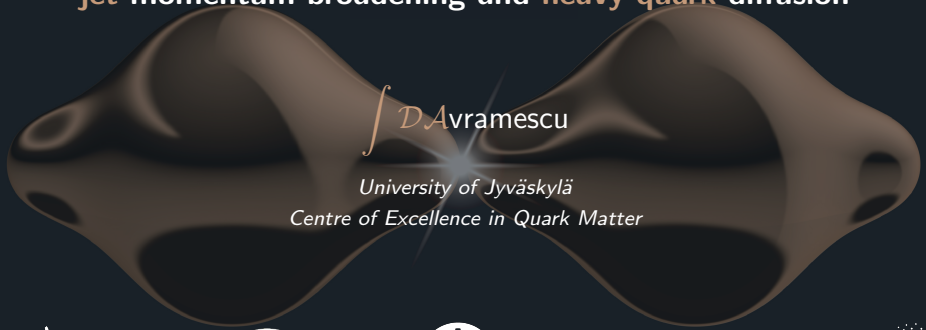
Pre-equilibrium and early time

jet momentum broadening and heavy quark diffusion



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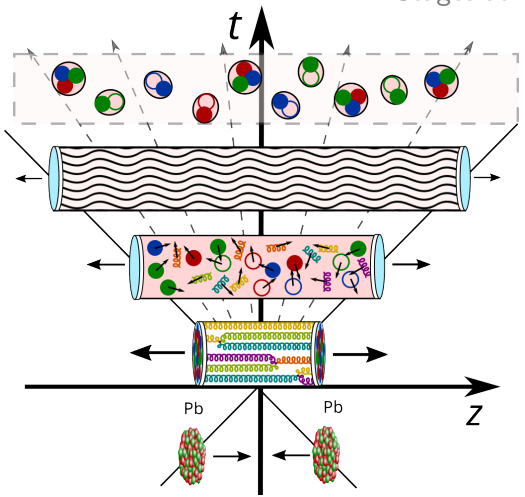
European Research Council

Initial Stages, Taipei, September 2025

Heavy-ion collisions

Stages at weak coupling

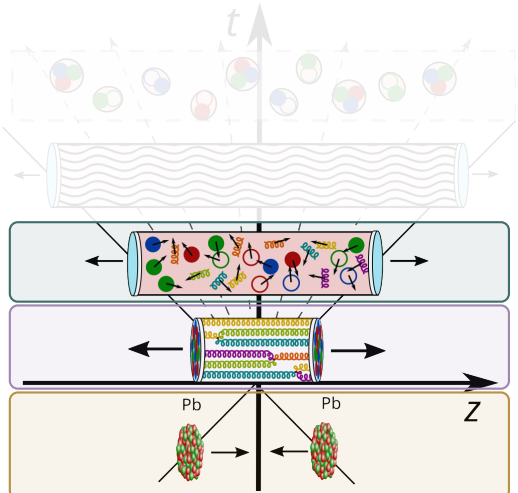


Collision stages

- **Before collision** $\tau \leq 0\,\mathrm{fm/c}$
  Color glass condensate (CGC)
- **Initial stage** $\tau \lesssim 0.3\,\mathrm{fm/c}$
  Glasma classical gluon fields
- **Thermalization** $\tau \lesssim 1\,\mathrm{fm/c}$
  Effective kinetic theory (EKT)
- Local equilibrium $\tau \lesssim 10\,\mathrm{fm/c}$
  Relativistic hydrodynamics
- Final stages $\tau \geq 10\,\mathrm{fm/c}$
  Particlization, hadronization

Berges, Heller, Mazeliauskas, Venugopalan [2005.12299] Schlichting, Teaney [1908.02113]

Pre-equilibrium stages



CGC

- QCD in the high-energy limit

Glasma

- Collision of CGC fields
- **Classical gluon fields**

  Yang-Mills equation for field A^μ

EKT

- QCD effective kinetic theory
- **Quarks, gluons as quasiparticles**

  Boltzmann equation for distribution $f_{q,g}$
- Bottom-up thermalization scenario

Gelis, Iancu, Jalilian-Marian, Venugopalan [1002.0333] Lappi [hep-ph/0606207] Gelis [1211.3327]
Baier, Mueller, Schiff, Son [hep-ph/0009237]