Optical Fiber Dosimetry

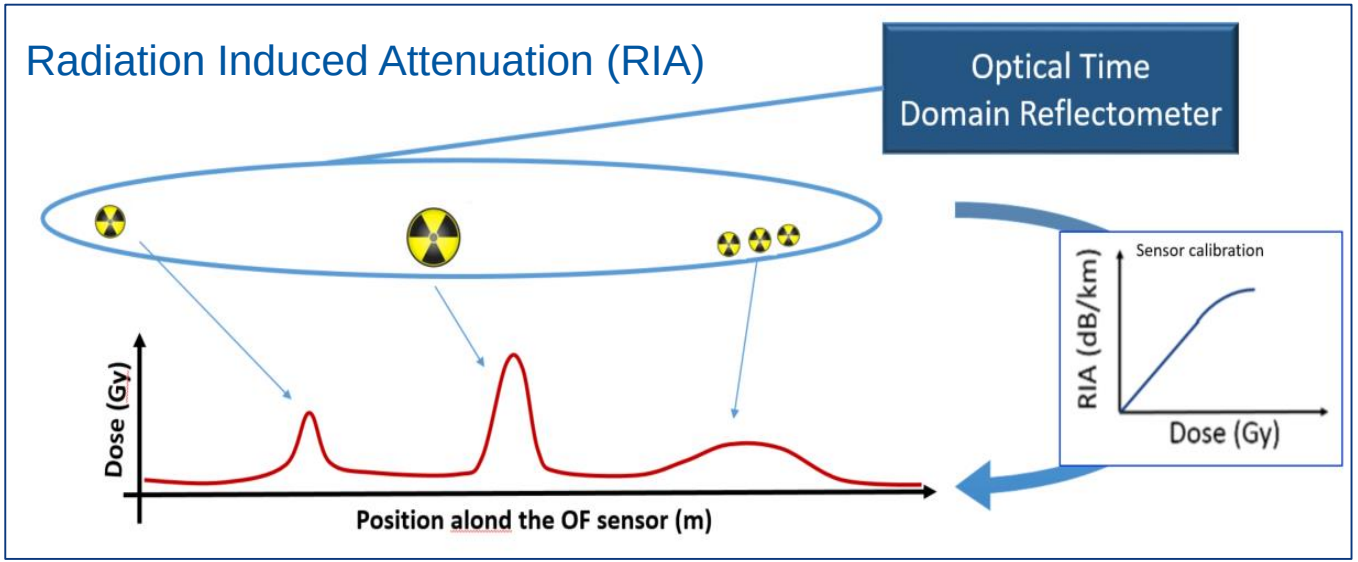
Diego DI FRANCESCA, Yacine KADI, Gaetano LI VECCHI, Keziban KANDEMIR
EN-EA-PE
Indico link: https://indico.cern.ch/event/760345/

Outline

- Motivation for Optical Fiber Dosimetry (OFD)
- Overview of the OFD in the last years
- Main features of the OFD system in 2018
- Status of the OFD installations in 2018
- Future installations and LS2 activities
- Collaborations and dissemination of results
- Conclusions

Motivations

Providing 1D radiation maps of the accelerators and online monitoring in order to prevent R2E-related failures

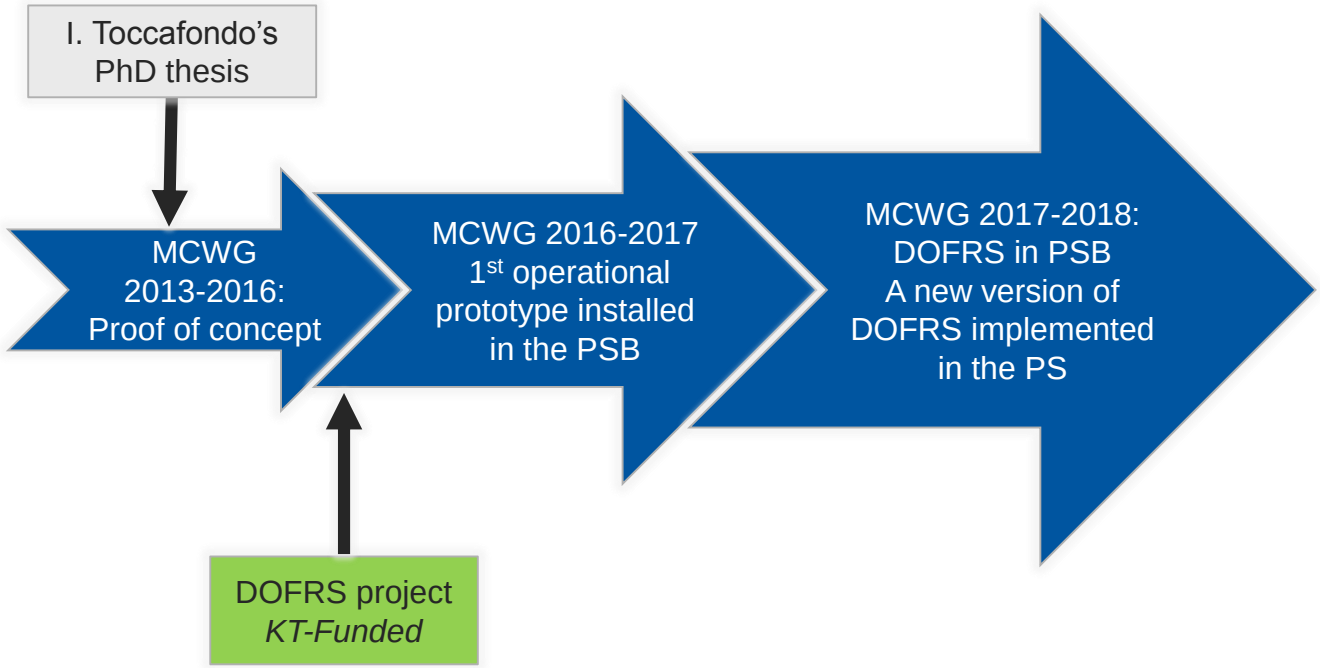


H. Henschel et al., *Nucl. Instrum. Methods Phys. Res. B*, 69, 307, 1992

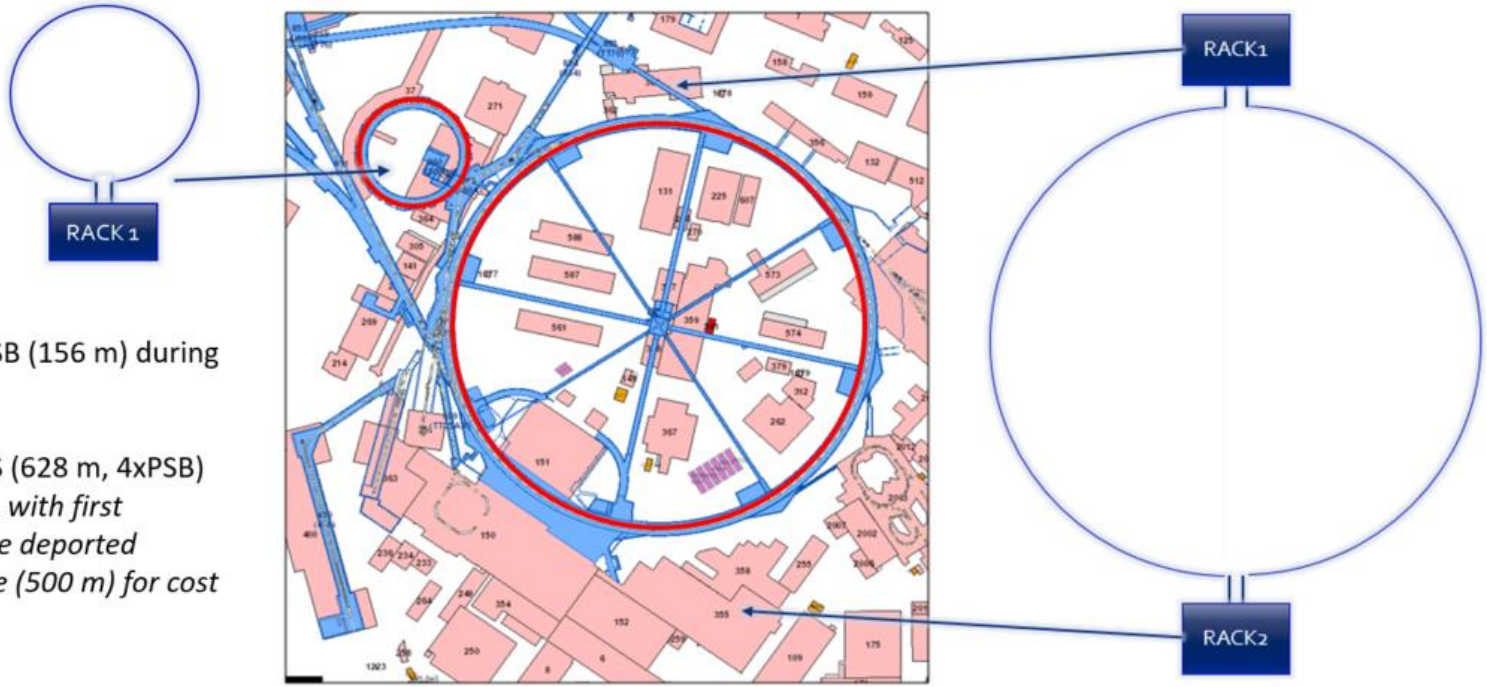
Key features

- **Well adapted for large facilities**
- **Distributed** 1D maps of the radiation dose
- **Online** monitoring
- All electronics installed in remote and radiation-free locations
- Cost effective
- Need to replace the OF sensors: cable blowing
- One cable -> multiple OFs -> multiple radiation sensitivities
- Information of the cumulated dose stored in the OF itself
- It also allows to perform distributed temperature measurement

Overview of Distributed Optical Fiber Radiation Sensor (DOFRS)



Today's installations



- Deployment in the PSB (156 m) during EYETS 2016/17
- Deployment in the PS (628 m, 4xPSB) during YETS 2017/18, *with first implementation of the deported measurement scheme (500 m) for cost effectiveness*

Main characteristics of DOFRS

2017 (PSB)	2018 (PS and future installations)
•	
•	
•	

- *Spatial resolution improved by a factor 2.5*
- *Larger dynamic range (8 dB to 12 dB at respective highest resolution!)*
- *No temperature dependence around RT (up to 50 °C)*
- *Higher sensitivity and lower radiation detection limit (from a few Gy to hundreds of mGy)*
- ***Measurement easily deported** (e.g. tested over hundreds of meters in PS) with further decrease of costs*

Sig[illegible] sensor

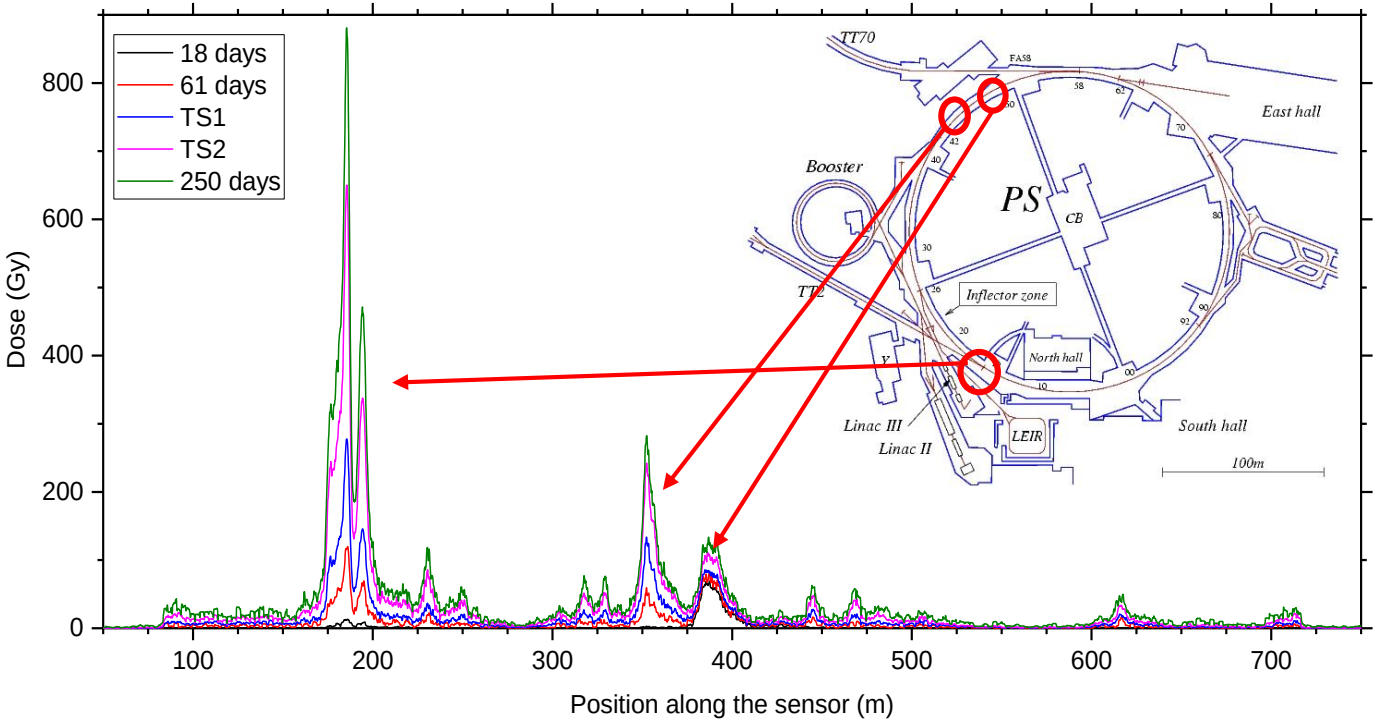
Example of operational year 2018: PS

Example of operational year 2018: PS

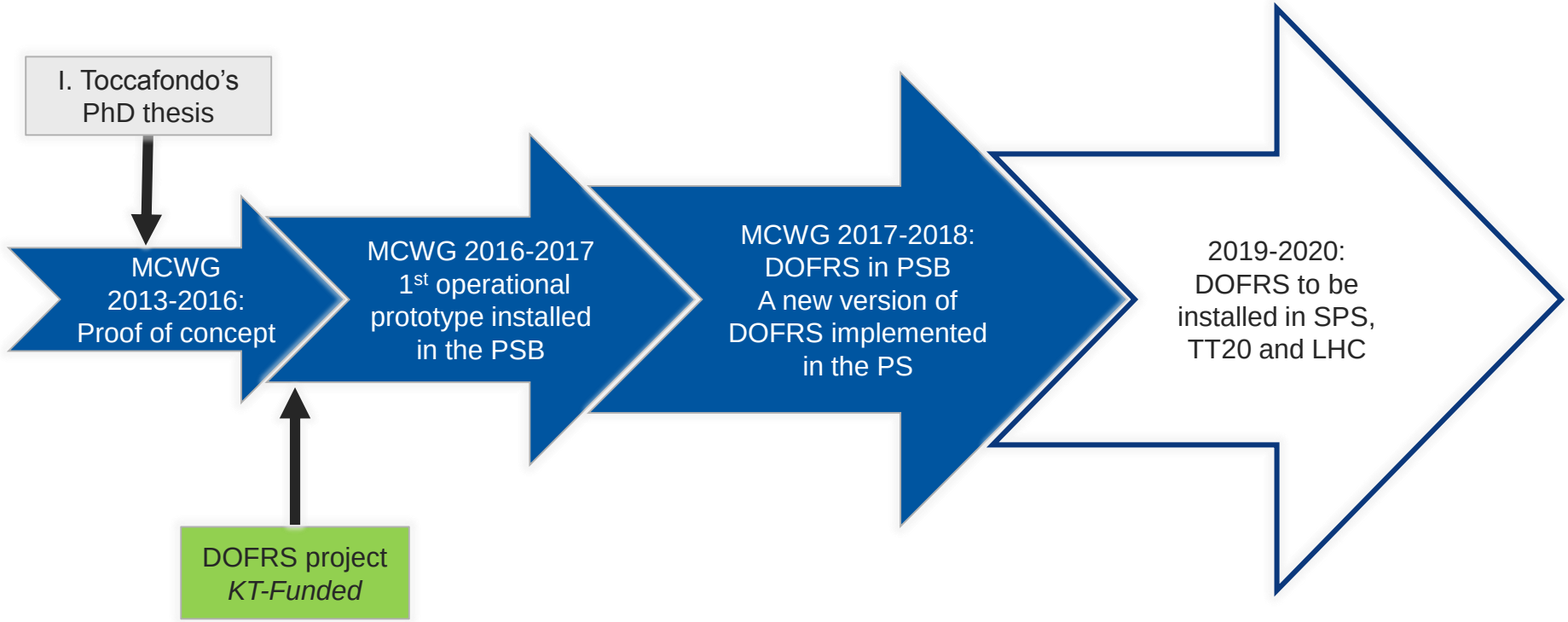
In 2018

270 days of continuous distributed monitoring of radiation dose levels in both PSB and PS.

Dose measurements cross-validated locally with point technologies.
(Scaling up factor ~4 wrt 2017)



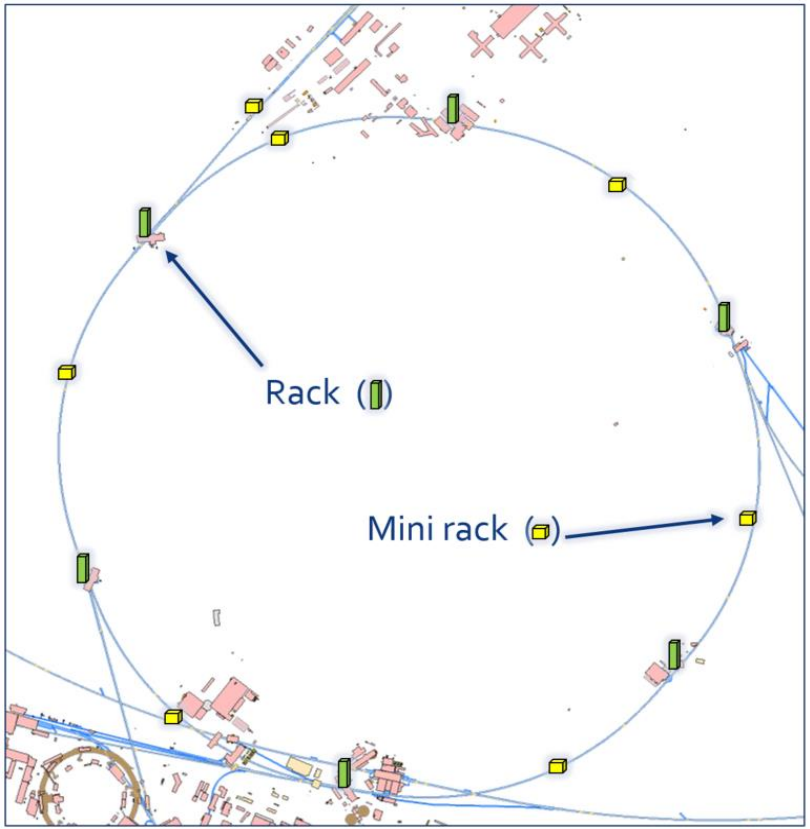
DOFRS future installations



Future installations: SPS and TT20

ECR (*EDMS 1969746*)

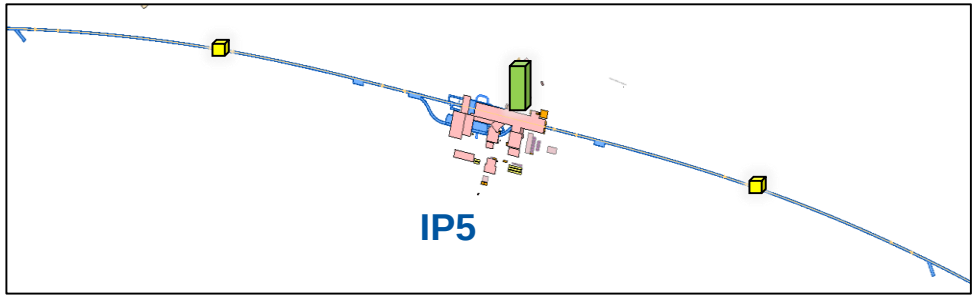
- *It will be completed during LS2 and* ***operational in Run 3***
- ***7.3 km*** *of monitored radiation areas*
- *Possibility to be* ***extended*** *and* ***consolidated***

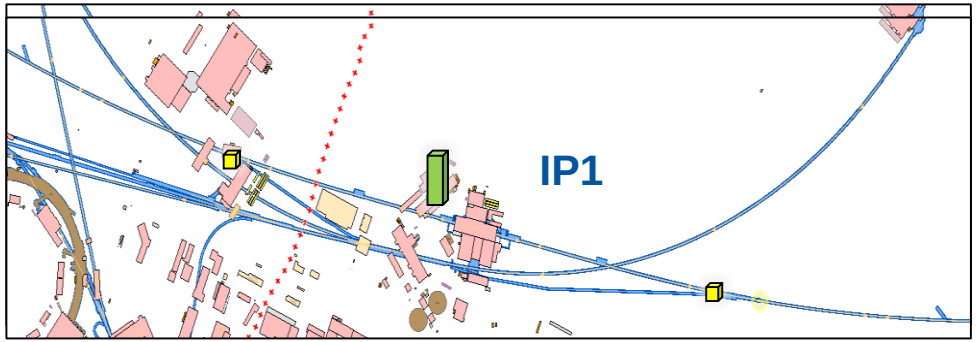


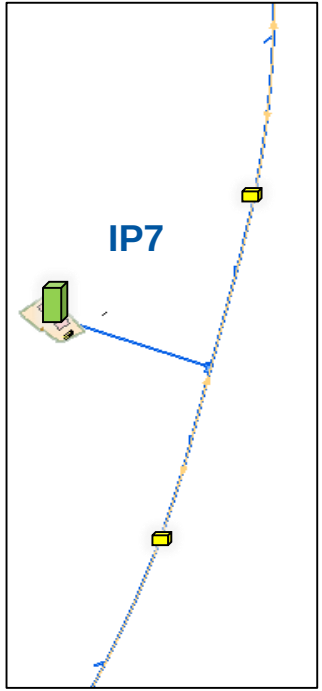
Future installations: LHC

ECR (*EDMS 1978574*)

- *It will be completed during LS2 and* ***operational in Run 3***
- ***DS regions of IP1, IP5 and IP7***







Other LS2 activities

- **Qualification and calibration of the new OF sensors**
  - Anticipating future needs
- **Upgrading our online monitoring tools**
  - After LS2 the size of our installations will increase **by a factor 14** wrt 2018
- **Anticipating our future needs in terms of automation of data analysis**

Today's Optical Fiber Dosimetry team today

OFD team in MCWG

Y. Kadi (Staff)
D. Di Francesca (Fellow)
G. Li Vecchi (PhD)
K. Kandemir (Tech. Student)

At CERN

RADWG and **SLAWG**

EN-SMM-RME
EN-EL-FC
EN-STI-BMI
and several other groups

Academic collaborations

UNIVERSITÉ JEAN MONNET SAINT-ÉTIENNE

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

PhLAM

Relations with industries

iXblue

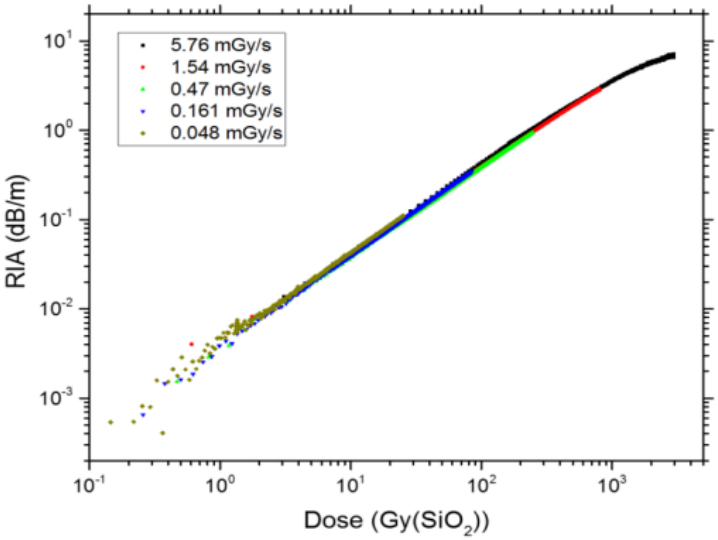
Prysmian Group

VIAVI

Technobis group

Qualification and calibration of the OF sensors for dosimetry

- Study of RIA in different types of Optical Fibers (OFs)
- Selection of the best candidates OFs for dosimetry:
  - Monotone dose dependence
  - No dependence on dose rate
  - No dependence on irradiation temperature
  - Absence of recovery processes
  - Absence of effects related to successive irradiations
- Calibration of the sensor under ^{60}Co radiation source
- Qualification of the sensor for employment in the Mixed field radiation environment CHARM facility
  - benchmark with other dosimeters
  - benchmark with Monte Carlo simulations (FLUKA)



Dissemination of results

7 publications (including *in press*) **with OFD team as first author**

- IEEE Transaction on Nuclear Science
- Physica Status Solidi A
- Optical Materials
- Journal of Material Science
- Journal of Non-Crystalline Solids
- Beilstein Journal of Nanotechnology

Submitted

- IEEE Transaction on Nuclear Science
- Journal of Lightwave Technology
- Optics Letters

Including collaborations

Some conference proceedings (IPAC, OFS, etc.)

R&D and future prospects

Proactive approach to radiation dosimetry

Tomorrow two presentations will be dedicated to R&D of OF dosimetry/radiation sensing and future challenges:

- *Optical fiber dosimetry: recent achievements and future prospects*
- *Specialty optical fibers for radiation sensing*

Conclusions

New version of DOFRS installed in 2018: interrogators and sensor

Proof of deported measurement capability. Essential to decrease the costs of future installations

Successful installation of DOFRS in the PS (4 times larger installation wrt 2017)

270 days of continuous and distributed dose levels monitoring in the PSB and PS (10 higher radiation dose levels wrt 2017)

2 approved ECR to install DOFRS in SPS+TT20 and DS regions of IP1, IP5 anf IP7 of LHC (14 times larger installation wrt 2018). Ongoing installations.

Constant proactive approach to radiation monitoring, R&D and sharing of our results at CERN and outside of it

Thank you for your attention

www.cern.ch

Diego Di Francesca

CERN EN-EA-PE
R2E Project
@ diego.di.francesca@cern.ch

Thanks to the members of MCWG,
EN-SMM-MRE, EN-EL-FC, EN-STI-MBI
and our Collaborators UJM and CNES