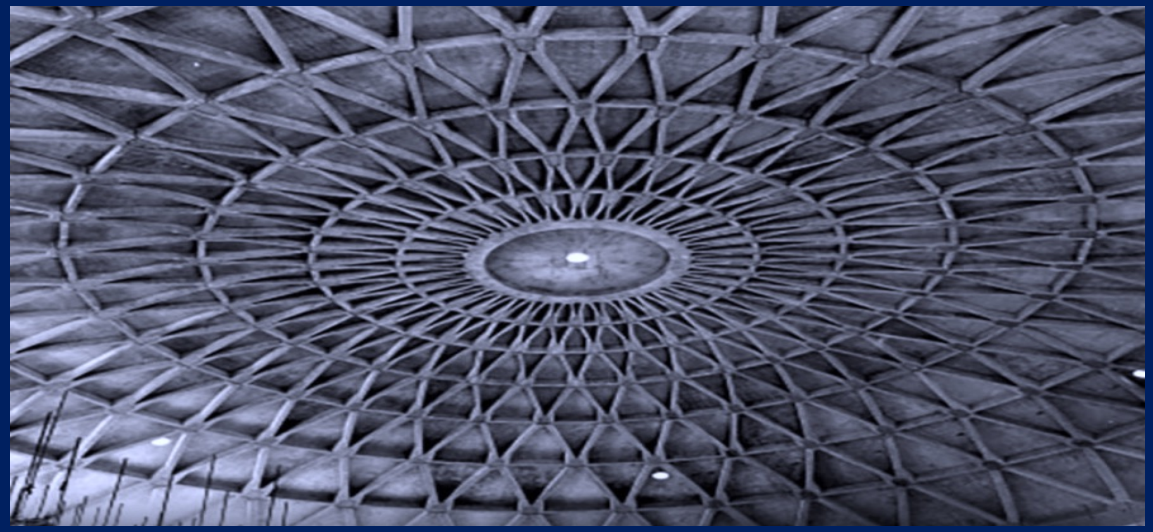
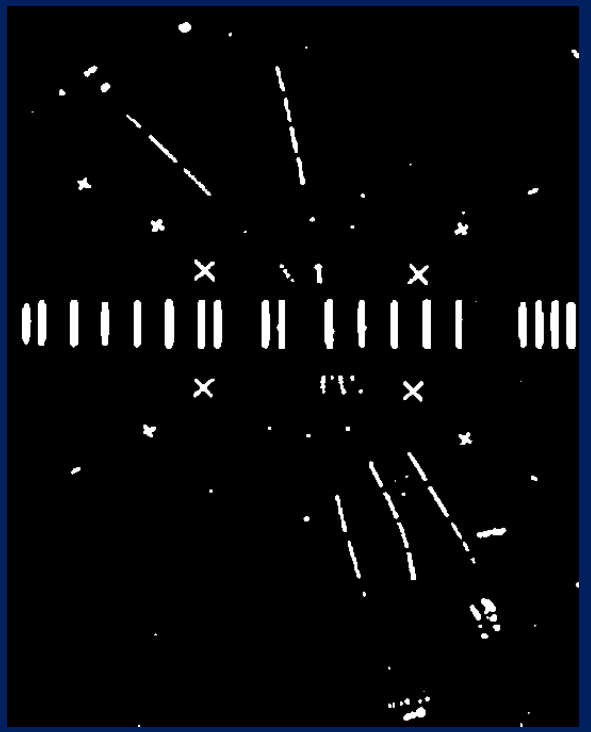


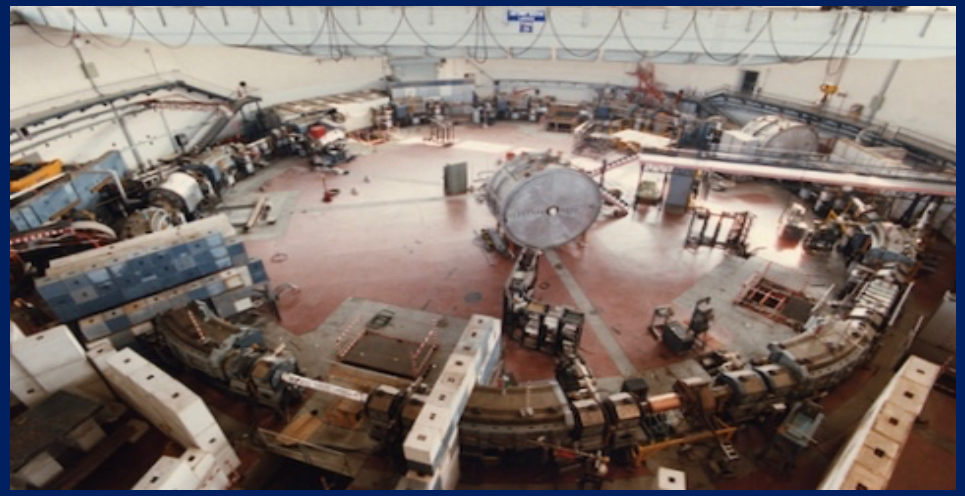
The J/ψ and the multihadrons at ADONE



The late-night of 13 November 1974

The energy scan

The multihadrons



Enzo Iarocci LNF INFN
Frascati 18 November 2024

Physical Review Letters 2 December 1974

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

C. Bacci, R. Baldini Celio, M. Bernardini, G. Capon, R. Del Fabbro, M. Grilli, E. Iarocci, L. Jones, M. Locci, C. Mencuccini, G. P. Murtas, G. Penso, G. Salvini, M. Spano, M. Spinetti, B. Stella, V. Valente

γγ2 Frascati - Roma

B. Bartoli, D. Bisello, B. Esposito, F. Felicetti, P. Monacelli, M. Nigro, L. Paoluzi, I. Peruzzi, G. Piano Mortari, M. Piccolo, F. Ronga, F. Sebastiani, L. Trasatti, F. Vanoli

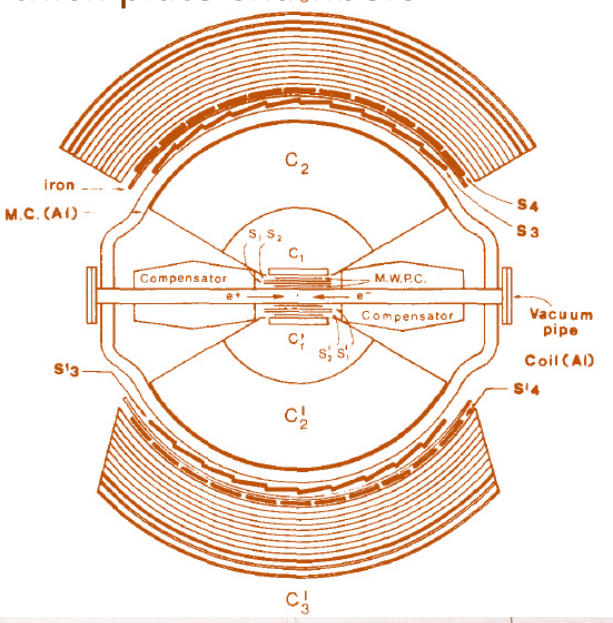
MEA Frascati - Napoli - Roma

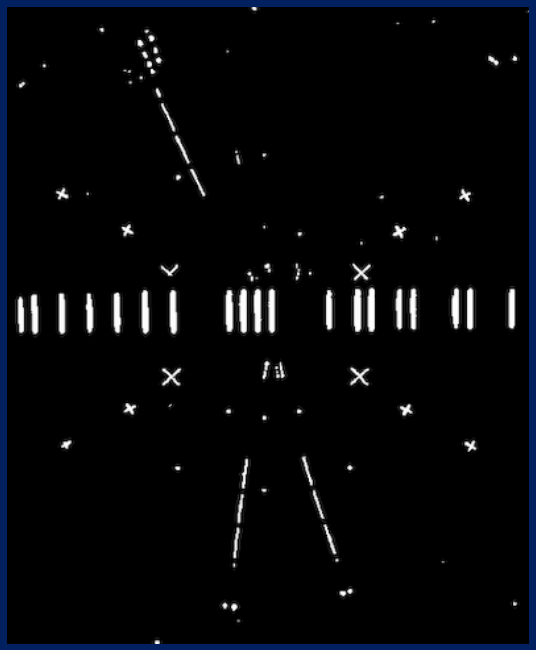
G. Barbarino, G. Barbiellini, C. Bemporad, R. Biancastelli, M. Calvetti, M. Castellano, F. Cevenini, F. Costantini, P. Lariccia, S. Patricelli, P. Parascandalo, E. Sassi, C. Spencer, L. Tortora, U. Troya, and S. Vitale

BBbar Frascati - Napoli - Pisa

MEA Detector ΔΩ = 0,35 x 4π sr

thick-plate chambers

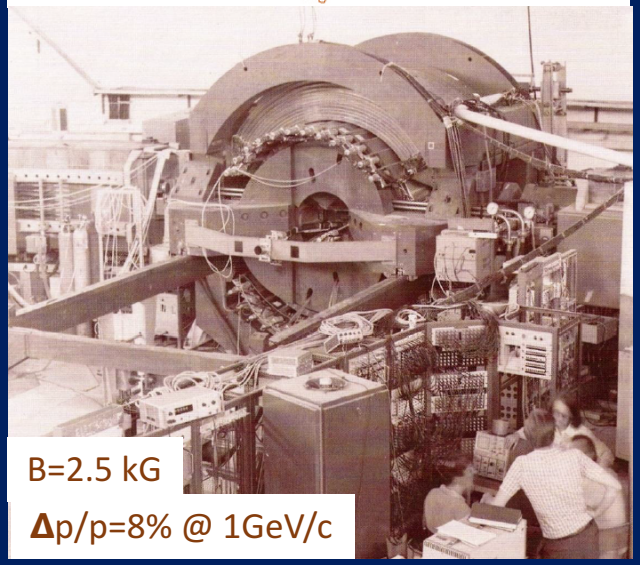




scintillation counters and spark chambers

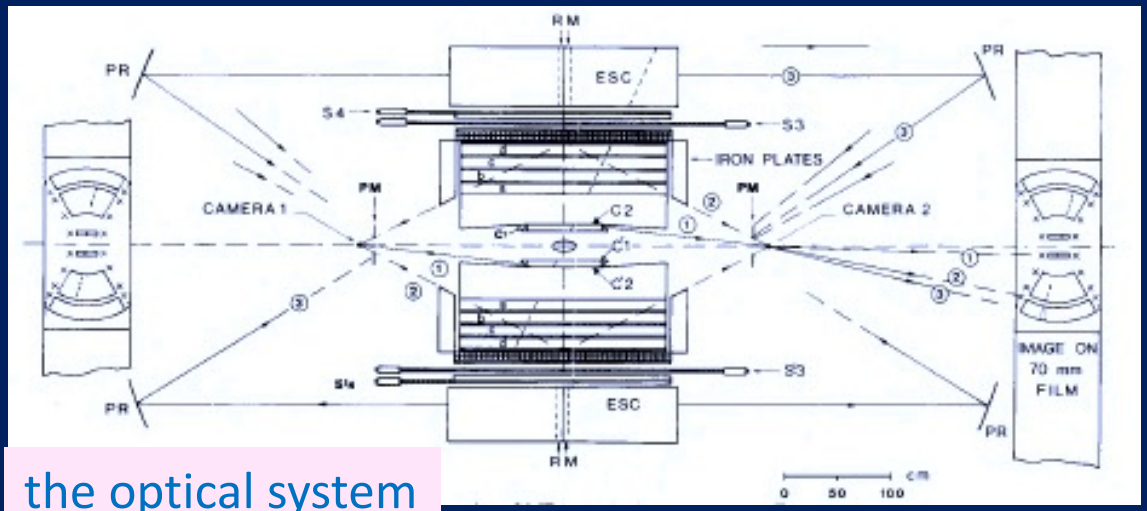
transverse cilindrical structure to simplify the optical read-out

wide gap chambers with transparent wire electrodes



B=2.5 kG

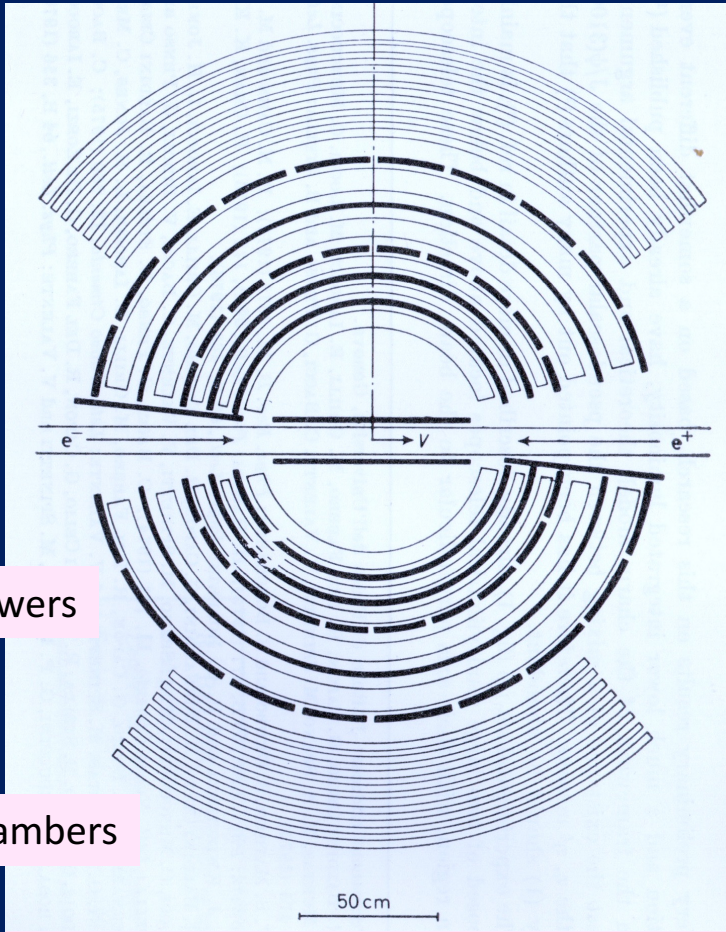
Δp/p=8% @ 1GeV/c



the optical system

γγ2 detector ΔΩ = 0.65 x 4π sr

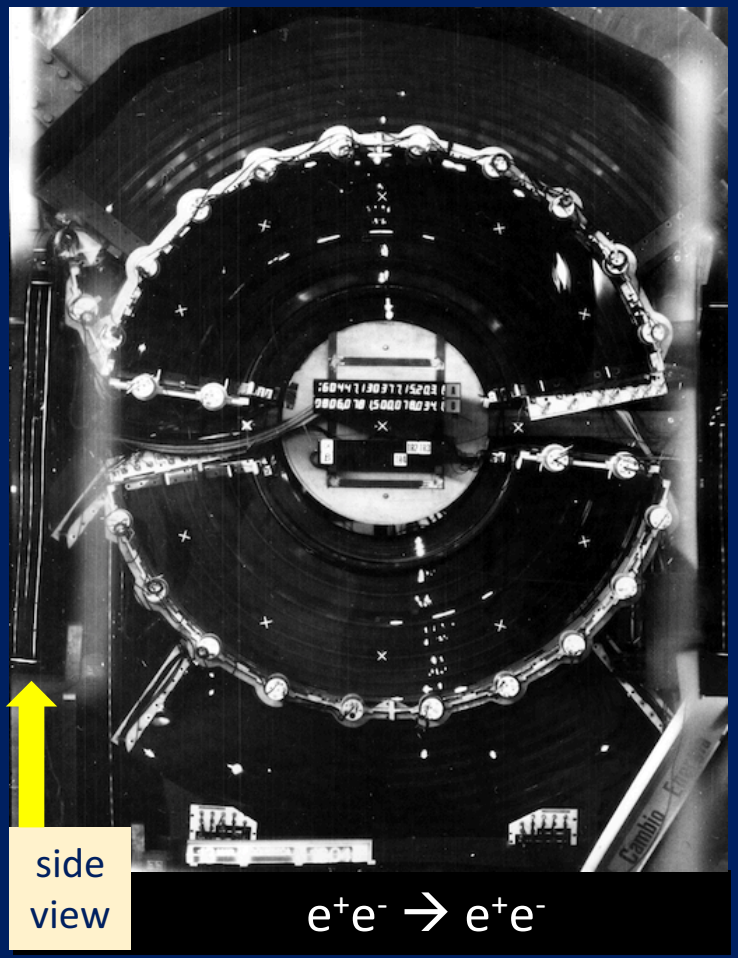
optical spark chambers → cilindrical structure ⊥ beams
good photon detection efficiency



em showers

iron chambers

magnetostrictive chambers side-caps

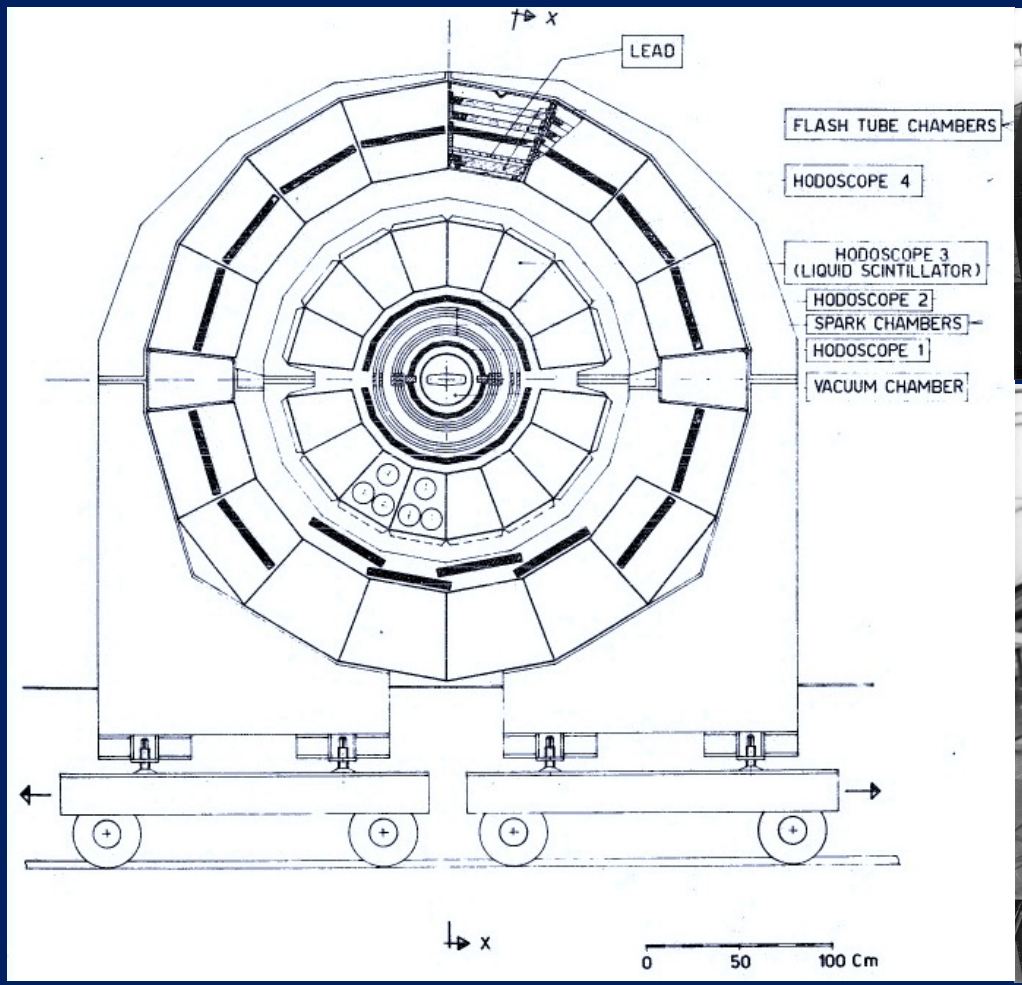


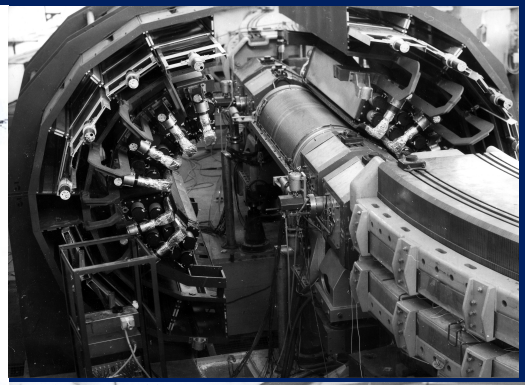
side view

$e^+e^- \rightarrow e^+e^-$

BBbar ΔΩ = 0,7 x 4π sr

magnetostrictive chambers and vidicon readout flash-tube chambers
4 scintillation counter hodoscopes
longitudinal cilindrical structure
good identification of low energy protons





The beginning of the Frascati paper

Soon after the news that a particle of 3.1 GeV with a width consistent with zero had been observed at Brookhaven National Laboratory by the Massachusetts Institute of Technology group,[1] it was immediately decided to push ADONE beyond its nominal limit of energy (2×1.5 GeV) to look

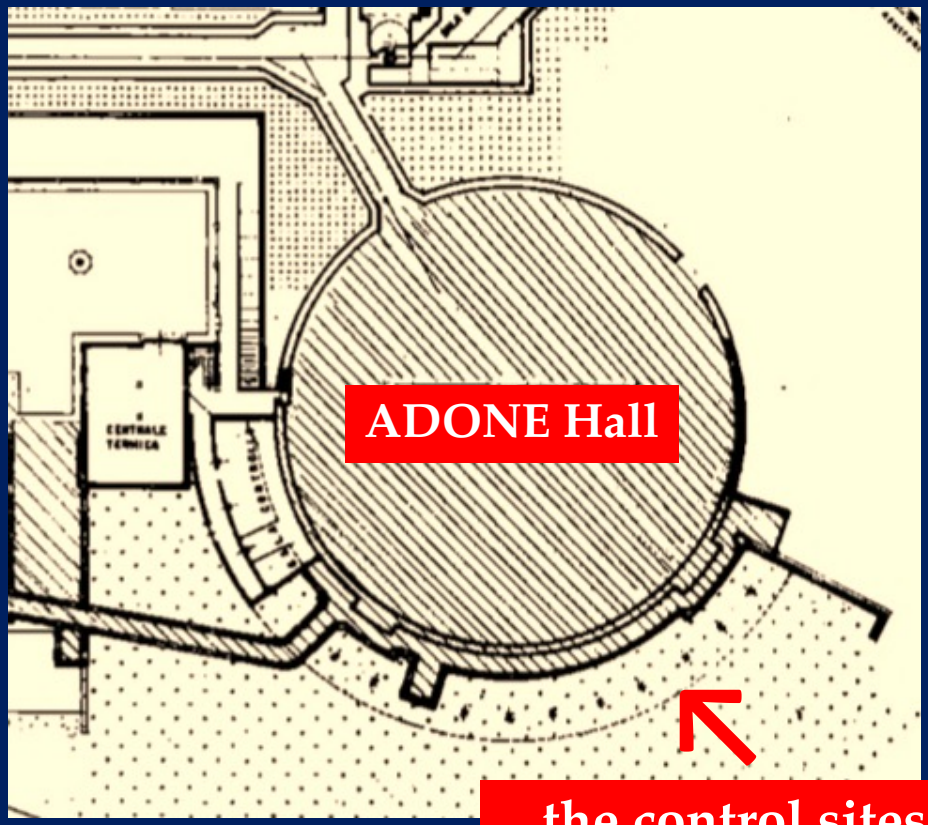
Call received by Giorgio Bellettini from Sau Lan Wu on the night 11-12 November

for this particle. On the following day the information had reached us that this particle had also been observed at SPEAR at the energy of exactly 3.10 GeV with a narrow width, <1.3 MeV.[2]

Call received by G. B. from Mario Greco

→ start searching between 3.08 and 3.12 GeV in 0.5 MeV steps

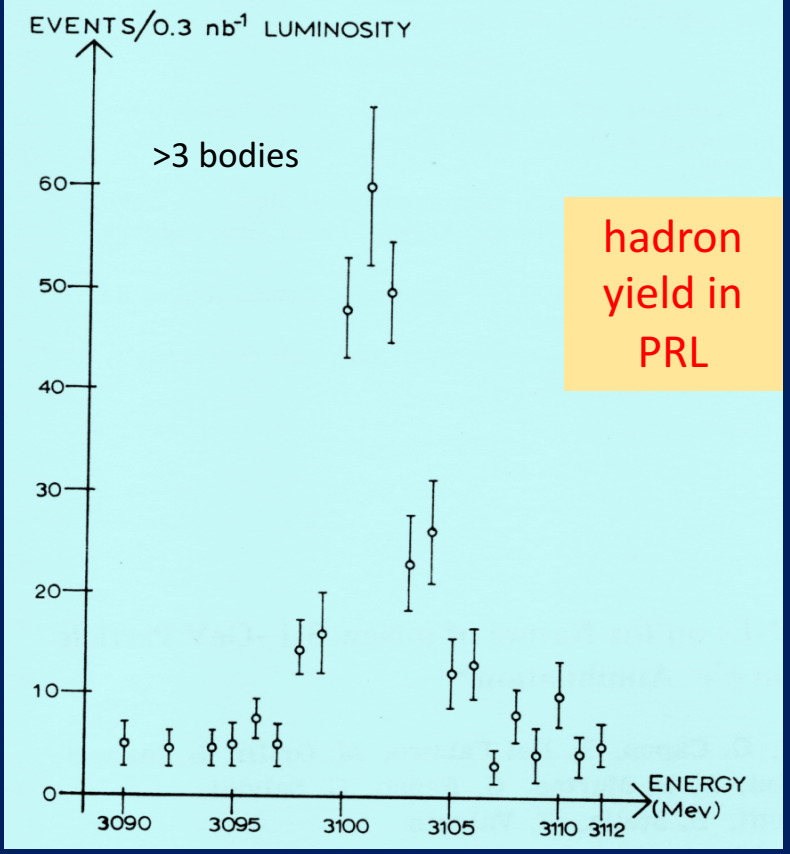
The late-night of 13 November



off resonance hadrons **few/hour**

$\gamma\gamma 2$ trigger rate **1/few minute**

on top of the J/ψ **few/minute**



B. Touschek proposed the 3 GeV maximum to study pair production of all known particles
(G. Pancheri "Bruno Touschek's Extraordinary Journey" Springer 2022)

The full time sequence

from Giorgio Bellettini - Pisa November 2017

First notice from Sau Lan Wu in the night 11-12 November
J/Psi found in the night 13-14 November
Paper ready 17 November

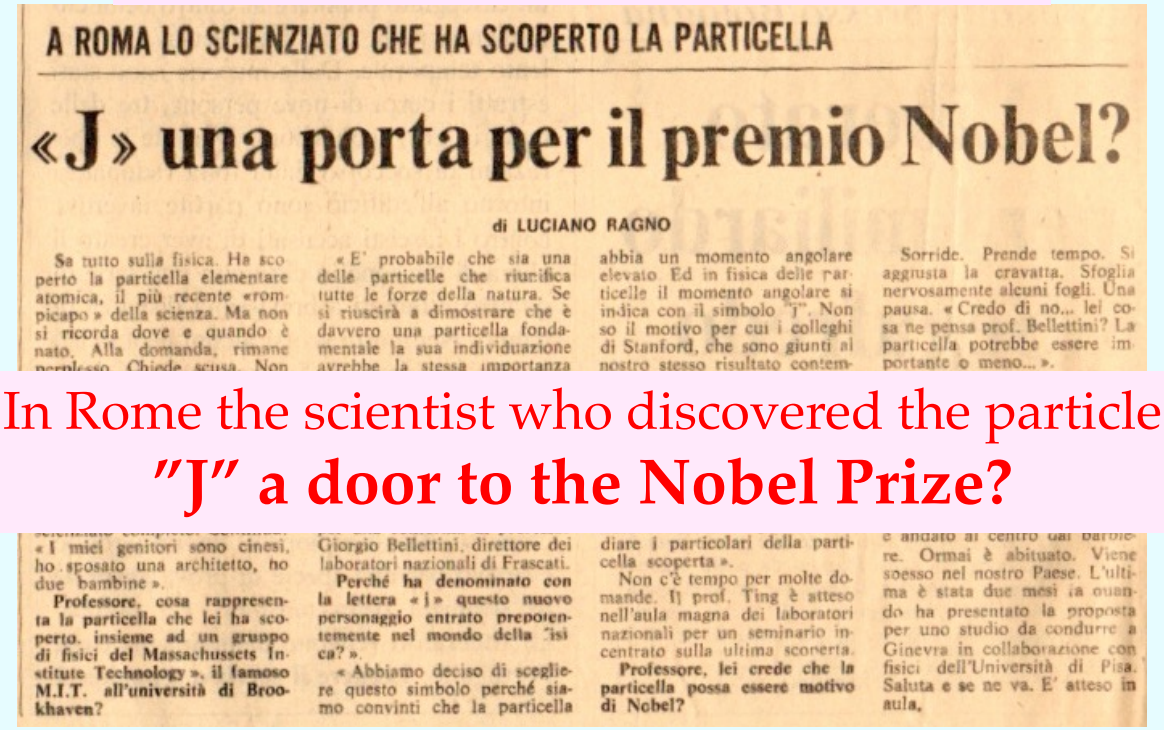
Paper by phone to Sau Lan Wu in the night 17-18 November
Paper received by PRL 18 November
Paper published 2 December in the same PRL
in line with BNL and SLAC

7 days from hearing to publishing

The day after

Exhibition of media at that time:
Newspapers and magazines kindly provided by Corrado Mencuccini

From *Il Messaggero* 21 November 1974



A ROMA LO SCIENZIATO CHE HA SCOPERTO LA PARTICELLA

«J» una porta per il premio Nobel?

di LUCIANO RAGNO

Sa tutto sulla fisica. Ha scoperto la particella elementare atomica, il più recente «rompicapo» della scienza. Ma non si ricorda dove e quando è nato. Alla domanda, rimane perplesso. Chiede scusa. Non

«E' probabile che sia una delle particelle che riunifica tutte le forze della natura. Se si riuscirà a dimostrare che è davvero una particella fondamentale la sua individuazione avrebbe la stessa importanza

abbia un momento angolare elevato. Ed in fisica delle particelle il momento angolare si indica con il simbolo "j". Non so il motivo per cui i colleghi di Stanford, che sono giunti al nostro stesso risultato contem-

Sorride. Prende tempo. Si aggiusta la cravatta. Sfoglia nervosamente alcuni fogli. Una pausa. «Credo di no... lei cosa ne pensa prof. Bellettini? La particella potrebbe essere importante o meno... ».

«I miei genitori sono cinesi, ho sposato una architetto, ho due bambine».

Professore, cosa rappresenta la particella che lei ha scoperto, insieme ad un gruppo di fisici del Massachussets Institute Technology», il famoso M.I.T. all'università di Brookhaven?

Giorgio Bellettini, direttore dei laboratori nazionali di Frascati.

Perché ha denominato con la lettera «j» questo nuovo personaggio entrato prepotentemente nel mondo della fisica?».

«Abbiamo deciso di scegliere questo simbolo perché siamo convinti che la particella

diare i particolari della particella scoperta».

Non c'è tempo per molte domande. Il prof. Ting è atteso nell'aula magna dei laboratori nazionali per un seminario incentrato sulla ultima scoperta.

Professore, lei crede che la particella possa essere motivo di Nobel?

e andato al centro dal barbiere. Ormai è abituato. Viene spesso nel nostro Paese. L'ultima è stata due mesi fa quando ha presentato la proposta per uno studio da condurre a Ginevra in collaborazione con fisici dell'Università di Pisa. Saluta e se ne va. E' atteso in aula.

In Rome the scientist who discovered the particle
"J" a door to the Nobel Prize?

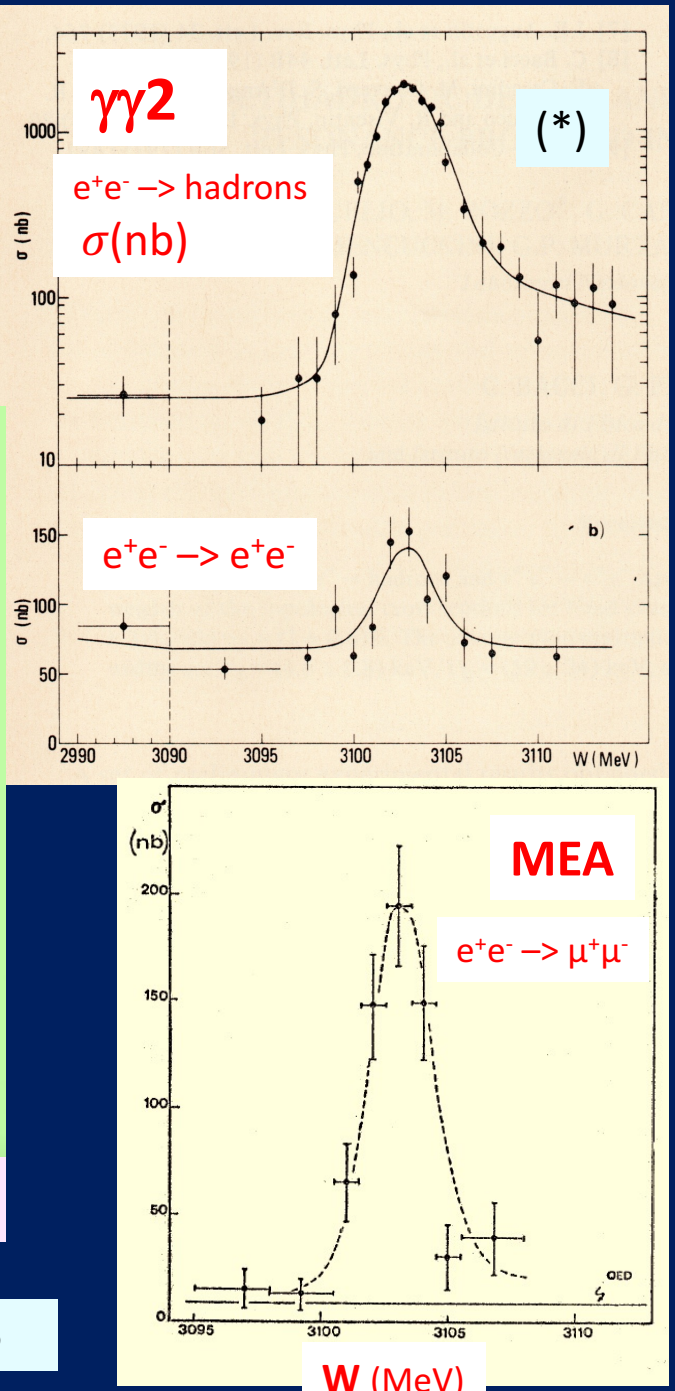
Video: O. Ciaffoni G. Pancheri
Curators: S. Bertelli E. Patrignanelli A. Postiglione S. Reda E. Santinelli

The J/ψ studies at ADONE

$\int \sigma_i dW$

GROUPS	$\gamma\gamma$	MEA	$B\bar{B}$
$\Gamma_e\Gamma_h/\Gamma$	4.8 ± 0.8 KeV	3.9 ± 0.8 KeV	-
Γ_e^2/Γ	0.32 ± 0.07 KeV	0.34 ± 0.09 KeV	0.34 ± 0.14 KeV
$\Gamma_e\Gamma_\mu/\Gamma$	--	0.38 ± 0.05 KeV	0.31 ± 0.09 KeV
Γ_e	4.6 ± 0.8 KeV	4.6 ± 1.0 KeV	--
Γ_μ	--	5.0 ± 1.0 KeV	not yet fully operational
Γ_h	59 ± 24 KeV	50 ± 23 KeV	
$\Gamma = \Gamma_e + \Gamma_\mu + \Gamma_h$	68 ± 26 KeV	60 ± 25 KeV	--
$\Gamma_{\pi^0\gamma}/\Gamma$	$< 0.5\%$ 90% C.L.	--	--
$\Gamma_{\eta^0\gamma}/\Gamma$	$< 1.6\%$ 90% C.L.	--	--
$\Gamma_{\eta'\gamma}/\Gamma$	$< 1.7\%$ 90% C.L.	--	--
$R_{\gamma\gamma/QED}$	1.6 ± 0.6	--	--

C. Bemporad Lepton-Photon 1975 Stanford

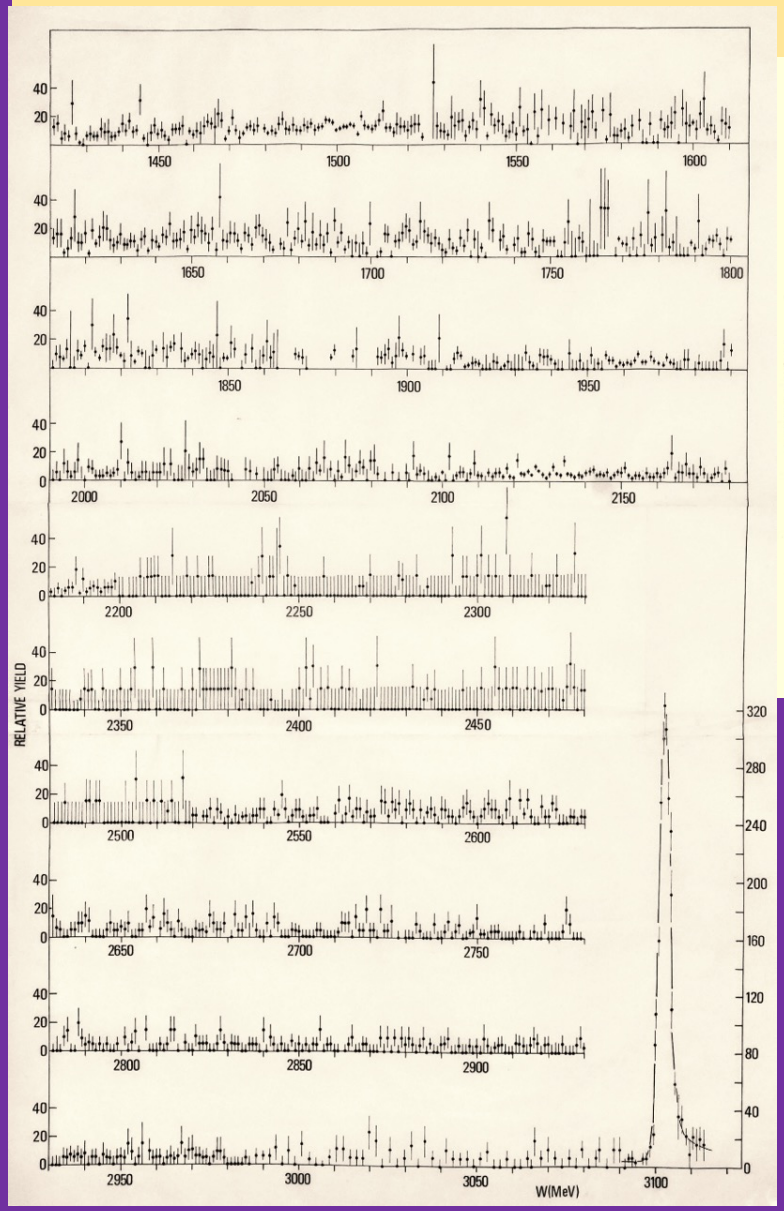


(*) Radiative corrections M. Greco G. Pancheri Y. Srivastava 1975

The energy scan in 3 rounds

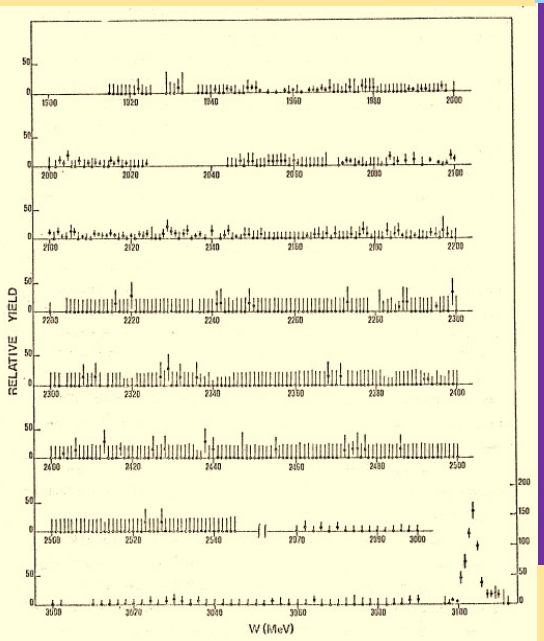
1975-77 1 MeV steps 1.45 – 3.1 GeV

$\gamma\gamma 2$ ≈ 350 nb^{-1} ≈ 4000 mh events



MEA 1.9 – 2.5 GeV

$\Gamma_W(\mathrm{MeV}) = 0.32\ W^2\ (\mathrm{GeV}^2)$

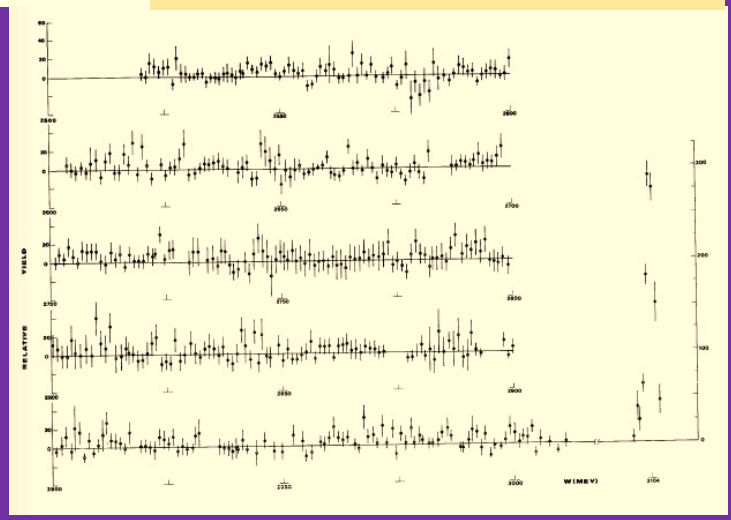


Overall upper limit for $\int \sigma_h dW$ of narrow resonances

~ 5 ÷ 10% of J/ψ

90% c.l.

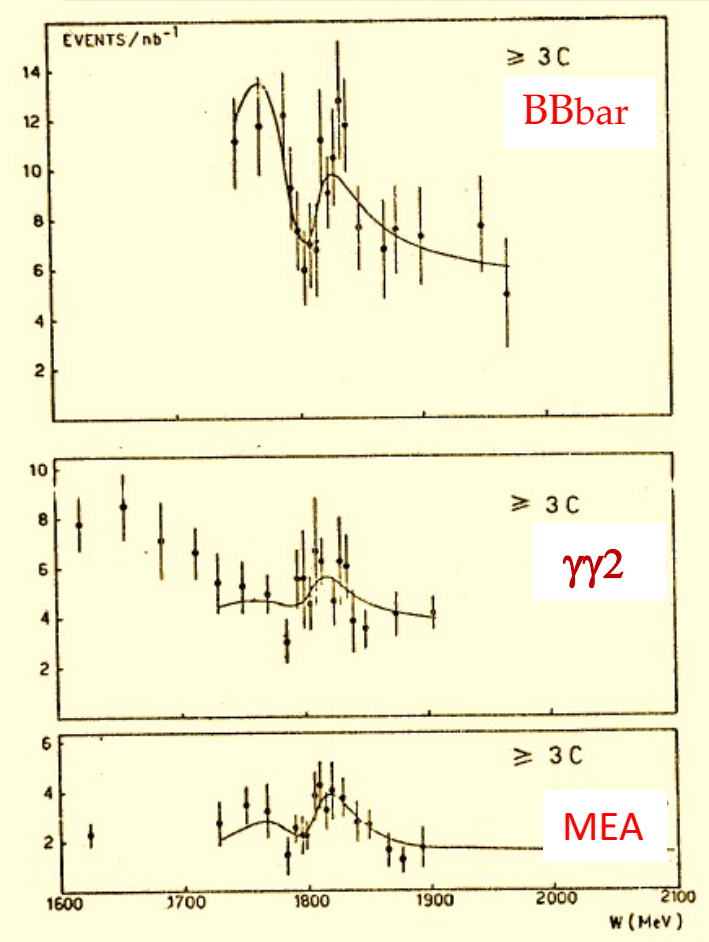
BBbar 2.5 – 3.1 GeV



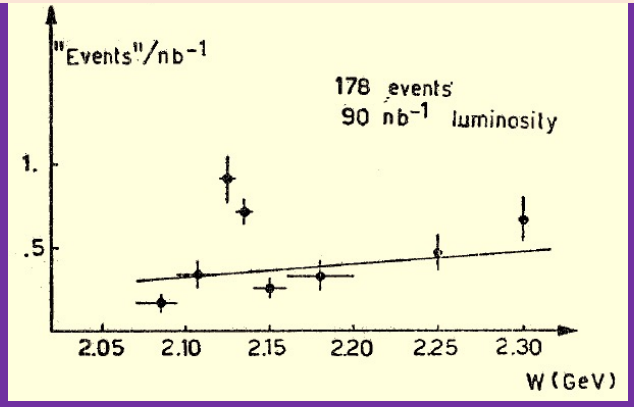
Search for broader structures

J. D. Bjorken "We really don't know much yet about what is going on above the Φ and below the J/ψ" LP-1975 Stanford

The 3 experiments around 1.82 GeV



MEA **K*** resonant production at 2.13 GeV



C. Bemporad conclusion at LP-1977 Hamburg

Saul Steinberg

Energy scan data used for an improved study of the multihadrons

The 4 first generation experiments at **ADONE**

Main interest in 2 body processes

γγ ππ μμ Heavy Lepton QED

experiments **γγ** **μπ** **BCF** (Bologna-Cern-Frascati)

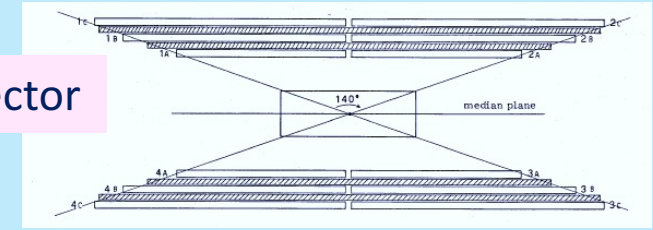
Angular acceptances $\gtrsim 0.20$ 4π sr for point source

1965 C. Bernardini **Vector Boson Hunting at ADONE (*)**

1966 C. Bernardini et al **ADONE as a Boson Mass Spectrometer**

The idea was that of a continuous scan by a slow triangular energy modulation for an explorative search with a view to narrow resonances.

sketch of an explorative detector



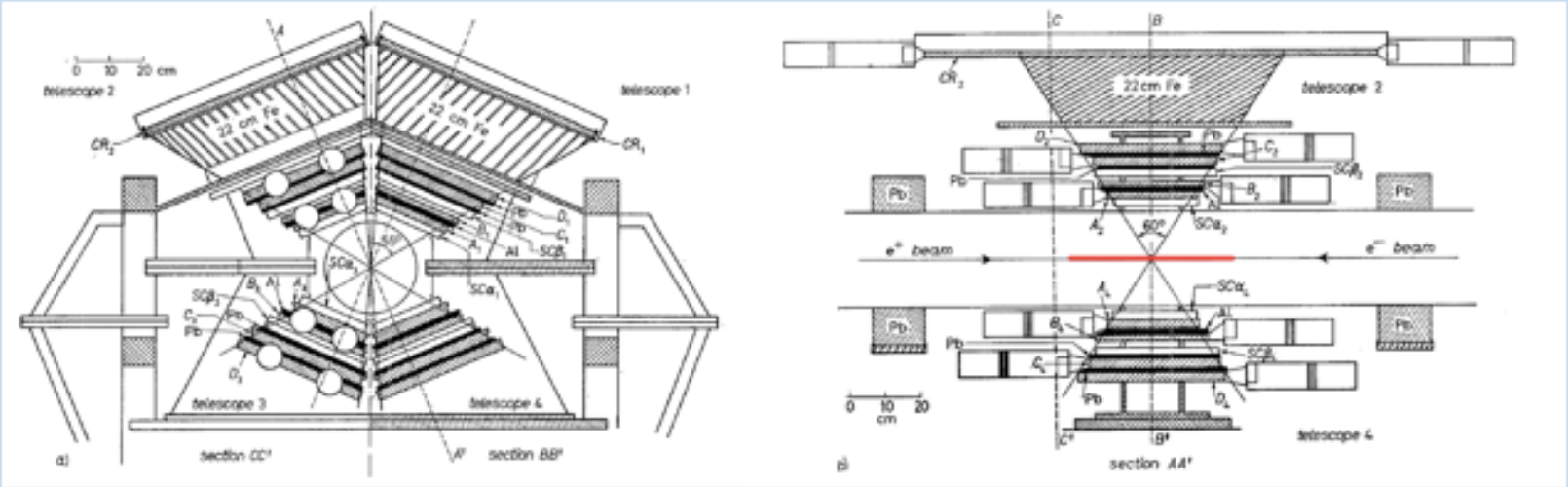
It was technically prohibitive … however it inspired the **BOSON** experiment

(*) Inspired by B. Touschek's view of the vacuum

He had a very strong picture of the microscopic world in his mind. He conceived the vacuum as a reactive dielectric resonating at frequencies $\nu = mc^2/h$

B. BARTOLI, F. FELICETTI, H. OGREN and V. SILVESTRINI Frascati
G. MARINI, A. NIGRO and N. SPINELLI Rome
F. VANOLI Napoli

The BOSON detector



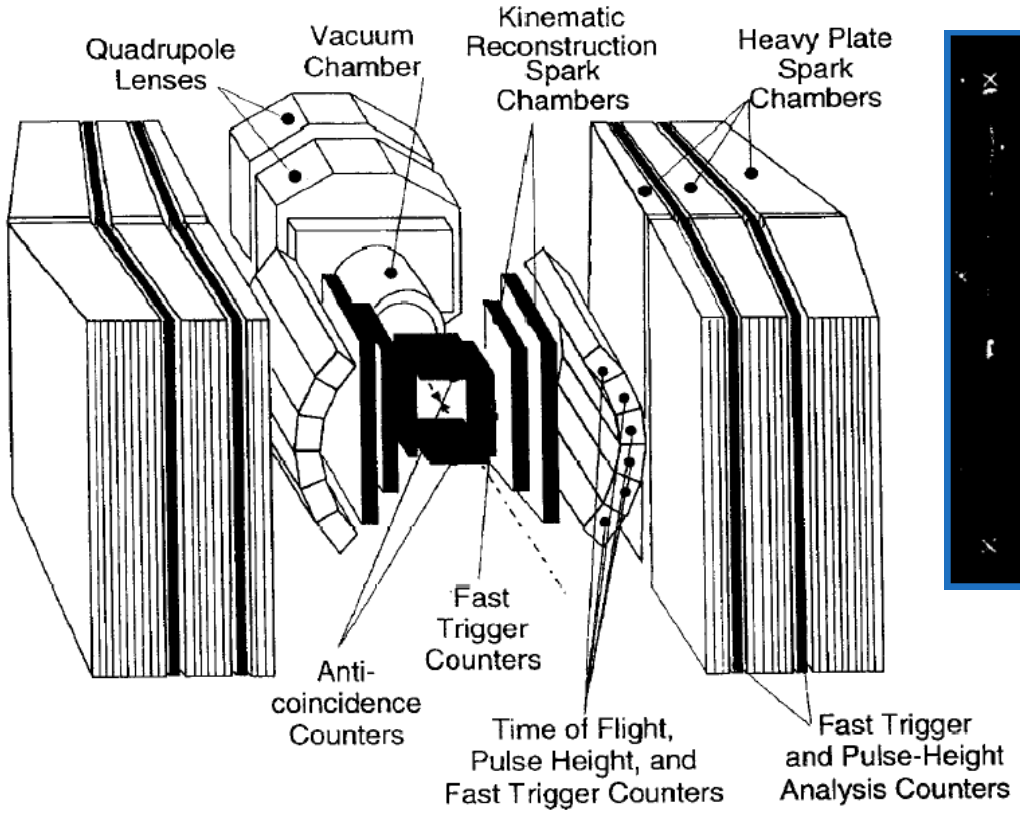
scintillation counters and magnetostrive spark-chambers → **PDP8 online**
(all other experiments tracking by optical spark chambers)
~ 0.35 4π for point source

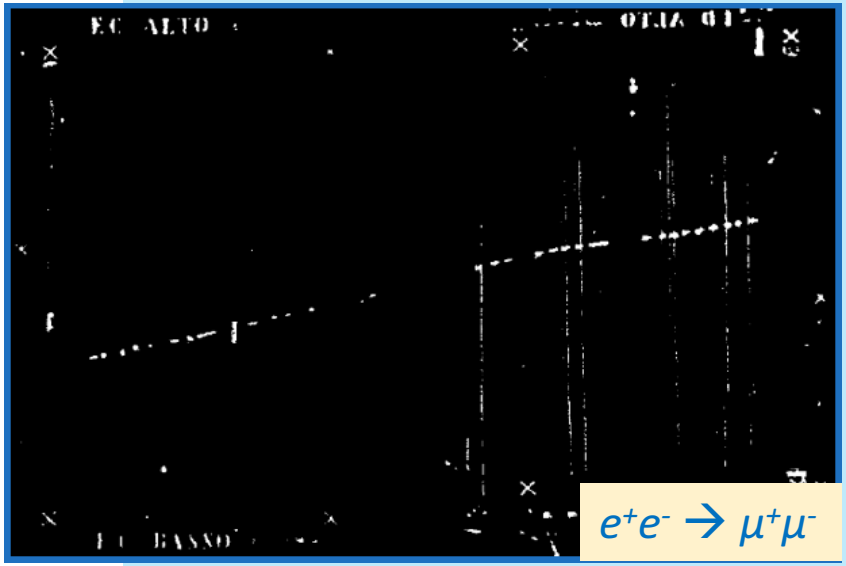
Source length ~ 50 cm × $E_{GeV}^{3/2}$ FWHM
→ all detectors ~ 20% effective angular acceptance

M. BERNARDINI, D. BOLLINI, P.L. BRUNINI, E. FIORENTINO, T. MASSAM,
L. MONARI, F. PALMONARI, F. RIMONDI and A. ZICHICHI

Bologna-Cern-Frascati

BCF





Search for a Heavy Lepton via the acoplanar μe method

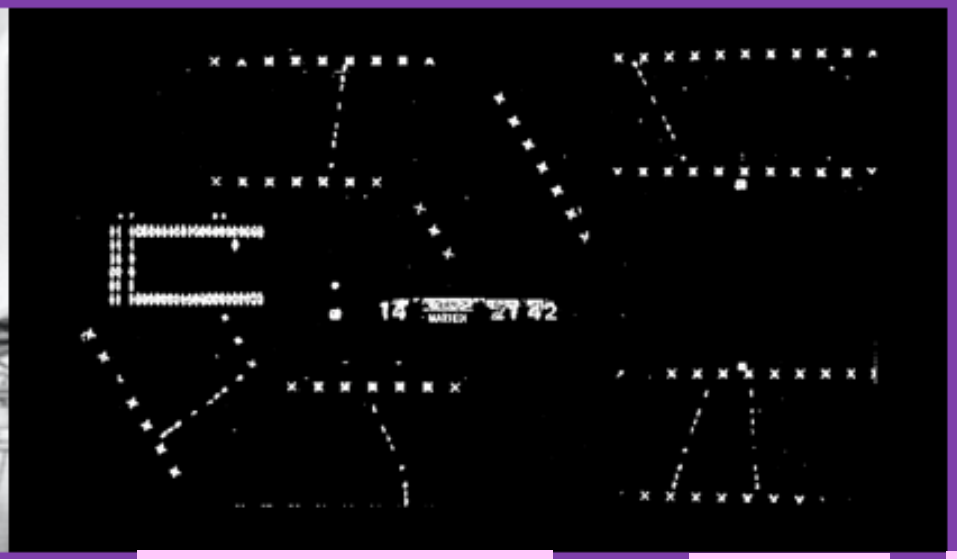
The only experiment with e μ π test beams for particle ID

ADONE experiments started at the beginning of 1970

surprising abundance of multiparticle events **>2 produced** hadrons, mostly pions

C. BACCI, G. PENSO, G. SALVINI and B. STELLA Rome
R. BALDINI CELIO, G. CAPON, C. MENCUCCINI, G.P. MURTAS,
M. SPINETTI and A. ZALLO Frascati

$\gamma\gamma$



front view $\perp$ beams

side view

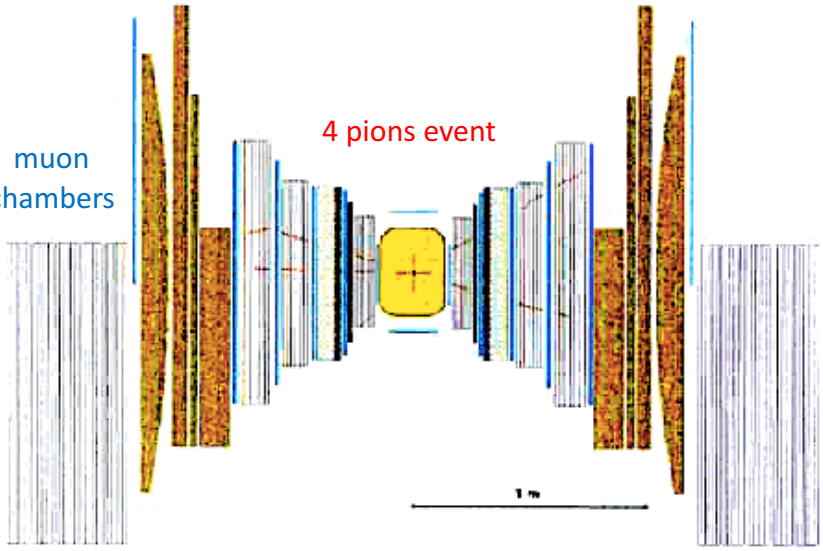
3 charged

the unexpected phenomenon was announced at **ICHEP-1970 Kiev**

the BOSON group published on Nuovo Cimento 1970

μπ

M. Grilli, E. Iarocci, P. Spillantini, V. Valente and R. Visentin — Frascati
B. Borgia, F. Ceradini, M. Conversi, L. Paoluzi and R. Santonico — Rome
M. Nigro — Padova — L. Trasatti and G. T. Zorn — Maryland

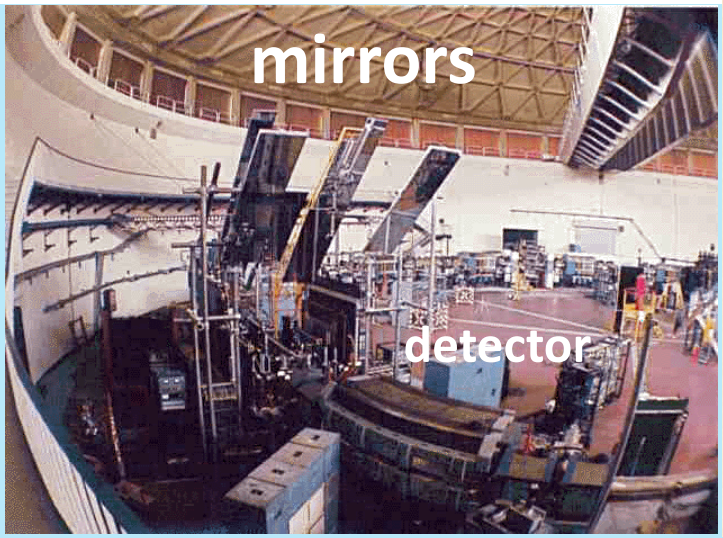


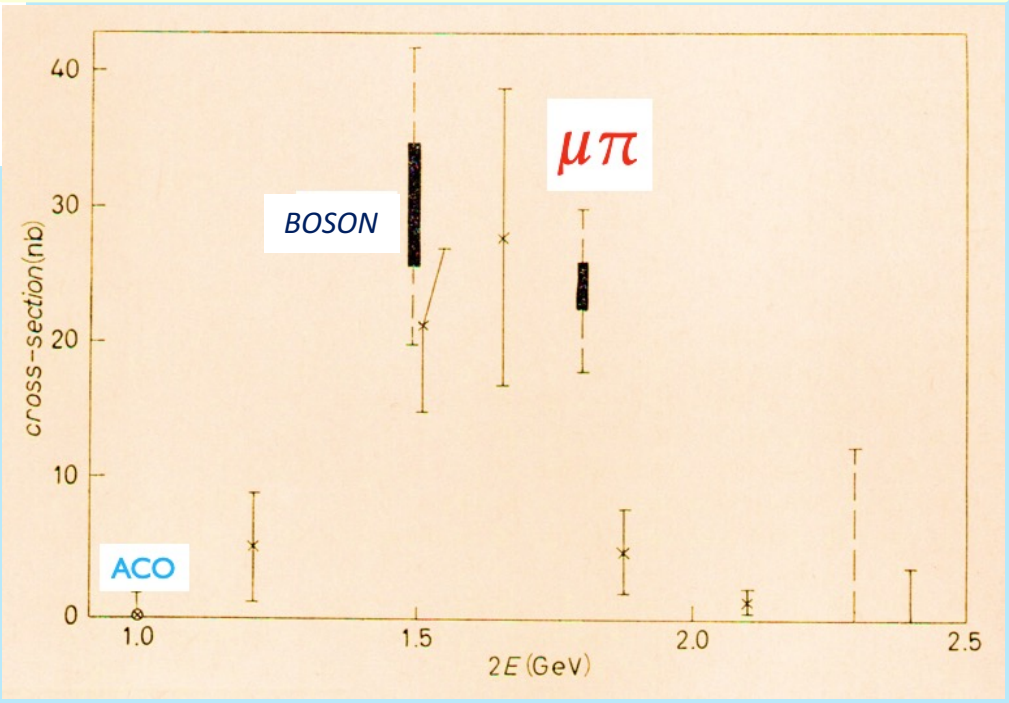
1972 observed broad peak around 1.6 GeV in

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

ρ′ interpretation by A. Bramon and M. Greco

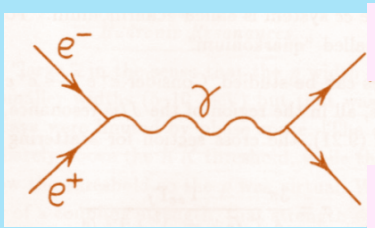
4 pions: angles → kinematics





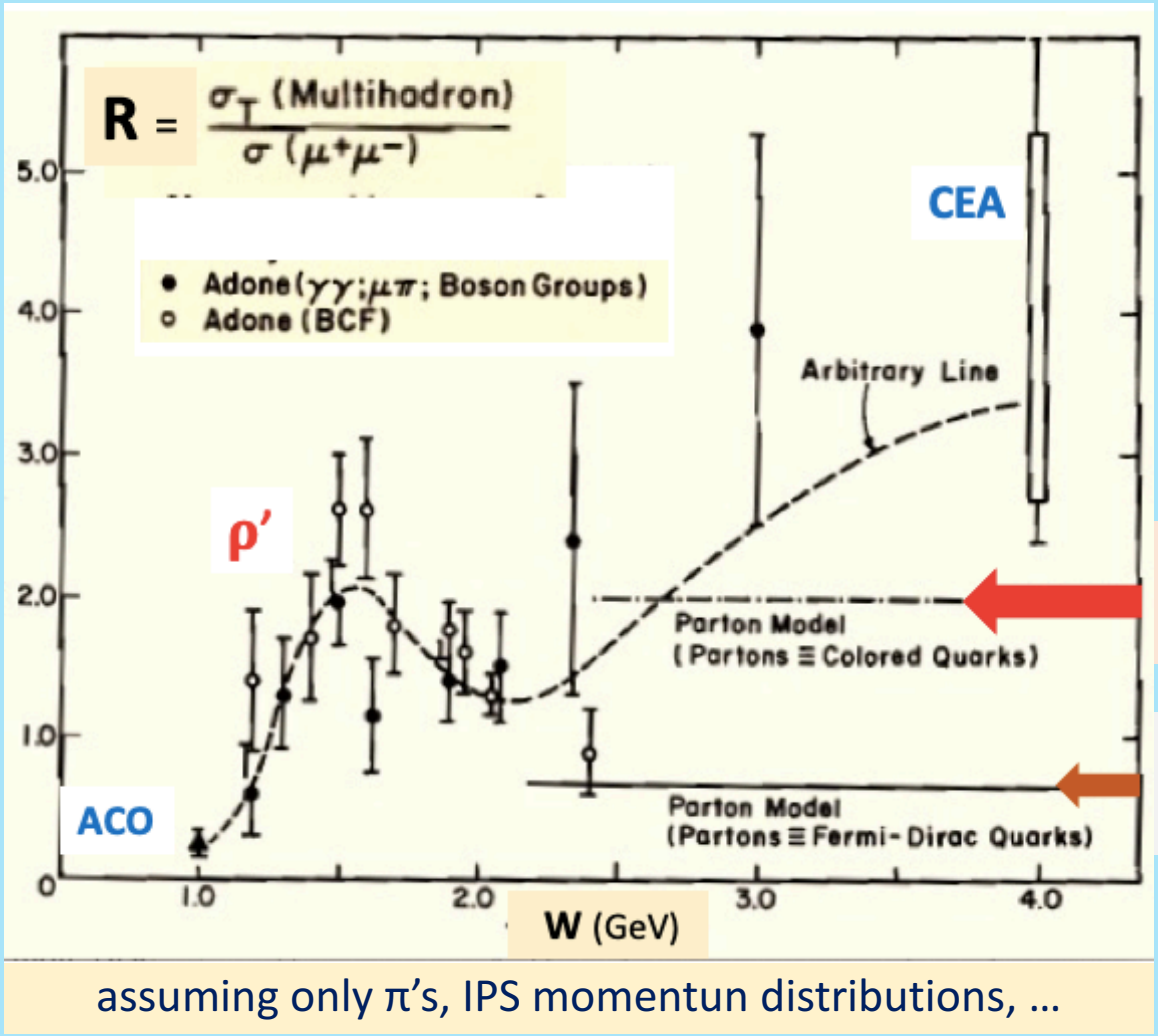
ICHEP-1972 Batavia

e^+e^- rapporteur V. Silvestrini
Models: EVDM, partons → quarks
(M. Gell-Mann's seminar in Rome in April)



quarks

antiquarks



assuming only π's, IPS momentun distributions, …

$$R_\infty = \sum Q_i^2 + \frac{1}{4}\sum q_i^2 .$$

= ∑(quark-charges)²
over all quark varieties
in e-charge units

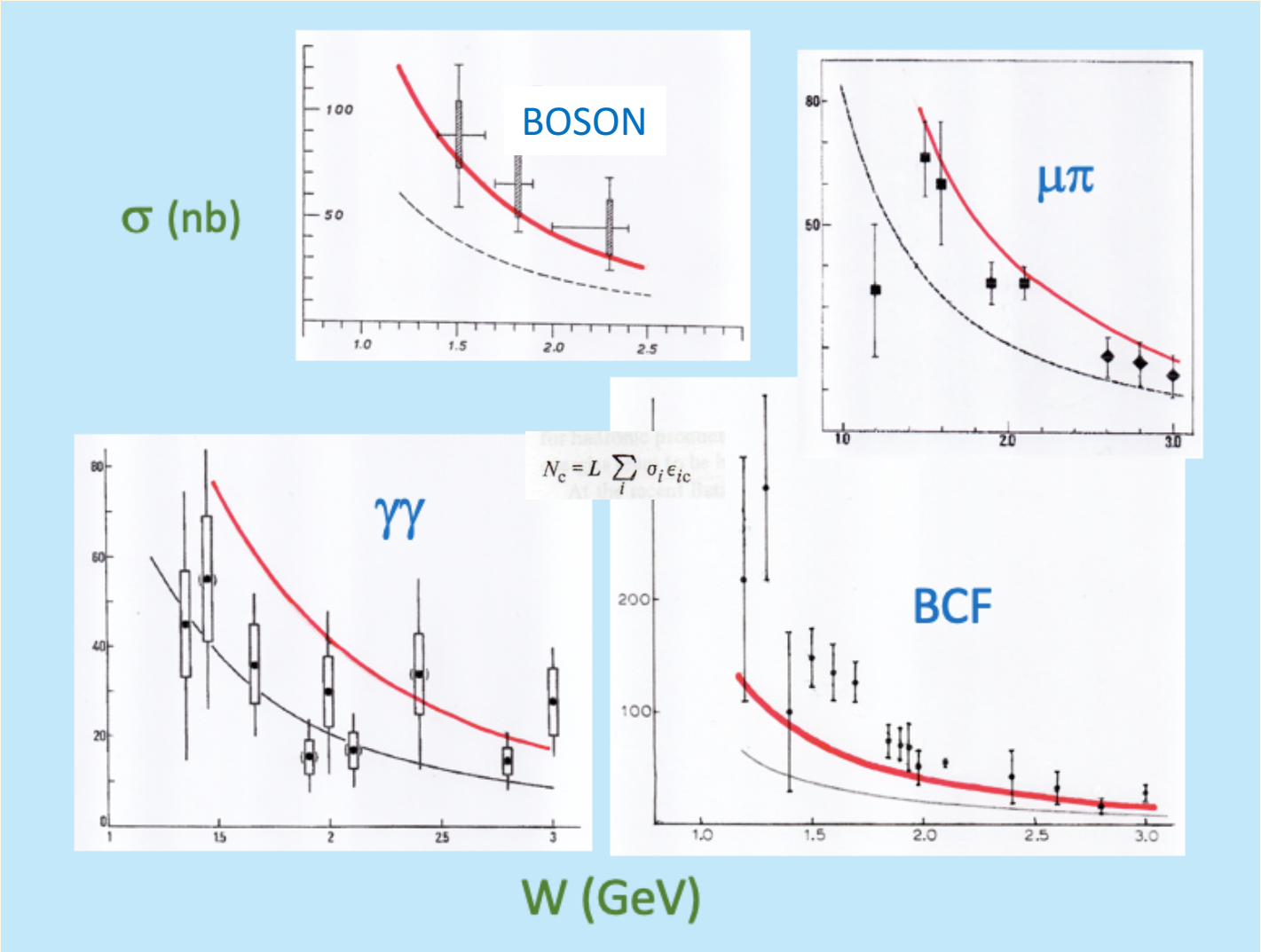
each quark in 3 colors
R = 3 (2/3) = **2**

u d s quarks
R = $(2/3)^2+(-1/3)^2+(-1/3)^2$ = **2/3**

ADONE first phase ended in
1972 with runs near 3.0 GeV

Final results in Physics Letters 1971-74

σ(hadrons) vs **σ**(muons) and **2σ**(muons)

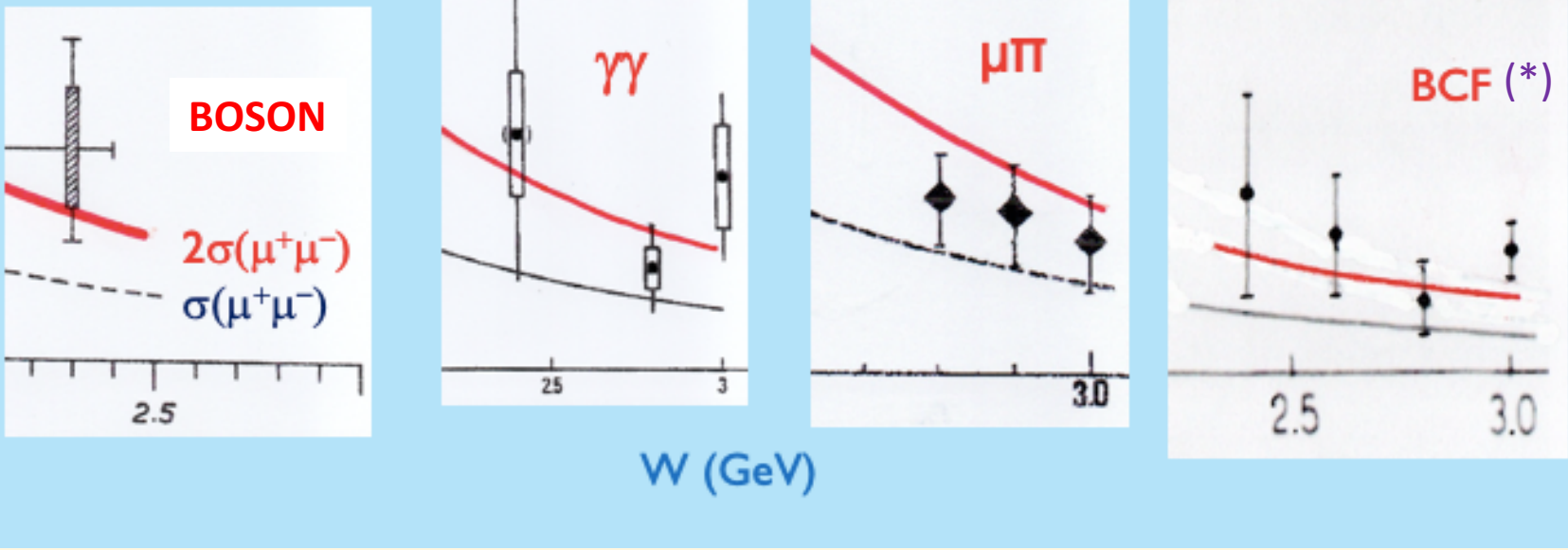


Total per experiment: ≈ 1 pb^{-1} ≈ 10^3 hadronic events

Large systematic errors from low efficiencies of small acceptance detectors

$N_c = L \sum_i \sigma_i \epsilon_{ic}$

σ(hadrons) vs σ(muons) and 2σ(muons) above 2.2 GeV

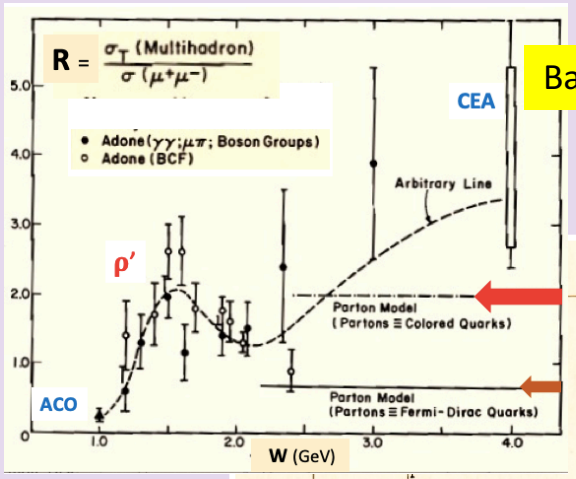


average **R ~ 2.2**

the first direct indication of color

this possible interpretation was pointed out in the γγ paper mentioning at the same time the compatibility with other models

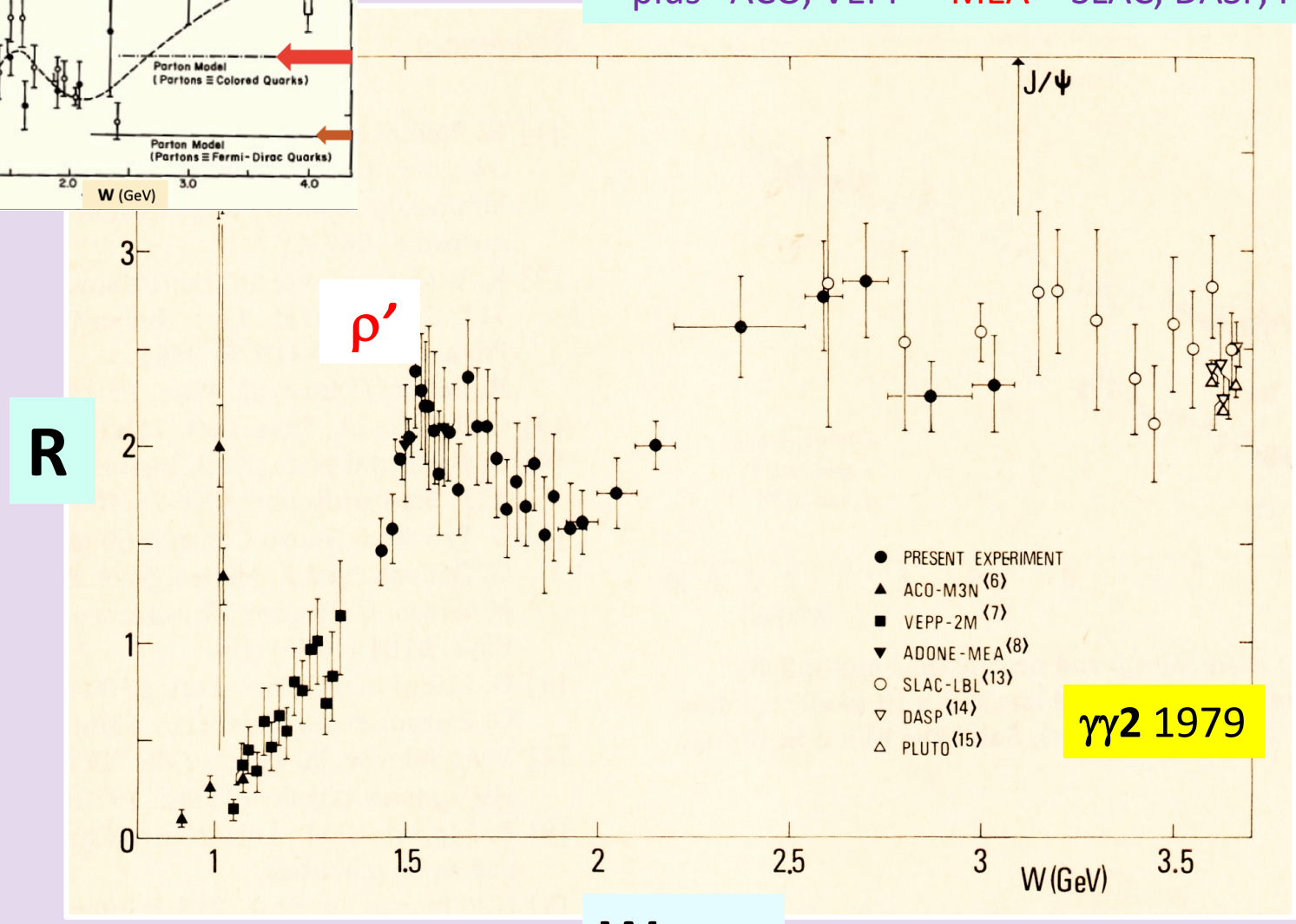
(*) The BCF σ(hadrons) is that obtained with the quasi-model-independent method



Batavia 1972

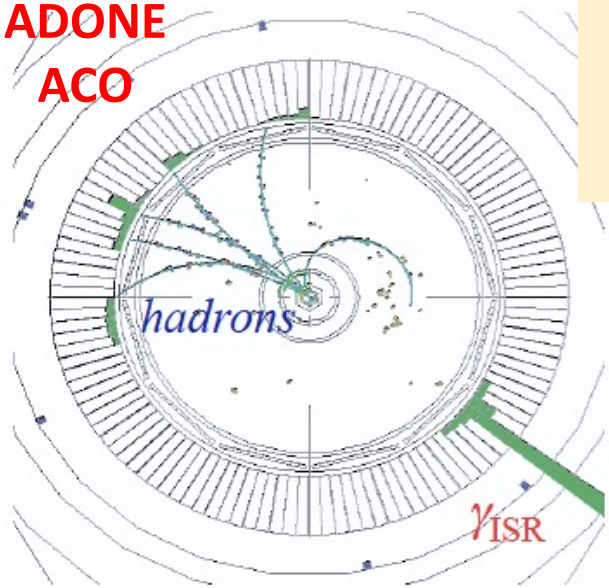
γγ2 data from the energy scan

plus ACO, VEPP - MEA - SLAC, DASP, PLUTO

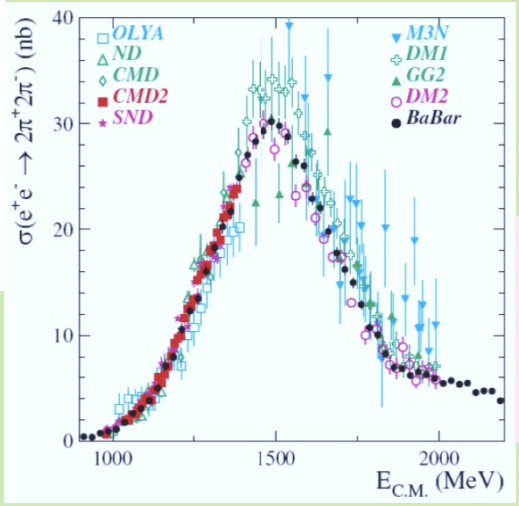


High accuracy R for the g-2 of the muon
flavor factories revisiting low energies by the ISR method

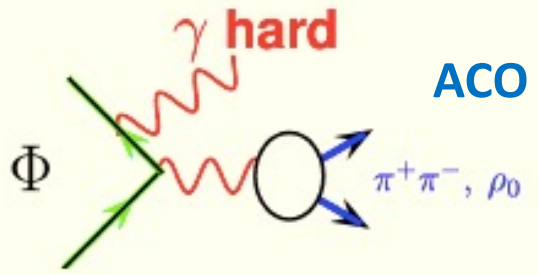
ADONE
ACO



BABAR at PEP
10.6 GeV $\Upsilon(4S)$
back to ADONE and ACO
from F. Anulli 2017



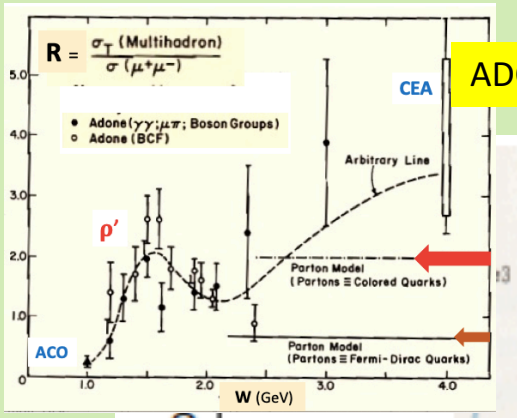
KLOE at DAΦNE



radiative return to **ACO**

$e^+e^- \to \pi^+\pi^-\pi^+\pi^-$
~ **30** events **μπ** 1972
~ **60,000** **BABAR** 2005

In mid 60's in view of ADONE B. Touschek initiated studies of radiative processes at Frascati

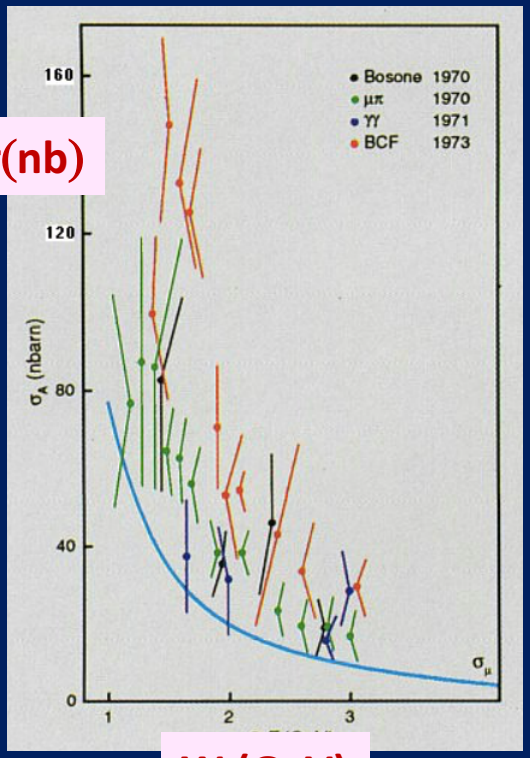

R = σT (Multihadron) / σ (μ+μ−)
CEA
Adone(γγ;μπ; Boson Groups)
Adone (BCF)
Arbitrary Line
ρ′
Parton Model
(Partons ≡ Colored Quarks)
ACO
Parton Model
(Partons ≡ Fermi-Dirac Quarks)
W (GeV)

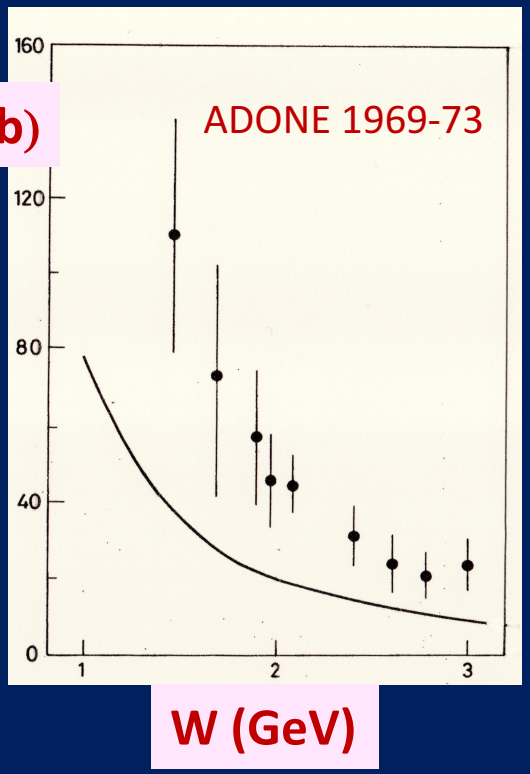
ADONE 1972

R
W (GeV)
BABAR 2017
ADONE 1979
φ
J/ψ
PRESENT EXPERIMENT
ACO-M3N (6)
VEPP-2M (7)
ADONE-MEA (8)
SLAC-LBL (13)
DASP (14)
PLUTO (15)
W (GeV)

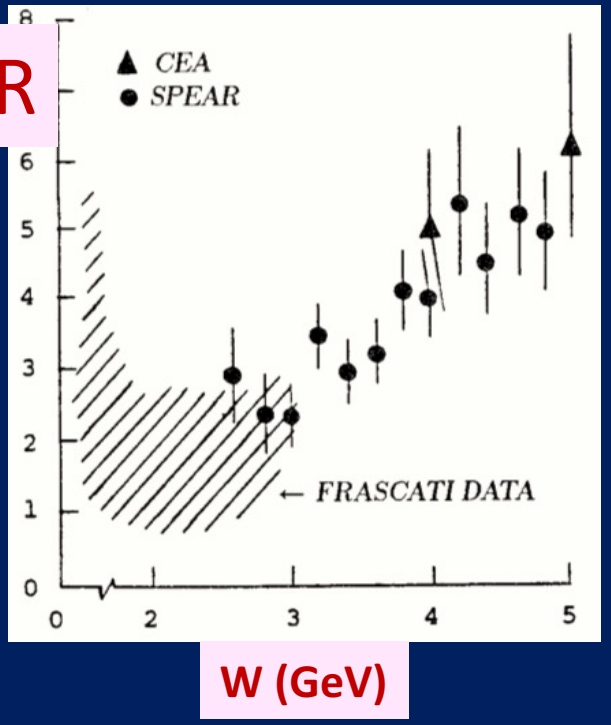
Conclusive comments

Born in 1955 as Accelerator Lab with the 1.1 GeV Electron-Synchrotron project the success of the initiative set Frascati at the world frontier in 1959.
The Laboratory touched the highest point in 1960 with Bruno Touschek's idea of particle-antiparticle collider and the AdA prototype, immediately followed by the ADONE project in 1961 and the discovery of multihadrons in 1970.
The initial role has been revived with the DAΦNE Φ-Factory project in 1990, and confirmed in perspective with the EuPRAXIA project in 2022.

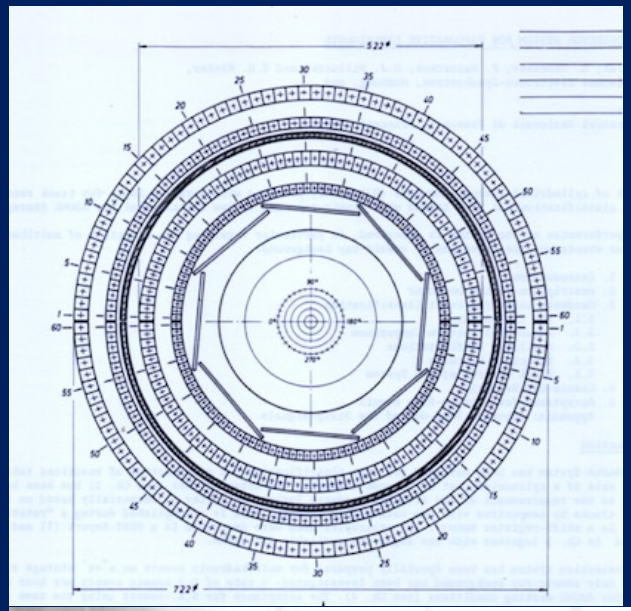




G. Salvini 1974
Enciclopedia EST
Mondanori

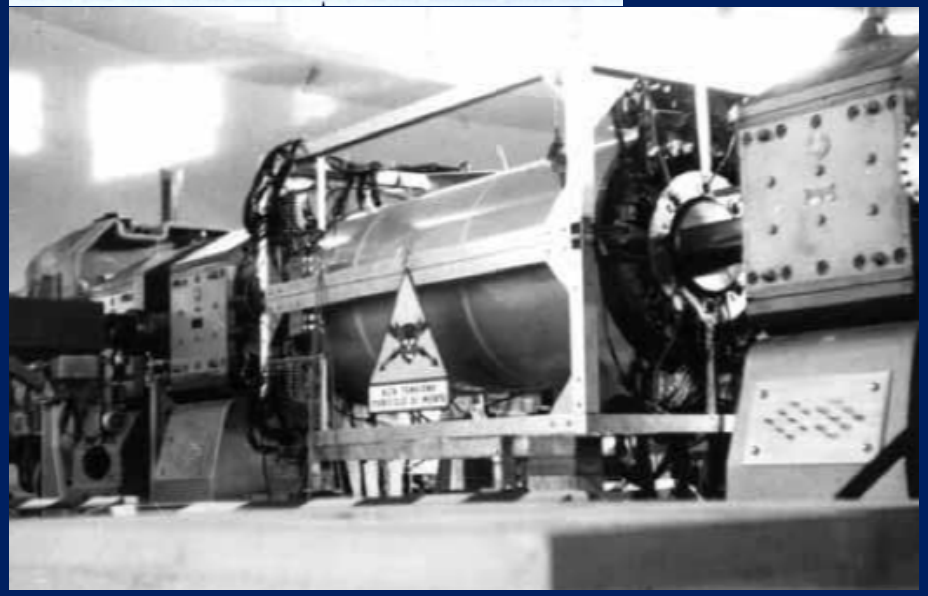


B. Richter on
Colliding beams. SLAC 1984



The MADKA R&D detector
in the 4th Interaction Region

A First Level Tracking Trigger prototype applied to a
4 cylindrical MWPC system for the PLUTO detector at DORIS



DEUTSCHES ELEKTRONEN-SYNCHROTRON **DESY**

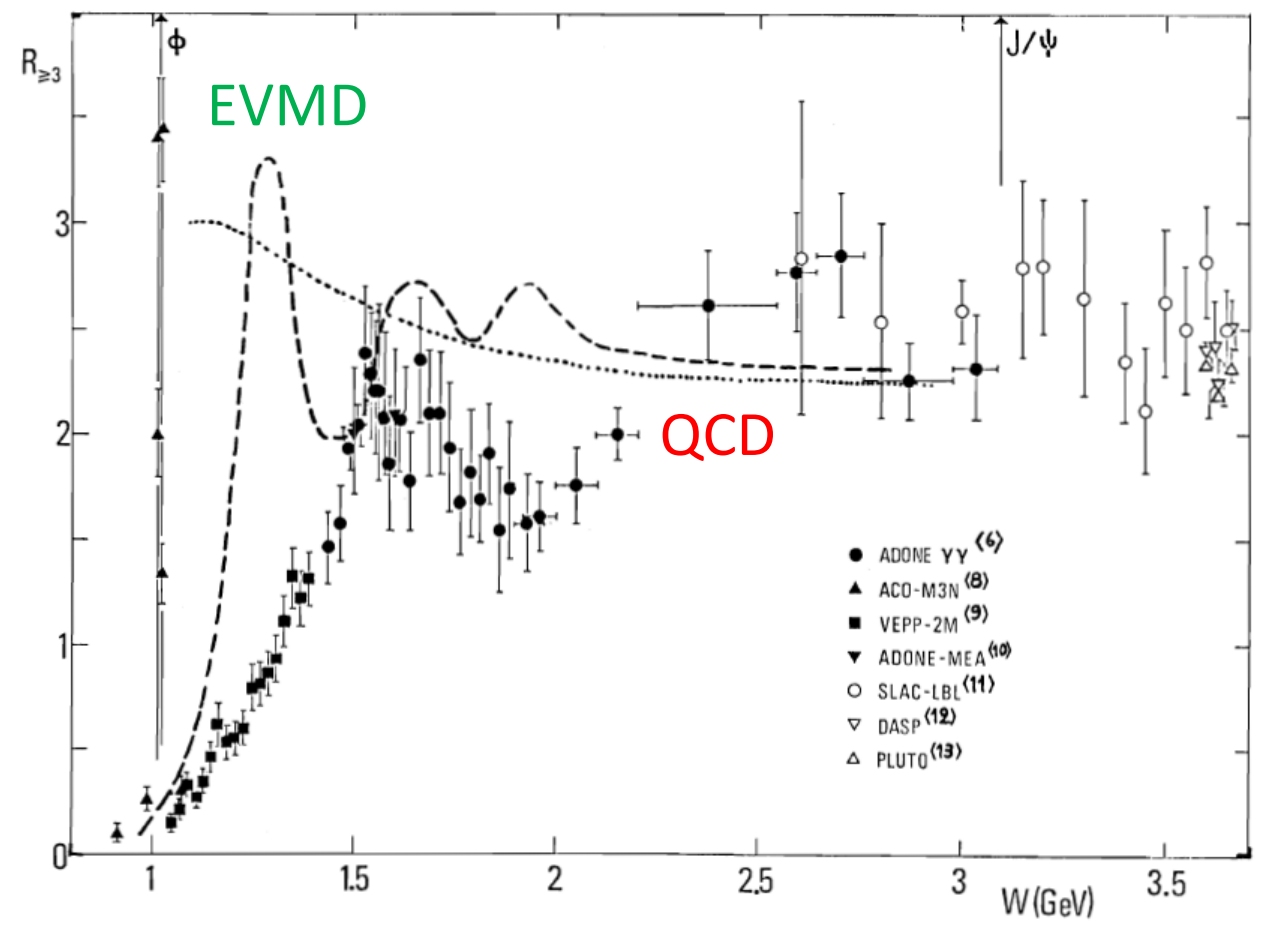
DESY 72/13
March 1972

E. Iarocci
LNF, Frascati (Roma)

P. Waloschek
Deutsches Elektronen-Synchrotron DESY, Hamburg

Hardware Logic for the Selection and Analysis of Events Observed in Charpak-Chamber and Counter Experiments

M. Spinetti, Lepton-Photon, Batavia 1972



…….T. Appelquist et al., Phys. Rev. 12, 43 (1975)

--------M. Greco, Phys. Letters 77B 84 (1978)

Physical Review Letters
2 December1974

EDITORIAL

Publication of a New Discovery

This issue of Physical Review Letters must certainly be one of the most unusual in our history, with not just one but three extremely stimulating reports of a new discovery. Undoubtedly, the activity which will