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)

UU GANIL GSI

UJM CERN UniPD UO UM TRIUMF FINT UKRI

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

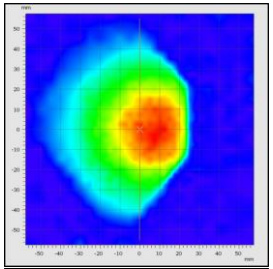
- **Sub-Task5.2.2** - *Definition and Standardization of Relevant Beam Parameters*

  - 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

Task #3

WP05-JRA1 Task 5.2 : Definition of the RADNEXT facilities & users instrumentation needs, inter-laboratory comparison

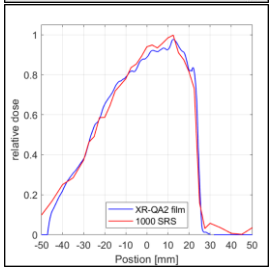


❑ **Sub-Task5.2.2** - *Improving the comparability and accuracy of beam and dose parameters*

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

Examples:

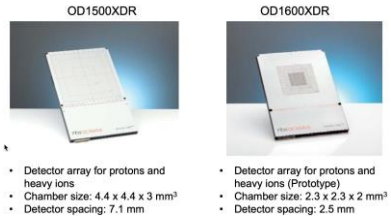
- particle types, fluences, flux, energy spectra,
- field-sizes, 2D-intensity/dose distribution
- absorbed dose to water/medium etc.



Wyrwoll *et al* 2020
Poppinga *et al* 2020
Kretschmer *at al* 2019
Brodbeck *et al* 2019
...

- 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-Task5.2.1 - *Optical fiber-based monitoring solutions***
  - Participants: UJM, TRIUMF, CERN, FINT, GSI
- **Sub-Task5.3.2 - *SEU monitor based on 3D NAND Flash***
  - Participants: UniPD
- **Sub-Task5.3.3 - *Characterization of neutron fields***
  - Participants: UU, GANIL, UKRI-STFC, UJM, FINT
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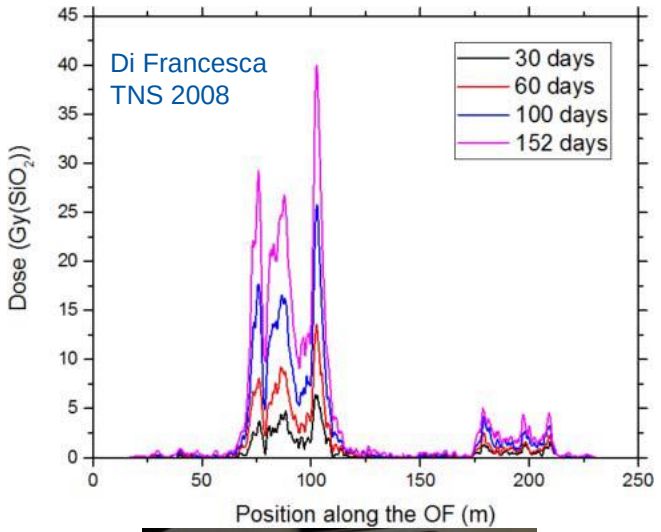
WP5-JRA1 Fiber-based dosimetry and instrumentation

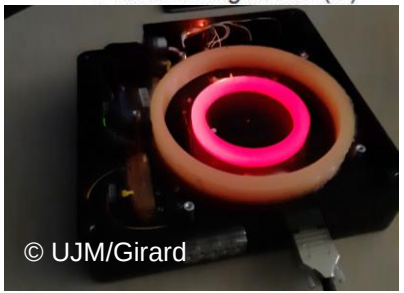
❑ There exists different types of fiber-based dosimeters

- **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

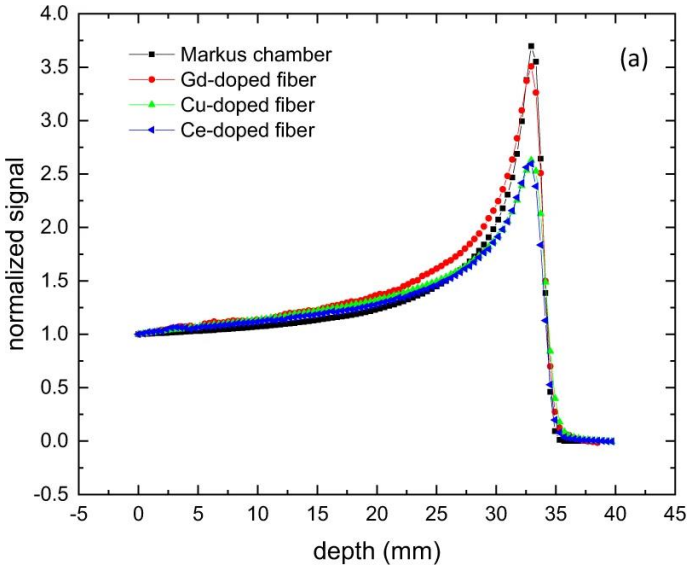
- **Versatile:** dosimeter architecture is optimized for a given application: dose, spatial resolution, acquisition rate…
- Interested in beam time
  - Protons, neutrons, mixed & pulsed environments





WP5-JRA1 Fiber-based dosimetry and instrumentation

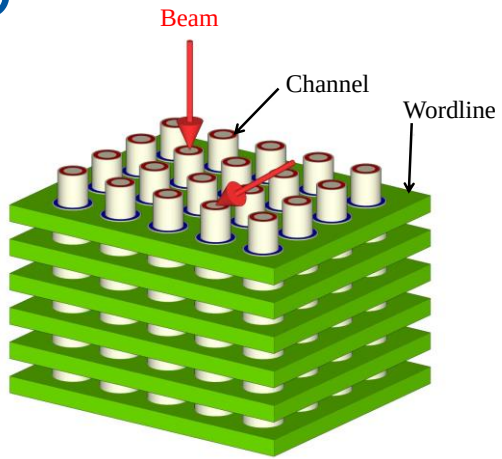
- There exists different types of fiber-based dosimeters
  - **Sensors based on Radiation Induced Luminescence**
    ➔ Using radiation sensitive optical fibers and appropriate interrogation schemes, **point dosimeters**
    - TRIUMF/UJM Collaboration on proton-therapy
    - CERN/CNES/UJM collaboration
    - 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

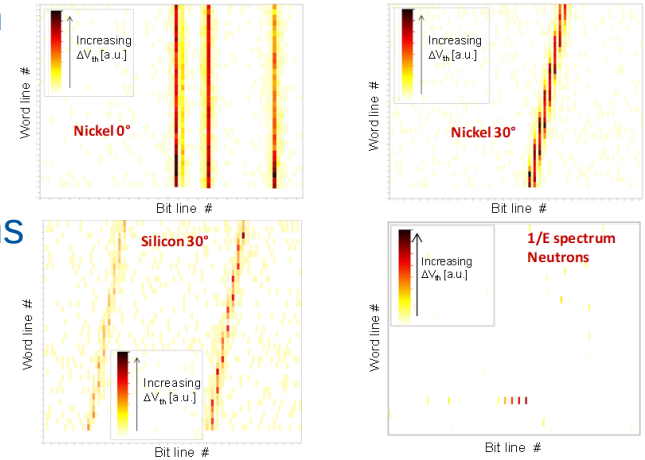


C. Hoehr et al., Scientific Reports, 2019

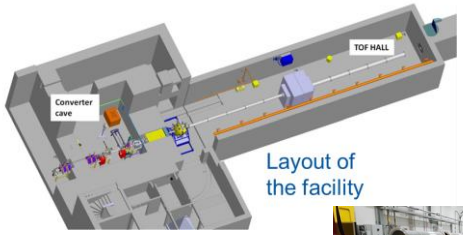
WP5-JRA1 SEU monitor based on 3D NAND Flash (UniPD)

- 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)

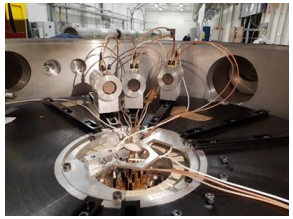




WP5-JRA1 Characterization of neutron fields



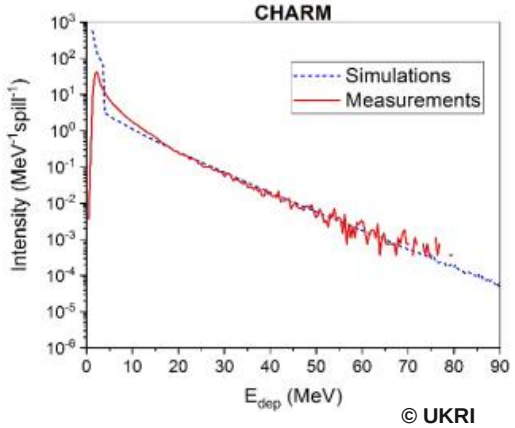
NFS facility at GANIL



A prototype detector setup in the Medley chamber

- 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 ΔE-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

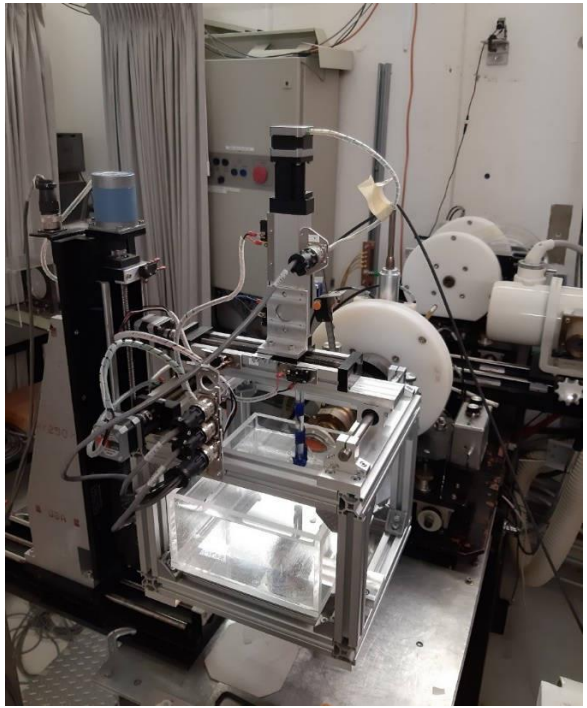
- **D5.3 (Prototype, M44, UJM, CERN)**

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