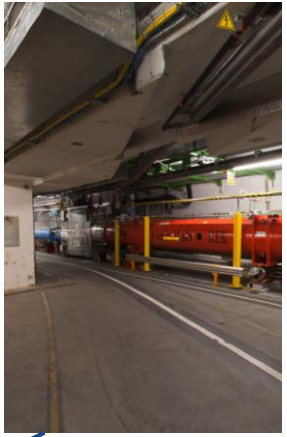
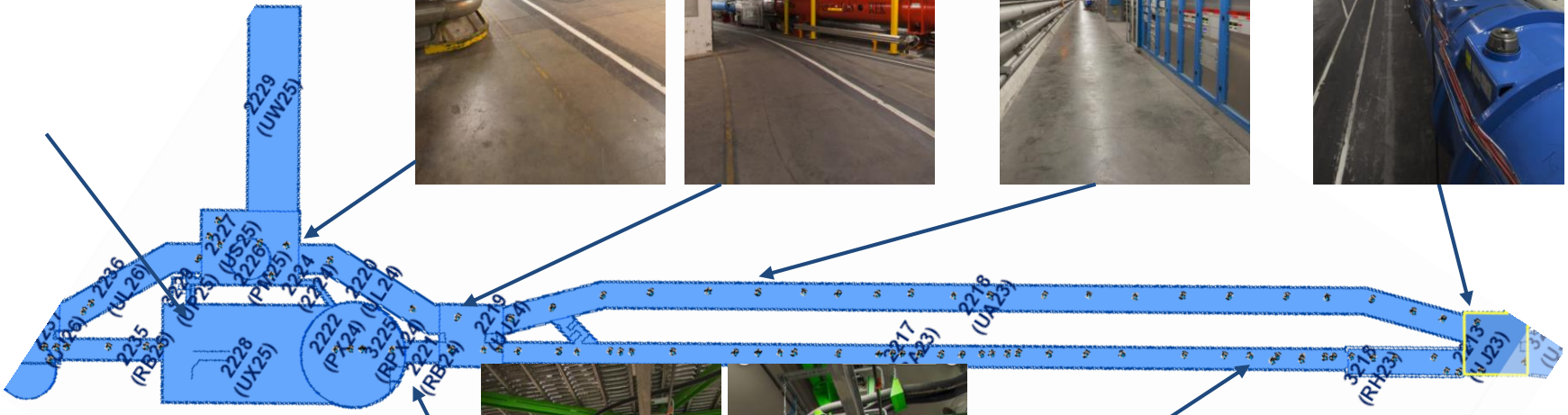
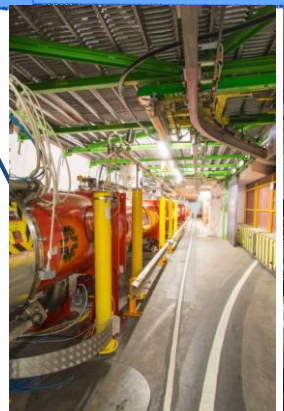
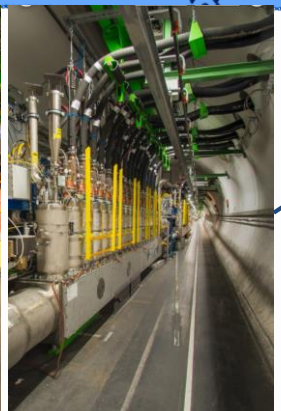
# LHC tunnel visit







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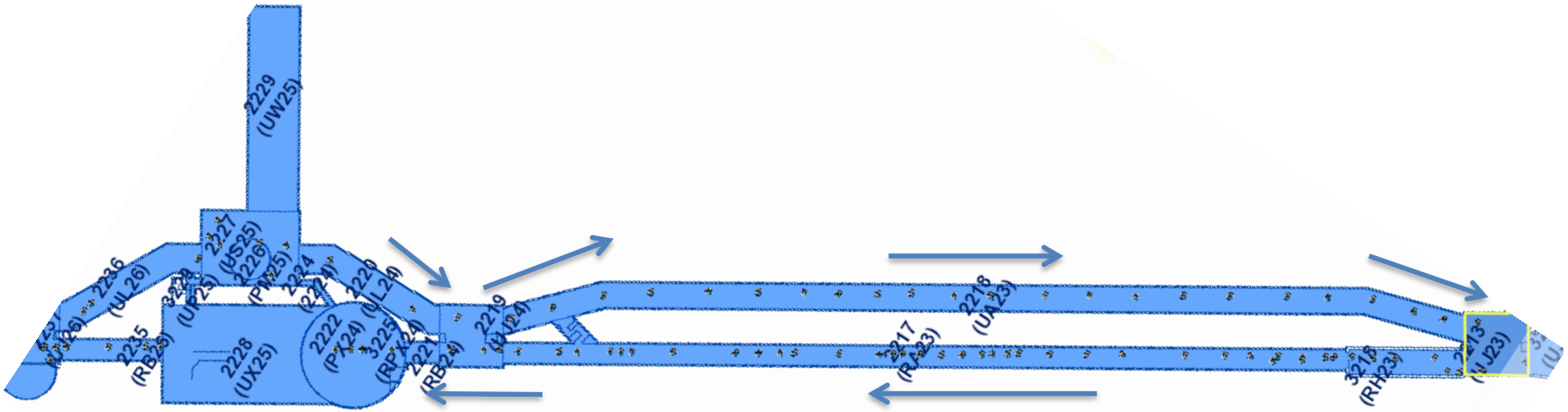
*Thanks to Mirko Pojer*

# General information on the tunnel visit

- Direction of the visit: UA → RA → ALICE
- **UA**: service tunnel, containing mostly power converters for the 3km magnets located in the arc and straight section left of P2 (3km). During beam operation the UA and RA are physically decoupled (section doors, shielding), and also the ventilation systems are decoupled. A 6m thick wall separates the UA from the RA, therefore the level of radiation in the UA is almost zero (all electronics not rad-hard). The water cooled cables enter the RA by means of bypass tunnels located along the straight section (visible during the visit). During a short access it is possible to enter the UA without performing an RP check.
- UJ23: here it is possible to see the injection line coming from the SPS and the LHC dipoles (note the QRL (cryo line) going around the injection line)
- **RA:** LHC dipoles, quadrupoles, triplets and magnets to insert the injected beam in the LHC



# 1. triplet power converter


These power converters provide the power to the triplets, which are located on the other side of the wall (in the RA)
The current in the cables is 6kA

Note the water cooled cables.

# 2. vacuum control racks

These racks provide the control of the vacuum sensors along the beamlines

# 3. bypass tunnel for cable passage

The length of the tunnel is 6m, it is possible to see a RADMON sensor sticking out in the hole for the measurement of the radiation in the UA

# 4. Quench Protection System electronics

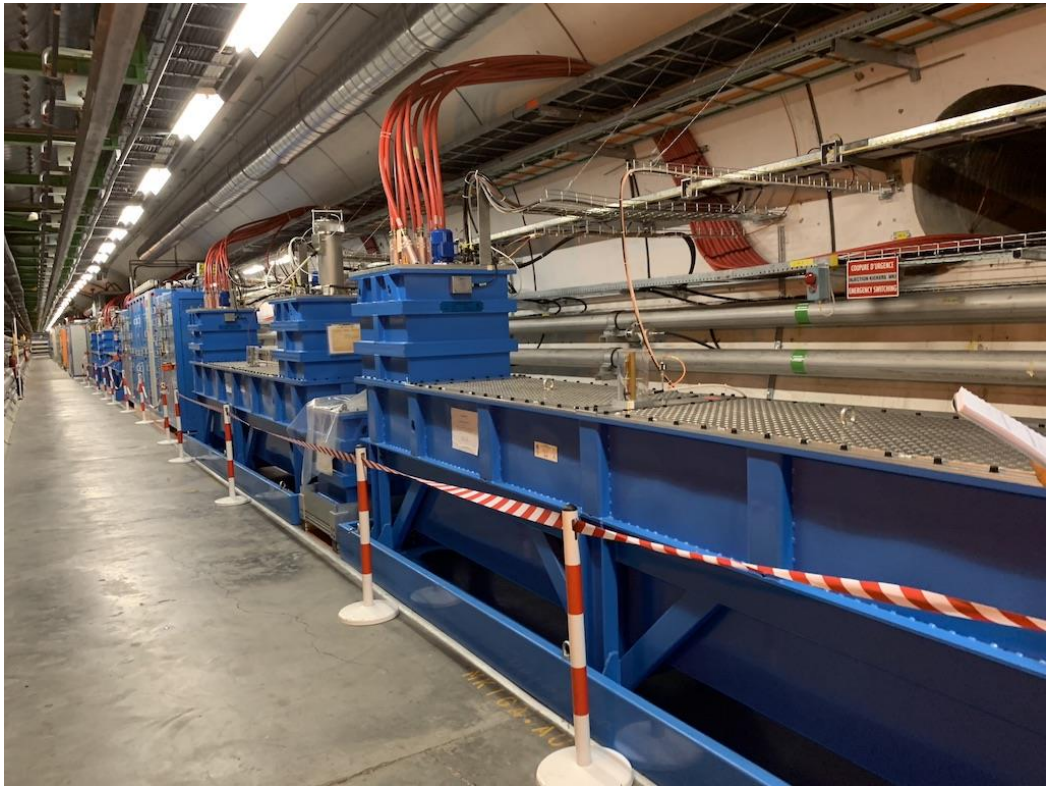
These racks provide the electronics for the QPS (Quench Protection System)

Quench of the magnet: A quench is an abnormal termination of magnet operation that occurs when part of the superconducting coil enters the normal (resistive) state. This can occur because the field inside the magnet is too large, the rate of change of field is too large (causing eddy currents and resultant heating in the copper support matrix), or a combination of the two. More rarely a defect in the magnet can cause a quench. When this happens, that particular spot is subject to rapid Joule heating from the enormous current, which raises the temperature of the surrounding regions. In order to mitigate against potentially destructive quenches, the superconducting magnets that form the LHC are equipped with fast-ramping heaters which are activated once a quench event is detected by the complex quench protection system.

# 5. RD2 power converter


RD2 = Recombination Dipole #2

# 6. Kickers pulse generators



These 4 generators provide the pulses for the 4 kickers installed in the RA. They have to provide high voltage (up to 60kV) but no high current. Therefore the (red) cables are not water cooled but their insulation is very thick.

# 7. LHC quadrupoles power converters

These power converters provide the power to the quadrupoles

# 8. Power supply

This power supply feeds various systems to correct the beam orbit in the LHC arc. The cables are not water cooled.

# 9. Quadrupole power converter


This power converter feeds 50 quadrupoles in the arc (left of P2, 3km of quadrupole magnets). The current produced is 13kA @ 18VDC.

Water cooled cables

# 10. Dipole power converter


This huge power converter feeds 154 LHC dipoles in the arc (left of P2, 3km of dipole magnets). The output is 13kA @ 190VDC.

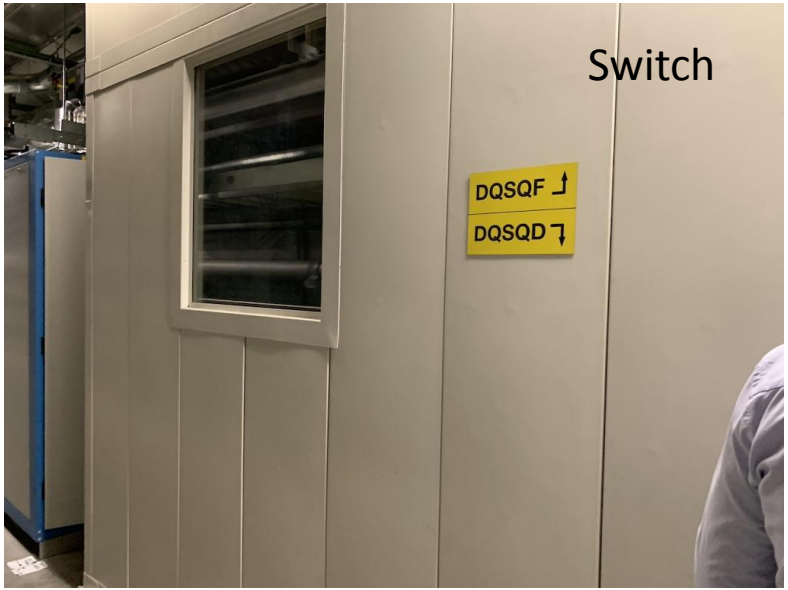
Water cooled cables

Note the cable cross section: 2’000mm2

# 11. Monorail

The monorail runs across the entire LHC, and is used to drive the MAFI (convoy to transport the magnets)

# 12-13. Quench system





In case of a quench on a magnet, the current must be steered to a set of 1ohm resistors. The switch acts in less than 100s. The total energy discharged is about 1GJoule

# 14. Power converters

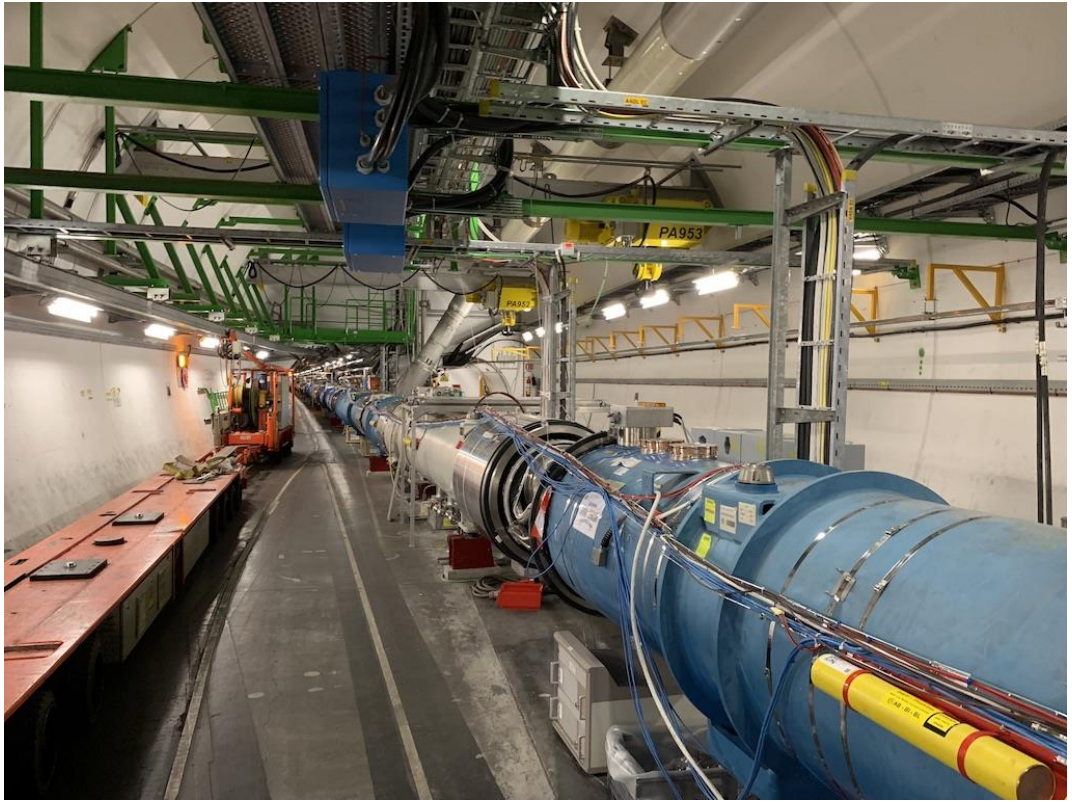

These are the power converters of the quadrupoles Q7 to Q10

# 15. end of zone door


This door separates the RA from the UA

Beyond this door, the radioprotection group has to intervene during the beam stop when an access is required.

# 1. View towards the arc (left)




The arc is visible on the left. The SPS tunnel is visible on the right. In this place the injected beam leaves the SPS and enters into the LHC (symmetric to P8). The QRL (cryogenic distribution line) is routed upwards to leave room for the injection line.

1232 dipole magnets installed in LHC, cooled at less than 10K

# 2. View towards the straight section (right)

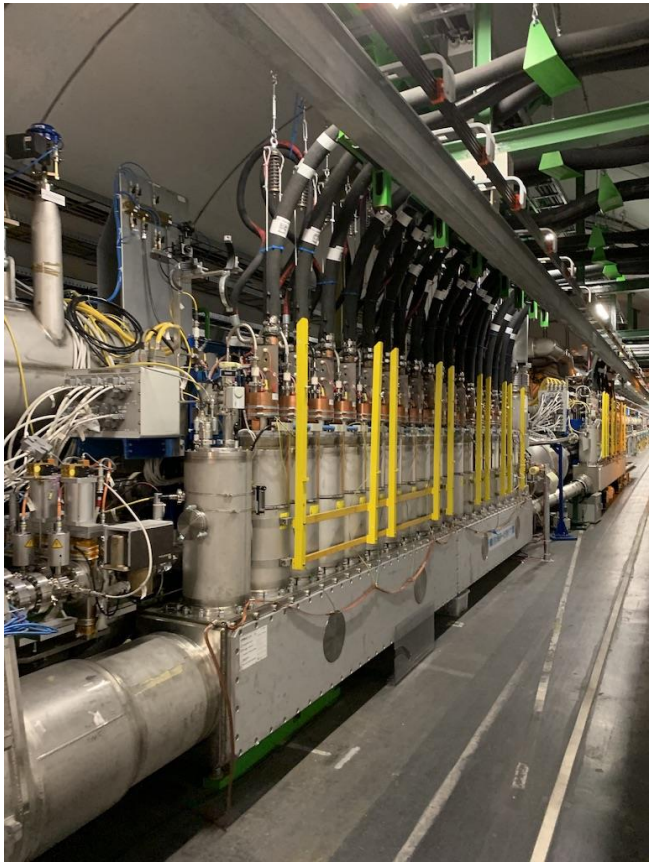
Before and after each interaction point there are straight sections. IN this straight section one can see the ZDC and the triplet just before the beam enters the ALICE cavern (the last focusing)

# 3. Interconnection between two dipoles


Note: injected line is located behind dipoles.

LS2 major work: consolidation of the protection diodes. These diodes (40kg) are there to protect each dipole against quenches. In the last years we have had some problems with these diodes, due to accumulation of dust (metallic chips) around the diode (located in the bottom part of the dipole). The diode gets shorted and it is impossible to operate the magnet. The LS2 work consists in cleaning the dipoles, eliminating the dust.

# 4. Direct Feed Box (DFBA's)



The LHC superconducting magnets are powered by current leads installed on cryogenic electrical distribution feedboxes called DFBA's which are feedboxes for the arc, DFBL's which are feedboxes for the long straight sections, powering the superconducting links and DFBM's which are feedboxes for the long straight sections, powering standalone magnets.

The 2'000mm2 water cooled cables coming from the UA enters the DFB and a 30mm2 superconductive cable leaves the DFB.

# 5. Beam Loss Monitor


These devices are installed all around the LHC beam and are used to measure the particles ‘lost’ outside the magnets.

There are 4000 BLMs installed in the LHC.

Protection of the machine from beam losses has two aspects:

- protection against beam losses that could lead to damage of equipment,
- protection against beam losses that could lead to a quench of a magnet.

# 6. beamlines

Here one sees the QRL (top), the two beamlines (right) and the injected line (left)

QRL : the cryogenic distribution line. It circulates Helium in liquid and gaseous phases, at different temperatures and pressures, to provide the necessary cryogenic conditions for the superconducting magnets

# 7. Collimator

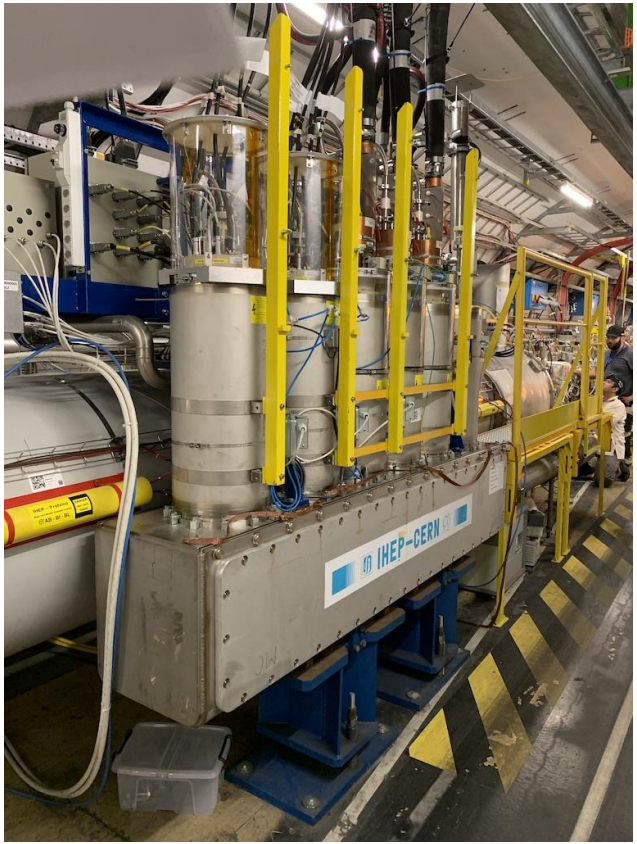
They are more than 100 of them in the LHC ring. Each one has  motors and the newest ones have their own beam-monitoring pickups. Their jaws constrain the relativistic, high-energy particles to a very small transverse area and protect the machine aperture. The ultra-precise LHC collimators leave escaping unstable particles no chance.

# 8. SEPTA

A septum (plural Septa) is a partition that separates two cavities or spaces.
In a particle-accelerator a **septum** is a device which separates two field regions.

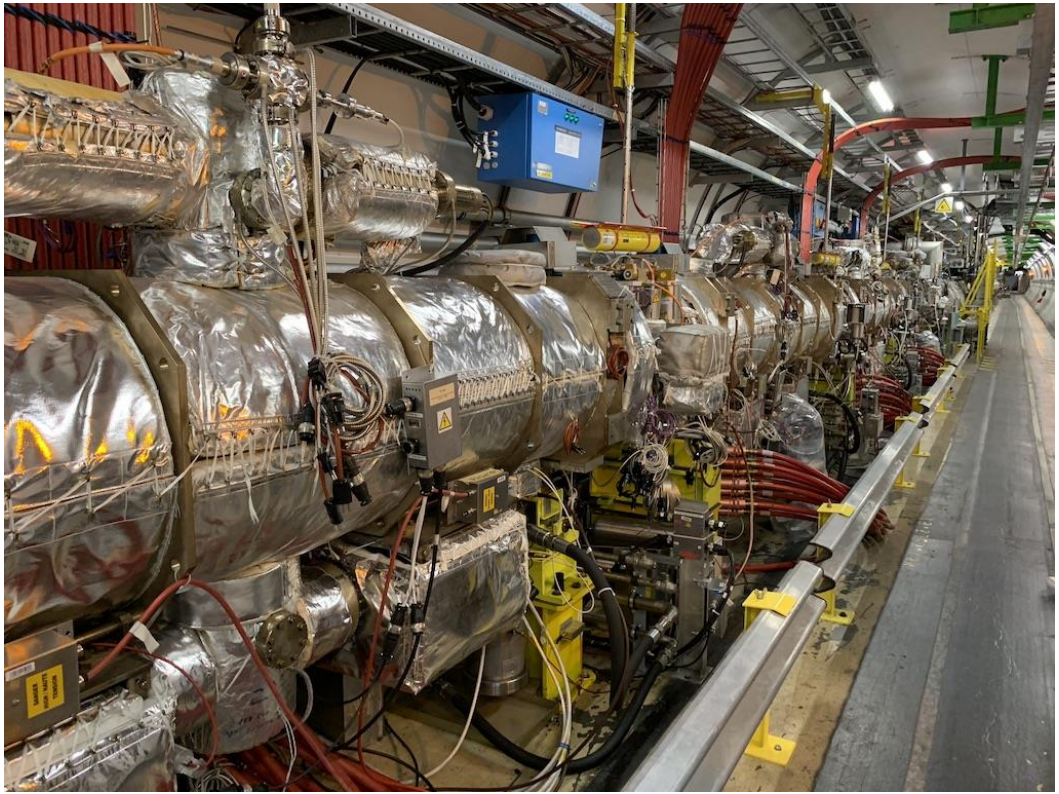
These devices, together with the Kickers are used to inject the beam from the SPS into the LHC orbit.

# 9. DFB’s




This DFB feeds the LHC quadrupoles

# 10. Kickers



The LHC is equipped with two kicker systems installed at the injection points (near points 2 and 8) where the particle beams coming from the SPS are injected into the accelerator's orbit. Each system comprises four magnets and four pulse generators in which the field rises to 0.12 Tesla in less than 900 nanoseconds and for a duration of approximately 8 microseconds. Although the injection kickers only pulse 12 times to fill the LHC up with beam, the LHC beam circulates through them constantly.

# 11. ALICE Zero Degree Calorimeter (ZDC)

The LHC collisions can be central or peripheral; it is crucial for physicists to distinguish between them. In peripheral collisions, only few protons and neutrons are involved and most of the nucleons fly along the beam line without participate (spectator nucleons) to the collision.

The ZDCs are calorimeters which detect the energy of the spectator nucleons in order to determine the overlap region of the two colliding nuclei. It is composed of four calorimeters, two to detect protons (ZP) and two to detect neutrons (ZN). They are located 115 meters away from the interaction point on both sides, exactly along the beam line.

# 12. D1 magnet

D1 = separation dipole magnet.
D1 and D2 separate the beams to the distance of the beampipes in the main magnets in the arc, 194 mm.  Looking direction IP, D1 brings the beams into collision.

# 13. Triplet magnets


Triplets are located on either side of the four interaction points at LHC. They are needed to focus the beam on the interaction point.  They consist of quadrupole magnets which squeeze the beam by a factor of 10.

Made in collaboration with US and Japan