APPENDIX 1

Report for 2002-03 and proposals for 2004-08

1 Introduction

The Royal Holloway Group currently has three major projects: BaBar, ATLAS and R&D for a future linear collider (FLC). BaBar is currently taking large quantities of data and our effort is directed towards support for the running of the experiment and analysis of a number of different decay channels. For ATLAS we are contributing to the construction of the high level trigger and DAQ system, and carrying out a number of physics studies in preparation for data taking in 2007. Our work on linear collider R&D has expanded significantly during the review period and is about to expand further following the award of two additional PDRA posts from the PPARC accelerator R&D initiative. At the time of writing we are in discussion with PPARC on setting up a second Accelerator Institute jointly between Royal Holloway and Oxford that would include two new academic staff posts at Royal Holloway. Our work on ALEPH has now ended apart from a very small contribution to the final LEP combined Higgs analysis. We have a small e-science effort that is being increasingly focussed towards ATLAS.

During the review period John Strong retired but continues to make important contributions to the ATLAS project as a Professor Emeritus. Hywel Phillips left in December 2002 to pursue interests outside physics and has been replaced by Antonella De Santo, who joined us in June 2003. Tania McMahon was on maternity leave from July 2003 to April 2004. Excluding the new linear collider posts, the group has six members of academic staff, six PDRAs, an electronics engineer, 2.06fte PPARC-funded technical staff, a postdoctoral fellow and ten PhD students in years one to three. In recognition of the additional PPARC resources for our linear collider effort our request to the PPGP for additional support is only for our programmer support post to be increased from 0.5fte to full-time. This additional support is necessary to service the larger group, to meet the additional requirements of computer security and to remove some of this support effort from those working directly on our physics projects.

During the next four years our ring-fenced effort on ATLAS is essentially stable but towards the end of the period will move from design and construction to maintenance and physics exploitation. Our effort on BaBar will begin to reduce towards the end of the period and we plan that eventually some of this effort will move to LHC exploitation and linear collider detector development. Our effort on the linear collider is now planned to increase sharply and will become a major project within the group. We anticipate that in about two years we may plan to join a further project.

2 ALEPH

2.1 Report for 2002 and 2003

Name	Cat.	Source	FTE	Name	Cat.	Source	FTE
M Green	Ph	HEFCE	0.1	O Awunor	St	Self	1.0
P Teixeira-Dias	Ph	HEFCE	0.1	A Garcia-Bellido	St	Self	1.0

As foreseen in the last report almost all of our work on the ALEPH project ended in 2002.

All of the ALEPH final results on Higgs searches (in the context of the SM as well as scenarios that go beyond the SM) have now been published. *Pedro Teixeira-Dias* - in his role of ALEPH co-representative in the LEP Higgs working group (LHWG) - has therefore concentrated on the combination the final results of the four LEP collaborations. The LEP-combined final results on the search for the Standard Model Higgs boson were published during 2003 [1]. The work on the combination of the results of the searches for MSSM Higgs bosons, fermiophobic Higgs bosons and Higgs bosons decaying either invisibly or in a flavour-independent way, is still ongoing and requires a continuing small contribution to the work of the LHWG by *Pedro Teixeira-Dias*.

Aran Garcia-Bellido completed an analysis to search for gauge mediated supersymmetry breaking (GMSB) topologies at centre-of-mass energies from 189 to 209 GeV. In this framework, a novel search for six-lepton final states when the stau is the next-to-lightest supersymmetric particle (NLSP) and has negligible lifetime was performed. Other possible signatures at LEP were studied including two acoplanar photons, non-pointing single photons, acoplanar leptons, large impact parameter leptons, detached slepton decay vertices, heavy stable charged sleptons and multi-leptons plus missing energy final states. No evidence was found for new phenomena and lower limits on the masses of the relevant supersymmetric particles were derived. A scan of a minimal GMSB parameter space including the results from the neutral Higgs boson searches, resulted in a NLSP mass limit of 77 GeV/c^2. These results were presented at SUSY02 [3] and published [4].

Onuora Awunor completed an analysis for his PhD thesis [5] to set a limit on the mass of the lightest supersymmetric particle that decays via R-parity violating couplings using data up to 209 GeV. Searches for direct and indirect decays of pair-produced neutralinos and charginos were made and constraints from the Z width measurement and from slepton, squark and Higgs searches were applied to exclude regions of parameter space. In the absence of signal and on the assumption that R-parity is violated via a single dominant coupling, mass limits were set on the LSP that are valid for all values of the SUSY parameters μ, $\tan\beta$, m_0 and $m_{1/2}$.

2.2 Publications

[1] Search for the Standard Model Higgs Boson at LEP
ALEPH, DELPHI, L3 and OPAL Collaborations, The LEP working group for Higgs Boson Searches
Physics Letters **B565** (2003) 61-75.

[2] Searches for Gauge Mediated Supersymmetry Breaking at ALEPH with centre-of-mass energies up to 209 GeV
A Garcia-Bellido
PhD thesis, September 2002.

[3] Searches for gauge mediated SUSY breaking at LEP
A Garcia-Bellido
Talk at SUSY02, June 2002, Hamburg, Germany.

[4] Search for supersymmetric particles with R-parity violating decays in e^+e^- collisions at up to 209 GeV
European Journal of Physics **C25** (2002) 339--351

[5] Searches for the lightest supersymmetric particle at LEP2 when R-parity is violated
O Awunor
PhD thesis, December 2002.

3 ATLAS

3.1 Report for 2002 and 2003

Name	Cat.	Source	FTE	Name	Cat.	Source	FTE
G Cowan	Ph	HEFCE	0.1	A Misiejuk	AP	PPARC	1.0
A De Santo (06/03 on)	Ph	HEFCE	0.6	M Gardner (to 9/03)*	AP	non-PPGC	1.0
H Phillips (to 12/02)	Ph	HEFCE	0.6	G Hollyman	St	Self	0.2
J Strong (to 12/02)	Ph	HEFCE	0.4	A Lowe	St	PPARC	1.0
P Teixeira-Dias	Ph	HEFCE	0.5	S McGarvie (10/02 on)	St	PPARC	1.0
S George	PP	PPARC	0.7	C Quarman (10/02 on)	St	RHUL	1.0
R Goncalo (10/03 on)	Ph	PPARC	1.0	TL Cheng (10/03 on)	St	RHUL	0.2
E Brambilla (to 06/03)	Ph	PPARC	1.0	G Kilvington (10/03 on)	St	RH/Self	0.2
B Green	E	PPARC	1.0	General Support	Pr/T	PPARC	0.4

Notes: FTE refers to the FTE fraction during period on project. * GridPP post

During the review period the Royal Holloway group in ATLAS has continued to play a leading role in software developments and to make major contributions to the T/DAQ Readout System work. The group has expanded its efforts on physics studies. All these activities will continue during the coming grant period.

Software Development

High Level Trigger

Simon George leads the project to develop the suite of software for event selection in the High Level Trigger (HLT). The design, which minimises the use of computing resources and works in both on-line and off-line environments, has been successfully implemented. A mini-workshop, organised at RHUL in June 2002, led to the software design now running in HLT test beds. Releases of the suite were produced in Spring 2003 and results reported in the HLT Technical Design Report (TDR). In addition, *Simon* and *Andrew Lowe* were responsible for the lightweight navigation component that is central to the steering and decision making in the HLT. This is now used in over ten algorithms [2, 4, 8, 15].

This work was commended at the ATLAS T/DAQ internal review in July 2002 and results have been reported widely [3, 5, 6, 7, 10, 11, 13, 16]. Following extensive use for the TDR, informal feedback sessions were organised at the T/DAQ workshop in Lisbon 2003 and the next iterations planned for use in the combined test beam of September 2004.

Studies of some resource-saving options for the B-physics trigger were carried out in 2002. In particular, *Simon George* studied the use of the Second Level Trigger result to seed Event Filter reconstruction for $B \to \pi\pi$ triggers. Further studies based on a full simulation of this technique are needed, but the initial findings show promise [14, 17].

Simon George will continue to manage the HLT software project. Current work centres on preparing the HLT Selection Software for use in HLT test beds and the ATLAS combined test beam in Autumn 2004. In 2005 initial software will be provided for commissioning and the full software suite will be validated on a large-scale test bed with DC2 data sets. Early in 2006 the final review will take place and the cosmic run will provide the opportunity to take data with the HLT ahead of the first LHC data runs in 2007.

Antonella De Santo and *Graham Kilvington* will work on e/γ trigger performance studies, utilising the UCL test-bed and the CERN test-beam, and working in close collaboration with colleagues at UCL and RAL. *Simon George* will continue his work on the framework design, in particular on a further iteration of the steering, based on test-bed/test-beam results.

Computing

ATLAS computing management appointed *Simon George* as Chair of the Reconstruction Task Force (RTF) in February 2003 with a mandate to perform a high-level re-design and decomposition of the reconstruction and event data model, from raw data to analysis, and to look for common solutions for HLT and off-line. The final report [9] proposes a specific, structured, modular design for algorithms and event data, and design patterns for navigation, steering and configuration were provided. The recommendations of the RTF are currently being implemented by the detector subsystems.

In September, *Simon George* and *Elena Brambilla* organised the 2002 ATLAS software workshop at RHUL, with PPARC sponsorship. The one-week international workshop attracted 120 delegates working on ATLAS off-line software, high-level trigger and the Grid.

We will become involved in the validation work by developing test suites for QA, installation validation and on-line monitoring. A new e-Science post (from April 2005) will contribute to this area and the off-line ATLAS core validation framework.

TDAQ/off-line liaison work will continue. This area will become increasingly important and time-consuming as installation, commissioning and running approach.

Grid

As part of the GridPP project, led by *Hywel Phillips* until his departure at the end of 2002, *Simon George* and *Mike Gardner* developed the tools for packaging, distribution and installation of the ATLAS off-line software [1]. They co-developed, documented and extensively tested this system. Through this work, the previously diverse efforts in ATLAS were refocused. The first prototype was tested in Spring 2003, and by the end of 2003 a developer's kit for the most recent ATLAS production release was available to download and install for wide testing in the collaboration. Ultimately this will allow the ATLAS software to be installed automatically everywhere from Tier 1 & 2 centres and developers' laptops, to physicists' workstations and HLT farms. Since January 2003 *Pedro Teixeira-Dias* has been leading this project.

The work described above will be extended to job submission, where requirements capture and problem analysis are already completed. *Simon George* and *Grigori Rybkine* (who replaced *Michael Gardner* from February 2004) will be responsible for support and maintenance of deployment tools and installation kits during DC2. Also for DC2 we will work on the full source distribution kit and the integration of installation tools with GANGA for packaging, transport and installation of user code for analysis job submission.

Procurement of a SRIF-funded high-performance 120-node PC-farm, 3 TB data store and refurbishment of the group's computer room is almost complete. This will provide a step change in the computing power available for CPU and data-intensive computing that is a key part of the ATLAS group's work.

T/DAQ Read-Out System (ROS)

Readout Buffer

Barry Green leads the RHUL efforts on the RobIn, which is the interface unit between the Sub-Detectors and the HLT/DAQ. The RobIn is the only non-commercial unit in the HLT/DAQ system. In early 2002 the ATLAS TDAQ community assigned responsibility for the development of RobIns to three groups, RHUL, Mannheim and NIKHEF. The joint design is based largely on the RHUL design using an on-board embedded processor and page-managed memory but with the large FPGA and lower-cost SDRAM used elsewhere [18, 19]. Prototypes of the new design have been manufactured (see Fig. 3.1) and distributed

to users for assessment. In December 2003, the TDAQ community agreed on a final design based on the prototype but with an enhanced specification. The final design review (FDR) for the RobIn is scheduled for May 2004. *Andrzej Misiejuk* is evaluating the FPGA code and developing programs to test FPGA firmware and PowerPC code for the final design.

We will start putting effort into the design and construction of the RobIn test system and will play a major role in the acceptance testing and commissioning of the RobIns from 2005. This will be combined with installation, maintenance and operation of the systems from 2006.

ROS software

The ROS is a PC-based system for controlling and monitoring the RobIns and steering messages and data between the HLT/DAQ and the RobIns. *Andrzej Misiejuk* provided two IO ROS classes for the ROS software package. As a part of the studies for a switch-based (as opposed to a bus-based) ROS, he developed, tested, and integrated the software for handling the fragments via Ethernet. Measurements made on test beds at CERN showed satisfactory transfer rates, exceeding 60 MB/s for fragment sizes above 1 kB (see Fig. 3.2) and limited principally by the bandwidth of the Gigabit interface.

Fig 3.1. Prototype RobIn (June 2003)

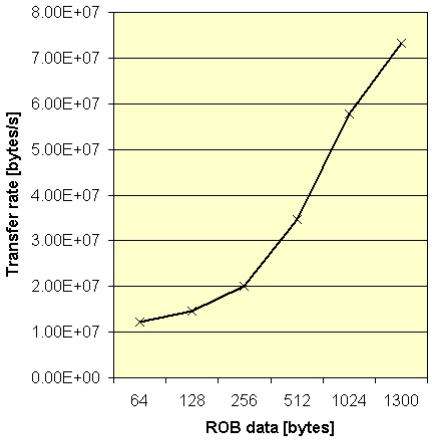

Fig 3.2. Switch based ROS data transfer rates as a function of fragment size.

Physics studies

The group has been developing a programme of analyses ahead of the exploitation phase. Most analyses are currently carried out using the fast detector-simulation program ATLFAST.

The physics programme being pursued is currently centred on the search for light Higgs boson signals predicted in the context of various models as well as on the determination of its properties. Until her departure in June 2003, *Elena Brambilla* worked on the search for an invisible Higgs signal in $t\bar{t}h$ production. This work has been taken over by *Ricardo Gonçalo*. Until his departure *Hywel Phillips* provided supervision for the *Wh* Higgs search.

Uncertainties in parton densities are an important limiting factor in many measurements planned for the LHC. We are pursuing a phenomenological study to provide a globally consistent treatment of uncertainties from experimental and theoretical sources.

At present the group is pursuing the following analyses:

- invisible Higgs in $t\bar{t}h$ production (*Ricardo Gonçalo*);
- CP-parity of a light Higgs, from $t\bar{t}h$ production (*Pedro Teixeira-Dias, Scott McGarvie*);
- light Higgs in the $W\,h \to \ell\,\nu\,b\bar{b}$ channel (*Pedro Teixeira-Dias, Graham Hollyman*);
- electron trigger robustness and Higgs searches (*Pedro Teixeira-Dias, Andrew Lowe*);
- Bayesian analysis of parton distributions (*Glen Cowan, Clare Quarman*).

Progress has been reported at numerous ATLAS meetings.

In 2003, *Teh Lee Cheng* and *Graham Kilvington* worked on ATLAS physics analyses for their MSc and MSci research projects [20, 21], respectively. Both are continuing in the group as PhD students.

The programme outlined above will be continued and expanded as part of our strategy to maximise the group's preparedness for data exploitation. Since joining the group, *Antonella De Santo* has been exploring supersymmetric particle searches, and *Graham Kilvington* is contributing to this activity. *Teh Lee Cheng* has been contributing to the invisible Higgs search in the $t\bar{t}h$ channel. Towards the end of the grant period there will be a small transfer of staff between projects to enhance and broaden the ATLAS analysis efforts as we move from construction to exploitation.

Additional positions of responsibility

Simon George is a member of the Software Project Management Board, the Software Architecture Team, the T/DAQ Steering Group, and the HLT Steering group. In these capacities he acts as liaison between the on-line and off-line software groups. He chaired the data collection review panel for the July '02 T/DAQ internal review. He is HLT-PESA software coordinator.

John Strong was Chair of the ATLASUK Collaboration Board for 2001 and 2002.

3.2 Publications

[1] Automated software packaging and installation for the ATLAS experiment
S George, M Gardner et al
Proc of UK e-Science All Hands Meeting 2003.

[2] "April" prototype for the HLT selection Software
S George, A Lowe et al
ATL-COM-DAQ-2002-018.

[3] Studies for a common selection software environment in ATLAS: from the Level-2 trigger to the offline reconstruction
S.George, A Lowe et al
IEEE NSS-MIC 2003, Portland, 19 - 24 Oct 2003
ATL-DAQ-2003-037.

[4] ATLAS high level trigger, data acquisition and controls - technical design report
S George, B Green, A Lowe, A Misiejuk, J Strong, P Teixiera-Dias et al.
ATLAS-TDR-016.

[5] Architecture of the ATLAS high level trigger event selection software
S George, A Lowe et al
CHEP 2003, La Jolla, April 2003
ATL-COM-DAQ-2003-016.

[6] A new implementation of the region-of-interest strategy for the ATLAS second level trigger
S George et al
CHEP 2003, La Jolla, April 2003
ATL-DAQ-2003-034.

[7] The algorithm steering and trigger decision mechanism of the ATLAS high level trigger
S George, A Lowe et al
CHEP 2003, La Jolla, April 2003
ATL-DAQ-2003-031.

[8] Design of the PESA core software data manager
S George
ATL-DH-EN-0004.

[9] Final report of the ATLAS reconstruction task force
S George et al
ATL-SOFT-2003-010.

[10] Architecture of the ATLAS high level trigger event selection software
S George, A Lowe et al
9th Pisa Meeting on Advanced Detectors: Frontier Detectors for Frontier Physics , La Biodola, Isola d'Elba, Italy , 25 - 31 May 2003
ATL-DAQ-2003-046.

[11] Architecture of the ATLAS online physics-selection software at the LHC
S George, A Lowe et al
ICATPP 2003, Como, Italy, 6-10 Oct 2003
ATL-DAQ-2003-050.

[12] The second level trigger of the ATLAS Experiment at CERN's LHC
S George, B Green, A Lowe, A Miseujuk, et al
IEEE NSS-MIC 2003, Portland, USA, Oct 2003
ATL-DAQ-2003-052.

[13] An overview of algorithms for the ATLAS high level trigger
S George, A Lowe et al
RT 2003, Montreal, May 2003
ATL-CONF-2003-003.

[14] The ATLAS B-physics trigger
S George et al
Proceedings of the 9th International Conference on B Physics at Hadron Machines
ATL-COM-DAQ-2004-006
(SG presented this at the conference).

[15] Analysis and conceptual design of the HLT selection software
S George et al
ATL-DAQ-2002-013.

[16] Design and expected performance of the ATLAS trigger and event selection
S George
3rd International Symposium on LHC Physics and Detectors
EPJ Direct, Sect. A-E: 4 (2002) no. CS1, pp.6
(SG presented this at the conference).

[17] Resource estimates for the ATLAS B-physics trigger
S George et al
Atlas Internal Communication: ATL-COM-DAQ-2002-013, May 2002.

[18] ATLAS trigger/DAQ RobIn prototype
B Green et al
RT 2003, Montreal, May 2003
ATL-COM-DAQ-2003-048.

[19] A RobIn prototype for a PCI-bus based ATLAS readout system
B Green et al
LECC 2003, Amsterdam, September 2003

[20] Observing an invisible Higgs at the LHC via the tth channel based on the full reconstruction of the two top decays
T L Cheng
University of London MSc thesis, 2003.

[21] Search for new phenomena with the ATLAS detector at the LHC
G Kilvington
University of London, MSci Major Project report, 2003.

4 BaBar

4.1 Report for 2002 and 2003

Name	Cat.	Source	FTE	Name	Cat.	Source	FTE
G Cowan	Ph	HEFCE	0.5	A Kurup (to 10/02)	St	PPARC	1.0
M Green	Ph	HEFCE	0.1	C Marker (to 6/03)	St	PPARC	1.0
T McMahon	Ph	HEFCE	0.6	G Vaitsas (to 9/03)	St	PPARC	1.0
S Ricciardi	Ph	PPARC	1.0	M Winter (to 12/03)	St	PPARC	1.0
P-F Salvatore	Ph	PPARC	1.0	H Flaecher (to 1/04)	St	RHUL	1.0
S George (to 12/02)	PP	PPARC	0.3	C Brown	St	PPARC	1.0
D Hopkins (from 10/03)	St	PPARC	1.0	R Flack	St	PPARC	1.0
P Jackson (from 10/02)	St	PPARC	1.0				

Note: FTE refers to the FTE fraction during period on project

In the past two years we have maintained a high level of activity in the BaBar experiment. We currently have in the group two academic staff, two PDRAs, one PPARC postdoctoral fellow (starting March 2004) and six students.

In BaBar, contributions to service tasks are expected from every institution in an amount proportional to size. Over the last two years we have had typically 10 members, and thus the group plays a large role in this type of activity. Our contributions include maintenance and operation of the experiment (including data taking shifts), development and maintenance of the trigger and the calorimeter, data distribution and Monte Carlo data production.

The group plays a significant role in several areas of physics analysis related to CP violation based on measurements of the decays $B\rightarrow\eta_c K^0_s$, $B\rightarrow D^* a_1$, $B\rightarrow D^*\rho$, $B\rightarrow D^*\pi$ and $B^- \rightarrow D^0 K^{*-}$ We have recently completed an analysis of the hadronic mass distribution in semileptonic B decays, which leads to important tests of Heavy Quark Effective Theory (HQET) and an improved determination of the CKM matrix element V_{cb}. Ongoing analyses include measurements of the decay rates of $b\rightarrow s\gamma$ and studies of tau lepton decays.

Development and maintenance of the BaBar experiment

While on LTA, *Robert Flack* was responsible for the day-to-day operations of the electromagnetic calorimeter. This required being on-call 24-hours a day for a large portion of the 2003 data taking (run 3), organising meetings of the calorimeter operations group and reporting on the calorimeter's status at plenary BaBar meetings. *Henning Flaecher* and *Mark Winter* have made important contributions to calorimeter energy calibration by exploiting photons from Virtual Compton Scattering (VCS) events. Several group members have contributed remotely from the UK to the monitoring of the calorimeter.

Starting from March 2002 *Fabrizio Salvatore* has been the convener of the Data Production and Distribution working group, which is responsible for making the data available to the wider BaBar community. For this purpose the data have been converted into n-tuples (known as kanga files), which can be easily distributed to the different university sites. This has involved software development activities such as creation of a Root-based Object-Oriented application for the automatic distribution of the BaBar data over the network. *Fabrizio* and *Paul Jackson* have played an important role in the design and implementation of data management software needed in connection with significant recent modifications to BaBar's general computing model. *Simon George* and *Stefania Ricciardi* have been responsible for the conversion of Monte Carlo data into the easily distributable n-tuple format.

Until the end of her LTA in October 2002, *Stefania Ricciardi* was responsible for maintenance and operation of the calorimeter trigger (EMT). She and other group members (*Mark Winter, Clare Brown*) have played an important role in day-to-day trigger operations, e.g. monitoring rates and dealing with hot trigger towers. *Clare* has made important contributions to the calorimeter trigger through simulation studies.

As in the previous grant period, the group makes a large contribution to the production of Monte Carlo events using the 40-node PC farm obtained as part of a BaBar-UK JIF award together with 3 Tbyte of disk from a JREI grant. With other UK groups we produce a significant fraction of the simulated data for the entire collaboration.

Physics analysis

Stefania Ricciardi and *Chris Marker* have played a leading role in study of exclusive decays of $B \to \eta_c K$. A preliminary measurement of the branching fraction was presented as a conference contribution [4], and forms the core of *Chris's* thesis [2]. They have recently completed a more refined analysis on a larger data sample which has been submitted for publication [13]. Because of the clean event selection and careful studies of backgrounds, we were able to exploit these events as part of BaBar's measurement of the CP violation parameter sin2β [5]. *Stefania* played a key role in the CP analysis.

The measurement of the angle γ of the Unitarity Triangle is both theoretically and experimentally challenging. One of the most promising approaches is to use decays of the form $B \to D^{(*)}K^{(*)}$. *Tania McMahon* has played an important role in this area, performing a measurement of the branching fraction of the decay $B^- \to D^0 K^{*-}$. The analysis relied on decays of the D^0 to flavour eigenstates, and the result is a measurement of the branching fraction with an uncertainty three times smaller than the only other published result for this decay. Mass distributions for three final states used are shown in Fig. 4.1. A measurement of the branching fraction for these decays has been accepted for publication [6]. The analysis techniques developed provide a vital first step in a future determination of γ from this mode.

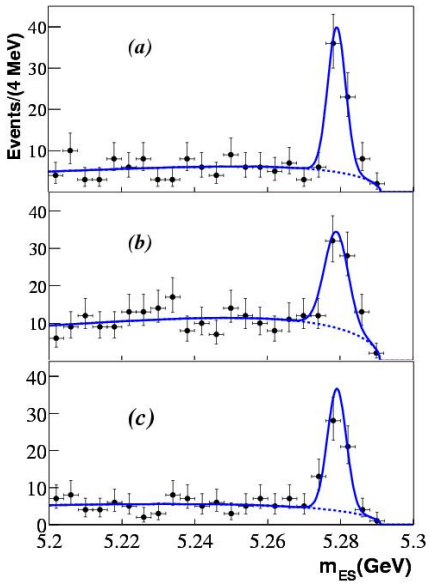

Fig. 4.1. The mass distributions of $B^- \to D^0 K^{*-}$ candidates: (a) $D^0 \to K^-\pi^+$, (b) $D^0 \to K^-\pi^+\pi^0$, and (c) $D^0 \to K^-\pi^+\pi^-\pi^+$ (from [6]).

Fabrizio Salvatore and *Greg Vaitsas* have developed an analysis for the measurement of the $B^0 \to D^* a_1$ branching ratio where only the a_1 from the B^0 is fully reconstructed and then combined with the pion coming from the $D^* \to D^0\pi$ decay. This technique allows a significantly higher selection efficiency than by using exclusive D^0 decays, and thus can provide an event sample large enough for CP studies. This measurement forms the topic of *Greg's* PhD thesis and the result has been shown at several conferences [7, 8]. *Fabrizio* and *Greg* also made important contributions, through studies of B flavour tagging, to the measurement of sin(2β+γ) using a similar partially reconstructed decay mode $B^0 \to D^*\pi$. This measurement was recently submitted for publication [9]. *Fabrizio* and *Ajit Kurup* also developed an analysis of $B^0 \to D^*\rho$ using partial reconstruction. This work formed the core of *Ajit's* PhD thesis [1] and led to an important contribution to the measurement of the B lifetime based on $B^0 \to D^*\rho$, published in 2003 [10].

Henning Flaecher has led the measurement of the hadronic mass distribution in semileptonic B decays. Moments of this distribution can be compared with predictions of Heavy Quark Effective Theory (HQET) leading to significant improvements in the determination of several HQET parameters. These same parameters appear in HQET predictions for the semileptonic branching ratio, which can be used to determine the CKM matrix element V_{cb}. As a result of the mass moments measurement, a significant improvement is obtained in the determination of V_{cb} (theoretical uncertainty reduced from 5% to 2%) and in the mass of the b quark. The measurements of the hadronic mass moments were recently submitted for publication [11] and were also shown at the 2003 EPS conference [12]. A paper which combines the mass moments with related information from moments of the lepton energy distribution in semileptonic decays for improved determinations of V_{cb} and m_b is to be submitted for publication very soon. A preliminary measurement of the first mass moment is shown in Fig. 4.2(a) as a function of the minimum energy required for the lepton from the B decay. Fig. 4.2(b) shows the preliminary determinations of the parameters V_{cb} and m_b (from *Henning's* PhD thesis [3]).

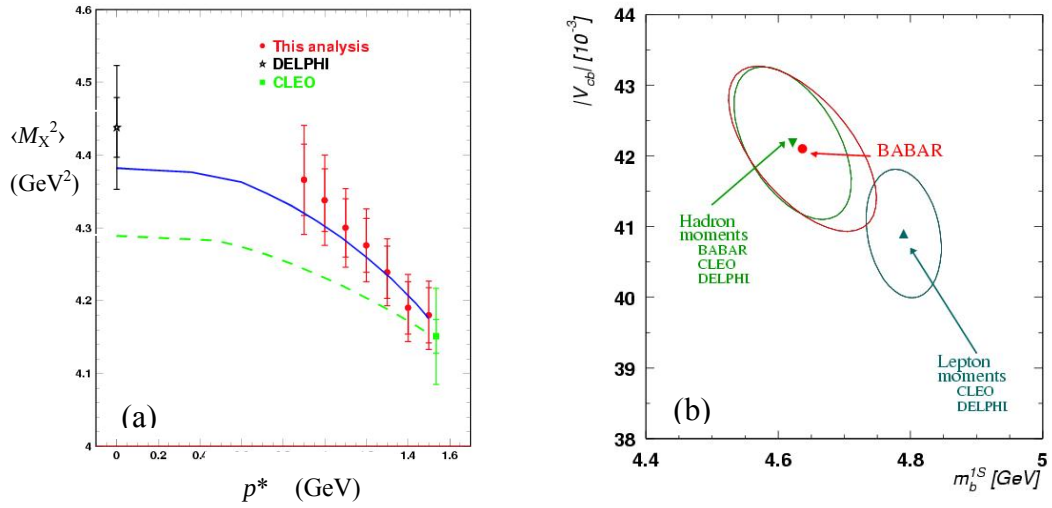

Fig. 4.2 (a) The measured first moment of the hadronic mass distribution in semileptonic B decays as a function of the minimum lepton energy. (b) Resulting constraints on the parameters V_{cb} and m_b [3,11,12].

Clare Brown is exploiting a data sample in which one of the B mesons produced is fully reconstructed, which then effectively identifies the decay products of the second B and in addition provides kinematical constraints. This second B is then used to measure the branching ratio of b→sγ. In addition to providing stringent constraints on new physics, this observable provides information on the same HQET parameters as those determined from the mass moments in semileptonic decays. The b→sγ analysis thus provides an important test of the HQET framework. Although the measurement is currently limited by statistical errors, it is expected to provide the most reliable measurement of the branching ratio and of the photon energy spectrum within a few years as more data are collected. A preliminary measurement is expected to be finished by summer 2004.

Mark Winter is finishing his thesis on a measurement of the branching fractions for the charged and neutral modes of B→ψ(2S)K*. Eventually it is planned to include the neutral B channel in the sin2β analysis. The branching fractions from this measurement are anticipated to have a significantly smaller uncertainty than from previous analyses.

Fabrizio Salvatore and *Robert Flack* are currently involved in studies of tau lepton decays. *Fabrizio* is developing a measurement of the branching ratio of $\tau \to K^* \nu_\tau$. Hadronic tau decays involving kaons are very important because they allow theoretically clean measurements of the mass of the s quark and the CKM matrix element V_{us}. *Robert* is developing a search for the lepton family number violating decay $\tau \to e\gamma$. Although the Standard Model expectation

for this decay rate is extremely small, some extensions can lead to decay rates within experimental reach. Preliminary results are expected by summer 2004.

4.2 Proposed programme for 2004 to 2008

Name	Cat.	Source	FTE	Name	Cat.	Source	FTE
G Cowan	Ph	HEFCE	0.3	C Brown (to 10/04)	St	PPARC	1.0
T McMahon	Ph	HEFCE	0.1	R Flack (to 10/04)	St	PPARC	1.0
S Ricciardi	Ph	PPARC	0.9	P Jackson (to 10/05)	St	PPARC	1.0
P-F Salvatore	Ph	PPARC	0.8	D Hopkins (to 10/06)	St	PPARC	1.0
H Flaecher (3/04 to 2/07)	Ph	PPARC	1.0	New students	St	various	1/yr
General Support	Pr/T	PPARC	0.4				

Note: FTE refers to the FTE fraction during period on project

The BaBar experiment is now well into the physics exploitation stage. Group members have played leading roles in several important papers and more publications are expected in the near future. The activity is currently the group's only experiment in the data taking phase and we expect to have at least one new PhD student joining each year. We will continue to support the maintenance, operation and software development of BaBar and to make major contributions to physics analysis. We expect the analysis programme to develop over the coming years with new investigations that make optimal use of our BaBar experience and expertise. The group's total effort in the BaBar experiment is expected to decrease slightly as several group members begin to shift a fraction of their effort onto the ATLAS experiment and the Linear Collider programme towards the end of the coming grant period.

Members of the group (*Henning Flaecher, Clare Brown*) have developed valuable expertise in the use of events with one fully reconstructed B meson. *Henning,* now as a PPARC postdoctoral fellow, will continue, along with *Clare*, *Glen Cowan* and *Stefania Ricciardi,* to apply these techniques to further studies of the decay $b\to s\gamma$. Given the larger data sample expected in the coming years, this should allow us to measure the photon energy spectrum down to energies of around 1.8 GeV (current measurements have a minimum photon energy of 2.0 to 2.1 GeV). The lower energy threshold will provide a significant improvement in the determination of HQET parameters and thus lead to a greatly improved determination of V_{cb}. *Henning* and *David Hopkins* will also continue with studies of semileptonic B decays, including measurements of branching ratios, V_{cb}, V_{ub}, m_b and HQET parameters. The group also intends to pursue CP violation measurements by comparing the rate of $b\to s\gamma$ with that of the corresponding antiparticle reaction. Kagan and Neubert (hep-ph/9803368) have pointed out that physics beyond the Standard Model could result in large asymmetries of this type even while still giving total decay rates consistent with SM predictions.

Tania McMahon, Stefania Ricciardi and *Paul Jackson* will continue towards a measurement of γ from $B^-\to D^0K^{*-}$ decays. The next stage is to build on the experience of the previous analysis, which used decays of the D^0 to flavour eigenstates, and to extend it to reconstruct decays in which the D^0 decays to specific CP eigenstates. The very low branching fractions of these decays make the analysis experimentally challenging. Initially it is planned to measure the branching fraction for $B^-\to D^0K^{*-}$ using these decays to give confidence in the event sample. Following this, the feasibility of a measurement of γ from these decays can be established.

Fabrizio Salvatore and *Robert Flack* will continue with studies of tau lepton decays. The large data sample expected in the coming years will allow for unprecedented reach in the search for lepton family number violating decays such as $\tau\to e\gamma$. *Robert's* thesis on this topic is planned for completion in October 2004. *Fabrizio* has recently begun to study hadronic tau decays and this activity is planned to continue well into the coming grant period.

4.3 Publications

[1] Studying CP-violation using $B^0 \rightarrow D^{*-}\rho^+$ at BaBar
A Kurup
University of London PhD thesis, 2002.

[2] Experimental analysis of the decay $B \rightarrow \eta_c K$, $\eta_c \rightarrow K^+K^- K^+K^-$
C Marker
University of London PhD thesis, 2003.

[3] Measurement of hadronic mass moments from semileptonic B meson decays
H Flaecher
University of London PhD thesis, 2003.

[4] Branching fraction measurements of the decays $B \rightarrow \eta_c K$, where $\eta_c \rightarrow KK\pi$ and $\eta_c \rightarrow 4K$,
The BaBar Collaboration
Contribution to the 37th Rencontres de Moriond on QCD and Hadronic Interactions, Les Arcs, France, 16-23 Mar 2002, hep-ex/0203040.

[5] Measurement of the CP-violating asymmetry amplitude sin2β,
The BaBar Collaboration
Phys.Rev.Lett.89:201802, 2002.

[6] Measurement of the branching fraction for $B^- \rightarrow D^0K^{*-}$
The BaBar Collaboration
Accepted by PRD Rapid Communications, hep-ex/0312051, SLAC-PUB-10285.

[7] Measurement of the $B^0 \rightarrow D^*a_1^+$ branching fraction with partially reconstructed D*
The BaBar Collaboration
hep-ex/0207085, contribution to ICHEP 2002.

[8] Recent results from the BaBar experiment
F Salvatore
Proceedings of "Hadron Structure 2002", Hel'any, Slovakia, 23-27 September 2002.

[9] Measurement of time-dependent CP asymmetries in $B^0 \rightarrow D^{(*)+}\pi^-$ decays and constraints on sin(2β+γ)
The BaBar Collaboration
hep-ex/0309017, submitted to Phys. Rev. D.

[10] Measurement of the B^0 meson lifetime with partial reconstruction of $B^0 \rightarrow D^{*-}\pi^+$ and $B^0 \rightarrow D^{*-}\rho^+$ decays
The BaBar Collaboration
Phys. Rev. D67:091101, 2003.

[11] Measurements of moments of the hadronic mass distribution in semileptonic B decays
The BaBar Collaboration
Submitted to Phys. Rev. Letters.

[12] Measurement of the first and second moments of the hadronic mass distribution in semileptonic B decays
The BaBar Collaboration
Contribution to the 2003 EPS conference, hep-ex/0307046.

[13] Branching fraction measurements of η_c decays
The BaBar Collaboration
BaBar-PUB-03/043, submitted to Phys. Rev. D.

5 Future Linear Collider

5.1 Report for 2002 and 2003

Name	Cat.	Source	FTE	Name	Cat.	Source	FTE
G Blair	Ph	HEFCE	1.0	F Poirier	St	Self	1.0
T Kamps (to 04/03)	Ph	PPARC	1.0	A Muir (to 09/02)	St	Self	0.5
G Boorman	T	PPARC	1.0	J Carter (07/03 on)	St	Self/PPARC	0.5

Note: FTE refers to the FTE fraction during period on project.

Royal Holloway has made significant contributions to the international linear collider workshop series and has played a central role in the initiation of future linear collider (FLC) accelerator physics as part of the UK programme. This role has been enhanced by continued hardware activity in the field of laser-based beam diagnostics (LBBD) for which the group has already gained international recognition.

Grahame Blair continues to act as a co-convenor in the ECFA LC Workshop Series, in the Machine-Detector Interface group. Benefiting from the award of a PPARC Senior Fellowship he spent the year until April 2002 at CERN funded by the CLIC collaboration and subsequently spent the year beginning 2003 at DESY funded by a Bessel Forschungspreis from the Humboldt Foundation. Additional funding was awarded from the British Council ARD programme with Germany, a Royal Society Joint Project with Japan, and INTAS. *Grahame* chaired the LC Steering Group that reported [1] to the PPAP in April 2002 on setting priorities for UK LC funding. He was co-spokesperson for the LC-ABD collaboration in forming its bid to PPARC in 2003 and will now act as PI for the collaboration. He is currently manager of the Diagnostics Work Package for the EU FP6 EUROTeV project . He is also a member of the CCLRC/PPARC JCBoARD.

Grahame Blair has continued his work with theoreticians in exploring how measurements at the FLC will allow precision extrapolations of supersymmetry (SUSY) models to very high energy scales [2-5]. He was also invited to present the particle physics case for the LC at the Advanced Study Institute on LHC physics at Prague [6] and the String Phenomenology workshop at Durham [7] and has written for a more general audience [8].

RHUL played an active part in setting up, data taking and analysis at the CLIC CTF2 laserwire test early in 2002 which gave vital experience for setting up the PETRA laser-wire system. The group has also gained valuable experience from the ATF project at KEK and collaboration with SLAC has been vital throughout this period. Stronger collaboration is currently being planned at the ATF facility.

The LBBD work [9] has been presented at international conferences [10, 11]. The laserwire activity currently centres on the PETRA ring at DESY, where first scans of the positron beams using the RHUL-designed piezo-driven fast scanning system were made in December 2002. Results are shown in Fig. 5.1 for low- and high-currents in PETRA.

Thorsten Kamps joined the group as a Responsive RA in August 2000. He was responsible for setting up the laser laboratory for LBBD work at RHUL and took a leading role in installing the laser-wire at DESY and in co-ordinating this activity internationally. The scanning and diagnostics systems were built and tested at RHUL (Fig. 5.2) before being transported DESY and commissioned in the PETRA ring. He returned to Germany in April 2003 but has continued to play an active role in the laserwire project, thereby bringing BESSY into the collaboration. We expect to replace him in April 2004 using LC-ABD funds.

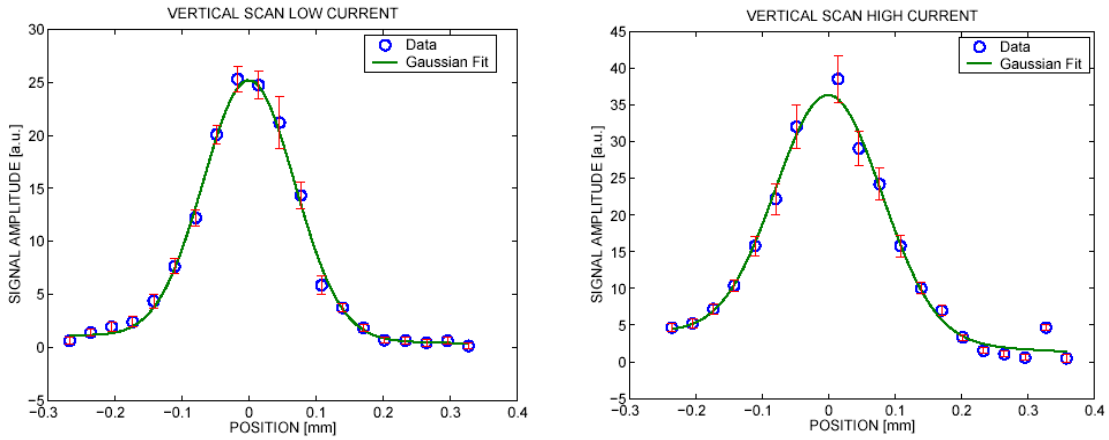

Fig. 5.1 *Results of laser-wire scans at PETRA with low PETRA machine current (0.458 mA bunch current) and high current (2.686 mA per bunch). The measured electron vertical transverse dimensions are 68 μm and 80 μm respectively.*

Gary Boorman was instrumental in setting up the RHUL laser laboratory, by providing essential technical input to both the design and operation of the key measurement systems and by commissioning the central LabView control. *Gary* also designed and built the control electronics for the laser-wire (Fig. 5.3), a new trigger box to fire the laser at PETRA including interfaces to the PETRA timing clock. He took a central role in setting up the PETRA laserwire controls and in getting the whole system running.

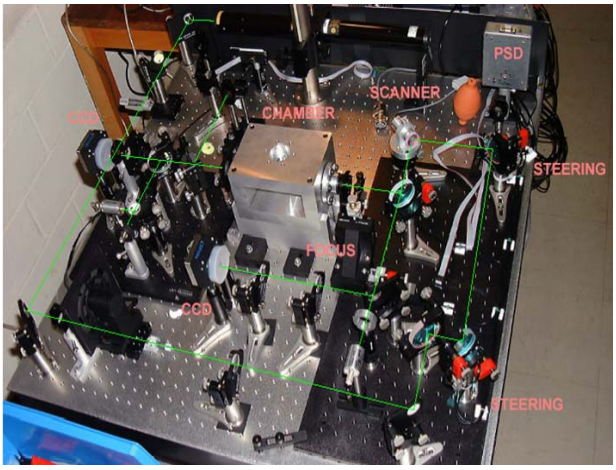

Fig. 5.2 *The steering and laser diagnostics set-up at RHUL before shipment to DESY. The test vacuum vessel (centre) was also made at RHUL.*

Fig. 5.3 *The electronics designed and built at RHUL to control the laser-wire scanning and diagnostics. This now sits in the PETRA tunnel.*

Freddy Poirier is working for his PhD with the FLC group. He has been based at DESY since April 2002, initially on a DAAD grant. He performed calibration measurements on the lead-tungstate calorimeter at the DESY test-beams and played a major role in the data taking of the laserwire and in analysing the results.

Alex Muir helped calibrate the lead-tungstate calorimeter in the test-beams for his MSc project.

John Carter, for his MSc project, interfaced the laser-wire Beam Position Monitor readout system to the PETRA control system and wrote the software to display the BPM readings during laser-wire data taking; this is now an essential part of the laser-wire system. He continues with us for his PhD.

Grahame Blair initiated a novel direction in the use of Geant4 for particle tracking in accelerators and has applied his simulation to the beam delivery systems (BDS) of the TESLA and CLIC accelerators [12-16]. He has been collaborating closely with the international LC community in determining efficiency measures for BDS collimation systems and in optimising their design [17-19]. This approach is expected to set the scale for BDS simulation in the coming years and an RA from LC-ABD funds will help drive this work forward.

The group will pursue FLC work as a growing activity over the next few years. *Grahame Blair* will concentrate his efforts here and additional academic staff effort is planned to contribute from October 2004. An additional two RAs supported from LC-ABD funds will be available from April 2004; one will work primarily on the laser-wire effort and the other will drive the beam delivery simulations. *Gary Boorman* will continue to lead the group's technical effort in laser-based beam diagnostics throughout this grant period and beyond. In addition to building on our existing laser-wire programme, including upgrading to new mode-locked systems and multi-dimensional scans, Gary's expertise will enable the activity to grow into new areas of beam diagnostics and control.

Towards the end of this grant period *Fabrizio Salvatore* will explore the opportunities for a LC detector involvement to complement the group's activities in LC accelerator R&D; this involvement is expected to be increasing from 2007. At around the same period *Barry Green* will start providing the necessary engineering support.

5.2 Publications

[1] The UK Linear Collider Project
G A Blair *et al*
Report to PPARC, April 2003.

[2] Sfermion precision measurements at a linear collider
G A Blair *et al*
FERMILAB-CONF-02-384, DESY-02-176, Proc. ICHEP 2002, Amsterdam.

[3] Reconstruction of fundamental SUSY parameters
G A Blair *et al*
FERMILAB-CONF-02-385, DESY-02-175, ZU-TH-21-02, Proc. ICHEP 2002, Amsterdam.

[4] The reconstruction of supersymmetric theories at high energy scales
G A Blair *et al*
Eur. Phys. J. C27 (2003) 263-281.

[5] The Snowmass points and slopes: benchmarks for SUSY searches
G A Blair *et al*
Eur. Phys. J. C25 (2002) 113-123.

[6] The physics programme at the LC
G A Blair
Proceedings of the LHC ASI, Prague 2002.

[7] The Linear Collider
G A Blair
Proceedings of the String Phenomenology Workshop, Durham 2002.

[8] The Future Linear Collider
G A Blair
Contemp. Phys. 43 325-338 (2002)

[9] A set of talks and conference notes from the LBBD collaboration can be found from:
http://www.pp.rhul.ac.uk/~lbbd/

[10] Laser wire scanner development on CTF II
G A Blair, T Kamps *et al*
CLIC-NOTE-534. Proc LINAC 2002, Gyeongju, Korea.

[11] R&D towards a laser based beam size monitor for the Future Linear Collider
G A Blair, T Kamps, F Poirier *et al*
DESY-M-02-01H. Proc. EPAC02, Paris, 2002.

[12] Simulation of the CLIC beam delivery system using BDSIM
G A Blair *et al*

CERN-OPEN-2002-057.

[13] Comparison of different tracking codes for beam delivery systems of linear colliders
G A Blair *et al*
Proc. EPAC 2002, Paris, 2002.

[14] CLIC simulations from the start of the LINAC to the interaction point
G A Blair *et al*
Proc. EPAC02, Paris, 2002.

[15] Background simulation for the CLIC beam delivery system with GEANT
G A Blair *et al*
CERN-SL-2002-029. Proc. EPAC02, Paris, 2002.

[16] Design status of the CLIC beam delivery system
G A Blair *et al*
CERN-SL-2002-031-AP. Proc. EPAC02, Paris, 2002.

[17] Collimation for CLIC
G A Blair *et al*
Proc. 29th ICFA HALO 03,Long Island, May 2003.

[18] Comparison of the TESLA, NLC and CLIC beam-collimation system performance
G A Blair *et al*
SLAC-PUB-9898, DESY-M-03-01H. Proc.PAC 03, Portland, May 2003.

[19] Comparison of the TESLA, NLC and CLIC beam collimation system performance
G A Blair *et al*
SLAC-TN-03-003, LCC-0111, CERN-AB-2003-006-ABP, CLIC-NOTE-555, FERMILAB-TM-2200, DESY-TESLA-2003-02.

6 Computing Strategy

Our guiding principles are as follows.

- We look for cost-effective solutions.
- We try to minimise our maintenance effort.
- We perform risk assessments for critical equipment, e.g. servers.
- We find solutions which minimise down time, recovery time, etc.
- We look for scalable solutions: our needs continue to grow rapidly.
- We track trends and consensus of large HEP labs with whom we collaborate.
- We consider user requirements - to be able to run standard HEP software (ROOT, Cernlib, LCG applications area), Grid software (LCG, EDG), experiments' software suites (ATLAS, BaBar, LC) and other software e.g. CAD, case tool, office.
- We look for user convenience - standardise so there are not too many peculiarities to our systems to confuse those who are also using systems at CERN, RAL, SLAC.

The resulting policy is as follows.

- We use Linux/PC desktop (where necessary, generic windows desktop supported by the College Computer Centre).
- We track CERN-recommended O/S version (currently Redhat 7.3).
- For a few critical central servers, we use established vendors who can provide the best support, performance tuning, management tools, and high availability configurations. For other services we use cheap, redundant Linux/PC servers.
- We provide "application" servers (running windows, Linux and Solaris operating systems) to meet users requests for software that cannot run on desktops, e.g. CAD, MS office, and to provide a central machine for remote logins.

Since the last grant we have continued to move towards application servers that are cost effective and minimise our maintenance efforts. Standardising on a Linux/PC desktop has reduced the amount of effort to support desktops and provides good functionality for the normal physicists' work.

We have rationalised our file server equipment to leave just two Sun/Solaris file servers (one for BaBar). The rest of our file servers are all PCs. This streamlining minimises maintenance and support contracts by focusing it on just two critical systems, and increases the efficiency of system management.

During the current grant period we have successfully commissioned several cost-effective PC-based RAID file servers of about 1TB each. Providing safe backup for important experimental data on these files servers is the next challenge, as the amount of disk space that is now easily available far outstrips our tape backup capacity.

7 Non-PPGP and non-PPARC support

PPARC support outside the rolling grant

- Senior fellowship for *Grahame Blair* (October 2000 to September 2003).
- Postdoctoral fellowship for *Henning Flaecher* (from March 2004).
- GridPP post (three years) for ATLAS off-line software.

- Two additional PDRA posts from April 2004 to support linear collider studies.
- e-science post from April 2005 for ATLAS HLT and off-line software.
- Science and Society Small Award to *Glen Cowan*.

Non-PPARC awards

- Small grants (£19,000 in total) from a number of bodies for linear collider studies.
- SRIF award of £200k for computer farm for e-science.
- About £33,000 annually from Royal Holloway central funds for equipment, consumables and travel.

8 Activities in the area of *Science and Society*

The group continues to be very active in this area. Ongoing activities include the following.

- Talks on particle physics to sixth formers and physics teachers.
- Continued distribution of the highly successful *Particle Physics Summary Sheets for Schools*. These have now been translated into four other languages.
- A new set of posters on cosmology and astrophysics is currently being completed by *Glen Cowan* with support from a PPARC Science and Society Small Award.
- Annual *Particle Physics Masterclasses* over two days with about 120 pupils and 20 teachers each year. An independent survey of three such masterclasses in 2002 showed that ours received significantly more positive feedback from pupils that the other two.
- We introduced an annual *Solar System Masterclass* in collaboration with our Geology Department in 2002.
- *Mike Green* is a member of the PPARC *Advisory Committee on Science and Society*.
- We continue to maintain and update material on our web site for schools and many teachers are known to use it.

Colin Winterton supports this activity with about 5% of his time.

9 Concordat

Royal Holloway is fully committed to the Concordat and continually strives to improve the position of contract researchers. This includes an annual review as part of the College's appraisal scheme and the opportunity to attend conferences and training courses. In 2002 the College removed the standard clause in fixed-term contracts revoking the right to redundancy pay. The Staff Development Office carried out a survey of contract researchers during 2003 that resulted in a number of changes; examples include improved communication on opportunities for training, and improved induction and probation procedures.

10 Interactions with industry

We have no special connections with industry at present. We use SMEs for production of pcbs.

END