Optimization of Particle Accelerators

A Marie Curie Research and Training Network

CONTENTS

INTRODUCTION

ACCELERATING SCIENCE AND TECHNOLOGY

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.

The development and optimization of accelerators requires the collaboration of engineers and scientists from a broad range of disciplines from theoretical physics and mathematical modelling through to material science, electronics and mechanical engineering.

The oPAC consortium carries out collaborative research to optimize the performance of present and future accelerators and light sources. The network brings together leading research centres, universities, and industry partners to pave the way for next generation research facilities and train the next generation of scientists and engineers.

oPAC RESEARCH

Beam Physics

A detailed understanding of the motion of charged particle beams in complex electromagnetic field distributions, the impact of beam-beam effects on experiment performance, as well as of collective effects and their potential to drive machine instabilities, and of beam halo formation and propagation processes is very important to optimize the performance of essentially any accelerator. The oPAC Fellows work on the development of beam handling techniques and carry out detailed studies into the beam dynamics of some of the most advanced particle beams in the world. This drives R&D also in other fields, as these developments are closely linked to new diagnostics tools, accelerator control systems and beyond state-of-the-art simulation tools.

Beam Diagnostics

Diagnostics systems are essential constituents of any accelerator; they reveal the properties of a beam and how it behaves in a machine. Without an appropriate set of diagnostic elements, it would simply be impossible to operate any accelerator let alone optimize its performance. Research of the network includes, for example, investigations into novel monitors for beam halo monitoring, advanced instrumentation for light sources such as ALBA and Soleil, intensity monitors for nano-Ampere antimatter beams, diamond-based beam loss monitors that can operate in cryogenic environments, and diagnostics for the world's most powerful proton beam at the European Spallation Source.

Simulation Tools

Numerical simulations are important for the design and continuous optimization of particle accelerators. Research in oPAC targets the development of new computational methods that help improve performance and accuracy of such design work, as well as GPU-based simulation codes that give access to increased simulation speeds and larger problem sizes in terms of the number of unknowns.

Accelerator Control and Data Acquisition Systems

Large scale research infrastructures have significantly more stringent performance requirements than can be achieved using off-the-shelf industrial automation and control systems. Within oPAC, novel accelerator control systems are being pioneered and developed into industrial scale tools and platforms. This is expected to benefit many large scale research infrastructures across Europe.

Courtesy of GSI

UNIVERSITY OF LIVERPOOL

UNIVERSITY OF LIVERPOOL

Founded in 1881, and a member of the Russell Group of major research-intensive universities in the UK, 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 programmes spanning 54 subject areas at its three faculties, including Health and Life Science; Humanities and Social Science; and Science and Engineering.

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. It was recently awarded with a 24/24 score in the Teaching Quality Assessment and was very positively reviewed in the nationwide Research Assessment Exercise. A rich variety of research is performed at Liverpool, including Particle Physics, Nuclear Physics, Condensed Matter Physics, Surface Science and Astrophysics.

Moreover, The University 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. Home to the QUASAR Group, carrying out investigations into beam dynamics, accelerator design, laser applications, and innovative beam diagnostics solutions, the Cockcroft Institute is also the perfect environment for the coordination of the oPAC project.

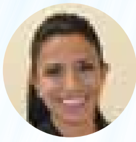
THE PROJECT: DEVELOPMENT OF DESIGNS FOR POSSIBLE LHC UPGRADE OPTIONS

Supervisor: Dr. David Newton

The project will contribute to the development of CERN's LHeC, a possible LHC upgrade option to expand its research programme by colliding an electron beam with the existing proton beam. The LHeC would run synchronously with the LHC and substantially extend and complete the investigation of the physics of the TeV energy scale, providing the study of open questions in high precision QCD, new physics such as Higgs or SUSY and electron-ion physics. The focus of this work lies on integrating an electron beam with the LHC lattice at one of the interaction regions without perturbing the colliding proton beams at other locations.

An important part of this development involves reducing the beta function of the proton beam in the interaction region to maximise the luminosity. The second proton beam must also be accommodated and must be matched to the current LHC optics scheme. The final focus optics needs to be optimised to achieve these goals, without unduly perturbing the second proton beam at other interaction points. To achieve this it is necessary to develop algorithms based on the study of the basic optics design taking into consideration the aperture requirements and constraints on magnet strengths and positions, the optimisation of a chromatic correction scheme and the need to provide a dynamic aperture that is as large as possible.

THE RESEARCHER: EMILIA CRUZ ALANIZ



Emilia Cruz Alaniz is from Guadalajara, Mexico. She moved to live in Mexico City to pursue her goal of studying Physics in the Science Faculty at the Universidad Nacional Autónoma de México (UNAM).

As an undergraduate in Physics, she participated in an exchange programme and studied one semester in the University of California, Berkeley. She also worked with the experimental nuclear and high-energy physics group in the Instituto de Física at UNAM and was involved in the CREAM project (Cosmic Ray Energetics and Mass). As part of this project Emilia spent a summer in the LPSC laboratory in Grenoble, France. Her work in this project consisted of analysing the resolution of one of the detectors called the Cherenkov Camera. Emilia undertook a Master's in Physical Science with specialisation in High Energy Physics. During this time she worked in the ALICE experiment at the LHC visiting CERN twice to develop her thesis. She worked on this project analysing the resonances phi and rho by their decays in kaons and pions respectively in proton-proton collisions at 7 TeV and obtained her Master's degree in January 2012.

In November 2012, Emilia joined the oPAC project and is now enrolled as a PhD student at the University of Liverpool, UK.

THE PROJECT:
BEAM MONITOR FOR HALO PROPAGATION MECHANISMS

Supervisor: Prof. Carsten P. Welsch

The detection and possible control of the beam halo is of utmost importance for high energy accelerators, where unwanted particle losses lead to an activation or even damage of the surrounding vacuum chamber. But also in low-energy machines, one is interested in minimizing the number of particles in the tail region of the beam distribution.

Since most part of a beam is concentrated in its core, observation techniques with a high dynamic range are required to ensure that halo particles can be monitored with sufficient accuracy. One option to monitor the beam halo is to use light generated by the beam, either through Synchrotron Radiation, Optical Transition Radiation, or luminescent screens. The development of a micro mirror-based halo monitor with a dynamic range of better than 10^5 is the goal of this project. Such monitor will use more than 1,000 x 1,000 microscopic mirrors to generate an adaptive optical mask that allows for detecting only particles of interest for study. The monitor will be based on the latest technology of high definition mirror matrix devices, providing very high frame rates and superior spatial resolution. By combining several such monitors in the same accelerator, direct investigations into halo propagation shall be carried out where results from beam transport codes will be benchmarked against experiments.

THE RESEARCHER:
BLAINE LOMBERG

Blaine Lomberg studied at the University of the Western Cape in South Africa. In his 3rd year he participated in astronomy and astrophysics research to complete his Bachelor's degree. Thereafter, he went on to study nuclear physics. In 2010, Blaine joined the Accelerator Group at iThemba Labs where he worked on ion source physics undertaking a Master's degree, focusing on a diagnostic device for beam quality measurements. His thesis title was 'Studies of an emittance measurement device for beam quality optimisation of ion sources'.

During the summer of 2010, he was a student at CERN working on the Linac3's ion source and developed a LabView application to investigate the charge state distribution of a lead ion beam. The CERN Summer School helped him discover special interests in accelerator physics and the desire to pursue a PhD which he started in September 2012.

THE PROJECT:
DEVELOPMENT OF A SIMULATION SUITE BASED ON THE MULTILEVEL FAST MULTIPOLE METHOD

Supervisor: Prof. Carsten P. Welsch

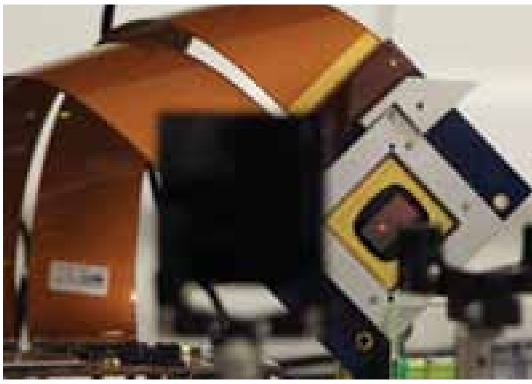
The project aims to optimise the performance of accelerators by applying the latest computational and numerical techniques in electromagnetic codes for the simulations of superconducting RF cavities. The Finite Difference Time Domain Method used for the discretisation of the 3D space leads to the dense matrix equations constituting millions of unknowns for complex electromagnetic structures. These matrix equations are solved iteratively where the matrix vector multiplications result in the need for large memories and processor speeds that often exceed the performance of even the best computers.

The Multilevel Fast Multipole Method could be more efficient than commonly used codes for particle accelerators as it might greatly speed up the computation and reduce the memory requirements. The development of a simulation suite based on this method is the goal of this project. The new code will then be used to calculate the fields for guiding and accelerating structures in existing and future accelerators. It will also be used to optimise beam instrumentation for charged particle beams and benchmarked against other, more conventional codes.

THE RESEARCHER:
SEHAR NAVEED

Sehar Naveed was born in June 1985 in Depalpur, Pakistan. She graduated from Islamia University Bahwalpur (IUB), Pakistan and earned a Silver Medal in Mathematics. In December 2011, Sehar completed her Master's degree in 'Mathematics and Computational Sciences' at the University of Manchester, UK. She wrote her dissertation underlying the field of computational fluid dynamics with the title of 'The Onset of Convection in the Aqueous Humor of Human Eye'.

In addition, Sehar Naveed worked as a lecturer in Mathematics after completing her post-graduation at the Government Degree College for Women, Depalpur, Pakistan. Previously, she had worked as a Science Teacher for Higher Secondary Classes at OPF Public School Depalpur during 2009/2010. Since 2012 she is undertaking PhD studies at the University of Liverpool, UK. Her research interests include Numerical Optimisation, Computational Finite Element Method and Computational Electromagnetism.



Halo monitor setup at the Cockcroft Institute.

University of Liverpool.

QUASAR GROUP The Cockcroft Institute of Accelerator Science and Technology

ALBA LIGHT SOURCE

ALBA is a 3 GeV 3rd generation synchrotron light source located near Barcelona, Spain. The laboratory lines of research range from materials science, macro molecular crystallography, condensed matter, magnetic properties to chemistry and biology. Since May 2012, ALBA has been welcoming scientific users from all over the world.

The ALBA team currently consists of about 160 dedicated engineers, scientists, support staff and technicians. The early operation phase of the facility is particularly well suited for training early stage researchers in all aspects of the machine and is also a phase when continuous machine optimization will be very important.

THE PROJECT:

ADVANCED BEAM PHYSICS PROBLEMS AT LIGHT SOURCES

Supervisor: Dr. G. Benedetti and Dr. Z. Marti

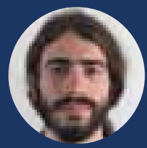
The goal of this project is to improve the knowledge and understanding of the non-linear beam dynamics of the ALBA storage ring through simulations, beam measurements and lattice optimization.

Non-linearities of a storage ring can be characterized and measured by means of two global parameters of the ring: the chromaticity and the tune shift with amplitude. A third parameter describing the non-linear behavior of a ring, are the so called 'resonance driving terms', appearing in the Hamiltonian due to non-linear interactions. The resonance driving terms can be measured by analyzing the spectra of turn-by-turn oscillations excited by a fast kicker magnet.

The turn-by-turn technique will be implemented for the first time at ALBA within this project. In addition, beam physics studies for a new low alpha mode will be carried out by testing, measuring and characterizing the linear and non-linear part of the lattice on the actual machine by applying turn-by-turn analysis techniques.

THE RESEARCHER:

MICHELE CARLA



Michele Carla is from Firenze, Italy where he studied Physics at the Università degli Studi di Firenze.

As an undergraduate in Physics, he worked on the MU-RAY experiment. The MU-RAY project is aimed at the construction of muon telescopes and the development of new analysis tools for muon radiography. His work in this project consisted of building and characterizing the resolution of a prototype of a scintillator odoscope. Michele obtained his Bachelor's degree in June of 2009.

Following this, Michele continued studying for a Master's in Physical Sciences with specialization in High Energy Physics. This time he worked in the SwissFEL experiment at the Paul Scherrer Institute in Switzerland where he spent 6 months in 2012 to work on his thesis. In his project he realised a systematic study of the Echo Enabled Harmonic Generation seeding scheme for the Athos beam-line for the SwissFEL facility.

Courtesy of ALBA.

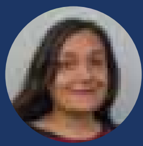
THE PROJECT:
OPTIMISATION OF BEAM INSTRUMENTATION FOR LIGHT SOURCES

Supervisor: Dr. Ubaldo Iriso

After more than a year of operation, ALBA is preparing for the 'top-up' mode of operation, for which it is essential to carefully control the machine filling pattern and the transverse characteristics of the beam. The filling pattern is currently controlled using a Fast Current Transformer. The first task of the research was to implement real time data analysis to give an estimation of the bunch by bunch intensity. This work will next be compared with the performance of a new design, based on electro-optical devices implementing time-correlated single photon counting, which should allow a higher dynamic range and better resolution. The results will be integrated in the general ALBA control system and will be available for users.

Transverse beam size measurements at ALBA are currently done using a classical x-ray pinhole. However, due to the limiting CCD electronics and decay time of YAG screens, this technique only provides a beam size measurement corresponding to the whole bunch train. In order to perform bunch by bunch beam size measurements, another set-up has to be designed and will be based on the study of the interference pattern produced by synchrotron light.

THE RESEARCHER:
LAURA TORINO



Laura Torino was born in Naples, Italy in 1988. In 2007 she started to study physics at the University of Pisa as an undergraduate. In the summer of 2010 she was a Visiting Scholar at the University of Mississippi in Oxford for two months. During that period she joined the LIGO collaboration (Laser Interferometer Gravitational wave Observatory), working on the characterisation of auxiliary instrumental and environmental channels used in the latest LIGO science run.

In January 2011 Laura obtained her Bachelor's degree defending a thesis about the measurement of the anomalous magnetic moment of the muon. She then studied for a Master's in Physics of Fundamental Interaction. Also during 2011 she was a summer student at DESY, Zeuthen where she worked on image processing of raw experimental data to measure size and emittance of an electron beam. She finalised her Master's thesis by measuring the longitudinal filling pattern of the ALBA storage ring using electro-optical devices at the Autonomus University of Barcelona and is now enrolled as a PhD student in the University of Pisa.

RF guides at ALBA.

Superconducting Wiggler at ALBA.

CERN - EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH

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 technology transfer, 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. Large portions of this training are geared towards early stage researchers. CERN has the capacity, the scientific and administrative infrastructure and the necessary expertise to achieve the proposed tasks. It has great experience in tutoring and mentoring ESRs as well as in the transmission of complementary skills.

THE PROJECT:

OPTICS AND LATTICE DESIGN STUDIES FOR THE INTERACTION REGION DESIGN OF THE LHC EXPERIMENTAL INSERTIONS

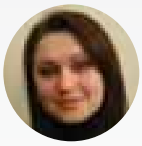
Supervisor: Dr. Elias Metral and Dr. Nicolas Mounet

Transverse collective instabilities of high-intensity and high-brightness beams are one of the most important limitations to achieve highest luminosities in the LHC. Currently applied techniques for beam stabilisation are likely to be insufficient for the future high-luminosity LHC upgrade, hence risking beam loss and potentially machine damage.

In this project longitudinal-to-transverse Landau damping is being investigated in detail. This sort of damping affects transverse oscillations by means of bucket nonlinearity and second-order chromaticity. The common action of both effects is being studied in simulation and experiment. A detailed comparison of the predicted results with observations will allow existing beam physics models to be improved.

THE RESEARCHER:

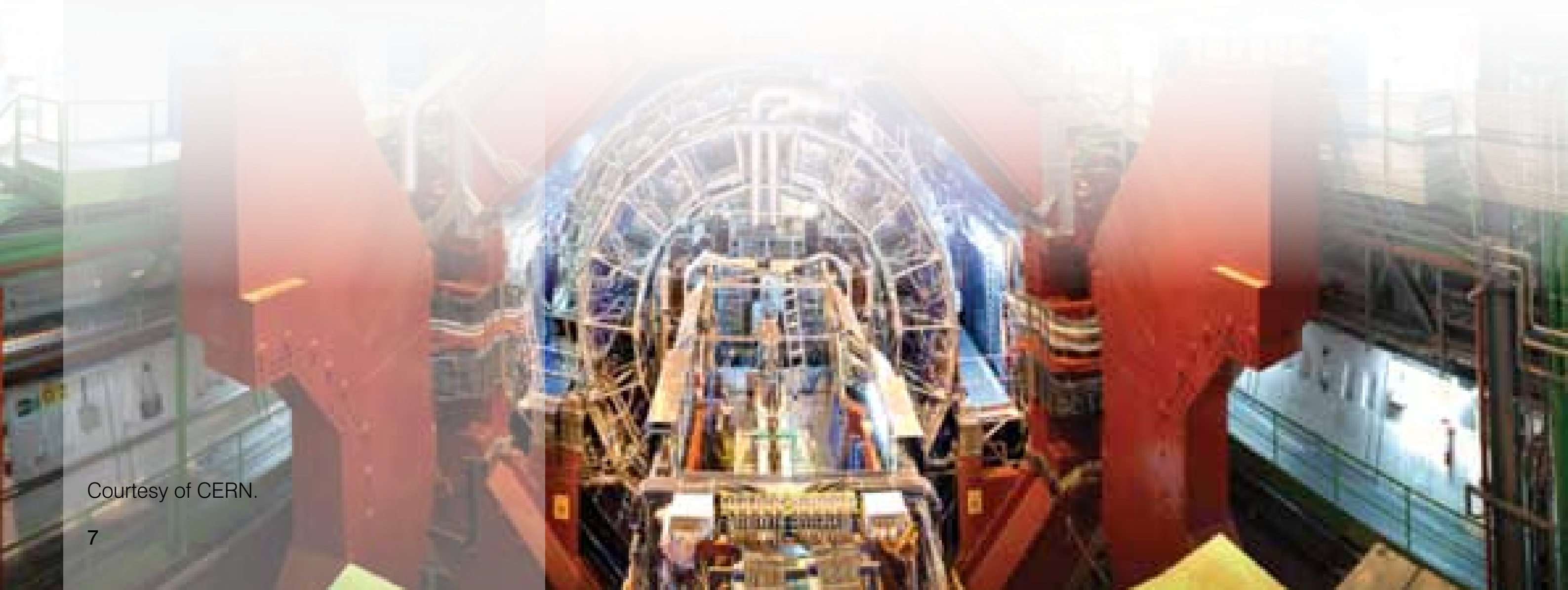
DARIA ASTAPOVYCH



Daria Astapovych was born in Sumy, Ukraine in May 1990 and gained her diploma in Physics at the Sumy State Pedagogical University. She obtained a Bachelor's degree in Physics during which she undertook pedagogical practice in schools as a teacher of physics and mathematics within the course 'General Physics/Electromagnetism'.

In May 2012 Daria obtained a Master's degree in Physics. She decided to focus on a computer simulation for beam dynamics, specifically in the electron cooling process using BETACOOL and worked at the Institute of Applied Physics of the National Academy of Science of Ukraine.

Now Daria is a Marie Curie Fellow within the oPAC project. Her research is focussed on coherent beam stability for the HL-LHC project, studying in particular the effect of the longitudinal degree of freedom on transverse Landau damping.



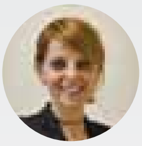
Courtesy of CERN.

THE PROJECT:
LHeC AS A FUTURE UPGRADE OPTION OF THE LHC

Supervisor: Dr. Frank Zimmermann

There is international interest in complementing the current physics programme in the TeV regime by a hadron-lepton collider. A Large Hadron electron Collider (LHeC) is therefore another upgrade scenario to further optimise LHC performance and expand its research programme. Within this project the linac layout, optics design and cryo-module development for the LHeC linac are being studied. In addition, investigations into the beam dynamics and collective effects in the LHeC re-circulating linac are being realised, taking several effects into account: (1) novel beam-break up instabilities driven by multi-turn wake fields, (2) ion accumulation and ion-driven instabilities for the electron beam plus their mitigation by clearing electrodes and gaps; and (3) electron-cloud effects for the positron beam.

THE RESEARCHER:
ALESSANDRA VALLONI



Alessandra Valloni was born in Teramo, Italy, in 1982. She attended the University of Rome to study Electronic Engineering and in 2009 joined the INFN National Laboratory of Frascati, Rome, as a postgraduate student to undertake work on her Master's degree thesis focusing on ultrafast time resolved electron diffraction with pulsed electron beams for atomic and molecular imaging.

Having taken part in a two year collaborative study with the Particle Beam Physics Laboratory (PBPL) at University of California, Los Angeles, she expanded her research to include extremely compact optical accelerators. Her expertise mainly focuses on analysis of problems involving bunching as well as simultaneous focusing and acceleration of charged particles in slab dielectric laser-powered systems based on biperiodic photonic bandgap structures. At UCLA she also participated in the GALAXIE (Gigavolt-per-meter Acceleration and X-ray free source Integrated experiment) project and was involved in the installation and initial experimental setup for Dielectric Wakefield Acceleration at FACET facility, SLAC, for testing of hollow dielectric fibers and slab dielectric structures as sources of Wakefield acceleration and THz Cherenkov Radiation Generation.

Currently Alessandra is a Marie Curie Fellow within the oPAC project. Her research is focussed on the development of a recirculating energy recovery linac for the LHeC project. She was awarded a PhD at Sapienza University in the Department of Fundamental and Applied Science for Engineering in April 2013.

THE PROJECT:
MEASUREMENT AND CORRECTION OF LINEAR AND NON-LINEAR OPTICS IN THE CERN PS BOOSTER

Supervisor: Dr. Christian Carli

Transverse direct space charge effects are the main beam brightness and intensity limitation for typical low-energy synchrotrons such as the PS Booster. The beam as a whole experiences a tune spread, making it impossible to locate the working point such that all low-order resonances are avoided. The maximum achievable beam brightness and intensity is compromised by resonance excitation from direct space charge forces and from machine imperfections.

In this project measurements will be made to identify perturbations of the real lattice in the PS Booster, and a compensation scheme will be devised based on the measured optics. The linear optics will be characterized by analyzing the measured response of the closed orbit to dipole corrector excitation. Turn-by-turn position data will allow investigations of linear optics properties as well as non-linear resonances and, in particular, determination of resonance driving terms. After the correction of optics perturbations, one expects that the PS Booster will be able to accelerate beams of higher brightness and intensity.

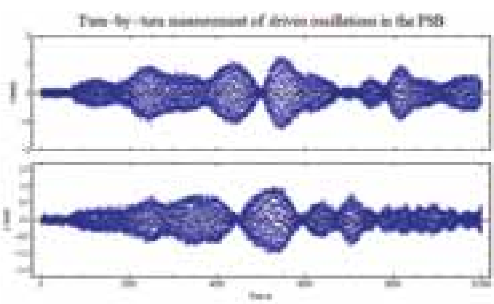
THE RESEARCHER:
MEGHAN MCATEER

Meghan McAteer grew up in Austin, Texas and earned Bachelor's degrees in Studio Art and in Physics from the University of Texas at Austin. She developed an interest in accelerator physics as an undergraduate, when she attended the first of many courses at the U.S. Particle Accelerator School and spent a summer at Fermi National Accelerator Laboratory working on commissioning instrumentation upgrades in the Fermilab Booster accelerator.

After qualifying for PhD candidacy at the University of Texas, she was admitted to the Joint University-Fermilab Doctoral Program in Accelerator Physics and Technology. Her research at Fermilab focused on measuring and correcting linear optics distortions in the Booster accelerator, as part of the effort to increase total proton throughput for Fermilab's planned high-intensity experimental program.

In addition to research, Meghan has also taught undergraduate physics classes and an introductory class in accelerator physics at the U.S. Particle Accelerator School. She is now a Marie Curie oPAC Fellow working in the Accelerator and Beam Physics group at CERN. Her work focuses on beam-based measurements and simulations to characterize and correct linear and higher-order optics perturbations.

Photograph of tune kicker.



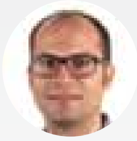
THE PROJECT:
STUDIES INTO A SQUID-BASED BEAM CURRENT MONITOR

Supervisor: Dr. Jocelyn Tan

The low energy antiproton beam obtained in the Antiproton Decelerator and future ELENA storage rings at CERN requires an increased sensitivity and resolution in beam intensity measurements. The limiting factor for the intensity measurement accuracy is the noise - either in the processing electronics, or acquired by the coupling of the measurement device to the vacuum chamber. Various laboratories have shown the potential of Superconducting Quantum Interference Devices (SQUIDS) to overcome some of these limits. These devices can provide a measurement dynamic range exceeding 80 dB and have enough resolution to measure beams down to the nano-Ampere level.

This project aims at developing a current measurement device with a resolution below 100 nA by means of a cryogenic current comparator using a SQUID device. The objective is to have a complete operational system after the 3-year Fellowship.

THE RESEARCHER:
MIGUEL FERNANDES



Miguel Fernandes was born in Porto, Portugal and has lived in the region of Lisbon since he was a child. There, he obtained the diploma in Electrical Engineering and Computer Science from Instituto Superior Técnico at the Universidade Técnica de Lisboa, specialising in control and electronic systems. After obtaining his degree, Miguel joined the telecommunication industry reference company Nokia Siemens Networks, where he stayed for 3 years.

Miguel then went on to continue his studies at Instituto Superior Técnico and enrolled in a Physics Master's degree. After completion he worked as a research fellow at the Laboratório de Instrumentação e física experimental de Partículas, in Lisbon, under the CMS project, one of the most important LHC experiments at CERN. There, he participated in the search for a beyond standard model super-symmetric stop particle. He has been an oPAC Fellow since January 2013.

Courtesy of CERN.

BLM detector tests at CERN.

THE PROJECT:
BEAM LOSS MONITORS FOR USE IN CRYOGENIC ENVIRONMENTS

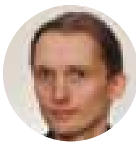
Supervisor: Dr. Bernd Dehning

Beam loss monitors for use in the cryogenic environment of the LHC insertions superconducting magnets are being studied within this project. The aim is to optimize the detectors for magnet protection and beam adjustments at the high luminosity insertions.

It is expected that the luminosity of the LHC will be limited by the maximum possible beam loss at the superconducting magnets in the future. To allow optimal detection of the energy deposition in the magnet coils by the beam particles, the detectors need to be placed close to the particle loss locations. This implies installing the particle detectors in the cold mass of the magnets. Dose measuring devices operating at 2 Kelvin have neither been used nor described in the current literature, but will be studied and developed in the frame of this project in partnership with CIVIDEC.

The selected detectors for cryogenic irradiation testing are silicon and single crystalline chemical vapour deposition diamond (scCVD) detectors, as well as a liquid helium chamber. In the theoretical part of the project the irradiation impact on silicon and scCVD diamond detectors is being simulated. To allow a deep understanding of cryogenic BLM materials the laser transient current measurement technique at cryogenic temperatures on silicon and scCVD diamond detectors will be applied. The ultimate goal of the project is the preparation of cryogenic BLM prototypes to be placed inside the cold mass of a LHC superconducting magnet in 2018.

THE RESEARCHER:
MARCIN BARTOSIK



Marcin Bartosik grew up in Krakow, Poland and attended the Jagiellonian University in Krakow from 2005, where he studied general physics for three years. Thereafter, he chose to focus on experimental physics and undertook a Master's degree, focusing on the research and development of an optoelectronic device for fibre Bragg grating spectroscopy.

After obtaining his Master's degree he joined an international team developing the first Polish synchrotron light source facility, Solaris. Since then, he has gained unique experience in synchrotron light source construction and design, and developed his knowledge in radiation protection. Marcin joined oPAC in October 2012.

Courtesy of CERN.

CIVIDEC INSTRUMENTATION GMBH

CIVIDEC Instrumentation GmbH is developing the latest generation of beam instrumentation devices, which are based on CVD diamond particle detectors. The company is specialised in the design and construction of diamond beam monitors for a wide variety of applications, such as for example charged particles (electrons, protons and ions), photons (X-ray and gamma rays) and neutrons (thermal neutrons, as well as fast neutrons).

CIVIDEC is working in an international network of specialists, comprising six nations and seven research institutes, which are related to particle detection and beam instrumentation. Main partners are CERN, the Slovak Technical University, the Jožef Stefan Institute in Slovenia and Ohio State University in the USA.

THE PROJECT:

DEVELOPMENT OF A VERSATILE BEAM LOSS MONITOR

Supervisor: Prof. Erich Griesmayer

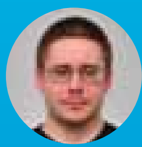
The aim of this project is to develop a CVD diamond detector for charged particles, neutrons and photons. The properties of diamond such as high radiation hardness, low leakage current, low capacitance, high thermal conductivity, and high mobility of charge carriers, make it a robust and effective detector material. A number of crucial advantages over common semiconductor materials used in particle detectors pre-suppose a variety of applications of diamond in particle physics and related fields.

This research project involves the design of dedicated software for PC-based readout systems with dead time free data processing; study of the interaction of particles with matter and charge collection in diamond; numerical estimation of the possible detector efficiency for different particle species; development of optimal solutions for neutral particle detection with CVD diamond; applications of diamond detectors for photon counting and spectrometry; Monte-Carlo simulations of various detector geometries; detector calibration with radioactive sources; beam tests of the detector and the readout electronics and software.

Possible applications of such a device would include high-energy experimental physics, accelerator physics and medical physics (computer tomography, PET).

THE RESEARCHER:

PAVEL KAVRIGIN



Pavel Kavrigin received his Master's degree at the Saint Petersburg State University of Russia (SPbSU) in 2011. His graduate research at the Department of Computational Physics was related to numerical simulations in particle and nuclear physics with applications in hadron therapy. The title of his Master's thesis was 'Simulation of processes of interaction of charged particles with matter in hadron therapy tasks'. Another important aspect of the research was high performance computing, in particular parallel algorithms and distributed environments.

He is now employed as an oPAC Fellow at CIVIDEC Instrumentation GmbH in Vienna, Austria and enrolled into a PhD programme at Vienna University of Technology working on diamond-based beam loss monitors.-

Photograph of a diamond detector.

COSYLAB

Cosylab is developing next generation technologies for global niche markets and is a fast growing technological company, committed to creating innovative products and services intended for demanding markets and customers.

The company was started in a laboratory at the Jožef Stefan Institute, the largest Slovenian research institute and, due to first-hand experience of working in major accelerator facilities, soon became the largest company specialized in developing control systems for particle accelerators. Amongst others, Cosylab is specialized in the field of control systems for particle accelerators and other large experimental physics facilities. They cover hardware and software products and accompanying services such as customization and integration of already existing solutions, custom development, consulting and tutoring.

The team combines research level know-how with a professional business approach on a daily basis. Their experience has accumulated with years of work on successful projects in collaboration with international partners, including the development of control systems for Swiss Light Source (PSI), Australian Synchrotron, Diamond Light Source, ANKA (FZK), ESO and many others.

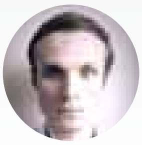
THE PROJECT:
ADAPTATION OF EXISTING OPEN-SOURCE CONTROL SYSTEMS FROM COMPACT ACCELERATORS TO LARGE SCALE FACILITIES

Supervisor: Klemen Žagar

In this project, novel control system concepts are being developed. The R&D addresses improved redundancy management, the analysis of existing protocols to define/adopt suitable candidate protocols and measure/analyse performance and scalability improvements.

A paradigm for decomposing large systems into subsystems will be defined and integrated in the core of the control system. In addition, new standards for graphical user interfaces in terms of performance, functionality, extensibility, ease of development, longevity and support will be developed. This includes the definition of a GUI that will diminish the possibility of human error, which is today one of the causes for downtime of large experimental facilities, and has hitherto not been given adequate consideration. This code suite shall also meet all important industry standards, provide a centralised system management, include on-line configuration of the application, and provide distributed capabilities for archiving data obtained through data acquisition.

THE RESEARCHER:
PAVEL MASLOV



Pavel was born and raised in St. Petersburg, Russia. In 2004 he was enrolled into the faculty of Robotics and Technical Cybernetics. Pavel went to the military department of the Polytechnic University in his 3rd year, and graduated as a Reserve Officer of Anti-aircraft Rocket Forces in 2010. During his 6th year at the Polytechnic he joined AIESEC, a global youth non-profit organisation that develops leadership capabilities, where he worked as a volunteer for one year. He earned his Bachelor's and Master's degrees in Automation and Control from the St. Petersburg State Polytechnic University. His Master's thesis was entitled 'Precise control of the Stewart platform (hexapod robot)'.

Employed as engineer and programmer by the D.V. Efremov Scientific Research Institute of Electrophysical Apparatus in December 2010, Pavel has been deeply involved in a joint international R&D project that aims to demonstrate the scientific and technical feasibility of fusion power, also known as ITER. As a result of his work, Pavel has implemented a distributed control system (based upon EPICS, a widely used open-source software suite for controlling particle accelerators, radio telescopes, etc) in the Fast Discharge Unit for ITER and a data acquisition system for the high-current test stand at the Pulsed power lab. He also got practical experience while conducting physical experiments using various cutting edge electrical instruments.

Courtesy of COSYLAB.

COMPUTER SIMULATION TECHNOLOGY (CST)

CST develops and markets high performance software for the simulation of electromagnetic fields in all frequency bands. CSTs success is based on the implementation of unique, leading edge technology in a user-friendly interface. Its products allow the computer based characterization, design and optimization of electromagnetic devices before actual lab measurements.

The extensive range of tools integrated in CST STUDIO SUITE® enables numerous applications to be analysed without leaving the user-friendly CST design environment and can offer additional security. Its customers operate in industries as diverse as telecommunications, defence, automotive, electronics, and medical equipment, and include market leaders such as IBM®, Intel®, Mitsubishi, Samsung, and Siemens.

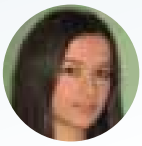
CST markets its products worldwide through a network of distribution and support centres which also provide comprehensive customer support and training.

THE PROJECT:
DEVELOPMENT OF A GPU-BASED PIC SOLVER

Supervisor: Dr. Frank Hamme

The final goal of this project is to develop a Multi-GPU based Particle in Cell (PIC) solver so that simulations can be executed much faster in comparison with a CPU or single-GPU solution. Such implementation is needed since optimization of accelerator structures generally requires PIC simulations with huge amounts of particles. These simulations can be quite time consuming, sometimes up to several weeks. The particular challenge is to develop interpolation and load balancing schemes which take full benefit from modern GPU architectures. Besides a standard domain decomposition scheme, alternative load balancing schemes need to be implemented. The standard scheme is only suitable for special applications, but in the context of this project a general solution is essential. The computation of 3D field distributions is of high relevance for almost all accelerator components. The more realistic an initial (numerical) design can be, the faster the progress towards an operating facility can happen.

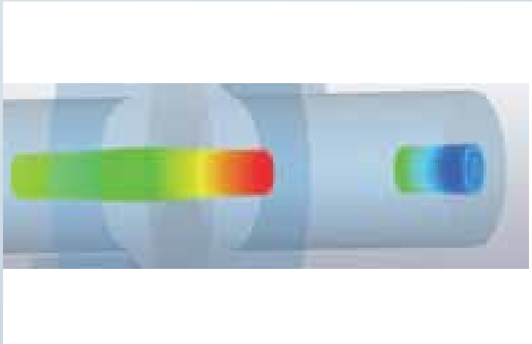
THE RESEARCHER:
MARTINA SOFRANAC



Martina Sofranac was born in Titograd, SFR Yugoslavia in 1984. In 2003 she obtained her Bachelor's at the Faculty of Electrical Engineering, University of Montenegro, graduating in 2007 as the student with the best average grade in her generation. Thereafter, she was an intern at the Research Center Dinamia which is part of ISCTE University in Lisbon.

In 2008 she enrolled for Master studies in 'Mathematical Modelling in Engineering: Theory, Numerics, and Applications', being from 2008 to 2010 a holder of an Erasmus Mundus Category A scholarship and studying at three Universities: University of L'Aquila in Italy, University of Nice-Sophia Antipolis in France and Gdansk University of Technology in Poland. During this period (2009) Martina took up an internship at Orange R&D Lab for Antennas in La Turbie (France), working on Inverse Computational Electromagnetics Problem. She defended her thesis on numerical solving of coupled nonlinear Schrödinger equations with periodic boundary conditions in July 2010.

After graduating Martina worked for two years as an implementer and developer in a software company in Montenegro before joining the oPAC project.



Beam energy distribution, calculated on multi-GPU.

EUROPEAN SPALLATION SOURCE

EUROPEAN SPALLATION SOURCE AB

The European Spallation Source, to be built in Lund, Sweden, will be the world's most powerful neutron source, once completed. Based on a 5 MW superconducting proton linac, it will also be at the forefront of high-intensity accelerators. The project is currently in a pre-construction R&D phase, where the accelerator R&D is carried out by a collaboration of mainly European institutes, including a number of oPAC partners. In addition, the local organisation in Lund is rapidly growing.

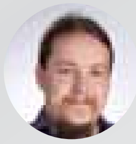
ESS will become a multi-scientific facility for advanced research and industry development. More than 300 researchers from 11 countries have taken part in the planning, which has lasted about 15 years. ESS will open up entirely new opportunities for researchers within a large number of fields of research: chemistry, nano and energy technology, environmental engineering, foodstuff, bioscience, pharmaceuticals, IT, materials and engineering science and archaeology.

THE PROJECT:
STUDIES INTO BEAM LOSS PATTERNS AT ESS

Supervisor: Dr. Andreas Jansson

The understanding of beam losses is essential for high energy, high intensity accelerators. The project focuses on the studies into beam loss patterns at European Spallation Source with the aim to optimise the distribution (location and type) for beam loss monitors and improve the interpretation of the BLM data. The project's main goal is to develop a full ESS accelerator's model in the Monte-Carlo simulation codes (FLUKA and MARS) and use it to study the optimal location of loss monitors and develop algorithms to analyse the measured spatial loss profile. The model starts as a rough estimation of the foreseen machine and will become more detailed as more information about the accelerator's components become available. The simulations performed using it will also bring answers to the questions concerning the activation of machine's components and surrounding, radiation mechanical damage and heating.

THE RESEARCHER:
MICHAL JAROSZ



Michał Jarosz, was born in September 1987 in Warsaw, Poland (birth-place of Marie Skłodowska-Curie), where he lived until graduating in 2012. He studied Electronics and Informatics in Medicine obtaining his Bachelor's and Master's degree at the Warsaw University of Technology. During his studies, he joined the Polish-Swedish cooperation programme for the future European Spallation Source (ESS). As part of this he worked at CERN on the Linac4 project, creating a bead-pull RF measurement system which was the topic for his Bachelor's degree thesis in 2010.

Solving radiation protection issues for the ESS proton accelerator's tunnel was his next assigment within the corporation. Michal spent the summers of 2010 and 2011 in Lund, Sweden, working with simulation tools such as FLUKA producing and analysing data and providing feedback for the future accelerator's tunnel layout. Based on this research, he wrote his Master's thesis and succesfully defended it in March 2012. In addition to studying, he worked at the National Centre for Nuclear Studies in Świerk, Poland, where he took part in some smaller accelerator projects for medicine and industry before joining oPAC.

THE PROJECT:
METHODS FOR MEASURING THE BEAM PROFILE IN HIGH INTENSITY BEAMS

Supervisor: Dr. Andreas Jansson

In this project alternative methods for measuring the beam profile in high intensity beams, including electron and ion beam scanners, ionisation profile monitors, quadrupole pick-ups, Compton scattering and luminescence are being evaluated. The extremely high beam power of the ESS proton beam, along with its cryogenic environment, poses stringent requirements on the instrumentation and a number of new challenges. Once an optimum beam profile monitoring method has been identified, a prototype will be designed, built up and tested.

THE RESEARCHER:
CHARLOTTE ROOSE

Charlotte Roose was born in Brussels, Belgium, in 1987. In 2008, she began engineering studies at the Institut Supérieur Industriel de Bruxelles (ISIB), Belgium. In 2011, she graduated of Bachelor's in Technological Engineering. During her 3rd year, she made an internship at the Cyclotron Research Centre (CRC) at the Université Catholique de Louvain (UCL). During that internship, she worked with the accelerator department in the implementation of quality control on the heavy ion line and the radioprotection department in the analysis of activated concrete samples.

In 2013, she graduated with a Master´s in Physics and Nuclear Engineering at ISIB. For her Master's thesis, she undertook an internship at the École Polytechique de Montréal, Canada. The subject was verifying the cross sections libraries used for the calculation of a cell of a supercritical water reactor fuelled with thorium. After graduation, she joined oPAC and is enrolled into a PhD programme at the University of Bologna.

GSI HELMHOLTZ CENTRE FOR HEAVY ION RESEARCH

GSI is operating a world-wide unique accelerator facility for heavy ions comprising a linac, a synchrotron and a storage ring. The facility allows the production and acceleration of ions ranging from protons up to uranium. The high energy heavy ion beams are used to produce and separate rare isotope beams produced by projectile fragmentation. Based on the experience with the existing accelerators GSI has designed the accelerators of the new international Facility for Antiproton and Ion Research (FAIR) which is amongst Europe's largest accelerator projects presently pursued.

The research covers a broad range of fields extending from nuclear and atomic physics to plasma physics and also involves materials research, biophysics and cancer treatment with heavy ion beams. GSI is most famous for the research of heavy elements culminating in the discovery of six new chemical elements. GSI has also developed a new type of cancer treatment using carbon beams. This advanced technique is the basis for a new generation of dedicated medical accelerators which is built in industry and delivered to hospitals for patient treatment.

THE PROJECT:

DESIGN AND DEVELOPMENT OF RESONANT STRUCTURES AS SCHOTTKY NOISE DETECTORS FOR VARIOUS FREQUENCIES

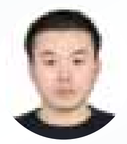
Supervisor: Dr. Markus Steck

The aim of this project is to design and develop resonant structures as Schottky noise detectors for different applications in mass and lifetime spectrometry in FAIR storage rings. Schottky noise detection is a powerful tool in storage rings to determine beam properties and to continuously optimise the beam quality. It is crucial for stochastic cooling which is applied at GSI for pre-cooling hot rare isotope beams. For highly charged ions it was demonstrated in 2010 that even single ions can be detected by this method. A resonant Schottky pickup was built into ESR at GSI Darmstadt and later also into CSRe in Lanzhou, China.

For the new FAIR storage rings, high sensitivity Schottky noise detectors are crucial where they will have two major applications: The extension of the analysis method to shorter isotope lifetimes and the detection of low intensity secondary beams, which also contains antiprotons. Also, the new Schottky noise detectors possess the ability to sense the transversal as well as longitudinal particle signals, to meet the 4-π detection challenge of FAIR storage rings. As a result of lower bandwidth of the resonant structures, different detectors may be needed in order to tune to different harmonic frequencies of the signal.

THE RESEARCHER:

XIANGCHENG CHEN



Xiangcheng Chen was born in Chaohu, China in 1989. He lived in his hometown until 2006 when he attended the University of Science and Technology of China (USTC). In his 3rd year, Xiangcheng specialised in High Energy Physics (HEP). He focused on analyzing decay data of J/Ψ- produced in BESIII in Beijing, and successfully defended his Bachelor's thesis in 2010. Thereafter Xiangcheng enrolled in the University of Chinese Academy of Sciences as a graduate student and took one-year-long specialized courses in Beijing, followed by moving to the Institute of Modern Physics in Lanzhou to carry out his Master program. Being the center for heavy ion research in China, IMP provided him a perfect environment to develop his interests on mass and lifetime measurements of exotic nuclides in storage rings. The first one focused on measurements of ^{86}Kr fragments of exotic nuclides with a storage ring as his main study area.

From 2011 to 2012, Xiangcheng participated in two experiments conducted with HIRFL-CSR complex in IMP. The first one focussed on measurements of 86Kr fragments and provided him with basic training on experimental nuclear physics. For the second experiment, he was already in charge of lifetime measurements of 112Sn fragments using Schottky pick-up. He joined oPAC in January 2013.

Courtesy of GSI.

Instrumentation Technologies

INSTRUMENTATION TECHNOLOGIES

Instrumentation Technologies was founded in 1998, combining eight years of accelerator experience with a new industrial approach. Two thirds of the thirty five employees are working in R&D. The first contracts for the equipment of whole BPM systems at the Synchrotrons SOLEIL and DIAMOND were signed in 2003. Instrumentation Technologies is a provider of the Libera family of instruments.

These state-of-the-art instrumentation systems are used for diagnostics and beam stabilization at 49 accelerator facilities around the world. Different Libera products are designed to work together, getting synergetic effects and enabling turnkey solutions for beam stabilization. Instrumentation Technologies specializes in instrumentation for beam stabilization in the accelerator field, including analogue and digital engineering, high and low level software, extensive FPGA programming, user-specific applications and solutions.

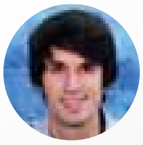
THE PROJECT:
DESIGN AND DEVELOPMENT OF COMMON APPLICATIONS FOR PARTICLE ACCELERATORS

Supervisor: Dr. Dejan Tinta

The instrumentation used in particle accelerators for machine operation and machine physics, demands performance which cannot be achieved by using generic instruments from the commercial market. Often the only alternative is to develop specialised and optimised instruments in-house. These unique solutions are not directly usable in other institutes. However, for some particular applications, common solutions do exist which can be designed in a more generally usable way.

This project will focus, in particular, on software architecture in the field of particle accelerator instrumentation. The aim is to develop generic functionalities and applications that will be useful across a broader range of different target environments. It will then be possible to adapt these solutions to each particular need with minimal effort.

THE RESEARCHER:
MANUEL CARGNELUTTI



Manuel Cargnelutti was born in Tolmezzo, Italy in March 1987 and studied Electronic Engineering at the Universita' degli studi di Udine. At the end of the third year he had the opportunity to undertake a five month internship with ST Microelectronics, which allowed him to approach the world of multimedia data processing. He worked on the development of a new algorithm for error concealment in the video transmission, obtaining his Bachelor's degree in November 2009.

Manuel continued studying for a Master's degree in Electronic Engineering with specialisation in Microelectronics, graduating in March 2012. During this time he moved his interests towards software development and integration, algorithm parallelisation and databases. For his Master's degree thesis, he undertook another seven month internship with ST Microelectronics. This project centred on the integration of support for a new streaming standard inside the Android OS. He started his oPAC Fellowship in September 2012.

Courtesy of Instrumentation Technologies.

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Royal Holloway University of London is one of the major constituent colleges that form the University of London. The current enrolment is over 9,000 students, 2,000 of which are postgraduates, from over 100 countries, distributed between 22 departments divided into three faculties of Science, Arts and Humanities and Management and Economics. 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. This includes world-leading efforts in the developments 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 programmes on a national and international level.

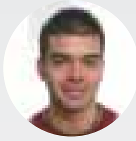
THE PROJECT:
OPTIMIZATION OF THE LAYOUT OF THE LHC COLLIMATION SYSTEM

Supervisor: Dr. Stewart Boogert

Machine related backgrounds arise mainly from the halo that accompanies the core beam or from accidental losses due to individual events. Particles at large displacements from the core can impact on beam-line apertures, including collimators, and then exit the beam-pipe downstream. Looking towards the initial LHC upgrades, this project will look into an optimisation of the layout of the LHC collimation system to minimise beam related backgrounds in the ATLAS detector at CERN and also look into optimising the LHC injection region to minimize activation in that region. The material interactions will be simulated using the simulation code BDSIM and then be cross-checked with FLUKA simulations performed at CERN.

The multi-turn tracking will then be performed using SIXTRACK and a suitable interface provided to streamline the transfer of large-amplitude particles to BDSIM. The beam loss monitors will be modelled in Geant4 and included within the BDSIM package; in this way an accurate modelling of the response of the LHC to beam losses shall be obtained.

THE RESEARCHER:
HECTOR GARCIA MORALES



Hector Garcia Morales was born in Barcelona, Spain, in 1987. He studied Physics at the University of Barcelona and after completing his degree, he started his Master studies in Particle Accelerators at the same University. His master thesis was carried out in collaboration with CERN and focused on the optics design of an emittance measurement station at the RTML line for CLIC. After presenting his master's thesis, he participated in the Joint Universities Accelerator School before getting a position at CERN as a PhD student.

In recent years he has been focused on the study and optimization of the final focus system for future linear and circular colliders, especially on CLIC and ILC. During his PhD, he attended the Linear Collider School 2011 in Monterey, Califorina. He joined the oPAC project in 2014.

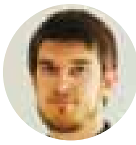
THE PROJECT:
LASER-WIRE BEAM PROFILE MONITOR FOR MEASURING THE TRANSVERSE BEAM PROFILE OF AN H- BEAM

Supervisor: Dr. Pavel Karataev

Laser-wire systems employ laser beams to scan accelerated particle beams to determine their transverse profile. They are well suited to operation at high power or low emittance machines because they are relatively non-invasive devices and they cannot be destroyed by the beam they are measuring. The project aims to develop a laser wire beam profile monitor for measuring the transverse beam profile of an H- beam.

In a first step experiments were carried out at KEK-ATF/ATF2 facility to learn the state-of-the-art system in laser-based diagnostics of the transverse electron beam size. During this period, laser transport and diagnostics, hands-on experience of the accelerator complex operation, the laser-wire data acquisition and analysis software were studied. Experiments on sub-micrometre optical transition radiation beam size diagnostics were also done for comparison with the laser-wire. The project will now develop a laser-wire system to measure the transverse profile and emittance of an H- ion beam at the Front End Test Stand at Rutherford Appleton Lab (RAL). The project involves designing a detector test stand and simulating photo-detached particles to develop a new type of detector. Particular challenges include the use of fibre lasers and of fibres for light transport.

THE RESEARCHER:
KONSTANTIN KRUCHININ



Konstantin Kruchinin was born in Aleksandrovsk-Sakhalinsky, Russia in June 1988. After finishing school he studied nuclear and particle physics at Tomsk Polytechnic University (TPU). During his studies he undertook an internship at the Joint Institute for Nuclear Research in Dubna (Russia) where he participated in CERN's ALICE experiment analysing the detector effects by extracting information on gluon structure functions from the data obtained through the modelling of the processes of heavy quarkoniums production in proton-proton collisions at the LHC with the centre of mass energy of 14 TeV. Konstantin developed an algorithm for calculating amendments for the data analysis using the software packages of the ALICE experiment.

Konstantin's interest was later focussed on diffraction radiation and its possible applications for beam diagnostic in modern accelerators. He developed and analysed a model for generation of diffraction radiation by a charged particle moving near a rectangular screen with finite sizes and finite permittivity. Konstantin represented the results of this research in his thesis gaining his Master's Degree at TPU in 2011, being then appointed part-time engineer in the Applied Physics Department. He joined the oPAC project in 2012.

Courtesy of RHUL.

SYNCHROTRON SOLEIL

SOLEIL is a 3rd generation synchrotron radiation facility aiming at delivering photon beams on 29 beam lines to national and international users on a free-access basis. 24 beam lines are presently operational and open to external visiting scientists; this number will reach 29 by the end of 2017.

The exceptional characteristics of its synchrotron light allow a considerable advance in the quality of measurements when compared to those obtained via classic laboratory photonic techniques. Almost 3,000 users were welcomed in 2013 on the beam lines after having been selected by 6 International Peer Review Programme Committees.

The SOLEIL staff is composed of about 350 permanent employees, either on secondment from research organizations or directly recruited by SOLEIL. 80% of the staff has scientific or technical vocations. SOLEIL has developed a strong policy in terms of training, hosting permanently about 20 PhD students, 30 post-docs and dozens of engineers under training alternating school and professional periods. About 50 SOLEIL personnel are regularly involved in training actions in regional universities and prestigious high schools. In the field directly linked to accelerator physics and technology, SOLEIL has already trained 12 PhD, about 40 undergraduate and 30 graduate students. In addition, there are presently 3 PhD and 2 Postdocs within the accelerator team.

THE PROJECT:

IMPROVEMENT OF THE UNDERSTANDING OF NON-LINEAR BEAM DYNAMICS EFFECTS IN LIGHT SOURCES

Supervisor: Dr. Laurent Nadolski

The goal of this project is to optimize the linear and non-linear beam dynamics to explore all possible optical settings available for the current accelerator lattice of the SOLEIL storage ring. The project will apply Multi-Objective Genetic Algorithms (MOGA) on the SOLEIL storage ring with other analysis techniques such as driving term analysis and frequency map analysis using information collected on turn-by-turn position monitors. The first results of this optimization have been demonstrated through a series of beam-based experiments in the SOLEIL storage ring.

In a next step new and challenging optics will be explored for reducing the effective horizontal emittance of SOLEIL while keeping a large enough lifetime and injection efficiency. The reduction of the effective horizontal emittance also improves one of the most important figures of merit that characterizes synchrotron light sources: the brightness. Using the MOGA results, lists of possible upgrades for the medium term improvement plan of the facility shall be obtained with the goal to reach a horizontal emittance close to 0.4 nm.rad.

THE RESEARCHER:

XAVIER NUEL GAVALDA

Xavier Nuel Gavaldà has a degree in Physics from the University of Barcelona. In October 2011 he started his Master's degree in Synchrotron Radiation and Particle Accelerator at the Autonomous University of Barcelona. In January 2012 Xavier joined the ALBA Beam Dynamics section to work on the final thesis of his Master's in collaboration with the Autonomous University of Barcelona and CELLS laboratory. His thesis is dedicated to linear and non-linear optics models of the ALBA gradient dipoles and consists of a comparison between the different dipole models based both on the magnetic measurements and on the orbit response matrix. Xavier joined oPAC in December 2012 and is registered for a PhD at Paris-Sud University, France.

Courtesy of SOLEIL.

UNIVERSITY OF SEVILLE / CENTRO NACIONAL DE ACELERADORES

The University of Seville (US), with more than 70,000 students and 6,700 staff, is the third largest university in Spain. More than 10,000 students are following postgraduate courses, enrolled into 86 master programmes and 152 doctoral programmes. The Centro Nacional de Aceleradores (CNA) is the national Centre of Excellence for particle accelerator research and development. A unique scientific and technological institute dedicated to interdisciplinary, fundamental and applied research with ion accelerators. CNA is a joint research centre belonging to the University of Seville, the Junta de Andalucia and the Spanish Research Council (CSIC).

US/CNA main facilities include a 3 MV Tandem accelerator, an 18 MeV Cyclotron for PET isotope production, a 1 MV Tandetron for AMS, a compact accelerator for ^{14}C dating, a ^{60}Co photon irradiator, and a human PET-CT scanner. CNA is a user-oriented facility, with more than 100 experimental applications per year, and 48 staff, from which 23 are doctors and 9 are PhD students. CNA produced 4 PhD theses in the last 2 years.

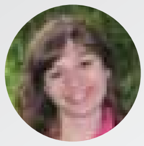
THE PROJECT:
DETECTION SYSTEM FOR VERIFICATION OF A 2D METHOD OF IMAGE RECONSTRUCTION FOR INTENSITY MODULATED RADIOTHERAPY TREATMENT

Supervisor: Dr. José Manuel Espino Navas and Dr. Marcos Alvarez

The project is embedded into the basic nuclear physics group at US/CNA and realised in collaboration with the Department of Atomic, Aolecular and Nuclear Physics and the hospital “Hospital Virgen Macarena”. The aim of the project is the design of a detection system to verify a 2D image reconstruction method for Intensity Modulated Radiotherapy Treatment (IMRT).

The experimental setup is based on a novel silicon strip detector, designed following clinical constraints, coupled to a home-made purpose-built electronics and acquisition systems. These will be installed around phantoms made of water-equivalent material. A Geant4 application to simulate the energy deposited in the detector, irradiated by 6MV beams from a Siemens PRIMUS linac dual energy machine is being developed. One important goal of these studies is the estimation of the detector sensitivity in different situations. According to the energy deposited in each electrode. Measurements to evaluate the performance of the detection system, test Geant4 calculations and validate the 2D reconstruction method will be performed. Finally, new detection technologies will be considered for improving IMRT.

THE RESEARCHER:
MARIA CRISTINA BATTAGLIA



Maria Cristina Battaglia was born in Comiso, Italy in August 1988. She moved to Catania to pursue her professional goal of studying Physics at the University of Catania in 2007. In 2010, she obtained her Bachelor’s degree in Physics and commenced her Master’s in nuclear physics at the University of Catania. As a Master’s student, she participated in an Erasmus exchange programme studying one semester at the University of Coimbra, Portugal. During her stay she developed her Master’s thesis in the application of medical physics, in particular, she worked on the development of a novel imaging technique named ‘Orthogonal Ray Imaging’. She obtained her Master's degree in November 2012. She became an oPAC Fellow in March 2013.

SARA, AMS system at CNA.

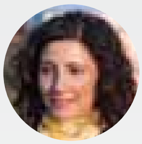
THE PROJECT: OPTIMIZATION OF ^{10}Be DETECTION

Supervisor: Dr. Jose María López

This project includes investigations into the physical processes involved in ^{10}Be detection by accelerator mass spectrometry (AMS), the search for the optimum settings of the existing system and the design of modifications to increase both, the sensitivity and the efficiency of the system.

The results of this project are expected to have strong impact on other small AMS facilities, as this radionuclide is probably the most requested from those measured by AMS after ^{14}C since it can be used as a dating tool or as a measurement of solar exposure.

THE RESEARCHER: GRAZIA SCOGNAMIGLIO



Grazia Scognamiglio was born in Pompei in 1987 and studied Physics at the University Federico II of Naples. As an undergraduate student, she collaborated within the ATLAS group of Naples, developing software for monitoring the muon detectors of the ATLAS experiment at LHC. This work became her Bachelor's Degree Thesis in 2010. In the same year, Grazia started a Master's course with specialization in Electronics. She implemented and tested communication protocols between FPGAs optimized for spatial applications, adapting them to the requirements of the JEM-Euso project and obtained her Master's Degree in 2012.

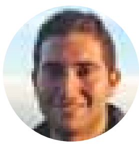
After her studies, Grazia improved her software and hardware programming skills in private and public companies, before joining oPAC in January 2014.

THE PROJECT: ION IMPLANTATION AT PARTICLE ACCELERATORS FOR NANOPARTICLE PRODUCTION.

Supervisor: Dr. Javier García López and Dr. F. Javier Ferrer Fernández

The goal of the project is to study the ion implantation of noble metals (Au, Ag, Pt, Pd) in transparent metal oxides thin films (SiO_2, TiO_2), and the subsequent coalescence of nanoparticle after thermal annealing. Specifically, we will study the differences in the formation of nanoclusters in host with different morphologies. The Fellow interacts with the Ion Beam Analysis group at CNA, IBA-CNA and learns about all relevant aspects of experimentation in particle accelerators, through the use of the 3MV Tandem at CNA. It is envisaged that Salvatore will also interact with researchers that collaborate regularly with the IBA-CNA group.

THE RESEARCHER: SALVATORE BRUSCHETTA



Salvatore Bruschetta was born in Palermo in 1990. He completed his Bachelor Degree in Energy Engineering at the University of Palermo, graduating in February 2012. The title of his thesis was "Measurement of the Neutron Flux produced by a Cyclotron to create PET Radiopharmaceuticals". Afterwards he continued his studies with a Master Degree in Energy and Nuclear Engineering at the same University.

In February 2013, Salvatore participated in the SARA project based in Prague, before writing a thesis on "Non-destructive quantitative analysis of various materials and evaluation of acquired data with XRF". He joined the oPAC network in 2014.

 Courtesy of US/CNA.

MANAGEMENT

PARTNERS

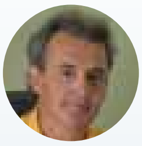
Twelve beneficiary partners are hosting between one and four fellows who each have their own specific research projects. The associate and adjunct partners play a distinct role within the network training with some providing secondment places in relevant scientific areas.

SUPERVISORY BOARD

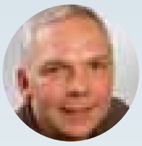
Every partner in the network has representation on the Supervisory Board. The board meets annually and its role is to monitor the progress of the fellows and the quality of their training. Feedback from industry partners is essential in ensuring that the training offered remains relevant to the job market.

STEERING COMMITTEE

The Steering Committee is responsible for the overall network strategy and takes all decisions concerning the network. It consists of the following elected members: In addition, an elected Fellow representative joins the Steering Committee in its meetings and provides feedback and input from the trainees.

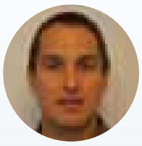


Prof. Joaquín Gómez Camacho studied physics at the University of Seville, graduating in 1982 and went to Daresbury Laboratory to work on nuclear reactions. He obtained his PhD in 1986. Afterwards, he went to the University of Surrey as a Postdoc to work on nuclear reactions with polarized nuclei. In 1987 he returned to the University of Seville, where he is a Full Professor and Director of CNA. His research interests include nuclear reactions with exotic beams, theory and experiment, and detector instrumentation.

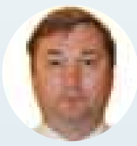


Prof. Erich Griesmayer is founder and CEO of CIVIDEC Instrumentation, formed at the end of 2009. During more than 20 years of work at CERN he collected broad knowledge and experience in accelerator technology. He is also an Associate Professor at the Vienna University of Technology. His professional background is in electronic measurement technology with a focus on diamond detectors and fast electronics.

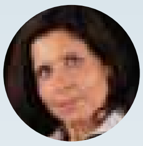
Dr. Andreas Jansson has an MSc from Linköping University and a PhD from Stockholm University. During his career, Andreas has been working on the development of various diagnostics devices, including ionisation profile monitors, microwave Schottky pick-ups and AC dipoles, mainly at the Fermilab Tevatron and the CERN LHC. Since 2010 Andreas has led the Beam Diagnostics Group at the European Spallation Source in Lund, Sweden.



Dr. Rhodri Jones is head of the Beam Instrumentation Group at CERN, responsible for the beam instrumentation and diagnostics on all CERN accelerators and transfer lines. He obtained his PhD on resonance ionisation laser spectroscopy in 1996 from the University of Wales, Swansea. His interests include high frequency RF diagnostics, laser and electro-optical diagnostics.



Dr Pavel Karataev is a Senior Lecturer at RHUL and a member of the John Adams Institute for Accelerator Science. With work experience in Tomsk Polytechnic University, Tokyo Metropolitan University and KEK, his research interests span the development of advanced charged particle diagnostics techniques and investigations into charged particle generated radiation and its transportation, detection and application.



Dr. Nika Vodopivec studied at the University of Trieste, International University Institute for European studies where she finished her master's thesis on European Policy Making in 2002 and completed her doctoral thesis on Transborder Policies for Daily Life in 2009. Since 2009 she has been working for Instrumentation Technologies as Head of HR and General Affairs.

Prof. Carsten P. Welsch initiated the oPAC project and is the scientific coordinator on behalf of the University of Liverpool, based at the Cockcroft Institute, UK. He carried out his PhD studies at the University of Frankfurt and his work brought him to UC Berkley, RIKEN, MPI Heidelberg, CERN and GSI before joining Liverpool in 2008. His QUASAR Group focuses on R&D into low energy accelerators and beam instrumentation.

EU PROJECT T.E.A.M.

The University of Liverpool has established a dedicated EU Project T.E.A.M., based at the Cockcroft Institute. This T.E.A.M. assists in the day-to-day running of the oPAC project, under the guidance of the coordinator, and comprises the project manager Rita Galan, a financial administrator, project assistant and web developer.

Fellows during tour of Daresbury Sci-Tech campus.

TRAINING PROGRAMME

TRAINING

In oPAC all Fellows receive extensive research-based training within a unique European partnership. Working within the network they will gain a broad insight into both the academic and industrial aspects associated with accelerator research with opportunities for specific training and secondments.

All project partners cover a very broad, yet closely interconnected, experimental programme that combines many different scientific disciplines, such as mechanical and radio frequency engineering, physics, electronics, IT, material sciences and medical applications. The contribution of industry partners to the definition phase of all research projects and their continued active role ensures that the transfer of industry-relevant skills is an integral part of all individual projects.

The fundamental core of the training is a dedicated cutting-edge research project for each Fellow at their host institution. The network is then used to provide opportunities for secondments for all Fellows to spend time working at other institutions within the network for hands-on training in specific relevant techniques and for broader experience including different sectors. Most Fellows will be in post for 36 months and are registered into a PhD programme. This local training will be complemented by a series of network-wide events that include external participation.

INTERNATIONAL SCHOOLS

As an introduction to the field of accelerator science all recruited oPAC fellows took part in either the CERN Accelerator School in autumn 2012 or the Joint Universities Accelerator School (JUAS) in 2013 or 2014.

Several oPAC Schools will be held throughout the four years of the project and bring together experts from across the world, in focused research areas, to discuss the present state-of-the-art and review challenges with the network's researchers. An international School on Accelerator Optimization will be held at Royal Holloway University of London in July 2014 and cover beam physics, instrumentation R&D and charged particle beam simulations at an advanced level. It targets PhD students, Postdocs, as well as experienced researchers and there are also opportunities for scholarships to support early career researchers from outside the network.

TOPICAL WORKSHOPS

A series of Topical Workshops will cover all important research areas within the network. The first of these on Challenges in Accelerator Optimisation took place at CERN, Geneva in June 2013 and attracted more than 100 delegates. In 2014 workshops took place at CIVIDEC on Beam Diagnostics and on Libera Technology at Instrumentation Technologies. In 2015 the University of Liverpool will host a workshop on Technology Transfer. Participation to these workshops is open to scientists external to the network.

In addition, specialist hands-on workshops have been provided by Bergoz on Beam Instrumentation and by CST offering training in Particle Studio hosted at CERN and at the Cockcroft Institute.

COMPLEMENTARY SKILLS TRAINING

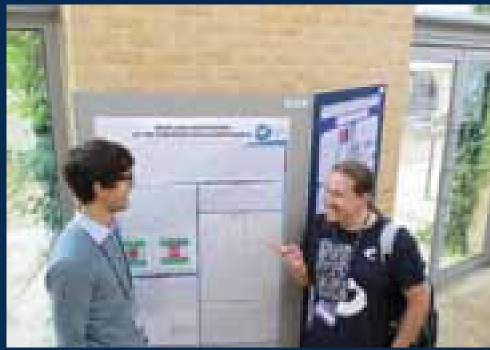
All Fellows receive training in aspects such as presentation skills, scientific writing, entrepreneurship and handling intellectual property through an established quality school implemented by the University of Liverpool, and recognised by the European Commission as 'best practice' for providing future generations of scientists and engineers with the skills to produce world-class research. This training provides the Fellows with the non-technical skills that will be invaluable for their future careers, whether that be in academia or industry.

The researchers work in small teams during this training course to develop and plan an outreach event. This familiarizes them with the challenges linked to team working, project management, event organization, publicity and delivery. An advanced skills training will be offered in 2015, covering CV writing, interview skills and working within international networks.

CONFERENCE AND OUTREACH SYMPOSIUM

A three day International Conference in the final year of the oPAC project will promote the developed techniques and research outcomes and enable the Fellows to engage with other university groups and private companies. The conference will also present the opportunity to pave the way for follow-up activities between the oPAC partners and with participating scientists from outside the network and serve as a career platform for all of the network's researchers who will get the opportunity to present the outcomes of their research projects.

A Symposium on Accelerators for Science and Society will be organized in Liverpool as a finale to the outreach activities undertaken during the course of the network. This will present the main project findings in an understandable way for the general public emphasizing the possible applications of the technologies concerned.



Manuel and Michal presenting at IBIC 2013.

Fellows' Daresbury visit.

Researcher Skills School in Liverpool.

SECONDMENTS, DISSEMINATION AND OUTREACH

SECONDMENTS

By the nature of the scientific collaborations within oPAC, all Fellows are immersed in a pool of networking opportunities and training. In addition to the numerous network-wide training events, oPAC provides a secondment scheme which allows them to train with the other partners involved in the network. This provides research training in areas that are not directly linked to their research projects, thereby broadening the expert knowledge of each Fellow substantially. These trans-national and cross-sectorial secondments also trigger exchange across institutional and national boundaries, and help developing and maintaining working relationships within the wider research community.

DISSEMINATION AND OUTREACH ACTIVITIES

Research results from the project are disseminated via our events and international peer reviewed journals and can be accessed through our web site www.opac-project.eu.

Our web site is regularly updated with news from the consortium partners and details of all research projects being undertaken by the Fellows. The oPAC Facebook page and quarterly newsletter serve to keep interested parties updated of our progress and advertises forthcoming events and any available scholarships.

Connections to accelerator scientists outside the network are enabled through adjunct partnership to oPAC in addition to providing scholarships for external participants wishing to contribute to our events. Membership is growing and several adjunct partners have now joined the consortium which furthers links and networking for the fellows.

The oPAC fellows are actively involved in outreach activities within their communities in order to educate and create interest with the general public, schools and teachers. Special lectures, tours and open days are amongst the events available to all.

www.opac-project.eu

PARTNERS

ASSOCIATED PARTNERS

There are 10 Associated Partners in the network. Although not financial beneficiaries, these contribute significantly to the training of the oPAC fellows. They are actively encouraged, through membership of the Supervisory Board, to improve training strategies and help ensure the highest possible standards of training are met, particularly with regard to industry-relevant skills.

Bergoz Instrumentation, France

Bergoz Instrumentation develops and manufactures transformers, transducers, monitoring devices and electronic instrumentation for current measurement and elementary particle beams diagnostics, non-destructively. Their instruments are found in applications as diverse as high energy particle accelerators - in research and medicine, synchrotron radiation light sources, ion implanters used for materials surface modification, conformance test benches - measure partial discharge and many more. Bergoz specialises in ultra-low-noise analogue electronics design in the DC – 3 GHz range. This is combined with knowledge of cobalt-based amorphous magnetic alloys annealing processes for response up to 2 GHz and very low Barkhausen noise. The company's workshop is well equipped with production machinery and test instruments.

Institute for Storage Ring Facilities, Denmark

The Institute for Storage Ring Facilities (ISA) is a Danish National Facility, where research is carried out in Physics, Chemistry, Materials Science and Biology using accelerators and storage rings. The institute has long standing experience in the design and operation of accelerators, in particular storage rings. It owns several facilities for the production and storage of ions, electrons and positrons. Recently, a low-emittance light source, ASTRID2, has been taken into operation, using top-up injection from the old ASTRID synchrotron/storage ring. Six synchrotron radiation (SR) beamlines at ASTRID2 cover a wide photon energy range from the visible to the soft X-Ray region supporting a diverse SR research programme. ELISA is an electrostatic storage ring with its own ion injector and is capable of storing a very wide range of ions.

Oxford Instruments, UK

Oxford Instruments plc is a leading provider of high technology tools and systems for industry and research. It uses innovation to turn smart science into world-class products that support research and industry to address the great challenges of the 21st Century. Oxford Instruments' core competencies lie in analyzing and manipulating matter at the atomic level and hence the company focuses on developing high-technology tools and systems that meet the stringent requirements demanded by its customers. The present products cover a very wide spectrum of applications, from cryogenic systems and coating thickness analysers to low temperature and high magnetic field applications.

Polish Light Source, Poland

Polish Light Source will be a state-of-the-art synchrotron light facility, once completed. It will provide its users with radiation from the far infrared to the X-ray region and hence allow a multitude of experiments for a very wide and interdisciplinary user community. At low energy operation, the production of intense coherent radiation at THz frequencies is envisaged. Successful design, construction, commissioning and operation of such a demanding facility are only possible in close collaboration with experienced international partners. The accelerator scientists and engineers of PLS are highly experienced in both cutting edge research and intense training of early stage researchers.

RHP-Technology GmbH & Co. KG, Austria

RHP Technology is a solution provider in powder technology and hot pressing. Rapid hot pressing is a pressure-assisted sintering technique, allowing the consolidation of high performance materials such as special alloys, ceramics as well as metal or ceramic matrix composites up to a temperature of 2,400°C. This is possible in overall cycle times of less than one hour and therefore very economic. The SME focuses on the development of metal matrix composite materials, i.e. high thermal conductivity materials with a low coefficient of thermal expansion, ceramic materials, as well as on the development of sputtering target materials with customised composition for thin film deposition.

Stockholm University, Sweden

Stockholm University has over 50,000 undergraduate and master's students, 1,800 doctoral students and 6,000 employees and 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 optimisation of particle accelerators. For many years, ground-breaking studies were realised 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.

Thermo Fisher, USA

Thermo Fisher Scientific CIDTEC Cameras & Imagers is the world leader in serving science. With annual revenues of more than $10 billion, they have approximately 35,000 employees and serve over 350,000 customers within pharmaceutical and biotech companies, hospitals and clinical diagnostic labs, universities, research institutions and government agencies, as well as environmental and industrial process control settings.

Thermo Scientific offers a complete range of high-end analytical instruments as well as laboratory equipment, software, services, consumables and reagents to enable integrated laboratory workflow solutions. The CIDTEC Cameras & Imagers product line has successfully collaborated with Universities and large research centres in the past, and is the direct partner within oPAC.

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.

Technical University of Darmstadt Germany

The Technical University of Darmstadt has been an internationally-oriented university since its founding in 1877. Many pioneering achievements and internationally recognized scholars have contributed to significant progress in many different fields. The Institute for Nuclear Physics at TU Darmstadt operates the superconducting, recycling electron linear accelerator S-DALINAC. This accelerator has been the key research infrastructure at the institute since 1991 and is being continuously improved. In 1996, for example, the very first IR-FEL light in Germany was produced in this machine, which has enabled many ground-breaking experiments since. High system availability and a cutting edge accelerator R&D program covering all aspects of the accelerator are only two of the outstanding characteristics of this facility.

University of Maryland USA

The Institute of Research in Electronics and Applied Physics at the University of Maryland has long standing experience in training graduate students at the University's Electron Ring and other accelerators in new diagnostic techniques. The accelerator physics group has pioneered the development of many new diagnostics for particle accelerators and FELs using a variety of different techniques, such as for example OTR, COTR, CTR, ODR, CDR, OSR and OER and is renowned around the world.

ADJUNCT PARTNERS

Adjunct Partners are those who have joined oPAC after its inception. These intuitions are active in R&D fields closely related to the network and they share the network's training visions. They are an important part of oPAC's long-term strategy in establishing lasting bonds and partnership across institutes and disciplines in Europe. This area of partnership will continue to grow during the life of the network.

CIEMAT Spain

A Public Research Agency attached to the Spanish Ministry of Economy and Competitiveness, CIEMAT is mainly focused in the fields of energy, environment and technology related with them. It is aiming at linking the basic research with the industrial applications, as a bridge between the R&D and the social goals. With a human team of around 1400 people, CIEMAT is diversified technologically and geographically. The main site is in Madrid, where most of the personnel are based. In addition CIEMAT is managing other centres like the Almeria Solar Platform (PSA), an outstanding solar technology facility.

CMAM Centre for Micro Analysis of Materials, Spain

CMAM is a research laboratory belonging to the Universidad Autónoma de Madrid (UAM) whose main experimental facility is an electrostatic ion accelerator devoted to the analysis and modification of materials. Their accelerator, built by HVEE, is of the tandem type and the acceleration system is the co-axial Cockcroft-Walton type with a maximum terminal voltage of 5 MV. It is equipped with two sources: a plasma source and a sputtering source and provides a broad range of ions in the six experimental stations.

INFN Laboratori Nazionali del Sud, Italy

Laboratori Nazionali del Sud (LNS) is one of four national laboratories of INFN. Founded in 1976, it currently employs about 150 people, and represents an advanced development centre for technology and instrumentation. The research activity is mainly devoted to the study of structure and properties of atomic nuclei, in collaboration with researchers coming from several countries. At LNS two particle accelerators are available: a 15MV Tandem Van De Graaff and a K800 Superconducting Cyclotron.

Institutul National pentru Fizica si Inginerie Nucleara Horia Hulubei, Romania

IFIN-HH is the central institute for nuclear and atomic physics in Romania. Its more than 400 scientists are collaborating with numerous institutes (e.g.: IUCN, CERN, IAEA, GSI...) and projects (PHARE, FAIR, IN2P3, SPIRAL2...) in almost all fields of fundamental and applied nuclear physics. 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 basic and applied research, particularly in the fields which are relevant for sustainable development and the national endeavour for integration in the European Union.

SLAC National Accelerator Laboratory, USA

SLAC National Accelerator Laboratory attracts thousands of users, visiting scientists and students from all over the world each year. Its 2-mile-long linear accelerator has enabled Nobel prize-winning discoveries in particle physics and now powers a revolutionary X-ray free-electron laser, the Linac Coherent Light Source (LCLS). Launched in 2009, the LCLS pushes photon science to new frontiers with ultrabright, ultrashort X-ray pulses that allow atomic-scale snapshots of material dynamics in the femtosecond regime. SLAC's other facilities include the Stanford Synchrotron Radiation Lightsource, providing bright, broad-spectrum X-rays and the Facility for Advanced Accelerator Experimental Tests (FACET).

University of Dundee, UK

The University of Dundee is one of the UK's leading universities, internationally recognised for its expertise across a range of disciplines. 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. Its laboratories are equipped with state-of-the-art facilities for miniature laser development, bio-photonics, biomedical physics and optical manipulation, materials deposition and laser processing, nano-scale materials research, and organic materials.

University of Manchester, UK

The University of Manchester is one of the largest in the UK. It has an exceptional record of generating and sharing new ideas and innovations and is applying its expertise and knowledge to solving some of the major social, economic and environmental problems. In the physics of particle accelerators, the University has international expertise in the dynamics of charged particles, RF accelerating structures and novel machines. It plays a key role in the luminosity upgrade of the Large Hadron Collider and central roles in future collider projects such as the LHeC.

University of Sussex, UK

Sussex is a leading research university with over 90 per cent of its being research activity rated as world leading, internationally excellent or internationally recognised. The Experimental Particle Physics (EPP) Research Group has leading roles in a number of experiments: ATLAS at CERN's Large Hadron Collider; NOvA and MINOS+ that use the NuMI neutrino beam at Fermilab, USA; CryoEDM that is searching for the Electric Dipole Moment (EDM) of the neutron at ILL, Grenoble; SNO+ and DEAP that are located at SNOLAB, Canada. They also host a Grid Computing site.

Uppsala University, Sweden

Uppsala University is the oldest university in the Nordic countries, with a living cultural environment and 40,000 students. World-class research and high quality education pursued here benefit society and business on a global level. The members of the Accelerator Physics Group participate in the realization of several large international projects ranging from the X-ray free electron laser X-FEL at DESY in Hamburg, seeding experiments at FLASH, various activities at CERN in Geneva such as the design and construction of the Two-beam Test-stand at CLIC test facility CTF3 and work at the European Spallation Source ESS in Lund, Sweden.

ViALUX, Germany

ViALUX GmbH was founded in 2000 and 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.

The University of Bologna, Italy

The University of Bologna is the oldest continually operating degree-granting university in the world. Its history makes it a landmark reference in European culture. It is one of the most important institutions of higher education across Italy with more than 90,000 students and over 6,000 permanent staff. Internationalization is one of its key strategies, including the participation as leader or partner in many EU cooperation initiatives. The School of Engineering, with a Faculty of approximately 300 members, offers majors in all branches of engineering. Nuclear competencies have been present since the mid 1960's.

Courtesy of CERN.

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