The CDHS Years

1974-1984

CERN

DORTMUND

HEIDELBERG

SACLAY

CDHS: Inclusive Neutrino Scattering

CERN/SPSC/P 73-1
27 July 1973

PROPOSAL TO STUDY HIGH-ENERGY NEUTRINO INTERACTIONS AT THE SPS

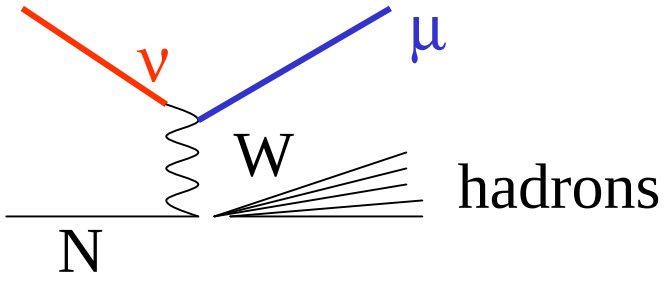
M. Holder, J. Steinberger, H. Wahl and E.G.H. Williams
CERN, Geneva, Switzerland

C. Geweniger*) and K. Kleinknecht
Institut für Physik, Dortmund

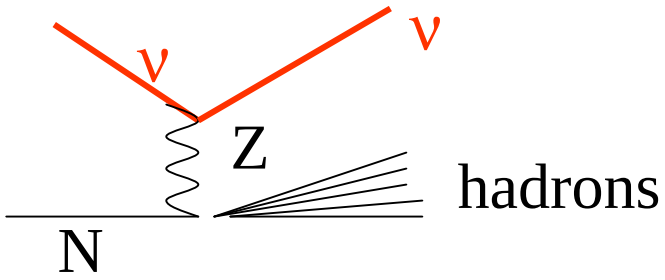
F. Eisele, V. Hepp, E. Kluge and K. Tittel*)
Institut für Hochenergiephysik, Heidelberg

M. Banner and R. Turlay
Centre d'Etudes Nuclaires de Saclay

Charged current reaction



Neutral current reaction



Charged current reaction

Neutrino and Antineutrino cross sections give direct access to quark and anti-quark densities in the Nucleon

$$\frac{d\sigma(\nu+N)}{dydx}=\frac{G^2}{\pi}ME_\nu\left[\mathbf{q}(x)+(1-y)^2\overline{\mathbf{q}}(x)\right]$$

$$\frac{d\sigma(\overline{\nu}+N)}{dydx}=\frac{G^2}{\pi}ME_{\overline{\nu}}\left[(1-y)^2\mathbf{q}(x)+\overline{\mathbf{q}}(x)\right]$$

$$where \quad x=Q^2/2MyE_\nu \; and \quad y=E_{hadrons}/E_\nu$$

In the simplest parton model (no QCD), q and $\overline{q}$ depend only on x (scaling)

Neutral current reaction

Cross sections linked to neutral courant couplings

In the Standard Model :

$$\frac{\sigma_{NC}}{\sigma_{CC}} = R_{\nu} = \frac{1}{2} - \sin^2 \Theta_W + \frac{20}{27} \sin^4 \Theta_W$$

$$\frac{\overline{\sigma}_{NC}}{\overline{\sigma}_{CC}} = R_{\overline{\nu}} = \frac{1}{2} - \sin^2 \Theta_W + \frac{20}{9} \sin^4 \Theta_W$$

Early CDHS

CDHS was the timely experiment to clarify the situation w.r.t. the parton model

Before CDHS:

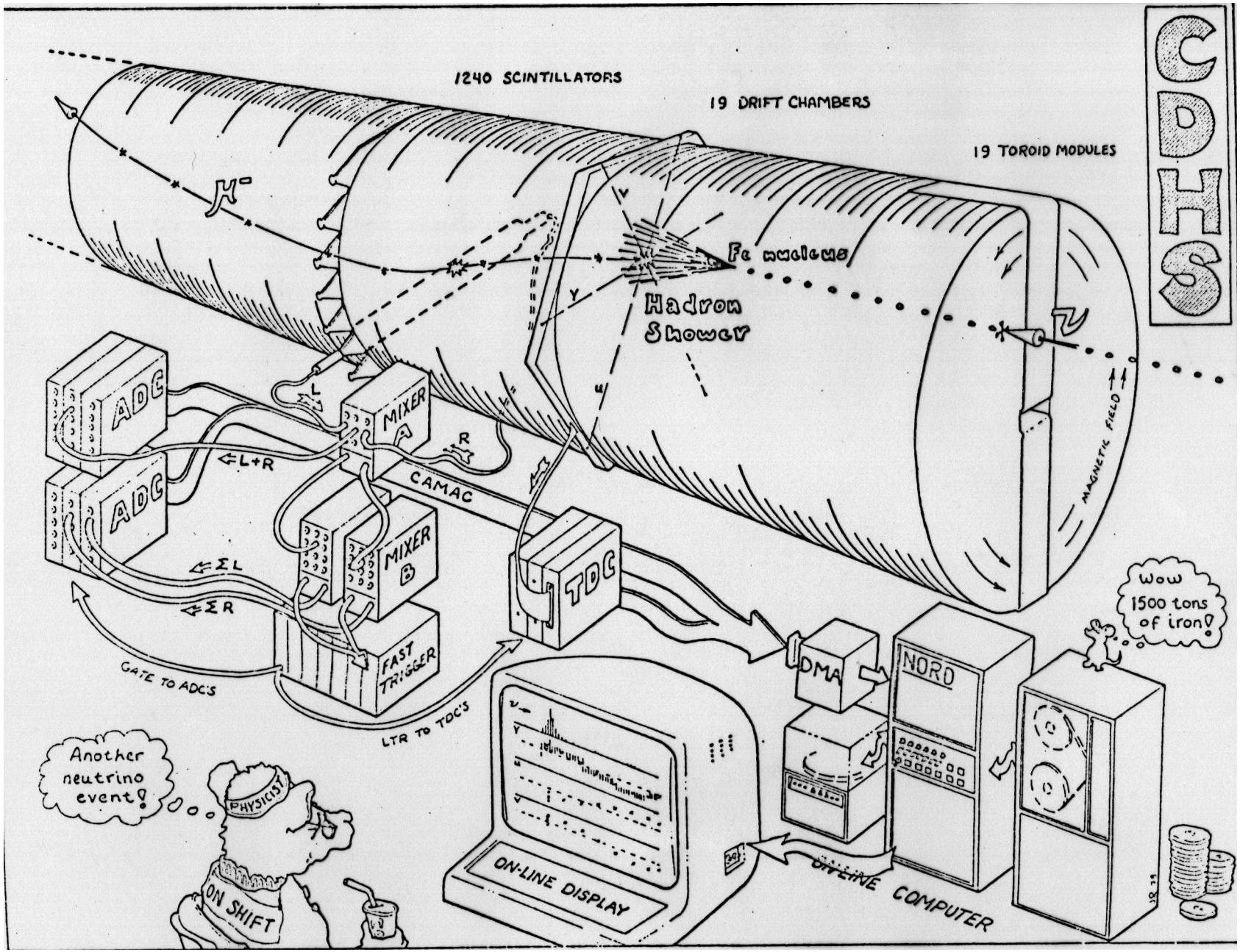
Good low energy results:

- Gargamelle/ SLAC (e-p) already shown that quarks carry only 50% of nucleon momentum
- but low statistics and/or too low Q^2 to really test scaling

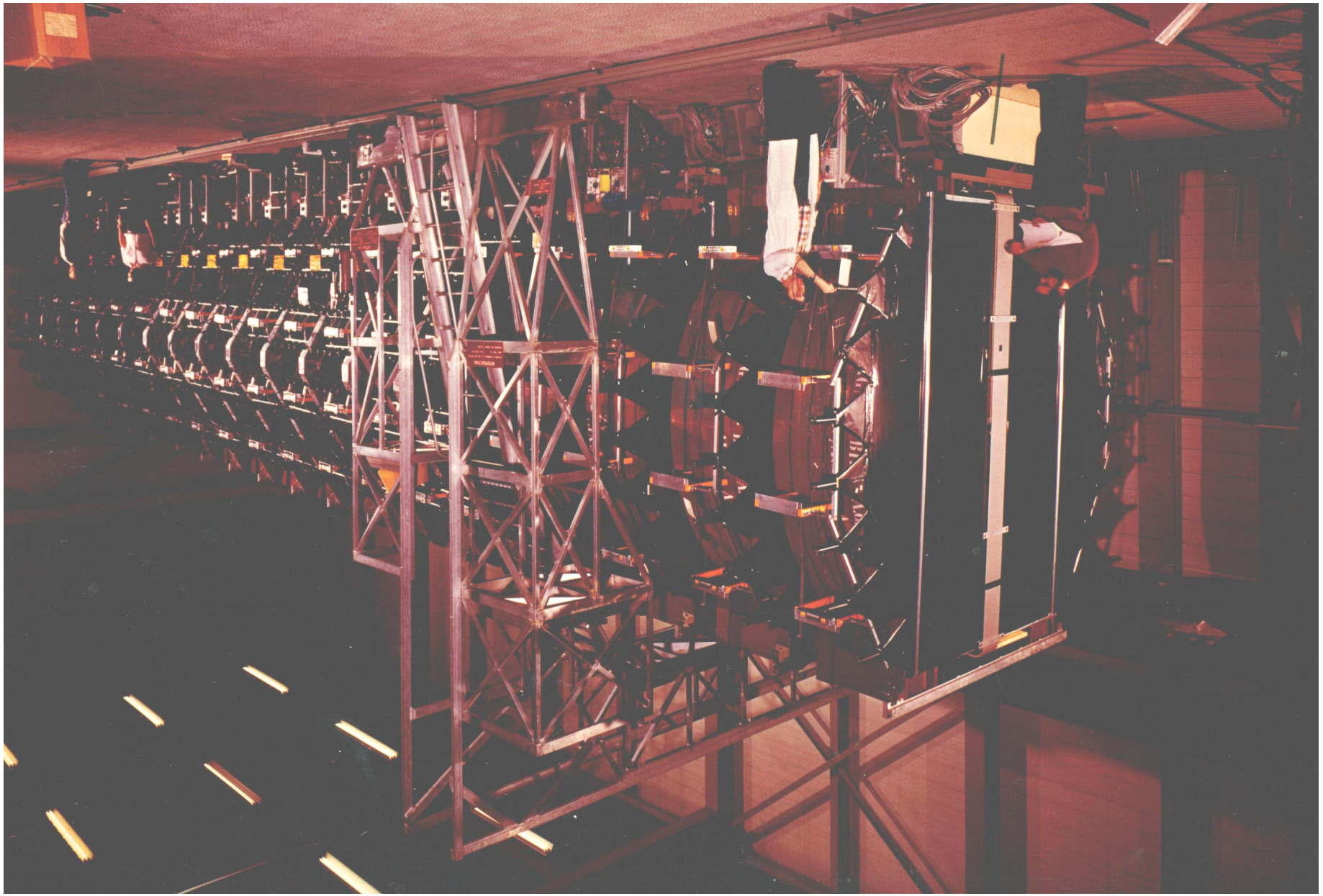
Confusion at high energy (FNAL experiments)

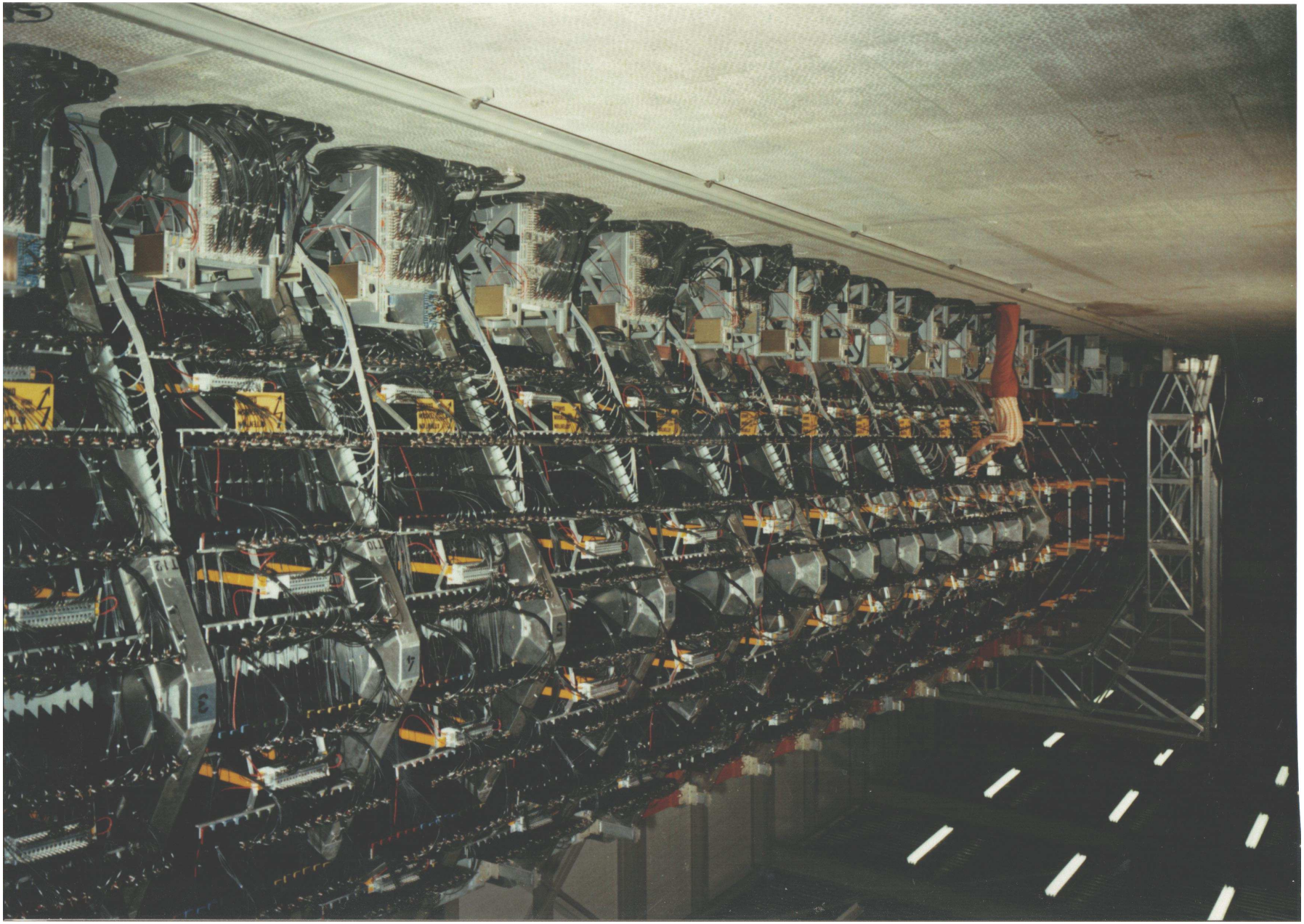
"High y anomaly" (strange behavior of high energy antineutrino events)

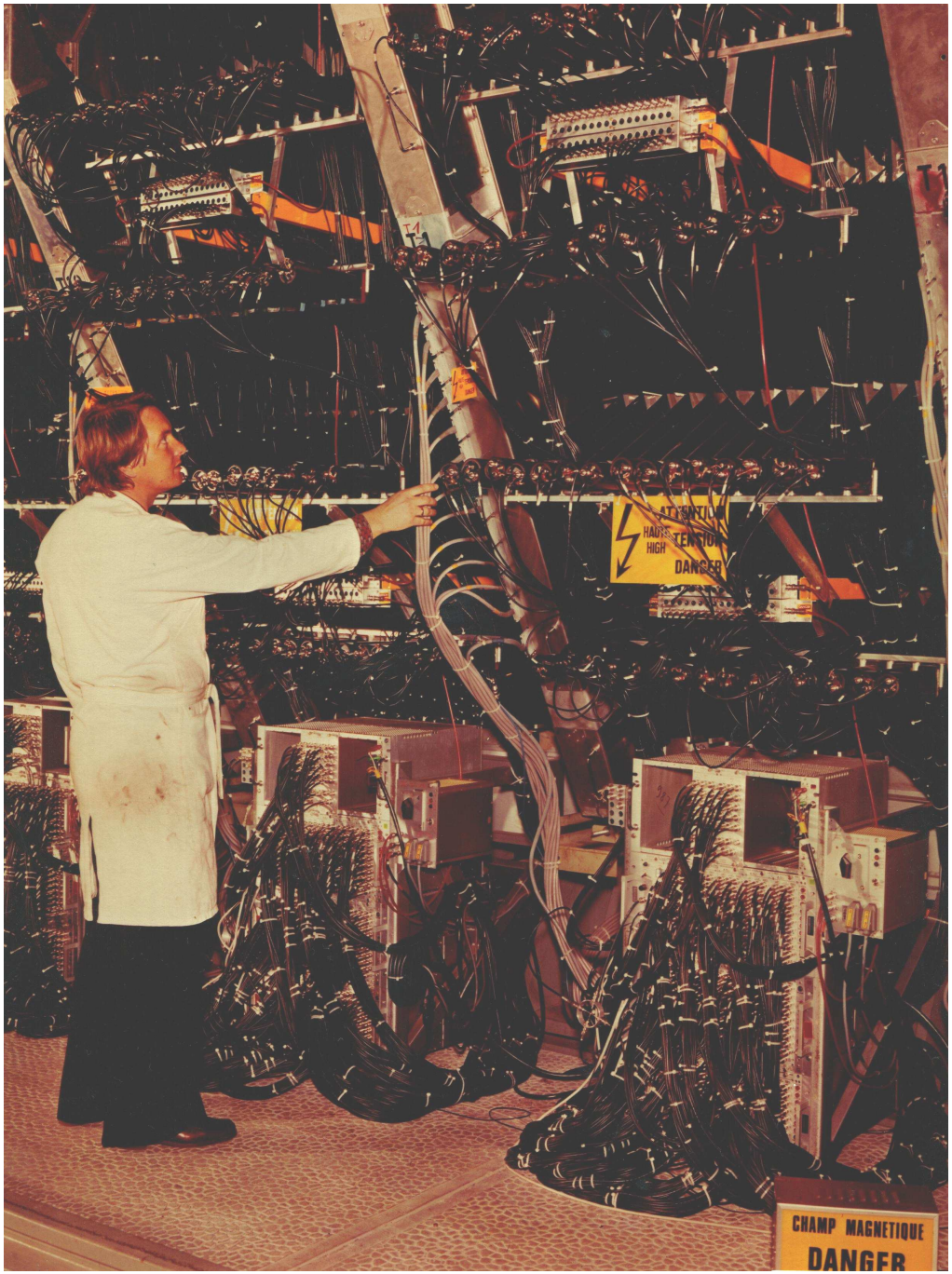
"Spectacular" Multi-muon events



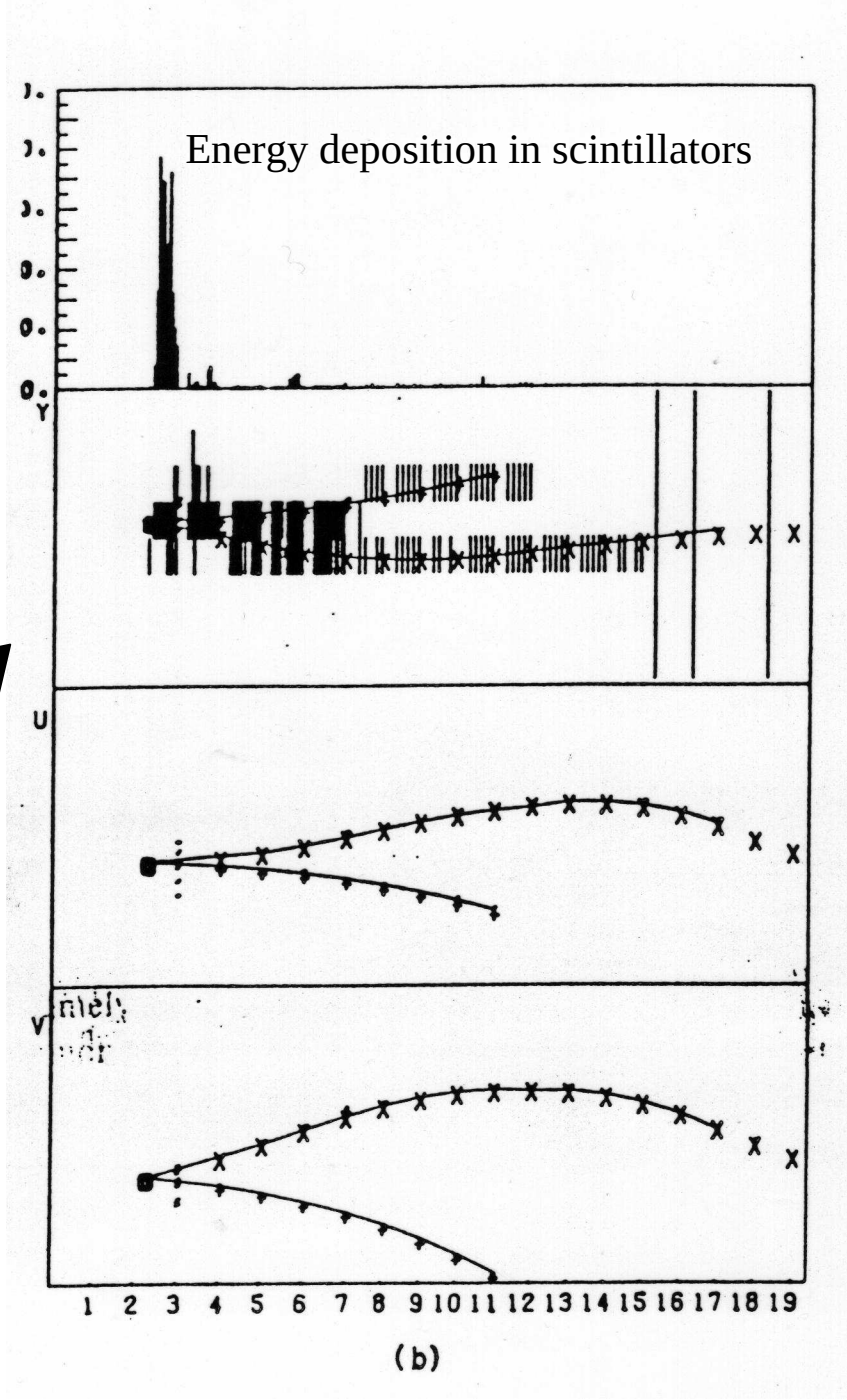
Courtesy of J.Rander






HAUTE TENSION
HIGH VOLTAGE
DANGER
CHAMP MAGNETIQUE
DANGER

On line display



Early battle

H. Wahl was the leader of the Charged Current Analysis

VOLUME 39, NUMBER 8 PHYSICAL REVIEW LETTERS ! 22 AUGUST 1977

Is There a High-y Anomaly in Antineutrino Interactions?

M. Holder, J. Knobloch, J. May, H. P. Paar, P. Palazzi, D. Schlatter,
J. Steinberger, H. Suter, H. Wahl, and E. G. H. Williams
CERN, Geneva, Switzerland

and

F. Eisele, C. Geweniger, K. Kleinknecht, G. Spahn, and H.-J. Willutzki
Institut für Physik der Universität, Dortmund, Federal Republic of Germany

and

W. Dorth, F. Dydak, V. Hepp, K. Tittel, and J. Wotschack
Institut für Hochenergiephysik der Universität, Heidelberg, Federal Republic of Germany

and

P. Bloch, B. Devaux, M. Grimm, J. Maillard, B. Peyaud,
J. Rander, A. Savoy-Navarro, and R. Turlay
Département de Physique des Particules Elémentaires, Centre d'Etudes Nucléaires, Saclay, France

and

F. L. Navarria
Istituto di Fisica dell'Università, Bologna, Italy
(Received 12 July 1977)

Accepted without review at the request of E. Picasso under policy announced 26 April 1976

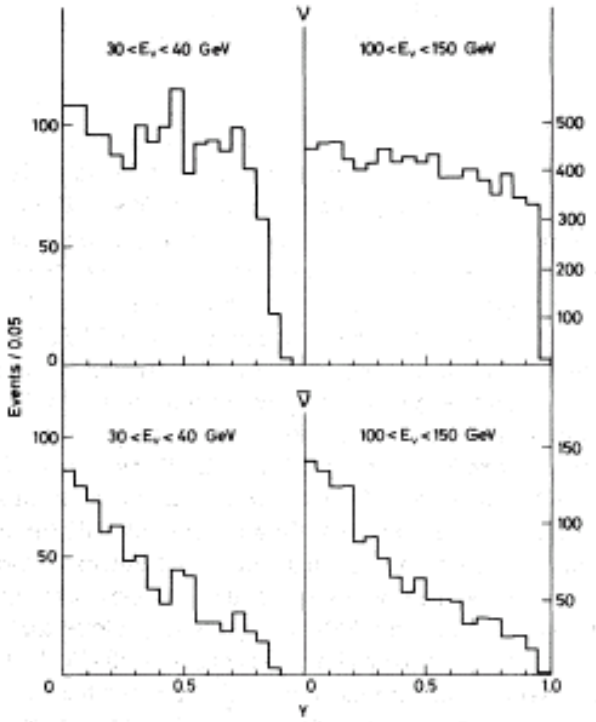


FIG. 1. The y distributions of neutrino and antineutrino events with $x<0.6$ in the two energy bands E_ν = 30–40 GeV and E_ν = 100–150 GeV.

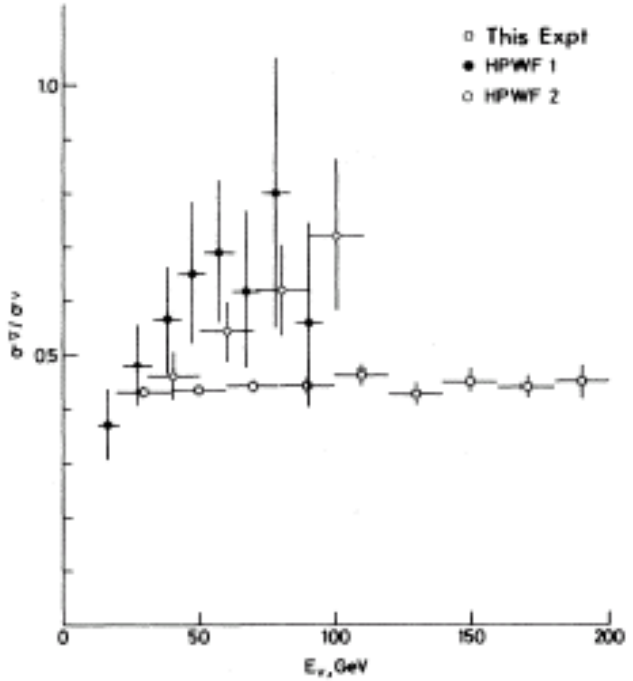


FIG. 5. The ratio between the antineutrino and neutrino charged-current total cross sections as a function of neutrino energy. The data marked HPWF 1/2 are taken from Ref. 7. The indicated errors are statistical only. Systematic errors are discussed in the text.

The present data allow the following conclusion relevant to the "high-y anomaly": The experimental observations on which the evidence was based are not confirmed. In particular, the antineutrino y distribution and the ratio between the antineutrino and neutrino cross sections are found to be essentially independent of neutrino energy.

More results (1977-1979)

- anti-quark content $\bar{q}/(q+\bar{q}) = 0.16 \pm 0.02$
- Valence quarks $\int q - \bar{q} = 3.2 \pm 0.5$
- Dimuons are due to Charm decays
- Comparison with e-p data shows agreement with fractional charges of quarks

$$F_2^{eD} \approx \frac{5}{18} F_2^{\nu N}$$

- Scaling violations, agreement with QCD

  First evaluation of Λ ~300 MeV

- First precise measurement of $\sin^2 \Theta_W = 0.24 \pm 0.02$

The first (and last?) neutrino tomography !

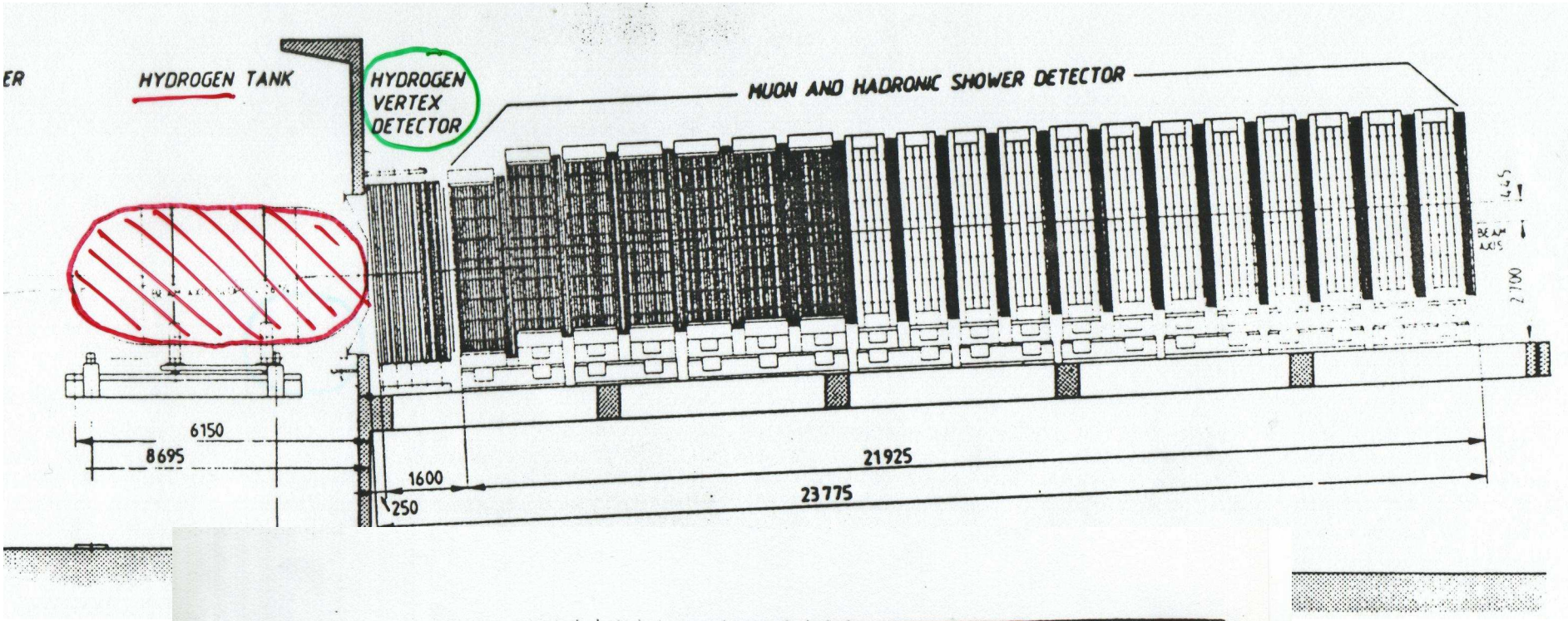
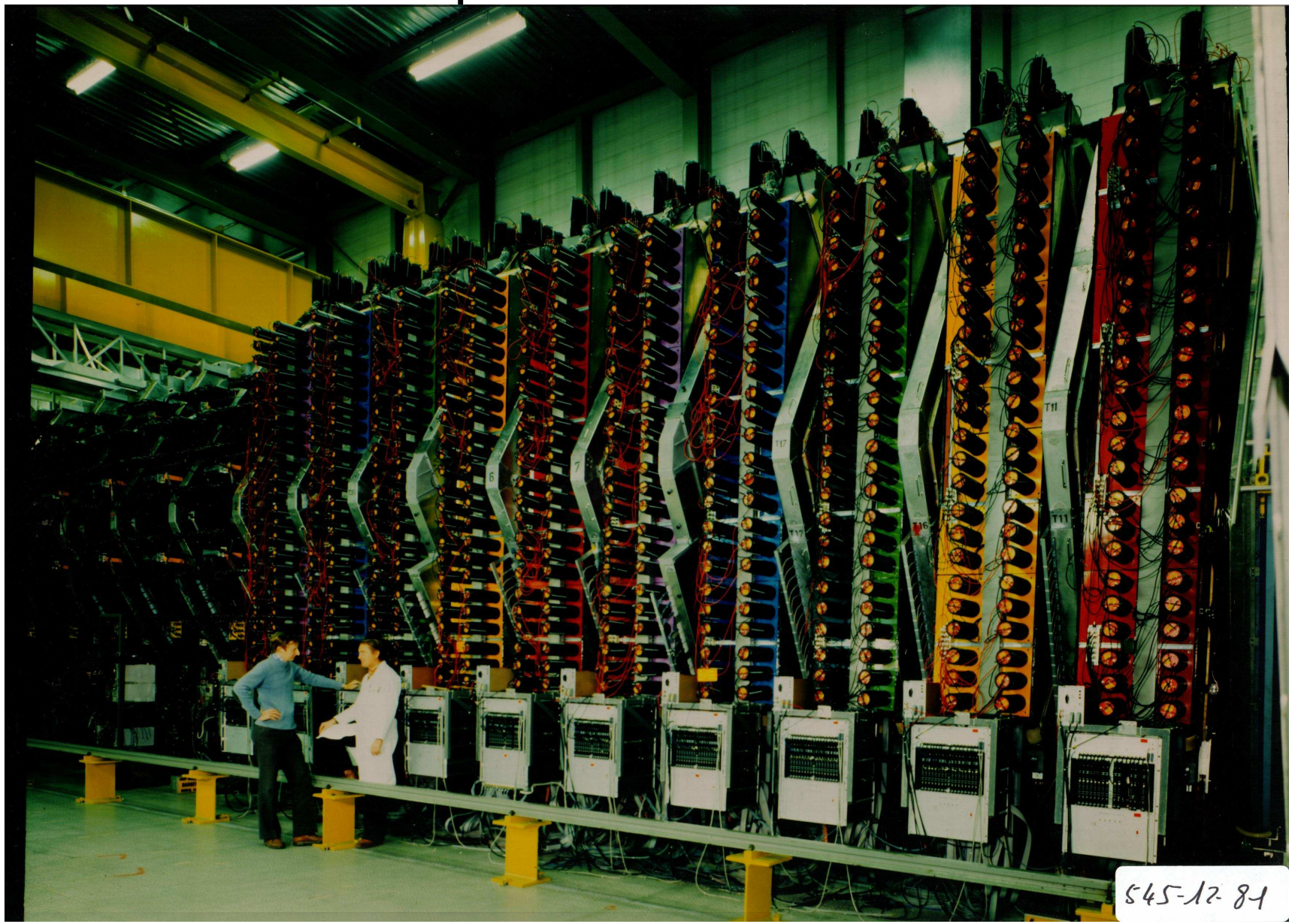


Fig. 5. Neutrinogram of the target. Two-dimensional projection of the vertex distribution of reconstructed events

CDHS-w : precision measurements

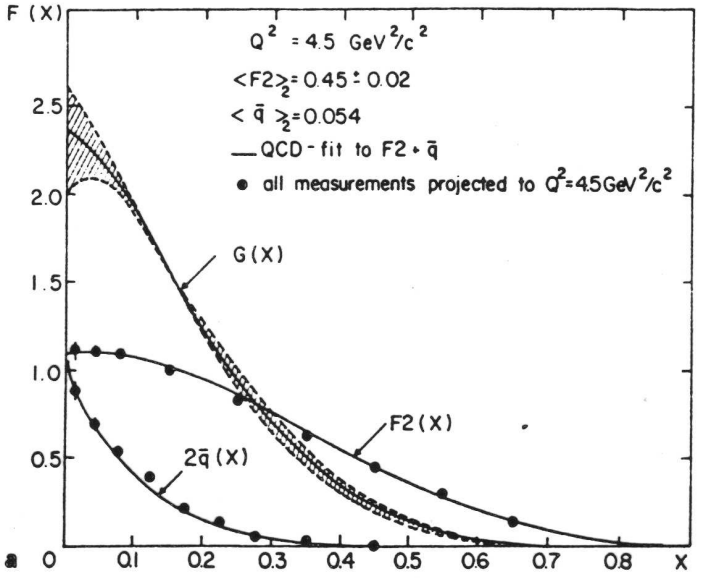


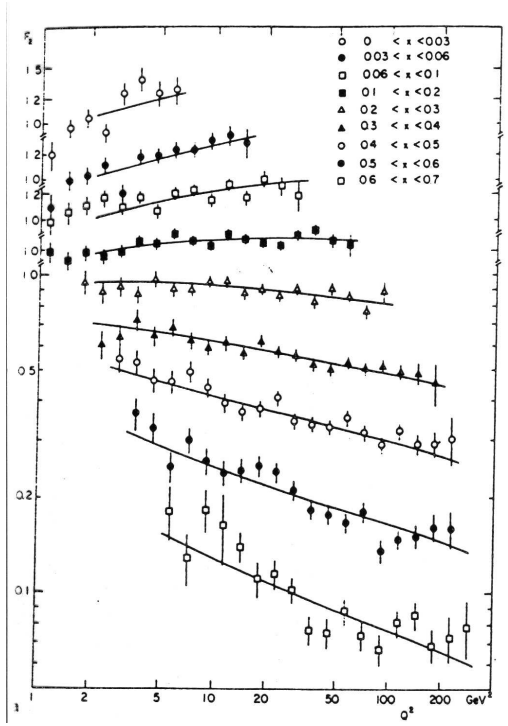
Precision results

- Gluon distribution in nucleon
- Precision measurement (4%) of total Cross Sections
- Precise structure functions and Λ_{MS}
- V_{cd} with dimuons
- Weinberg angle measurement

$$\sin^2 \Theta_W = 0.228 \pm 0.005$$

- Beam dump experiments, axion searches
- Neutrino oscillation searches





(What I remember from) Heiner at Work

A guy who liked precision

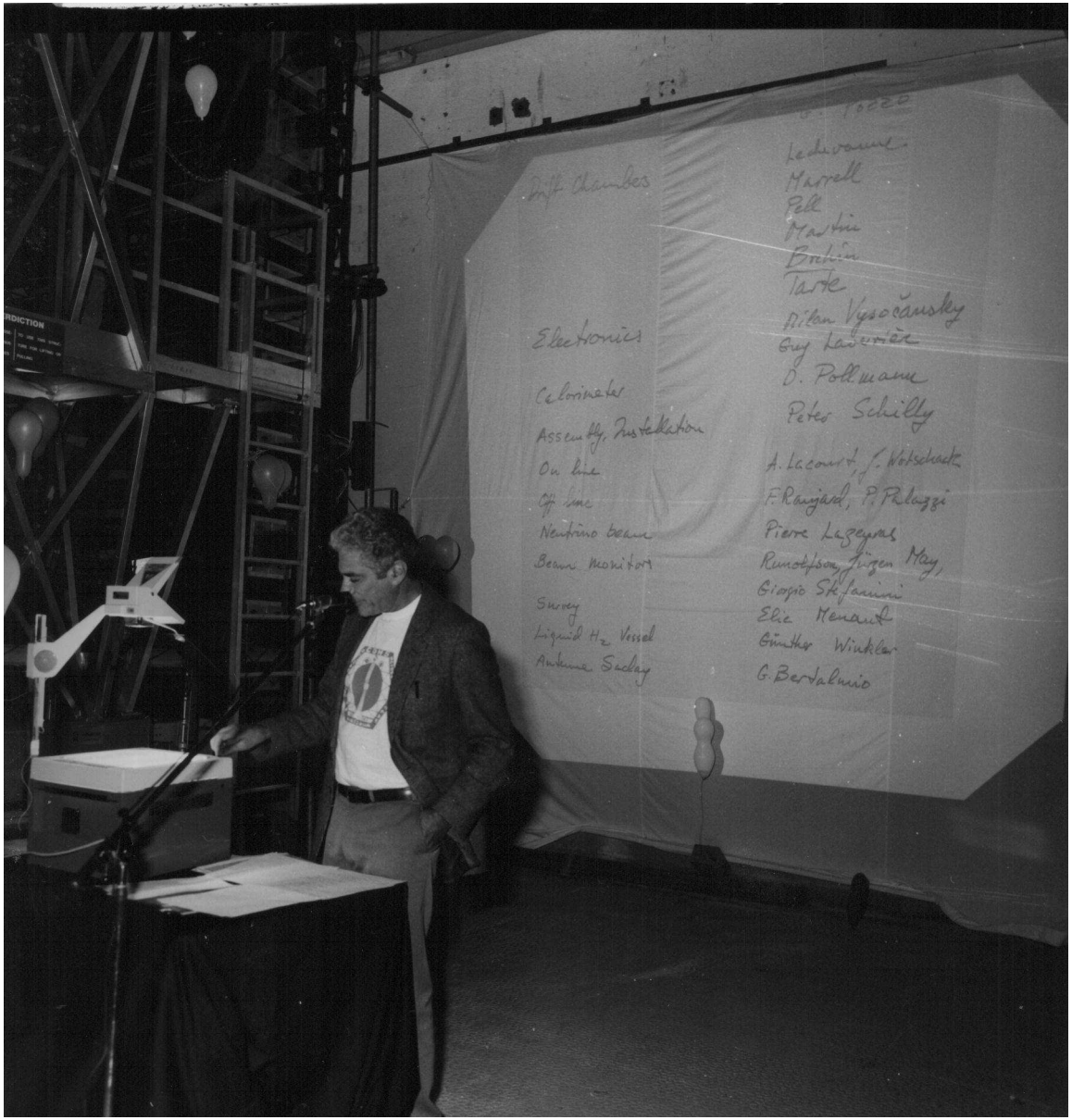
A fan of Mortran (*not* Fortran)

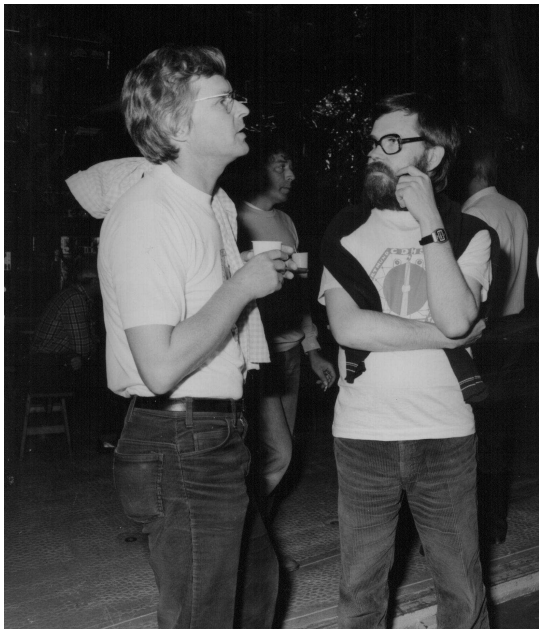
a bit shocked at the start by the lack of respect from the French students….

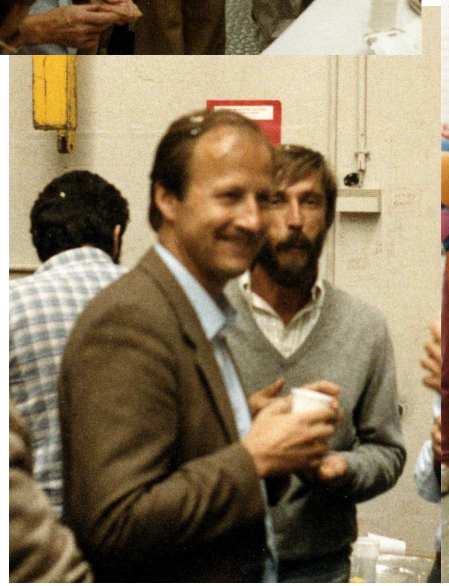
But predominantly a good friend, always ready to give clear and clever guidance to the young students like me

At the end….

Jack gave a summary talk







Thank you Herr Wahl,

It was a great pleasure to work and to learn with you !