

**INTER-UNIVERSITY INSTITUTE FOR HIGH ENERGIES**

**ULB-VUB, BRUSSELS**

**ANNUAL REPORT 2004**



Vrije Universiteit Brussel

**INTER-UNIVERSITY INSTITUTE FOR HIGH ENERGIES**  
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**C. DE CLERCQ and D. BERTRAND**  
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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-Vlaanderen (FWO), the Fonds pour la Formation à la Recherche dans l'Industrie et dans l'Agriculture (FRIA), the Instituut voor de aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen (IWT), the Belgian Federal Science Policy Office and the European Union.

The scientists whose names are listed below have contributed to the various activities of the Institute in 2004.

### U.L.B.

D. Bertrand (directeur de recherche FNRS; chargé de cours temps partiel)  
 P. Berghaus (chercheur PAI)  
 O. Bouhali (collaborateur scientifique IISN until end of March)  
 B. Clerbaux (chercheur qualifié FNRS)  
 L. Favart (chercheur qualifié FNRS)  
 P. Marage (professeur ordinaire)  
 L. Neukermans (chercheur PAI)  
 Y. Piersaux (collaborateur scientifique)  
 B. Roland (boursier FRIA)  
 J. Sacton (professeur émérite)  
 R. Toncelli (collaborateur scientifique)  
 C. Vander Velde (professeur)  
 P. Vanlaer (1<sup>er</sup> assistant since October 2004)  
 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.U.B.

A. Astvatsaturov (FWO postdoctoraal onderzoeker since July 2004)  
 B. Baret (wetenschappelijk medewerker FWO since November 2004)  
 P. Bruyndonckx (wetenschappelijk medewerker GOA)  
 C. De Clercq (hoofddocent)  
 O. Devroede (wetenschappelijk medewerker)  
 S. De Weirdt (wetenschappelijk medewerker FWO since November 2004)  
 J. D'Hondt (FWO postdoctoraal onderzoeker)  
 J. Heyninck (IWT specialisatiebeurs)  
 D. Hubert (IWT specialisatiebeurs)  
 D. Johnson (assistent VUB)  
 M. Krieguer (wetenschappelijk medewerker FWO)  
 C. Lemaître (IWT specialisatiebeurs)  
 J. Lemonne (gewoon hoogleraar, professor-emeritus from October 2003)  
 S. Leonard (wetenschappelijk medewerker FWO till November 2004)  
 S. Lowette (wetenschappelijk medewerker FWO)  
 P. Olbrechts (IWT specialisatiebeurs and postdoctoraal onderzoeker OZR-VUB)  
 A. Rizzo (wetenschappelijk medewerker FWO since December 2004)  
 R. Roosen (onderzoeksdirecteur FWO)  
 S. Rugovac (wetenschappelijk medewerker OZR-VUB since November 2004)  
 S. Tavernier (gewoon hoogleraar)  
 F. Udo (wetenschappelijk medewerker)  
 R. Vandenbroucke (logistiek medewerker VUB)  
 W. Van Doninck (onderzoeksdirecteur FWO, on leave of absence at CERN since January 2000)  
 D. Wisniewski (wetenschappelijk medewerker Bilateraal akkoord Vlaanderen-Polen from September 2004)  
 M. Wisniewska (wetenschappelijk medewerker Bilateraal akkoord Vlaanderen-Polen from November 2004)  
 C. Yu (wetenschappelijk medewerker FWO till September 2004)  
 Y. Wu (wetenschappelijk medewerker Bilateraal akkoord Vlaanderen-China)

T. Anthonis, W. Beaumont, T. Beckers, E. De Wolf, F. Moortgat, M. Tasevsky, P. Van Mechelen and N. Van Remortel from the Universiteit Antwerpen (UA) have been working in close collaboration with the Institute.

Research in the field of telecommunications and data communication is conducted at IIHE/VUB by O. Bouhali and R. Vandembroucke in collaboration with the members of the "Service Télématic et Communication" led by P. Van Binst at the ULB.

## II. RESEARCH ACTIVITIES IN PARTICLE PHYSICS

### II.1. NEUTRINO PHYSICS

#### A. CHORUS experiment (CERN WA95)

(P. Vilain, B. Van de Vijver, G. Wilquet)

Built in 1993, the CHORUS detector has been exposed between 1994 and 1997 to the CERN-SPS neutrino beam. About one million interactions were recorded in the 770 kg nuclear emulsion target and more than 10 millions were produced in the calorimeter and spectrometer material. Events of this latter type were also recorded in 1998, when the beam was mainly operated for the NOMAD experiment.

The main purpose of the experiment was the search for  $\nu_\mu$ - $\nu_\tau$  oscillation through the observation for the reaction  $\nu_\tau + N \rightarrow \tau^- + \text{hadrons}$ . The very high spatial resolution power of nuclear emulsion enables the direct detection of the  $\tau^-$  trajectory.

In the phase I of the analysis, today completed, the microscope scanning speed was not sufficient to treat all events and selection criteria optimised for the  $\nu_\tau$  interactions were applied. About 180000 vertices were located in the emulsion volume and 13500 further selected for visual inspection. After kinematical analysis, none of these events is retained as a  $\nu_\tau$  signal, while the expected background from other processes is estimated at 1.1 events.

In an effective two-flavours scheme, the  $\nu_\mu$ - $\nu_\tau$  transition probability is given by:

$$P_{\mu\tau} = \sin^2 2\theta_{\mu\tau} \times \sin^2 \left( \frac{1.27 \Delta m^2 \cdot L}{E} \right)$$

where  $E(\text{GeV})$  and  $L(\text{km})$  are the neutrino energy and flight length,  $\Delta m^2(\text{eV}^2)$  is the squared mass difference of the mass eigenstates and  $\theta_{\mu\tau}$  the mixing angle.

In the absence of a significant signal, an upper limit on  $P_{\mu\tau}$  was established, after integration on  $E$  and  $L$ . At large  $\Delta m^2$ , this limit corresponds, at 90 % C.L., to the limit:

$$\sin^2 2\theta_{\mu\tau} < 6.8 \cdot 10^{-4}$$

The phase II of the data analysis started in 1999 and should lead this year to an improvement by a factor 2 to 3 of this limit thanks to :

- A refined track reconstruction code and more accurate alignment of the fibre trackers;
- The location of all events, without kinematical selection;
- The search around each located vertex of all the produced tracks and secondary activities (so called "net scan").

The two last items were made possible by the enormous progress achieved at the University of Nagoya in automated microscopes, allowing a gain in speed by two orders of magnitude. The final oscillation limit based on this new analysis will be published in 2005.

The net scan method has opened, in addition, the possibility to accumulate a large and unbiased sample of charmed particles production and decay events. Several new results have been published or accepted for publication in 2004 in addition to the six papers already published earlier on this topic :

- Experimental Study Of Trimuon Events In Neutrino Charged-Current Interactions,
- Measurement of charm production in antineutrino charged-current interactions,
- Measurement of fragmentation properties of charmed particle production in charged-current neutrino interactions,
- Measurements of D-zero production and branching fractions in neutrino nucleon scattering,
- Measurement of D-star production in neutrino interactions.

Several additional analyses are in progress and will be published during 2005.

## B. OPERA experiment (CERN CNGS1).

(*G. Van Beek, P. Vilain, G. Wilquet*)

In 2000, the CERN Council approved the construction of the SPS CNGS neutrino beam, pointing towards Gran Sasso LNGS underground laboratory. The long baseline neutrino oscillation OPERA project, based on this beam, was approved in February 2001.

The motivation for this experiment resides in the now clear evidence, mainly from the Super Kamiokande experiment, of an energy and zenithal dependent deficit in the flux of atmospheric  $\nu_\mu$ 's. The data are well fitted in terms of  $\nu_\mu$ - $\nu_\tau$  oscillation for  $\Delta m^2$  about  $2.5 \cdot 10^{-3} \text{ eV}^2$  and  $\sin^2 2\theta > 0.9$  and compatible with full mixing. OPERA aims at covering this domain of the parameters space and demonstrate the  $\nu_\mu$ - $\nu_\tau$  oscillation hypothesis through the direct observation of  $\nu_\tau$  interactions.

The detector design was based on two conflicting requirements: the  $\tau$  detection calls for the spatial resolution of nuclear emulsion but the required target mass of at least 1000 tons prohibits the use of a pure emulsion target as was done in the CHORUS experiment. The solution consists in stacking 1 mm thick lead foils interleaved with 200  $\mu\text{m}$  plastic sheets covered on both sides by 50  $\mu\text{m}$  emulsion layers. Detailed simulations of this configuration have shown that high  $\tau$  detection efficiency can be preserved while keeping the background at a tolerable level.

The modular detector structure is as follows:

- 56 foils of lead interleaved with emulsion sheets of about 120  $\text{cm}^2$  area stacked to form a 8.5 kg brick;
- 3264 bricks are assembled in a wall. Each wall, of about 40  $\text{m}^2$  area, is followed by a pair of orthogonal planes of plastic scintillator strips trackers;
- A super-module is made from 33 walls followed by a muon spectrometer;
- Two identical super-modules compose the detector that reaches an effective target mass of 2000 tons.

Our group is more specifically involved in the conception, construction and installation of the Target Trackers (TT) together with IReS, Strasbourg, the universities of Bern and Neuchâtel, IPNL, Lyon and JINR, Dubna. A tracker plane consists of 4 modules, each composed of 7-m long 64 scintillator strips equipped with wavelength shifting fibres. A tracker is made of two planes with orthogonal readings. The optical signals transmitted by the fibres are readout at both ends by 64-channel photomultipliers.

The assembly of a first batch of 12 trackers has started in autumn 2004 and the first tracker has been installed in the target section in December 2004. The required planarity of better than 1 mm over an area of more than 50  $\text{m}^2$  has not been achieved and a new assembly procedure is being investigated. It is however still planned that one of the two OPERA super-modules will be ready to take data by mid-2006 when the CNGS beam is foreseen to enter into operation.

## C. Neutrino astronomy with AMANDA

(*B. Baret, D. Bertrand, O. Bouhali, C. De Clercq, J.-P. Dewulf, L. Etienne, D. Hubert, Ph. Olbrechts and A. Rizzo*)

This research project is pursued with J.-M. Frère ("Professeur Ordinaire" in theoretical physics at the ULB), co-promotor at the FNRS level.

### c.1 Physics results

The AMANDA neutrino telescope aims at the observation of high energy neutrinos from astrophysical sources in the northern hemisphere. The detector is located at the geographical South Pole and consists of 677 photo multiplier tubes (PMT) deployed on an array of diameter 200m and height 500m in the Antarctic ice at depths between 1500 and 2000m. This neutrino detector is the first step towards the construction of the IceCube  $\text{km}^3$  neutrino telescope. The PMTs measure the Cherenkov light emitted in the ice by charged relativistic particles, like the muons which are produced in charged current muon-neutrino nucleon interactions below the detector.

A few analyses were still performed on data collected with the AMANDA-B10 detector (302 PMT in 10 strings representing an array of diameter 120 m and height 500m).

In 2004 the main analyses were:

- ***Search for neutrino-induced cascades***

Events with high energy cascade-like signature were searched for in the data taken with AMANDA II in 2000 (197 days live-time). The observed events are consistent with expected backgrounds from atmospheric neutrinos and catastrophic energy losses from atmospheric muons. The limit on cascades from a diffuse flux of the three flavours of neutrinos and anti-neutrinos with an  $E^{-2}$  spectrum was found to be:

$$E^2 \phi_{90\%} < 8.6 \times 10^{-7} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

at a 90% confidence level, for a neutrino in the 50 TeV to 5 PeV range and assuming a neutrino flux ratio 1:1:1 at the detector.

- ***Measurement of the cosmic ray composition at the “knee” of the spectrum***

The SPASE-2 surface air shower array and the AMANDA-B10 detector were used in coincidence to measure air showers at energies above  $10^{15}$  eV. Information from the electron component at SPASE and the high-energy muon component at AMANDA were used together to determine the change in the cosmic ray mass composition in the energy range from 500 TeV to 5 PeV. The data showed an increase by about 0.8 of the mean log atomic mass  $\langle \ln A \rangle$  within this energy range.

- ***Search for extraterrestrial point sources of neutrinos***

Flux limits on several active-galactic-nuclei blazars, micro quasars, magnetars and other candidate neutrino sources were established using the data collected during the years 2000-2002. A search for excesses above a random background of cosmic-ray-induced atmospheric neutrinos and misreconstructed down going cosmic-ray muons revealed no statistically significant neutrino point sources. A comparison with the previously published results obtained from an analysis of the data taken in 2000 showed an improvement in sensitivity by a factor 2.2. A search was also performed in the data taken in the period 00-03 for neutrinos associated with variable point sources of  $\gamma$ -rays. The preliminary results revealed no evidence for such neutrino emission.

- ***Search for a diffuse flux of high energy neutrinos of all flavours***

The rates of electro-magnetic and/or hadronic showers (cascades) induced by a diffuse flux of high energy neutrinos were consistent with the expected rate of atmospheric neutrinos and muons. The analysis of the data taken in 97 allowed to put the following 90% CL upper limit on the flux of neutrinos following a  $E^{-2}$  spectrum and consisting of an equal mix of all flavours:

$$E^2 \phi(E) = 8.4 \times 10^{-7} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

for a neutrino energy range 6 to 1000 TeV.

A search for ultra high energy neutrinos, above 10 PeV, in the data taken in 97 revealed no excess above expectation from atmospheric neutrinos and showed that a neutrino flux following  $E^{-2}$ , with an equal mix of all flavors, is limited to

$$E^2 \phi(10^{15} \text{ eV} < E < 3 \cdot 10^{18} \text{ eV}) < 0.99 \cdot 10^{-6} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

at 90% confidence level.

- ***Determination of the neutrino and muon spectra***

A new method to reconstruct the muon and neutrino energy spectra based on neural networks and regularized unfolding was developed. The atmospheric muon spectrum was used as a cross-check of the method and the atmospheric neutrino spectrum was measured for the first time up to 100 TeV. It was found to match well with the low energy spectrum measured with the Frejus experiment, and to be compatible with theoretical expectations.

- ***Search for high energy muon neutrinos from gamma-ray bursts***

The AMANDA detector has an effective area of the order of 50,000 m<sup>2</sup> for detecting a PeV muon. The data sets spanning 1997-2003 were searched for high energy neutrinos, that were spatially and temporally



coincident with about 451 triggered GRB's, detected by the Burst And Transient Source Experiment (BATSE) on NASA's Compton Gamma-Ray Observatory (CGRO) satellite, and 153 non-triggered GRB's, obtained by searching the BATSE archived data and using the data of the IPN satellites (InterPlanetary Network). The preliminary results were consistent with no observation of neutrinos from GRBs and allowed to set a 90% CL upper limit of

$$E^2 \phi_\nu < 3 \times 10^{-8} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

on the flux of neutrinos at earth.

- ***Online search for neutrino bursts from supernovae***

Although designed to detect neutrinos with energies of 100 GeV and above, the AMANDA telescope is also capable of detecting multi MeV anti-electron neutrinos for supernovae. The signature of such events is the simultaneous increase in rate in all optical sensors in the detector. The recent improvements in the reduction of correlated noise allowed the development of a fast and robust online filter which allowed participating to the SNEWS world wide alert system.

In 2004 the IceCube project was submitted to a review by the NSF, which decided to fund 70 out of the 80 needed strings. About 300 Digital Optical Modules (DOM) were built and shipped to the South Pole for installation in January 2005. A completely new hot water drill was constructed and successfully transported to the station. Finally one IceCube string has been successfully installed in the ice during the 2004-05 austral summer, with 60 DOMs which function as expected.

### ***c.2 Activities of the IIHE group***

The IIHE group took a large responsibility in the analysis of the data taken with AMANDA-B10 in 1997-99. This is a difficult task as the reconstruction and simulation programs had to be adapted to the varying detector configuration (10 strings in 98, 13 strings in 99 and 19 strings from 2000 onwards). Two analyses were pursued with these data in 2004 :

- study of WIMP (neutralino) annihilations in the centre of the earth
- search for high energy point like neutrino sources inside and outside our galaxy.

The results of the WIMP search in the 99 data is terminated and will be submitted for publication in the coming weeks. They were shown at several conferences, and are published as the thesis of Ph. Olbrechts.

For the combined 97-99 point source search the main effort was the filtering and reconstruction of the data, and the production of samples of simulated data.

The data taken with AMANDA II in 2000-03 are being analysed with the aim of searching for WIMP annihilations in the sun. In 2004 the main effort was put in the simulations.

In the context of the preparation of the IceCube detector, the OM tests which were started in 2001 were pursued. Tests of Wave Length Shifters (WLS) were continued and gave some encouraging results. Besides this two IceCube DOMs were installed with the aim of developing online software for the monitoring and control of the high voltage.

Finally the IIHE has significantly contributed to the upgrading of the AMANDA reconstruction software (SIEGLINDE) and to analytical methods to describe the photon behaviour in ice which could be implemented in the simulation software. The IIHE has also contributed to the installation of IceCube in situ during the deployment campaign.

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

*(D. Bertrand, C. De Clercq, J. D'Hondt, J. Lemonne, N. Van Remortel, F. Verbeure<sup>1</sup> and J. Wickens)*

During 12 years, between 1989 and 2000, the DELPHI experiment has taken about 4 million events at the  $Z^0$  resonance (LEP I experiment), and about 10,000  $W$ -pair events at energies between 161 and 209 GeV (LEP II experiment). The analysis of the data taken at the  $Z^0$  peak is essentially finished, while the analysis of the high energy data is still in progress. In the following paragraphs the main results published in 2004 are discussed with special emphasis on the contributions from the physicists of the Brussels-Antwerp group.

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<sup>1</sup> Deceased, see annual report 2003

## A. DELPHI results

At LEP I, the study of b-hadrons remained one of the main topics. The standard methods used for tagging b-hadrons in the DELPHI experiment were described in detail and final results from the DELPHI collaboration on the lifetime of  $B^+$  and  $B^0$  mesons and the mean b-hadron lifetime  $\tau_b$  were published. The results are:

$$\tau_{B^+} = 1.624 \pm 0.014(\text{stat}) \pm 0.018(\text{syst}) \text{ ps}$$

$$\tau_{B^0} = 1.531 \pm 0.021(\text{stat}) \pm 0.031(\text{syst}) \text{ ps}$$

$$\tau_b = 1.570 \pm 0.005(\text{stat}) \pm 0.008(\text{syst}) \text{ ps}$$

Measurements of the forward-backward asymmetries in the processes  $e^+e^- \rightarrow b\bar{b}$  and  $c\bar{c}$  were updated, leading to the pole asymmetries:

$$A^{0,b} = 0.1021 \pm 0.0052(\text{stat}) \pm 0.0024(\text{syst})$$

$$A^{0,c} = 0.0728 \pm 0.0086(\text{stat}) \pm 0.0063(\text{syst})$$

Data from Z decays have been searched for  $\overline{B_d^0} \rightarrow D^{*+} l \overline{\nu_l}$  decays leading to the following results:

the CKM matrix element

$$|V_{cb}| = 0.0414 \pm 0.0012(\text{stat}) \pm 0.0021(\text{syst}) \pm 0.0018(\text{theory})$$

and the b-quark semileptonic branching fraction into a  $D^{*+}$  emitted from higher mass charmed excited states:

$$\text{BR}(b \rightarrow D^{*+} X l^- \overline{\nu_l}) = (0.67 \pm 0.08 \pm 0.10)\%$$

No signal was observed in a search for  $B_s^0 - \overline{B_s^0}$  oscillations using high- $p_t$  leptons and  $D_s$  lepton events. The combination of the results with those obtained in previous DELPHI analyses leads to the following limit on the mass difference between the physical  $B_s^0$  states:

$$\Delta m_s > 8.5 \text{ ps}^{-1} \text{ at } 95\% \text{ C.L.}$$

A measurement of the form factor of the  $\Lambda_b^0$  beauty baryon has been achieved in the  $\Lambda_b^0 \rightarrow \Lambda_c^0 l^- \overline{\nu_l}$  decay channel. Assuming an exponential behaviour of the Isgur-Wise function the slope factor of the latter was found to be:

$$\rho^2 = 2.03 \pm 0.46(\text{stat}) \pm 0.72(\text{syst})$$

A combination using all measurements of the  $\tau$  decay lifetime, using the full LEP1 data sample, yielded the result:

$$\tau_\tau = 290.9 \pm 1.4(\text{stat}) \pm 1.0(\text{syst}) \text{ fs.}$$

A study of tau-pair production in photon-photon collisions at LEP2 was performed in the reaction  $e^+e^- \rightarrow e^+e^- \tau^+ \tau^-$  for which the average LEP2 cross-section was found to be  $429 \pm 17 \text{ pb}$ , in good agreement with the QED prediction. The measured cross-sections were used to extract limits on the anomalous magnetic and electric dipole moments of the  $\tau$  lepton. The 95% C.L. are:

$$-0.052 < a_\tau < 0.013$$

and  $|d_\tau| < 3.7 \cdot 10^{-16} \text{ e.cm.}$

Final results on  $e^+e^- \rightarrow W^+W^-$  production cross-sections at LEP2 centre-of-mass energies up to 209 GeV were published. Measurements of total cross-sections, W angular differential distributions and decay branching fractions are in good agreement with the expectations of the Standard Model (SM).

The value of the CKM matrix element  $|V_{cs}|$  was derived from the measurement of the leptonic W branching fractions with the result:

$$|V_{cs}| = 0.973 \pm 0.019(\text{stat}) \pm 0.012(\text{syst})$$

A search for single top production ( $e^+e^- \rightarrow t \bar{c}$ ) via flavour changing neutral currents was also performed using the data taken at LEP2 from which upper limits on the anomalous couplings  $\kappa_\gamma$  and  $\kappa_Z$  were derived.

Final results from DELPHI on the searches for SM and MSSM neutral Higgs bosons were published. The 95% C.L. lower mass bound on the Standard Model Higgs boson is  $114.1 \text{ GeV}/c^2$ . Limits were also given on the lightest scalar and pseudo-scalar Higgs bosons in the MSSM. Searches for H Z production with the Higgs particle decaying into an invisible final state (e.g. the lightest supersymmetric particle LSP or a Majoron J) remained unsuccessful setting a lower limit at 95% C.L. of  $112.1 \text{ GeV}/c^2$  on the mass of the Higgs produced with a SM cross-section and with 100% branching fraction into invisible decays. Further searches for charged Higgs bosons in general two Higgs doublet models and for supersymmetric particles also remained negative.

## B. Activities of the Brussels-Antwerp group

At the IIHE we concentrated our efforts on:

- ***Determination of the W-boson mass and width***

The invariant mass spectrum of the W boson is described by a relativistic Breit-Wigner probability density function which has two parameters, the pole mass ( $m_W$ ) and the width ( $\Gamma_W$ ). Using the fully hadronic decaying WW events at LEP, the preliminary results for the mass is

$$m_W = (80.383 \pm 0.053 (\text{stat}) \pm 0.028 (\text{syst}) \pm 0.056 (\text{FSI}) \pm 0.017 (\text{LEP})) \text{ GeV}/c^2$$

while the preliminary result for the width, combined with the leptonic channels, is

$$\Gamma_W = (2.109 \pm 0.099 (\text{stat}) \pm 0.057 (\text{syst}) \pm 0.042 (\text{FSI})) \text{ GeV}/c^2.$$

The uncertainty on the W boson mass in the fully hadronic channel is dominated by our knowledge about the colour reconnection effect between the fragmentation products of both decaying W bosons. Two estimators were designed which are sensitive to the magnitude of the effect on the decay topology of the fully hadronic final state. The first estimator measures the energy flow between the four jets in the final state and the second estimator is constructed from the difference of two W boson mass estimators.

The difference of both W mass estimators is sensitive to the inter-jet region and therefore to the colour reconnection effect. The measurements of both colour reconnection estimators were compared to predictions using Monte Carlo simulation. They indicate a 1.0 standard deviation from the hypothesis of having no colour reconnection. With this information of all four LEP experiments we could reduce the uncertainty on the measured W boson mass in the fully hadronic channel.

Those results were shown at several conferences.

- ***Bose-Einstein correlations (BEC)***

Several analyses were made to examine whether there are BEC between pions from different W's in hadronically decaying WW's. Different mixing methods were used to make a reference sample and selection cuts were applied to improve the sensitivity of the measurement. An indication for the existence of inter-W-BEC was found which is however not confirmed by other LEP experiments.

- ***Measurement of the W-boson polarisation and determination of anomalous Triple Gauge Boson couplings (TGC)***

The Spin Density Matrix elements were measured for semi-inclusive W production in the energy domain ranging from 189 GeV up to 208 GeV. The semi-leptonic muon and electron events were used. Preliminary results on the W polarisation as a function of the W production angle and on anomalous CP-conserving and CP-violating TGC's have been derived from these data and presented at conferences.

These preliminary results with only statistical errors are :

for the average fraction of longitudinally polarized  $W$ 's:

$$\sigma_L / \sigma_{\text{tot}} = 24.9 \pm 3.2\%$$

From one parameter fits of the SDM elements to the full data sample one obtains:

$$\Delta g_1^Z = 0.03 \pm 0.11 \quad \lambda_\gamma = 0.06 \pm 0.09 \quad \text{and} \quad \Delta \kappa_\gamma = -0.30 \pm 0.17 \quad \text{for the CP-conserving TGC's}$$

and

$$g_4^Z = -0.30 \pm 0.17 \quad \bar{\kappa}_Z^\perp = -0.03 \pm 0.06 \quad \text{and} \quad \bar{\kappa}_Z^\parallel = -0.08 \pm 0.07 \quad \text{for the CP-violating TGC's.}$$

All those results, including those from 2- and 3-parameter fits are in good agreement with the predictions of the Standard Model.

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

(*A. Astvatsatourov, T. Anthonis, E. De Wolf, L. Favart, D. Johnson, P. Marage, B. Roland, R. Roosen, and P. Van Mechelen*)

In October 2003, the phase II of HERA started. This upgrade took place to enable a higher luminosity up to a gain of a factor 4. The year 2004 was mainly devoted to data taking. Using sequentially both longitudinally and anti-longitudinal polarized positron beams, a luminosity of  $40 \text{ pb}^{-1}$  were accumulated by H1.

Overall the H1 detector has continued to function well. The new VFPS (Very Forward Proton Spectrometer) detectors, installed in 2003 under the responsibility of the IIHE group, took the data. This device is dedicated to the study of diffractive events measuring the scattered protons which have lost 1% or less of their energy with respect to the initial proton beam energy. This is possible using the Roman Pot technique. The Roman Pot detectors are inserted inside the beam pipe and are retracted during particle injection and tuning of the proton beam, then entered very close to the passing circulating proton beam during stable running conditions and diffractive data taking. A pair of pots are separated by 3.7 meters and are installed in a long magnet free region of the beam line 6.2 meters in length. The pots are located at some 220 meters forward in the proton direction from the nominal interaction point in the H1 detector. The location of the Roman pots is in the "cold" section of the HERA ring; namely that part of the beam line reserved for supra-conducting magnets maintained at low temperature by liquid helium circulation. It was necessary to reroute the circulating liquid helium conduction in the cold regions in order to operate the pots at ambient temperature. The first data analysis show the good acceptance of the detector in the expected kinematic region. Complete data taking for physics analysis has started in summer 2004.

During the year 2004 a total of 12 articles were published in international journals. The various topics studied can be grouped under the following headings:

- QCD: Inclusive dijet production at low Bjorken- $x$  in deep inelastic scattering, Forward  $\pi^0$ -production deep inelastic scattering, Measurement of Dijet Production at Low  $Q^2$  ;
- proton structure Function Measurement:  $F^2$  at Low  $Q^2$  in QED Compton Scattering ;
- pentaquark: Evidence for a narrow anti-charmed baryon state ;
- exotic searches: search for single top quark production, for squark production and bosonic stop decays in R-parity violating supersymmetry ;
- muon pair production in  $ep$  collisions ;
- measurement of Anti-Deuteron Photoproduction and a Search for Heavy Stable Charged Particles.

#### Activities of the IIHE group

The physicists of the IIHE have been working in the field of diffraction: Deeply Virtual Compton Scattering (1 PhD, 1 other analysis submitted for publication), Vector Meson exclusive production (1 analysis close to publication) and Hadronic Final State (1 PhD).

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

*(W. Beaumont, O. Bouhali, B. Clerbaux, E. De Wolf, J.P. Dewulf, J. D'Hondt, R. Goorens, J. Heyninck, S Lowette, L. Neukermans, M. Tasevsky, S. Tavernier, F. Udo, C. Vander Velde, W. Van Doninck, P. Vanlaer, L. Van Lancker, J. Wickens, Yu Chunxu).*

In December 1994, the CERN council decided the construction in the LEP tunnel of a "Large Hadron Collider" (LHC) which is expected to be operational in June 2007. This machine will allow to study proton-proton interactions at a centre-of-mass energy of 14 TeV with luminosities around  $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ . Two multipurpose detectors, ATLAS and CMS, are presently being constructed and installed at the LHC.

A large research program will be performed at this collider. The machine and detectors have been optimised for the search of new physics at high energy, with particular focus on the discovery of the Higgs boson(s) over a very large mass range. In particular, it will discriminate between different theories to extend the Standard Model, as could be done, for example, with the observation of supersymmetric particles or with manifestation of extra spatial dimensions. The energy and luminosity at the LHC will allow a detailed study of the symmetry breaking mechanism in the electroweak interactions, and extensive analyses of the top quark properties will become possible due to the large top pair production rate.

The Compact Muon Solenoid (CMS) collaboration consists of more than 1700 physicists and engineers from 150 institutes all over the world among which five Belgian research groups from the IIHE (ULB-VUB), UA, UCL and UMH. The Belgian teams have chosen to participate to the design and construction of the Silicium tracker detector of CMS. The IIHE took the following responsibilities: coordination of the design and production of 17000 frame components to support the Silicium detector modules and 17000 pitch adapters, assembly of 6000 frames, assembly of around 1700 modules for the forward wheels of the tracker using a high precision positioning machine (gantry), mounting of modules on 42 support structures in the shape of a sector of a wheel (so called petals), and detailed long term tests of the modules and the petals.

The procurement of the pitch adapters is now successfully terminated. Concerning the module frame components, nearly 80% were delivered to the assembly centres in Italy, in Pakistan and at the IIHE. Carbon fiber plates from the different batch production were checked to be within specification concerning the thermal conductivity property. Around 5000 frames of 8 different geometries were assembled at the IIHE in the year 2004. The storage of detector components, their shipping among the various laboratories of the collaboration and their registration in the data base is now well organised.

Brussels is one of the eight centres having a gantry positioning machine in order to assemble modules, with a precision of around 10 microns. Detailed calibration and tests were undergone during the year 2004 and around 200 modules from the four different geometries were assembled. The production had to stop at the end of the summer because of a problem found on the hybrid production process in the industry. It has restarted in march 2005.

Another important responsibility from the IIHE group is the assembly and the long term test of 42 petals. A module test station was built in Antwerpen in order to develop the software related to the long term test. A clean room has been constructed in the IIHE. The petal assembly set-up has been installed during the year 2004 and is ready to assemble petals. A first petal was assembled successfully beginning of 2005. In parallel, the petal test set-up is being installed with the help of the UA. The IIHE also participated to the development of the optical electronic system to be used in these tests.

In parallel, the CMS physicists of the IIHE, both in Brussels and in Antwerp, continue to prepare the physics analyzes. They contribute to the simulation studies of several physics channels of high relevance at the LHC. They participate to the development of the simulation and reconstruction programs which are required in order to perform the analyzes.

The physics channels studied are the following :

- the search for a MSSM heavy charged Higgs boson through the decay into a top-antibottom quark pair ;
- the search for Kaluza-Klein recurrences of the Z and photon through the decay into an electron-positron pair, in models with large extra dimensions ;
- the semi-leptonic decay of a top-antitop quark pair within the Standard Model, in order to measure the top mass with 1 GeV precision.

The related software developments are :

- precise reconstruction of the particle interaction and decay points (vertices) in the ambiguous and noisy events expected at the LHC; Brussels is coordinating these developments for the collaboration ;
- fast Monte-Carlo simulation (FAMOS) of the response of the muon detector and the electromagnetic calorimeter ;
- reconstruction and calibration of jets from light and heavy partons ;
- reconstruction of very energetic electrons, in particular the treatment of saturated cells of the CMS electromagnetic calorimeter.

A fraction of these studies have been already approved by the CMS collaboration and have been presented at international conferences, or accepted for publication in international scientific journals. The IIHE physicists are also actively interacting with theorists and phenomenologists, in the framework of the Belgian Inter-University Attraction Pole on Fundamental Interactions.

### III. APPLIED R&D AND SPIN-OFF

#### DEVELOPMENT OF NEW SCINTILLATION MATERIALS AND OF RADIATION DETECTORS FOR BIOMEDICAL IMAGING APPLICATIONS -THE CRYSTAL CLEAR PROJECT.

*(P. Bruyndonckx, O. Devroede, M. Krieguer, C. Lemaître, S. Léonard, D. Wisniewski, M. Wisniewska, S. Tavernier, Y. Wu)*

At the front line of organic research, molecular and cellular biologists engineer new molecular arrangements, including genes and proteins. Having produced these new strains, the next task is to investigate what happens when they are implanted in living tissue. The researchers want to know how the new genes "express" themselves. In a different area - pharmaceutical research - the effects of potential new drugs have to be established as quickly as possible. In the past, results have been established "in vitro", by either killing the samples or by taking biopsies. Until recently, there has been no other way of studying the effects of genetic manipulation or drug administration. Now researchers have found how imaging techniques used in medical diagnosis can be adapted for genetic or drug research, providing an immediate picture of how the modified tissue behaves "in vivo". One of these techniques is Positron Emission Tomography (PET).

Since a few years there has also been a steadily growing interest to use PET for mammography studies. Existing clinical PET systems are not optimized for this and the development of dedicated Positron Emission Mammograph (PEM) scanners, which are specifically designed and optimized for the task at hand, is required.

From its inception, PET technology has continually benefited from new developments in radiation detection, first using sodium iodide crystals, then the improved performance from bismuth germinate (BGO), and more recently superior materials such as lutetium orthosilicate or aluminates, faster and more effective than BGO. The arrival of more advanced position sensitive PMTs (PS-PMTs) and Avalanche photo diodes (APDs) make it possible to read out matrices of small crystals individually without the introduction of excessive dead space.

In the framework of the Crystal Clear Collaboration (CCC), the IIHE, together with the RUG, CERN, the Université Claude Bernard, Lyon, the Ecole Polytechnique Fédérale de Lausanne, and the Forschungszentrum Juelich is developing a new generation of high-resolution small animal PET scanners. We have also negotiated license contracts of our technology with major commercial companies. The first design of these small animal PET scanners is based on the use of position sensitive PMTs (PSPMT) and a phoswich of LSO/LuAP scintillators to provide the depth of interaction information. In addition, a project for a mammography PET camera (ClearPEM) has been set-up. This CCC project is in collaboration with the VUB university hospital and a Portuguese consortium of scientific institutes led by LIP (Lisbon), which is also a member of the Crystal Clear Collaboration.

The IIHE is responsible for the design and construction of the front-end detector modules for a number of small animal PET systems being developed within the collaboration. These detector modules consist of a double layered 8x8 crystal matrix mounted on a position sensitive PMT. The upper layer contains 64 LSO crystals measuring 2x2x8 mm while the bottom layer consists of 64 LuYAP crystals measuring 2x2x8 mm. To check several thousand LSO and LuYAP crystals, an automated crystal evaluation set-up was developed. This set-up measures the light yield and decay time of crystal batches. The results are stored in a database and used for crystal selection. Because LSO and LuYAP have significantly different light yields, their light output need to be equalized before they can be used in a phoswich configuration. Extensive testing was performed to select the best procedure. To check the quality of a fully assembled detector module, energy spectra and sensitivity of each

pixel in the detector are measured in a dedicated evaluation set-up.

The construction ClearPET<sup>TM</sup> prototype started with the delivery of the gantry and the front-end electronics for 4 detector modules, each containing two detector heads. In parallel the data acquisition was put in place allowing the development and evaluation of the data acquisition software and graphical user interface controlling the scanner rotation and detector module settings.

In preparation for the design of the PEM prototype, studies using Avalanche Photo diodes (APD) are performed. APDs are more compact, are more easily subdivided in small pixels, and are potentially lower in cost. In these prototype detector modules, very small individual crystals are replaced by a solid scintillator block to eliminate dead zones in-between the crystals. In addition, these scintillator blocks are much cheaper to produce and easier to mount. The position and depth of interaction is determined from the light distribution measured over the pixels in the APD array. The information is extracted from the light profile using neural networks, support vector machines or statistically based methods. The performance of these detector configurations for tomographic imaging was evaluated on a hardware simulator. This device consists of two rotating platforms onto which two detector modules can be mounted. The two platforms can rotate over 360° and can also rotate relative to one another. This allows us to simulate a complete (or partial) detector ring of a PEM (or a next generation small animal PET) scanner and reconstruct tomographic images of an object. Coincidence events from a <sup>22</sup>Na point source were taken and processed using neural networks. These tomographic data were reconstructed using filtered back-projection algorithm and the iterative OSEM algorithm. The resulting image showed the very encouraging FWHM resolution of resp 1.8 mm and 1.6 mm.

In addition to the hardware development, the IIHE is also involved in the development of the software to acquire the list mode data and store all necessary scan and instrumentation information in an appropriate format for image reconstruction. Furthermore, the description of the scanner geometry for generic cylindrical systems and the implementation of a process to compute the 3D coordinates of an event in the laboratory (x, y, z) system have been implemented. This library is now full operational and has been tested by using LMF data produced by GATE (Geant4 Application for Tomographic Emission). GATE is a PET simulation platform based on the Geant4 Monte-Carlo toolkit, developed by Crystal Clear members together with others groups interested in the field of nuclear medicine, and in collaboration with the Geant4 low energy development team. It is now employed to validate the measurements done on individual detector modules and predict the performance of the complete ClearPET<sup>TM</sup> prototype.

## IV. COMPUTING AND NETWORKING

Since April 2004 R. Vandenbroucke passed the management of the IIHE computer team to O. Bouhali. This covers the following tasks:

- coordinating the work of the technical staff ;
- follow-up of the maintenance and insurance contracts ;
- planning for hardware and software upgrade ;
- providing support for LINUX users ;
- co-representing the IIHE in the BEgrid and Belgrid projects ;
- organizing regular meetings with the users.

The computer support team (G. Rousseau and E. Torisaen) was reinforced with a new member, Danny Vijverman, since November 2004. His task will be focused on providing support for LINUX users. Two additional temporary members were recruited: Stijn De Weirtdt who works on CMS grid computing and Shkelzen Rugovac who works on general GRID computing in collaboration with the informatics department of VUB.

Over the last year the following projects have been followed up:

### A. Storage system backup

To cope with the large amount of experimental/simulation data produced, we upgraded our MA8000 SAN to its maximum raw capacity, i.e. 3 TB. The backup strategy had then to be reviewed. Given the increase in the actual and near future demand, a new SAN system (hp MSA1500) has been purchased. Its maximum raw capacity can go up to 20 TB. A volume of 7.2 TB is already installed (using RAID 5 as a backup solution) together with a new dedicated disk server.

## **B. Computers and clusters**

The BEO cluster, running PBS under Debian 3.0, has been extended to 22 CPU's and is intensively used. Due to the well known PBS limitations a new cluster, running CONDOR under SLC3.0.3, has been setup. It consists of four mono-processor and six dual-processor machines. Three public PC's have been made accessible to the users. They are running Scientific Linux 3.3.0.

## **C. Web server**

A new web server running LINUX has been installed. In parallel a new design of the Institute homepage is under construction.

## **D. GRID computing**

The major challenge we are facing is the enormous data produced and the consecutive need in the processing power. A GRID-based solution is the most ultimate. Therefore we're participating to two Belgian grid projects: BEgrid and BelGrid.

Within the BEgrid projects, we have setup two IIHE GRID clusters. One of them is for local tests and the other is part of the BETEST Virtual Organization. This latter is a collaboration between BELNET and the following universities: KUL, UA, ULB and VUB.

In the BelGrid project we have setup a very basic grid-like environment in collaboration with: CETIC, FUNDP, UCL, ULg, UMH and a few private partners.

# **V. THE INTER-UNIVERSITY ATTRACTION POLE (IAP) IN FUNDAMENTAL INTERACTIONS**

The IIHE is part of the IAP 5/27 in collaboration with the following groups: Theoretische Fysica (KUL), Elementaire Deeltjes Fysica (UA), Unité de Physique Théorique et de Physique Mathématique and Unité de Physique des Hautes Energies (UCL), Physique des Particules Élémentaires (UMH), Physique Mathématique des Interactions Fondamentales and Physique Théorique (ULB), Theoretische Natuurkunde (VUB).

The purpose of this IAP, extending over the years 2002 to 2006, is to improve our understanding of Fundamental Interactions through a closer collaboration between Belgian research teams engaged in theoretical or experimental investigations in the field.

Most of the physicists of the IIHE participated, in 2004, to the general meetings of the IAP which took place in January at the ULB, in June at the KUL and in December at the UMH, as well as to the thematic journal clubs (neutrinos and extra-dimensions) organised in this framework ( see <http://www.belhep.be>).

# **VI. TECHNICAL AND ADMINISTRATIVE WORK**

The members of the workshop staff in 2004 were: J. De Bruyne, J.-P. Dewulf, L. Etienne, R. Gindroz, R. Goorens, S. Hannaert, B. Meerschaut, G. Van Beek, R. Vanderhaeghen, L. Van Lancker and Ch. Wastiels, with the help of A. De Coster, M. Goeman, D. Pirnay, J. Liesen and M. Pins. D. Bertrand was in charge of the general coordination.

L. Van Lancker has the general responsibility of the design and of the assembly process of carbon fiber frames which will support the silicon detector of the forward CMS tracker. He is also responsible for the mechanics of the Gantry Robot used to glue silicon sensors and readout hybrids to the frames during module assembly. Mass production of the carbon fiber support frames for the silicon detector modules is ensured by A. De Coster with the help of J. Liesen, S. Hannaert and several job students. The Gantry electronics maintenance is the responsibility of Ch. Wastiels (who coordinated the production of the Gantry control electronics) and J.-P. Dewulf. Daily operation of the Gantry is performed by B. Meerschaut with the help of M. Goeman, M. Pins, D. Pirnay and G. Rousseau.



J.-P. Dewulf is responsible for the chain of readout electronics and safety controls used to test the Petals. He has been closely involved in the design of the readout chain used during these tests, and designed a test facility for the analog optical hybrids for CMS. R. Vanderhaeghen was involved in the installation of the readout system. Construction of the clean room used for Petal assembly was coordinated by L. Van Lancker. R. Gindroz and S. Hannaert participated to this construction. Petal assembly will be performed by R. Goorens and Ch. Wastiels.

R. Goorens was in charge of the design and tests of the pitch adapters which will interface the modules to the amplification electronics. The quality of the pitch adapters was checked during all the production on special machine at CERN. R. Gindroz participated to these tests in 2004.

The logistics involved in the shipping of modules and parts between the IIHE and other laboratories of the CMS collaboration is taken care of by M. Goeman and D. Pirnay. R. Gindroz and S. Hannaert have acted as courier for several shipments to nearby Institutes.

G. Van Beek is responsible for the mechanics of the scintillator strips target tracker modules for OPERA. His contributions include R/D on tracker design. He is co-responsible for the trackers installation on the OPERA detector and has contributed to the conception of the procedure used for their survey. He is following-up the production by industry of the tracker end-caps and of the mechanical parts used in the tracker planes assembly. He has participated to the construction of a dozen of trackers in the LNGS cavern and the insertion and survey of a first set of trackers in the OPERA target. R. Gindroz and S. Hannaert have contributed to OPERA through the fabrication of mechanical parts. They, together with R. Vanderhaeghen, have taken routinely charge of the transportation of the end-caps and other components to CERN and to IReS, Strasbourg.

L. Etienne participated to the design, implementation and calibration of the test stations for the wave length shifter tests for the optical modules of the AMANDA detector. He is also responsible of the installation of the test station for the DOM modules (Digital Optical Modules) of the IceCube experiment.

J.-P. Dewulf and L. Etienne were in charge of the design and the realisation of a new data acquisition system for a cosmic rays experiment to be implemented in secondary schools.

In the framework of the spin-off activities related to detector developments for medical applications, J. De Bruyne and Ch. Wastiels were in charge of the technical support of the CRYSTAL CLEAR project.

The secretarial work and the general administrative support of the experiments was accomplished by R. Alluyn and D. Peymans. They were assisted by M. De Schutter, M. Goeman, J. Liesen and D. Pirnay. D. Peymans had in charge the organisation of the general meeting of the MICAS doctoral school (Doctoral school in microscopic physics and astrophysics at the ULB). M. Pins contributed with the help of M. De Schutter to the maintenance of our documentation centre and provided illustrations, (photos, video) for several publications and lectures of members of the laboratory. A. De Coster took care of the library. Ch. Carlier took care of the DELPHI and CMS documentation.

## VII. REPRESENTATION IN ACADEMIC COUNCILS AND COMMITTEES

### *D. Bertrand*

- Vice président du Conseil du Département de Physique de l'ULB,
- Président de l'Ecole Doctorale en Physique Microscopique et Astrophysique (MICAS),
- Responsable pour le Département de Physique de l'ULB pour le Programme européen d'échange d'étudiants "Erasmus",
- Membre de la Commission Doctorale du Département de Physique.

### *C. De Clercq*

- Lid Commissie PR faculteit Wetenschappen of VUB,
- Lid BaMa commissie faculteit Wetenschappen VUB,
- Lid Gelegenheids commissie tgv de opvolging van H. Eisendrath,
- Lid Facultaire Selectiecommissie Elementaire Deeltjesfysica, UA.

**P. Marage**

- Depuis 1995, Membre du CA Altaïr, asbl d'Histoire des Sciences attachée à l'ULB,
- Vice-doyen 2003-2004 Faculté des Sciences, ULB,
- Membre du Bureau, secrétaire du CA Centre de Culture scientifique de l'ULB à Charleroi - Parentville,
- Membre du Comité scientifique asbl DISC (ULB-VUB),
- Président du Comité scientifique Inforsciences, cellule de diffusion des sciences de la Faculté des Sciences de l'ULB,
- Membre du Comité scientifique Expérimentarium de Physique de l'ULB,
- Depuis 1999, membre du Conseil d'Administration Institut national des Radioéléments, à Fleurus.

**R. Roosen**

- Lid OZC,
- Afgevaardigde DNTK Commissie doctorale opleiding,
- Sekretaris Doctorale examen commissie.

**S. Tavernier**

- Lid Bevorderings commissie ZAP,
- Lid lid commissie samenwerking VUB-China.
- Voorzitter commissie Visitatie Natuurkunde

**C. Vander Velde**

- Présidente de la Commission Bologne didactique de la Faculté des Sciences,
- Membre Commission Bologne didactique de l'université,
- Membre Commission Bologne de la Faculté des sciences.

**P. Vanlaer**

- Membre de la Commission Bologne du département de Physique,
- Membre, représentant du corps scientifique non définitif, du Conseil du Département de Physique de l'ULB.

**P. Vilain**

- Président du Conseil du Département de Physique de l'ULB,
- Président du Collège du Département de Physique de l'ULB.

**VIII. REPRESENTATION IN SCIENTIFIC COUNCILS AND COMMITTEES****D. Bertrand**

- Member, representant of the FNRS, of the ApPEC Steering Committee,
- Member, representant of the FNRS, of the DESY Experiments Finance Review Board,
- Member, representant of the FNRS, of the ILIAS Steering Committee.

**C. De Clercq**

- Member, representant of VUB of the Vlaamse Raad Voor Wetenschapebeleid - commissie CFIS,
- Member, representant of the FWO, of the ApPEC steering committee.

**J. Lemonne**

- Member, representant of the FWO, CMS-Resources Review Board(RRB) and LHC computing RRB,
- Chairperson National Committee for Pure and Applied Physics of the Royal Academies for Science and the Arts of Belgium.

**P. Marage**

- Member of the international committee DIS04,
- Membre associé depuis 1995, titulaire depuis 2001 Comité national de Logique, de Philosophie et d'Histoire des Sciences.

**Y. Pierseaux**

- Member of the committee "Physical Interpretation of Relativity Theory (PIRT)", London, 6-9 September 2004.

**S. Tavernier**

- Member of the CMS collaboration board, finance board, tracker institution board and tracker finance board,
- Chairman of the Crystal Clear steering committee and executive committee,
- Member of the organising committee of the IEEE conference on nuclear science and medical imaging in Rome, Italy, October 2004,
- Chairperson of the NSS poster session at the IEEE conference on nuclear science and medical imaging in Rome, October 2004,
- Member of the scientific committee of the EUROMEDIM-2006 conference, European Conference on Nuclear Medical Imaging Techniques, Marseille, France, May 2006,
- Member of the Scientific committee of the 9<sup>th</sup> World congress of Nuclear medicine and Biology, October 2006, Seoul,
- Member of the executive committee of CERIMED, Marseille.

**C. Vander Velde**

- Member of the FWO committee "Subatomaire fysica",
- Member of the Belgium Outreach Subcommittee of the European Linear Collider Steering Group,
- Member of the CMS Thesis Award committee,
- Referee of the Mozaïek program of the NWO (Netherlands).

**P. Vilain**

- Member of the Board of High Energy Physics section of European Physical Society.

**G. Wilquet**

- Membre de la Commission Hautes et Basses Energies, IISN-FNRS,
- Member FNRS Advisory Committee of CERN Users (ACCU),
- Member FNRS European Committee for Future Accelerators (ECFA),
- Membre du Comité d'évaluation de l'IRIS-IN2P3, Strasbourg.

**IX. TEACHING ACTIVITIES****ACADEMIC YEAR 2003-2004****• D. Bertrand**

- STAT606 "Computer Principles" (39/13/0/0) First year in Sciences,
- "Description des Ordinateurs" (45/15/0/0) Année préparatoire à la licence en informatique (horaire décalé),
- "Stage de laboratoire" (0/0/40/0) 1<sup>ère</sup> Licence sciences physiques,
- "Astro-particules Physics" (3/0/0/0) BND school Gent.

**• P. Bruyndonckx**

- "Inleiding tot Mathematica" (3/0/12/0) 1<sup>e</sup> Kan,
- "Labo elementaire deeltjes (muon proef)" (0/0/18/0) 1<sup>e</sup> lic.,
- "Fysische modellen in de geneeskunde" (15/0/0/0) 2<sup>e</sup> lic.,
- "Aanvullend practicum (Beeldvormingstechnieken)" (4/0/10/0) 1<sup>e</sup> lic.

**• B. Clerbaux**

- Travaux pratiques de "Physique Générale" (0/0/32/0) première candidature sciences physiques,
- Travaux pratiques "expérience H1" (0/0/35/0) première licence,
- Travaux pratiques "expérience H1" (0/0/35/0) première licence.

**• C. De Clercq**

- WE-DNTK-9246 "Meten en Experimenteren" (responsible) 1<sup>st</sup> Bachelor fysica,
- "Elementaire Deeltjesfysica I" (0/0/20/0) 1<sup>ste</sup> licentie natuurkunde VUB,
- "Organisation of the visit of CERN for VUB and UA students in physics and engineering" () 2<sup>nd</sup> and 3<sup>rd</sup> years in physics, chemistry and engineering.

**• J. D'Hondt**

- "Waarschijnlijkheidsleer en statistiek" (13/0/0/0) 1<sup>st</sup> Bachelor VUB - Physics,
- "Statistiek" (26/0/0/0) 2<sup>nd</sup> Bachelor VUB - Physics,

- "Seminar : 'De LHC versneller'" (3/0/0/0) 1st Bachelor VUB - Physics/Mathematics.
- **D. Hubert**
  - "Practicum algemene natuurkunde - correctie verslagen practicum wisselstromen" (0/0/0/8) 1e kandidatuur.
- **D. Johnson**
  - DNTK Departement Nat "Laboratorium voor Eerste Kandidatuur Studenten", VUB; 1ste Kan Wetenschappen met Polyvalentie; 1ste Ka" (30/0/5/30) 2003-2004.
- **C. Lemaitre**
  - "Meten en experimenteren (Fys 3)" (0/13/0/6) 1<sup>ste</sup> Bachelor.
- **J. Lemonne**
  - "Fysica van de Elementaire Deeltjes" (26/0/26/0) 1<sup>ste</sup> Licentie Natuurkunde VUB.
- **S. Lowette**
  - WE-DNTK-11346 "Mechanica: beginselen" (0/13/0/>39) 2003-2004,
  - WE-DNTK-11347 "Elektromagnetisme, golven en trillingen" (0/13/0/>39) 2003-2004.
- **P. Marage**
  - PHYS096 "Histoire des sciences" (15/0/0/0) 2<sup>ème</sup> licence math, phys,
  - METH083 "Histoire des sciences et épistémologie" (15/0/0/0) Agrégation de l'Enseignement secondaire,
  - PHYS-F-104 "Physique générale" (48/0/0/0) BA1 biol, geog., geo,
  - HIST-F-101 "Histoire des Sciences" (24/0/0/0) BA1 Faculté des sciences (option),
  - "Physique des particules élémentaires" (0/60/0/0) 1<sup>ère</sup> licence,
  - "TP à option" (0/10/0/0) 1<sup>ère</sup> licence physique.
- **Ph. Olbrechts**
  - PHYS "Exercices of Elementary Particle Physics" (0/6/2/6) 1st licentiate.
- **Y. Pierseaux**
  - Haute Ecole de Bruxelles (HEB), Ecole Supérieure d'Informatique (ESI) - 67 rue Royale, 1000 Bruxelles from September 15 to July 2004.
- **R. Roosen**
  - "Elementaire deeltjes fysica Deel II" (15/0/0/0) 2de Licentie,
  - "Geschiedenis van de natuurkunde" (10/0/0/0) 2de Licentie.
- **S. Tavernier**
  - "Detectie van ioniserende stralingen" (13/13/0/0) 2de Licentie Natuurkunde,
  - "Radiation protection and nuclear measurement" (12/12/0/0) BNEN-GGS nucleaire techniek,
  - "Detectie van ioniserende stralingen, klinische dosimetrie, wetgeving en kwaliteitsbewaking" (30/30/0/10) GGS biomedische en klinische ingenieurstechnieken.
- **C. Vander Velde**
  - PHYS 163 "Eléments d'électromagnétisme" (36/0/0/0) 1ère candi info,
  - METH031 "Physique du secondaire et du supérieur" (30/0/110/0) AESS,
  - PHYS026 "Electronique" (coordination (30 h)) 2ème candi info.
- **P. Vanlaer**
  - PHYS-F-104 "Physique générale" (0/0/96/0) 1<sup>ère</sup> candidature,
  - PHYS026 "Physique générale et cristallographie" (0/0/48/0) 2<sup>ème</sup> candidature,
  - PHYS106 "Techniques de la physique expérimentale" (0/0/32/0) 1<sup>ère</sup> licence,
  - PHYS105 "TRAVAUX PRATIQUES DE PHYSIQUE (stages de 75h)" (0/0/150/01<sup>ère</sup> licence.
- **P. Vilain**
  - PHYS109 "Introduction à la Physique des Particules" (26/0/70/0) 3rd year in Physics Full time,
  - PHYS115 "Questions approfondies de Physique des Particules" (16/0/35/0) 4th year in Physics Full time.
- **G. Wilquet**
  - PHYS106 "Techniques de la physique expérimentale" (14/90/0) première licence en sciences physiques, ULB

## **X. PHD THESES, "MEMOIRES DE LICENCE" AND "LICENTIAATSVERHANDELINGEN" COMPLETED IN 2004**

### **A. PHD THESIS**

- ***Philip Olbrechts***

- "The Search for Neutralino Dark Matter with the AMANDA-B10 Detector"  
28 May 2004 Promotor: Prof. C. De Clercq

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

- ***J.-R. Diericks***

- "L'œuvre scientifique d'E. Henriot"  
September 2004 Promotor: Prof. P. Marage

## **XI. SEMINARS AND ORAL PRESENTATIONS AT CONFERENCES, SCHOOLS AND COLLABORATION MEETINGS**

### **XI.1. SEMINARS AT THE IIHE (ORGANISED BY L. FAVART)**

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

- Prof. Lars Bergström (SCFAB, Stockholm University) : " Dark matter: models and methods for detection ".
- Prof. M. Polyakov (ULg) : "Pentaquarks of baryons: predictions, discoveries and implications".
- Dr. Fabien Cavalier (LAL - Université de Paris Sud) "Virgo and the quest for Gravitational Waves".
- Dr. Grégory Soyez (Liège) "Deep Inelastic Scattering, Regge theory and DGLAP evolution".
- Dr. Veronique Van Elewyck (Universidad Nacional Autonoma de Mexico) "The Pierre Auger Observatory and the detection of ultra-high energy neutrinos".
- Dr. Marie Jacquet (Orsay) "Measurement of the longitudinal polarisation at HERA with a Fabry-Perot cavity".
- Dr. Caroline Collard (Ecole Polytechnique - Palaiseau) "Search for extra dimensions at LHC".
- Bruny Baret (LPSC - Grenoble) "Astroparticle physics with the AMS experiment".
- Raffaella Toncelli (ULB) "The Foundations of Gravitation Theory: the Equivalence Principle and the current status of experiments".
- Dr. S. Hamieh (KVI - Nederland) "On the quark-gluon plasma search".
- Dr. Tariq Mahmoud (Heidelberg) "Beautiful Little Bang with ALICE".
- Dr. Veronique Van Elewyck (Universidad Nacional Autonoma de Mexico) "The Detection of Horizontal Air Showers by the Pierre Auger Observatory's Ground Array".

## XI.2. SEMINARS

- **J. D'Hondt**
  - "Review of the D0 top mass measurement" June 2004, Brussels IIHE – Belgium.
- **L. Favart**
  - "Inelastic scattering and diffraction at high energy - HERA results" 14 May 2004, European Graduate School Basel-Tubingen, Tubingen.
- **P. Olbrechts**
  - "The results of the AMANDA Detector" 19 January 2004, Brussels – Belgium.
- **Y. Pierseaux**
  - Université de Nice, "La cinématique relativiste sous-jacente à l'ellipse de Poincaré" 8, 9 décembre 2004, Faculté des sciences,
  - VUB, "La cinématique relativiste de Poincaré" 23 février 2004, Séminaire d'épistémologie empirique.
- **S. Tavernier**
  - "Positron Emission Tomography present status and future prospects", Lezing op de Internationale zomer school voor elementaire deeltjes fysica, 15 September 2004, GENT,
  - "De Crystal Clear collaboration en het ClearPET en ClearPEM project" AGFA headquarter, Moortsel, 7 April 2004,
  - "Positron Emission Tomography present status and future prospects", University of science and technology China, Friday 29 May 2004, China.
- **P. Vanlaer**
  - "Vertex reconstruction methods in CMS" 20-21 January 2004, ETH Zurich,
  - "CMS OO Software Tutorial: Vertex reconstruction" 9 January 2004, CERN,
  - "CMS OO Advanced Tutorial series: Vertex reconstruction" 12 November 2004, CERN.

## XI.3. ORAL PRESENTATIONS AT CONFERENCES, SCHOOLS AND COLLABORATION MEETINGS

- **D. Bertrand**
  - "The IceCube Experiment" December 2004, Mons - General Meeting UIAP – Belgium.
- **P. Bruyndonckx**
  - "Front-end module with undivided scintillator block readout : first images" - CERN 29/09/2004,
  - "Introduction to workshop on ClearPET® data acquisition software and user interface" - CERN 30/09/2004,
  - "Status of the ClearPET® construction in Brussels" - Lyon 11/03/2004.
- **B. Clerbaux**
  - "Search for WW decay of a Higgs boson produced in association with a fermion pair in  $e^+e^-$  collisions at LEP" - Mons 25/05/2004.
- **J. D'Hondt**
  - "Precision of the module assembly with the Gantry" - TEC meeting Lyon - France Jan 2004,
  - "Treatment of precision pins for module assembly" - Tracker week CMS - CERN Febr 2004,
  - "Cross-check of precision of module assembly" - CMS week - CERN March 2004,
  - "Kinematic fit : a first toy model" - CMS week - CERN March 2004,
  - "Ring 3 module assembly in Brussels" - Tracker week CMS - CERN April 2004,
  - "Hard lepton selection in  $t\bar{t}$  events" - CPT week CMS - CERN May 2004,
  - "Measuring systematic uncertainties :  $\Lambda_{b\bar{b}}$  QCD" - CPT week CMS - CERN May 2004,
  - "Towards full module production in Brussels" - CMS week - CERN June 2004,
  - "Tools needed for a top quark mass reconstruction" - CMS week - CERN June 2004,
  - "Start-up of module production in Brussels" - Tracker week CMS - CERN July 2004,
  - "Module production in Brussels : results" - CMS week - CERN Sept 2004,
  - "Rotation motor studies for the Gantry robot" - Tracker week CMS - CERN Oct 2004,
  - "Top physics studies in Brussels" - Standard Model Workshop CMS - CERN Nov 2004,
  - "Module production in Brussels with new rotation motor" - CMS week - CERN Dec 2004,
  - "Measurement of the top quark mass at the LHC and jet physics" June 2004, Louvain-la-Neuve - General Meeting

UIAP – Belgium

- **C. De Clercq**

- "Spin density matrix analysis of the reaction  $e^+e^- \rightarrow w^+w^-$  and measurement of CP violating TGC's" - Lake Louise Winter Institute LWWI 2004, Lake Louise, Canada 15-2-2004,
- "Neutrino Astronomy at the South Pole : results from AMANDA" - XXVIII SCAR Open Science Symposium, Bremen, Germany 25-7-2004.

- **L. Favart**

- "Deeply Inelastic Compton Scattering at HERA (H1 results)" - DIS 2004. Strbske Pleso - Slovakia 16 April 2004,
- "Experimental review of diffractive phenomena" - BARYON 04. Palaiseau - France 28 October 2004,
- "Introduction a la structure hadronique" - JJC04. Ile de Berder - France 1st December 2004,
- "Status Report of the Diffractive Working Group" - H1 Collaboration Meeting - DESY - Hamburg - German 17 June 2004.

- **D. Hubert**

- "Application of Machine Learning Methods to the Modelling of AMANDA/IceCube Optical Properties" - IIHE, Brussels, Belgium April 1, 2004,
- "Modelling optical properties of deep Antarctic ice with Neural Networks" - International Scientific Meeting, Belgian Physical Society, Mons, Belgium May 25, 2004,
- "Update on PHOTONICS table fitting" - AMANDA/Icecube collaboration meeting, Bartol Research Institute, University of Delaware-Newark, USA March 21-27, 2004,

- **M. Krieger**

- "Data acquisition software in Brussels" - Lyon 11 March 2004,
- "Performance measurements in Brussels" - CERN 30 September 2004.

- **J. Lemonne**

- "Spin Density Matrix analysis of the reaction  $e^+e^- \rightarrow W^+W^-$  and fits of TGC's." - Delphi General Meeting CERN 30/06/04.

- **S. Lowette**

- "Heavy Charged Higgs in  $H^+ \rightarrow tb$ " - CMS Plenary Physics Meeting, CERN, 15 January 2004,
- "b-Tagging Efficiency Measurements" - CMS Tracker bTau Workshop, Bari, Italy, 31 May 2004,
- "Search in CMS for Heavy Charged MSSM Higgs Bosons in the  $H^+ \rightarrow tb$  Decay" - BPS International Scientific Meeting, Mons, Belgium, 25 May 2004,
- "Higgs Physics at the LHC" - PAI-IUAP Meeting, Mons, Belgium, 2 December 2004.

- **P. Marage**

- "Les domaines d'emploi des diplômé(e)s universitaires" - Journée d'étude : Les femmes et les professions sciences, 26 octobre 2004.

- **P. Olbrechts**

- "The results of the AMANDA Detector" - Cracow (Poland), 8 - 11 January 2004,
- "The Results of the AMANDA Detector" - Beijing (China), 16 - 22 August 2004,
- "The search for neutralino dark matter with the AMANDA-B10 detector" - Wuppertal (Germany), 20 - 24 June 2004,
- "The Search for Neutralino Dark Matter with the AMANDA-B10 Detector" - C.E.R.N. (Switzerland), 1 - 2 November 2004.

- **Y. Pierseaux**

- "Poincaré's special relativity with ellipsoïdal waves and Einstein's special relativity with spherical waves" - Pirt, London, Imperial College 8 September 2004,
- "Le front d'onde ellipsoïdal de Poincaré" - Sophia-Antipolis, Alpes, Haute-Provence 10 décembre 2004.

- **B. Roland**

- "Study of L1, L2 and L4 trigger efficiencies for DVCS" - Desy, Hamburg, Germany, 13.07.2004,
- "Study of DVCS" - Desy, Hamburg, Germany, 19.10.2004,
- "Research of a low energy electromagnetic particle in LAr" - Desy, Hamburg, Germany, 21.10.2004,
- "Etude de la diffusion Compton a haute virtualité a H1" - île de Berder, Morbihan, France, 30.11.2004.

- **R. Roosen**

- "Experimental review of inclusive diffractive phenomena" – Mons, 2/12/2004.
- **S. Tavernier**
  - "Status of the gantry in Brussels" - Crystal Clear Collaboration meeting, CERN 1 October 2004,
  - "State of art in de ontwikkeling van detectoren voor small animal PET" Spreekbeurt op symposium, 2 Februari 2004, TI-KVIF symposium State of art in medische technologie, Brussel.
- **P. Vanlaer**
  - "Status of vertex reconstruction" - Workshop of the CMS Tracker-B/tau group for the pr 28 May - 1 June 2004,
  - "Vertex reconstruction in CMS" - Workshop of the PRSat LHC European network, Louvain 28-30 June 2004.

#### XI.4. POSTER PRESENTATIONS AT CONFERENCES, WORKSHOPS AND SCHOOLS

- **Steven Lowette**
  - "Heavy Charged MSSM Higgs Bosons in the  $H^+ \rightarrow tb$  Decay in CMS" - European School of High Energy Physics 2004, Sant Feliu de Guixols, Spain, 3 June 2004,
  - "Heavy Charged MSSM Higgs Bosons in the  $H^+ \rightarrow tb$  Decay in CMS" - Physics at LHC 2004, Vienna, Austria, 13 July 2004.
- **P. Vanlaer**
  - "Contribution to the construction of the CMS" - Mons BPS meeting, May 2004,
  - "Properties of robust vertex fitting algorithms at high luminosity hep experiments" - Mons BPS Meeting, May 2004.

#### XII. SCIENTIFIC VULGARISATION AND OUTREACH ACTIVITIES

- **D. Bertrand :**
  - "Cosmic Rays Detection" - Practicals for College Pupils Whole scholar year,
  - "Cosmic rays experiment for secondary school pupils" - Seminar for the Physics Teachers aggregation, 17/04/2004,
  - "La Physique du neutrino" Emission radio – RTBF1 – Semence de Curieux, 21 et 28/11/2004.
- **P. Bruyndonckx:**
  - "Power of molecular imaging (Introduction to medical instrumentation at IIHE)" - Master Class, 10/07/2004.
- **J. D'Hondt**
  - "Meesterklas Deeltjesfysica" - Master class organizer, July 2004.
- **C. De Clercq**
  - "Visit of CERN for high school students" - CERN visit, 11-15 July 2004,
  - "Meesterklas Elementaire Deeltjesfysica" - master class exercices, 10 July 2004,
  - "Visits of the Experimentarium" - visits to the ULB Experimentarium, several visits.
- **L. Favart**
  - "Scientific film presentation and discussion", in the Institut de la Vallée Bailly, 23 April 2004.
- **D. Hubert**
  - "Experimentarium" - Laboratory visit, March 2, 2004,
  - "Experimentarium" - Laboratory visit, October 26, 2004,
  - "Meesterklassen Elementaire Deeltjes" - Master class, July 10, 2004.
- **S. Lowette**
  - "Master Classes Elementaire Deeltjes Fysica" - Master Classes, 10 july 2004.



- **P. Marage**

- "L'histoire du vide" - Conférence, Université du Temps Libre, Cambrai le 20 janvier 2004,
- "L'affaire Galilée" - Conférence, Université du Temps Libre, Arlon 22 janvier 2004,
- "Les Conseils Solvay et les débuts de la physique moderne" - Conférence, CEPULB, ULB 23 novembre 2004,
- "De Parménide à Einstein, l'histoire du vide" - Conférence, Extension de l'ULB, Bouillon 24 novembre 2004,
- "L'affaire Galilée" - Conférence, Extension de l'ULB, Courcelles 9 décembre 2004,
- "La condamnation de Galilée" - Interview radio, Radio Campus 30 novembre 2004,
- "L'emploi des diplômés universitaires" - Conférence, ULB, Journée de contact avec les professeurs de l'enseignement secondaire 27 octobre 2004.,
- "Les femmes et les professions scientifiques - Diplômes universitaires et accès à l'emploi" - Livre : M. Alaluf, N. Imatouchan, P. Marage, S. Pahaut, R. Sanvura, A. Valkeneers, Ed. Université Libre de Bruxelles 2004,
- "L'emploi des diplômées universitaires" - Interviews radio, RTBF: Midi Première et journal parlé de 18 h, journal parlé de 7h. 15 mars 2004,
- "Galilée, ses combats et sa « réhabilitation »" - Conférence, Extension de l'ULB, Jodoigne le 27 avril 2004.

- **P. Olbrechts**

- "Astroparticle Physics with AMANDA" - Master class, May 2004,
- "Electro-magnetics" - Visit in the experimentarium (ULB), September 2004.

- **R. Roosen**

- "Speaker" - Meesterklassen 15/05/2004.

- **C. Vander Velde**

- "Entre microscopique et macroscopique: le nanomonde" - Formation continue pour les enseignants du secondaire – organisation, January 2004,
- "Printemps des sciences" - Encadrement de laboratoires pour les élèves du secondaire, mars 2004.

- **P. Vilain**

- "Le carnaval des neutrinos" - 2 articles dans la Revue d'électricité et d'électronique industrielle décembre 2004.

- **G. Wilquet**

- "Les Neutrinos de l'Univers, l'Univers de Neutrinos" - Conference for Club 51 11/5/2004,
- "Organisation/guiding of the CERN visit by the students in licence en sciences physiques ULB" - Visit 21-23/1/2004.

### XIII. ATTENDANCE TO CONFERENCES, WORKSHOPS AND SCHOOLS

#### XIII.1. CONFERENCES AND WORKSHOPS

- **D. Bertrand**

- American Physical Society General Meeting (April 2004), Denver (USA),
- Workshop on e-Infrastructures in Europe, Dublin (Ireland).

- **O. Bouhali**

- Computing in High Energy Physics, Interlaaken, Switzerland

- **P. Bruyndonckx**

- IEEE Nuclear science conference and medical imaging conference, Rome,
- Belgian Physical society : International scientific meeting 2004, Mons, Belgium.

- **B. Clerbaux**

- Belgian Physical society : International scientific meeting 2004, Mons, Belgium,

- **C. De Clercq**

- Belgian Physical society : International scientific meeting 2004, Mons, Belgium,
- Lake Louise Winter Institute LWWI 2004, Lake Louise, Calgary, Canada,
- XXVIII SCAR Open Science Symposium, Bremen, Germany,
- Hartill III NSF review of the IceCube project, Madison, Wisconsin, USA.

- **J. D'Hondt**
  - Workshop of the CMS Tracker-\$B/au\$ group for the preparation of the Physics TDR, Bari, Italy,
  - Journées Jeunes Chercheurs, Ile de Berder – France,
  - The 32nd International Conference on High Energy Physics (ICHEP), Beijing (China).
- **L. Favart**
  - Journées Jeunes Chercheurs, Ile de Berder - France,
  - 12th International workshop on Deep-Inelastic Scattering - DIS 2004, Strbske Pleso, Slovakia,
  - BARYONS 2004, Palaiseau – France.
- **D. Johnson**
  - Division of Particles and Fields 2004 , American Physical Society Meeting, University of California, Riverside, California, USA.
- **M. Krieguer**
  - 2004 IEEE Nuclear science symposium and Medical imaging conference, Rome, Italy.
- **S. Léonard**
  - Belgian Physical society : International scientific meeting 2005, Mons, Belgium.
- **S. Lowette**
  - Belgian Physical society : International scientific meeting 2005, Mons, Belgium,
  - Physics at LHC, Vienna, Austria,
- **P. Marage**
  - Journée d'étude : Les femmes et les professions scientifiques, ULB,
  - The 32nd International Conference on High Energy Physics (ICHEP), Beijing (China).
- **P. Olbrechts**
  - The Cracow Epiphany Conference on Astroparticle Physics, Cracow (Poland),
  - The 32nd International Conference on High Energy Physics (ICHEP), Beijing (China),
- **Y. Pierseaux**
  - Physical Interpretation of Relativity Theory (PIRT), London, 6-9 September 2004", London, Imperial College.
- **B. Roland**
  - Journées Jeunes Chercheurs, Ile de Berder - France,
- **S. Tavernier**
  - 2004 IEEE Nuclear science symposium and Medical imaging conference, Rome, Italy,
  - Workshop CRIMED, Marseille, France.
- **P. Vanlaer**
  - Belgian Physical society : International scientific meeting 2005, Mons, Belgium
  - Workshop of the CMS Tracker-\$B/au\$ group for the preparation of the Physics TDR, Bari, Italy
  - Journées Jeunes Chercheurs, Ile de Berder – France
  - Workshop of the PRS at LHC european network, Louvain-la-Neuve
- **P. Vilain**
  - "XXIth International Conference on Neutrino Physics and Astrophysics", Paris, France
- **G. Wilquet**
  - "XXIth International Conference on Neutrino Physics and Astrophysics", Paris, France

### XIII.2. SCHOOLS

- **D. Hubert**
  - 16th joint Belgian-Dutch-German Graduate School on Particle Physics - Universiteit Gent, Gent, Belgium from September 6 to September 17, 2004.

- **M. Krieguer**
  - Detectors in PET and SPECT - Rome from 24 October 2004 to 24 October 2004
  - Ecole Joliot Curie - La londe les maures from 12 September 2004 to 19 September 2004.
- **S. Lowette**
  - European School of High Energy Physics 2004 - Sant Feliu de Guixols, Spain from 30 may 2004 to 12 June 2004.
- **B. Roland**
  - 16th joint Belgian-Dutch-German Graduate School on Particle Physics - Universiteit Gent, Gent, Belgium from September 6 to September 17, 2004.

### XIII.3. TECHNICAL FORMATIONS

- **O. Bouhali**
  - Cisco networking academy - Brussels from 01/2004 to 06/2004,
  - Linux administration - Brussels from 01/2004 to 06/2004.
- **D. Hubert**
  - DOM testing campaign - University of Wisconsin - Madison, USA from August 2 to August 15, 2004,
- **M. Krieguer**
  - LabVIEW seminar: data acquisition hardware and software - Gosselies from 25 march to 25 march 2004.

### XIII.4. RESPONSIBILITIES IN EXPERIMENTS

- **D. Bertrand**
  - Member IceCube Collaboration Board,
  - Member AMANDA Collaboration Board,
  - Membre DELPHI Collaboration Board,
- **P. Bruyndonckx**
  - Member Crystal Clear Collab Steering committee.
- **C. De Clercq**
  - Principal Investigator for VUB IceCube Collaboration Board,
- **L. Favart**
  - Working Group Convener H1 Diffractive Physics Working Group,
- **J. Lemonne**
  - Acting as representative of the FWO, in the Resources Review Board of the CMS experiment.
- **R. Roosen**
  - Coordinator VFPS,
  - Member H1 Collaboration Board
- **J. Sacton**
  - Acting as representative of the FNRS, in the Resources Review Board of the CMS experiment.
- **S. Tavernier**
  - Spokesperson, chairman - Crystal Clear Collab Collaboration board,
  - Member CERIMED - CERIMED executive committee,
  - Member CMS - CMS finance board,
  - Member CMS - CMS institution board,
  - Member CMS - CMS tracker institution board.

- **C. Vander Velde**
  - Member CMS Collaboration Board,
  - Member CMS Finance Board,
  - Member CMS Tracker Institution Board,
  - Member CMS Tracker Finance Board,
  - Responsible of the procurement CMS Pitch adapters of the Si Tracker,
  - Responsible of the procurement CMS Frames for the Si modules.
- **P. Vanlaer**
  - Coordinator of Vertex reconstruction group CMS Physics Reconstruction and Selection (b/tau).
- **P. Vilain**
  - Member OPERA editorial board,
- **J. Wickens**
  - Member CMS Responsible for frame production,
  - Member of collaboration Delphi Responsible for offline software.
- **G. Wilquet**
  - Member CHORUS Collaboration Board,
  - Member OPERA Collaboration Board,
  - Member CHORUS Academic and Editorial Board.

### XIII.5. MEMBERSHIP IN ACADEMIC JURY'S

- **C. De Clercq**
  - Ph D. Katholieke Universiteit Nijmegen "Measurement of Triple Gauge-Boson Couplings in  $e^+e^-$  collisions at LEP".
- **L. Favart**
  - PhD Universtite de Liege "Deep inelastic scattering at small x".
- **P. Marage**
  - Mémoire de licence en physique - directeur ULB "L'oeuvre scientifique d'Emile Henriot",
  - Habilitation à diriger des recherches - rapporteur Paris VI "La préparation de l'expérience ATLAS".
- **R. Roosen**
  - Doctoral VUB "Abelian and Non-Abelian D-brane Effective actions" - Secretary ,
  - Doctoral VUB "The influence of binaries on the Galactic Chemical Evolution" - Secretary ,
  - Doctoral VUB "Studies of variable stars in stellar clusters" - Secretary .
- **S. Tavernier**
  - Ph.D. thesis VUB "Development of an irradiation setup for deep lithography with protons",
  - Ph.D. thesis VUB "Deep lithography with ions",
  - Ph.D. thesis U Gent "Monte Carlo simulations for system modeling in emission tomography".
- **P. Vilain**
  - Ph. D. Thesis Paris-VI "Etude du faisceau CNGS et identification des muons dans l'expérience OPERA".
- **G. Wilquet**
  - PhD thesis Université Claude Bernard, Lyon 1 "Développement des outils d'analyse et de reconstruction dans OPERA et analyse du canal Tau en 3 hadr".

## **XIV. LIST OF PUBLICATIONS, REPORTS AND CONTRIBUTIONS TO CONFERENCES**

### **XIV.1. PUBLICATIONS**

#### **A. NEUTRINO PHYSICS : CHORUS**

Experimental study of trimuon events in neutrino charged-current interactions  
G. Önengüt et al.  
Phys. Lett.B596 (2004) 41-53

Measurement of charm production in antineutrino charged-current interactions  
G. Önengüt et al.  
Phys. Lett.B604 (2004) 11-21

Measurement of fragmentation properties of charmed particle production in charged-current neutrino interactions  
G. Önengüt et al.  
Phys. Lett.B604 (2004) 145-156

#### **B. NEUTRINO PHYSICS : AMANDA**

Search for Extraterrestrial Point Sources of Neutrinos with AMANDA-II  
J. Ahrens et al.  
Phys. Review Letters Vol.92, N° 7 (2004) 071102-1 : 071102-5

Calibration and survey of AMANDA with the SPASE detectors  
J. Ahrens et al.  
Nucl. Instr. and Meth. Phys. Research A A522(2004) 347-359

Muon track reconstruction and data selection techniques in AMANDA  
J. Ahrens et al.  
Nucl. Instr. and Meth. Phys. Research A A524 (2004) 169-194

Sensitivity of the IceCube detector to astrophysical sources of high energy muon neutrinos  
J. Ahrens et al.  
Astroparticle Physics 20(2004) 507-532

Measurement of the cosmic ray composition at the knee with the SPASE-2/AMANDA- B10 detectors  
J. Ahrens et al.  
Astroparticle Physics 21(2004) 565-581

Search for neutrino-induced cascades with AMANDA  
J. Ahren et al.  
Astroparticle Physics 22(2004) 127-

#### **C. $ep$ PHYSICS : H1**

Muon pair production in  $ep$  collisions at HERA  
A. Aktas et al.  
Phys. Letters B 583 (2004) 28-40

Evidence for a narrow anti-charmed baryon state  
A. Aktas et al.  
Phys. Letters B 588 (2004) 17-28

Measurement of the proton structure function  $F_2$  at low  $Q^2$  in QED Compton scattering at HERA  
 A. Aktas et al.  
 Phys. Letters B 598 (2004) 159-171

Search for bosonic stop decays in R-parity violating supersymmetry in  $e^+p$  collisions at HERA  
 A. Akta et al.  
 Phys. Letters B 599 (2004) 159-172

Inclusive dijet production at low Bjorken- $x$  in deep inelastic scattering  
 A. Aktas et al.  
 Eur. Phys. J. C 33 (2004) 477-493

Measurement of anti-deuteron photoproduction and a search for heavy stable charged particles at HERA  
 A. Aktas et al.  
 Eur. Phys. J. C 36 (2004) 413-423

Search for squark production in R-parity violating supersymmetry at HERA  
 A. Aktas et al.  
 Eur. Phys. J. C 36 (2004) 425-440

Forward  $\pi^0$  production and associated transverse energy flow in deep-inelastic scattering at HERA  
 A. Aktas et al.  
 Eur. Phys. J. C 36 (2004) 441-452

Search for single top quark production in  $ep$  collisions at HERA  
 A. Aktas et al.  
 Eur. Phys. J. C 33 (2004) 9-22

A general search for new phenomena in  $ep$  scattering at HERA  
 A. Aktas et al.  
 Phys. Letters B 602 (2004) 14-30

A general search for new phenomena in  $ep$  scattering at HERA  
 A. Aktas et al.  
 Phys. Letters B 602 (2004) 14-30

#### **D. $e^+e^-$ PHYSICS : DELPHI**

Final results from DELPHI on the searches for SM and MSSM neutral Higgs bosons  
 J. Abdallah et al.  
 Euro.Phys. Journal C 32, 145-183 (2004)

b-tagging in DELPHI at LEP  
 J. Abdallah et al.  
 Euro. Phys. Journal C 32, 185-208 (2004)

Searches for invisibly decaying Higgs bosons with the DELPHI detector at LEP  
 J. Abdallah et al.  
 Euro. Phys. Journal C 32, 475-492 (2004)

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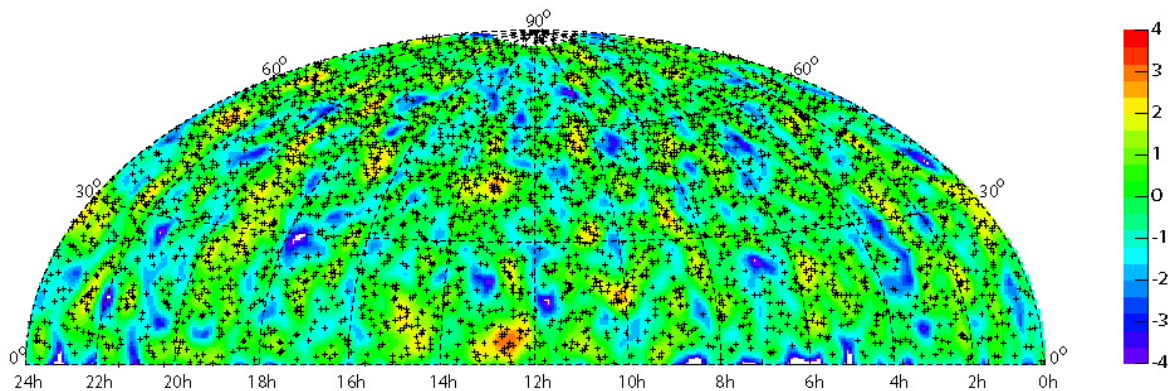
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The OPERA detector during construction in hall C of the LNGS underground laboratory in December 2004. In the foreground, the storage arch supports six scintillator strips target trackers. A first tracker is installed in front of the dipole magnet of the muon spectrometer in the empty volume that will host the target of the first super-module. The second magnet is being constructed in the rear.

**Figure 1**



Neutrino sky plot of the northern hemisphere obtained from the AMANDA point source analysis on data collected from the year 2000 up to the year 2003. Horizontal coordinates are right ascension and vertical coordinates are declination. The colour scale gives the level of significance of a signal in number of standard deviations. The observed fluctuations are compatible with the statistics.

**Figure 2**



Assembly of the first production petal in the CMS clean room.

**Figure 3**



Partial view of the computing nodes (Opteron 64 bits dual processors) of the new grid infrastructure of the IIHE.

**Figure 4**