L’optique en environnement radiatif extrême

DE LA RECHERCHE À L’INDUSTRIE

16/12/2021

LADACI Ayoub

Colloque Alain BOUYSSY

Parcours

Bac scientifique

L2 science et technologie ⟶ **L3** Electronique générale

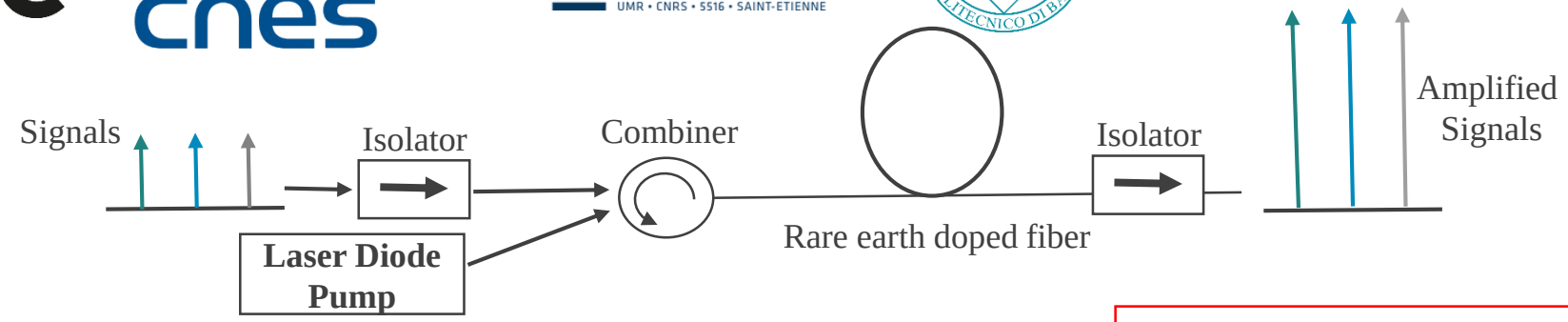
Master 1 optronique ⟶ **Master 2** Optique Image et vison

PHD en physique ‘optique, photonique et hyperfréquence’

Post-doc CEA ‘Mesure de température en réacteur de recherche’

Ingénieur chercher CEA en ‘instrumentation nucléaire’

Rare earth doped optical fibers and amplifiers for space applications



Advantages

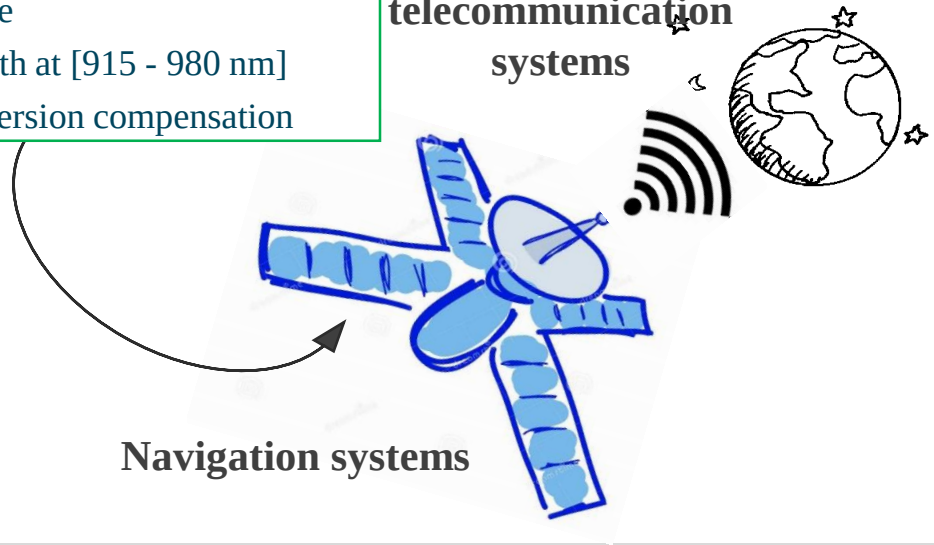
- High amplification gain 40 dB
- Wide bandwidth 35-40 nm (5000 GHz)
- High output powers
- Low noise figure
- Pump wavelength at [915 - 980 nm]
- No need of dispersion compensation

Drawbacks

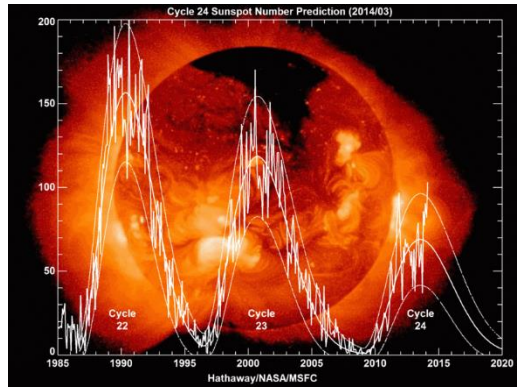
Radiation vulnerability

Gain decreases with the irradiation dose during the mission lifetime

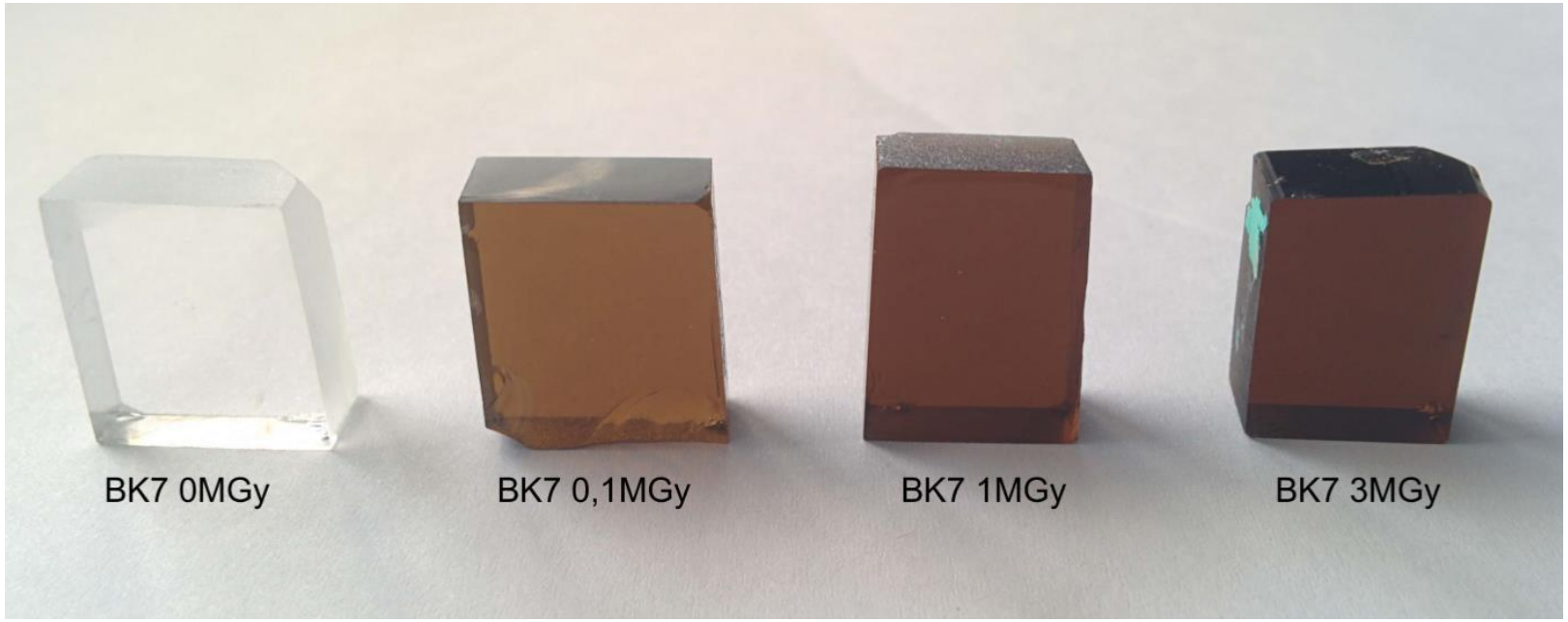
Free space telecommunication systems



Navigation systems

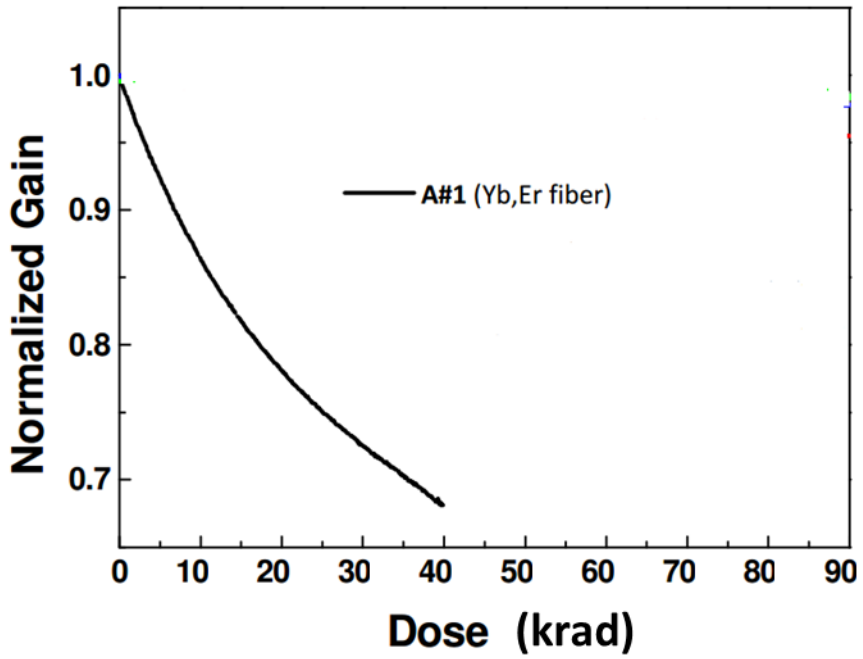


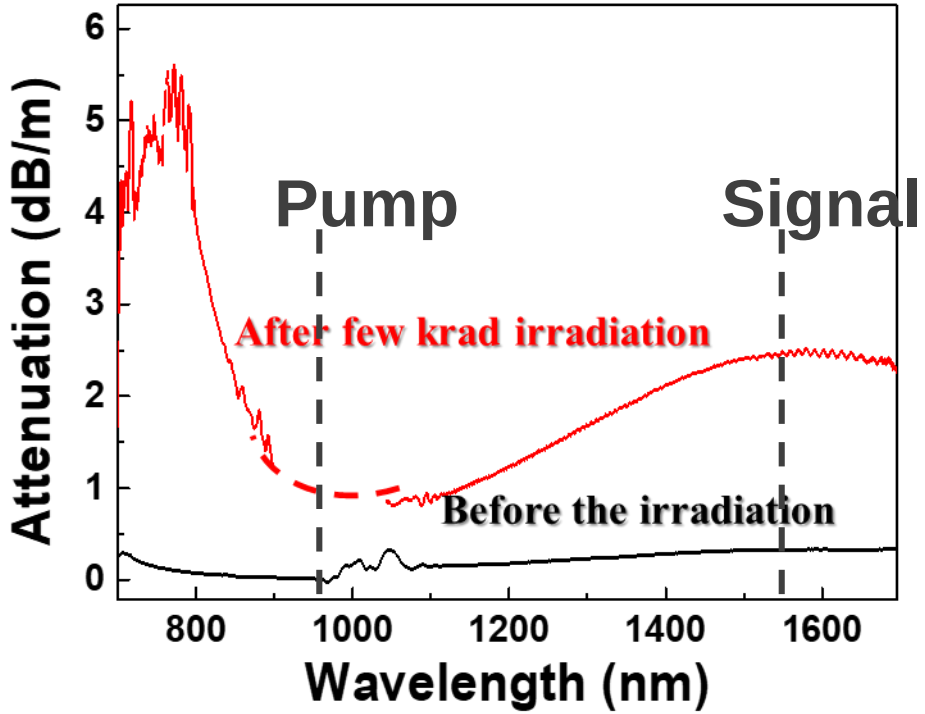
Defect generation mechanisms



Irradiation dose

Defect generation mechanisms

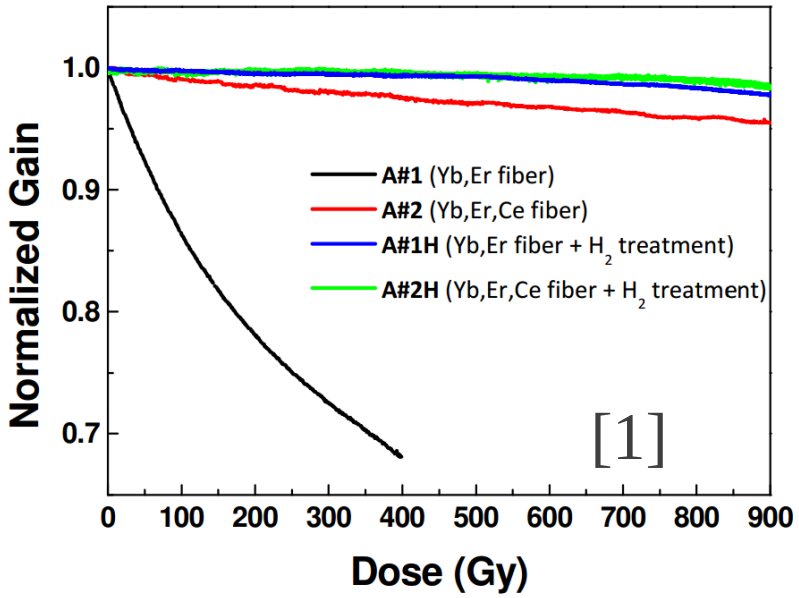

Normalized Gain
1.0
0.9
0.8
0.7
A#1 (Yb,Er fiber)
0
10
20
30
40
50
60
70
80
90
Dose (krad)

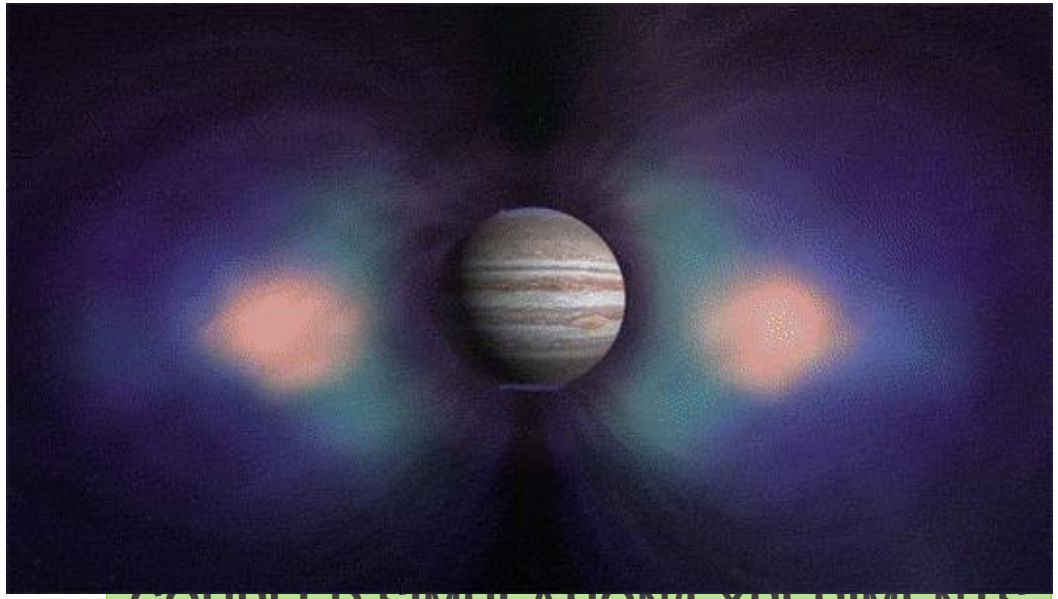

Attenuation (dB/m)
6
5
4
3
2
1
0
Pump
Signal
After few krad irradiation
Before the irradiation
800
1000
1200
1400
1600
Wavelength (nm)

1- Use of alternative fiber compositions and/or fabrication processes

- [1] Hydrogen loading
- [1] Cerium co-doping
- [2] RE Nano-particles doping

All these techniques allow to reduce the RIA by limiting the defect generation and then limit the REDFA gain decrease



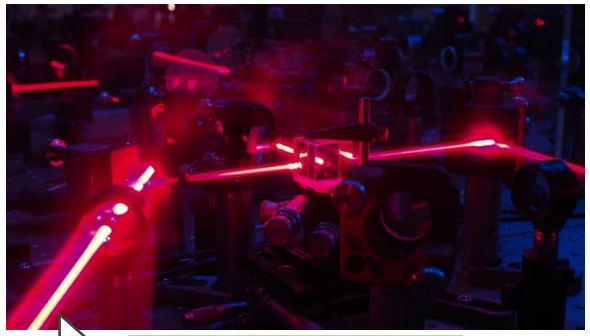


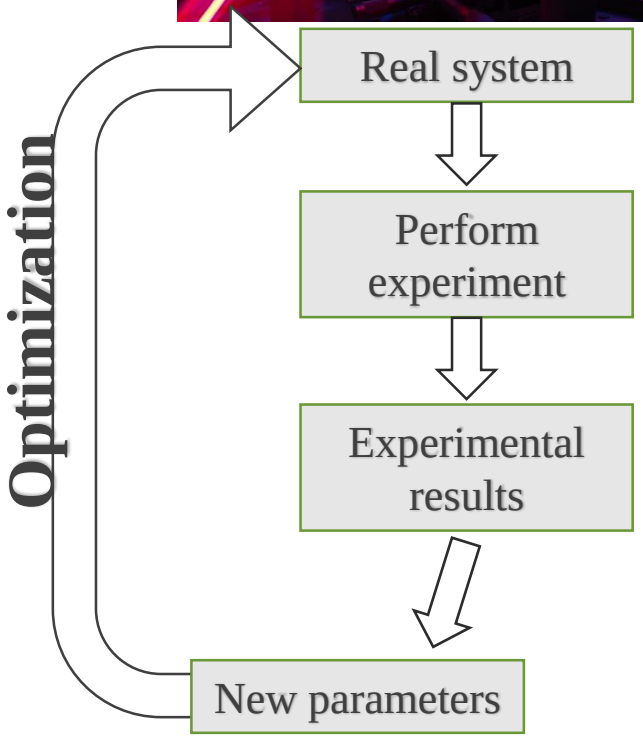
COUPLED SIMULATION/EXPERIMENTS APPROACH

Jovian mission [3]

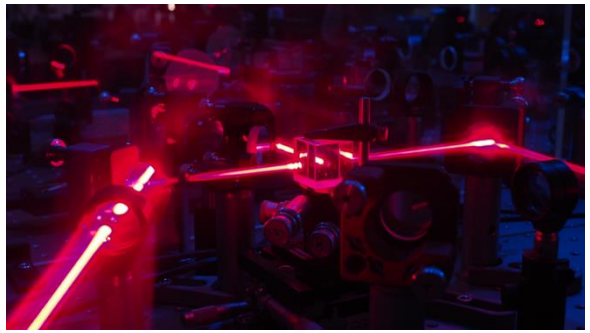
[1] S, Girard, Opt, Express Vol. 20, Issue 8, pp. 8457-8465 (2012)
[2] J. Thomas et al, Opt. Express 20, 2435-2444 (2012)
[3] G. De Angelis et al Adv. Space Res. 34(6), 1395–1403 (2004).

Optimization





Optimization



Real system

Construct approximate theories

Make a model

Perform experiment

Experimental results

Model validation

Simulation results

Perform simulations

Compare new and previous results

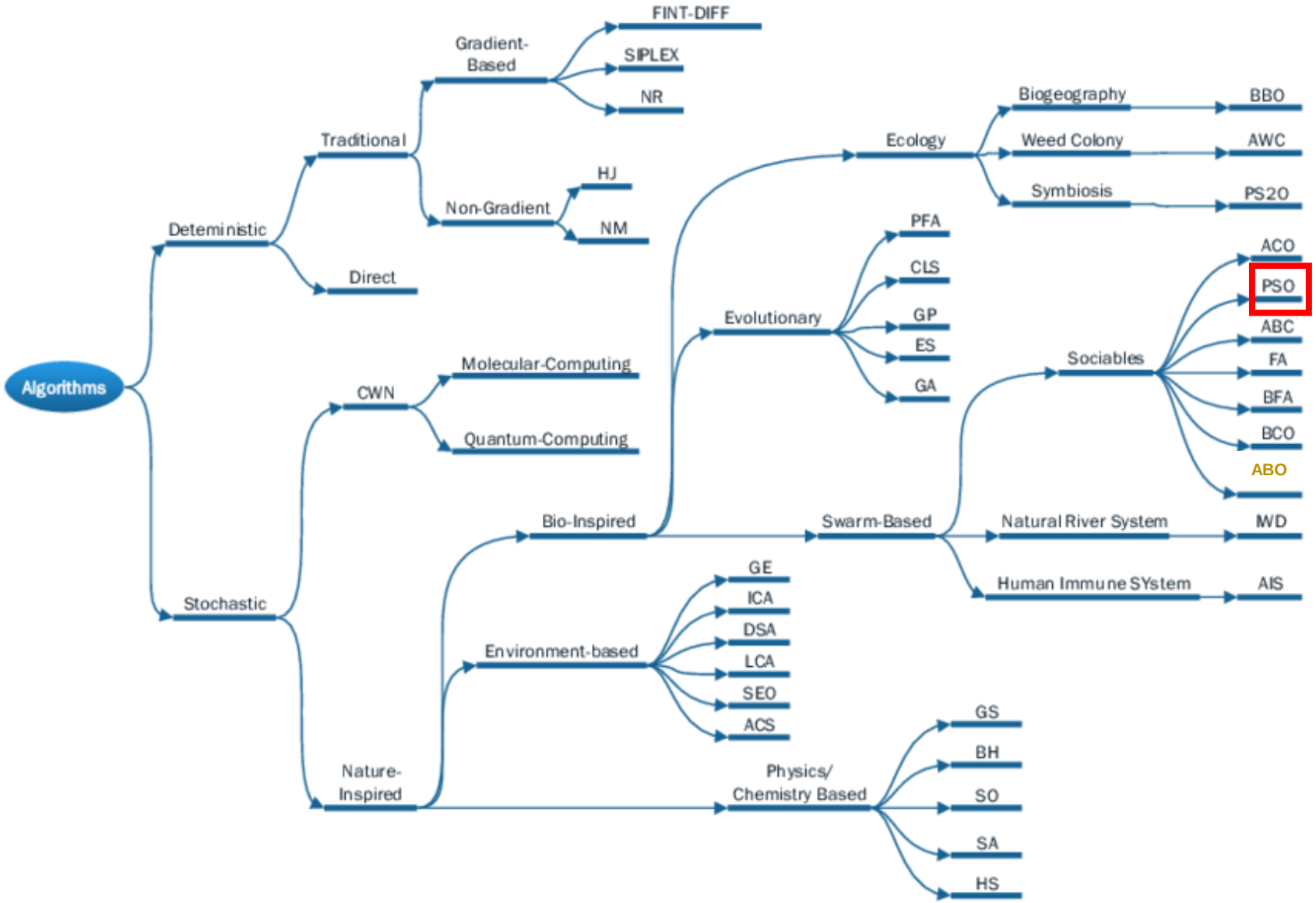
Optimize the parameters

Best simulation results

System improvement

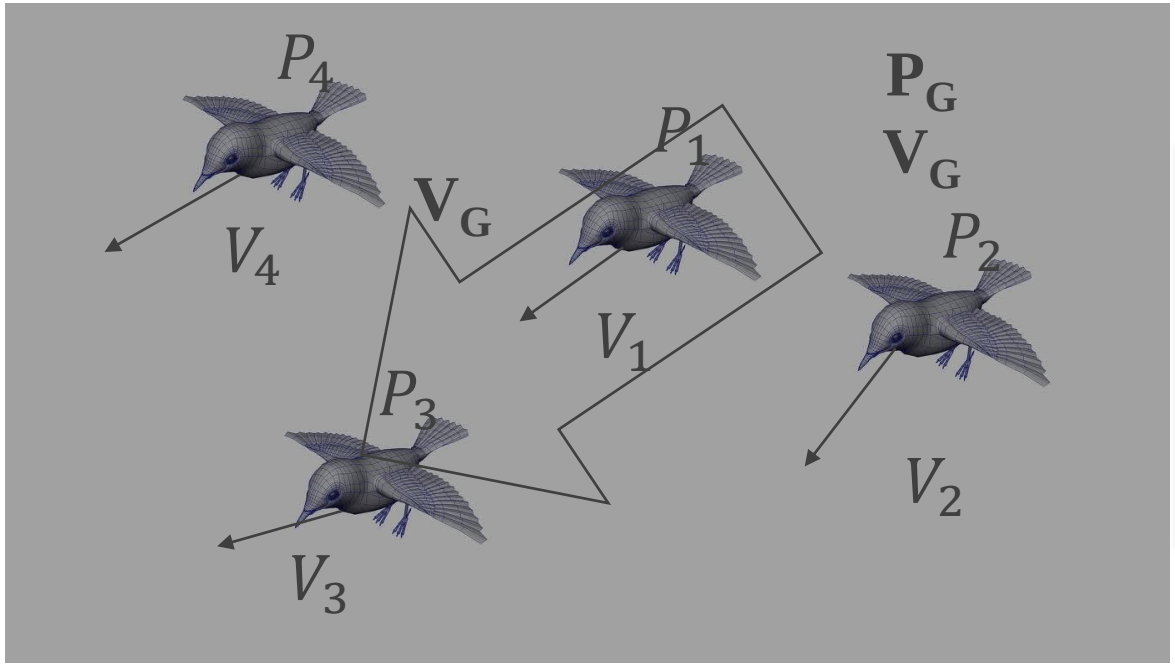
The Optimization loop

Principle of PSO (Particle Swarm Optimization)



Principle of PSO (Particle Swarm Optimization)

James Kennedy

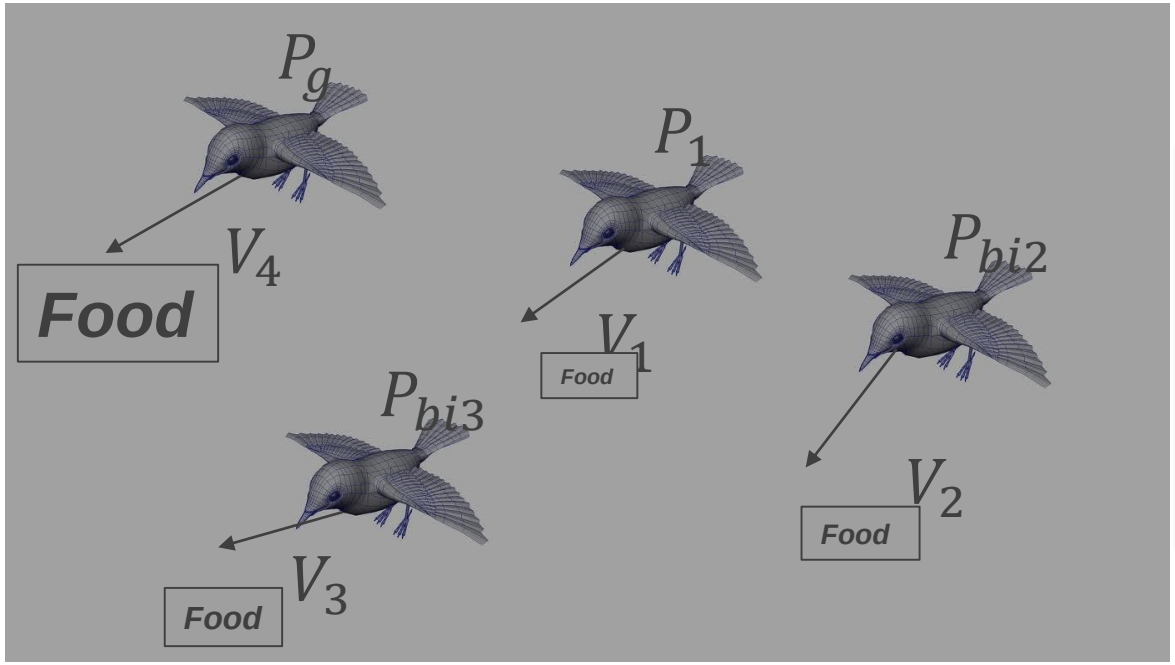


Russel.C.Eberhert

Swarm of birds

Principle of PSO (Particle Swarm Optimization)

James Kennedy



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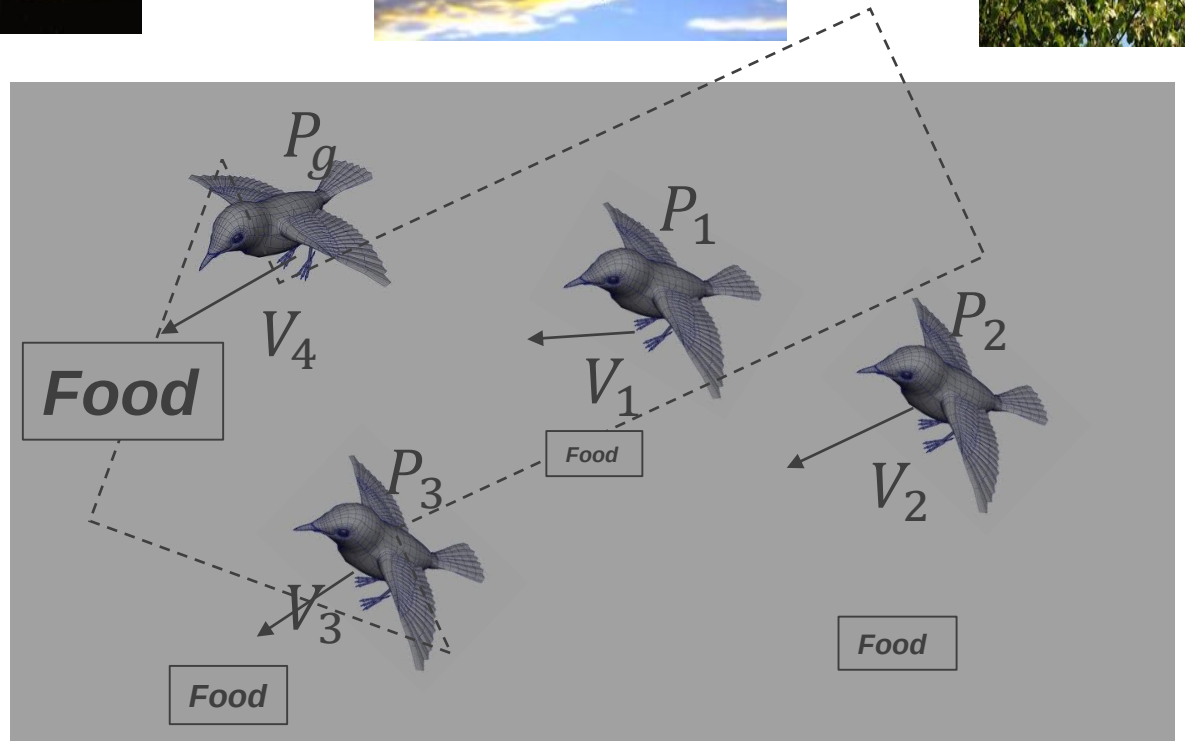

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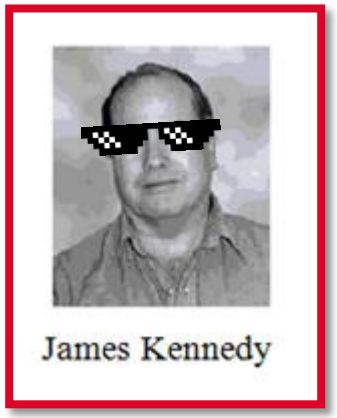

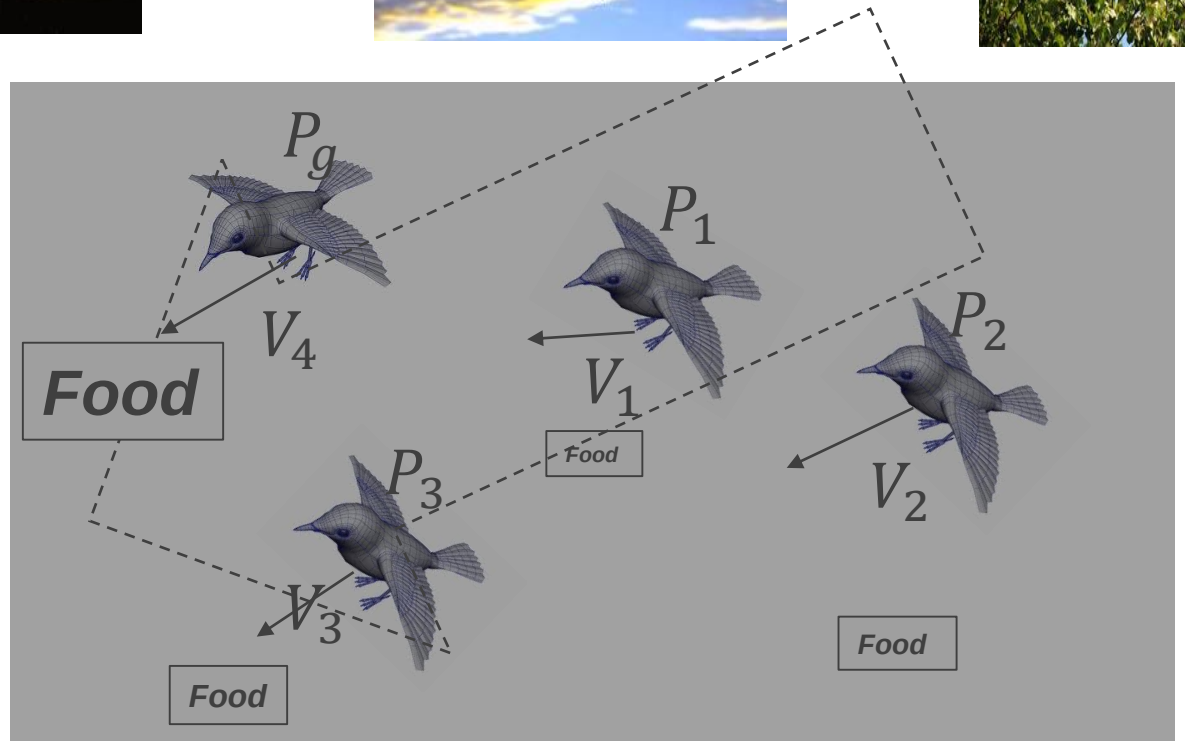

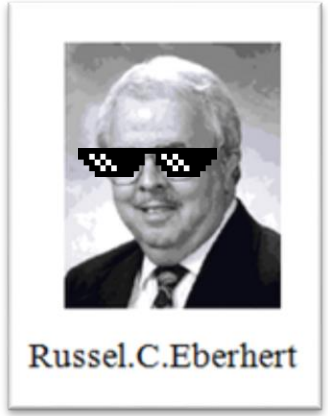

Swarm of birds

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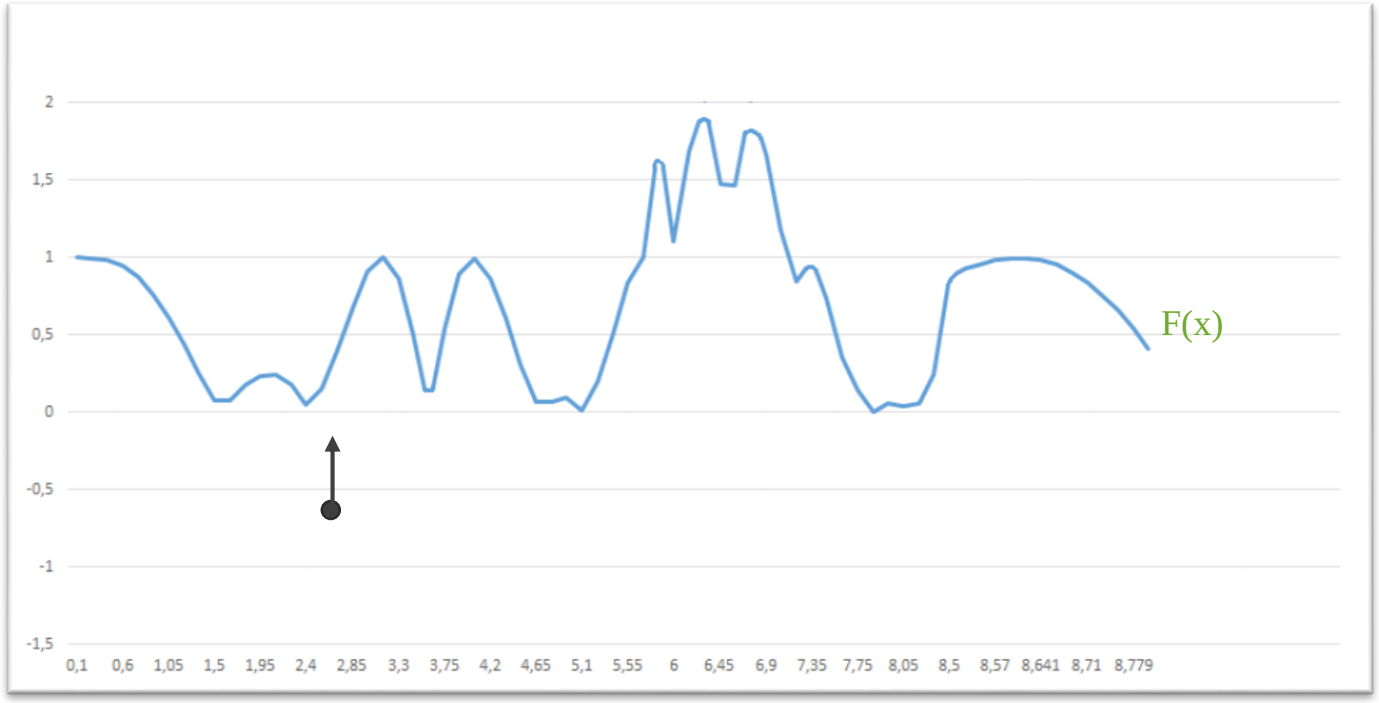

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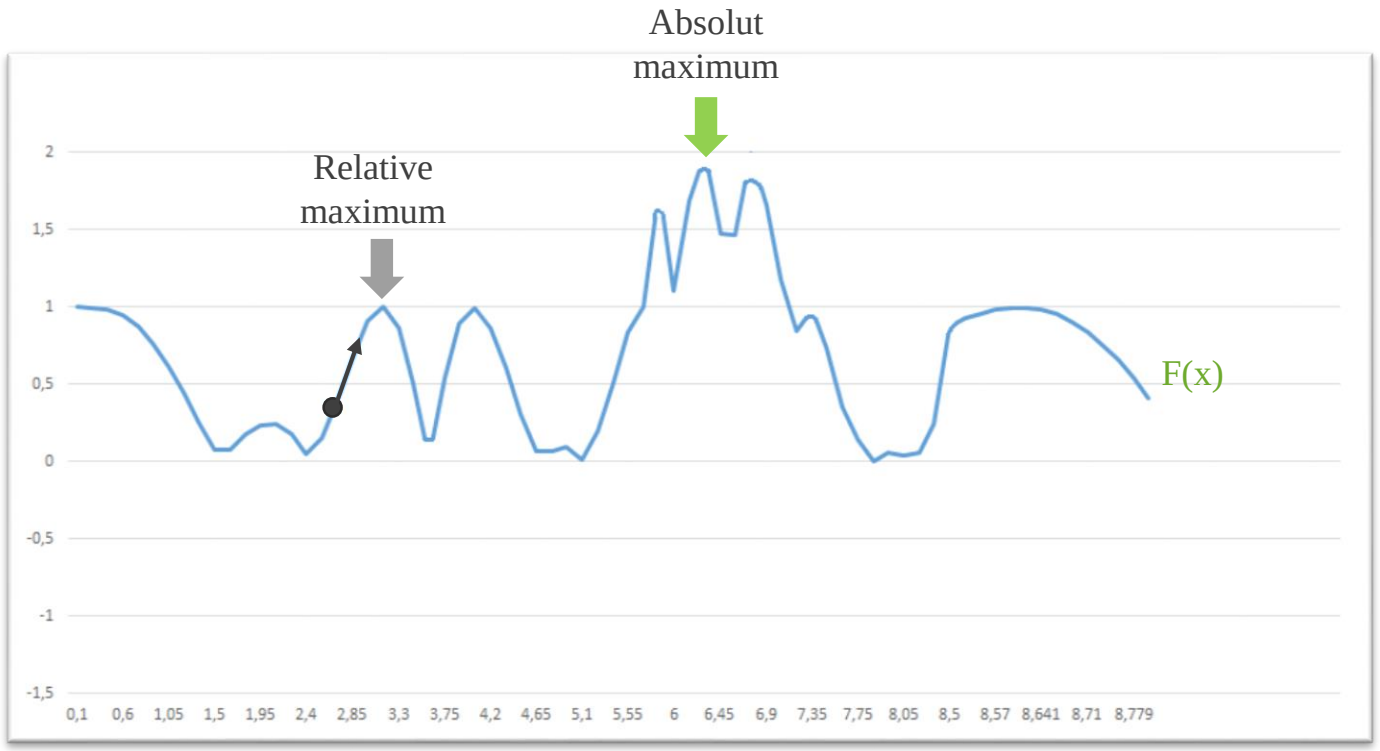

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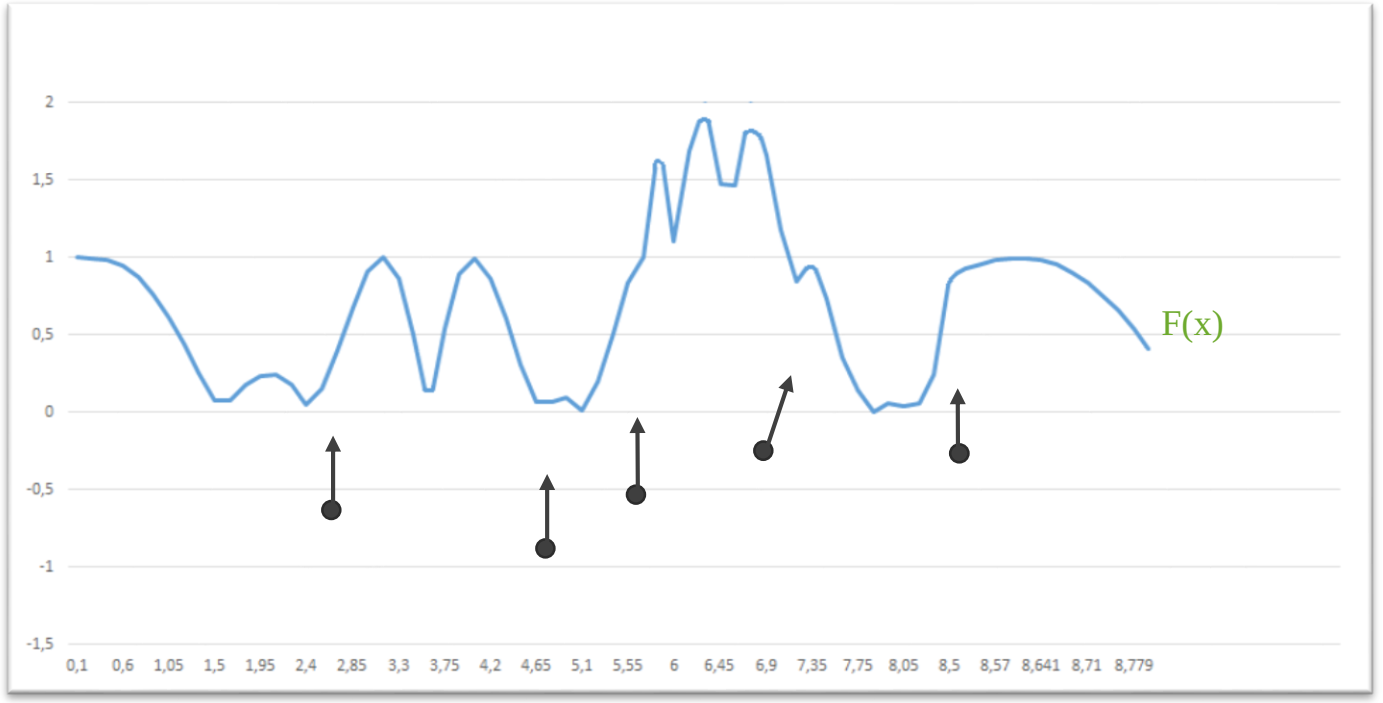

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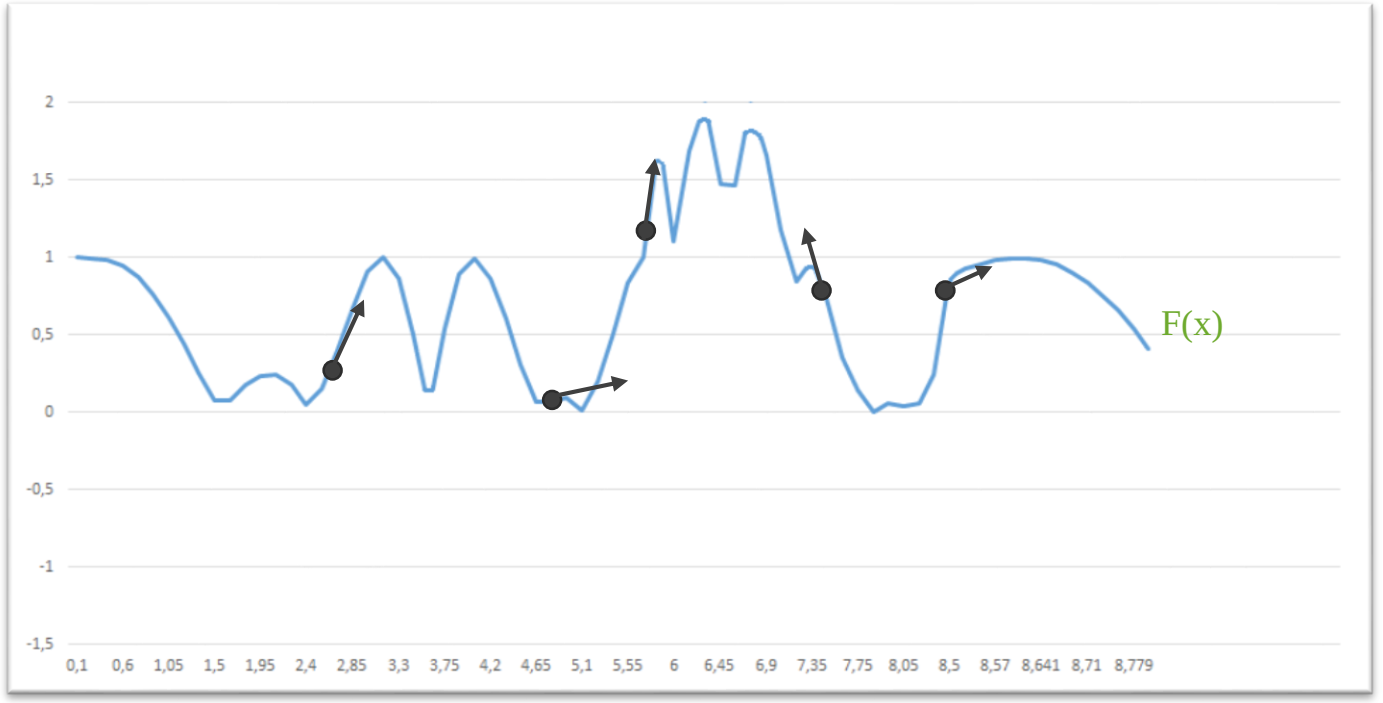

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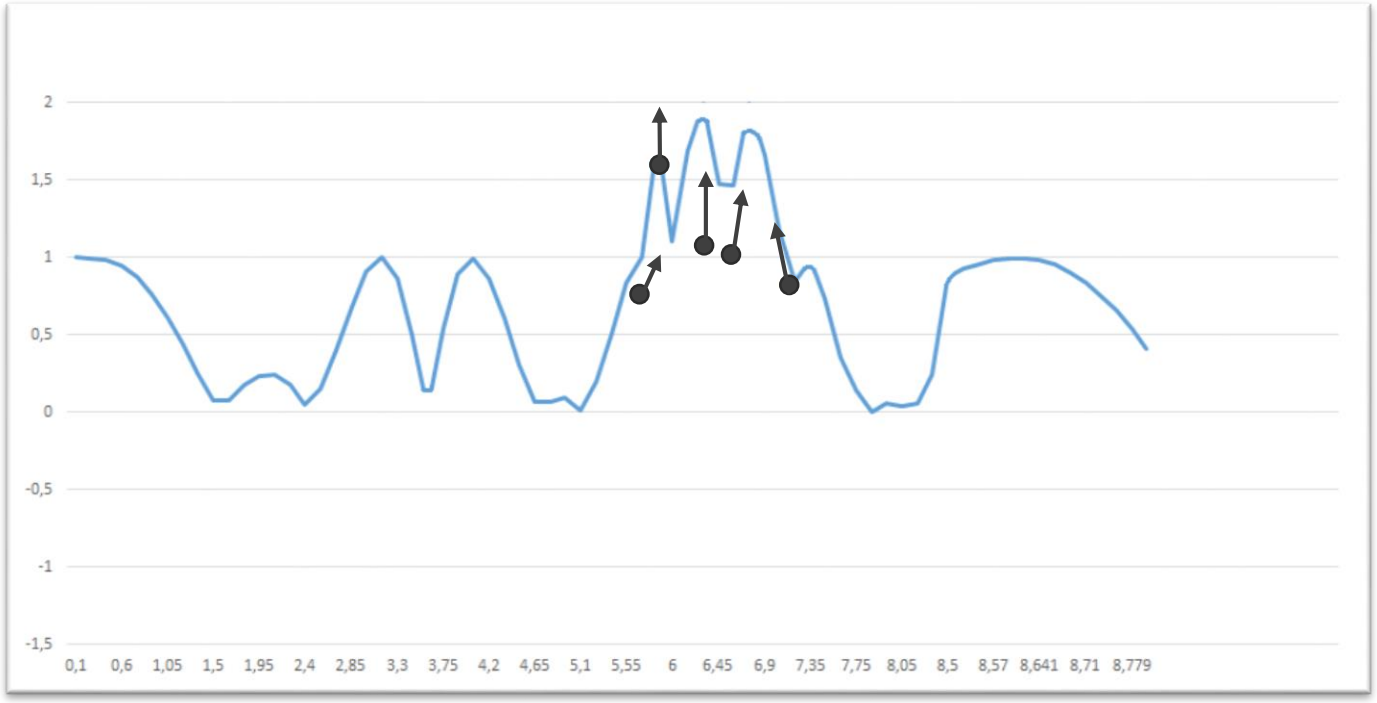

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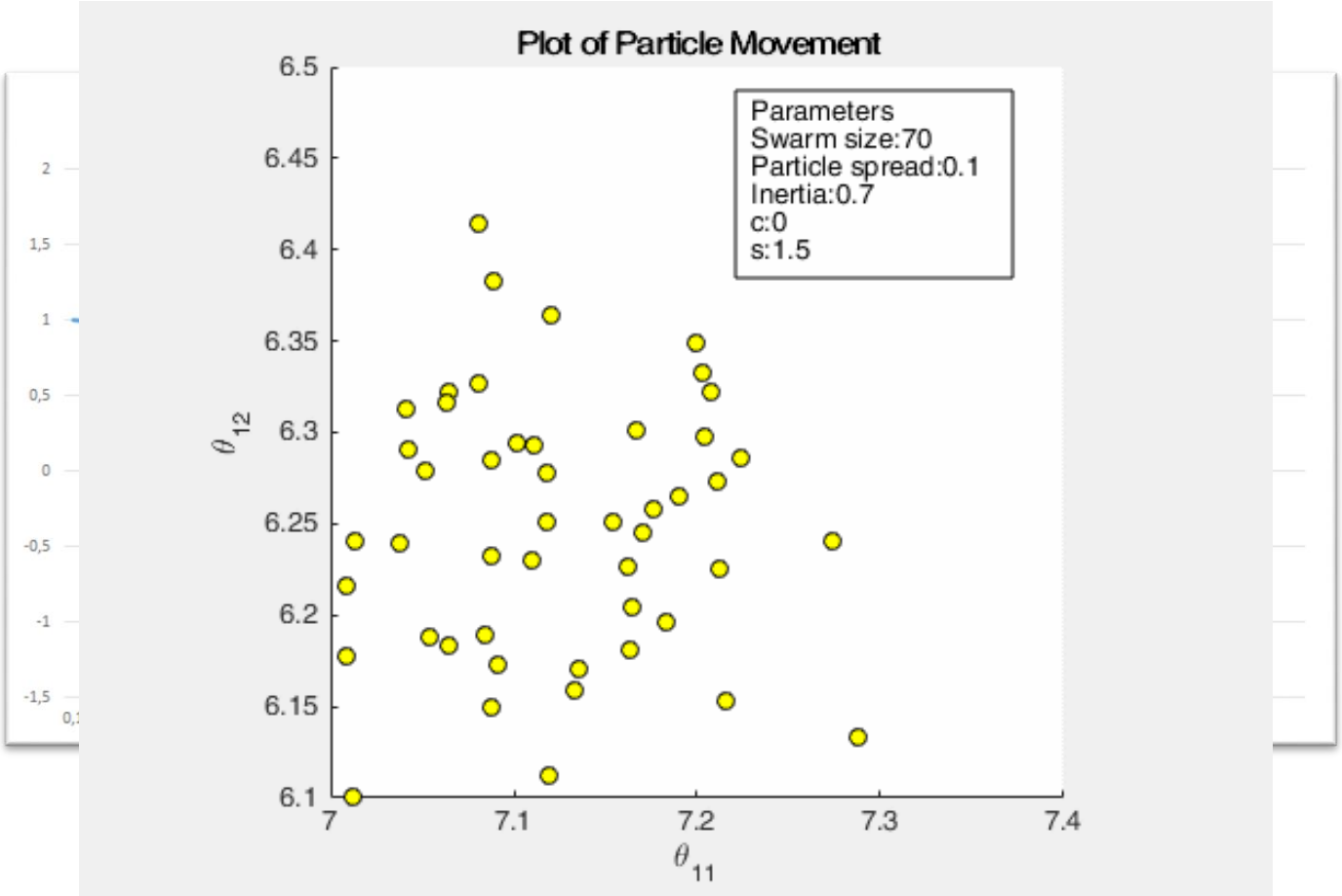
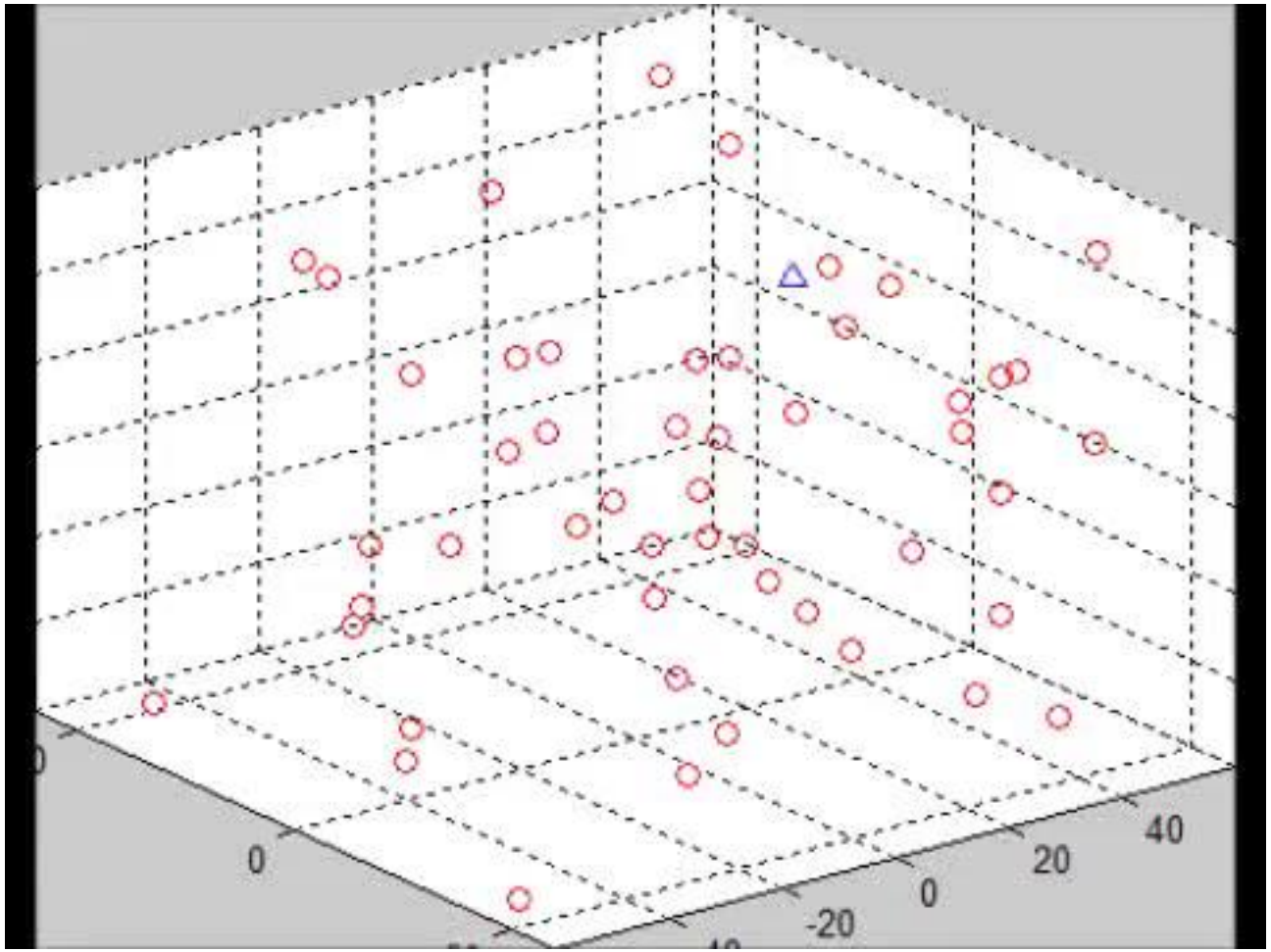
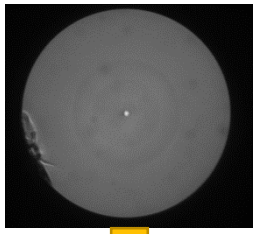


Principle of PSO (Particle Swarm Optimization)

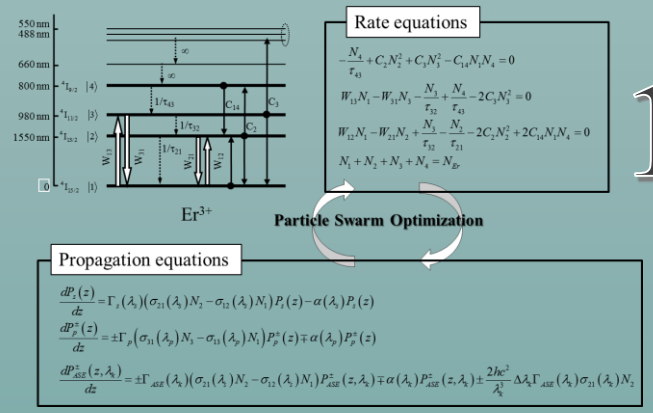
$$Z = f(x, y, z, A(t))$$



Fiber properties (geometry, spectroscopic properties,…)



State-of-the-art REDFA Codes



1

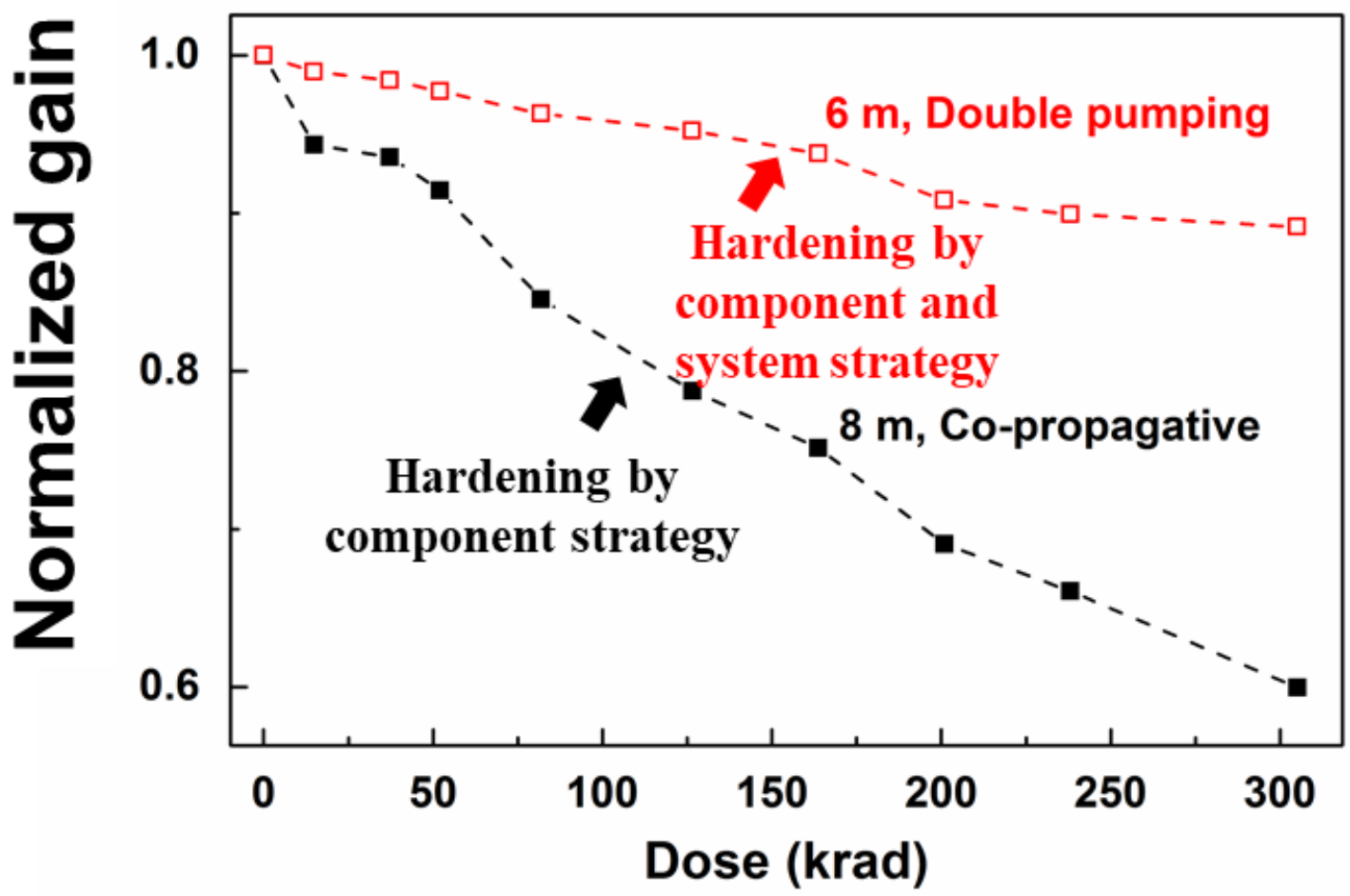
Radiation Effects

2

Optimization of the REDFA architecture to obtain the best optical performances **during the space mission**

3

The addition of the Hardening by system strategy in complement of the conventional component hardening improves the amplifier response to radiations



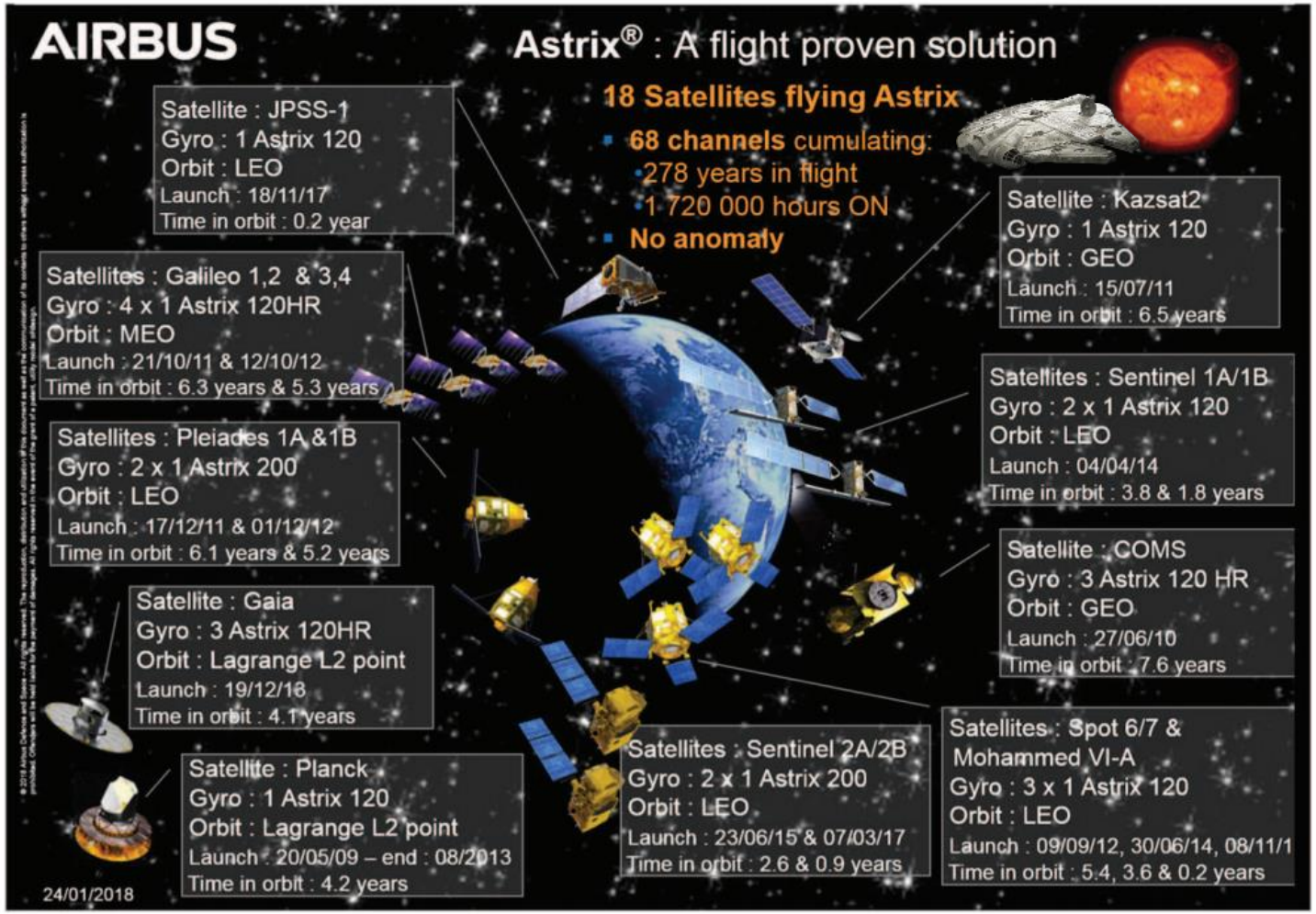


Figure 28. Astrix® fiber optic gyro space fleet (last update: 01/24/18). Image created by Airbus for this article. Used with permission.

Sylvain Girard et al 'Recent advances in radiation-hardened fiber-based technologies for space applications,' journal of Optics, 20, 9 (2018)

Merci de votre attention

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