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

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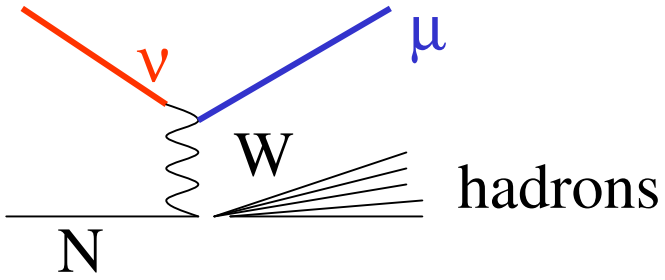
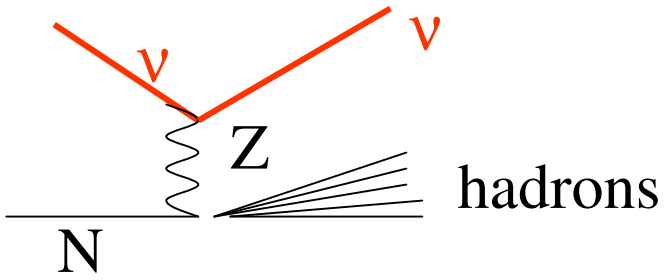
Charged current reaction



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 $\bar{q}$ 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:

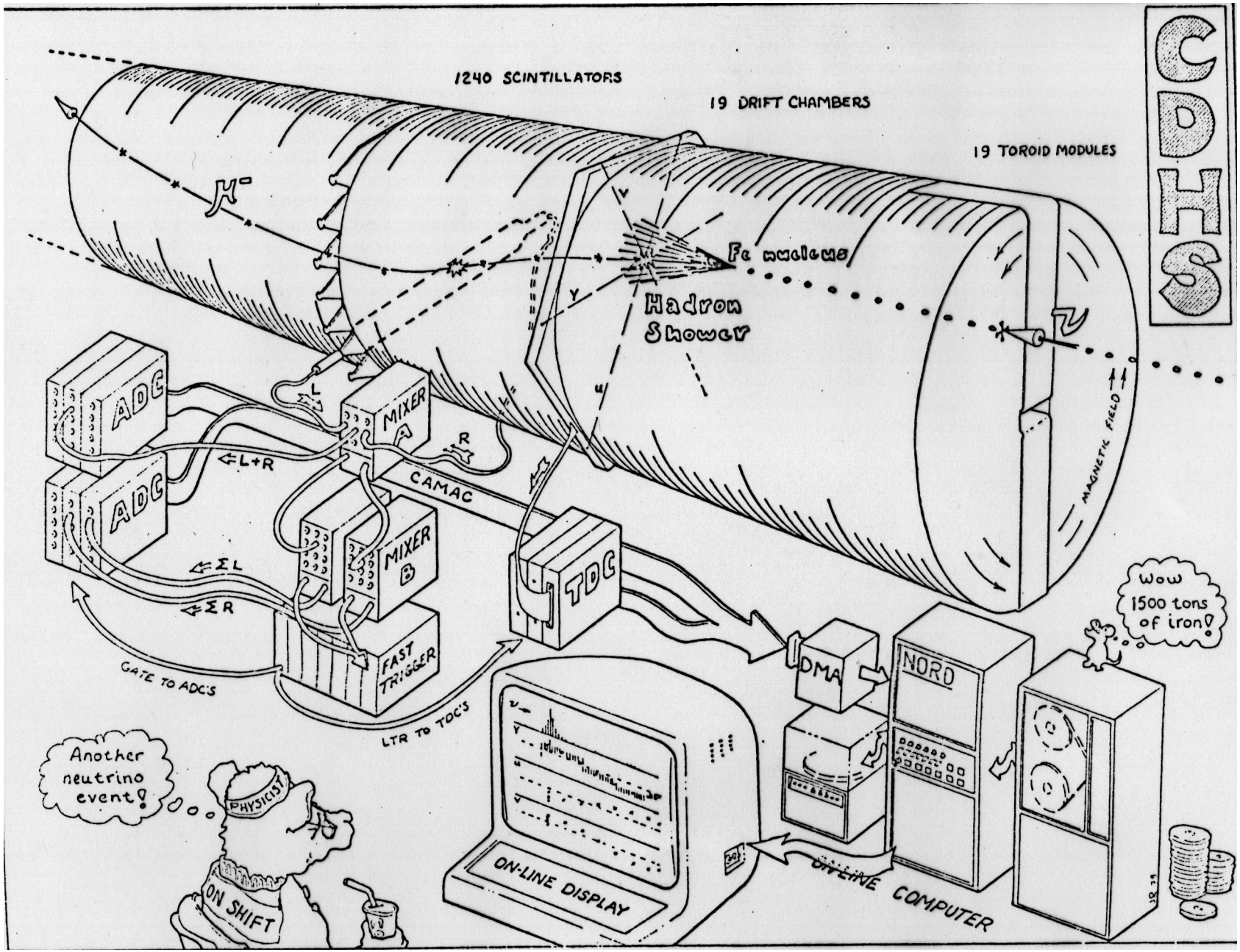
Good low energy results:

- 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

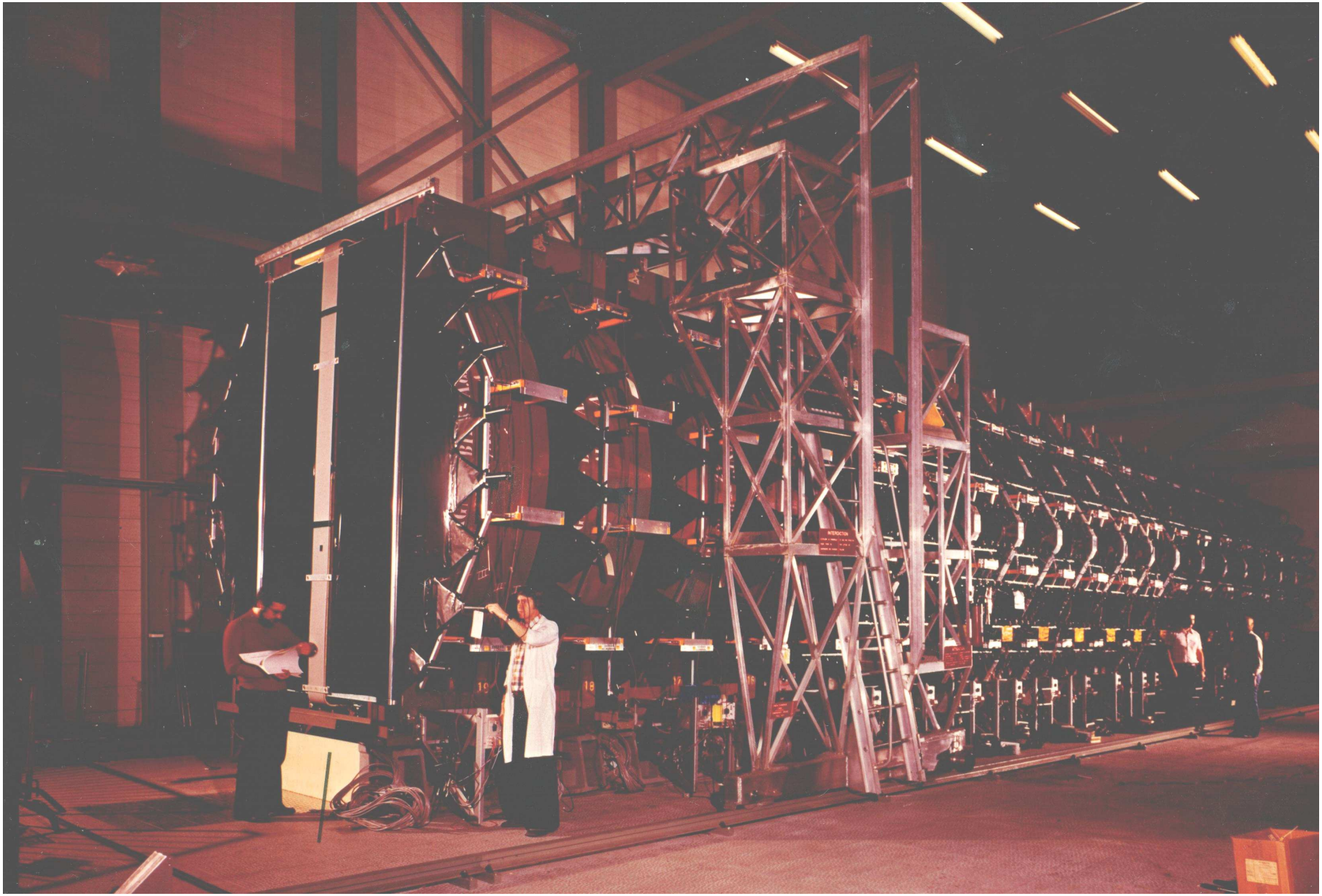
Confusion at high energy (FNAL experiments)

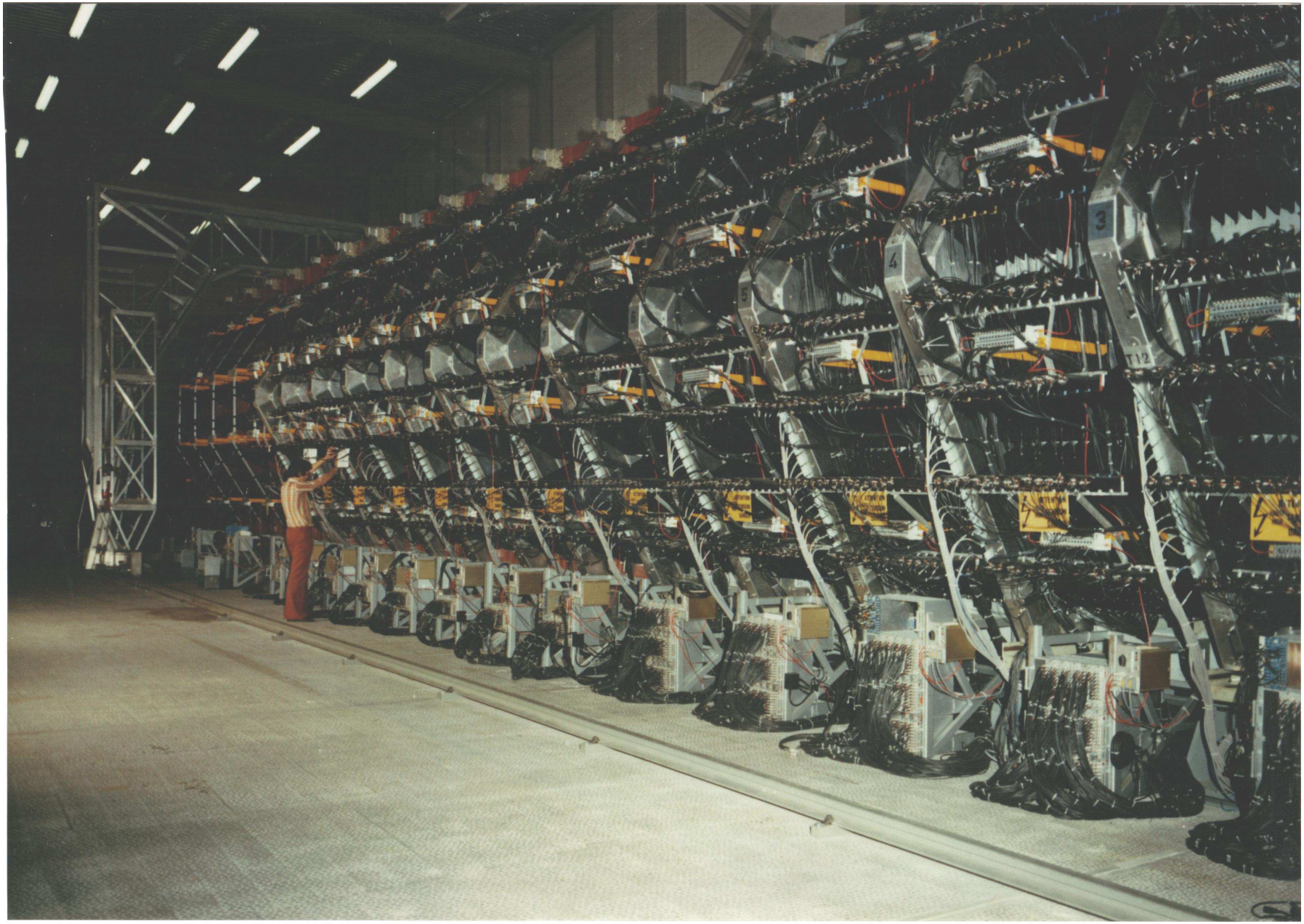
"High y anomaly" (strange behavior of high energy antineutrino events)

"Spectacular" Multi-muon events



Courtesy of J.Rander




3
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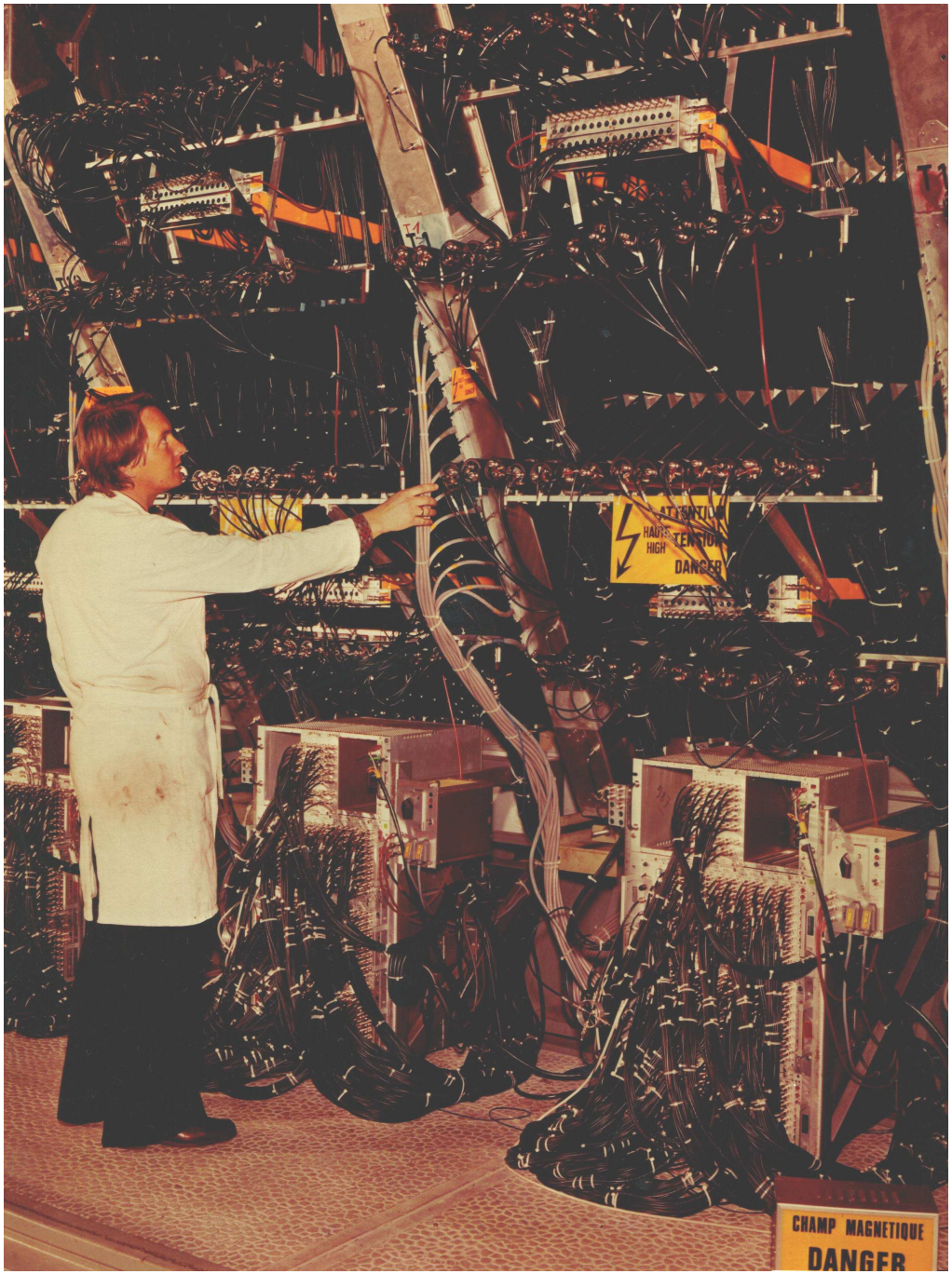
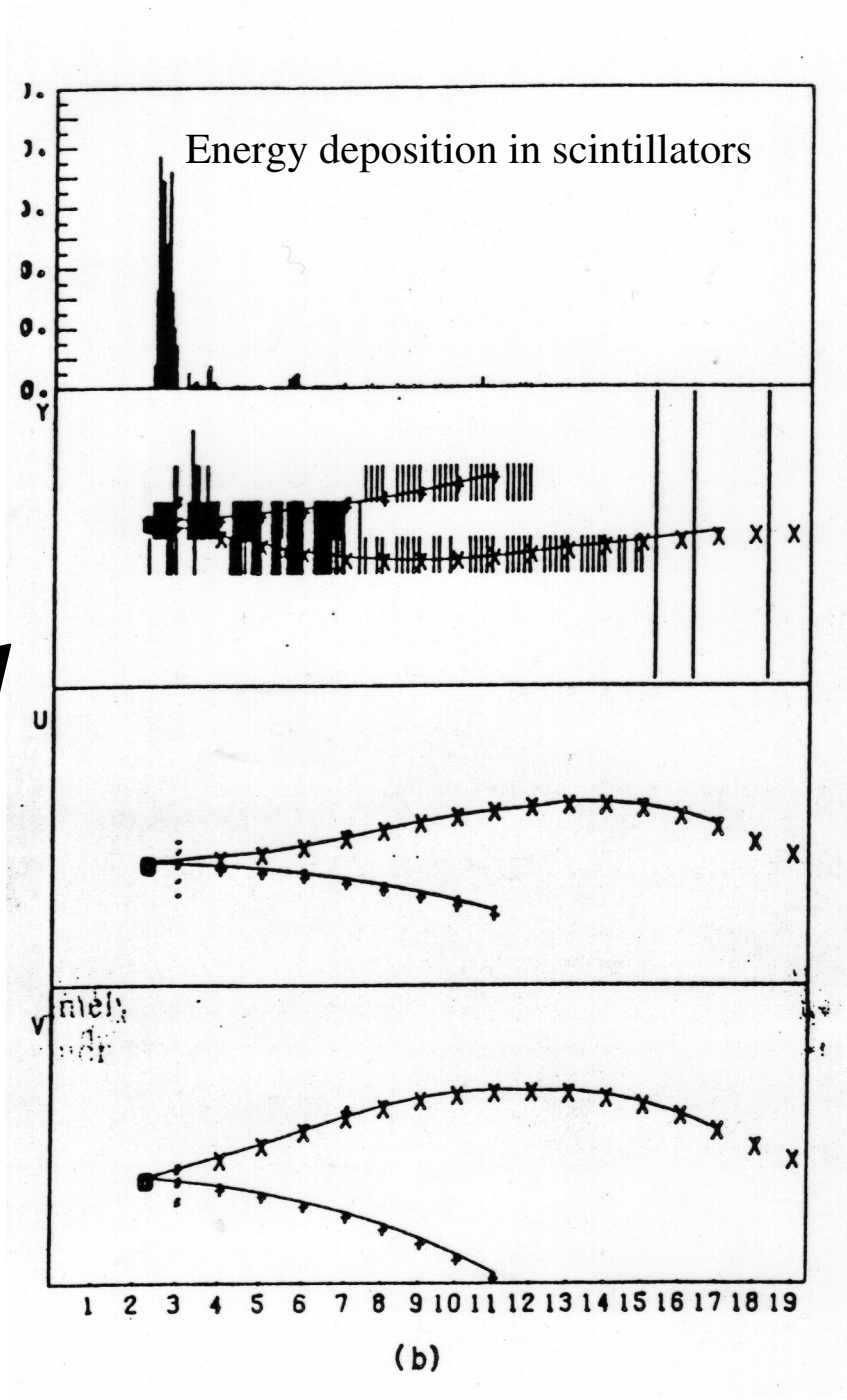

HAUTE TENSION
HIGH VOLTAGE
DANGER
CHAMP MAGNETIQUE
DANGER

On line display



Early battle

H. Wahl was the leader of the Charged Current Analysis

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Is There a High-y Anomaly in Antineutrino Interactions?

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(Received 12 July 1977)

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

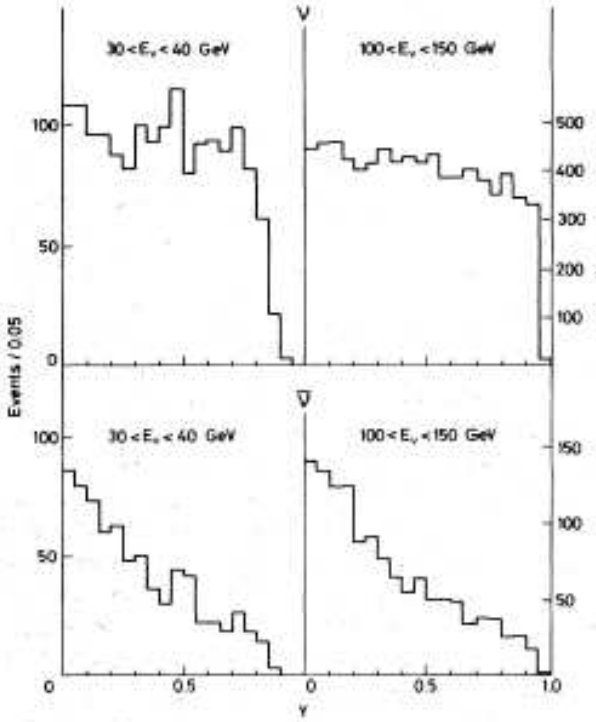


FIG. 1. The y distributions of neutrino and antineutrino events with $x < 0.6$ in the two energy bands $E_\nu = 30$–40 GeV and $E_\nu = 100$–150 GeV.

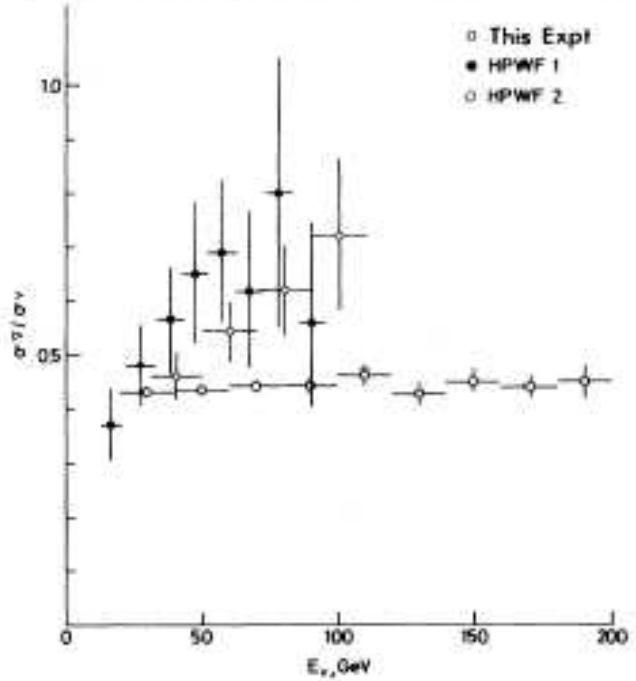


FIG. 5. The ratio between the antineutrino and neutrino charged-current total cross sections as a function of neutrino energy. The data marked HPWF 1/2 are taken from Ref. 7. The indicated errors are statistical only. Systematic errors are discussed in the text.

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

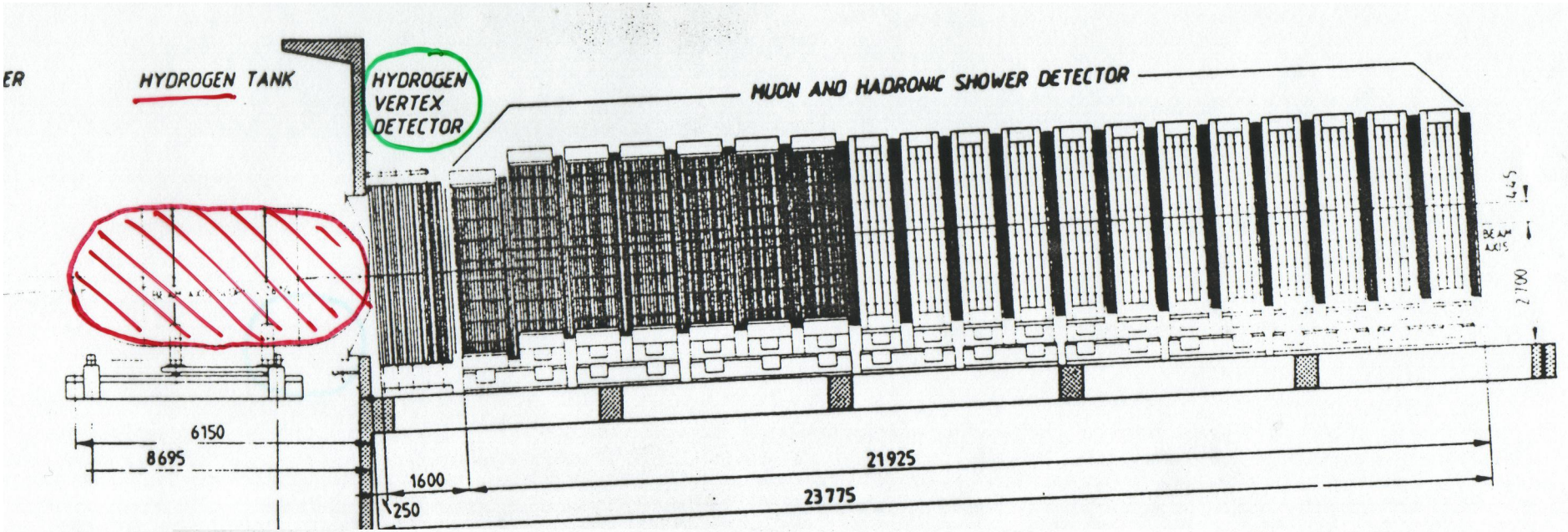
$$F_2^{eD} \approx \frac{5}{18} F_2^{\nu N}$$

- 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 !



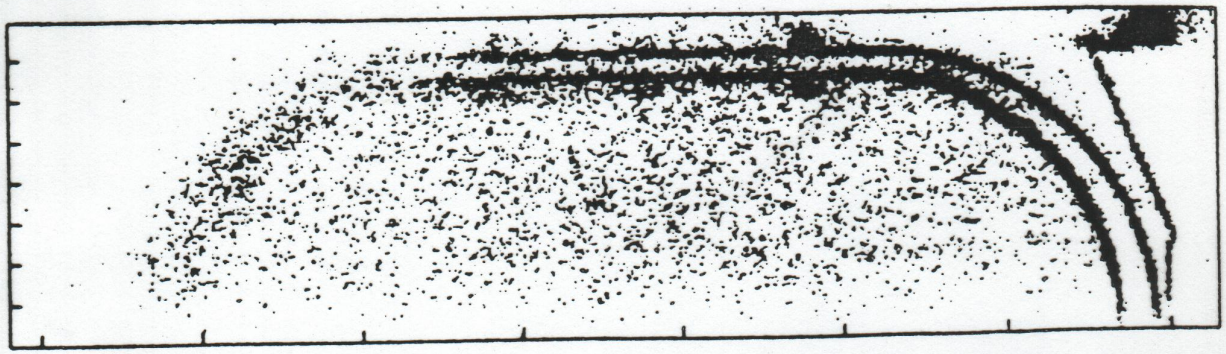
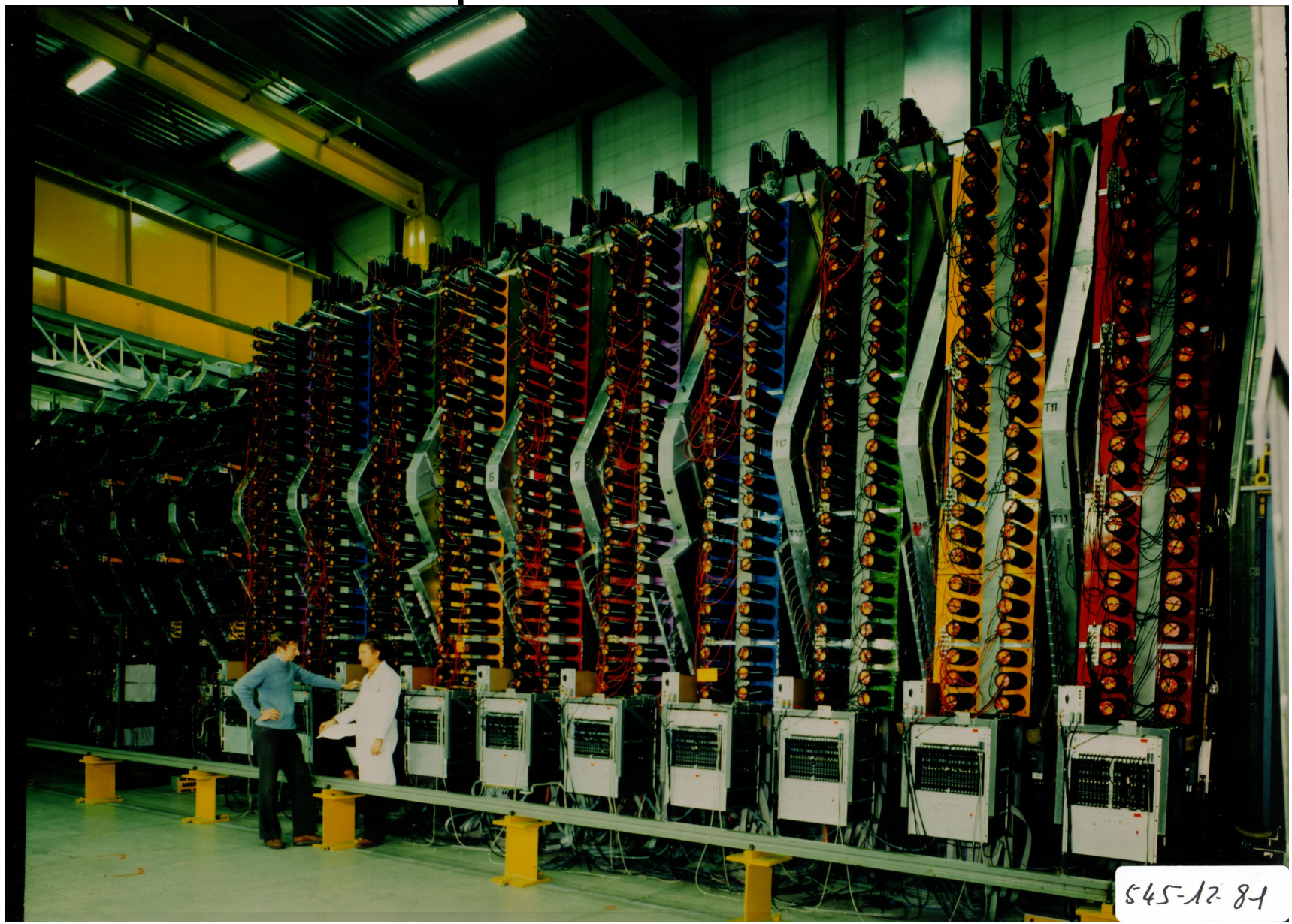


Fig. 5. Neutrinogram of the target. Two-dimensional projection of the vertex distribution of reconstructed events

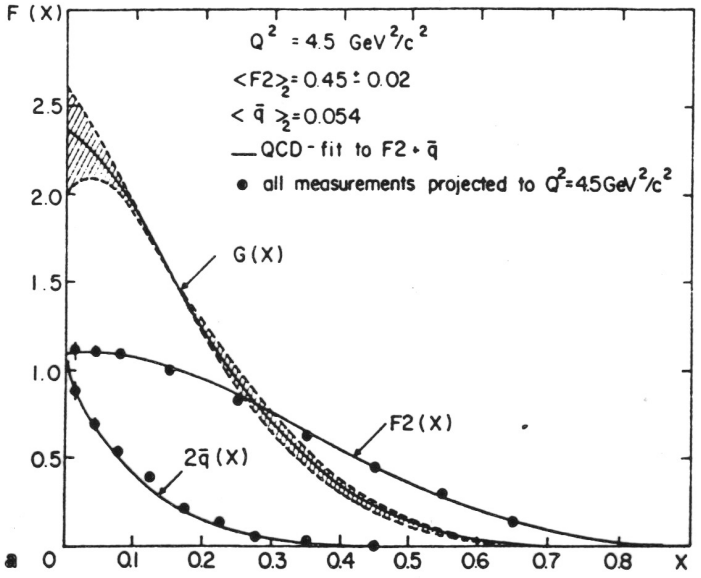
CDHS-w : precision measurements



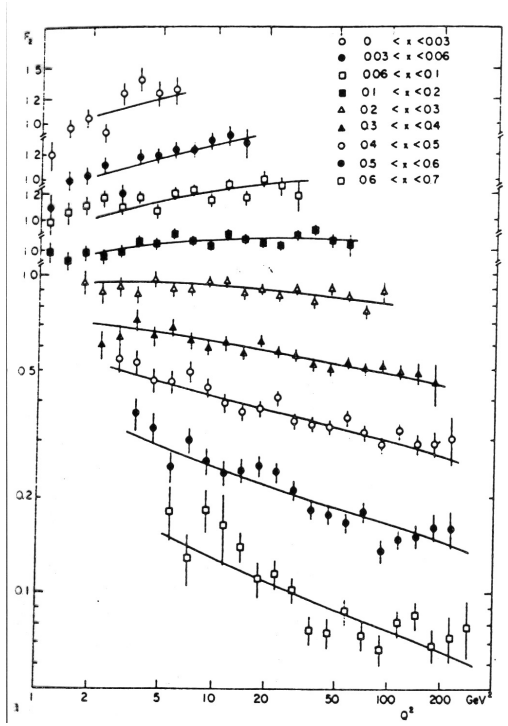
Precision results

- 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

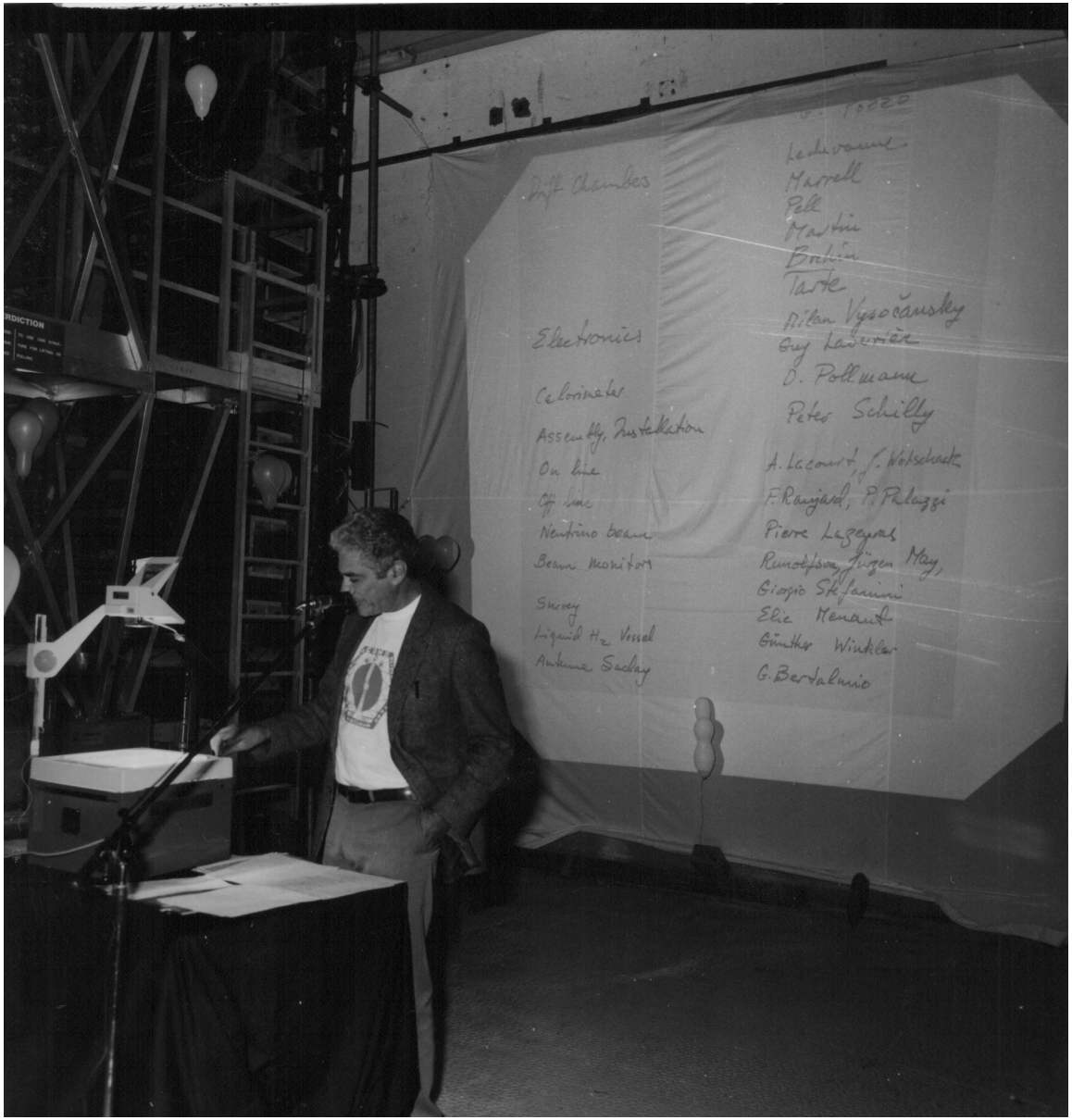
A fan of Mortran (*not* Fortran)

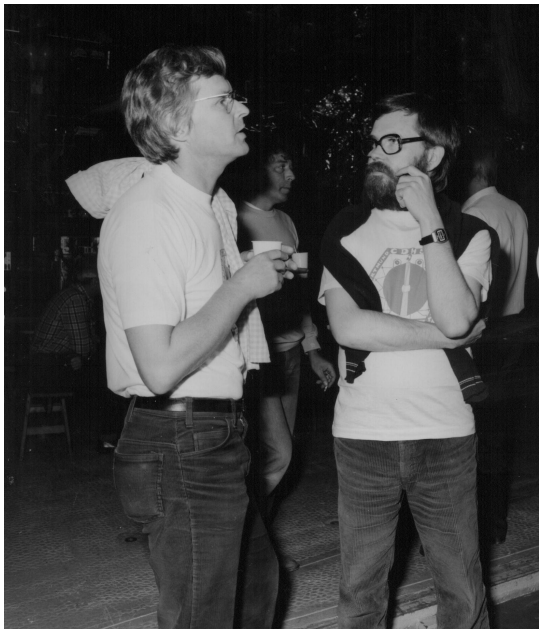
a bit shocked at the start by the lack of respect from the French students….

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 !