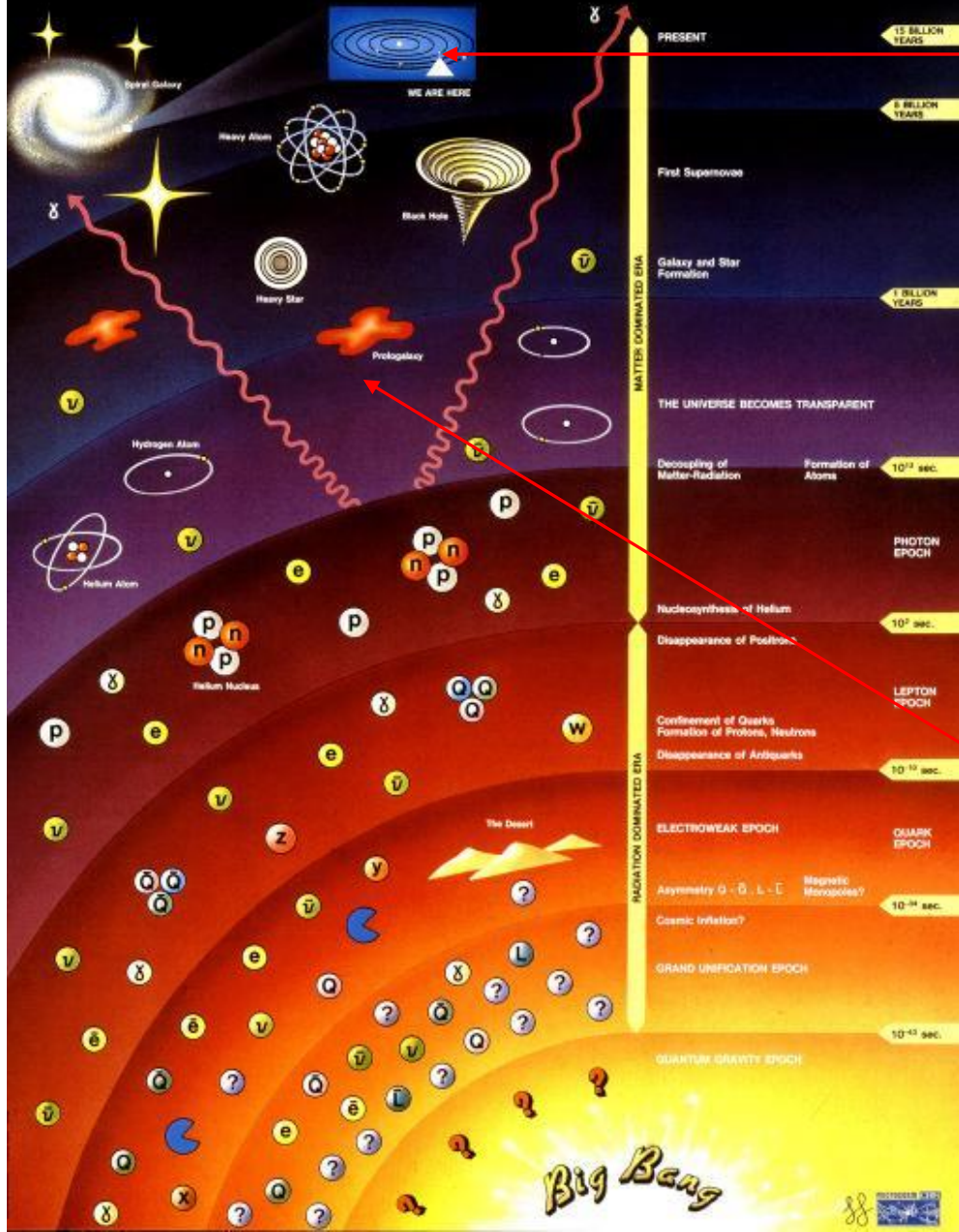


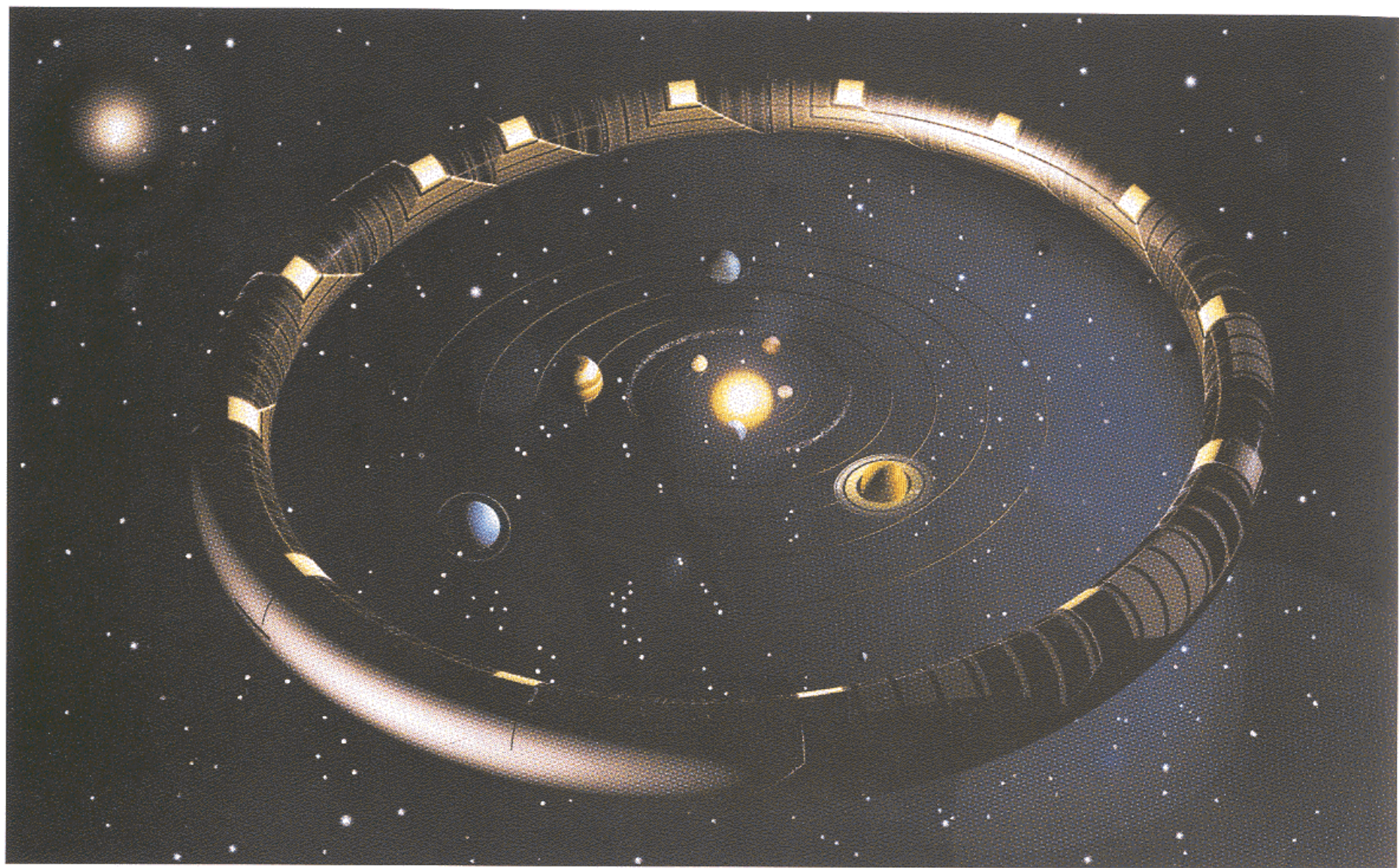
# Tervetuloa CERNiin

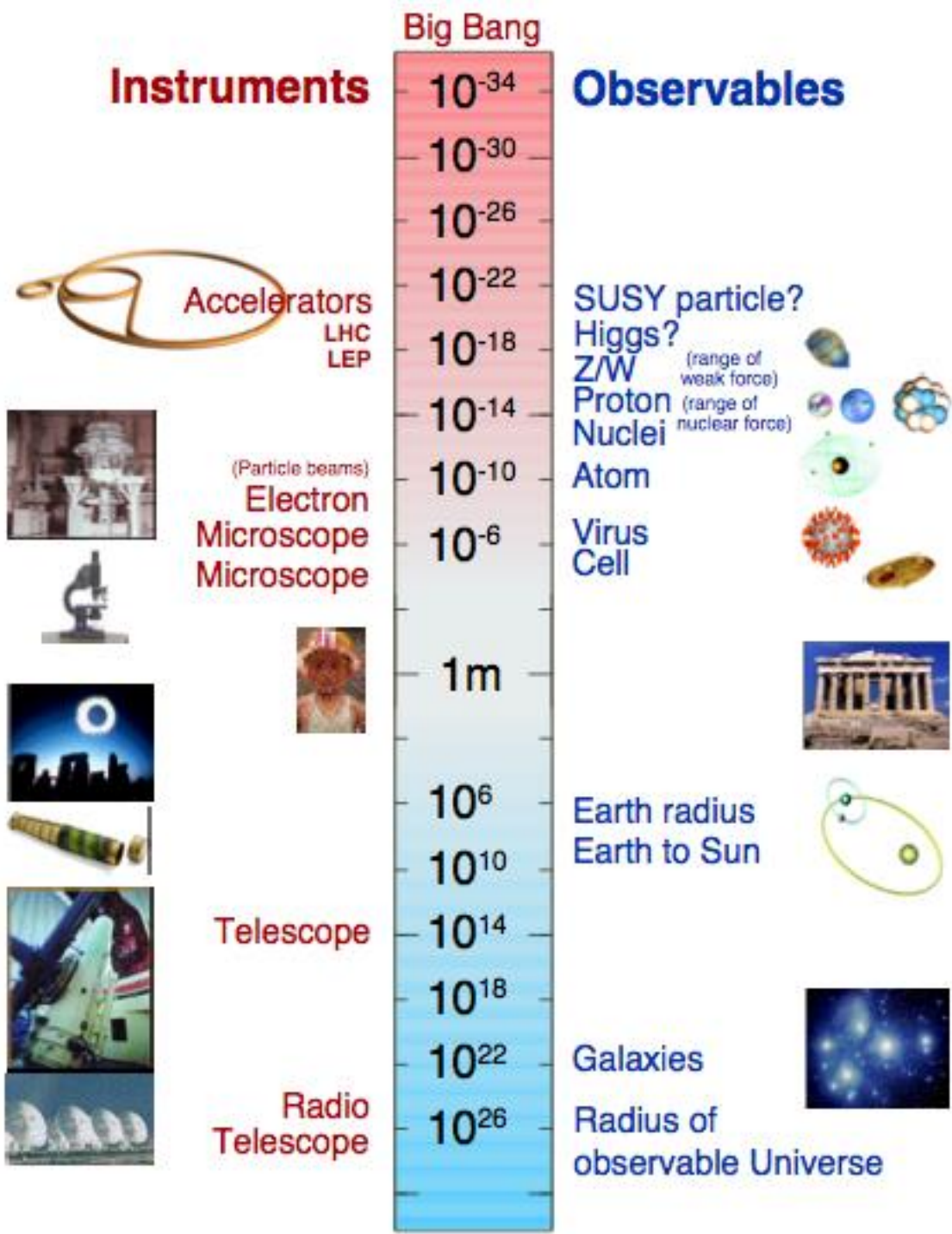
Haukiputaan, Kiimingin, Merikosken, Oulunsalon ja Oulun suomalaisen yhteiskoulun lukiot 18.4.2018

# History of the Universe

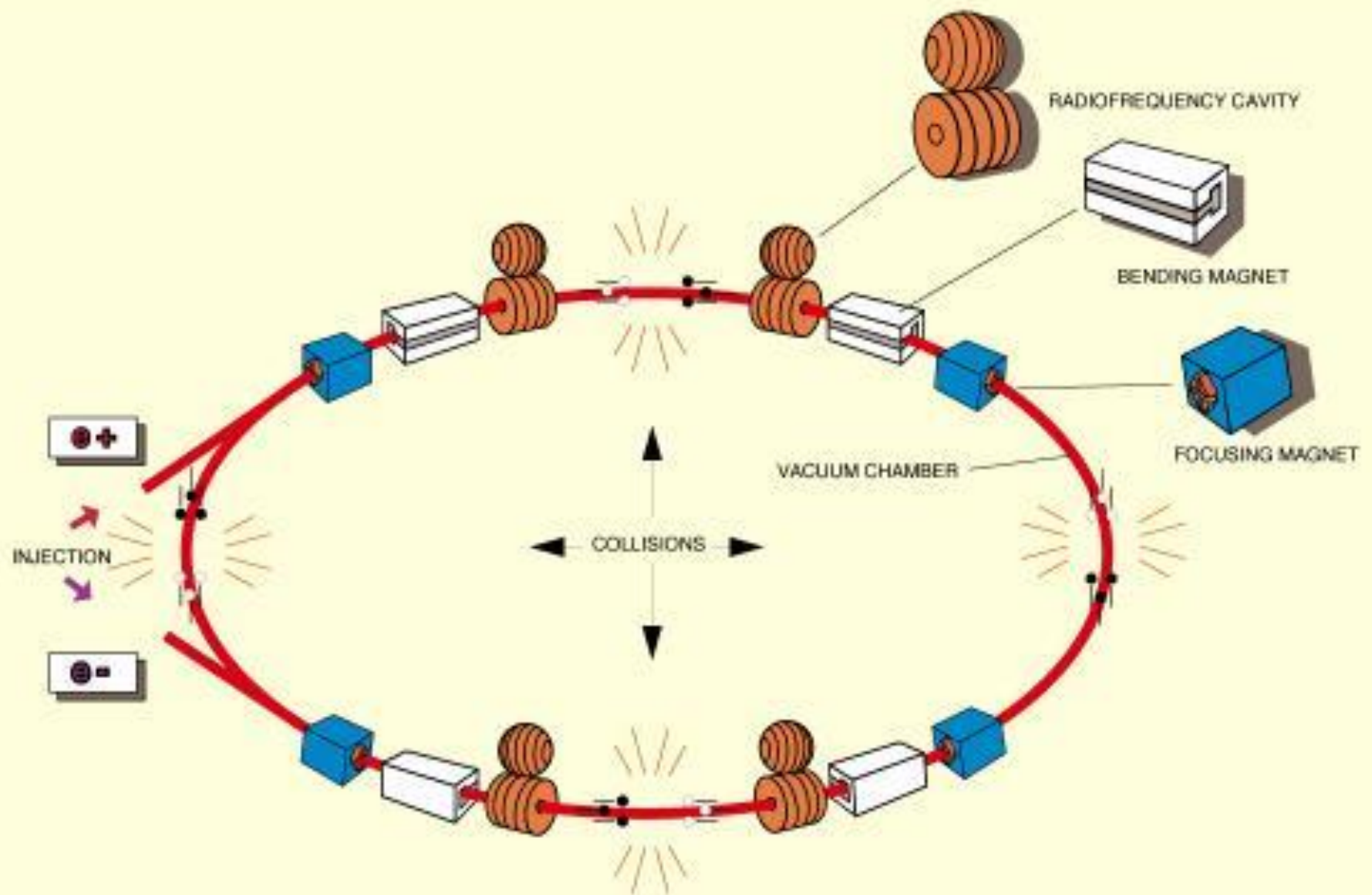




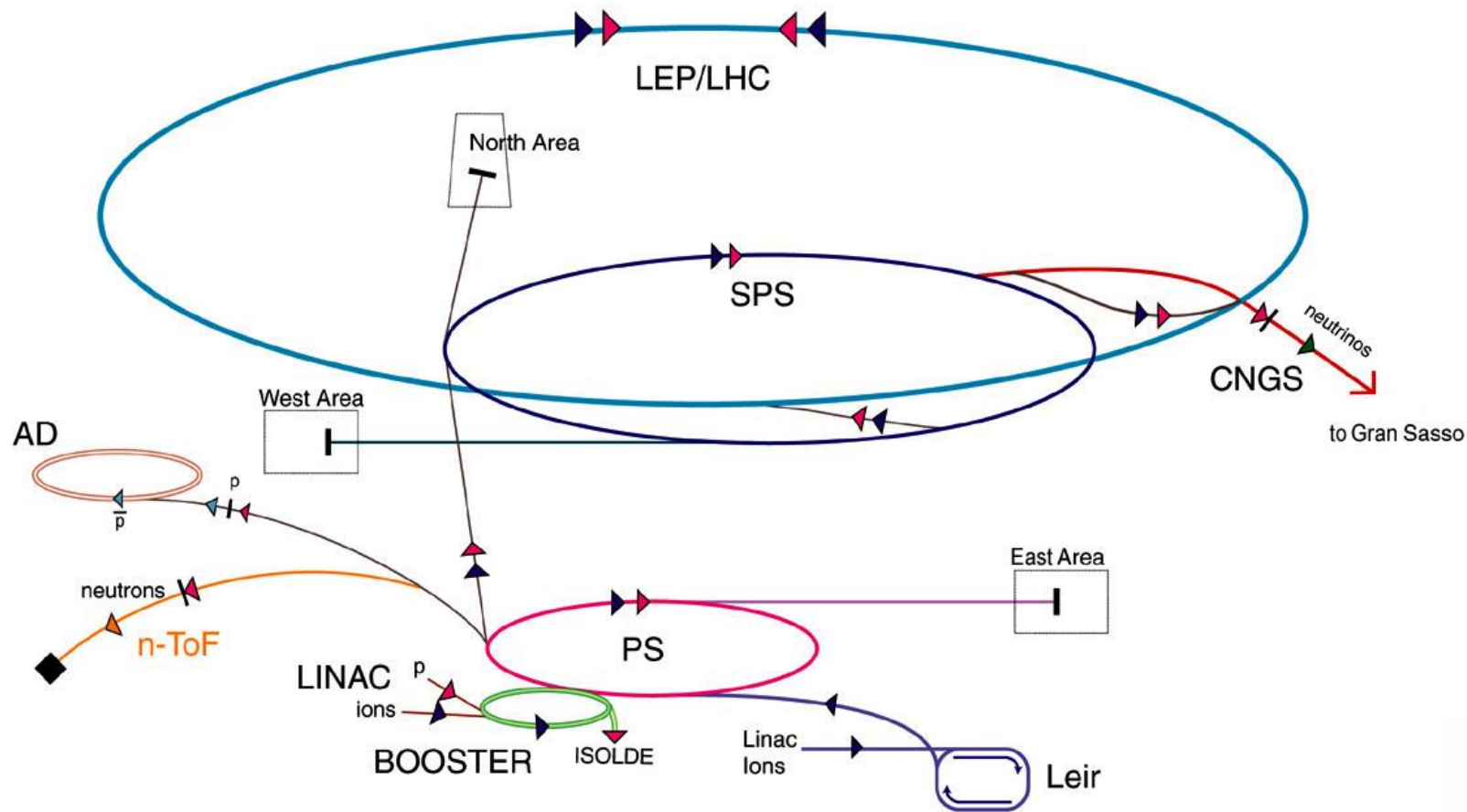




# THE PRINCIPAL MACHINE COMPONENTS OF THE LEP ACCELERATOR.



# Accelerator chain at CERN, a complex business



- ▶ p (proton)
- ▶ ion
- ▶ neutron
- ▶  $\bar{p}$  (antiproton)
- ▶  $\leftrightarrow$  proton/antiproton conversion
- ▶ neutrino

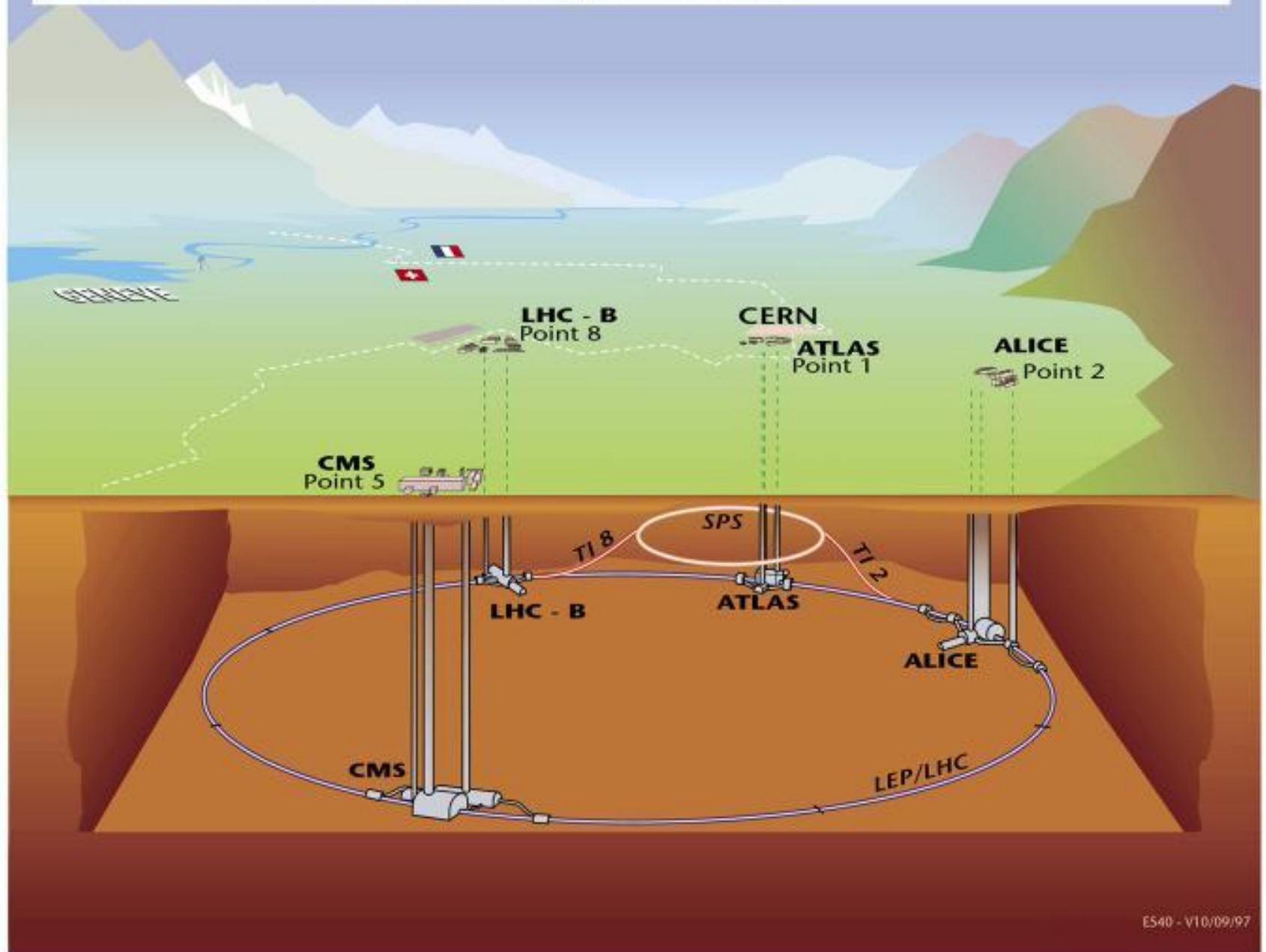
- AD Antiproton Decelerator
- PS Proton Synchrotron
- SPS Super Proton Synchrotron

- LHC Large Hadron Collider
- n-ToF Neutron Time of Flight
- CNGS Cern Neutrinos Gran Sasso

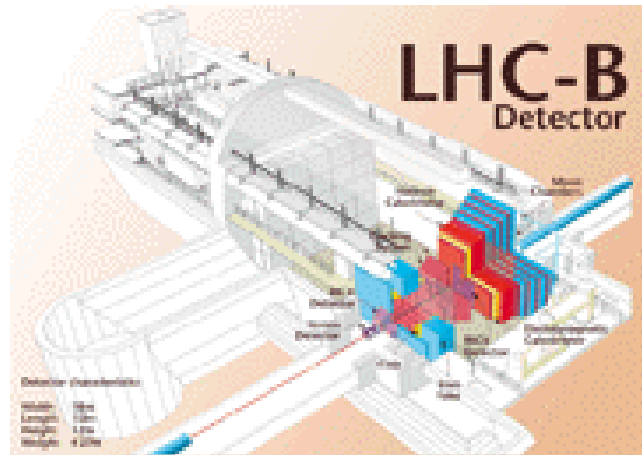
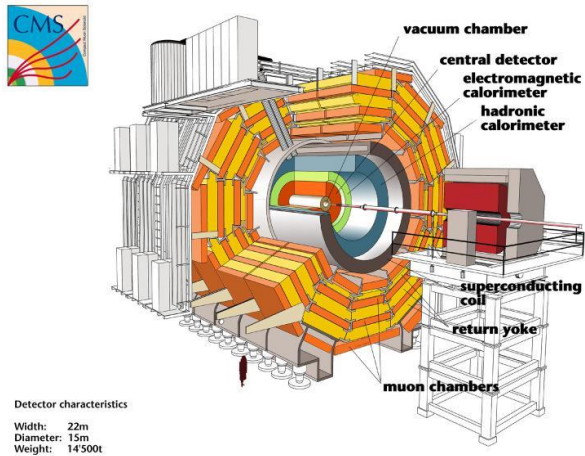
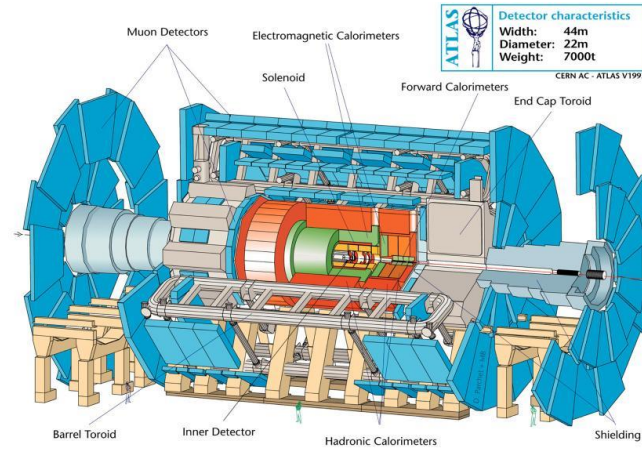
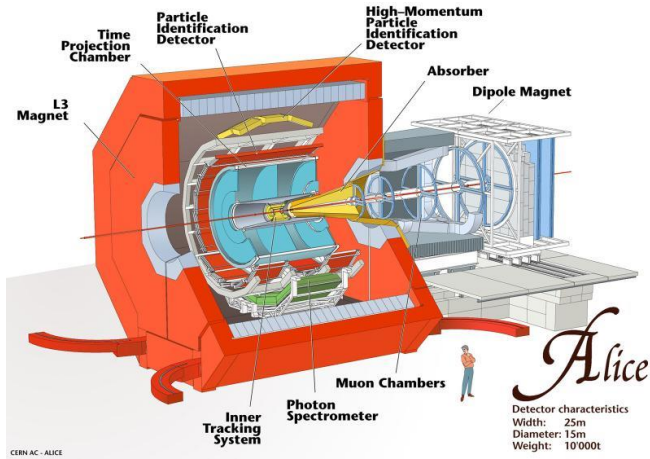


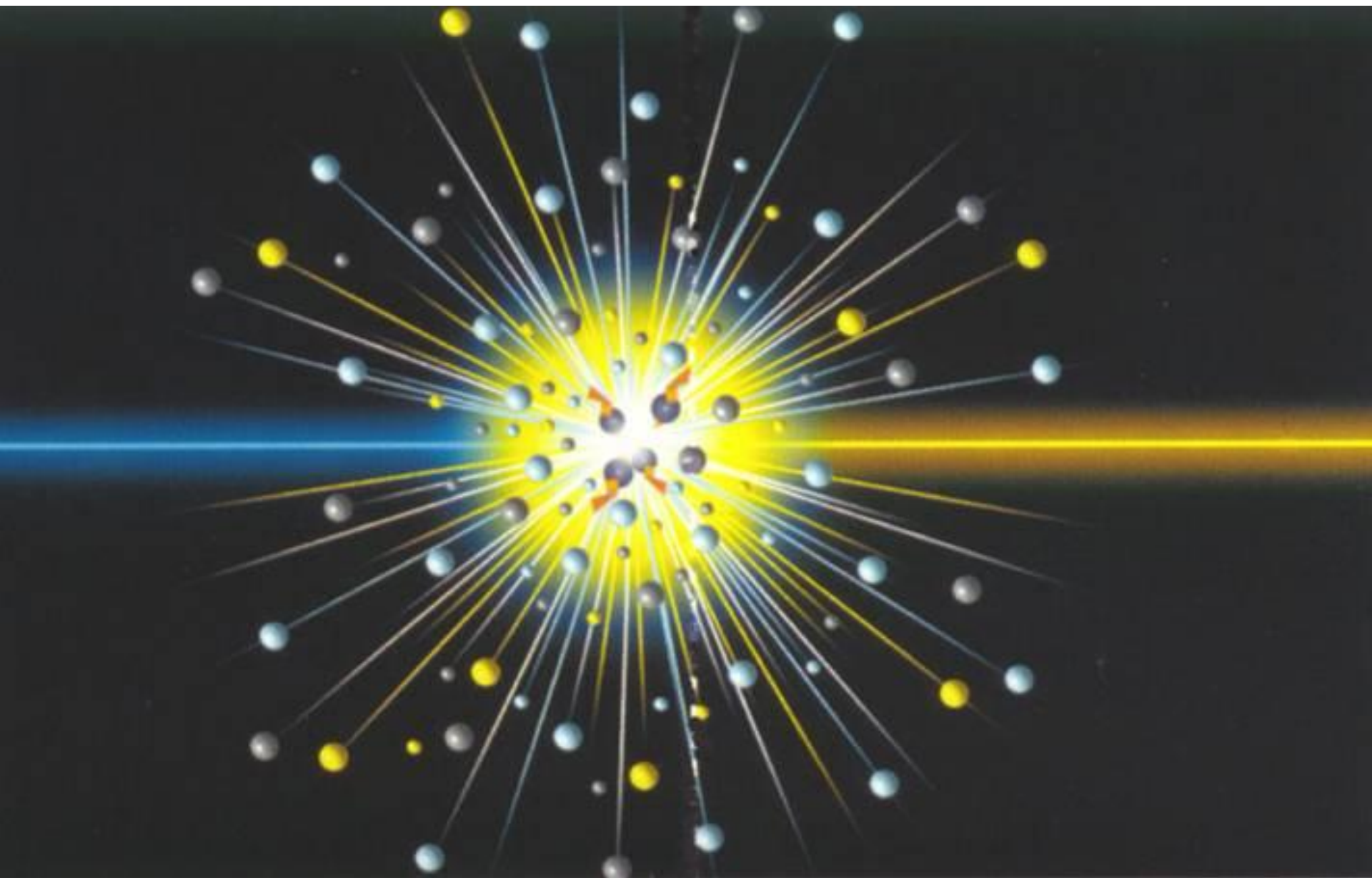


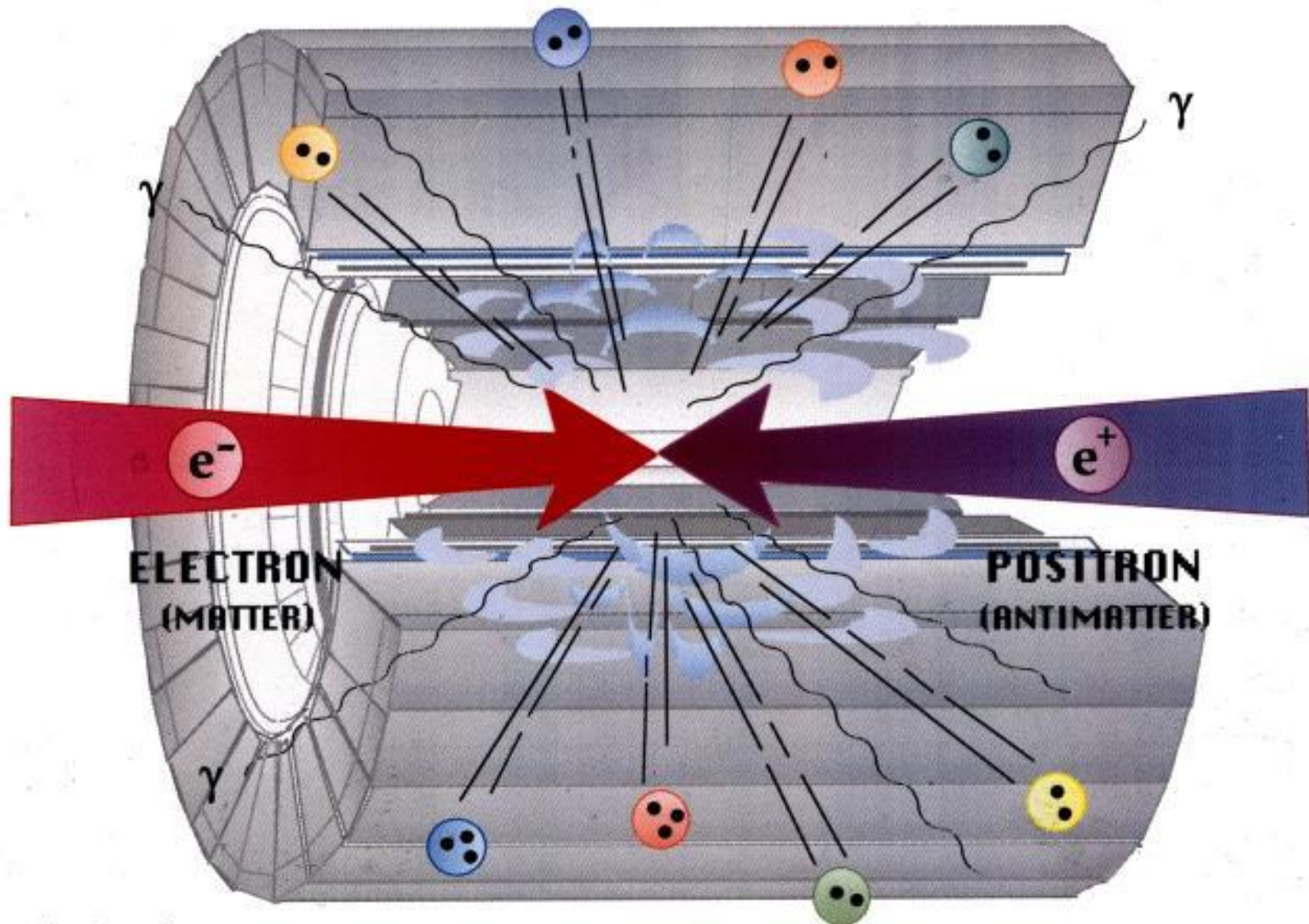
# Overall view of the LHC experiments.

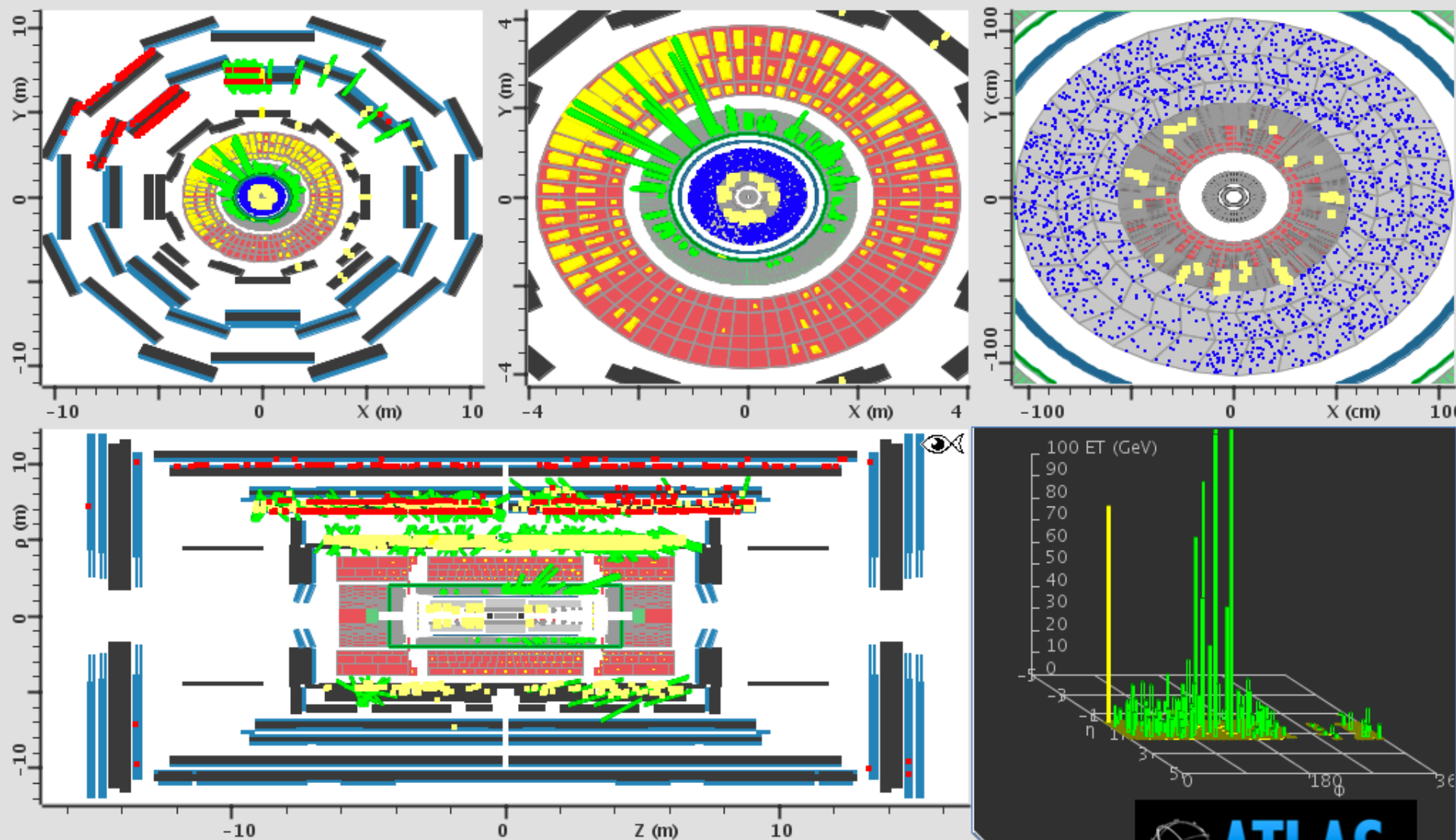


# LHC Experiments

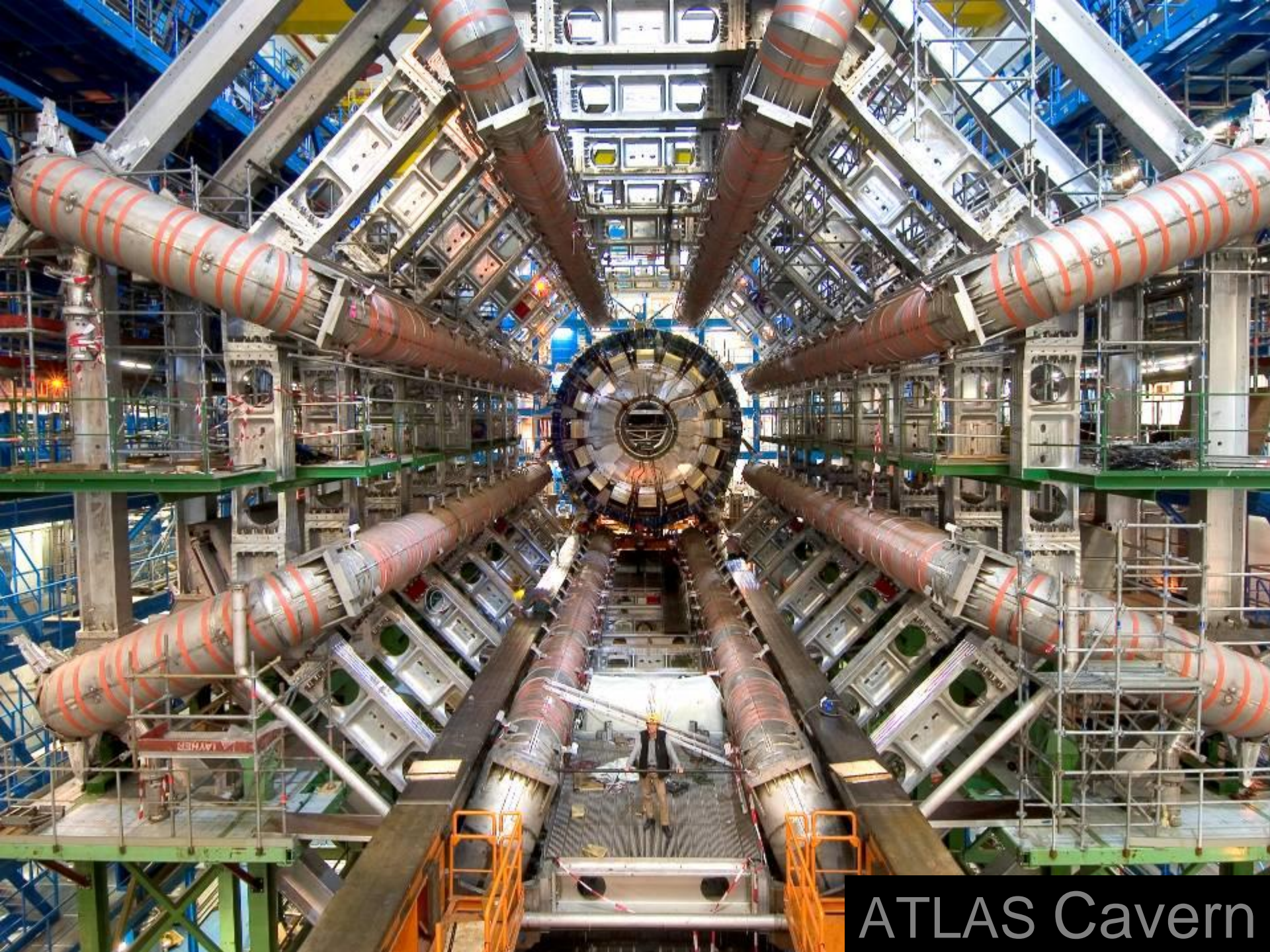






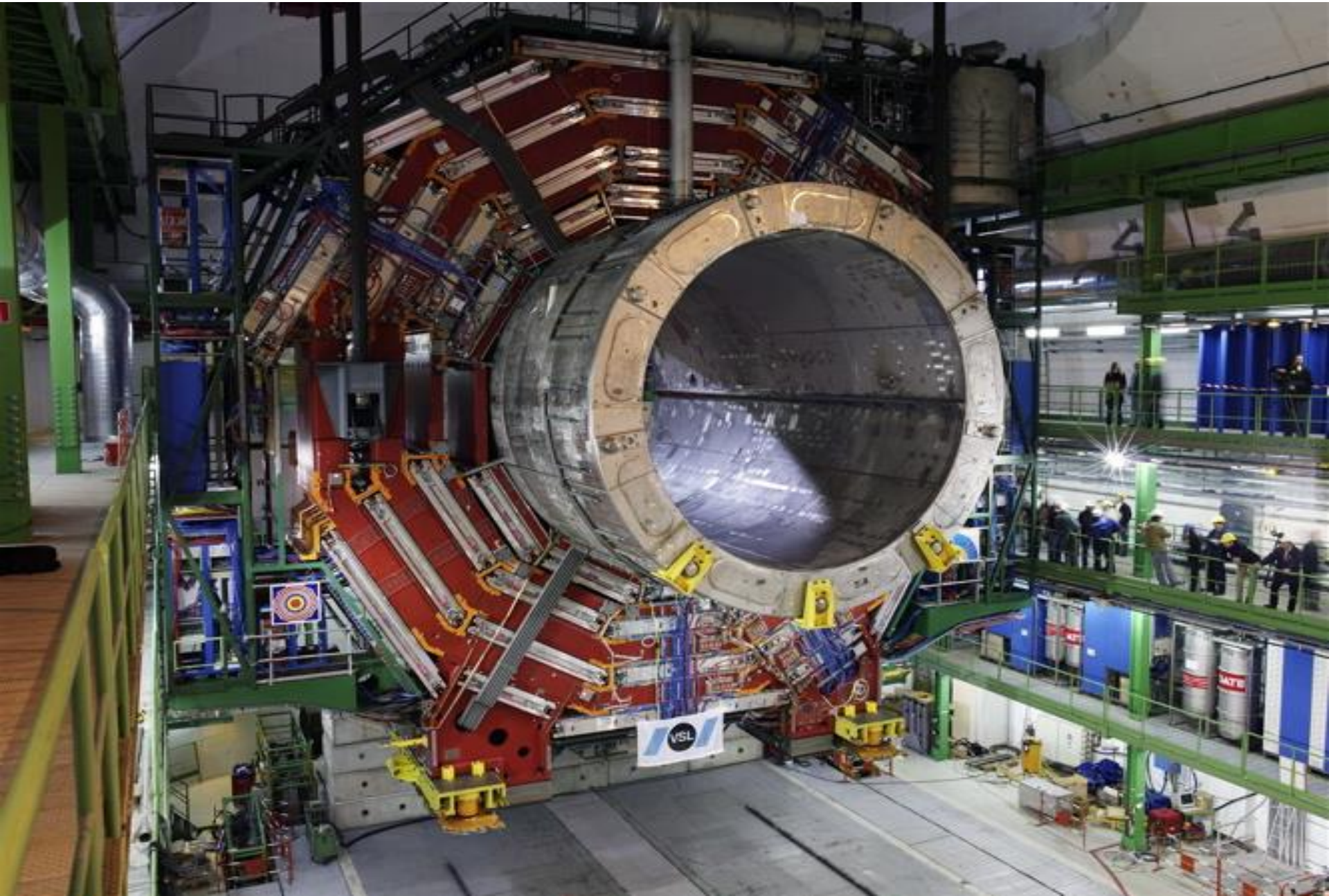


2nd beam event seen in ATLAS



ATLAS Cavern

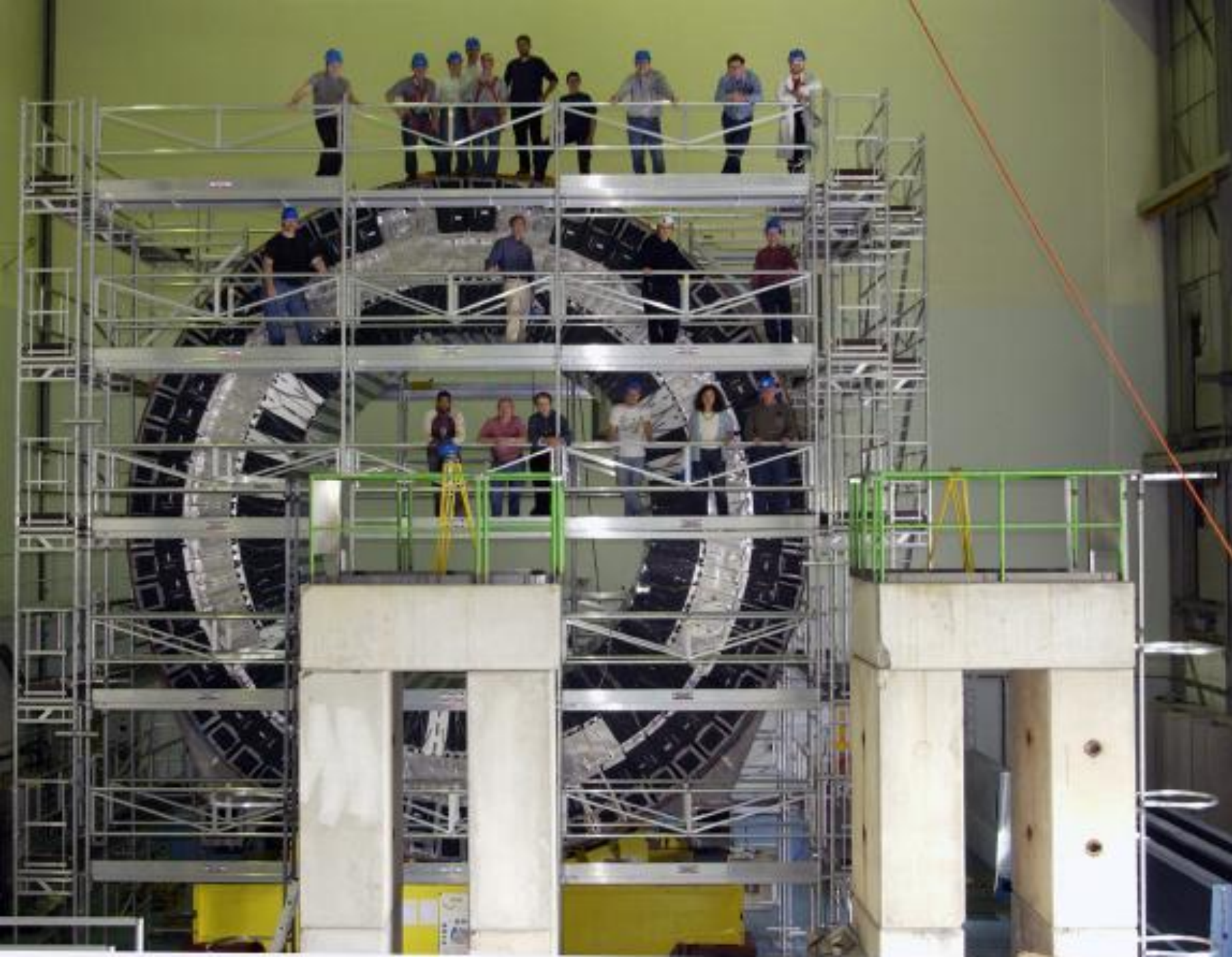
# Building CMS

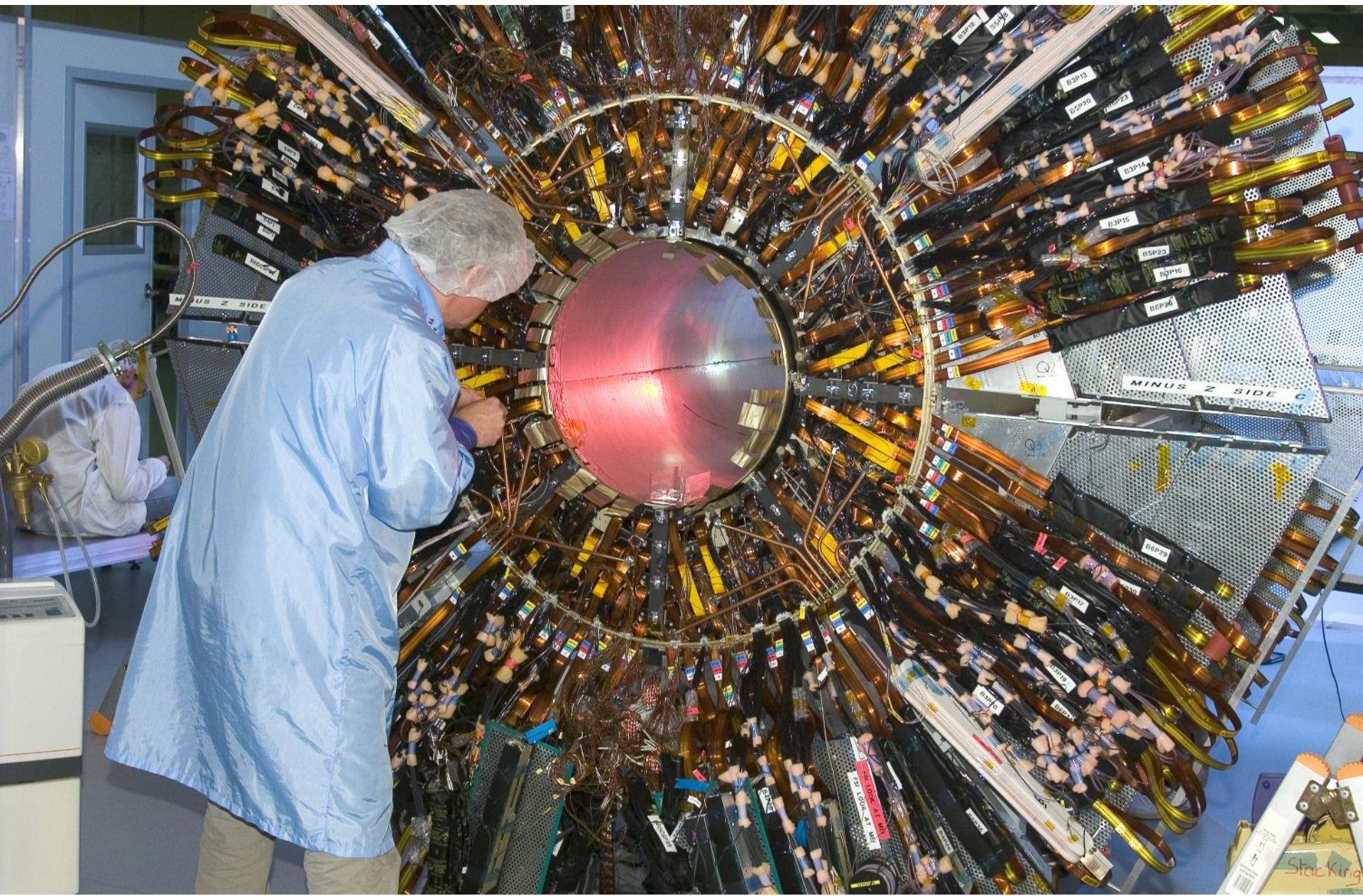


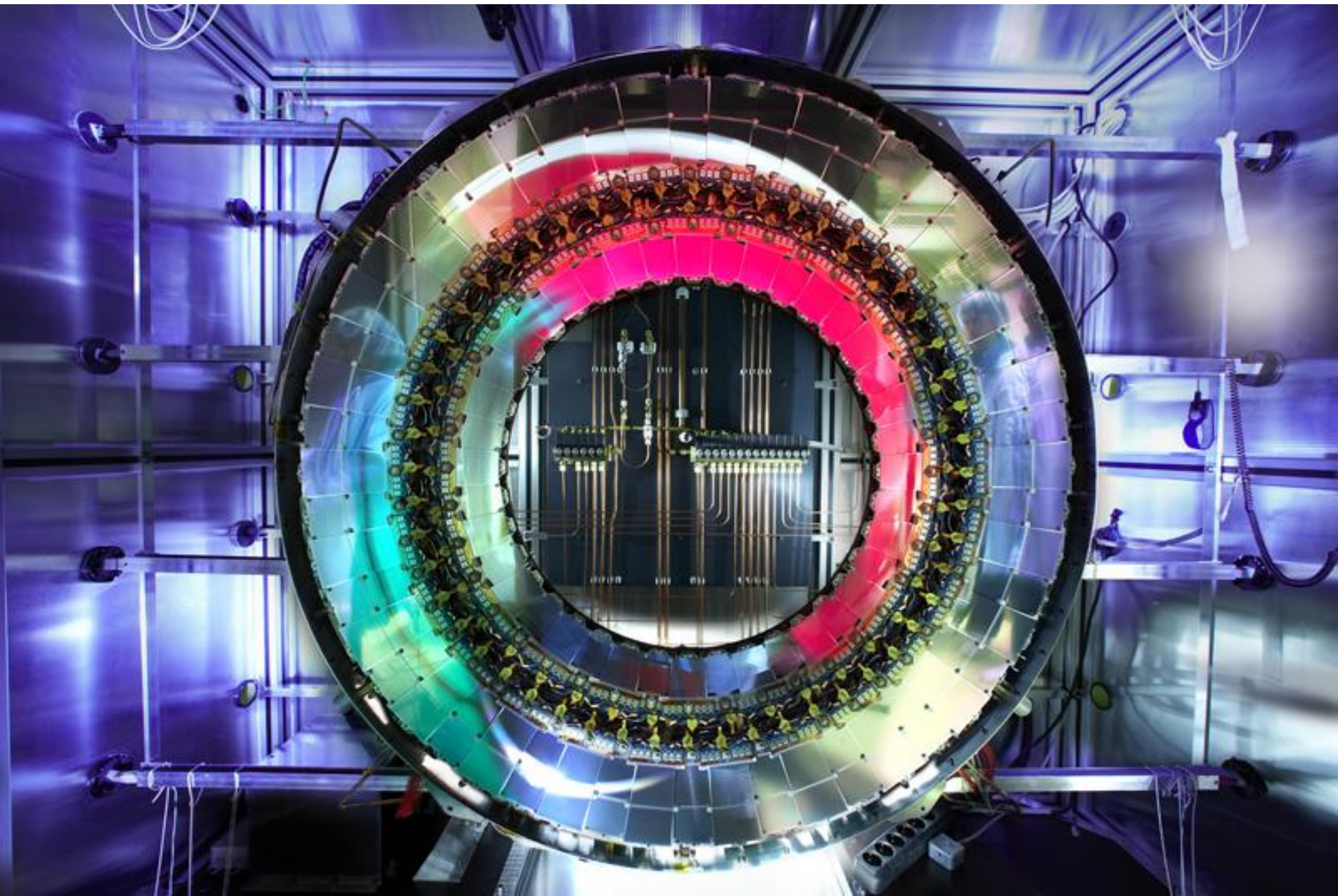


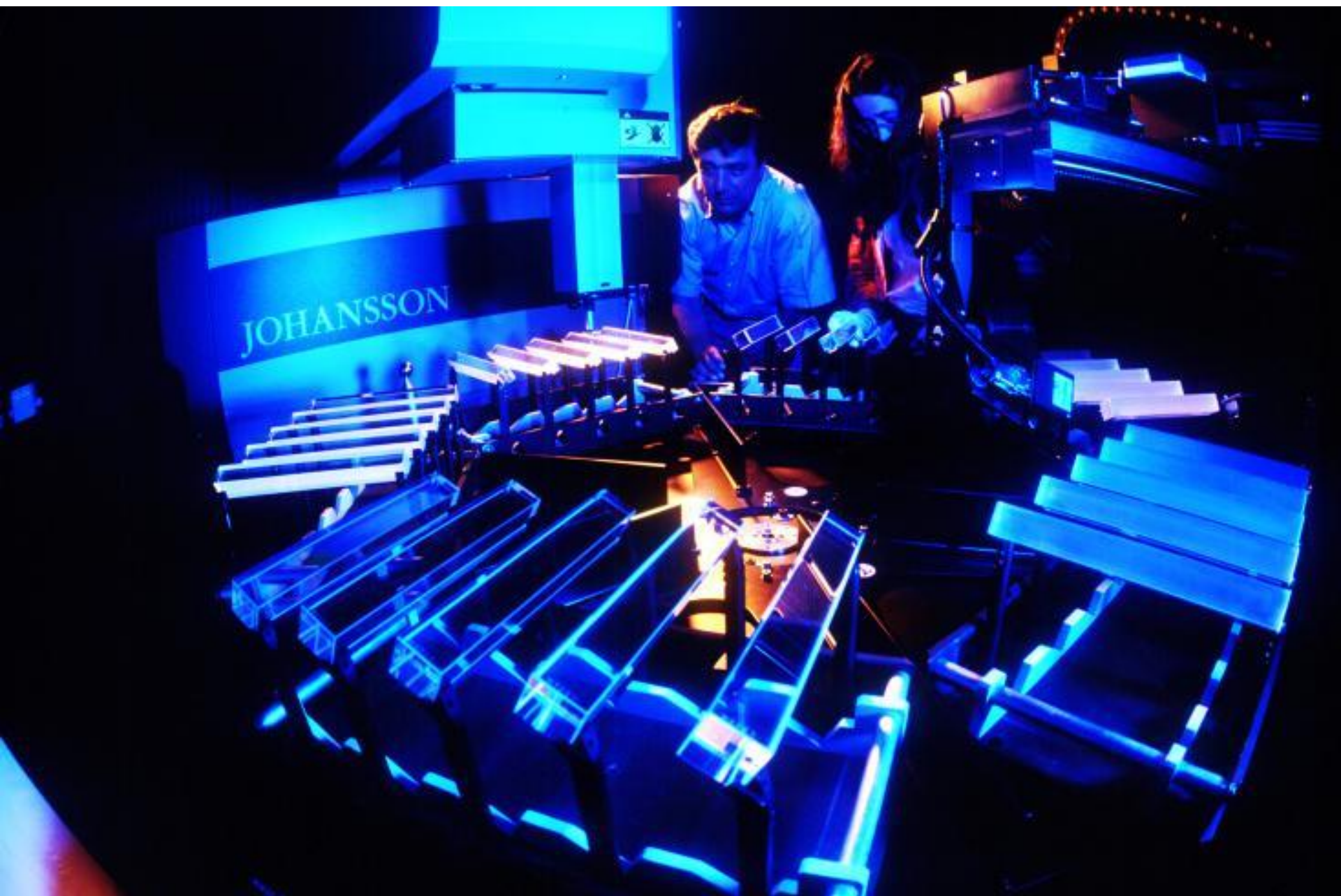


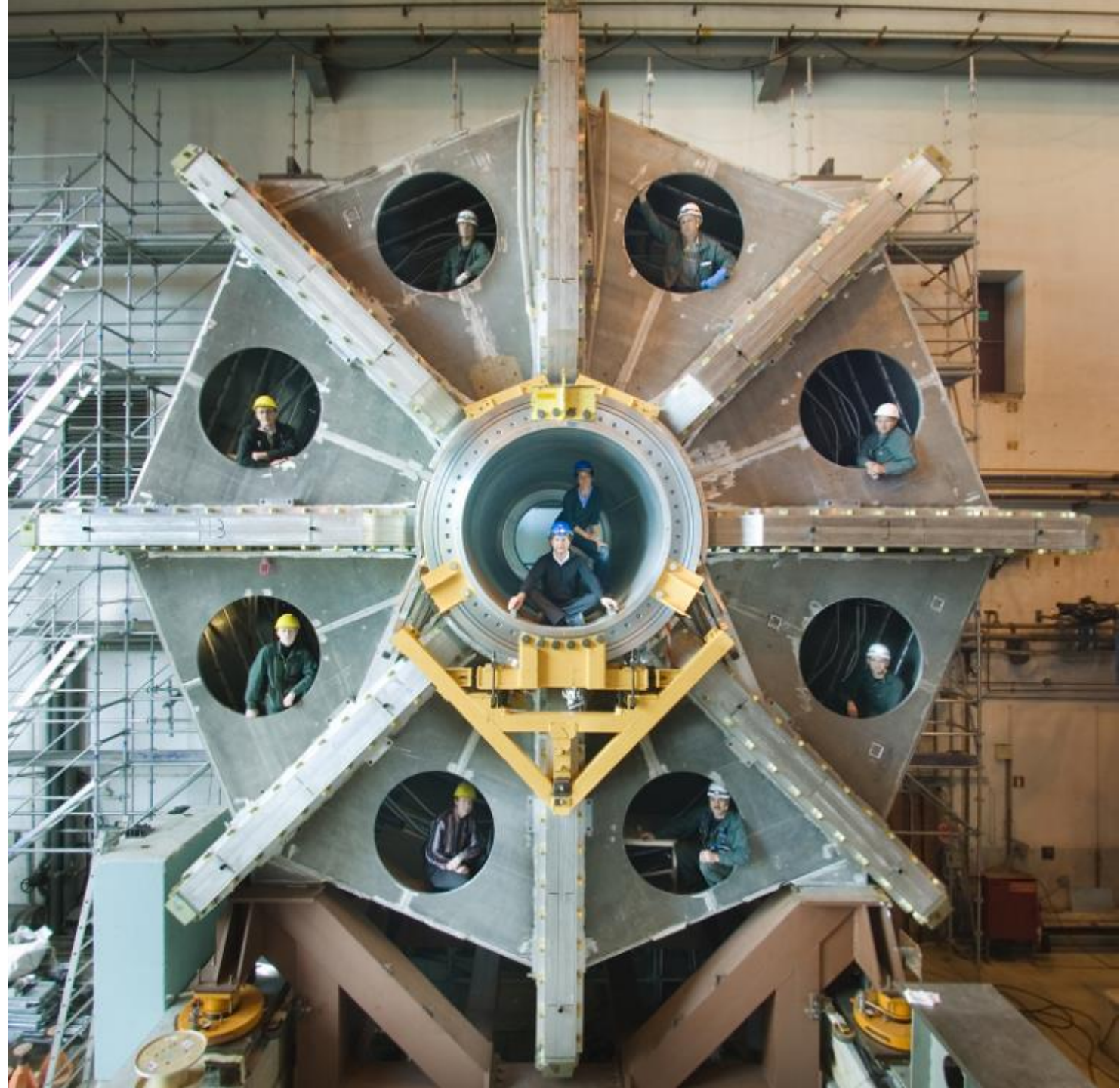


















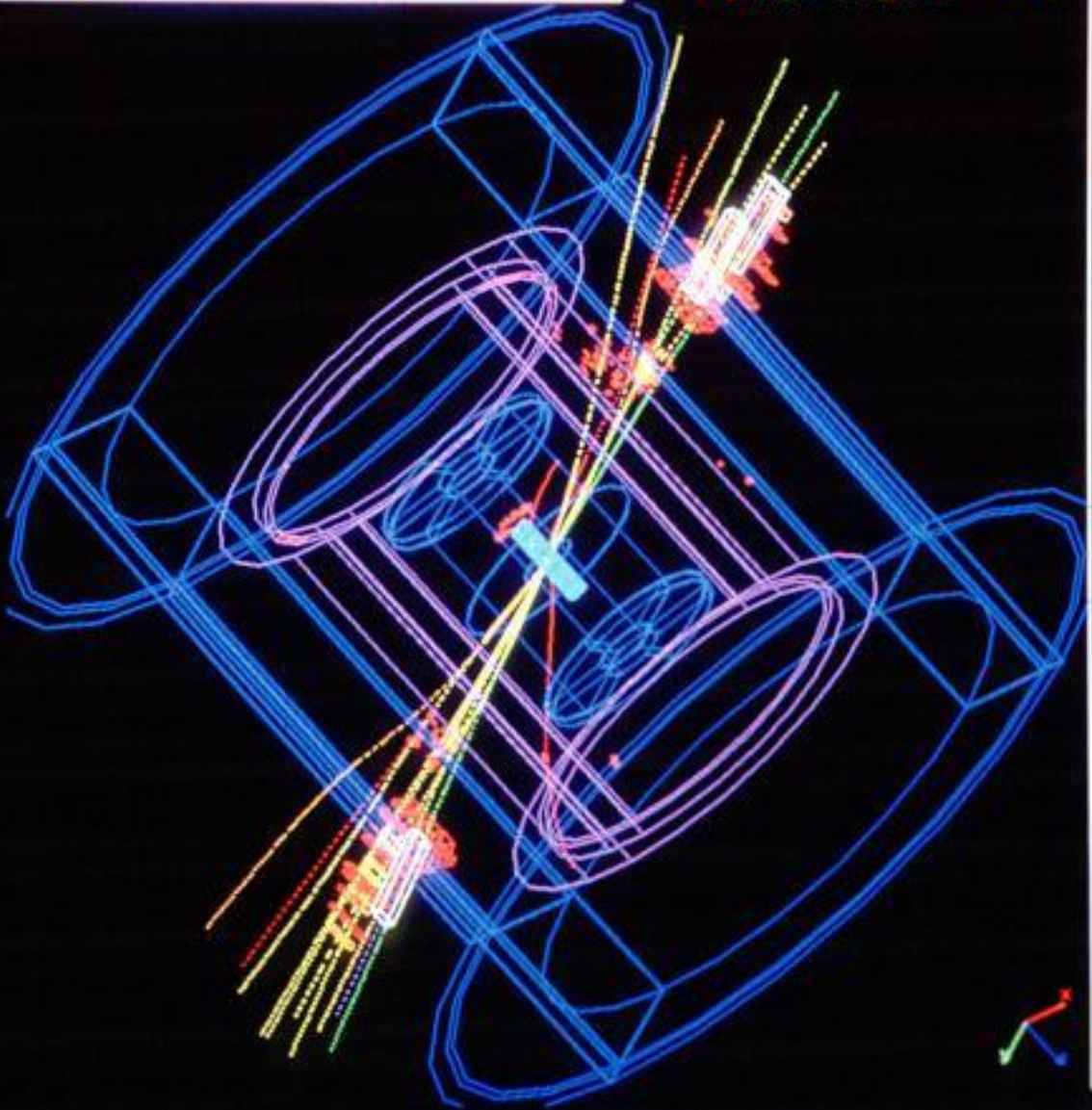





**DELPHI Interactive Analysis**  
 Beam: 45.0 GeV Run: 26154 DAS: 25-Aug-1991  
 Prog: 1-Oct-1991 Evt: 3018 21:47:02  
 Scan: 13-Jan-1992

	T0	T1	T2	T3	T4	T5	PA
Det	02	10	0	20	0	0	0
Event	< 00 >	< 100 >	< 0 >	< 20 >	< 0 >	< 0 >	< 0 >

- DELPHI
- ENCAPS
- BARREL
- CENTRAL
- Return



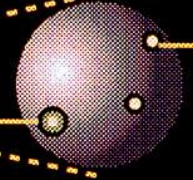
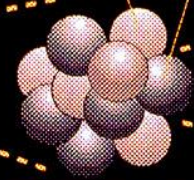
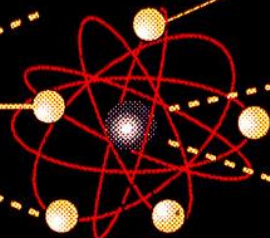
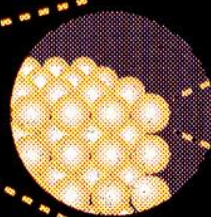
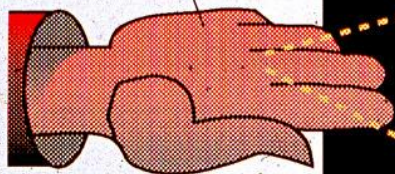
MATTER

ATOM

NUCLEUS

PROTON

QUARK



# LEPTONS

# QUARKS

ALL ORDINARY MATTER BELONGS TO THIS GROUP.



**electron**

Electric charge  $-1$ .

Responsible for electricity and chemical reactions

**electron neutrino**

Electric charge  $0$ .

Rarely interacts with other matter.

**up**

Electric charge  $+2/3$ .

Protons have 2 up quarks  
Neutrons have 1 up quark

**down**

Electric charge  $-1/3$ .

... and one down quark.  
... and two down quarks.

THESE PARTICLES EXISTED JUST AFTER THE BIG BANG.



**muon**

A heavier relative of the electron.



**muon neutrino**

Created with muons when some particles decay.

**charm**

A heavier relative of the up.



**strange**

A heavier relative of the down.



NOW THEY ARE FOUND ONLY IN COSMIC RAYS AND ACCELERATORS.

**tau**

Heavier still.

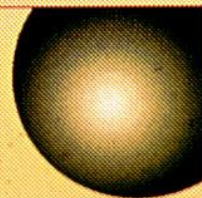


**tau neutrino**

Not yet observed directly.

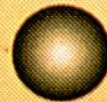
**top**

Heavier still, recently observed.



**bottom**

Heavier still.



## ANTIMATTER

Each particle also has an antimatter counterpart ... sort of a mirror image.



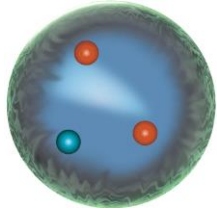
## Mass Ratios of Elementary Particles (MeV)

	Lepton	Neutrino	Quark 1	Quark 2
1st Family	0.5	0	3	6
2nd Family	106	0	1300	100
3rd Family	1800	0	175000	4500

	Lepton	Neutrino	Quark 1	Quark 2
1st Family	1	0	1	1
2nd Family	212	0	433	17
3rd Family	3600	0	58333	750

	Lepton	Q1/Q2	L/(Q1/Q2)
1st Family	1	1	1
2nd Family	212	26	8
3rd Family	3600	78	46

# Basic Forces and their Carriers



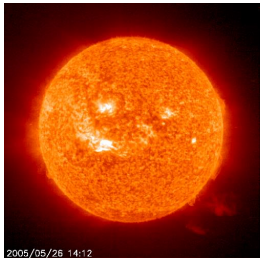
Strong Force:

Gluon



Electro-Magnetic Force:

Photon



Weak Force:

Bosons (W, Z)



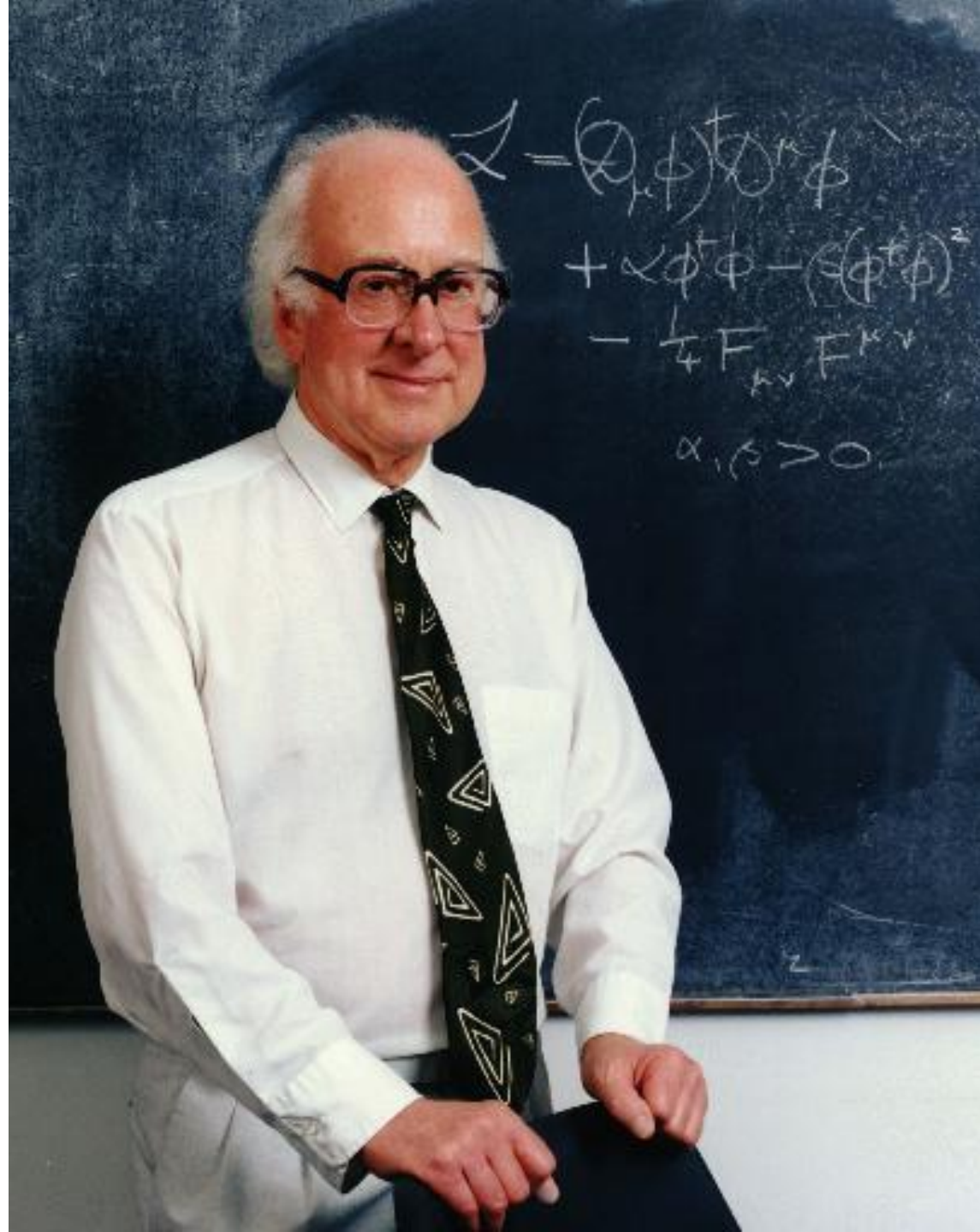
Gravitation:

Falling apples, orbiting Moon

Relative strength  $\sim (1/10^{38})$

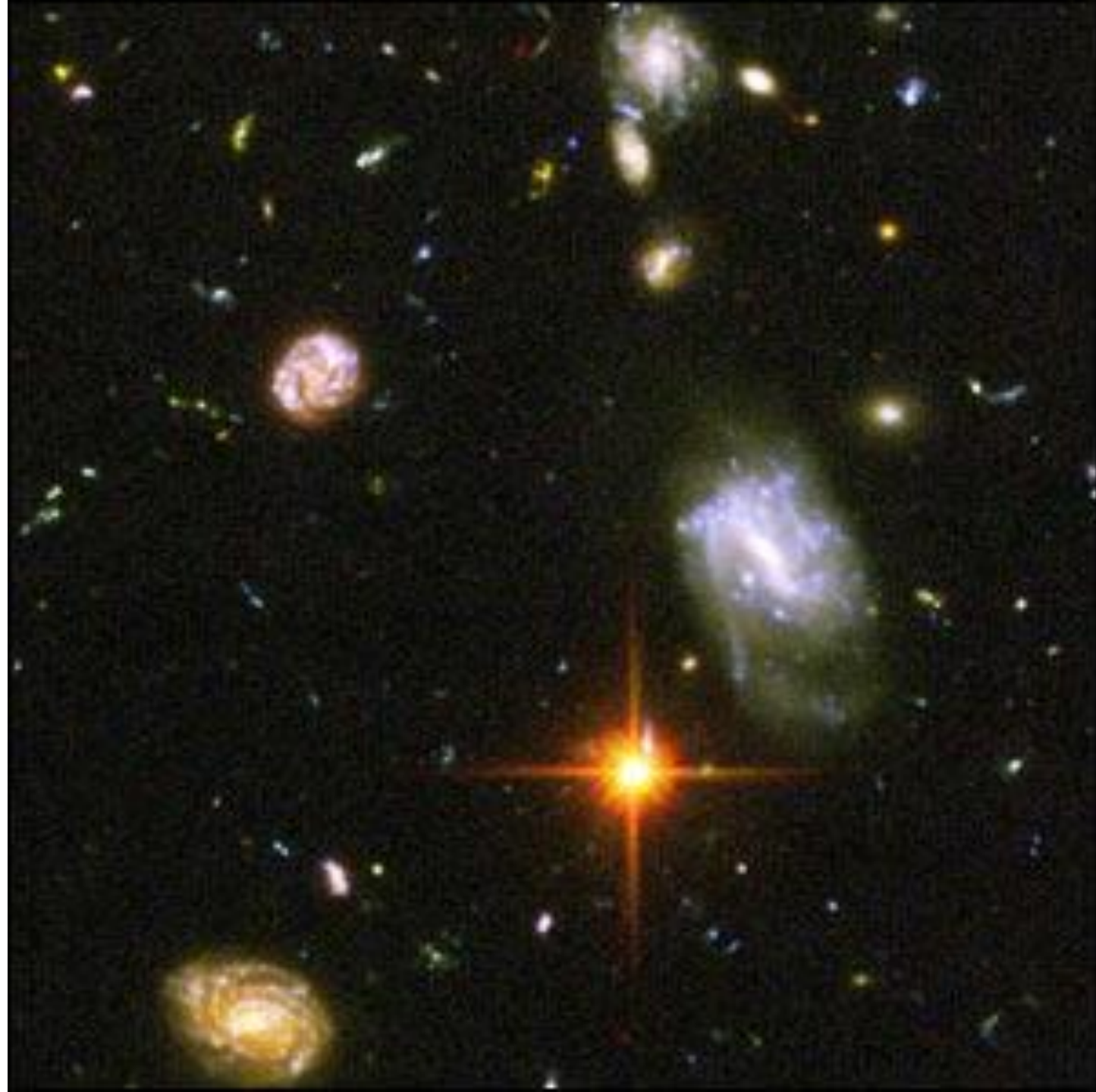
Graviton

No mass (?)

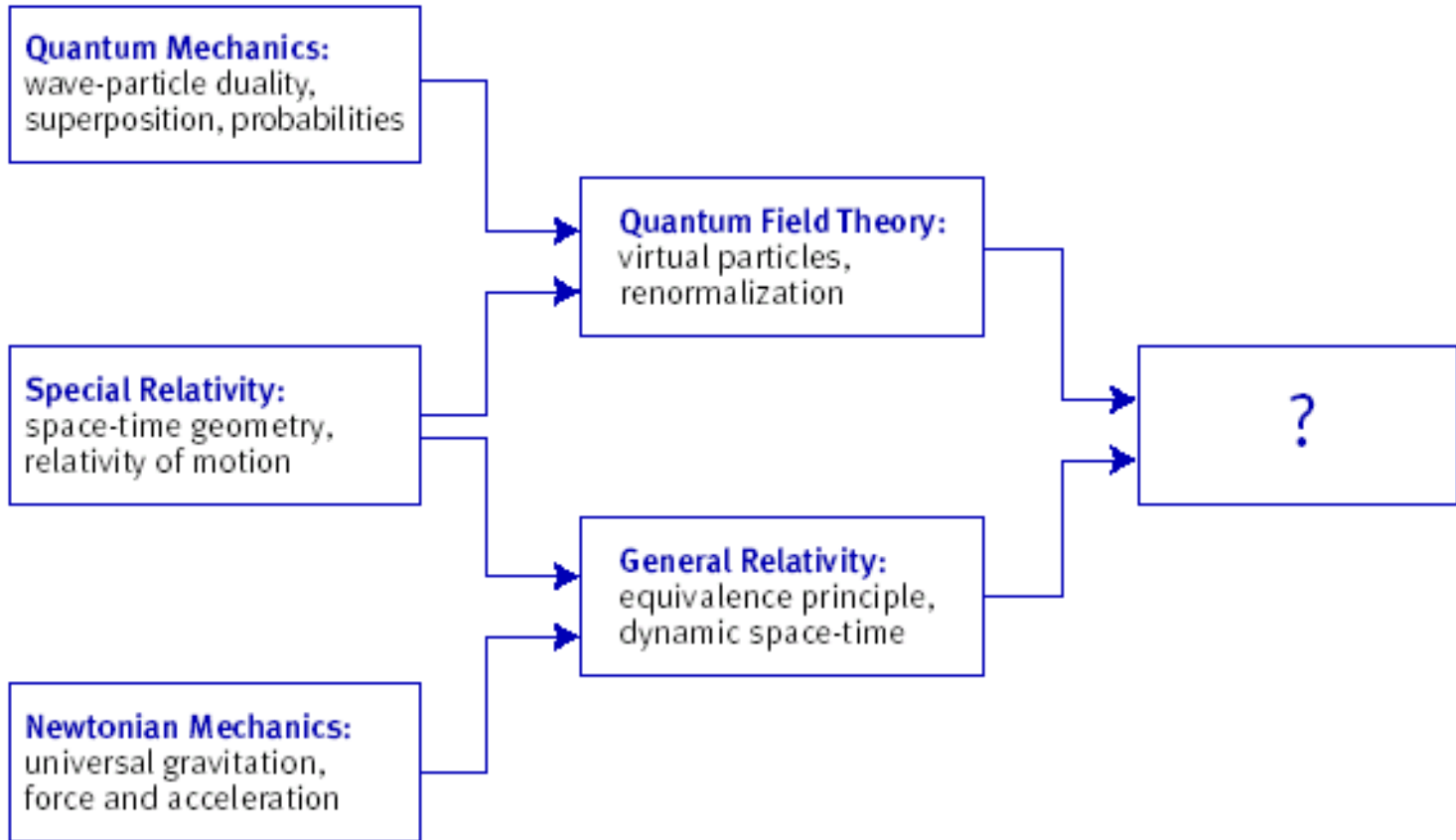


$$\mathcal{L} = (\partial_\mu \phi)^\dagger \partial^\mu \phi + \alpha \phi^\dagger \phi - \beta (\phi^\dagger \phi)^2 - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

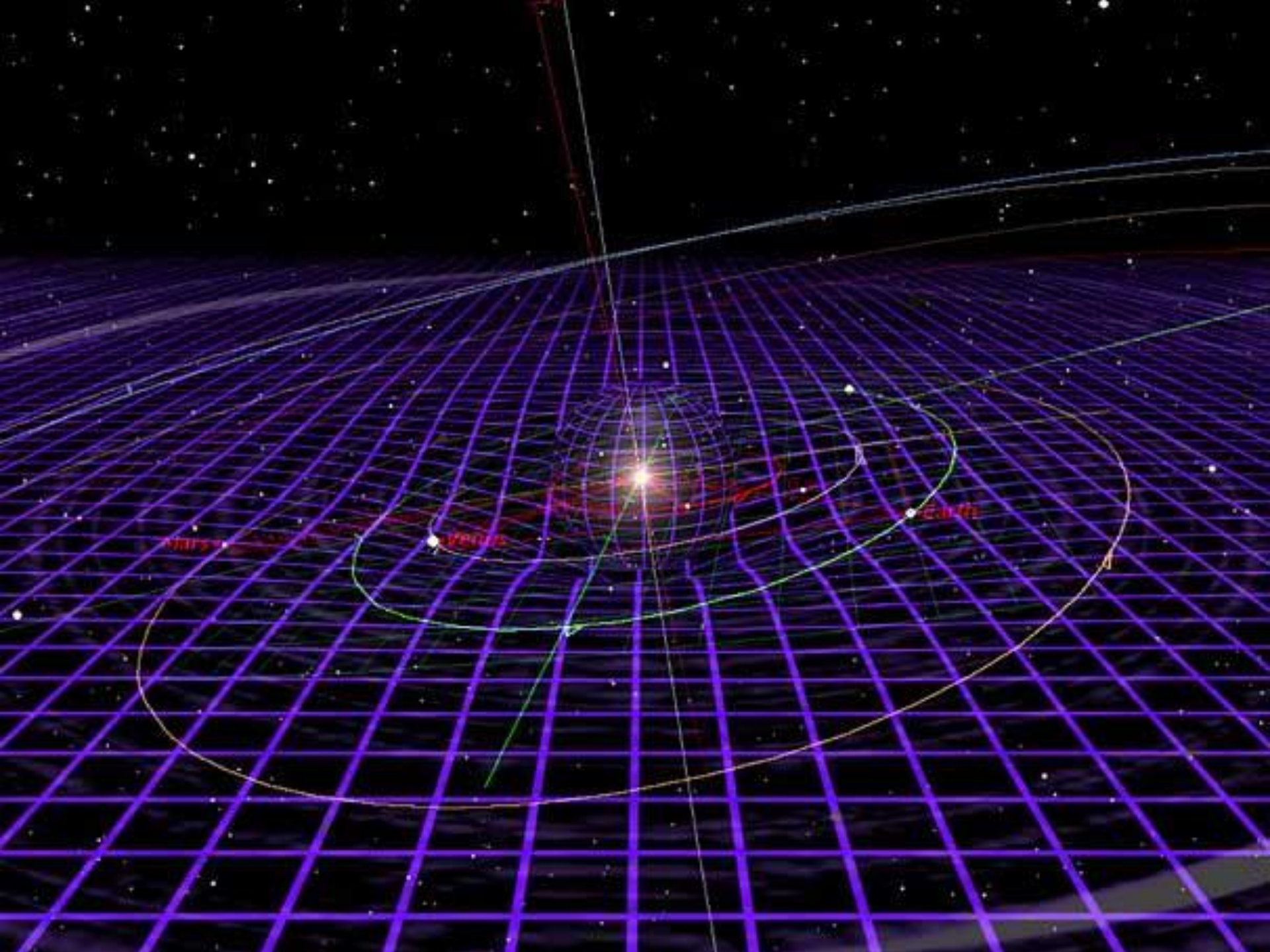
$\alpha, \beta > 0$



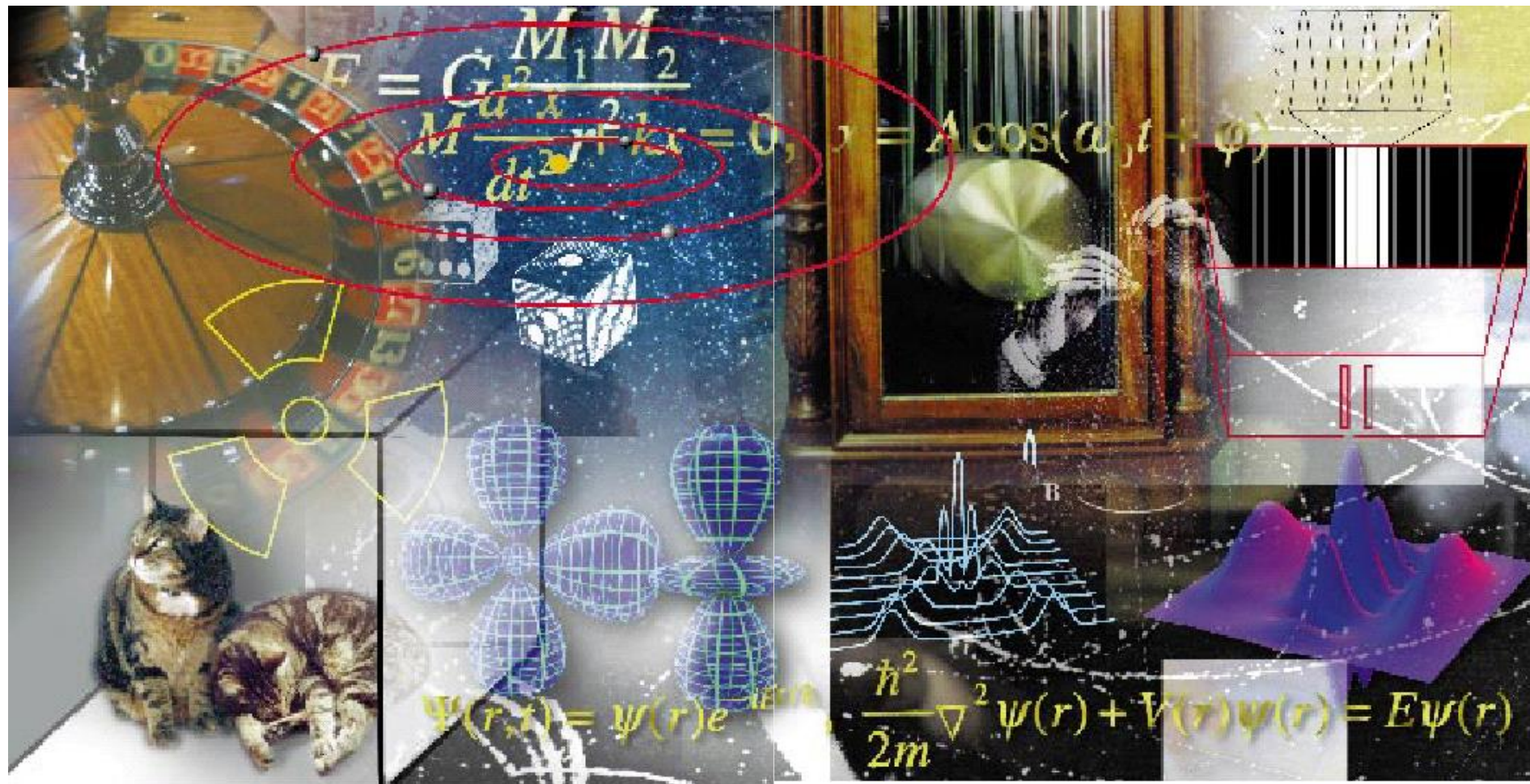






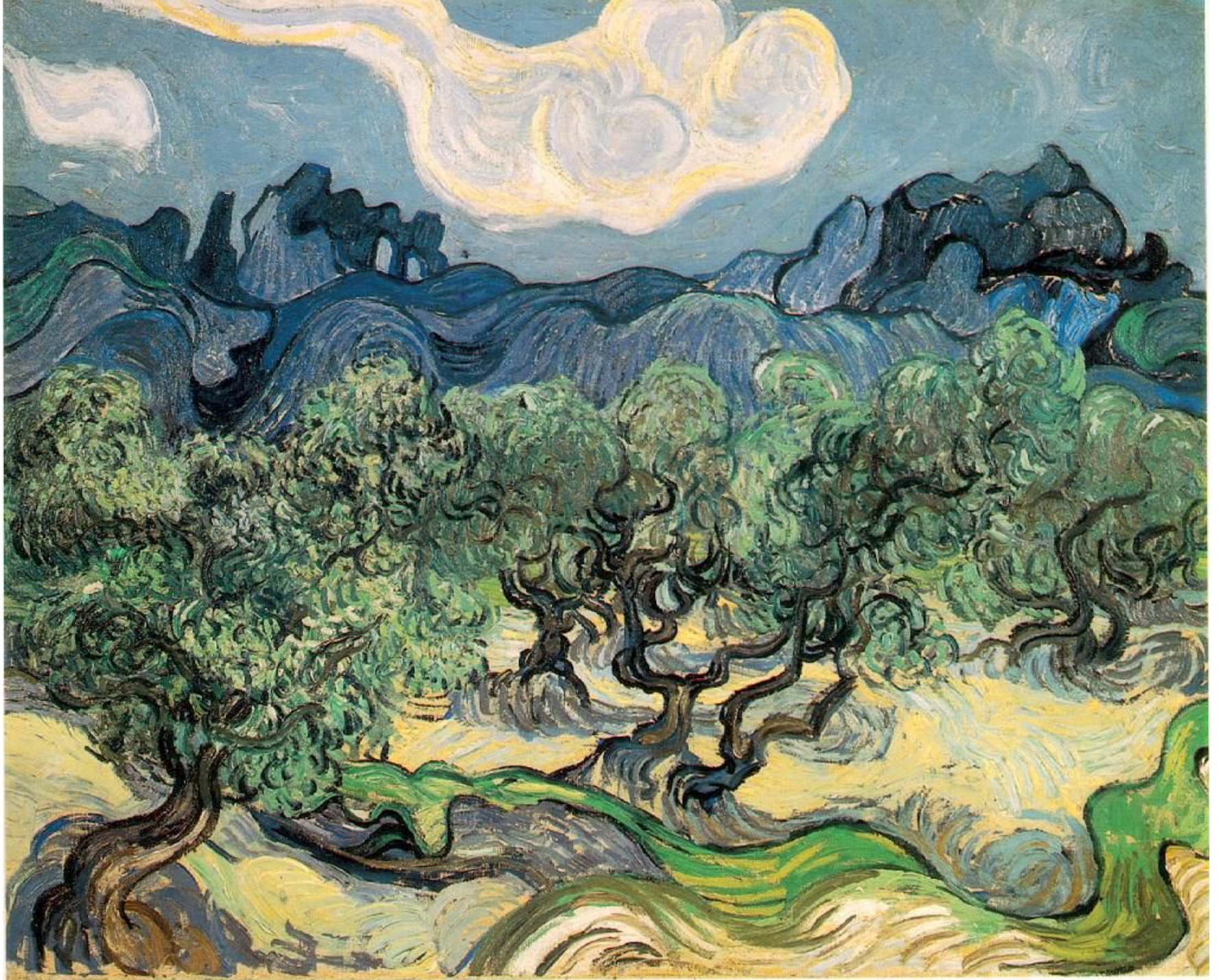






Copyright 1997 Scientific American, Inc.

*Bringing Schrödinger's Cat to Life*



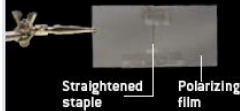






# Quantum Erasing in the Home

The steps presented here outline how to see quantum erasure in action. See [www.sciam.com/ontheweb](http://www.sciam.com/ontheweb) for a fuller description and additional information, such as the basics of how waves interfere and produce fringes.

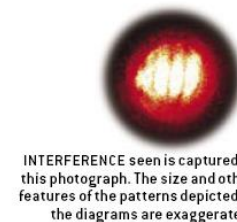
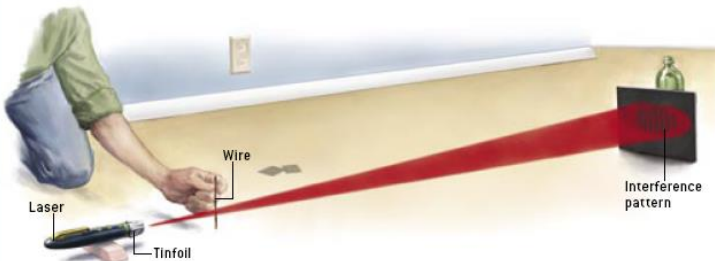


## 1 SEEING INTERFERENCE

- Wrap the tinfoil around the business end of the laser and put a pinhole in it to let through some of the light beam.
- Set up the laser so it shines on the screen from at least six feet away. It should produce a circular spot of light on the screen.
- Position the wire vertically and centered in the light.

**WHAT HAPPENS:** As shown, you should see an interference pattern consisting of a row of fringes (bright and dark bands). The interference pattern arises because light passing on the left of the

wire is combining, or "interfering," with light passing on the right-hand side. If you hold a piece of paper just after the wire, you will see a lobe of light on each side of the shadow of the wire. The lobes expand and largely overlap by the time they reach the screen. For each individual photon arriving at the screen in the overlap region, it is impossible to tell whether it went on the left or the right side of the wire, and the combination of the two ways it went causes the fringes. Although you are looking at trillions of photons, each of them is interfering only with itself.

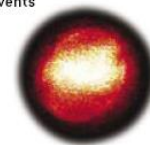
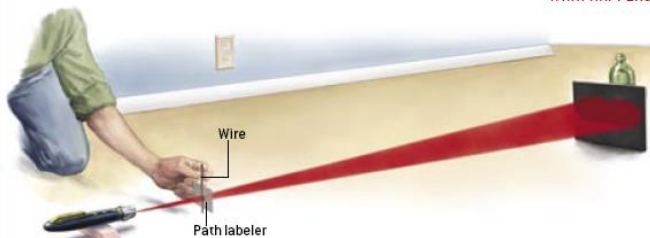


## 2 LABELING THE PATH

- Take two polarizers and rotate one of them so that their axes are perpendicular; you have done this correctly if when you overlap the film temporarily, no light goes through the overlap region.
- Tape them together side by side with no gap or overlap. Do the taping along the top and bottom so the tape will not block the light. We will call this the path labeler.

- Position the labeler in the beam so that its join is right behind the wire. Attaching the wire to the labeler might be easiest. Wire and labeler will not be moving for the rest of the experiment. We will say that the left-hand polarizer produces vertically polarized light (V), and the right-hand one horizontally polarized (H). It does not matter if we have these labels reversed.

**WHAT HAPPENS:** Even though the light is again passing on both sides of the wire, the fringes should be gone. If a photon reaches the screen by passing to the left of the wire, it arrives V-polarized; if to the right of the wire, H-polarized. Thus, the labeler has made available the information about which way each photon went, which prevents the interference.

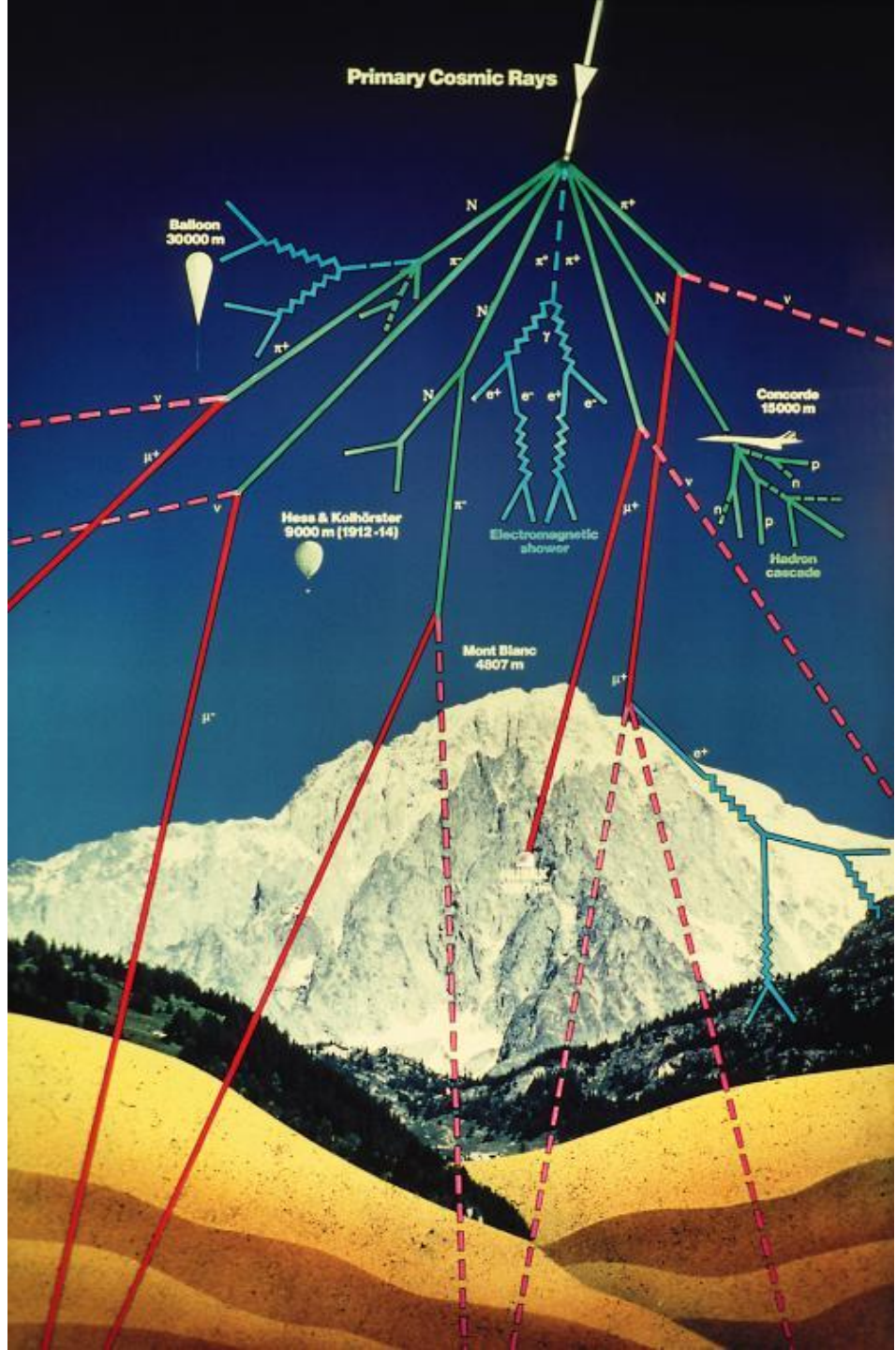




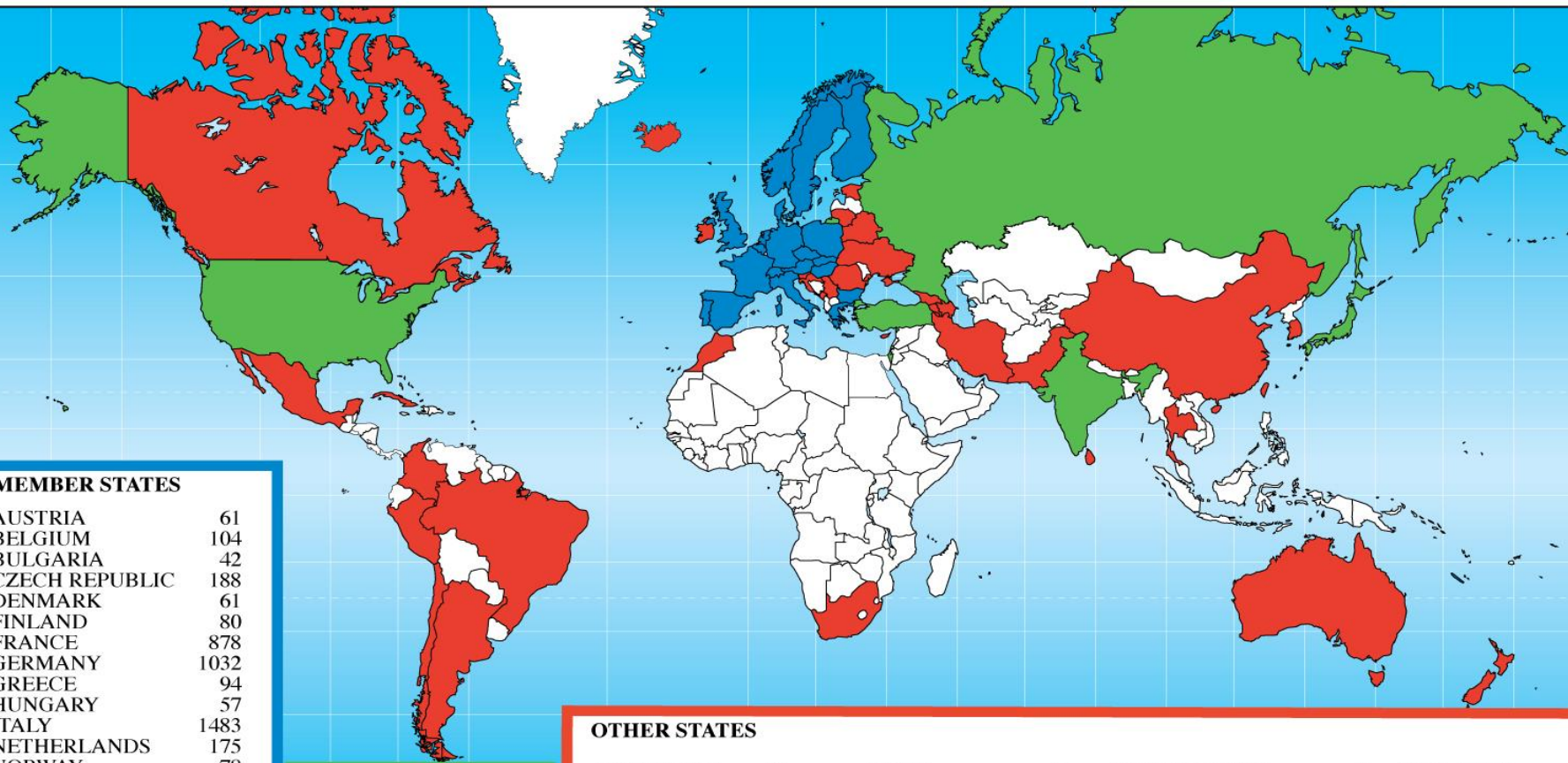




# Primary Cosmic Rays



# Distribution of All CERN Users by Nation of Institute on 6 January 2009



## MEMBER STATES

AUSTRIA	61
BELGIUM	104
BULGARIA	42
CZECH REPUBLIC	188
DENMARK	61
FINLAND	80
FRANCE	878
GERMANY	1032
GREECE	94
HUNGARY	57
ITALY	1483
NETHERLANDS	175
NORWAY	78
POLAND	174
PORTUGAL	111
SLOVAKIA	49
SPAIN	286
SWEDEN	73
SWITZERLAND	330
UNITED KINGDOM	715

## OBSERVER STATES

INDIA	89
ISRAEL	59
JAPAN	200
RUSSIA	883
TURKEY	52
USA	1485

## OTHER STATES

ARGENTINA	10	CUBA	3	MONTENEGRO	1	SRI LANKA	1
ARMENIA	15	CYPRUS	6	MOROCCO	5	TAIWAN	42
AUSTRALIA	14	ESTONIA	11	NEW ZEALAND	6	THAILAND	1
AZERBAIJAN	1	GEORGIA	11	PAKISTAN	24	UKRAINE	18
BELARUS	19	ICELAND	1	PERU	1		
BRAZIL	73	IRAN	12	ROMANIA	49		
CANADA	136	IRELAND	12	SERBIA	17		
CHILE	4	KOREA	51	SLOVENIA	16		
CHINA	64	LITHUANIA	5	SOUTH AFRICA	8		
COLOMBIA	11	MEXICO	28				
CROATIA	20						

**6071**

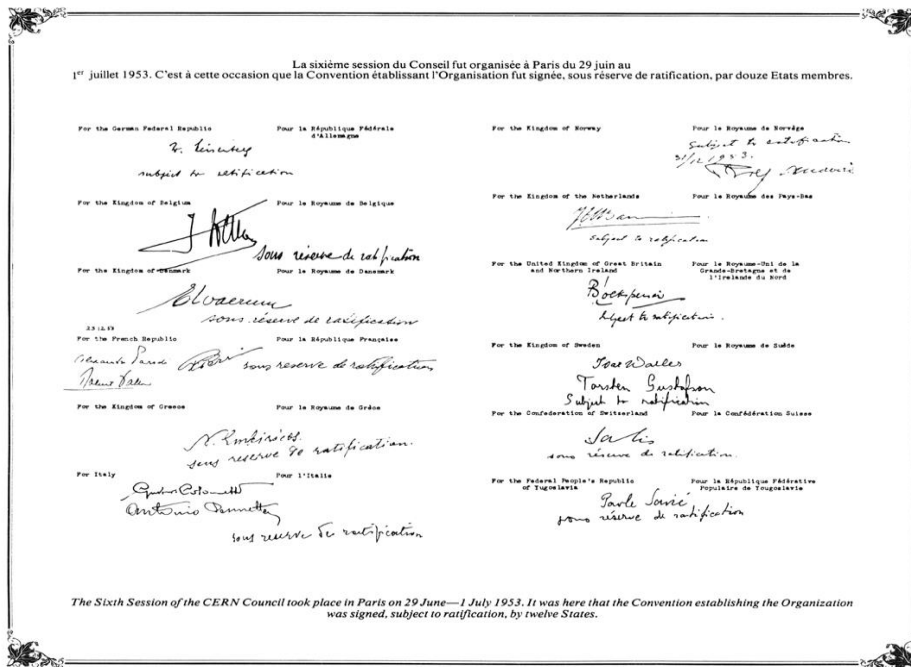
**2768**

**696**

# CERN

## European Organization for Nuclear Research

- Founded in 1954 by 12 countries
- Now: 22 member states, 5 + 2 observers (jp, ru, tr, us, EU, Unesco)
- More than 7000 users from all over the world
- ~1000 Meur / Year budget

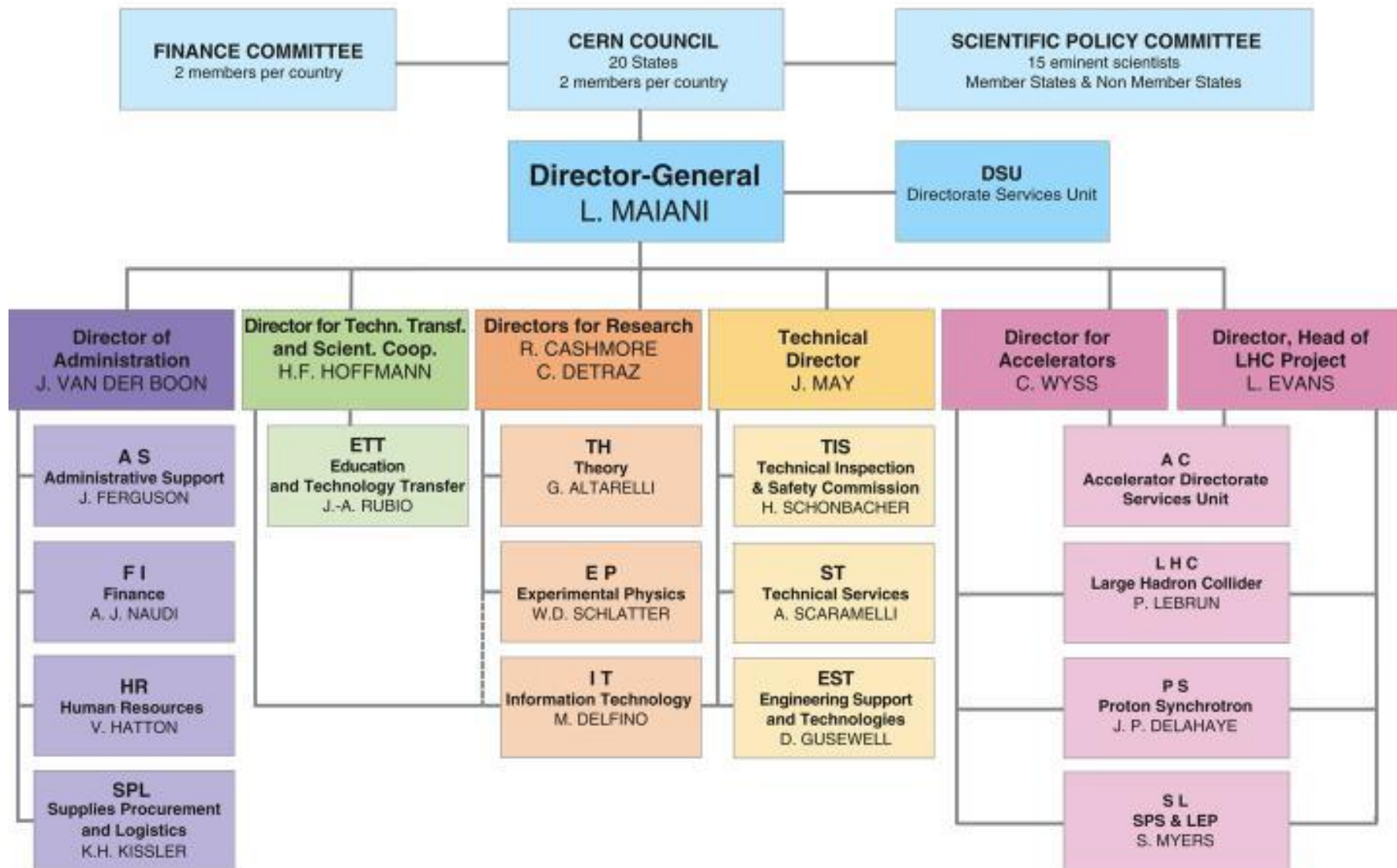


1954: Convention establishing the Organization - original signatures



2007: The 20 member states

# CERN ORGANISATIONAL CHART 07/2001

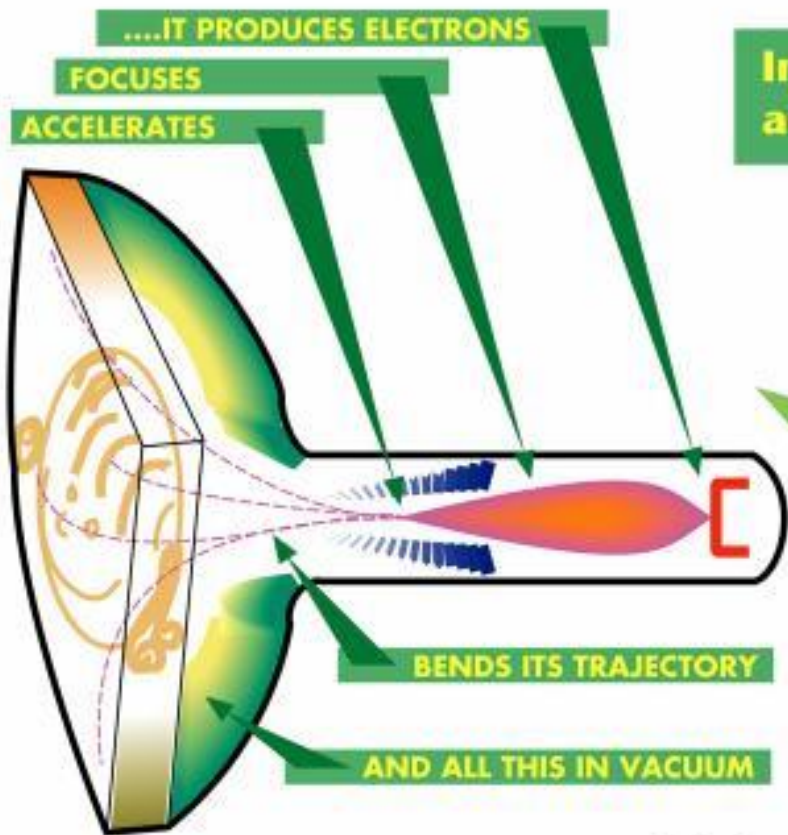






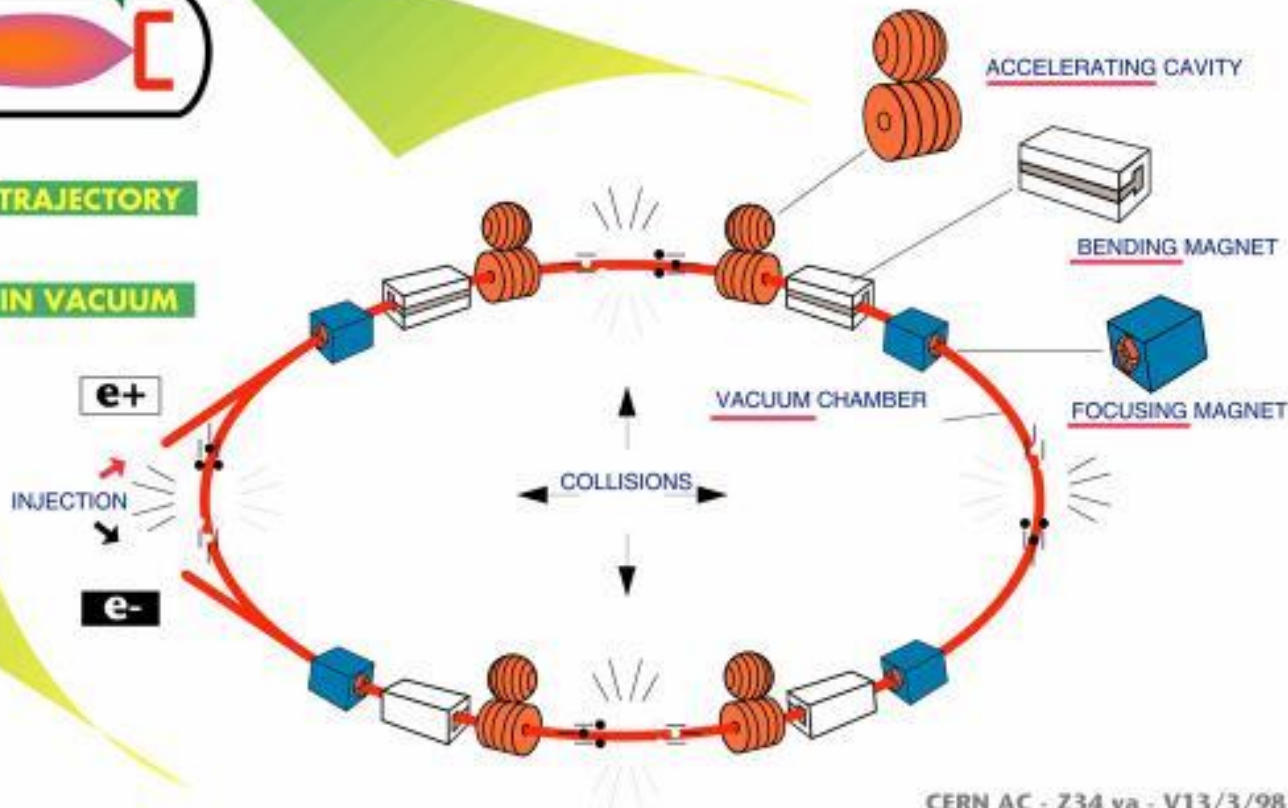
Teilchen

# DID YOU KNOW YOUR TELEVISION SET IS AN ACCELERATOR ?



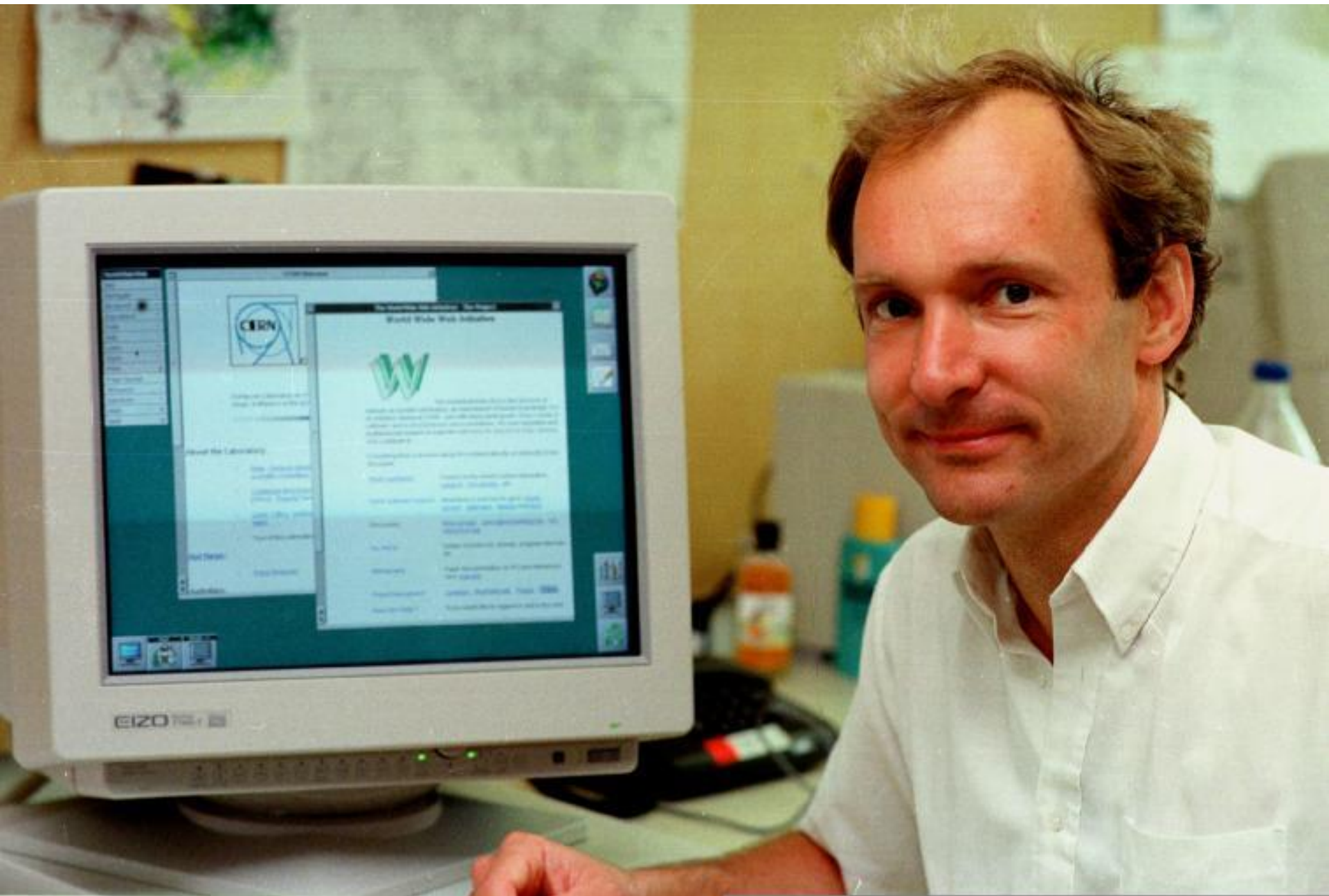
In your TV set, the electrons are accelerated to 20000 volts.

In LEP, they are accelerated to 100 000 000 000 volts.









Modern Physics  
Relativity  
Thermodynamics  
Optics  
Biology

+

Quantum  
Mechanics

QM describes physics phenomena  
at very small distances

- 1) Objects described with a wavefunction WF
- 2) The WF fills the entire (Hilbert) space

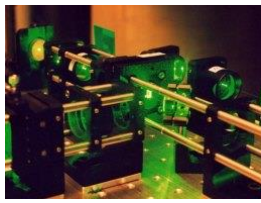
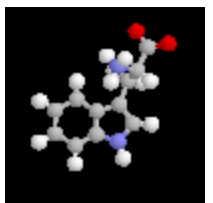


Chemistry

Electronic  
s  
(transistor)

Optics  
(lasers)

(Other)



Bioinformatics

Computer  
(chip)

Quantum  
Computing

Software

Communi-  
-cations

Teleportation?

Grid

