INTER-UNIVERSITY INSTITUTE
FOR
HIGH ENERGIES
ULB-VUB, BRUSSELS

ANNUAL REPORT 1990

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J. LEMONNE and J. SACTON
January 1991.

I. INTRODUCTION.

The physicists, engineers and computer scientists whose names are listed below have contributed to the different activities of the Institute during the year 1990.

U.L.B.

F. Alexandre (chercheur)
M. Barth (maître de recherche FNRS)
D. Bertrand (chercheur qualifié FNRS)
G. Bertrand-Coremans (chef de travaux associé)
A. Cohen (assistante)
M. Gruwé (boursier IRSIA since October 1990)
C. Hanon (assistant de recherche)
P. Huet (aspirant FNRS)
D. Maes (assistant de recherche since 1 October 1990)
P. Malisse (chercheur)
P. Marage (1er assistant ULB)
T. Massart (assistant de recherche)
P. Paridans (chercheur sous contract)
O. Paridaens (chercheur)
J. Sacton (professeur associé until 1st Oct. 1990 and then professeur ordinaire)
E. Tsigres (chercheur sous contract since 15 October 1990)
B. Sales (assistant until September and then chercheur sous contract)
F. Stichelbaut (collaborateur scientifique FNRS)
P. Van Binst (chargé de cours associé)
C. Vander Velde (chef de travaux associé)
P. Vilain (chercheur qualifié FNRS - CERN Research Associate April-September 1990)
J. Wickens (chercheur IISN)
G. Wilquet (chercheur qualifié FNRS)
S. Willocq (doctorant) has spent the whole year at Tufts University - Boston in support of the E632 experiment.

V.U.B.

P. Bruyndonckx (vorser IWONL)
F. Cao (VUBAROS fellow)
C. De Clercq (logistiek medewerker IIKW)
E. Evrard (vorser IIKW)
D. Geiregat (vorser IIKW - military service since August 1990)

B. Guerard (EC grant)
T. Heiremans (vorser IIKW since November 1990)
D. Johnson (professor Vesalius College)
P. Kluit (vorser IIKW)
J. Lemonne (gewoon hoogleraar)
N. Meulemans (vorser op extern kontrakt)
C. Mommaert (vorser IIKW since September 1990)
J. Moreels (assistent VUB)
R. Roosen (bevoegdverklaard navorser NFWO)
S. Tavernier (onderzoeksleider NFWO)
R. Vandenbroucke-Tassin (eerst aanwezend informaticus IIKW)
M. Vanderkelen (vorser IIKW from February until September 1990)
W. Van Doninck (bevoegdverklaard navorser NFWO)
S. Zhang (VUBAROS fellow since Septembre 1989).
F. Verbeure, J. Buytaert, H. De Boeck, M. Charlet, E. De Wolf, and L. Verluyten from the Universitaire Instelling Antwerpen have been working in close collaboration with the Institute.

II. RESEARCH ACTIVITIES.

II.1. Neutrino physics.

II.1.1. Neutrino and antineutrino interactions in BEBC filled with an heavy H2/Ne mixture.

(P. Marage, L. Verluyten and J. Sacton; WA59 Collaboration : Athens, Bari, Birmingham, Brussels, CERN, Cracow, Ecole Polytechnique - Palaiseau, I.C. London, U.C. London, Munich, Oxford, Rutherford, Saclay, Stockholm).

The results summarized hereafter were obtained from the analysis of a sample of 16500 $\bar{\nu}_\mu$ and 10000 ν_μ charged current interactions.

· The coherent production of 3π systems by charged current antineutrino interactions on neon nuclei has been studied. The coherent signal is attributed mainly to $(\rho\pi)$ production, where the $(\rho\pi)$ system is either non resonant or results from the decay of a_1 mesons. The kinematical variables and the total cross section were compared with the predictions of the meson dominance model. This analysis completes the study of the channels contributing to the signal of coherent scattering (π^- and ρ^- by antineutrinos, π^+ by neutrinos).

· The W- and Q^2-dependences of the transverse momentum of the forward going hadrons in deep inelastic charged current (anti-)neutrino

interactions were studied. The data are compared to a model which includes first order QCD, intrinsic quark momentum in the nucleon and Fermi motion, as well as a simple model for hadronization. A fit of the model to the data yields a value of the strong coupling constant

$$\alpha_s = 0.15 \pm 0.03 \text{ (stat)} \pm 0.03 \text{ (syst)}$$

at an average Q^2 of 15.4 ± 0.4 GeV^2. Fitting Λ_{MS} for three flavours yields

$$\Lambda_{MS} = (220 \pm 100 \text{ (stat)} \; {}^{+\,210}_{-\,190} \text{ (syst)}) \text{ MeV}$$

Combining data from the WA59 collaboration with those, obtained under similar conditions at Fermilab by the E180 collaboration, evidence had been found last year for the production of vector charmed D_s^{*-} mesons in a sample of 22700 $\bar{\nu}_\mu$ interactions in the energy range 10-200 GeV. From an analysis of D_s^{*-} mesons identified through their radiative decays $D_s^{*-} \rightarrow D_s^- + \gamma$, with D_s^- subsequently decaying into $\phi\pi^-$, $\phi\pi^-\pi^\circ$ and $K^{+\circ}K^-$, the D_s^* -production rate times the $D_s^- \rightarrow \phi\,\pi^-$ branching fraction is estimated to be (2.3 ± 0.7) 10^{-3} per charged current event with hadronic mass W above 3 GeV.

In the framework of intermittency studies, results were obtained on the reduced scaled factorial moments of order 2, 3 and 4 in $\nu_\mu Ne$ and $\nu_\mu D_2$ charged current interactions. Comparisons of the data with a Monte Carlo simulation were presented (see fig. 1). The simulation, based on the Lund programs LEPTO 4.3 and JETSET 6.3, includes nuclear reinteractions and smearing due to measurement errors. Nuclear effects are shown to bias the estimate of the intermittency strengths.

II.1.2. Neutrino and antineutrino interactions in the 15' bubble chamber filled with an heavy H2/Ne mixture and exposed to the Tevatron high energy neutrino beam.

(M. Barth, E. De Wolf, P. Marage, J. Moreels, J. Sacton, L. Verluyten; E632 Collaboration : Berkeley, Birmingham, Brussels, CERN, Chandigarh, Fermilab, Hawaii, IHEP-Protvino, Illinois Institute of Technology, ITEP-Moscow, I.C. London, Jammu, Moscow State University, Munich, Oxford, Rutgers, Rutherford, Saclay, Stevens Institute of Technology, Tufts).

Experiment E632 took data both in the 1985 and in the 1987-1988 running periods for Fixed Target experiments at the Quadrupole Triplet neutrino beamline in Fermilab. About 150000 pictures were collected during the 1985 run, corresponding to roughly 15000 ν_μ and $\bar{\nu}_\mu$ charged current (CC) events in a 75/25 mole % Ne/H_2 mixture. In the 1987-988 run, the chamber was filled with a lighter mixture of 63/37 mole % Ne/H_2. Some 300000 conventional pictures were taken, corresponding to about 20000 ν_μ and $\bar{\nu}_\mu$ CC events, together with 220000 holograms. The average neutrino and antineutrino event energies are 150 GeV and 110 GeV respectively.

The main objects of study in 1990 were the production of protons in CC ν_μ-Ne interactions, neutral strange particle (kaons and lambdas) production, coherent production of single mesons in ν_μ and $\bar{\nu}_\mu$ CC interactions and the determination of the neutral to charged current event ratio.

If the final state particles produced in the CC ν_μ - nucleon interaction would not undergo any reinteractions within the neon nucleus, the average charge in the final state is expected to be 0.34. However, secondary interactions inside the nucleus would result in a larger average final state charge. In fact, a net charge excess of 0.30 ± 0.04 was observed in CC ν_μ - Ne interactions. This excess was found to be consistent with being made of protons with momenta between 0.35 and 1.2 GeV/c, arising from reinteractions within the neon nucleus. The amount of such protons per event is in excellent agreement with the theoretical model of Andersson, Otterlund and Stenlund. The average number of secondary collisions per event was estimated to be 0.60 ± 0.08.

Neutral strange particle production was studied using a sample of 5257 events. Production rates in ν_μ CC interactions with E_ν larger than 5 GeV are determined to be 0.337 ± 0.027 (stat) ± 0.007

(syst) for neutral kaons and 0.124 ± 0.012 (stat) ± 0.005 (syst) for lambdas. The cross sections for neutral strange particle production are observed to increase with event energy with a slower rise for lambdas than for neutral kaons.

Coherent single meson production was studied in a sample of ~ 25600 CC events (21800 ν and 3800 $\bar{\nu}$) with a visible event energy larger than 40 GeV. Preliminary studies indicate a clear signal in the single pion channel. Evidence exists for a signal in the ρ channel and even hints are present for coherent a_1 production. The kinematical characteristics of the coherent signal in the single π channel are in good agreement with a model based on PCAC and meson dominance.

The ratio of neutral current to charged current interactions is measured to be 0.288 ± 0.032. This ratio is for events with visible hadron momentum above 10 GeV/c and corresponds to a combined minimum bias sample of 1187 neutrino plus 172 antineutrino CC events. The K° and Λ production rates and distributions of the fractional hadron energy variable z in NC events are consistent with those in CC events. These results agree with those from previous experiments at lower energies.

II.1.3. Neutrino and antineutrino scattering on electrons.

(D. Geiregat, P. Vilain, G. Wilquet; CHARM II or WA79 Collaboration : Brussels, CERN, Hamburg, Louvain-La-Neuve, ITEP-Moscow, Munich, Naples, Rome).

During 1990 the detector has been exposed for about 100 days to the CERN SPS wide band neutrino beam and the data, corresponding to 6 10^{18} protons on target, are almost completely analysed. The data from the running periods 87 to 89 corresponding to 15 10^{18} p.o.t., have been reanalysed to incorporate some important improvements :

- a better calibration of the detector, performed at the end of 1989 with pion and electron beams of many different energies;
- a more precise determination of the electron shower angle and energy using refined algorithms derived from the new calibration analysis;

- much larger samples of Monte Carlo simulated events of various kinds, allowing the effects of the background processes to be evaluated with higher precision.

From a signal of 1481 ± 56 ν_μ e^- and 1621 ± 62 ν_μ e^- events, the electro-weak mixing parameter (without radiative corrections) was determined.

$$\sin^2 \Theta° = 0.240 \pm 0.009 \text{ (stat)} \pm 0.007 \text{ (syst)}$$

In a model independent analysis, we derived the vector coupling constant g_v of the Z boson to the electron

$$g_v = -1/2 + 2 \sin^2 \Theta° = - 0.020 \pm 0.024$$

Although the neutrino electron elastic scattering is the major subject of the experiment, other interesting channels were successfully studied :

. For the first time, a significant signal (55 ± 16 events) has been observed for the reaction

$$\nu_\mu + A \rightarrow \nu_\mu + \mu^- + \mu^+ + A$$

corresponding to the muon pair production in the Coulomb field of the nucleus A. The measured cross-section

$$\sigma = (3.0 \pm 0.9 \pm 0.5) \quad 10^{-41} \text{ cm}^2/\text{nucleus}$$

is in agreement with the Standard Model prediction but still not accurate enough to prove the existence of interference between W and Z exchange.

· The inverse muon decay reaction

$$\nu_\mu + e^- \rightarrow \mu^- + \nu_e$$

was studied on the basis of a clear signal of 4808 ± 192 (stat) ± 202 (syst) events. The ratio of the measured cross section to the Standard Model prediction is found to be

$$R = 1.054 \pm 0.079$$

This result can be used to impose a limit on the scalar coupling of the electron to its neutrino

$$|g^s|^2 < 0.405$$

II.1.4. Preparation of future projects on neutrino physics : search for ν_μ-ν_τ oscillations (proposal)

(**M. Gruwé, C. Mommaert, P. Vilain, G. Wilquet**; Ankara, Bari, Brussels, CERN, Ferrara, Japan (8 groups), Korea (2 groups), Louvain-la-Neuve, Moscow, Naples, Rome, Salerno, Zeuthen)

Since about one year intensive preparation work is going on to set up a proposal for a new experiment aiming at the discovery of ν_τ interactions. On the hardware side, the accent was put on research and development in the scintillating fibres technology. On the software side, simulation programs were developed to optimize the set-up and estimate the signal and backgrounds levels.

The experiment, if accepted, would run in 93 and 94 in the SPS ν wide band beam. It is designed to observe (or to put limits on) the charged current interactions

$$\nu_\tau + N \rightarrow \tau^- + X$$

through the detection of the decay topology of the τ^- either into $\mu^- \nu_\tau \bar{\nu}_\mu$ (branching ratio 18%) or into $\pi^- \nu_\tau$ + neutrals (branching ratio 50 %). Since, at SPS energies, the prompt ν_τ flux is negligibly small, this observation would be a proof of the existence of ν_μ-ν_τ oscillations, hence of a non-zero mass difference Δm between the two neutrino species.

The sensitivity of the experiment is usually expressed as an upper limit on the ν_μ-ν_τ mixing parameter $\sin^2 2\Theta$ as a function of the ν mass difference squared : Δm^2. For "large" Δm^2, which, for the conditions of this experiment, means $\Delta m^2 > 80$ eV^2, the mixing parameter is given by :

$$\sin^2 2\Theta = \frac{2 . N_\tau}{\varepsilon . N_\tau^{max}}$$

where :

N_τ is the observed number of ν_τ charged current interactions (after background substraction)

ε is the detection efficiency of this process

N_τ^{max} is the number of ν_τ charged current interactions which would occur in the target, if all the incoming ν_μ would have transformed into ν_τ.

The existing limit on $\sin^2 2\Theta$ is $4\ 10^{-3}$ (N. Ushida et al.; Phys. Rev. Letters 57 (1986)2897). The proposed experiment aims to explore the domain of small mixing parameter down to $\sin^2 2\Theta \sim 3\ 10^{-4}$.

Three conditions have to be met to achieve this goal :

- A high detection efficiency of the τ^-decay, which requires a vertex detector of very good spatial resolution (< 10 μm).
- A large number of interactions, which implies a massive target exposed to an intense neutrino beam.
- A low background level, of the order of 10^{-6} times the number of recorded ν interactions.

A schematic view of the proposed set-up is shown in figure 2. Its main components are :

- VETO, T1, T2 : scintillator hodoscopes for first level trigger
- The target region : A total of 800 kg nuclear emulsion, divided in 4 stacks, will form the active target. Each stack, of 1.45 x 1.45 m^2 surface area and 2.75 cm thickness, is segmented along the beam axis in 25 emulsion layers. The localisation of an event in the emulsion is performed by following backward the tracks reconstructed in scintillating fibres planes placed behind each stack (not shown on fig.2). As an R and D project, a prototype of 100μm scintillating fibres target will be exposed simultaneously.
- The hexagonal magnet : This aircore magnet will allow charge and momentum determination of charged particles up to 10 GeV.
- The calorimeter is of the "spaghetti" type, i.e. a combination of Pb and scintillating plastic fibres of 1 mm diameter. Thanks to its compensating property, this device was shown to have good energy resolution for hadronic as well as for electromagnetic showers.
- The muon spectrometer is, with some modifications, the one presently used in the CHARM-II experiment.

A Monte Carlo generated event is shown in fig. 3a. Fig.3b shows, for another event, an expanded view of the vertex region. The τ^- decay point is indicated by an arrow.

The detector will be exposed for about 400 days to the Neutrino Wide band Beam of the CERN SPS. A total of $2\ 10^{19}$ protons on target is requested and will lead to about $5\ 10^6$ ν_μ charged current interactions in the target.

Detailed Monte Carlo studies have shown that the overall detection efficiency of τ^- decays (including branching ratios, scanning and reconstruction losses, kinematical cuts, ...) will be $(4.5 \pm 0.5)\ 10^{-2}$. Careful consideration of possible background sources, of which charm production is the most important, lead to an estimate of 1 background event. In case 1 event is observed, it would correspond to a 90% confidence limit on the number of ν_τ interactions

$$N_\tau < 3.5$$

and to a sensitivity, at large $\Delta\ m^2$,

$$\sin^2 2\theta < \frac{2 \times 3.5}{0.045\ .\ 50\ 10^5} = 3.10^{-4}$$

The intention of the Brussels group is to be involved, in addition to analysis work, in the construction of scintillating fibres trackers, including mechanical mounting, optoelectronics and CCD read-out.

II.2. Hadron physics.

The research programme on hadron physics has come to an end in 1989. Various papers presenting the last results of this programme which has been described in detail in previous reports appear in the list of publications (see section IX).

II.3. Study of e+e- annihilations at LEP.

(D. Bertrand, C. Bricman, J. Buytaert, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens;
DELPHI Collaboration : Ames-Iowa, Athens, Athens-NTU, Belgium, Bergen, CERN, Collège de France, Copenhagen, Dubna, Ecole Polytechnique - Palaiseau, Helsinki, INFN-Bologna, INFN-Genova, INFN-Milano, INFN-Padua, INFN-Roma, INFN-Trieste, INFN-Torino, Karlsruhe, Krakow, LAL-Orsay, LIP-Lisboa, Liverpool, Lund, NIKHEF-Amsterdam, Oslo, Oxford, Paris-LPNHE, Rutherford, Saclay, Santander, Serpukhov, Stockholm, Strasbourg, Uppsala, Valencia, Vienna, Warsaw, Wuppertal).

The collaboration between Belgium (IIHE/ULB-VUB, Mons UIA) and the laboratories of Oxford and Rutherford is responsible for the muon part of the DELPHI detector.

The Belgian groups have constructed the forward muon identifier consisting of 16 detector modules called "quadrants". Each of them covers a sensitive area of about 4.4 x 4.4 m^2 and is made of two orthogonally crossed layers of 22 drift chambers. Four such quadrants assembled into a square of approximately 9 x 9 m^2 provide one detection plane of the forward muon identifier. Two such detection planes are installed in both end caps of DELPHI, the outer plane being situated at the outer edge of the forward part of the magnet yoke, just behind the forward scintillator layer which was built by Serpukhov (USSR) with the help of the Belgian groups. The inner detection plane is embedded in the iron yoke itself, separated from the outer plane by 30 cm of which 20 cm are steel.

During the first 3 months of 1990 the LEP collider was shut down for repairs and upgrades. This time was used by DELPHI to improve the data acquisition and trigger systems, to repair parts of the detector and to install some of the missing elements.

For the Forward Muon Chambers the trigger electronics had to be completed and parts of the on-line software still needed to be installed. In March 1990 DELPHI tested the detector with cosmic rays. By the end of March the LEP collider provided e^+e^- collisions of that year. The run lasted for 5 months. During this data taking period DELPHI recorded about 120000 hadronic Z° decays, about 18000 leptonics and about 147000 Bhabha scattering interactions for luminosity measurements. These data are spread over 7 centre-of-mass energies around the mass of the Z° boson. The data taking rate varied from 2 to 3 triggers per second. Only the "fast" first and second level hardware triggers were active. Besides, some of the trigger electronics was not final and did not perform according to specifications. As a consequence about 5 million triggers had to be recorded on tape to obtain the above event sample. After some problems with the readout electronics the Forward Muon detector fully participated to the data taking. Since July 1990 it also participated to the forward trigger.

The beam background muons which cross DELPHI parallel to the beam direction were used to determine the Forward Muon chamber efficiency, to check the calibration constants (drift velocity and delay line

velocity) and the chamber resolution. Some problems were found for the data taken in April, representing 15% of the 1990 sample. For the remaining data sample the average quadrant layer efficiency was about 86%, to be compared to the geometrical acceptance of 92%. The chamber resolution was found to be 3.5mm, averaged over drift and delay line. This should be compared to the values of 1mm for the drift and 2.5mm for the delay line which were obtained in prototypes. For the daily supervision of the Forward Muon chambers shifts were shared with the Oxford group, responsible for the Barrel Muon chambers. It was essential to have two Belgian physicists based at CERN, to assure the technical support and to take a share in the central DELPHI shifts. In addition, on average, 2 physicists visited CERN for short periods to support the muon shifts. One engineer took an essential part in the optimization of the overall trigger system of DELPHI a task which required its full time presence at CERN throughout the year. Besides, one physicist was responsible for the DELPHI offline reconstruction software, and therefore visited CERN for about 1/3 of the year.

The DELPHI experiment has produced a vast amount of results which agree well with the predictions of the Standard Model and with results from the other LEP experiments.

A fit applied simultaneously to hadronic and to the three leptonic cross-sections determines the following parameter values :

$$M_z = (91.188 \pm .013 \text{ (stat)} \pm .030 \text{ (syst)}) \text{ GeV/c}^2$$

$$\Gamma_z = (2.476 \pm .026 \pm .010) \text{ GeV}$$

$$\Gamma_l = (83.7 \pm 1.0 \pm 1.1) \text{ MeV with } l = e, \mu \text{ or } \tau$$

$$\Gamma_h = (1.756 \pm .023 \pm .020) \text{ GeV}$$

$$\Gamma_{\text{invisible}} = (469 \pm 19 \pm 22) \text{ MeV}$$

$$R = \Gamma_h/\Gamma_l = 21.00 \pm .38 \pm .29$$

From those numbers one gets estimates of the number of neutrino species N_ν and of the Weinberg mixing angle $\sin^2\Theta_W$, namely :

$$N_\nu = 2.82 \pm .11 \pm .13$$

$$\sin^2\Theta_W = 0.2309 \pm .0048$$

The corresponding vector and axial vector coupling constants to charged leptons are :

$$v_l = -\ 0.055 = {}^{+\ .025}_{-\ .017} \pm .008$$

$$a_l = -.501 \pm .004 \pm .005$$

The above results are based on a subsample of ~ 68000 hadronic and ~ 4000 leptonic events collected at seven centre-of-mass energies by July 1990 in the region of polar angles $43 \leq \Theta \leq 137$.

A recent measurement of the cross section and forward backward asymmetry ($22 \leq \Theta \leq 158°$) for the reaction $e^+e^- \rightarrow \mu^+\mu^-$ based on all the available two muon data of DELPHI (~ 3900 events) led to the results displayed in figure 4.

The forward-backward asymmetry at the resonance peak energy was found to be $A_{FB} = .028 \pm .020 \pm .005$. From a combined fit to the cross section and forward-backward asymmetry data the square root of products of the electron and muon vector and axial vector coupling constants are determined to be (assuming the negative sign):

$$v_l = -\ (v_e v_\mu)^{1/2} \quad -.050 \quad {}^{+\ .020}_{-\ .014} \pm .004$$

$$a_l = -(a_e a_\mu)^{1/2} = -.504 \pm .003 \pm .003$$

again in excellent agreement with the expectations of the Standard Model ($v_l = -1/2 + 2\ \sin^2\Theta_W$ and $a_l = -1/2$).

Separate measurements of the partial widths of Z°'s into $c\bar{c}$ and $b\bar{b}$ heavy quark pair yielded the results :

$$\Gamma_{c\bar{c}} = (.282 \pm .053 \pm .088)\ \text{GeV}$$

$$\Gamma_{b\bar{b}} = (.209 \pm .030 \pm .031)\ \text{GeV}$$

Global studies of the hadronic final states concerned :

- charged multiplicity and rapidity distributions
- an analysis of intermittency in agreement with the parton-shower hadronization model
- jet production rates (leading to $\alpha_S(M_z^2) = .114 \pm .003$ (stat) $\pm .004$ (syst) $\pm .012$ (theor))
- energy-energy correlations (yielding $\alpha_S(M_z^2) = .106 \pm .003 \pm .003 \,^{+\,.003}_{-\,.000}$).
- and an experimental study of the triple gluon vertex in good agreement with perturbative QCD predictions.

Finally, searches for : non standard Z° decays in two particle final states ($\pi^\circ\,\gamma$ and $\eta\gamma$), t and b' quarks, scalar quarks, sleptons and gauginos as well as various searches for Higgs particles remained negative.

In the latter case, the lower limit on the mass of the neutral Higgs of the Minimal Standard Model has been set to be $m_H > 34$ GeV/c^2 at the 95% confidence limit.

II.4. Study of e-p collisions at HERA.

(M. Barth, G. Bertrand-Coremans, E. De Wolf, E. Evrard, D. Johnson, P. Huet, P. Marage, J. Moreels, R. Roosen, J. Sacton, M. VanderKelen; H1 Collaboration : RWTH-Aachen (I and III), Antwerp and Brussels, Cracow, Davis, DESY, Dormund, Ecole Polytechnique - Palaiseau, Glasgow, Hamburg (I and II), Kosice, Lancaster, Liverpool, Manchester, Moscow (ITEP & Lebedew), München, Orsay, Paris (P. & M. Curie), Prague, Rome, Rutherford, Saclay, Wuppertal, Zeuthen and Zurich.

Three Belgian groups from the UIA, ULB and VUB have joined - as a single group - the H1 Collaboration in the construction of a complex 4π-multipurpose detector which is now being installed at the HERA collider (30 GeV electrons colliding with 820 GeV protons) in DESY. Their contributions to the detector consist in

a) the construction of a double layer of 2.2m long and 1 m in diameter cylindrical MWPC's - called COP (Central Outer Proportional

chamber) - to be located inside the system of central tracking chambers as part of the first level trigger system of the H1 detector.

b) the design and construction of the front-end data acquisition system of the entire set of proportional chambers of the H1 detector.

Prototyping work and construction procedure of the COP chambers have been presented in various status reports. The final set of chambers was completed in summer 90, transported to DESY and successfully inserted into the central tracking system at the end of the year (see fig. 5). Various tests of the COP filled with a mix of 50% Ar, 50% C_2H_4 and 0.2% freon have demonstrated their good functioning and reliability; in particular a time resolution of ~ 60 ns has been measured well below the 96 ns bunch crossing time (see fig. 6). The assembling of the H1 detector is proceeding well in the North Hall of HERA and should be achieved by Easter 91.

The front end electronics of the 4 MWP chambers of H1 (in total 4500 channels) are based on a simple backplane split into 4 subbranches for which there are 280 receiver cards distributed between 16 crates. Each receiver card consists of a discriminator which feeds a pipeline, keeping synchronisation with the collider 10 MHz clock. Controller Cards (CC) interface these crates with the central DAQ system via VME Branch Driver Cards (BDCs), each equipped with a DMA controller and on-board FIFO. The whole of this read-out system is under software control and run on a VME based 68020 CPU connected with the central data acquisition via an optical fibre crate interconnect. All this equipment - for a large part designed and built at the IIHE - is now available (see e.g. fig. 7), has been tested, and is being installed at DESY. It is presently used to read-out the proportional chambers and to control a part of the H1 fast trigger.

On the software side, in addition to the development of tools needed to test the hardware and its reliability, a major effort has been devoted to design and install the data acquisition programmes.

The MWPC DAS software is based on three sets of programs

1. A read-out program controls the whole MWPC electronics, loads all the constants, tests the reliability of the hardware, interacts with the central trigger system (and the central DAQ system), reads all the data at the appropriate time, reformats the data into correctly-formatted off-line databanks and send these banks over the optical fibre to the event builder. It is written in a 68020-assembler code and runs on a VME FIC processor. Integration tests with the Central DAQ and Central Trigger systems took place, and the program was tested and debugged with the final and complete front-end electronics.
2. A control program, written in MPW Pascal, runs on the Master Macintosh computer and is used to control the read-out program. It allows parameters and constants to be set and down loaded by the users of the MWPC's. It allows to steer the read-out program if the data-acquisition runs in local mode.
3. MWPC Monitor programs such as an HBOOK/HPLOT implementation for the Mac, dedicated interface-routines for communication with the read-out program and other utilities.

III. TEACHING ACTIVITIES AND SEMINARS.

III.1. Teaching activities.

. **J. Sacton** :
- "Physique des Particules Elémentaires" (30 h + 45 h of practical work - 1ère licence en sciences physiques - ULB).

. **J. Lemonne** :
- "Elementaire Deeltjes" (60 h + 60 h of practical work - 1ste and 2de licentie natuurkunde - VUB)
- "Algemene Natuurkunde" (60 h + 60 h of practical work - 2de kandidatuur Natuurkunde, Scheikunde, Geologie - VUB).

. **M. Barth, D. Bertrand, P. Huet, P. Marage, F. Stichelbaut, P. Vilain and G. Wilquet** have contributed to the practical work for students attending the lectures of J. Sacton on "Physique des

Particules Elémentaires" and organized specific practical work for students of the 3rd year in physics at the ULB.

. **D. Bertrand** :
- "Computer Principles" (26 h + 13 h of practical work - 1st year University Studies in Sciences - ULB).
- "Graphical Event Analysis (CERN School of Computing - Nieuwpoort)

. **G. Bertrand-Coremans** :
- "Questions Approfondies de Physique des Particules" (part time 30 h + 45 h of practical work - 2ème licence en sciences physiques - ULB).
- Participation to the practical work of the "1ère candidature polyvalente en médecine et pharmacie" - 120 h

. **E. Evrard, S. Tavernier and W. Van Doninck** have contributed to the practical work for students attending the lectures of J. Lemonne on "Elementaire Deeltjes".

. **D. Johnson** :
- "Introduction to Physics II - Physics 103" (45 h - Vesalius College VUB)
- "Introduction to Physics I - Physics 101" (45 h - Vesalius College VUB)
- "Solid State Physics - Physics 104" (45 h - Vesalius College - VUB).

All these lectures are accompanied by student consultation and regular interval student exercises.
D. Johnson also assisted in the teaching and laboratory planning for the course "Physics Laboratory I - Physics 102" (Vesalius College - VUB).

. **P. Kluit** assisted D. Johnson with the practical work for
- "Physics Laboratory I - Physics 102" (45 h - Vesalius College)

. **P. Marage** :
- "Introduction à la Physique Générale : électricité" (20 h "enseignement de propédeutique" organized by the EPFC (ULB - Chambre de Commerce))
- "Physique" (120 h of practical work - 1ère candidature Ecole de Commerce Solvay).

. **J. Moreels** :
- "Algemene Natuurkunde" (60 h practical work - 2de kandidatuur Natuurkunde - Prof. J. Lemonne - VUB)
- Coordinator of the laboratory work related to the course "Algemene Natuurkunde" (240 h practical work - 1ste kandidatuur Geneeskunde, Farmacie, Tandheelkunde, polyvalente Wetenschappen, Diergeneeskunde, Wiskunde, Natuurkunde - Prof. H. Eisendrath - VUB).

. **S. Tavernier** :
- "Detectie van Ioniserende Stralingen" (15 h + 15 h of practical work - 2de licentie Natuurkunde and bijzondere licentie medische fysica - VUB).

. **P. Van Binst** :
- "Introduction à l'Informatique" (30 h + 30 h of practical work - Section Informatique et Sciences Humaines; Faculté des Sciences Sociales, Politiques et Economiques - ULB)
- "Informatique (pratique)" (60 h + 30 h of practical work - Section Informatique et Sciences Humaines; Faculté des Sciences Sociales, Politiques et Economiques - ULB)
- "Télématique" (30 h - Section Informatique et Sciences Humaines; Faculté des Sciences Sociales, Politiques et Economiques - ULB and licence spéciale en Sciences de l'Information et de la Documentation, Faculté de Philosophie et Lettres - ULB).
- "Télématique Grand public" (partime 10 h - Licence Spéciale en Télématique et Organisation - Faculté des Sciences - ULB).
- "Analyse critique des systèmes télématiques" (partim 12 h - Licence Spéciale en Télématique et Organisation - Faculté des Sciences - ULB).

. **C. Vander Velde** :
- "Physics" (34 h + 23 h of practical work - 1st year University Studies in Sciences - ULB)
- "Introduction à la Physique Générale : mécanique" (22 h - "enseignement de propédeutique" organized jointly by ULB and Chambre de Commerce)
- "Travaux pratiques de laboratoire à option" (30 h - 1ère Licence en Sciences Physiques - ULB)
- "Physique" (60 h of practical work - 1ère candidature Ecole de Commerce Solvay).

. **W. Van Doninck** : "Statistische analyse van experimentele gegevens" (15h + 15h exercises)

. **P. Vilain** :
- "Questions Approfondies de Physique des Particules" (part time 30 h + 45 h of practical work - 2ème licence en sciences Physiques - ULB)

. **G. WILQUET** has accompanied students in physics (1ère licencen) from the ULB on a visit to CERN.

. **A. Cohen** (50 % of her time) has contributed to the practical work for the students of the "Section Informatique et Sciences Humaines" (Faculté des Sciences Sociales, Politiques et Economiques - ULB).

. **T. Massart** (30 % of his time) and **B. Sales** (50 % of his time) have contributed to the practical work for the students of the "Section Informatique" (Faculté des Sciences - ULB).

One PhD thesis was completed during this year :
- **A. Cohen** (ULB) : "Contribution à l'étude de la transmission de données par satellite selon les normes internationales - Architecture de réseaux et performances"

The following "Mémoires" have been made at the IIHE/ULB :
- **M. Gruwé** (supervisors J. Sacton and S. Tavernier) : "Etude comparative des rendements lumineux des cristaux scintillants de BaF_2 et de $LaF_3:Nd^{3+}$ en vue de leur utilisation comme détecteur de rayons gamma".

- **G. Wallenborn** (supervisor P. Marage) : "Recherche de la production du meson D^*_s dans les interactions d'antineutrinos"

- **Y. Gancberg** (supervisor P. Van Binst) : "Etude de l'installation d'un réseau local au sein d'une grande entreprise"

- **E. Many** (supervisors : P. Van Binst and B. Salès) : "Intégration de l'architecture TCP/IP dans un environnement OSI en vue de permettre une interconnexion avec d'autres architectures"

- **J.M. Verbergt** (supervisors : P. Van Binst and F. Alexandre) : "Etude et amélioration d'outils de développement de logiciels utilisant des syntaxes abstraites ASN.1"

- **A. Compillo** (supervisors P. Van Binst and A. Cohen) : "Transfert de données à grande vitesse par satellite : une étude par simulation"

- **P. Dehoux** (supervisor P. Van Binst) : "Traitement d'images par processeurs parallèles"

- **Y. Leurquin** (supervisor P. Van Binst) : "Le réseau numérique à intégration de services. Une étude socio-économique de la situation belge"

- **J. Massaut** (supervisor P. Van Binst) : "Système informatisé de mapping pour la chirurgie des troubles du rythme cardiaque"

- **B. Paris** (supervisor P. Van Binst) : "Etude d'implantation d'un réseau local dans une faculté de l'UCL"

- **C. Poulaint** (supervisor P. Van Binst) : "Enjeux et stratégies du videotex. Etude du contexte belge"

- **D. Renard** (supervisor P. Van Binst) : "Inter-opérabilité X.400"

III.2. Seminars

The following seminars were given by members of the IIHE

. **D. Bertrand** :
- "DELGRA interactive Graphics" (Milano - Italy)
- "Computing around a LEP experiment" (Universitech - VUB)

. **E. De Wolf** :
"Multiplicity distributions, correlations and intermittence (CERN, Genève)

. **J. Lemonne** :
- "e^-e^+-annihilaties in geuren en kleuren" (in the lecture series "Navorming leraren" - VUB).
- "Fysica van de Elementaire Deeltjes in België" (Universitech - VUB)
- "Elementary Particle Physics in Belgium" (CERN School of Computing - Nieuwpoort 1990)
- "Report on the Protvino ICFA seminar on Future Perspectives in High Energy Physics" (IIHE - Brussels)

. **P. Marage** :
"Autonomie de la recherche scientifique et ses limites" (séminaire de Sciences politiques et administratives belges, Prof. A. Morelli, 1ère et 2ème lic. en Sciences Politiques, ULB)

. **J. Sacton** : "Le CERN et l'essor de la physique des particules en Europe " (CEPULB- ULB)

. **C. Vander Velde** :
"Le CERN et l'essor de la physique des particules en Europe" (CEPULB-ULB)

. **W. Van Doninck and G. Wilquet** :
"Echos from the ECFA workshop on the Large Hadron Collider (IIHE, Brussels)

. **G. Wilquet** :
"Fibres in HEP" (UCL, Louvain-la-Neuve) - 2 seminars

. **P. Van Binst** :
- "Physique et informatique : même combat. Du rôle de l'informatique dans la vie des physiciens (ULB, Faculté des Sciences).
- "La normalisation, une idée d'avenir (UNISYS, St.Paul-de-Vence)
- "La télématique, facteur déstabilisant ou restructurant des organisations? (Siemens, Genval)
- "L'apparition des normes dans les années 90. L'état de la question, son importance stratégique et comment y adhérer (UNISYS, St.Paul-de-Vence)

- "L'évolution des techniques de télécommunication et leur impact sur la gestion et les stratégies de l'entreprise (ASAB, Liège)
- "The use of UNIX systems in a "Multivendor OSI Shop" (UNISYS, Brussels)

. **O. Paridaens** :
"X.400-88 : evolution ou révolution ? (L.I.T.- ULB)

. **B. Salès** :
"X.25 et lesLANs : une romance inachevée ? (L.I.T. - ULB)

In the framework of the Seminars on Elementary Particles Physics organized at the IIHE by G. Wilquet, the following talks were given :

. **W. Wallraff** (I-Physikalisches Institut, RWTH -Aachen) :
"Physics results from the first 20000 Z°'s observed with the L3 detector"

. **D.R. Ward** (Cavendish Lab, Cambridge) :
"First results from the OPAL experiment at LEP

. **A. Blondel** (LPNHE, Palaiseau) :
"What have we learned from the first LEP running period ?

. **D.R.O. Morrison** (CERN, Genève) :
"N-rays, Cold Fusion and Pathological Science

. **F. Stichelbaut** (ULB) :
"First results of the DELPHI experiment"

. **J. Lemonne** (VUB) :
"Singapore Conference Review Talk on the LEP and SLC results"

. **B.Z. Kopeliovich** (JINR, Dubna) :
"Coulour effects in hadron-hadron and hadron-nucleus interactions at high energy"

. **A. De Roeck** (DESY, Hamburg) :
"HERA Physics in 1991"

IV. COMPUTER MATTERS

Management : P. Van Binst and R. Vandenbroucke
Scientific (HELIOS-B group) : F. Alexandre, A. Cohen, D. Maes, P. Malisse, T. Massart, N. Meulemans, O. Paridaens, P. Paridans, E. Tsigros, B. Salès
Administrative and logistic : J. Castera, G. Depiesse, J. Liesen (part-time), D. Pirnay (part-time), G. Rousseau, W. Van Droogenbroeck)

The following are the notable facts about the evolution of the computing and networking resources of the IIHE during the year

- acquisition of a DECstation 3100, running UNIX, installed on the IIHE Ethernet.
- creation of a disk server subsystem, integrated in the IIHE Local Area VAXcluster, and consisting of the following elements : a VAXstation 3100, 5 disks of 1 Gbyte and an Exabyte tape back-up system
- acquisition of a DEC LNO3R Postscript laser printer (under a HELIOS-B contract with RARE)
- acquisition of a VAXstation 3100, installed on the IIHE Ethernet (under a contract of "Section Informatique et Sciences Humaines" with DEC Belgium)
- acquisition of a DECrouter 2000 X.25 gateway at 64 Kbps, integrated in the IIHE Local Area VAXcluster (under a IIHE contract with DEC Europe)
- acquisition of an OST ECOM 25 X.25 switch at 64 Kbps, linking a number of IIHE and HELIOS-B computers with the RTT DCS network (under a HELIOS-B contract with COMTECH)
- possibility to use the RARE/COSINE IXI (International X.25 Interconnect) network through the RTT DCS network in order essentially to access the CERN computers and networks at a much reduced cost (under a special agreement with the Belgian Ministry of Scientific Policy, RARE/COSINE and the RTT)

The activities of the HELIOS-B group are reported elsewhere.

V. TECHNOLOGICAL R&D

V.1. Technology transfer from basic research to applications

(P. Bruyndonckx, B. Guerard, S. Tavernier and S. Zhang)

The photosensitive wire chamber technology was developed over the last decade in a number of High Energy Physics research institutes. It allowes to detect and localise very weak light signals over large areas. It is now used in a number of instruments like the DELPHI Ring Image Cherenkov detector. The aim of the present project is to use this technology to build a Positron Emission Tomograph camera with improved performances compared to present commercial systems.

The project is a collaboration between Brussels, Brunel University, CERN, Ecole Polytechnique-Palaiseau and LAL/Orsay. It is supported by the EC under the program SCIENCE. In Belgium it is supported by the Nationale Loterij and the IIKW.

Positron Emission Tomography (PET) is a non-invasive, atraumatic method which allows the in vivo determination of the three-dimensional density distribution of a radioactively labeled substance. It is an important medical research tool.

In a PET study the patient is administered a drug which is labeled with a positron emitting isotope. The positron annihilates with an electron into two back-to-back gamma rays of 511keV which can be detected. From the observation of a sufficiently large sample of such annihilations it is possible to reconstruct the three-dimensional density distribution of a radioactively labeled substance in the patient.

From the instrumental point of view a PET scanner is thus a detector for gamma rays of 511keV which surrounds the patient. It has to have a high detection efficiency, a good time resolution, a good spatial resolution, and it has to cover a sufficient solid angle around the patient. Nearly all commercial scanners use scintillating crystals and photomultipliers. In the present project we want to replace the photomultipliers with a photosensitive wire chamber. This should allow to improve the spatial resolution.

We have built and tested a number of small technical prototypes with BaF_2 scintillator and a photosensitive wire chamber

using TMAE vapour as a photosensitive agent. Stable and reproducible operating conditions could be obtained with the following performance of the detector :

- time resolution 10ns
- chamber gain 10^6
- detection efficiency for gamma rays having deposited 511keV better than 99%.
- number of photoelectrons for crystals of $5x5x50mm^3$: 6/511keV
- spatial resolution limited by the size of the crystals to ~ 5mm.

The position resolution will be given by charge division on the signals induced on the cathodes. In collaboration with CERN we are therefore developing fast Analog to Digital (ADC) converters in a VME bus environment.

A number of variants and alternatives were studied, namely : operation of the wire chamber at atmospheric pressure, double readout where the crystals are read on one side with a PM and on the other side with a photomultiplier to give time and energy resolution, the use of LAF_3:Nd to replace BaF_2, and CsI photocathodes to replace TMAE. Of these, particularly the last one is potentially very interesting. The use of CsI would considerably improve the time resolution of the chamber, and it would remove a number of complications related to the use of TMAE like the need to operate the chamber at a temperature of ± 60°C. We have successfully used a wire chamber with CsI photocathode to detect the scintillation light of BaF_2, but more work is necessary before this becomes a valid alternative to TMAE.

V.2 R&D on the scintillating fibres technology

(M. Gruwé, C. Mommaert, G. Van Beek, P. Vilain, G. Wilquet)

Most of the effort has been put in the construction of modules of glass capillaries filled with liquid scintillators. The aim is to use these modules for the construction of high resolution active targets or tracking planes. As part of this development, three series of measurements have been made.

- Attenuation length measurements in capillaries of various diameters, in order to select a dye, a solvent and an ideal dye concentration. These tests have also been useful to improve capillaries preparation and filling techniques.
- Light yield measurements in liquid scintillator filled cuvettes, for various dye concentrations and solvents.
- Observation of tracks, due to the crossing of particles, in bundles of capillaries read out by means of an opto-electronic chain and a CCD.

The results achieved are quite promising. In addition, elaborate software tools have been developed to calculate the relevant parameters, gain, temporal and spatial resolution and magnification of complex opto-electronic read-out chains made of image intensifiers, active and passive, optical windows, lenses and CCD's.

VI. TECHNICAL AND ADMINISTRATIVE WORK.

The members of the workshop staff were : J. De Bruyne, J.M. Dehoux, J.P. Dewulf, L. Etienne, R. Gindroz, R. Goorens, E. Lievens, R. Ruidant, H. Turtelboom, G. Van Beek, J. Vanbegin, R. Vanderhaegen, L. Van Lanker, J. Van Vaerenbergh, G. Vincent and C. Wastiels with the help of J. De Schutter-Gevers, D. Luypaert-Peymans, M. Pins, R. Pins and A. De Coster-Van Cauwenberge.

P. Marage was in charge of the general coordination; R. Goorens and G. Van Beek organised the work of the electronics and mechanics workshops respectively.

L. Etienne, R. Goorens, R. Turtelboom and L. Van Lancker contributed to the running or the maintenance of the DELPHI end-cap detectors at CERN.

For the H1 experiment, the members of the mechanical workshop have constructed several additional infrastructure pieces and tools for the making of the COP chamber and its installation in DESY. Those who contributed to the construction of the COP itself (see section II.4) were J.P. Dewulf, J. De Schutter-Gevers, R. Gindroz, E. Lievens , D. Luypaert, M. Pins, R. Pins, G. Van Beek, A. De Coster-Van Cauwenberge, J. Van Vaerenbergh and G. Vincent.

J.M. Dehoux, J.P. Dewulf, L. Etienne, H. Turtelboom and C. Wastiels contributed to the electronics. For the fabrication (wave soldering method) and testing of the electronic cards for the MWPC's, J.P. Dewulf and H. Turtelboom received the help of A. De Coster-Van Cauwenberge, M. Delasorte, J. De Schutter-Gevers, D. Legrand-Mahaux, D. Luypaert-Peymans, R. Pins, M.L. Ronsmans, L. Vermeersch-Polderman and A. Vermijlen-Pels. The installation of the chambers at DESY was achieved by R. Grindroz, E. Lievens, L. Van Lancker and J. Van Vaerenbergh for the mechanics and J.M. Dehoux, H. Turtelboom and C. Wastiels for the electronics.

J. De Bruyne was mostly engaged in the PET camera project, to which L. Etienne and L. Van Lancker significantly contributed - as well as occasionally other members of the mechanical workshops.

R. Gindroz, R. Ruidant, G. Van Beek, G. Vincent and C. Wastiels were in charge of the maintenance of the bubble chamber film measuring machines.

R. Gindroz, E. Lievens, R. Ruidant, J.M. Dehoux, J.P. Dewulf and G. Van Beek contributed to the setting up of a new experiment on muon decay for students.

With the end of the building of the H1 chambers and of the measurement of bubble chamber film, a large reorganisation of the mechanical workshop took place, including the dismounting of 4 bubble chamber film measuring machines and the redistribution of the storing rooms. The personnel of both workshops, helped by J. De Schutter-Gevers, R. Pins, M.L. Ronsmans and J. Vanbegin contributed to this reorganisation and to the general maintenance in the laboratory.

In performing the neutrino bubble chamber experiments which were presented in section II.1, the physicists have benefited from the efficient work of the scanning and measuring teams of the laboratory : C. Carlier, M. Delasorte, M. De Schutter, Ch. Garnier-Stoffen, D. Legrand-Mahaux, D. Luypaert-Peymans, L.Vermeersch-Polderman and A. Pels-Vermijlen.

Scanning of Delphi data, on the graphics devices, was undertaken by C. Carlier, M. De Schutter, Ch. Garnier-Stoffen and R. Pins.

The secretarial work was accomplished by R. Alluyn-Lecluse and M. Van Doninck-Garnier - assisted by M. Goeman and J. Liesen - and by J. Castera for the HELIOS-B program. M. Pins has contributed to the maintenance of a documentation centre and has provided figures for several publications and lectures of members of the laboratory. A. De Coster-Van Cauwenberge and M. Delasorte took care of the library.

VII. REPRESENTATION IN COUNCILS AND COMMITTEES.

J. Lemonne has been the Belgian scientific representative in the CERN Council; he is the representative of the academic personnel of the Faculty of Science in the Council of the VUB.

J. Lemonne and **J. Sacton** were members of the Organizing Committee of the 1990 CERN School for Computing (Nieuwpoort).

J. Lemonne, **J. Sacton** and **F. Verbeure** contributed to the organization of the Second Joint Belgian, Dutch and German (Aachen) Summer School on Elementary Particle Physics at Nijmegen (The Netherlands).

J. Lemonne, **J. Sacton** and **F. Verbeure** were members of the Scientific Committee "High Energies" of the IIKW-IISN and of the Belgian Selection Committee of CERN fellows.

J. Sacton acted as Vice-Chairman of the Faculté of Sciences of the ULB, as advisor of the Rector of the ULB for all matters dealing with computing; he has deputized the Rector as Chairman of the Conseil de l'Informatique, at the Conseil de Gestion du Centre de Calcul ULB-VUB and at the Comité d'Accompagnement du programme d'Impulsion en Technologie de l'Information (Service de Programmation de la Politique Scientifique). He has been nominated as Member of the C11 Commission (Particles and Fields) of the International Union for Pure and Applied Physics (IUPAP) and Chairman of the High Energy Physics Computer Coordinating Committee.

F. Verbeure has acted as Belgian representative at Plenary ECFA and Restricted ECFA.

P. Vilain was the Belgian representative at Plenary ECFA.

P. Marage has acted at the ULB as member of its Council, of the Council of the Institut de Sociologie, the Council of the Faculty of Sciences, the Commission des Finances, the Commission de la Programmation et des Investissements, the Commission des Affaires Sociales.

S. Tavernier was member of the "Bureau van de Onderzoeksraad" of the VUB, of the Committee for the development of new PET instrumentation in the "European Concerted Action on PET instrumentation" of the board of directors of the Belgian Physical Society, and member of the Commission Computing at the VUB.

G. Van Beek has acted as the representative of PATG in the "Conseil de Physique".

The following responsabilities were taken in the organisation of the DELPHI experiment :

. **D. Bertrand** : member of the Software Coordination Panel (SCOOP).

. **J. Lemonne** : Vice-Chairman of the Collaboration Board and representative of "Belgium", representative of the IIKW-IISN in the DELPHI Finance Committee.

. **C. Vander Velde** : responsible for the muon subtrigger

. **C. De Clercq** : project leader of muon detectors

. **J. Wickens** : member of SCOOP and PAP (Physics Analysis Panel) and of the DPSP (Delphi Production Steering Panel).

The following responsabilities were taken in the organisation of the H1 experiment :

. **R. Roosen** : representative of "Belgium" in the Collaboration Board.

. **J. Sacton** : representative of the IISN-IIKW in the H1 Finance Committee.

P. Van Binst was member of : RARE Executive Committee, Council of Administrtaion and Working Groups, COSINE Policy Group, IXI Coordination Comittee, EWOS Steering Comittee and Technical Assembly, ETSI General Assembly and Technical Assembly, ECTUA, European DECUS Council and DECUS BELUX Board, HEPNET Requirements Committee, IBN, Commission Informatique and NBT, FNRS, Commission Informatique, Ministry of Scientific Policy, technical committee for a Belgian academic and research network.

R. Vandenbroucke-Tassin was member of the DECUS Europe SIG Advisory Committee (untill September 90). She was chairperson of DECUS Belux Networks SIG, and of DECUS Europe Networks SIG (untill September 90). She represented DECUS Europe in EWOS, Belgium in the IXI Coordination Committee and the Belgian HEP Community in the HEPNET Requirements Committee.

B. Sales was a member of :

- ISO/IEC JTC1 SC6/WG 1 (ISO expert group on OSI Data link Layer),
- ISO/IEC JTCQ SC6/WG 2 (ISO expert group on OSI Network Layer),
- ISO/IEC JTC1 SC6/WG 3 (ISO expert group on OSI Physical Layer),
- EWOS EG LL (European Workshop for Open Systems - Expert Group on Lower Layer)
- RARE WG 4
- IBN SCCI-4A (Expert group on Lower Layers within tyhe Belgian National Member body)

VIII. ATTENDANCE TO CONFERENCES, WORKSHOPS AND SCHOOLS.

VIII.1. Conferences and Workshops.

- 25th International Conference on High Energy Physics (Singapore)
  J. Lemonne, C. Vander Velde, E. De Wolf

- Neutrino '90 Conference (CERN-Genève)
  L. Verluyten, P. Vilain

- XXVth Rencontres de Moriond
  "Electroweak Interactions and Unified Theories" (Les Arcs, France)
  W. Van Doninck

- XIth International Conference on Physics in Collisions (Duke University, Durham, USA)
  S. Tavernier

- First International Symposium on Particles, Strings and Cosmology (Boston, USA)
  P. Kluit

- International Accelerator Conference (Houston, Texas)
  D. Johnson

- Second European Particle Accelerator Conference (Nice, France)
  J. Sacton

- ICFA Seminar on Future Perspectives in High Energy Physics (Protvino, USSR)
  J. Lemonne

- ECFA Large Hadron Collider Workshop (Aachen, Germany)
  W. Van Doninck, G. Wilquet

- Xth International Seminar on High Energy Physics Problems (Dubna, USSR)
  P. Marage

- Workshop on Intermittency (Santa Fe, USA)
  E. De Wolf

- CAMP Workshop (Marburg, Germany)
  F. Verbeure

- PANIC '90 Conference (Boston, USA)
  F. Verbeure

- Multiparticle Dynamics Symposium (Dortmund, Germany)
  E. De Wolf, F. Verbeure

- Workshop on correlations (Nantes, France)
  M. Charlet

- 1990 Summer Study on High Energy Physics, Research Directions for the DECADE (Snowmass, Colorado, USA)
  D. Johnson

- High Energy Physics Executive Seminar - Digital (Montreux, Suisse)
  D. Bertrand and J. Sacton

- London Conference on Positron Sensitive Detectors (London, U.K.)
  L. Etienne, B. Guerard, P. Huet, S. Tavernier, Zhang Shuping

- 2nd EEC Workshop on PET instrumentation (Liège)
  P. Bruyndonckx, B. Guerard, S. Tavernier, Zhang Shuping

- North Sea Conference on biomedical engineering 1990 (Antwerpen)
  S. Tavernier

- Application of Scintillating Fibers in Particle Physics (Blossin, Germany)
  G. Wilquet

- Eerste net-overschrijdend congres voor leraars wetenschappen (Diepenbeek)
  J. Lemonne

- International Telecommunications Society 8th Conference (Venice, Italy)
  P. Van Binst

- ICC 90/SUPERCOMM 90 (Atlanta, USA)
  P. Van Binst

- Colloque International "L'ordinateur, l'homme et l'organisation II" (Nivelles)
  P. Van Binst

- EARN/RARE Joint European Networking Conference (Killarney, ????)
  P. Van Binst

- Journée ARISTOTE, "Les réseaux. Techniques de pointe et besoins des entreprises" (Palaiseau, France)
  P. Van Binst

- CEN, CENELEC & ETSI, CTS Conference (Brussels)
  P. Van Binst

- IFIP Fourth International Conference on Data Communication Systems and their Performance (Barcelona, Spain)
  P. Van Binst

- DECUS Europe Symposium (Cannes, France)
  P. Van Binst

- IFIP International Symposium on Message Handling Systems and Application Layer Communication Protocols (Zurich, Switzerland)
  P. Van Binst

- Journée "Télématique Grande Vitesse" 9, "Broadband Islands in Europe II" (Berlin, Germany)
  P. Van Binst

- "Fast Packet Switching" Conference (Paris, France)
  P. Van Binst

- ICCC 90, 10th International Conference on Computer Communication (New Delhi, India)
  B. Salès, P. Van Binst

- CEC ESPRIT Conference (Brussels)
  P. Van Binst

- BELGACCOM, La réforme de la législation en matière de télécommunications en Belgique (Namur)
  P. Van Binst

- INDC-90 Conference (Lillehamer, Norway)
  P. Paridans

- IFIP WG 6.5 MHS'90 Symposium (Zurich, Switzerland)
  P. Paridans

- IFIP WG 6.5 MHS'90 Symposium (Zurich, Switzerland)
  F. Alexandre, P. Malisse, O. Paridaens, P. Paridans

- 1st European Conference on Hypertext (Versailles, France)
  A. Cohen

- COMNET '90 (Budapest, Hungary)
  N. Meulemans

VIII.2. Schools

- Second Joint Belgian-Dutch-German (Aachen) Summer School on Elementary Particle Physics (Nijmegen, the Netherlands)
  F. Cao, M. Charlet, H. De Boeck, F. Stichelbaut

- Z° Physics (Inst. d'études scientifiques de Cargèse, Corse)
  F. Stichelbaut

- UNIX Systems Administration and Organization (Apeldoorn, the Netherlands)
  F. Alexandre

IX. LIST OF PUBLICATIONS, REPORTS AND CONTRIBUTIONS TO CONFERENCES

IX.1. Publications

· **Neutrino Physics**

1. Dimuon production by neutrinos in the Fermilab 15-ft bubble chamber at the Tevatron
V. Jain, ..., M. Barth, E. De Wolf, P. Marage, J. Moreels, J. Sacton, L. Verluyten et al.
Phys. Rev. D41, 2057, 1990

2. First observation of neutrino trident production
D. Geiregat, G. Wilquet, ..., P. Vilain et al.
Phys. Lett. B245, 271, 1990

3. A new measurement of the cross section of the inverse muon decay reaction $\nu_\mu + e^- \rightarrow \mu^- + \nu_e$
D. Geiregat, G. Wilquet, ..., P. Vilain et al.
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· **Hadron Physics**

4. Intermittency effects in π^+p and K^+p collisions at 250 GeV/c
I.V. Ajinenko, ..., E.A. De Wolf, ..., F. Verbeure, ..., et al.
Phys. Lett. 235B, 373, 1990

5. Inclusive production of vector mesons in π^+p interactions at 250 GeV/c
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Z. Physik C, Particles and Fields 46, 387, 1990

6. Negative binomials and multiplicity distributions in 250 GeV/c K^+ and π^+ interactions on Al and Au nuclei
I.V. Ajinenko, ..., E.A. De Wolf, ..., F. Verbeure, ..., et al.
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8. Study of Hadronic Decays of the Z° boson
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9. Study of the leptonic decays of the Z° boson
P. Aarnio, ..., D. Bertrand, J. Buytaert, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, J. Wickens, ... et al.
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10. A precise measurement of the Z resonance parameters through its hadronic decays
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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12. Search for light neutral higgs particles produced in Z° decays
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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13. Search for the t and b' quarks in hadronic decays of the Z° boson
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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14. Search for pair production of neutral higgs bosons in Z° decays
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P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure J. Wickens, ... et al.
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16. Search for scalar quarks in Z° decays
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemnne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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17. Searh for sleptons and gauginos in Z° decays
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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18. A comparison of jet production rates on the Z° resonance to perturbative QCD
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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19. Energy-energy correlations in hadronic final states from the Z° decays
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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20. Measurement of the partial width of the decay of the Z° into charm quark pairs
P. Abreu, ..., D. Berrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemnne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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· **Experimental techniques**

21. Construction of a cylindrical MWPC for the central tracking detector of H1
G. Bertrand-Coremans, A. De Roeck, J.P. Dewulf, E. Evrard, P. Huet, D. Johnson, P. Marage, J. Moreels, R. Roosen, G. Van Beek, ... et al.
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22. Sources of noise in high-resolution tracking with scintillating fibres
C. Angelini, ..., G. Wilquet, ... et al.
Nucl. Instr. and Meth. A289, 356, 1990

23. Laser pulse stretching via enhanced close loop control with slow Q-switching
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24. Monitoring of a high-power pulsed ruby laser
L. Verluyten, S. Willocq, ... et al.
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25. Holography of particle tracks in the Fermilab 15-foot bubble chamber
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Nucl. Instr. and Meth. A297, 364 (1990)

· **Computing**

26. Les superordinateurs en Belgique
N. Apraxine, ..., J. Sacton et al.
Belgian Academy Council of Applied Sciences, 1990

27. Lower Layers Relays
B. Salès
EWOS Technical Guide 006

IX.2 Reports

1. Graphical event analysis
D. Bertrand,
Bulletin IIHE 90/07

2. Summary of the 1990 processing of the Delphi farm
A. Bjorkebo, ..., J. Wickens et al.
Delphi 90-38 Prog 156, 1990

3. Investigations on capillaries filled with liquid scintillator for high resolution particle tracking
A. Arbamos, ..., G. Wilquet, ... et al.
CERN EP 90/58

IX.3 Contributions to conferences

a. Presented by members of the IIHE

1. BaF_2 scintillators with wire chamber readout for positron emission tomography
P. Bruyndonckx, J. Debruyne, L. Etienne, M. Gruwé, B. Guérard, S. Tavernier and Shang Shuping
Talk presented by S. Tavernier at the Conference on Positron Sensitive Detectors, London
Bulletin IIHE 90/09

2. New trends in PET instrumentation
Invited review talk presented by S. Tavernier at the "North Sea Conference on biomedical engineering, Antwerpen, 1990

3. Progress report on the development of a PET scanner based on BaF_2 scintillator and wire chambers in Brussels
2nd EC Workshop on PET instrumentation, Liège, 1990

3. Neutrino electron scattering
Talk presented by P. Vilain at the Neutrino 90 Conference, Genève 1990

4. New results from the DELPHI experiment
Talk given by P.M. Kluit at the First International Symposium on Particles, Strings and Cosmology, Boston, 1990

5. Higher order correlations in small phase space domains : a series of observations
E. De Wolf
Invited talk at Workshop on Intermittency, Santa Fe, 1990
Bulletin IIHE 90/04

6. First results on factorial moments in neutrino and antineutrino interactions in Ne/H_2 at the CERN SPS
E. De Wolf
Invited talk at Workshop on Intermittency, Santa Fe, 1990

7. Hadron physics in fixed target experiments
E. De Wolf
Invited review talk at XVth International Conference on High Energy Physics, Singapore, 1990

8. Soft multiparticle production and related topics
E. De Wolf
Invited talk at XXth International Symposium on Multiparticle Dynamics, Gut Holmecke, 1990
Bulletin IIHE 90/11

9. Factorial moments and correlations in π^+/K^+ interactions in Al/Au
Talk presented by F. Verbeure at the CAMP Workhop, Marburg, 1990 and at Multiparticle Dynamics Symposium, Dortmund, 1990

10. Low Q^2 neutrino interactions and hadronic component
P. Marage
Review talk presented at the Xth International Seminar on High Energy Physics Problems, Relativistic Nuclear Physics and QCD, Dubna, 1990
Bulletin IIHE 90/06

11. Intermittency in charged current ν_μ-Ne interactions
Talk presented by L. Verluyten at the General Scientific Meeting of the Belgian Physical Society, UCL, 1990

12. Developments in visualization
Talk presented by D. Bertrand at the DIGITAl High Energy Physics Executive Seminar, Montreux, 1990

13. Elementaire Deeltjes : hoe elementair ?
Talk presented by J. Lemonne at the "Eerste net-overschrijdend congres voor leraars wetenschappen", LUC-Diepenbeek, 1990

14. A critical Assessment of the Telematics Technologies, Promises, and Reality
Talk presented by P. Van Binst at the 8th Conference of the International Telecommunications Society, Venice, Italy, 1990

15. Teaching telematics : Why, How and to Whom?
Talk presented by P. Van Binst at the "Colloque International "L'ordinateur, l'homme et l'organisation II", Nivelles, 1990

16. Performance of Public Packet Switched Networks : Experience and Theory
Talk presented by R. Vandenbroucke on the IVth IFIP International Conference on Data Communication Systems and their Performance, Barcelona, Spain, 1990

17. A first step towards international high speed networking in Europe
Talk presented by P. Van Binst at the 10th International Conference on Computer Communication, New Delhi, India, 1990

18. High Speed Networking in Europe and the EBIT Project
Invited paper at the ESPRIT '90 Conference, Brussels, 1990

19. Satellites
Invited lecture presented by P. Van Binst at the International Chair in Computer Science, Brussels, 1990

20. Standards in Computer Networking
Invited lecture presented by P. Van Binst at the 1990 Cern School of Computing, Nieuwpoort, 1990

21. Etat de la normalisation. Rôle de l'ETSI.
Invited talk presented by P. Van Binst at the "Fast Packet Switching" Conference, Paris, 1990

22. Realizing the message store with a relational database
Talk presented by O. Paridaens at the IFIP WG 6.5 MHS'90 Symposium, Zurich, 1990

23. An ASN.1 macro parser prototype
Talk presented by F. Alexandre at the IFIPWG 6.5 MHS'90 Symposium, Zurich, 1990

24. Specification and development of the SMID (Simple Multi-Purpose Internet Directory), a UNIX integrated decentralised Name Server based on X.500 and containing an interface to it.
N. Meulemans
COMNET'90 Conference, Budapest (Hungary), 1990

25. Design of LAN/WAN Relay Systems in the European Context
B. Salès
ITS'90, Rio de Janeiro, Brasil, 1990

26. A study of protocols supporting the connection oriented network service in a LAN/WAN environment
B. Salès
10th International Conference on Computer Communication, New Delhi, India, 1990

· **Others**

1. Beam Gas Effects at HERA ep Collider
D. Johnson
Summer study on High Energy Physics, Snowmass, USA, 1990
Bulletin IIHE 90/05

2. e-p Collider experiments and Physics
D. Atwood, D. Johnson et al.
Summer study on High Energy Physics, Snowmass, USA, 1990
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3. Study of High Energy Neutrino Neutral Current Interactions
H.H. Ballagh, ..., M. Barth, E. De Wolf, P. Marage, J. Moreels, J. Sacton, L. Verluyten, S. Willocq et al.
Neutrino 90 Conference, CERN, Geneva, 1990

4. Intermittency in neutrino-Ne and neutrino-D2 charged current interactions
E.A. De Wolf, P. Marage, L. Verluyten, et al.
Neutrino 90 Conference, CERN, Geneve, 1990
Bulletin of the IIHE-ULB/VUB 90.02

5. Study of factorial moments in neutrino neon and deuterium charged current interactions
WA59 and E180 collaborations : E.A. De Wolf, P. Marage, L. Verluyten, et al.
25th International Conference on High Energy Physics, Singapore, 1990

6. TMAE vapour or CsI layer as photocathodes in a multiwire proportional counter working at atmospheric pressure
P. Bruyndonckx, B. Guerard, S. Tavernier and S. Zhang
Contribution to the Conference on Positron sensitive detectors, London, 1990
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7. DELPHI results on the Z° resonance parameters through its hadronic and leptonic decay modes
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al. (Delphi collaboration)
CERN-PPE/90-119
Paper presented at the 25th International Conference on High Energy Physics, Singapore, 1990

8. A measurement of the partial with of the Z° boson into b quark pairs
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al. (Delphi collaboration)
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Paper presented at the 25th International Conference on High Energy Physics, Singapore, 1990

9. Search for Higgs bosons using the DELPHI detector
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
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Paper presented at the 25th International Conference on High Energy Physics, Singapore, 1990

10. Search for non-standard Z° decays in two-particle final states
P. Abreu, ..., D. Bertrand, J. Buytaert, C. Bricman, F. Cao, H. De Boeck, C. De Clercq, P. Kluit, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, W. Van Doninck, F. Verbeure, J. Wickens, ... et al.
CERN-PPE/90-167
Paper presented at the 25th International Conference on High Energy Physics, Singapore, 1990

We would like to thank all those who contributed to the preparation of this report.

FIGURE CAPTIONS

Figure 1 : Logarithm of the measured and simulated reduced scaled factorial moments $F_2^R(a)$, $F_3^R(b)$ and $F_4^R(c)$ as a function of the logarithm of the bin size δy for charged hadrons in the rapidity region $-2 \leq y \leq 2$ for $\nu_\mu Ne$ and $\nu_\mu D_2$ interactions. The continuous and dashed curves are the Monte Carlo predictions for $\nu_\mu Ne$ and $\nu_\mu D_2$ interactions, respectively, including the effects due to smearing and nuclear reinteractions and renormalisation discussed in the text.

Figure 2 : General lay-out of the experimental set-up proposed to search for ν_μ-ν_τ oscillations.

Figure 3 :

a) Graphical display of a computer simulated ν_τ event.

b) Expanded view around the vertex region of a ν_τ event.

Figure 4 : Cross sections σ and forward-backward asymmetry A_{FB} for $e^+e^- \rightarrow \mu^+\mu^-$ events as a function of the centre of mass energy around the Z°-pole.

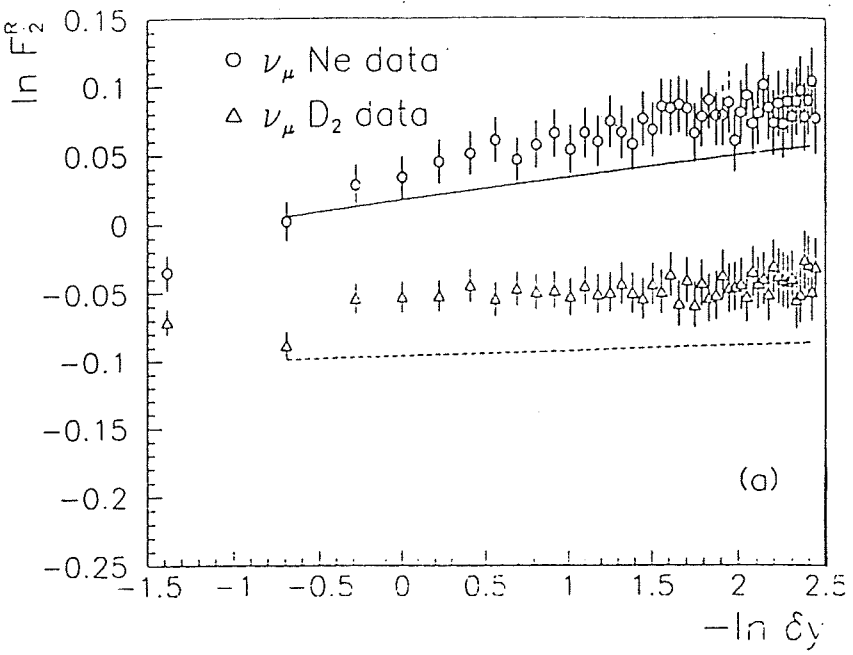
Figure 5

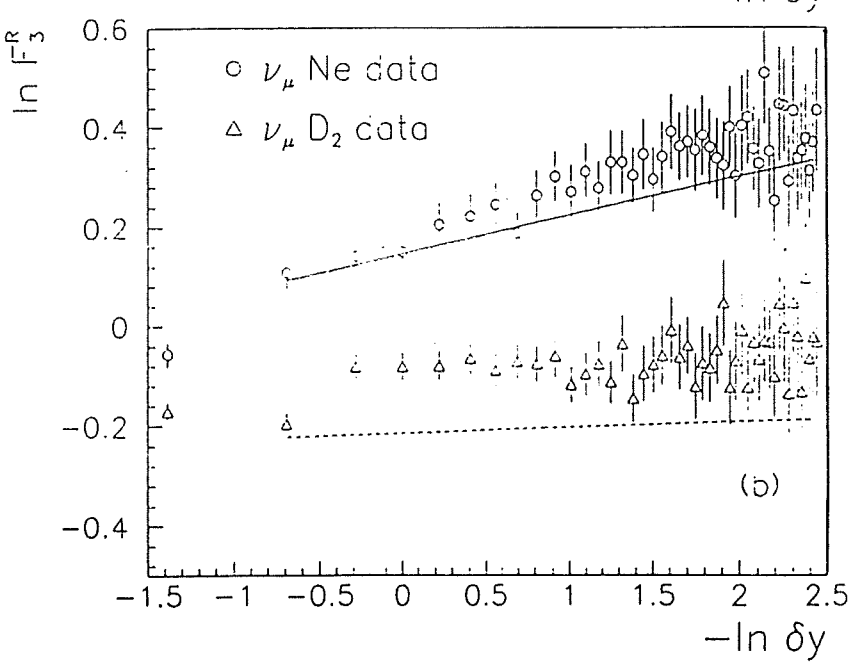
a) Installation at DESY of the COP built in Brussels inside the central tracking system of the H1 detector.

b) View of the complete central tracking system of the H1 experiment before cabling.

Figure 6 : Time resolution measured by the COP of the H1 detector.

Figure 7 : Wave soldering procedure used in Brussels for the production of cards of the front end electronics of the MWPC of the H1 detector.


ln F_2^R
ν_μ Ne data
ν_μ D_2 data
(a)
−ln δy


ln F_3^R
ν_μ Ne data
ν_μ D_2 data
(b)
−ln δy

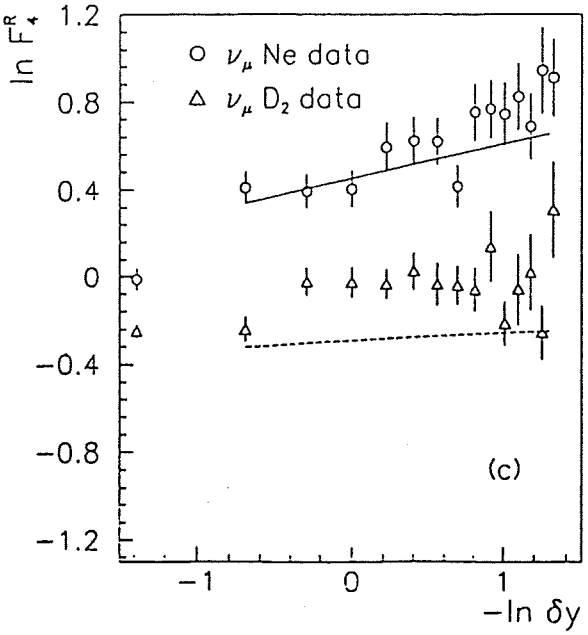

ln F_4^R
ν_μ Ne data
ν_μ D_2 data
(c)
−ln δy

Fig. 1

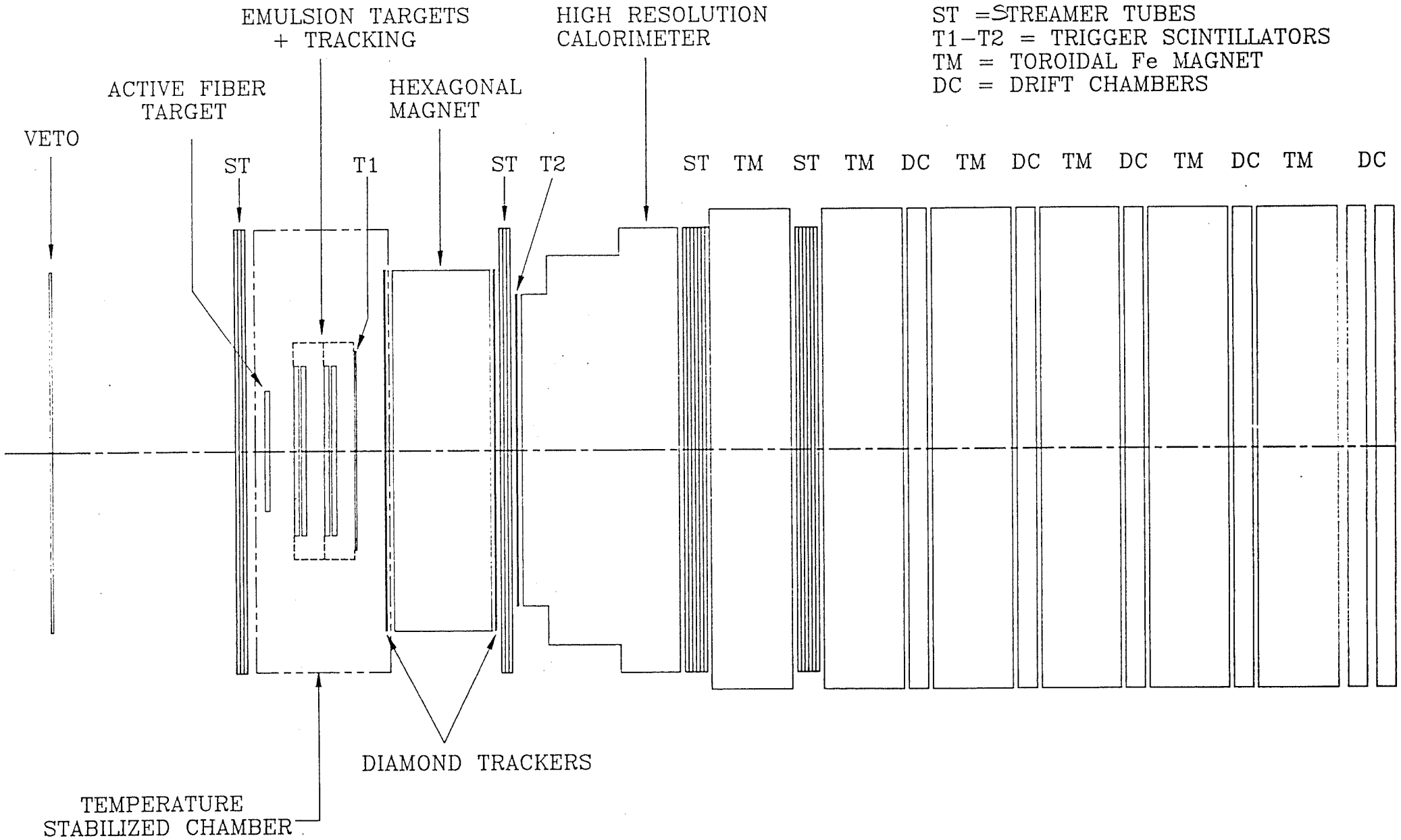

EMULSION TARGETS
+ TRACKING
HIGH RESOLUTION
CALORIMETER
ST =STREAMER TUBES
T1-T2 = TRIGGER SCINTILLATORS
TM = TOROIDAL Fe MAGNET
DC = DRIFT CHAMBERS
ACTIVE FIBER
TARGET
HEXAGONAL
MAGNET
VETO
ST
T1
ST
T2
ST
TM
ST
TM
DC
TM
DC
TM
DC
TM
DC
TM
DC
DIAMOND TRACKERS
TEMPERATURE
STABILIZED CHAMBER

Fig. 2

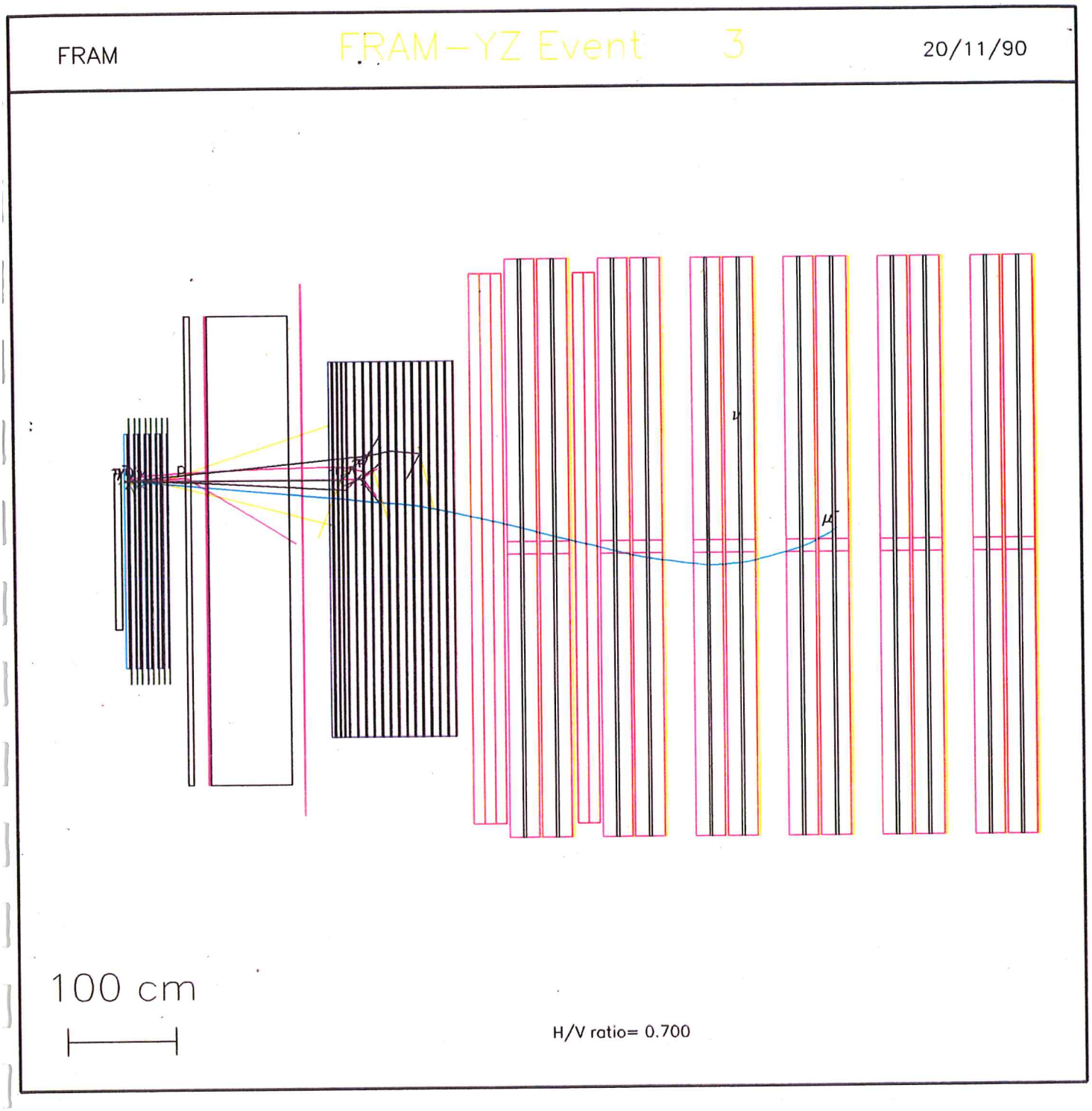


Fig. 3.a

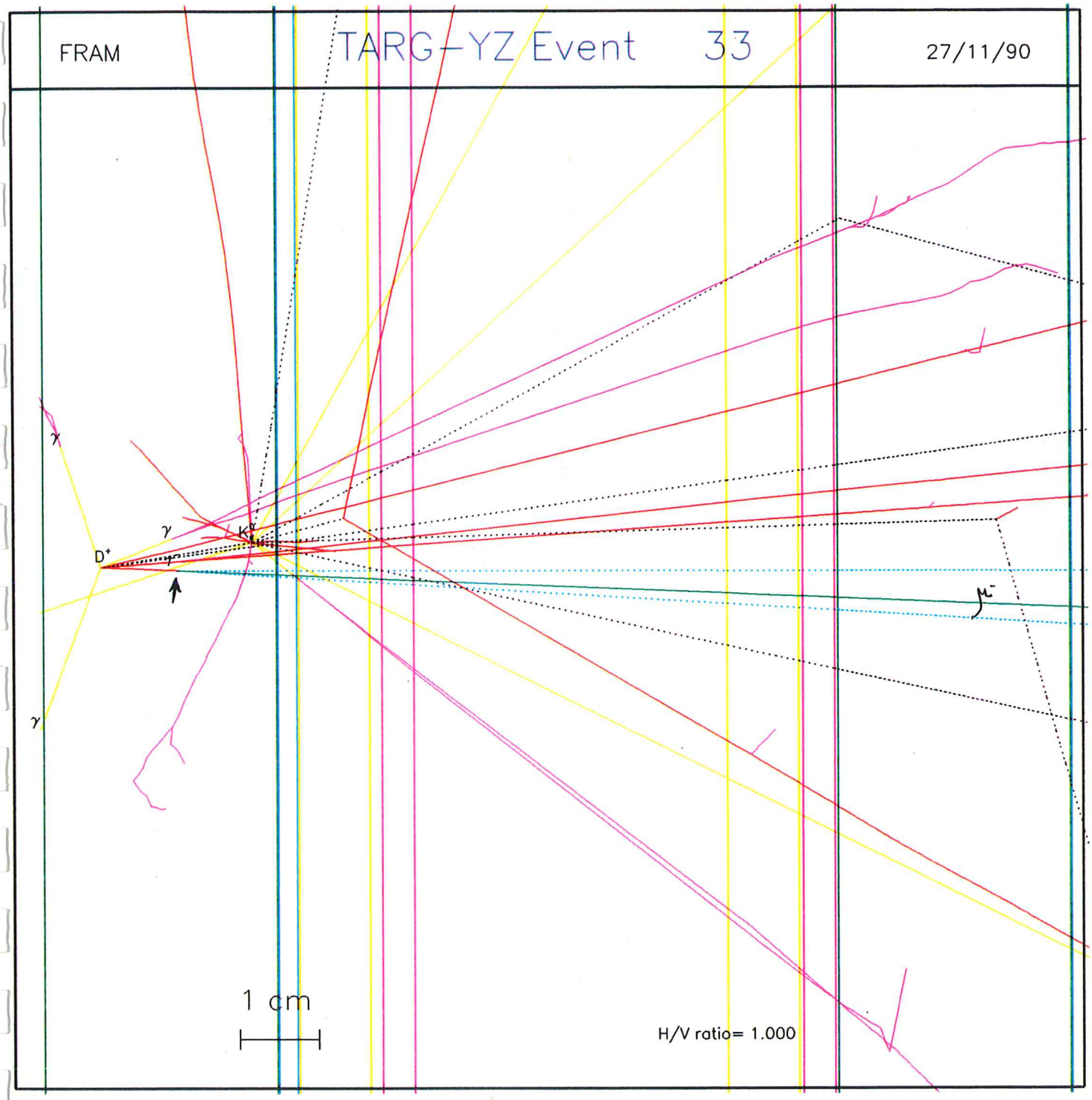


Fig. 3.b

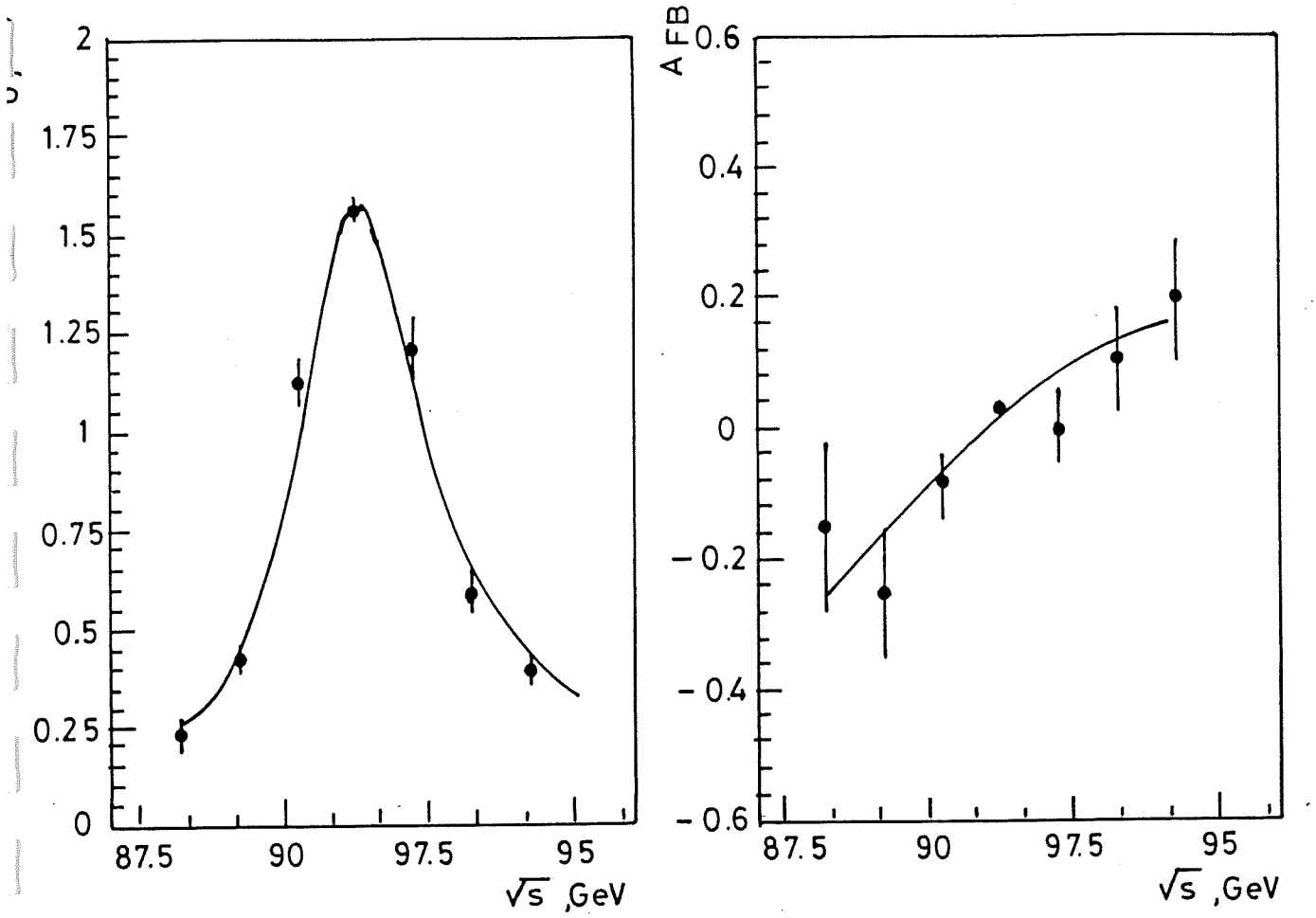

DELPHI μ⁺μ⁻ events
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
87.5
90
97.5
95
√s ,GeV
A FB
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
87.5
90
97.5
95
√s ,GeV

Fig. 4

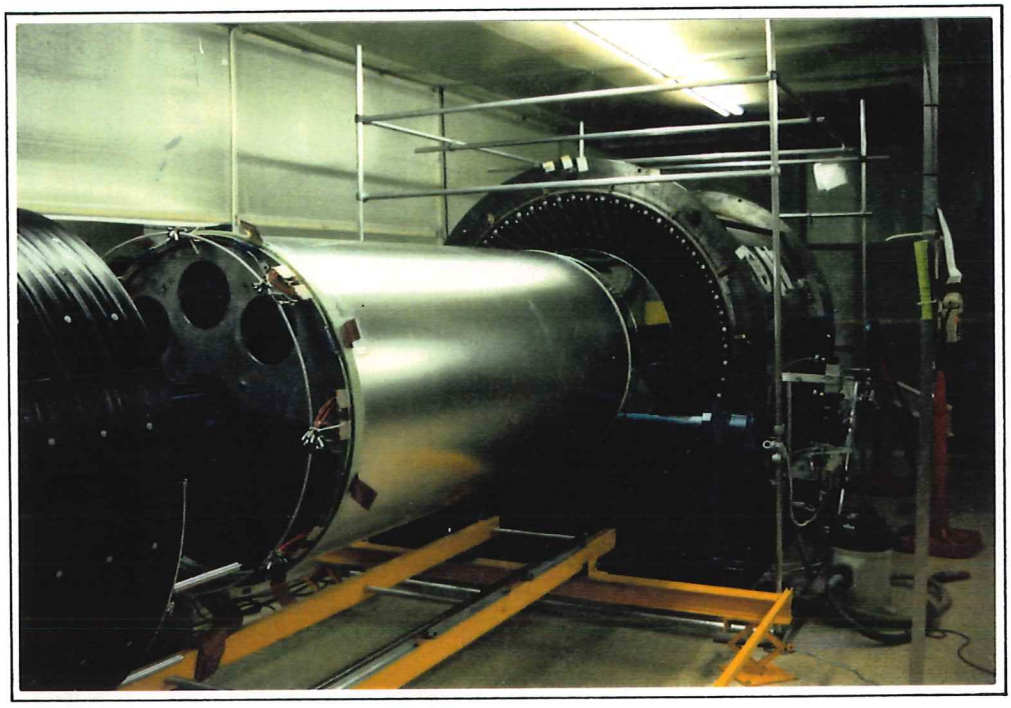


Fig. 5.a

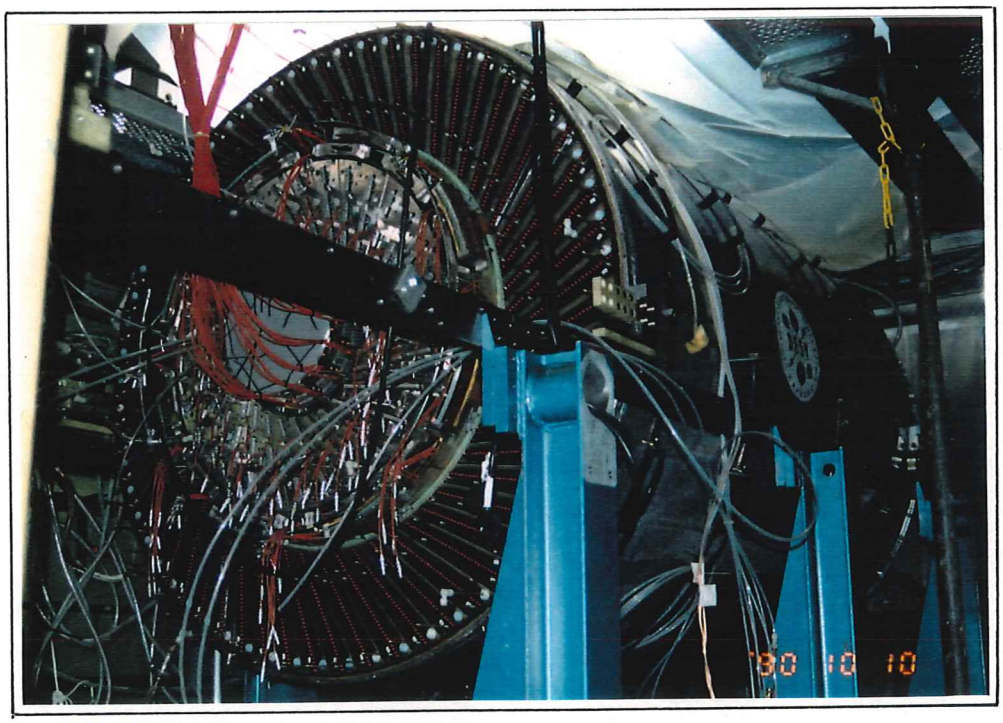


Fig. 5.b

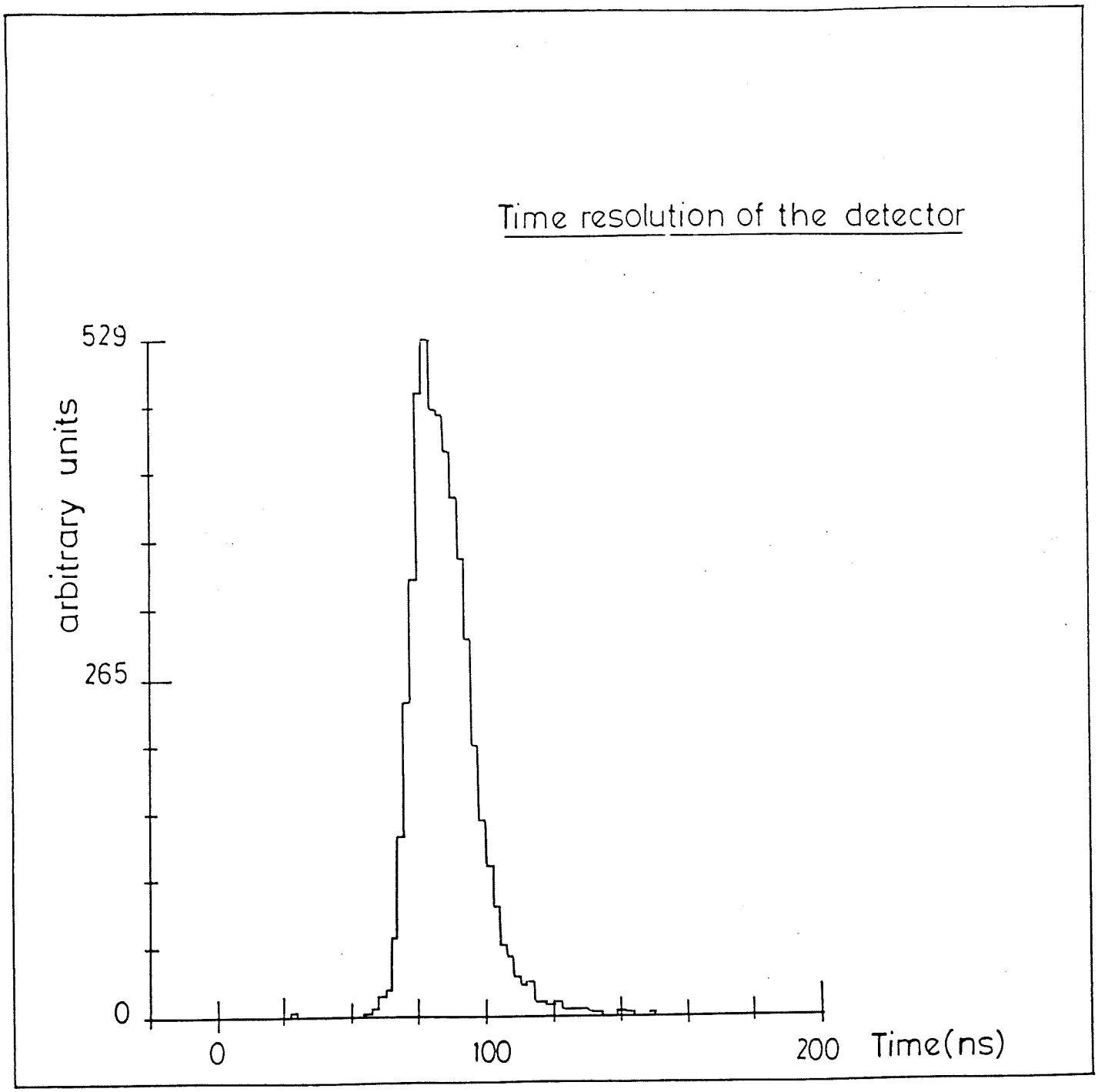

Time resolution of the detector
529
arbitrary units
265
0
0
100
200
Time(ns)

Fig. 6

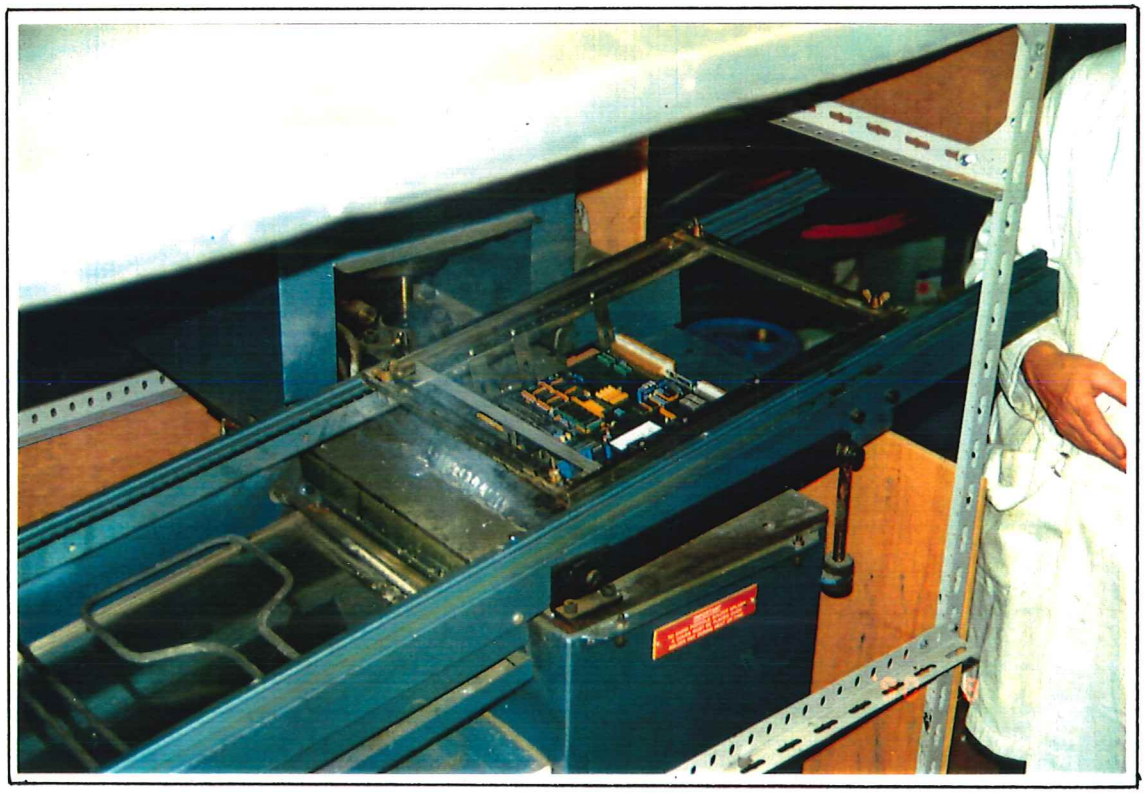


Fig. 7