# *Exploring Jet Quenching Effects During QGP Initialisation*

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# QCD

- Standard Model
- Quarks and gluons
- Phase Diagram of QCD

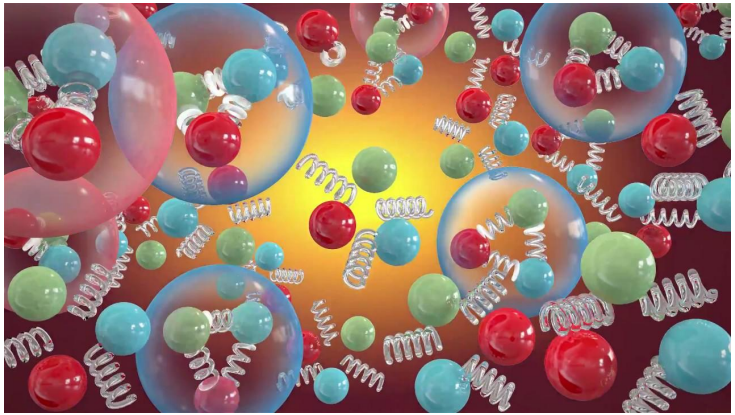


Fig 1: quarks and gluons

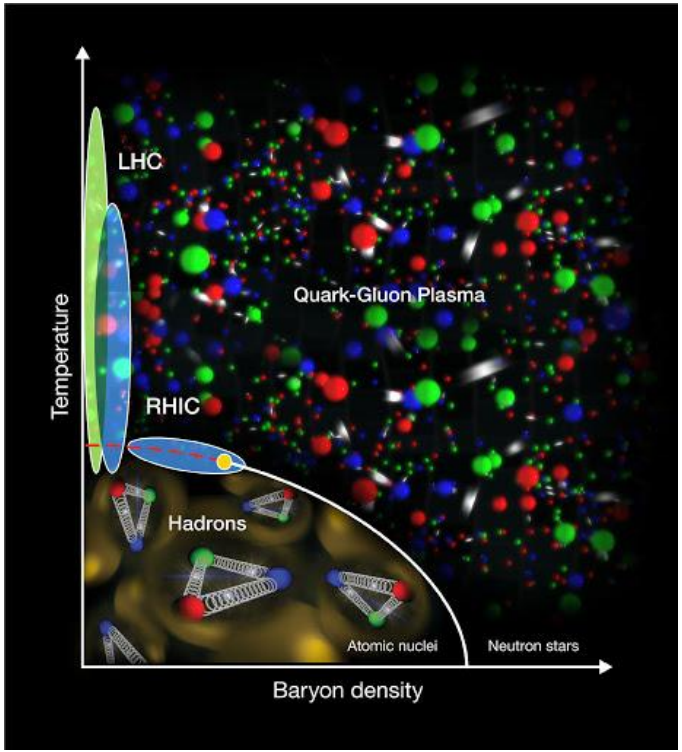



Fig 2: Phase Diagram QCD

# QGP

- PbPb Collisions (LHC CMS)
- Most perfect fluid
- Most vortical liquid
- Hottest liquid ( ~$10^{12}$ K)
- Smallest liquid:
  - yoctosecond ( $10^{-24}$ s)
  - fermi ( $10^{-15}$ m)

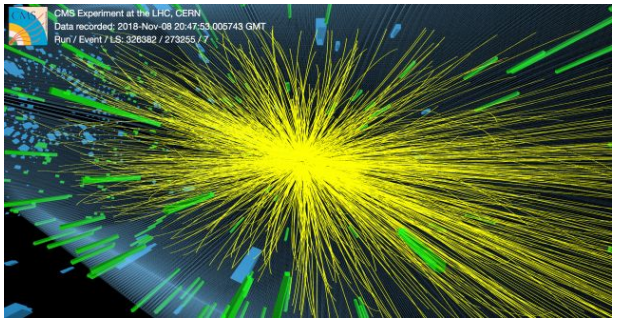



Fig 3: Collision Pb-Pb LHC

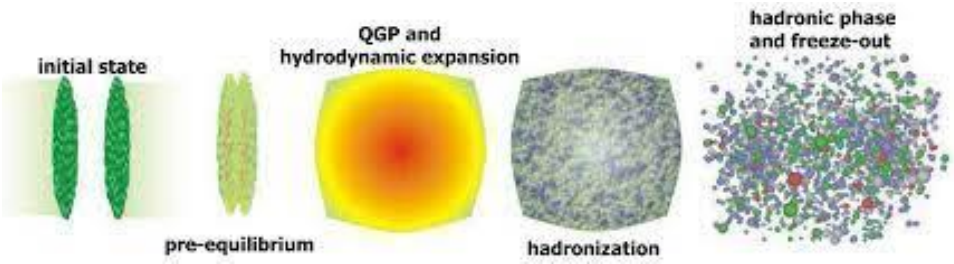



Fig 4: QGP

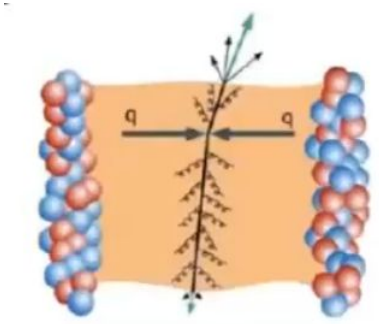



Fig 5: Jets from Pb-Pb collisions

# Study objects

- Transverse momentum (pT)
- $$D(p_{\mathrm{T}}) \equiv \frac{1}{N_{\mathrm{jet}}} \frac{dn_{\mathrm{ch}}}{dp_{\mathrm{T}}}$$
- $$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

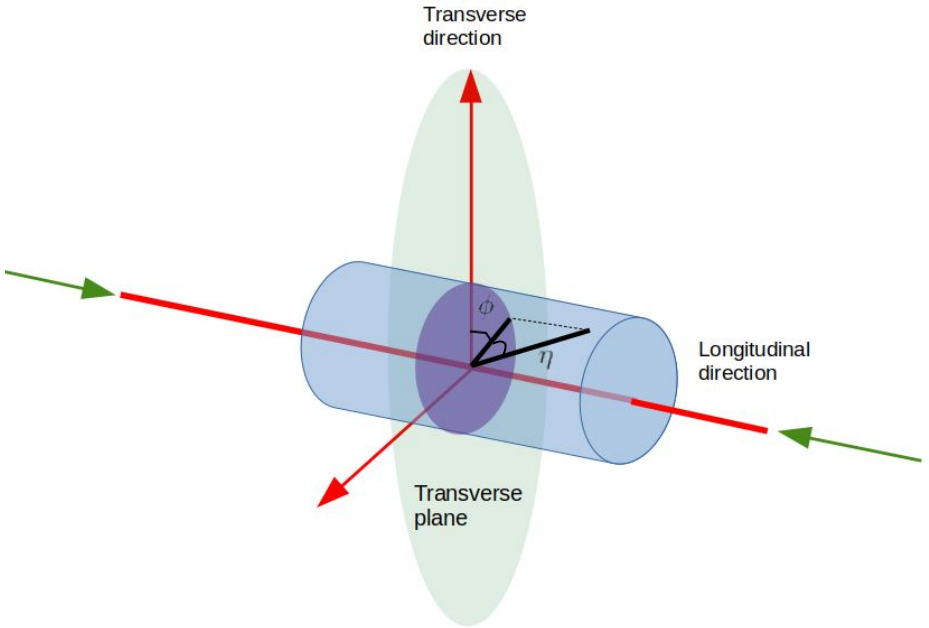



Fig 6: Direction schematics

# Bjorken Model

$$T = \begin{cases} T_i \frac{\tau}{\tau_0} & , \quad \tau < \tau_0 \\ T_i \left(\frac{\tau}{\tau_0}\right)^{-\frac{1}{3}} & , \quad \tau \geq \tau_0 \end{cases}$$

Initialization Temperature $T_i$

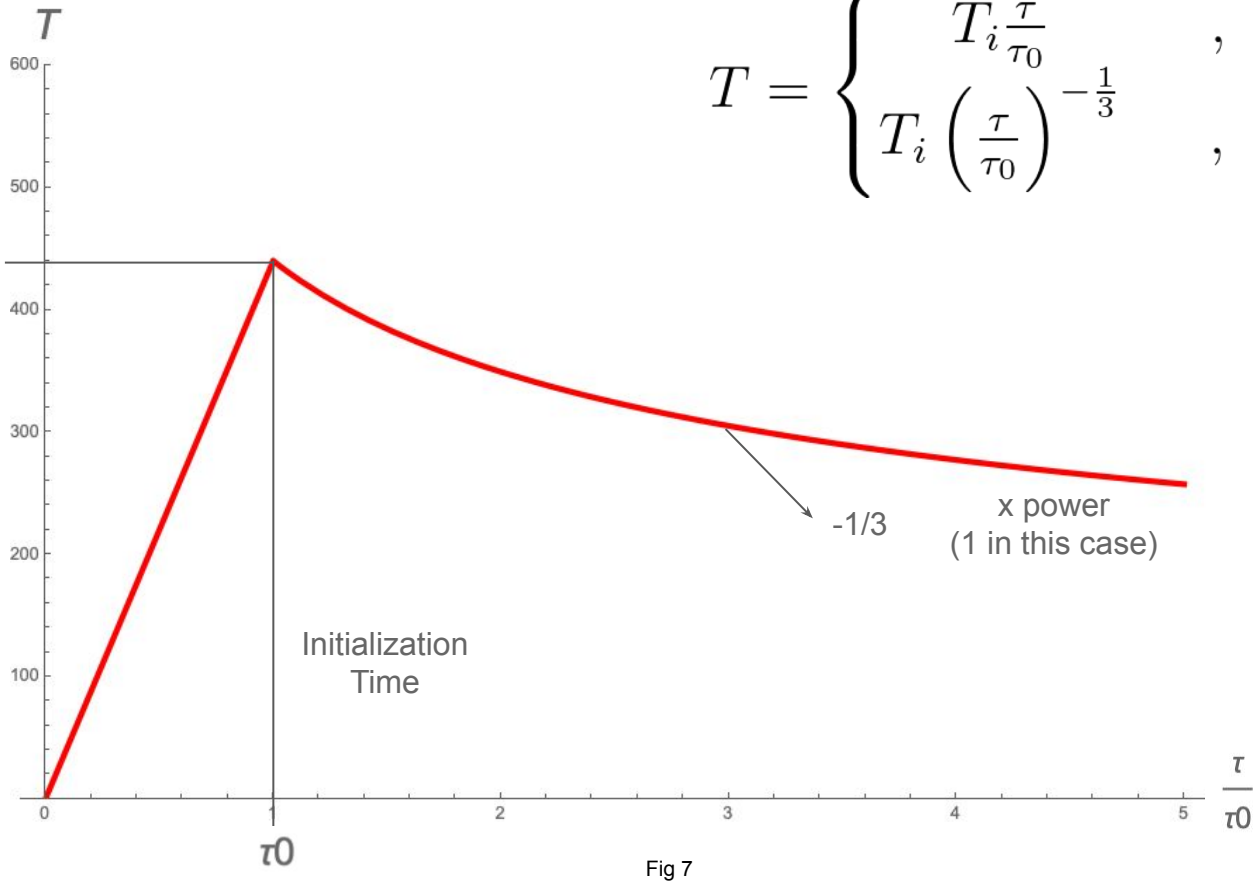



Fig 7

# 2 Big Unanswered Questions

- How does the initial temperature profile affect the subsequent Jet development?

- How sensitive are Jet probes to modifications to the cooling region of the Bjorken Model?

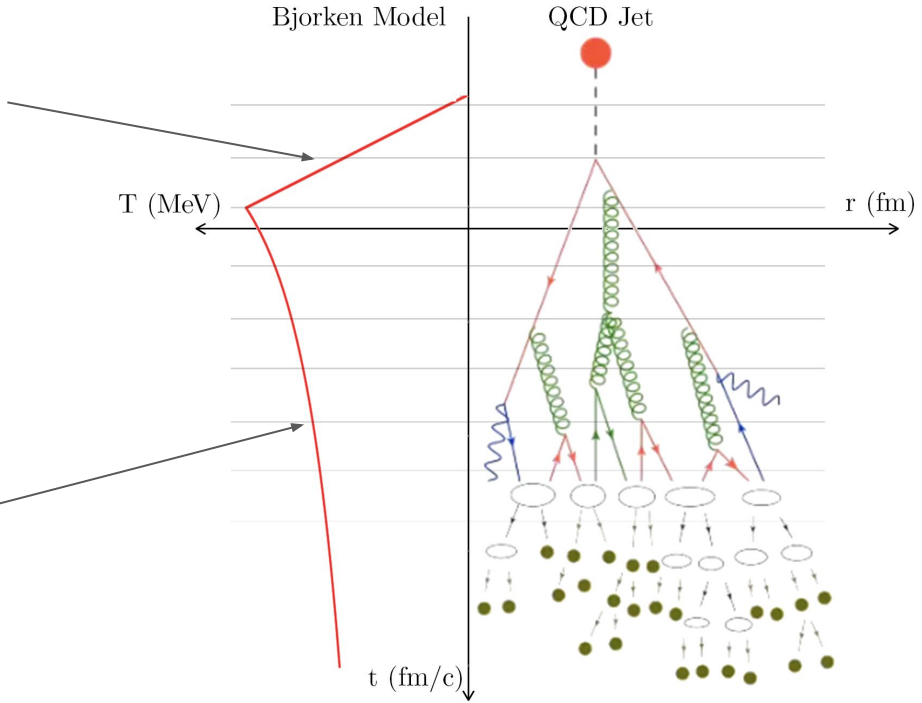



Fig 8

# Main Tool: JEWEL

- Simulates heavy-ion collisions;
- Reproduces effects of Jet quenching;
- Evolution based on the Bjorken Model;

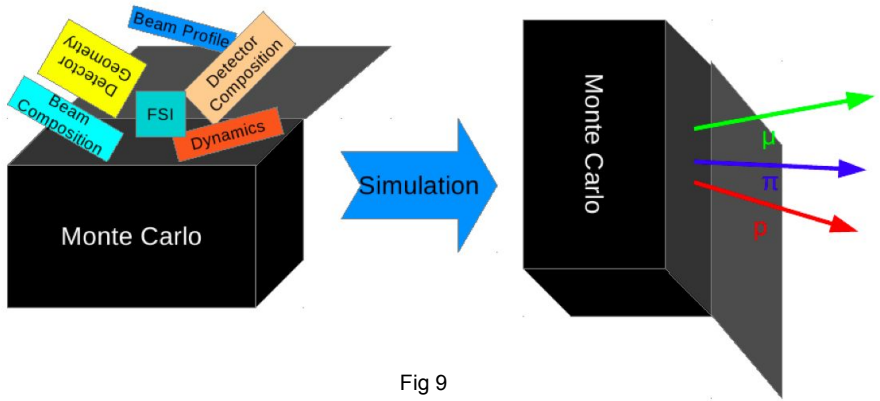



Fig 9

Our Solution: Modify the Bjorken Model and check it’s effects on a given set of variables!

# Modifications to the Bjorken Model

$$T = \begin{cases} T_i \frac{\tau}{\tau_0} & , \quad \tau < \tau_0 \\ T_i \left(\frac{\tau}{\tau_0}\right)^{-\frac{x}{3}} & , \quad \tau \geq \tau_0 \end{cases}$$

$T_i = 0, 220, 330, 440, 550 (MeV)$

$\tau_0 = \{0.2, 0.4, 0.6\}\ (fm/c)$

$x = \{0.5, 1, 2, 3\}$

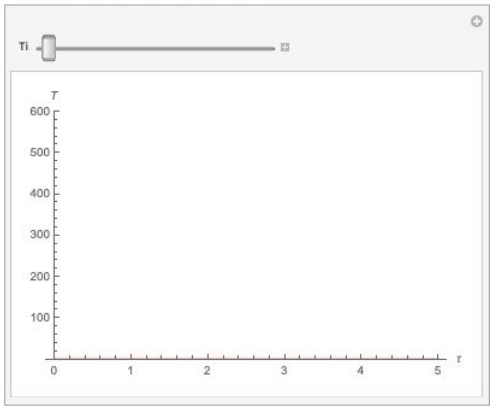



Fig 10

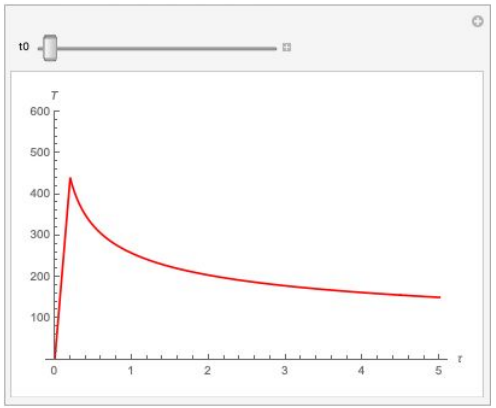



Fig 11

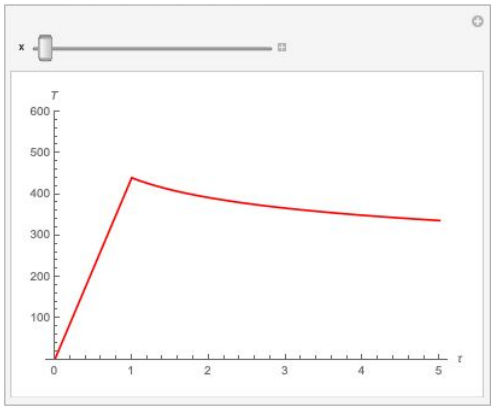



Fig 12

# Z boson and Jet

- Jet quenching (Jet interacts with QGP);
- Z boson (doesn't  interact with QGP);

- Transverse momentum of Pb-Pb collisions is lower than transverse momentum of pp collisions;

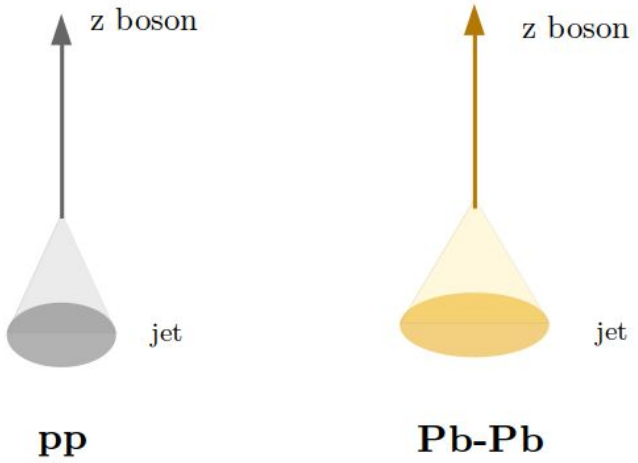
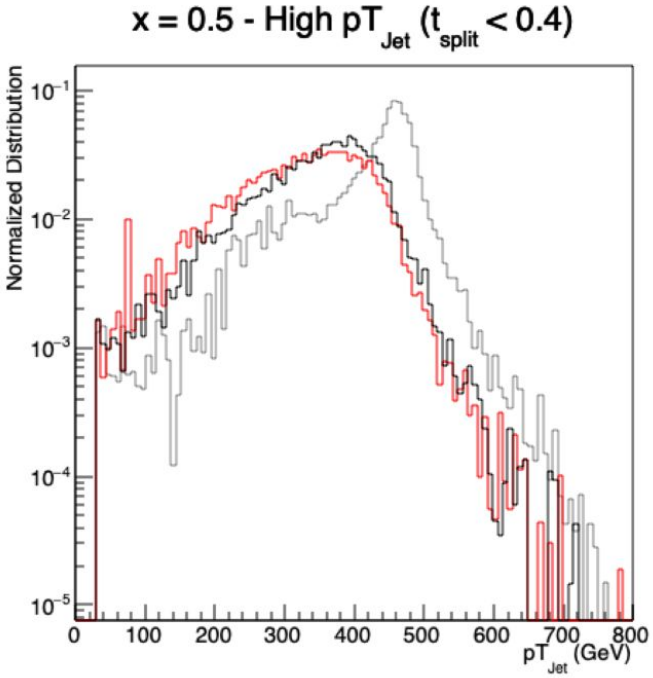
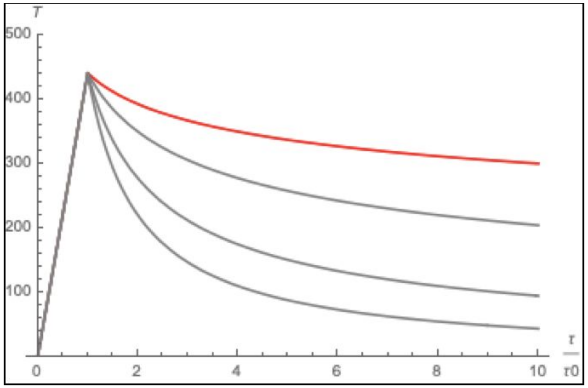



Fig 14

# How sensitive are Jet probes to modifications to the *cooling region* of the Bjorken Model?




pT Z ∈ [450,490] GeV



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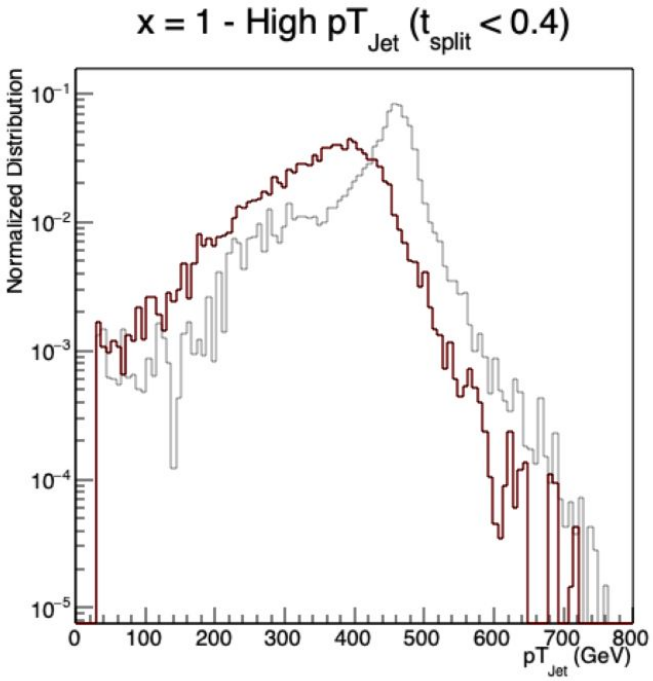


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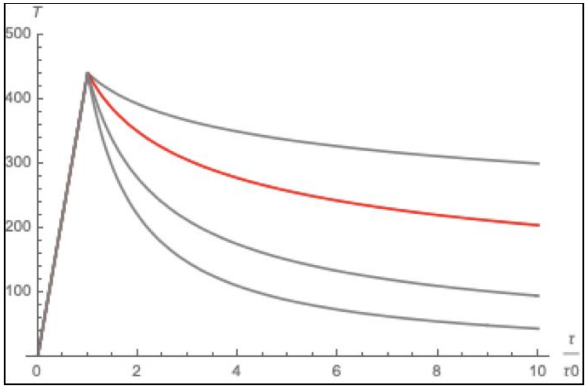

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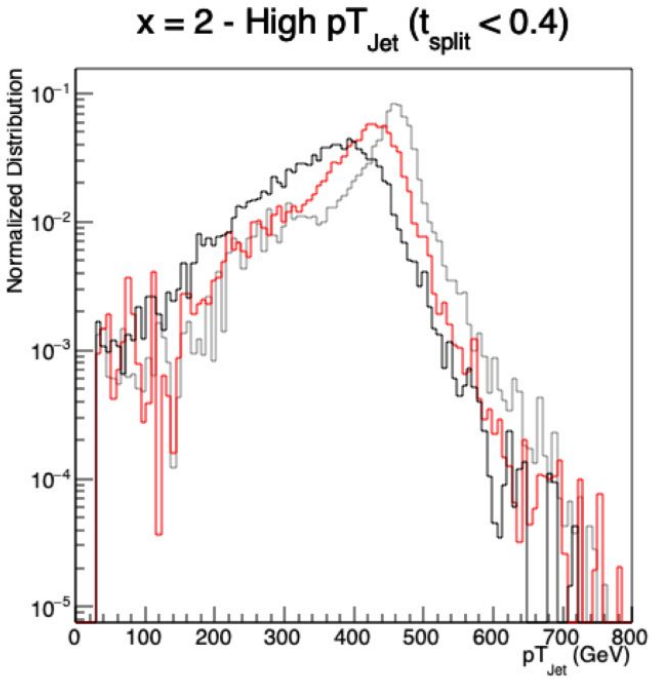


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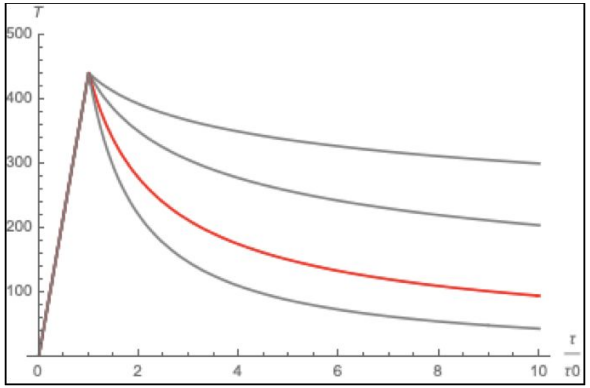

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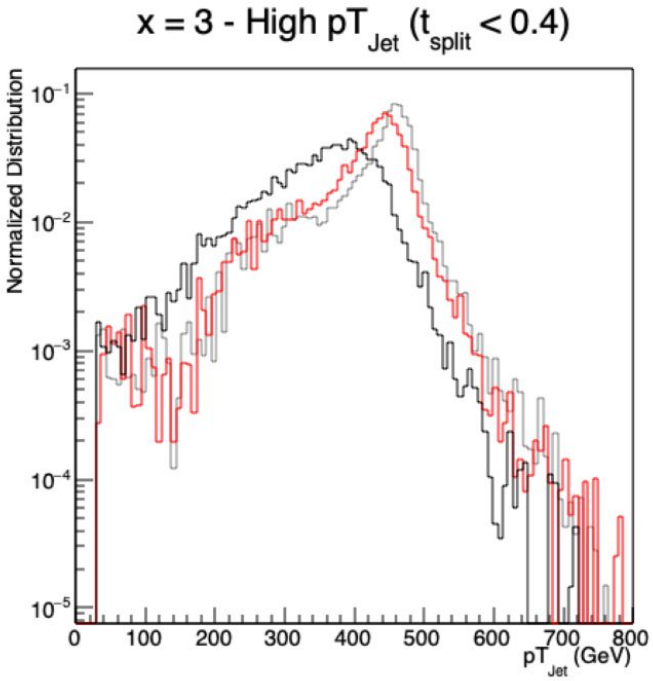


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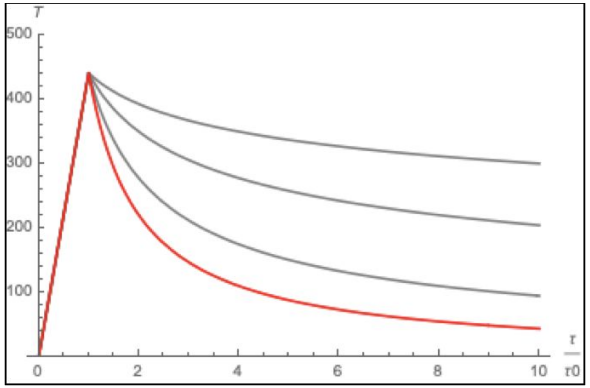
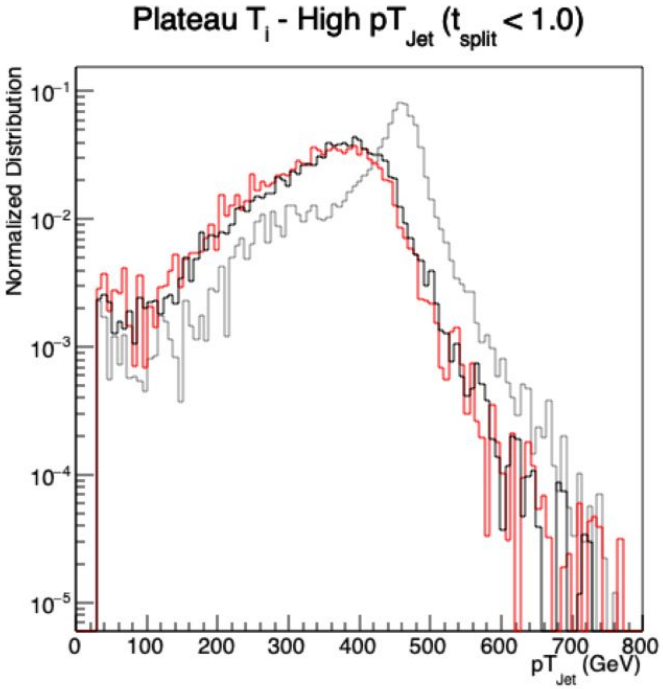


# How does the initial temperature profile affect the subsequent Jet development?

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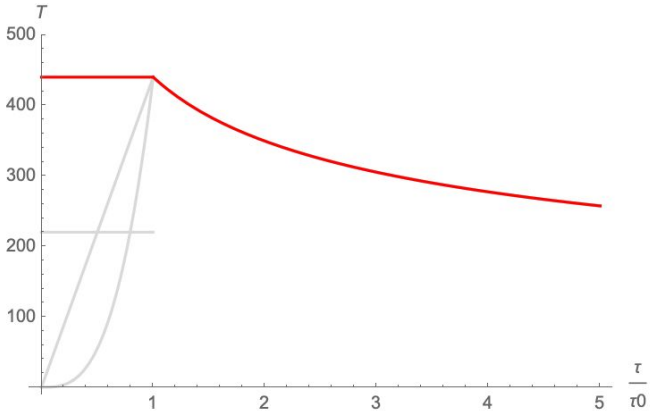

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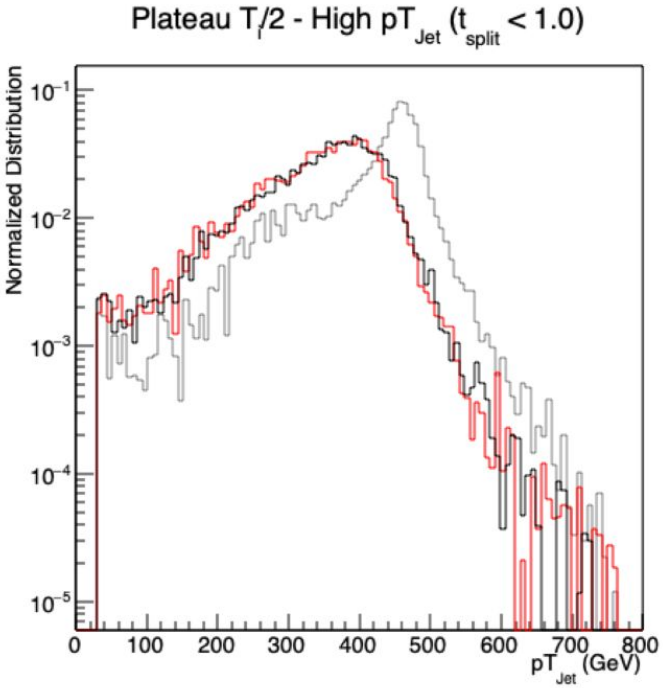
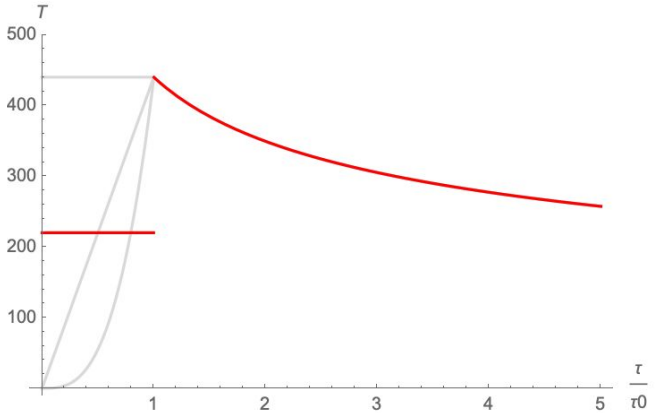



pT Z ∈ [450,490] GeV



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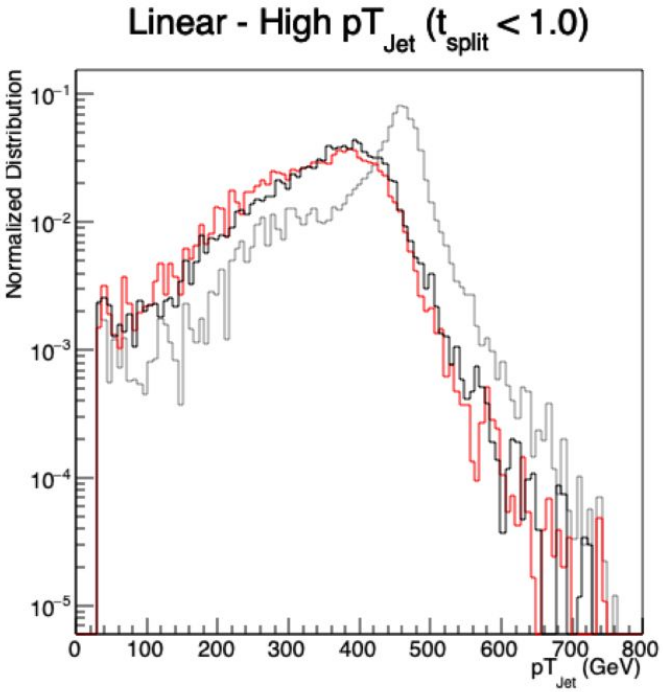


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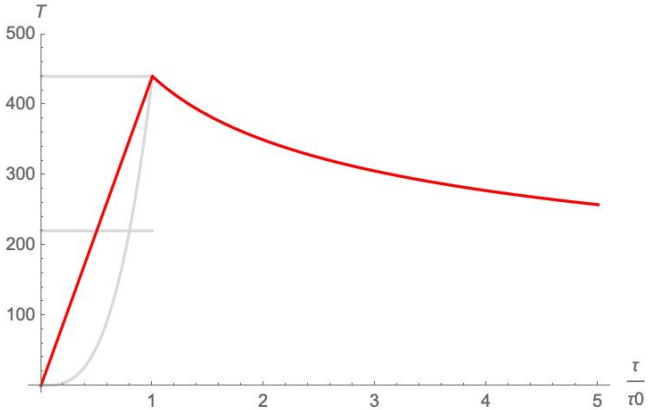

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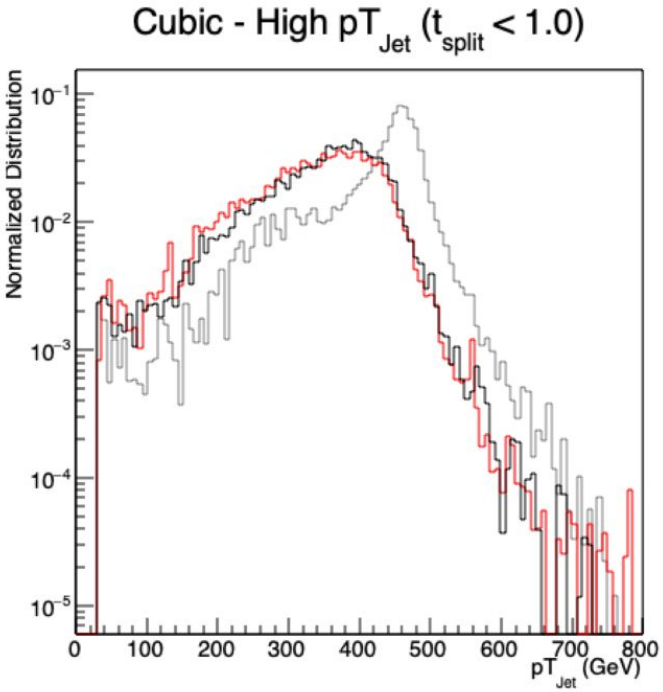


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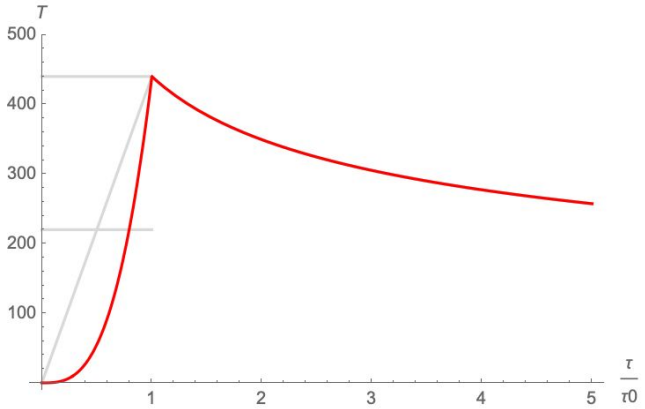
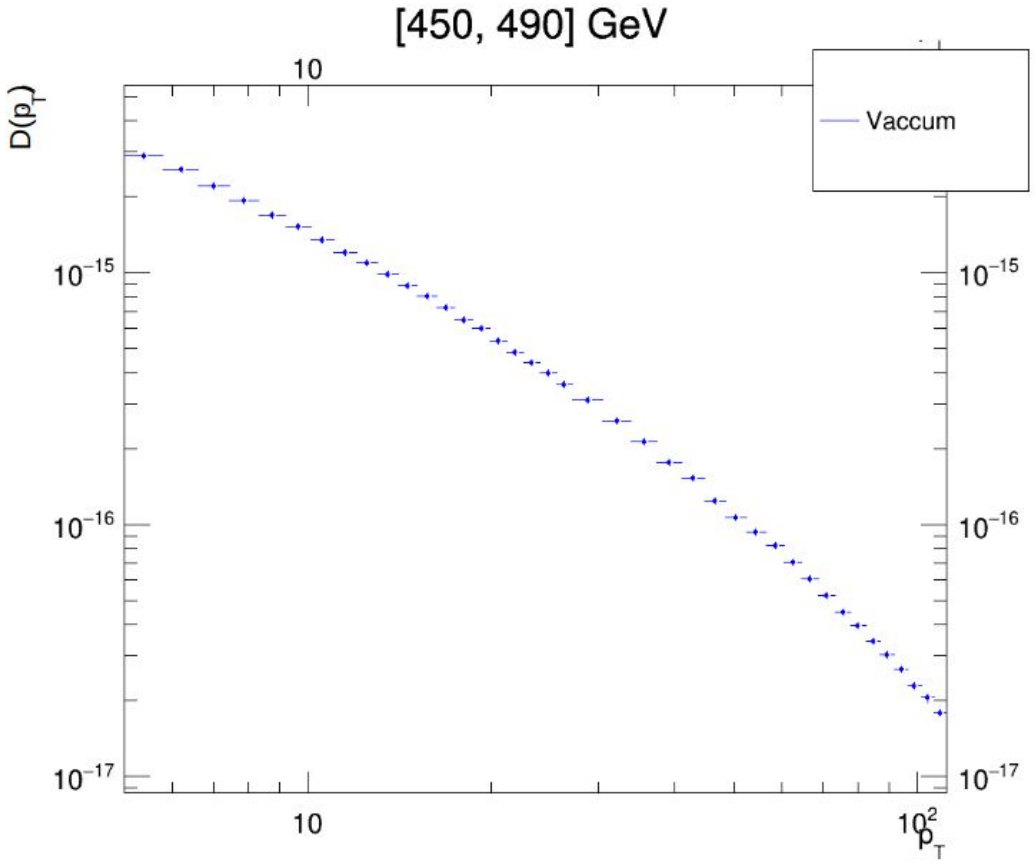
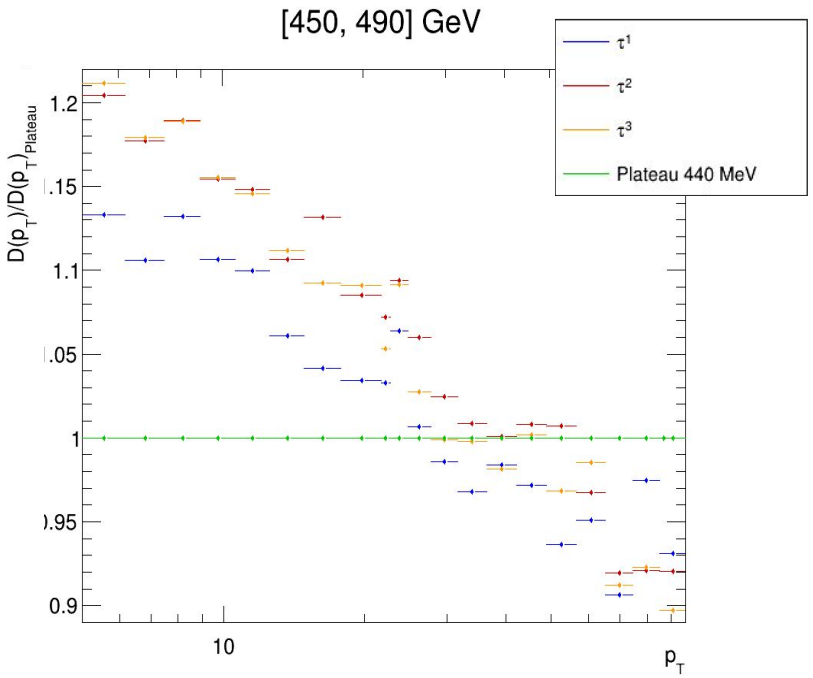


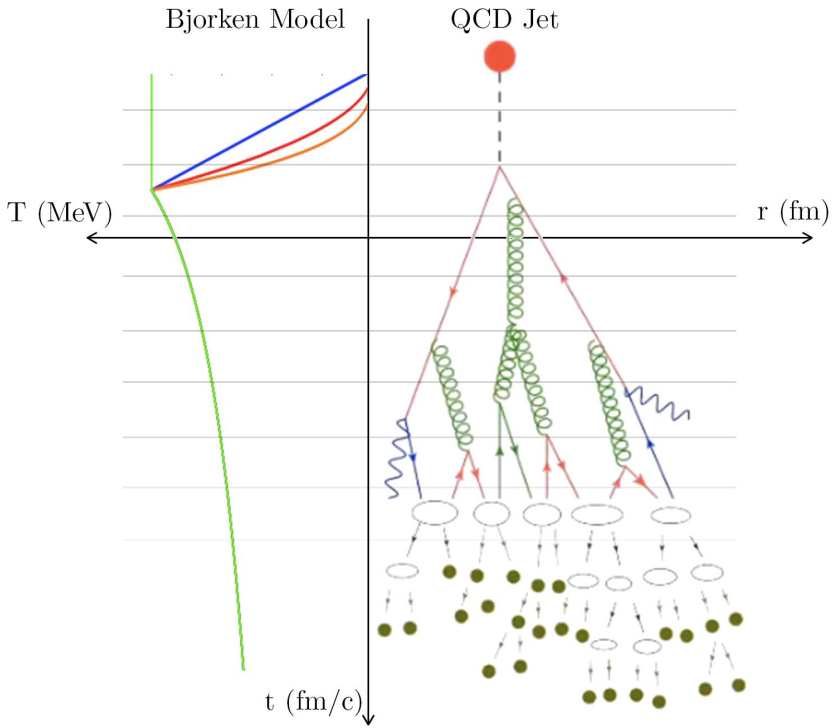
# What if we looked inside the Jet?

# D(pT)

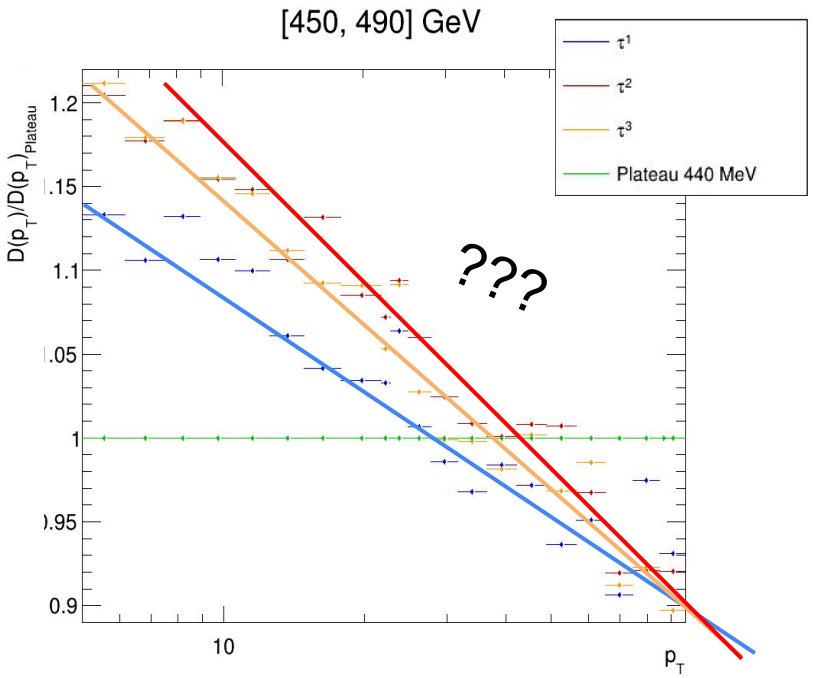


# Ratio


[450, 490] GeV
τ1
τ2
τ3
Plateau 440 MeV
D(p_T)/D(p_T Plateau)
1.2
1.15
1.1
1.05
1
0.95
0.9
10
p_T


Bjorken Model
QCD Jet
T (MeV)
r (fm)
t (fm/c)

# Ratio


[450, 490] GeV
τ1
τ2
τ3
Plateau 440 MeV
???
D(p_T)/D(p_T Plateau)
1.2
1.15
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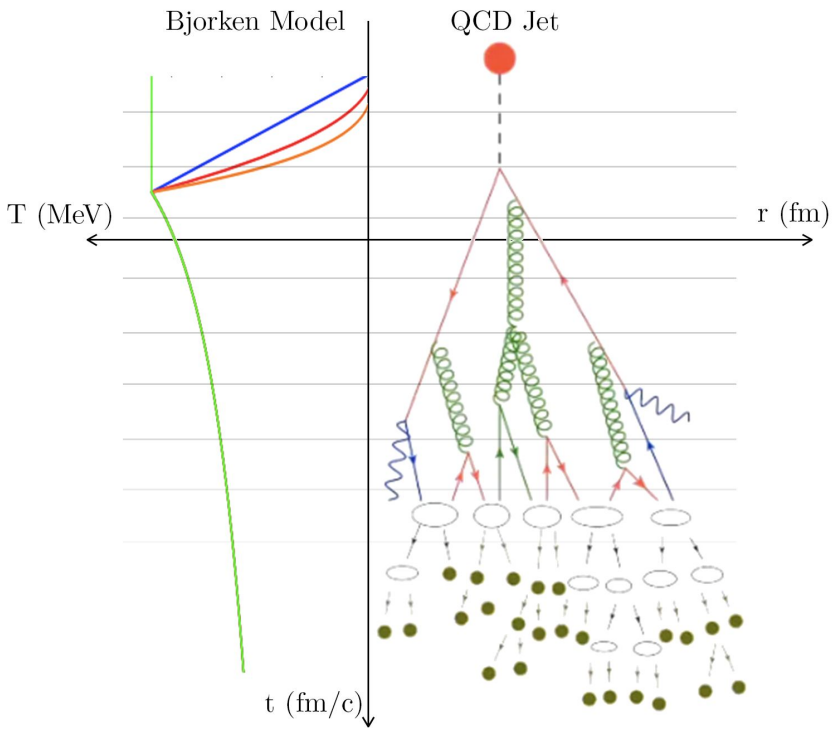
Bjorken Model
QCD Jet
T (MeV)
r (fm)
t (fm/c)

# Summary:

- Goal: Understand the impact of QGP initialization profiles on Jets
- Setup: Calibrated energy loss Jet+Z channel
  - JEWEL with altered baseline model (Bjorken model);
  - Z boson pT restricted to 2 bins (low: [60,100] GeV & high: [450,490] GeV)
- Main Findings:
  - Confirmation that modifications to the bulk evolution of the Bjorken Model affect the Jet's pT distribution;
  - Modification to the initialization profile do not affect the pT distribution of Jets;
  - Mild alterations to the particle multiplicity inside Jets;
  - Fragmentation functions show significant dependence on initial temperature profile;

The results seem to indicate that the initial profile do not affect the Jet's pT distribution but it does affects the pT distribution of particles ***inside*** it!