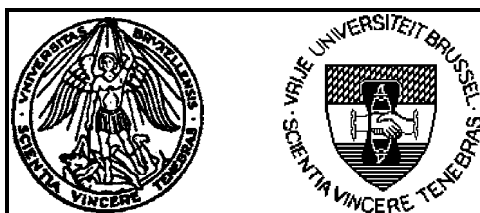


INTER-UNIVERSITY INSTITUTE FOR HIGH ENERGIES

ULB-VUB, BRUSSELS

ANNUAL REPORT 1997



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J. LEMONNE and J. SACTON,

May 1998.

CONTENTS

PART A : SURVEY OF THE 1993-1997 IHE SCIENTIFIC PROGRAMME

I.	NEUTRINO PHYSICS	p. 1
II.	e^+e^- INTERACTIONS AT LEP - THE DELPHI EXPERIMENT	p. 2
III.	ep INTERACTIONS AT HERA - THE H1 EXPERIMENT	p. 3
IV.	pp INTERACTIONS AT LHC - THE CMS EXPERIMENT	p. 4
V.	R & D ACTIVITIES	p. 5

PART B : ANNUAL REPORT 1997

I.	INTRODUCTION	p. 6
II.	RESEARCH ACTIVITIES	p. 7
II.1.	NEUTRINO PHYSICS - THE CHORUS EXPERIMENT	p. 7
II.2.	STUDY OF e^+e^- ANNIHILATIONS AT LEP - THE DELPHI EXPERIMENT	p. 7
II.3.	STUDY OF ep COLLISIONS AT HERA - THE H1 EXPERIMENT	p. 10
II.4.	STUDY OF pp COLLISIONS AT LHC - THE CMS EXPERIMENT	p. 12
III.	TEACHING ACTIVITIES AND SEMINARS	p. 13
III.1.	TEACHING ACTIVITIES (academic year 1996-1997)	p. 13
III.2.	Ph.D. THESES AND "MEMOIRES DE LICENCE" COMPLETED DURING 1997	p. 15
III.3.	SEMINARS	p. 15
III.4.	ORAL PRESENTATIONS AT SCHOOLS AND COLLABORATION MEETINGS	p. 17
IV.	COMPUTER MATTERS	p. 17

V. TECHNOLOGICAL R & D	p. 18
V.1. TECHNOLOGICAL TRANSFER FROM BASIC RESEARCH TO APPLICATIONS	p. 18
V.2. R & D ON HEAVY SCINTILLATORS	p. 19
V.3. R & D ON HIGH RESOLUTION TRACKING DEVICES BASED ON CAPILLARIES FILLED WITH LIQUID SCINTILLATOR	p. 19
VI. TECHNICAL AND ADMINISTRATIVE WORK	p. 19
VII. REPRESENTATION IN COUNCILS AND COMMITTEES	p. 20
VIII. ATTENDANCE TO CONFERENCES, WORKSHOPS AND SCHOOLS	p. 22
VIII.1 CONFERENCES AND WORKSHOPS	p. 22
VIII.2. SCHOOLS	p. 23
IX. LIST OF PUBLICATIONS, REPORTS AND CONTRIBUTIONS TO CONFERENCES	p. 24
IX.1. PUBLICATIONS	p. 24
IX.2. REPORTS	p. 28
IX.3. CONTRIBUTIONS TO CONFERENCES	p. 29

FOREWORD.

This year one celebrates the 25th anniversary of the Interuniversity Institute for High Energies (IIHE-ULB/VUB). In 1992, we produced a document presenting the first twenty years of scientific activities at the Institute⁽¹⁾. The present report consists in two parts. Part A is devoted to a global survey of our scientific programme during the period 1993-1997 whilst Part B will contain more detailed information about all our activities in 1997.

The work presented here has been supported by the Université Libre de Bruxelles (ULB), the Vrije Universiteit Brussel (VUB), the Fonds National de la Recherche Scientifique (FNRS), the Fonds voor Wetenschappelijk Onderzoek (FWO), the Fonds pour la Formation à la Recherche dans l'Industrie et dans l'Agriculture (FRIA), the Vlaams Instituut voor de bevordering van het Wetenschappelijktechnologisch onderzoek in the industrie (IWT) and the LOTTO (Loterie Nationale, Nationale Loterij).

We gratefully acknowledge the collaboration of the many colleagues at the IIHE who helped us in preparing this report.

Typing and illustration of this document are due to Mrs M. Van Doninck and Miss M. Pins.

J. LEMONNE

J. SACTON

(1) 1972-1992 Scientific activity report of the IIHE (ULB/VUB)

PART A

SURVEY OF THE 1993-1997 IIHE SCIENTIFIC PROGRAMME.
I. NEUTRINO PHYSICS.

In this field of research, two main programmes have been completed : the study of high energy ν_μ and $\bar{\nu}_\mu$ interactions with the giant bubble chambers at CERN and FNAL and the CHARM II experiment.

The analysis of the data taken in the eighties before the shutdown of BEBC at CERN and of the 15 foot chamber at FNAL has been pursued until recently. The main most recent results concerned :

- At the Tevatron energies : the production of strange particles and of charmed mesons and evidence for the coherent production of single pions and ρ mesons
- At the SPS energies : the production of charmed and charmed strange mesons, the production properties of charged hadrons and of ρ° mesons.

The CHARM II experiment stopped data taking at the end of 1991, after 5 years of successful operation. The analysis of this experiment which aimed at a precise measurement of the weak mixing parameter $\sin^2 \theta_W$ from the purely leptonic neutral processes $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$ and $\bar{\nu}_\mu + e^- \rightarrow \bar{\nu}_\mu + e^-$ is now completed. The CHARM II detector consisted of a 700 tons fine grained low density target calorimeter followed by a muon spectrometer. Some 30 millions neutrino and antineutrino interactions were registered in the calorimeter from which 5000 examples of the above reactions were selected.

The weak mixing parameter was obtained from the measurement of the ratio of the $\nu_\mu e^-$ and $\bar{\nu}_\mu e^-$ cross sections :

$$\sin^2 \theta_W = 0.2324 \pm 0.0083$$

whilst a fit of the shapes of the differential cross sections $\frac{d\sigma}{dy}(\nu e)$ and $\frac{d\sigma}{dy}(\bar{\nu} e)$ allowed to determine both the values and signs of the vector and axial vector couplings of the electron to the Z° boson :

$$g_V^{e^-} = -0.035 \pm 0.017 \text{ and } g_A^{e^-} = -0.503 \pm 0.017$$

Various other interesting results were obtained by the CHARM II Collaboration :

- From a leading-order QCD analysis of neutrino and antineutrino dimuon events, the charm quark mass and the CKM matrix element V_{cd} were estimated to be $m_c = 1.79 \pm 0.38 \text{ GeV}/c^2$ and $|V_{cd}| = 0.209 \pm 0.017$.
- The cross section for the production of three leptons $(\nu_\mu + A \rightarrow \nu_\mu + \mu^- + \mu^+ + A')$ was measured to be $2.84 \pm 0.27 \pm 0.27 \times 10^{-41} \text{ cm}^2$ from which the diagonal coupling of the muon weak currents was estimated to be $G_D = G_F \times (0.959 \pm 0.046 \pm 0.070)$, in agreement with the standard model predictions.
- More exotic topics included negative searches for muonic photons, additional Z° bosons and heavy neutrinos.

The third neutrino experiment in which the IIHE is involved - the CHORUS experiment - is on the floor since April 1994. It is installed in the CERN SPS muon neutrino wide band beam and aims at detecting neutrino oscillations via the observation of the reaction $\nu_\tau + N \rightarrow \tau^- + X$, followed, after 10^{-13} s, by the decay of the τ lepton. The detector is composed of a 770 kg emulsion target to record the neutrino interactions, a scintillating fiber tracker providing accurate trajectory predictions of produced charged particles back in the emulsion, scintillator trigger hodoscopes, an air-core magnet, a lead/scintillator calorimeter and a muon spectrometer. The main hardware contribution of the IIHE to this experimental set-up mainly concerned the design and construction of the scintillating fiber tracker and its quite sophisticated optoelectronic read-out system (in collaboration with CERN and the university of Louvain-la-Neuve).

Data were taken in two runs of two years each; indeed, at the end of 1995, the emulsion stacks were removed from the set-up and replaced by new ones. Today, more than 10^6 neutrino interactions have been registered in the emulsion targets and those corresponding to the first run have been reconstructed. The first results of this partial analysis are presented in part B of this report.

During the running periods, the detector has been upgraded to increase both the momentum resolution of the charged particles emitted from the neutrino interactions and the track reconstruction downstream the magnet.

II. e^+e^- INTERACTIONS AT LEP - THE DELPHI EXPERIMENT.

From 1993 until the autumn of 1996, LEP has run at, and around, the energy corresponding to the Z^0 boson peak. From then onwards, the installation of additional RF superconducting cavities has allowed to increase the LEP center-of-mass energy in successive steps up to $\sqrt{s} = 130, 136$ and 161 GeV, to reach finally the record energy of 172 GeV.

During this period, the chambers of the forward muon identifier of DELPHI (one of the four multipurpose detector in operation at LEP since 1989) which had been built by the Belgian groups of the IIHE, the UIA and the UMH have run smoothly. In fall 1997, however, the chamber efficiencies dropped significantly; the origin of this bad behaviour is being investigated but is almost certainly due to the supply of a contaminated gas mixture.

The analysis of a few millions Z^0 boson decays has produced a variety of interesting results among which :

- accurate measurements of the Z^0 resonance parameters and of the electroweak couplings (see last values in part B of this report)
- various tests of the lepton universality and of the lepton number conservation
- mass, lifetime, decay branching ratios and polarisation measurements of the τ lepton
- mass, lifetime and decay branching ratios for various species of B mesons and B baryons
- negative searches for various kinds of new particles such as Higgs bosons, heavy leptons, supersymmetric particles, heavy bosons, lepto quarks ... leading to the estimation of mass limits
- measurements of time dependence $B_d^0 - \bar{B}_d^0$ and $B_s^0 - \bar{B}_s^0$ mixing leading to an estimation of the mass difference of the B_d^0 and B_s^0 mass eigenstates
- determination of quark and gluon jet properties

- production characteristics of charged and neutral hadrons, of hadronic resonances (using data from the RICH, a unique feature of DELPHI) with detailed comparison with QCD inspired models
- study of quark and gluon fragmentation
- measurement of the photon structure function.

At energies above the Z^0 peak, the first efforts were concentrated on the analysis of single and pair production of W^\pm bosons and on extending the forbidden mass range for different species of new particles to values around the allowed kinematical limits for single or pair production.

Until now all the results obtained by the four LEP experiments are consistent with the predictions of the standard model.

In this vast programme, the physicists of the IIHE and the UIA have contributed mainly to the following topics :

- (i) the study of the $Z^0 \rightarrow \mu^+\mu^-$ and $Z^0 \rightarrow \tau^+\tau^-$ line shapes and asymmetries
- (ii) the delicate measurements of the $Z^0 \rightarrow b\bar{b}$ partial width for which the most recent reported value is $R_b^0 = \Gamma_{b\bar{b}} / \Gamma_h = 0.22194 \pm 0.0032 \pm 0.0022$
- (iii) the analysis of particle correlations in Z^0 hadronic decays : strong short range three particle correlations were observed which could at least partly be explained by Bose Einstein correlations
- (iv) the measurement of the τ lepton polarisation using τ decays into one charged particle and any number of neutrals. The classification of these one-prong topologies into the various physical decay channels was done using an original approach making use of the neural network technique. The kinematics of the τ decay products were then used as a polarimeter to determine the Z end τ polarisations from which the coupling constants of the Z boson to the electron and the τ lepton as well as the weak mixing angle $\sin^2 \theta_W$ were inferred
- (v) a study of the τ lepton decay in three charged pions
- (vi) initial state radiation in the radiative processes $e^+e^- \rightarrow \mu^+\mu^- \gamma$ (see part B)
- (vii) WW pair production and the triple gauge boson coupling (see part B).

III. ep INTERACTIONS AT HERA - THE H1 EXPERIMENT.

HERA, the only ep collider in the world, came in operation in 1992. The hardware contributions of the IIHE to the H1 detector, one of the two multipurpose apparatuses at HERA, consisted in the design and construction of (i) two coaxial cylindrical multiwire proportional chambers (COP) of 2.2 m length and 1 m inner diameter and (ii) the front-end data acquisition system of all the H1 proportional chambers.

During the last 5 years the H1 detector has been upgraded by the installation of a series of new elements among which a new backward calorimeter (SPACAL) and a forward proton spectrometer (FPS). Apart from 3 sectors (out of 32) lost since 1992 (one broken wire), the COP chambers which are an essential part of the first level trigger have been functioning in a very satisfactory way.

The yearly integrated luminosity delivered by HERA from 1993 to 1997 has increased from 300 nb^{-1} to 30 pb^{-1} . So far, the analysis of the accumulated data which is still in progress has been concentrated on the following major topics :

- the measurement of the proton structure function $F_2(x, Q^2)$ in a kinematic domain until now unexplored, extending from $Q^2 = 0.35 \text{ GeV}^2$ to $Q^2 = 15000 \text{ GeV}^2$, and down to $x \sim 6 \times 10^{-6}$, showing a strong rise at low x , down to lowest Q^2 values,
- the observation of a large diffractive contribution to the DIS cross section,
- the study of photo- and electroproduction of vector mesons : ρ^0 , ϕ and J/Ψ mesons, showing in particular a strong rise of the J/Ψ cross section with energy, interpreted as an indication for "hard" diffraction,
- extensive study of the characteristics of hadronic final states in diffractive interactions, DIS interactions and photoproduction events : particle multiplicities and transverse momenta, jets, energy flow, event shape, correlations, ...
- significant limits were placed on the production of new particles : leptoquarks, leptogluons, supersymmetric particles, excited fermions, ...

Whenever possible, this impressive amount of experimental results has been extensively compared with theoretical predictions : HERA is an exceptional benchtest for QCD.

The Brussels-Antwerp group input to the H1 physics analyses can be summarized as follows :

- several contributions to the measurement of the $F_2(x, Q^2)$ structure function, specially at low x ;
- several contributions to the study of the characteristics of diffractive interactions in deep-inelastic scattering, in particular measurement of the ρ and ϕ meson electroproduction cross section, study of the multiplicity distributions and measurement of p_T factorisation breaking;
- contribution to the study of the hadronic final states in deep-inelastic scattering, in particular multiplicity distributions and correlations;
- contribution to the analysis of radiative corrections in deep-inelastic scattering.

Three members of the group have acted as convenors of working groups (diffraction, final states, radiative corrections).

IV. pp INTERACTIONS AT LHC - THE CMS EXPERIMENT.

In December 1994, the CERN council decided the construction in the LEP tunnel of a "Large Hadron Collider" (LHC) which is expected to be operational in 2005. This machine will allow the study of proton-proton interactions at a center-of-mass energy of 14 TeV with luminosities around $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. Two multipurpose detectors, ATLAS and CMS, will be installed at the LHC.

The Compact Muon Solenoid (CMS) collaboration consists of more than 1700 physicists and engineers from 150 institutes over the world among which five Belgian research groups from the IIHE (ULB/VUB), UIA, UCL and UMH. The Belgian teams have chosen to participate to the design and construction of a few thousands of microstrip gas counters (MSGC) to equip the forward part of the central detector of CMS. This work is being conducted in collaboration with groups from RWTH Aachen, CRN Strasbourg, Budker Institute Novosibirsk and the universities of Karlsruhe and Lyon.

Until now, the efforts at the IIHE and the UIA concentrated on :

- generic R & D on the MSGC performances in the framework of an international programme at CERN (RD 28 collaboration). Extensive studies were made on the substrate characteristics with the support of IMEC-Leuven and VITO-Mol and on the gas composition,
- setting up of the needed infrastructure for the development of the MSGC technique,
- design, construction and test of a full size prototype of the mechanical support (carbon fiber "wheels") of the chambers in the forward part of the central tracker (in collaboration with the engineering department of professor P. De Wilde at the VUB),
- design and development of radiation hard read-out chips (in collaboration with CERN, IMEC, NIKHEF and Lyon),
- design, construction and tests of a milestone prototype consisting of a single gas box containing eight trapezoidal counters with their read-out electronics,
- in parallel, parts of the general software for the tracker have been developed in Brussels and incorporated in the detector simulation programme CMSIM.

V. R & D ACTIVITIES.

Besides the technological developments directly related to our participation to the scientific programmes described above, R & D activities were developed along three lines :

- design and construction of a **Positron Emission Tomograph (PET)** with a rotating gantry dedicated to small animal imaging; it uses 3000 Ba F₂ crystals 3 x 3 x 20 mm each and photosensitive wire chambers with tetrakis-dimethylamine-ethylene (TMAE) filling,
- systematic investigation of the properties of new heavy scintillation materials such as Pb WO₄, Ce F₃ and Cerium doped rare earth oxides in view of their application in calorimetry at the LHC,
- design and construction of high resolution tracking devices based on capillaries filled with liquid scintillator to be used as active targets for future neutrino experiments or as tracker for collider experiments.

PART B**I. INTRODUCTION.**

The scientists whose names are listed below have contributed to the various activities of the Institute in 1997.

U.L.B.

P. Annis (boursier, région Sardaigne)
D. Bertrand (directeur de recherche FNRS; chargé de cours temps partiel)
G. Bertrand-Coremans (chef de travaux)
O. Bouhali (doctorant)
B. Clerbaux (boursière FRIA)
R. El Aidi (doctorant)
M. Elamiri (doctorant)
L. Favart (chargé de recherche FNRS since October 1997)
V. Lefébure (boursière FRIA until October 1997)
P. Marage (agrégé de faculté; chargé de cours temps partiel)
J. Sacton (professeur ordinaire)
J. Stefanescu (boursière FRIA)
F. Tallouf (doctorant)
M. Vander Donckt (boursière FRIA until October 1997; for the last 3 months of the year, she stayed at Nagoya University with a combined Japan/FNRS scholarship)
C. Vander Velde (chargé de cours associé)
P. Vanlaer (aspirant FNRS)
P. Vilain (chercheur qualifié FNRS; chargé de cours temps partiel)
J. Wickens (chercheur IISN)
G. Wilquet (chercheur qualifié FNRS; chargé de cours temps partiel)
V. Lefébure presently at CERN is also "collaborateur scientifique" at the ULB

V.U.B.

P. Bruyndonckx (IWT post-doc)
R. Chen (VUBAROS fellow)
C. De Clercq (logistiek medewerker FWO)
O. Devroede (wetenschappelijk medewerker FWO since October 1997)
A. Fremout (wetenschappelijk medewerker FWO)
R. Heremans (wetenschappelijk medewerker FWO)
D. Johnson (hoogleraar VESALIUS College)
J. Lemonne (gewoon hoogleraar)
Liu X. (VUBAROS beurs)
R. Roosen (onderzoeksleider FWO)
S. Tavernier (onderzoeksdirecteur FWO)
F. Udo (gastprofessor - deeltijds 20 %)
R. Vandenbroucke (logistiek medewerker FWO)
B. Van De Vyver (aspirant FWO)
W. Van Doninck (onderzoeksdirecteur FWO)
P. Van Esch (wetenschappelijk medewerker FWO until June 1997)
A. Van Lysebetten (wetenschappelijk medewerker FWO)
Y. Wang (visitor May, June, July 1997)
V. Zhukov (vrijwillig medewerker since February 1997)

W. Beaumont, T. Beckers, M. Charlet (since November 1997), S. De Brabandere (until May 1997), J. Detroy, E. De Wolf, A. Rostovtsev (since September 1997), A. Tomaradze (until July 1997), Ch. Van Dyck, P. Van Mechelen and F. Verbeure from the Universitaire Instelling Antwerp (UIA) have been working in close collaboration with the Institute.

Research in the field of telecommunications and data is conducted at IIHE/VUB by R. Vandenbroucke and Z. Cekro in collaboration with the members of the "Service Télématique et Communication" led by P. Van Binst at the ULB.

II. RESEARCH ACTIVITIES.

II.1. NEUTRINO PHYSICS - THE CHORUS EXPERIMENT.

(P. Annis, R. El Aidi, M. Vander Donckt, B. Van de Vyver, P. Vilain and G. Wilquet).

The data taking of this experiment ended in November 97. A subset of the neutrino interactions collected during 1994 and 1995 has been analyzed, looking for ν_τ charged current interactions where the produced τ lepton decays into $\mu \bar{\nu}_\mu \nu_\tau$. In a sample of 31.423 ν_μ charged current interactions, no ν_τ candidates were found. For large $\Delta m_{\mu\tau}^2$ values, this negative result allows to set a limit on the mixing angle of $\sin^2 2\theta_{\mu\tau} < 3.5 \times 10^{-3}$ at 90 % C.L., improving the previous best value. It is worth to note that the main sources of potential background - charm production and ν_τ contamination of the ν_μ beam - would have produced 0.06 events.

A similar analysis is in progress using events without muons. The hadronic decay modes of the τ lepton amounts to 50 % of all modes compared to 17 % for the muon decay mode. However the reduced efficiencies of the hadron tracks reconstruction and of the vertex location for such events, will lead probably to comparable sensitivity. The IIHE team is in charge of coordinating this search.

In parallel, the emulsion stacks of the 1996-1997 runs are in the process of being developed whilst the corresponding vertex predictions are being calculated using the tracking data provided by the downstream detectors.

Considerable effort has been devoted to simulate the expected response of the detector for a variety of events, genuine or background.

II.2. STUDY OF e^+e^- ANNIHILATION AT LEP - THE DELPHI EXPERIMENT.

(D. Bertrand, S. De Brabandere, C. De Clercq, M. Elamiri, V. Lefébure, J. Lemonne, A. Tomaradze, C. Vander Velde, W. Van Doninck, A. Van Lysebetten, F. Verbeure and J. Wickens).

The running of the muon chambers of the DELPHI detector has been under the responsibility of the collaboration between the Belgian groups (IIHE ULB/VUB, UMH and UIA) and the British laboratories of Oxford and Rutherford. These chambers have worked smoothly until the middle of the 1997 LEP run when, over a period of one month, the chamber efficiencies of the 16 quadrants of the forward muon identifier dropped from the usual 97 % down to about 70 %. Extensive tests have demonstrated that this bad behaviour was due to an admixture of chlorine (a strong electronegative pollutant) in the isopropanol alcohol present in the gas mixture (Ar/CO₂/C₄H₁₀). Flushing with a clean gas mixture during the winter shut-down should restore the chamber efficiencies for the 1998 LEP runs.

The main physics results obtained during the present year are summarized below; all were published or presented at the major conferences in the field of particle physics.

A. Analysis of the data accumulated at the Z^0 peak energy.

- The updated measurement of the Z^0 resonance parameters and of the electroweak couplings obtained from a fit to the hadronic and leptonic cross sections and asymmetries (allowing for lepton conservation) yields the following values :

M_Z	=	91.1866 ± 0.0029 GeV
Γ_Z	=	2.4893 ± 0.0040 GeV
σ_0^h	=	41.567 ± 0.079 nb
$R_l = \mathbf{Error!}$	=	20.759 ± 0.062 with $l = e, \mu$ or τ
$A^{0,FB}(l)$	=	0.0178 ± 0.0021

- In the leptonic sector, the main results were :

- The correlation parameter $C_{\tau\tau}$ between the transverse spin components of $\tau^+ \tau^-$ pairs collected during 1992 to 1994 was measured to be $C_{\tau\tau} = 0.87 \pm 0.20$ (stat.) ${}^{+0.10}_{-0.112}$ (syst.), in agreement with the standard model expectation.
- A search for lepton flavour number violating Z^0 decays in the channels : $Z^0 \rightarrow \mu \tau$, $Z^0 \rightarrow e \tau$ and $Z^0 \rightarrow e \mu$ in data collected during the 1991-94 LEP-runs remained negative and 95 % confidence upper limits of 1.2×10^{-5} , 2.2×10^{-5} and 0.25×10^{-5} were obtained for the respective branching fractions.
- From a study of the reaction : $e^+ e^- \rightarrow \gamma +$ no detected particle, the number of light neutrino species was determined to be $N_\nu = 2.89 \pm 0.38$.
- A sample of about 400 dimuon events with initial state radiation was used to measure the differential and total cross sections of the reaction $e^+ e^- \rightarrow \mu^+ \mu^- \gamma_{ISR}$ at energies $\sqrt{s'}$ between 20 and 80 GeV. No deviation from the standard model was observed. The polar angle distributions were used to determine the ratio $\sigma_{LL} + \sigma_{RR} / \sigma_{RL} + \sigma_{LR}$ where the subscripts represent the helicities of the incoming e^- and outgoing μ^- respectively. No evidence for new physics was seen.

- Several searches for new particles were carried out :

- Mass dependent 95 % CL upper limits ranging from 8 to 4×10^{-6} have been set on the branching ratio for excited neutrino ν^* production in the process $Z^0 \rightarrow \nu^* \nu$ for $0 < m_{\nu^*} \leq 90$ GeV / c^2 .
- Weak isosinglet neutral heavy leptons (ν_m) have been searched for in a sample of 3.3 million Z^0 events. According to current theoretical models they would dominantly be produced in conjunction with their standard ν -partner ($Z^0 \rightarrow \nu_m \bar{\nu}$) and decay through processes such as :

$$\begin{array}{ccc} \nu_m \rightarrow \nu Z^* & & \nu_m \rightarrow \ell' W^* \\ \downarrow & & \downarrow \\ \bar{\nu}\nu, \ell\bar{\ell}, q\bar{q} & & \nu\bar{\ell}, q\bar{q}' \end{array}$$

No indication of the existence of these particles has been found, leading to an upper limit for the branching ratio of $Z^0 \rightarrow \nu_m \bar{\nu}$ decays of 1.3×10^{-6} at 95 % CL.

- From the data recorded from 1991 to 1994, (3.2 million hadronic Z^0 decays), B meson production was studied :

- Based on the inclusive reconstruction of approximately 3500 semileptonic decays of the type : $\bar{B}_d^0 \rightarrow D^{*+} \ell \bar{\nu}_\ell$, the \bar{B}_d^0 meson life-time was found to be :

$$\tau(\bar{B}_d^0) = (1.532 \pm 0.041 \pm 0.040) \text{ ps}$$

- In a sample of 270 $J/\psi \rightarrow \ell^+ \ell^-$ candidates, a search was made for B_c^\pm decay channels containing a J/ψ particle. No signal above background was observed. This allowed to determine the following 90 % confidence upper limits on various branching ratio products (assuming $\tau_{B_c} = 0.4$ ps) :

$$\text{Br}(Z^0 \rightarrow B_c^\pm X) \times \text{Br}(B_c^\pm \rightarrow J/\Psi \ell^\pm \nu_\ell) < 5.8 \times 10^{-4}$$

$$\text{Br}(Z^0 \rightarrow B_c^\pm X) \times \text{Br}(B_c^\pm \rightarrow J/\Psi \pi^\pm) < 1.05 \times 10^{-4}$$

$$\text{Br}(Z^0 \rightarrow B_c^\pm X) \times \text{Br}(B_c^\pm \rightarrow J/\Psi \pi\pi) < 1.75 \times 10^{-4}$$

- Oscillations of B_d^0 mesons were studied in events with a large transverse momentum lepton. A limit on the mass difference between the physical B_d^0 states $\Delta m_S > 6.5 \text{ ps}^{-1}$ at 95 % C.L. was obtained.
- B_d^0 meson oscillations were studied using the charge of a lepton or the mean charge of an event hemisphere to sign the presence of a produced b or a \bar{b} quark, and using the charge of a lepton of large p_t or of a D^* to

sign the presence of a decaying B or \bar{B} meson. The mass difference between the physical B_d^0 states was found to be $\Delta m_d = 0.497 \pm 0.035 \text{ ps}^{-1}$.

- Studies of the global aspects of hadronic Z^0 decays led to the following results :
 - i) Evidence for chain-like charge-ordered particle production along the thrust axis has been observed confirming a fundamental and long-standing prediction of string-like fragmentation models. The weak coupling between the rank of a particle in the string and its position in the rapidity chain allows this effect to be studied. The JETSET and HERWIG models both agree with the data.
 - ii) An inclusive measurement of the average multiplicity of gluons splitting into $b\bar{b}$ pairs in Z^0 decays has been made : $g_{b\bar{b}} = (0.21 \pm 0.11 \text{ (stat)} \pm 0.09 \text{ (syst)}) \%$.
A check with a different method, looking for events with four b quarks in the final state, gave a result compatible with this within its substantially larger errors. This result is also compatible with theoretical expectations and with the JETSET model prediction of 0.16 %.
 - iii) A sample of about 1.4 million hadronic Z decays, selected among the data recorded during 1994, was used to measure for the first time the momentum spectra of K^+ , K^0 , p, Λ and their antiparticles in gluon and quark jets. As observed for inclusive charged particles, the production spectra of identified particles were found to be softer in gluon jets than in quark jets, with a higher total multiplicity.
 - iv) The spin density matrix elements for the ρ^0 , $K^{*0}(892)$ and ϕ produced in hadronic Z^0 decays were measured. There is no evidence for spin alignment of the $K^{*0}(892)$ and ϕ in the central region $x_p \leq 0.3$ ($x_p = p/p_{\text{beam}}$), where $\rho_{00} = 0.33 \pm 0.05$ and $\rho_{00} = 0.30 \pm 0.04$, respectively. In the fragmentation region, $x_p \geq 0.4$, there is some indication for spin alignment of the ρ^0 and $K^{*0}(892)$, since $\rho_{00} = 0.43 \pm 0.05$ and $\rho_{00} = 0.46 \pm 0.08$, respectively. The off-diagonal spin density matrix element ρ_{1-1} is consistent with zero in all cases.
 - v) A reanalysis of scaling violation in the fragmentation function of gluons and quarks of various flavours has been performed using DELPHI (1.75 million hadronic events) and other e^+e^- annihilation data at centre of mass energies $14 \leq \sqrt{s} \leq 91.2$ GeV. A large scaling violation is observed, which is used to extract the strong coupling constant from a fit based on a numerical integration of the second order DGLAP evolution equations. The result is :
$$\alpha_s(M_Z) = 0.124^{+0.006}_{-0.007} \text{ (exp)} \pm 0.009 \text{ (theory)}.$$
 - vi) 4-jet events (two of the four jets being tagged as jets from c or b quarks) from 2.7 million multihadronic e^+e^- interactions were analyzed to determine the contribution of the triple-gluon vertex. From the two-dimensional distributions in the generalized Nachtmann-Reiter angle versus the opening angle of the two secondary jets the ratio of the coupling strength of the triple gluon vertex C_A to that of gluon bremsstrahlung C_F was found to be $C_A/C_F = 2.51 \pm 0.028$, and the ratio of the number of quark colours N_C to the numbers of gluons N_A to be $N_C/N_A = 0.38 \pm 0.10$. These results agree with the QCD expectations, i.e. $C_A/C_V = 9/4$ and $N_C/N_A = 3/8$.

B. Analysis of the data at energies above the Z^0 peak.

- Hadronic decays :
Inclusive charged particle and event shape distributions have been measured from 321 events observed at the centre of mass energies of 130 and 136 GeV. The changes in these distributions with respect to Z^0 data are well described by fragmentation models. A method independent of fragmentation model corrections was used to determine α_s from the energy dependence of the mean thrust and heavy jet mass. The result is :
$$\alpha_s(133\text{GeV}) = 0.116 \pm 0.007 \text{ (esp.) } ^{+0.005}_{-0.004} \text{ (th.)}$$
- New phenomena :
 - i) A search has been made at $\sqrt{s} = 161$ GeV for excited leptons ($e^* \mu^* \tau^*$ and ν^*) decaying through γ , W or Z transitions. The search for pair produced excited leptons established the 95 % confidence limits : $m_{e^*} > 79.6 \text{ GeV}/c^2$, $m_{\mu^*} > 79.6 \text{ GeV}/c^2$, $m_{\tau^*} > 79.4 \text{ GeV}/c^2$, $m_{\nu^*} > 56.4 \text{ GeV}/c^2$.
 - ii) At a centre of mass energy of 161 GeV, just above the threshold for W-pair production, DELPHI accumulated data corresponding to an integrated luminosity of 9.93 pb^{-1} and observed 29-WW production candidates. From these, a cross section for the doubly resonant $e^+ e^- \rightarrow WW$ process of $3.67^{+0.97}_{-0.85} \pm 0.19 \text{ pb}$ has been measured. According to the standard model this cross section corresponds to a mass of the
W-boson :
$$m_W = (80.40 \pm 0.44 \text{ (stat)} \pm 0.09 \text{ (syst)} \pm 0.03 \text{ (LEP)}) \text{ GeV}/c^2$$

By fixing all Triple Gauge Couplings apart from one to their SM-values one obtains the 95 % confidence limits : $-1.9 < \alpha_{W\phi} < +2.0$ and $-1.1 < \alpha_W < 1.3$.

- iii) Correlations between pions from different W's in $e^+ e^- \rightarrow W^+ W^-$ produced at the centre of mass energy of 172 GeV has been studied. Within the statistical limits no enhancement of the correlation function for like sign pions has been observed at small Q-values. Fixing the value of the radius $r = 0.5$ fm, the Bose-Einstein correlation strength is found to be $\lambda = -0.20 \pm 0.22 \pm 0.08$.
- iv) The searches for stable or long lived charged (supersymmetric) particles carried out at the $\sqrt{s} = 91$ GeV have been extended to masses above 45 GeV/c² by using the data collected at center of mass energies $\sqrt{s} = 130 - 136, 161$ and 172 GeV. The analysis was based on particle identification provided by the TPC and RICH-detectors. Upper limits at 95 % confidence limit have been given for the cross-sections of pair produced charge $\pm e, \pm 2/3 e$ particles in the range of 0.4 - 2.3 pb for masses from 45 to 84 GeV/c². At the 95 % confidence level, long-lived charginos with masses ranging from 45 to 84 (80) GeV/c² for high (low) neutrino masses and left-handed (right-handed), long lived or stable muons and staus with masses between 45 and 68 (65) GeV/c² are also excluded.

II.3. STUDY OF ep COLLISIONS AT HERA - THE H1 EXPERIMENT.

(G. Bertrand-Coremans, M. Charlet, R. Chen, B. Clerbaux, E. De Wolf, L. Favart, R. Heremans, D. Johnson, P. Marage, R. Roosen, P. Van Esch, A. Rostovtsev and P. Van Mechelen).

In 1997, HERA has run very efficiently, from February to mid-October, delivering an integrated luminosity of 34 pb⁻¹, i.e. slightly more than the total luminosity accumulated from 1992 to 1996. Of these, 25 pb⁻¹ were collected by H1 for physics analyses. This includes two special runs (2 pb⁻¹) : minimum biased deep inelastic events and minimum biased photoproduction events, the latter being especially requested by members of the Brussels group, in the framework of the diffractive working group.

The running conditions and the data acquisition by H1 were smooth and stable. The detector components installed during the 1995-96 shutdown, after calibration in 1996, were fully operational and well under control in 1997 (in particular the backward calorimeter SPACAL and the backward drift chamber BDC).

The COP chambers, which are under the responsibility of the Belgian group, were functioning in a very stable way over the years. Apart for the 3 sectors (on a total of 32) which are down since 1992 because of a broken wire, the sector efficiencies ranged from 90 to 99 %. It is intended to open the COP chamber and repair the broken wire during the 1997-98 shutdown. The large apparatus necessary for the chamber dismounting and repair was designed, built and tested during the years 1996 and 1997.

The members of the Belgian group have taken part to the data taking, also providing the responsibility of a shift leader.

The main physics results obtained in 1997 are summarized below; all have been published or presented at the major conferences in the field of particle physics.

A. Measurement and QCD analysis of the proton structure functions.

The proton structure function $F_2(x, Q^2)$ has been studied at very low x ($x > 6.10^{-6}$) and Q^2 ($0.35 < Q^2 < 3.5$ GeV²) values, using data taken in 1995 during a run period when the interaction vertex was shifted with respect to the nominal position. The rise of F_2 with decreasing x was found to be less steep than for higher Q^2 values.

The longitudinal structure function $F_L(x, Q^2)$ has been determined for $8.5 < Q^2 < 35$ GeV² and $y = 0.7$, using the cross section measurement and a NLO QCD fit to $F_2(x, Q^2)$ at lower y values; the F_L value was determined to be $F_L = 0.52 \pm 0.03_{-0.22}^{+0.25}$ at $Q^2 = 15.4$ GeV², still affected by a large systematic error.

B. Diffractive interactions.

- Diffractive structure function :
The structure function $F_{2D}^3(x, Q^2, \beta)$ was measured for events with a large rapidity gap, including shifted vertex data, with $1.5 < Q^2 < 80 \text{ GeV}^2$. A Regge analysis of the data supports the presence of both pomeron and reggeon exchange, for $x/\beta < 0.05$. The pomeron intercept is $\alpha_{Pom} = 1.20 \pm 0.04$, i.e. significantly higher than for the soft pomeron. Within the present data, no evidence is found for a Q^2 dependence of α_{Pom} .
- Diffraction dissociation in photoproduction :
A triple Regge analysis was performed of photoproduction events with a large rapidity gap. The pomeron intercept was found to be $\alpha_P(0) = 1.068 \pm 0.016 \pm 0.022 \pm 0.041$ (model), in agreement with the value obtained from the total and elastic hadronic and photoproduction cross sections.
- Vector meson production :
The dependence on Q^2 and p_t^2 of the cross sections of the elastic electroproduction of ϕ mesons for $Q^2 > 6 \text{ GeV}^2$ and of the ρ meson electroproduction with proton diffractive dissociation for $Q^2 > 7 \text{ GeV}^2$ have been measured. The ratio of the proton dissociative cross section to the elastic ρ meson production cross section was found to be $0.65 \pm 0.11 \pm 0.3$ for $\langle Q^2 \rangle \sim 10 \text{ GeV}^2$ and $\langle W \rangle \sim 128 \text{ GeV}$. In both processes, the ρ mesons are mostly longitudinally polarized. In the Q^2 and W ranges $6 < Q^2 < 20 \text{ GeV}^2$ and $42 < W < 134 \text{ GeV}$, the elastic electroproduction of ϕ mesons is larger than in fixed target experiments at the same $\langle Q^2 \rangle$ but smaller $\langle W \rangle$. Elastically electroproduced ϕ mesons are mostly longitudinally polarized. The ratio of the cross sections for elastic electroproduction of ϕ and ρ mesons was found to be 0.18 ± 0.03 for $5 < Q^2 < 20 \text{ GeV}^2$, significantly larger than in photoproduction.

C. Hadronic final state studies.

- The charged particle transverse momentum spectra in deep inelastic scattering were measured as a function of x and Q^2 . The data provide evidence for a relatively large amount of parton radiation between the current and the remnant systems.
- A measurement of Bose-Einstein correlations in deep inelastic scattering has been performed. The observed source radii do not differ strongly from those measured in lower energy lepton-nucleon inelastic scattering and e^+e^- annihilation.
- The event shape variables (thrust, jet broadening and jet mass in the current hemisphere of the Breit frame) have been measured in deep inelastic events in the range $7 < Q < 100 \text{ GeV}$. The mean value of these variables were found to decrease with rising Q , i.e. the energy flow in the Breit current hemisphere becomes more collimated.
- A study of the evolution of the ep fragmentation function and charged hadronic multiplicity distributions in the Breit frame has been made as a function of Q . A comparison with e^+e^- annihilations gives strong support to the concept of quark fragmentation universality.
- The transition between photoproduction and deep inelastic scattering was investigated by measuring low Q^2 jets. The data are best described by QCD calculations which include a partonic structure of the virtual photon that evolves with Q^2 .
- Inclusive K^0 and Λ photoproduction has been studied at an average photon-proton centre of mass energy of 200 GeV in the transverse momentum range $0.5 < p_t < 5 \text{ GeV}/c$. Production rates were compared to those obtained in DIS at $\langle Q^2 \rangle = 23 \text{ GeV}^2$.
- The charged particle multiplicity structure in diffraction and non diffraction deep inelastic ep collisions has been measured.

D. Search for new particles.

- Both the ZEUS and H1 Collaborations have reported, on basis of the data accumulated up to 1996, an excess of events at high Q^2 , as compared to the standard model predictions. The excess was observed both in charged and in neutral currents. In spite of the limited statistics, these signals have attracted much interest and stimulated an intense theoretical activity. In particular, it has revealed that a rather large set of channels beyond the standard model (R breaking supersymmetry, leptoquarks) were not experimentally excluded. Using the 1997 data, work is going on to confirm this excess, or to attribute it to statistical fluctuations.
- New bounds for excited fermions production and the observation of real W boson production have been reported.

E. Preliminary results have been reported on :

- various variables characterizing semi-inclusive hadronic final states in diffractive interactions (thrust, energy flow, multiplicity, single particle momentum, ...)
- jets in photoproduction and in deep inelastic scattering, both in diffractive and non-diffractive interactions
- leading baryon production using the leading proton spectrometer and the forward neutron counter

II.4. STUDY OF pp COLLISIONS AT LHC - THE CMS EXPERIMENT.

(*W. Beaumont, T. Beckers, O. Bouhali, J. Detroy, F. Udo, J. Stefanescu, S. Tavernier, W. Van Doninck, C. Vander Velde, Ch. Van Dyck, P. Vanlaer, L. Van Lancker, J. Wulleman and V. Zhukov*).

The teams from the IIHE (ULB/VUB) and the UIA, in close collaboration with their colleagues from the U.C. Louvain-la-Neuve and the UMH, are embarked in the design and construction of the microstrip gas counters which will equip the forward part of the central tracker of CMS.

The progress made during 1997 is summarized below :

- construction of a full size mock-up of a module (three wheels) of the mechanical support structure of the MSGC's. It has allowed to test the stiffness of the system as well as the MSGC's mounting and fixing procedures,
- construction of a full size MSGC banana shaped sector containing eight fully equipped counters. This prototype has been tested in the laboratory (high tension tests, detection of dead channels and gas tightness) and later at CERN (beam tests) together with five other prototypes built in other laboratories. The analysis of these tests is in progress,
- extensive study of the operational conditions of MSGC's with various DME based gas mixtures. From the measurements of the signal amplitude, the detection efficiency and the spatial resolution for minimum ionizing particles as well as of the electron drift velocity and transverse diffusion coefficient in the counting gases, it was concluded that the triple gas mixture Ne/DME/CO₂ - 40/40/20 % performed satisfactorily at rates and magnetic fields required for trackers in future hadron collider experiment,
- the performances of a set of 5 MSGC's with passivated electrodes and assembled according to the CMS baseline specifications have been studied at the CERN PS T10 facility in an intense 3 GeV/c π -meson beam. Stability of efficiency and response to minimum ionising particles and heavily ionising fragments from nuclear interactions have been investigated and found to be adequate. No unexpected pathologies (such as the appearance of destructive sparks between anodes and cathodes) have been observed. Similar tests performed in a neutron beam at the U.C. Louvain-la-Neuve cyclotron are being analysed.

Although electrode passivation technology seems adequate to overcome sparking, alternative solutions, such as "GEM" and "MICROMEGAS", are still under investigation at the IIHE.

In parallel to these hardware activities the simulation study of the CMS detector is going on. In order to estimate the potential of CMS for the study of CP violation in the $B^0\bar{B}^0$ system and for the detection of the Higgs particle various problems affecting vertex and track reconstructions are being investigated.

III. TEACHING ACTIVITIES AND SEMINARS.

III.1. TEACHING ACTIVITIES (academic year 1996-1997).

- **D. Bertrand, O. Bouhali, B. Clerbaux, G. Coremans-Bertrand, P. Marage, J. Stefanescu, C. Vander Velde, P. Vanlaer, P. Vilain, J. Wickens and G. Wilquet** have contributed to the practical work for students attending the lectures of J. Sacton on "Physique des Particules Élémentaires", of P. Vilain on "Questions approfondies de physique des particules" and of D. Bertrand C. Vander Velde and G. Wilquet on "Simulation, prise et analyse de données". They organized specific practical work for students of the 3rd year in physics at the ULB.
- **D. Bertrand**
 - "Computer Principles" (26 h + 13 h exercises - 1st year University Studies in Sciences - ULB)
 - "Simulation, prise et analyse de données expérimentales" (partim for 10 h - DEA en physique théorique - 2^{ème} licence en physique - ULB)
 - He acted as "coordonnateur pédagogique en physique" at the Faculty of Sciences - ULB.
- **G. Bertrand-Coremans**
 - "Physique Expérimentale" (135 h of practical work - 1^{ère} candidature en sciences pharmaceutiques - ULB).
 - She acted as secretary of the "Commission de coordination pour la physique" at the Faculty of Sciences - ULB.
- **P. Bruyndonckx**
 - 20 h of practical work for the students attending the lectures of D. Johnson "Introduction to Physics II - Physics 103" at the Vesalius College
 - "Beeldvormingstechnieken" (7 h of practical work).
- **P. Bruyndonckx, C. De Clercq, R. Roosen and B. Van De Vyver** have contributed to the practical work for students attending the lectures of J. Lemonne on "Elementaire Deeltjes" - 1^{ste} licentie natuurkunde VUB.
- **E. De Wolf**
 - "Waarschijnlijkheidsrekening en statistiek" (30 h - 2^{de} kandidatuur natuurkunde - RUCA)
 - "Fundamentele wisselwerkingen tussen elementaire deeltjes" (30 h - 2^{de} licentie natuurkunde - UIA)
 - "Elementaire deeltjes fysica" (30 h - 2^{de} licentie natuurkunde - UIA).
- **A. Fremout**
 - "Algemene Natuurkunde" (30 h exercises - 1^{ste} kandidatuur wiskunde and natuurkunde - VUB).
- **B. Goorens**
 - Basiskennis informatica (80 h - analyst programmer A1 at the Industriële Hogeschool Anderlecht - Erasmus Hogeschool)
 - Bestandorganisatie en databanken (80 h - ibidem)
 - Data communicatie en netwerken (40 h - ibidem)
 - Labo systeemontwikkeling en eindwerken (80 h - ibidem)

He took part in the examination board at KTA - Anderlecht and at the Erasmus Hogeschool - Anderlecht.

- **R. Heremans**
"Algemene Natuurkunde II" (40 h exercises - 2^{de} kandidatuur natuurkunde, scheikunde, geologie - VUB).
- **D. Johnson**
 - "Introduction to Physics II - Physics 103" (45 h - Vesalius College - VUB)
 - "Introduction to Physics I - Physics 101" (45 h - Vesalius College - VUB)
 - "Engineering 231" (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).
- **J. Lemonne**
 - "Elementaire Deeltjes" (60 h + 60 h of practical work - 1^{ste} licentie natuurkunde - VUB)
 - "Algemene Natuurkunde II" (60 h + 60 h of practical work - 2^{de} kandidatuur natuurkunde en scheikunde VUB and 30 h + 30 h of practical work - 2^{de} kandidatuur geologie VUB)
 - "Algemene Natuurkunde" (90 h + 60 h practical work - 1^{ste} kandidatuur wis- en natuurkunde - VUB).
- **P. Marage**
 - "Histoire des sciences" (15 h - 2^{ème} licence en sciences physiques et sciences mathématiques - ULB)
 - "Physique" (60 h of practical work - 1^{ère} candidature Ecole de Commerce Solvay - ULB)
 - "Histoire des sciences en relation avec la pédagogie" (15 h - agrégation de l'enseignement secondaire - sciences physiques)
 - "Introduction à l'histoire de la physique du XX^{ème} siècle" (6 h for the CEPULB).
- **R. Roosen**
 - "Elementaire deeltjes II b - Electromagnetische and zwakke wisselwerkingen" (15 h - 2^{de} licentie natuurkunde - VUB)
 - Local coordinator of an ERASMUS-TEMPUS exchange program : European mobility scheme for physics students.
- **J. Sacton**
 - "Physique des Particules Élémentaires" (30h - 1^{ère} licence en sciences physiques - ULB)
 - Local coordinator of an ERASMUS student exchange programme at the level of the 3rd and 4th years in physics.
- **S. Tavernier**
 - "Detectie van Ioniserende Stralingen" (15 h + 15 h of practical work - 2^{de} licentie natuurkunde and bijzondere licentie medische fysica - VUB)
 - "Transmission lines" (practical work - 2^{de} kandidatuur natuurkunde - VUB).
- **C. Vander Velde**
 - "Physique générale" (60 h + 26 h exercices + 30 h practical work - 1^{ère} candidature en chimie, géologie, physique et mathématique - ULB)
 - "Simulation, prise et analyse de données expérimentales" (partim for 10 h - DEA en physique théorique - 2^{ème} licence en physique - ULB)
 - "Experimentarium" (8 h - 1^{ère} candidature en chimie, géologie, physique et mathématique - ULB).
- **W. Van Doninck**
"Elementaire deeltjes II a - Standard model van electrozwakke wisselwerkingen" (15 h - 2^{de} licentie natuurkunde - VUB).
- **A. Van Lysebetten**
"Algemene Natuurkunde II" (30 h practical work - 1^{ste} kandidatuur wiskunde and natuurkunde - VUB).

- **F. Verbeure**

- "Subatomaire fysica" (30 h - 1^{ste} licentie natuurkunde - UIA)
- "Numeriek rekenen" (15 h + 15 h of practical work - 1^{ste} licentie natuurkunde - UIA)
- "Radioactiviteit" (15 h - 2^{de} licentie natuurkunde - UIA)
- "Meten en simuleren" (15 h + 15 h of practical work - 2^{de} licentie informatica - UIA)
- "Detectoren voor deeltjesfysica" (15 h - 2^{de} licentie natuurkunde - UIA).

- **P. Vilain**

- "Questions Approfondies de Physique des Particules" (partim for 15 h + 45 h of practical work - 2^{ème} licence en physique - ULB).

- **G. Wilquet**

- "Simulation, prise et analyse de données expérimentales" (10 h - DEA en physique théorique - 2^{ème} licence en physique - ULB)
- "Technique de la physique expérimentale" (14 h + 14 h of practical work - 1^{ère} licence en physique - ULB).

The visits to CERN of the ULB students of the 3rd year in physics and of the VUB students in the last two years have been organized by P. Vilain and G. Wilquet and by W. Van Doninck, respectively.

III.2. Ph.D. THESES AND "MEMOIRES DE LICENCE" COMPLETED DURING 1997.

* **Ph D Theses.**

- **De Brabandere, Sabine** (UIA) : "The decay of the heavy lepton τ to three charged mesons". Promotor : F. Verbeure.
- **Lefébure, Véronique** (ULB) : "A measurement of the τ polarisation in e^+e^- interactions produced at LEP". Promotor : D. Bertrand.
- **Wulleman, Johan** (VUB - Toegepaste Wetenschappen) : "Study and development of integrated and radiation hard read-out electronics for capacitive tracking detectors". Promotor : J. Cornelis; supervisor : W. Van Doninck.

* **Mémoires de licence.**

- **Dautrebande, Martin** (ULB) "Détection de la désintégration muonique du tau dans l'expérience CHORUS". Promotor : P. Vilain.
- **Devos, Caroline** (ULB) "Contribution à la mise en place des compteurs à gaz à micropistes pour les roues avant-arrière du traceur de CMS". Promotor : C. Vander Velde, assistant : O. Bouhali.

III.3. SEMINARS.

The IIHE had the pleasure to welcome the following invited speakers :

- **P. Bloch** (CERN) : "Study of CP, T and CPT symmetries in the CP LEAR experiment at CERN".
- **Y. Sirois** (Ecole Polytechnique - Palaiseau) : "Observation of events at high x and very large Q^2 in ep collisions at HERA".
- **F. Udo** (NIKHEF - VUB) : "Applications of the microstrip gas counter (MSGC)".

- **A. Sharma** (CERN and University of Mulhouse) : "Discharge problems in microstrip gas chambers : problems and solutions".
- **P. Pralavorio** (CRN - Strasbourg) : "CMS performance for CP violation measurements and present experimental status".
- **J. Orloff** (LAPP - Annecy le Vieux) : "Cosmological constraints on particle physics".
- **S. Willocq** (SLAC) : "B Physics at SLD : lifetimes, mixing and search for $b \rightarrow sg$ decays".
- **A.M. Fiorello** (ALENIA) : "Microelectronic technologies for fabrication of large area particle detectors".

The following seminars were given by members of the IIHE :

- **Y. Brants** : "Introduction to the IIHE computing environment" - IIHE Brussels.
- **C. De Clercq** : "Het onderzoek van het oneindig kleine : de elementaire deeltjes, bouwstenen van de materie" - Uitstraling - permanente vorming VUB - Mechelen.
- **A. Fremout** : - "Development of a detector module for a new positron emission tomography scanner based on the use of avalanche photodiodes" - Studieavond biomedische ingenieurs techniek, Hoboken - "Nucleaire medische fysica stralingsdetector ontwikkeling" - Dag van de Jonge Vorser - VUB.
- **J. Lemonne** : "Elementaire deeltjes - Hoe elementair ?" - S^t Barbara College - Gent (Uitstraling VUB).
- **P. Marage** : - "Diffraction at HERA" - Université de Paris-Sud - Orsay - France and Centre d'Etude Nucléaires du CEA - Saclay - France
- "Galilée : réhabilité ou amnistié ?" - Extension de l'ULB - Libramont
- "Matière, forces et symétries" - Journée de contact avec les professeurs de l'enseignement secondaire - ULB Brussels.
- **S. Tavernier** : - "Avalanche photodiodes to read scintillator light as an alternative to photomultiplier tubes in positron emission tomography" - Beijing Institute for High Energy Physics - Beijing - China.
- "Micromegas, a new and promising concept in gas detector for ionising radiation" - Beijing Institute for High Energy Physics - Beijing - China and University of Science and Technology - China - Keda
- "Towards true digital medical x-ray radiography" - Beijing University (Beida) and University of Science and Technology China - Keda.
- **R. Vandenbroucke** : - "Introduction to Internet" - Teleport Brussels
- "Local Area Networks" - Siemens Brussels.
- **M. Vander Donckt** : "Neutrino oscillations and the CHORUS experiment" - Toho University - Funabashi - Japan.
- **G. Wilquet** : "On the mysteries of the omnipresent neutrino" - Toho University - Funabashi - Japan.

III.4. ORAL PRESENTATIONS AT SCHOOLS AND COLLABORATION MEETINGS.

- **D. Bertrand** : "Tau physics : production and decay"; lectures given at the IXth Annual graduate school of particle physics - Monschau - Germany.
- **O. Bouhali** : - "Test of MSGC's in a high rate environment"; student talk at the IXth Annual graduate school of particle physics - Monschau - Germany.
- "Results from the test of a MF1 prototype with cosmics"; CMS week - CERN
- "Summary of test beam results"; FWD MSGC meeting - Mons.
- **P. Bruyndonckx** : "The APD - PET project in Brussels"; 26th CRYSTAL-CLEAR meeting - CERN.
- **R. Chen** : "Amplifiers for APD's in PET"; February 97 - CRYSTAL-CLEAR meeting - CERN.
- **A. Fremout** : "APS readout of scintillators for PET"; February 97 - CRYSTAL-CLEAR meeting - CERN.
- **P. Marage** : "Exclusive vector meson production at HERA"; "diffraction" H1 working group - Saclay - France.
- **S. Tavernier** : "Test of APD readout of LSO, YAP and Lu AP for PET"; January 97 - CRYSTAL-CLEAR meeting - CERN.
- **G. Wilquet** : "Introduction to elementary particle physics"; lectures given at the Toho University - Funabashi - Japan.

IV. COMPUTER MATTERS : COMPUTING AND NETWORKING.

Management : R. Vandembroucke

Scientific staff : Z. Cekro

Logistic and technical staff : Y. Brants, G. Depiesse, D. Pirnay, G. Rousseau.

A. Management.

The management of the IIHE computer and network infrastructure and services is realised by R. Vandembroucke. She coordinates the tasks of the technical staff and regularly meets with them to ensure the follow-up of all tasks. She is responsible for all maintenance contracts as well for the insurance of all computer related equipment. She plans for system and network upgrades and holds contact with suppliers of IT equipment. Good communication between the computer group and the physicists is realised by the IIHE Computer Coordinating Committee which was installed in 1996. The members of this committee are : D. Bertrand, Y. Brants, C. De Clercq, J. Lemonne (replaced in September 97 by J. Sacton) and R. Vandembroucke.

B. Operations.

Y. Brants, G. Depiesse and G. Rousseau are sharing the day-to-day logistic tasks necessary to be done in the IIHE computing environment; these tasks include backups, printers maintenance and management of the redistribution of user equipment, follow-up of repairs ... and the very important user support. More specifically G. Depiesse takes care of the VMS cluster. G. Rousseau has in charge the network infrastructure and realises all cabling and network connections needed for the maintenance and extension of the IIHE local area network. He gives a first level support for Macs, PCs, VMS and Unix machines. Y. Brants takes care of software installation for all UNIX flavoured machines and PCs and gives high-level support for PCs and UNIX. Next to administrative tasks D. Pirnay creates web pages for the IIHE as well as for DECUS BELUX. She contributes also to the organisation of the DECUS BELUX Conferences and provides logistic support for the EuroDemo project.

C. Systems.

A DIGITAL Alphaserver 4000 with a CPU at 433 Mhz, 512 Mbyte memory and a raid controller, installed in July 1997, has solved the diskserving problems that created serious program execution delays and caused local network problems. This new diskserver is directly connected to the FDDI backbone ensuring in this way fast communication with the Alphastations. At the same time 6 disks of 4 Gbytes were acquired and integrated with the existing ones in the new raid array. Logical groups of disks were created for each experiment.

D. Networking.

There were few changes to the local area network infrastructure during 1997. The newly acquired Alphaserver was connected to the FDDI backbone. This connection showed clearly the advantage of having a backbone at a higher speed than the IIHE LAN at 10 Mbps. It showed also the performance of the Alphaserver and the Alphastations and it could be concluded that data transfer was limited by the 10 Mbps ethernet connection of the Alphastations. Heavy data transfer between the Alphaserver and an Alphastation also caused a full load of the ethernet segment on which the Alphastation is located and rendered other traffic on that network segment impossible. From these conclusions a plan to upgrade the IIHE LAN is drawn up.

Wide area networking has been a major problem during the largest part of 1997. Both the connections to CERN and DESY were bad. This bad situation started about March 1997 when most of the other European research networks transferred their international connections from Europanet to TEN-34 rendering the Belnet connection to Europanet almost useless. The situation was corrected during the second half of October when the connection of Belnet to TEN-34 became operational.

Officially the TEN-34 projects should stop at the end of June 1998 but will probably be prolonged till the end of December 1998. At the end of 1997 it was still not clear what could happen to the Belnet international connections at the end of TEN-34.

E. Scientific activities.

Zlatica Cekro worked essentially on ATM. She especially focused on network management issues related to IP over ATM. She is the group leader in the management workgroup for the TEN34-James tests in the frame of a TERENA taskforce on lower layers and is co-author of the report about the TEN34-James tests.

V. TECHNICAL R & D.

V.1. TECHNOLOGICAL TRANSFER FROM BASIC RESEARCH TO APPLICATIONS.

(P. Bruyndonckx, R. Chen, A. Fremout, Liu Xuan, F. Tallouf, S. Tavernier, W. Yongyang - Collaboration : Hammersmith Hospital (London), Royal Hospital (London)).

A small diameter Positron Emission Tomograph (PET) dedicated to animal imaging, using BaF₂ crystal and photosensitive wire chambers with tetrakis-dimethylamine-ethylene (TMAE), has been designed and built. It consists of 17 cylindrical rings with a 200 mm inner diameter and without inter-ring septa, thus allowing for 3D data acquisition and reconstruction. The instrument contains 2958 BaF₂ crystals 3x3x20 mm each.

In January 1997 the scanner was moved to the Institute of Cancer research at the Royal Marsden Hospital in London. In the summer of 1997 the readout electronics were upgraded to increase the maximum average speed from 15.000 events/s to 130.000 events/s. A further upgrade of the trigger logic was designed and its implementation is planned for the summer 1998. Both upgrades are done in collaboration with the University of Science and Technology in China. The dynamic imaging performance of the scanner was validated using tumour bearing rats. The uptake of Fluorodeoxyglucose (FDG) in the tumours was measured as a function of time. The FDG uptake rate constants, obtained using a Patlak plot, were in agreement with values published in the literature.

The ultimate performance of a PET scanner is obtained when all the scintillation crystals are readout individually. To study such a system we are developing detector modules using LSO crystals which are read out by Avalanche Photo Diodes (APDs). The initial design of such a detector module consists of a 2x8 matrix of square APD's measuring 3 mm. The APD matrix will be coupled to 16 individual LSO crystals measuring $3 \times 3 \times 10 \text{ mm}^3$. We obtained several samples of APDs produced by Hamamatsu. These samples were studied by measuring the capacitance, QE, gain, excess noise factor and dark current. In addition some amplifiers to read out the APDs were also tested.

In a first stage towards the construction of a new high resolution PET system only two detector modules will be build. To simulate a complete scanner with the two modules a rotating gantry was constructed to turn the two modules back and forth over 360° .

V.2. R & D ON HEAVY SCINTILLATORS.

(R. Chen, F. Tallouf and S. Tavernier - the Crystal Clear Collaboration - CERN, RD-18).

During 1997, the CRYSTAL CLEAR Collaboration has mainly pursued its systematic investigation of the properties of Pb WO_4 scintillators and of Cerium doped rare earth oxides.

Our studies of $\text{Lu Al O}_3 : \text{Ce}$ have confirmed that this is indeed a fast ($\tau = 17 \text{ ns}$) and luminous scintillator emitting at about 360 nm. However, all samples studied so far suffer from a strong self absorption of the scintillation light. This seriously limits the light yield in most applications. We tentatively ascribe this self absorption to Ce^{3+} ions at perturbed sites. We have, as yet, not been able to ascertain the nature of these perturbed sites.

V.3. R & D ON HIGH RESOLUTION TRACKING DEVICES BASED ON CAPILLARIES FILLED WITH LIQUID SCINTILLATORS.

(P. Annis, P. Vilain and G. Wilquet - the RD46 Collaboration CERN).

The tests of two prototypes of active targets made of capillaries which started in 1996 in the SPS neutrino beam have been pursued this year. Some 150 neutrino interactions were registered. A very good spatial resolution was obtained both with the classic optoelectronic chain and the Electron Bombarded CCD prototype. Despite this success, the interest of this technique in neutrino physics is decreasing because of the cost of the needed high mass targets and of the rapid progress made in the development of fast automatic emulsion scanning microscopes.

The R & D activities have thus been oriented towards the use of capillaries as vertex detectors for collider experiments, such as LHC-B at the CERN future proton-proton collider. Efforts are being made in order to produce fiber capillaries in thin ($\sim 2 \text{ mm}$) layers, to find radiation resistive scintillating liquids and to develop optoelectronic read-out systems able to cope with very high interaction rates (e.g. Vacuum Image Pipeline).

VI. TECHNICAL AND ADMINISTRATIVE WORK.

The members of the workshop staff were : J. De Bruyne, H. De Nil, J.P. Dewulf, L. Etienne, R. Gindroz, R. Goorens, E. Lievens, E. Raspoet, G. Van Beek, J. Vanbegin, R. Vanderhaeghe, L. Van Lancker, C. Wastiels with the help of M. Pins and R. Pins.

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

For the H1 experiment at DESY (Hambourg) the IIHE is responsible for the **Central Outer Proportional Chambers (COP)**. A tool has been developed and built for the COP extraction and insertion by L. Van Lancker, E. Raspoet and R. Gindroz. During the HERA shutdown period the COP has been extracted for maintenance and reinserted in the H1 detector using this tool by the people mentioned above. The maintenance of the COP detector and electronics has been achieved by C. Wastiels and H. de Nil with the help of R. Pins and M. Pins. All the technicians mentioned spent several periods at DESY to accomplish these tasks.

For the DELPHI experiment at the LEP collider of CERN, J.P. Dewulf and R. Goorens designed, build and tested new electronic boards for the central trigger. J.P. Dewulf spend 2 months at CERN to develop a new ZEUS daughter board. During several stays at CERN, R. Goorens ensured the maintenance of the forward muon chambers built in Belgium and the associated high voltage distribution and read out electronics. A small DELPHI muon detector has been installed and brought into operation at the IIHE with the help of L. Etienne. This set up well be used for the practical work of physics students.

The maintenance of the fiber trackers of the CHORUS neutrino experiment at CERN has been conducted by G. Van Beek with the help of E. Raspoet and R. Gindroz. This maintenance includes the opto-electronic chains for the read out of the fiber trackers. R. Pins and M. Pins contributed to the development of the nuclear emulsion target of CHORUS. This task required several stays at CERN.

For the CMS project at the **Large Hadron Collider (LHC)** of CERN a series of technical tasks had to be achieved to built and test the MSGC milestone prototype containing 8 detectors for a total of 4096 read out channels. M. Pins and R. Pins contributed to the production of the substrates and pitch adapters at SRON (Utrecht). They both contributed to the detector assembly including the ultrasonic wire bonding to the read out chips. The toolings for detector assembly were developed and built in the mechanical workshop under the responsibility of L. Van Lancker and with the help of E. Lievens, R. Gindroz and E. Raspoet. The carbon fibre composite multi substrate detector module has been built by L. Van Lancker and E. Lievens. For the electronics associated to the read out of this milestone prototype the following technicians made substantial contributions : L. Etienne, C. Wastiels, H. De Nil and R. Vanderhaeghen.

In the framework of the spin-off activity related to detector development C. Wastiels designed and constructed a constant fraction discriminator for the **Positron Emission Tomograph (PET)** now operational in the Amersham hospital in London. The installation and tests of the discriminator required several stays in London. J. De Bruyne was in charge of the logistic support of this activity.

C. Carlier contributed to logistic tasks for the DELPHI experiment.

The secretarial work was accomplished by R. Alluyn-Lecluse and M. Garnier-Van Doninck - assisted by M. De Schutter, M. Goeman, J. Liesen and D. Luypaert-Peymans. M. Pins has contributed to the maintenance of a documentation centre and has provided illustrations 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.

D. Bertrand was member of the commission in charge of selecting the candidates applying for a post of "premier assistant" at the physics department.

C. De Clercq was the Belgian representative at the HEPCCC Technical Advisory Subcommittee (HTASC).

E. De Wolf, C. Vander Velde and W. Van Doninck were members of the FWO-committee "Subatomic fysica".

D. Johnson was member of the Academic Standards Committee for Upperclassmen at the Vesalius College, VUB.

J. Lemonne has been the Belgian scientific representative in the CERN Council; he was member of the EPS-HEP board and of the Physics Research Training Grants Panel (TMR) of the EC. He was vice-dean of the Faculty of Sciences and president of the Department of Physics of the VUB until October 1997 when he became dean of the faculty. He was the representative of the Faculty of Sciences in the "Senate" of the VUB and chairman of the "Commissie Middelen en Personeel" of this Faculty. He was also a member of the "Commissie Begroting en Financiën" of the Vlaamse Raad voor Wetenschapsbeleid.

J. Lemonne and J. Sacton were members of the Scientific Commission "Hautes et Basses Energies" of the IISN.

J. Lemonne, J. Sacton and F. Verbeure were members of the Belgian Selection Committee of CERN fellows.

P. Marage was vice-dean of the Faculty of Sciences of the ULB and acted as expert at the "Commission des Finances" and at the "Commission du Patrimoine" of the ULB. He was associated member of the "Comité National de Logique, de Philosophie et d'Histoire des Sciences", member of the "Comité scientifique attaché au Musée des Sciences et des Technologies", of the Council of Altaïr, an ASBL devoted to the history of science (ULB) and of the local organisation committee of the XXth International congress of History of Science (Liège).

J. Sacton was member of the "Commission de Physique" at the FNRS. He was vice-chairman of the "Comité Scientifique attaché au Musée des Sciences et Technologies" of the ULB at Parentville and also acted as member of the "Groupe de Pilotage" preparing the visit at the ULB of experts from the Commission of European Rectors and as member of a committee in charge of proposing a reform of the administration. He was project co-ordinator of an INTAS programme intitled "Development of substrates suitable for use in radiation hard microstrip gas counters".

S. Tavernier acted as chairman of the physics department of the VUB since October 1997; he was member of the "Onderzoeksraad" and chairman of the "Facultaire onderzoekscommissie Wetenschappen" van de Onderzoeksraad. He is spokesman of the "Crystal Clear Collaboration (CERN, R & D18). He acted as project co-ordinator of the EC/INNOVATION project MICADO. He was member of the scientific advisory committee of the International Conference on Inorganic scintillators and their applications (SCINT 97) held in Shanghai - China.

R. Vandenbroucke acted as member and communication coordinator of the board of DECUS BELUX, as delegate of DECUS BELUX in the DECUS Europe Council, as Belgian representative in the Public Procurement Group of the European Commission. She was also delegate of the VUB at the Belgian ATM platform, member of the ATM platform symposium planning committee. At the VUB she was member of the ITI commission of the Faculteit Wetenschappen.

C. Vander Velde acted as chairperson of the physics department at the ULB.

W. Van Doninck acted as a Belgian representative in plenary ECFA and as a member of the Board of directors of the Belgian Physical Society.

F. Verbeure acted as vicerector of the UIA and ex-officio chairman or vice-chairman of a series of committees of that institution, among which the "Onderzoeksraad".

P. Vilain was the Belgian representative at the Restricted European Committee for Future Accelerators (RECFA).

G. Wilquet was member of the SPS Committee at CERN. He acted as Belgian representative on the Advisory Committee of CERN users and as project co-ordinator of an INTAS program intitled "A tracking detector based on capillaries filled with liquid scintillator using a read-out via electron bombarded charge coupled device for future experiments in elementary particle physics".

The following responsibilities were taken in the organisation

1) of the *DELPHI experiment* :

- **D. Bertrand** : representative of "Belgium" in the collaboration board (since October 97), member of the editor committee and of the committee in charge of selecting the conference speakers.

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- **J. Lemonne** : vice-chairman of the Collaboration Board and representative of "Belgium", representative of the IKW-IISN in the Finance Committee.
 - **J. Wickens** : project leader of the off-line software, member of the Executive Committee, of the Collaboration Board, of the physics steering panel and of the software steering panel.

2) of the *H1 experiment* :

- **E. De Wolf** : convener of the working group on energy flow and final states.
- **P. Marage** : convener of the working group on diffraction.
- **R. Roosen** : representative of "Belgium" in the Collaboration Board.
- **J. Sacton** : representative of the IISN-IKW in the Finance Committee.

3) of the *CMS experiment* :

- **W. Van Doninck** : member of the management board and of the collaboration board. He was deputy MSGC coordinator and chairman of the MSGC steering committee.
- **J. Lemonne** and **J. Sacton** : representatives of the IIKW and IISN, respectively, in the Finance Committee.
- **S. Tavernier** : member of the ECAL institution board.
- **C. Vander Velde** : member of the collaboration board and of the tracker institution board.

4) of the *CHORUS experiment* :

- **P. Vilain** : representative of the IIHE at the Collaboration Board and member of the committee in charge of supervising the designation of the conference speakers and the edition of contributions.
- **G. Wilquet** : convener of the committee "Detector and Emulsion".
- **P. Annis** : member of the group for the maintenance of the tracker system.

VIII. ATTENDANCE TO CONFERENCES, WORKSHOPS AND SCHOOLS.

VIII.1. CONFERENCES AND WORKSHOPS.

- International Europhysics Conference on High Energy Physics; Jerusalem - Israël : *J. Lemonne and W. Van Doninck*
- XVIIIth International Symposium on Lepton-Photon Interactions; Hamburg - Germany : *J. Sacton and G. Wilquet*
- Sixth Conference on the Intersections of Particles and Nuclear Physics; Big Sky - USA : *D. Johnson*
- International Workshop on Low x Physics; Madrid - Spain : *P. Marage*
- International Workshop on Interplay between Soft and Hard Interactions in Deep Inelastic Scattering; Heidelberg - Germany : *P. Marage*
- Particles and the Universe - Lake Louise Winter Institute 97; Lake Louise - Canada : *B. Clerbaux*
- The Irresistible Rise of the Standard Model; San Miniato - Italy : *C. De Clercq*
- Workshop on High Energy Cosmic Neutrinos; Marseille - France : *C. De Clercq*
- 5th International Workshop on Deep Inelastic Scattering and QCD - DIS 97; Chicago - USA : *E. De Wolf, P. Marage, R. Roosen and P. Van Mechelen*
- International Symposium on Multiparticle Dynamics; Frascati - Italy : *E. De Wolf and F. Verbeure*
- XXXIInd Rencontres de Moriond on Electroweak and Grand Unified Theories; Les Arcs - France : *M. Vander Donckt*
- OECD Megascience Forum on a Deep-Sea Neutrino Observatory; Taormina - Italy : *J. Sacton*
- Ringberg Workshop : New trends in HERA Physics; Tegernsee - Germany : *R. Roosen*
- Annual Scientific Meeting of the Belgian Physical Society; Hasselt - Belgium : *O. Bouhali, R. Chen, C. De Clercq, J. Sacton, M. Vander Donckt and W. Van Doninck*
- XXth International Congress of History of Science; Liège - Belgium : *P. Marage*

- Frontier Detectors for Frontier Physics - 7th Pisa Meeting on Advanced Detectors; Isola d'Elba - Italy : *P. Annis and C. Vander Velde*
- Scint 97 - Inorganic Scintillators and their Applications; Shangai - China : *R. Chen and S. Tavernier*

- Micromegas Workshop; Nantes - France : *P. Annis, S. Tavernier and P. Vanlaer*
- IEEE Nuclear Science and Medical Imaging Conference; Albuquerque - USA : *P. Bruyndonckx*
- International Workshop on High Resolution PET and Single Photon Imaging in Small Animals; Albuquerque - USA : *P. Bruyndonckx*
- ICCE/4 - Fourth International Conference on Composites Engineering; Hawaii - USA : *L. Van Lancker*
- CAD/CAM Systems; Veldhoven - the Netherlands : *L. Van Lancker*
- Rand - Axis User Pro-engineer Group Meeting; Genval - Belgium : *L. Van Lancker*
- Update Ansys 5.3 Workshop; CERN - Switzerland : *L. Van Lancker*
- Spreadsheet EXCEL Workshop; VUB - Belgium : *L. Van Lancker*
- DECT 97 Conference; London - UK : *R. Vandenbroucke*
- GSM 97 World Conference; Cannes - France : *R. Vandenbroucke*
- EURESCOM Workshop on IP over ATM and QOS; Heidelberg - Germany : *R. Vandenbroucke*
- ATM 97 Conference; Rennes - France : *R. Vandenbroucke*
- 2nd International Distributed Conference on Network; Madeira - Portugal : *R. Vandenbroucke*
- International Conference on Human Computer Interaction; San Francisco - USA : *R. Vandenbroucke*
- ITU Interactive 97; Geneva - Switzerland : *R. Vandenbroucke*
- DECUS Europe Symposium; Copenhagen - Danmark : *Y. Brants and R. Vandenbroucke*
- DECUS Belux Symposium; Mol - Belgium : *Y. Brants and R. Vandenbroucke*

VIII.2. SCHOOLS.

- The 1997 European School of High Energy Physics; Menstrup - Danmark : *B. Clerbaux, J. Stefanescu, Van de Vyver and A. Van Lysebetten* *B.*
- 9th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School); Monschau - Germany : *Bouhali, J. Detroy, R. Heremans and A. Van Lysebetten* *O.*
- 1997 ICFA School on Instrumentation in elementary particle physics - Guanajuato - Mexico : *T. Beckers*
- ALTERA - Westford USA : *B. Goorens*

IX. LIST OF PUBLICATIONS, REPORTS AND CONTRIBUTIONS TO CONFERENCES.

IX.1. PUBLICATIONS.

Neutrino Physics

- Production of D^* (2010) mesons by high energy neutrinos from the Tevatron
A.E. Asratyan et al.
Z. Phys. C76 (1997) 647-652
- Prompt ν_τ background in wide band ν_μ beams
B. Van de Vyver
Nucl. Instrs & Meth. A385 (1997) 91-99
- A search for $\nu_\mu - \nu_\tau$ oscillation with CHORUS at CERN
H. Shibuya et al
Nucl. Phys. B59 (1997) 277-282

e^+e^- physics

- Measurement of event shape and inclusive distributions at $\sqrt{s} = 130$ and 136 GeV
P. Abreu et al.
Z. Phys. C73 (1997) 229-242
- Search for lepton flavour number violating Z^0 decays
P. Abreu et al.
Z. Phys. C73 (1997) 243-251
- A precise measurement of the B_d^0 meson lifetime using a new technique
P. Abreu et al.
Z. Phys. C74 (1997) 19-32
- Search for neutral heavy leptons produced in Z decays
P. Abreu et al.
Z. Phys. C74 (1997) 57-71
- Search for new phenomena using single photon events at LEP1
P. Abreu et al.
Z. Phys. C74 (1997) 577-586
- A study of the reaction $e^+e^- \rightarrow \mu^+\mu^- \gamma_{ISR}$ at LEP and search for new physics at annihilation energies near 80 GeV
P. Abreu et al.
Z. Phys. C75 (1997) 581-592
- Measurement of $B_d^0 - \overline{B_d^0}$ oscillations
P. Abreu et al.
Z. Phys. C76 (1997) 579-598

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- Search for excited leptons in e^+e^- collisions at $\sqrt{s} = 161$ GeV
P. Abreu et al.
Phys. Lett. B393 (1997) 245-260
 - Search for stable heavy charged particles in e^+e^- collisions at $\sqrt{s} = 130 - 136, 161$ and 172 GeV
P. Abreu et al.
Phys. Lett. B396 (1997) 315-326
 - Measurement and interpretation of W-pair cross-section in e^+e^- interactions at 161 GeV
P. Abreu et al.
Phys. Lett. B397 (1997) 158-170
 - A measurement of α_s from the scaling violation in e^+e^- annihilation
P. Abreu et al.
Phys. Lett. B398 (1997) 194-206
 - Search for the B_c meson
P. Abreu et al.
Phys. Lett. B398 (1997) 207-222
 - Identified particles in quark and gluon jets
P. Abreu et al.
Phys. Lett. B401 (1997) 118-130
 - Measurement of correlations between pions from different W's in $e^+e^- \rightarrow W^+W^-$ events
P. Abreu et al.
Phys. Lett. B401 (1997) 181-191
 - Measurement of the transverse spin correlation in $Z \rightarrow \tau^+\tau^-$ decays
P. Abreu et al.
Phys. Lett. B404 (1997) 194-206
 - Measurement of the multiplicity of gluons splitting to bottom quark pairs in hadronic Z^0 decays
P. Abreu et al.
Phys. Lett. B405 (1997) 202-214
 - Measurement of the spin density matrix for ρ^0, K^{*0} (892) and ϕ produced in Z^0 decays
P. Abreu et al.
Phys. Lett. B406 (1997) 271-286
 - Observation of charge-ordering in particle production in hadronic Z^0 decay
P. Abreu et al.
Phys. Lett. B407 (1997) 174-184
 - Search for $B_S^0 - \overline{B_S^0}$ oscillations
W. Adam et al.
Phys. Lett. B414 (1997) 382-400
 - Measurement of the triple gluon vertex from double quark tagget 4-jet events
P. Abreu et al.
Phys. Lett. B414 (1997) 401-418

ep physics

- Search for excited fermions with the H1 detector
C. Adloff et al.
Nucl. Phys. B483 (1977) 44-64
- Measurement of charged particles transverse momentum spectra in deep inelastic scattering
C. Adloff et al.
Nucl. Phys. B485 (1977) 3-22
- A measurement of the proton structure function $F(x, Q^2)$ at low x and low Q^2 at HERA
C. Adloff et al.
Nucl. Phys. B497 (1977) 3-28
- Evolution of ep fragmentation and multiplicity distributions in the Breit frame
C. Adloff et al.
Nucl. Phys. B504 (1977) 3-23
- Scale influence on the energy dependence of photon-proton cross sections
S. Aid et al
Phys. Lett. B392 (1997) 234-242
- Determination of the longitudinal proton structure function $F_L(x, Q^2)$ at low x
C. Adloff et al.
Phys. Lett. B393 (1997) 452-464
- Measurement of event shape variables in deep inelastic ep scattering
C. Adloff et al.
Phys. Lett. B406 (1997) 256-270
- Low Q^2 jet production at HERA and virtual photon structure
C. Adloff et al.
Phys. Lett. B415 (1997) 418-434
- Observation of events at very high Q^2 in ep collisions at HERA
C. Adloff et al.
Z. Phys. C74 (1997) 191-205
- Diffraction dissociation in photoproduction at HERA
C. Adloff et al.
Z. Phys. C74 (1997) 221-235
- Bose-Einstein correlations in deep inelastic ep scattering at HERA
C. Adloff et al.
Z. Phys. C75 (1997) 437-451
- Proton dissociative ρ and elastic ϕ electroproduction at HERA
C. Adloff et al.
Z. Phys. C75 (1997) 607-618
- Photoproduction of K^0 and Λ at HERA and a comparison with deep inelastic scattering
C. Adloff et al.
Z. Phys. C76 (1997) 213-221

- Inclusive measurement of diffractive deep-inelastic ep scattering
C. Adloff et al.
Z. Phys. C76 (1997) 613-629

Hadron-hadron interactions

- Factorial moments and correlations in transverse momentum in π^+p and K^+p collisions at 250 GeV/c
N.M. Agababyan et al.
Phys. Lett. B393 (1997) 205-209
- Reactions with leading hadrons in meson-proton interactions at 250 GeV/c
N.M. Agababyan et al.
Z. Phys. C75 (1997) 229-236

Experimental techniques

- A new vertex detector mode of glass capillaries
P. Annis et al.
Nucl. Instrs & Meth. A386 (1997) 72-80
- Capillary detectors for high resolution tracking
P. Anis et al.
Nucl. Phys. B54 (1997) 86-91
- The optical alignment monitoring system of CHORUS (RASNIK)
J. Dupraz et al.
Nucl. Instrs & Meth. A388 (1997) 173-179
- The CHORUS experiment to search for $\nu_\mu \rightarrow \nu_\tau$ oscillations
E. Eskut et al.
Nucl. Instrs & Meth. A401 (1997) 7-74
- The H1 detector at HERA
I. Abt et al.
Nucl. Instrs & Meth. A386 (1997) 310-347
- The tracking, calorimeter and muon detectors of the H1 experiment at HERA
I. Abt et al.
Nucl. Instrs & Meth. A386 (1997) 348-396
- Performance study of a 3D small animal PET scanner based on Ba F₂ crystals and a photo sensitive wire chamber
P. Bruyndonckx, Liu Xuan, S. Tavernier and Zhang Shuping
Nucl. Instrs & Meth. A392 (1997) 407-413
- Performance of a small animal PET scanner based on photosensitive wire chambers
P. Bruyndonckx, Liu Xuan and S. Tavernier
IEEE transactions on Medical Imaging - December 1997 issue

Varia

- D'un infini à l'autre; physique des particules et cosmologie
P. Marage
"Réflexions", revue de l'Institut Emile Vandervelde n° 18 (1997) 6-7
- L'invention du vide
P. Marage
"Les Enigmes du vide", Sciences et avenir - n° de novembre-décembre (1997) 78-83
- Il y a cent ans : la découverte de l'électron
P. Marage
"L'écho des savants", organe des Jeunesses scientifiques de Belgique, n° 270 (1997) 15-18
- "Avant-propos" des Actes du Colloque "Les transports à Bruxelles - regards sur le futur" organisé par Objectif Recherche
P. Marage

IX.2. REPORTS.

- Search for $\nu_{\mu} - \nu_e$ oscillations at the CERN PS
N. Armenise et al.
CERN SPSC/97-21; SPSC/I216 (34 p.)
- A high sensitivity short baseline experiment to search for $\nu_{\mu} - \nu_{\tau}$ oscillation
A.S. Ayan et al.
CERN SPSC/97-5; SPSC/I213 (39 p.)
- Selection of hadrons for ϕ mu scanning
M. Vander Donckt
CHORUS note 97004
- Vibration study for the CMS-MSGC forward tracker
W. Van Doninck and L. Van Lancker
CMS note/1997-012
- Technical design report : A possible approach for the construction of the CMS forward-backward MSGC tracker
O. Bouhali et al.
CMS note/1997-081
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