

Research and career possibilities at CERN

*Particle Physics International
Masterclasses @ JU*

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CERN

European Organization for Nuclear Research

France

Switzerland



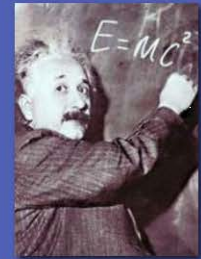
The Mission of CERN



Research

- **Pushing the frontiers of knowledge**

Studying the structure of matter on the smallest distances/highest energies... what was the matter like in the first moments of the Universe's existence?

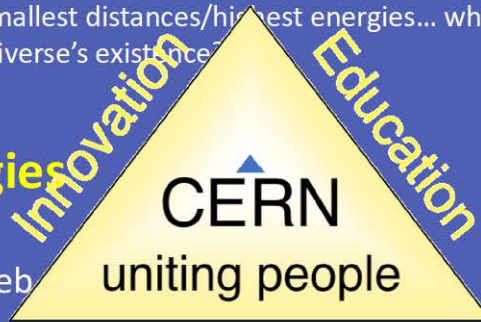


- **Develop new technologies**

Accelerator technology

Information technology - the Web

Medicine - diagnosis and therapy



Research



- **Train scientists and engineers of tomorrow**



- **Unite people from different countries and cultures**





CERN



“Science without borders”

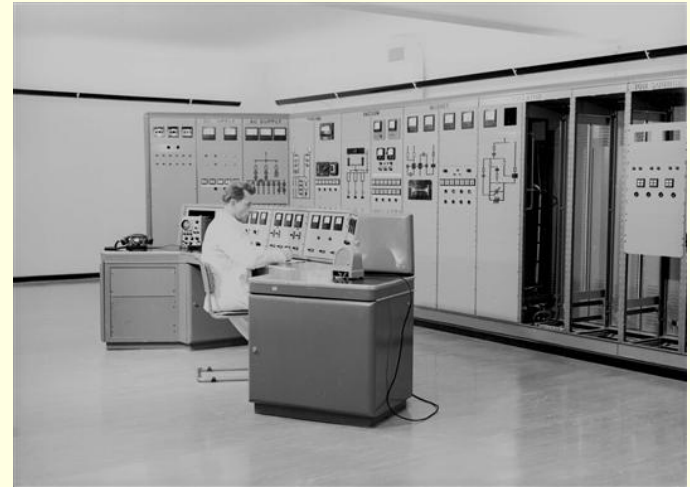


CERN

1954: foundations for European science



1957: the first accelerator begins operation



1971: the world's first proton-proton collider



1976: the SPS is commissioned



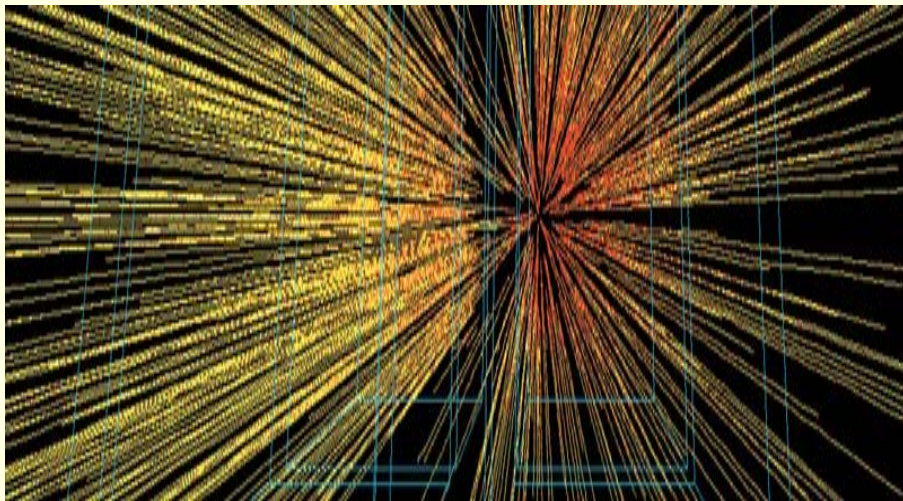
1968: Georges Charpak revolutionizes detection



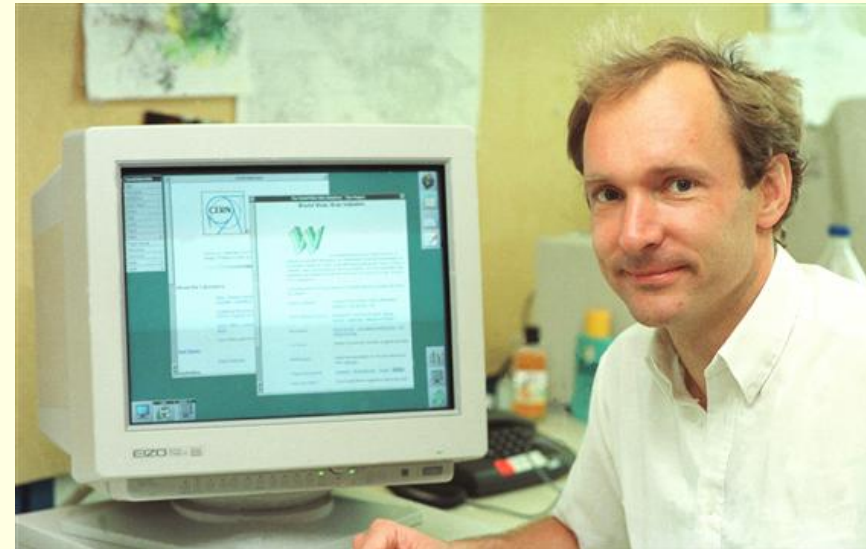
1983: discovery of the W and Z particles



1986: heavy-ion collisions begin



1990: Tim Berners-Lee invents the Web



Large Hadron Collider 2008

LHC Tunnel



- 27kilometer tunnel, 50-150m below ground
- Two beams circulating in opposite directions
- Total of 9300 magnets: beams controlled by 1800 superconducting magnets (up to 8T) ⁷

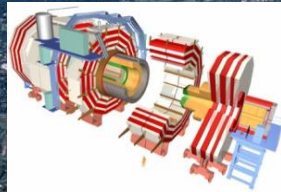
Colliding protons (14 TeV),
Lead ions (5.5 TeV)



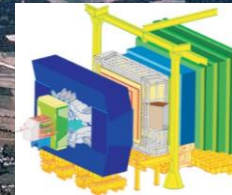
World's Most Powerful Accelerator: The Large Hadron Collider

Jura mountains

Lake Geneva



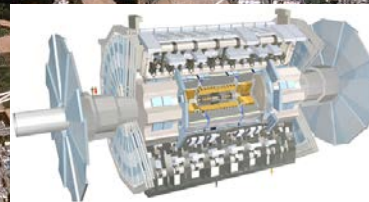
CMS



LHCb



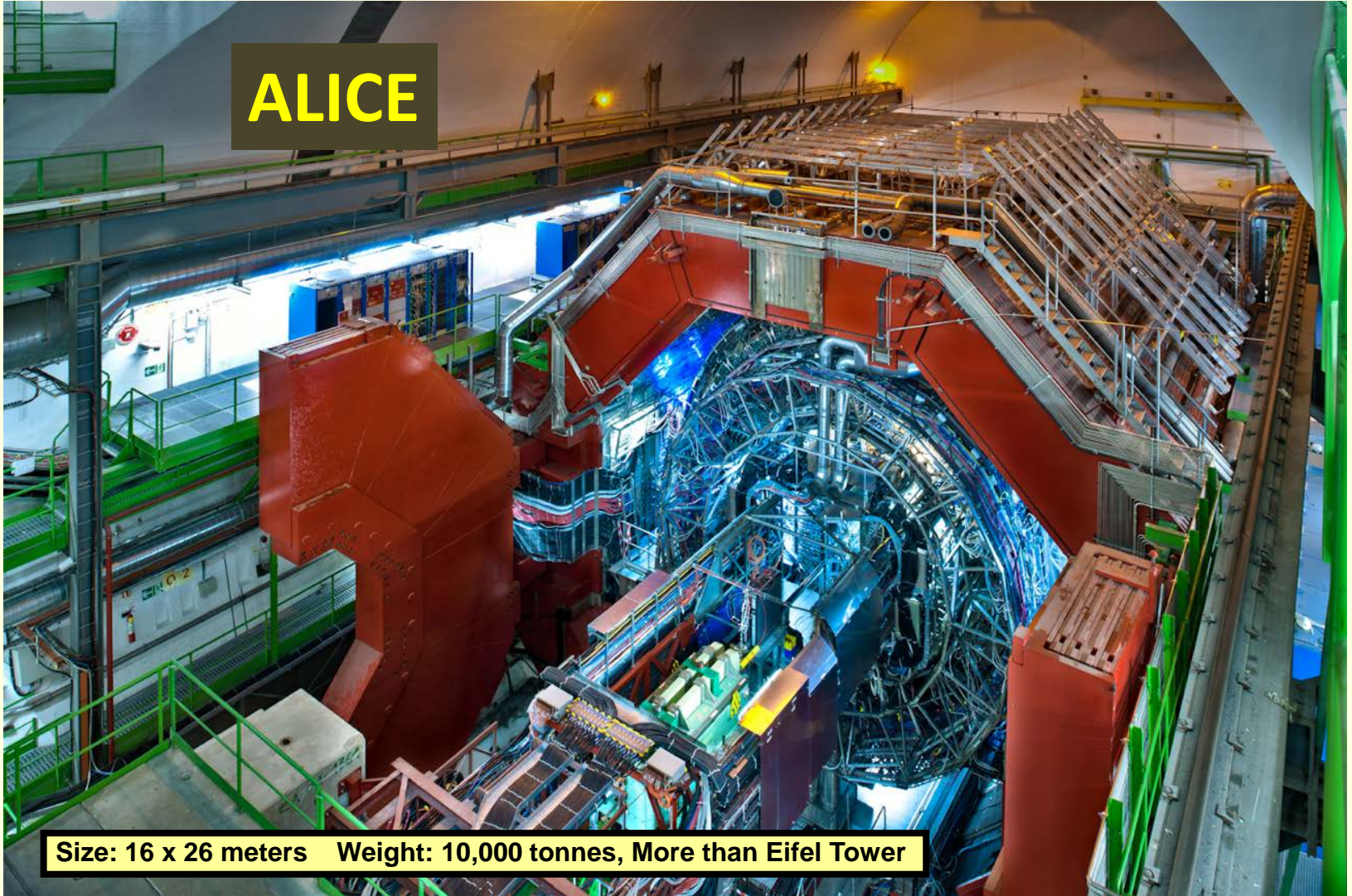
ALICE



ATLAS



ALICE



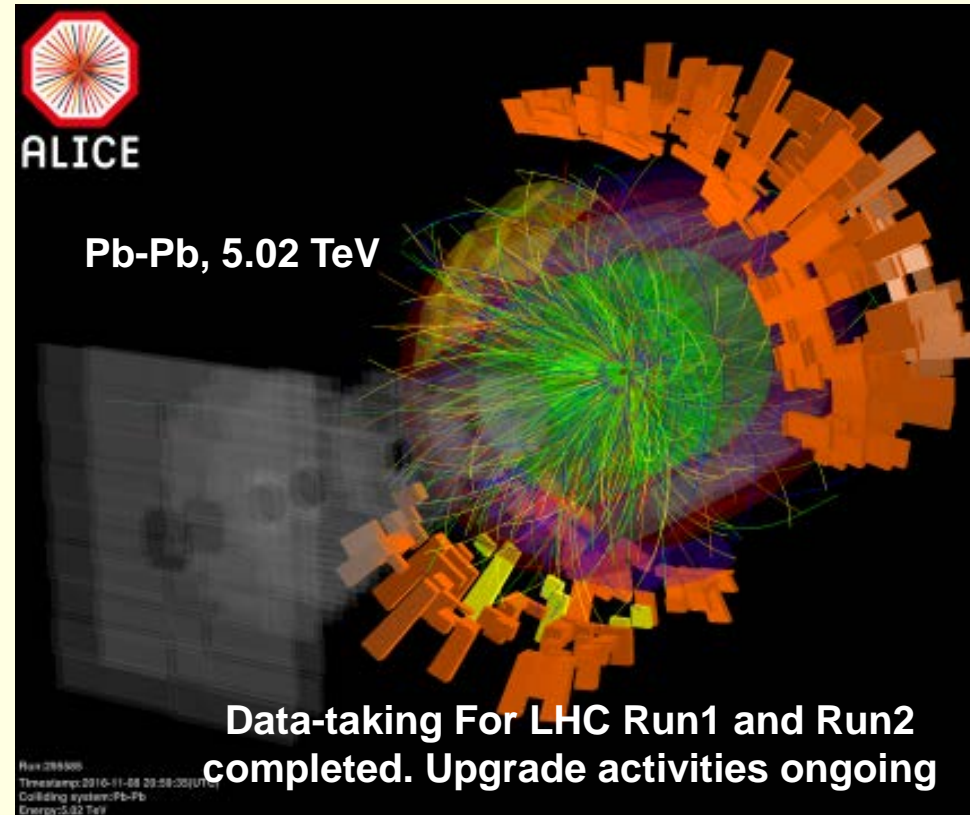
Size: 16 x 26 meters Weight: 10,000 tonnes, More than Eiffel Tower

ALICE at the CERN Large Hadron Collider

Study of Quark Gluon Plasma (QGP):

- A journey to the beginning of the Universe

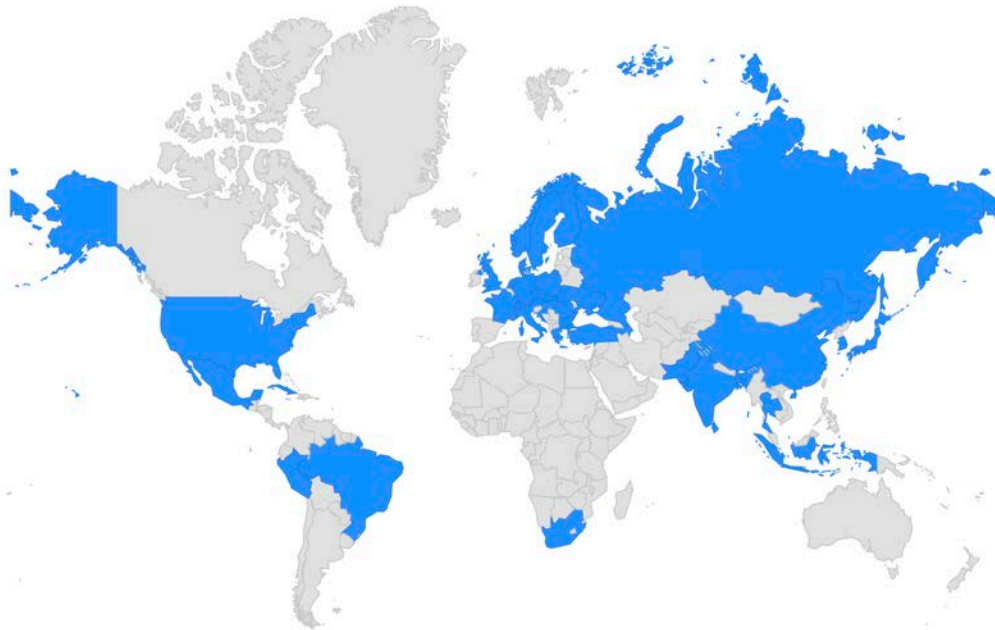
- Our Universe is thought to have been in a primordial state of extreme temperature and/or energy density for the first few millionths of a second after the Big Bang.
- The ALICE Collaboration has built a dedicated detector to study matter at extreme conditions by colliding heavy-ions (such as Pb on Pb) at the Large Hadron Collider.
- Provides experimental data for testing the fundamental theory of strong interaction – Quantum Chromo Dynamics (QCD) and establishing the phase diagram (deconfined and chiral phase transitions).



ALICE Collaboration



40 countries, 172 institutes, 1970 members



Indian scientists are involved since the conception of ALICE

Funded by DAE & DST

India is a major partner in ALICE with ~125 members

New Associate institute:
Jadavpur University, Kolkata
joined on 5 March 2022

ALICE 2 DETECTOR

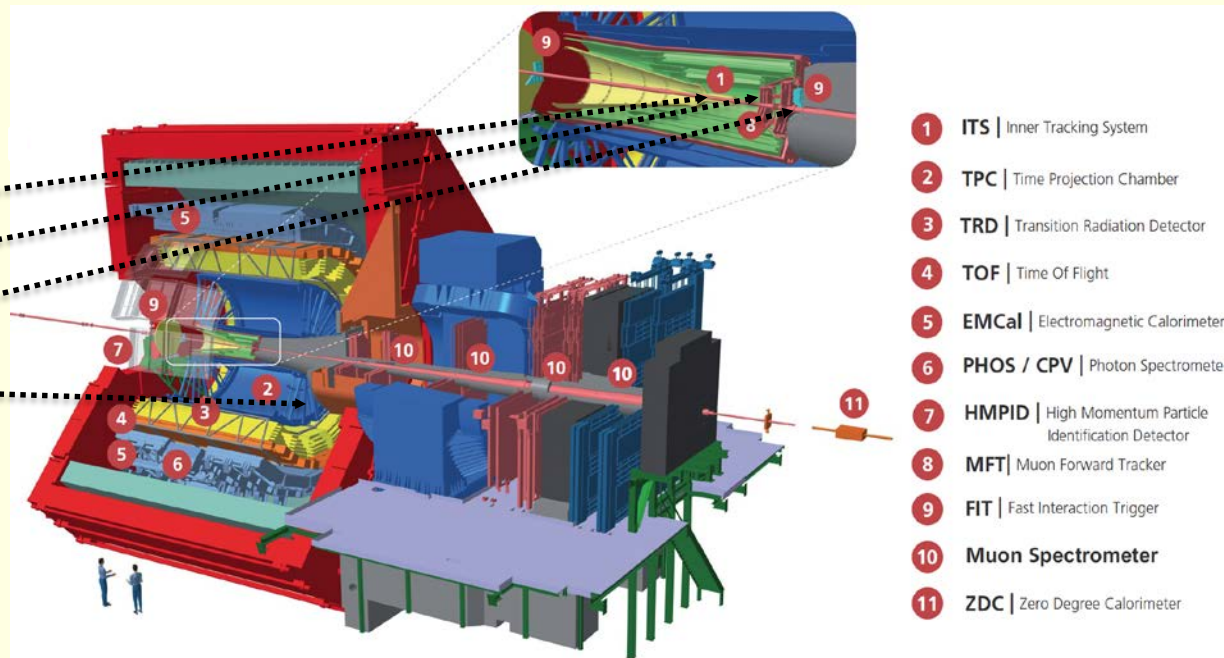


Main objectives for ALICE detector for Run 3+4:

- Substantial improvements in **vertexing capabilities** and **tracking efficiency**

New/improved systems:

- New **tracking systems** based on **MAPS**:
 - **Inner Tracking System (ITS)**
 - **Muon Forward Tracker (MFT)**
- New **Fast Interaction Trigger (FIT)** detector
- **TPC** readout chambers employing GEM
- New **Online/Offline** system (O^2) for data processing and reconstruction
- Upgraded **readout systems** for the other detectors, to cope with continuous readout



India in ALICE



ALICE

Photon Multiplicity Detector (PMD)



Muon Tracking Chamber and MFT



MANAS: Multiplexed ANALog Signal Processor



First large scale production
of ASIC in India

Common Readout Unit (CRU):



ALICE LS2 Upgrade

Performs data concentration,
reconstruction and multiplexing.

Silicon-Tungsten Calorimeter



FOCAL

LHC GRID Computing

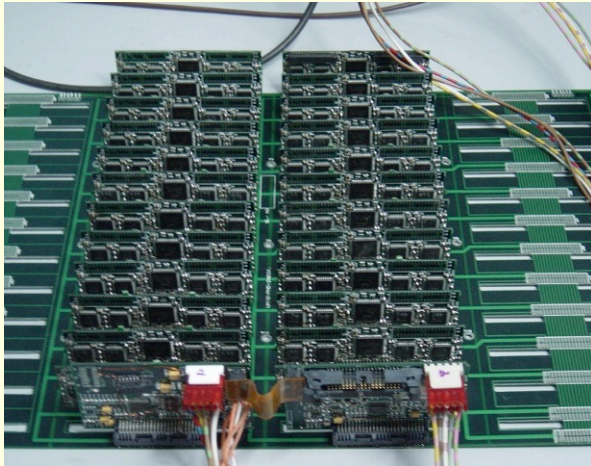


PMD: Photon Multiplicity Detector

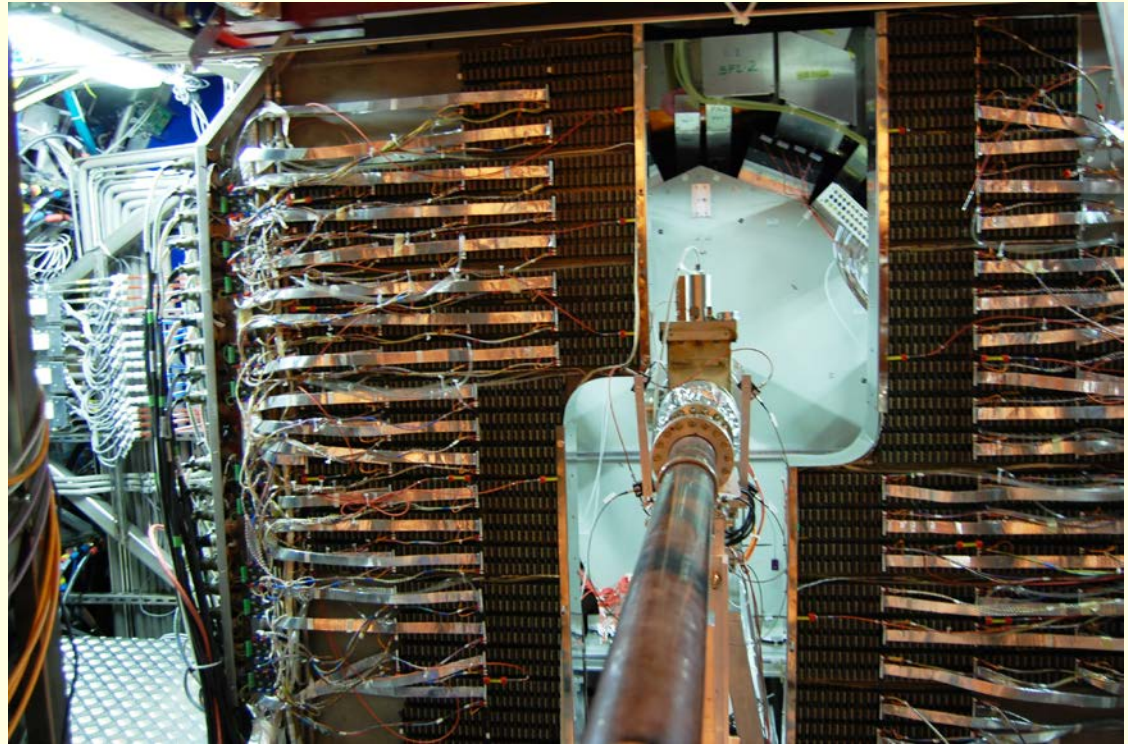


100 % Indian effort: from conception to commissioning (Design, Fabrication, Installation, Detector Control, and DAQ)

48 Modules with 221,184 gas cells:



PMD in the ALICE cavern



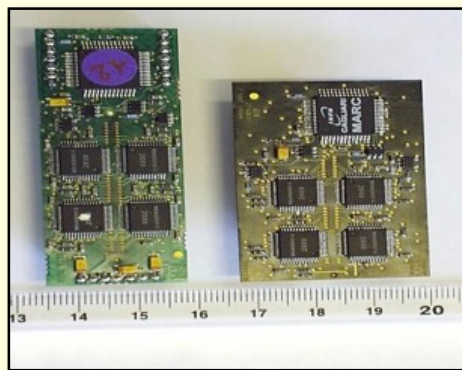
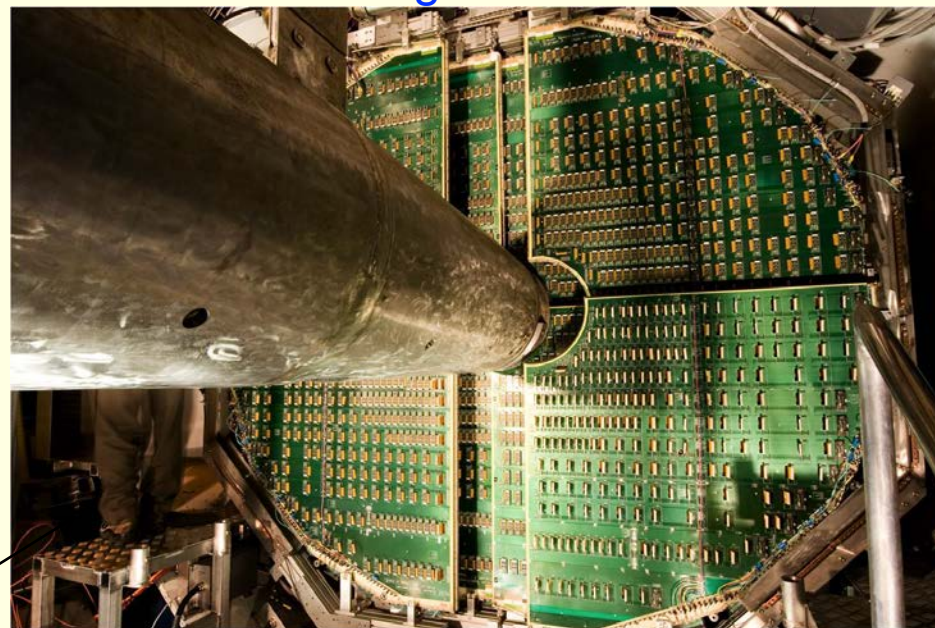
Muon Tracking Chambers



Collaboration France, India, Italy, Russia:

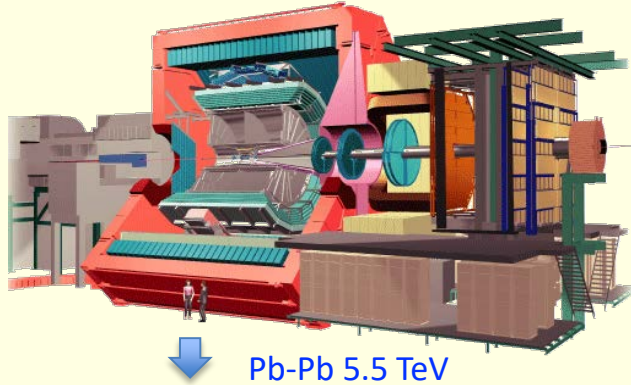
- 5 stations of two Cathode Pad Chambers ~ 100 m²
- 1.1×10^6 channels, occupancy $< 5\%$ (in Pb+Pb)
→ Read out at 1 kHz
- Chamber thickness $\sim 3\% X_0$
- Beam test results for the spatial resolution : 50 μm for a required resolution $< 100 \mu\text{m}$

Station 2 of the Muon Tracking Chamber



- **MANAS electronics chip: 16-channel Amplifier, shaper, track-and-hold**
- **MANU board: Reads 1.1 million pads of tracking chambers of ALICE**

Common Readout Unit (CRU) in Run3



Pb-Pb 5.5 TeV

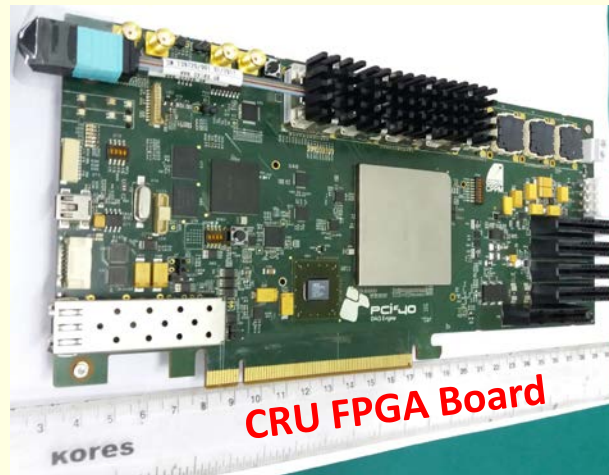
50 kHz (70 MB/event)
Total ~3 TB/s



50 kHz (1.5 MB/event)

Storage 90 GB/s (peak)

In Run3: The total data volume from the front-end cards of the detectors will increase significantly, reaching a sustained data throughput of up to 3 TB/s. The ALICE computing model is designed for a maximal reduction in the data volume



CRU is tasked to perform online data concentration, reconstruction and multiplexing.

This makes CRU one of the most important components of ALICE.

India's Contribution:
400 CRU boards for TPC

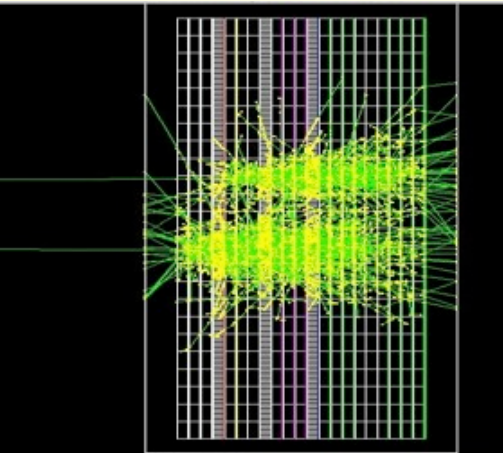
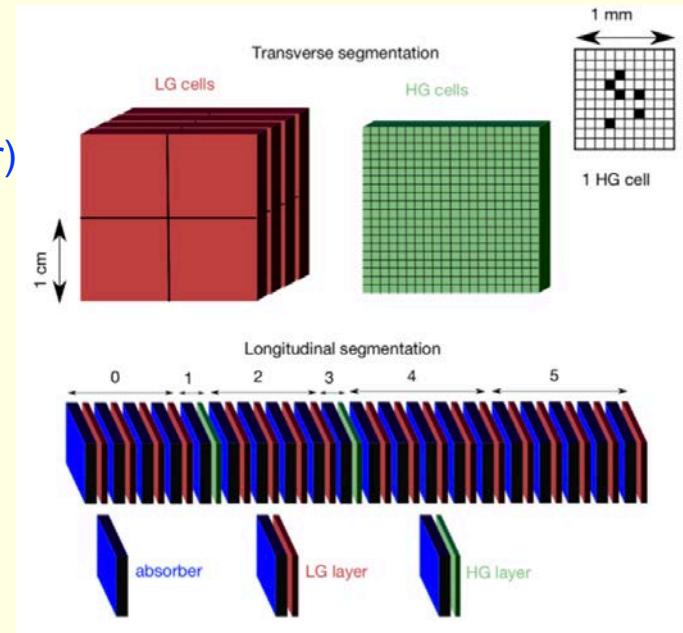
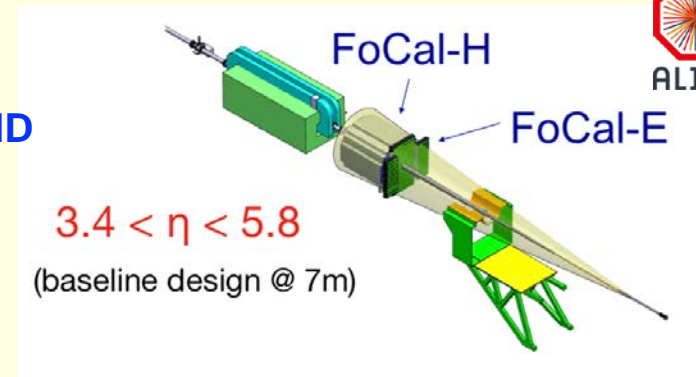
Indian scientists and engineers have contributed to the design, prototyping and testing of the CRU over the last five years in collaboration with CERN, Wigner Institute, and CPPM, Marseille.

ALICE upgrade: FOCAL



2008: First Proposal from India as a replacement for PMD

- **Physics:**
 - Initial State: Low-x Gluon Saturation
 - Initial State: Nuclear PDFs
 - Jet quenching, flow and correlations ...
- **Detector R&D done in India**
- **All components from India:**
 - High resolution Silicon Pad Detector
 - Readout chips (MANAS, AnuIndra, AnuSanskar)



Simulation of a π^0 decaying to two photons

Opportunities at CERN

- High School Students Internship Programme
 - Summer students
 - Doctoral students
 - Technical students
 - Administrative students
 - CERN fellows
-
- High School Teachers' Programme
-
- Positions (HR Department) web pages
-
- Visits / Virtual visits

For teachers

<https://teacher-programmes.web.cern.ch>

- High School Teachers' Programme
- <https://teacher-programmes.web.cern.ch/national-teacher-programmes>
- One week, in the language of the participants
- <https://teacher-programmes.web.cern.ch/international-teacher-programmes>

3-week programme in July

2-week programme in August

SUMMER STUDENT PROGRAMME

<https://home.cern/summer-student-programme>

Applications until end of January

Need to have completed 3 years of University studies
(physics, engineering, computer science, mathematics)

Stay at CERN 8-13 weeks during the summer

Lectures (~1.5 months); Visits to experiments / accelerators / other CERN sites

Work in a group

Member states students; additional programmes for non member states

OPEN LAB SUMMER STUDENT PROGRAMME

<https://openlab.cern/education>

Nine-week programme during the summer

(bachelor's and master's students specialising in subjects related to computer science)

Specialised + general summer students lectures

Visits to experiments / accelerators / external companies

Work on a project

For students

- <https://careers.cern/students>
- Doctoral students
- Up to 36 months, to work on a PhD thesis (in collaboration with and to be submitted to a University)
- Technical students
- For students in Applied Physics, Engineering or Computing
- 4-12 months, can be extended up to 16 months
- Administrative students
- For students in administration.
- Up to 14 months
- Internships
- Undergraduates more than 18 years old; up to 6 months