Бегущая константа связи в голографических моделях КХД в сильном магнитном поле

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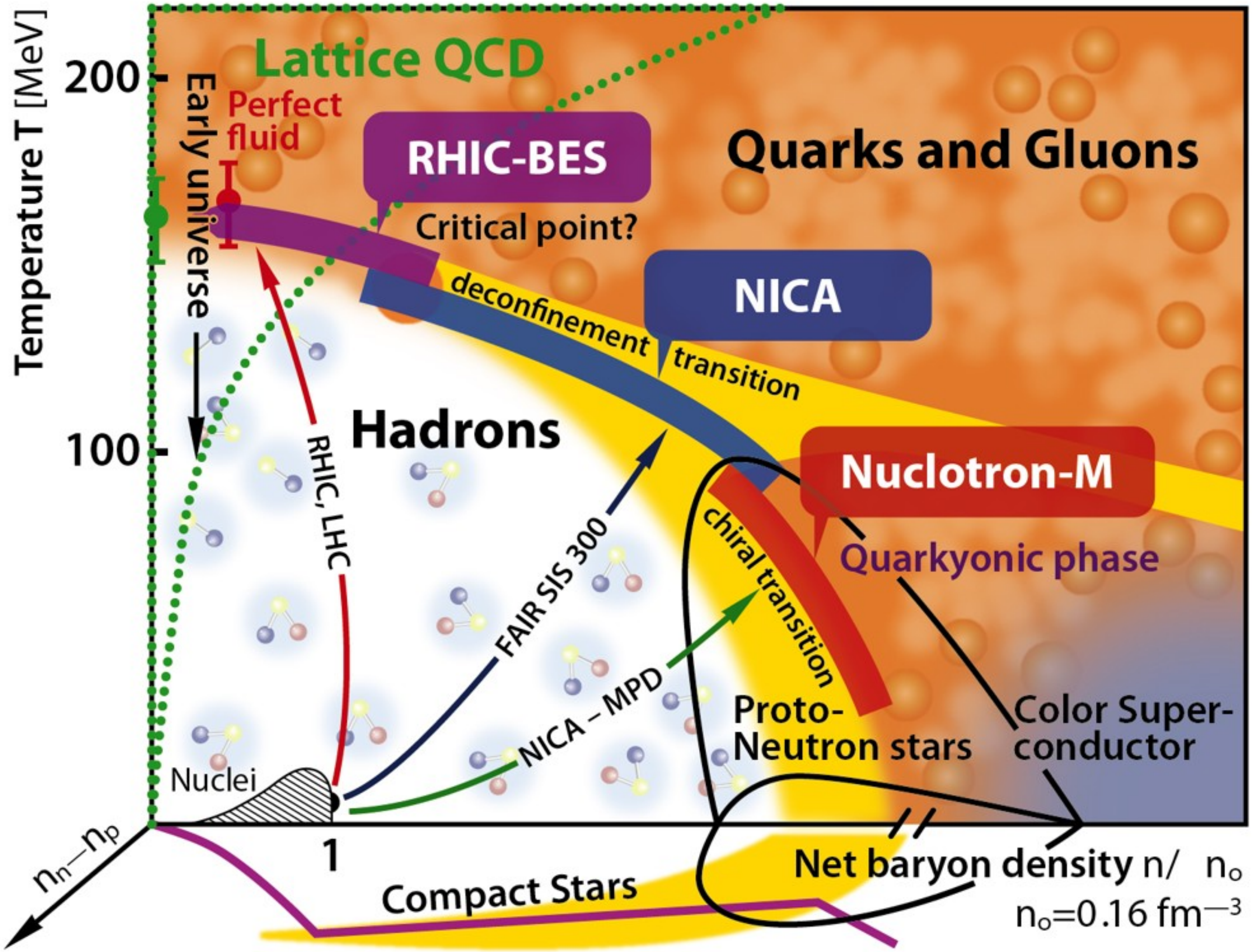
Studies of QCD Phase Diagram is the main goal of new facilities



From: https://nica.jinr.ru/physics.php

Prehistory and motivation

Perturbative methods are not suitable ➡

Lattice QCD calculations ➡

Problems in the case of chemical potential ➡

Holographic duality approach

⇕

Motivated by AdS/CFT duality Maldacena, 1998

Temperature in QCD ⇔ black hole temperature in (deform.) AdS5

Thermalization in QCD ⇔ black hole formation in (deform.) AdS5

Goal: **describe running coupling constant behavior in a magnetic field**

Holographic model setup of an anisotropic QGP in a magnetic field at a nonzero chemical potential

$$S = \int \frac{d^5x\sqrt{-g}}{16\pi G_5}\left[R - \frac{f_0(\phi)}{4}F_{(0)}^2 - \frac{f_1(\phi)}{4}F_{(1)}^2 - \frac{f_3(\phi)}{4}F_{(3)}^2 - \frac{\partial_\mu\phi\partial^\mu\phi}{2} - V(\phi)\right]$$

$$A_\mu^{(0)} = A_t(z)\delta_\mu^0, \quad F_{y_1y_2}^{(1)} = q_1, \quad F_{xy_1}^{(B)} = q_3\,.$$

<u>Ansatz for the metric:</u>

$$ds^2 = \frac{L^2}{z^2}e^{2A(z)}\left[-g(z)dt^2 + dx^2 + \left(\frac{z}{L}\right)^{2-\frac{2}{\nu}}dy_1^2 + e^{c_Bz^2}\left(\frac{z}{L}\right)^{2-\frac{2}{\nu}}dy_2^2 + \frac{dz^2}{g(z)}\right],$$

$$A(z) = -\,cz^2/4 - (p - c_Bq_3)\,z^4$$

$$c = 1.16\ GeV^2, \quad p = 0.273\ GeV^4, \quad \nu = 1, \quad L = 1\ GeV^{-1}$$

Holographic model setup of an anisotropic QGP in a magnetic field at a nonzero chemical potential

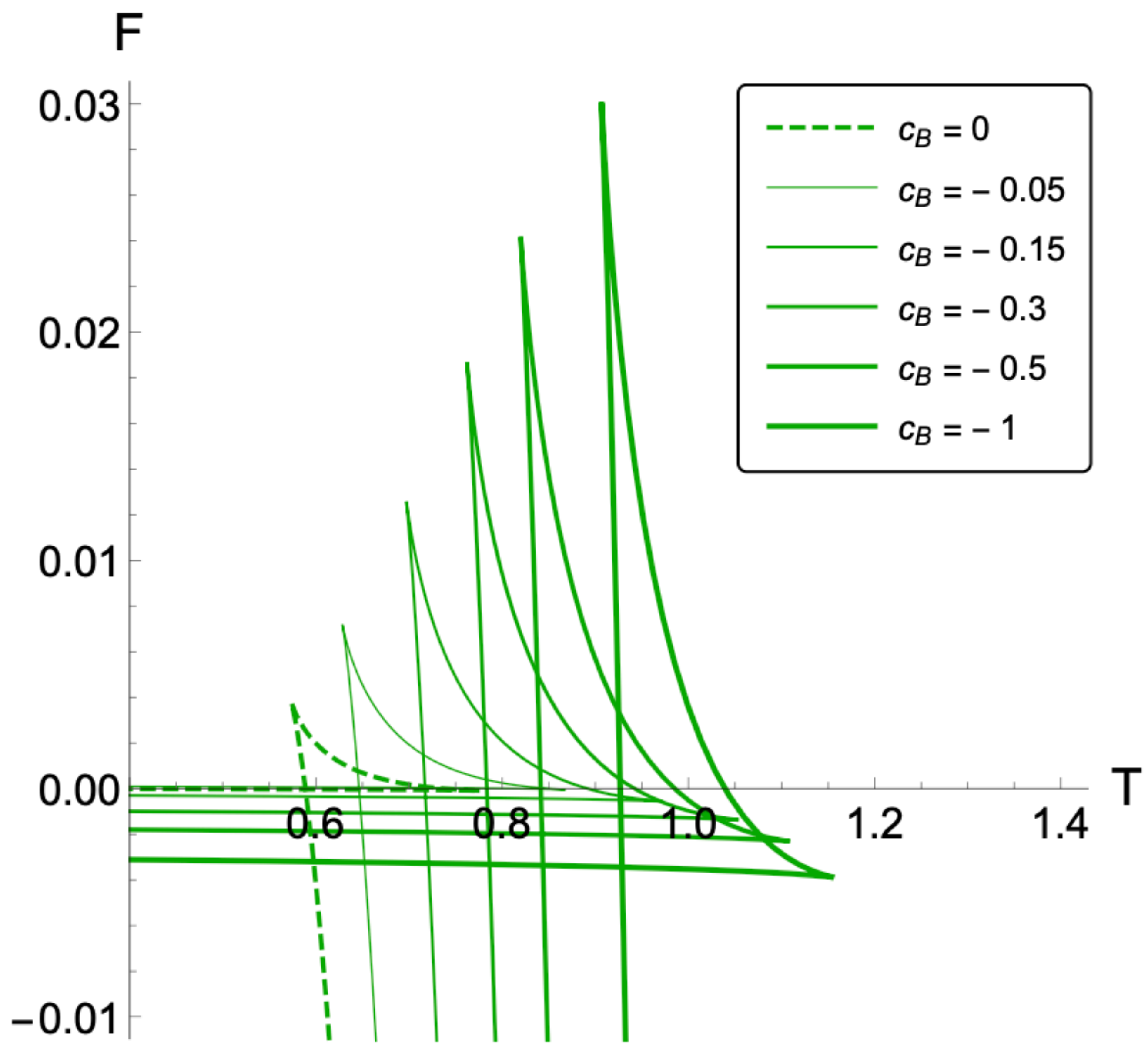
General form of the boundary conditions:

$$A_t(0) = \mu, \quad A_t(z_h) = 0, \qquad g(0) = 1, \quad g(z_h) = 0,$$

$$\varphi(z)\Big|_{z=z_0} = 0, \qquad z < z_h, \quad z_0 = exp(-z_h/4) + 0.1$$

Aref'eva, Slepov, Hajilou, Usova
arXiv:2402.14512

Temperature and Free energy

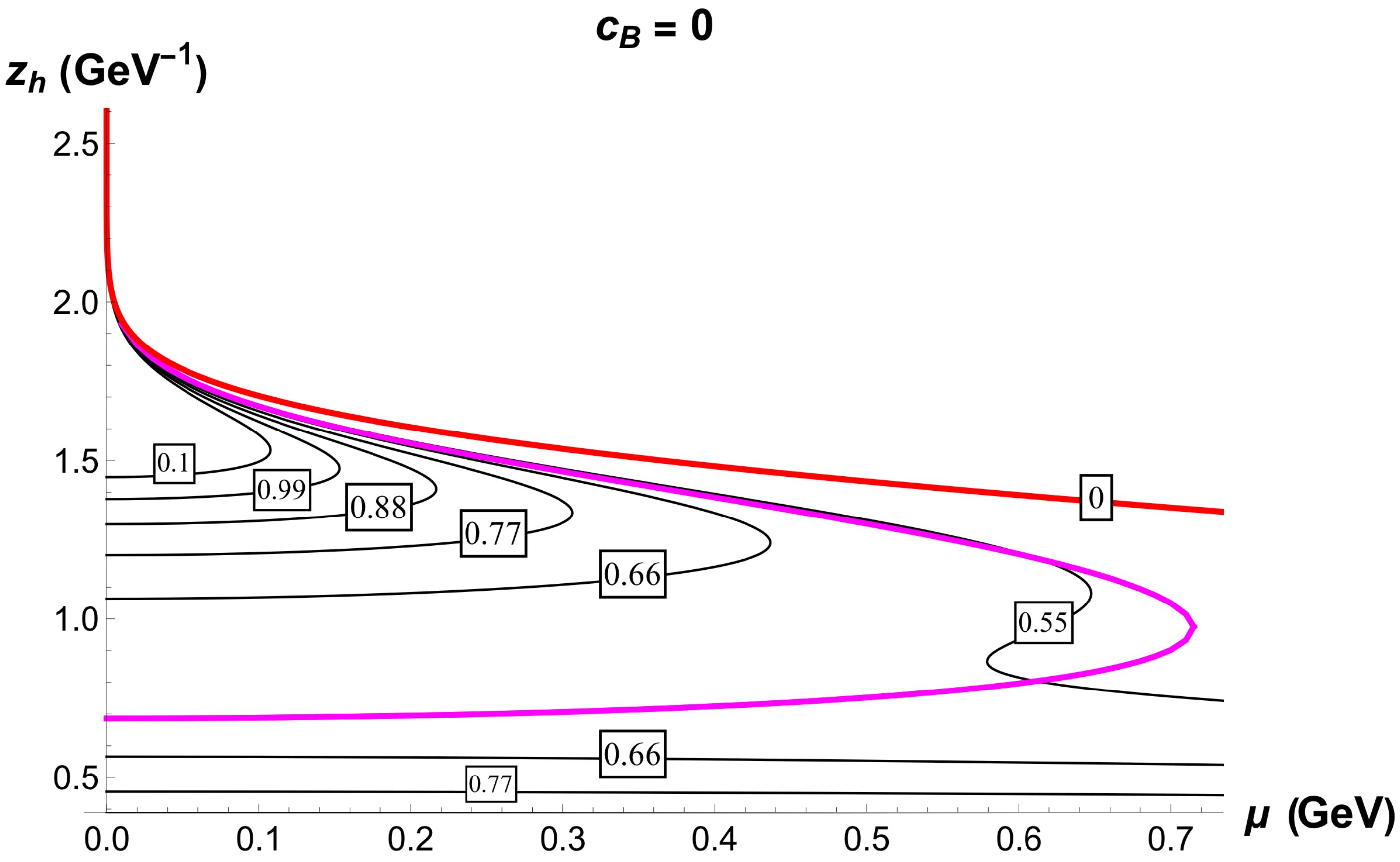


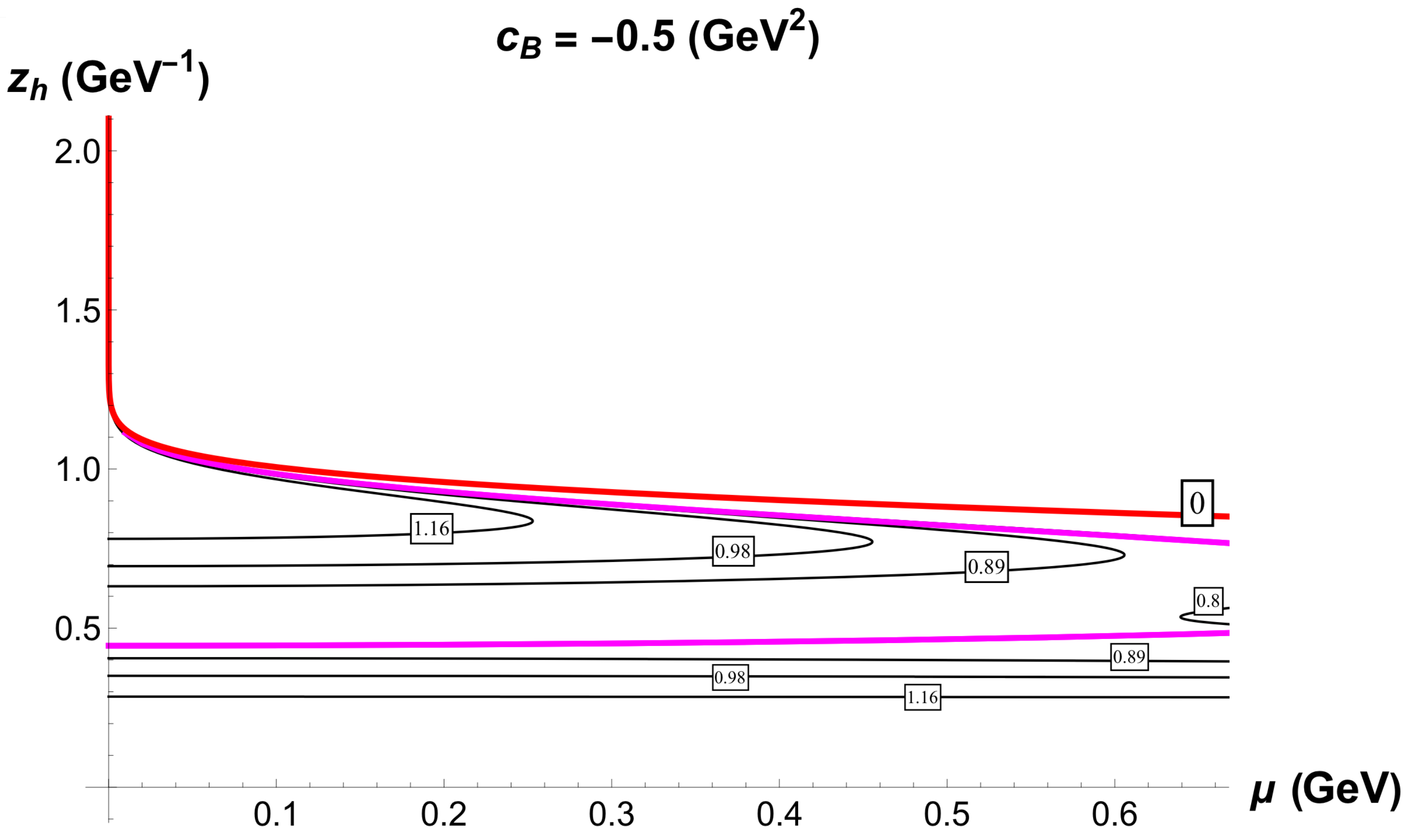
$$T = \left.\frac{|g'|}{4\pi}\right|_{z=z_h},$$

$$F = -\int s\, dT = \int_{z_h}^{\infty} s\, T'\, dz_h$$

Aref'eva, Ermakov, Rannu, Slepov 2203.12539

First order Phase transition





Running coupling constant

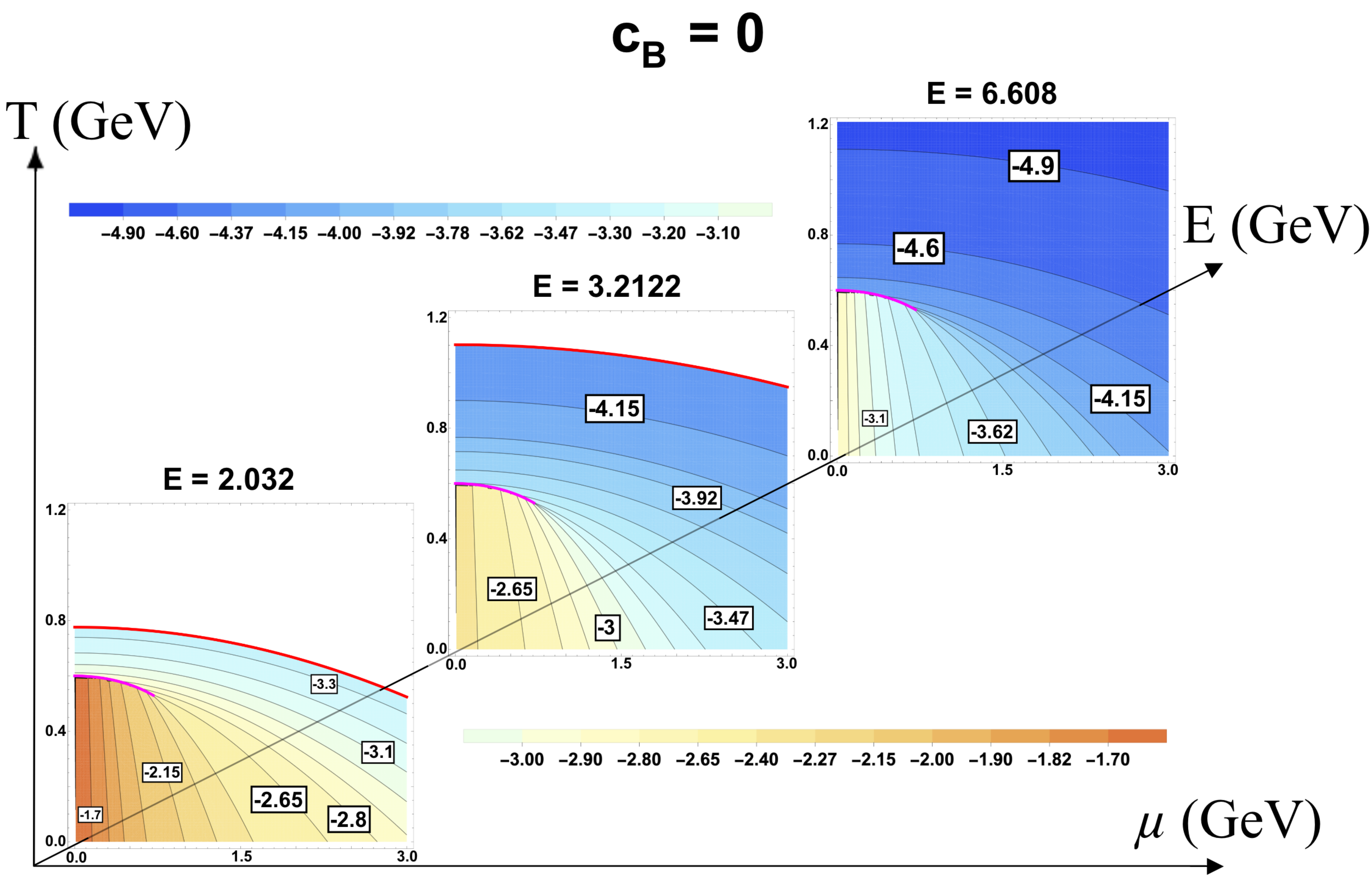
We have the following holographic dictionary:

- $B(z) = \dfrac{e^{A(z)}}{z}$ — **corresponds to the energy scale E of the dual field theory**
- $\phi(z) = \log(\alpha)$ — **must be identified as running coupling of the field theory**

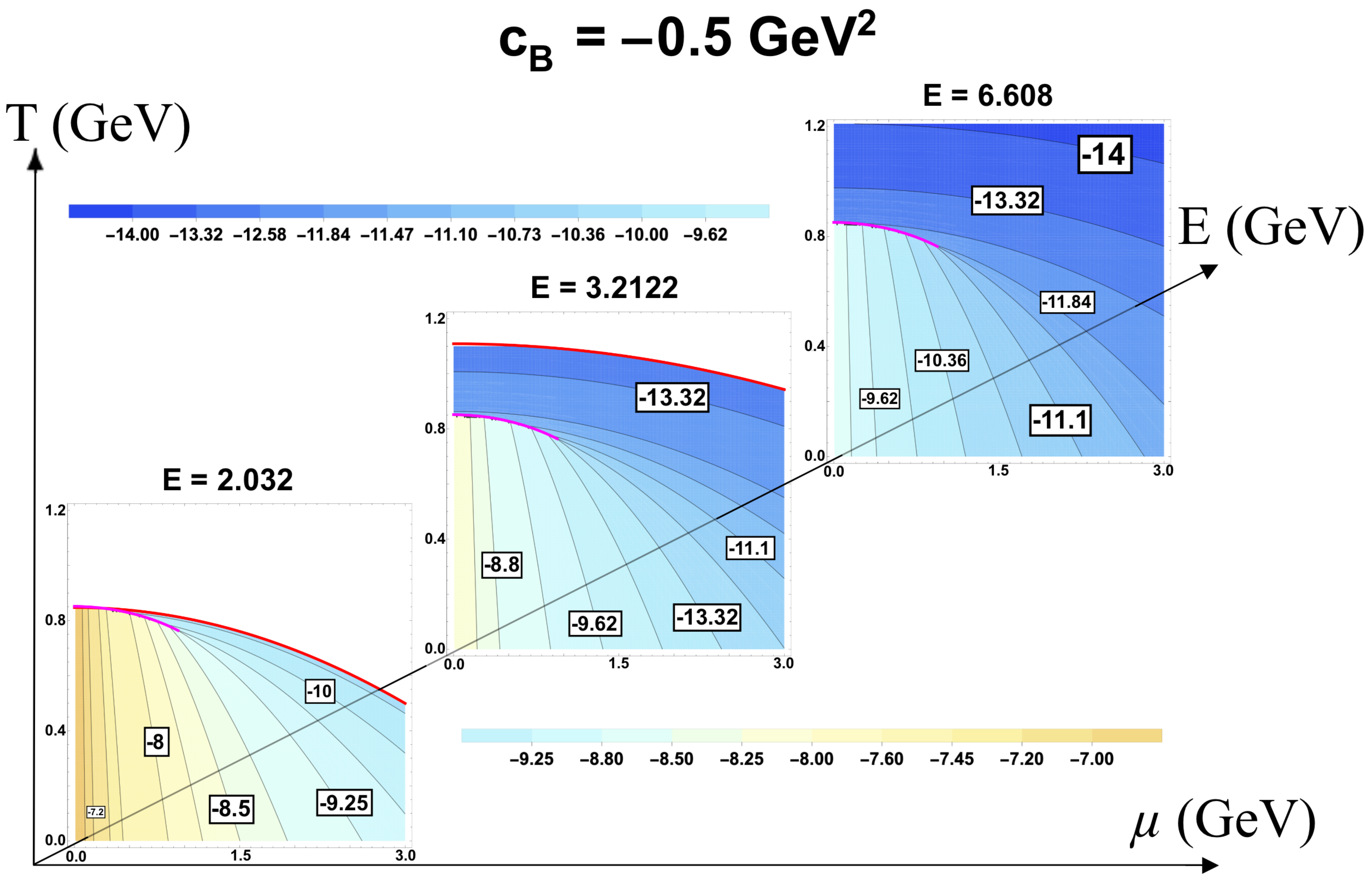
- **Connection with β-function in this background (DeWolfe et. al. '14, Kiritsis et.al.'14):**

$$\beta = \frac{d\alpha}{d\log E}\bigg|_{QFT} = \alpha \frac{d\varphi}{d\log B}\bigg|_{Holo}$$

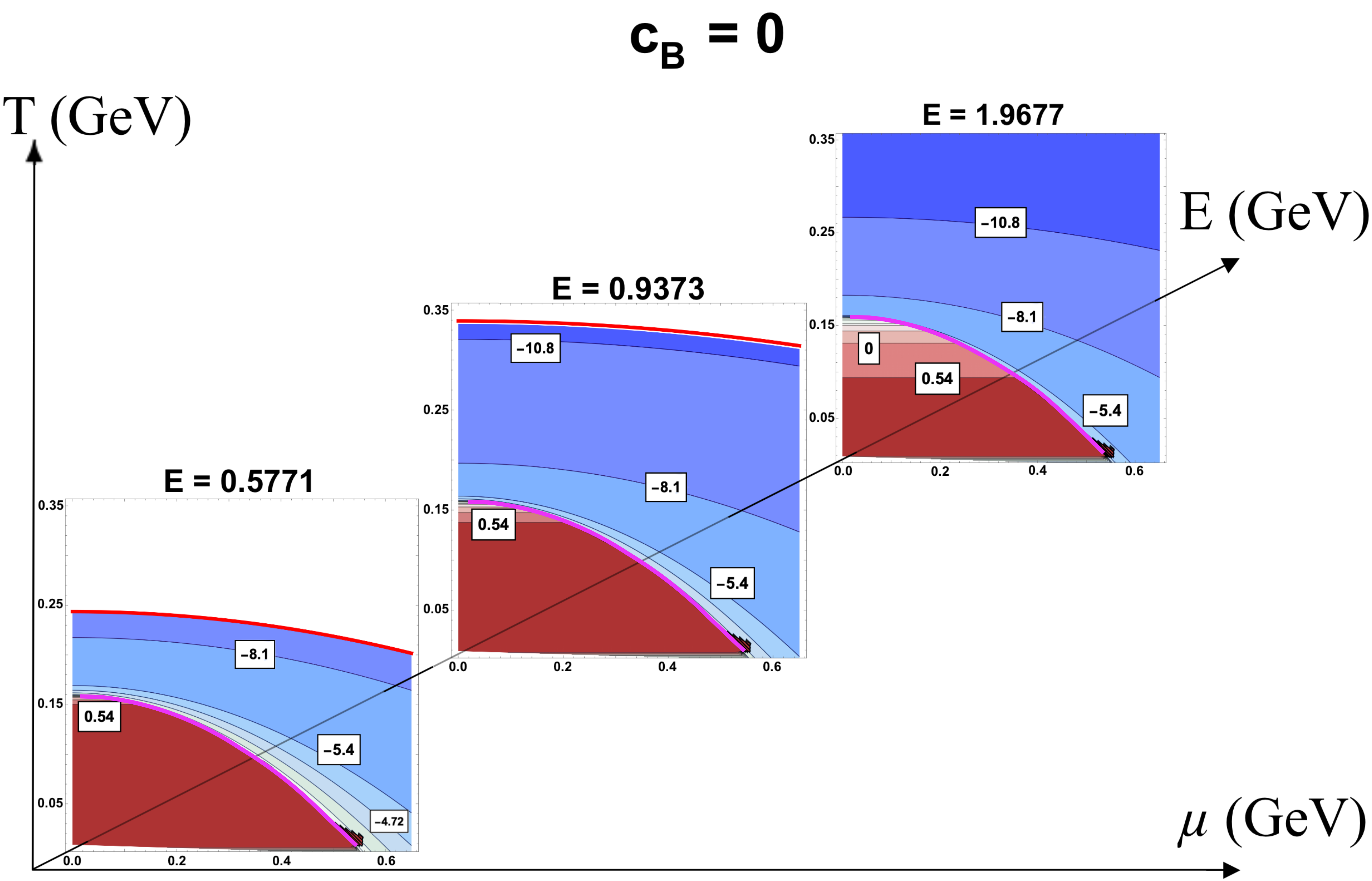
Running coupling in magnetic field HQ



Running coupling in magnetic field HQ

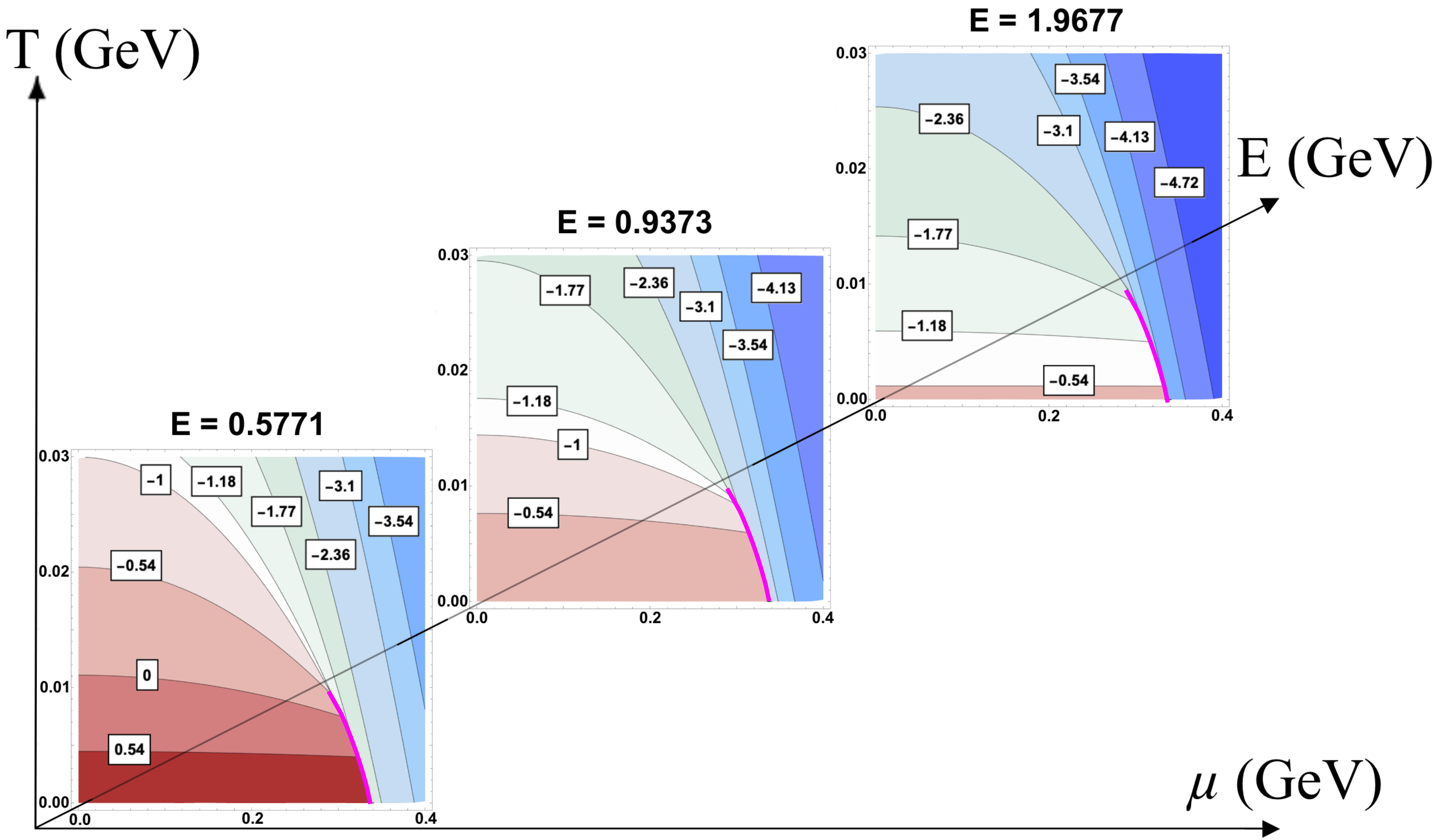


Running coupling in magnetic field LQ



Running coupling in magnetic field LQ

$c_B = -0.05\ \mathrm{GeV}^2$



Conclusion

- **The magnetic field reduces the value of the running coupling constant α at fixed temperatures T and chemical potentials μ.**
- **The running coupling α decreases with increasing energy scale E**
- **In the hadronic phase, the HQ running coupling α varies slowly with changes in T for both variants.**
  LQ's α varies slowly with changes in chemical potential μ
- **Significant dependence of α in the QGP phase on chemical potential and temperature for both variants**
- **Along the 1st order phase transition line, the running coupling exhibits a discontinuity. This discontinuity decreases along the transition line and vanishes at the critical end point (CEP).**


Thank you!