CERN'70

70th anniversary of the European Organization for Nuclear Research

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Foundation, motivation
First successes
Scientific achievements
Successes in technology
Hungarian context
Current results and difficulties

Based on the presentation of Prof. L. Musa at ICNFP'24, Kolymbari, Crete, Greece, August 2024
With Hungarian flavors added by T. Cs.
https://indico.cern.ch/event/1307446/contributions/6112042/

MOTIVATION

PEACEFUL COLLABORATION ON THE RUINS OF EUROPE

Peaceful scientific collaboration: a vision takes shape

1945: Europe is in ruins after World War II

1946: French proposal to the United Nations

1949: European Cultural Conference, Lausanne

COMMON VISION OF SCIENTISTS AND POLITICIANS

FIRST PROPOSAL: LOUIS DE BROGLIE (NOBEL LAUREATE)

1940s: first proposals

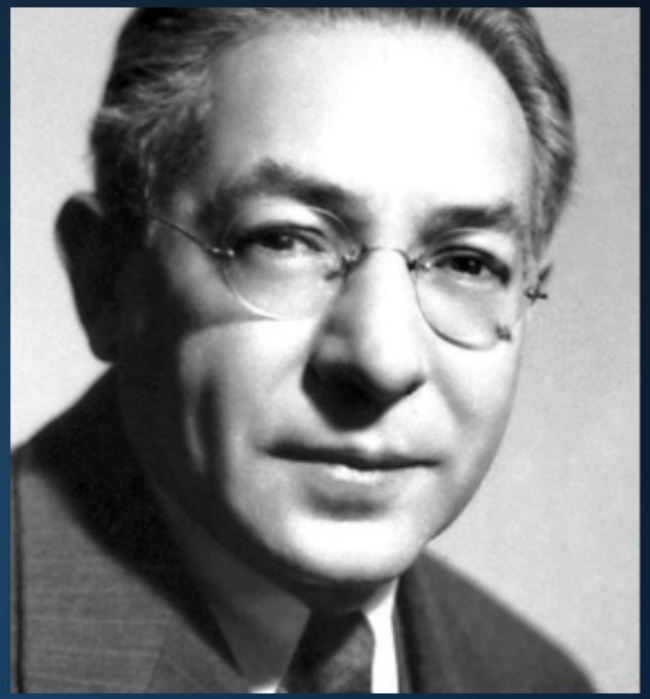
Louis de Broglie proposed: *"the creation of a laboratory or institution where it would be possible to do scientific work, but somehow beyond the framework of the different participating states [Endowed with more resources than national facilities, such a laboratory could] undertake tasks, which, by virtue of their size and cost, were beyond the scope of individual countries".*

1950-51: formation, birth of acronym CERN

1950: UNESCO Conference

US Nobel laureate Isidor Rabi tables a resolution authorising UNESCO to:

"assist and encourage the formation of regional research laboratories in order to increase international scientific collaboration…"



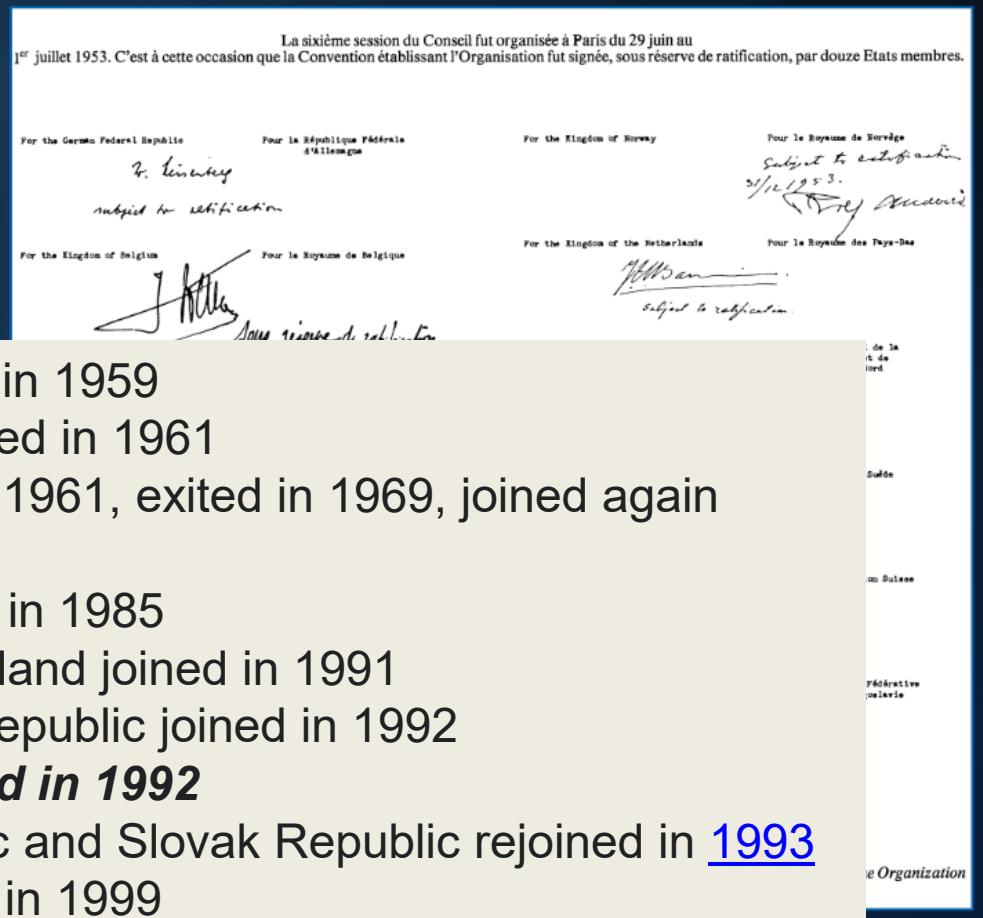
1951: UNESCO Resolution

- At a meeting of UNESCO in Paris in December 1951, the first resolution concerning the establishment of a European Council for Nuclear Research was adopted.
- Two months later, 11 countries signed an agreement establishing the provisional Council – **the acronym CERN was born**.

September 29, 1954 : Birth of CERN

1954: CERN is born

- The CERN Convention, established in July 1953, was ratified by 12 founding Member States: Belgium, Denmark, France, the Federal Republic of Germany, **Greece**, Italy, the Netherlands, Norway, Sweden, Switzer the UK, and Yugoslavia.
- On 29 September 1954, the European Organization for Nuclear Research offi came into being.
- CERN was dissolved but the acronym


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.

For the German Federal Republic — Pour la République Fédérale d'Allemagne — For the Kingdom of Norway — Pour le Royaume de Norvège

For the Kingdom of Belgium — Pour le Royaume de Belgique — For the Kingdom of the Netherlands — Pour le Royaume des Pays-Bas

- Ausztria joined in 1959
- Yugoslavia exited in 1961
- Spain joined in 1961, exited in 1969, joined again in 1983
- Portugal joined in 1985
- Finland and Poland joined in 1991
- Czechslovak Republic joined in 1992
- ***Hungary joined in 1992***
- Czech Republic and Slovak Republic rejoined in 1993
- Bulgaria joined in 1999
- Romania joined in 2015
- Serbia joined in 2018
- Slovenia joined in 2024

TODAY'S GLOBAL COLLABORATION: 25 MEMBER STATES, 8 ASSOCIATE MEMBER STATES …

From founders' vision to today's global collaboration

24 Member States

Austria – Belgium – Bulgaria – Czech Republic
Denmark – Estonia – Finland – France – Germany
Greece – Hungary – Israel – Italy – Netherlands – Norway
Poland – Portugal – Romania – Serbia – Slovakia Spain
Sweden – Switzerland – United Kingdom

2 Associate Member States in the pre-stage to membership

Cyprus – Slovenia

8 Associate Member States

Brazil – Croatia – India – Latvia – Lithuania – Pakistan
Türkiye – Ukraine

6 Observers

Japan – Russia (suspended) – USA
European Union – JINR (suspended) – UNESCO

As of 31 December 2023
Employees:
2666 staff, **1002** graduates
Associates:
12 370 users, **1513** others

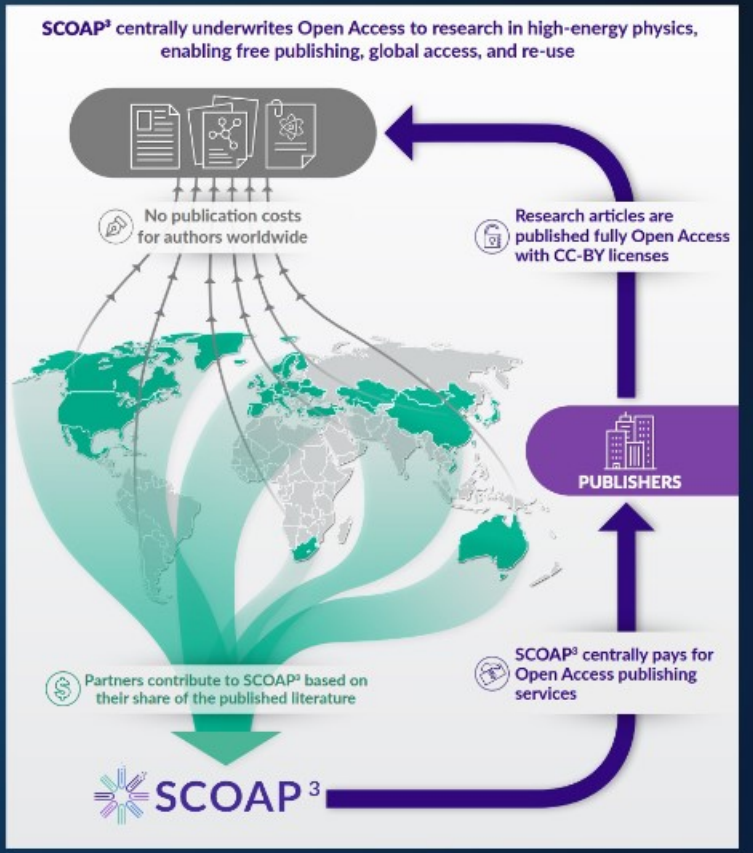
Around 50 Cooperation Agreements with non-Member States and Territories

Albania – Algeria – Argentina – Armenia – Australia – Azerbaijan – Bangladesh – Belarus – Bolivia
Bosnia and Herzegovina – Canada – Chile – Colombia – Costa Rica – Ecuador – Egypt – Georgia – Honduras
Iceland – Iran – Jordan – Kazakhstan – Lebanon – Malta – Mexico – Mongolia – Montenegro – Morocco – Nepal
New Zealand – North Macedonia – Palestine – Paraguay – People's Republic of China – Peru – Philippines – Qatar
Republic of Korea – Saudi Arabia – Sri Lanka – South Africa – Thailand – Tunisia – United Arab Emirates – Vietnam

Core value underlying the collaboration: Open Science

CERN Convention Art. II.1.: *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***

- **Open Access Policy (2014)**
  - >90% of research produced at CERN published OA (CC-BY licenses)
  - Sponsoring Consortium for Open Access Publishing in Particle Physics - SCOAP^3 (44 countries)
  - Inspired major global OA initiatives: PlanS, OA2020, etc.
- **LHC Open Data Policy (2020)**
  - LHC experiments release experimental data and associated analysis tools for diverse scientific and educational uses
- **CERN Open Science Policy (2022)**
  - Policy broadened to explicitly include open software, hardware, research integrity and assessment, education, training and outreach, citizen science



SCIENTIFIC MILESTONES

1957: ARRIVAL OF THE FIRST ACCELERATOR TO CERN

1957: first accelerator

The **Synchrocyclotron**

MOTTO: „WE ACCELERATE”

NEW MILESTONES: NEW ACCELERATORS

PS – 28 GeV

SPS – 630 GeV

LHC – 13 600 GeV

SC 0.6 GeV

ISR - 31.5 GeV

LEP - 209 GeV

1957 1959 1971 1976 1989 2009

1958 - 62: CERN'S FIRST DISCOVERY

1958: CERN's first discovery

1957: the **Synchrocyclotron is** CERN's first accelerator to begin operation (600 MeV proton beam)

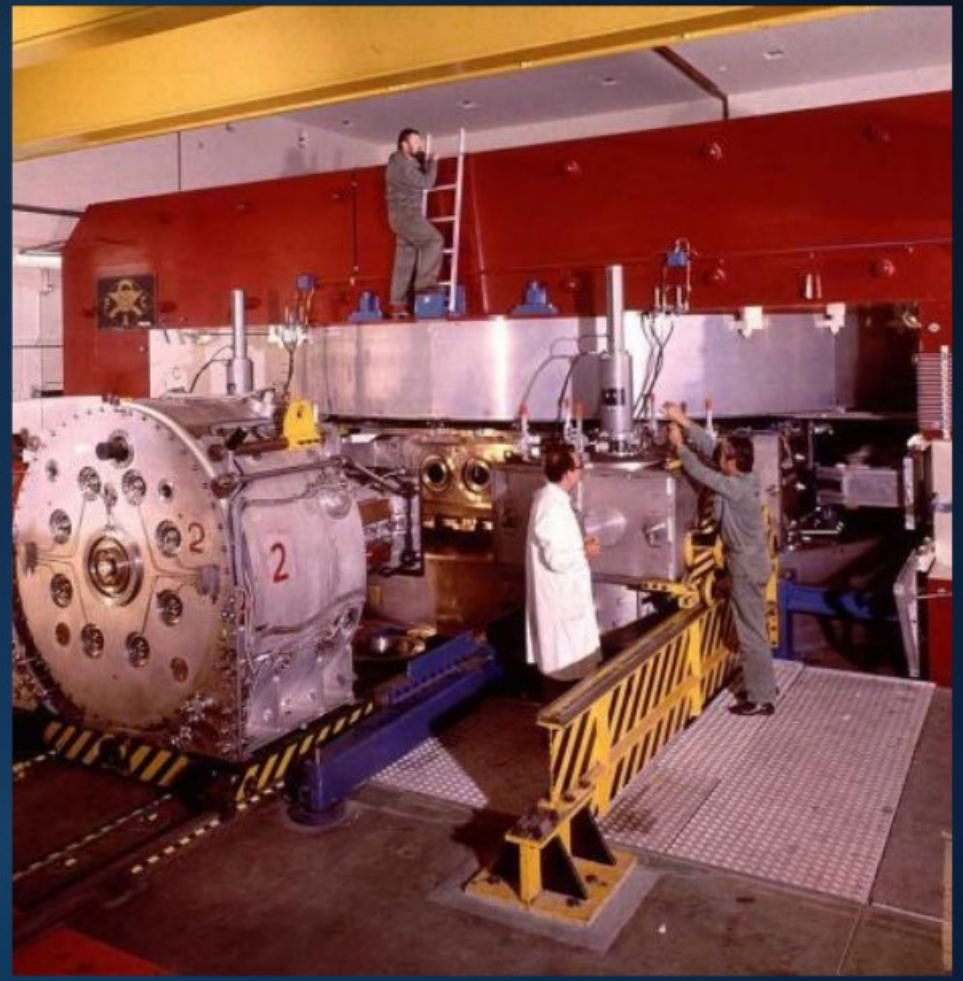
Discovery of "rare pion decays" 1958-1962

$$R = \frac{\Gamma(\pi \to e\upsilon_e)}{\Gamma(\pi \to \mu\upsilon_\mu)} = (1.22 \pm 0.30) \times 10^{-4}$$

G. Fidecaro et al.

Crucial verification of a universal "weak" force with a Vector - Axial coupling

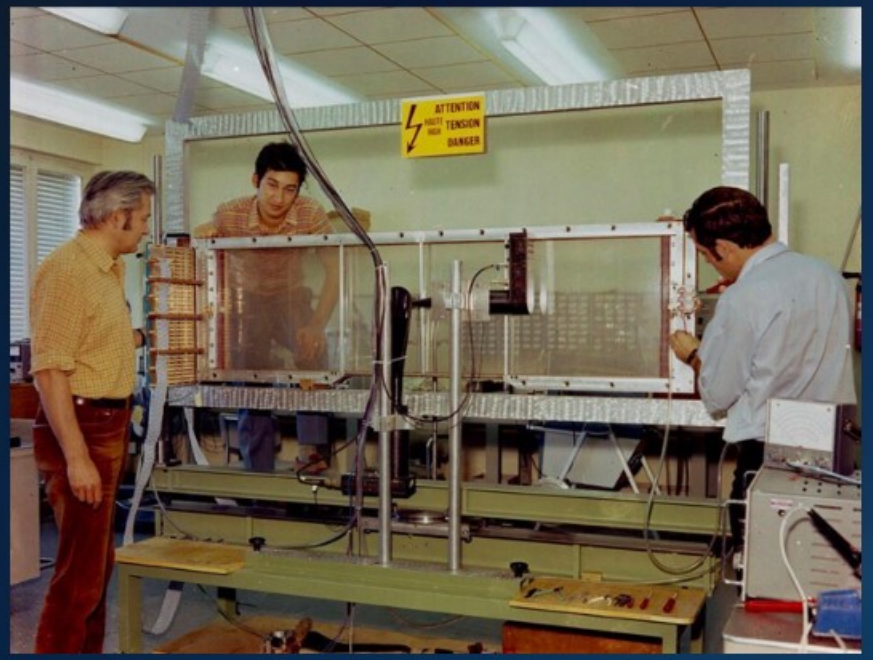
A turning point for the emerging electroweak theory



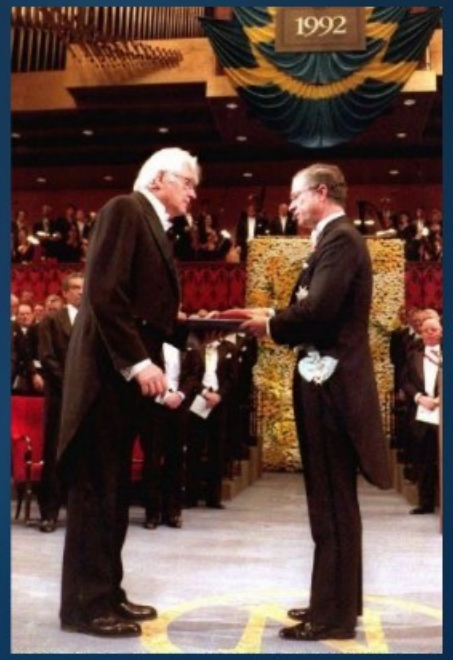
1971-72: MWPC DEVELOPED, 1992: CHARPAK'S NOBEL

Georges Charpak: Revolutionizing particle detection

from "visual detectors" to "electronic detectors"



1971-1972 – Large-size Multiwire Proportional Chamber

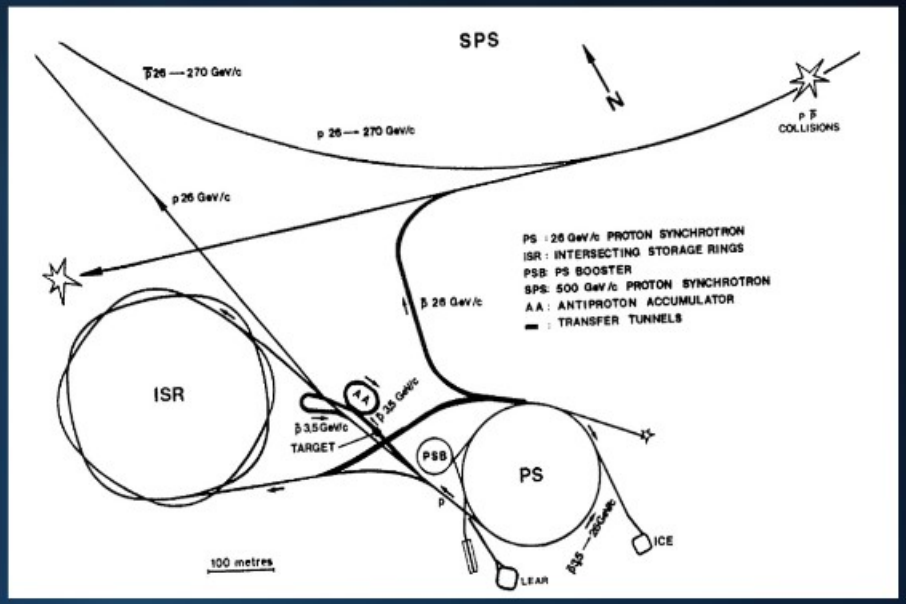


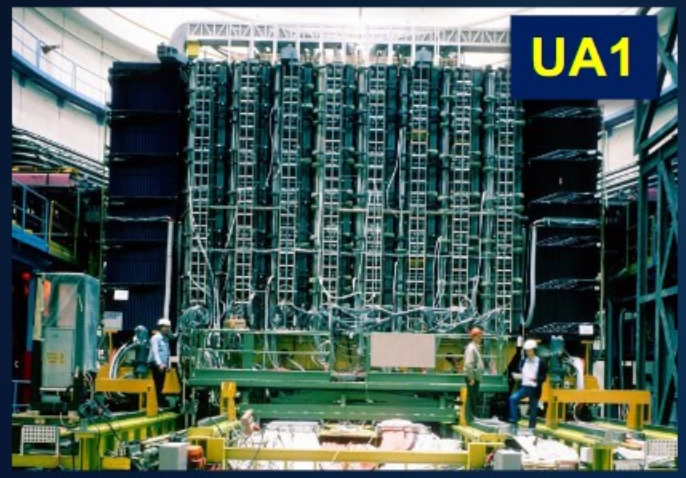
1992 Nobel award ceremony

1976 - 1983: DISCOVERY OF W AND Z

1983: discovery of the W and Z

- Gargamelle and the discovery of neutral currents guided the search: look in the region 60-90 GeV
- In 1976 Rubbia proposes to modify the SpS into a collider of protons and antiprotons
- First collisions at sqrt(s)=540 GeV were obtained in 1981



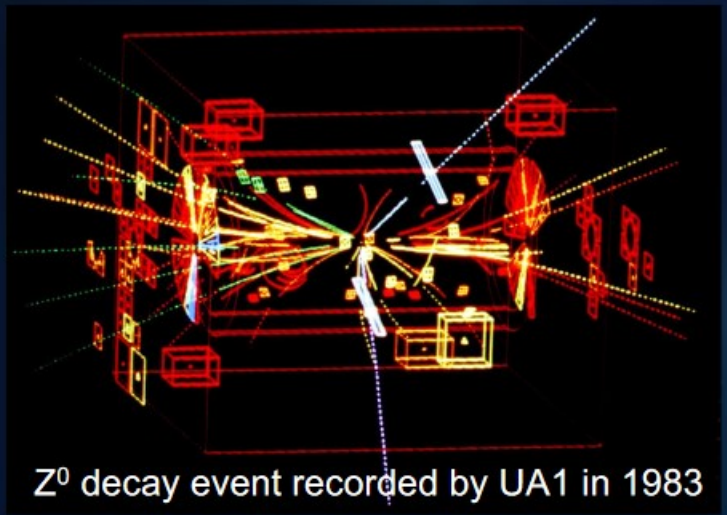


Two multipurpose detectors UA1 and UA2 were built to detect the elusive W and Z in their decays to leptons.

1984: C. RUBBIA'S AND S. VAN DER MEER'S NOBEL PRIZE

1983: discovery of the W and Z

- UA1 and UA2 presented the first results (in two separate seminars) at CERN on 20 and 21 **January 1983**
- 6 candidates for both experiments with high energy electrons and high missing energy (i.e. neutrinos).
- **The quest for the W boson was over!**



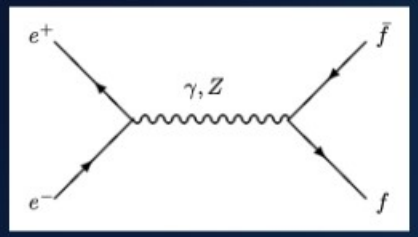
Z^0 decay event recorded by UA1 in 1983

In **July 1983**, **clear evidence of the Z boson** was also presented.

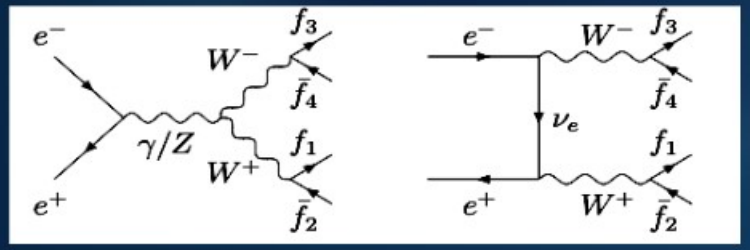
Carlo Rubbia and Simon van der Meer were awarded the 1984 Nobel prize

LEP era

- First beams in LEP: 15 July 1989
- LEP 1: center of mass energy around the mass of the Z boson (91 GeV) for 7 years. LEP was a Z-factory with millions of produced Z bosons.



- LEP 2: starting in 1996, energy reached and surpassed the threshold for production of 2 W boson (160 GeV). Max energy reached 209 GeV.



1989 - WEB WAS BORN AT CERN

The World Wide Web

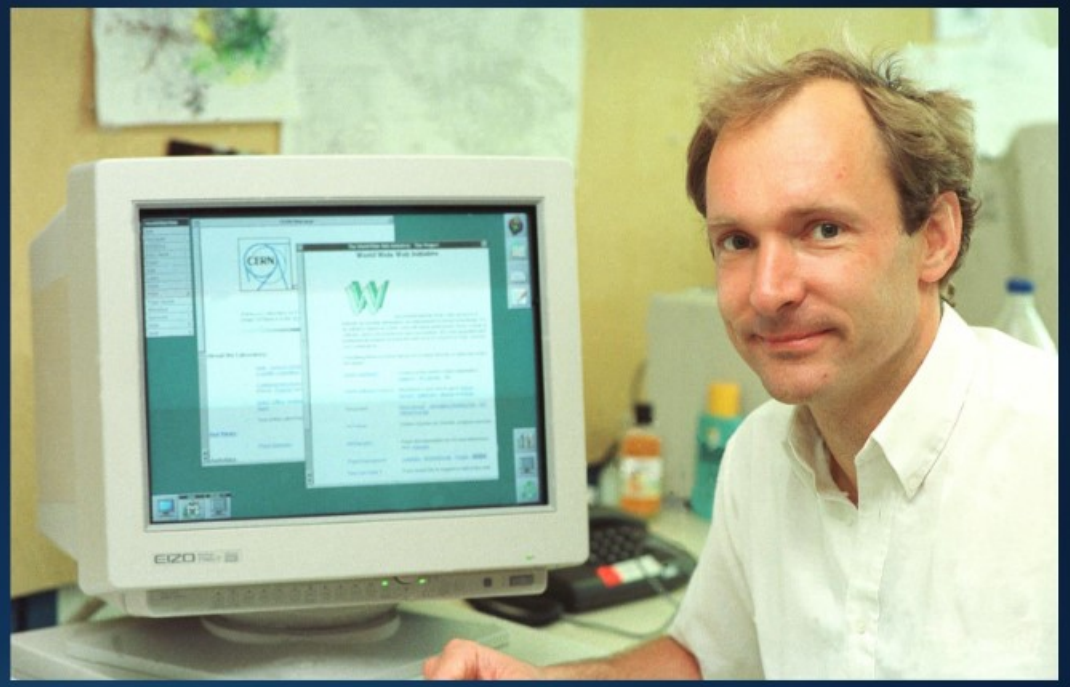
March 1989: Tim Berners Lee submits the first proposal for the World Wide Web

merge data networks and hypertext in an easy-to-use global information system

By the end of 1990, the first Web server and browser is up and running

In 1993, CERN makes the source code of the World Wide Web available on a royalty-free basis

By the end of 1994, the Web already has **10,000 servers** and **10 million users**



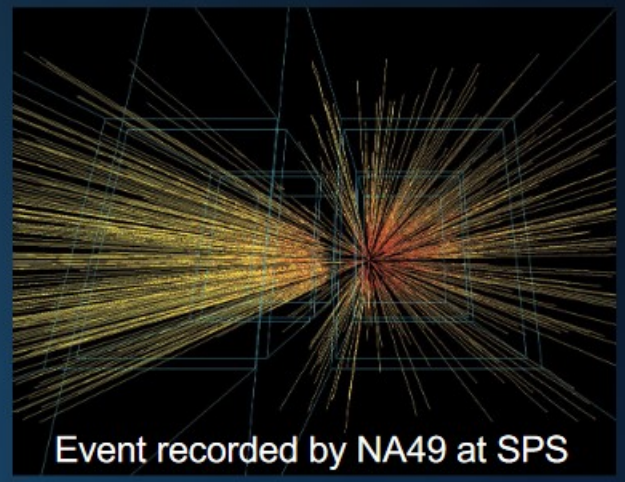
Tim Berners Lee displaying some of the first web pages in 1994

2000 - QGP ANNOUNCEMENT – PRESS RELEASE AT CERN

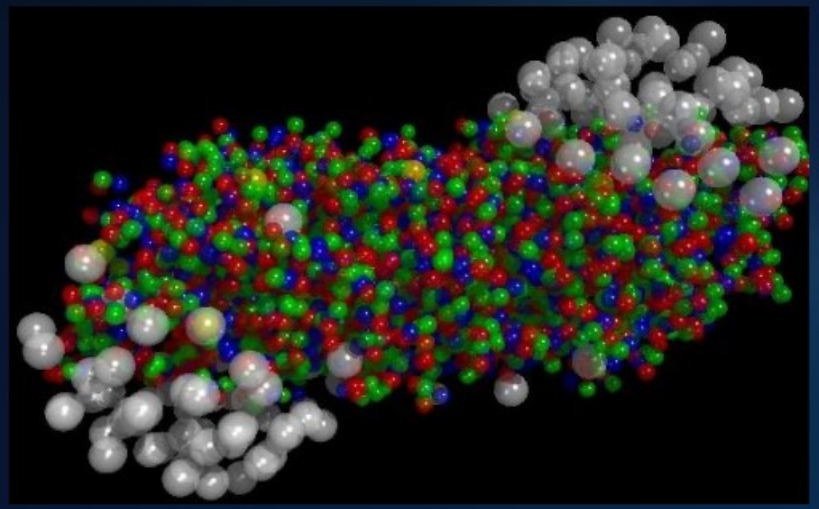
A NEW STATE OF MATTER, CREATED AT CERN (?)

CERN, February 2000: first evidence of a new state of matter, the quark-gluon plasma

- Combined data from the 7 experiments on CERN's HI programme
- Proves an important prediction of the QCD theory. An important step forward in the understanding of the early evolution of the Universe.

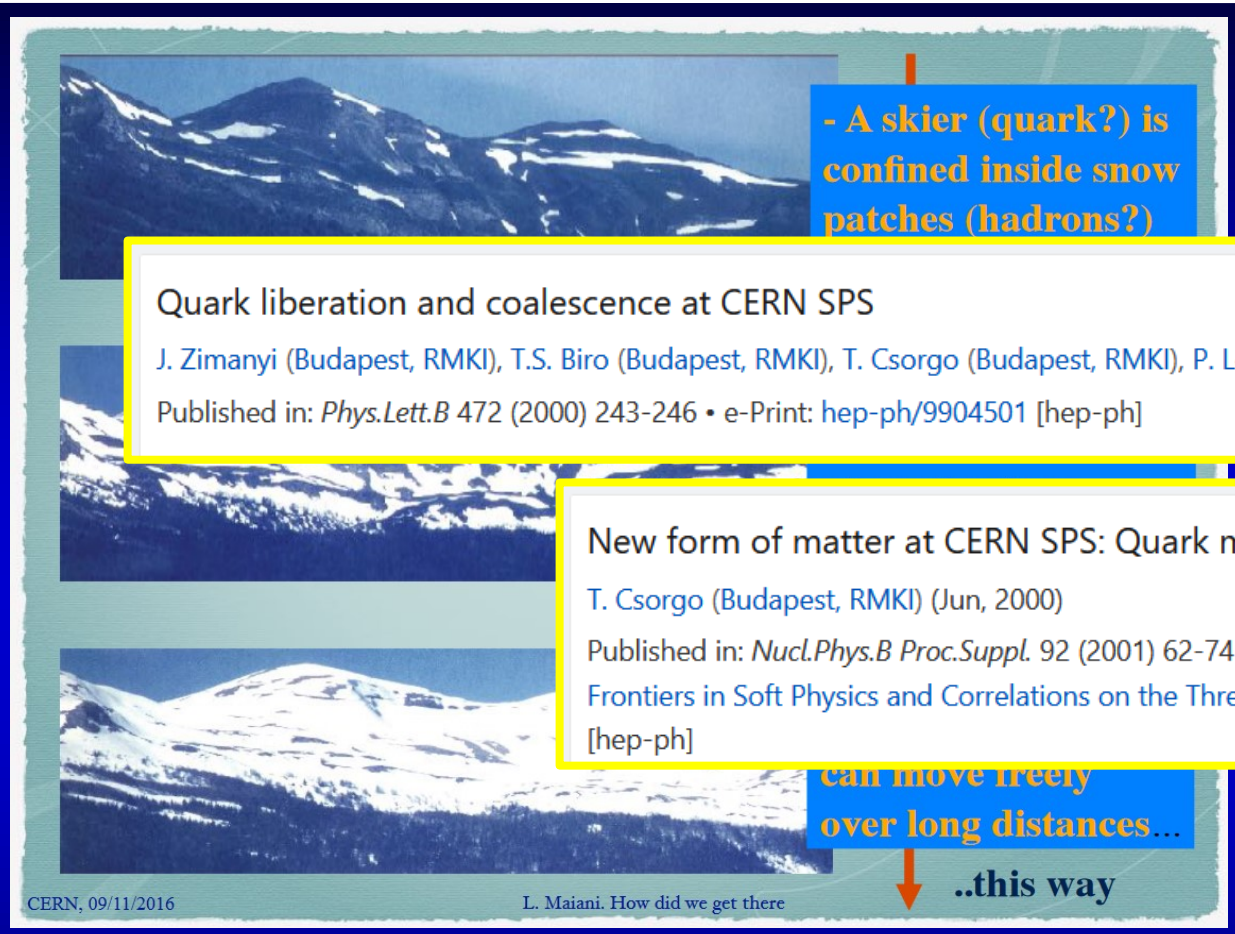


Event recorded by NA49 at SPS



Luciano Maiani (CERN DG): "… We now have evidence of a new state of matter where quarks and gluons are not confined. … There is still an entirely new territory to be explored concerning the physical properties of quark-gluon matter. The challenge now passes to RHIC at BNL and later to the LHC."

2000 – HOW BIG IS THE MEAN FREE PATH OF QUARKS ??



Quark liberation and coalescence at CERN SPS #1

J. Zimanyi (Budapest, RMKI), T.S. Biro (Budapest, RMKI), T. Csorgo (Budapest, RMKI), P. Levai (Budapest, RMKI) (Apr, 1999)

Published in: *Phys.Lett.B* 472 (2000) 243-246 • e-Print: hep-ph/9904501 [hep-ph]

New form of matter at CERN SPS: Quark matter but not quark gluon plasma #7

T. Csorgo (Budapest, RMKI) (Jun, 2000)

Published in: *Nucl.Phys.B Proc.Suppl.* 92 (2001) 62-74 • Contribution to: 9th International Workshop on Multiparticle Production: New Frontiers in Soft Physics and Correlations on the Threshold of the New Millenium (Torino 2000), 62-74 • e-Print: hep-ph/0011339 [hep-ph]

In the nonrelativistic region $m_\perp < 2m_0$, on the other, flow does couple to the rest mass: for a linear transverse flow velocity profile and a Gaussian transverse density profile one finds exactly [16,17]

$$T_{\rm slope} = T_{\rm f} + \tfrac{1}{2} m_0 \langle v_\perp \rangle^2 \,. \qquad (4)$$

s dependence is indeed observed. Figure 3 shows
tive flow component; inverse slopes of 300 MeV
n obviously not be interpreted as hadronic tem-
is some scatter between the data from different

n tends to reduce the size of the regions within
which particles can develop such correlations: thermal motion, controlled by the thermal
ts in the opposite
effective emission
size is controlled
nula [21,16,17]

(5)

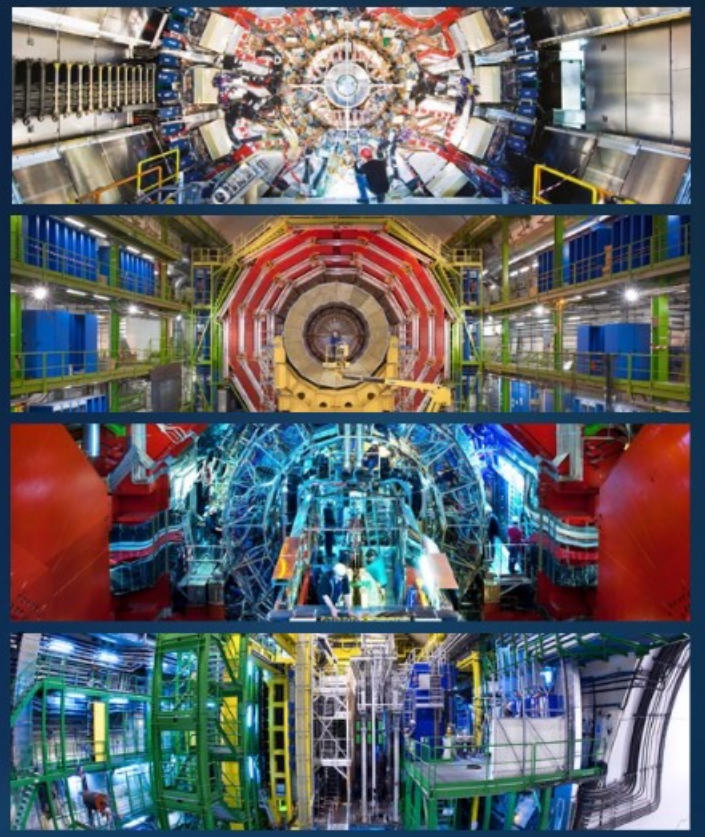
16. T. Csörgő, B. Lörstad, Nucl. Phys. A 590 (1995) 465c; Phys. Rev. C 54 (1996) 1390.
17. R. Scheibl and U. Heinz, Phys. Rev. C 59 (1999) 1585.

L. Maiani, DG OF CERN :
MEAN FREE PATH OF QUARKS tends to infinity (macroscopic)

U. W. Heinz: signs of hydro, it is a fluid, Mean free path tends to zero, with references to Hungarian (Buda-Lund) results: Nucl.Phys.A 685 (2001) 414-431,PRC54 (1996) 1390 Proc. NN2000, e-Print: hep-ph/0009170 [hep-ph]

2008 - START OF LHC

The Large Hadron Collider era



ATLAS

CMS

ALICE

LHCb

7 experiments at LHC: ALICE, ATLAS, CMS, FASER, LHCb, LHCf és TOTEM.

HIGGS DISCOVERY

Higgs discovery … and the SM triumph

July 4th 2012 announcement

F. Gianotti (ATLAS) and J. Incandela (CMS)

F. Englert and P. Higgs

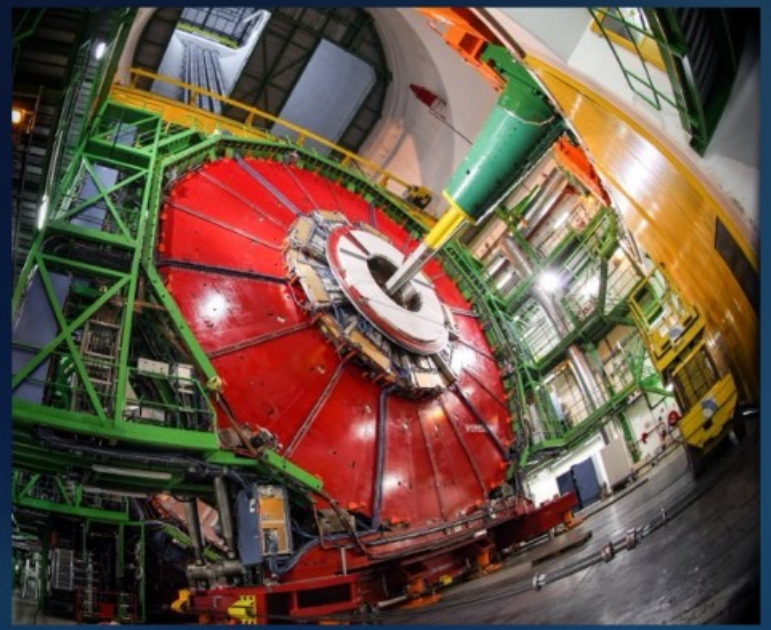
2013 Nobel Prize

ATLAS AND CMS: HONORABLE MENTION in NOBEL JUSTIFICATION.

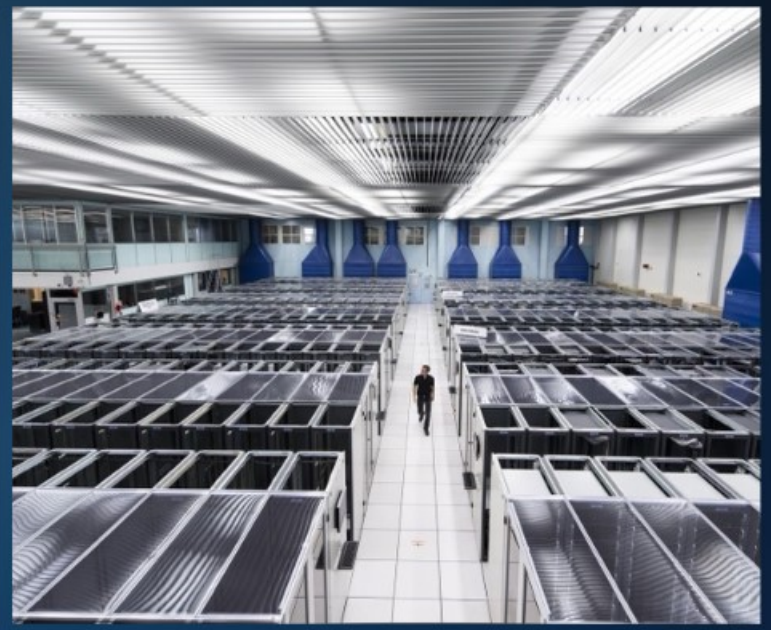
TECHNOLOGY DEVELOPMENT AT CERN

We develop technologies in three key areas

ACCELERATORS



DETECTORS



COMPUTING

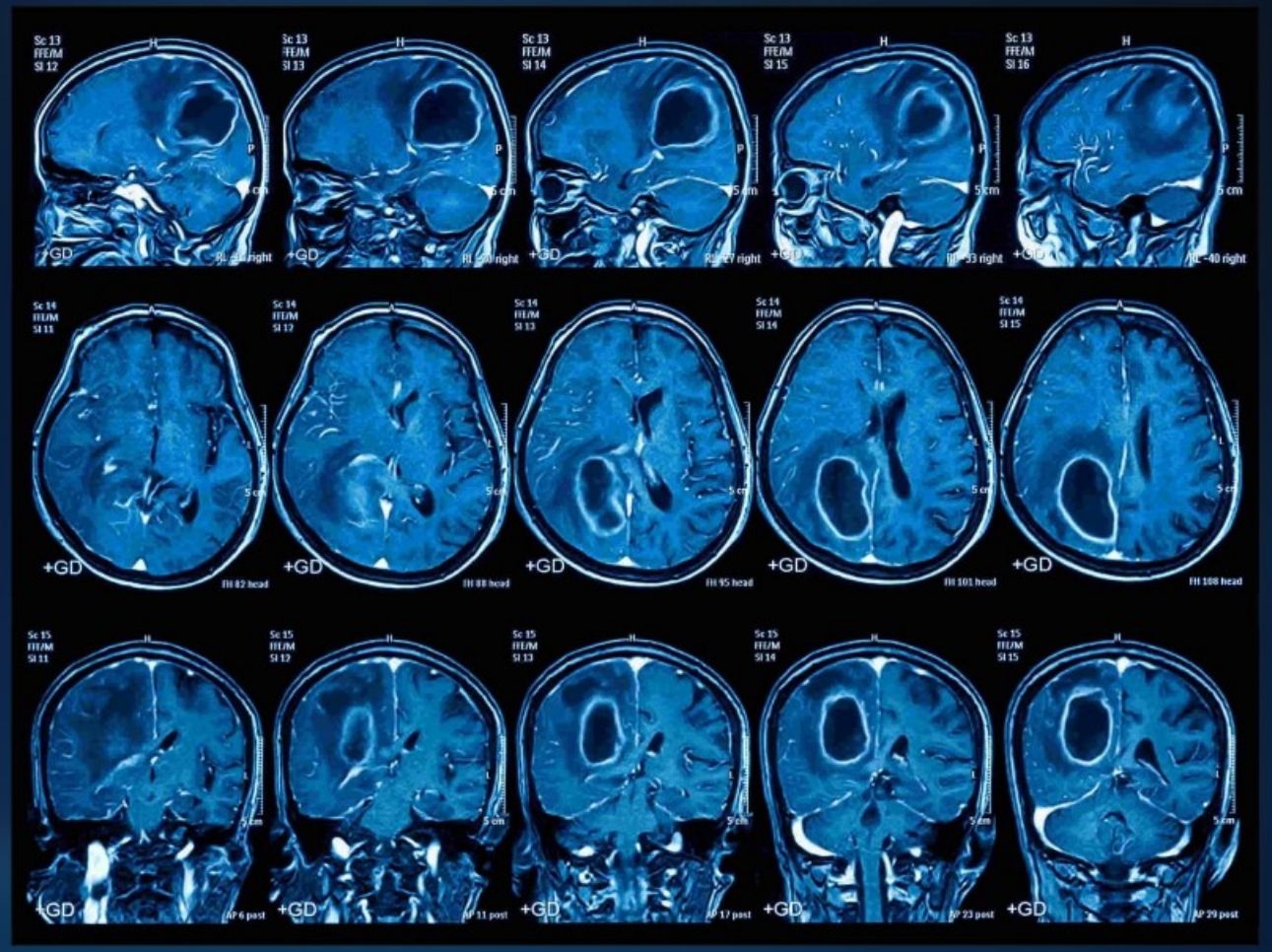
MRI AND fMRI

MRI Magnets

Superconducting magnets in MRI:
Non-invasive 3D anatomical imaging

MRI industry consumes ~4000 tons of Nb-Ti annually

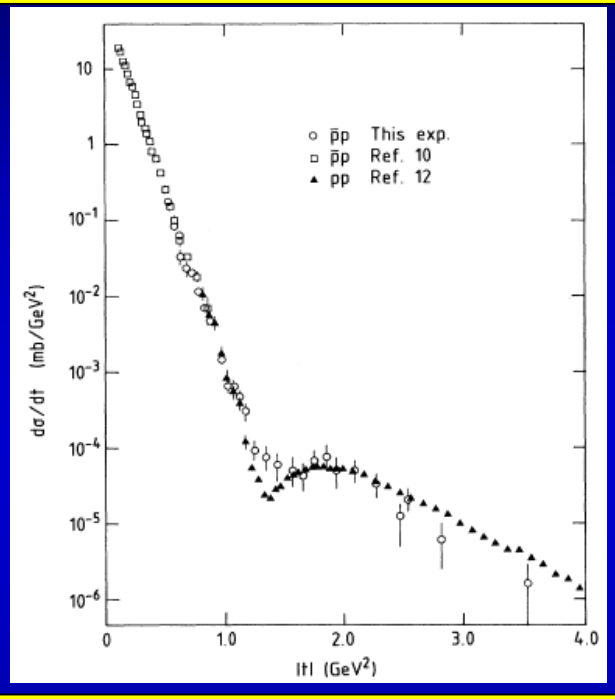
Over 50,000 MRI scanners worldwide

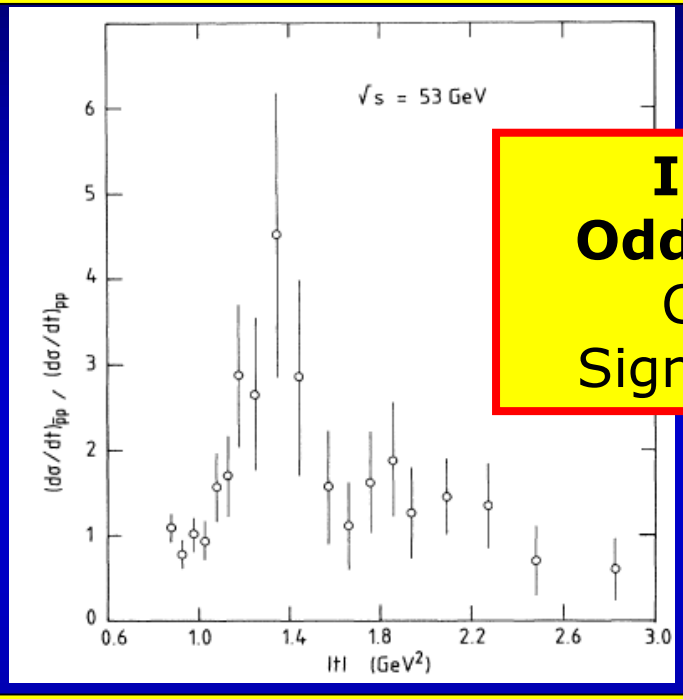


Jövő egyik legérdekesebb iránya

ODDERON DISCOVERY: ELUSIVE EXPERIMENTALLY

Odderon search at ISR: indication, but not yet a discovery
Breakstone et al, Phys. Rev. Lett. 54, 2180 (**1985**): CL = 99.9 %





Indication of Odderon-exchange
CL = 99.9 %,
Significance: 3.35 σ

Terminológy:
Agreement: if stat. significance < **3** σ
Indication, signal: if **3** σ ≤ significance < **5** σ
Evidence, or observation: if **5** σ ≤ significance
Discovery if **5** σ ≤ significance, az **for the first time**.
Accepted discovery: Clay Mathematical Institute (CMI) criteria satisfied.
MIScovery: if CMI criteria for Millenium Prize Problems **NOT** satisfied.

Odderon: First refereed result with > 5 σ

EPJ Web of Conf. (2020) **235**: 06005
https://doi.org/10.1051/epjconf/202023506002

Proton Holography -- Discovering Odderon from Scaling Properties of Elastic Scattering #4

T. Csorgo (Wigner RCP, Budapest and Eszterhazy Karoly U., Eger), T. Novak (EKU KRC, Gyongyos), R. Pasechnik (Lund U. and Rez, Nucl. Phys. Inst.), A. Ster (Wigner RCP, Budapest), I. Szanyi (Wigner RCP, Budapest and Eotvos U.) (Apr 15, 2020)

Published in: *EPJ Web Conf.* 235 (2020) 06002 • Contribution to: ISMD 2019 • e-Print: 2004.07095 [hep-ph]

Első publication, with at least 5.0 σ (6.26 σ) for Odderon-exchange:
Published on: **May 11, 2020**
EPJ Web of Conf. 235 (2020) 06002
Anonymously peer-reviwed, refereed conference proceedings.
(Proc. ISMD 2019, Santa Fe, USA)

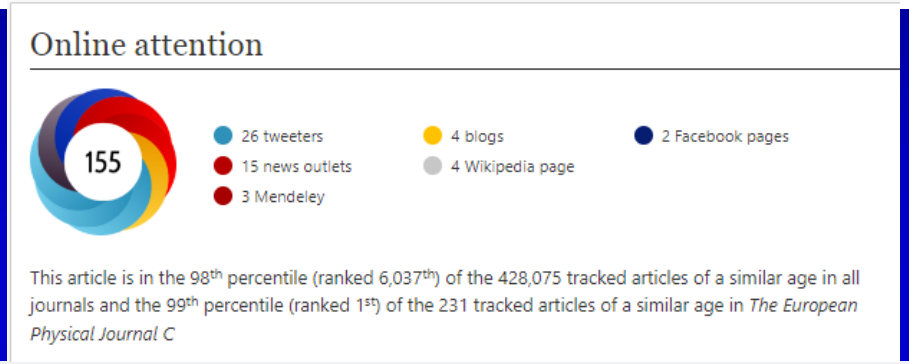
DE: *„Never be the first! It is too eary!"*
Prof. P. Carruthers ~ 1990

First papers with Odderon exchange signal > 5 σ

Evidence of Odderon-exchange from scaling properties of elastic scattering at TeV energies #5

T. Csörgő (Wigner RCP, Budapest and CERN), T. Novak (Unlisted, HU), R. Pasechnik (Lund U., Dept. Theor. Phys.), A. Ster (Wigner RCP, Budapest), I. Szanyi (Wigner RCP, Budapest) (Dec 26, 2019)

Published in: *Eur.Phys.J.C* 81 (2021) 2, 180 • e-Print: 1912.11968 [hep-ph]



Hungarian-Swedish team:
Eur. Phys. J. C (2021) **81**: 180, Published: 23 February 2021
https://doi.org/10.1140/epjc/s10052-021-08867-6

Observation of Odderon effects at LHC energies: a real extended Bialas–Bzdak model study #2

T. Csorgo (Wigner RCP, Budapest and EKU KRC, Gyongyos), I. Szanyi (Eotvos U. and Wigner RCP, Budapest) (May 28, 2020)

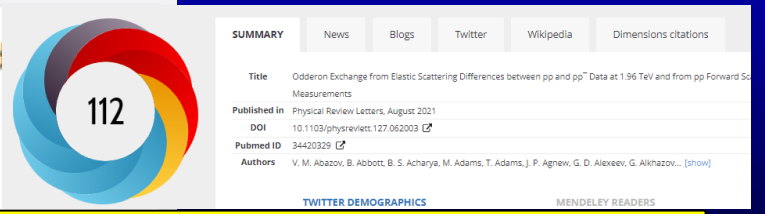
Published in: *Eur.Phys.J.C* 81 (2021) 7, 611 • e-Print: 2005.14319 [hep-ph]

Hungarian team, Polish-Hungarian model:
Eur. Phys. J. C (2021) **81**:611 , Published: 13 July 2021
https://doi.org/10.1140/epjc/s10052-021-09381-5

Odderon Exchange from Elastic Scattering Differences between pp and $p\bar{p}$ Data at 1.96 TeV and from pp Forward Scattering Measurements

TOTEM and D0 Collaborations • V.M. Abazov (Dubna, JINR) et al. (Dec 7, 2020)

Published in: *Phys.Rev.Lett.* 127 (2021) 6, 062003 • e-Print: 2012.03981 [hep-ex]



D0 and TOTEM Collaborations:
Phys. Rev. Lett. **127** (2021) 6, 062003, Published: 4 August 2021
https://doi.org/10.1103/PhysRevLett.127.062003

THANK YOU FOR YOUR ATTENTION !

QUESTIONS?