

Hydrodynamical Study of Jet Energy Loss

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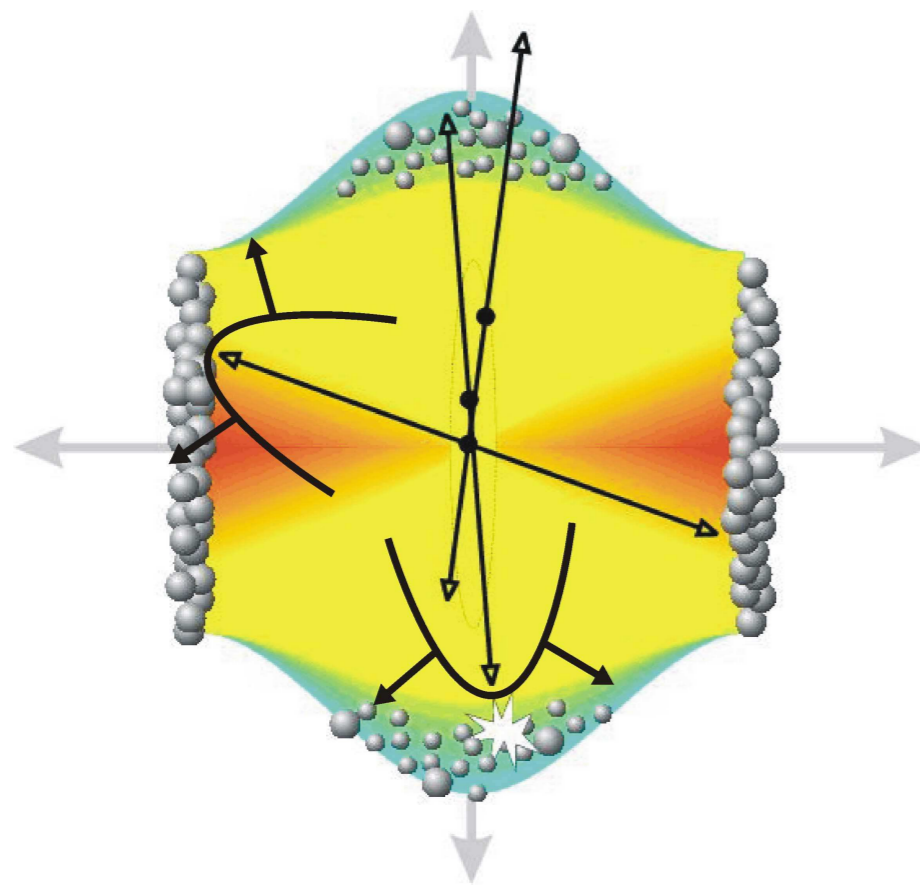
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Motivation

- Jet quenching occurs in a hot and dense medium [1].
 - RHIC experimental data show anomalous behaviour of angular distribution in particle multiplicity [2].
- ⇒ Study jet quenching in a spherically symmetric expanding medium within (3+1)d ideal hydrodynamics.

Jets in Nuclear Collisions

- In high-energy collisions, hard scattering of quarks and gluons early in the collision leads to jet production.
- Jets serve as a probe for the matter created in the collision.



Jet suppression

- The away-side jet in Au+Au collisions

- for high- p_{\perp} particles

$$(p_{\perp}(\text{assoc}) > 2 \text{ GeV}/c, \\ 4 < p_{\perp}(\text{trigger}) < 6 \text{ GeV}/c)$$

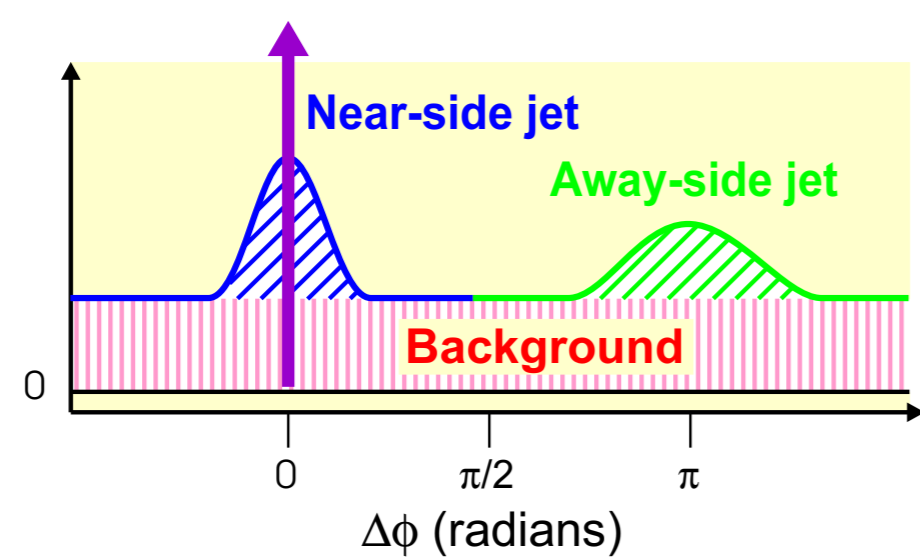
- with pseudo-rapidity $|\eta| < 0.7$

- is **suppressed** [2],

- whereas the away-side jet in p+p collisions is **not suppressed**.

⇒ This is commonly interpreted as parton-energy loss (jet quenching):

- One jet escapes but the other jet deposits a large fraction of energy into the dense medium.



[Figure from STAR Collaboration <http://www.star.bnl.gov>]

(3+1)d hydrodynamical approach

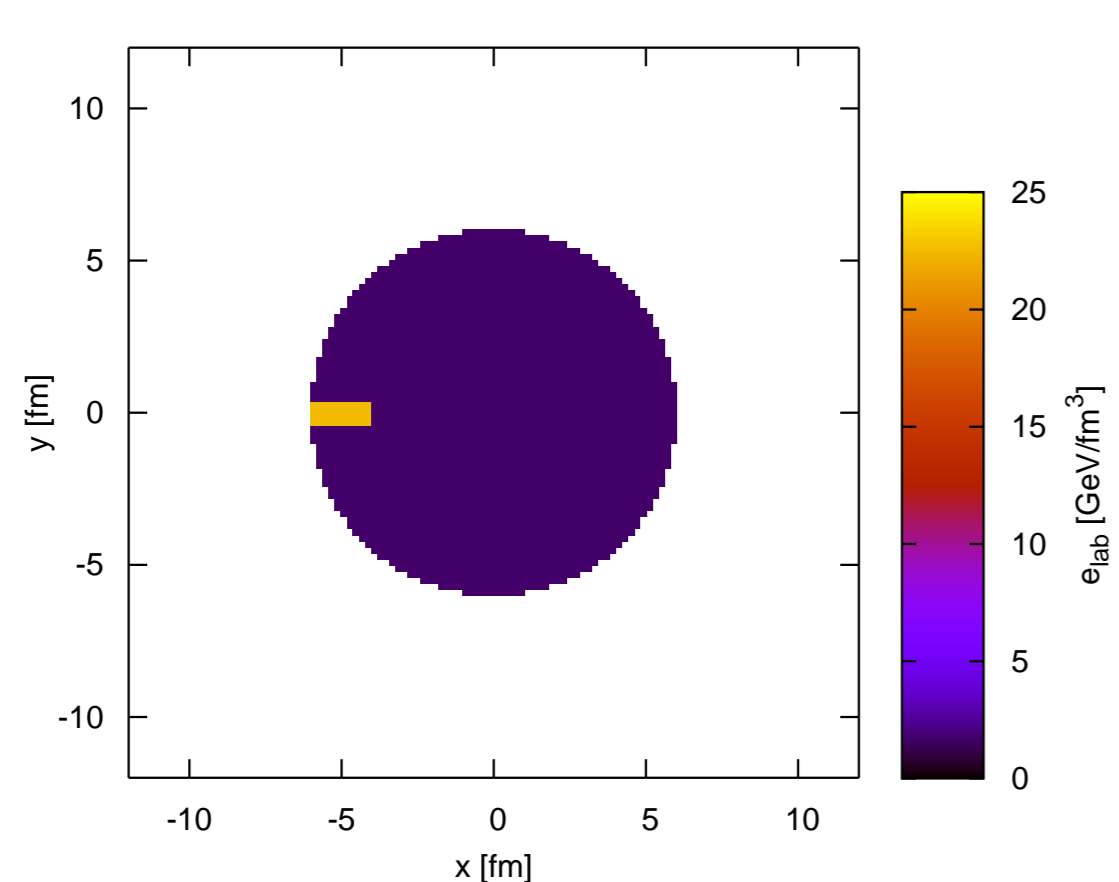
- We use (3+1)d ideal hydrodynamics and an ultrarelativistic ideal gas EoS,

- employ the (3+1)d SHASTA (SHarp And Smooth Transport Algorithm) [3]

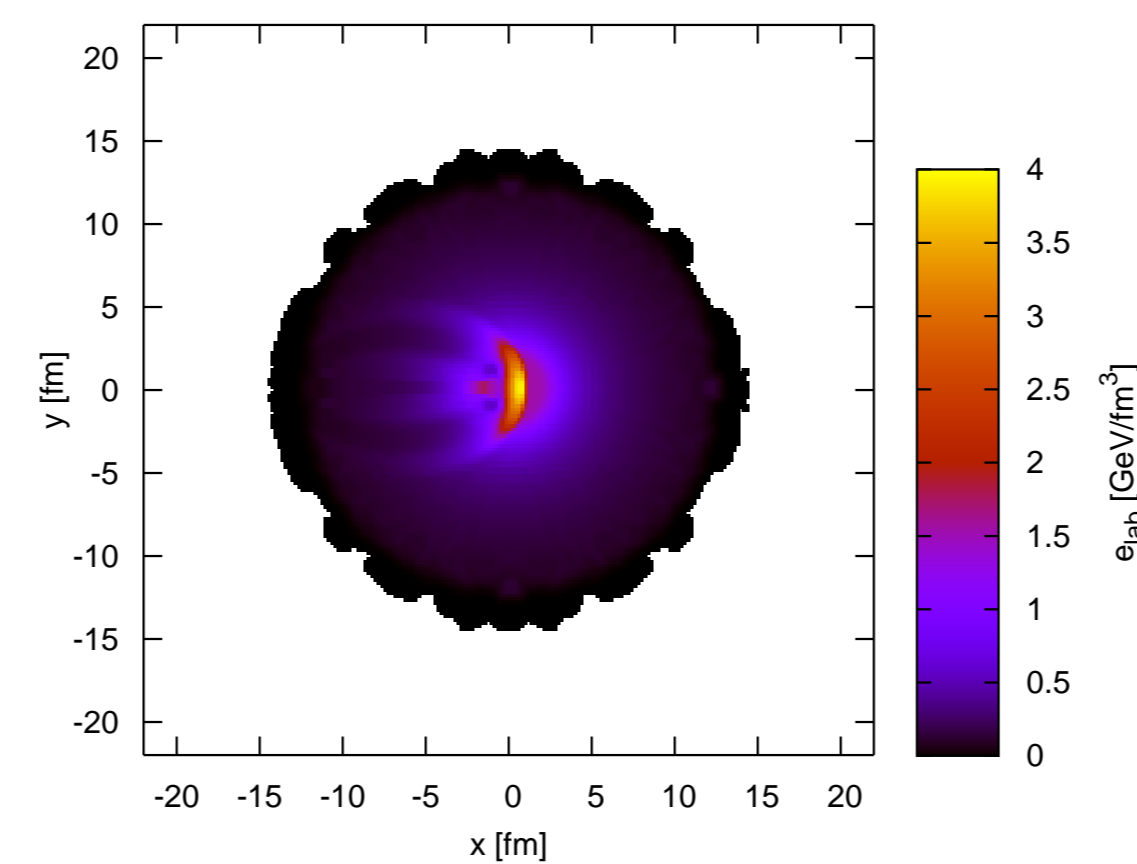
- and implement a jet that deposits its energy and momentum completely during a very short time in a small spatial volume.

- The medium has an initial energy density of $e = 11.5 \text{ GeV}/\text{fm}^3$,

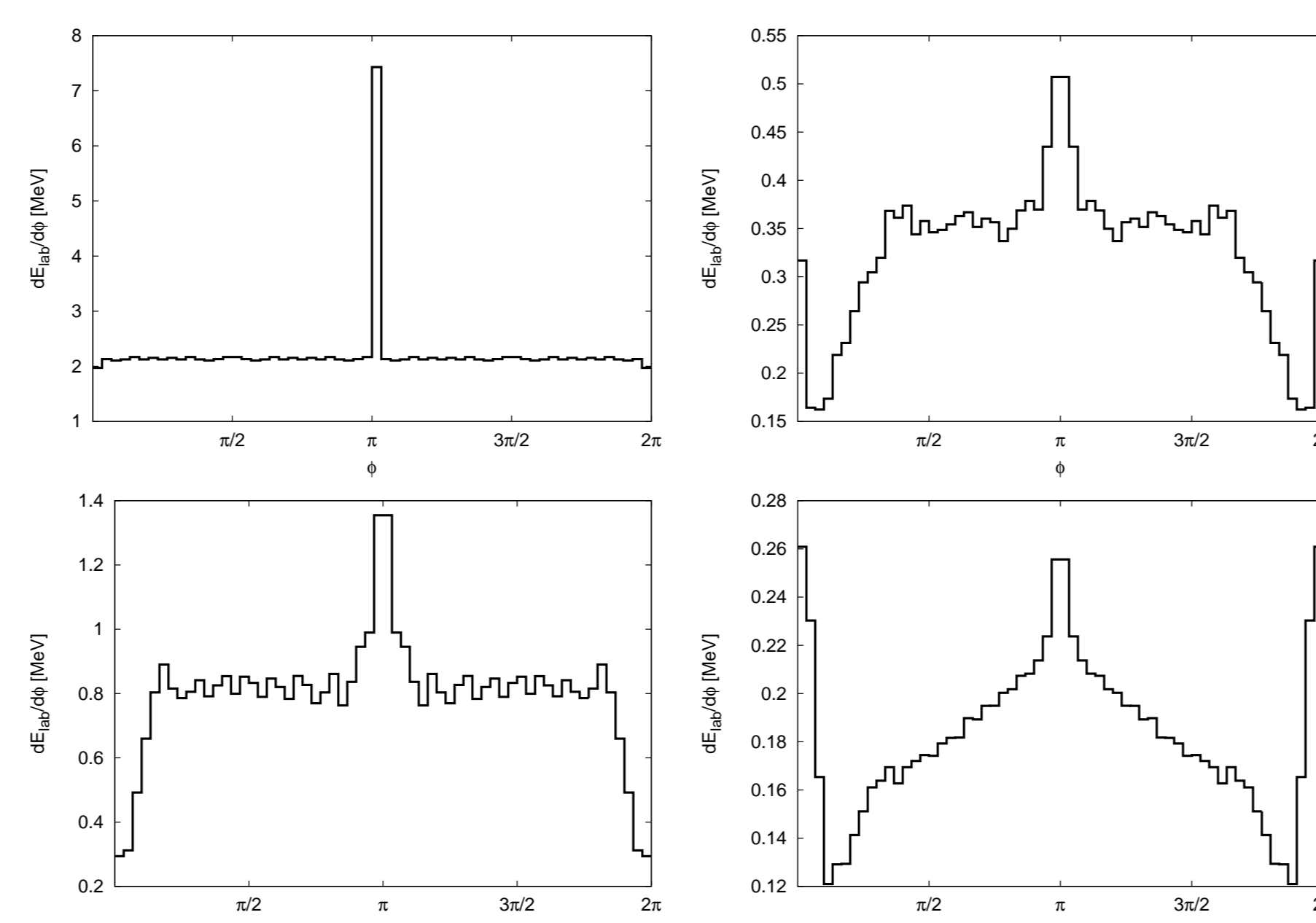
- the jet deposits in a volume of $V = 1 \times 1 \times 2 \text{ fm}^3$ and has extra energy density of $e = 5 \text{ GeV}/\text{fm}^3$ and initial velocity in x-direction of $v_x = 0.8 c$.



- Contour plot of the laboratory energy density at $t = 6.4 \text{ fm}/c$:



- Azimuthal angular distribution of the laboratory energy (pseudo-rapidity cut of $|\eta| < 0.5$) for $t = 0, 1.6, 4.0, 6.4 \text{ fm}/c$:

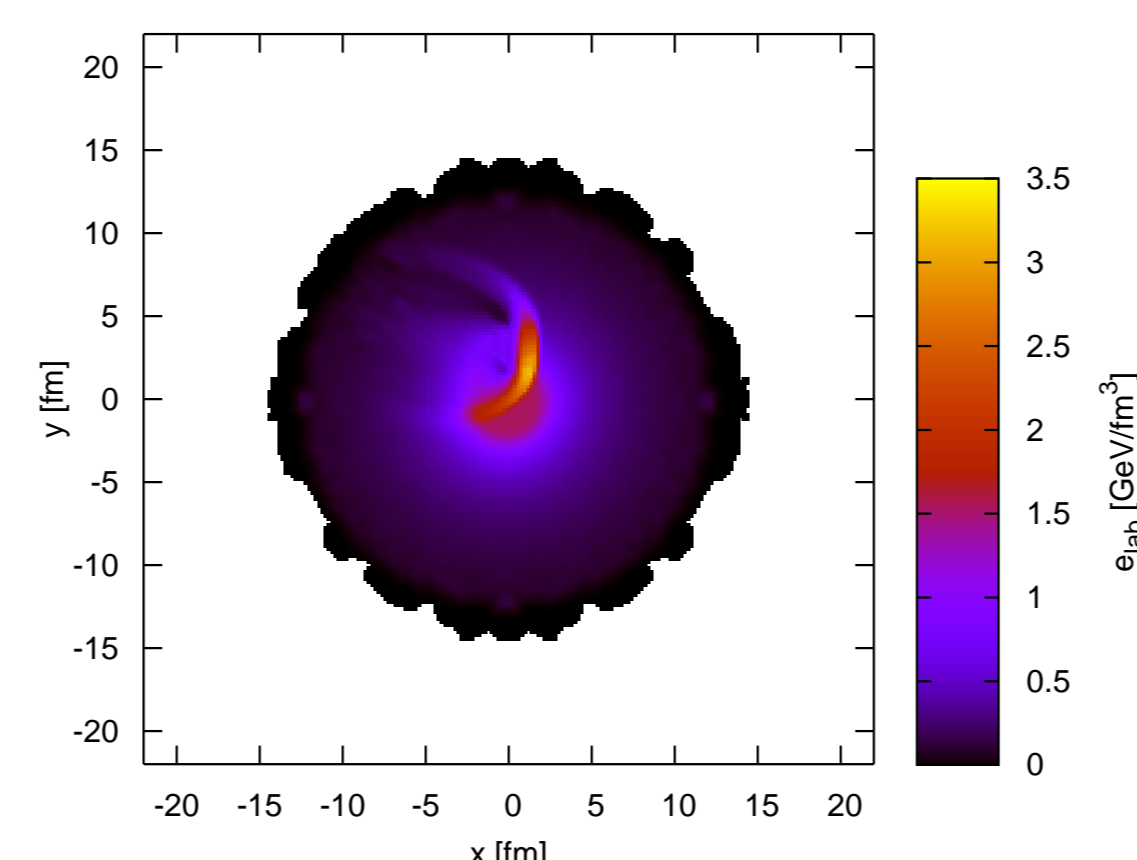
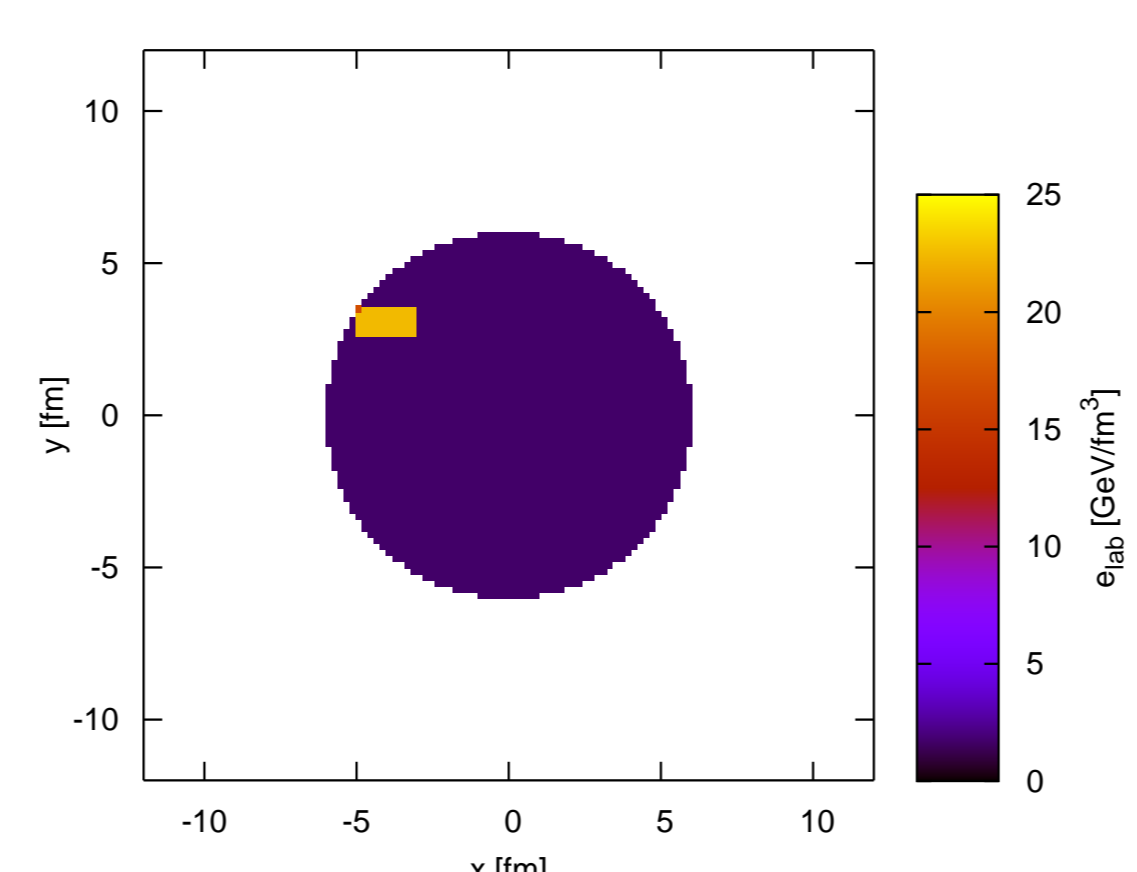


- shows a broadening of the jet due to distribution of energy along the bow shock.

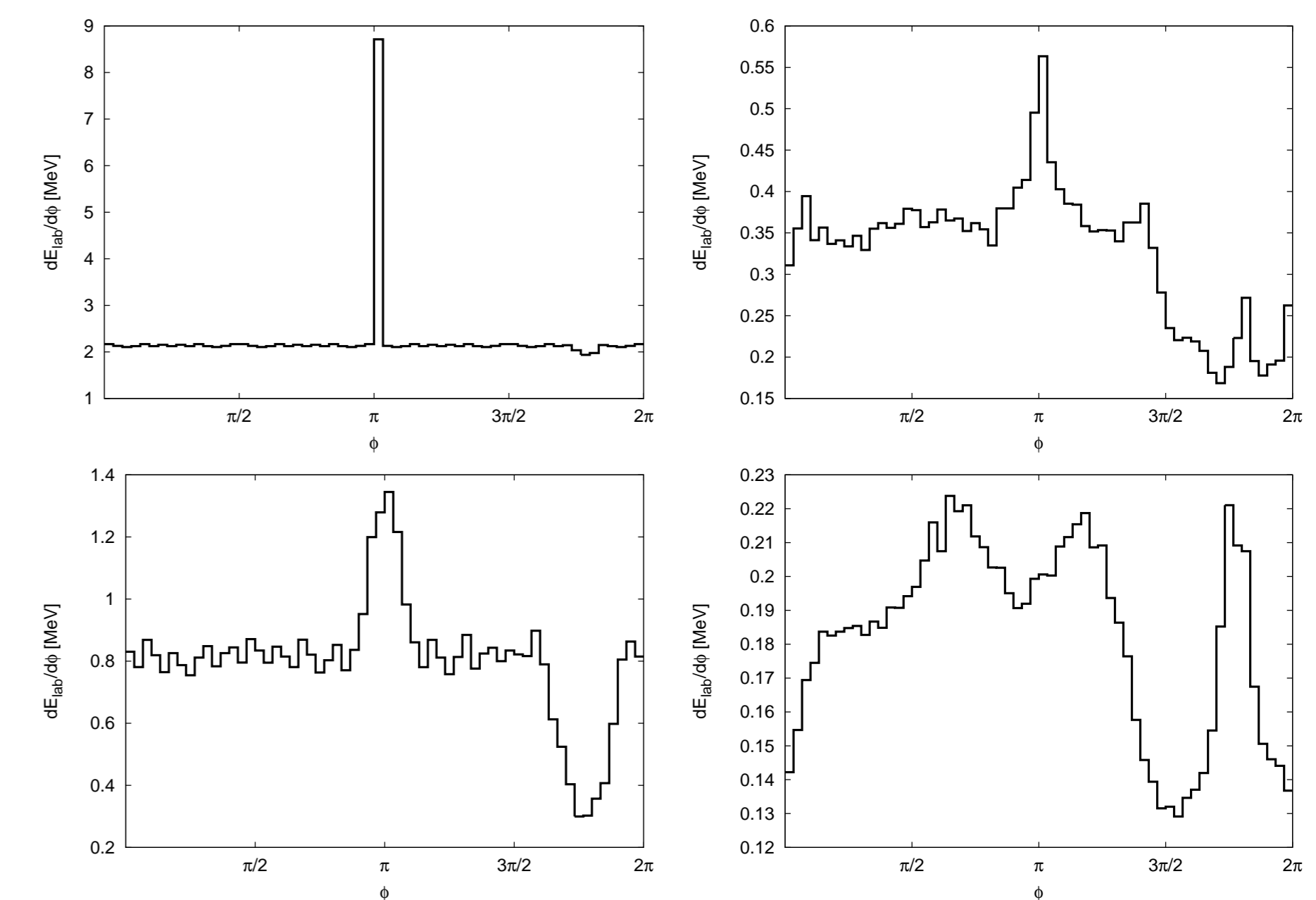
Jet Orientation Dependence

- In order to study the influence of a different jet orientation, we shift the jet parallel to the y-axis.

- Contour plot of the laboratory energy density for $t = 0 \text{ fm}/c$ and $t = 6.4 \text{ fm}/c$:



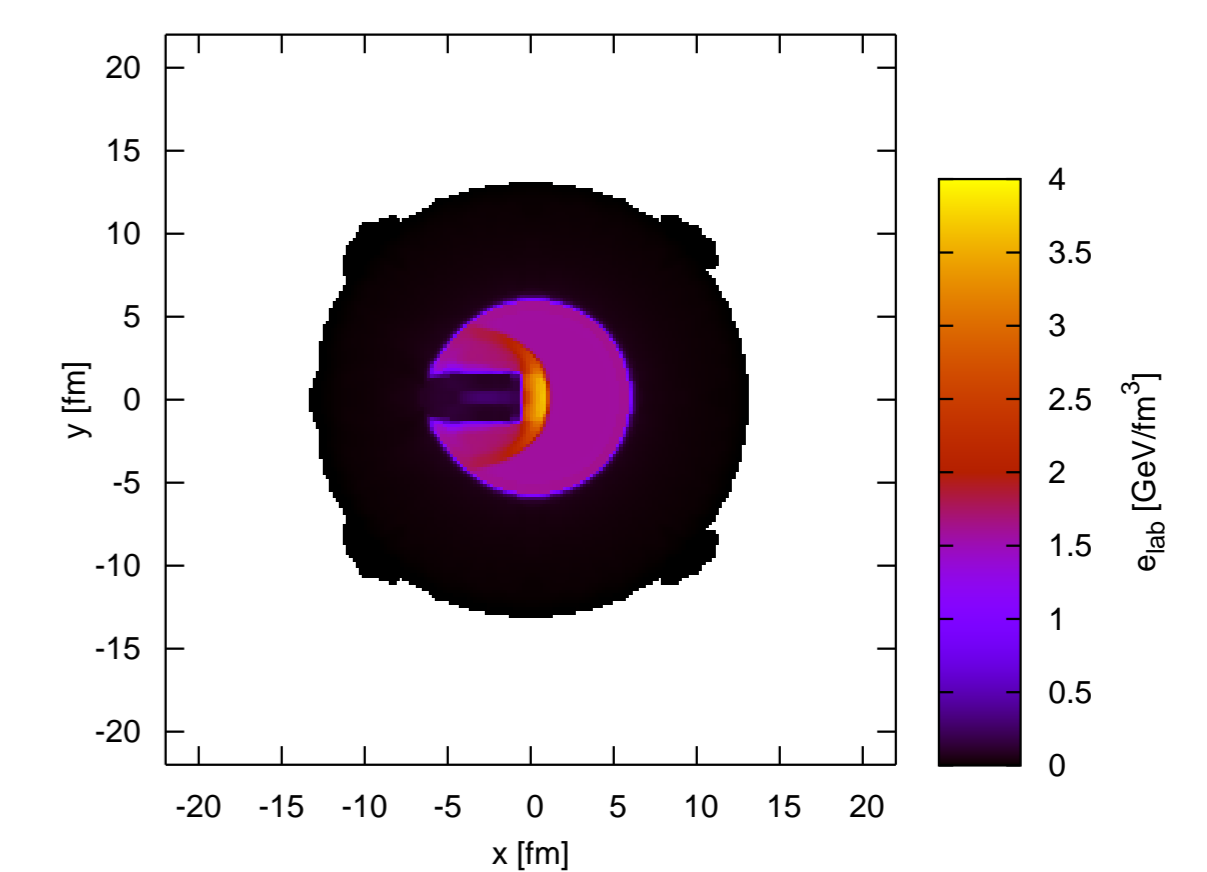
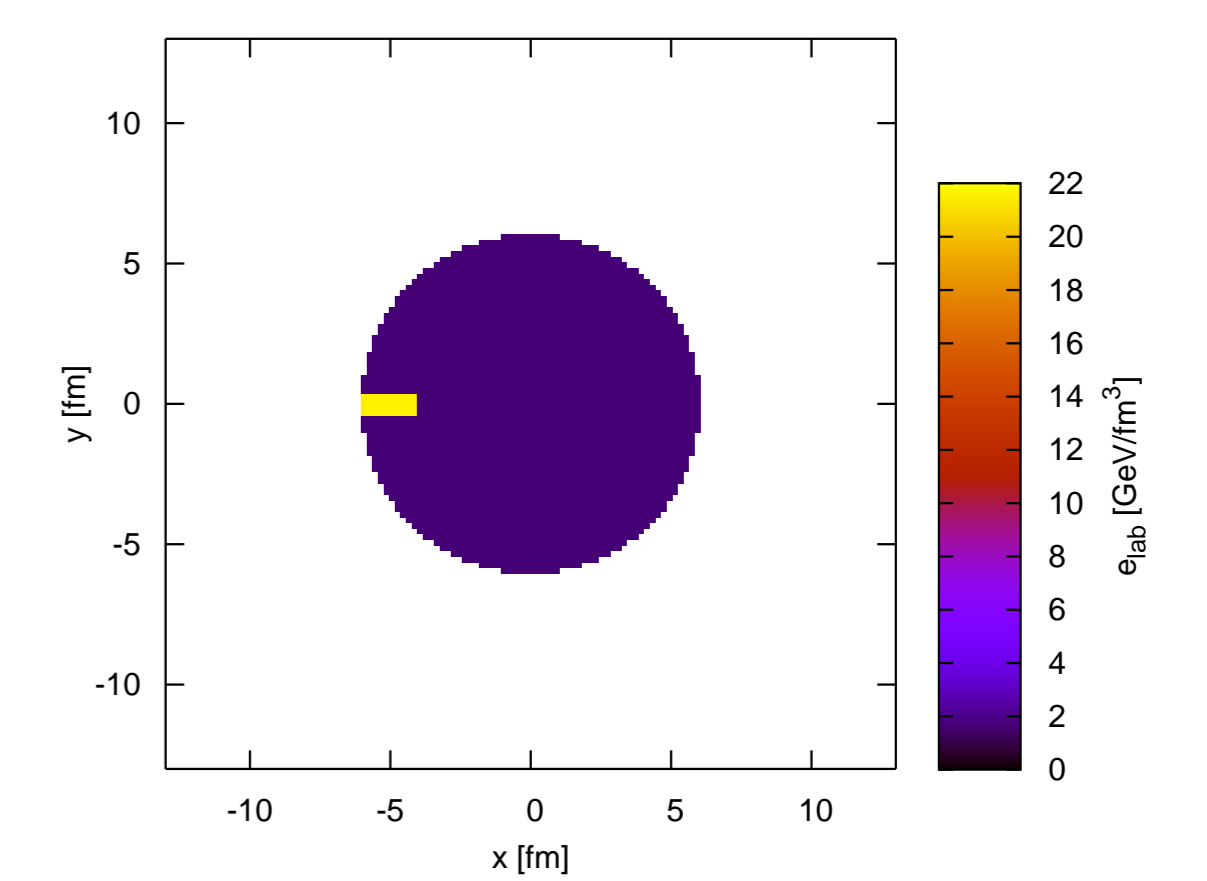
- Azimuthal angular distributions of the laboratory energy for $t = 0, 1.6, 4.0, 6.4 \text{ fm}/c$:



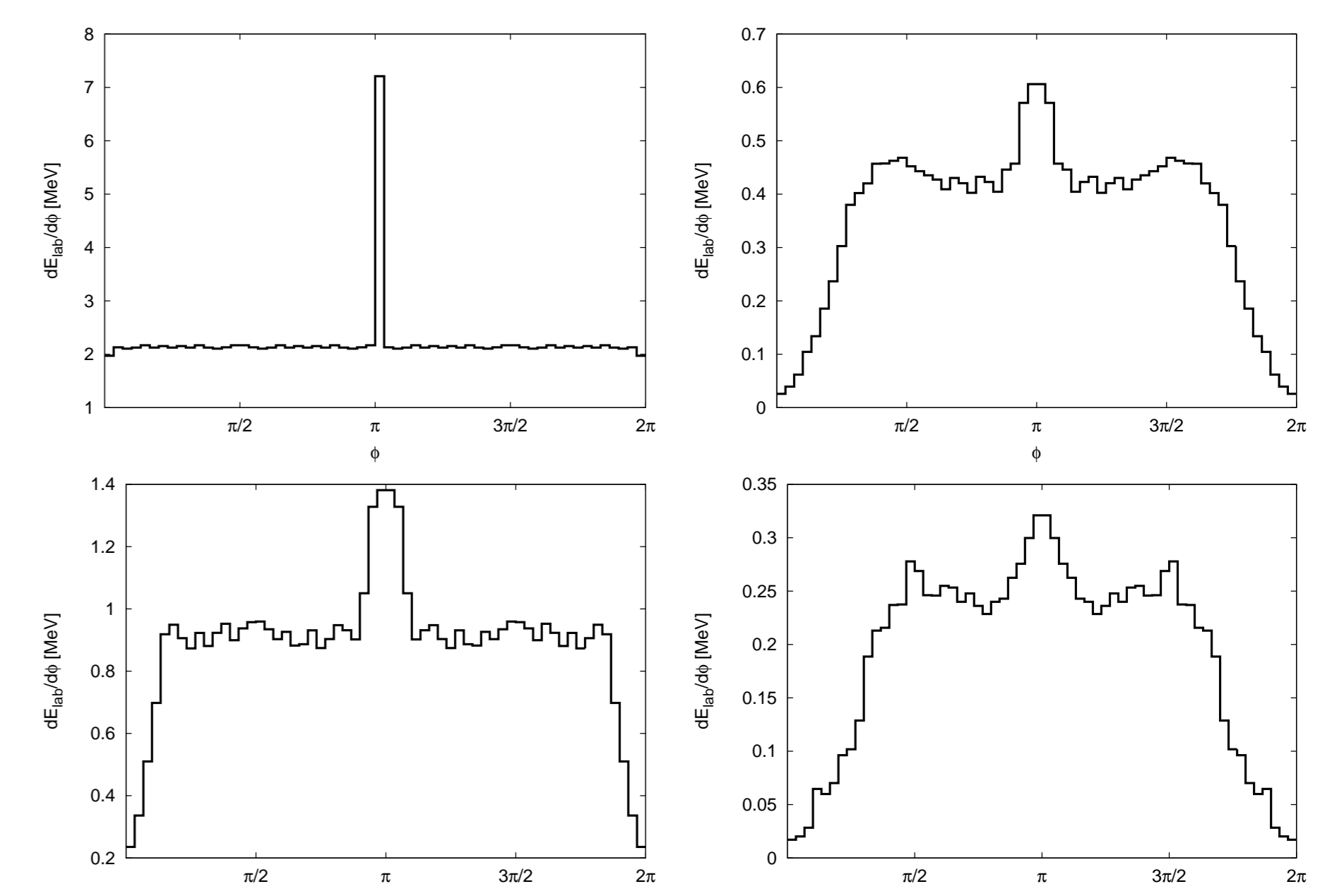
Influence of EoS

- Equation of State with phase transition to the quark-gluon plasma.

- Contour plot of the laboratory energy density for $t = 0 \text{ fm}/c$ and $t = 6.4 \text{ fm}/c$:



- Azimuthal angular distributions of the laboratory energy for $t = 0, 1.6, 4.0, 6.4 \text{ fm}/c$:



References

- [1] M. Gyulassy, P. Levai and I. Vitev, Nucl. Phys. B 594, 371 (2001); H. Stöcker, Nucl. Phys. A 750 (2005) 121; F. Antinori and E. V. Shuryak, J. Phys. G 31, L19 (2005).
- [2] C. Adler et al. [STAR Collaboration], Phys. Rev. Lett. 90, 082302 (2003); J. Adams et al. [STAR Collaboration], Phys. Rev. Lett. 91, 072304 (2003).
- [3] D. H. Rischke, S. Bernard and J. A. Maruhn, Nucl. Phys. A 595, 346 (1995).