SEVENTH FRAMEWORK PROGRAMME

THE PEOPLE PROGRAMME

Grant agreement for: **Initial Training Networks**

Annex I – "Description of Work"

Proposal acronym: MC-PAD

Proposal full title: Marie Curie Training Network on Particle Detectors

Grant agreement no.: 214560-2

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PART A:

A.1 List of beneficiaries and project summary

A.1.1 List of Beneficiaries

Beneficiary no.	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1 (co-ordinator)	European Organization for Nuclear Research (CH)	CERN	Switzerland	m1	m48
2	Stiftung Deutsches Elektronen-Synchrotron (DE)	DESY	Germany	m1	m48
3	Gesellschaft für Schwer-ionenforschung mbH (DE)	GSI	Germany	m1	m48
4	Jožef Stefan Institute (SI)	JSI	Slovenia	m1	m48
5	AGH University of Science and Technology (PL)	AGH	Poland	m1	m48
6	Laboratori Nazionali di Frascati - Istituto Nazionale di Fisica Nucleare (IT)	LNF	Italy	m1	m48
7	Stichting voor Fundamenteel Onderzoek der Materie (NL)	NIKHEF	Netherlands	m1	m48
8	Paul Scherrer Institut (CH)	PSI	Switzerland	m1	m48
9	University of Hamburg (DE)	UHH	Germany	m1	m48

List of Associated Partners

Associated partner no.	Associated partner name	Associated partner short name	Country	Date enter project	Date exit project
1	Evatronix SA (PL)	Evatronix	Poland	m1	m48
2	Instytut Fizyki Jadrowej im. Henryka Niewodniczanskiego Polskiej Akademii Nauk (PL)	IFJ PAN	Poland	m1	m48
3	Micron Semiconductor Ltd. (UK)	Micron	United Kingdom	m1	m48
4	National Institute of Materials Physics (NIMP), Bucharest	NIMP	Romania	m1	m48
5	Photonis SAS Holding	Photonis	France	m1	m48

A.1.2 Project Summary

Abstract

The challenging questions of particle physics, like the origin of mass, the existence of new forms and states of matter, can only be addressed in technically complex and expensive large-scale research facilities. Well coordinated international effort is required to design, build and operate world class infrastructure comprising accelerators of highest energy and/or intensity and detector systems of unprecedented performance. Frequently the quality of the results and hence the progress of science is limited by the quality of the detectors and by the level of understanding of their characteristics and performance. Future detectors need to cap current state-of-the art performance in terms of position and energy resolution, number and density of read-out channels, dynamic range and noise, speed, radiation tolerance, robustness and reliability. We propose an Initial Training Network on Particle Detectors which spans 4 years. A multi-site network has been formed which comprises nine academic participants, three associated industrial partners and two associated academic partners[1)] from nine European countries. It will provide extraordinary training opportunities to young researchers (physicists and engineers) in the field of radiation detectors. The proposed Training Network will play an essential role to form a new generation of excellent detector scientists which is required to conceive, design, build and exploit the next generation of experiments which may come into operation in the years 2012-2020. Internationally renowned supervisors will provide scientific and technical training at the highest level. The trainees will be integrated in existing collaborative structures and profit from a unique spectrum of expertise and facilities available in the network. Complementary training, involving particularly our industrial partners, e.g. in communication skills, project and financial management, is an integral part of the programme.

[1)] Since the submission of the stage-2 proposal, one institute joined the MC-PAD network as academic associated partner: National Institute of Materials Physics (NIMP), Bucharest, Romania.

Keywords: Physical sciences, Experimental physics, Electronic engineering, Radiation Detectors.

PART B:

B.1 Description of the joint Research Training Programme

The network as a whole undertakes to provide a minimum of 732 person-months of Early Stage and Experienced Researchers whose appointment will be financed by the contract. Quantitative progress on this, with reference to the table contained in Part C and in conformance with relevant contractual provisions, will be regularly monitored at the consortium level.

B.1.1 Project Overview

A multi-site network has been formed which will provide excellent training opportunities to young researchers in the field of radiation detectors for the next generation of particle physics experiments and other applications. We are targeting mainly physicists and (electronics) engineers. The network with the acronym MC-PAD (**M**arie **C**urie – **PA**rticle **D**etectors) comprises nine academic participants, three industrial partners and two associated academic partners.

The proposed ITN will make substantial contributions to an internationally-coordinated effort in developing new and optimizing existing particle detector technologies to make them suitable, well understood and reliable solutions. The training network covers major detector categories present in modern particle physics experiments. Moreover, the network is not limited to the development of basic sensors only, but includes the design, construction and integration of fully functional detector systems. This means that important aspects like front-end electronics design, mechanical integration, system architecture and signal processing are part of the overall approach.

The proposed research will be organized as a number of common projects carried out in small teams, involving typically two to five network partners. Some of the projects are related, e.g. by addressing the same problem from a different angle, others are largely independent. The projects focus mainly on the development of novel particle detector devices and fully functional prototype detector systems for particle physics experiments at SLHC, ILC, CLIC, FAIR, DAFNE or Super-B-Factories. Generally, the projects aim to establish novel detector concepts, extend and optimize the performance of existing devices or adapt and integrate devices in larger systems.

The projects are grouped into the following categories:

- radiation tolerant silicon detectors,
- gaseous detectors,
- calorimetry,
- photon detection and particle identification,
- monolithic detectors and front-end electronics,
- simulation tools.

While we expect the major part of the projects to be completed within the first 3 years, the network spans a total period of 4 years

B.1.2 Concept and Project Objective(s)

This training network is formed by major European institutions in the field of radiation detectors in which European science has a leading role worldwide. The network will contribute to reinforce this role through challenging common projects. The results of the proposed projects will find their applications in the next generation of particle physics experiments like at the SLHC, the Super-B factory, ILC and FAIR, as well as in astro-particle physics, medicine, photon science and a number of other scientific and industrial applications.

The main scientific achievement of this training network will be an overall and clearly visible gain in the performance of particle detectors for SLHC, ILC and other future particle physics experiments. The R&D conducted in the network is expected to lead to the following main results:

- Silicon tracking devices: Availability of specifically engineered materials and optimized detector layouts which withstand the unprecedented radiation loads expected in SLHC or FAIR.
- Novel tracking detectors: Understanding the intrinsic limitations. New performance records for novel particle detectors like MAPS, 3D semiconductor detectors, GEMs or Micromegas;
- Photon detectors: Development for fast single photon detection devices, able to cover large areas and/or operate in high magnetic fields.
- Construction and complete characterization of fully functional prototypes of particle detector subsystems for considered applications in HEP experiments (calorimetry, particle ID).

To fully exploit future accelerator facilities like SLHC, FAIR and ILC, which may come into operation in the years 2012 to 2020, a new generation of detector scientists is required. The proposed Training Network will make an essential contribution to train them.

The partners of this consortium are universities, national research institutes, international accelerator laboratories and industrial partners. Together they provide a unique stimulating international environment for a broad high-quality education in all aspects of detector science for young scientists, starting from BSc students to post-doctoral fellows. The network provides the trainees access to a broad range of world class facilities and allows them to perform research in direct collaboration with industrial partners. The trainees profit from the combined research and teaching experience and the full spectrum of training programmes offered by the network.

This Training Network primarily targets young scientists who have recently completed formal university training at the Master (or Diploma) level. It will provide training in the field of radiation detectors at the highest quality level and stimulate the creativity of young scientists in a competitive research environment for a future career in both academia and industry. All early stage trainees will be offered the possibility to do a doctorate. If required and as often practiced in the past, research labs like CERN, DESY, GSI, PSI, etc. will organize arrangements with universities inside or outside the network to enrol the trainees in PhD programmes. Several research labs are linked to universities through Joint Professorships.

Upon completion of the training program, the ESRs will be able to carry out experimental work, analyse characterisation measurements and evaluate their own work in written and oral presentations. They will have become used to working in an international team and have experience in reviewing and critically analysing research ideas and results. The ESRs will also have gained experience in preparing and planning experiments. Moreover, the ERs will have developed leadership skills, for example by coordination and planning of joint test beam or irradiation programs.

A solid background in (particle) physics will be established by embedding the ESRs in the local PhD programs and events like seminars and colloquia. An essential part of the training is based on the full participation in a research project (WP1-12) carried out at several network partners.

The partners of the network have a successful, long-term experience in training researchers at all stages of their scientific career. MC-PAD will offer exceptionally broad, high-quality and well coordinated training possibilities in scientific, technical and practical training. Complementary training courses on general topics like safety, project management, how to apply for positions in academia and industry, science & society, etc., are given at most of the partner institutes and will be accessible for all MC-PAD researchers.

B.1.3 Overall Approaches and Methodology

Detector development projects in particle physics normally follow a sequence of well-identified phases.

- First the measurement problem needs to be identified and a (detector) concept needs to be developed. 'Practical' aspects, like technical feasibility and cost-effectiveness, may not be a main focus at this stage, but deserve some consideration even at this early phase.
- Lectures, talks, literature/database studies and discussions with colleagues allow developing a clear understanding of the state-of-art in the field.
- Simplified analytical calculations, from back of the envelope type to using mathematics software or home-grown programs, are made to obtain a rough estimate of the expected performance and possible limitation of the envisaged new concept.
- The concept is tested and refined by Monte-Carlo calculations and other appropriate tools (e.g. Finite Element models), which should provide a realistic performance evaluation.
- If the chosen concept still appears promising, a (small scale) prototype device is designed and built.
- An appropriate test bench is designed and set up in the laboratory.
- The new device is tested and its performance compared with state-of-the-art devices.
- Tests with particle beams allow characterizing the device under realistic conditions.
- Questions like robustness, aging, lifetime tests, behaviour after strong irradiations and other environmental effects, must be considered.
- Aspects related to (industrial) mass production, quality control and assembly are studied.
- The developed device can finally be integrated in a larger detector system.

For devices like solid state sensors, microelectronics, gas detectors, vacuum based photodetectors, very powerful tools and refined methods have been developed over the years, to allow an in-depth characterization. The network has access to the full spectrum of equipment and infrastructure to perform this work. This also holds for the range of simulation and analysis software tools.

The recruited researchers will often be integrated in ongoing projects and therefore they will be exposed to the full sequence of a detector development. The researcher will then concentrate on a certain aspect or sub-project, for which the above sequence is still a very valid guide. The progress of the projects is documented in various ways. Presentations at different levels (team, group, department, collaboration), usually publicly accessible on the internet, document the evolution of the project and allow for direct feedback by colleagues. Written documentation, i.e. short technical notes or more comprehensive design reports are appropriate to mark the completion of some of the phases.

Modern large particle experiments at the LHC or the ILC comprise hundreds of square meters of active detector surface. More and more detector concepts rely on industrial technologies originally developed for micro electronics (photolithography, micro-structuring) and optics, which can only be performed in a competitive and cost effective way by specialized high tech companies. Collaboration with industrial partners already in the design and prototype phase is an absolute must to guarantee the perfect match of requirements and final deliveries. The industrial and academic partners provide complementary input to the project and often dispose of complementary equipment for testing and quality control. Direct collaboration with the industrial partners, by working with their development and production teams, will be a unique experience for the trainees, contribute to an efficient idea and technology transfer from academia to industry and generally boost the advancement of the projects.

Training

The training provided by the network comprises 5 main components:

1) An essential part of the training is based on the full participation in a research project (WP1-12, described below) carried out at several network partners, as part of a research team.

2) Local training at the network partner at which the researcher was recruited. This comprises academic lectures and specialized courses given by leading scientists from European universities and research laboratories, which on the one hand deepen the understanding in the field of detectors, and on the other broaden the view and sponsor novel ideas for detectors and their applications in particle physics and beyond. Furthermore, it comprises hands-on training, to acquire practical experience in all aspects of “high-tech” projects, using the unique state-of-the-art equipment available at the partner institutions under the guidance of world leading experts.

3) Specialized lectures and courses that are not covered by existing events will be systematically treated by training events that are organized by the network. Those will be tailored to meet the specific demands of the research projects and be given by leading experts being involved in most recent developments in the field. An indicative list of topics is given in the table below. Typically twice per year, network-wide training events will be organized at which all trainees and in some cases also students and researchers from outside the network will participate. These events will ensure that all trainees, regardless of their specialization and their specific projects, receive a comprehensive overview of the whole field of particle detectors and an appropriate spectrum of technical and complementary training units. For all training programmes, the MC-PAD ITN will take great care to ensure the highest quality of the speaker, often with world leaders in their field providing the training.

4) Complementary training involving industrial partners. Some of the research projects involve direct common research with the industrial partners of the network. The young researchers will have the opportunity to perform certain phases of their projects in an industrial environment. The training will cover different aspects of technical developments in the fields of detectors, electronics, complete detector systems, detector applications and possibly marketing. Examples are photocathode processing (PHOTONIS), silicon sensor fabrication (Micron), etc. A crucial aspect will be the understanding of the importance of clear and unambiguous definitions of product specifications and their follow-up for production control and quality assurance. The exchange between industry and academia of the different experience and expertise in this field will strengthen the mutual collaboration. The training will be organized in the form of short (1-2 months) secondments of young researchers at the industrial partners. The industrial partners

have a particular expertise and practical experience in project management, financial planning and marketing which will allow the trainees to acquire skills which are becoming ever more important with the increasing complexity and extended time scales of the projects. The collaboration on the projects will also allow the industrial partners to get acquainted with potential first rate scientists for future collaborations.

5) Presentations at workshops or conferences will enable the young scientists to present their ideas and achievements to their colleagues as well as recognized international experts. In addition, the young researchers are expected – and strongly encouraged – to contribute to teaching at the regular MC-PAD ITN meetings and to collaborate with and supervise students. Many of them will also have the option of formal teaching at a university.

Table: Indicative list of training topics to be organized by the MC-PAD network.

Type	***Content***
Network Training Events	- Data acquisition systems - Microelectronics, VLSI-technology, ASIC design - Radiation damage and ageing
Open Training Events	- Detectors for future colliders - Detectors for astroparticle physics - Detector applications in photon research, medicine, industry
Annual Workshops	- Presentation skills (talks, proceedings, poster) - Evaluation and reviewing of scientific results - International networking - Active participation in organization of the workshop
Hands on Training	- Semi-conductor detector measurements - Processing and handling of wafers - Working in clean rooms - Low current measurement equipment - Beam tests of detectors (planning and organization) - Irradiation programs (planning and organization)
Web-based training	- Most lectures, seminars and courses will be available via the web

The network participants ensure that all recruited researchers of the network are provided with: adequate office space, an up-to-date personal computer, commonly used office software, free access to internet, communication media and scientific libraries, adequate lab space and equipment to perform the planned research work.

B.2 Implementation

B.2.1 Planning of work packages, milestones and deliverables

The projects drawn up for the Early Stage Researchers last 3 years, while the projects of the Experienced Researchers last 2 years. We expect the researchers to spend about two thirds of their time at the main partner of the project. The other third will be spent at one or several other partners involved in the project in order to profit from special infrastructure, exchange with other trainees and colleagues and to contribute to a general transfer of knowledge and technologies between the partners. Project-specific plans and lists of milestones and deliverables have been drawn up for each of the 12 training projects. Work package 13, which was not included in the proposal, comprises the network management activities.

Table: Work package list

no.	Work Package Title	Type of activity	Lead bene-ficiary	Person months	Start month	End month
WP 1	Radiation Tolerant Mini-strip Tracking Detectors	RTD	CERN	72	1	36
WP 2	Hybrid Pixel Detectors	RTD	PSI	72	1	36
WP 3	Radiation Hard Crystals / 3D Detectors	RTD	UHH	72	1	36
WP 4	Micro Pattern Gas Detectors	RTD	CERN	60	1	36
WP 5	TPC with MPGD Readout	RTD	DESY	108	1	36
WP 6	Very Forward Calorimetry	RTD	DESY	72	1	36
WP 7	Advanced Photodetectors	RTD	CERN	24	1	24
WP 8	Photodetectors for High-B Fields	RTD	JSI	36	1	36
WP 9	Front-end Electronics for Hybrid Pixel Detectors	RTD	NIKHEF	60	1	36
WP 10	Monolithic Detectors	RTD	AGH	36	1	36
WP 11	Front-end Electronics	RTD	GSI	60	1	36
WP 12	Optimization of Monte Carlo Tools and Comparison with Benchmark Data	RTD	LNF	60	1	36
WP 13	Network coordination	MGT	CERN	tbd	1	48

For most of the projects we intend to hire two researchers who work on related subjects and will perform certain activities in common. The following table gives an overview of the S&T and training activities of each of the 22 researchers. Local training, organized by the host institutes, and network wide training events, which are open to all MC-PAD researchers, are not explicitly mentioned in the following table.

Table: Descriptions of the tasks of the recruited researchers.

	Task description
WP 1 ESR 1 CERN	The ESR will design and build a characterization set-up for silicon mini-strip sensors allowing for measurements with a laser (TCT - Transient Charge Technique) and a beta-source (CCE – Charge Collection Efficiency). Irradiated mini-strip detectors made from various silicon materials (n- and p-type FZ, DOFZ, EPI, MCZ) will be investigated. Additionally to the network training, the ESR will receive specific training on silicon detector technology at CERN and GSI, work at GSI for 2 months and stay at the company Micron for 2 weeks.
WP 1 ESR 2 GSI	The ESR will build a detector module test setup with a complete DAQ system that allows to study the performance of an integrated Silicon detector module. A first detector module will be prepared and studied realizing single sided detector readout. This module will then

	be developed towards a double sided detector readout module and the final module will be fully characterized. The ESR will receive specific training on silicon detector technology at CERN and GSI as well as training on the particularly complicated system integration challenges.
WP 2 ESR 1 UHH	The ESR will design sensors suitable the high radiation environment to be expected by future applications in particle physics and at the XFEL. For this he will develop an optimized design using commercial FEA-tools. The pre- and post-irradiated pulse shape of the prototypes will be analyzed in great detail. He/she will receive training in sensor physics at the collaboration partner and on production processes at the industrial partner producing the prototypes.
WP 2 ESR 2 PSI	Task: The ESR will analyze the response of small pixel sensors read out with the CMS pixel chip to beta particles. The samples are irradiated to SLHC-relevant fluences and cover different producers and designs. He/she will receive training in sensor modelling at the collaboration partner and on production processes at an industrial partner.
WP 3 ESR 1 UHH	The task of the ESR hired by Hamburg University is to design and construct a set-up for radiation hardness studies, use it to characterize the irradiated crystals and sensors and, based on the results of these measurements, simulate the performance in terms of charge collection, efficiency and position resolution. He/she will receive training in sensor modelling, defect engineering, characterization and measurement technologies. The activities will be performed in direct contact and exchange with the project partner JSI and NIMP.
WP 3 ESR 2 JSI	The task of the ESR hired by the JSI-Ljubljana is to upgrade a test set-up for the studies of 3D prototype sensors, characterize them for performance as function of irradiation and annealing conditions, simulate the charge transport in 3D sensors and develop and optimize position reconstruction algorithms. He/she will receive training in sensor modelling, characterization and measurement technologies. The activities will be performed in direct contact and exchange with the project partner UHH and NIMP.
WP4 ESR 1 CERN	Task: the ESR will design, build and evaluate small size, planar GEM detector prototypes based on a single mask technology scalable to sqm-size. This will also include performance comparison with alternative technologies (Bulk Micromegas; Thick GEM). He/she will participate in design, construction and test beam evaluation of a full size LHC upgrade prototype detector. He/she will receive training on modern gaseous detectors technologies, readout electronics, data acquisition and analysis as well as detector simulation tools. Several stays (about 3 months) at Frascati and Nikhef are foreseen.
WP 4 ER 1 LNF	The ER will participate in design, construction, laboratory and beam test evaluations of the ultra-light, cylindrical, dead zone–free tracker which consists of five concentric layers of triple-GEM detectors. He/she will receive training on modern radiation gaseous detectors technologies, detector readout electronics, data acquisition systems, data analysis and detector simulation tools. He/she will work at LNF for 24 months and stay at CERN for 1-2 months to participate in the beam tests and be in regular contact with the ESR at CERN.
WP 5 ESR 1 GSI	The ESR will design and build a characterization set-up for the prototype allowing for measurements with cosmic rays, a laser and a radioactive source. Detector assemblies with various designs of the pad-plane and GEM foil patterns will be investigated. Additionally to the network training, the ESR will receive specific training on technology for gaseous detectors at GSI and DESY and work at DESY for 4 months taking part in running experiments and gaining expertise with already working detectors and data analysis.
WP 5 ESR 2	The researcher will for the first year participate in the running and analysis of a test beam experiment of a large TPC prototype in DESY. In the second year he/she will contribute

DESY	to the design and construction of an advanced low mass readout system. This will eventually be used in an experiment at CERN, where different sub detectors are planned to be integrated within one effort. The candidate will participate in the planning and preparations of this experiment and will be trained in detector physics, readout and data acquisition.
WP 5 ESR 3 Nikhef	The researcher will start with systematic performance studies of a novel readout concept for TPCs using an amplification grid on the pixel readout chip obtained by advanced wafer post-processing. Prototypes of this new technology will be tested in a particle beam at DESY to prove the potential application in TPCs to reach a new level of tracking performance. The researcher will be trained in the physics and technology of micro pattern gas detectors and advanced wafer level fabrication technologies.
WP 6 ESR 1 AGH	Task: Design optimization of the Luminometer of a detector at a future e+e- collider. Design of a prototype of a sensor plane and integration of the FE Asics. At several stages test beam preparation and studies of the assembled sensor planes prototype in the beam. Test beam data analysis and systematic study of the performance. Close collaboration with IFJ PAN and DESY. Test beam studies will be done at DESY.
WP 6 ESR 2 DESY	Task: Design optimisation of the innermost calorimeter at a future e+e- collider (BeamCal). Test of the radiation tolerance of several prototype sensors in a beam. Design of prototypes of very thin sensor planes and integration of the FE electronics. Investigation of sensor planes in a test beam. Test beam data analysis and systematic study of the performance. Close collaboration with IFJ PAN and AGH Cracow in all phases. Common test beam studies at DESY.
WP 7 ER 1 CERN	The ER will work on three ongoing activities: (1) the fabrication of a XHPD prototype tube and its integration in an optical module; (2) the design, construction and test of a scintillating fibre tracker module for ATLAS with G-APD readout; (3) test of a novel geometrical concept of a PET camera module with WLS strip and G-APD readout. The ER will be trained on advanced photodetector design, qualification and applications. He/she will spend several months at our industrial partner Photonis and participate in beam (at Frascati) and possibly phantom tests (PET project).
WP 8 ESR 1 JSI	The ESR will be involved in the design of PET module and RICH prototype with magnetic field tolerant sensors. He/she will prepare the setups and analysis software for evaluation of the prototypes in the lab and test beam, and measure their time and position resolution. He/she will receive training on particle identification and medical imaging detectors, and will stay at CERN/DESY for three months.
WP 9 ER 1 PSI	The ER will translate the analogue part of the present CMS pixel read out chip from the 0.25 to 0.13 μm technology and submit test structures with an MPW. After this the readout architecture for the increased luminosity at a distance of ~4cm from the SLHC interaction point will be analysed. He/she will receive training in chip layout and simulation at PSI and will frequently consult the collaboration partner at NIKHEF. The ESR will be based at PSI in Villigen/CH.
WP 9 ESR 1 Nikhef	The ESR will work in close collaboration with the ER based at PSI. The goal is to arrive at a translation of the current 025 μm pixel chips (used at the LHC experiments CMS and ATLAS) to a version in a 0.13 μm technology. Components of this design can be tested in a submission to a multi-project wafer processing run. The ESR will be trained in the design of deep sub-micron ASICs, its characterization and application in particle physics experiments.
WP 10 ESR 1 AGH	Task: The ESR will participate in prototype measurements and development of monolithic detectors. The ESR will perform electrical measurements of prototype parameters, design and build a readout set-up to study the response of the detector to radiation sources and contribute to a design of new prototypes. The ESR will receive

	training on instrumentation in high energy physics, design of ASICs, FPGA programming. The ESR will work normally at IFJ PAN and AGH, 3-4 stays of duration 0.5-3 months at irradiation and beam test facilities (CERN, JSI, KEK) are also foreseen. The ESR will spend 3-4 weeks at Evatronix to learn FPGA programming.
WP 11 ESR 1 AGH	The ESR will participate in the design and tests of readout electronics for the forward calorimetry at ILC. The ESR will go through and learn the process of designing a dedicated VLSI circuit using CADENCE software. Depending upon the design status and ESR preferences the ESR will take part in the design of front-end electronics, analogue to digital conversion blocks or digital electronics. In addition the ESR will take part in the design of the digital (FPGA) part of the readout which will be connected with about 2 months training at the Evatronix company. Dedicated tests with sensors and irradiation facilities will be performed at DESY.
WP 11 ESR 2 GSI	The ESR will start out realizing a discrete circuit for fast diamond detector readout under the guidance of expert analogue designers at GSI. The ESR will be introduced into the intricate aspects of fast analogue circuit design and gain experience in tools and judgement. He/she will then be introduced into VLSI circuit design using CADENCE. An interim visit to the DESY diamond detector development group as well as the fast electronics development group at INFN Milano will allow him/her to focus the development work towards a multi channel diamond detector readout ASIC application. With the prototype chip at hand, the ESR will perform an extensive characterization employing a diamond detector in a heavy ion beam.
WP 12 ESR 1 CERN	The ESR will create an application interfacing Garfield with Geant4, model the effect of neutrons on the energy deposition in gas chambers and collaborate on the Geant4 description of neutron interaction in calorimeters. The comparison with existing data will be a significant part of his/her job. The ESR will mainly stay at CERN and will travel a few weeks/year to LNF for training on data, sharing results and helping on code implementation.
WP 12 ER 1 LNF	The ER will develop two simulation programs with Fluka/Geant4 to describe neutron interaction on calorimeters. The Geant4 version will be produced in close collaboration with the CERN group. The ER will mainly stay at LNF and spend a few weeks/year at CERN to be trained by the Geant4 group and in Milan to collaborate with Fluka experts. He/she will qualify the programs with dedicated data-MC comparisons.

Table: List and schedule of milestones

no.	Milestone name	WP no	Lead beneficiary	Delivery Date	Comment
P1-M1	Test set-ups (at CERN an GSI) operational	1	CERN	m10	Set-up
P1-M2	Full size detector modules tested	1	GSI	m30	Prototype
P2-M1	Definition of specifications	2	UHH	m6	Report
P2-M2	Layout of sensor prototypes	2	UHH	m21	Report
P2-M3	Source set-up available	2	PSI	m12	Report
P2-M4	Bump bonding of single sided sensors	2	PSI	m15	Report

P3-M1	Radiation damage for epitaxial sensor materials	3	UHH	m18	Measurement
P3-M2	Performance of epitaxial prototype detectors	3	UHH	m30	Measurement
P3-M3	Simulation of charge transport in radiation damaged crystals	3	UHH	m30	Software
P3-M4	Simulation tools for 3D detectors	3	UHH	m12	Software
P3-M5	Characterization of irradiated 3D detectors	3	UHH	m30	Measurement
P4-M1	Small prototype single mask GEM available	4	CERN	m3	Prototype
P4-M2	C-GEM prototype available	4	LNF	m12	Prototype
P4-M3	Full scale prototype single mask GEM available	4	CERN	m15	Prototype
P5-M1	ILC-TPC prototype available	5	DESY	m9	Prototype
P5-M2	Discharge protection technology established	5	NIKHEF	m12	Prototype
P5-M3	PANDA prototype available	5	GSI	m20	Prototype
P6-M1	Monte Carlo calculations to optimize LumiCal sensor granularity	6	AGH	m12	Report
P6-M2	Monte Carlo calculations to optimize BeamCal sensor structure	6	DESY	m12	Report
P6-M3	Prototype sensor plane for LumiCal ready	6	AGH	m18	Prototype
P6-M4	Prototype sensor plane for BeamCal ready	6	DESY	m24	Prototype
P7-M1	X-HPD tube characterized in lab	7	CERN	m6	Prototype
P7-M2	Scint. fibre tracker prototype with G-APD readout	7	CERN	m22	Prototype
P8-M1	Compact PET module with SiPM readout available	8	JSI	m12	Prototype
P8-M2	RICH counter with B-field tolerant sensors available	8	JSI	m24	Prototype
P9-M1	MPW submission of pixel analog circuit in 130nm	9	NIKHEF	m12	Layout
P10-M1	MAPS SOI functionality	10	AGH	m18	Prototype
P10-M2	MAPS SOI radiation hardness test	10	AGH	m24	Report
P11-M1	Single channel discrete diamond detector front-end available	11	GSI	m08	Prototype
P11	Calorimeter front-end ASIC	11	AGH	m18	Prototype

-M2	available				
P11 -M3	Calorimeter multi-channel readout	11	AGH	m30	Prototype
P12 -M1	First version of generic MC code application(s) for neutrons on calorimeters with Geant4/Fluka	12	LNF	m9	Software
P12 -M2	Initial version of coupled MC application for simulation of neutrons in gas detectors	12	LNF	m14	Software
P12 -M3	Results of comparisons of MC application against available data for electrons in calorimeter setup and for neutrons in calorimeter and gas setups.	12	CERN	m24	Report
P12 -M4	Improved Geant4/Garfield application for gas detector simulation	12	CERN	m36	Software

Table: Tentative schedule of project reviews

Review no.	**Tentative timing**	**Planned venue**	**Comments**
R0	m1-2	CERN	Kick-off meeting
R1 [1)]	m12	tbd	
R2 [1)]	m24	tbd	Mid-term review.
R3 [1)]	m36	tbd	
R4 [2)]	m48	tbd	Closing meeting

[1)] Review will be combined with an Open Training Event, at the same venue. Depending on the actual hiring profile, the closing meeting may take place earlier in the fourth year.

Table: List of Deliverables

no.	Deliverable name	WP no.	Lead bene-ficiary	person-months	Na-ture	Disse-mination	Del. Date
P1-D1	Set-ups at CERN and GSI commissioned	1	GSI	10	R	PU	m10
P1-D2	Recommendations on materials and designs	1	CERN	26	R	PU	m36
P2-D1	Simulation of sensor response	2	UHH	18	R	PU	m18
P2-D2	Characterization of prototype sensors	2	UHH	18	R	PU	m36
P2-D3	Characterization of irradiated CMS standard sensors	2	PSI	12	R	PU	m12
P2-D4	Characterization of irradiated single sided sensors	2	PSI	24	R	PU	m36
P3-D1	Simulation of signal shape for detectors of general geometry	3	UHH	16	R	PU	m16

P3-D2	Running scenario for epi sensors for SLHC	3	UHH	8	R	PU	m24
P3-D3	Performance of epi detectors at high luminosities	3	UHH	12	R	PU	m36
P3-D4	Optimized reconstruction algorithms	3	JSI	12	R	PU	m30
P3-D5	Performance of 3D detectors at high luminosities	3	JSI	18	R	PU	m36
P4-D1	Characterization of single GEM mask small prototype	4	CERN	9	R	PU	m9
P4-D2	Analysis of C-GEM beam test	4	LNF	18	R	PU	m18
P4-D3	Technology assessment report C-GEM	4	LNF	3	R	PU	m21
P4-D4	Technology assessment report single mask GEM	4	CERN	24	R	PU	m33
P5-D1	Evaluation of effectiveness of discharge technologies	5	NIKHEF	18	R	PU	m18
P5-D2	Analysis of ILC-TPC testbeam campaign	5	DESY	6	R	PU	m24
P5-D3	Beam tests of PANDA prototype analyzed	5	GSI	8	R	PU	m32
P6-D1	LumiCal prototype sensor plane; performance measurements in the lab	6	AGH	24	R	PU	m24
P6-D2	BeamCal prototype sensor plane; performance measurements in the lab	6	DESY	24	R	PU	m24
P6-D3	Prototype of LumiCal sensor plane	6	AGH	10	R	PU	m34
P6-D4	Prototype of BeamCal sensor plane	6	DESY	10	R	PU	m34
P7-D1	Test results of X-HPD lab tests	7	CERN	12	R	PU	m12
P7-D2	Characterization of PET based camera	7	CERN	6	R	PU	m18
P7-D3	Scint. Fibre characterization results	7	CERN	6	R	PU	m24
P8-D1	First laboratory test results	8	JSI	16	R	PU	m16
P8-D2	Test results of RICH prototype	8	JSI	14	R	PU	m30
P9-D1	Translation of the analogue part of the pixel circuit from 0.25 to 0.13 μm	9	NIKHEF	12	R	PU	m12
P9-D2	Simulation and evaluation of different readout architectures	9	NIKHEF	12	R	PU	m24
P10-D1	Characterization of MAPS SOI prototypes	10	AGH	24	R	PU	m24

P10 -D2	MAPS SOI technology assessment	10	AGH	12	R	PU	m36
P11 -D1	Multi-channel high speed front-end electronics	11	GSI	24	O	PU	m24
P11 -D2	Assessment of calorimeter front-end ASIC	11	AGH	24	R	PU	m24
P11 -D3	Test beam results of a multi-channel diamond detector system	11	GSI	10	R	PU	m34
P11 -D4	Characterization of calorimeter multi-channel readout	11	AGH	12	R	PU	m36
P12 -D1	First version of generic application(s) with simple controls for Fluka/Geant4 simulation of neutrons in sample detector setups	12	LNF	9	R	PU	m9
P12 -D2	Monte Carlo application for simulation of neutrons in gas detector setups	12	CERN	14	R	PU	m14
P12 -D3	Comparison of MC applications with available data	12	LNF	15	R	PU	m24
P12 -D4	Improved coupled Geant4/Garfield application for neutrons in gas	12	CERN	10	R	PU	m34
P13 -D1	Annual Reports: data base report and updates, initial submission	13	CERN		R		m2
P13 -D2	Midterm Review: two months before mid-term review meeting	13	CERN		R		m22
P13 -D3	Final report	13	CERN		R		m48 [1)]

1) Depending on the actual hiring profile, the final report may be scheduled earlier in the fourth year.

Table: Work Package descriptions. Common research projects of the MC-PAD network.

Work package number	**WP 1**	**Start date or starting event:**			**m1**		
Work package title	**Radiation Tolerant Mini-strip Tracking Detectors**						
Activity type	**RTD**						
Participant id	**CERN**	**GSI**	**JSI**	**UHH**	**Micron**	**NIMP**	
Person-month per beneficiary:	36	36	0	0	0	0	
Objectives: Develop silicon detector modules for particle tracking in a high rate and high occupancy environment.							

Description of work: We address the issues of radiation tolerance paired with high rate capability and high occupancy relevant for the SLHC as well as several FAIR experiments. The CERN based ESR will study radiation damage as well as signal deterioration in close contact with P3, the GSI based ESR will focus upon system aspects, system integration and robust detector operation. This includes the detailed investigation of the deterioration of the signal shape. The considerable difference in radiation fields of the SLHC as compared to FAIR as well as differences in the timing scheme and signal intensities make this project particularly challenging and interesting.

Work package number	**WP 2**	**Start date or starting event:**		**m1**			
Work package title	**Hybrid Pixel Detectors**						
Activity type	**RTD**						
Participant id	**DESY**	**PSI**	**UHH**	**Micron**	**NIMP**		
Person-month per beneficiary:	0	36	36	0	0		
Objectives: Develop hybrid pixel detectors for tracking at the innermost regions of the LHC and SLHC and photon research at X-FEL.							
Description of work: This project addresses the issues of radiation hardness and high particle densities of the innermost detector layers at the (S)LHC and X-FEL. It aims at an optimized design of pixel sensors using existing and future (see P3) measurements of the macroscopic radiation damage. The project focuses on cost effective hybrid pixel detectors using "standard" components. A key part will be the careful modeling of the sensor response as a function of the radiation fluence and annealing scenario using commercial solid state device simulation tools as well as specifically developed programs to simulate signal shapes. Lab measurements on prototype detectors and test experiments in photon and particle beams (e.g. at DESY and CERN) will allow to study and improve the performance under realistic conditions.							

Work package number	**WP 3**	**Start date or starting event:**		**m1**			
Work package title	**Radiation Hard Crystals / 3D Detectors**						
Activity type	**RTD**						
Participant id	**CERN**	**JSI**	**NIMP**	**UHH**			
Person-month per beneficiary:	0	36	0	36			
Objectives: New materials and read-out geometries for ultra radiation hard sensors.							
Description of work: Epitaxially-grown silicon sensors with thicknesses up to 150 µm will be fabricated and investigated regarding their radiation hardness. Using solid-state measurement techniques, the microscopic and macroscopic damage will be studied as function of type of radiation, radiation dose and annealing scenario. The performance of 3D detectors will be investigated starting with a prototype of the double column type detectors (3D-dct), which will be processed by mid 2008 (IRST, CNM, Glasgow University). The initial focus will be the measurements of the signal formation in different columns. For both projects, simulation tools will be developed to interpret the measurements and to improve the design. Using measurements with prototype sensors connected to LHC/SLHC speed electronics the charge collection efficiency, detection efficiency, and position resolution will be determined and reconstruction algorithms							

optimized. Finally a running scenario for the SLHC will be proposed.

Work package number	**WP 4**	**Start date or starting event:**	**m1**					
Work package title	**Micro Pattern Gas Detectors**							
Activity type	**RTD**							
Participant id	**CERN**	**GSI**	**LNF**					
Person-month per beneficiary:	36	0	24(ER)					
Objectives: High precision and ultra-low mass tracking detectors based on the GEM technology.								
Description of work: The single mask GEM technology will be optimized which allows building large area detectors. Small size detector prototypes will be constructed and evaluated and will lead to the design, construction and testbeam evaluation of a full size prototype detector. Electronics cross talk issues will be addressed in readout structure design by detailed detector and signal simulations and the radiation tolerance and material budget will be investigated. In parallel, an ultra-light, cylindrical and dead-zone free triple-GEM detector (C-GEM) made of five concentric layers will be worked on. Based on the experience with a successfully built small size prototype, it will be optimized for applications where large size combined with low mass is essential.								

Work package number	**WP 5**	**Start date or starting event:**			**m1**			
Work package title	**TPC with MPGD Readout**							
Activity type	**RTD**							
Participant id	**CERN**	**DESY**	**GSI**	**NIKHEF**	**UHH**			
Person-month per beneficiary:	0	36	36	36	0			
Objectives: Large volume tracking for ILC and PANDA at FAIR using MPGD and pixel readout.								
Description of work: For the next generation of experiments e.g. at FAIR (PANDA) and at the ILC and in order to cope with the enormous particle densities and data rates, the TPCs will need to be equipped with micro-patterned amplification, gating and readout structures. All 3 ESRs will work on technological feasibility and prototype studies. For PANDA, a GEM-TPC will be tested in the running experiment FOPI. DESY and NIKHEF are pursuing the development of a large high precision TPC as the main tracker for a detector at ILC. A detailed test of large MPGD detectors is under preparation within the EUDET framework, which will demonstrate their capabilities for large scale applications. The ESR at NIKHEF will participate in the creation of an amplification grid directly on the readout chip by advanced wafer post-processing techniques.								

Work package number	**WP 6**	**Start date or starting event:**			**m1**			
Work package title	**Very Forward Calorimetry**							
Activity type	**RTD**							
Participant id	**DESY**	**UHH**	**AGH**	**LNF**	**IFJ PAN**			

Person-month per beneficiary:	36	0	36	0	0			

Objectives: Development of very forward calorimeter for the ILC.

Description of work: The ILC forward calorimeters have to be mechanically precise to the micrometer level. They have to be equipped with radiation hard sensors and fast and low power FE electronics to allow feedback for beam tuning. Both calorimeters must be compact and finely segmented to reach the required performance. Within the EUDET framework, the ESRs will work on the following topics: Monte Carlo studies to optimise the shape and granularity of the calorimeter, sensor development for both calorimeters (Silicon, GaAs and CVD diamond), sensor performance studies in the laboratory and test beam, development of ultra-thin sensor planes for both calorimeters, integration of sensor planes and FE ASICS, preparation of a fully equipped prototype module for performance studies in the EUDET test beam.

Work package number	**WP 7**	**Start date or starting event:**		**m1**				
Work package title	**Advanced Photodetectors**							
Activity type	**RTD**							
Participant id	**CERN**	**LNF**	**Photonis**	**PSI**				
Person-month per beneficiary:	24(ER)	0	0	0				

Objectives: Development and application of novel photodetectors.

Description of work: The development program covers concept, design, construction and performance evaluation of various photodetectors, in close collaboration with the industrial partner Photonis. The project comprises 3 lines of activities: (1) Integration of an X-HPD in a pressure sphere and measure performance under water. (2) Design, construction and test of a scintillating fibre tracker module for ATLAS with G-APD readout. Test of a prototype of a highly granular lead-scintillating fibre or tile-wavelength shifter calorimeter readout with G-APDs at the Frascati Test Beam facility. (3) In collaboration with PSI: Test of a positron emission tomography (PET) camera based on long axially oriented crystals with wavelength shifter strip readout with G-APDs.

Work package number	**WP 8**	**Start date or starting event:**			**m1**
Work package title	**Photodetectors for High-B Fields**				
Activity type	**RTD**				
Participant id	**DESY**	**CERN**	**JSI**	**Photonis**	**UHH**
Person-month per beneficiary:	0	0	36	0	0

Objectives: Development of photodetectors compatible with high magnetic fields and their application for particle identification and medical imaging.

Description of work: The aim of this project is to develop and test novel position sensitive single photon detectors for operation in high magnetic fields, and use them in prototype devices. Novel sensors currently evaluated are e.g. multianode micro-channel plates (MCP), silicon photomultipliers (SiPM) and Geiger mode APDs. Prototype photon detectors will be tested in collaboration with CERN, Photonis and other network partners. Pulsed light sources will allow scans of the spatial uniformity of response, sensitivity and time resolution. The photon detectors will be installed in two prototype detector set-ups, a proximity focusing ring imaging Cherenkov counter, and a PET apparatus.

Work package number	**WP 9**	**Start date or starting event:**					**m1**		
Work package title	**Front-end Electronics for Hybrid Pixel Detectors**								
Activity type	**RTD**								
Participant id	**NIKHEF**	**PSI**							
Person-month per beneficiary:	36	24(ER)							
Objectives: New readout architectures for the front-end electronics for the upgrades of the ATLAS and CMS pixel detectors.									
Description of work: The inner layer of the present LHC pixel detectors is estimated to last about 3 years at high LHC luminosity and will thus require a replacement. A simple copy of the system is not sensible as the present chips suffer from the limitations of the 0.25 micron technology which was the state of the art at the time of construction. During the project we aim at the development of a full scale pixel chip based on 0.13 micron CMOS technology. This technology offers the opportunity to implement new features like an increased high rate capability, which is especially important for the innermost pixel layer. Further, a reduction of the readout pitch can be envisaged.									

Work package number	**WP 10**	**Start date or starting event:**					**m1**	
Work package title	**Monolithic Detectors**							
Activity type	**RTD**							
Participant id	**AGH**	**IFJ PAN**	**JSI**	**UHH**	**DESY**			
Person-month per beneficiary:	36	0	0	0	0			
Objectives: Monolithic active pixel sensors and detectors based on silicon-on-insulator technologies.								
Description of work: Detectors for a future high luminosity B-factory and for the proposed ILC require precision vertex reconstruction in a high track density and radiation dose environment. This requires a significant reduction in overall material thickness. Thin CMOS-based Monolithic Active Pixel Sensors (MAPS) will be investigated, mostly concerning their radiation hardness and readout speed. The work is embedded in detector development teams and will cover MAPS design, readout electronics, detector irradiations and testing and vertex detector layout studies.								

Work package number	**WP 11**	**Start date or starting event:**					**m1**	
Work package title	**Front-end Electronics**							
Activity type	**RTD**							
Participant id	**AGH**	**DESY**	**EVATRONIX**	**GSI**				
Person-month per beneficiary:	36	0	0	24(ER)				
Objectives: Very low noise electronics for ILC-calorimeters and ultra fast microwave circuits for diamond detectors.								
Description of work: For the readout of CVD-diamond sensors at FAIR experiments, ultra fast microwave analogue pre-amplifier and discriminator circuits have to be developed. Likewise, the front-end electronics for the LumiCal detector of the FCAL at the ILC have to meet challenges like dynamic range, speed, noise, particle occupancy, linearity, signal amplitude, resolution and power consumption. Prototypes of discrete electronic components as well as integrated front-end and ADC conversion ASICs will be designed, produced and tested. A prototype digital readout system will be developed for LumiCal. The devices will be tested extensively on the respective detectors. The digital components will be developed and built in close collaboration with the company Evatronix.								

Work package number	**WP 12**	**Start date or starting event:**					**m1**	
Work package title	**Optimization of Monte Carlo Tools and Comparison with Benchmark Data**							
Activity type	**RTD**							
Participant id	**CERN**	**LNF**						
Person-month per beneficiary:	36	24(ER)						
Objectives: Improved description of the neutron response in calorimeters and gas detectors.								
Description of work: The detailed simulation of lead/scintillating fibre (Scifi) calorimeters of different structures using Monte Carlo tools (Fluka, Geant4) is relevant to evaluate and improve their energy response and sensitivity to neutrons. The effect of background neutrons on the energy deposition measured in gas chambers is expected to be a significant limitation for gas detectors in many experiments. To model these accurately the physics models in Geant4 for neutrons will be validated e.g. using test beam data. Also they will be coupled with simulation of resulting gammas and the ionization in Geant4 and transport of lower energy electrons/gammas in the Garfield tool, to create an integrated tool for assessing the effects of neutrons in gas detectors.								

Work package number	**WP 13**	**Start date or starting event:**					**m1**	
Work package title	**Network coordination**							
Activity type	**MGT**							
Participant id	**CERN**							
Person-month per beneficiary:	36							

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Objectives: Effective of use of network resources, optimal training for researchers, maximum impact**.**
Description of work: The work package comprises the management and administration of the MC-PAD network in agreement with the Commission's rules, contractual obligations and the agreed network procedures. This includes reporting (scientific and financial) to the Commission, supervision of all network activities, ensuring the application of standards and procedures across the whole network, organization of common network training events, organization of management meetings.

B.2.2 Management structures and procedures

The network will be managed by a Supervisory Board (SB) and an Executive Board (EB) according to the diagram below.

The main tasks of the Supervisory Board are to support the Executive Board with advice, to monitor its activities and to follow up the general operations and progress of the network. The Supervisory Board comprises a representative of each of the network partners, including associated and industrial partners and will meet twice a year. The Board elects its chairperson that is not a member of the Executive Board. The Board should monitor all actions taken by the Executive Board to ensure that the network's goals are effectively fulfilled. It appoints two external advisors for an independent peer-review of the quality of the training programme.

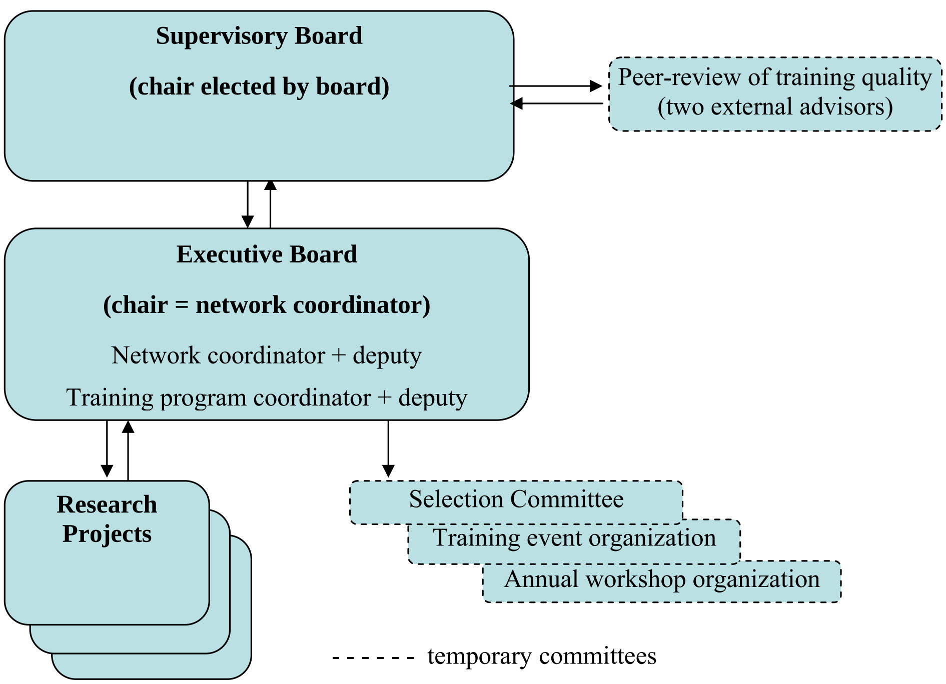

Diagram: Management of the MC-PAD network.

The Executive Board is in charge of the overall management of the network's research and training programme. The EB is chaired by the Co-ordinator of the MC-PAD network. The other members of the EB are appointed by the Supervisory Board for a period of one year (renewable): the deputy network co-ordinator, a co-ordinator for the training program, a co-ordinator for selection matters, and deputies for the latter two.

One of the EB's tasks of particular importance is organization and follow-up of recruitment. It assures that the selected candidates are matched with a project and assigned to a supervisor and that a career development plan including a personal training schedule is established. The organization of network wide training events and workshops will be initiated by the EB. Two external experts will provide feedback and advice on the quality and organization of the training activities.

The EB will follow up the research carried out in the projects of the network. For each project, contact persons have been identified who manage and follow up the progress of the projects and also monitor the development of the researchers assigned to the project.

Frequent contact and exchange of results between the partners within a project is mandatory and is organized by the partners of that project. Structural problems, disputes or changes to the research plans must be reported to the EB. If required, the EB will intervene to try and solve disputes amicably.

The Executive Board will have monthly meetings using modern telecommunication means. The Executive Board has the freedom to appoint committee members for a finite duration in time, to organize selection, implement training and prepare the annual workshops.

An administrative employee will be financed on a part-time basis from the network's management budget. He/she will support the activities and the organization of the network, in particular the financial follow-up and reporting, and provide administrative help to the recruited researchers.

- *Rules for decision-making*

The Executive decisions for the implementation of the research training programme will be taken by the Executive Board. Any changes in the research and/or training programme will have to be approved by the Supervisory Board. Where such changes may have impact on the contractual obligations of the ITN, they will be submitted to the EC Project Officer in charge of the ITN for approval.

- *Scientific and administrative co-ordination of the research projects (WP 1-12)*

The scientific and administrative co-ordination of the individual research projects WP 1-12 are carried out by the participating institutes. The project contact persons will inform the Executive Board about progress, delays or unforeseen problems of technical or other natures. Whenever possible, the EB will propose and monitor corrective measures.

- *Financial management*

The network co-ordinator has the overall responsibility for the financial management of the ITN. The financial management will be handled by each participating institution. Financial controlling and management will the responsibility of the local finance departments, which will create project accounts and all necessary monitoring tools as well as other formal financial arrangements. Expenditure for each researcher is monitored closely according to expenditure type in order to ensure compliance with the relevant ceilings and rules of the Commission. Additionally, local finance departments report to the network co-ordinator of the ITN for an overall control of the funds as well as potential active redirection of funds. The network participants are in charge of an appropriate auditing of their financial matters.

- *Recruitment planning*

The MC-PAD network applies for 17 early-stage and 5 experienced researchers, i.e. 22 positions in total. The typical duration of an appointment is 36 months for an ESR and 24 months for an ER. Most of the researchers are recruited into already ongoing R&D activities. We foresee to recruit all researchers as early as possible, i.e. ideally in month 1 after the official start of the network. It is realistic to assume that the recruitment of all researchers can be completed in the first 6 months.

- *Recruitment process*

The recruitment process comprises the following steps: (1) creation of the vacancy notice, (2) advertisement of the vacancy, (3) selection of the researcher, (4) employment and induction into the network. The process is run locally by the HR department of the recruiting network participant. Steps 1 – 3 need to take place before the official start of the network. The network's Executive Board coordinates and follows up the process and ensures a timely filling of the jobs.

- *Vacancy notice:* The network participant, which will recruit a researcher for a project, creates a vacancy with a description of the research work (see projects WP1-WP12 and individual task descriptions of researchers) and the profile of the candidate. The Executive Board is asked for comments and final approval.
- *Advertisement:* All positions will be advertised on the Cordis mobility portal, the MC-PAD web site, the participating institutions´ local (electronic) recruitment tools, e.g. e-RT at CERN, as well as via networks inside the project and its participants and partners. Each position will have an application deadline, in conformity with rules in place, which will be respected strictly.

  After approval of the MC-PAD network, an advertisement in a monthly magazine like the *CERN Courier*, which is read widely by high energy physics researchers, may be an effective way to make the network known in the community.
- *Selection of researchers:* Applicants will submit their applications to the recruitment office of the locally employing institution. Following screening of applications by the Human Resources department, applicants will undergo a rigorous selection on grounds of quality and potential, as well as a matching of their scientific profile with job specifications. Assessment is made according to academic qualifications, experience, achievements, and other elements including language knowledge, mobility and volunteer work. This assessment will be done by a board comprising the local HR co-ordinator, a representative of the local network participant (normally the supervisor for the position) and two representatives of the MC-PAD Executive Board, namely the Network Co-ordinator and the Recruitment Co-ordinator. The equal opportunity commissioner may be involved if underprivileged candidates are among the applicants (see below). Candidates may be invited to meet their potential supervisors. The board will try to reach unanimous agreement.
- *Employment and induction into the network:* The employment process is carried out under the auspices of the local Human Resources department to ensure correct application of the rules and criteria. The respective Human Resources department acts as guarantor for the fair and uniform application of employment policies, in particular with regard to gender balance and related equal opportunities issues. The supervisor is in charge of the induction of the recruited researcher into the local environment and the training network.

B.2.3 Planning of conference and Visiting Scientists contribution

We will organize a number of meetings and training events as summarized in the table below. The *kick-off meeting* will take place in the first two months after the start of the project. Its main purpose is to bring together the participants of the network, to form the management structure and discuss details of the research and training programme and its implementation.

We plan to organize *network training events* and *open training events* which involve the researchers from several or all research projects. Whenever possible, the training will put emphasis on the common aspects in detector development. Many of the training events aim at subjects that lie outside the normal particle physics training programs. Topics of these training events are, for example, radiation damage, ageing of detectors and microelectronics. The topics are chosen such that researchers from several projects should profit from the training during their daily research activities. It is stressed that the training events are open to all members of the networks.

The *annual meetings* bring together all people involved in the network, i.e. the recruited researchers, their supervisors and the members of the Executive and Supervisory Boards. The meetings have a two-fold function. (1) The projects present scientific progress reports to promote sharing of ideas and dissemination of results. Talks and posters will be presented by the ESRs and ERs in the projects. Written reports of these yearly workshops will result in a collection of proceedings which provides an overview of the scientific progress of the research carried out at the network institutes and projects. (2) Meetings of the Supervisory and Executive Boards will permit a review of the overall progress of the network and a discussion of possible adaptations of strategy and implementation to cope with experienced difficulties or shortcomings. These meetings will start the preparation of the annual reports which will be completed in the following weeks.

The *closing meeting* has the same function as an *annual meeting*, however, in addition it will serve as a forum to critically review and compare the overall scientific progress with the goals, and to judge the achievements and impact of the network in the fields training and dissemination.

Table: Tentative schedule of network meetings and training events

	Milestones	**Dates (months after start)**	**Deliverables**
1.	Kick-off meeting	m1-m2	Protocol
2.	Network training events	m9, m18, m30	Training certificates
3.	Open training events	m12, m24, m36	Training certificates
4.	Annual meetings	m12, m24, m36	Proceedings, annual reports
5.	Closing meeting [1)]	m48	Report, recommendations

[1)] Depending on the actual hiring profile the closing meeting may take place earlier in the fourth year.

Visiting Scientists

We consider the recruitment of visiting scientists (VS) an excellent way of efficient knowledge transfer into the network projects and a means to significantly enhance the training capacity and quality. We intend to recruit senior scientists with an international reputation for a total duration of 18 months.

Visiting scientists, generally senior researchers with an international reputation in the field of radiation detectors, will be invited to work for periods of typically 1-2 months with one of the network participants. The VS will be chosen for their specific expertise, know-how and skills. They will work with the local teams on their project, in direct contact with the ESRs and ERs. The trainees will profit from their particular expertise and experience. These visits will contribute to a mutual transfer of knowledge between the network and outside institutions.

Visiting scientists will also be invited to give special lectures and seminars, preferably at the network's training events.

Large infrastructures are available on the various sites and at the sites of the industrial partners. The use of these highly-specialised experimental set-ups is quite often in the hands of very few experts. Visiting scientists can transfer essential knowledge among the different institutes. Also the evaluation of certain development processes at other institutes can reveal new roads to success. For young researchers it is attractive to get training from well known experts on the use of specialised apparatuses.

B.3 Impact

B.3.1 Research Indicators of Progress

The network will provide the following indicators of progress in its periodic, mid-term review and final reports.

B. 3.1.1 Research Activities

- General progress with research activities programmed at individual, participant team and network level. Possible problems encountered and nature/justification for adjustments, if any, to the original research work plan and/or timetable.
- Highlights of scientific achievements and recognitions (innovative developments, scientific/technological breakthrough, publications, patents, awards and prizes etc...).
- Progress on cross interaction among disciplines and between academic and industrial partners other stakeholder or relevant users groups.
- Specialist exchange among network teams and visit of Senior Researchers from inside and/or outside the network.
- Individual and joint publications, directly related to the work undertaken within the project (including citation index).

B. 3.1.2 Training Activities

- General progress with training programmed at individual, participant team and network level (Career development plan, supervision, coaching or mentoring in place at each host institution).
- The rate of recruitment of ESR/ER for each participant and for the network as a whole (ratio person-months filled/offered) and time and duration of each individual appointment.
- The nature and justification for any deviation from the original plan (as referred to table A3.1 of part C) or adjustments, if any, to the original research work plan and/or timetable.
- The number and place of the short visits/secondments undertaken or organized by each ESR and ER within the network (full participant and associated members including number of visits of the ESR and ER to their home scientific community).
- Participation in training events and network meetings (workshops, seminars, summer schools ...) and to international conferences (number, names, place date).
- Achievements regarding the acquisition of complementary skills (for example: project management, presentation skills, language courses, ethics, intellectual property rights, communication, entrepreneurship…).

- Level of satisfaction of the trainees (e.g. as expressed in response to questionnaire and their expectation to present their PhD thesis and when).
- Highlights on more particularly innovative developments (novel concepts, approaches, methods and/or products) and on wider societal and/or ethical components of the project, such as public outreach activities.

B. 3.1.3 Management and impact

- Effectiveness of networking, communication and decision-making between partners (at all levels: co-ordinator, team leaders, supervisor, ESRs and ERs), between the network and the Commission, and with the Industrial and/or other relevant stakeholders.
- Effectiveness of the recruitment strategy in terms of equal opportunities (including gender balance) and open competition at international level.
- Effectiveness of the "training events and conferences" open to external participants and integration in the training programme.
- Effective contribution of Visiting Scientists to the research training programme.
- Development of any specific planning and management tool(s) and databases management of intellectual property and commercialization of network research output (if applicable).
- Nature and justification for adjustments, if any, to the original training plan and/or timetable (e.g. opportunities for new collaborations regarding training activities).

B.3.1 Dissemination and Impact

By the very nature of the large international scientific collaborations in high energy physics, all researchers will be immersed in a pool of *networking* possibilities. Whether it is via inter-team meetings or via collaboration meetings and international conferences, the researchers will have excellent networking opportunities both in academic areas of activity and with the industrial partners involved on the ITN.

Dissemination of research results in the particle physics world is most commonly done using journal publications, presentations at conferences (with subsequent publication in proceedings) or seminars of which a great number are given at the network's institutions. This gives the researchers ample opportunity to hone their skills in writing or making presentations.

The FP7 IPR rules will apply in general, and in particular we will respect any IPR agreements already in place in pre-existing agreements. For the secondment of researchers to the industrial partners, a specific non-disclosure agreement may be required in some cases.

A *network web site* will be created and maintained. It will serve for the internal communication and information exchange between the network partners. It will also be used for outreach purposes, advertisements of vacancies, announcement of network events as well as relevant conferences and workshops. Research results, in the form of notes, talks etc. will be published on this web site (in so far as industrial / confidentiality clauses allow).

B.4 Ethical Issues

(not applicable)

B.5 Gender aspects

Recent surveys have shown that female students and scientists are under-represented in many engineering and scientific fields. Particle Physics is one of these fields. Gender balance or, in more general terms, equal opportunities have moved into the focus of the human resource policy of many research organizations. Equally important are respect and dignity in the workplace, a reasonable balance between work and home-life and an appropriate support for working parents.

In the MC-PAD project, the network participants are committed to a fair treatment in recruitment and career development regardless of sex, ethnic origin, physical handicap, sexual orientation or religion, nationality, etc.

To improve female participation in all job categories and at all levels, gender distribution is monitored and statistics are published annually (experience has shown the absence of any gender bias at the selection level). In training lectures and seminars, particular attention is paid to choosing, whenever possible, women scientists as speakers in order to provide positive role models to young female scientists. In addition, potential supervisors will be asked to pay particular attention to female candidates when applications are circulated.

With the aim of increasing the number of women coming into in the field of particle physics, and retaining them, CERN has also been an active member of the FP6 initiative SET-Routes and has introduced new courses in its internal Management & Communication curriculum which specifically address issues of women in management.

PART C:

(to be filled in later)

PART D:

(to be filled in later)