CERN Roadshow in Finland - 6 April 2017

Opportunities in CERN experiments → Examples from CMS and CLOUD

Antti Onnela
CERN – Experimental Physics department – Detector Technologies group

https://events.hip.fi/cernroadshowinfinland/

Outline

- Upgrade of the CMS experiment
  - Ready by 2025
  - Major investments – and many opportunities – through the next 8 years

- CLOUD experiment
  - Outside of high-energy physics

CMS upgrade

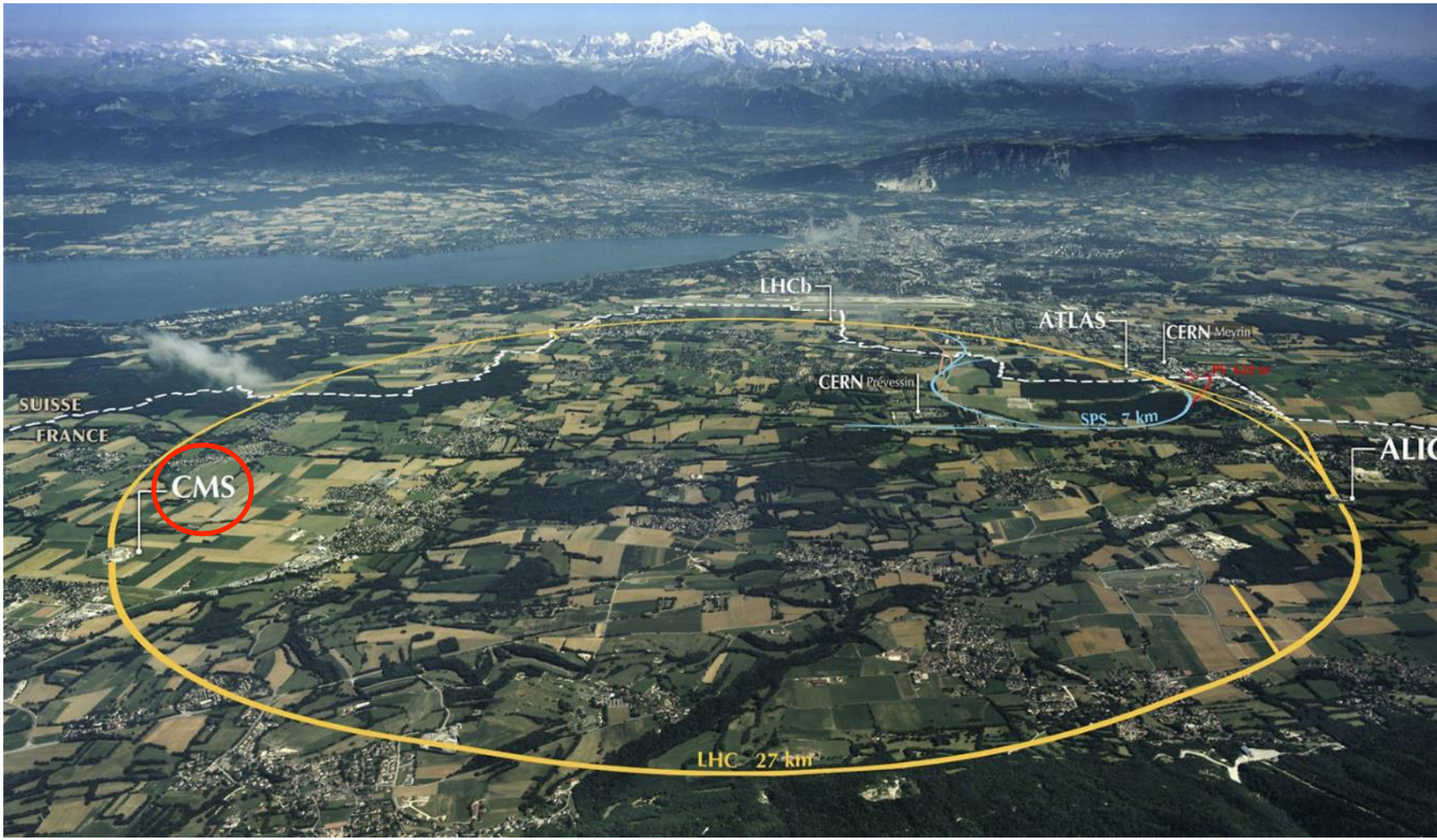
CMS upgrade

S was ready in 2008.
gned for 10 years of LHC
ration, which will be
ched in 2023.

t upgrades being done,
right now Pixel detector
acement – with major
ish involvements (HIP,
acam).

h luminosity LHC in 2026.
higher intensity of
icles than in LHC.

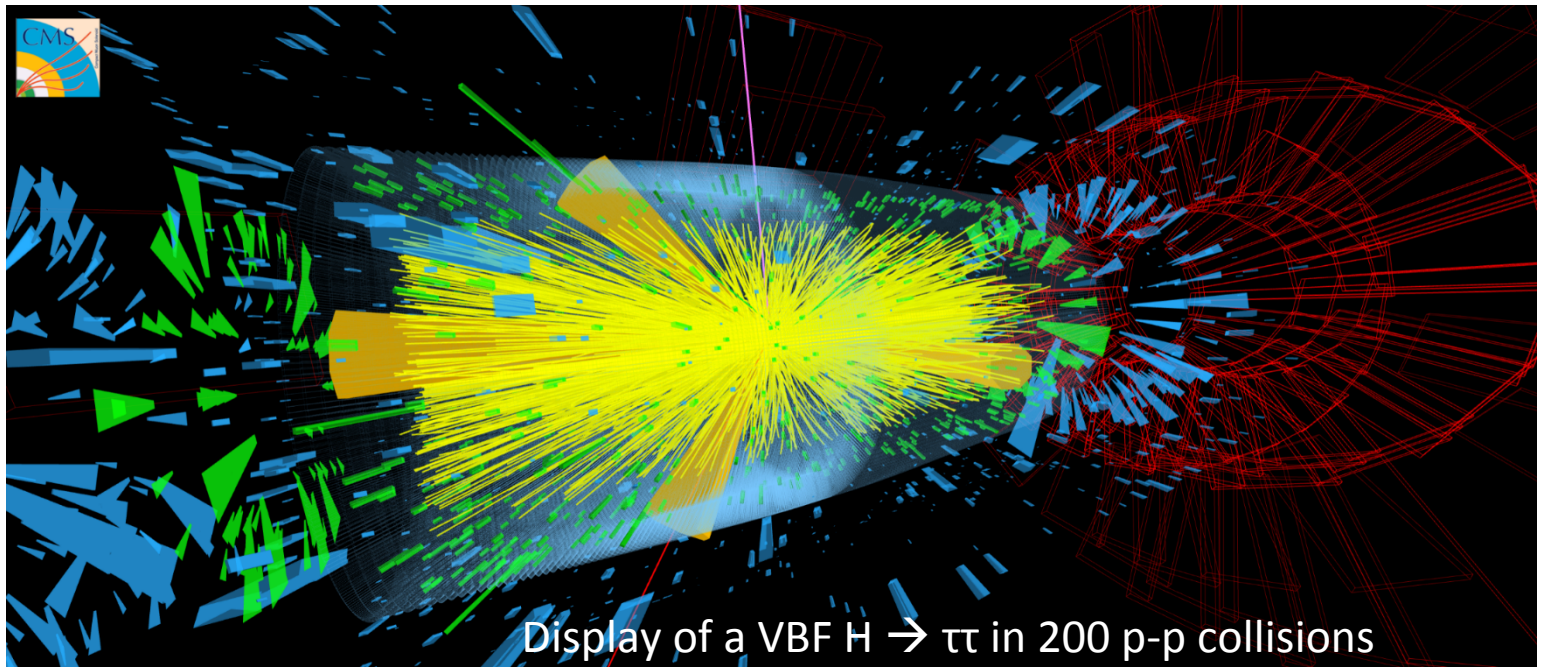
S, like other LHC
eriments, need to have
ajor upgrade.



CMS Upgrade

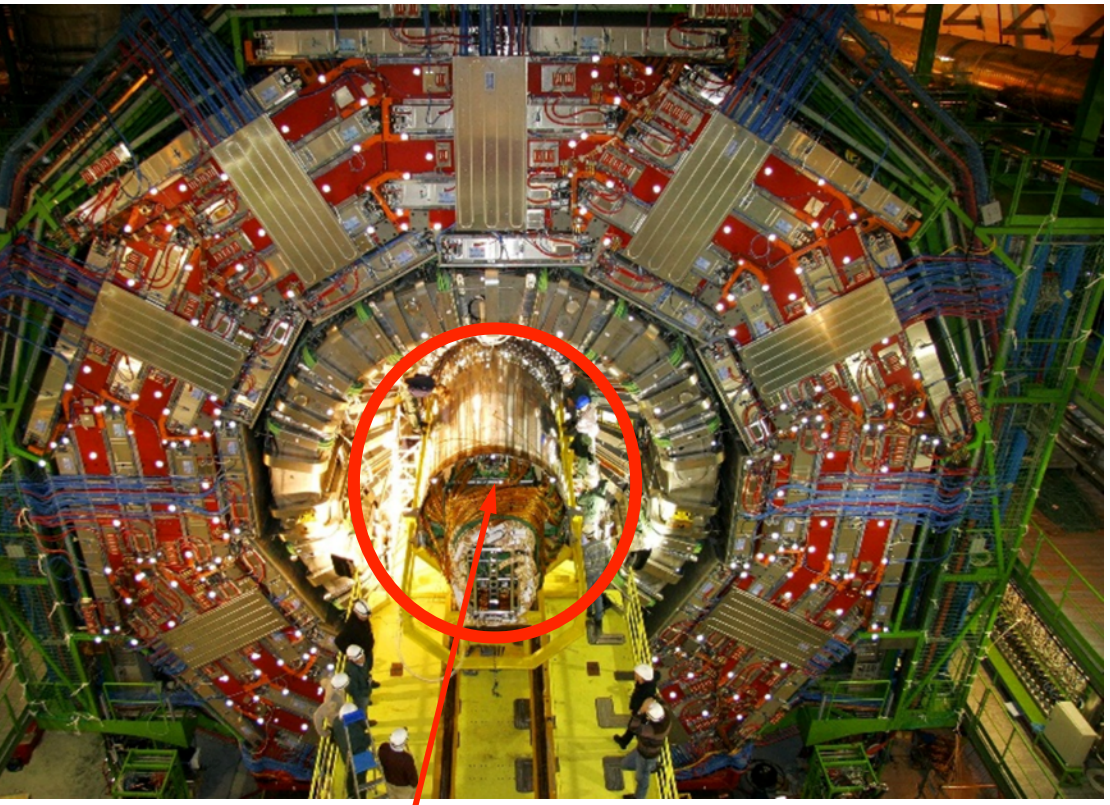
Goal: Maintain and improve physics performance at 10x higher luminosity

- More radiation hard detectors → survive in the harsh radiation conditions.
- Lighter detectors and structures next to interaction point → better physics.
- Better read-out → handle higher data rates.

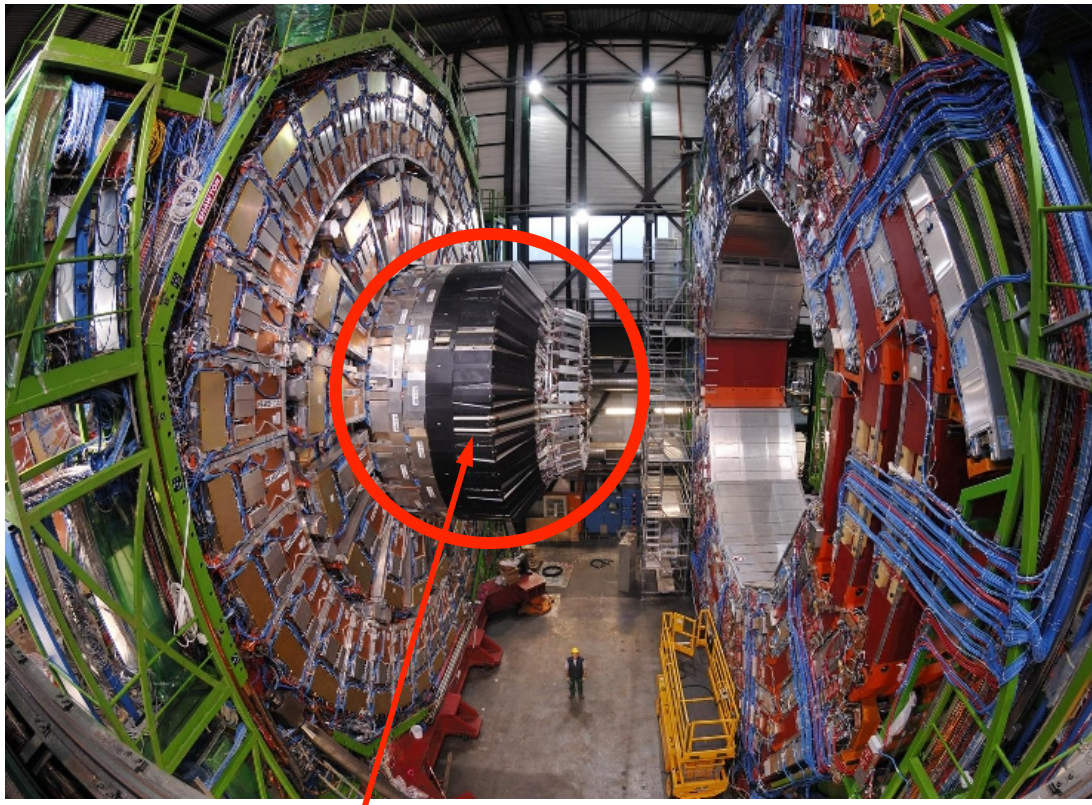


Display of a VBF H → ττ in 200 p-p collisions

CMS upgrade: Main items



Tracker to be replaced

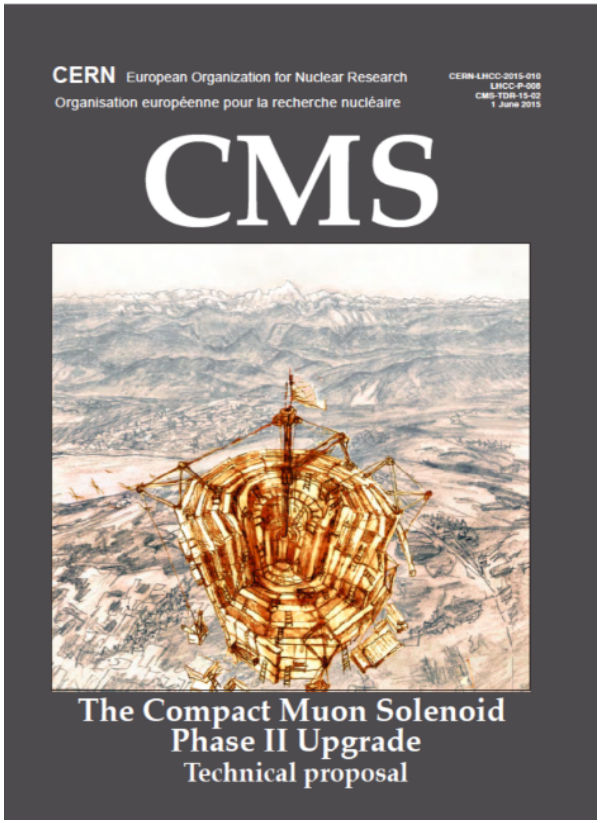


End-cap calorimeters (2x) to be replaced

CMS Upgrade: Cost estimate

1 CHF ≈ 0.9 Euro

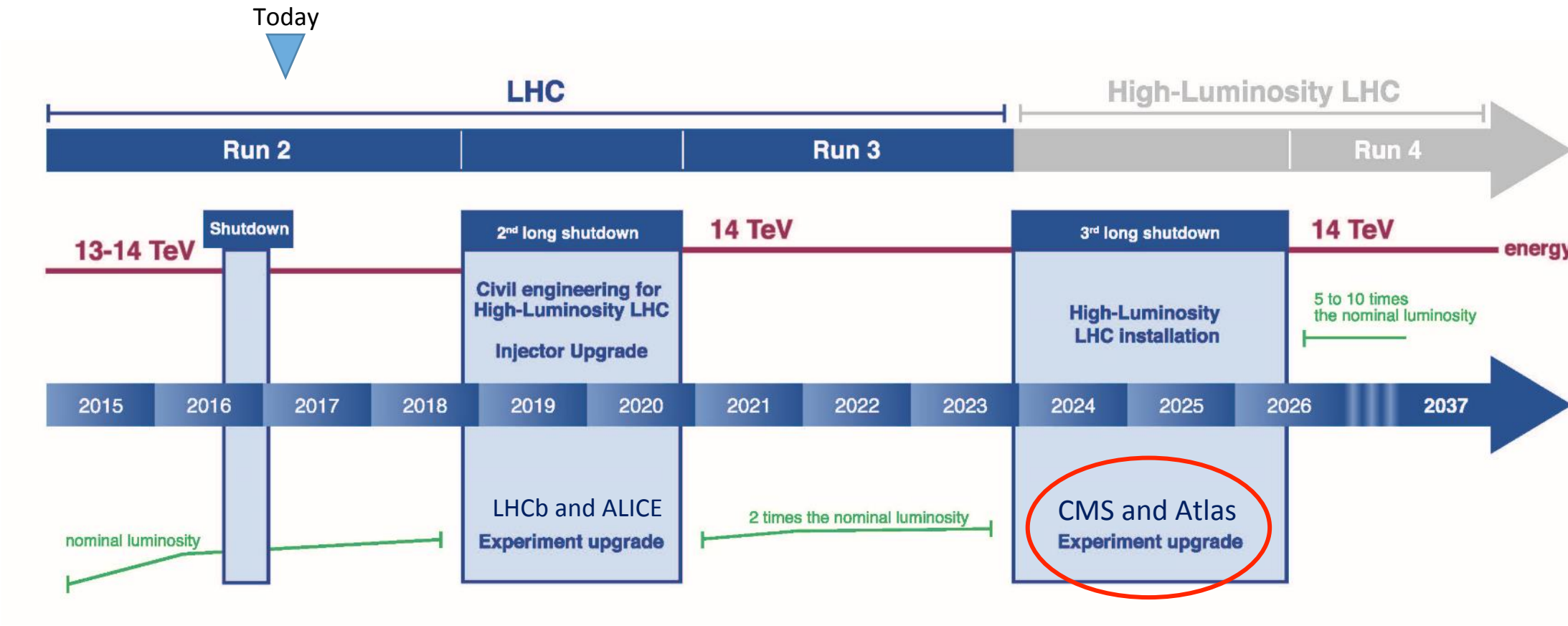
CORE cost estimate	MCHF (2014)
Pixel Detector	23
Outer Tracker	89
Tracking System	**112**
EB electronics	10
HB scintillators	1
Endcap HGC+BHE	64
Calorimeters	**75**
DT and CSC electronics	10
Muon stations:GE11,GE21, RP31 and RP41	10
Muon extension ME0	5
Muon Systems	**25**
Beam Monitors and Luminosity	**4**
L1 Trigger	7
HLT	11
DAQ	6
Trigger and DAQ	**24**
Infrastructure, Systems and Support, Installation	**25**
Total	**265**



CORE costs cover materials and services for the production phase of the project.

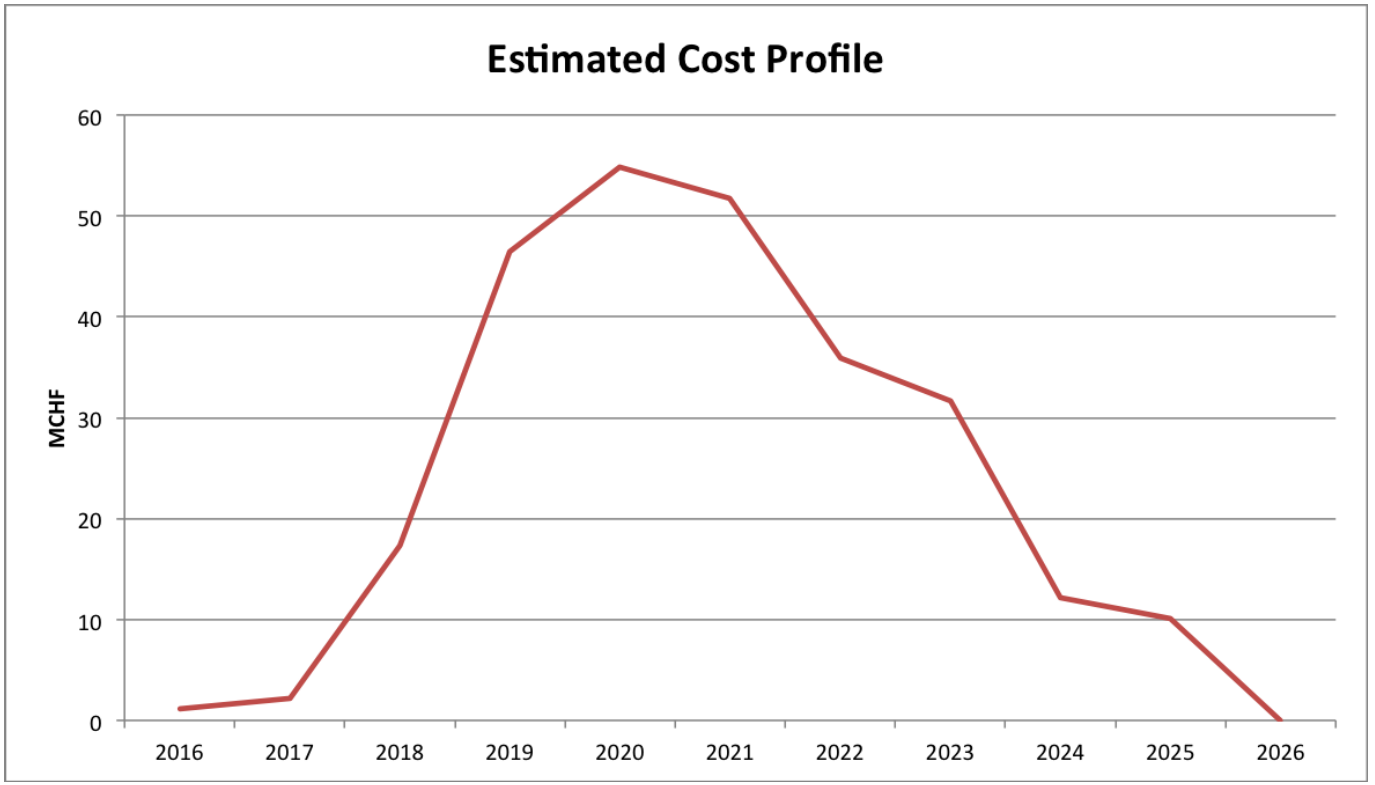
Other costs (not in CORE): R&D and prototype costs for the design development; infrastructure, facility and personnel costs at CMS institutions; maintenance.

Upgrading of CERN's main accelerators and experiments



Concepts, R&D → Design, protos → Production → Installation

CMS upgrade: Cost profile (CORE)

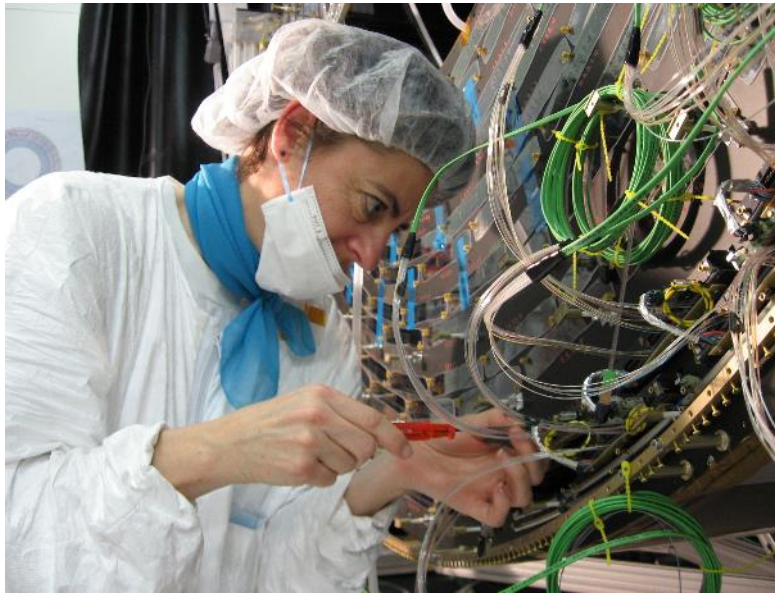


Now there is still time to join !

In addition: Further costs on R&D, prototypes and engineering, not counted in these CORE costs.

CMS upgrade: What and who is involved?

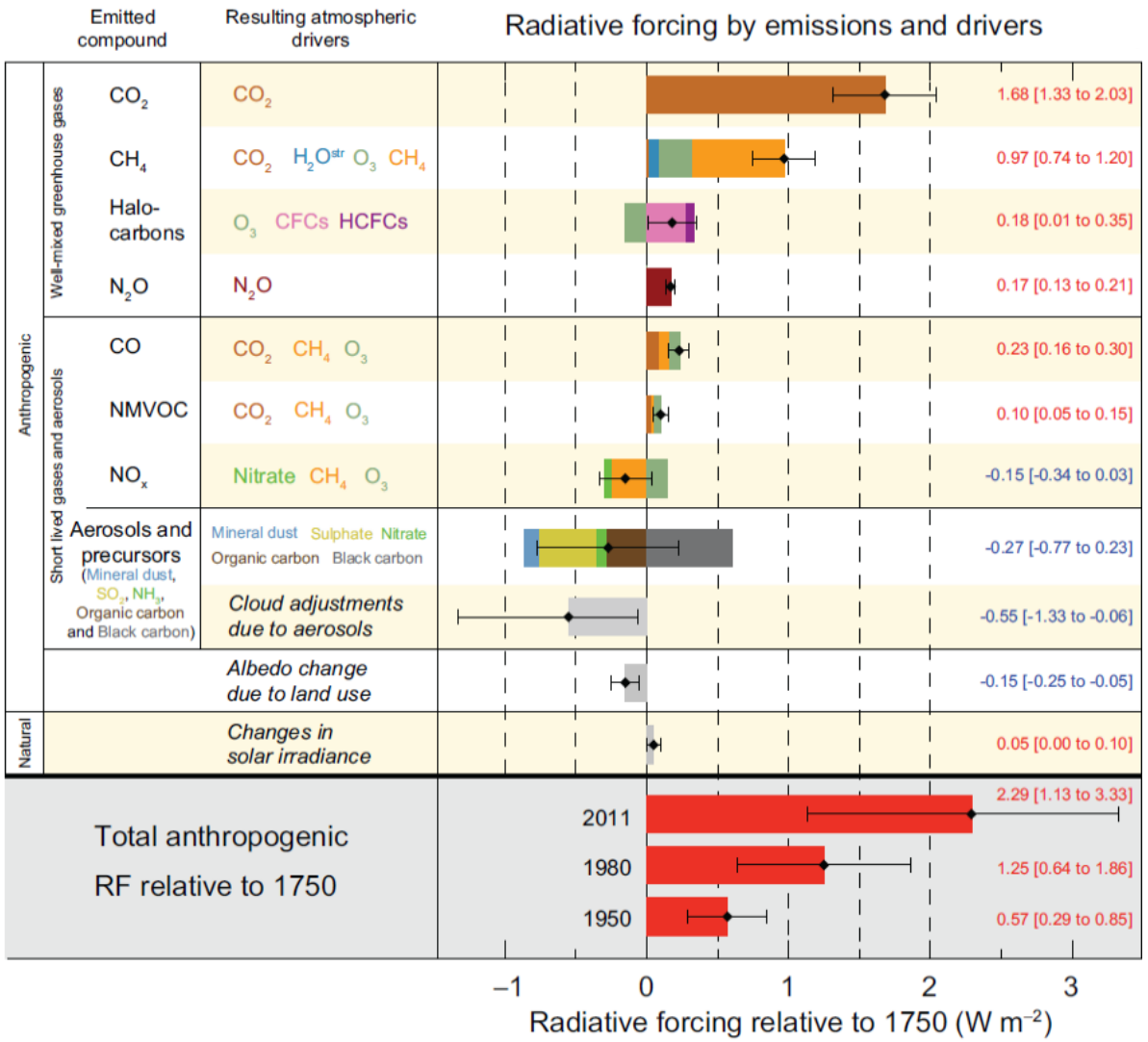
- Wide range of fields involved, from semiconductor detectors and electronics to mechanics and software.
- Production in industry and collaborating institutes (components, sub-assemblies) and at CERN (final assemblies).
  - Opportunities for product and methods development, expanding of know-how.
- In addition to physicists, many engineers and technicians needed.
  - Professional opportunities on leading edge technologies.
  - Training opportunities at CERN and in institutes.



- More info:
  - www.hip.fi, CMS Programme and CMS Upgrade
  - https://cms.cern/detector
  - https://jobs.web.cern.ch/
  - http://procurement.web.cern.ch/en

2nd example of opportunities: CLOUD, outside of high-energy physics

Why CLOUD?



What influences climate changes?

This graph shows radiative forcing on Earth's atmosphere.

Source: IPCC, Summary for Policymakers, 201

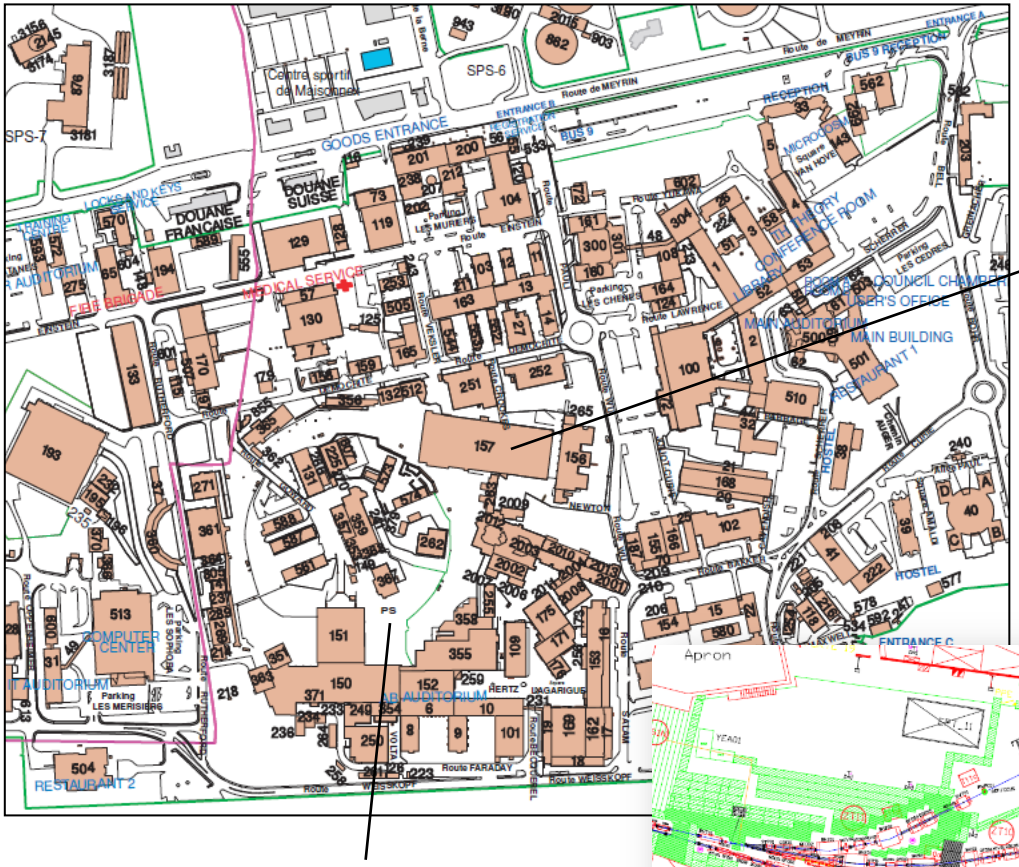
A. **Anthropogenic aerosol forcing are poorly understood.**

B. Natural part is very small.
Is there a missing natural forcing?
Is that from varying cosmic ray flux, modulated by sun?

A + B → The CLOUD experiment

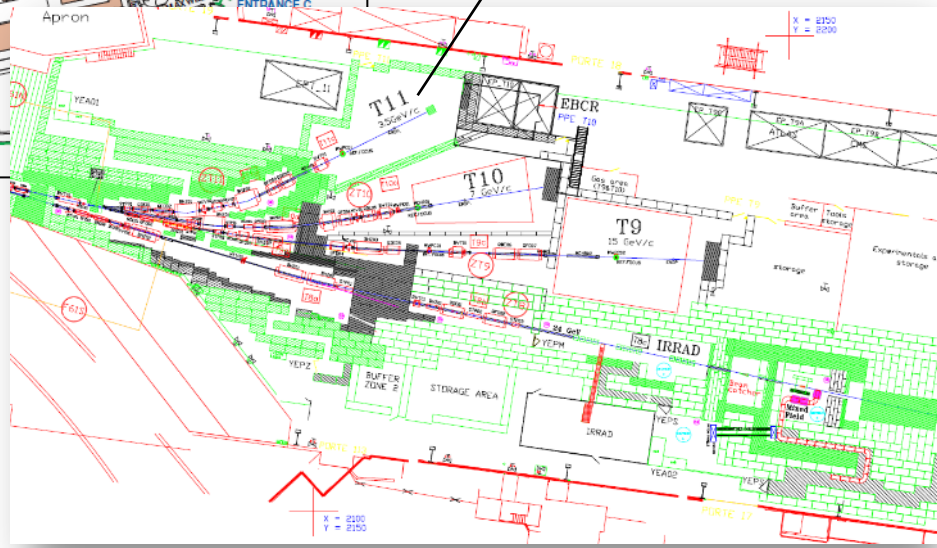
Why at CERN?

- Controlled ‘cosmic rays’
- Beam from PS
  - Low energy beam, limited interest to high-energy physics.
- Existing CERN know-how is very useful!
  - Ultra-clean surfaces and gas systems
  - Vacuum
  - Thermal control
  - Radioactive sources
  - Etc.

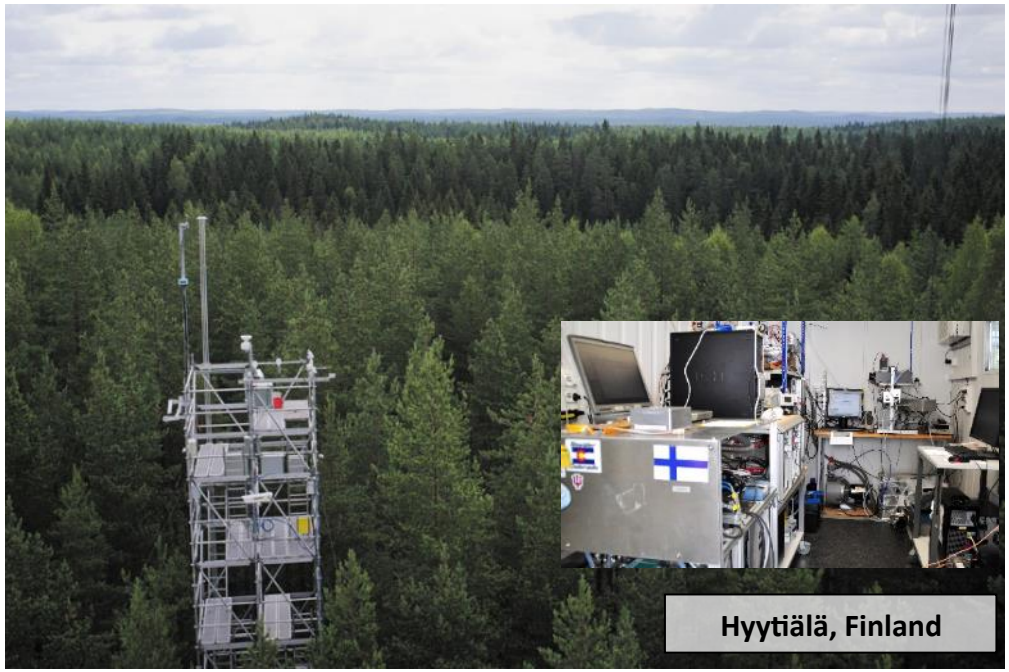


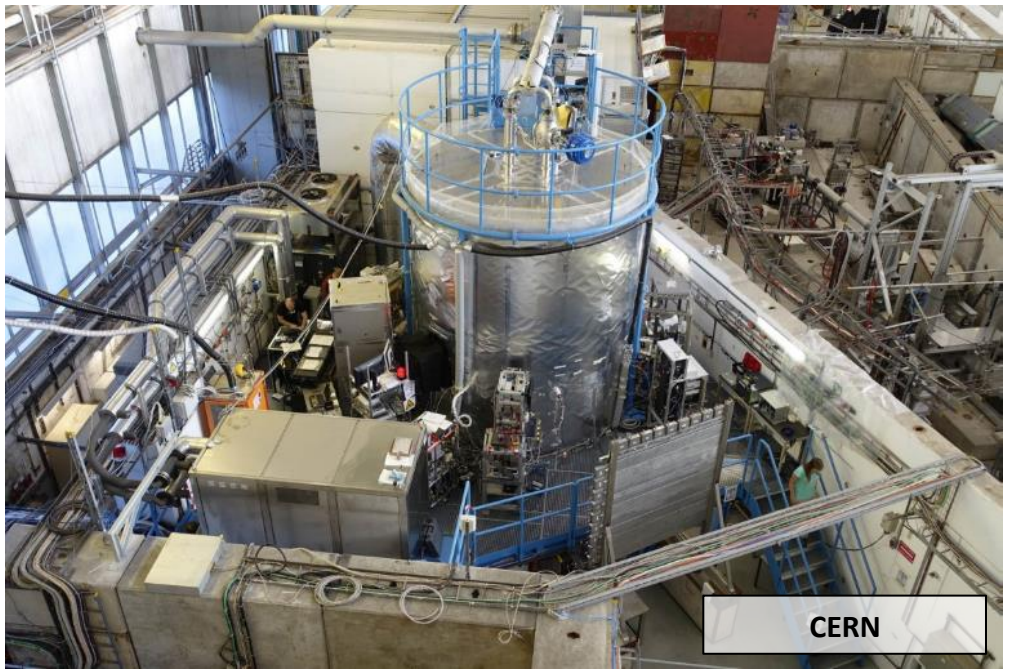
Proton Synchrotron (PS) accelerator
first operation in 1959 !

T11 beam
(3.5 GeV/c)



Close links between field measurements and CLOUD





Example of measurements at CLOUD:
Recreating of boreal forest conditions, to understand the observed aerosol particle nucleation and growth.

- More info:
  - www.hip.fi, CLOUD experiment
  - https://home.cern/about/experiments/cloud

Aerosol and atmospheric know-how from participating institutes

Finnish institutes in leading roles.

Opportunities for scientists from wide range of fields (aerosols, atmospherics, chemistry, etc.)

LETTER

25 AUGUST 2011 | VOL 476 | NATURE | 429

doi:10.1038/nature10343

Role of sulphuric acid, ammonia and galactic cosmic rays in atmospheric aerosol nucleation

Jasper Kirkby[1], Joachim Curtius[2], João Almeida[2,3], Eimear Dunne[4], Jonathan Duplissy[1,5,6], Sebastian Ehrhart[2], Alessandro Franchin[5], Stéphanie Gagné[5,6], Luisa Ickes[2], Andreas Kürten[2], Agnieszka Kupc[7], Axel Metzger[8], Francesco Riccobono[9], Linda Rondo[2], Siegfried Schobesberger[5], Georgios Tsagkogeorgas[10], Daniela Wimmer[2], Antonio Amorim[3], Federico Bianchi[9,11], Martin Breitenlechner[8], André David[1], Josef Dommen[9], Andrew Downard[12], Mikael Ehn[5], Richard C. Flagan[12], Stefan Haider[1], Armin Hansel[8], Daniel Hauser[8], Werner Jud[8], Heikki Junninen[5], Fabian Kreissl[2], Alexander Kvashin[13], Ari Laaksonen[14], Katrianne Lehtipalo[5], Jorge Lima[3], Edward R. Lovejoy[15], Vladimir Makhmutov[13], Serge Mathot[1], Jyri Mikkilä[5], Pierre Minginette[1], Sandra Mogo[3], Tuomo Nieminen[5], Antti Onnela[1], Paulo Pereira[3], Tuukka Petäjä[5], Ralf Schnitzhofer[8], John H. Seinfeld[12], Mikko Sipilä[5,6], Yuri Stozhkov[13], Frank Stratmann[10], Antonio Tomé[3], Joonas Vanhanen[5], Yrjo Viisanen[16], Aron Vrtala[7], Paul E. Wagner[7], Hansueli Walther[9], Ernest Weingartner[9], Heike Wex[10], Paul M. Winkler[7], Kenneth S. Carslaw[4], Douglas R. Worsnop[5,17], Urs Baltensperger[9] & Markku Kulmala[5]

CLOUD institutes:

Austria:	University of Innsbruck
	University of Vienna
Finland:	Finnish Meteorological Institute
	Helsinki Institute of Physics
	University of Eastern Finland
	University of Helsinki
Germany:	Johann Wolfgang Goethe University Frankfurt
	Karlsruhe Institute of Technology
	Leibniz Institute for Tropospheric Research
Portugal:	University of Beira Interior
	University of Lisbon
Russia:	Lebedev Physical Institute
Switzerland:	CERN
	Paul Scherrer Institut
United Kingdom:	University of Manchester
	University of Leeds
United States of America:	California Institute of Technology

First major p
5 years after
approved in
programme,
2 years after

n full-speed production of leading-edge scientific results!

da et al., *Molecular understanding of amine-sulphuric acid particle nucleation in the atmosphere,* Nature, 2013

nen et al., *Evolution of particle composition in CLOUD nucleation experiments*, Atmospheric Chemistry and 2013

esberger et al., *Molecular understanding of atmospheric particle formation from sulfuric acid and large organic molecules*, PNAS, 2013

bono et al., *Oxidation Products of Biogenic Emissions Contribute to Nucleation of Atmospheric Particles*, 2014

hi et al., *Insight into acid-base nucleation experiments by comparison of the chemical composition of positive, e and neutral clusters*, PNAS, 2014

et al., *Ion-induced nucleation of pure biogenic particles*, Nature, 2016

et al., *The role of low-volatility organic compounds in initial particle growth in the atmosphere*, Nature, 2016

e et al., *Global particle formation from CERN CLOUD measurements*, Science, 2016

These were some quick high-lights on opportunities in CERN experiments.
Thank you for your attention.

Questions?