LHC and beyond in 10 minutes

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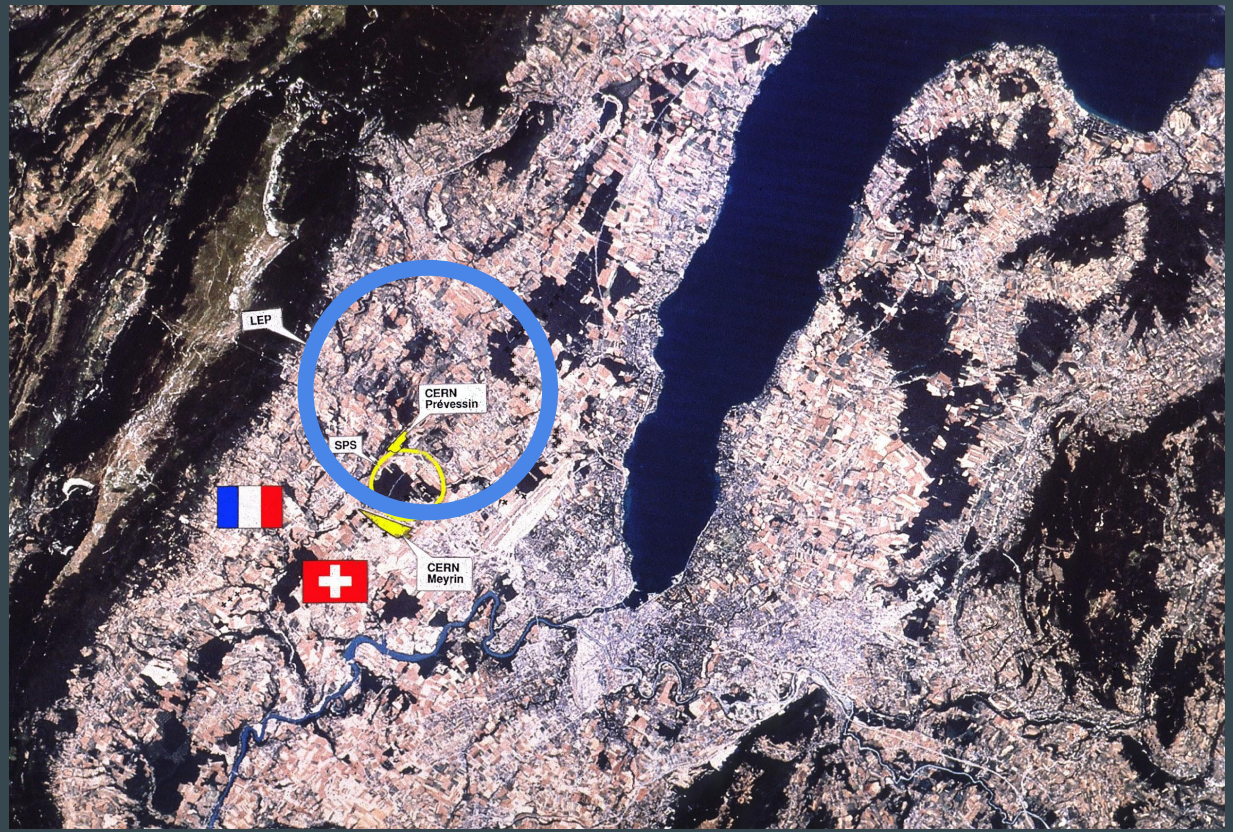
A quick tour

Since my talk is short it contains suggested questions for the Q&A in red as well as answers!

Largest machine in the world!

Border of France/Switzerland



By Geneva, Lake Geneva and the Alps

Underground 27 km tunnel

Installing magnets during 2005

Timeline

- 1954 - CERN founded
- 1984 - Idea for LHC in LEP tunnel (what was LEP?)
- 1992 - ATLAS and CMS “letters of intent”
- 1994 - Project approved
- 2002 - Excavation completed
- 2010 - First scientific results

My interests

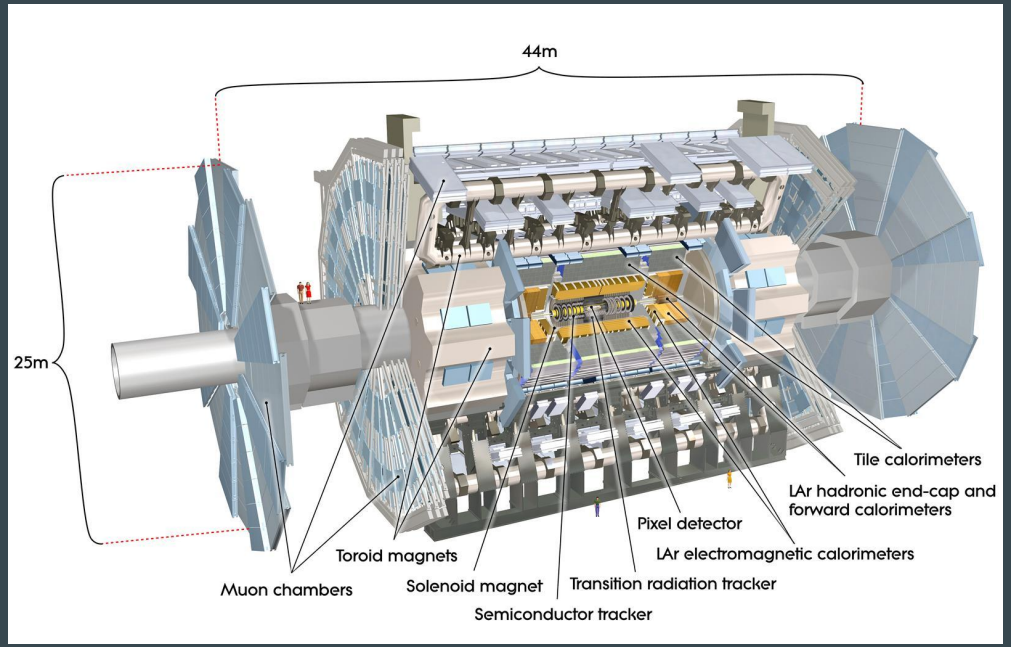
- LHC construction, apparatus, detectors and engineering challenges are interesting
- **But my primary interest is the (potential) scientific results from the LHC**
- **and the implications for so-called new physics**

In a nutshell, what does it do?

- Proton-proton collider at high energy at “crossing points” in a circular collider (why protons? why a circle?)
- Thousands of huge magnets (~10 m) direct the beams
  - Protons collide at close to the speed of light
  - A proton is a type of hadron - a bound state of 3 three quarks (what holds it together?)
- **High-energy collision produces interesting new particles**
- At the crossing points, huge detectors take “photographs” of the particle produced

What are the detectors?

- E.g. ATLAS detector
- Big! 25 m by 44 m
- Detects products of proton collision
  - General purpose
  - **Ideal for searches for new physics**
- Also: CMS, LHCb and ALICE (Why so many?)
- ATLAS and CMS very similar and interesting to me (Why?)



Great machine. But why? What are the goals?

- Understand nature at the smallest scales!
- Is there a Higgs boson? (yes!)
- Is it as expected?
- Can we confirm the Higgs mechanism?
- Is nature supersymmetric?
- Are there large extra dimensions?
- Are there any as yet unknown forces?
- Is there anything unexpected? Uncharted territory!

Ask many questions on these topics!

Major successes (so far)

- "Re-discovered" Standard Model (What's that?)
- **Discovered the Higgs boson**
- Ruled-out many scenarios of new physics

Higgs boson discovery

- Higgs is particle predicted by Peter Higgs in the 1960s
- LHC made Higgs bosons in proton collisions
- Higgs bosons decayed to e.g. two photons
- “Needle in a haystack” - found interesting Higgs boson decays in amongst millions of boring “background” data
- **Huge significance for theory (ask about it)**
- Huge experimental challenge (ask about it)

Hopes and fears for run-2

- Run-1 collided protons with 8 TeV energy (TeV is a unit of energy, like the Joule, ask about it)
- This year, run-2 began at 13 TeV. What can it do?
- Measure properties of Higgs with high precision
- Hope: Find something unusual about the Higgs
- Fear: Find that Higgs is as expected
- Hope: Discover new physics e.g. supersymmetry
- Fear: Exclude new physics e.g. supersymmetry (why do theorists have this outlook?)

The Future

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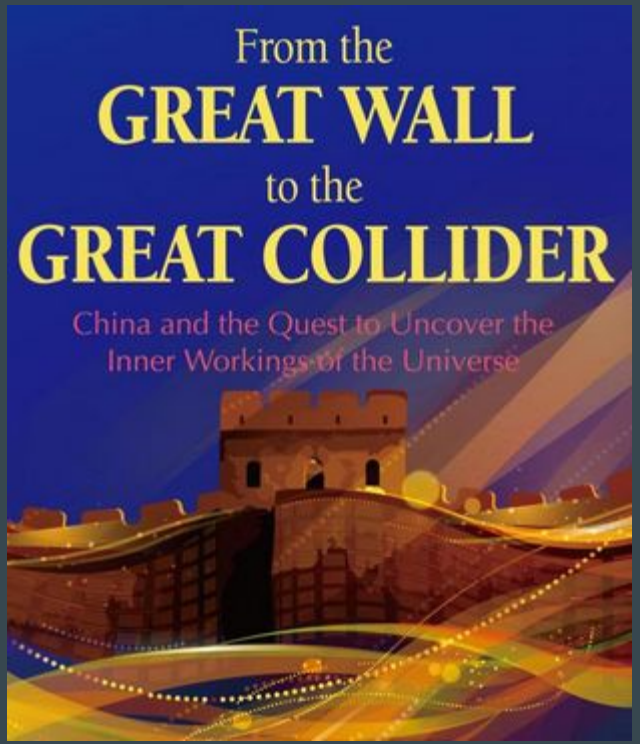
Since I am speaking to young people, I must say something about the future

Very LHC? 100 TeV? A Higgs machine?

- We must think about physics beyond the LHC
- What collider do we want?
  - Electron-electron “Higgs factory?” (what’s that?)
  - 100 TeV “SUSY machine”?
- Do we have the technology?
- What is best for learning about physics?

Possibilities

- “Great Collider” of China
  - Circular proton collider
  - 100 TeV 100 km
- “Higgs factory” in Japan
  - Other sites possible
  - Linear electron collider
- VLHC or LEP-3 at LHC site



- LHC took decades from idea to scientific results
- Next collider could be your job