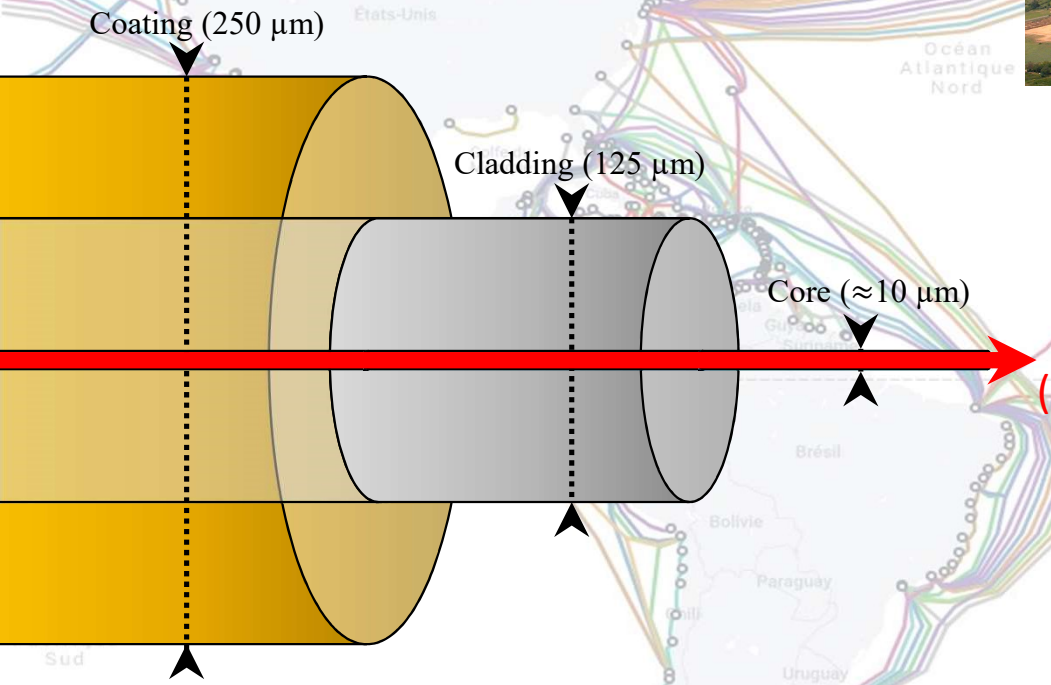
Overview of the Infrared Radiation Responses of Telecom-grade Single Mode Optical Fibers

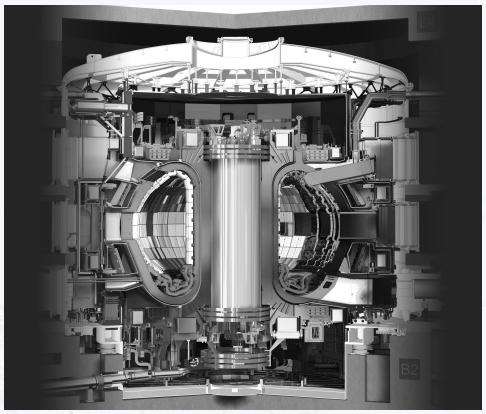
Alexis DUFOUR (Post-Doc)

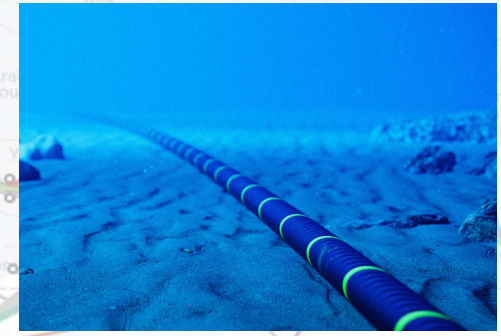
and A. Morana, A. Meyer, E. Marin, A. Boukenter, Y. Ouerdane and S. Girard

Context



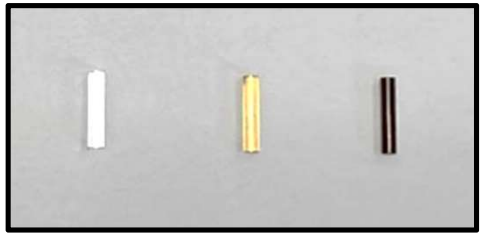
Light transfert
(telecom, sensing)





Objectives

➔ Demonstrate their potential use and limits in harsh environments for data transfer and sensing
➔ Measure the Radiation Induced Attenuation (RIA)



Compare the kinetics of 10 different commercially available OF (3 manufacturers) exposed to 100 kV **X-Rays**, including ULL fibers (Ultra Low Loss).

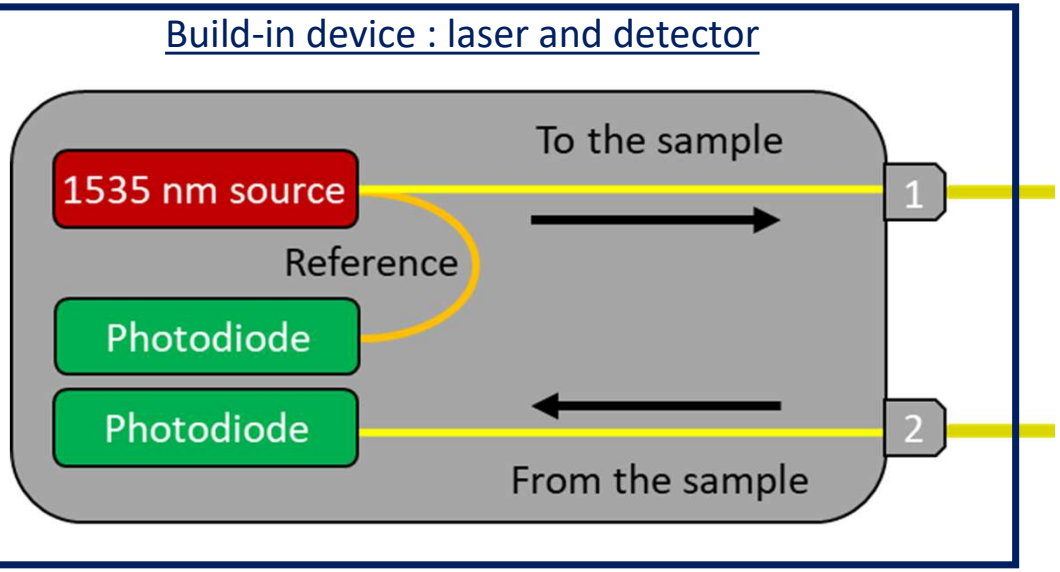
- 2 dose rates : 6 Gy/s and 0.6 Gy/s
- 2 TID : 100 kGy and 10 kGy
- Temperature : ≈25°C
- Wavelength : 1535 nm (+ Spectral IR)
- SMF

TABLE I
SPECIFICITIES OF THE USED OPTICAL FIBERS

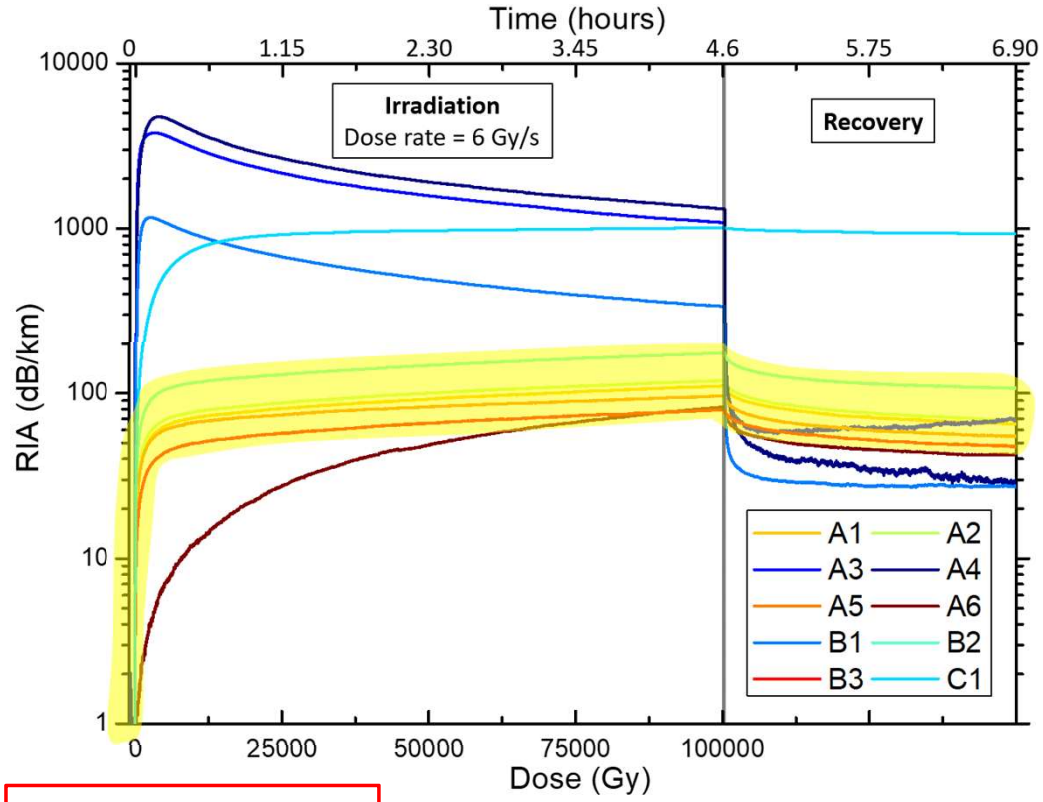
OF name	Loss @1550 nm	Cut-off wavelength	G.652	G.654	G.657
A1	<0.20 dB/km	1280	A-B-C-D	-	-
A2	<0.18 dB/km	1260	D	-	A0
A3	<0.17 dB/km	1260	B	C	-
A4	<0.174 dB/km	1520	-	D	-
A5	<0.20 dB/km	1260	D	-	A2-B2
A6	<0.17 dB/km	1520	-	E	-
B1	0.155 dB/km	1530	-	D	-
B2	0.17 dB/km	1520	-	B	-
B3	<0.18 dB/km	1260	D	-	A1
C1	<0.20 dB/km	1260	D	-	-

Setup

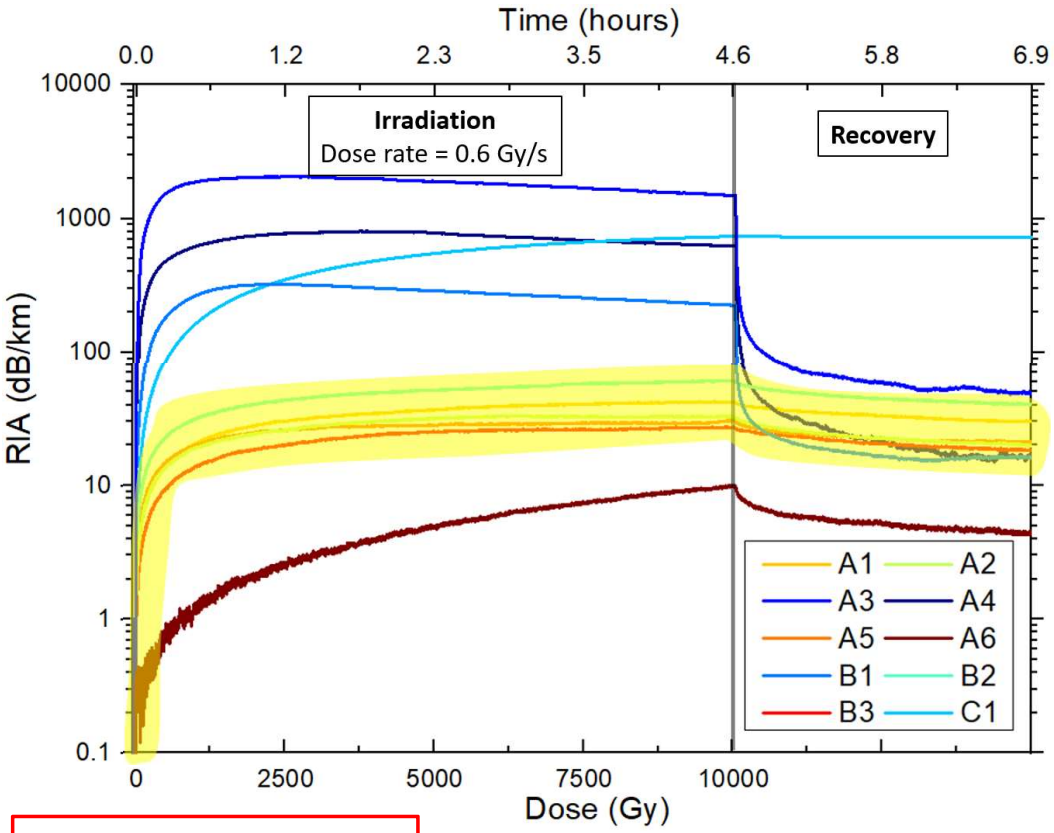
Build-in device : laser and detector



Overall results : 1535 nm

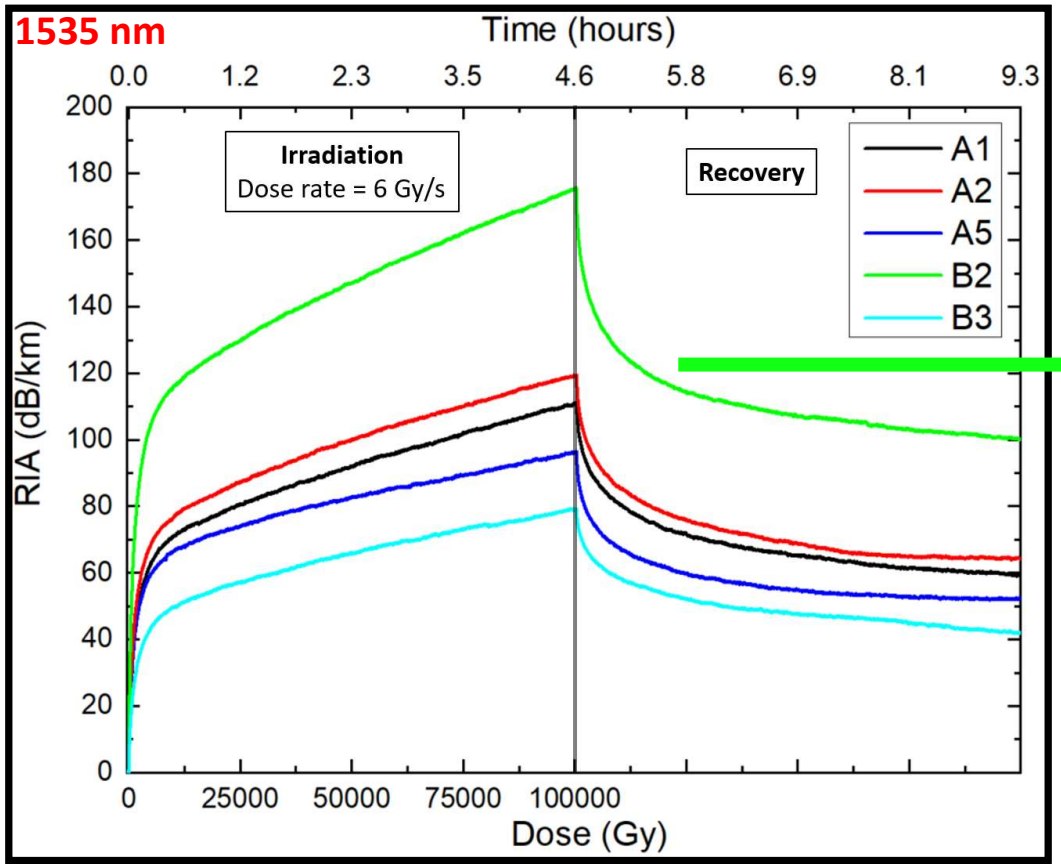


Dose rate ➔ 6 Gy/s
TID = 100 kGy

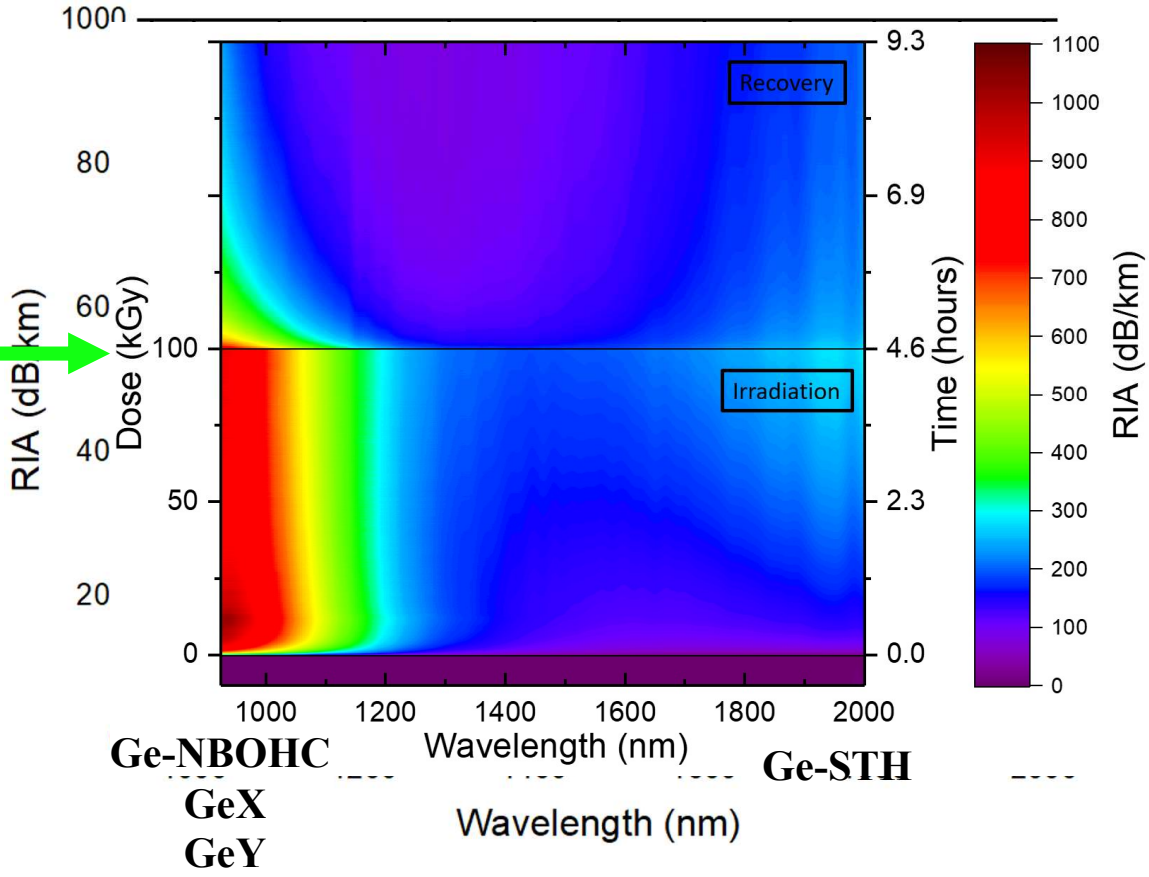


Dose rate ➔ 0.6 Gy/s
TID = 10 kGy

Type I – Germanosilicate optical fiber without P-codoping



Spectral



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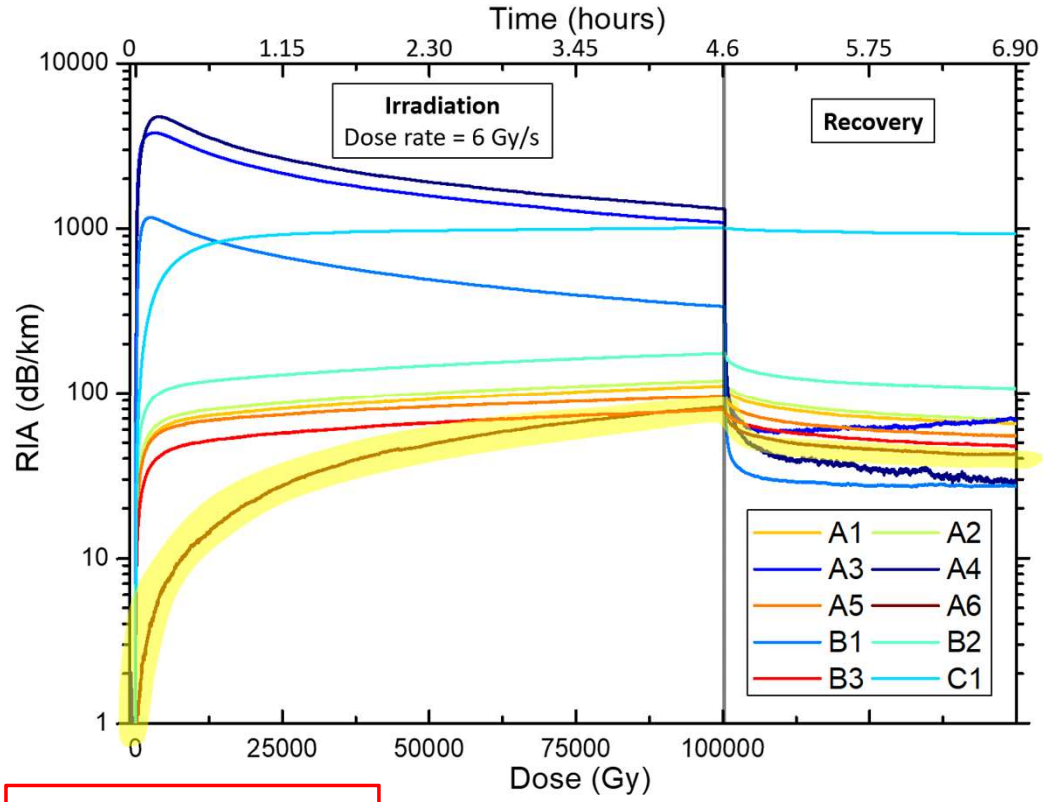
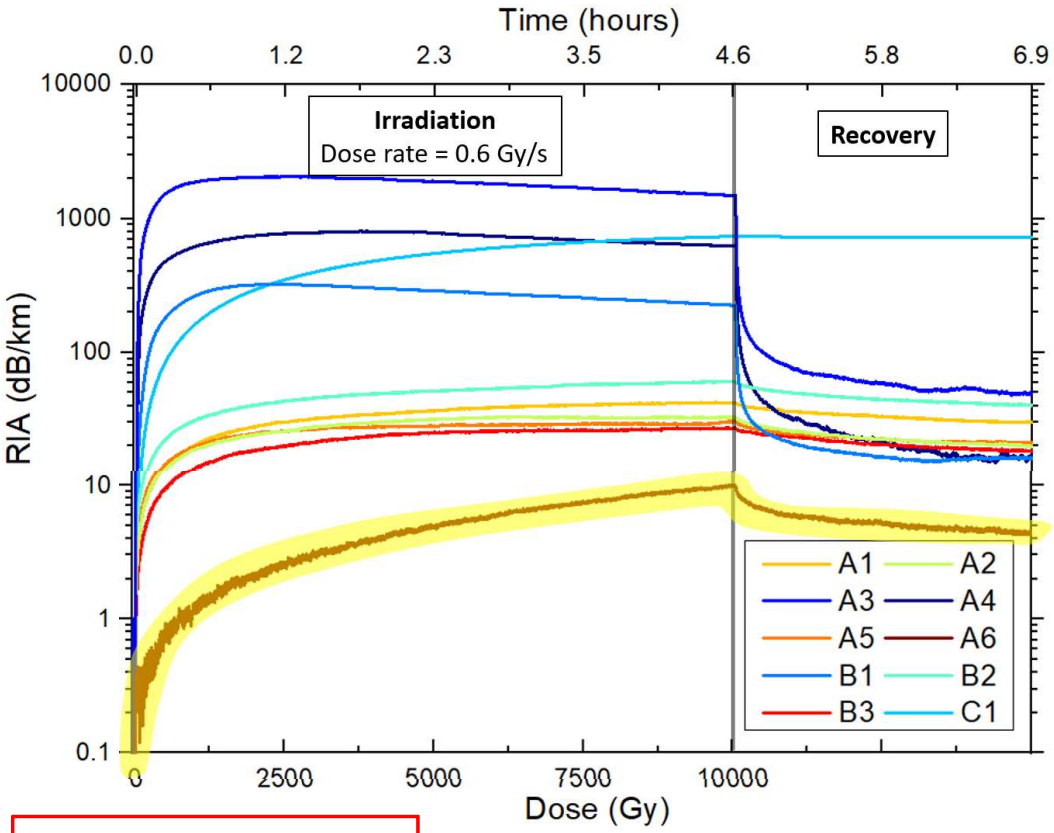
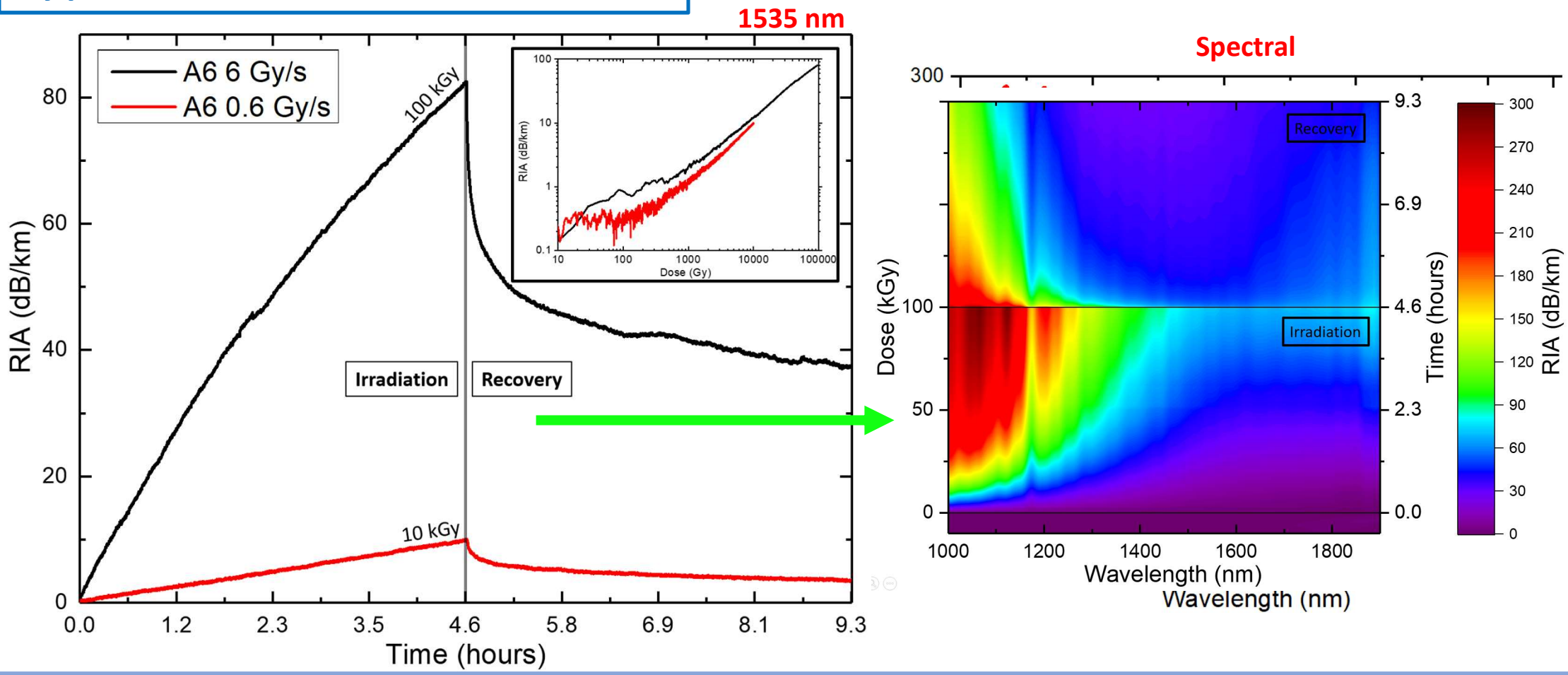


Dose rate ➔ 6 Gy/s
TID = 100 kGy

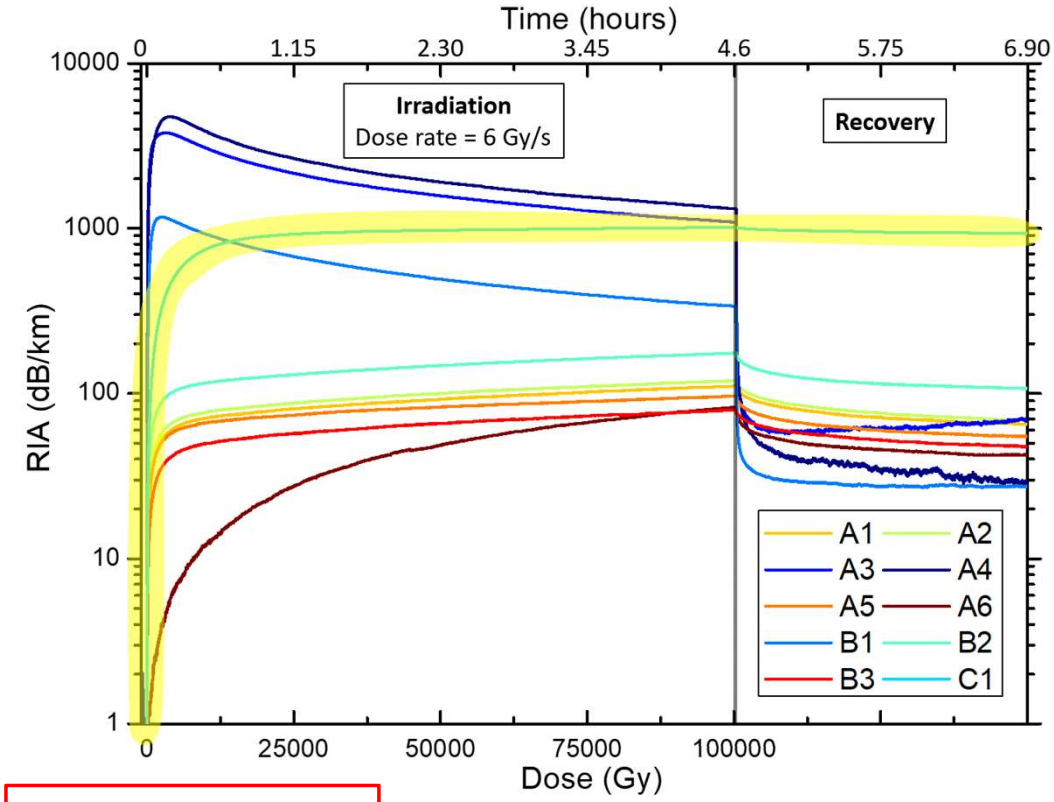


Dose rate ➔ 0.6 Gy/s
TID = 10 kGy

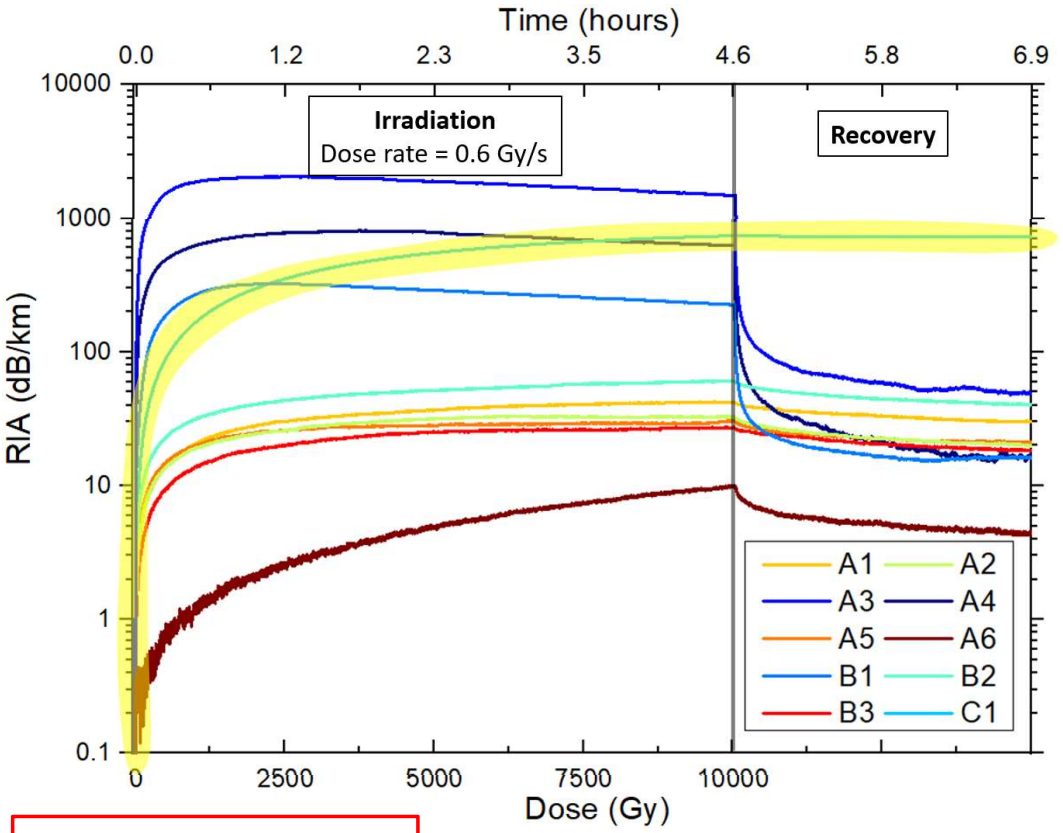
Type II – Linear-like kinetics



Overall results : 1535 nm

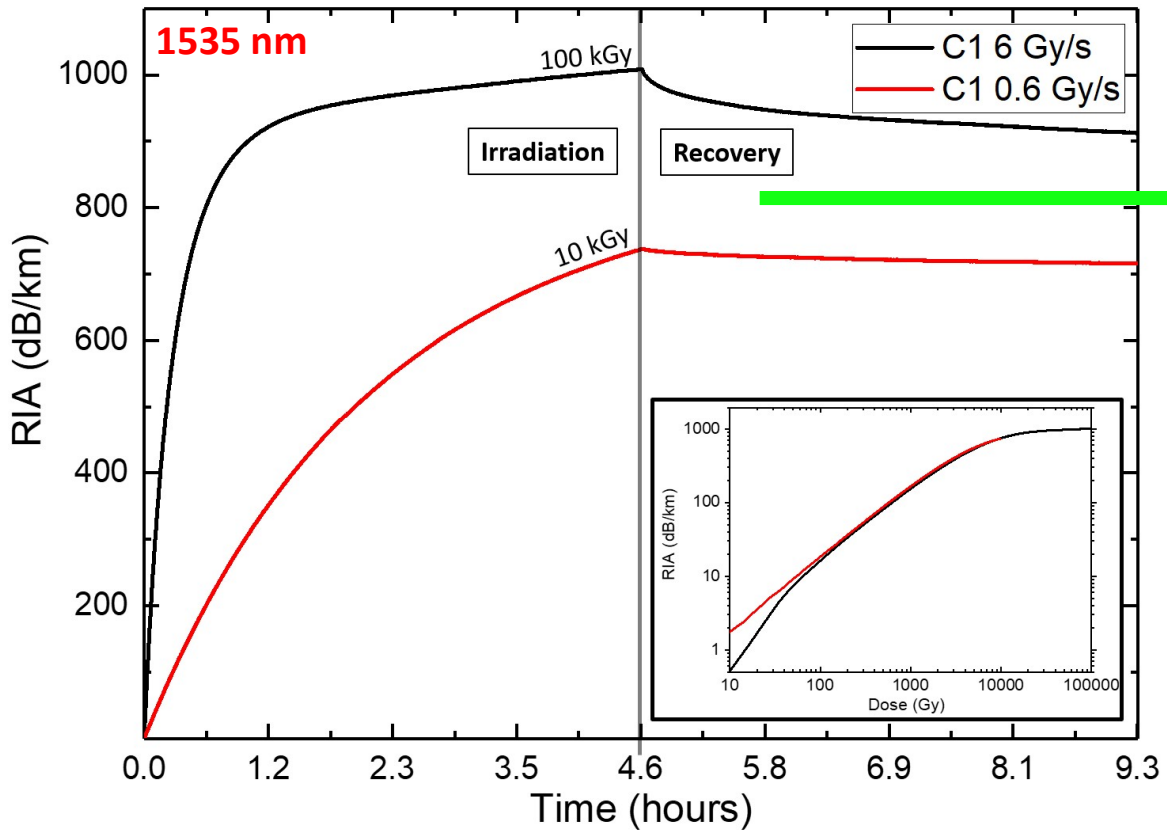


Dose rate ➔ 6 Gy/s
TID = 100 kGy

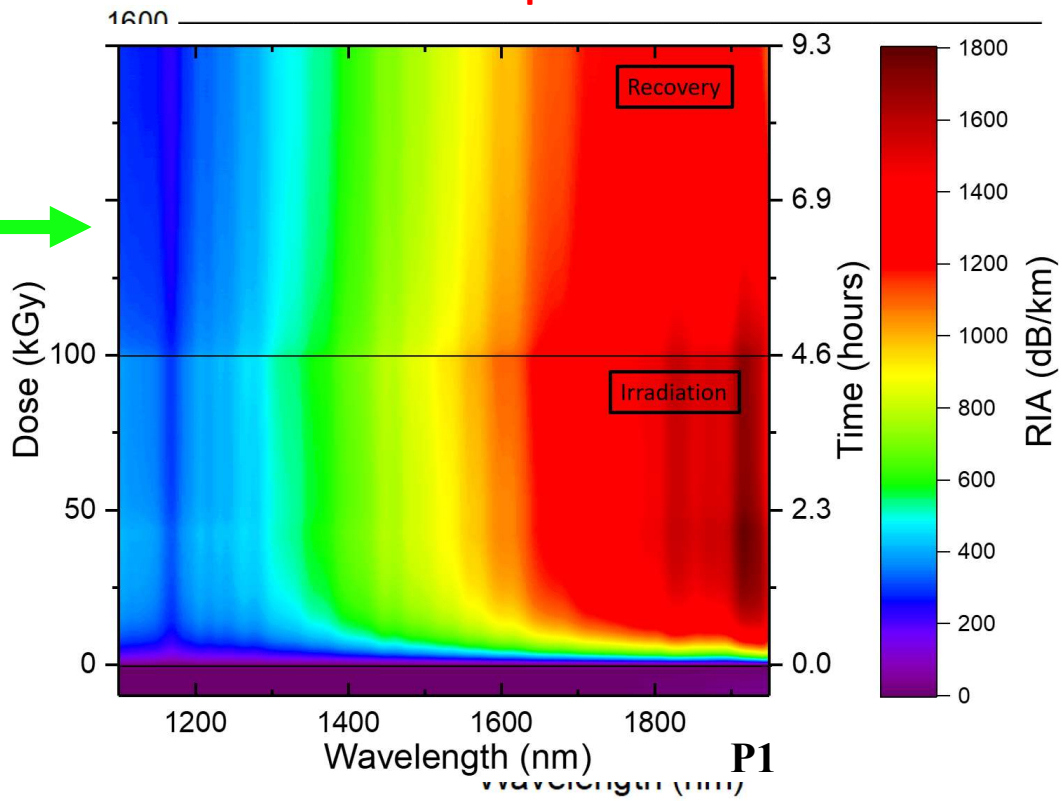


Dose rate ➔ 0.6 Gy/s
TID = 10 kGy

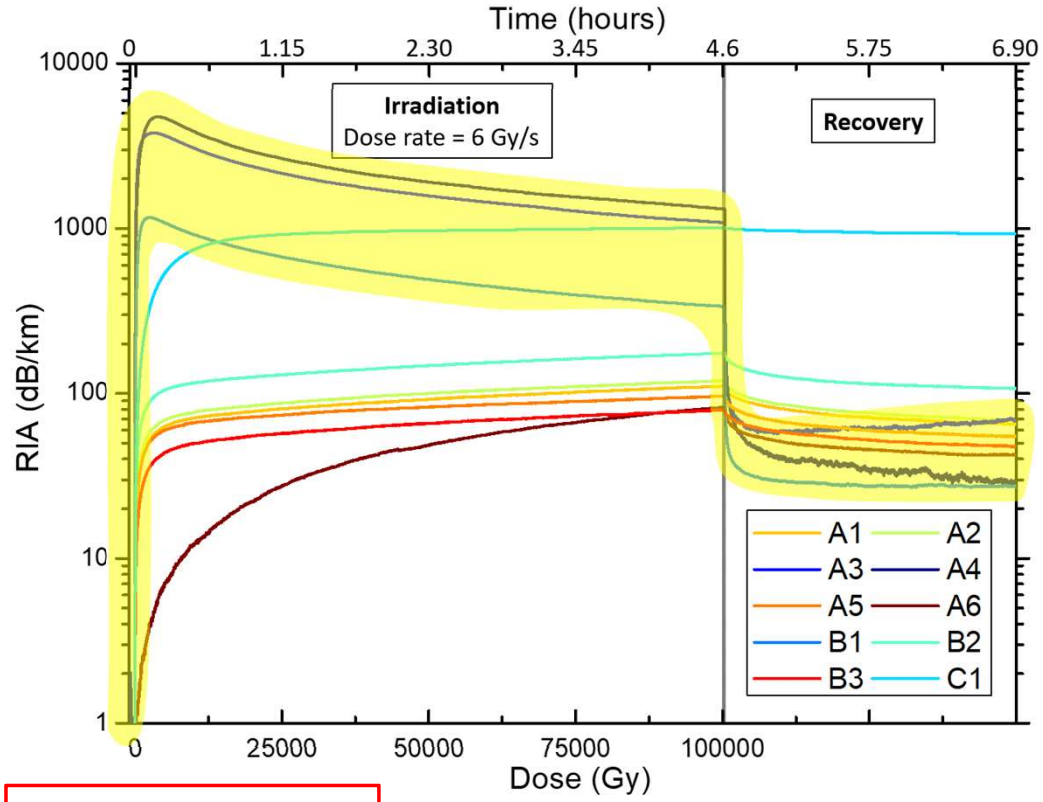
Type III – Phosphorus-codoped optical fiber



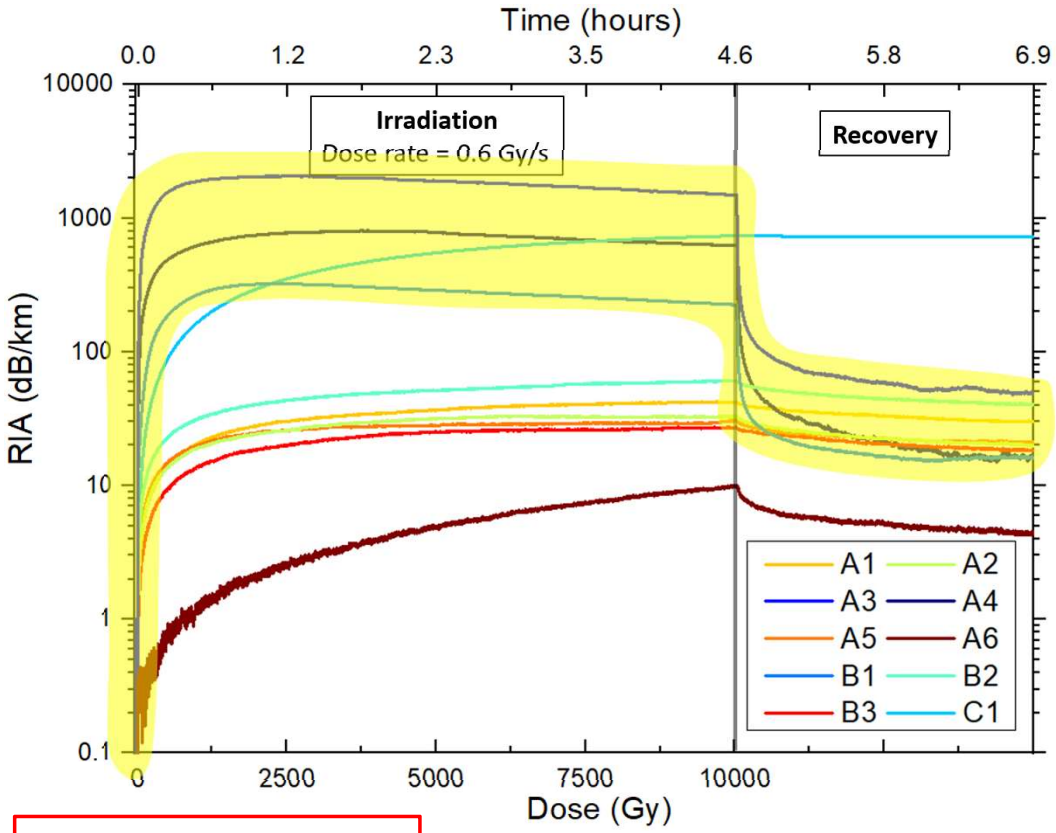
Spectral



Overall results : 1535 nm

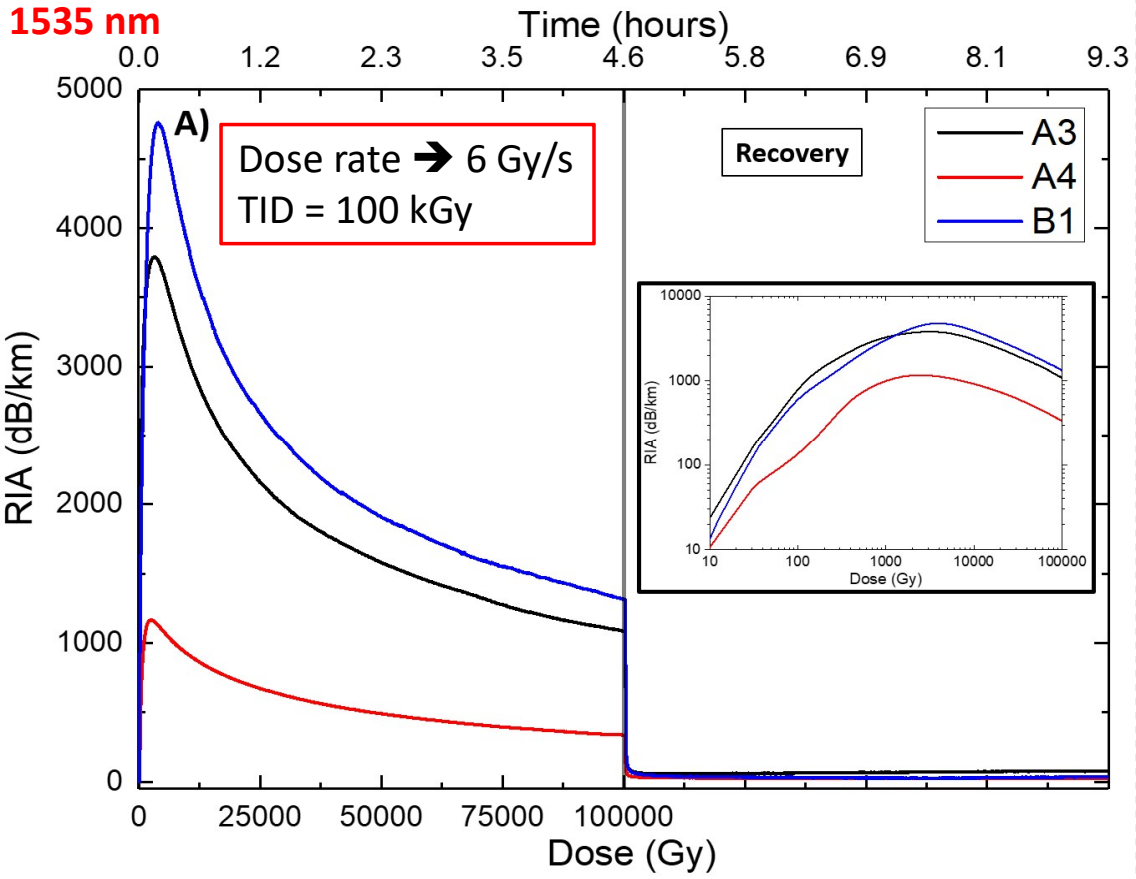


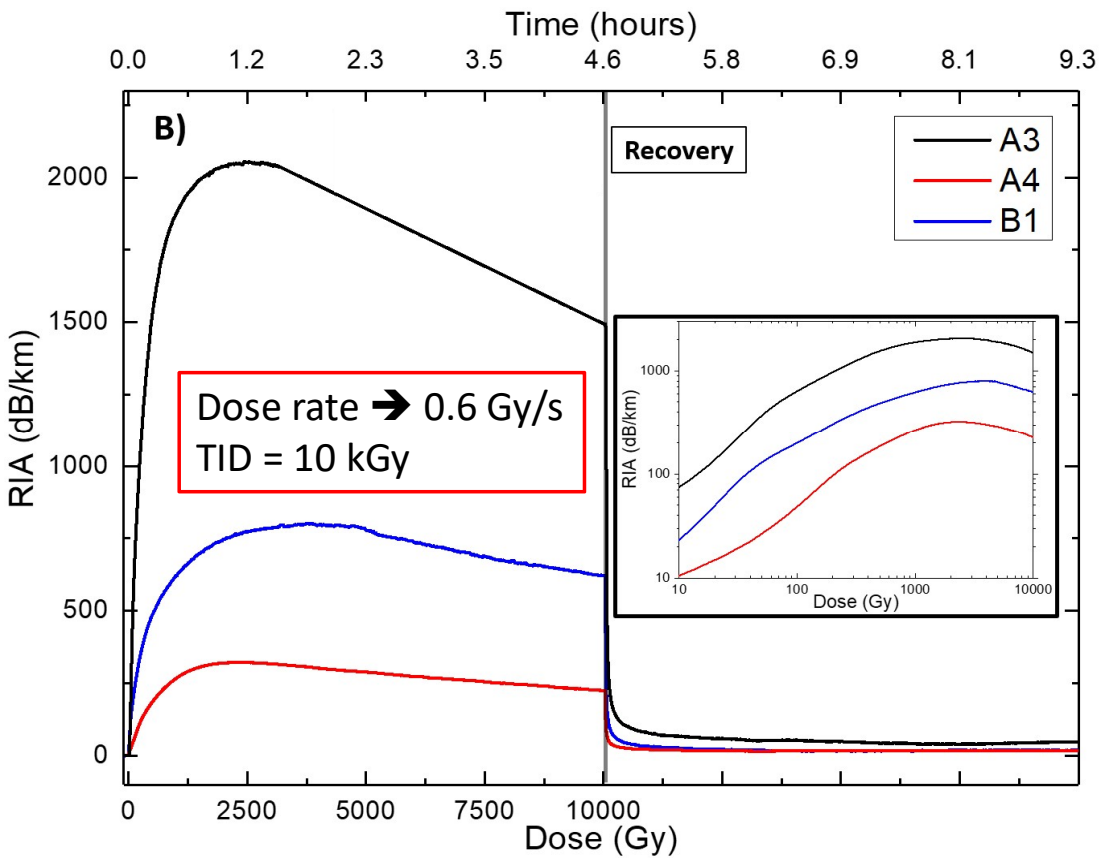
Dose rate ➔ 6 Gy/s
TID = 100 kGy



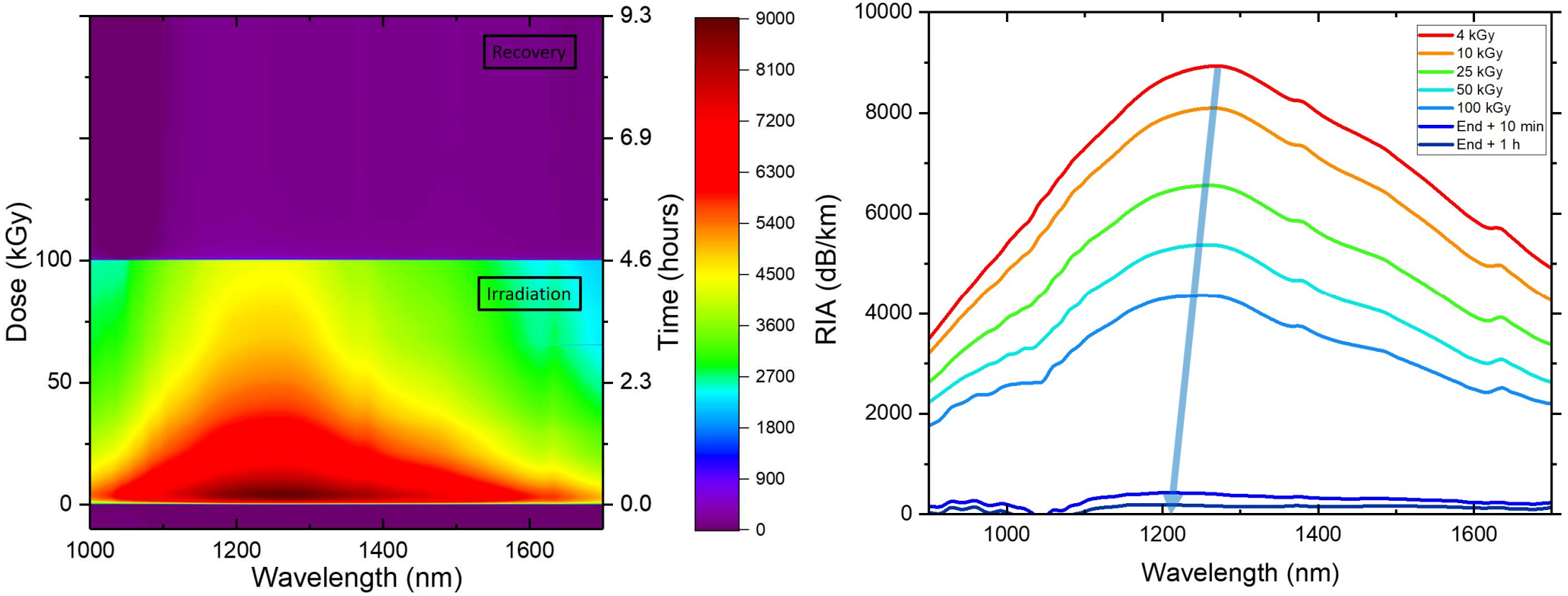
Dose rate ➔ 0.6 Gy/s
TID = 10 kGy

Type IV: Ultra-sensitive optical fibers (ULL)





Type IV: Ultra-sensitive optical fibers (ULL)



Conclusion

Not all telecom fibers are equals when it comes to radiation:

Type I – Germanosilicate optical fiber without P-codoping

Type II – Linear-like kinetics

Type III – Phosphorus-codoped optical fiber

Type IV: Ultra-sensitive optical fibers (ULL)

➔ **Reveals how the evolution of the fiber manufacturing techniques pushed by the telecommunication market could affect the fiber radiation response.**

➔ **Highlights the difficult use of commercial fibers in radiation-demanding applications such as those associated with New Space.**

TABLE II
SUMMARY OF EXPERIMENTS

OF name	Losses 6 Gy/s (dB/km) at 100 kGy	Losses 6 Gy/s (dB/km) at 10 kGy	Losses 0.6 Gy/s (dB/km) at 10 kGy	Ratio 6/0.6 Gy/s at 10 kGy	Recovery 6 Gy/s (dB/km)
A1	111	71	43	1.65	56
A2	119	77	33	2.33	62
A3 (max)	3790	3077	2530	1.22	78
A3 (end)	1085		1483		
A4 (max)	4740	3890	902	4.31	35
A4 (end)	1293		689		
A5	98	66	31	2.12	51
A6	83	12	10	1.20	30
B1 (max)	1160	921	323	2.85	27
B1 (end)	337		225		
B2	174	116	61	1.9	93
B3	79	50	27	1.85	28
C1	1008	745	738	1.01	882

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Thank you for your attention

Alexis DUFOUR (PhD)

LABORATOIRE HUBERT CURIEN

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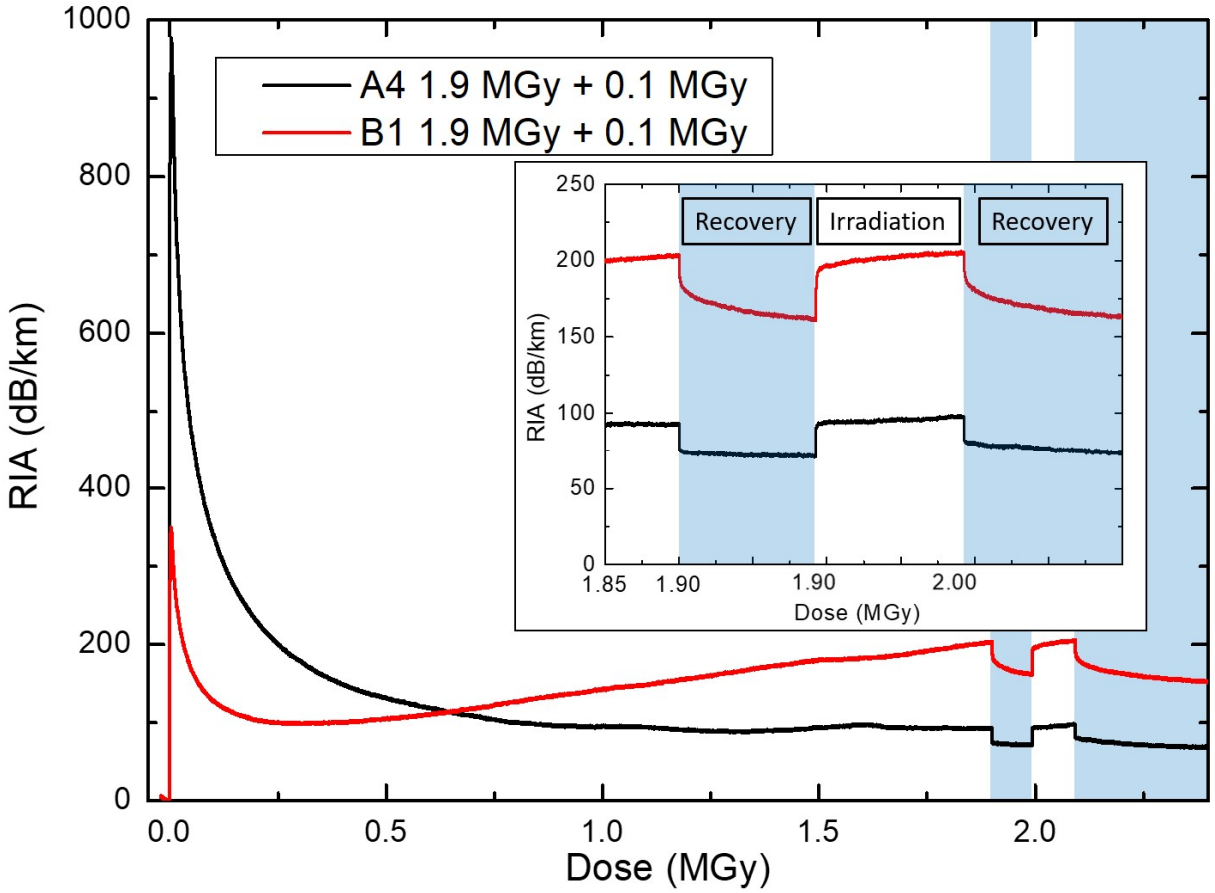
Long period measurement : ULL



Max loses at ≈3 kGy

Up to 2 MGy
➔ Kinetics during the decreasing phase of ULL

1) Continuous decreases until stabilized
2) Decreases then continuous increase (250 kGy)

Metastable defect recovery

ON-OFF radiation sensor