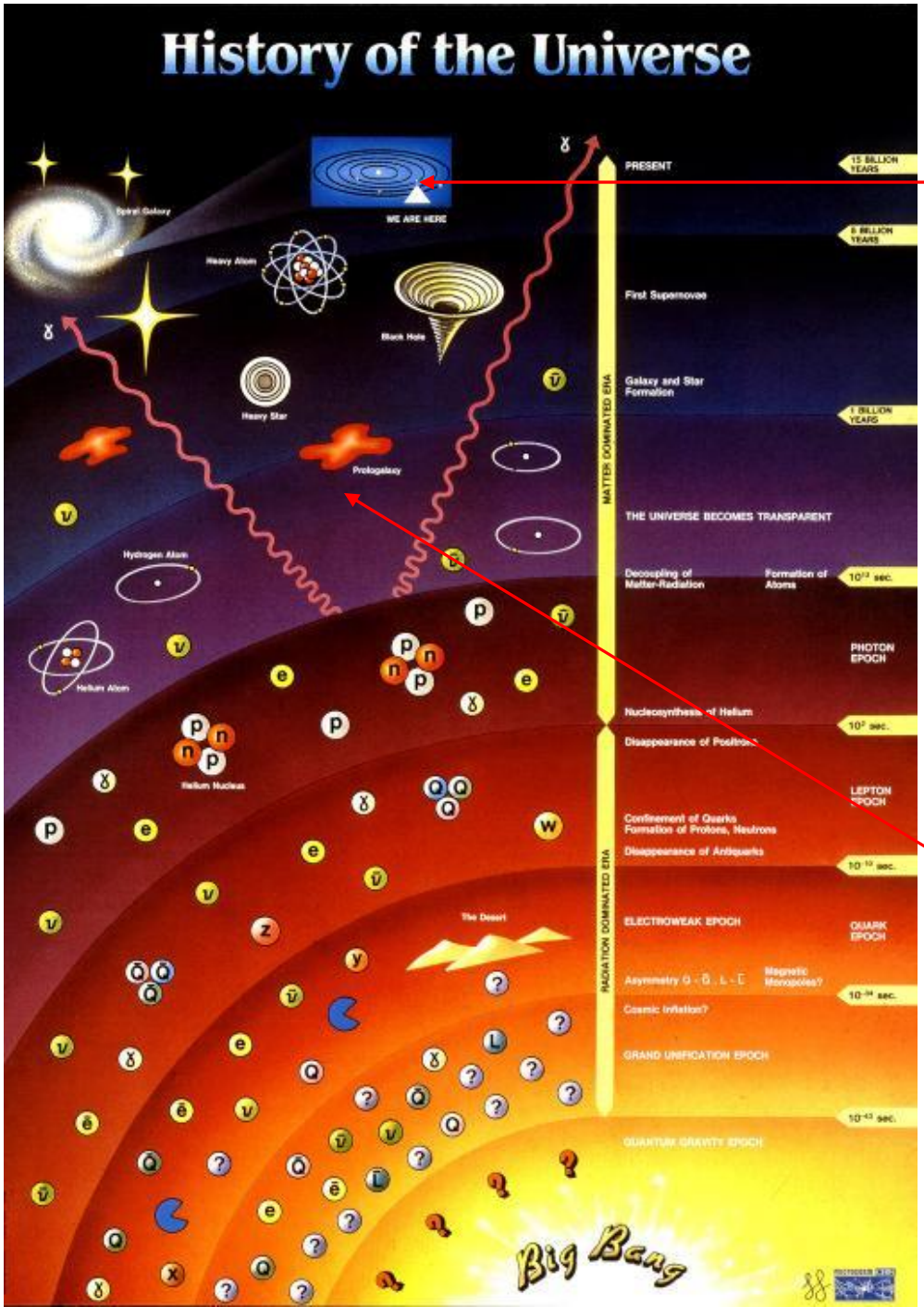
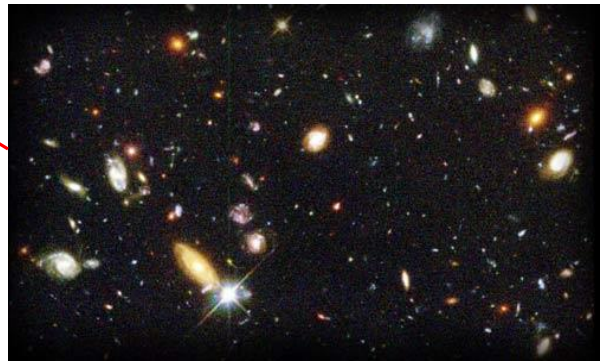
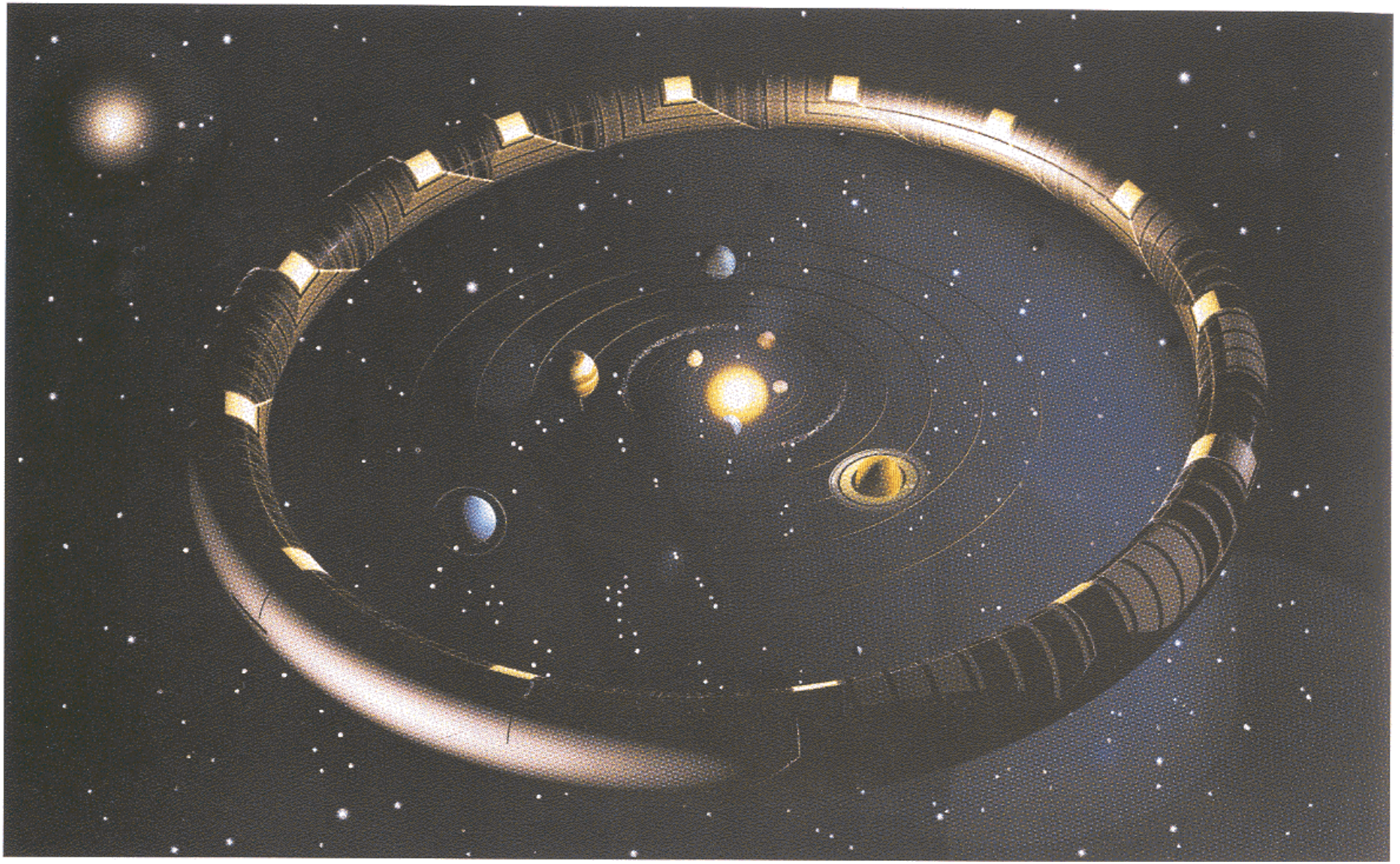

Tervetuloa CERNiin
Hankasalmen, Jämsän ja Laukaan lukiot 5.2.2018


History of the Universe
PRESENT
15 BILLION YEARS
8 BILLION YEARS
First Supernovae
Galaxy and Star Formation
1 BILLION YEARS
THE UNIVERSE BECOMES TRANSPARENT
Decoupling of Matter-Radiation
Formation of Atoms
PHOTON EPOCH
Nucleosynthesis of Helium
Disappearance of Positrons
LEPTON EPOCH
Confinement of Quarks
Formation of Protons, Neutrons
Disappearance of Antiquarks
ELECTROWEAK EPOCH
QUARK EPOCH
Asymmetry
Magnetic Monopoles?
Cosmic Inflation?
GRAND UNIFICATION EPOCH
QUANTUM GRAVITY EPOCH
MATTER DOMINATED ERA
RADIATION DOMINATED ERA
WE ARE HERE
Spiral Galaxy
Heavy Atom
Black Hole
Heavy Star
Protogalaxy
Hydrogen Atom
Helium Atom
Helium Nucleus
The Desert
Big Bang





Big Bang

Instruments

Observables

10^{-34}

10^{-30}

10^{-26}

10^{-22}

Accelerators
LHC
LEP

SUSY particle?
Higgs?

10^{-18}

Z/W (range of weak force)

10^{-14}

Proton (range of nuclear force)
Nuclei

(Particle beams)
Electron Microscope

10^{-10}

Atom

10^{-6}

Virus
Cell

Microscope

1m

10^{6}

Earth radius

10^{10}

Earth to Sun

10^{14}

Telescope

10^{18}

10^{22}

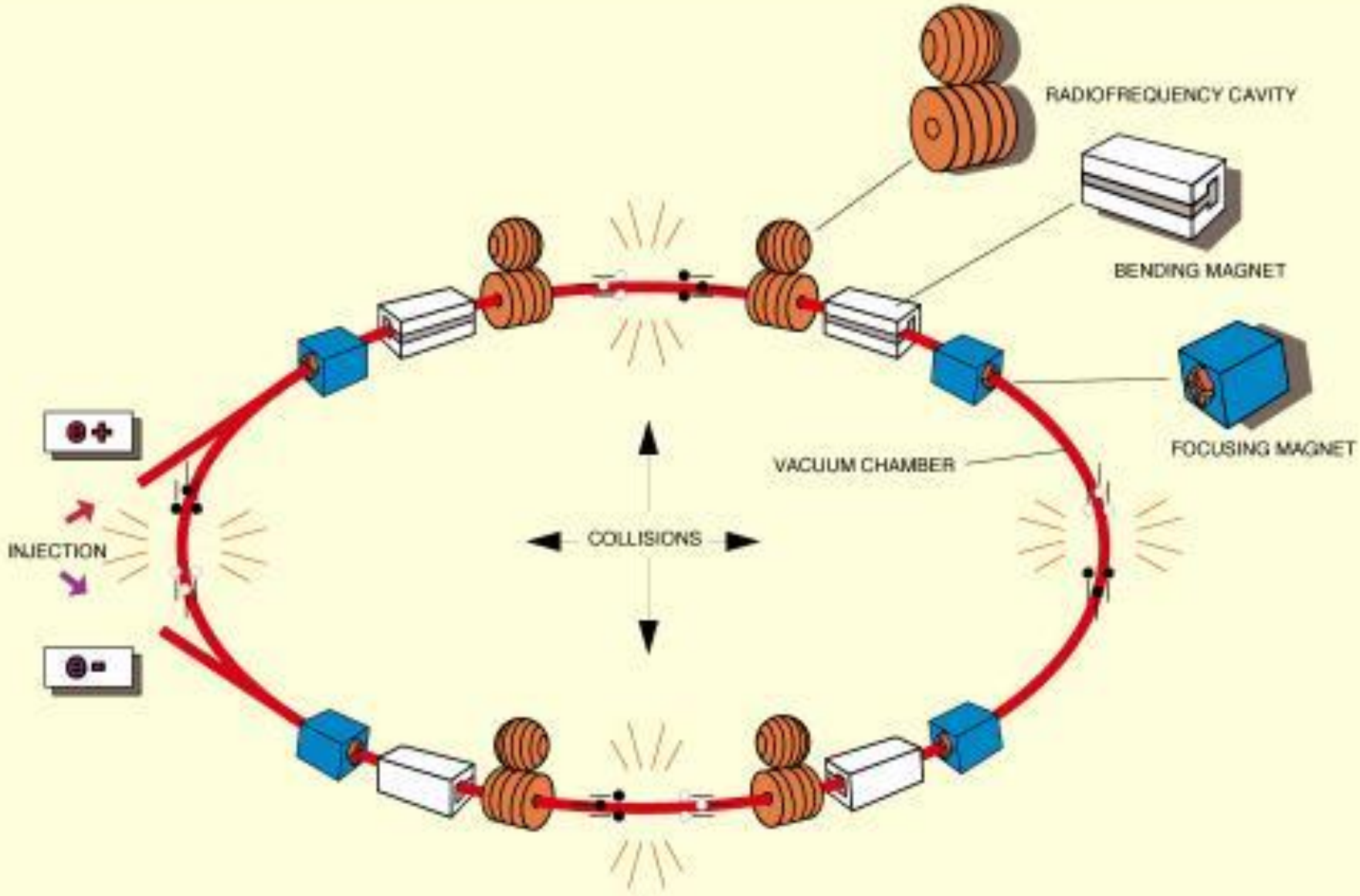
Galaxies

Radius of observable Universe

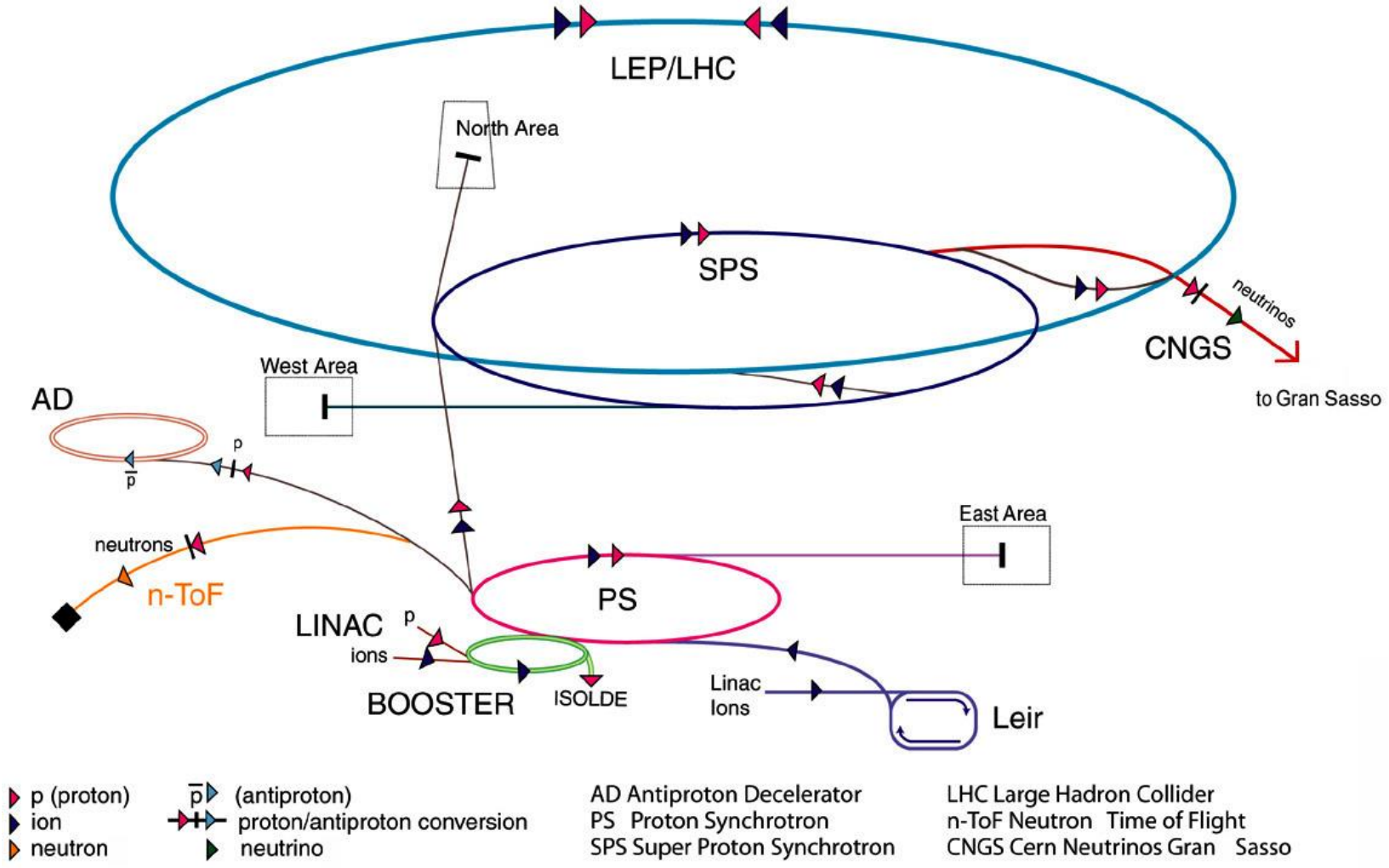
10^{26}

Radio Telescope

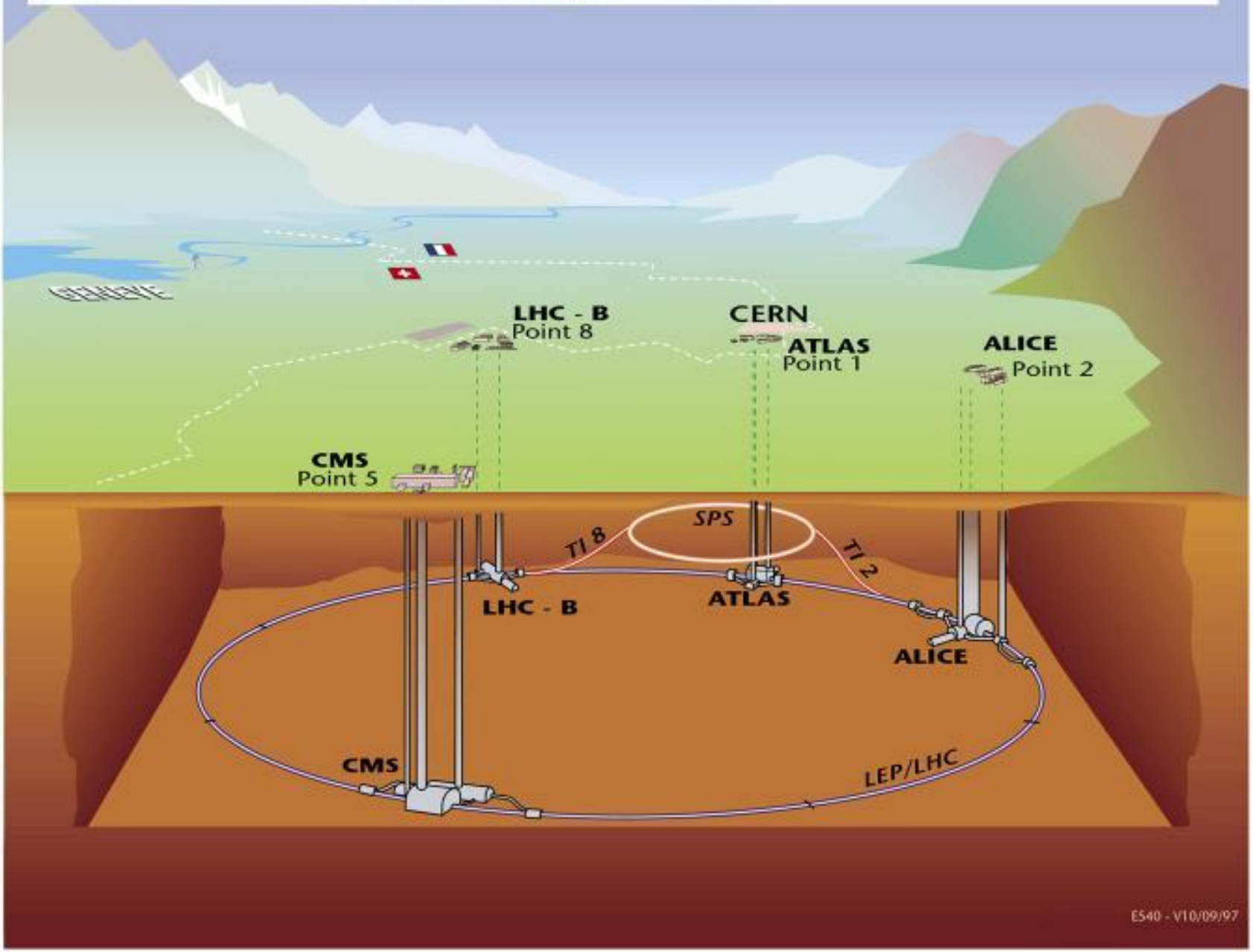
THE PRINCIPAL MACHINE COMPONENTS OF THE LEP ACCELERATOR.



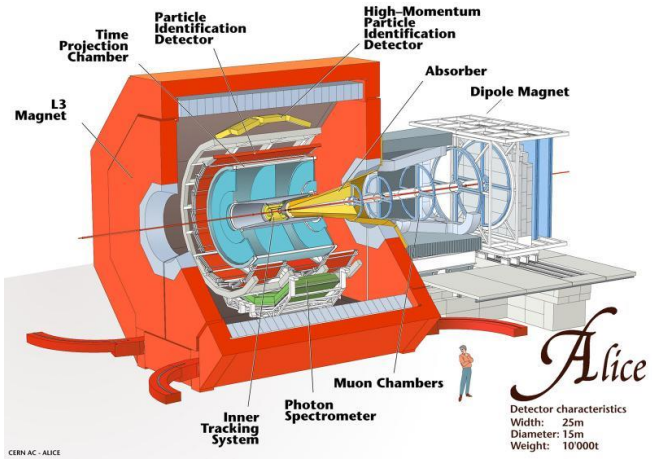
Accelerator chain at CERN, a complex business

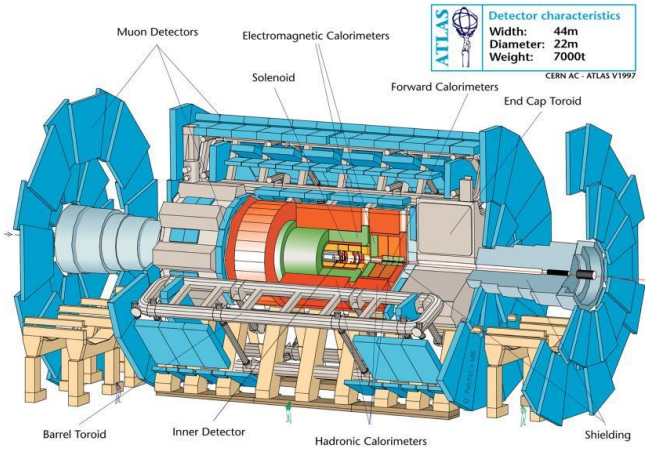


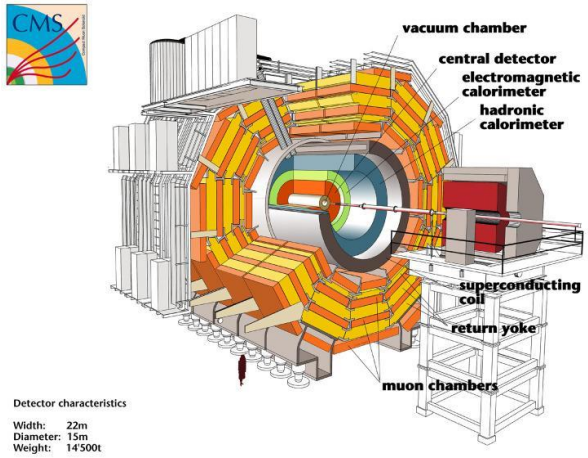
Overall view of the LHC experiments.

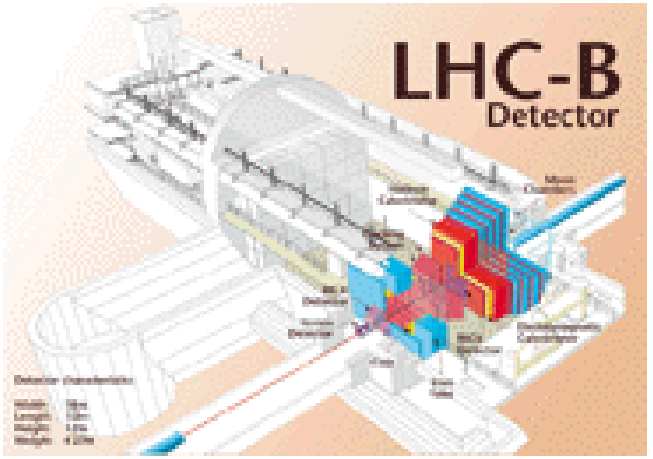


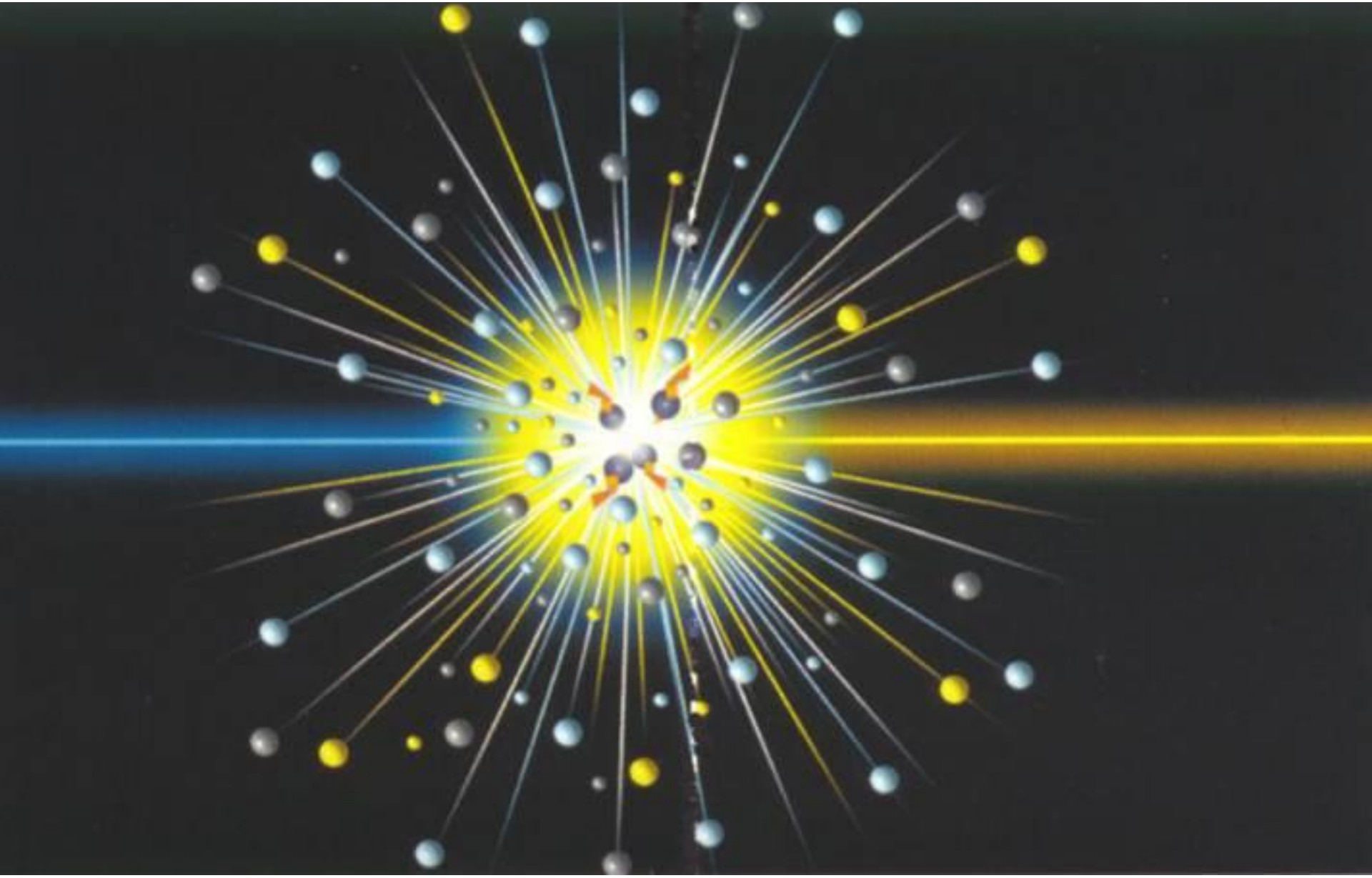
LHC Experiments

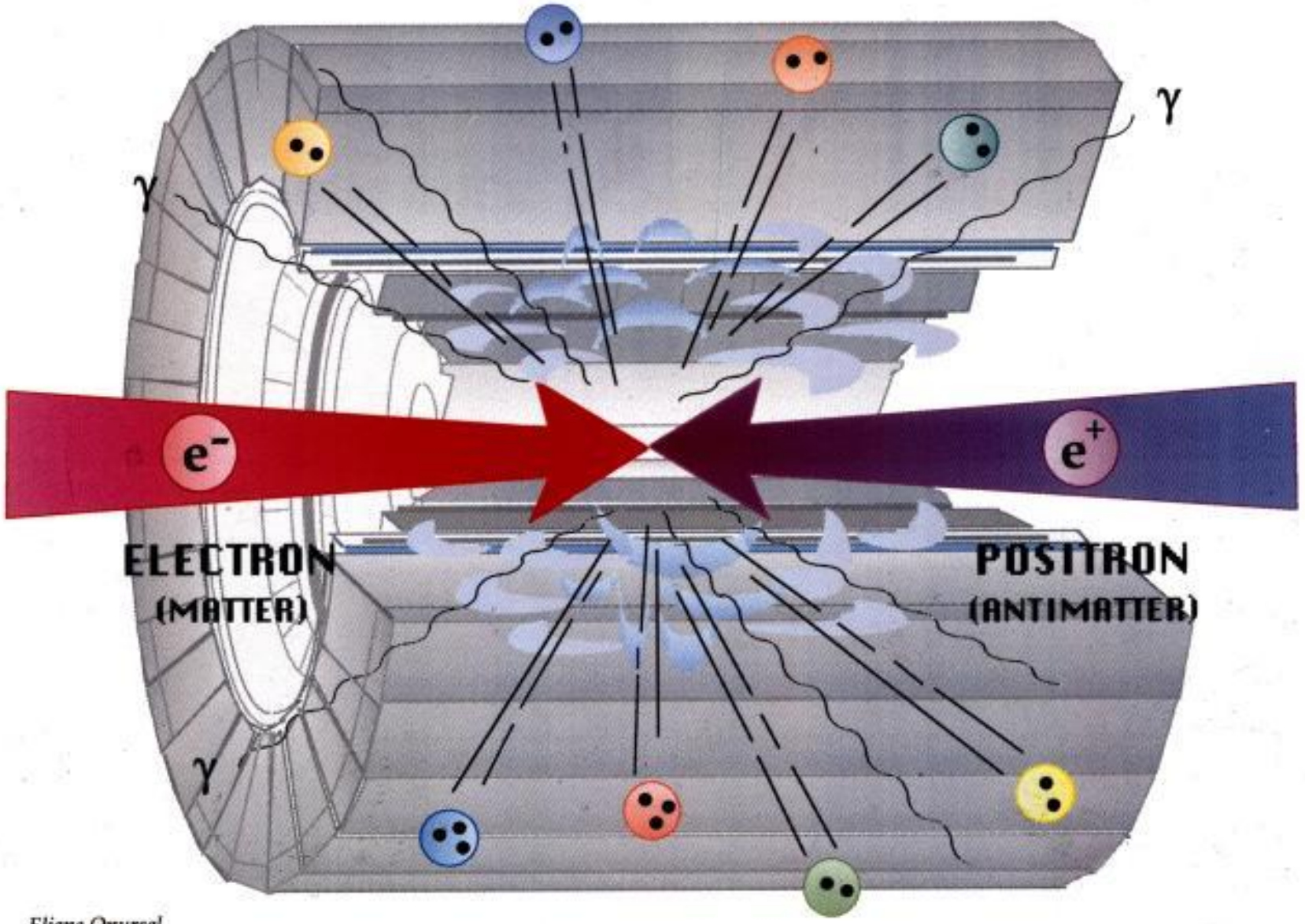




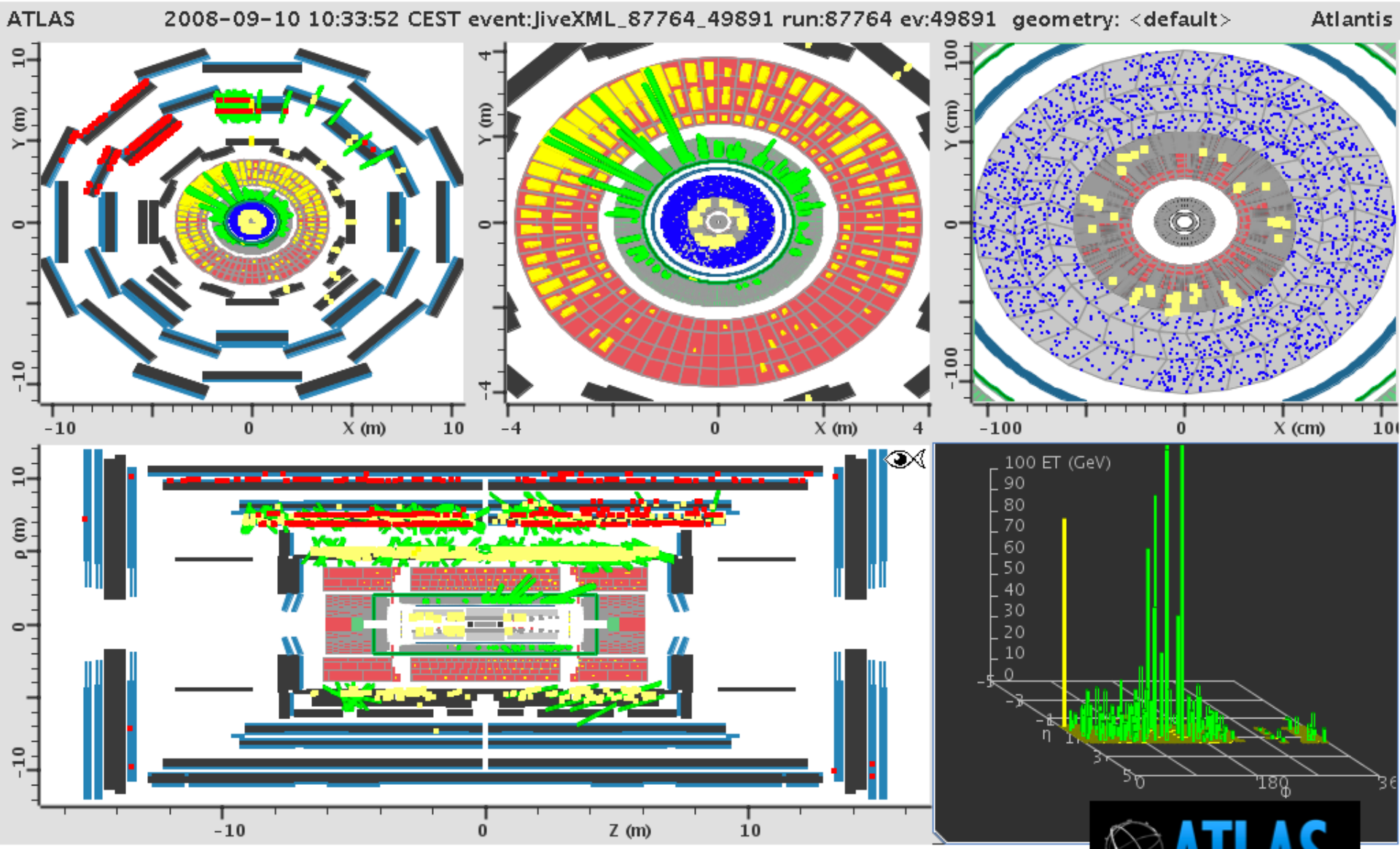






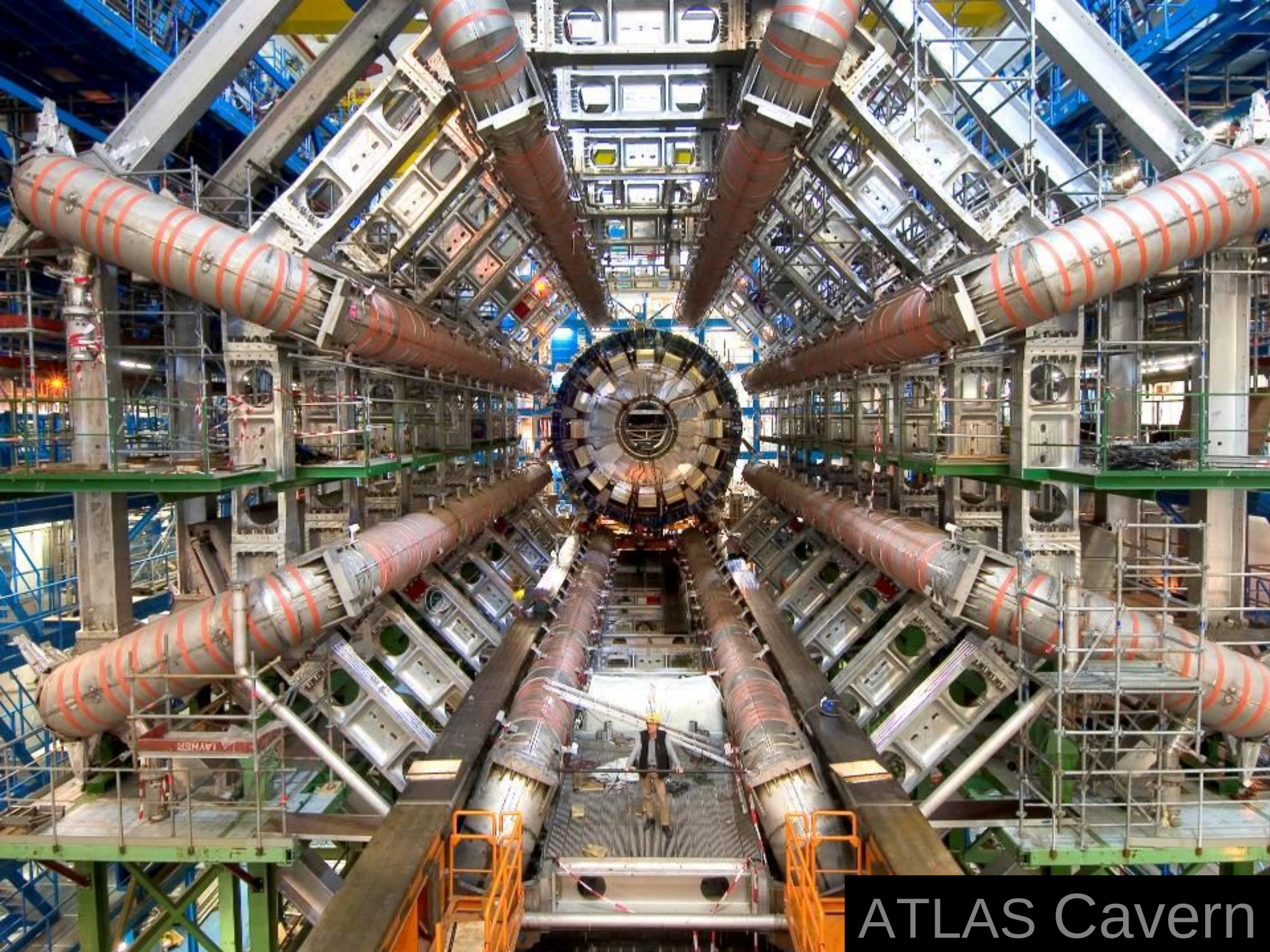


Eliane Onursal



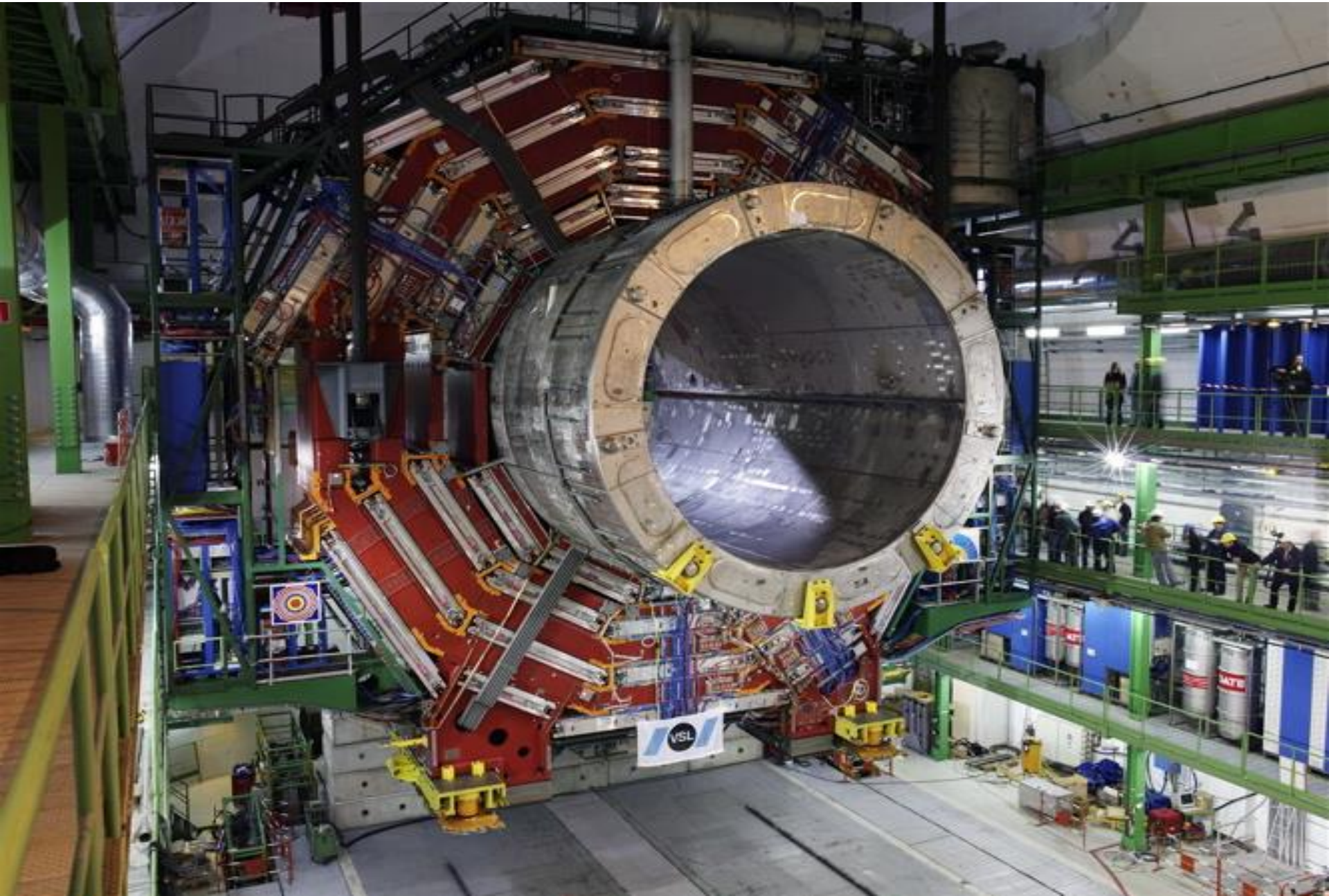
2nd beam event seen in ATLAS

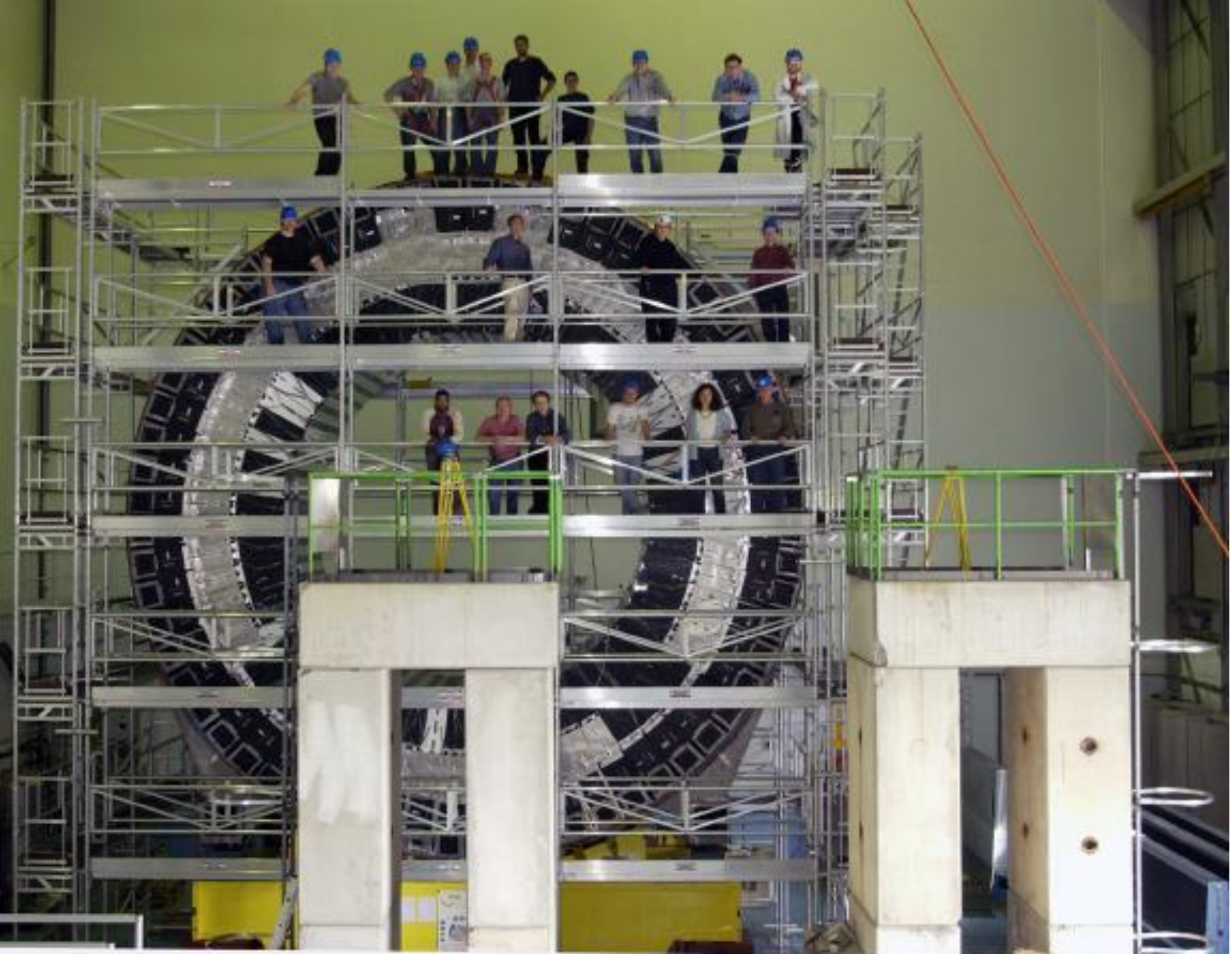
ATLAS EXPERIMENT
http://atlas.ch

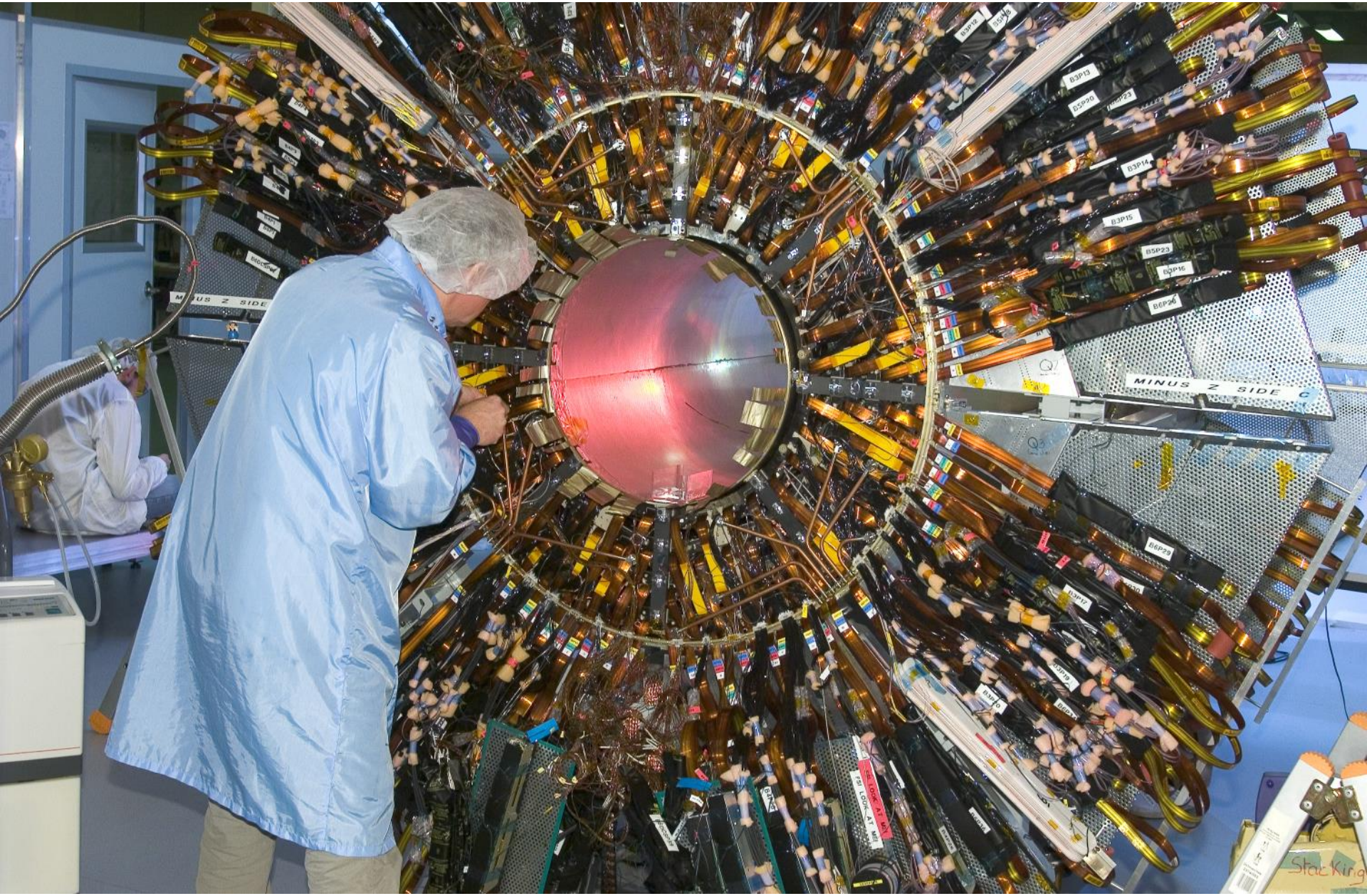


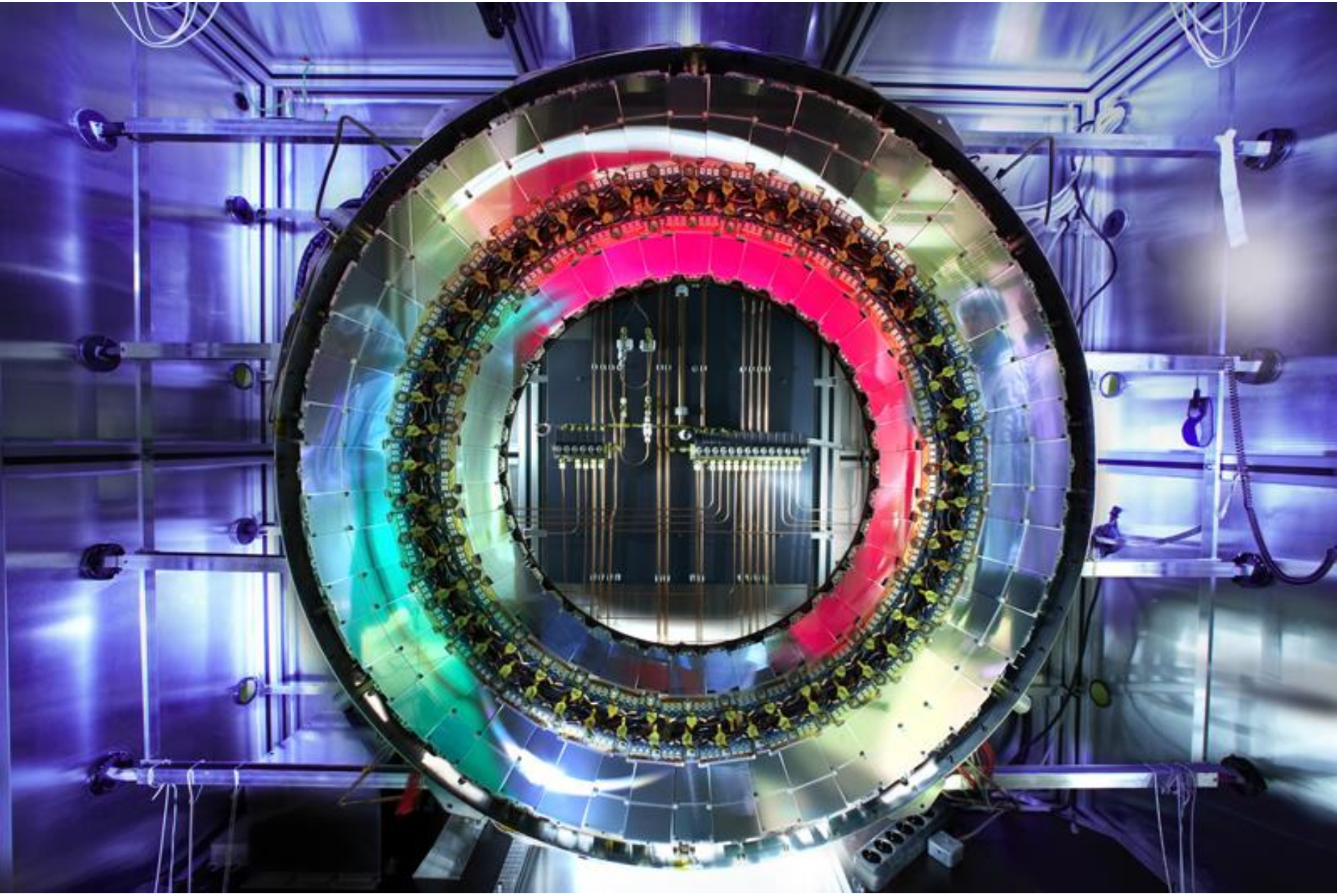
ATLAS Cavern

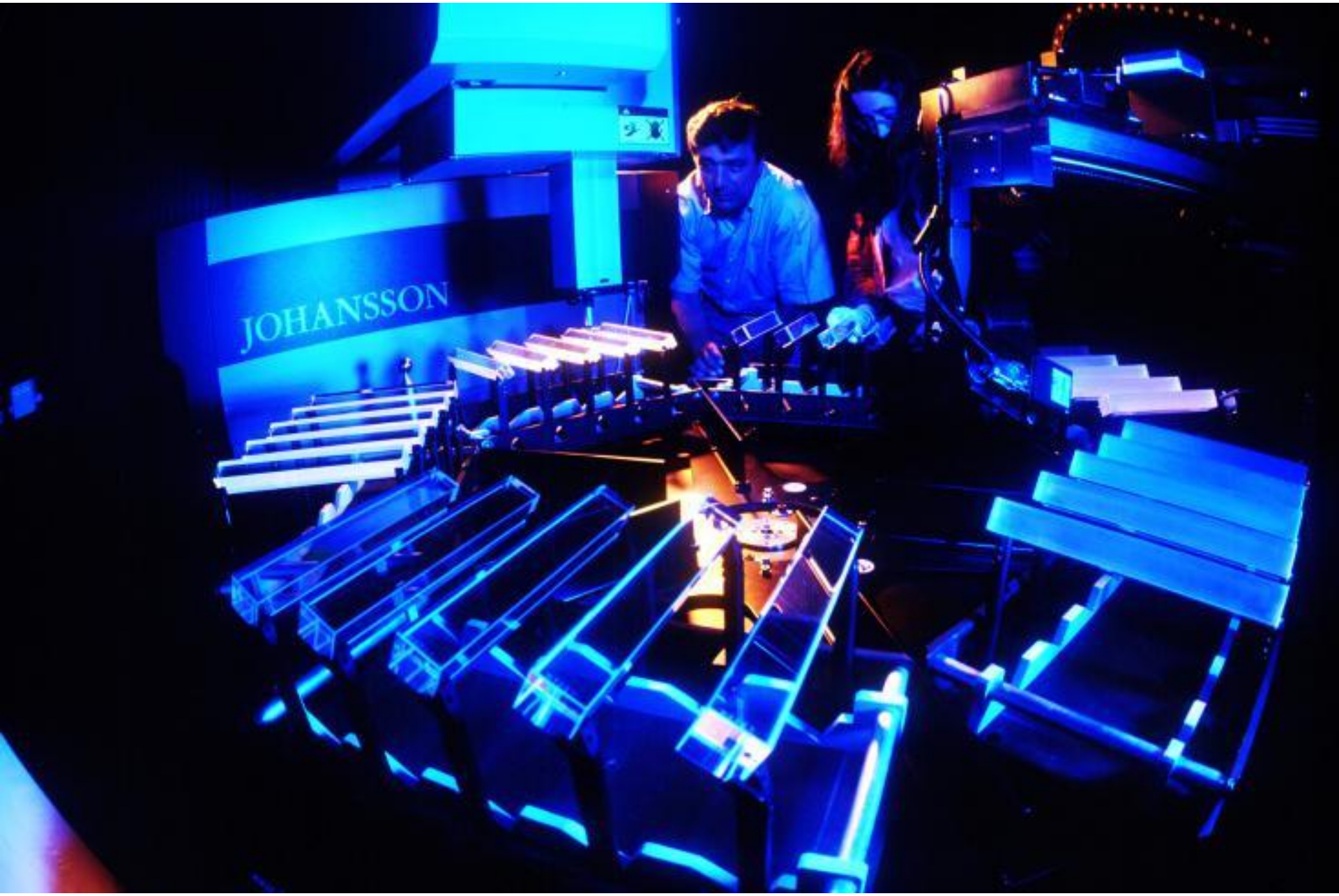
Building CMS

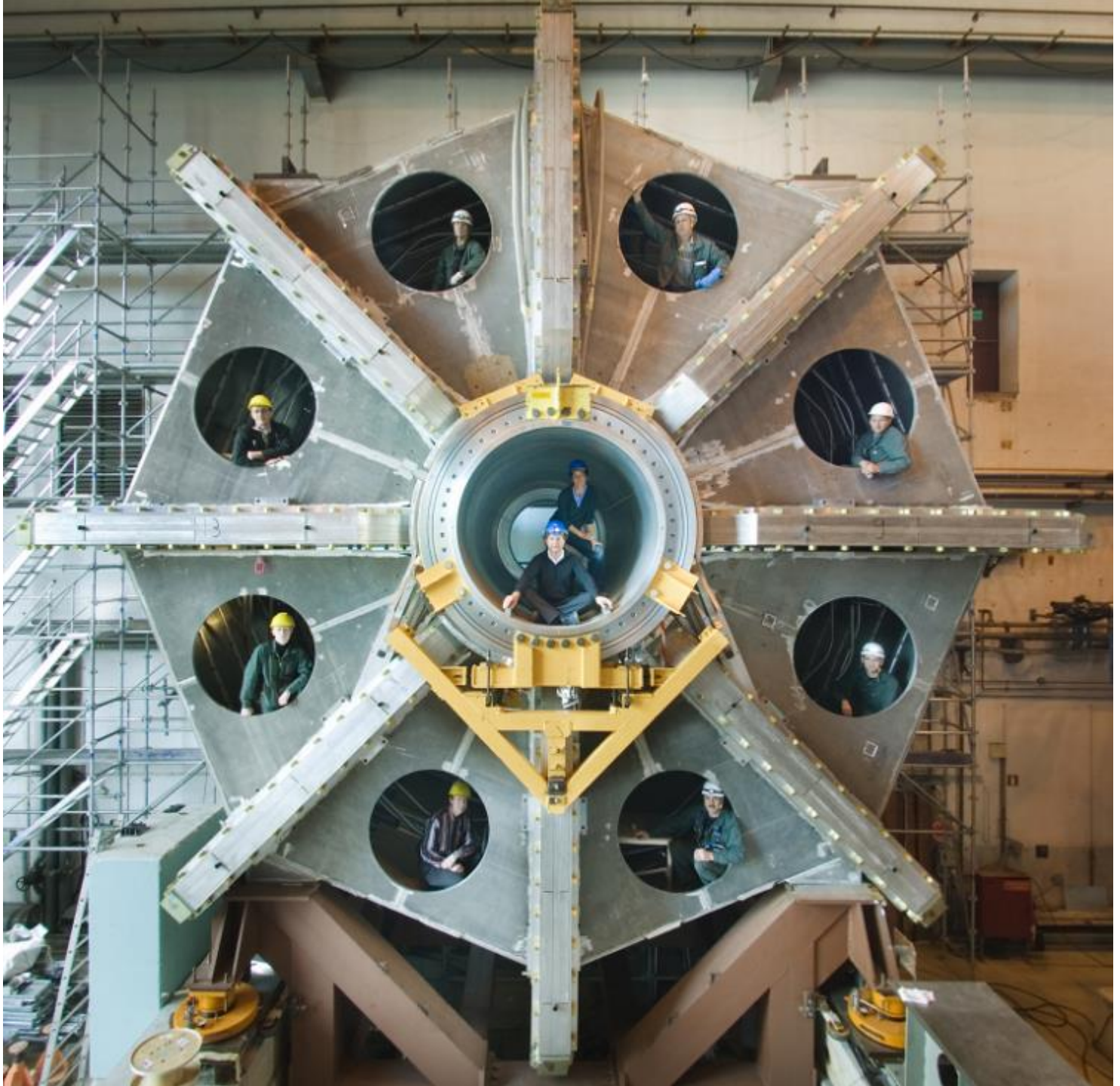





MINUS Z SIDE



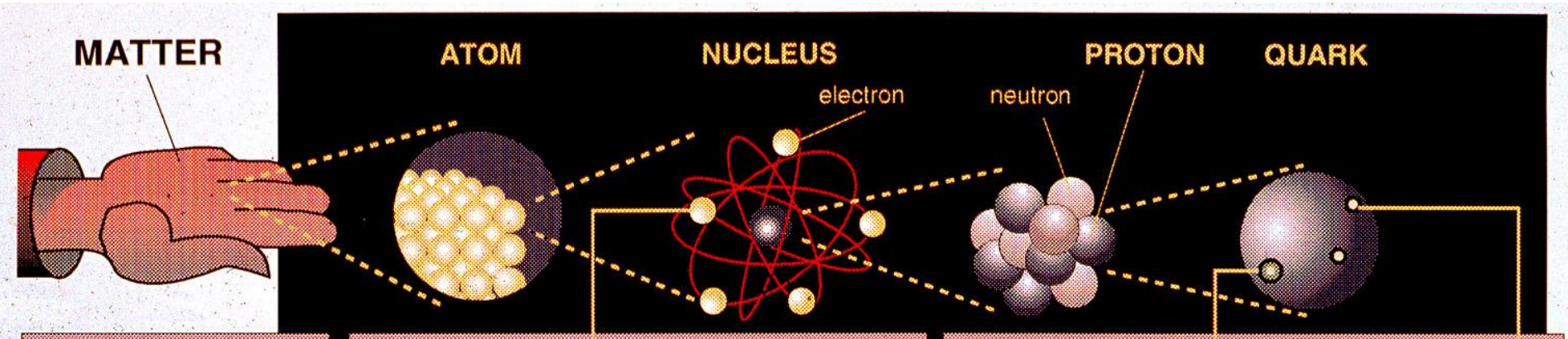

JOHANSSON




C
D


17
17


DELPHI Interactive Analysis
Beam:45.6 GeV
Run:26154
Evt:5018
25-Aug-1991
21:47:02
TD TE TS TK TV ST PA
Nut
Donut
DELPHI
ENDCAPS
BARREL
CENTRAL
Return



ALL ORDINARY MATTER BELONGS TO THIS GROUP.

THESE PARTICLES EXISTED JUST AFTER THE BIG BANG.

NOW THEY ARE FOUND ONLY IN COSMIC RAYS AND ACCELERATORS.

LEPTONS

electron
Electric charge –1.
Responsible for electricity and chemical reactions

electron neutrino
Electric charge 0.
Rarely interacts with other matter.

muon
A heavier relative of the electron.

muon neutrino
Created with muons when some particles decay.

tau
Heavier still.

tau neutrino
Not yet observed directly.

QUARKS

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.

charm
A heavier relative of the up.

strange
A heavier relative of the down.

top
Heavier still, recently observed.

bottom
Heavier still.

ANTIMATTER

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

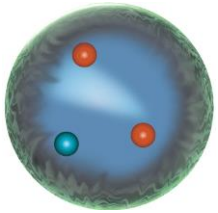
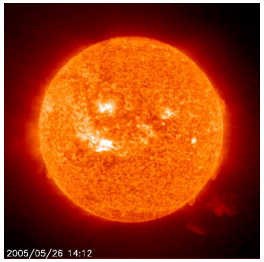
Mass Ratios of Elementary Particles (MeV)

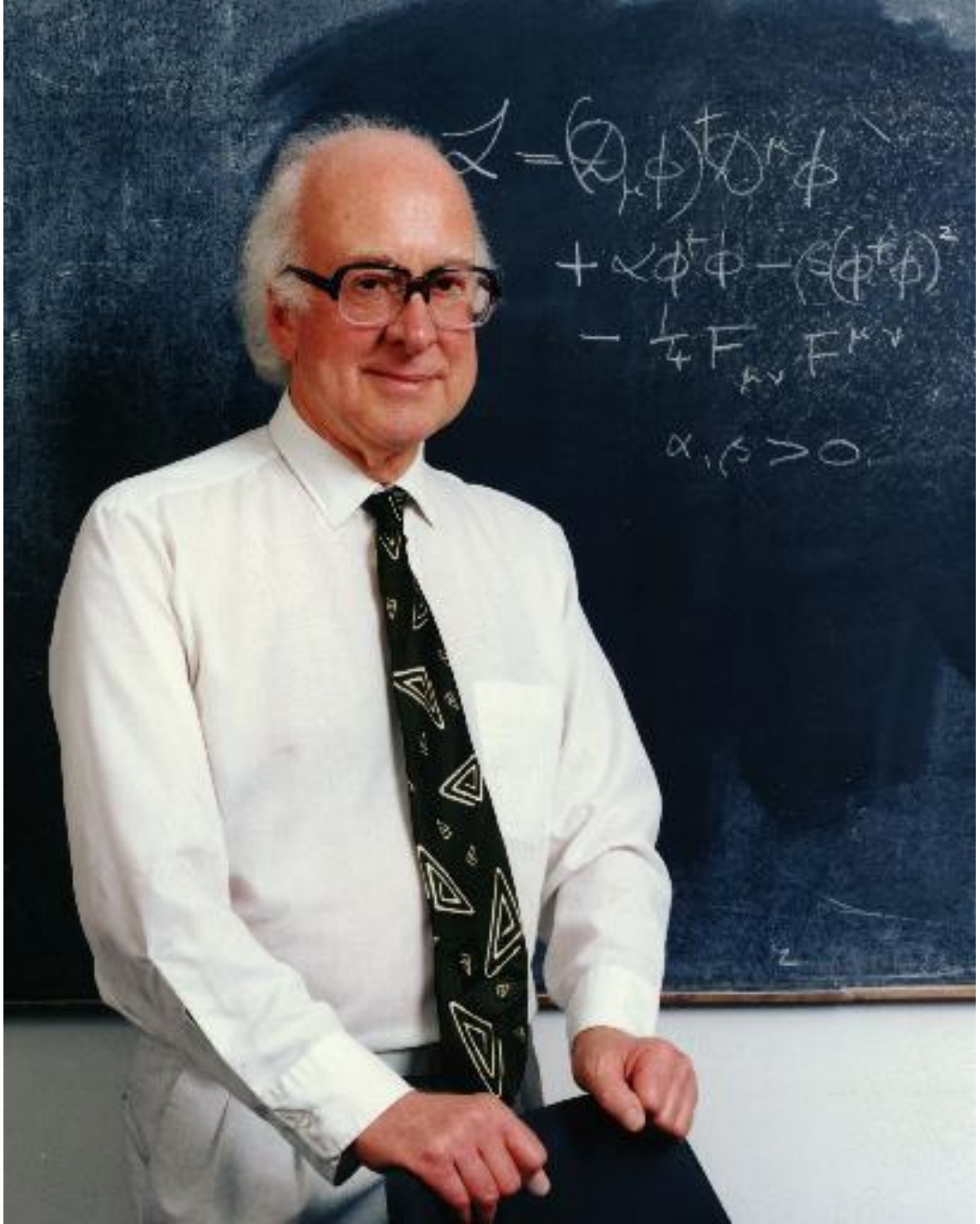
	Lepton	Neutrino	Quark 1	Quark 2
1st Family	0.5	0	3	6
2nd Family	106	0	1300	100
3rd Family	1800	0	175000	4500

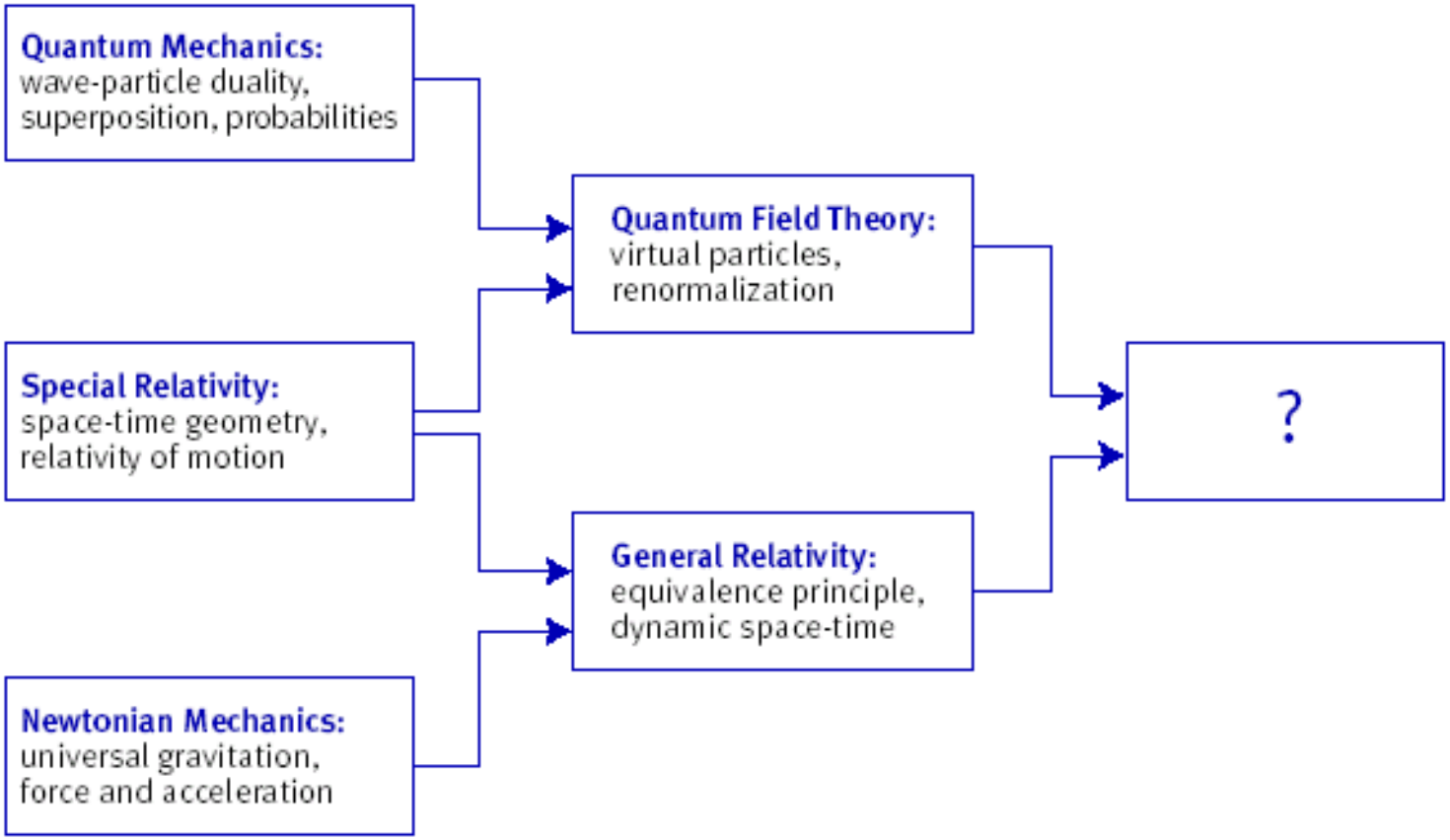
	Lepton	Neutrino	Quark 1	Quark 2
1st Family	1	0	1	1
2nd Family	212	0	433	17
3rd Family	3600	0	58333	750

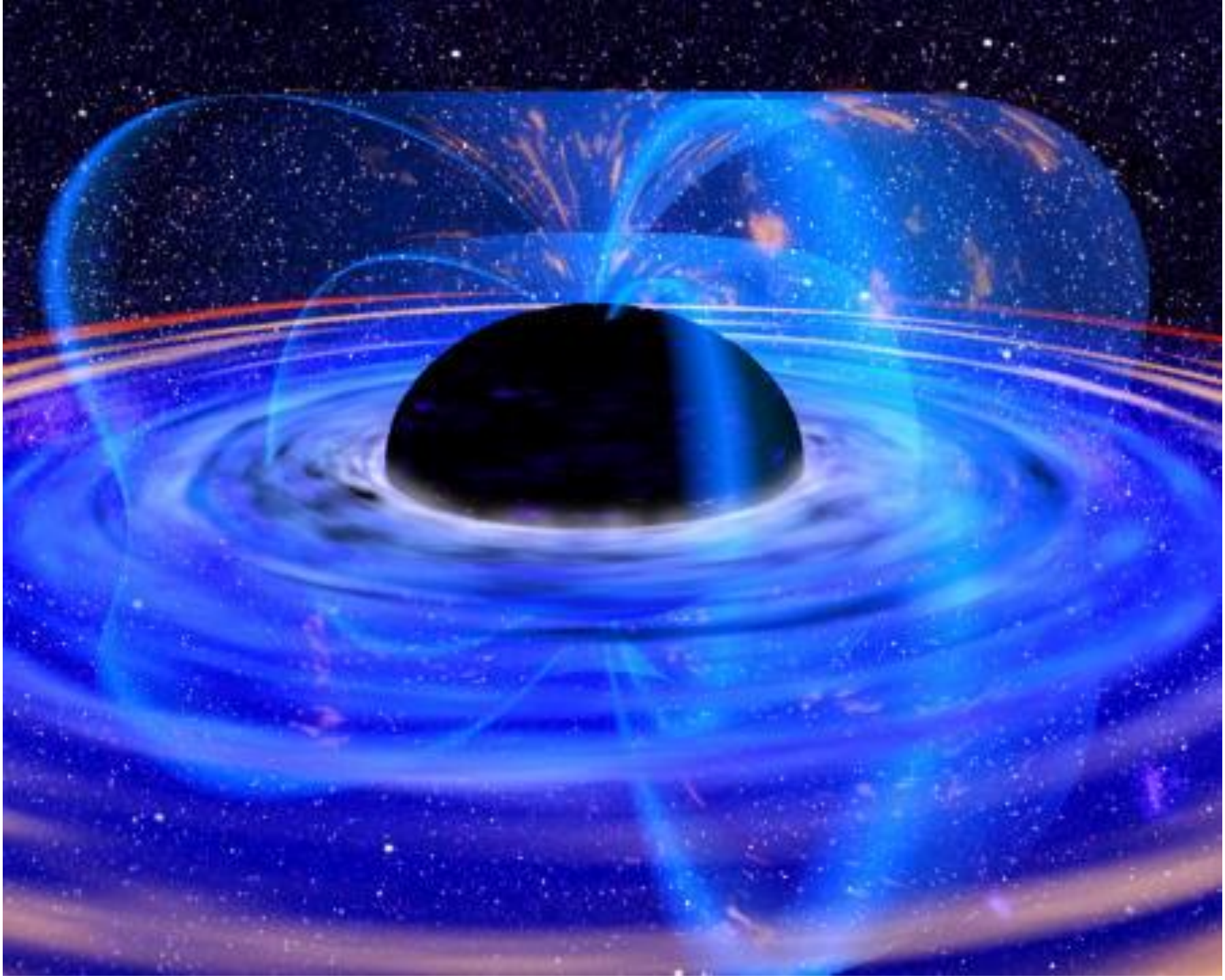
	Lepton	Q1/Q2	L/(Q1/Q2)
1st Family	1	1	1
2nd Family	212	26	8
3rd Family	3600	78	46

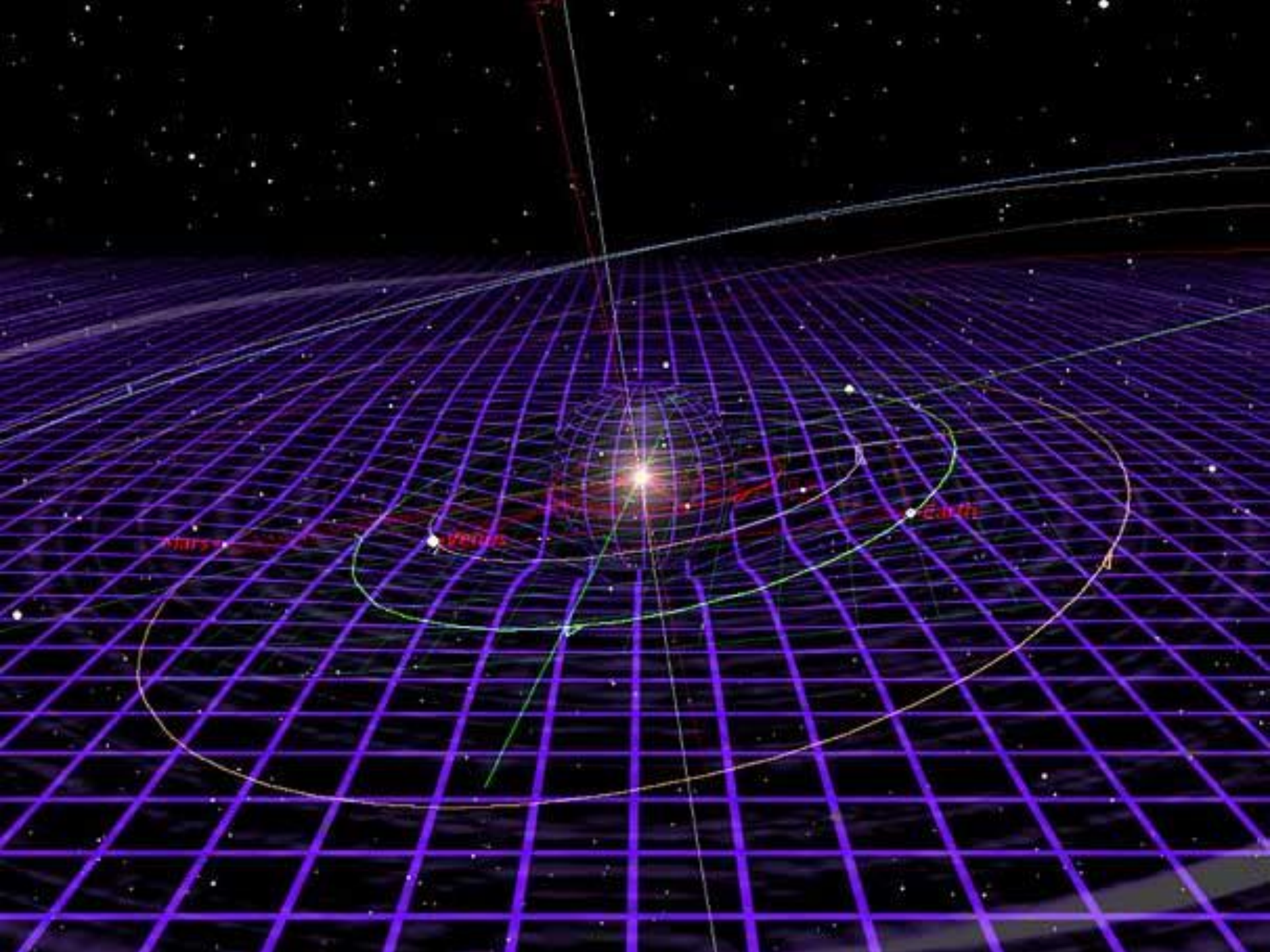
Basic Forces and their Carriers

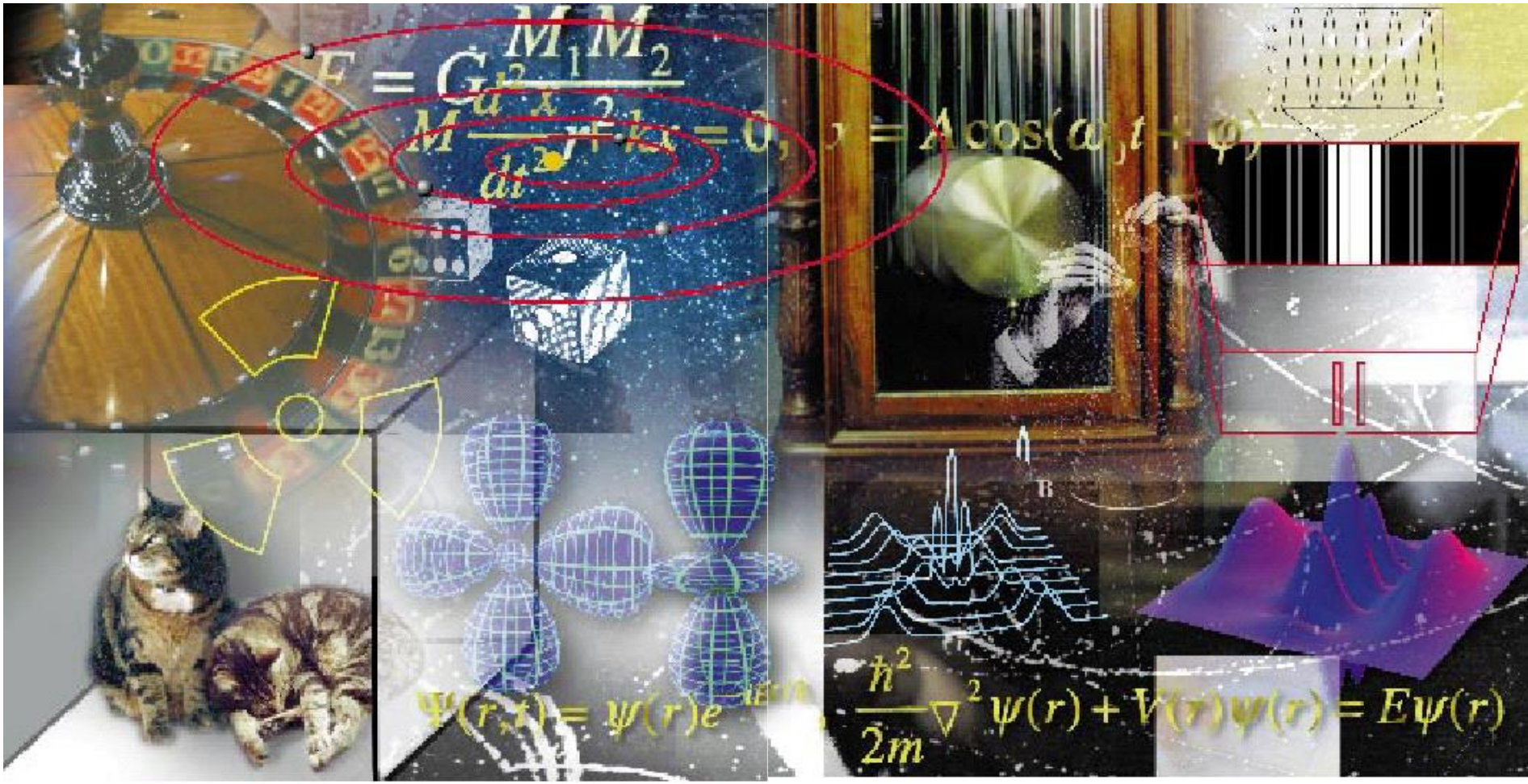
	Strong Force:	Gluon
	Electro-Magnetic Force:	Photon
	Weak Force:	Bosons (W, Z)
	Gravitation: Falling apples, orbiting Moon Relative strength ~ $(1/10^{38})$	Graviton No mass (?)


$\mathcal{L} = (\partial_\mu \phi)^\dagger \partial^\mu \phi$
$+ \alpha \phi^\dagger \phi - \beta (\phi^\dagger \phi)^2$
$- \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$
$\alpha, \beta > 0$


Quantum Mechanics:
wave-particle duality,
superposition, probabilities
Special Relativity:
space-time geometry,
relativity of motion
Newtonian Mechanics:
universal gravitation,
force and acceleration
Quantum Field Theory:
virtual particles,
renormalization
General Relativity:
equivalence principle,
dynamic space-time
?



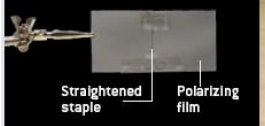

Venus
Earth



Bringing Schrödinger's Cat to Life

Quantum Erasing in the Home

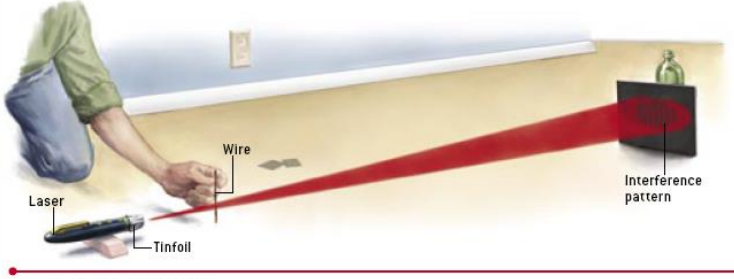
The steps presented here outline how to see quantum erasure in action. See www.sciam.com/ontheweb for a fuller description and additional information, such as the basics of how waves interfere and produce fringes.



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.

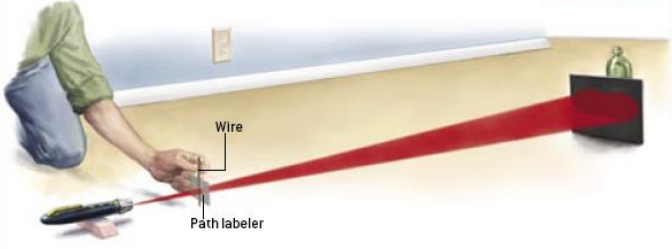


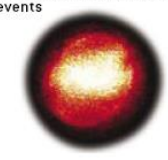
INTERFERENCE seen is captured in this photograph. The size and other features of the patterns depicted in the diagrams are exaggerated.

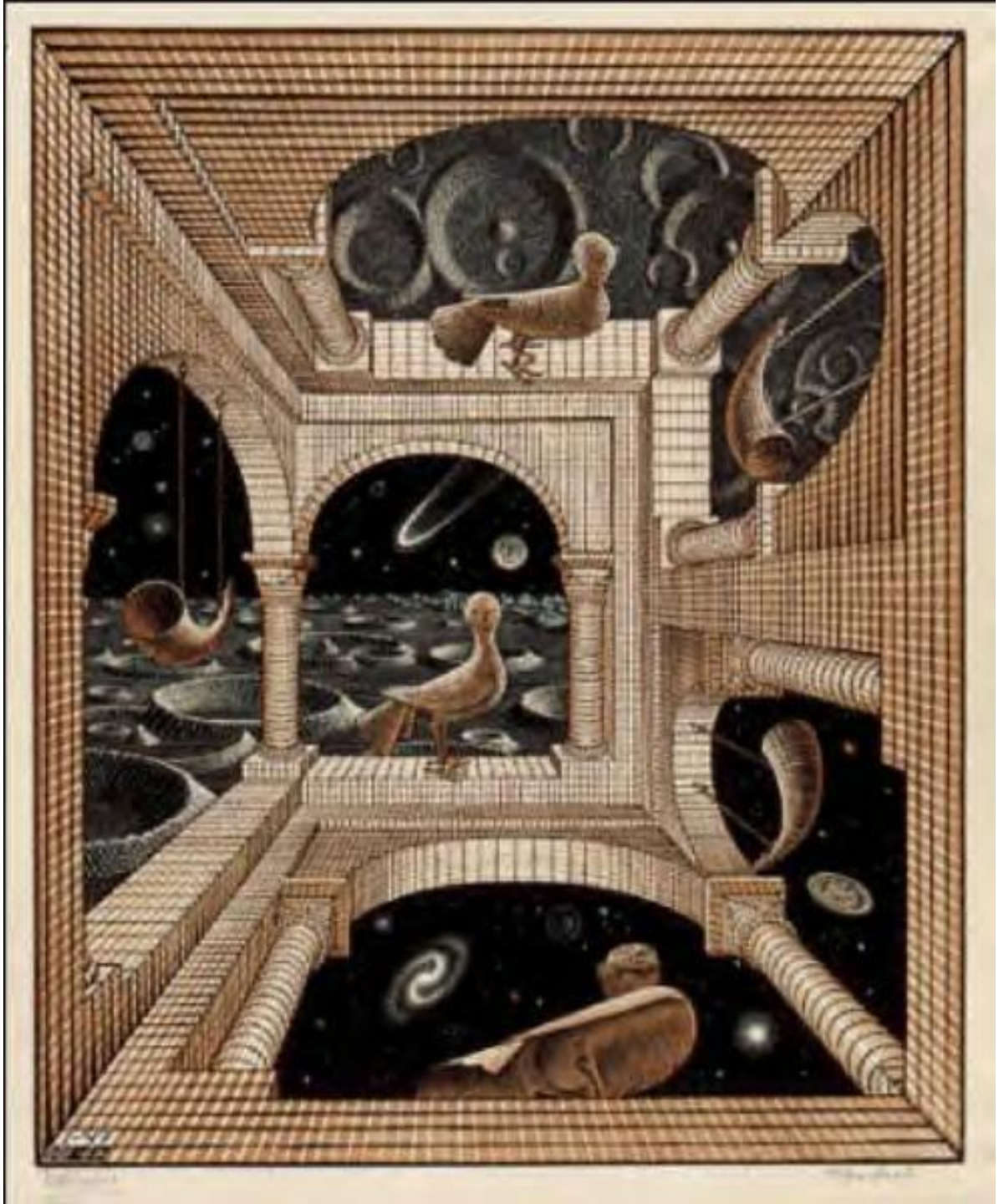
2 LABELING THE PATH

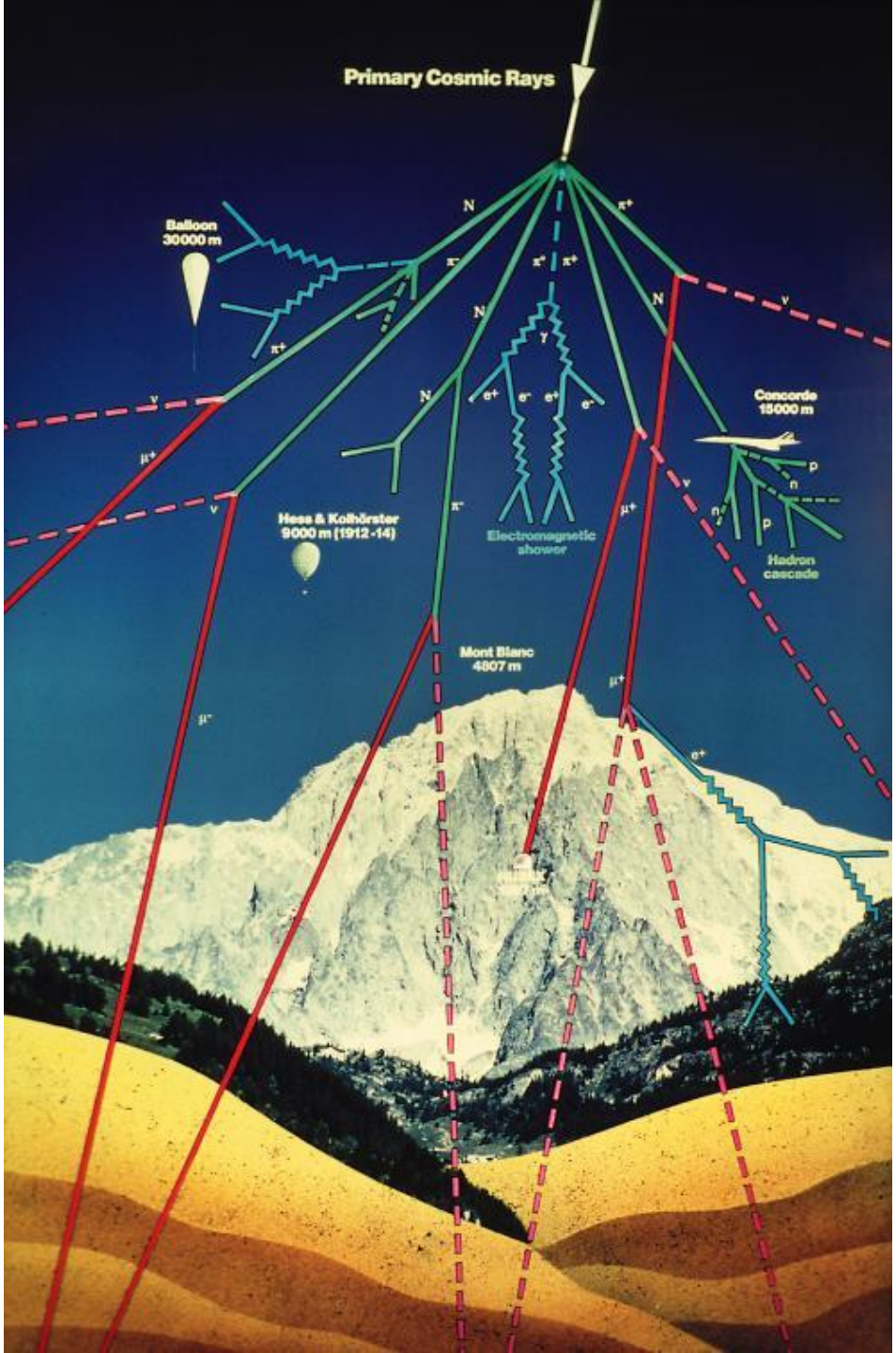
- Take two polarizers and rotate one of them so that their axes are perpendicular; you have done this correctly if when you overlap the film temporarily, no light goes through the overlap region.
- Tape them together side by side with no gap or overlap. Do the taping along the top and bottom so the tape 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.

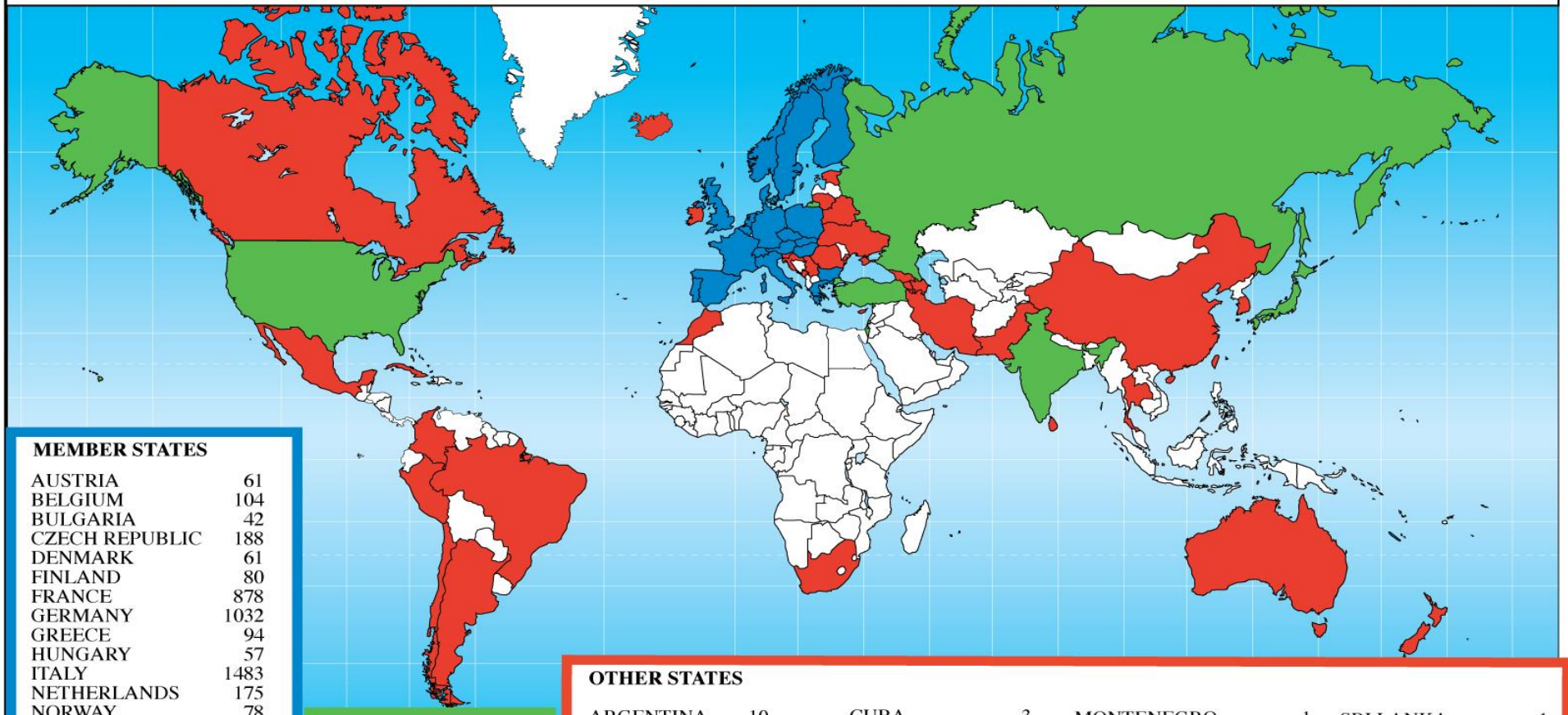







Primary Cosmic Rays
Balloon
30000 m
Hess & Kolhörster
9000 m (1912-14)
Electromagnetic
shower
Concorde
15000 m
Hadron
cascade
Mont Blanc
4807 m

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

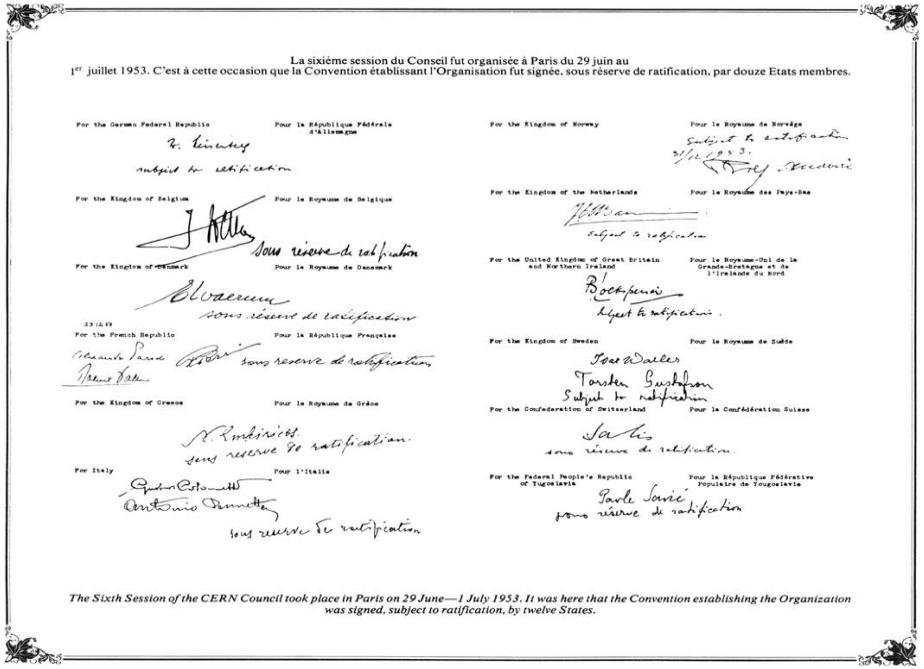
OTHER STATES

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



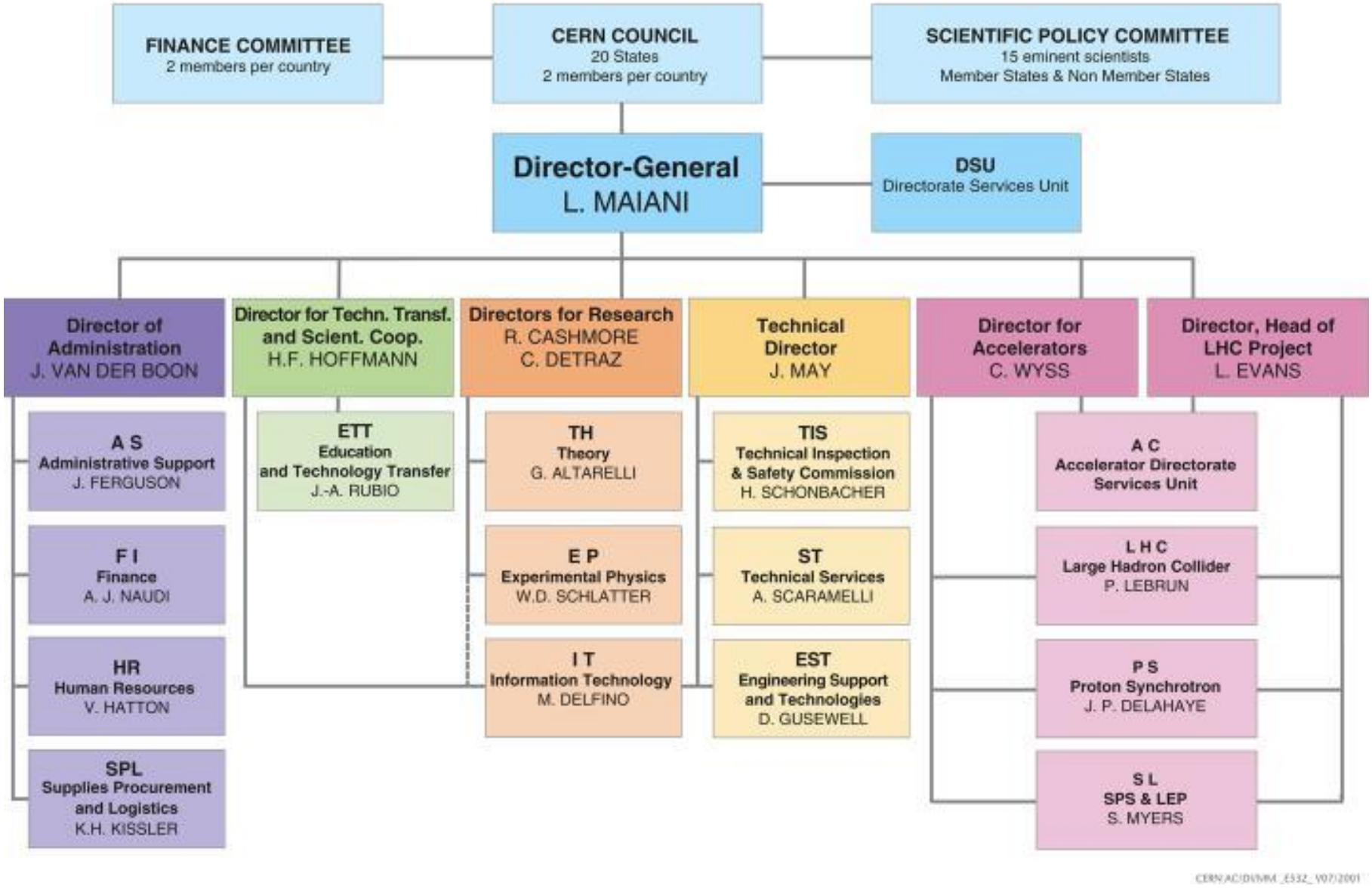
La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

1954: Convention establishing the Organization - original signatures

2007: The 20 member states

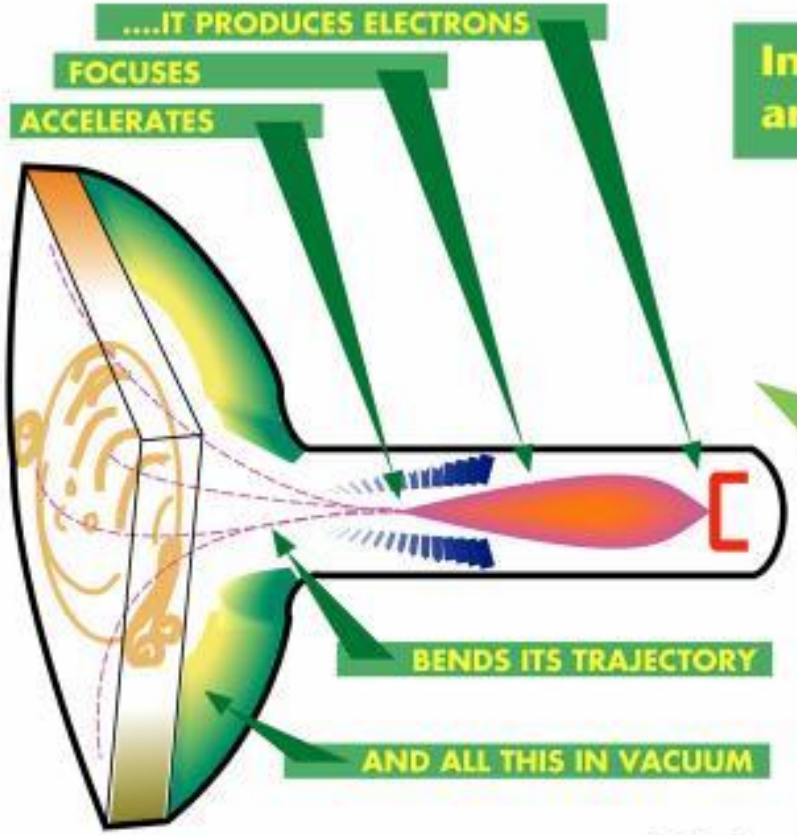
CERN ORGANISATIONAL CHART 07/2001



CERN AC/DI/MM_ES32_ V07/2001

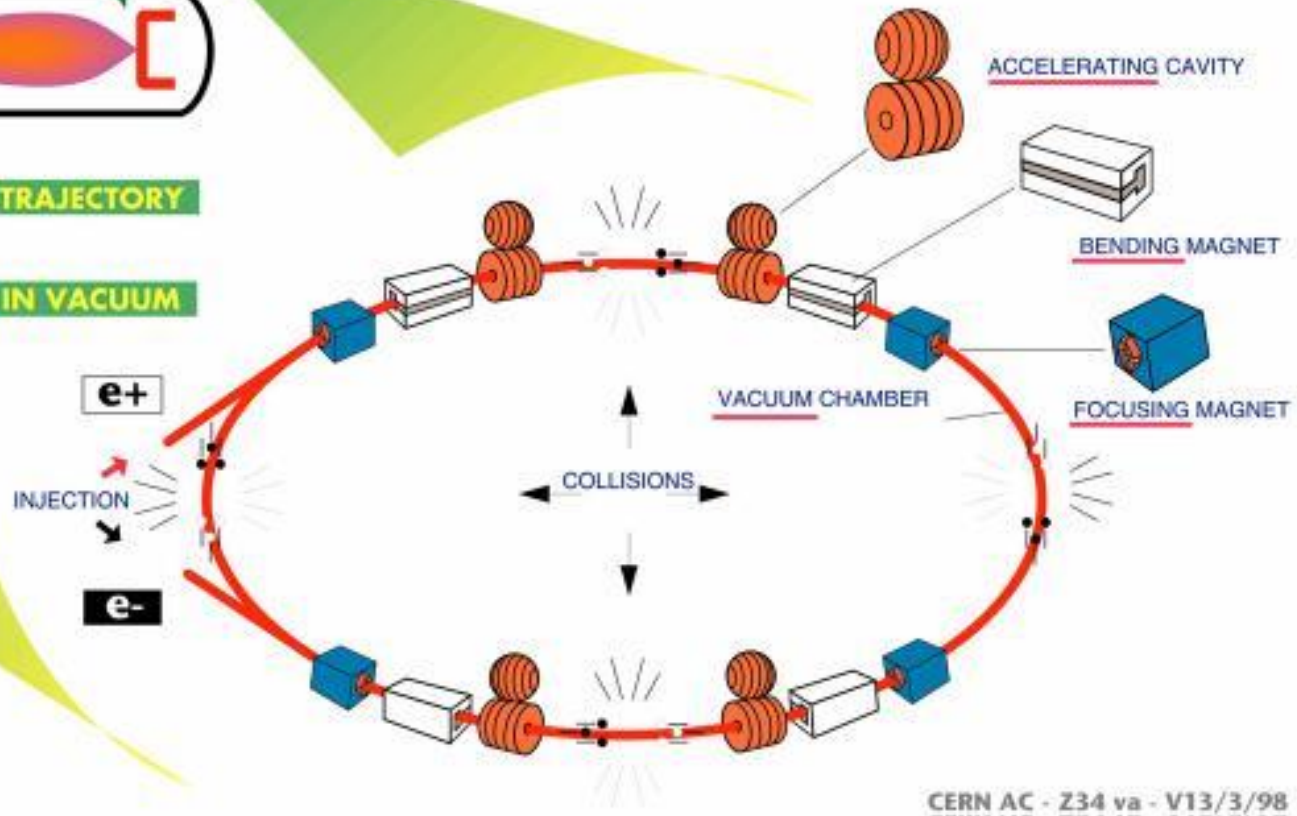

Teilchen

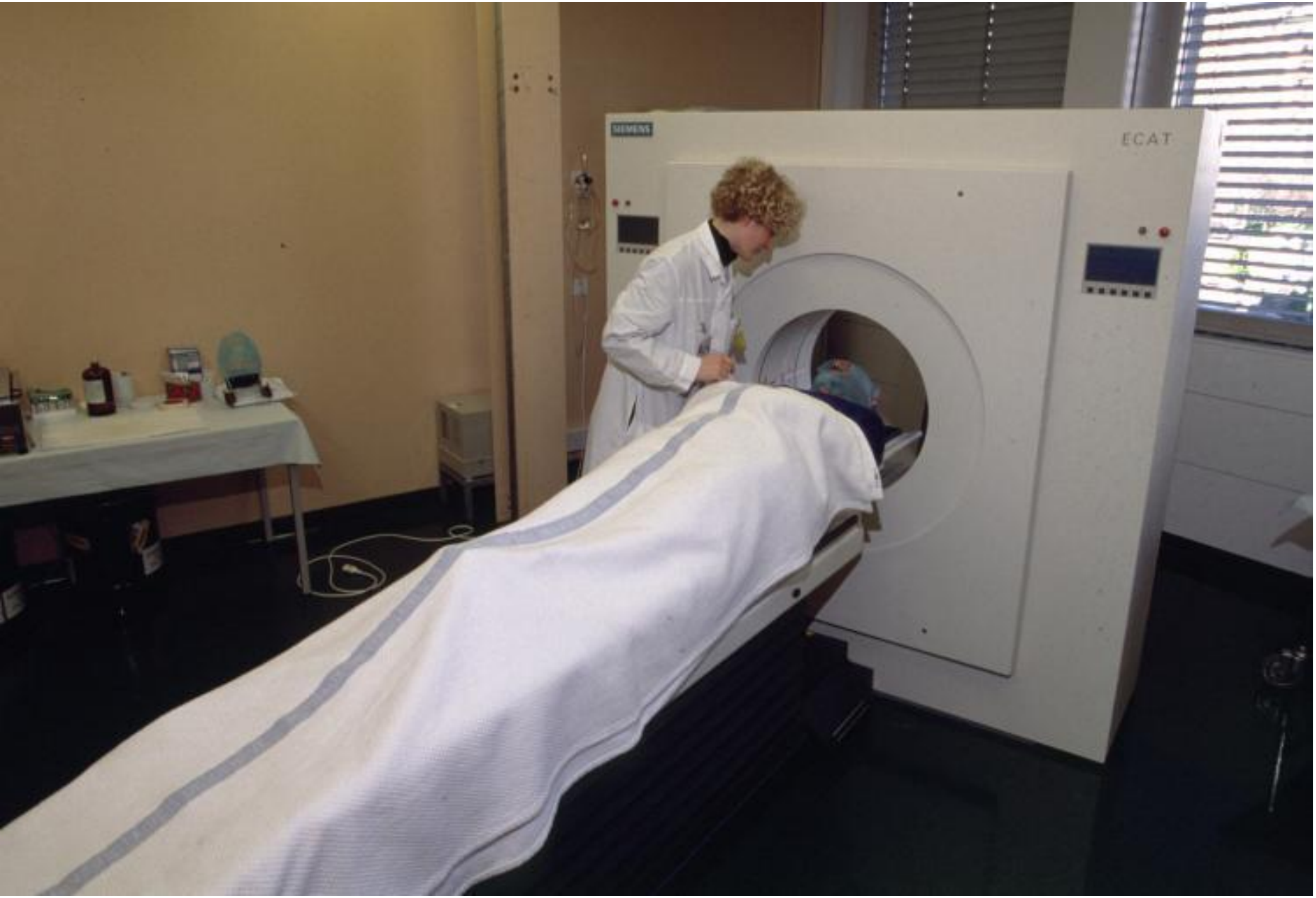
DID YOU KNOW YOUR TELEVISION SET IS AN ACCELERATOR ?

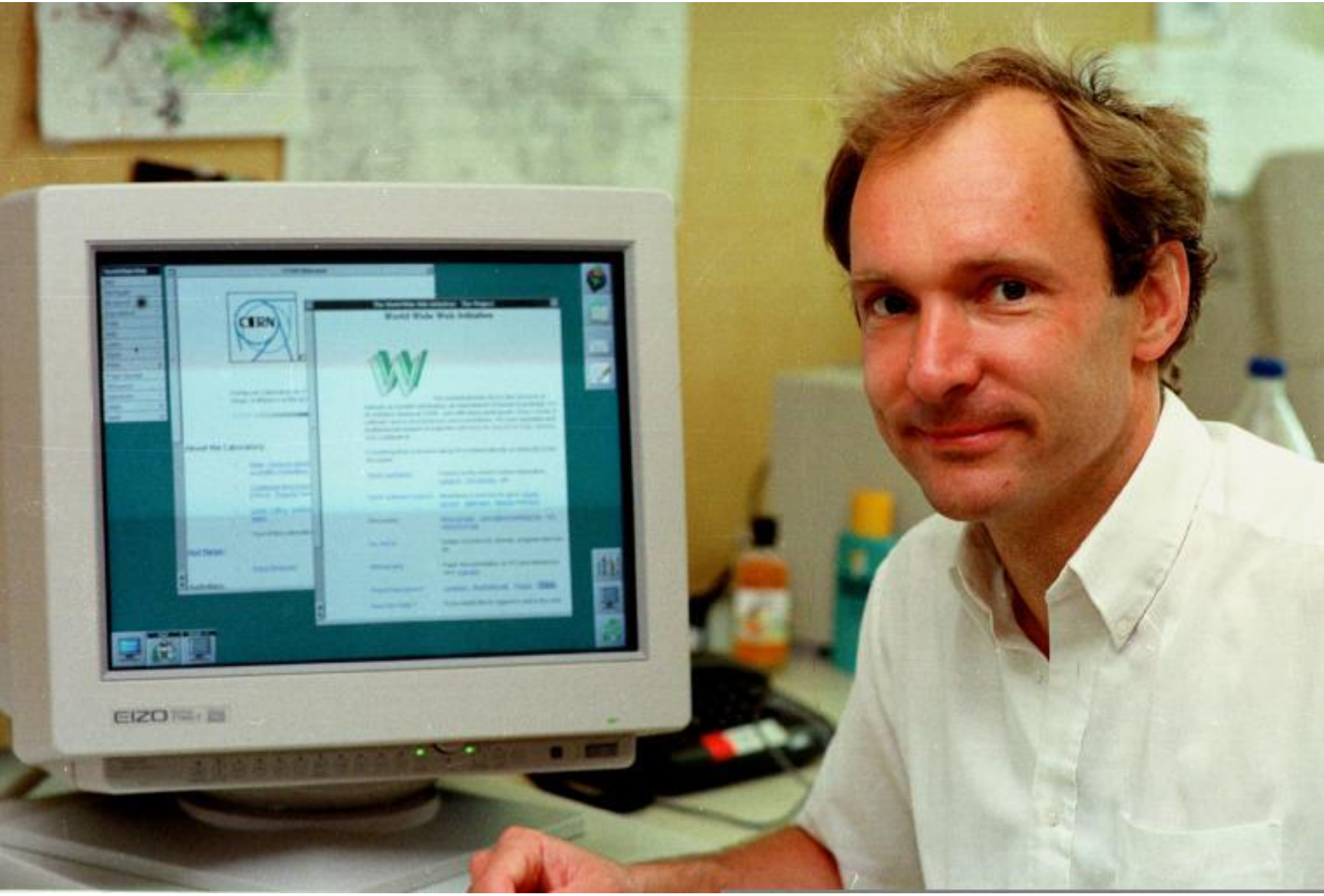


In your TV set, the electrons are accelerated to 20000 volts.

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




SIEMENS
ECAT


CERN
World Wide Web Initiative
EIZO

Modern Physics
Relativity
Thermodynamics
Optics
Biology

+

Quantum Mechanics

QM describes physics phenomena at very small distances

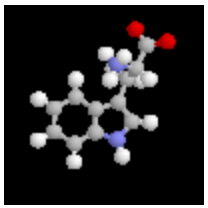
1) Objects described with a wavefunction WF
2) The WF fills the entire (Hilbert) space

Chemistry

Electronics (transistor)

Optics (lasers)

(Other)



Bioinformatics

Computer (chip)

Quantum Computing

Software

Communi-cations

Teleportation?

Grid