

Task 4.3 - Common Tools for Irradiation Facilities QC: Data Management, Traceability, Dosimetry and Activation Measurements

Blerina Gkotse on behalf of Task 4.3

24th of April 2023



➤ Task Objectives

➤ Activities Status

- IDM generalization
- Integrated system for induced activation measurements and RFID tagging
- Common dosimetry calibration set for cross-comparison of irradiation facilities

➤ Timeline

➤ Conclusions

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- **Generalize the IRRAD facility Data Manager (IDM) system to include new facilities (e.g., CERN GIF++) and improve the sharing of irradiation experiment results and operational data**
- **Design and development of a prototype for an integrated system to manage induced activation (APEX - gamma) and traceability data for irradiated objects (CAEN –DigiWaste) based on IDM**
- **Produce a common dosimetry calibration set for cross-comparison of irradiation facilities by evaluation of Non-Ionizing Energy Loss (NIEL) of irradiation facilities with dedicated dosimeter structures**

➤ Task Objectives

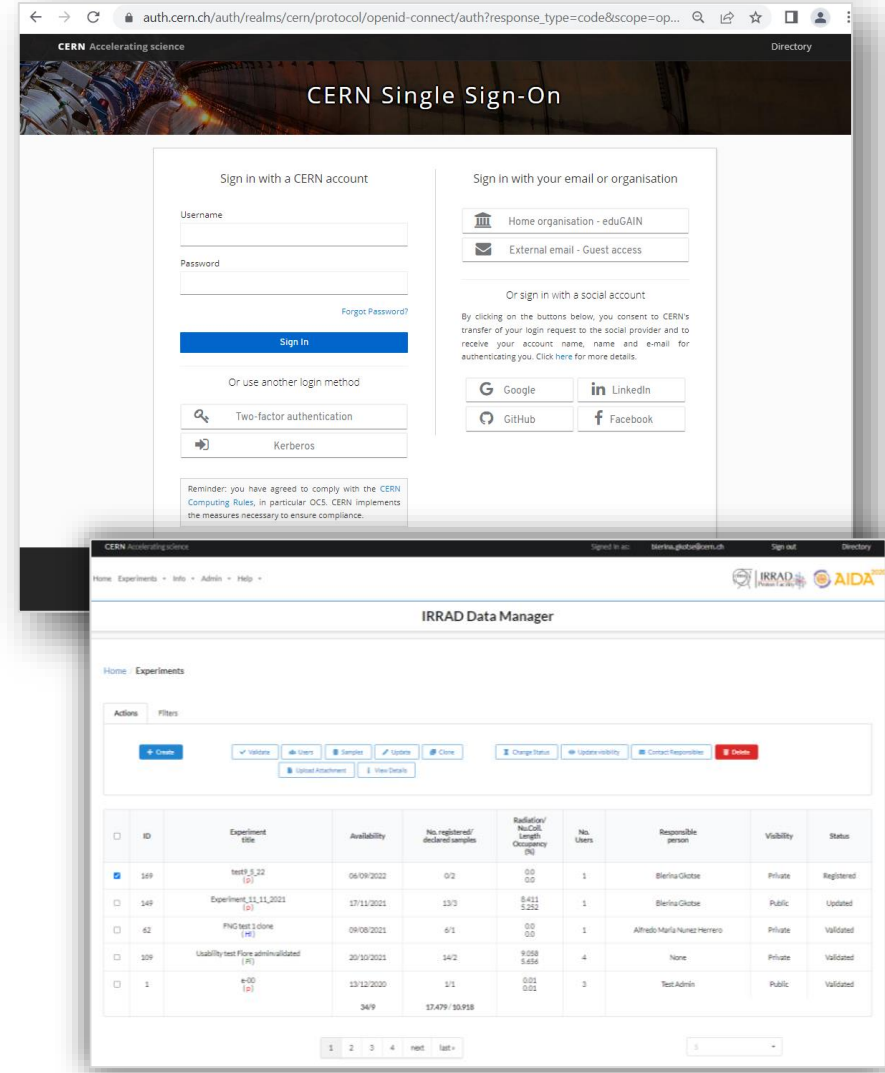
➤ Activities Status

- **IDM generalization**
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- **New CERN Single Sing-On (SSO)** deployed
- **IDM user model changes** to adapt to the new SSO authentication
- **Fixing new user notification for EURO-LABS** information (complementary European Project for Transnational Access)
- **Separating past/current experiments**
- **Data privacy** notice published
- **Usability sessions** organized for new/improved functionalities



The top screenshot shows the CERN Single Sign-On page with fields for CERN account login (Username, Password) and options for email/organisation or social media login (Google, LinkedIn, GitHub, Facebook). The bottom screenshot shows the IRRAD Data Manager interface with a table of experiments.


ID	Experiment title	Availability	No. registered/declared samples	Radiation/No.Cat Length Occupancy (%)	No. Users	Responsible person	Visibility	Status
149	test_5_22 (P)	04/09/2022	0/2	0.0 0.0	1	Blerina Gkotse	Private	Registered
149	Experiment_11_11_2021 (P)	17/11/2021	13/3	8.411 5.252	1	Blerina Gkotse	Public	Updated
62	PHG test done (H)	09/08/2021	0/1	0.0 0.0	1	Alejo Maria Nunez Herrero	Private	Validated
209	Usability test Flow admin validated (R)	20/10/2021	14/2	9.058 5.656	4	None	Private	Validated
1	+00 (P)	13/12/2020	1/1	0.01 0.02	3	Test Admin	Public	Validated
		34/9	17479 / 10.918					

Milestone MS13 finalised and released

Available in Zenodo:
<https://zenodo.org/record/7323846#.Y3y5FHbMIuU>



MS13



Grant Agreement No: 101004761
AIDAinnova
 Advancement and Innovation for Detectors at Accelerators
 Horizon 2020 Research Infrastructures project AIDAINNOVA

MILESTONE REPORT

DEFINE REQUIREMENTS, GLOBAL ARCHITECTURE AND DESIGN THE EXTENDED DATA MANAGEMENT SYSTEM FOR ENEA-FNG AND CERN-GIF++

MILESTONE: MS13

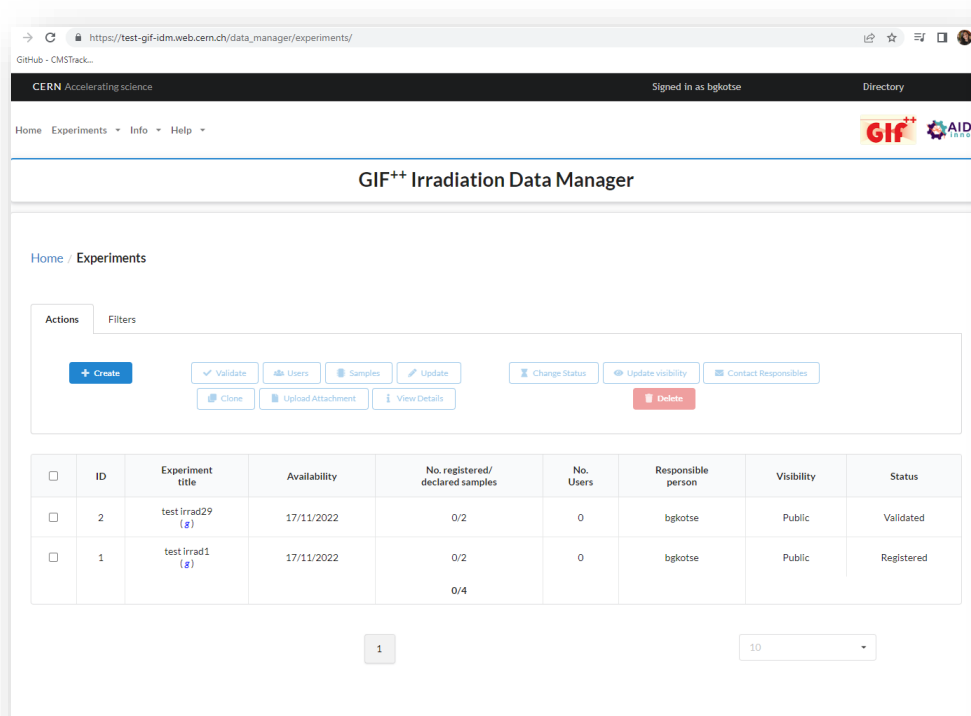
Document identifier:	AIDAinnova-MS13
Due date of milestone:	End of Month 18 (September 2022)
Report release date:	30/10/2022
Work package:	WP4: Upgrade of Irradiation and Characterisation Facilities
Lead beneficiary:	CERN
Document status:	Final

Abstract:
 This milestone report describes the requirements, global architecture, and design of a new data management system for the CERN Gamma Irradiation Facility (GIF++) and the Frascati Neutron Generator in ENEA (ENEA-FNG). These systems will be a generalisation of the IRRAD Data Manager, developed and deployed in the framework of AIDA-2020 EU-Project.

AIDAinnova Consortium, 2022

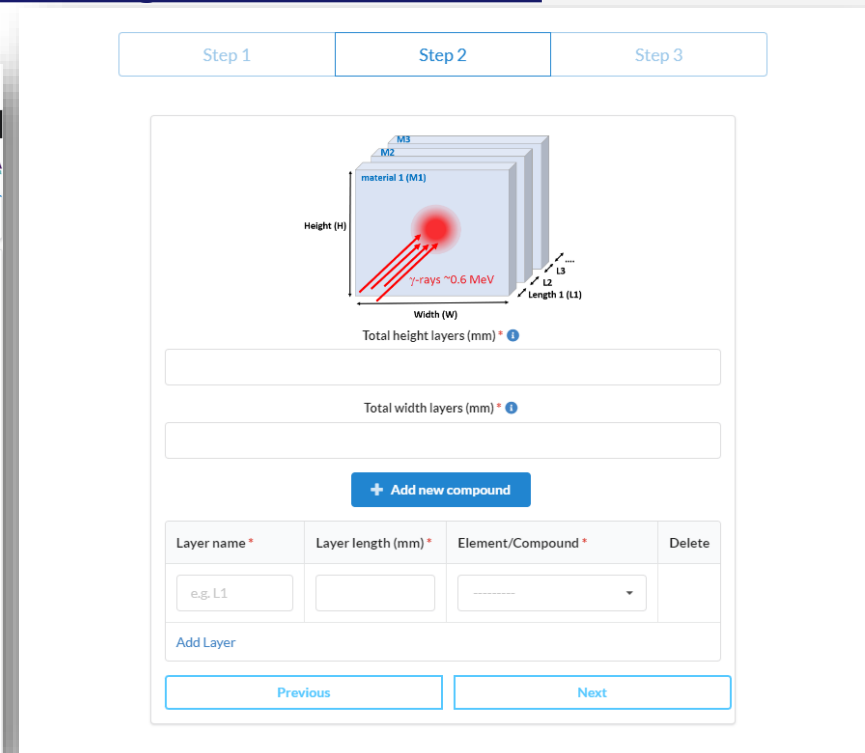
Grant Agreement 101004761
PUBLIC
1 / 12

- Cloning and adapting IDM for GIF++ according to identified requirements (e.g., computation of photons attenuation factor, etc.)
- Deployment using the OpenShift platform
- Available in this link (CERN network): <https://test-gif-idm.web.cern.ch/>



The screenshot shows the web interface of the GIF++ Irradiation Data Manager. The browser address bar shows the URL https://test-gif-idm.web.cern.ch/data_manager/experiments/. The page header includes the CERN logo and the text "CERN Accelerating science". The main title is "GIF++ Irradiation Data Manager". Below the title, there is a navigation menu with "Home", "Experiments", "Info", and "Help". The interface features a table of experiments and a set of action buttons.

ID	Experiment title	Availability	No. registered/ declared samples	No. Users	Responsible person	Visibility	Status
2	test irradi29 (g)	17/11/2022	0/2	0	bgkotse	Public	Validated
1	test irradi1 (g)	17/11/2022	0/2	0	bgkotse	Public	Registered



The diagram illustrates a stack of three layers labeled M1, M2, and M3. A red dot represents a source of γ -rays with an energy of 0.6 MeV. The diagram labels the Height (H), Width (W), and Length 1 (L1) of the layers. Below the diagram, there are input fields for "Total height layers (mm)" and "Total width layers (mm)". A blue button labeled "+ Add new compound" is positioned above a table for adding layers.

Layer name *	Layer length (mm) *	Element/Compound *	Delete
e.g. L1			

Buttons for "Previous" and "Next" are located at the bottom of the form.

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- **Spectrometry data model and report finalised**
 - ARAMIS report - <https://edms.cern.ch/document/2796416/>
- **Data model configured** and integrated to IDM
- **Communication with the spectrometry APEX-gamma database and IDM**
- **Calculation of proton fluence-related values in IDM**

CERN
 CH1211 Genève 23
 Suisse


№ EDMS
2796416

REV.
1.0

VALIDITÉ
See EDMS

RÉFÉRENCE

07/10/2020



Report



Pre-studies about the Analytical Results Analyzer and Management Information System - ARAMIS

<small>DOCUMENT PRÉPARÉ PAR :</small> Blerina Gkotse Xavier Eric Ouvrard	<small>DOCUMENT VÉRIFIÉ PAR :</small> Nabil Menaas Federico Ravotti	<small>DOCUMENT APPROUVÉ PAR :</small> Chris Theis Federico Ravotti
<small>GRUPE D'APPROBATION</small>		



CERN Accelerating science
Signed in as: blerina.gkotse@cern.ch [Sign out](#) [Directory](#)

[Home](#) [Experiments](#) [Info](#) [Admin](#) [Help](#)

IRRAD Data Manager

[Home](#) / [Fluences](#) / DOS-004480

Actions Filters

<input type="checkbox"/>	Measurement ID	Nuclide Name	Description	Fluence Result	Acquisition Time	Detector Name	Geometry	NWM	NWM Error	Activity (Bq)	Activity Error (%)
<input type="checkbox"/>	42571	NA-22	0.0270g, Ge-0, Na-22	5.6645E+16 (± 7.0 %)	Nov. 14, 2022, 7:06 p.m.	GE-0-B93020	D1	0.0117	0.0002	4312.372	0.02
<input type="checkbox"/>	42571	NA-24	0.0270g, Ge-0, Na-22	9.9164E+16 (± 8.8 %)	Nov. 14, 2022, 7:06 p.m.	GE-0-B93020	D1	2.498	0.078	924211.8	7.792

- CAEN RadBASE interface tested for CERN IRRAD
- Need to define the requirements for IDM integration
- RadHAND test with RadBASE at CERN planned end of May



swagger

RadBase App

RadBASE REST API for Caerlys's waste digitalization services

Support Team - Website
Send email to Support Team

CLOSED

Authorize

account-group-rest-api-controller Account Group Rest Api Controller

account-rest-api-controller Account Rest Api Controller

authorization-controller Authorization Controller

device-model-rest-api-controller

device-rest-api-controller Device Rest

generic-event-rest-api-controller

isotope-rest-api-controller Isotope R

item-category-rest-api-controller

item-rest-api-controller Item Rest Api C

GET /item findAll

POST /item create

GET /item/{id} find

PUT /item/{id} update

RadBASE Accounts - Items - Locations - Devices - Tasks - Utility - Profile Logout

List of items

ID	NAME	RFID	CATEGORY	STATUS	CREATOR	CONTAINED IN	CONTAINED ITEMS	Validate	Edit	Delete
1	bla	E2800D12000000211126AD	drum	measured	admin		0	Validate	Edit	Delete
2		E28011052000795AD5140913			admin			Validate	Edit	Delete
33	test01				admin			Validate	Edit	Delete
34	test02		drum	measured	admin		0	Validate	Edit	Delete
65	e28011052000735ad52a0913		box	measured	admin			Validate	Edit	Delete
66	e280110520007adad5310913		drum	created	admin		0	Validate	Edit	Delete
97	abcd_1234		drum	measured	apepperosa		0	Validate	Edit	Delete
99	1010_abab	E2800D1200000021F4728D2	drum	measured	apepperosa		0	Validate	Edit	Delete
99	RadHAND-Barcode-Test	E2800D1200070021F4725CD	drum	measured	apepperosa		0	Validate	Edit	Delete
129	test03	E28011052000795AD5140913	drum	created	admin		0	Validate	Edit	Delete
130	test04	E28011052000798D52A0913			admin			Validate	Edit	Delete

DigiWaste platform

- Some bibliography data exist (gamma)
- Two irradiation campaigns already performed:
 - IRRAD Proton Irradiation Facility – protons 24 GeV
→ Report finalized
<https://edms.cern.ch/document/2680300/>
 - ENEA-FNG – neutrons (funded by RADNEXT TA)
→ report finalized and to be release
- Campaign in a mixed-field facility is under discussion (CHARM)



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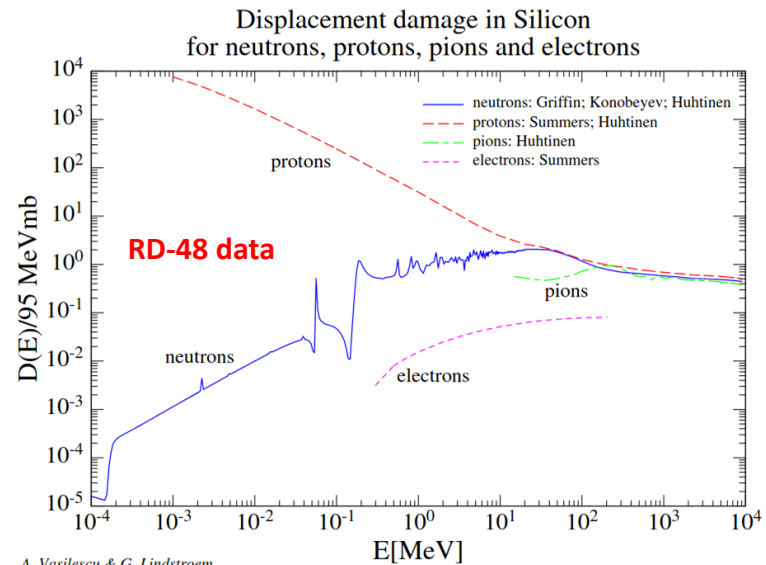
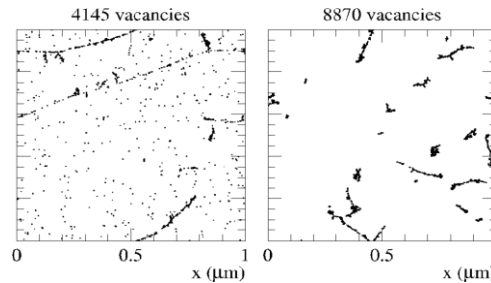
➤ Conclusions

- **NIEL** is a physical quantity describing the non-ionizing energy loss as the particle travels through the medium
- **NIEL** can be used to predict the radiation damage and therefore to predict the lifetime of the detectors and components necessary for measurements
- **NIEL** is usually expressed as an equivalent to **NIEL** of 1 MeV neutrons
- **NIEL is used by most of the LHC experiments**

V. Subert
PhD, synergy
with EP-R&D

NIEL for Silicon was determined from various sources 20 years ago by A. Vasilescu and G. Lindstrom¹⁻⁵ (RD-48 data).

NIEL does not distinguish in point defects/ cluster defects, NIEL violation has been reported.⁶⁻⁷ → need to **revisit NIEL**



A. Vasilescu & G. Lindstrom

- 1) Data from A. Vasilescu (INPE Bucharest) and G. Lindström (Univ. of Hamburg)
- 2) P.J. Griffin et al., SAND92-0094 (Sandia Natl. Lab.93), priv. comm. 1996; E = 1.025E-10 - 1.995E+01 MeV
- 3) Konobeyev, Alexander Yu., et al. "Nuclear Data to Study Damage in Materials under Irradiation by Nucleons with Energies up to 25 GeV." Journal of Nuclear Science and Technology, vol. 39, no. sup2, Aug. 2002, pp. 1236–39. Taylor and Francis+NEJM, <https://doi.org/10.1080/00223131.2002.10875327>.
- 4) Huhtinen, M., and P. A. Aarnio. "Pion Induced Displacement Damage in Silicon Devices." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 335, no. 3, Nov. 1993, pp. 580–82. ScienceDirect, [https://doi.org/10.1016/0168-9002\(93\)91246-J](https://doi.org/10.1016/0168-9002(93)91246-J).
- 5) Summers, G. P., E. A. Burke, P. Shapiro, et al. "Damage Correlations in Semiconductors Exposed to Gamma, Electron and Proton Radiations." IEEE Transactions on Nuclear Science, vol. 40, no. 6, Dec. 1993, pp. 1372–79. IEEE Xplore, <https://doi.org/10.1109/23.273529>.
- 6) Huhtinen, M. "Simulation of Non-Ionising Energy Loss and Defect Formation in Silicon." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 491, no. 1, Sept. 2002, pp. 194–215. ScienceDirect, [https://doi.org/10.1016/S0168-9002\(02\)01227-5](https://doi.org/10.1016/S0168-9002(02)01227-5).
- 7) Gurimskaya, Yana, et al. "Radiation Damage in P-Type EPI Silicon Pad Diodes Irradiated with Protons and Neutrons." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 958, Apr. 2020, p. 162221. ScienceDirect,

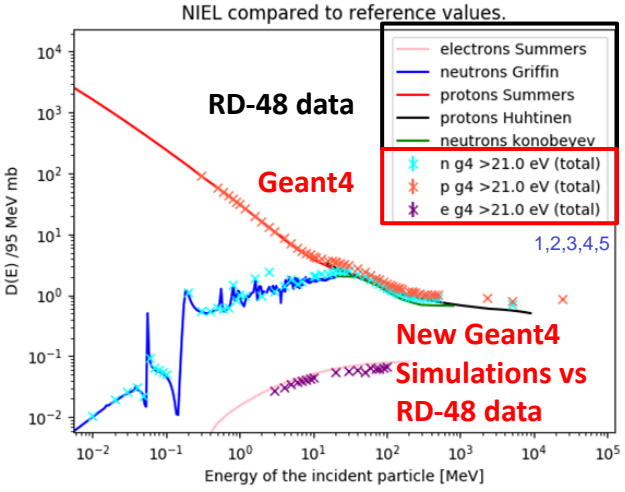
$$NIEL(T_0) = \frac{N_A}{A} \sum_i \int_{T_{min}}^{T_{max}} Q(T) T \left(\frac{d\sigma}{dT} \right)_i dT$$

Displacement damage function

$$NIEL(T_0) = \frac{N_A}{A} D(T)$$

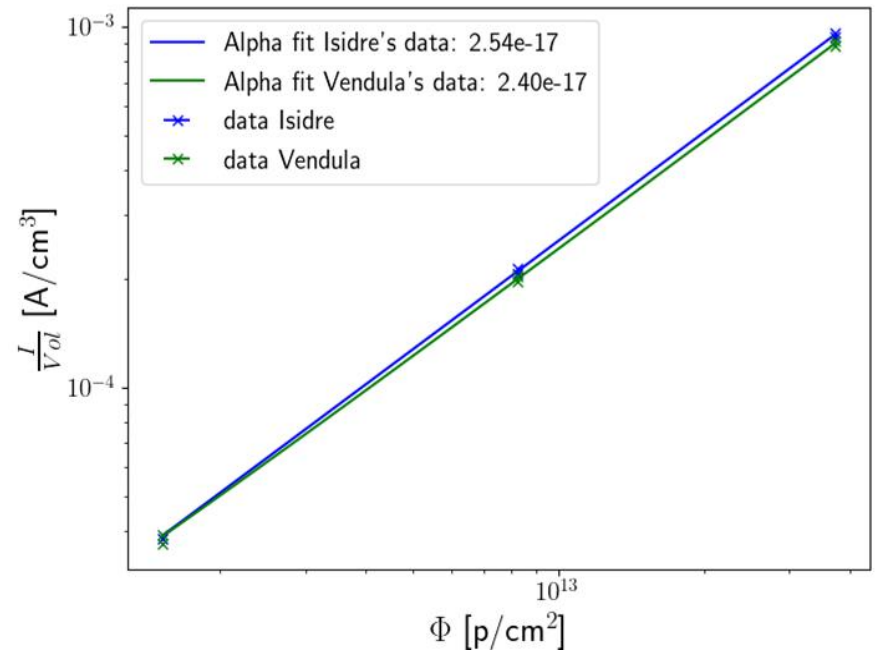
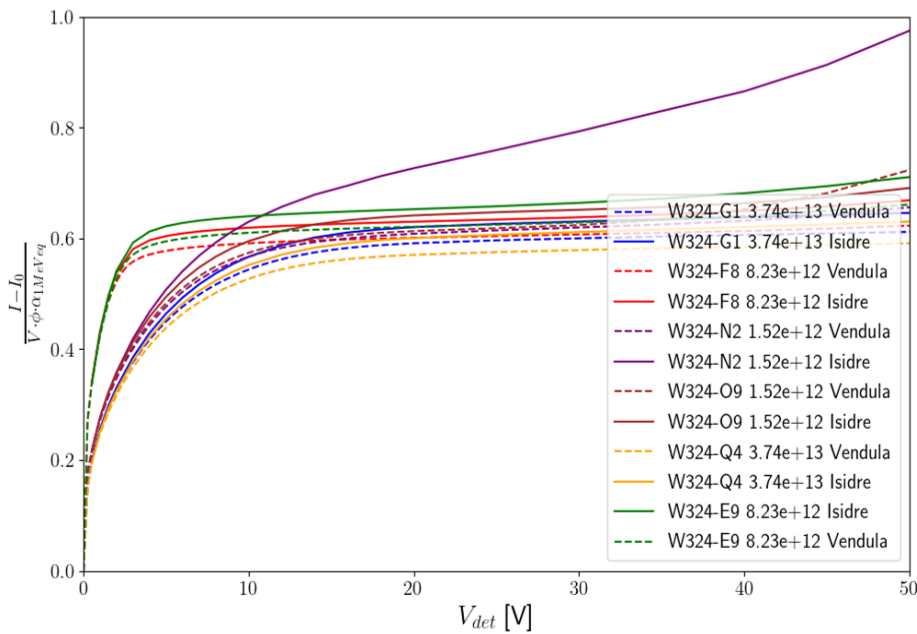
↓
↓
 MeV cm²/g MeV mb

- T_0 : energy of incident particle
- T : energy transferred to the recoil atom
- $(d\sigma/dT)$: differential partial cross section for a particle with energy T_0 to create a recoil atom with energy T in the i -th reaction
- $Q(T)$: partition factor giving the fraction of T that is going into further displacements
- N_A : Avogadro number
- A : atomic mass of target atom



- NIEL curves in literature with Geant4 and Fluka simulations successfully reproduced
- **Algorithm for identifying clustered versus point defect damage implemented**
- Agreement with qualitative analysis reached
- Further developments of algorithm for damage differences between different particles are envisioned

- Diodes irradiated in IRRAD and measured in 2018 (Isidre Mateu)
- Comparison of original measurements and measurements done 4 years later (Vendula Subert)
- Measurements seem to agree



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- Objective 1 – Generalisation of IDM
 - IDM specifications for ENEA-FNG and GIF++ finalised (MS13)
 - Deployment in GIF++ under test
- Objective 2 – Integrated system for induced activation data management and traceability
 - APEX-gamma DB communication with IDM and proton fluence computation
 - Two irradiation campaigns for CAEN RFID tags performed in IRRAD (protons) and ENEA-FNG (neutrons) while mixed-field tests are under discussion (CHARM)
 - CAEN RadHAND to be tested RadBASE API - IDM integration in progress
- Objective 3 – **Common dosimetry calibration set for cross-comparison of irradiation facilities** by NIEL evaluation
 - Geant4 and Fluka simulations for NIEL curves **successfully reproduced**
 - Algorithm for identifying **clustered vs point defect damage implemented**
 - **Agreement** with qualitative analysis reached
 - Existent NIEL **experimental measurements confirmed** (for IRRAD)
 - Development of algorithm for **damage differences between different particles envisioned**

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