

Carlo Rubbia and CERN

Introduction to celebration of
Carlo Rubbia's 90th birthday and the 40th
anniversary of the announcement of the award
of the Nobel Prize

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Very Selective CV

- Born 31 March 1934 Gorizia
- Studied Physics at Scuola Normale Superiore Pisa
- Post Doc at Columbia University
- **CERN Staff** - from 1961 to 'retirement' in 1999: Director General 1989-1993
+ Higgins Professor at Harvard (1970-1988)
- Professor Pavia (1997-2006)
- President (1999-2005) Italian National Agency for New Technologies, Energy and the Environment (ENEA)
- Scientific Director (2010-2015) Institute for Advanced Sustainability Studies, Potsdam
- + **Nobel Prize** 1984, Italian Senator for Life 2013, numerous other honours, membership of academies, and awards – too numerous to list (2 pages of A4)

Carried out experiments at

Nevis, CERN (SC, PS, SPS, ISR), Fermilab, Brookhaven and Gran Sasso

I will mention some of the many particle physics experiments in which Carlo was involved, while focussing mainly on activities at CERN – especially the p-pbar collider, leaving Carlo's many contributions to detectors and energy to others

Inspire lists 771 publications, conference talks, proposals and reports by Carlo, although it does not include all his publications related to energy

In Pisa his thesis was on cosmic rays, under the guidance of Conversi, and he participated in work on the first pulsed gas particle detector (ancestor of spark and streamer chambers)

In the 1960s Carlo's work included studies of

- muon capture
- pi decay (beta decay and of π^+ to $e^+ \nu \gamma$)
- K_S - K_L regeneration, and time dependence of mixing

By the end of the 1960s he was being invited to speak at major conferences and had proposed a NAL neutrino experiment (HPW)

1970s – a few highlights

1971: Carlo studied small angle pp scattering at the ISR, followed in 1972 by finding evidence for a central rapidity plateau ...

October 1982: Carlo and I were founder members of the SPSC

This was my first encounter with Carlo. I was immediately impressed by the enormous breadth of his knowledge of physics, detectors, and accelerators, his quickness – he grasped points before anyone else – and his originality, and his deployment of English

Tearing hair out – NAL about to start (some comfort that Bob Wilson's focus was on the machine, rather than experiments): I was impressed by Wilson's 'build it quick, fix it later' philosophy, but later CERN benefitted from Adams having built a more reliable machine with a much better vacuum

April 1973: first HPW paper on neutrino and anti-neutrino cross-sections, followed by numerous papers on neutral currents, x and y distributions etc.

1977: proposed liquid argon time projection chamber (ICARUS): worked at Gran Sasso in 2010, now at Fermilab

The proton-antiproton collider 1*

*Based mostly on Chapter 6 of Vol 3 of the history of CERN which describes the heated discussions of technical and policy issues and personality clashes, 'warts and all'

Following commissioning of the ISR in 1972 thoughts turned to future projects

Discussions intensified as the SPS neared completion

Following a study by Burt Richter, while on sabbatical at CERN, major focus on LEP.

In April 1976 a study was set up, which reported in November:

PHYSICS WITH VERY HIGH ENERGY
 e^+e^- COLLIDING BEAMS

L. Camilleri, D. Cundy, P. Darriulat, J. Ellis, J. Field,
H. Fischer, E. Gabathuler, M.K. Gaillard, H. Hoffmann,
K. Johnsen, E. Keil, F. Palmonari, G. Preparata, B. Richter,
C. Rubbia, J. Steinberger, B. Wiik, W. Willis and K. Winter

Meanwhile in early 1976, encouraged by studies of electron-cooling at Novosibirsk, Rubbia, McIntyre and Cline proposed colliding protons with anti-protons at Fermilab. In June 1976 the PAC decided that it would be premature to choose between various schemes for reaching very high energies but recommended that exploration of very high energy proton-proton and antiproton collisions should continue.

In Europe, LEP was enthusiastically taken up ECFA, which led John Adams (Executive DG) to drop his initial opposition *provided* the tunnel was kept wide enough to accommodate a proton machine later: this was the origin of the LHC

While LEP emerged as the favoured major future project, other ideas were in play – Super Conducting **ISR**, CERN High Energy **EP**, and converting the SPS to run as a p-pbar collider – which was enthusiastically supported by Van Hove (Research DG), and not opposed by Adams (although he raised many question) who saw it as a 'budget filler'

The proton-antiproton collider 2

A group convened by Van Hove (which included Carlo) met to discuss p-pbar collisions on 6 Sept 1976

The CERN management's interest in p-pbar was reported to the SPC on 6-7 Sept, where according to Weisskopf 'all were agreed that it was a wonderful opportunity' although Veltman expressed doubts, and in the following weeks 'Scepticism not to say downright hostility from John Ellis and Tini Veltman was brushed aside' in the words of Krige

CERN set up groups to look at the technical aspects (led by Bonaudi and van der Meer) and the physics (led by Pope), which were discussed in an open meeting in November 1976, and initiated cooling studies

Germany and the UK were looking for ways to cut the budget, so Adams and Van Hove decided to treat the collider as an SPS experiment which would not need the Council's approval

In early 1977 Carlo Rubbia wrote a report on the feasibility of p-pbar in the SPS, and on 1 March wrote a letter to 30 physicists at CERN and in its Member States + Dave Cline, inviting them to a study week to discuss a possible detector

With competition with Fermilab driving CERN's plans forward, and vice-versa, the CERN management set about selling the project to the SPC, the users and the Council

Opposition came from a number of people, including Veltman and Jentschke, who argued that at a time of economic stringency CERN should not do something which would otherwise be done by Fermilab, and others (especially in the UK) who liked CHEEP and SCISR

Adams countered this by pointing out that in the SPS machine, not only were the magnets more reliable, but the greatly superior vacuum would give a beam lifetime of 18 hours, compared to 150 seconds at Fermilab

The proton-antiproton collider 3

Van Hove was keen to have more than one experiment – as a check, and to involve more physicists from a wide range of Member States

SPSC called for proposals by the end of January 1978

May 1978 SPSC: recommended approval of UA1 (Rubbia et al)
Did not commit to UA2 (Darriulat et al) or others

8 June 1978: the Executive Board officially decided to proceed with the p-pbar project and UA1

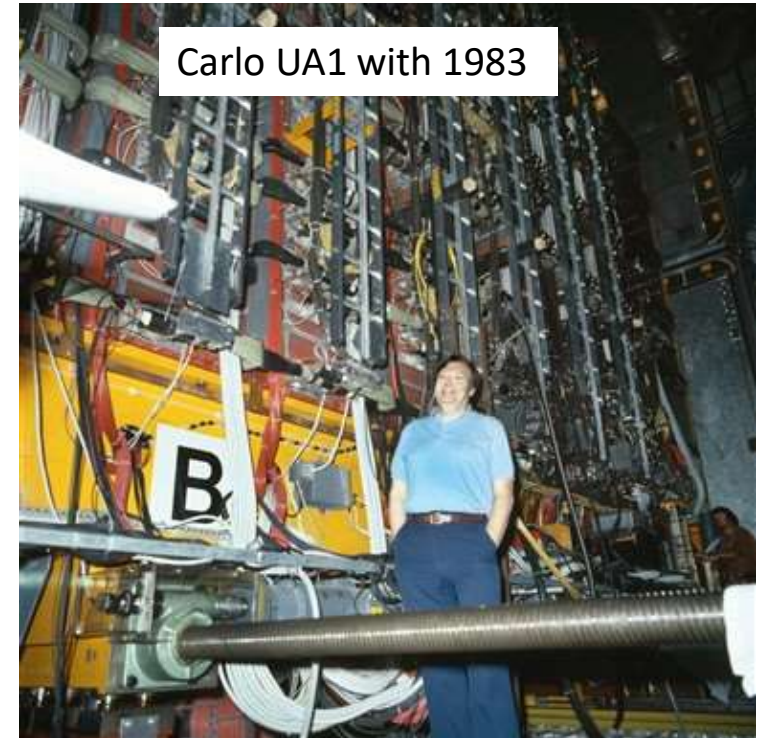
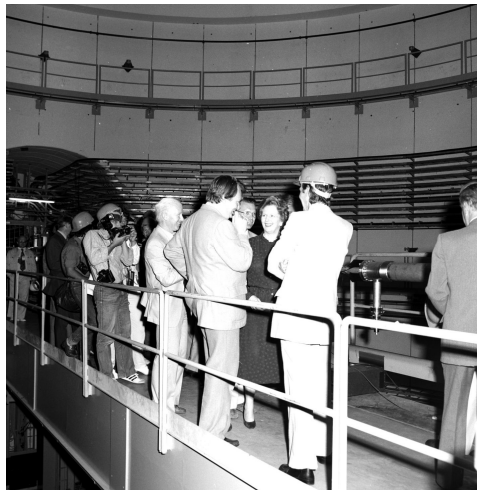
13 December 1978: the SPSC recommended approval of UA2, in competition with other proposals, including one for a large detector from Sam Ting

5 am on 10 July 1981: collisions observed in UA1



With Dalai
Lama 1983

Mrs Thatcher visits UA1
August 1982



Carlo UA1 with 1983

The proton-antiproton collider 4

Press Conference announcing the discovery of the W
21 January 1983



Press Conference announcing the
discovery of the Z, 1 June 1983



Numerous papers
followed on other
measurements at
the collider, jets etc



Stockholm
10 December 1984

Meanwhile

At CERN: Herwig Schopper (DG) had obtained the approval of LEP in October 1981

In the USA:

While a HEPAP subpanel (of which Carlo and John Adams were members) was considering the future of Isabelle (a 200 GeV x 200 GeV collider at BNL), which had run into trouble, on 6 June 1983 the New York Times published an opinion piece with the title **Europe 3, US Not Even Z-zero** (3 being the gluon, the W and the Z), which read

A panel of physicists is meeting this week ...to decide the fate of the limping Brookhaven accelerator and to plan a new machine for the future.

The 3-0 loss in the boson race cries out for earnest revenge. The physics team needs to try harder, and coach Keyworth (President Reagan's Science advisor) should reward any sensible new strategy with management's full support.

On 1 July 1983, the HEPAP subpanel recommended cancelling Isabelle and, encouraged by Keyworth, pushing for a 40 TeV Superconducting Super Collider to 'regain US leadership'

Herwig's reaction was to announce an intention to make a further study of a proton ring in the LEP tunnel, which began later in 1983, in preparation for the International Committee for Future Accelerators (ICFA) seminar in Japan in May 1984. The climax of these studies was the Lausanne workshop in March 1984, at which I was theoretical convenor.



Carlo with Simon van der Meer and Sir Alec Merrison (Char of Council) at the LEP Ground Breaking Ceremony 1983

Lausanne Workshop and ICFA Seminar at KEK in Japan

- **Luminosity/energy trade-off** understood (and pressed by European theorists) but whether $10^{33} \text{ cm}^2 \text{ s}^{-1}$ could be used was questioned, e.g.
 - Huson (at Snowmass 1982) ‘ 10^{31} viable, 10^{33} not viable’
 - Carlo (BNL 1983 Summer School) ‘with regard to a luminosity as high as 10^{33} , it is a matter of learning how to handle it’
 - “Consensus at Lausanne Workshop that the number of events per bunch crossing should not exceed one”
[Today the number is typically 30, and it will be 140-200 at Hi Luminosity LHC. The experiments can cope thanks to a vigorous CERN R&D programme which started in 1986 with 40 MCHF funding from the Italian government (Zichichi’s LAA Project), while the luminosity is up to 2×10^{34} and expected to go to $5-7.5 \times 10^{35}$]
- **At the ICFA Seminar**, the SSC was presented as a national project, to regain national leadership, to the great annoyance of the Japanese

Note: SSC design luminosity was 10^{33} . Could have gone to 10^{34} , but 5 times synchrotron radiation, so either 5 x cooling or a larger aperture to allow insertion of a beam liner to absorb the radiation at higher temperature (as done at the LHC) – both would have increased the cost by an amount that was unthinkable by 1988 when there were cost problems

Until he became DG in 1989, Carlo was mainly occupied with UA1, but still found time to lead the **Long-Range Planning Committee (LRPC)** established by Council in December 1984

Impressively thorough and detailed report published December 1987 (254 pages including 3 Annexes), focused on reaching 1 TeV at constituent level. Two options

1. **LHC (13-15 TeV with 8-10 T magnets) at $\geq 10^{33}$ – pp** , not p pbar: needs R&D. Energy/luminosity trade-off noted.
2. **Linear e^+e^-** - huge step, needs R&D, with intermediate step

Recommend: vigorous R&D to allow a decision between options in 1989, taking into account the evolution of the world situation .

A decision then to construct the LHC would allow collisions in 1995

Conversely, by 1989 one should have better ideas on the technical problems in building a linear e^+e^- collider should that option seem most desirable

Reading between the lines LHC was clearly favoured, and it soon became the priority

Then and after he became DG on 1 Jan 1989, Carlo stressed that compared to the SSC

- the higher luminosity would largely compensate for the lower energy

- LHC would also offer heavy ion collisions, at unprecedented energy, and ep collisions (the intention then being to leave LEP in place)

and resisted a suggestion (liked by the Chair of Council J Rembser) that CERN might build the injector for the SSC

I witnessed these developments as a member (1986-1992) and chair (1990-1992) of the SPC, and DG Designate – September 1982-December 1983 (when Carlo involved me in decisions, and asked me to prepare the LHC proposal)

Engagement of the CERN Council

- The CERN Council (which set up the Long Range Planning Committee) was kept informed of plans for the LHC, which were met with varying degrees of enthusiasm, and scepticism as the Council was aware that the SSC was under construction
- A push by Carlo Rubbia, and Bill Mitchell – President of CERN Council (1990-93), kept the LHC on the agenda, and built up support in the community
- The LHC was presented in to a special open Council session in December 1991, at the end of which Mitchell presented a Council Resolution which *inter alia* stated that

‘the LHC is the right machine for the advance of the subject and the future of CERN’

and asked

‘for more detailed information on the project before the end of 1993 ‘so that Council may move towards a decision on the LHC’

This was an important forward, which might appear to be a ‘ratchet [no going back] moment’ in the history of the LHC. **However**, the German Delegation had made it clear that a number of conditions would have to be satisfied before the LHC could be approved, and even then there would be ‘no automatic next step as it might transpire that a decision was not yet appropriate or that the project would not be approved’.

While DG (1989-93), Carlo **oversaw**

The outstanding success of LEP, which consolidated CERN's position as the world's leading HEP lab

Major steps towards LEP 200

Finland (1991), Poland (1991), Czechoslovak Republic (1992), Hungary (1992) becoming members

kept the flame burning for the LHC, despite SSC being under construction

dealt with the challenges that confront DGs:



Addressing CERN staff following a meeting of the Council and a strike Dec 1989

while miraculously **finding** time to think about physics - energy amplifier, heavy ion fusion

and **enjoying** some lighter moments:



1st beam circulating in LEP July 1988



With his team at the end of his mandate

From the end of his mandate, through his 'retirement' to today, Carlo remained very active working on ICARUS, muon colliders, energy issues....

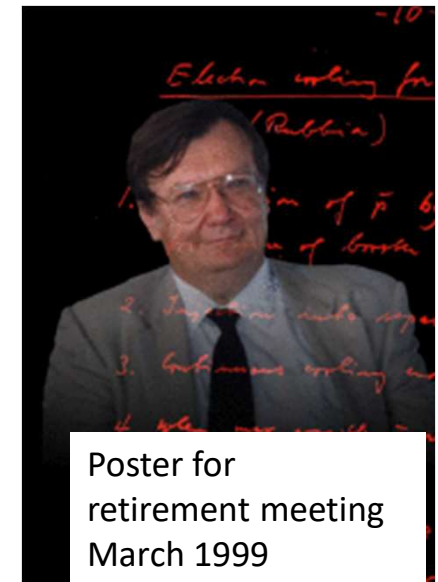
Colloquium on August 1998 "Neutrons in a highly diffusive medium: a new proposition tool for deep space exploration?"



Some incidents:



Meeting on the occasion of Carlo's 65th birthday



Poster for retirement meeting March 1999



Presentation on nuclear fusion 1989



Speaking on liquid argon imaging 2002



LHC control room 10 Sept 2008



75th birthday celebration 2009



50th Anniversary ISR 2021

In conclusion:

Carlo's imaginative and seminal contributions to a wide range of fields include

- advocacy of the p-pbar collider, design and leadership of UA1, and the discovery of the W and Z
- keeping the LHC flame burning and laying the ground for its approval

which ensure his major place in the history of CERN



Carlo earlier in 2024