The Pioneers of FRAMM

Tracking the Elusive: 50 Years of High Precision Measurements with Luigi Rolandi

Pisa, November 7, 2025

M. Agnese Ciocci & Francesco Fidecaro

FRAMM - NA1

- FRAMM was conceived at the stone age of particle physics
- NO J/Psi, no charm, no beauty and of course no Higgs boson
- FRAMM meant FRAMMENTAZIONE for hadron fragmentation
- NA1 was approved in 1975
- A fully Italian collaboration at the beginning with Lorenzo Foà as spokesperson:

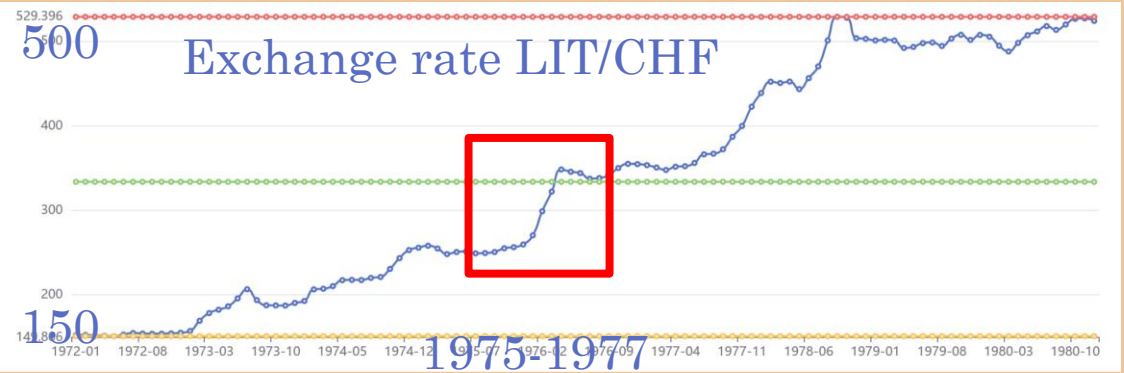
ISS, Laboratori Nazionali Frascati, Pisa, Milano, Roma La Sapienza

→ No CERN participation in the collaboration!
However CERN gave a splendid support to the experiment

A do it yourself experiment

where everybody build a piece of it in the local workshops

this created since the beginning a strong community sharing scientific goals, and building lasting relationships well beyond work



1975-1977

Huge impact on experiment budget and travel expenses whatever housing was shared among several persons

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN LIBRARIES, GENEVA

CM-P00044805

CERN SPSC/ I 73-36
20 August 1973

LETTER OF INTENTION TO THE SPS COMMITTEE

COMPARATIVE STUDY OF HADRON FRAGMENTATION WITH THE SPS

A. Baroncelli, C. Bosio and G. Matthiae
Istituto Superiore di Sanità, Roma

G. Bologna, B, D'Ettore Piazzoli, F.L. Fabbri, G. Matone, P. Picchi,
A. Reale, L. Satta, M. Severi, P. Spillantini and R. Visentin
Laboratori Nazionali di Frascati
Istituto di Fisica dell'Università, Roma
Istituto Nazionale di Fisica Nucleare, Sezione di Roma

G. Bellini, A. Cantore, M. Di Corato, P.F. Manfredi,
F. Palumbo, P.G. Rancoita and G. Vegni
Istituto di Fisica dell'Università, Milano
Istituto Nazionale di Fisica Nucleare, Sezione di Milano

S.R. Amendolia, E. Bertolucci, C. Bradaschia, A. Del Guerra, L. Foà,
A. Giazotto, M. Giorgi, A. Menzione, G. Pierazzini, P. Rehak,
L. Ristori, A. Scribano, A. Stefanini and L. Vincelli
Istituto di Fisica dell'Università, Pisa
Scuola Normale Superiore, Pisa
Istituto Nazionale di Fisica Nucleare, Sezione di Pisa

ADDENDUM 3 TO PROPOSAL P6

STATUS REPORT ON EXPERIMENT NA1 AND PROPOSAL FOR
THE DETERMINATION OF $\eta_c(2.8)$ LIFETIME VIA PRIMAKOFF EFFECT

Frascati-Milano-Pisa-Rome (FRAMM) Collaboration

The FRAMM Spectrometer

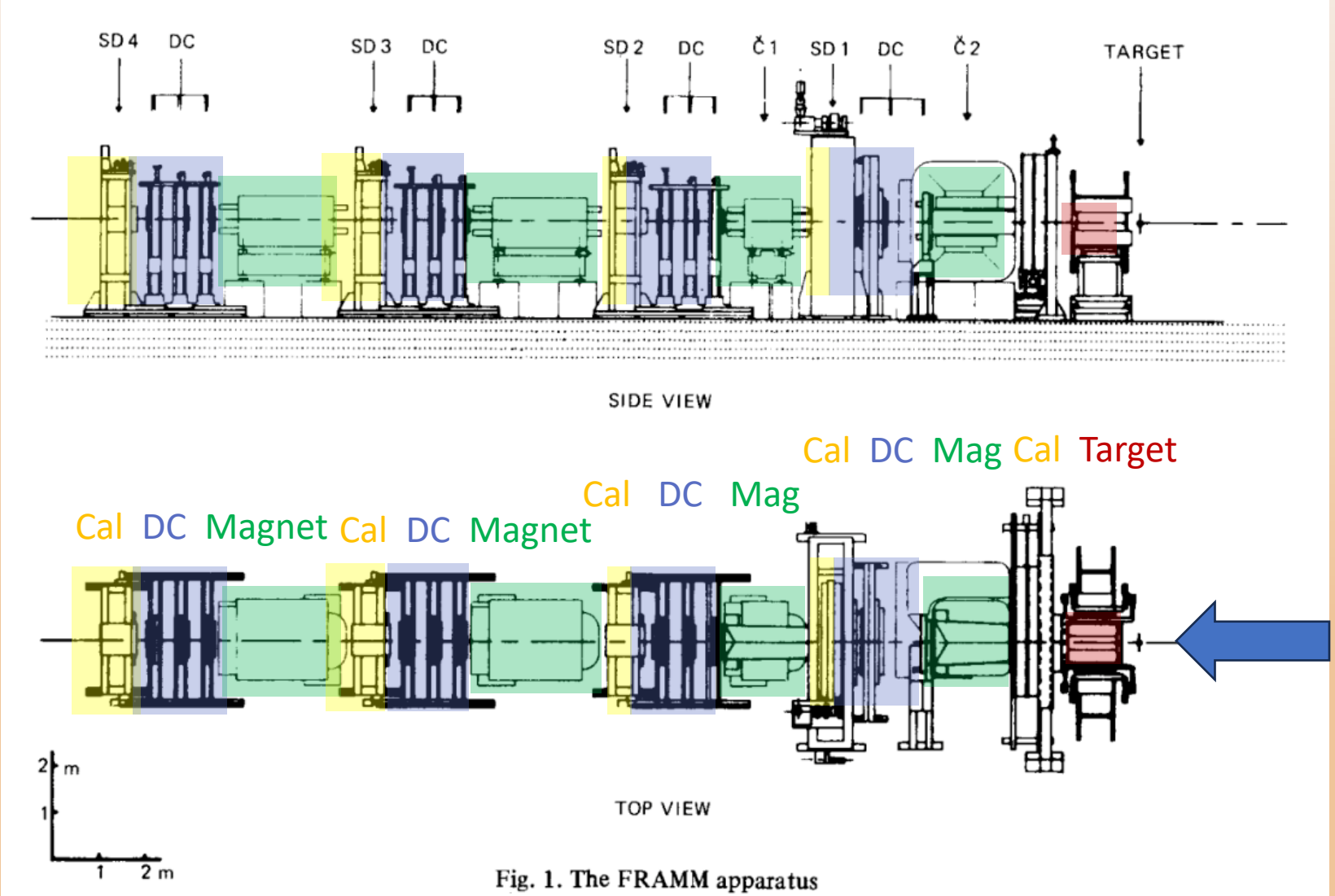


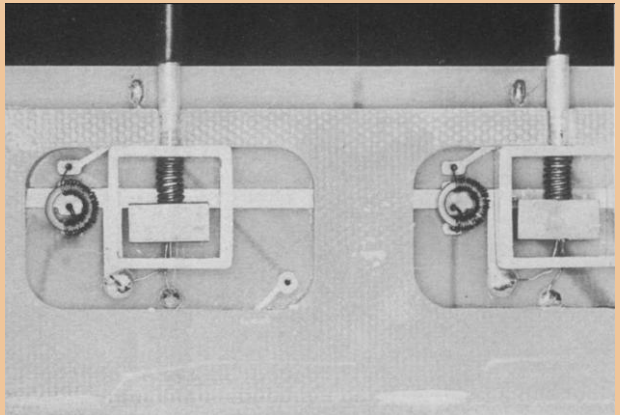
Fig. 1. The FRAMM apparatus

The Drift Chambers

Chambers were built in the Pisa San Piero mechanical workshop by the full team, from technicians to professors not forgetting last but not least, students

- Field wires were woven by older students while sense wires (20 μm ϕ) were left to the more expert technicians
- Delay lines were wound on a lathe by our specialist Gigi and put under tension in the frame
- Everything was then wrapped into a heat shrinkable bag (coke can package like) and baked

A drift chamber was born!



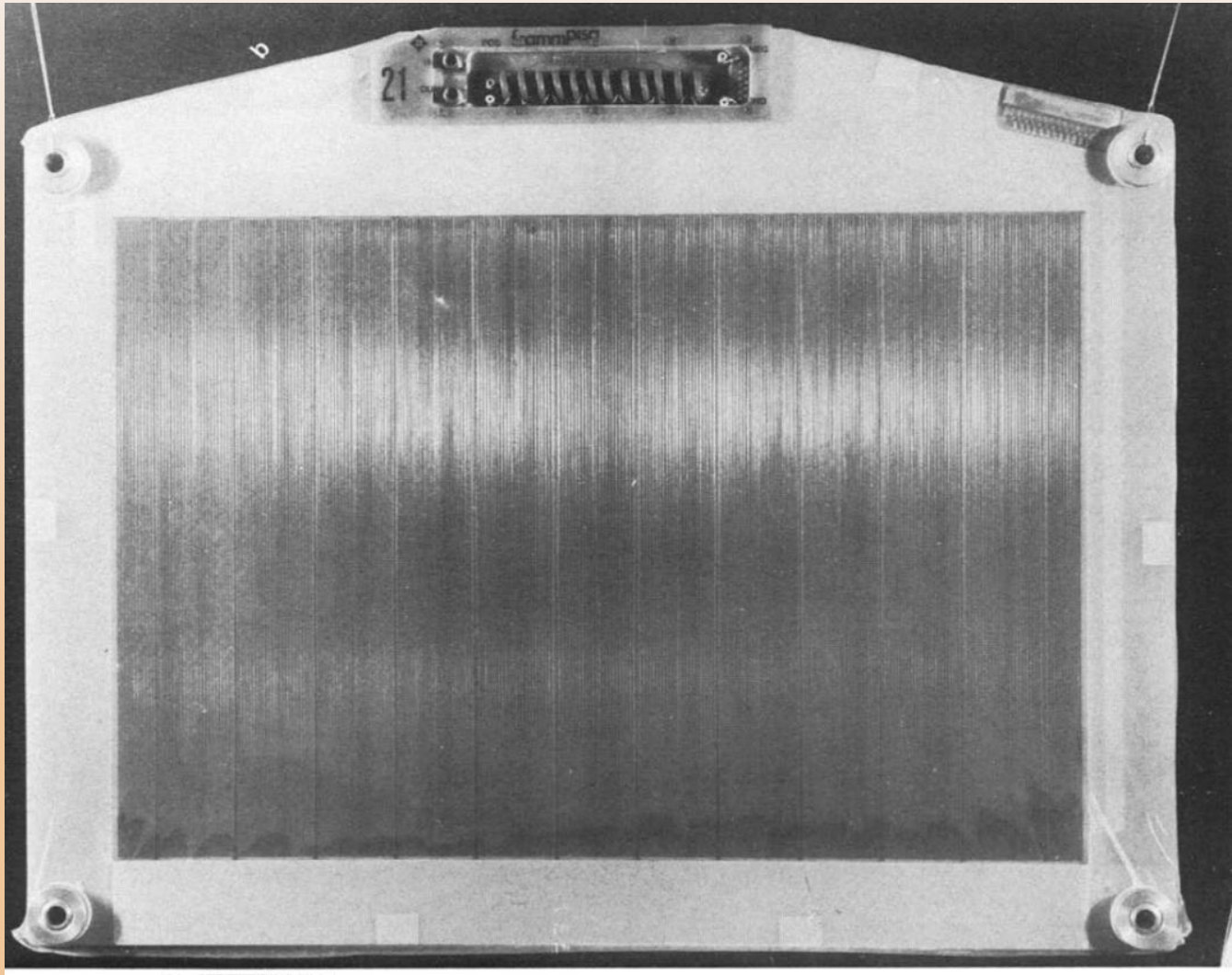


Fig. 5. A completely assembled chamber inside its bag

Drift chambers in place

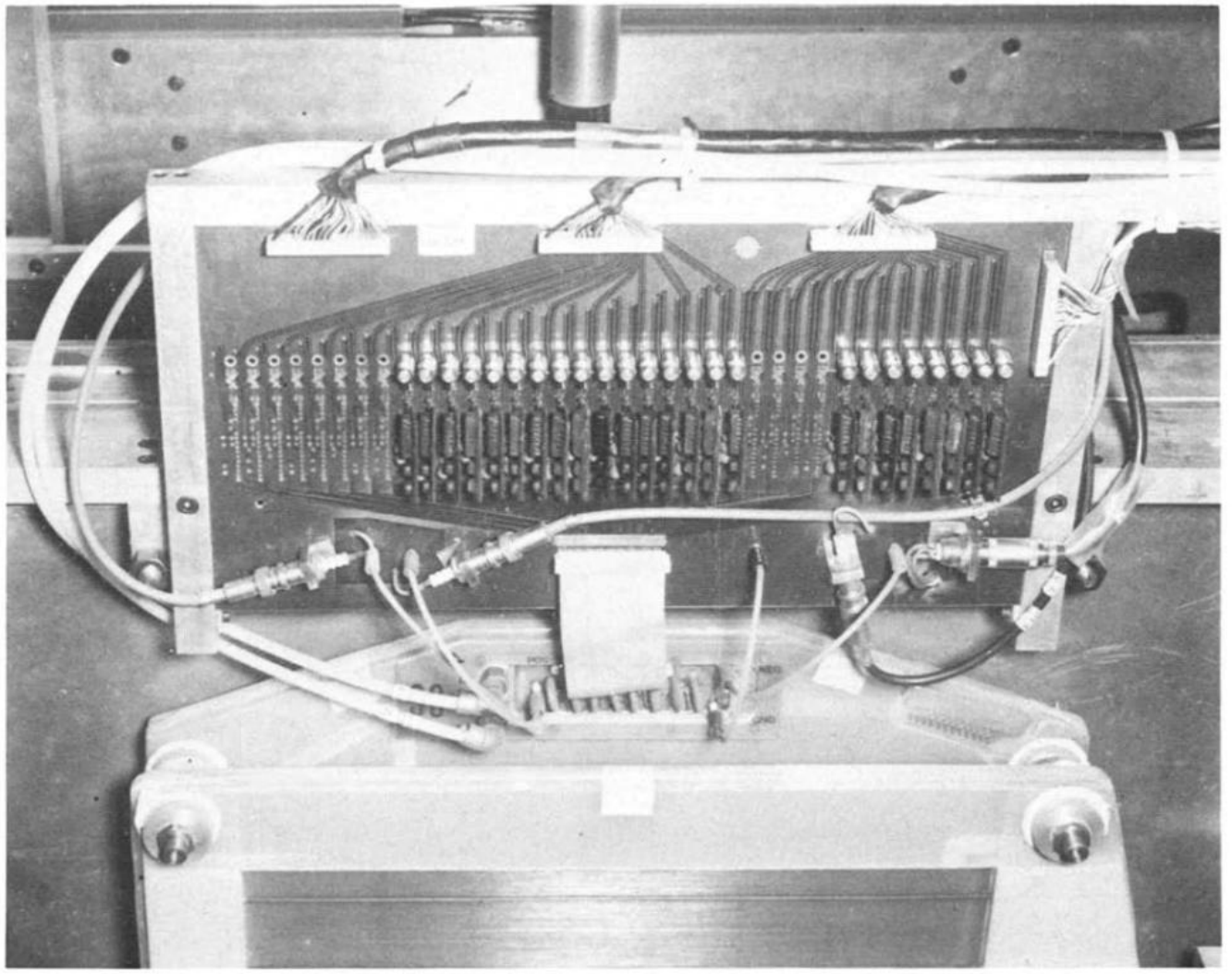


Fig. 7. The connections (gas, HT and signals) between the chamber, through its window, and the hybridized preamplifier board.

σ_x 120 μm

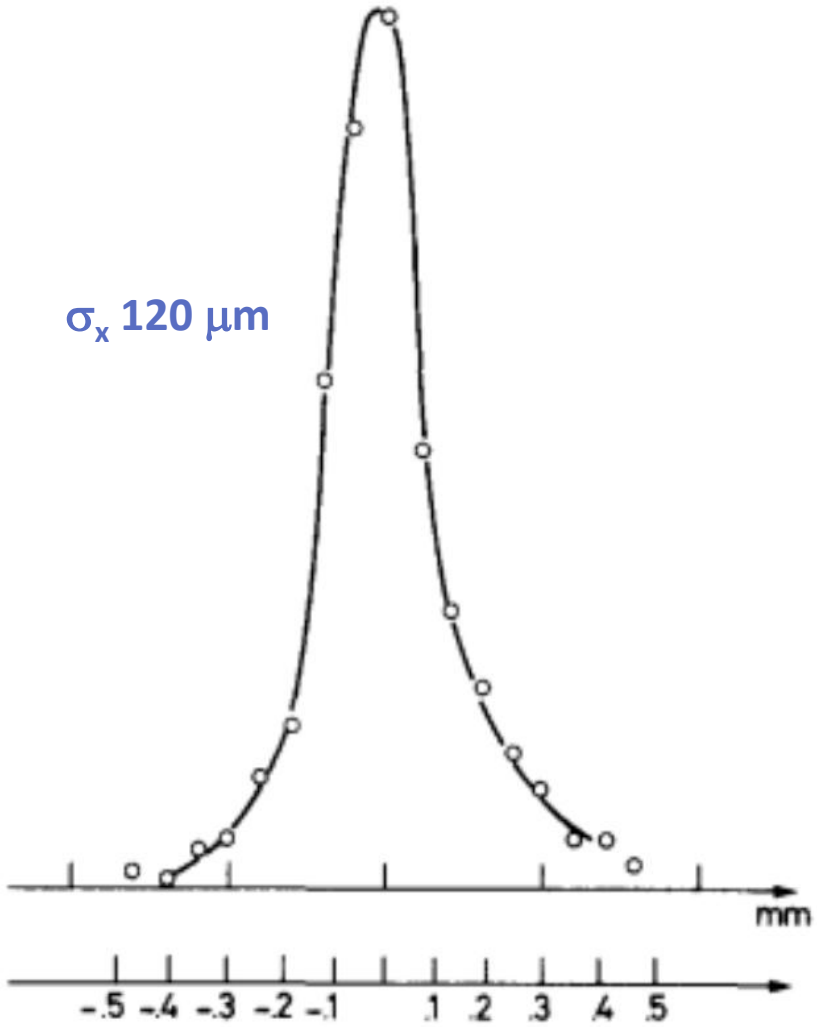


Fig. 10. Unfolded spatial resolution of sense wires averaged over the whole sensitive area of the chamber.

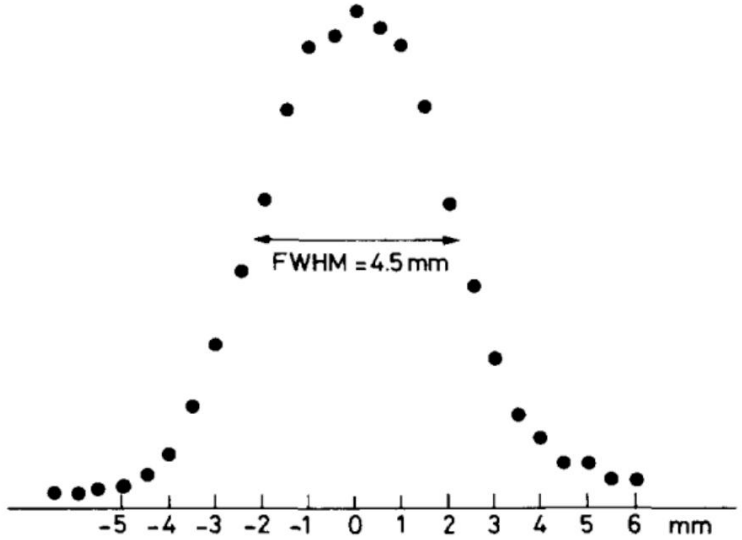


Fig. 11. Spatial resolution of delay lines, integrated over the whole sensitive area of the chamber.

We are greatly indebted to the staff of the mechanics and electronics workshops to the Sezione INFN di Pisa, for building the spectrometer with enthusiasm, great professional ability and endless patience for the continuous interference of so many jumpy physicists. In particular we wish to express our deep gratitude to Mr. Mario Del Colletto, without whose intelligent and skilfull cooperation in both the design and construction stages of the chambers, these would not be now producing physics.

In a Master thesis on track reconstruction

From the article on drift chambers

This is a rather severe definition, since it is possible to recover the event even if one of the three times is missing. With the exception of a region within 1 cm of the edge of the frame, the efficiency of all the chambers, using the above definition, was = 98%. Since an event is recoverable even if one time element is missing, we may consider this to be a lower limit to the efficiency of our chambers.

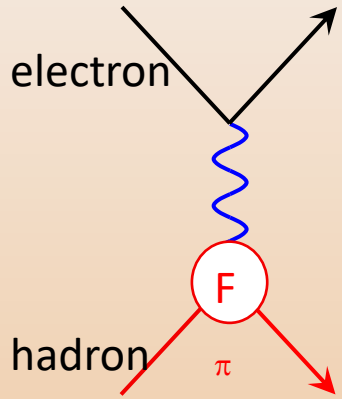
Which turned into the following (miracle?)

If a spark is suppressed due to inefficienty, it nevertheless gets printed and identified

Se una scintilla è soppressa per inefficienza, viene ugualmente stampata e identificata

NA7 – The π and K radius

From deep inelastic scattering: probe the hadron structure with a pointlike lepton bullet



What if the hadron is not stable?

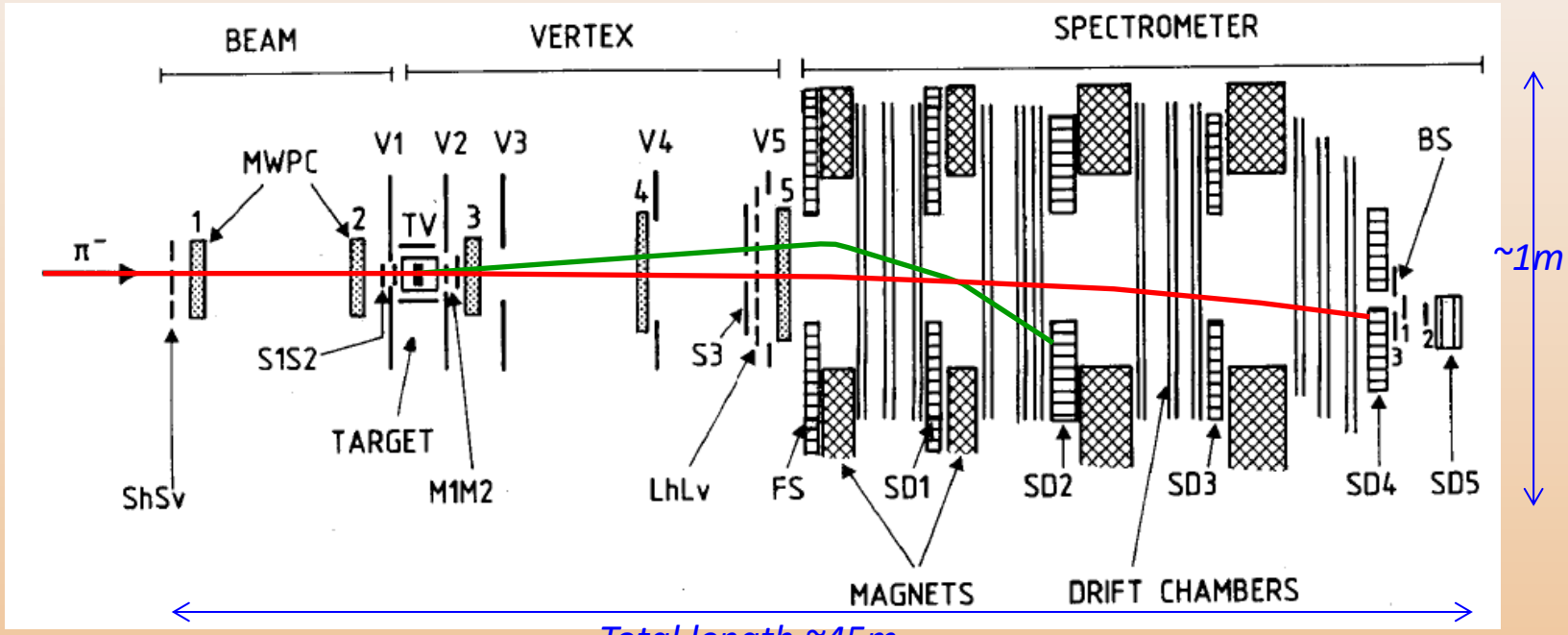
Answer: NA7, have the hadron hit on flight the stable lepton at rest

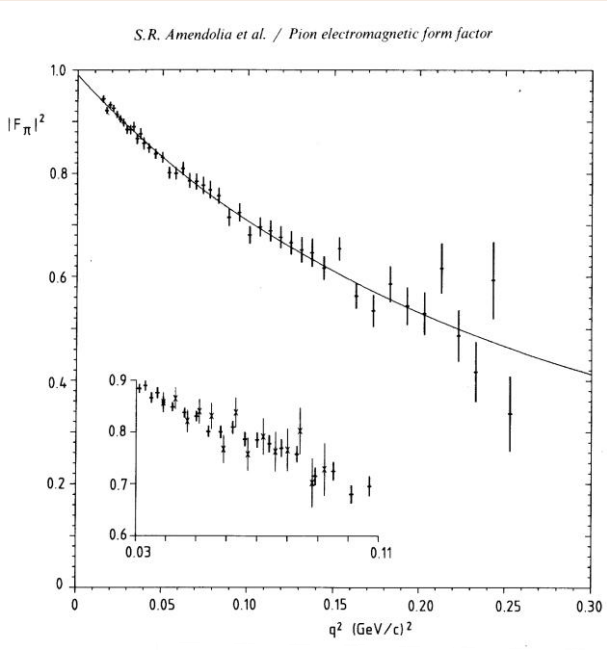
Elastic scattering on the electrons of a liquid H_2 target

π^- (K^-) + e^- → π^- (K^-) + e^-

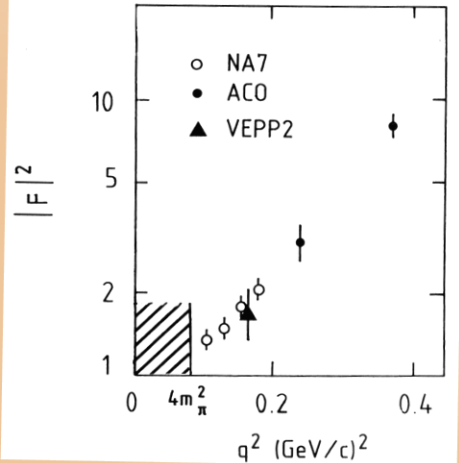
NA7

NA1 took a break: 20m upstream of the Spectrometer was cleared and the hydrogen target + NA7 vertex detector installed





$\langle r_\pi^2 \rangle^{1/2} = 0.663 \pm 0.006$ fm Nucl.Phys. B277 (1986) 168



Why not time-like? Phys.Lett.138B, 454 (1984)

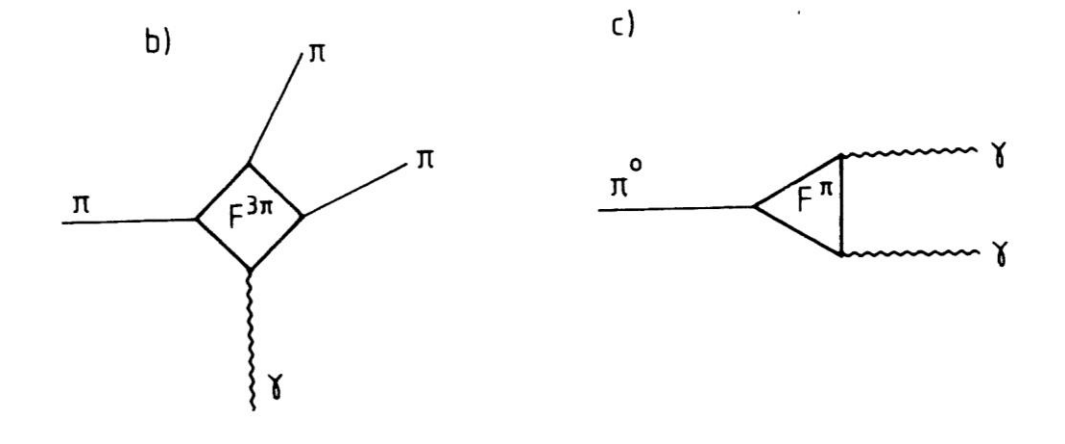
$e^+ + e^- \rightarrow \pi^+ + \pi^-$

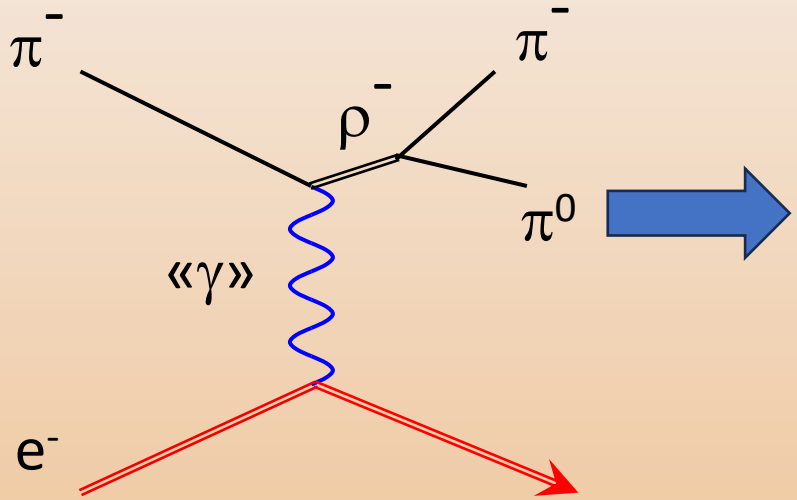
NA7 – N_{colour}

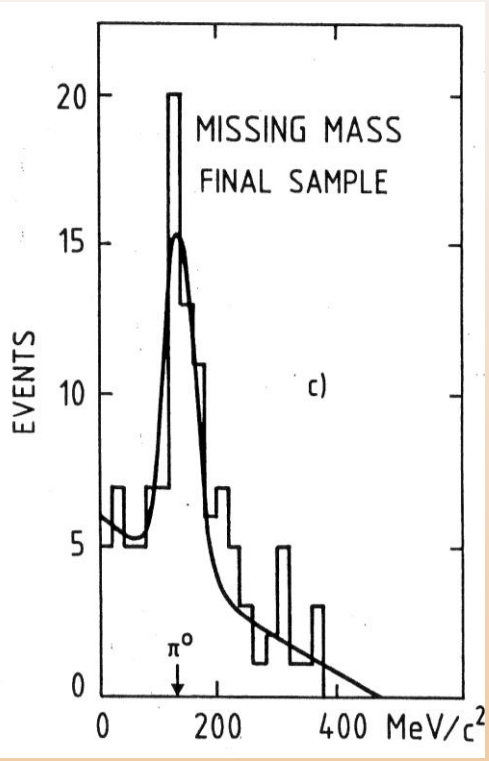
Why not Primakoff? $\pi^- + «\gamma» \rightarrow \rho^- \rightarrow \pi^- + \pi^0$

- Off ρ resonance: virtual γ from e^-

$F_{3\pi}$, F_π : Loop summed on N_{colour}







FIRST MEASUREMENT of the REACTION $\pi^- e \rightarrow \pi^- \pi^0 e$ Phys.Lett. 155B, 457 (1985)

We concluded: " *…(our) data firmly dictate the necessity of three quark colours.*"

- On ρ resonance: virtual γ from heavy nuclei (Cu, Pb)

NA29 – The ρ^- radiative width Γ_ρ =83±4±4 keV

The Collaborations

NA7

S.R.AMENDOLIA, M.ARIK, B.BADELEK, G.BATIGNANI, G.A.BECK, F.BEDESCHI, E.H.BELLAMY. E.BERTOLUCCI, D.BETTONI, H.BILOKON, G.BOLOGNA, L.BOSISIO, C.BRADASCHIA, M.BUDINICH, A.CODINO, M.DELL'ORSO, B.D'ETTORRE PIAZZOLI, M.ENORINI, F.L.FABBRI, F.FIDECARO, L.FOA, E.FOCARDI, S.G.F.FRANK (Spokesman), A.GIAZOTTO, M.A.GIORGI, M.G.GREEN, J.HARVEY, G.P.HEATH, M.P.J.LANDON, P.LAURELLI, F.LIELLO, G.MANNOCCHI, P.V.MARCH, P.S.MARROCCHESI, A.MENZIONE, E.MERONI, L.MORONI, E.MILOTTI, P.PICCHI, F.RAGUSA, L.RISTORI, L.ROLANDI, S.SALA, C.G.SALTMARSH, A.SAOUCHA, L.SATTA, A.SCRIBANO, P.SPILLANTINI, A.STEFANINI, D.STOREY, J.A.STRONG, R.TENCHINI, G.TONELLI, G.TRIGGIANI, W.VON SCHLIPPE, E.VAN HERWIJNEN, A.ZALLO

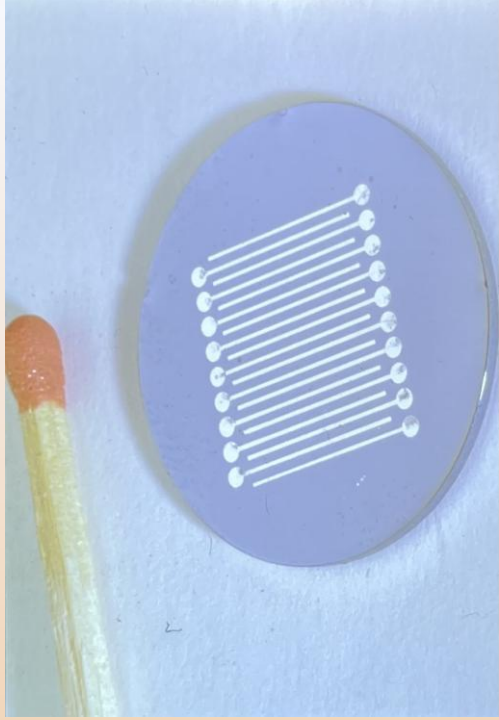
NA29 additionally:

G.BELLINI (Spokesman), S.BONETTO, U.BOTTIGLI, L. CAPRARO, A. FINCATO, P.GIANETTI, B.VAN HECKE, M.LEOPOLD, P.LEVY, D.MENASCE, N.PAVER, D.PEDRINI, L.PERASSO, M.QUERROU, S.SALA, M.VERBEKEN, M.VITTONE

Frascati, Milano, Pisa, Torino, Trieste, Southampton, Westfield, Clermont-Ferrand.

The launch pad for innovation was now ready

- Confidence with detectors and new ideas
- Transverse ionization sampling: Multi Electrode Silicon Detectors: a vertex story
- Longitudinal ionization sampling: for lifetime



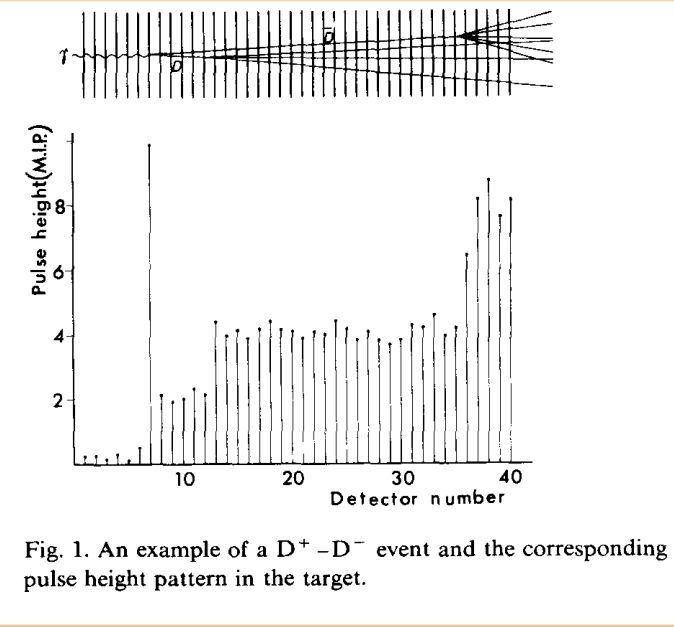
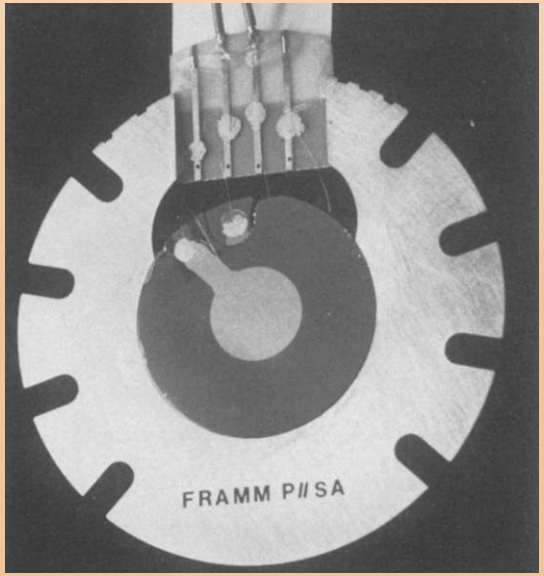


Fig. 1. An example of a $D^+ - D^-$ event and the corresponding pulse height pattern in the target.



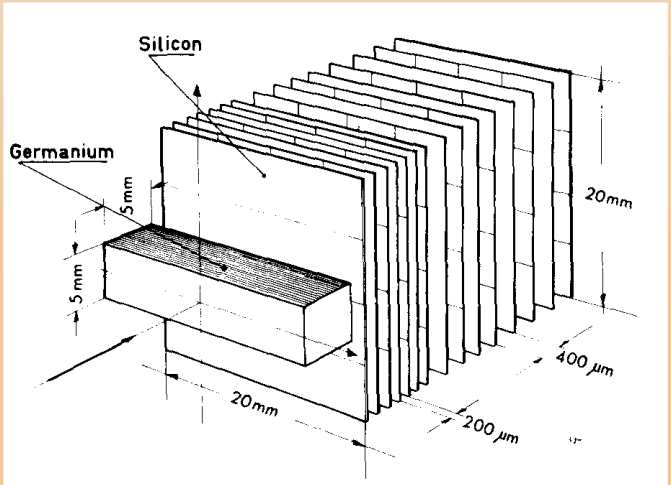


Fig. 2. A picture of the new Ge–Si active target employed in the CERN NaI experiment.

Many years ago…

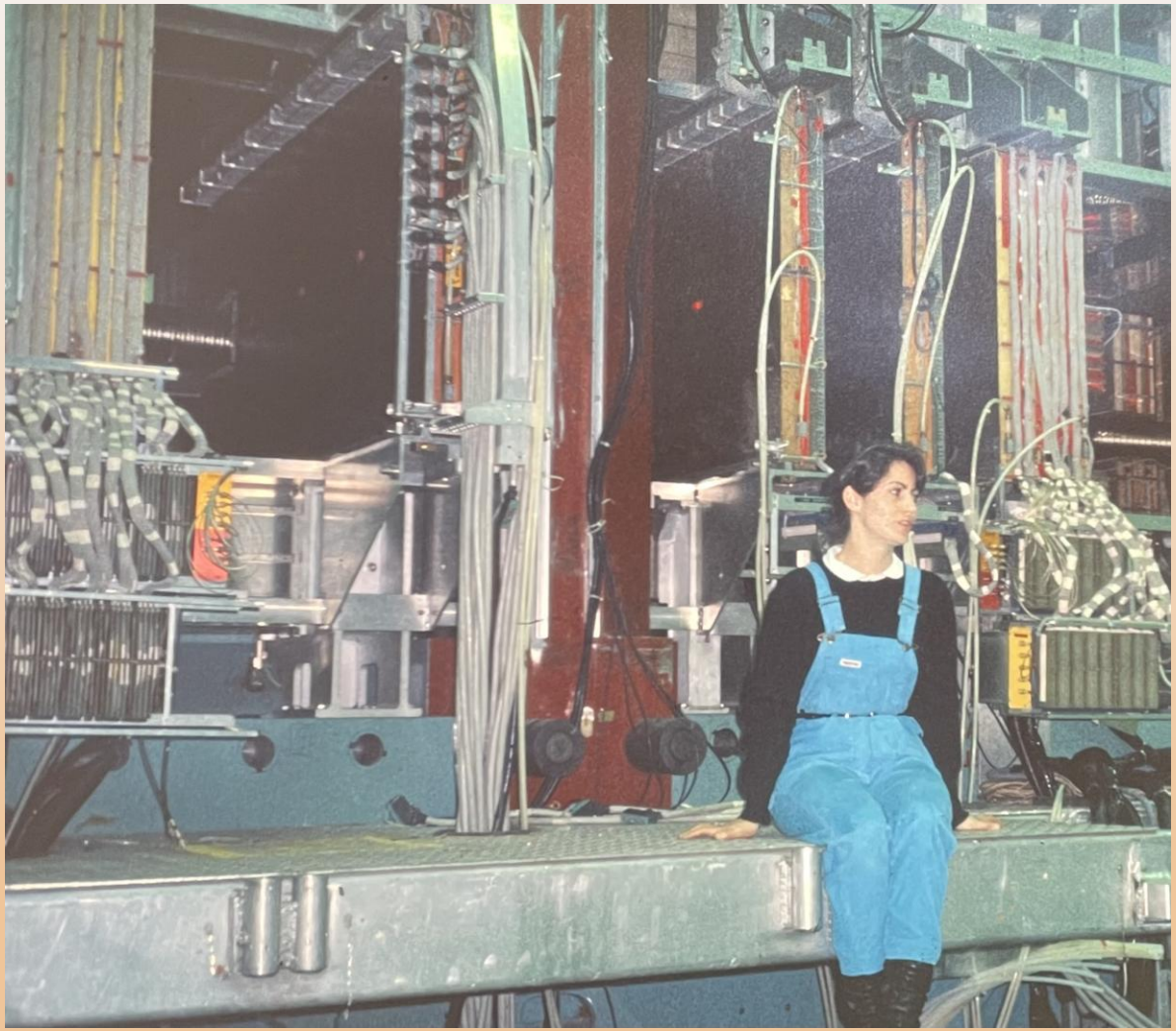
I joined the wonderful group of NA1 in 1984

I was a master's student from Frascati Laboratories and my thesis was supposed to be on Charmed mesons

First time at CERN, as a graduate student at a collaboration meeting:

I remember my advisor of Frascati had told me "Caveat Pisanos ut quam dona ferentes"

But since then my life was enriched both scientifically and in friendship that still endure today, in particular with *Pisanis (latin)*
(I even married one of them!)



Why not?

When I arrived the run of the data taking was ended:

just at the moment when the collaboration was pressed to show scientific results:
the race for charmed mesons searches was starting

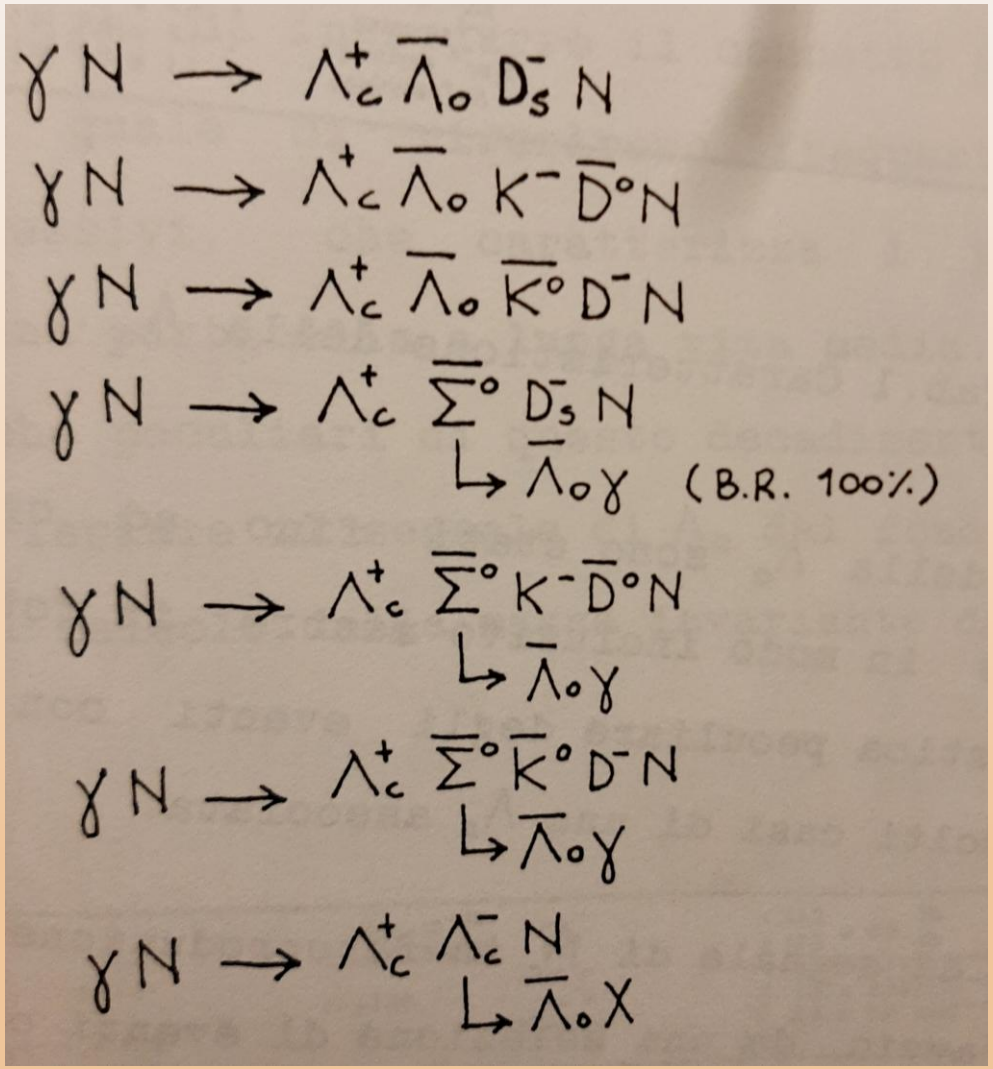
The Pisa group was working on charmed mesons

The presence of the Cherenkov counters for PID in NA1 was very appealing for a possible search of charmed baryons, since at that time only few tens of $\Lambda_C^{\pm}$ had been observed by NA32

I was convinced that if a consistent number of Λ was reconstructed in the NA1, we could search for $\Lambda_C^{\pm}$

I suggested in a meeting to follow this idea, many were perplexed, but among the people inside the room someone standing much taller than everybody else, and usualy very active in discussions said "why not?"

guess who he was?



And so began the NA1 adventure in the search for the $\Lambda_C^{\pm}$, and my work as a graduate student with Gigi — at that time a very young professor at the University of Trieste

This search was the first using a solid state target detector, capable of measuring the charged track multiplicity downstream the interaction point, showing the decay point

After three years of hard work, the result finally arrived — and so did the end of my master's thesis!

Z. Phys. C – Particles and Fields 36, 513–516 (1987)

Zeitschrift für Physik C Particles and Fields

Λ_c Photoproduction and lifetime measurement

NA1 Collaboration

S.R. Amendolia [2], G. Bagliesi [2], G. Batignani [2], G.A. Beck [4], E.H. Bellamy [7], G. Bellini [1], E. Bertolucci [2], D. Bettoni [2], A. Bizzeti [2], G. Bologna [4], S. Bonetti [1], L. Bosisio [2], U. Bottigli [2], C. Bradaschia [2], M. Budinich [5], J. Carter [6], M.A. Ciocci [3], M. Dell'Orso [2], B. D'Ettorre Piazzoli [4], M. Enorini [3], F.L. Fabbri [3], F. Fidecaro [2], L. Foà [2], E. Focardi [2], P. Giannetti [2], M.A. Giorgi [2], M.G. Green [6], M.P.J. Landon [6], P. Laurelli [3], F. Liello [5], P.F. Manfredi [1], G. Mannocchi [3], P.V. March [6], P.S. Marrocchesi [2], D. Menasce [1], A. Menzione [2], E. Meroni [1], L. Moroni [1], E. Milotti [5], G. Oriani [1], L. Perasso [1], P. Picchi [4], D. Pedrini [1], F. Ragusa [1], G. Raso [2], L. Ristori [2], L. Rolandi [5], L. Sacks [6], S. Sala [1], A.H. Sanjari [6], A. Scribano [2], L. Simonelli [3], P. Spillantini [3], A. Stefanini [2], J.A. Strong [6], R. Tenchini [2], G. Tonelli [2], G. Triggiani [2], M. Vittone [1], A. Zallo [3]

[1] Dipartimento di Fisica and Sezione INFN, I-20100 Milano, Italy
[2] Dipartimento di Fisica, Sezione INFN and Scuola Normale Superiore, I-56100 Pisa, Italy
[3] INFN-Laboratori di Frascati, I-00044 Frascati, Italy
[4] Istituto di Fisica Generale and Istituto di Cosmogeofisica del CNR, I-10100 Torino, Italy
[5] Dipartimento di Fisica and Sezione INFN, I-34100 Trieste, Italy
[6] Department of Physics, Royal Holloway and Bedford New College, Egham-Surrey TW20 0EX, UK
[7] Department of Physics, Westfield College, London NW3 7ST, UK

Received 4 August 1987

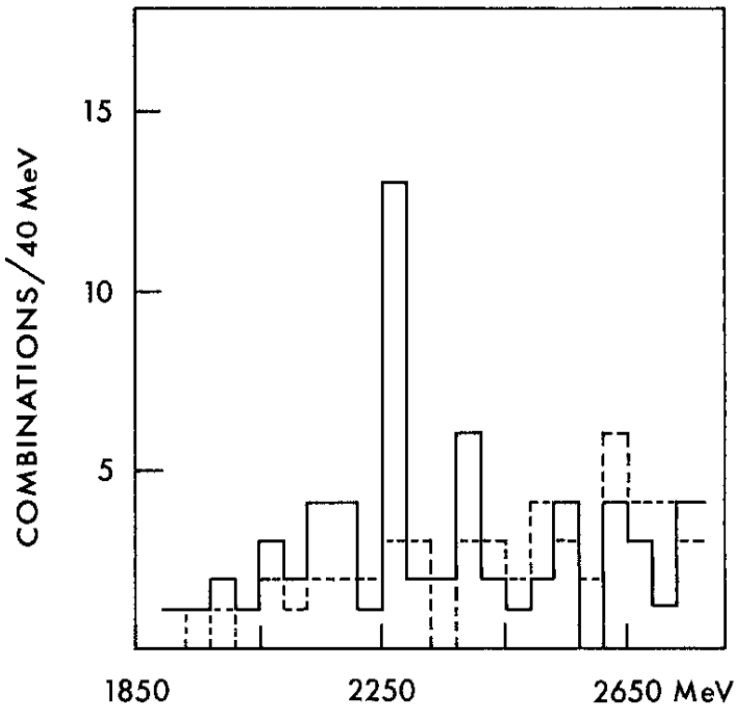


Fig. 2. Invariant mass plot of $pK^-\pi^+\pi^0$ and charge conjugated channel (solid line) in the events with a Λ^0 tagging. The dashed line represents the background

"Among the 13 combinations in the peak we found 7 combinations with the Kπ system compatible with the K* mass and 6 combinations with the pπ system compatible with the Δ mass. We then replaced the Λ tagging requirement by the condition that either a K* or a Δ be present in the combination"

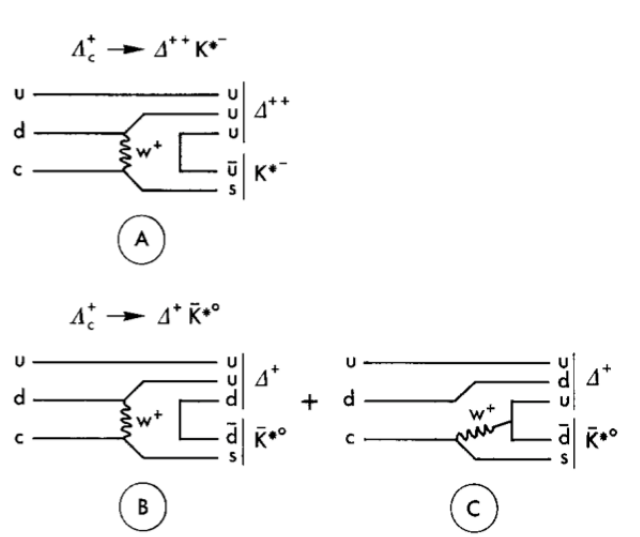


Fig. 6. Diagrams contributing to the decay $\Lambda_c \to \Delta K^*$

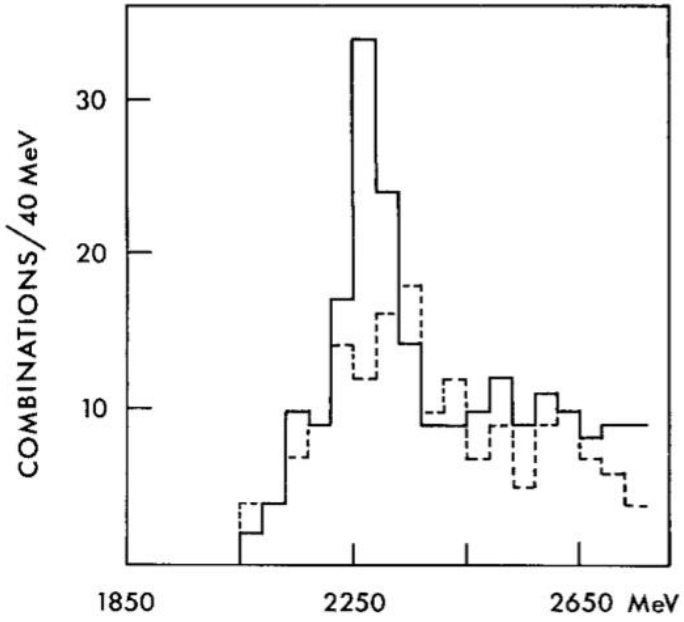


Fig. 5. Invariant mass plot of $pK^-\pi^+\pi^0$ and charge conjugated channel (solid line) in the events with a Δ and K^* tagging. The dashed line represents the background

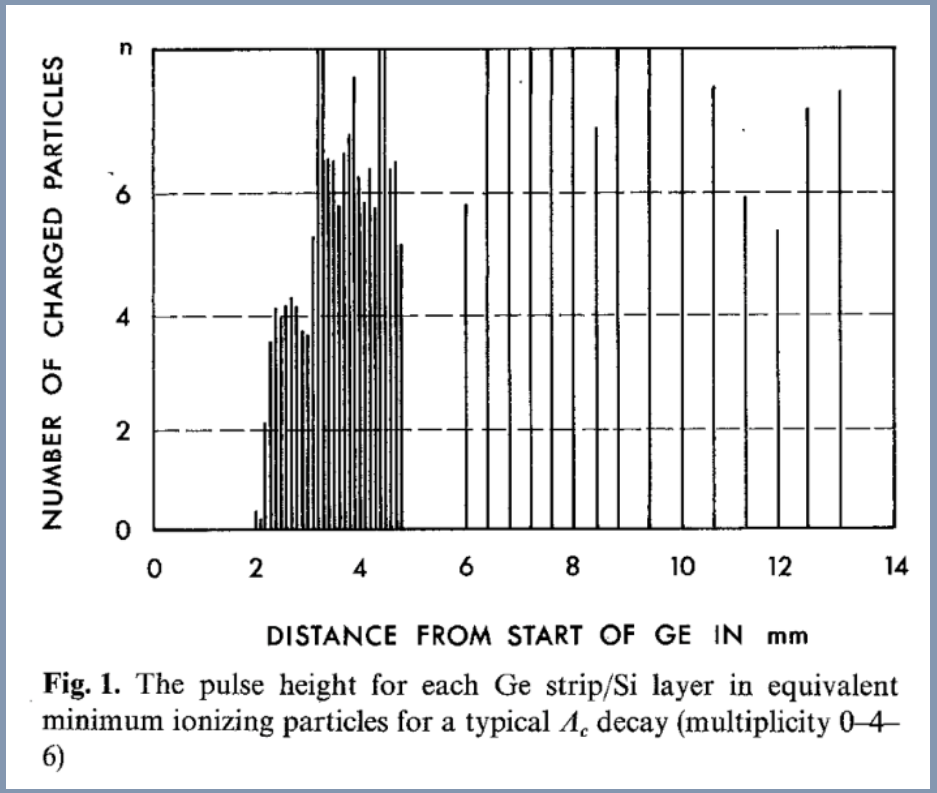


Fig. 1. The pulse height for each Ge strip/Si layer in equivalent minimum ionizing particles for a typical Λ_c decay (multiplicity 0–4–6)

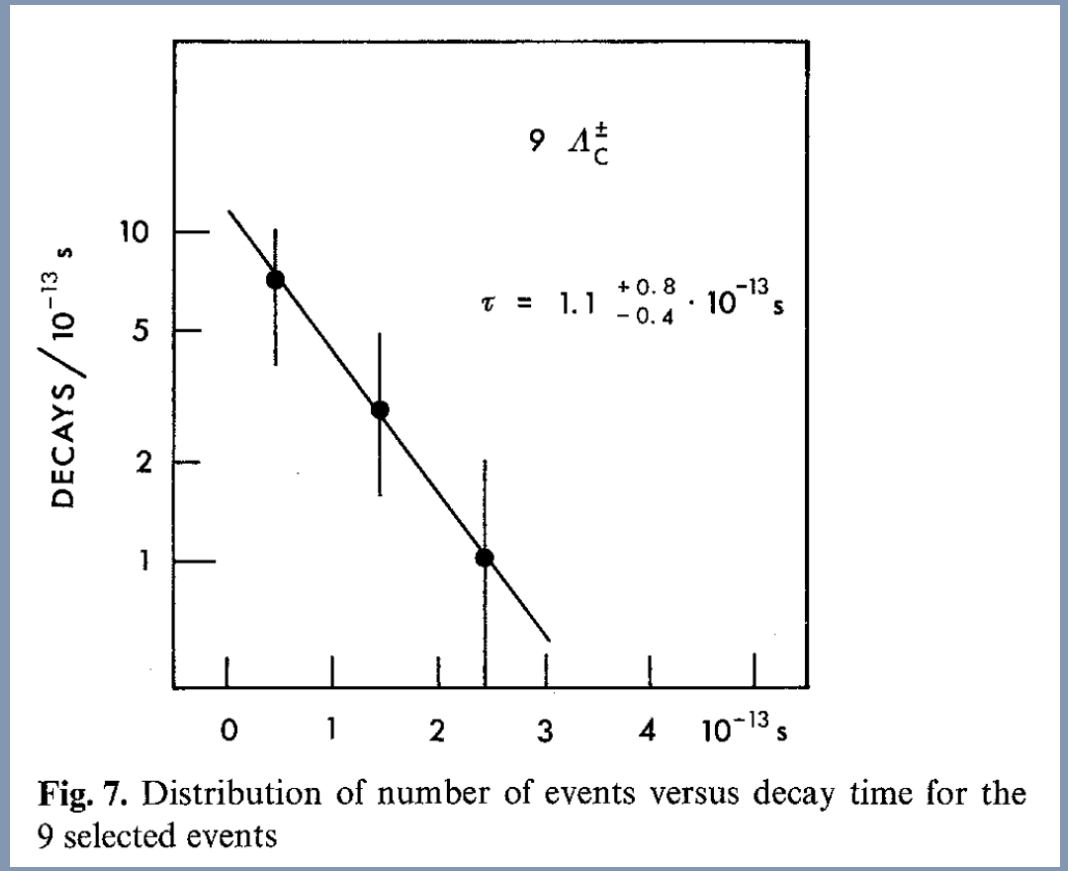


Fig. 7. Distribution of number of events versus decay time for the 9 selected events

For the measurement of the lifetime we used only the sample with a single charged multiplicity change of 2 because the presence of two multiplicity steps of 2 makes the association with the reconstructed Λ_C ambiguous

Roberto Tenchini spent many nights to obtain this result!