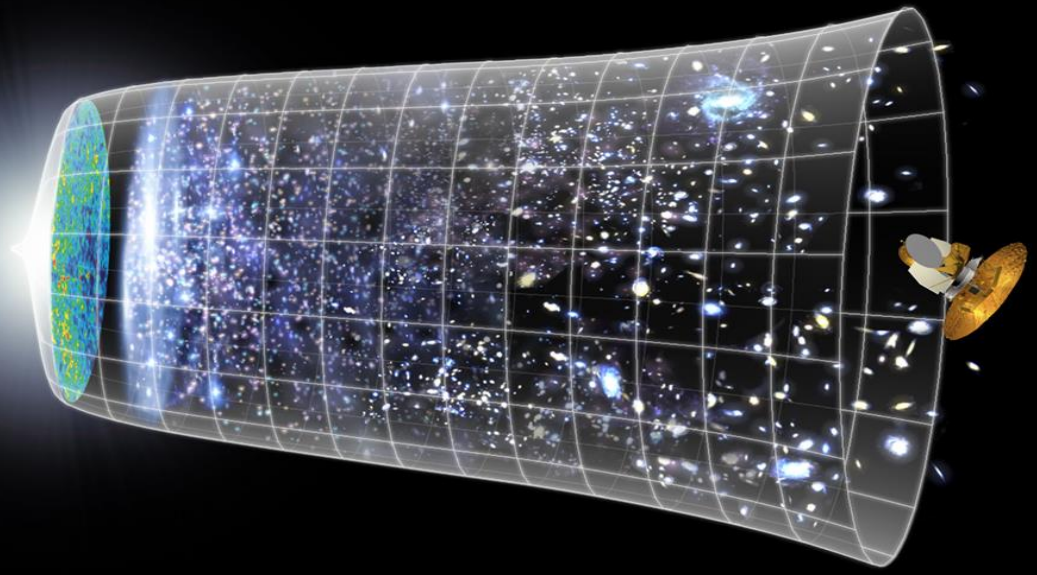
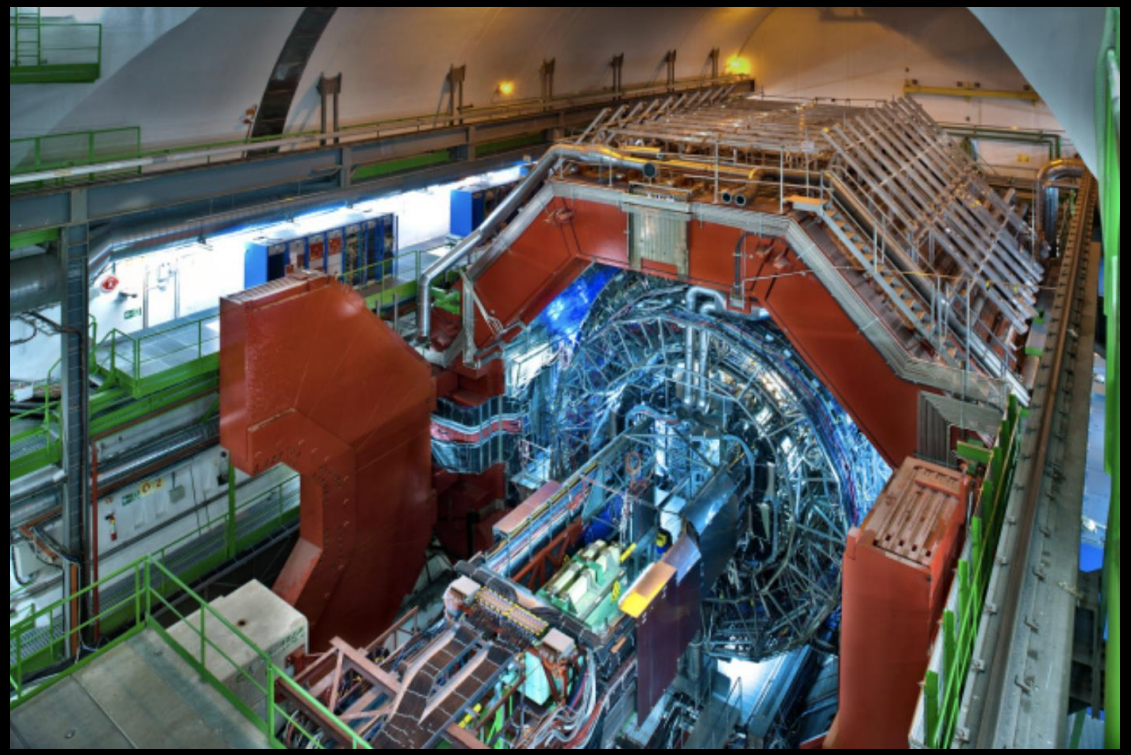
Welcome to CERN

Welcome to ALICE





home.cern
alice.cern

21 March 2023


CERN
CERN
“Science without borders”

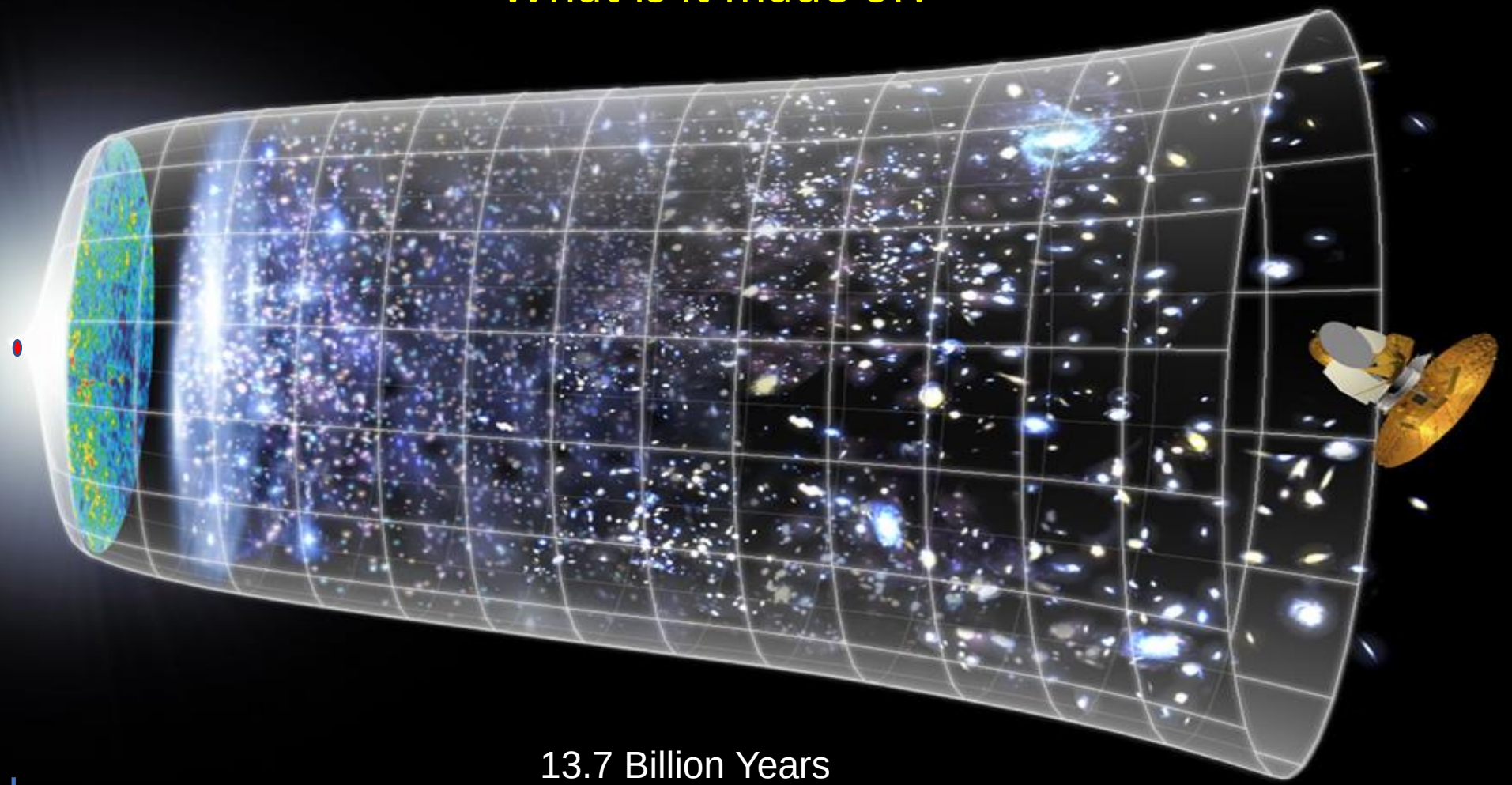
Established in 1954, CERN has become a prime example of international collaboration with a mission to:

- perform world-class research in fundamental physics.
- provide a unique range of particle accelerator facilities that enable research at the forefront of human knowledge, in an environmentally responsible and sustainable way.
- unite people from all over the world to push the frontiers of science and technology, for the benefit of all.
- train new generations of physicists, engineers and technicians, and engage all citizens in research and in the values of science.

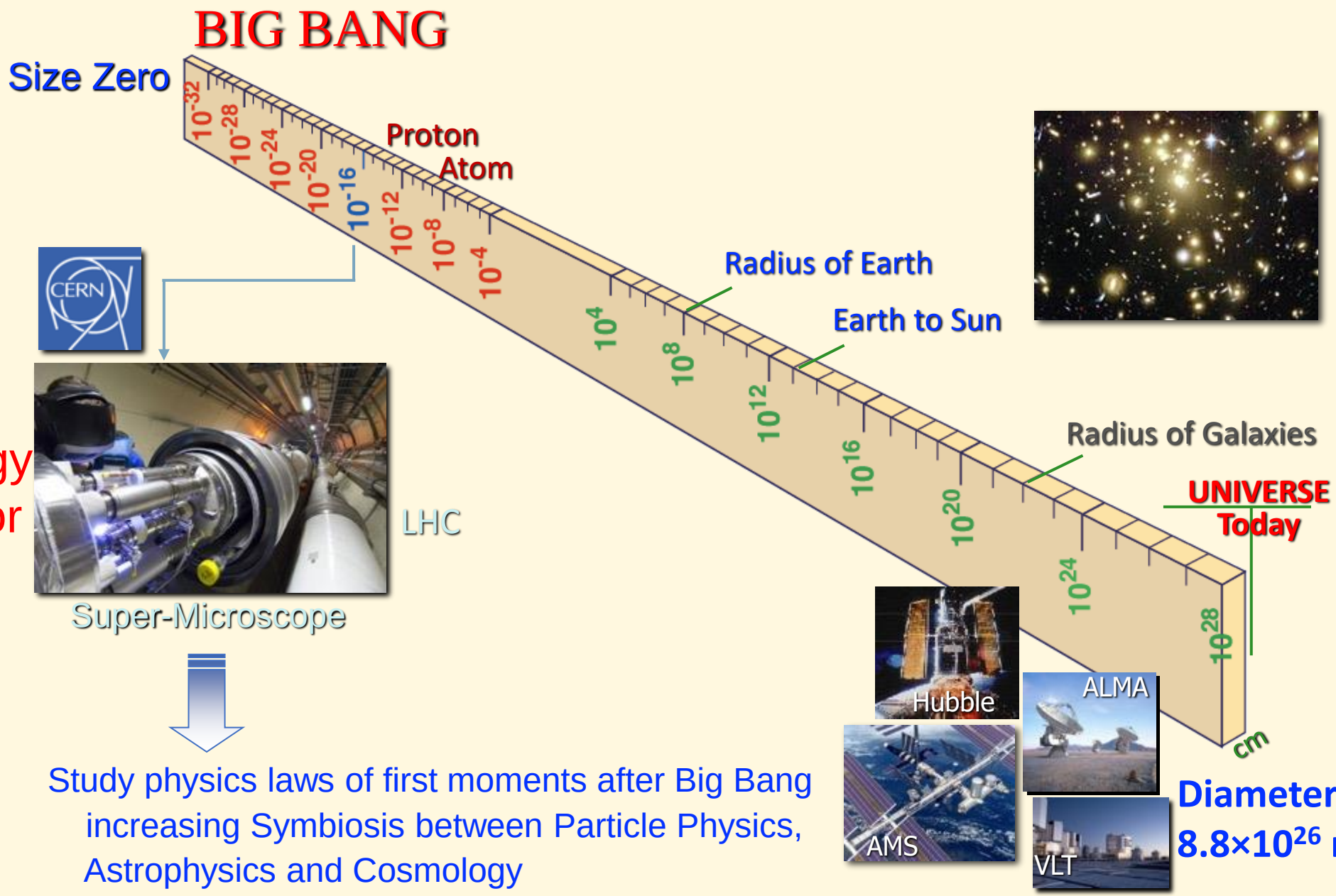
At CERN, our work helps to uncover what the universe is made of and how it works.

Our Universe ..... How did it start?

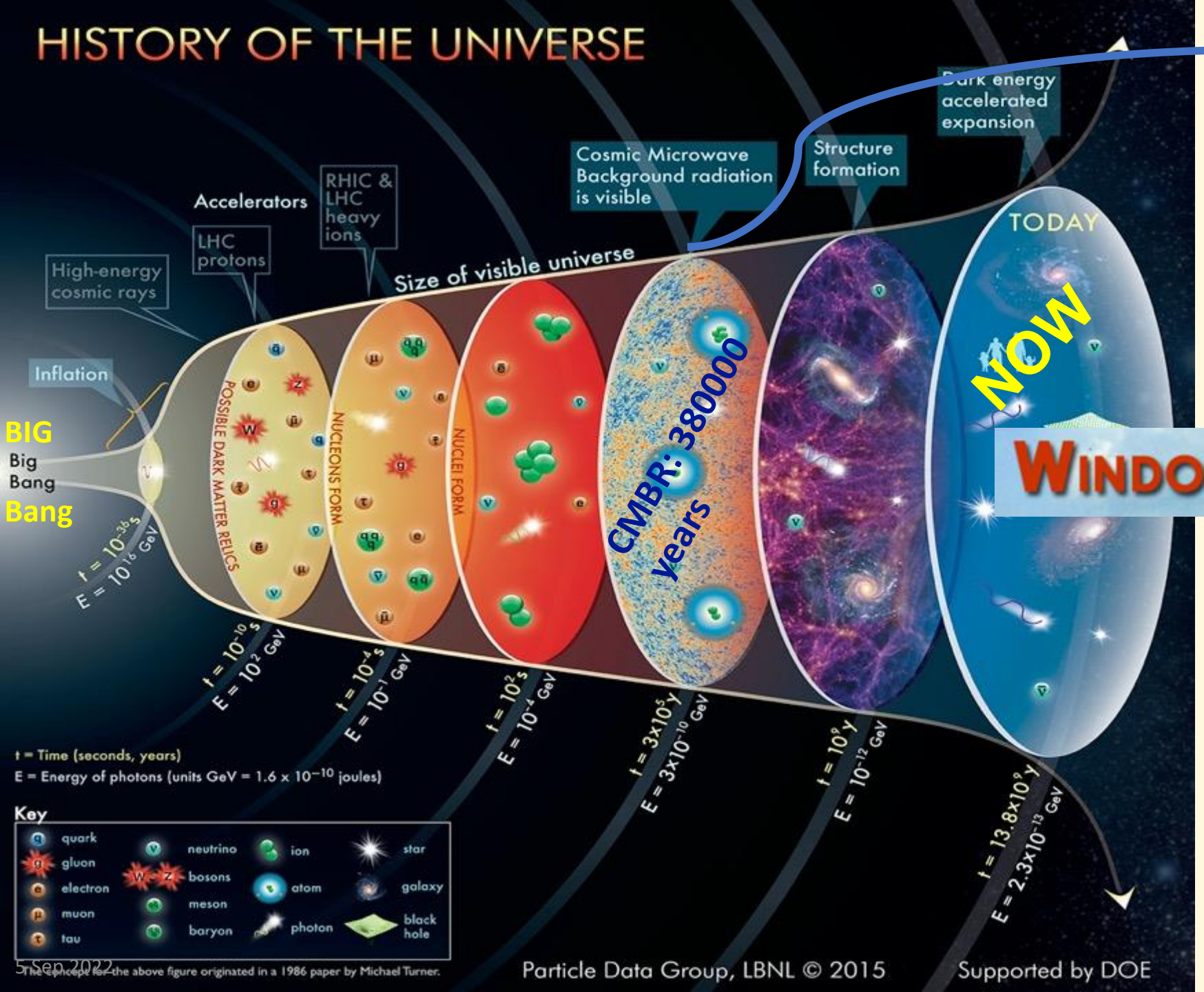
What is it made of?



Accessing Big Bang conditions



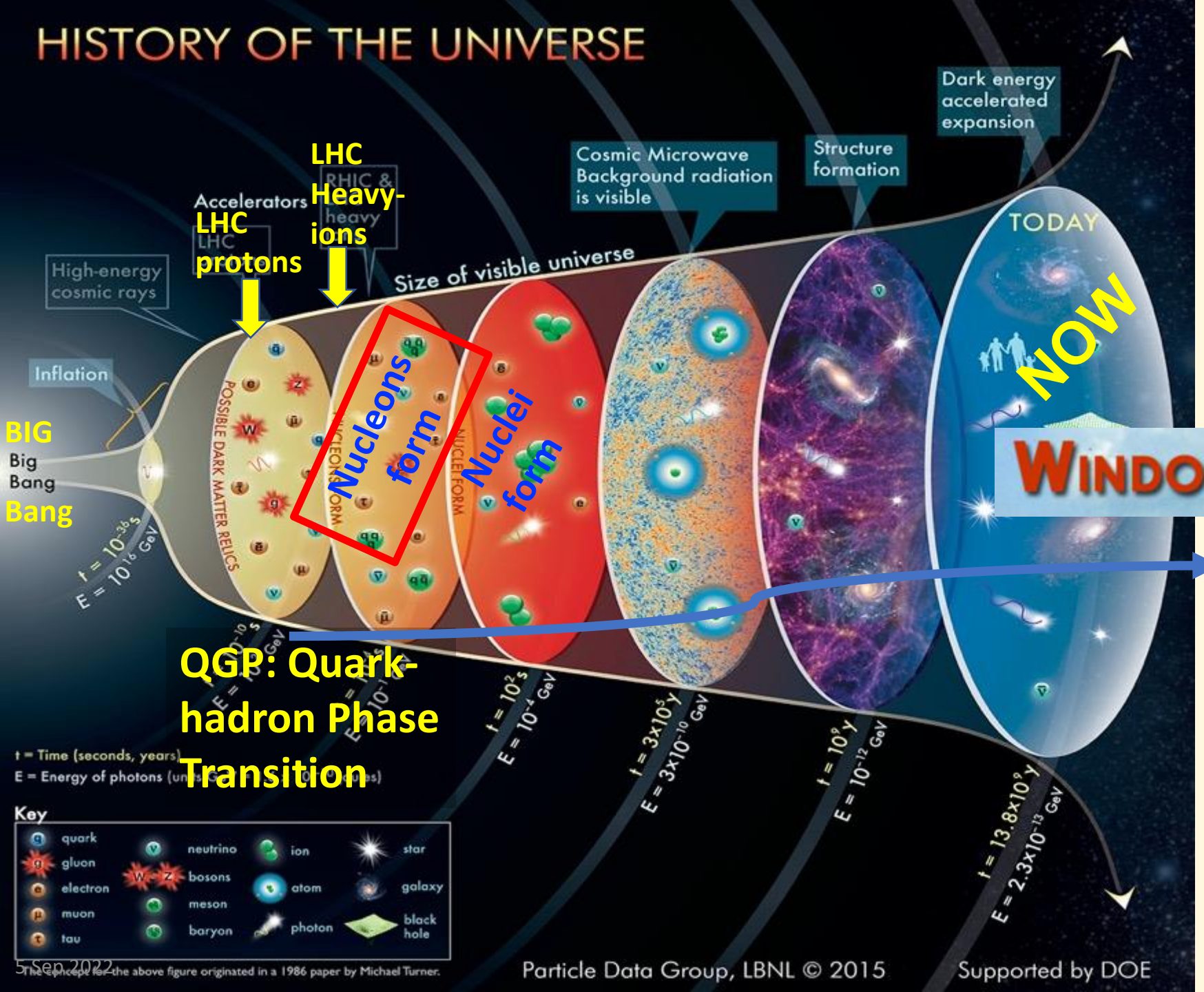
Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology



Astrophysical Probes

Takes us back to 380,000 years after the Big Bang

WINDOWS ON THE UNIVERSE

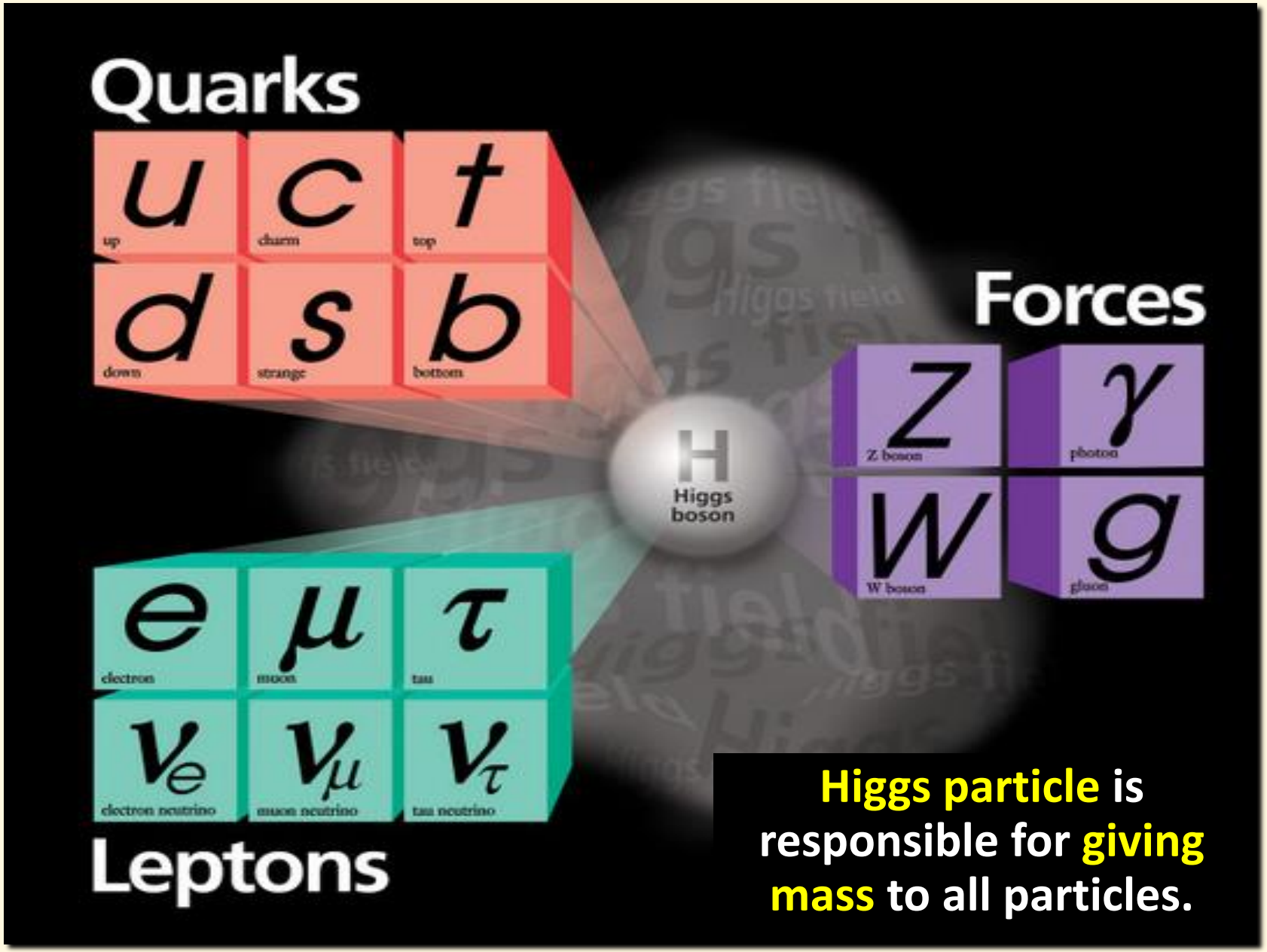


WINDOWS ON THE UNIVERSE

Accelerators (LHC)

Takes us back to within few Microseconds of the Big Bang

Fundamental constituents of matter



- Understanding the primordial state of matter after the Big Bang before protons and neutrons formed?
- understanding the Higgs mechanism
- finding the reason why antimatter and matter did not completely destroy each other
- finding the particle(s) that make up the mysterious ‘dark matter’ in our Universe?

The World Wide Web (www)

Tim Berners-Lee
CERN May 1990

Capacitive touch screens

Frank Beck and Bent Stumpe, engineers from CERN, developed a transparent touch screen in the early 1970s.

It was manufactured by CERN and put to use in 1973

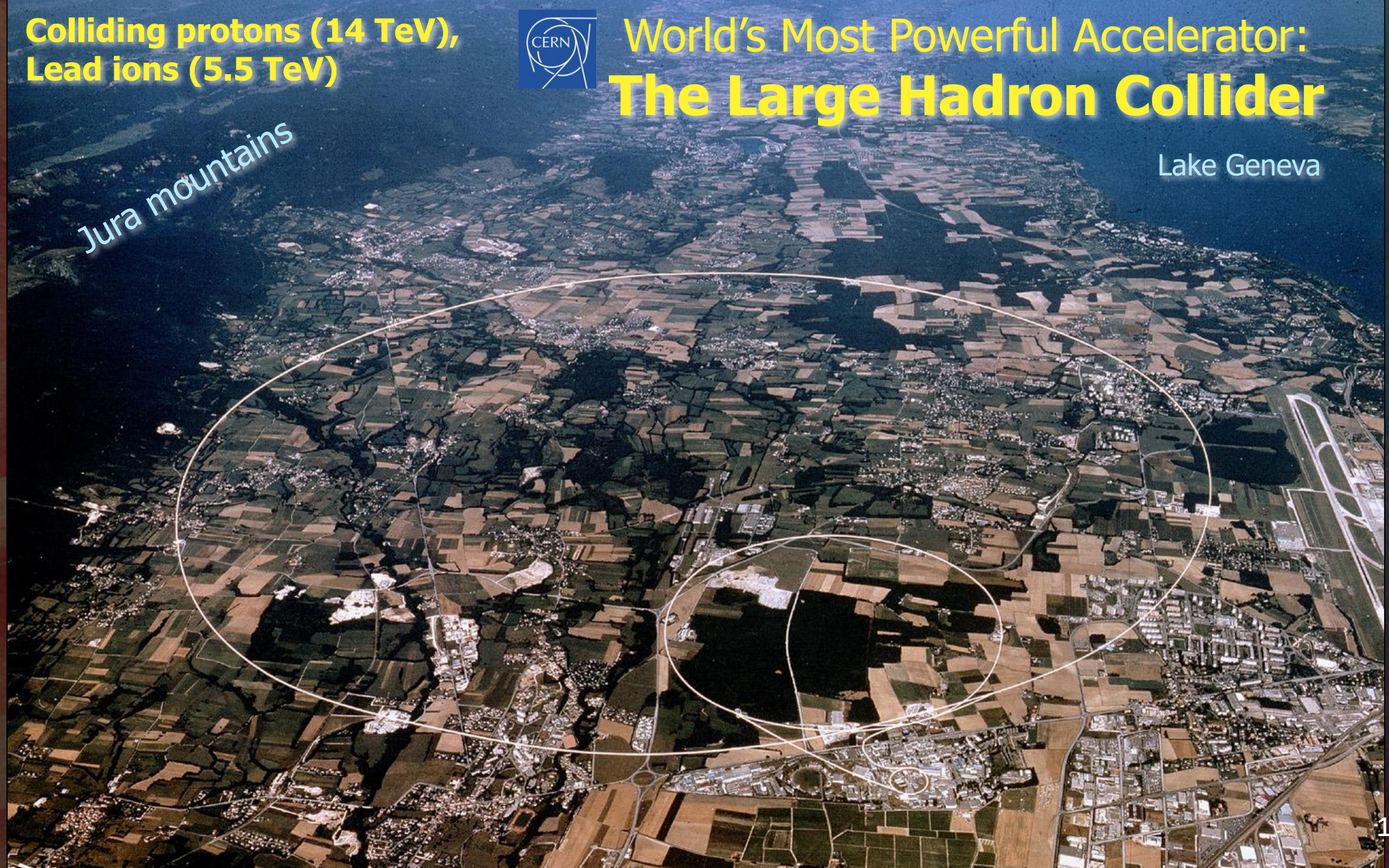
Positron Emission Tomography (PET) and many more spin-offs

Large Hadron Collider (LHC)

5 Sep 2022

27km tunnel:

- 50-150m below ground
- Two beams circulating in opposite directions
- Total of 9300 magnets: beams controlled by 1800 superconducting magnets (up to 8T)


Colliding protons (14 TeV),
Lead ions (5.5 TeV)
CERN
World's Most Powerful Accelerator:
The Large Hadron Collider
Jura mountains
Lake Geneva

Colliding protons (14 TeV),
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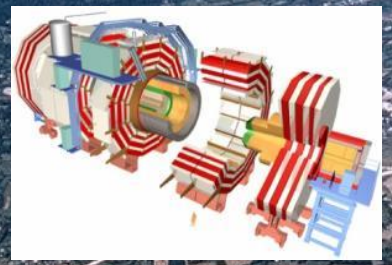
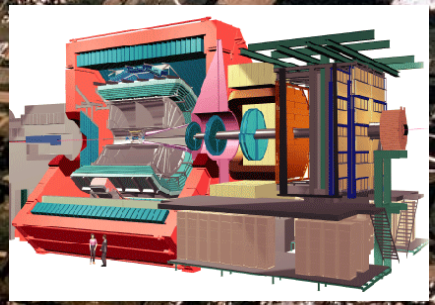


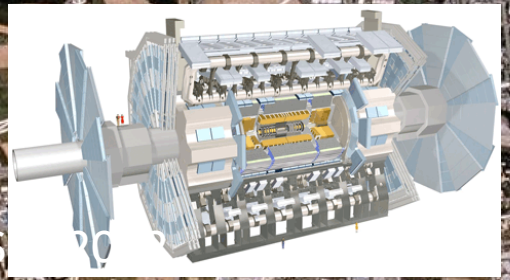
CMS

LHCb

ATLAS



ALICE



5 S

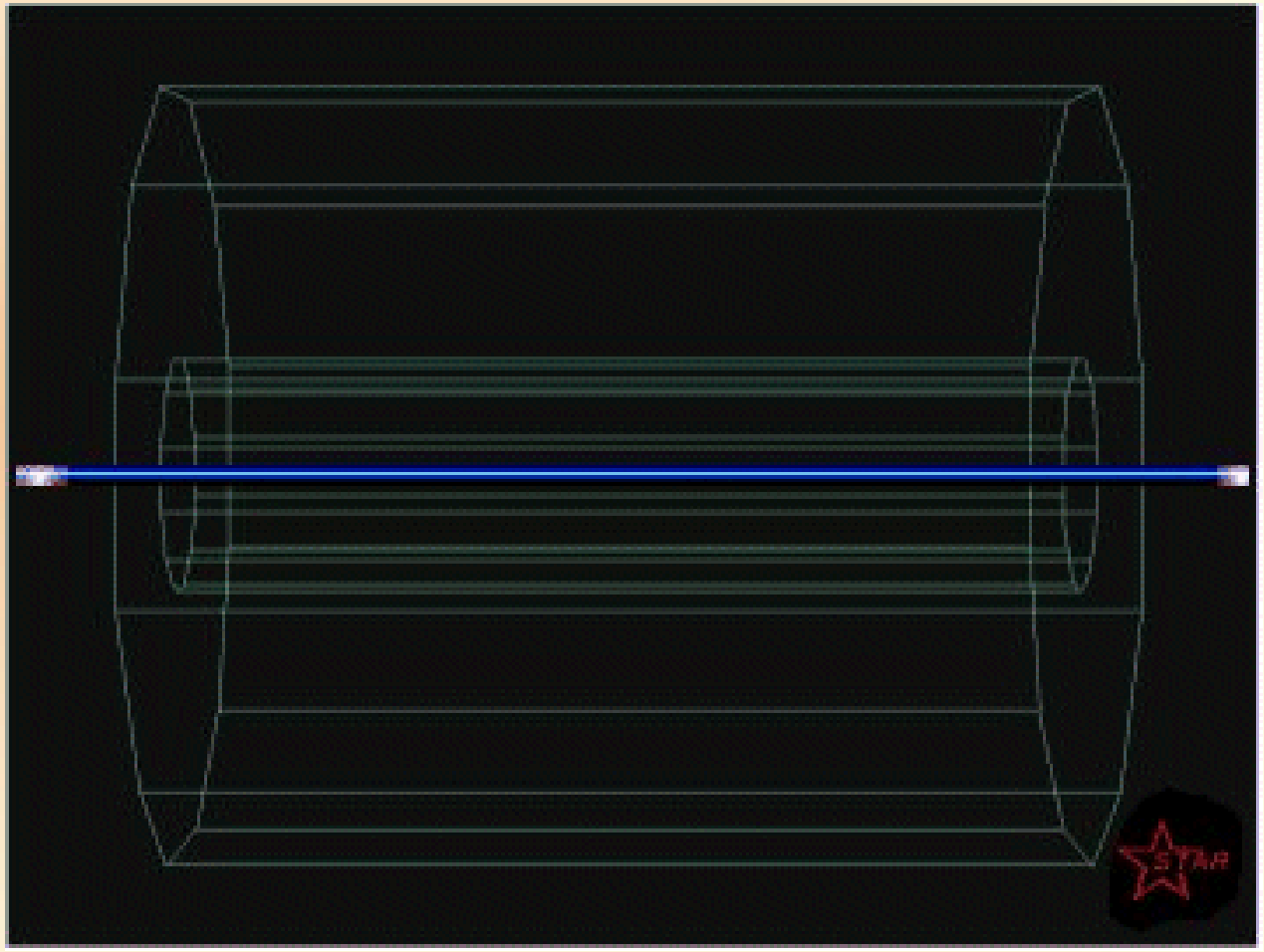
ALICE at the Large Hadron Collider

Study of Quark Gluon Plasma (QGP):
- A journey to the beginning of the Universe

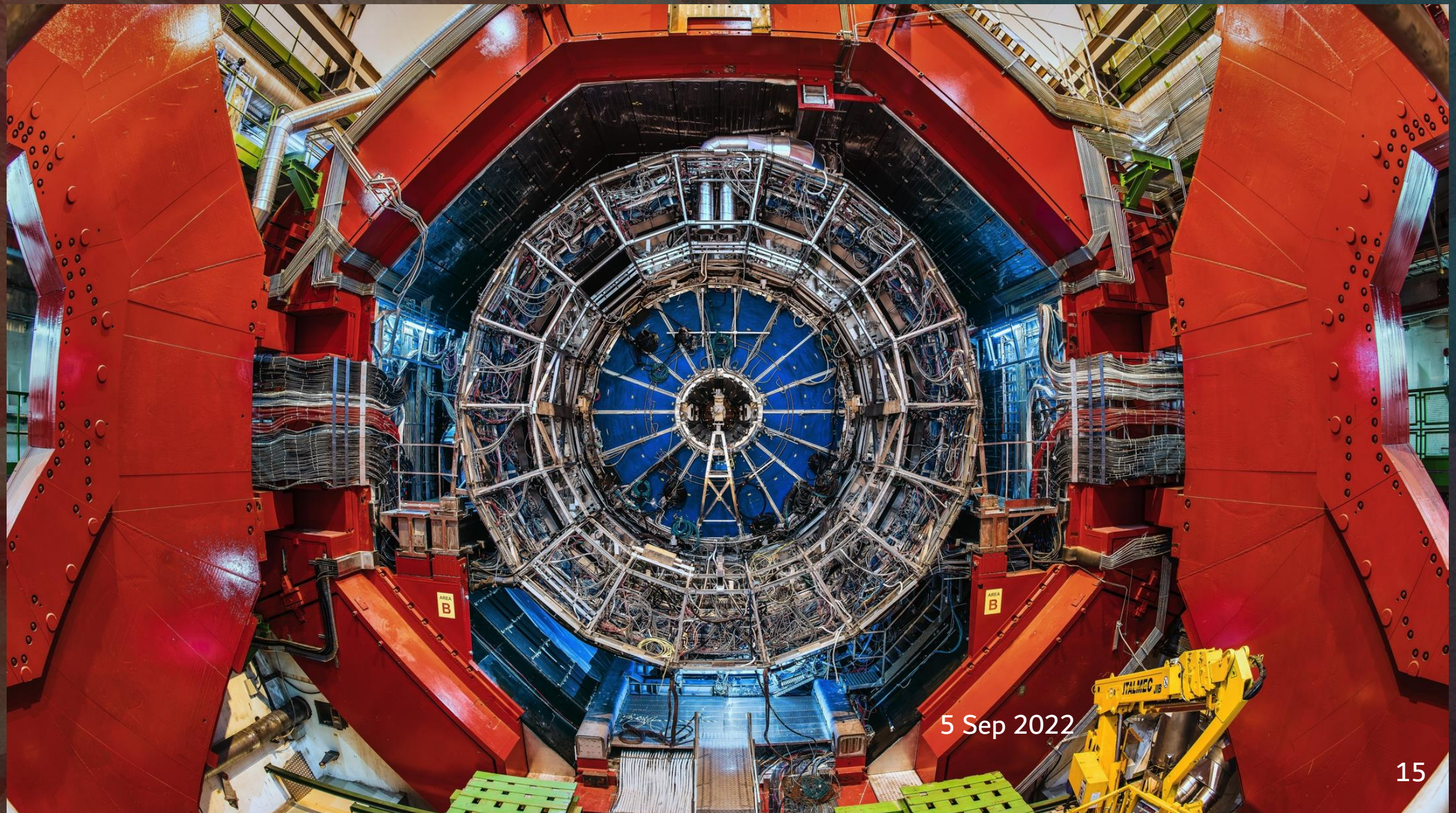
- Our Universe is thought to have been in a primordial state of extreme temperature and/or energy density for the first few millionths of a second after the Big Bang.
- The ALICE Collaboration has built a dedicated detector to study matter at extreme conditions by colliding heavy-ions (such as Pb on Pb) at the Large Hadron Collider.
- The properties of such a state provide key issues for Quantum Chromo Dynamics, the understanding of deconfined and chiral phase transitions.

Heavy-ion collisions: Creating the Quark-Gluon Plasma

- Take a high-mass atom like Au or Pb
- Take away the electron => Ion (***Heavy-ion***)
- ***Accelerate the Ion*** to almost the speed of light
- ***Collide the Ions => Create the Little Bang***
- Study the aftermath by specialized detector systems which surround the collision point ***=> Experiment***



ALICE at Point-2 of the LHC



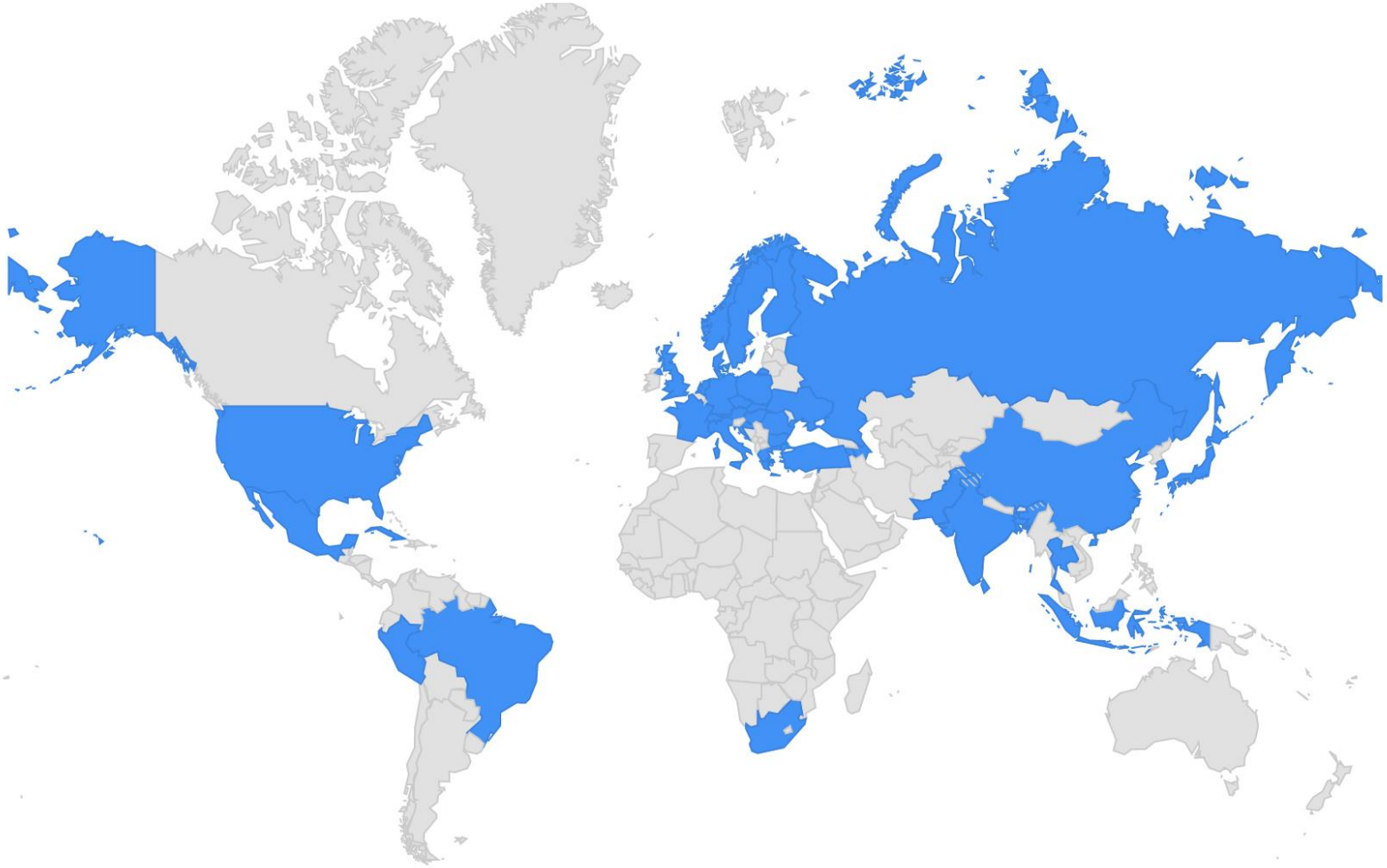
5 Sep 2022

ALICE Collaboration

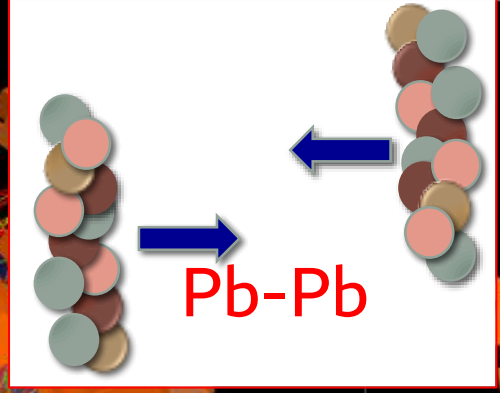
alice.cern

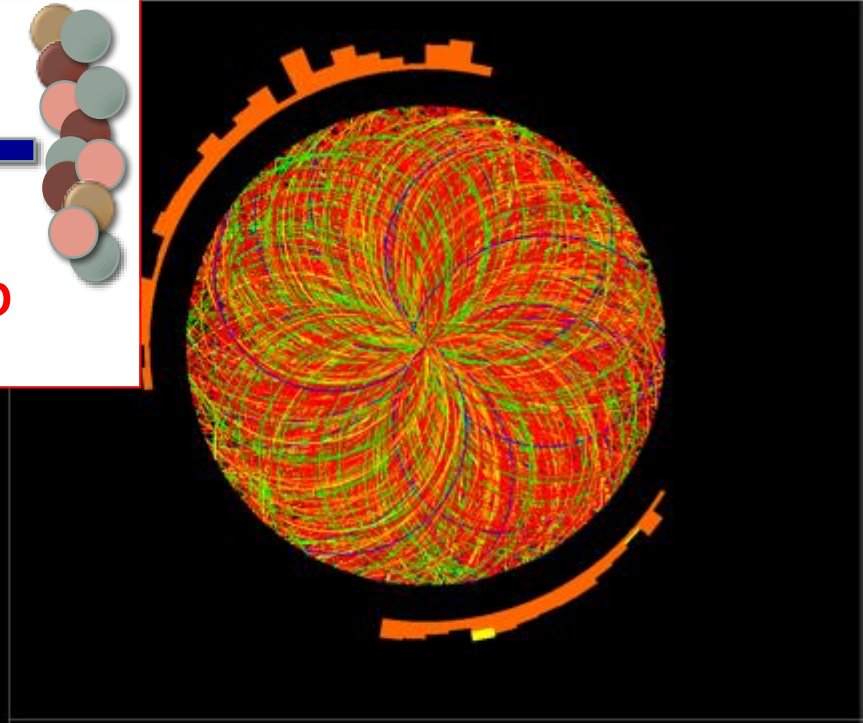
ALICE

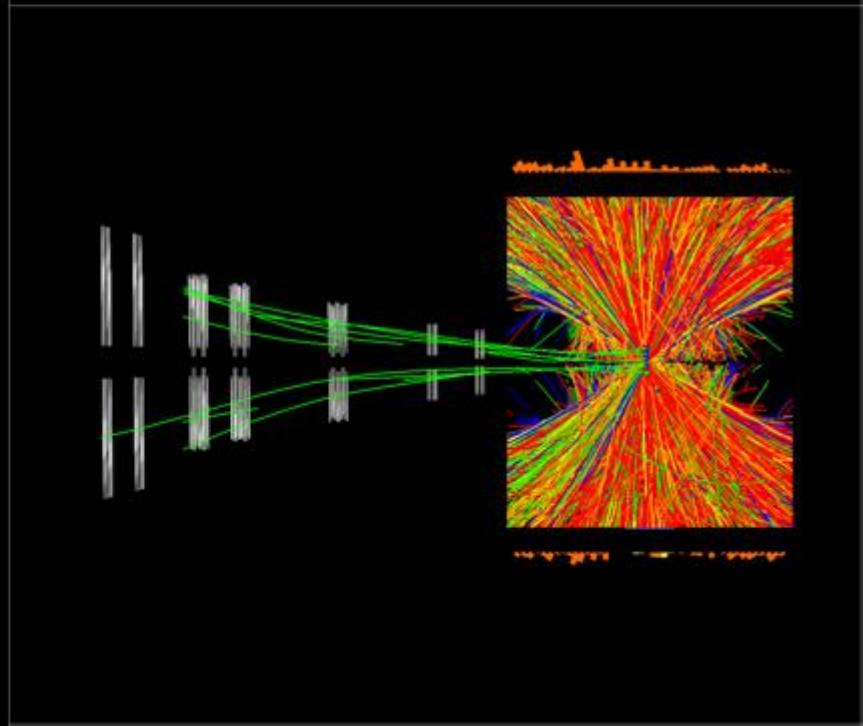
40 countries, 171 institutes, 1996 members



ALICE



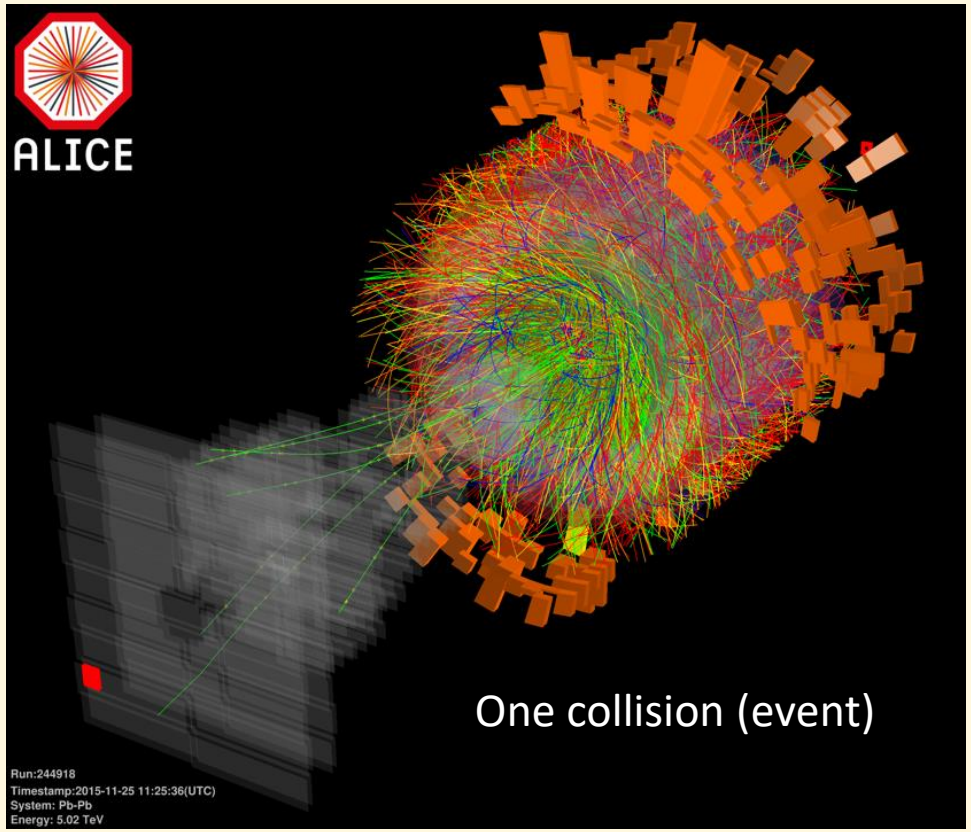




Pb-Pb at 5.02 TeV: One PeV Collision

Run:244918
Timestamp:2015-11-25 11:25:36(UTC)
System: Pb-Pb
Energy: 5.02 TeV

Reconstructing the collision



What has just happened?

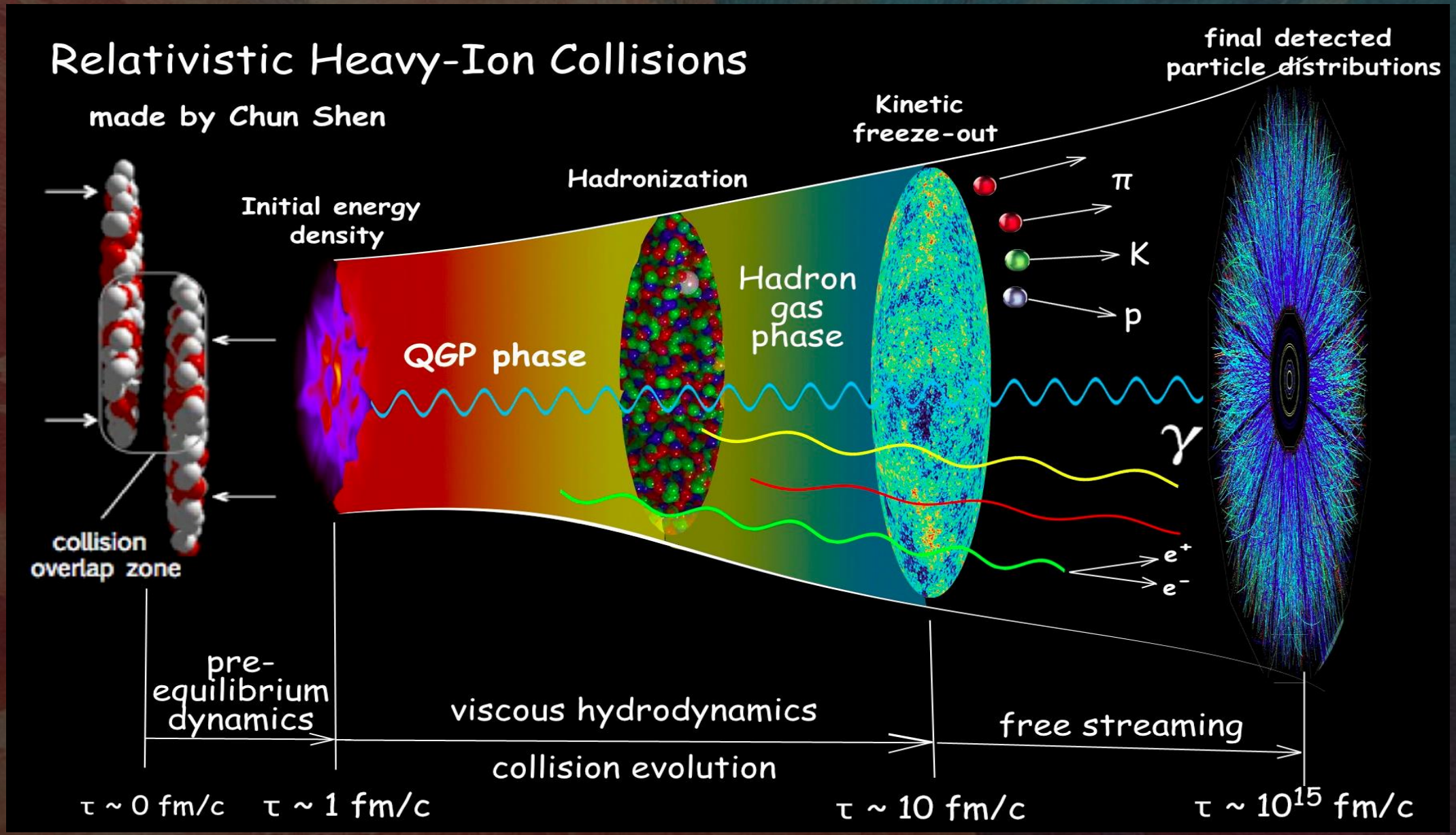
- What particles were created?
- Where were they produced?
- What were the parent particles?

=> Online (live):

- Online data quality monitoring, calibrations.
- Using Triggers to keep events of interest and sends to storage.

=> Offline: Event reconstruction:

- Vertexing
- Tracking
- Particle identification of each of the tracks



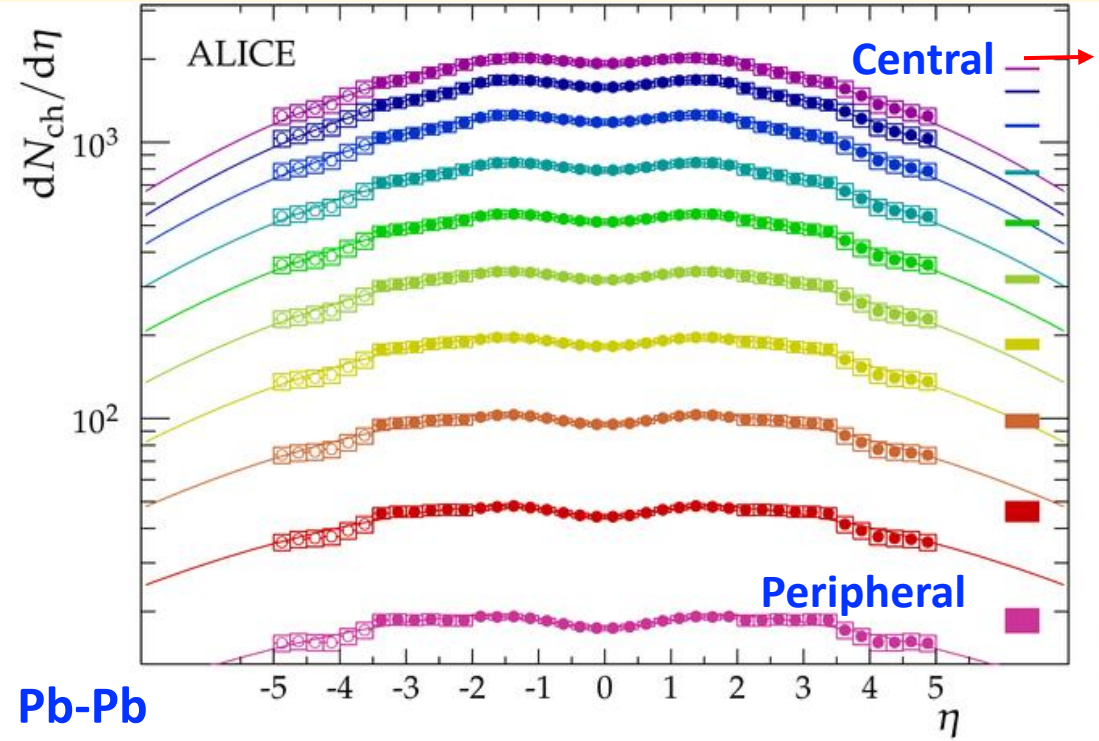
Initial State Fluctuations

Thermal Fluctuations

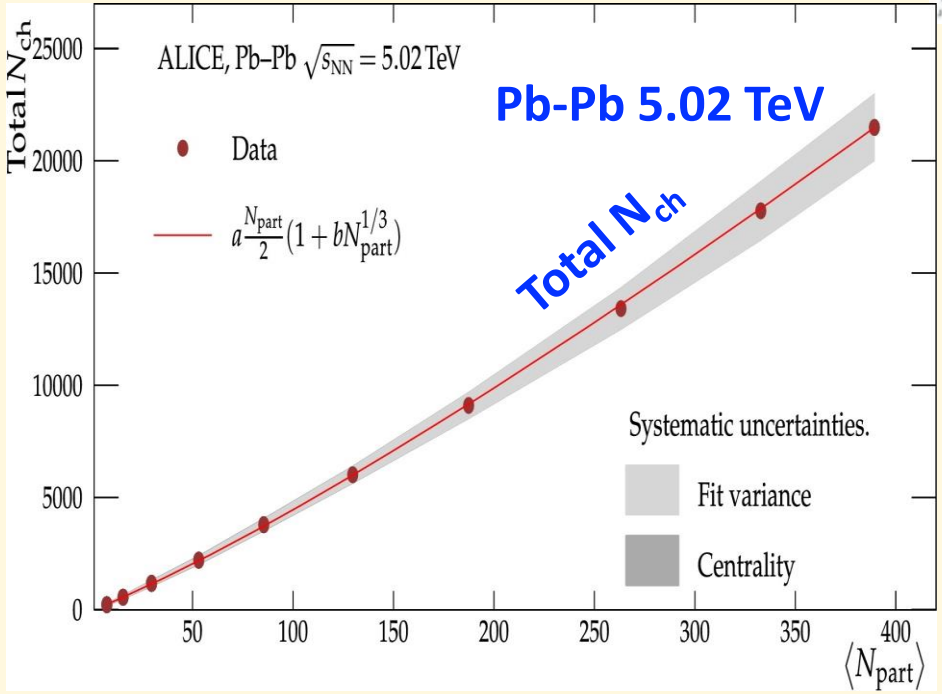
Hadronization

Measurement

Charged particle multiplicity



~2000



Number of charged particles in one collision:

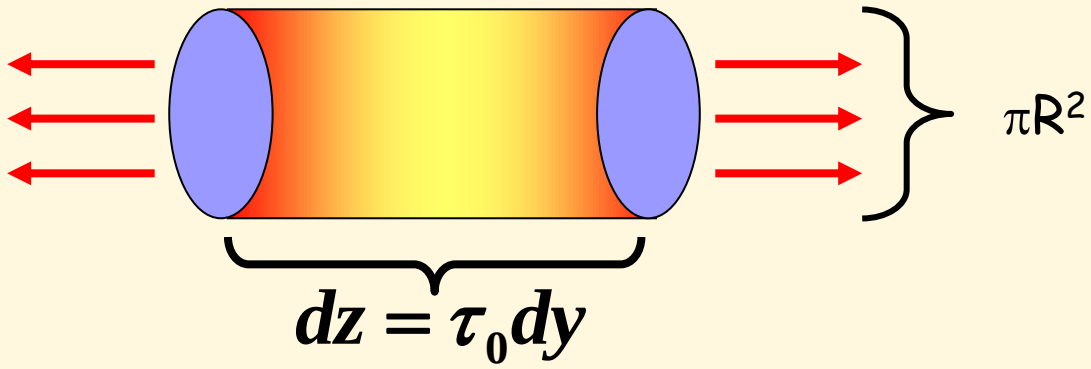
- Central collisions: 21400 ± 1300
- Peripheral collisions: 230 ± 38

Phys.Lett. B 772 (2017) 567577
Phys. Rev. Lett. 116 (2016) 222302

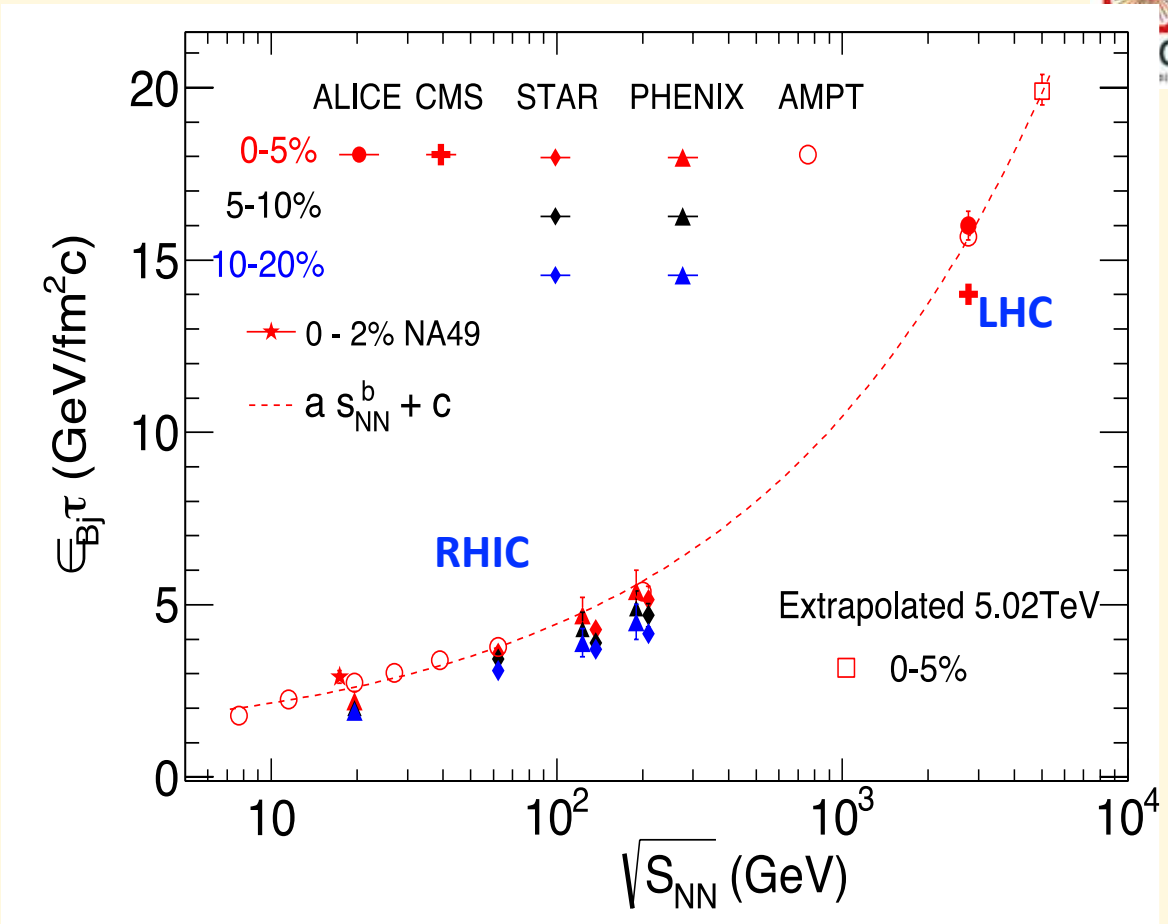
VERY LARGE NUMBER OF PRODUCED PARTICLES

Particle density & Energy density

J. D. Bjorken, Phys. Rev. D 27, 140 (1983).



$$\varepsilon_{Bj}(\tau) = \frac{1}{\pi R^2 \tau}\frac{dE_T}{dy} \approx \frac{1}{\pi R^2 \tau} < m_T > \frac{3}{2}\frac{dN_{ch}}{d\eta}$$



ε.τ ~ 16 GeV/fm²c

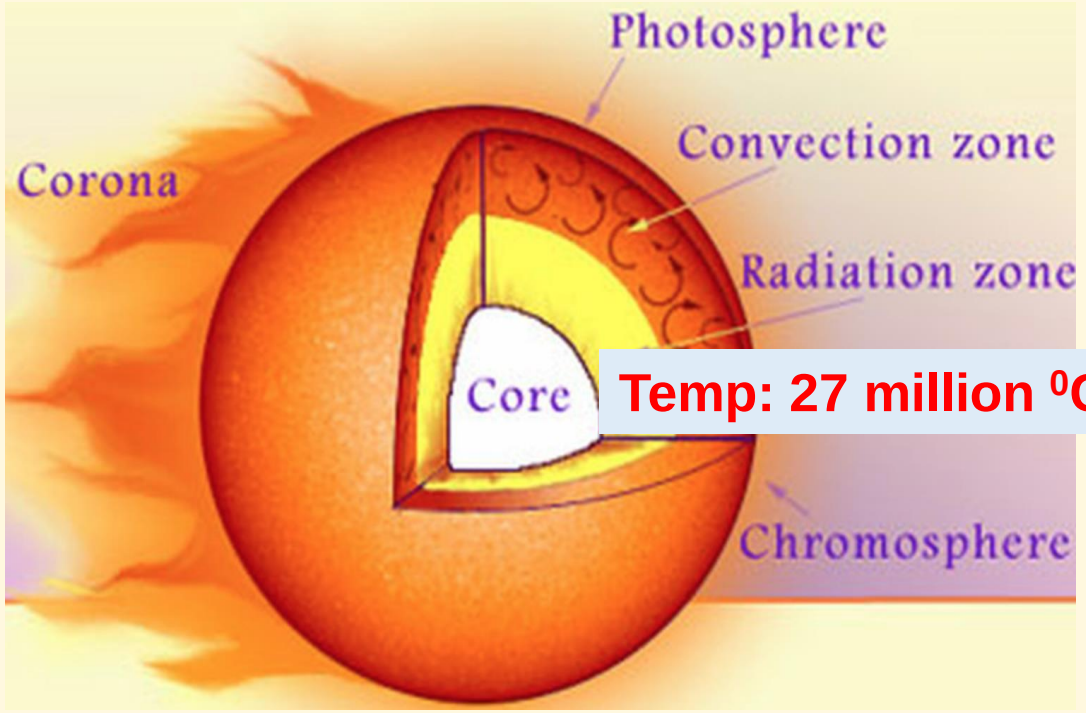
LARGEST ENERGY DENSITIES EVER ACHIEVED ….

S. Basu et al. PRC 93 (2016) 064902
R. Sahoo et al. Adv. in HEP, Vol. 2015

Photon Spectra and QGP temperature

- Photons do not interact via the nuclear force → transparent to the medium
- Photons are emitted in all stages and are unaffected by the medium.

Core of the Sun:

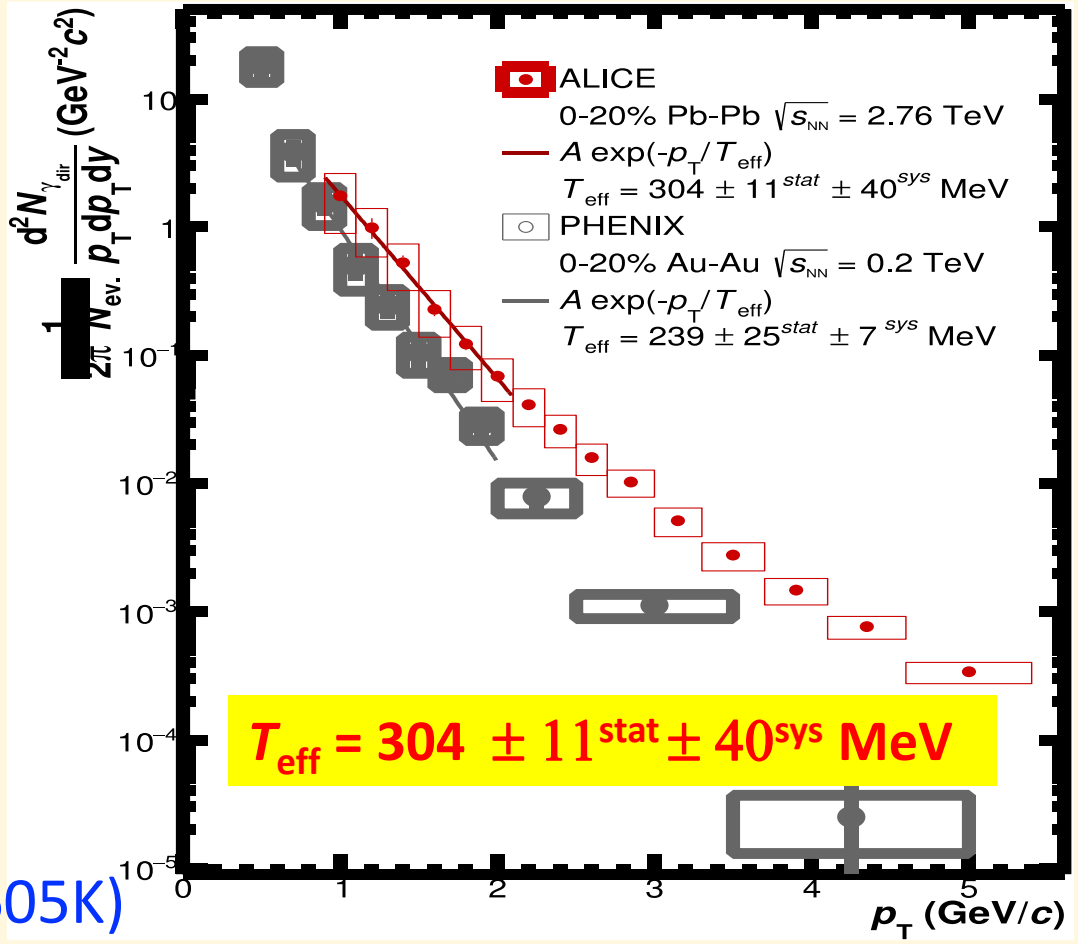


Temp: 27 million ^{0}C

(1eV=11605K)

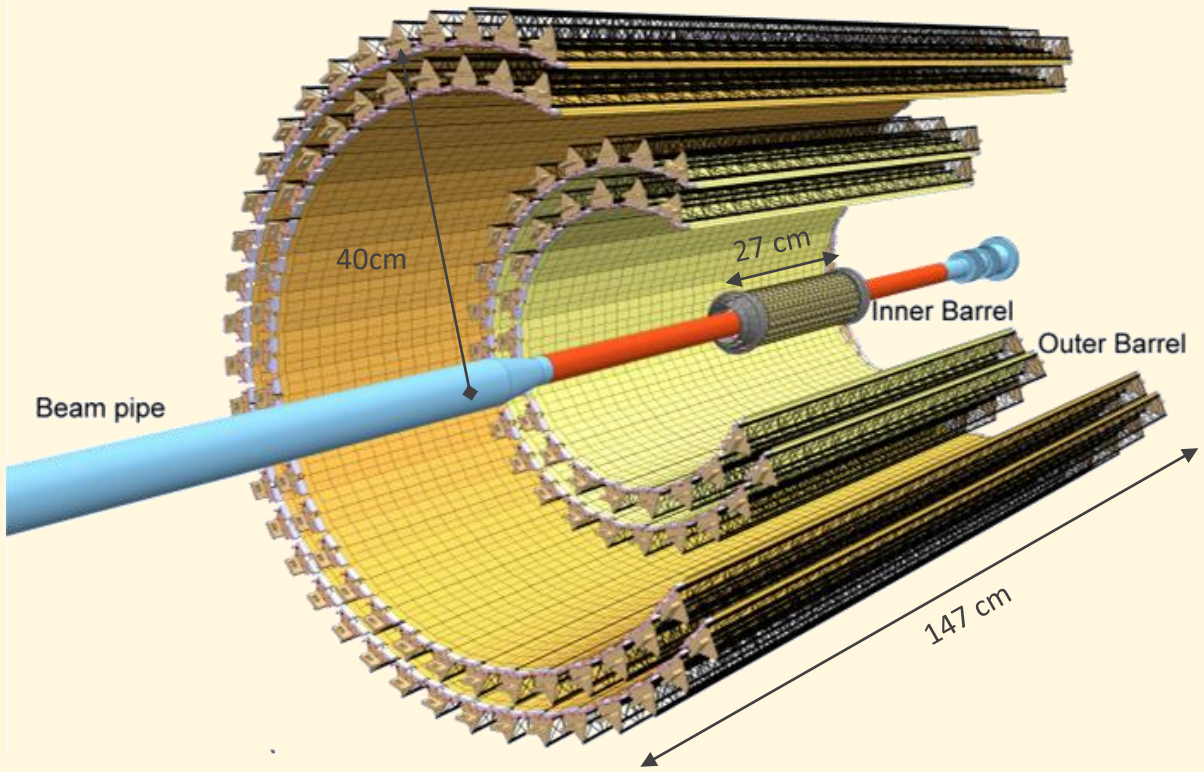
T_{eff} = 3,527,920 million deg

Phys. Lett. B 754 (2016) 235-248



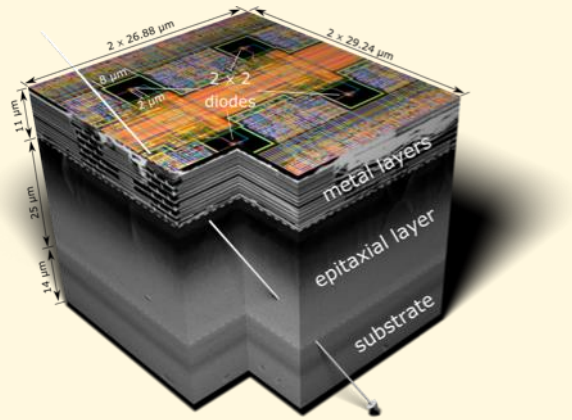
LARGEST EVER TEMPERATURE REACHED IN THE LAB ….

New Inner Tracking System (ITS)



- 7-layer geometry (23 – 400mm), $|\eta| \leq 1.5$)
- 10 m^2 active silicon area (**12.5 G-pixels**)
- Pixel pitch 28 x 28 μm^2
- Spatial resolution ~5μm
- Power density < 40mW / cm^2
- Material thickness: ~0.3% / layer (IB)
- Maximum particle rate: 100 MHz / cm^2

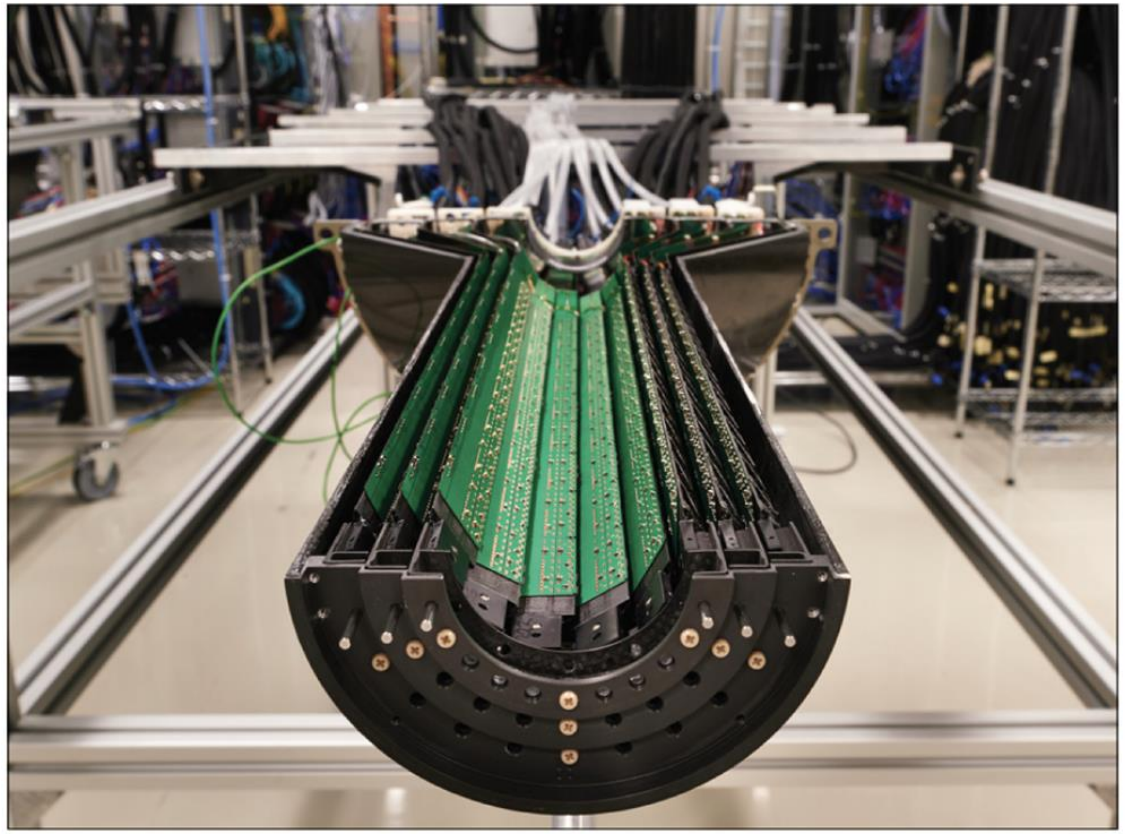
Based on CMOS Monolithic Active Pixel Sensors (MAPS)

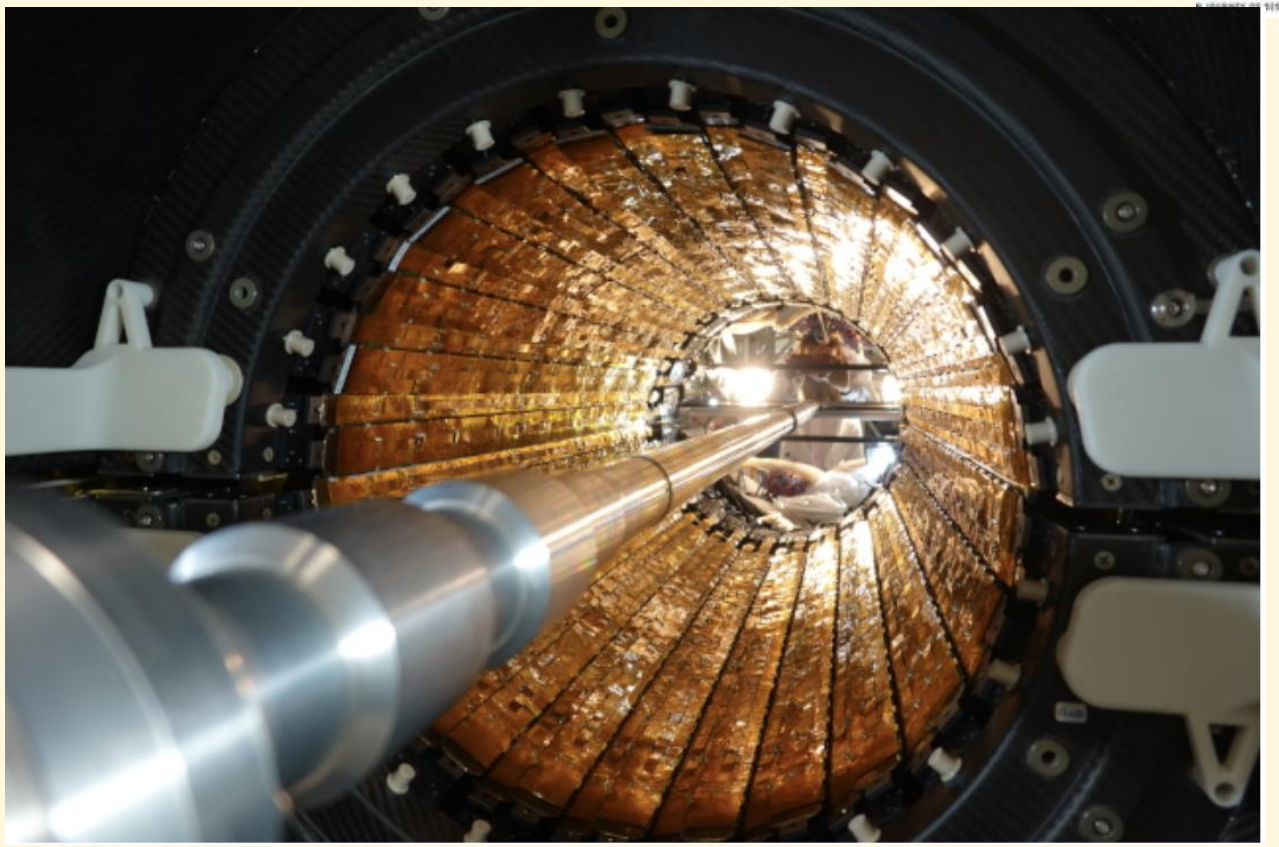


ITS inner

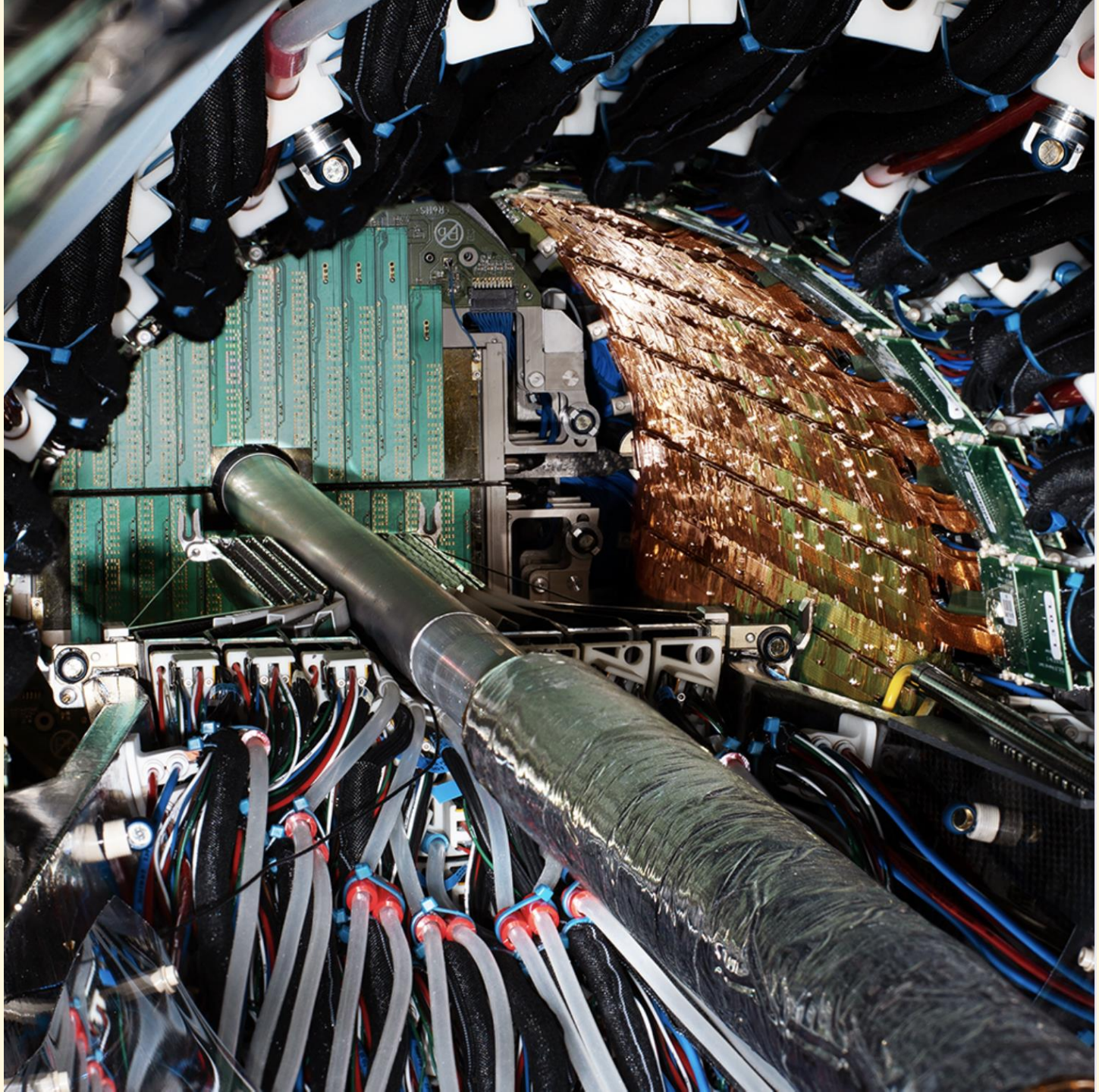
10 m^2 active silicon area (**12.5 G-pixels**)

ITS outer





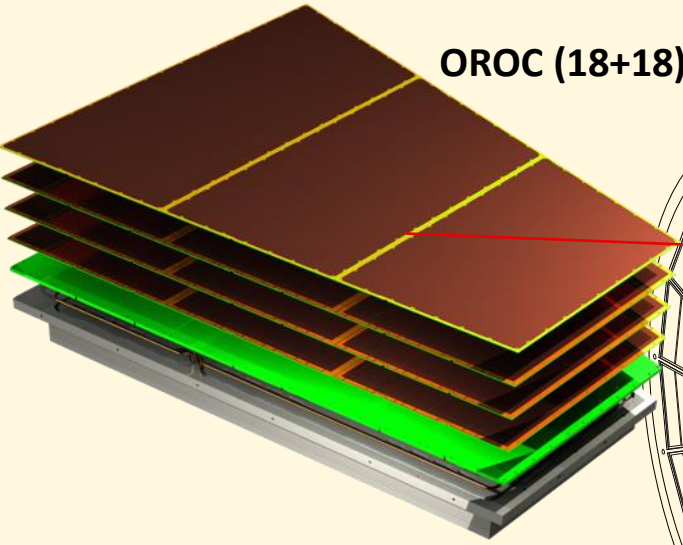
- In recent years, CMOS image pixel sensors have been widely used in digital cameras and smartphones. The ALICE ITS uses the same technology for detecting particles.
- In contrast to consumer applications, it is significantly larger: 10m^2 surface area (more than the sensors of 25000 cameras), and contains 12.5 billion pixels, a thousand times more than most consumer devices.
- On top of it, it takes 50000 pictures a second.



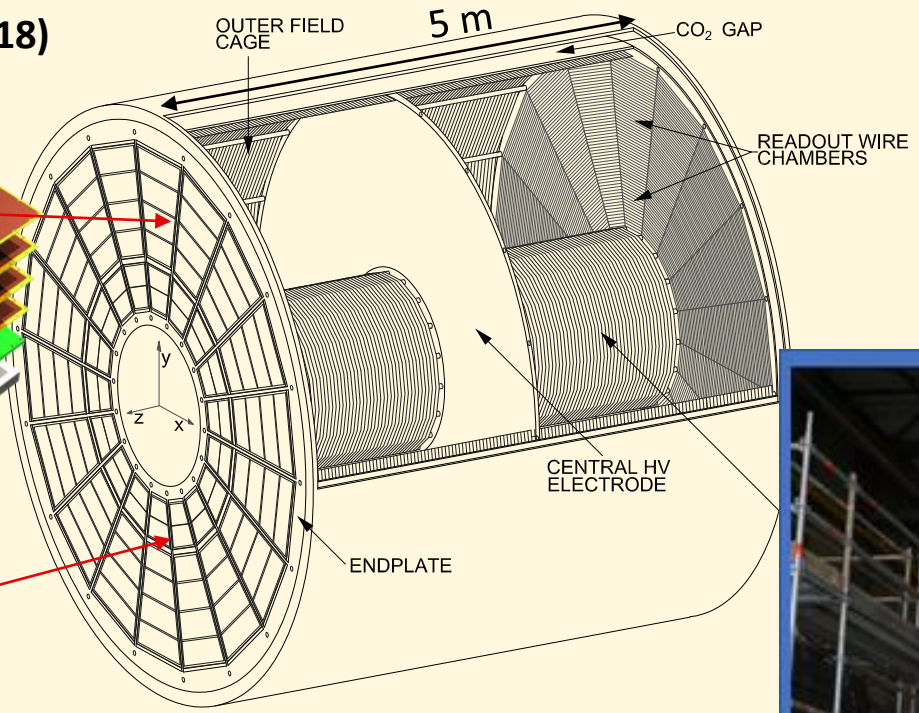
The inner (left, middle) and outer (gold colour) barrels of ALICE's state-of-the-art **Inner Tracking system (ITS)** along with the new **Muon Forward Tracker (MFT)** (green panel).

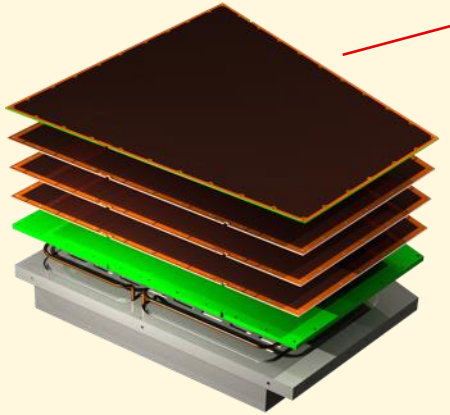
https://cerncourier.com/a/alice-tracks-new-territory/

Time Projection Chamber (TPC) with GEM detectors



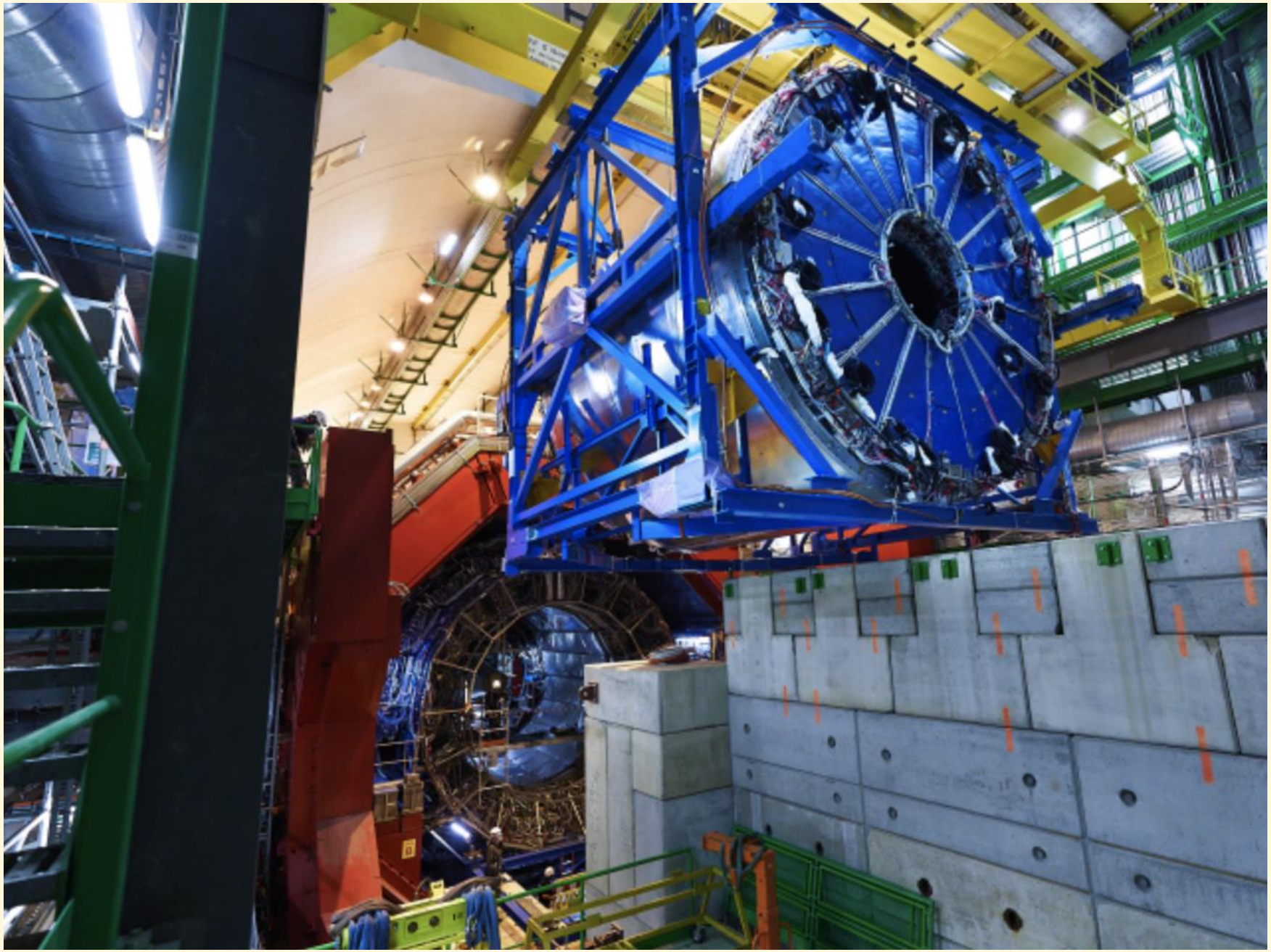
OROC (18+18)





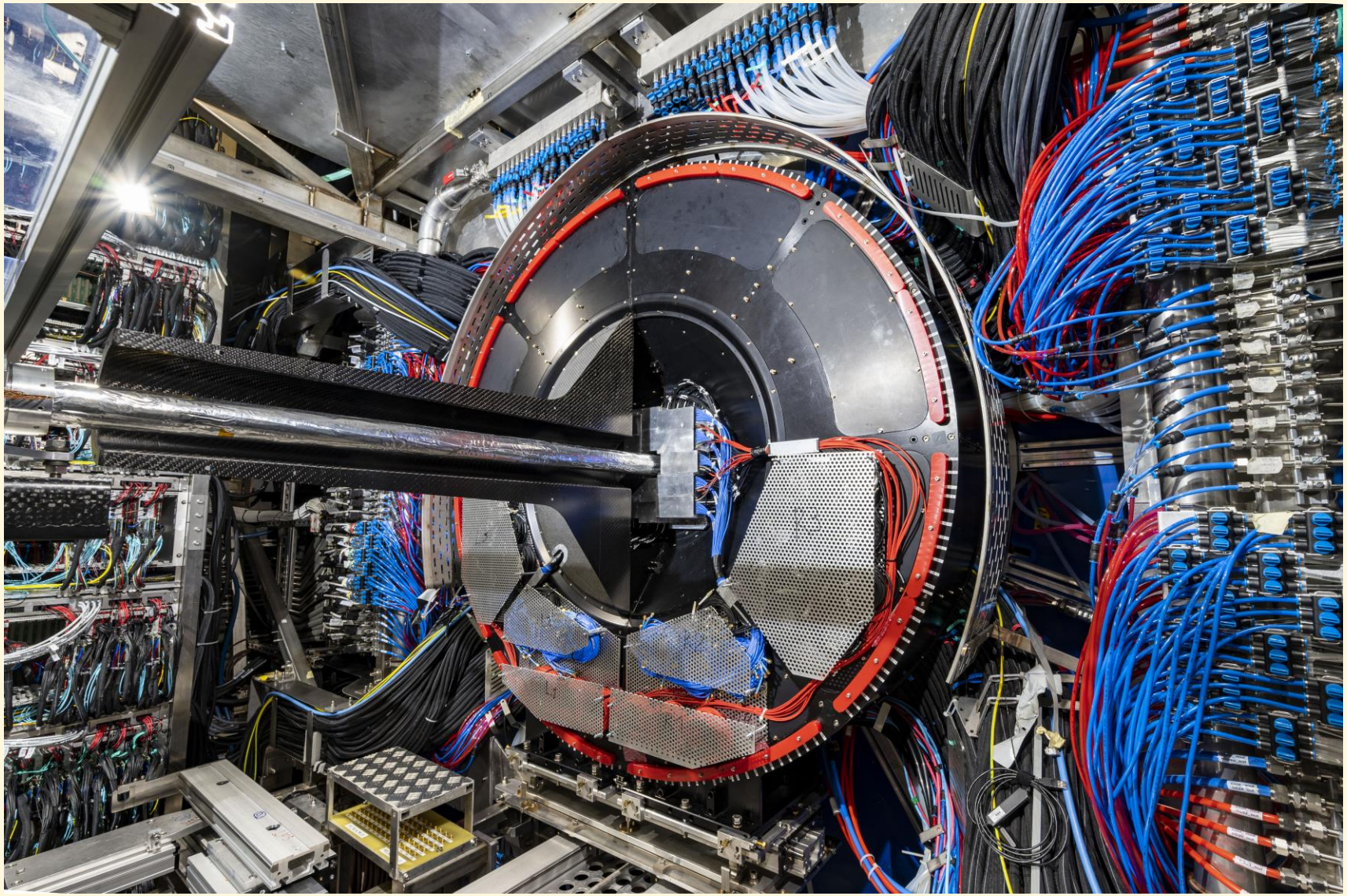
IROC (18+18)

TPC installation



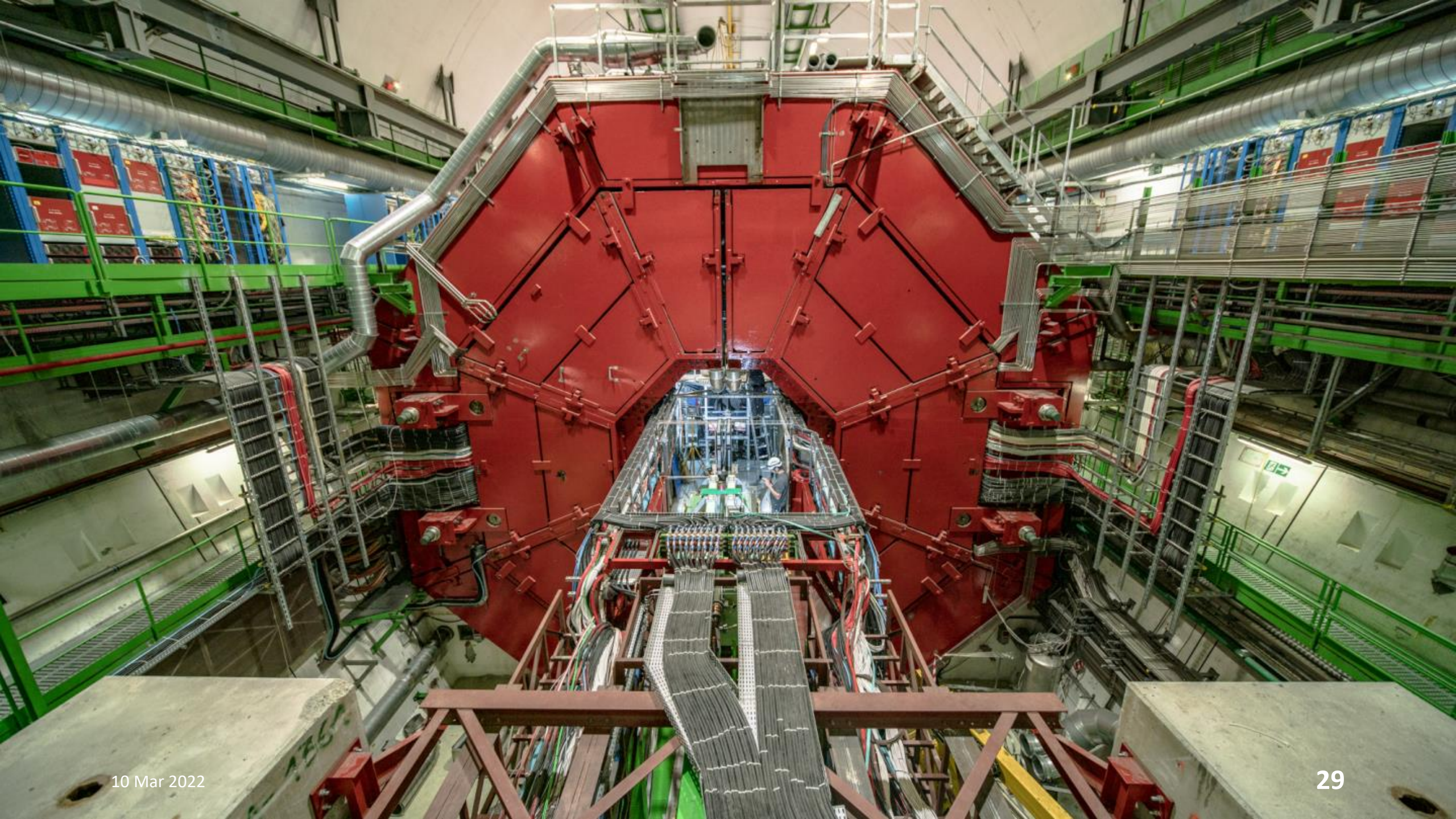
https://videos.cern.ch/record/2729677

Fast Interaction Trigger (FIT)



FIT is the

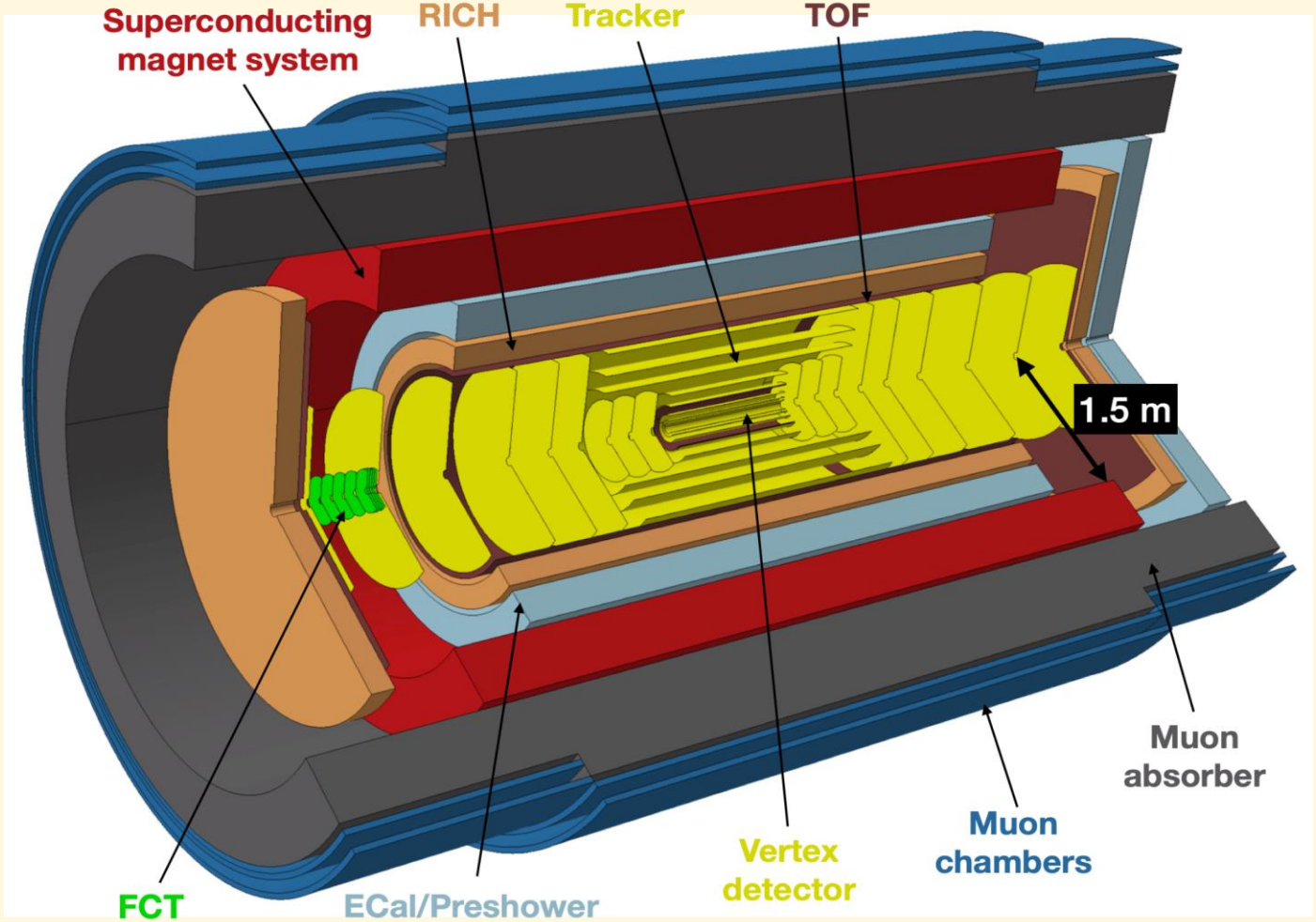
- fastest trigger,
- Online luminometer,
- initial indicator of the vertex position, and
- The forward multiplicity counter for ALICE.



A "New ALICE 3" for LHC Run-5 (from 2035)

https://arxiv.org/abs/1902.01211

(2035 onwards ….)



CMOS imaging technologies: high-precision spatial and time resolution

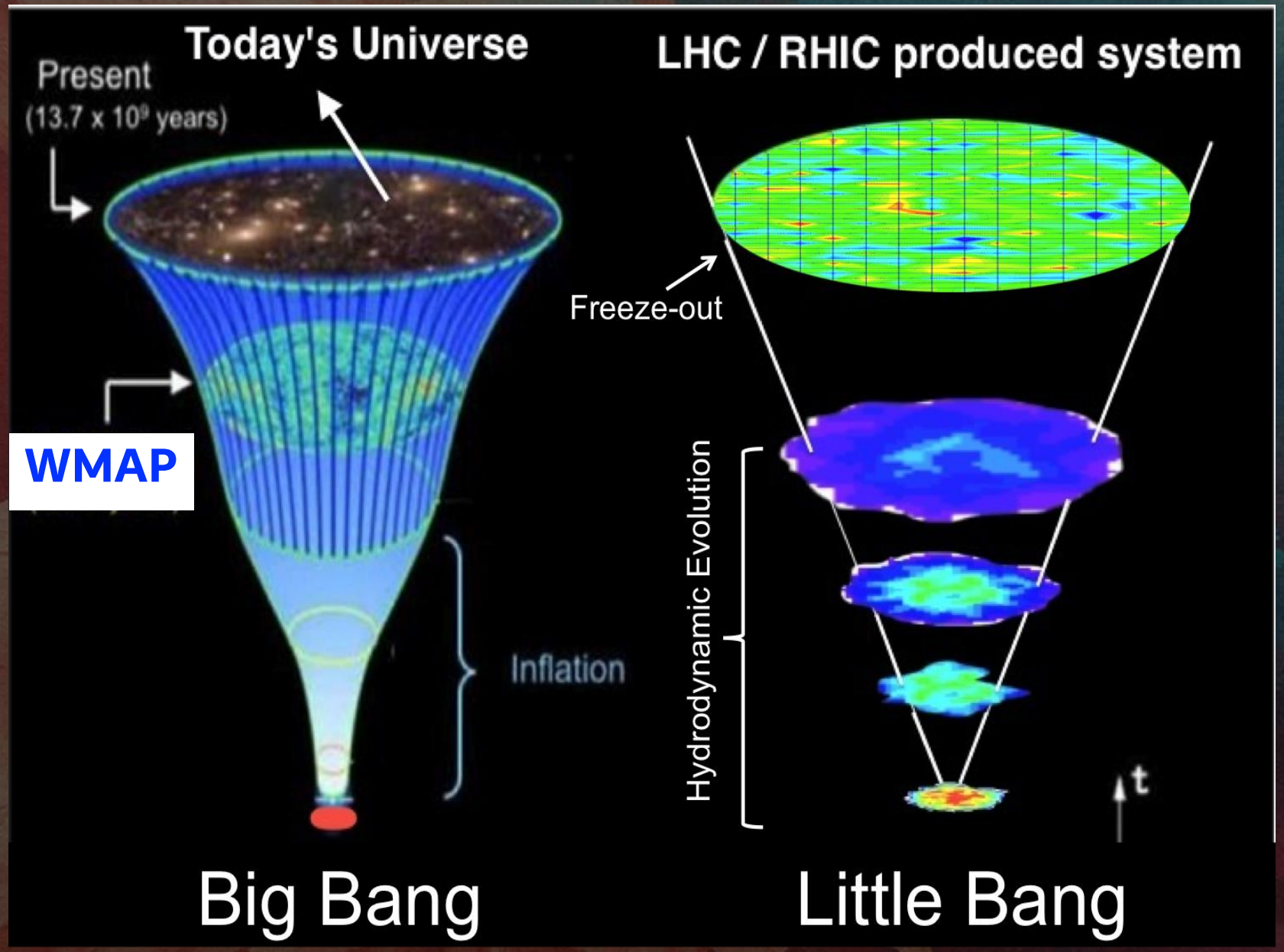
LHC Run-5:

- Tracker: ~10 tracking barrel layers
- Hadron ID: TOF with outer silicon layers
- Electron ID: pre-shower
- Conversion photons

Low p_T down to ~20 MeV/c

Extended rapidity coverage: up to 8 rapidity units
+ FoCal (Forward Calorimeters)

The Big Bang and Little Bangs



High Energy Accelerator:

Heavy-ion Collisions:

Billions of Events (Little Bangs)

One HUGE Event