NUCLEAR PHYSICS SUPPORT ACTIVITIES

1st April 2004 – 31st March 2006

Nuclear Physics Group, CCLRC Daresbury Laboratory

This document summarises the programme of work carried out by the CCLRC Daresbury Nuclear Physics Group on behalf of the EPSRC. It is intended to satisfy the reporting requirement stipulated in the relevant Service Level Agreement between EPSRC and CCLRC.

1. INTRODUCTION

The Nuclear Physics Group at Daresbury Laboratory is part of the Surface and Nuclear Division of the Council for the Central Laboratory of the Research Councils (CCLRC) with access to the support staff, expertise and facilities available at both Daresbury and Rutherford Appleton Laboratories. The group's principal role is to provide scientific, technical and engineering expertise to support and co-ordinate the programme of research supported by EPSRC in the field of nuclear physics. This programme is carried out at a number of overseas accelerator facilities and requires the design, construction and installation of specialised equipment at those facilities. The group undertakes this design and development work for both existing programmes and new initiatives, including programmes of development aimed at the generation and exploitation of new opportunities in the overseas facilities. It continues to seek out new opportunities for the UK in terms of access to such facilities. Expertise is provided to co-ordinate these and other activities within EPSRC's overall nuclear physics programme.

2. OVERVIEW

This report covers all of the Nuclear Physics Group (NPG) activity relating to the UK nuclear physics experimental research programme in the period 2004/06. This activity has been funded through a dual support mechanism in which the funds arise from two sources:

(a) A core service level agreement (SLA)

(b) Responsive mode grants (pre Full Economic Costs grants)

The core SLA is intended to mimic the provision of a well-found laboratory implicit in the dual funding of universities. It therefore provides for the costs of the nuclear physicists in the group, allowing them to act as Principal Investigators on grant proposals, as well as for additional overhead charges such as accommodation costs. It also covers the general support services provided by the group that are not funded through grants as well as support for small-scale

ad-hoc activities. These latter categories encompass support for local computer hardware and software installations (particularly important for smaller university groups) and the feasibility studies or exploratory work necessary for any UK institution prior to the submission of a grant. It also covers the role played by the senior members of the group in representing the UK and its interests on several international working groups and committees, a list of which is given in Section 7.

The responsive mode grant funding is obtained in parallel with the university groups with the NPG acting as one of several institutions collaborating on a specific project. The two strands combine to fund the overall activities of the group. The majority of the group's output is related to responsive mode grants that are the subject of detailed peer review through specific, end-of-grant IGR reports. The current document will not attempt to duplicate or pre-empt those reports but will rather provide an overview of the activities and principal achievements of the group in the four, broadly defined areas of technical support provided, namely, instrumentation and design, electronics support, software support and target fabrication. The final section of the report provides year-end financial statements for 2004/2005 and 2005/2006.

The physicists in the group also undertake internationally competitive research programmes. These include the spectroscopy of exotic nuclei using TIARA, spectroscopy of the very highest spins, investigation of heavy proton rich nuclei and studies along the N = Z line. The group's publication list can be found via http://www.dl.ac.uk/NPG/research.html

The Group performs a series of miscellaneous activities for the community. These include hosting web pages for meetings and workshops and in some cases their general organisation. In this period they have included the May 2005 community meeting at Cosener's House, a QCD workshop in March 2005, the UK FAIR meeting in January 2006 and the symposium in honour of Dave Warner in February 2006.

The group was also very active in Grant request preparation work (outline system design, selection and discussion of appropriate technology for design, detectors, electronics and data acquisition, planning manpower and costing) for several projects. These included: SAGE (an enhancement for GREAT), LISA, PORGAMRAYS and the UK nuclear physics platform grant.

During the period a platform grant for Nuclear Physics was awarded to support the UK's experimental research programme. This grant supports a team of engineers and detector instrumentation specialists (the Engineering and Instrumentation team EIT) in CCLRC and the Universities. The NPG currently has seven staff in the team and is the largest group.

Table 1 below summaries the EPSRC responsive mode grants that were active during the current reporting period.

Table 1

Title	Known as	Grant Reference	Participating UK institutions
Nucleon Transfer and Coulomb Excitation with Radioactive Beams	TIARA	(GR/N38541/01)	Bi, P, S
Isobaric Analogue States at High Spin	MIRRORS	(GR/R40081/01)	K
Study of Valance Space Limitations	HIGH SPIN	(GR/R57713/01)	L
Nuclear Molecules and Exotic Clusters	CLUSTERS	(GR/S19318/01)	L, M, K, S, Y
AGATA – The Ultimate Gamma-ray Spectrometer	AGATA	(GR/S72504/01)	Bi, S

Exotic Isospin Studies Using Fragmentation Reactions	MIRRORS 2	(GR/T18493/01)	Bi, P, S
Exploring the Changing Shell Structure of Nuclei	PRISMA	(EP/C51646X/1)	K
Portable Gamma Ray Spectrometer	DTI	(EP/C536797/1)	L, M +Industrial partners
Probing the limit of nuclear existence for heavy proton rich nuclei.	DRIPLINE	(EP/C01537/1)	L, S
Spectroscopy of Superheavy nuclei: The SAGE spectrometer.	SAGE	(EP/D00148X/1)	L
Platform Grant	EIT	(EP/D001463/1)	UK

Key: Bi = Birmingham; B = Brighton; E = Edinburgh; K = Keele; L = Liverpool;

M = Manchester; P = Paisley; S = Surrey; Y = York

The most important achievements during the period of the current SLA were:

GREAT/TDR: The successful operation of the GREAT spectrometer and the Total Data Readout acquisition system at the accelerator laboratory in Jyväskylä, Finland. Continual support provided.

TIARA: The successful operation of the TIARA array coupled to the EXOGAM and VAMOS recoil spectrometer at GANIL. Continual support provided.

MIDAS: The further development and extension of the MIDAS data acquisition system.

RISING: The successful design and installation of upgrade of the RISING spectrometer at the GSI facility in Darmstadt, Germany to include the MINIBALL detectors.

Design, construction and installation of the RISING stopped beam array of 15 Cluster detectors.

EXOGAM at SPEG. Trial assembly of the new EXOGAM frame for a series of experiments at Ganil in 2006.

AGATA Conceptual design of the 4π gamma-ray tracking spectrometer and specification of much of the front-end electronics.

Ganil beam line Preparatory design of a beam line from the CIME cyclotron.

All of the above attest to the role played by the NPG in paving the way for UK exploitation of the major accelerator facilities currently available or under construction in Europe. This work is particularly prominent in the establishment of the UK in the radioactive beam projects SPIRAL2 and FAIR. In FAIR D. Warner and J. Simpson are the UK CCLRC representatives on the STI committee and are coordinating the discussions between the UK academic community, CCLRC and EPSRC regarding the UK's contribution to the facility. Members of the group have key roles in several of the FAIR projects, for example in the R3B, EXL, Hispec and Despec projects of NUSTAR. Key roles include R. Lemmon as the chair of the R3B technical board and I. Lazarus as a co-ordinator of all ASIC developments for NUSTAR and SPIRAL2.

More details on the activities can be found on the NPG web pages at:

http://www.dl.ac.uk/NPG/

The sudden death of the Dave Warner in June 2005 left a gaping hole in the lives of his family, friends and colleagues and in particular the NPG. Dave was a brilliant experimental and

theoretical nuclear physicist. Since the closure of the Nuclear Structure facility Dave worked hard to establish the NPG and its standing in the UK and worldwide nuclear physics community. Recently he spearheaded the UK's interest in radioactive beam facilities and pushed hard for involvement in the new FAIR and SPIRAL2 facilities. Dave is sorely missed by all the members of the group and this report is dedicated to his memory.

3. INSTRUMENTATION AND DESIGN

The NPG works in collaboration with the project engineering division at Daresbury Laboratory to provide mechanical engineering and design support to the experimental UK nuclear physics community. The physicists in the group provide overall design concepts, simulations and specifications of the detectors and detector systems. The mechanical engineers and designers have designed highly complex structures for supporting arrays of radiation detectors for both photon and charged particles using advanced 3D modelling techniques and FEA software. They have designed and or provided input to many projects during the current period. In many instances, a UK design team coming from the NPG and the Universities of Liverpool and Manchester performs the design work. This team is co-ordinated by the NPG mechanical engineer and comprises skilled and experienced 3D CAD design engineers and physicists from the institutions involved. This team is world class and, for example, has designed almost all the large gamma-ray spectrometers currently in use in Europe. In the latter part of the period this team became an integral part of the EIT of the UK nuclear physics platform grant. Technical effort from Daresbury has also been used to assemble many of these complex systems before shipment to the host overseas laboratory.

The NPG has performed design work on the AGATA spectrometer. AGATA (Advanced Gamma Tracking Array) is the next generation of gamma-ray spectrometers that will be based on the new concept of gamma-ray tracking in electrically segmented germanium detectors. The design team has worked on the conceptual design of the full 4π instrument of 180 detectors. These detectors are complex shaped tapered hexagons that are grouped into to triple modules to make 60 cryostats. The conceptual design has involved working in close collaboration with detector designers in the collaboration to build the array in the CAD system, check and define the geometry and propose holding and assembly schemes. Preliminary FEA analysis has been performed on the full mechanical structure. The team is currently working on the design of the first phase of this instrument, called the AGATA demonstrator. The AGATA demonstrator will comprise between 15 and 45 detectors, and will be operated initially at the Legnaro National Laboratory, Italy, starting in 2007. The team is responsible for all the design work for this phase. J. Simpson and K. Fayz are joint team leaders for the mechanical design for AGATA.

The design team is responsible for all the mechanical design of the RISING (Rare ISotope INvestigations at Gsi) spectrometer. RISING is an array Ge detectors that is used for spectroscopic studies of nuclei excited by the exotic relativistic beams from the GSI facility in Darmstadt, Germany. The NPG designed and installed during the previous reporting period the first RISING array, which comprised 15 EUROBALL Cluster Ge detectors. In this period this array was enhanced with the segmented triple cluster Ge detectors from the MINIBALL collaboration. The group performed all the design for this upgrade, a trial assembly at Daresbury and installation of the array at GSI.

These two arrays with the EUROBALL and then the EUROBALL plus MINIBALL Clusters were used successfully for the so-called fast-beam campaigns at GSI. The next phase of operation was to perform stopped-beam experiments where the exotic nuclei at the end of the

fragment recoil separator are stopped either in a passive or active stopper and their decay properties investigated. The NPG, in collaboration with Liverpool University, designed this array, which is essentially a 4π Ge detector array of 105 detectors using the EUROBALL Cluster Ge detectors. The array was again assembled at Daresbury before shipment to GSI and is now part of a very successful physics programme.

The NPG are world-leading experts in array design and the NPG's Java based program that can predict the performance of arrays of gamma-ray detectors was again used for the RISING design. This program was also used to provide general advice, not just for RISING, given to members of the UK community planning new gamma-ray experiments and arrays and for the preparation of individual experimental proposals.

The NPG has constructed a new framework to allow the EXOGAM gamma-ray spectrometer to be used together with the SPEG high-resolution magnetic spectrometer at GANIL. Such a combination of detectors allows experiments such as one-nucleon removal reactions and in-beam gamma-ray fragmentation reactions to be performed with increased efficiency and resolution. The new framework was design at Liverpool under the supervision of the Daresbury engineer and assembled by the group at Daresbury before being shipped to GANIL. It will be installed during Summer 2006 for a campaign of experiments scheduled to start in September 2006.

During the current period the NPG has been instrumental in the successful exploitation of TIARA at GANIL, France. TIARA (Transfer and Inelastic All-angle Array) is a state-of-the-art detector system for studying direct reactions, in particular transfer reactions, of exotic nuclei. It consists of Si and Ge detector arrays, coupled to the high efficiency magnetic spectrometer VAMOS. Work has also been completed during this period on an upgrade to TIARA, focussing on adding E-ΔE particle identification. A second layer of Si has been added to the barrel and a CsI array constructed for forward angles. To accommodate these new detectors, a new vacuum vessel was designed and built by the NPG.

During this period two grants were awarded aimed at the spectroscopy of nuclei close to the proton drip line and very heavy nuclei. The NPG has been involved in the conceptual design of the spectrometers associated with these grants namely LISA (Light Ion Spectrometer Array) and SAGE (Silicon And GErmanium spectrometer). The main design of these will be performed in the next period. Associated with these is the upgrade to the gamma-ray array at Jyväskylä, called JUROGAM. This upgrade may include 4-element Clover Ge detectors, currently being used in CLARA. The NPG has provided papers on the performance of the various possible configurations using a variety of Ge detectors.

The NPG has been designing, in collaboration with Manchester, a new focal plane detector for the PRISMA magnetic spectrometer at Legnaro, Italy. The detector is based on the concept of secondary electron emission, which enables a very thin tracking detector to be built. Such a detector is essential for PRISMA to be used to detect the heavy ions that will be provided from the new PIAVE accelerator. The mechanical design and construction of the secondary electron detector (SED) is done in Manchester, while the design of the electronics is done by the NPG. Approximately 1000 channels of electronics are necessary to instrument the detector and so a concept based on ASIC readout has been implemented. Prototypes of the detector and electronics have been constructed and are under test. The final design will be completed over the next reporting period.

During the current period, preparatory design has been undertaken by the NPG, using effort from Manchester, for a beamline to be constructed at the newly funded SPIRAL2 facility at GANIL, France. This beamline is an essential component of the new facility and will allow

parallel operation of the SPIRAL2 accelerator system. Preliminary layouts of the beamline within the SPIRAL2 complex have been completed.

The NPG has carried out work for the European project ACTAR. This is an R&D project with the aim of proving the viability of constructing an active target detector for studies of reactions with exotic beams. Of the various research and development tasks associated with this project, the NPG is specifically involved in the physics, simulations, readout chamber design and front-end electronics and data acquisition. A document describing the physics, which will be performed with this detector has been written with input from the NPG. A readout chamber prototype based on GEM micropattern gas detectors has been designed and constructed in collaboration with Liverpool. The chamber has been installed in the NPG detector laboratory for testing. A conceptual front-end electronics design has been made and first investigations into suitable ASIC chips carried out. Related design work has been carried out on TACTIC, an active detector for use at TRIUMF, Canada. An initial design, made by physicists in TRIUMF and at York, has been developed into a workable design and detailed by the NPG. The detector will be manufactured in the near future at York to this design.

Design effort has also been used for a BRAGG spectrometer, requested by York University, to be used at the Rex-ISOLDE facility in CERN. Preliminary design work was completed and detailed design is now required prior to manufacture.

During the current period, the NPG detector laboratory has been completely refurbished. General infrastructure, such as electrical supplies, water and compressed air has been installed, together with new work surfaces and cabinets. A COSHH system suitable for working with flammable gases such as isobutane has been installed. A vacuum chamber has been constructed in the Daresbury Laboratory workshops and a vacuum system designed and constructed by the NPG. A new gas flow system, capable of also pre-mixing up to four different gases has also been designed by the NPG and components bought. The system is currently under construction by the NPG. Electronics and data acquisition infrastructure has also been specified and purchased. The refurbishment has been carried out to ensure that the NPG has a detector laboratory that can be used to perform research and development and test state-of-the-art detection systems for the various projects that it is involved with.

The NPG collaborates in a European programme to develop an Electron Cyclotron Resonance Ion Source, ECRIS, for potential use in a radioactive ion beam accelerator. The source traps an injected, singly charged ion beam and, by stripping electrons from the ions in the source's hot plasma, enables the ion beam to be extracted in a highly charged state for acceleration to high energy. Such a "charge breeding" device makes the subsequent acceleration process far more efficient, reducing the cost and scale of the accelerator. The ECRIS, originally tested at Daresbury during the previous reporting period, has now been moved to the ISOLDE facility at CERN where it has been commissioned and is now established as a test facility. Initial tests were carried out with the facility operating at 30kV and radioactive ion beams of some noble gasses have been successfully charge bred. The source is currently being upgraded to operate at 60kV to allow a greater variety of ions from the ISOLDE facility to be accelerated.

4. ELECTRONICS SUPPORT

During this period the electronics support has been focussed largely on the AGATA project. The electronics for AGATA builds on the work done for the UK Gamma Ray Tracking grant (completed in previous reporting period). The GRT4 digital electronics cards designed and

manufactured by the NPG for the tracking grant continue to find applications within AGATA. They are currently at the Liverpool University where they are used on a scanning table to characterise detector responses for AGATA (and other) detectors. Regular upgrades, including new algorithms and software were provided to the GRT digital electronics cards. AGATA is based on the principle, proven in the previous Gamma Ray Tracking project, of digitising all incoming data and then implementing digital processing algorithms to determine energy, timing and position information by analysis of the digitised detector pulse shapes. The Compton Scattering formula relates deposited energy and scattering angle so that a group of interactions selected from the whole of AGATA (not just one detector) in time coincidence can be reconstructed to reveal the track of interactions in a suitably dimensioned processor farm. A time stamp is implemented so as to permit software triggering (analogous to, but not the same as, that designed for TDR system of GREAT). A hardware trigger mechanism is implemented as well to deal with cases where the data rate is too high to be handled by the processor farm doing the pulse shape analysis. In the UK, work has been undertaken in the digitiser part (specification, circuit design, prototype production) and the pre-processing (specification, management and work on implementing algorithms in hardware (useful for several projects)) as well as providing leadership in organising meetings to sort out the system design aspects which fall between the officially convened teams (e.g. specifying interfaces, protocols and data flow paradigms).

A background task has been the preparatory discussions regarding electronics and data acquisition for NUSTAR within the new European FAIR facility. NUSTAR work includes overall co-ordination of ASICs (including looking for synergy with SPIRAL2) and involvement in the NUSTAR DAQ design team. More detailed work on design studies, cost and schedule estimates has been undertaken for the EXL, R3B and Hi/DeSpec experiments. The ACTAR project is potentially a part of NUSTAR and work has been performed to evaluate possible candidates for the ASIC to be used for this project. To this end an FPGA based readout system is being developed with flash ADCs reading the ASIC outputs and the FPGA taking the ADC data and sending it out via Ethernet.

Another new project, awarded during this period, is PORGAMRAYS, which will, jointly with Universities of Liverpool and Manchester and our industrial partners, perform the research necessary to develop a hand held radiation detector unit. The unit will have both spectroscopic and imaging capability so as to be able to both identify and locate sources of radiation. Work at Daresbury includes management and project planning of the academic aspects of this project (in collaboration with the company John Caunt Scientific who are funded via the DTI to work on the project as overall project managers). Electronics and ASICs specifications have been generated, an ASIC engineer within CCLRC has been identified and allocated to the project under the control of NPG. This work will continue into the next reporting period.

The existing GREAT TDR system continues to operate extremely well and attracts regular compliments from its users and also, recently, an unsolicited testimonial from Rauno Julin (head of Jyväskylä's accelerator laboratory) who remains very impressed that it runs so reliably and produces good results! Ongoing support was provided throughout this period.

Recently work has been started on the electronics and system design for new projects LISA and SAGE, mentioned in section 3. This will involve incorporating digital electronics into the TDR data acquisition system.

Installed equipment continues to function and occasionally require some support. In addition to GREAT (see earlier) other equipment that was supported by the NPG during this period includes EXOGAM at GANIL, the ex-Euroball electronics for RISING at GSI, and the ex-

Euroball electronics for CLARA at Legnaro. The NPG are working in collaboration with other departments in CCLRC on the design of a preamplifer ASIC for Germanium detectors. This has since been produced and is awaiting testing.

Several further SAC[1] modules have been produced during the report period for both UK Universities and our European collaborators.

5. SOFTWARE SUPPORT

The NPG software team provides data acquisition and data analysis software solutions for all activities of the community. In many cases since all experimental facilities are outside the UK these are international collaborations and the team works closely with the hosts to ensure that the software systems are compatible with the environment and requirements of the host laboratory. It also works closely with university groups who provide data analysis software.

Throughout the period covered by this report there was continued development of the MIDAS [Multi Instance Data Acquisition System – see http://npg.dl.ac.uk/MIDAS/] system to ensure that it continued to meet the requirements of the UK community and the experimental programme; to ensure that it takes advantage of the latest technologies available, in particular where these offer more cost effective solutions; and to ensure that it is ready to meet the future requirements of the various activities of the NPG.

Complementary to this activity there was a continued development and exploitation of a general purpose and modular data acquisition and control system, which is fully integrated into the MIDAS environment. This permits, to a large degree, common solutions to be deployed across all of the departments' activities. Not only is this common solution approach highly efficient from the development and maintenance aspect but also the users of the system see a familiar control interface. This development is fundamental to and used by all the activities that are reported here.

An online data analysis package (MIDASsort) is now available fully integrated into the MIDAS environment. Options exists to distribute event data in real-time to a cluster of workstations for analysis.

See http://npg.dl.ac.uk/MIDAS/download/midassort/midassort.html and http://npg.dl.ac.uk/MIDAS/download/tapeserver.html.

Further development of the MIDAS general purpose data acquisition system to enable data sources other than the Silena 9418 VME ADCs to be used was undertaken. Support for two families of CAEN TDC is now available. In addition, following problems obtaining hardware from Silena the system was enhanced to allow CAEN ADCs to be used as an alternative. A facility to allow general purpose VME data sources (such as scalers) to be included is also now available.

Migration of the MIDAS data acquisition software to use a new VME single board computer and the Linux operating system was undertaken. This permits the latest and most cost effective hardware to be used. Further savings occur as a result of using the open source Linux software. A significant amount of international interest has been generated by this development partly because of the very low-cost solutions which it can produced and partly as a result of the use of open standards (POSIX) in the software itself.

[1] SAC is the Silena Adc Control card- used with Silena and CAEN VME ADCs to simultaneously start and stop multiple ADC cards.

A bi-parameter histogramming facility was added to the standard MIDAS Data Acquisition system, which is feasible given the much larger RAM available with the latest generation of VME single board computers.

These points combine to make available a powerful but very low cost solution, which is particularly useful for detector testing within University departments as projects for Nuclear Physics students. This allows a "hands on" opportunity, which is not possible at the major facilities and so is an excellent training tool. All of the University groups have taken advantage of this possibility to some degree.

As a consequence of the use of open standards by the data acquisition software a port of the software to the Microsoft Windows operating system has been undertaken. This allows the use, where desirable, of commercial hardware which may have closed interfaces that are only supported by the manufacturer for the Windows OS.

Work has been undertaken to integrate the latest Web Services technologies within the MIDAS environment. This permits the use of a standard Web browser to be used as the graphical user interface. While there are limitations as to how far online data can be visualized by a Web browser this can be a very powerful technique for configuration and diagnostics. The communications protocols used by MIDAS were defined around 1990 using what was at the time the most general purpose methods. These are now being replaced by the open standards used by the Web Services protocols.

The NPG also provided support to groups installing the standard MIDAS data acquisition system at laboratories in Madrid, Louvain-La-Neuve, Grenoble, Strasbourg, Cape Town and Canberra plus UK Universities at Manchester, Liverpool, York, Edinburgh and Birmingham.

The NPG provided ongoing support and upgrades as required to data acquisition systems installed and operational at GANIL (EXOGAM and TIARA), GSI (RISING), Legnaro (PRISMA and CLARA), Jyväskylä (GREAT and Laser Spectroscopy), TRIUMF (TUDA) and ANU (CHARISSA).

During summer 2004 the NPG was asked to update the EXOGAM data acquisition software at GANIL using the developments mentioned above. The aim was to improve the overall data throughput of the system and to increase ability for online monitoring and also to improve the reliability of the software. This was carried out in 2 phases; first to install the MIDAS data acquisition software (June 2004) and secondly to install the new processor when it became available (Sept 2004). The result has been very successful leading (potentially) to data rates higher than anything ever achieved at GANIL. Feedback from experiments that have run since the final upgrade have confirmed the absolute reliability of the software.

The NPG responded to an approach by a York-Uppsala-GANIL collaboration to provide data acquisition options for coupling the Neutron Wall to EXOGAM-VAMOS.

The NPG provided software to support and control the SPACE module (a digital processing module) being developed by Orsay. This software allows the use of MIDAS during test of the SPACE module within the EXOGAM array.

The NPG provided ongoing support for PRISMA-CLARA installed at INFN Legnaro. Software was provided for the control of the PRISMA Silicon Shaper Amplifiers within the MIDAS environment. Software, consisting of a Web Service + MIDAS GUI to be used for testing electronics being developed for readout of a new Silicon Strip detector was also provided.

The group continued to support the TUDA collaboration at TRIUMF. During a visit in July 2005 V. Pucknell performed a general software update and installed MIDASsort to encourage

the TUDA group to use this online for in-beam experiments. The general problems that can occur during real in-beam experiments were discussed and discovered. The cause of poor network performance between the TUDA Sun workstations and the external TRIUMF network was identified.

The NPG is responsible for the control, setup and monitoring of the AGATA digitizers. An initial version of the software has been written in order to aid testing of the hardware as it is produced.

There has been an ongoing program of maintenance and enhancement to the GREAT TDR acquisition system at Jyväskylä. In particular, there have been significant developments in three areas:

i) Versions of the collator and merge programs have been produced that run in the same processor. This allows a simple but fully functional single processor based system to be built for testing and development in the laboratory.

ii) Software was provided for new modules (pattern register, metronome) as they were introduced. This software produces appropriate statistical and debugging output as requested by engineers and other staff.

iii) A new, Motorola MVME 5500, merge processor was purchased. This has a higher processor clock speed and has onboard Gigabit ethernet. Thus, as well as being inherently faster it avoids the problems previously seen with an add-on gigabit ethernet interface. There were significant difficulties with the LynxOS Board Support Package provided for this new card. However it now works well offering greater throughput and data rates and thus a greater range of experiments and detectors.

The NPG provided a data acquisition module to York University as an option for the standard MIDAS VME DA package for the VF48 (Tactic Kopio) digital ADC module.

The NPG provided a data acquisition module as an option for the standard MIDAS Data Acquisition for the Lyrtech VHS-ADC as a standalone digital ADC. This is a commercial hardware module, which uses the cPCI interface and the Microsoft Windows OS. This system will be used for SAGE and LISA.

The NPG upgraded the data acquisition software for the LASER spectroscopy set-up at Jyväskylä for the Manchester and Birmingham groups to implement a new mode of operation.

Finally the NPG continues to provide software support for the UK University groups, particularly the smaller groups. This support includes advice and assistance on local computing hardware problems and software upgrades. This support service is by email and telephone and on-site visits when necessary.

6. TARGET LABORATORY

Thin film targets and foils are required for low-energy nuclear physics experiments. In order to meet current demands of UK physicists engaged in nuclear structure experiments around the world, a large variety of targets are required from elements throughout the periodic table. The target preparation laboratory (TPL) at Daresbury Laboratory provides this service to the UK community and is the only facility of its kind available in the UK. The TPL has been in operation since the early days of the Nuclear Structure Facility at Daresbury and target preparation has to be performed by a specialist technician. In March 2002 a new technician

was employed and since then the TPL has been refurbished and new equipment installed. The laboratory is now equipped with two sputtering units, an electron beam gun, and three coating rigs, all for target preparation. In addition, several items essential for efficient operation of such a facility, such as an accurate balance and vacuum storage system, are now available.

The new technician has rapidly become familiar with this equipment and new fabrication techniques for different target species are under continual investigation. During this reporting period the range of targets that can be produced has expanded and a full list of those produced is given in table 1. The range now includes rare earth elements (e.g. Sm, Er) and difficult oxidising materials (e.g. Calcium).

Capital has been used for example for the maintenance of the vacuum evaporation systems, upkeep and inspection of COSHH systems required by health and safety in the laboratory. In addition natural materials have been purchased and used to perform tests and develop target preparation techniques, before using the expensive isotopically enriched material. In addition the TPL has been continually upgraded and now has a new vacuum storage facility and a digital temperature controlled hot plate unit

A description of the target preparation laboratory, equipment and range of targets plus an online target request form can be found at:
http://www.dl.ac.uk/NPG/target_manufacture.htm

Table 1
List of target produced in the period.

Requested	Institute	Used at:	Target requested
David Jenkins	York	Rex Isolde	^{nat}Ti 1 mg cm^{-2}
Paddy Regan	Surrey	Yale	^{98}Mo 500 μg cm^{-2}
Paddy Regan	Surrey	Yale	^{100}Mo 500 μg cm^{-2}
Paddy Regan	Surrey	Yale	^{98}Mo 500 μg cm^{-2} Au 10 mg cm^{-2}
Paddy Regan	Surrey	Yale	^{100}Mo 500 μg cm^{-2} Au 10 mg cm^{-2}
John Smith	Manchester	Jurogam	^{58}Ni 1 mg cm^{-2}
John Smith	Manchester	Jurogam	^{58}Ni 750 μg cm^{-2}
John Smith	Manchester	Jurogam	^{58}Ni 500 μg cm^{-2}
David Jenkins	York		Al 2 mg cm^{-2}
David Jenkins	York		^{120}Sn 2mg cm^{-2}
Alison Bruce	Brighton		^{124}Sn 1.5 mg cm^{-2}
Tom Davinson	Edinburgh		CH_2 50μg cm^{-2}
Tom Davinson	Edinburgh		CH_2 250 μg cm^{-2}
Tom Davinson	Edinburgh		CH_2 500 μg cm^{-2}
John Simpson	Daresbury	Jyväskylä	^{144}Sm 500 μg cm^{-2}
Gavin Smith	Manchester	Argonne	Au 1mg cm^{-2}
Gavin Smith	Manchester	Argonne	Au 2 mgcm^{-2}
Rodi Herzberg	Liverpool	Jyväskylä	^{207}Pb 500 μg cm $^{-2}$
Rodi Herzberg	Liverpool	Jyväskylä	Bi 500μg cm^{-2}
Tom Davinson	Edinburgh		CH_2 120 μg cm^{-2}
Tom Davinson	Edinburgh		CH_2 180 μg cm^{-2}
Tom Davinson	Edinburgh		CH_2 200 μg cm^{-2}

Dave Joss	Daresbury	Jyväskylä	^{106}Cd 1mg cm^{-2}
Dave Jenkins	York	Jyväskylä	Ca
Paddy Regan	Surrey	Yale	^{170}Er
Robert Page	Liverpool	Oak Ridge	Fe
Dave Jenkins	York	Jyväskylä	^{40}Ca 300 μg cm^{-2} Au 300 μg cm^{-2} & Au Flash
Scott Williams	Surrey	Orsay	^{24}Mg 500 μg cm^{-2}
Simon Fox	York	TRIUMF	C foils flashed with Au
Paddy Regan	Surrey	Yale	^{82}Se 500 μg cm^{-2}
Paddy Regan	Surrey	Yale	^{82}Se 1 mg cm^{-2}
Paddy Regan	Surrey	Orsay	^{100}Mo 10 mg cm^{-2}
Paddy Regan	Surrey	Orsay	^{98}Mo 10 mg cm^{-2}
Robert Page	Liverpool	Jyvaskyla	^{109}Ag 1 mg cm^{-2}
Robert Page	Liverpool	Jyvaskyla	^{109}Ag 750 μg cm^{-2}
Dave Joss	Liverpool	Jyvaskyla	^{106}Cd 1 mg cm^{-2}
Eddie Paul	Liverpool	Jyväskylä	^{58}Ni 1 mg cm^{-2}
John Simpson	Daresbury	South Africa	^{24}Mg 500 μg cm^{-2}
John Simpson	Daresbury	Jyväskylä	^{92}Mo 800 μg cm^{-2}
John Simpson	Daresbury	Jyväskylä	^{94}Mo 800 μg cm^{-2}

7: COMMITTEES

The following summarises the activity of group members in respect of committee memberships and related duties:

D. Warner:

- EPSRC Peer Review College.
- EURISOL Steering Committee
- ISOLDE and Neutron Time-of-Flight Committee, CERN.
- IOP Divisional Committee.
- EPSRC/CCLRC Working Group on Future of Nuclear Physics.
- UK Heads of (Nuclear Physics) Groups
- GANIL Evaluation Panel
- Referee of SPIRAL2 facility proposal for IN2P3 Council
- Science and Technological Issues Committee for GSI facility

J. Simpson:

- EURISOL Steering Committee
- UK Heads of (Nuclear Physics) Groups
- Science and Technological Issues Committee for GSI FAIR facility
- AGATA Project manager
- Chairperson of the AGATA Management Board
- AGATA mechanical design joint team leader

- UK AGATA Management Board
- Chairperson of Programme Allocation Panel, Accelerator Laboratory, University of Jyväskylä, Finland
- Chairperson of the RISING design and infrastructure group
- UK representative on RISING Steering Committee
- IN2P3/EPSRC Loan Pool Committee
- EPSRC Peer Review College
- GSI Community council
- Nuclear Physics Platform Grant Management Committee
- UK SAGE/LISA Management Boards
- Co-organiser of the UK community Cosener's House meeting in 2005
- Co-organiser of the UK FAIR community meeting in 2006
- Co-organiser of the Dave Warner Symposium in 2006
- PORGAMRAYS Project Management Committee
- SAGE/LISA design group

R.Lemmon:

- Chair of R3B (FAIR) Technical Board
- R3B Management Board
- R3B Collaboration Board / Steering Committee
- Coordinator of R3B High Resolution Spectrometer Working Group
- EXL Management Board
- Coordinator of EXL Si Recoil Detector Working Group
- Coordinator of SPIRAL2 Charged Particle Detection Working Group
- Bureau des Utilisateurs du GANIL, UK representative
- Chair of the Nuclear Physics Group of the Institute of Physics
- Co-organiser of IOP Meetings on:
    - Beyond the Mean Field: Nucleon-Nucleon Correlations and Spectroscopic Factors
    - Workshop on QCD in Nuclear and Hadronic Physics

I.Lazarus:

- Gretina, Department of Energy, USA, review teams (2003-2005)
- Joint co-ordinator for ASICs between NUSTAR and SPIRAL2
- FAIR CORE-E group
- NUSTAR DAQ design group
- Leader EXL EDAQ team
- R3B EDAQ design group

- Hi/Despec EDAQ design group
- Leader, AGATA pre-processing team
- AGATA Digitizer team
- AGATA Local level processing working group
- PORGAMRAYS Project Management Committee (designated CCLRC's "Key personnel" contact for the project)
- SAGE/LISA electronics and acquisition group

P.J.Coleman-Smith:

- GREAT Electronics and data acquisition working group
- RISING Electronics and data acquisition working group
- AGATA Global clock and trigger team
- AGATA Local Level Processing working group
- AGATA Digitiser team.
- Prisma SED UK data acquisition working group.
- SAGE/LISA electronics and acquisition group

V.Pucknell:

- AGATA Global level processing working group
- AGATA Run control and Graphical User Interface team
- AGATA Electronics and data acquisition integration team
- CLARA/PRISMA data acquisition system coordinator
- SAGE/LISA electronics and acquisition group

S.Letts:

- GREAT Electronics and data acquisition working group
- SAGE/LISA electronics and acquisition group

K.Fayz:

- UK mechanical design team leader for EIT
- GREAT design working group
- AGATA Mechanical design joint team leader