Experimental Particle Physics at Pisa

from the Frascati Electron Synchrotron to the Fermilab Collider

Giorgio Bellettini

Contribution to the meeting

"Fisica e Fisici a Pisa nel 900"

Pisa, november 7-9, 2017

An amazing speed of growth

Around 1960, when the 1 GeV Frascati Electron-synchrotron, the first Italian particle accelerator, started operating, the Pisa Physics Department hosted just a handful of smart graduate students looking impatiently around, urging to do something of new and interesting. Among their teachers were Giorgio Salvini, Marcello Conversi, Carlo Franzinetti, Ludovico Radicati. With time, the community has grown enormously.It includes word-famous scientists, and has produced results which will stay forever in the physics books

1963: we were not 30 yet.

The $\gamma\gamma\pi^0$ coupling, and with it the π^0 lifetime, can be measured by means of the forward π^0 production on nuclei. In photoproduction at $\theta \approx 0$, the coupling of the incident photon with a quasi-real target photon of the nuclear field dominates over coherent nuclear production.

At the Frascati synchrotron we used a bremsstrahlung beam with $E\gamma$,max $\approx$ 1GeV.

The Primakoff peak

A strong Primakoff peak at $\Theta \approx \mu^2/2E^2$

μ = neutral pion mass

For γ energy ≈ 1 GeV, peak is at $\theta \leq 1^0$

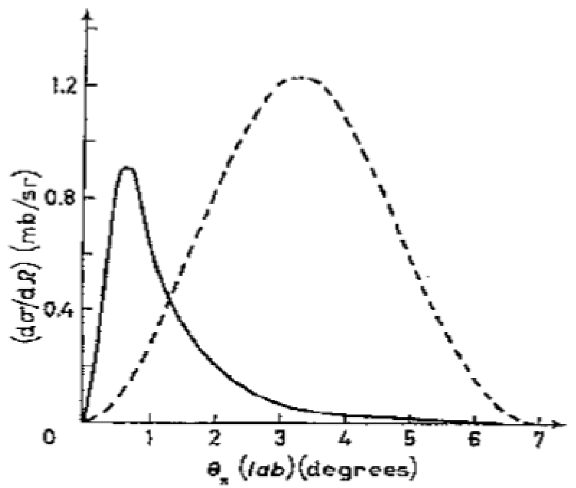
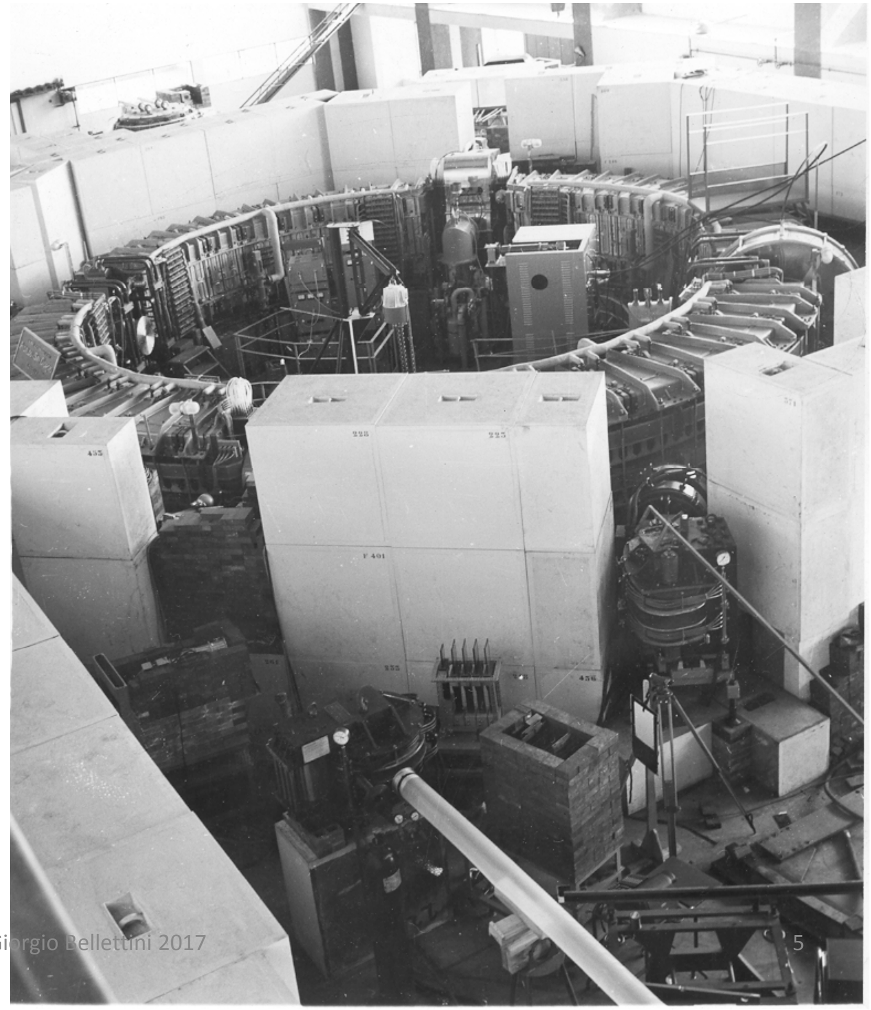


Fig. 1. – Angular behaviour of the electromagnetic and nuclear cross-sections (2.4) and (2.7) in lead, in the 1 GeV energy range: —— electromagnetic ($\tau = 10^{-16}$ s); – – – nuclear ($C = 25$ mb/sr).

On the photon beam at Frascati

The Frascati electron synchrotron

$E_\gamma \approx 1000$ MeV



The Primakoff peak seen for the first time

Four physicists tutored by Ted Bellamy designed for Frascati a forward π^0 photoproduction experiment with angular resolution $\Delta\theta \approx 1^0$.

They and their smart technicians built the detector in-house, run the experiment and measured the π^0 lifetime by observing the Primakoff effect.

At Frascati, year 1983

A.Bechini L.Foa` G.Bellettini

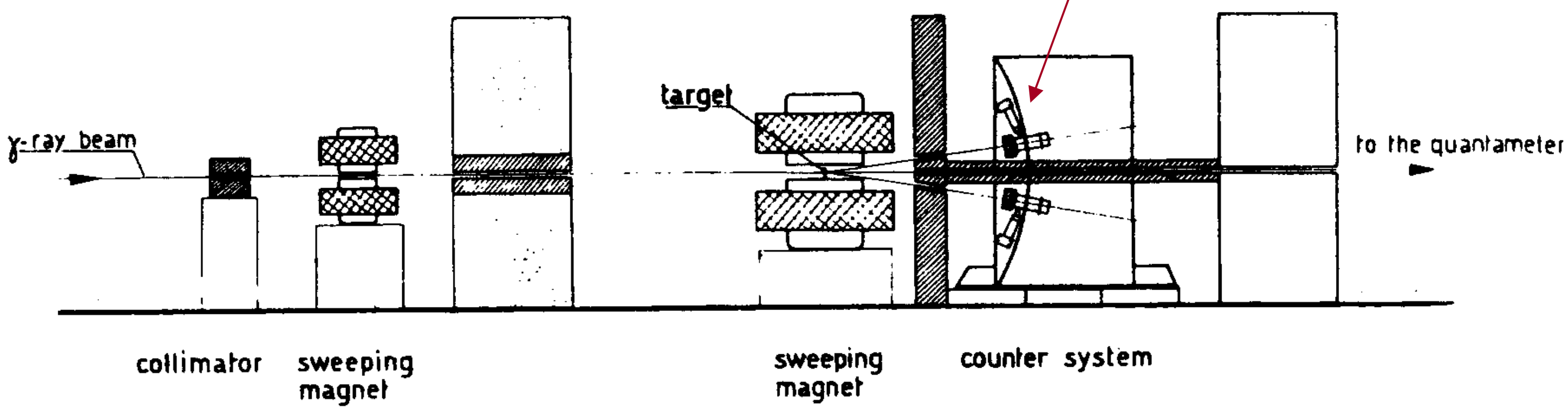
P.L.Braccini C.Betti A.Mariotti C.Bemporad I.F.Quercia E. Gradl

The Primakoff spectrometer at Frascati

$\pi^{0`} \rightarrow \gamma\,\gamma$ seen by two Pb-glass Cerenkoff counters

$$\gamma A \rightarrow \pi^0 A, \quad \theta \cong 0$$

Volume 18, number 3 PHYSICS LETTERS 1 September 1965



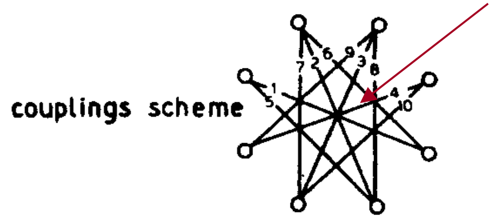


Fig. 1. Experimental layout (side view). The schematic front view of the counter system illustrates the 10 couplings between the top and the bottom counters. With a top energy of the bremsstrahlung beam of 1.05 GeV, channels 1 to 4 and 5 to 10 detected pions of 0.95 and 1.00 GeV mean energy, respectively.

The data

Pulse heights of $\gamma\gamma$ events

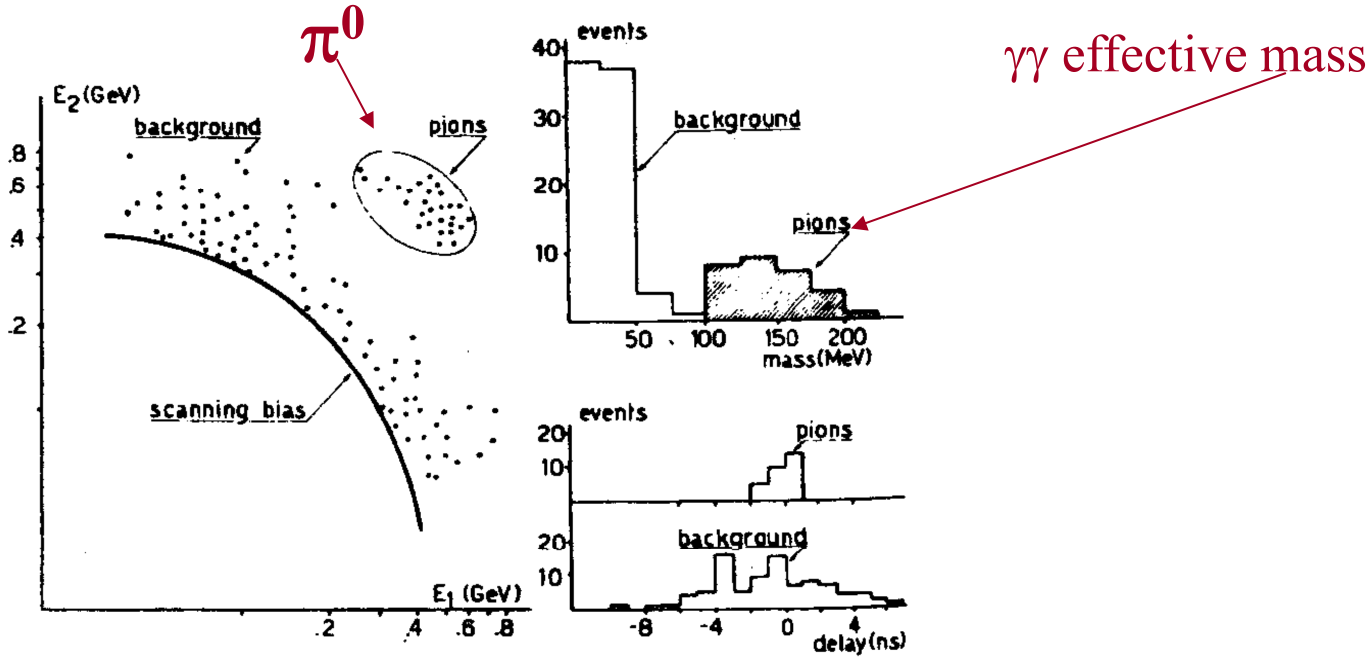
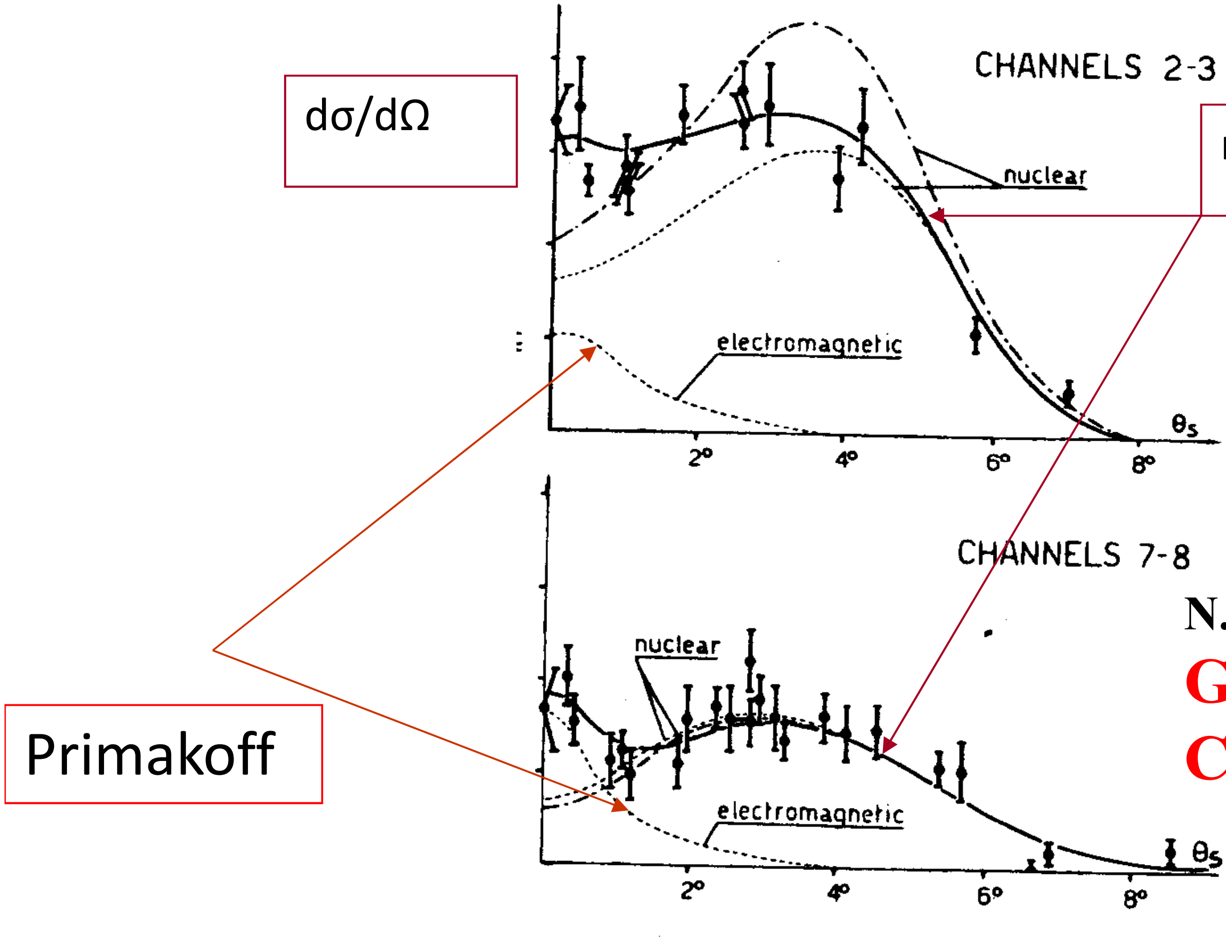


Fig. 2. Typical plot showing the pulse height correlation for gamma-gamma events, and the corresponding mass distribution if each event is attributed to the decay of a single particle into two photons. The delay histograms for events inside and outside the pion locus. as discussed in the text, are also given.

The small angle Primakoff peaks



N. Cim. XL A, 21 Dec. 1985

G. Bellettini, P.L. Braccini, C. Bemporad, L. Foa`

The π^0 lifetime in 1965

$$\tau = (0,74 \pm 0,105) \cdot 10^{-16}\ \text{sec}$$

Quoted on P.D.G. (year 2003):

$$\tau = (0,84 \pm 0,06) \cdot 10^{-16}\ \text{sec}$$

The η Primakov effect at DESY
Br($\eta \to \gamma\gamma$) ~ 40%

EXPERIMENTAL DETERMINATION OF THE η LIFETIME BY THE MEASUREMENT OF THE PRIMAKOFF EFFECT

C. BEMPORAD*, P. L. BRACCINI and L. FOÀ
Istituto di Fisica dell'Università di Pisa and Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, Pisa, Italy

and

K. LÜBELSMEYER and D. SCHMITZ
Physikalisches Institut der Universität Bonn, and Kernforschungsanlage Jülich, Germany

Received 26 August 1967

An expe iment for determining the η lifetime has been performed at DESY. The cross section for η photoproduction has been measured between 0^{o} and 4^{o}, at 4.0 GeV and 5.5 GeV incident γ ray energies and on different target materials (lead, silver, zinc).

η's were detected through their γ-γ decays.

The production is dominated by the Primakoff effect from which a value of $\Gamma_{\gamma\gamma} = (1.21 \pm 0.26)$ keV is derived.

The Pisa photon detector at DESY in 1986

The Pisa result (1967):

$\Gamma_{\gamma\gamma}$ = (1,21 ± 0,26) KeV

P.D.G. (2003):

Γ_{η} = (1,18 ± 0,11) KeV

C. Bemporad
P.L. Braccini
L. Foa`
K. Lubelsmeyer.
D. Schmitz

At NINA (Daresbury) from 1969 to 1973

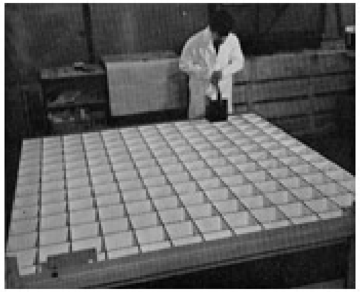
$$e^- + p \rightarrow e^- + \pi^+ + n$$

A.Giazotto A.Del Guerra M.Giorgi A.Stefanini (not in slide)

Piero Salvadori

$$e^- + p \rightarrow e^- + \pi^+ + n$$

The Pisa neutron detector at NINA



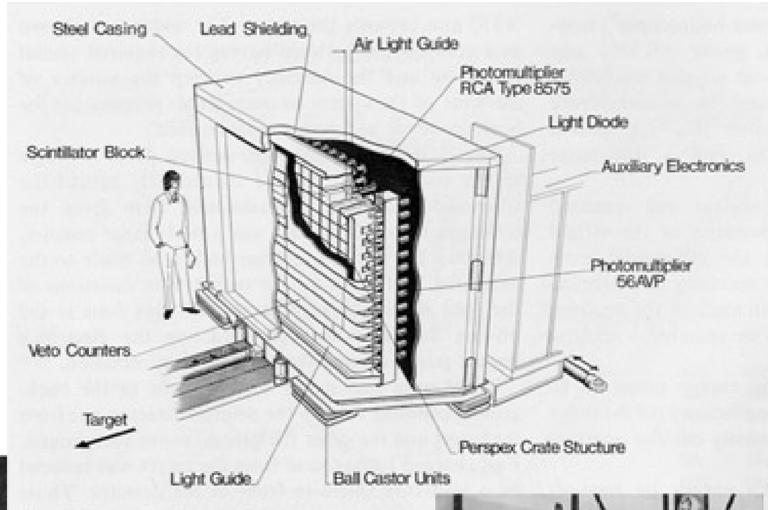
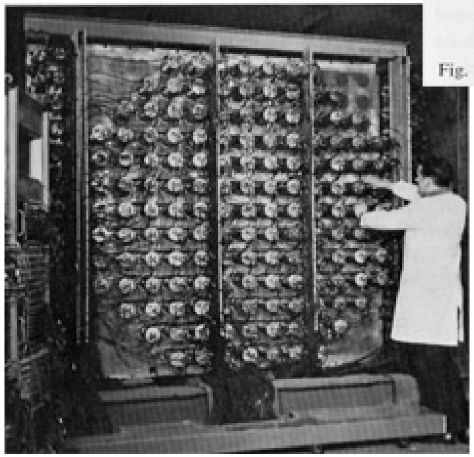
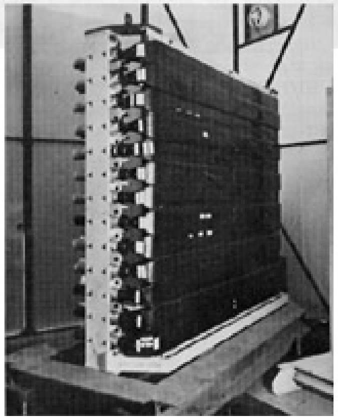


Fig. 3. Schematic diagram of the neutron counter.





The neutron detector was the main piece of hardware built in Pisa

The NINA electroproduction paper in 1975

A. Del Guerra
A. Giazotto
M. Giorgi
A. Stefanini

MEASUREMENTS OF THRESHOLD π^+ ELECTROPRODUCTION AT LOW MOMENTUM TRANSFER

A. DEL GUERRA, A. GIAZOTTO, M.A. GIORGI and A. STEFANINI
Istituto di Fisica dell'Università, Piazza Torricelli 2, I 56100 Pisa, Italy
and
Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, Via Livornese, S. Piero a Grado, I 56010 Pisa, Italy

D.R. BOTTERILL, D.W. BRABEN ‡, D. CLARKE and P.R. NORTON
Daresbury Laboratory, Daresbury, Warrington WA4 4AD, England

Received 18 August 1975

The reaction $e^- + p \to e^- + \pi^+ + n$ has been studied near threshold at momentum transfers $|k^2|$ of 0.078, 0.155, 0.233 and 0.311 $(\mathrm{GeV}/c)^2$. The slope of the total cross section evaluated at threshold has been compared with models based on PCAC and current algebra to deduce the axial vector form factor of the nucleon, $G_A(k^2)$. In the dipole parametrisation $G_A(k^2)/G_A(0) = (1 + |k^2|/M_A^2)^{-2}$ we find that the models give values of M_A ranging between 1.0 and 1.2 GeV. The $\pi^+ n$ angular distributions are compared with fixed-*t* dispersion relations and with a pseudovector Born approximation and are found to be in good agreement.

The “Russia campaign”
(the NICE experiment)

E.Bertolucci
I.Mannelli
G.M.Pierazzini
A.Scribano
F.Sergiampietri
M.L.Vincelli

$$\pi^- p \rightarrow X^0 n$$

from 1971 to 1976

↓

go to Angelo Scribano

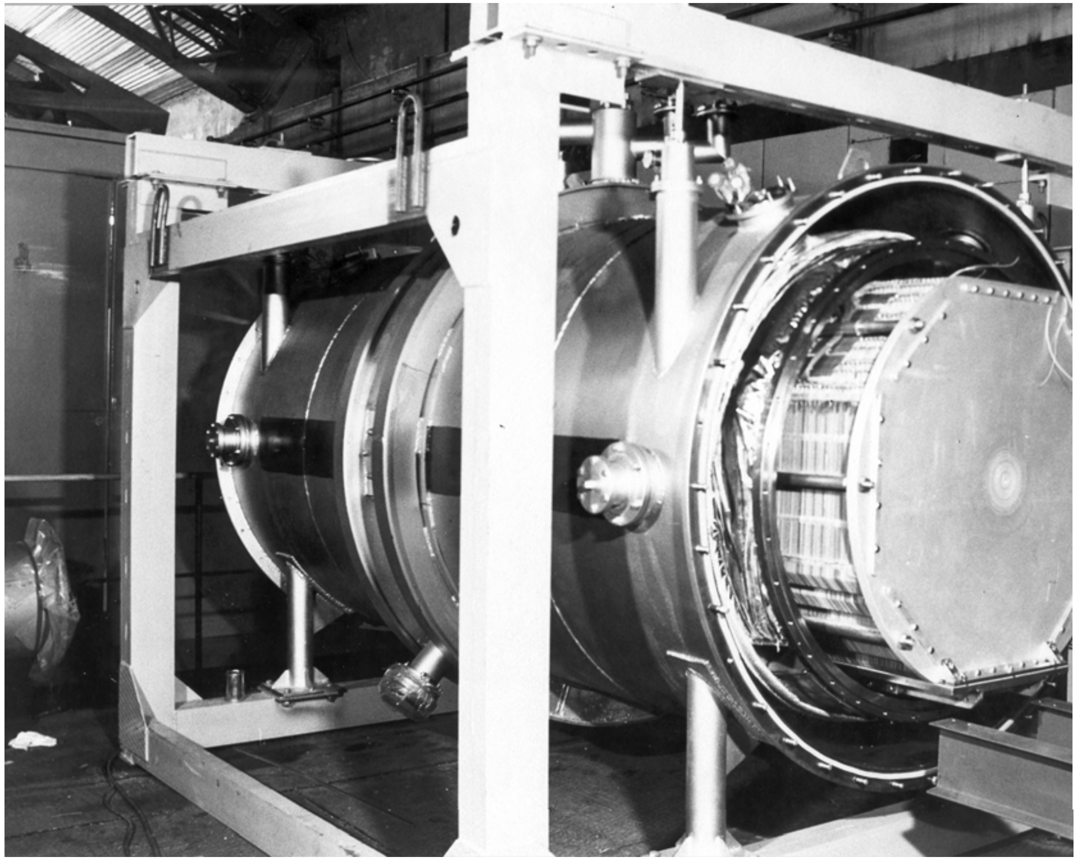
Tagged Neutrino Experiment TNE at Protvino

F. Sergianpietri C. Cerri R. Castaldi V. Flaminio

A follow-up of NICE

The TNE liquid Argon calorimeter
1978

Designed and fabricated
by
Claudio Cerri
Franco Sergianpietri



A telephone call to Frascati by night on November 11,1974

An excited Sau Lan Wu calling G.B. from BNL:

"We have found a new particle!"
"What is so special about it?"
"It is very heavy and very narrow! It decays into e^+e^- "
"How heavy?"
"About 3.1 GeV."

In the conversation we considered that Adone`s energy could possibly be stretched to reach that value.

Discovery of the J particle

J.J Auber et al., Phys. Rev. Letters, 33 (1974)

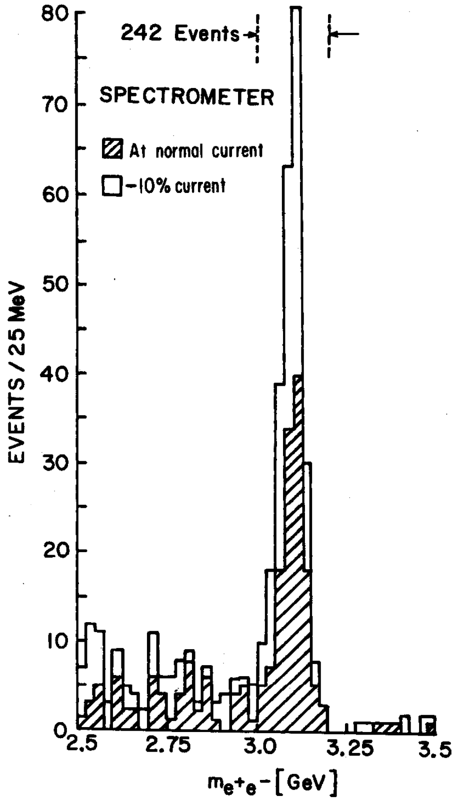


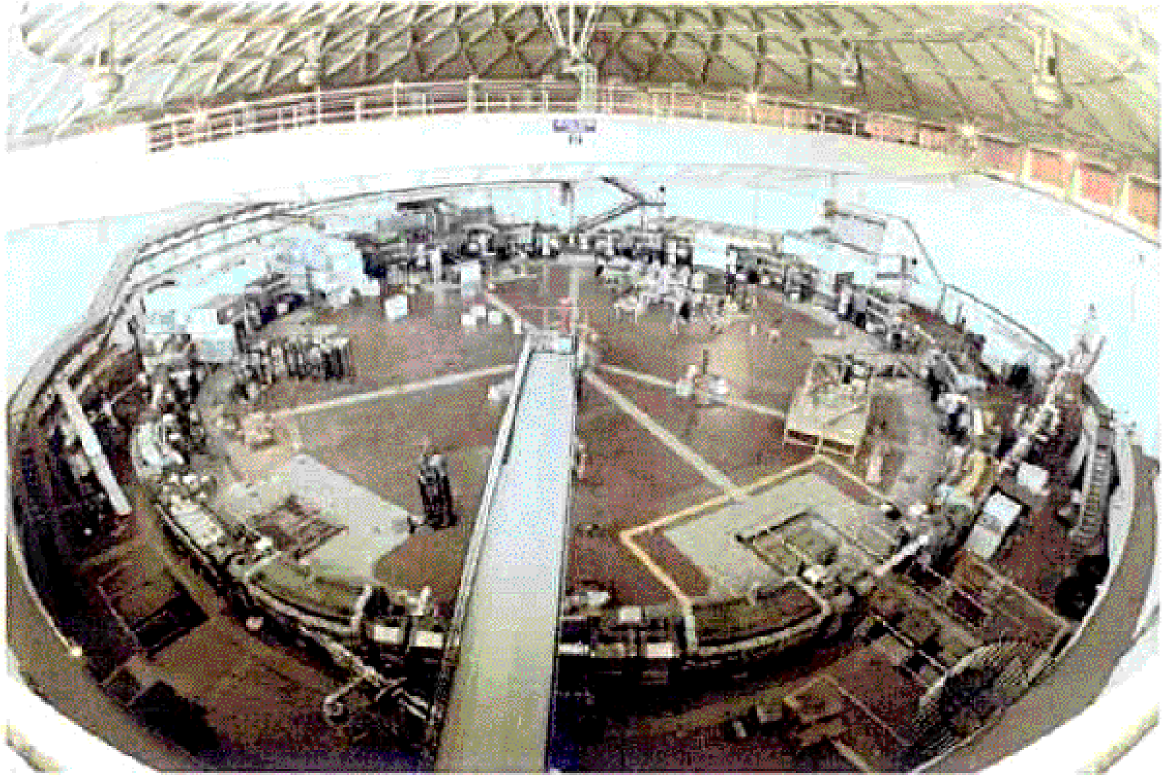
FIG. 2. Mass spectrum showing the existence of J. Results from two spectrometer settings are plotted showing that the peak is independent of spectrometer currents. The run at reduced current was taken two months later than the normal run.

The E598 experiment was proposed on May 11, 1972

The first data were collected in May 1974.

The "J" discovery was announced on November 11, 1974.

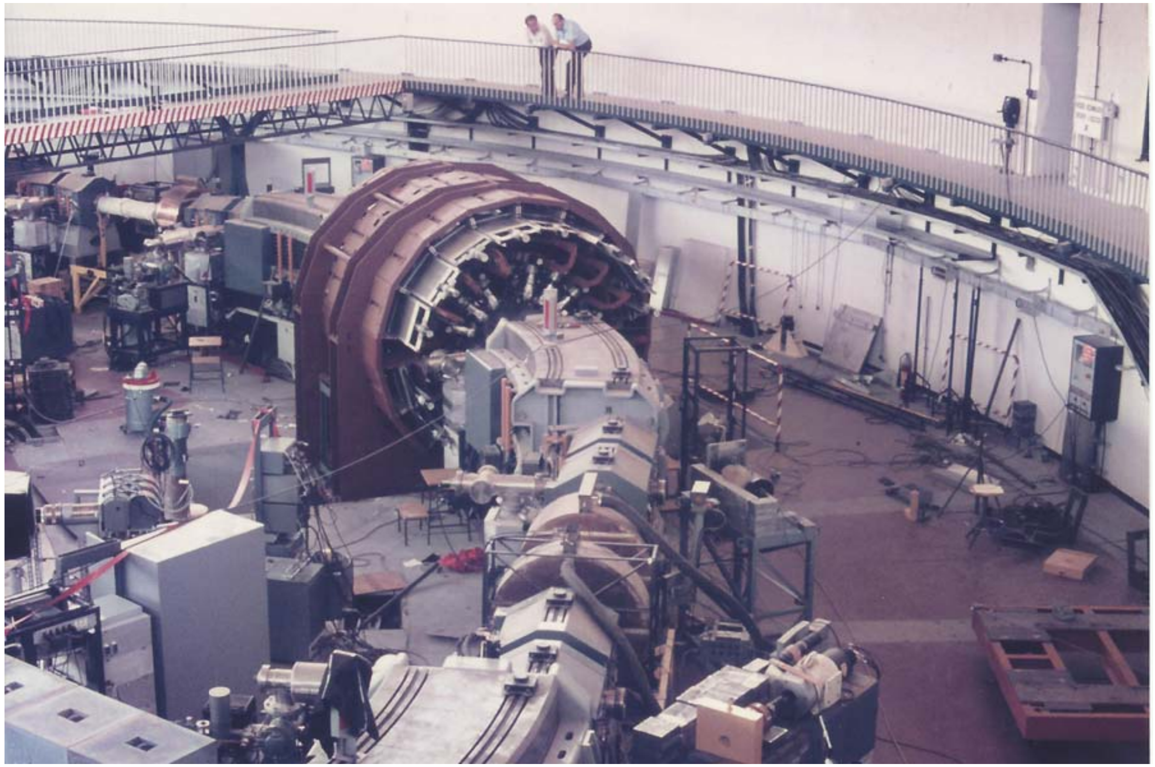
ADONE
1969-1993



With a design energy of 3.0 GeV,
Adone used to run at 2.8 GeV.

Second generation experiments:
MEA,
γγ,
Barion-Antibarion

The Barion-Antibarion experiment



A cilindrical detector around the beam line

C. Bemporad
M. Calvetti,
F. Costantini,
P. Lariccia

Frascati, ISS, Naples, Pisa Collaboration

7 days from hearing to publishing

Info received: night of November 11th

Resonance found at ADONE: November 13th

Data collected, paper written: November 17th

Paper-by-phone from G.B. to S. L. W.: night of November 17th

Paper received by P.R.L: November 18th.

Paper published in the same PRL, in line after BNL and SLAC.

The amazing spelling mistakes

Preliminary Result of Frascati (ADONE) on the Nature of a New 3.1-GeV Particle Produced in e^+e^- Annihilation*

C. Bacci, R. Balbini Celio, M. Berna-Rodini, G. Caton, R. Del Fabbro, M. Grilli, E. Iarocci, M. Locci, C. Mencuccini, G. P. Murtas, G. Penso, G. S. M. Spinetti, M. Spano, B. Stella, and V. Valente
The Gamma-Gamma Group, Laboratori Nazionali di Frascati, Frascati, Italy

and

B. Bartoli, D. Bisello, B. Esposito, F. Felicetti, P. Monacelli, M. Nigro, L. Paolufi, I. Peruzzi, G. Piano Mortemi, M. Piccolo, F. Ronga, F. Sebastiani, L. Trasatti, and F. Vanoli
The Magnet Experimental Group for ADONE, Laboratori Nazionali di Frascati, Frascati, Italy

and

G. Barbarino, G. Barbiellini, C. Bemporad, R. Biancastelli, F. Cevenini, M. Celvetti, F. Costantini, P. Lariccia, P. Parascandalo, E. Sassi, C. Spencer, L. Tortora, U. Troya, and S. Vitale
The Baryon-Antibaryon Group, Laboratori Nazionali di Frascati, Frascati, Italy
(Received 18 November 1974)

We report on the results at ADONE to study the properties of the newly found 3.1-BeV particle.

The Frascati result

C.Bacci et al., Phys.Rev.Lett. 33, 1408, 1974

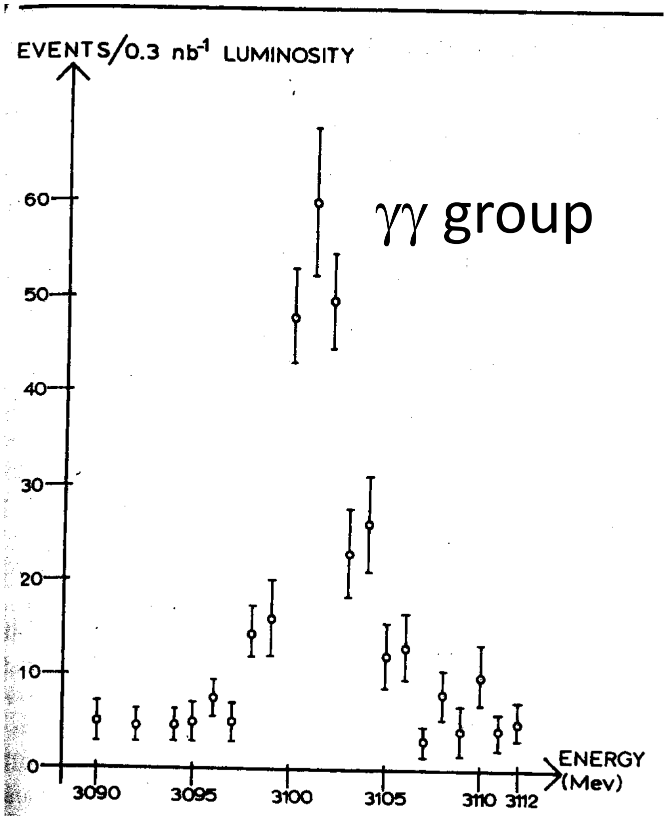
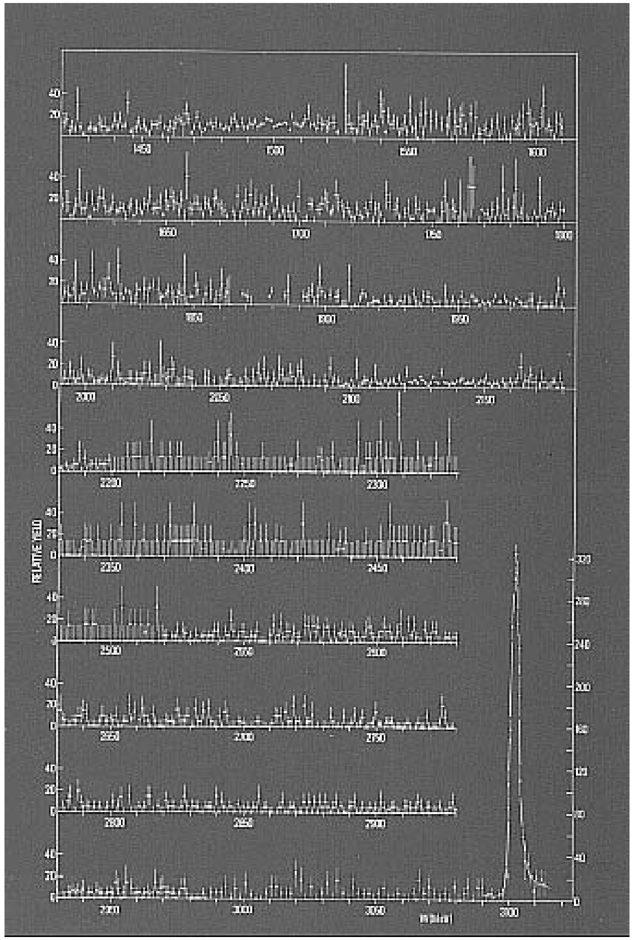


FIG. 1. Result from the Gamma-Gamma Group, total of 446 events. The number of events per 0.3 nb^{-1} luminosity is plotted versus the total c.m. energy of the machine.

All Adone groups reported a similar evidence.

Adone found the ψ much faster than Doris, where it was observed only on November 19th.

Search for narrow resonances below the J/ψ



One year earlier this would have been a triumph for Adone

The birth of the hadron colliders: ISR in 1970

p-p collision up to $\sqrt{s} = 62$ GeV

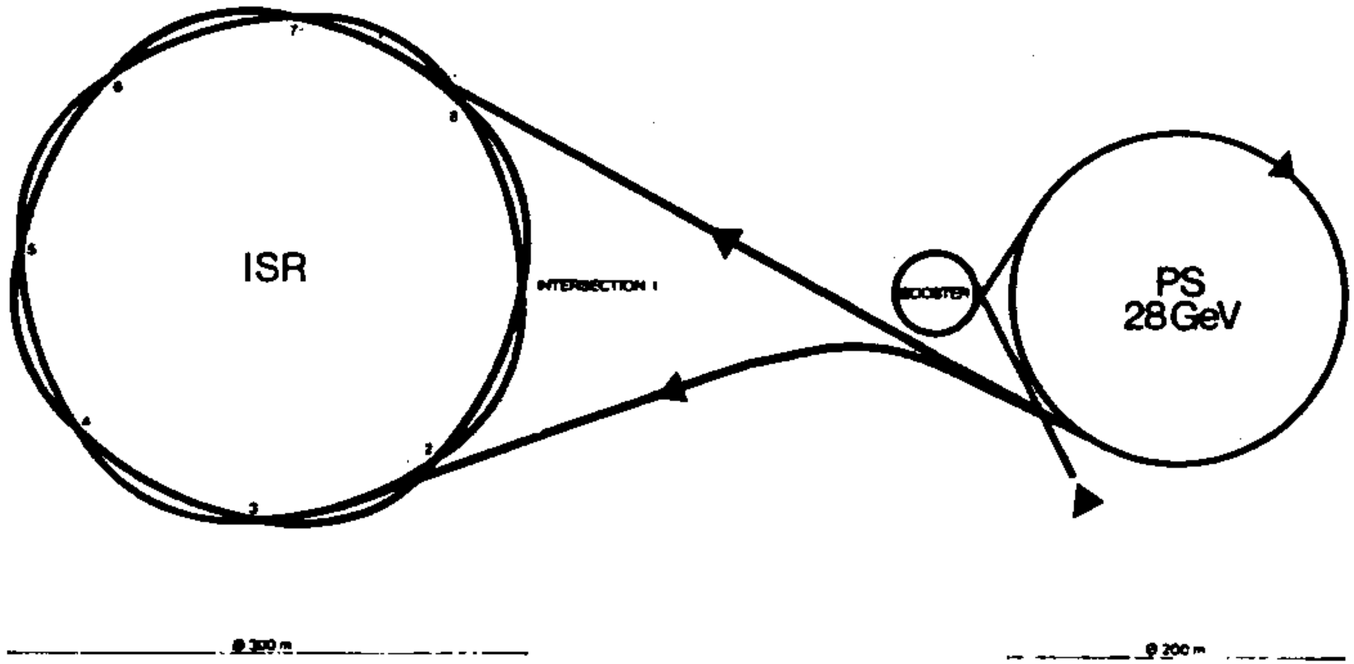
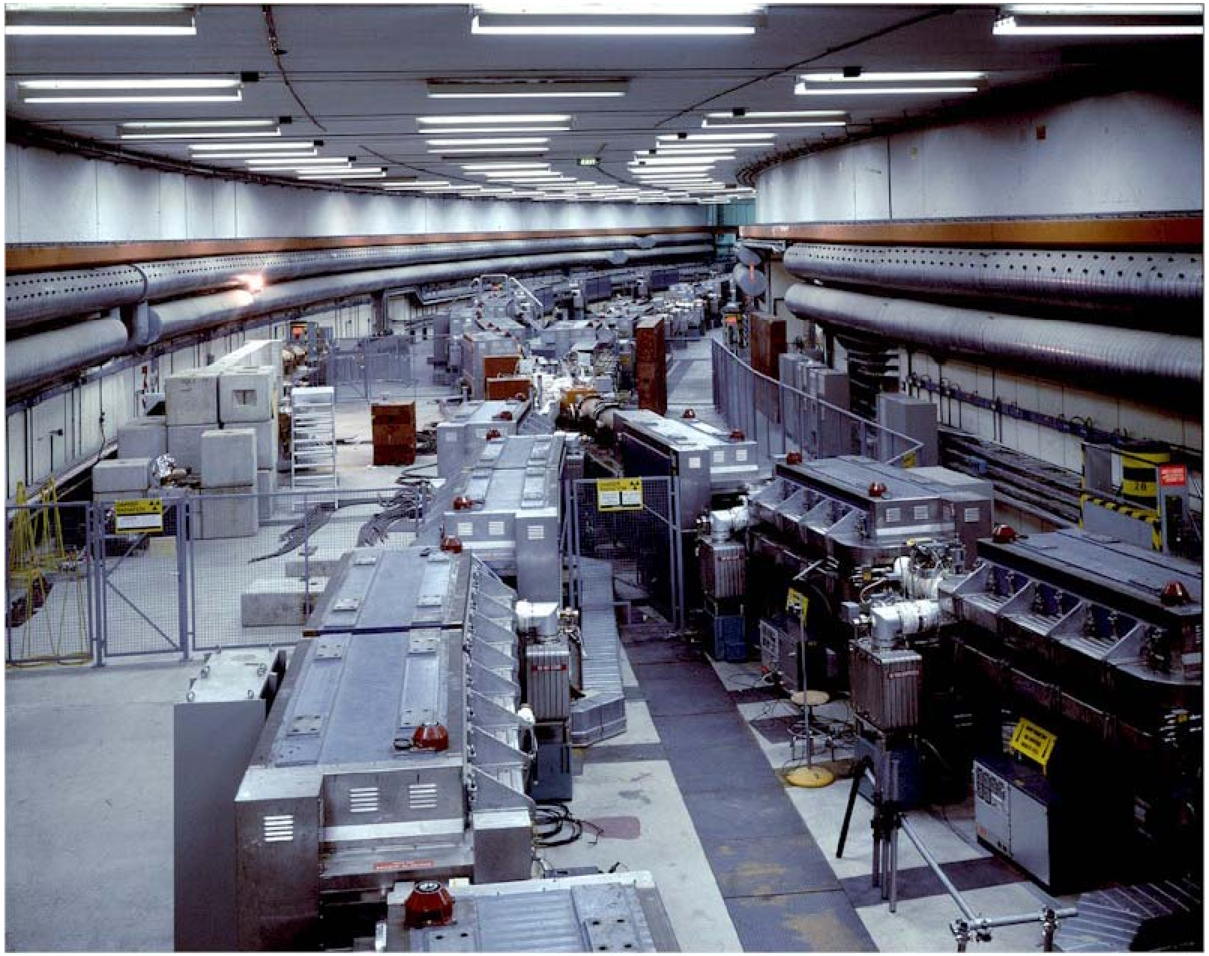


Fig. 2.1. Schematic view of the PS and ISR rings.

Two proton beams in the ISR tunnel



The R801 collaboration at the ISR
Pisa-Stony Brook

MEASUREMENT OF THE TOTAL PROTON-PROTON CROSS-SECTION AT THE ISR ☆

S.R. AMENDOLIA, G. BELLETTINI*, P.L. BRACCINI, C. BRADASCHIA,
R. CASTALDI**, V. CAVASINNI, C. CERRI*, T. Del PRETE,
L. FOA*, P. GIROMINI, P. LAURELLI, A. MENZIONE,
L. RISTORI, G. SANGUINETTI, M. VALDATA,
Istituto Nazionale di Fisica Nucleare, Sezione di Pisa
Istituto di Fisica dell'Università, Pisa
Scuola Normale Superiore, Pisa, Italy

G. FINOCCHIARO, P. GRANNIS*, D. GREEN, R. MUSTARD and R. THUN
State University of New York, Stony Brook, New York, USA

Received 23 February 1973

The first 4π detector at a hadron collider.

Pisa-Stony Brook

G. Giacomelli and M. Jacob, Physics at the CERN-ISR 17

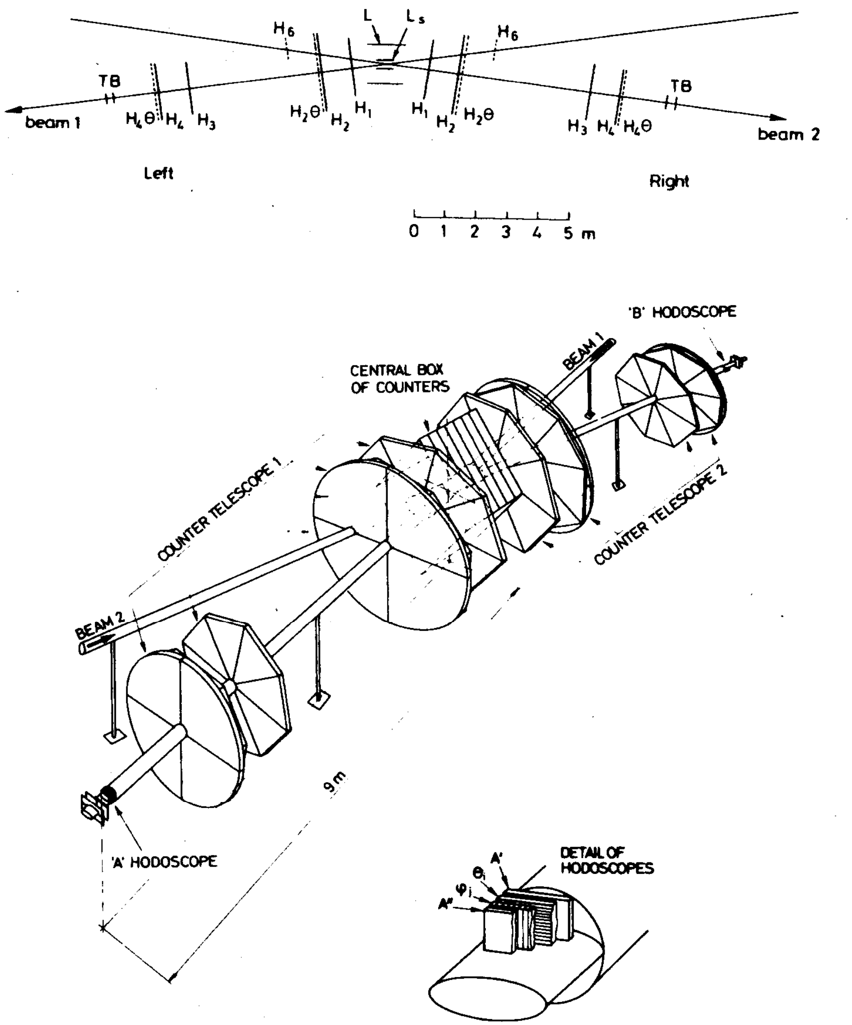
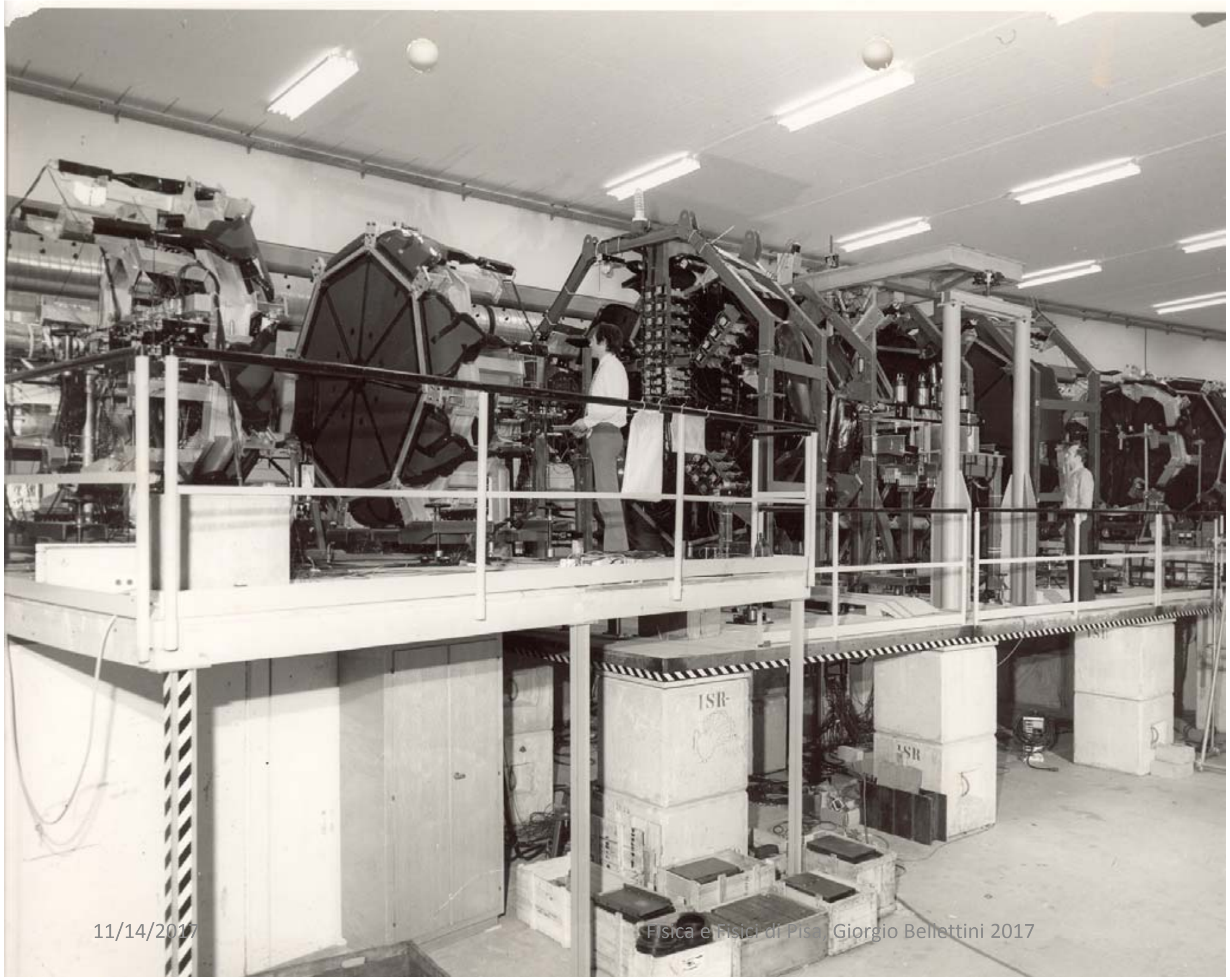


Fig. 4.1. Layout of the proton–proton cross section measurement performed at the ISR. A system of counter hodoscopes (H, L) surrounding the intersection region, counts almost all the interactions and allows an extrapolation to 4π coverage. The H_i hodoscopes are binned in the φ direction; the $H_i\Theta$ hodoscopes are split into Θ-bins; the L-hodoscopes are four planes of x- and y-counters interspersed with lead plates; TB are triggering counters (R801).

The total pp cross section was measured as it is defined:

$$\sigma_t(cm^2) = \frac{R(s^{-1})}{L(cm^{-2}s^{-1})}$$

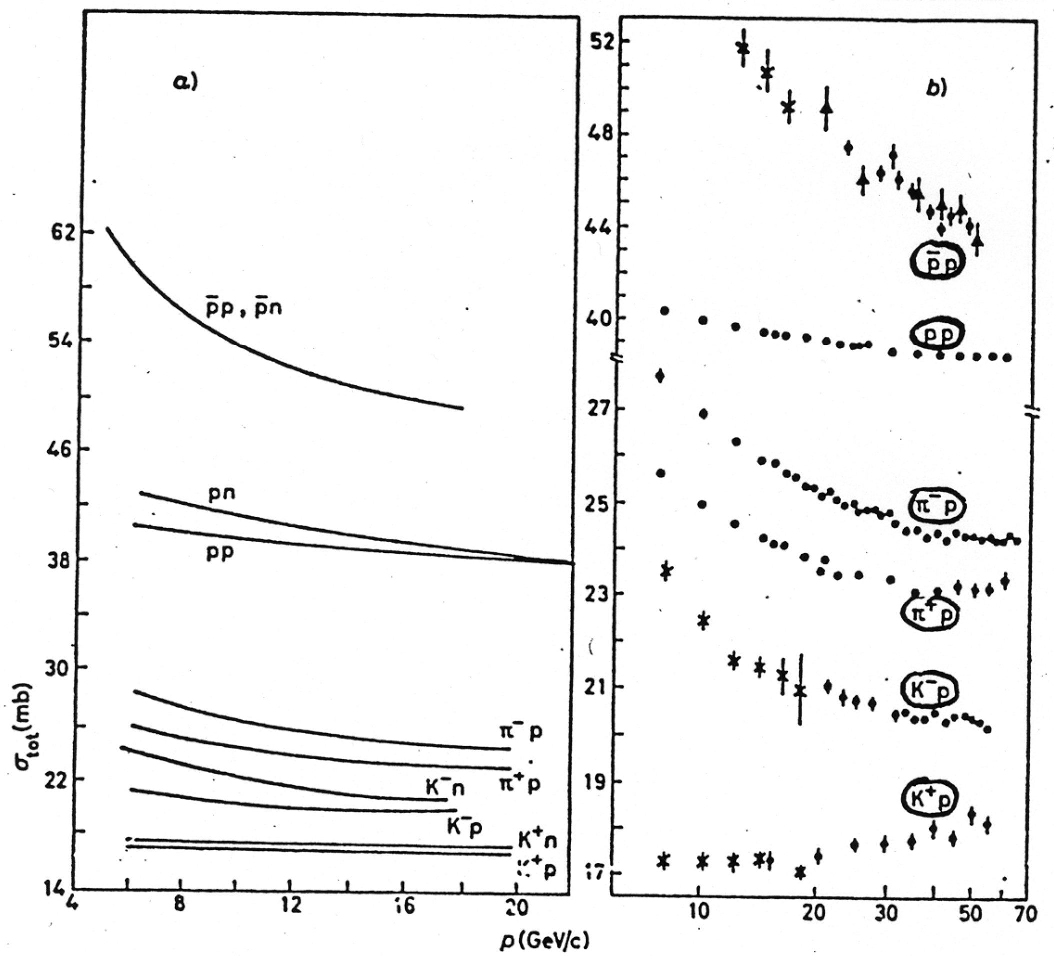
The R801 detector **1973**



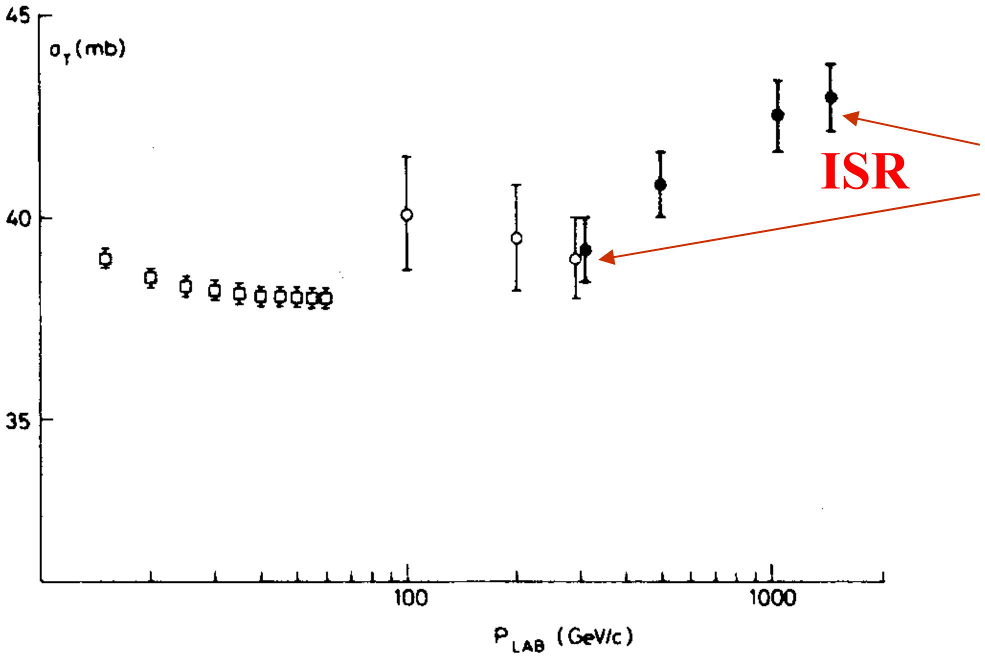
A cyclopean endeavor for Pisa at that time

Total hadron cross sections before the ISR

In the 70`s, all hadron cross sections seemed to be approaching (someone from below) a constant value at asymptotic energy.



A R801 discovery: $\sigma_t(pp)$ was increasing with energy



S.R.Amendolia, et al., Phys. Lett. 44B 1,1973.

Fig. 3. Plot of the results versus equivalent beam momentum. The Serpukhov [5] and NAL [6–8] data are shown for comparison. ▫: Data of ref. [5]. ○: Data of refs. [6–8]. ●: This experiment.

R801 diffraction studies

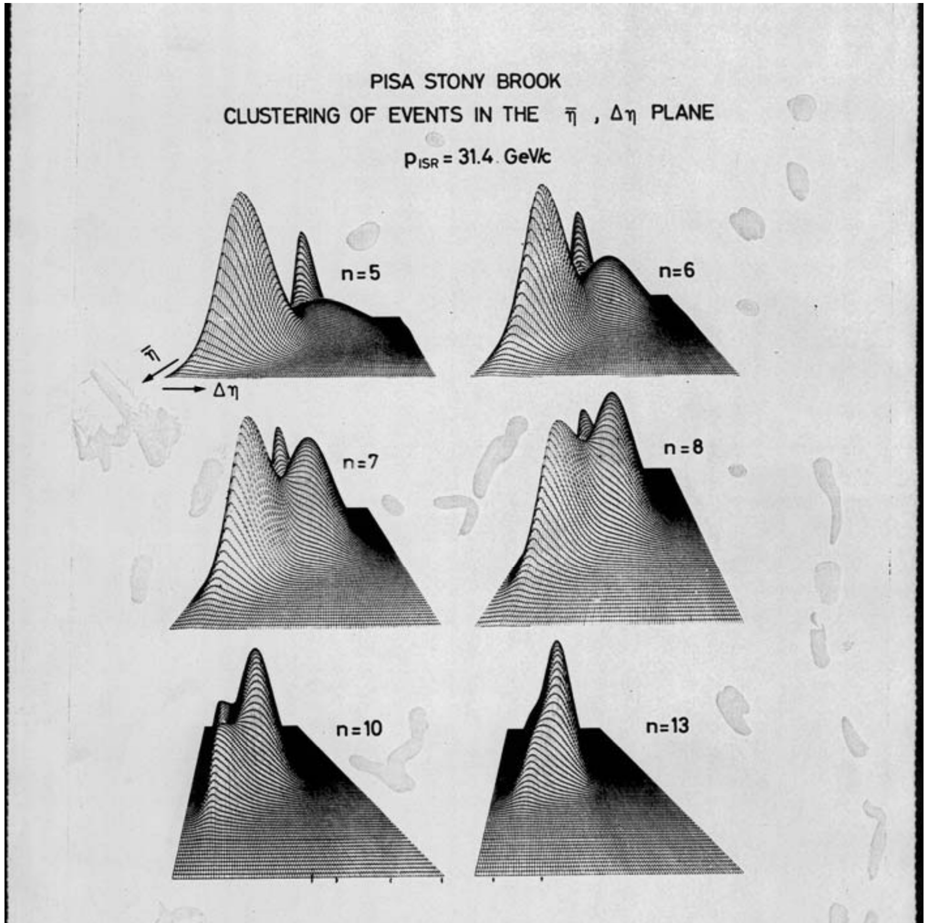


Fig. 16 Three-dimensional view of event distribution in the <η>, Δη plane, for various multiplicities at p_{ISR} = 31.4 GeV/c.

The correlations among secondaries were measured in inelastic events.

Diffracted protons were seen in a pictorial way in low multiplicity inelastic events.

Events grouped in bumps when azimuthal angle was plotted versus average pseudorapidty ("LE PUPPE").

The MIT-Pisa R209 detector
search for $Z \rightarrow \mu^+\mu^-$

1980

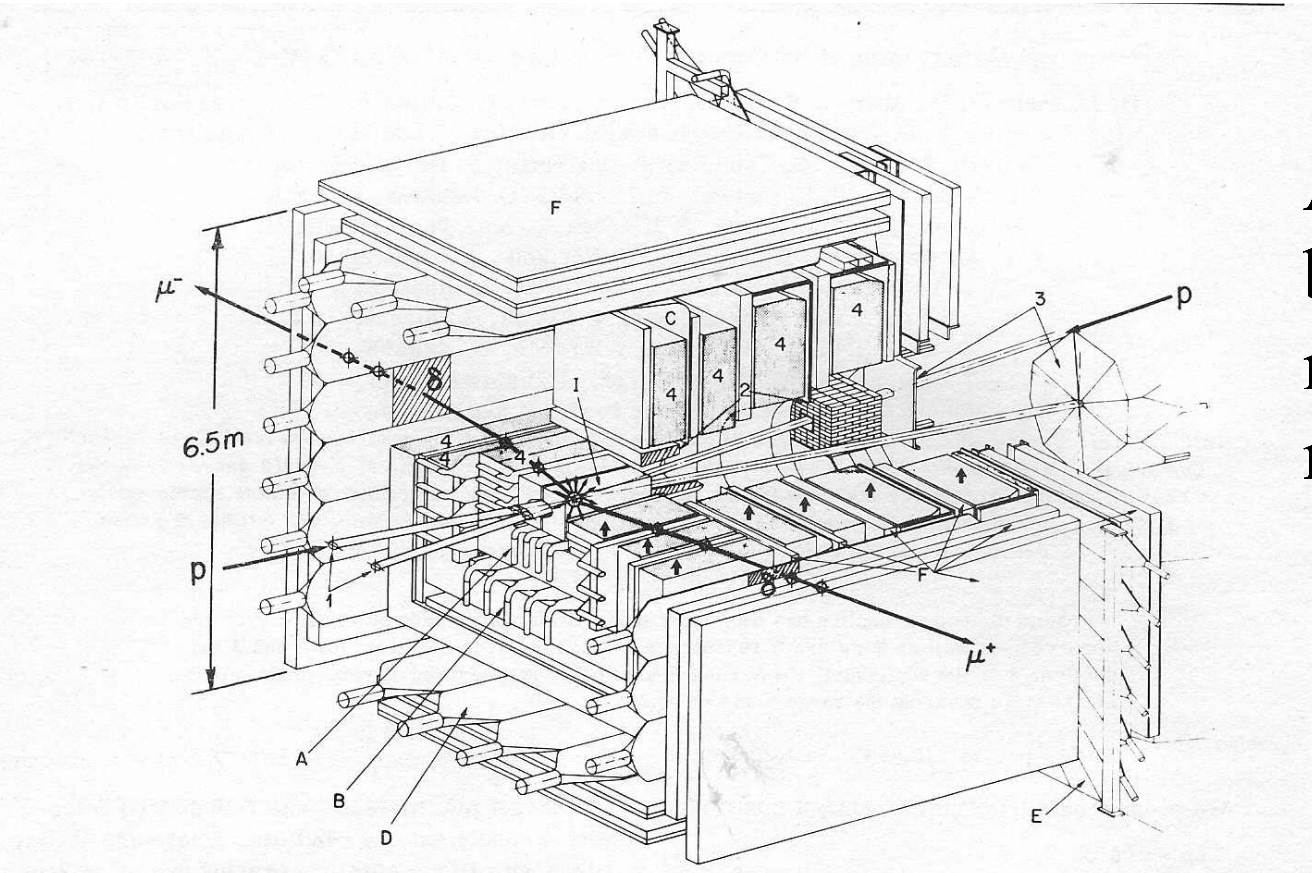


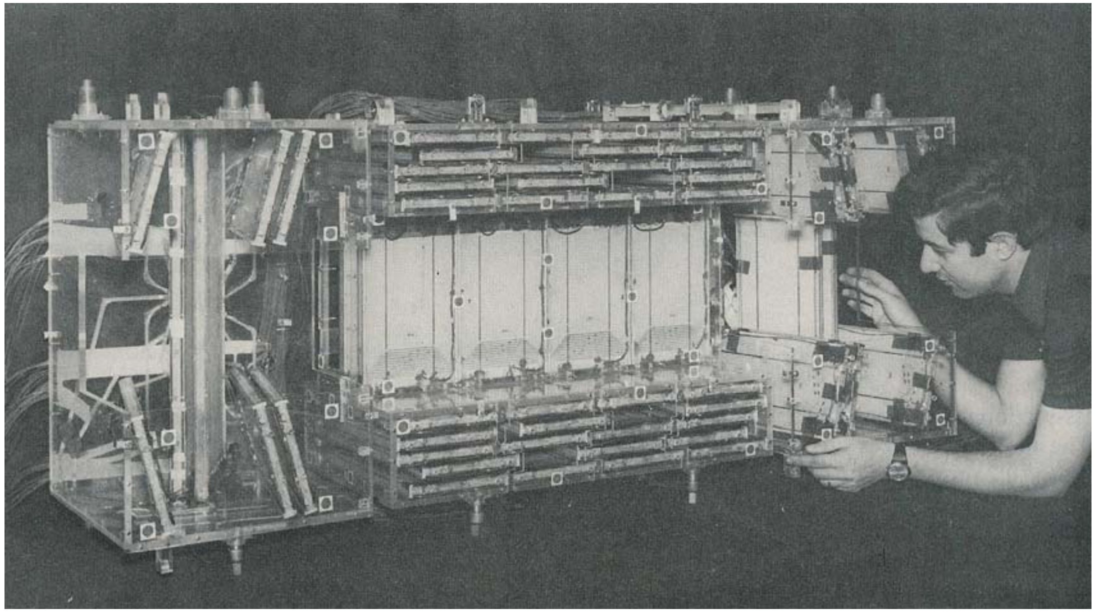
FIG. 1. Cut-away view of the detector at the CERN intersecting storage rings. Shown are beam pipes (1), interaction region and inner detector (*I*), lead absorbers (2), trigger counter hodoscopes (*A*), (*B*), (*C*), (*D*), (*E*), magnetized iron toroids (4), muon drift chambers (*F*), and luminosity monitors (3). Superimposed is the computer reconstruction showing a dimuon event of 24.5 GeV/c^2 mass and $p_T = 1.2$ GeV/c.

A vertex tracker backed by a 4π magnetized-iron muon spectrometer

R209 MIT-Pisa

The Pisa group built the vertex tracker

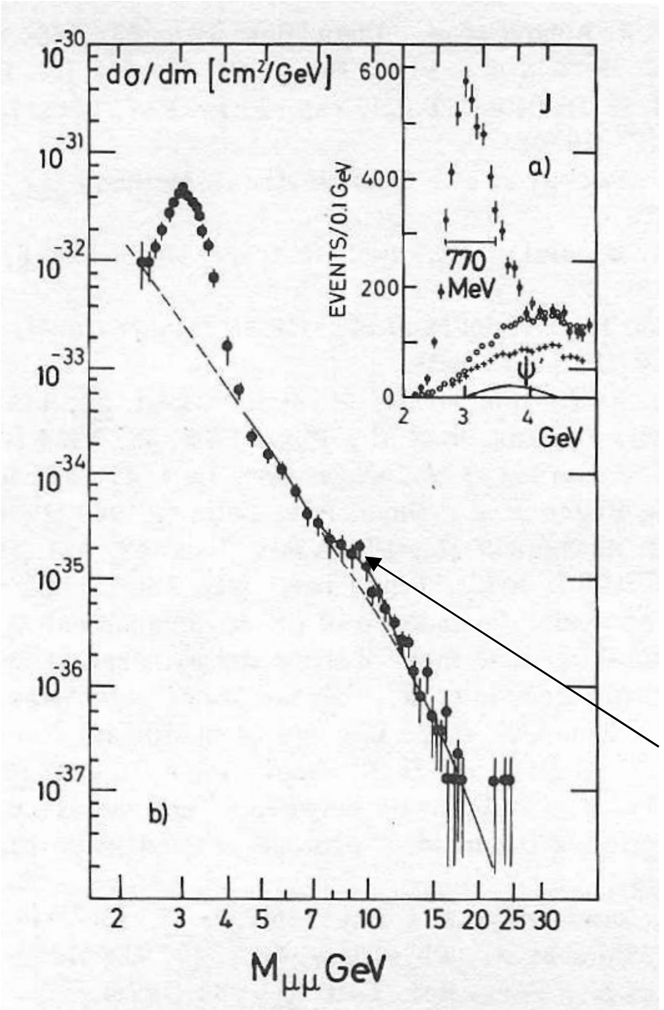
G. Bellettini, P.L. Braccini, R. Carrara, R. Castaldi, V. Cavasinni. F. Cervelli, T. Del Prete, P. Laurelli, M.M. Massai, M. Morganti, G. Sanguinetti, M. Valdata-Nappi, C. Vannini



← **Paolo Laurelli**

Central tracker with sense wires and delay lines

R 209: μ-pair production cross section



Production cross section of $\mu^+ \mu^-$ pairs up to $M(\mu\mu) \approx 20$ GeV.

The energy was not high enough for producing the Z

First observation of the Y at the ISR

σ_t(p-pbar) at R210 1983

G.Carboni
V.Cavasinni
T.Del Prete
M.Morganti
M.Valdata-Nappi

L. Camilleri, Proton–antiproton physics at the CERN intersecting storage rings 59

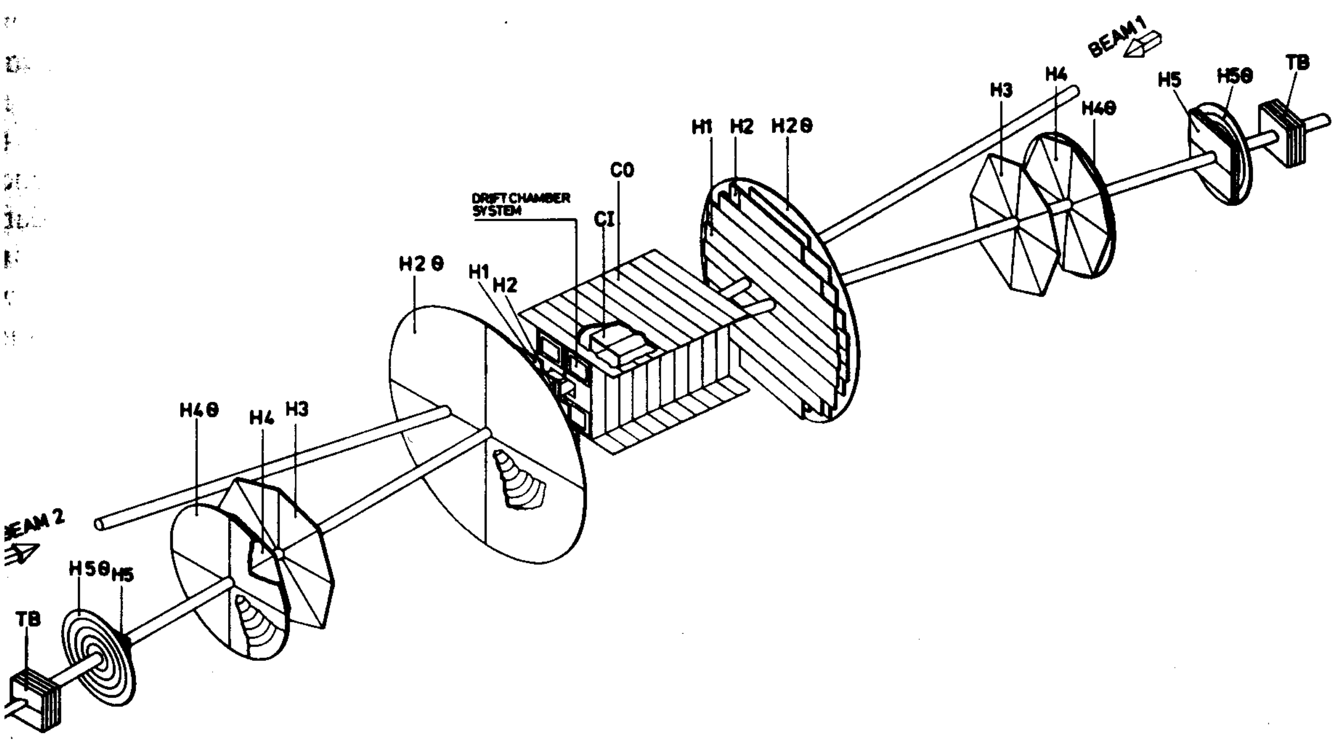


Fig. 2. Layout of the apparatus used by experiment R-210 for a measurement of the p$\bar{\text{p}}$ total cross section by the total rate method.

The R210 result

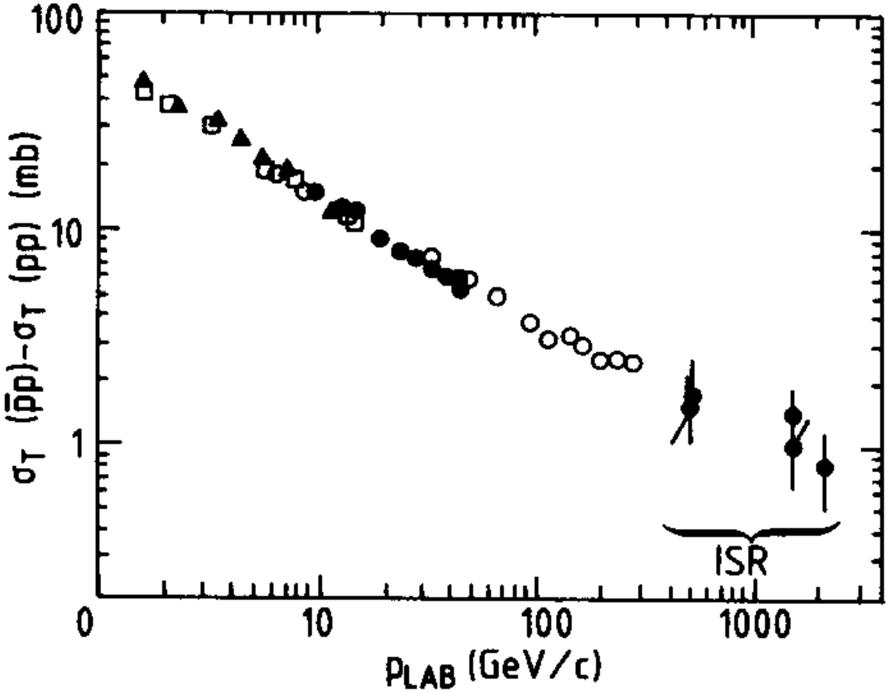


Fig. 43 Measurements of the total cross-section difference, $\sigma_T(p\bar{p})-\sigma_T(pp)$, vs. p_{lab}

σ_t(p-pbar) - σ_t(p-p) was found to decrease steadily with increasing energy.

At higher energies a p-p collider appeared as good for new physics as a p-pbar collider.

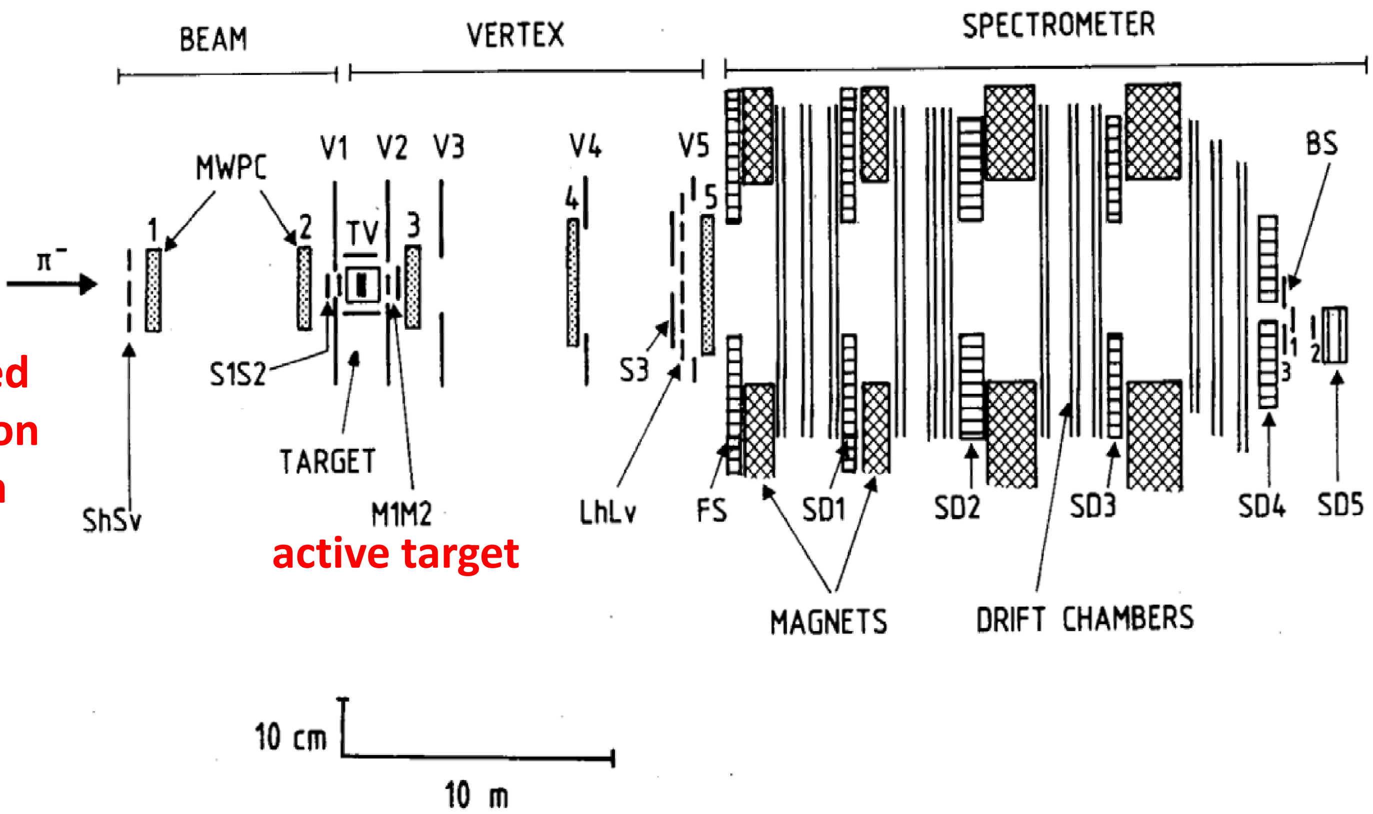
NA1 “FRAMM”, at the brand new SpS

Forward production processes with hadron and photon beams

Lifetime and production properties of charmed hadrons

Frascati - Milano - Pisa - Trieste
Westfield College-Southampton

NA1-NA7 layout



Also tagged photon beam

active target

The NA1 spectrometer

1979-1986

The Italians in NA1

S.R. Amendolia, G. Batignani, E. Bertolucci, L. Bososio, C. Bradaschia, M. Dell`Orso, F. Fidecaro, L. Foa`, E. Focardi, P. Giannetti, A. Giazzotto, M. Giorgi, P.S. Marrocchesi, A. Menzione, L. Ristori, A. Scribano, G. Tonelli, G. Triggiani,

and

L. Rolandi (Ts), A. Stefanini (Ts.), R.Tenchini (Bedford)

Advanced R/D in silicon detectors at Pisa

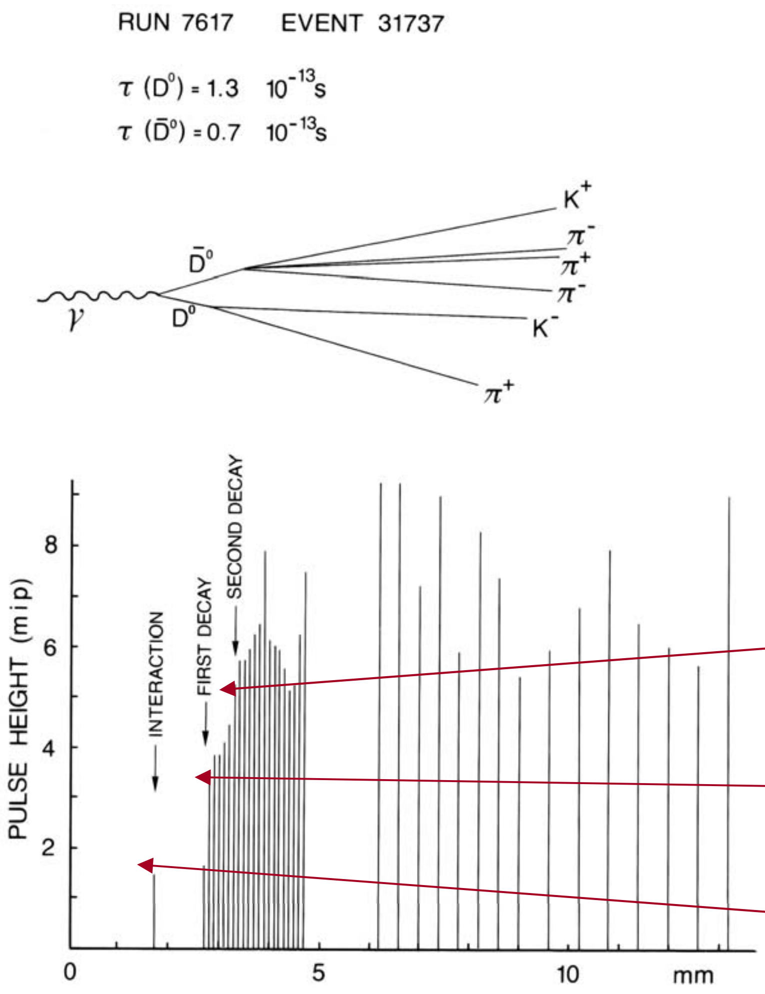
1980 – 1984
NA1 germanium target, Surface barrier detectors for CDF (among the first ever silicon detectors).

1985 – 1990 double sided detectors for Aleph mini-vertex

1990 – 1995 Aleph VDET200

…and more later

Birth of decay vertex tagging



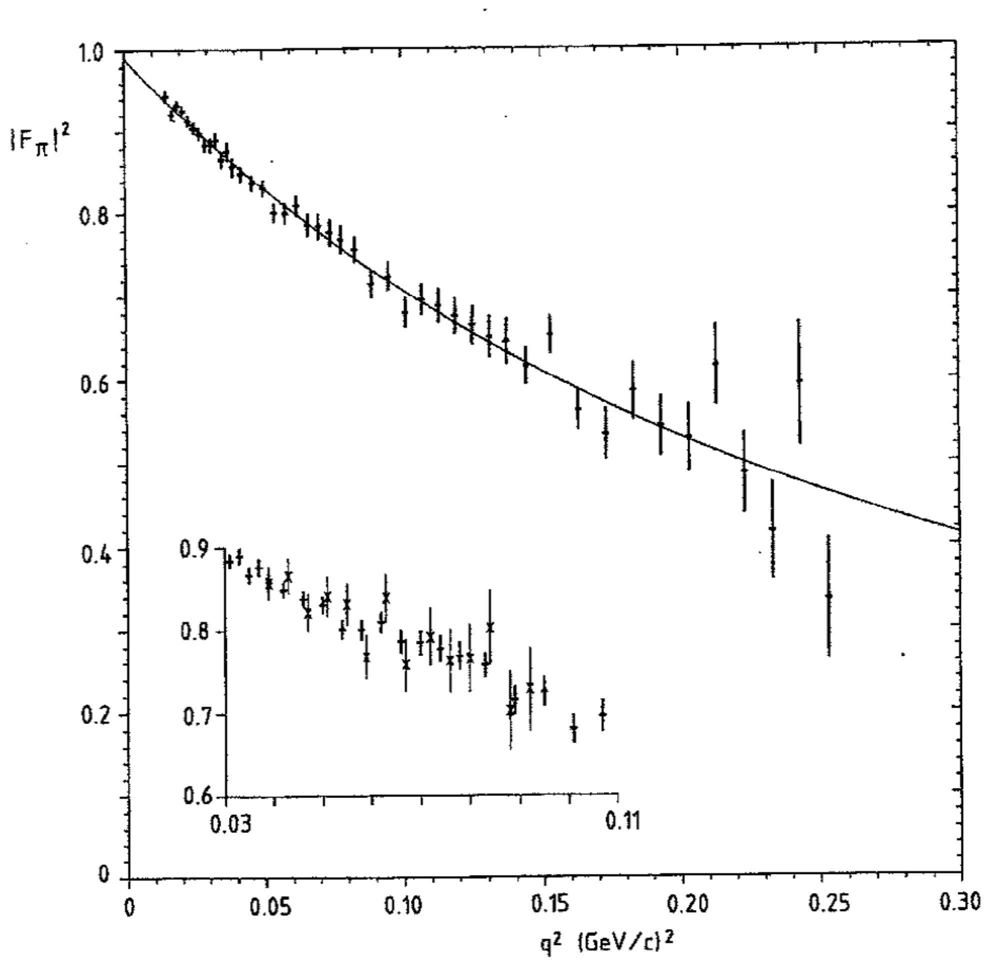
Observe the pulse-height jump due to charm decays in the **multilayer germanium target**

$\bar{D}^0$ decay

D^0 decay

Production vertex

NA7 space-like pion form factor



S.R. Amendolia, G. Batignani, F. Bedeschi, E. Bertolucci, D. Bettoni, G. Bologna, L. Bososio, C. Bradaschia, M. Budinich, A. Codino, M. Dell`Orso, B. D`Ettorre Piazzoli, M. Enorini, F.L. Fabbri, F. Fidecaro, L. Foa`, E. Focardi, A. Giazzotto, M. Giorgi, F. Laurelli, f. Liello, G. Mannocchi, P.S. Marrocchesi, A. Menzione, E. Meroni, L. Moroni, E. Milotti, P. Picchi, F. Ragusa, L. Ristori, L. Rolandi, S. Sala, L.Satta, A. Scribano, P. Spillantini, A. Stefanini, R. Tenchini, G. Tonelli, G. Triggiani. A. Zallo

The NA31 experiment at the CERN SpS 1982-1990

Measure of the direct CP violation in the K^0 decay

L. Bertanza, A. Bigi, M.Calvetti, R. Carosi, R. Casali, C. Cerri, F. Fantechi, I. Mannelli, A. Nappi, G.M.Pierazzini

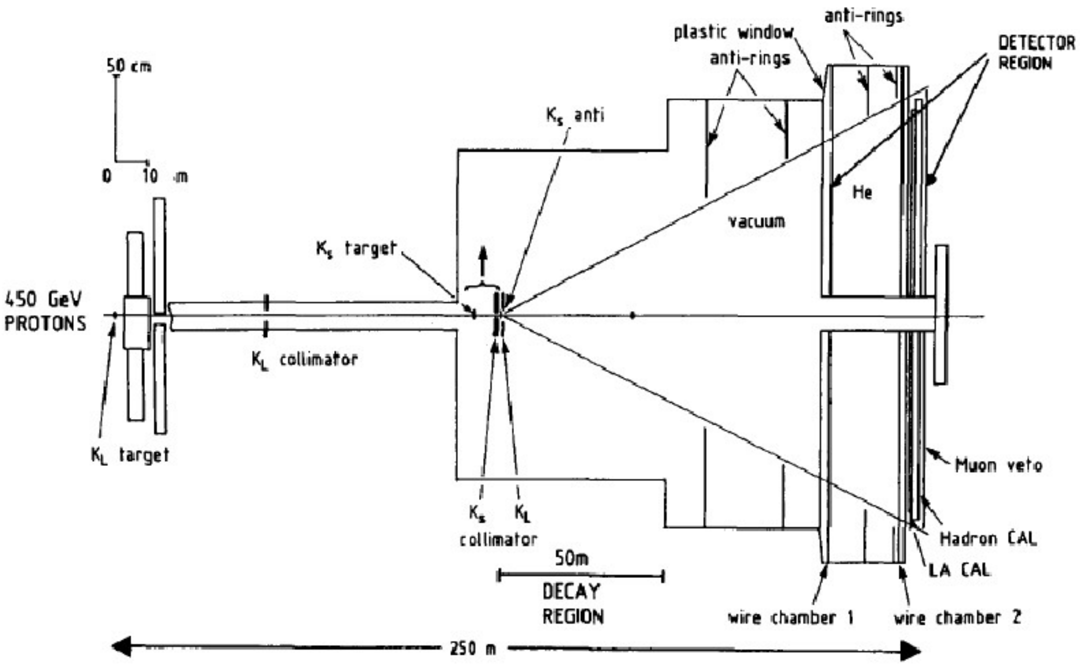
A major effort and a great success by the Pisa group, originating a long term program.

Courtesy of Marco Sozzi

The NA31 setup
the start of an on-going glorious campaign

L. Bertanza, A. Bigi, M.Calvetti, R. Carosi, R. Casali, C. Cerri, F. Fantechi, I. Mannelli, A. Nappi, G.M.Pierazzini

Alternating K_S and K_L beams with movable K_S target, lquid Krypton sampling calorimeter



Courtesy of Marco Sozzi

Volume 206, number 1 PHYSICS LETTERS B May 1988 12 May 1988

FIRST EVIDENCE FOR DIRECT *CP* VIOLATION

$\varepsilon'/\varepsilon = (3.3 \pm 1.1)\cdot 10^{-3}$

CERN–Dortmund–Edinburgh–Mainz–Orsay–Pisa–Siegen Collaboration

The situation in 1996 was however inconclusive:

E731 (Fermilab) final:
$\mathrm{Re}(\varepsilon'/\varepsilon) = (7.4\pm 6.0)\cdot 10^{-4}$
Not disproving superweak

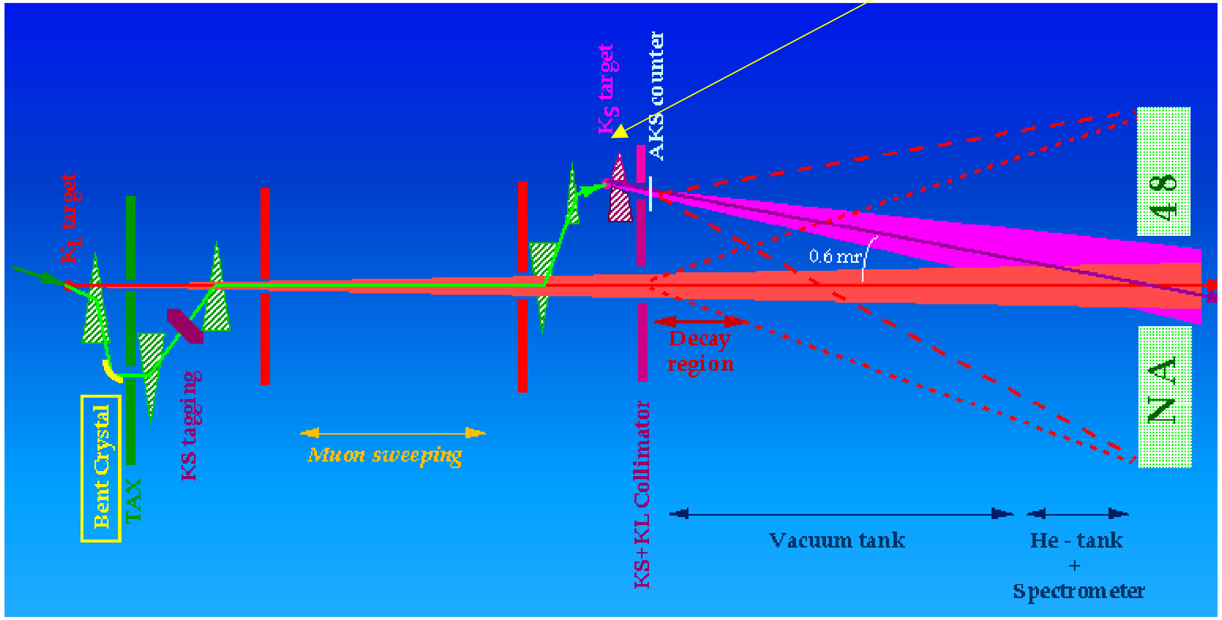
NA31 (CERN) final:
$\mathrm{Re}(\varepsilon'/\varepsilon) = (23.0\pm 6.5)\cdot 10^{-4}$
Inconsistent with superweak

Two new, further improved experiments started in the '90s on both sides of the ocean: KTeV (Fermilab) and NA48 (CERN)

Courtesy of Marco Sozzi

The NA48 layout

Simultaneous K_S and K_L beams with close K_S target



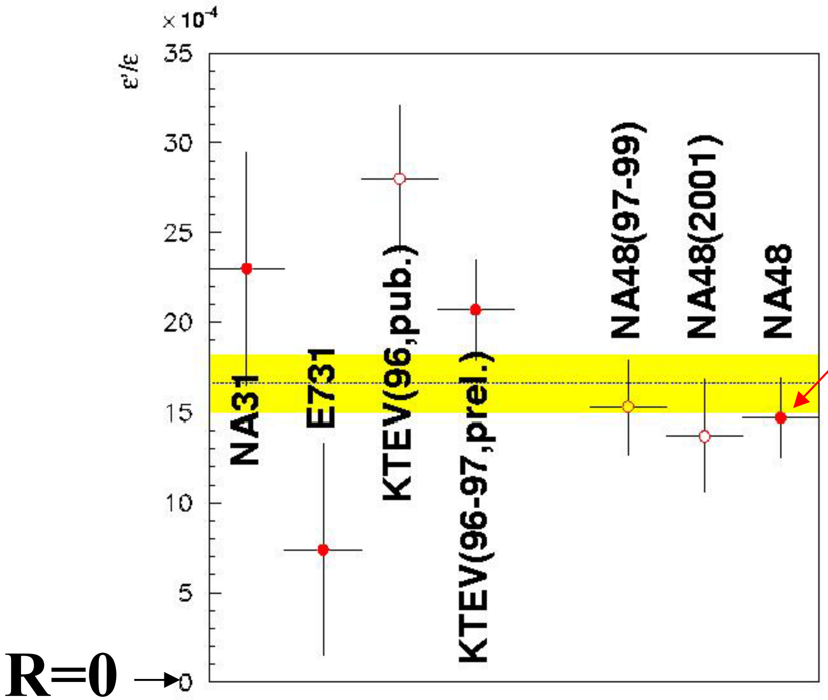
LKr homogeneous calorimeter
(still happily in use in 2017!)

Courtesy of Marco Sozzi

NA48 Pisa physicists
(over the time)

- **L. Bertanza**
- **A. Bigi**
- **R. Casali**
- **C. Cerri**
- **M. Cirilli**
- **G. Collazuol**
- **F. Costantini**
- **L. Di Lella**
- **N. Doble**
- **R.Fantechi**
- **L. Fiorini**
- **S. Giudici**
- **G. Lamanna**
- **I. Mannelli**
- **G.M. Pierazzini**
- **M. Sozzi**

NA48 final result



The final result (2002):

- ***Re***$(\varepsilon'/\varepsilon)$ **= (14.7**$\pm 2.2) * 10^{-4}$

Establishes the direct CP violation to 6.7 σ

NA48 will be described in more detail in the frame of the Pisa later program

SpS as a p-antip 540 TeV collider

In 1982 at CERN, antiprotons were produced by a PS beam, collected, cooled and accelerated first to 26 GeV in the PS and next to 270 GeV in the SpS, where they were stored and collided with an opposite stored proton beam.

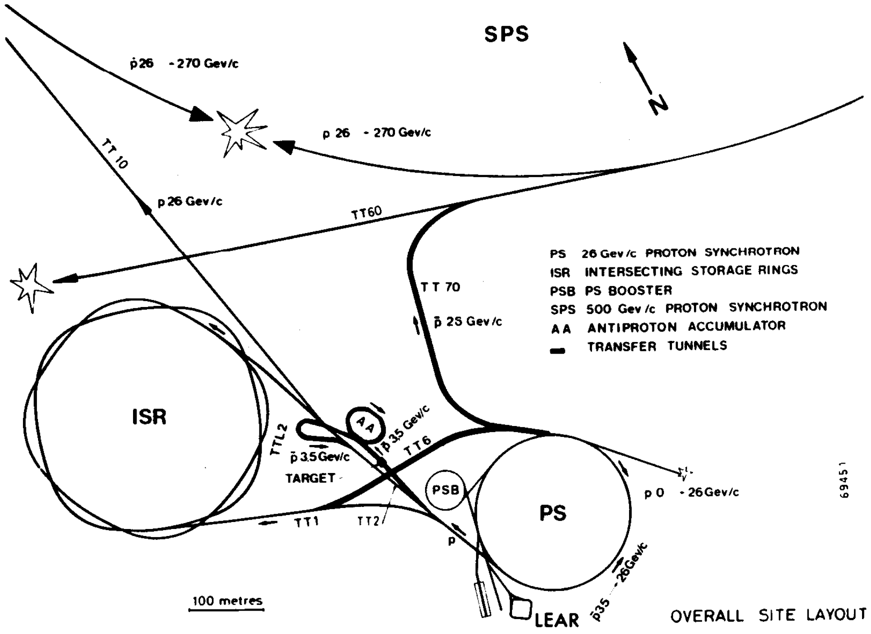
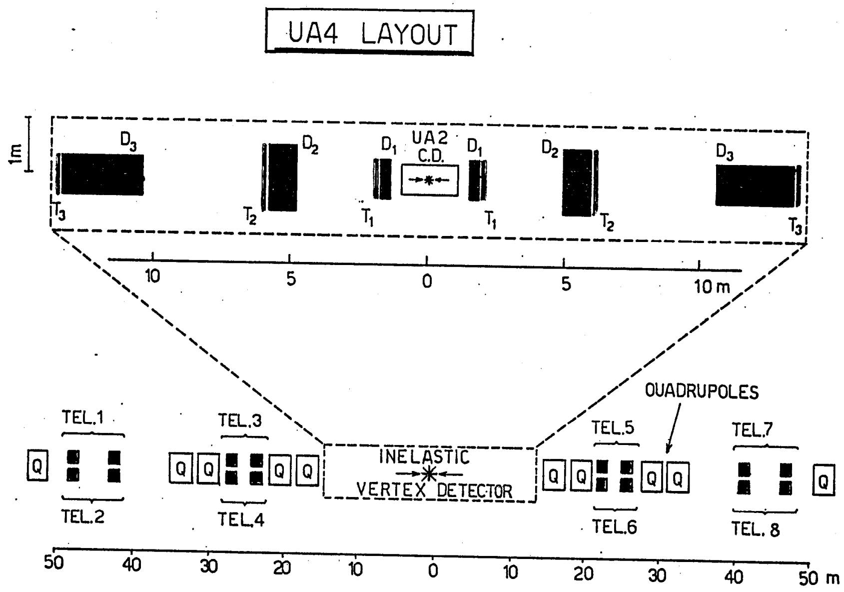


Fig. 1. The CERN accelerator complex.

The UA4 experiment

At the SpS p-pbar collider UA 4 measured the total and the forward elastic cross section with two small angle spectrometers left and right of UA2 detector.



D. Autiero, G. Carboni, V. Cavasinni, F. Costantini, T. Del Prete, E. Iacopini, S. Lami, M. Morganti, C. Petridou, M. Valdata-Nappi

Telescopes 3,4,5,6 measured intermediate angle inelastic events. The UA2 detector was used to measure the total inelastic rate.

σ_{tot}(p-antip) of UA4

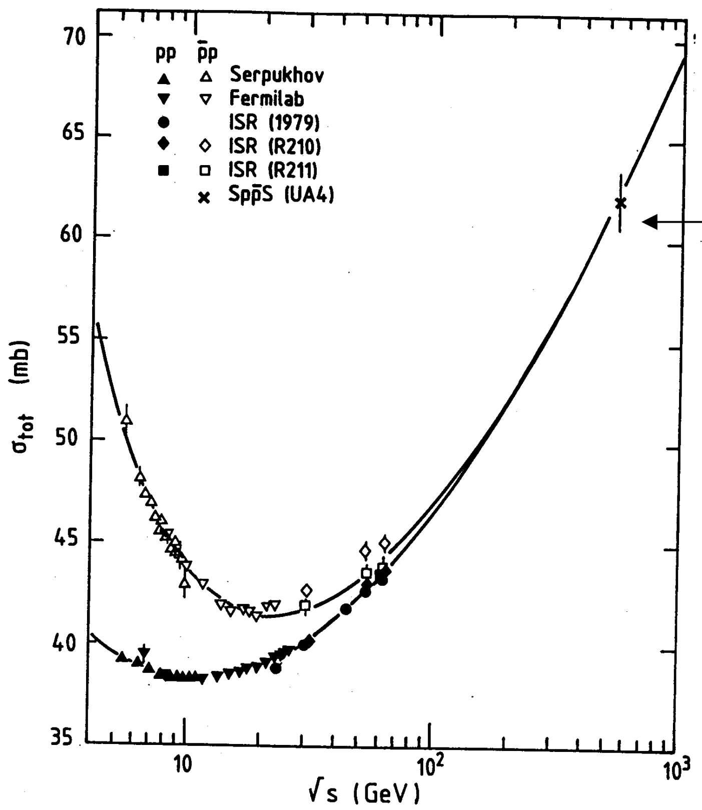


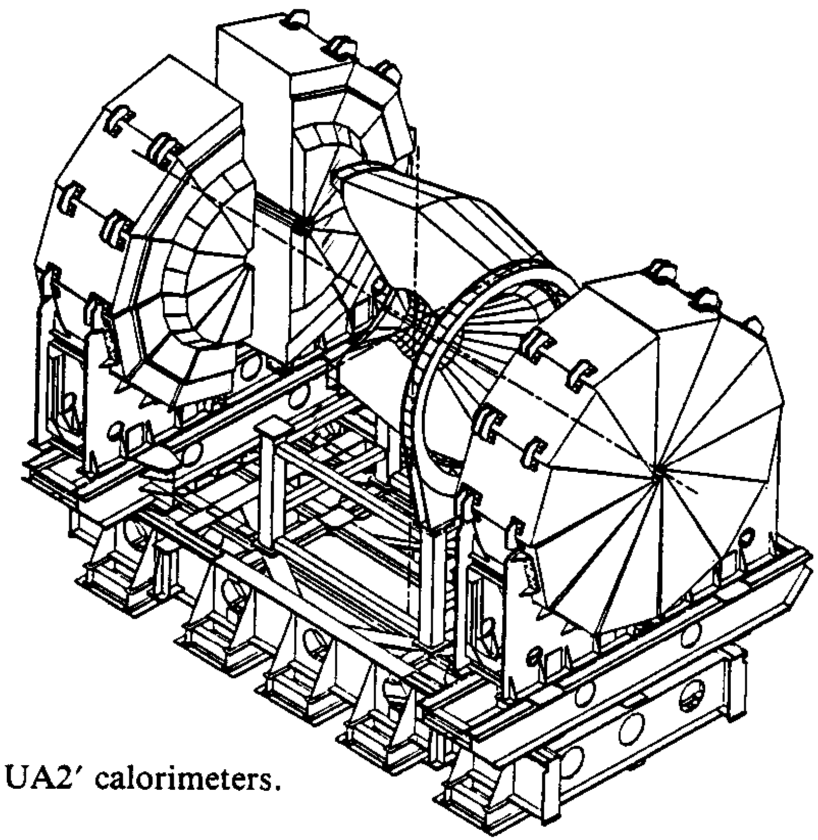
Figure 11. Total cross-section data for pp and p̄p scattering [early, low-statistics measurements at the SPS Collider (18,35) are not shown]. The curve represents the dispersion relation fit of Reference (7).

σ_t at $\sqrt{s}$ = 540 GeV

More on this experiment in the report by Rino Castaldi

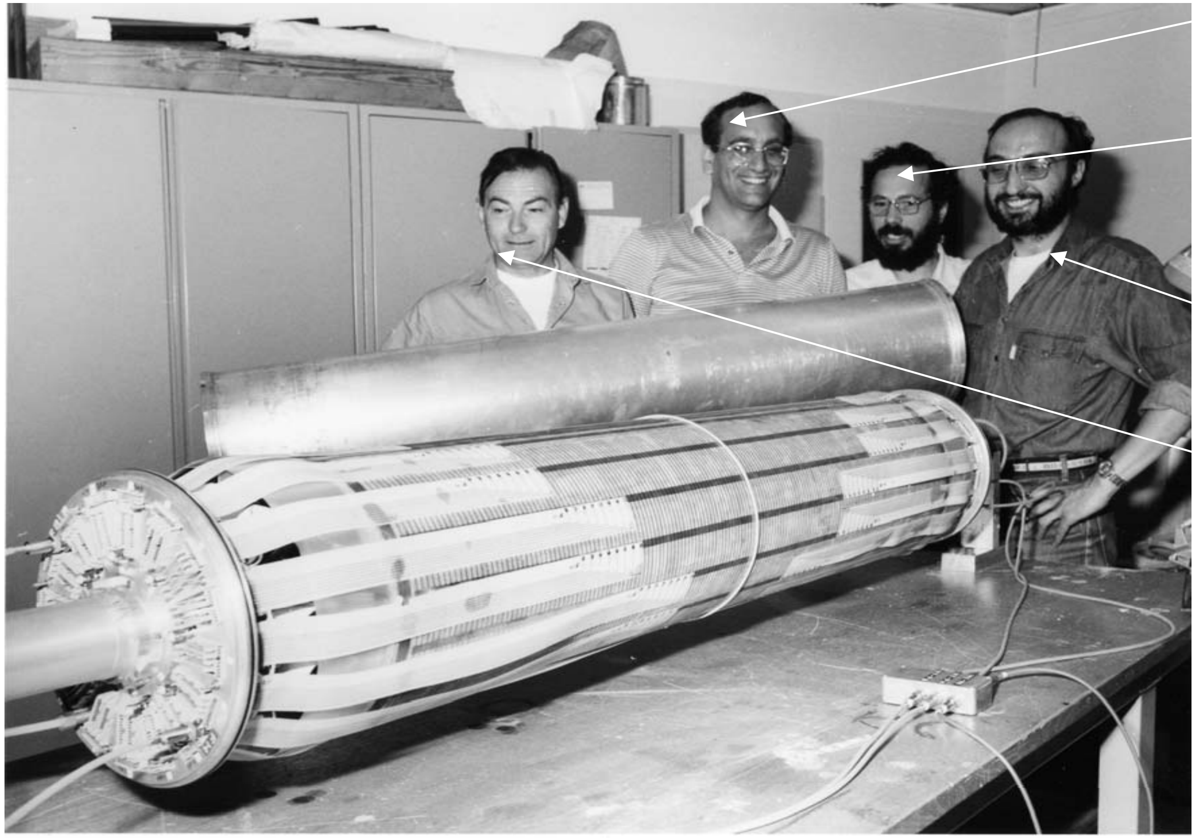
The UA2 experiment

A full coverage plastic scintillator calorimeter and a vertex tracker with no magnetic field



' the UA2' calorimeters.

The vertex JVD detector of UA2



Mauro Morganti

Enrico Iacopini

Vincenzo Cavasinni

Luciano Giacomelli

The birth of hadron jets

The first undeniable two-jets event was reported by UA2

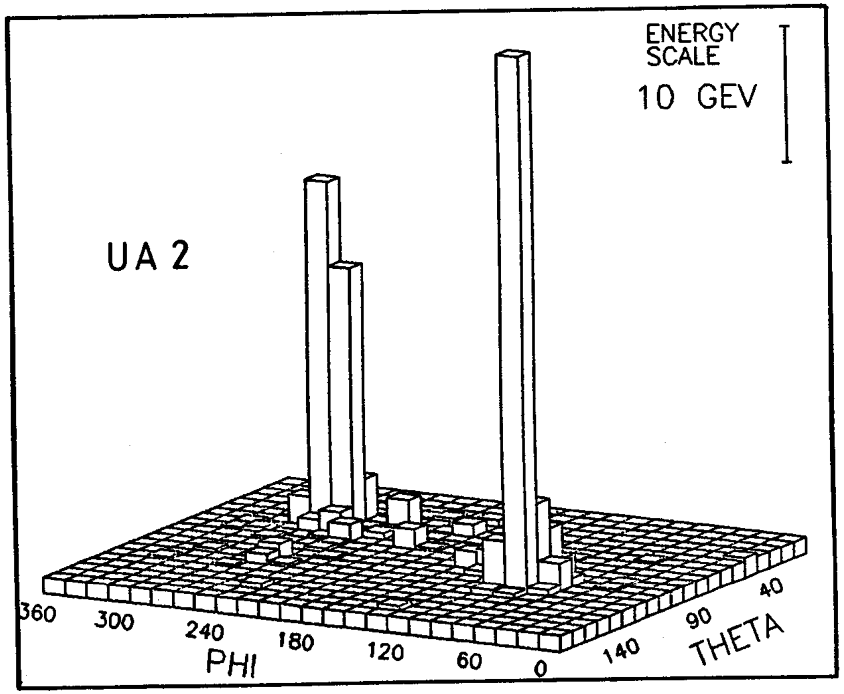
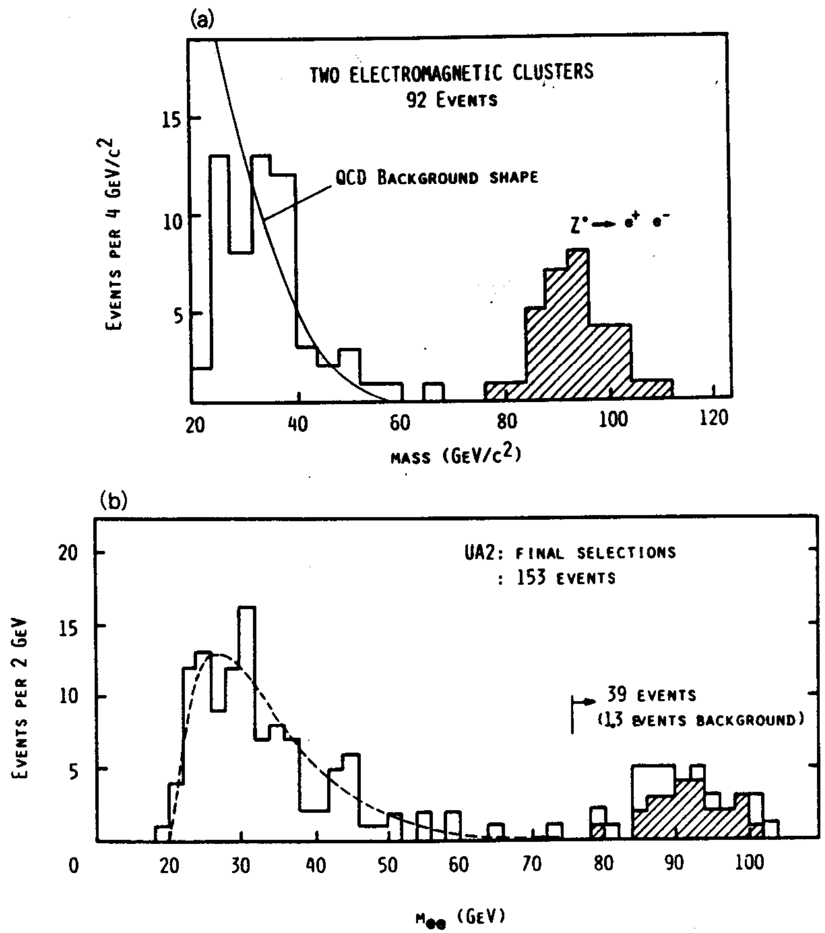


Fig. 10 The highest E_T event of Fig. 9, showing the E_T distribution in θ and ϕ (experiment UA2)

Discovery of the Z boson at UA1, UA2

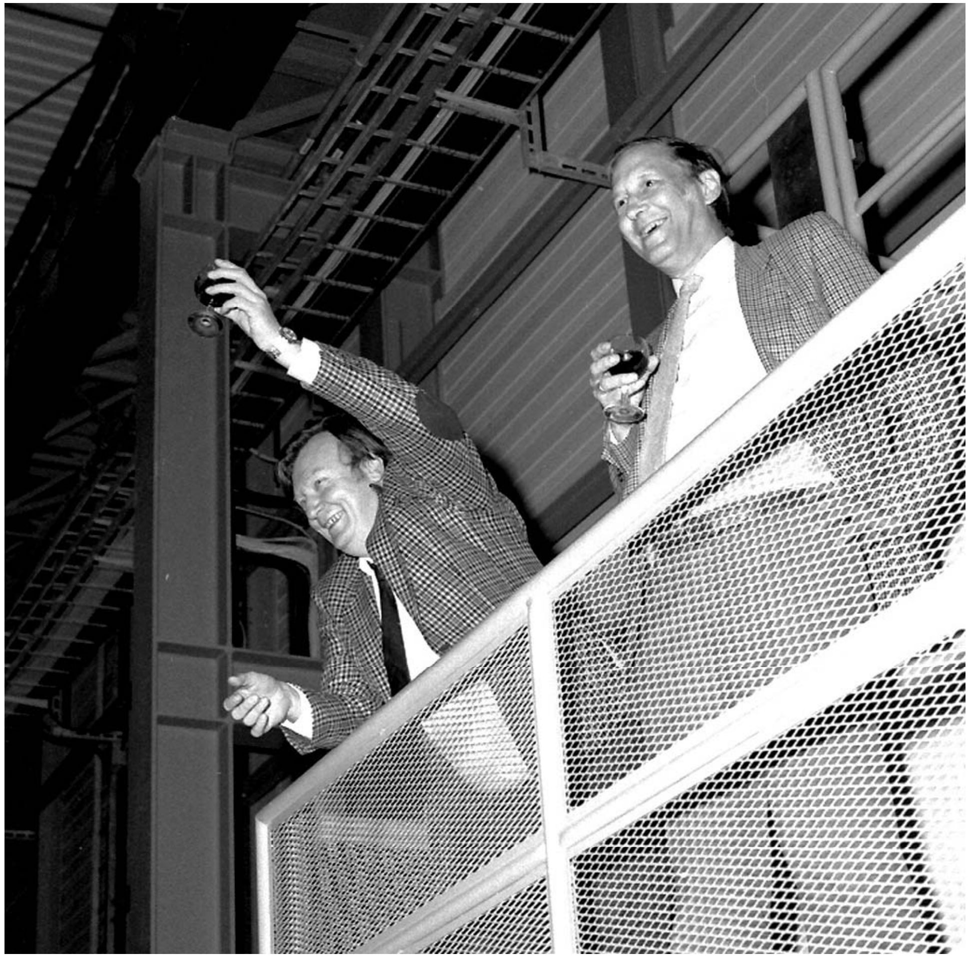


UA1

UA2

Fig. 3.9. (a) The distribution of e^+e^- pairs, recognized as $Z^0 \rightarrow e^+e^-$ processes (UA1 [21]). (b) The e^+e^- events, collected by UA2 [22].

Carlo Rubbia and Simon Van der Meer



The discovery of the W and Z boson by UA1 and UA2 was rewarded by a Nobel Prize to Carlo Rubbia and Simon Van der Meer

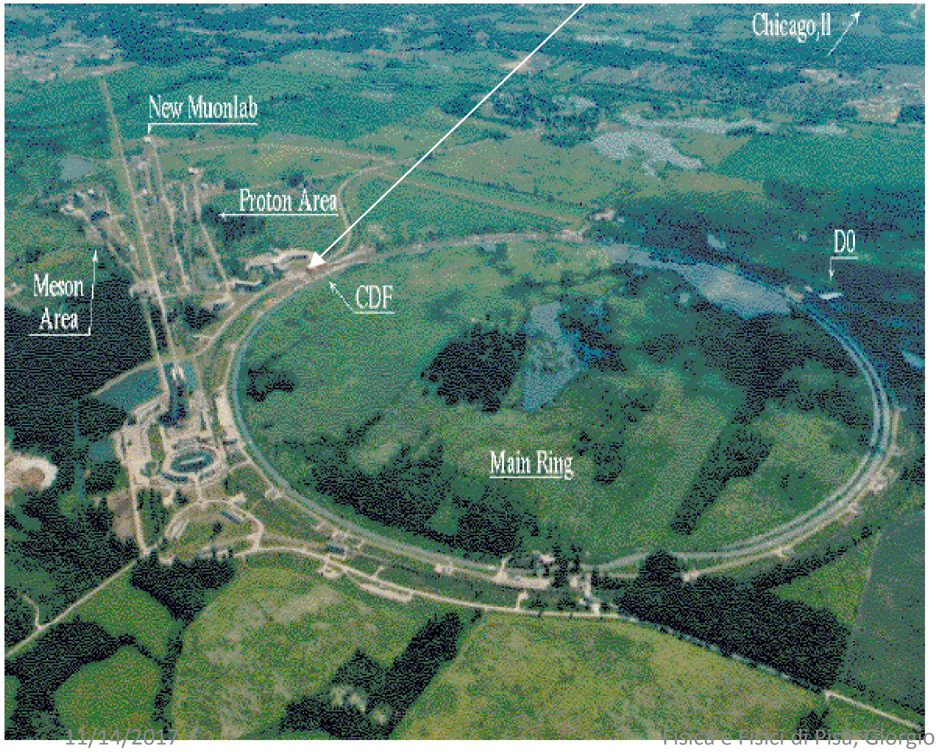
More on this experiment in the report by Luigi Di Lella

The Tevatron in the prairie of Illinois

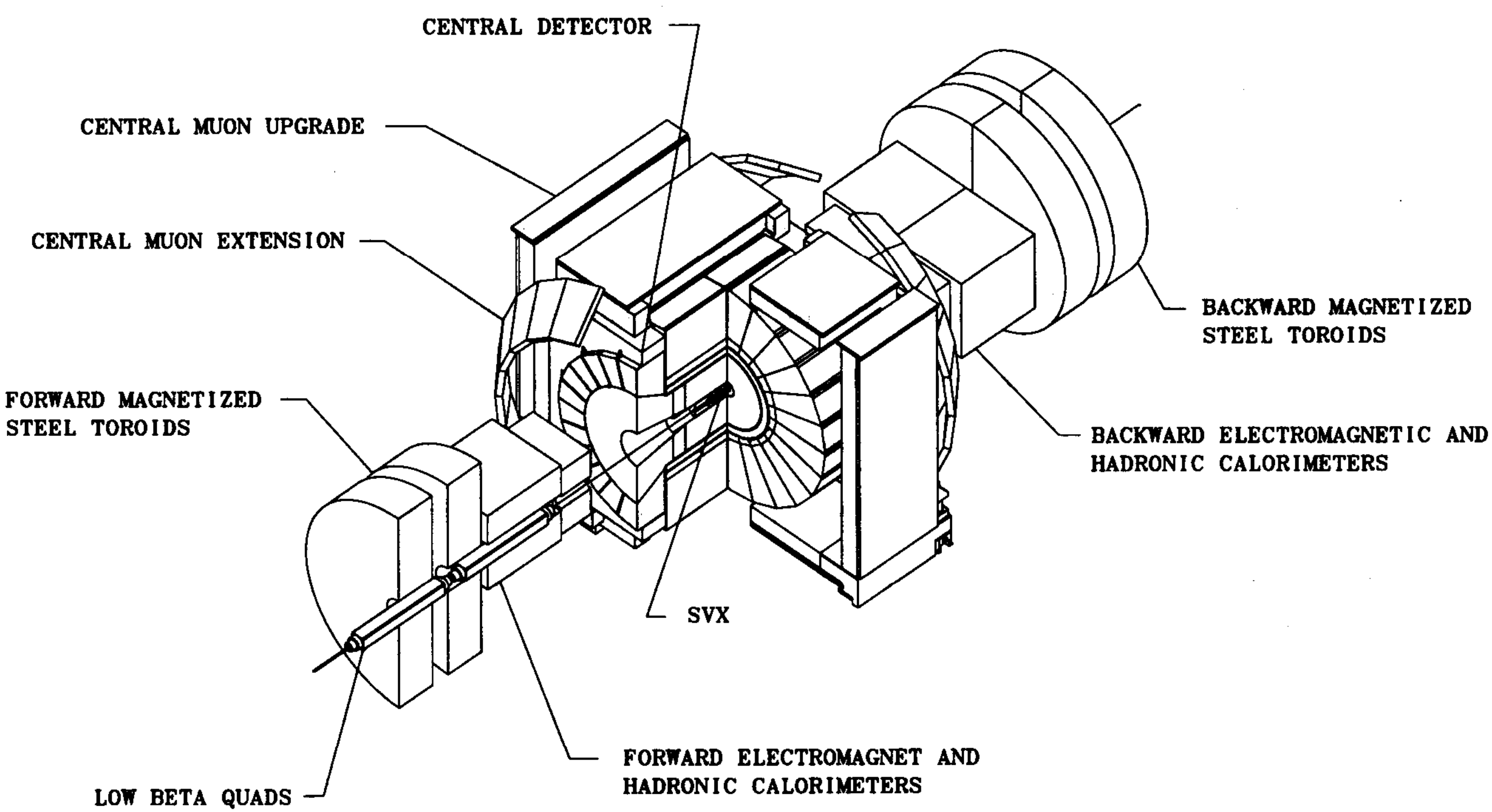
1985

CDF

The Main Ring injector on top of the Tevatron collider



CDF layout (1988-1995)



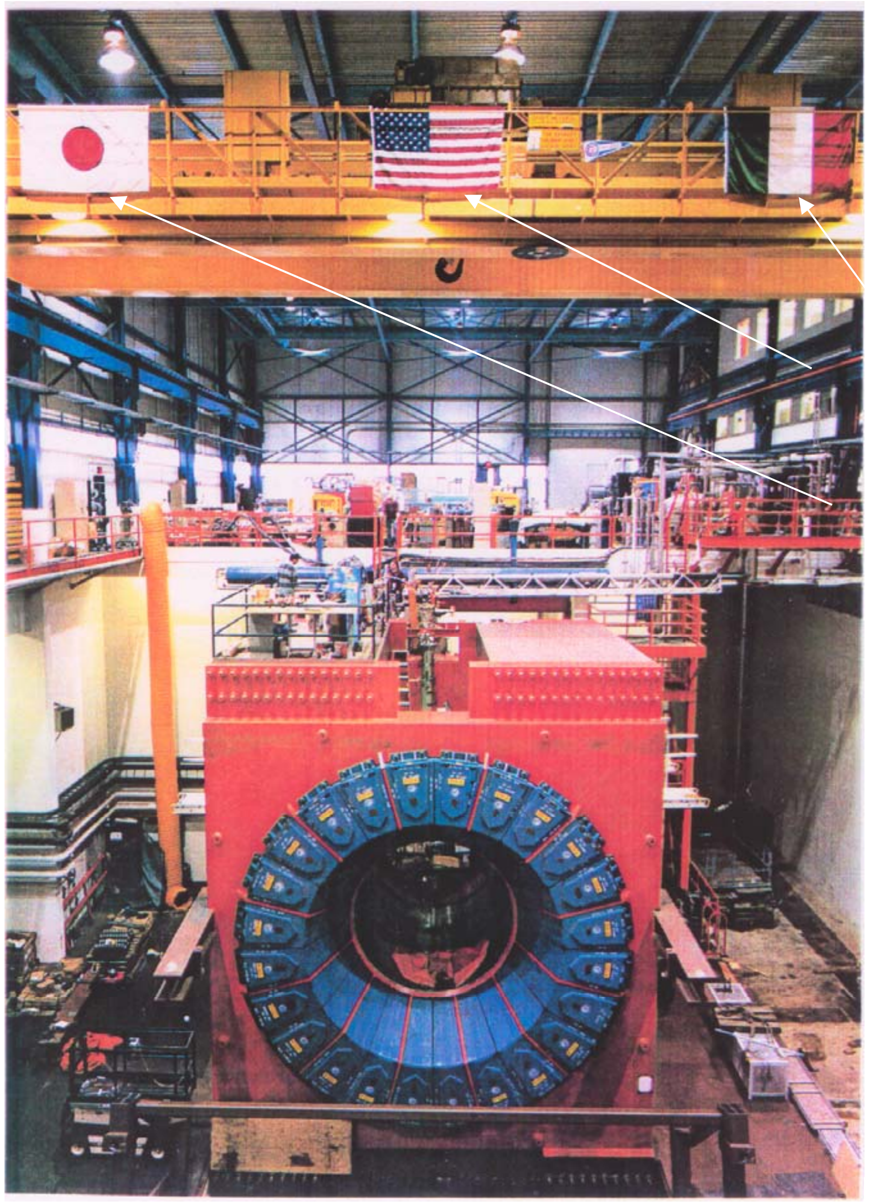
Many years of lower limits to the top quark mass

PETRA/PEP	> 22 GeV/c^2 in 1984	**(95% c.l.)**
TRISTAN	> 26 GeV/c^2 in 1988	
SLC	> 41 GeV/c^2 in 1989	
LEP	> 45 GeV/c^2 in 1989	
UA1	> 50 GeV/c^2 in 1990	
UA2	> 69 GeV/c^2 in 1990	
CDF	> 70 GeV/c^2 in 1990	
UA2 and CDF	> 77 GeV/c^2 in 1991	

Since $M_{top} > M_W$

t-tbar → WWbb, a very complex final state

CDF in 1985: a US- Japan-Italy project



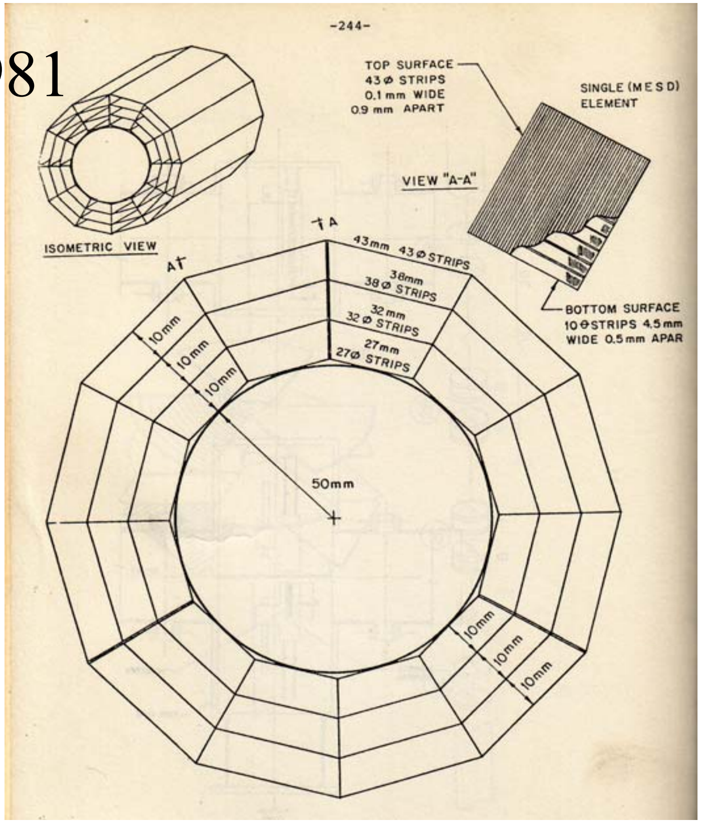
Italy

USA

Japan

SVX sketched in the 1981 design report

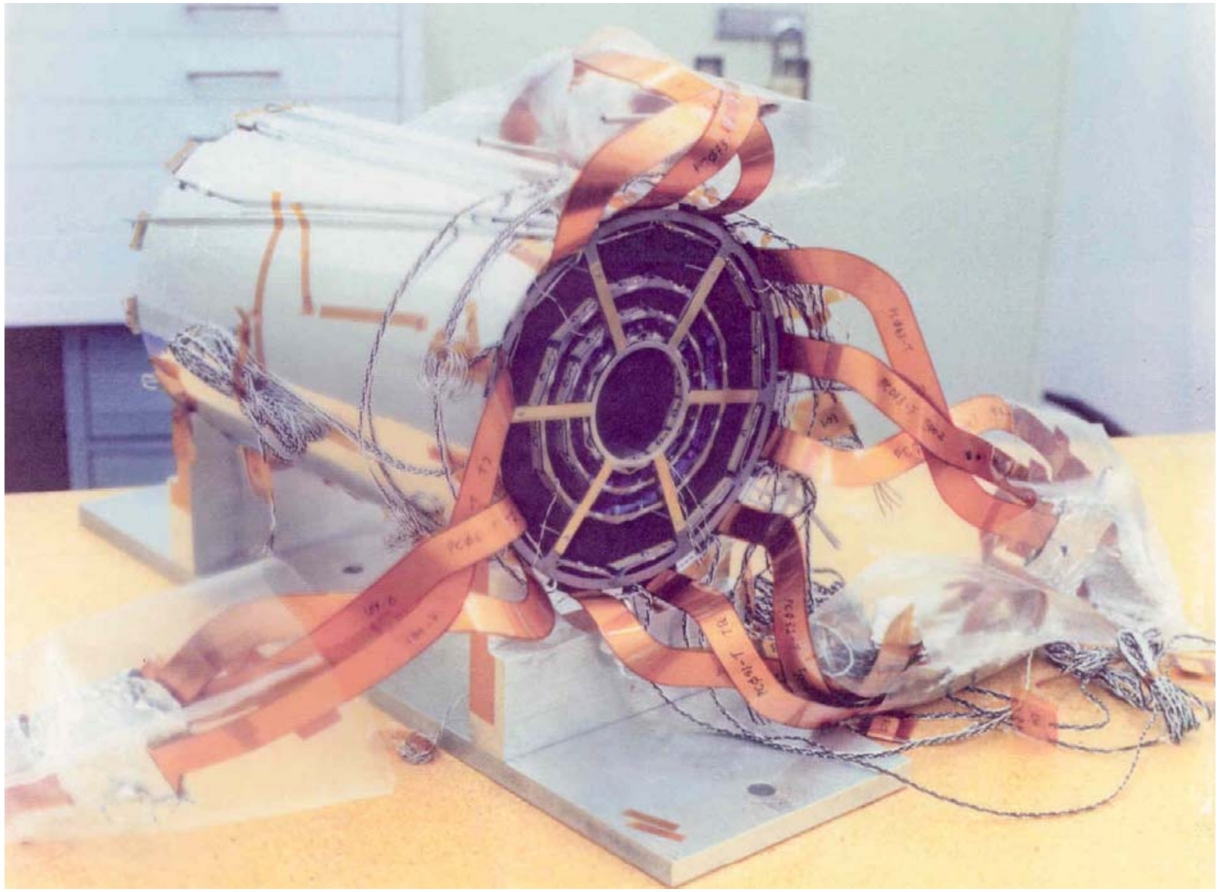
1981



Italians in the CDF design report

F. Bedeschi
G. Bellettini
R. Bertano
S. Bertolucci
L. Bosisio
C. Bradaschia
M. Cordelli
R. F. Del Fabbro
E. Focardi
M. A. Giorgi
P. Giromini
A. Menzione
L. Ristori
A. Scribano
P. Sermoneta
G. Tonelli

SVX1: a Pisa project



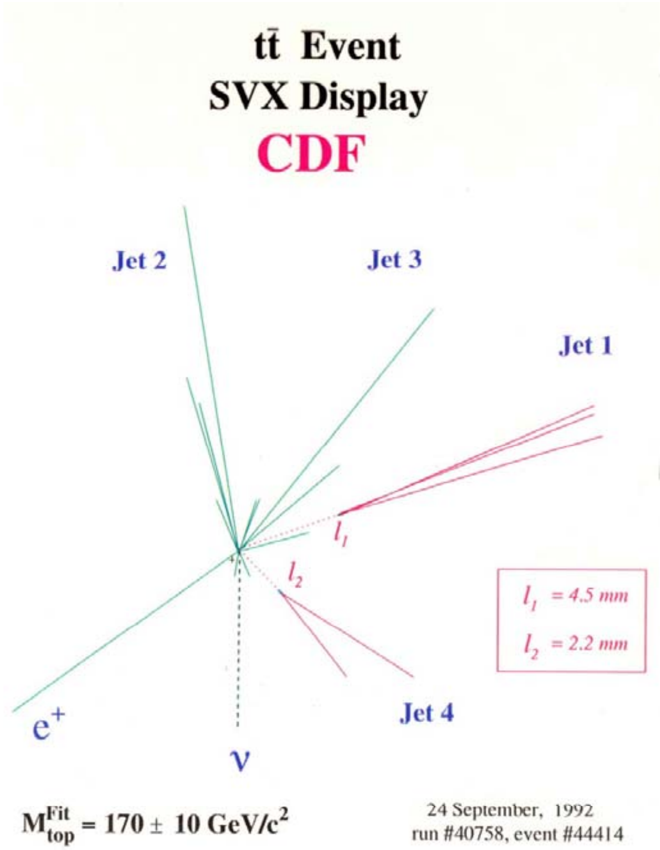
Operating in 1992

Eventually the discovery (1994-1995)

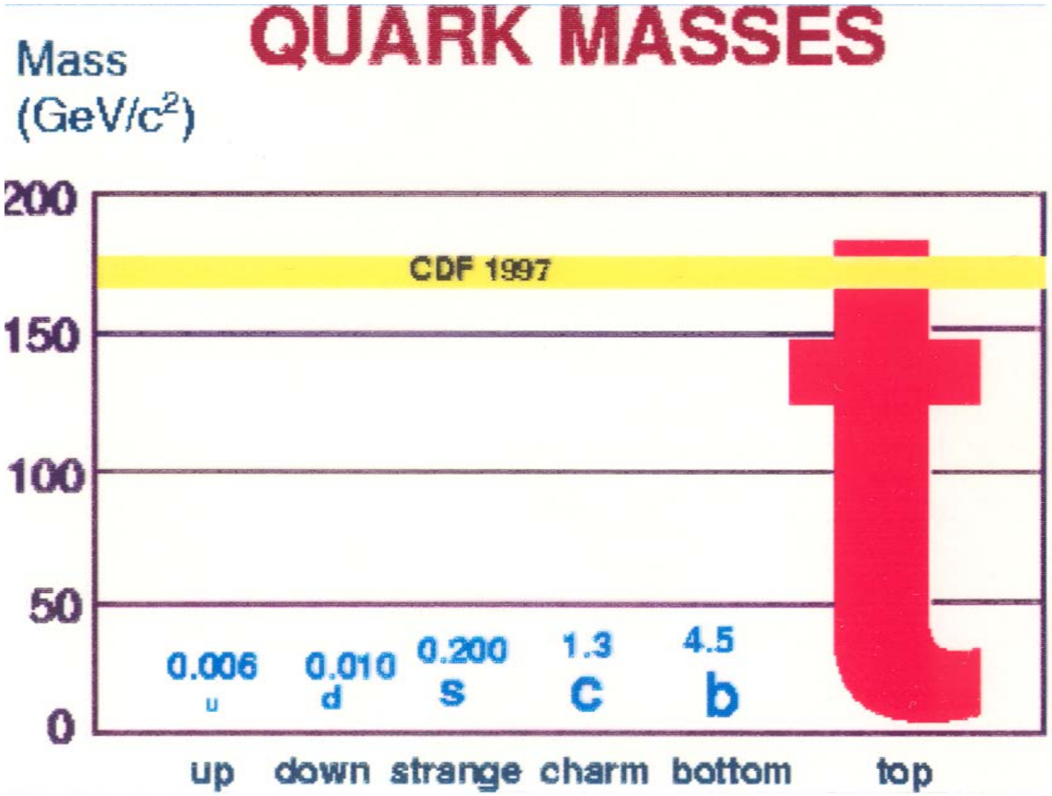
VOLUME 73, NUMBER 2 PHYSICAL REVIEW LETTERS 11 JULY 1994

Evidence for Top Quark Production in $\bar{p}p$ Collisions at $\sqrt{s} = 1.8$ TeV

F. Abe,[13] M. G. Albrow,[7] S. R. Amendolia,[23] D. Amidei,[16] J. Antos,[28] C. Anway-Wiese,[4] G. Apollinari,[26]



The incredible mass of the top quark



Final comment

I welcomed this meeting, very much.

We did well enough. However, the future will be in the hands of new young people. Knowing of our achievements can be instructive for them. This would not be possible if accurate records of the past are not saved.