

## AIDAInnova Second Project Review Meeting

*Thursday 20<sup>th</sup> June 2024*

### WP4

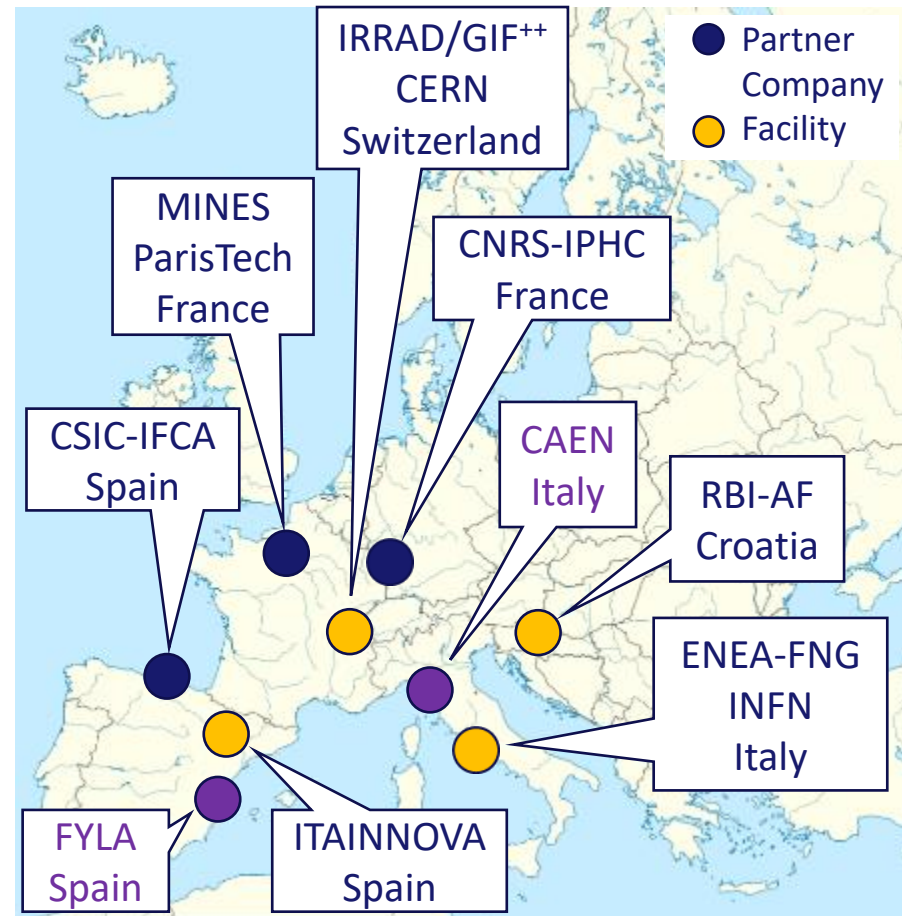
# Upgrade of Irradiation and Characterization Facilities

Federico Ravotti (CERN), Fernando Arteche (ITAINNOVA)




- **Irradiation and characterization tests** required for the R&D on next generation of particle detectors **demand more accurate and reliable procedures**, as well as a **higher efficiency in their execution**
- ***The main goal of WP4 is to develop & standardize common tools for testing infrastructure to better support the next detector generation***
  - Improve facilities, systems and methods
- The activities are covered by different partners:
  - Academia
  - Industry
  - Research and Technology Organizations (RTOs)
- Good collaboration between partners ensures the readiness of the detector support infrastructure for AIDAinnova's TRLs

- **Task 4.1:** Task Coordination (CERN, **ITAINNOVA**<sup>(+)</sup>)
- **Task 4.2:** Micro-beam Upgrade at RBI Accelerator Facility (RBI-AF)
- **Task 4.3:** Common Tools for Irradiation Facilities QC: Data Management, Traceability, Dosimetry and Activation Measurements (CERN, *MINES*<sup>(\*)</sup>, INFN, *ENEA*<sup>(\*)</sup>, **CAEN**)
- **Task 4.4:** Design & Development of a New Sensor Characterization System based on TPA-TCT Technique (CERN, CSIC-IFCA, **FYLA**)
- **Task 4.5:** Design & Development of a New Electronics Characterization System for EMC Control (**ITAINNOVA**<sup>(+)</sup>, CNRS-IPHC)



(\*) *Collaborating Institute*

(+) **RTO**

- New precise and monitored **sample positioning system** (1nm to tenths nm) & software control – SPECTOR upgrade. **MS12** 

- **Sample cooling system** ( low Temp)

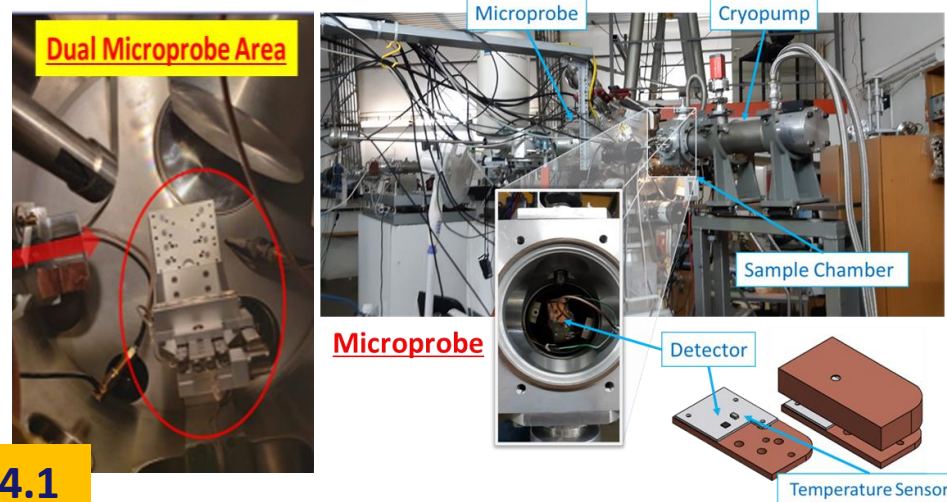
- The present setup for low temperatures **can achieve temperatures ~ 40-50 K**

- Upgrades are already very useful

- Time for sample precise positioning and micro-analyses on areas of interest is significantly decreased

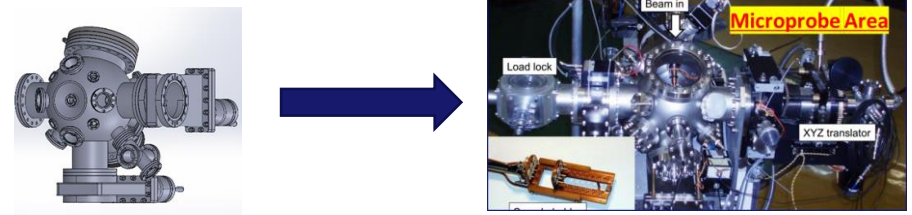
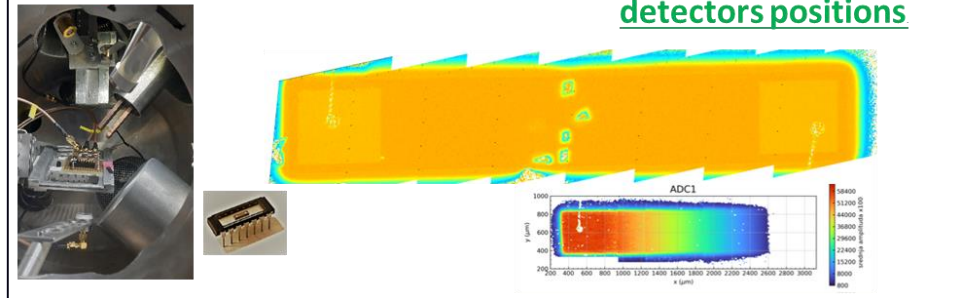
- Additional work

- New XYZ piezo stage has been designed
  - It will deliver soon and control system will be integrated in SPECTOR
  - Activity covered with RBI funds

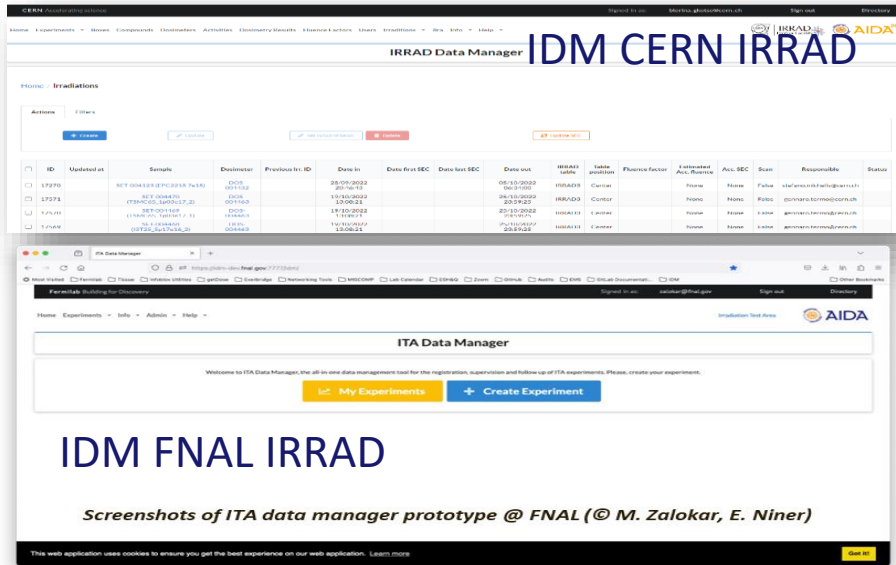


**D4.1**

**Precise irradiations can be carried out at well defined detectors positions**



- For irradiation run 2024, **new version of generalize IDM deployed** implementing the recommendations gathered during the **usability session:**



- The goal of ENEA-FNG's contribution to D4.3 is to **demonstrate IDM's applicability in facilities beyond CERN**, highlighting the software's generalization capabilities.
- The extension of the **IDM to CERN-GIF++ is complete**, but the departure of key staff at ENEA-FNG in Rome halted the software deployment work required for D4.3.
- Change of target facility for D4.3**



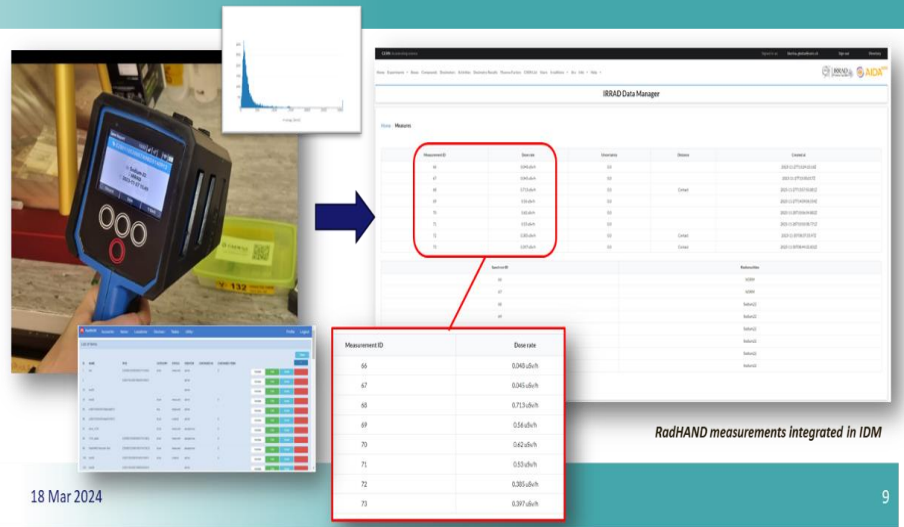
- IDM specifications for deployment to new facilities finalized MS13** ✓
- Deployment @ GIF++ finalized**
- Deployment @ FNAL ongoing**

Due to the challenges at ENEA-FNG, it's proposed to shift the software deployment from ENEA-FNG to the Fermilab-ITA proton irradiation facility in the USA, with the change not affecting the original scope or objectives of D4.3



### Sample tracking control system

➤ A new integrated RFID-based system (DigiWaste platform from CAEN), which combines spectroscopic radiation measurements and RFID tagging, has been evaluated.



• Data from the CAEN RadHAND tool and CANBERRA APEX-Gamma spectrometry system have been integrated into IDM.

➤ Complete workflow tested

• Milestone MS14 completed and released

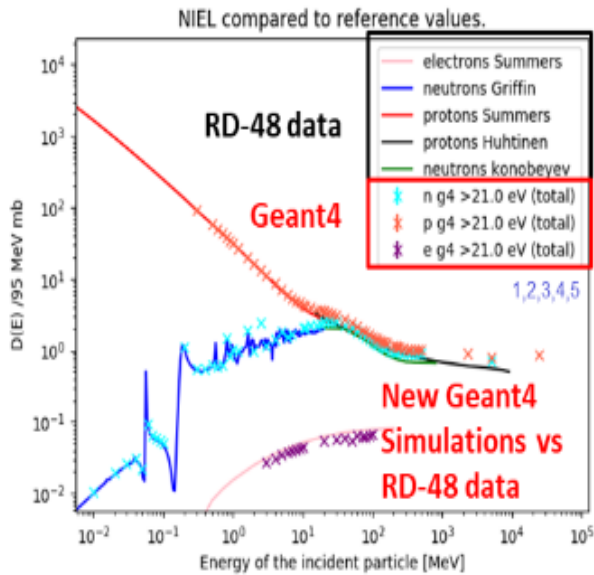
➤ Including a Video



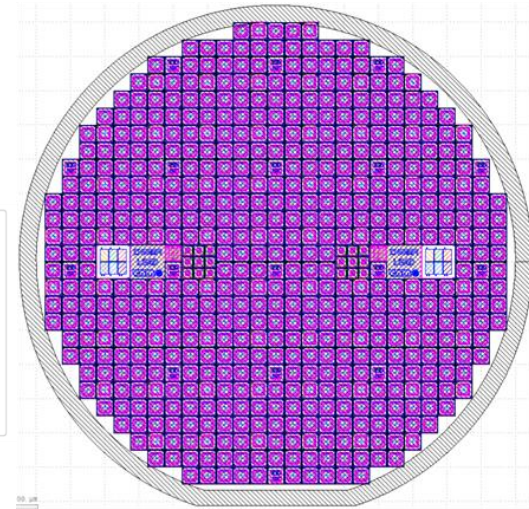
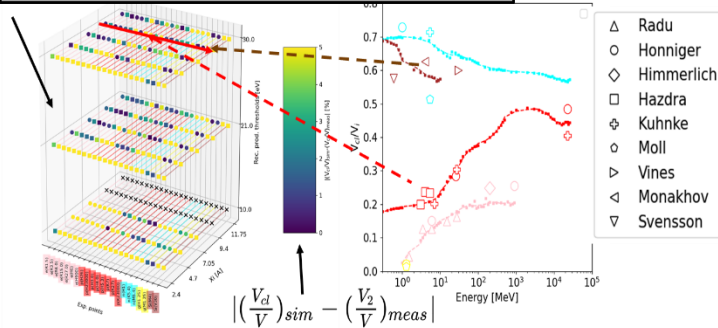
➤ Last Irradiation campaign is ongoing to test the radiation tolerance of RFID tags



- **Produce a common dosimetry calibration set for cross-comparison of irradiation facilities** by evaluating, with dedicated dosimeter structures, the Non-Ionizing Energy Loss (NIEL) of their particle beam



X: axis measurement points  
 Y axis: nearest neighbor parameter in A  
 Z: recoil threshold production cutoff  
 Yellow shows the settings for which the simulation and measurements does not agree by > 5 %  
 We look for a row that is dark along the X-axis: good candidate for parameter tuning.  
 Cubes: Simulation predict higher fraction of clusters/isolated then measurements  
 Spheres: Simulation predict lower fraction of clusters/isolated then measurements



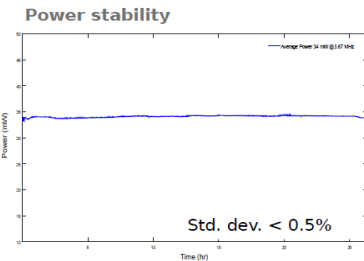
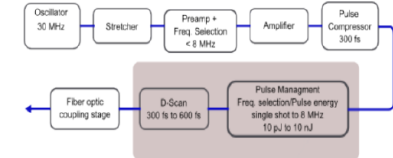
- Geant4 and FLUKA simulations for NIEL curves **successfully reproduced** and algorithm for identifying **clustered vs point defect damage implemented**
  - **Tuning of algorithm parameters is ongoing**

- D4.2**
  - It will benefit of Benchmarking simulations with measurements data
  - A set of Silicon Sensors (n-in-p) are in production at CNM, Barcelona

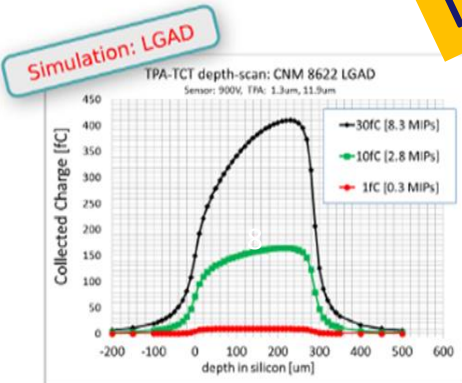
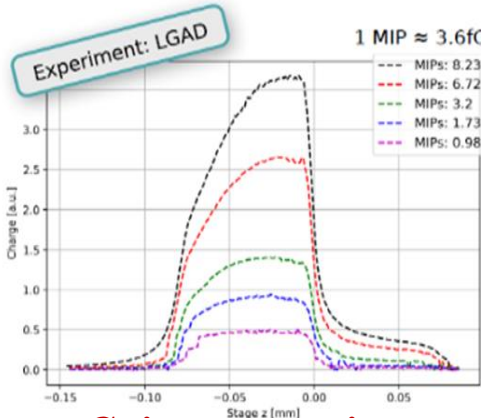
- Since 2023 Re-designed Laser system at Fyla
  - The new “Pulsar” laser system was manufactured
  - The system fully integrates the laser pulse source (LPS), the pulse management module (LPM) and the dispersion compensation module (D-scan) in a single box component with fiber optic beam delivery.
  - The system “Pulsar” presents robustness and great stability in optical and temporal properties.

### “Pulsar” system specifications


- **LPS: Laser Pulse Source**
  - All-fiber CPA femtosecond pulses generation
  - Pulse rep rate selection. **Single shot to 8MHz**
- **LPM: Laser Pulse Management module**
  - Pulse energy modulation: **10pJ to 10nJ**
  - Synchronized shutter, **rise/fall time < 1µs**
- **D-SCAN: Dispersion scanning**
  - Pulse duration tuning: **300fs to 600fs**
  - Pulse temporal properties characterization



**D4.4**



**Gain suppression measured with TPA-TCT in LGADs. Reproduce in TCAD simulations**

- (5+1) TPA-TCT laser systems have been installed within the user community, utilizing the Fyla laser model LFC1500X.  **MS16**

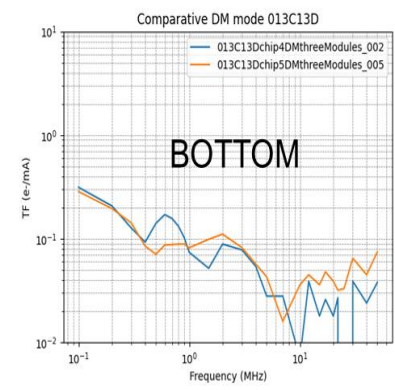
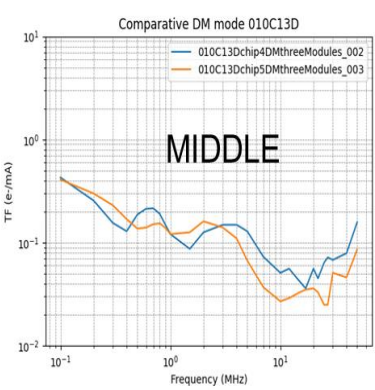
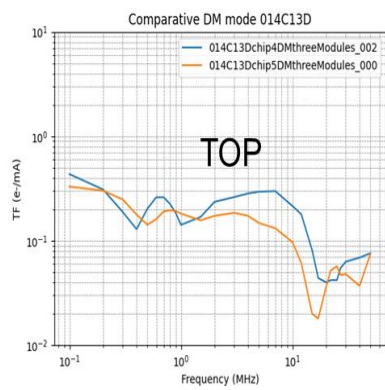
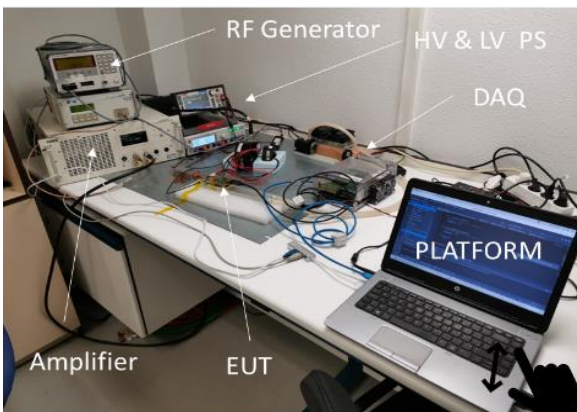
- Many tests have been already performed
- A new TPA-TCT system with the Fyla laser model Pulsar is being set up at the University of Oxford.



- EMC Transfer Functions (TF) measurement system development has been completed.  **MS17**

Noise studies at system level  
CMS-ITK –phase II












➤ System is fully operational - already used in EUROLABs project



- A portable test bench is being developed for conducting EMC emission measurements of PS in IRRAD facilities
  - It will be tested and validated at IPHC-Strasbourg facilities,
- During P2 a dedicated PCB has been designed
  - Data acquisition will use a high-resolution, 14-bit, four-channel oscilloscope (Transient capabilities)
- A Python-based software layer is being developed.

**D4.5**



Milestone or Deliverable	Description	Lead Beneficiary	Month
<b>Task 2</b>	<b>Micro-beam upgrade at RBI accelerator facility (RBI-AF)</b>		
MS12	Upgrade RBI-AF infrastructure for detector characterisation, SEE, micro hardness testing	RBI	M23 
D4.1	Integrate the data acquisition and control system at RBI-AF	RBI	M40 
<b>Task 3</b>	<b>Common tools for irradiation facilities Quality Control: Data Management (DM), Traceability, Dosimetry and Activation measurements</b>		
MS13	Define requirements, global architecture and design the extended DM system for ENEA-FNG and CERN-GIF++	CERN	M18 
MS14	Extend IDM for FNG, GIF++ and communication with CAEN DigiWaste and CANBERRA Apex-Gamma Platforms	CERN	M36 
MS15	Test RFID tagging for irradiation facilities	INFN	M42 
D4.2	Evaluate Non-Ionizing Energy Loss (NIEL) of irradiation facilities with dedicated dosimeter structures	CERN	M42 
D4.3	Deploy full prototype for irradiation facilities data management with sample tagging and spectrometry features	CAEN	M45 
<b>Task 4</b>	<b>Design &amp; Development of a new sensor characterization system based on TPA-TCT technique</b>		
MS16	Commission a complete TPA-TCT system	FYLA	M23 
D4.4	Support the implementation of TPA-TCT systems and contribute to the evaluation of new sensors technologies	CERN	M46 
<b>Task 5</b>	<b>EMC Characterization</b>		
MS17	Apply TF test bench to FEE prototypes	ITAINNOVA	M23 
D4.5	Develop a conductive noise test bench for irradiation facilities	ITAINNOVA	M44 

- **6 Milestones (MS): M18 – M42: 5/6 completed**

- M36: **MS14** achieved during the last year (March 2024)
- M42: **MS15** is the last one (September 2024)

- **5 Deliverables (D): M40 – M46**

- **Resources**

- Budget – 1.04 M€ (69 %)

# Back up slides

<https://aidainnova.web.cern.ch/publications>

## Acknowledgement text

All AIDAInnova publications must include the following acknowledgement text:



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA no 101004761.

Please do not forget to include the EC acknowledgement in all your publications (journal articles, conference papers, presentations, internal notes, etc.) related to AIDAInnova and to upload a copy of your publication on [Zenodo](https://zenodo.org).

September 22, 2022 (v1) Technical note Open Access

View

### First Irradiation test of U7-XM2 RFIDs at CERN IRRAD Facility

Alfredo María Núñez Herrero;

This document shows the results of two proton irradiation experiments using radio-frequency identification (RFID) tags. It also defines an initial testing methodology to be used as reference by other irradiation facilities, with the objective of enabling the result comparison of different future re

Uploaded on September 22, 2022

August 16, 2022 (v1) Journal article Open Access

View

### Characterisation of irradiated and non-irradiated silicon sensors with a table-top two photon absorption TCT system

S. Pape; M. Fernández García; M. Moll; R. Montero; F.R. Palomo; I. Vila; M. Wiehe;

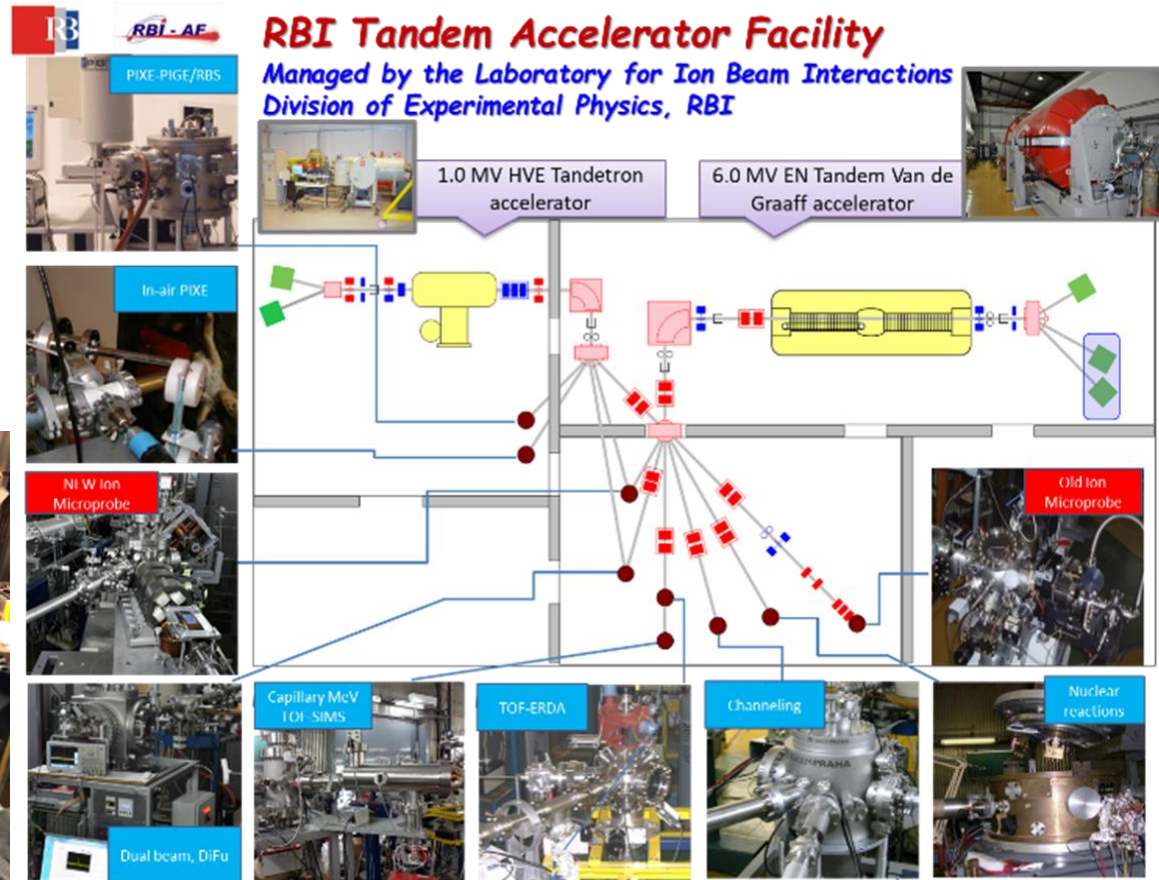
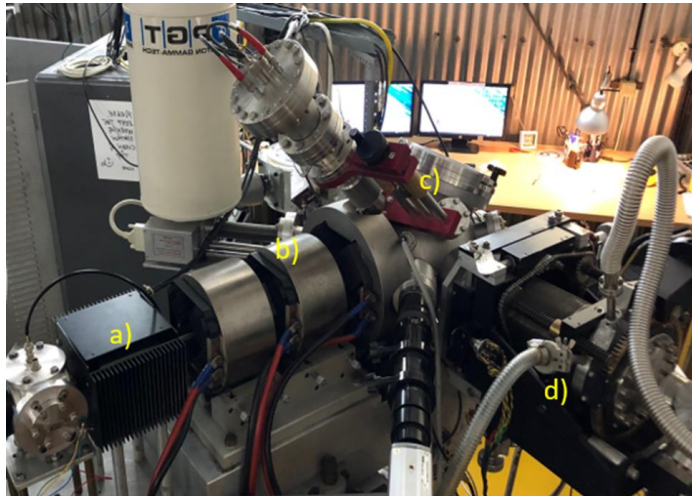
A tabletop Two Photon Absorption-Transient Current Technique (TPA-TCT) set-up built at CERN was used to investigate a non-irradiated PIN diode, an irradiated PIN diode, and a non-irradiated 5 × 5-multipad HPK LGAD. The intrinsic three dimensional spatial resolution of this method is

Uploaded on November 2, 2022

- **12 publication records** for WP4 in Zenodo
  - **7 other than MS reports** (articles, notes, presentations, etc.)
  - 1 in the pipeline for task 4.3, other 7 still pending to be uploaded in Zenodo
- **e-groups** to communicate with TLs and WP4 members
- **INDICO category** to host WP- and Task-related meetings:
  - <https://indico.cern.ch/category/13502/> (**14 events**)



- Upgrade of the RBI Tandem Accelerator Facility (RBI-AF) infrastructure for detector characterization and radiation hardness studies at micron-scales



- **Objective 1:** Generalization of the IRRAD Data Manager (IDM) to include new facilities and improve the data sharing
- **Objective 2:** Design and development of an integrated system prototype for induced activation and traceability data management
- **Objective 3:** Produce a common NIEL dosimetry calibration set for facilities cross-comparison



Detector development, irradiation, characterization (CH)



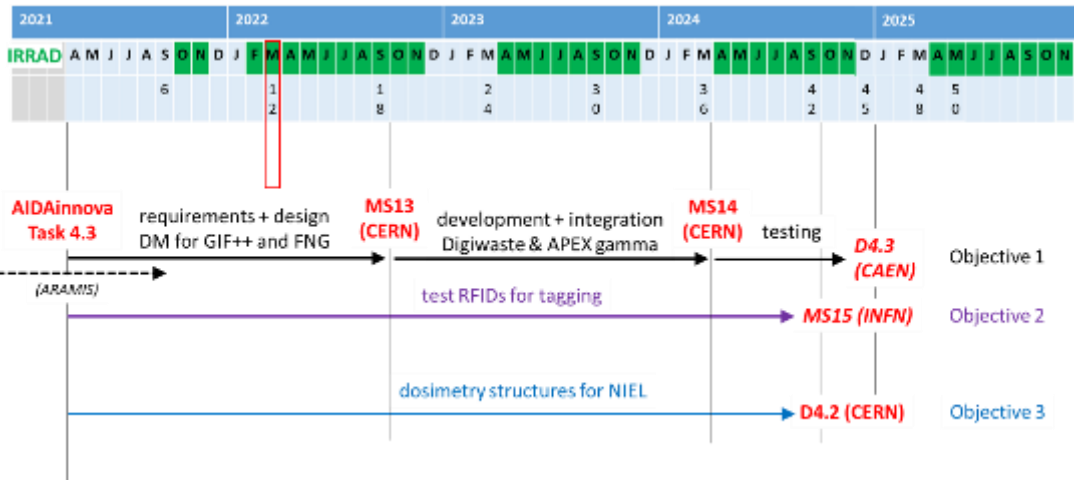
Irradiation/testing of electronics (IT)



Electronic Instrumentation for Nuclear and PP (IT)



Data management SW, ontologies and ML (FR)

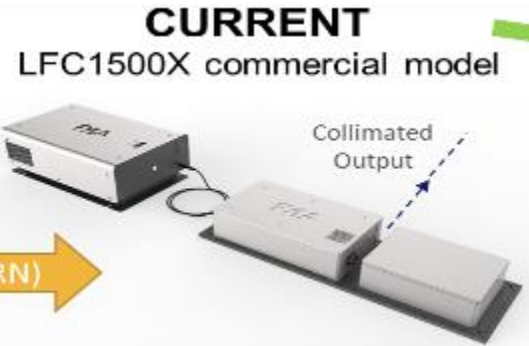


**7 task meetings organized during the first year to review the progress in the three objectives ...**

- **Development of a customizable and user friendly Two Photon Absorption – Transient Current Technique (TPA-TCT) system** for the characterization and test of silicon devices.
- Two activities are planned in task 4.4:
  - System upgrade
  - Promote the use of this technique within detector community



Current TPA-TCT (CERN)

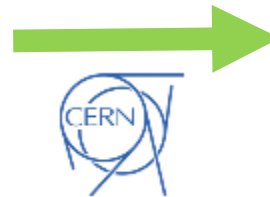


**AIDA INNOVA**  
Single box fully all-fiber

Fiber delivery



- **LPS: Laser Pulse Source**
  - All-fiber CPA femtosecond pulses generation
  - Pulse rep rate selection. **Single shot to 8 MHz**
- **LPM: Laser Pulse Management module**
  - Pulse energy modulation: **<10 pJ to > 10 nJ**
  - Synchronized shutter. **rise/fall time < 1 us**
- **D-SCAN: Dispersion scanning**
  - Pulse duration tuning: **300 fs to 600 fs**
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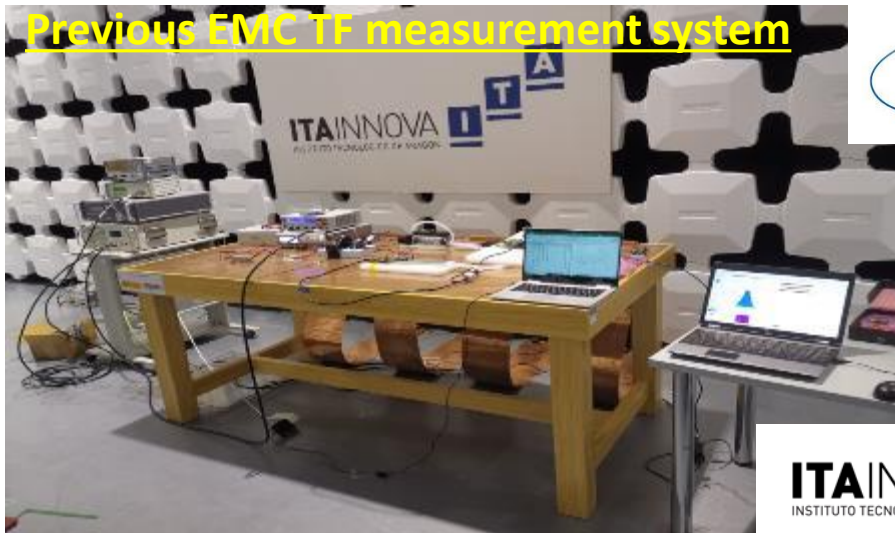
- **LPS + LPM + D-SCAN in single box fully all-fiber**
  - Pulse duration goal **< 100 fs**
  - Fiber-based tunable dispersion compensation: **< 100 fs to 1 ps**
  - Fiber-pigtailed AOM functionalities:
    - Energy modulation
    - Pulse rep rate selection
    - Sync shutter
  - Dispersion-less fiber output delivery to TPA-TCT optical sub-system



- This task plans to upgrade Electromagnetic Compatibility (EMC) tests in order to improve the support for detector electronics designers.
- Activities:
  1. Design and develop an automatic EMC test bench to measure the noise transfer functions (TF) of physics detectors.
  2. Design and develop a portable test bench to perform in-situ EMC conducted emission measurements of power units in irradiation facilities.

> 1 week → a few hours ...

Previous EMC TF measurement system



EMC TF measurement system upgraded

