CERN OPEN DAYS 2019
SUGGESTIONS FOR ALICE/LHC GUIDES

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On behalf of the Open Days 2019 ALICE organisers

(Arturo Tauro, Andre Augustinus, Klaus Barth, Roberto Divià, DH, Julia Cachet)

SUGGESTIONS FOR GUIDES

The time of the visit is strictly limited to 28 minutes total, the guide can not give as much information / explanations as during our usual underground visits

ACTIONS BEFORE START OF VISIT:
Helmets and hair nets to visitors
Put bags in cage / guide takes the lock

Role of guide : in front of group when walking, does the talking
Portable microphone and loudspeaker will be provided
Role of crowd marshal : at the end of group when walking, pushes visitors gently
Keeps the time (stopwatch will be given)

AFTER THE VISIT, ENCOURAGE VISITORS:

- to visit the exhibition
- to attend introductory lecture in conference room (every two hours)
- to wonder around in the hall / other activities

Group forming

Introduce yourself

Will visit part of the LHC tunnel and the cavern where ALICE is installed.

Emphasize that they are lucky to see both the accelerator (producing the beams which collide) and the experiment (which sees the products of the collisions)

Radiation area, measure dose with operational dosimeter, show 0 microsievert after visit

If enough time: ALICE in a nutshel (HI exper. of LHC, Pb collisions 4 weeks/year, QGP)

Inside lift, going down

Going 50 m below ground, Point 2 less deep point of LHC, tunnel inclined

8 Points all around the 27 km ring (4 experiments, 4 accelerator infrastructure)

Will first walk in the service tunnel all the way to the injection Point; then in the main tunnel all the way to Alice; and then to the experiment

Going out of the lift, ready to walk

In the service tunnel are installed all electronics for the control of the accelerator components and are thus shielded from radiation. A 6 m wall separates service tunnel from main tunnel

Stop at injection point

LHC in a nutshell : Double Accelerator, two beams circulating in opposite directions, coming from the previous accelerator, SPS. Show trasfer line, arc, straight section. Main components : RF cavities (8 per beam) accelerate the beams, double dipoles (1232) 15 m long guide the beams, quadrupoles (~ 400) focus the beams. All cooled to -271 C (1.9 K) with liquid Helium -> superconducting -> no resistance, no energy loss due to heating. 12 kA current for very high magnetic field (8.3 Tesla) for 7 TeV beams.

Stop at one more point with 3 beam lines

Explain beam loss monitors..triplets (final focusing), ZDC (ALICE detector for proton / neutron «spectators»)

Stop at low beta

Magnet (solenoid, conventional, doors some hundred tons each, 30 kA, 0.5 T, x10000 terrestrial magnetic field. Explain where collisions happen. The role of detector layers.

Stop at muon spectrometer

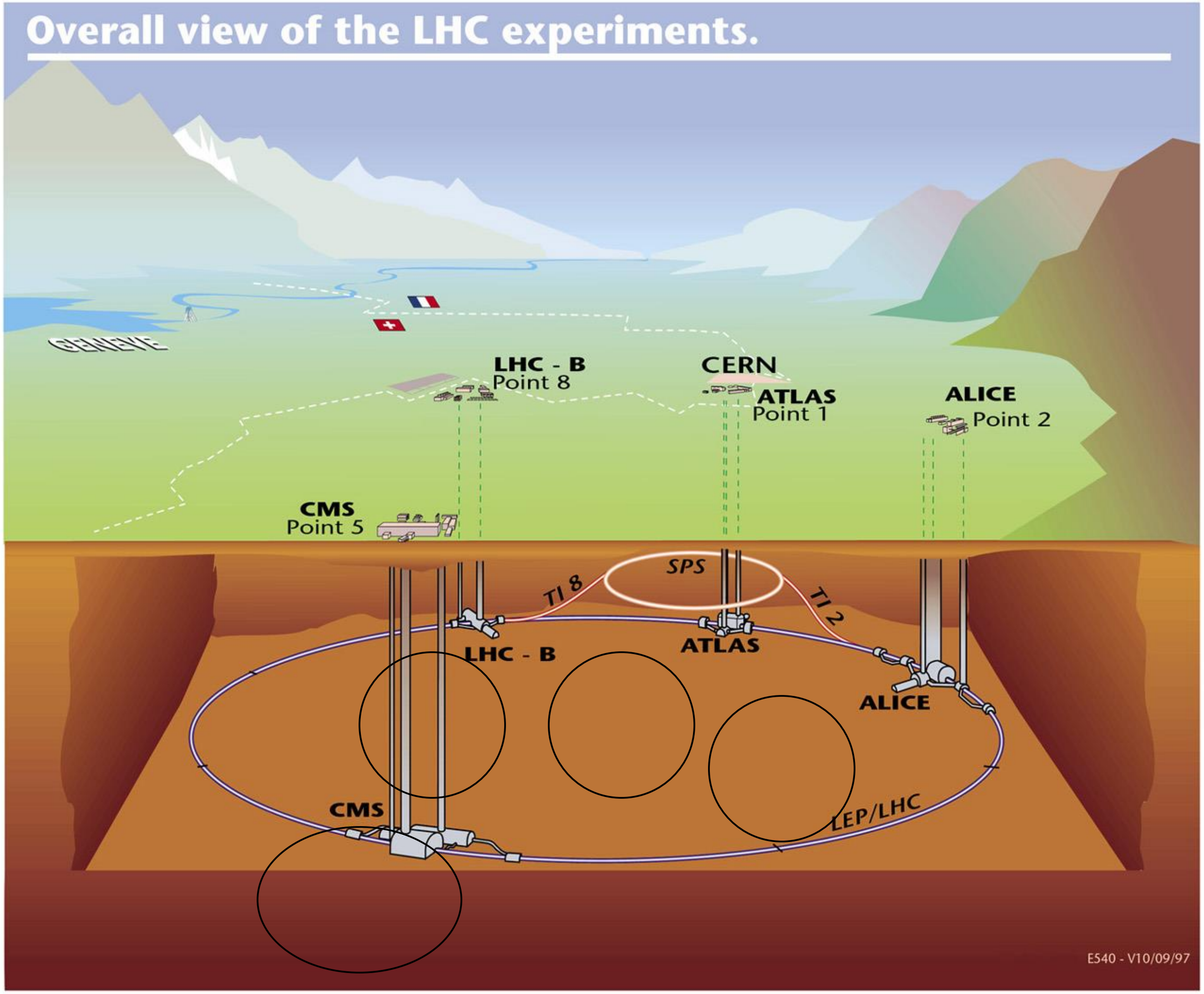
Say what muons are; Show dipole, filter, precision chambers, trigger chambers

Inside lift going up

Thank them for the attention.

- Encourage visitors to visit the exhibition / find out about what ALICE does, details about detectors, ask questions to exhibition guides...
- Encourage visitors to attend introductory seminar in conference room (every two hours, alternating with Physics is Fun show (liquid nitrogen experiments)
- Encourage them to wonder around in the hall / other activities
- Propose to saty with them and discuss (after they have given back helmets and recuperated bags) : If enough guides to allow breaks between tours

INFORMATION ABOUT LHC



The largest accelerator in the world, inside a ring of 27 km circumference, 100 m underground

At LHC two beams of protons collide at the highest accelerator energy (13 TeV up to now, 14 TeV in Run3)

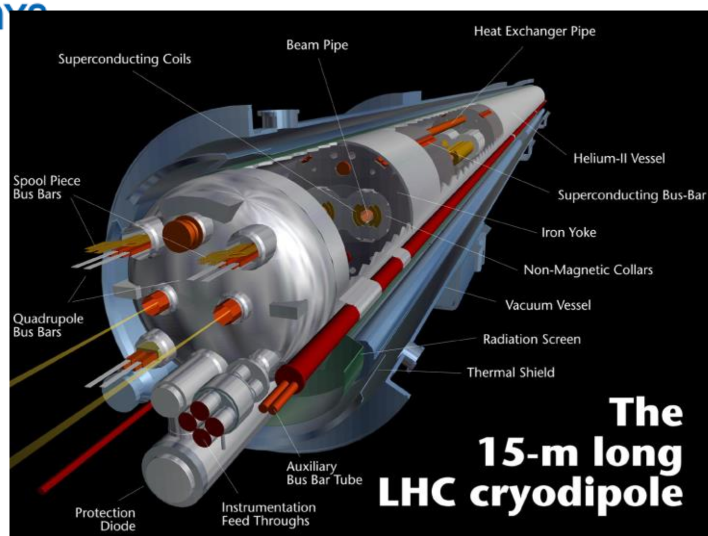
LHC is the coldest installation in the universe: its superconducting magnets, cooled with liquid helium, operate at -271° C (1.9 K, just above absolute zero)

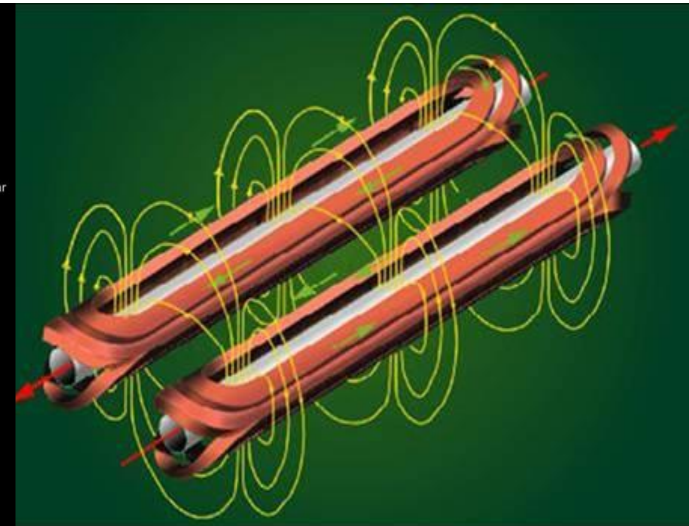
8 radiofrequency (RF) cavities for each beam, installed in groups of 4 in cryomodules, accelerate the beams

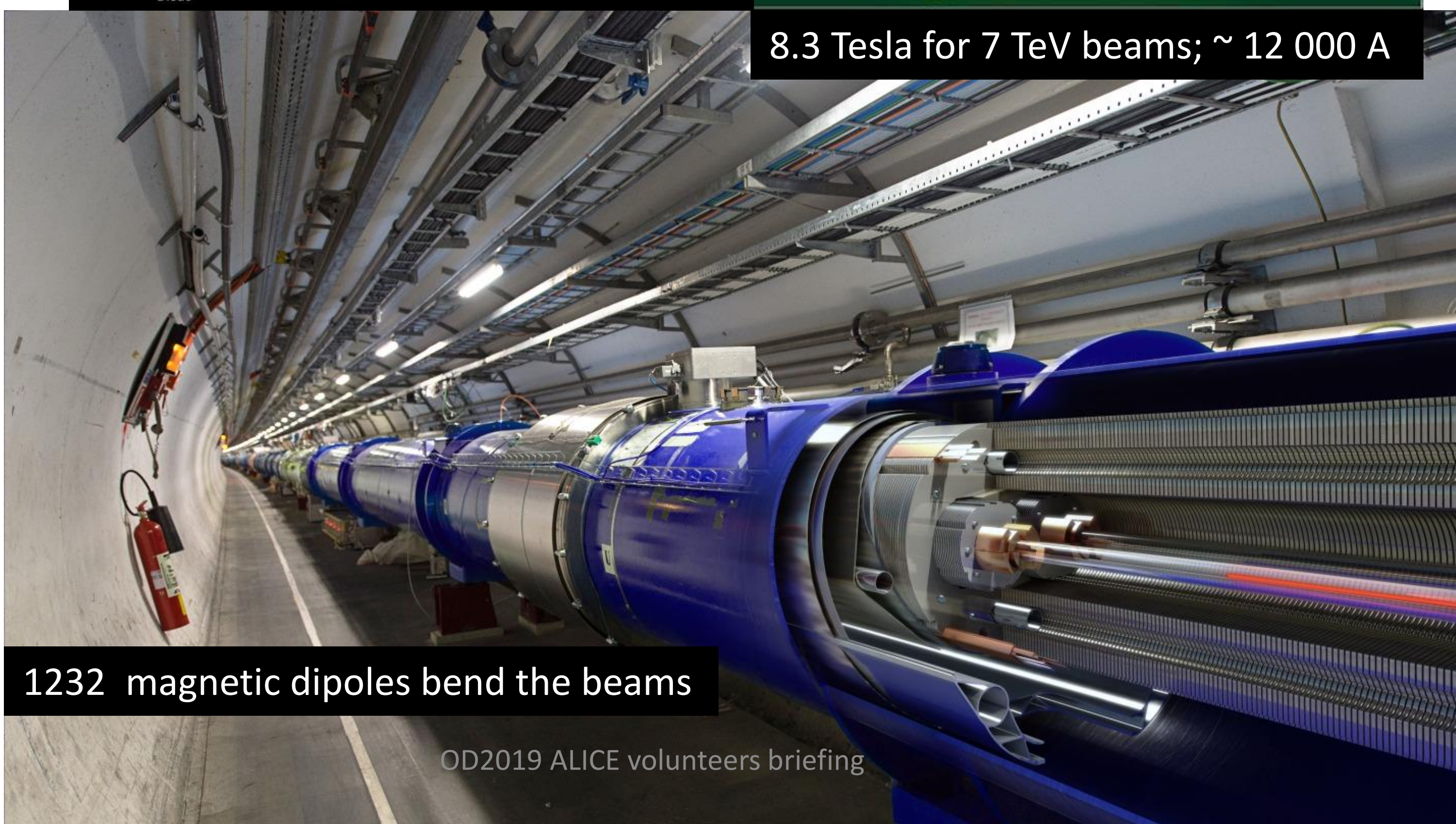
Each delivers 2 MV
Frequency : 400 MHz

The RF cavities are superconducting, cooled at 4.5 K

The beams circulate in specially designed beam pipes, with very high vacuum, 10^{-13} atm

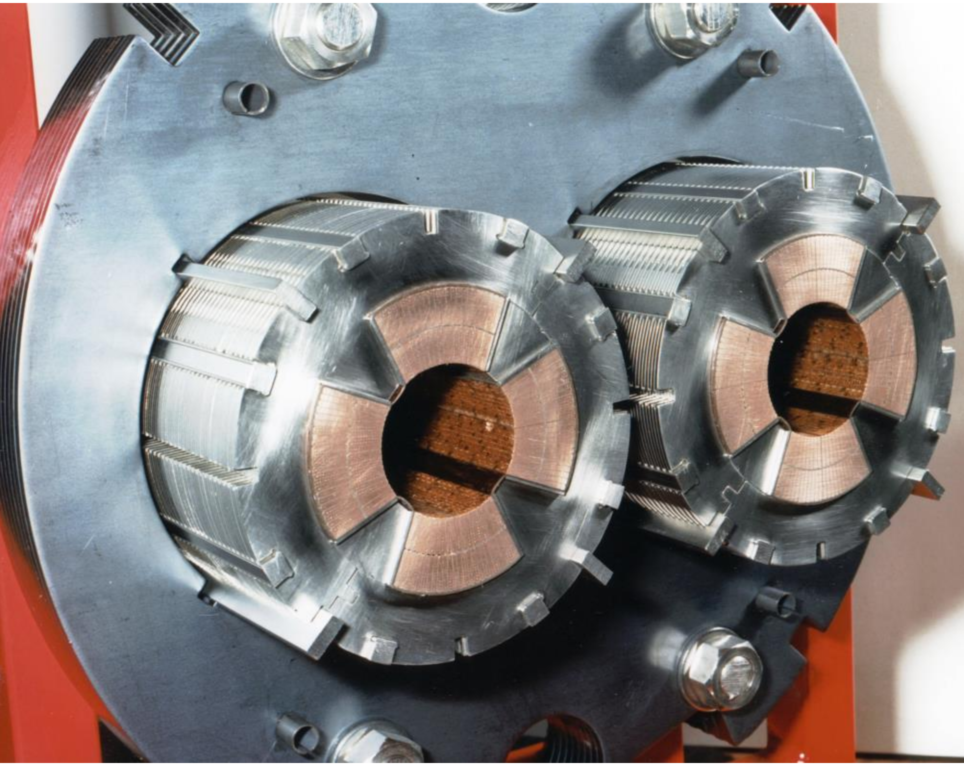




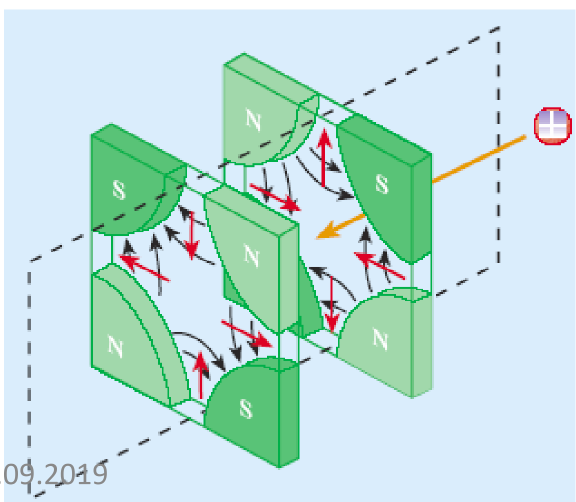


8.3 Tesla for 7 TeV beams; ~ 12 000 A

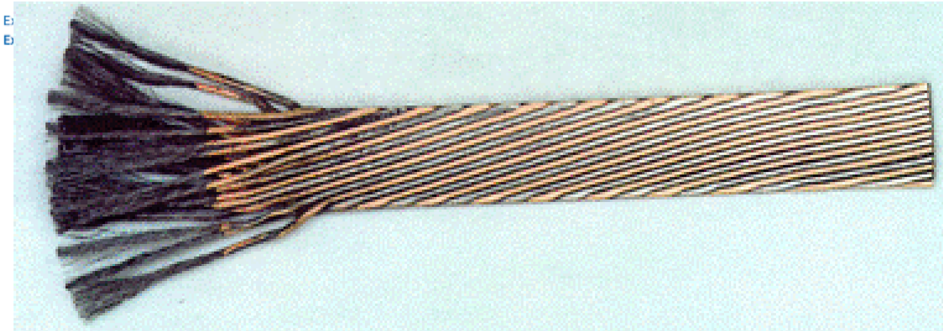
1232 magnetic dipoles bend the beams



~ 400 quadrupole magnets focus the beams

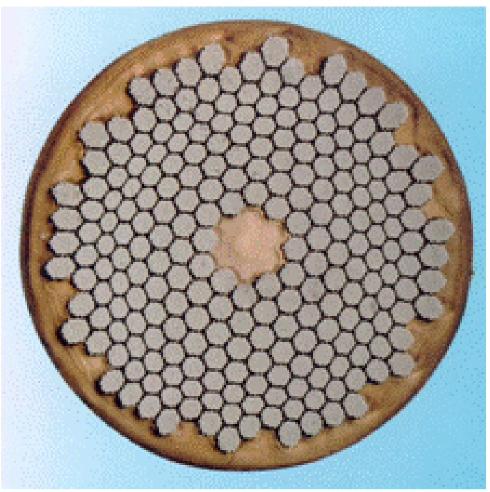


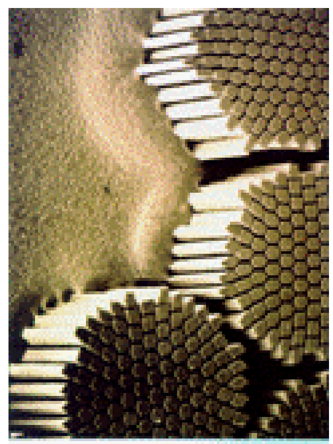
Superconducting cable : zero resistance; no losses (no heat)



- 1200 tons of superconducting cable
- 7600 km of cable
- Total length of filaments : 10 times the distance earth - sun

Rutherford cable : 36 strands





Cryogenics
- Cooled with 5000 tons of liquid Helium at 1.9 K
- 10000 tons of liquid Nitrogen cool the gaseous Helium to 80 K

Each strand (d = 0.825 mm) ~ 6500 filaments (d = 8 μm)
Niobium – Titanium supeconducting filament
(+ 0.5 μm layer of high-purity copper)

Some facts about LHC

- protons in LHC in bunches (of 100 billion p) every 25 ns;
- accelerated from 450 GeV to 7 TeV
- reaching a speed of 99.9999991% the speed of light
- 40 million times/s bunches pass each collision point
- The protons go around the LHC ring 11245 times/s
- 31.2 MHz crossing rate
- 20 collisions expected in average (from 100 on 100 billion p)
- 600 million proton collisions per second
- After filtering, 100 – 1000 collisions of interest per second
- 1 Megabyte of data digitised for each collision
- recording rate of 0.1 Gigabytes/sec
- 10^{10} collisions recorded each year
- >10 Petabytes/year of data

1 Megabyte (1MB)
A digital photo

1 Gigabyte (1GB) = 1000MB
A DVD movie

1 Terabyte (1TB) = 1000GB
World annual book production

1 Petabyte (1PB) = 1000TB
Annual production of one LHC experiment

1 Exabyte (1EB) = 1000 PB
World annual information production

Some facts about LHC

- protons in LHC in bunches (of 100 billion p) every 25 ns;
- accelerated from 450 GeV to 6.5 TeV (7 TeV)
- reaching a speed of 99.9999991% the speed of light
- 40 million times/s bunches pass each collision point
- The protons go around the LHC ring 11245 times/s
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- 20 collisions expected in average (from 100 on 100 billion p)
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ALICE..IN TWO PAGES

See document ALICE-2pages on this indico event

FREQUENTLY ASKED QUESTIONS
(my compilation)

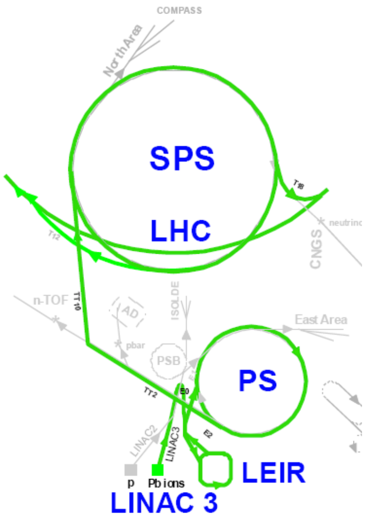
Why lead

One of the heaviest elements. 208 nucleons (compared with 1 in pp)
Energy : 82 times higher than in pp
We need a certain mass to create a droplet of QGP
Spherical shape of the nucleus (more convenient)

How are lead beams produced

A small cylindrical piece of Pb^{208} (2 cm, 500 mg) is heated at 500° C and evaporates.
Inside the lead source (ECR) it is ionized due to a high electric current. Acceleration of Pb ions:

- ECR source: Pb^{27+} (80 mA)
- RFQ: Pb^{27+} to 250 A keV
- Linac3: Pb^{27+} to 4.2 A MeV
- Stripper: Pb^{53+}
- LEIR: Pb^{53+} to 72 A MeV
- PS: Pb^{53+} to 4.25 A GeV
- Stripper: Pb^{82+} (full ionisation)
- SPS: Pb^{82+} to 158 A GeV
- LHC: Pb^{82+} to 2.76 A TeV (Run 1)
- LHC: Pb^{82+} to 5.02 A TeV (Run 2)



What have you discovered

QGP behaves like a perfect liquid (first observed at RHIC, before LHC, and came as a surprise).
Plasma expected to behave like a gas, with uncorrelated morion of its constituents)
Measured trillions of degrees initial temperature (direct photons emitted as QGP cools down)
Absorption of energy / particles due to their interactions with the hot and dense state of deconfined quarks and gluons
No discoveries like Higgs etc. Detector optimized for the study of HI collisions

What is the application of all this

Nothing at the moment. But who can tell what will be in 100 years?
The study and understanding of physical laws leads to applications that improve life.
The electric bulb was the result of understanding electricity, not of effort to improve the candle
Technology developed -> applications : : www, accelerators (for medicine etc), detectors (Medipix, PET), cryogenics, superconducting magnets, fast electronics, fast computers, the Grid

How long did it take to build all this

ALICE is now 26 years old (from submission of Letter of intent)
Construction and installation ~ 10 years

What was the cost

6 billion CHF for LHC (half cost is the magnets); the tunnel existed from the times of LEP

ALICE some hundreds of millions CHF

Who pays for all this

CERN : the 23 member states (+ observer states) according to GNP; yearly budget 1 billion CHF

ALICE experiment : the collaborating institutes

What after the LHC

LHC will continue until ~ 2035 (depending also on the results).

Current luminoscity upgare, HL-LHC after LS3

Various ideas under study for the future.

CLIC (Compact Linear Collider), e+e- for precision studies

FCC (Future Circular Collider) 100 km ring for 100 TeV pp (scenarios for FCCee / FCCeh)

What do you hope to find with increased luminosity

Hope to “see” supersymmetry (if it exists); discover particles that could explain dark matter;

Understand asymmetry between matter-antimatter.

ALICE to extend the precision and the range of measurements

What happens with this high temperature of 10^{12} K

This temperature is at the point of collision (nuclear scale dimensions, fm, 10^{-15} m) in vacuum. No heat goes out. Kinetic energy transformed to mass (new particles)

Where do you get electricity from

CERN has no dedicated power plant to generate electrical energy; it buys electricity from the Grid (France and Switzerland)

What is the power consumption

~ 200 MW, the equivalent of Canton de Genève, population 0.5 million
ALICE 10 MW (4 MW solenoid, 4 MW dipole, 2 MW electronics, cooling, etc)

Why is LHC underground

Natural shielding for radiation from high energy collisions; reduce cosmics background; keep cost low (no need to buy land, but had to dig the tunnel)

Why is LHC circular

To reach high energies we exploit the accelerating cavities many times: linear accelerator would have to be impossibly long; can use the beams continuously (in a linac once only).

Why protons

Easy to create proton breams (from hydrogen); easy to accelerate to very high energies.

Hadron colliders : discovery machines

Lepton colliders : precision measurements (electrons can not be accelerated to very high energies, synchrotron radiation energy loss; being elementary, signal is much cleaner-> precision).

What does ALICE do during the pp run

ALICE takes data with pp collisions (most of the time)

- Needed for reference (comparison) for PbPb data
- Do pp physics (what our apparatus allows)

Is there any danger from radiation

With a shielding of 50-100 meters soil/rock, no radiation escapes. The shafts are closed with concrete blocks during operation. Nobody is underground, all controls (machine and experiments) from Control Centres at the surface. All people entering monitored with personal dosimeters / operational dosimeters.

Is there any danger from black holes

No. Cosmic ray particles, many orders of magnitudes more energetic than p or Pb in LHC, produce much more powerful collisions with the atmosphere . If the scenario of black holes is valid we would have been destroyed – but we still exist.

Creation of mini black holes not excluded : short lived, no results

SOME USEFUL MATERIAL

About CERN - Useful links

- Selection of photos and videos about CERN classified by topics https://home.cern/resources-topic
- LHC the guide – faq: https://home.cern/resources/brochure/accelerators/lhc-facts-and-figures
- https://home.cern/resources/faqs - Q & A on frequestly asked questions from the public (dangerous? how to visit? Future? God? Black holes?)
- CERN IT in 8 minutes - https://videos.cern.ch/record/1604210
- HiLumi Fact sheet: http://hilumilhc.web.cern.ch/sites/hilumilhc.web.cern.ch/files/HiLumiFactsheet_final.pdf

On indico, this event
OD-LHC photographs + explanations of various elements inside the LHC tunnel
ALICE-2pages : some facts and tips about ALICE