



# Upgraded simulation of the CERN Gamma Irradiation Facility (GIF++)

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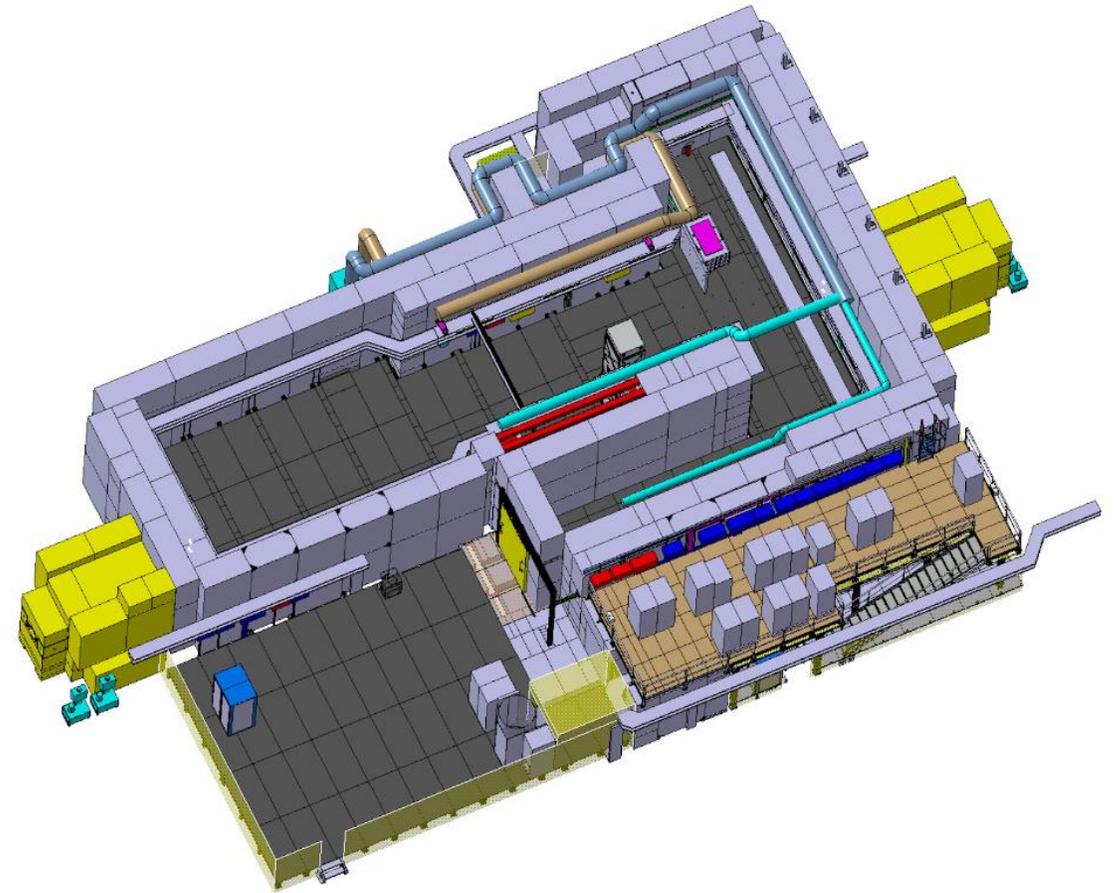
# State of art

- Since 2014, test at [Gamma Irradiation Facility](#) at CERN has been extensively performed for Eco-gas, longevity, and R&D detector studies involving various detector technologies such as DT, MDT, CSC, RPC, iRPC, GEM, and more.
- A simulation study was developed by Pfeiffer Dorothea and published (“**The radiation field in the Gamma Irradiation Facility GIF++ at CERN**” [1]). It used GEANT4-10.0 to model the radiation background at GIF++ and it was performed without the detectors installed.
- Moreover, a new bunker geometry was implemented in 2018
- New simulation work is needed....

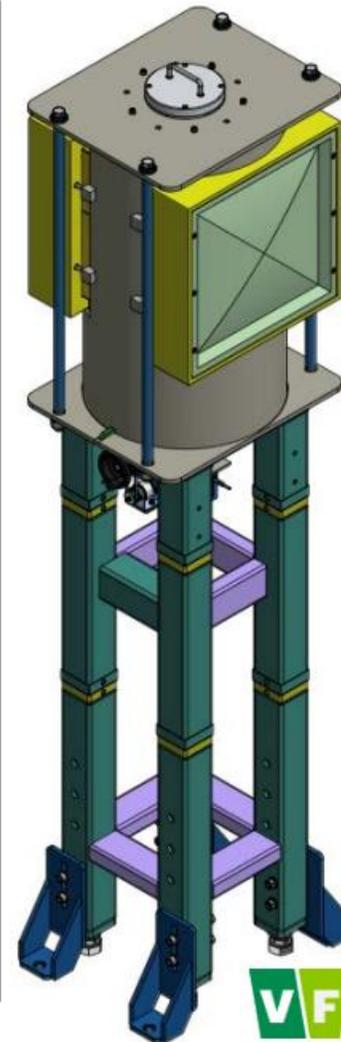
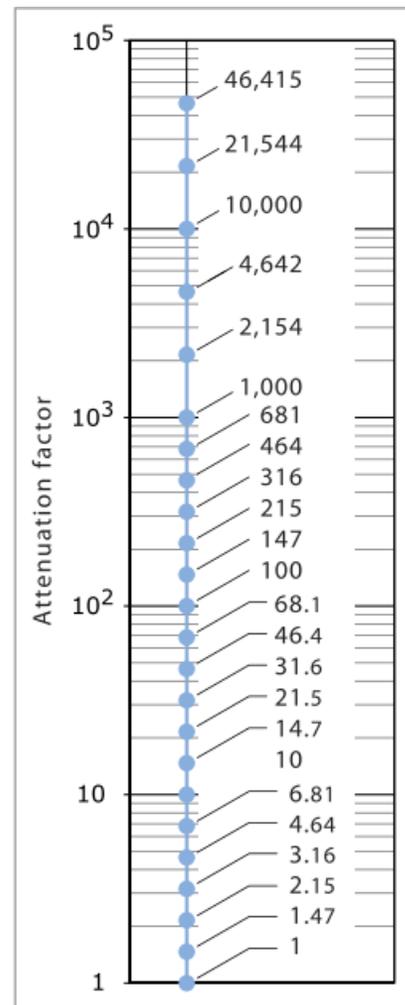
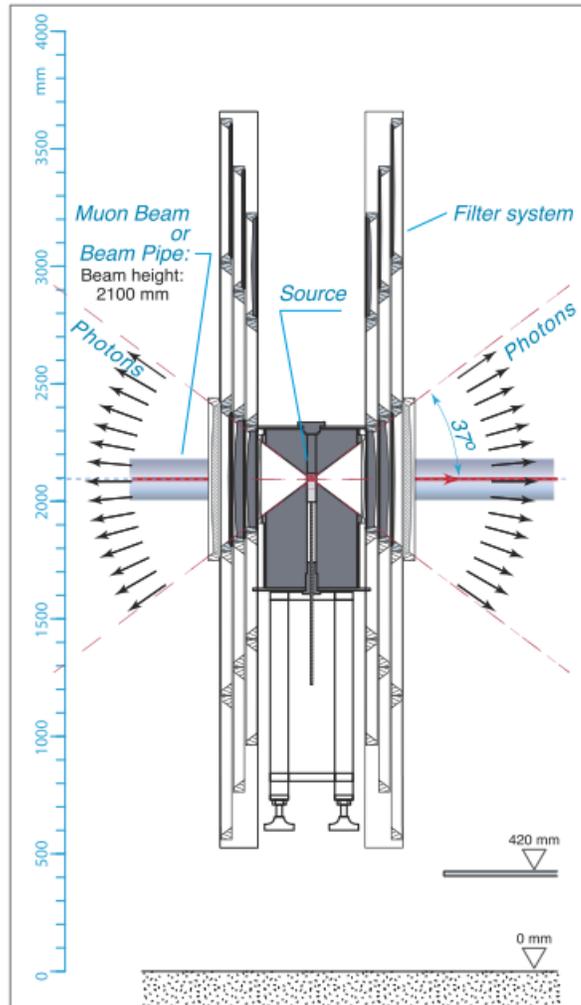
[1] <http://dx.doi.org/10.1016/j.nima.2017.05.045>

# The GIF++ facility @ CERN

1. Source of  $^{137}\text{Cs}$  of 662 keV photons at 11.5 TBq (January 2024)
2. Beam from SPS (muons)
3. Intensity controlled by a combination of attenuation filter
4. Field shaped from point-like to planar
5. Gas and electronics infrastructures
6. Unified control/monitoring system
7. Setups for beam & cosmic trigger, radiation monitoring, environmental monitoring, DAQ,...



# Gamma Filters



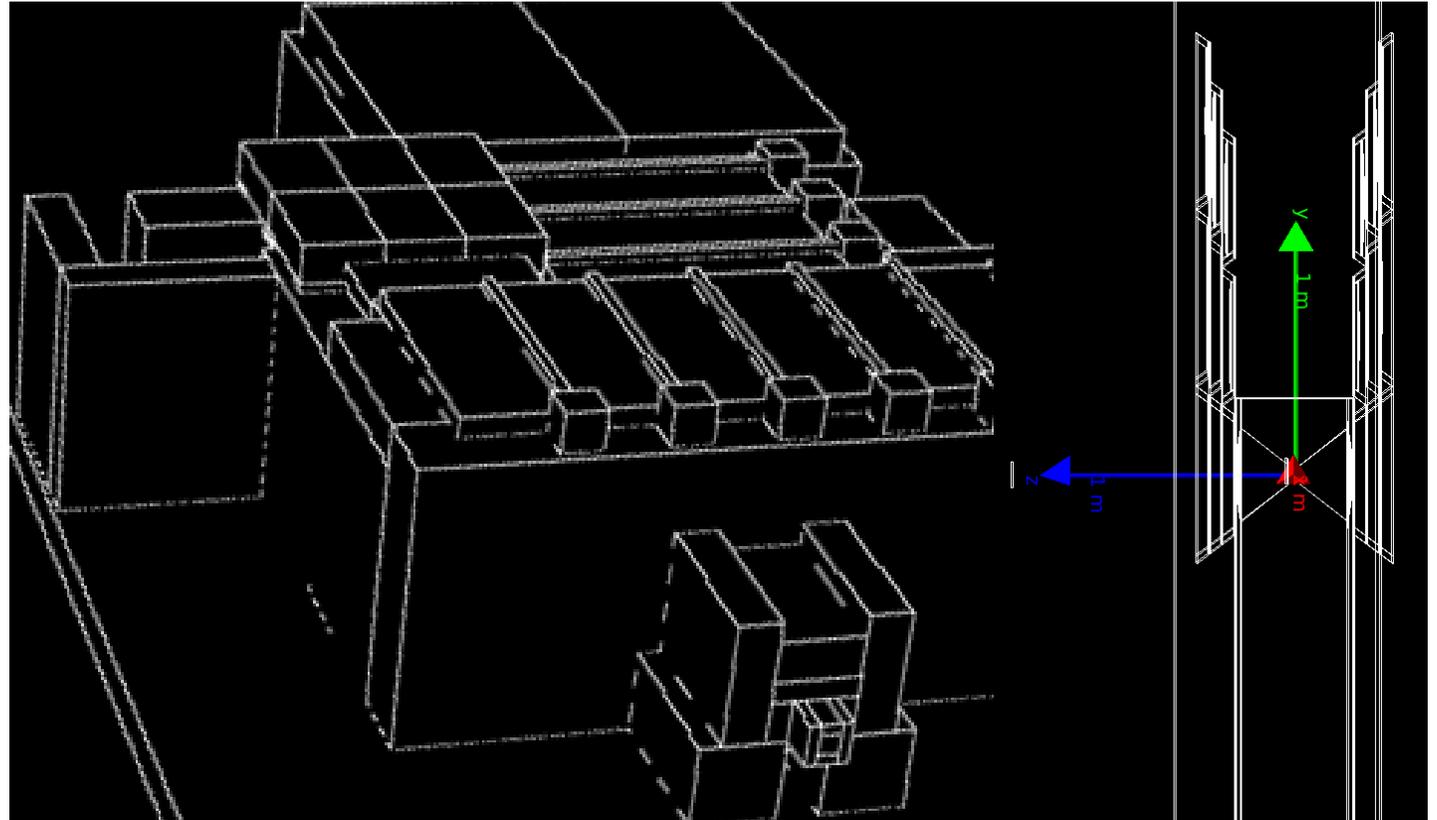
Array of  $3 \times 3$  convex lead attenuation filters, to fine tune the photon flux for each irradiation field individually, upstream (UP) and downstream field (DOWN)

Systems of movable lead attenuators for large irradiation zone that allows attenuation factors (ABS) between 1 and 46420 in several steps

# Simulation layout

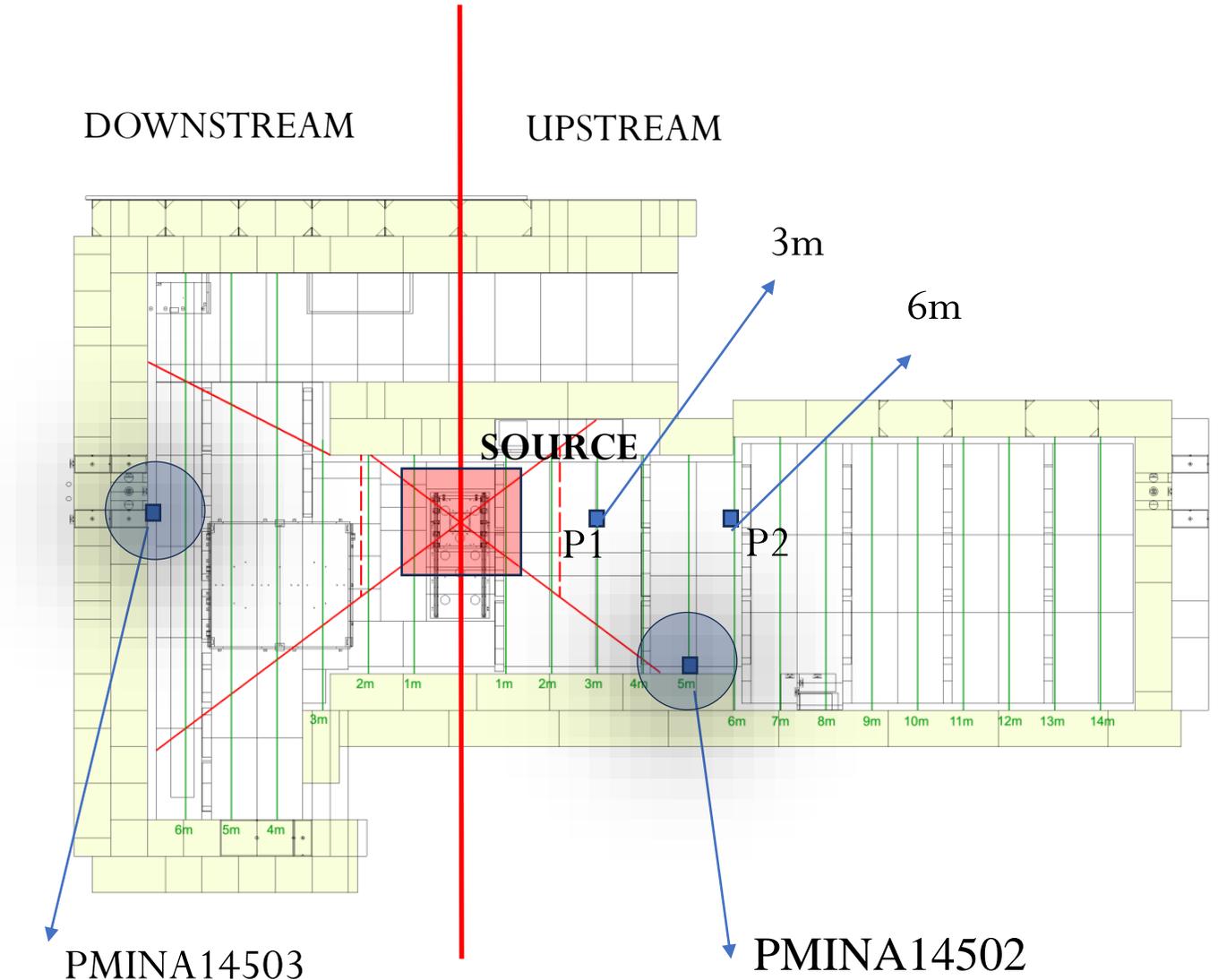
New GDML Gif++ layout implemented for Geant4

1. Geometry updated to 15 m upstream
2. Version Geant4-11.0
3. Physics List- G4EmLivermorePhysics
4. Filter implementation: mounted on aluminum support plates, the filters are positioned inside steel frames, as collimators.
5. **NO EXPERIMENTAL INSTALLATION INCLUDED IN THE SIMULATION LAYOUT**



# Simulation validation

- Two detectors (PMINA) are installed in the bunker at fixed position for dose rate measurements. PMINA are ionization chambers with a calibrated measurement range of  $5 \mu\text{Sv/h}$ – $500 \text{mSv/h}$ .
- Measured dose rate is compared with simulation results at different filter set-up
- Additional measurements performed by ECOGAS@GIF++ collaboration in points P1 and P2 are compared with simulation
- In each point a sensitive volume of TISSUE was considered in the simulation.



# Ambient dose equivalent rate calculation

## PROCEDURE:

Simulation of tissue equivalent phantom divided into 8 voxels

Simulated voxel dose  $D(Sv)$

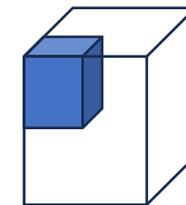
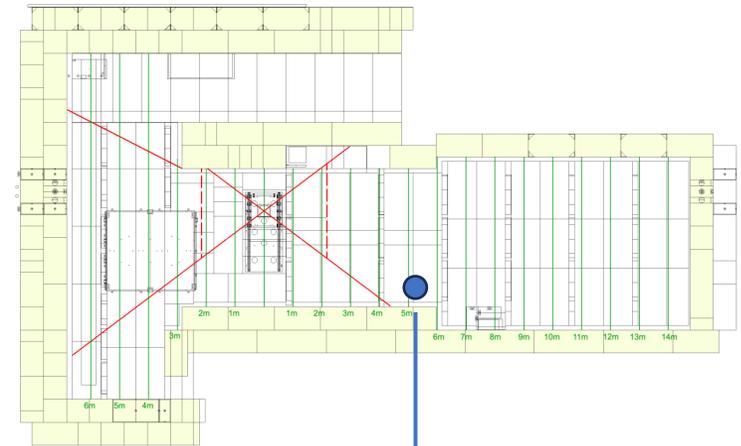
Source activity  $A = 11,5TBq$

Generated gammas  $N_{\gamma} = 2 \cdot 10^7$

Reference time  $T (s) = \frac{N}{A} = 0,174 \cdot 10^{-5} s$

$$\text{Rate Dose} = \frac{D}{0,174 \cdot 10^{-5}} * 3600 \frac{Sv}{h}$$

Error calculation based on standard deviation of dose among different voxels.



PHANTOM 20x20x20 cm<sup>3</sup>  
Subdivided in 8 voxel

# Extraction of PMINA experimental data

PMINA data available at:

<https://timber.cern.ch/>

Data and Time    Dose rate value

|                |              |
|----------------|--------------|
| 18/04/24 10:33 | 0,0013967800 |
| 18/04/24 10:34 | 0,0013973500 |
| 18/04/24 10:35 | 0,0013957100 |
| 18/04/24 10:36 | 0,0013973200 |
| 18/04/24 10:37 | 0,0013961900 |
| 18/04/24 10:38 | 0,0013969200 |
| 18/04/24 10:39 | 0,0013967000 |
| 18/04/24 10:40 | 0,0013968100 |
| 18/04/24 10:41 | 0,0013970500 |
| 18/04/24 10:42 | 0,0013972400 |
| 18/04/24 10:43 | 0,0013972800 |
| 18/04/24 10:44 | 0,0013969400 |
| 18/04/24 10:45 | 0,0013973900 |
| 18/04/24 10:46 | 0,0013970200 |
| 18/04/24 10:47 | 0,0013963100 |
| 18/04/24 10:48 | 0,0013973500 |
| 18/04/24 10:49 | 0,0013963900 |
| 18/04/24 10:50 | 0,0013970100 |
| 18/04/24 10:51 | 0,0013956900 |
| 18/04/24 10:52 | 0,0013970700 |

Search in GIF database, <https://epdt-rd-monitoring.web.cern.ch/>

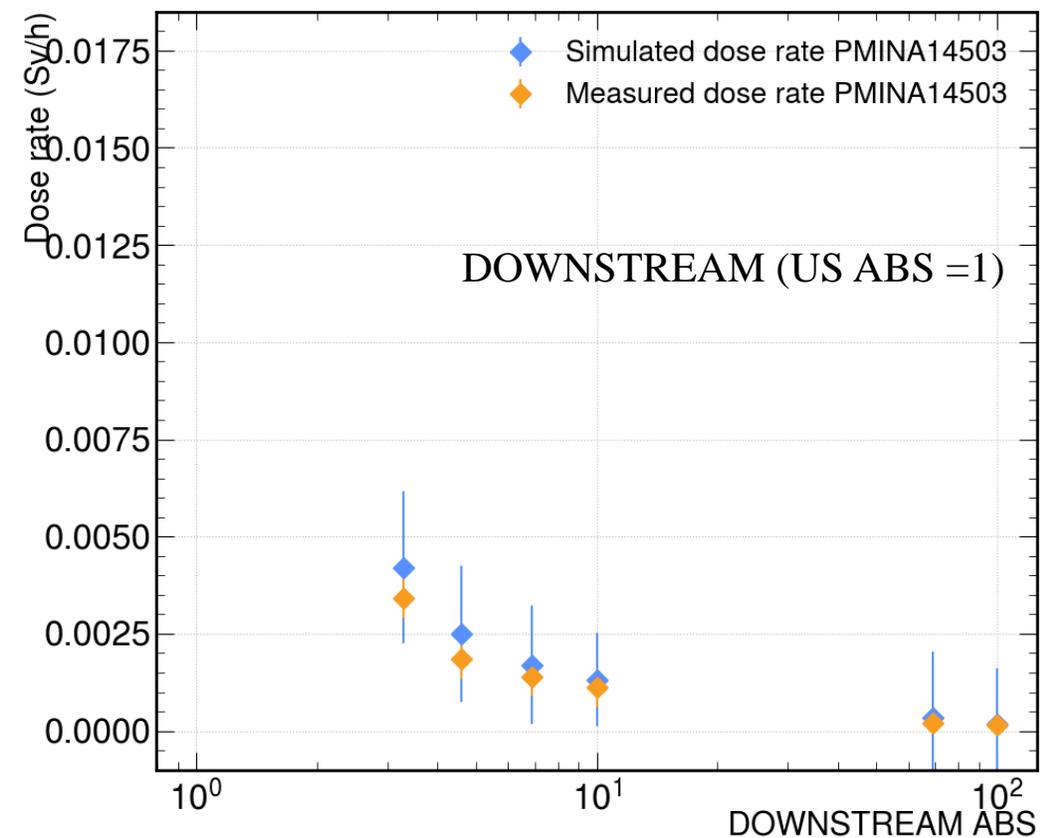
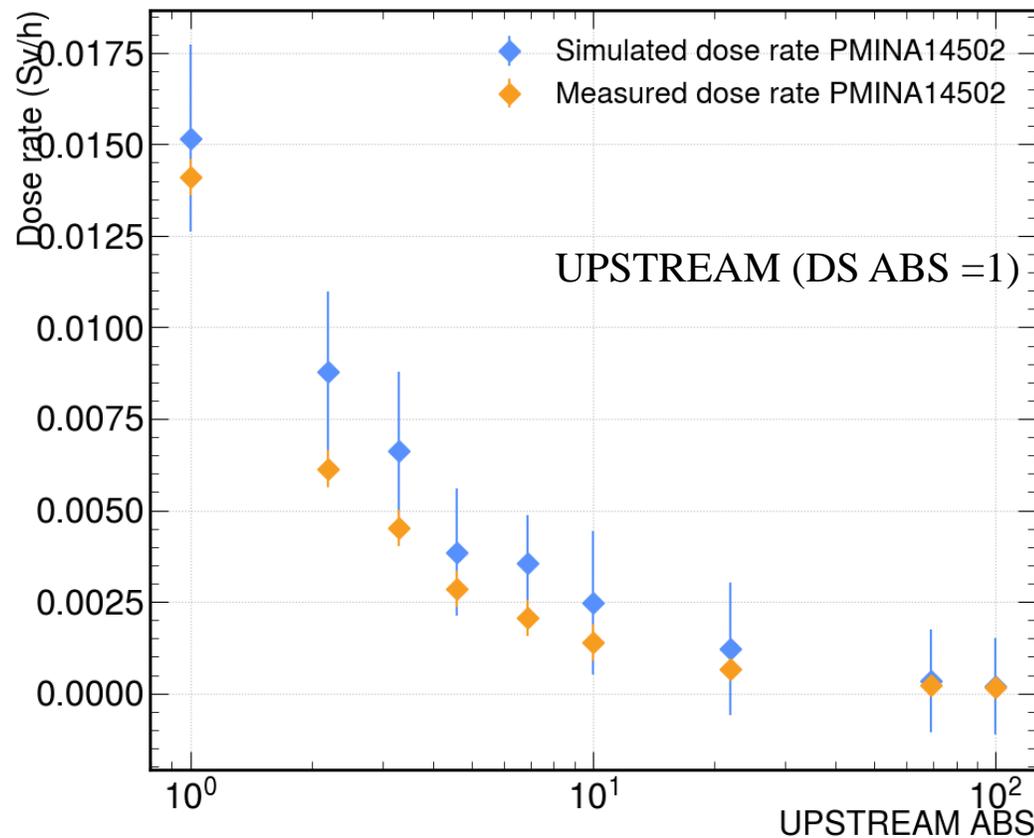
ABS values for the choosen data and times

Data and Time    ABS value

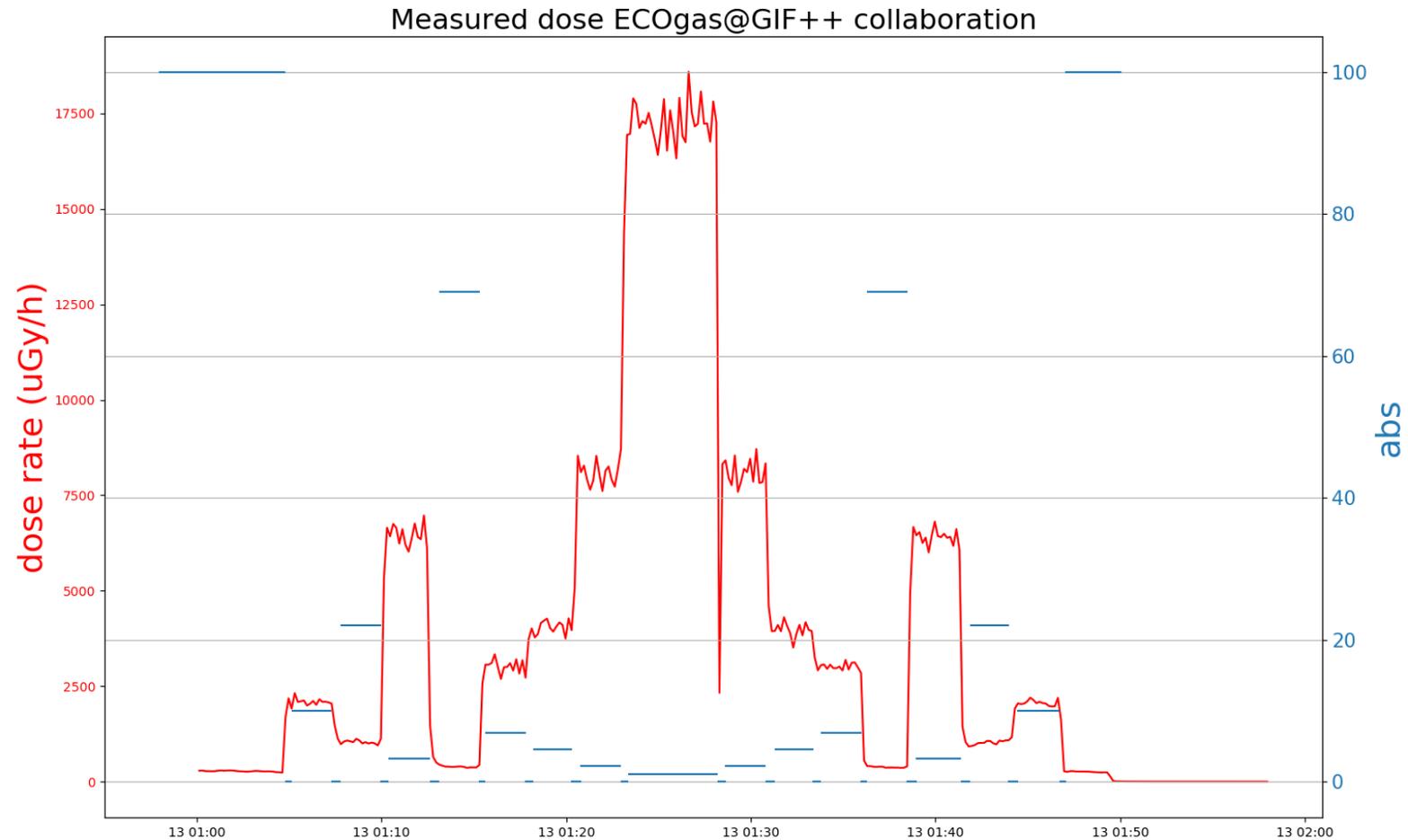
|                  |            |
|------------------|------------|
| 18/04/2024 12:55 | 10,0000000 |
| 18/04/2024 13:00 | 10,0000000 |
| 18/04/2024 13:05 | 10,0000000 |
| 18/04/2024 13:10 | 10,0000000 |
| 18/04/2024 13:15 | 10,0000000 |
| 18/04/2024 13:20 | 10,0000000 |
| 18/04/2024 13:25 | 10,0000000 |
| 18/04/2024 13:30 | 10,0000000 |
| 18/04/2024 13:35 | 10,0000000 |
| 18/04/2024 13:40 | 10,0000000 |
| 18/04/2024 13:45 | 10,0000000 |
| 18/04/2024 13:50 | 10,0000000 |
| 18/04/2024 13:55 | 10,0000000 |
| 18/04/2024 14:00 | 10,0000000 |
| 18/04/2024 14:05 | 10,0000000 |
| 18/04/2024 14:10 | 10,0000000 |
| 18/04/2024 14:15 | 10,0000000 |
| 18/04/2024 14:20 | 10,0000000 |
| 18/04/2024 14:25 | 10,0000000 |
| 18/04/2024 14:30 | 10,0000000 |
| 18/04/2024 14:35 | 10,0000000 |
| 18/04/2024 14:40 | 10,0000000 |
| 18/04/2024 14:45 | 10,0000000 |

# Gamma dose validation with PMINA dosimeters

- Upstream and Downstream validation
- **Simulated and measured values (test beam campaign 2024) in agreements inside error margin**
- **NO SHADOW** from experimental set-up on the PMINA response



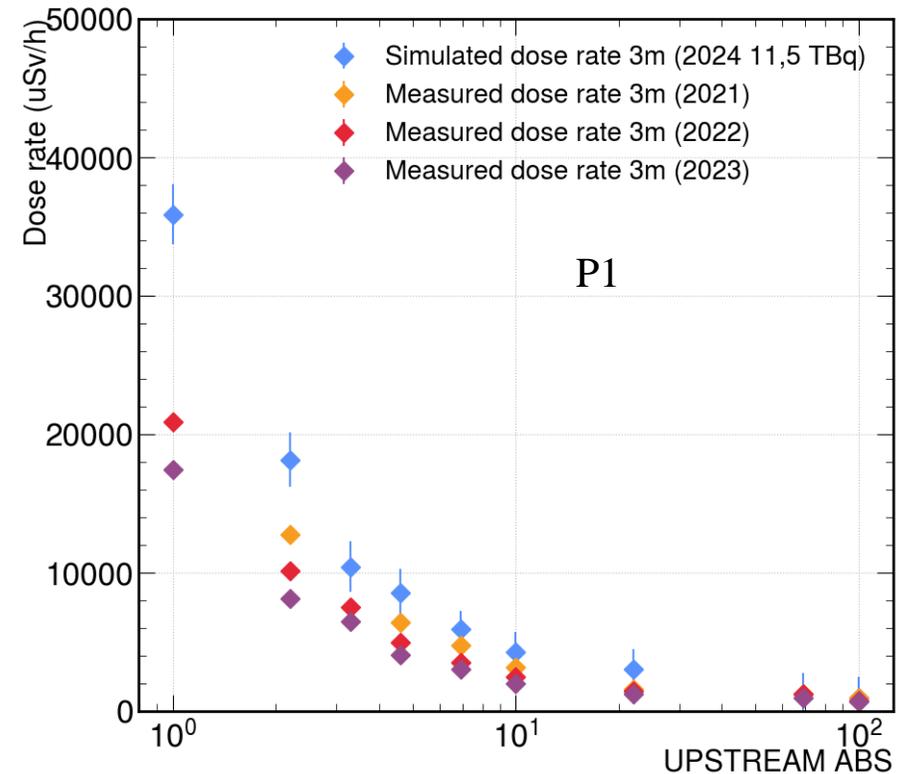
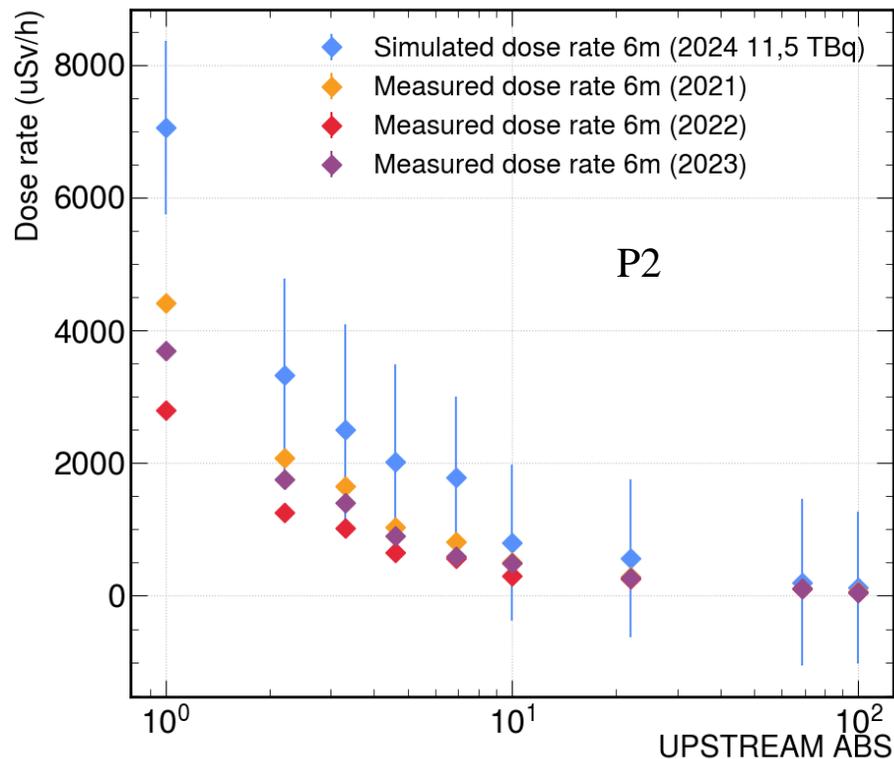
# Dosimeter data from ECOGAS@GIF++ collaboration



- Ecogas measurement at trolley position P1
- Dose rate and ABS are shown
- Dose rate is the mean of experimental data for every ABS value
- Data from 2023

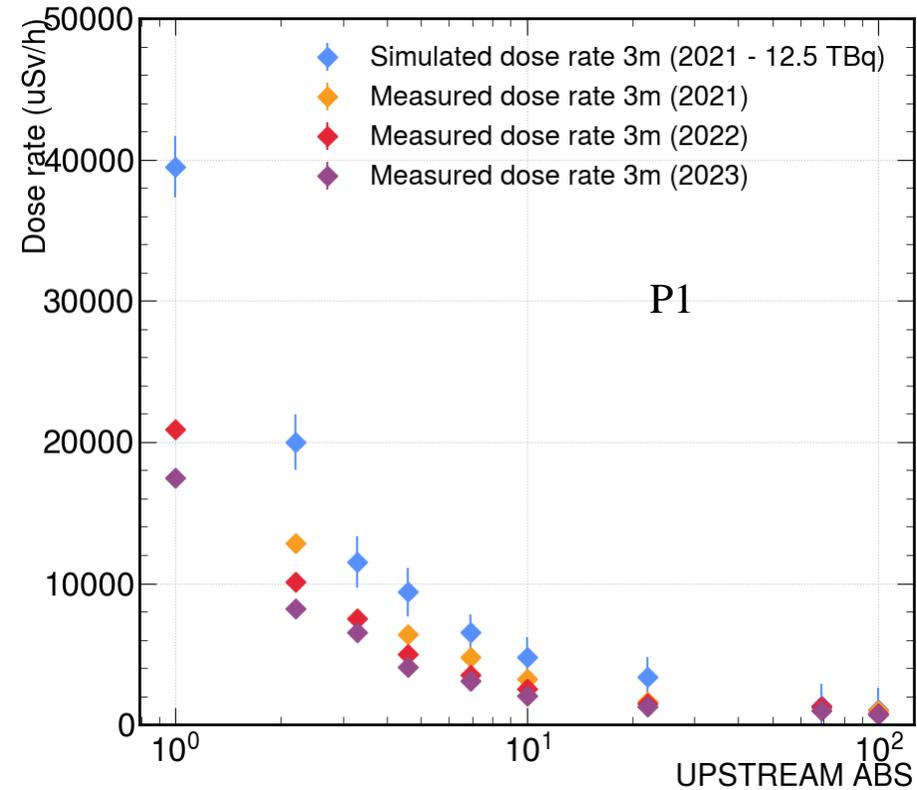
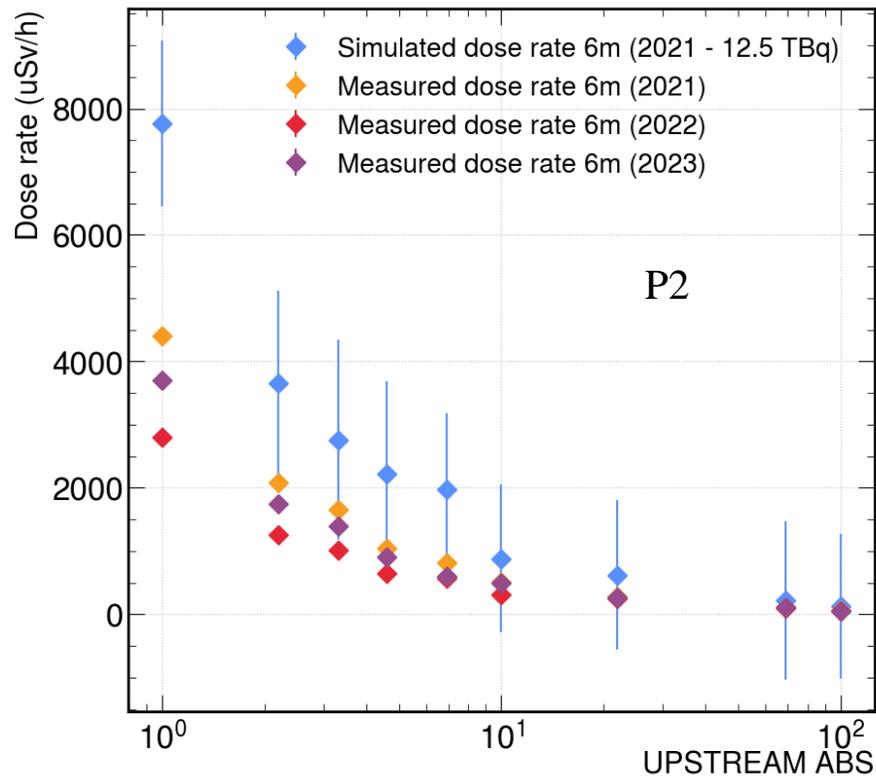
# Dose rate comparison

- Comparison at P1 and P2 with data provided by ECOGAS@GIF++ collaboration measured during 2021-2022-2023
- **Difference in dose rate due to presence of mechanical structure and setups in the bunker and difference of source activity**
- Comparison assuming activity of 11,5 TBq

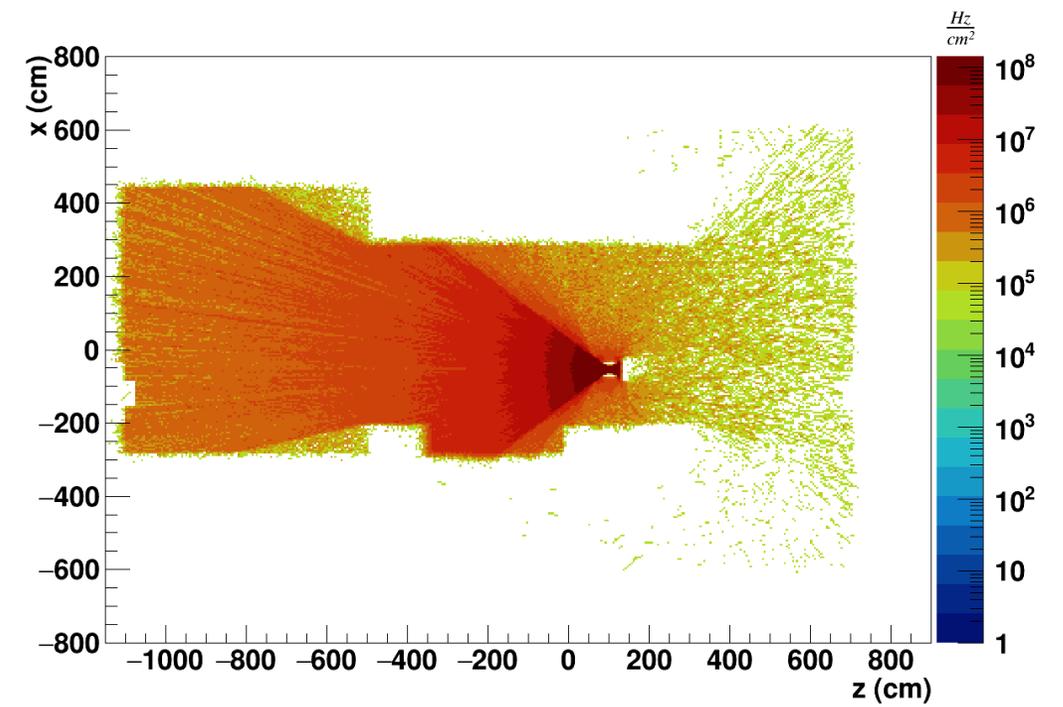
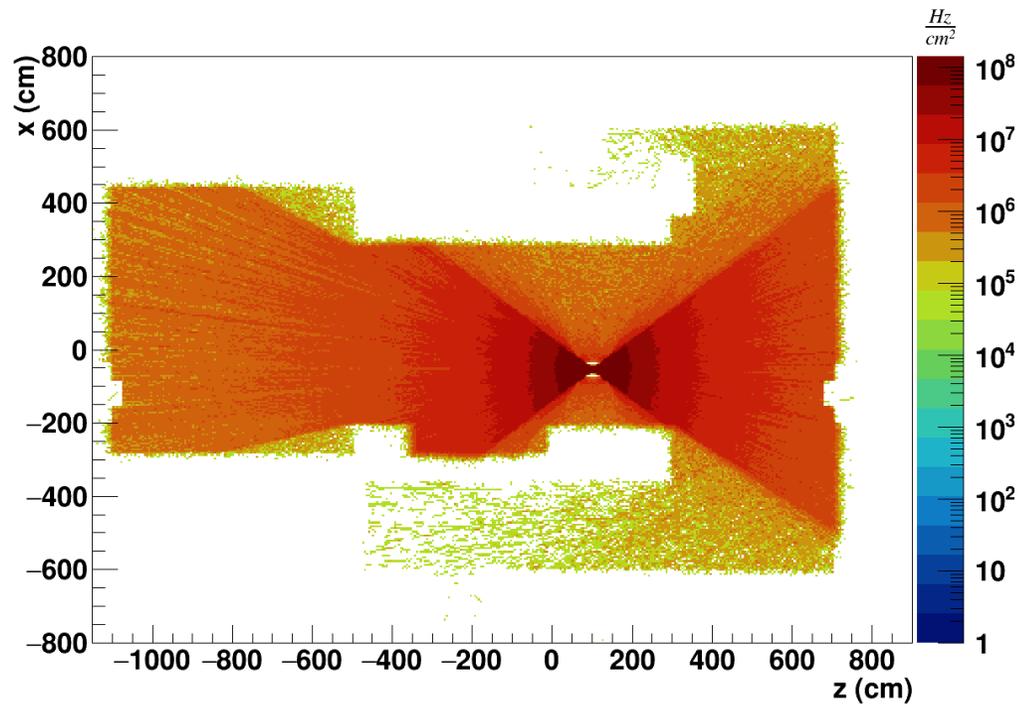


# Dose rate comparison taking into account change of activity

- Comparison at P1 and P2 with data provided by ECOGAS@GIF++ collaboration measured during 2021-2022-2023
- Comparison assuming activity of 12,5 TBq (2021)



# Gamma Flux estimation

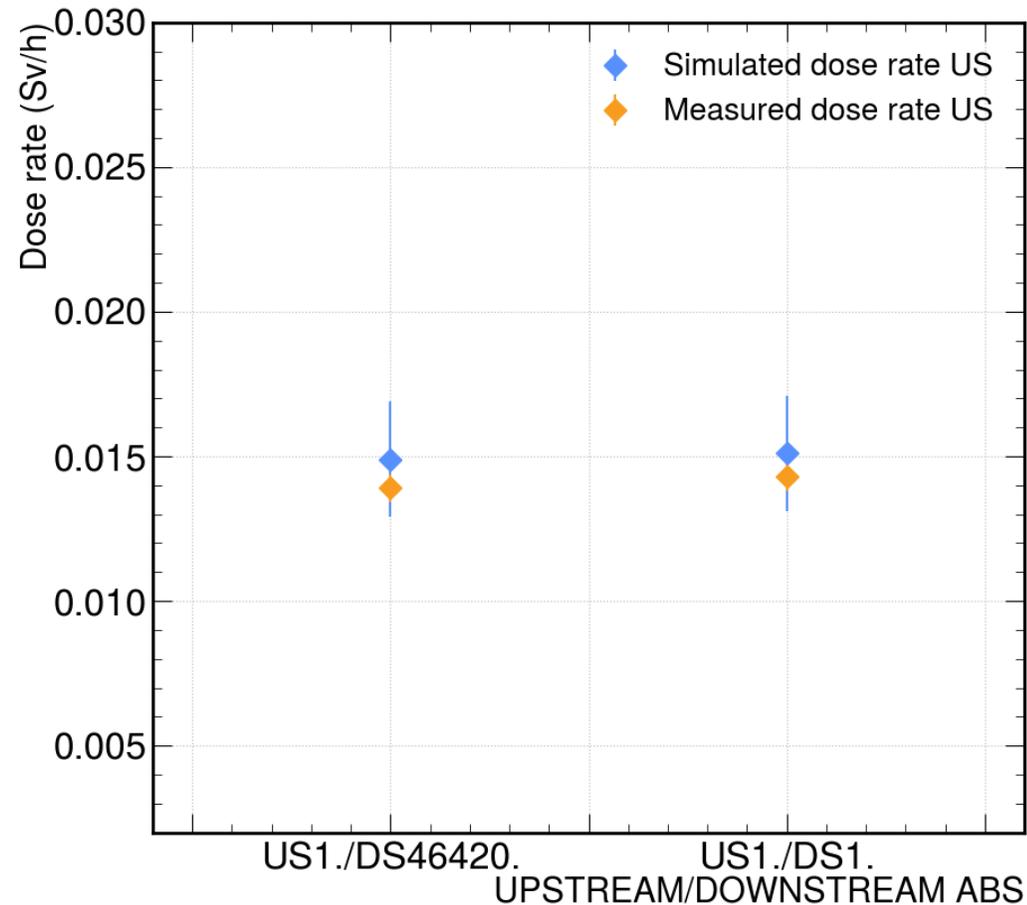


At ABS 1

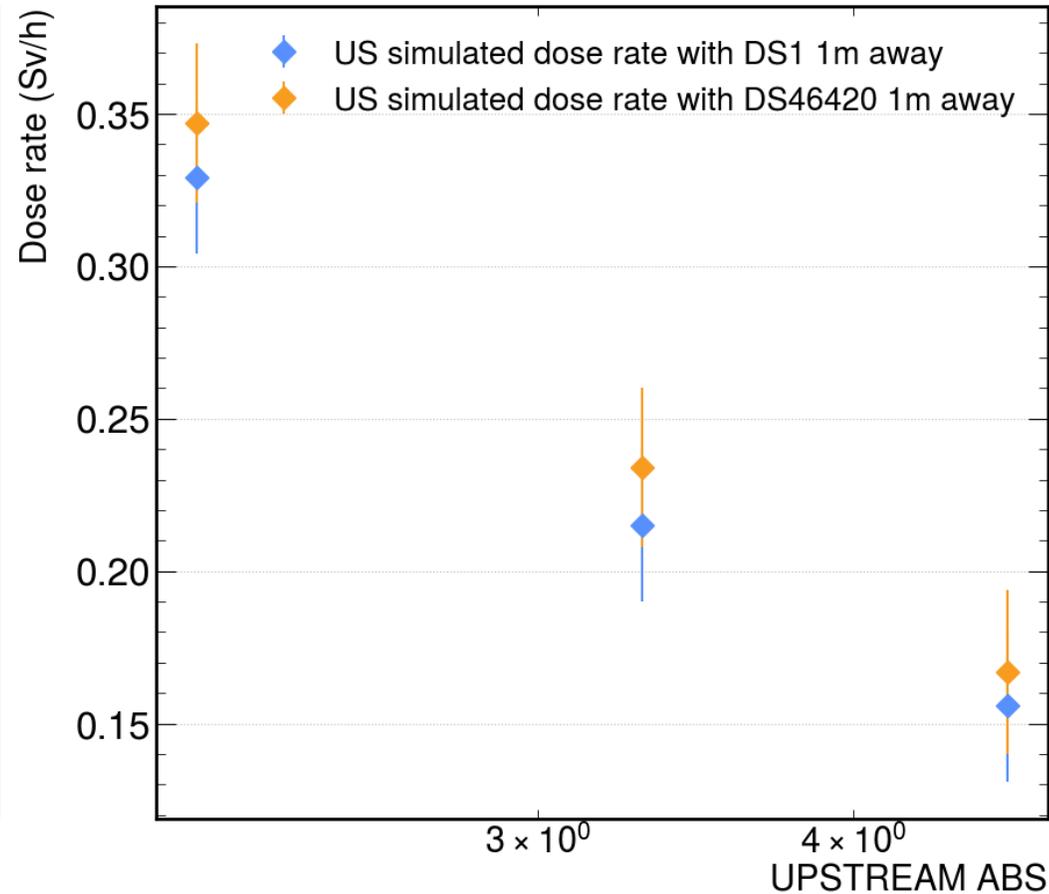
Around  $10^7$  gamma/ s  $\text{cm}^2$  estimated gamma flux from plot at 3m from the source

# Backscattering study

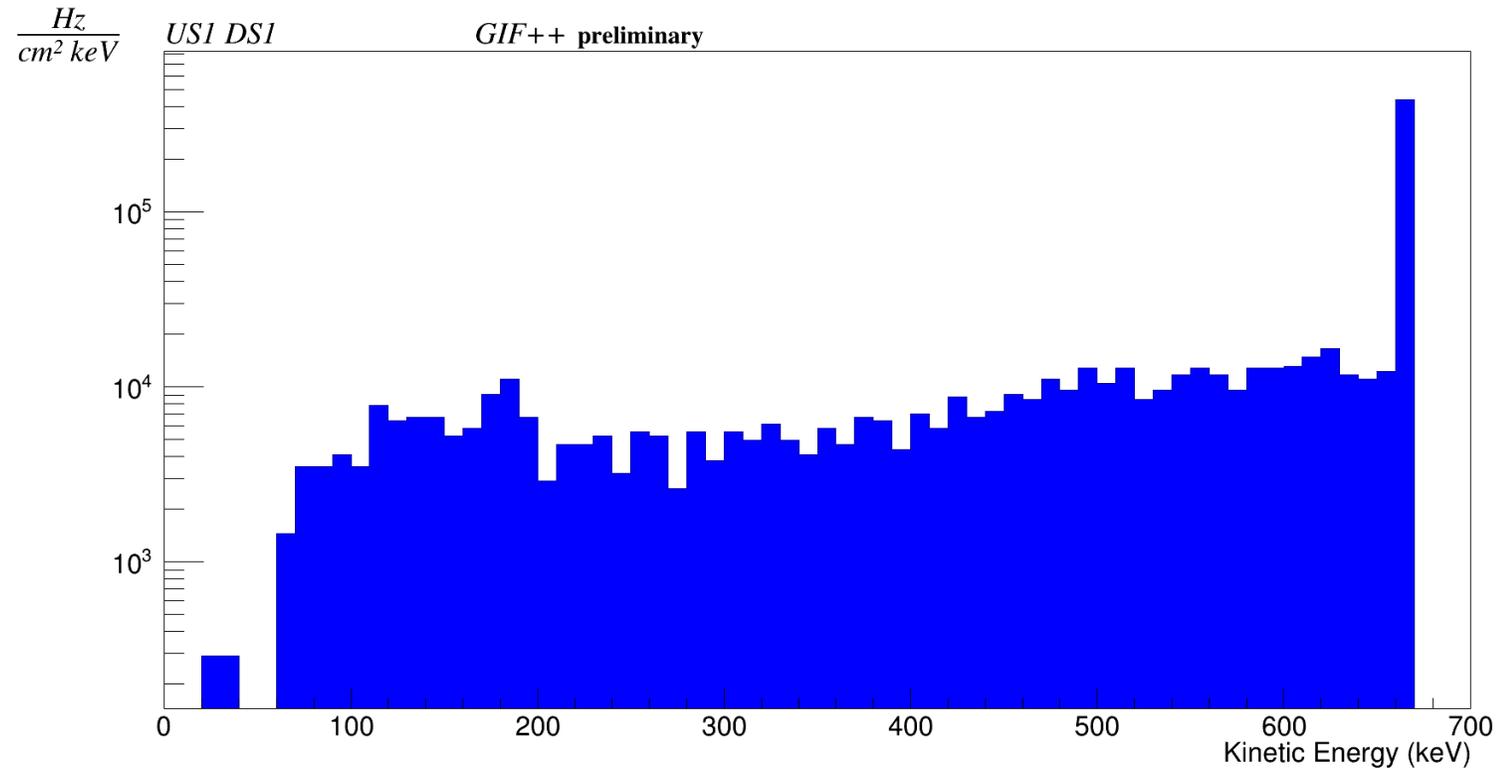
Dose rate of PMINA detectors used for backscattering measure, no evident difference



Simulation at 1m for backscattering investigation with 2.2 , 3.3 and 4.6 filters



# Gamma energy spectrum



Simulated gamma energy at 3m from the source for US1 and DS1 with  $10^7$  gammas in the simulation.

# Conclusions and Next steps

1. The simulation has been validated by the comparison of the dose rate with the measurements done with PMINA sensors
2. The validated simulation provides results in agreement with the measured dose rate taken at 6 m and 3 m from the source.

1. The simulation tool can be enriched including all detectors installed inside the GIF.
2. Extensive dose campaign are planned to improve the simulation validation
3. Increase number of generated gammas to improve precision
4. Study of the gamm sensitivity of the detector

THANKS