Newsletter
December 2016
Issue 16

Special Interest Articles

Individual Highlights

It has been a fantastic journey

After 5 years, you are now reading the final version of our oPAC newsletter. Your input, contributions and feedback have made it a great resource for the wider accelerator community and triggered many interesting discussions.

You will see in this issue that the research of our Fellows is far from having come to an end with results now being published in peer-reviewed journals and also PhD theses being finalized. In the future we will communicate further news from our Fellows and project partners primarily through social media channels of the University of Liverpool and the Cockcroft Institute; and of course there will also be news and updates at our well-known IPAC and IBIC conference stand.

oPAC has linked and served the accelerator community very well. The project has enabled close collaboration between machine designers, beam instrumentation specialists, as well as code developers. Our Fellows have built up a very remarkable skills set which I am sure will be an excellent basis for their future careers, they have also enjoyed their time within the network very much – as you can read for example in Pavel's interview in this newsletter.

Our oPAC schools and topical workshops have been an enormous success, attracting up to 120 participants and establishing a comprehensive set of presentations on our indico sites that will benefit accelerator experts for years to come.

It makes me very proud to look back at what oPAC has achieved over its life time and am very happy that I was part of this fantastic initiative. I would like to use this opportunity to thank all our Fellows for their hard work and friendship, our project partners and the wider community for their support throughout the years, and my TEAM for their great work.

Let's see what the future brings. There is clearly much more need and demand for highly skilled experts in the wider accelerator sector. Areas such as laser-based accelerators that aim at demonstrating highest accelerating gradients whilst providing good output beam quality would surely benefit from a coordinated international training effort and it would be great to see that a new initiative arises on the foundations that oPAC has now laid.

Carsten P. Welsch, Coordinator

Research News

Turn-by-turn measurements of transverse impedance in a synchrotron light source – Michele Carlà

ALBA Synchrotron

Transverse beam coupling impedance is a source of beam instabilities that limits the performance of circular accelerators. Several beam based techniques have been used to measure the transverse impedance of an accelerator, usually based on the optics distortion produced by the impedance source itself. Beam position monitor turn-by-turn analysis for impedance characterization has been usually employed in large circumference machines, while synchrotron light sources have mainly used slow orbit based techniques.

In a paper just accepted in the journal Physical Review Accelerators and Beams, oPAC fellow **Michele Carlà** and co-workers from the ALBA synchrotron in Spain have presented for the first time the results of turn-by-turn impedance measurements at ALBA, advancing the measurement technique into the range of the typically small impedance values of modern light sources.

The authors measured local impedance contributions through the observation of phase advance versus bunch charge using the betatron oscillations excited with a fast dipole kicker. The ALBA beam position monitor system and the precision of the turn-by-turn analysis allowed to characterize the main sources of transverse impedance, in good agreement with the model values, including the impedance of an in-vacuum undulator.

Further information:

Michele Carlà, Gabriele Benedetti, Thomas Günzel, Ubaldo Iriso, and Zeus Martí, Local transverse coupling impedance measurements in a synchrotron light source from turn-by-turn acquisitions, Phys. Rev. ST Accel. Beams (accepted 24 October 2016)

Non-invasive intensity measurements of low energy beams demonstrated for the first time – Miguel Fernandes

A precise measurement of absolute beam intensity is essential for many experiments. It is a key parameter to monitor losses in a beam and to calibrate the absolute number of particles delivered to the experiments. However, this type of measurement is very challenging with traditional beam current diagnostics when it comes to low energy, low intensity beams due to the very low signal levels.

oPAC fellow **Miguel Fernandes** and colleagues from the University of Liverpool, have now experimentally demonstrated a new type of monitor in collaboration with CERN, the GSI Helmholtz Centre for Heavy Ion Research and Friedrich Schiller University and Helmholtz Institute Jena.

The Antiproton Decelerator (AD) is a synchrotron machine that provides low-energy antiprotons for studies of antimatter. These studies typically rely on creating antimatter atoms (such as anti-hydrogen) and using them as probes for the most fundamental symmetries in nature such as the invariance of CPT, or of the gravitational acceleration on matter and antimatter.

A precise measurement of the beam intensity in the AD is essential to monitor any losses during the deceleration and cooling phases of the AD cycle, and to calibrate the absolute number of particles delivered to the experiments. However, this is rather challenging with traditional beam current diagnostics due to the low intensity of the antiproton beam which is of the order of 107 particles, corresponding to beam currents as low as a few hundred nano-Amperes. To cope with this, a Cryogenic Current Comparator (CCC) based on a Superconducting QUantum Interference Device (SQUID) was developed and installed in the AD, in a collaboration between CERN, the GSI Helmholtz Centre for Heavy Ion Research, Friedrich Schiller University and Helmholtz Institute Jena.

Previous incarnations of CCC's for accelerators suffered from issues concerning sensitivity to mechanical vibrations and electromagnetic perturbations. Furthermore, these setups were used for measuring slow beams, usually from transfer lines of accelerators, and were unable to measure short bunched beams presenting fast current variations. In order to measure the beam current and intensity throughout the cycle of a synchrotron machine such as the AD, the CCC needed to be adapted to cope with the fast signals of bunched beams.

Close up of the CCC and the cartridge holding the SQUID sensor already installed inside the cryostat.

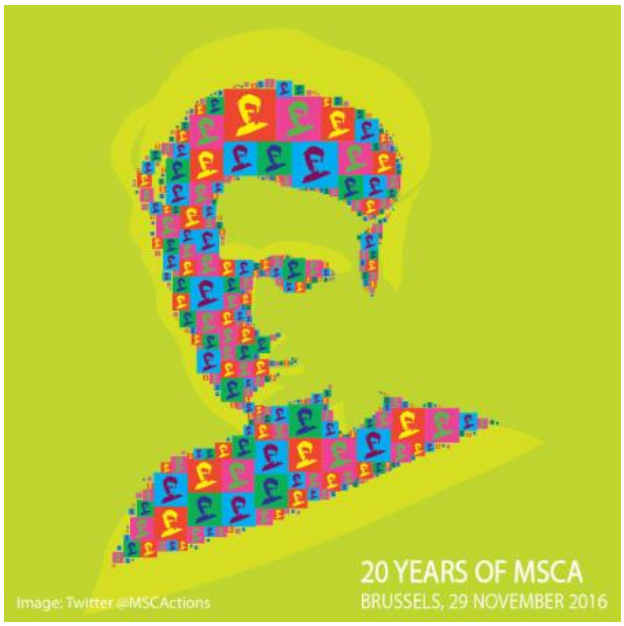
In an open access paper just published in the IOP "Superconducting Science and Technology" journal, oPAC fellow **Miguel Fernandes** and co-authors describe the challenges of implementation and first beam measurements. These are the first-ever CCC beam current measurements performed in a synchrotron using both coasting and short bunched beams. The paper demonstrates the exciting prospects of this new type of beam diagnostics device.

Further information:

M. Fernandes, *et al.*, Non-perturbative measurement of low-intensity charged particle beams, Superconductor Science and Technology, Volume 30, Number 1 (2016).

Network News

20 years of Marie Skłodowska-Curie Actions



The European Union is celebrating 20 years of its Research Fellowship Programme. Since 1996, the Marie Skłodowska-Curie Actions (MSCA) have provided grants to train excellent researchers at all stages of their careers - be they doctoral candidates or highly experienced researchers – while encouraging transnational, inter-sectoral and interdisciplinary mobility. The programme is named after the double Nobel Prize winner Marie Skłodowska-Curie to honour and spread the values she stood for. To date, 98 000 researchers have benefited from the programme – among them five Nobel laureates and an Oscar winner.

One of the MSCA flag schemes are European Training Networks which provide high quality doctoral-level training in and outside academia. These networks bring together universities, research centres and companies from different countries worldwide to train a new generation of researchers. The funding boosts scientific excellence and business innovation, and enhances researchers' career prospects through developing their skills in entrepreneurship, creativity and innovation.

oPAC as a European Training Network has provided training to 23 young researchers in the optimization of particle accelerators. The network offered an interdisciplinary and inter-sectoral environment for the fellows who were hosted at several institutions across Europe and worked on joint research projects addressing challenges in the optimization of particle accelerators. The fellows also benefited from a 'complementary skills training' concept which was implemented through a series of schools and workshops and an active programme of outreach and dissemination.

The Marie Skłodowska-Curie Actions have set the benchmark for attracting and retaining the most talented researchers. By making researchers mobile and encouraging cooperation, the programme boosts knowledge transfer and contributes to strengthening Europe's research and innovation capacity.

AVA project video released

A new video describing the Fellowship opportunities in the AVA network has just been released.

AVA (*Accelerators Validating Antimatter physics*) is a new research and training network currently offering Fellowships to 15 talented, energetic, highly motivated early career researchers who will be employed by different beneficiary partners across Europe. The project, which is directed by oPAC Coordinator Prof. Carsten P. Welsch, targets new scientific and technical developments in antimatter research and aims at boosting the career prospects of its Fellows. AVA will directly build up on experience and expertise gained with oPAC, offering each Fellow a wide range of training activities, both local and networkwide.

The application deadline is 31st January 2017.

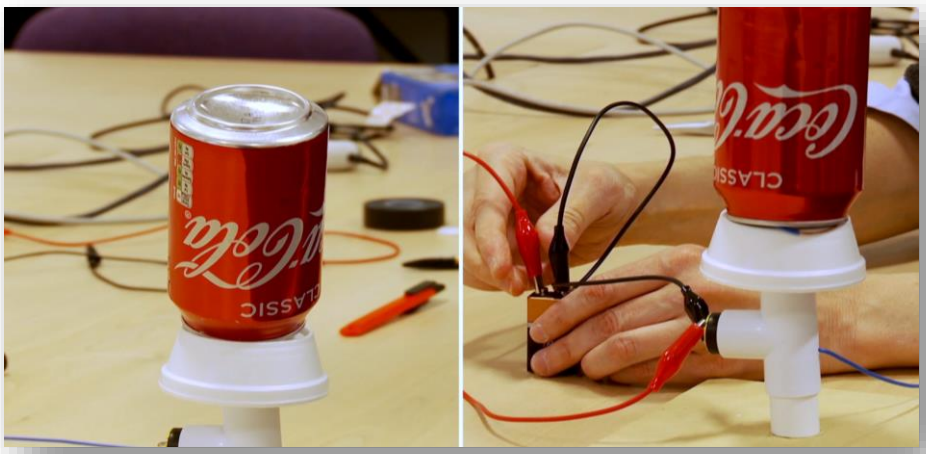
Watch the video now!
https://youtu.be/m6NWbzBUFaU

More information about the project can be found on the project home page: http://www.ava-project.eu

How to build a particle accelerator at home

The University of Liverpool's Quasar Group has launched a series of outreach videos with instructions on how to build some basic experiments related to accelerator science. The videos demonstrate fundamental concepts of electromagnetism like electrostatic potential and magnetic induction, including instructions on how to build a Van de Graaff generator, a rail gun, a salad bowl accelerator, and an electric motor, all of them using household materials.

The experiments were designed for a series of outreach workshops on accelerator engineering for 13 – 14 year old school children. The events, funded by the Royal Academy of Engineering and the Science and Technology Facilities Council (STFC), were held over the summer at the Cockcroft Institute and proved a massive hit with the children. With the videos now on YouTube, the activities can be replicated at home or in the school laboratory.



Check out the videos here:

Salad bowl accelerator
https://www.youtube.com/watch?v=8NQtjvGQAl8
https://www.youtube.com/watch?v=UQKDtHx9ZV0

Rail Gun and Gauss Rifle
https://www.youtube.com/watch?v=wO4MeVwbwAo
https://www.youtube.com/watch?v=NUgU8lXdD7c

Electric Motors
https://www.youtube.com/watch?v=tw7IaX7ZBBM
https://www.youtube.com/watch?v=ZPPU_7Mnok4

Home-made Van de Graff generator
https://www.youtube.com/watch?v=EnRbHK8zlyE
https://www.youtube.com/watch?v=V6F__MYxOXU

Upcoming Events

ANAR2017 Workshop

The Advanced and Novel Accelerators for High Energy Physics Roadmap Workshop 2017 will take place at CERN on April 2017, 25th - 28th .

Organised at the initiative of the ICFA panel for Advanced and Novel Accelerators, the ANAR2017 workshop aims at discussing issues to be addressed in the near future to be in a position to identify promising technologies for future advanced accelerators, and to establish an international scientific and strategic roadmap. The general goal is to define an international roadmap towards colliders based on advanced accelerator concepts, including intermediate milestones, and to discuss the needs for international coordination.

The workshop is open to the scientific community at large. It is organized around working groups that will examine the various schemes that are currently under active investigation (LWFA, PWFA, DWA, DLA) as well as those that need to be addressed in the near- mid- and long-term to reach parameters relevant to a high-energy collider. The last part of the workshop will be dedicated to discussion of the working group results and to the strategy to push forward the development of advanced accelerators in the context of the next international project at the TeV scale. The results will be synthesized in a document that will be broadly distributed.
Please visit the website for updates about registration and general information.

FCC Week 2017

In 2017 the FCC Week will take place in Berlin, Germany between May 29th and June 2nd . The registration and abstract submission is now open, as well as application for the FCC Innovation Award via poster submission.
The annual meetings of the worldwide Future Circular Collider study http://cern.ch/fcc (FCC) are major international events that review the progress in every domain which is relevant to develop feasible concepts for a next generation frontier particle accelerate based high-energy physics research infrastructure. This 3rd meeting is jointly organised by CERN and DESY. It is also the annual meeting of the EuroCirCol http://eurocircol.eu/ EC Horizon 2020 Research and Innovation Action project.

For details and registration please check: https://fccw2017.web.cern.ch/

EAAC2017 announced

The 3rd European Advanced Accelerator Concepts workshop (EAAC2017) will take place in the island of Elba in Italy, September 25th -29th , 2017.
The conference is organized in the context and with sponsoring of the EU/ARIES funded European Network for Novel Accelerators (EuroNNAc3), a network of 52 institutes and universities. EU funding for this network has now been extended up to 2021. Additional sponsors for EAAC2017 are CERN, DESY, Ecole Polytechnique and INFN.
The workshop will be followed by a 1-day EuroNNAc3 network meeting by invitation only.
A special session on the Horizon2020 EU design study on a European Plasma Research Accelerator with eXcellence In Applications (EuPRAXIA http://www.eupraxia-project.eu/) will be included in EAAC2017.

Fellows News

Xavier Nuel Gavaldà awarded PhD degree

Dr. Xavier Nuel Gavaldà

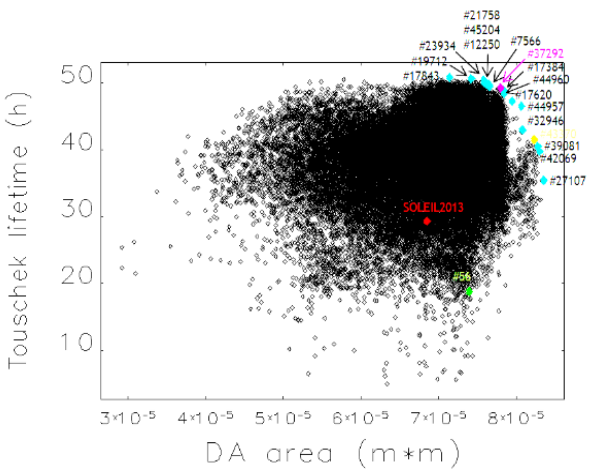
Xavier defended successfully the PhD of the University of Paris-Saclay on September 6th 2016.

The thesis was hosted in Synchrotron SOLEIL and it was dedicated to the optimization of the nonlinear beam dynamics of synchrotron radiation light sources using Multi-Objective Genetic Algorithms (MOGA-ELEGANT). In the first part the ELEGANT code was benchmarked against TRACY3; then MOGA was tuned and used to find the best settings of quadrupole and sextupole magnets in order to maximize the dynamic and momentum apertures, strongly related to the Touschek lifetime and the injection efficiency respectively. Solutions obtained after one month of computation in the high level computational cluster of SOLEIL using 200 CPUs were analyzed. The improvement of the Touschek lifetime obtained with MOGA was confirmed by the beam-based experiments. The beam lifetime of the SOLEIL storage ring was increased by 40–50 % while keeping the 95% injection efficiency.

The second part of the PhD work was devoted to study experimentally the beam lifetime of the SOLEIL storage ring to improve the understanding of the beam lifetime and its contributions: the Touschek and gas lifetimes. The beam lifetime was measured in function of important parameters as coupling, horizontal and vertical scrapers, and bunch current. The experimental results were compared with the simulated ones. The composition of the residual gas and the local pressure along the entire machine vary significantly between the arcs and the in-vacuum insertion devices: new effective atomic numbers were obtained. This type of measurement remains difficult to analyze without a large error margin; in-vacuum insertions have a dominant contribution. The shape of the experimental curves is closed to the expected ones and compatible with an effective atomic number of about 7.

Xavier would like to thank for the support received of oPAC during his work at Synchrotron SOLEIL.

The thesis is available here: http://www.theses.fr/2016SACLS205



Optimized solutions of the SOLEIL2013 storage ring lattice obtained by MOGA-ELEGANT after 1 month of computation using 200 CPUs in terms of area of dynamic aperture and Touschek lifetime. The red point is the SOLEIL2013 lattice called starting point and the cyan points with ID numbers are points of the Pareto-optimal front. The solutions chosen for experiments are highlighted in green (#56), magenta (#37292) and orange (#43370). The black points are the solutions dominated by the Pareto-optimal front. 6D-tracking parameters: 2.665 MV of RF-voltage and 1,000 of turns including the synchrotron radiation and the radiation damping for the off-momentum acceptance calculation.

Interview with 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 as Reserve Officer of the Anti-aircraft Rocket Forces in 2010. During his 6th year at the Polytechnic he also he worked as a volunteer in AIESEC, a global youth non-profit organization that develops leadership capabilities. Pavel earned his bachelor's and master's degrees in automation and control with honors. His master's thesis was entitled 'Precise control of the Stewart platform (hexapod robot)'.

In December 2010 Pavel was employed as engineer and programmer by the D. V. Efremov Scientific Research Institute of Electrophysical Apparatus, were he got involved in the ITER project, implementing a distributed control system (based upon EPICS) in ITER's Fast Discharge, and a data acquisition system for the high-current test stand at the Pulsed Power Lab. Pavel received a Marie Curie fellowship within the oPAC project at Cosylab in Ljubljana, Slovenia, in May 2013. His main focus was the study and optimization of control systems for large physics machines, including particle accelerators, fusion reactors and radio telescopes.

Pavel Maslov

What did attract you to the oPAC network? Has it fulfilled your expectations?

Back in the day (oh how many years have passed, unbelievable) I had just started to discover the area of control systems for science. Personally, I had an interest and liking of international collaboration, and oPAC was a good chance for me to get international experience (which I desperately needed), and primarily professional experience in a field that is not covered in any university course. I should point out that I was intending to go study in the US, I applied for the Fulbright grant, was considering different labs to work at. But in the end, Europe was closer and more accessible, so I changed my mind. Besides, I was advised to try Cosylab by one of the members of the EPICS community, so I decided to give it a go.

Why did you choose to go to Cosylab?

I knew Cosylab because we collaborated on the ITER project together while I was working at the Efremov Institute. They were recognised as the leader in software development and control systems maintenance for scientific installations. I would read their monthly newsletter with the latest achievements in the field and I got really hooked. I thought, that I could get very good-quality hands-on experience there. And as it turned out I never regretted :)

Can you explain in a few words what your project was about and what have you achieved?

The project was dedicated to the study of open source control systems and putting all those small tools into a single product capable of quickly managing a set of typical devices (physics sensors, valves, etc.) and integrating them in the EPICS control system. As a result I have come up with the DCDB tool, which helps accelerator personnel during commissioning of the equipment, as well as engineers and researchers, who can simply build their experiment using bottom-up approach.

What has oPAC provided you professionally?

First of all, as an engineer I didn't have proper education in Computer Science. oPAC (with the help of Cosylab) helped me to fill in the gaps and become a decent software developer. Secondly, I wasn't a particle physicist either, but rather a fusion / pulsed-power engineer. During the intense trainings, conferences and workshops that oPAC has provided, I have learned a lot in this new area, too. Last but not least, I have had a chance to meet professionals and scientists from all over the world and exchange lifelong contacts (both professional and human).

What are your professional plans now that oPAC has finished?
After oPAC had finished, I decided to gain some in-depth knowledge in the field of information systems for the enterprise. So I spent nearly six months at the laboratory of information systems of the University of Ljubljana, participating in 2 EU projects, namely AgroIT and Flexiciency.
Right now I am developing the decision support system for an EU project called Heartman together with colleagues from the Laboratory of Ambient Intelligence of the Jozef Stefan Institute in Ljubljana, Slovenia. Generally speaking, I am planning to stay in IT and wish to become an experienced and versatile IT professional.

What will be your most cherished memory from oPAC?
I cannot define just one, everything I experienced was new and exciting to me. Perhaps, my first ever trip across Europe, visiting CERN, playing frisbee with the young fellow physicists in the campus lawn. My internship in Stockholm was great, too - playing curling, yeah! And IPAC 2014 - trying a roasted piglet on a spit with Carsten and Co. Priceless!

And the one you'd rather forget?
nah :)

Partner News

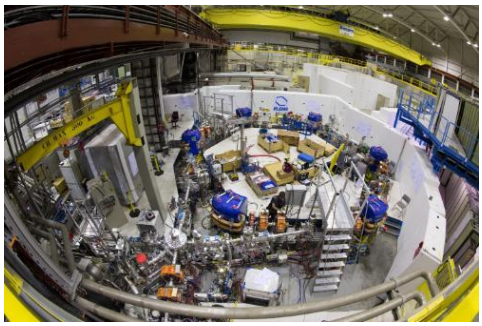
Happy birthday, Sir James Chadwick

On 20th October the University of Liverpool celebrated the 125th birthday of one of its most illustrious members, Sir James Chadwick.
Chadwick, who was born in 1891 and discovered the neutron in 1932, became a professor of physics at the University of Liverpool in 1935, the same year he was awarded the Nobel Prize in Physics.
Chadwick earned his PhD in 1921 under the supervision of Ernest Rutherford at the Cavendish Laboratory, University of Cambridge. He worked as Rutherford's assistant director of research for over a decade at the Cavendish Laboratory, where he made the famous breakthrough. Chadwick followed the discovery of the neutron by measuring its mass, and anticipated that neutrons would become a major weapon in the fight against cancer.
After taking his position in the Department of Physics at the University of Liverpool, Chadwick overhauled an antiquated laboratory and, by installing a cyclotron, made it an important centre for the study of nuclear physics. Therefore, the current status of the University of Liverpool as one of the world's leading institutions in nuclear, particle, and accelerator physics draws directly from Chadwick's work.
Likewise, the university's position as an international hub for the training of accelerator experts, through coordinating international research and training networks, such as oPAC, can be said to be part of Chadwick's legacy.

By Los Alamos National Laboratory - Los Alamos National Laboratory, Public Domain, wikimedia

ELENA in Wonderland

At the start of Lewis Carroll's *Through the Looking-Glass*, young Alice wonders what life would be like in the house at the other side of the mirror, before being magically transported into it.
Almost a century and a half after the publication of the celebrated tale, physicists at CERN have made this crossing through the looking-glass a reality. As a token of the inverted world to be found there, the particle accelerator scientists had to build an *antiparticle decelerator*.



ELENA - Image CERN/Maximilien Brice

The so-called Antiproton Decelerator (AD), slows down antiprotons to an energy of 5.3 MeV. In service since 2000, the AD has been helping scientists address fundamental questions like the effect of gravity on antimatter or the imbalance between matter and antimatter in the Universe.
The lowest the energy of the antiprotons the easier it is for the experimenters to manipulate and study them. A new machine called ELENA (Extra Low ENergy Antiproton deceleration ring) has been built to slow the antiprotons down even further, to just 0.1 MeV. In addition, the density of the beams will be improved, increasing the amount of data available for experiments.

ELENA measures 30 metres in circumference and has just begun its first tests with beam. After the tests have been finalised, the antiprotons will be sent to experiments were they will be used to produce atoms of antimatter and study its properties.

oPAC fellow Miguel Fernandes has had an important role in the development of the Antiproton Decelerator by designing and building a new type of monitor to measure accurately the extremely low intensities of the antiproton beams (of the order of a few hundreds of nano-Amps).
A precise measurement of the antiproton beam intensity is essential to monitor any losses during the deceleration and cooling phases of the decelerator cycle, and to calibrate the absolute number of antiparticles delivered to the experiments.
In a paper just published in the IOP "Superconducting Science and Technology" journal, Miguel Fernandes and co-authors describe the challenges of implementation and first beam measurements of a Cryogenic Current Comparator (CCC) based on a Superconducting QUantum Interference Device (SQUID). The paper demonstrates the exciting prospects of this new type of beam diagnostics device.

Further information:
CERN Courier, "CERN soups up its antiproton source" Nov 11, 2016
http://cerncourier.com/cws/article/cern/66893
M. Fernandes, *et al.*, Non-perturbative measurement of low-intensity charged particle beams, Superconductor Science and Technology, Volume 30, Number 1 (2016).

Vacancies

Early Stage Researcher fellowships within AVA network
AVA project, Application deadline: 31st January 2017.

COSYLAB is currently hiring software, hardware and medical engineers. They are looking to fill a large number of positions in their HQ in Ljubljana (Slovenia), with options to work in Switzerland, USA, China or Japan. Please contact jobs@cosylab.com for more details.

Selected Publications

Michele Carlà, Gabriele Benedetti, Thomas Günzel, Ubaldo Iriso, and Zeus Martí, Local transverse coupling impedance measurements in a synchrotron light source from turn-by-turn acquisitions, Phys. Rev. ST Accel. Beams (accepted 24 October 2016)

M. Fernandes, *et al.*, Non-perturbative measurement of low-intensity charged particle beams, Superconductor Science and Technology, Volume 30, Number 1 (2016).

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Events	
Feb 27th – March 1st 2017	PHOTOPTICS 2017, Porto, Portugal
April 25th – 28th 2017	ANAR2017 Workshop, CERN, Switzerland
May 14th - 19th 2017	IPAC'17, Copenhagen, Denmark
May 29th – July 2nd 2017	Future Circular Collider Week 2017, Berlin, Germany
Aug 20th – 24th 2017	IBIC'17, Grand Rapids, MI, USA
Sept 25th – 29th 2017	EAAC2017, Elba, Italy

NOTICE BOARD

Please note this is the last oPAC newsletter. We will continue to post news on our website and the following social media channels:

Quasar Group: www, Facebook and Twitter

We remain open to suggestions regarding the organization of events for the wider laser and accelerator communities under the oPAC umbrella.

Please contact the Project Coordinator if you would like to express interest in such activities and find out more.

About oPAC

The optimization of the performance of any Particle ACcelerator (oPAC) is the goal of this new network within the FP7 Marie Curie Initial Training Network (ITN) scheme. oPAC aims at developing long term collaboration and links between the involved teams across sectors and disciplinary boundaries and to thus help defining improved research and training standards.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 289485.