Horizon 2020 Framework Programme

HadronPhysicsHorizon  
(HPH)

Joint Research Activity:

|  |  |
| --- | --- |
| Topical areas (*indicate all that apply*): | X High-tech challenge   * Precision challenge * Complexity challenge * Data challenge   X International collaboration challenge   * Outreach challenge   X Application challenge |
| Activity Descriptive Title: | Cost-effective photon detection systems with large-area, high spatial and temporal resolutions for applications in Hadron Physics and Medical Imaging |
| Activity Acronym: |  |
| Leading Institution: | INFN |
| Name of acting spokesperson: | Marco Contalbrigo |
| E-mail: | Marco.[contalbrigo@fe.infn.it](mailto:contalbrigo@fe.infn.it) |
| Telephone number: | +29 0532 974308 |
| Fax number: | +39 0532 974343 |
| Mobile: | +39 333 6725544 |

# A. WORK PACKAGE DESCRIPTION

***(maximum length: 4 pages)***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Work package number** | | WPx | **Start date** | 01.01.2015 | |
| **Activity Type** | | RTD | | | |
| **Activity number and acronym** | |  | | | |
| **Work package title** | | Cost-effective photon detection systems with large-area, high spatial and temporal resolutions for applications in Hadron Physics and Medical Imaging | | | |
|  |  | | |  |  |
| **Beneficiary number** | **Organization legal name**  *(in italics the Research Units)* | | **Short name** | **Activity leaders**  *(in* ***bold*** *the spokesperson)* | **Human effort**[[1]](#footnote-1)  (see note below)  *(person-months)* |
| 1 | Istituto Nazionale  di Fi­sica Nucleare | | **INFN** |  |  |
|  | *INFN Sezione di Ferrara* | | **INFN-FE** | M. Contalbrigo |  |
|  | *INFN Laboratori Nazionali di Frascati* | | **INFN-LNF** | M. Mirazita |  |
|  | *INFN Sezione di Bari* | | **INFN-BA** | R. Perrino |  |
|  | *INFN Sezione di Genova* | | **INFN-GE** | P. Musico |  |
| 2 | Istituto Superiore di Sanita’ | | **ISS** | E. Cisbani |  |
| 3 | Foundation Bruno Kessler | | **FBK** | C. Piemonte |  |
| 4 | University of Glasgow | | **UGlasgow** | B. Seitz |  |
| 5 | J. Gutenberg Universitat, Mainz | | **UMainz** | M. Hoek |  |
|  |  | |  |  |  |
|  |  | |  |  |  |
|  |  | |  |  |  |
| **Other involved institutions not receiving EC funds** | | | | **Activity leaders** | **Estimated human effort involved in the WP** |
| Tomas Jefferson National Lab, VA, USA | | | | P. Rossi |  |
|  | | | |  |  |
|  | | | |  |  |
|  | | | |  |  |

##### 1. OBJECTIVES

The project foresees the research and development of innovative photon detection systems allowing the covering of large areas in a cost-effective way. The foreseen applications are:

\*) extend the physics range of the upcoming JLab12 facility design to work with polarized electron beams at the luminosity frontier;

\*) validate new technologies for the next generation of physics experiments;

\*) evaluate cost effective solutions for medical imaging.

**Large-area cost-effective photon detectors.**

Lasciamo generico o dichiariamo che puntiamo al visibile ?

Detection of photon is rather challenging in terms of costs. The detection of the relatively low-energetic visible light photons is still based on the use of expensive photomultipliers. The fast aging of bi-alkali photo-converters in the presence of gas has so far prevented an effective use with cheap gas detectors, despite several years of research. The project plan to explore two innovative and alternative technologies:

\*) silicon photomultipliers (SiPM): now undergoing a rapid development in performances improvement and cost reduction, are robust devices with low (<100 V) bias voltage, fast response and high gain, and can operate in magnetic fields. INFN groups have started to test these devices in real conditions during the prototyping stage of the CLAS12 RICH.

\*) micro-channel plates (MCP): a sort of electron-multiplier …. A R&D activity is ongoing in US to engineering the construction and reduce the costs. JLab is supporting the activity and going to take charge of the characterization of the newly produced devises.

Probabilmente meglio glissare, si sovrappone al WP di Trieste.

Magari accennarlo come altri sviluppi in corso.

Gaseous based photomultiplier detector (GPM) and in particular GEM most likely represents the cheapest solutions among the considered options, however their effective use as visible photon detector have still to be demonstrated. The ISS group is assembling the current largest GEM camera as tracking detectors for the JLab high-luminosity experiments in hall-A. The applicative branch of the project exploits this in-house technologic background.

The innovation in photo-detectors should proceed in parallel with the development of dedicated integrated electronics able to maximize the performances in terms of gain and time-resolution while containing the cost. INFN and ISS groups have several years experience in developing front-end electronics for Physics and Medical Imaging detectors.

DAQ and analysis software.

**Hadron Physics at JLab12**

The non-perturbative nature of the strong-force has always challenged our comprehension of the ordinary matter from first principles in terms of quarks, gluons and QCD, the gauge theory describing their interactions.

The recent experiments in various Laboratories in the world (DESY, CERN, JLab, BNL, SLAC, KEK, etc.) and the parallel theoretical developments, partly funded with the previous HP2 and HP3, opened the way to new fields of investigation and showed the importance of a comprehensive study of the parton dynamics, and in particular of the correlations between transverse momentum and spin of partons, related to partonic orbital momenta and spin-orbit effects, with flavor sensitivity.

This is part of the more general problem of confinement and hadron formation. Indeed this innovative approach has implications also for the study of hadronization in general and in particular on the observables related to hadron formation in cold matter (transverse momentum broadening). The precise knowledge of parton distribution functions is not only interesting on its own, but can also have an important impact on fields that are not strictly related to the structure of nucleons, such as the precise determination of the W boson mass or the studies of the distribution of transverse momentum in collisions at LHC (CERN).

Jefferson Lab aims to become the most complete facility in this field in the medium term. The proposed experiments are based on deep-inelastic scattering of a high-intensity and high-polarization 11 GeV electron beam off light polarized targets, and are expected to work at the luminosity frontier (from 1034 to1038 cm−2s−1). The completion of the 12 GeV JLab upgrade was recently recommended by NSAC to DOE as the first priority for the Nuclear Physics program in the United States. The beam will start to be delivered to the experimental halls in spring 2014.

The CLAS12 large acceptance spectrometer in Hall-B of JLab has unique features (luminosity and resolution) to allow for a substantial progress in this field in the medium term. The approved physics program requires a RICH detector able to improve the identification among the produced hadrons, and thus to distinguish the flavor of the involved quarks. The instrument has to match with the rest of the spectrometer already under construction. In particular, it has to cover a large area in order to extend the measurements in the most interesting kinematic regions and to allow multi-dimensional analyses, a key element for such kind of research.

Within the previous FP7 a solution was found for the RICH basic configuration (two azimuthal sectors out of six, each covering an area of about 4 squared meters) in time for the beginning of the dedicated experiments with the 12 GeV beam. In order to match the strict CLAS12 time schedule, a mature technology has been adopted for the photon detector. In order to limit the cost, a novel hybrid optics design based on aerogel radiator and composite mirrors was adopted to reduce the active area to about 1 m2 per sector. Moreover a cost-effective multi-anode photomultiplier have been adopted although not advertised as the optimal device for single photon detection purposes, after several units have been characterized in laboratory tests and used in test beams of RICH prototypes in conjunction with a dedicated electronics probing to be able to achieve performances adequate to the CLAS12 RICH requirements.

In order to extend the detector to the remaining sectors and to obtain precision data in kinematic region otherwise inaccessible, innovative techniques are needed to reduce the cost per surface unit.

**New generation of Physics experiments.**

Sovrapposizione con EIC dove pero’ mancano le specifiche, ma anche con PAX (e/o PANDA) dove pero’ I rivelatori sono gia’ definiti, oppure ?.....

**Cost-effective solutions for Medical Imaging.**

The development of innovative photo-detection techniques, that allow large areas at affordable costs, can find valuable applications in Nuclear Medicine and related fields. High spatial and time resolution, compactness and insensitivity to magnetic fields are key aspects of photon detectors applied to molecular imaging with radionuclides (Single Photon Emission-SPE, Positron Emission -PE and their tomographic versions SPECT and PET) today in use for early diagnosis of tumors (breast, prostate) as well as for studies in-vivo on animal models of human diseases (cardiovascular, brain,...) and of their therapy (i.e. by stem cells and their tracking in the animal model). For example, the good time (a few hundreds of ps) and spatial (a few mm) resolutions allow for the development of new TOF-PET solutions. The Micro Channel LAPP is expected to provide few tens of ps time resolution: being also competitive in price this would represents the detector of election in TOF-PET. With equivalent relevance, the insensitivity to magnetic fields of the SiPM can allow the realization of innovative multi-modal medical devices based on the integration of PET-SPECT techniques and MRI systems, resulting in a substantial reduction of the scanning duration, a wider angular coverage and a consequent effectiveness in photo attenuation corrections (crucial for quantitative analysis).

Large area optical photon detectors are also central component of the Compton Camera: one of the most technologically complex device in medical physics. The Compton Camera exploits the gamma Compton scattering to backtrack the photon to its emission point and therefore imaging the gamma emission density related to what one is investigating. Compton Cameras are potentially superior to both SPECT and PET imaging although their routine application is not yet achieved due to the technological challenges (both hardware and software) and costs. In fact Compton Camera potentially offers: wide field of view; superior performance (efficiency/sensitivity and spatial resolution) respect to mechanical collimation at medium (100-500 keV) and high gamma energies (larger than 500 keV); it virtually provides 3 dimensional imaging without tomography. On the other side, as mentioned, the technology is rather complex and several parameters need to be properly optimized to achieve the desired performances. There are few examples of real (prototypes) Compton Camera for medical application (generally derived from devices used in astrophysics). Cameras in molecular imaging, properly adapted, can be exploited for the imaging of prompt photons emitted by the hadrons beam in hadron-therapy when delivering the dose to the patient. In this way it can provide a precise real time measurement of the released dose and its spatial 3D distribution.

All these applications can, to various degrees, benefit of the developments that are planned for the RICH, especially concerning noise suppression, reduction of dead areas between sensitive pixels, enhancement of uniformity in the detector response, reduction of costs and development of integrated electronics, with independent control of the readout channels.

The project foresees the impact assessment of the novel photodetectors suitable for RICH applications in medical and biomedical applications, performing proof-of-principle tests with small prototypes of innovative devices completed with a custom integrated electronics.

Specifically, we intend to investigate the possibility to equip a small Compton Camera prototype based on properly adapted (with low Z radiant material) GEM or microMeGas chambers as single (or multiple) scatterers and the investigated large area photon detectors coupled to plastic scintillators as photon absorbers, taking in mind both potential applications in molecular imaging (as SPECT/PET improvement) and hadron therapy (as prompt gamma detector for delivered dose measurement).

##### 2. DESCRIPTION OF WORK AND ROLE OF PARTICIPANTS

Tasks:

Innovative new technologies of photo-detectionion will be applied for the RICH in order to cope with the geometrical restrictions for integration in the CLAS12 spectrometer and with the operation in the high intensity electron beam and in presence of magnetic fields. This requires intensive R&D before final design of the RICH detector under stringent time constraints.

Photo-detector: study of the reply of SiPMs to the Cherenkov light produced in the chosen aerogel type; test measurements for comparative studies of the characteristics of SiPM; final design for the photo detection regarding an optimized performance to cost ratio; development of a fast readout system.

Construction of a RICH prototype of final design and test measurements of the RICH performance.

Technical design report.

Definition of a small prototype of Gamma Camera (montecarlo analysis …). based on achievement in photon detector characterization. Implementation of the prototype. Test of the prototype and analysis of the results. Definition of a full scale system for potential final application, with cost estimation.

INFN Section of Ferrara and University of Ferrara (contact M. Contalbrigo): it is among the initial promoters of the 3D study of the nucleon structure, holding various responsibilities (Analysis Coordinator, Convener of Transverse Physics) in the precursor HERMES experime nt. It promotes an extensive physics program at JLab, his members being co-author (as co-spokesperson) of several proposals approved by JLab PAC. It offers a broad competenc e in the field of SiPM, originally developed for the IFR muon detector of SuperB: it has Developed a dedicated front-end electronics and verified the response of SiPMs to single photon and to radiation-damage in a number of test-beam experiments.

Laboratori Nazionali di Frascati (contact M. Mirazita): it collaborates with the JLab s ince the early years of activity, contributing to build some Hall-B detectors and covering respo nsibility positions within the Collaborations Clas and Clas12; researchers of LNF were and are responsible for the various analyses of experimental data on the study of the 3D nucleon structure, and are among the proponents of further experiments with the 12 GeV beam of JLab. The LNF also offers a high-stability laser test-station for photodetector charact erization, a clean room for delicate detector assembling, and a cutting-edge machine workshop where a prototype of the RICH, used in two test-beams at CERN, were realized.

INFN Section of Genova (contact P. Musico): since years develops electronic systems for acquisition of photo-detectors (PMT and SiPM) and charged particles (GEM) for applications in Nuclear Physics, Astrophysics and Nuclear Medicine.

Istituto Superiore di Sanit`a - ISS (contact E. Cisbani): collaborates since years at N uclear Physics experiments on the structure of the nucleon (at DESY and JLab) in particular by contributing to the Cherenkov detectors, RICH. Is involved in the construction of GEM tracking detectors and offers a evaporation chamber that can be used for depositing photo-conversion layers. It is involved in various research activities and R&D for Nuclear Medicine.

INFN Section of Bari and University of Bari (contact R. De Leo): has been working for years in the construction of Cherenkov detectors and is collaborating to the realization of GEM tracking devices.

Thomas Jefferson National Accelerator Facility (contact P. Rossi) of US Depart ment of Energy: is the host laboratory for the facility foreseen in the project. Provides expertise in mechanics and electronics and advanced laboratories, in particular for the production of elliptical mirrors. LAPP part!

Universidad Tecnica Federico Santa Maria de Valparaiso, Chile (contact William Brooks): contributes to the development of dedicated electronics for photo-detectors.

University of Glasgow, UK (contact Ken Livingston): works on data analysis and characterization of aerogel radiators and photomultipliers.

J. Gutenberg Universitat of Mainz, Germany (contact Matthias Hoek): is involved in data acquisition programs and characterization of photomultipliers and aerogel radiators.

The project foresees collaborations with various public and private Italian subjects at the forefront of the detectors and electronics, as the FBK foundation of Trento for SiPM development and electronic companies like CAEN, as well as with producers of printed circuit boards. The project I s linked to activity in Nuclear Medicine, in collaboration with medical diagnostics companies. Examples are the TOPEM experiment and the MBI (Molecular Breast Imaging) project, which brings toget her ISS, INFN and Metaltronica (a company that produces mammographies) funded by Regione Lazio (through its agency Filas) for the development of a scintimammograph, where solutions with SiPM are being considered

##### 3. DELIVERABLES BRIEF DESCRIPTION

The project plans an impact in the following areas:

1. Knowledge of the structure of the nucleon in 3D, the strong force and QCD.

2. Reconstruction techniques (pattern-recognition) and data analysis.

3. Innovative techniques of position sensitive photo-detection at low cost.

4. Integrated electronics for new types of photodetectors.

5. New instruments for medical diagnostics and therapy and biomedical research.

# B. EXPECTED IMPACT

***(maximum length: 3 page)***

## Impact for science

### On existing Research Infrastructures

### On future Research Infrastructures

### On the development of advanced theoretical methods

### On new opportunities for synergies

### On specific areas of technological development

### On applications

## Impact for industry and business

### On collaboration with companies of mutual benefit

### On marketable applications

### On other aspects

## Impact for society

### On education of young researchers

### On partnership between non-European and European institutes

### On other aspects

# C. RISK ASSESSMENT

***(maximum length: 1 page)***

The test measurements, prototype construction and design studies for large area cost-effective photon detectors with applications for the CLAS12 RICH detector upgrade and novel Compton cameras for medical imaging constitute an extremely ambitious project. The location in the CLAS12 spectrometer requires the coverage of a large surface but allows only for a relatively small gap depth. Owing to these geometrical conditions and the desired momentum range for full particle identification, innovative new technologies have to be used for both radiator material and photo-detection. For the first time, aerogel radiators with variable refraction index will be tested for installation in a large size RICH detector. The solutions for photo-detection must be adequate to obtain excellent spatial and time resolutions while operating in presence of the CLAS12 magnetic fields and high radiation rates. The innovative solutions for Compton camera must achieve performances in gamma tracking comparable with the traditional approaches with a smart assembling of cheaper devices. Most of the groups participating in this task are committed to the construction of RICH detectors and medical imaging devices for more than ten years. This expertise together with excellent relations to the major fabrication sites of SiPM and LAPP detectors in Italy, Japan and USA will provide the best conditions for the success of the project.

The medical application of a Gamma Camera based on the achievement on the photon detection development, is conducted by groups already involved since several years in Nuclear Medicine. The Gamma Camera remains a challenging detector and any improvement in its component helps to make it a practical medical device.

The major part of groups participating in this JRA already demonstrated an excellent collaboration and a high level of experience in the physics field, matured in previous common projects. This level of expertise and well established relationships between participating groups together with a well defined physics program and a solid infrastructure of participating laboratories will ensure the success of the project. This success will be measured by the promised deliverables. A monitoring of the progress of the JRA will be performed periodically by referring to the timelines and milestones listed in the following Tables.

# D. TABLES

##### 1. GANTT CHART

*[Use the Gantt chart to indicate, for each sub-project in which eventually is structured the work package, the tasks or subtasks. For each task, the relevant milestones and the expected deliverables should be specified. Milestones are control points where decisions are needed with regards to the next stage of the project. Upon completion, each task leads to a well defined deliverable.]*

|  |  |
| --- | --- |
| **Work package number** | WPx |
| **Activity type** | RTD |
| **Work package acronym** |  |
| **Work package title** |  |

*(Timelines are indicate in grey, milestones with black boxes)*

| **TASKS/**Subtasks | **2015** | | | | **2016** | | | | **2017** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| **1.** | | | | | | | | | | | | |
| 1.1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.2 |  |  |  |  |  |  |  |  |  |  |  |  |
| **2.** | | | | | | | | | | | | |
| 2.1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.2 |  |  |  |  |  |  |  |  |  |  |  |  |
| **3.** | | | | | | | | | | | | |
| 3.1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.2 |  |  |  |  |  |  |  |  |  |  |  |  |

|  |
| --- |
| **Milestones** |
| 1  2  3 |

##### 2. LIST OF MILESTONES

| **Milestone number[[2]](#footnote-2)** | **Milestone name** | **Work package** | **Expected date[[3]](#footnote-3)** | **Means of verification[[4]](#footnote-4)** |
| --- | --- | --- | --- | --- |
| WPx.1 | Characterization of innovative photon detectors | x | 12 | Internal Report, Publications |
| WPx.2 | Design of the large area RICH prototype completed | x | 12 | Internal Report |
| WPx.3 | Design of the optimized readout electronics | x | 16 | Internal Report |
| WPx.4 | Compton camera conceptual design completed | x | 18 | Internal Report |
| WPx.5 | Large area RICH prototype construction completed | x | 18 | Prototype assembled and working as expected |
| WPx.6 | Compton Camera prototype construction completed | x | 24 | Prototype assembled and working as expected |
| WPx.7 | Large area RICH prototype commissioning and test completed | x | 30 | Publications |
| WPx.8 | Compton Camera prototype test completed | x | 36 | Internal Report, Publications |
| WPx.9 | Technical Design Report for CLAS12 RICH Upgrade | x | 36 | Public Report |
| WPx.10 | Definition of a full scale system for medical application; cost estimate | x | 36 | Public Report |
| WPx.11 | Communications at the topical workshops | x | 14,32,36 | Presentations |

##### 3. LIST OF DELIVERABLES

| Deliverable No.[[5]](#footnote-5) | Deliverable name | WP No. | Nature[[6]](#footnote-6) | Dissemination level[[7]](#footnote-7) | Delivery date[[8]](#footnote-8) |
| --- | --- | --- | --- | --- | --- |
| WPx.1 | Report on innovative photon detection specifications | x | R,D | PU | 12 |
| WPx.2 | Design of the optimized readout electronics | x | R,D | PP | 16 |
| WPx.3 | Compton camera conceptual design | x | R,D | PP | 18 |
| WPx.4 | Large area RICH prototype | x | P | PU | 18 |
| WPx.5 | Compton Camera prototype | x | P | PU | 24 |
| WPx.6 | CLAS12 RICH Upgrade Technical Design Report | x | R,D | PU | 36 |
| WPx.7 | Cost estimate for full scale systems in applications for society | x | P | PU | 36 |

# E. FINANCIAL CONTRIBUTION

##### 1. JUSTIFICATION OF FINANCING REQUEST

*[Fill in the following tables to provide the budget sharing among participants listing both the total requested EC contribution and the complementary resources (home contribution), broken down in the following items: personnel; other costs (such as durables; consumables and prototyping; travels; workshops). Also indicate the indirect costs calculated according to the cost model adopted by each beneficiary.]*

*[If Community financing is to be used to conclude subcontracts justify why these subcontracts are necessary for the performance of the work.]*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **WPx: ACRONYM**  **COMPLEMENTING RESOURCES PER BUDGETARY ITEM AND PER BENEFICIARY** | | | | | | |
| **REQUESTED EC CONTRIBUTION PER BUDGETARY ITEM AND PER BENEFICIARY** | | | | | | |
| **Contr. No** | **Contractor Acronym** | **Personnel (EUR)** | **Other costs (durables, consumables, travel, workshops) (EUR)** | **Total direct costs (EUR)** | **Indirect costs (EUR)** | **Requested EC contribution (EUR)** |
|
| 1 | **INFN** | 0 | 0 | 0 | 0 | 0 |
|  | ***INFN-FE*** | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-LNF*** | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-BA*** | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-GE*** | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-RM1*** | *0* | *0* | *0* | *0* | *0* |
| 2 | ***ISS*** | *0* | *0* | *0* | *0* | *0* |
| 3 | **FBK** | 0 | 0 | 0 | 0 | 0 |
| 4 | **UGlasgow** | 0 | 0 | 0 | 0 | 0 |
| 5 | **UMainz** | 0 | 0 | 0 | 0 | 0 |
|  | **TOTAL** | **0** | **0** | **0** | **0** | **0** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WPXX: PhotoMed**  **REQUESTED EC CONTRIBUTION PER BUDGETARY ITEM AND PER BENEFICIARY** | | | | | | | | |
| **Contr. No** | **Contractor Acronym** | **Personnel (EUR)** | **Durables (EUR)** | **Consumables (EUR)** | **Travel and workshops (EUR)** | **Total direct costs (EUR)** | **Indirect costs (EUR)** | **Total complementing resources (EUR)** |
|
| 1 | **INFN** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | ***INFN-FE*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-LNF*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-BA*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-GE*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-RM1*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| 2 | ***ISS*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| 3 | **FBK** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | **UGlasgow** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | **UMainz** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | **TOTAL** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WPXX: PhotoMed**  **COMPLEMENTING RESOURCES PER BUDGETARY ITEM AND PER BENEFICIARY** | | | | | | | | |
| **Contr. No** | **Contractor Acronym** | **Personnel (EUR)** | **Durables (EUR)** | **Consumables (EUR)** | **Travel and workshops (EUR)** | **Total direct costs (EUR)** | **Indirect costs (EUR)** | **Total complementing resources (EUR)** |
|
| 1 | **INFN** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | ***INFN-FE*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-LNF*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-BA*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-GE*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
|  | ***INFN-RM1*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| 2 | ***ISS*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| 3 | **FBK** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | **UGlasgow** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | **UMainz** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | **TOTAL** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **WPx: ACRONYM** | | | | | |
| **INDICATIVE TOTAL COSTS AND INDICATIVE REQUESTED EC CONTRIBUTION PER BUDGETARY ITEM** | | | | | |
|  | **Personnel (EUR)** | **Other costs (durables, consumables, travel, workshops) (EUR)** | **Total direct costs (EUR)** | **Indirect costs (EUR)** | **Total costs (EUR)** |
|
| REQUESTED EC CONTRIBUTION |  |  |  |  |  |
| COMPLEMENTING RESOURCES |  |  |  |  |  |
| **TOTAL BUDGET** |  |  |  |  |  |

1. *Give the human effort in person-months to be justified to the EC, as costs of the project (EC contribution + home contribution). If the Beneficiary/Research Unit is not receiving EC funds in the WP, no number will be given.*

   *Indicate in brackets the total estimated human effort involved in the WP (costs to be justified + extra home contribution).* [↑](#footnote-ref-1)
2. Milestone numbers in order of control points. Please use the numbering convention <WP number> <number of milestone within that WP>. For example, milestone WP20.4 would be the fourth milestone within WP20. [↑](#footnote-ref-2)
3. Measured in months from the project start date (month 1). [↑](#footnote-ref-3)
4. Show how you will confirm that the milestone has been attained. Refer to indicators if appropriate. [↑](#footnote-ref-4)
5. Deliverable numbers in order of delivery dates. [↑](#footnote-ref-5)
6. Please indicate the nature of the deliverable using one of the following codes: **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other [↑](#footnote-ref-6)
7. Please indicate the dissemination level using one of the following codes: **PU** = Public; **PP** = Restricted to other programme participants (including the Commission Services); **RE** = Restricted to a group specified by the consortium (including the Commission Services); **CO** = Confidential, only for members of the consortium (including the Commission Services). [↑](#footnote-ref-7)
8. Measured in months from the project start date (month 1). [↑](#footnote-ref-8)