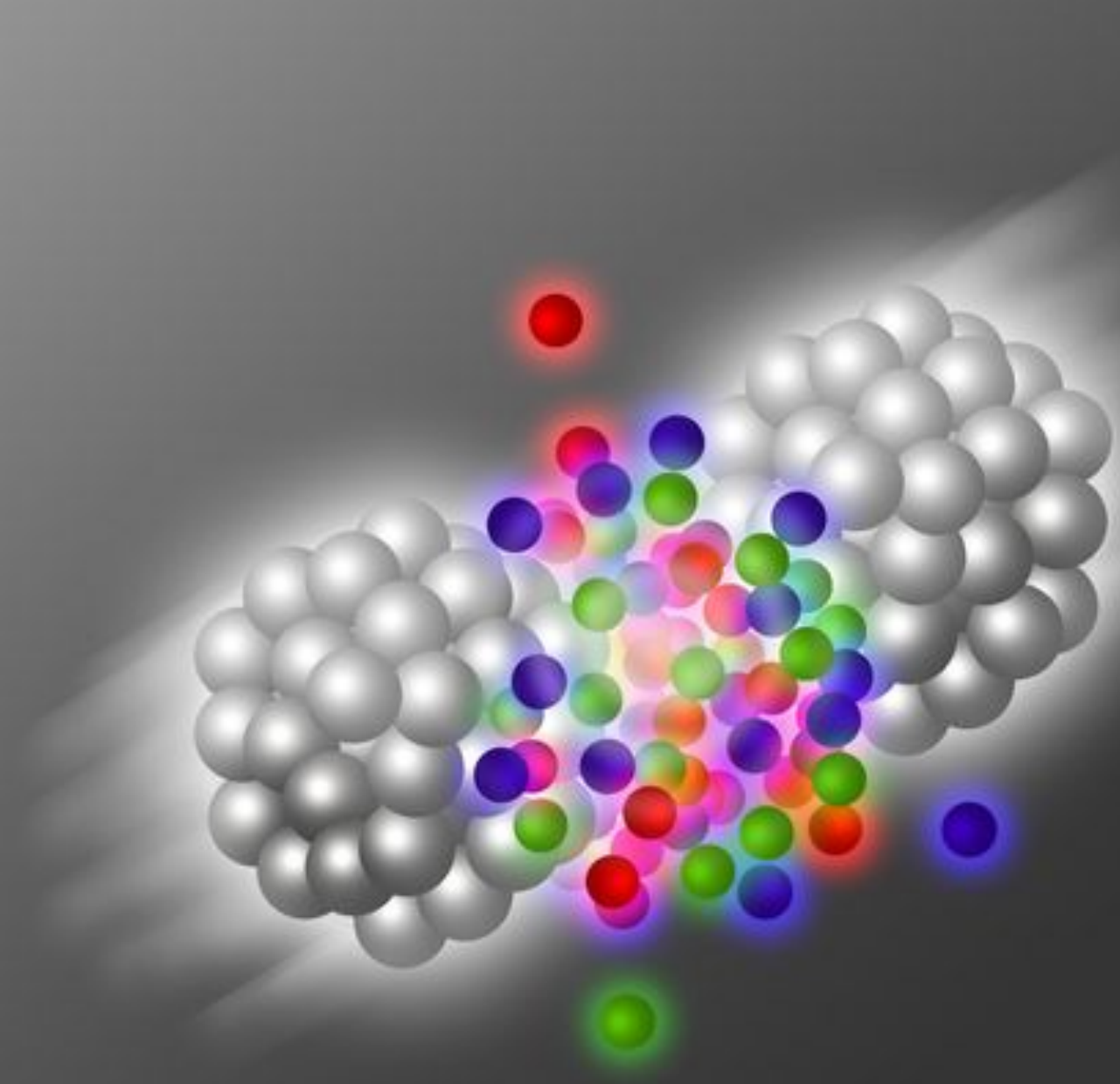


JetQCD: Multi-Differential Jet Studies of QCD Matter



Liliana Apolinário

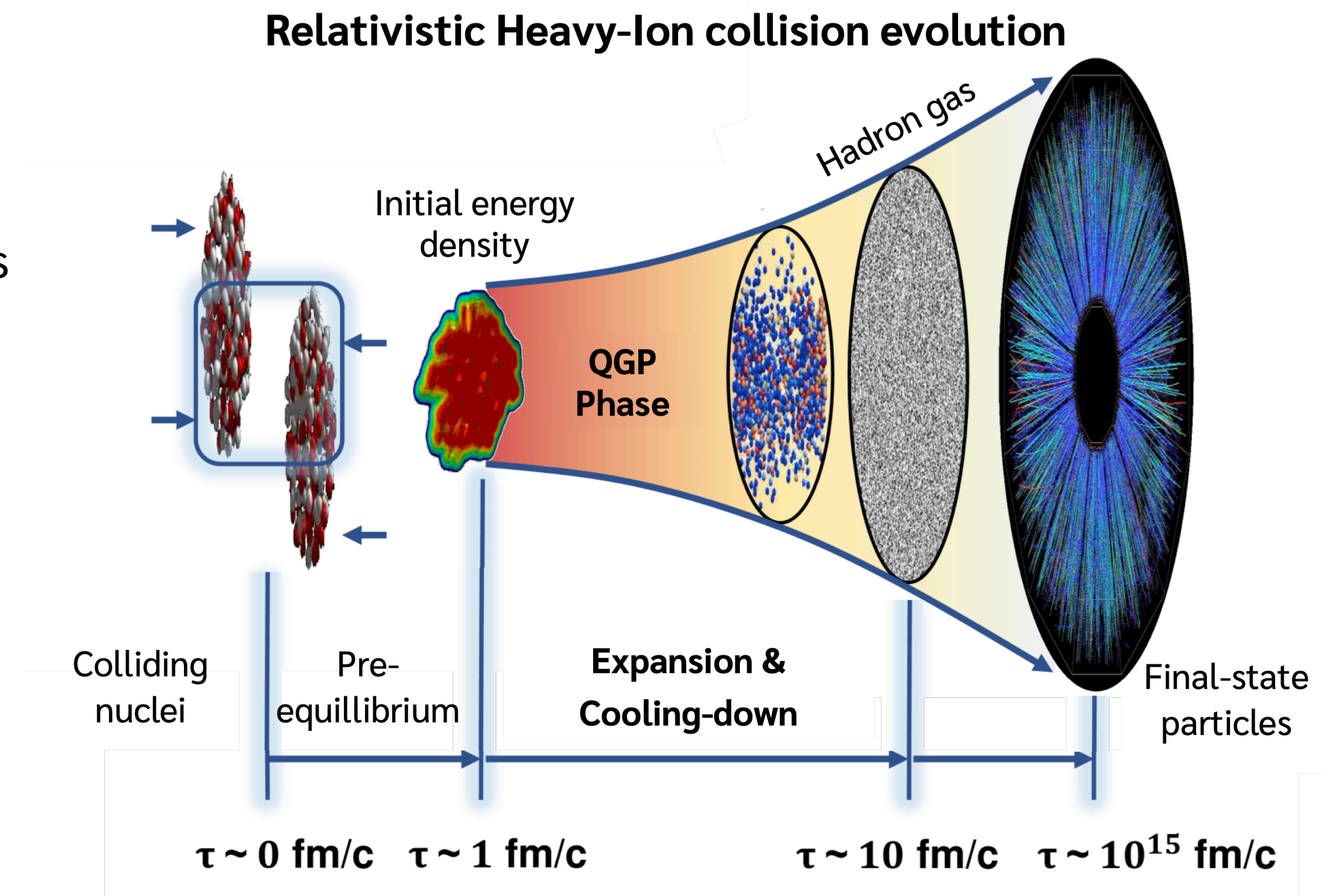


Leticia Cunqueiro



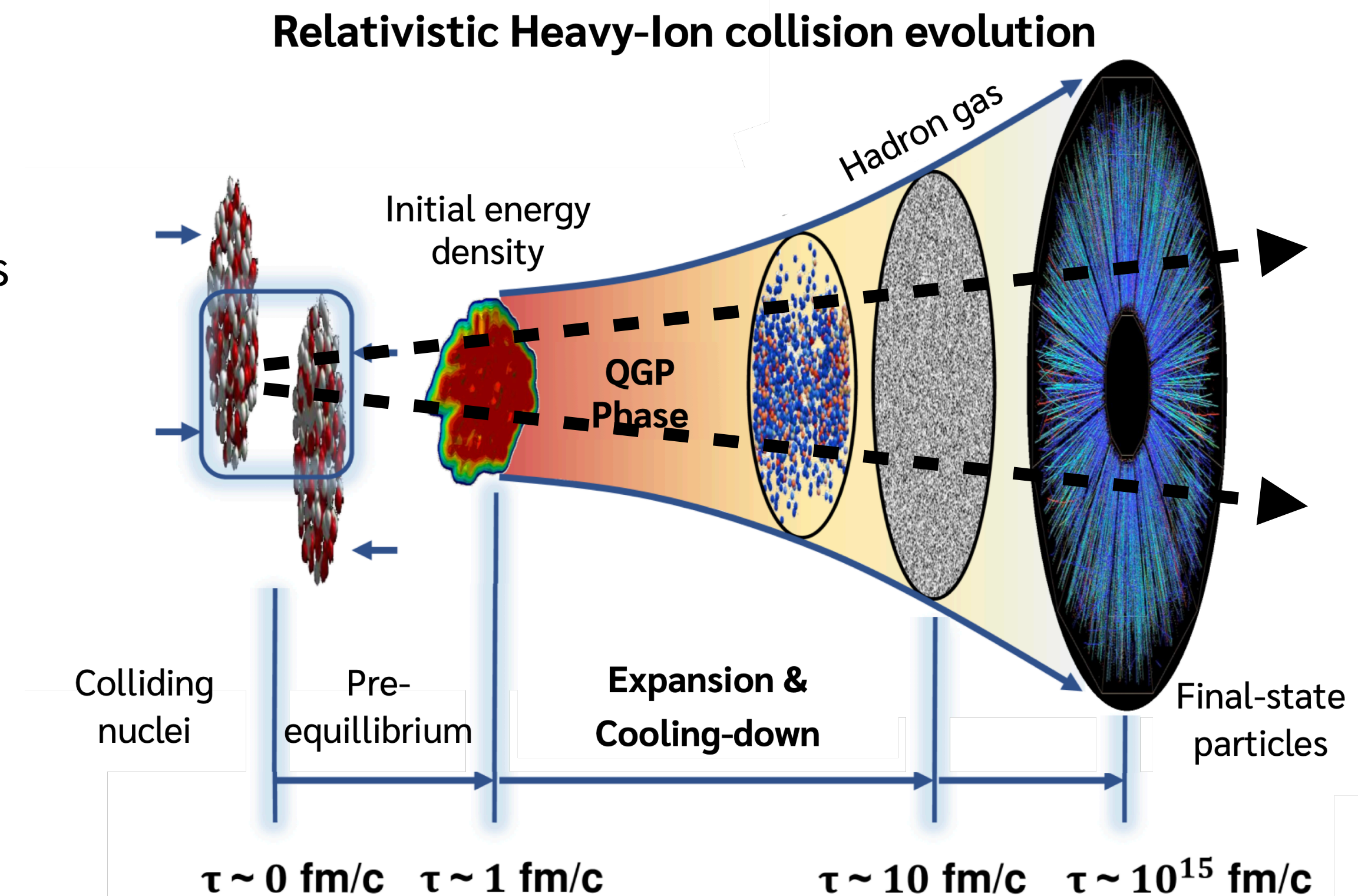
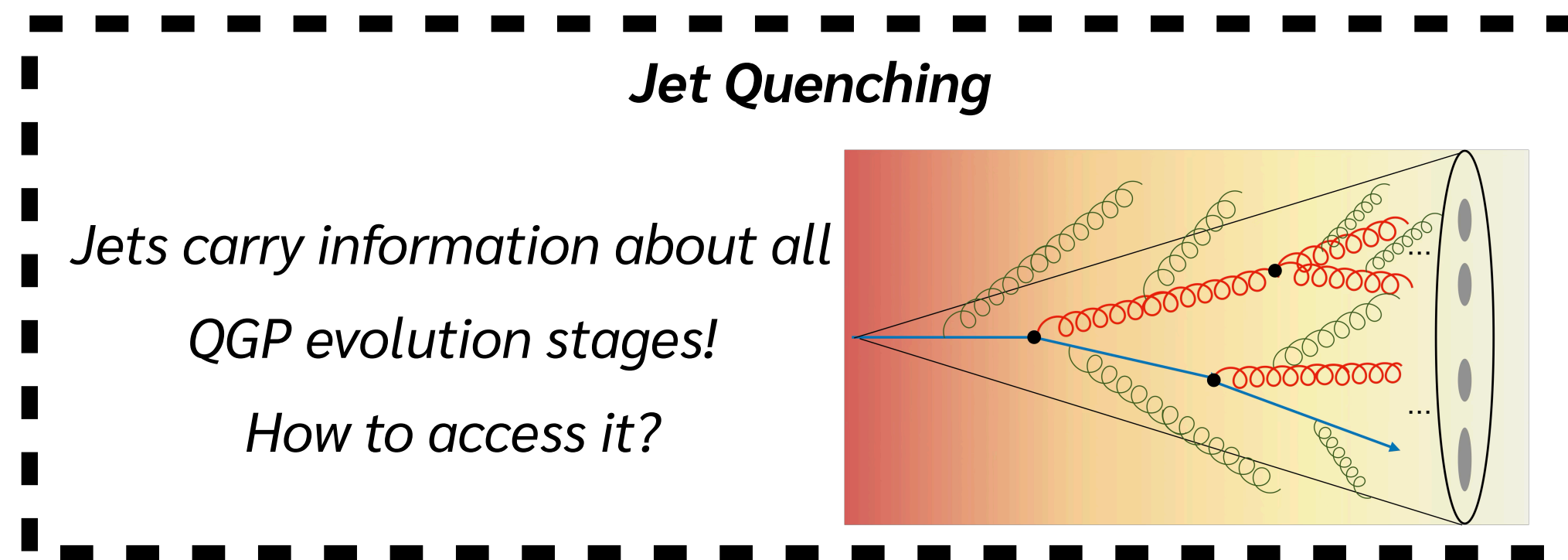
Probes of the evolving QGP

- In a heavy-ion collision, QCD jets are **usually regarded as probes** of the **fully integrated** Quark-Gluon Plasma (QGP) **evolution**:
- QGP-induced effects evaluated on inclusive jet/particle yields (R_{AA}), Jet-boson or di-jet correlations (x_{jz}, \dots), among others.



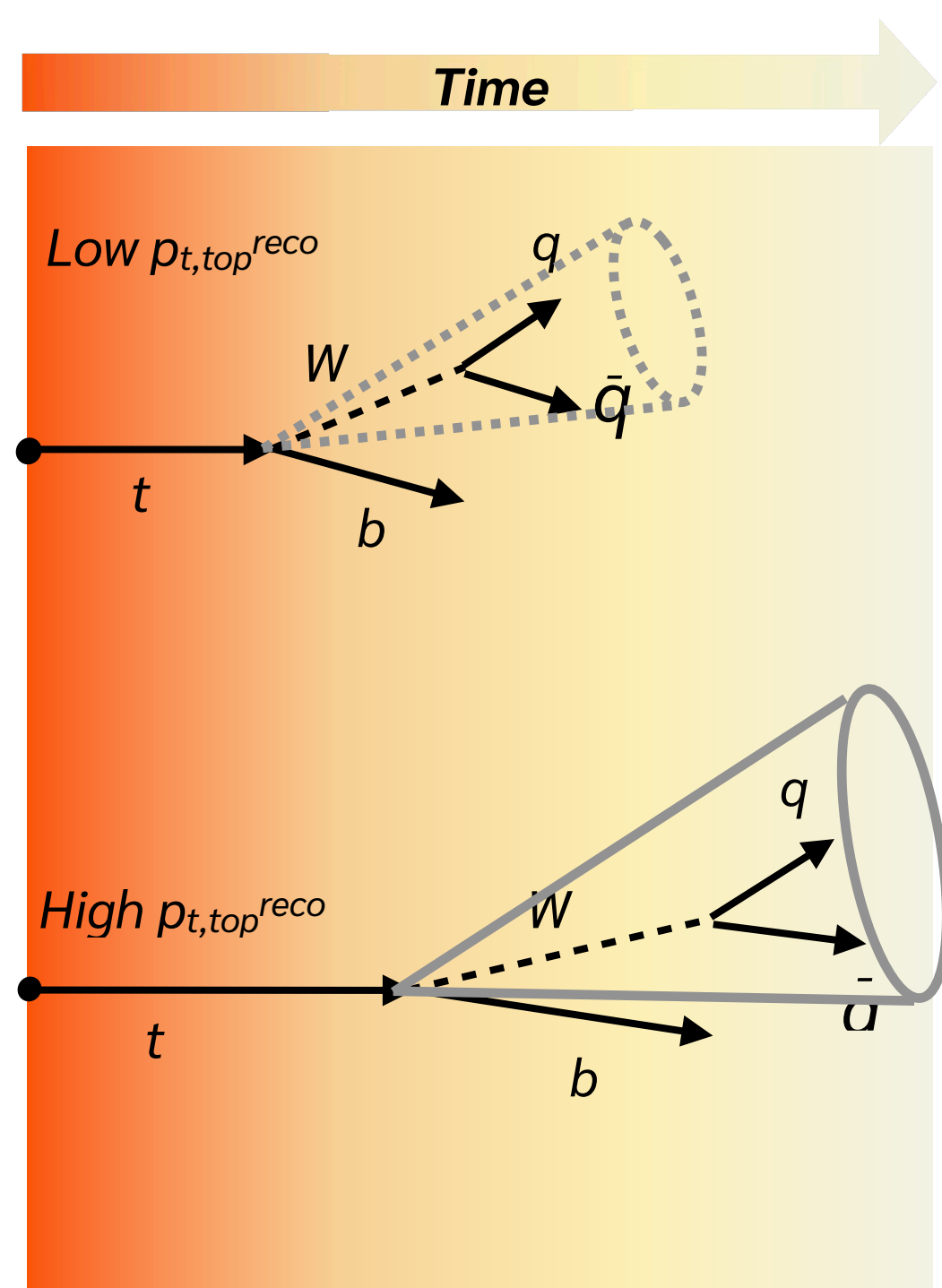
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- However, the **QGP is a time evolving medium**.



QGP Tomography

- Initiated via boosted objects (top initiated jets), but with limited statistics at current colliders...

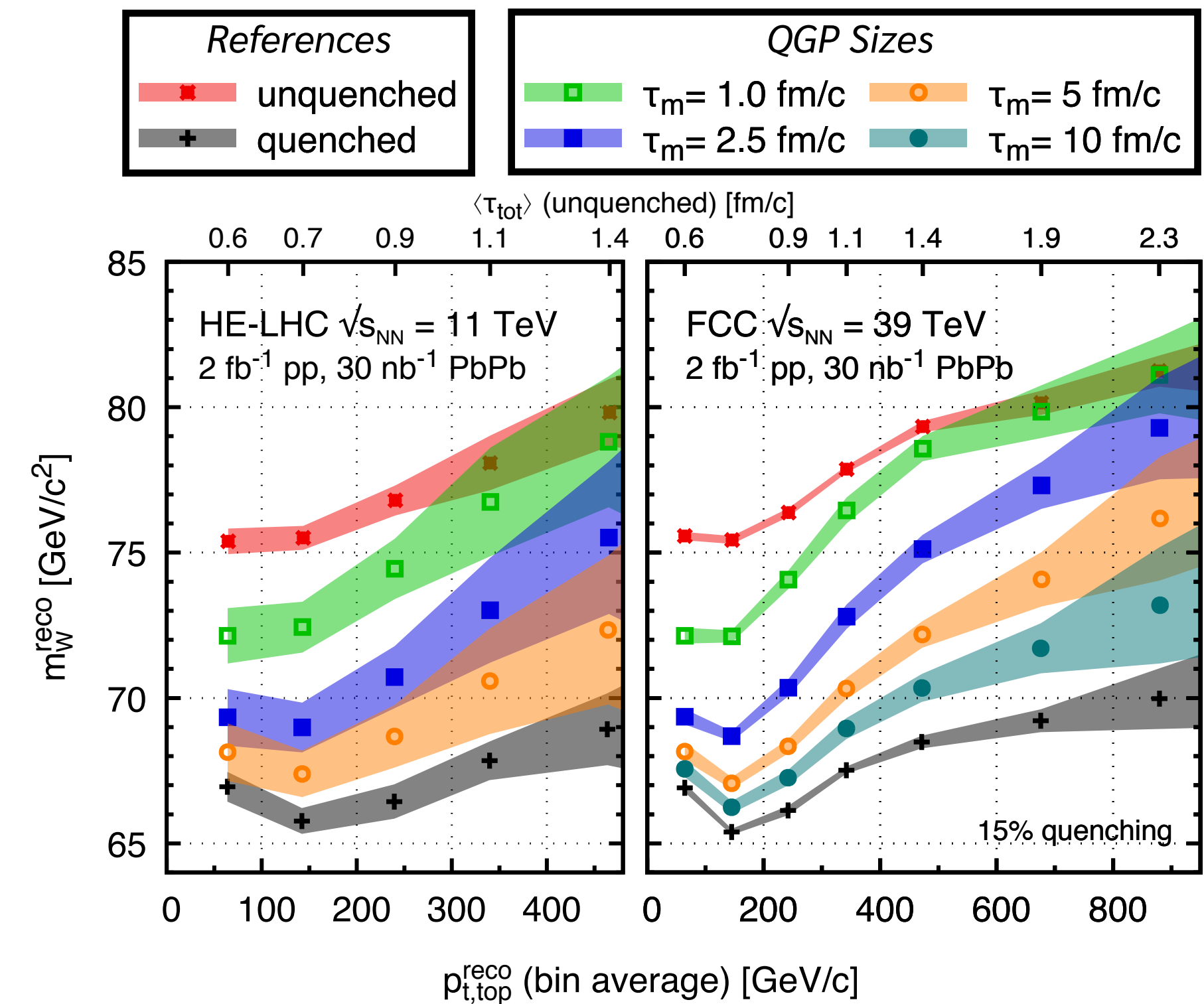


Decay inside the QGP will create
delayed probes of the QGP

⇒ Smaller W-boson mass
(More energy loss)

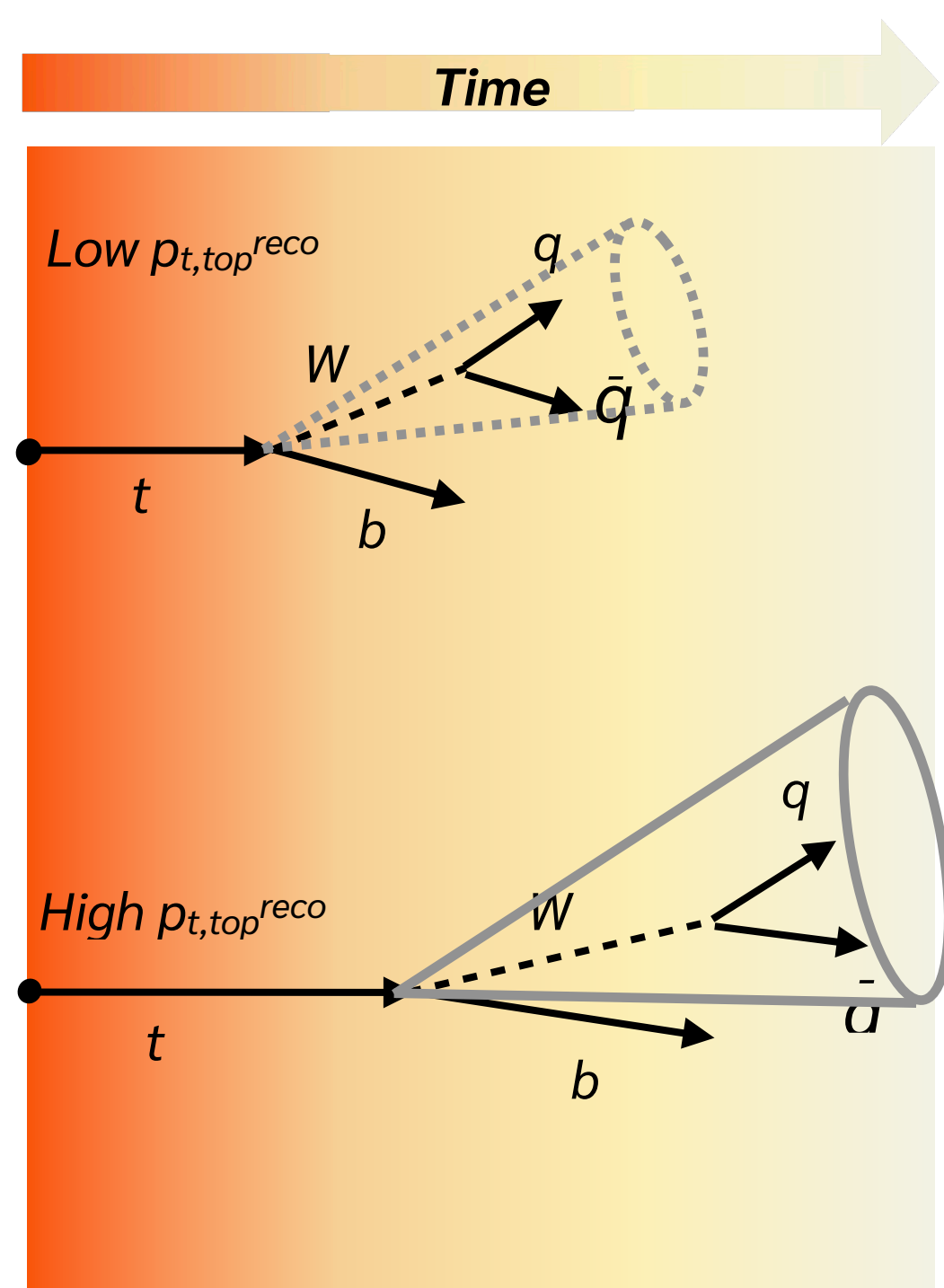
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L.A., Milhano, Salam, Salgado, *PRL* (2018)



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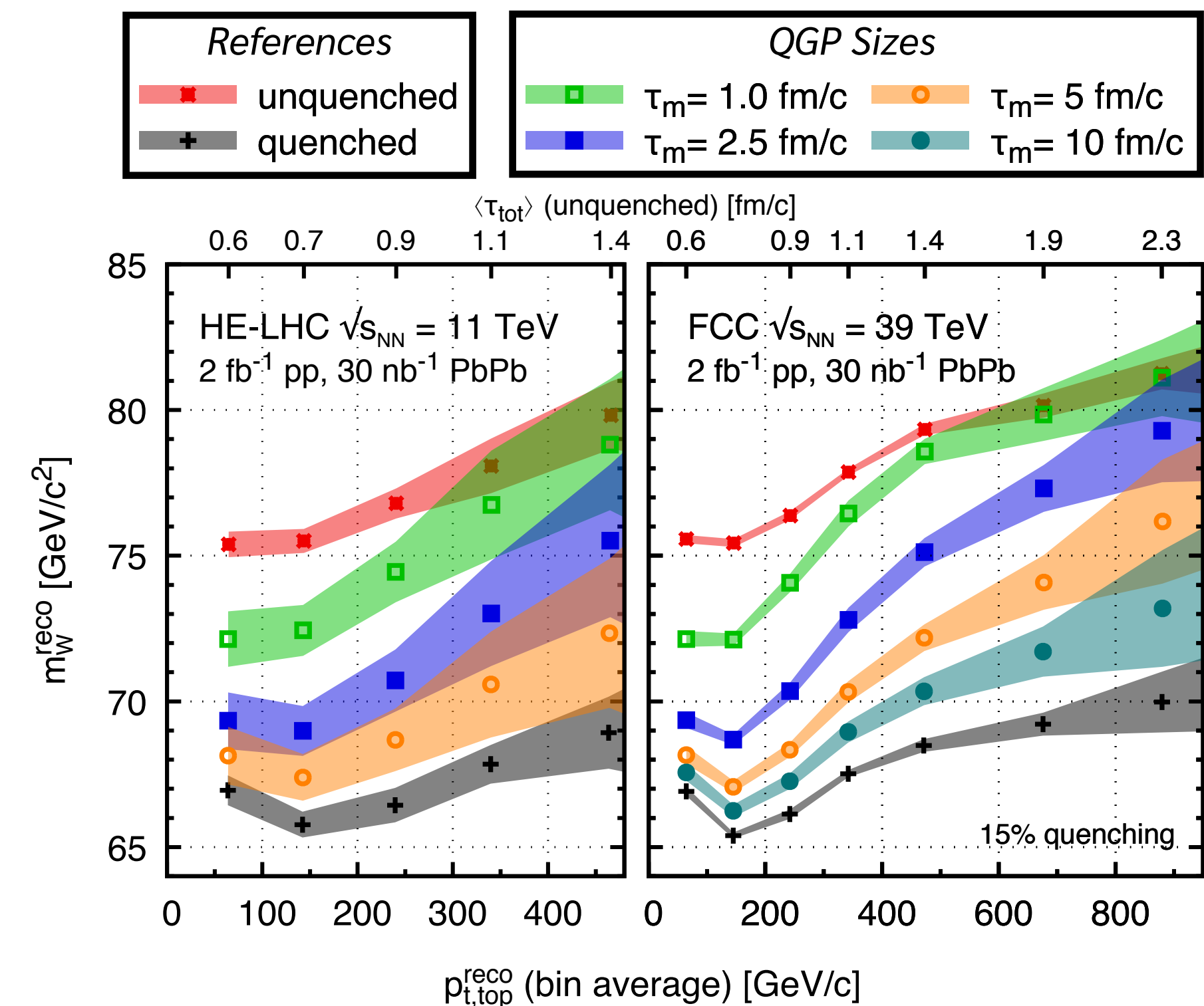


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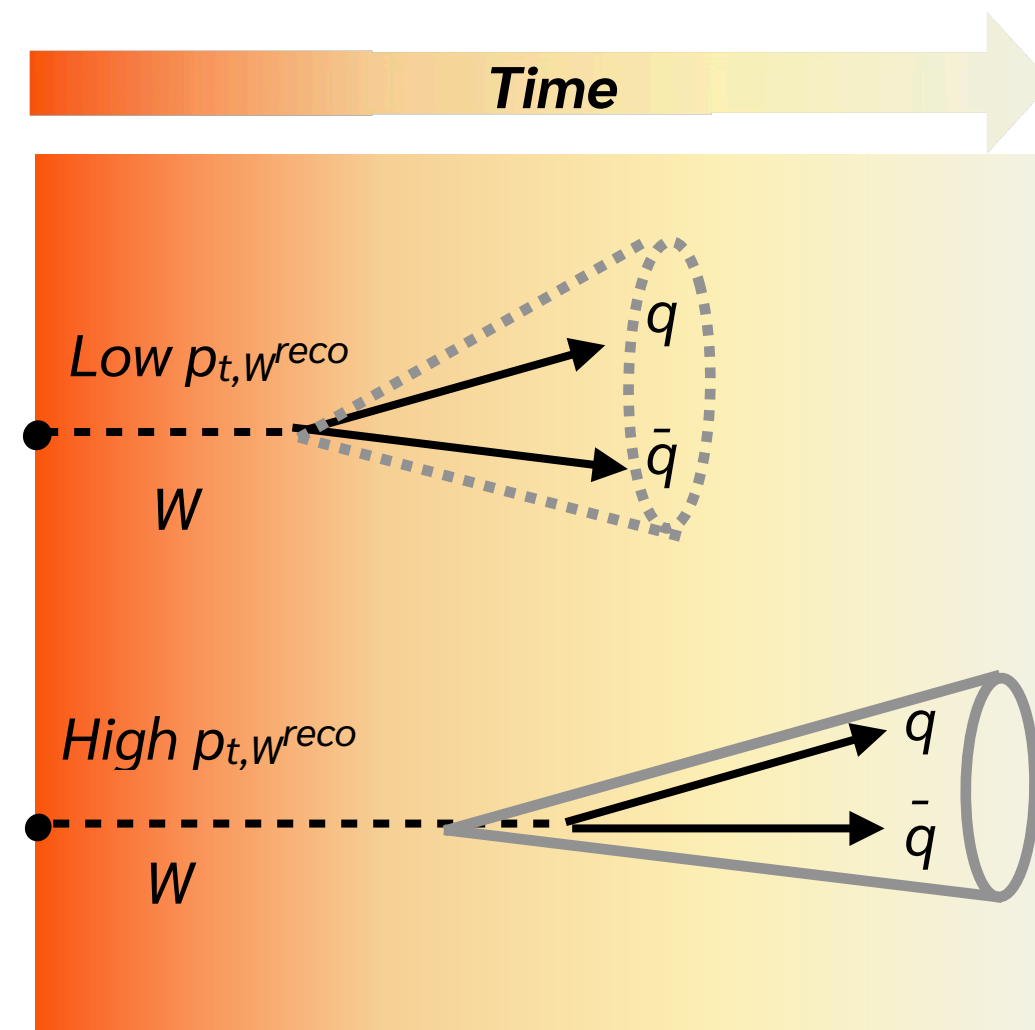
How to fully exploit the wealth of PbPb data accumulated by the LHC ($\sim 30 \text{ nb}^{-1}$) to learn about QGP evolution and structure?

Multi-Differential Jet Observables

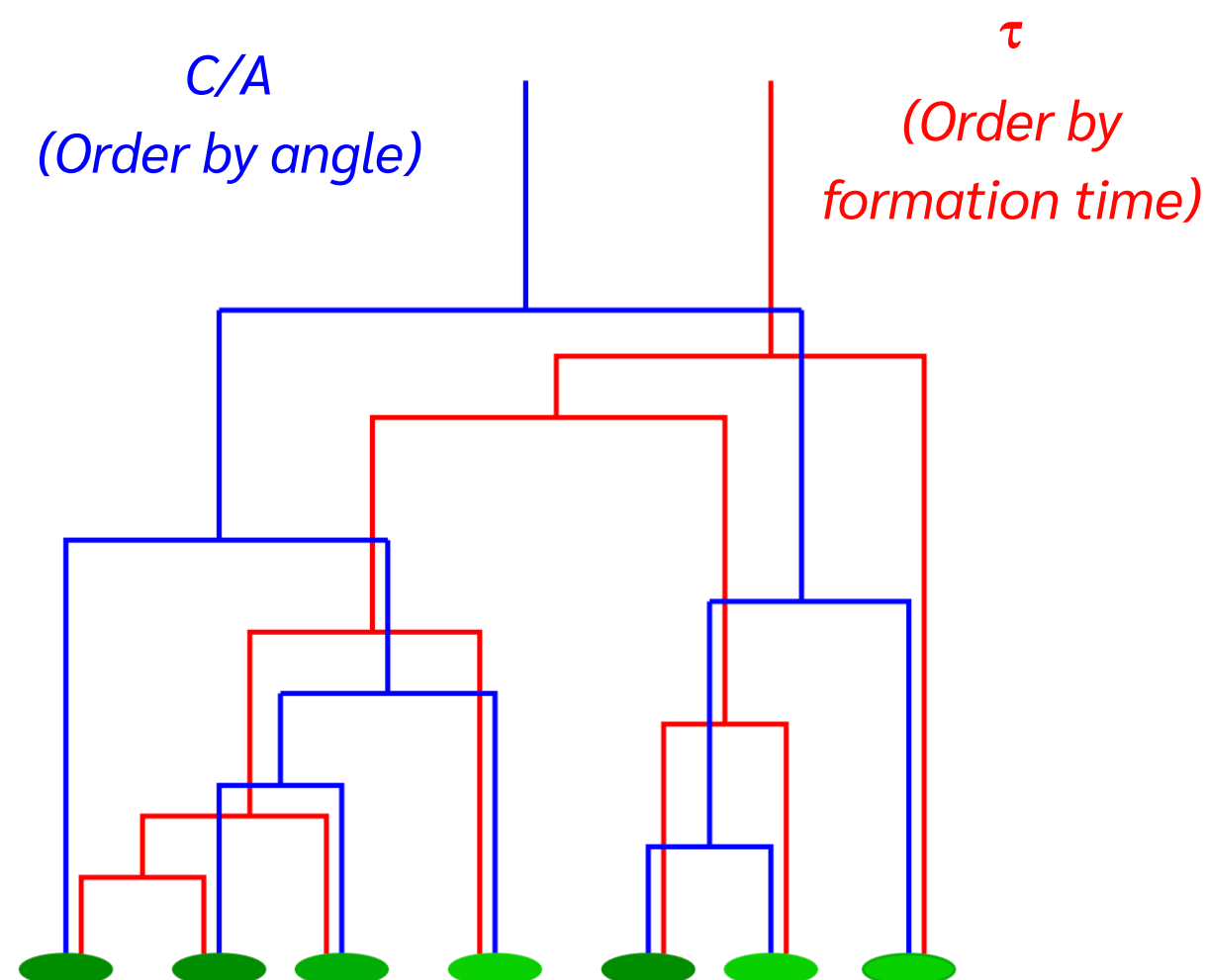
- Some recent examples of **novel proposals** that try to access a given time or momentum scale of the QGP:

Jet substructure observables across multiple axes — e.g. momentum, time and angle

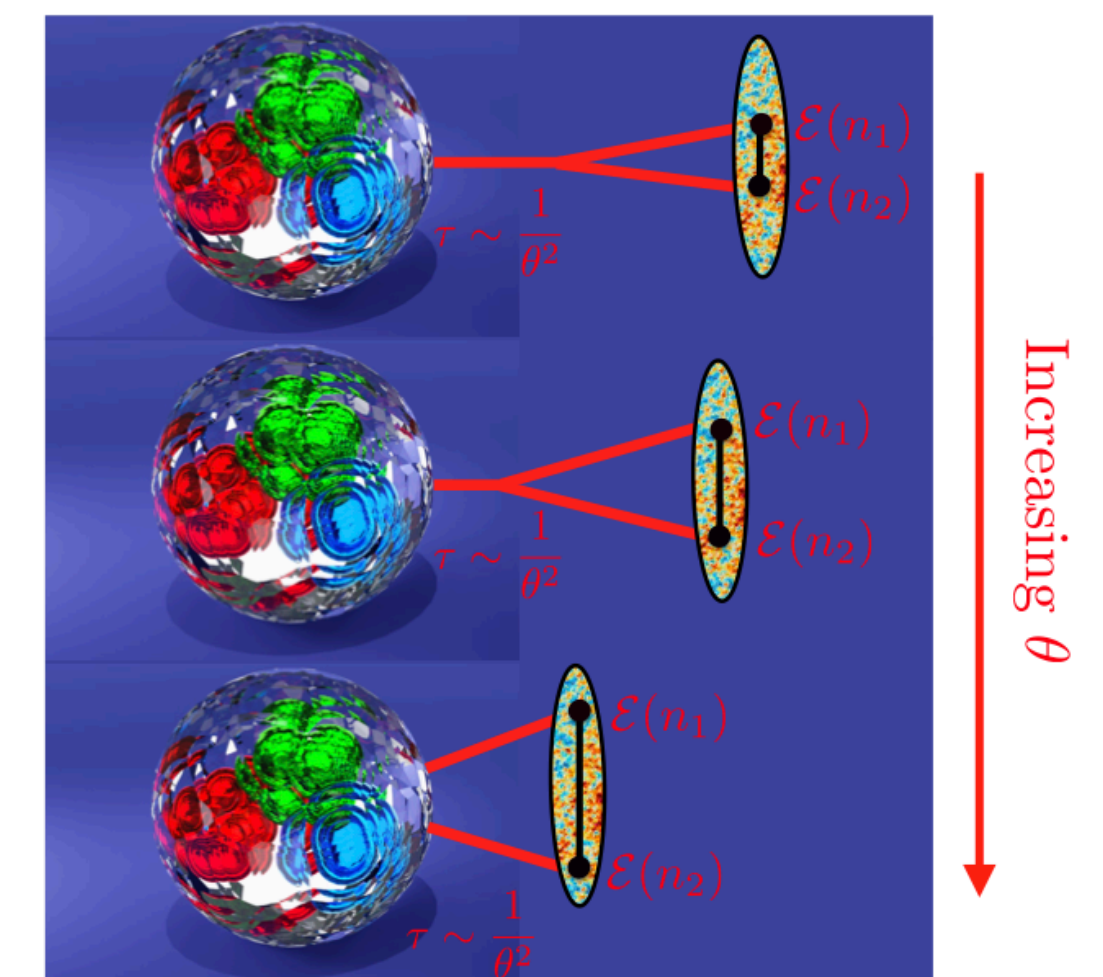
W-boson initiated jets
(Delayed probes)



Jet clustering trees
(QCD formation time)



Energy-Energy Correlators
(QGP scales)

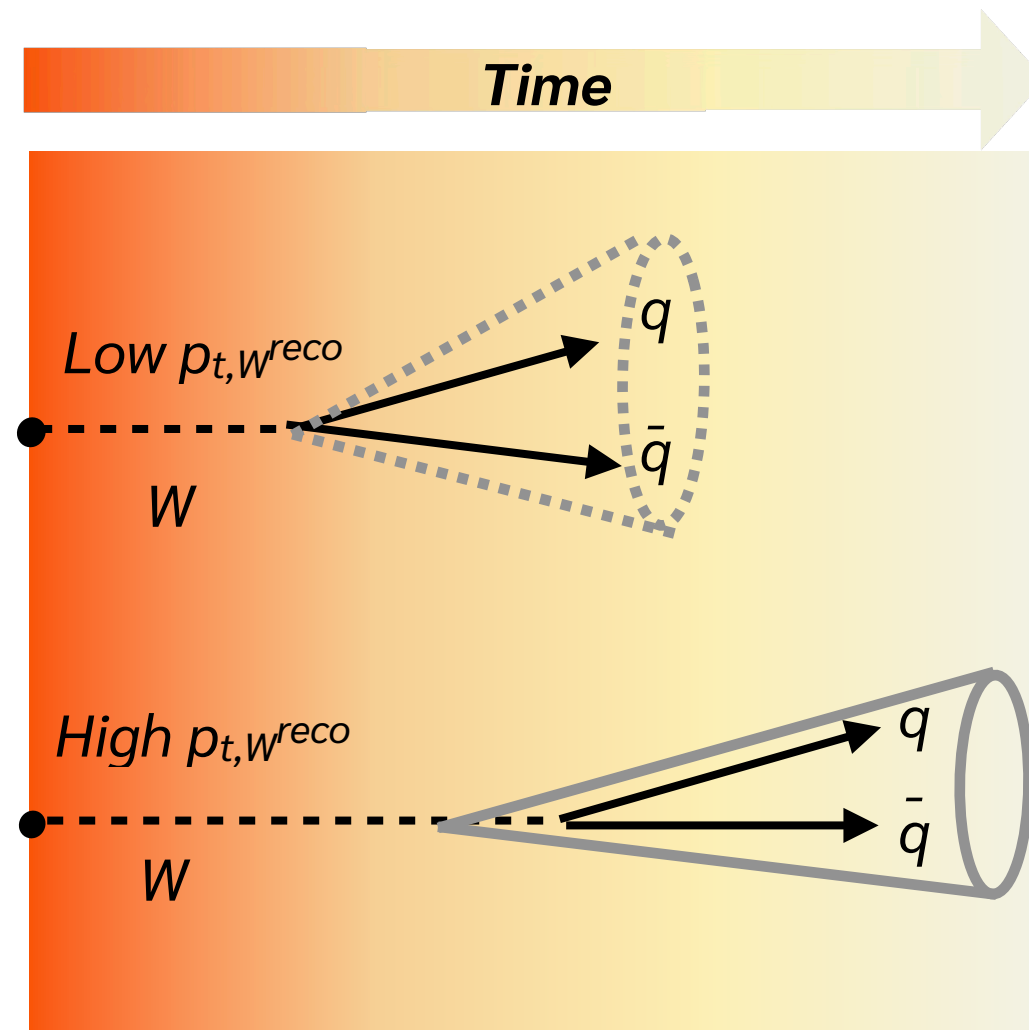


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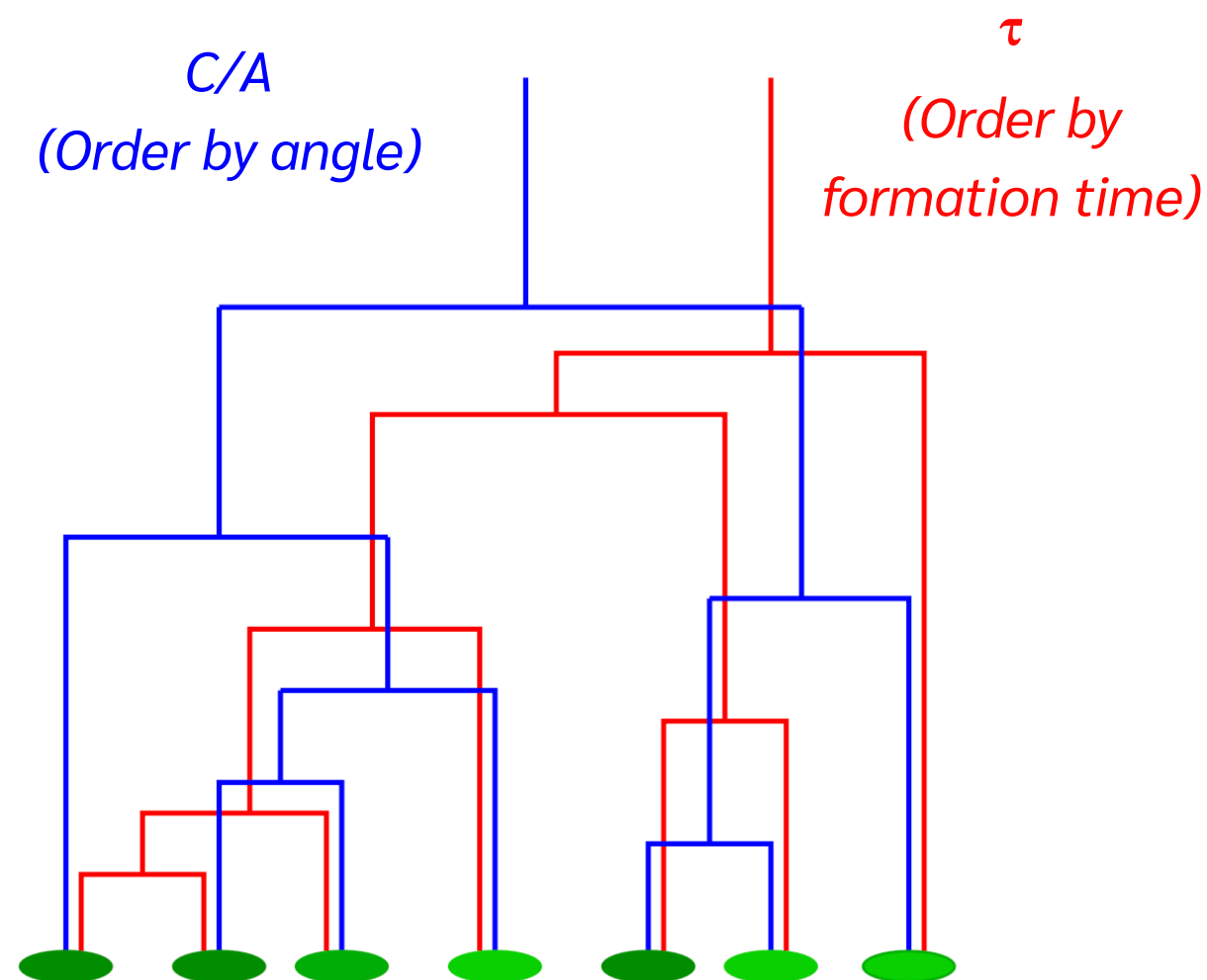
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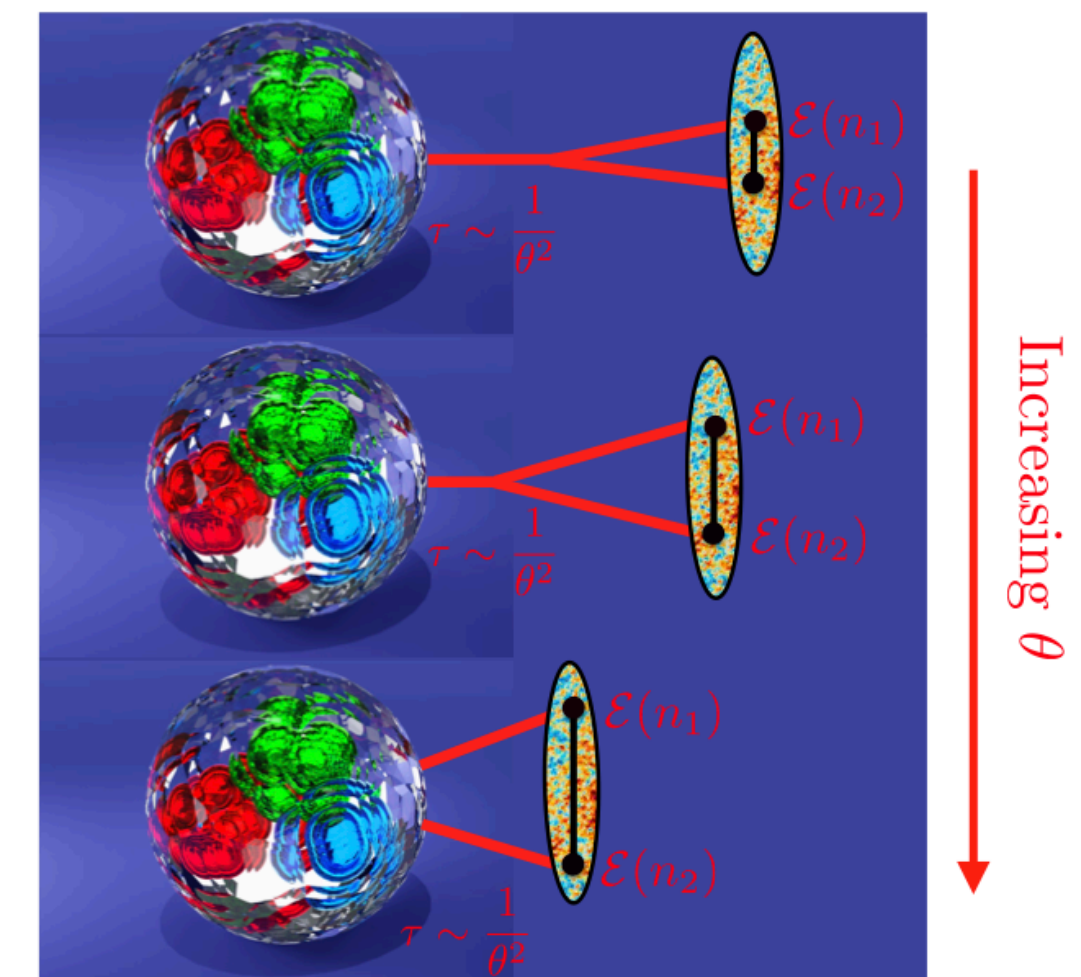
Statistical feasibility for an upcoming HL run?

Jet clustering trees (QCD formation time)



Experimentally applicable Soft-Drop grooming procedures?

Energy-Energy Correlators (QGP scales)



How to separate among QGP-scales and from underlying event?

JetQCD Objectives

- Design, validate, and disseminate **jet observables** that access different QGP stages, from early-time formation to late-time QGP evolution;
- Provide **reproducible workflows for these observables**, enabling community-wide use;
- Support **systematic comparisons across collision systems** (PbPb, pPb, OO) through MC datasets;
 - Provide further scientific input for a **possible upcoming heavy-ion run** (lighter ions? More PbPb?)
- **Foster collaboration between theory and experiment** by sharing benchmarks, facilitating hybrid task teams, and hosting regular coordination workshops.



JetQCD Main Activities

Multi-differential Jet Observables

- **Observable** definition, implementation *guidelines* and usage examples;
- **Report on Physics reach** based on current Monte Carlo models.

System-Scaling Translation

- **Theoretical benchmarks** to interpret how proposed jet observables evolve across: **system size, temperature, and lifetime.**

— Workshops and Virtual Access —

- Modular **open-source** analysis **code**;
- Examples runnable on publicly available **CERN data**;
- **MC datasets** with system-scaling options for direct use in feasibility studies;
- **Bayesian inference tools** for systematic model–data comparison (*if time permitting).

Budget and Institutes

- Total budget: 450k€
- 2 postdocs (yearly gross cost ~50k€, total~300k€)
- Workshops & Training: 4 events at ~25k€ each (totalling 100k€)
- Travel: ~50k€

Participating Institutes/Researchers:

Charles University (Czech Republic) Martin Rybar, Martin Spousta (EXP-ATLAS); **Czech Technical University (Czech Republic)** Jaroslav Bielcik, Barbara Trzeciak (EXP-ALICE); **Nuclear Physics Institute of the Czech Academy of Sciences (Czech Republic)** Jana Bielcikova, Filip Krizek (EXP-ALICE); **IPhT, CEA-Saclay (France)** Gregory Soyez (TH/PH); **École Polytechnique Paris (France)** Carlota Andrés, Cyrille Marquet (TH/PH), Matthew Nguyen (EXP-CMS); **La Sapienza Rome University (IT)** Leticia Cunqueiro (EXP-CMS); **LIP (Portugal)** Liliana Apolinário, Guilherme Milhano, Andrey Sadofyev (TH/PH), Helena Santos (EXP-ATLAS); **Nikhef (The Netherlands)** Marco van Leeuwen, Marta Verweij (EXP-ALICE); **SUBATECH, Nantes (France)** François Arleo, Paul Caucal (TH/PH); **U. Bergen (Norway)** Konrad Tywoniuk (TH/PH); **U. Granada (Spain)** Alba Soto-Ontoso (TH/PH) **U. Oxford (UK)** Gavin Salam (TH/PH); **U. Santiago de Compostela/IGFAE (Spain)** Néstor Armesto, Bin Wu (TH/PH); **CERN** Urs Wiedemann, João Barata (TH/PH), Andreas Morsch, Nima Zardoshti (EXP-ALICE)