

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

***ANNUAL REPORT 1991***

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J. LEMONNE and J. SACTON  
March 1992

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## **I. INTRODUCTION**

The physicists, engineers and computer scientists whose names are listed below have contributed to the different activities of the Institute during the year 1991.

### **U.L.B.**

F. Alexandre (chercheur sous contrat)  
 M. Barth (maître de recherche FNRS)  
 D. Bertrand (chercheur qualifié FNRS)  
 G. Bertrand-Coremans (chef de travaux)  
 A. Cohen (assistante SISH)  
 L. Favart (boursier IRSIA since October 1991)  
 M. Gruwé (boursier IRSIA)  
 P. Huet (aspirant FNRS)  
 D. Maes (assistant de recherche)  
 E. Mannie (chercheur sous contrat)  
 P. Marage (1er assistant)  
 T. Massart (assistant LIT)  
 N. Meulemans (chercheur sous contrat)  
 Thuan An Nguyen (assistant de recherche intérimaire)  
 O. Paridaens (chercheur sous contrat)  
 P. Paridans (chercheur sous contrat)  
 J. Sacton (professeur ordinaire)  
 B. Sales (assistant de recherche)  
 E. Tsigros (chercheur sous contrat)  
 F. Stichelbaut (collaborateur scientifique FNRS)  
 P. Van Binst (professeur ordinaire)  
 C. Vander Velde (chef de travaux)  
 J.M. Verbergt (chercheur sous contrat)  
 P. Vilain ((chercheur qualifié FNRS)  
 J. Wickens (chercheur IISN)  
 G. Wilquet (chercheur qualifié FNRS)  
 S. Willocq (doctorant) has spent the whole year at Tufts University - Boston in support of the E632 experiment.

### **V.U.B.**

P. Bruyndonckx (vorser IWONL)  
 Cao Fang (VUBAROS fellow)  
 C. De Clercq (logistiek medewerker IIKW)  
 E. Evrard (vorser IIKW)  
 B. Guerard (E.C. grant until may 1991)  
 T. Heiremans (vorser IIKW)  
 D. Johnson (hoogleraar VESALIUS COLLEGE)  
 J. Lemonne (gewoon hoogleraar - CERN Associate March-October 1991)  
 C. Mommaert (vorser IIKW)  
 J. Moreels (aangesteld navorser NFWO)  
 R. Roosen (bevoegdverklaard navorser NFWO)  
 S. Tavernier (onderzoeksdirecteur NFWO)  
 R. Vandembroucke-Tassin (logistiek medewerker IIKW)  
 W. Van Doninck (bevoegdverklaard navorser NFWO)  
 P. Van Esch (vorser IIKW)  
 Zhang Shuping (Rectorale beurs)

F. Verbeure, H. De Boeck, E. De Wolf and L. Verluyten from the Universitaire Instelling Antwerpen have been working in close collaboration with the Institute.

## **II. RESEARCH ACTIVITIES**

### **II.1. NEUTRINO PHYSICS**

#### **II.1.1. Neutrino and antineutrino interactions in BEBC filled with an heavy H<sub>2</sub>/Ne mixture.**

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

During 1991 results were obtained concerning :

- a) The coherent production of  $a_1^-$  mesons and  $(\rho\pi)^-$  systems by antineutrinos in the processes

$$\bar{\nu} \text{ Ne} \rightarrow \pi^+ \pi^- \pi^0 \pi^0 \text{ Ne}$$

$$\rightarrow \pi^+ \pi^- \pi^0 \gamma \text{ Ne}$$

$$\rightarrow \pi^+ \pi^- \pi^+ \pi^- \text{ Ne}$$

The cross section of the coherent signal is equal to  $(99 \pm 24) \times 10^{-40} \text{ cm}^2$ . The study of the invariant mass distributions of the two and three pion systems leads to an interpretation of the coherent signal in terms of the production and subsequent decay of  $a_1^- \rightarrow \rho\pi$  or by non resonant  $\rho\pi$  production. A detailed analysis of the differential cross sections does not allow to separate these two possibilities.

- b) A determination of the strong coupling constant  $\alpha_s$  from the  $W$  (hadronic mass)- and  $Q^2$ -dependence of the transverse momentum of hadrons produced in the forward direction in deep inelastic interactions of neutrinos with Ne nuclei. The comparison of the experimental results with the predictions of a QCD-model taking into account the Fermi momentum of the nucleons, the momenta of the quarks as well as hadronization leads to

$$\alpha_s = .16 \pm .02 \text{ (stat)} \pm .03 \text{ (fragm)} \text{ for } \bar{Q}^2 = 15.4 \pm .4 \text{ GeV}^2/c^2$$

$$\text{and } \bar{M}_{\text{MS}} = (216_{-99}^{+113}) \text{ (stat)}_{-90}^{+100} \text{ (syst)}_{-90}^{+130} \text{ (fragm)) MeV}$$

- c) A study of the reduced factorial moments of order 2, 3 and 4 in neutrino interactions with Ne and deuterium nuclei. A comparison of the experimental results with Monte-Carlo simulations based on the Lund model programs called LEPTO4.3 and JETSET 6.3 including measurement errors and nuclear effects shows that the latter considerably affect estimates of the importance of particle density fluctuations related to the intermittency effect.

- d). The production of  $D_s^{*-}$  mesons in antineutrino charged current interactions observed through the decay mode :  $D_s^{*-} \rightarrow D_s^- \gamma$  followed by  $D_s^-$  decay into  $\phi\pi^-$ ,  $\phi\pi^-\pi^0$  and  $K^{*0}K^-$ . The rate for  $D_s^-$  production followed by its decay in  $\phi\pi^-$  is  $(2.3 \pm .7) 10^{-3}$  for events with hadronic mass  $W > 3 \text{ GeV}$

### **II.1.2. Neutrino and antineutrino interactions in the 15' bubble chamber filled with an heavy H<sub>2</sub>/Ne mixture and exposed to the Tevatron high energy neutrino beam.**

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

Experiment E632 took data both in the 1985 and in the 1987-1988 running periods for fixed target experiments at the Quadrupole Triplet (QT) neutrino beamline in Fermilab. About 150000 pictures were collected during the 1985 run, corresponding to roughly 15000  $\nu_\mu$  and  $\bar{\nu}_\mu$  charged current (CC) events in a 75/25 mole % Ne/H<sub>2</sub> mixture. In the 1987-1988 run, the chamber was filled with a lighter mixture of 63/37 mole % Ne/H<sub>2</sub>. Some 300000 conventional pictures were taken, corresponding to about 20000  $\nu_\mu$  and  $\bar{\nu}_\mu$  CC events, together with 220000 holograms. The average neutrino and antineutrino event energies are 150 GeV and 110 GeV respectively. The analysis of these data is still in progress.

Coherent single meson production was studied in a sample of  $\sim 25600$  CC events (21800  $\nu$  and 3800  $\bar{\nu}$ ) with a visible event energy larger than 40 GeV. Preliminary studies indicate a clear signal in the single pion channel. Evidence exists for a signal in the  $\rho$  channel and even hints are present for coherent  $a_1$  production. The kinematical characteristics of the coherent signal in the single  $\pi$  channel are in good agreement with a model based on PCAC and meson dominance. The following cross sections for the coherent production of single and two  $\pi$  mesons have been found :

$$\sigma_{1\pi} = (314 \pm 71) \times 10^{-40} \text{ cm}^2 \text{ and } \sigma_{2\pi} = (227 \pm 10) \times 10^{-40} \text{ cm}^2$$

The ratio of neutral current to charged current interaction cross sections is measured to be  $0.288 \pm 0.032$ , for events with visible hadron momentum above 10 GeV/c. It corresponds to a combined minimum bias sample of 1187 neutrino plus 172 antineutrino CC events. After correction for the  $\bar{\nu}$  contamination in the QT beam one finds :

$$\left. \frac{\sigma(\text{NC})}{\sigma(\text{CC})} \right|_\nu = 0.274 \pm 0.038$$

When selecting interactions with a visible momentum greater than 25 GeV/c the measured cross section ratio (not corrected for the  $\bar{\nu}$  contamination) becomes  $0.323 \pm 0.025$ . It should be noted that at higher energies there is a lower contamination of the neutral current sample by neutral hadron interactions.

The neutral and charged current samples have been used for the study of the production of neutral strange particles. One measures a production of  $0.375 \pm 0.064$  and  $0.322 \pm 0.073$   $K^0$  particles respectively per CC and NC event; for  $\Lambda$  production one finds the following result  $0.161 \pm 0.030$   $\Lambda$  per CC and  $0.113 \pm 0.020$   $\Lambda$  per NC. These results are only based on the event sample obtained during the 1985 run. The distributions of the fractional hadron energy variable  $z$  in NC events are consistent with those in CC events. These results agree with those from previous experiments at lower energies.

### II.1.3. Neutrino and antineutrino scattering on electrons

*(M. Gruwé, C. Mommaert, P. Vilain, G. Wilquet; CHARM-II or WA79 Collaboration : Brussels, CERN, Hamburg, Louvain-la-Neuve, ITEP-Moscow, Munich, Naples, Rome)*

The last data taking period of this experiment which started in 1987, has been successfully performed this year, leading to a total of about 2500 events (after background subtraction) in each of the channels

$$\nu_{\mu} + e^{-} \rightarrow \nu_{\mu} + e^{-}$$

$$\bar{\nu}_{\mu} + e^{-} \rightarrow \bar{\nu}_{\mu} + e^{-}$$

The preliminary value of the electroweak mixing parameter,  $\sin^2\theta_W$ , obtained from the full statistics is

$$\sin^2\theta_W = 0.2370 \begin{matrix} + 0.0062 \\ - 0.0077 \end{matrix} \text{ (statistical error)} \pm 0.007 \text{ (systematic error)}$$

From the shape of the differential cross-sections  $\frac{d\sigma}{dy}$ , one can also measure, in a model independent way, the vector and axial coupling constants between the electron and the Z boson :

$$g_V^e = 0.025 \pm 0.019$$

$$g_A^e = 0.503 \pm 0.01$$



in nice agreement with the values measured at LEP. The final analysis of the data will be completed in the spring of 92.

Other interesting reactions are also studied with the full statistics :

- Inverse muon decay  $\nu_\mu e^- \rightarrow \mu^- \nu_e$
- Dimuon production  $\bar{\nu}_\mu + N \rightarrow \mu^- \mu^+ + \text{anything}$
- Coherent and diffractive production of single pions
- Possible oscillation signals from  $\nu_\mu$ - $\nu_e$  and  $\nu_\mu$ - $\nu_\tau$  mixing

#### II.1.4. Search for $\nu_\mu$ - $\nu_\tau$ oscillations

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

The problem of the neutrino masses is, since many years, an experimental as well as a theoretical challenge. One possible way to investigate this question is to detect a mixing between different neutrino species leading to the so-called oscillation phenomena. The amount of mixing is governed by two parameters, the mixing angle  $\theta$  and the difference between the masses squared of the 2 neutrinos,  $\Delta m^2$ . Various experiments, using neutrinos from the sun, from reactors or from accelerators, have put upper limits on these parameters but no firm evidence of mixing has been obtained so far.

The approach chosen by the CHORUS collaboration is to detect an eventual  $\nu_\tau$  content in the CERN SPS  $\nu_\mu$  beam through the observation of the production and subsequent decay of a  $\tau^-$  lepton in a charged current interaction :

$$\nu_\tau + N \rightarrow \tau^- + \text{anything} \quad \text{followed by}$$

$$\tau^- \rightarrow \mu^- + \bar{\nu}_\mu + \nu_\tau$$

$$\text{or } \tau^- \rightarrow \pi^- \nu_\tau + \text{neutrals}$$

The experiment relies heavily on the high spatial resolution of nuclear emulsion, used as target, as well as on the quality of track reconstruction provided by the recently developed scintillating fibres technology (see figure 1). Its sensitivity will be at least one order of magnitude better than previous experiments.

After a long preparation work, the proposal was approved in September 1991 by the CERN Experiment Committee. The experiment is scheduled to run for 400 days, shared between 1994 and 95. A technical test run is foreseen in November 93 and the aim is to complete the detector and make it operational for that date. To reach this goal, many activities have been started in 91 :

- A detailed design of the detector, including the support structures, is being worked out. More and more realistic simulations were made to optimize the detector performances while taking into account the engineering constraints.
- Many tests were performed on prototypes of fiber bundles and image intensifier chains. Significant progress has been achieved by various firms and the required specifications are almost reached.
- The design of the electronic boards needed in the trigger logic and in the read-out of the CCD cameras is under way. The associated data acquisition software is developing in parallel.
- Several rooms in the IIHE were equipped in view of the construction of scintillating fiber planes. Various test benches were designed to perform the quality control both of fibers and optoelectronic chains.

These activities will progressively turn into production and construction work in '92.

## **II.2. HADRON PHYSICS.**

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

## **II.3. STUDY OF $e^+ e^-$ ANNIHILATIONS AT LEP.**

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

Four Belgian groups (IIHE/ULB-VUB, Mons, UIA) and the laboratories of Oxford and Rutherford are responsible for the muon part of the DELPHI detector.

The Belgian groups have constructed the forward muon identifier consisting of 16 detector modules called "quadrants". Each of them covers a sensitive area of about  $4.4 \times 4.4 \text{ m}^2$  and is made of two orthogonally crossed layers of 22 drift chambers. Four such quadrants assembled into a square of approximately  $9 \times 9 \text{ m}^2$  provide one detection plane of the forward muon identifier. Two such detection planes are installed in both end caps of DELPHI, the outer plane being situated at the outer edge of the forward part of the magnet yoke, just behind the

forward scintillator layers which were built by Serpukhov (USSR) with the help of the Belgian groups. The inner detection plane is embedded in the iron yoke itself, separated from the outer plane by 30 cm of which 20 cm are steel.

Since the start-up of the data taking in 1989, DELPHI has accumulated  $\sim 400.000$   $Z^0$  events and results based on subsamples of these data have been published. They relate to : the properties of  $Z^0$ -particles and their decays, including a determination of the number of light neutrino species  $N_\nu$ ; detailed tests of the standard model of electroweak and strong interactions; indirect estimates of the mass of the top quark; lower limits on masses of Higgs-particles, supersymmetric particles, ...

The DELPHI results concerning the  $Z^0$ -parameters are in good agreement with those of other LEP-experiments and can be summarized as follows :  
A simultaneous fit of the cross sections for the hadronic (h) and the true leptonic (l) channels ( $\sim 150.000$  events) led to the following results :

$$M_Z = (91.177 \pm .010 \text{ (stat)} \pm .020 \text{ (syst)}) \text{ GeV}/c^2$$

$$\Gamma_Z = (2.465 \pm .019 \pm .005) \text{ GeV}$$

$$\Gamma_l = (83.4 \pm .7 \pm .5) \text{ MeV with } l = e, \mu \text{ or } \tau$$

$$\Gamma_{\text{inv}} = (488 \pm 13 \pm 11) \text{ MeV}$$

$$R = \Gamma_h/\Gamma_l = 20.70 \pm .25 \pm .14$$

From this one derives :

$$N_\nu = 2.94 \pm .08 \pm .07$$

The  $Z^0$ -properties and effective couplings  $\bar{v}_l$  and  $\bar{a}_l$  to charged leptons from 5 parameter fits to the lineshapes and charge asymmetries are determined to be :

$$M_Z = (91.177 \pm .010 \pm .02) \text{ GeV}/c^2$$

$$\Gamma_Z = (2.465 \pm .019 \pm .005) \text{ GeV}$$

$$\sigma_0 = 41.84 \pm .22 \pm .39 \text{ nb} \quad (\text{Born cross-section at pole})$$

$$\bar{v}_l^2 = .003 \pm .009 \pm .002$$

$$\bar{a}_l^2 = 0.2508 \pm .0024 \pm .0014$$

In the improved Born approximation, the coupling constants can be expressed in terms of the effective weak mixing angle and  $\rho$  parameter using the relations.

$$\overline{v}_1^2 = \frac{1}{4} \rho_{\text{eff}} (1 - 4 \sin^2 \theta_W^{\text{eff}})^2$$

$$\overline{a}_1^2 = \frac{1}{4} \rho_{\text{eff}}$$

giving :  $\rho_{\text{eff}} = 1.003 \pm .011$

$$\sin^2 \theta_W^{\text{eff}} = .241 \pm .009$$

Lower mass bounds on new particles (95 % C.L.) are summarized in the following table :

Particle type	Lower bound(GeV)
top quark	43
b'quark	45
$L^\pm$	33
$L_{\text{Dirac}}^0$	44
$L_{\text{Dirac}}^0$ (from $\Gamma_{\text{inv}}$ )	45
$L_{\text{Majorana}}^0$	38
$L_{\text{Majorana}}^0$ (from $\Gamma_{\text{inv}}$ )	40
u-type squark (L+R)	39
d-type squark (L+R)	40
squarks (L+R) (5 flavours)	44
sleptons (L+R)	22
sneutrino	32
LSP sneutrino (from $\Gamma_{\text{inv}}$ )	36
chargino	44
$u^*$	45
$d^*$	45
$L^{\pm*}$	33
neutral Higgs	38

The mass of the top quark was further constrained to lie within the interval  $43 < m_{\text{top}} < 215 \text{ GeV}$ .

Finally, among the many new results published by the DELPHI Collaboration in 1991 let us also mention the determination of the  $\tau$ -lifetime found to be :

$$\tau_{\tau} = 314 \pm 25 \text{ fs.}$$

## **II.4. STUDY OF e-p COLLISIONS AT HERA**

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

Three belgian groups from the UIA, ULB and VUB have joined - as a single group - the H1 Collaboration in the construction of a complex  $4\pi$ -multipurpose detector which is now installed in DESY (see figure 2). Their contributions to the detector consist in

- (a) the construction of a double layer of 2.2 m long and 1 m in diameter cylindrical MWPC's - called COP (Central Quter Proportional chamber) - to be located inside the system of central tracking chambers as part of the first level trigger system of the H1 detector
- (b) the design and construction of the front-end data acquisition system of the entire set of proportional chambers of the H1 detector.

The final set of chambers was completed in summer 90, transported to DESY and successfully inserted into the central tracking system at the end of the year. After the mechanical installation, it took about three months to connect electronically the detector to the MWPC frontend crates. During this period, the MWPC's, including the COP, were systematically and extensively checked. As this testing also involved the MWPC-DAQ interface cards and the 280 frontend cards which had been made at the IIHE, the debugging of this electronics went on in parallel. In the same period the "test-software" developed earlier was finalised.

In April 1991, a first full scale test of the H1 detector was undertaken by recording cosmic ray data using all the H1 subdetectors. The signals from the central proportional chambers and in particular the COP were found to suffer severely from noise which was related to the H1 environment and which had not been observed before. The noise level was such that it prevented the chambers from an efficient operation. To overcome this noise problem the detector grounding had to be modified. This, however, meant modifying connections situated at the level of the detector, an area extremely difficult to access due to the

dense infrastructure. Because of this, the grounding modifications took a rather long time and lasted from July until September.

The April "Cosmic Run" also meant the first complete test of the MWPC-DAQ hardware and software. Full integration with the Central DAQ and Central trigger showed that there were still problems in the MWPC-DAQ system. However they did not prevent good cosmic data taking. These problems were later investigated during the summer period and successfully cured.

A second "Cosmic Run" took place in October and was meant as a final run with cosmic ray data preceding the first ep running. Analysis of the COP data showed that the grounding modifications performed during summer were adequate to make the COP perform efficiently and hence that this detector can be operated as foreseen as one of the subdetectors that feeds data to the first trigger level. Also the MWPC-DAQ system performed well during this second cosmic test run; it is ready to accept the data from the first ep collisions expected in June 1992.

### **III. TEACHING ACTIVITIES AND SEMINARS**

#### **III.1. TEACHING ACTIVITIES**

- **M. Barth, D. Bertrand, M. Gruwé, P. Huet, P. Marage, F. Stichelbaut, P. Vilain and G. Wilquet** have contributed to the practical work for students attending the lectures of J. Sacton on "Physique des Particules Élémentaires" and organized specific practical work for students of the 3rd year in physics at the ULB.
  - **D. Bertrand**
    - "Computer Principles" (26h + 13h of practical work - 1st year University Studies in Sciences - ULB)
    - "Analyse, simulation et prise de données expérimentales (10h - Licence Spéciale en Physique Théorique - ULB)
  - **G. Bertrand-Coremans**
    - "Questions Approfondies de Physiques des Particules" (10h + 15h of practical work - 2ème licence en sciences physiques - ULB)
    - Participation to the practical work of the "1ère candidature polyvalente en médecine et pharmacie" - 120h
  - **P. Bruyndonckx** contributed to laboratories attached to the physics courses ensured by D. Johnson for the VESALIUS College.
  - **C. De Clercq, E. Evrard and S. Tavernier** have contributed to the practical work for students attending the lectures of J. Lemonne on "Elementaire Deeltjes".
  - **E. De Wolf**
    - "Scaling phenomena in soft hadronic production"  
Series of 2 lectures given at the 1991 Joint Belgian-Dutch-German (Aachen) School of Particle Physics
  - **D. Johnson**
    - "Introduction to Physics II - Physics 103" (45h - Vesalius College - VUB)
    - "Introduction to Physics I - Physics 101" (45h - Vesalius College - VUB)
    - "Solid State Physics - Physics 104" (45h - Vesalius College - VUB)
- All these lectures are accompanied by student consultation and regular interval student exercises.
- D. Johnson also assisted in the teaching and laboratory planning for the course "Physics Laboratory I - Physics 102" (Vesalius College - VUB)

- **J. Lemonne**

- "Elementaire Deeltjes" (60h + 60h of practical work - 1ste and 2de licentie natuurkunde - VUB)
- "Algemene Natuurkunde" (60h + 60h of practical work - 2de kandidatuur Natuurkunde, Scheikunde, Geologie (30h + 30h of practical work) - VUB)
- "Statistische Analyse van Experimentele Gegevens" (15h + 15h excercises - licentie Natuurkunde - VUB)

- **P. Marage**

- "Physique générale" (120h of practical work - 1ère candidature Ecole de Commerce Solvay)

- **J. Moreels**

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

- **J. Sacton**

- "Physique des Particules Élémentaires" (30h + 45h of practical work - 1ère licence en sciences physique - ULB)

- **S. Tavernier**

- "Detectie van Ioniserende Stralingen" (15h + 15h of practical work - 2de licentie Natuurkunde and Bijzondere Licentie Medische Fysica - VUB)

- **C. Vander Velde**

- "Mechanics 2" (26h + 13h of exercises) and "Introduction to Experimental Physics (8h + 16h lab) - 1ère candidature en Sciences ULB (in english)
- "Simulation, prise et analyse de données" (10h - licence spéciale en Physique Théorique - ULB)
- "Exercices complementing the course of "Physique Générale" (60h - Prof. J. Jeener - ULB)
- Special laboratory sessions in particle physics for students of the "1ère Licence in Physics - ULB (80h)

- **W. Van Doninck**

- "Leptonic decays of the  $Z^0$  from an experimental point of view"  
Series of 4 lectures given at the 1991 Joint Belgian-Dutch-German (Aachen) School of Particle Physics



- **P. Vilain**

- "Questions Approfondies de Physique des Particules" (part time 30h + 45h of practical work - 2ème licence en sciences physique - ULB)
- Special laboratory sessions in particle physics for students of the "1re licence" in physics - ULB (80h)

- **T. Massart**

- gave exercises on the following subjects :  
 "Algorithmique générale" : 2ème Cand. en Informatique - ULB (30h)  
 "Analyse et Programmation II" : Stage d'algorithmes et de structures de données : 2ème cand. en Informatique - ULB (30h)
- "Algorithmique et Programmation" (45-45 + 60 exercices) - 1ère candidature en Informatique (ULB)
- "Elements de Programmation Appliquée (15h + 30h d'exercices) 1ère Candidature en Sciences Appliquées ULB
- He has acted as a "suppleant" at the ULB for the following courses :  
 "Algorithmique, aspects formels" ((30 + 15) - 1ère Licence en Informatique (titulaire M. Latouche)  
 "Introduction à la théorie des langages" (30 + 15) - 1ère Licence en Informatique (replacement of M. Pirotte)  
 "Langages et Programmation" (30 + 30) - 2ème Candidature en Informatique et Sciences Humaines

- **B. Salès**

- Exercises of the following lectures provided at the ULB :  
 "Analyse et méthodologie informatique"; 2ème candidature en informatique  
 "Architecture d'un système d'exploitation", 2ème candidature en informatique  
 "Assembleur", 1ère licence en informatique  
 "Exercices de programmation II", partie Système, 2ème candidature en informatique  
 "Exercices de programmation II, partie Gestion, 2ème candidature en informatique

- **P. Van Binst**

- ULB, Faculté des Sciences Sociales, Politiques et Economiques, Section Informatique et Sciences Humaines :  
 - "Introduction à l'informatique (30h + 30h)  
 - "Informatique (techniques et stratégies) (50h + 30h)  
 - "Télématique" (30h)

- ULB, Faculté de Philosophie et Lettres, Licence Spéciale en Sciences de l'Information et de la Documentation :
  - "Télématique" (30h)
- ULB, Faculté des Sciences, Licence Spéciale en Télématique et Organisation :
  - "Télématique Grand Public" (partime 10h)
  - "Analyse et évaluation critique des systèmes télématique" (partime 15h)

The following PhD Thesis works were completed during this year :

- **D. Geiregat - VUB** (supervisors J. Lemonne (promotor) and P. Vilain) : "A determination of the electroweak mixing angle from the elastic scattering of muon-neutrinos and muon-antineutrinos on electrons"
- **T. Massart - ULB** (promotor P. Van Binst) : "A basic agent calculus and bisimulation laws for the design of systems"
- **L. Verluysen - UIA** (promotor E.A. De Wolf) : "Holography in the FNAL 15-foot bubble chamber and particle density fluctuations in neutrino interactions"

The following mémoires have been made at the ULB :

- **L. Favart** (supervisors J. Sacton (promotor) and P. Marage) : "Production quasi-élastique d'hypérons  $\Lambda^0$  par antineutrinos"
- **A. Bayla** (supervisors J. Sacton (promotor) and P. Marage) : "Production de particules étranges neutres par interaction d'antineutrinos"
- ULB, Faculté des Sciences, Licence en Informatique :
  - **T.A. Nguyen** (supervisors R. Devillers (promotor) and D. Bertrand) : "Conception d'une interface de communication interprocessus via réseau par adressage logique sous UNIX B.S.D. 4.2"
  - **M. Colin** (promotor P. Van Binst) : "Etude de la gestion dans le cadre du modèle OSI et réalisation d'une entité de transfert d'information de gestion"
  - **R. Najmabadi Kia** (promotor P. Van Binst) : "Etude des procédures de routage dans le contexte OSI et conception d'un protocole de routage inter-domaine dans un environnement orienté connexion"
- ULB, Faculté des Sciences Sociales, Politique et Economiques, Licence en Informatique et Sciences Humaines :
  - **J. Delmee** (promotor P. Van Binst) : "Le téléport de Bruxelles"
  - **D. Dreesen** (promotor P. Van Binst) : "Impact and performance of the IXI project"
  - **P. Duc Thanh** (promotor P. Van Binst) : "Case study of two high performance transport protocols"

- **B. Renders** (promotor P. Van Binst) : "Le RNIS et la normalisation européenne"
- **T. Van Laethem** (promotor P. Van Binst) : "Etude d'un système d'aide à la résolution de problèmes survenant sur un réseau informatique"

### **III.2. SEMINARS**

The following seminars were given by members of the IIHE :

- **C. De Clercq**  
"De Belgische bijdrage tot het DELPHI experiment bij de LEP versneller van het CERN"  
(Navorming leraren - VUB)
- **S. Tavernier**  
"Instrumentation for Positron Emission Tomography"  
(Weizmann Institute, Tel Aviv, Israel)
- **C. Vander Velde**  
Report on the Workshop on "Physics with Linear Colliders"  
(Saariselka, Finland) - IIHE, Brussels
- **P. Van Binst**  
"Enjeux du Grand Marché en termes de formation des utilisateurs professionnels  
SYSDM-LENTIC, L'impact du Grand Marché sur l'emploi et les qualifications dans le  
secteur des télécommunications en Belgique"  
VUB, Brussels  
"Evolution des techniques de télécommunication et leur impact sur la gestion et les stratégies  
des entreprises"  
ASAB-IA, Brussels  
"Les normes internationales en matière de communication"  
Point Com, Paris  
"Télématique et société"  
CEPULB, Braine-l'Alleud  
"Télécommunications, télématique et stratégie d'entreprise"  
ASAB-IA, Brussels
- **O. Paridaens**  
"Using OSI in the academic research world" - Digital, Belgium

## **IV. COMPUTER MATTERS**

### **IV.1. COMPUTING AND NETWORKING**

Management : P. Van Binst and R. Vandenbroucke

Scientific : (Helios-B group) : F. Alexandre, A. Cohen, D. Maes, E. Mannie, T. Massart, N. Meulemans, Thuan-an Nguyen, O. Paridaens, P. Paridans, B. Salès, E. Tsigros, J.M. Verbergt

Administrative and logistic : J. Castera, G. Depiesse, J. Liesen (part-time), D. Pirnay (part-time), G. Rousseau, W. Van Droogenbroeck (till October 1991)

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

- acquisition of a UNIX server consisting of a DECstation 5000/125, 2.8 Gbyte of disk and a tape streamer of the "Exabyte" type
- acquisition of a DECstation 5000/120 with colour monitor and CAD/CAM software
- acquisition of a DECserver300, a terminal server which has the LAT protocol as well as the Telnet protocol
- installation of an ICL DRS3000 (under a HELIOS-B contract with LEVEL 7)
- possibility to use the RARE/COSINE IXI (International X.25 Interconnect) network through RESULB resulting in no-cost communications to other European research institutes, especially CERN and DESY
- acquisition of two Macintosh LC for secretarial work

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

### **IV.2. GRAPHICS DEVELOPMENT**

*(D. Bertrand, T. Heiremans)*

The interactive graphics analysis program, originally developed in the framework of a DIGITAL VAX environment including DECNET, has been adapted to UNIX platforms. This was an opportunity to increase the portability of the program in two main areas :

- Adaptation of the user interface for the interactive commands handling. The procedure was completely redesigned, using the standard X11 windowing system which is available on all UNIX systems.
- Creation of an inter-process communication package working as a layer on top of the TCP-IP ethernet protocol.

The graphical part of the program had already a GKS3D interface which needed a minimal adaptation to the DECWindow version of the software. Unfortunately this code suffers from many bugs and imperfections and is poorly supported by Digital. Thus, we intend to produce a PEX/PHIGS version for the graphics part which will be more general than the present one.

Another development concerns the creation of an interactive graphical interface in the context of multidimensional analysis. This statistical tool is more and more used in the high energy physics data analysis programs. Many of the existing softwares appear as "black boxes" and have "unfriendly" interfaces. The idea is to give ways to visualize multidimensional projections of the total space using the full power of high end graphics workstations, to show in real time the evolution of the algorithms and to offer the possibility to interact with the corresponding procedures.

## **V. TECHNOLOGICAL R&D**

### **V.1. TECHNOLOGY TRANSFER FROM BASIC RESEARCH TO APPLICATIONS : THE PET SCANNER PROJECT**

*(P. Bruyndonckx, B. Guerard, S. Tavernier and Zhang Shuping - Collaboration : Brunel University, Brussels, CERN, Ecole Polytechnique-Palaiseau and LAL/Orsay).*

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

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

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

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

We have built and tested a number of small technical prototypes with BaF<sub>2</sub> scintillator and a photosensitive wire chamber using TMAE vapour as a photosensitive agent. Stable and reproducible operating conditions could be obtained with the following performance of the detector :

- time resolution 11ns
- chamber gain few  $10^6$
- detection efficiency for gamma rays having deposited 511keV better than 98%
- number of photoelectrons for crystals of  $3 \times 3 \times 20 \text{ mm}^3$  or  $2 \times 2 \times 15 \text{ mm}^3 \sim 5/511 \text{ keV}$
- spatial resolution limited by the size of the crystals to 3.7 and 3.0 mm FWHM for the above mentioned crystals

Figure 3 shows some of the test chambers used to obtain the above results.

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

A number of variants and alternatives were studied, namely : operation of the wire chamber at atmospheric pressure, double readout where the crystals are read on one side with a PM and on the other side with a photomultiplier to give time and energy resolution, the use of  $\text{LaF}_3\text{:ND}$  to replace  $\text{BaF}_2$ , and CsI photocathodes to replace TMAE. Of these, particularly the last one is potentially very interesting. The use of CsI would considerably improve the time resolution of the chamber, and it would remove a number of complications related to the use of TMAE like the need to operate the chamber at a temperature of  $\pm 60^\circ\text{C}$ . We have successfully used a wire chamber with CsI photocathode to detect the scintillation light of  $\text{BaF}_2$ , but more work is necessary before this becomes a valid alternative to TMAE.

## **V.2. R&D ON THE SCINTILLATING FIBRES TECHNOLOGY**

*(M. Gruwé, C. Mommaert, G. Wilquet)*

Most of the effort has been put in 1991 on the design of the trackers for the CHORUS experiment and on testing various products : fibres, fibre ribbon, optoelectronics, CCD camera to be used in their construction.

Some additional work has gone on the construction of very high resolution targets to be used for heavy flavour physics (B in hadron beams,  $\tau$  in  $\nu_\tau$  beams or as signature of oscillations in  $\nu_\mu$  beams). These targets are made of thin (20-100  $\mu\text{m}$  diameter) coherent glass capillaries up to 1m long for which filling techniques have been prepared and good homogeneous optical performances has been achieved. Among the various highly purified solvents doped with large stoke shifts dyes, the combination of 1MN or IBP doped with PMP has produced the best results. A hit density larger than  $2\text{ mm}^{-1}$  at large distances ( $\sim 1\text{m}$ ), a spacial resolution of 12  $\mu\text{m}$ , a background level compatible with the physical limit coming from  $\delta$  rays and an attenuation length in the 1m domain have been observed.

## **VI. TECHNICAL AND ADMINISTRATIVE WORK**

The members of the workshop staff were : J. De Bruyne, J.P. Dewulf, L. Etienne, S. Franchomme, R. Gindroz, R. Goorens, E. Lievens, R. Ruidant, H. Turtelboom, G. Van Beek, J. Vanbegin, L. Van Lancker, J. Van Vaerenbergh, G. Vincent and C. Wastiels with the help of D. Luypaert-Peymans and R. Pins.

G. Wilquet was in charge of the general coordination; R. Goorens and L. Van Lancker organised the work of the electronics and mechanics workshops respectively.

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

A large mounting hall has been divided into two clean rooms, a dark room and a small mounting room to be used for the tests and construction of the scintillating fibres trackers for the CHORUS experiment. Those involved were R. Gindroz, H. Turtelboom, R. Ruidant, J. Van Vaerenbergh, C. Wastiels and G. Van Beek.

For the CHORUS experiment, a bench for the measurement of scintillating fibres optical properties and a prototype of the mechanical structure of the optoelectronics chain have been constructed by S. Franchomme, R. Gindroz, R. Goorens, R. Ruidant, G. Van Beek, L. Van Lancker, J. Van Vaerenbergh and G. Vincent. J.P. Dewulf has worked in collaboration with the electronics workshop at the Université Catholique de Louvain-la-Neuve on the design of electronics cards for the trigger of the experiment.

L. Etienne, H. Turtelboom and C. Wastiels have contributed to the maintenance and repair of the COP electronics at DESY.

A set-up for drift chamber ionisation via a UV nitrogen laser has been constructed with the help of L. Etienne, R. Goorens, R. Ruidant and L. Van Lancker.

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

R. Gindroz, R. Ruidant, G. Vincent and C. Wastiels were in charge of the maintenance of the bubble chamber film measuring machines kept in used for teaching applications.

Scanning of DELPHI data, on the graphics devices, was undertaken by C. Carlier and R. Pins.

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



## **VII. REPRESENTATION IN COUNCILS AND COMMITTEES**

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

**J. Lemonne, J. Sacton** and **F. Verbeure** contributed to the organization of the Third Joint Belgian, Dutch and German (Aachen) Summer School on Elementary Particle Physics at the RWTH-Aachen (Germany)

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

Until September 91, **J. Sacton** acted as Vice-Chairman of the Faculty of Sciences of the ULB, as adviser of the Rector of the ULB for all matters dealing with computing; he has deputized the Rector as Chairman of the Conseil de l'Informatique, at the Conseil de Gestion du Centre de Calcul ULB-VUB. Since the 1st of October he is "Doyen de la Faculté des Sciences de l'ULB". He is member of the "Commission de Physique" at the FNRS. He also acted as a member of the C11 Commission (Particles and Fields) of the International Union for Pure and Applied Physics (IUPAP) and as Chairman of the High Energy Physics Computer Coordinating Committee (HEPCCC).

**F. Verbeure** has acted as Belgian representative at Plenary ECFA and Restricted ECFA. He is Dean of the Faculty of Science of the U.I.A. since the 1st of October 1991.

**P. Vilain** was the Belgian representative at Plenary ECFA.

**P. Marage** was a member of the Council of the ULB and of the "Commission des Finances", the "Commission de la Programmation et des Investissements" and the "Commission des Affaires Sociales".

**G. Cooremans-Bertrand** was a delegate of the Scientific Staff in the "Conseil de Physique" of the ULB.

**S. Tavernier** was member of the "Bureau van de Onderzoeksraad" of the VUB and Chairman of the "Commissie voor Basis en Toegepaste Wetenschappen" van de Onderzoeksraad, member of the Committee for the development of new PET instrumentation in the "European Concerted Action on PET instrumentation", of the board of directors of the

Belgian Physical Society, and Chairman of the Organizing Committee of the "International Meeting on Fully Three Dimensional Image Reconstruction in Nuclear Medicine and Radiology, Corsendonk, June 1991. Spokesman of the EC-SCIENCE collaboration ST200106 on "Development of gamma detectors based on BaF<sub>2</sub> scintillator and photosensitive wire chambers"; organisator of the "Session on High Energy Physics" of the Annual Meeting of the Belgian Physical Society, May 1991

**D. Johnson** was a member of the Academic Standards and Forum Committees of the Vesalius College of the VUB.

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

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

- **D. Bertrand** : member of the Software Coordination Panel (SCOOP)
- **J. Lemonne** : Vice-chairman of the Collaboration Board and representative of "Belgium", representative of the IIKW-IISN in the DELPHI Finance Committee
- **C. Vander Velde** : responsible for the muon subtrigger
- **C. De Clercq** : project leader of muon detectors
- **J. Wickens** : member of SCOOP and PAP (Physics Analysis Panel) and of the DPSP (Delphi Production Steering Panel)

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

- **R. Roosen** : representative of "Belgium" in the Collaboration Board
- **J. Sacton** : representative of the IISN-IIKW in the H1 Finance Committee

**P. Van Binst** was a member of :

- RARE Executive Committee, Council of Administration and Working Groups
- COSINE Policy Group
- IXI Coordination Committee
- EWOS Steering Committee and Technical Assembly
- ETSI General Assembly and Technical Assembly
- ECTUA
- European DECUS Council and DECUS BELUX Board
- IBN, Commission Informatique and NBT
- FNRS, Commission Informatique

- Ministry of Scientific Policy, technical committee for a Belgian academic and research network
- Région Bruxelloise, Syndicat d'études Téléport Bruxelles, Comité de Direction et Comité de Coordination
- Member of the Editorial Board of "Revue Réseaux et Informatique Répartie"

**R. Vandenbroucke-Tassin** represented Belgium in the IXI-telecommunication project and was a member of the IXI-project team. She was the chairperson of the DECUS BELUX Networks SIG and acted as Communication Coordinator. She became a delegate to the European Decus Council since September 91. She was a member of the DECUS Europe Networks SIGCC and European Communications Coordinator. She also represented DECUS Europe in EWOS (European Workshop on Open Systems).

**B. Salès** was a member of :

- ISO/IEC JTC1 SC6/WG 1 (ISO expert group on OSI Data Link Layer),
- ISO/IEC JTCQ SC6/WG2 (ISO expert group on OSI Network Layer),
- ISO/IEC JTC1 SC6/WG3 (ISO expert group on OSI Physical Layer),
- EWOS EGLL (European Workshop for Open Systems - Expert group on Lower Layer),
- RARE WG4 (Network Services)
- IBN SCCI-4A d (Expert group on Lower Layers within the Belgian National Member body)

**N. Meulemans** was a member of :

- EWOS EG FTAM (File Transfer, Access and Management)
- RARE WG3 (Directory Services)

**O. Paridaens** was a member of :

- EWOS EG MH (Message Handling Systems)
- CCITT Study Group on Message Handling Systems

**F. Alexandre** was a member of :

- RARE WG1 (Message Handling Systems)

## **VIII. ATTENDANCE TO CONFERENCES, WORKSHOPS AND SCHOOLS**

### **VIII.1. CONFERENCES AND WORKSHOPS**

- Joint International Lepton-Photon Symposium and Europhysics Conference on High Energy Physics (Geneva)  
J. Sacton, S. Tavernier, F. Verbeure
- XXVIth Rencontre de Moriond : "Massive Neutrinos and tests of fundamental symmetries"  
W. Van Doninck
- XXVIth Rencontre de Moriond : "Elektroweak interactions and unified theories"  
H. De Boeck, F. Stichelbaut
- High Energy Physics Directors Seminar (Nyon-Switzerland)  
J. Sacton
- Workshop on "Physics with Linear Colliders" (Saariselkä, Finland)  
C. Vander Velde
- E.P.S. Conference "Hadronic Structure and Electroweak Interactions" (Amsterdam, Nederland)  
E. Evrard
- International Workshop on Electroweak Physics (Valencia, Spain)  
P. Marage
- Conference on "Physics in Collision" (Colmar, France)  
G. Bertrand-Coremans and P. Vilain
- Workshop on "Photon Radiation from Quarks" (Annecy-le-Vieux, France)  
D. Johnson
- Ringberg Workshop on Multiparticle Production (Ringberg, Germany)  
E. De Wolf
- International Workshop on Relativistic Aspects of Nuclear Physics (Rio de Janeiro, Brazil)  
F. Verbeure
- XXI International Symposium on Multiparticle Dynamics (Wuhan, China)  
F. Verbeure
- INFN Eloisatron Project : 18th Workshop : Image Processing in High Energy Physics Detectors (Erice, Italy)  
C. Mommaert
- International Meeting on Fully Three-Dimensional Image Reconstruction in Nuclear Medicine and Radiology (Cortendone, Belgium)  
P. Bruyndonckx, S. Tavernier, S. Zhang
- Annual meeting of the BNV-SBP (Gent, Belgium)  
C. De Clercq, F. Stichelbaut, S. Zang

- European Conference on Integrated Home Applications (Amsterdam, Nederland)  
P. Van Binst
- Télématique Grande Vitesse - 100 Mbit LANs (Torino, Italy)  
P. Van Binst
- International Symposium on Subscriber Loops and Services (Amsterdam, Nederland)  
P. Van Binst
- International Networking Conference (Copenhagen, Denmark)  
P. Van Binst
- Télématique Grande Vitesse - Is Gbit really easy ? (Bristol, UK)  
P. Van Binst
- Second European Conference on Satellite Communications (Liège)  
P. Van Binst
- Mobile Radio Confernce (Nice, France)  
P. Van Binst
- CEC, ESPRIT Conference (Brussels)  
P. Van Binst
- 2nd Joint European Networking Conference (Blois, France)  
P. Van Binst, R. Vandenbroucke, E. Tsigros, B. Salès, P. Paridaens, D. Maes
- High Speed Networking (Brussels)  
R. Vandenbroucke, P. Van Binst
- DECUS BELUX Symposium (Oostende)  
R. Vandenbroucke, P. Van Binst
- DECUS EUROPE Symposium (The Hague, Nederland)  
R. Vandenbroucke
- CICSO Seminar (London, U.K.)  
R. Vandenbroucke, P. Van Binst
- IFIPNG 61 : 11th International Symposium on Protocol Specification, Testing and Verification (Stockholm, Sweden)  
T. Massart
- CFIP'91 : Colloque Francophone sur l'Ingenierie des Protocoles (Pau, France)  
T. Massart
- Formal Technique FORTE '91 (Sidney, Australie)
- 10th Annual Joint Conference of the IEEE Computer & Communication Sections - IEEE INFOCOM'91. Networking in the 90's (Bal Harbour, USA)  
J.M. Verbergt
- Eurodoct Colloquium (Saclay, France)  
P. Marage

## **VIII.2. SCHOOLS**

- 1991 Joint Belgian-Dutch-German (Aachen) Summer School on Elementary Particle Physics (RWTH-Aachen, Germany)

M. Gruwé, C. Mommaert

- JINR-CERN Joint School (Alushta, USSR)

M. Gruwé, L. De Boeck

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

### IX.1. PUBLICATIONS

#### NEUTRINO PHYSICS

- 19    ① - Coherent production of  $a_1^-$  mesons and  $(\rho\pi)^-$  systems by antineutrinos on neon  
P. Marage, ..., J. Sacton, ..., S. Willocq, ... et al.  
Z. Phys. C - Part. and Fields 49 (1991) 385
- 20    ② - Production of  $D_s^*$  mesons in antineutrino-neon charged current interactions  
A.E. Astratyan, P. Marage, J. Sacton ... et al.  
Phys. Lett. B257 (1991) 525
- 21    ③ - Study of Factorial Moments in neutrino charged current interactions on new and deuterium  
L. Verluyten, ..., P. Marage, ... et al.  
Phys. Lett. B260 (1991) 456
- 22    ④ - A determination of  $\alpha_s$  from the transverse momenta of hadrons produced in  $\nu$  and  $\bar{\nu}$  interactions  
M. Berggren, ..., P. Marage, ... et al.  
Z. Phys. C50 (1991) 427
- 23    ⑤ - Neutrino electron scattering  
P. Vilain  
Nucl. Phys. B (Proc. Suppl.) 19 (1991) 306-315
- 24    ⑥ - An improved determination of the electroweak mixing angle from muon-neutrino electron scattering  
D. Geiregat, P. Vilain, G. Wilquet et al.  
Phys.Lett. B259 (1991) 499-507

#### Hadron Physics

- Tripple Regge analysis of inclusive  $\Lambda$  production in  $K^+p$  and  $\pi^+p$  interactions at 250 GeV/c  
N.M. Agababyan, ..., A. De Roeck, E.A. De Wolf, ..., B. Michalowska, ..., F. Verbeure, ... et al.  
Z. Physik C, Particles and Fields 49 (1991) 235

- Collective characteristics of hadron systems produced in beam fragmentation of  $\pi^+p$  collisions at 250 GeV/c  
I.V. Ajinenko, ..., A. De Roeck, E.A. De Wolf, ... B. Michalowska, ..., F. Verbeure, ..et al.  
Z. Physik C, Particles and Fields 49 (1991) 367
- Factorial correlators from  $\pi^+p$  and  $K^+p$  collisions at 250 GeV/c  
V.V. Aivazyan, ..., A. De Roeck, E.A. De Wolf, ..., F. Verbeure, ...et al.  
Phys. Lett. 258B (1991) 487
- A study of double pomeron exchange in  $\pi^+$  and  $K^+p$  interactions at 250 GeV/c;  
M.R. Atayan, ..., A. De Roeck, E.A. De Wolf, ..., B. Michalowska, ..., F. Verbeure, ..  
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Z. Physik C, Particles and Fields 50 (1991) 353
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- X 113 (151) - Liquid scintillator filled capillary arrays for particle tracking

J. Baehr, ..., M. Gruwé, C. Mommaert, G. Wilquet et al.

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- VUB X - TMAE vapour or CsI layers as photocathodes in a multiwire proportional counter working at  
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B. Guerard, P. Bruyndonckx, S. Tavernier, Zhang Shuping

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- A simple agent calculus where the LOTOS enabling and disabling are derived operators  
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- A search for neutral Higgs particles in  $Z^0$  decays

P. Abreu, ..., D. Bertrand, C. Bricman, J. Buytaert, F. Cao, H. De Boeck, C. De Clercq, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, F. Verbeure, W. Van Doninck, J. Wickens et al

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P. Abreu, ..., D. Bertrand, C. Bricman, J. Buytaert, F. Cao, H. De Boeck, C. De Clercq, J. Lemonne, F. Stichelbaut, S. Tavernier, C. Vander Velde, F. Verbeure, W. Van Doninck, J. Wickens et al

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- Study of final state photons in hadronic  $Z^0$  decays and limits on new phenomena

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CERN-PPE/91-174

- Searches for heavy neutrinos from Z decays

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CERN-PPE/91-175

X - Experimental aspects of selectron pair searches

C. Vander Velde

IIHE - 91.06

Contributed paper to the Workshop : "e<sup>+</sup>e<sup>-</sup> linear colliders at 500 GeV : the physics potential

### **IX.3. CONTRIBUTIONS TO CONFERENCES**

#### **a) Presented by members of the IIHE**

- Intermittency, correlations and correlators

E. De Wolf

Invited talk at the Ringberg Workshop on Multiparticle Production, June 1991, Ringberg, Germany

- Multidimensional moments and cumulants  
F. Verbeure  
Talk at the XXI International Symposium on Multiparticle Dynamics, September 1991, Wuhan, China
- High Energy Hadron-Nucleus Interactions : an experimental review  
F. Verbeure  
International Workshop in Relativistic Aspects of Nuclear Physics, August 1991, Rio de Janeiro, Brazil
- Results on positive meson-nucleus interactions  
F. Verbeure  
Talk at the Joint International Lepton-Photon Symposium and Europhysics Conference on High Energy Physics, August 1991, Geneva, Switzerland
- Scintillating fibre trackers for the CHORUS experiment at CERN  
Talk presented by C. Mommaert at the 18th Workshop of the INFN Eloisatron Project - November 91 - Erice - Italy
- Interactive Graphics at LEP  
Communication made by D. Bertrand at the 18th Workshop of the INFN Eloisatron Project - November 91 - Erice- Italy
- Monte Carlo studies on Slepton Production  
Contribution of C. Vander Velde to the Workshop on "Physics with Linear Colliders", Saariselkä, Finland
- The researcher's career in Belgium  
Communication presented by P. Marage at the Eurodoct Colloquium - Saclay - France
- A fully 3D small PET scanner  
Talk presented by S. Tavernier at the International Meeting on Fully Three-Dimensional Image Reconstruction in Nuclear Medicine and Radiology, Corsendonk, Belgium
- Design study of a small animal PET scanner based on a new detection principle  
Communication presented by Zhang Shuping at the Annual Meeting of the Belgian Physical Society (Gent)
- A study of the reaction  $e^+e^- \rightarrow \mu^+\mu^-$  around the  $Z^0$  pole using the DELPHI detector at the LEP collider at CERN  
Communication made by F. Stichelbaut at the Annual Meeting of the Belgian Physical Society (Gent)

- High Speed Networking in Europe : Dream, Nightmare, Utopia or Reality ?  
Closing address presented by P. Van Binst at the Symposium on High Speed Networking for Research in Europe, RARE/CEC Brussels  
Computer Networks and ISDN Systems, North-Holland, 21, 1991, 1-3
- Report on the RARE High Speed Networking Symposium  
Invited communication given by P. Van Binst at the 2nd Joint European Networking Conference, organized by RARE, Blois - France  
Computer Networks and ISDN Systems, North-Holland, 21, 1991, 1-3, 41
- Future of networking in Europe  
Invited plenary talk by P. Van Binst at the INET'91 Conference, Copenhagen
- Les réseaux : quelles sont les tendances futures ?  
Invited talk given by P. Van Binst "Les systèmes de communication de l'entreprise" organisé par ARIA, Rochefort
- Telematic Services : the technology challenge  
Invited paper presented by P. Van Binst at the Conference on Informatics in Food and Nutrition, Stockholm  
Proceedings 11

#### **b) Others**

- Bose Einstein correlations in Neutrino Interactions  
V.A. Korotkov, ..., P. Marage, ..., J. Sacton, ..., S. Willocq, ... et al.  
Paper submitted to the Joint International Lepton-Photon Symposium and Europhysics Conference in High Energy Physics (Geneva) 1991
- Scintillating fiber arrays for particle tracking  
J. Baehr, ..., M. Gruwé, C. Mommaert, G. Wilquet et al.  
Contribution to the XIth Rencontre de Moriond Workshop, Tests of Fundamental Laws in Physics (Les Arcs, France) 1991
- CCD camera readout system developments for HEP experiments at CERN  
E. Falk, ..., C. Mommaert et al.  
IEEE-symposium on Nuclear Science (Santa Fe, USA) 1991
- Scintillator fibre arrays for particle tracking  
J. Bahr et al.  
Contribution to the XIth Moriond Workshop, Tests of Fundamental Laws in Physics (Les Arcs, France) 1991

- Experimental aspects of selectron pair searches

C. Vander Velde

Contributed paper to the Workshop "e<sup>+</sup>e<sup>-</sup> linear colliders at 500 GeV : The Physics Potential,  
Hamburg, Germany

Papers presented by the DELPHI collaboration to the Joint International Lepton Photon Symposium and Europhysics Conference in High Energy Physics, Geneva (1991)

- Determination of Z<sup>0</sup> resonance parameters and couplings from its hadronic and leptonic decays  
PPE/91-95
- A measurement of the lifetime of the tau lepton  
PPE/91-XX
- A measurement of sin<sup>2</sup>θ<sub>W</sub> from the charge asymmetry of hadronic events at the Z<sup>0</sup> peak  
DELPHI note 91-47 PHYS 102
- A measurement of the b $\bar{b}$  asymmetry using the semileptonic decay into muons  
DELPHI note 91-49 PHYS 103
- Partial width of the Z<sup>0</sup> into b $\bar{b}$  final states and mean b semileptonic branching fraction  
DELPHI note 91-49 PHYS 104
- Measurement of the tau polarization using the DELPHI detector  
DELPHI note 91-60 PHYS 115
- Study of final state photons in hadronic Z<sup>0</sup> decay and limits on new phenomena  
DELPHI note 91-46 PHYS 101
- Z<sup>0</sup> partial width into b $\bar{b}$  from DELPHI data  
DELPHI note 91-71 PHYS 125
- Improved electroweak constraints from Z<sup>0</sup> lines shapes and asymmetries  
DELPHI note 91-75 PHYS 129
- Constraints on physics beyond the standard model  
DELPHI note 91-76 PHYS 130
- Search for low mass Higgs bosons produced in Z<sup>0</sup> decays  
PPE/90-193
- Search for neutral Higgs particles with mass below 45 GeV/c<sup>2</sup> produced in Z<sup>0</sup> decays  
DELPHI note 91-50 PHYS 105
- Search for excited charged leptons in Z<sup>0</sup> decays  
PPE/91-100
- Search for scalar leptoquarks from Z<sup>0</sup> decays  
DELPHI note 91-66
- The reaction e<sup>+</sup>e<sup>-</sup> → γγ(γ) at Z<sup>0</sup> energies  
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- Searches for heavy neutrinos from  $Z^0$  decays  
DELPHI note 91-51 PHYS 106
- Update of the search for heavy Higgs doublets produced in  $Z^0$  hadronic decays  
DELPHI note 91-42 PHYS 97
- Search for new particles in the SUSY framework  
DELPHI note 91-65 PHYS 199
- A search for lepton flavor violation in  $Z^0$  decays  
DELPHI note 91-68 PHYS 122
- Test of composite models through the reaction  $e^+e^- \rightarrow Z^0 \rightarrow H^0\gamma$   
DELPHI note 91-45 PHYS 100
- A contribution to the study of the  $l^+l^- V$  events  
DELPHI note 91-73 PHYS 127
- Update on the search for excited charged leptons in  $Z^0$  decays with the DELPHI detector  
DELPHI note 91-72 PHYS 126
- Evidence for the triple gluon vertex by measuring the color-factor  
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- Study of orientation of 3-jets events in  $Z^0$  hadronic decays using the DELPHI detector  
PPE/91-79
- Determination of  $\alpha_s$  in second order QCD from event shapes measured in hadronic  $Z^0$  decays  
DELPHI note 91-54 PHYS 109
- Bose-Einstein correlations at LEP  
DELPHI note 91-57 PHYS 113
- Charged particle multiplicity and rapidity distributions in  $Z^0$  hadronic decays  
PPE/90-117
- Charged particle multiplicity distributions in restricted rapidity intervals in  $Z^0$  hadronic decays  
PPE/90-78
- Multiplicity dependence of mean transverse momentum in  $e^+e^-$  annihilations at LEP energies  
DELPHI note 91-59 PHYS 114
- Comparison of data with QCD models  
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- Production of  $K^0$  and  $K^*$  in the hadronic decays of the  $Z^0$   
DELPHI note 91-56 PHYS 111
- Preliminary results for inclusive  $\Lambda$  production in the hadronic decays of the  $Z^0$   
DELPHI note 91-64 PHYS 118
- Measurement of the average lifetime of B hadrons and of the partial decay width  $\Gamma_{b\bar{b}}$  of the  $Z^0$   
DELPHI note 91-55 PHYS 110
- Topological measurement of the partial width of the  $Z^0$  into b quark pairs  
DELPHI note 91-23 PHYS 93

- Reconstruction of charmed particles  
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- A measurement of  $D^{*+}$  production in hadronic  $Z^0$  decays  
DELPHI note 91-63 PHYS 117

### Computing and networks

- A profile for wide area X.25 operating at 2 Mbps  
B. Salès  
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- TCP/IP-OSI/CONS Interoperation : from the intermediate term to the long term  
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Proceedings of the 2nd Joint European Networking Conference, Computer Networks and  
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- A methodology for LAN/WAN interworking  
B. Salès  
Proceedings of the 2nd IFIP TC6 International Conference on Local Communication  
Systems : LAN and PABX, Palma de Majorca, 1991, 107
- Support of the OSI Application services on Interconnected DoD and OSI/X.25 systems  
B. Salès  
Proceedings of Computer Networks '91, Wroclaw (1991)
- Interworking between DoD systems and OSI based on X.25 environments  
B. Salès  
Computer Standards and Interfaces 12 (1991) 13
- Un calcul algébrique pour définir des raffinements corrects de spécifications LOTOS  
T. Massart  
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- A calculus to define correct transformations of LOTOS specifications  
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## **FIGURE CAPTIONS**

- Fig. 1 : Upstream part of the CHORUS detector; this part is followed by a calorimeter and a muon spectrometer.
- Fig. 2a : Schematic diagram of the H1 Particle Detector.
- Fig. 2b : COP installation "in situ" (North Hall on HERA ring) at Hamburg.
- Fig. 3a : Inside of one of the technical prototype chambers for the PET experiment. This prototype was used to determine the spatial resolution. The row of small crystals is clearly visible.
- Fig. 3b : Prototype used in the gain and efficiency measurement

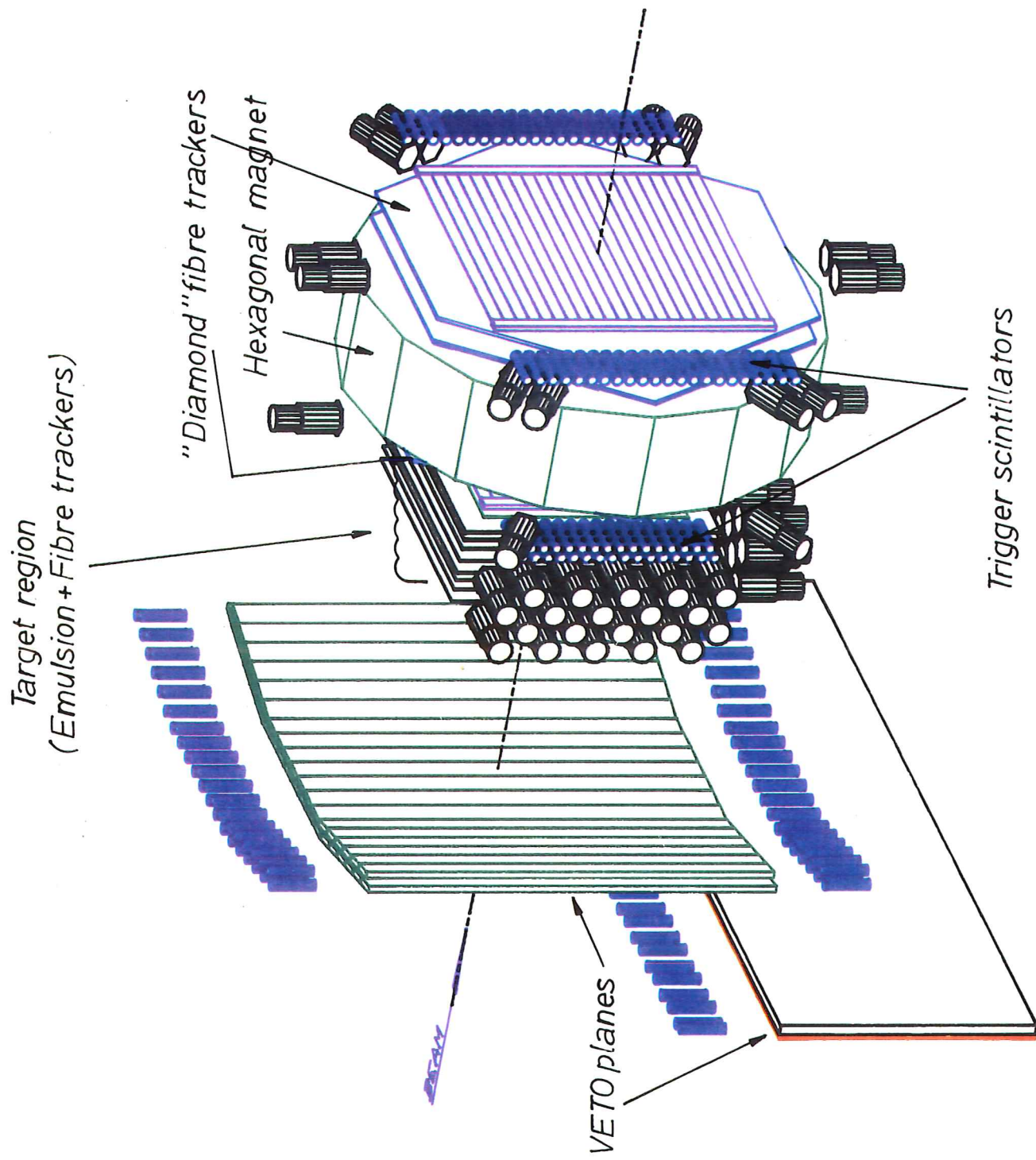


Fig.1

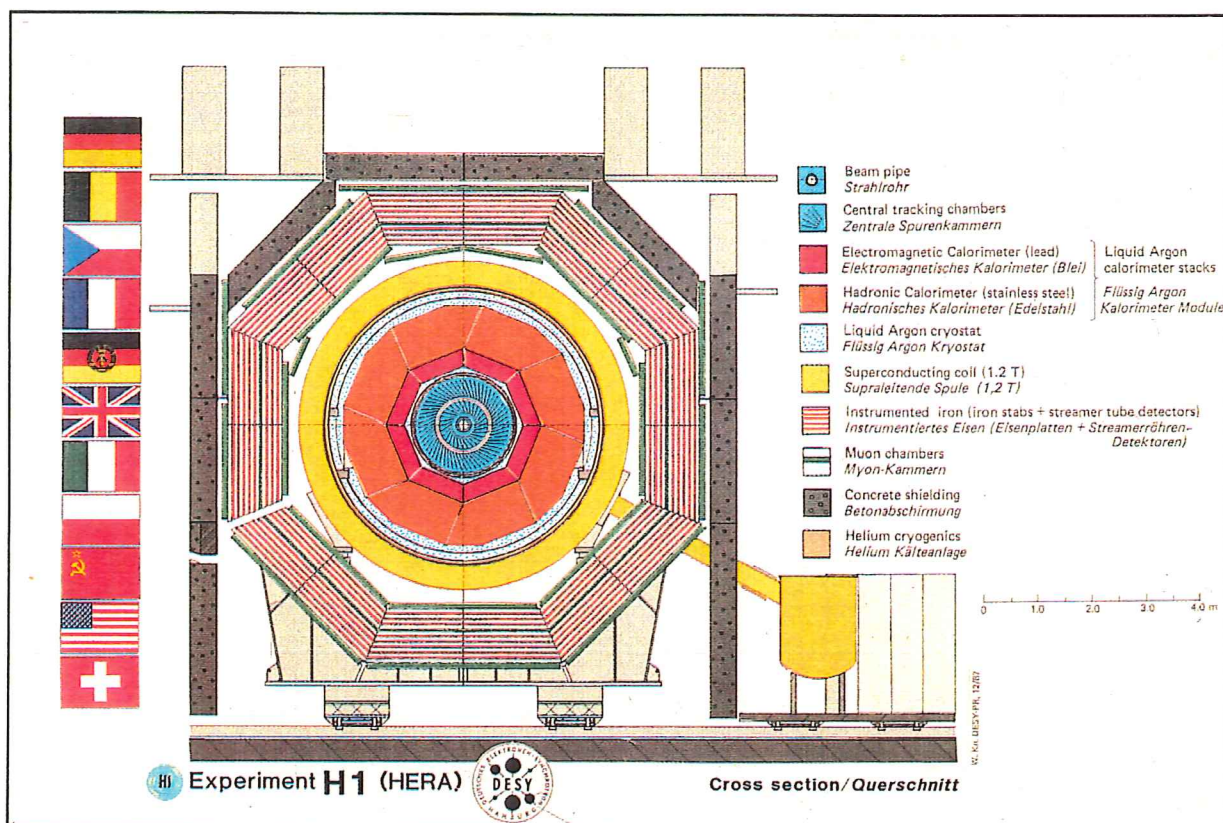


Fig. 2 a

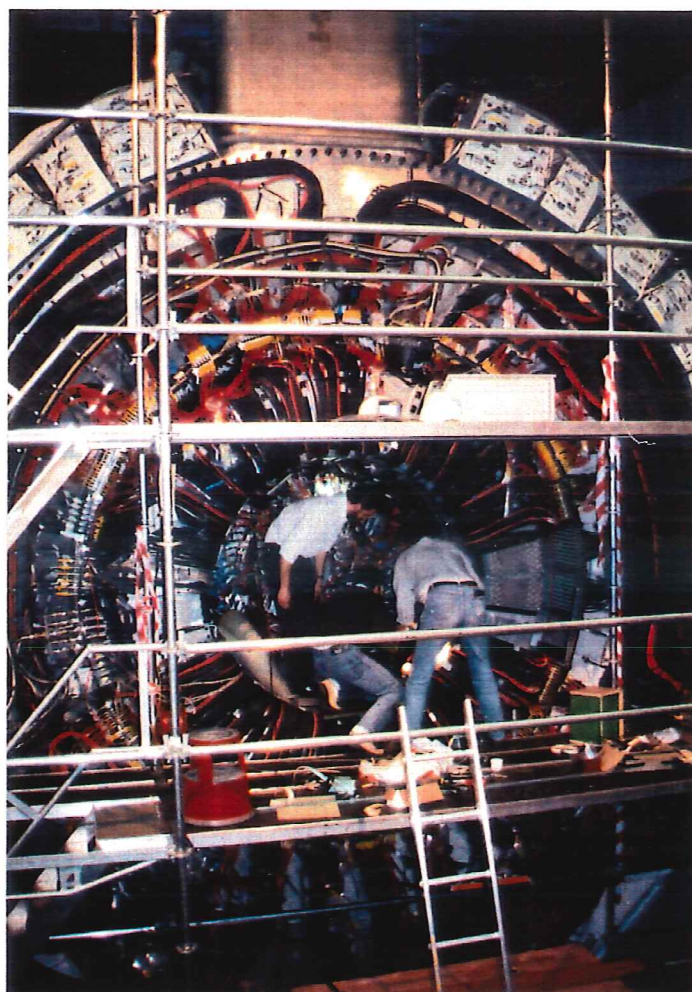
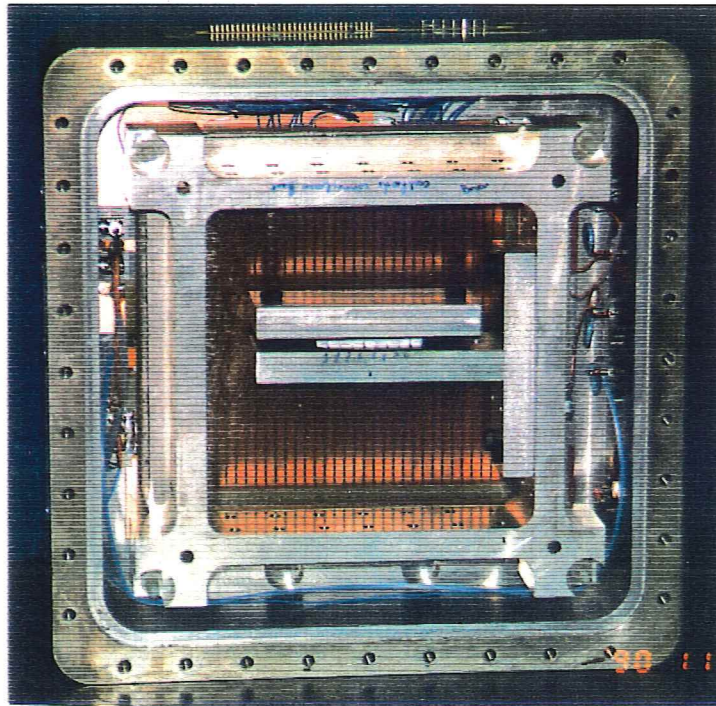


Fig. 2 b





*Fig. 3a*



*Fig. 3b*