Summary of EuCARD WP4 Accelerator Science Networks "AccNet" 2009-2013

Zimmermann, F (CERN)

03 July 2013

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EuCARD WP4 - Accelerator Networks

Frank Zimmermann, CERN/BE

thanks to
Ralph Assmann, Mariusz Grecki, & Jean-Pierre Koutchouk

EuCARD 2013 Workshop
CERN, 10 June 2013
partners/contributors: DESY, GSI, INFN, CI, PSI, CERN, US-LARP, KEK, UJF, EU universities in particular Polish & French institutes, ANL, SNS, BINP, ... (>60 institutes!)

3 scientific work packages:

- **RFTech** – RF technologies
- **EuroLumi** – high-intensity high-brightness accelerators and colliders (LHC upgrades, FAIR, etc.)
- **EuroNNAc** – novel accelerators  [*added in 2010*]

impact/results:
43 workshops ; > 160 documents; new concepts & proposals (LHC crab cavities, (V)HE-LHC, TLEP, SAPPHiRE, AWAKE, RF SSA,...); new collaborations

http://cern.ch/accnet
first ACCNET meeting: 04.12.2008
Annual AccNet Steering meetings

e.g. 2nd general AccNet Steering meeting, RAL, 13 April 2010
Annual AccNet Steering meetings

e.g. 3rd general AccNet Steering meeting, CNRS, May 2011
EuCARD-AccNet coordination

Coordination & Management
coordinated by Walter Scandale [Alessandro Variola], IN2P3; Peter Spiller, GSI; Frank Zimmermann, CERN

EuroLumi
accelerators & collider performance
coordinated by Frank Zimmermann & Ezio Todesco, CERN

RFTech
sc & nc rf technologies
coordinated by Jean-Marie de Conto, UJF; Mariusz Grecki, DESY; Wolfgang Weingarten, CERN

EuroNNAc
novel accelerators
coordinated by Ralph Assmann, CERN; Arnd Specka, [Henri Videau] E.Pol.; Jens Osterhoff, DESY
EuroLumi: network on accelerators & collider performance
brainstorming & proposing novel concepts

15+11 topical workshops in 4 years, gathering EU, Swiss, US, Japanese & Russian accelerator scientists and more

recognized place for world-level discussions, largely sponsored by participants

important source of proposals for CERN and European HEP:

• turned crab cavities into a realistic possibility for an optimal LHC upgrade: now CC’s now at the heart of the LHC luminosity upgrade
• launched brainstorming on higher-energy pp colliders: HE-LHC/VHE-LHC
• launched brainstorming on TLEP as an alternative to LC’s, with large potential for its longer tunnel
• launched brainstorming on ERL based gg colliders – SAPPHiRE, HFiTT

initiation of new collaborations with ESA/ESTECH space satellite community on electron-cloud modeling; with Mexico (CINVESTAV, CONACYT) on HL-LHC (e-cloud, crab cavities, H-source); with laser industry, LLNL & ICAN (SAPPHiRE)
RFTech: network on SC & NC RF technologies
joining communities & exploiting synergies

4+18 topical workshops in 4 years, gathering EU, Swiss, US and Japanese accelerator scientists and more

joint meetings of RF experts from different communities, e.g. working on hadron and lepton beams, on accelerators and RF systems for space satellites, on light sources, NP or HEP facilities, on rings and linacs,...

- exchange over all aspects of RF systems: structures, electro-magnetic field calculations, LLRF, SS power amplifiers, RF for LHC, for FELs, for crab crossing, costing procedures & tools, ...
- important report on strategy for SC technology and test stations
- report on general strategy for RF technologies in preparation

initiation of new collaborations with ESA/ESTECH & VALSPACE space satellite community on multipacting simulations & high-gradient breakdown studies
EuroNNAc: network on novel accelerators

exploiting synergies & proposing novel concepts

5 topical workshops in 3 years, gathering EU, Swiss, US and Russian accelerator & plasma scientists and more

initiated as a voluntary EuCARD NA after exchanges with V. Malka (JRA), R. Assmann (EuCARD Deputy Coordinator at the time), and others.

Goals:
• creating a stronger link between PWA and accelerator communities;
• working together in EU to combine forces;
• creating new infrastructures dedicated to PWA (“from acceleration to accelerators”)

Impact:
• successful workshops to prepare a roadmap;
• EuroNNAc PWA network included in EuCARD2, links established with initiatives in lasers and PWA (ICAN/IZEST,...)
EuroLumi – main themes

improving LHC & preparing HL-LHC & FAIR

• LHC *optics* measurement & correction (2 workshops)
• *e-cloud* (3 workshops, collaboration w ESA & Mexico)
• *space charge* (1 CERN-GSI workshop)

HL-LHC

• advanced *crab cavities* to baseline! (2 workshops & Mex.)
• crystal collimations (2 workshops)
• LPA, *flat beams & crab-waist option* (together w WP11)

beyond HL-LHC

• HE-LHC (1 workshop)
• VHE-LHC (1 workshop)
• LEP3 & TLEP (5 workshops)
• SAPPHiRE (1 workshop)

*after start of CERN/EU LHC HiLumi project; EuroLumi activities refocused on the time after HL-LHC*
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<th>Date</th>
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<tr>
<td>16.-18.09.2009</td>
<td><strong>LHC-CC09, 3rd LHC crab cavity workshop</strong>, CERN</td>
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<td>12-13.10.2009</td>
<td><strong>AccNet EuroLumi Workshop on Anti E-Cloud Coatings that require no activation &quot;AEC'09&quot;</strong>, CERN</td>
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<td>09.-10.11.2009</td>
<td><strong>EuCARD-AccNet-EuroLumi mini-Workshop on Crystal Collimation</strong>, CERN</td>
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<td><strong>Working meeting on proton driven plasma acceleration PPA09</strong>, CERN</td>
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<td>02.-04.02.2010</td>
<td><strong>AccNet Co-Sponsored Workshop on &quot;Physics for Health in Europe&quot;</strong>, CERN</td>
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<td>11.-12.03.2010</td>
<td><strong>Workshop on Proton Driven Plasma Wake Field Acceleration</strong>, CERN</td>
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<td>25.-26.10.2010</td>
<td><strong>Annual Workshop on Crystal Collimation</strong>, CERN</td>
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<td>15.-17.12.2010</td>
<td><strong>LHC-CC10, 4th LHC Crab Cavity Workshop</strong>, CERN</td>
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<td>07.-08.03.2011</td>
<td>CERN-GSI Electron-Cloud Workshop, CERN</td>
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<tr>
<td>20.-21.06.2011</td>
<td>Workshop on Optics Measurement, Correction &amp; Modelling &quot;OMCM&quot;, CERN</td>
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<td>21.-23.09.2011</td>
<td>MulCoPim'11, Valencia</td>
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<td>14.-15.11.2011</td>
<td>LHC-CC11- 5th LHC Crab Cavity Workshop, CERN</td>
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<td>05.-09.06.2012</td>
<td>ECLoud'12, INFN-LNF/INFN-Pisa/LER/EuCARD-AccNet Joint workshop, Elba</td>
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<td>18.06.2012</td>
<td>1st EuCARD AccNet LEP3 Day, CERN</td>
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<td>23.10.2012</td>
<td>2nd EuCARD AccNet LEP3 Day, CERN</td>
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<td>14.-16.11.2012</td>
<td>2nd Joint HiLumi LHC - LARP Annual Meeting, Frascati, Italy</td>
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Eurolumi (co-)organized events, 2013

10.01.2013  3rd EuCARD AccNet TLEP3 Day, CERN
15.-16.01.2013 EuCARD co-sponsored WAMSDO workshop on magnets quenches, CERN
19.02.2013  EuCARD AccNet SAPPHiRE Day, CERN
04.05.2013  4th TLEP mini-workshop, CERN
16.-19.04.2013 SpaceCharge2013, CERN, Switzerland
17.-18.06.2013 LHC Optics Measurement and Corrections Review, CERN
25-26.07.2013 5th EuCARD TLEP mini-workshop, FNAL
MULCOPIM ’11
21, 22, 23 September 2011
Valencia, Spain

Particle Accelerators
technical sponsors

ACCONET
EuCARD
MulCoPim topics: multipactor components, multipactor Tx lines, multipactor dielectrics; corona, multipactor experimental, multipactor software, multipactor multichannel; PIM, SEY, Accelerators
LHC-CC09 workshop

LHC Crab Cavity Workshop, jointly organized by CERN, EuCARD-ACCNET, US-LARP, KEK, & Daresbury
Lab/Cockcroft Institute
CERN, 16-18 September 2009

~50 participants, LHC Crab Cavity Advisory Board established
5th Joint EuCARD-AccNet – LARP – KEK – CI/DL workshop on LHC crab cavities, LHC-CC11
14-15 November 2011, CERN

https://indico.cern.ch/conferenceDisplay.py?confId=149614

Participants: about 52 persons (many institutes in Europe, US, and Japan)
46+3 presentations

Main results: convergence to 2 (3) compact crab-cavity designs; first Al prototypes; detailed cavity specifications will be prepared by April 2012 based on initial set of HL-LHC parameters; beam test of the compact design in the SPS and the LHC are pre-requisites for a final installation in LHC Points 1 and 5.

Organizers:
Rama Calaga, Rogelio Tomas, Frank Zimmermann
LHC crab cavities: only 19 cm beam separation, but long bunches

in 2004 considered on the “imaginary” axis, but now thanks to AccNet part of HL-LHC baseline¹

final compact cavity designs: 4-rod cavity design by Cockcroft I. & JLAB (left), $\lambda/4$ TEM cavity by BNL (centre), and double-ridge $\lambda/2$ TEM cavity by SLAC & ODU (right)

prototype compact $Nb-Ti$ crab cavities for the LHC: 4-rod (left) and 2-ridge cavity (right)
AccNet mini-workshop on crystal collimation in 2010
CERN, 25-27 October’10, ~32 participants, about 1/3 from CERN, and others from Italy (INFN Ferrara, Legnaro, Napoli, Roma), Russia (JINR Dubna, IHEP Moscow, St. Petersburg), Germany (GSI Darmstadt), UK (Imperial College), USA (SLAC), and Switzerland (EPFL Lausanne).

http://indico.cern.ch/conferenceDisplay.py?confId=109124

topics:
• collimation procedures assisted by bent crystals for HL-LHC and future large colliders
• critical review of results from H8 line,
• results of collimation experiments in “low energy” storage rings, such as the SPS,
• possible use of bent crystals for LHC collimation
• other applications of crystals and alternative advanced methods of collimation in other laboratories
Crystal clear ideas for beam collimation

October marked the annual crystal collimation workshop at CERN, where encouraging results from tests in CERN’s Super Proton Synchrotron (SPS) were revealed. These show potential for crystal collimation applications, possibly even in the LHC.

Crystallizing collimation ideas

In particle accelerators, collimators trim and filter a beam, removing stray particles and keeping the beam focused and on track. Collimator R&D forms part of the EuCARD project (WP8) and conventional collimators are usually made from about 1 metre of carbon, though designs vary (see newsletter issue 3).

What makes crystal collimation a novel approach is that it performs the role of the 1m of carbon with just half a centimetre of silicon crystal. Large magnetic fields created by the atoms of the crystal create a large deflection of the beam halo.

The current SPS experiment, known as UA9, is looking at effects of crystal collimation in a circular machine, where the beam interacts with the crystals many times.

This 2mm-thick transparent slice (shown here in a metallic frame) is a quasimosaic silicon crystal. It is one of the new crystals currently being tested in CERN’s Super Proton Synchrotron (SPS). Image courtesy of Walter Scandale. Thumbnail image main page courtesy of Nico van Diem, sxc.hu.
EuroLumi E CLOUD’12, Elba, 5-9 June 2012

• reviewed recent e-cloud observations at LHC, DAFNE, PETRA-III, Cesr-TA, J-PARC,.. & e-cloud predictions for SuperKEKB, SuperB, Project-X, ISIS upgrade, RHIC upgrade, HL-LHC, HE-LHC, ILC,..
• established & strengthened links with space community (ESA, Val Space consortium, ONERA, ICMM, Princeton SPL, EPFL LEMA,...)
• discussed new powerful simulation tools (SYNRAD3D/Cornell, OSMOSEE/ONERA, PyE CLOUD/CERN, WARP-POSINST/LBNL, BI-RME-E CLOUD/EPFL, FEST3D/Aurora, ...)

62 participants
ECLOUD’12 photos

EuCARD *workshop proceedings* in print (eds. R. Cimino, G. Rumolo, F. Zimmermann); in addition PRST-AB special edition ECLOUD’12
A recent workshop reviewed the latest experiences with the phenomenon of electron clouds at the LHC and other accelerators.

Electron clouds—abundantly generated in accelerator vacuum chambers by residual-gas ionization, photonemission and secondary emission—can affect the operation and performance of hadron and lepton accelerators in a variety of ways. They can induce increases in vacuum pressure, beam instabilities, beam losses, resonance growth, and collect on the beam lifetime or additional heat load on a (cold) chamber wall. They have recently regained some prominence since autumn 2010, all of these effects have been observed during beam commissioning of the LHC.

Electron clouds were recognized as a potential problem for the LHC in the mid-1990s (CERN Courier July/August 1999 p39) and the first workshop to focus on the phenomenon was held at CERN in 2000 (CERN Courier July/August 2000 p35). Ten years later, the fifth electron-cloud workshop has taken place, again in Europe. More than 60 physicists and engineers from around the world gathered at La Biolle, Elba, on 3–5 June to discuss the state of the art and review recent electron-cloud experience.

Valuable test beds
Many electron-cloud signatures have been recorded and a great deal of data accumulated not only at the LHC but also at the CESR Damping Ring Test Accelerator (CeaTAT) at Cornell, DAΦNE at Frascati, the Japan Proton Research Complex (J-PARC) and PETRA III at DESY. These machines all serve as valuable test beds for simulations of electron-cloud build-up, simulations and heat load, as well as for new diagnostics methods. The latter include measurements of synchronous phase-shift and recombination effects at the LHC, as well as microwave transmission, coded-aperture images and time-resolved shadow pickup at CeaTAT. The impressive resemblance between simulation and measurement suggests that the existing electron-cloud models correctly describe the phenomenon. The workshop also analyzed the means of mitigating electron-cloud effects that are proposed for future projects, such as the High-Luminosity LHC, SuperKEKB in Japan, SuperLPC in Italy, Project X in the US, the upgrade of the ESS machine in the UK and the International Linear Collider (ILC).

An international advisory committee has assembled an

ECL12oud2 s
on electron

The first look at a new boson

Some aspect of New codes
from computer
devoted to the
study of electron-cloud phenomena
and SuperB are less finalized and perhaps more challenging.

ECL12oud2 was organized jointly and co-sponsored by INFN-Frascati, INFN-Pisa, CERN, EucARD-AccNet (CERN Courier November 2009 p16) and the Low Emittance Ring (LER) study at CERN. In addition, the SuperB project provided a workshop on "Made in Italy". The participants also enjoyed a one-hour football match (another novel feature) between experimental and theoretical electron-cloud experts—the latter clearly outnumbered as well as post-dinner discussions until well past midnight. The next workshop of the series could be ECL12oud2, which would coincide with the 50th anniversary of the first observation of the electron-cloud phenomenon at a small proton storage ring in Wisconsin and an explanation by Gersh Bitter.

* For all of the presentations at ECL12oud2, see http://agenda.infn.it/3ec12oud2/OtherViews.py?view=standard&confId=4033. The ECL12oud2 workshop was dedicated to the memory of the late Francesco Ruggiero, former leader of the accelerator physics group at CERN, who launched an important remedial electron-cloud crash programme for the LHC in 1997.

Revue:

ECL12oud2 : un savoir plus sur les mangles d’électrons

Les mangles d’électrons produits dans les accidents à vide peuvent avoir des effets sur le fonctionnement et la performance des accélérateurs. Ces phénomènes ont été reconnus au milieu des années 1990 et des mesures ont été prises pour les contrôler à l’ECL12oud2, qui a récemment réuni des experts de différents pays pour discuter des phénomènes et de leurs effets sur l’énergie. Les participants sont venus de la plupart des accélérateurs du monde, et ont partagé leurs expériences pour mieux comprendre et gérer ces phénomènes. Le résultat de ce travail est un meilleur compréhension des mangles d’électrons et une meilleure performance des accélérateurs.
SAPPHiRE: Small Accelerator for Photon-Photon Higgs production using Recirculating Electrons

workshop topics:
laser system,
optical cavity,
IR design,
FEL approaches

scale ~ European XFEL,
about 10-20k Higgs per year

step towards linear collider,
20-nm spot sizes,
first-rate physics
EuCARD-AccNet SAPPHiRE Day, 19 February: laser

Y. Zaouter, Amplitude Systems

G. Mourou, LOA;
M. Velasco, Northwestern U.
(after SAPPHiRE Day)

SAPPHiRE laser

Risk:
- High
- Medium
- Low

Cavity enhancement
- Q = 1000
- 5 J, 10 MW circuit

Amplifier + Compressor

THG

Cavity enhancement

A possible laser system for SAPPHiRE

Another possible laser system for SAPPHiRE

J. Gronberg, LLNL


10 J at 10 kHz

A 3rd possible laser system for SAPPHiRE – synergy with ICAN!
EuroLumi: HE-LHC & VHE-LHC

EuCARD-AccNet workshop HE-LHC’10, Malta, 14-16 October 2010

56 participants (13 US, 26 CERN)
Proceedings (ed. E. Todesco, F. Zimmermann)
“EuCARD-AccNet EuroLumi Workshop: The High Energy Large Hadron Collider”
arXiv:1111.7188 ; CERN-2011-003

→ HE-LHC included in HiLumi LHC WP16 (2011)

Joint Snowmass-EuCARD/AccNet-HiLumi LHC meeting 'Frontier Capabilities for Hadron Colliders 2013’ a.k.a. VHE-LHC Days, 21-22 February 2013
Proposed increase in energy takes LHC even further into the future

Accelerator scientists from around the world came together in Malta in October to discuss the possibility of increasing the energy of the present LHC. Organised by AccNet within EuCARD, the High Energy (HE) LHC workshop was convened to discuss the possible future LHC upgrade to a 16.5 TeV beam machine.

Participants in the HE-LHC'10 workshop. Image courtesy of Kazuhito Ohmi. Thumbnail image on main page courtesy of CERN.
Joint Snowmass-EuCARD/AccNet-HiLumi LHC meeting 'Frontier Capabilities for Hadron Colliders 2013’ a.k.a. VHE-LHC Days, 21-22 February 2013

topics: parameters & 20-T magnets for a 33-TeV & 100-TeV c.m. pp colliders, magnet R&D status & plans at CERN & LBNL, antiproton option,...
1st EuCARD LEP3 Day, 18 June 2012

physics case, beam parameters, beam dynamics (beamstrahlung), hardware (RF, vacuum, magnets), tunnel,...

~40 participants

followed by series of AccNet LEP3 & TLEP mini-workshops:

1st EuCARD LEP3 Day, 18 June 2012, CERN
2nd EuCARD LEP3 workshop, 23 October 2012, CERN
3rd EuCARD TLEP3 workshop, 10 January 2013, CERN
4th EuCARD TLEP mini-workshop, 4-5 April 2013, CERN
5th EuCARD TLEP mini-workshop, 25-26 July 2013, FNAL
Circulating ideas about a new Higgs factory

Frank Zimmermann (CERN)

Could the LHC tunnel one day house a high-luminosity electron-positron collider? This idea joined others at the LEP3 Day, held at CERN on 18 June 2012.

In 2011, early LHC indications suggested that the Higgs boson might be light, with a mass in the range 115-130 GeV. On Christmas’ Eve 2011 the first concrete proposal for a high-luminosity circular electron-positron collider was presented after Alain Blondel of Geneva University realised that an object like this could be studied in the LHC tunnel at about 240-GeV centre-of-mass energy.

This, along with the numerous encouraging reactions to this proposal, led the EuCARD Work Package 4 “AccNet” to organise a “LEP3 Day”, which was only a few weeks before the LHC’s ATLAS and CMS experiments announced the discovery of a Higgs-like boson with a mass of 125 GeV. About 40 motivated accelerator physicists from Switzerland, Japan, Russia, US and the UK participated in this EuCARD LEP3 Day, including Steve Myers, CERN Director of Accelerators and Technology, the KEK trustee Yasuhiro Okada, and members of CMS and ATLAS. A full report on the LEP3 Day is now available.

EuCARD “LEP3 Day” looks at circular Higgs factories

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Alain Blondel opened by recalling the short history and key elements of a high-luminosity circular collider Higgs factory, “LEP3,” in the LHC tunnel. The projected target performance achieved 500 times the luminosity of LEP at 15% higher beam energy while respecting acceptable power consumption limits. This was made possible by three innovations: (1) using a lower-emittance optics (e.g. as for the LHeC project), (2) much stronger focusing at the collision point (albeit not quite as strong as for the SuperB factories), and, in particular, (3) complementing the collider ring running at constant energy with a fast cycling accelerator ring for top-up injection. He explained how this top-up injection is necessary at luminosities at the $10^{32}$cm$^{-2}$s$^{-1}$ level because the beam lifetime, due to radiative Bhabha scattering, will be only 15-20 minutes (for comparison at the former LEP2 it was a couple of hours).

Keywords: LEP3, EuCARD, LHC"
AccNet articles in Accelerating NEWS issue 5

Targeting the Energy Frontier for next Accelerators by Frank Zimmermann (CERN)

Recently two EuCARD AccNet events explored options for the next accelerators at the energy frontier. The EuCARD “SAPPHIRE DAY” on 19 February focused on the key components of a proposed g-g collider Higgs factory, based on a recirculating SC linac. The “Joint Snowmass-EuCARD/AccNet-HilumilHC meeting on Frontier Capabilities for Hadron Colliders 2013” on 21-22 February investigated the next generations of hadron colliders up to the 100 TeV scale. Both workshops attracted about 50 experts from around the world.

The proposed SAPPHIRE layout is a moderately expensive step towards a higher-energy linear collider, demonstrating the handling of 20-μm spot sizes while delivering first-rate physics results. The emphasis of the SAPPHIRE Day was on the laser system, optical cavity, interaction region design, and FEL approaches.

The joint workshop on frontier capabilities explored the parameters and 20-T magnets for a 53-TeV c.m. pp collider in the existing LHC tunnel and for a 100-TeV c.m. collider in a new 80-km tunnel. The workshop reviewed the high-field magnet development status and plans at CERN and LBNL.

“TLEP” — Circular Higgs Factory and a Long-Term Perspective for High Energy Physics by Frank Zimmermann (CERN)

Following the first EuCARD “LEP3 Day” on 18 June 2012 (see article ‘Circulating ideas about a new Higgs factory’ in Accelerating News issue 3), which revealed a great interest in a circular-collider “Higgs factory”, EuCARD Work Package 4, AccNet, has been organizing several workshops discussing the key ingredients, the physics potential, experimental detector concepts, and synergies with other projects of such a facility.

Emphasis has shifted from LEP3, a machine installed in the 27-km LHC tunnel originally proposed, to TLEP, an electron-positron collider in a new 80 or 100-km long ring tunnel. Advantages are manifold: TLEP construction would be fully decoupled from LHC/HL-LHC operation. TLEP could achieve up to 5 times higher luminosity than LEP3, promising a precision for Higgs coupling measurements much better than any other planned or proposed machine. Such precision is needed to discover physics beyond the standard model at energies above 1 TeV. In addition, TLEP could possibly provide the infrastructure (tunnel, cryogenics, injector, ring magnets, detectors) for a future 100-TeV proton-proton collider in the same tunnel — the “Very High Energy LHC” or “VHE-LHC” —, paving a path towards extremely high hadron collision energies, while also allowing for highest-energy electron-proton collisions.

Presently a TLEP conceptual design study is being set up aiming at delivering a design report by 2014/2015.

Read more >>
possible long-term strategy for HEP emerging from AccNet workshops & studies

VHE-LHC ($pp$, up to 100 TeV c.m.)

same detectors!? & $e^\pm$ (120 GeV) – $p$ (7, 16 & 50 TeV) collisions ($[(V)HE-]TLHeC$

≥50 years of $e^+e^-$, $pp$, $ep/A$ physics at highest energies
RFTech – main themes

cavities, cryomodules, couplers

- Spiral-2 couplers, HIE ISOLDE cavity & test cryostat, LHC crab cavities, Perturbation methods for cavity calculation, finite integration Maxwell solvers and FEM schemes,...

SC & NC linacs, rings, “projects”

- SPL, FLASH full beam loading, X & C band, SwissFEL, LHC RF limits, MYRRHA/MAX, CLIC, TESLA, ELI-NP, LHeC ERL, TLEP, LHC, PS Booster, MedAustron

RF power sources

- SSAs at PSI, ESRF and SOLEIL; klystron lifetimes & efficiency

low level RF

- LHC LLRF, xTCA, high reliability digital system, CERN PS renovation, SuperB, FLASH, uTCA for XFEL machines, synchronization

RF costing tools, RF diagnostics, reliability

SRF test & R&D infrastructure

- TUD SRF test stand, Grenoble SBT, Saclay, Orsay
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RFTech (co-)organized events, 2011-13

17.-21.10.2011  LLRF-2011, DESY
14.-15.11.2011  LHC-CC11 on LHC Crab Cavities, CERN
12.-13.12.2011  Third Annual RFTech Meeting, Rostock
24.-26.05.2012  MixDes2012, Warsaw,
11.-15.06.2012  IEEE RT2012, Berkeley
25.-27.06.2012  HOMSC2012 workshop, Daresbury
06.-08.008.2012 LLRF collaboration meeting, Lodz
19.25.08.2012  ICAP’12, Warnemünde
19.-21.02.2013  Advanced Techniques in LLRF Control for XFEL, Swierk
24.-26.03. 2013  Fourth Annual RFTech Meeting, Annecy
First Annual RFTech Meeting
DESY, 29 March 2010

https://indico.desy.de/conferenceDisplay.py?confId=2831

17 participants (DESY, CERN, TUD, UROS, ASTeC, LPSC, UJF, ESS, U London, TUL, UG, SINS) organized by M. Grecki, J.-M. De Conto, W. Weingarten & DESY

Spiral-2 couplers, SPL simulations & measurements, FLASH full beam loading, LHC LLRF, xTCA, high reliability digital system, HIE ISOLDE cavity & test cryostat, TUD SRF test stand, LHC crab cavities, RF costing tools, SRF test & R&D infrastructure
Second Annual RFTech Meeting
PSI, 2-3 December ‘10
Second Annual RFTech Meeting

PSI, 2-3 December ‘10

https://indico.desy.de/conferenceDisplay.py?confId=2831

30 participants, ~2x 1st meeting! (BNL, DESY, CERN, CNRS, CEA, ESRF, IPJS, LU, LPSC, PSI, RHUL, SBT, SOLEIL, UJF, TUD, TUL, WU, ...) organized by T.Garvey, M.Grecki, J.-M.DeConto, W.Weingarten & PSI ; sharing experience among several fields of RF technology!

- Low Level RF: CERN's PS complex LLRF renovation, SuperB project, FLASH system, as well as use of specific components like uTCA for XFEL machines
- Solid State Amplifiers, both in general and particular techniques as well as some specific developments, like at PSI, ESRF and SOLEIL
- RF technology for FELs: normal- and superconducting RF aspects (X Band structures, the Swiss FEL project, cryomodule technology), summary of XFEL RF synchronization workshop
- RF limitations related to LHC ultimate beam
- Cavity optimization: crab-cavity design for the LHC, HOM free copper cavities
- Superconducting RF, e.g. cryomodule assembly in Saclay, SRF infrastructures in Saclay/Orsay, SBT in Grenoble, with analysis and round-table discussion on the need of a European SRF test infrastructure for R&D and test of cavities & cryomodules. Presenting work of young scientists, about cavity design & modelling
RF cavity and couplers design
Perturbation methods for cavity calculation, Finite integration Maxwell solvers and FEM schemes, Progress of crab-cavities (HL-LHC + general)

HOM based diagnostics
Diagnostic via Beam excited HOMs models and experiment

Cavity tuning
Tuning issues for flat fields (FLASH)

LLRF
associated software, instrumentation, workshops FLASH, developments

RF systems highlights
CERN, SPIRAL2, Large CERN panorama, Review of Darmstadt activities
SRF infrastructure: completed

Reliability
may be strengthened?

Costing tools?
development of the LLRF system for XFEL and FLASH accelerators
4th & Final Annual RFTech Meeting
Annecy, 24-26 March ‘13

http://lpsc.in2p3.fr/Indico/internalPage.py?pageId=2&confId=862

33 participants (DESY, CERN, INF-INFN, TUD, UROS, GANIL, PSI, LPSC/CNRS, UJF, TUL, ISE-WUT) organized by J.-M. De Conto and M. Grecki

Projects: SPIRAL2, MYRRHA/MAX, CLIC, TESLA, ELI-NP, LHeC ERL, TLEP, LHC, FLASH, PS Booster, MedAustron, SwissFEL

RF topics: C-band RF, X-band RF, reliability, LLRF, RF diagnostics, reliability, costing, breakdown, operation, klystron lifetime, efficiency,
A sustained decrease in specific cost

Specific cost vs center-of-mass energy of CERN accelerators

Specific cost $[\text{2008 MCHF/GeV c m}]$ vs $E_{cm}$ [GeV]

- Cost of 100 TeV $pp$ collider $\sim 2 \times$ LHC cost
- Cost of 1000 TeV $pp$ collider $\sim 5 \times$ LHC cost

P. Lebrun, RFTech2013
The learning curve is not everything
Breakthrough vs gradual progress in genome sequencing

P. Lebrun, RFTech2013

Cost per Genome

Sanger-based chemistry
Capillary-based instruments

Ligation chemistry
Nanopore technology

Moore's Law
Learning curve

National Human Genome Research Institute
genome.gov/sequencingcosts
The learning curve is not everything. Commercial competition remains a prime mechanism for cost reduction.

Price of klystrons purchased by CERN (1982-2010)
Source: CERN FC adjudications, prices indexed by CERN material index

Learning curve $c(n) = c(1) \cdot n^{\log_2 a}$

- $a = 0.95$
- New entrant

P. Lebrun, RFTech2013
Sampling from LHC tender price distribution to estimate lowest-bidder price vs number of offers

Mean price applying lowest-bidder purchasing

- Monte Carlo
- Analytical

P. Lebrun, RFTech2013
Solid State Amplifier Development
ex.: PSI 500 MHz (other efforts at SOLEIL & ESRF)

- Expected Max. CW Output Power (Complete System): > 70kW
- Expected “Wall-Plug” Efficiency at Maximum Output Power (Complete System): ~ 60%

M. Gaspar, RFTech 2013
AccNet RFTech Deliverable D4.3.2

“Strategy/result for SRF test infrastructures”

published as EuCARD monograph!
RFTech Co-ordinator W. Weingarten
retired 29.11.2011
EuroNNAc – main themes

EU-wide (global?) coordination of adv. accelerators
- table of facilities, excel files, ...

input statement to European HEP strategy process
- "On the Prospect and Vision of Ultra-High Gradient Plasma Accelerators for High Energy Physics"

vision into more realistic accelerator proposals
- preparation of AWAKE experiment at CERN (PDPWA)

negotiations on EuroNNAC2 as part of EuCARD2
- funded!
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>17.-18.12.2009</td>
<td>Working meeting on proton driven plasma acceleration PPA09, CERN</td>
<td>CERN</td>
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<tr>
<td>11.-12.10.2010</td>
<td>Workshop on Proton Driven Plasma Wake Field Acceleration, CERN</td>
<td>CERN</td>
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<tr>
<td>03.-06.05.2011</td>
<td>1st general AccNet EuroNNAc workshop, CERN</td>
<td>CERN</td>
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<tr>
<td>02.-04.05.2012</td>
<td>EuroNNAc 2012 Meeting, CERN</td>
<td>CERN</td>
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<tr>
<td>02-07.06.2013</td>
<td>EuroNNAc EAAC2013 Conference, La Biodola, Elba</td>
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</table>
AccNet workshop on proton driven plasma acceleration “PPA09”
17-18 December ’09, 24 participants

http://indico.cern.ch/conferenceDisplay.py?confId=74552

Workshop pushes proton-driven plasma wakefield acceleration

AccNet in CERN Courier 2010/2
EINDHOVEN University of Technology
University of Oxford
University of Strathclyde
Manchester University
Lancaster University
Cockcroft Institute
STFC Daresbury Laboratory
John Adams Institute
ASTeC
STFC Central Laser Facility
Liverpool University
University College London
Imperial College
Instituto Superior Tecnico de Lisboa
LULI
Soleil
LPGP
LOA
IRAMIS/CEA
Laboratoire Leprince-Ringuet (Ecole polytechnique - CNRS/IN2P3)
LAL
European Organization for Nuclear Research (CERN)
PSI
University Düsseldorf
LMU University Munich
DESY
GSI
Max-Planck-Institute for Quantum Optics
Max-Planck-Institute for Physics
Helmholtz Institute Jena
Helmholtz-Zentrum Dresden-Rossendorf
University Hamburg
Lund University
Bucker INP
Institute of Applied Physics RAS
Extreme Light Infrastructures (ELI)
Inst. of Physics, Chinese Academy of Sciences
Tsinghua University, Beijing
Shanghai Jiao Tong University

EuroNNAc
European Network for Novel Accelerators

Fermilab
SLAC
UCLA
LBNL
BNL
ICFA
ICUILL
EuCARD²
EAAC2013, 2-7 June 2013

145 participants
Goal: distributed European test facility
Conclusion: substantial extra funding needed
AccNet publications

EuCARD AccNet documents
• about **160 in total**
  - 2 CERN Yellow Reports
  - 4 journal articles
  > 60 conference presentations
  - ~12 workshop summaries
  - 1 PhD thesis
  - 2 master theses
  - 2 EuCARD monographs

not all in the database
AccNet outreach & dissemination examples


Article on EuCARD LEP3, TLEP, SAPPHiRE, VHE-LHC Days in **Accelerating News** Magazine, issues 3 & 5

*presentations and seminars:*

TU Darmstadt, MEPAS, Hiroshima, Kyoto, SLAC SSI, SLAC50, Oxford, KEK, CERN, Frascati, CEA Saclay, LAL Orsay, APS Denver, Sendai, ...

*recent posters & papers at conferences:*

≥7 contributions to IPAC’13 Shanghai, 10 to IPAC’12 New Orleans, 6 to RT2012 Berkeley, 6 contributions to ICAP’12 Warnemünde
## AccNet deliverables

<table>
<thead>
<tr>
<th>Deliverables of tasks</th>
<th>Description/title</th>
<th>Nature</th>
<th>Delivery month</th>
<th>Status</th>
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<tr>
<td>4.1.1</td>
<td>Continually updated AccNet web site</td>
<td>O</td>
<td>M2</td>
<td>DONE, OK</td>
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<tr>
<td>4.1.2</td>
<td>AccNet Strategy for future proton &amp; electron facilities in Europe</td>
<td>R</td>
<td>M48</td>
<td>to come soon!?</td>
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<tr>
<td>4.2.1</td>
<td>Continually updated EuroLumi web site</td>
<td>O</td>
<td>M2</td>
<td>DONE, OK</td>
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<tr>
<td>4.2.2</td>
<td>EuroLumi Strategy and issues for LHC IR, LHC injector and beam-parameter upgrade path(s), with comment on longer-term prospects, and for FAIR</td>
<td>R</td>
<td>M48</td>
<td>to come soon!?</td>
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<tr>
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<td>Continually updated RFTECH web site</td>
<td>O</td>
<td>M2</td>
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<tr>
<td>4.3.2</td>
<td>Strategy/result for SRF test infrastructures</td>
<td>R</td>
<td>M24</td>
<td>Published!</td>
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<td>4.3.3</td>
<td>RFTech strategy/result for cavity design, LLRF &amp; HPRF systems and design integration, and costing tools</td>
<td>R</td>
<td>M48</td>
<td>to come soon!?</td>
</tr>
</tbody>
</table>
AccNet success indicators

excellent attendance to AccNet workshops from many European labs, universities, US laboratories, Japan, international organizations, industry

impact: - new collaborations (Mexico, ESA, Kyoto)
- crab-cavity program for LHC
- e-cloud modeling & mitigation
- advances on new concepts: HE-LHC, VHE-LHC, LEP, TLEP, SAPPHiRE, PDPWA,

cost efficient!; 43 topical workshops; ~160 documents; outreach articles & invited talks
AccNet summary

EuroLumi, RFTech & EuroNNAc extremely active; helped launch & support many new initiatives

many activities previously initiated or promoted by EuCARD-AccNet became real projects + new ideas emerged; EuroLumi activities refocused in response

strong dissemination efforts in parallel

final deliverables being completed (EuroLumi, RFTech, AccNet, EuroNNAc?)
Coming together is a beginning, staying together is progress, and working together is success.

Henry Ford