WP05-JRA1 Radiation monitors, dosimeters and beam characterization

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RADNEXT Kick Off Meeting – 19-21 May 2021
https://indico.cern.ch/event/983095/
https://indico.cern.ch/event/1029314/
WP05-JRA1 Radiation monitors, dosimeters and beam characterization

- In this WP, the RADNEXT facilities and user needs will be defined and answered in terms of radiation detectors, beam instrumentation and dosimetry.
- 11 RADNEXT partners involved in WP05
- 4 Tasks (Task 5.1 = Management)
WP05-JRA1 Main tasks

- Three main technical tasks:
  1. **Definition of the correlation matrix between the facility needs and the established or innovative monitoring solutions** as well as the **definition and standardization of the relevant beam parameters to be monitored** across the facility network.
  2. **To investigate innovative instrumentation** regarding their potential high impact on facility operation and optimization of radiation to electronics testing.
  3. **To develop, characterize and qualify low-cost detectors and dosimeters** and have them accessible to RADNEXT users.

**Main objective:** rendering the facility network more accessible, homogeneous and complementary.
WP05-JRA1 Task 5.2: Definition of the RADNEXT facilities & users instrumentation needs, inter-laboratory comparison

- **Task Leader:** UO (Björn Poppe)
- **Participants:** TRIUMF, UJM, UU, CERN, FINT, UnPd, Ganil, GSI, UKRI-STFC
- A first PhD student will be recruited at UO (joint degree with UJM)

- **Sub-Task5.2.1 -** Definition of the correlation matrix between RADNEXT facilities needs and established or innovative sensing solutions

  ➔ provide a detailed overview of the current needs in terms of instrumentation across the RADNEXT facility network.

  ➔ This will be done in close collaboration with **RADNEXT facilities coordinators** as well as **WP8-JRA4** as the definition of their associated environments necessitates both simulation and experimental tools.
WP05-JRA1 Task 5.2: Definition of the RADNEXT facilities & users instrumentation needs, inter-laboratory comparison

- Sub-Task 5.2.2 - *Definition and Standardization of Relevant Beam Parameters*

- To achieve a very challenging targeted harmonization of 20-30%, protocols for dose, fluence or flux measurement should be defined including reference conditions and traceable detectors which shall be used to characterize special features of the radiation fields ➔ **WP05 goal is then to develop and establish a system improving the comparability and accuracy of beam and dose parameters for the RADNEXT facilities.**

- From the correlation matrix, **new promising technologies will be selected for the project.** An overview of the potential and performances of these advanced technologies to fulfill the needs and expectations from RADNEXT facilities and users will be realized.
WP05-JRA1 Task 5.2 : Definition of the RADNEXT facilities & users instrumentation needs, inter-laboratory comparison

Sub-Task 5.2.2 - Improving the comparability and accuracy of beam and dose parameters

Goal: to define important/accurate parameters available for each facility

Examples:
- particle types, fluences, flux, energy spectra,
- field-sizes, 2D-intensity/dose distribution
- absorbed dose to water/medium etc.

- Define set of standardized measurements with (traceable) detectors and MC-simulations to improve inter-comparability.

- Model may be found in international codes (such as IAEA TG-398)
- UO: experience at clinical photon and particle beams and with research beams such as CLEAR or 150 GeV/n lead campaign
WP05-JRA1 Task 5.3 : Innovative instrumentation applied to RADNEXT facilities

- **Task Leader:** UJM
- **Participants:** TRIUMF, CERN, FINT, GSI, UniPD, UU, GANIL, UKRI-STFC
- A second PhD student will be recruited at UJM (joint degree with UO) / L. Weninger

- **Sub-Task 5.2.1 - Optical fiber-based monitoring solutions**
  - Participants: UJM, TRIUMF, CERN, FINT, GSI

- **Sub-Task 5.3.2 - SEU monitor based on 3D NAND Flash**
  - Participants: UniPD

- **Sub-Task 5.3.3 - Characterization of neutron fields**
  - Participants: UU, GANIL, UKRI-STFC, UJM, FINT
WP5-JRA1 Fiber-based dosimetry and instrumentation

- There exists different types of fiber-based dosimeters
  - **Sensors based on Radiation Induced Attenuation** ➔ Using radiation sensitive fibers and appropriate interrogation schemes ➔ **point** or **distributed** point dosimeters
    - CERN/UJM Collaboration on DOFRS project
    - LUMINA project (CNES/UJM/CERN/iXblue)
  - **Advantages:** dose rate and temperature (up to 100°C) independent, sensitive to ionization-only (dose in mixed environments), deported instrumentation, passive sensing
  - **Versatile:** dosimeter architecture is optimized for a given application: dose, spatial resolution, acquisition rate…
  - Interested in beam time
    - Protons, neutrons, mixed & pulsed environments
WP5-JRA1 Fiber-based dosimetry and instrumentation

- There exists different types of fiber-based dosimeters
  - **Sensors based on Radiation Induced Luminescence**
    - Using radiation sensitive optical fibers and appropriate interrogation schemes, **point dosimeters**
      - TRIUMF/UJM Collaboration on proton-therapy
      - CERN/CNES/UJM collaboration
      - JYU/UJM collaboration (RADSAGA ESR2)
  - **Advantages**: low dose rate detection, steady state or pulsed beams monitoring, very small size, immune to electromagnetic perturbations…
  - **Versatile**: can be adapted for fast radiation detection, beam monitoring….
  - Interested in beam time
    - Protons, neutrons, mixed & pulsed environments

C. Hoehr et al., Scientific Reports, 2019
WP5-JRA1 SEU monitor based on 3D NAND Flash (UniPD)

- Development and test of a **dosimeter/SEU monitor based on 3D NAND Flash memories**
  - **Advantages**
    - direction of particles can be tracked in a 3D volume
    - higher precision in determining the features of the beam
    - compact, low-cost, low-power, no special equipment required
    - same device for various purposes (data/code storage, single ion detection, total dose measurement)
    - possibility to be measured offline with a separate reader
    - avoidance of data loss in case of SEFI/reboot
  - **Aspects to improve thanks to dedicated beam test campaigns**
    - increase resolution (ad-hoc algorithms, dedicated techniques)
    - increase speed
  - **Interested in beam time**
    - heavy ions (especially medium to high energy)

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WP5-JRA1 Characterization of neutron fields

- Characterization of neutron fields at the emerging NFS (Neutron For Science) facility (UU, GANIL)
  - Detection of recoil protons from the H(n,p) reaction
  - Particle identification using $\Delta E-E$ techniques
  - Neutron energy determination using ToF techniques

- Solid state detectors (Silicon, Diamond, SiC)
  - measure the energy deposition, event-by-event, and have been used with success at high energy neutron facilities, mixed fields, and heavy ion facilities.
  - Can be used for benchmark of Monte Carlo simulation (FLUKA, GEANT4...),

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WP05-JRA1 Task 5.4 : Development of low-cost dosimetry systems accessible to RADNEXT users

- **Task Leader:** CERN
- **Participants:** UJM, UM
- The second PhD student will have CERN endorsements / Collab with UM JRA3 Post-Doc

- A common need for low-cost detectors and point dosimeters ➔ several advances regarding the development of a new generation of radiation monitors or dosimeters
  
  - **Dosimeter based on floating gates (FG-DOS)** to complement the well-established RADFETs ➔ The test and qualification of the FG-DOS will be performed during RADNEXT.
  
  - A system (low-cost, open hardware/software) has been developed over the last decade for TID and NIEL measurements at CERN. This system combines RADFET and PIN diode sensors. A dedicated and portable readout system for non-LHC applications (the ReadMON) ➔ The qualification of ReadMon at the various RADNEXT facilities will be of major interest
WP05-JRA1 Deliverables & Milestones

- **D5.1 (Book of Knowledge, M38, UO)**
  *Definition and Standardization of Relevant Beam Parameters*[Milestone 5.1]*

- **D5.2 (Report, M40, UniPD)**
  *Potential of SEU monitor based on 3D NAND Flash memories for R2E*

- **D5.3 (Prototype, M44, UJM, CERN)**
  *Prototypes of Fiber-based dosimeter and Low cost RadMON detector*[Milestone 5.2]*

- **D5.4 (Report, M46, UU)**
  *Characterization of neutron fields at the NFS facility*
Thanks for your attention!

TRIUMF Facility – Fiber testing

Medley chamber @ NFS facility

CERN North Area, 2D ion chamber detector