Novel Shielding Concepts and Materials (Joint Research development):

Leading beneficiary: U. Filges (Paul Scherrer Institut PSI, Switzerland) and Phil Bentley (European Spallation Source ESS,Sweden)

Partners: S. Ansell, M. Fletcher (Rutherford Lab ISIS, UK), P. Böni (TU Munich, Germany)

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Observer: F. Gallmeier (SNS, US),

Estimated budget and tentative distribution per partner:

1 PostDoc for 2 years – 24 MM; 2 Senior Scientists - 12 MM over 2 years; Hardware 100 kEUR

Abstract of your innovative activity: (State of the Art)

The design of neutron sources and high energy physics beams for research and medical applications have been highly active fields over the last 50 years. The performance of these facilities has increased by orders of magnitude over this time. A major cost, however, is the heavy shielding that is needed to ensure safety and low experimental noise. The latter is important yet frequently overlooked, and gains in performance can be significantly reduced in real terms as a result. To be competitive, the background radiation level on the most sensitive experimental facilities needs to be several orders of magnitude lower than required for the biological shielding. In particular, the treatment of fast neutrons is non-trivial, and the approximations used for reactor shielding do not generally apply.

Today Monte-Carlo particle transport codes are used in the fields of nuclear and particle physics as well as nuclear engineering (including shielding design). Worldwide a large variety of code systems have been developed to solve coupled particle transport equations in more or less complex geometries for almost all known particles. The following Monte-Carlo particle transport code packages are widely used: GEANT4, PHITS, FLUKA, MARS and MCNP(X).

Presently background simulations with the aforementioned codes require huge computing power resources. In the last few years efforts were made at ISIS and PSI to improve MCNP(X) in numerous ways for enabling such investigations.

Simulating these science facilities is time-consuming, and hindered by uncertainties in the engineering and science processes. This is why accurate particle measurements at existing facilities are very important with a range of detectors and methods.

1. What is new? Why should it be done on a European consortium level (synergies)?

   We will enhance our understanding on high energy backgrounds with a portfolio of high energy physics measurements and theoretical work. These will involve new Bonner Sphere spectrometers, helium-4 high energy neutron detectors, medipix cameras with multiple conversion layers, Wendi-2 neutron

survey meters and gamma spectroscopy. These surveys will be carried out at PSI and ISIS in some detail to map out the various physics processes around the site (accelerator, muon targets, neutron targets and beamlines) and how these can contribute to the neutron background measurements and radiological doses to the users, visitors and public.

The research into new concrete mixes and the optimisation of laminate shielding structures is central to our strategy. PSI, ISIS and ESS have performed some preliminary work on these areas, and together we have a strong desire to take this to the next level. These will involve the ores of several elements - elements used at high energy physics labs such as CERN - but by mixing the ores with concrete and in laminates rather than using pure, refined materials we aim to find effective solutions that are compact, efficient, low cost and light weight. Broadly similar concepts have been explored to a limited extent for solar radiation in space exploration, and at nuclear reactors.

Our new concepts will be tested at PSI on the BOA beamline, and at ISIS on the ChipIR beamline, before deployment in the field.

2. How could your activity be connected with other methods and techniques (outside the neutrons community)?

   The concrete and laminate shielding developments are likely to be applicable in the medical fields (x-ray facilities at hospitals, heavy ion and neutron therapy for cancer patients) along with fundamental high energy physics and human space exploration.

3. Is there any link with national initiatives/projects (e.g. national data initiatives, but also European roadmaps etc)?

   Recently Swiss National Foundation SNF has accepted our project proposal for the validation of the MCNXP/McStas coupling software at SINQ, PSI. In addition the PSI management has decided to force the investigations of different upgrade scenarios for the SINQ facility at PSI. Background simulations and measurements are main tasks within the project.

   In addition ISIS is currently examining an upgrade to target station 1, which will benefit from this research, along with the ESS design and construction.

4. How is the user community involved in your activity? Benefit for the user (for any specific science community?)

   At all facilities, new instrument concepts are under consideration/investigation, and old infrastructure is continuously improved and upgraded. A major topic is the reduction/handling of neutronic background within the instrument concepts.

It is becoming increasingly clear that extremely low instrument background noise is a priority across the neutron science community. Our team is active and experienced in improving the quality of data across several facilities, both for neutron science and high energy physics. This new, combined effort will have significant, direct benefits to users across these disciplines. We are particularly keen on ensuring open, non-patented materials and concepts emerge, that allow as wide a benefit as possible to the European community, without restrictions.