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ALICE

Making the hottest liquid in the universe

What jets can tell us about the Quark-Gluon Plasma

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PhD Day
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Target audience: High
school students

Why collide nuclei?

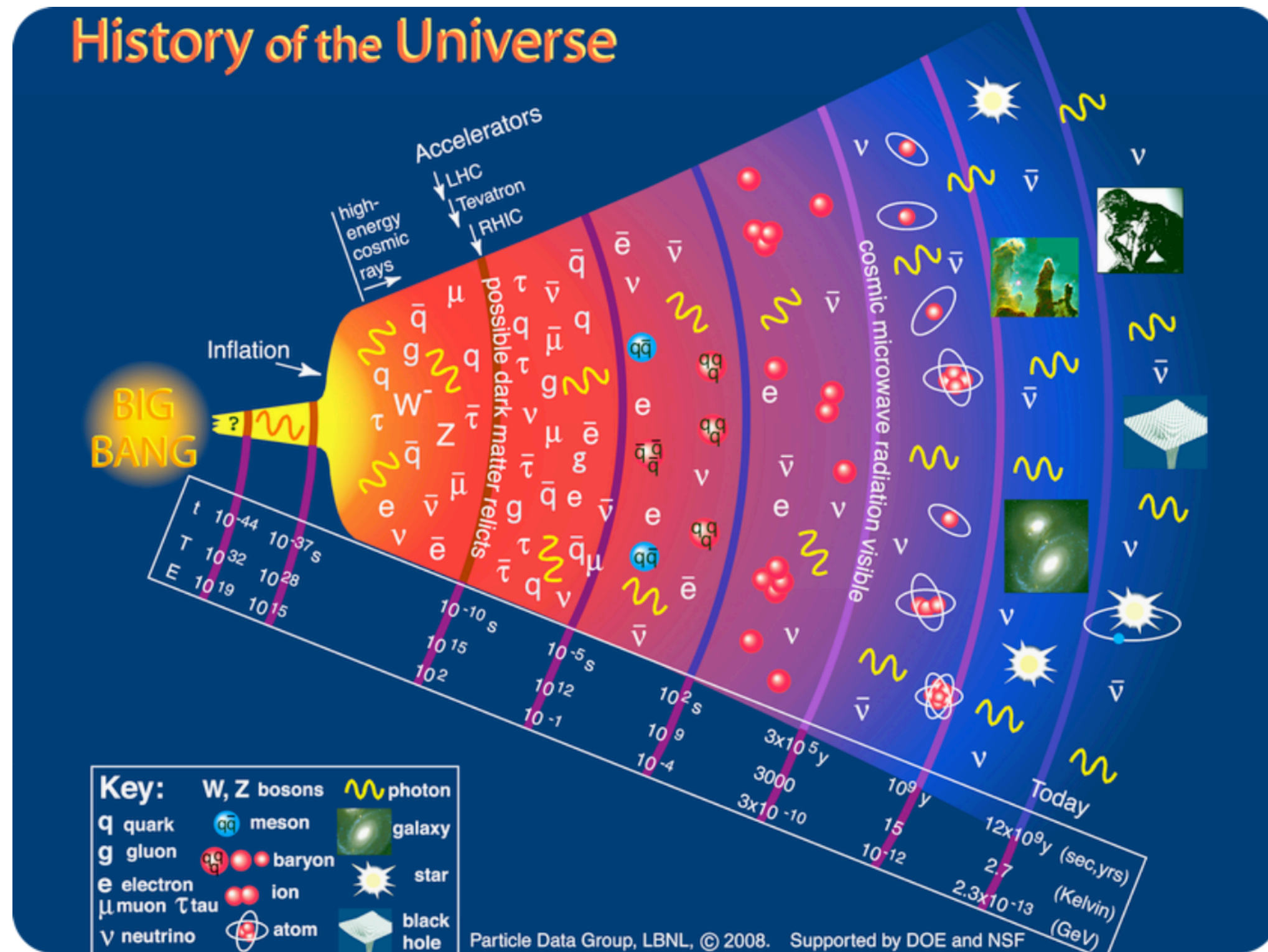


image credit



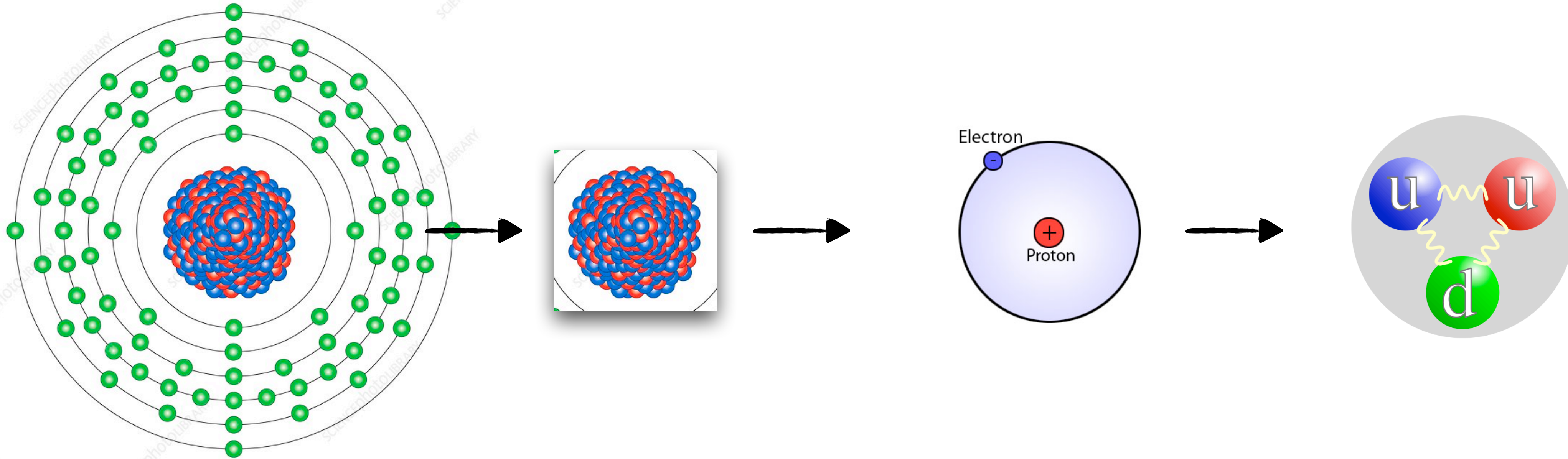
image credit: CERN

Could The Large Hadron Collider Make An Earth-Killing Black Hole?

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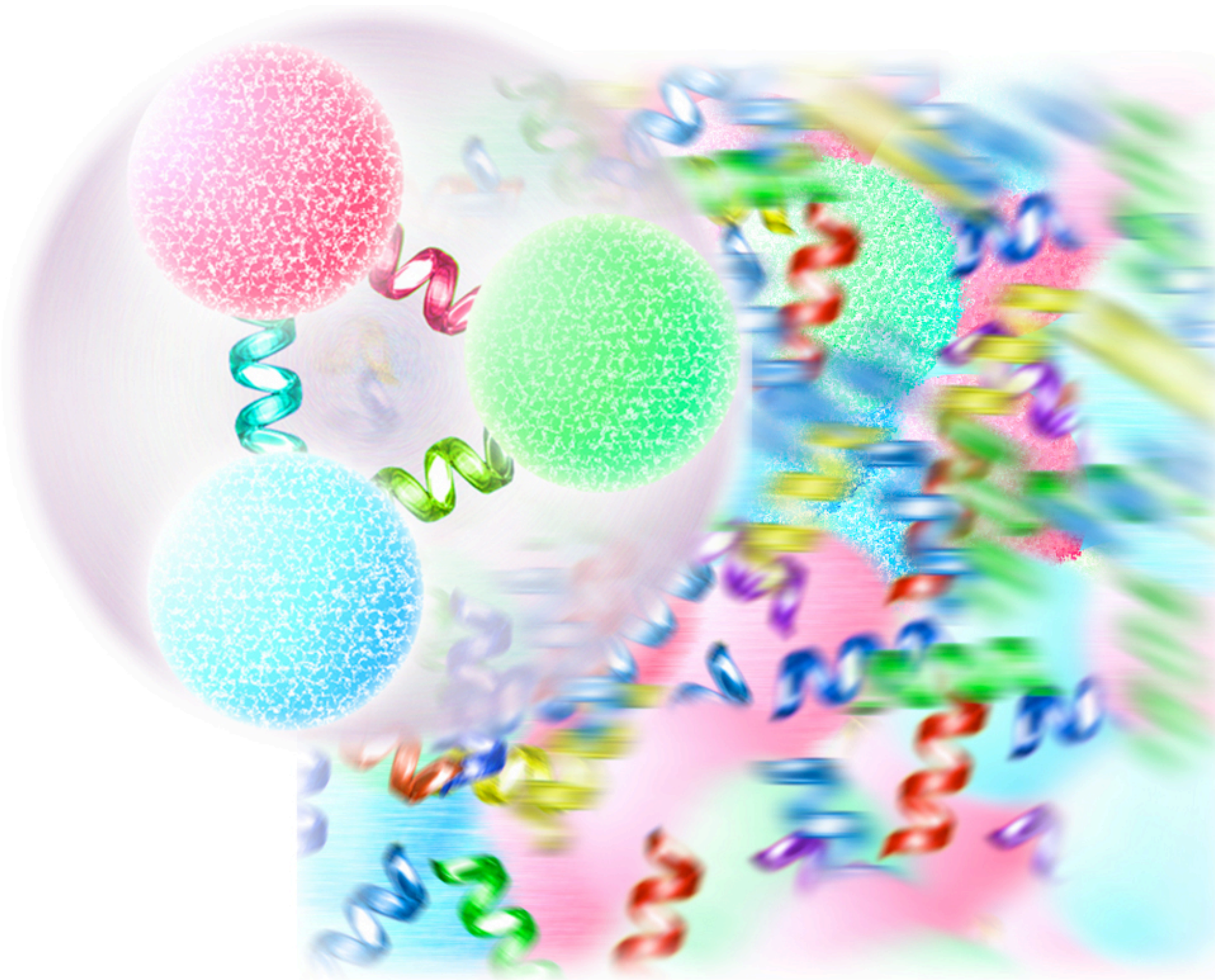
- *What happens if we recreate the universe a microsecond after the Big Bang?*

Ordinary matter



- Normally quarks are **confined**

Quark-Gluon Plasma



At extreme temperature the nucleons “melt”

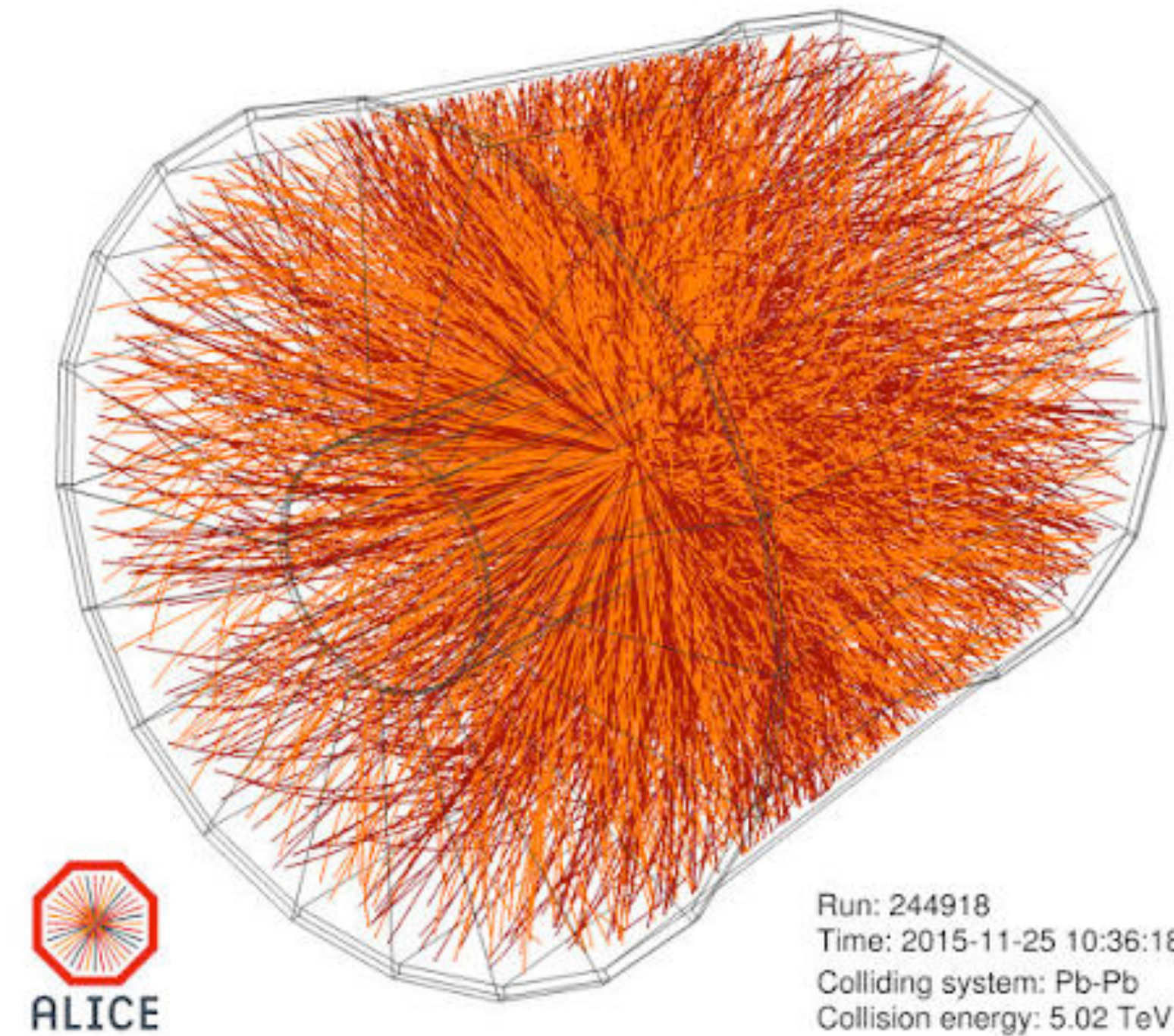
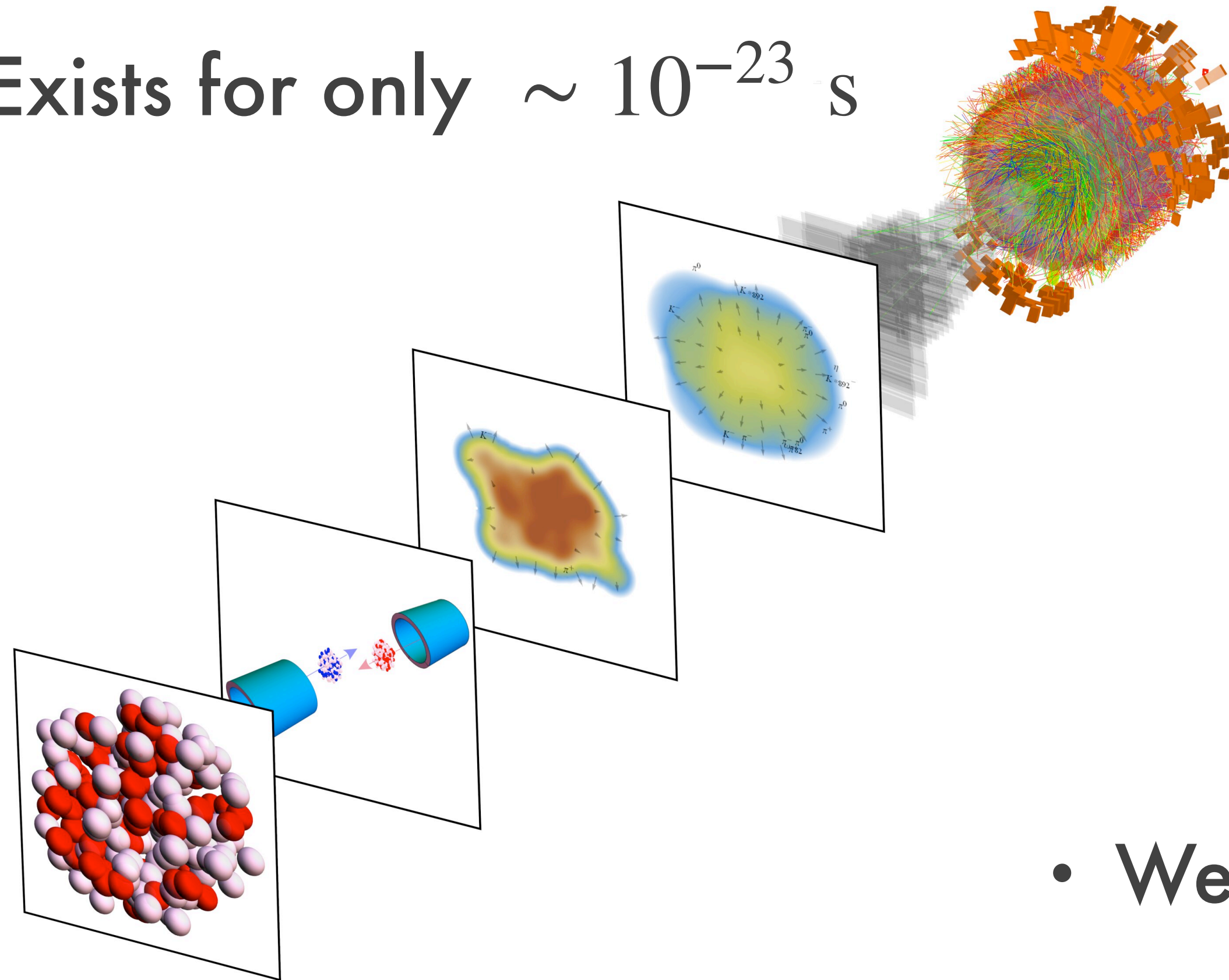
- 2×10^{12} K $\sim$ 100.000 times hotter than the suns core

Images
[image credit](#)
[image credit](#)
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image credit: steam

How do we observe it?

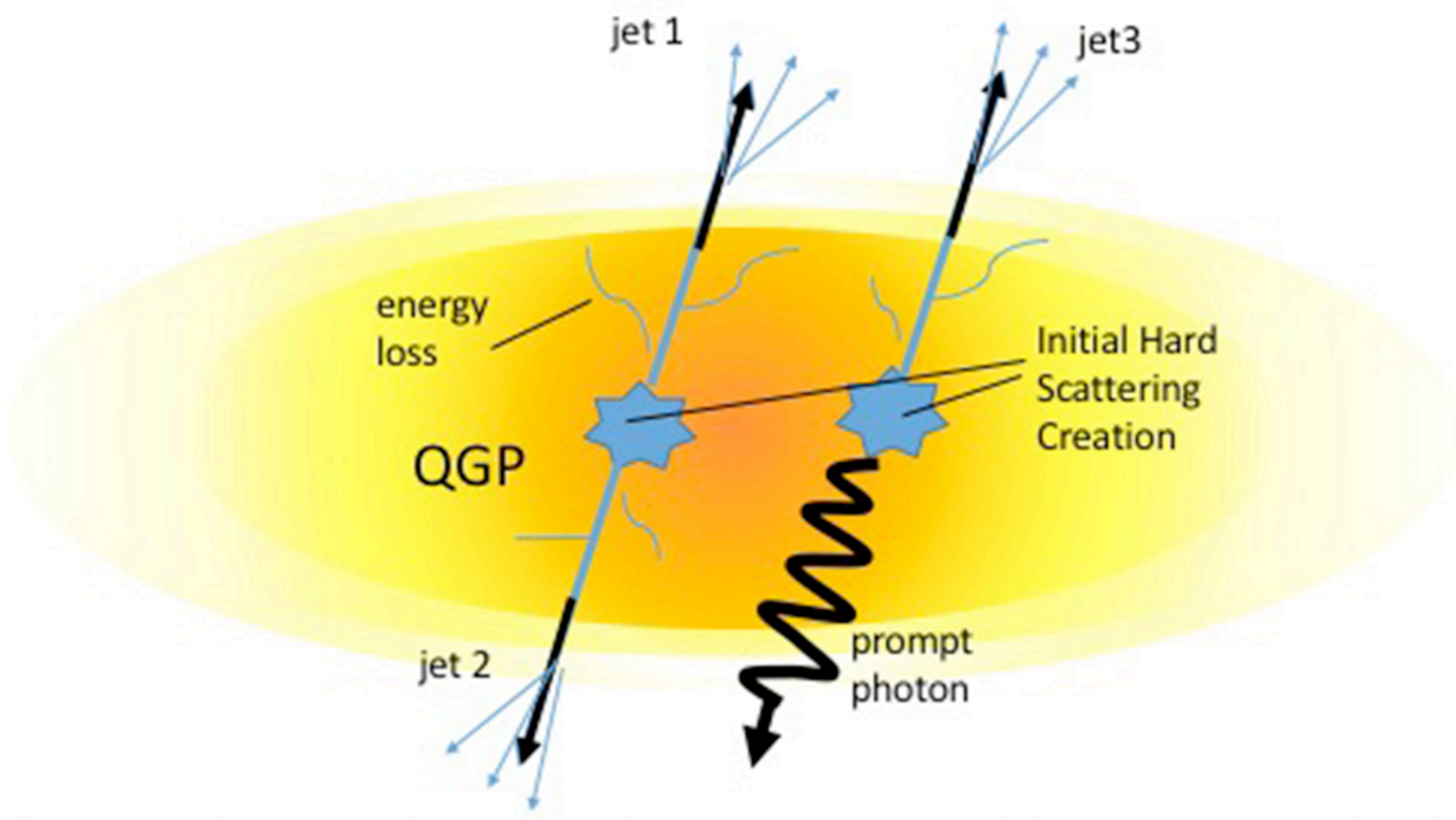
- ... How do we know it exists?
- Exists for only $\sim 10^{-23}$ s



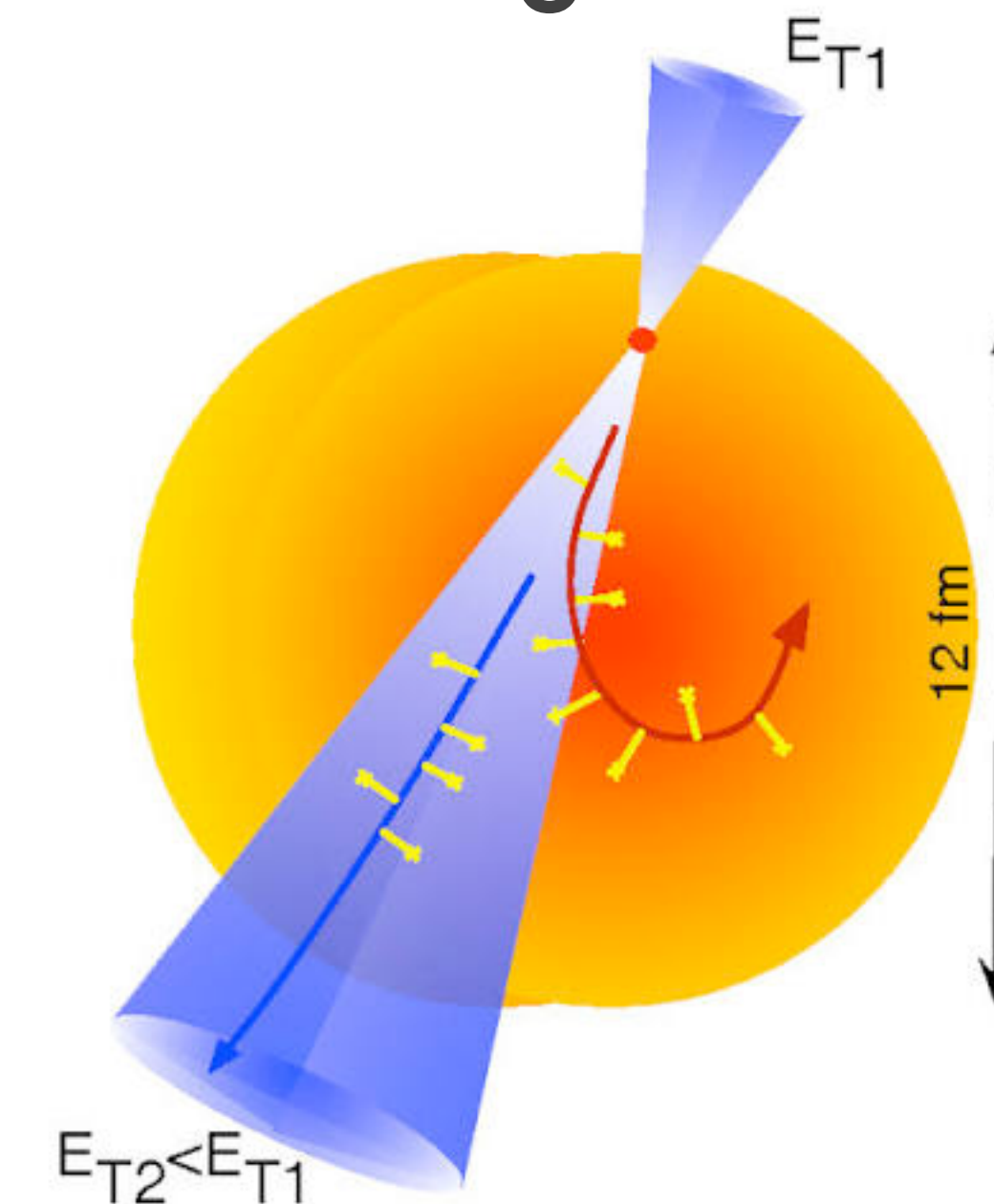
- We cannot see it directly
- Need experimental probes

Jets as probes

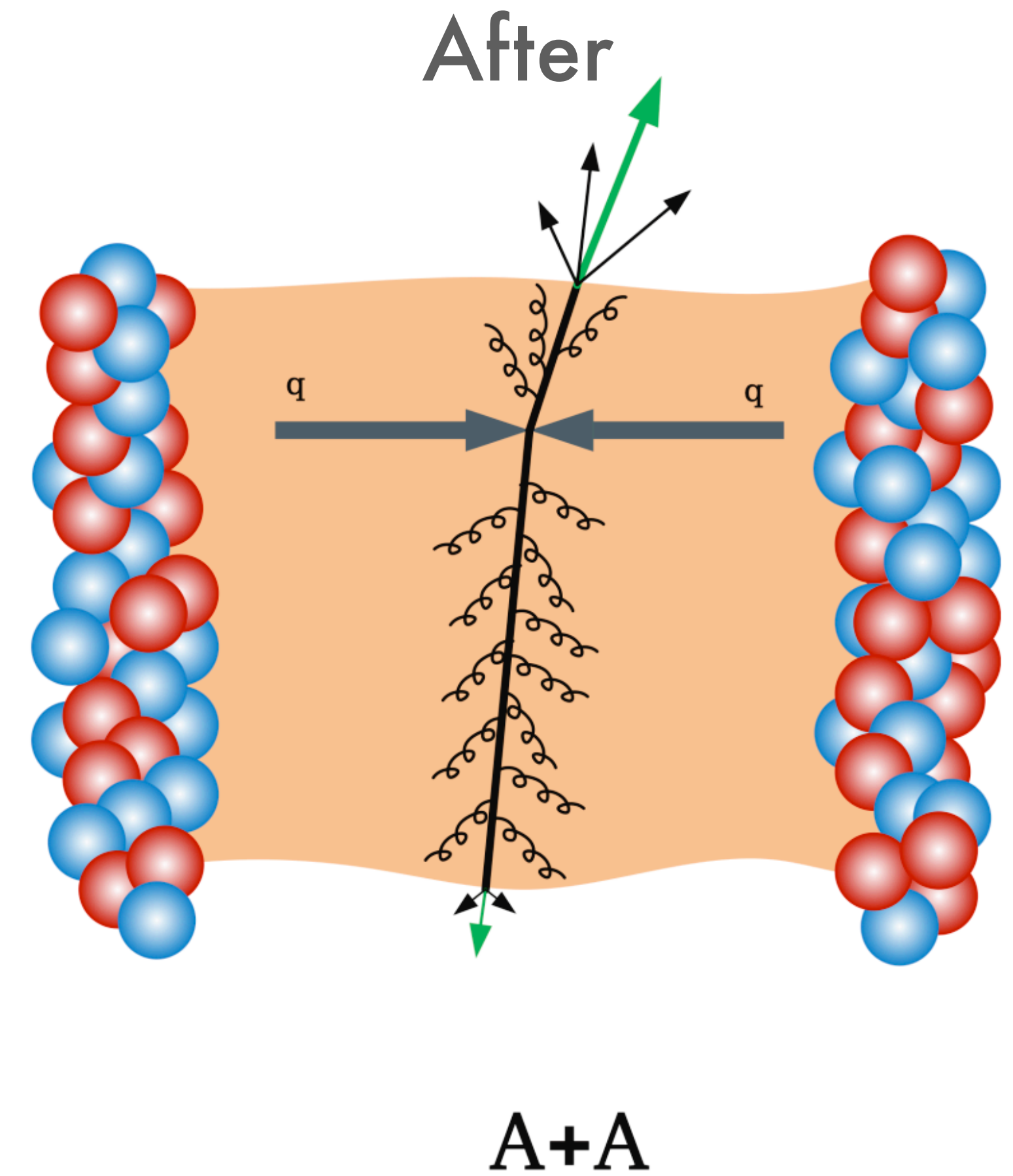
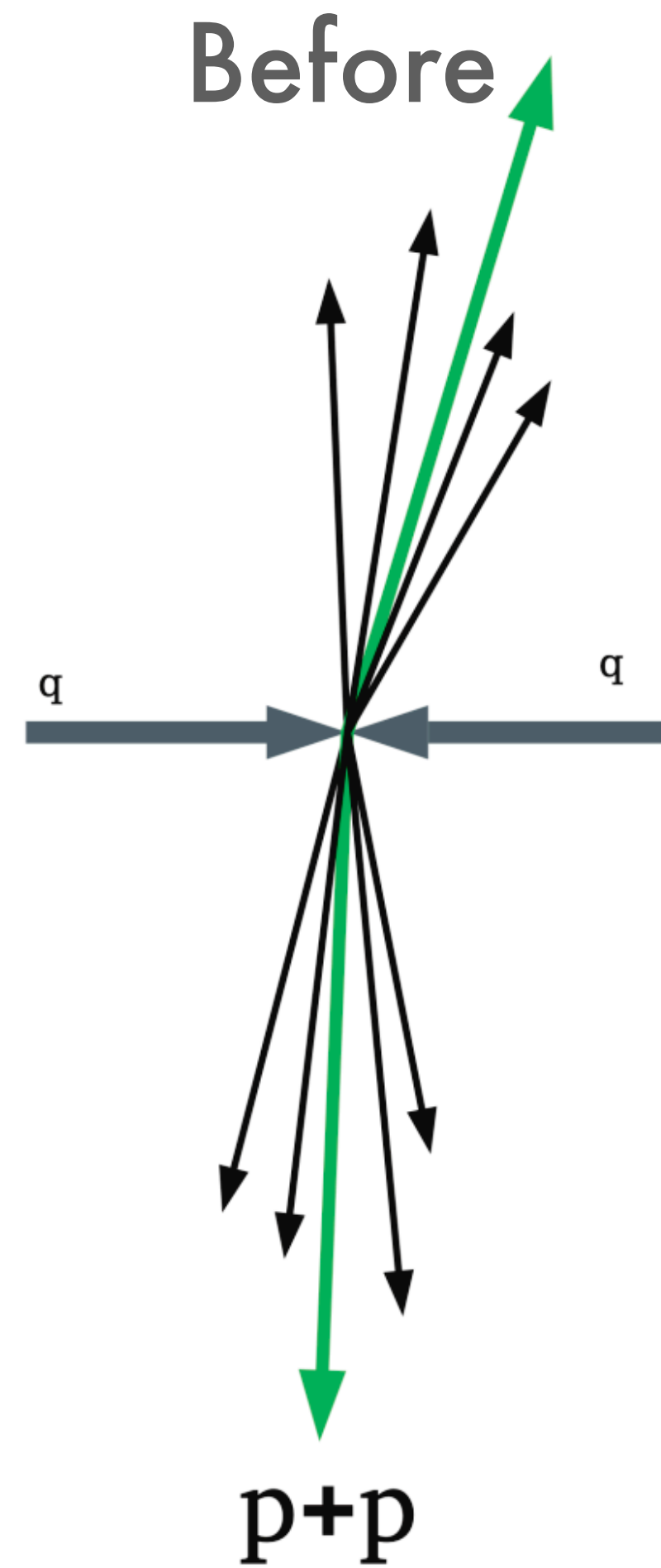
- Hard scattering produces jets
- Collimated “sprays” of particles



- Jets are produced early, and travel through the medium

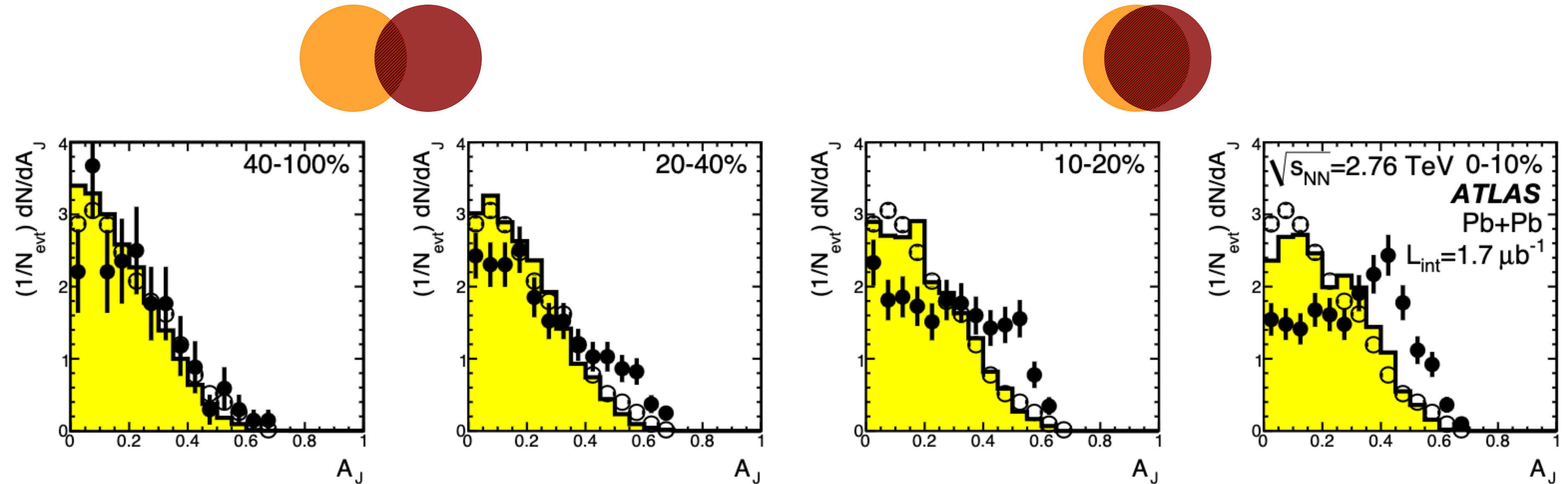


Jet quenching



[image credit](#)

Experimental signs: Dijet asymmetry

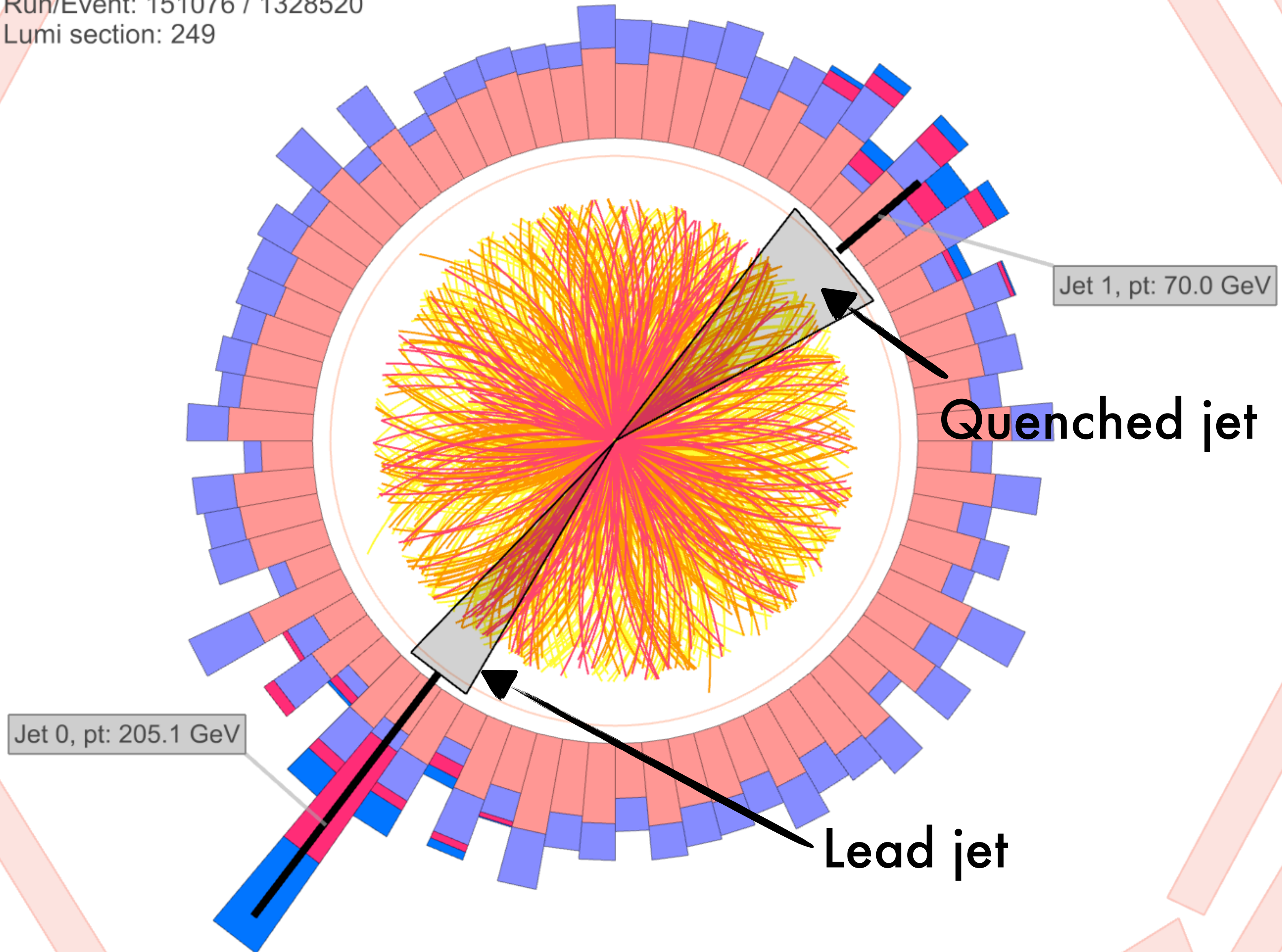


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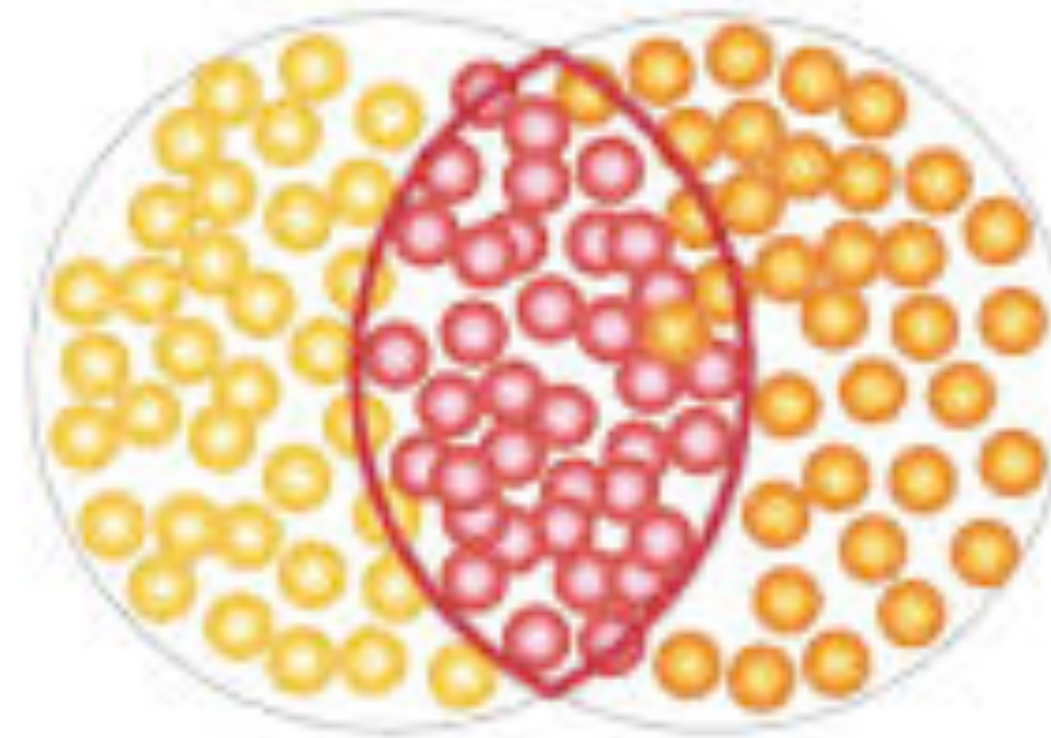
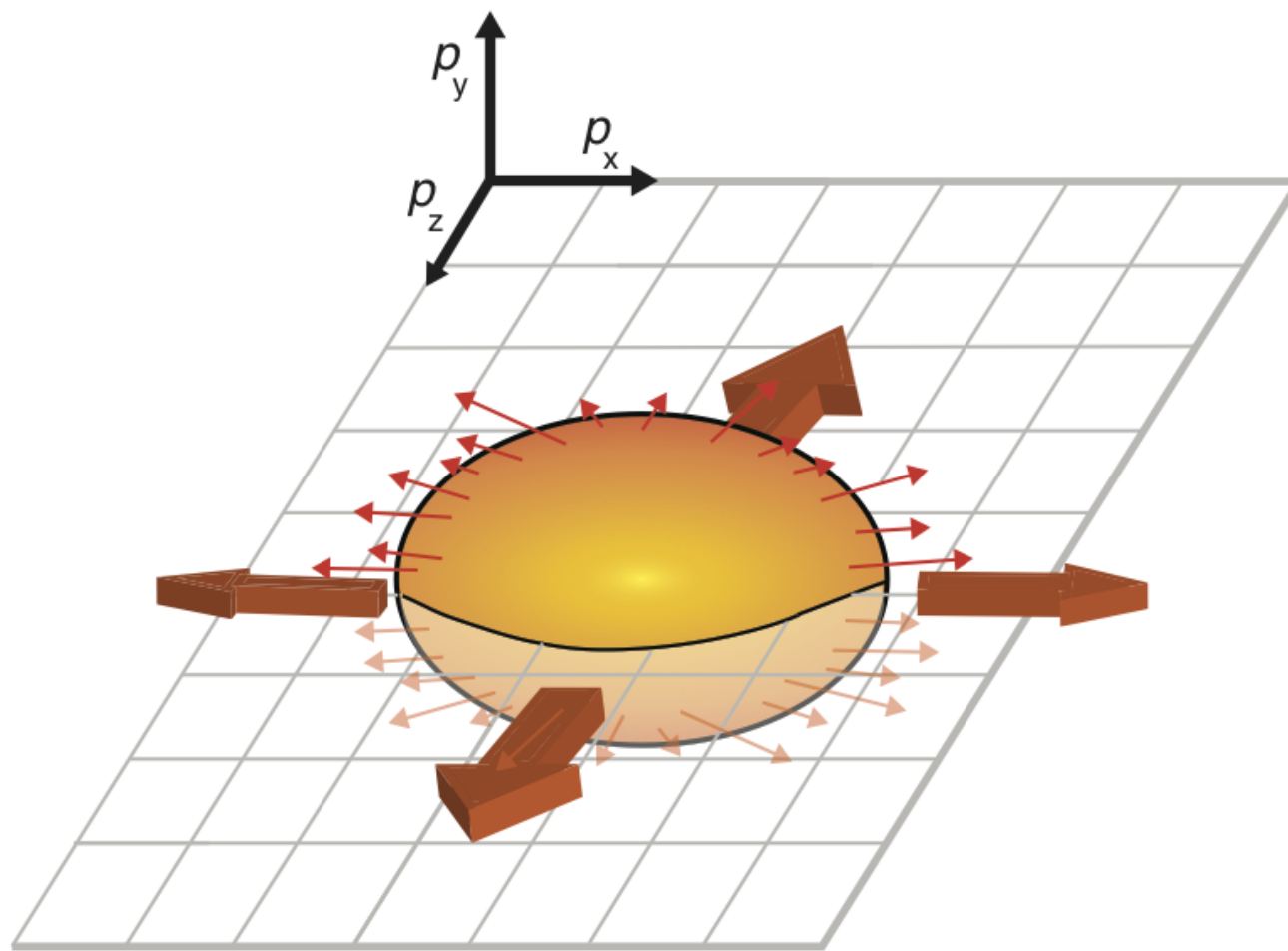
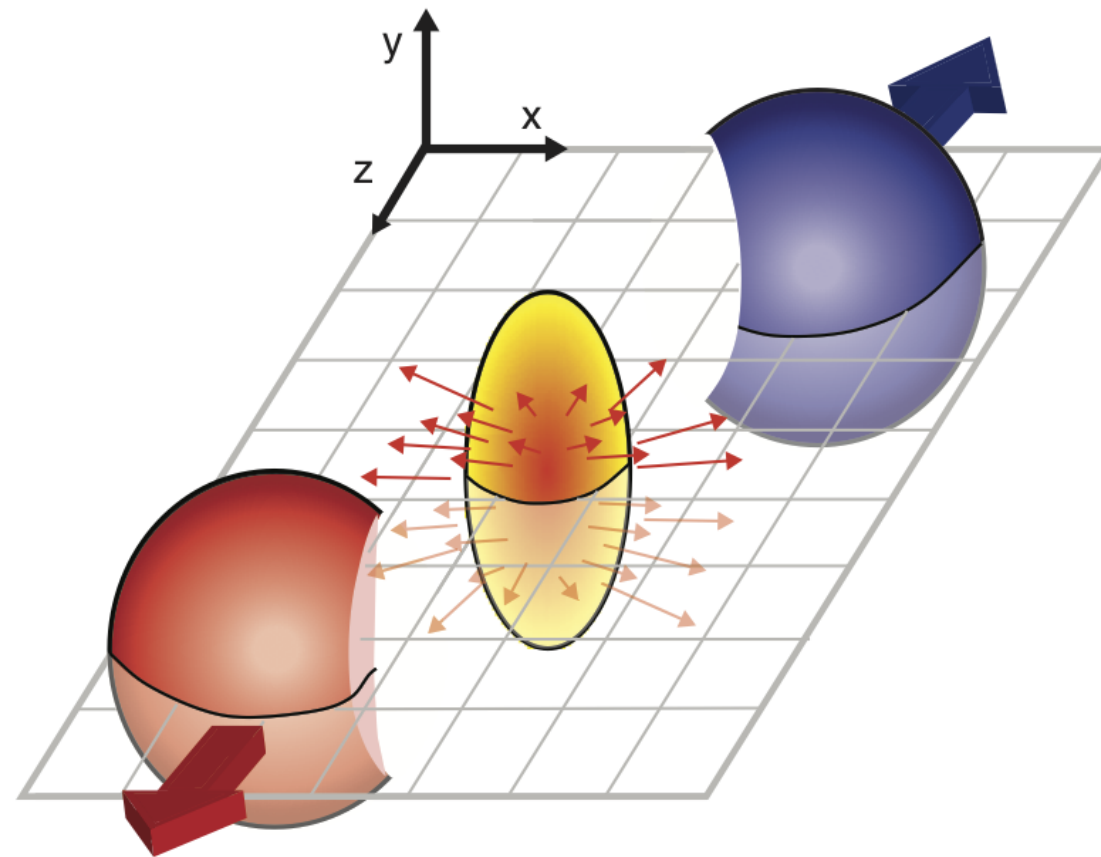
- Clear differences in pp and Pb–Pb
 - Stronger asymmetry in Pb–Pb
- One jet loses energy while crossing the plasma

What happens?

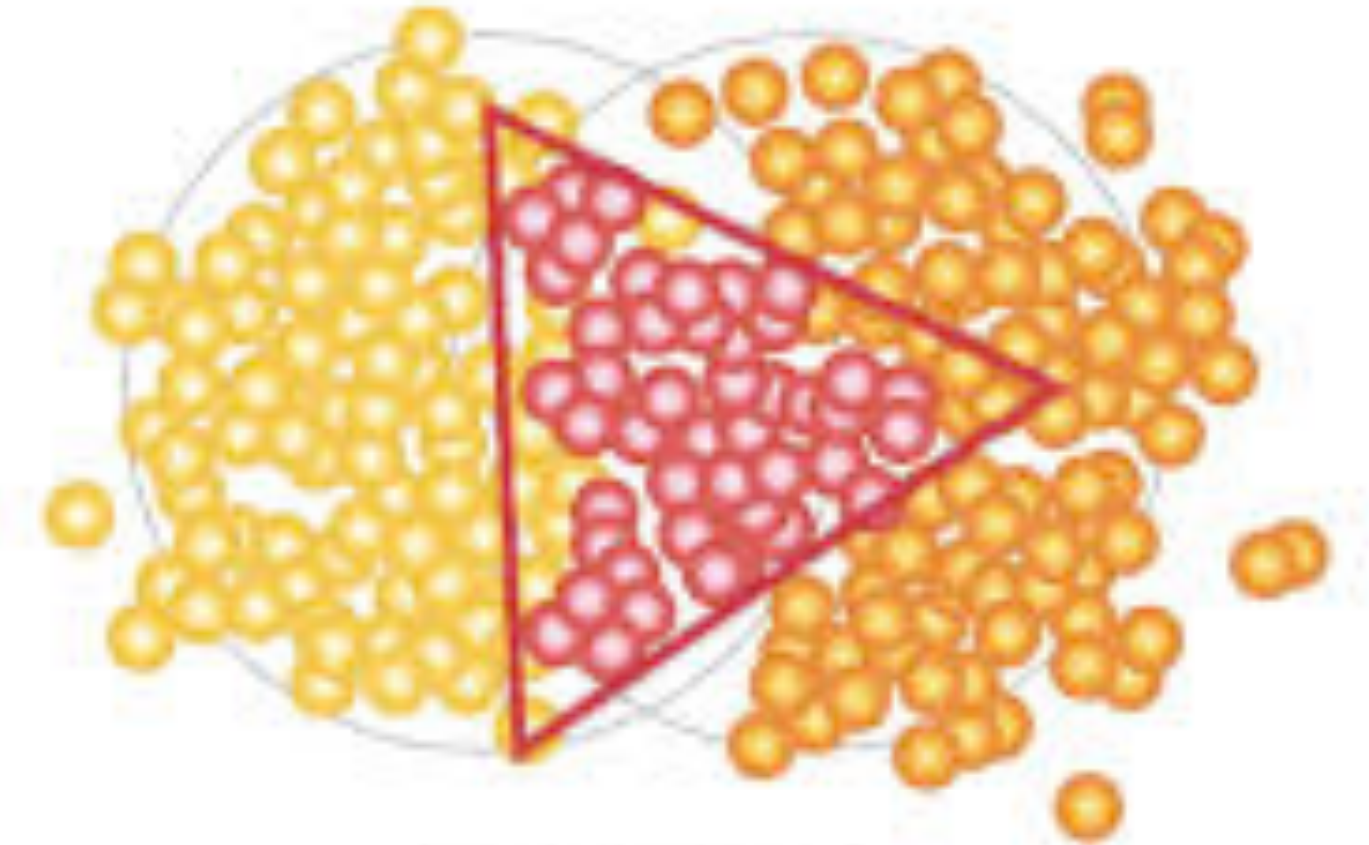
- The energy lost by the jet does not disappear
- Redistributed into lower energy particles spread over a wider region



Anisotropic flow



Elliptic flow

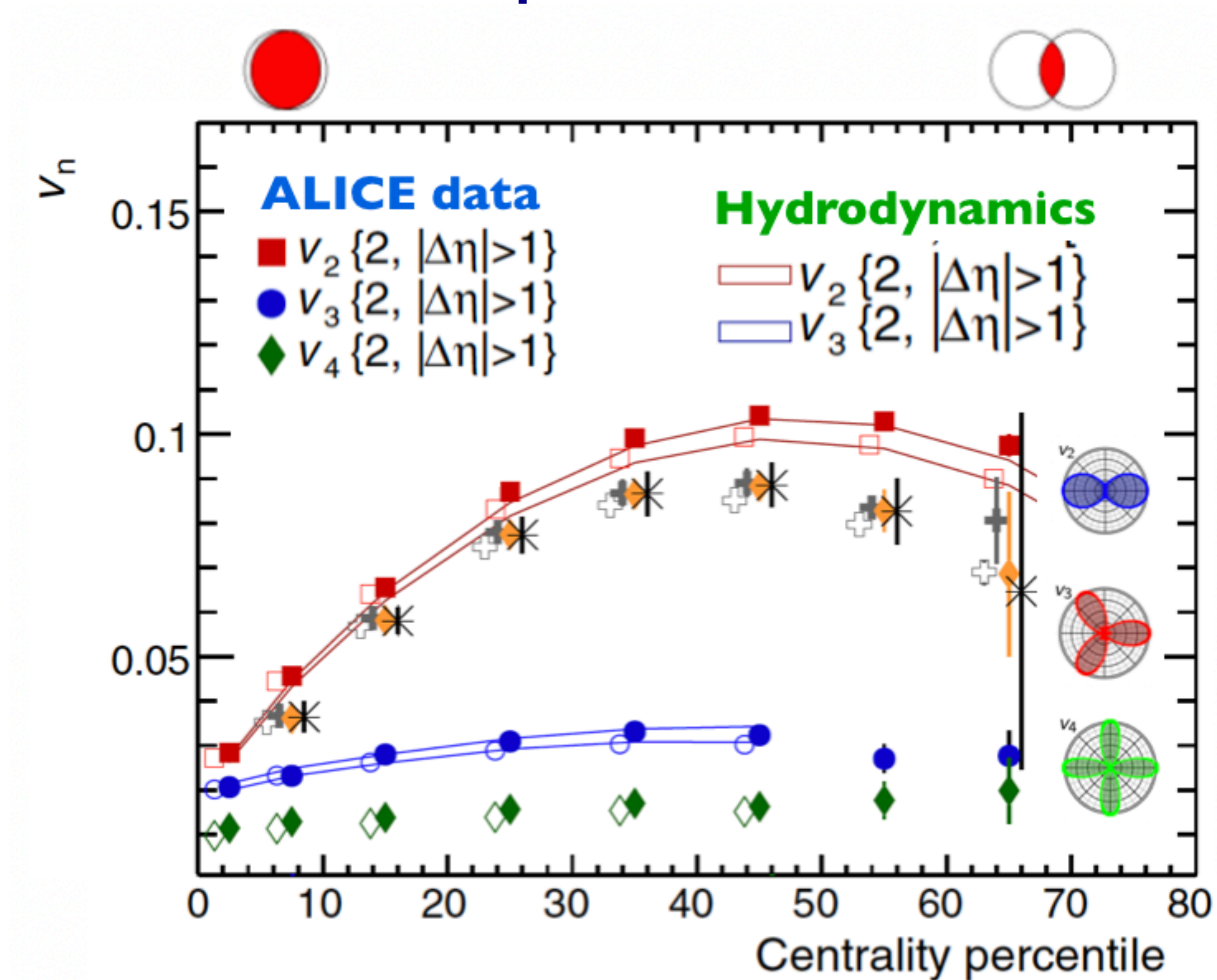


Triangular flow

[image credit](#)

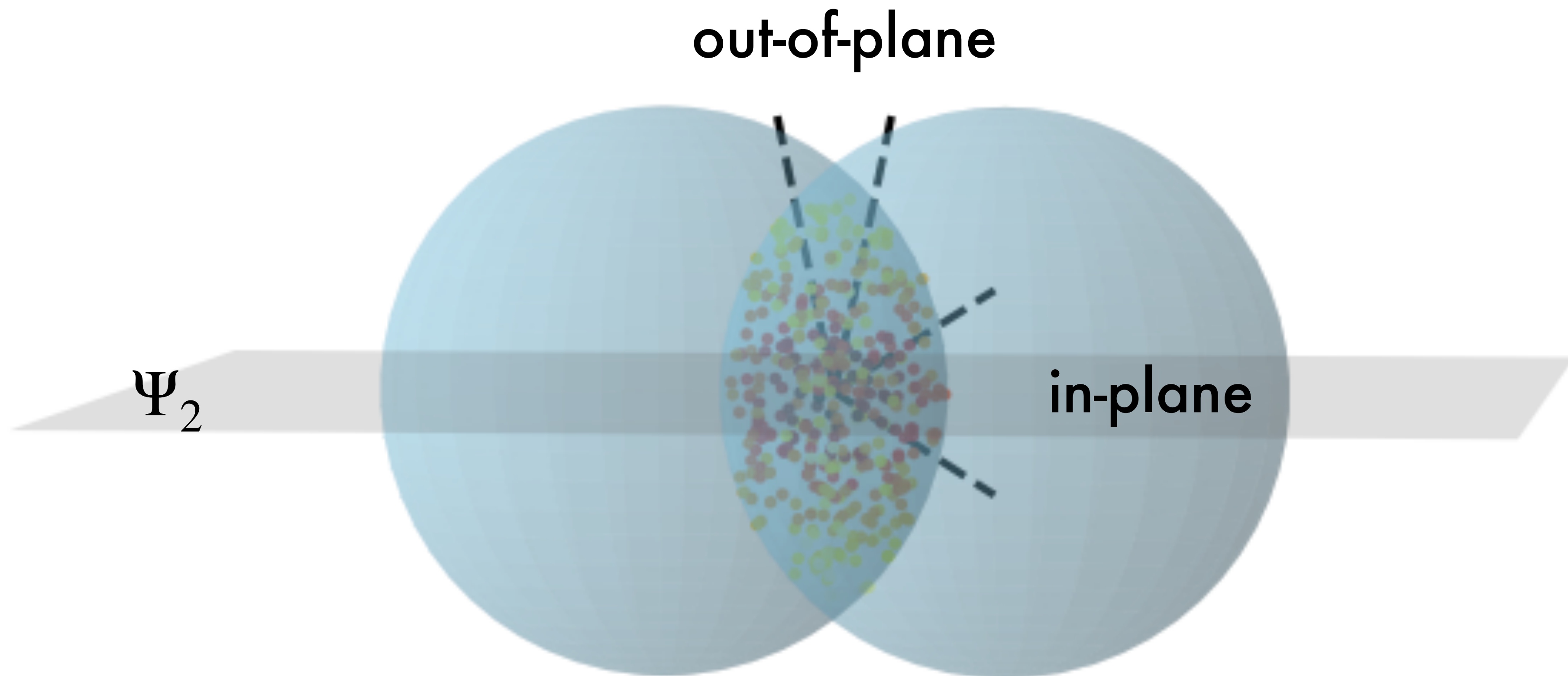
$$\frac{dN}{d\phi} \sim 1 + 2 \sum_{n=1} v_n \cos(n(\phi - \Psi_n))$$

The plasma acts like a liquid

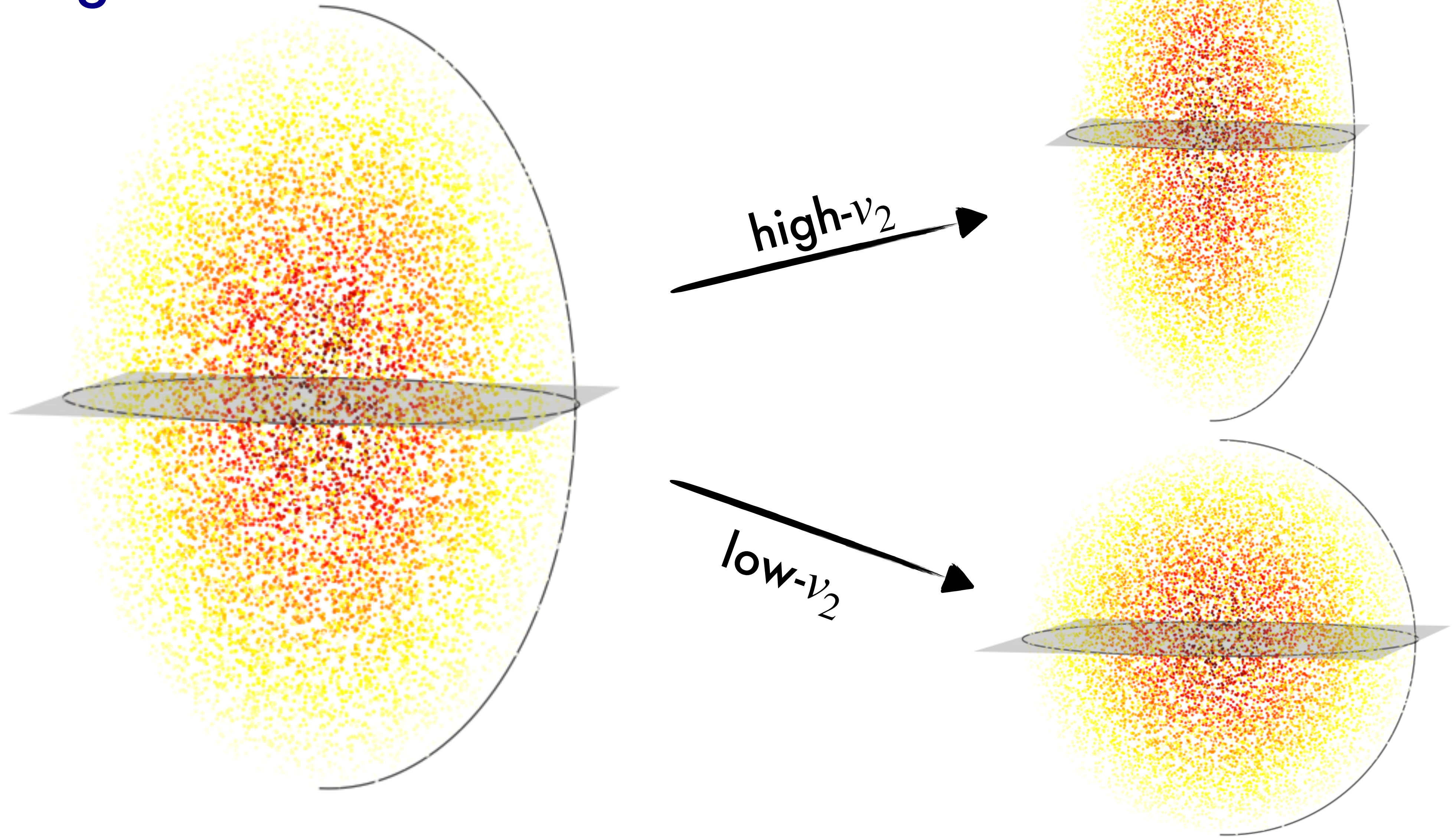


Phys.Rev.Lett.116.132302

Does it depend on direction?

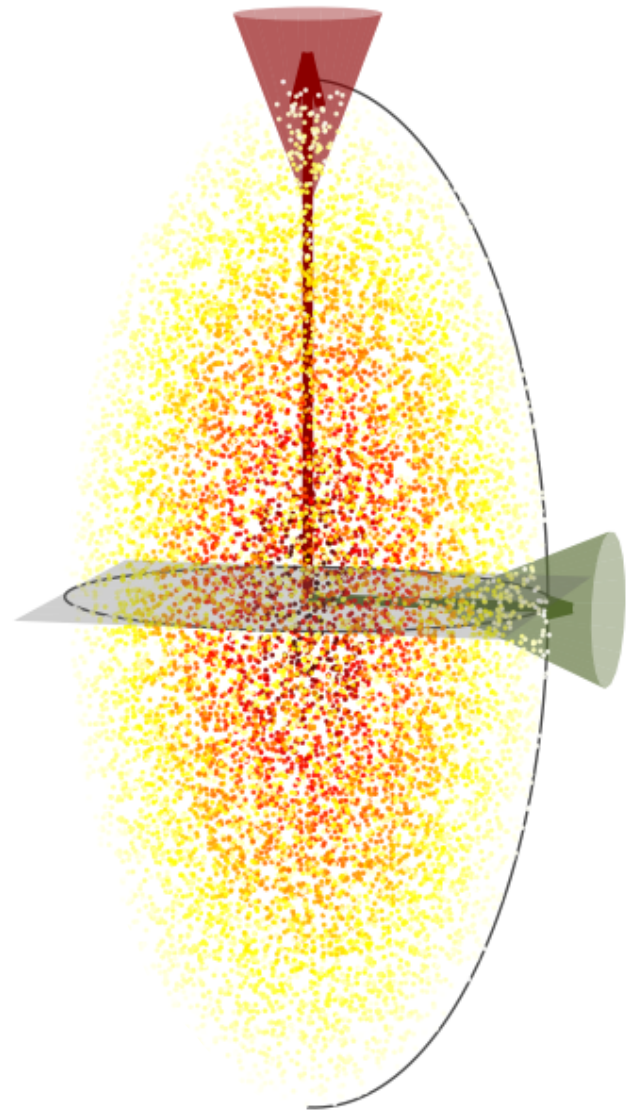


"shaping" the medium

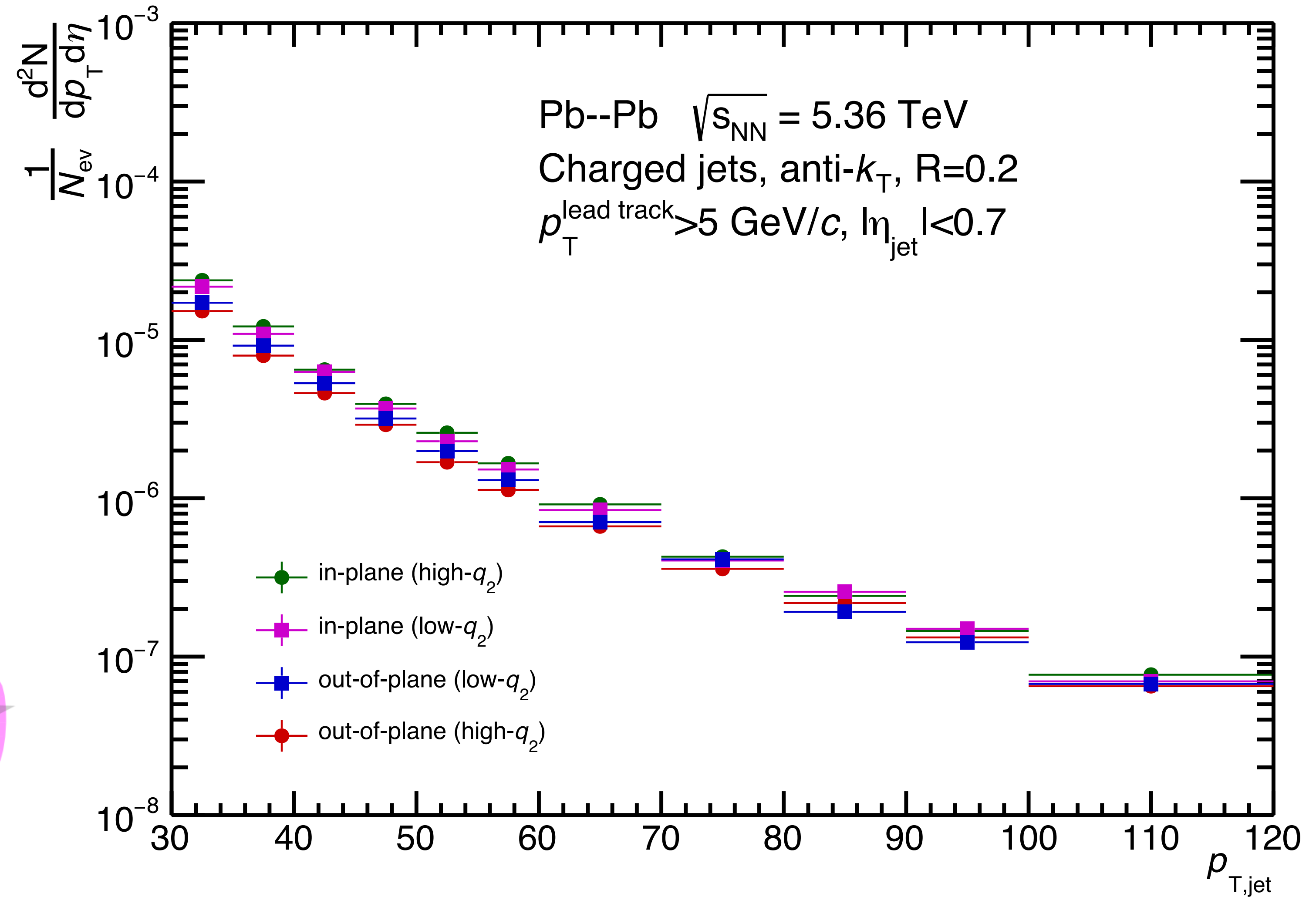
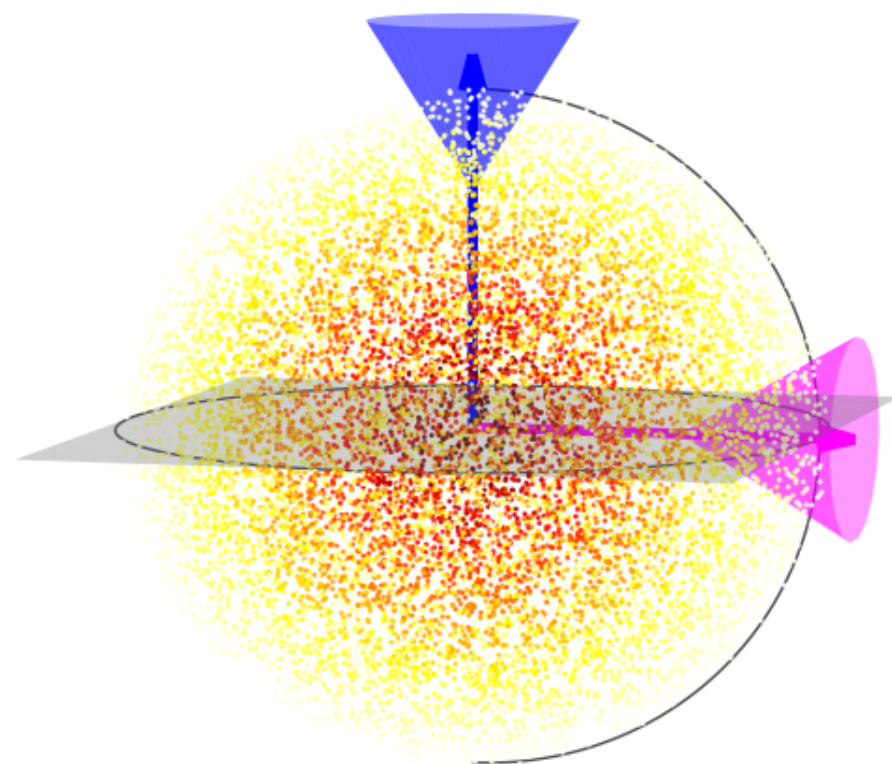


Modification of jets with event shape engineering

high- ε_2



low- ε_2



Take home messages

- Heavy-ion collisions recreate the early universe
- Jets act as probes of the Quark-gluon plasma (QGP)
- By studying how jets are modified, we learn about the properties of the QGP

Thank you!