

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

Alexis DUFOUR (Post-Doc)

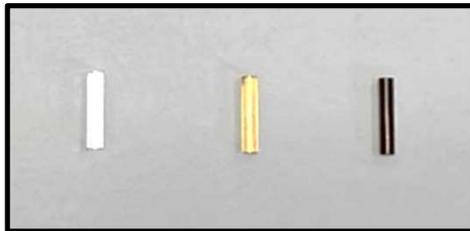
and A. Morana, A. Meyer, E. Marin, A. Boukenter, Y. Ouerdane and S. Girard

The image is a composite of several elements related to fiber optic technology. On the left, a cross-section of a fiber optic cable is shown with three layers: a yellow outer layer labeled 'Coating (250 μm)', a grey middle layer labeled 'Cladding (125 μm)', and a central red line labeled 'Core (≈10 μm)'. A red arrow points from the core towards the right, labeled 'Light transfert (telecom, sensing)'. The background features a map of the Atlantic Ocean with various fiber optic routes connecting continents like North America, Europe, and Africa. Other elements include a photograph of a cable-stayed bridge, a 3D cutaway of a satellite, and an underwater view of a blue fiber optic cable on the seabed.

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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).

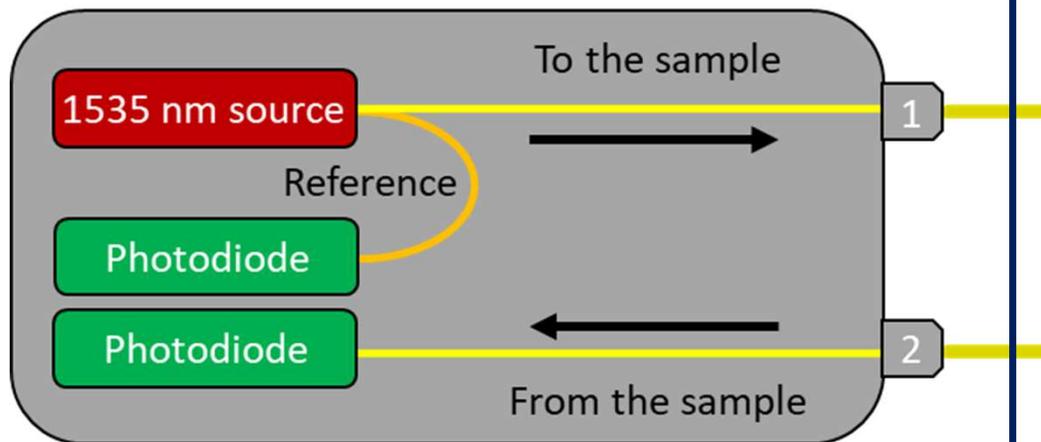
- 2 dose rates : 6 Gy/s and 0.6 Gy/s
- 2 TID : 100 kGy and 10 kGy
- Temperature : ≈25°C
- Wavelength : 1535 nm (+ Spectral IR)
- SMF

TABLE I
SPECIFICITIES OF THE USED OPTICAL FIBERS

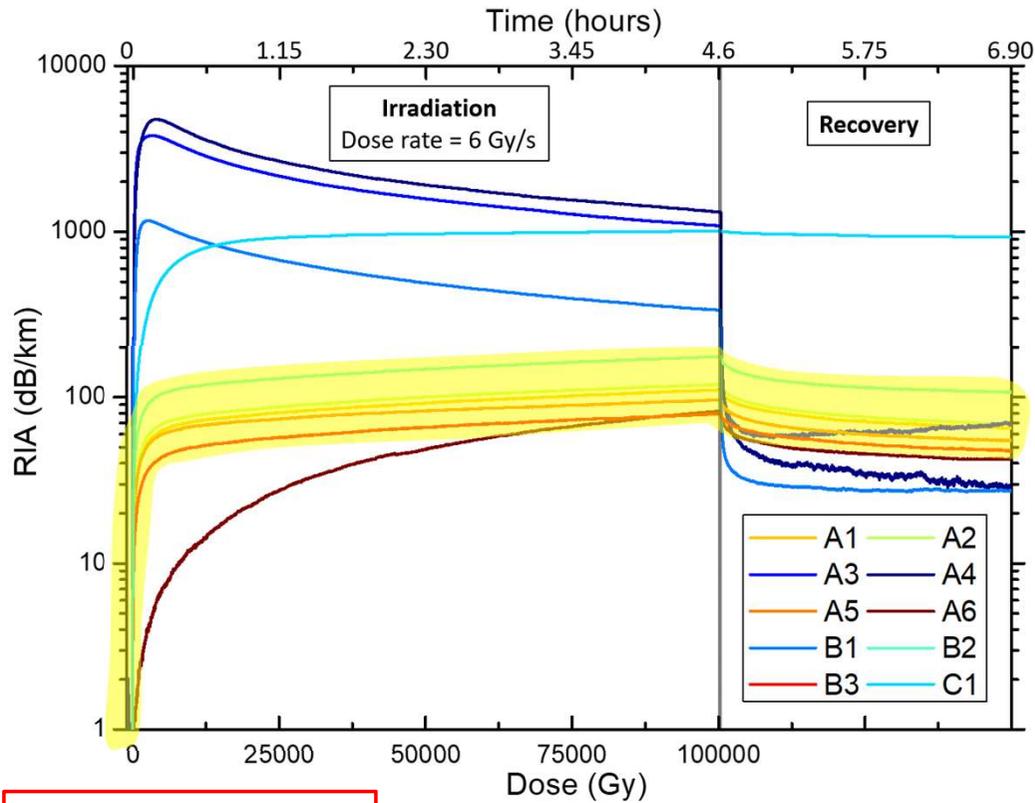
OF name	Loss @1550 nm	Cut-off wavelength	G.652	G.654	G.657
A1	<0.20 dB/km	1280	A-B-C-D	-	-
A2	<0.18 dB/km	1260	D	-	A0
A3	<0.17 dB/km	1260	B	C	-
A4	<0.174 dB/km	1520	-	D	-
A5	<0.20 dB/km	1260	D	-	A2-B2
A6	<0.17 dB/km	1520	-	E	-
B1	0.155 dB/km	1530	-	D	-
B2	0.17 dB/km	1520	-	B	-
B3	<0.18 dB/km	1260	D	-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

Setup

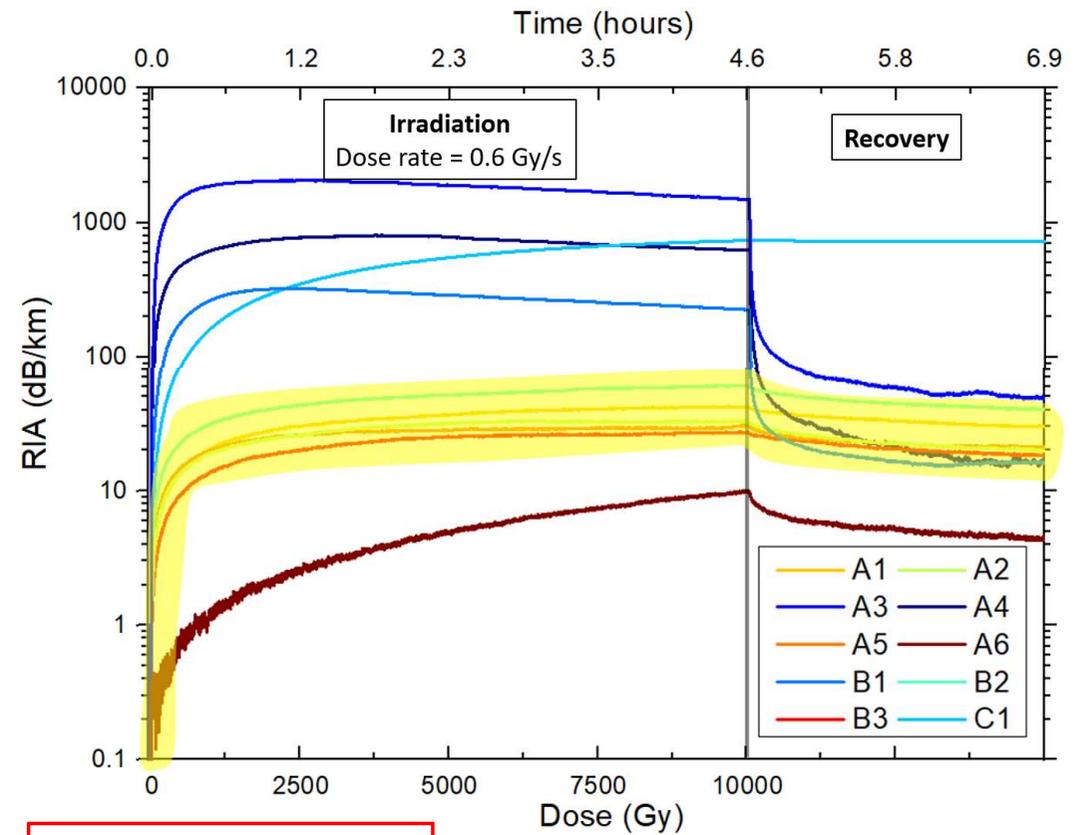
Build-in device : laser and detector



Overall results : 1535 nm

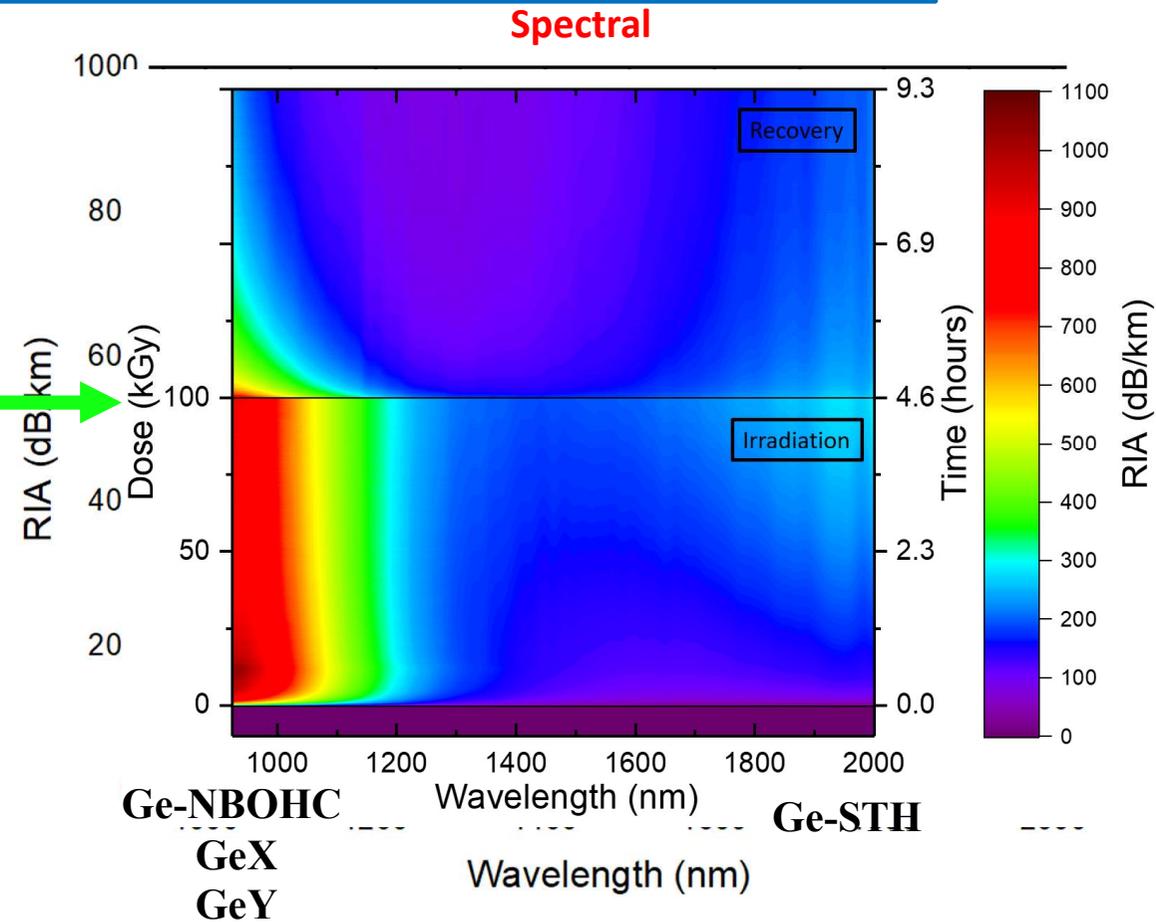
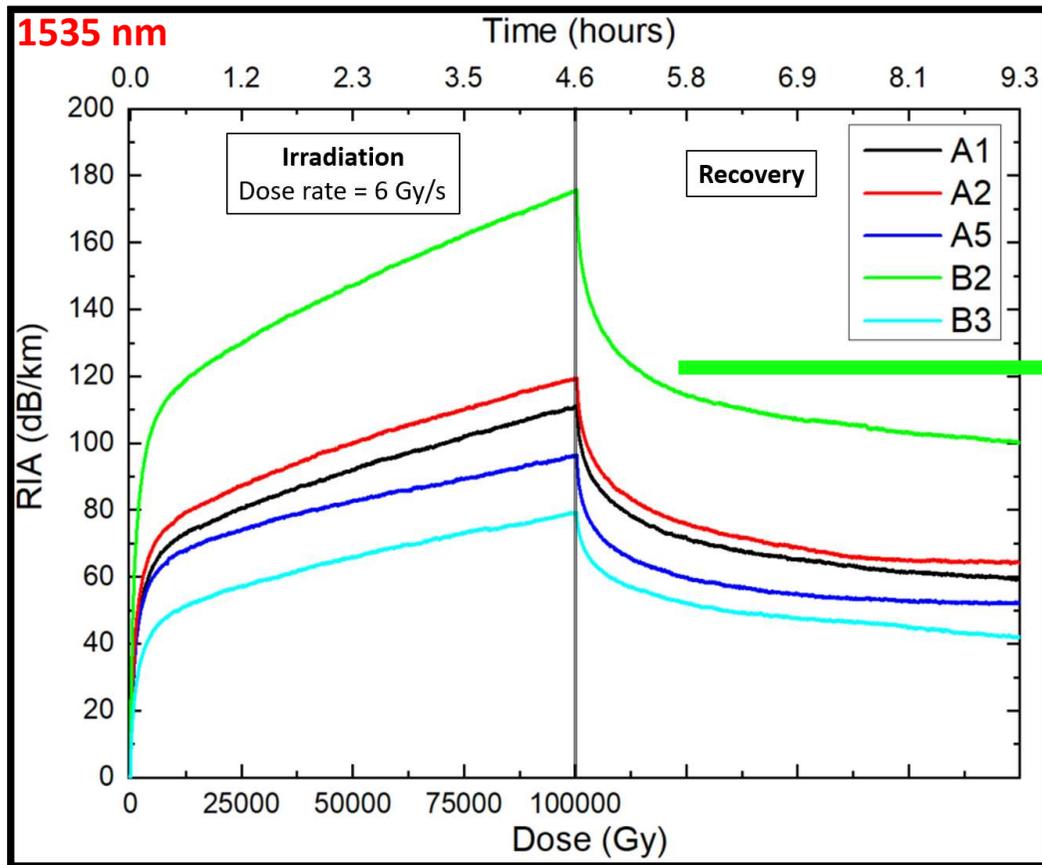


Dose rate → 6 Gy/s
TID = 100 kGy

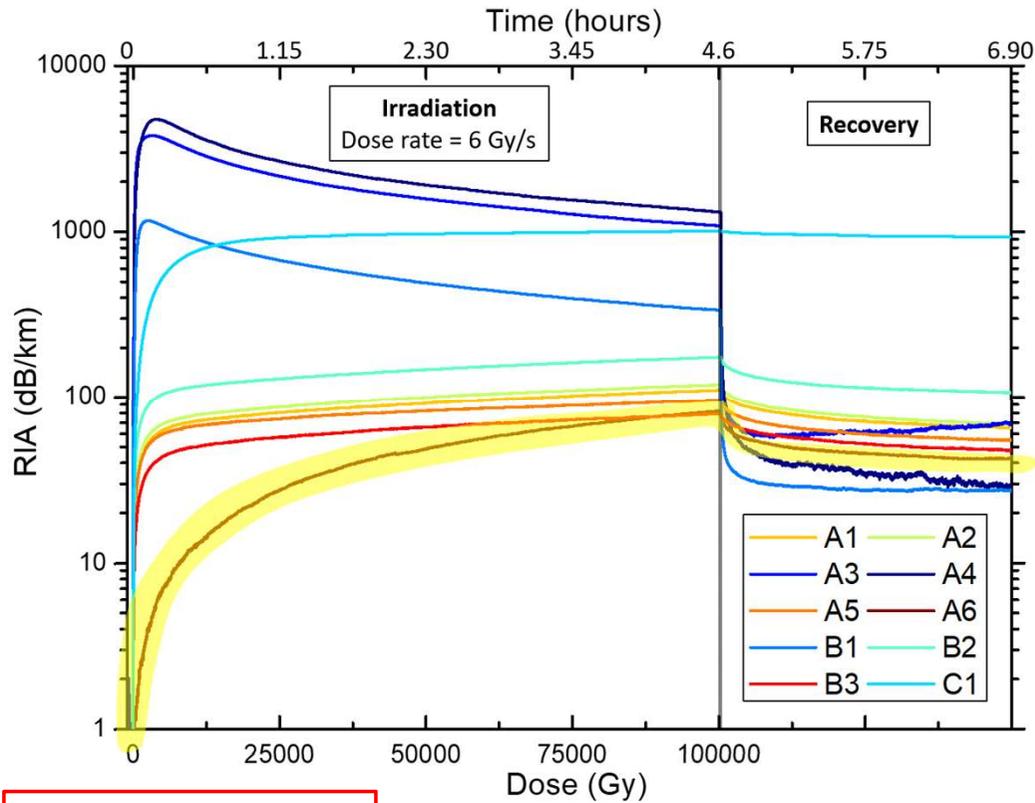


Dose rate → 0.6 Gy/s
TID = 10 kGy

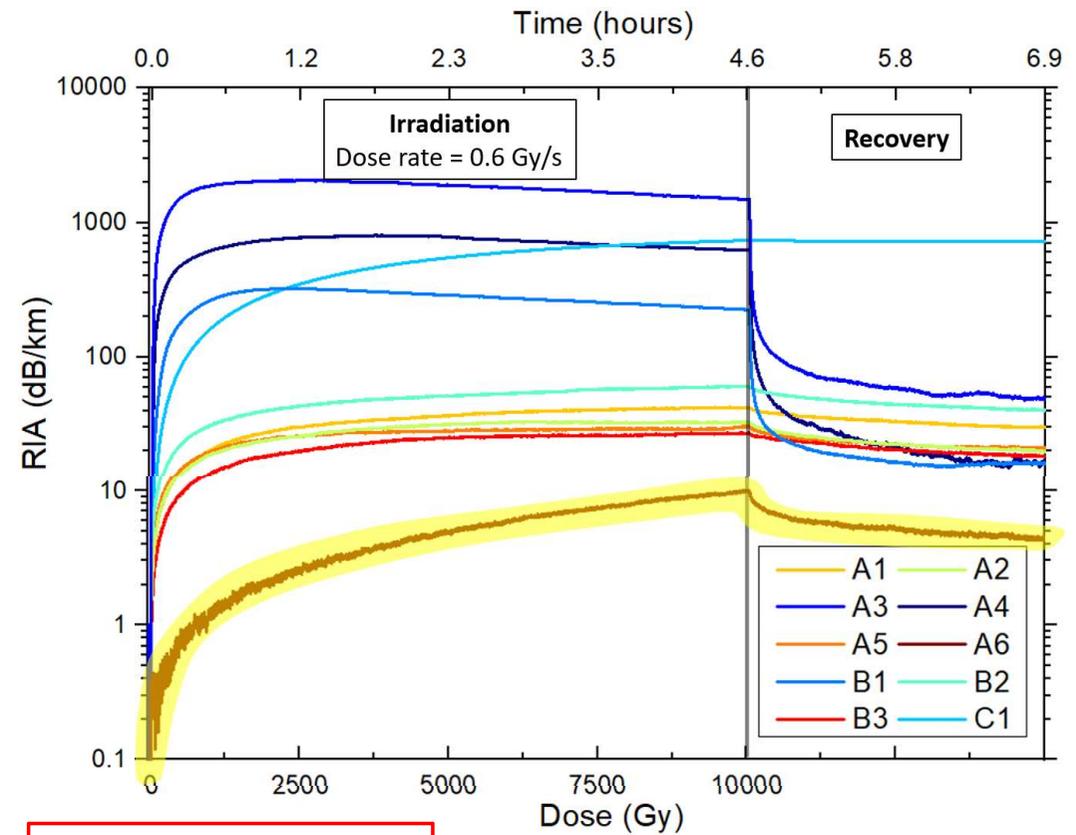
Type I – Germanosilicate optical fiber without P-codoping



Overall results : 1535 nm

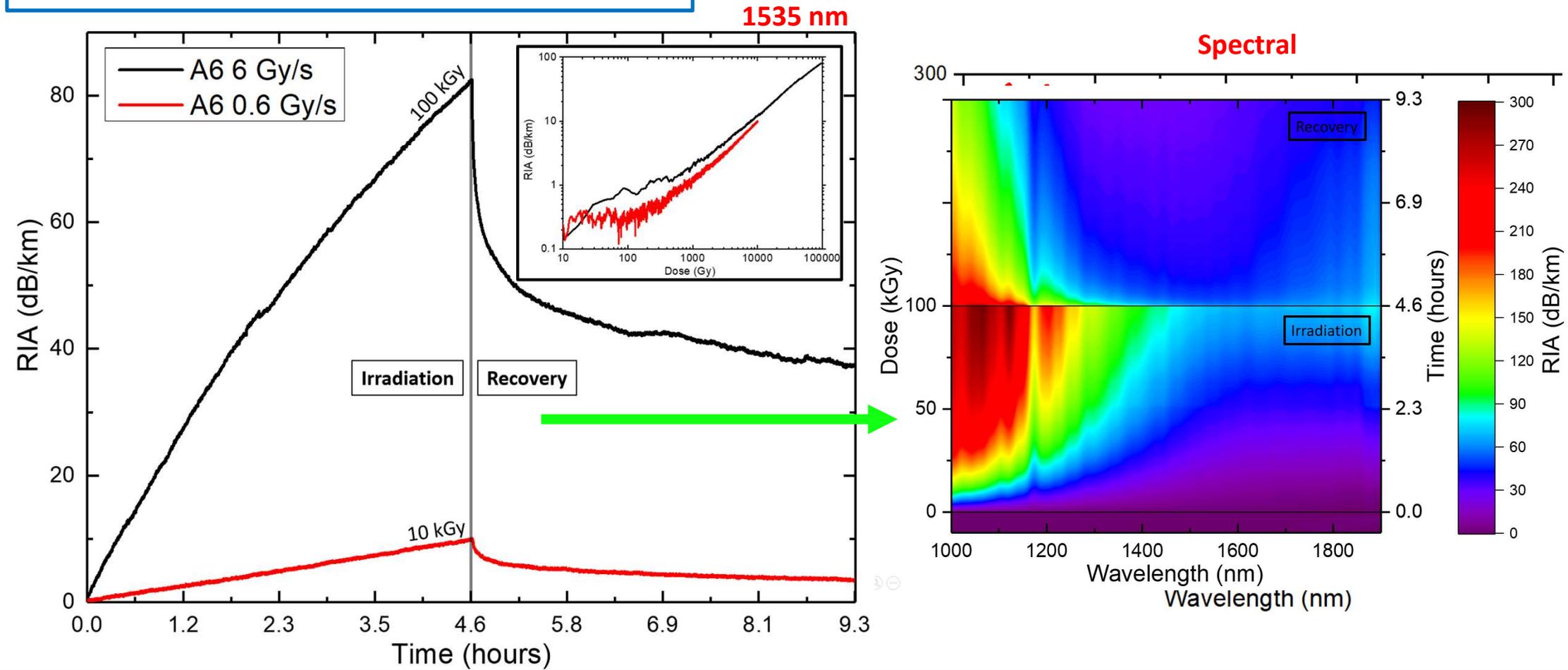


Dose rate → 6 Gy/s
TID = 100 kGy

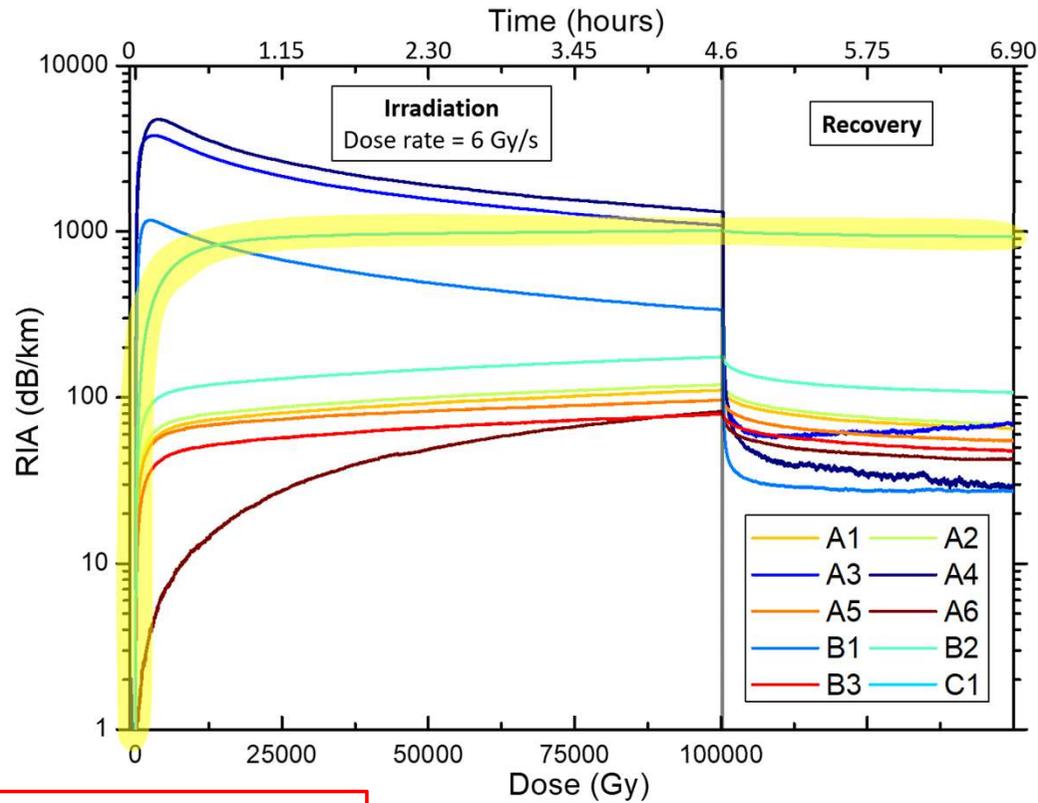


Dose rate → 0.6 Gy/s
TID = 10 kGy

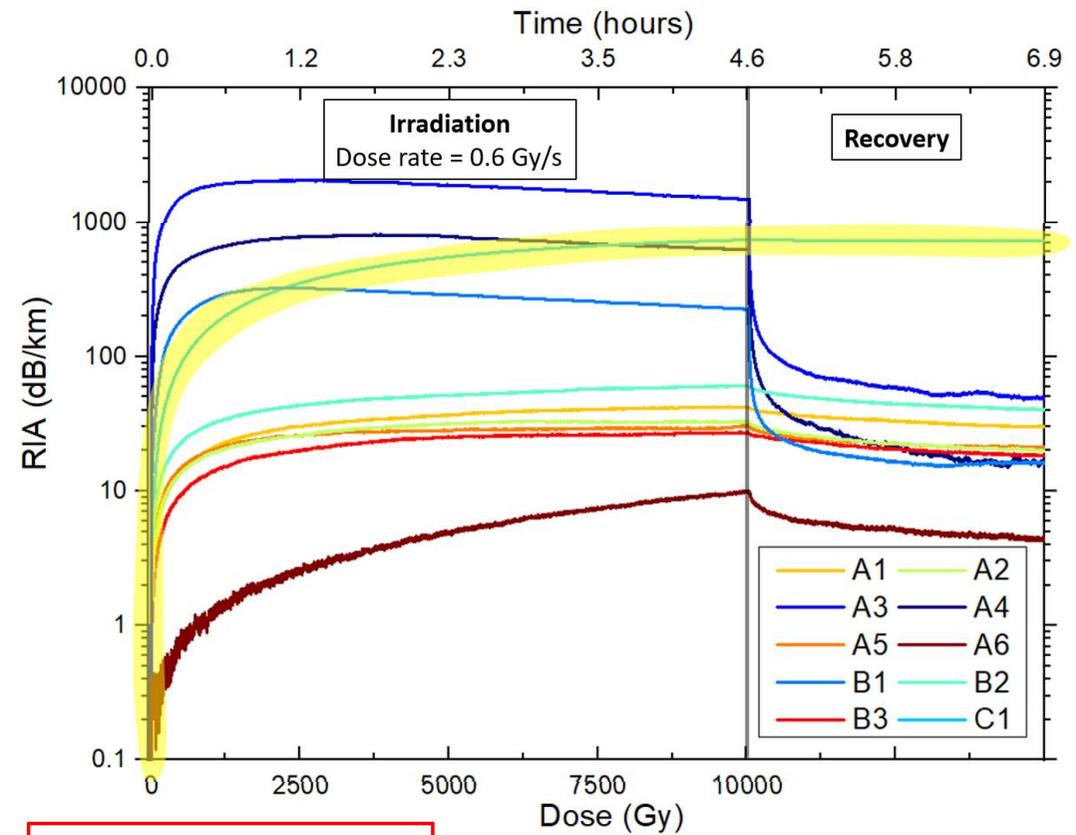
Type II – Linear-like kinetics



Overall results : 1535 nm

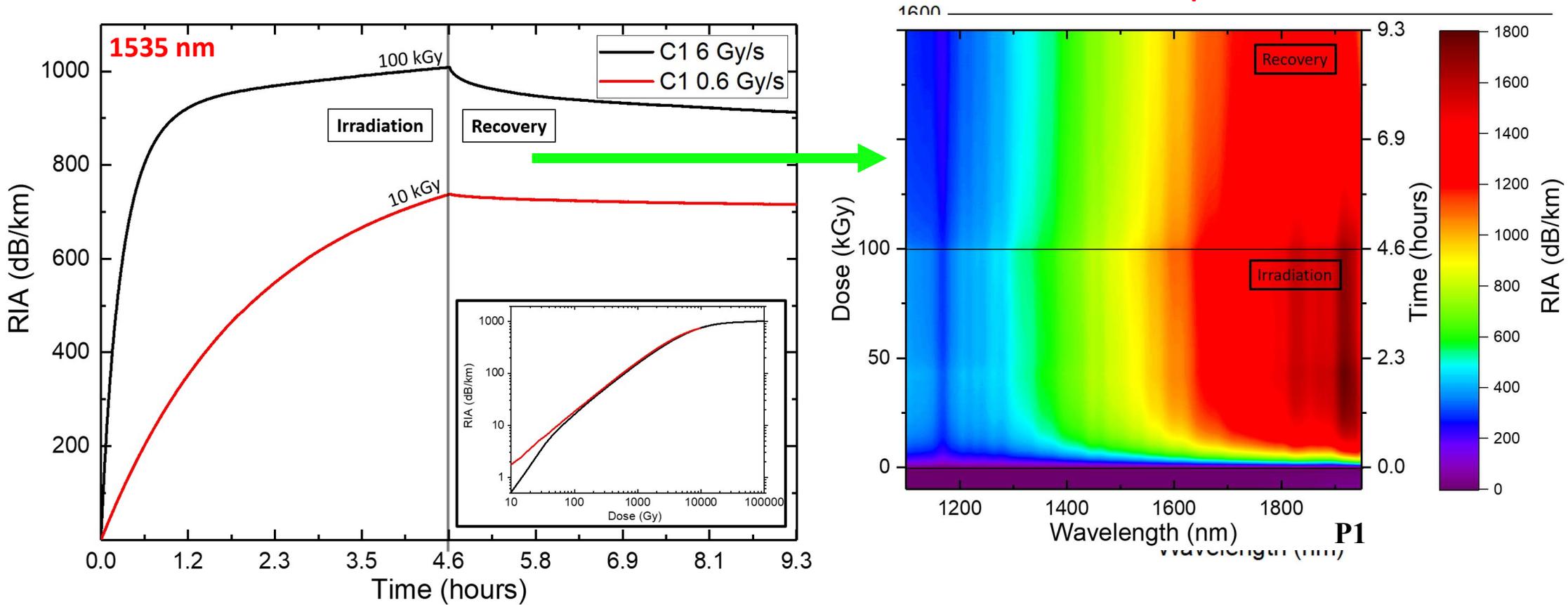


Dose rate → 6 Gy/s
TID = 100 kGy

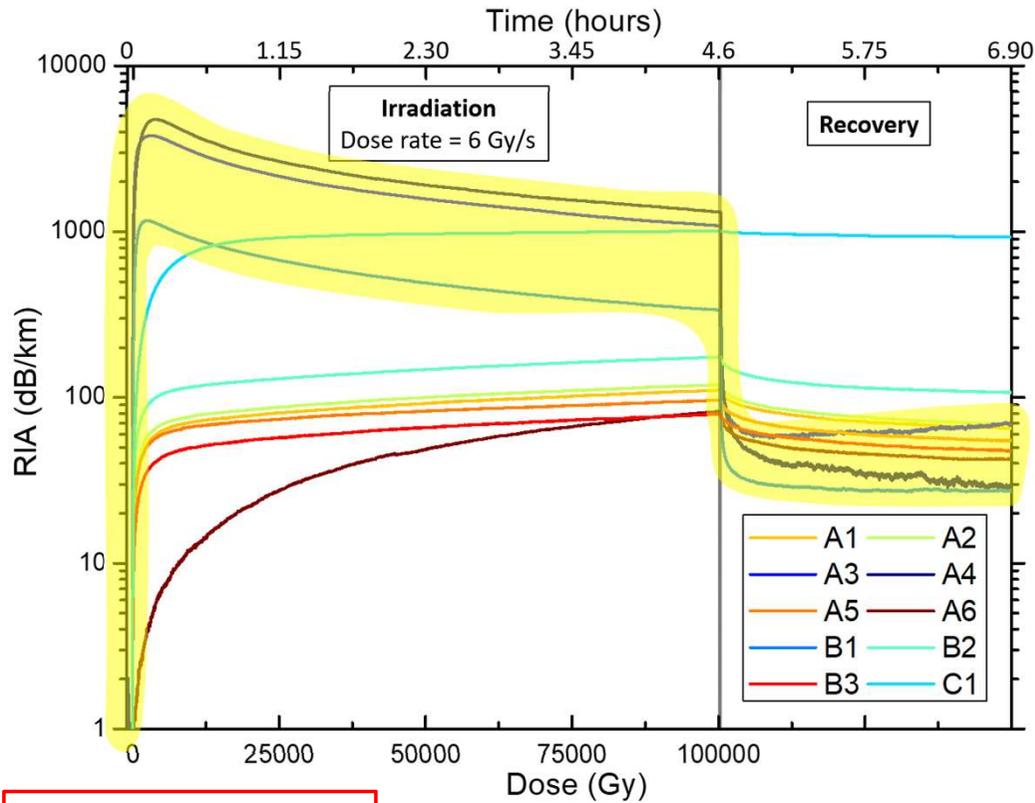


Dose rate → 0.6 Gy/s
TID = 10 kGy

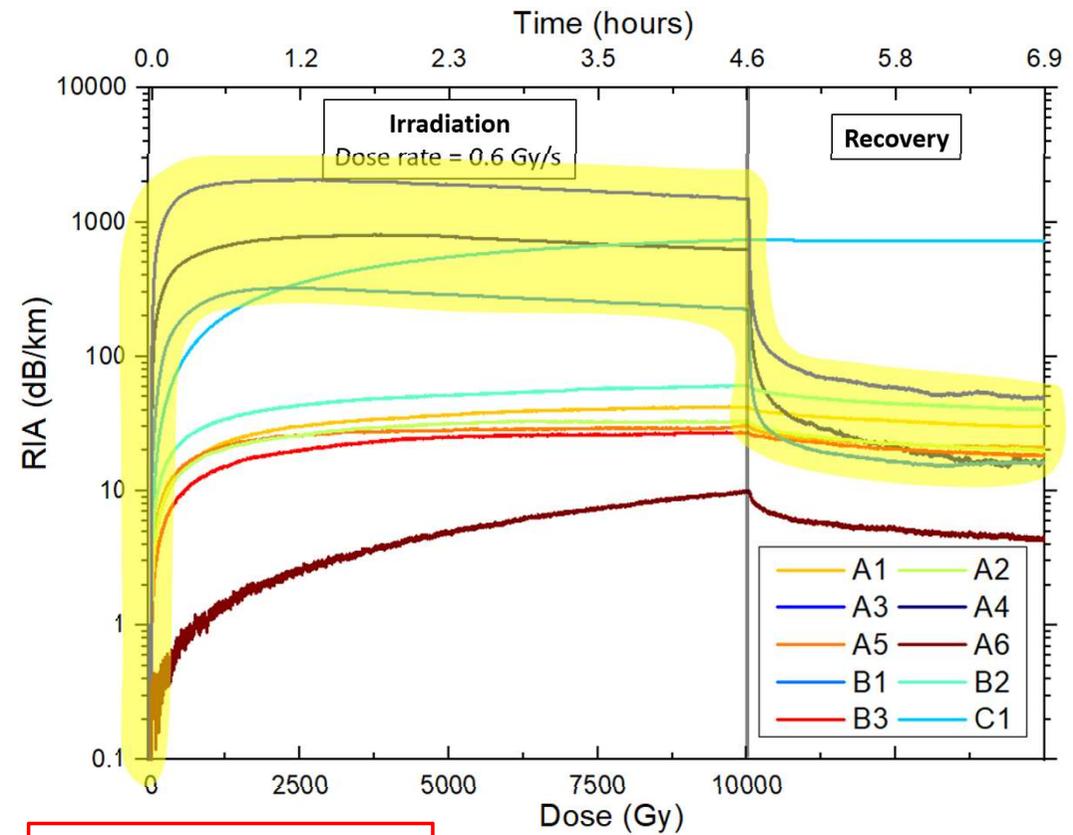
Type III – Phosphorus-codoped optical fiber



Overall results : 1535 nm

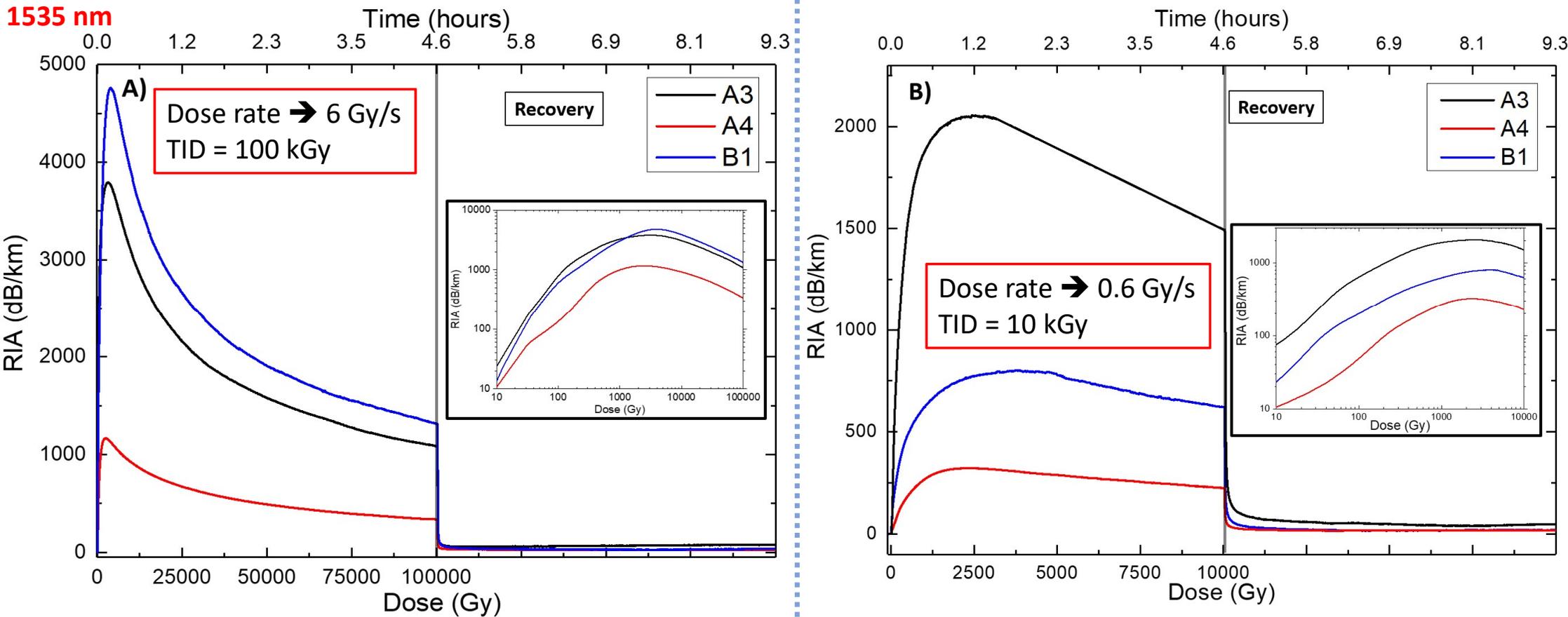


Dose rate → 6 Gy/s
TID = 100 kGy

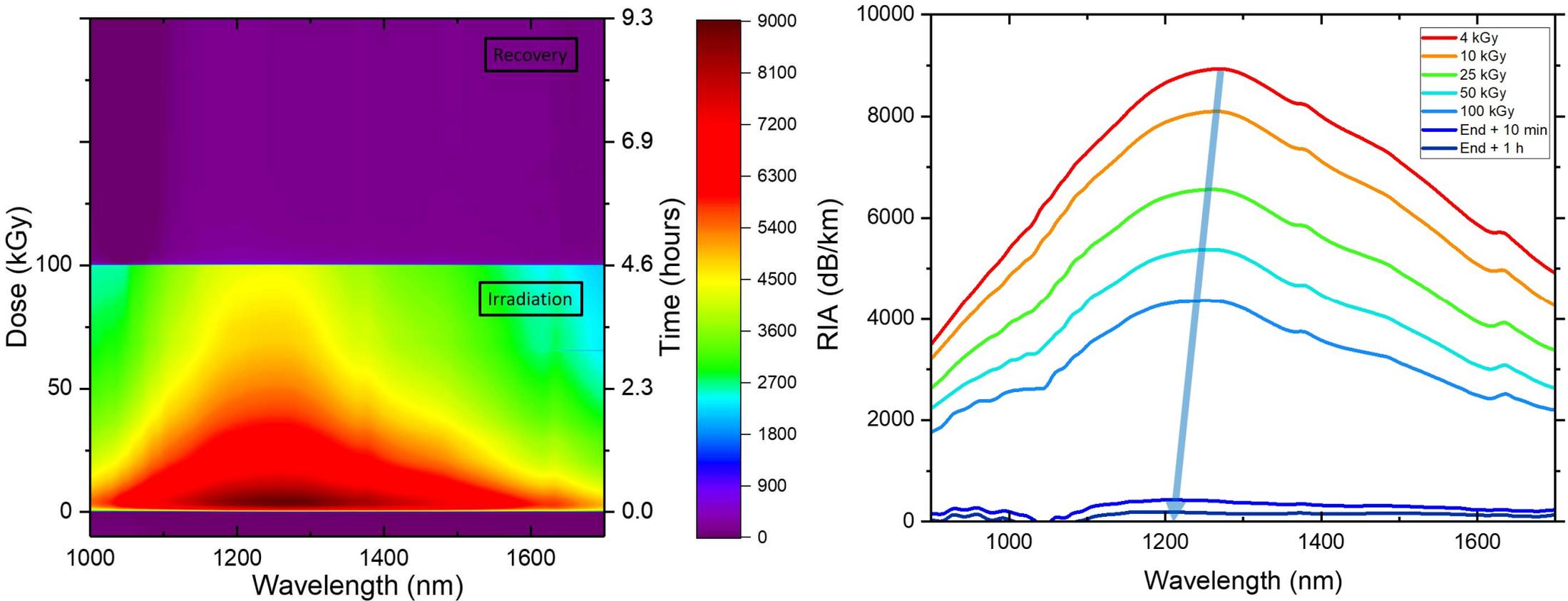


Dose rate → 0.6 Gy/s
TID = 10 kGy

Type IV: Ultra-sensitive optical fibers (ULL)



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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		2530		
A3 (end)	1085	3077	1483	1.22	78
A4 (max)	4740		902		
A4 (end)	1293	3890	689	4.31	35
A5	98	66	31	2.12	51
A6	83	12	10	1.20	30
B1 (max)	1160		323		
B1 (end)	337	921	225	2.85	27
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

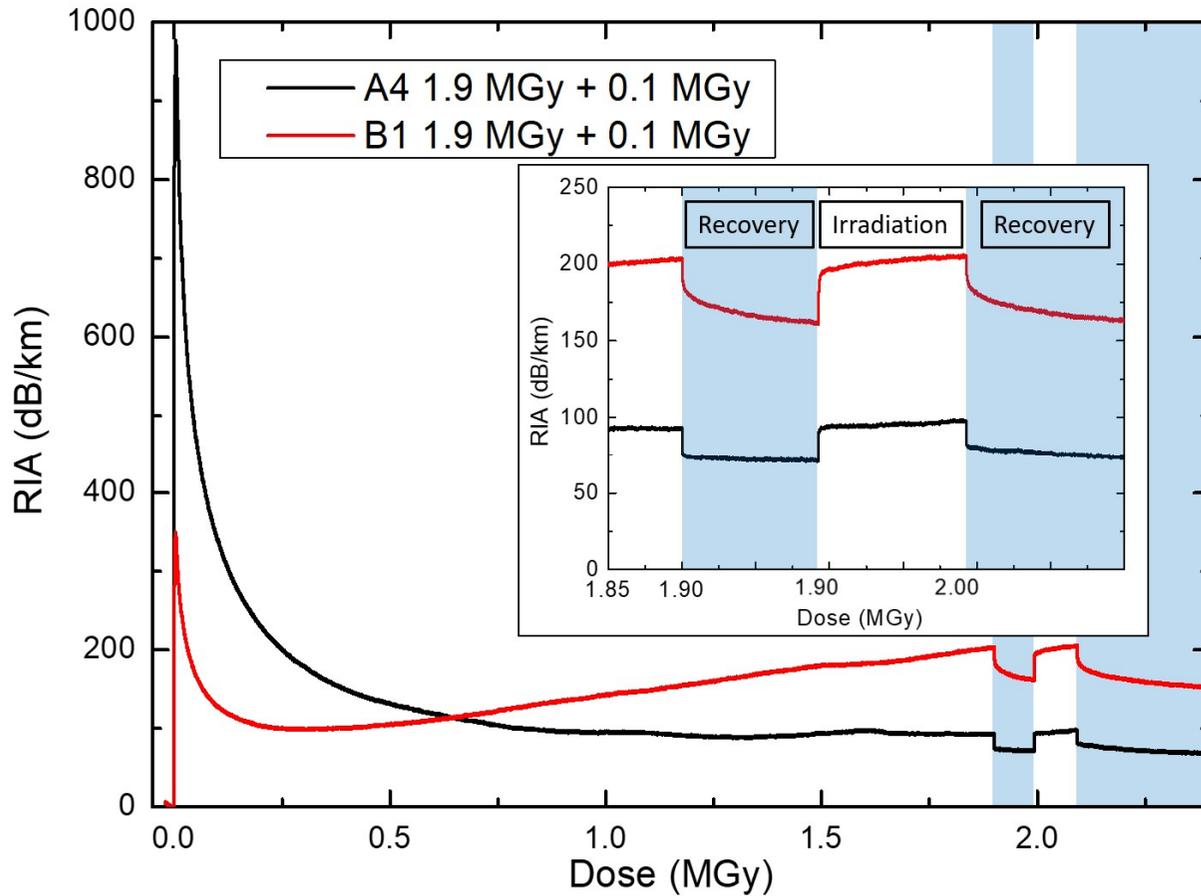
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Long period measurement : ULL



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