M. Spiro, Split October 4, 2010

: Accelerating Science and Innovation

Importance of Science

"If this importance (of Science) has been cast sometime into doubts, it is because the efforts of mankind toward its most beautiful aspirations have been imperfect, as everything which belongs to the human sphere, and have been distracted from their path by the forces of national egoism and social regression. Above all, it is by this daily effort toward more science that mankind has reached the exceptional place that she occupies on Earth. We must belong to those who.... believe, invincibly, that science will triumph over ignorance and war."

Marie Curie , 1926

These are some of the early creators of modern physics, at the 7th Solvay Physics Congress in Brussels, 1933. Even though Max Born said at the time, "Physics as we know it will be over in six months," virtually all of particle physics followed this meeting.

H. A. Kramers N. F. Mott G. Gamow P. Blackett M. Cosyns A. Piccard
E. Stahel P. A. M. Dirac J. Errera C. D. Ellis E. O. Lawrence
E. Henriot F. Joliot W. Heisenberg E. Walton P. Debye B. Cabrera W. Bothe E. Bauer J. Verschaffelt J. Cockcroft L. Rosenfeld
F. Perrin E. Fermi M. Rosenblum W. Pauli E. Herzen R. Peierls
E. Schroedinger I. Joliot N. Bohr A. Joffe M. Curie O. Richardson E. Rutherford M. De Broglie L. Meitner J. Chadwick
P. Langevin T. De Donder L. De Broglie
Absent: A. Einstein and E. Guye

De Broglie 1949

A Laboratory for the World

- The first proposal (De Broglie, 1949)

"...a laboratory or institution where it would be possible to do
scientific work, but somehow beyond the framework of the
different participating states.
...this body could be endowed with more resources than national
laboratories and could, consequently, undertake tasks...beyond their scope..."

Collaboration could be easier due to the "true nature of science"
This kind of cooperation would serve also other disciplines

What is CERN?

The CERN convention (1954) states:

The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.

- CERN was created 56 years ago as a European Organization with the aim, after the war, to get Europe to a competitive level in particle physics.

EXPERIMENTAL OBSERVATION OF ISOLATED LARGE TRANSVERSE ENERGY ELECTRONS WITH ASSOCIATED MISSING ENERGY AT $\sqrt{s}$ = 540 GeV

UA1 Collaboration, CERN, Geneva, Switzerland

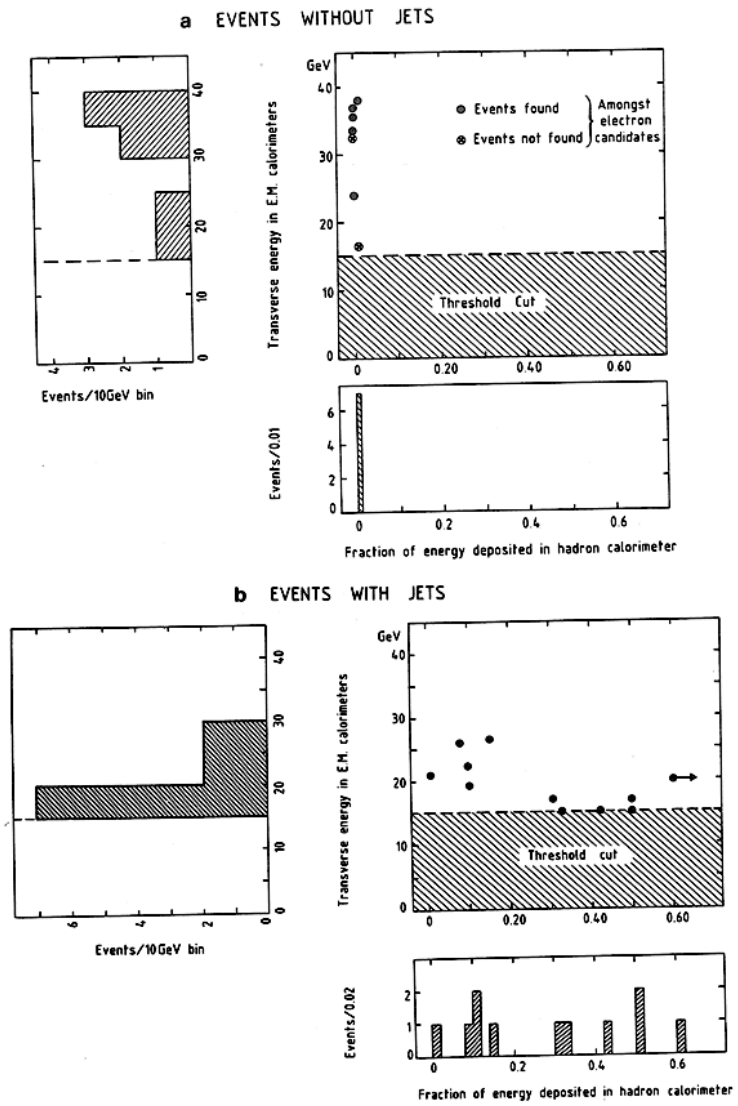
G. ARNISON [j], A. ASTBURY [j], B. AUBERT [b], C. BACCI [i], G. BAUER [1], A. BÉZAGUET [d], R. BÖCK [d], T.J.V. BOWCOCK [f], M. CALVETTI [d], T. CARROLL [d], P. CATZ [b], P. CENNINI [d], S. CENTRO [d], F. CERADINI [d], S. CITTOLIN [d], D. CLINE [1], C. COCHET [k], J. COLAS [b], M. CORDEN [c], D. DALLMAN [d], M. DeBEER [k], M. DELLA NEGRA [b], M. DEMOULIN [d], D. DENEGRI [k], A. Di CIACCIO [i], D. DiBITONTO [d], L. DOBRZYNSKI [g], J.D. DOWELL [c], M. EDWARDS [c], K. EGGERT [a], E. EISENHANDLER [f], N. ELLIS [d], P. ERHARD [a], H. FAISSNER [a], G. FONTAINE [g], R. FREY [h], R. FRÜHWIRTH [1], J. GARVEY [c], S. GEER [g], C. GHESQUIÈRE [g], P. GHEZ [b], K.L. GIBONI [a], W.R. GIBSON [f], Y. GIRAUD-HÉRAUD [g], A. GIVERNAUD [k], A. GONIDEC [b], G. GRAYER [j], P. GUTIERREZ [h], T. HANSL-KOZANECKA [a], W.J. HAYNES [j], L.O. HERTZBERGER [2], C. HODGES [h], D. HOFFMANN [a], H. HOFFMANN [d], D.J. HOLTHUIZEN [2], R.J. HOMER [c], A. HONMA [f], W. JANK [d], G. JORAT [d], P.I.P. KALMUS [f], V. KARIMÄKI [e], R. KEELER [f], I. KENYON [c], A. KERNAN [h], R. KINNUNEN [e], H. KOWALSKI [d], W. KOZANECKI [h], D. KRYN [d], F. LACAVA [d], J.-P. LAUGIER [k], J.-P. LEES [b], H. LEHMANN [a], K. LEUCHS [a], A. LÉVÊQUE [k], D. LINGLIN [b], E. LOCCI [k], M. LORET [k], J.-J. MALOSSE [k], T. MARKIEWICZ [d], G. MAURIN [d], T. McMAHON [c], J.-P. MENDIBURU [g], M.-N. MINARD [b], M. MORICCA [i], H. MUIRHEAD [d], F. MULLER [d], A.K. NANDI [j], L. NAUMANN [d], A. NORTON [d], A. ORKIN-LECOURTOIS [g], L. PAOLUZI [i], G. PETRUCCI [d], G. PIANO MORTARI [i], M. PIMIÄ [e], A. PLACCI [d], E. RADERMACHER [a], J. RANSDELL [h], H. REITHLER [a], J.-P. REVOL [d], J. RICH [k], M. RIJSSENBEEK [d], C. ROBERTS [j], J. ROHLF [d], P. ROSSI [d], C. RUBBIA [d], B. SADOULET [d], G. SAJOT [g], G. SALVI [f], G. SALVINI [i], J. SASS [k], J. SAUDRAIX [k], A. SAVOY-NAVARRO [k], D. SCHINZEL [f], W. SCOTT [j], T.P. SHAH [j], M. SPIRO [k], J. STRAUSS [1], K. SUMOROK [c], F. SZONCSO [1], D. SMITH [h], C. TAO [d], G. THOMPSON [f], J. TIMMER [d], E. TSCHESLOG [a], J. TUOMINIEMI [e], S. Van der MEER [d], J.-P. VIALLE [d], J. VRANA [g], V. VUILLEMIN [d], H.D. WAHL [1], P. WATKINS [c], J. WILSON [c], Y.G. XIE [d], M. YVERT [b] and E. ZURFLUH [d]

Aachen [a]–Annecy (LAPP) [b]–Birmingham [c]–CERN [d]–Helsinki [e]–Queen Mary College, London [f]–Paris (Coll. de France) [g] –Riverside [h]–Rome [i]–Rutherford Appleton Lab. [j]–Saclay (CEN) [k]– Vienna [1] Collaboration

Received 23 January 1983

Transverse energy in EM calormeters

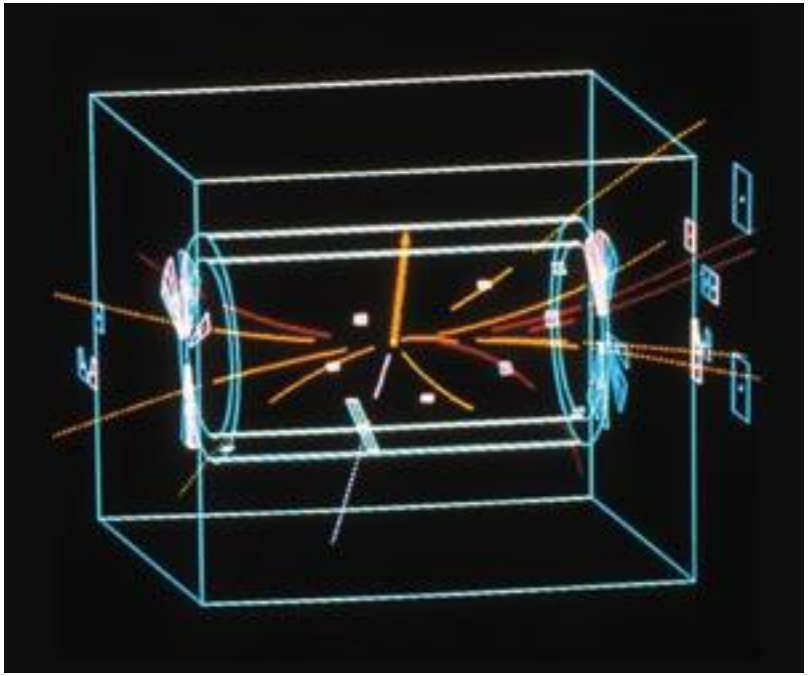
Volume 122B, number 1 PHYSICS LETTERS 24 February 1983



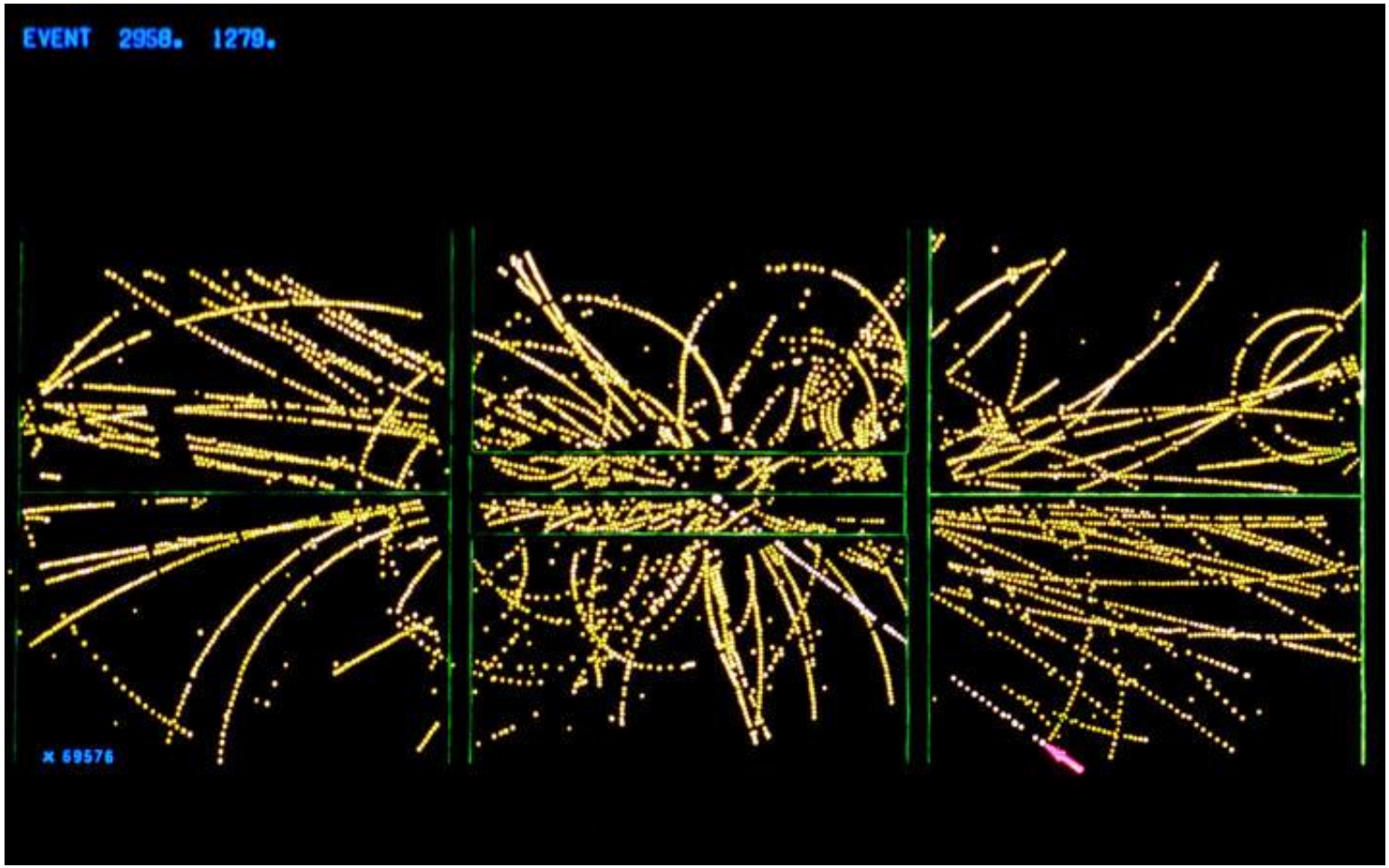
Fraction of energy deposited in hadron calorimeter

One of the first Denegri W events January 1983

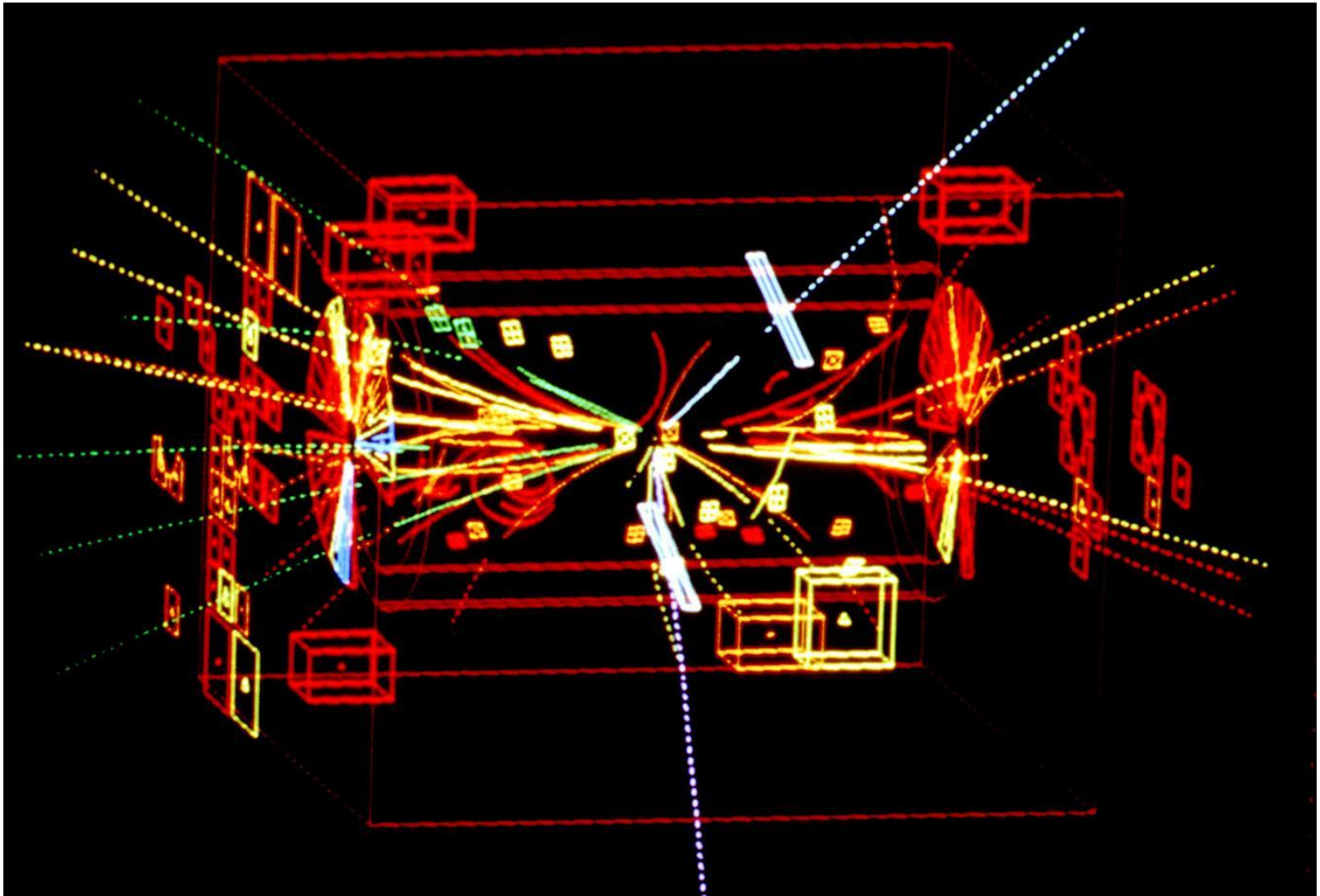
The decay of a W particle in the UA1 detector, showing the track of the high-energy electron towards the bottom. The yellow arrow marks the direction of the missing transverse energy and hence the path of the unseen neutrino.



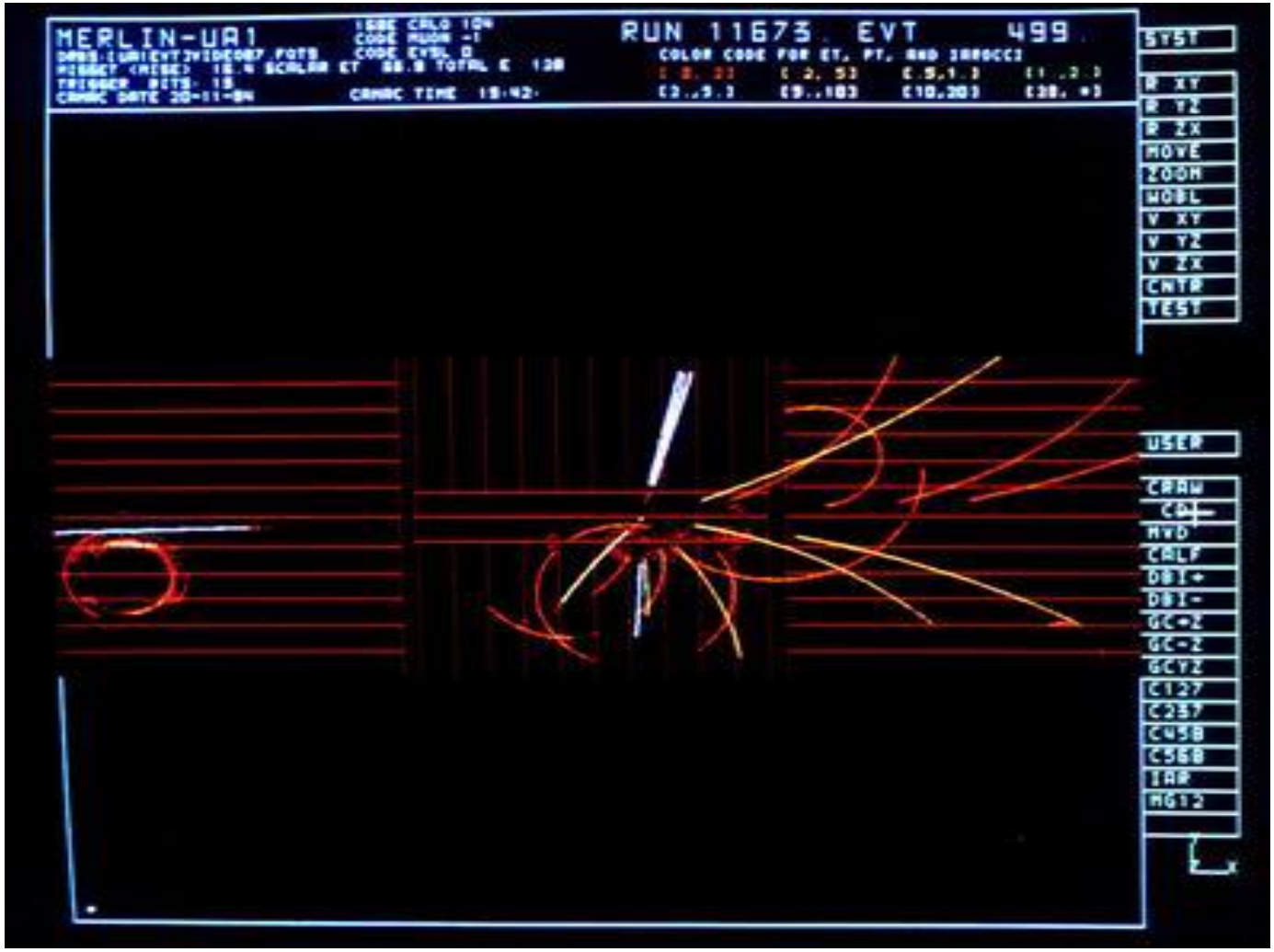
Another of the first Denegri W events January 1983



First Z0 event June 1983



W in tau neutrino (monojet)



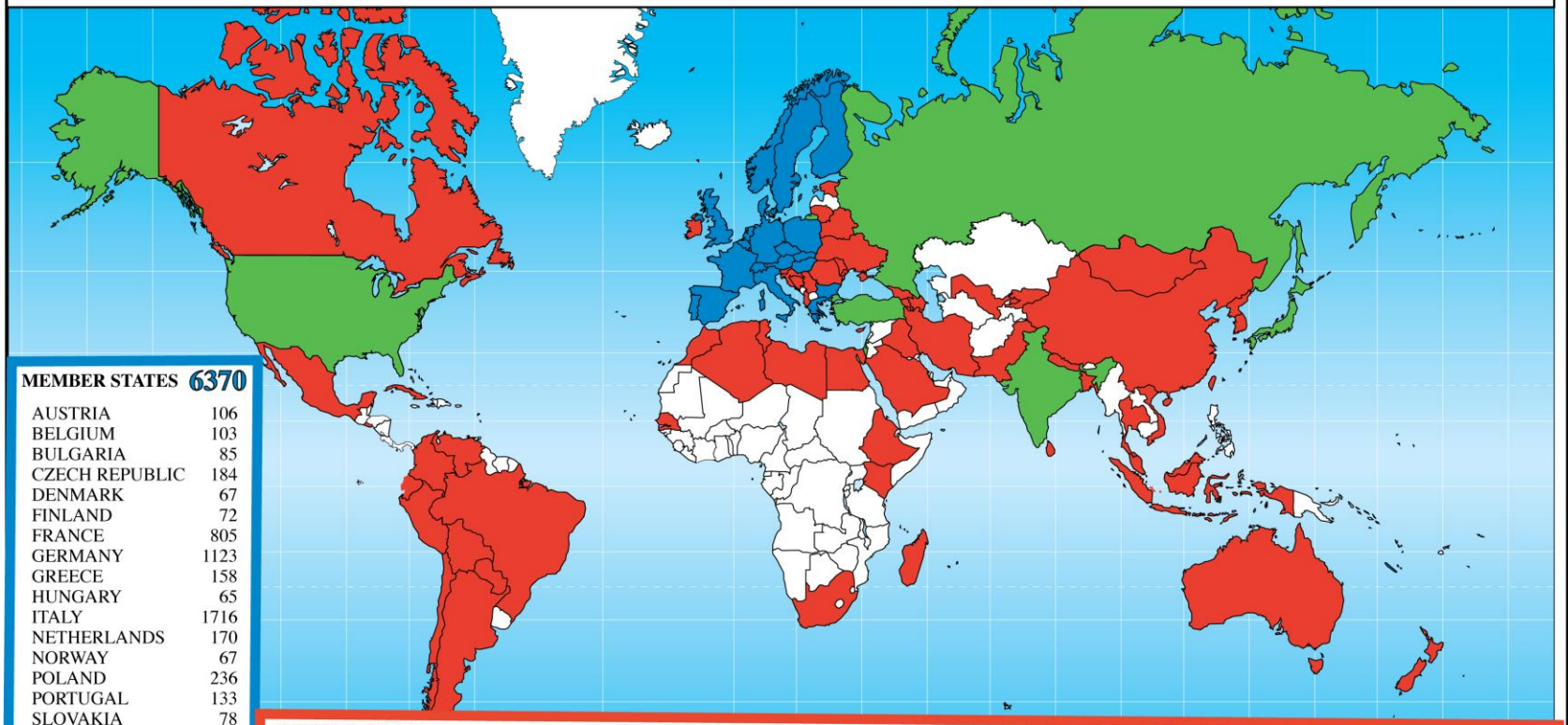
CERN was founded 1954: 12 European States
Today: 20 Member States

- ~ 2300 staff
- ~ 790 other paid personnel
- > 10000 users
- Budget (2010) 1200 MCHF

- **20 Member States:** Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.
- **1 Candidate for Accession to Membership of CERN:** Romania
- **8 Observers to Council:** India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO

CERN in Numbers

Distribution of All CERN Users by Nationality on 20 January 2010



MEMBER STATES 6370

AUSTRIA	106
BELGIUM	103
BULGARIA	85
CZECH REPUBLIC	184
DENMARK	67
FINLAND	72
FRANCE	805
GERMANY	1123
GREECE	158
HUNGARY	65
ITALY	1716
NETHERLANDS	170
NORWAY	67
POLAND	236
PORTUGAL	133
SLOVAKIA	78
SPAIN	330
SWEDEN	67
SWITZERLAND	200
UNITED KINGDOM	605

OBSERVER STATES 2444

INDIA	158
ISRAEL	51
JAPAN	229
RUSSIA	1027
TURKEY	87
USA	892

OTHERS 1205

ALBANIA	2
ALGERIA	8
ARGENTINA	11
ARMENIA	24
AUSTRALIA	20
AZERBAIJAN	5
BANGLADESH	3
BELARUS	36
BOLIVIA	2
BOSNIA AND HERZEGOVINA	1
BRAZIL	79
CANADA	136
CHILE	3
CHINA	202
CHINA (TAIPEI)	41
COLOMBIA	19
CROATIA	24
CUBA	4
CYPRUS	12
ECUADOR	2
EGYPT	6
EL SALVADOR	1
ESTONIA	9
ETHIOPIA	1
GEORGIA	31
GIBRALTAR	1
HONG KONG	2
INDONESIA	1
IRAN	20
IRAQ	1
IRELAND	20
KENYA	2
KOREA, D.P.R.	3
KOREA REP.	85
KYRGYZSTAN	1
LEBANON	8
LITHUANIA	9
LUXEMBOURG	5
LIBYA	1
MADAGASCAR	3
MALAYSIA	7
MALTA	3
MAURITIUS	1
MEXICO	46
MOLDOVA	1
MONGOLIA	1
MOROCCO	16
NEPAL	3
NEW ZEALAND	10
PAKISTAN	33
PALESTINE (O.T.).	1
PARAGUAY	1
PERU	2
ROMANIA	101
SAN MARINO	1
SAUDI ARABIA	2
SENEGAL	1
SERBIA	34
SINGAPORE	1
SLOVENIA	20
SOUTH AFRICA	9
SRI LANKA	6
SYRIA	2
THAILAND	1
TUNISIA	5
UKRAINE	40
UZBEKISTAN	2
VENEZUELA	5
VIET NAM	6

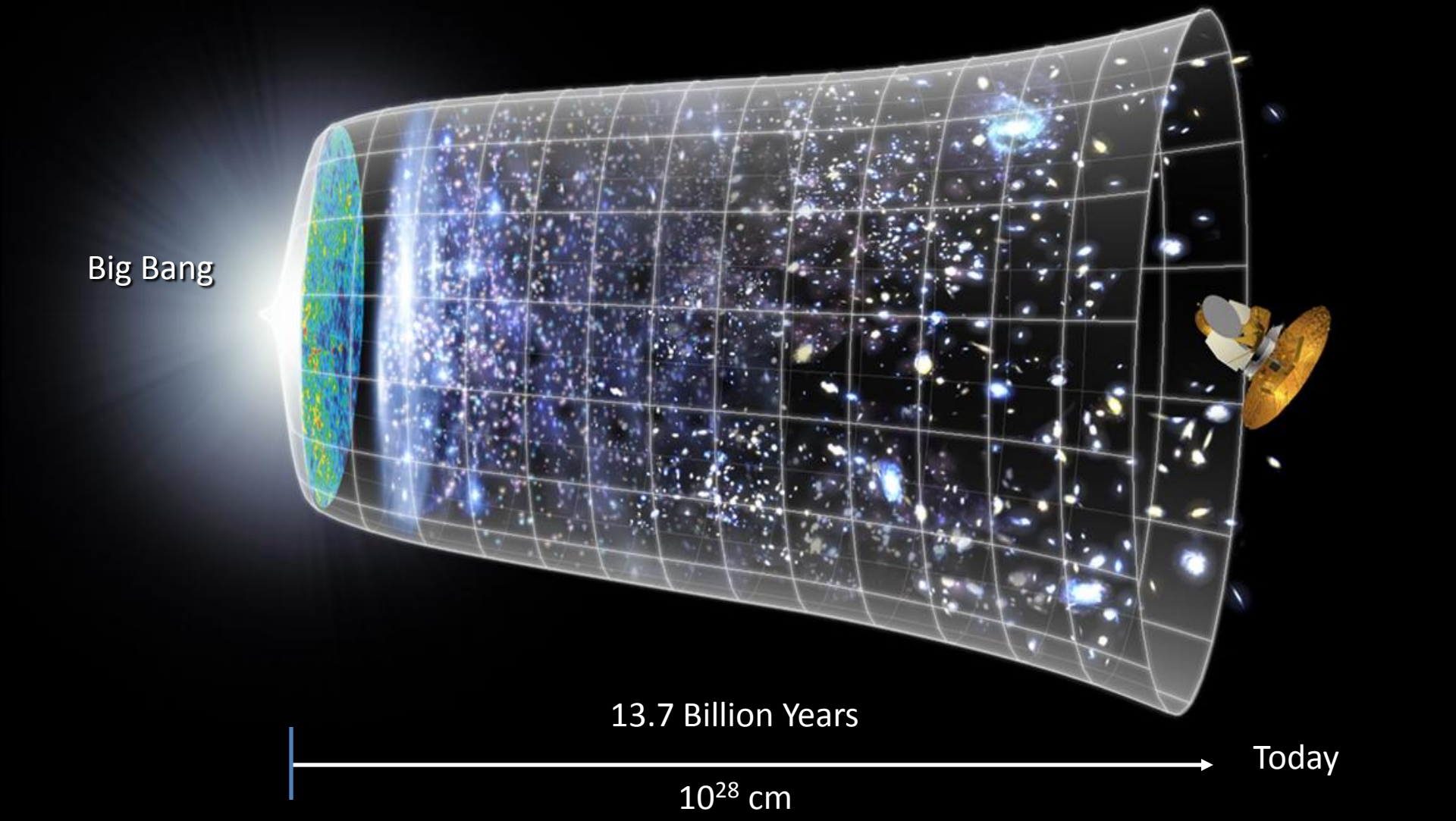
CERN ENLARGEMENT

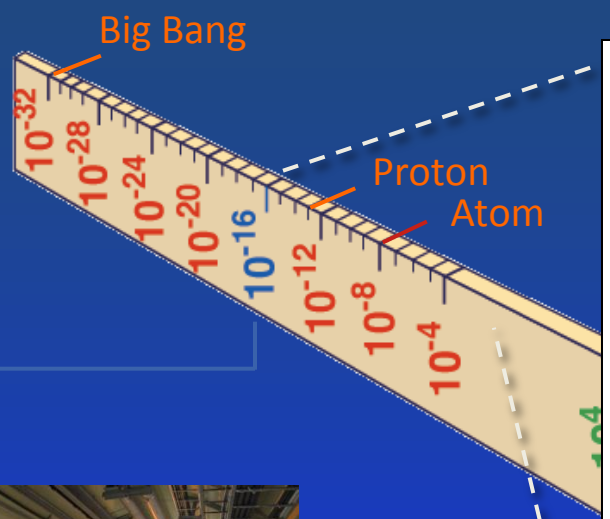
- CERN was created 56 years ago as a European Organization with the aim, after the war, to get Europe to a competitive level in particle physics.
- Today, CERN is a European Organization in membership but has in mind a global approach for particle physics in Europe, in partnership with other regions which also develop projects with a global approach. CERN is ready to host the next High Energy Frontier machine if it is deemed to be necessary (and with an extended governance compared to the LHC machine)
- The Convention allows Membership to the Organization beyond Europe. CERN has opened its membership and Associate membership worldwide
- The Convention allows the scope of the Organization to extend from accelerator based Particle Physics to Non Accelerator Particle Physics and Cosmic Rays (Astroparticle Physics). This will be discussed in the framework of the update of the European Strategy.

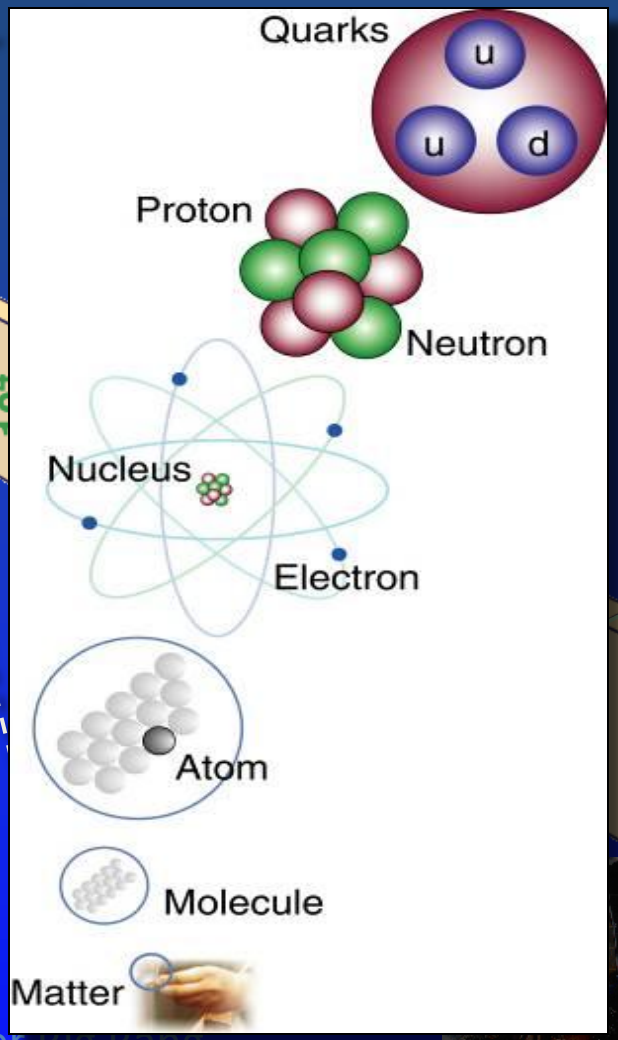
PRESENT STATUS

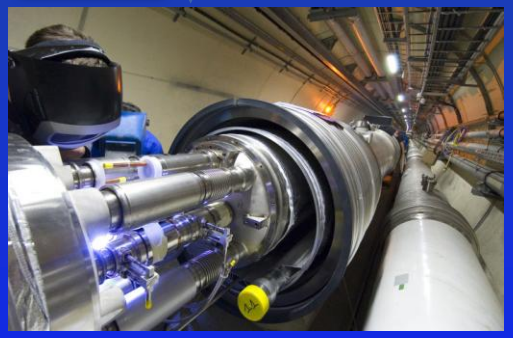
- 5 new applicants for full membership: Cyprus, Israel, Serbia, Slovenia, Turkey
- 2 declared interests for becoming associate member states: Brazil, India
- Yugoslavia was one of the 12 founder countries of CERN in 1954. Later withdrew in 1961. What about Croatia now.

Evolution of the Universe



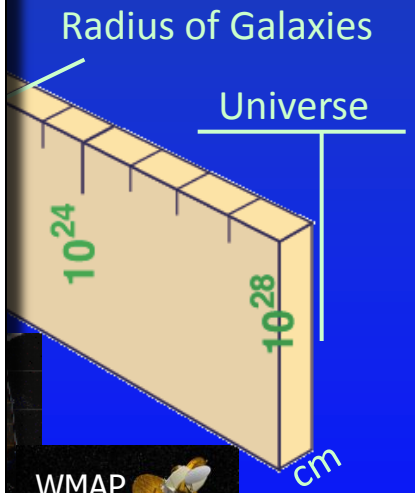






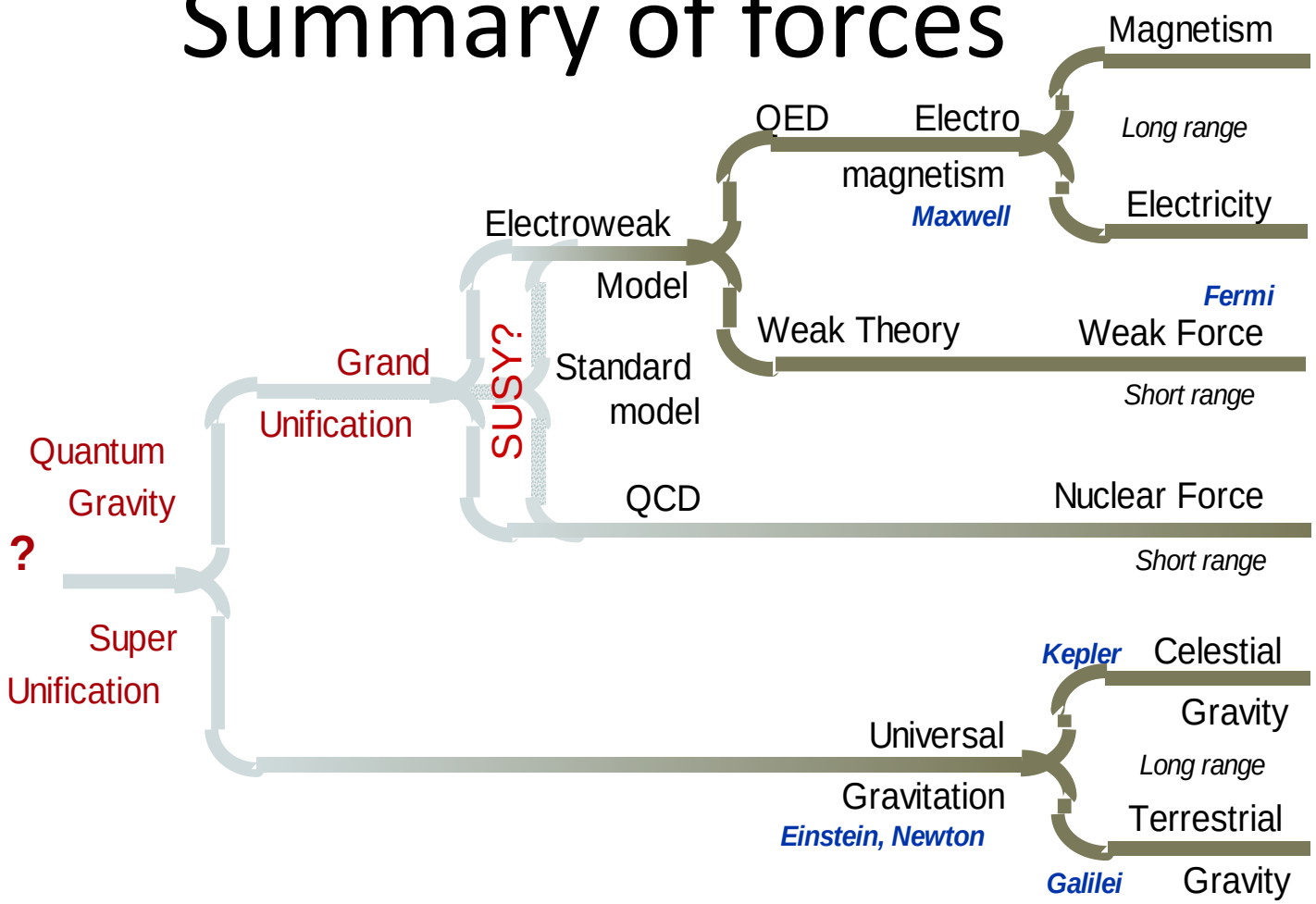
LHC

Super-Microscope



Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology

Summary of forces



Theories:

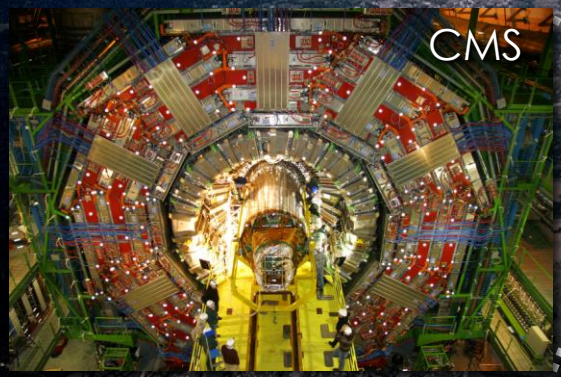
STRINGS? **RELATIVISTIC/QUANTUM** **CLASSICAL**

TOWARDS A SCIENTIFIC COSMOGONY

- **Human quest**
- **Based on a collective rational approach**
- **Beyond citizenship, religious… particularities**
- **An interplay (global vs local) between random occurrences (fluctuations, broken symetries…), necessity (laws, effective theories): appearance or emergence of a nest of structures and laws**
- **Still a long way to go…**

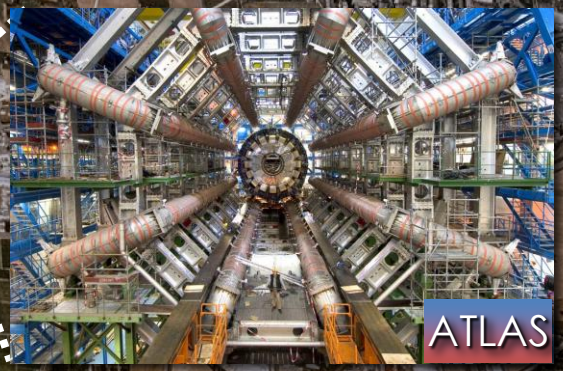
Enter a New Era in Fundamental Science

Start-up of the Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.



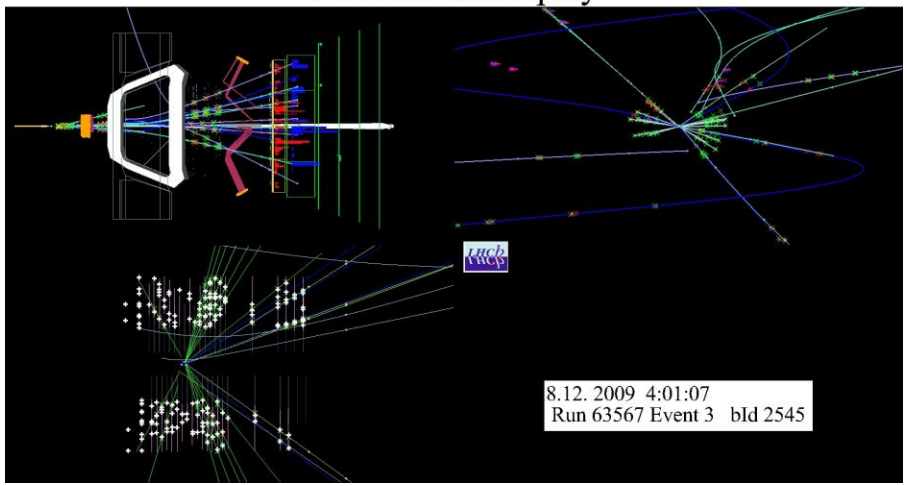
Exploration of a new energy frontier

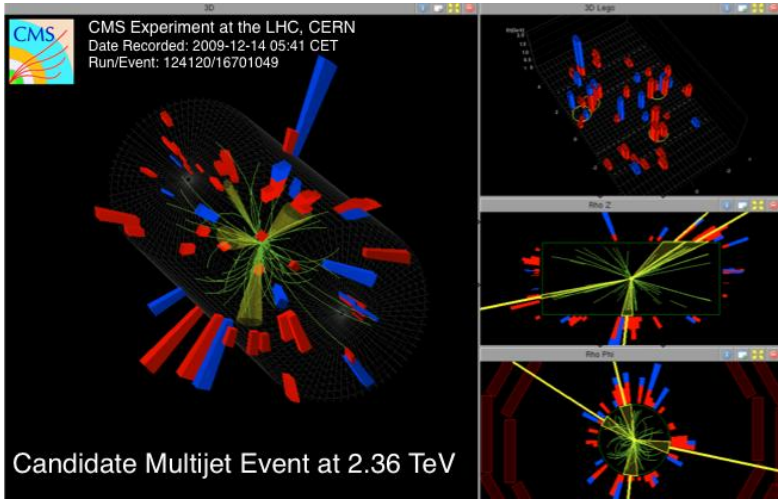
Proton-proton collisions at E_{CM} = 14 TeV

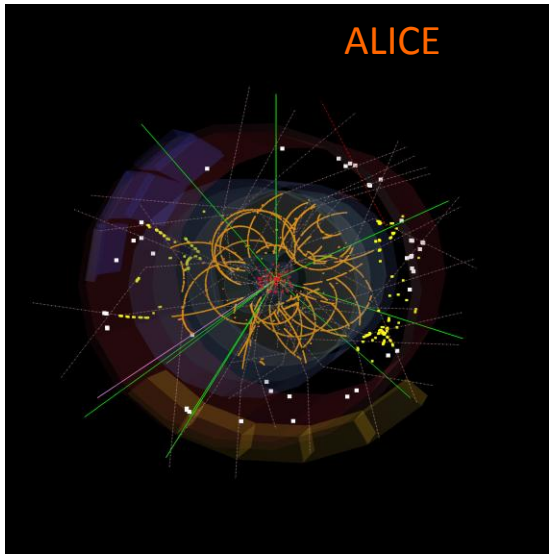


LHC successfully started operation in Nov 2009

LHCb Event Display



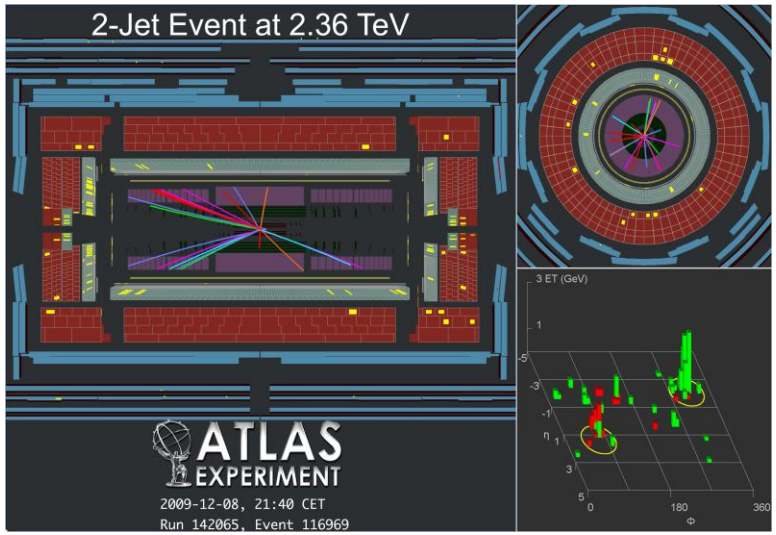




First collisions events at 0.9 TeV and 2.36 TeV

Now 7 TeV

Nominal 14 TeV

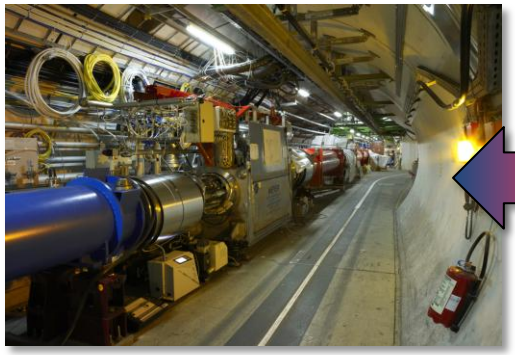


CERN Technologies - Innovation

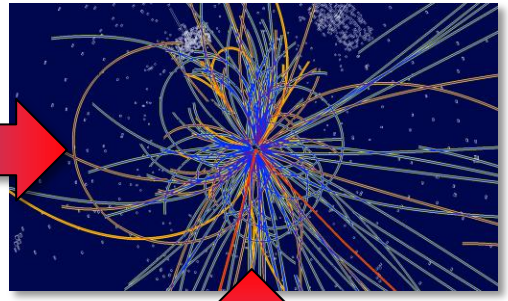
Exemple: applications médicales

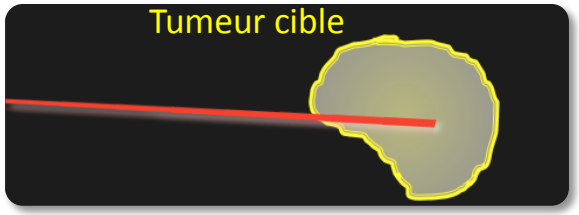
Imagerie médicale

Accélération
de particules



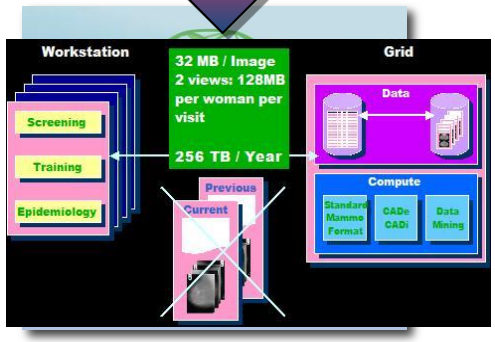
Détection





Faisceau de hadrons chargés qui perd de l'énergie dans la matière

Traitement de données
à grande échelle (Grille de calcul)



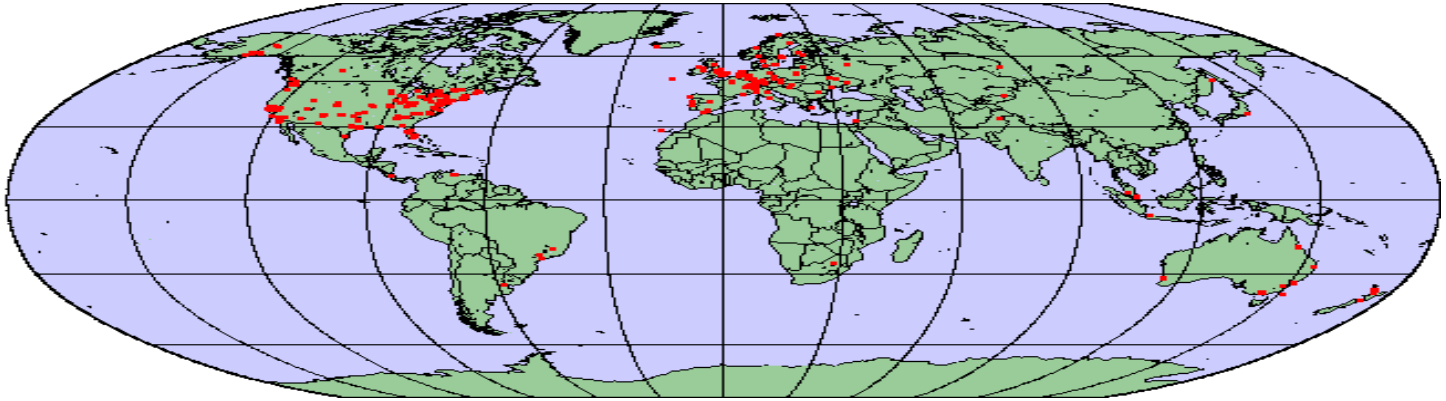
Grille pour la gestion et l'analyse des données médicales

Computing for LHC: The GRID

- Problem: even with Computer Centre upgrade, CERN can provide only a fraction of the necessary resources. Next hope after the Web: the Grid.
- **Solution:** Computing centers, which were isolated in the past, will be connected, **uniting the computing resources of particle physicists worldwide**

Europe:
267 institutes
4603 users

Elsewhere:
208 institutes
1632 users



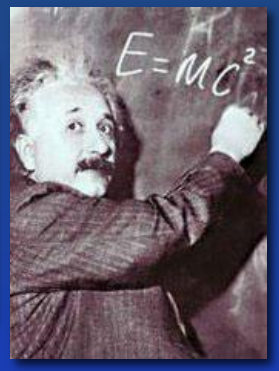
The World Wide Web

1990:Tim Berners-Lee, a CERN computer scientist invented the World Wide Web.

The "Web" as it is affectionately called, was originally conceived and developed for the large high-energy physics collaborations which have a demand for instantaneous information sharing between physicists working in different universities and institutes all over the world. The CERN made it public. Now it has millions of academic and commercial “free” users.

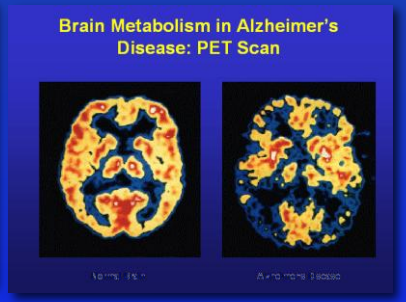
Innovation
Education
CERN
uniting people
Research

The Mission of CERN



- Push back the frontiers of knowledge

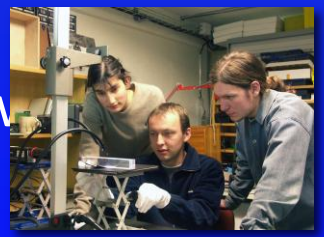
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



- Develop new technologies for accelerat and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- Train scientists and engineers of tomorrow

- Unite people from different countries and cultures


Thank You!