



Report from WP2: Dissemination, Communication & Outreach (DCO)

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EuCARD 3rd Annual Meeting, Warsaw



- 1. Newsletter**
- 2. Public website**
- 3. Scientific publications**
- 4. Monographs**
- 5. PhD statistics**

- Issue 1 (spring 2012) out now:
 - Collaborative newsletter initiated by EuCARD with TIARA, HiLumi LHC & EUROnu
 - Nearly 900 subscribers
 - Quarterly, next issue summer 2012
- Add your EuCARD news, contact eucard-editor@cern.ch

www.acceleratingnews.eu



The screenshot shows the homepage of the Accelerating News website. At the top, there is a navigation bar with links for 'About', 'Archive', 'Subscribe', and 'Contact'. Below this, the 'NEWS' section is highlighted in yellow. The main content area features several articles:

- From the editors** (Acc): A welcome message for the first issue, mentioning the newsletter's evolution from EuCARD and its focus on showcasing news from EuCARD, TIARA, HiLumi LHC, and EUROnu projects.
- Jewels in the crown: TIARA's key research areas and R&D issues** (TIA): A report on TIARA implementation, describing its purpose in setting the ground for a European distributed accelerator R&D infrastructure.

On the right side, there are logos for EuCARD, TIARA, HiLumi LHC, and EUROnu, along with a note that the newsletter is sponsored by these four projects. A 'Read more >>' link is provided for the 'From the editors' article.

- Issues 1 to 11 now available in archive

<http://cern.ch/EuCARD/news/newsletters/archive/>

- Subscribers rose from 200 to 800

- All EuCARD members
- + related projects
- + requests via website



EUCARD Web site outreach section

Outreach material now online, thanks to Naomi

Different types of accelerator

Particle accelerators come in many different shapes and sizes and they are used for many different things. But they all have one thing in common: they accelerate charged particles.

The fact that the particles are charged is important. These machines use electric fields to accelerate particles (like protons or alpha) and the particles will only respond if they have a charge on them. A lot of particle accelerators produce a beam of particles that are not normally seen on earth.

Some are RFs and some are linear accelerators or add-ons to make them charged.

Colliders

Perhaps the most famous type of particle accelerator is the collider. These machines collide particles together at very high energies in order to use these conditions near the start of the universe. The energy in these collisions can produce particles that are not normally seen on earth.

Collider conditions are not all the same. Two different types of colliders can be produced. The first type involves firing a beam of particles at a fixed target. The second type involves firing two beams of particles at each other. Because the particles in the beam are so small it is very difficult to steer the beam accurately enough to make the particles meet each other. Not the best idea of this method is that because both beams are moving very fast (instead of one beam being fixed into a stationary target) the total energy in the collision is much higher, therefore the mass (energy) of particles that can be produced is much greater.

Another difference between colliders is their shape. Some are linear and others are circular. The advantage of a circular collider is that the beam can be sent around the ring many times, each time gaining more and more energy. This is why the LHC is so big. However, as the beam goes round it is constantly losing energy via synchrotron radiation. This energy has to be replaced otherwise the beam will lose too much energy that it no longer takes the next turn.

To avoid energy losses via synchrotron radiation, a linear accelerator can be built. There is a limit to the rate at which particles can be accelerated and very high energy particles must be accelerated over a very long distance to be able to reach the energy they require. However, very space accelerators are required to build these accelerators.

Synchrotron Radiation Sources

Synchrotron Radiation Sources (also known as synchrotron light sources) produce the synchrotron radiation which is described above as a disadvantage in circular accelerators.

The original Synchrotron Radiation Sources were operated as a facility of machines designed for particle physics (colliders). These are known as first generation light sources. Such was the demand for the use of synchrotron radiation that decided to build machines designed to do this purpose. These are known as second generation light sources. Second generation machines only used dipole magnets to produce synchrotron radiation.

Some beam lines (third generation machines) are fixed to assist. These have linear sections in the straight sections between the dipole magnets. Insertion devices are a series of dipoles which bend the particle beam vertically from side to side. The result of this is that the synchrotron radiation produced (these magnets are called wigglers) or that a weak source at one particular energy (these are called undulators).

In recent years fourth generation light sources have started to appear. These light sources contain Free Electron Lasers (FELs). FELs can either be called FELs or SASE (Self-Amplified Spontaneous Emission) FELs.

Synchrotrons and Cyclotrons

Synchrotrons are the name assigned to keep things synchronized. Not only does the RF have to remain synchronized with the beam, so does the power to RF for the magnets. A lot of particle beams have to remain synchronized as well. As a particle beam travels around a circular machine, being accelerated each turn by the RF, the field of the magnets must be increased to keep the particle on the same path. As the energy of the beam increases, the magnetic field required to turn the beam through a particular angle increases. So to be able to increase the energy of a particle beam and store it in a machine for any length of time a synchrotron is required.

If FELs are necessary to store a beam. Sometimes a beam can be passed around a machine a few times, still being accelerated each time, and then it can be used for a few minutes. Magnets with fixed fields, which do much shorter than one whole turn (can be called) can be used for such a machine. Such machines are often found with medical straight accelerators and they are called cyclotrons.

Luminosity

When you think of luminosity you probably think of it in terms of light and how bright or intense a light source is. Well, in particle accelerators it actually means a very similar thing, only we are dealing with particles (electrons, protons etc.) instead of photons.

Luminosity is simply the number of particles it sends a colliding pair unit of time. It is effectively measuring how tightly the particles are squashed together (high luminosity) or spread out (low luminosity).

We often want the particles in a particle accelerator to be close together.

- To collide with the particles close together without necessarily being in the plane of the particle collision when they undergo collisions.
- When two bunches collide many of the particles will not be in the other or central region.
- Therefore, the more particles and the closer they are to the collision point, the more particles will be in the collision region.
- The light source will want the particles to be close together so that the accelerator runs when it produces a central region of particles.

However, we don't always want the particles in a particle accelerator to be close together; sometimes they can become unstable and they will be lost or they will bunch too closely together.

Magnets

A lot of different sorts of magnets are used in particle accelerators. They are all used to steer the beam in some way.

When a charged particle passes through a magnetic field it experiences a force. It will turn at a right angle to both the direction the particle is travelling in and the magnetic field. To work out which way the force is acting we have to use Fleming's left hand rule. If you hold your left hand with your thumb, first finger and second finger all at right angles to each other, your fingers are pointing in the direction of Motion (your magnetic field) (first finger) and your second finger is pointing in the direction of Force (second finger).

Dipole magnets

Perhaps the simplest form of magnet found in a particle accelerator is the dipole magnet. These magnets bend the particle beam to enable them to go around corners. Other than their specific function in a particle accelerator, they are used in many other applications. The figure on the right shows a simple magnet. On the left is North and on the right is South. The field lines are shown in blue and they flow from North to South. The particle beam is assumed to be flowing from right to left across the top of the magnet. From right to left any charged particle will experience a force in the downward direction. (MMF Fleming's left hand rule we can work out that the particle beam will experience a force pointing out of the page (we have the particle beam's perspective, it being turned to the left).

Particle accelerators normally have many dipole magnets, particularly in circular machines. Circular machines are not built in circles; they are in fact built in circular shapes with many straight sections. The four rectangles on the page represent the four straight sections.

There are many other magnets in particle accelerators such as quadrupole magnets. These include wiggler magnets and correctors. A wiggler magnet is used to bend a particle beam in a storage ring. It only wiggles or corrects when the particle beam is passing so that it does not reduce the particle stability in the ring. Wiggler magnets are also part of this function set up and steer the beam onto the next part in the storage ring. Corrector magnets are used to correct the position of a beam while it is in the storage ring.

Quadrupole magnets

Perhaps the next most common form of magnet in a particle accelerator is the quadrupole magnet. As the name suggests, these magnets have 4 poles. These magnets are used to focus the particle beam. The pole on the left shows a quadrupole magnet with the magnetic field lines shown. The field lines all pass each other out at the centre of the quadrupole so a particle beam tends to focus and pass through the centre. The further from the centre of the quadrupole you get the steeper the field lines so particle beams which are further off axis get focused very strongly.

The particle also shows the direction of the force on the particle beam assuming that it is travelling out of the page (into the page). It can be seen that while the particle beam is being focused in the vertical direction it is simultaneously being defocused in the horizontal direction. Consequently, two different types of quadrupole have to be used. One is as shown and the other is the same thing rotated through 90 degrees. These magnets are used to focus the particle beam to be focused in the horizontal plane and defocused in the vertical plane. When an exact opposite pair of quadrupoles can lead to net focusing in both axes. Quadrupoles which focus in the horizontal plane are often referred to as focusing quadrupoles while those which defocus in the vertical plane are often referred to as defocusing quadrupoles.

Other multiple particle magnets

There are many other multiple magnets used in particle accelerators such as hexapoles (6 poles) and octapoles (8 poles). These are always arranged in a circle with alternating North and South poles. The field lines can be seen in the diagram. This helps the beam maintain its size and direction of flow in a conventional particle accelerator.

Some particle magnets are used to correct the errors which are caused by quadrupoles. A quadrupole magnet acts like a lens designed to have a particular focusing strength (which can be thought of as a focal length). If the focusing is not correct, the desired focal length is only partially achieved. In reality there will always be some variation in the energy of particles after a quadrupole so some will be under-focused and others will be over-focused. This leads to the beam increasing in size and taking through successive quadrupoles.

The focal length of a quadrupole is independent of the position which the beam passes through the magnet, for a particle of a given energy. However, the focal length of a quadrupole is inversely proportional to the position of the particle, so particles which are further off axis are more strongly focused. This corrects the beam which would otherwise be defocused by the quadrupoles.

Other higher order multipole magnets are used to correct other errors in beam position and energy but will not be mentioned here.

Synchrotron Radiation and Insertion Devices

What is Synchrotron Radiation?

Synchrotron Radiation is produced when ultra-relativistic charged particles (and ions) are travelling near to the speed of light in a circular orbit. This radiation can be in any direction and includes a variety of wavelengths. The particle is constantly accelerating (due to the centripetal force of the orbit). The radiation is emitted from the path of the particle and is directed away from the particle. The radiation is polarized and covers the electromagnetic spectrum from infrared to high energy X-rays. The radiation is very intense, highly collimated and can be directed both linearly and circularly.

Radiation is always produced when charged particles are accelerated. When the particles are not travelling near the speed of light the radiation does not follow the same rules as synchrotron radiation but radiation is still produced. An everyday example of this effect is a radio antenna. In the antenna, electrons are forced to oscillate up and down and as a result radiation is produced. This radiation is called radio waves which travels through the air and is received by a device such as a radio or television.

How is Synchrotron Radiation produced in particle accelerators?

Synchrotron Radiation is produced in particle accelerators when particles go around corners/bends. The most common way this is produced is when the particle beam passes through a dipole magnet. While the beam goes around the corner the radiation which is produced is either in a straight line. Synchrotron Radiation from dipole magnets was used particularly in machines which were designed for other purposes. It wasn't until later that dedicated synchrotron on radiation facilities were built. Particle accelerators which are designed to produce synchrotron radiation (rather than those where it is produced as a by-product) use quadrupoles as their bending magnets.

As well as dipole magnets there are also devices put into the straight sections of machines which are designed to produce other forms of radiation from a dipole magnet or radiation with particular properties. These are called insertion devices (ID) and they are an essentially series of alternating dipoles which cause the particle beam to oscillate from side to side.

Types of Insertion Device

Wigglers are ID's which make the electron beam oscillate from side to side. The beam oscillates in the horizontal plane and synchrotron radiation is produced. By making the beam oscillate up and down a lot more synchrotron radiation can be produced than is produced by a dipole.

Undulators are also ID's which make the beam oscillate from side to side. However, they are arranged with an oscillation period, such that the radiation from one oscillation constructively interferes with the radiation from the next oscillation. This causes a very intense beam of radiation at one particular wavelength.

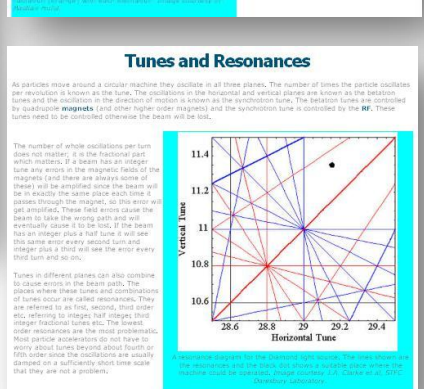
Free electron lasers also use this set up but in this case the electrons bunch together and emit radiation coherently (like in a laser). Synchrotron radiation is produced.

Tunes and Resonances

As particles move around a circular machine they oscillate in all three planes. The number of times the particle oscillates in each plane is known as the tune. The oscillation in the horizontal plane is known as the synchrotron tune. The betatron tunes are controlled by quadrupole magnets and the synchrotron tune is controlled by the RF. These tunes need to be controlled otherwise the beam will be lost.

The number of whole oscillations per turn does not matter, it is the fractional part which matters. If in the fractional part which matters, if the fractional part is not zero, the error will be exactly the same plus each time the particle goes through the error will get amplified. These small errors cause the beam to take the wrong path and will eventually cause it to be lost. If the beam has an integer tune and the fractional part is not zero, the same error every second turn will be amplified and this will see the error every third turn and so on.

Tunes in different planes can also combine to cause errors in the beam path. The places where these tunes and combinations of them are integers are called resonances. They are referred to as first, second, third order and so on. Resonances are particularly dangerous if they are integer fractional tunes etc. The lowest order resonances are the most problematic. Most particle accelerators do not have to worry about tunes beyond about fourth or fifth order since the collisions are usually designed to be sufficiently dense so that they are not a problem.



Radio Frequency (RF)

There are many things in our everyday lives where we come across the electromagnetic spectrum. Radio waves are broadcast every radio station, we find ourselves in our kitchens, we can feel heat in the form of infrared (IR), we can see visible light, we are warned of the dangers of ultraviolet (UV) radiation and we see X-rays in hospitals. All of these are types of electromagnetic radiation. The difference between them is that they have different frequencies/wavelengths.

The electromagnetic spectrum is divided into radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. The wavelength is different from the frequency.

The RF is often seen everywhere in a particle accelerator, just in certain locations, the RF cavities. When the RF cavities the RF can be thought of a sinusoidal oscillating voltage (electric field). When a charged particle sees this voltage it is accelerated. The charged particle needs to keep passing through cavities and being accelerated otherwise it will lose energy and eventually be lost.

Since the voltage (electric field) is oscillating the charged particle must pass through the cavity at the correct time otherwise it will see the wrong voltage. If the particle sees a higher or lower voltage than it needs to it will see less or more energy than it needs. However, small deviations can be tolerated and these simply cause particles to oscillate within the beam. For these oscillations to happen particles must arrive early (and lose too much energy) or late (and lose too much energy).

As the energy of a particle increases the RF needs to keep going to keep accelerating it, keeping the beam and particles in phase with each other is very important. Once the beam has reached the ground energy it will either be used or stored. If the beam is going to be stored in a storage ring the RF still has to remain tuned on even though the beam is no longer increasing in energy. This is because as the beam passes through dipole magnets synchrotron radiation is produced. This slightly reduces the energy of the particle beam so this energy loss needs to be replaced on each turn by the RF.

Emittance

Emittance, or to be more precise, beam emittance, is a term which is widely used in particle accelerators but can be difficult to describe and visualize. It is a measure partly of how much space a beam takes up, but also of how the space changes. It is a vector of three properties.

The coordinate system used in particle accelerators varies but a common system uses an coordinate to measure the distance a particle has travelled along the design path of the accelerator (this can be a straight line or a circle) and then an x and y coordinate to measure the distance from the design path in the orthogonal directions (horizontal and vertical). So at any given time a particle has the coordinates (x, y, z).

A particle beam is typically made up of millions or billions of particles. Each of these particles has its own position (x, y, z) at any given time. No two particles can be in exactly the same place at the same time. This is, however, one particular (x, y, z) where the particles should be if they were following the designed path exactly, it is therefore the deviation from this that is usually referred to instead of the particle absolute positions.

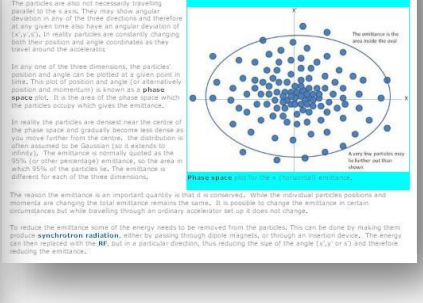
The particles are also not necessarily travelling parallel to the x, y, z. They may show angular deviation from the x, y, z of the free electron and therefore at any given time also have an angular deviation of their x and y. In reality particles are constantly changing both their position and angular deviation as they travel around the accelerator.

In any one of the three dimensions, the particle's position and angle are plotted at a given point in time. The plot of position and angle (or alternatively space and momentum) is known as a phase space plot. It is the area of the phase space which the particles occupy which gives the emittance.

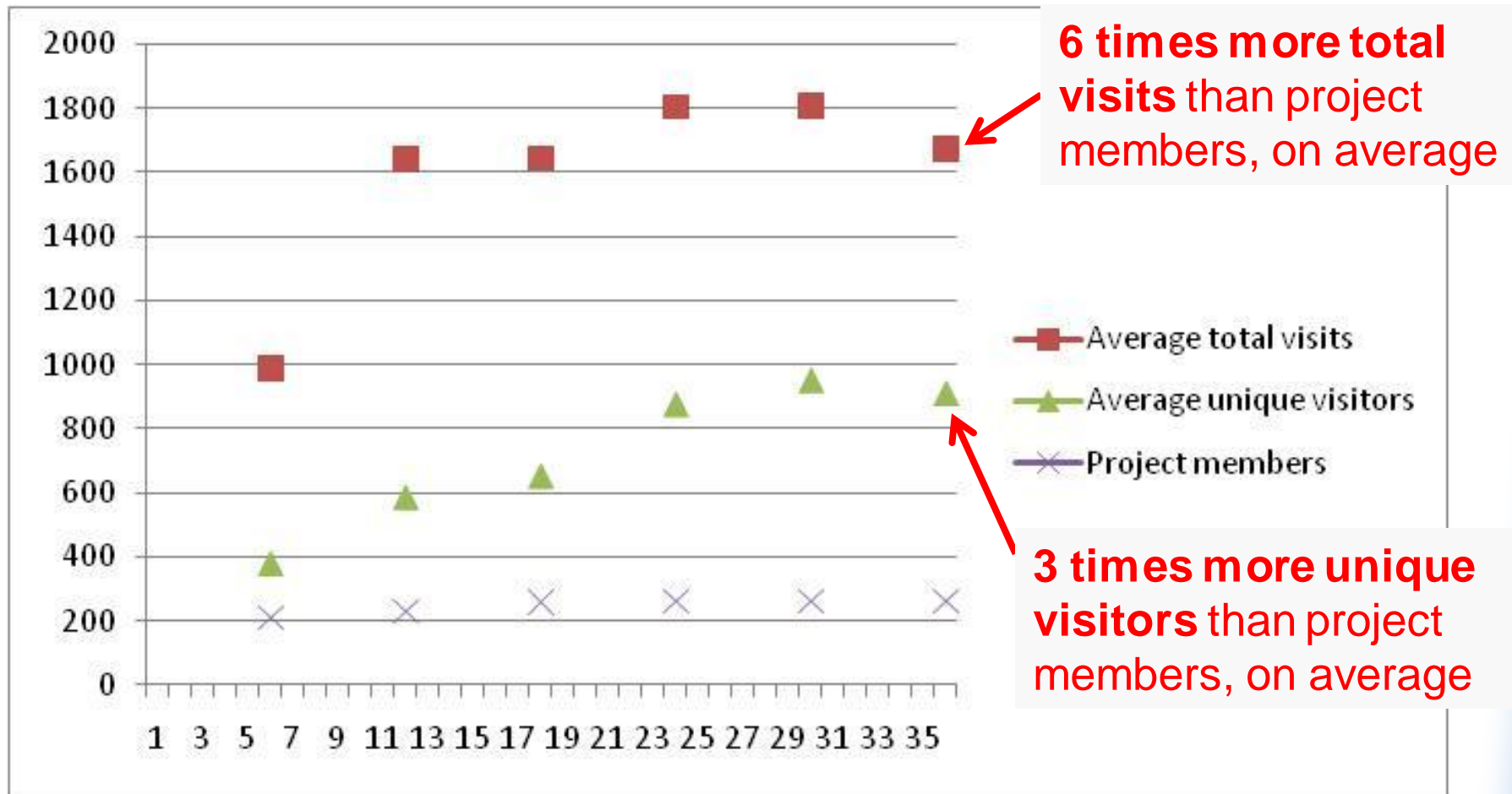
In reality the particles are densest near the centre of the phase space and gradually become less dense as you move further from the centre. The distribution is often assumed to be Gaussian (it extends to infinity), the emittance is normally quoted as the 90% or other percentage emittance, so the area in which 90% of the particles are. The emittance is different for each of the three dimensions.

The reason the emittance is an important quantity is that it is conserved. When the individual particles' position and momentum are changing the total emittance remains the same. It is possible to change the emittance in certain circumstances but while travelling through an ordinary accelerator set up it does not change.

To reduce the emittance some of the energy needs to be removed from the particles. This can be done by making them pass through synchrotron radiation, either by passing through dipole magnets, or through an insertion device. The energy can then be stored in the RF, but in a particular direction, thus reducing the size of the angle (x, y, z) and therefore reducing the emittance.



- Fluctuations over the year, so average visits are shown below



- **Acknowledgement text**

- Please acknowledge EuCARD in your publication
e.g. *Research supported by FP7 EuCARD*
<http://cern.ch/eucard>

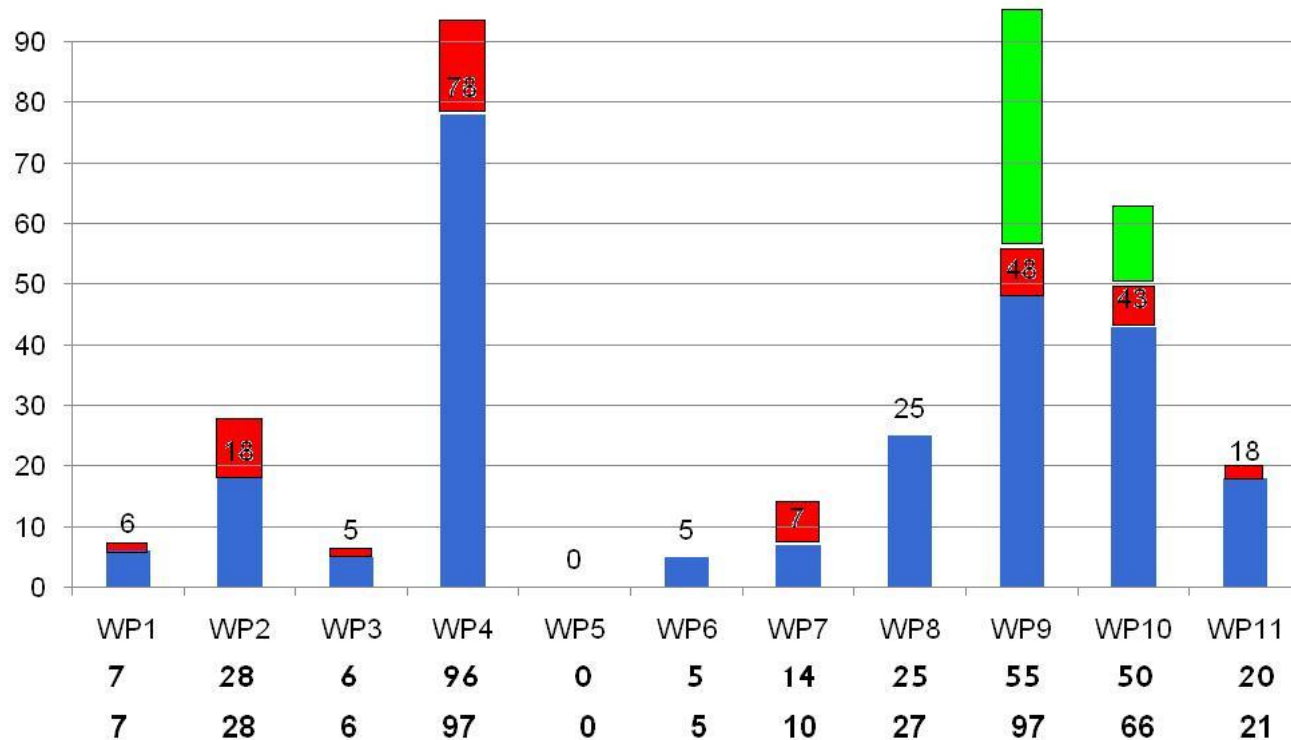
- **Copyright issues**

- For copyrighted material e.g. journals
- Upload an as-final-as-possible preprint to avoid issues

Wish list for version 2	Status
New “miscellaneous” category	Done
More info in notification emails	Done
Allow publications from multiple work packages	Done
Link EuCARD publications to those already in CDS	<p>Foreseen for Period 3</p> <p>Simple tagging does not fulfill consortium agreement:</p> <ul style="list-style-type: none"> - Need automatic front page of acknowledgements - Need to send out automatic approval emails <p>For now submit file copy/pasting details & CDS report number, library then automatically notified to merge 2 CDS entries</p>

- 357 in publication database (24/04/12), was 306 (01/12/11) and 245 (31/03/11)

Number of publications by Work Package



- Red = increase since annual meeting (presented in Dec Steering Committee)
- Green = increase since Dec Steering Committee

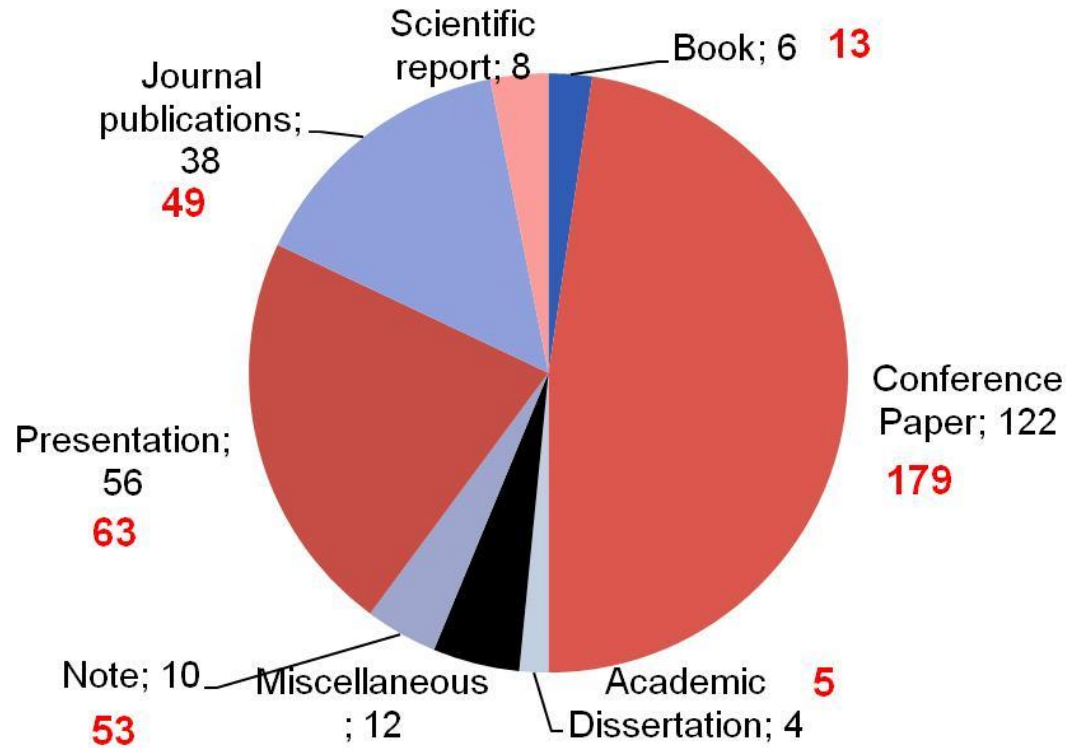
Publications and presentations (12/4/2012)

	M12	M24	M36	
Conf. papers	40	135	179	+44
Presentations	...	60	63	+3
Journal publications	19	38	49	+11
Notes, reports, other	...	36	53	+17
Academic	2	4	5	+1
Books	13	
TOTAL	77	273	362	+89

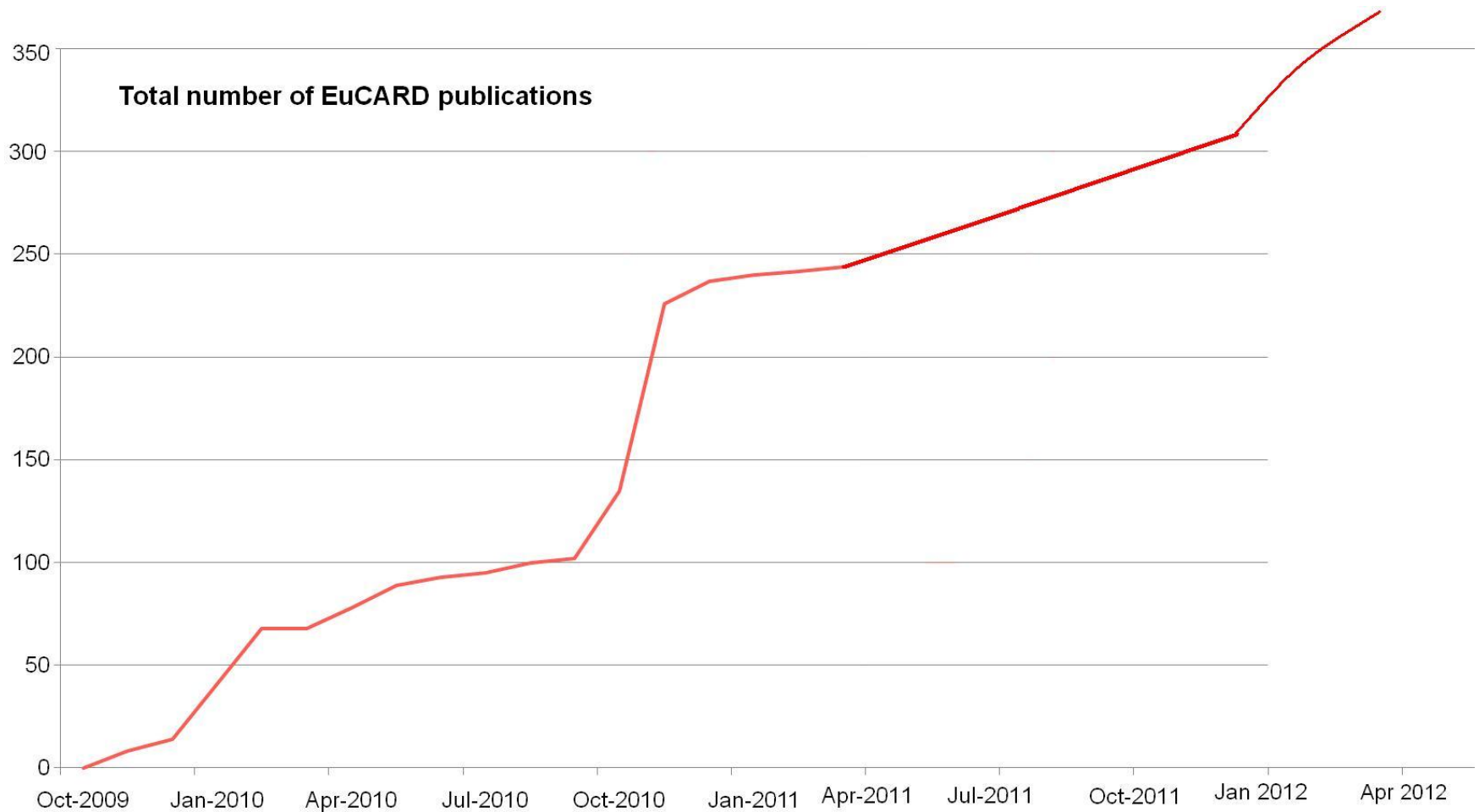
(in CARE, 70 publications per year on average)

EuCARD 2012 management report

EuCARD publications by type: (12/04/2011) and (24.04.2012)

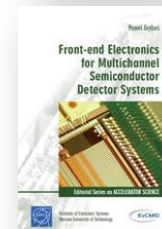
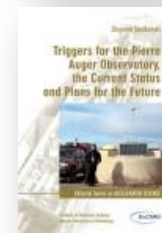


- All types of document produced are encouraged to be submitted



EuCARD Series: 13 volumes published

- **Vol.1.** J.Sekutowicz, *Multi-cell Superconducting Structures for High-Energy e+e- Colliders & Free Electron Laser Linacs*
- **Vol.2.** K.Pozniak, *TRIDAQ Detector Systems for High Energy Physics Experiments*
- **Vol.3.** Z.Szadkowski, *Triggers for the Pierre Auger Observatory, the current status and plans for the future*
- **Vol.4.** R.Aleksan, O.Napoly, *Coordinated Accelerator Research in Europe, Summary of Project Achievements*
- **Vol.5.** H.Mais, *Some topics in beam dynamics of storage rings*
- **Vol.6.** G.Sterbini, *An early separation scheme for the LHC luminosity upgrade*
- **Vol.7.** T.Czarski, *Complex envelope control of pulsed accelerating fields in superconducting cavities*
- **Vol.8.** P.Grybos, *Front-end electronics for multichannel semiconductor detector systems*



5 published since last annual meeting

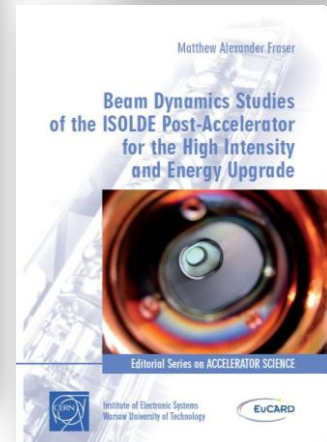
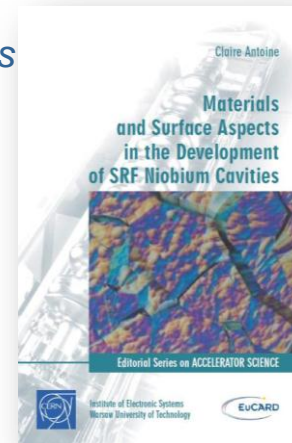
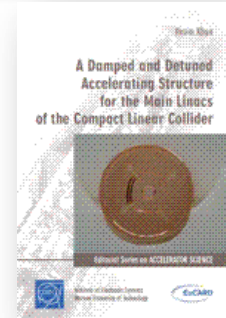
- **Vol.9.** V.Khan, *A damped and detuned accelerating structure for main linacs of the compact linear collider*
- **Vol.10.** W.Weingarten, *European infrastructures for R&D and test of superconducting RF cavities and cryo-modules*
- **Vol.11.** G.Kasprowicz, *Determination of beam intensity and position in a particle accelerator*
- **Vol.12.** C. Antoine, *Materials and Surface Aspects in the Development of SRF Niobium Cavities*
- **Vol.13.** M.A. Fraser, *Beam Dynamics Studies of the ISOLDE Post-Accelerator for the High Intensity & Energy Upgrades*

Next volumes foreseen

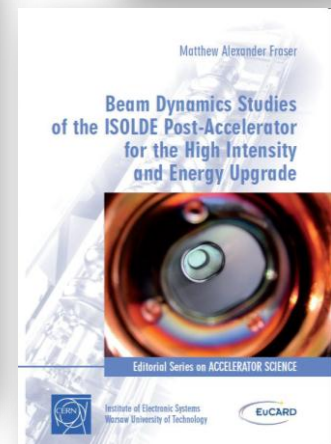
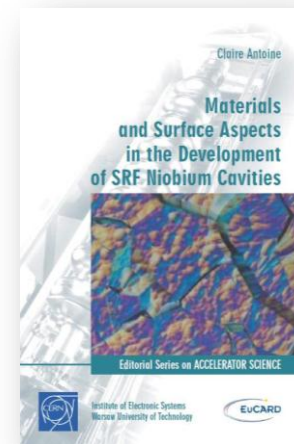
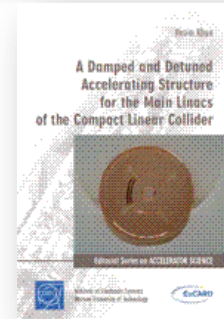
- **Vol.14.** T. Plawski, *CEBAF LLRF upgrade*
- **Vol.15.** S. Wronka, *Selected aspects of security applications based on electron accelerators*
- **Vol.16.** W.Scandale, "Crystals" in Accelerator technology

We encourage potential authors to contact us

<http://cern.ch/EuCARD/activities/communication/booklets/>

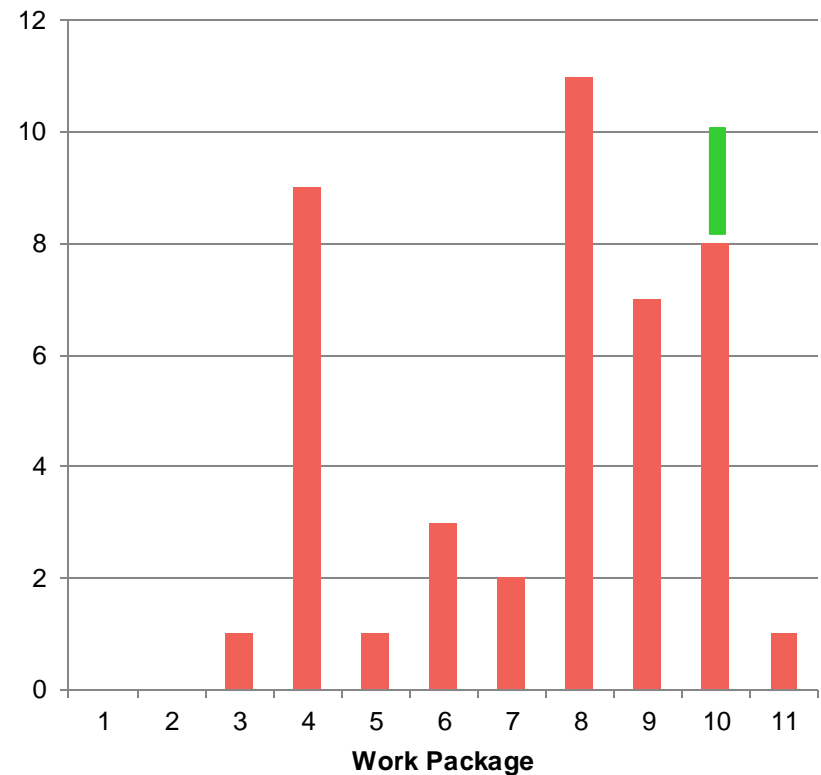


- **Distribution foreseen to**
 - EuCARD partner libraries
 - Steering Committee members
 - Governing Board members
 - SLAC
 - Fermilab
 - KEK
 - Small quantity at CERN for online requests
- **Planned for Period 3**



- We are aware of 45 PhDs being undertaken as part of the project
- PhDs can be added to the list on the intranet
<https://espace.cern.ch/EuCARD/WP2/Lists/EuCARD%20PhDs/AllItems.aspx>
- Please let us know if data is incomplete!

Number of EuCARD PhDs by work package



- **DCO Network:** Work with DCO contacts to enhance flow of information
- **Web site:** Keep events, news and results are up-to-date
- **Newsletter:** Continue extended newsletter
- **Publications**
 - Encourage publications to be submitted into publication database
 - Link EuCARD publications to those already in CDS
- **Monographs**
 - Publish several volumes of EuCARD monographs
 - Distribute monographs
 - Encourage WP coordinators to publish technical results in monographs

WP2: Dissemination, Communication & Outreach (CERN, WUT) Evaluation by Project Coordinator

Results	Possible issues or improvements
D&C: results well beyond contract O: modest	<ul style="list-style-type: none">▪ D&C: insufficient reference to EuCARD support in publications & presentations; focus and distribution of monographs.▪ O: all partners invited to contribute in Outreach, or inform DCO of their actions.

- Showcase your work package achievements by:
 - Suggesting articles for *Accelerating News*
 - Providing images for EuCARD **website**
 - **Acknowledging EuCARD** in your publications
 - **Uploading** scientific publications in **CDS database**
 - Authoring EuCARD **monographs**
 - Informing us of any **outreach** activities you have done
 - Updating **PhD** statistics
- Send material to EuCARD-editor@cern.ch

Any Questions?