EuCARD-2, the first year

M. Vretenar, Project Coordinator

EuCARD-2 is co-funded by the partners and the European Commission under Capacities 7th Framework Programme, Grant Agreement 312453

EuCARD-2, what ?

EuCARD-2 = European Coordinated Accelerator Research and Development, an *Integrating Activity* co-funded by the European Commission under the *Capacity – Research infrastructure* Program

Coordinated Accelerator R&D = development of R&D topics of excellence related to accelerators for particle physics and beyond, enhancing and coordinating the individual programs of EU laboratories , national institutions and universities.

Integrating Activity = sharing ideas and resources among 40 partners from research institutions, universities and industries from 14 different countries (EU and partners)

Co-funded: EU contribution amounts to 1/3 of total cost (60% of direct cost)

Research Infrastructure = the objective is improving the European Scientific Infrastructure

- **4 years duration** (05.2013 – 04.2017)
- **40 beneficiaries**
- **14 countries** (+ CERN)
- **23.5 M€ total cost**
- **8 M€ EC contribution**

EuCARD²

EU and accelerators*

*: only programs coordinated by the ESGARD committee, with particle physics as primary objective

ESGARD

Integrating Activities

FP6

- **CARE** 01/2004 – 12/2008
  5 years, 15.2 M€ EU contribution

FP7

- **EuCARD** 04/2009 – 03/2013
  4 years, 10.0 M€ EU contribution
- **EuCARD-2** 05/2013 – 04/2017
  4 years, 8.0 M€ EU contribution

Design Studies, Preparatory Phases

- EuroNu DS, 2008/12, 4M€
- SLHC-PP, 2008/11, 5.2M€
- ILC-HiGrade, 2008/12, 5M€
- TIARA-PP, 2011/13, 3.9M€
- HiLumi LHC, 2011/15, 4.9M€

LABORATORIES: Infrastructure experience

UNIVERSITIES: Intellectual potential, creativity

INDUSTRY

Long-term R&D not a priority for large laboratories focused on short-term projects, small institutions lack critical mass and the experience to be effective
→ a joint collaborative effort with the EU support is the most effective way to push the limits of our technologies.

Long standing support, but budget shrinking (3 → 2.5 → 2 M€/year), more focus on networking and less on tecnological R&D. Supplemented by DS and PP (up to 4.5 M€/year in 2011).

EuCARD²

13 Workpackages

6 Networks

4 Research &Technology Developments

2 Access to Research Infrastructures

Extreme Beams – F. Zimmermann (CERN)
Frontier performance of accelerators.

Low emittance rings – Y.Papaphilippou (CERN), S.Guiducci (INFN), R.Bartolini (UOXF)
Synergies synchrotron light sources, storage rings, damping rings, lepton colliders.

Novel Accelerators – R. Assmann (DESY)
European roadmap for plasma-based accelerators.

Energy Efficiency – M. Seidel (PSI)
Energy management in accelerators.

Accelerator Applications – R. Edgecock (HUD)
Accelerator technology for industry, health care, energy, ..

Catalysing Innovation – G.Anelli (CERN), P.Woodman (STFC)
Transfer to society of EuCARD-2 technologies.

Future Magnets – L. Rossi (CERN), P. Fazilleau (CEA)
High Temperature Superconductors for 20 T magnets.

Collimator Materials – A. Rossi (CERN), J. Stadlmann (GSI)
New materials for future collimators.

Innovative RF Technologies – P. Macintosh (STFC)
High gradients for SC and NC accelerating cavities, RF diagnostics, photocathodes.

Novel Acceleration Techniques – V. Malka (CNRS)
R&D topics on plasma wakefield acceleration.

Ion Cooling Test Facility at STFC
R. Preece (STFC)

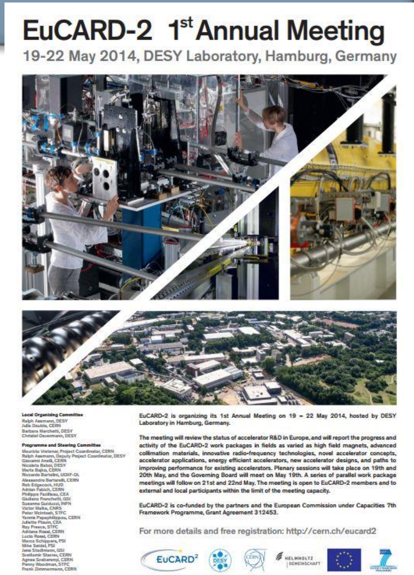
HighRadMat, MagNet at CERN
A. Fabich and M. Bajko (CERN)

EuCARD² 2014 Annual Meeting - DESY

The main event of the year!

- Presentations of the status of the different WPs
- Highlights on WP activities
- Parallel WP sessions
- Contact with the SAC

(build a common denominator for the very diverse EuCARD-2 activities)



SAC = Scientific Advisory Committee :
C. Biscari (ALBA-CELLS)
S. Peggs (BNL)
A. Yamamoto (KEK)
J.P. Koutchouk (Uppsala)

The EuCARD-2 Scientific Advisory Committee (SAC) is an external advisory body composed of members with an international reputation endorsed by the Governing Board upon proposition of the EuCARD-2 Steering Committee.

This committee will receive the EuCARD-2 Yearly Activity Reports and is expected to meet at least once per year during the EuCARD-2 Annual Meeting.

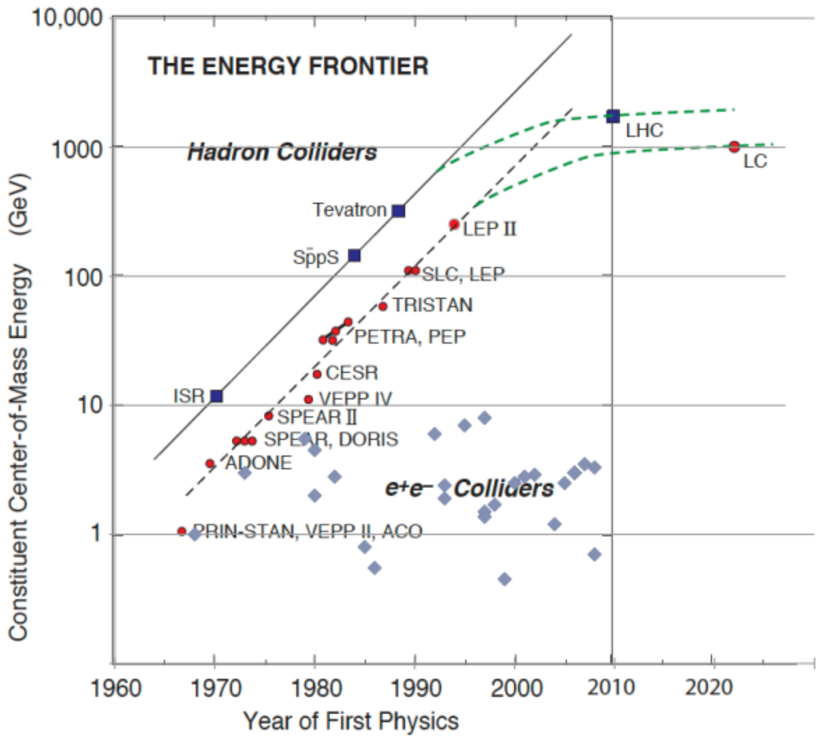
The role of the committee consists in:

- Monitoring the scientific and technical activities and advising the EuCARD-2 management in case of possible failure/delays in the EuCARD-2 deliverables/milestones.
- Giving recommendation to the EuCARD-2 management about scientific/technical choices to be made throughout the project or actions to be taken with the partners and or within the Work Packages.
- On request of the EuCARD-2 management, participating to an EuCARD-2 internal review.
- Providing a short document after each SAC meeting, and reporting at the EuCARD-2 plenary or EuCARD-2 governing board meeting

Finally the scientific advisory committee is expected to participate to the strategy reflections about the continuation of EuCARD-2 within the European framework but also with non European partners.

The 2014 Accelerator Landscape

Are we approaching a saturation?



Updated Livingstone-type chart
(Wikipedia 2014, uploaded by J.Nash, Imperial College)

But the field has never been so flourishing…

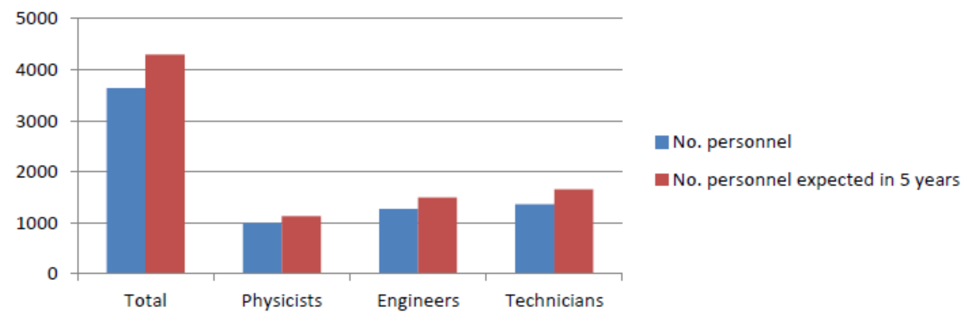


Figure 2.1: Total number of current personnel (blue) engaged in accelerator science activities a research institutes. The number of personnel expected in 5 years is shown in red.

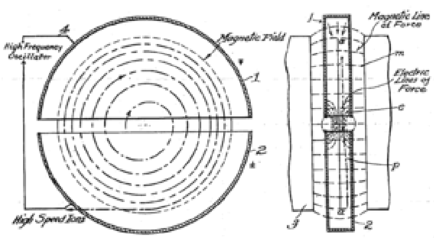
TIARA, Need for Accelerator Scientists report, 2013:
3’700 people engaged in accelerator science in European research institutes, number expected to grow by 18% in 5 years.

90 years of accelerators: new challenges, new opportunities

The four EuCARD-2 themes for the future of particle accelerators

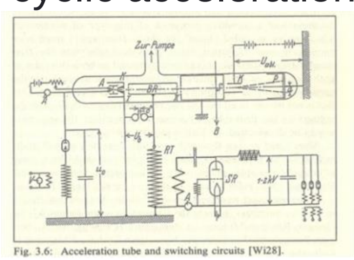
1 Push the gradients (B, E)
Improve efficiency
WP3, WP10, WP12

2 Push the limits:
Higher beam densities and energies
WP5, WP6, WP11

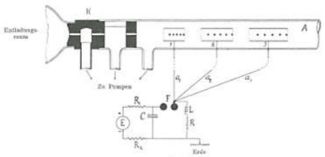


90 years of particle accelerators

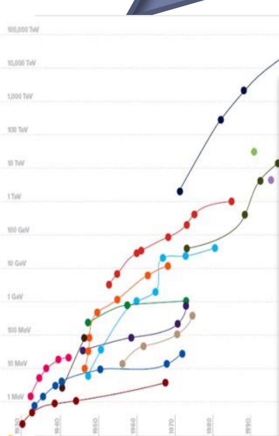
1931: Lawrence, cyclic acceleration



1928: Wideröe, RF acceleration



1924: Ising, periodic acceleration



Enabling technologies
- RF acceleration
- Cyclic acceleration
- Strong focusing, ph. stability
- Colliders
- Superconductivity
- (Plasma acceleration?)

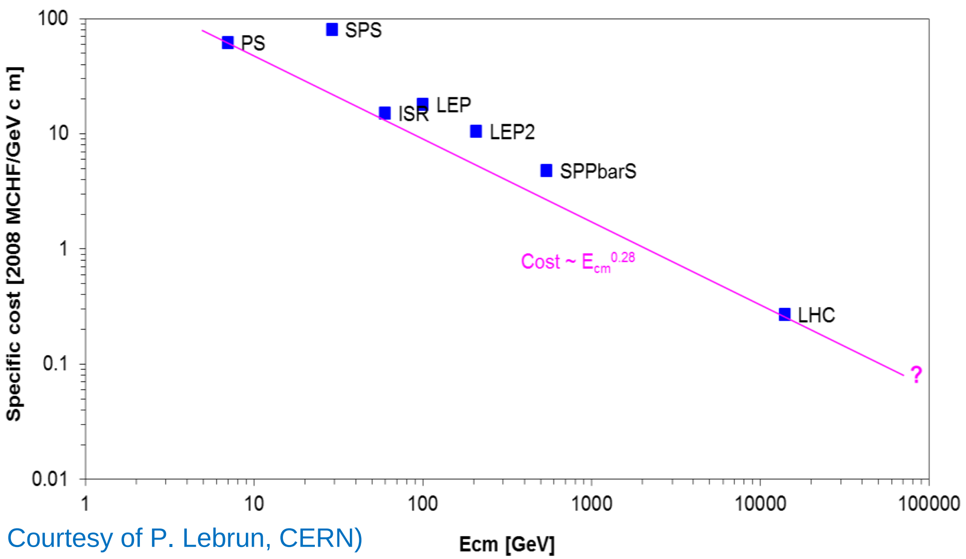
Applied science
Medecine
Industry

3 A new paradigm: Plasma wakefield acceleration
WP7, WP13

4 Improve applications and technology transfer
WP2, WP4

Frontiers of accelerators

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



Courtesy of P. Lebrun, CERN)

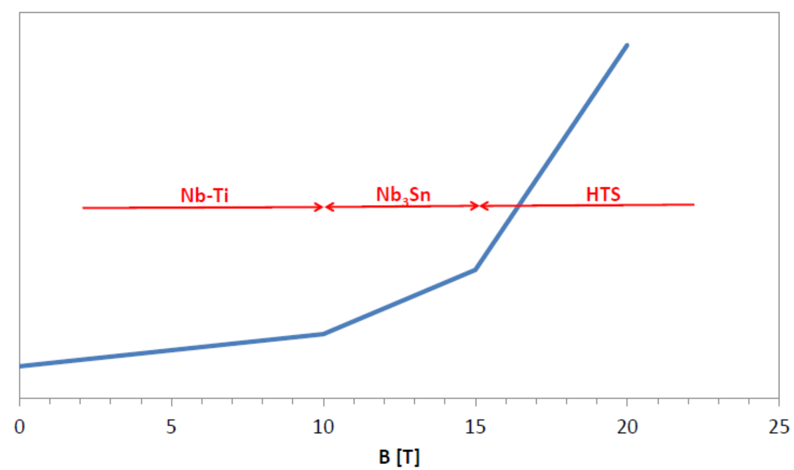
Primary goal → reduce cost/energy

Traditional way → increase gradients (B, E)

BUT: cost and power do not scale linearly with the gradient.

Up to the final frontier: public acceptance

Cost of high-field magnets



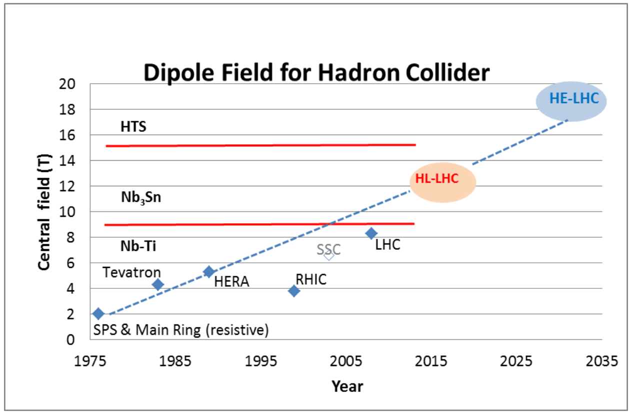
Complex system of "frontiers" that become more and more interrelated and/or overlapping, common to many different types of accelerators.

The EuCARD-2 collaborative effort becomes essential to optimize and develop the new technologies.

The gradient frontier

(the devil is in the details…)

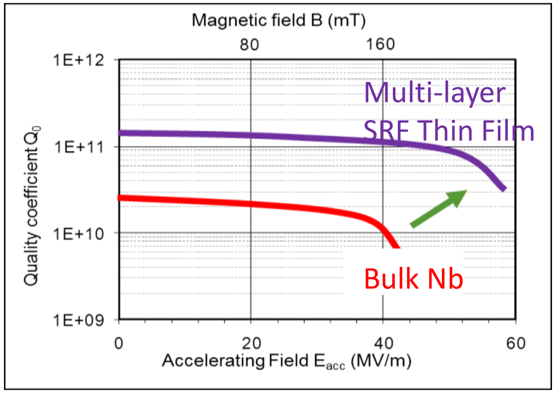
B-field

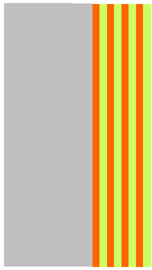


WP10 Future Magnets: R&D towards a 20 T HTS dipole magnet, develop 10 kA cable

First results: focus R&D on REBCO material in Roebel cables, (rare-earth based YBCO, high current densitiy but mechanical issues still to be cleared)

E-field





WP12 RF: R&D new higher-gradient superconductors: bulk Nb3Sn and nanometric multilayers of high Tc SC.

Support to the CLIC R&D for high-gradient NC: wakefield management, RF sources.

(+ Nb sputtering, beam generation, beam diagnostics)

EuCARD²

Energy management

Total electricity consumption (GWh/y)	
PSI	125
ESRF	60
ISIS	70
KVI	4
INFN	25
ALBA-CELLS	20
GSI	60
CERN	1200
SOLEIL	37
ESS	317
MAX IV	66
DESY	150

From EuCARD2 Deliverable D3.1

Electrical power consumption (MW) for LHC and future projects (estimated)		
	normal	Stand-by
LHC	122	89
HL-LHC	141	101
ILC	230	
CLIC 500 GeV	235	167
CLIC 1.5 TeV	364	190
FCC pp	250?	150?

Efficient energy management is the key to survival in the XXIst century.

Future large projects require a power corresponding to a fraction of nuclear reactor;
Going green? 200 large windmills (80m diameter, 2.5 MW, 50% efficiency) covering a 100 km distance needed to supply CLIC500 or ILC…

EuCARD-2 WP3: energy recovery from cooling, efficient klystrons, energy storage, virtual power plant, low-power transport channels.

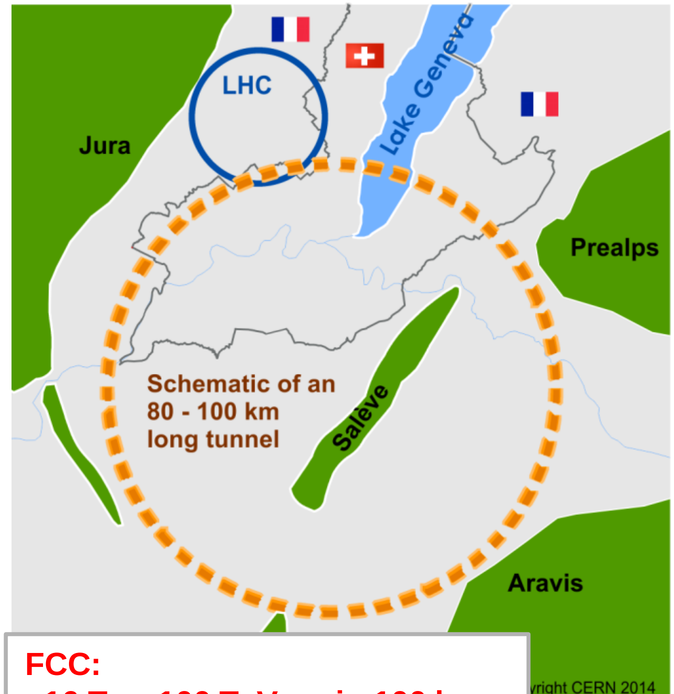
The WP has produced the 1st EuCARD2 deliverable:
COOLING RELATED INVENTORY by J. Torberntsson, ESS: Survey of power and cooling requirements and solutions for different EU laboratories.

Need new techniques for efficient energy utilisation and heat recovery → impact on accelerators and on public opinion (key to public acceptance!).

- Modelling of energy flows and optimisation in time
- How can heat distribution generate an income? Low temperature heat is the main issue: LTHD, greenhouses, fish farms (integrated?) , wastewater treatment,…

MY WASTE YOUR RESOURCE
Sustainable Industry Forum 2013
Treating Waste as a Resource

Pushing the limits



FCC:
~16 T ⇒ 100 TeV *pp* in 100 km
~20 T ⇒ 100 TeV *pp* in 80 km

WP5, Extreme Beams + WP6 Low Emittance Rings
Networks to discuss new ideas and create synergies.

WP5 present in the Future Circular Collider study, launched this year by CERN. R&D areas include beam optics, SC magnets, SC RF, reliability, civil engineering, impedances, synchrotron radiation, collimation, efficiency

WP5 organisation of «Beam dynamics meets magnets» workshop: more communication between communities required by new projects.

1st Low Emittance Ring Prize
Awarded to 2 students, July 2013

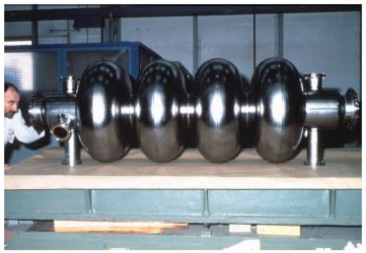
WP6: series of Workshops to bring together different accelerator communities working on the design of ultra low emittance lattices (synchrotron light sources, damping rings, collider test facilities).

WP11: development of new materials for collimation (and beyond!).

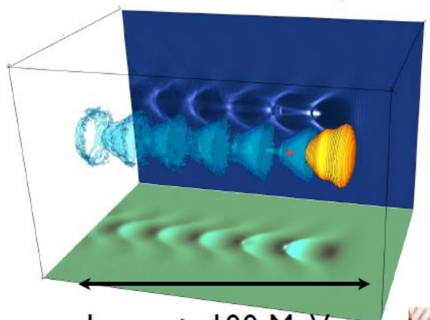
Plasmas: the new paradigm?

Opportunities…

RF Cavity



Plasma Cavity



1 m => 100 MeV Gain

Electric field < 100 MV/m

1mm => 100 MeV

Electric field > 100 GV/m

… and challenges

Malka *et al.*, Science **298**, 1596 (2002)

Concept of Laser-Driven Plasma Linac : Challenges

1 PW laser at high rep rate (>100Hz): today in the best 1 Hz

Plasma and vacuum chambers

Transport between stages

Thermal effects on the guiding structure wall

External guiding/self-guiding

Collimation and beam filtering

Accelerating plasma structure: linear (<1GV/m) or non-linear (>few GV/m to 100s GV/m)

High efficiency laser driver : today in the best 1%

Courtesy of R. Assmann

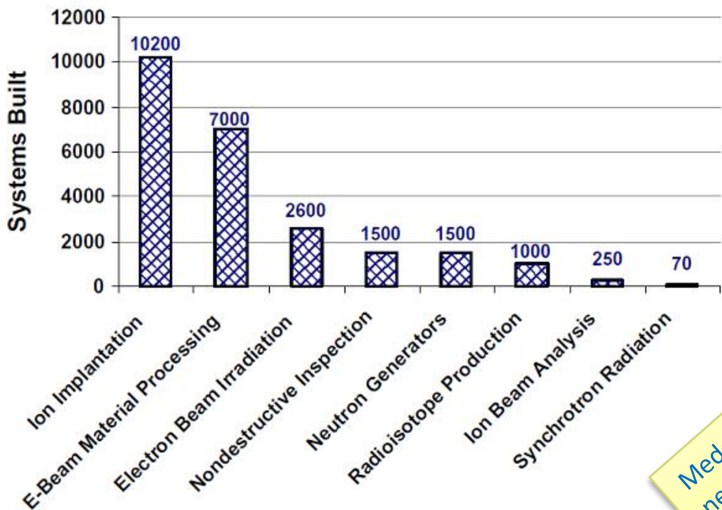
WP7 (EuroNNAC) is now the main European actor in the plasma acceleration field:

- EAAC workshop in June 2013.
- The community is now preparing an application to the EU for a Design Study on "European Plasma Accelerator with High Beam Quality and Pilot Applications"

WP13 (ANAC) is progressing in its objectives:

- Compare laser plasma acceleration techniques to produce high brightness electron beams
- Ultra-fast acceleration
- Modulation of long plasmas

The application frontier



from R. Hamm, Applications of Accelerators

Medecine: the new technology driver in Europe!

EuCARD-2 Milestone 21, WP4
56 accelerator applications listed
http://eucardapplications.hud.ac.uk/wp-content/uploads/2014/01/Accelerator-applications.xlsx

+ Concepts for transfering technology from research to industry (how to bridge the *valley of death*): new ides coming out of WP2 (see WAMAS Workshop)

Area	Application	Accelerator Type	Primary Beam type
Energy			
	Nuclear fission via ADS	Linac	Ion
	Magnetic Confinement Fusion - plasma heating with neutral ion beams	Linac, electrostatic	Ion
	Heavy Ion Inertial Fusion	Induction linac	Ion
	Muon catalysed fusion	Requires muon production	Proton
	Nuclear Waste transmutation via ADS	Linac	Proton
	Bio-fuel production	Linac, electrostatic	Electron
Environment			
	Treatment of beehives for disease	Linac	Electron
	Water Treatment - removal of micro-organisms, chemicals, etc	Linac, mainly electrostatic	Electron
	Flue Gas treament - removal of NOx and SOx	Linac, electrostatic	Electron
	Radiocarbon dating via atomic mass spectroscopy	Tandem	Ion
	Dating using cosmogenic radionuclides with AMS	Tandem	Ion
	Cosmogenic Radionuclides production measurements for dating studies	Cyclotron	Ion
	Dating of Ground Waters via AMS	Tandem	Ion
Medicine			
	Radioisotope production	Cyclotron	Proton
	Radiotheraphy	Linac	Electron
	Proton therapy	Cyclotron, synchrotron	Proton
	Neutron Stimulated Emission Computed Tomography	?	?
	Sterilisation of medical equipment	Linac	Electron
	Ion Beam Therapy	Synchrotron	Ion
	CT Scan	X-ray tube	Electron
	Boron Neutron Capture Therapy	Voltage multiplier, linac, cyclotron	Proton
	Proton Computed Tomography	Cyclotron	Proton
Industry			
	Semi-Conductors: Ion Implantation	Electrostatic	Ion
	Surface Treatment	Various	Electron/Ion
	Food Irradiation	Various	Electron
	Cross Linking of materials	Various	Electron
	Grafting of filter membranes & battery separators	Electrostatic	Electron
	Ink & Coating Curing	Electrostatic	Electron
	IBA: Accelerator Mass Spectrometry	Tandem/electrostatic	Ion
	IBA: Particle Induced X-ray Emission	Tandem/electrostatic	Proton
	IBA: Rutherford Back Scattering Spectronomy	Tandem/electrostatic	Ion
	IBA: Elastic Recoil Detection Analysis	Various	Many ions
	IBA: Particle Induced Gamma ray Emission	Tandem/electrostatic	Ion
	IBA: Nuclear Resonance Reaction Analysis	Various	Ion
	IBA: Charged Particle Activation Analysis	Tandem/electrostatic	Ion
	Neutron activation analysis	Neutron generators	
	Gemstone Enhancement	Linac	Electron
	Electron Beam welding	Electrostatic	Electron
Security & Defense			
	Hydrodynamics tests	Linac - induction	Electron
	Cargo Scanning - especially shielded nuclear materials	Linac and betatron	Electron
			Neutron
			Muon
	Proton radiography	Linac?	Proton
Research			
	Synchrotron Light Source	Synchrotron	Electron
	Spallation Neutron Sources	Synchrotron & cyclotron	Proton
	MuSR	Cyclotron, synchrotron	Proton
	Particle Physics	Synchrotron, linac	Proton, Electron
	Heavy ion physics	Synchrotron	Ions
	Radioactive ions	Linac, cyclotron & synchrotron	Proton & ion
	Nuclear Physics	Linac, cyclotron & synchrotron	Proton & ion

Sharing our tools

The EuCARD-2 Transnational Access programs: Access to accelerator test facilities (WP8, 9)

ICTF (RAL): muon beams for cooling studies, detector and instrumentation development
HiRadMat (CERN): high-intensity and energy proton beams for material testing
MagNet (CERN): infrastructure for magnet and instrumentation testing at cryogenic temp.

.3

Excellent start for the newcomer MagNet!

...ow temperature *instrumentation* based on optical fibbers has been submitted

FOSxCRYO

A project made in collaboration between **Italian** and **Hungarian** Institutes and University and a start up company form Italy

First accesses given!!!!in November 2013

For superconducting *magnet testing* for thermal modelling is under preparation

THMO_Nb_3Sn

A project from 2 Italian Universities

NEW!!!

Preliminary quench performance of a superconducting solenoid for medical application

AMIT_Mag HeBP

A project from **Spain**: collaboration between institute and industry
First test foreseen for February 2014

Public outreach, the key to societal acceptance

A priority for EuCARD-2, even if we don't …
specific budget and we have only a …
- Video on the EuCARD-2 w…
- Ideas: beam lines f…
- And a good pi…

Thank you for your attention, and have a good and profitable meeting!