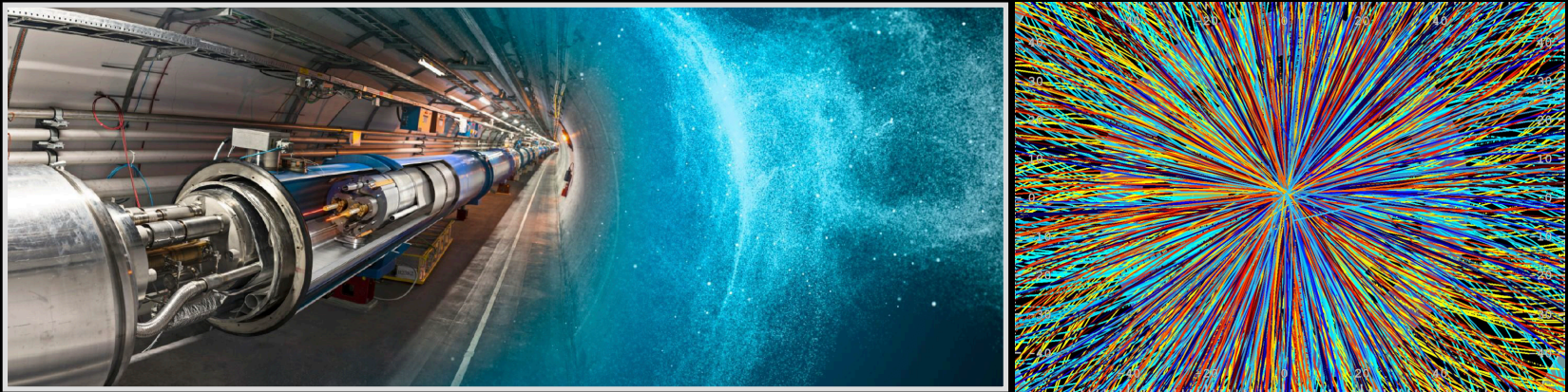


A **discovery** journey through your thesis project

*With the Little **Big Bang***



ALICE Group@NBI



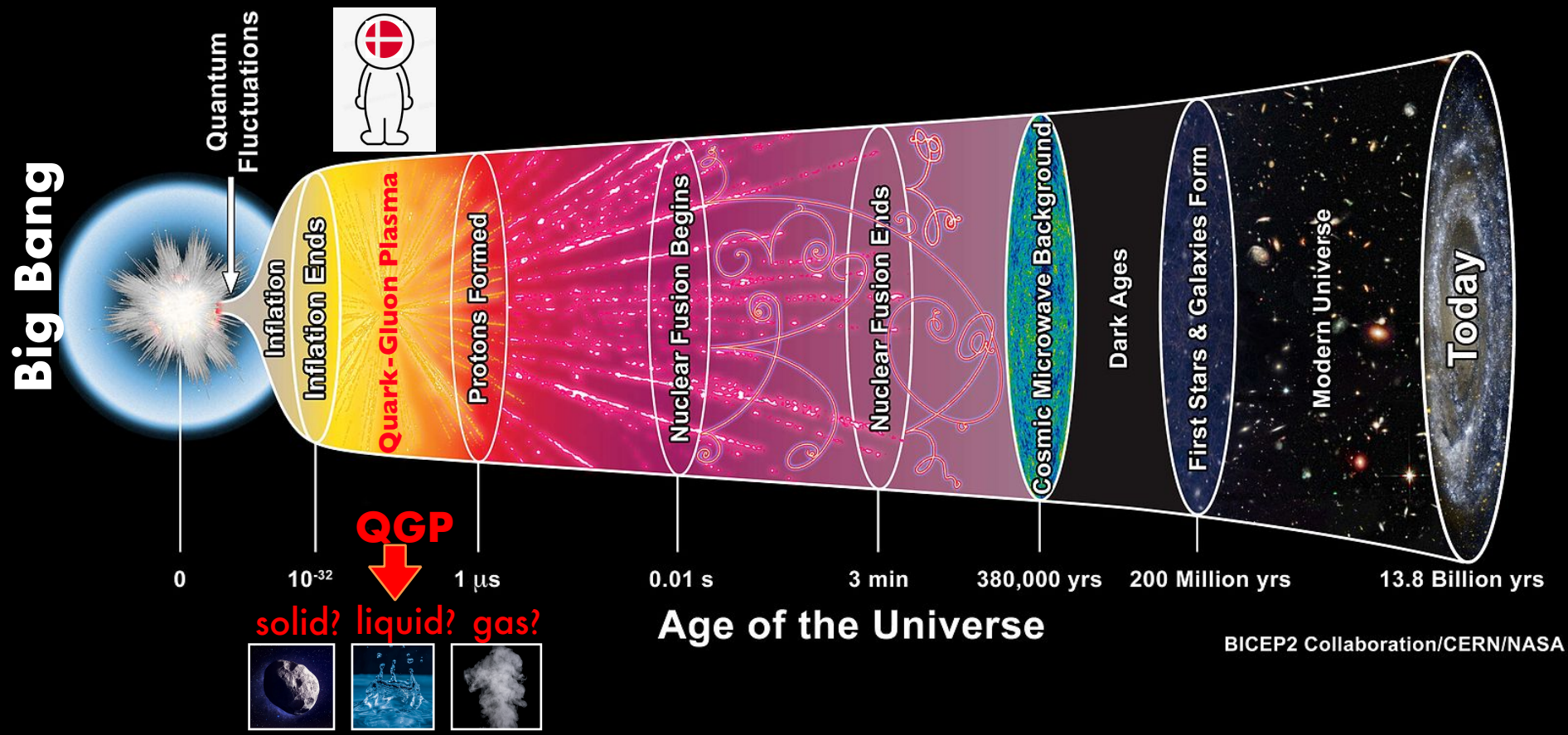
ALICE

Niels Bohr Institute, Københavns Universitet

What is the beginning of the beginning?



History of the Universe



Little Big Bang



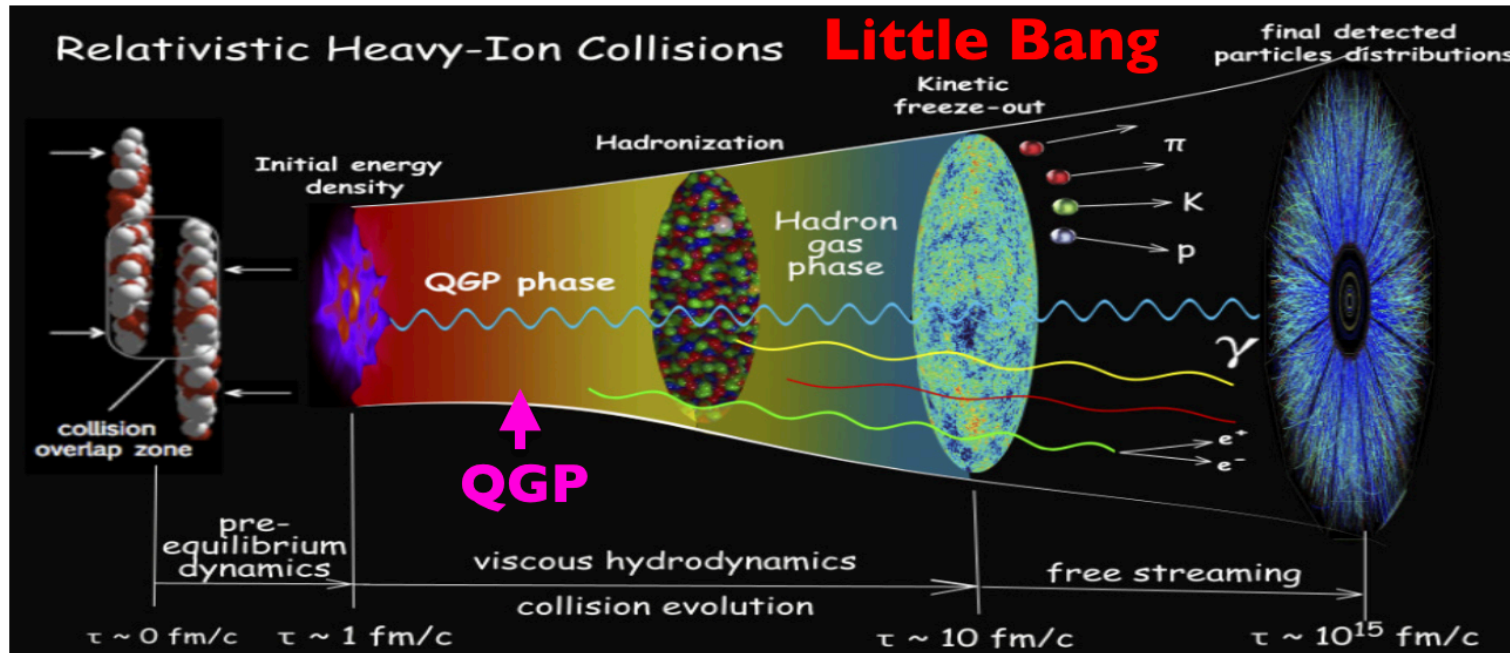
Highest temperature

WHO
CERN, LARGE HADRON COLLIDER

WHAT
5X10¹² DEGREE(S) KELVIN

WHERE
SWITZERLAND

WHEN
13 AUGUST 2012



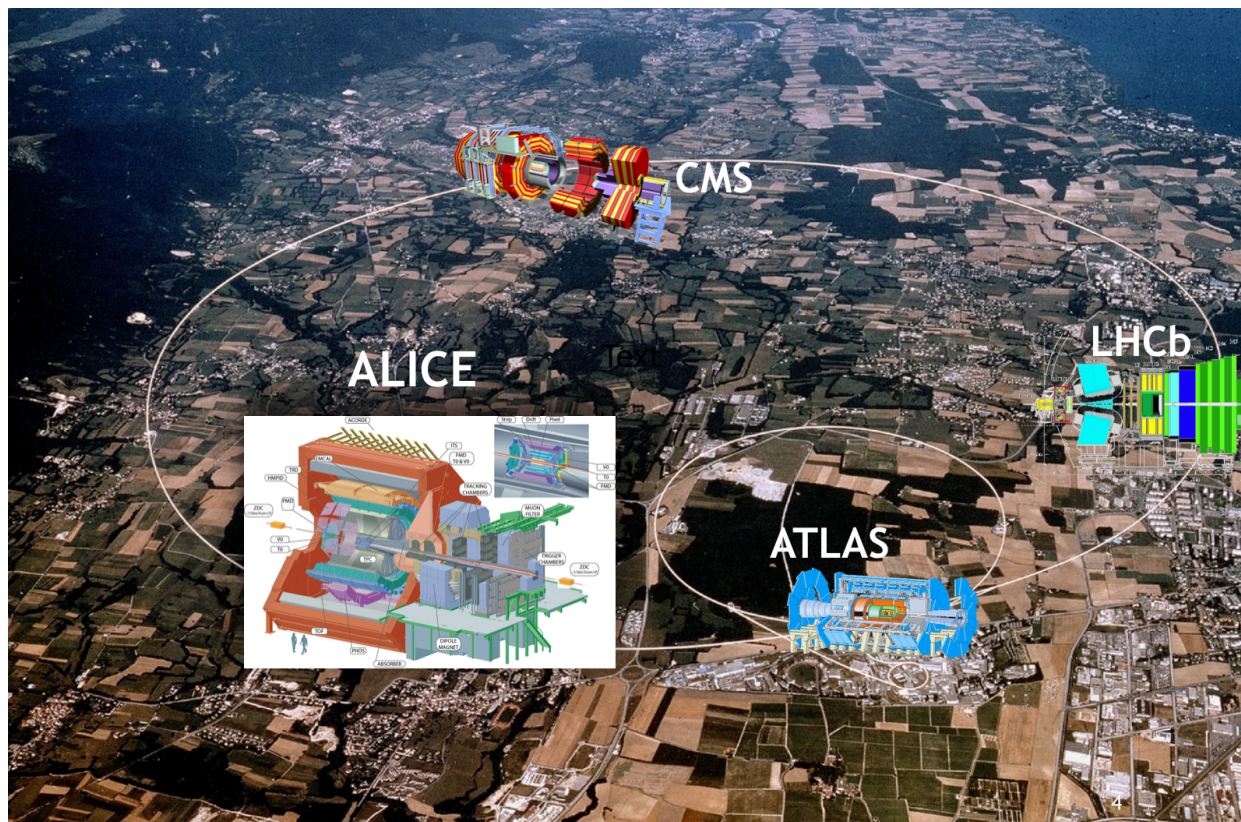
- ❖ Heavy-ion collision creates a **Little Bang**
 - T~5.5 thousand billion Kelvin (350.000 times hotter than sun's core)
 - Produces **QGP**



Creating the Little Big Bang at the LHC

Large Hadron Collider, CERN, Geneva

Our home laboratory, co-owned by Denmark



Early Universe is a Perfect Fluid

Daily Mail, February 2016

MailOnline Science & Tech

Home | News | U.S. | Sport | TV&Showbiz | Australia | Femail | Health | **Science** | Money | Video | Travel | Fashion Collider

Latest Headlines | Science | Pictures Login

How the early universe behaved like a LIQUID: Cern's atom smasher recreates the 'primordial soup' that began the universe

- Feat was achieved by colliding lead atoms at an extremely high energy
- The test took place in the 16.7 mile (27km) long Large Hadron Collider
- Allowed scientists to carry out measurements on a drop of 'early universe', that only has a radius of about one millionth of a billionth of a meter

By [ELLIE ZOLFAGHARIFARD FOR DAILYMAIL.COM](#) 

PUBLISHED: 22:01 GMT, 9 February 2016 | UPDATED: 23:02 GMT, 9 February 2016

Water
Small viscosity



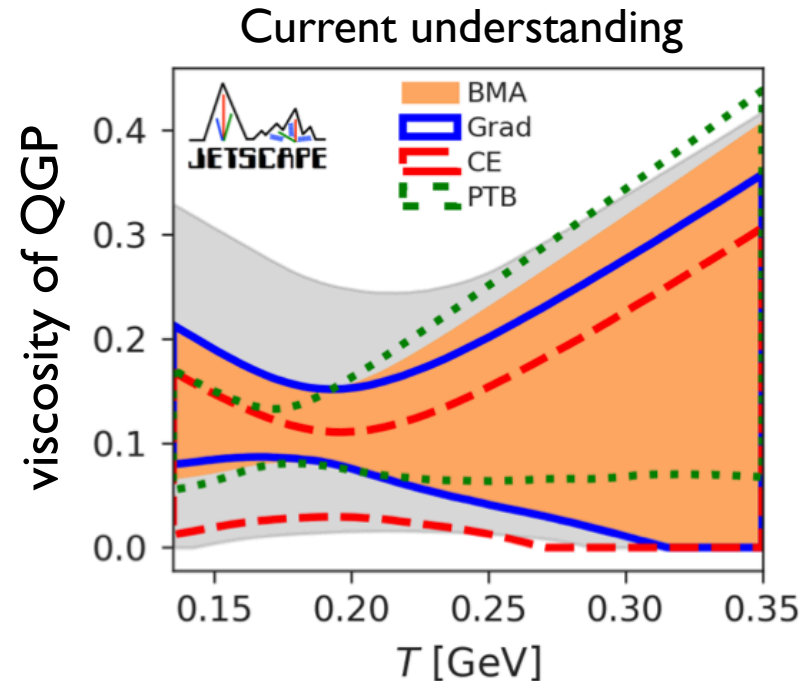
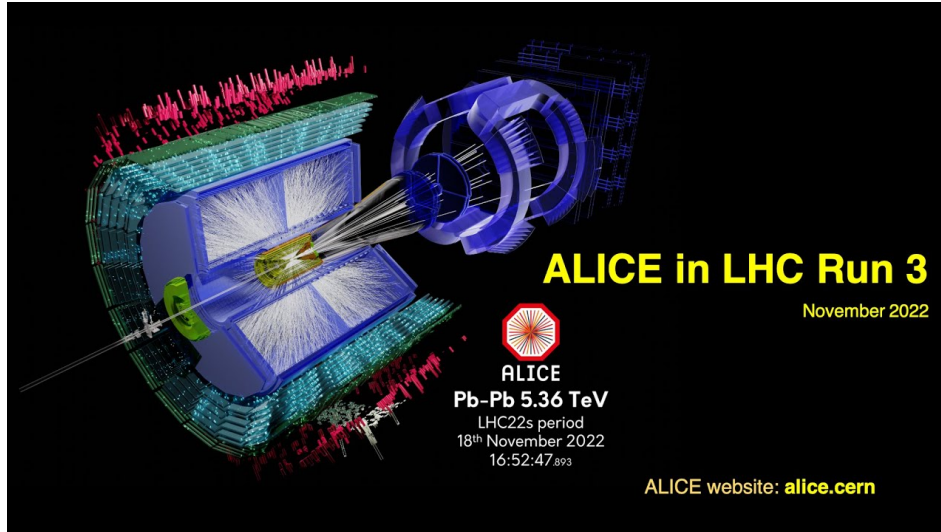
Honey
Large viscosity



- ❖ The measurements done by ALICE-NBI group show that
 - **Quark-Gluon Plasma (Early Universe) behaves like a perfect fluid**



Project I: Evolution of Early Universe

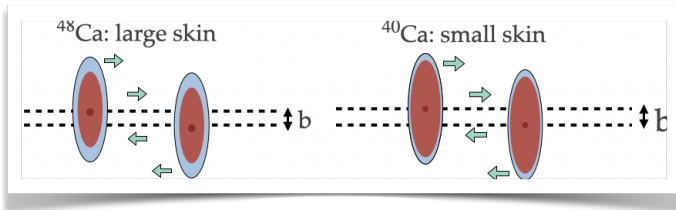
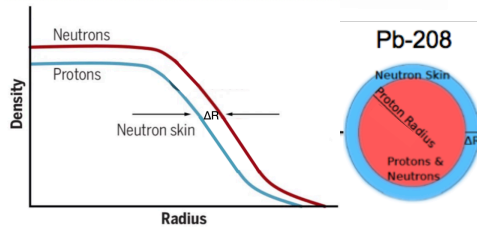
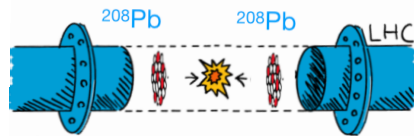


- ❖ Precise extraction of temperature dependent viscosity of QGP
-> Unravel the mystery of Early Universe after the first 0.000001 second

Project 2: From underground collider to Sky

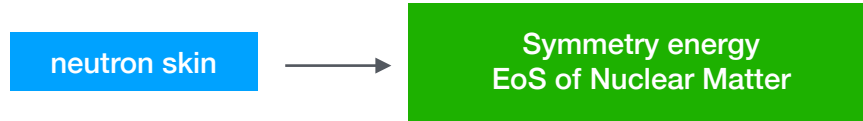
neutron skin

Heavy-ion collisions

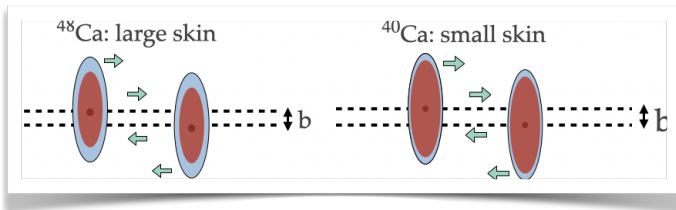
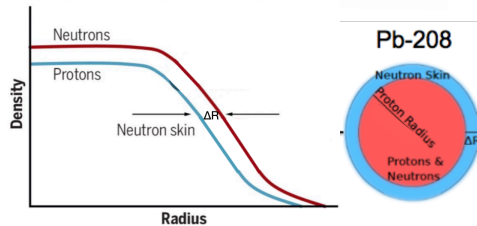


❖ Determine the critical size/mass of neutron stars with the super collider!

Project 2: From underground collider to Sky



Heavy-ion collisions



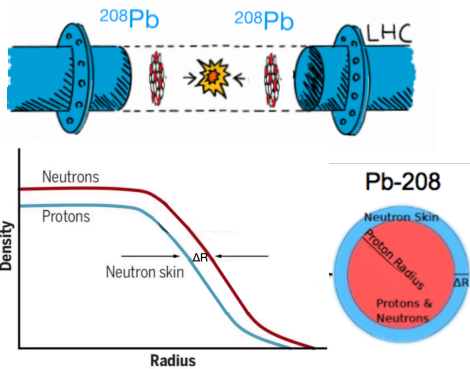
❖ Determine the critical size/mass of neutron stars with the super collider!



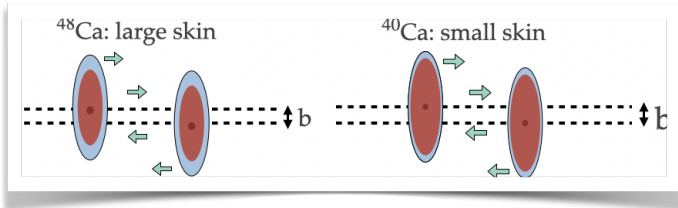
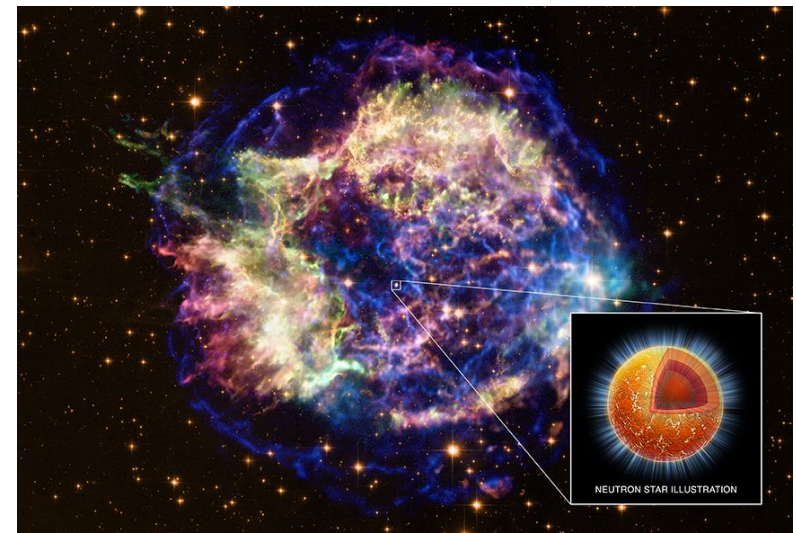
Project 2: From underground collider to Sky



Heavy-ion collisions



Neutron stars



❖ Determine the critical size/mass of neutron stars with the super collider!

Projects in ALICE

❖ **New frontier research in ALICE data analysis**

- Using the latest data collected at the LHC, supported by prestigious EU/DK fundings

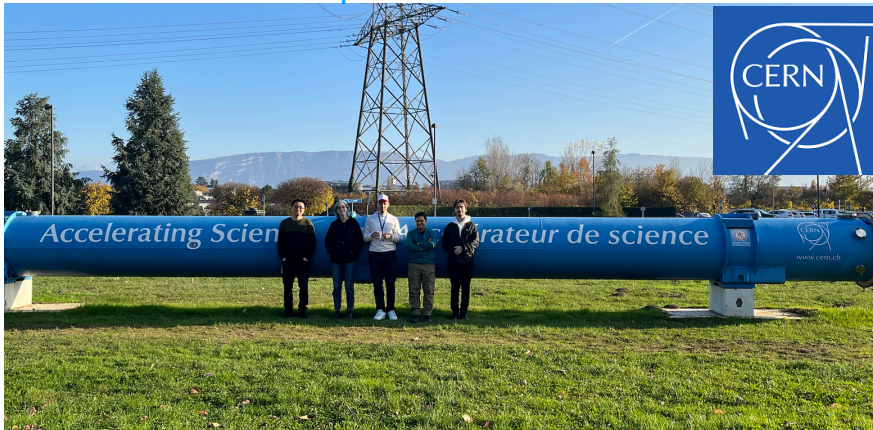


Projects in ALICE

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- Opportunities to attend and present in the conference & workshops at CERN

International workshop with bachelor and master students

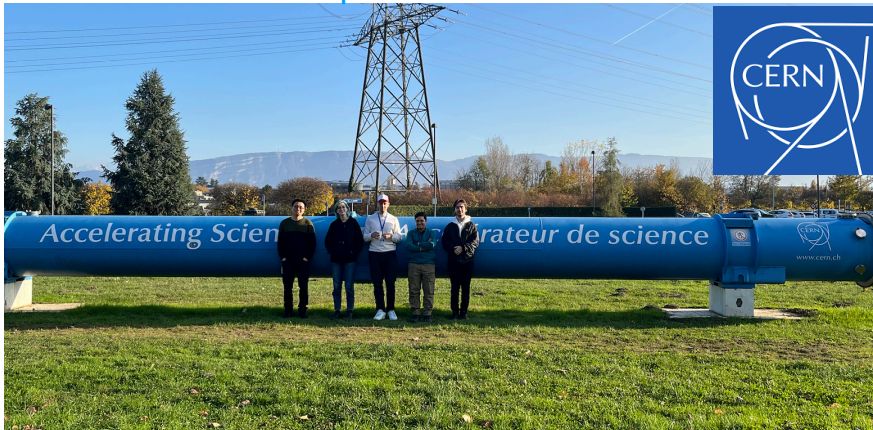


Projects in ALICE

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International workshop with bachelor and master students



Master students taking data for ALICE @ CERN



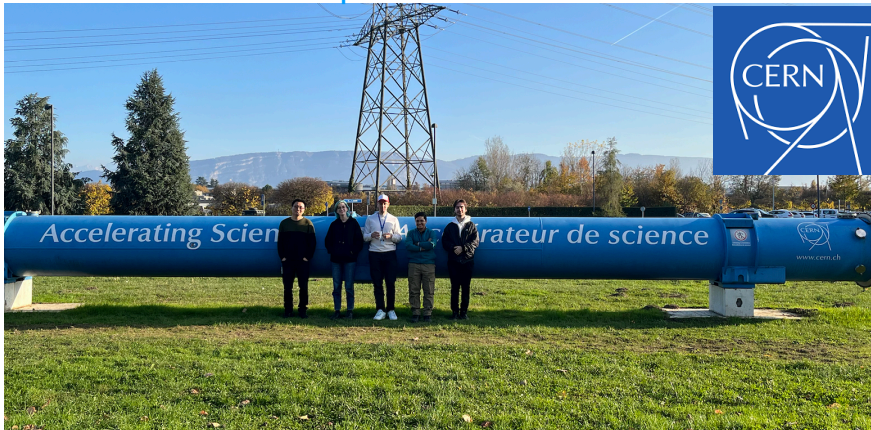
Projects in ALICE

❖ New frontier research in ALICE data analysis

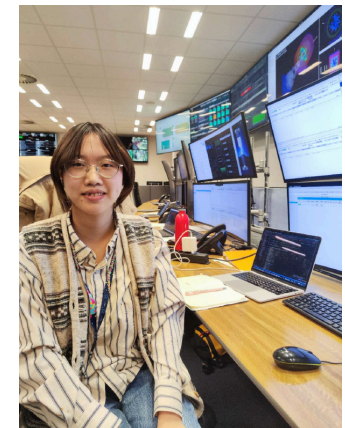
- Using the latest data collected at the LHC, supported by prestigious EU/DK fundings
- Opportunities to attend and present in the conference & workshops at CERN
- Get the professional training and become a crew for the ALICE shift
- **Whenever you have the results approved by ALICE, or results for publications, you will attend international conferences and present your works there!**



International workshop with bachelor and master students



Master students taking data for ALICE @ CERN



Students activities & achievements

❖ Publications based on Master Theses

Eur. Phys. J. A (2024) 60:38
<https://doi.org/10.1140/epja/s10050-024-01266-x>

THE EUROPEAN
PHYSICAL JOURNAL A



Regular Article - Theoretical Physics

Generic multi-particle transverse momentum correlations as a new tool for studying nuclear structure at the energy frontier

Emil Gorm Dahlbæk Nielsen, Frederik K. Rømer, Kristjan Gulbrandsen, You Zhou^a

Niels Bohr Institute, University of Copenhagen, 2200 Copenhagen, Denmark

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THE EUROPEAN
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Probe nuclear structure using the anisotropic flow at the Large Hadron Collider

Zhiyong Lu¹, Mingrui Zhao^{1,2}, Xiaomei Li¹, Jiangyong Jia^{3,4}, You Zhou^{2,a}

¹ China Institute of Atomic Energy, Beijing, China

² Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark

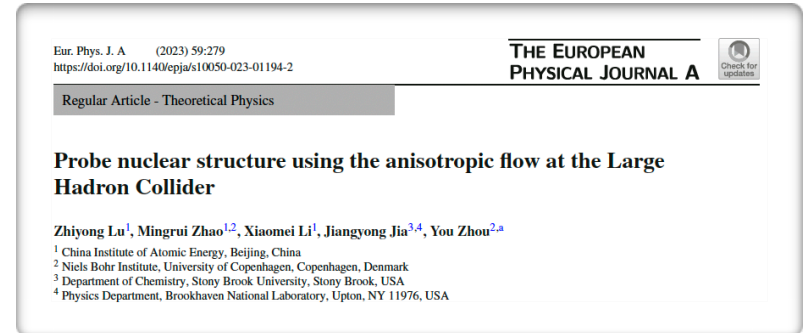
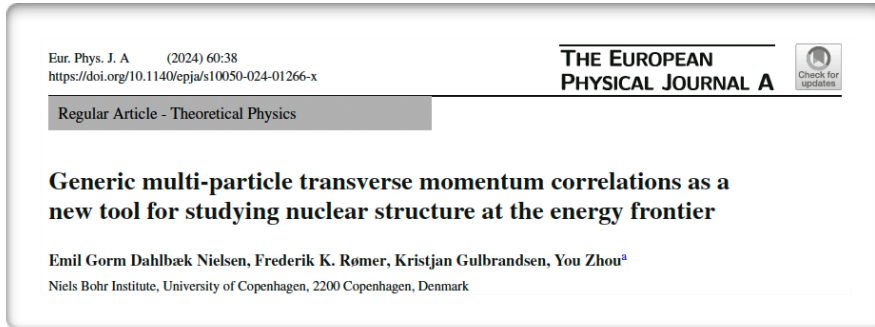
³ Department of Chemistry, Stony Brook University, Stony Brook, USA

⁴ Physics Department, Brookhaven National Laboratory, Upton, NY 11976, USA



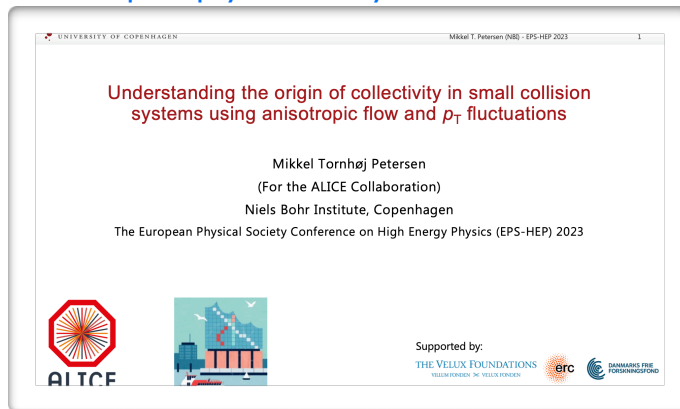
Students activities & achievements

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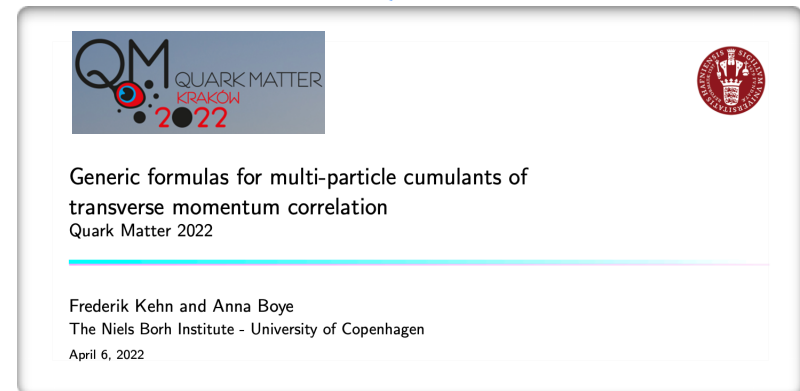


❖ Presenting at the International conferences, based on students' projects

European physics society conference



International conference Quark Matter



Students activities & achievements

❖ Publications based on Master Theses

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³ Department of Chemistry, Stony Brook University, Stony Brook, USA
⁴ Physics Department, Brookhaven National Laboratory, Upton, NY 11976, USA

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European physics society conference

UNIVERSITY OF COPENHAGEN

Mikkel T. Petersen (NBI) - EPS-HEP 2023

Understanding the origin of collectivity in small collision systems using anisotropic flow and p_T fluctuations

Mikkel Tornhøj Petersen
(For the ALICE Collaboration)
Niels Bohr Institute, Copenhagen
The European Physical Society Conference on High Energy Physics (EPS-HEP) 2023

ALICE

Supported by:
THE VELUX FOUNDATIONS
erc
DANMARKS FRIE FORSKNINGSFOND

International conference Quark Matter

QM QUARK MATTER
KRAKÓW
2022

Generic formulas for multi-particle cumulants of transverse momentum correlation
Quark Matter 2022

Frederik Kehn and Anna Boye
The Niels Bohr Institute - University of Copenhagen
April 6, 2022

All master & bachelor students got **Top Grade** for the last 5 years



Supporting team for your projects

❖ Group Structure

- You Zhou (main supervisors)



- Postdocs (daily supervisors)

- Debojit Sarkar (2022.9 -)
- Emil G. D. Nielsen (2023.9 -)



- New Postdoc 2 (2025-)

- PhDs (daily supervisors):

- Nina Nathanson (2024.9-)
- Preet Bhanjan Pati (2024.10 -)
- Zhiyong Lu, joint student (2021.9-)
- Tao Jiang, joint student (2023.12-)



- New PhD 2 (2025.9 -)
- New joint PhD 2 (2025.9 -)

- Master students

- Andreas Vitsos (2024.8 -)



- Bachelor students

- Thor Jensen (2024.8-)



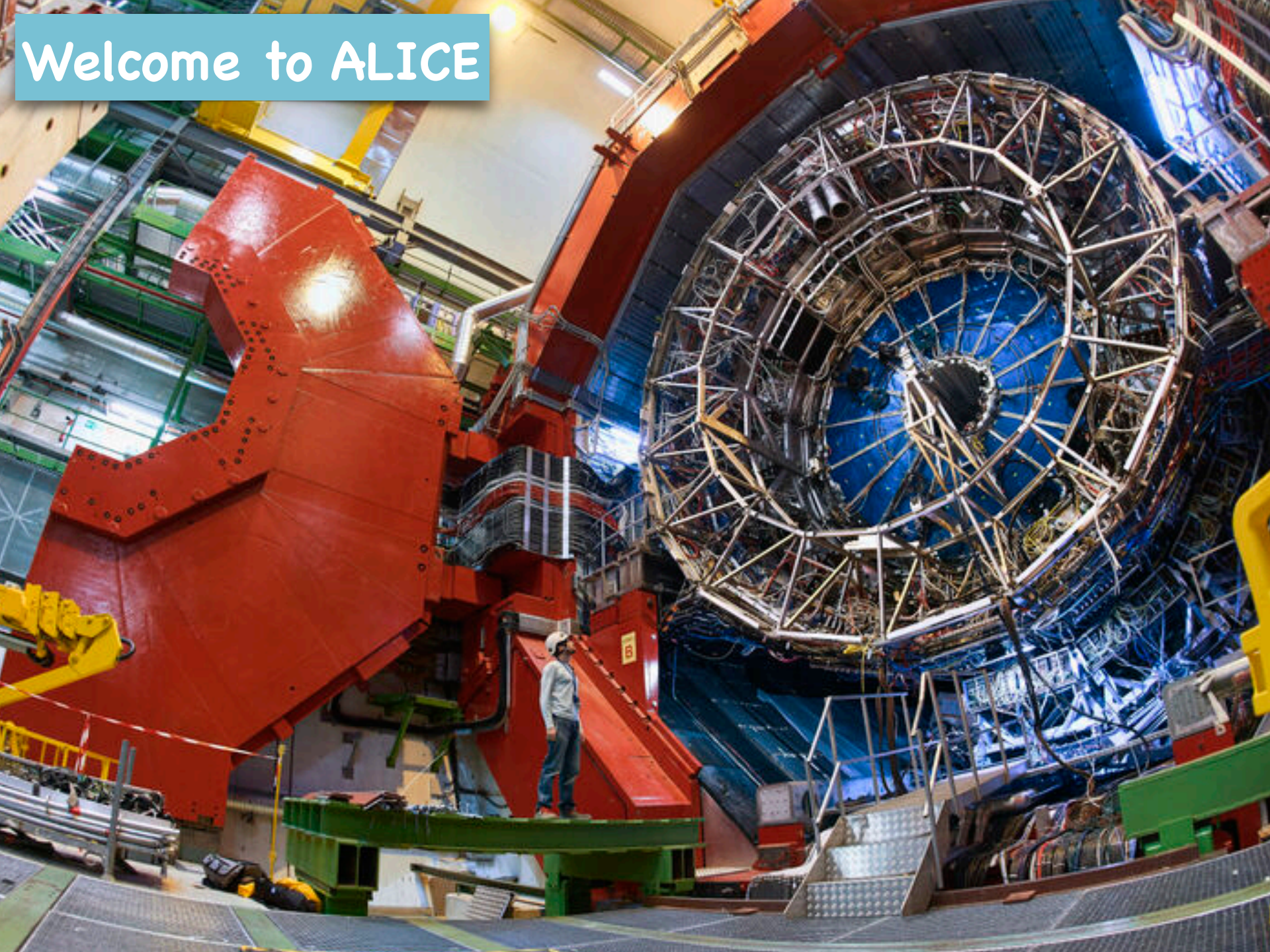
Project 3: next generation detector

❖ Design, construction of next generation detector FoCal for ALICE

- Major contributions by master and bachelor students
- Actively participant in the beam test @ CERN



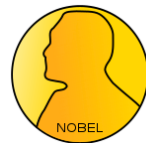
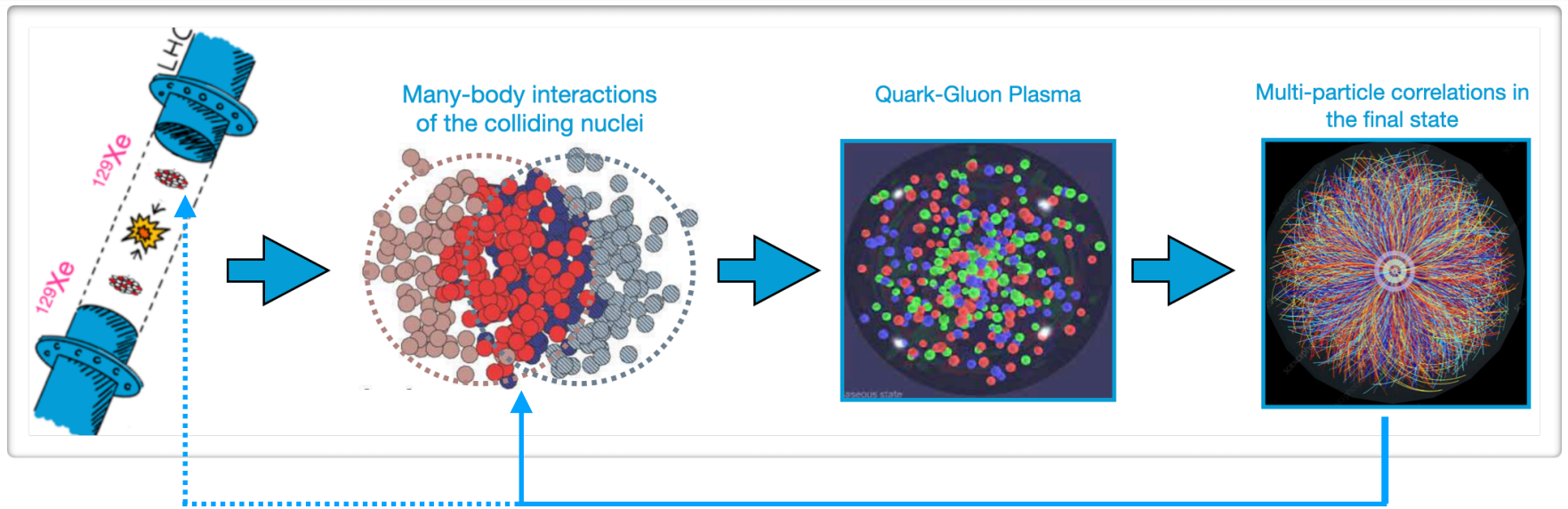
Welcome to ALICE



backup



Back to the Nobel Prize work



Nobelprisen i fysik
1975

“for the discovery of the connection between **collective motion and particle motion** in atomic nuclei and the development of the theory of the **structure of the atomic nucleus** based on this connection”

The Nobel Prize in Physics 1975



Photo from the Nobel Foundation archive.
Aage Niels Bohr



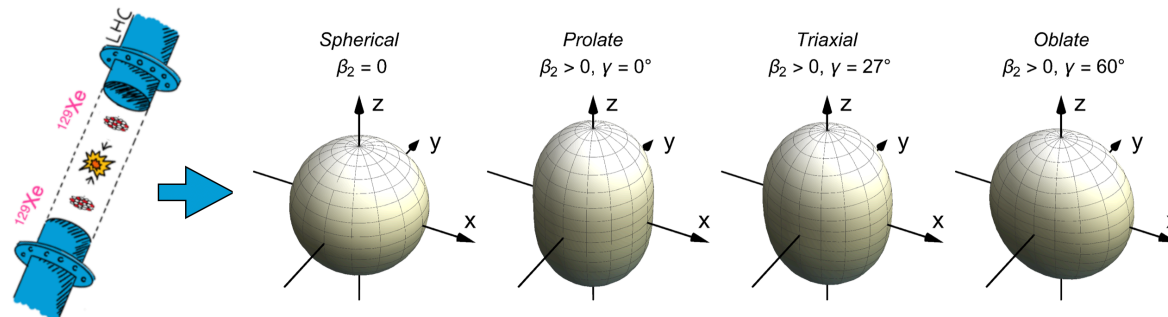
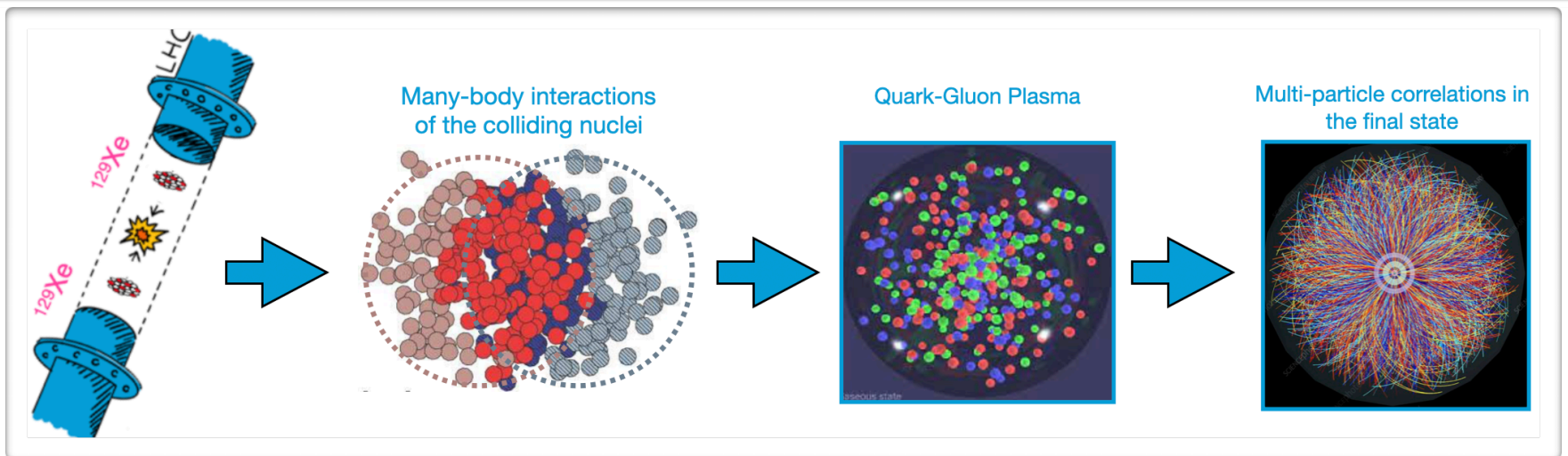
Photo from the Nobel Foundation archive.
Ben Roy Mottelson



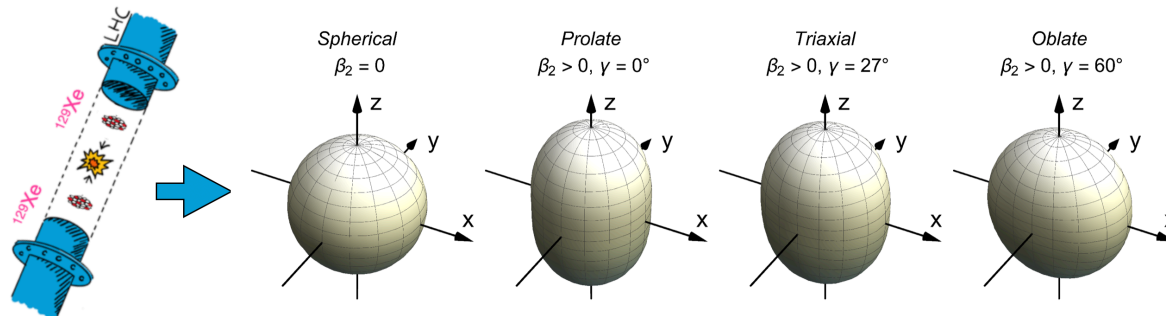
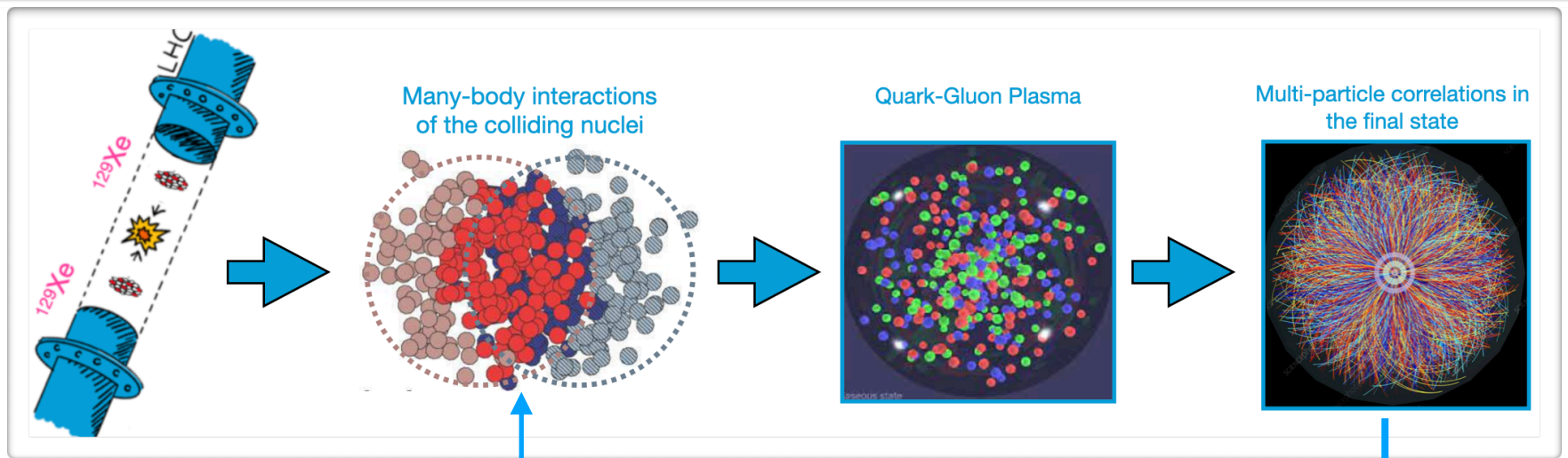
Photo from the Nobel Foundation archive.
Leo James Rainwater



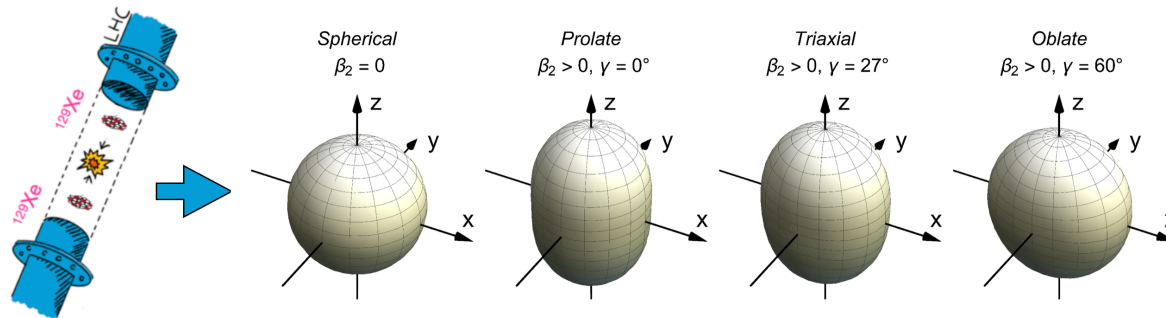
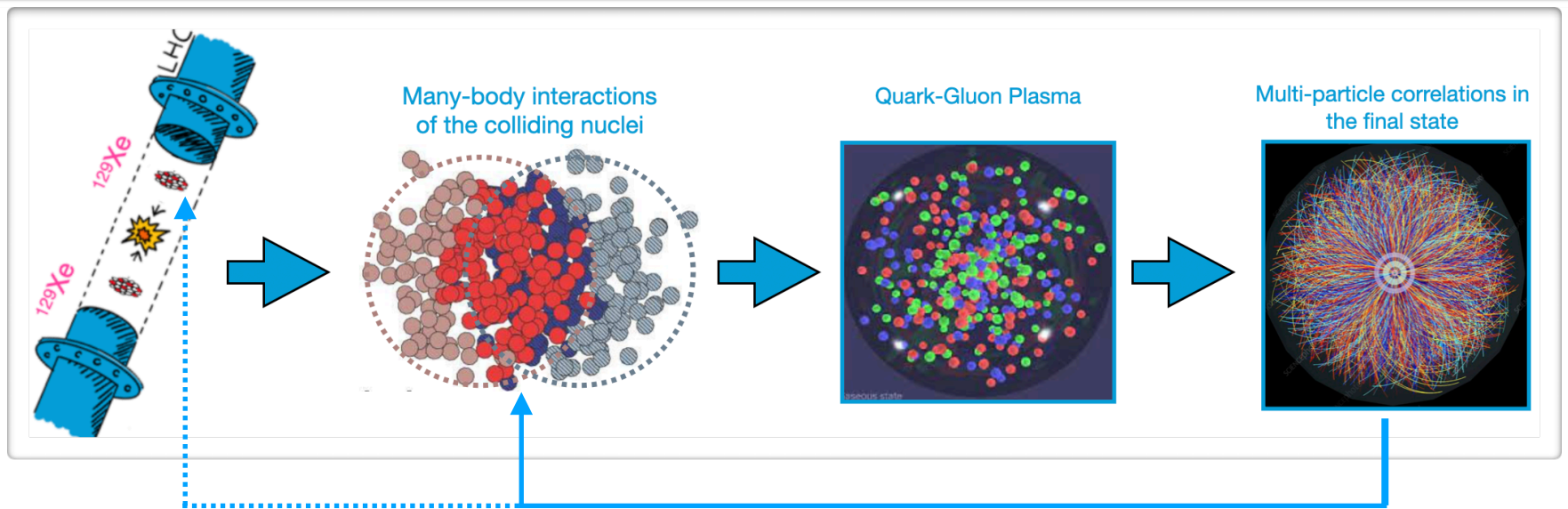
Project 2: Nuclear structure at high energies



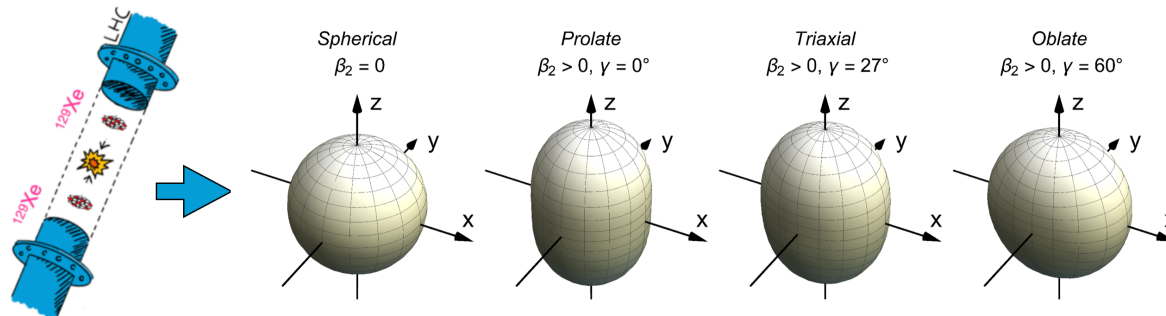
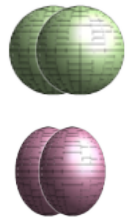
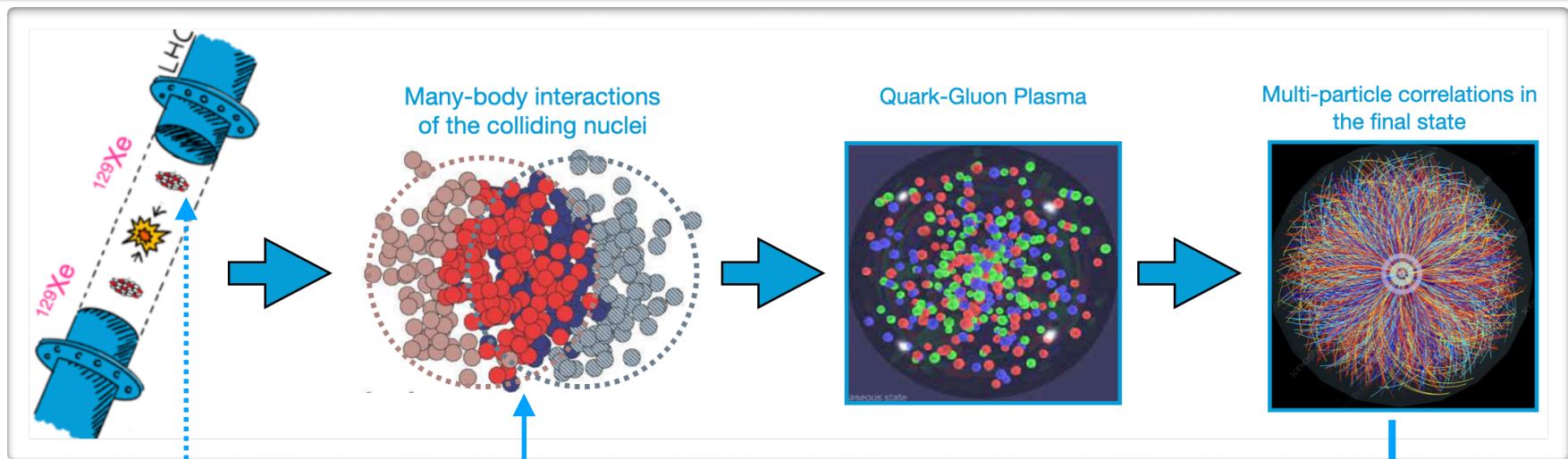
Project 2: Nuclear structure at high energies



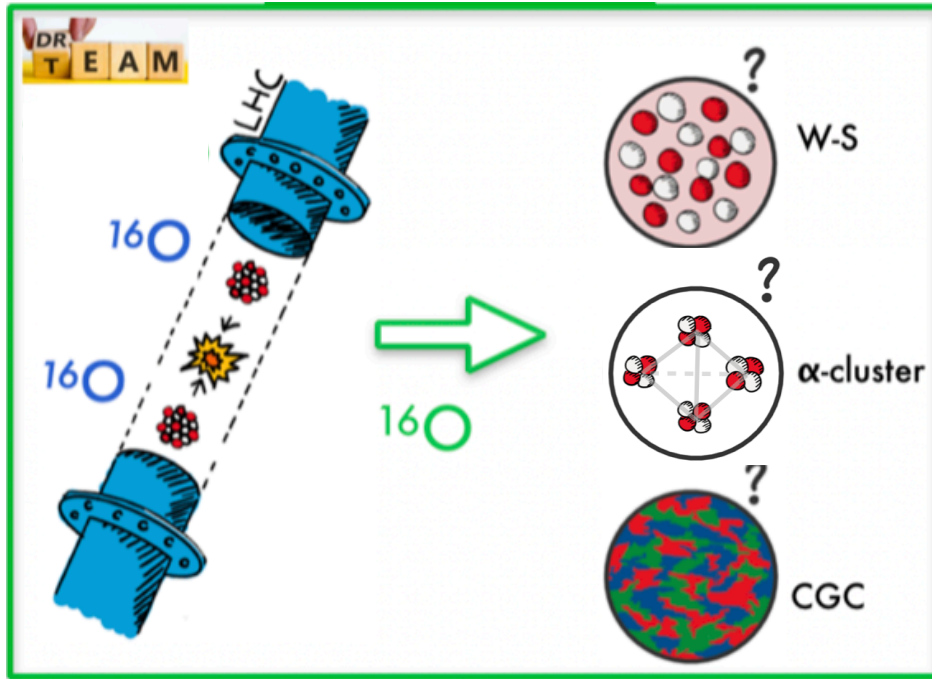
Project 2: Nuclear structure at high energies



Project 2: Nuclear structure at high energies



Discovering the α -cluster structure



Light ion collisions at the LHC

Location: 4/3-006, CERN
Website: cern.ch/lightions

Date: Nov. 11-15, 2024

Topics covered in relation to small systems:

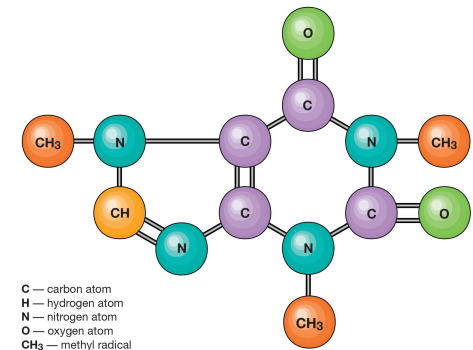
- Experimental highlights and projections
- Heavy flavour
- Hydrodynamics
- Initial conditions
- Jets
- Ultraperipheral collisions
- Nuclear parton distribution functions
- Nuclear structure
- LHC accelerator opportunities

Organisers:

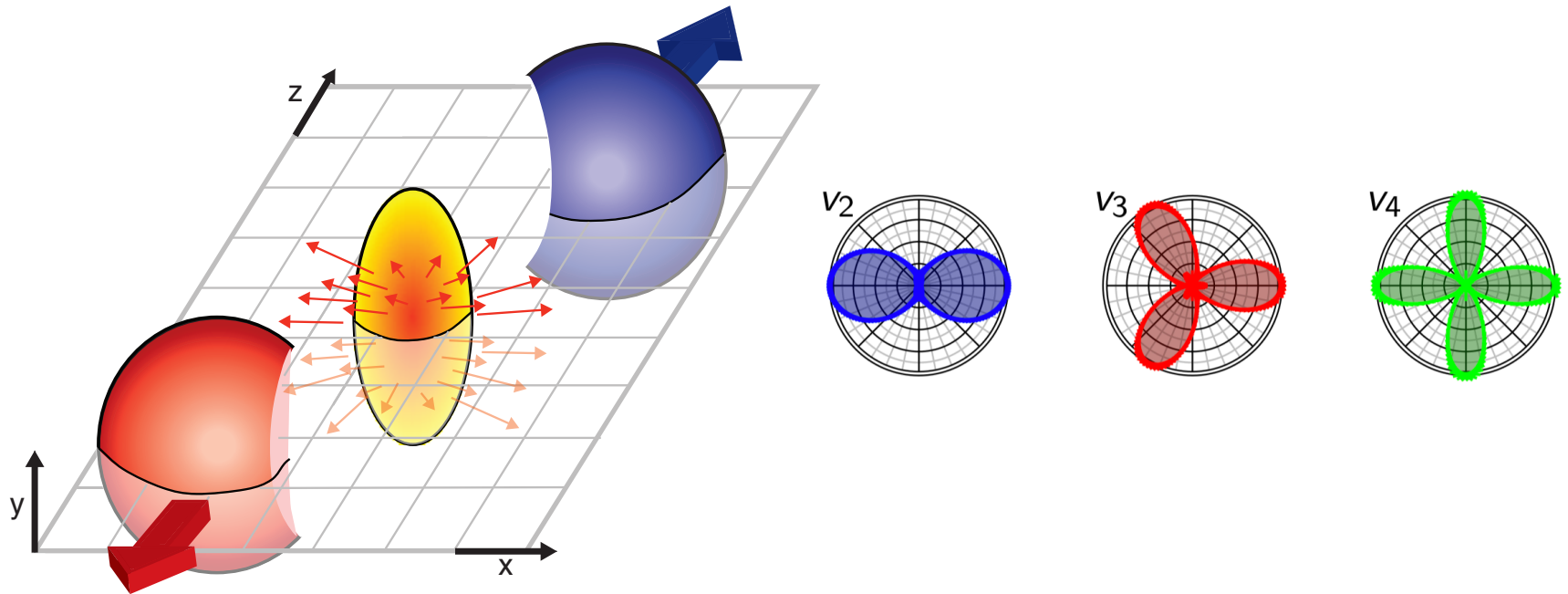
- Reyes Alemany-Fernandez
- Giuliano Giacalone
- Qipeng Hu
- Goverd Hugo Nijis
- Saverio Mariani
- Wilke van der Schee
- Huchao Song
- Jing Wang
- Urs Wiedemann
- You Zhou

Leading the proposal of ^{20}Ne - ^{20}Ne collisions at the LHC

- Discovery of α -cluster structure of light ions:
 - The precise description on the nuclear structure \rightarrow impact on the electron distributions \rightarrow how do ^{12}C and ^{16}O connected to form the molecule \rightarrow evolution in the life science and green agenda (CO_2)

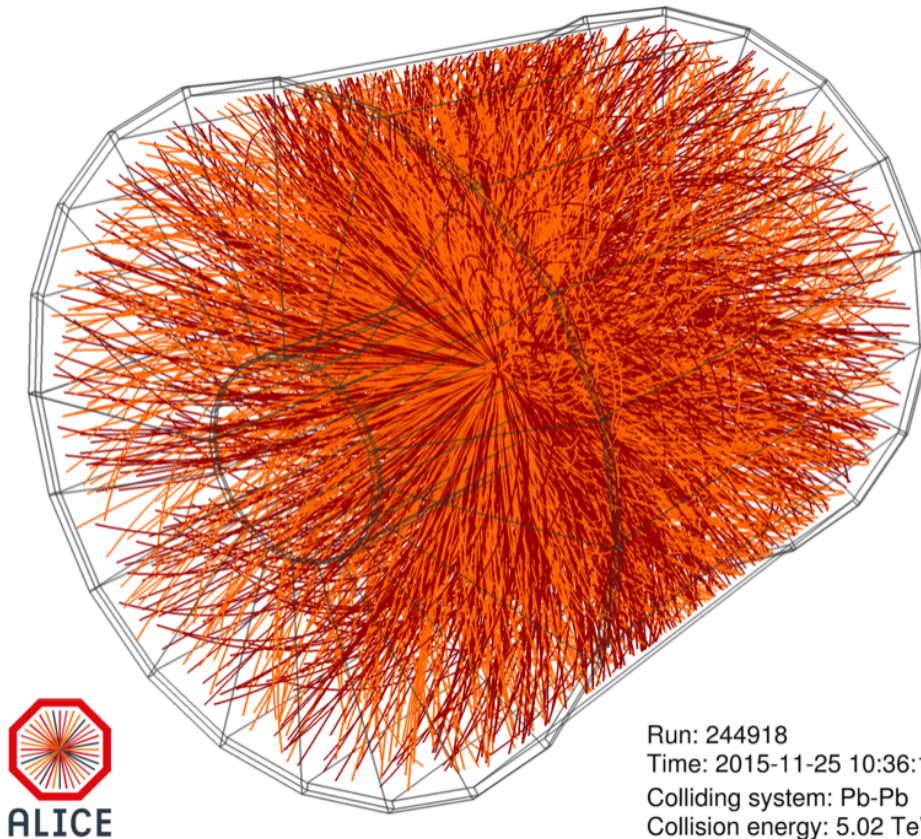


Anisotropic flow at the LHC



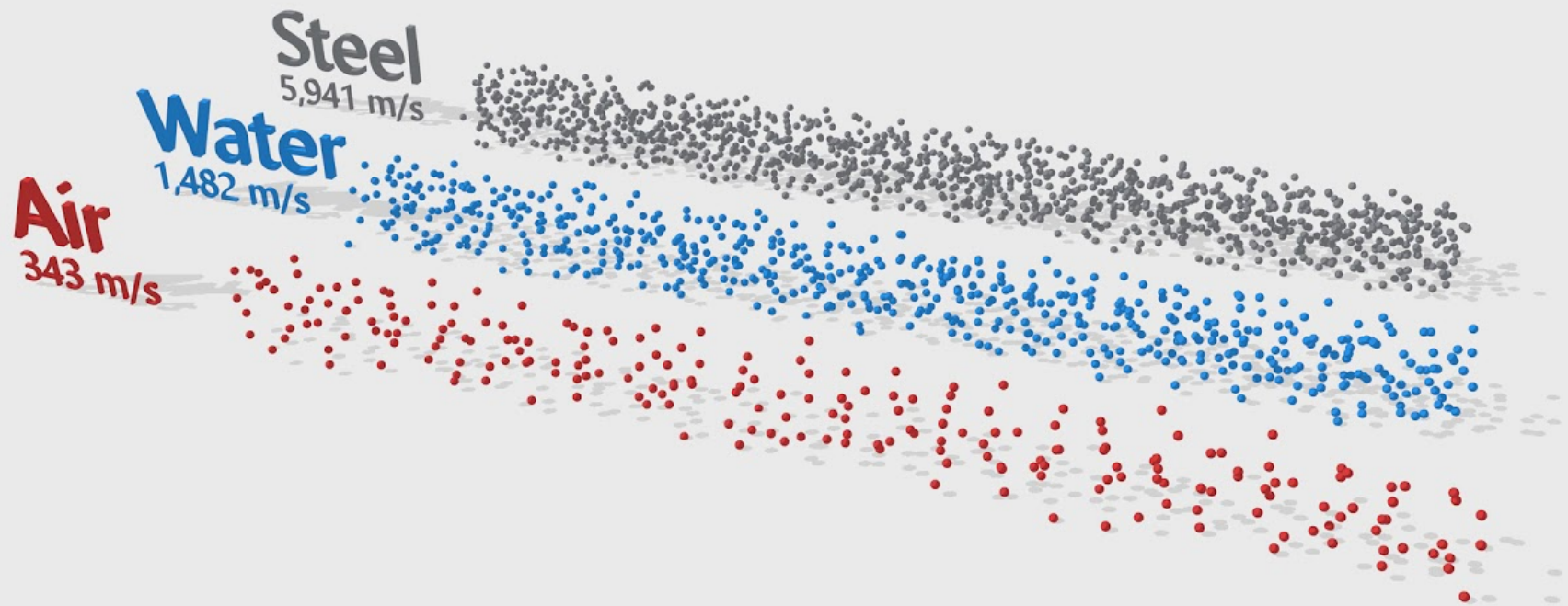
Initial Eccentricity \rightarrow Final state particle anisotropic expansions called **Anisotropic flow**

Heavy-ion collision

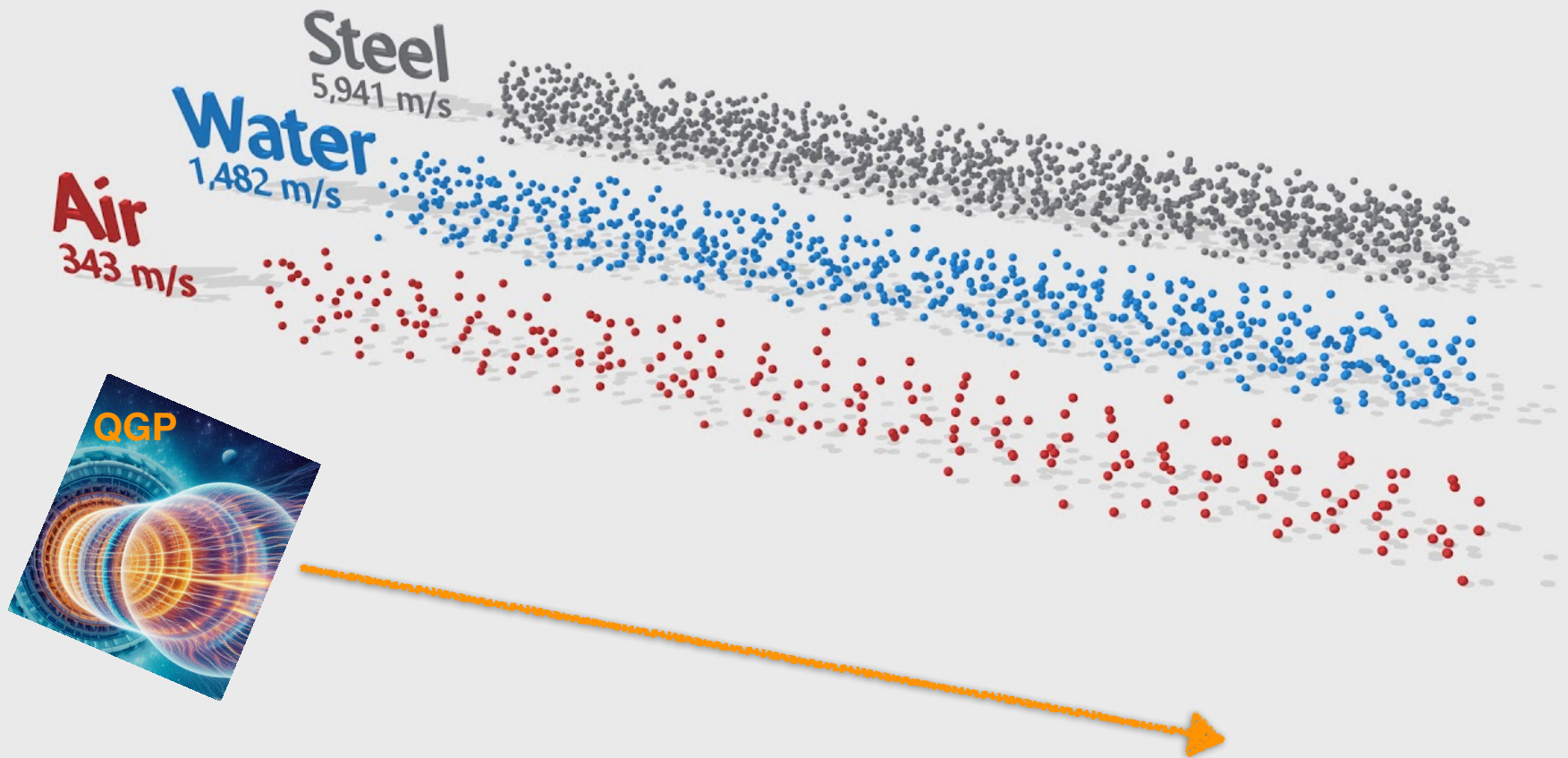


More than 35.000 particles produced in a single Lead-Lead collisions event
How can we study the QGP from this event?

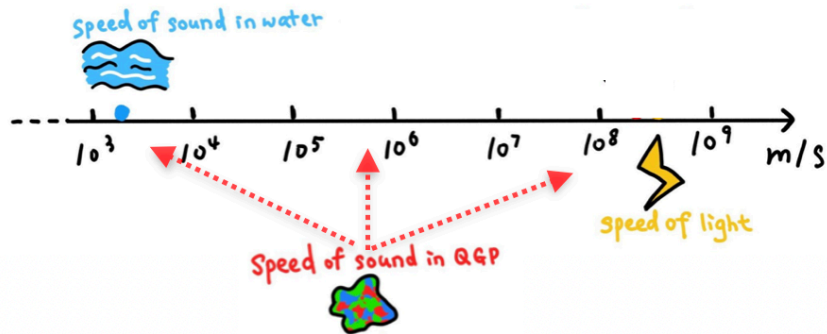
Speed of sound in the Early Universe



Speed of sound in the Early Universe



Speed of sound in QGP



ALICE hearing the QGP

- ❖ Precise measurements of speed of sound of QGP in Pb-Pb collisions @ Run 3