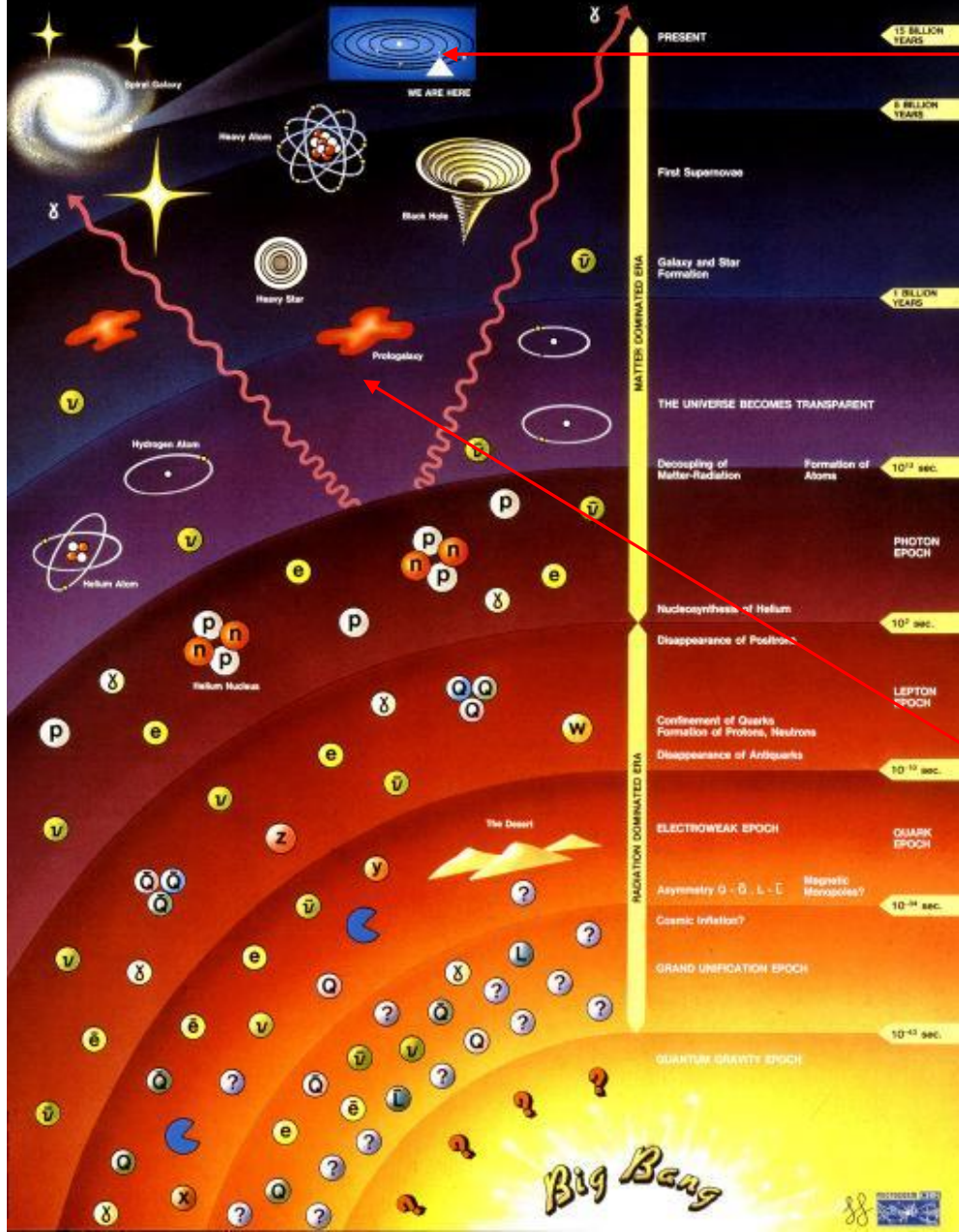


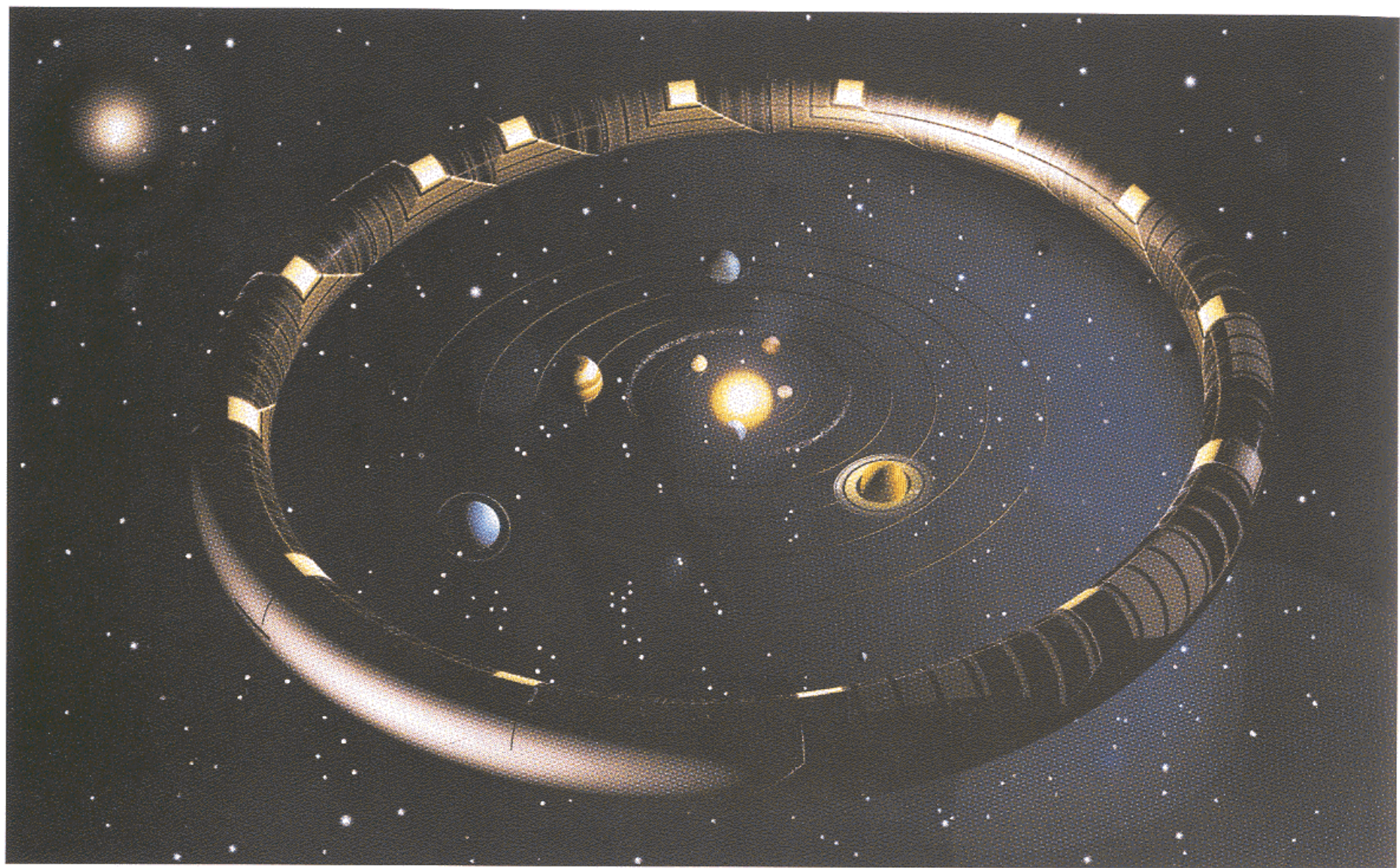
Tervetuloa CERNiin

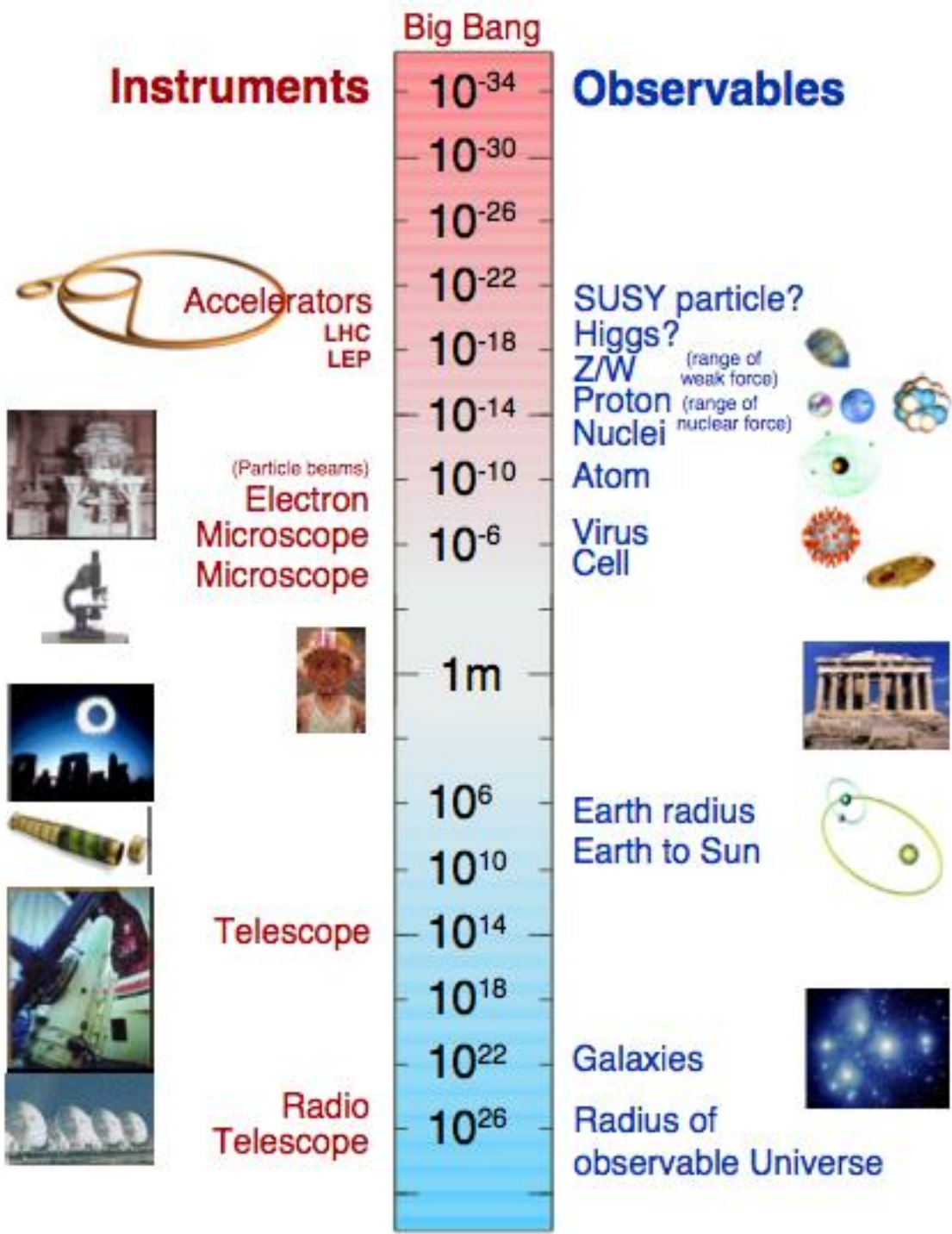
Joroisten, Leppävirran ja Varkauden lukiot 15.5.2019

History of the Universe

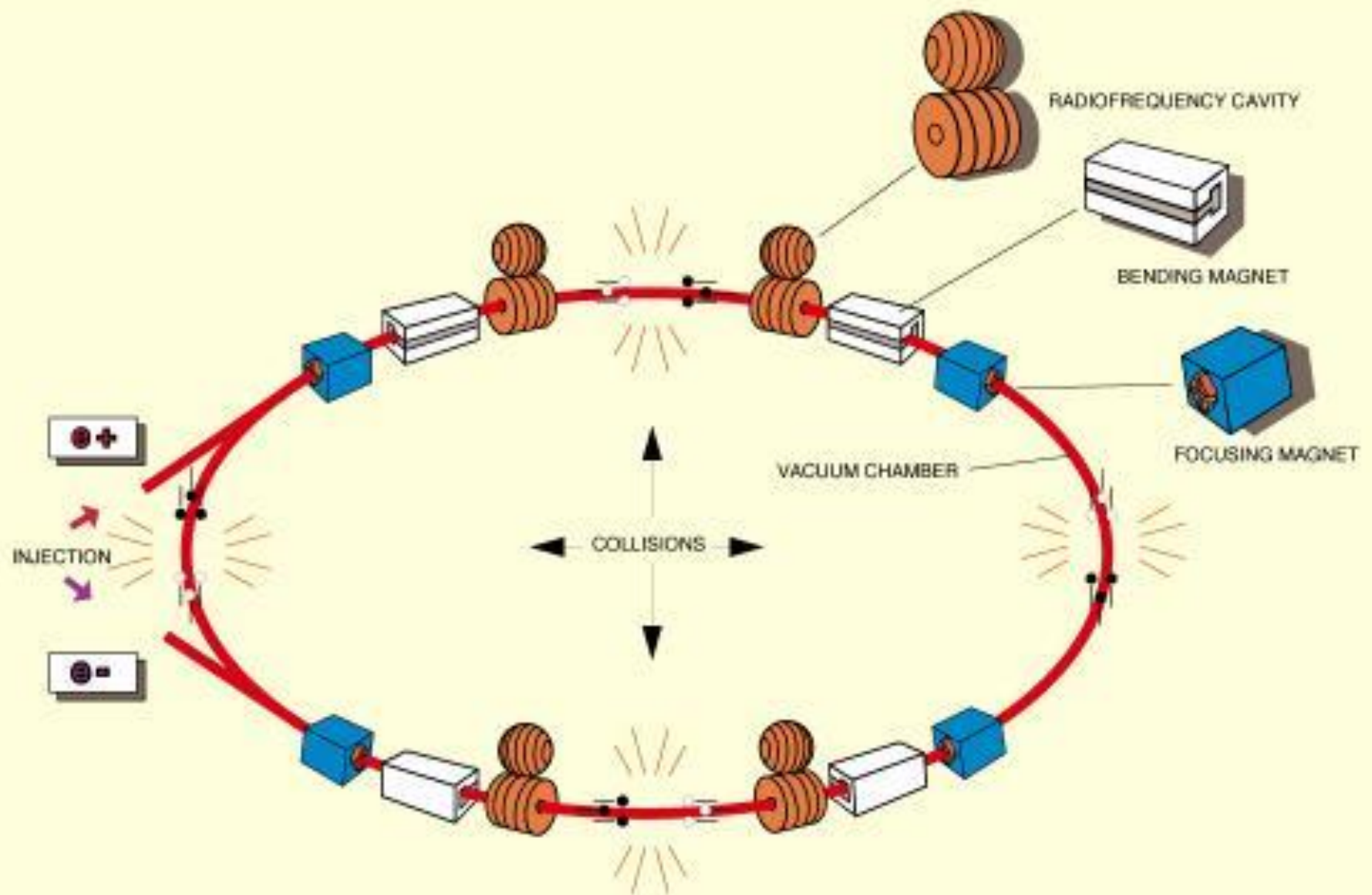




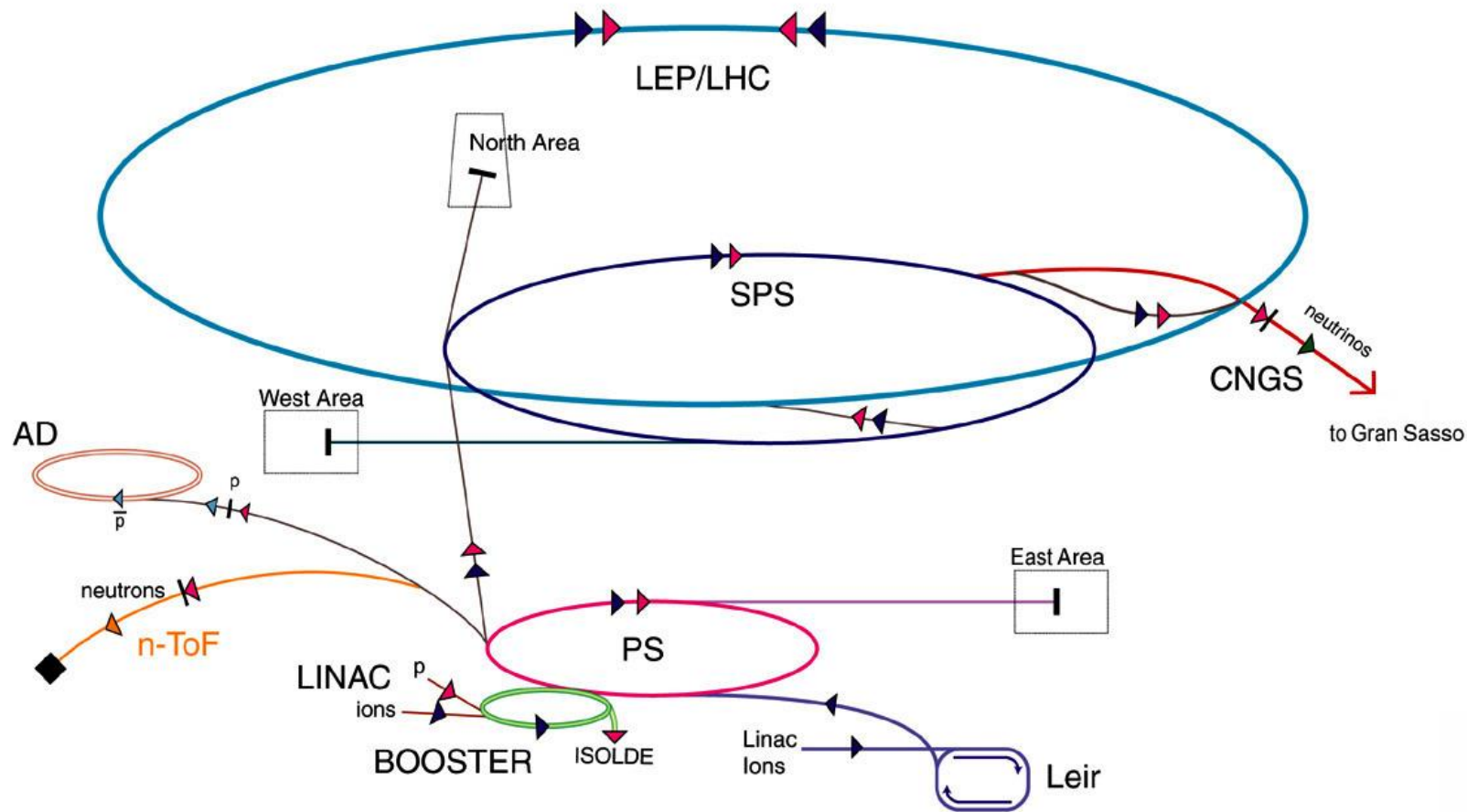




THE PRINCIPAL MACHINE COMPONENTS OF THE LEP ACCELERATOR.



Accelerator chain at CERN, a complex business



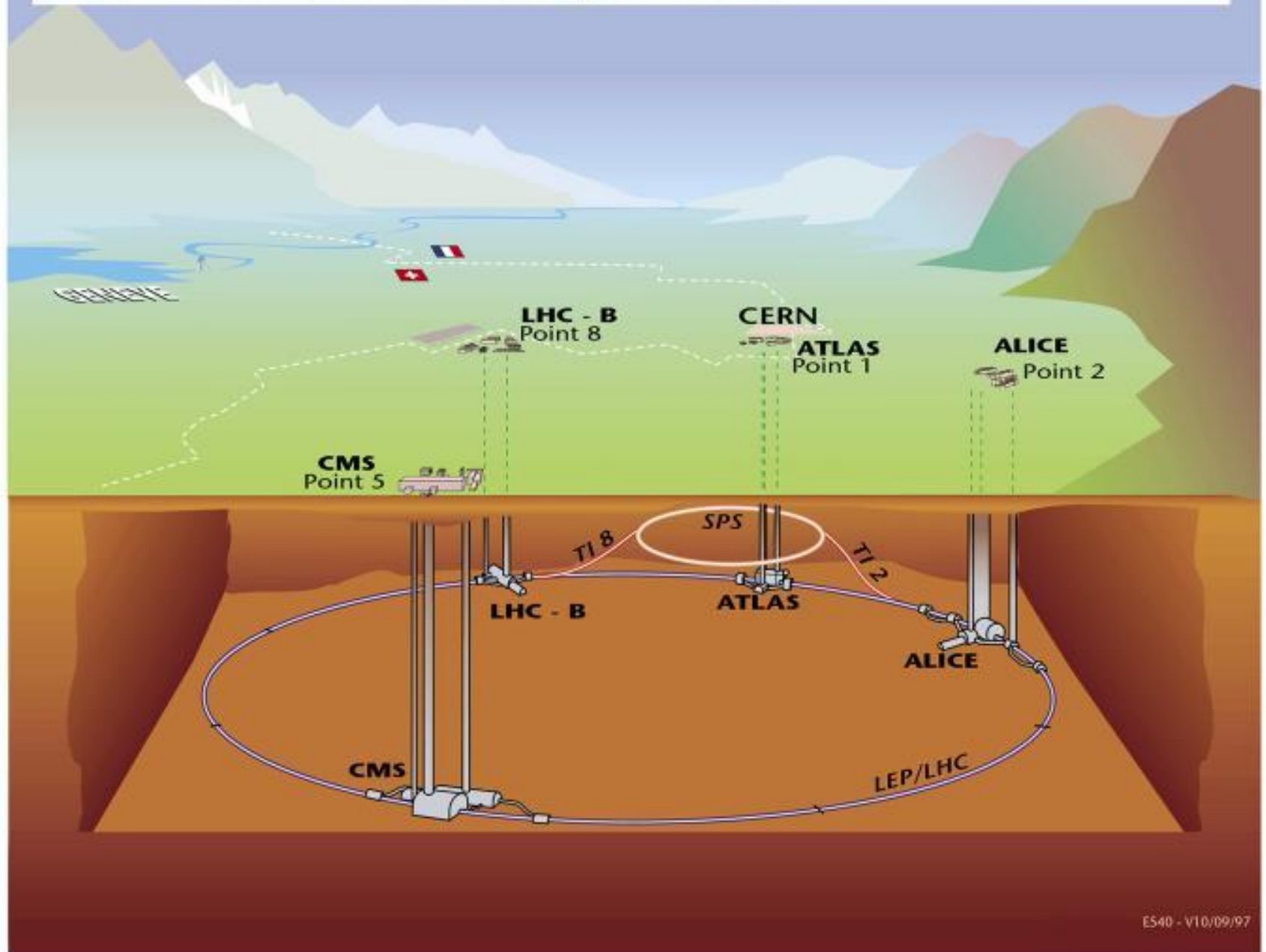
- ▶ p (proton)
- ▶ ion
- ▶ neutron
- ▶ \bar{p} (antiproton)
- ▶ \leftrightarrow proton/antiproton conversion
- ▶ neutrino

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

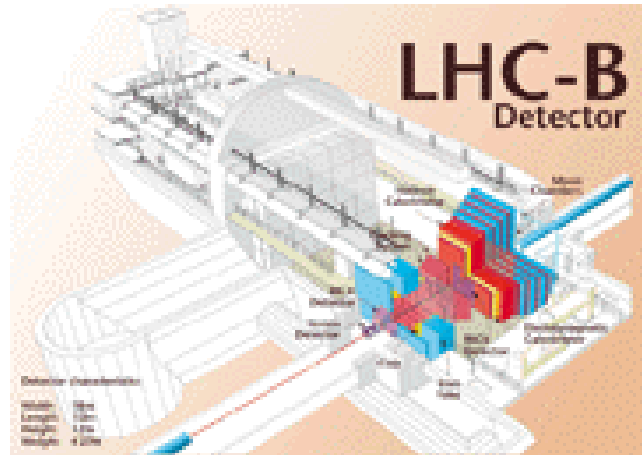
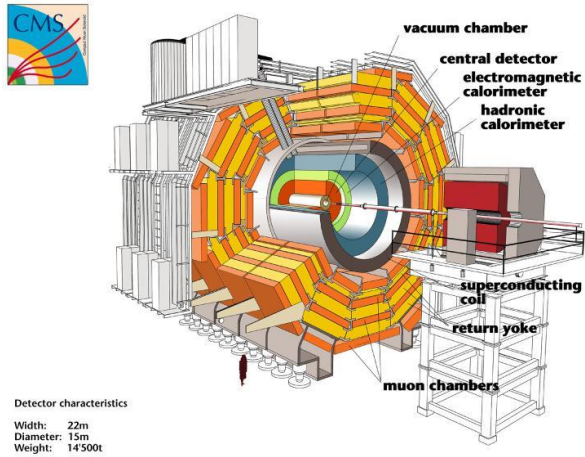
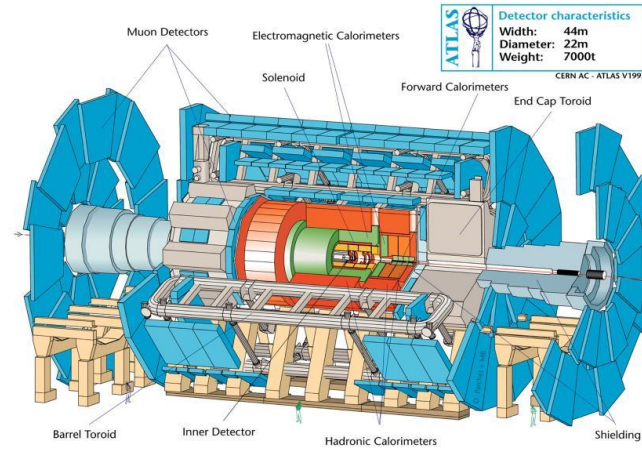
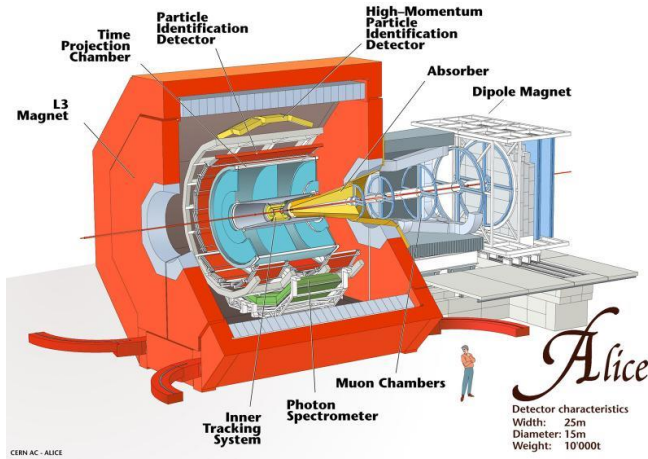
- LHC Large Hadron Collider
- n-ToF Neutron Time of Flight
- CNGS Cern Neutrinos Gran Sasso

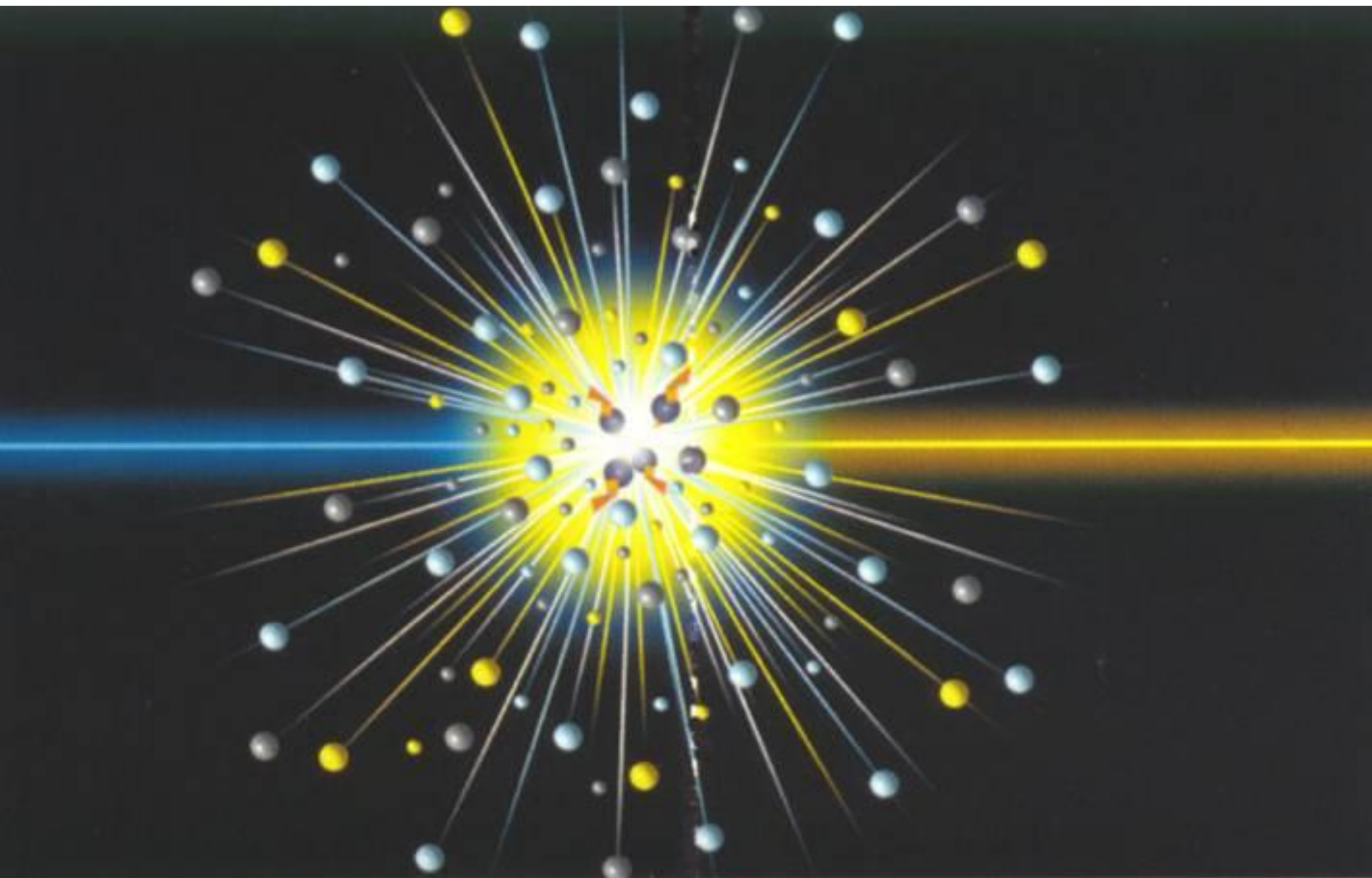


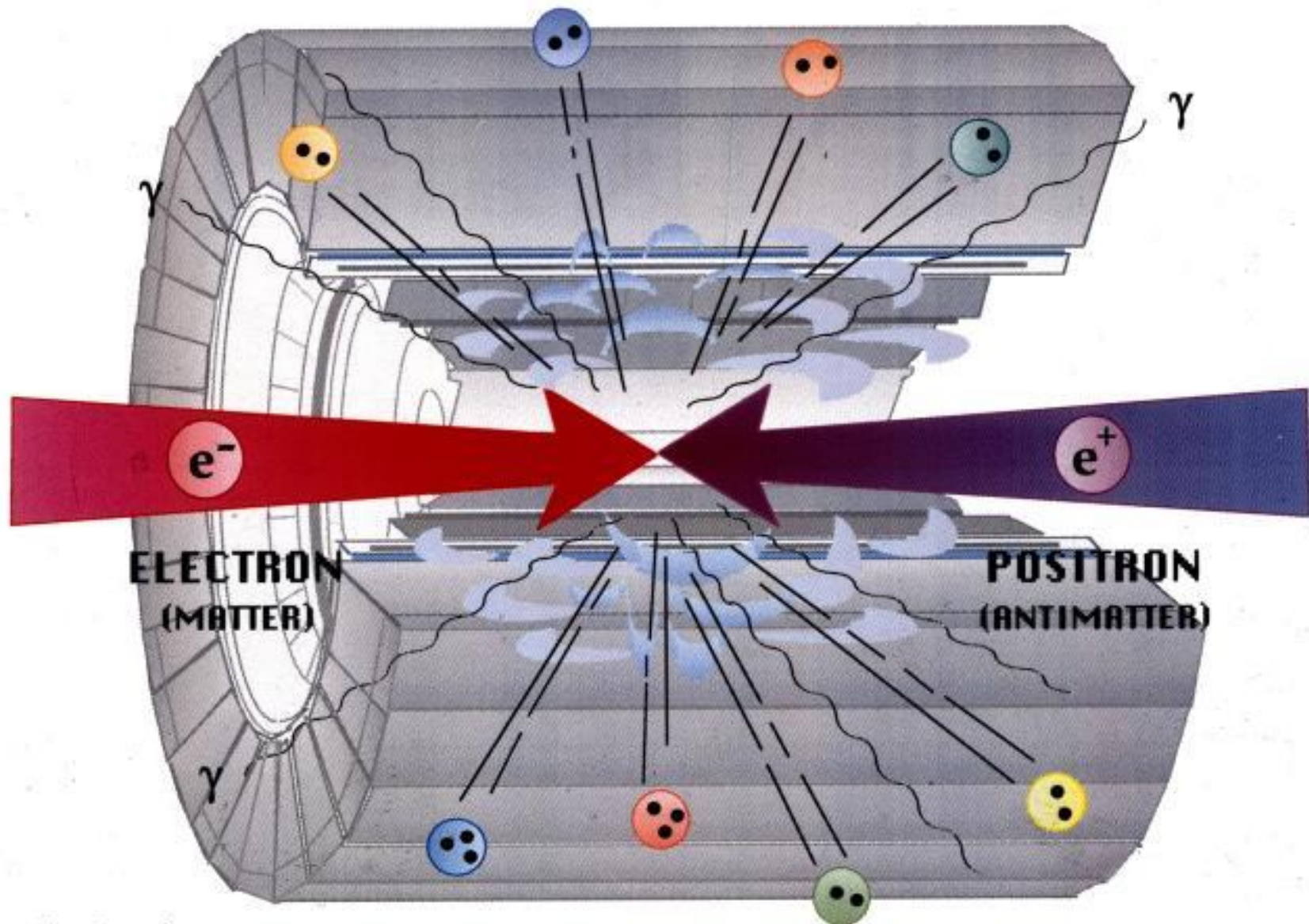
Overall view of the LHC experiments.

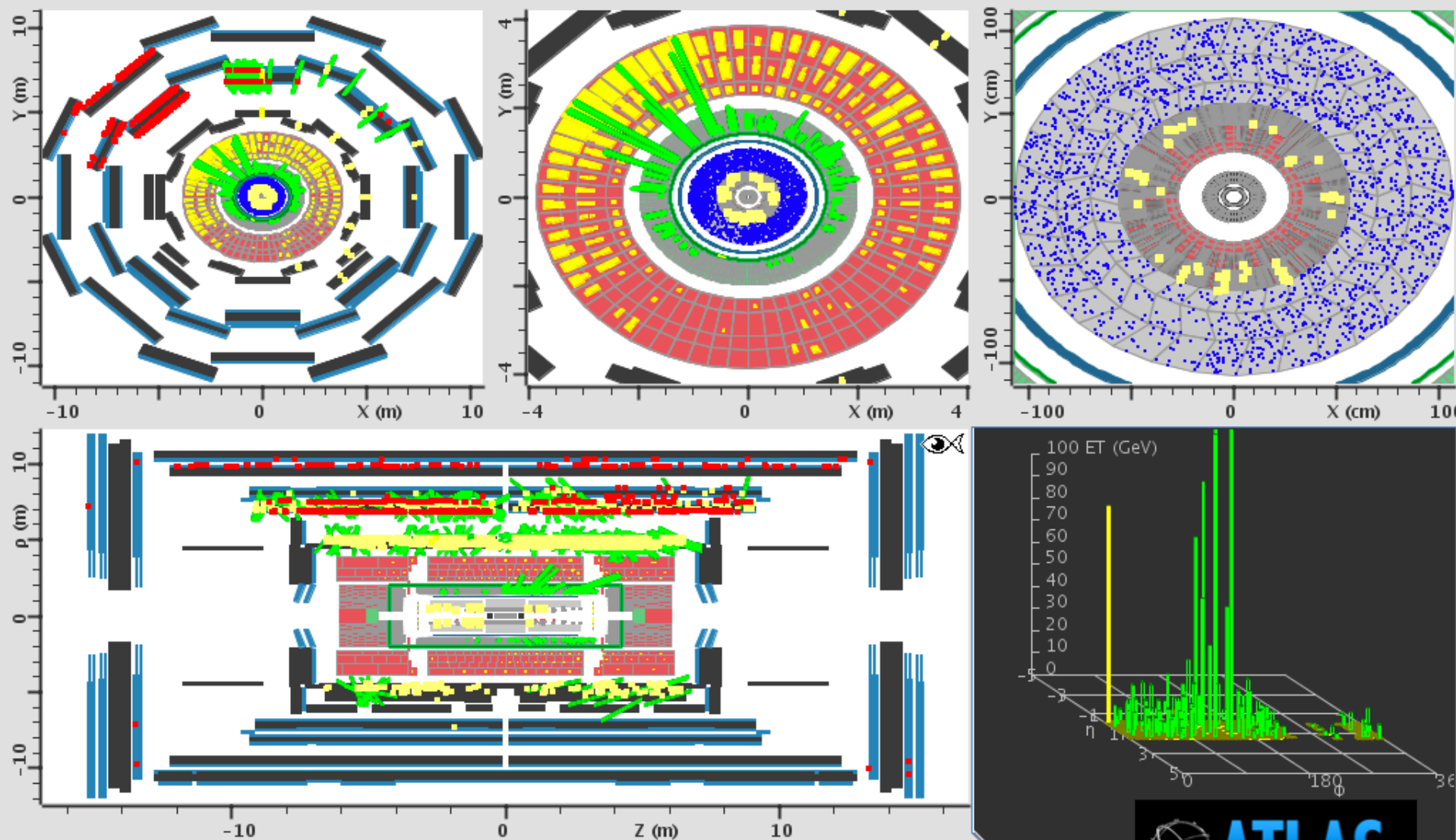


LHC Experiments

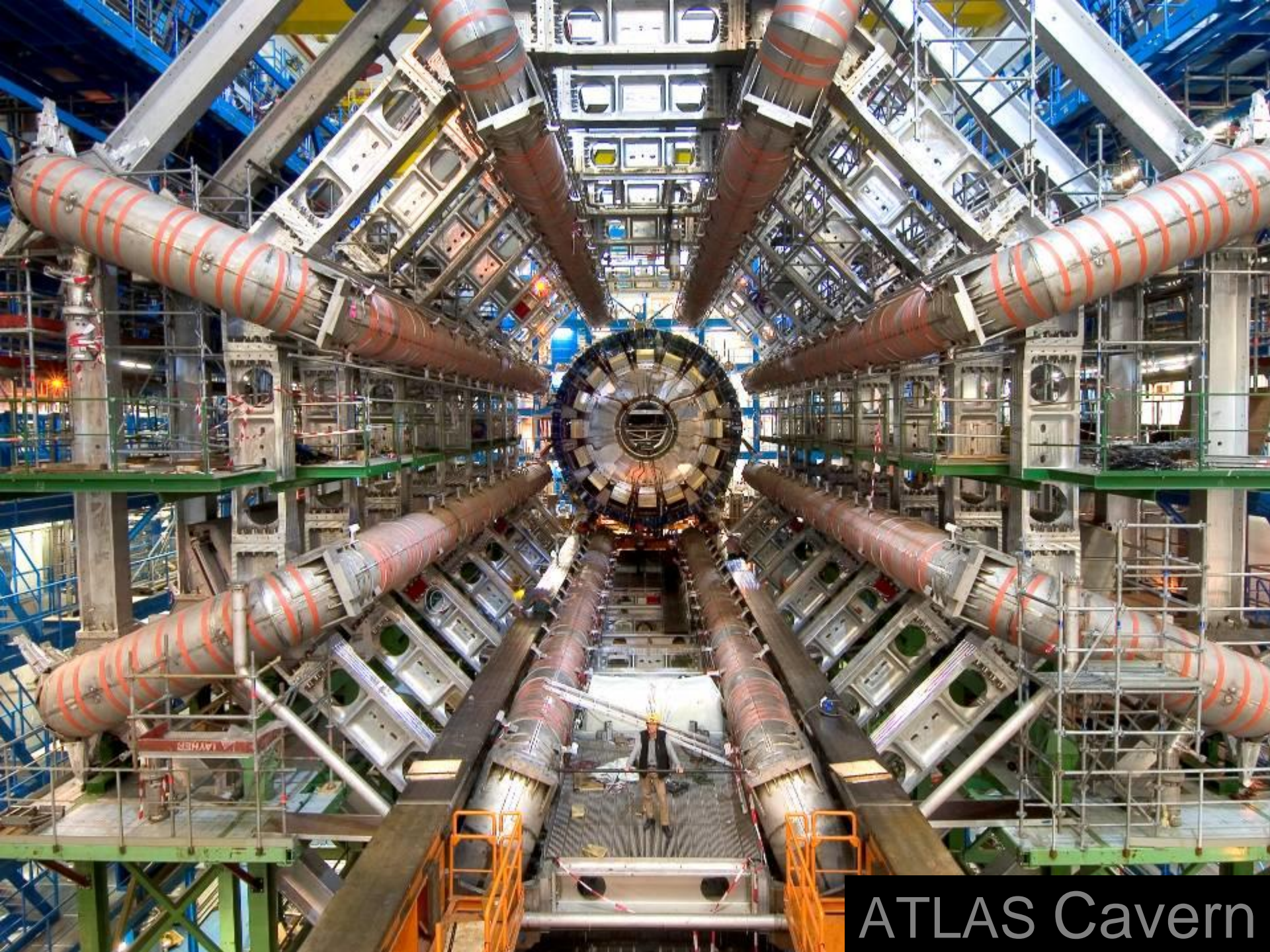






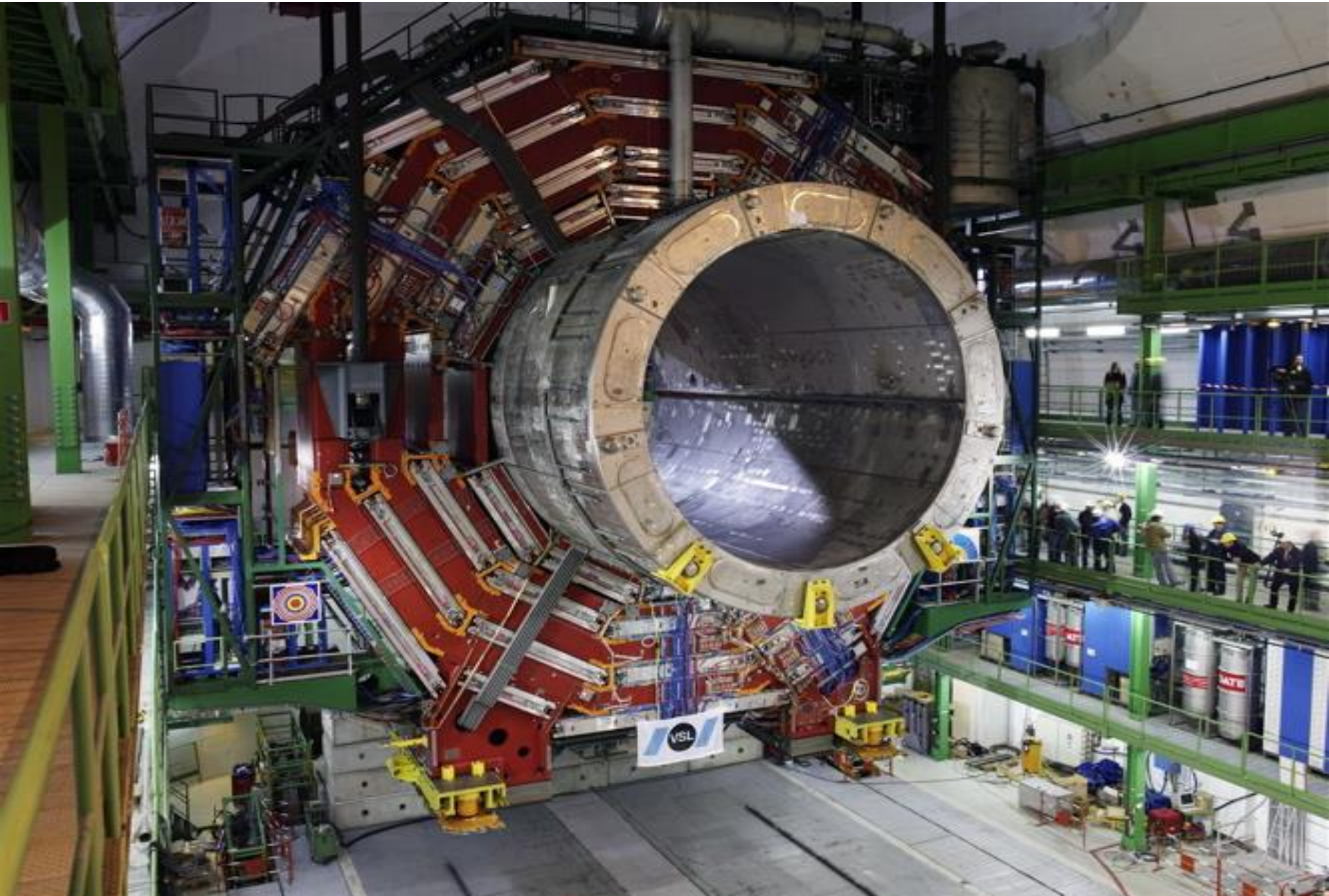


2nd beam event seen in ATLAS



ATLAS Cavern

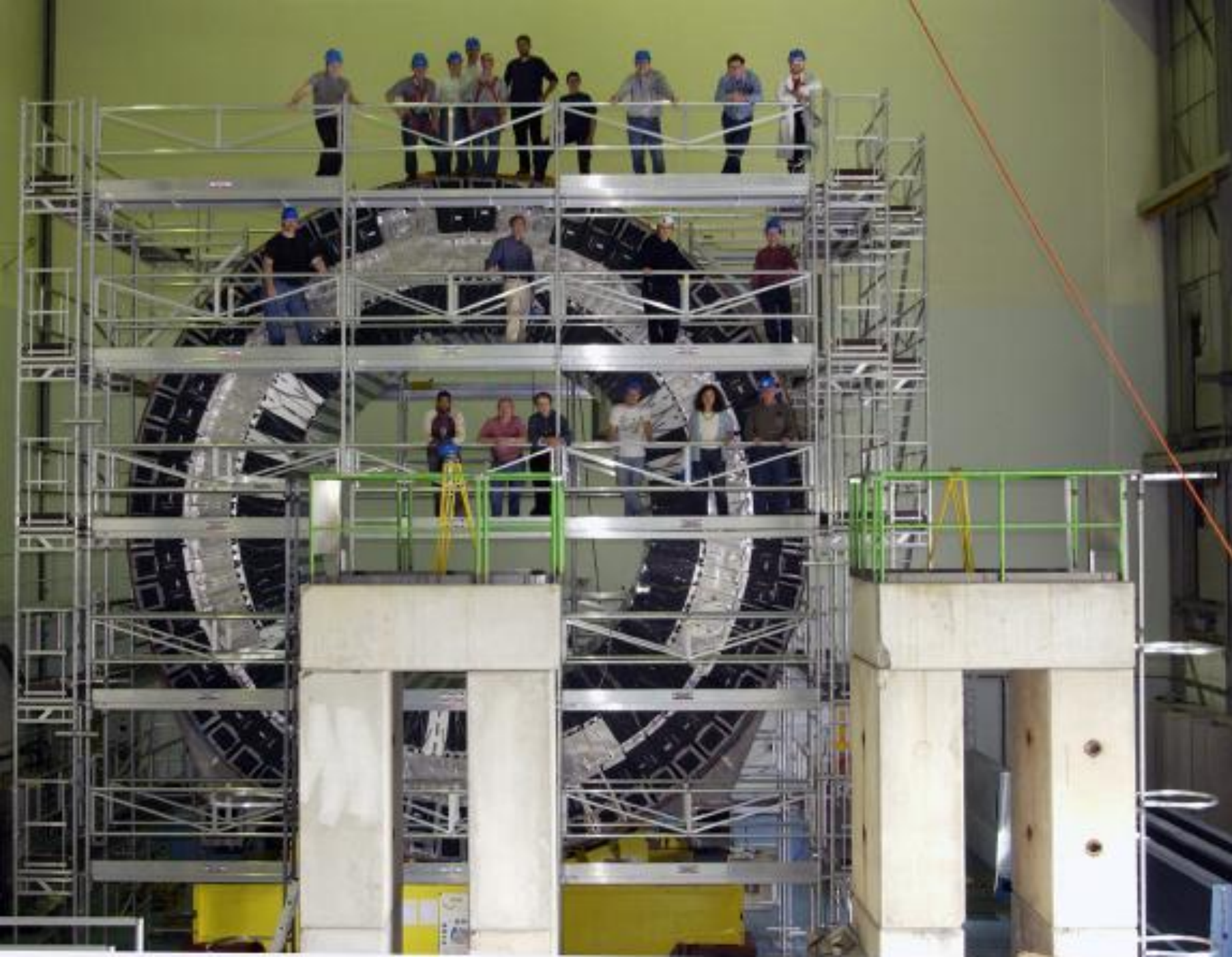
Building CMS

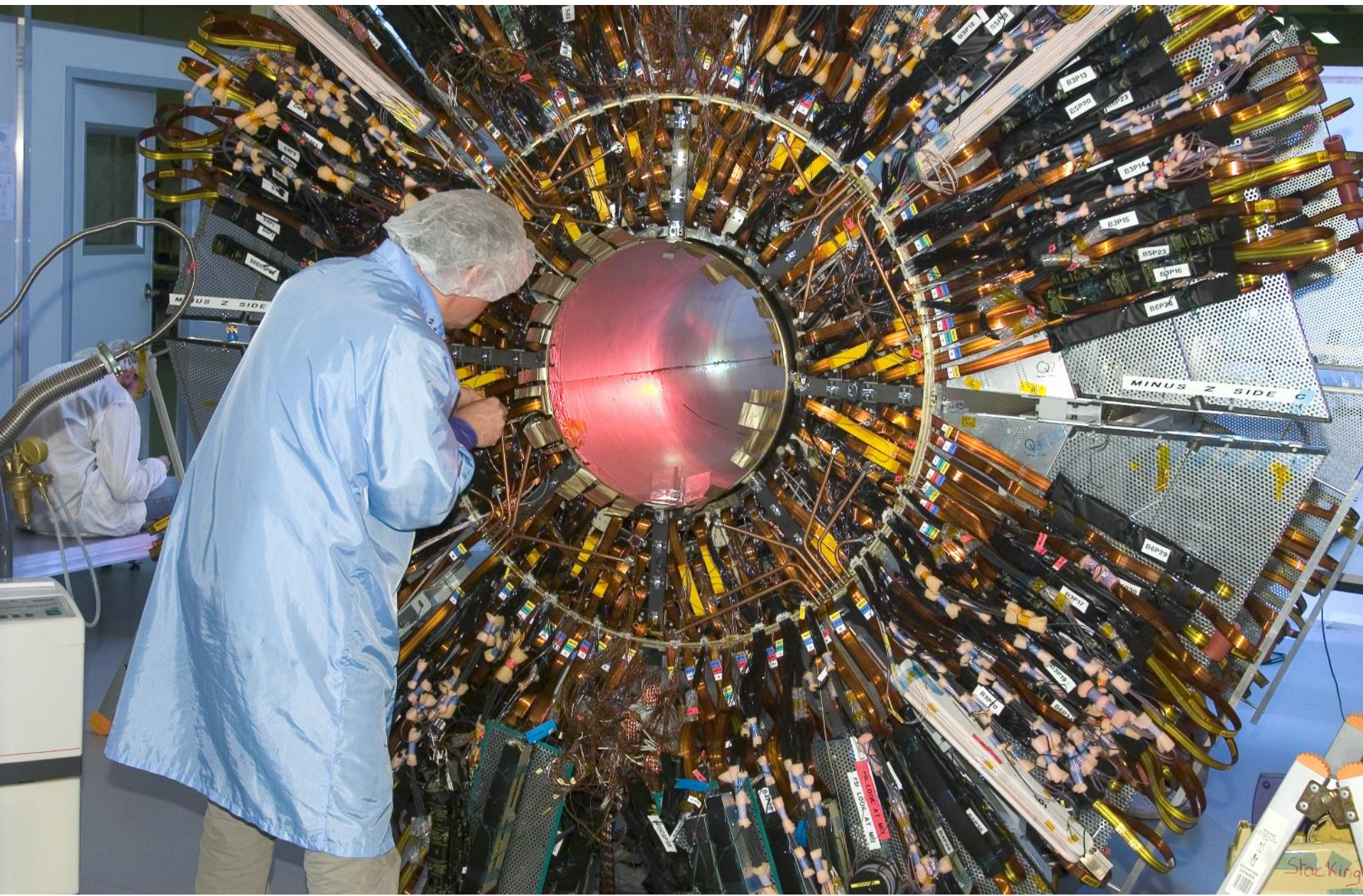


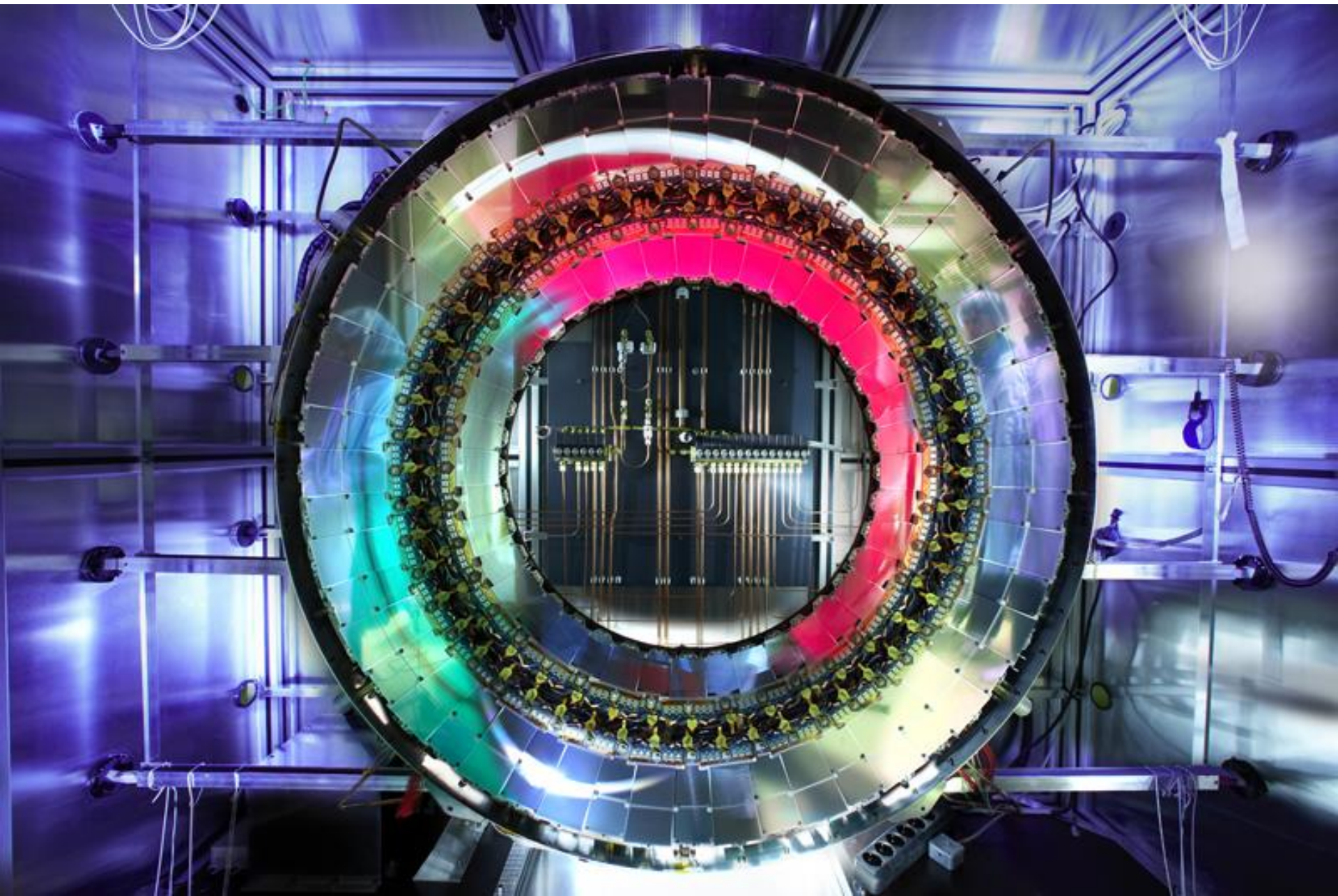


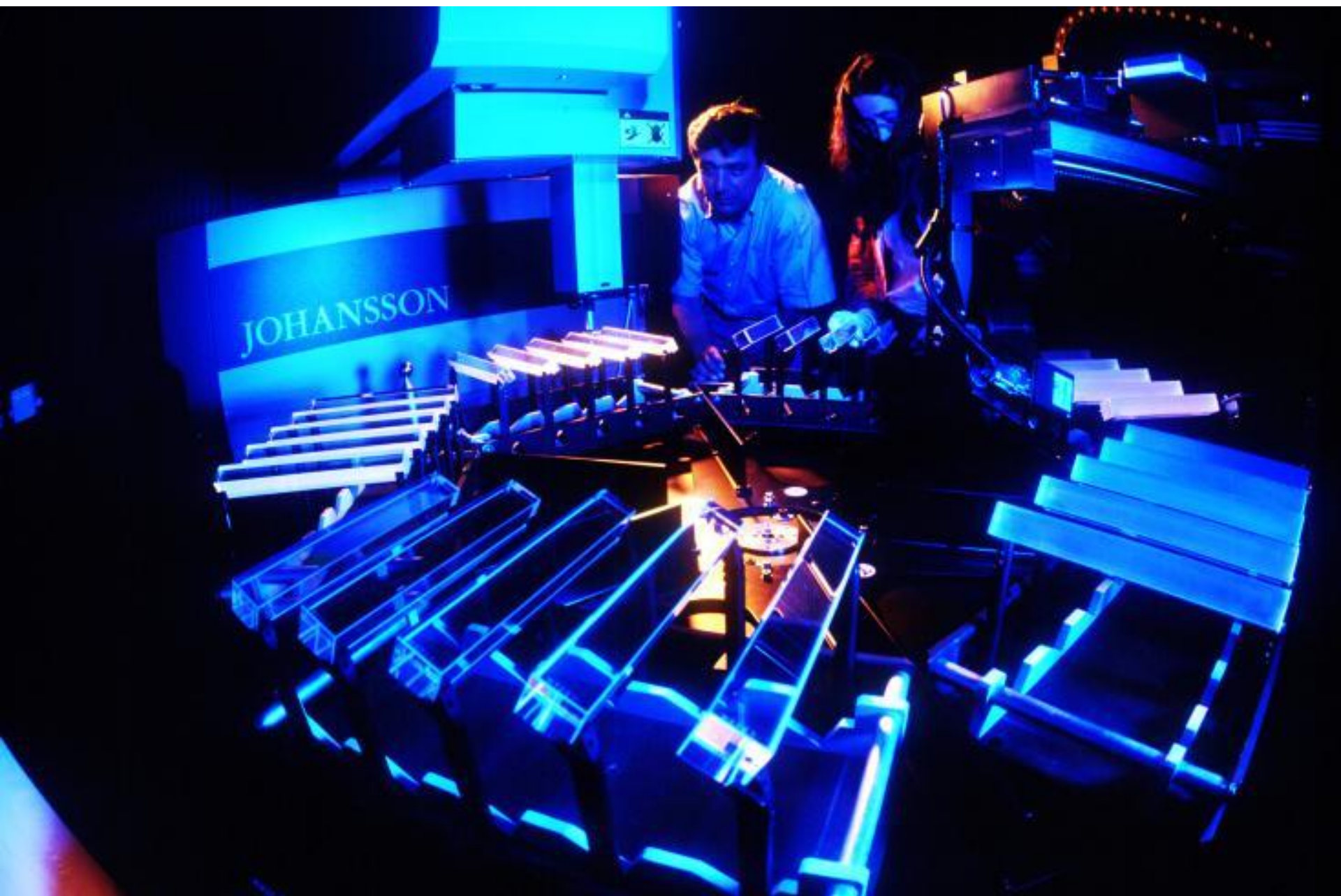
EMERGENCY EXIT
EVACUATION
FIRE
EXIT

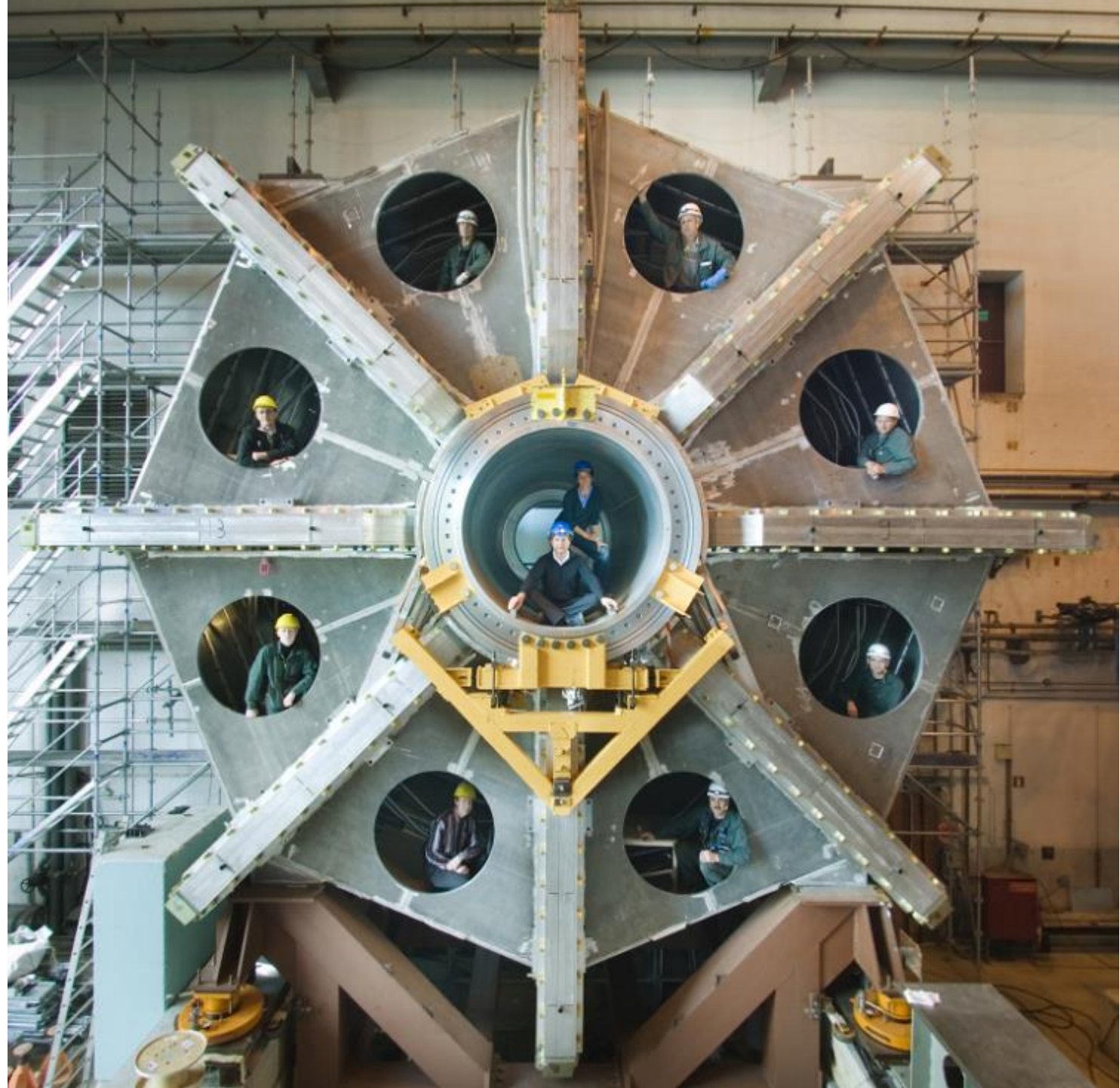

















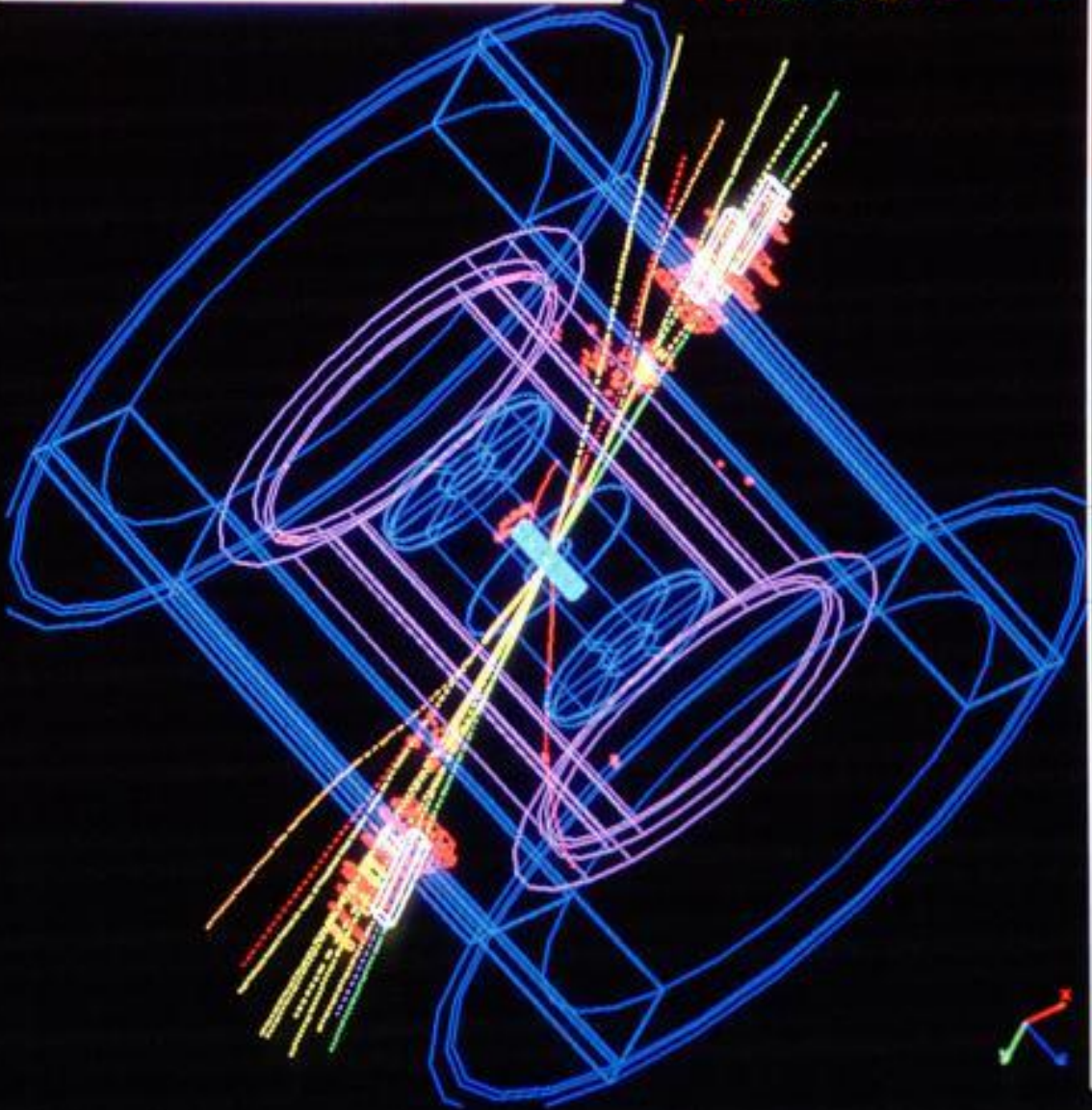




 **DELPHI Interactive Analysis**
Beam: 45.0 GeV Run: 26154 DAS: 25-Aug-1991
Prog: 1-Oct-1991 Evt: 3018 21:47:02
Scan: 13-Jan-1992

	T0	T1	T2	T3	T4	T5	T6
Det	02	10	0	20	0	0	0
	< 00 >	< 100 >	< 0 >	< 20 >	< 0 >	< 0 >	< 0 >
Event	0	0	0	0	0	0	0
	< 0 >	< 10 >	< 0 >	< 20 >	< 0 >	< 0 >	< 0 >

- DELPHI
- ENCAPS
- BARREL
- CENTRAL
- Return



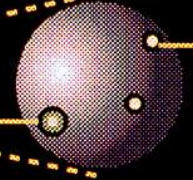
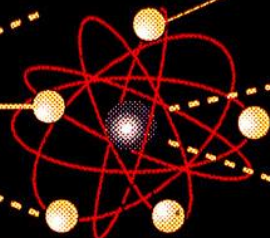
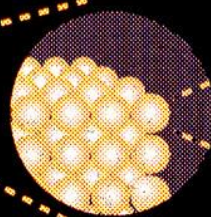
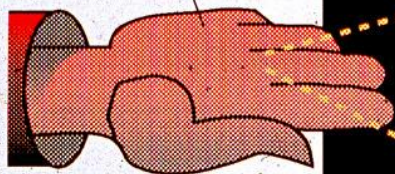
MATTER

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.

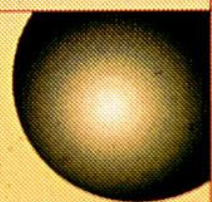


tau neutrino

Not yet observed directly.

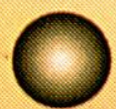
top

Heavier still, recently observed.



bottom

Heavier still.



ANTIMATTER

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



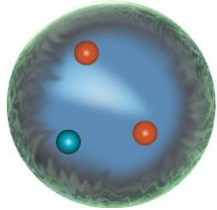
Mass Ratios of Elementary Particles (MeV)

	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



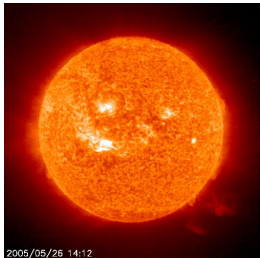
Strong Force:

Gluon



Electro-Magnetic Force:

Photon



Weak Force:

Bosons (W, Z)



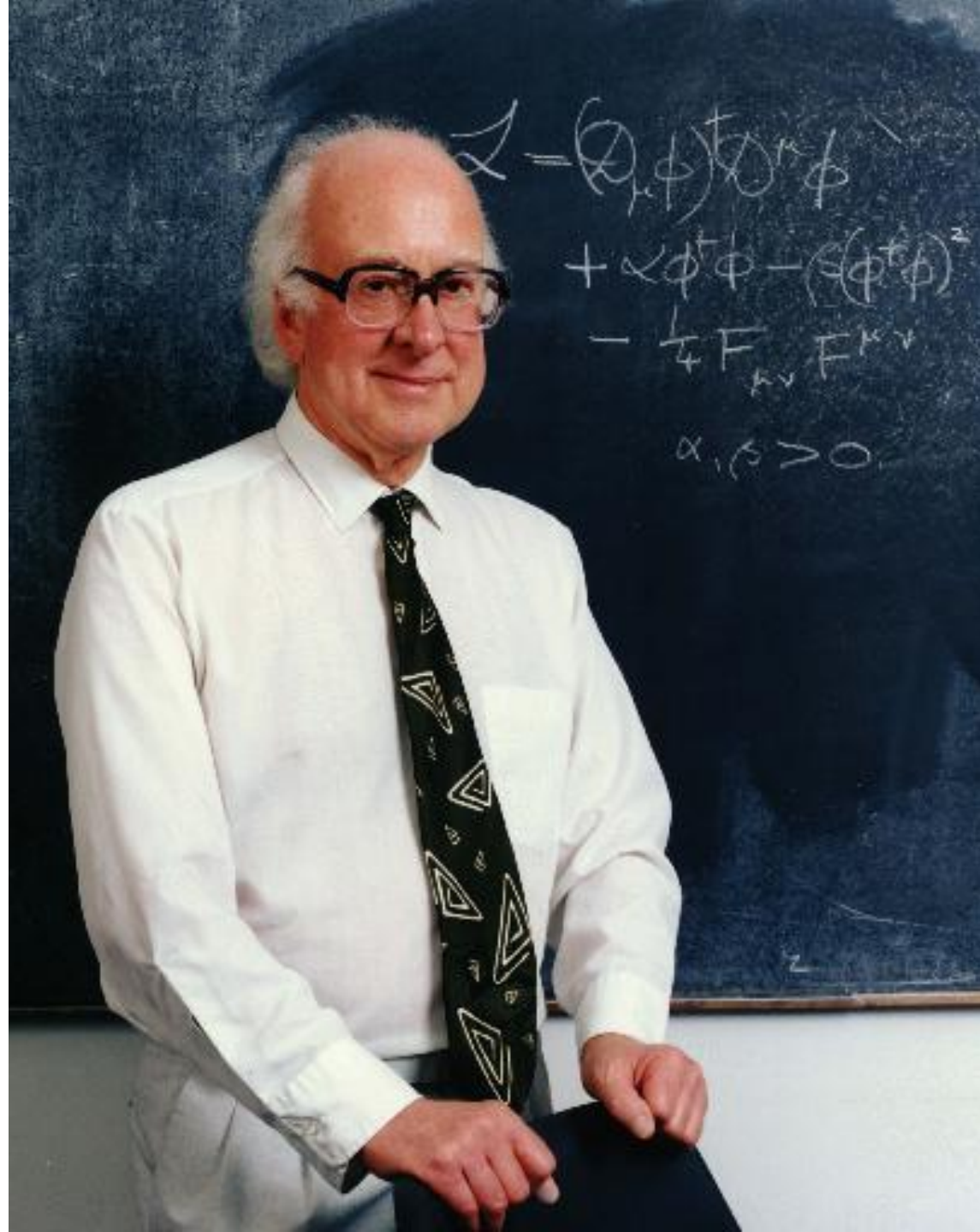
Gravitation:

Falling apples, orbiting Moon

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

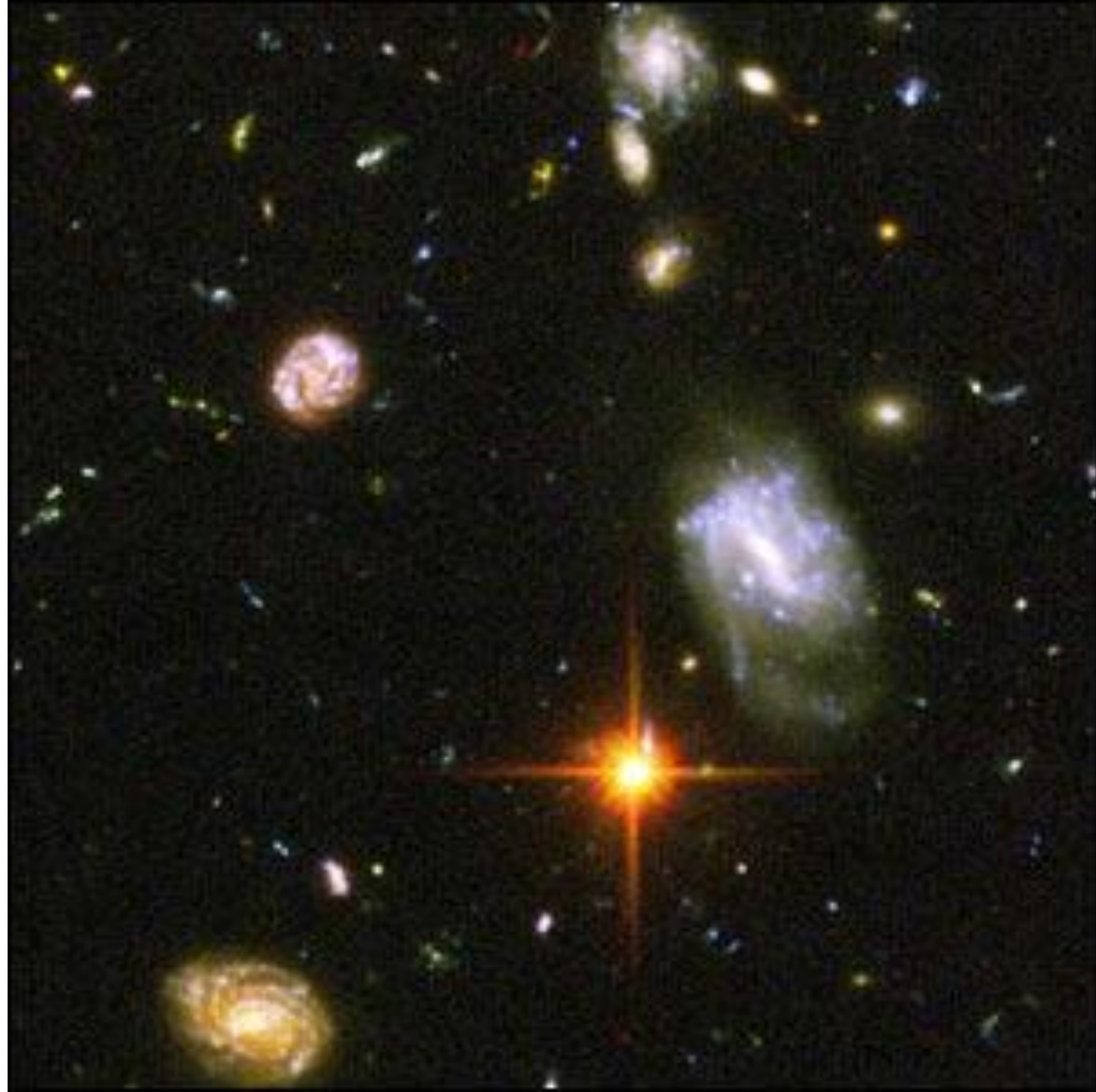
Graviton

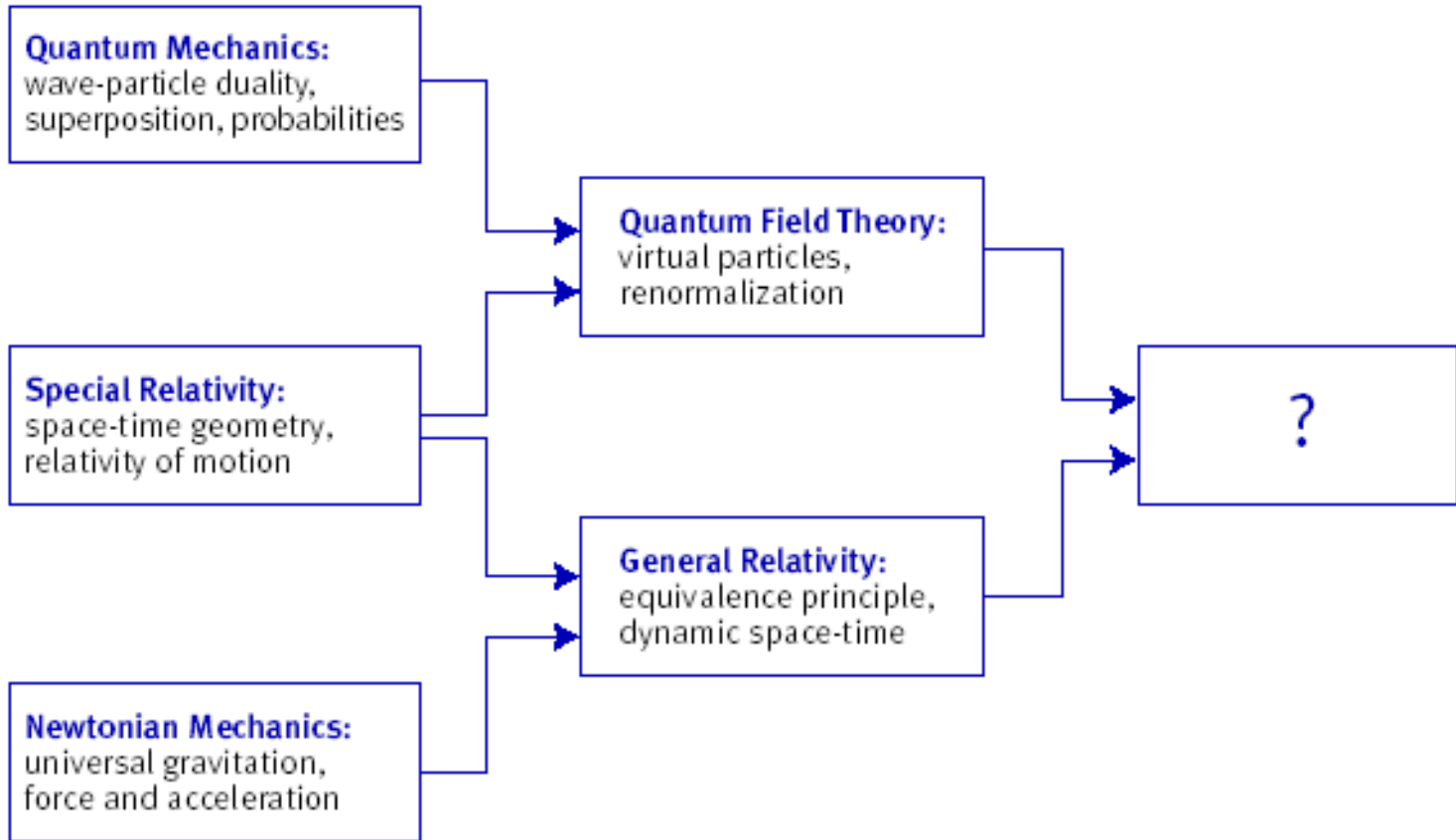
No mass (?)



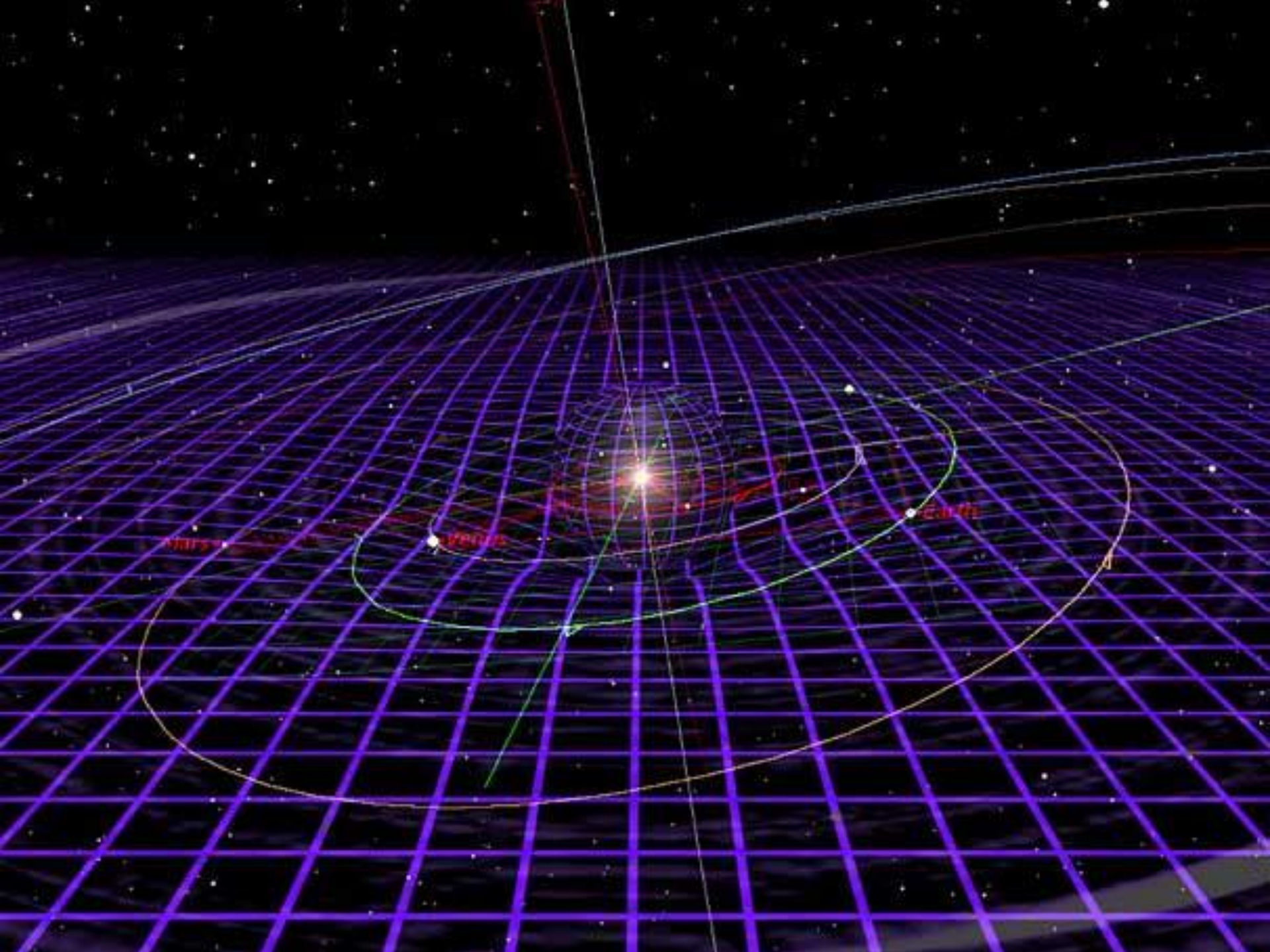
$$\mathcal{L} = (\partial_\mu \phi)^\dagger \partial^\mu \phi + \alpha \phi^\dagger \phi - \beta (\phi^\dagger \phi)^2 - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

$\alpha, \beta > 0$

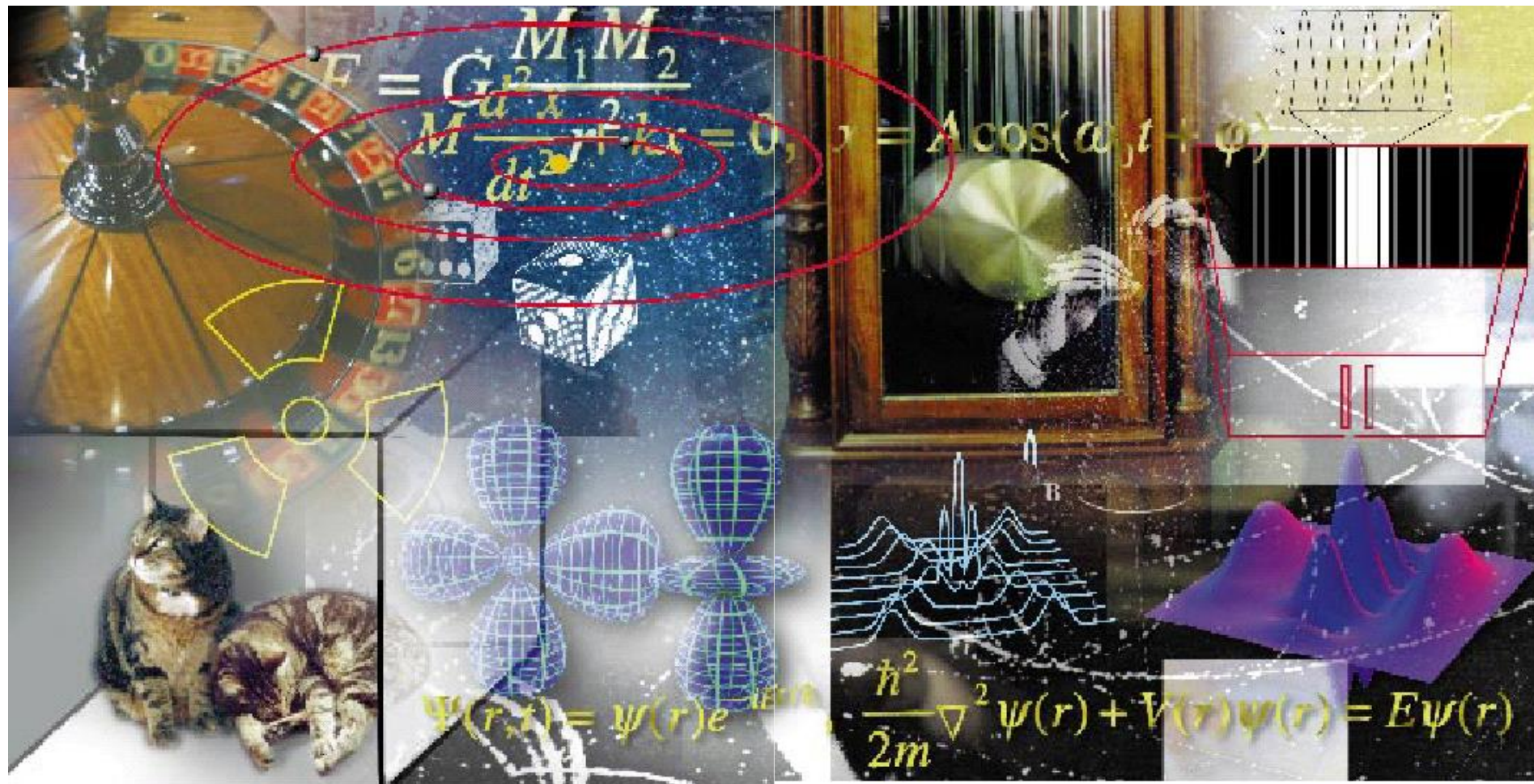












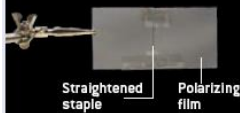






Quantum Erasing in the Home

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

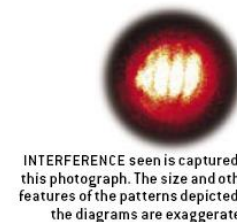
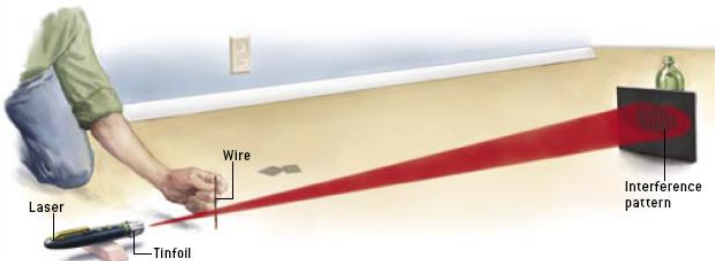


1 SEEING INTERFERENCE

- 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.

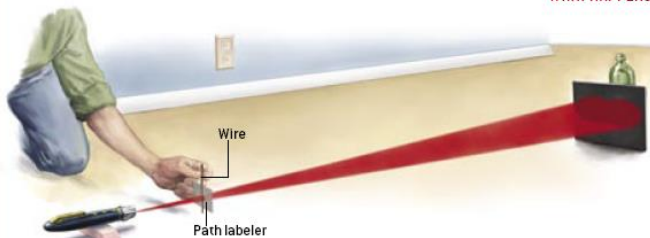


2 LABELING THE PATH

- 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.

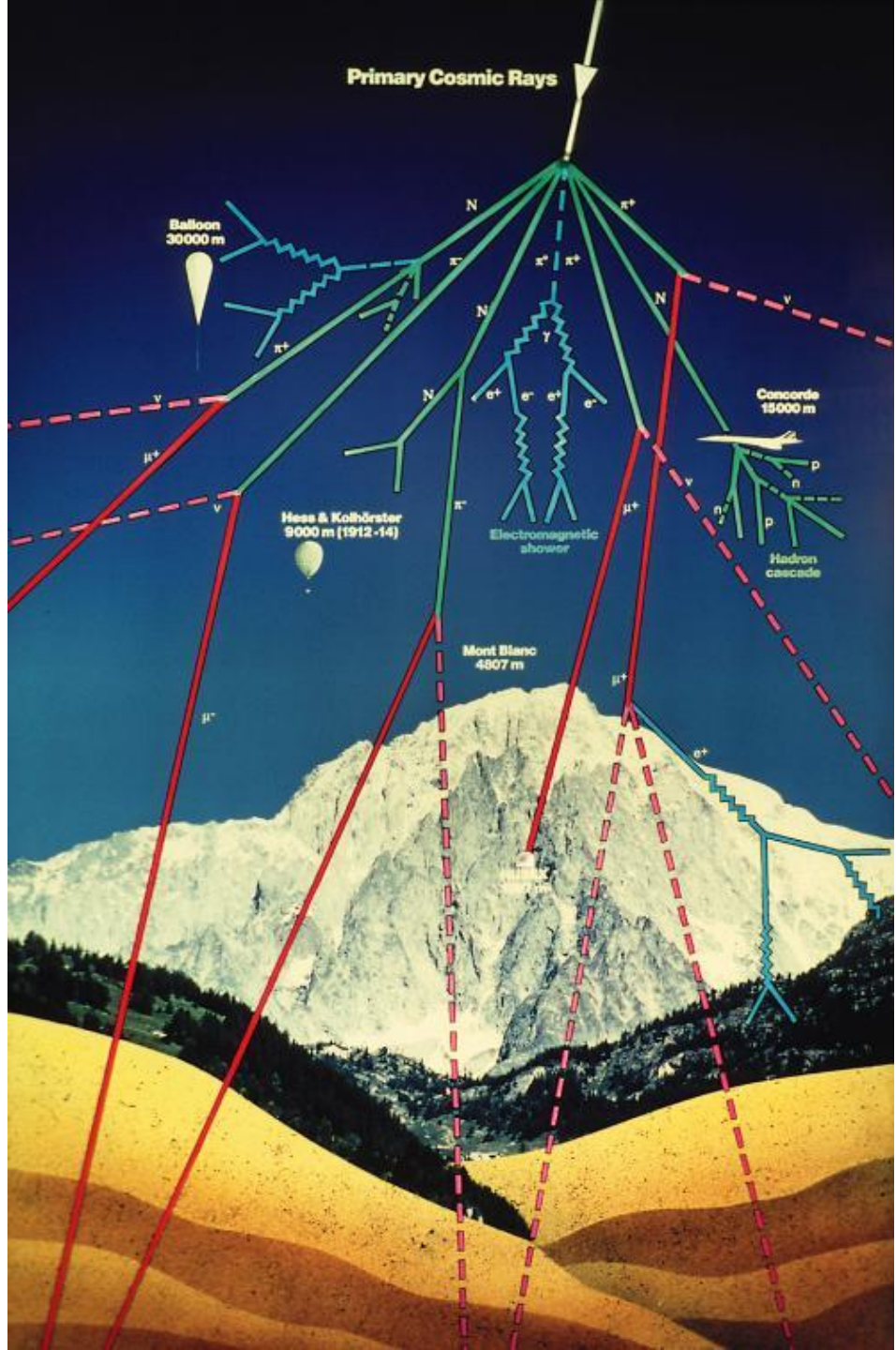




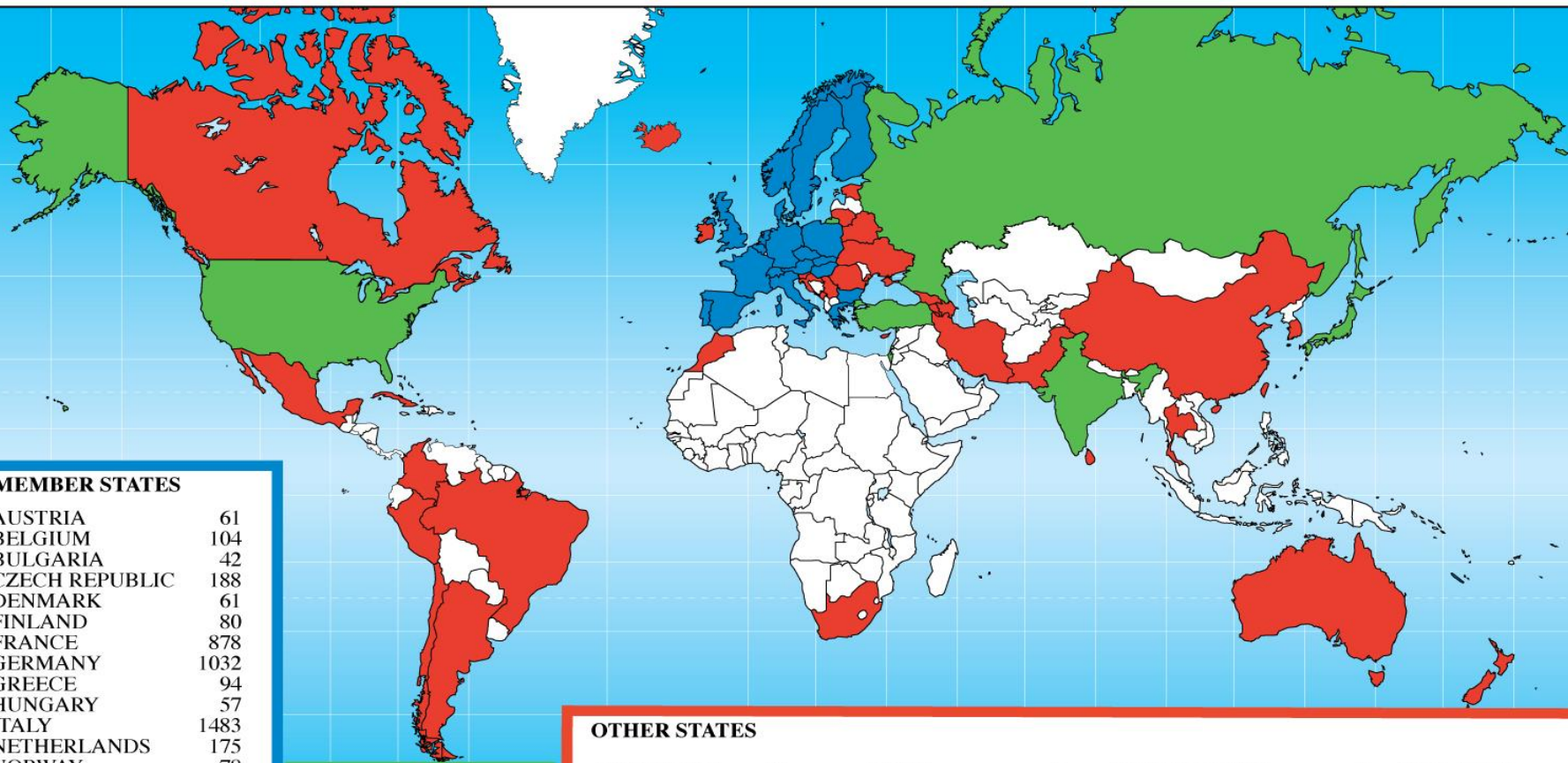




Primary Cosmic Rays



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

6071

OBSERVER STATES

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

2768

OTHER STATES

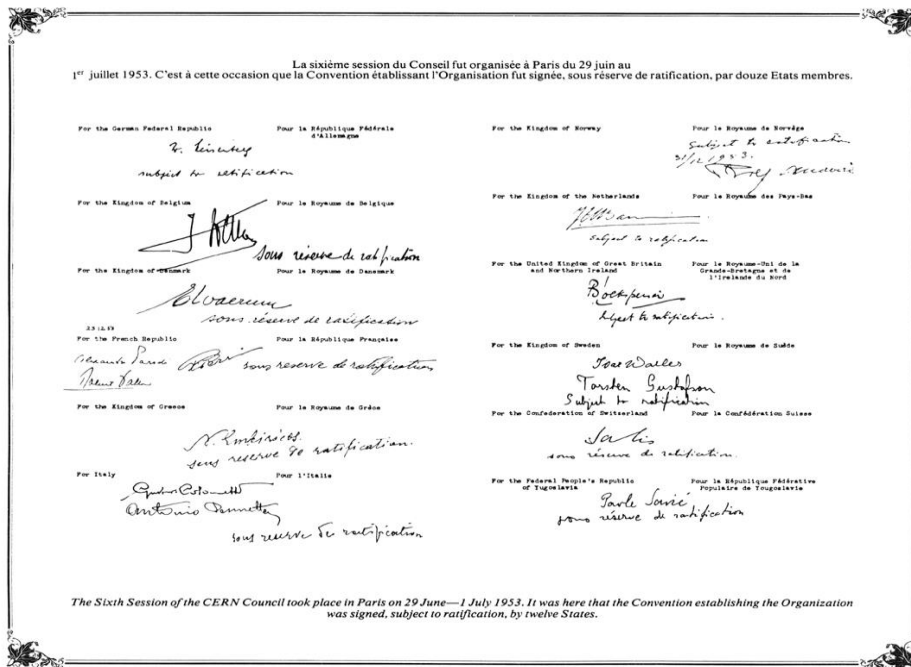
ARGENTINA	10	CUBA	3	MONTENEGRO	1	SRI LANKA	1
ARMENIA	15	CYPRUS	6	MOROCCO	5	TAIWAN	42
AUSTRALIA	14	ESTONIA	11	NEW ZEALAND	6	THAILAND	1
AZERBAIJAN	1	GEORGIA	11	PAKISTAN	24	UKRAINE	18
BELARUS	19	ICELAND	1	PERU	1		
BRAZIL	73	IRAN	12	ROMANIA	49		
CANADA	136	IRELAND	12	SERBIA	17		
CHILE	4	KOREA	51	SLOVENIA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

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

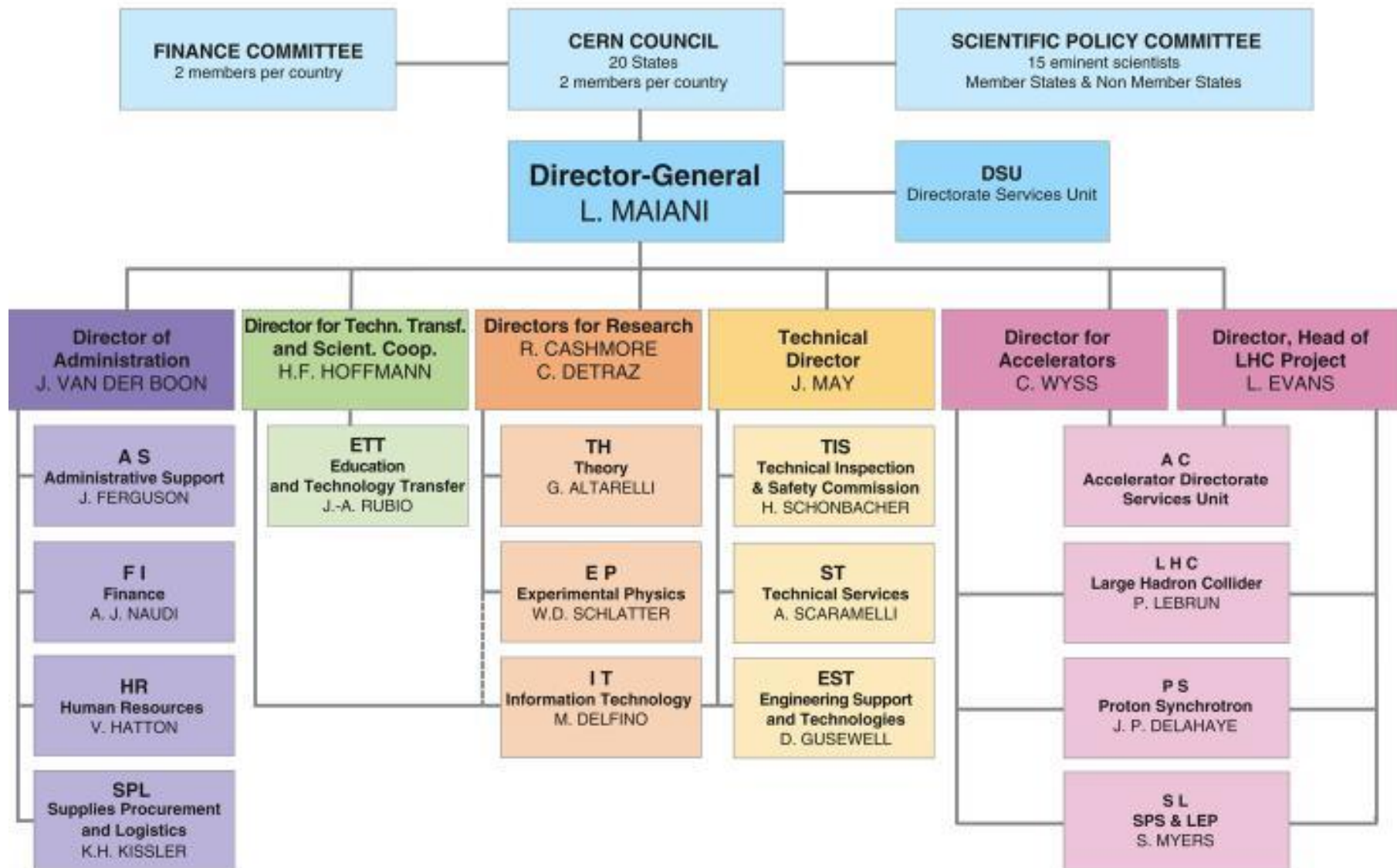


1954: Convention establishing the Organization - original signatures



2007: The 20 member states

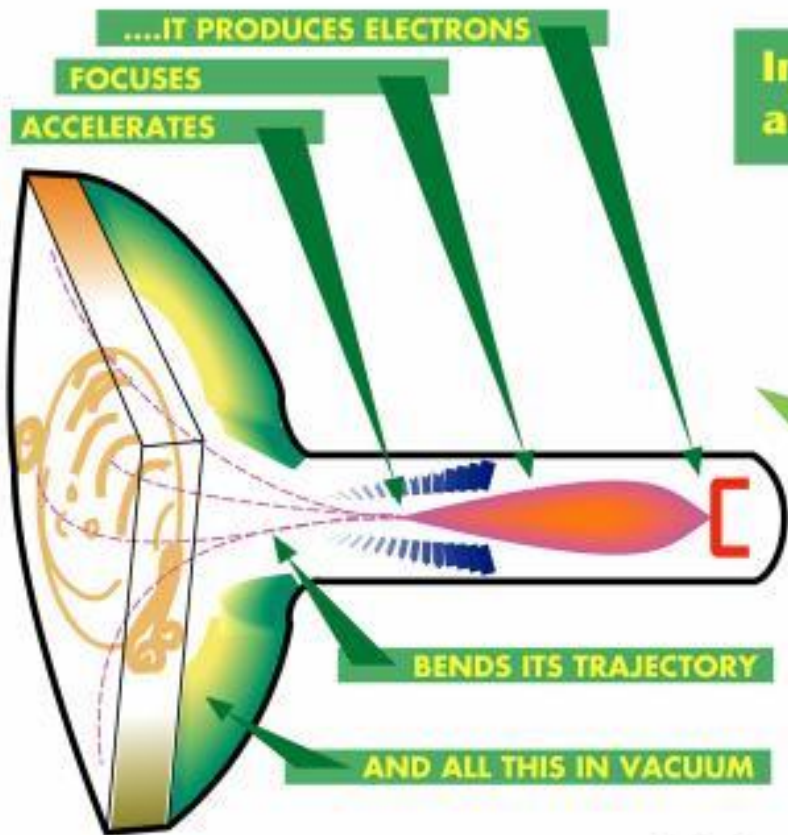
CERN ORGANISATIONAL CHART 07/2001





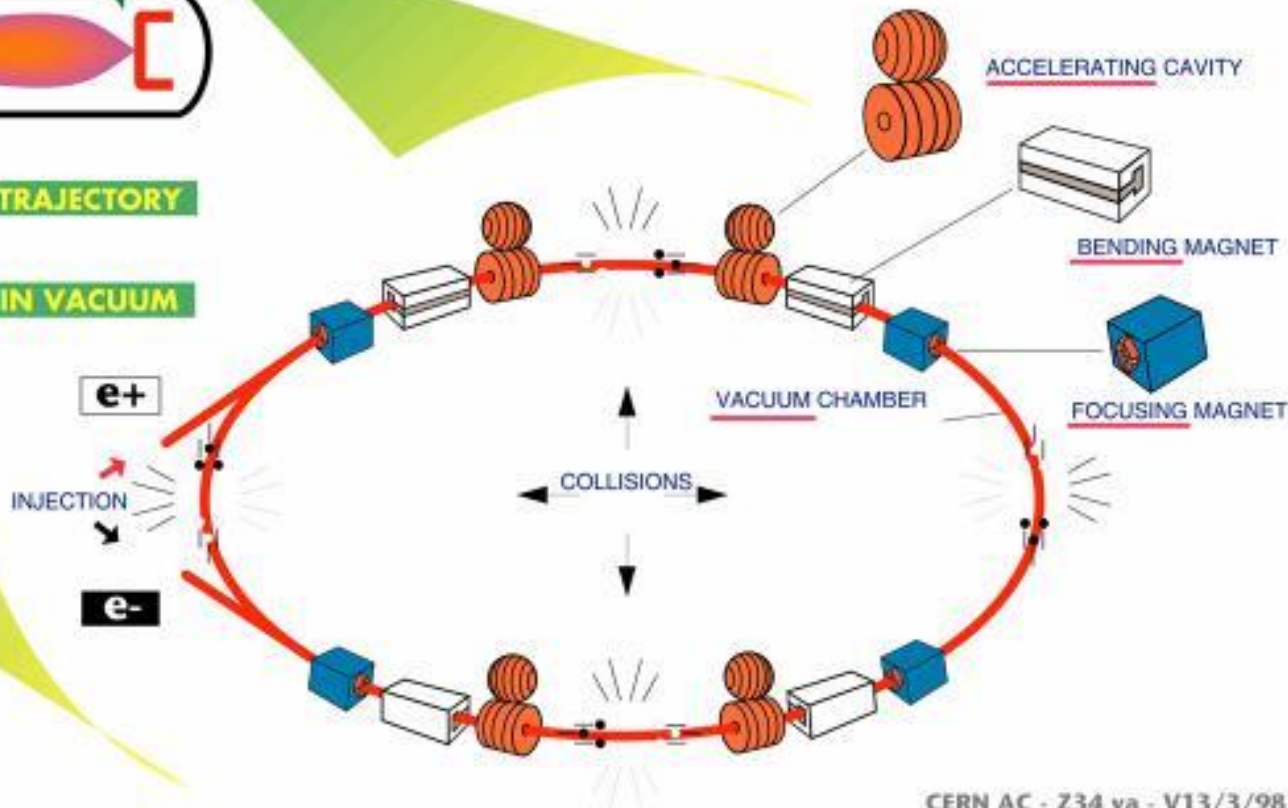
Teilchen

DID YOU KNOW YOUR TELEVISION SET IS AN ACCELERATOR ?



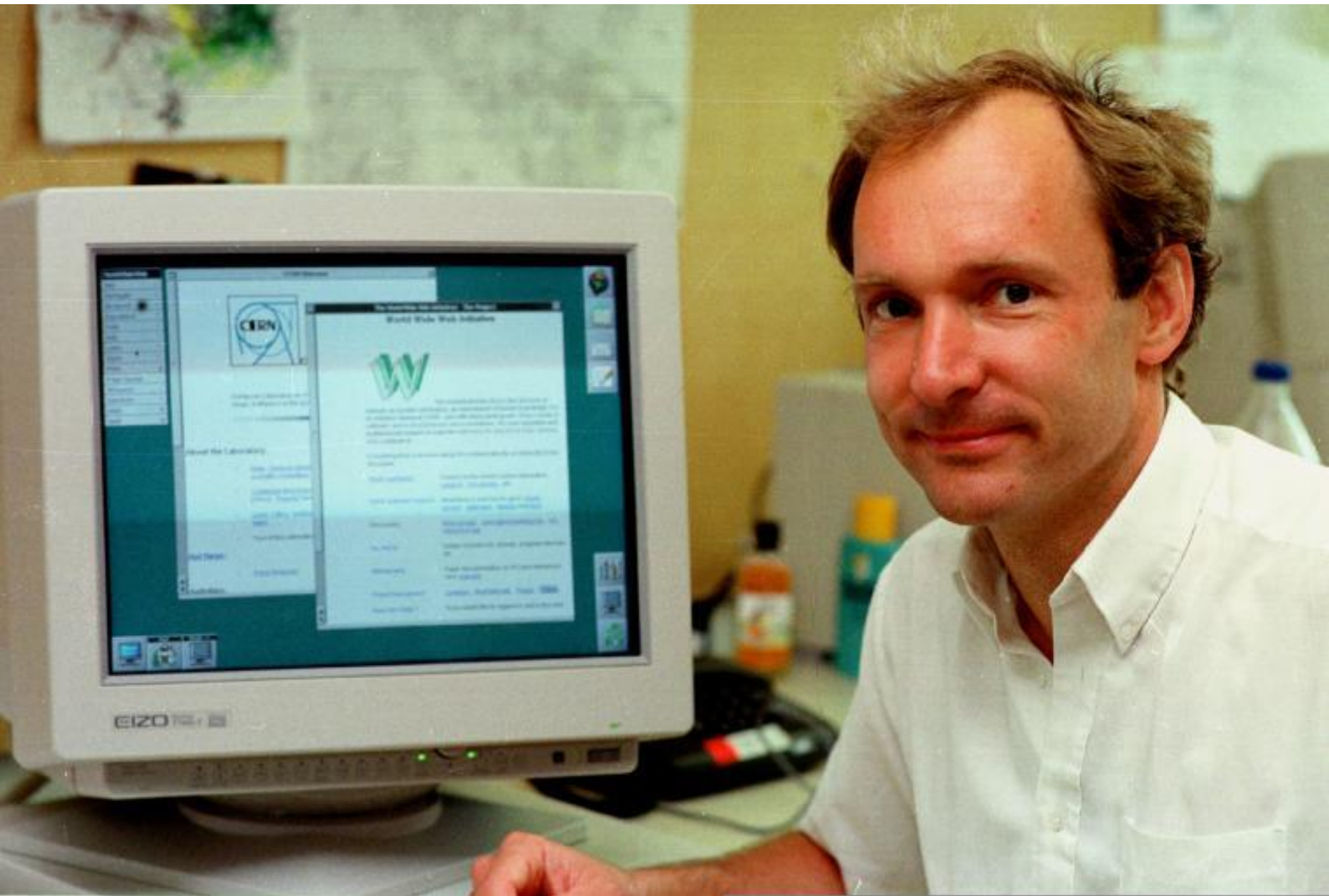
In your TV set, the electrons are accelerated to 20000 volts.

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

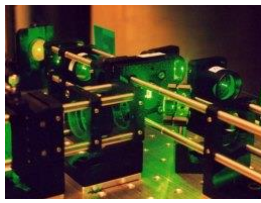
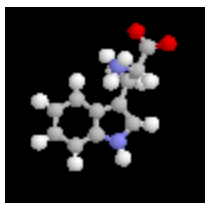


Chemistry

Electronics
(transistor)

Optics
(lasers)

(Other)



Bioinformatics

Computer
(chip)

Quantum
Computing

Software

Communi-
cations

Teleportation?

Grid

