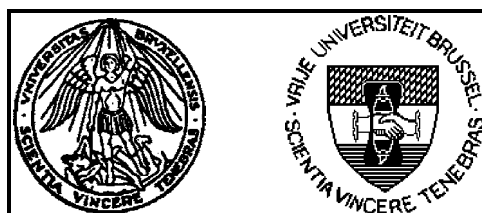


INTER-UNIVERSITY INSTITUTE FOR HIGH ENERGIES

ULB-VUB, BRUSSELS

ANNUAL REPORT 1998



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J. LEMONNE and J. SACTON,
April 1999.

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I. INTRODUCTION.

The work presented in this report is 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)** and the **Vlaams Instituut voor de bevordering van het wetenschappelijk-technologisch onderzoek in de industrie (IWT)**. Various R & D activities are supported by the European Community.

The scientists whose names are listed below have contributed to the various activities of the Institute in 1998.

U.L.B.

- P. Annis (boursier, région Sardaigne until July 1998)
 - L. Benussi (TMR fellowship from April 1998 until October 1998)
 - D. Bertrand (directeur de recherche FNRS; chargé de cours temps partiel)
 - G. Bertrand-Coremans (chef de travaux)
 - O. Bouhali (doctorant)
 - B. Clerbaux (boursière FRIA until October 1998; since then, assistant intérimaire)
 - C. Collard (boursière FRIA since October 1998)
 - G. De Lentdecker (boursier FRIA since October 1998)
 - R. El Aidi (doctorant)
 - M. Elamiri (doctorant until mid 1998)
 - V. Fanti (TMR fellowship from November 1998)
 - L. Favart (chargé de recherche FNRS)
 - X. Janssen (boursier FRIA since October 1998)
 - P. Marage (agrégé de faculté; chargé de cours temps partiel)
 - J. Sacton (professeur ordinaire)
 - J. Stefanescu (boursière FRIA)
 - F. Tallouf (doctorant)
 - M. Vander Donckt (doctorant "Fonds Van Buuren" until October 1998)
 - C. Vander Velde (chargé de cours associé)
 - P. Vanlaer (aspirant FNRS until October 1998)
 - 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 (chargée de recherche FNRS since October 1998) is presently at CERN
 P. Vanlaer presently at IreS Strasbourg is "collaborateur scientifique" at the ULB.

V.U.B.

- P. Bruyndonckx (IWT post-doc until August 1998; since then, wetenschappelijk medewerker FWO)
- R. Chen (VUBAROS fellow)
- C. De Clercq (logistiek medewerker FWO until October 1998; since then, onderzoeksdirecteur FWO)
- O. Devroede (wetenschappelijk medewerker FWO)
- A. Fremout (IWT scholarship)
- R. Heremans (wetenschappelijk medewerker FWO)
- F. Iacopi (wetenschappelijk medewerker FWO since February 1998)
- D. Johnson (hoogleraar VESALIUS College until September 1998; since then, doctor assistent VUB)
- J. Lemonne (gewoon hoogleraar)
- C. Mommaert (E.U.contract since September 1998)
- R. Roosen (onderzoeksleider FWO)
- S. Tavernier (onderzoeksdirecteur FWO)
- F. Udo (gastprofessor - deeltijds 20 %)
- W. Van den Boeck (wetenschappelijk medewerker FWO since October 1998)
- R. Vandenbroucke (logistiek medewerker FWO)

B. Van De Vyver (aspirant FWO)
 W. Van Doninck (onderzoeksdirecteur FWO)
 A. Van Lysebetten (wetenschappelijk medewerker FWO)
 V. Zhukov (vrijwillig medewerker until February 1998)

B. Van De Vijver stayed at CERN in the framework of the CHORUS Collaboration
 A. Van Lysebetten stayed at CERN from April to October as responsible person for the DELPHI forward muon chambers.

W. Beaumont, T. Beckers, M. Charlet, J. Detroy, E. De Wolf, 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, Z. Cekro and M. Hensmans 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.

A. The CHARM-II experiment.

(P. Vilain and G. Wilquet).

- Dimuon events observed in the CHARM-II detector have been analyzed to search for muonic photons. Such particles could be produced by internal radiation in the decays $\pi, K \rightarrow \mu + \nu_{\mu} + \gamma_{\mu}$ or by external radiation in the reaction $\mu + \text{Fe} \rightarrow \mu + \gamma_{\mu} + \text{Fe}$ occurring in the muon shielding; in the Coulomb field of the detector nuclei of charge Z they could lead to the reaction $\gamma_{\mu} + Z \rightarrow \mu^{+} + \mu^{-} + Z^{*}$. The distribution of the missing transversal momentum (w.r.t. the neutrino beam direction) of dimuon events doesn't show evidence for this process. A 90 % C.L. limit on the ratio of the coupling constants of muonic photons (α_{μ}) to "ordinary" photons (α) was set : $\alpha_{\mu} / \alpha < (1.5 \text{ to } 3.2) \times 10^{-6}$ for a neutrino mass in the range $m_{\nu_{\mu}} = (10^{-20} \text{ to } 10^5) \text{ eV}$. This result is about five times more accurate than previous estimates derived from the measurement of the anomalous magnetic moment of the muon.
- From a leading order QCD analysis of 4111 ν_{μ} and 871 $\bar{\nu}_{\mu}$ interactions containing a pair of opposite sign muons, the following results were obtained
 - $m_c = 1.79 \pm 0.38 \text{ GeV}/c^2$
 - $|V_{cd}| = 0.219 \pm 0.016$

where m_c is the mass of the charm quark and V_{cd} the corresponding CKM mixing matrix element. In addition, the strange quark content of the nucleon is found to be suppressed with respect to non-strange sea quarks by a factor $K = 0.39 \pm 0.09$.

B. The CHORUS experiment.

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

- This experiment has been designed to search for $\nu_{\mu} \rightarrow \nu_{\tau}$ oscillation through the observation in the CERN wide band ν_{μ} beam of charged current interactions $\nu_{\tau} + N \rightarrow \tau^{-} + X$, followed by the decay of the τ lepton. It uses a hybrid set up consisting of a nuclear emulsion target followed by electronic detectors. The data taking of

the experiment ended in November 1997; more than 10^6 neutrino interactions have been recorded in the emulsion target. At present about half of the data has been analyzed and no ν_τ interaction have been found, the τ^- decay channels investigated being $\tau^- \rightarrow \mu^- + \bar{\nu}_\mu + \nu_\tau$ and $\tau^- \rightarrow h^- + \nu_\tau + \text{neutrals}$. This negative result allows to put 90 % C.L. limits on the mixing angle $\sin^2 2\theta_{\mu\tau} < 1.8 \times 10^{-3}$ at large Δm^2 and on $\Delta m^2 < 1.1 \text{ eV}^2$ at maximum mixing.

- In the course of this study, an example of the diffractive production of D_S^* by charged current neutrino interaction has been identified via the observation of the following reactions sequence : $\nu_\mu + n \rightarrow \mu^- + D_S^{*+} + n \rightarrow \mu^- + D_S^+ + \gamma + n \rightarrow \mu^- + \tau^+ + \nu_\tau + \gamma + n \rightarrow \mu^- + \mu^+ + \nu_\mu + \bar{\nu}_\tau + \nu_\tau + \gamma + n$. The diffractive character of the production mechanism is established by small values of Q^2 ($0.8 \pm 0.1 \text{ GeV}^2/c^2$) and of the four-momentum transfer to the target nucleon ($1.1 \pm 0.4 \text{ GeV}^2/c^2$).
- During 1998, after removal of the emulsion target, the CHORUS detector was kept in operation in the CERN wide band beam for calibration purposes, tests of new tracking devices and active targets and search for very heavy neutrinos (analysis in progress).

C. The AMANDA experiment.

(D. Bertrand, C. De Clercq).

In July 1998, D. Bertrand joined the AMANDA collaboration. A new research project was built in collaboration with J.-M. Frère (professor in theoretical physics at the ULB), Freddy Binon (Directeur de recherches FNRS at the ULB) and C. De Clercq. The AMANDA collaboration groups the following universities and institutes :

- University of California, Berkeley, USA
- Lawrence Berkeley National Laboratory, USA
- University of California, Irvine, USA
- University of Wisconsin, Madison, USA
- Stockholm University, Sweden
- Bartol Research Institute, USA
- DESY-Zeuthen, Germany
- University of Pennsylvania, USA
- Kalman University, Sweden
- South Pole Station, Antarctica.

The experimental technique is based on the detection of the Cerenkov light produced by muons resulting from the interaction of neutrinos in the antarctic ice. The detector is made of strings of photomultipliers called optical modules deployed to a depth of 2 km into the ice at the south pole. It is a neutrino telescope able to detect these particles from a threshold energy of 20 GeV. The experimental studies will cover the galactic and extra galactic high energy neutrino production, the supernovae, the dark matter in the Universe and the neutrino oscillation. The second phase of the deployment of the detector (AMANDA II) started during the austral summer of 1997-1998. It will be finalised during the austral summer of 1999-2000. We shall participate to this installation by collaborating to the developments of the hardware and the software of the data acquisition system, most particularly the trigger part. Furthermore we will take part to the analysis of the data by looking to the generators of the simulation program and developing a strategy for the study of the GRB's (gamma ray bursts). We are also participating in the preparation of the Deep Ice Center, a multidisciplinary scientific project (particle physics, astrophysics, cosmology, geology, paleoclimatology, biology and education). This center will be built around an extension of the AMANDA detector to a km^3 volume; the project is presently submitted to the NSF (National Science Foundation - USA).

D. Future NEUTRINO programme.

(D. Bertrand, P. Vilain, G. Wilquet, M. Vander Donckt, B. Van de Vyver).

In the last couple of years various working groups and proto collaborations have been set up to prepare the next generation of neutrino experiments in Europe aiming at a coherent programme centred around the search for neutrino oscillations. Various signals for such oscillations have been reported already (solar neutrinos, atmospheric

neutrinos and low energy neutrinos from accelerators) which need, however, to be confirmed (or invalidated) and understood.

In this context, extensive discussions are under way about the construction of a neutrino beam from CERN to the Gran Sasso Laboratory, a proposal which is strongly recommended by the scientific committees of CERN and Gran Sasso laboratories.

The most natural way to extend our present neutrino activities would be to favour a two step programme including :

- a low energy neutrino experiment at the CERN PS (CERN - I216) to confirm, in different experimental conditions, the LSND signal for $\nu_\mu \rightarrow \nu_e$ oscillation.
- a long base line ν_τ appearance experiment in the Neutrino Gran Sasso (NGS) beam (the OPERA proposal) to complement the Super Kamiokande results.

An interesting alternative to step 1 would be to join an atmospheric neutrino experiment at the Gran Sasso Laboratory aiming, at the observation of the characteristic oscillation modulations in the relevant Δm^2 domain (SPSC/M615).

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

(D. Bertrand, C. De Clercq, J. Lemonne, W. Van den Boeck, C. Vander Velde, W. Van Doninck, A. Van Lysebetten, N. Van Remortel, F. Verbeure and J. Wickens).

Since 1995-96, the energy of LEP has been gradually increased with the goal to reach 100 GeV per beam by 1999. By the end of the 1998 runs, the maximum centre-of-mass energy reached was 189 GeV.

During the 1997-1998 winter shut-down, the muon chambers of the DELPHI detector had been flushed with a clean gas mixture. This allowed to restore their initial efficiencies which had dropped to about 70 % during the 1997 run.

The main results published in 1998 can be summarized as follows :

A. At the Z^0 peak.

1. The splitting of identified quark and gluon jets has been studied using longitudinal and transverse observables. Scaling violations in gluon jets were observed for the first time. The scale energy dependence of the gluon fragmentation function was found to be about two times larger than for the corresponding quark jets, consistent with the QCD expectation $\left(\frac{C_A}{C_F} = 9/4\right)$. The primary splitting of gluons and quarks into sub-jets agrees with the predictions of fragmentation models.

2. In multihadronic events the rapidity correlations for $\Lambda\bar{\Lambda}$ and $p\bar{p}$ pairs were found to agree with each other and with the string fragmentation model expectation. The correlation for $\Lambda\bar{p}$ pairs is unexpectedly smaller than for $\Lambda\bar{\Lambda}$ and $p\bar{p}$. For $\Lambda\bar{p}$ pairs there is evidence for short range compensation of strangeness whose range depends strongly on the rapidity difference of the baryon pair.

3. The b-quark mass at the M_Z scale defined in the \overline{MS} renormalization scheme has been measured as $m_b(M_Z) = 2.67 \pm 0.25(\text{stat}) \pm 0.34(\text{frag}) \pm 0.27(\text{th}) \text{ GeV}/c^2$ using some 2.8 millions hadronic decays. The values of the running b-masses at the M_Z and M_T scales were compared and their difference $m_b(M_Z) - m_b(M_T/2) = -1.49 \pm 0.52 \text{ GeV}/c^2$ agrees with the predicted QCD evolution.

4. The charged particle multiplicity of weakly decaying B-mesons was measured to be $4.97 \pm 0.03 \pm 0.06$, excluding K^0 and Λ decay products. This value agrees with previous measurements but has a smaller uncertainty.
5. Using a fit to the b-tagging probability distribution based on the impact parameter measurements from the microvertex detector, inclusive charmless and double-charm B branching ratios and the mean number of charmed particles per B decay have been measured :
- i/ $Br_{0C} = 0.033 \pm 0.021$, including B decays into hidden charm. This result leads to a truly charmless B branching ratio of 0.007 ± 0.021 , in agreement with the standard model prediction
 - ii/ $Br_{2C} = 0.136 \pm 0.042$
 - iii/ $N_C = 1.147 \pm 0.041$, slightly lower than the theoretical expectation (1.2 to 1.3).
6. Using D^{*+} mesons exclusively reconstructed, an excess of $66 \pm 14(\text{stat})$ events is observed in the $D^{*+} \pi^+ \pi^-$ final state at a mass of $2637 \pm 2(\text{stat}) \pm 6(\text{syst}) \text{ MeV}/c^2$ with full width smaller than $15 \text{ MeV}/c^2$ (95 % CL). This signal is interpreted as the first evidence for a radially excited D^{*1} ($J^P = 1^-$) meson.
7. The hadronic structure in the decay $\tau \rightarrow 3\pi\nu$ has been studied. The invariant mass of the 3π system, $m_{3\pi}$, has been fitted to the models of Kühn and Santamaria, of Isgur, Morningstar and Reader and of Feindt. Below $m_{3\pi}^2 = 2.3 \text{ GeV}^2$, all are in good agreement. Above that mass, anomalous behaviour is observed, consistent with a hitherto unobserved τ -decay mode through a radial excitation of the a_1 meson.
8. The π^\pm , K^\pm , p and \bar{p} normalized production rates, differential cross sections, multiplicities and the maxima ζ_p^* of the $\zeta_p = \ln(1/x_p)$ distributions were measured for $Z^0 \rightarrow q\bar{q}$, $Z^0 \rightarrow b\bar{b}$ and $Z^0 \rightarrow (u\bar{u}, d\bar{d}, s\bar{s})$ events and compared with the JETSET string fragmentation model and the HERWIG cluster fragmentation model. In general, JETSET describes the data better than HERWIG which fails for the proton data. This analysis has been made possible by the use of the RICH detectors which allow charged particle identification over the full momentum range from 0.7 to $45.6 \text{ GeV}/c$.
9. A search for the production of the η_c' meson, the first radial excitation of the ground state of charmonium η_c (2980), has been made in $\gamma\gamma$ reactions. No evidence of η_c' production is found in the mass region $3520 - 3800 \text{ MeV}/c^2$ of the $\rho^0\rho^0$, $K_S^0 K^+ \pi^-$, $K^{*0} K^- \pi^+$, $K_S^0 K_S^0 \pi^+ \pi^-$ and $K^+ K^- K^+ K^-$ final states. Assuming the same decay branching ratios for η_c and η_c' into these channels, the 90 % C.L. upper limit for the ratio of the 2γ widths of η_c and η_c' is found to be 0.34.

B. Above the Z^0 peak.

W boson properties.

- At $\sqrt{s} = 172 \text{ GeV}$, 118 events were selected as W-pair candidates from which the following results were obtained :
 - i. $Br(W \rightarrow q\bar{q}) = 0.660_{-0.037}^{+0.036} (\text{stat}) \pm 0.009(\text{syst})$
 - ii. $\sigma(e^+ e^- \rightarrow W^+ W^-) = 11.58_{-1.35}^{+1.44} (\text{stat}) \pm 0.32(\text{syst}) \text{ pb}$
 - iii. $m_W = 80.22 \pm 0.41(\text{stat}) \pm 0.04(\text{syst}) \pm 0.05(\text{int}) \pm 0.03(\text{LEP}) \text{ GeV}/c^2$

where "int" denotes the uncertainty from interconnection effects like color reconnection and Bose Einstein interference.
- Using a sample of about 100 W pairs collected at $\sqrt{s} = 161$ and 172 GeV , the value of the $|V_{CS}|$ element of the CKM matrix has been measured to be $0.91_{-0.14}^{+0.15} (\text{stat}) \pm 0.05 (\text{syst})$ from both the measured hadronic branching ratio of W^\pm decays and by tagging the flavour of hadronic jets produced in W^\pm decays.

- Trilinear gauge boson couplings have been measured using data corresponding to integrated luminosities of 10 pb^{-1} at both $\sqrt{s} = 161 \text{ GeV}$ and $\sqrt{s} = 172 \text{ GeV}$. Values of the CP conserving and CP violating WWV couplings (where $V \equiv Z, \gamma$), have been derived using data from topologies populated both by WW production ($e^+ e^- \rightarrow W^+ W^-$) and by single W production ($e^+ e^- \rightarrow W e \nu$). Limits on the ZV γ couplings were obtained from an analysis of the reaction $e^+ e^- \rightarrow \gamma + \text{inv. part.}$ No evidence for deviations from the standard model predictions was observed.

New particle searches.

- A search for charged Higgs bosons was performed at $\sqrt{s} = 172 \text{ GeV}$, assuming pair production and decays into a quark pair or into $\tau \nu_\tau$. The number of candidates found is compatible with the background expected from standard processes. Combining the result of this analysis with those obtained at lower energies ($\sqrt{s} = 130 - 136 \text{ GeV}$ and $\sqrt{s} = 161 \text{ GeV}$), one can exclude at a CL of 95 % the existence of charged Higgs bosons with masses below $54.5 \text{ GeV}/c^2$ (for all values of the decay branching ratio into hadrons).
- Negative searches for charginos, neutralinos and gravitinos performed at $\sqrt{s} = 161$ and 172 GeV , have allowed the exclusion of a large domain of the SUSY parameters.
- A search for neutral Higgs bosons was made at $\sqrt{s} = 161$ and 172 GeV assuming the production of the lightest such particle, h, to be associated with either a Z^0 boson or a neutral pseudoscalar Higgs boson A. All final state topologies expected for the decay of the h and A into hadrons or a τ lepton pair have been considered. The following lower mass limits at the 95 % CL were obtained :
 - $66.2 \text{ GeV}/c^2$ for the h in the standard model
 - $59.5 \text{ GeV}/c^2$ for the h and $51 \text{ GeV}/c^2$ for the A in the minimal supersymmetric extension of the standard model with sensible assumptions on the model parameters.
- A search for stable and long lived heavy charged particles has been made in leptonic and hadronic final states at energies from 130 to 183 GeV, using particles identified by the Cerenkov light in the RICH and the ionization loss measured in the TPC. No significant signal was observed leading to the following conclusions :
 - The upper limit (95 % C.L.) of the cross section for slepton and for quarks of charge $\pm 2/3 e$ varies between 0.06 and 0.5 pb in the mass range from 2 to $90 \text{ GeV}/c^2$.
 - The upper limit for hadronizing squarks varies between 0.15 and 0.5 pb in the mass range from 5 to $90 \text{ GeV}/c^2$.

QED tests.

The total and differential cross sections for the reaction $e^+ e^- \rightarrow \gamma \gamma(\gamma)$ have been measured at LEP centre of mass energies from 130 to 183 GeV. All results agree with the QED predictions. Lower bounds at 95 % CL were obtained for the QED cut-off parameters $\Lambda_+ > 253 \text{ GeV}$ and $\Lambda_- > 225 \text{ GeV}$ as well as on the mass of an excited electron $M_{e^*} > 231 \text{ GeV}$ for an effective coupling constant $\lambda_\gamma = 1$.

Others.

Two-particle angular correlations in jet cones have been measured at $\sqrt{s} = 91$ and 183 GeV . Comparison with QCD predictions using the **Local Parton Hadron Duality** (LPHD) has shown sizeable deviations. In view of the many approximations used and of the fact that the data are still far away from the asymptotic energy, these deviations are not surprising.

Most of these results were presented also at various international conferences and workshops.

At the IIHE we concentrated our efforts on

- The study of $\tau^+ \tau^-$ pairs.
- The determination of the W boson mass.

- The determination of the triple gauge bosons couplings (γWW , ZWW).
- The determination of the WW cross section.

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

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

In 1998, the HERA collider has been running from June to November with 820 GeV protons and 27.5 GeV electrons. This was the first run with electrons since 1994, when positrons were injected instead of electrons because of the rapid deterioration of the electron beam due to beam-gas interactions. The electron beam lifetime is now satisfactory. Successful tests were also performed with 920 GeV protons.

A total luminosity of 8pb^{-1} has been delivered to H1. A leak in the proton beam pipe slightly upstream of the H1 detector has led to serious deterioration of the data taking : a high level of charged particles emitted in beam-gas interactions has induced a severe instability of the tracker. As a result, a total luminosity of 4.7pb^{-1} only has been accumulated for physics studies by H1.

Under normal running conditions, the H1 detector has functioned in a stable and satisfactory manner. New pieces of equipment have performed efficiently, in particular the silicon tracking detector sitting inside the beam pipe and the forward proton spectrometer (high z , horizontal "Roman Pots"). A new trigger and event filtering scheme, intended at decreasing the event rate and selecting specific classes of events (in particular those characterised by the presence of a "hard scale") have worked successfully.

The COP chambers, which have been built at the IIHE and remain under the responsibility of the Belgian group, have been repaired during the 1997-1998 winter shutdown for the presence of a broken wire which has induced, since 1992, the loss of 3 azimuthal sectors on a total of 32. The repair implied the full uncabling and dismantling of the H1 central tracking detector, and - for the first time since 1990 - the dismantling of the COP chambers. The construction in the IIHE workshop in 1996-97 and the installation in Hamburg of specially designed high precision tools, have allowed the successful opening of the chambers and the repair of the broken wire. However, the repair revealed the presence of local deformations of the chamber wall in the region of the broken wire, which could only partly be cured. After reassembling of the chamber, 2 sectors are still inefficient.

In 1998, the interest concentrated on searches for new phenomena, precision studies of Quantum Chromodynamics in the presence of a hard scale (jets, high Q^2), measurement of the proton structure functions at very small x and Q^2 , intensive studies of diffraction and vector meson production. The main results of these studies are summarised below.

A. Diffraction.

Hadronic final state studies.

- The study of diffraction inclusive final states in deep-inelastic scattering focussed on :
- the p_t distribution of the thrust jet with respect to the γ^* pomeron axis,
 - energy flow, charged particle p_t spectra and "sea gull" plots,
 - charged particle multiplicity distributions and correlations.

Model independent comparisons with results of e^+e^- and hadron-hadron interactions, and comparison with predictions of Monte Carlo simulations indicate that, in a pomeron structure function approach based on diffraction factorisation, the pomeron can be described as a gluon dominated object. A good description of the data is provided using the parton density distribution in the pomeron extracted from the QCD DGLAP analysis of the inclusive

diffractive cross section. The data are also consistently described, in the photon fluctuation approach, with dominance of the $q\bar{q}g$ Fock state.

Jets in diffractive photo- and electroproduction.

Cross sections of jet production were measured in photo- and electroproduction. The results confirm the adequacy with the data of the approach based on a factorisable, gluon dominated pomeron, both for total and differential cross sections. In contrast, an approach based on the photon fluctuation in a $q\bar{q}$ system, with the diffractive interaction modelled as a gluon pair exchange, accounts for only a small part of the cross section. In resolved photoproduction, a breaking of factorisation due to spectator interactions cannot be excluded.

Leading baryon production.

Leading neutron production was studied with the H1 Forward Neutron Calorimeter, for $0.3 \leq z \leq 1$, where z is the fraction of the incoming proton momentum carried by the outgoing leading baryon. Leading proton production was studied with the Leading Proton Spectrometer for $0.7 \leq z \leq 0.9$.

A Regge model of leading baryon production which consists of pion, pomeron and secondary reggeon exchanges gives an acceptable description of both semi-inclusive cross sections in the region $0.7 \leq z \leq 0.9$. The leading neutron data are used to estimate for the first time the structure function of the pion at small Bjorken- x .

Vector meson production.

Quasi-elastic photoproduction of $\psi(2s)$ mesons has been measured to be $15 \pm 3 \pm 2$ % of that for J/ψ mesons, in agreement with QCD calculations.

B. Jet and large p_t particle production.

Jet production in deep-inelastic scattering.

Three analyses have been published about jet production in deep-inelastic scattering.

Dijet and multijet event rates lead to consistent measurements of the strong coupling constant :

$$\alpha_s \left(M_Z^2 \right) = 0.118 \pm 0.002(\text{stat}) \pm 0.007(\text{syst}) \pm 0.007(\text{model})$$

$$\alpha_s \left(M_Z^2 \right) = 0.117 \pm 0.003(\text{stat}) \pm 0.011(\text{syst}) \pm 0.006(\text{algorithm})$$

Dijet event rates have been studied in deep-inelastic scattering when $p_t^2 > Q^2$. Leading order models of point-like interacting photons fail to describe the data. Models adding resolved interacting photons or implementing the colour dipole model give a good description of the dijet event rate. This is also the case for next-to-leading order calculations including contributions from direct and resolved photons.

Forward jet and particle production.

Single particles and jets in deep-inelastic scattering at low x have been measured in the forward region, and azimuthal correlations have been studied between the forward jet and the scattered lepton. Models implementing the traditional DGLAP evolution and including only direct photon interactions grossly underestimate the amount of

perturbative radiation required. Also $O(\alpha_s^2)$ jet calculations predict less jet production. Models which include also the resolved photon component successfully describe all the data. BFKL calculations at leading order describe the strong rise of the forward single jet and particle cross-sections at low x . Calculations implementing the Colour Dipole Model provide sufficient QCD radiation to match the data.

Charged particle cross sections in photoproduction.

The p_t distributions of charged particles in photoproduction have been measured. Following model calculations based on perturbative QCD, these distributions were used to determine the leading order x_γ distributions of partons in the photon. The gluon content of the photon is extracted and found to rise with decreasing x_γ .

C. Search studies.

A search for events with an imbalance in transverse momentum and with isolated high energy leptons has been carried out. One event with an e^- and five events with a μ^\pm are found together with evidence for undetected particles carrying transverse momentum. Within the Standard Model the dominant origin of events with this kind of topology is the production of W bosons with subsequent leptonic decay. Three of the six events are found in a region of phase space likely to be populated by this process, while the remaining events show kinematic properties which are atypical of all Standard Model processes considered.

Members of the IIHE and the UIA were directly involved in three analyses :

1. Charged particle multiplicity studies in diffractive final states.

2. Low Q^2 proton structure function.

The analysis performed with the 1996 deep-inelastic events with initial state QED radiation allowed the extension of the measurement of the proton structure function at very low Q^2 and moderate x .

3. Elastic electroproduction of ρ mesons.

The elastic electroproduction of ρ mesons was studied in the Q^2 range $1 < Q^2 < 60 \text{ GeV}^2$ using the 1995 shifted vertex and the 1996 data. The skewing of the $(\pi\pi)$ mass distribution and the t -dependence of the ep cross section were studied as a function of Q^2 . The Q^2 dependence of the γ^*p cross section is well parameterised as $d\sigma/dQ^2 \propto (Q^2 + m_\rho^2)^{-n}$, with $n = 2.25 \pm 0.09$. The W dependence of the γ^*p cross section is found to be steeper than in hadron-hadron interactions, especially at high Q^2 . The full set of 15 spin density matrix elements was studied for the first time, as a function of Q^2 , W and t . It was found that s-channel helicity conservation is violated at the level of $8 \pm 3 \%$ by the single-flip amplitude $T_{\lambda_\rho = 0, \lambda_\gamma = 1}$, where λ_ρ and λ_γ are the ρ meson and photon helicities.

In addition, preliminary studies are being performed of the physics relevance and technical feasibility of the installation of a new forward proton spectrometer ("Roman Pots"), to be installed after the scheduled luminosity upgrade in the far away ($\sim 200 \text{ m}$), "cold" region of HERA.

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

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

- In November 1997 a full size MSGC banana shaped sector built at the IIHE and containing eight fully equipped counters has been tested with five other prototypes built in other laboratories in a muon beam at CERN. The main results of these tests are as follows :
 - good uniformity of the response of all tested counters ($\pm 11\%$); the observed variations could be accommodated by small modifications of the high voltage applied to the various sectors
 - constant gain along the non parallel strips resulting from the trapezoidal shape of the counters
 - acceptable variation of the spatial resolution with the inter-anode distance-d (38 to 44 μm for d-varying from 220 to 240 μm)
 - in 4 out of the 6 tested sectors the drift plane resistivity was too high to allow a stable operation for drift fields above 9 kV/cm. Reducing this resistivity permitted to reach without problem the requested drift field of 12.5 kV/cm
 - too many dead strips (due to construction mistakes) prevented to test the sector response to charged particles traversing the free space between two counters.
- The first MSGC's substrates produced by IMEC were delivered in September 98 and tested at CERN in October and at PSI in November in intense pion beams. At PSI, the rate of inelastic interactions producing heavily ionising particles is such that the experimental conditions mimic the LHC running conditions. The IMEC substrates with quite thick strips were found to be more robust than those previously produced with thin gold strips.
- Various alternatives to the MSGC's - for which hard radiation still remains a problem - are being studied, such as MICROMEGAS, MICROMEGEM and MSGC's + GEM. This last option seems promising in solving the instability and discharge problems observed with the MSGC's. In addition, such a detector with two amplification stages has been tested in the muon hodoscope at the IIHE with various gas mixtures. The best results were obtained with Ar/CO₂ (70/30 %) and Ne/CO₂ (70/30 %) which were found to be faster in the electron collection than the best gas mixtures used in the MSGC's and do not contain DME, an inflammable and corrosive ingredient.
- Simulation of the CMS detector has been pursued in order to estimate its potential in the study of the B-hadrons properties :
 - the identification of b-jets has been investigated using b-tagging algorithms relying on the precise measurement of the transverse impact parameter provided by the tracker
 - the expected precision on the CP violation parameter $\sin 2\beta$ in the channel $B_d^0 \rightarrow J/\psi \phi$ has been evaluated.

III. ORGANISATION OF THE 6th INTERNATIONAL WORKSHOP ON DEEP INELASTIC SCATTERING AND QCD (DIS 98) .

The DIS 98 Workshop was held under the chairmanship of P. Marage at the Brussels Free Universities in April 1998; previous editions took place in Durham, Eilat, Paris, Rome and Chicago. Organized over a period of five days it was attended by more than 200 physicists. On the first day, plenary talks were delivered under the general title "From Chicago to Brussels, Highlights and Open Questions". During the next three days, four working group sessions were held in parallel. Gathering theorists and experimentalists, they covered the following topics : structure functions (proton and photon), diffraction, final states and spin physics. On the closing day, the working group conveners presented a summary for each of these parallel sessions. Final conclusions were drawn by J. Ellis.

The organisation of the workshop has benefited from the competence and dedication of many members of the secretarial and technical staffs of the Institute.

We acknowledge the financial support of DESY, the FNRS, the FWO, the ULB and the VUB.

The proceedings of the workshop were edited by G. Coremans and R. Roosen.

IV. TEACHING ACTIVITIES.

IV.1. TEACHING ACTIVITIES (academic year 1997-1998).

- **D. Bertrand, O. Bouhali, B. Clerbaux, G. Coremans-Bertrand, L. Favart, P. Marage, J. Stefanescu, C. Vander Velde, P. Vanlaer, P. Vilain, J. Wickens and G. Wilquet** (coordinator) have contributed to the practical work for students attending the lectures of J. Sacton on "Physique des Particules Elémentaires", of P. Vilain on "Questions approfondies de physique des particules", of D. Bertrand C. Vander Velde and G. Wilquet on "Simulation, prise et analyse de données" and of G. Wilquet on "Techniques de la physique expérimentale". They organized specific practical work for students of the 3rd year in physics at the ULB.
- **D. Bertrand**
 - "Computer Principles" (39 h + 13 h exercises - First 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 and seminars - 1^{ère} candidature en sciences pharmaceutiques - ULB).
 - "Mechanics II" and "Electricity and Magnetism" (42 h of practical work - First year University Studies in Sciences - ULB)
 - She acted as secretary of the "Commission de coordination pour la physique" at the Faculty of Sciences - ULB.
- **P. Bruyndonckx**
 - "Beeldvormingstechnieken (7 ½ h of practical work).
- **P. Bruyndonckx, C. De Clercq, R. Roosen, B. Van De Vyver and W. Van Doninck** have contributed to the practical work for students attending the lectures of J. Lemonne on "Elementaire Deeltjes" - 1^{ste} licentie natuurkunde VUB.
- **O. Devroede**
 - "Algemene natuurkunde" (15 h exercises - 1^{ste} kandidatuur 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 fysika (30 h - 2^{de} licentie natuurkunde - UIA).
- **A. Fremout**
 - "Algemene Natuurkunde" (15 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 met inbegrip van de kristallografie" (40 h exercises - 2^{de} kandidatuur natuurkunde, scheikunde, geologie - VUB).
- **D. Johnson**
 - "Physics I - Physics 103" (45 h - Vesalius College - VUB)
 - "Physics II - Physics 202 - Solid State Physics" (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**
 - "Algemene Natuurkunde" (90 h + 60 h practical work - 1^{ste} kandidatuur wis- en 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)
 - "Elementaire Deeltjes" (30 h + 30 h of practical work - 1^{ste} licentie 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 supérieur - sciences physiques - ULB)
 - "Approches des pratiques scientifiques" (15 h - 1^{ère} licence journalisme et communications - ULB).
- **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 a SOCRATES 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 + 46 h exercices + 44 h practical work - 1^{ère} candidature en chimie, géologie, physique, mathématique et polyvalente - 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, mathématique et polyvalente - ULB).

- **W. Van Doninck**
 - "Elementaire deeltjes II a - Standard model van electrozwakke wisselwerkingen" (15 h - 2^{de} licentie natuurkunde - VUB)
 - "Elementaire deeltjes - Inleiding" (3 h; 1^{ste} kandidatuur burgerlijk ingenieur 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)
 - Member of the PhD thesis jury of G. Brooymans (U.C. Louvain-la-Neuve).
- **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 two-days visit to CERN of the ULB students of the 3rd year in physics has been organized by P. Vilain and G. Wilquet.

P. Marage organized a visit of the IIHE for the students of the Athénée d'Ottignies.

IV.2. PhD THESES, "MEMOIRES DE LICENCE" AND "LICENTIAATSVERHANDELINGEN" COMPLETED IN 1998.

* Ph D Theses.

- **Clerbaux, Barbara** (ULB) : "Electroproduction élastique de mésons ρ à HERA". Promotor : P. Marage.
- **Van Esch, Patrick** (VUB) : "Studie van de p_t -afhankelijkheid bij de factorisatie van de diffractieve diep-inelastische werkzame doorsnede in een flux-factor en een diffractieve structuurfunctie aan de hand van gebeurtenissen waargenomen in het H1 experiment". Promotor : R. Roosen.
- **Vanlaer, Pascal** (ULB) : "Contribution to the study of the central tracking system of the CMS detector, at the future proton collider LHC". Promotor : C. Vander Velde.
- **Van Mechelen, Pierre** (UIA) : "Multiplicity structure of the hadronic final state in deep inelastic ep scattering". Promotor : E. De Wolf.

P. Marage has acted as co-promotor (with J. Reignier) for the PhD thesis of Y. Pierseaux : "La 'structure fine' de la théorie de la relativité restreinte".

* **"Mémoires de licence" and "licentiaatverhandelingen".**

- **Collard, Caroline** (ULB) "Production de bosons W réels à HERA". Promotor : P. Marage.
- **De Lentdecker, Gilles** (ULB) "Etude d'un compteur à gaz à grille microscopique (MICROMEGAS) pour un traceur au LHC". Promotor : C. Vander Velde.
- **Hermans, Davy** (VUB) "Bijdrage tot de verwerking van gegevens verzameld tijdens een bundelbestraling te CERN van een multi-substraat micro strip gas teller module". Promotor : W. Van Doninck.
- **Janssen, Xavier** (ULB) "Electroproduction diffractive de mésons ρ avec dissociation du proton à HERA". Promotor : P. Marage.
- **Van den Boeck, Wim** (VUB) "Bepaling van de werkzame doorsnede voor het proces $e^+e^- \rightarrow W^+W^-$ by 183 GeV". Promotor : J. Lemonne.

IV.3. SEMINARS.

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

- **J.J. Aubert** (CPPM Marseille) : "The ANTARES experiment".
- **K. Eggert** (CERN) : "FELIX, a full acceptance detector proposed for the Large Hadron Collider at CERN".
- **P.O. Hulth** (Stockholm University) : "AMANDA, the neutrino detector in deep ice".
- **L. Smirnova** (Moscow State University) : "Studying the physics beyond the Standard Model in rare semi-leptonic B-decays at LHC".
- **H. Weerts** (Michigan State University) : "Current and future results from the Tevatron".

The following seminars were given by members of the IIHE :

- **T. Beckers, O. Bouhali and J. De Troy** : "Review of the 8th International Wire Chamber Conference in Vienna" - IIHE - Brussels.
- **Y. Brants** : "Introduction to Windows NT for physicists" - IIHE - Brussels.
- **P. Bruyndonckx** : "Performance assessment and in-vivo imaging using the VUB-PET system" - Hammersmith Hospital - and Royal Marsden Hospital; London - U.K.
- **P. Marage** : - "L'histoire du vide" - Musée des Sciences et Techniques, Parentville - Belgium; also Physics Department ULB, seminar organized for secondary school teachers; also ALTAÏR, ASBL d'histoire des sciences de l'ULB
 - "Le vide" - Athénée Léon Lepage - Brussels - Belgium
 - "Autour du vide" - round table for the presentation of the book "Le vide, Univers du Tout et du Rien" - ULB
 - "Science et citoyenneté" - Musée des Sciences et des Technologies - Parentivelle - Belgium
 - "Diffraction at HERA and QCD" - CERN (CHORUS Collaboration)

- **S. Tavernier** : - "Ontwikkeling van instrumentatie voor de detectie van sub-atomaire deeltjes in the Interuniversitair Instituut voor Hoge Energie" - VUB (Bezoekdag SCK)
 - "Validation of the microgap chamber technology for digital radiography, specific mammography applications" - E.U. Innovation headquarters - Luxemburg
 - "The physics of scintillators and phosphors" - Doll-Schlumberger Research Institute - Richfield - USA
 - "The MICADO project" - IIHE - Brussels.
- **R. Vandenbroucke** : - "Introduction to Internet" - various seminars for schools in Brussels
 - "Introduction to networking" - various seminars for schools in Brussels
 - "Introduction to Windows NT" - IIHE - Brussels
 - "X 25" - Mobistar Charleroi - Belgium.
- **C. Vander Velde** : "News from the ECFA/DESY e^+e^- linear collider project" - IIHE - Brussels.
- **W. Van Doninck** : "MSGC's and their use in the CMS tracker at the LHC" - Universität Zurich - Switzerland.
- **P. Vanlaer** : "Etude du trajectographe de CMS : MSGC, reconstruction de traces et sélection des jets de quarks b" - IReS Strasbourg - France.

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

- **R. Chen** : - "Amplifiers for APD's in PET application"; talk at a Crystal Clear collaboration meeting at CERN - Switzerland
 - "Use of preshape 32 for the read-out system of a LSO/APD PET"; talk at a Crystal Clear collaboration meeting at CERN - Switzerland.
- **G. De Lentdecker** : "Study of a gas detector with micromesh (Micromegas) as tracker for the LHC"; student talk at the Annual CERN Summer Student School - CERN - Switzerland.
- **O. Devroede** : "Towards performance prototype of MSGC's at IMEC (Leuven, B)"; talk given at CMS tracker week - CERN - Switzerland.
- **A. Fremout** : "Avalanche photodiodes to read scintillator light as an alternative for photo multiplier tubes in PET"; talk at a Crystal Clear collaboration meeting at CERN - Switzerland.
- **R. Heremans** : - "Diffractive dissociation in photoproduction at HERA"; student talk at the 10th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School) - Ysermonde - Belgium
 - "Forward detector studies for Min Bias Run"; talk given at the "diffractive meetings" - DESY - Hamburg - Germany
 - "DIFFVM and PHOJET compared with 1997 data"; talk given at the "diffractive meetings" - DESY - Hamburg - Germany
 - "Forward detector studies for 1997 data"; talk given at the "diffractive meetings" - DESY - Hamburg - Germany
 - "Diffractive dissociation in photoproduction"; talk given at the "diffractive meetings" - DESY - Hamburg - Germany.
- **F. Iacopi** : "Towards a performance prototype of MSGC's at IMEC (Leuven, B)"; two talks at CMS Tracker weeks - CERN - Switzerland.
- **X. Janssen** : "Exclusive ρ meson production at HERA"; student talk at the 10th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School) - Ysermonde - Belgium.
- **R. Roosen** : "Diffractive physics at HERA"; Course given at the 10th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School) - Ysermonde - Belgium.

- **S. Tavernier** : "Scintillators and phosphors in medical imaging"; Lecture given at the 10th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School) - Ysermonde - Belgium.

V. COMPUTING AND NETWORKING.

Management : R. Vandembroucke

Scientific staff : Z. Cekro, Manuel Hensmans (since 1 November 1998)

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 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 users is realised by the IIHE Computer Coordinating Committee (D. Bertrand, Y. Brants, C. De Clercq, 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 takes care of 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 (workstations and PCs) and gives high-level support for PCs and UNIX. Y. Brants, G. Rousseau and R. Vandembroucke have installed Windows NT PCs and PC applications.

Next to administrative tasks D. Pirnay creates web pages for the IIHE and for DECUS BELUX. She contributed to the organisation of the DECUS BELUX Symposium and provides logistic support for the EuroDemo project.

C. Systems.

The CPU capacity has been increased. Three Digital workstations and 5 PCs have been added to the existing computers. The workstations contribute to the pool of generally available CPU power while the PCs provide individual CPU power. The PCs will gradually replace the black/white X-Window terminals which are not any longer adapted to the new network applications such as Netscape and mail with attached documents in PC formats. Moreover the administrative applications for the secretaries have been moved from MACintoshes to PCs and a first PC has been installed to do real-time measurements.

The disk capacity on the Digital Alpha diskserver has been increased; a total of 27 Gbytes, distributed over several experiments, has been added.

D. Networking.

Local area networking.

During 1998 a 100 Mbps ethernet has been installed. A high performance twisted pair cabling supporting speeds up to 1 Gbps has been put throughout the laboratory. A Xylan 100 Mbps ethernet/FDDI switch has been installed in parallel. All new workstations and PCs have been connected to this fast ethernet. The existing 10 Mbps

ethernet and the FDDI are totally integrated with this new ethernet. Equipment is attached to one of these types of local area network depending upon the needs of the user and the applications.

Wide area networking.

Wide area networking has been a major problem during the second half of 1998. Both the connections to CERN and DESY were bad. After Belnet connected to TEN-34 during October 1997 the European internet connections stayed good till about April 1998 after which date the performance gradually became worse. This bad performance is mainly due to the overload of some routers at the European Level (e.g. the Frankfurt router) and to the overload of the ULB/VUB connection to Belnet.

The TEN-34 project was prolonged till the end of 1998. In the beginning of December 1998 the first European connections to TEN-155, the new European research network, were put in place. Belnet connected to TEN-155 on the 23rd of December. The performance of the European connections are again good since that day.

E. Training activities.

R. Vandembroucke gave an initiation to Windows NT for all the interested people in the laboratory. Y. Brants explained the daily use of the Windows NT PC.

F. 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.

Manuel Hensmans started to work on the project that defines and realises an extranet for the province Vlaams-Brabant.

VI. TECHNICAL R & D.

VI.1. DEVELOPMENT OF INSTRUMENTATION FOR POSITRON EMISSION TOMOGRAPHY.

(P. Bruyndonckx, R. Chen, A. Fremout, F. Tallouf, S. Tavernier, in collaboration with the Royal Marsden Hospital - London and the Hôpital Universitaire de Genève).

The small animal PET scanner based on BaF₂ scintillation crystals and photosensitive wire chambers filled with TMAE, designed and built at the IIHE, is presently at the Institute of cancer research at the Royal Marsden Hospital in London. It is used for the development of new PET radiotracers for monitoring tumour response to anticancer treatment. It is hoped that this will provide a much earlier indication of the efficacy of new anticancer drugs than current methods (X-ray CT, MRI) allow. Currently FDG is the only available tracer for doing this kind of study, and we know that it is not selective for tumour cells or anti-cancer drug targets. The studies performed in 1998 were used to look at the changes in FDG uptake kinetics of experimental rat mammary tumours as they responded to hormonal manipulation. This model system allows the intercomparison of FDG PET as it is commonly applied in the clinic, with alternative PET radiotracers under development. Our interest so far has focused on the development of [¹²⁴I]-IUdR as a probe for tumour cell proliferation.

In the summer of 1998 a new iterative image reconstruction algorithm was implemented to improve the image quality for low statistic scans.

A design study is being made for the construction of a high resolution Positron Emission Tomography (PET) system based on avalanche photodiodes to read out LSO, a new fast ($\tau \approx 40$ ns) scintillator with a high light-

yield. A first step is to build a system with only two detector modules, mounted on a gantry, which allows them to rotate independently of each other. Thus, it will be possible to simulate a complete PET system. Each module consists of an APD array coupled to LSO. In order to understand more thoroughly how APD's work, some fundamental studies on the characteristics of APD's have been performed. Experimental results on gain, dark current, capacitance, excess noise factor and quantum efficiency were used to compare the theoretical noise formulae with the measured electronic noise. These studies were done with individual APD's of different sizes (3 mm diameter and 5 mm diameter) as well as with arrays (163 x 3 mm²) APD's, all of which were supplied by Hamamatsu. The main conclusion from these studies is that APD's are a valid alternative for photomultiplier tubes in PET. Individual coupling between APD and crystal will yield a very good signal to noise ratio, while for block-detector systems, where light sharing occurs, the high light-yield of LSO is clearly a benefit. Several possible coupling schemes of APD's and crystals have to be considered. The 32-channel preamplifier-shaper circuit RD20 Preshape 32, which was developed at CERN, is implemented to read out all the channels of the APD array.

In parallel with the construction, Monte-Carlo simulations are developed for this system. After matching the simulations with the real performance, they will be used as a starting point to develop simulations for a complete PET scanner based on the same principles.

VI.2. R & D ON HEAVY SCINTILLATORS.

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

The Crystal Clear Collaboration (RD-18) is an interdisciplinary network set up by CERN and involving solid state physicists with expertise in the study of scintillating phenomena, and instrument builders with expertise in several of the areas where scintillating materials are used, with the aim of finding new fast scintillators. In the beginning, the main aim of the project was to find a scintillating material which could be used at the new large hadron collider (LHC). The main materials studied were CeF₃, PbWO₄ and cerium doped hafnium glasses. On the basis of this study, the CERN management decided to equip the CMS experiment with a electromagnetic calorimeter using about 80 tons of PbWO₄ scintillator.

In many other applications the scintillating materials are used to detect low energy gamma rays in the range 100keV to 1 MeV. This is the case in gamma ray astrophysics, in nuclear medicine, and in most industrial uses of scintillators. Because of the low energy of the gamma rays, a high light yield scintillator is mandatory in such applications. There is also a need for faster scintillators. Traditional scintillators have a decay time of several 100 ns, which is slow compared to the possibilities of modern electronics. For example Bi₄ (GeO₄)₃ (BGO), which is one of the commonly used heavy scintillators today, has a decay time of 300 ns.

Partly as a result of our thorough study of CeF₃ scintillator as a candidate material for LHC, the scintillation properties of CeF₃ and of Ce³⁺ doped materials are now much better understood. We can predict that several heavy rare earth oxides doped with cerium or praseodymium are likely to be dense, fast and luminous scintillators. Indeed, excited Ce³⁺ ions exhibit a 4d → 3f allowed transition which gives rise to a fast, near UV or blue luminescence with a decay time of a few 10 ns. The interaction of a high energy gamma ray in the scintillator will, after a complex cascade of interactions, give rise to the creation of a number of electron-hole pairs. This number of electron-hole pairs is equal to the energy lost by the ionizing particle divided by the factor b.E_g, where E_g is the bandgap energy. The factor b is typically in the range 2-3. The light yield of a scintillator will mainly depend on the efficiency with which the energy contained in these electron-hole pairs is transferred to the scintillating Ce³⁺ centres. This transfer mechanism is complex since it may involve excitonic effects, carrier capture, carrier and exciton self trapping etc., and it is difficult to predict reliably if it will be efficient. In the ground state, the "4f" level of the Ce³⁺ ion is occupied by one electron, and this level usually lies in the lower energy region of the forbidden band gap. The empty "4d" level is 3.4 eV above the "4f" level. In rare earth oxides the 4f level is often situated about one eV above the top of the valence band, making hole capture by this centre a likely process. The energy transfer from electron-hole pairs to Ce³⁺ ions can in this case be described as a hole capture by Ce³⁺, followed by electron capture of the Ce⁴⁺ giving rise to an excited Ce³⁺ ion with one electron in the excited "4d" level. This electron will return to the ground state with emission of a scintillation photon.

One material belonging to this class is Cerium doped yttrium orthoaluminate, more commonly called yttrium aluminum perovskite or YAP. Since 1991, members of our network have been involved in developing this material together with the Czech company Preciosa. It has a moderate density (5.36 g/cc), but gives two times more

light than BGO, with a broad emission band centred around 370 nm, and a decay time of 30 ns. It can now be considered an established scintillator material. It is used in electronic microscope screens and several other applications are under development, e.g. it is being used by a group in Rome in a mammography scanner.

Another interesting cerium activated oxide is cerium doped lutetium orthosilicate ($\text{Lu}_2(\text{SiO}_4)\text{O}$ or LSO). It has a high density (7.41 g/cc), a decay time of 42 ns (but with some afterglow) and a light yield 5 times larger than BGO. It is difficult to produce material with constant properties, and the light is strongly non-linear below 100 keV. Both effects result in an energy resolution which is significantly worse than one would expect on the basis of the light yield.

The Crystal Clear Network is investigating a number of other dense rare earth perovskites, garnets and complex orthosilicates doped with cerium and praseodymium. One interesting material which is presently under study is $\text{LuAlO}_3:\text{Ce}$ (LuAP). It is very dense (8.34 g/cc) and fast (17 ns decay time), but its light yield is, in our present samples, only comparable to BGO. We will have to see if this is an intrinsic property of the material, or simply due to defects in our present samples.

VI.3. THE MICADO PROJECT.

(P. Bruyndonckx, C. Mommaert and S. Tavernier).

In the frame of the "INNOVATION" programme of the European Commission, a new project was launched under the name of MICADO, with the VUB as project-coordinator. The official starting date was August 1998 and a first term is set for 21 months.

The aim of the project is to validate the MicroGap Chamber (MGC) technology for digital radiography, specifically mammography applications as a replacement for photographic films or phosphor screens. This new detector will allow for more efficient mammography with possible dose reduction, high throughput, high resolution, digital storage and on-line inspection capabilities. It fits within the new approach of bringing medical files in a centralized hospital information system.

A demonstration radiographic imaging detector of $5 \times 5 \text{ cm}^2$ will be built, with newly developed blue light photocathode for operation in the gaseous environment of the MGC and with appropriate low noise readout electronics. The pre-production investigation for large area (commercialisable) systems will be executed as well.

The development is a joint effort between IMEC, VUB, INFN Pisa and the Weizmann Institute of Science, with Agfa-Gevaert and Electron Tubes Limited as industrial collaborators. The specifications for the medical validation study are given by Agfa-Gevaert.

VI.4. R & D ON HIGH RESOLUTION TRACKING.

(P. Annis, L. Benussi, V. Fanti, P. Vilain and G. Wilquet).

In the framework of a Training and Mobility of Researcher programme, the universities of Berlin, U.L. Bruxelles, Haifa, Münster, Napoli, Roma and NIKHEF are pursuing R & D studies with the objective to develop high resolution tracking devices based on thin glass capillary arrays filled with liquid scintillator. Because of high hit densities for traversing ionizing particles and a track resolution better than $10 \mu\text{m}$, the technique is attractive for high energy physics application, like micro-vertex devices or active targets for short-lived particle detection. Real-time read-out will be accomplished through a novel and highly compact design of an **Electron Bombarded CCD** (EBCCD) imaging tube using a megapixel CCD. A high resolution **Vacuum Image Pipeline** (VIP, capable of pipelining of order 10^3 frames) employing a similar technique will be developed to allow use of imaging techniques in extreme high rate environments.

The concept is based on coherent arrays of glass capillaries with an inner core diameter of order $10 - 20 \mu\text{m}$ filled with an organic liquid scintillator. Low level light signals from traversing ionizing particles will be transmitted

along the capillary fibre providing track images at the endface of the large area capillary bundle. Massively parallel signal amplification, gating/triggering and real-time read-out is accomplished through electronic imaging devices and vacuum image pipelines (VIP) based on a novel design of image intensifiers (II) and charge coupled devices (CCD's). In this novel concept, a thinned down (to 10 μm thickness), backside (photo)-electron bombarded charge coupled device (EBCCD) incorporated into the image intensifier tube is used to detect and store the spatial information. The key advantages of EBCCD imaging tubes are their extreme low light level detection sensitivity (photon counting level), their much enhanced signal-to-noise ratio, their large dynamic range, their excellent spatial resolution characteristics and their enhanced lifetime. Through their large gain, the presently used multi-stage amplification schemes become obsolete, thereby making such a new system highly compact, cost-effective and much superior to any commercially available light imaging system today.

These novel techniques will be developed for high energy physics applications, but there is also a significant application potential in astrophysics, medical diagnostics, biophysics, high speed photography with high speed image analysis, security systems and others. The Collaboration will also actively address these areas during the course of this project.

VII. TECHNICAL AND ADMINISTRATIVE WORK.

The members of the workshop staff in 1998 were : J. De Bruyne, H. De Nil, J.P. Dewulf, L. Etienne, R. Gindroz, R. Goorens, E. Lievens, E. Raspoet, G. Van Beek, 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.

The CHORUS experiment at CERN finished data taking in 1998. G. Van Beek and R. Gindroz contributed to the decommissioning of the CHORUS detector. In particular G. Van Beek organised the dismantling of the fibre tracker and its optoelectronic read out chains. He has also constructed a new demonstration device made of a scintillating fibres target read by an optoelectronic chain for the Microcosm permanent exhibition at CERN. For further analysis of the data, G. Van Beek contributed to the study, development, production and installation of the optical oil circulation system of the large stage and of the light box of the three new automatic microscopes at CERN. M. Pins and R. Pins contributed at CERN to the processing of the emulsion stacks.

For the H1 experiment at DESY, the COP multiwire proportional chamber has been dismantled from the central tracker for the first time since its installation in 1992. A dedicated extraction tool was finalised in the mechanical workshop during 1998 by E. Raspoet. The reason for dismantling COP was to get access to the outer chamber in which a broken wire was suspected to cause a short circuit in one of the chamber sectors which resulted in 3 non operational sectors out of 15. The repair occurred during January-February 1998. The opportunity was also exploited to improve gas tube and electrical connections which had suffered damage. One sector was completely recovered and the inefficiency on the 2 remaining ones was reduced by modifying the high voltage supply. The persons who contributed to this major intervention were L. Van Lancker, E. Raspoet, M. Pins and R. Gindroz from the mechanical workshop and C. Wastiels and H. De Nil from the electronics workshop.

The DELPHI experiment at the LEP collider at CERN has benefitted from the contributions of J.P. Dewulf and R. Goorens. J.P. Dewulf was responsible for the central trigger improvement, the maintenance of it and the MUF read-out and trigger hardware. R. Goorens ensured the maintenance of the front-end electronics, trigger and slow controls hardware of the Forward Muon detector.

For the CMS project, a series of Micro Strip Gas Counter (MSGC) prototype detectors have been built to be tested in various particle beams at CERN and PSI (Zürich). The mechanical assembly of these detectors has been performed under the responsibility of L. Van Lancker and achieved with the help of E. Lievens, E. Raspoet and R. Gindroz. The connections to the read out electronics and ditto testing have been performed by C. Wastiels, H. De Nil and L. Etienne. The mechanical assembly of a new cosmic hodoscope was the work of E. Lievens and E. Raspoet. The production of MSGC substrates at IMEC (Leuven) was performed with the help of R. Pins. She also

contributed to detector assembly and testing and in particular to the ultrasonic wire bonding of the strips to the read out chips.

In the framework of the spin-off activities related to detector development for medical applications, J. De Bruyne was in charge of the technical support of the PET project. He has designed and built a computer controlled gantry consisting of two independently rotating rings. This gantry will be used to simulate a complete scanner system. L. Etienne has adapted the pre shape circuit such that it can be used to read out APD's for a PET prototype module read out by such devices. C. Wastiels has been to the Royal Marsden hospital to install the upgrade for the discriminator module of the PET scanner. He also built a test circuit for the low noise read out of the APD's for the MICADO project.

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. Ch. Carlier took care of the DELPHI and CMS documentation and the running of the DELPHI data quality software.

VIII. REPRESENTATION IN COUNCILS AND COMMITTEES.

D. Bertrand acted as chairman of the "Ecole Doctorale en Physique Microscopique et Astrophysique" (ULB); he 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 in the HEPCCC Technical Advisory Subcommittee (HTASC) and in the European Particle Physics Outreach group depending from RECFA. She acted as member of the "Evaluatiecollege 42 - Kernfysica of IWT for the selection of PhD students and as public relation for the Vakgroep Natuurkunde VUB.

E. De Wolf was member of the "Onderzoeksraad" U.I.A. and U.A.

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

L. Favart acted as representative of the "corps scientifique non définitif" at the Council of the physics department (ULB) and as convenor of the "Radiative Effects Working Group" at the Workshop : "Monte Carlo Generators for HERA Physics".

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 dean of the Faculty of Sciences and member of the Council of the VUB. He was also member of the "Commissie Begroting en Financiën" of the Vlaamse Raad voor Wetenschapsbeleid and member of the "Nationaal Comité voor Natuurkunde" of the Belgian Academy of Sciences.

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. He was associated member of the "Comité National de Logique, de Philosophie et d'Histoire des Sciences", member (and since October, vice chairman) of the "Comité scientifique au Musée des Sciences et des Technologies", of the Council of Altaïr, an ASBL devoted to the history of science (ULB). He acted as referee for European Physical Journal C, as convenor of the session "Low Q^2 ,

soft phenomena, two photon physics" at the 29th International Conference on High Energy Physics (Vancouver - Canada) and organized the "Journée de contact du FNRS" sur "Les Relativités" (Brussels).

R. Roosen acted as co-covenor at the DESY Workshop on "Monte Carlo Generators for HERA physics" and at the DIS 98 Conference in Brussels (Diffractive Working Group). He also acted as referee for European Physical Journal C.

J. Sacton was member of the "Commission de Physique" at the FNRS. He was vice-chairman (until October) of the "Comité Scientifique au Musée des Sciences et Technologies" of the ULB at Parentville and member of the "Commission de recours contre les refus d'inscription d'étudiants" of the ULB.

S. Tavernier acted as chairman of the physics department of the VUB; 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 5th International Conference on positron sensitive detectors held in London - UK.

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 vice-chairperson of the physics department at the ULB.

W. Van Doninck acted as a Belgian representative in RECFA 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), until May 1998.

G. Wilquet was member of the PS and SPS Experiments Committee at CERN. He acted as Belgian representative on the Advisory Committee of CERN users and as member of the Advisory Committee of the "Neutrino Oscillations Workshop 1998 held at NIKHEF - Amsterdam.

The following responsibilities were taken in the organisation

1) of the *DELPHI experiment* :

- **D. Bertrand** : representative of "Belgium" in the collaboration board, member of the editor committee and of the committee in charge of selecting the conference speakers.
- **C. De Clercq** : project leader of the muon detector since September 1998.
- **J. Lemonne** : representative of the IIKW-IISN in the Finance Committee.
- **J. Wickens** : 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** : convenor of the working group on energy flow and final states.
- **L. Favart** : convenor of the Radiation Corrections Working group.
- **P. Marage** : convenor of the working group on diffraction.
- **R. Roosen** : representative of "Belgium" in the Collaboration Board.
- **J. Sacton** : representative of the IISN-IIKW in the Finance Committee.
- **P. Van Mechelen** : librarian of the H1 PHAN software package for physics analyses.

3) of the *CMS experiment* :

- **W. Van Doninck** : member of the management board, of the collaboration board, of the finance board and of the tracker steering committee. He was deputy MSGC coordinator and chairman of the MSGC steering committee.
- **J. Lemonne** and **J. Sacton** : acting as representatives of the FWO and FNRS, respectively, in the Resources Review Board.
- **C. Vander Velde** : representative of the belgian groups at the collaboration board and the tracker institution board.

4) of the *CHORUS experiment* :

- **P. Annis** : member of the group for the maintenance of the tracker system.
- **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** : convenor of the committee "Detector and Emulsion".

IX. ATTENDANCE TO CONFERENCES, WORKSHOPS AND SCHOOLS.

IX.1. CONFERENCES AND WORKSHOPS.

- The XXIXth International Conference on High Energy Physics; Vancouver - Canada : *D. Bertrand, C. De Clercq, J. Lemonne, P. Marage, J. Sacton and W. Van Doninck*
P. Marage was convenor of the session "Low Q^2 , soft phenomena, two photon physics"
- The XXXIIIrd Rencontres de Moriond - Weak interactions and unified theories; Les Arcs - France : *D. Bertrand, M. Vander Donckt and A. Van Lysebetten*
- International Nuclear Physics Conference 1998; UNESCO - Paris - France : *L. Favart*
- IInd International Conference on Dark Matter in Astro and Particle Physics; Heidelberg - Germany : *M. Vander Donck.*
- Neutrino 98; Takajama - Japan : *P. Annis*
- The Neutrino Oscillations Workshop; NIKHEF - Amsterdam - the Netherlands : *C. De Clercq, B. Van de Vyver, P. Vilain and G. Wilquet*
- The 6th International Workshop on Deep Inelastic Scattering and QCD; Brussels - Belgium : *B. Clerbaux, M. Charlet, G. Coremans, E. De Wolf, L. Favart, R. Heremans, D. Johnson, P. Marage, R. Roosen and J. Sacton*
- Workshop on Small-x and Diffractive Physics; Chicago - USA : *B. Clerbaux*
- Workshop on Diffractive Physics, LISHEP 98; Rio de Janeiro - Brasil : *P. Marage*
- Workshop on Low-x Physics at HERA; Zeuthen - Germany : *E. De Wolf, P. Marage and P. Van Mechelen.*
E. De Wolf was discussion leader of the session on "final states in DIS"
P. Marage was discussion leader of the session on "Diffraction"
- The IIIrd International Conference "Hyperons, Charm and Beauty Hadrons"; Genova - Italy : *J. Stefanescu*
- XXVIIIth International Symposium on Multiparticle Dynamics; Delphi - Greece : *P. Marage*
E. De Wolf was organiser of the session on "Hadronic final states in e^+e^- and DIS"
- Workshop "LC 98"; Paris - France : *C. Vander Velde*

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- Workshop "LC 98"; Frascati - Italy : *C. Vander Velde*
 - General Scientific Meeting of the Belgian Physical Society; FUNDP Namur - Belgium : *O. Bouhali, B. Clerbaux, C. De Clercq, O. Devroede, R. El Aidi, L. Favart, R. Heremans, F. Iacopi, J. Lemonne, J. Sacton, J. Stefanescu, M. Vander Donckt, C. Vander Velde, B. Van de Vyver, W. Van Doninck, P. Vanlaer, A. Van Lysebetten, P. Van Mechelen, P. Vilain and J. Wickens*
 - The First International Workshop on Nuclear Emulsion Techniques; Nagoya - Japan : *J. Sacton*
 - The 8th International Wire Chamber Conference; Vienna - Austria : *T. Beckers, O. Bouhali and J. De Troy*
 - 6th International Conference on Advanced Technology and Particles Physics; Como - Italy : *T. Beckers and C. Vander Velde*
 - Workshop on "Monte Carlo Generators for HERA Physics"; DESY - Hamburg - Germany : *L. Favart and R. Roosen*
 - The 4th Workshop on Electronics for LHC experiments; Roma - Italy : *W. Beaumont, J.P. Dewulf and C. Van Dyck*
 - 6th International Conference on Computer Methods in Composite Materials - CADCOMP 98; Montreal - Canada : *L. Van Lancker*
 - IEEE Nuclear Science Symposium and Medical Imaging Conference; Toronto - Canada : *P. Bruyndonckx and S. Tavernier*
 - International Week on Radiation Detectors in Life Sciences; Archamps - France : *R. Chen, A. Fremout, F. Tallouf and S. Tavernier*
 - CADCAM Systems; Veldhoven - the Netherlands : *L. Van Lancker*
 - Rand-Axis User Pro-engineer Group Meeting; Genval - Belgium : *L. Van Lancker*
 - Composite show workshop; Paris - France : *L. Van Lancker*
 - Pro Eng Workshop (Update Release 20); Louvain-la-Neuve - Belgium : *L. Van Lancker*
 - Conference on Broadband Communications in Education and Training; Cambridge - UK : *R. Vandenbroucke*
 - Telematics Applications Conference; Barcelona - Spain : *R. Vandenbroucke and Z. Cekro*
 - International Symposium on Services and Local Access; Venetia - Italy : *R. Vandenbroucke*
 - GINA project meeting; Kopenhagen - Danmark : *R. Vandenbroucke*
 - Symposium and Exhibition on Radio and Wireless Communications; Montreux - Switzerland : *R. Vandenbroucke*
 - Interworking 98 - International Symposium on Interoperability of Networks for Interoperable Services; Ottawa - Canada : *R. Vandenbroucke*
 - IFIP World Congress; Vienna/Budapest - Austria/Hungary : *R. Vandenbroucke*
 - Telematics for Research, project meetings; Florence - Italy : *R. Vandenbroucke*
 - ETSI General Assembly; Nice - France : *R. Vandenbroucke*
 - DECUS Europe General Assembly; Geneva - Switzerland : *R. Vandenbroucke*

- Workshop : Windows NT in High Energy Physics; Geneva - Switzerland : *Y. Brants and R. Vandenbroucke*
- DECUS Europe Symposium; Paris - France : *Y. Brants*
- Several Microsoft Technet meetings; Belgium - *Y. Brants*
- TERENA Task Force TEN (Trans-European Networking); Barcelona - Spain : *Z. Ceko*
- ATM FORUM EMAC meeting; Brussels - Belgium : *Z. Ceko*
- TERENA Task Force TEN (Trans-European Networking); Prague - Tchèque : *Z. Ceko*
- COST256 Modelling and Simulation Environment for Satellite/Terrestrial Networks; Istanbul - Turkey : *Z. Ceko*
- TERENA Working group for Lower Layer Technologies; Dresden - Germany : *Z. Ceko*
- TERENA Task force TANT (Testing Advanced Networking Technologies); Cambridge - UK : *Z. Ceko*.

IX.2. SCHOOLS.

- 10th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School); Ysermonde - Belgium : *C. Collard, O. Devroede, J. De Troy, R. Heremans, F. Iacopi, X. Janssen and W. Van den Boeck*
- HEP CERN School; St Andrews - UK : *O. Bouhali*
- European School of Medical Physics (ESMP) about Detectors for Medical Imaging; Archamps - France : *R. Chen and A. Fremout*
- *A. Van Lysebetten* attended a series of lectures on "C++ for particle physicists" given at CERN by P. Kunz.

With the help of G. Bertrand-Coremans and R. Alluyn, W. Van Doninck has been in charge of the practical organization of the 10th Annual Graduate School of Particle Physics (Aachen, Belgian, Dutch School) which took place in Ysermonde from 7 to 18 September.

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

X.1. PUBLICATIONS.

Neutrino Physics

- "A search for $\nu_{\mu} \rightarrow \nu_{\tau}$ oscillation"
E. Eskut et al.
Phys. Lett. 424B (1998) 202-212
- "Experimental search for muonic photons"
B. Akkus et al.
Phys. Lett. 434B (1998) 200-204

- "Search for $\nu_\mu \rightarrow \nu_\tau$ oscillation using the τ decay modes into a single charged particle"
E. Eskut et al.
Phys. Lett. 434B (1998) 205-213
- "Observation of neutrino induced diffractive D_s^{*+} production and subsequent decay $D_s^{*+} \rightarrow D_s^+ \rightarrow \tau^+ \rightarrow \mu^+$ "
P. Annis et al.
Phys. Lett. 435B (1998) 458-464

e^+e^- physics

- "Search for charginos, neutralinos and gravitinos at LEP"
P. Abreu et al.
Eur. Phys. J. C1 (1998) 1-20
- "Search for neutral and charged Higgs bosons in e^+e^- collisions at $\sqrt{s} = 161$ GeV and 172 GeV"
P. Abreu et al.
Eur. Phys. J. C2 (1998) 1-37
- "Measurement of the W-pair cross-section and of the W mass in e^+e^- interactions at 172 GeV"
P. Abreu et al.
Eur. Phys. J. C2 (1998) 581-595
- "Investigation of the splitting of quark and gluon jets"
P. Abreu et al.
Eur. Phys. J. C4 (1998) 1-17
- " π^\pm, K^\pm, p and p_{bar} production in $Z^0 \rightarrow qq_{\text{bar}}, Z^0 \rightarrow bb_{\text{bar}}, Z^0 \rightarrow uu_{\text{bar}}, dd_{\text{bar}}, ss_{\text{bar}}$ "
P. Abreu et al.
Eur. Phys. J. C5 (1998) 585-620
- "Charged particle multiplicity in $e^+e^- \rightarrow qq_{\text{bar}}$ events at 161 and 172 GeV and from the decay of the W boson"
P. Abreu et al.
Phys. Lett. B416 (1998) 233-246
- "Rapidity correlations in Λ baryon and proton production in hadronic Z^0 decays"
P. Abreu et al.
Phys. Lett. B416 (1998) 247-256
- " m_b at M_z "
P. Abreu et al.
Phys. Lett. B418 (1998) 430-442
- "Search for charged Higgs bosons in e^+e^- collisions at $\sqrt{s} = 172$ GeV"
P. Abreu et al.
Phys. Lett. B420 (1998) 140-156
- "Measurement of the trilinear gauge couplings in e^+e^- collisions at 161 GeV and 172 GeV"
P. Abreu et al.
Phys. Lett. B423 (1998) 194-206

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- "Measurement of the charged particle multiplicity of weakly decaying B hadrons"
P. Abreu et al.
Phys. Lett. B425 (1998) 399-412
 - Measurement of the inclusive charmless and double-charm B branching ratios"
P. Abreu et al.
Phys. Lett. B426 (1998) 193-206
 - "First evidence for a charm radial excitation, D*"
P. Abreu et al.
Phys. Lett. B426 (1998) 231-242
 - "A study of the hadronic resonance structure in the decay $\tau \rightarrow 3\pi\nu_\tau$ "
P. Abreu et al.
Phys. Lett. B426 (1998) 411-427
 - Measurement of the $e^+e^- \rightarrow \gamma\gamma(\gamma)$ cross section at the LEP energies"
P. Abreu et al.
Phys. Lett. B433 (1998) 429-440
 - "Measurement of $|V_{cs}|$ using W decays at LEP 2"
P. Abreu et al.
Phys. Lett. B439 (1998) 209-224
 - "Two-particle angular correlations in e^+e^- interactions compared with QCD predictions"
P. Abreu et al.
Phys. Lett. B440 (1998) 203-216
 - "A search for η'_c production in photon-photon fusion at LEP"
P. Abreu et al.
Phys. Lett. B441 (1998) 479-490
 - "A search for heavy stable and long-lived squarks and sleptons in e^+e^- collisions at energies from 130 to 183 GeV"
P. Abreu et al.
Phys. Lett. B444 (1998) 491-502

ep physics

- "Measurement of the inclusive di-jet cross section in photoproduction and determination of an effective parton distribution in the photon"
C. Adloff et al.
Eur. Phys. J. C1 (1998) 97-107
- "Thrust jet analysis of deep-inelastic large-rapidity-gap events"
C. Adloff et al.
Eur. Phys. J. C1 (1998) 495-507
- "Multiplicity structure of the hadronic final state in diffractive deep-inelastic scattering at HERA"
C. Adloff et al.
Eur. Phys. J. C5 (1998) 439-452

- "Observation of events with an isolated high energy lepton and missing transverse momentum at HERA"
C. Adloff et al.
Eur. Phys. J. C5 (1998) 575-584
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- "Photoproduction of $\Psi(2S)$ mesons at HERA"
C. Adloff et al.
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- "Hadron production in diffractive deep-inelastic scattering"
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- "Estimation of hydrodynamical model parameters from the invariant spectrum and the Bose-Einstein correlations of π^- mesons produced in $(\pi^+/K^+)p$ interactions at 250 GeV/c"
N.M. Agababyan et al.
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- "Self-affine scaling from non-integer phase-space partition in π^+/K^+p interactions at 250 GeV/c"
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Experimental techniques

- "Reconstruction of neutrino interactions observed in a liquid-core fibre detector"
K. Hoepfner, P. Vilain and K. Winter
Nucl. Instr. and Methods A406 (1998) 195-212
- "Capillary detectors"
J. Konijn et al.
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- "Tracking with capillaries and liquid scintillator"
P. Annis et al.
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- "The CHORUS scintillating fiber tracker and its monitoring systems"
P. Annis
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- "The CHORUS scintillating fiber tracker and opto-electronic readout system"
P. Annis et al.
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- "Operation of microstrip gas counters with DME-based gas mixtures"
O. Bouhali et al.
Nucl. Instr. and Methods A413 (1998) 105-118 and A419 (1998) 381
- "Test of a CMS MSGC tracker prototype in a high-intensity hadron beam"
D. Abbaneo et al.
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- "Studies of an MSGC equipped with a GEM grid as a tracking device"
W. Beaumont et al.
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- "Optical and scintillation properties of large size LuAlO₃:Ce³⁺ crystals"
C. Dujardin et al.
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- "The study of small and large size LuAlO₃:Ce³⁺"
C. Dujardin et al.
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- "The Crystal Clear network"
S. Tavernier
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- "Physics with e⁺e⁻ linear colliders"
E. Accomando et al.
Physics Reports 299 (1998) 1-78
- "Book review : Y.I. Frenkel, His work, life and letters"
P. Marage
Physicalia XXXIV, n° 2, p. 37-38
- "Chiraliteit in de wereld van de elementaire deeltjes"
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- "Pour une histoire du vide"
P. Marage
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X.2. REPORTS.

- "TOP - A prototype for the TOSCA experiment"
A.S. Ayan et al (TOSCA Collaboration)
CERN SPSC notes 98.2 and SPSC/M604 (21 pages)

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- "Search for $\nu_\mu \rightarrow \nu_e$ oscillations at the CERN PS - memorandum"
N. Armenise et al.
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 - "Search for $\nu_\mu \rightarrow \nu_e$ oscillations at the CERN PS - memorandum"
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 - "A high sensitivity short baseline experiment to search for $\nu_\mu \rightarrow \nu_\tau$ oscillation - Addendum to I213"
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 - "A high sensitivity short baseline experiment to search for $\nu_\mu \rightarrow \nu_\tau$ oscillation - Addendum to I213"
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 - "Measurement of trilinear gauge boson couplings in e^+e^- collisions at 183 GeV"
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 - "Measurement of trilinear gauge boson couplings WWV ($V \equiv \gamma, Z^0$) in e^+e^- collisions at 183 GeV"
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 - "A short historical survey of nuclear emulsion experiments in particle physics"
J. Sacton
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 - "Systematic studies of SPACAL performance using '96 QED - Compton events"
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 - "The trigger system of the CHORUS experiment"
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 - "MSGC test with fast neutrons"
W. Beaumont et al.
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 - "Performance of the CMS tracker - version V3"
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 - "CMS Forward-Backward MSGC milestone"
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 - "High rate behaviour and discharge limits in micro pattern detectors"
A. Bressan et al.
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- "Gas electron multiplier : performance and possibilities"
M. Negodaev et al.
hpe-ex/988 10009 - Lebedev Physics Institute - Moscow - Russia
- "Calibration of the IIIHE muon hodoscope"
O. Bouhali
Bulletin of the IIHE (ULB/VUB) 98.01
- "Spin-off from scintillator development at CERN"
S. Tavernier and P. Lecoq
in "Basic Science and Technology Transfer : Means and Methods in the CERN Environment"
CERN/BLIT 98-101
- "Science et Démocratie"
P. Marage
Le Journal de l'Education n° 5.

X.3. CONTRIBUTIONS TO CONFERENCES.

- "Neutrino dark matter search with accelerators"
M. Vander Donckt
IInd International Conference on Dark Matter in Astro- and Particle Physics; Heidelberg - Germany
- "Measurement of the trilinear gauge couplings at LEP 2 with the DELPHI detector"
C. De Clercq, J. Lemonne and A. Van Lysebetten
(presented by A. Van Lysebetten)
General Scientific Meeting of the Belgian Physical Society - FUNDP Namur
- "Differential distributions for electroproduction of ρ meson at HERA"
B. Clerbaux
Proceedings of the 6th International Workshop on Deep Inelastic Scattering and QCD - Ed. Gh. Coremans and R. Roosen - Brussels p. 312-314
- "Summary of the diffractive working group"
A. Gaussian et al. (R. Roosen)
Proceedings of the 6th International Workshop on Deep Inelastic Scattering and QCD - Ed. Gh. Coremans and R. Roosen - Brussels p. 801-816
- "Diffractive DIS : convention summary"
A. Gaussian et al. (R. Roosen)
Proceedings of the 6th International Workshop on Deep Inelastic Scattering and QCD - Ed. Gh. Coremans and R. Roosen - Brussels p. 312-314
- "Foreword"
P. Marage
Proceedings of the 6th International Workshop on Deep Inelastic Scattering and QCD - Ed. Gh. Coremans and R. Roosen - Brussels p. 312-314
- "Diffraction at HERA"
P. Marage
Review talk at the "Workshop on Diffractive Physics", LISHEP 98; Rio de Janeiro - Brasil (to be published)
- "Summary talk" of the International Workshop in Low x Physics; Zeuthen - Berlin
P. Marage

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- "Hard and Soft Diffraction : Vector Meson Production at HERA"
P. Marage
Review talk at the XXVIIIth International Symposium on Multiparticle Dynamics; Delphi - Greece (to be published)
 - "Vector meson production at HERA"
B. Clerbaux
Workshop on Small-x and Diffractive Physics; Chicago - USA
 - "Vector meson production at HERA"
B. Clerbaux
General Scientific Meeting of the Belgian Physical Society - FUNDP Namur
 - "Diffractive physics at HERA"
L. Favart
International Nuclear Physics Conference 1998 - UNESCO; Paris - France
 - "Final states in diffractive deep inelastic scattering"
P. Van Mechelen
Workshop on low-x-physics at HERA; Zeuthen - Germany
 - "Summary of the "Radiative effects working group"
L. Favart
Workshop on "Monte Carlo Generators for HERA Physics"; DESY - Hamburg - Germany
 - "Mid-term status report of the diffractive working group"
R. Roosen
Workshop on "Monte Carlo Generators for HERA Physics"; DESY - Hamburg - Germany
 - "QCD effects in elastic scattering processes"
R. Heremans
H1 Workshop "Cross talks"; DESY - Hamburg - Germany
 - "Tracking and b-tagging with the CMS central tracker"
P. Vanlaer
General Scientific Meeting of the Belgian Physical Society - FUNDP Namur
 - "CP violation in CMS : expected performance"
J. Stefanescu
General Scientific Meeting of the Belgian Physical Society - FUNDP Namur
 - "CP violation in CMS : expected performance"
J. Stefanescu
3rd International Conference on Hyperons, Charm and Beauty; Genoa - Italy (to be published)
 - "Results from a beam test of a milestone prototype system of Micro Strip Gas Counters for CMS"
O. Bouhali
General Scientific Meeting of the Belgian Physical Society - FUNDP Namur (1998)
 - "Operation of a Micro Strip Gas Counter equipped with a Gas Electron Multiplier"
W. Beaumont et al. (presented by C. Vander Velde)
6th International Conference on Advanced Technology; Como - Italy (to be published)
 - also poster by T. Beckers at the 8th International Conference on Wire Chambers; Vienna - Austria

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- "Operation of a microstrip gas counters with DME - based gas mixtures"
O. Bouhali et al. (presented by O. Bouhali)
Proceedings of the 8th International Conference on Wire Chambers; Vienna - Austria
published in Nucl. Instr. and Methods A419 (1998) p. 381

 - "Report on the CMS forward-backward MSGC milestone"
O. Pooth for the CMS forward MSGC collaboration
Proceedings of the 8th International Conference on Wire Chambers; Vienna - Austria
published in Nucl. Instr. and Methods A419 (1998) 375-380

 - "Recent test beam of CMS MSGC tracker prototypes"
D. Abbaneo et al.
Proceedings of the 5th International Workshop on B-physics at hadron machines; UCLA - USA (to be published)

 - "A short historical survey of nuclear emulsion experiments in particle physics"
J. Sacton
Invited opening talk at the International Workshop on Nuclear Emulsion Techniques; Nagoya - Japan (to be published)

 - "Automatic scanning of nuclear emulsions in the CHORUS neutrino oscillation experiment"
B. Van de Vyver
General Scientific Meeting of the Belgian Physical Society - FUNDP Namur

 - "Performance assessment and in-vivo imaging using the VUB-PET system"
P. Bruyndonck et al.
Proceedings of the IEEE Nuclear Science Symposium and medical imaging Conference; Albuquerque - USA (1997) p. 1-6

 - "Scintillators and phosphors in medical imaging"
S. Tavernier
Invited review talk at the "International week on Radiation Detectors and Imaging in Life Science"; Archamps - France

 - "A tunable light pulse generator to investigate properties of photodetectors"
D. Clement et al.
IEEE - N55 98 Conference; Toronto - Canada (to be published)