John Dowell

Reminders of some early experiments where John played a leading role

Birmingham Particle Physics – Early days – 1960s

- Electronic Counter experiments at RAL and CERN (John Dowell)

- Bubble Chamber experiments (Derek Colley)

  I joined this group for my PhD

CERN accelerator for both was Proton Synchrotron (PS) – 26 GeV

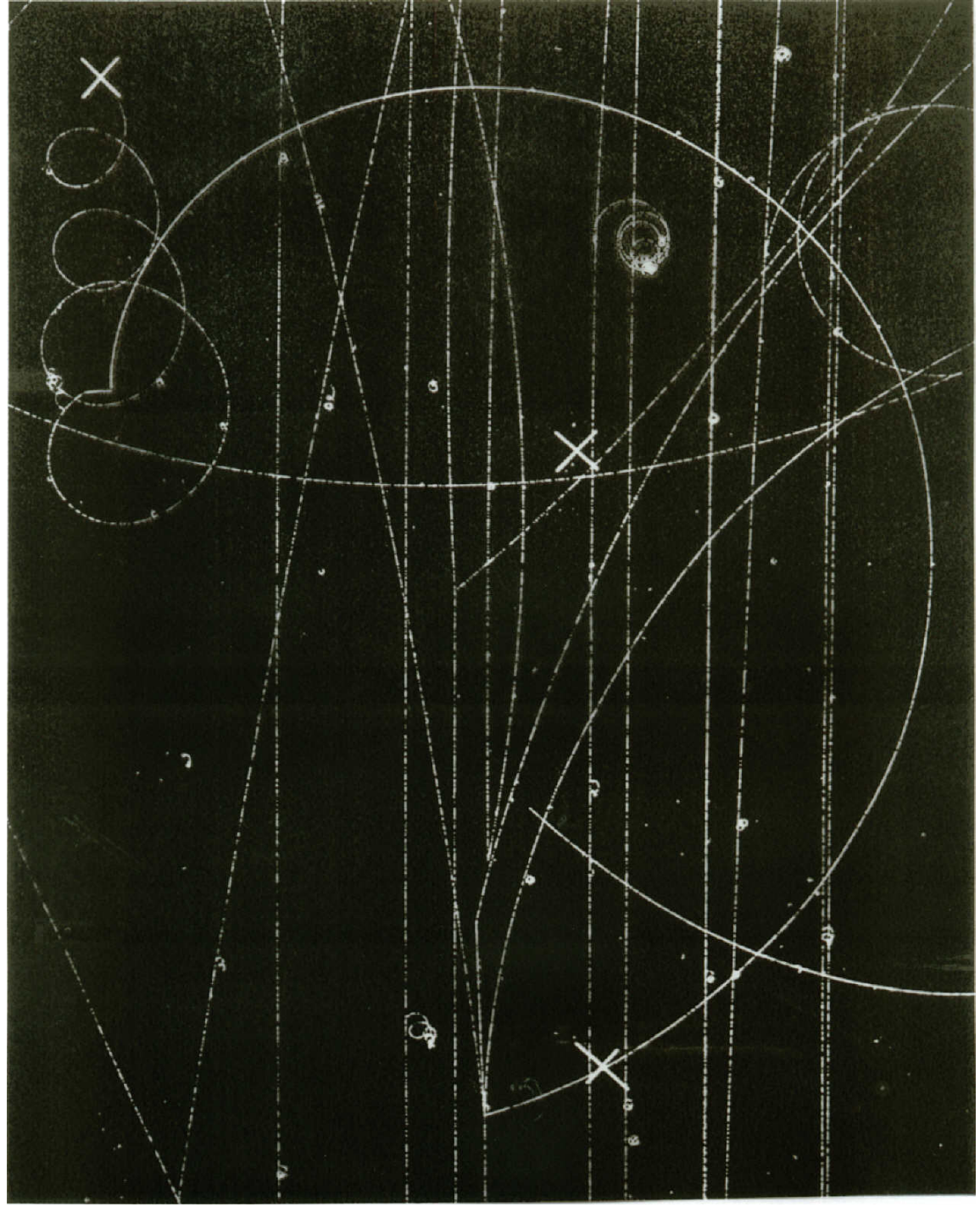
Bubble Chamber experiments

Millions of photographs taken at CERN 2 metre hydrogen bubble chamber in a magnetic field from three cameras

Beams of particles at a known energy passed through chamber every two seconds

Some interacted with protons of the hydrogen atoms.
A moving charged particle left a trace of its path

These photos were distributed to groups around the world to be scanned and measured



Many new short-lived particles were discovered in these experiments even though they decayed so fast that we only saw their decay products. (m**2 = E**2- p**2)

Far too many of these new particles for them to be fundamental

Scattering experiments at Stanford in USA showed point like particles inside proton which was first direct evidence of quarks.

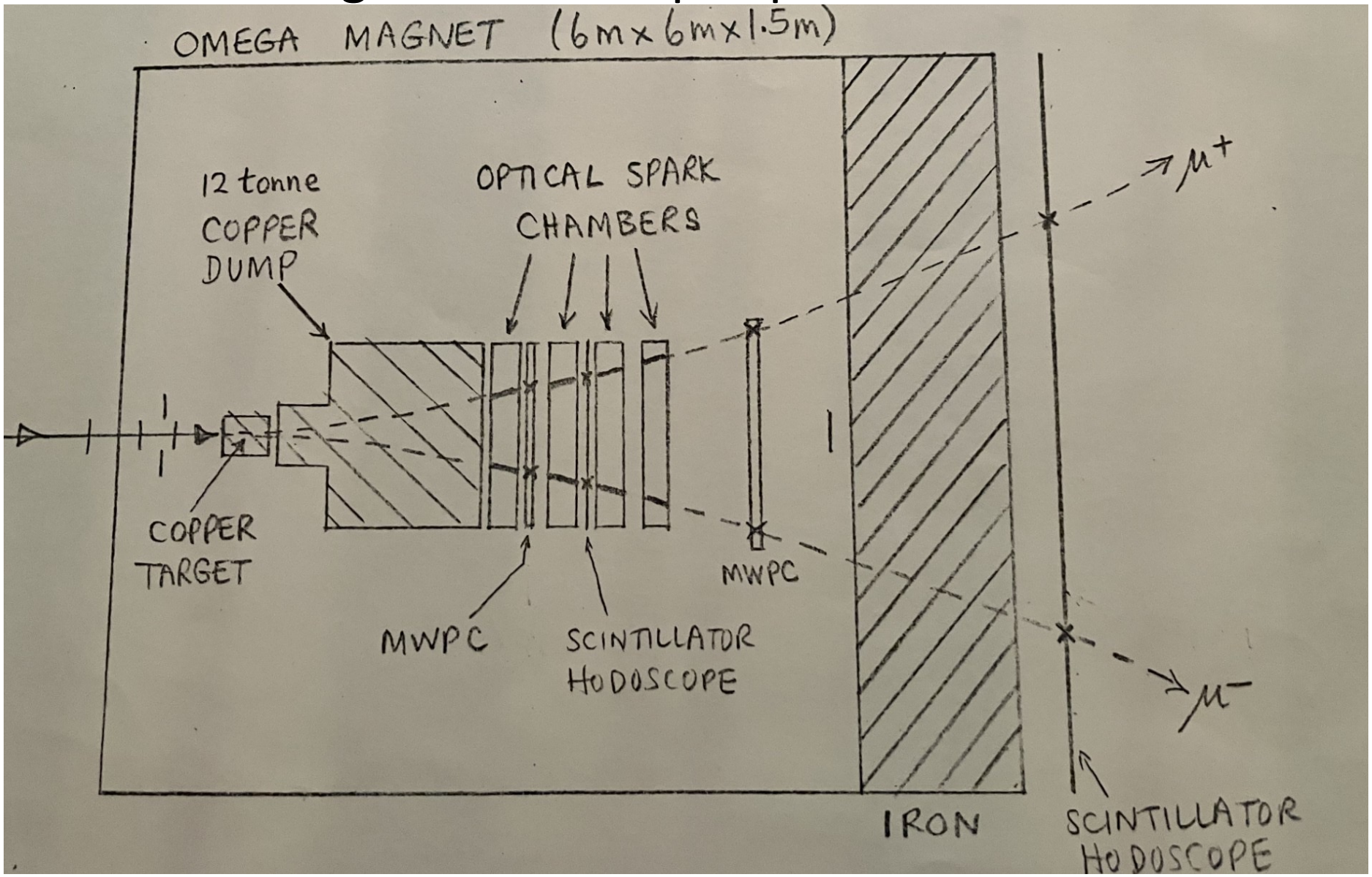
All these new particles were made of quark antiquark pairs (mesons) or three quarks (baryons)

Beam Dump experiments

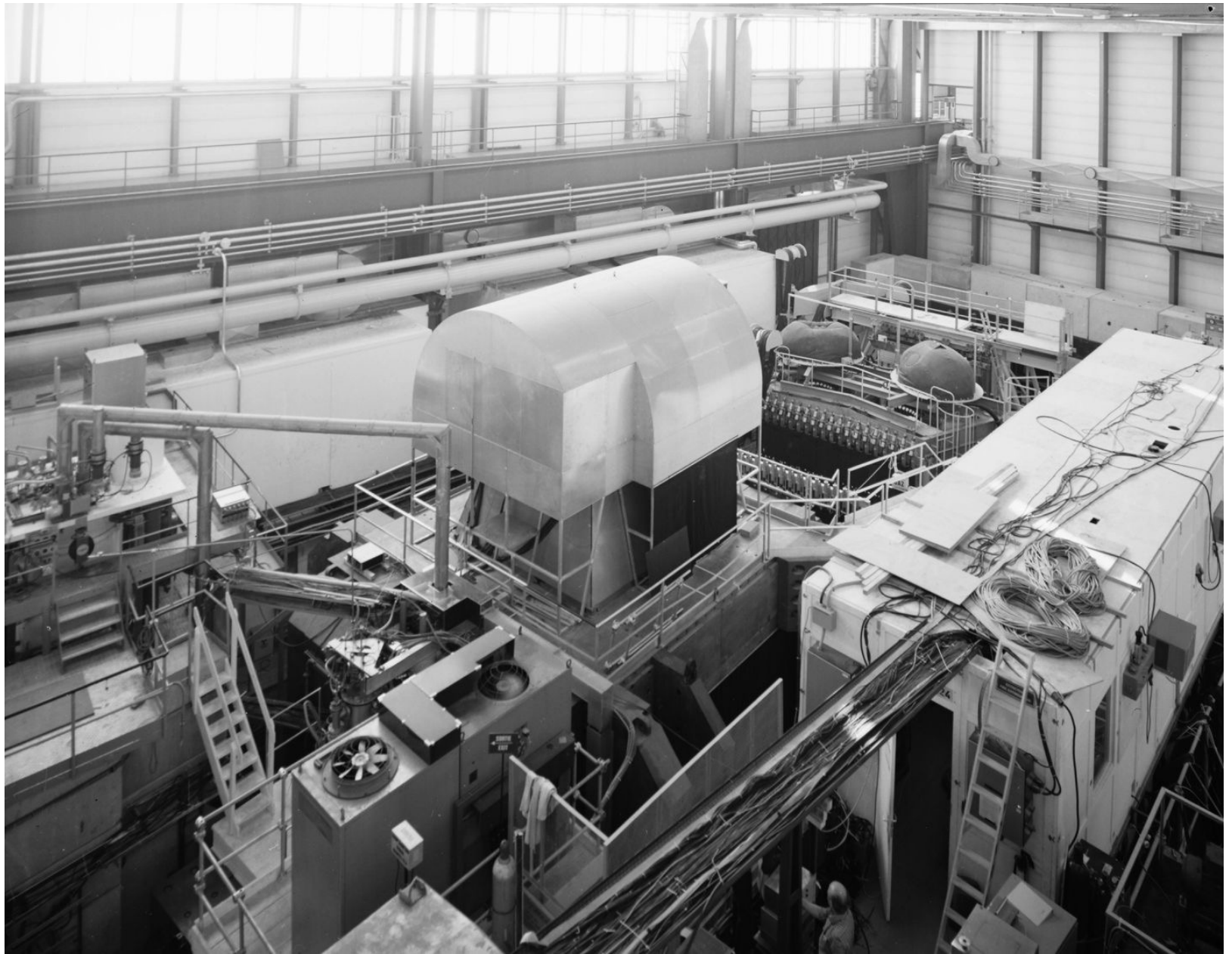
- New CERN accelerator 1976 – Super Proton Synchrotron (SPS)
- Energy 400 GeV , Circumference 2 kilometres.
- Forty experiments approved from sixty universities and research centres
- John Dowell proposed experiment at Omega spectrometer

  Compare Psi production (decay into two muons) with beams of pions, kaons, protons and antiprotons at 40 GeV
- Several of us joined this effort and this was the beginning of the Particle Physics group as we know it today

Omega Beam Dump Experiment



Omega spectrometer



Big challenge – Learned a lot

We were biggest group (11) in collaboration of 29 from six institutes

We took data for many weeks with staff based at CERN and heavy commuting load.

We produced the FIRST RESULTS from the SPS including

Psi production ratio from proton/antiproton beams 0.19 +– 0.03

Drell Yan measurements complemented earlier higher energy results from Fermilab. Early information on quark structure function.

We made a second measurement in 1978 including a hydrogen target to measure the A dependence.

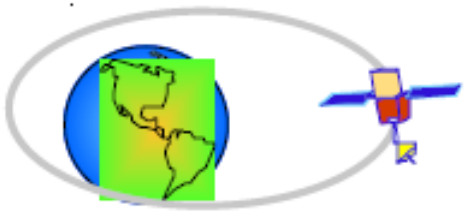
Next Project ?

- We were invited to join several other projects and John Dowell played a key role in these discussions.

- Most challenging idea was to join the proposal for the UA1 experiment to search for the carriers of the weak force

  W and Z bosons

Unification of forces

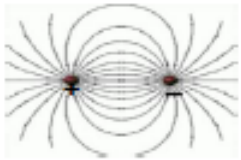


Terrestrial mechanics

Celestial mechanics

Universal Gravitation

Inertial vs. Gravitational mass
(I. Newton, 1687)

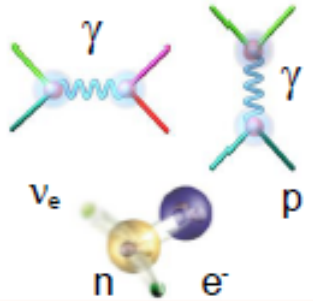


Electricity

Magnetism

Electromagnetism

Electromagnetic waves (photon)
(J.C. Maxwell, 1860)



Electromagnetism

Weak force

Electroweak

Intermediate bosons W, Z
(1970-83)

?

Probing shorter distances
reveals
deeper regularities

UNIFIED DESCRIPTIONS

Collider Option

- More efficient to produce 100 GeV particles by head on collisions
- There were plans to build higher energy colliders but a short cut idea

  from Rubbia et al

  Use existing SPS and instead of just using protons –

  add antiprotons in the opposite direction.

  How to get antiprotons ? Produce them using PS and store them in ring of magnets. Takes around 24 hours.

  Inject p and pbar into SPS , accelerate to 270 GeV and keep beams apart

  except where they collide in two new detectors UA1 and UA2

CERN/SPSC/78-06
SPSC/P 92
30 January 1978

A 4π SOLID ANGLE DETECTOR FOR THE SPS USED AS A PROTON-ANTIPROTON COLLIDER AT A CENTRE OF MASS ENERGY OF 540 GeV

A. Astbury, B. Aubert, A. Benvenuti, D. Bugg, A Bussière, Ph. Catz
S. Cittolin, D. Cline, M. Corden, J. Colas, M. Della Negra,
L. Dobrzynski, J. Dowell, K. Eggert, E. Eisenhandler, B. Equer,
H. Faissner, G. Fontaine, S. Y. Fung, J. Garvey, C. Ghesquèire,
W.R. Gibson, A. Grant, T. Hansl, H.Hoffmann, R.J. Homer, M. Jobes,
P.I.P. Kalmus, I. Kenyon, A. Kernan, F. Lacava, J.Ph. Laugier,
A. Leveque, D. Linglin, J. Mallet, T. McMahon, F. Muller, A. Norton,
R.T. Poe, E. Radermacher, H. Reithler, A. Robertson, C. Rubbia†,
B. Sadoulet, G. Salvini, T. Shah, C.Sutton, M. Spiro
K. Sumorok, P. Watkins, J. Wilson, R. Wilson

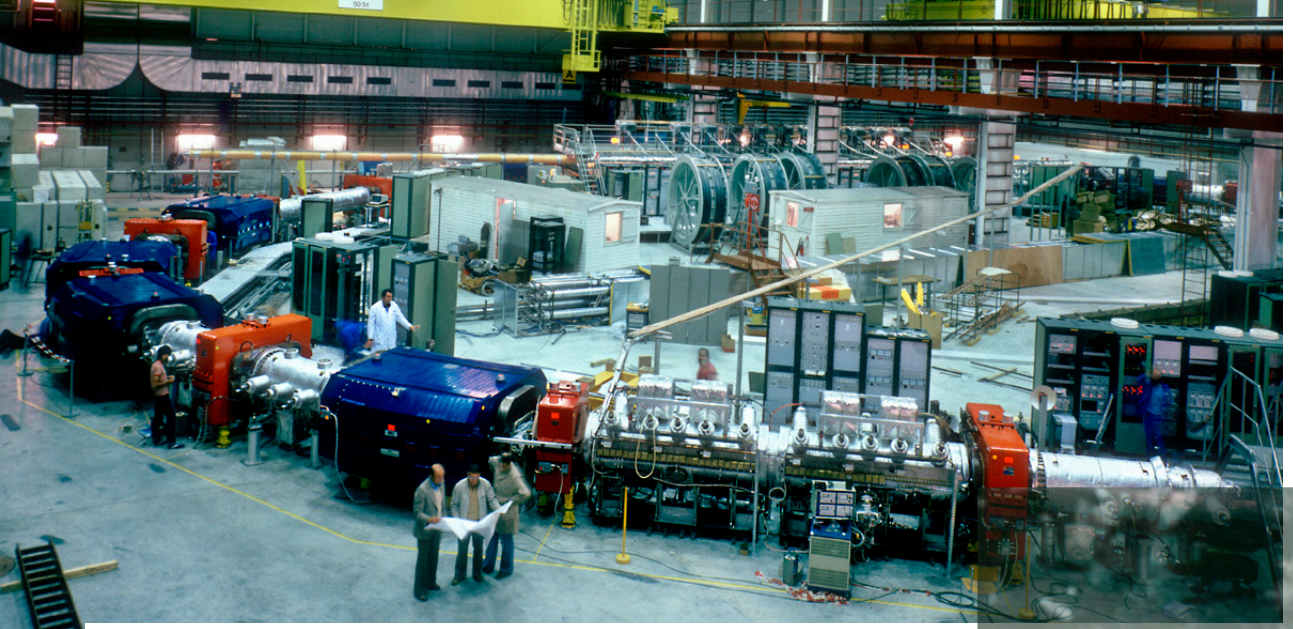
18 UK = 35 %

12 from Birmingham

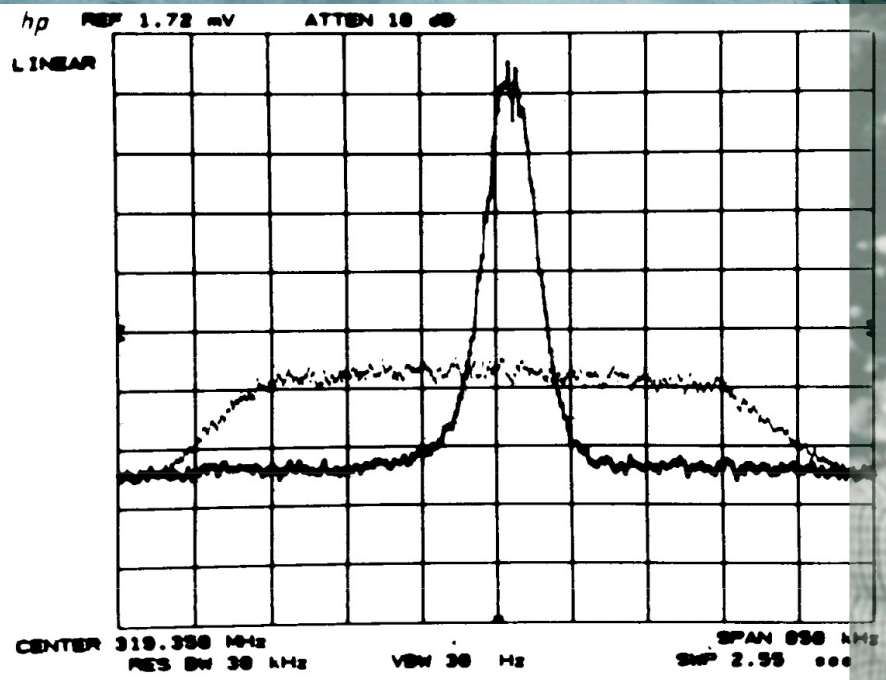
Aachen-Annecy-Birmingham-CERN-College de France-Queen Mary College-
Riverside-Rutherford-Saclay Collaboration

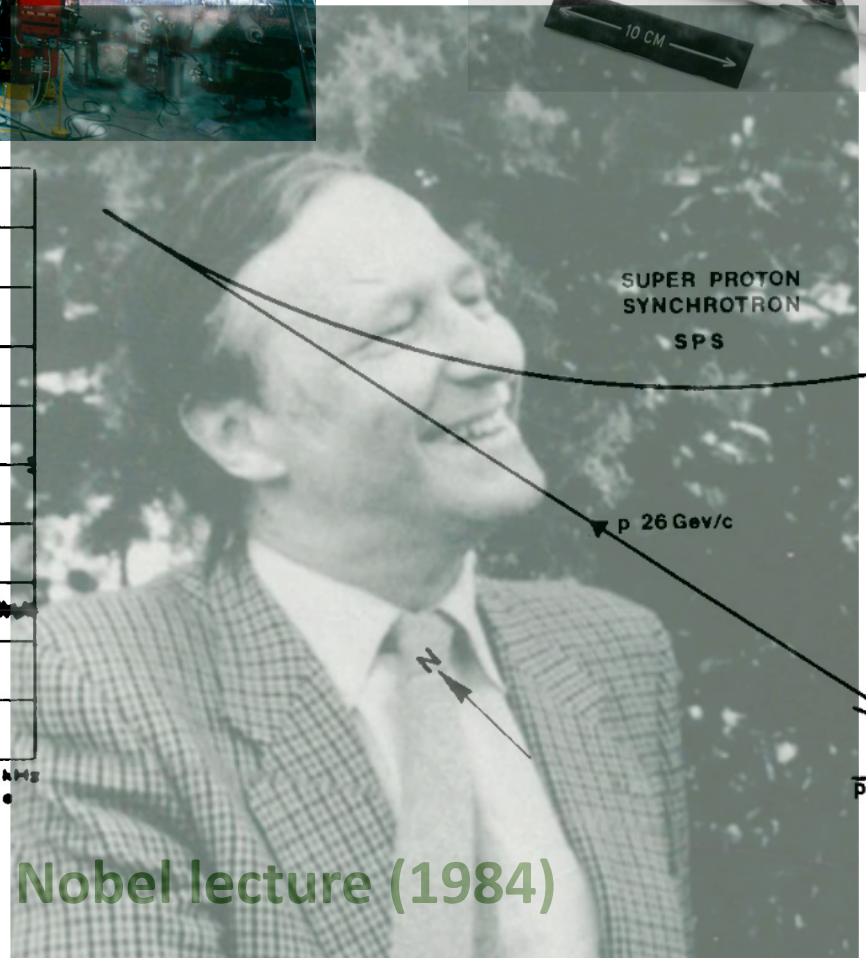
Carlo Rubbia

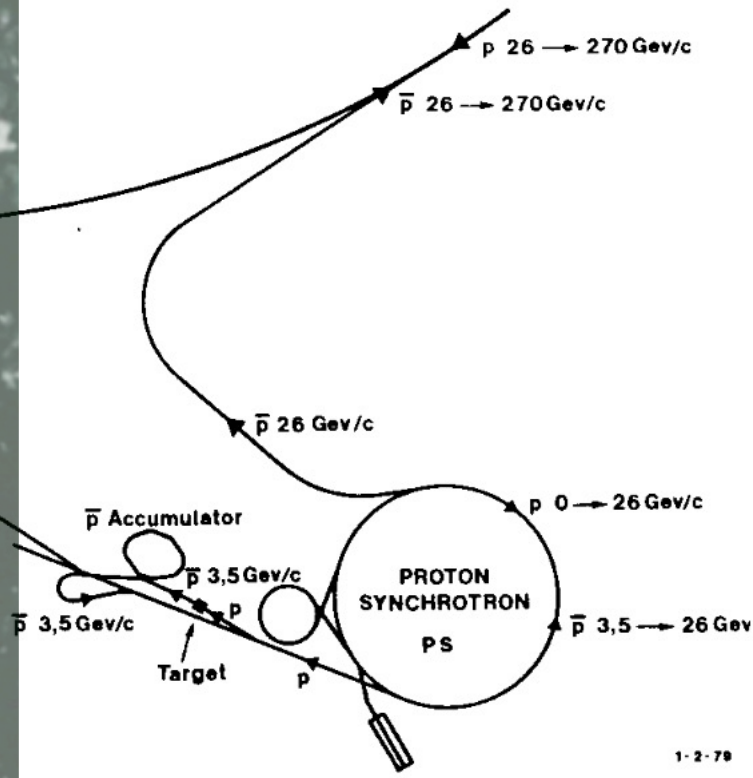
CERN Antiproton Accumulator



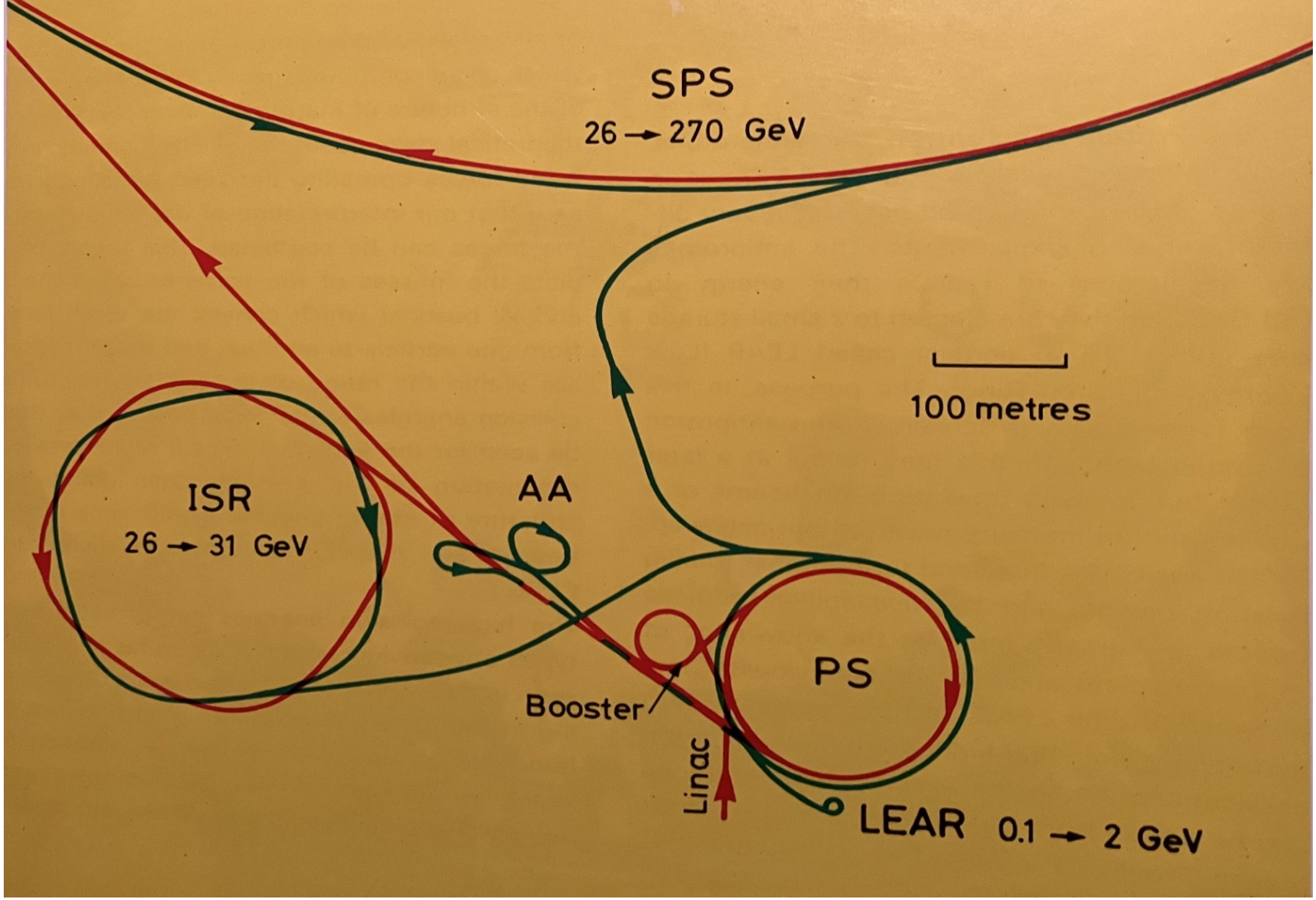
target







From Simon Van der Meer, Nobel lecture (1984)


SPS
26 → 270 GeV
100 metres
ISR
26 → 31 GeV
AA
PS
Booster
Linac
LEAR 0.1 → 2 GeV

SPS Inauguration (1977)

Burt Richter,
letter to Carlo Rubbia,
“if you are lucky enough and the machine runs well, I believe you will find the Z... but you will never be able to observe the W”

Challenges of W and Z detection

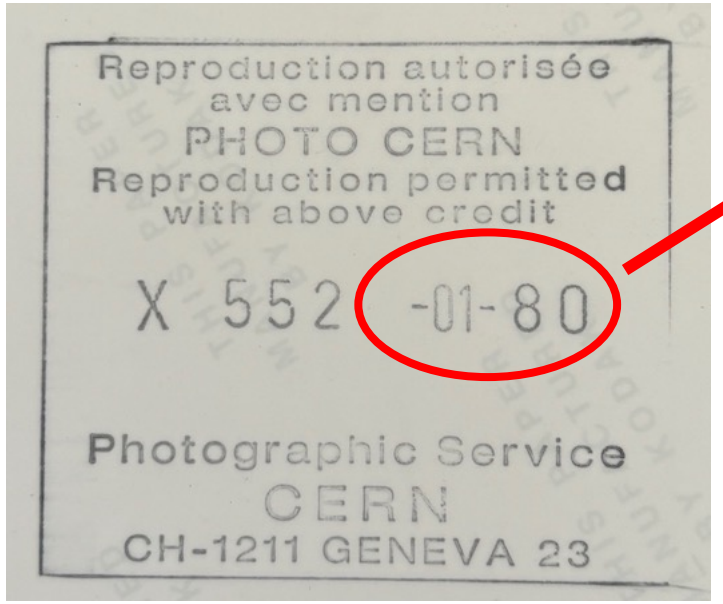
Very rarely produced needs very efficient trigger
Both decay before any trace in detector but decay products energetic

W expected rate ten times larger than Z

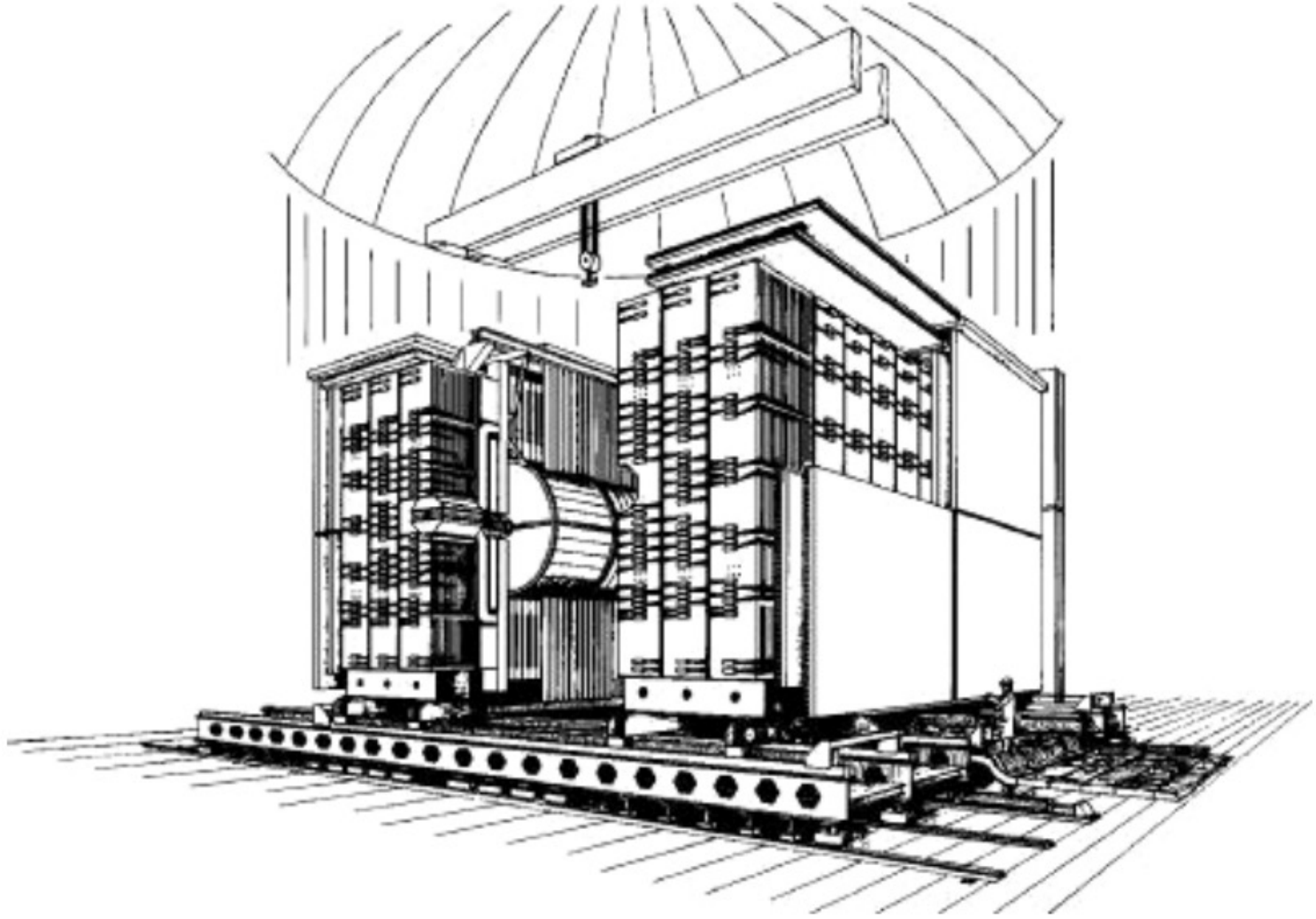
Z decay to e- e+ or mu- mu+ most recognizable
W- decay to e- neutrino and mu- neutrino
 (neutrino escapes detection)

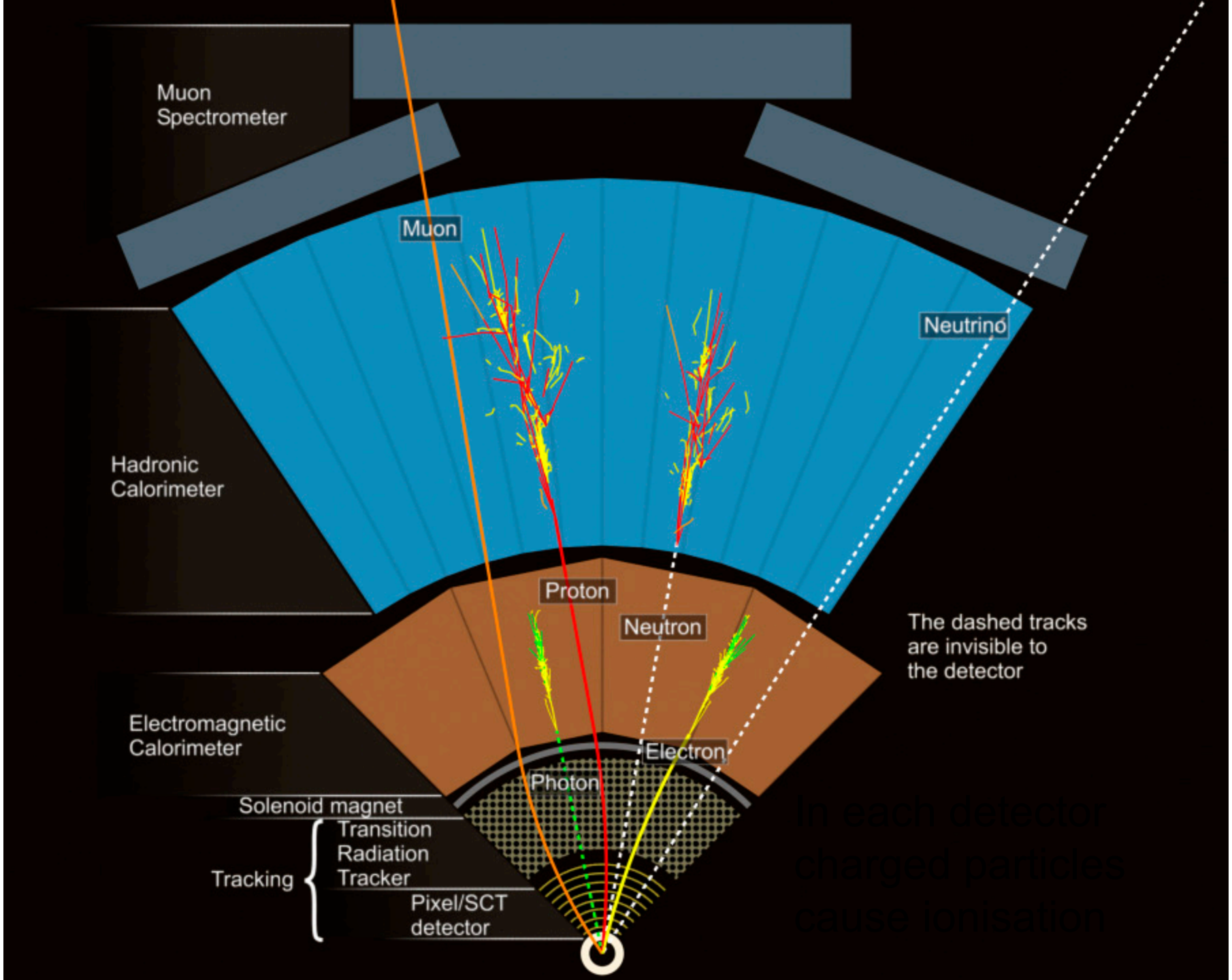
UA1 measure electrons and muons
(hermetic detector helps with ‘missing energy’)
UA2 measure electrons

January 1980



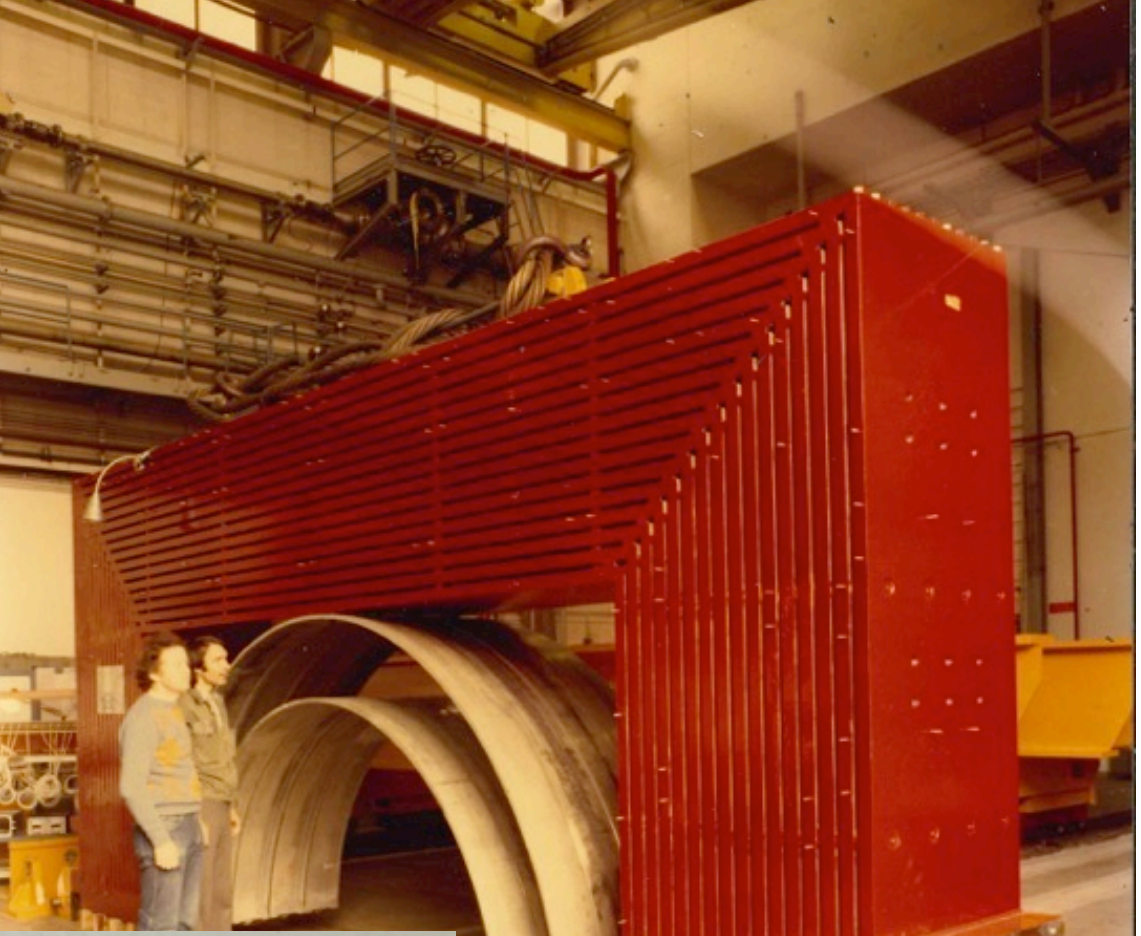
There were to be proton-antiproton collisions there in 18 months!

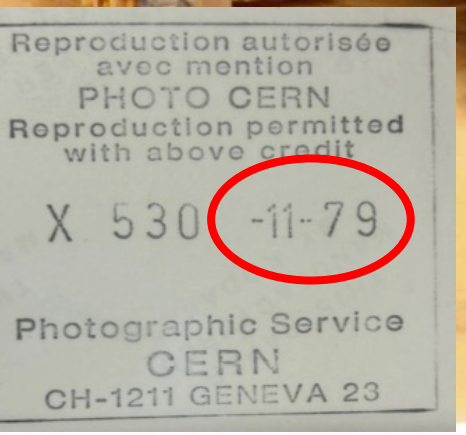



Muon Spectrometer
Muon
Neutrino
Hadronic Calorimeter
Proton
Neutron
The dashed tracks are invisible to the detector
Electromagnetic Calorimeter
Electron
Photon
Solenoid magnet
Tracking
Transition Radiation Tracker
Pixel/SCT detector
In each detector charged particles cause ionisation

UK major contributions to UA1

Hadron Calorimeter
Trigger – Selection of Events to record
Muon Software
Event Display
Physics Analysis

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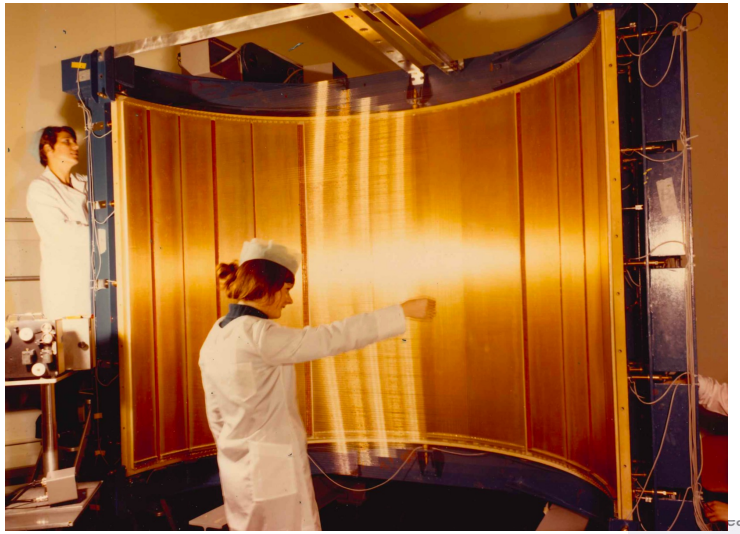
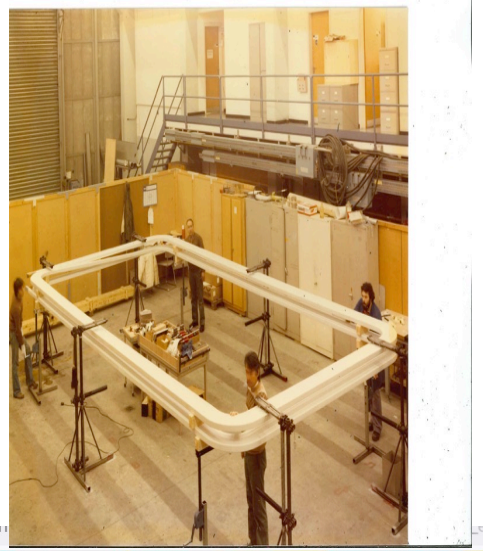
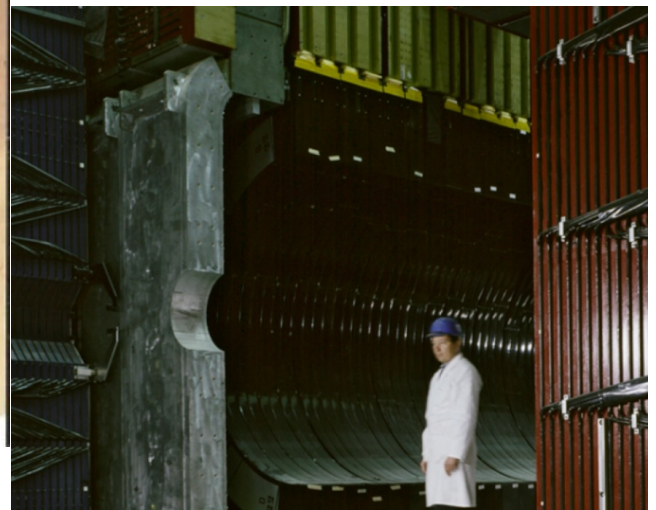
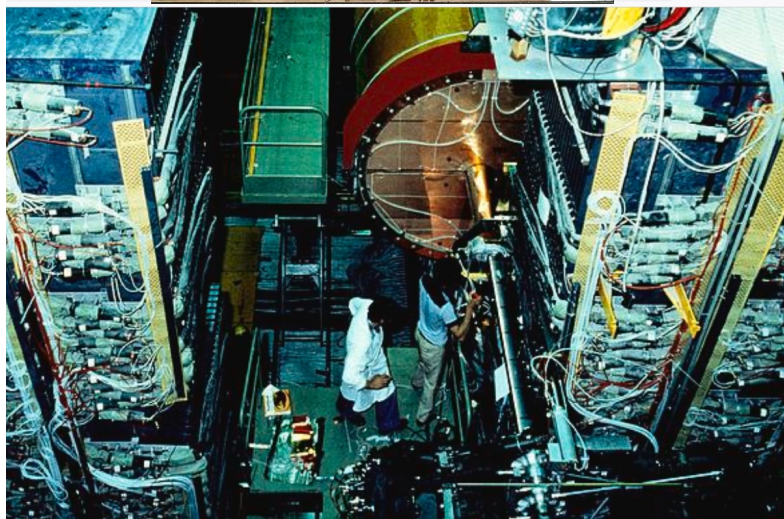
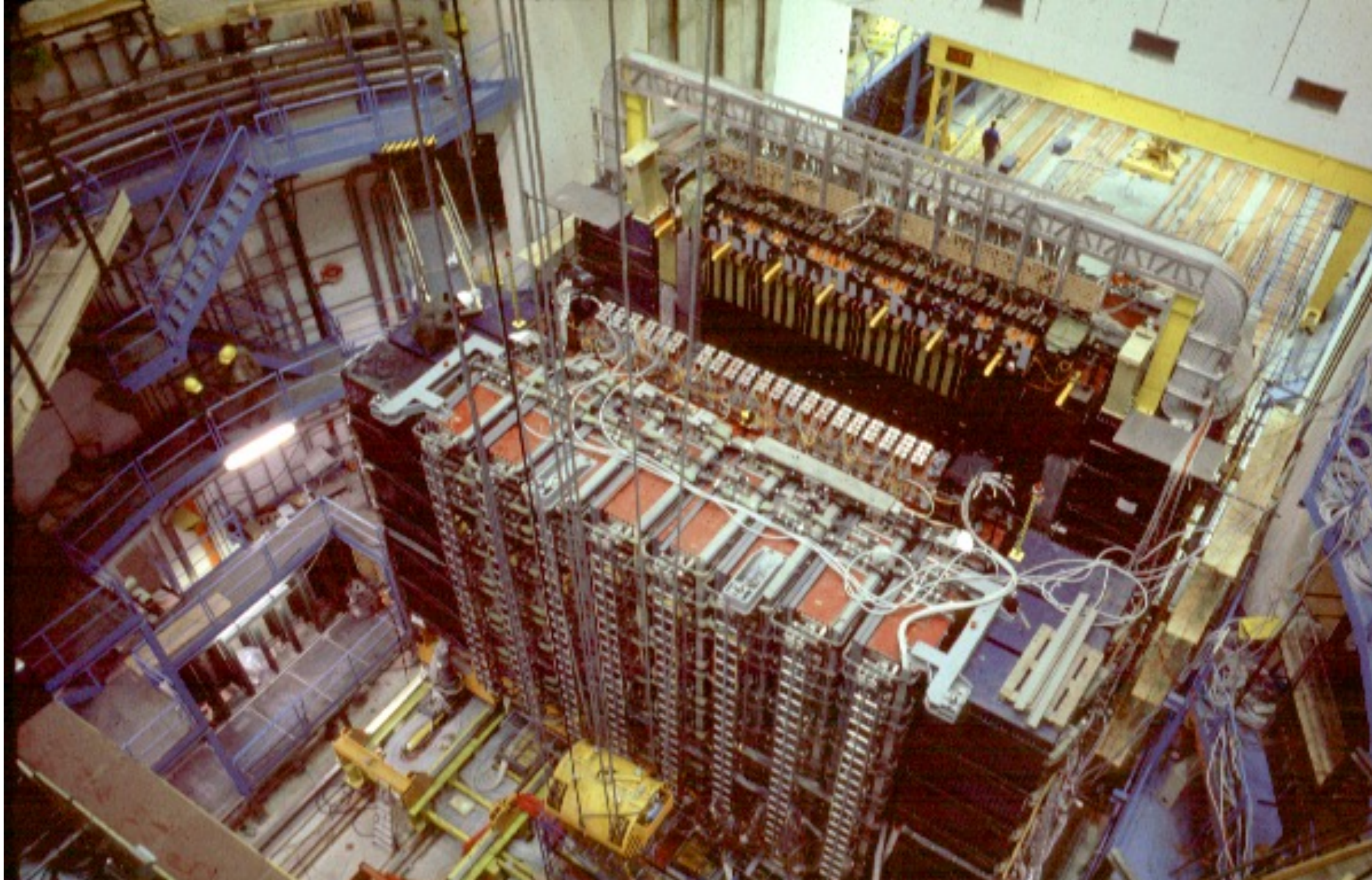
CH-1211 GENEVA 23

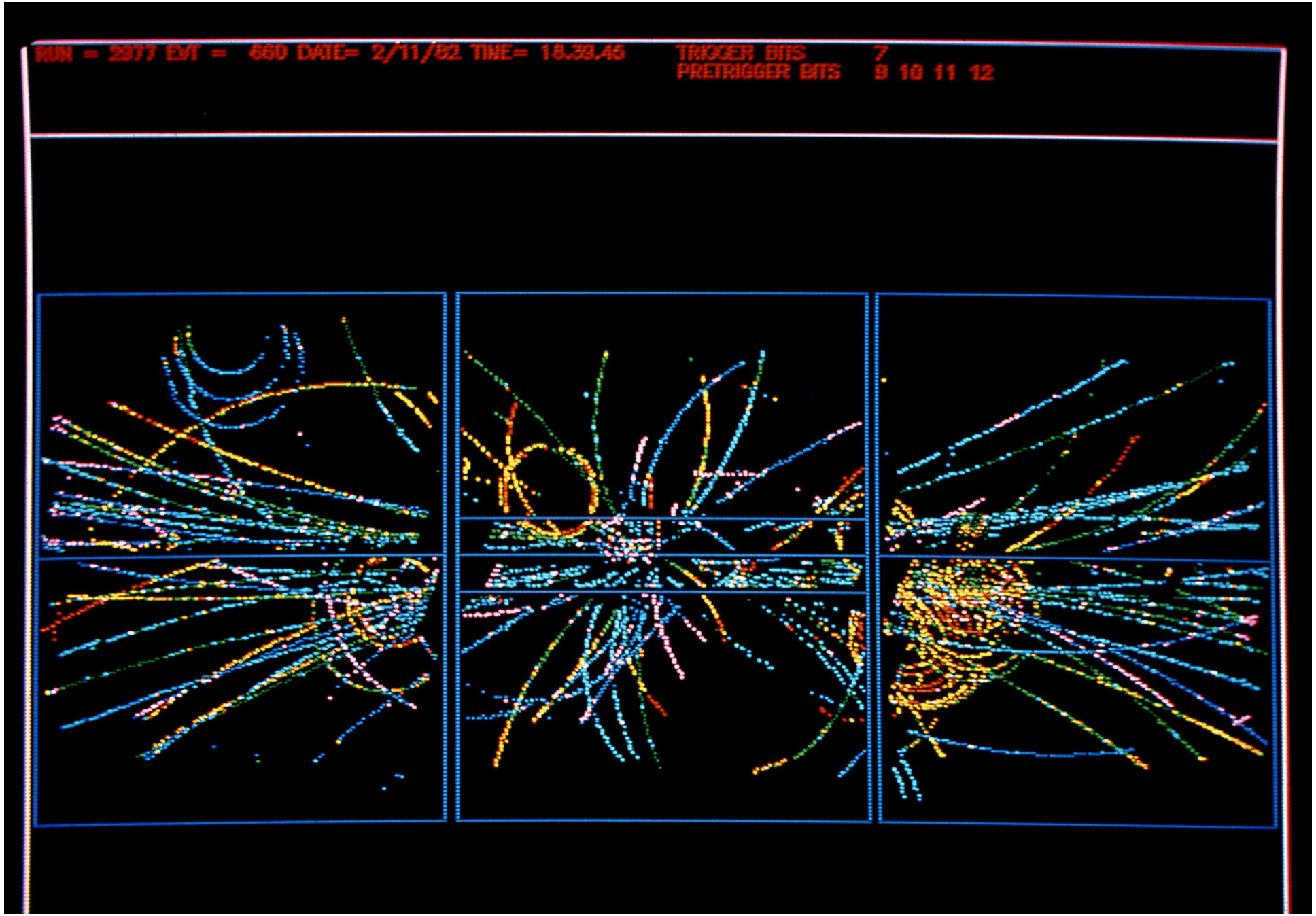








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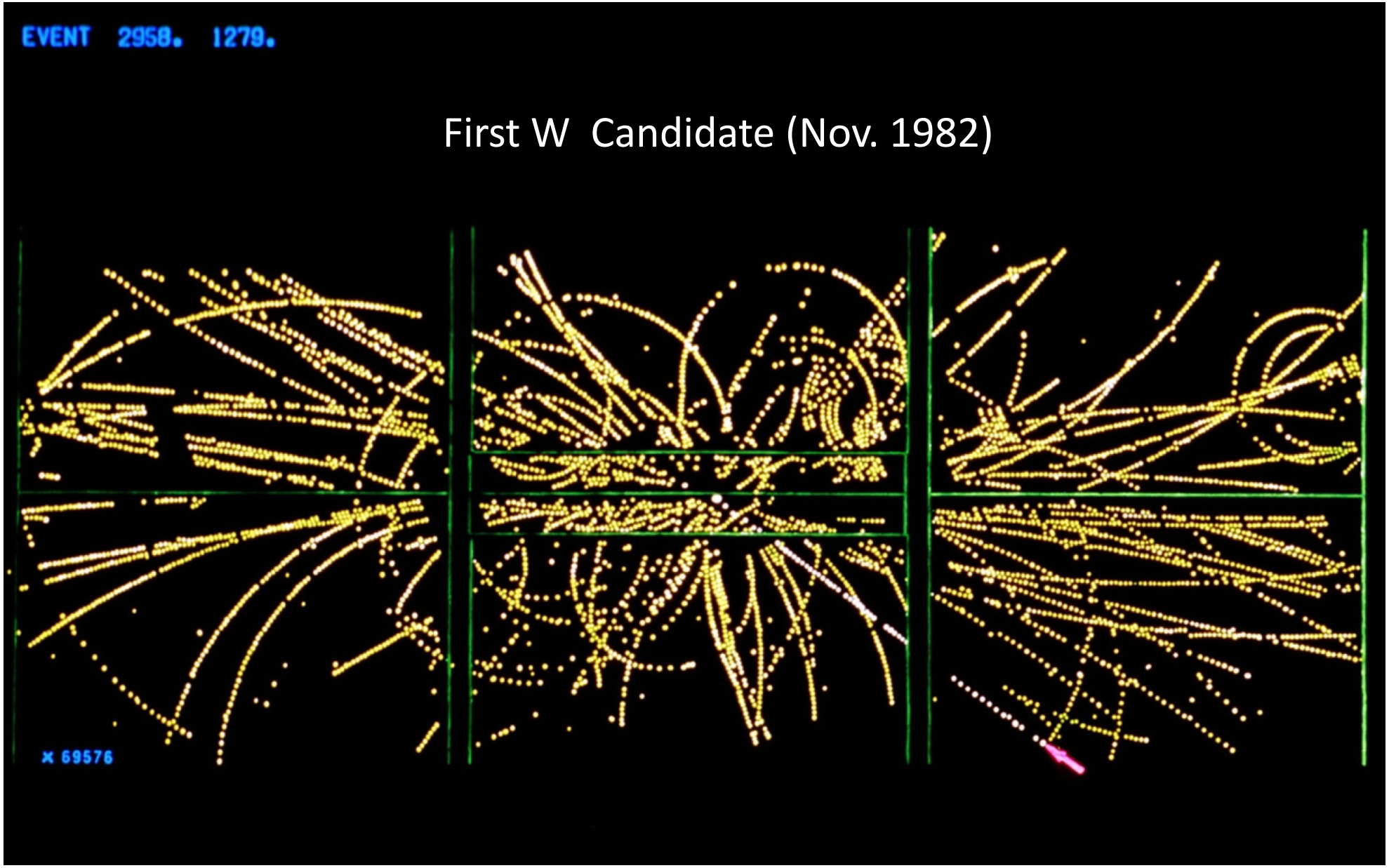
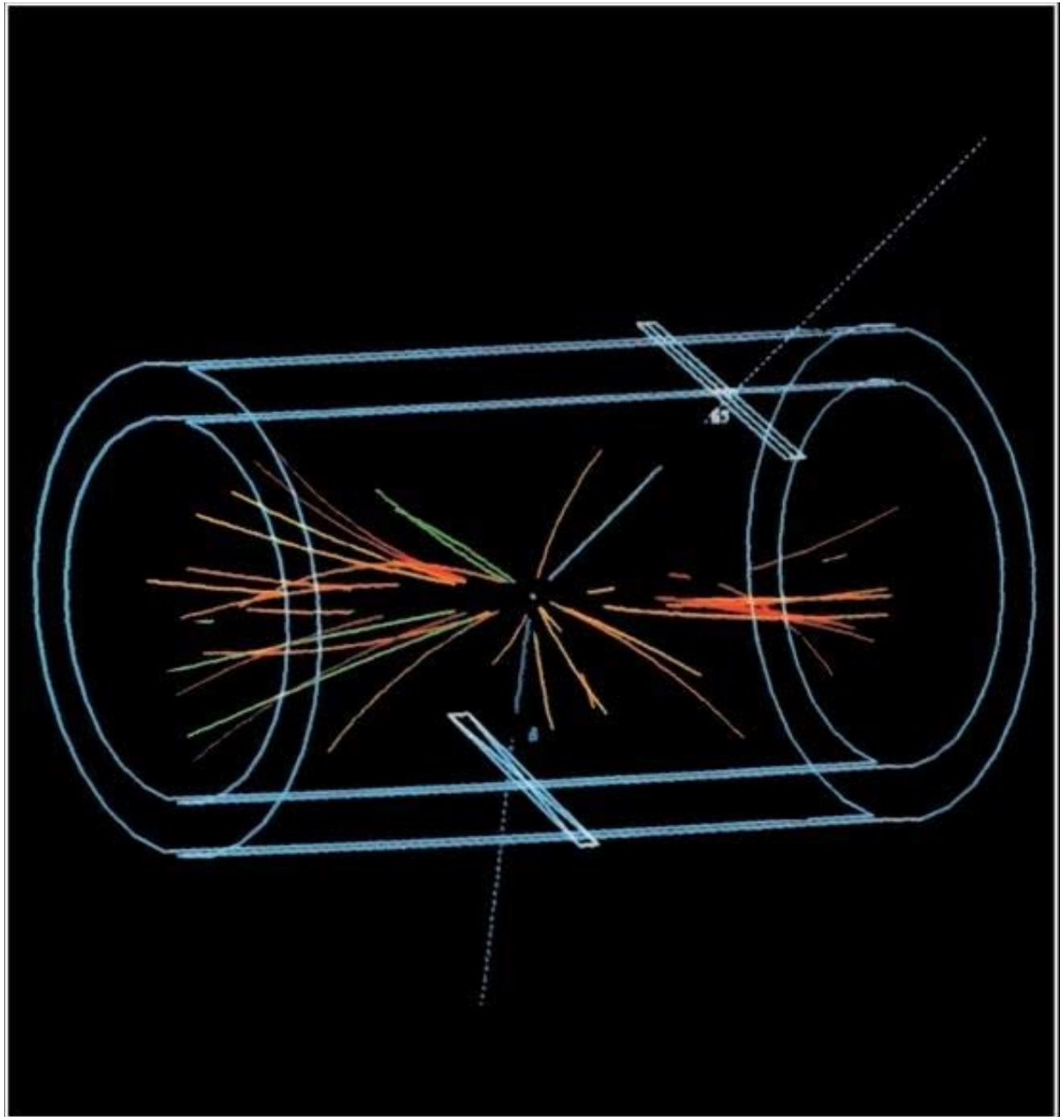
TRIGGER BITS 7
PRETRIGGER BITS 9 10 11 12


EVENT 2958. 1279.
First W Candidate (Nov. 1982)
x 69576

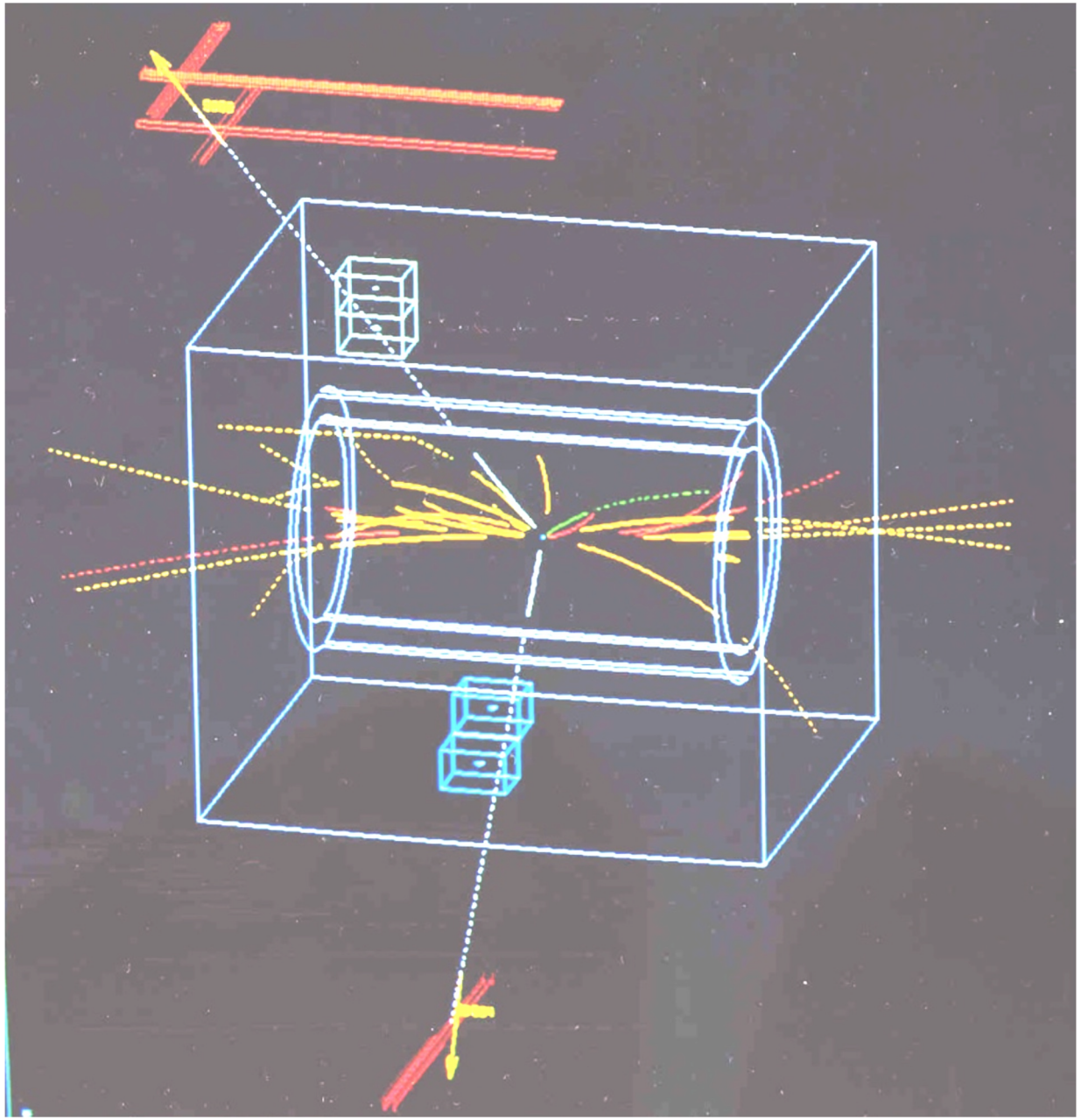
Z boson candidate 1983

Decay to
electron positron pair



Z boson candidate 1983

Decay to muon pair



Our most important discoveries

1983

Experimental observation of isolated large transverse energy electrons with associated missing energy at $\sqrt{s}$ = 540 GeV

UA1 Collaboration Phys Lett 122B, p103, 24 February 1983

W

N = 136 authors

20 Jan 1983 CERN Seminar by Rubbia
23 Jan 1983 Paper received by Phys Lett
24 Jan 1983 BBC TV "The Geneva Event"

Experimental observation of lepton pairs of invariant mass around 95 GeV / c^2 at the CERN SPS Collider

UA1 Collaboration Phys Lett 126B, p398, 7 July 1983

Z

N = 138 authors

The Dalai Lama visits the UA1 Megatek 1983

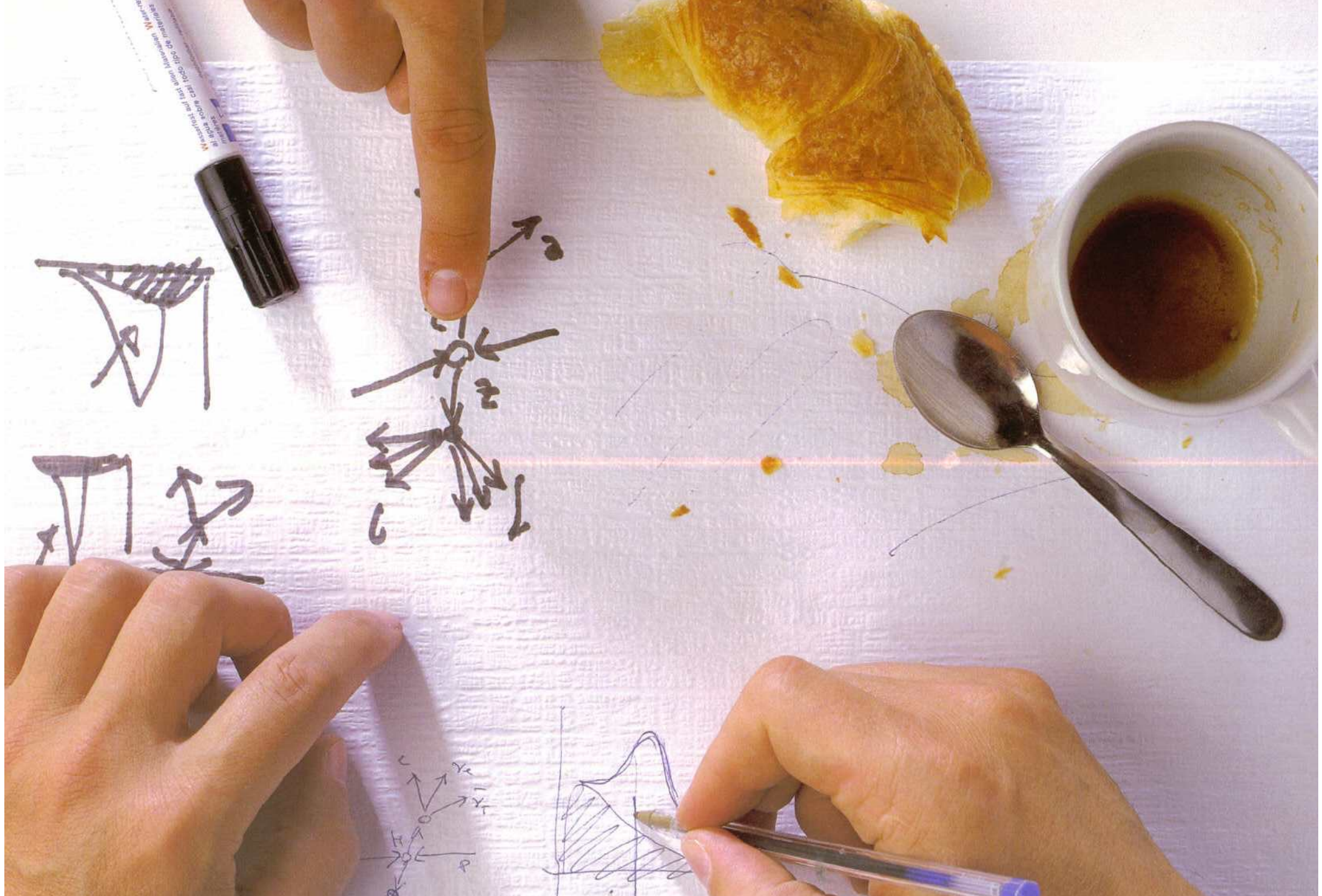
Carlo Rubbia and Simon Van der Meer - Nobel prize celebration at CERN 1984

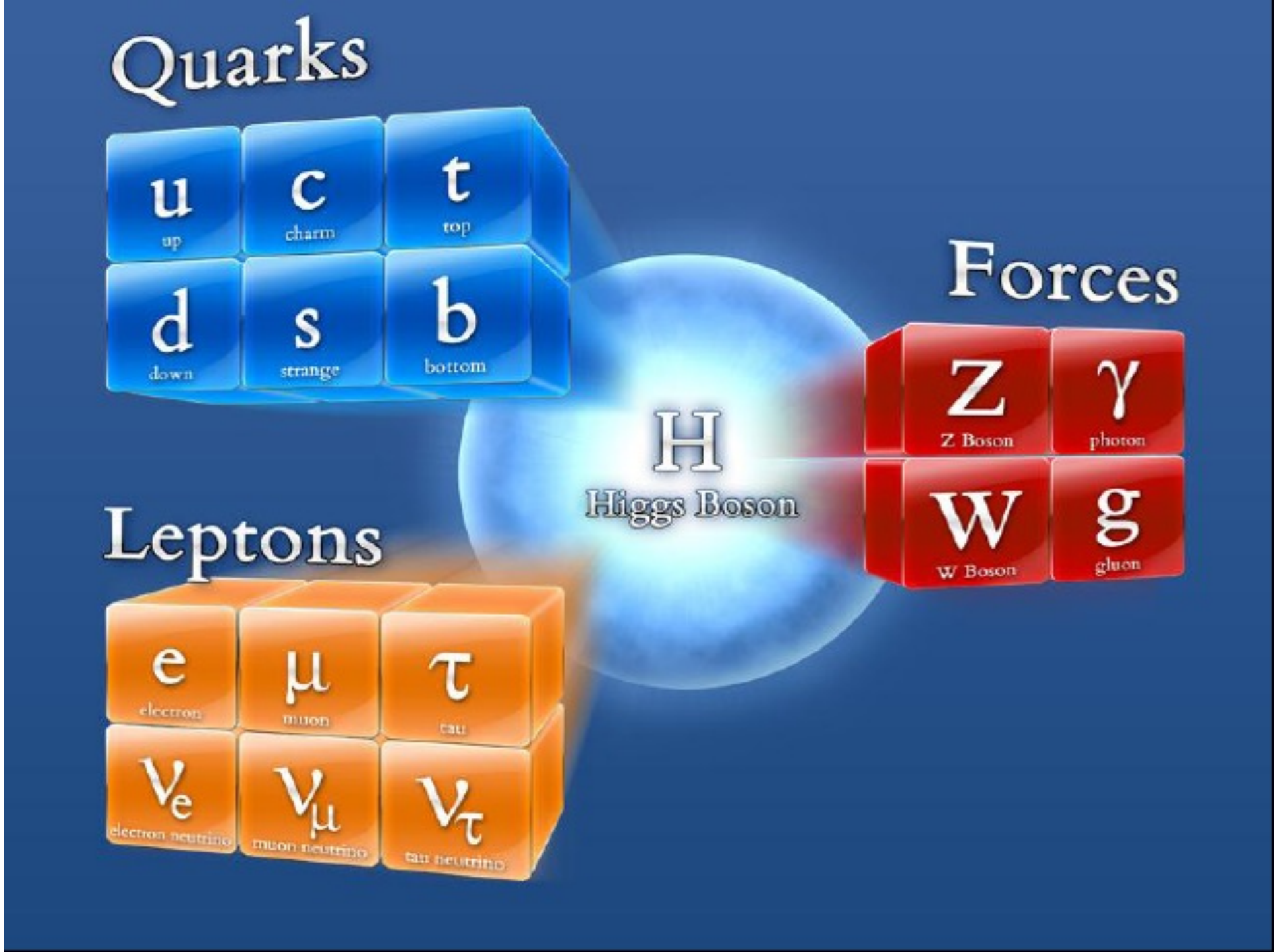
Post W and Z discovery by UA1 and UA2

Many more precise measurements of a wide range of processes were later made by both experiments .

Much later some members of the Birmingham UA1 group including John joined the H1 experiment at DESY
(next talk by Paul)

Others joined the OPAL experiment at LEP where together with RAL we constructed the endcap muon chambers and readout and trigger systems.




Quarks
u
up
c
charm
t
top
d
down
s
strange
b
bottom
Forces
Z
Z Boson
γ
photon
W
W Boson
g
gluon
H
Higgs Boson
Leptons
e
electron
μ
muon
τ
tau
νe
electron neutrino
νμ
muon neutrino
ντ
tau neutrino

John Dowell

Many thanks for all your contributions to the Birmingham Particle Physics group.

It has been a pleasure working with you.

Acknowledgements
Many helpful discussions with John Wilson
Few slides from Jim Rohlf talk at Carlo Rubbia's 90th birthday meeting