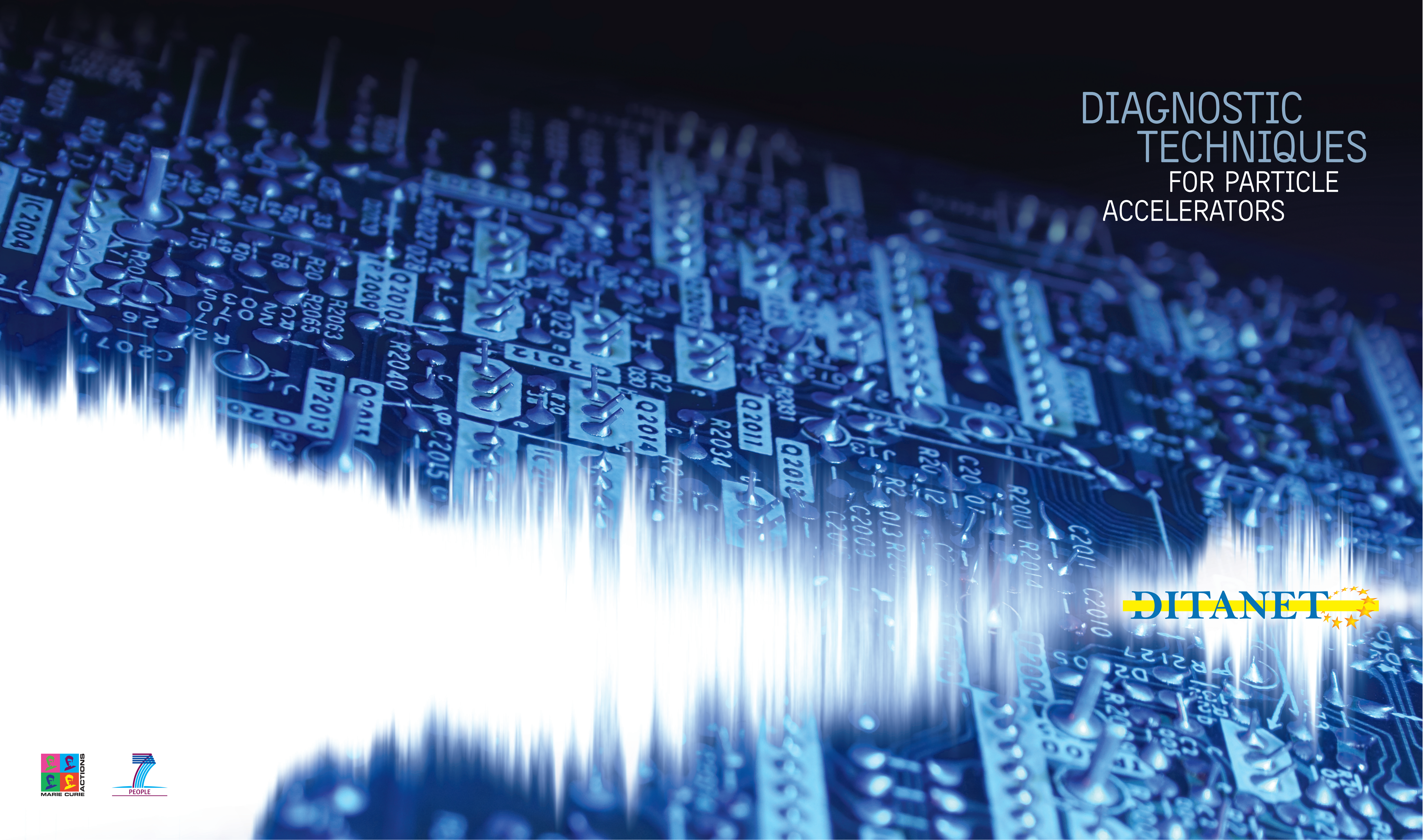


DIAGNOSTIC TECHNIQUES FOR PARTICLE ACCELERATORS

DITANET

MARIE CURIE ACTIONS

PEOPLE

INTERNATIONAL COLLABORATION PUSHING THE BOUNDARIES OF ACCELERATOR INSTRUMENTATION

There are more than fifteen thousand particle accelerators in the world, ranging from the linear accelerators used for cancer therapy in modern hospitals to the giant 'atom-smashers' at international particle physics laboratories used to unlock the secrets of creation.

Without an appropriate beam diagnostics system, it would simply be impossible to operate any accelerator complex let alone optimize its performance. DITANET covers the development of advanced beam diagnostics methods for a wide range of existing and future accelerators.

INTRODUCTION

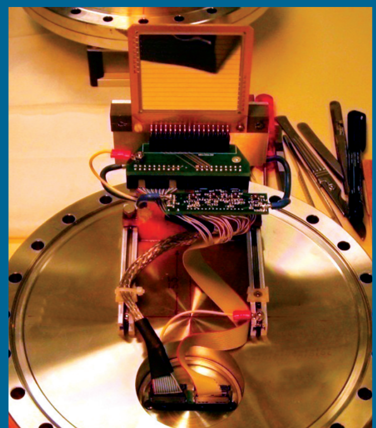
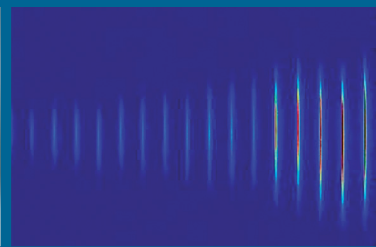
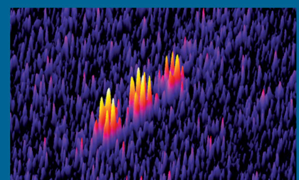
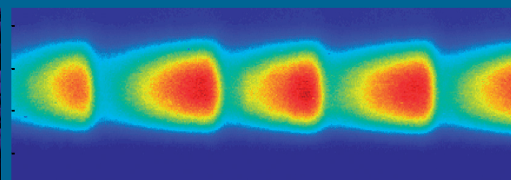


Image: GSI







Beam Instrumentation – Vital Tool for Accelerator Operation

For many decades particle accelerators have formed one of the main pillars of modern research across scientific disciplines and countries. The development of new research infrastructures with unprecedented beam characteristics drives the need for an intense R&D program in diagnostic techniques. The successful operation of these machines will only be possible with adequate beam instrumentation.

Beam diagnostics is a truly multi-disciplinary field in which a great variety of physical effects are made use of and consequently provides a wide and solid base for the training of young researchers. Moreover, the principles that are used in any beam monitor or detector enter readily into industrial applications or the medical sector. Partners within DITANET develop beyond-state-of-the-art diagnostic techniques for existing and future accelerator facilities and train early stage and experienced researchers within an international network of major research centres, leading Universities and industry partners.

Image courtesy of CERN

Some of the particular challenges in this field are:

Exact knowledge of the **transverse profile** of a beam of charged particles is of utmost importance for the safe and efficient operation of any accelerator. It also allows for a continuous optimization of all important beam parameters. Particular focus is often set on the fraction of particles in the tail regions of the transverse beam distribution –only accessible by measurements with high dynamic ranges, pose strong requirements on the diagnostic elements.

Particle detection is one of the key aspects to obtain good experimental resolution. Cutting edge detectors are needed that provide detailed information about particle position and energy along with very good time resolution and sufficient radiation hardness. This typically drives a strong R&D program with a strong involvement of the industry sector.

Precise determination of the integral number of ions or electrons of a beam in an accelerator is an important task that has direct implication on the experimental areas, the machine protection system or other diagnostic elements that interact with the beam. Measurement of the **beam current** is thus a characteristic beam parameter that needs to be known in any accelerator.

Output from an accelerator-based experiment or application can only be maximized when the exact **beam position** in an accelerator is known. The machines that are covered within DITANET put significantly more stringent requirements on this measurement technique than the current state-of-the-art and new concepts are developed to reach the envisaged accuracies and sensitivities.

Exact determination of the **longitudinal beam profile**, i.e. the time structure of ever shorter bunches in accelerators and light sources is a must for a successful operation. It imposes strong demands on the quality of the beam instrumentation as this parameter should ideally be measured in a non-destructive, easy-to-maintain way, providing a time resolution down to the femtosecond regime!

UNIVERSITY OF LIVERPOOL

Founded in 1881, the University of Liverpool has built up an international reputation of pioneering education and research. Currently around 20,000 students are enrolled into more than 400 programs spanning 54 subject areas at its 3 faculties.

The Department of Physics at Liverpool is currently one of the very few academic departments in the UK to obtain top ratings for both teaching and research. A rich variety of research is performed at Liverpool, including Particle Physics, Nuclear Physics, Condensed Matter Physics, Surface Science and Astrophysics.

The University also has the lead role in the Cockcroft Institute, an international centre of excellence for accelerator science and technology. Embracing academia, government and industry, it is unique in providing the intellectual focus, educational infrastructure and the essential facilities in innovating tools for scientific discoveries and wealth generation.

Finally, the University is home to the QUASAR Group, carrying out investigations into antimatter and innovative beam diagnostics solutions.

THE PROJECT: Design, Construction and Tests of a Full Set of Diagnostics for Future Low-energy Storage Rings

Supervisor: Carsten P. Welsch

To enable the efficient investigation of some very essential questions regarding the physics with low-energy antiprotons, a novel electrostatic cooler synchrotron, the ultra-low energy storage ring (USR) is being developed in the QUASAR group at the Cockcroft Institute in close collaboration with experts at the MPI for Nuclear Physics and the GSI Atomic Physics Division.

The aim of the USR will be to slow down antiprotons to very low energies between 300 and 20 keV. This will provide world-wide unique conditions for both in-ring studies with an intensity of up to 10^{12} cooled and stored antiprotons per second, as well as for experiments requiring extracted slow beams. The boundary conditions of the USR project put very high demands on the machine's instrumentation: The extremely low vacuum pressure of the USR, together with a beam energy of only 20 keV and low currents of antiprotons between 1 nA and 1 μA require the development of new diagnostic methods as most of the standard techniques will no longer work.

In this project the beam diagnostics elements as they are required for a successful operation of this storage ring have been developed. Prototypes of a purpose-built Faraday Cup, a capacitive beam position monitor and a secondary emission monitor have been designed and built up. This was complemented by investigations into scintillating screen materials. Close collaboration with DITANET partners MPI for Nuclear Physics, CERN, Stockholm University and INFN-LNS took place throughout the project.

THE RESEARCHER: Janusz Harasimowicz

During his fourth year of study at the Department of Biomedical Physics at the University of Warsaw, Janusz joined the accelerator research group at the Soltan Institute for Nuclear Studies in Poland. It gave him the opportunity, not only to develop his skills both in applied and theoretical accelerator physics, but also to get acquainted with a demanding medical and industrial environment. Janusz combined his experience gained at the Soltan Institute and the University of Warsaw; describing his research in his 2006 master's thesis entitled 'Derivation of Medical Accelerator Electron Beam Energy Spectrum Using an Inverse Monte Carlo Method'. His attitude and team spirit were quickly appreciated and in 2007 he became leader of a group of young researchers at the Soltan Institute.

Since January 2008, Janusz has been expanding his knowledge in the field of beam instrumentation for future particle accelerators. As a DITANET trainee, he is responsible for the development of novel diagnostic devices for the USR. Janusz has been studying and proposing new solutions for monitoring low energy antiproton beams and has been collaborating with colleagues from across the network.

THE PROJECT: Development of a Modified Neutral Beam Scanner

Supervisor: Carsten P. Welsch

At the lowest beam energies and low intensities that will become available in future low-energy ion storage rings, existing beam profile monitors cannot provide the necessary information. Therefore, new diagnostic techniques have to be developed. The aim of this project is to develop a modified neutral beam scanner, which relies on an ultra-thin extended (4 cm x 4 cm) gas-target "curtain" and on the three-dimensional detection of the ions created via charge exchange or ionization.

The image of these ions will provide complete information about the stored beam over a wide range of stored particle numbers, for all beam energies and for any particle species in the accelerator. The design of this monitor requires careful optimization of all its components, in particular detailed studies into the dynamics of the gas jet shaping and control. Within the project, the monitor has been designed, built up and is now being used for detailed studies with beam.

Faraday Cup prototype developed for the USR.

THE RESEARCHER: Massimiliano Putignano

Massimiliano earned his International Baccalaureate in May 2000 at the United World College of Atlantic, Wales. The years spent at Atlantic College, whose mission is to bring together students from all around the world to foster culture exchange in an environment of academic excellence, proved instrumental both to his passion for Physics and love for internationality. He studied Physics at the University of Bari/Italy, specializing in solid state physics and lasers. His master's thesis focused on the analysis and development of an interferometric sensor measuring off-axis displacements, and included both experimental work and theoretical analysis.

Massimiliano joined DITANET in 2009 and has since been working on the development of the curtain gas jet based beam profile monitor. Through the course of this project he has been exploring various aspects of accelerator physics and fluid-dynamics, both in theoretical and experimental work. He sees great benefit in international collaboration and knowledge exchange and also enjoys working with and supervising undergraduate students.

THE PROJECT: Beam Diagnostics for Medical Accelerators

Supervisor: Carsten P. Welsch

The Clatterbridge Centre for Oncology hosts one of the best-equipped radiotherapy centres in the UK. Facilities include nine linear accelerators, a cobalt unit, superficial and orthovoltage X-ray machines, two simulators, two scanners - a wide bore single slice Computer Tomography (CT) simulator and a multi-slice helical Computer Tomography (CT) simulator. In addition, the centre's cyclotron facility remains as the only patient treatment cyclotron in the UK, providing a service with proton therapy for eye tumours. While the precise measurement of beam intensity and position is very important for many accelerators, it is crucial for medical accelerators.

Within this project, beam instrumentation for the precise measurement of the proton beam position and intensity is being developed. This includes Monte Carlo studies into the energy deposition of the proton beam in different target materials for the design of current and energy spread monitors, as well as the utilization of the LHCb VELO detector for the purpose of least-destructive beam monitoring. Ultimately, this work will lead to a detector phantom able to measure all important characteristic parameters of the therapeutic particle beam.

THE RESEARCHER: Tomasz Cybulski

Tomasz studied medical physics and dosimetry at the AGH University of Science and Technology in Krakow/Poland. His Master's thesis dealt with TL dosimetry for mixed fields of ionizing radiation of photons and charged particles. His experimental work was conducted at both the iInstitute of Nuclear Physics in Krakow/Poland and the Joint Institute for Nuclear Research, Dubna/Russia. He investigated into the properties of thermo-luminescent detectors, as part of the international MATROSHKA project on the International Space Station.

After graduating in 2006 he started his work in the industry sector with Synektik Sp. z o.o., Warszawa/Poland where he worked as a dosimetrist in the quality assurance of X-ray diagnostic medical devices. He was also responsible for the development of measurement methods and procedures.

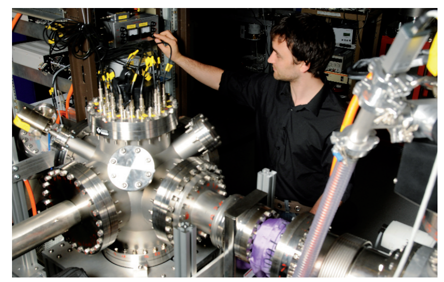
Tomasz joined the QUASAR Group and DITANET on June 1st 2010. He is developing beam monitoring detectors for the Clatterbridge Centre for Oncology, specializing in hadron therapy for eye tumours. He will also investigate into the biological effects of particle beams on patients undergoing treatment.

Selected publications:

J. Harasimowicz, et al., "Scintillating Screens Sensitivity and Resolution Studies for Low Energy, Low Intensity Beam Diagnostics", Rev. Sci.Instr. 81 (9) 2010

M. Putignano et al, "A Fast, Low Perturbation Ionization Beam Profile Monitor Based on a Gas-jet Curtain for the Ultra Low Energy Storage Ring.", Hyperfine Interact. 193 (2009)

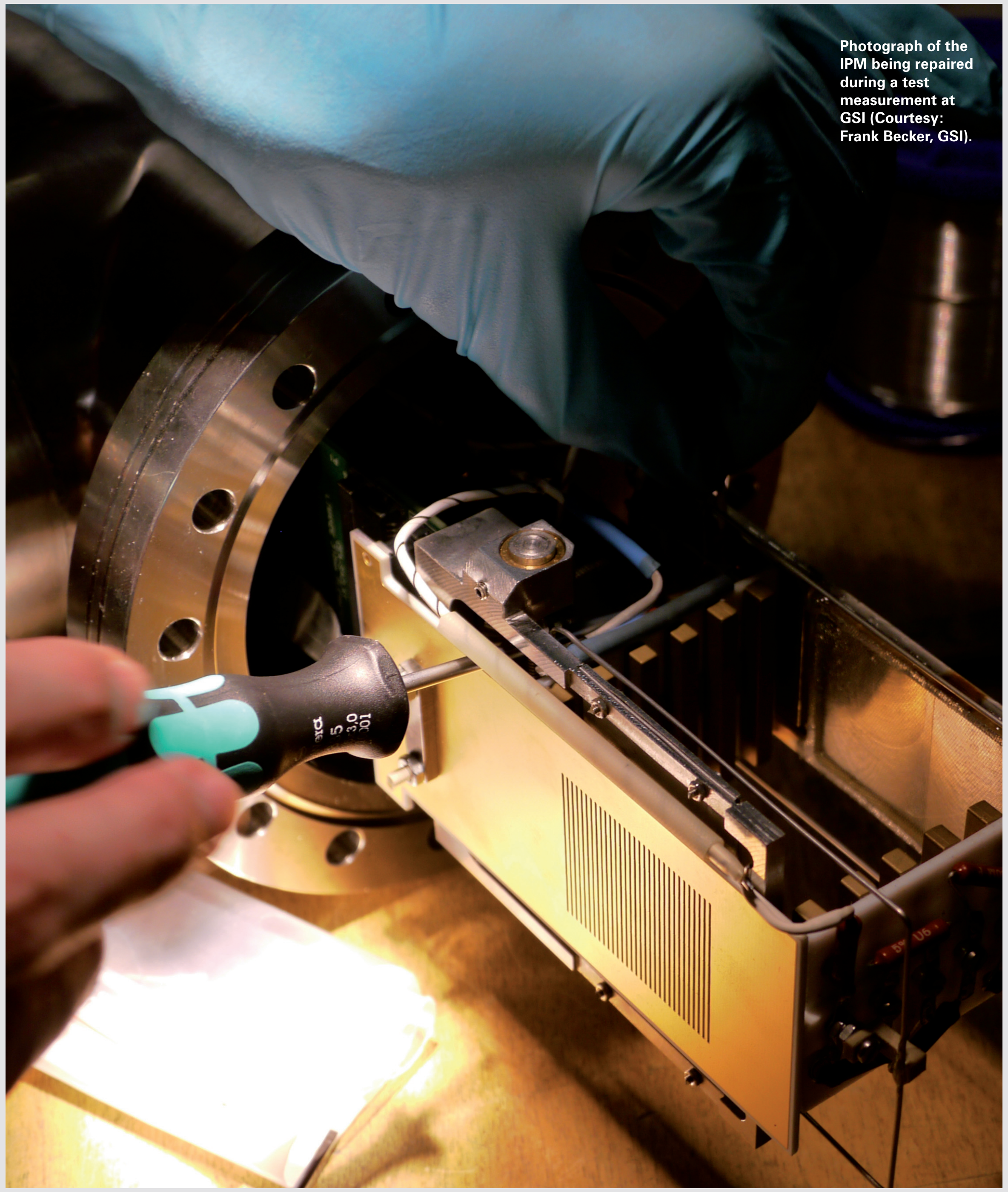
J. Harasimowicz, et al., "Experimental Results from Test Measurements with the USR Beam Position Monitoring System", Proc. IPAC, San Sebastian, Spain (2011)



Photograph of the gas jet experiment at the Cockcroft Institute

COMMISSARIAT À L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA)

Since 1952, CEA-Saclay has been one of the nine research centers of the CEA. It presently hosts more than 5,000 researchers in multi-disciplinary fields including nuclear energy, biology, technology, climatology and basic research.



Photograph of the IPM being repaired during a test measurement at GSI (Courtesy: Frank Becker, GSI).

Within CEA, DAPNIA is in charge of studies related to fundamental laws of the Universe. It participates in numerous international projects, such as for example the particle physics experiments ATLAS and CMS, the high energy accelerators LHC and CLIC, and the International Fusion Materials Irradiation Facility (IFMIF).

Many PhD candidates are trained in DAPNIA's various laboratories. Among the excellent research environment they find on site, they also benefit from the different courses provided by CEA's own educational department.

THE PROJECT: A Beam Profile Monitor Based on Light Emission from Excited Rest Gas Atoms

Supervisor: Raphaël Gobin

Many accelerator projects make use of high intensity ion beams. These are then used for example for the production of neutrons, at neutrinos factories or in nuclear physics research. The transverse distribution of these beams needs to be accurately known to avoid any unwanted interaction with the vacuum chamber walls and to properly interact with the target.

The power of these beams prevents using intrusive methods since any kind of screen would be rapidly destroyed by the temperature increase. One can rely on the neutral gas present in the vacuum chamber that is excited by the beam. The light emitted by this gas may then be used to obtain a good representation of the beam path.

At CEA a beam profile monitor based on light emission from excited rest gas atoms is being developed. The design of this instrument has been finalized and a prototype setup was already realized. In addition, tomography algorithms are being studied to reconstruct the 2D transverse beam profile observed along different directions. Measurements will then be realized to collect information on specific ion beams and to apply this information for fine tuning of the accelerator.

THE RESEARCHER: Cherry May Mateo

Cherry was awarded her Bachelor of Science in Physics by the University of the Philippines, Diliman, Quezon City. She was an active member of the semiconductor research group in the Condensed Matter Physics Laboratory. Having been trained in optical characterization of GaAs-based semiconductors, her bachelor thesis topic was on optical characterization of strained GaAs heterostructures. This study led to her first international publication in a peer reviewed journal.

Following graduation, Cherry proceeded with her master's degree and continued carrying out research in the same laboratory. Her affiliation and active participation in this laboratory continued as she became a graduate student and a part time junior faculty of this same institute. She finished her master's degree within two years and was able to co-author three further peer reviewed scientific papers. Cherry became a DITANET trainee on beam diagnostics at the LEDA (Laboratoire d'études et de développements pour les accélérateurs) in CEA Saclay in January 2010.

THE PROJECT: Beam Diagnostics for IFMIF Accelerator

Supervisor: Jacques Marroncle

Within the framework of the IFMIF project, a high-intensity deuteron accelerator prototype will be built and tested at Rokkasho (Japan). The development of non-interceptive diagnostics for such a powerful accelerator (1.125MW) is very challenging, as all monitors have to work in a high radiation environment. Within the frame of this project, a transverse beam profile monitor based on the ionization of the residual gas is being developed and tested in close collaboration with international partners, such as GSI/Germany. Optimization of the monitor's electric field homogeneity, participation to the electronics design, measurements with beam, as well as a detailed analysis and simulation of the monitor response all form part of the project.

In addition, investigations into beam loss monitors are being carried out. This includes a calibration of the ion chambers with neutrons and γ in the MeV range. Energy loss simulations to define safety margins for the electronics and numerical simulations of expected thermal loads on different detector components complement this project.

THE RESEARCHER: Jan Egberts

Jan began studying physics in Heidelberg/Germany in April 2003. After he received his pre-diploma by the end of 2004 he was accepted for the Baden Wuerttemberg - North Carolina exchange programme and spent one year at the University of North Carolina. In 2006 he returned to Heidelberg University to complete his studies with a focus on atomic physics, particle physics and applied accelerator physics.

Jan undertook a diploma thesis at the University of Heidelberg on accelerator beam diagnostics. His thesis entitled 'Investigations on Transverse Beam Profile Measurements with High Dynamic Range' was carried out at the Max Planck Institute for Nuclear Physics. Jan graduated in July 2009.

In October 2009, Jan began his PhD project at CEA Saclay as a DITANET trainee.

Selected publications:

C.M. Mateo, et. al. "Non-interceptive profile measurements using an optical_based tomography technique", Proc. DIPAC, Hamburg, Germany (2011)

J. Marroncle, Ph. Abbon, J. Egberts, M. Pomorski, "μ-Loss Detector for IFMIF-EVEDA", Proc. DIPAC, Hamburg, Germany (2011)

J. Egberts, et al., "Detailed experimental Characterization of an Ionization Profile Monitor", Proc. DIPAC, Hamburg, Germany (2011)

CERN

Being one of the leading accelerator laboratories of the world, CERN is the ideal place to study and develop ultimate detection and imaging techniques, and test them directly in the different accelerators, including the Large Hadron Collider.

CERN is the world's largest particle physics laboratory which acts as a focal point for European physics and technology collaborations. It hosts each year a community of over 6,000 visitors from more than 300 external institutes around Europe, and from many non-CERN-Member States. CERN has world-class accelerator facilities, including the Isolde/PS/SPS/LHC complexes, a Technology Transfer Unit which enhances the transfer of ideas into the commercial sector, and an Outreach program which promotes communication and public education through press, publications, web pages, exhibitions and visits to the Laboratory. CERN has a very strong track record as a European training centre. In recent years the volume of training given has been in the order of 11,000 person-days per year. Much of this training is geared towards young researchers.

THE PROJECT: Development of a Longitudinal Beam Distribution Monitor for LHC

Supervisor: Andrea Boccardi

The Large Hadron Collider (LHC) at CERN is the world's largest particle accelerator. It is designed to accelerate and collide protons or heavy ions up to center-of-mass energies of 14 TeV for protons.

Knowledge of the longitudinal distribution of particles is important for various aspects of accelerator operation, in particular to check the injection quality and to characterize the development of ghost bunches before and during the physics periods. In order to study ghost bunches at levels very much smaller than the main bunches, a longitudinal profile measurement with a very high dynamic range is needed.

With this project a new detector, the LHC Longitudinal Density Monitor (LDM) has been developed. It is a single-photon counting system measuring synchrotron light by means of an avalanche photodiode detector. The unprecedented energies reached in the LHC allow synchrotron light diagnostics to be used with both protons and heavy ions.

A prototype monitor has been developed and was installed during the 2010 LHC run. The longitudinally profile of the whole beam has now been successfully measured with a resolution close to the target of 50 ps. On-line correction for the effects of the detector dead time, pile-up and after pulsing allowed a dynamic range of 10^5 to be achieved.

THE RESEARCHER: Adam Jeff

Adam attended the University of Wales, Aberystwyth between 2001 and 2005, where he completed an MPhys degree in Physics with Planetary and Space Physics. The last semester of this degree was spent on an Erasmus exchange at UNIS, the Norwegian university and research center on Svalbard, where he studied the physics of the upper polar atmosphere and the aurora borealis. In winter not only does the Aurora provide a beautiful spectacle, but its careful measurement can be used to draw inferences about the physics of the upper atmosphere. By the time Adam left in June, however, the midnight sun had made work impossible and so observations switched to the EISCAT incoherent scatter radar system. This was followed by a period of two years teaching physics at the Colombo International School in Sri Lanka.

THE PROJECT: A Transverse Beam Distribution Monitor for Linac4

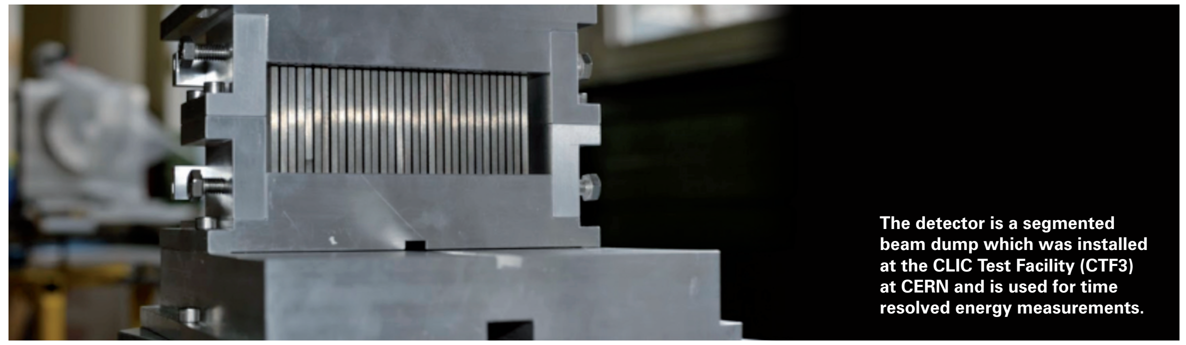
Supervisor: Federico Roncarolo

Linac4 is a rather new project at CERN. Its aim is to build a high current H- linac as replacement of the current proton linac as the first stage of the LHC injectors. This new machine will require improved instrumentation as the beams will be so powerful that imperfections in the functioning will cause real damage to the machine. In low energy linacs transverse profile monitors are usually based on interceptive techniques. Typically, a foil or a wire are inserted in the beam path and secondary signals like light or electrical currents, generated by the interaction between the beam and the obstacle, are detected and used in the computation of the particles distribution.

In this project, a monitor based on a set of parallel wires is being developed for the measurement of the profiles of the Linac4 high intensity H- beams. In addition, a system for the measurement of the beam emittance for the whole energy range from the source to 160 MeV is being developed.

THE RESEARCHER: Benjamin Cheymol

Benjamin began studying Physics at the Université Paul Sabatier and following his DEUG he went onto the Université Blaise Pascal in Clermont-Ferrand to study high energy physics. The field of his master thesis was in medical physics, focusing on imagery for breast cancer treatment. He completed his degree in June 2007, with a work on the 'Measurement of the Generalized Polarizability of Protons in a Virtual Compton Scattering Experiment'. Benjamin has been working as a DITANET trainee since 1st December 2008.



The detector is a segmented beam dump which was installed at the CLIC Test Facility (CTF3) at CERN and is used for time resolved energy measurements.

THE PROJECT: Time-resolved Spectrometry and Emittance Measurements on a High Current Electron Beam

Supervisor: Enrico Bravin

The CLIC Test Facility 3 (CTF3) is an international collaboration at CERN that aims at demonstrating the feasibility of a 3TeV e^+-e^- Collider, based on the so-called "two-beam acceleration scheme". The CTF3 provides high current (28 A), high frequency (12 GHz) electron beams which are used to generate high power radiofrequency pulses at 12 GHz by decelerating the electrons in resonant structures.

A Test Beam Line (TBL) has been built up to prove the efficiency and the reliability of the RF power production with the lowest level of particle losses. As the beam propagates along the line, its energy spread grows up to 80% which makes this beam unique. For instrumentation, this unusual characteristic implies the development of new and innovative techniques. One of the most important tasks is to measure the beam emittance and its energy spread with a good resolution. For this purpose the performances of the already existing devices had to be improved or modified significantly.

Time resolved spectrometry has been performed with a time resolution better than a nanosecond. In addition, investigations into new OTR screen materials and shapes are being carried out.

THE RESEARCHER: Maja Olvegård

After having studied Mathematics and Portuguese for one year at the University of Stockholm, Maja switched to study physics at the University of Gothenburg, Sweden. The topic of her bachelor's thesis was 'Fast Dilation in 3D' and the work was carried out in collaboration with a company developing mathematical software for various types of industries. After a short study trip to CERN in 2006 her interest in more fundamental physics in general, and accelerator physics in particular, grew, and she decided to focus her studies on particle physics.

In June 2008 Maja went back to CERN to spend three months there as a summer student. During these three months she worked on time-resolved energy measurements at CTF3. This work later became the project upon which her Master thesis was based, which she completed in January 2009. She joined the network right after the end of her studies.

THE PROJECT: Electro-Optical Techniques for the Measurement of Longitudinal Beam Profiles

Supervisor: Thibaut Lefevre

Another big challenge in the CTF3 and CLIC projects is to provide accurate measurements of the longitudinal beam profile with a time resolution of better than 20 fs. One of the most promising devices would be based on electro-optical techniques. This project is being realized in close collaboration between CERN and the ultrafast electro-optics diagnostics group based jointly at Dundee University and STFC Daresbury Laboratory, which has an international reputation in the measurement of femtosecond relativistic electron beam bunches. These measurements were pioneered by the group, and have evolved into a range of techniques involving terahertz optical pulses, non-linear optics and ultrashort electron beam transport systems.

In the frame of the project, the limits of these electro-optic techniques are being pushed, requiring significant advances in both the theoretical and experimental aspects of the problem, and consequently extensive work on new optical materials and laser techniques.

THE RESEARCHER: Rui Pan

Rui graduated from Capital Normal University (CNU), Beijing, China in 2007 with a bachelor's degree in Optical Engineering. During his study he did two internships, one testing scintillators with cosmic rays at the Institute of High Energy Physics, Chinese Academy of Sciences, and the other testing aircraft engine turbine blades at the Institute of Aeronautical Materials in Beijing.

Following this he was very interested in the Terahertz field choosing to study for a master's degree in Optical Engineering, graduating from CNU in 2010. The Master's course specialized in the principles of optics, nonlinear optical, advanced laser physics, and THz science and technology. His master's thesis focused on THz Time Domain Spectroscopy and Thz fast imaging, including electro-optical detection techniques.

Rui entered the DITANET network in January 2011. Although based at CERN, he also spends a considerable amount of time at STFC and Dundee University, working with the ALICE test accelerator and thus gaining hands-on experience.

DEUTSCHES ELEKTRONEN-SYNCHROTRON (DESY)

The German Electron Synchrotron DESY, a member of the Helmholtz Association, is one of the leading accelerator centres in the world and will be home to the European X-ray free electron laser XFEL.

DESY has a broad experience in building and running particle accelerators. New developments in beam diagnostics can be tested at different accelerators on site as well as at other European institutes which are deeply involved in developments for the XFEL.

The Machine Diagnostic and Instrumentation group at DESY (MDI) is responsible for the instrumentation and diagnostics for all accelerators on site (electron, proton circular and linear accelerators and FELs). DESY and the University of Hamburg, a physics institute of which is on site, offer joint and well established multi-disciplinary training courses for students and young scientists.

THE PROJECT: Resonant Diffraction Radiation from Inclined Targets as a Tool for Bunch Lengths Diagnostics

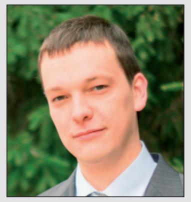
Supervisor: Kay Wittenburg

There exists considerable interest in studying the properties of coherent Smith-Purcell radiation (CSPR) because of the potential possibility to use such a type of radiation from relativistic electrons for "non-invasive" bunch length diagnostics. Radiation with wavelengths $\lambda > \sigma$ (σ = bunch length) is emitted coherently, resulting in an emission intensity which scales proportional to N^2 (N = number of particles per bunch), and for wavelengths $\lambda < \sigma$ the intensity scales only proportional to N.

Due to the grating dispersion relation the wavelength of Smith-Purcell (SP) radiation is defined by the grating period and the photon emission angle. Therefore, the investigation of the SP radiation yield dependence on the polar angle enables to observe the intermediate zone where the transition from incoherent to coherent SP radiation takes place, and as a result to extract a bunch length.

In frame of this project an inclined grating with one/two detectors placed at fixed positions (observation angles) is used to measure the radiation yield as a function of the grating inclination angle. In contrast to CSPR which is emitted from a grating whose surface is oriented parallel to the beam axis the term coherent resonant diffraction radiation (CRDR) seems more appropriate when the grating surface is tilted.

In this diagnostics scheme the information of both individual detectors is available with only one scan of the grating inclination angle. Furthermore, under abandonment of the need for bunch reconstruction and restricting to the case of bunch length measurement the information of both detectors can be combined by taking the intensity ratio R of the signals from detectors D_1 and D_2. The advantage of such a diagnostics scheme is that one has not to rely on absolute values of the radiation yield, avoiding the need to know the individual sensitivity of each detector to a high level of accuracy.



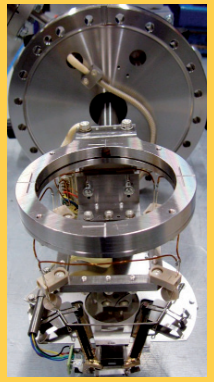
THE RESEARCHER: Leonid Sukhikh

Leonid joined the Maschine, Diagnose und Instrumentierung (MDI) Group at DESY in January 2011 as an Experienced Researcher within DITANET.

He finished his graduate education in Tomsk Polytechnic University (Tomsk, Russia) in 2007 as engineer-physicist with specialization 'Physics of atomic nuclear and elementary particles'. The diploma thesis 'Focusing of the diffraction radiation generated by parabolic target' was based on the results of a joint experiment at KEK-ATF (Tsukuba, Japan) devoted to the investigation of optical transition and diffraction radiation from a concave target. Leonid defended his PhD thesis 'Focusing of the transition and diffraction radiation by concave targets' in 2009 under the supervision of Prof. Alexander Potylitsyn at the Nuclear Physics Institute of Tomsk Polytechnic University. The thesis included not only incoherent radiation focusing but also the focusing of coherent radiation. After the thesis Leonid worked in Tomsk Polytechnic University as an assistant.

HEIDELBERG ION THERAPY CENTRE (HIT)

The Heidelberg Ion-beam Therapy Centre, a 100% daughter company of the University hospital at Heidelberg, was founded in May 2004 to operate the accelerator facility and to manage the dose application to the patients.



The HIT accelerator facility consists of two ECR ion sources for the production of ions, ranging from protons to oxygen with a main focus on carbon, a linear accelerator with an end energy of 7 MeV/u, followed by a synchrotron of 65 m circumference and a maximum magnetic rigidity of 6.5 Tm.

Besides two horizontal and one gantry patient treatment rooms there is a further target place equipped like the others but dedicated to quality assurance and research activities. This experiment place can be used for biophysical experiments as well as for the enhancement of treatment equipment and in particular for accelerator studies. In addition, the accelerator part includes three well equipped workshops/laboratories (about 90 m2) for vacuum-related problems, electronics, mechanics and beam diagnostics maintenance and developments.

THE PROJECT: Diagnostics Based on Scintillating Screens for Ion Beam Characterisation

Supervisor: Andreas Peters

This project covers R&D work into the enhancement of a beam measurement system that detects the transverse 2D-beam profile as well as the beam emittance in an accelerator-based cancer therapy centre with a focus at low beam energies. The work includes investigations into adequate screen materials in terms of screen life time and linearity of the signal output, followed by beam tests and evaluation of the experimental data. A particular challenge is to identify a material that can withstand the comparably high ion beam currents of up to 20 mA, resulting in a high heat load on the screen.

In a second step, a pepper-pot type emittance meter will be developed that fits in the existing beam line. This device will then be used to optimize the output emittance of the ion source.

THE RESEARCHER: Marion Ripert

Marion's first two years of studying in France with an emphasis on Astronomy lead her to graduate with a bachelor's degree in Astronomy and Astrophysics at the Euro American Institute of Technology and at the Florida Institute of Technology, respectively. During summer of 2002, she was a summer student at CERN working on aging studies for the ATLAS Transition Radiation Tracker, which brought her to complete her master's in Particle Physics on the CMS experiment at the Florida Institute of Technology. A USPAS course and a summer job at Fermi National Accelerator Laboratory in 2005 brought her to finally discover the field of accelerator physics. However, she has pursued particle physics for her PhD studying QCD phenomenology on the CMS experiment, until she heard about DITANET, which she joined in October 2008.

Selected publications:

M. Ripert, A. Peters, "Target Materials For A Low Energy Ion Beam Pepper Pot Emittance Device", Proc. DIPAC, Basel, Switzerland (2009)

M. Ripert, et al., "A Low Energy Ion Beam Pepper Pot Emittance Device, Proc. BIW, Santa Fe, USA (2010)

A. Peters, R. Cee, E. Feldmeier, M. Galonska, T. Haberer, K. Höppner, M. Ripert, S. Scheloske, C. Schömers, T. Winkelmann, "Operational Status and Further Enhancements of the HIT Accelerator Facility", Proc. IPAC, Kyoto, Japan (2010)

GSI HELMHOLTZ CENTRE FOR HEAVY ION RESEARCH

Founded in 1969, GSI is the national centre for heavy-ion physics in Germany and a member of the Helmholtz association. GSI operates a large, in many aspects worldwide unique accelerator facility for heavy-ion beams.

The research program at GSI covers a broad range of activities extending from nuclear and atomic physics to plasma and materials research to biophysics and cancer therapy.

The GSI beam diagnostic group, a division of the GSI accelerator department, consists of a team of 27 physicists, engineers and technicians responsible for the beam diagnostic equipment of the existing accelerator facility and the development of new devices for the future project FAIR. The GSI PhD program in accelerator physics is organized in collaboration with the University of Frankfurt and the Technical University of Darmstadt. Additionally, master students in technical physics are hosted by GSI in collaboration with the Fachhochschule Wiesbaden. With the official start of the future project FAIR (Facility for Antiproton and Ion Research), the trainees become part of one of the most advanced accelerator complexes in the world from the beginning.

THE PROJECT: Tune Measurement and Feedback for Heavy Ion Synchrotrons and Storage Rings at FAIR

Supervisor: Peter Forck

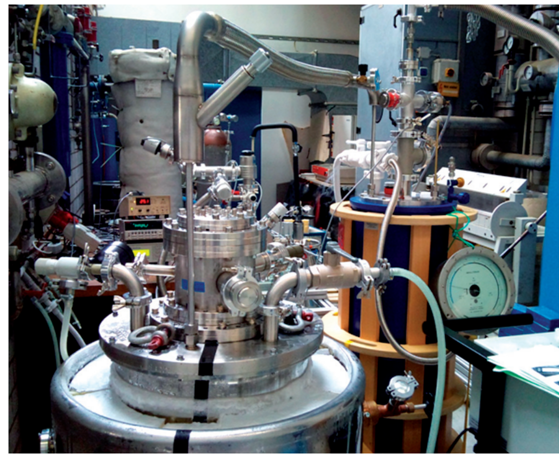
The high beam currents that shall be reached in the FAIR synchrotrons can only be achieved with accurate beam parameter control. The determination and correction of the closed orbit and tune is essential for high current operation of the FAIR accelerators to prevent severe beam losses. Due to the fast acceleration of the beam in the high energy synchrotrons SIS18 and SIS100 the closed orbit correction must have a response time in the order of 1 to 10 ms. This is one order of magnitude faster than comparable installations.

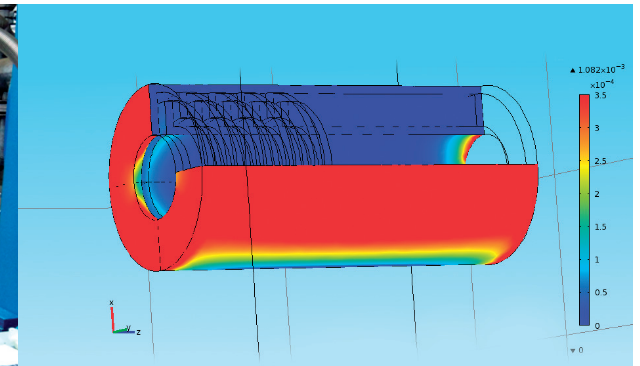
Standard methods for tune measurement are based on beam excitation. This normally leads, however, to an emittance increase and is thus non-ideal. Recently, a much gentler excitation has been developed using a digital Phase-Locked Loop PLL method. It has already been successfully applied at RHIC (Brookhaven Laboratory, USA), Tevatron (Fermilab, USA) and the SPS (CERN, Switzerland). Compared to these accelerators, the FAIR synchrotrons will have a much larger tune spread and varying revolution frequencies. Moreover, the reaction time has to be shorter due to the smaller circumference of the FAIR synchrotrons and storage rings.

The digital signal processing foreseen for beam position measurement is a well-suited starting point for the use of advanced closed-orbit feedback. For sensitive tune measurement and feedback a full digital signal path seems favourable and has to be compared to the signal evaluation by analogue means. Within this project, a general feasibility study is being realized with a prototype installation at the existing SIS18 ring.

THE RESEARCHER: Rahul Singh

Rahul graduated from the SGGS Institute of Engineering Nanded, India in 2006 with a bachelor's degree in Electronics and Telecommunication. Following this he made a significant career shift by choosing to study for a master's degree in photonics from the three collaborating universities of Gent, VUB Brussels and KTH Stockholm through an Erasmus Mundus fellowship, graduating in 2008. After graduation Rahul worked for over a year as a systems manager for Ericsson in Sweden, on its switching centre platform, until August 2009. At this time Rahul began to explore the many possibilities for a continuing research career, and learnt about the DITANET network. Initially, this seemed to be a very distant field, but after a careful study of the various projects within DITANET and considering the background requirements for the work and future perspectives, he chose to pursue it. Rahul began his PhD on 1st October 2009 at the Technical University Darmstadt whilst being based at GSI.





Attenuation of an externally applied magnetic field through the meander shaped superconducting magnetic shield geometry. The magnetic field is applied in the X-direction.

THE PROJECT: Diagnostic Methods for Low Ion Current

Supervisor: Marcus Schwickert

The FAIR storage rings have to be capable of operating with very low ion currents, well below 1 μA. In particular in the case of radioactive ion beams and antiprotons the number of stored particles will be too low for standard beam diagnostics devices. For some of the high-energy beam transfer lines diagnostic devices for the nondestructive measurement of ion currents down to the nA regime will be required.

For this purpose, the installation of Cryogenic Current Comparators (CCC) is foreseen, opening a route for non-intercepting and absolute beam current measurement. The basic working principle of this monitor is the determination of the beam's magnetic field using a sensitive SQUID based magnetic flux detector. In the frame of this project, the design of the monitor is being optimized and a prototype will be built up and commissioned. As a first step the general requirements for a new standardized CCC-prototype with regard to the different installation locations of the FAIR facility are worked out. The design of the high permeability magnetic field sensor is optimized, taking into account of the material science research results achieved by the collaborating partner University of Jena. The SQUID sensor operates at liquid Helium temperature, thus the design of a compact cryostat with a small insertion length is required. Additionally, the whole mechanical detector set up has to be optimized to effectively suppress mechanical vibrations that otherwise would distort the sensitive measurement of the beam's magnetic field. The project will be finalized with beam tests of the CCC-prototype with slowly extracted beam from the existing SIS 18 synchrotron at GSI.

THE RESEARCHER: Febin Kurian

Febin moved to Cochin University of Science and Technology (CUSAT), Kochi, India to undertake a Masters in Physics, after finishing the Bachelors in Physics from Mahatma Gandhi College, Iritty/India in 2002. His Masters course was specialized in modern optics, thin film physics and solid state physics with a strong support of quantum mechanics and nuclear physics. After graduation, Febin worked for over a year in Sungkyunkwan University/South Korea on 'fabrication and the low temperature transport measurement of single and double quantum well HEMT structures' at Sungkyunkwan Advanced Institute of Nanotechnology. He entered the DITANET network in March 2010. Febin is currently joined as a PhD student in Goethe University, Frankfurt together with the DITANET Early Stage Researcher Position at GSI.

Selected publications:

R. Singh, et al., „Tune Measurements with High Intensity Beams at SIS-18", Proc. DIPAC, Hamburg, Germany (2011)

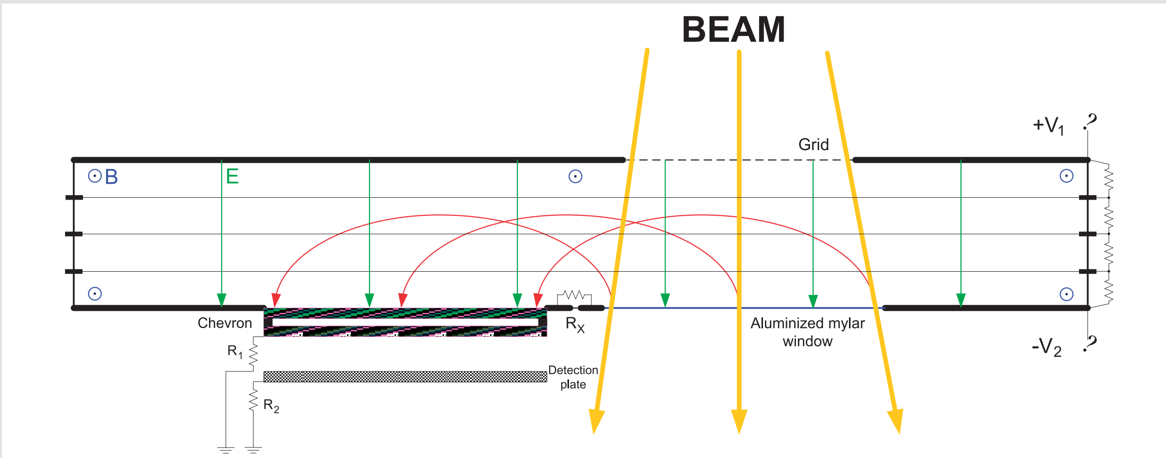
R. Haseitl, H. Bräuning, T. Hoffmann, K. Lang, R. Singh, "Development of FESA-based Data Acquisition and Control for FAIR", Proc. DIPAC, Hamburg, Germany (2011)

M. Schwickert, T. Hoffmann, F. Kurian, et al., „Diagnostic Devices for Beam Intensity Measurement at FAIR", Proc. IPAC, San Sebastian, Spain (2011)

R. Singh, et al., "Observation of Space Charge effects on Tune at SIS-18 with new Digital Base Band Tune Measurement System", Proc. ICFA Advanced Beam Dynamics Workshop on High-Intensity and High-brightness Hadron Beams, Morschach, Switzerland (2010)

INSTITUTUL NATIONAL PENTRU FIZICA SI INGINERIE NUCLEARA HORIA HULUBEI (IFIN-HH)

The Institutul National pentru Fizica si Inginerie Nucleara Horia Hulubei (IFIN-HH) is the central institute for nuclear and atomic physics in Romania. Its more than 400 scientists are collaborating with numerous international partners in almost all fields of fundamental and applied nuclear physics.



IFIN-HH has a very strong record as a national training centre and much experience in hosting Diploma and PhD students. Its accelerator departments have long standing experience in the development and use of accelerators and components of beam transport and analysis systems.

The Department of Nuclear Physics IFIN-HH is a multidisciplinary research unit in the field of nuclear and atomic physics. The department's mission lies in the areas of fundamental research, particularly in fields which are relevant for sustainable development. The research projects underway are well suited also for training and education and clearly beyond the possibilities of a single University department.

The beam diagnostics developments within DITANET are realized in close collaboration between the Nuclear Physics Department (DFN) and the Department of Applied Nuclear Physics (DFNA), as well as the Optoelectronics Research Centre of the Faculty of Electronics and Telecommunications at the 'Polithecnica' University of Bucharest.

THE PROJECT: A 'Zero Time Detector' for Future Particle Accelerators

Supervisor: Horia Petrascu

In particular in particle accelerators used for industry and health applications, such as accelerators for ion beam cancer therapy, a detailed knowledge of the beam geometry is required. Ideally, all parameters should be measured in real time and a so-called "zero time detector" is one option to achieve this ambitious goal.

Such a monitor can be used to study the composition of the beam, as well as the location of heavy ions inside the beam. In addition, the position of the beam can be determined and a focalization of beam can be done.

One example of how such detector can be realized is shown in the image to the right: The backscattered electrons released by an Aluminium foil are deflected away from the main beam, by means of a magnetic field perpendicular to the applied electric field. The heavy ions pass through the grid of the anode, toward the cathode. Following interaction with the aluminized Mylar window, back scattered electrons with zero velocity are released in the chamber. Because of the applied electric field they are accelerated and the magnetic field bends their trajectories on an ellipsoidal path, out of the main beam.

Within DITANET the detector design shall be realized and a prototype built up. This requires detailed numerical studies, as well tests with beam.

At the time of print, this is the only open position vacancy within the network.

STOCKHOLM UNIVERSITY

With over 50,000 undergraduate and master's students, 1,800 doctoral students and 6,000 employees, Stockholm University is one of the largest universities in Sweden and one of the largest employers in the capital.

People of many different nationalities, with contacts throughout the world, contribute to the creation of a highly international atmosphere at Stockholm University.

Staff in the physics department has extensive experience in the design, operation and continuous optimization of particle accelerators. For many years, groundbreaking studies were realized at the University's CRYRING facility and the accelerator experts have pioneered many developments related to beam handling and cooling techniques in medium and low energy storage rings.

THE PROJECT: Diagnostics for DESIREE

Supervisor: Anders Källberg

The Double ElectroStatic Ion Ring ExpEriment (DESIREE) consists of two electrostatic storage rings with a common straight section where merged-beams experiments on positive/negative ion collisions can be performed. The two rings are housed in a single double walled vacuum chamber built like a cryostat with a radiation screen and several layers of super insulation in between the two chambers. The inner chamber, which holds all optical elements, is cooled by cryogenerators attached to the bottom of this chamber. The whole accelerator structure is cooled to temperatures below 20 K. This low temperature in combination with the unique double ring structure results in a very powerful machine for studying interactions between cold molecular ions close to zero relative energy.

In experiments for which the primary objective is to determine the absolute cross section for the process under investigation, it is a necessity to have reliable and accurate diagnostic tools for determination of the absolute currents stored and the position, width and shape of the two beams in the merger section. The main ingredients necessary for this have been identified to be electrostatic pick-up electrodes, position-sensitive detection of neutralized particles from residual-gas collisions and a system of beam scrapers. The fact that all diagnostics inside DESIREE has to be compatible with the cryogenic environment as well as the ultra-high vacuum requirements is a challenge to the design.

Within this DITANET project, key diagnostics components have been developed. In addition to the before-mentioned instrumentation a secondary emission monitor has been designed and successfully tested with beam. Investigations into applications for medical accelerators, as well as for other electrostatic storage ring projects complemented this project. During the project, close collaboration took place with partners at HIT/Germany, the Max Planck Institute for Nuclear Physics in Heidelberg/Germany and the University of Liverpool/UK.

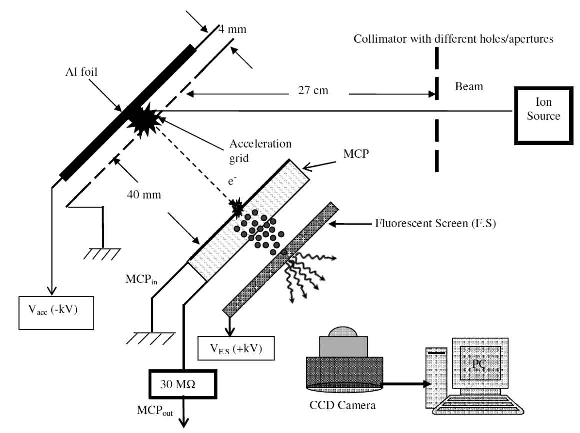
THE RESEARCHER: Susanta Das

Susanta joined the Manne Siegbahn Laboratory (MSL) at Stockholm University in August 2009 as an Experienced Researcher within DITANET. He completed his Ph.D. at Western Michigan University, USA in 2009 on the transmission and guiding of electrons through insulating nanocapillaries under Prof. John A. Tanis. In addition, he studied the interference phenomenon associated with emitted electrons in collisions of fast ions with molecules. Susanta's research interests are, therefore, quite broad from nano- and materials science to fundamental processes in atomic physics. Having visited many countries to discuss his research, both as a collaborator and an international conference participant, Susanta has worked with researchers and students from a variety of countries.

Selected Publications:

R.D. Thomas, (…), S. Das, et al., "DESIREE: a unique cryogenic electrostatic storage ring for merged ion-beams studies", Rev. Sci. Instr. 82 065112 (2011)

S. Das, J. Harasimowicz, and A. Källberg, "Spatial Resolution Test of a BPMS for DESIREE Beam Line Diagnostics", Proc. DIPAC, Hamburg, Germany (2011)



ROYAL HOLLOWAY, UNIVERSITY OF LONDON

Royal Holloway, University of London was a founding member of the John Adams Institute (JAI) together with Oxford University and the UK Science and Technology Facilities Council (STFC). Central to the mission of the JAI is the training of accelerator physicists at PhD level.

Research activities include world-leading efforts in the development of laser wire scanners for high energy particle accelerators as well as advanced simulation of accelerator beam lines, including secondary particle production and transport. The accelerator group has been involved in many research and training programs on national and international level. The university environment at Royal Holloway is very supportive to student training.

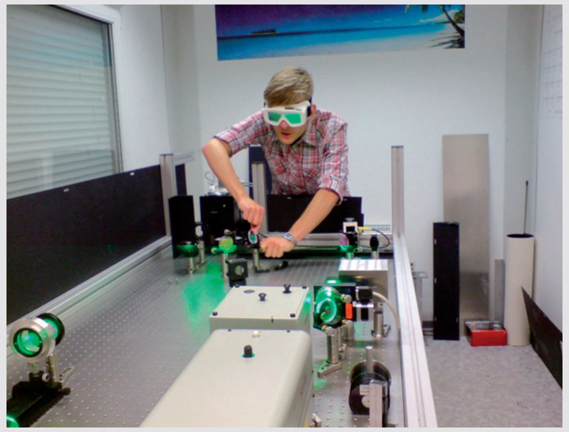
THE PROJECT: Simulation of the Coherent Diffraction Radiation Process

Supervisor: Pavel Karataev

Any method for diagnostics of a charged particle beam is based on interaction of the particles or fields generated by the particles with surrounding media losing a small fraction of their energy. A part of the lost energy is transformed into electromagnetic (EM) radiation whose characteristics depend on different particle beam parameters. By measuring the EM radiation characteristics, or, to be more precise, their distortion, one can measure such particle beam parameters as transverse size and divergence, position, bunch length and chromaticity. In most cases the ideal EM radiation characteristics must be predictable either for diagnostics itself or for optimization of the device performance before manufacturing it.

One method for longitudinal particle beam profile diagnostics is the analysis of Coherent Diffraction Radiation (CDR) generated when a charged particle (electron) moves in the vicinity of a conducting screen. The beauty of the phenomenon is that the particle beam does not directly interact with the screen hence excluding changes in the beam parameters introduced by the screen itself. In order to derive the longitudinal profile of the bunch from a measured spectrum one must know the spectrum generated by a single electron. Therefore the screen configuration is usually chosen to be as simple as possible to predict the spectrum using some approximation theory. However, such a simple target is often not an ideal approach.

Within this project, the characteristics of CDR for different target geometries are being investigated in detail through simulations. Therefore, a dedicated computer code for the simulation of the CDR process has been developed and the results benchmarked against measurements at CTF3 (CERN).



THE RESEARCHER: Konstantin Lekomtsev

Konstantin received his diploma degree in Mathematics at Moscow Engineering Physics Institute in February 2009. This background provides him with deep knowledge in mathematical physics, applied and computational mathematics and theoretical physics.

His diploma work was devoted to the development of a theoretical basis of the interaction between a moving charge and a chain of spherical particles. Konstantin developed a local field theory for a chain of spheres, characterized by an arbitrary dielectric function, thus ensuring that the results were valid for particles of any size, including nanoparticles. In this process Smith-Purcell and Diffraction Radiation were investigated.

Within his project Konstantin has an opportunity to apply his theoretical knowledge practically. In addition, there is also a great opportunity to accumulate practical experience, by working on a CDR setup, installed in the CRM line at CTF3.

THE PROJECT: High Resolution Cavity Beam Position Monitors

Supervisor: Stewart Boogert

Beam position monitors are essential diagnostics devices for monitoring the beam relative to magnetic devices and extracting important properties of magnetic lattices. In addition, position and angle feedback signals from BPMs can be used as a signal for closed loop feedback applications, where the response of the BPM is used directly after some processing to modify the beam control, such as kickers, steering magnets and quadrupoles.

The main aim of this project is the development of a new type of beam position monitor for electron accelerator facilities such as ILC or CTF3/CLIC. The main aim of the project is to develop a beam position monitor for CLIC-like probe beams. Particular emphasis is placed on the electromagnetic design, ease of fabrication and analogue signal processing.

In collaboration with CERN experts and collaborators in KEK and SLAC the next generation of beam position monitors is being developed. An integral part of the project is to understand with industry the most cost effective, yet high performance design.

THE RESEARCHER: Nirav Joshi

Nirav studied undergraduate physics at Bhavnagar University, India in 2002 and in November of that year joined the plasma diagnostics division at Institute for Plasma Research (IPR) - India's national research institute on Nuclear Fusion. His major contribution was determining plasma parameters, for example, temperature, density and plasma instabilities using diagnostics systems such as super-heterodyne microwave radiometer, microwave interferometer and correlation reflectometer. Whilst working Nirav obtained his master's degree in physics awarded by Annamalai University, India in 2007.

He has successfully designed, simulated, fabricated and tested various microwave components during which time he learnt to use various simulation software including HFSS, CST and ZEMAX, as well as the operation of various microwave instruments.

Nirav has contributed, as a main and contributory author, to various papers and presented his work at both national and international conferences. He has guided several summer school projects within his group, as lead and co-guide. He joined DITANET in March 2009.

THE PROJECT: A Beam Profile Monitor Using Laser-wire Systems

Supervisor: Grahame Blair

Laser-wire systems use a finely focused beam of laser-light to scan across the particle beam in order to measure the transverse beam profiles; measurement of the transverse beam profile is an essential input into determining the transverse beam emittance. Laser-wires can be employed at electron machines using the Compton Effect, where the laser photons are scattered by the electrons and can be detected downstream as gamma rays in a calorimeter; alternatively the scattered electrons can be detected because they are over-focused by downstream magnets. Within this project a laser-wire monitor at PETRAIII is being developed for application at future accelerators.

The electron machine under study is the newly-completed PETRAIII accelerator at DESY, Hamburg. PETRAIII is a new synchrotron light source and is the world's most brilliant source of synchrotron light in the wavelengths it offers. Understanding the emittance of PETRAIII is very important to achieving its ultimate performance; the electron beam size is typically of order ten microns. The laser-wire experiment at PETRAIII was installed in early 2009, using green laser-light, and within a week was producing first data; this was a remarkable achievement, building on experience at the previous PETRAII system. Using a vertical optical table, laser light can be directed so as to scan in either the vertical or horizontal directions. The trainee, Thomas Aumeyr, was heavily involved in testing the system at RHUL before it was shipped to DESY and he has also been heavily involved in its commissioning. The current emphasis is on automation and on integrating the laser-wire data acquisition into the PETRA system so that the laser-wire will become a central diagnostic tool for the machine operators. Once this is complete, the emphasis will shift to data taking and analysis in the context of PETRAIII optimisation. This work, with associated simulations, will provide important input into the CLIC Conceptual Design Report.

THE RESEARCHER: Thomas Aumeyr

Thomas studied technical physics at the Vienna University of Technology and the Royal Institute of Technology in Stockholm. During his studies he did several internships, for example improving the Beagle2 image processing software at the UCL Mullard Space Science Lab and designing an automatic gauging station for strong magnetic fields at the Austrian Research Centers in Seibersdorf.

In 2007, he conducted his diploma thesis within the scope of a technical studentship at CERN, where he spent seven months working on the CMS beam position monitors for timing purposes (BPTX). This work included developing the hard- and software of the read-out and testing it at the SPS. After graduating from the Vienna University of Technology in 2008, Thomas went back to CERN for a further two months to install the BPTX read-out. Thomas joined DITANET in September 2008.

Selected publications:

T. Aumeyr et al., "A 2-D Laser Wire Scanner at Petra III", Proc. IPAC, Kyoto, Japan (2010)

K. Lekomtsev et al., "Coherent Diffraction Radiation Longitudinal Beam Profile Monitor for CTF3", Proc. IPAC, Kyoto, Japan (2010)

N. Joshi et al., "Position Determination of Closely Spaced Bunches using Cavity BPMs", Proc. IPAC, San Sebastian, Spain (2011)

UNIVERSIDAD DE SEVILLA (US), CENTRO NATIONAL DE ACELERADORES (CNA)

The CNA is the result of an initiative of the University of Seville, the Education and Science Department of the Andalucía Government and the Scientific Research Council (CSIC) to install in Spain a Centre of Excellence for particle accelerator based interdisciplinary research.

The laboratory is composed of a 3MV tandem van de Graaff, a 18 MeV proton cyclotron and a 1 MV tandem Cockcroft-Walton for accelerator mass spectrometry. Beside these instruments, the centre has sample preparation laboratories as well an installation for radiopharmaceutical production. A small positron emission tomograph (PET) for animal studies completes the cyclotron laboratory.

The applications in CNA range from nuclear physics to archaeology, including ^{14}C dating, environmental studies, geology, biomedicine, PET nuclides production to material sciences. The 3 MV tandem accelerator, which is used in the frame of DITANET, has two different ion sources: a radiofrequency Alphatross ion source and a Cs-sputter SNICS II ion source. There are seven independent beam lines: a multi-purpose reaction chamber, an external micro-beam line, a basic nuclear physics line, a channelling line, an ultra-high vacuum chamber, a nuclear micro-probe beam line and an ion implantation-irradiation beam line. In 2008, a new ion source of the Duoplasmatron type was installed.

THE PROJECT: Characterization of new instruments for medical applications and implementation of beam tracking detectors for particle identification

Supervisor: Joaquín Gómez Camacho

With the idea of transferring the knowledge of nuclear reaction instrumentation to medical applications, a project dedicated to radiotherapy with high-energy photon beams has been started. This collaboration is between the Basic Nuclear Physics Group (FNB) of CNA, the Department of Atomic, Molecular and Nuclear Physics and the Engineering School of the University of Seville, the Virgen Macarena University Hospital of Seville and the private company INABENSA (ABENGOA group). Within this project two tasks will be addressed: First, the most advanced modalities of radiotherapy need a complex planning which requires, among other things, a careful verification of the dose distribution that the patient will receive. The second task is to develop a new detection system to measure doses in the axial plane of the patient. The aim of the project is to validate a novel method to obtain dose maps in the pre-treatment of patients with Intensity Modulated Radiation Therapy (IMRT) using a dedicated set-up and a commercial silicon strip detector. Measurements are performed at Virgen Macarena University Hospital using the 6 MV photon beam produced by a Siemens Primus accelerator. Future improvements of the actual experimental set-up for obtaining a better spatial resolution will be also investigated with the use of 2D silicon detectors.

Recently the FNB group joined in a new collaboration framework between INFN, CEA Saclay, GSI and ESA. This collaboration is dedicated to an experiment named FIRST: Fragmentation of Ions Relevant for Space and Therapy,

dedicated to an extensive study of nuclear reactions of interest for hadron therapy and space applications at GSI. The study of the fragmentation processes is relevant in different fields of physics concerning both basic research and applications. The energy range that is accessible at the heavy-ion synchrotron SIS at GSI is of fundamental importance for shielding in space radiations and hadron therapy. The final goal of the FIRST experiment is to measure the nuclear fragment cross-sections from the projectile fragmentation of ^{12}C and heavier beams, in the energy range 200-1000 AMeV on several targets (light and heavy), using a complex system of detectors. The understanding of the reaction mechanisms in this experiment will be necessary for developing reliable nuclear interaction models to be used in transport codes for different applications.

THE RESEARCHER: Alessio Bocci

Alessio studied Physics at the University of Roma "La Sapienza" and graduated in 2004 with a degree Laurea in Physics, specializing in Astrophysics and working on the characterization of an IR array detector dedicated to spectroscopical applications.

Between 2005 and 2008 Alessio studied for a PhD in Astronomy at the Department of Astronomy and Space Science of the University of Florence in Italy, at the XUVLab, working on the R&D of diamond detectors for spectroscopical applications in the detection of photons at soft and hard X-rays energies.

During this period Alessio was involved in the R&D of fast un-cooled IR HgCdTe photo-detectors for the diagnosis of particle beams, in collaboration with the DAΦNE-Light facility at the Laboratori Nazionali di Frascati (LNF) of the National Institute of Nuclear Physics (INFN) in Italy. During his final year at LNF he held a position as "Ricercatore-Tecnologo" within the Accelerator Division. He was involved in the framework of the Time Resolved Positron Light Emission (3+L) experiment; a project devoted to the diagnosis of the e+ beam of DAΦNE. He became a DITANET ER in October 2009.

THE PROJECT: Secondary Emission Detectors for Beam Tracking

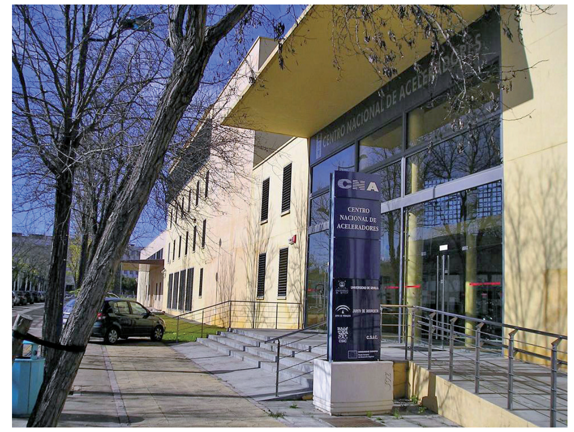
Supervisor: Marcos A. González Álvarez

One of the important accomplishments of this project is to have the Secondary Electron Detectors (SED) operating at CNA to track ion beams produced at the facility. The trainee is in charge of developing a suitable environment at the basic nuclear physics (FNB) line for operating and testing the detector. This includes upgrades to the FNB line as well as the installation and management of a data acquisition system and its adaptation to the electronics. Ziad has also investigated the electric field distribution and particle tracks inside the SED.

Ziad was actively involved in testing beam profile monitors developed by different collaborating institutes such as for example CIEMAT at the external line of the cyclotron at the CNA. He has also participated in tests of beam tracking using microchannel plate detectors for the slowed down particle beams at GSI (Germany). Moreover, Ziad has received intensive trainings at the CNA facilities as well as at other facilities (ITN-Portugal, RIBRAS-Brazil, GANIL-France) where he participated actively in mounting experimental setups and analyzing data of nuclear reaction experiments.

The trainee is also involved in a dose reconstruction project for Intensity-Modulated Radiation Therapy – IMRT. The objective of this project is to implement a detecting system to verify the planned dose before delivering the treatment to the patient.

In addition, beam profile monitors developed by different collaborating institutes, such as for example CIEMAT have been tested. This research was complemented by active participation in stable nuclei experiments and theoretical treatment of experimental data as one of the main scientific specialties of the Basic Nuclear Physics group at CAN.



THE RESEARCHER: Ziad Abou-Haidar

Having obtained his scientific baccalaureate in 2002 in Lebanon, Ziad moved to Paris and gained a bachelor's degree in fundamental physics and engineering sciences from the University of Paris VII – Denis Diderot. Following this degree he was awarded an internship at the French National Research Center (CNRS) working at the Parametric Imaging Laboratory (LIP) on the diagnosis of osteoporosis using ultrasound.

During his master's studies, Ziad's interest in fundamental physics and particle detectors grew and in April 2008 he began an internship at the CEA Saclay (France) where he worked for 6 months on the improvement and testing of the micromegas detectors for the CAST (CERN Axion Solar Telescope) experiment. In September 2008 Ziad presented his master's thesis on the micromegas detectors for CAST and graduated from the University of Paris VII – Denis Diderot. During his work at the CEA, Ziad learned about DITANET and the trainee position available at the CNA in Seville/Spain which provided an opportunity to continue working on detectors. He commenced his training with DITANET in October 2008.

Selected publications:

A. Bocci, et al., "Empirical characterization of a silicon strip detector for a novel 2d mapped method for dosimetric verification of radiotherapy treatments", Radiotherapy and Oncology 99 (2011)

M.A. Cortés-Giraldo, M. I. Gallardo, R. Arráns, J.M. Quesada, A. Bocci, J. M. Espino-Navas, Z. Abou-Haidar, M.A.G. Álvarez, "Geant4 Simulation to Study the Sensitivity of a MICRON Silicon Strip Detector Irradiated by a SIEMENS PRIMUS Linac", Proc. SNA-MC, Tokyo, Japan (2010)

J.M. Carmona, A. Ibarra, I. Podadera Aliseda, Z. Abou-Haidar, A. Bocci, B. Fernández, J. García López, M.C. Jiménez-Ramos, M.A.G. Alvarez, "First Measurements of Non-Interceptive Beam Profile Monitor Prototypes for Medium to High Current Hadron Accelerators", Proc. ICFA Adv. Beam Dynamics Workshop, Morschach, Switzerland (2010)

TRAINING AND OUTREACH

In addition to the local training provided by the respective host institutions, DITANET organizes a number of network-wide events, such as Schools, Topical Workshops and an international conference. These events target the network trainees, but are also open to the wider beam diagnostics community.

International Schools

The network has organized two international schools on beam diagnostics to date. The first took place in 2009 (30th March - 3rd April) at Royal Holloway, University of London. This school started with an introduction to accelerator physics and the definition of particle beams, before basic beam instrumentation such as beam energy, beam current or transverse beam profile measurement were covered. More advanced topics followed including the monitoring of the machine tune or electron cloud diagnostics. An excursion to Rutherford Appleton Laboratory including visits to ISIS and DIAMOND, as well as two tutorials and one poster session complemented the broad program.

An advanced DITANET School took place in Stockholm, Sweden 7th - 11th March 2011. The event was hosted by Manne Siegbahn Laboratory. This school joined around 70 researchers and started with a recap of some of the key concepts introduced during the first school back in 2009. Helmut Wiedemann, Professor emeritus from Stanford University, gave an introduction to accelerator physics, before beam profile and beam position measurements were covered in one hour lectures by leading experts in the respective field. Beam instrumentation for specific applications, such as low energy accelerators, light sources, colliders or high intensity accelerators were presented in detail. The intense lecture program was complemented by dedicated Question & Answer sessions, as well as focused tutorials. In addition, participants were given the opportunity to present their own work in this interdisciplinary field in a poster session that triggered many interesting discussions.

The network has also organized a Complementary Skills School at the University of Liverpool from 15th - 19th March 2010. This course aimed at providing the network's trainees with the necessary skills base for a future career in both, the academic and industry sectors.

The course was designed to combine both generic skills (such as project management, time management and work/life balance) with subject specific skills (for example collaboration skills and scientific writing). Training sessions were interspersed with talks and discussions with topics covered by expert trainers who were also available for further discussions during breaks.

In addition to knowledge transfer, this school was designed to build links between all trainees highlighting areas of possible collaboration. This aspect was aimed at creating a friendly working atmosphere in which the researchers may develop their working relationships, share commonalities in their work and discuss their career aspirations. It also provided a forum for them to discuss common challenges they have in their work and exchange information on any training they had received in the course of their training.

Topical Workshops

As a new tool to promote knowledge exchange and inter-sectorial contacts, the network has introduced a series of Topical Workshops since 2009. To date, workshops on "Low Energy, Low Intensity Beam Diagnostics" in Hirschberg, Germany (November 2009), "Longitudinal Beam Profile Measurements" at the Cockcroft Institute, UK (July 2010), "Ultra Bright Electron Sources" at the Cockcroft Institute, UK (July 2011), "High Intensity Proton Beam Diagnostics" (Paris, France, September 2011) and "Technology transfer" (Solkan, Slovenia, September 2011) have been realized. Additional workshops on "Particle Detection Techniques" (Seville, Spain, November 2011), "Beam Loss Monitoring" (DESY, December 2011) and "Beam Position Monitoring" (CERN, 2012) complement this series.

Conference on Beam Diagnostics

An international conference on diagnostic techniques for particle accelerators and beam instrumentation in Seville, Spain (9th - 11th November 2011) summarizes the network's research outcomes and brings together all DITANET partners as well as participants from the world-wide diagnostics community. The purpose of this event is to present the latest developments and trends in the field of accelerator instrumentation in both, oral and poster sessions. The conference provides ample opportunities for critical discussions of research outcomes, exchange of knowledge and for meeting friends from the diagnostics community. It is hosted by the Centro Nacional de Aceleradores (CNA).

Dissemination

The DITANET web site is hosted by the University of Liverpool and can be found at www.liv.ac.uk/ditanet. It is a central point for all information regarding the network and includes information about all partners, their trainees and the projects in which they are involved.

In addition, it provides information on events and is a collection point for all presentations and papers within the network.

The network also issues a quarterly newsletter by e-mail to partners and colleagues in beam diagnostics and accelerator science across the world. Its aim is to inform and disseminate, providing information on members of the DITANET project, its partners, trainees and its scientific work.

An annual prize is part of the network's wider dissemination strategy. It is awarded for an outstanding contribution to the field of beam instrumentation for particle accelerators and presented to a researcher in the first five years of their professional career.

DITANET STRUCTURE

The network brings together major accelerator-based research centers, several large Universities and world-renowned partners from industry. Each network partner has a strong record of training research students and postdoctoral researchers. In addition to the beneficiary partner institutions that were described in detail earlier on, the following associated and adjunct partners contribute significantly to the overall research and training activities.

Associated Partners

There are 12 Associated Partners in the network. Although not financial beneficiaries, these contribute significantly to the training of the DITANET trainees. They are actively encouraged, through membership of the Supervisory Board, to improve training strategies and help ensuring the highest possible standards of training are met, particularly with regard to industry-relevant skills.

ESRF - European Synchrotron Radiation Facility, France

The European Synchrotron Radiation Facility (ESRF), located in Grenoble - France, is a joint facility supported and shared by 19 European countries. It operates the most powerful synchrotron radiation source in Europe. Each year several thousand researchers travel to Grenoble where they work in a first-class scientific environment to conduct exciting experiments at the cutting edge of modern science.

At ESRF, physicists work side by side with chemists and materials scientists. Biologists, medical doctors, meteorologists, geophysicists and archaeologists have become regular users. Industrial applications are also growing, notably in the fields of pharmaceuticals, cosmetics, petrochemicals and microelectronics.

idQuantique, Switzerland

idQuantique's focus is to provide innovative and cost-effective solutions that leverage the tremendous capabilities offered by quantum photonics, associated with cutting edge analog and digital electronics. The company was created in Geneva/Switzerland in 2001 and a continuous passion, strong focus on innovation, flexibility of a dedicated team and excellent customer service have allowed idQuantique to reach profitability and establish itself as a leader in the fields of network encryption, scientific instrumentation and random number generators.

INFN-LNS - Istituto Nazionale di Fisica Nucleare Laboratori Nazionali del Sud, Italy

INFN is an organization dedicated to the study of the fundamental constituents of matter, and conducts theoretical and experimental research in the fields of subnuclear, nuclear, and astroparticle physics. Fundamental research in these areas requires the use of cutting-edge technologies and instrumentation, which the INFN develops both in its own laboratories and in collaboration with the world of industry. Its four Laboratories—in Catania, Frascati, Legnaro, and at Gran Sasso—are home to major facilities which are available to the national and international scientific community.

Instrumentation Technologies, Slovenia

Founded in 1998, Instrumentation Technologies has grown to become a world leader in cutting-edge instrumentation, primarily for the accelerator beam diagnostics market. I-tech designs innovative solutions, aspiring to be at the cutting edge of technology. With partners and customers from all over the world i-tech aims to build a model based on tight collaboration, being committed to superior quality, reliability and life-long technical support.

Max Planck Institute for Nuclear Physics, Germany

The Max-Planck-Institut für Kernphysik is one out of 80 institutes and research establishments of the Max Planck Society, which has been founded in 1948 and is committed to basic research.

Founded in 1958, the initial scientific goals were basic research in nuclear physics and the application of nuclear-physics methods concerning questions in the physics and chemistry of the cosmos. Today, the activities concentrate on the two interdisciplinary research fields: astroparticle physics and quantum dynamics

PSI - Paul Scherrer Institut, Switzerland

The Paul Scherrer Institute is Switzerland's largest research centre for the natural and engineering sciences. Approximately 400 scientists at the Institute are investigating a large variety of scientific questions that can be grouped into three main fields: "Structure of Matter", "Human Health", and "Energy and Environment". Most of these scientists use the Institute's unique large-scale research facilities in their work.

PSI operates several scientific large-scale facilities that allow experiments to be performed that are impossible in smaller laboratories.

THALES Electron Devices, France

Thales is a global leader in security. With operations in 50 countries and 68,000 employees, Thales is a world leader in mission-critical information systems for defence and security, aerospace and transportation. With its global network of 22,500 high-level researchers, Thales has earned particular recognition for its ability to develop and deploy dual civil and military technologies.

Thermo Fisher Scientific CIDTEC Cameras & Imagers, USA

Thermo Fisher Scientific Inc. is the world leader in serving science. Their mission is to enable customers to make the world healthier, cleaner and safer. With revenues of nearly $11 billion, Thermo Fisher Scientific have approximately 37,000 employees and serve customers within pharmaceutical and biotech companies, hospitals and clinical diagnostic labs, universities, research institutions and government agencies, as well as in environmental and process control industries.

TMD Technologies Limited, UK

TMD Technologies Limited is among the world's leading manufacturers of microwave tubes, high voltage power supplies, and transmitters for Radar, EW, communications, EMC RF testing, and other Laboratory applications.

TMD can trace its roots back to the early 1940's, when the microwave tube research division of EMI Electronics was established to develop high power klystrons. TMD has continued to invest in research and development of new products and technologies and together with significant investment from customers has resulted in a wide range of leading edge products.

TU Prague, Czech Republic

The Faculty of Nuclear Sciences and Physical Engineering (FNSPE) was established in 1955, as part of the Charles University, but in 1959 became a new special faculty of the Czech Technical University in Prague.

The characteristics of the Faculty activities developed during its history, and the most advanced areas of technological progress have always attracted its attention. The DITANET partner group focuses on the application of ionizing radiation and dosimetry. In this field, they have pushed forward research over many years and have been collaborating with partners from all over the world.

ViALUX, Germany

ViALUX GmbH was founded in 2000and is a privately held company with a worldwide network of representatives. It is a highly innovative company with a continuing focus on latest technology developments.

ViALUX engineers work on sustained product development along customer needs. Combining advanced opto-electronics with outstanding metrology software forms the core competence and is the key of success.

WZW Optics AG, Switzerland

WZW OPTICAG have been manufacturing high-end quality optics and designing solutions for global customers for more than 45 years. Their aim is to consolidate and extend their technical lead, as new technologies and materials become available. They provide precise solutions from their facility in Balgach, Switzerland and the high degree of vertical integration in the production of high-end optics begins with the manufacture of blanks and ends with quality control. Highly-qualified employees, decades of experience, the use of cutting-edge tools, instruments and machines, and constant supervision of each stage of the production ensures the utmost precision.

Adjunct Partners

DITANET has recently introduced the level of adjunct partnerships. Adjunct Partners are institutions that are active in R&D fields closely related to the network and that share the network's training visions. They are an important part of DITANET's long term strategy in establishing lasting bonds and partnerships across institutes and disciplines in Europe.

Diamond Detectors Ltd, UK

Diamond Detectors Ltd. is a subsidiary company set up by Element Six to manufacture innovative diamond radiation detectors. It offers a range of fully packaged diamond radiation detectors and diamond plates as well as custom design services. High purity synthetic CVD Diamond presents unique characteristics that make it an excellent material for radiation detection experiments and beam diagnostics applications for both particle accelerators and synchrotrons where position monitoring, volume sensitivity, radiation hardness and/or temperature insensitivity are required.

Fermi National Accelerator Laboratory (Fermilab), USA

Fermi National Accelerator Laboratory advances the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to conduct basic research at the frontiers of high energy physics and related disciplines. At Fermilab, a robust scientific program pushes forward on three interrelated frontiers: energy, intensity and cosmic. Each frontier has a unique approach to making discoveries, and all three are essential to answering key questions about the laws of nature and the cosmos.

Lawrence Berkeley National Laboratory, USA

In the world of science, Lawrence Berkeley National Laboratory (Berkeley Lab) is synonymous with "excellence." Eleven scientists associated with Berkeley Lab have won the Nobel Prize. Fifty-seven Lab scientists are members of the National Academy of Sciences (NAS), one of the highest honours for a scientist in the United States. In addition, Berkeley Lab has trained thousands of university science and engineering students.

Berkeley Lab was founded in 1931 by Ernest Orlando Lawrence, a UC Berkeley physicist who won the 1939 Nobel Prize in physics for his invention of the cyclotron, a circular particle accelerator that opened the door to high-energy physics.

University of Dundee, UK

The University of Dundee is one of the UK's leading universities, internationally recognized for its expertise across a range of disciplines including science, medicine, engineering and art. The Carnegie Laboratory of Physics is part of the School of Engineering, Physics and Mathematics. It has a history of world-leading research into photonics, materials, biophysics and communications and is renowned for its research activities into electro-optical beam diagnostics.

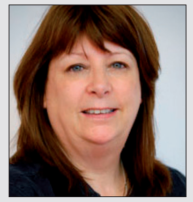
University of Maryland, USA

University of Maryland has a long-standing experience in training graduate students at their electron ring UMER and other accelerators. The partner group has pioneered and continuously improved many beam diagnostic techniques such as for example transition and diffraction radiation. The group has developed instrumentation solutions for both accelerators and light sources since many years.

Uppsala University, Sweden

Uppsala University are engaged in beam instrumentation activities related to the CLIC Test-Facility CTF3 at CERN, where they have contributed a monitor to measure the beam frequency spectrum at each step of the bunch train combination process in the CTF3 Preliminary Phase which was complemented later with a study of a novel so-called confocal resonator monitor. Furthermore, the two-beam test stand at CTF3 with all integrated diagnostics to monitor the two-beam acceleration process were designed and constructed by Uppsala University.

The Network structure consists of the Coordinator and Project Manager who are responsible for the overall running and administration of the project in line with the Grant Agreement and recommendations of the Steering Committee.



The Project Manager

Mrs. Glenda Wall joined DITANET as Project Manager in September 2009 and is the first point of contact for communication from partners. In addition to the day to day running of the network she is responsible for the compilation of the newsletter and updates to the DITANET web page; whilst ensuring the project meets all its milestones and deliverables as outlined in the Grant Agreement.

The Coordinator

Carsten P. Welsch initiated the DITANET project and is responsible for the overall project coordination and administration. He is an academic at the University and Liverpool/ Cockcroft Institute in the UK and leader of the QUASAR Group. His research interests focus on the development of accelerator instrumentation, antimatter research, beam dynamics studies, superconducting RF, next generation light sources, medical applications of accelerators and high energy colliders.

The Steering Committee consists of 10 members including the Coordinator, Project Manager and a Student Representative (presently: Nirav Joshi - previously: Maja Olvegård and Marion Ripert). Two of the remaining members of the Steering Group are from the industry sector (Armel Beunas, Thales and Kevin Oliver, Diamond Detectors – previously: Andreas Peters, HIT), two from academia (Grahame Blair, RHUL and Joaquin Gomez Camacho, University of Seville, CNA) and the other three from (inter)national research centers (Thibaut Lefèvre, CERN, Horia Petrascu, IFIN-HH and Paolo Finocchiaro, INFN-LNS – previously: Peter Forck, GSI).