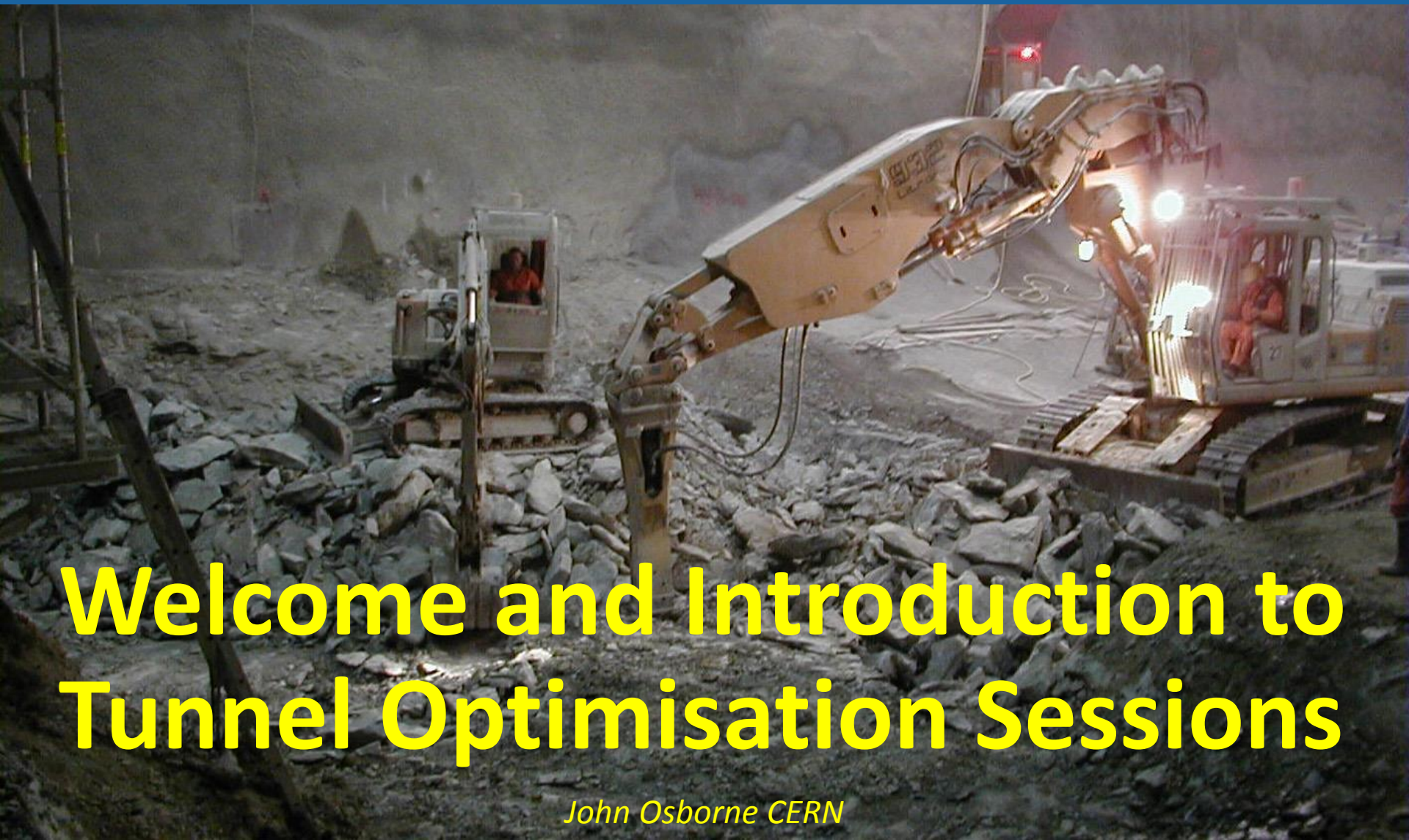

CERN

CERN Tunnelling Workshop

23 Oct 2019, 09:00 → 24 Oct 2019, 18:00 Europe/Zurich

60/6-015 - Room Georges Charpak (Room F) (CERN)

John Andrew Osborne (CERN), Ben Swatton (CERN), Alexandra Tudora



Welcome and Introduction to Tunnel Optimisation Sessions

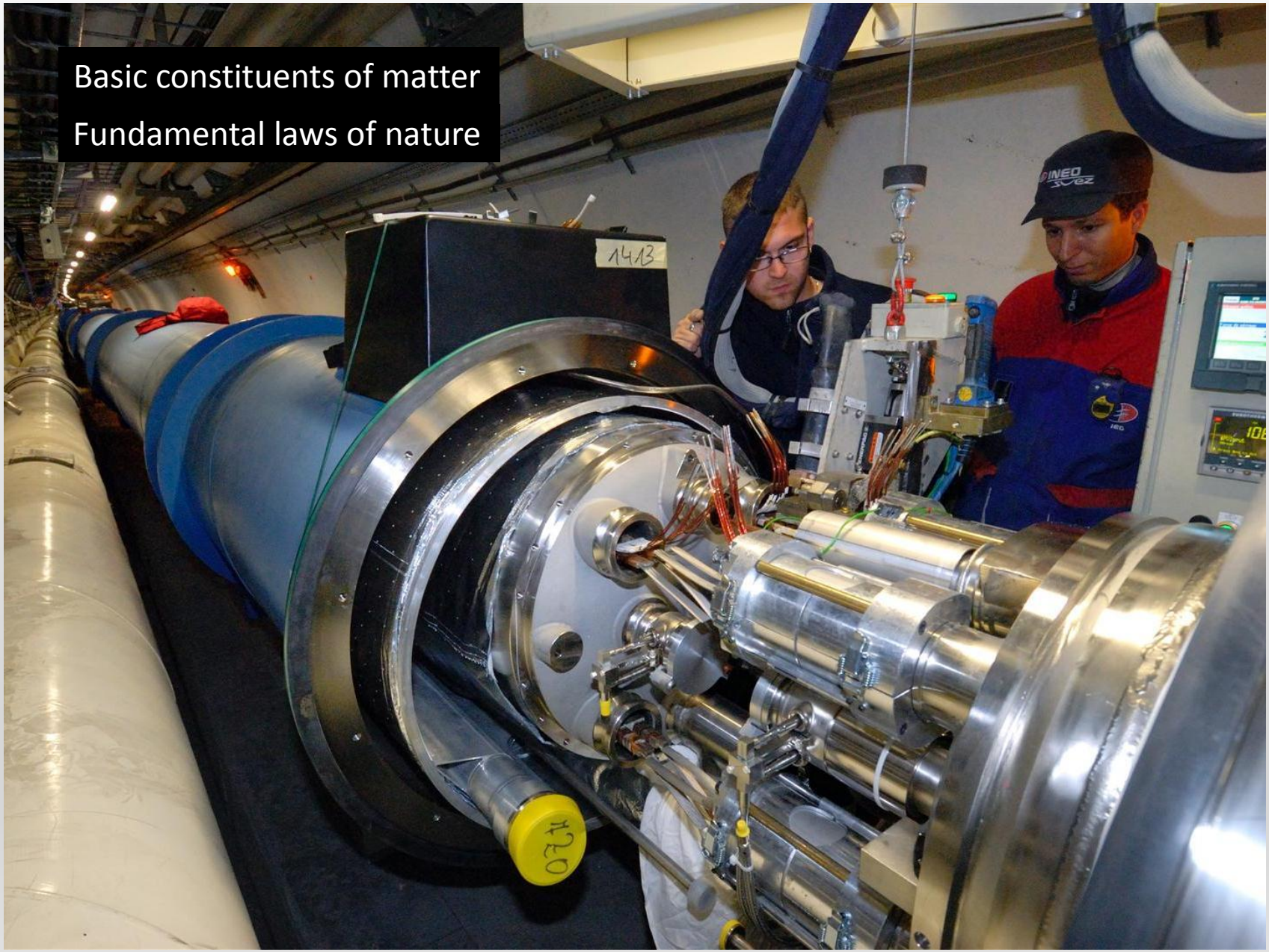
John Osborne CERN

Introduction

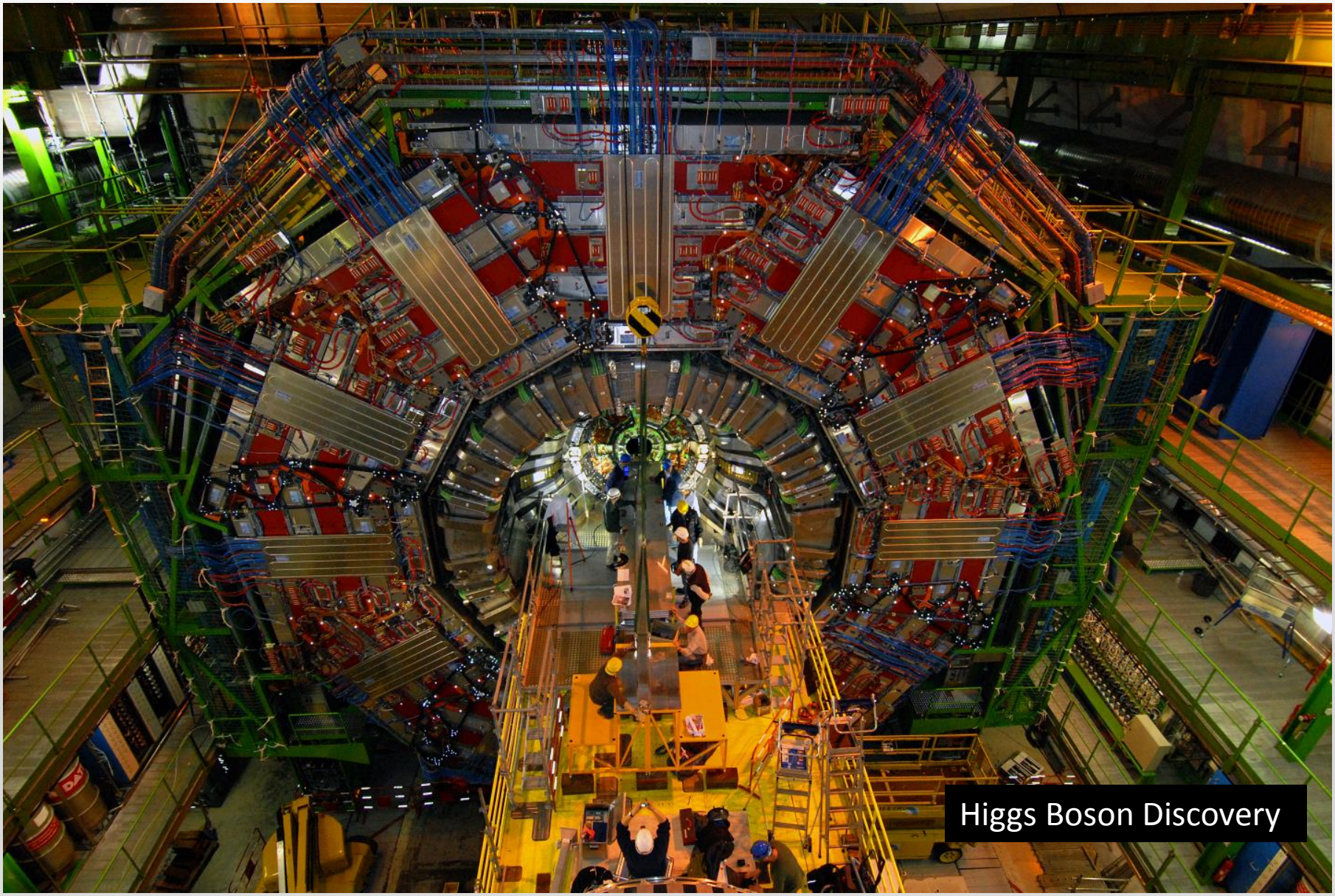
- Agenda and attendance list
- CERN Introduction and existing Infrastructure
- CERN area geology
- Future Plans
  - Future Circular Collider FCC
  - Compact Linear Collider CLIC
  - Physics Beyond Colliders PBC
- Goal of this workshop

CERN Civil Engineering Works : Past and Future Projects

John Osborne

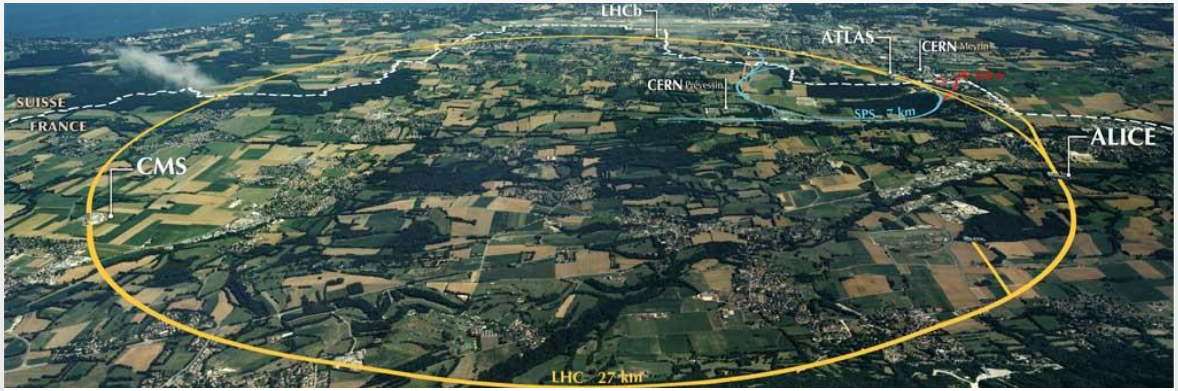

Basic constituents of matter
Fundamental laws of nature

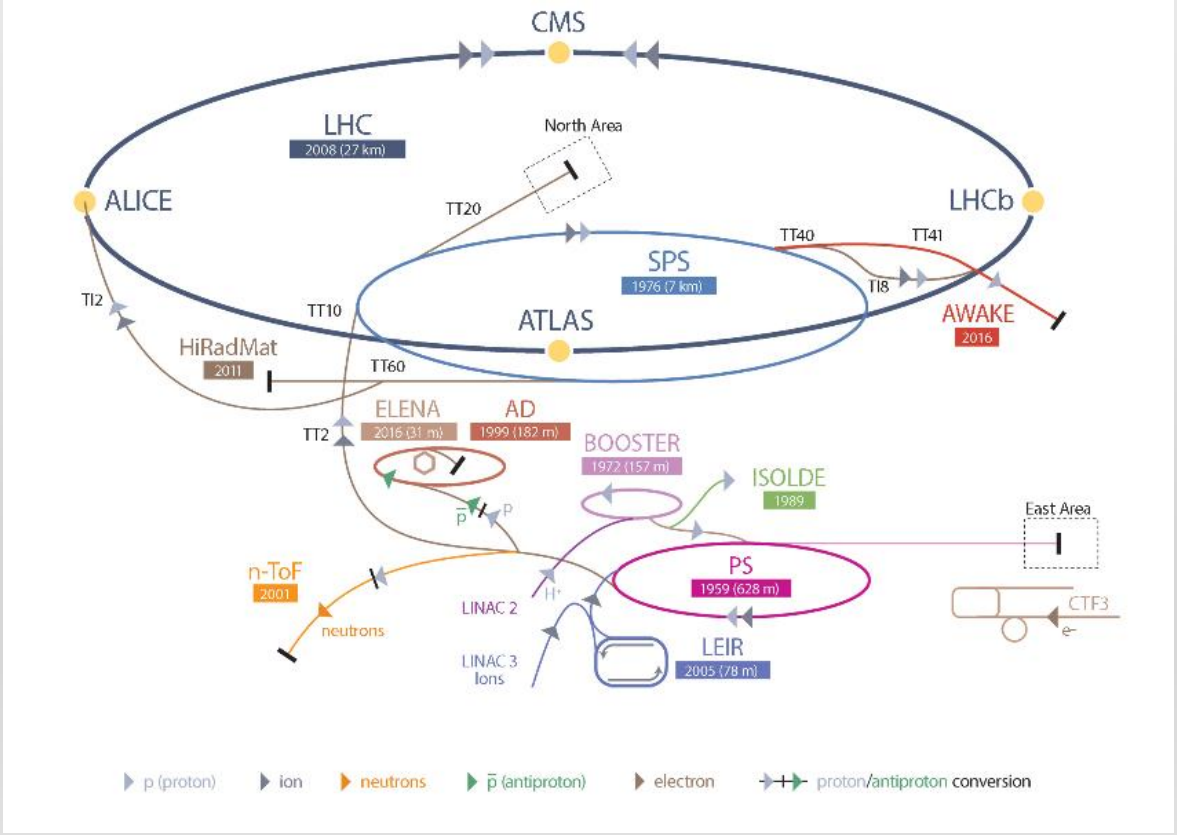
CERN – European Centre for Nuclear Research



Higgs Boson Discovery

CERN tunnels and geology





- Large Hadron Collider :
  - 27km long
  - 50-175m depth
  - 4.5m ø TBM tunnels
  - Molasse and limestone

Total underground tunnels >70km
More than 80 Caverns

‘CERN’ Geology

Rock properties

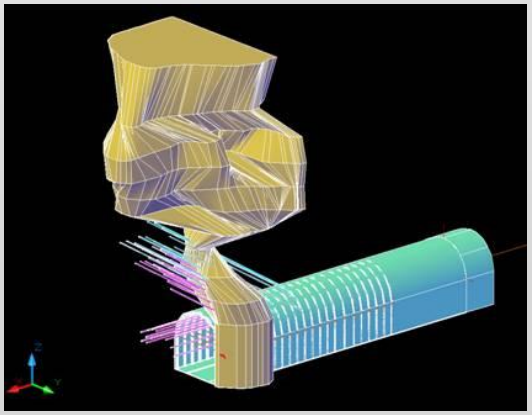
Moraines
- Glacial deposits comprising gravel, sands silt and clay
- Water bearing unit
- Low strength

Molasse
- Mixture of sandstones, marls and formations of intermediate composition
- Considered good excavation rock
- Relatively dry and stable
- Relatively soft rock
- However, some risk involved
- Weak marl horizons between stronger layers are zones of weakness
- Faulting due to the redistribution of ground stresses
- Structural instability (swelling, creep, squeezing)

Limestone
- Hard rock
- Normally considered as sound tunneling rock
- In this region fractures and karsts encountered
- Risk of tunnel collapse
- High inflow rates measured during LEP construction (600L/sec)
- Clay-silt sediments in water
- Rockmass instabilities

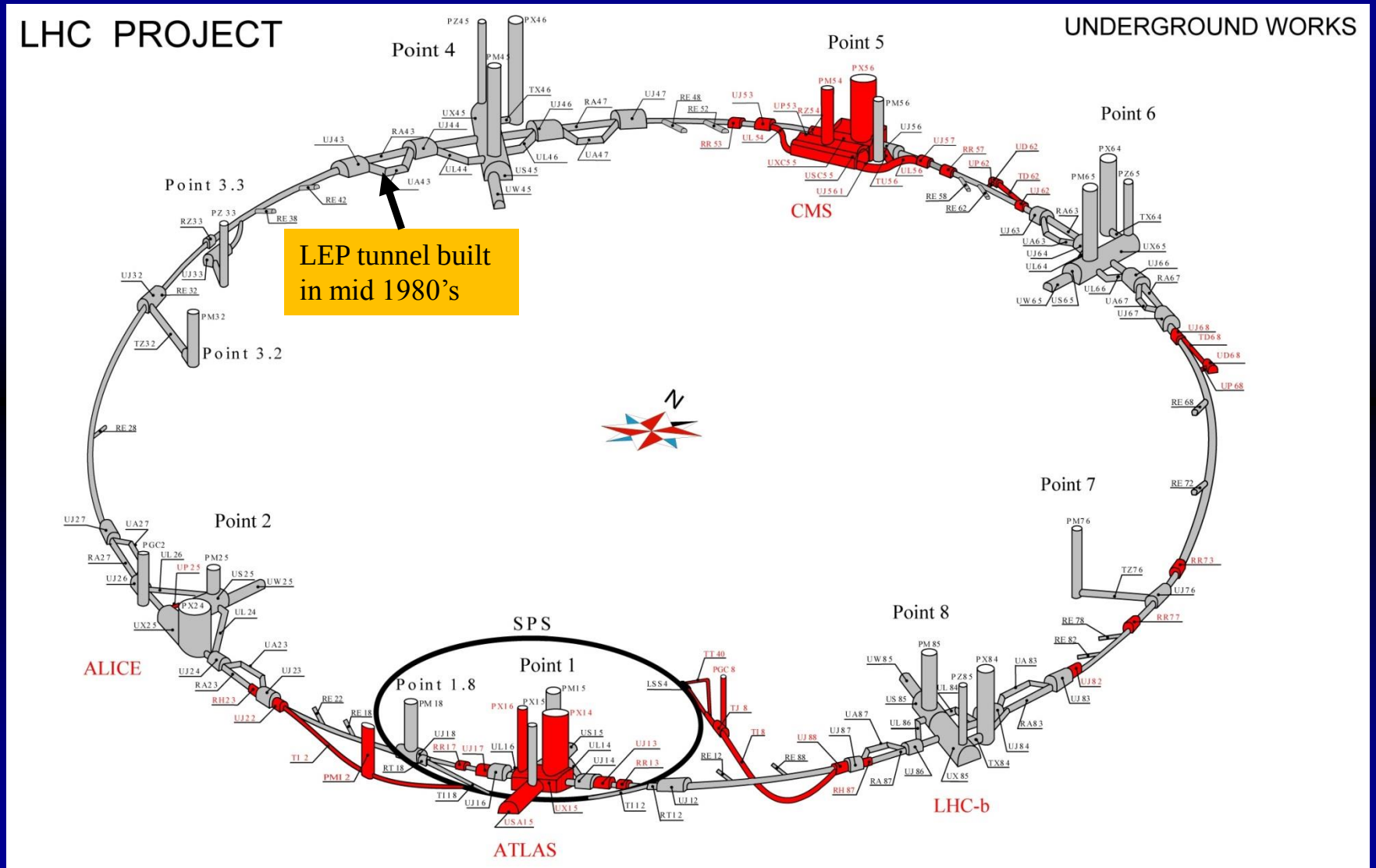
Rock type		Average σc (Mpa)
Sandstone	*weak*	10.6
	strong	22.8
	Very strong	48.4
Sandy marl		13.4
Marl		5.7

Molasse Compression strengths

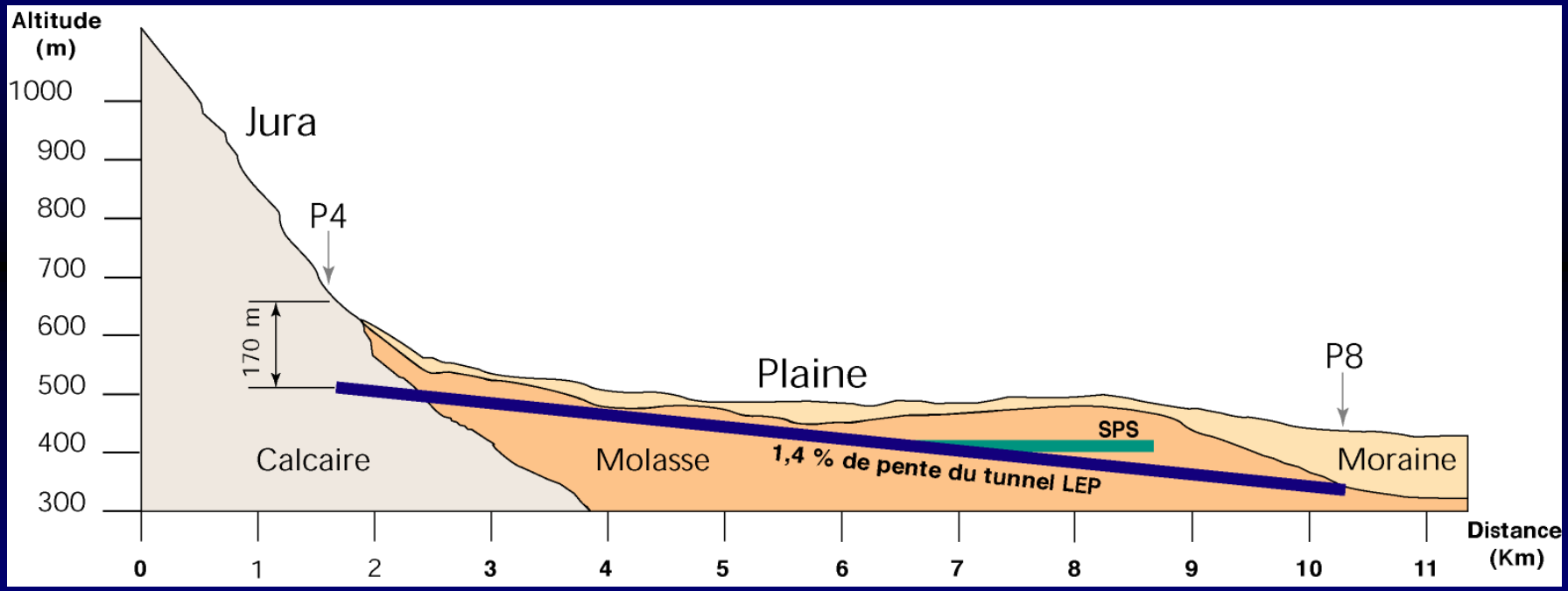


Model of tunnel collapse caused by Karsts

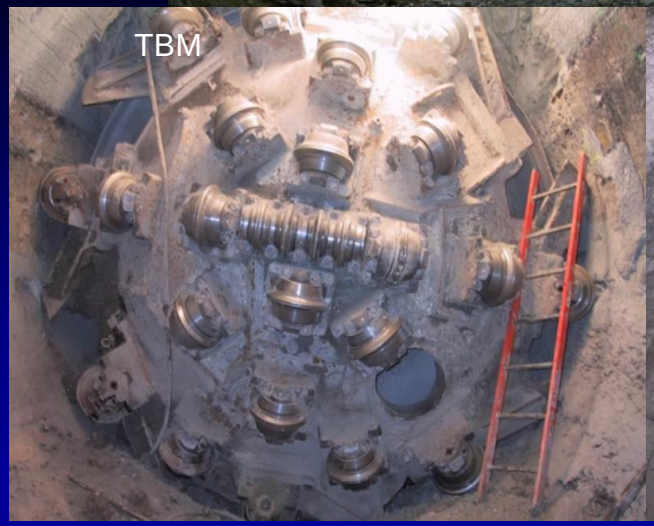
LHC Civil Engineering (in red) 1998-2005



LHC tunnel alignment



Tunnel excavation options

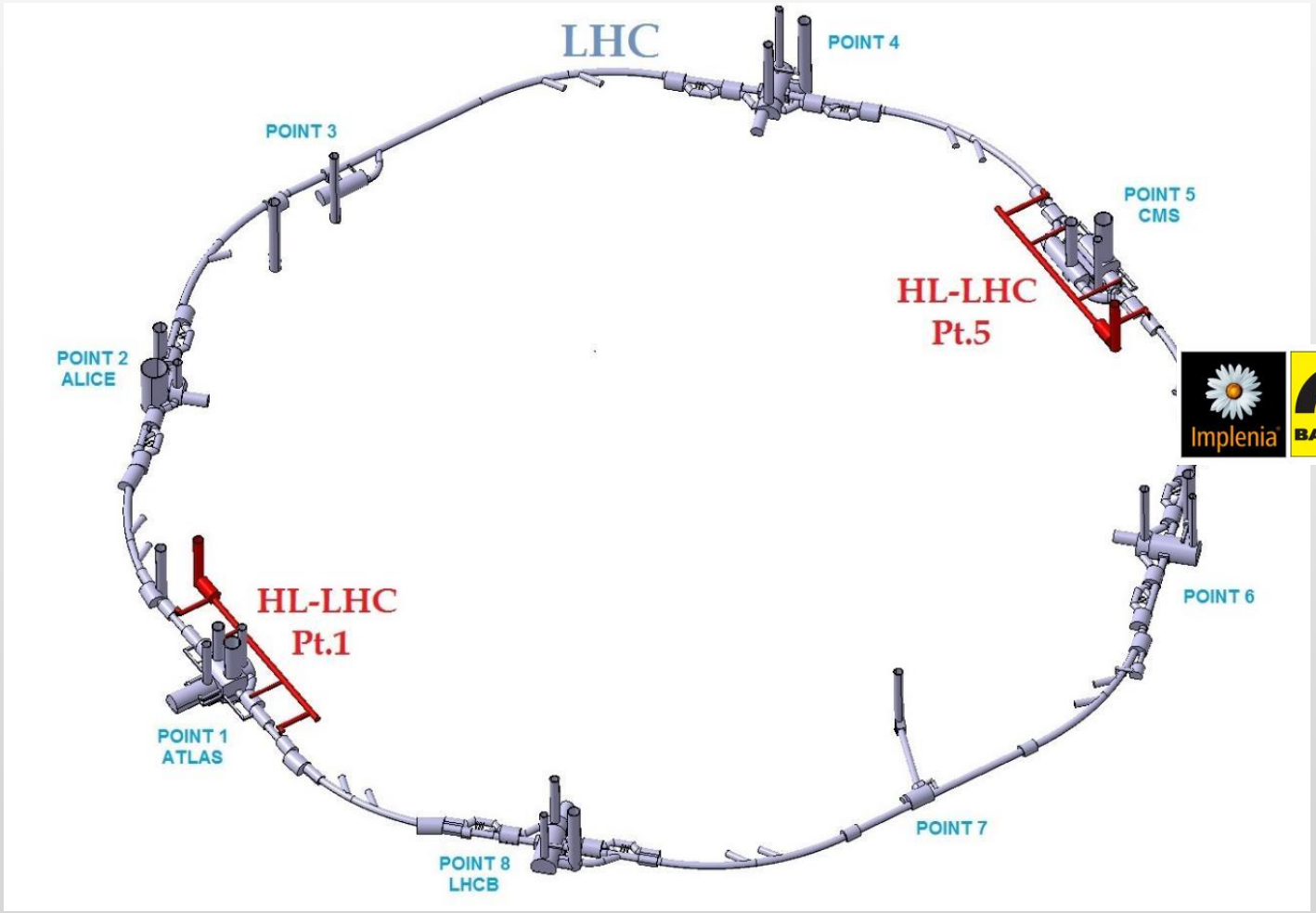


No explosives were used for LHC excavation

CMS cavern 53m long, 27m wide by 25m high

2005

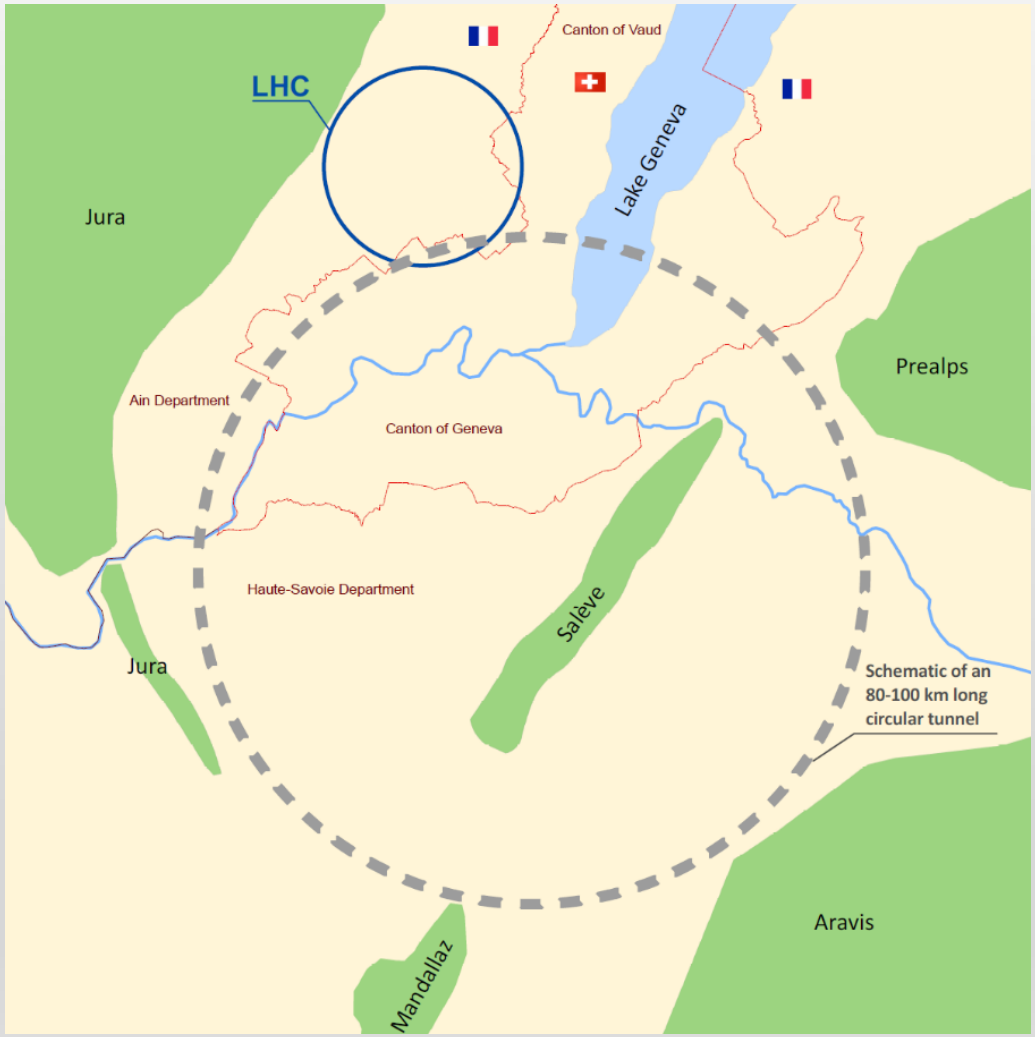
High Luminosity LHC Project (HL-LHC) 2017-2022



The Future Circular Collider Study (FCC)

Collision energy:
100TeV
Circumference:
80km-100km
Physics considerations:
Enable connection to the LHC (or SPS)
Construction:
c.2025-35
Cost:
~6Billion CHF for Civil works
Aims of the civil engineering feasibility study:
Is 80km-100km feasible in the Geneva basin?
Can we go bigger?
What is the 'optimal' size?
What is the optimal position?

Spoil:
~10million m^3 of excavated material



Potential locations : European Strategy : 2012

Pre-feasibility study focused on:

- geology & hydrogeology,
- tunneling & construction,
- environmental impacts

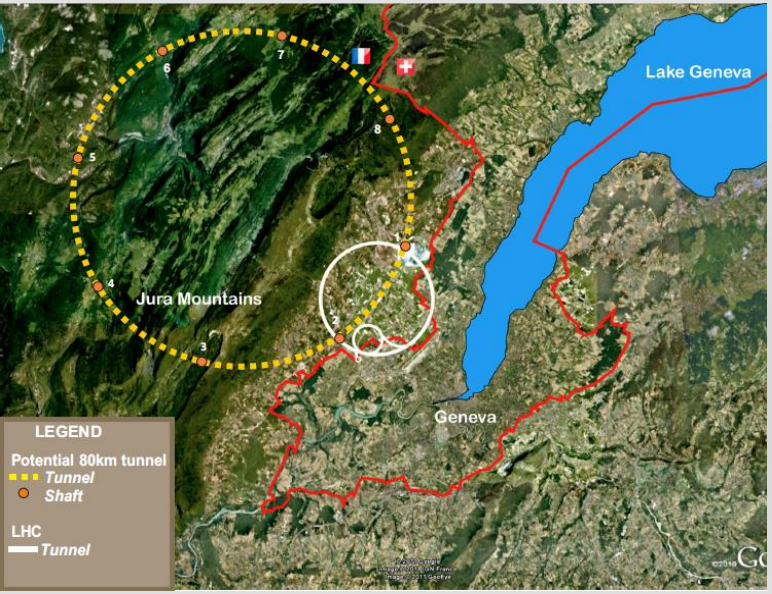
Result: for the 80km long tunnel location 2 '80km Lakeside' is most feasible.

	Risk										
	water ingress	heaving ground	weak marls	hydro carbons	support & lining	ground response & convergence	hydrostatic pressure & drainage	Pollution of aquifers	effect of shafts on nature	effects of shafts on urban areas	Total
Jura 80	5	3	0	0	5	4	5	5	4	2	**33**
Lake 80	2	0	3	3	3	3	2	2	3	2	**23**
Lake 47	1	0	2	2	2	2	1	1	2	5	**18**

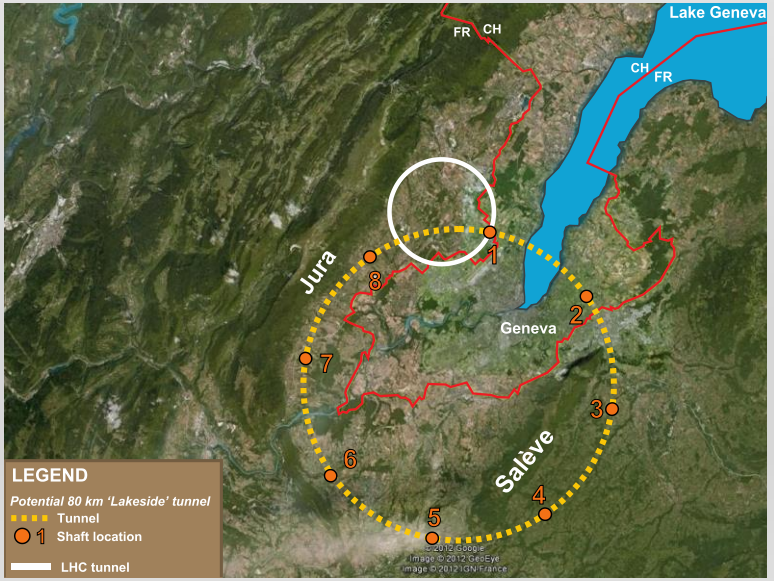
Feasibility

Low

High



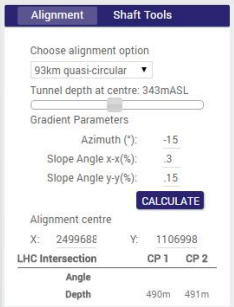
Option 1: 80km Jura

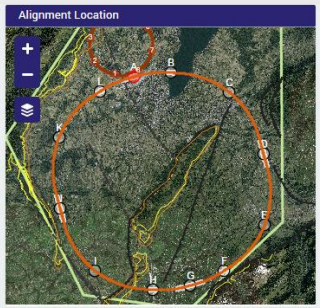


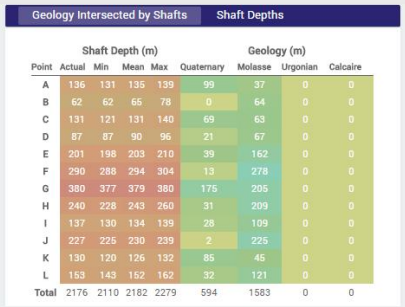
Option 2: 80km Lakeside

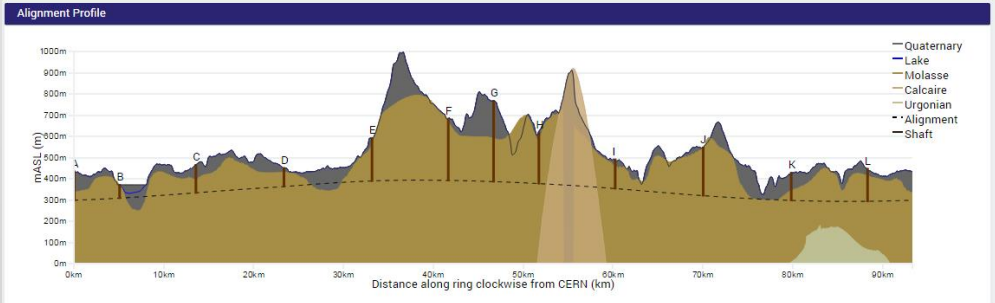
The Digital Approach – ARUP & the Tunnel Optimisation Tool (TOT)

- ARUP(UK) produced a 3D geological model to allow various layouts for the machines to be analysed. This model allowed different tunnel shapes, circumferences, inclinations etc. to be entered into the model and determine the rock types housing the machine



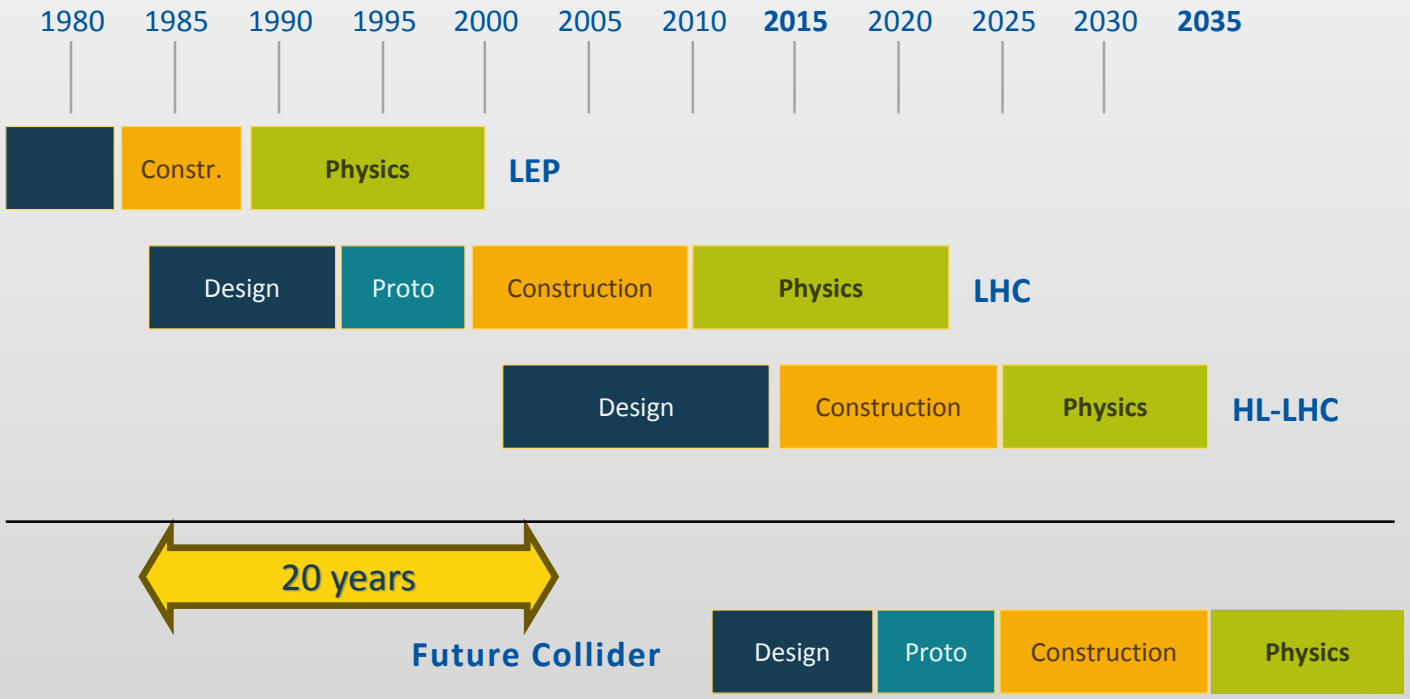






See next talk from Alex Tudora for TOT details

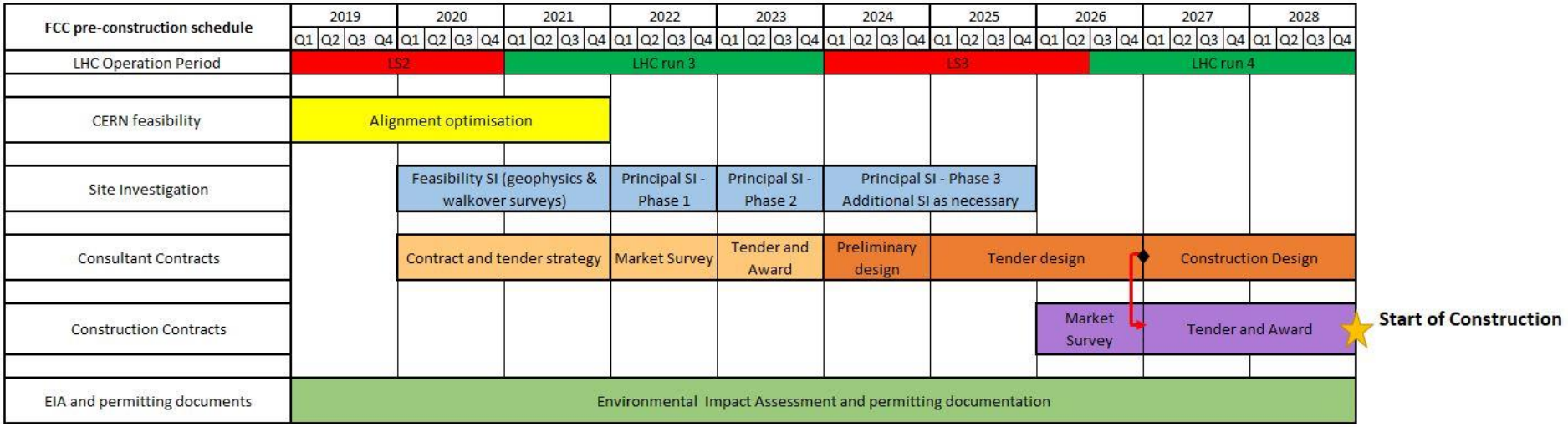
CERN Circular Colliders + FCC



FCC Site investigation planning and pre-construction planning

Conceptual Design Report

European Strategy Update 2020



Types of site investigation:

- Collection of existing information
- Walkover survey
- Geophysical investigations (to define interfaces)
- Boreholes
  - Site testing (eg Insitu stress test, point load testing, SPT)
  - Rock laboratory testing.

Phases:

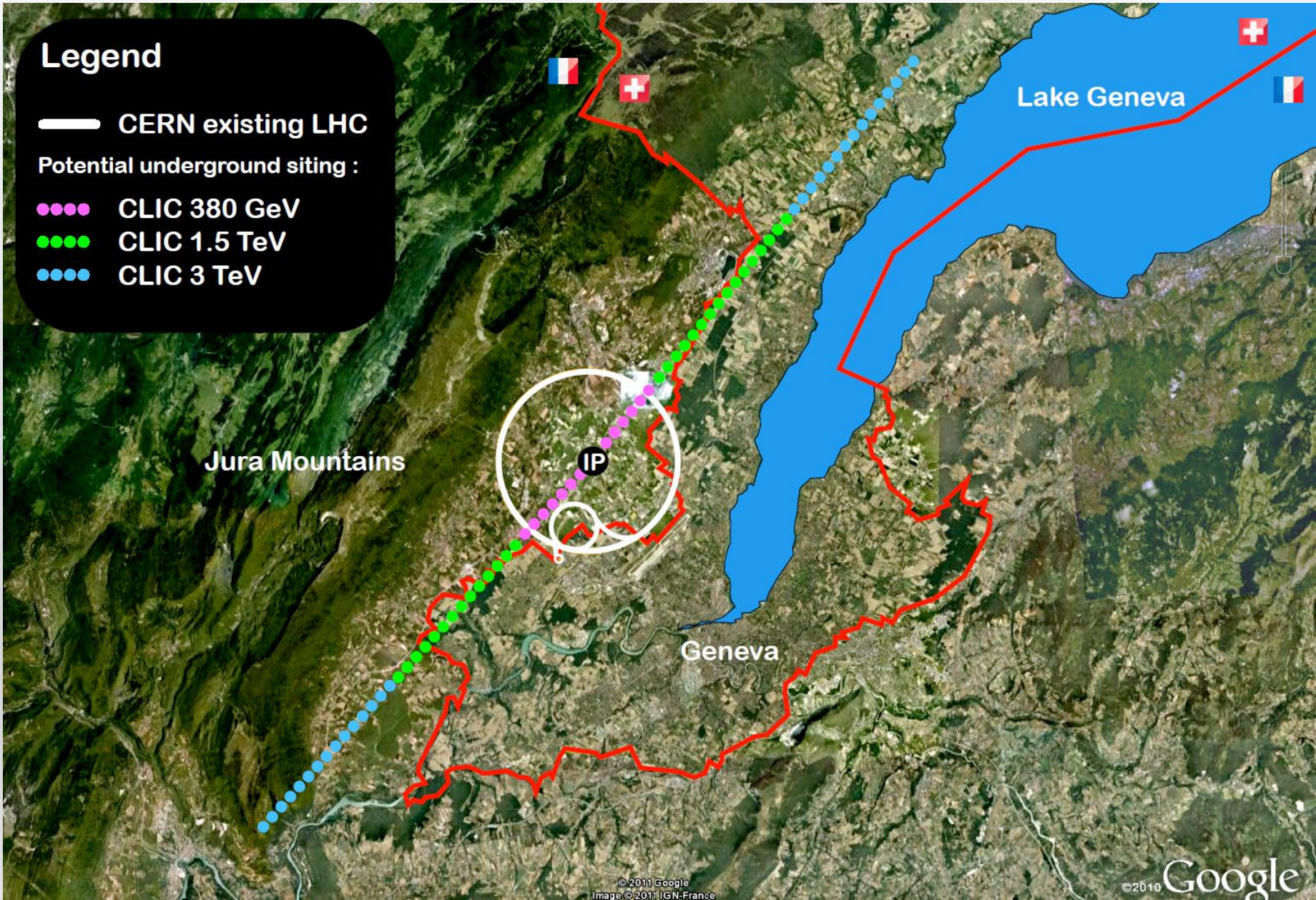
Feasibility: Non-intrusive investigations to allow consolidation of alignment. Focus on access points, Lake crossing and the Rhone and Arve crossings.

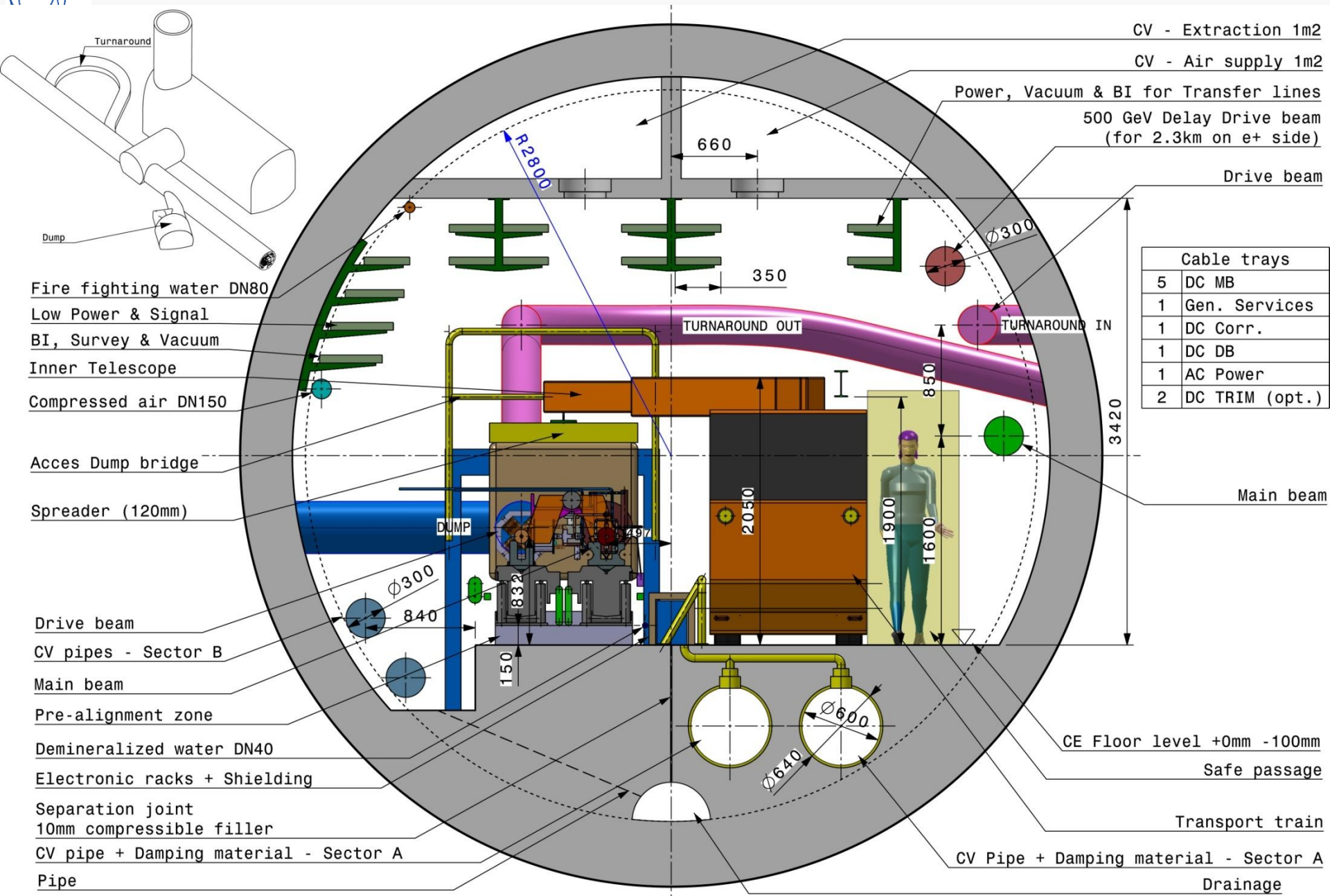
Principal: Substantial portion of the geotechnical investigations. As a result of this, the alignment might need to be changed.

Additional: Any investigations required for the final design, emphasis on obtaining date required for the contractors.

Administration

Compact Linear Collider (CLIC) Studies at CERN



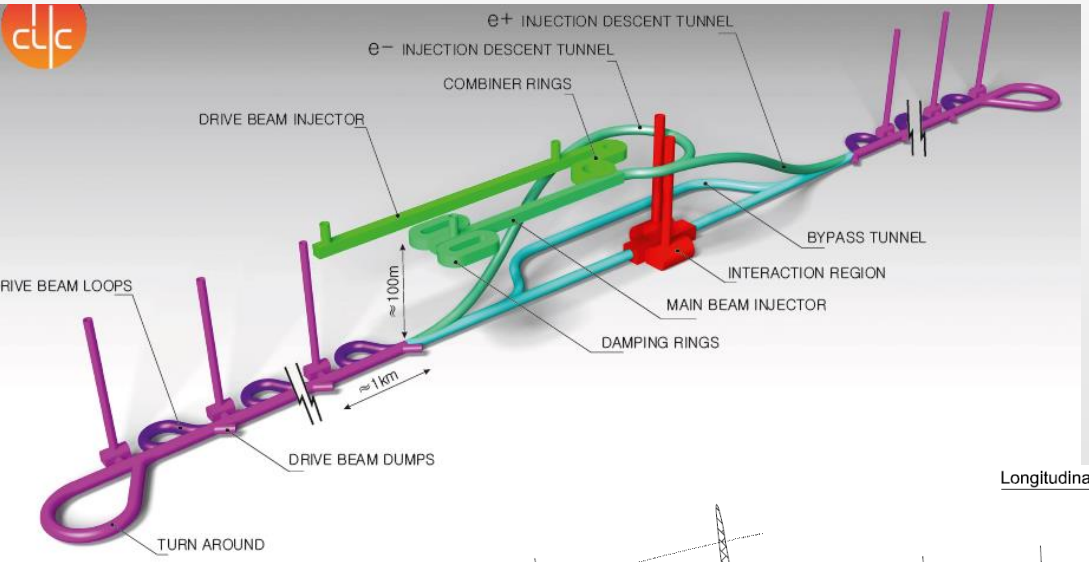


Cable trays	
5	DC MB
1	Gen. Services
1	DC Corr.
1	DC DB
1	AC Power
2	DC TRIM (opt.)

CLIC - Typical Cross Section - Diameter 5600mm - Junction with Turnaround - 1:25

Draft - J.Osborne / A.Kosmicki - August 9th 2010

CLIC Studies at CERN



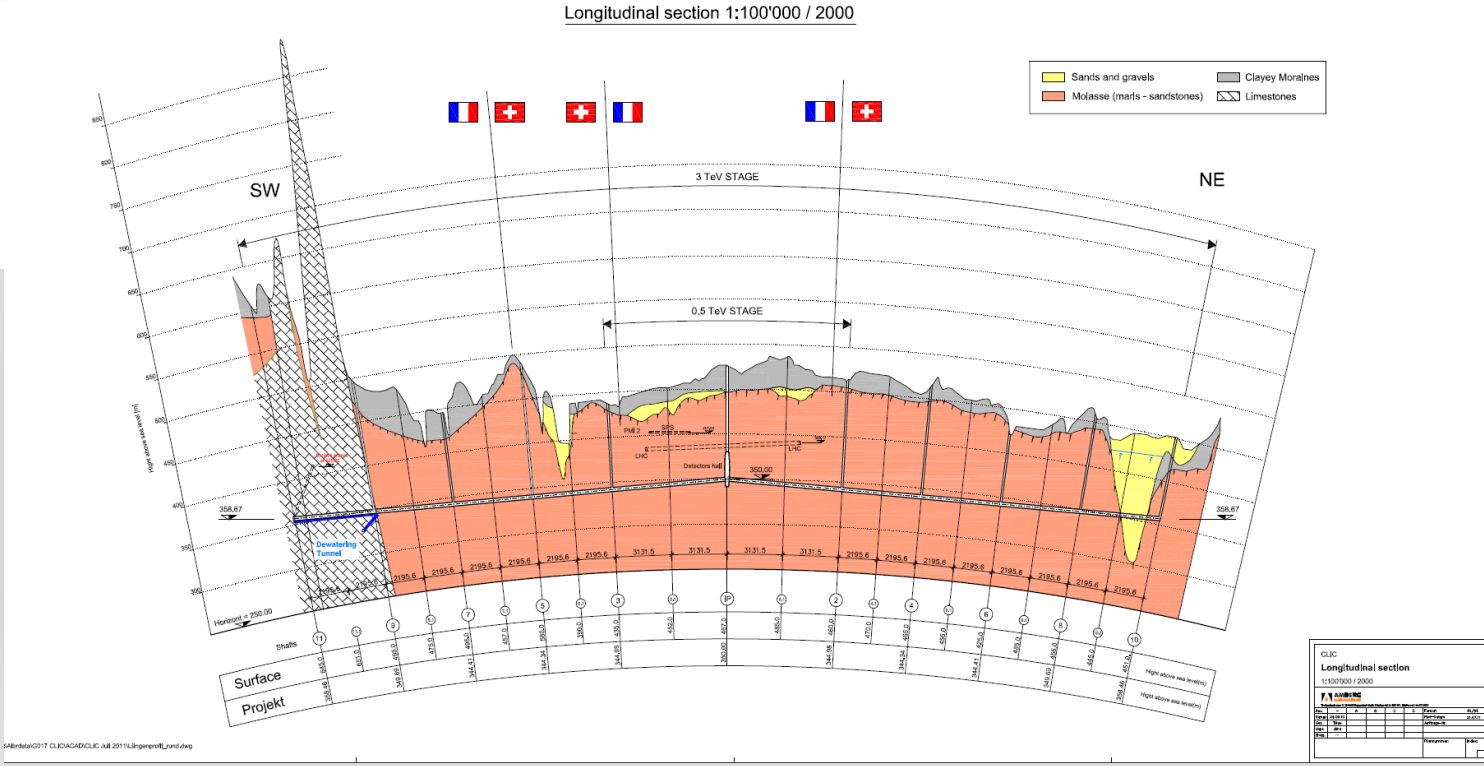
CLIC SCHEMATIC
(not to scale)

New 380GeV, 1.5TeV and 3.0TeV accelerator layouts to be developed in 2017 ready for next European Strategy update.

Klystron option also being studied.

CLIC TOT

New Infrastructure WG being set-up (CE, EL, CV etc).



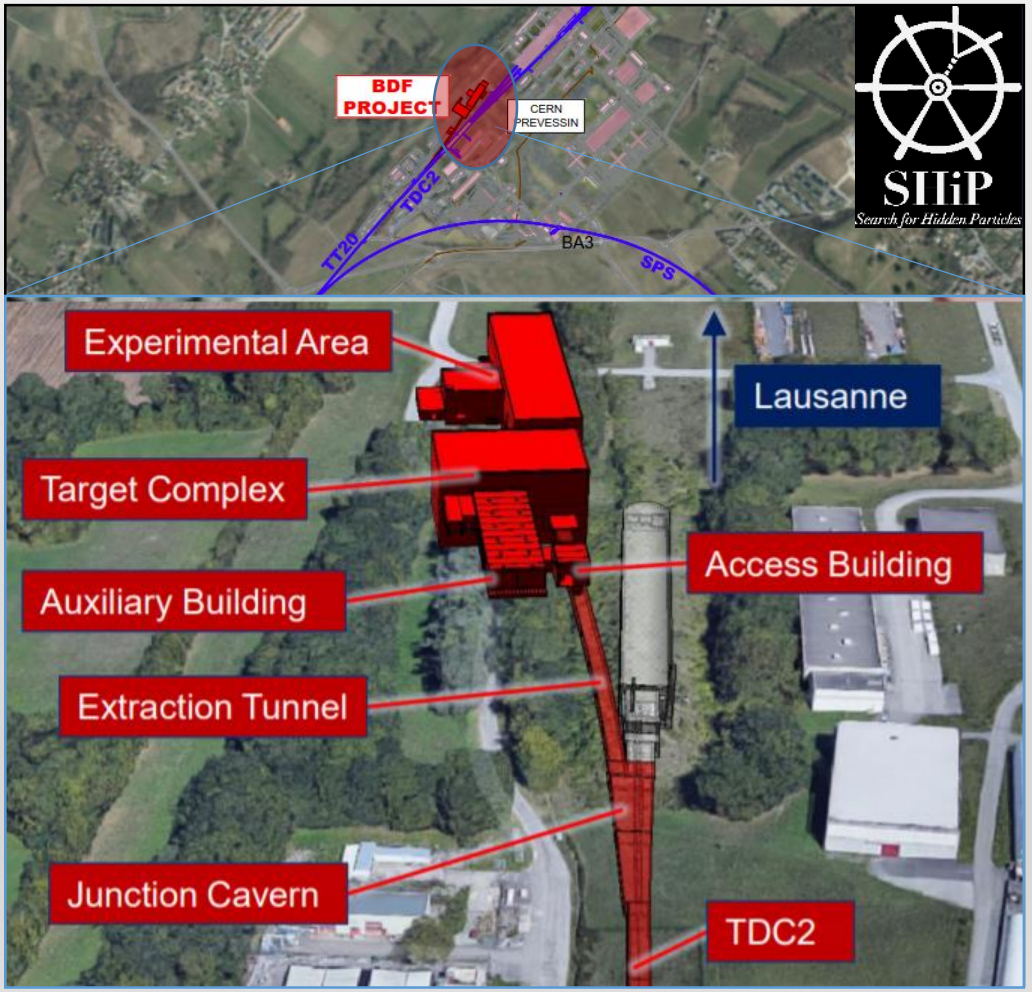
Physics Beyond Colliders (PBC)

PBC is a programme aimed at exploiting the full scientific potential of CERN's accelerator complex and its scientific infrastructure through projects complementary to the LHC, HL-LHC and other possible future colliders.

- Main studies:
  - Beam Dump Facility (BDF)
  - electrons in the SPS (eSPS)
  - ForwArd Search ExpeRiment (FASER)
  - Neutrinos from STORed Muons (nuSTORM)
  - Plasma Electron Proton/Ion Collider (PEPIC)
  - Advanced Proton driven Plasma Wakefield Experiment (AWAKE)++
  - Electric Dipole Moments (EDM) Storage Ring
  - MAssive Timing Hodoscope for Ultra Stable neutraL pArticles (MATHUSLA)

BDF Study - Overview

- Location
  - Prévessin Site
  - Just off SPS
- Description
  - Fixed target experiment looking for dark matter particles
- Status
  - Comprehensive design study complete
- Challenges
  - Very high radiation levels
  - Existing infrastructure
  - Considerations for target



Goal of this workshop today

- CERN to present the status of our studies and to establish links with industry experts
- Understand what is industry best practice at this feasibility stage of our studies for FCC & CLIC (and others?), especially related to fixing tunnel alignment
- Learn about state of the art tools and software to aid our design developments
- Any new tools must have a long life span, that can be easily maintained, and possibility to add any new data (geotechnical from SI, constraints etc)
- Tools must be flexible to allow changes in the future (circular v linear machines)
- Depending on EU strategy outcome, CERN may start tendering next Spring/Summer (2020) for support contract(s) to assist with tunnel studies (alignment optimisation, costings, technical support, site investigation studies/works, safety designs, heat recovery, contract strategy etc etc)

THANK YOU FOR YOUR ATTENTION

And Questions

John Osborne (CERN SMB Department)