Grant Agreement No: 312453

EuCARD-2

Enhanced European Coordination for Accelerator Research and Development

Seventh Framework Programme, Capacities Specific Programme, Research Infrastructures, Combination of Collaborative Project and Coordination and Support Action

MILESTONE REPORT

TRANSPORT CHANNELS WORKSHOP

MILESTONE: MS17

Document identifier:	EuCARD2-Mil-MS17- Final
Due date of milestone:	End of month 18 (October 2014)
Report release date:	05/12/2014
Work package:	WP3: EnEfficient
Lead beneficiary:	GSI
Document status:	Final

The due date has been delayed to Month 20 (December 2014) because the workshop was held on 26th to 28th November 2014

Abstract:

A Workshop on "Compact and Low Consumption Magnet Design for Future Linear and *Circular Colliders"* was hold at CERN on Wednesday 26th November to Friday 28th November 2014. Aim of the workshop was to bring together experts from Laboratories and Industry working on magnet design mainly focusing on the two aspects of consumption and compactness.

The European Coordination for Accelerator Research and Development (EuCARD-2) is a project co-funded by the European Commission in its 7th Framework Programme under the Grant Agreement no 312453. EuCARD-2 began in May 2013 and will run for 4 years.

Delivery Slip

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1. WORKSHOP SUMMARY

The workshop put together participants of the main European Accelerator Physics Laboratories plus colleagues from Russian, Japanese and United States Laboratories as well as few industrial representatives. The subjects covered were mainly:

- *Status of compact magnet design at the main European Laboratories (highlighting the energy saving aspects).*
- *Status of magnet design investigation for the main future linear and circular accelerators projects (highlighting the energy saving aspects).*
- *Some specific magnet design saving technologies presentation and discussions.*
- *General estimation, analysis and trends for electrical energy consumption in the western countries, as well as analysis of efficiency and cost impact for future accelerator projects.*

The workshop successfully covered the above list of subjects. The participation and presentations were in big majority done with a positive "workshop attitude". Various magnet technologies were presented and discussed, including general design proposal and solutions and real applications done in different Laboratories and Projects.

In some cases, (ex. for power supplies vs. magnet integration, or for beam dynamic request for future projects) the discussions between speakers and audience, were lively and contributing positively to a real mutual comprehension between the experts of the different systems.

2. BASIC DETAILS ABOUT THE WORKSHOP (LANDSCAPE FORMAT)

Type of activity	Workshop
Title	"Compact and Low Consumption Magnet Design for Future Linear and Circular Colliders"
Date	26 to 28 November 2014
Place	CERN, Geneva, CH
Type of audience	Scientific community and Industry
Size of audience	60-70 persons
Scope of the workshop	International
Link	https://indico.cern.ch/event/321880/
Present Institutions	CERN, DESY, Diamond Light Source Ltd, EuCARD2, GSI, Elettra-Sincrotrone, ESRF, Fermilab, IEA, JINR, KEK, Max IV Lab, PSI, STFC Daresbury Laboratory, Synchrotron Soleil, Vacuumschmelze Gmbh, Voestalpine Stahl Gmbh.

3. MAJOR OUTCOMES / RELATION TO OTHER EUCARD-2 WORK

3.1. INTRODUCTION

The workshop put together participants of the main European Accelerator Physics Laboratories, of Fermilab (USA) and KEK (J) as well as few industrial representatives (from permanent magnet, soft magnetic material and special steel manufacturing companies). The subjects covered were mainly:

- Status of compact magnet design (highlighting the energy saving aspects) at the main European laboratories and at Fermilab and KEK.
- Status of magnet design (highlighting the energy saving aspects) at the main future linear and circular accelerators projects.
- Specific magnet design saving technologies presentation and discussion. General estimation, analysis and trends for electrical energy consumption in the Western countries, as well as analysis of efficiency and cost impact for future accelerator projects.
- General estimation, analysis and trends for electrical energy consumption in the western countries, as well as analysis of efficiency and cost impact for future accelerator projects.

3.2. WORKSHOPS TALKS CONTENT

The workshop successfully covered the subjects listed above. The speakers presentations and participation to the discussion after each talk were in majority done with a real positive “workshop attitude” (i.e. presenting technical details; presenting the analysis and solving of practical problems and of procurement aspects; adding exhaustive references list, etc.).

A variety of magnet technologies were presented. Some presentations (ex. in-vacuum magnet design, iron dominated pulsed SC design, the overall possible saving opportunities in magnet design) included theoretical aspects and highlighted the advantages of the different design possibilities.

The majority of the talks were reporting the direct experience on past, present and future project in Particle Accelerator Laboratories in Europe in US (Fermilab) and in Japan (JPARC and KEK).

The Workshop covered the majority of magnet designs that can have positive impact for energy saving for example:

- Compact (small aperture) normal conducting electromagnets (EM),
- Permanent magnets (PM),
- Hybrid (EM+PM) magnets,
- Pulsed magnets (reducing r.m.s. current and consumption for a potential cost saving).
- Super-ferric magnet design (with cold and warm iron yokes).

- Superconducting (coils dominated) compact magnets design.

Two industrial representatives were invited to talk about specific aspects related with innovative materials for energy saving in magnet design. The subjects were:

- Permanent magnets alloys and soft magnetic materials (by Vacuumschmelze, D)
- Electrical and special steels for magnet applications (by Voestalpine, A)

3.3. DISCUSSIONS

The status of energy saving approaches at the different Laboratory and Projects show different and valuable solutions (ex. the transfer lines (TL) saving approach at GSI, the extreme integration of accelerator lattice components at Max IV Lab, the compact SC coils dominated magnet design at JPARC (KEK), the studies for CLIC transfer lines fully based on PM).

In several cases very interesting and lively discussions took places between speakers and experts of different technical subsystems linked to magnet design and operation (ex. magnet design engineers, beam physicists, power supplies engineers, etc.).

3.4. CONCLUSIONS

The workshop presented many innovative developments for efficient and compact accelerator magnets. The main outcomes are listed below:

1. The Transfer Lines (TL) systems are probably the best candidates to be studied in view of efficient solutions concerning energy saving. The WS presented many examples of TL studies and realizations showing pro and contra of different room temperature and cryogenic solutions.
2. The Permanent Magnet (PM) technology is mature for wide application in the domain of Particle Accelerators. The talk about the experience obtained with the Recycler Ring built at Fermilab is a clear example. Also the results on PM long term stability obtained in wigglers and undulators confirm this point. The PM market is nowadays more focused on applications for electrical motors, but in case a future accelerator project will demand big amounts of PM materials, the market should not have problem to follow requests in this direction.
3. Piezo-movers utilized in the nano-positioning technology can be also applied in the Particle Accelerator domain. Using piezo-movers will permit to work with more compact magnets as they can be used to perfom high precision alignments. Up to now this solution is only envisaged in CLIC project. It is expected that the market can easily answer to a large scale procurement and will be able to supply specific piezo-movers with larger stroke, and admissible loads (weight).
4. Magnetic measurements are developing “ad hoc’ systems, based on printed circuit board (PCB) rotating coils and on new methods using stretched wires for magnetic field quality measurements, in order to deal with magnetic measurements of very small aperture magnets.
5. Synergies with other accelerator domains became visible. At least in three cases it was highlighted as synergies with experts of the systems complementary to the magnet design will have very positive effect:

a. Beam Dynamics: The colleagues of BD start their lattice design for future project on "what the magnet experts can design/built" and this is based on their previous experience/knowledge. In case of improved and positive collaboration the magnet and the magnetic lattice design can be performed iteratively and together in order to increase the efficiency of the overall particle accelerator.

b. Magnetic Measurements: The possibility to perform MM turning the magnets around its main symmetry axes will permit to investigate and better determine any systematic magnetic field error. This will lead to significant advantages for future accelerator operation and performance. Evidently these possibilities of easily turning the magnet during the MM phase must be studied and integrated from the beginning of the magnet design process.

c. Power Supply: Two talks highlighted this aspect. A magnet and its power supply (PS) is an indissoluble couple. The better the design of the magnet coils and connecting cables is done, taking into account also the required parameters for the PS, the more efficient and economic can be the procurement and integration of the full system. This is more difficult to be applied when magnets are recovered from existing accelerator systems and the electrical parameters of the coils are already fixed.

ANNEX: GLOSSARY

Acronym	Definition
WS	Workshop
EM	Electro Magnets
PM	Permanent Magnet
SC	Super Conducting
TL	Transfer Line
BD	Beam Dynamic
PS	Power Supply
MM	Magnetic Measurement
PCB	Printed Circuit Board