Giordano Diambrini Palazzi e la stagione degli esperimenti ibridi

CERN 1975-85

Sergio Petrera – L'Aquila

- Premessa: le emulsioni nucleari all'avvento degli heavy quarks
- La ricerca di charm
- La ricerca di beauty
- L'eredita'

Le emulsioni nucleari 1970-75

Prima degli heavy quarks attivita' in declino:

- *Intrinseca lentezza delle misure*
- *Impossibilita' di misure in campo magnetico*
- *Personale tecnico (scanners)*

⟺ Camere a bolle

Buoni collegamenti e collaborazioni collaudate

Il gruppo guidato da Giustina Baroni, un'eccellenza nel panorama internazionale

Alla partenza del Fermilab:

- *fisica adronica a 300 GeV*

  (molteplicita', correlazioni di rapidita'...)

1974 ➔ arriva il charm!

Le emulsioni ideali allo scopo

Ricerca del charm

A Search for Charmed Particles Originating from the Interactions of 300-GeV/c Protons in Emulsion Nuclei.
Brussels – Dublin – London – Rome – Strasbourg – Warsaw

Ricerca di produzione associata di charm: area scanning in 150 μm

"*The failure to observe any candidates for this process among some 60,000 interactions investigated implies, provided charmed particles lifetimes are in the range 10^{-12} to 10^{-14} s, a cross section for their associated production by the interactions of 300 GeV/c protons with nucleons of less than 1.5 microbarns at a 90% confidence level.*"

La forza bruta non basta!

La soluzione: *usare una produzione e/o selezione piu' efficace*

- **Neutrini** (Baroni – Conversi)

- **Fotoni** (Diambrini-Palazzi)

Nascono gli esperimenti ibridi

Perche' i neutrini?

1. *Produzione singola*
2. *Charm/CC ~ $\sin^2\theta_c \cos^2\theta_c$*

Neutrini in emulsione ?!

Apparente contraddizione in termini:
grande massa vs piccolo scan volume
Energie piu' bassa – topologia piu' “leggera”

Pioneering experiment E.H.S. Burhop
CERN PS Em+Spark Chambers

E247:
Hybrid emulsion-spark-chamber experiment @ WBNB Fermilab

IL NUOVO CIMENTO VOL. XXXIX, N. 4 16 Ottobre 1965

The Location and Analysis of Neutrino Interactions in Photographic Emulsion.

E. H. S. BURHOP, W. BUSZA, D. H. DAVIS, B. G. DUFF (*), D. A. GARBUTT, F. F. HEYMANN, K. M. POTTER and J. H. WICKENS
University College - London

C. BRICMAN, J. LEMONNE, J. SACTON and G. SCHOROCHOFF
Université Libre de Bruxelles - Bruxelles

M. A. ROBERTS and W. T. TONER
CERN - Geneva

(ricevuto il 15 Aprile 1965)

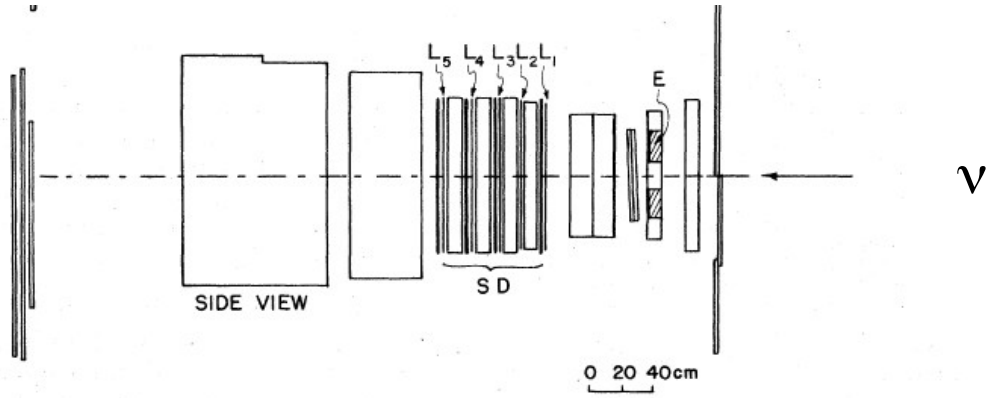
Summary. — A stack of nuclear emulsion pellicles of total volume 10 litres was placed, together with two spark chambers in the neutrino beam of the CERN proton synchrotron. The tracks of secondary particles from neutrino interactions in the emulsion were observed in the spark chamber. The spark chamber tracks were used to locate the tracks produced by the same particles in the emulsion. These tracks were then followed back in the emulsion to the neutrino interaction in which they originate. Of a total of seven neutrino interactions expected to be produced in the emulsion stack during this exposure four were located in this way and their characteristics studied.

La collaborazione E247 (1975-78)

I gruppi di emulsione del charm search (Brussels,...,Strasbourg)

+

Mulhouse e il gruppo di M. Conversi: veto + spark-chambers + μ det



'IG. 1. Diagram illustrating the experimental arrangement; V, veto counter; C_0, NG spark chamber; E, six emul-n stacks on frame; S_0, scintillation counter; WG, wide-gap spark chamber; SD, shower detector comprising scin-ator counters S_{1-4}, NG spark chambers C_{1-4} and lead plates L_{1-5}; M, muon identifier.

Il primo esperimento ibrido visto da Roma

Qualche diffidenza reciproca:
GB vedeva la localizzazione esterna molto innaturale
area scanning vs track following
MC era intimorito dal ruolo cruciale delle emulsioni
“the emulsion mafia”

Il ruolo di Carlo Bernardini, neo direttore INFN, grande supporter.

Questa attivita' e' stata una pietra miliare per tutti gli esperimenti Ibridi successivi.

Observation of a Likely Example of the Decay of a Charmed Particle Produced in a High-Energy Neutrino Interaction.

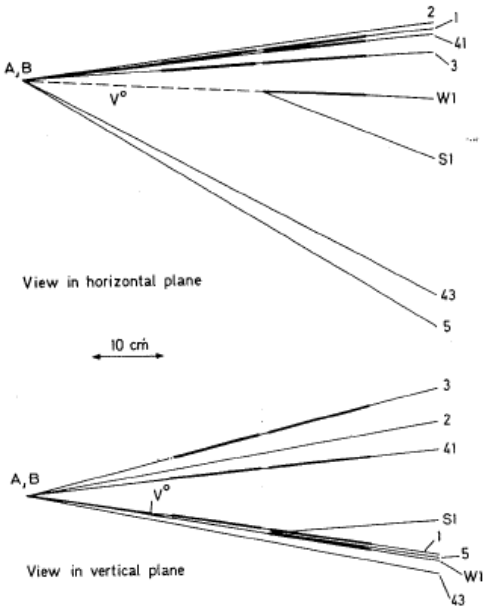


Fig. 3. Schematic drawing based on the spark chamber photographs associated with the event. The tracks seen in the wide gap spark chamber are shown by thick lines. Tracks 5, 43 seen in emulsion, as well as S_1, seen in the narrow gap chambers of the shower detector, are too oblique to have been seen in the wide gap chamber. Track 42 interacts before leaving the emulsion. Track 2 seen in emulsion is not seen in the spark chamber although it might have been expected to be seen there. The dotted line indicates the flight path of the neutral particle interpreted as a V°.

of the tracks seen in the wide gap chamber. There was no other candidate in the predicted volume.

The table also shows the angles of the tracks as measured in the emulsion at the vertices A and B and

E247 ha dimostrato la tecnica ibrida.
Occorre migliore VX reco e spettrometria di qualita' per lo studio del charm.

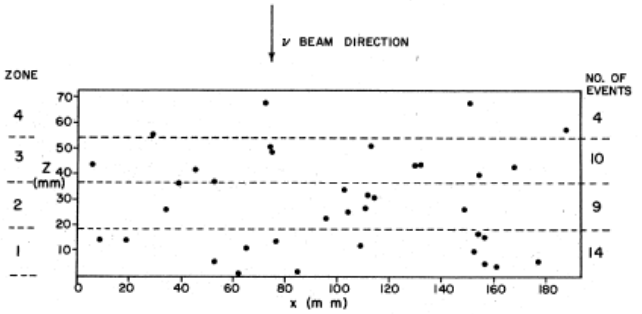


TABLE I. Total area scanned and events found in different areas of plates in the z (beam) direction.

	Total	Zone 1	Zone 2	Zone 3	Zone 4
Range of z in mm from emulsion edge closest to WG spark chamber	0–73	0–18.25	18.25–36.5	36.5–54.75	54.75–73
Area scanned (cm^2)[a]	3345	878	1005	891	571
No. of events found[b]	34	14	9	7	4
Area scanned per event found (cm^2)	95.6	62.7	111.7	127.3	142.8

[a] An area cutoff of 30 cm^2 for any single event has been applied in order to make the results from different laboratories comparable. This cut means that two events found after a scan greater than 30 cm^2 have been omitted from the table.

[b] The detailed area scan figures for one event were not available.

WA 17 (1976-80)

Conversi entusiasta dell'approccio ibrido
Arrivano:

- neutrini al CERN
- BEBC

WA17 = Em + BEBC (+EMI)

Collaborazione: E247 +
Pisa (BEBC)
Torino (Em)

A Roma la collaborazione si allarga: si aggiunge il gruppo di Guido Ciapetti

On the lifetime of charged charmed particles : first direct observation of a charmed baryon decay - PLB 84 (1979) 150-155

Since the momenta of these three particles are all known, a 2C fit to the event allows the mass M_c and momentum p_c of the primary baryon to be derived. The results of this fit are

$$M_c = 2.295 \pm 0.015 \text{ GeV/c}^2, \quad p_c = 3.72 \pm 0.04 \text{ GeV/c}$$

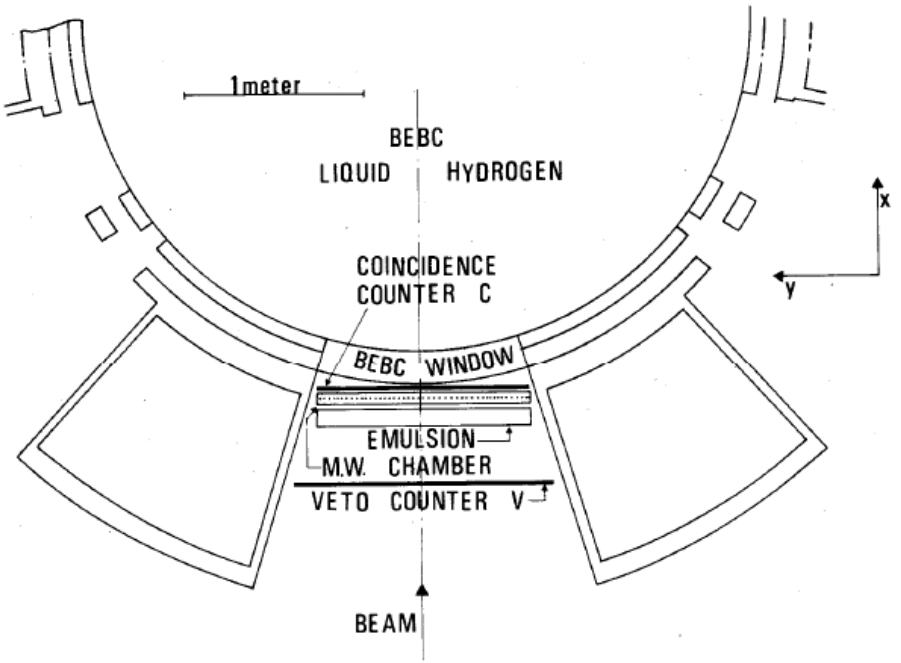
This mass value is higher than those reported previously[5], even though still compatible with them.

From these data and the observed decay path, AB=354 ± 3 μm, the proper decay time, t_c, of the charged baryon is found to be

$$t_c = (7.3 \pm 0.1)\times 10^{-13} \text{ s}$$

It is also worthwhile to point out that the invariant mass of the $(K^- \pi^+)$ system in this event is 0.866 ± 0.010 GeV/c², suggesting a decay scheme

$$\Lambda_c^+ \rightarrow p + \bar{K}^{*0}, \quad \bar{K}^{*0} \rightarrow \pi^+ K^-$$



169 found CC events: 8 charmed decays

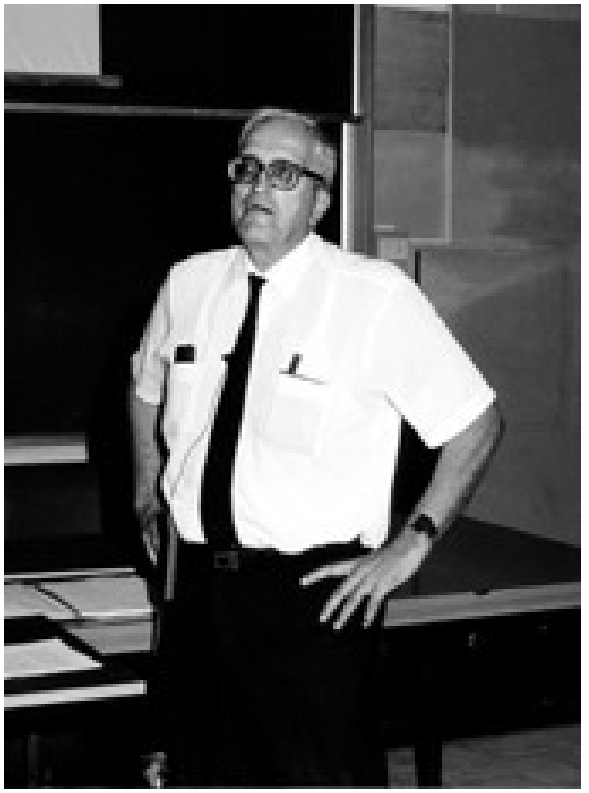
- 3 charged → 3 prongs
- 3 neutral → 2 prongs
- 2 charged → 2 prongs

Distanza Em-BEBC (40 cm) maggiore limitazione

WA58 – Photon-Emulsion Collaboration (1979-86)

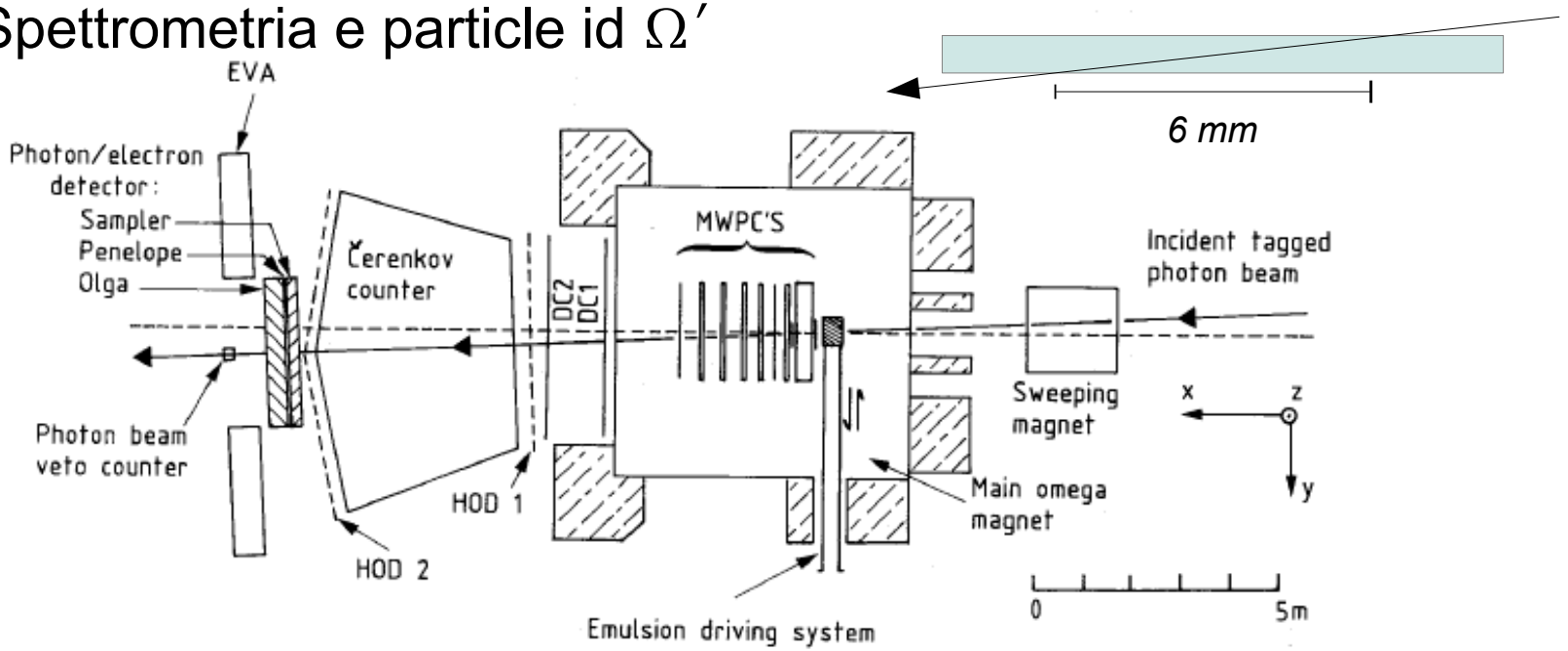
Bologna – CERN – Firenze – Genova – Madrid – Mosca - Paris - Santander - Valencia

- Tagged photons 20-70 GeV
- Emulsioni tilted 5° esposte singolarmente
- Spettrometro Omega'

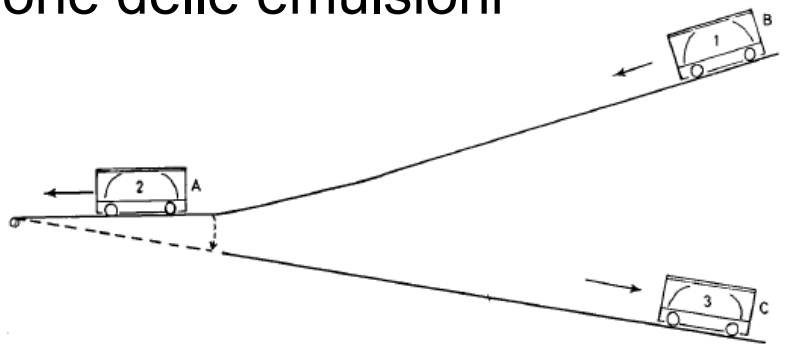


Aspetti migliorativi:

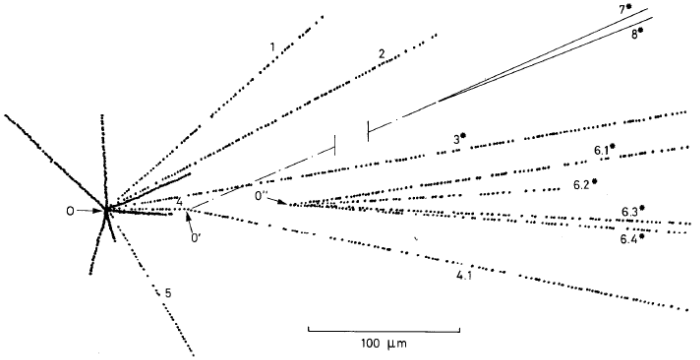
- Fotoni piu' efficaci
- Localizzazione VX piu' facile (area scan ~ 50 mm^2)
- Spettrometria e particle id Ω^-



… ma necessaria movimentazione delle emulsioni

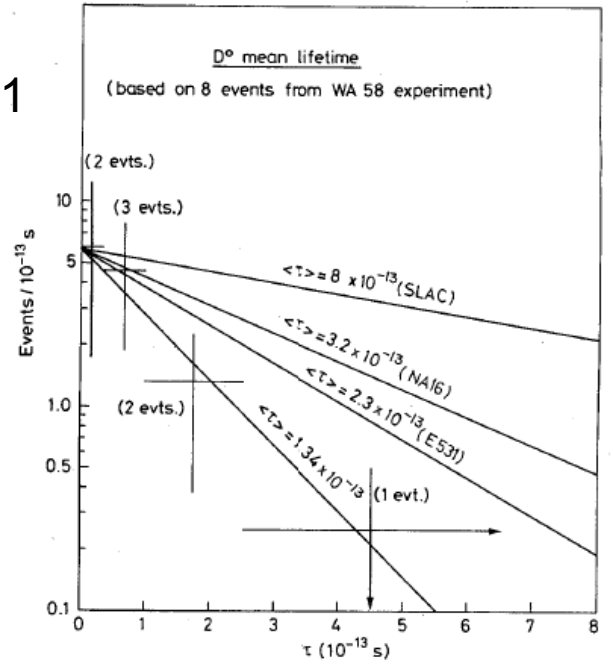


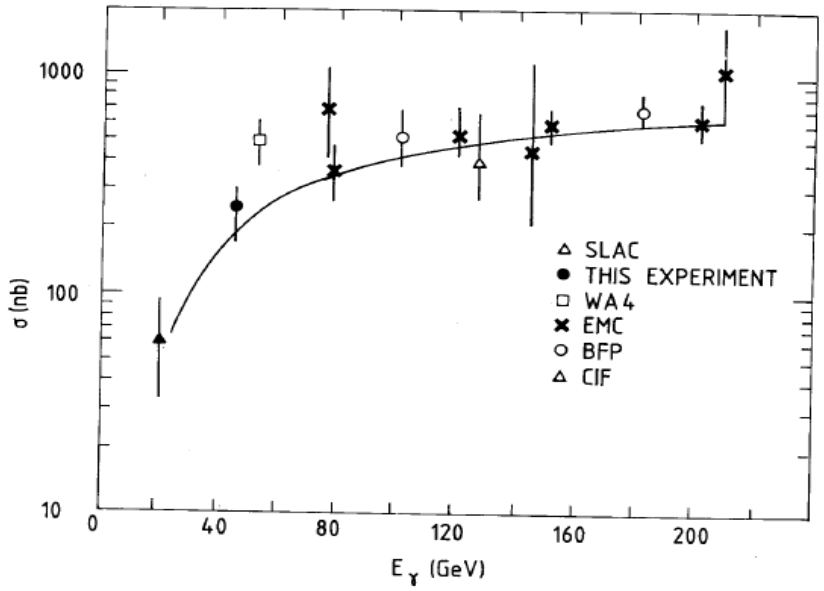
WA58 ottiene risultati (8 articoli) su: vite medie, branching ratios, photoproduction cross section



NC Lett. 30 (1981) 166-170

Erice 1981





PLB187 (1987) 437

TABLE 1

Channels	$\bar{D}^0 D^0$	$\bar{D}^0 D^+$	$D^- D^0$	$D^- D^+$	$\bar{D}^0 \Lambda_c^+$	$D^- \Lambda_c^+$	$D^- F^+$
Number of events	10	6	5	2	7	5	1
Fraction of total cross section (%)	30 ± 13	23 ± 13	5 ± 3	12 ± 11	22 ± 12	6 ± 3	2 ± 2
Lund model	28	25	9	7	20	8	1

Ricerca della beauty

NA19 (1980-81)

Bari - Brussels - CERN - Dublin - London - Roma - Torino + Japan

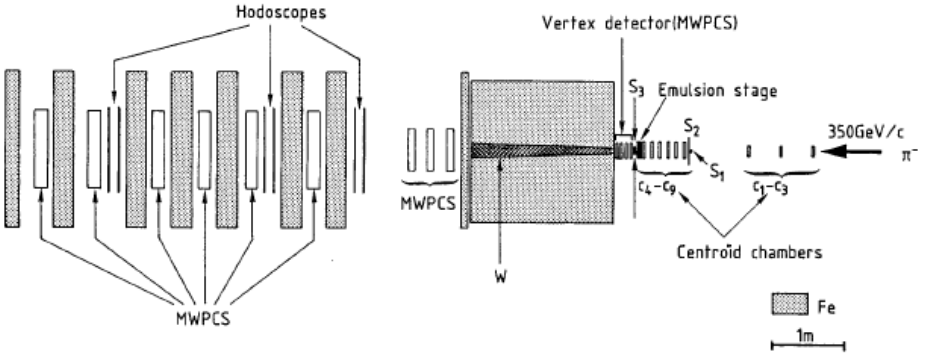
La prima idea di cercare produzione e decadimento del b in apparati ibridi viene da Paul Musset:

- *Adroproduzione associata*
- *Decadimenti muonici di b e c*

Disegnato e realizzato in circa un anno + presa dati, con riutilizzo di camere esistenti (EMI) e pochi rivelatori nuovi:

VX det + dump + mu-det

Trigger $\geqslant 2\ \mu$



An attempt to observe directly beauty particles in nuclear emulsions

PLB 122 (1983) 197-200

The geometrical and muon cut-offs of the apparatus lead to an acceptance of 0.33, the location and scanning efficiencies are together estimated to be 0.5, and the probability of observing a beauty event with decays occuring within the scanning window is $\sim$ 0.8 for beauty lifetimes of 10^{-13}s. This probability drops by less than a factor two in the lifetime range $2 \times 10^{-14}\text{s} < \tau < 10^{-12}\text{s}$.

With the above assumptions the observation of one event would correspond to a beauty production cross-section by 350 GeV/c π^- mesons of 39 nb. The absence of any such candidates, indicates an upper limit for beauty particle production of $\sim$ 90 nb at a 90% confidence level for a lifetime of 10^{-13}s..

Sezione d'urto sovrastimata (H. Fritzsch)
Ricerca dei decadimenti solo topologica.
Insufficiente "ibridazione": 25 ev in Em per evento ricostruito
Vita media sottostimata (10^{-14} – 10^{-13} s): 1-2 mm track foll. + 200 μm area scan

⇒ *Apparati ibridi piu' performanti per la ricerca della beauty*

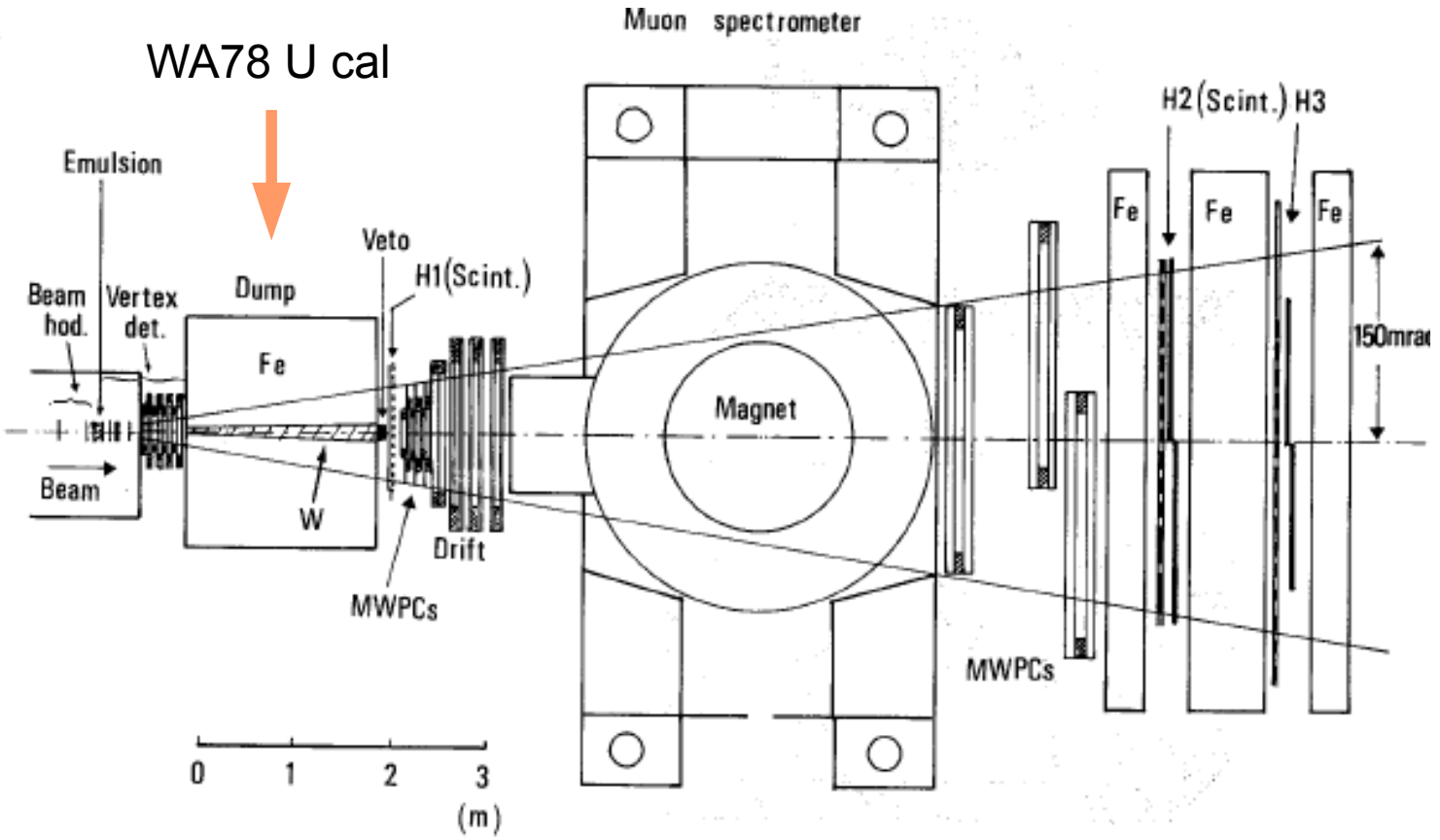
WA75 ≃ ex NA19 coll. (P. Musset)

WA71 ≃ ex WA58 coll. (G. Diambrini-Palazzi)

Giordano e' a Roma: il gruppo emulsioni si divide in parte sulle due attivita'

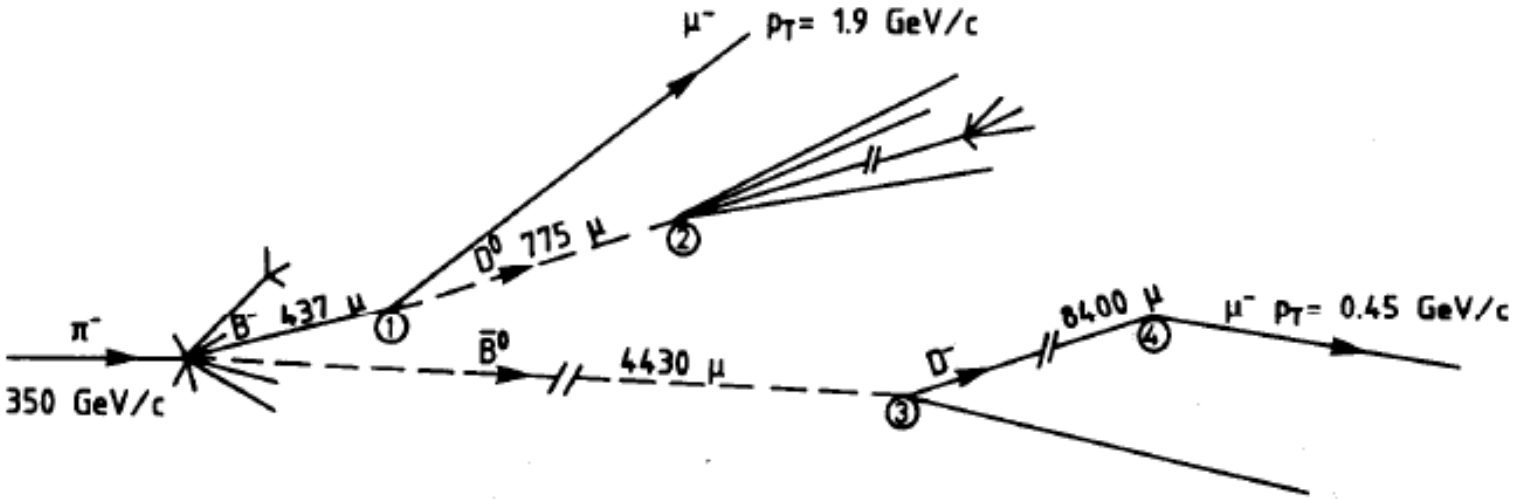
	WA75 (1982-87)	WA71 (1982-85)
Em	vertical (4 cm) + horizontal (8 mm) intercalibration sheet target mover	vertical 1.2 mm thick single stack on movable trolley
VD	beam+VD Si μstrips	beam+VD Si μstrips + WA TPC
Spec.	dump+spectrometer	upgraded Ω' (RICH, Ecal)
Evsel	high pT muons (+missing E)	charm selection (Si telescope)

WA75

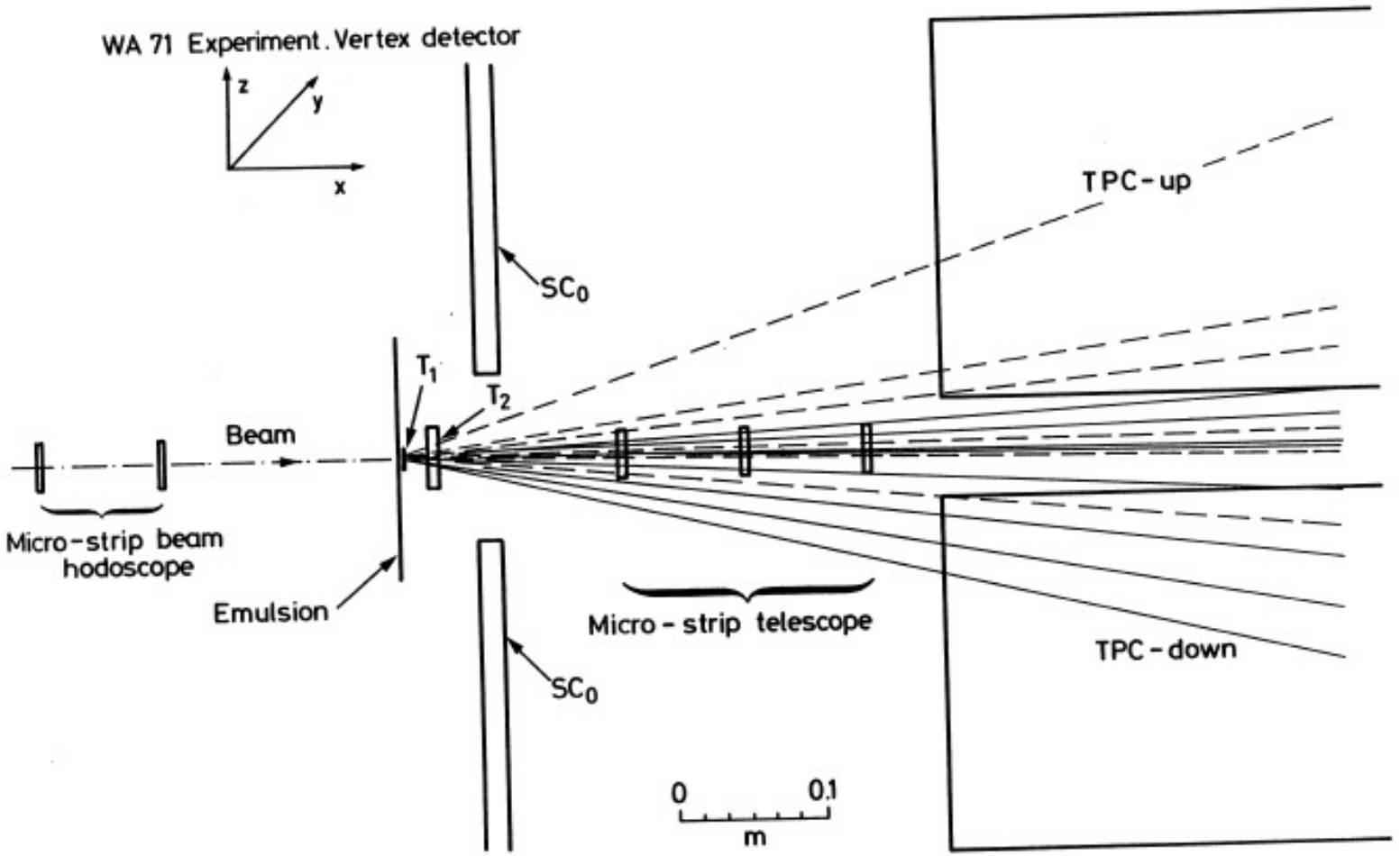

WA78 U cal
Muon spectrometer
Emulsion
Beam hod.
Vertex det.
Dump
Fe
Veto
H1(Scint.)
Beam
W
Drift
MWPCs
Magnet
H2(Scint.)
H3
Fe
Fe
Fe
MWPCs
150mrad
0
1
2
3
(m)

WA75: *Direct observation of the decay of beauty particles into charm particles*

PLB 158 (1985) 186-192



WA71
Vertex region



Nessun evento b → c trovato in WA71

Alcune criticita' emerse durante le prese dati iniziali:

- Charm selection (multiplicity jump T2-T1) non sufficientemente selettiva
- Esposizione con singoli trolleys critica
- Spessore Em troppo piccolo (oggi $c\tau_B \sim 0.5$ mm)

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Dopo WA71 e WA75 la ricerca di beauty in esperimenti ibridi ha uno stop:

- Programma fixed target al CERN ridimensionato
  (Continua al Fermilab)
- Notevole sviluppo dei VD a microstrips ⇒ colliders
- B physics: B factories

L'eredita'

E' tutto andato perduto di quella stagione?

Il “concetto ibrido” ha continuato a svilupparsi principalmente nello studio delle interazioni da neutrini (SBL, LBL):

Neutrino τ direct detection (CHORUS, OPERA)

Si ritrovano metodi sperimentati e non ancora maturi fino agli anni 80:

- *Emulsioni verticali + handling grandi masse*
- *Changeable emulsion sheets*
- *Automazione degli scanning systems*

Una grande eredita':

L'eredita'

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Grazie Giustina

Grazie Marcello

Grazie Giordano!