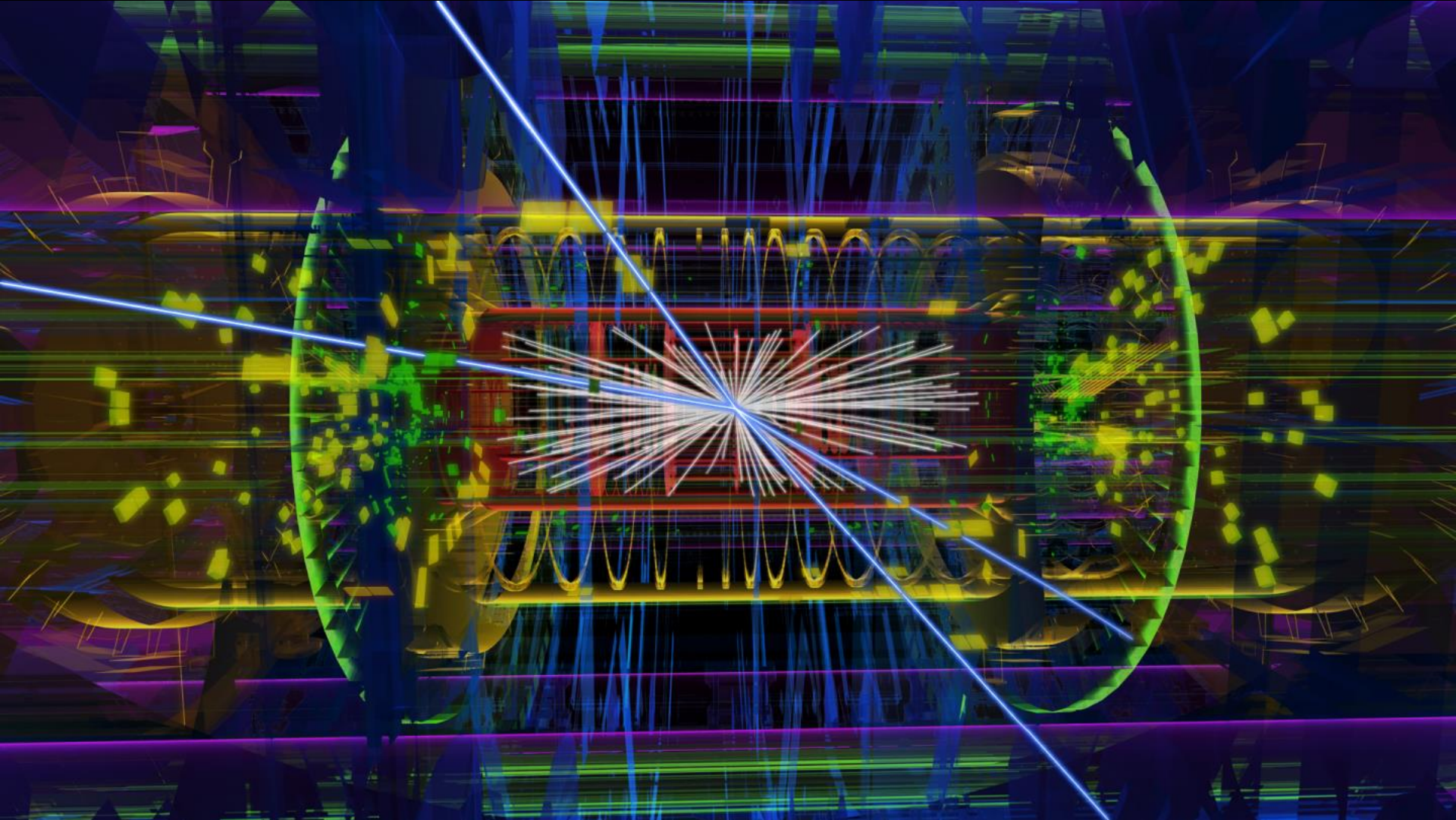
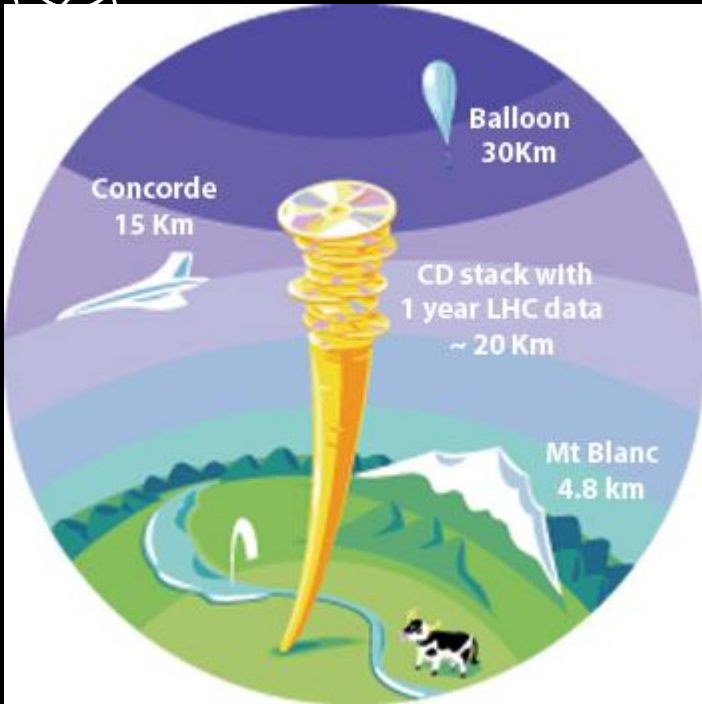


An Introduction to Engineering at CERN

Ray Veness
CERN



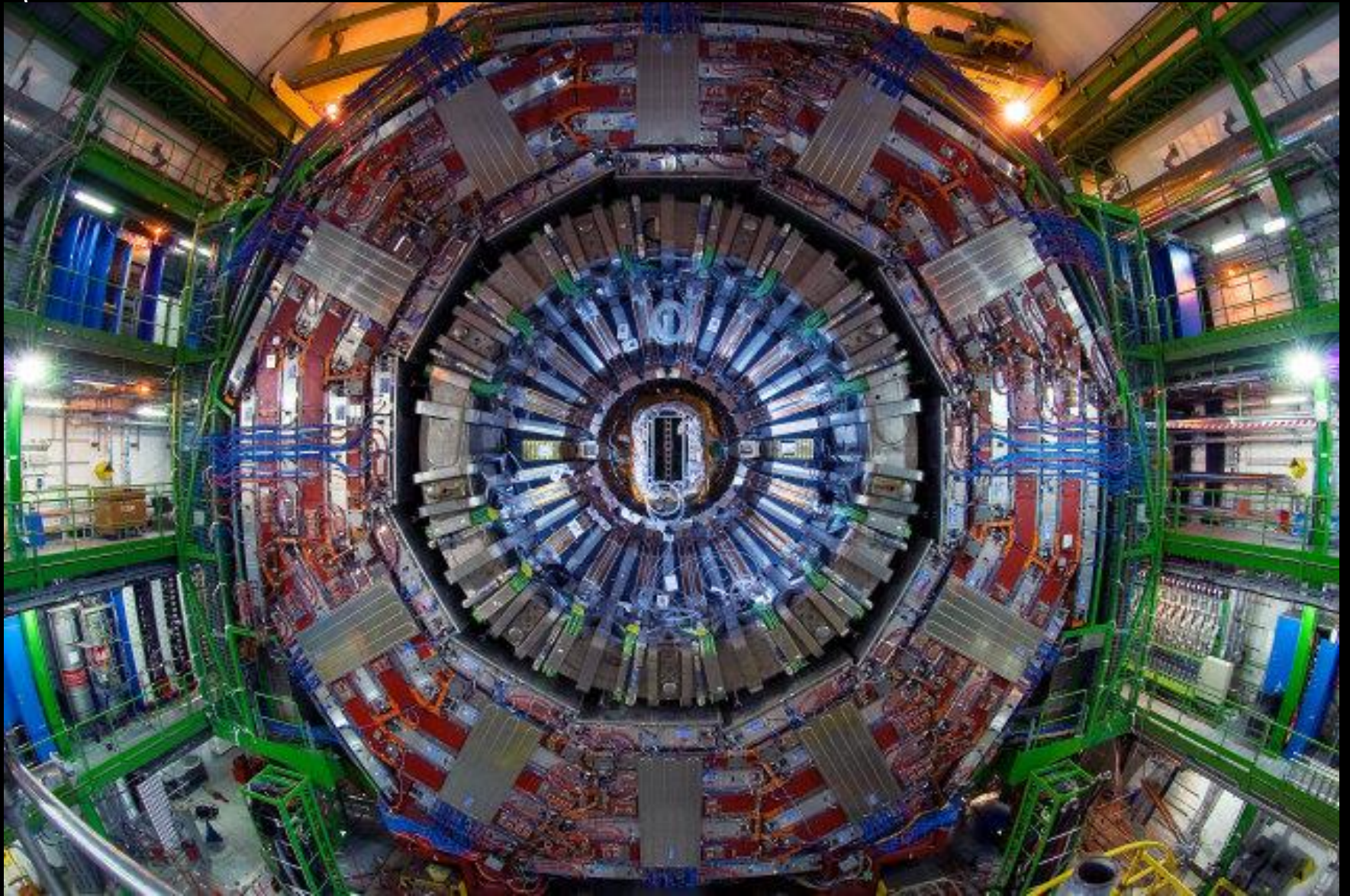


LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors**

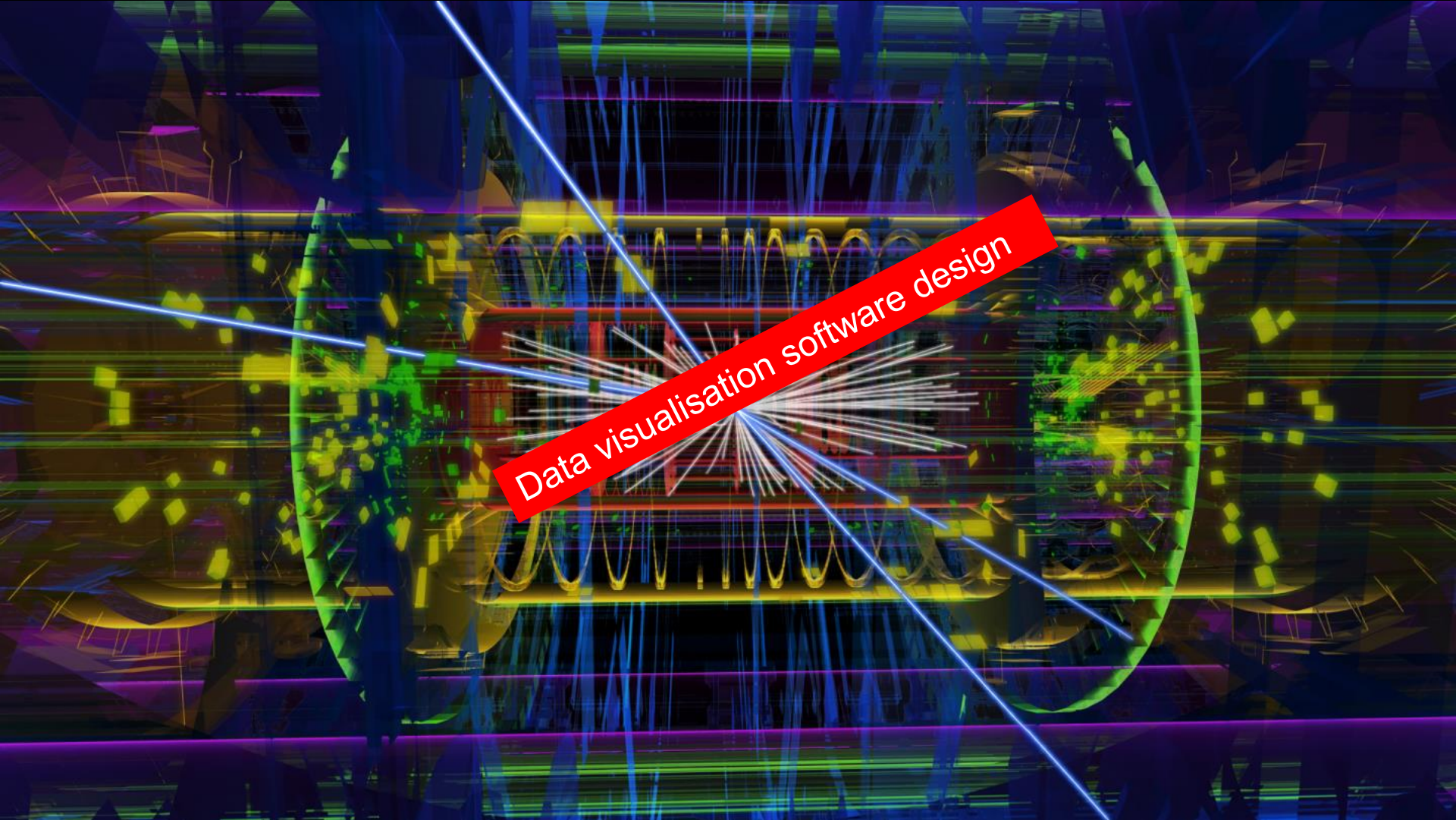
Experiments are producing about **25 Million Gigabytes** of data each year (about 3 million DVDs – 850 years of movies!)



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



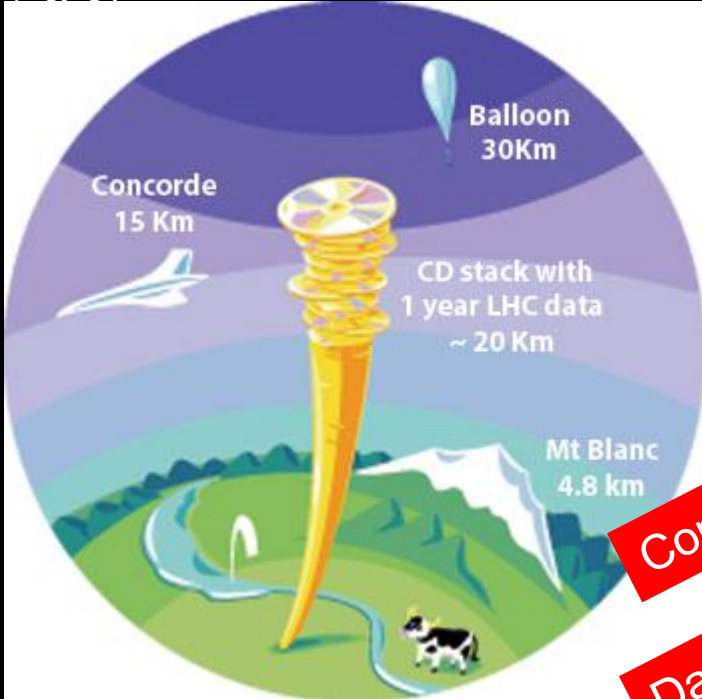




Data visualisation software design



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**



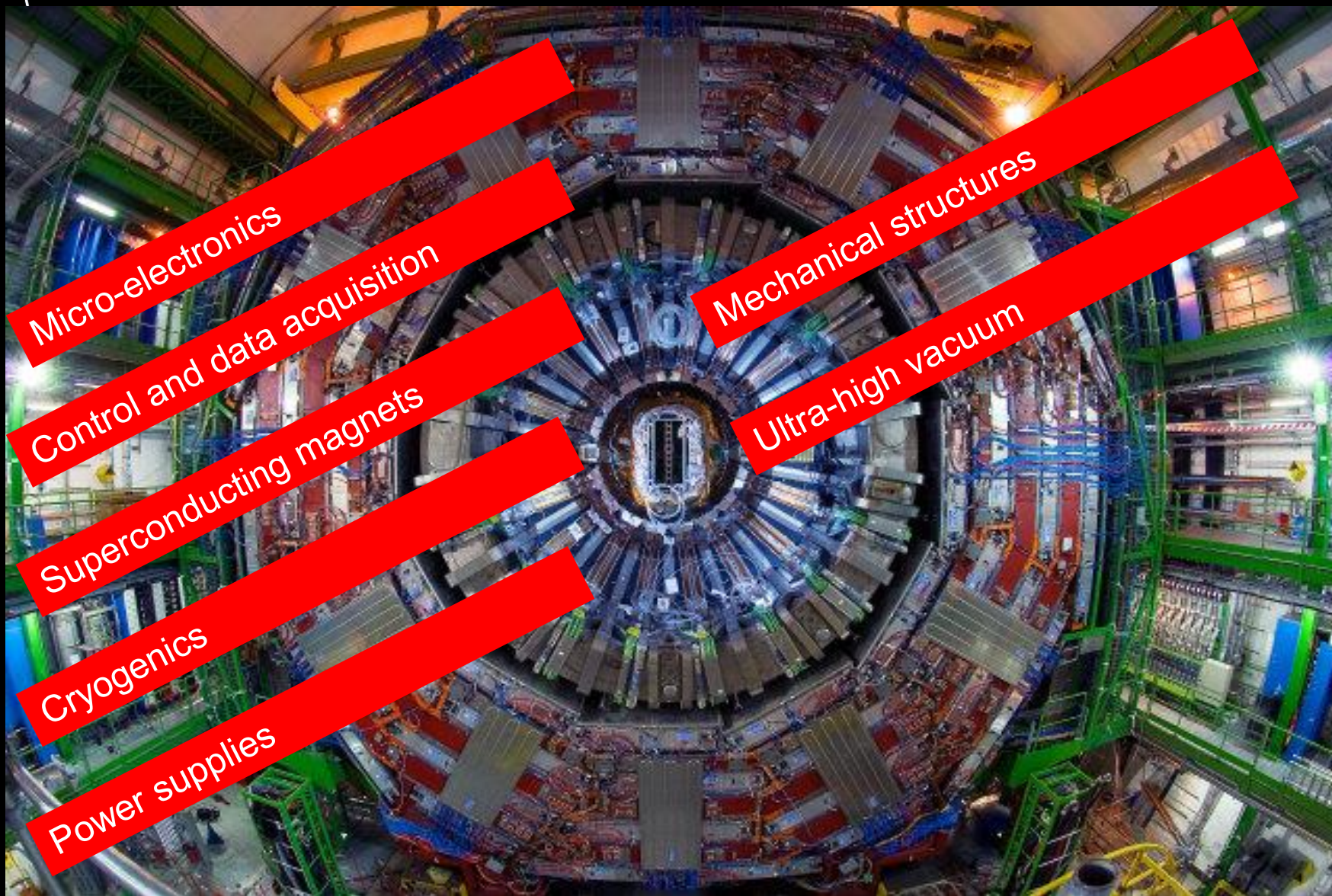
3/4/2013 4:10:16 pm
4:10 pm 4:20 pm

Running jobs: 259835
Transfer rate: 6.15 GiB/sec



© 2013 Ches/Spot Image
Image © 2013 GeoContent
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO, ERGRID





Micro-electronics

Control and data acquisition

Superconducting magnets

Cryogenics

Power supplies

Mechanical structures

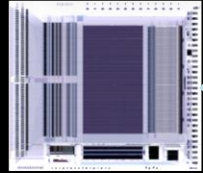
Ultra-high vacuum



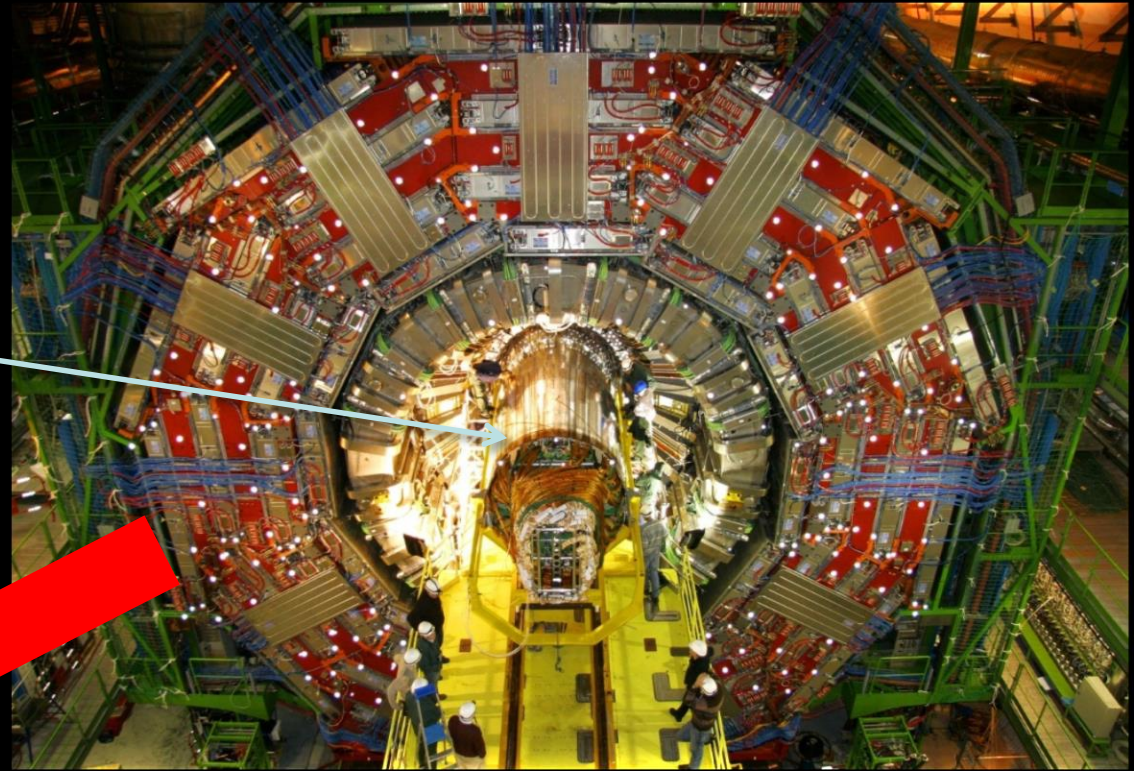
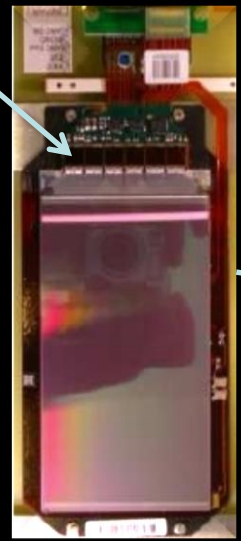
Microchips for Megastructures

Front-End ASIC

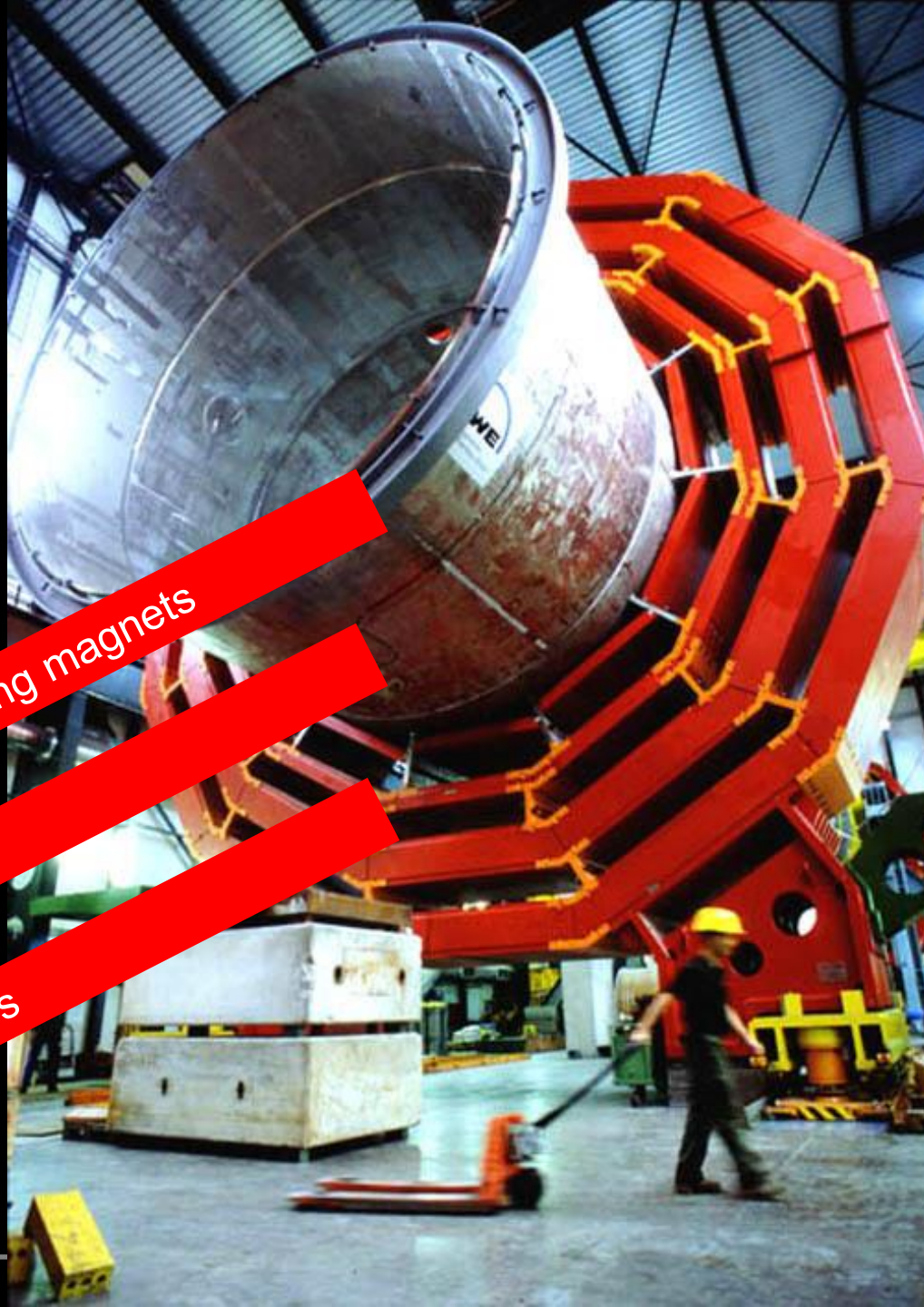
CMS experiment on the LHC accelerator at CERN



Silicon Tracker Hybrid



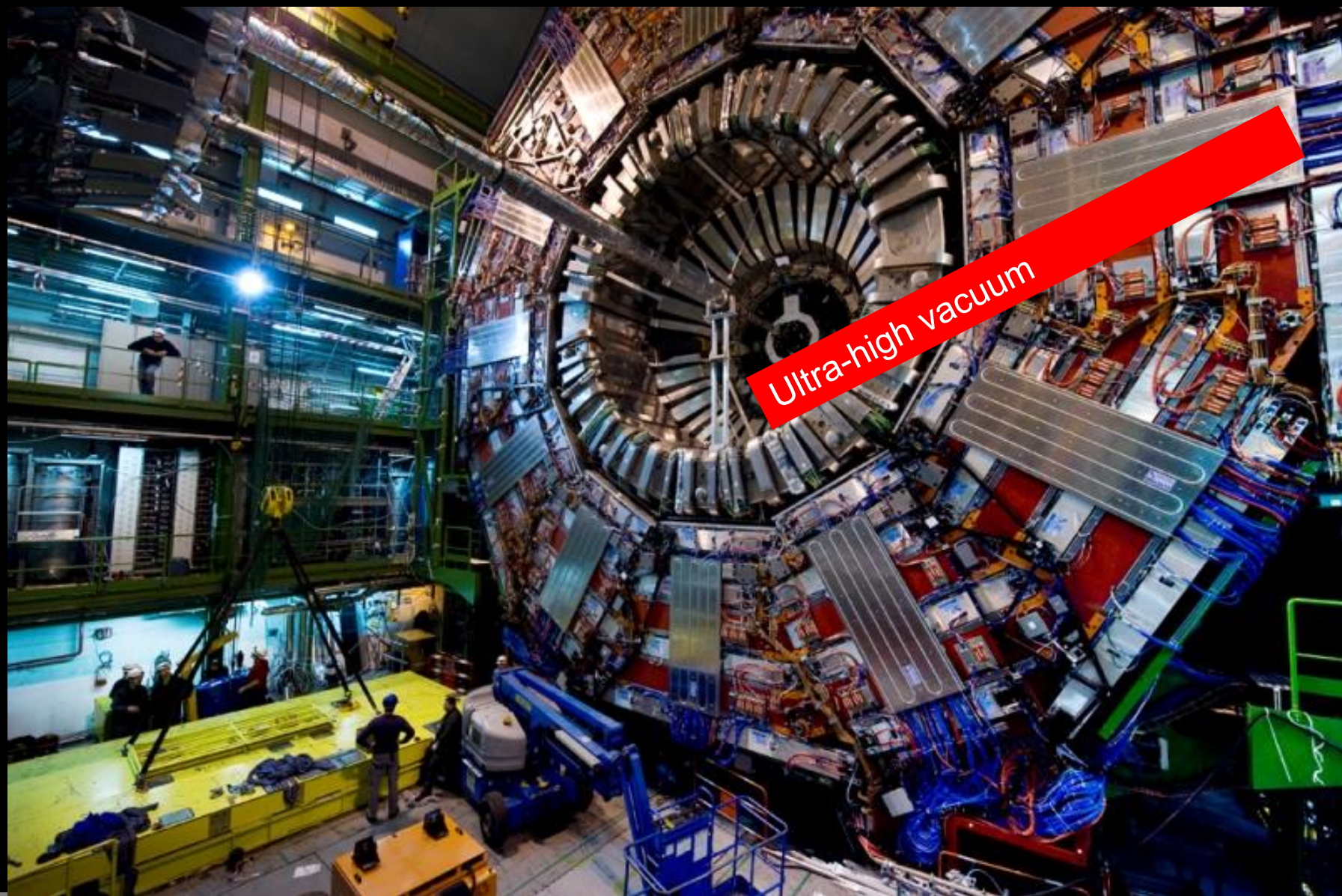
Micro-electronics



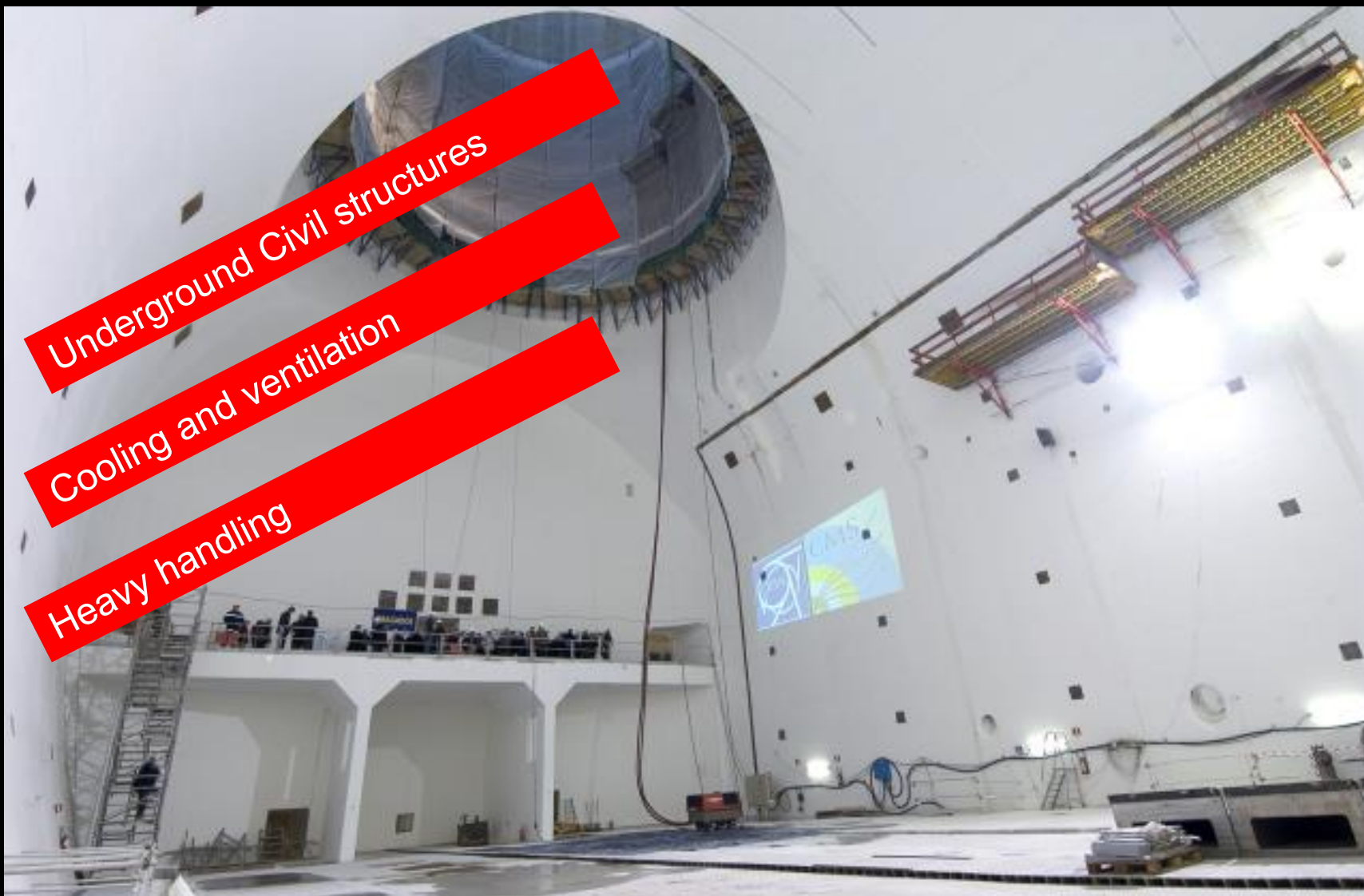
Superconducting magnets

Cryogenics

Power supplies



Ultra-high vacuum





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





Total Concrete
Volume =
90,000m³

2004







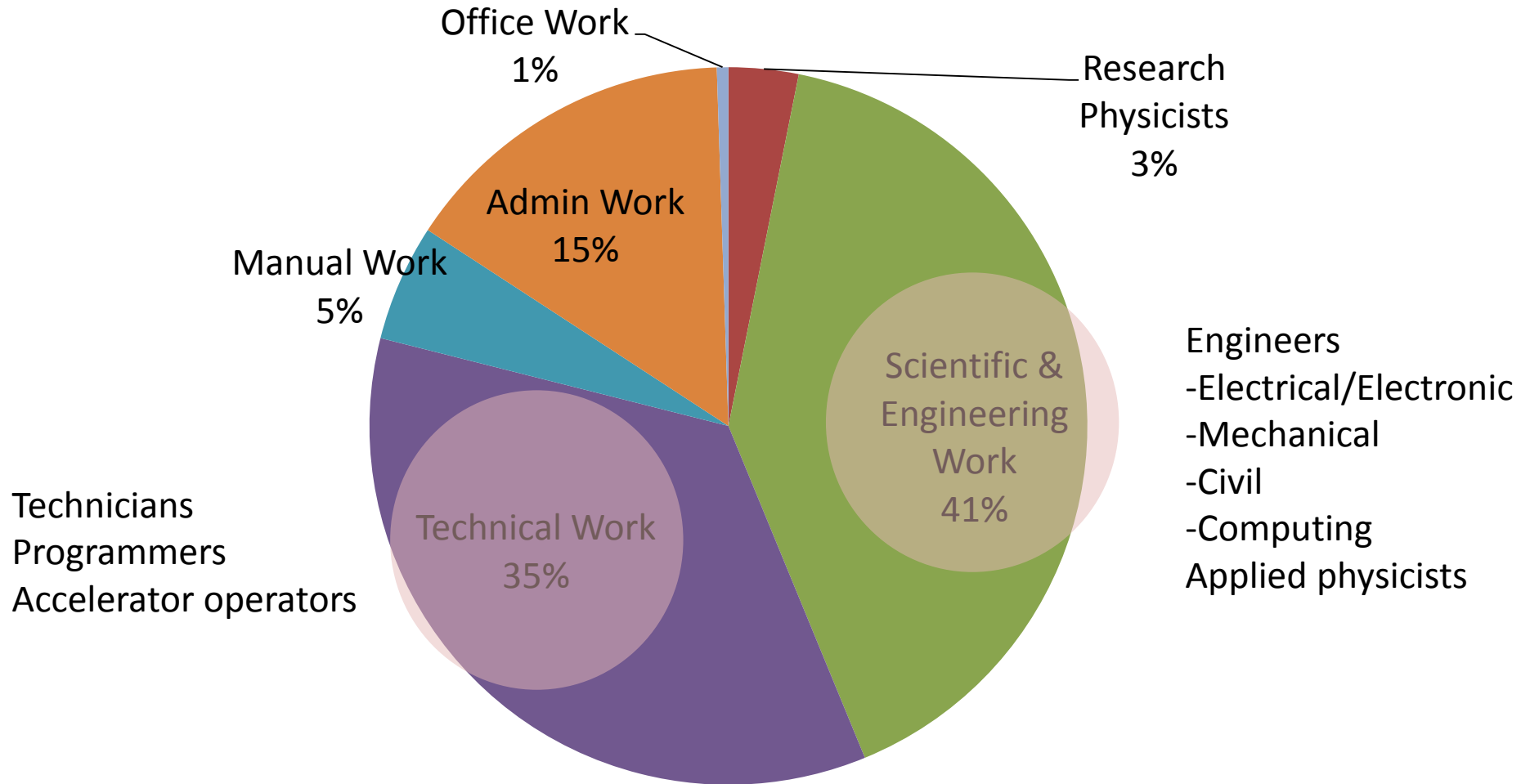


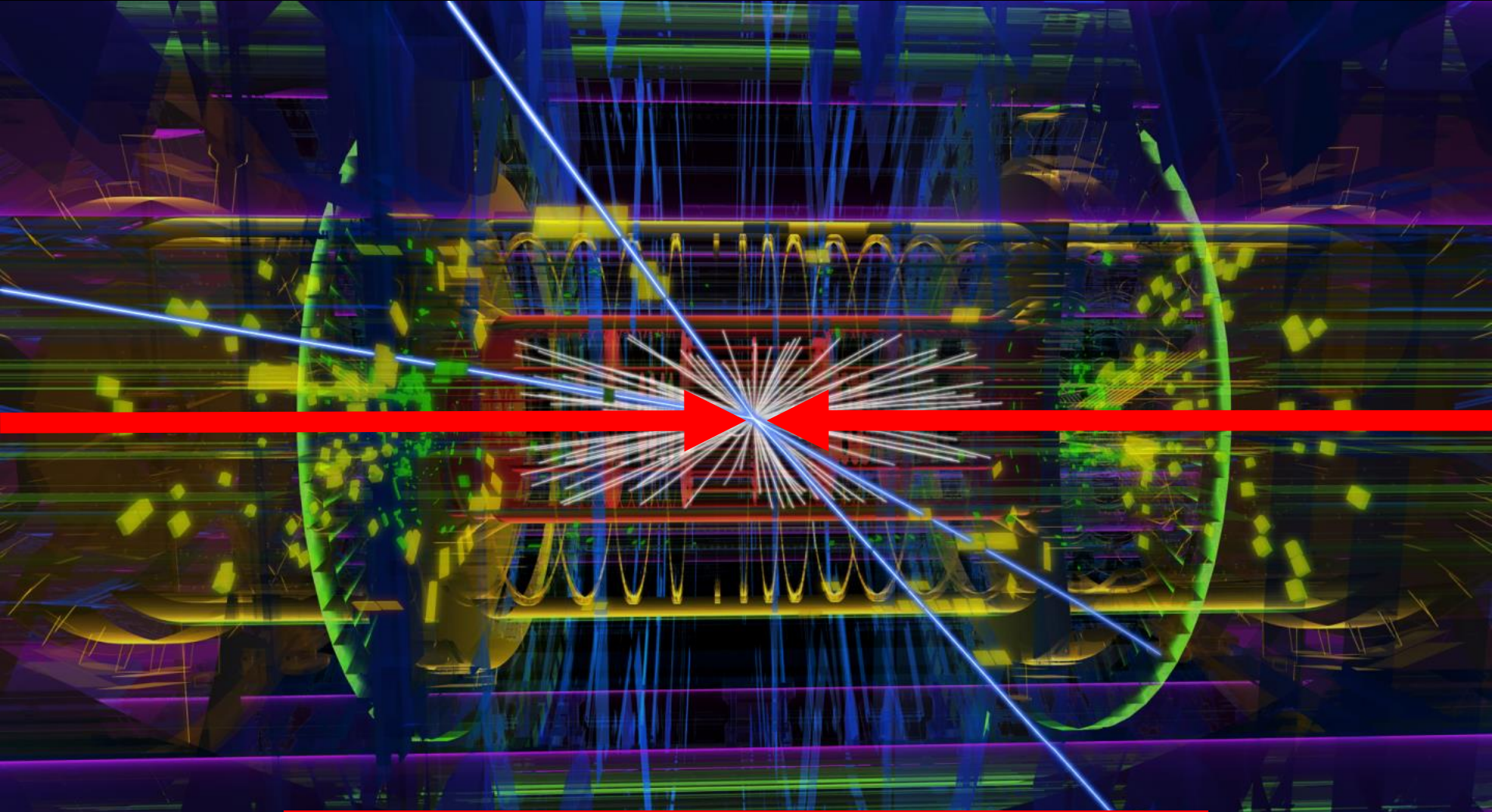
ROSS

THE BOILER
ENGINEER

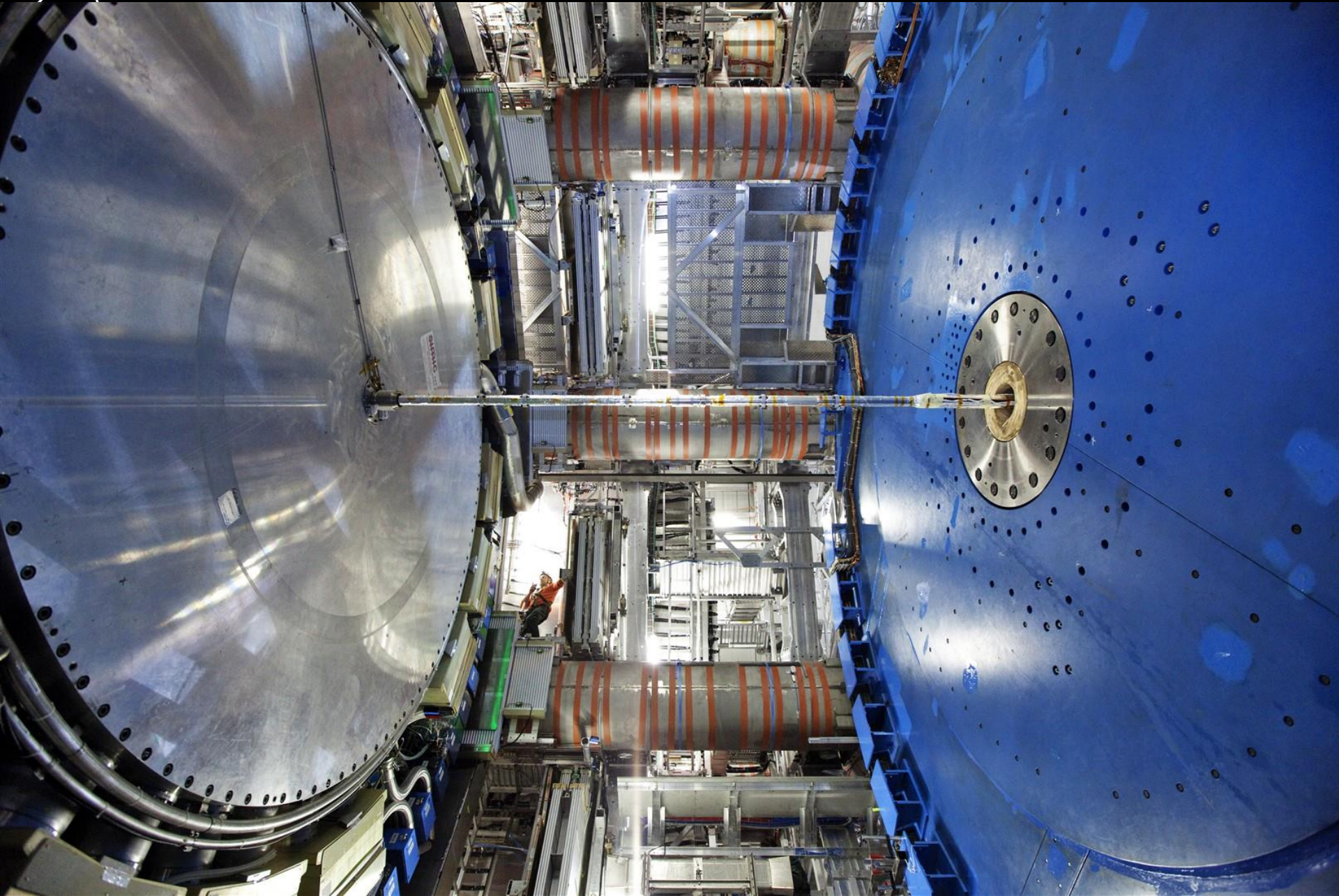
Image courtesy British Gas

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			
104	105	106	107	108	109	110	111	112	113																									

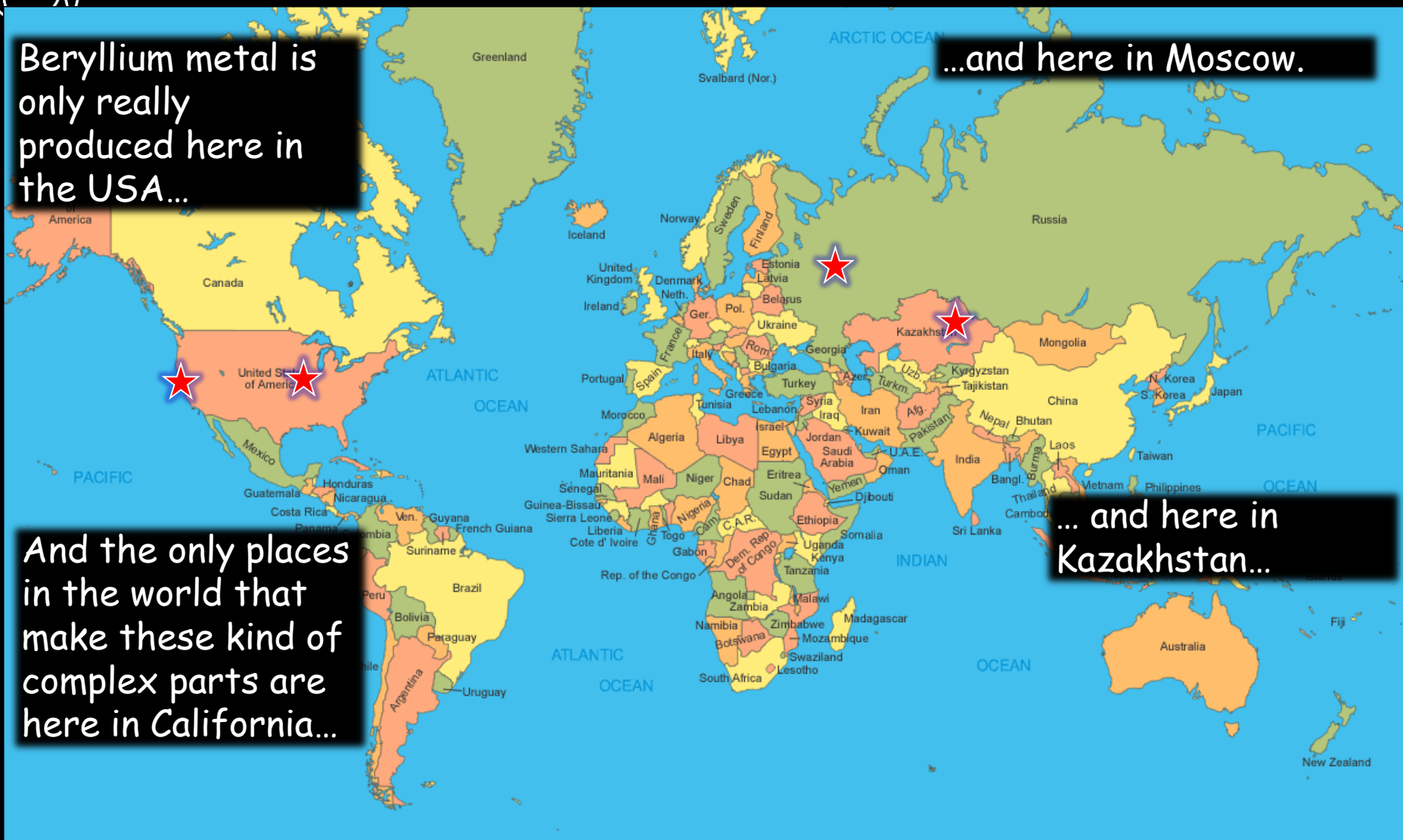
* Lanthanide Series	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
+ Actinide Series	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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

...and here in Moscow.

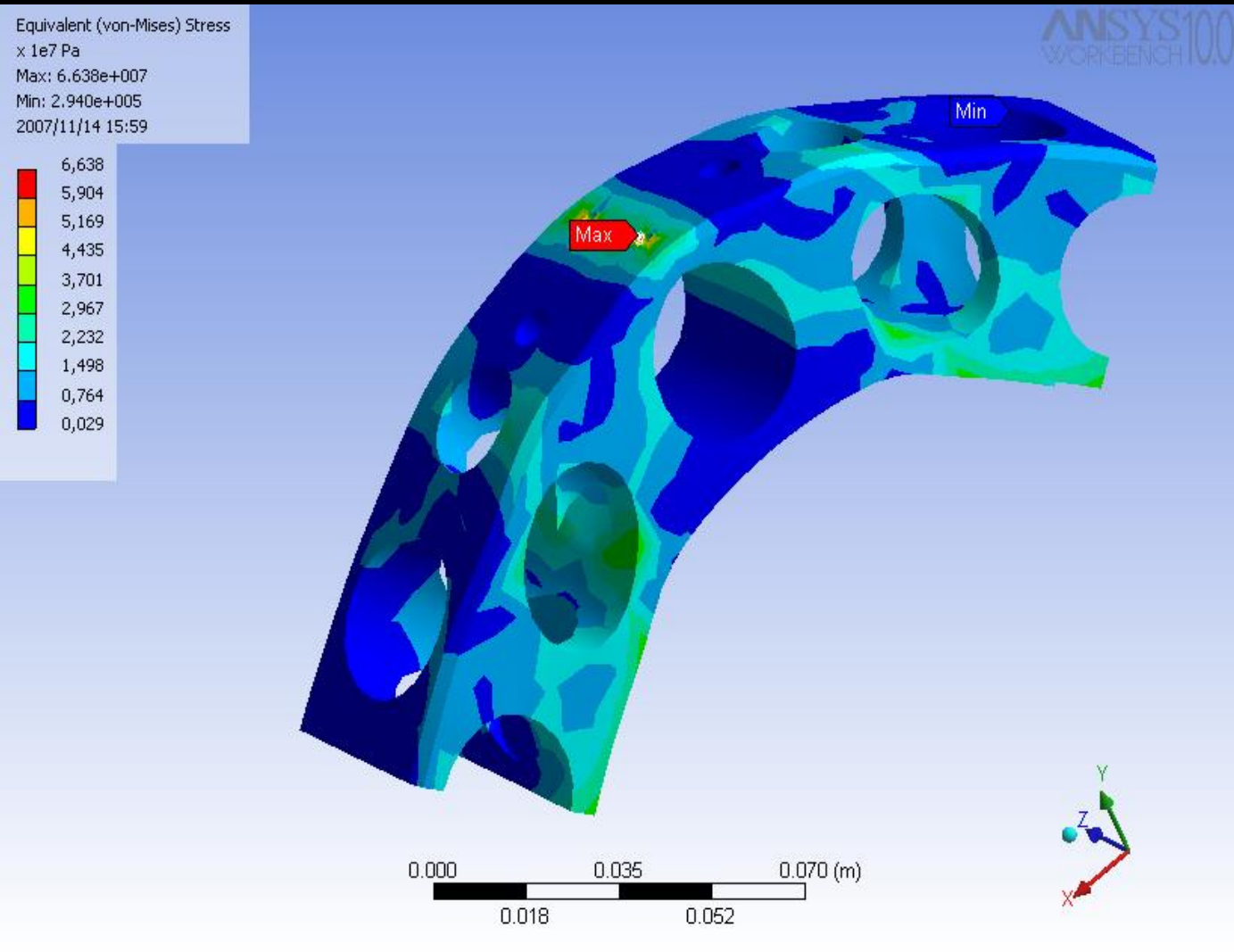
And the only places in the world that make these kind of complex parts are here in California...

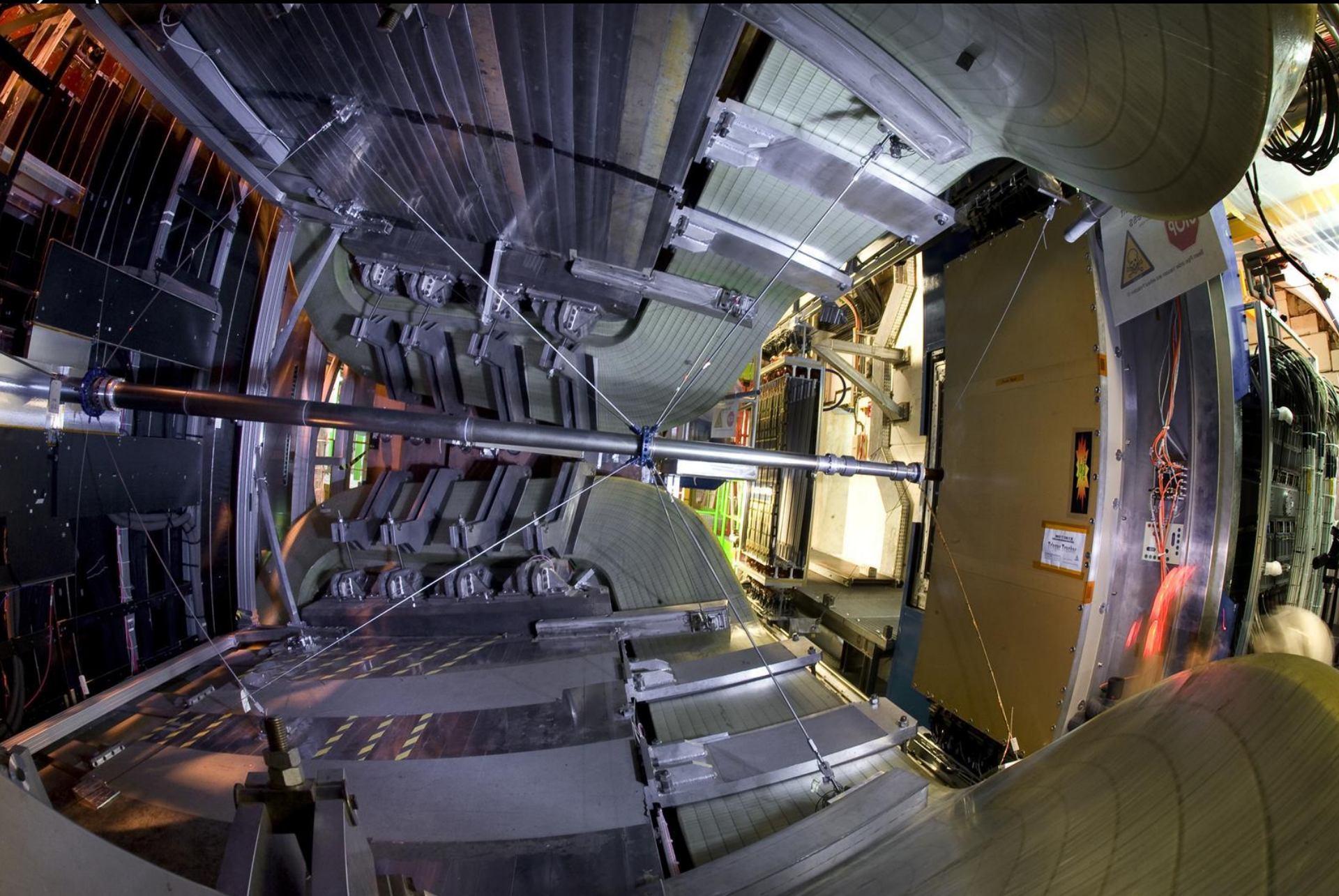
... and here in Kazakhstan...





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)

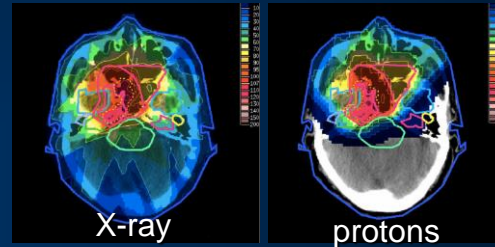
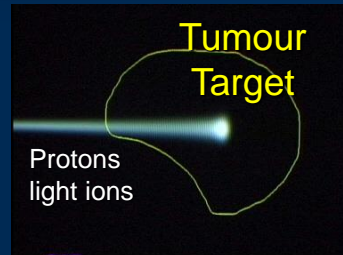
Medical Application as an Example of Particle Physics Spin-off

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



Hadron Therapy

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



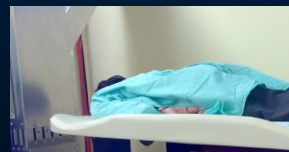
Leadership in Ion Beam Therapy now in Europe and Japan

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

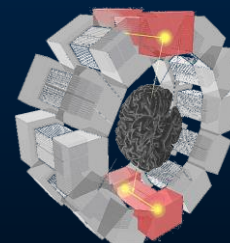


Imaging

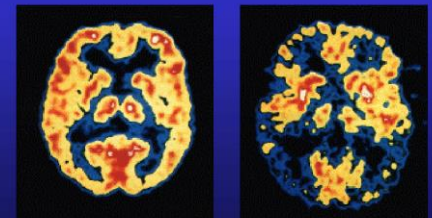
Clinical trial in Portugal for new breast imaging system (ClearPEM)



PET Scanner



Brain Metabolism in Alzheimer's Disease: PET Scan



Normal Brain

Alzheimer's Disease



Detecting particles



ROSS THE BOILER ENGINEER

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



What is Engineering?

OED, 3rd 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

- I hope you have enjoyed your visits over the last week
- You have seen some incredible examples of engineering
 - Magnet test facility, data centre,
 - CMS, LEIR
- Give your students a different impression of what a career in engineering might mean
 - Europe needs more engineers...and so does CERN



Thank you!

...and please feel free to
take some of our
enthusiasm for engineering
home with you!