A short GARGAMELLE story

J.P. Vialle / LAPP
On behalf of the Gargamelle collaboration

Birth of Gargamelle

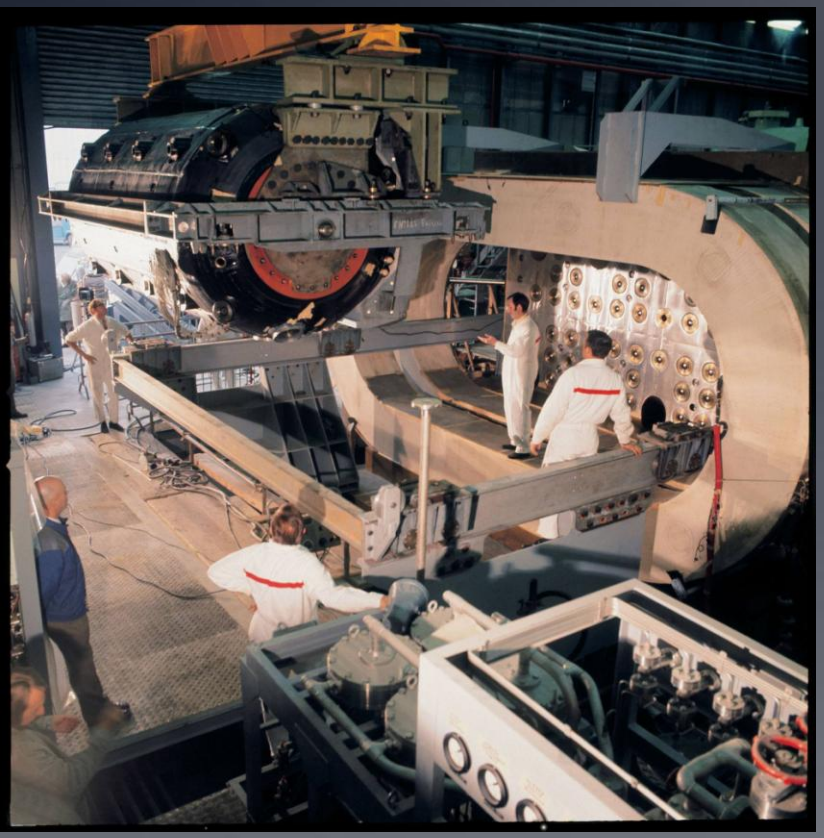
- 1963 : at the sienna conference in 1963 from a discussion between Luis Alvarez and André Lagarrigue:

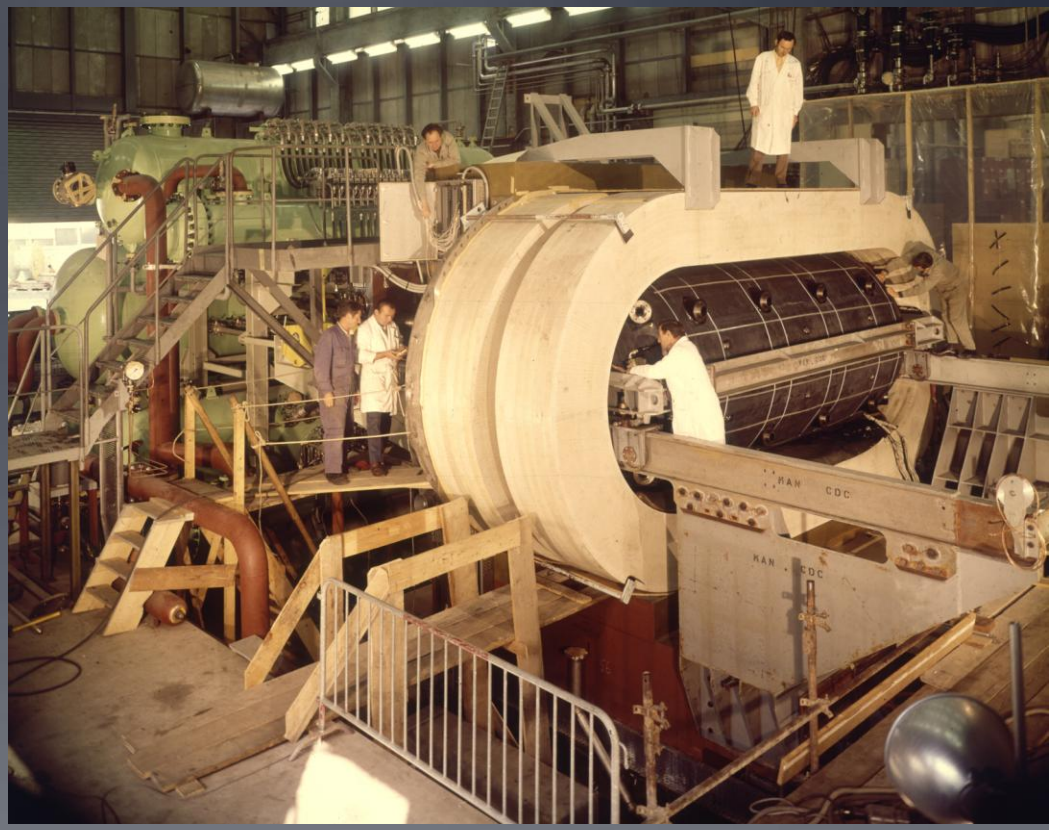
  Idea to build a big (for statistics) and long (to see and identify all particles from interactions) heavy liquid bubble chamber for detailed study of weak interactions

- 1965 : CEA (near Paris) agrees to build the chamber. Agreement with CERN for operating it in a neutrino beam.
- 1967 : Gargamelle. First big international collaboration (7 institutes!)
- 1970 : Gargamelle is assembled at CERN. First picture taken in december with cosmic rays.

The name Gargamelle was given due to its giantness (refering to the masterwork of Rabelais)

Assembly of GGM at CERN (1970)



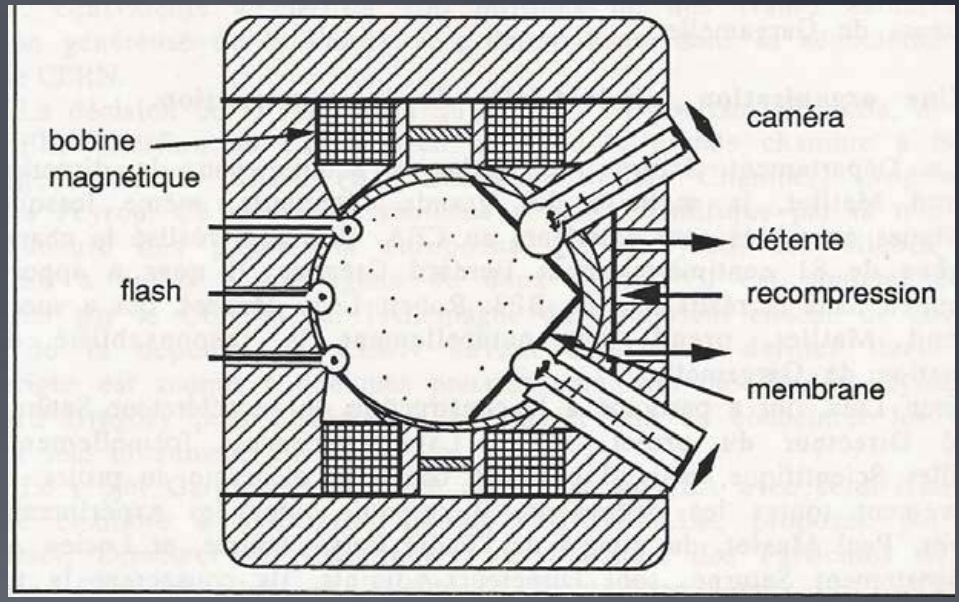


GGM : preparation of chamber body

Installation of optics

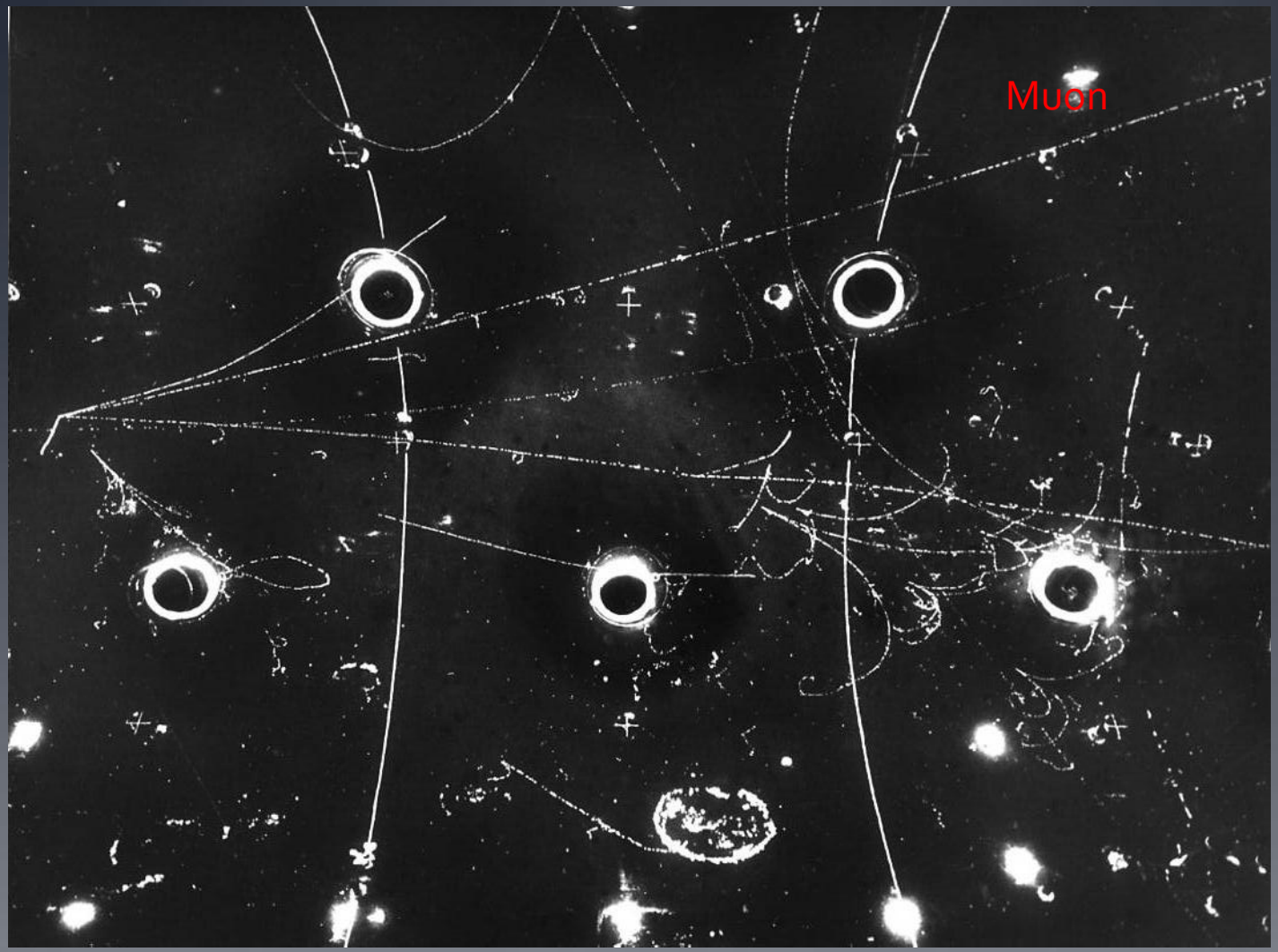
Some key numbers

- Chamber length : 4.8 meters
- Chamber diameter : 1.8 meters
- Liquid : CF_3Br
  - Inel. Interaction length Λ : 75 cm
  - Radiation length X0 : 11 cm

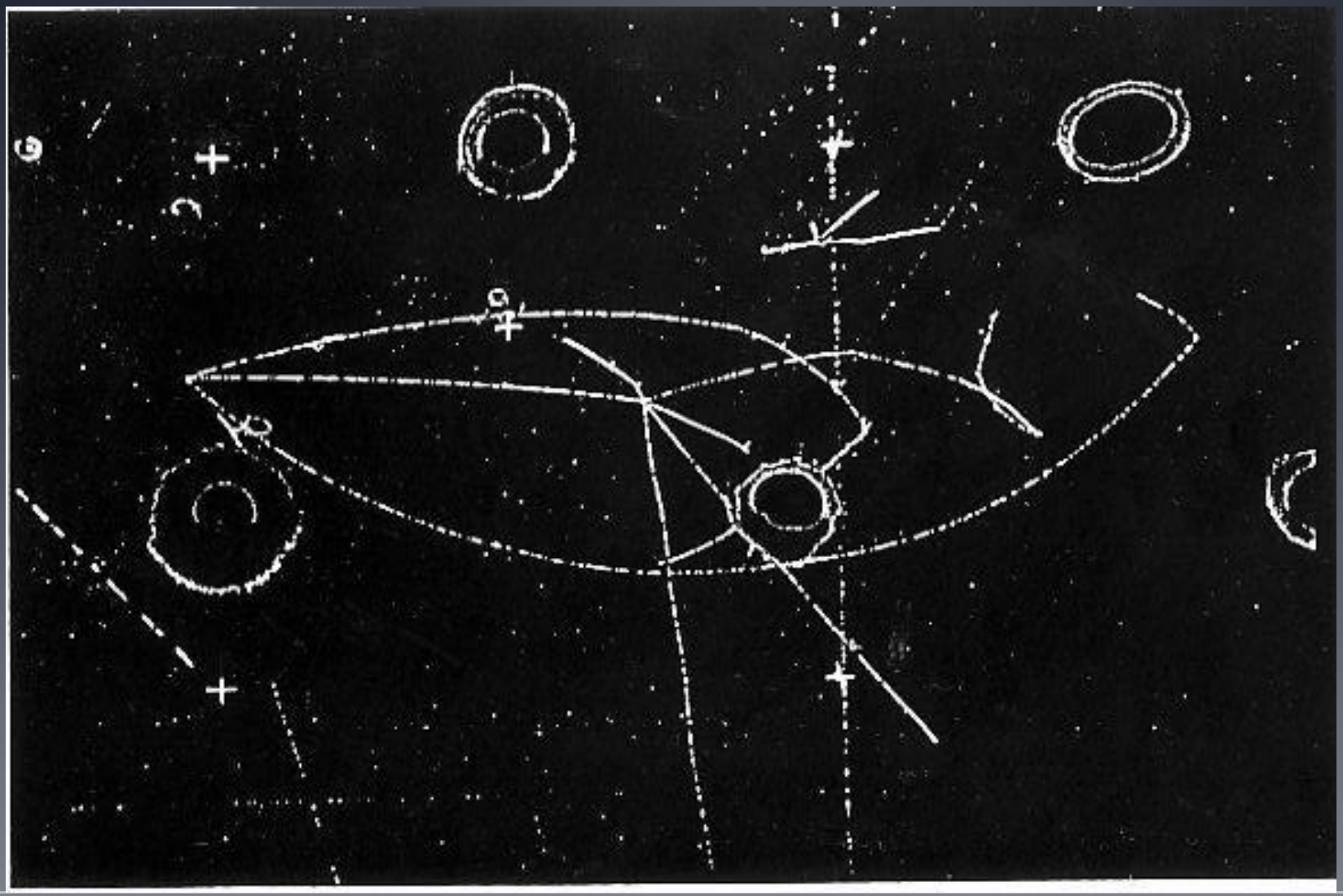


- The high probability to see and identify all particles going out of the interaction and their secondaries as well was a key factor.

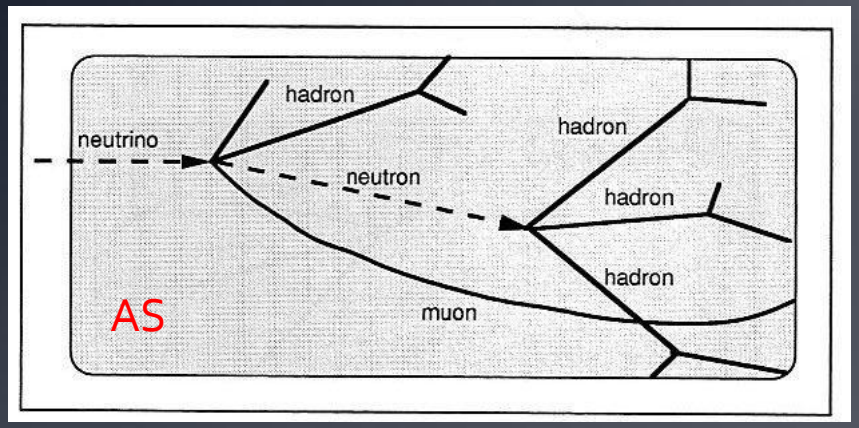
Neutrino charged current (CC)



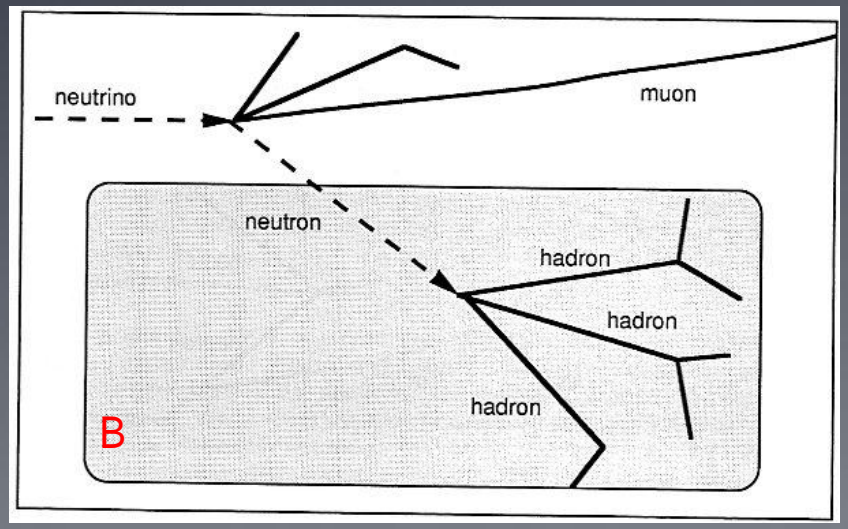
Hadronic neutral current candidate



NC main background source : Neutrons



ν interaction producing a neutron star (AS)



Neutron star with ν interaction not visible

Are all the events without charged lepton due to neutrons ?

Selection of stars with E> 1 GeV

If all stars (NC) are produced by neutrons (Background B = NC)

Then experimentally from the events found :

B/AS (neutrinos) = 102/15 ≈ 6.8
B/AS (antineutrinos) = 63/12 ≈ 5.3

Background calculation

- 2 independant simulations : CERN and LAL/Orsay
  - Input : geometry (beam, shielding, chamber, …); physics data (neutrino flux, liquid parameters, …)
  - Λ_{eff} = 0.95 ± 010 cm from Bartlett method with AS (A. Pullia)

- Result :
  - B/AS = 0.7 ± 0.3 (CERN)
  - B/AS = 0.6 ± 0.3 (Orsay)

- A independant method based on equilibrium of fluxes gave : B/AS <1

Consequence:Only a small fraction of so-called « NC » events are due to neutrons. They are produced by a new kind of interaction of neutrinos, similar to what Weak Neutral Currents would look like.

Hadronic neutral currents. 3 september 1973

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OBSERVATION OF NEUTRINO-LIKE INTERACTIONS WITHOUT MUON OR ELECTRON IN THE GARGAMELLE NEUTRINO EXPERIMENT

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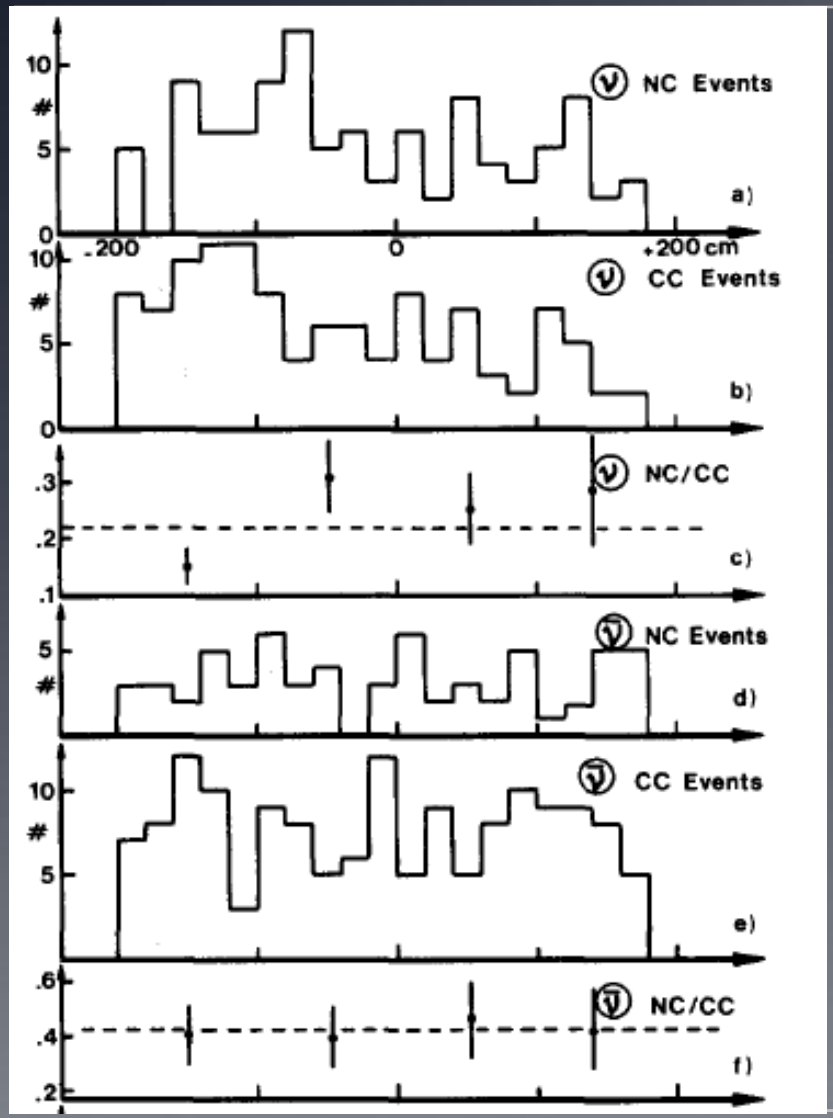
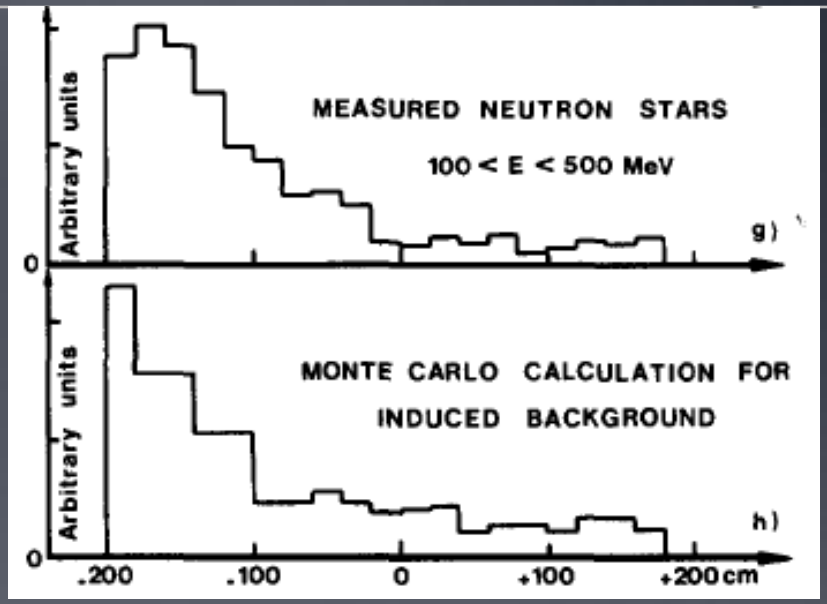
ν / $\bar{\nu}$ events and conclusion





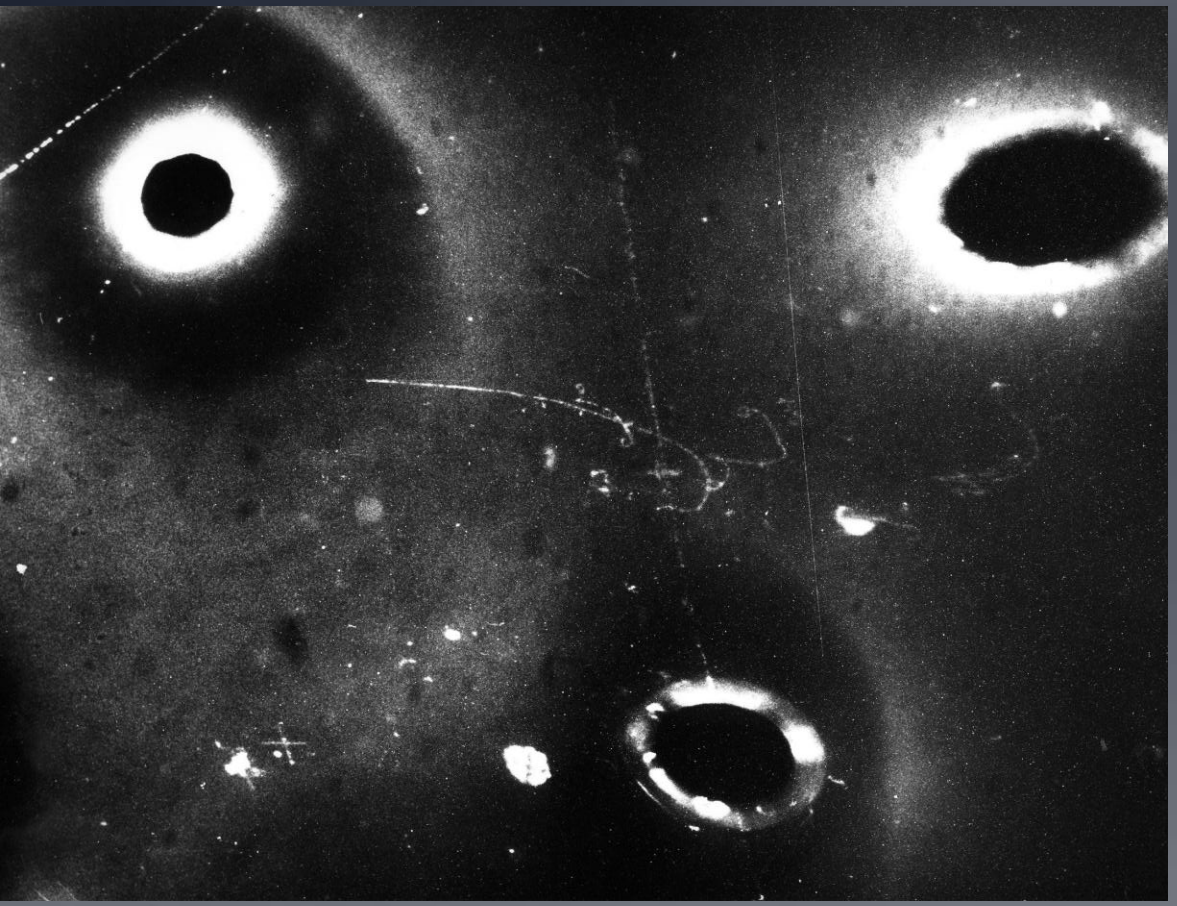
On subtraction of the best estimate of the neutral hadron background, and taking into account the $\nu(\bar{\nu})$ contamination in the $\bar{\nu}$ (ν) beam, our best estimates of the NC/CC ratios are

$(NC/CC)_{\nu} = 0.21 \pm 0.03$

$(NC/CC)_{\bar{\nu}} = 0.45 \pm 0.09$

where the stated errors are statistical only. If the events are due to neutral currents, these two results are compatible with the same value of Weinberg parameter, $\sin^2 \theta_W$ [1–3] in the range 0.3 to 0.4.

Other NC channel : elastic ν – e scattering



1 event found in antineutrino beam in december 72 (Aachen)

Published, but 1 not enough to get firm conclusion

A second one found in january 74 (Orsay), and a third one in Brussels

-> NC are confirmed

3 events in total in 1,000,000 pix.

Leptonic neutral currents. 3 september 1973

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SEARCH FOR ELASTIC MUON-NEUTRINO ELECTRON SCATTERING

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One possible event of the process $\nu_\mu^- + e^- \to \nu_\mu^- + e^-$ has been observed. The various background processes are discussed and the event interpreted in terms of the Weinberg theory. The 90% confidence limits on the Weinberg parameter are $0.1 < \sin^2\theta_W < 0.6$.

In order to combine the neutrino and anti-neutrino results a maximum likelihood method has been used, taking into account the fluxes and backgrounds. The 90% confidence limit gives:

$0.1 < \sin^2\theta_W < 0.6$.

It may be remarked that, in the context of the Weinberg theory, the proportion of electrons with $E_e > 1$ GeV is much lower in neutral current events than in the ν_e background, and hence our quoted background is over-estimated. We conclude that the probability that the single event observed in the $\bar{\nu}$ film is due to non-neutral current background is less than 3%.

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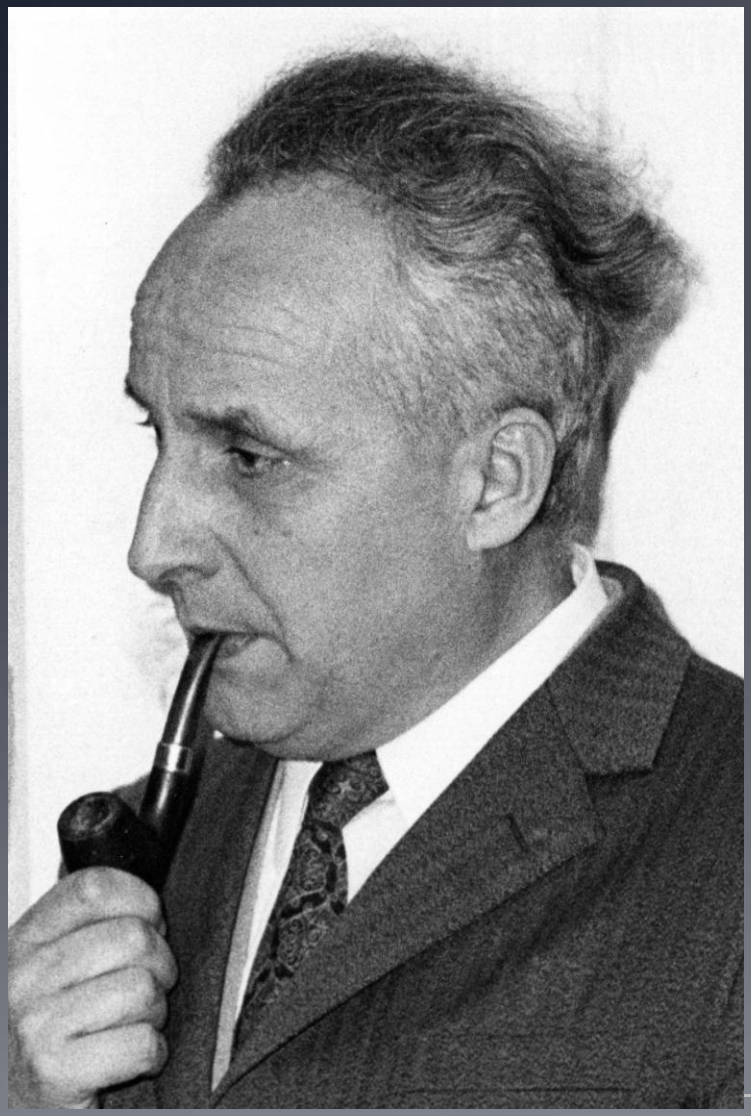
Memorabilia



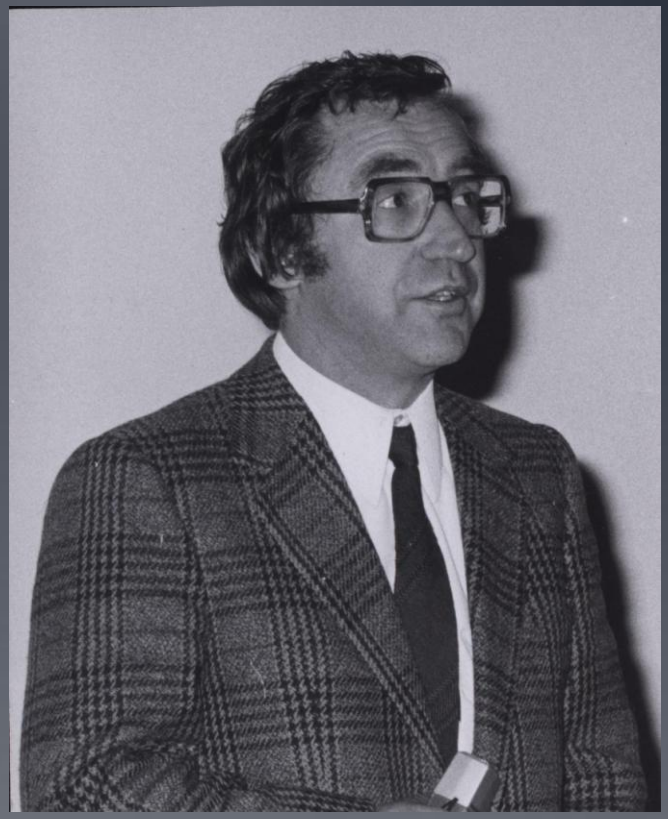
Prof. André Lagarrigue

He was at the origin of the Gargamelle project.

His leadership for the construction of the chamber and for the physics work was a key for the success of the project and for the discovery of Neutral Currents.

Memorabilia (2)

Prof. André Rousset



Dr. Paul Musset

They were in charge of Gargamelle at CERN. They were strongly involved in the discovery of Neutral Currents.

Conclusions

- A great experiment and an exciting period in which our view of fundamental interactions changed dramatically
- The best possible apparatus, at the right time
- A strong team working closely : the decision to publish a result so controversial needed everybody to be truly confident in the work done. The leadership of André Lagarrigue was very important for this.