European Coordination for Accelerator Research and Development

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European Coordination for Accelerator Research and Development Newsletter

Issue 6: July - September 2010

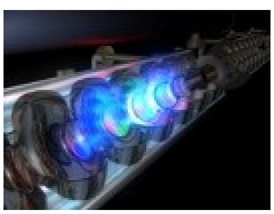
A word from the editor

The EuCARD project is now 18 months old. Kate Kahle, the EuCARD newsletter editor, talks about the stories so far and those still to come. ***Read more»***

Beaming smiles from CLIC test success

Paving the way to a complete feasibility demonstration of the Compact Linear Collider (CLIC), August 2010 saw the first successful results of two-beam acceleration tests, as Roger Ruber explains. ***Read more»***

Hamburg in a FLASH

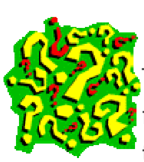


FLASH - the world's first X-ray free-electron laser - achieved record wavelengths over the summer. Mariusz Grecki tells more about how EuCARD is involved with the facility through LLRF control system upgrades. ***Read more»***

A smörgåsbord of accelerator challenges

ESS, the European Spallation Source in Lund, Sweden, should be constructed by 2018. Mats Lindroos explains the accelerator R&D challenges that this new facility brings, as well as plans for sustainability and even profit-making. ***Read more»***

For EuCARD members



The end of September 2010 marks the end of the project's first reporting period (P1). Find out what reporting you need to do and for when. ***Read more»***

Upcoming events

4-6 Oct 4th International Workshop on **Thin Films** and RF Superconductivity, Italy

18-22 Oct IWLC2010 - International Workshop on Linear Colliders 2010 (ECFA-CLIC-ILC Joint Meeting), Switzerland

20-25 Oct NuFact10: International Workshop on Neutrino Factory, Superbeam and Betabeam, India

25 Oct - 5 Nov Fifth International Accelerator School for Linear Colliders (**2010 LC School**), Switzerland

Read more»

Project Results

Recent **publications** include: *A method to transfer concentrated Lorentz forces to a finite element mechanical model.* ***Read more»***

Monographs Volume 8 of the EuCARD monograph series is now available ***Read more»***

Deliverables and **milestones** have been completed ***Read more»***

Please contact the EuCARD editor with any news, events, achievements, images and ideas that you would like publicized.

The EuCARD project is co-funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, under Grant Agreement no 227579

A word from the editor

It is hard to believe that the EuCARD project is already ending its 18th month. This 4-year project has achieved a great deal of results so far, with a great deal more still to come...

EuCARD newsletters are published every three months, back issues are available via the **archive**. *Image courtesy of EuCARD.*

The highlights so far

Already the project has achieved a number of **deliverables** and **milestones**, and publications are continuously being added to the project's **publication database**.

The **monograph series** now has eight volumes, with more foreseen in the coming months. Authors that are active in the relevant research fields, from EuCARD and related projects, are encouraged to submit their results for future volumes (see **information for authors**).

Every three months the EuCARD newsletter has been published, profiling different areas of research within or related to the project. Past issues are available in the **archive**.

As the editor of the newsletter, I have been extremely grateful to the researchers that have contributed so far. Through them, readers have gained an insight into the range of research within the project and the developments to date.

In addition, the newsletter has profiled related projects, facilities and activities, such as **TIARA**, **USLARP**, **ESS** and medical accelerators for **hadron therapy**.

Through newsletter articles, readers have learnt about **crab cavities** and **crab crossing**, **proton "surfatrons"**, **cryocatchers**, **compact accelerators** and **more**.

Highlights still to come

With 6 newsletters now produced and 10 still to come, there is still much of the project ahead and much more to still report. Many deliverables are still to be produced and many advancements are foreseen in the networking and R&D activities.

If you are working within EuCARD and you have a story to tell, please **contact me**. Or if you are outside EuCARD with a story that might interest newsletter readers, please **get in touch**. I look forward to the many more news stories to come.

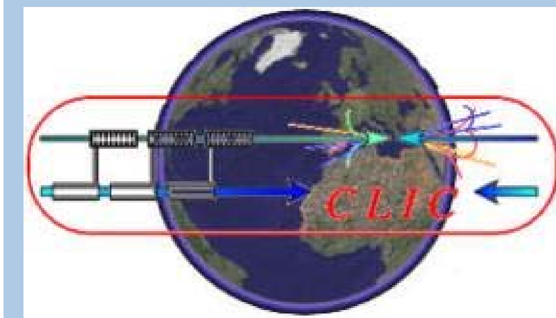
*- Kate Kahle, CERN, EuCARD-**DCO** (WP2)*

Beaming smiles from CLIC test success

August 2010, while most are enjoying the sunshine, CLIC/CTF3 researchers enjoyed successful first results of two-beam acceleration.

With the Large Hadron Collider (LHC) now in operation, high-energy physicists have plenty to keep them busy in the near future with the promises of new discoveries.

But in the longer term, physicists will require high-energy precision measurements of the expected new physics. For this reason a worldwide collaboration is working on a Compact Linear Collider (CLIC) study, for a future high-energy (multi-TeV) electron-positron collider.



The Compact Linear Collider (CLIC) study investigates a future electron-positron collider to explore new energy regions beyond those of today's particle accelerators. *Image & thumbnail image on main page courtesy of* ***CLIC*** *and CTF3.*

Two beam or not two beam

"The idea for CLIC is to use a two-beam acceleration scheme, with one (drive) beam accelerating another (probe) beam," explains Roger Ruber of Uppsala University, Sweden, member of the CLIC/CTF3 collaboration.

"To demonstrate this scheme's feasibility, and to address key technological challenges, the CLIC Test Facility (CTF3) has been constructed at CERN," continues Ruber. "The results of the test facility provide vital input for the CLIC conceptual design report that is currently being prepared."

The Two-beam Test Stand (TBTS) of the CLIC Test Facility (CTF3). *Image courtesy of Maximilien Brice,* ***CERN****.*

The previous test facilities (CTF1 and CTF2) provided proof of principle for two-beam acceleration, albeit with low intensity and low energy beams. The present CTF3 facility aims to demonstrate the feasibility of drive beam generation with appropriate time structure and acceleration, and two-beam acceleration with prototype CLIC structures.

The CTF3 facility has two linear accelerators (linacs): a 3 GHz drive beam linac with a thermionic gun, and a 3 GHz probe beam linac with a photoinjector. The drive beam linac is connected to two rings, a delay loop (DL) and combiner ring (CR), to create a beam with 12 GHz bunch repetition frequency.

Central to the CLIC test facility is the Two-beam Test Stand (TBTS), overseen by Ruber and his team. "TBTS is a key experiment where the power generation with subsequent acceleration of a second (probe) beam are tested and key beam dynamics questions answered," states Ruber.

Driving tests

"The TBTS is the only facility where CLIC type structures can be tested with beam. Instrumentation is available to investigate acceleration, wakefield and breakdown phenomena."

"The TBTS will be adapted in the future for testing 2 m long CLIC prototype two-beam modules consisting of Power Extraction and Transfer Structures (PETS) and quadrupole magnets in the drive beam connected to accelerating structures in the probe beam."

During the 2009 run, the PETS produced over 170 MW peak in full RF recirculation mode, well above the nominal 135 MW foreseen in CLIC, but in the presence of pulse shortening.

The performance was limited by this pulse shortening, linked to RF breakdown in the recirculation components (power splitter and phase shifter). These parts have been repaired and improved in 2010.

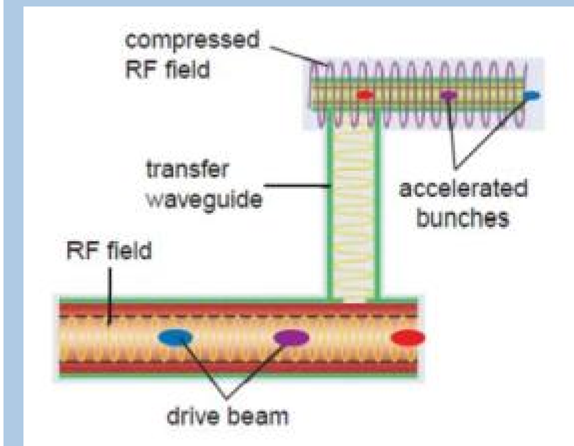
The 2010 run, which began in August, has already produced its first results of two-beam acceleration of the probe beam (see graph below right).

It all CLICs into place

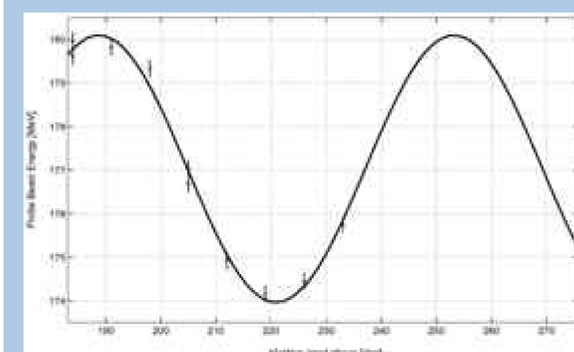
CTF3 has reached its first milestones and is well on its way to complete its feasibility demonstration program. Drive beam generation with fully loaded acceleration has been demonstrated, and likewise two-beam acceleration with prototype PETS power production and CLIC accelerating structures.

The CTF3 facility and its experiments will continue to optimize operation and study two-beam acceleration, drive beam deceleration the possible effects of RF breakdown on the beams.

Two-beam acceleration was originally proposed using a superconducting drive linac, but later adapted to a normal conducting linac. The TBTS research at CTF3 is supported by the Swedish Vetenskapsraadet, the Knut and Alice Wallenberg foundation, as well as the EuCARD project, as a sub-task within the Normal Conducting Linear Accelerator (**NCLinac**) work package.



Two-beam acceleration scheme. The RF field created by the drive beam is transferred to main beam accelerating structures. Due to differences in structure volume and shunt impedance the field is compressed. *Image courtesy of **CERN Courier**.*



First results of probe beam acceleration in the TBTS: Probe beam energy after passing the accelerating structure as function of the CALIFES klystron phase input. *Image courtesy of Roger Ruber, **UU** and **CLIC**/CTF3.*

*- Kate Kahle, CERN, EuCARD-**DCO** (WP2); Roger Ruber, Uppsala University, EuCARD-**NCLinac** (WP9).*

Hamburg in a FLASH

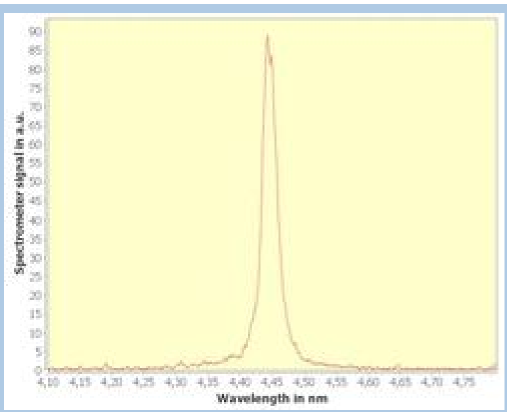
This summer, FLASH - the Free-electron LASer in Hamburg - produced laser light with a record wavelength of 4.45 nanometres thanks to machine upgrades. But how is EuCARD helping to improve the laser's performance?

An aerial photo of the experimental hall for **FLASH** - the Free-electron LASer in Hamburg. *Image courtesy of* ***DESY****. Thumbnail image main page shows electromagnetic fields accelerating electrons in superconducting resonators. Image courtesy of DESY.*

FLASH, the world's first X-ray free-electron laser has been available to the photon science user community for experiments since 2005.

Record wavelength success

In June 2010, DESY's free-electron laser managed for the first time to produce laser light with a wavelength of 4.45 nanometres, beating the previous record of 6.5 nanometres. In addition, the peak intensity of single light pulses nearly doubled, with 0.3 millijoule.



Spectrum of the record laser pulse peaks at FLASH of a wavelength of 4.45 nanometres. *Image courtesy of* ***DESY***

This event followed a five-month machine upgrade. A seventh superconducting accelerator module was added to increase the maximum electron energy to 1.2 Giga-electronvolts (GeV). In addition, to improve the quality of the accelerated electron bunches, a special 3.9-GHz module was installed. These additions were both seen as prototypes for the European XFEL project, their success is also an important milestone for **XFEL**.

"It is absolutely impressive how fast and promising FLASH is operating after such a substantial upgrade," congratulated Reinhard Brinkmann, director of the DESY accelerator section.

Record wavelengths lower than 4.45 nanometres are expected soon.

Low Level Radio Frequency (LLRF) at FLASH - EuCARD's contribution

The upgrades mentioned above are just some of the improvements to FLASH, but more are foreseen. For example, EuCARD researchers are currently developing a new Low Level Radio Frequency (LLRF) control system. The current control system, though operational, needs improvements in field regulation, availability, maintenance and operability to fulfill user needs over the next 10 years.

The planned LLRF control system upgrade uses technology based on Telecommunications Computing Architecture (xTCA), which is being specially adapted to include the instrumentation needed for High-Energy Physics experiments.

The input signals require processing by AMC plug-in modules, which are being developed using state-of-the-art processes to optimize costs while keeping high commercial standards on reliability, availability, maintainability etc. Several components of the LLRF system (such as the controller, distribution of reference frequency, radiation monitoring) and control software were partially developed within the CARE project, these are now being extended and implemented within EuCARD.

Progress so far

"We are well advanced in design and manufacturing of the new LLRF system", explains Mariusz Grecki, task leader of LLRF at FLASH within EuCARD.

"The first revision of AdvancedTCA carrier board (prototype) has been designed, manufactured and debugged."

"Multiple tests of commercial downconverter modules have been performed. Problems with inter-channel crosstalks have been identified and special PCB design for multi-coax connector has been developed and implemented in the system. The Vector Modulator and Timing modules (AMCs) have been debugged and successfully tested."

"The piezo controller compatible with xTCA based system has been designed and manufactured and is being debugged."

"The AMC module for gamma and neutron radiation monitoring has been designed and is being produced. The strategy for beam feedbacks has been prepared. As a final solution, dedicated board in AMC form factor will be designed and manufactured."

The AMC vector modulator board. *Image courtesy of Mariusz Grecki, DESY*

"A large amount of work has been done in the area of the software development. A DOOCS (local control system) server has been rewritten. FPGA firmware code has been simplified and improved, and several bugs have been removed."

"We are now preparing tests of second revision of the system with the aim on demonstrating system performance."

"The collaboration works so efficiently thanks to EuCARD support."

*- Kate Kahle, CERN, EuCARD-**DCO** (WP2); Mariusz Grecki, DESY, EuCARD-**SRF** (WP10)*

A smörgåsbord of accelerator challenges

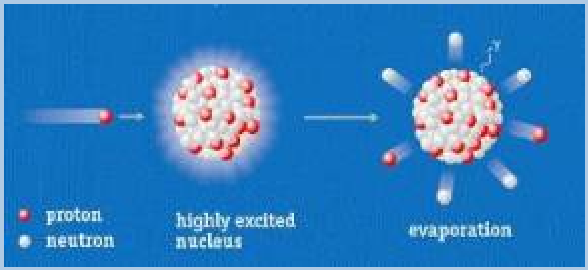
The European Spallation Source (ESS) promises to be a world-leading European science lab using neutron scattering techniques for material sciences, life sciences, engineering and more. Currently in the design phase, with construction foreseen for 2013-18, Mats Lindroos, head of the ESS Accelerator Division, has a number of accelerator challenges to address.

"ESS accelerator has high-level technical objectives" explains Lindroos. "A 5 MW long pulse source, ≤2 ms pulses, ≤20 Hz, with low losses and a high reliability of at least 95%."

"In addition, we want to be a sustainable, cost-effective research centre."

How the European Spallation Source (ESS) works:

- An ion source creates positive hydrogen ions (protons).
- Pulses of protons are accelerated into a target with neutron rich atoms.
- In the target neutrons are liberated by a spallation reaction.
- The neutrons are then guided to instruments where they are used for materials studies.



Spallation: A nuclear process in which a high energy proton excites a neutron rich nucleus, which decays sending out neutrons (and other particles). *Image and thumbnail image on main page courtesy of* ***ESS***

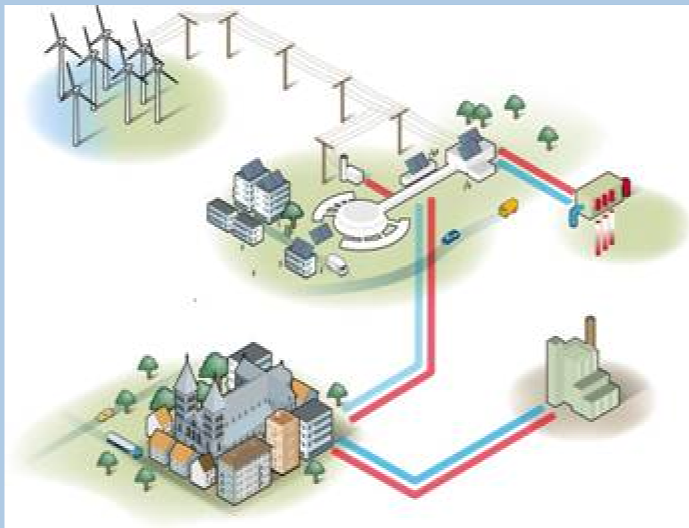
Challenge 1: Sustainable and cost-effective

ESS will be a 40 MW facility (using about a fifth of the energy of a facility such as CERN). To be sustainable, it wants to be CO_2 neutral, to recycle and to benefit from renewable energy sources, such as on-site solar systems, biomass and wind farms using new forms of blade technology.

In Sweden district heating is standard, with people receiving hot water from multiple sources via a large grid. The nearby city of Malmo uses an underground saline aquifer for hot and cold storage and ESS intends to also act as a heat store for the local area during the summer months.

But a major challenge for sustainability and accelerator design involves the ESS cooling water. In most facilities, water is pumped in at 5^{o}C and leaves via cooling towers at 20^{o}C. But ESS have found a way to rethink the facility's plumbing to boost the water to commercially useful temperatures of >70^{o}C and feed into the district heating system of Lund. Not only is this useful, but it also generates money for the facility.

"By selling hot water to the district heating system, minus the costs of running the facility, ESS calculates a net income of 1.5 M€ a year," enthuses Lindroos.



ESS aims to be carbon dioxide neutral over the lifetime of the facility, including transportation to and from the site. It foresees using renewable energy sources such as wind farms and on-site solar systems and linking with the district heating system of the town of Lund to provide and store cooling and hot water (click on image for enlarged, annotated version). *Image courtesy of **ESS** energy management team (Thomas Parker and Jörgen Persson).*

Spoke cavities are radio frequency (RF) cavities still in the design stage that show promise for reliability and cost. ESS plans to be the first facility to use these cavities. This image shows multi-spoke cavities developed for the Rare Isotope Accelerator (RIA). *Image courtesy of **Michael Kelly**.*

The cooling water plumbing needs to be carefully considered, with one line coming in and many lines coming out. Sensitive equipment such as electronics, which would age too fast at >70°C, needs to be close to the start of the cooling water chain, whereas magnets could be later in the process.

Radio Frequency (RF) dumps, compressors and targets need to all be placed at the end of the chain, to act as boosters to get the water to the required high temperatures.

Challenge 2: Low losses

When protons are accelerated there are a lot of losses, for this reason ESS needs a collimator strategy. Beam stability also needs to be understood to a high degree as well as beam dynamics with multi-particle simulations. This needs to be first understood theoretically and for that reason ESS is collaborating with CERN, CEA Saclay and Orsay and other European partners.

Challenge 3: High reliability >95%

The ESS beam will penetrate material to understand it, but it must be prevented from penetrating the material that the machine is made of! To ensure equipment is reliable and can withstand the beam requires material testing. One example is the wish for the 1,000 required power supplies to have a mean time of 20 years between failures per supply. This requires strong collaboration with industry to develop such equipment.

Challenge 4: Using spoke cavities

ESS plans to use a type of superconducting RF cavity known as a spoke cavity. Though actively researched for the last decade, these cavities have so far not been used in a major facility and have not yet seen a particle beam. Their advantages are that they have a high fault tolerance and high longitudinal and transverse acceptance.

In addition, being superconducting cavities they have less RF losses, can operate with less electrical power and take up less space (they are ~1m), making them a cheaper, more energy-efficient option. There is no reason why spoke cavities shouldn't work, but the high-order mode (HOM) effects are unknown at present.

ESS is also investigating the use of elliptical RF cavities, with research currently in collaboration with CNRS-IPNO in Orsay and other European and potentially worldwide laboratories to build prototypes.

Challenge 5: RF distribution system

The RF cavities need amplifiers, known as klystrons. For efficiency and cost, ESS is investigating 1, 2, or 4 cavities per klystron to see what is more efficient. More cavities per klystron means fewer power sources and lower cost, but higher complexity, bulk, power overhead and tolerance.

ESS will also use European test stands to test the RF network. A test setup shielded from x-rays, using expensive RF sources and liquid helium is required by many European projects, including ESS and XFEL. One challenge is whether there are enough European test stands available, and whether projects coordinate to use these effectively.

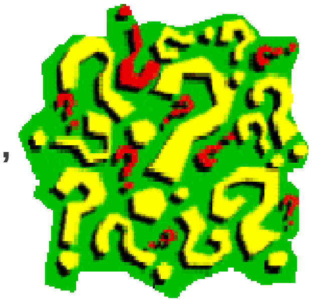
Challenge 6: Planning future upgrades now

At the design stage, costs need to be balanced against potential upgrades as changes further down the line can be expensive. This is why ESS is thinking about upgrades and costs now, and is discussing with various user communities to find out what would be of interest, to build these into the design (see EuCARD newsletter **issue 3**).

To address the above R&D challenges, ESS is setting up a project in January 2011, led by Lindroos, which aims to write a design report by the end of 2012. Though not EU-funded it will collaborate with a number of EU projects including EuCARD and TIARA.

*- Kate Kahle, CERN, EuCARD-**DCO** (WP2); Mats Lindroos, **ESS***

For EuCARD members



For answers to questions about the first reporting period, P1, see below.

For additional FAQs, see previous newsletters:

Issue 1 | **Issue 2** | **Issue 3** | **Issue 4** | **Issue 5**

If you have further questions, please **contact us**.

Q. What reporting is needed now?

A. 30 September 2010 marks the end of the first "period" P1 (18 months) of the project. As outlined in the contractual Grant Agreement, a periodic report containing scientific and financial information is required by the European Commission.

For the scientific section, periodic activity reports are needed from task leaders and work package leaders. These reports are based on the Interim Activity Reports that have been produced at month 6 and month 12, but need to cover the full first 18 months of the project.

For the financial section, Interim Resource Utilisation Summaries for the first 18 months are needed from the administrative contacts at each EuCARD participant, as well as Forms C and explanations of the resources.

Q. What is included in the reporting?

A. The Periodic activity reports contain summaries of work in progress for each task in each work package. They cover work done, deliverables and milestones, plans for the next period and a summary of the man-power efforts.

The Interim Resource Utilisation Reports for M1-M18 cover the estimated full costs for the first 18 months of the project, including man-power. For any major deviations in the man-power and overall resource utilization (i.e. exceeding 20% from the expected values for Period 1), an explanation has to be provided in the IRUS report.

The Forms C (Cost Claims) contain a fraction of the full costs that will be reported to the EC and claimed for reimbursement. As a general rule for EuCARD, the EC would expect to see mainly personnel costs declared in the Forms C and claimed for reimbursement. The Forms C will be submitted electronically by each beneficiary (or by the Coordinator on behalf of the beneficiary) through the on-line EC reporting tool called FORCE, and the pdf version should be signed by an authorized financial officer from each beneficiary. The draft of the Form C must be sent to the Coordinator for verification before the electronic submission. An individual excel template for the drafts of these forms will be provided to the partners.

Explanations for the resources that are reported in the Form C, i.e. a short justification for all personnel and other direct costs that appear in the Cost Claim, per Work Package for each beneficiary. These explanations will be part of the financial section of the Periodic Report and will be strictly scrutinized by the EC. They should be sent to the Coordinator who will compile the relevant section of the Periodic report. A template with examples will be provided by the Coordinator to all beneficiaries.

Q. Why is the reporting needed?

A. The EuCARD project has agreed with the European Commission to deliver contractual periodic reports at month 18 (now), month 36 (March 2012) and month 48 (March 2013). This periodic report will be the main document used during the EC mid-term project review, foreseen for spring 2011.

Q. What do task coordinators need to do?

A. Task leaders should use the Periodic Activity Report Task leader **template**, gathering information from the people working in their task and submit the report to their Work Package Coordinator (ccing Jean-Pierre Koutchouk) by **8th October 2010**. Please adhere to the 1.5 page per task limit including pictures and remember that the full 18 months need to be reported. Please mention any prominent results you would like mentioned in the overall summary of the final combined report, which will be prepared by the coordination office.

Q. What do work package coordinators need to do?

A. Each WP Coordinator should present their Work Package progress at the **Steering Committee meeting** on **12 October 2010**. They should then combine all the task reports into a Periodic Work Package Activity Report, which should include a 0.5 page summary at the beginning of the work package progress and achievements in the first 18 months. WP reports should be sent to the coordination office by the **end of October**. The coordination office will then compile the full periodic report to be submitted in time (60 days after the end of M18 i.e. 29th November 2010.

Transnational access work packages require additional reporting if the transnational access has begun, details have been sent to you personally via email.

Q. What do administrative contacts at each participant need to do?

A. Administrative contacts at each participant need to provide an Interim Resource Utilisation Summary (IRUS) for the first 18 months, as well as a Form C and an explanation of the resources, see **above** for details.

IRUS summaries for P1, drafts of Forms C, and explanations on resources should be sent to the Coordinator by **31 October 2010**. Forms C should be finalized on FORCE (the EC's electronic tool) and signed Forms sent to the Coordinator by **15 November 2010**.