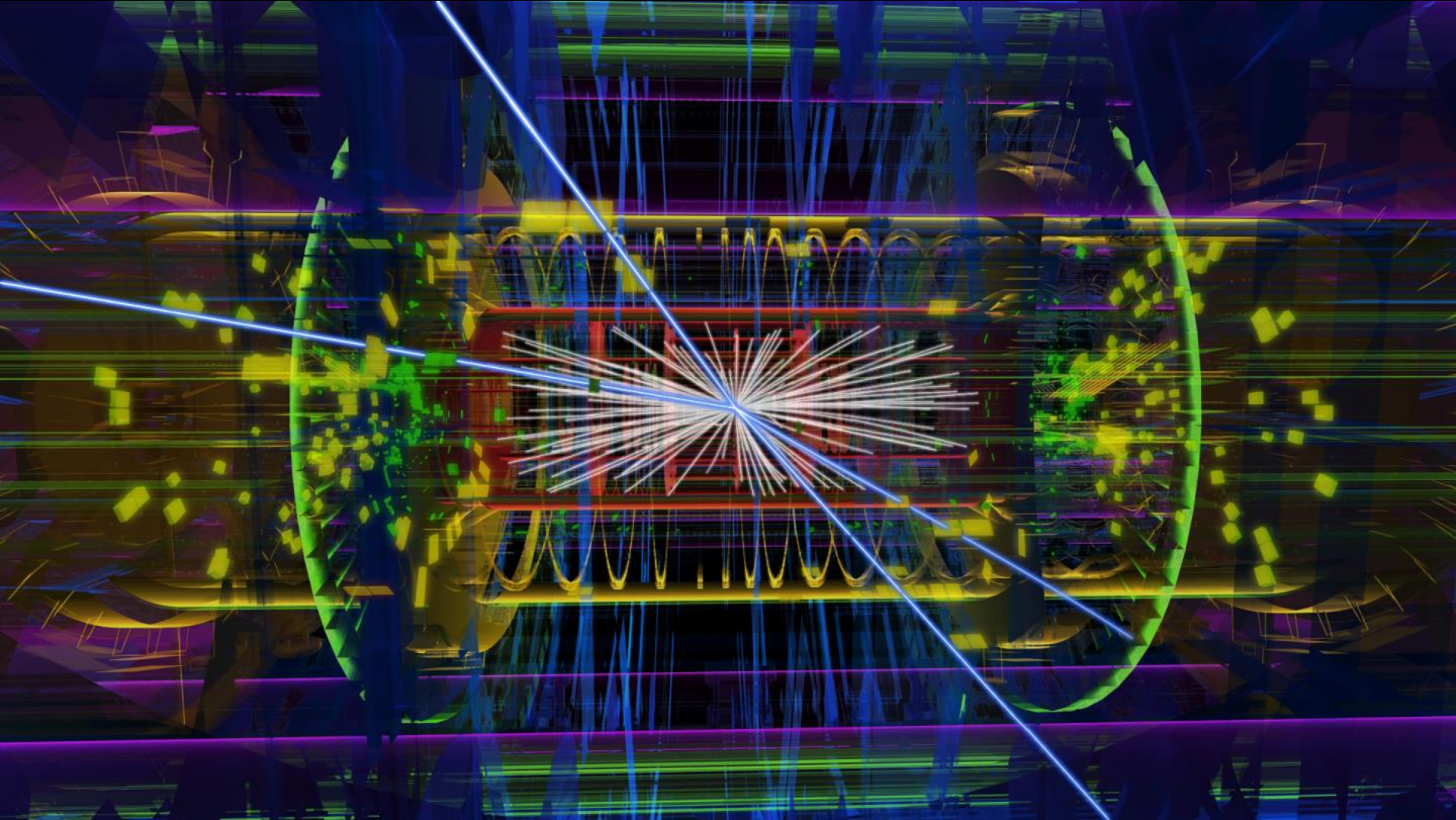
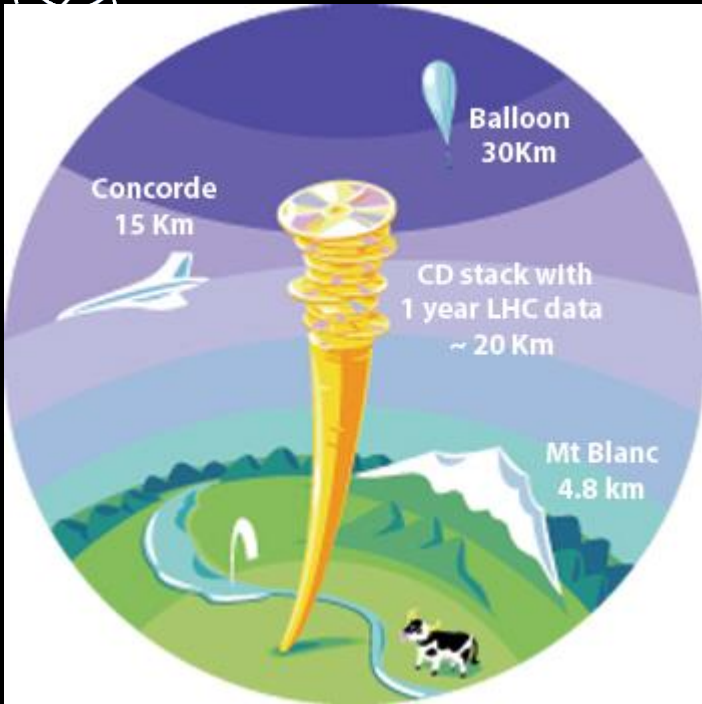


# An Introduction to Engineering at CERN

Ray Veness  
CERN





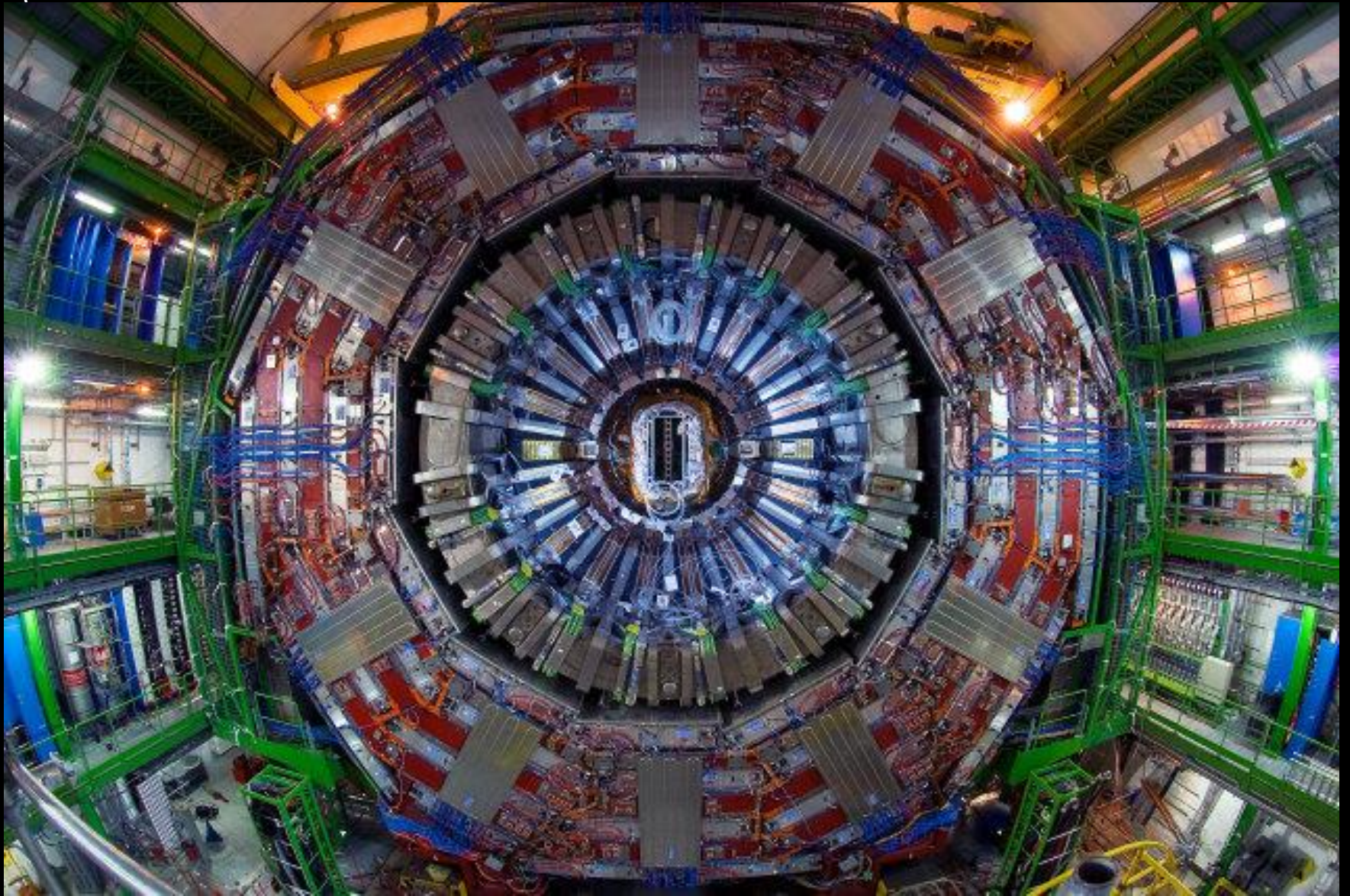
LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors**

Experiments are producing about **25 Million Gigabytes** of data each year (about 3 million DVDs – 850 years of movies!)



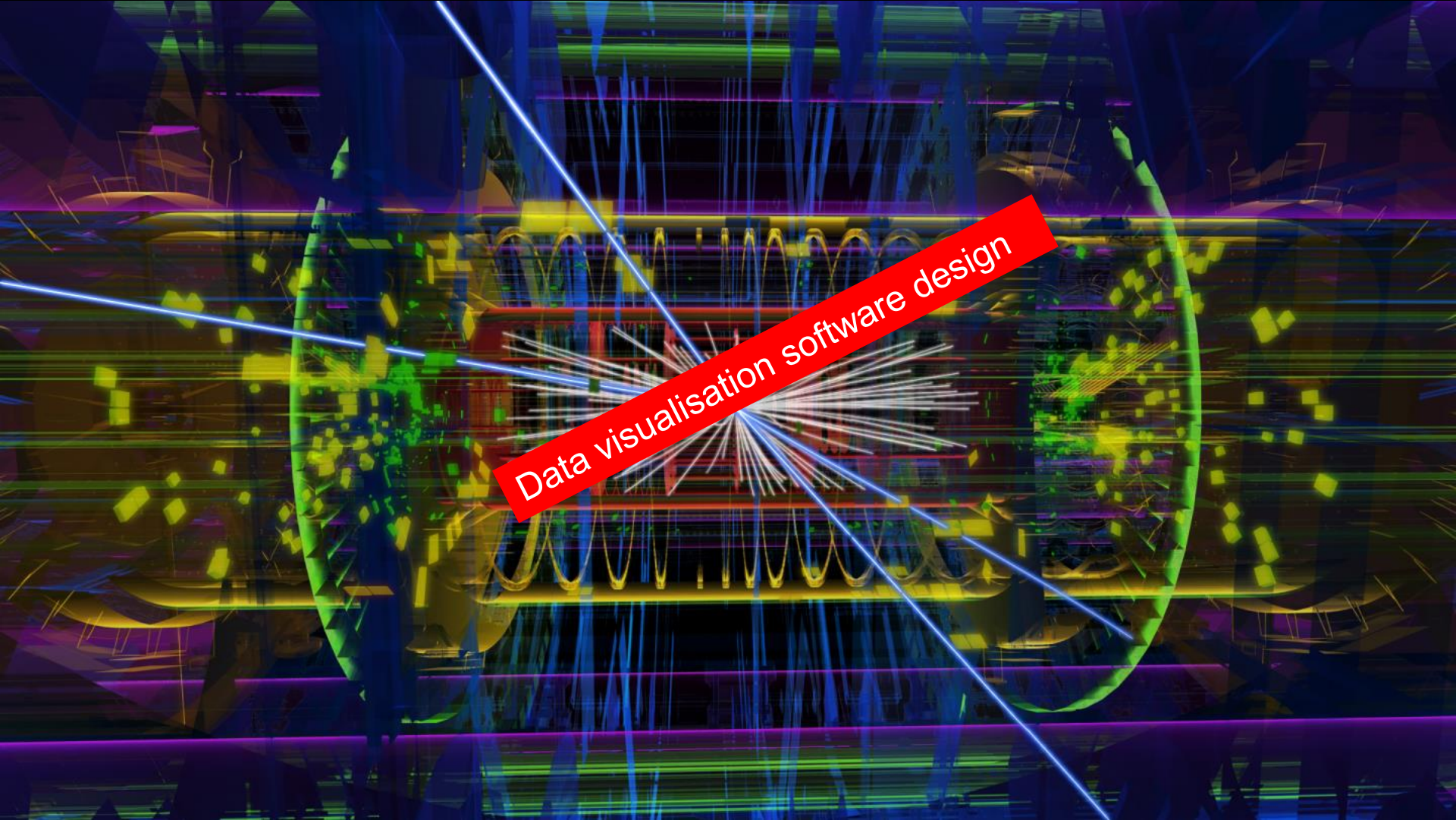
CERN can only provide **~20% of the capacity** the rest is fired around the world by the **LHC computing grid**









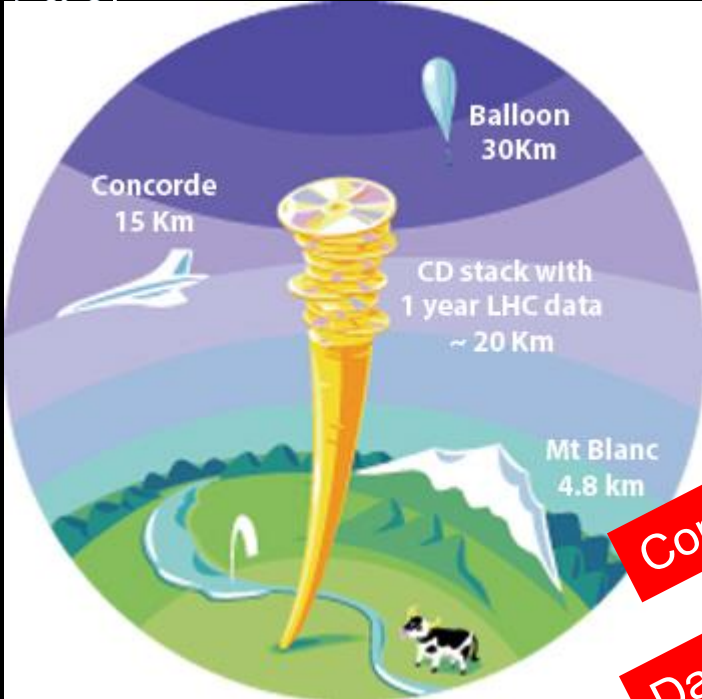


Data visualisation software design





# The LHC Data Challenge



Computer hardware

Databases

Network Infrastructures

Grid computing

LHC data analysis requires a computing power equivalent to 100,000 of today's fastest PC processors

Experiments are producing about **25 Million Gigabytes** of data each year (about 3 million DVDs – 850 years of movies!)

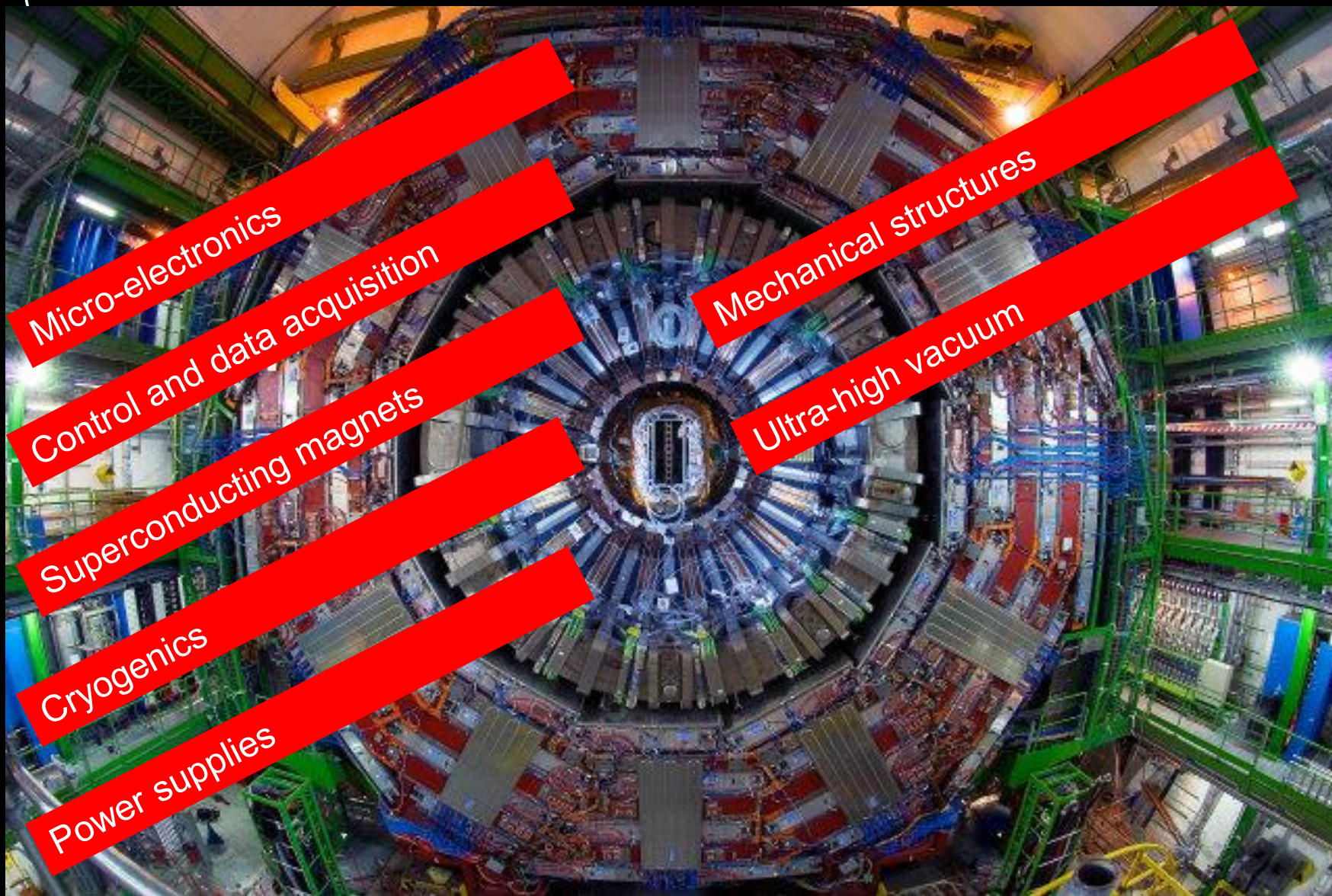


CERN can only provide **~20% of the capacity** the rest is fired around the world by the **LHC computing grid**









Micro-electronics

Control and data acquisition

Superconducting magnets

Cryogenics

Power supplies

Mechanical structures

Ultra-high vacuum

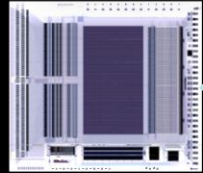




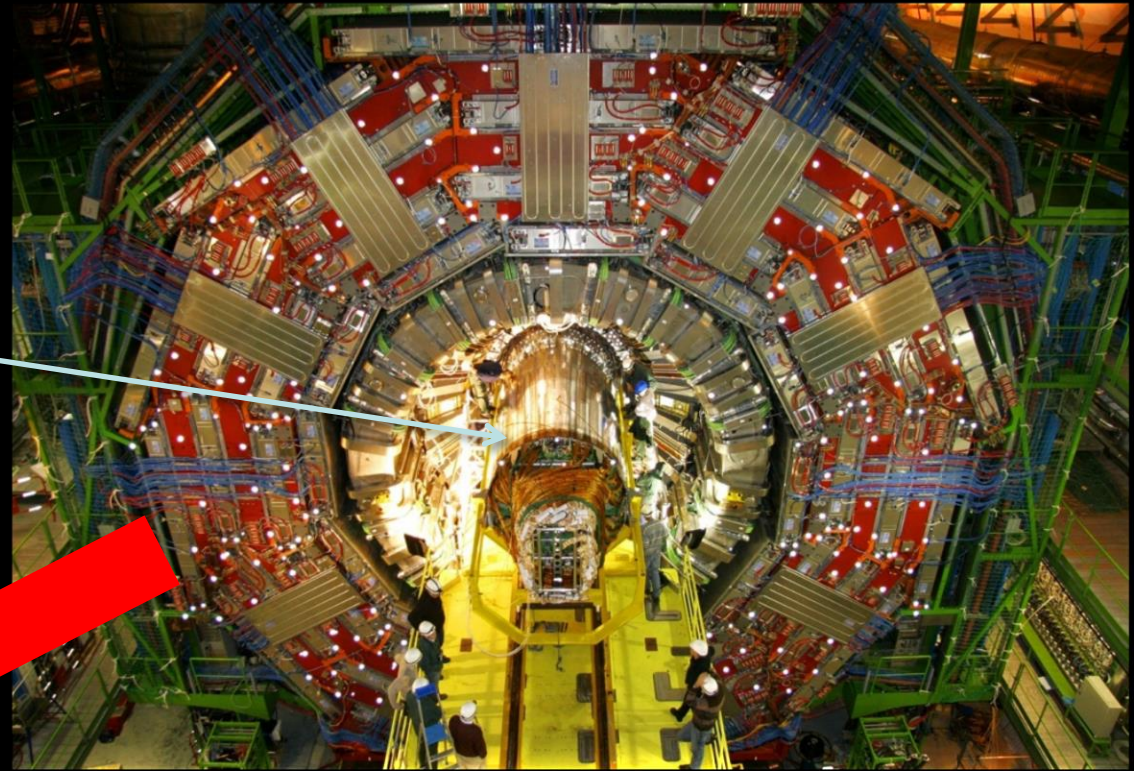
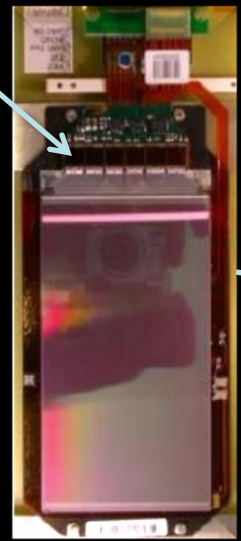
# Microchips for Megastructures

Front-End ASIC

CMS experiment on the LHC accelerator at CERN

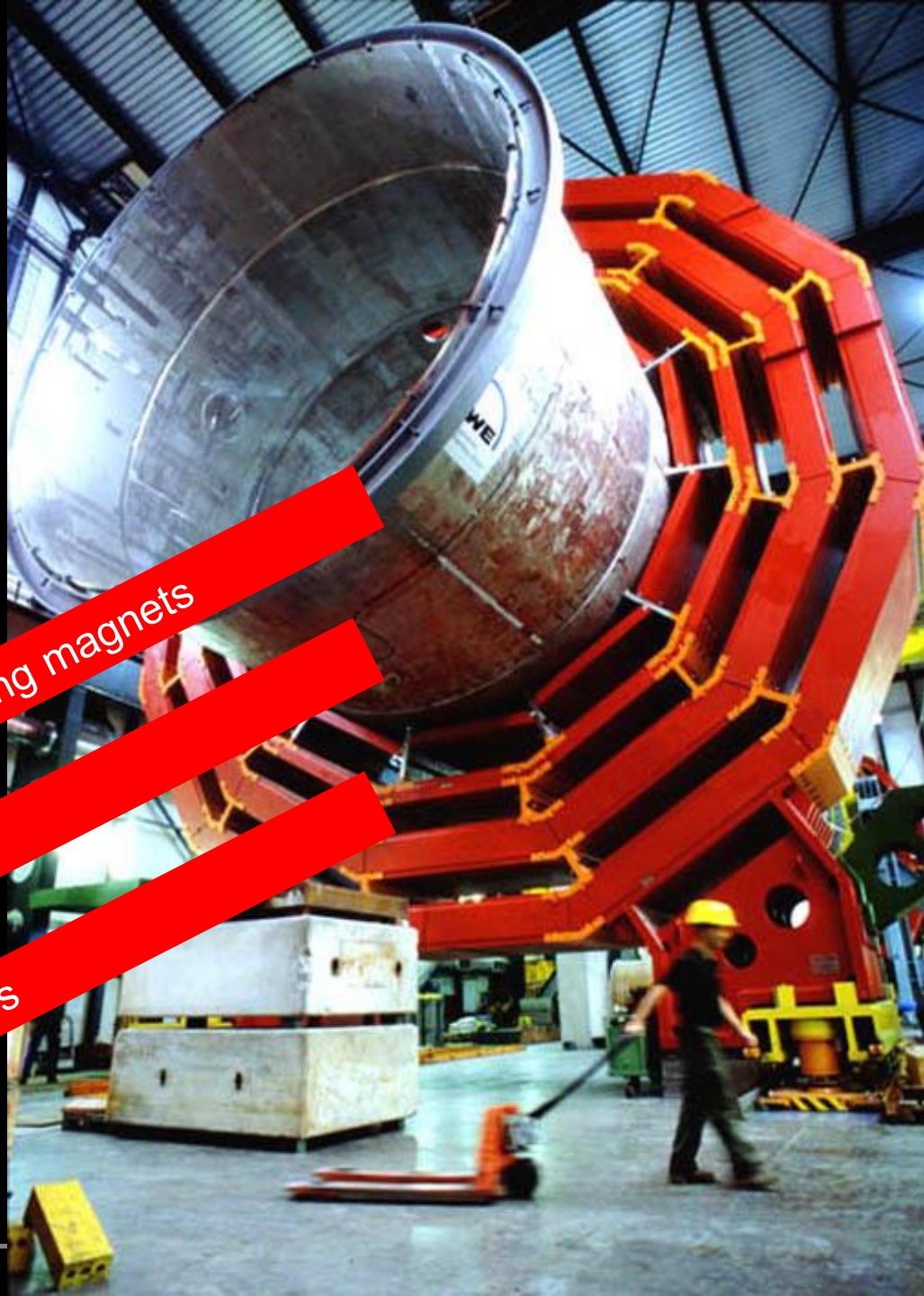


Silicon Tracker Hybrid



Micro-electronics



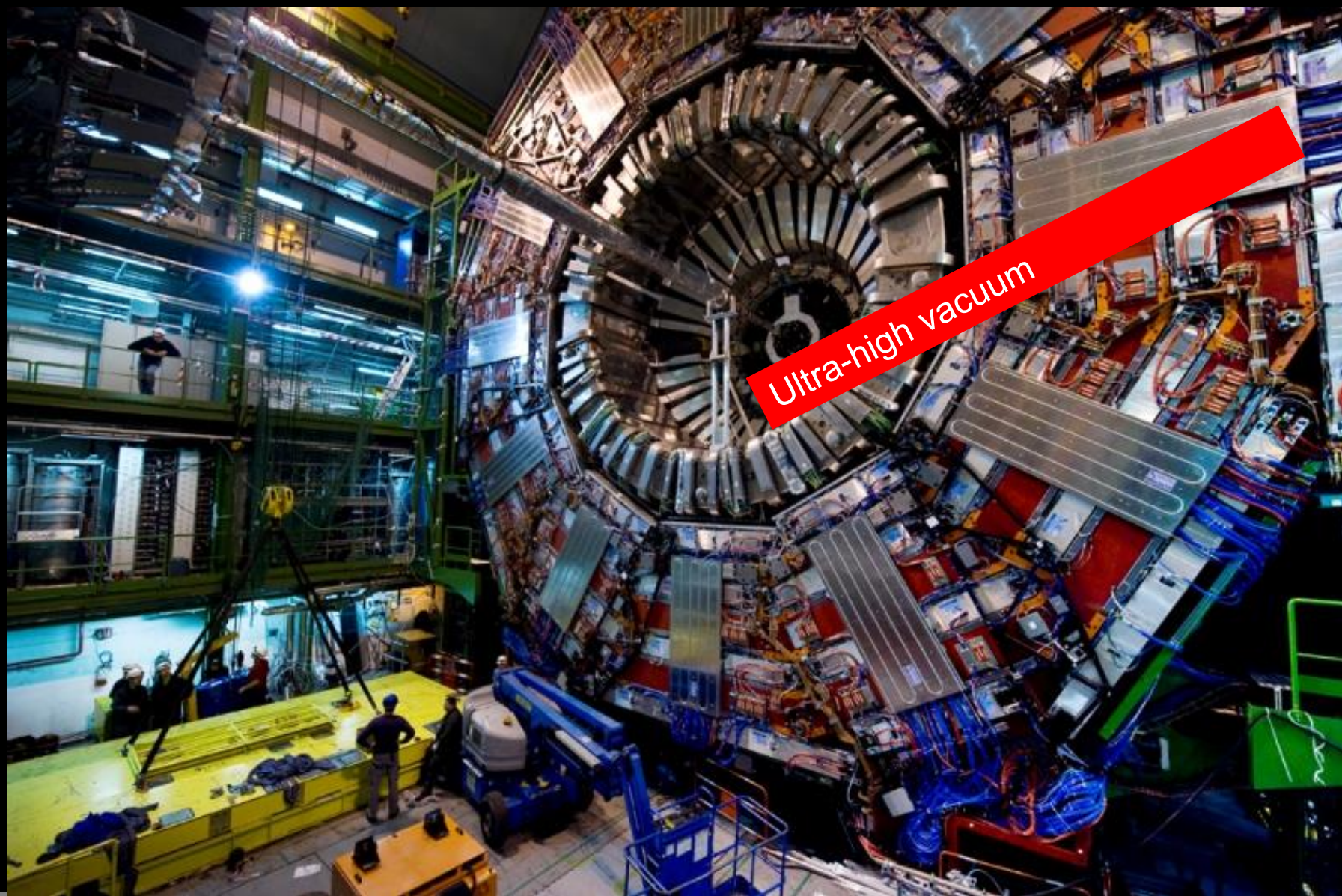


Superconducting magnets

Cryogenics

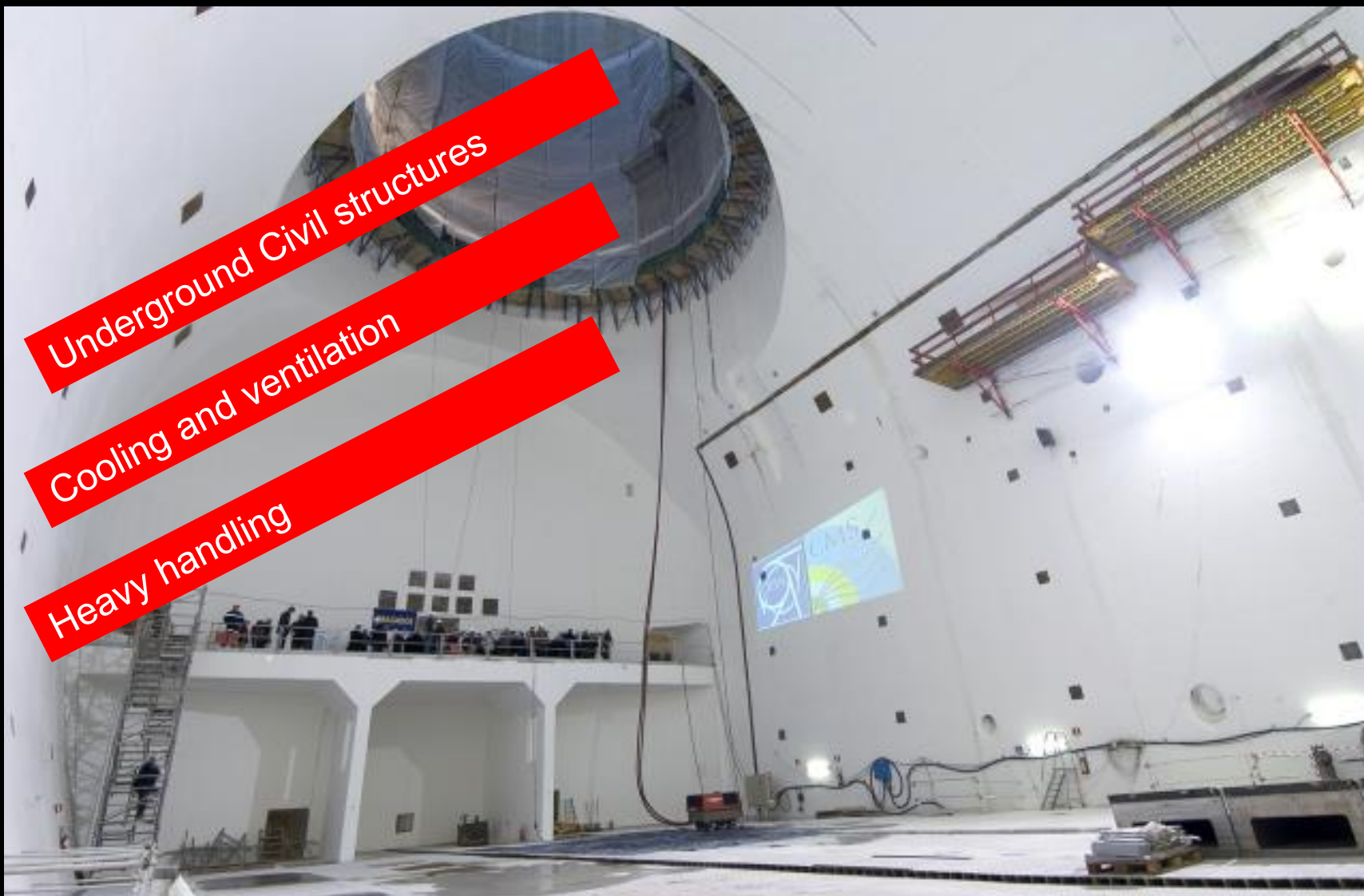
Power supplies





Ultra-high vacuum







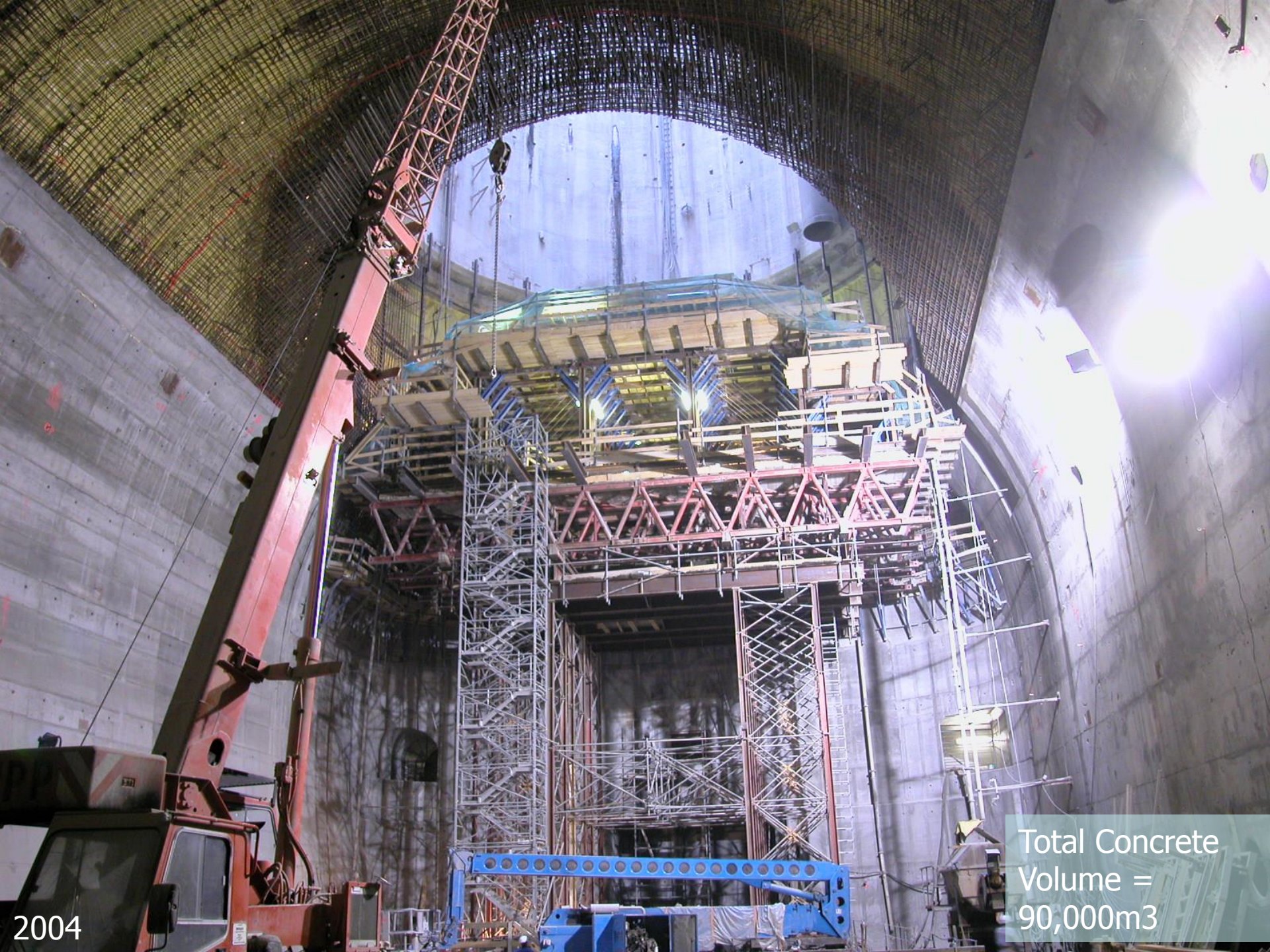


**Point 5 -Excavation commencement of PM54 shaft - July 09, 1999 - CERN ST-CE**









Total Concrete  
Volume =  
90,000m<sup>3</sup>

2004















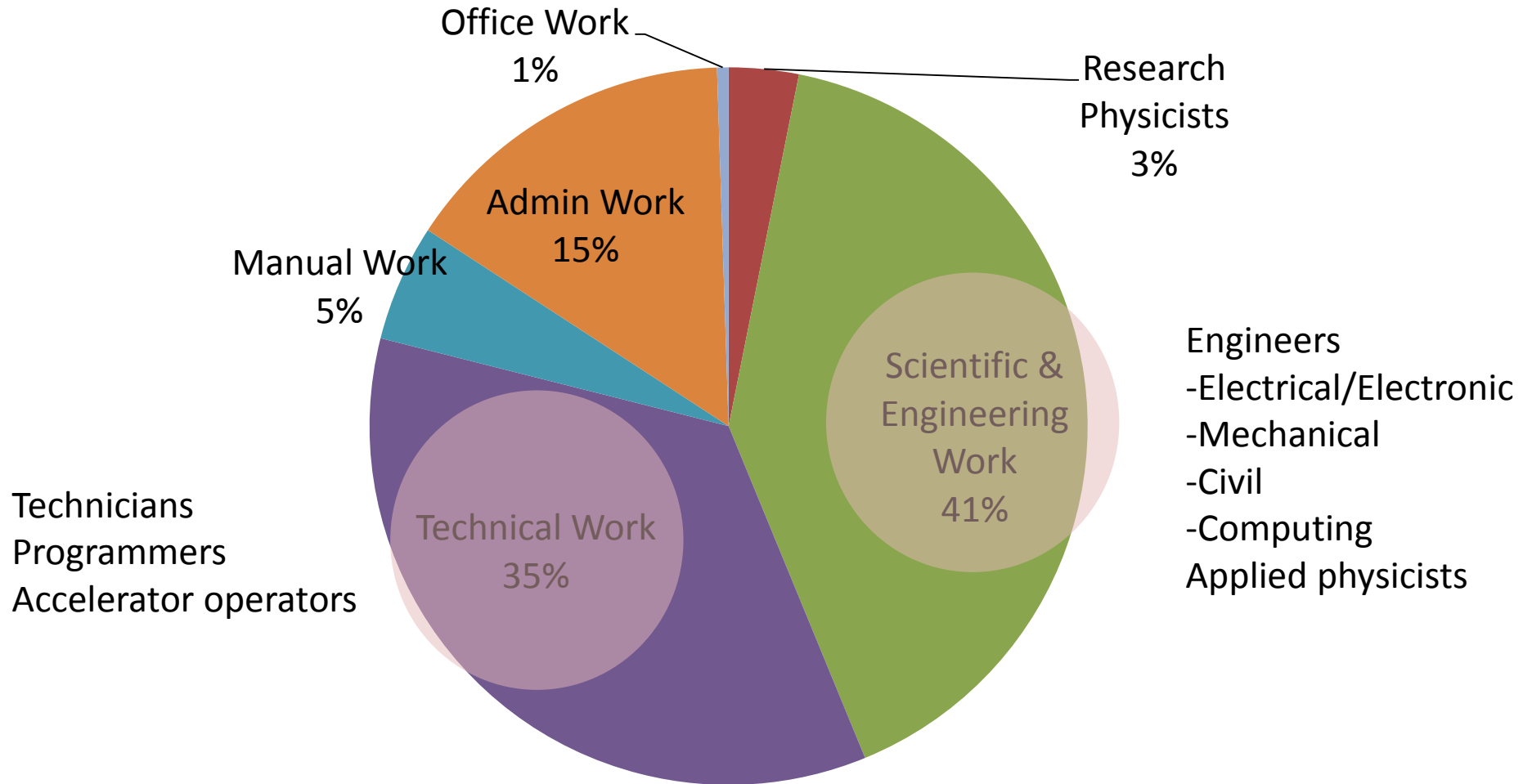


# ROSS

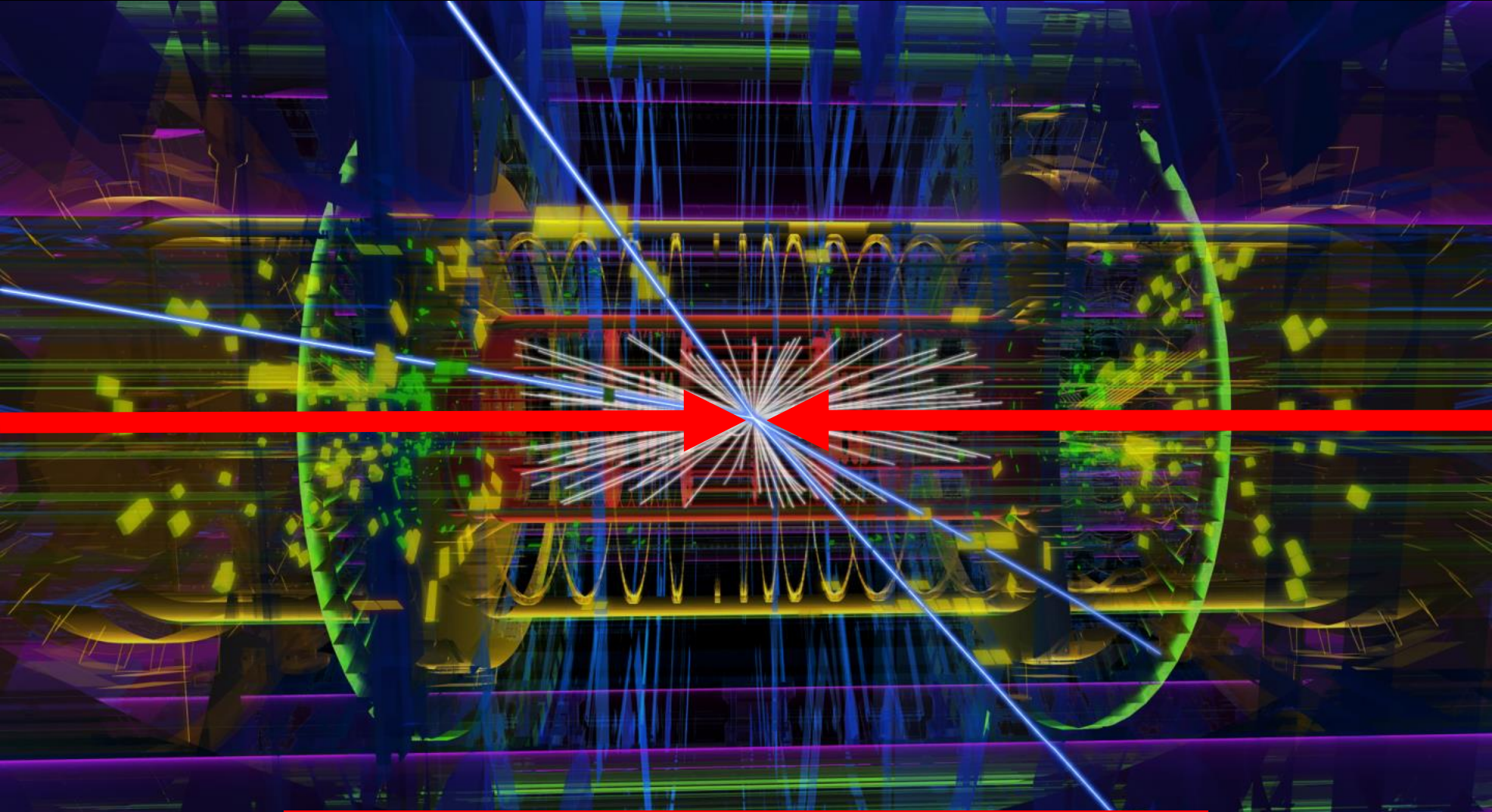
THE BOILER  
ENGINEER



# CERN Staff in 2012

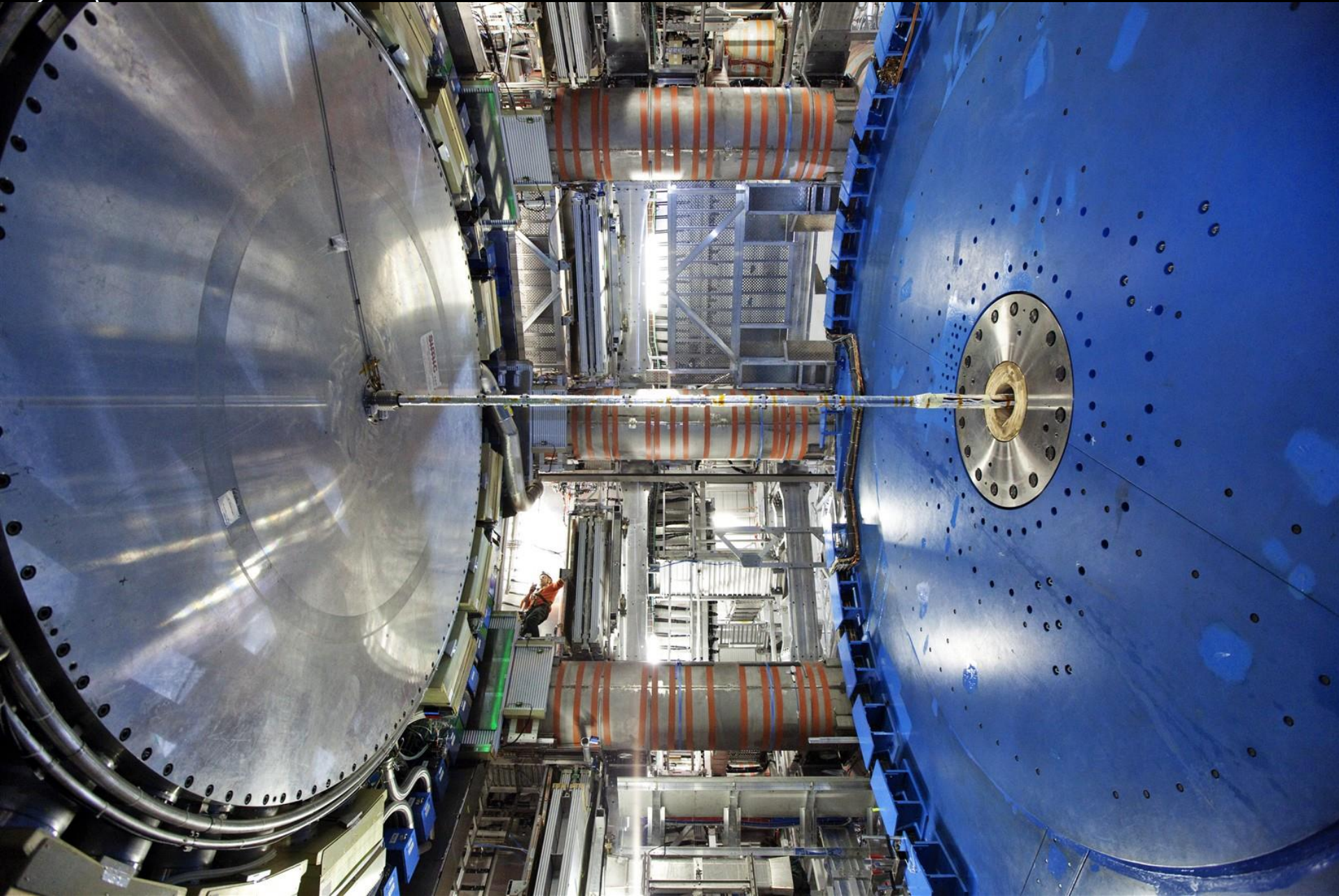






Physics specification for an experimental beampipe :  
Nothing, contained by nothing!









# Nothing, contained by nothing!

Hydrogen is a gas at room temperature!

So is helium...

Lithium explodes in air... not so good

Beryllium... that would be good!

...except that it is pretty hard to get hold of!

Periodic Table of the Elements

|    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |    |    |     |     |     |     |    |    |    |
|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|-----|-----|-----|-----|----|----|----|
| 1  | 2  |    |    |    |    |    |    |    |     |     |     | 10  |     |     |     |     |     |     |     |     |     |     |    |    |    |    |    |     |     |     |     |    |    |    |
| 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |    |     |     |     |     |     |     |     |     |     | 18  |     |     |     |     |    |    |    |    |    |     |     |     |     |    |    |    |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  | 34 | 35 | 36 |    |    |     |     |     |     |    |    |    |
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46  | 47  | 48  | 49  | 50  | 51  | 52  | 53  | 54  | 55  | 56  | 57  | 58  | 59  | 60 | 61 | 62 | 63 | 64 | 65  | 66  | 67  | 68  | 69 | 70 | 71 |
| 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81  | 82  | 83  | 84  | 85  | 86  | 87  | 88  | 89  | 90  | 91  | 92  | 93  | 94  | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |    |    |    |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 |    |    |    |    |    |     |     |     |     |    |    |    |

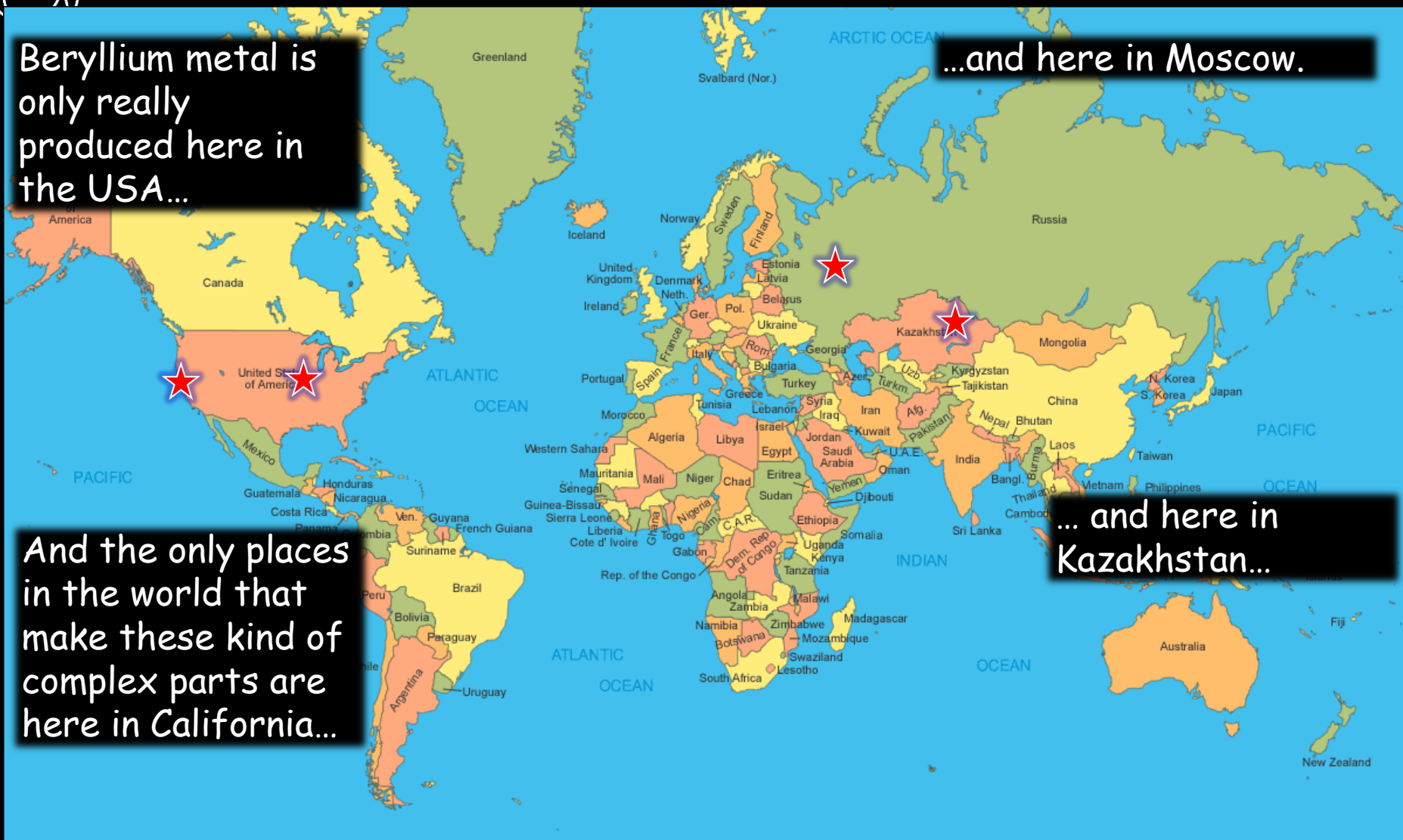
\* Lanthanide Series  
+ Actinide Series

Beryllium metal is only really produced here in the USA...

...and here in Moscow.

And the only places in the world that make these kind of complex parts are here in California...

... and here in Kazakhstan...

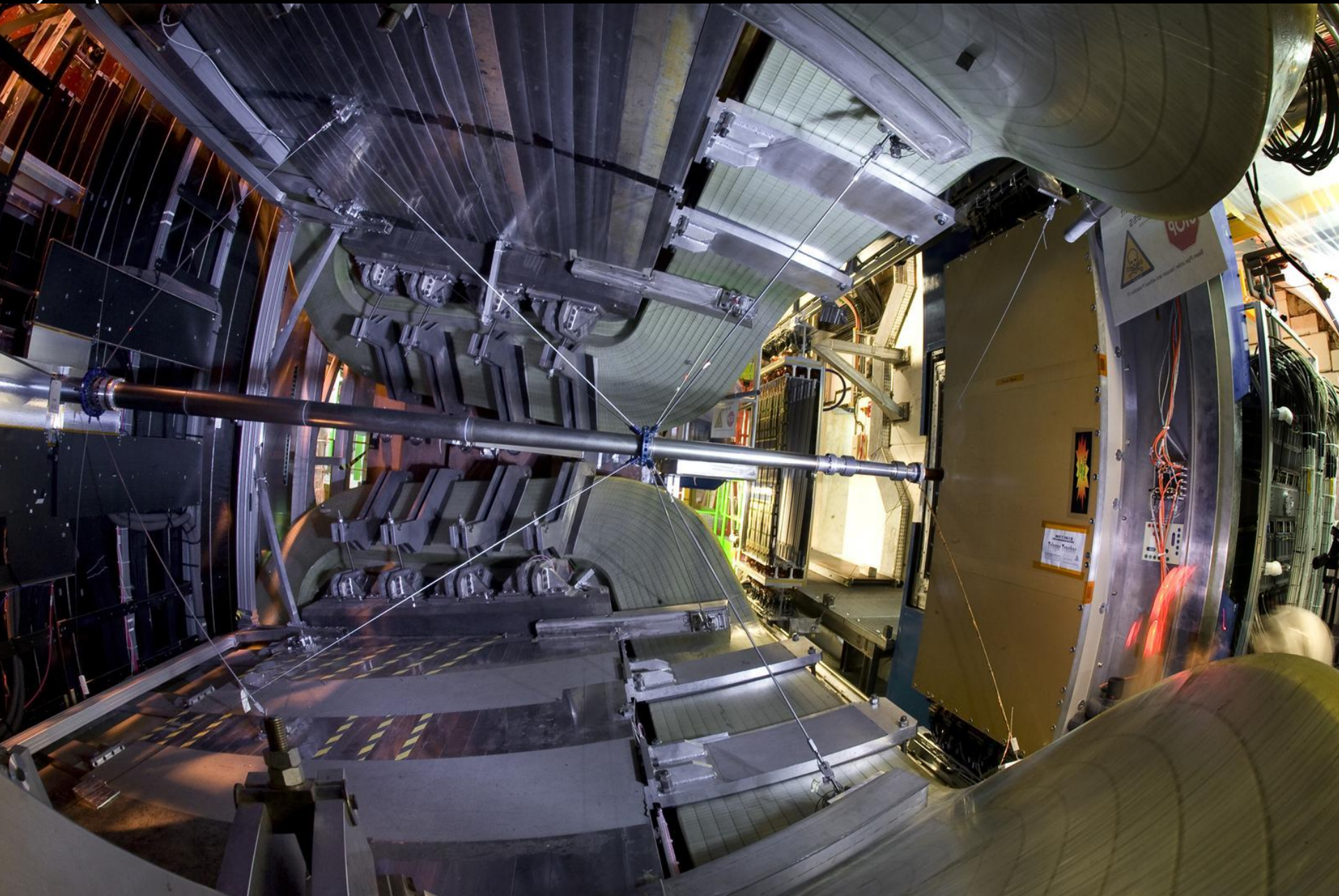






A photo I took of a CERN colleague, as we waited to cross the Khasakh-Russian border in 2004...









Engineering at CERN



Ray Veness (CERN)



# So engineering means...

- **Discussion, negotiation, consensus:**
  - Communication!
- **Need to be ready for lifelong learning:**
  - particle and accelerator physics, material science, leadership, commerce, Russian...
- **Based, of course, on good science:**
  - Start from first principles
  - But don't re-invent the wheel... unless you need to!
  - Good engineering design
- **Get it done, on time and on budget!**





# CERN: Particle Physics and Innovation

- **Interfacing** between fundamental science and key technological developments



- **CERN Technologies and Innovation**



Accelerating particle beams



Detecting particles



Large-scale computing (Grid)

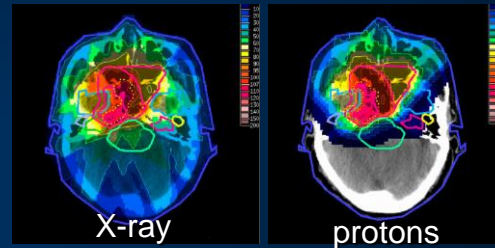
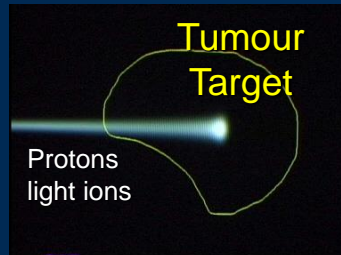
# Medical Application as an Example of Particle Physics Spin-off

Combining Physics, Engineering, ICT, Biology and Medicine to fight cancer



## Hadron Therapy

Accelerating particle beams  
~30'000 accelerators worldwide  
~17'000 used for medicine



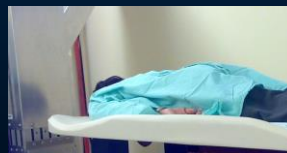
Leadership in Ion Beam Therapy now in Europe and Japan

>70'000 patients treated worldwide (30 facilities)  
>21'000 patients treated in Europe (9 facilities)

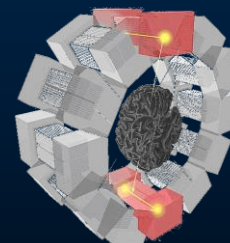


## Imaging

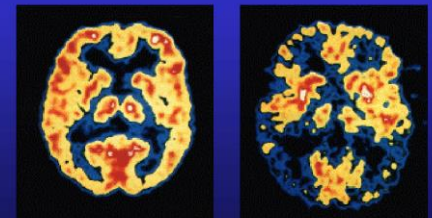
Clinical trial in Portugal for new breast imaging system (ClearPEM)



## PET Scanner



Brain Metabolism in Alzheimer's Disease: PET Scan



Detecting particles





“...It’s my job to install your boiler and help with any boiler problems you may have...”



# What is Engineering?

OED, 3<sup>rd</sup> Ed.

*The branch of science and technology concerned with the **development and modification of engines** (in various senses), **machines, structures, or other complicated systems and processes using specialized knowledge or skills, typically for public or commercial use...***

Wikipedia

(from **Latin** ingenium, meaning "cleverness" and ingeniare, meaning "to contrive, devise") is *the application of **scientific, economic, social, and practical knowledge in order to invent, design, build, maintain, research, and improve structures, machines, devices, systems, materials and processes.***





# CERN

- **CERN is a particle physics facility**
  - But we employ very few particle physicists
  - Most theoretical and experimental scientists work for our member institutes
- **and most of what we do is “Engineering”**
  - 2/3 of our staff are engineers, applied scientists or technicians
  - Work together, we can produce the most amazing, complex and beautiful things



# ...and can I just ask you

- Enjoy your visits over the next 3 days
- Look at things with an eye to the engineering as well as the physics
  - SM18, superconducting magnets
  - Experiments (especially CMS) and machines
- Give your students a different impression of what a career in engineering might mean
  - the UK needs more engineers...
  - and so does CERN





Thank you!

And enjoy your  
time at CERN