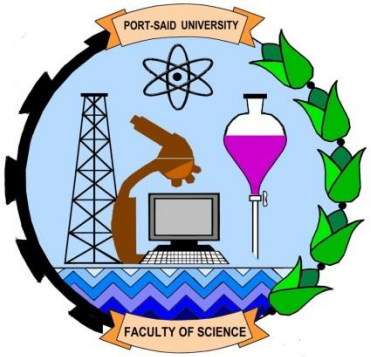
Egyptian Network for High Energy Physics

(ENHEP)



What is the "Perfect Liquid" ?

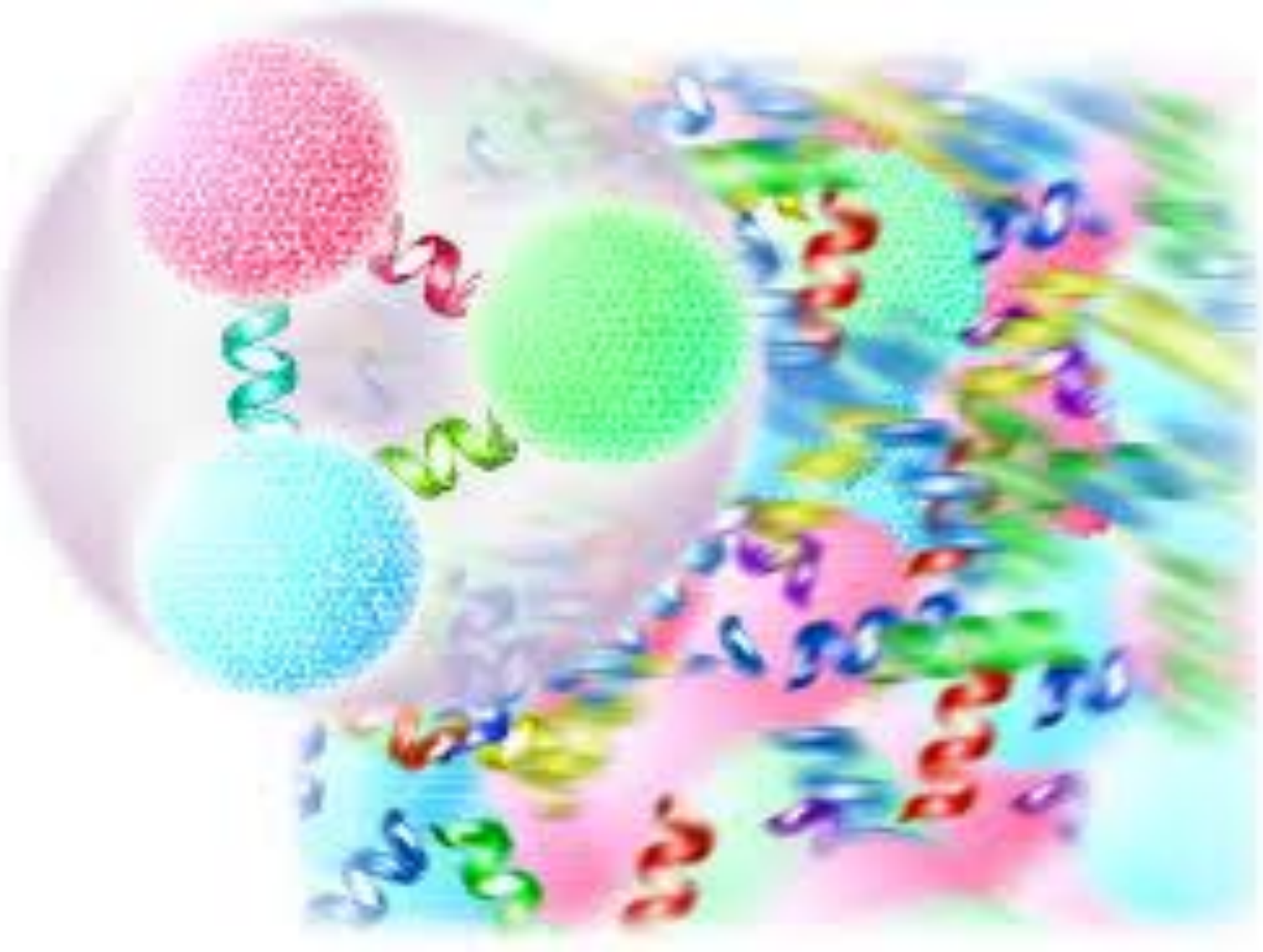
Is it coffee ?

Actually No

Is it a beer ?

No it's not

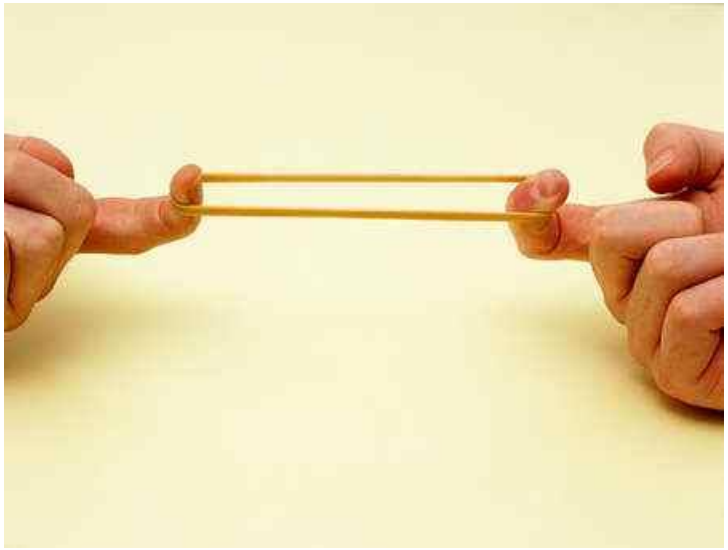
It is Quark Gluon Plasma (QGP)

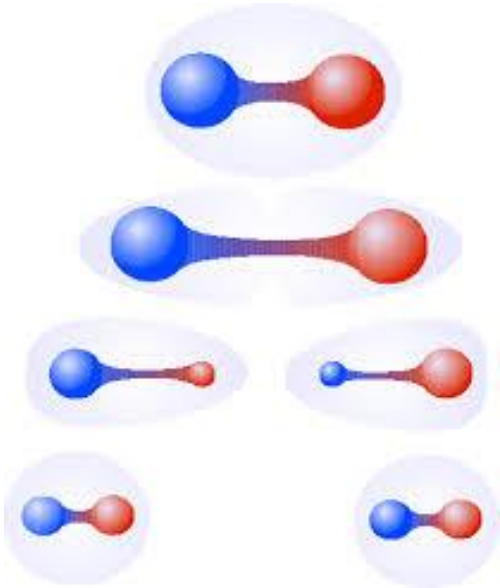


The Idea of Quark-Gluon Plasma

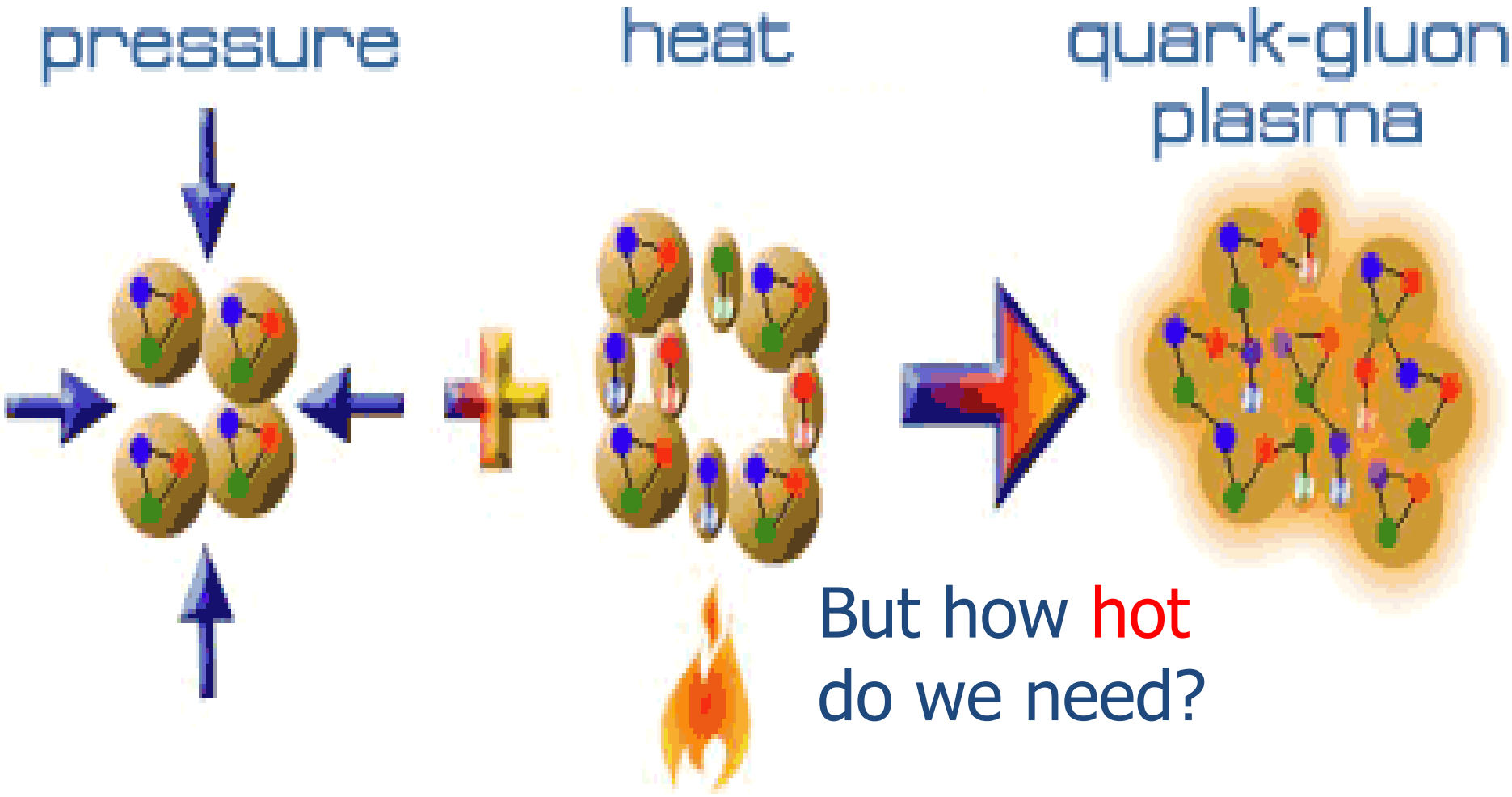
- Typical nucleon energy density (energy inside the nucleon) is about 0.13 GeV/fm^3.
- Higher temperature → higher energy density → create more new particles (by $E = mc^2$)
- When the energy density exceeds 1GeV/fm^3, many new particles are made → packed close together
- matter will exist not as hadrons (protons, neutrons…), but as independent quarks and gluons.
- In this medium, the quarks and gluons are deconfined.
- It is called "Quark–Gluon Plasma "

Quarks are slaves of their own color charge ... bound like prisoners of a chain gang ... Any locksmith can break the chain between two prisoners, but no locksmith is expert enough to break the gluon chains between quarks ... Quarks Remain Slaves Forever ! ...



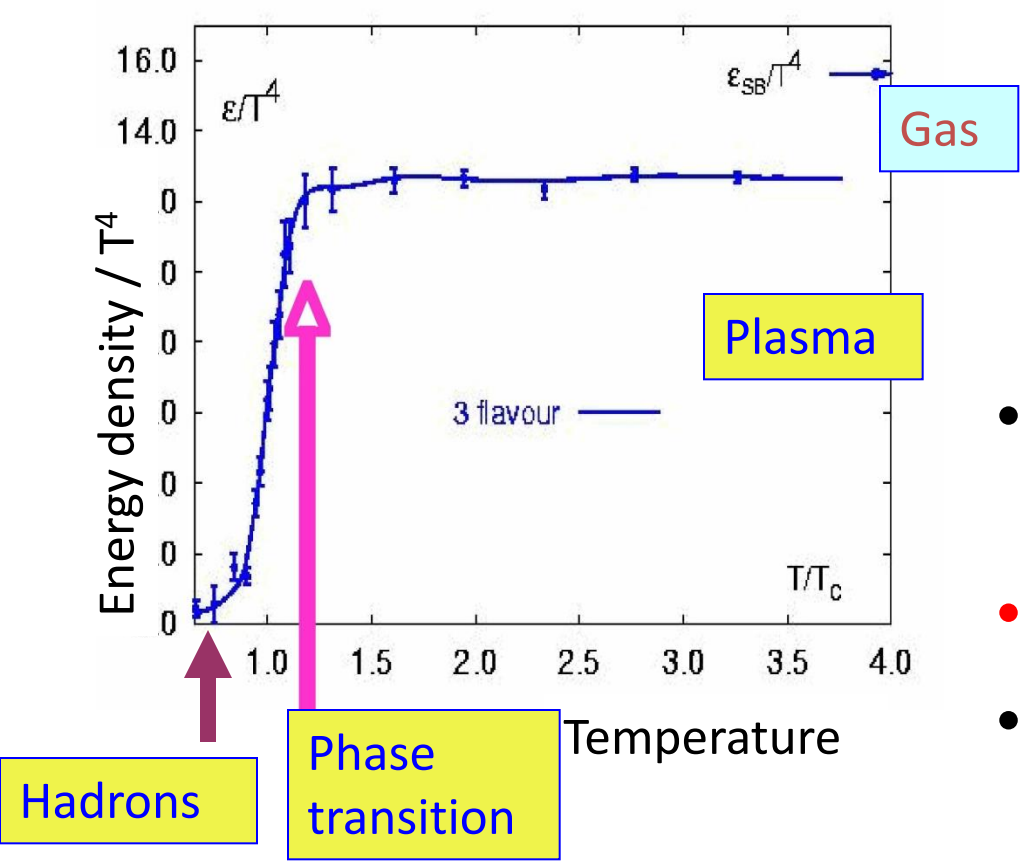


How do we melt the nucleon?



But how hot do we need?

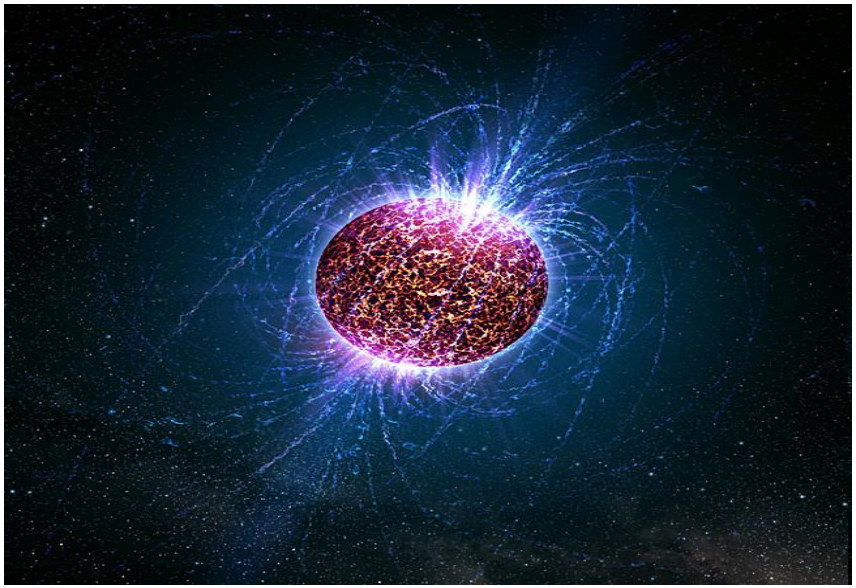
How hot do we need?



- At critical temperature, T_C, the energy density increases rapidly due to the increase of degrees of freedom. (d_p -> d_{QGP})
- T_C ~ 175MeV. The energy density ε~1GeV/fm^3.
- T_C ~ Trillion (10^{12}) K
- Temperature of the core of Sun: T~10^7 K

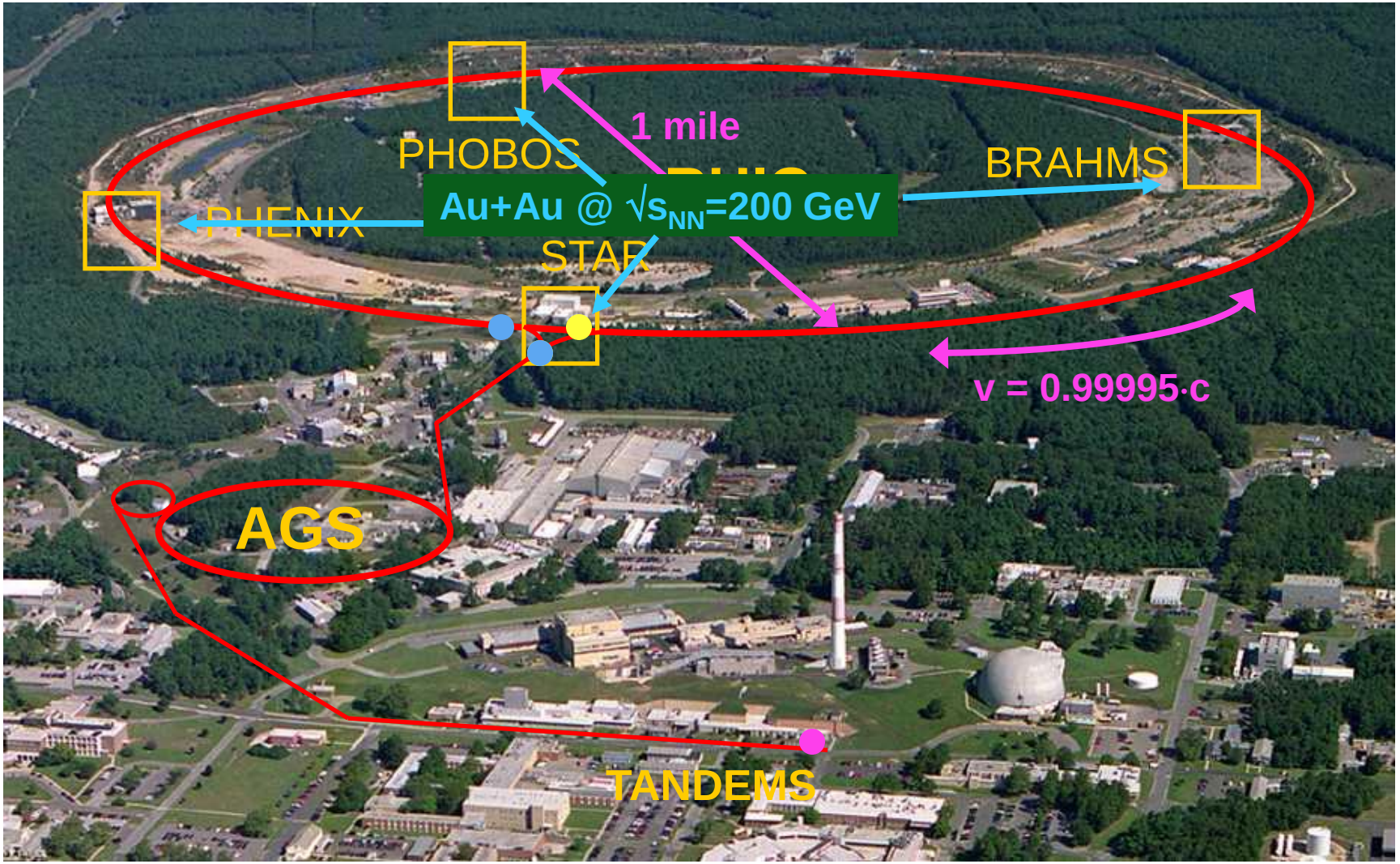
Where in the universe can we achieve this extreme condition?

- $T \sim 10^{12}$ K: 1 micro second after the Big Bang



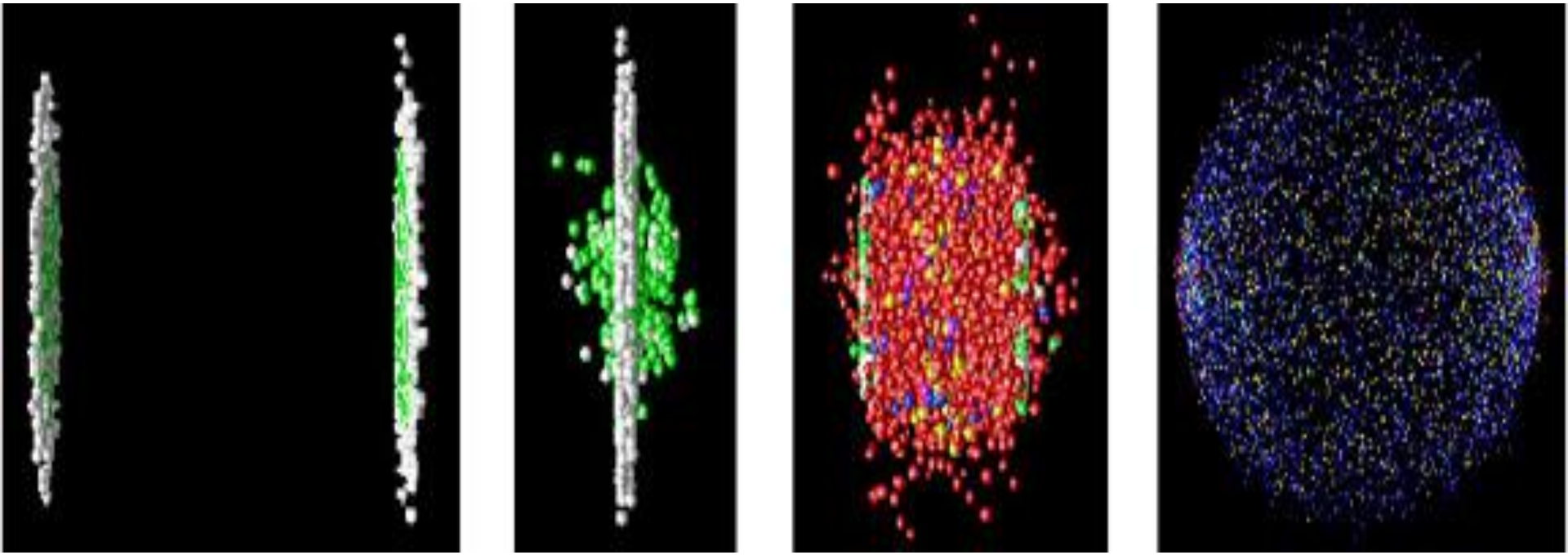
- Super high pressure: maybe inside the neutron star
- Where else?

Relativistic Heavy Ion Collider (RHIC)



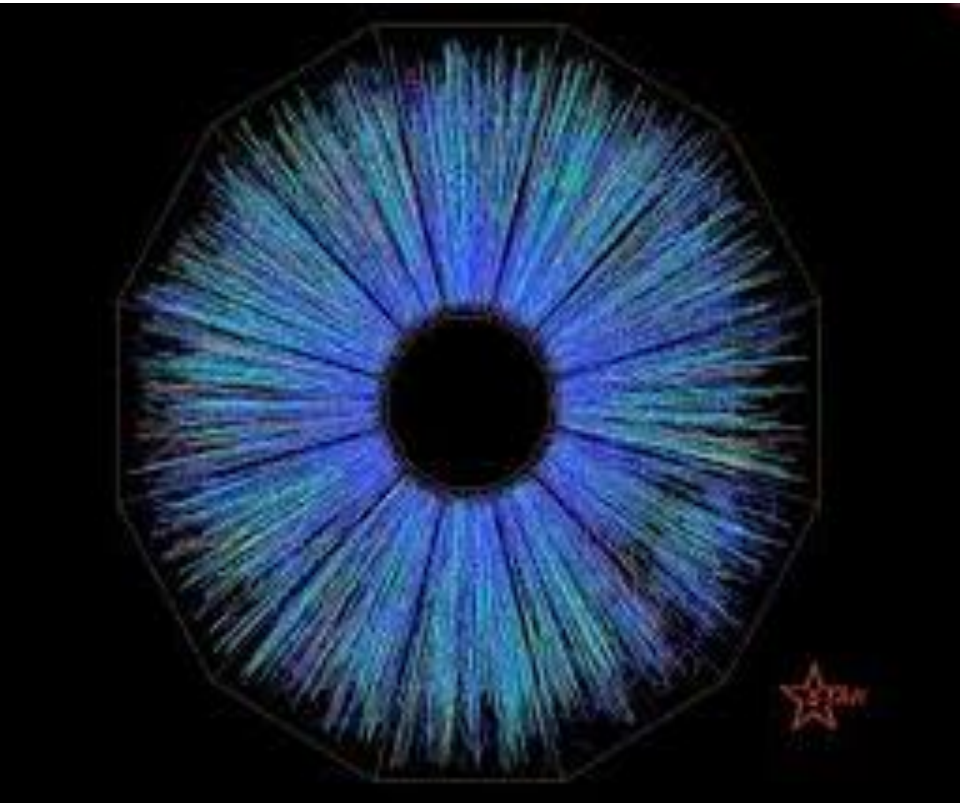
Maximum energy: Au+Au at √s = 200 GeV per nucleon pair

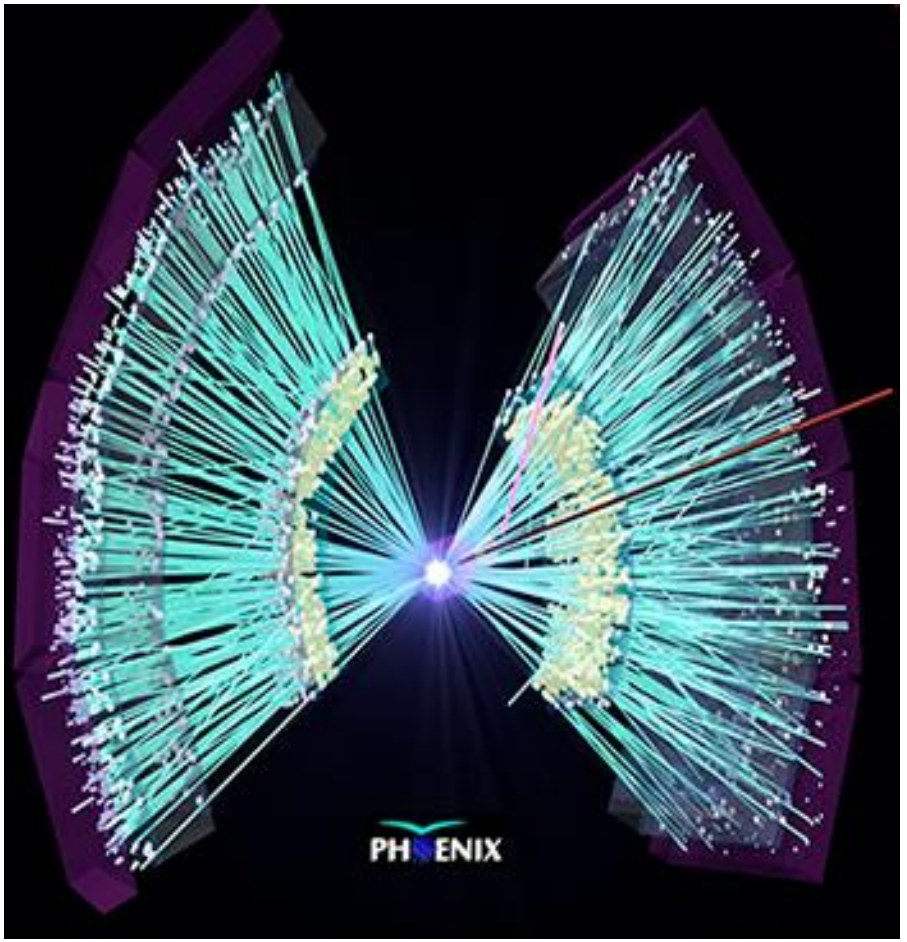
What happens in heavy ion collisions?



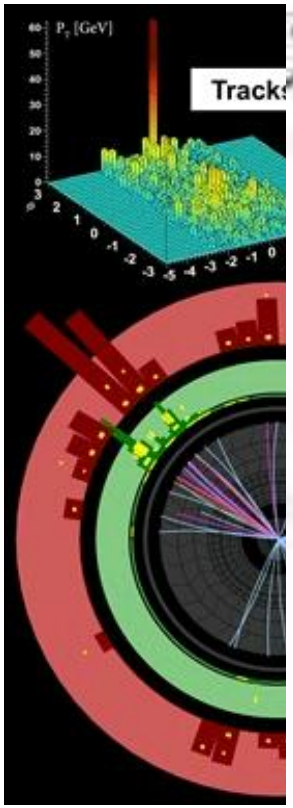
- The beams travel at 99.995% the speed of light.
- The two ions look flat as a pancake due to Relativity. (γ~106 at full energy collision at RHIC).
- The two ions collide and smash through each other for 10^{-23} s
- The collision “melts” protons and neutrons, and liberates the quarks and gluons.

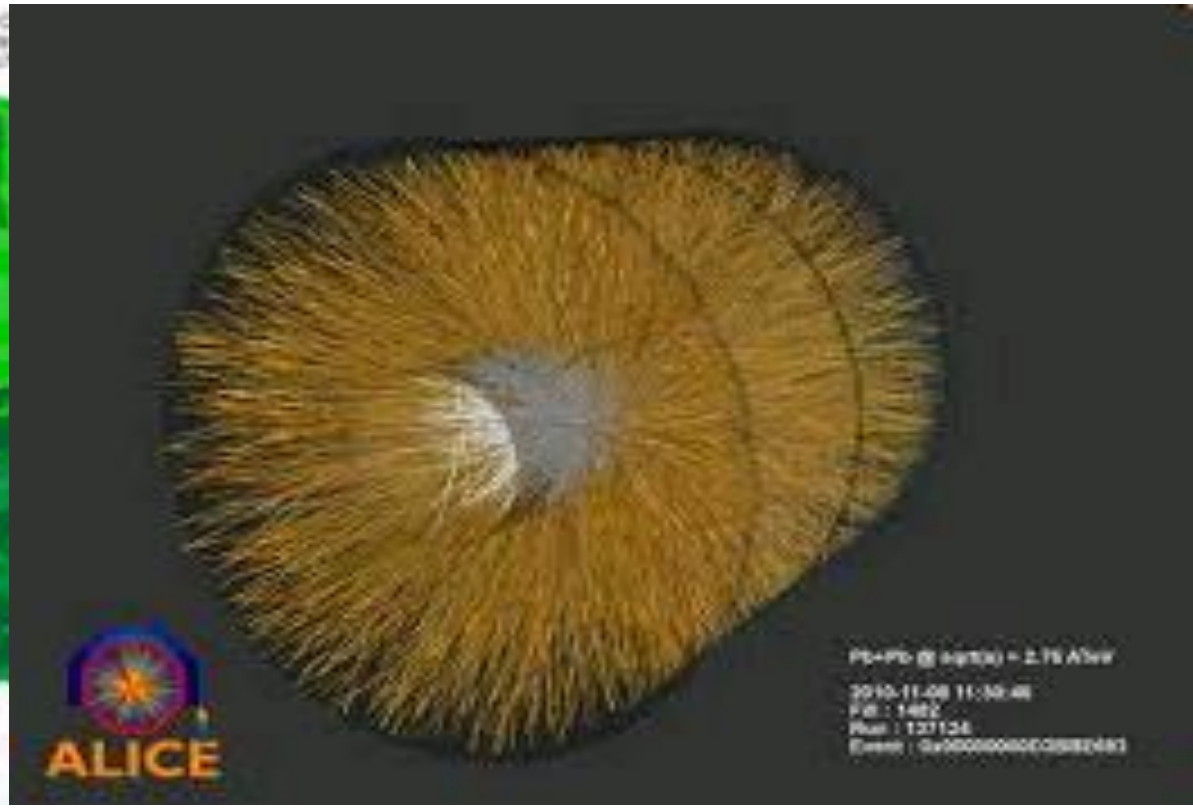
Events viewed by detectors





A even hotter matter at LHC



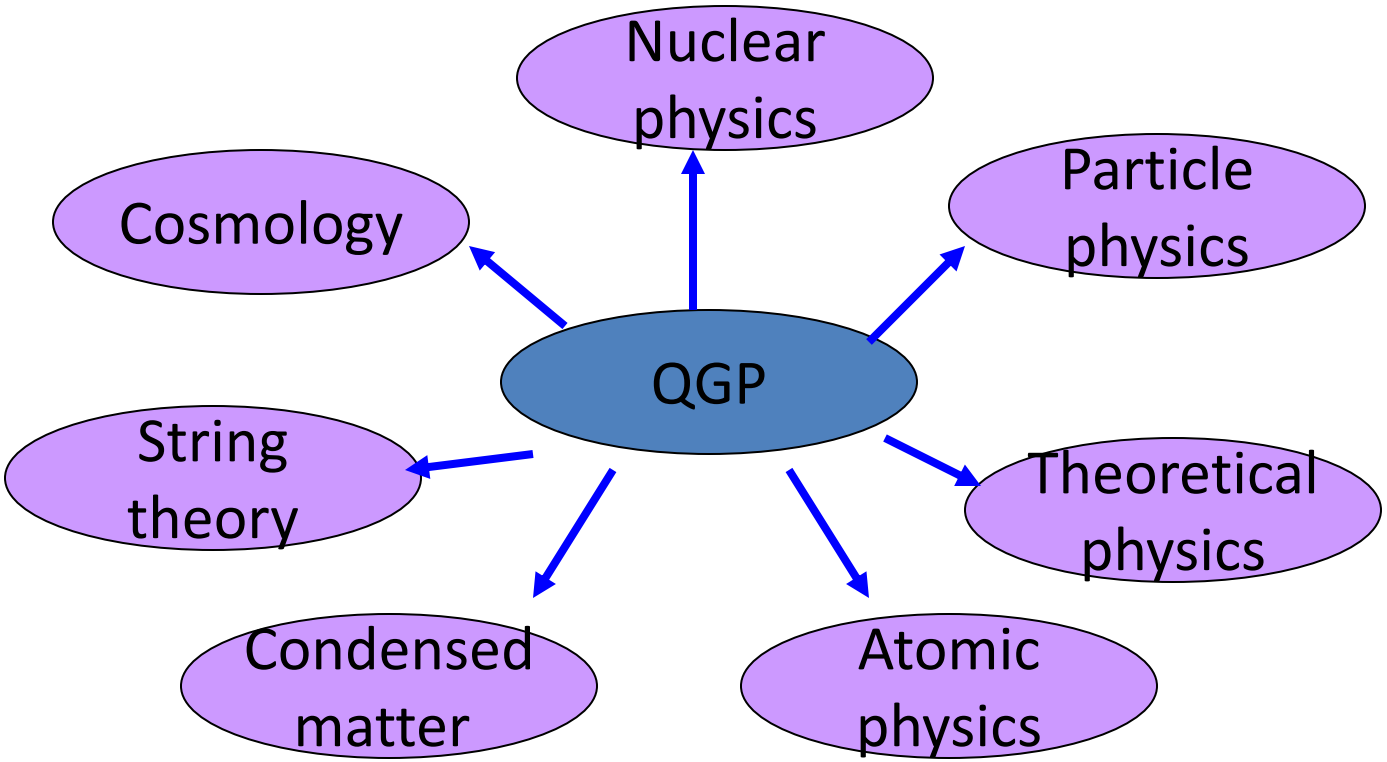


- The Large Heavy Ion Collider
- Three experiments: ATLAS, CMS, ALICE (dedicated HI experiment)
- Collides Pb+Pb at $\sqrt{s_{NN}}$ = 2.76/5.5 TeV, and p+p at $\sqrt{s}$ = 2.76 TeV for reference

Some Properties of QGP

- Low Viscosity.
- High Opacity.
- Very High Temperature.
- Collective Flow: it flows like a perfect fluid; lowest viscosity in the world.

Connection with other area of physics



QGP is highly active!!

References

- http://home.web.cern.ch/about/physics/heavy-ions-and-quark-gluon-plasma
- http://en.wikipedia.org/wiki/Quark%E2%80%93gluon_plasma
- http://www.bnl.gov/rhic/physics.asp

Thank you!

Samy Salem