_using_dN_dxtdy_4all_particles finished in 2.1448 seconds.
perform resonance decays...
[Info] 557MB  JetScape finished after 1 events!
[Info] Finished!

CPU time: 913.331726 seconds.
Real time: 154.000000 seconds.
jetscape-user@49687e725b02:~/JETSCAPE/build$
```

Visualization with Jupyter Notebook

- **Preparation**
  - If you have already launched any jupyter notebooks, please close them all.
- **Launch Jupyter Notebook (Inside Docker!)**

jupyter-notebook --ip 0.0.0.0 --no-browser > notebook.log 2>&1 &
cat notebook.log

- Then Open the displayed address starting with "http://127.0.0.1:8888/?token=..." in your browser

```
[I 11:13:44.255 NotebookApp] Serving notebooks from local directory: /home/jetscape-user/JETSCAPE/build
[I 11:13:44.256 NotebookApp] The Jupyter Notebook is running at:
[I 11:13:44.256 NotebookApp] http://49687e725b02:8888/?token=806f90013a6d0a8c3e560a8c3ed5b87ae8f651f3c1a2f0db
[I 11:13:44.256 NotebookApp]  or http://127.0.0.1:8888/?token=806f90013a6d0a8c3e560a8c3ed5b87ae8f651f3c1a2f0db
[I 11:13:44.257 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[C 11:13:44.273 NotebookApp]

    To access the notebook, open this file in a browser:
        file:///home/jetscape-user/.local/share/jupyter/runtime/nbserver-1771-open.html
    Or copy and paste one of these URLs:
        http://49687e725b02:8888/?token=806f90013a6d0a8c3e560a8c3ed5b87ae8f651f3c1a2f0db
     or http://127.0.0.1:8888/?token=806f90013a6d0a8c3e560a8c3ed5b87ae8f651f3c1a2f0db
jetscape-user@49687e725b02:~/JETSCAPE/build$
```

* Shaded part is different everytime.

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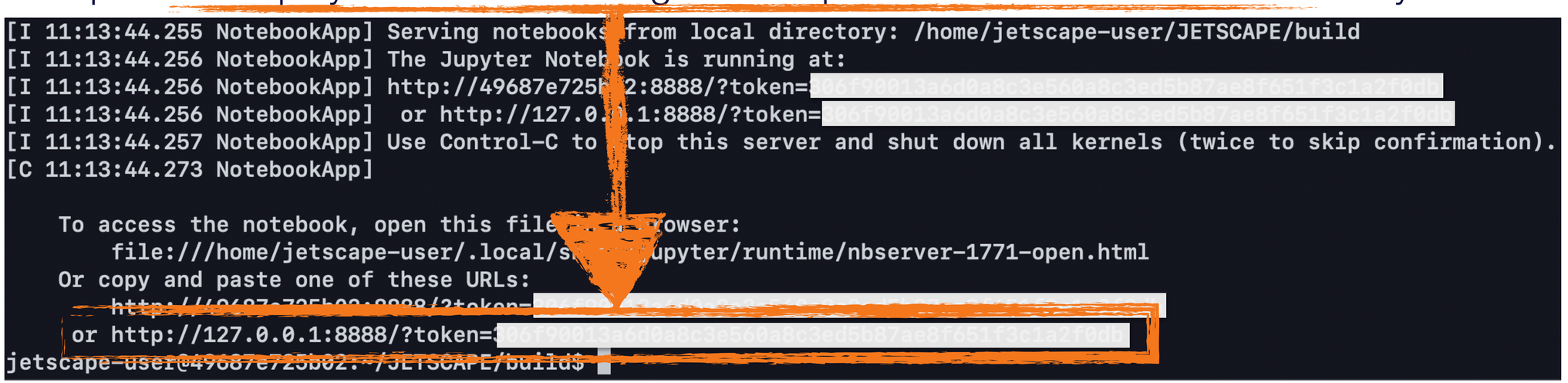
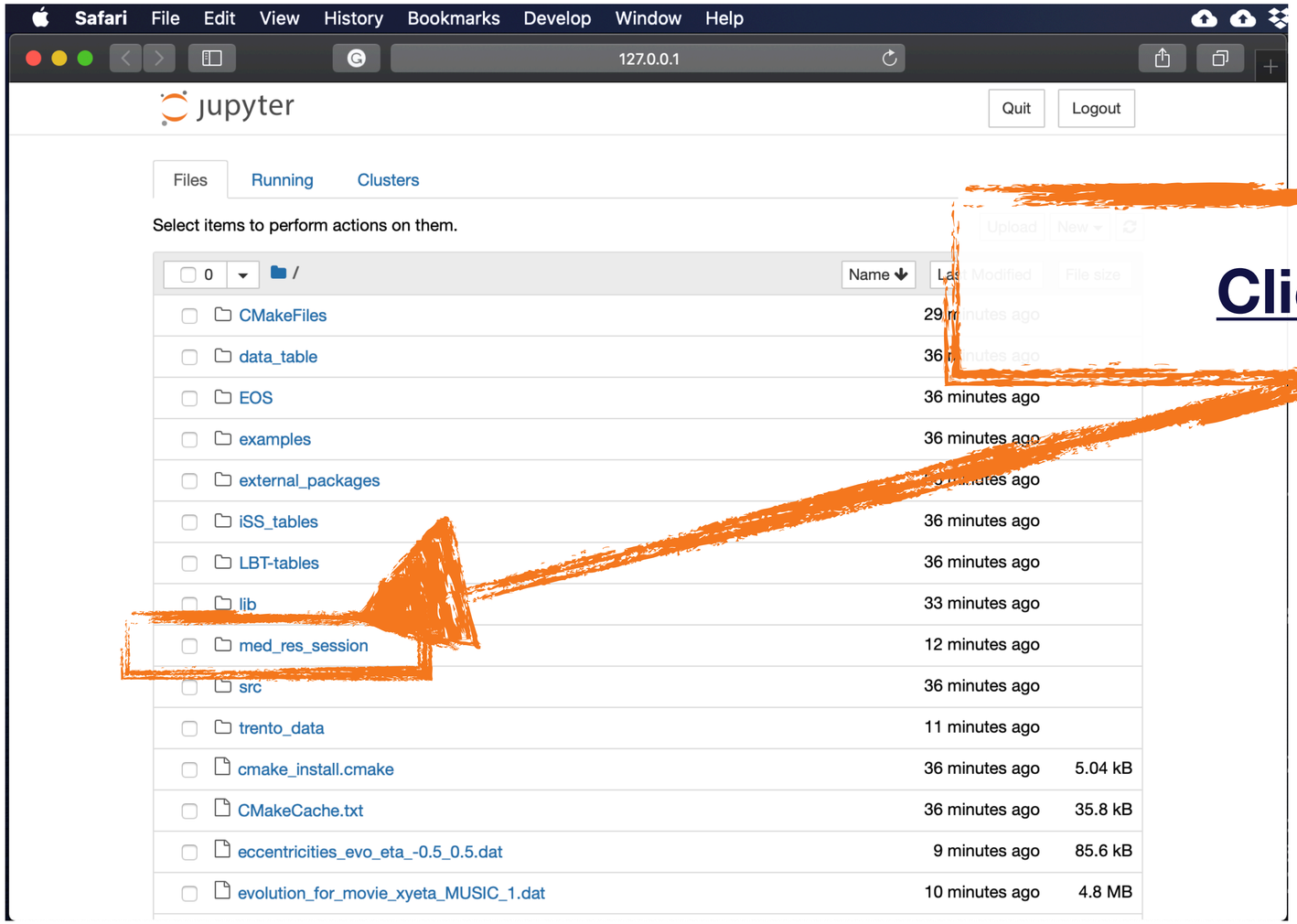


* Shaded part is different everytime.

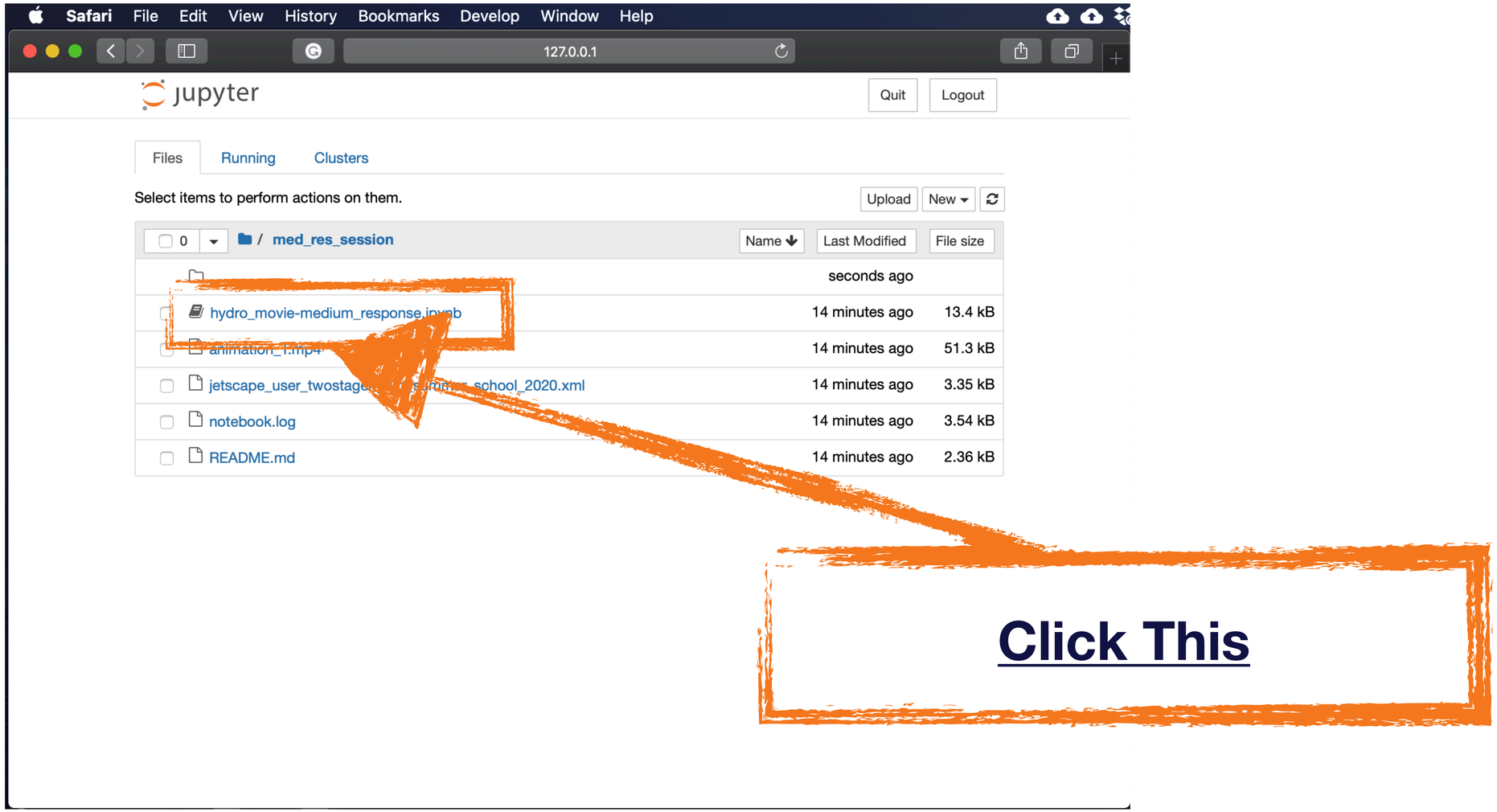
Visualization with Jupyter Notebook

- Move to `med_res_session` in Jupyter Notebook



Visualization with Jupyter Notebook

- Open **hydro_movie-medium_response.ipynb**



Visualization with Jupyter Notebook

- **Run the codes in the jupyter notebook**
  - Shift+Return to run the codes
  - *Demonstration

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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 -->
```