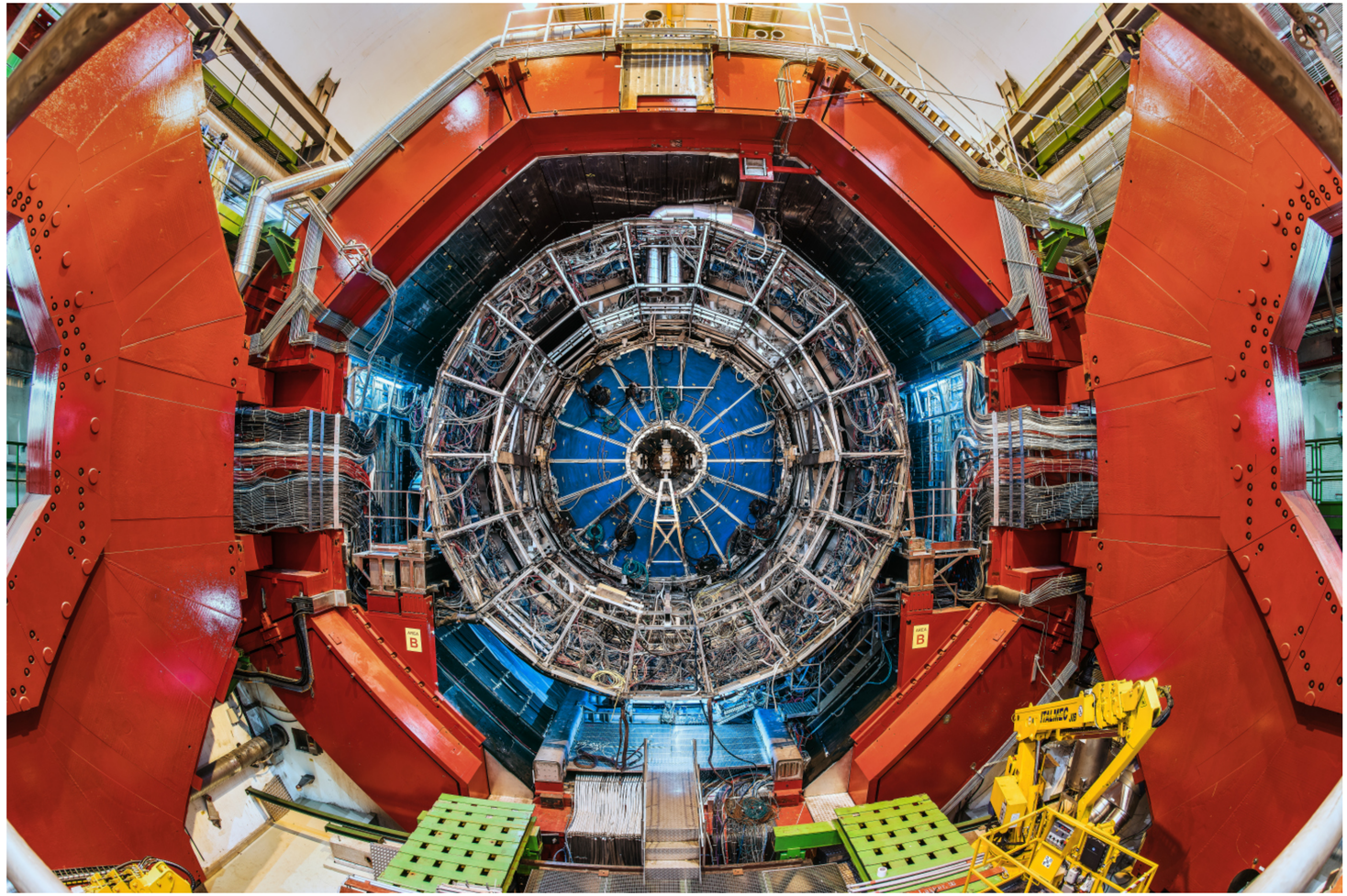
ALICE at CERN — a very short introduction

Public website: http://alice.cern/

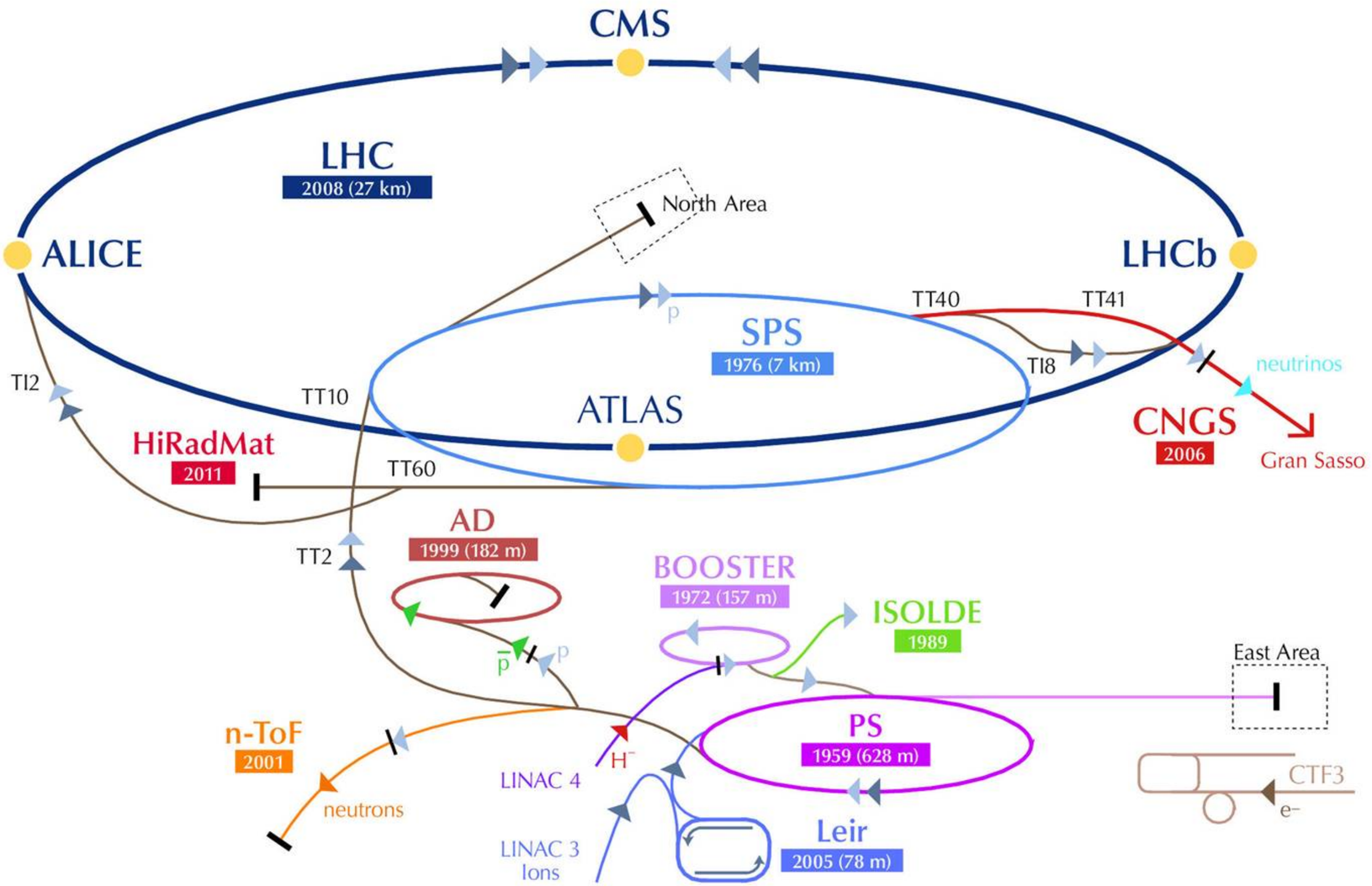


Twitter: @ALICEexperiment
Facebook: @ALICE.experiment

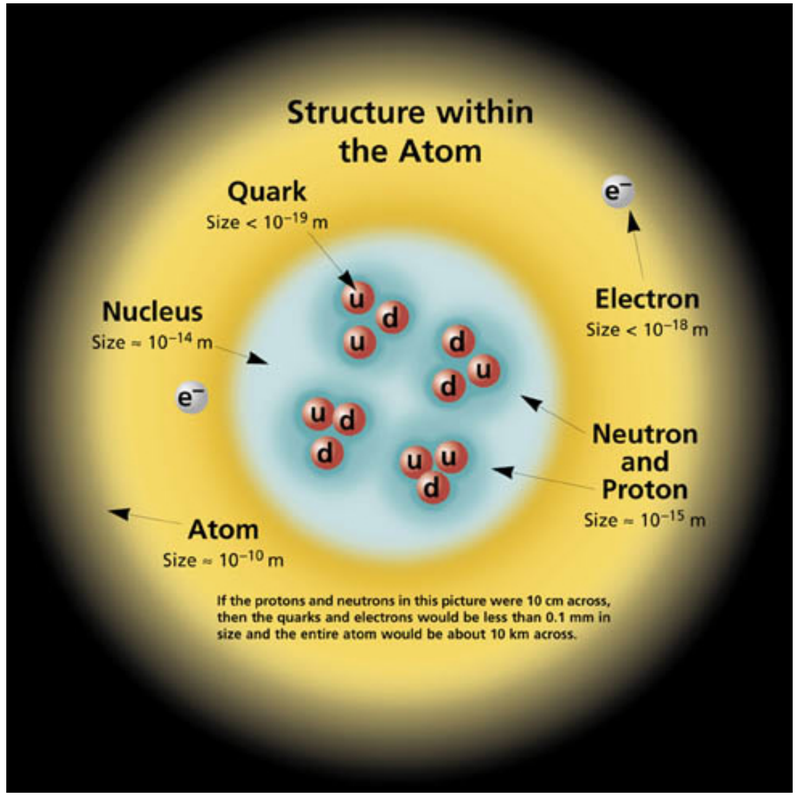
Marco van Leeuwen, Nikhef

Nikhef

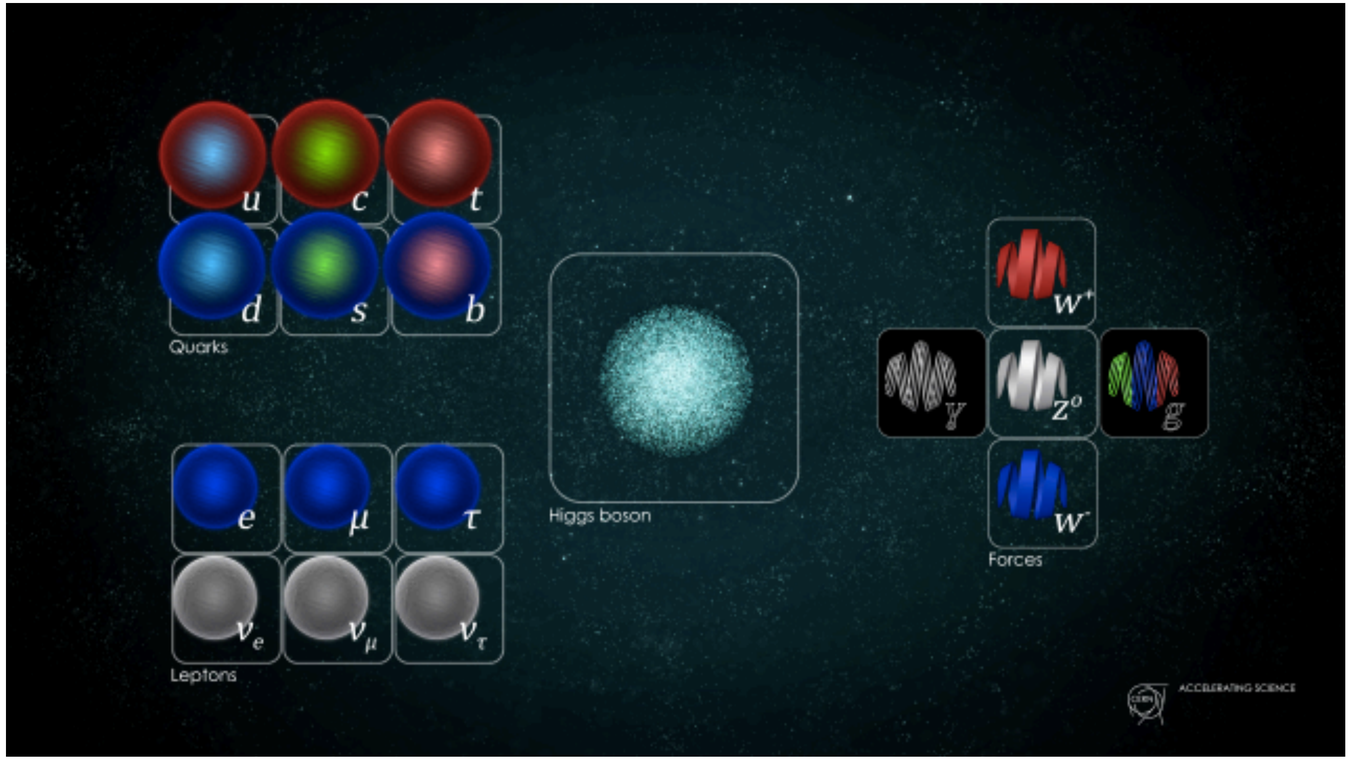
The CERN accelerator complex



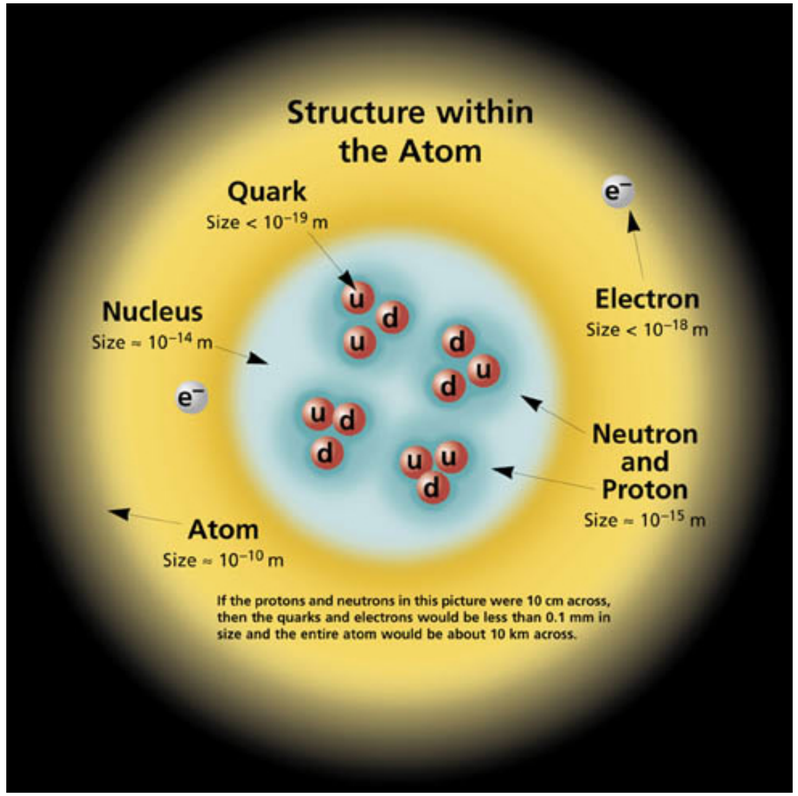
Structure of matter



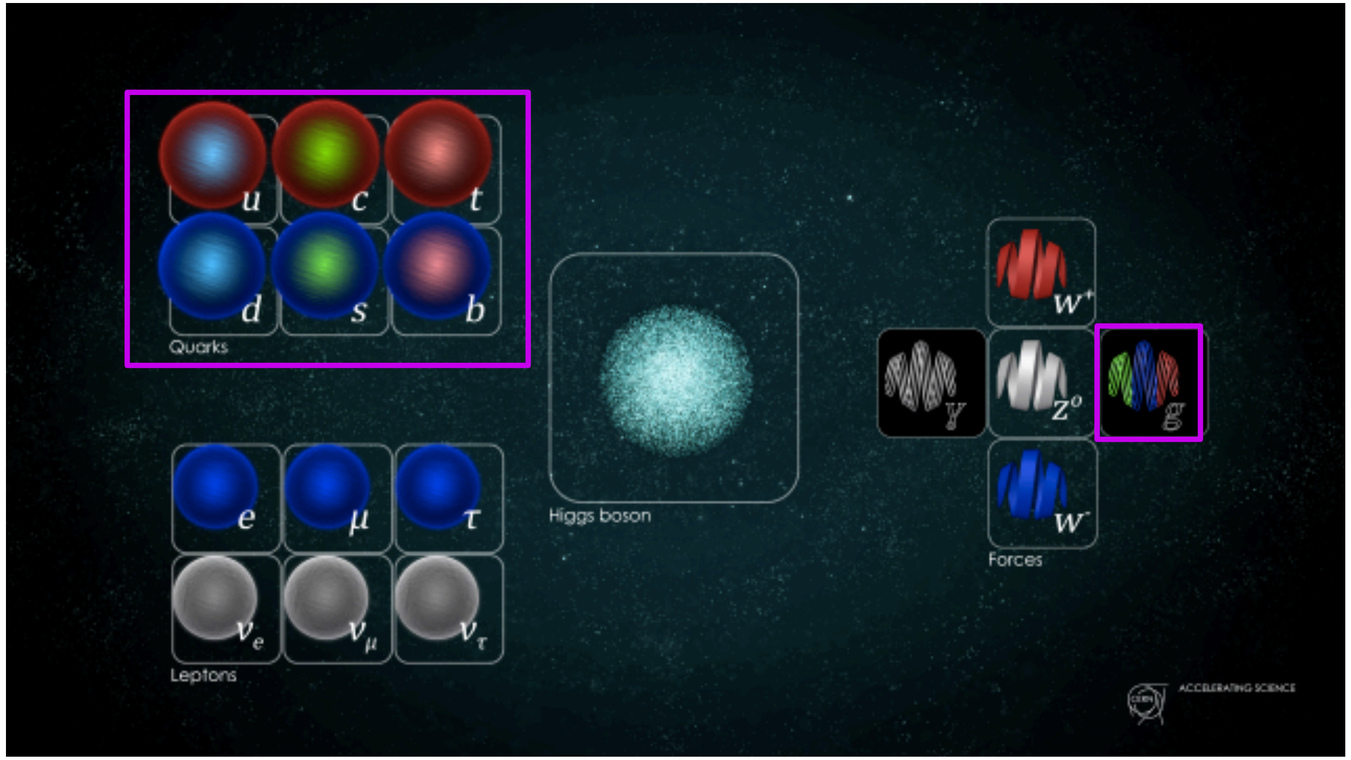
The particles of the Standard Model



Structure of matter



The particles of the Standard Model

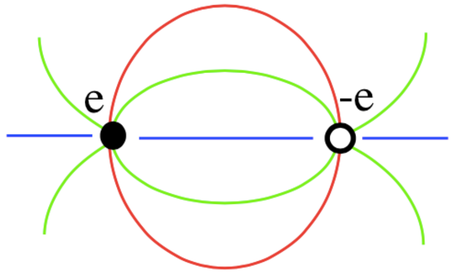


Quarks and gluons are the building blocks of nuclear matter
Main interaction: Strong interaction (QCD)

Strong interaction: the QCD potential

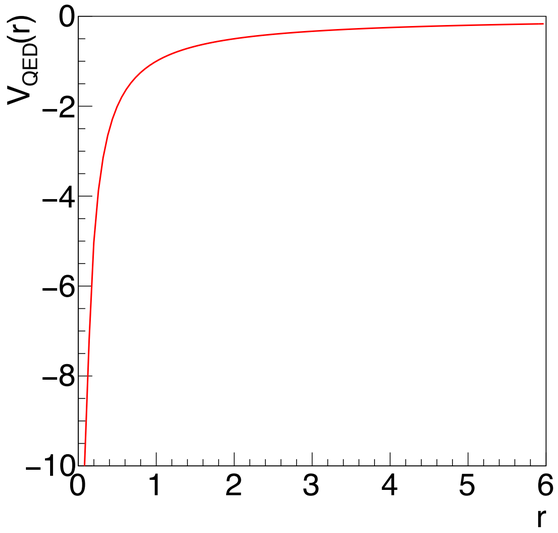
QED
electromagnetic interaction

Field lines
in dipole system

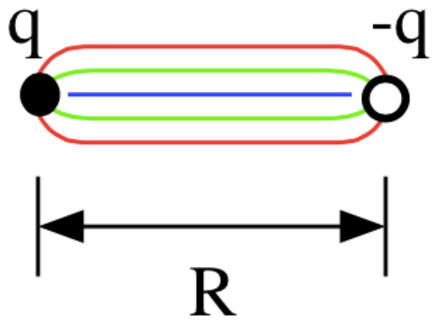


$$V(R) \sim - \alpha / R$$

Potential

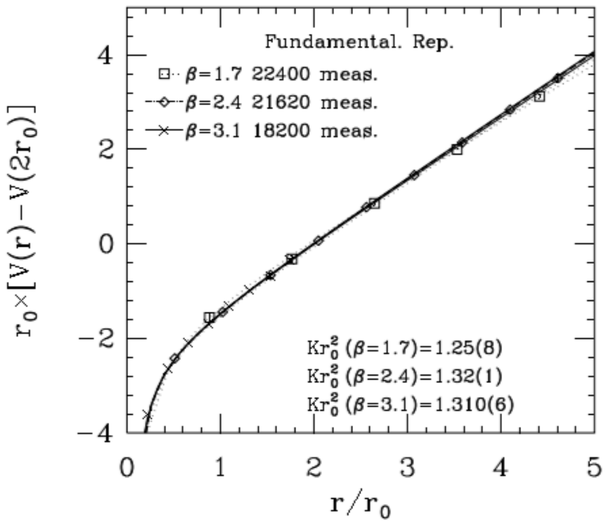


QCD
strong interaction



$$V(R) \sim \sigma R$$

S. Deldar, hep-lat/9909077

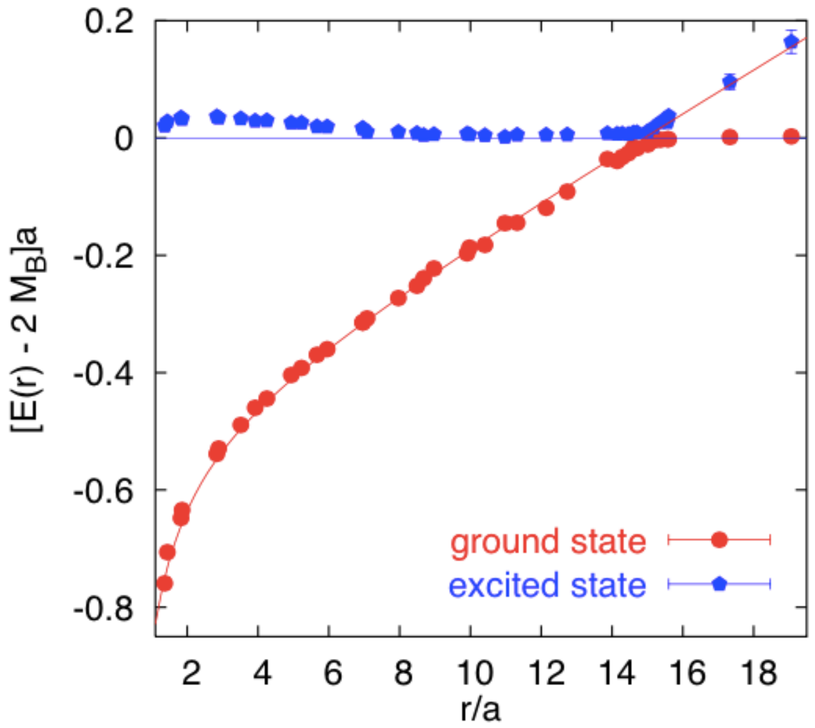


QCD is very different from electromagnetism, gravity; common intuition may fail

QCD strings

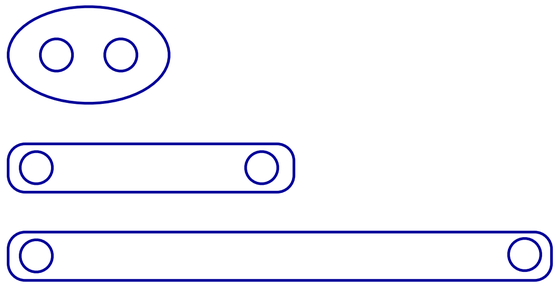
A simple picture of the strong interaction

G.S. Bali, hep-ph/0411206



QCD potential for 2-quark system rises indefinitely

Thought experiment: separating charges



For larger separation: generating a qqbar pair is energetically favoured

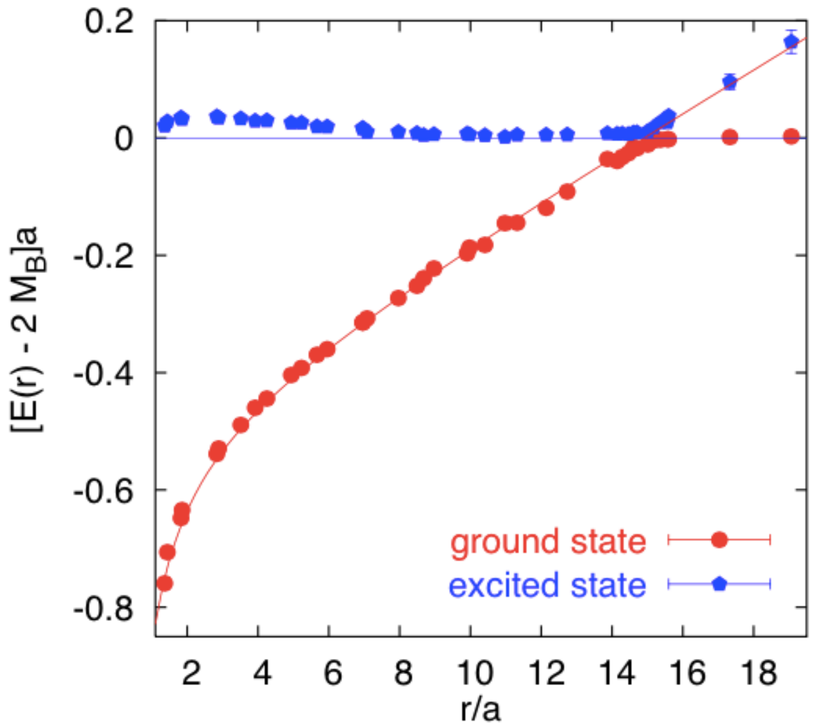
Color charges (quarks and gluons) cannot be freed

Confinement important at length scale $1/\Lambda_{QCD} \sim 1$ fm

QCD strings

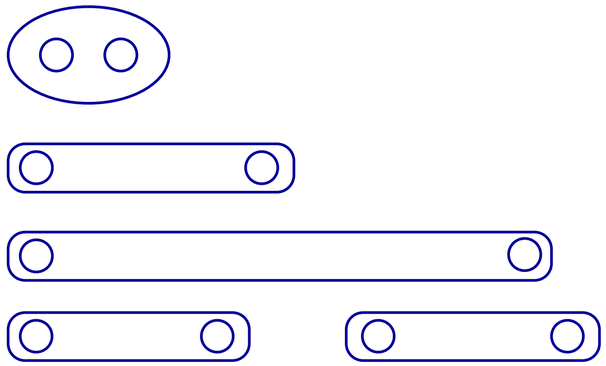
A simple picture of the strong interaction

G.S. Bali, hep-ph/0411206



QCD potential for 2-quark system rises indefinitely

Thought experiment: separating charges

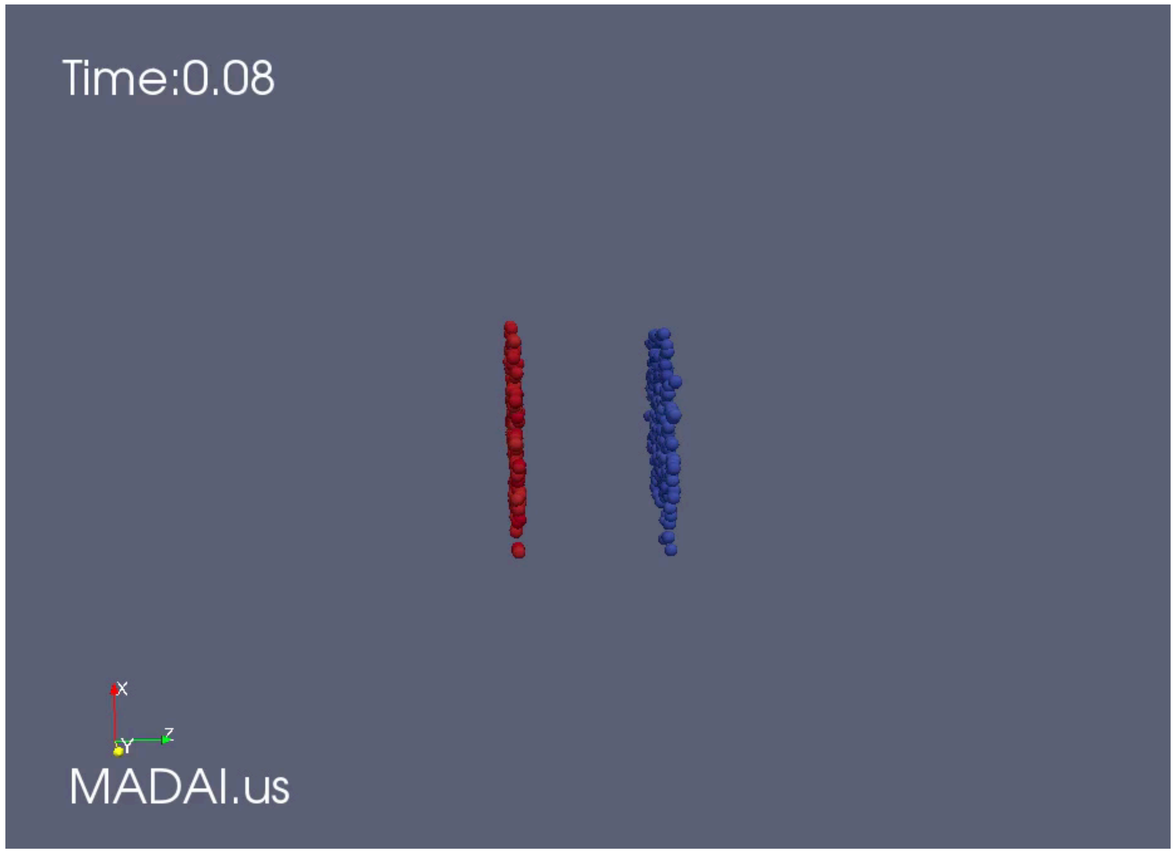


For larger separation: generating a qqbar pair is energetically favoured

Color charges (quarks and gluons) cannot be freed

Confinement important at length scale $1/\Lambda_{QCD} \sim 1$ fm

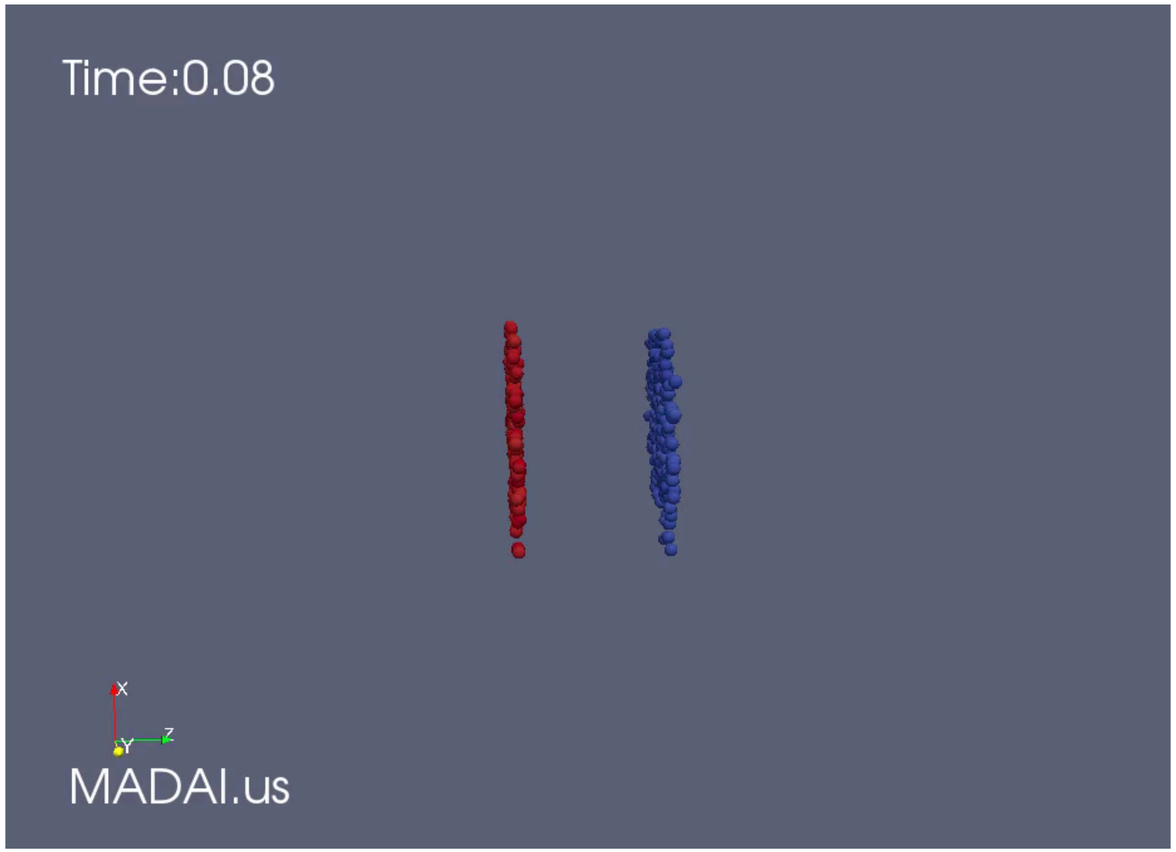
A heavy ion collision



MADAI

Initial stage: nuclei —> Quark Gluon Plasma (T ~ 10^{12} K) —> Hadrons

A heavy ion collision

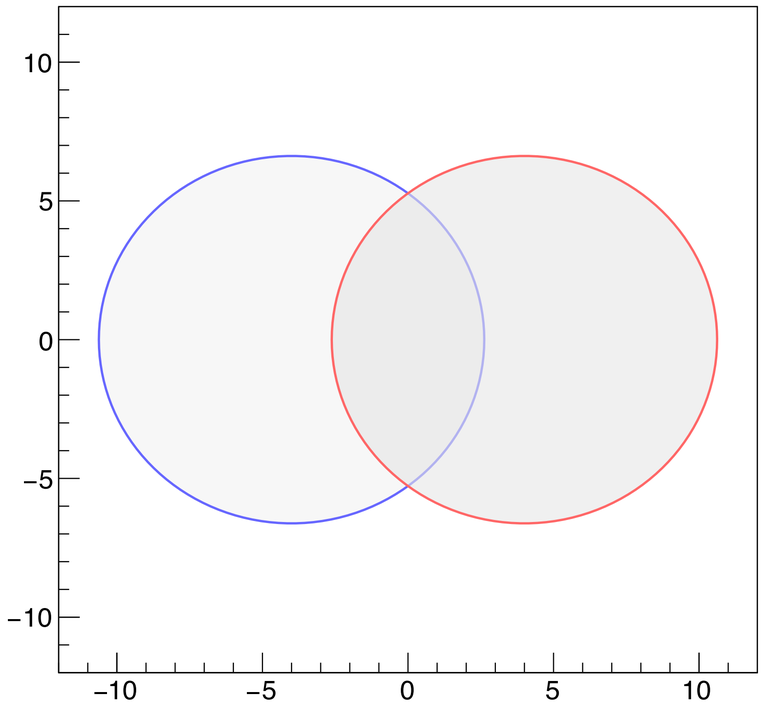


MADAI

Initial stage: nuclei —> Quark Gluon Plasma (T ~ 10^{12} K) —> Hadrons

Azimuthal anisotropy: initial and final states

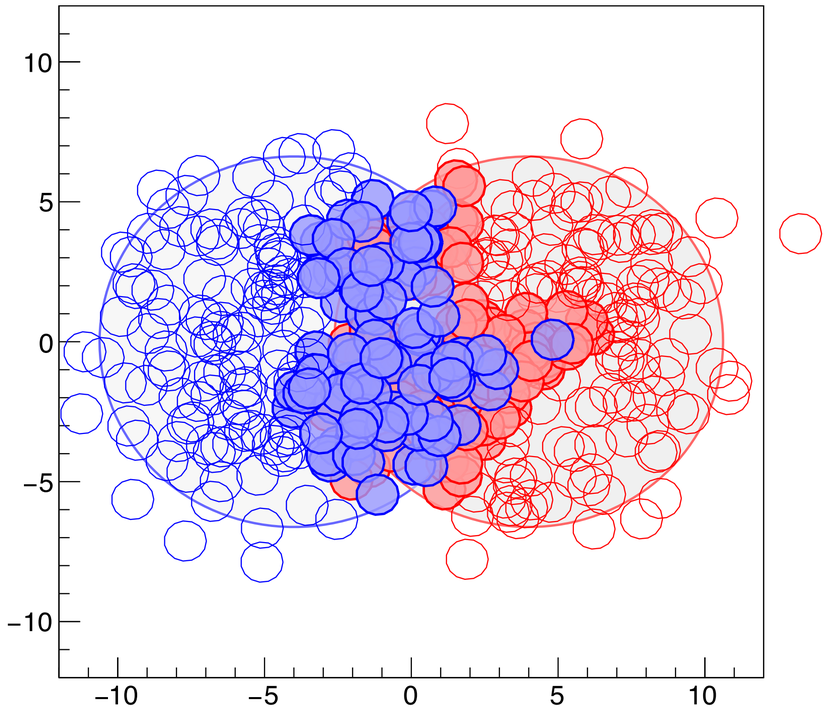
Simplified collision picture: location of nucleons



$$\varepsilon_n = \frac{\sum r^2(\cos^2 n\varphi + \sin^2 n\varphi)}{\sum r^2}$$

Azimuthal anisotropy: initial and final states

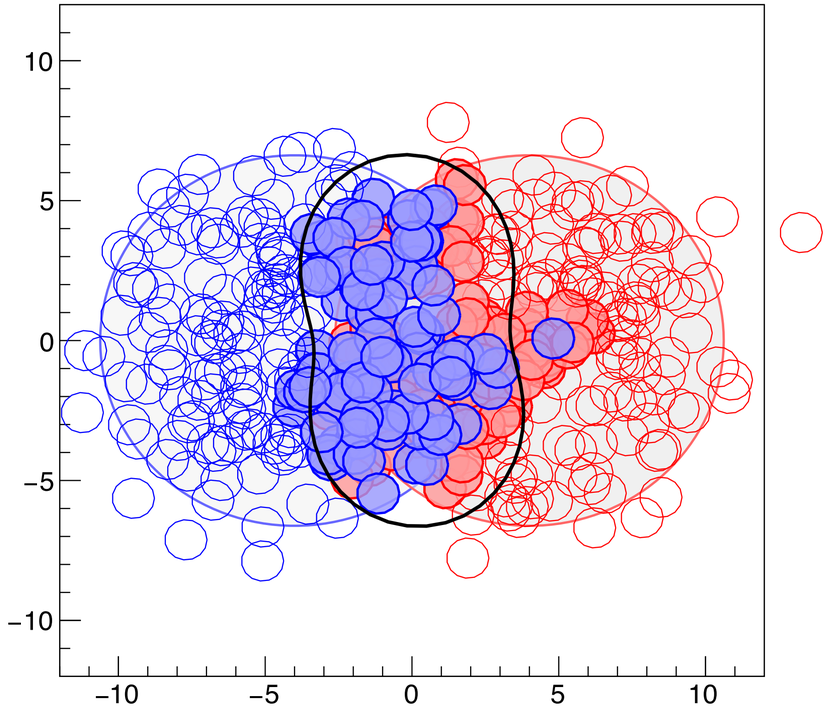
Simplified collision picture: location of nucleons



$$\varepsilon_n = \frac{\sum r^2(\cos^2 n\varphi + \sin^2 n\varphi)}{\sum r^2}$$

Azimuthal anisotropy: initial and final states

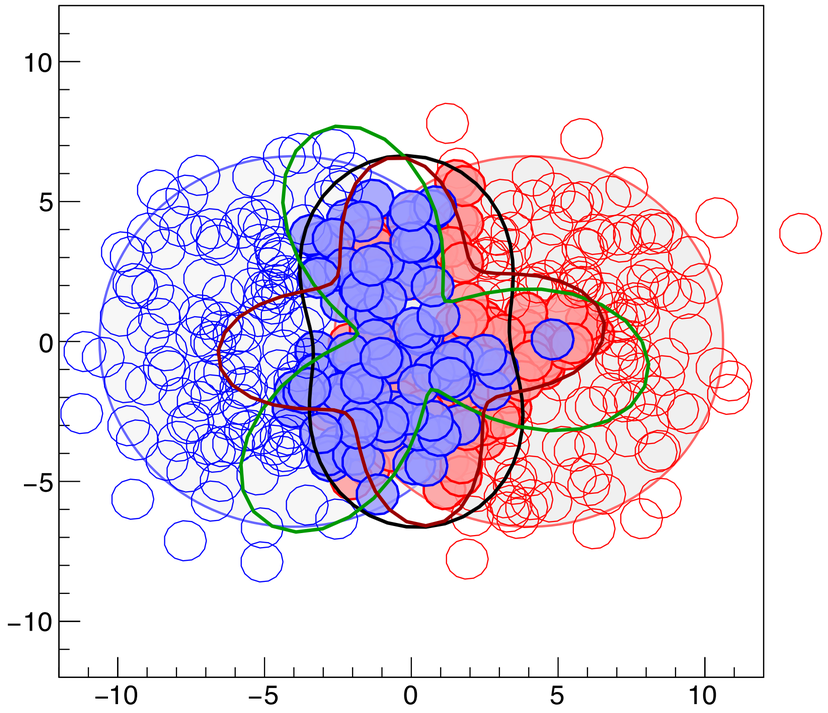
Simplified collision picture: location of nucleons



$$\varepsilon_n = \frac{\sum r^2(\cos^2 n\varphi + \sin^2 n\varphi)}{\sum r^2}$$

Azimuthal anisotropy: initial and final states

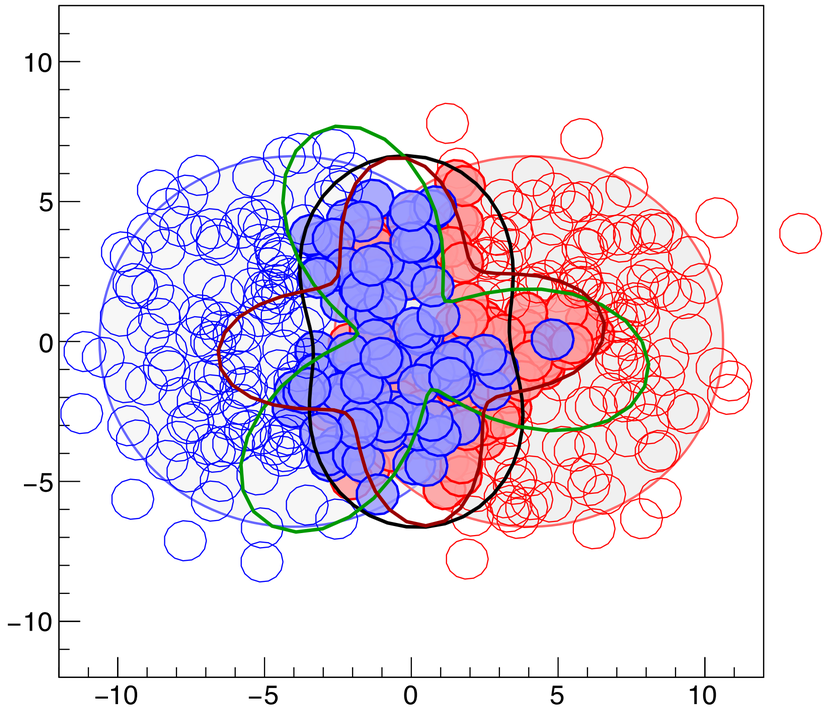
Simplified collision picture: location of nucleons



$$\varepsilon_n = \frac{\sum r^2(\cos^2 n\varphi + \sin^2 n\varphi)}{\sum r^2}$$

Azimuthal anisotropy: initial and final states

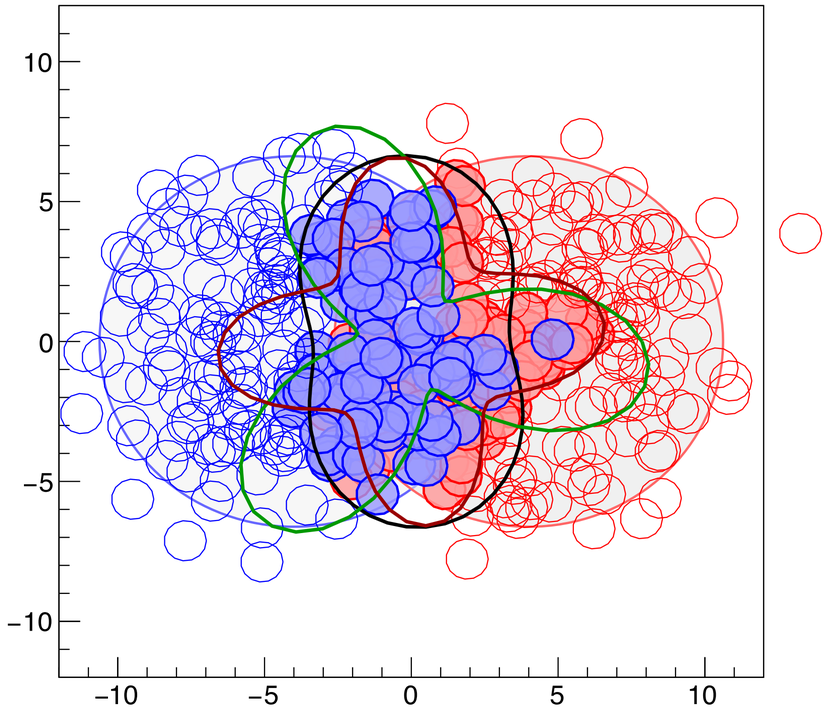
Simplified collision picture: location of nucleons



Initial state spatial anisotropies ε_n are transferred into
final state momentum anisotropies v_n
by pressure gradients, flow of the Quark Gluon Plasma

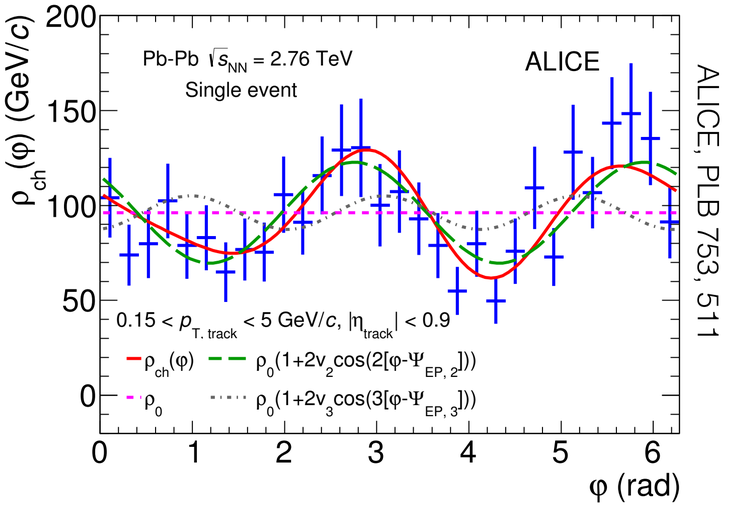
Azimuthal anisotropy: initial and final states

Simplified collision picture: location of nucleons

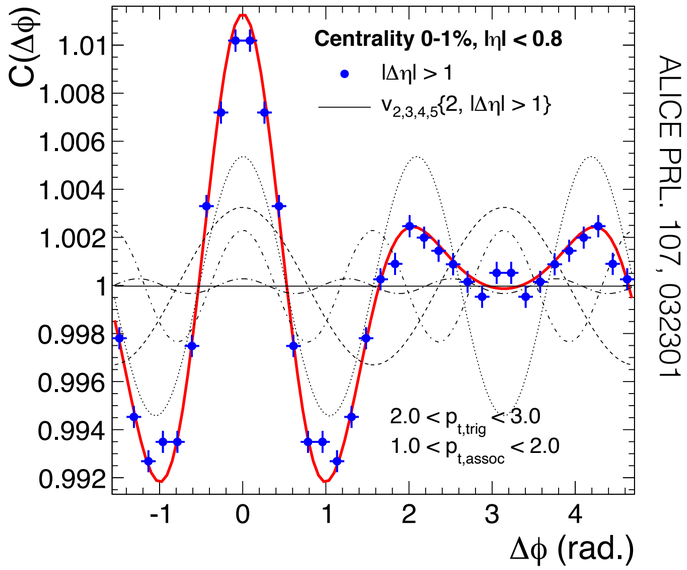


Initial state spatial anisotropies ε_n are transferred into final state momentum anisotropies v_n by pressure gradients, flow of the Quark Gluon Plasma

Azimuthal distribution single event

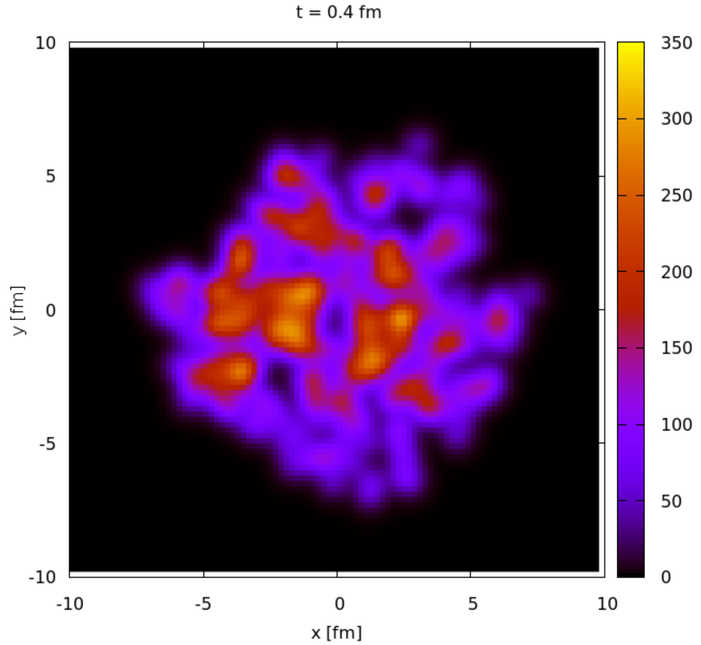


Sum over many events



Anisotropic flow: expansion of the Plasma

Energy density in initial state:
lumpy

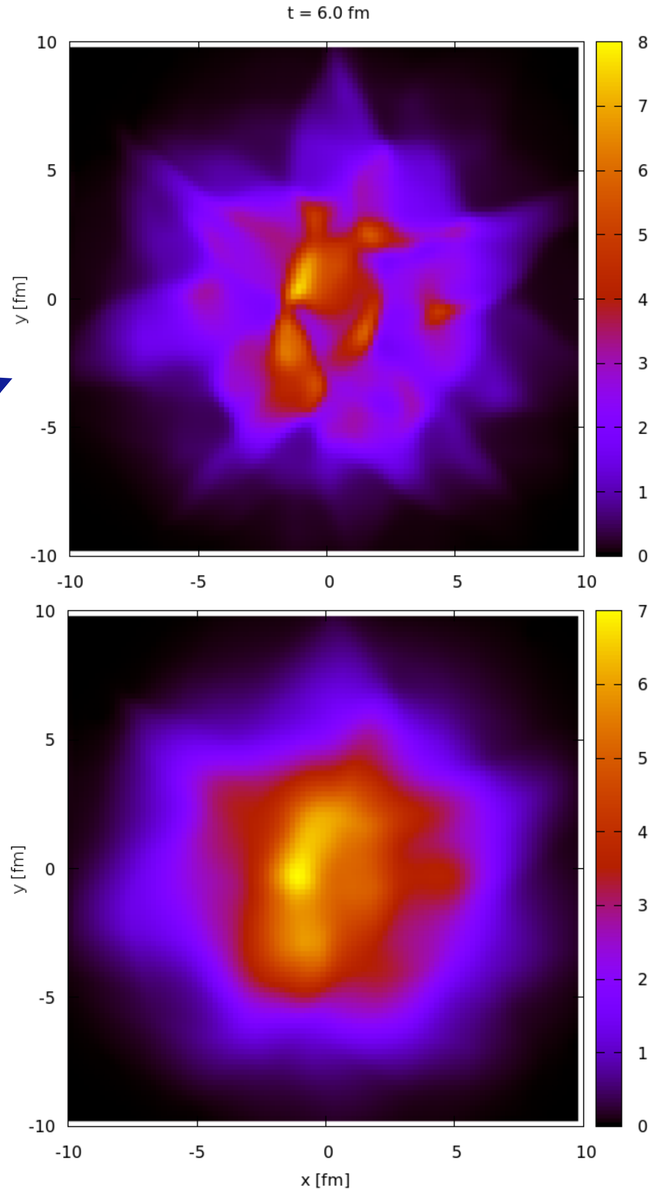


No viscosity

$\eta/s = 0$

$\eta/s = 0.16$

Some viscosity

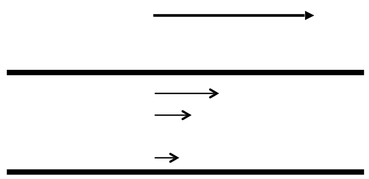


How much of this is visible in the final state,
depends on shear viscosity η

Schenke and Jeon, Phys.Rev.Lett.106:042301

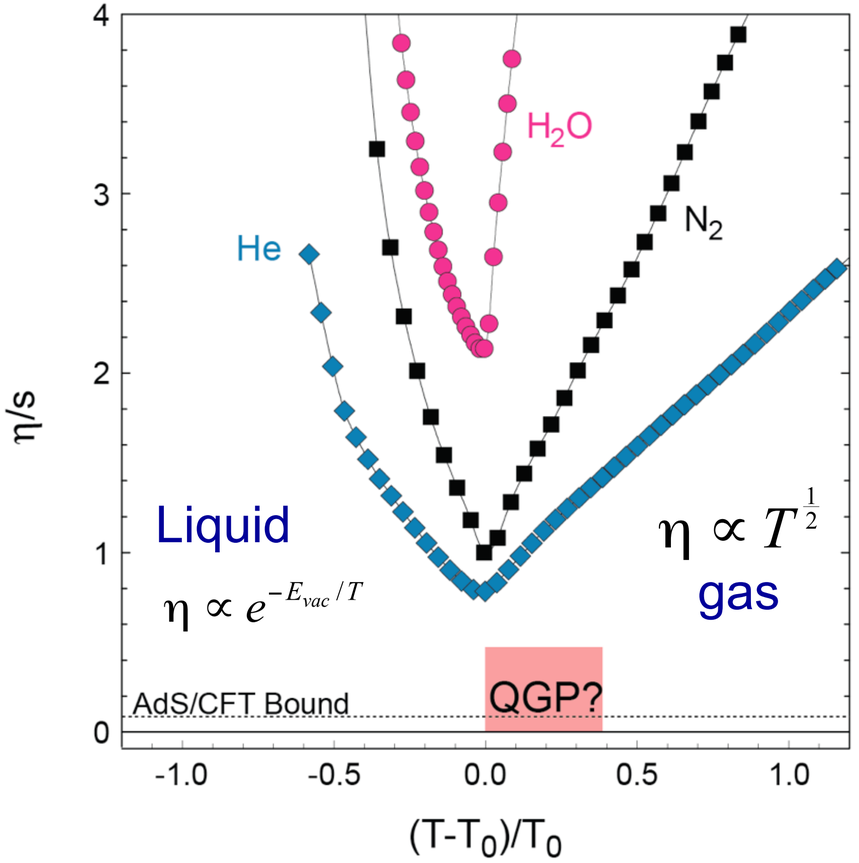
Viscosity of the Quark Gluon Plasma

J. E. Bernhard et al, arXiv: 1605.03954



$$\frac{F}{A} = \eta \frac{dv}{dz}$$

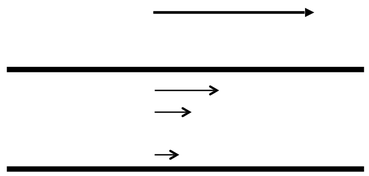
Comparing to other fluids/liquids



Viscosity minimal at liquid-gas transition

QGP viscosity smaller than any atomic matter

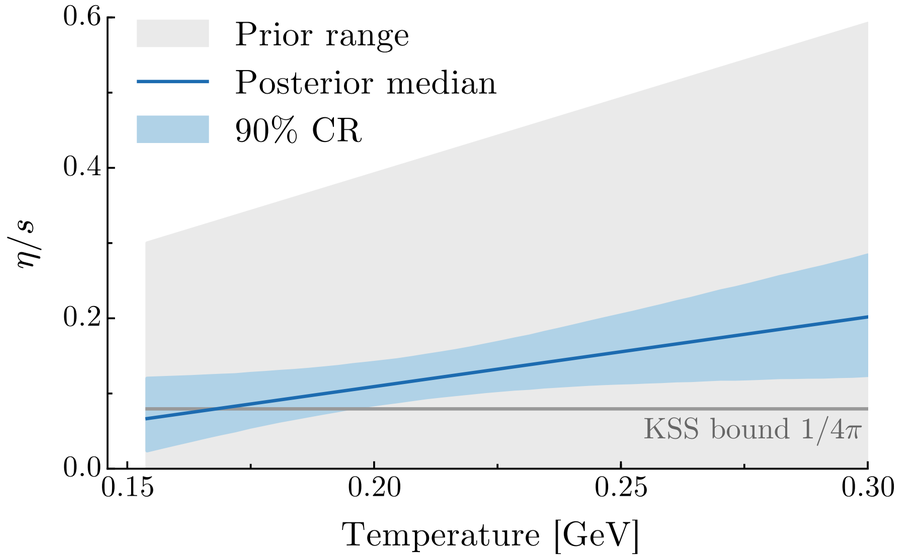
Viscosity of the Quark Gluon Plasma



$$\frac{F}{A} = \eta \frac{dv}{dz}$$

J. E. Bernhard et al, arXiv: 1605.03954

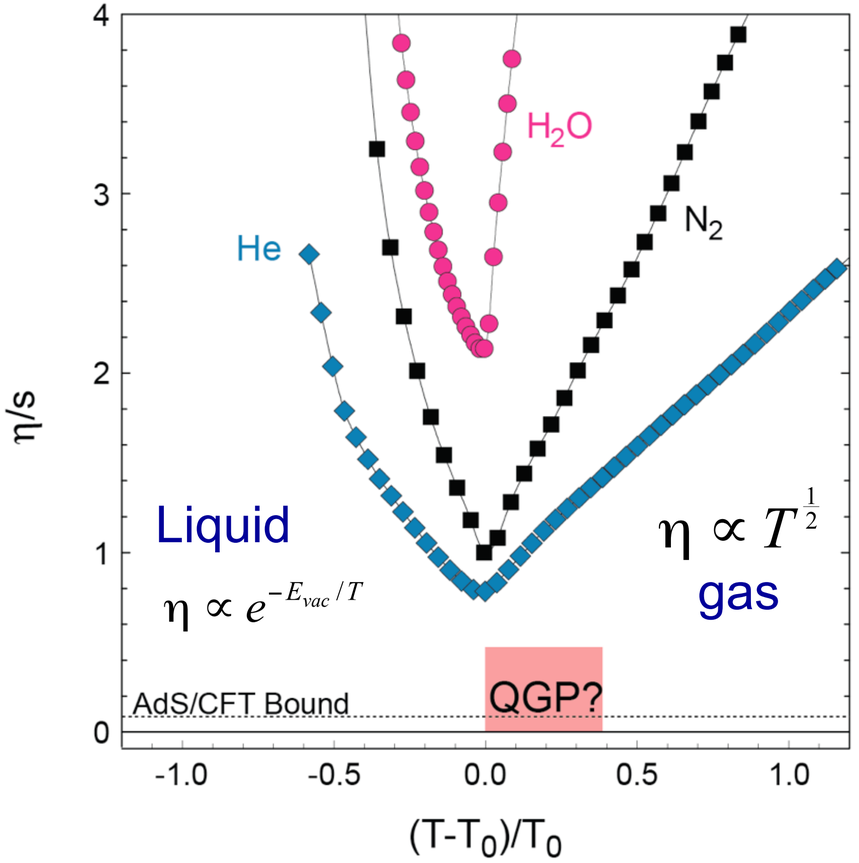
viscosity of the QGP



Fit constrains initial state geometry and transport properties at the same time

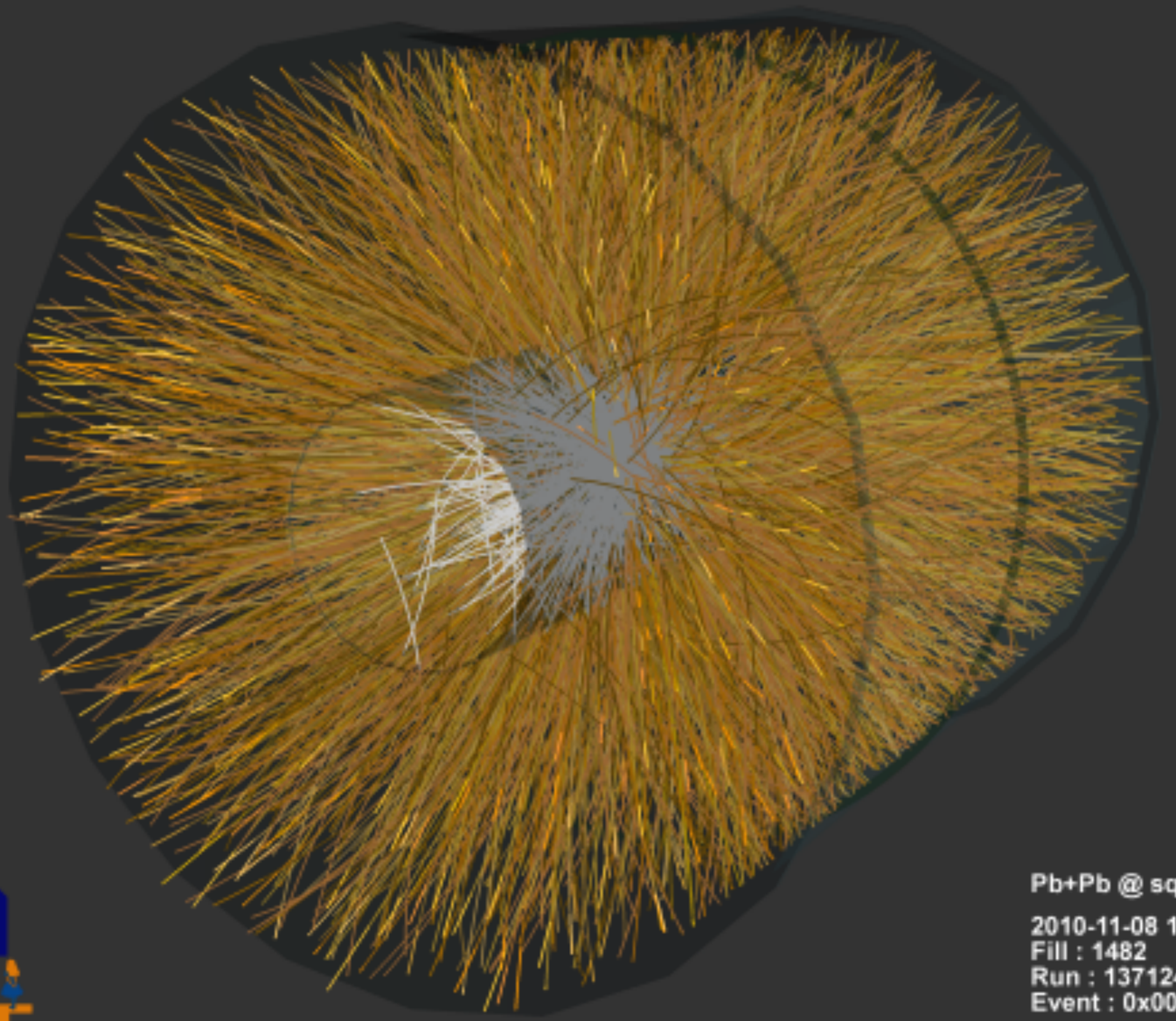
Viscosity close to lower bound

Comparing to other fluids/liquids



Viscosity minimal at liquid-gas transition

QGP viscosity smaller than any atomic matter



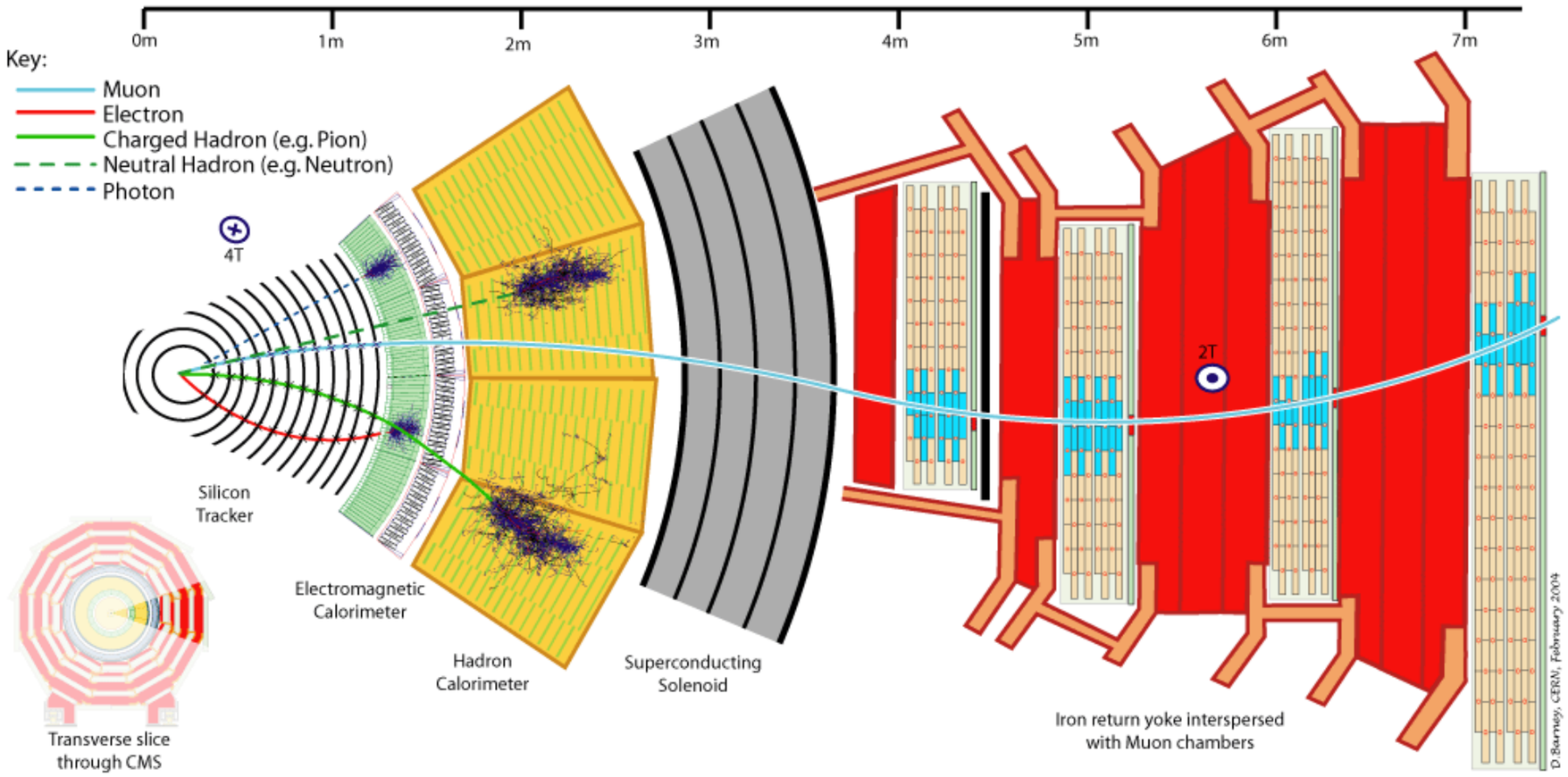
ALICE

Pb+Pb @ sqrt(s) = 2.76 ATeV

2010-11-08 11:30:46
Fill : 1482
Run : 137124
Event : 0x00000000D3BBE693

Roles of different detector systems

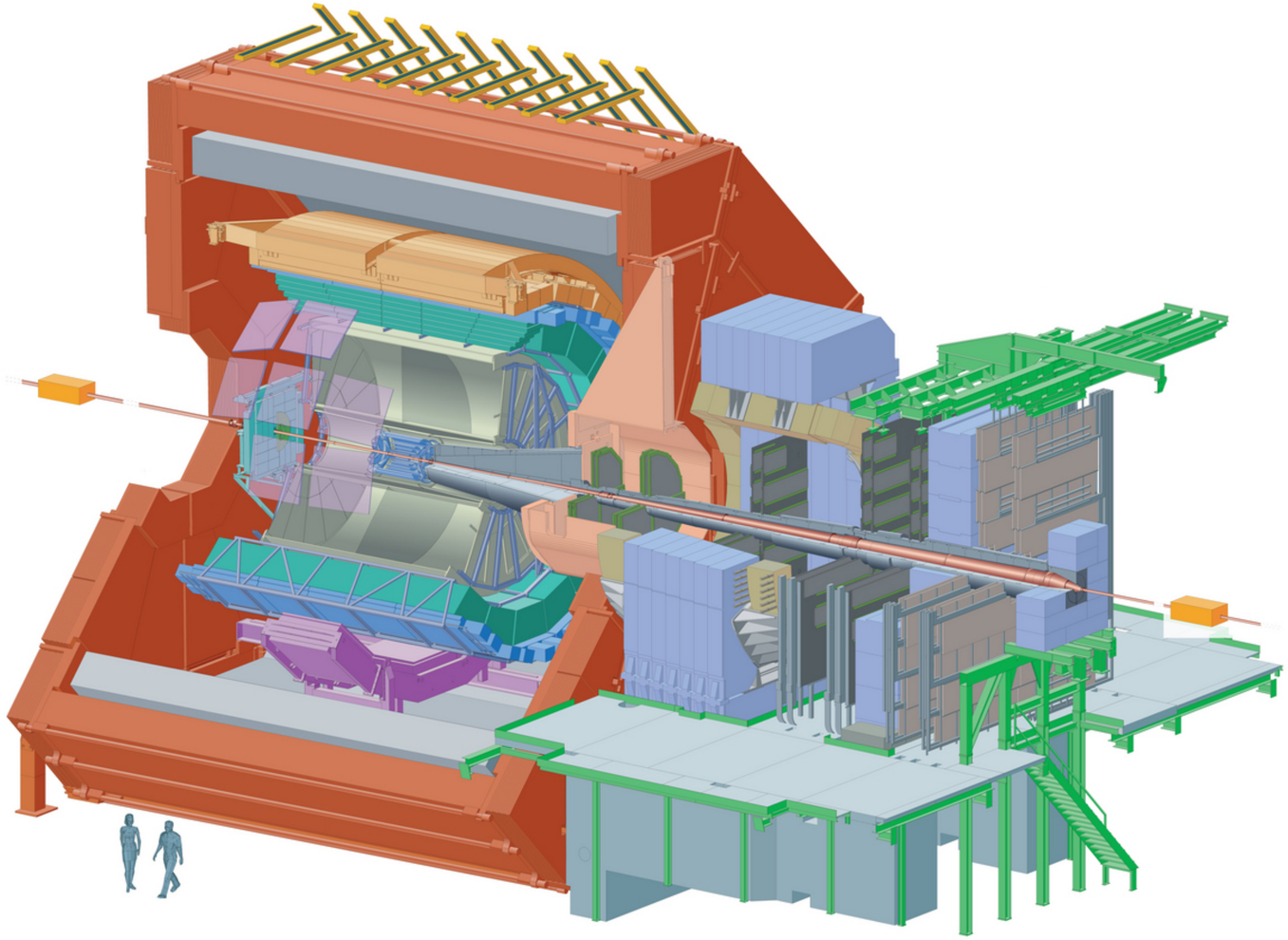
Example: CMS



Particles have different properties/interactions with material

Specialised detector systems for e.g.: charged particles, photons, electrons, muons

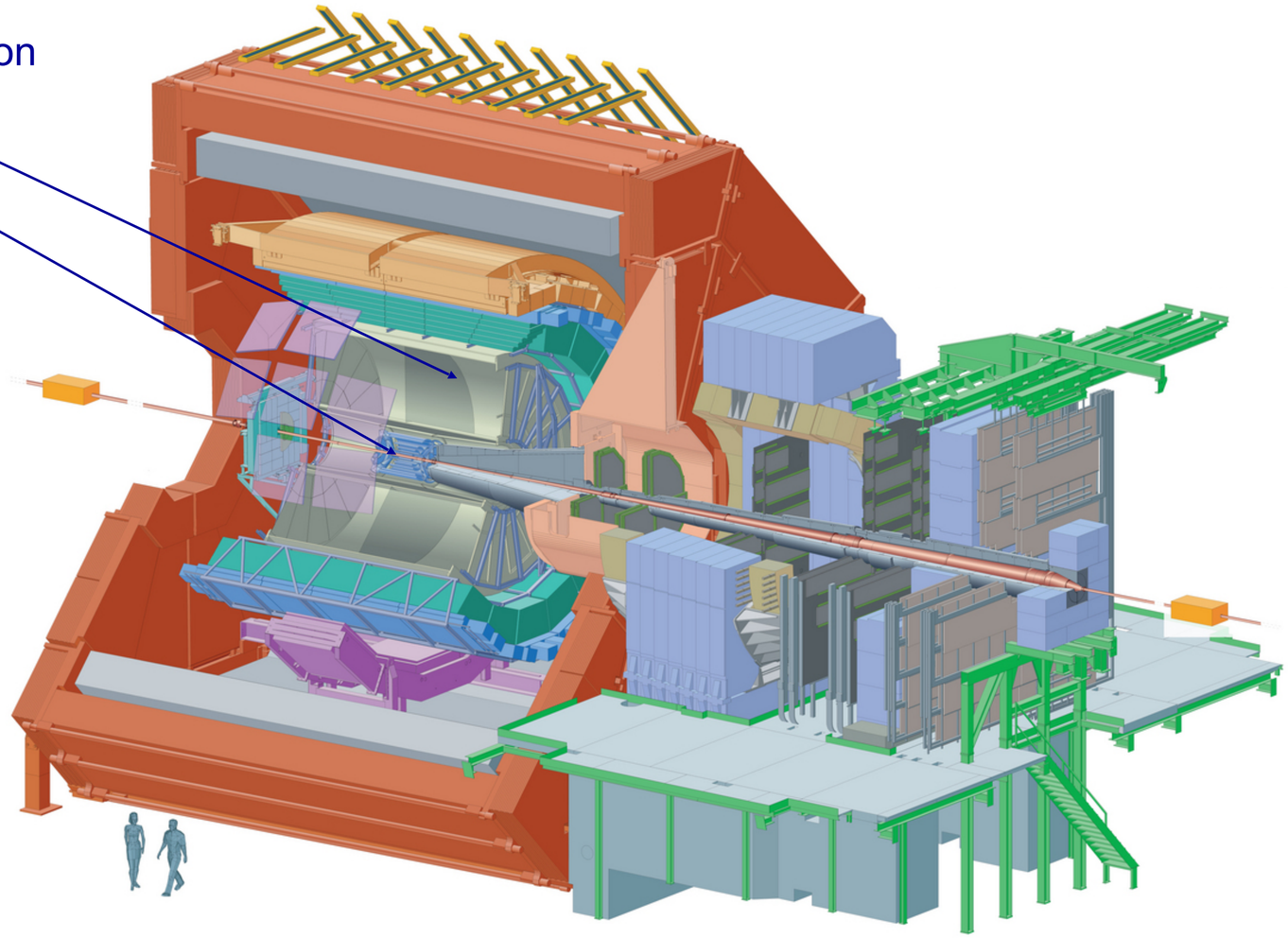
Detector example: ALICE



e.g. 2015: 100M hadronic Pb+Pb collisions, 800M p+p collisions

Detector example: ALICE

Central tracker:
$|\eta| < 0.9$
High resolution
- TPC
- ITS

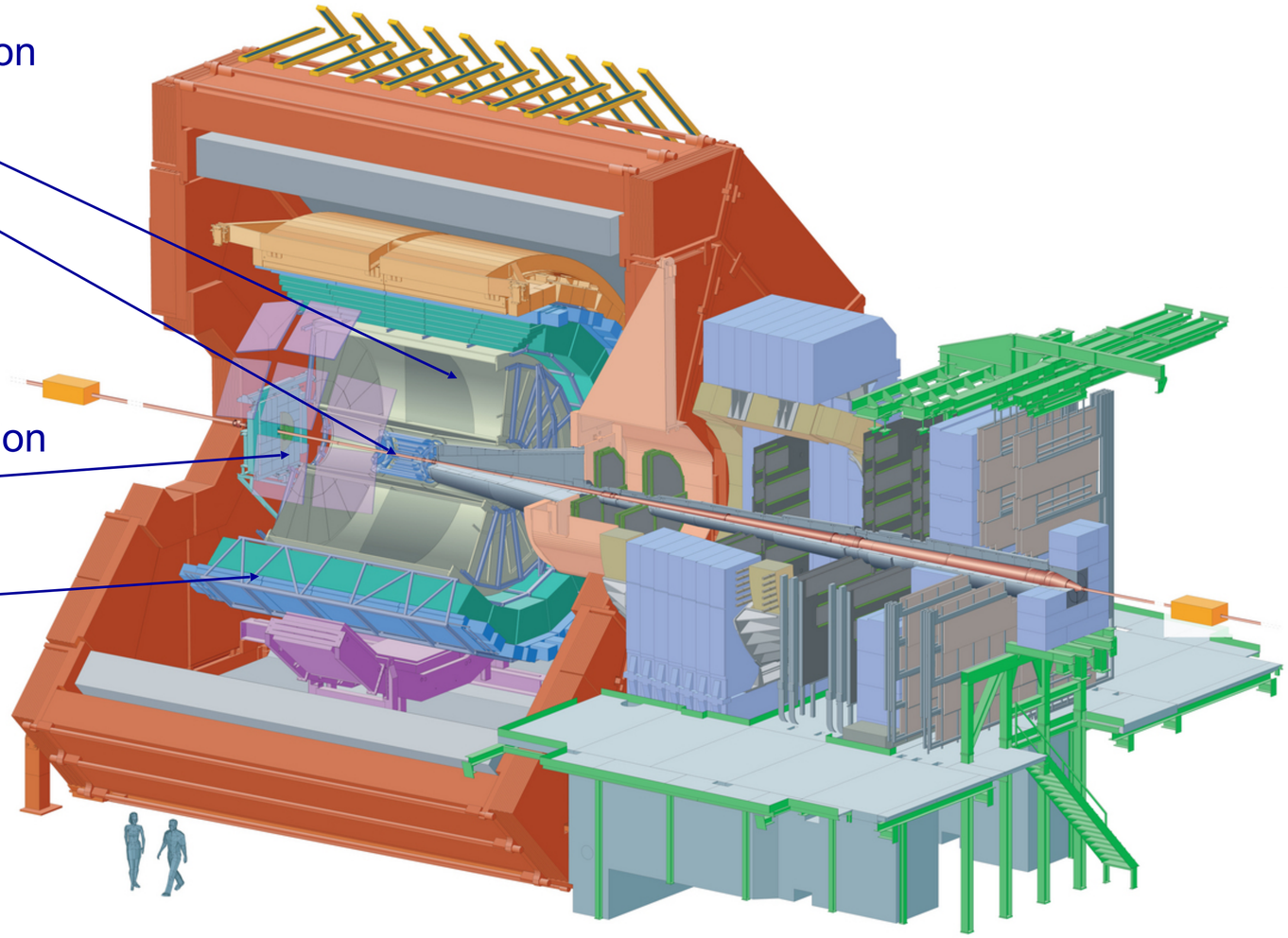


e.g. 2015: 100M hadronic Pb+Pb collisions, 800M p+p collisions

Detector example: ALICE

Central tracker:
$|\eta| < 0.9$
High resolution
- TPC
- ITS

Particle identification
- HMPID
- TRD
- TOF



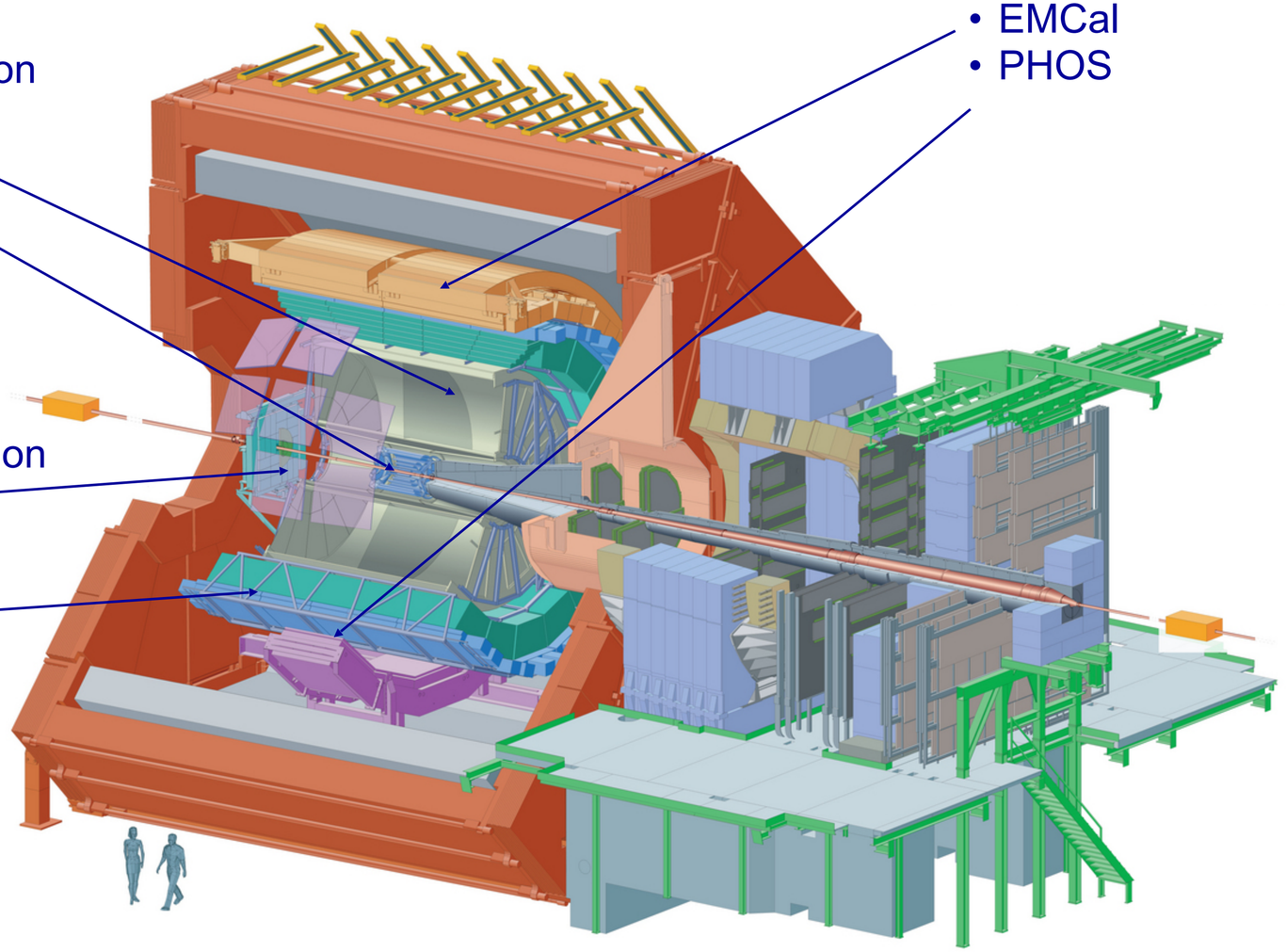
e.g. 2015: 100M hadronic Pb+Pb collisions, 800M p+p collisions

Detector example: ALICE

Central tracker:
$|\eta| < 0.9$
High resolution
- TPC
- ITS

EM Calorimeters
- EMCal
- PHOS

Particle identification
- HMPID
- TRD
- TOF



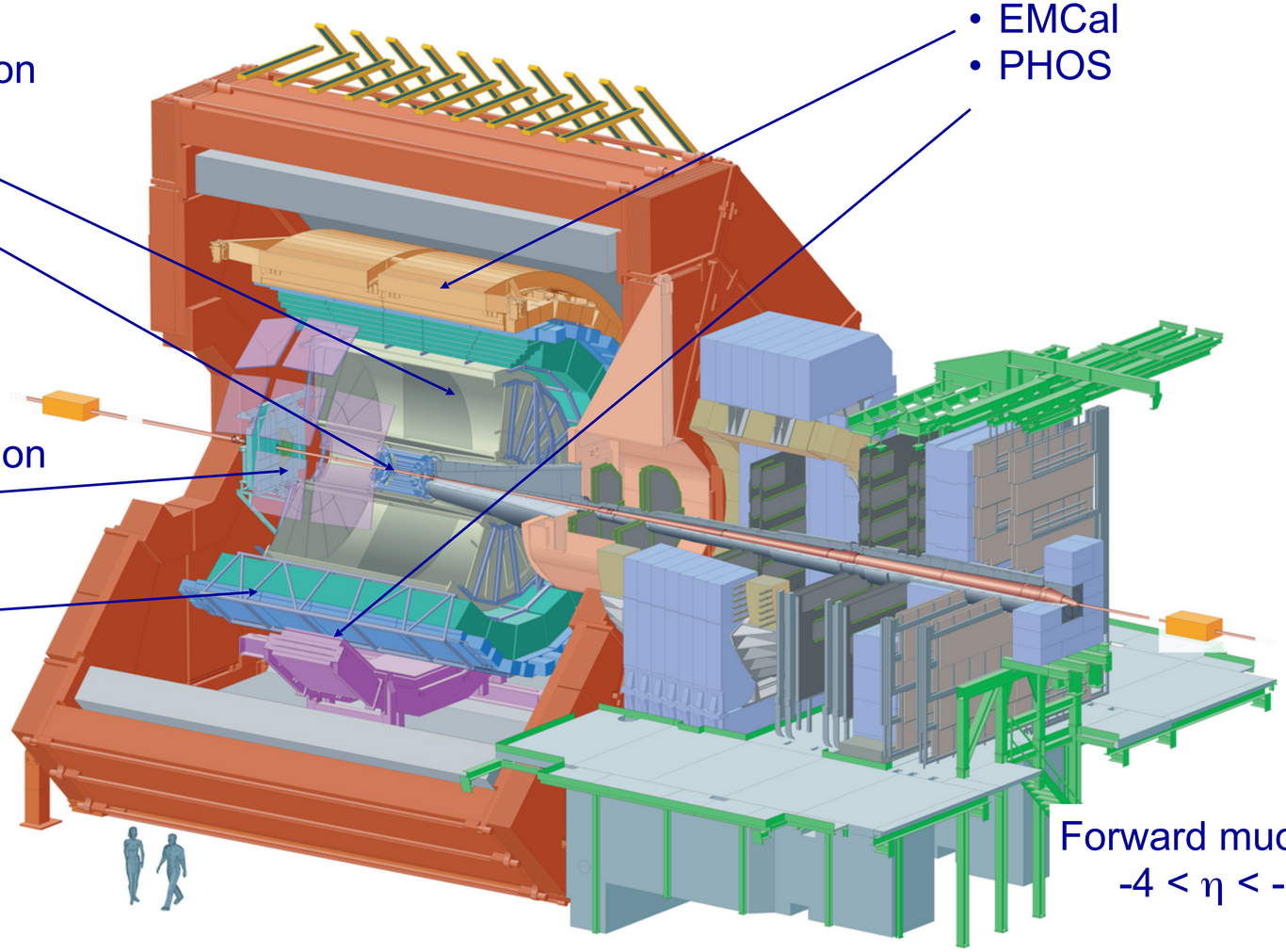
e.g. 2015: 100M hadronic Pb+Pb collisions, 800M p+p collisions

Detector example: ALICE

Central tracker:
$|\eta| < 0.9$
High resolution
- TPC
- ITS

EM Calorimeters
- EMCal
- PHOS

Particle identification
- HMPID
- TRD
- TOF

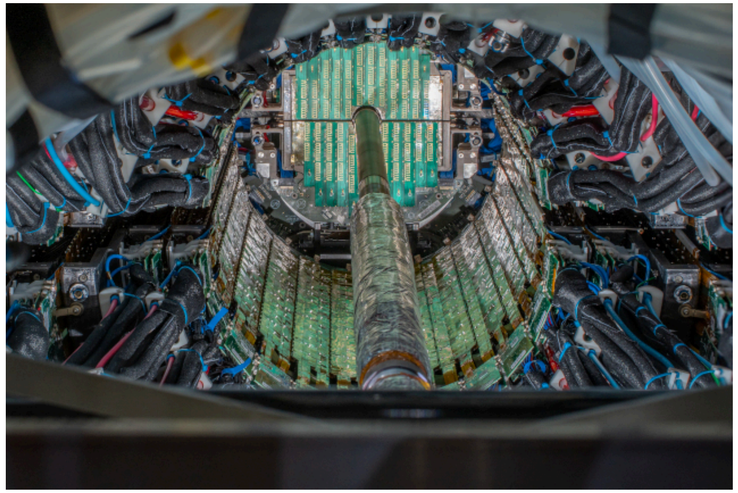


Forward muon arm
$-4 < \eta < -2.5$

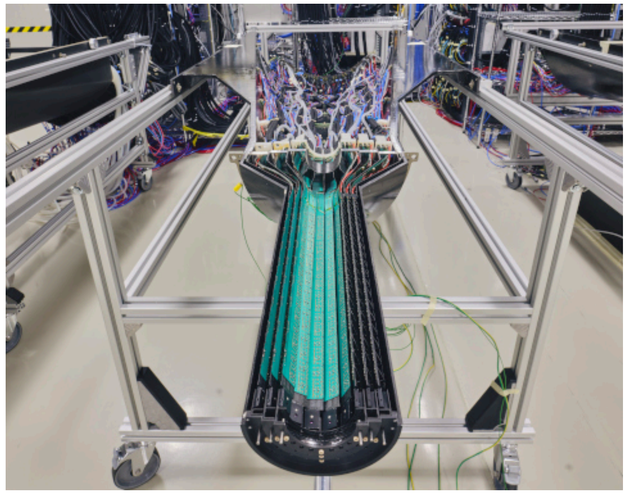
e.g. 2015: 100M hadronic Pb+Pb collisions, 800M p+p collisions

ALICE detector upgrades: ITS, TPC installation

New inner tracking system



Outer barrels

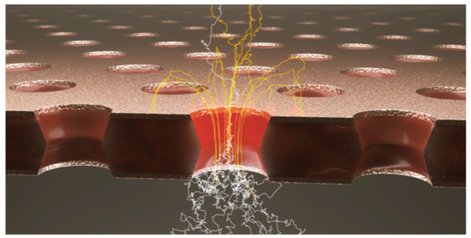


Inner barrels

Large ‘digital camera’
7 layers, pixels: 30x30 μm: precise tracking of charged particles
Total area: 10 m^2; 12.5 Gpixels

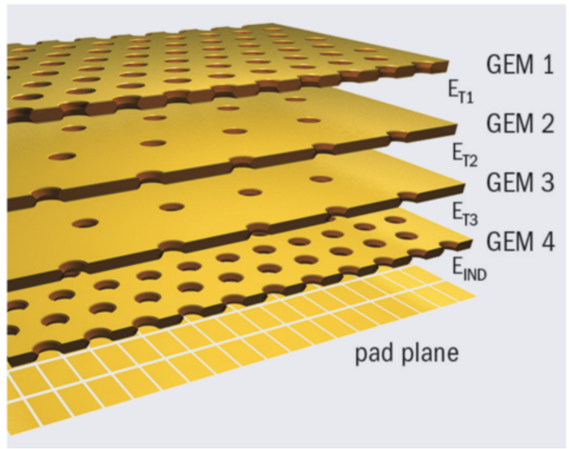
Integration time: 5 μs: up to 200 000 pictures per second!

Time projection chamber



Gas Electron Multiplier (GEM)

New readout/amplification chambers
GEM: plastic foils + gas
for electron multiplication



39 countries
174 institutes
1927 members

How does a scientific collaboration work?

http://alice-collaboration.web.cern.ch/

- General information
- Collaboration members
- Organization
- Visits
- Service Works
- Diversity office
- Technical Coordination
- Run Coordination
- Physics Coordination
- Documents & Conferences
- Online
- Offline
- Analysis

Meetings on a typical weekday

CALENDAR TODAY

- 06:30 **Tsukuba ALICE analysis meeting**
- 09:00 **ALF-FRED : LLA and PARALLEL SLOW CONTROL**
- 09:30 **CANCELLED // DPG & BTG Calibration & Tracking meetings** CERN 14/4-002
- 09:30 **CTS-O2 simulation** CERN 4/R-050
- 09:30 **MFT Technical Board meeting** Vidyo
- 10:00 **ALICE ITS DCS** CERN 53/R-044
- 10:30 **PWG-HF Physics Analysis Group HFCJ** CERN
- 11:00 **DPG AOT - Track properties and selections** Vidyo only
- 12:00 **JYFL meeting**
- 12:00 **FIT logos**
- 13:00 **NIHAM AliAP meeting**
- 13:00 **TRD O2 Planning**
- 14:00 **Images of detector**
- 14:00 **Physics Board Meeting** CERN 160/R-009
- 14:00 **Xe-Xe towards paper proposal** Virtual only
- 14:00 **ITS3 WP2 Meeting**
- 14:00 **PWG-HF-HFL Meeting**
- 15:00 **UCT Group Meeting**
- 15:00 **WP1 data model meeting**
- 15:00 **PWG - UD PAG - Diffractive meeting** CERN 4/3-006
- 15:00 **Birmingham ALICE weekly meeting**
- 15:30 **FIT Software Meeting**
- 16:00 **ALICE Nuclei and Exotica PAG meeting** Virtual Zoom
- 16:00 **ALICE Journal Club** CERN
- 16:00 **EbyE PAG meeting**
- 16:00 **TG06 meeting**
- 17:00 **HMPID weekly meeting** Other Institutes
- 17:00 **ALICE Review paper - Topical Group 5 (Hadronization of the QGP)**
- 19:30 **Creighton Group Meeting**
- 22:00 **ALICE-USA Council Meeting**

update on - 21:46:14

A place to start: the ALICE website
Freely accessible, mostly used for internal communication

Large community:
meetings to discuss, collaborate
disseminate information and reach decisions

Activities in an LHC collaboration

- Detector construction and upgrades
  - ALICE initially constructed in early 2000s
  - Various minor upgrades implemented:
    - New detector systems
    - Faster readout electronics
  - Long Shutdown 2: 2019-2021: large upgrade, new detector systems
- Data taking and detector operations
  - Large activity in running years (e.g. 2015-2018): control room staffed 24h/day
  - Many experts ‘on call’
- Physics analysis and publication
  - Data analysis: computing, statistics
  - Detector simulation for corrections to measurements
  - Physics modeling/interpreting the results
  - Writing papers and preparing conference presentations