Isochronous Annealing Experiment Applied To Erbium Doped Fiber For Spatial Application

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Presentation outline

Introduction : Background

- ✓ Various applications of Erbium Doped Fiber
- ✓ Aim of this work

First Part : Theory

- ✓ Radiation sensivity of glasses
- ✓ Recovery

Second Part : Experiments and results

- ✓ Irradiation
- ✓ Annnealing

Conclusion : Perspectives

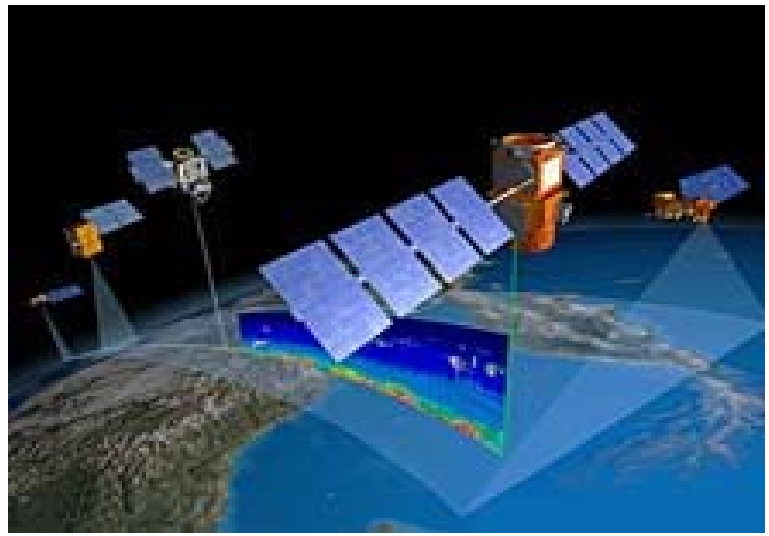
Why studying ?

Example of Application for a spatial EDFA

Satellite optical link

Lidar

(**LI**ght **D**etection **A**nd **R**anging)



Radiation effect on optical fiber

Additional absorption of light

➥ Radio Induced Absorption (RIA)

➥ Efficiency ↓, system failure

RIA depends on …

…irradiation parameters :

✓ Dose (Time)

…optical parameters :

✓ Materials

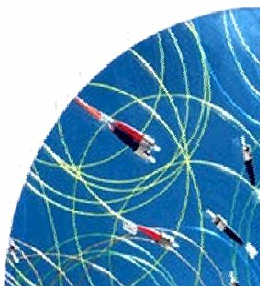
✓ Wavelength

✓ Optical Power(Time)

…system parameters :

✓ Temperature(Time)

✓ Fiber Length

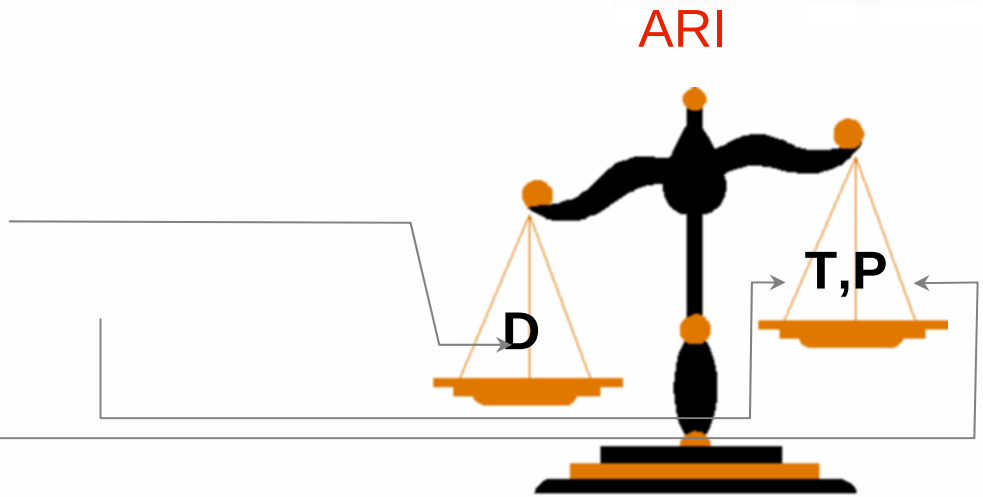


Aim of this study

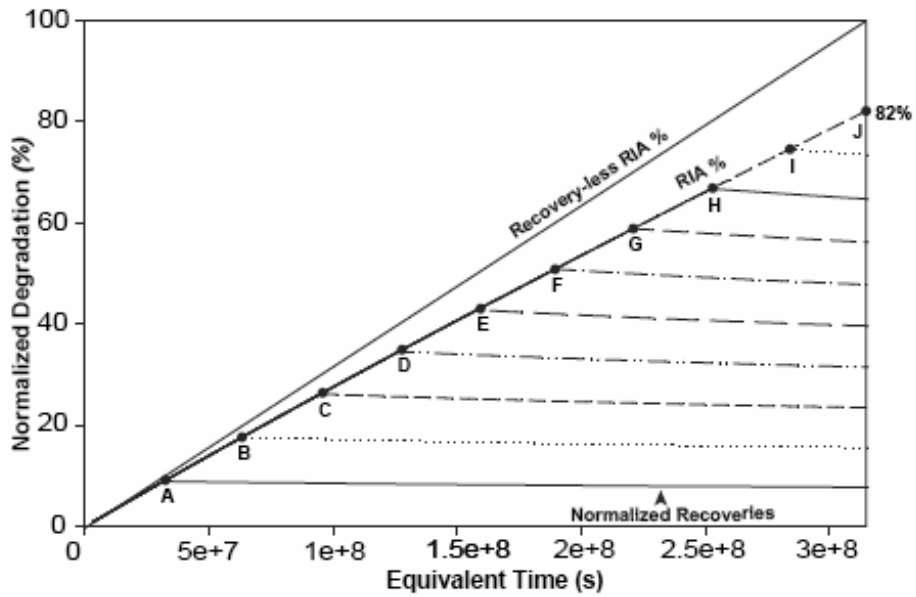
<u>Assessment under radiation</u>

Competition between

- Degradation (Dose)
- Recovery (Optical, Thermal)



Knowledge of RIA during the whole mission time



To spatial application :
Need « quick » procedure to test device.

Degradation & Recovery

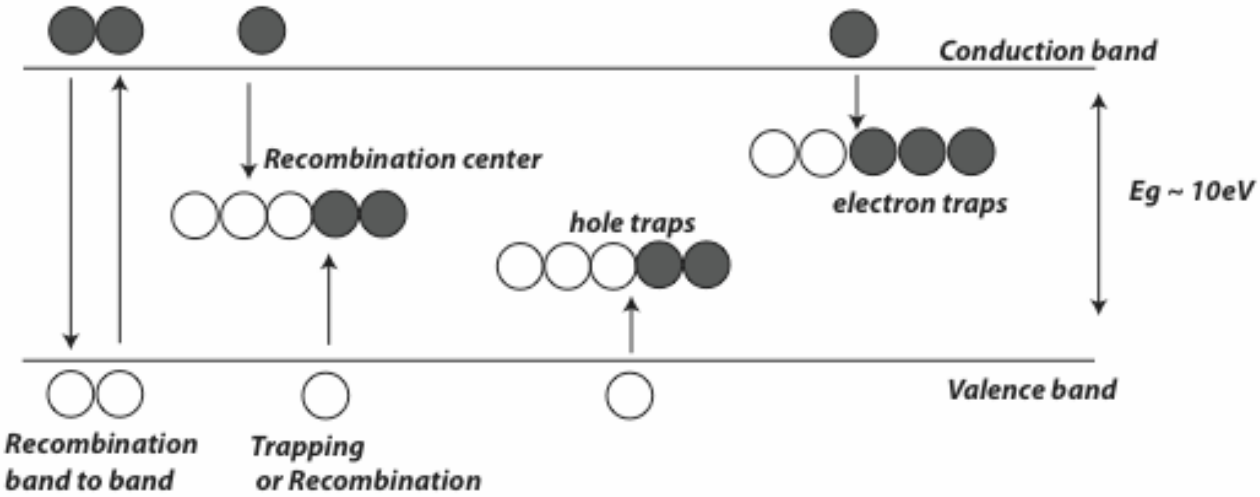
RIA origin

Degradation

→ Trap level creation in glasses

Recovery

→ Detrapping



$$\frac{d(n(t))}{dt} = -\frac{1}{\tau} \times n(t)$$

with $$\frac{1}{\tau} = \frac{1}{\tau_b} \times \exp\left(-\frac{E_{trap}}{kT}\right)$$

Arrhenius Equation

$1/\tau$: Detrapping probability

n(t) : trapped charge density

$1/\tau_b$: Attempt to escape factor

E_{trap} : Activation energy

k : Boltzmann constant

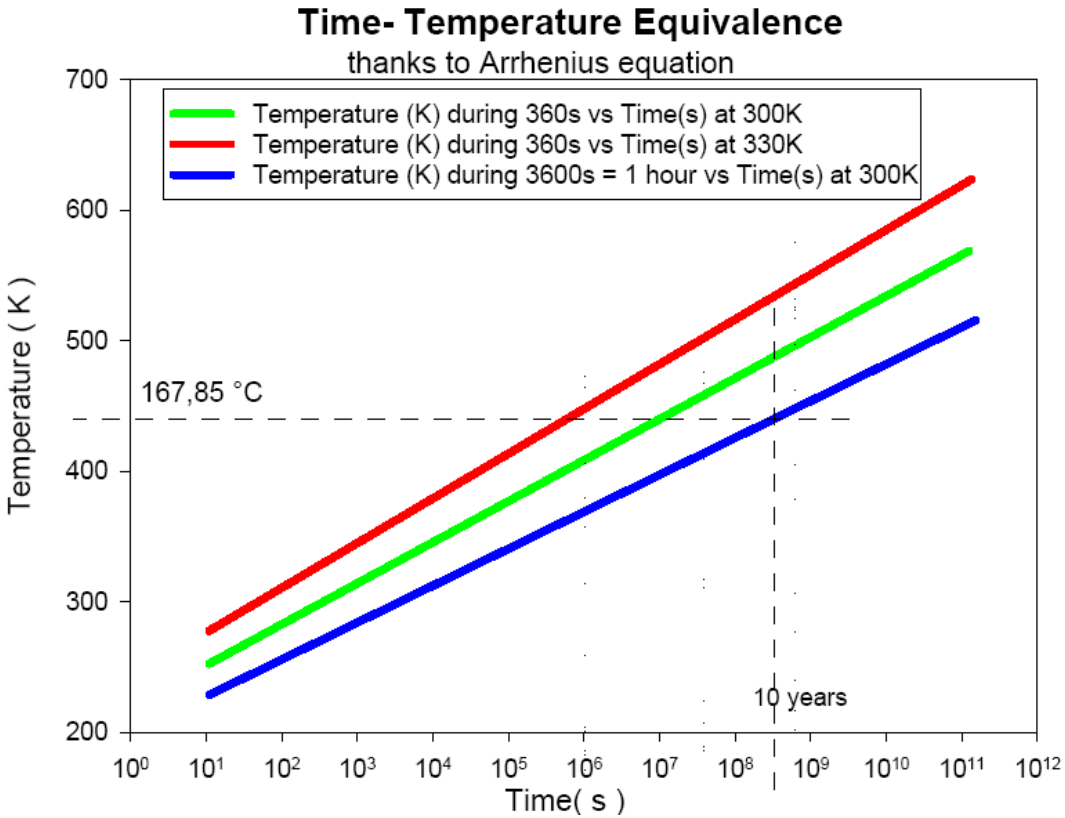
T : Temperature

Arrhenius Equation

$$\frac{1}{\tau} = \frac{1}{\tau_b} \times \exp\left(-\frac{E_{trap}}{kT}\right) \longrightarrow$$

$$\tau_2 = \tau_b^{\left(1-\frac{T_1}{T_2}\right)} \times \tau_1^{\left(\frac{T_1}{T_2}\right)}$$

Time - Temperature Equivalence



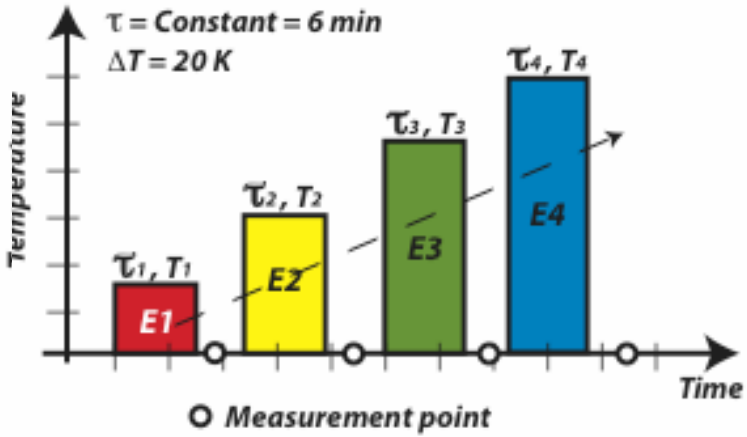
Thus
10 years at 25°C is equivalent at
1 hour à 167,85°C

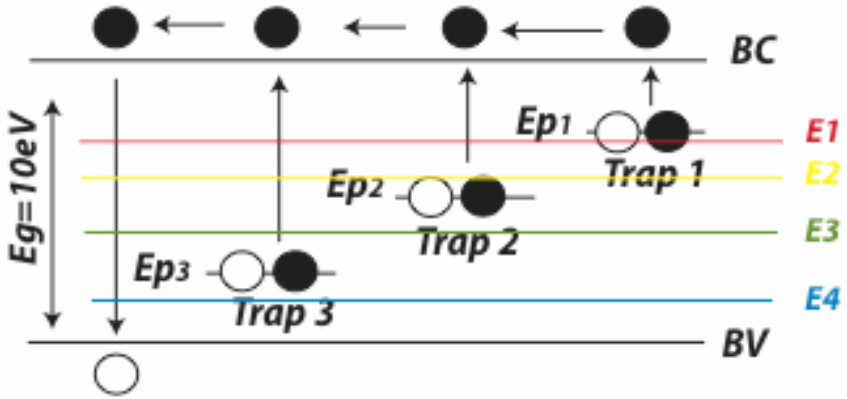
→ **Isothermal experiment**

But RIA during the mission ?

→ **Isochronous experiment**

Isochronous Annealing

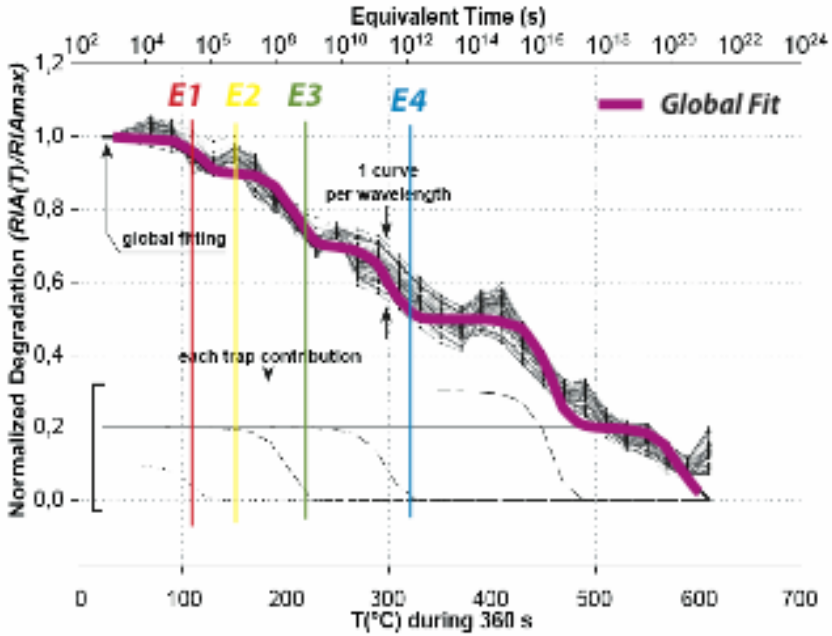


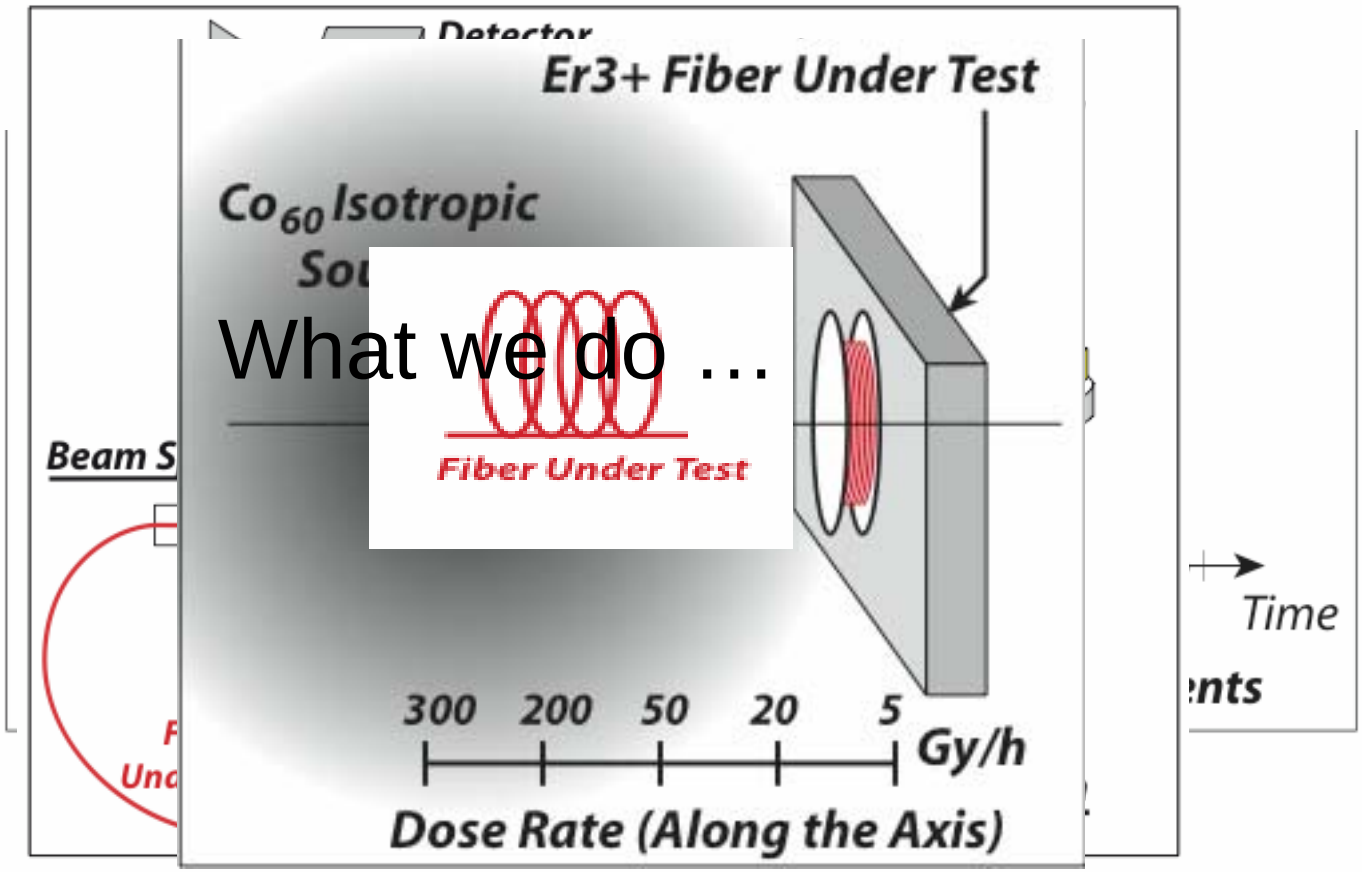


Increasing step temperature

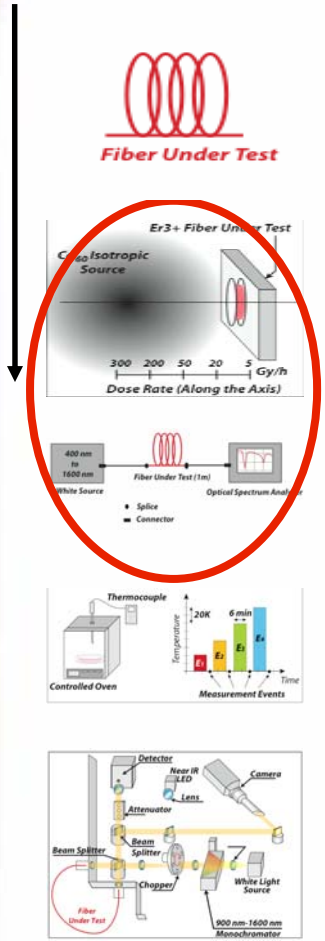
Deeper and deeper levels are detrapped

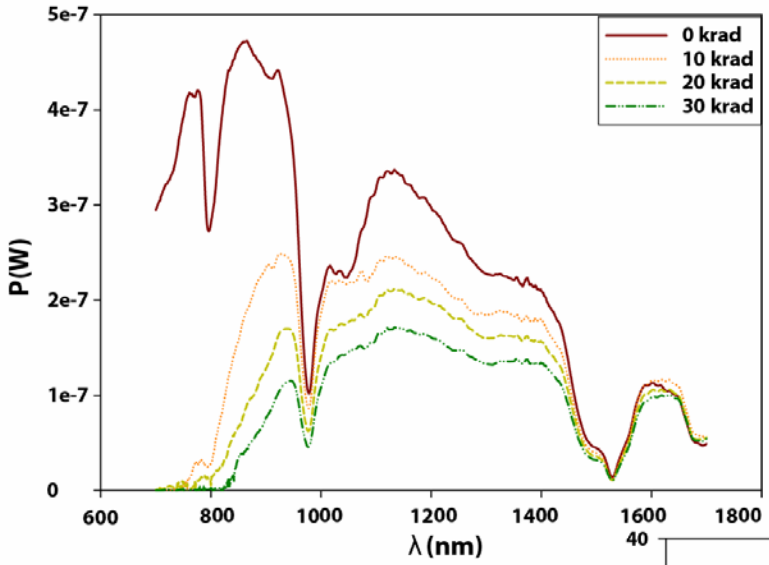
Consequently the total RIA decreases




Detector
Er3+ Fiber Under Test
Co60 Isotropic
Sou
What we do …
Fiber Under Test
Beam S
Time
300 200 50 20 5 Gy/h
Dose Rate (Along the Axis)

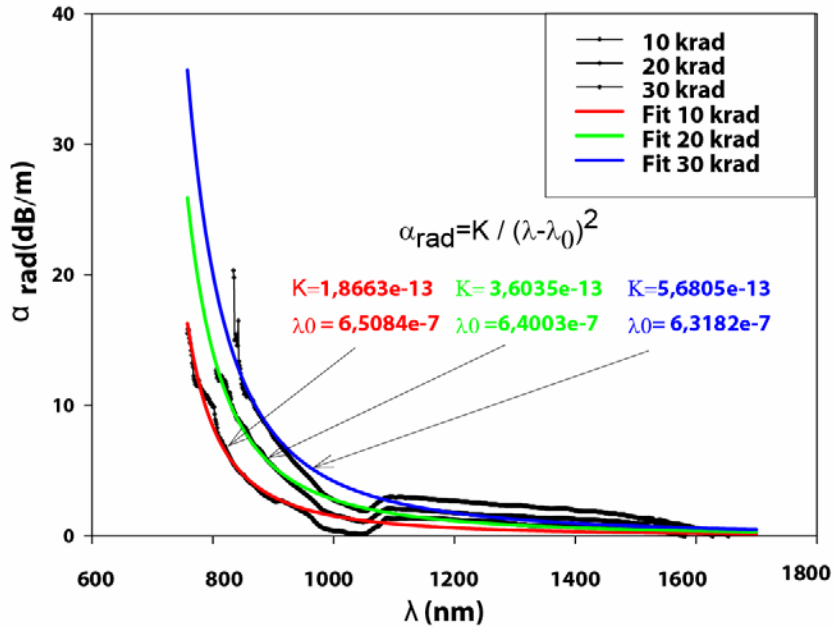
Irradiation => Degradation



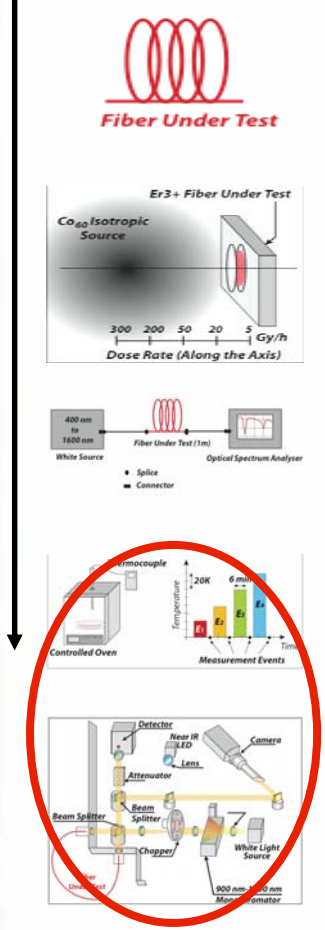


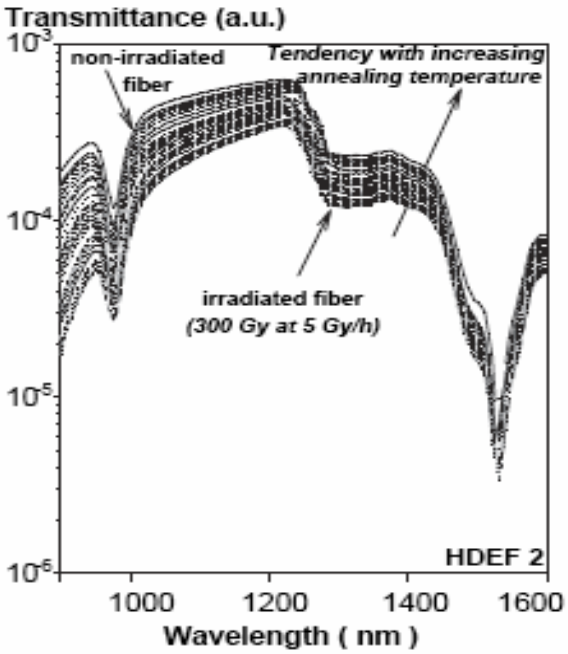
Transmitted power spectra at each dose deposit step.

Determination of total RIA at each dose step.



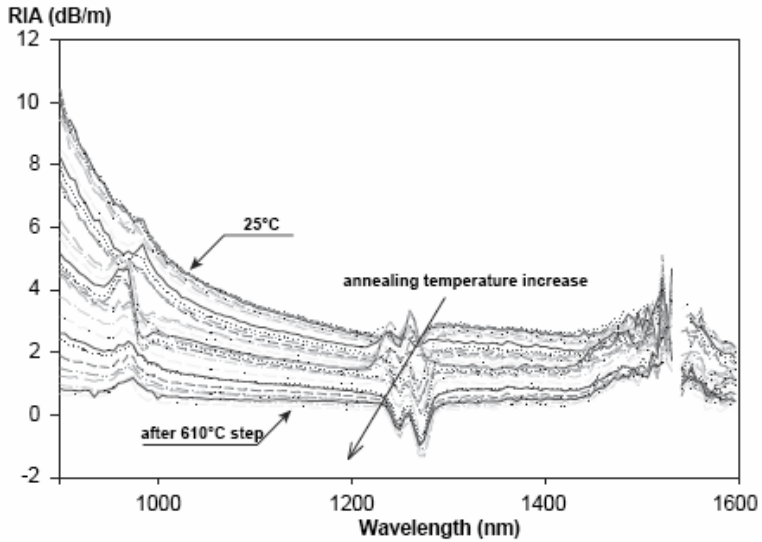
Thermal annealing => Recovery



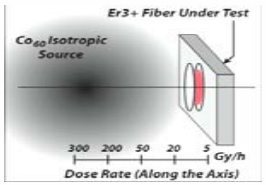


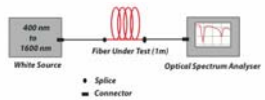
Transmitted power spectra at each temperature step.

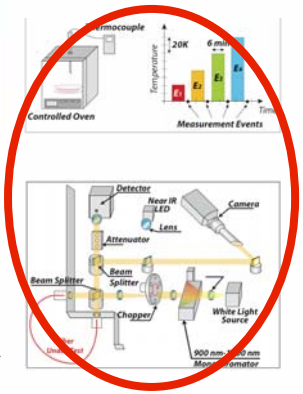
Determination of RIA at each temperature step

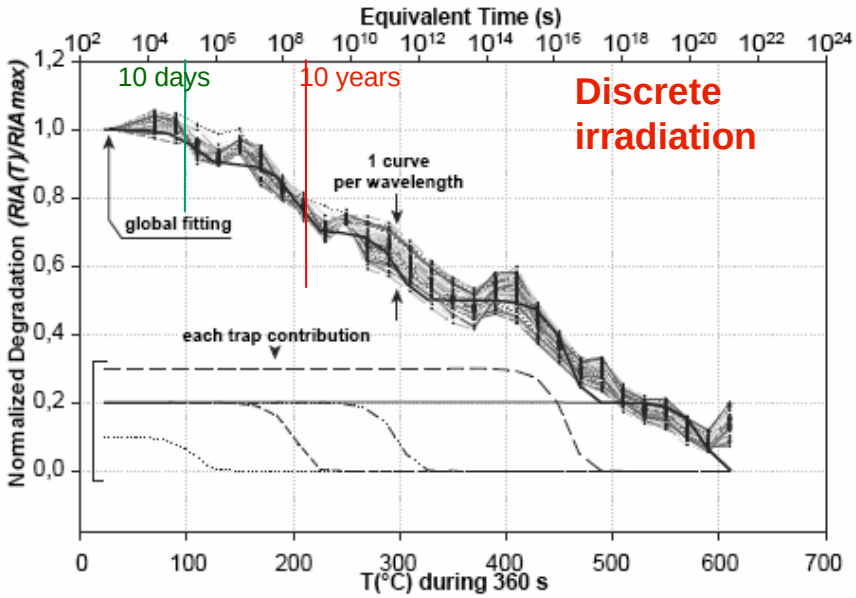


The aim of this procedure



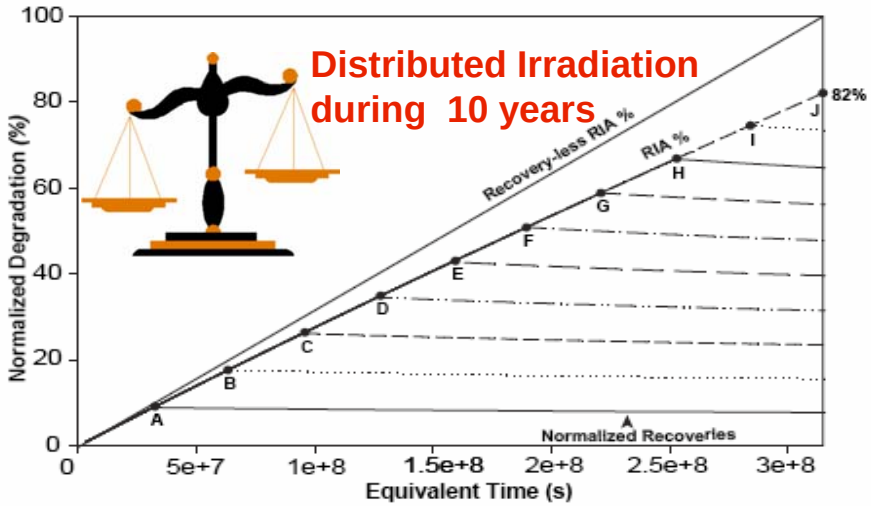






Extraction of Normalized Recovery as a function of temperature and time.

Assessment of RIA as a function of mission time

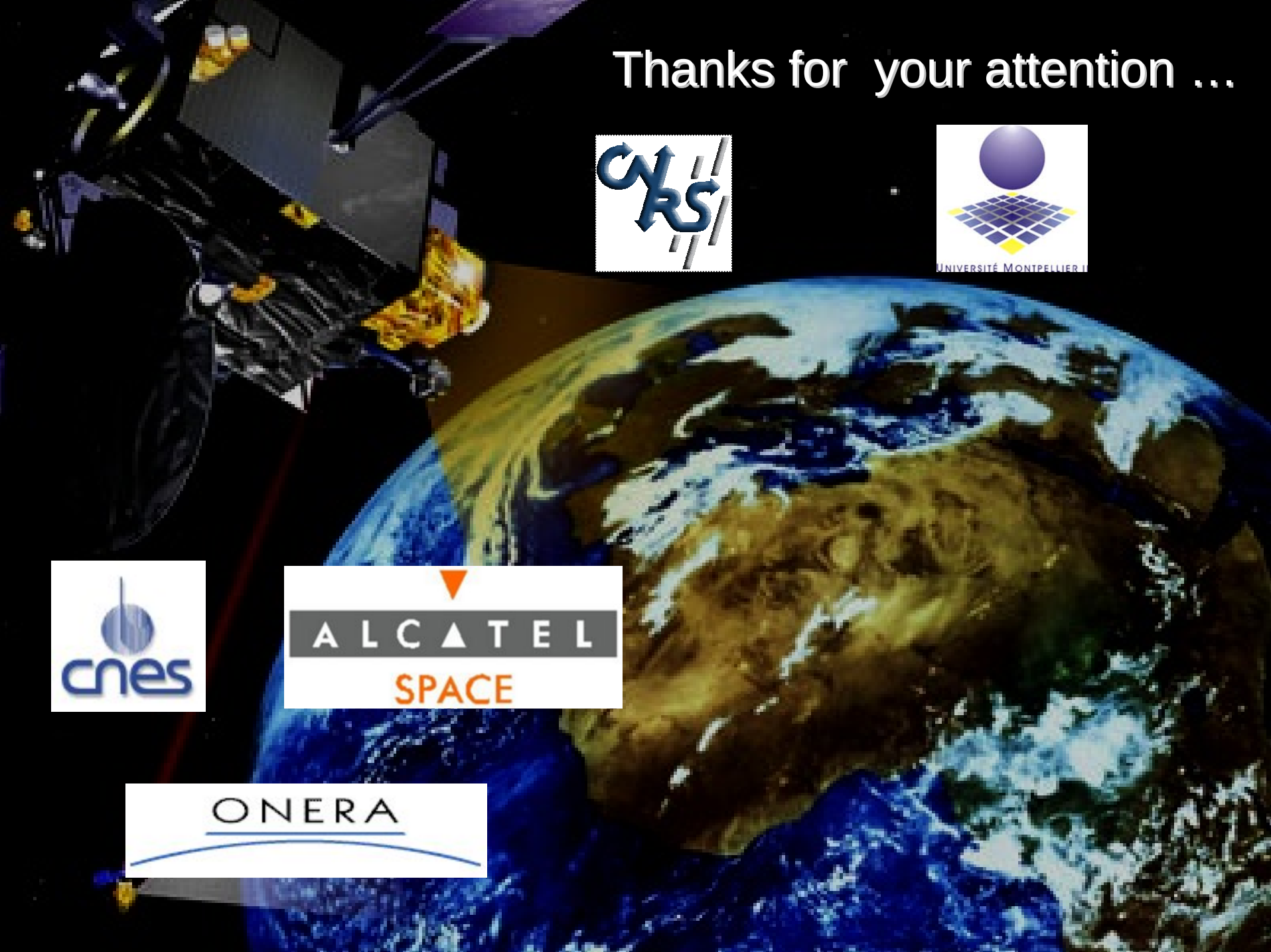


Conclusion

- Usual test => too conservative.
- Worst-case but more precise.
- Taking into account the recovery => more optical fibers are selectable.

Perspectives

- Better knowledge of recovery in oxyde
- Experiment to compare the co-dopant recovery possibilities.
- Addition of the photobleaching study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