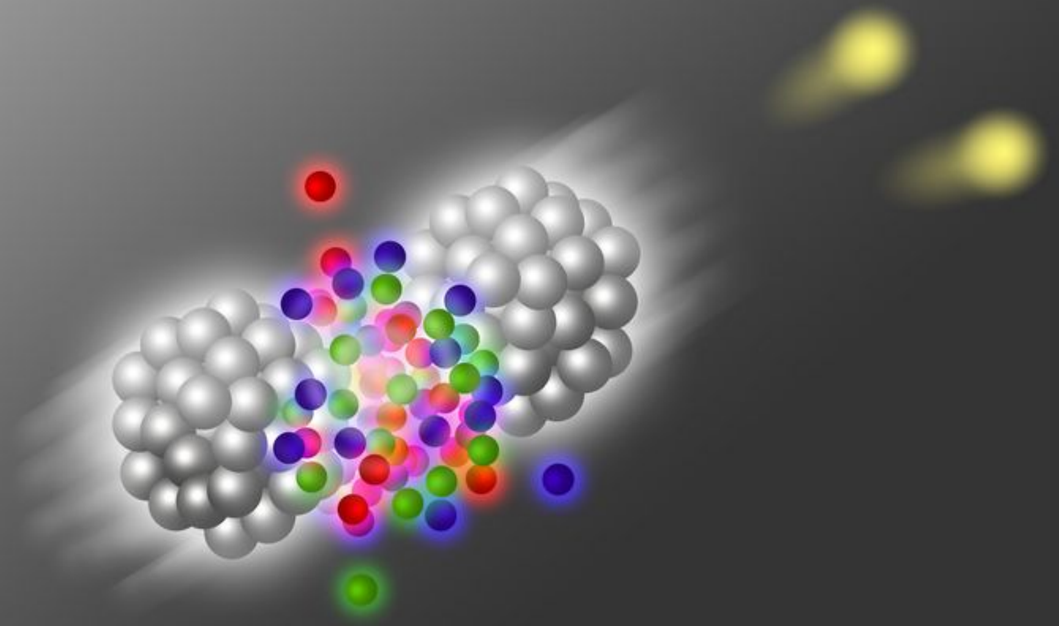
LIP Phenomenology group
2025 Highlights



Liliana Apolinário

LIP Advisory Meeting

Thursday, April 23rd

Pheno Group

Core Activities

QCD	Heavy-Ions	BSM
High-precision studies at the LHC NNLO corrections Saturation scale in high-energy QCD / Small-x Physics @ Lisbon	Theoretical development of jet quenching Monte Carlo Event Generators Jets as probe of the QGP @ Lisbon, Braga	AI and ML techniques as anomaly detection @ Braga

Internal (LHC, Astroparticles, Big Data) and External Collaborations / Outreach

Pheno Group

Core Activities

QCD

High-precision studies at the LHC
NNLO corrections

Saturation scale in high-energy QCD / Small-x Physics

+2 CEEC Candidates?

@ Lisbon

Heavy-Ions

Theoretical development of jet quenching

Monte Carlo Event Generators

Jets as probe of the QGP

+2 CEEC Candidates?

@ Lisbon, Braga

BSM

AI and ML techniques as anomaly detection

Dark matter candidates and their interactions at colliders

+2 CEEC Candidates?

@ Braga

Internal (LHC, Astroparticles, Big Data) and External Collaborations / Outreach

Group Members

Members that left and new entries in 2024/2025

Leaving:

Grigorios Chachamis (QCD): permanent position @ Navarre University (Spain)

Carlota Andrés (HI): permanent position @ École Polytechnique (France)

Pablo Rodriguez-Guerrero (HI): post-doc @ USC (Spain)

→ *Applying for CEEC with Pheno group*

Afonso Guerreiro (HI): completed MsC degree

→ *Applying for PhD in the group*

Diogo Costa (HI): completed MsC Degree

→ *Applying for PhD in the group*

Guilherme Crispim (HI): completed MSc Degree (*in collaboration with LIP Auger group*)

Guilherme Calé (QCD): completed MSc Degree

Entering:

António Morais (BSM): permanent position @ Braga

Marco Finetti (BSM): PhD Student

Marco Leitão (HI): PhD Student

Vinicious Oliveira (BSM): PhD Student

João Pino (BSM): PhD Student

Daniel Araujo (BSM): MSc students

Tomás Gaspar (HI): MSc Student

Ilda Martins (BSM): MSc students

Funding

Current status and on-going applications

Successful in 2024/2025:

FCT **Exploratory projects**: “Anomalous collective modes in Weyl semimetals” - **50 k€**
FCT **ERC-PT projects**: “Unveiling the Time Dynamics of Quantum Chromodynamics in the Quark-Gluon Plasma” - **250k €**

Existent

ERC YoctoLHC: “Yoctosecond imaging of QCD collectivity using jet observables” - **400 k€**

On-going in 2025:

ERC-Consolidator 2025 (re-applying): “Unveiling the Time Dynamics of Quantum Chromodynamics in the Quark-Gluon Plasma” - ChronoQCD
ERC-Consolidator 2025: “Jet Tomography of QCD Matter” - iJet

Scientific Impact

International visibility

22.5 FTEs (8.2 Researchers): 13 Published Papers + 12 submitted + ~40 talks/seminars
(+1 in collaboration with LIP-SWGO group)

Selected talks in main conferences with 1000+ participants

O LIP na Quark Matter 2025

MARCH 18, 2024

Hard Probes 2024

Two of our PhD students (Nuno Olaves and João Silva) as well as one of our researchers (Andrey Sadofyev) will attend and deliver talks. Click on their names to see their respective contributions!

Invited lectures at International PhD schools

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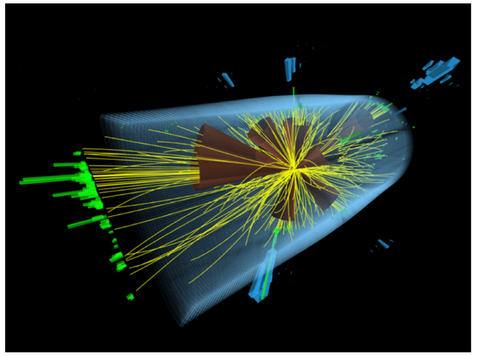
Workshop organisation 2024

FEBRUARY 28, 2024

Energy Correlators at the Collider Frontier



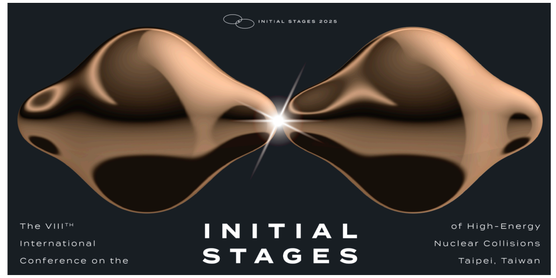
+ Applied for long workshop at C3NT 2026

HI Convener ICHEP 2024

Poster Evaluator Hard Probes 2024

HP2024 NAGASAKI

IAC Member (on-going)



Heavy-Ion Theory Convener (On-going)

LPCC
LHC Physics Centre at CERN

SWOT

Strengths: **Internationally recognized and highly active** research program in Heavy-Ions and BSM searches, driving high-impact advancements. Strong track record in securing national and European funding, ensuring financial sustainability and research excellence.

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Opportunities: **Strong interest from researchers at all career stages** fosters growth and renewal. Synergies with Astroparticle groups and the Simulation & Big Data Competence Centre enable interdisciplinary research. Established collaborations with top international centers (CERN-TH, Santiago, Granada, Jyvaskyla, MIT) enhance global impact. ***Most senior members connected to local Universities as (invited) professors.***

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Threads: **Uncertainty in retaining key researchers**, with precarious employment creating **risks of losing expertise and disrupting established research areas**. Reduction in available PhD grants, limiting the ability to secure current MSc students and attract external candidates for PhD positions, threatening long-term sustainability.
Need for the opening of theory positions at Universities.

Acknowledgments

REPÚBLICA PORTUGUESA

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Fundação para a Ciência e a Tecnologia

STRONG 2020

LIP

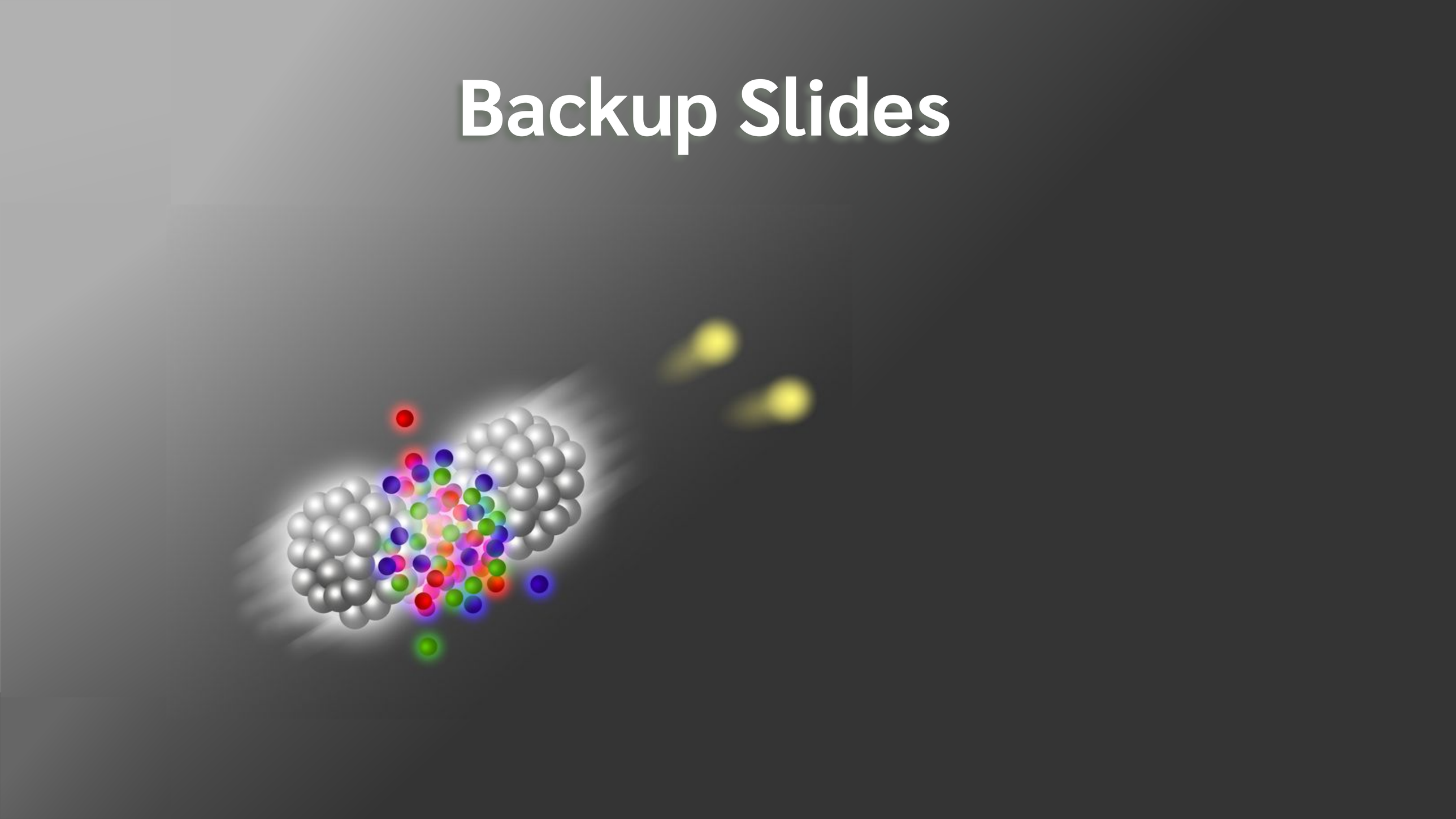
TÉCNICO LISBOA

erc

European Research Council

Established by the European Commission

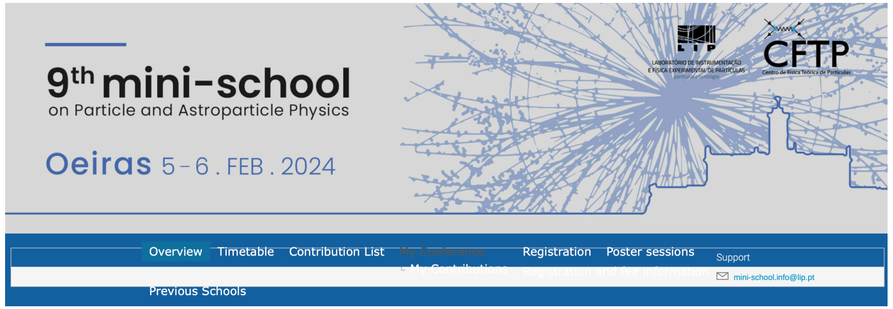
Backup Slides



Outreach

Local reach of Pheno group

Hands-On QCD Jets session and QCD lectures



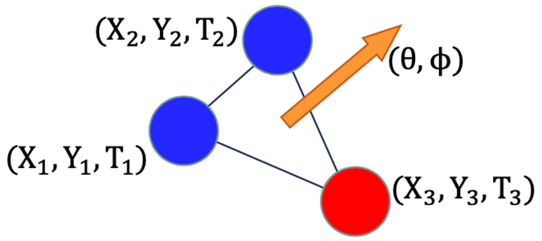
Pheno Webpage News and Outreach

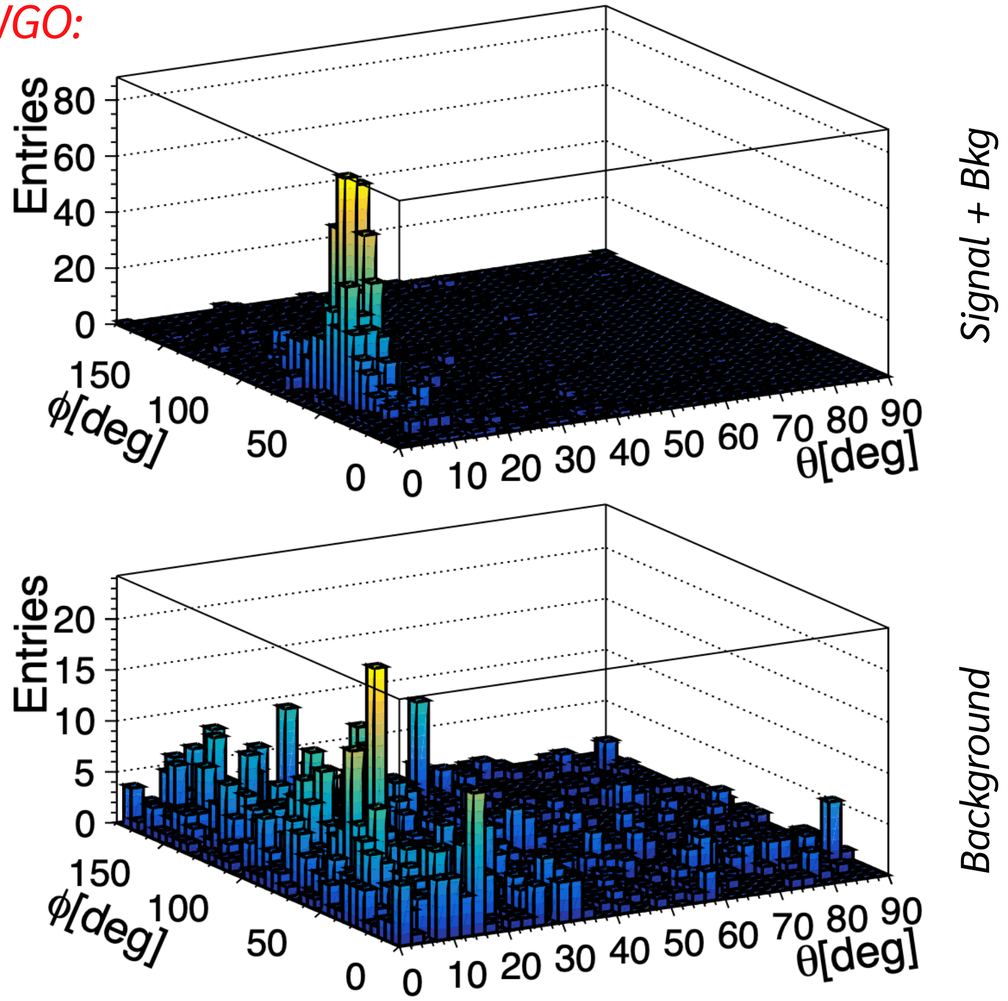
LIP Summer Internships: 3 projects

Internal Collaborations

Collaboration with SWGO:

- **L. Apolinário et al., JCAP 04 (2025) 029**
- Compute the plane formed from each 3 active stations
- Caracterize this plane using the normal vector to the plane
- Reconstruct the direction of the gamma-ray shower using a QCD-jet algorithm





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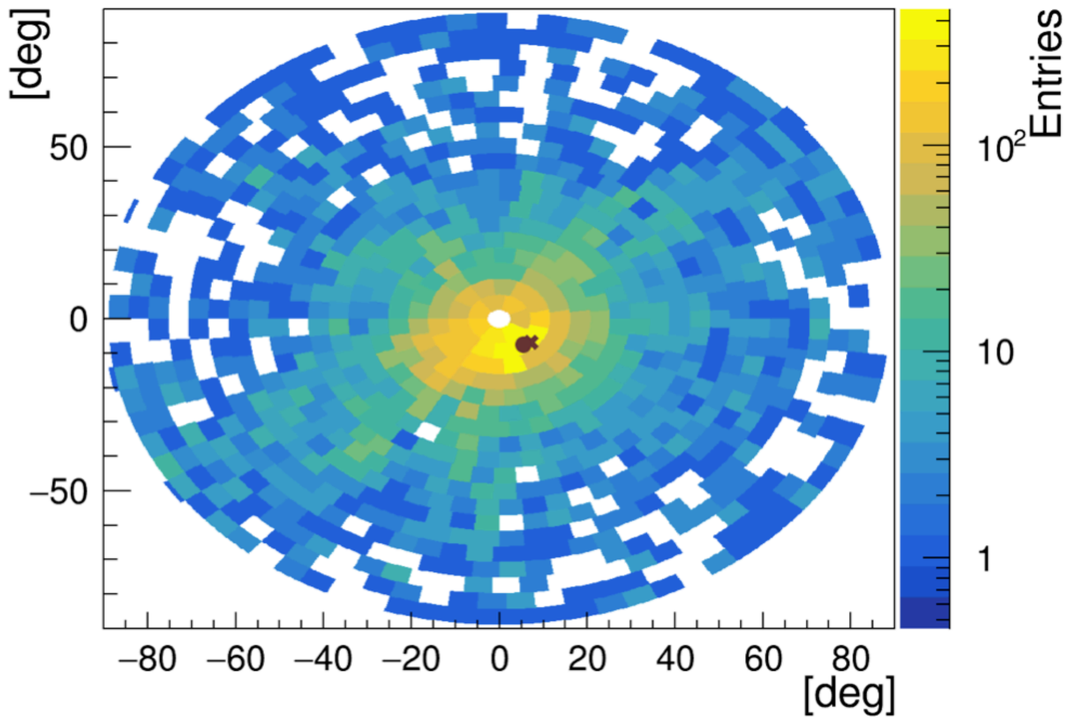
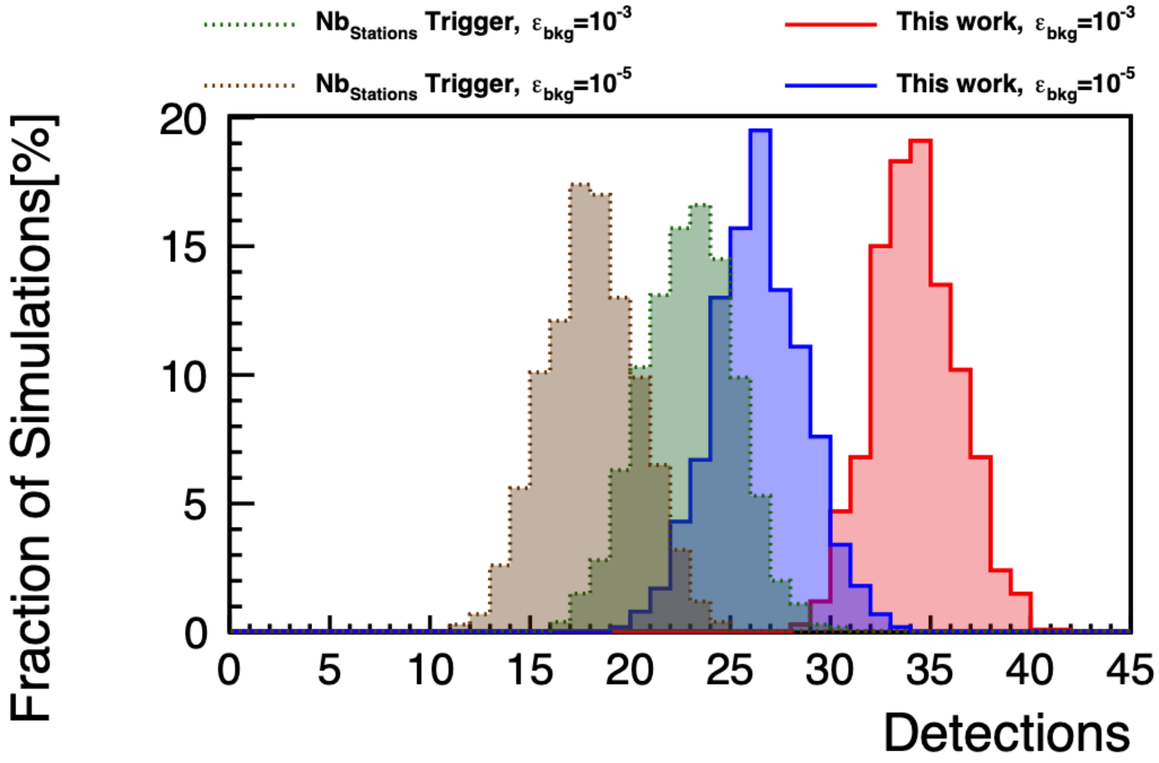


Gamma shower event embedded in atmospheric muons background



Gamma Ray Bursts detected

iJet

Matter branch:

- the latter stages (th+ex)
- the early stages (some th)

main tool: hydrodynamics

the gap

compromises the success of the ongoing and future experimental programs

Jet branch:

- jets at latter stages (th+ex)
- some jet tomography

main tool: perturbative QCD

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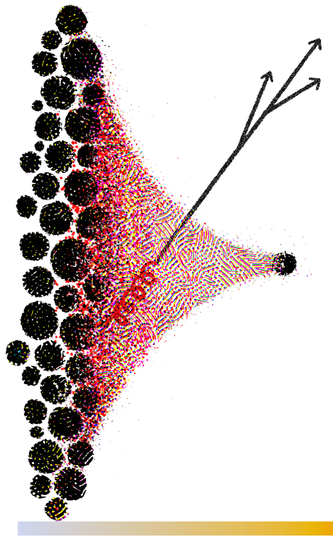

- jets in non-equilibrium/evolving QCD matter (**fluctuating** evolving matter)
- formation of QCD matter in smaller systems?

formation of complex QCD matter

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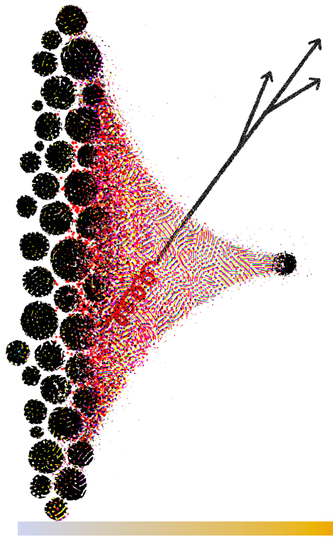

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formation of QCD matter in smaller systems?

formation of complex QCD matter

iJet

Main goals:

jets as a tool to study

- fluctuating QCD matter
- 3D structure of QCD matter

jet observables sensitive to

- non-equilibrium dynamics
- 3D structure

Main results:

- coupling jets to **fluctuations** (non-equilibrium matter)
- treating the **medium response**
- **tomographic** jet observables

Outcomes & Impact:

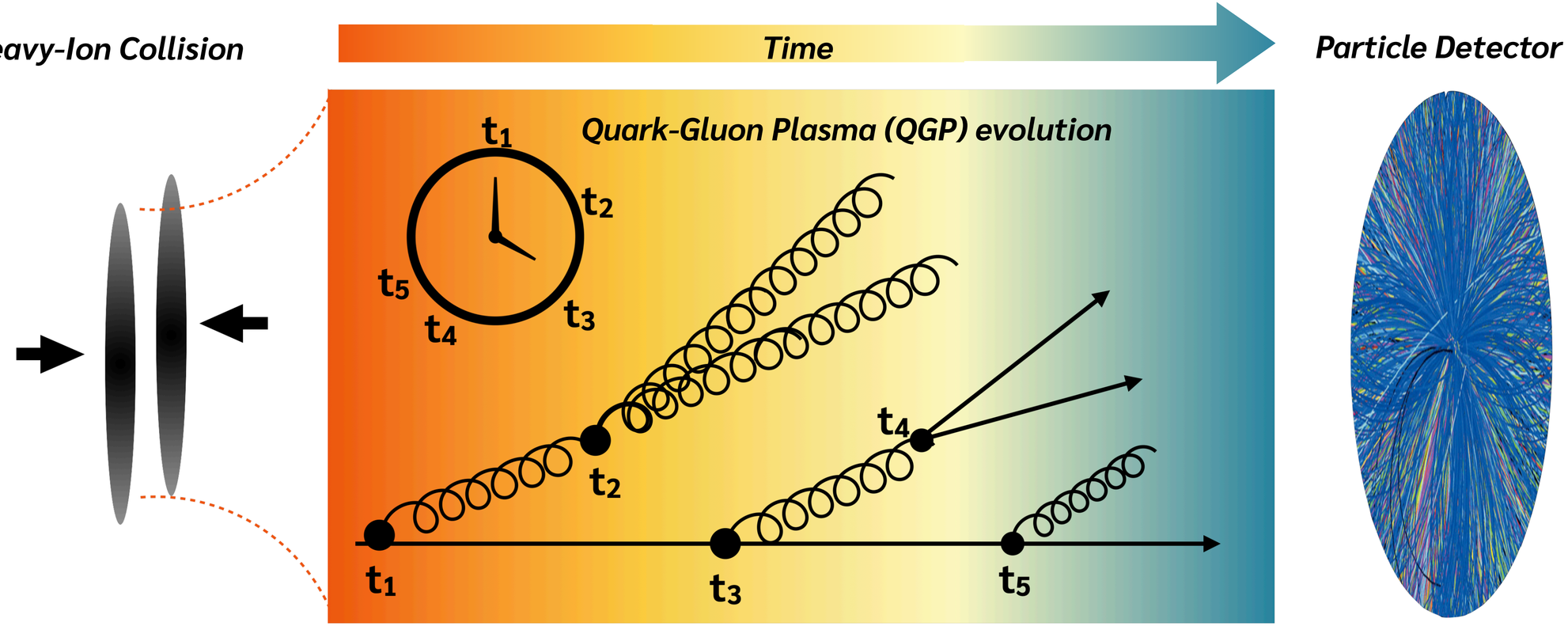
- **jet tomography from large to small systems**
- jet tomography at EIC
- possible implications to cosmology and astrophysics

Shifting the paradigm
in our understanding of
the complex nuclear matter

ChronoQCD

How to probe the time structure of QCD radiation?

Use the Quark-Gluon Plasma as a reference frame!



Break from conventional approaches and develop a space-time based formulation for QCD jets

ChronoQCD

WP1: Time-dependent jet quenching evolution

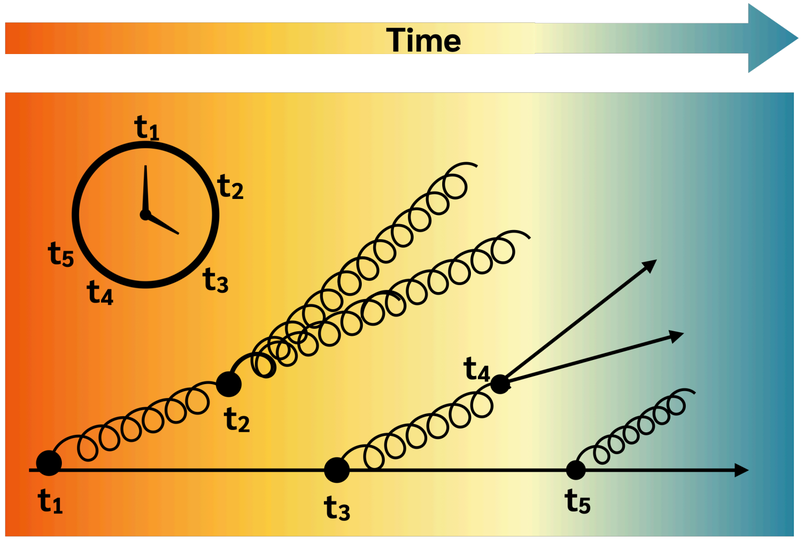
Goal: Space-time dependent formulation of QCD jets

(Theoretical development)

WP2: QGP transient properties

Goal: Interleaved QCD showers + QGP evolution

(Application to heavy-ion events)



WP3: Exploration of the QCD time-axis

Goal: Exploration of unique opportunities on QGP-onset conditions and time-reverse violations in QCD