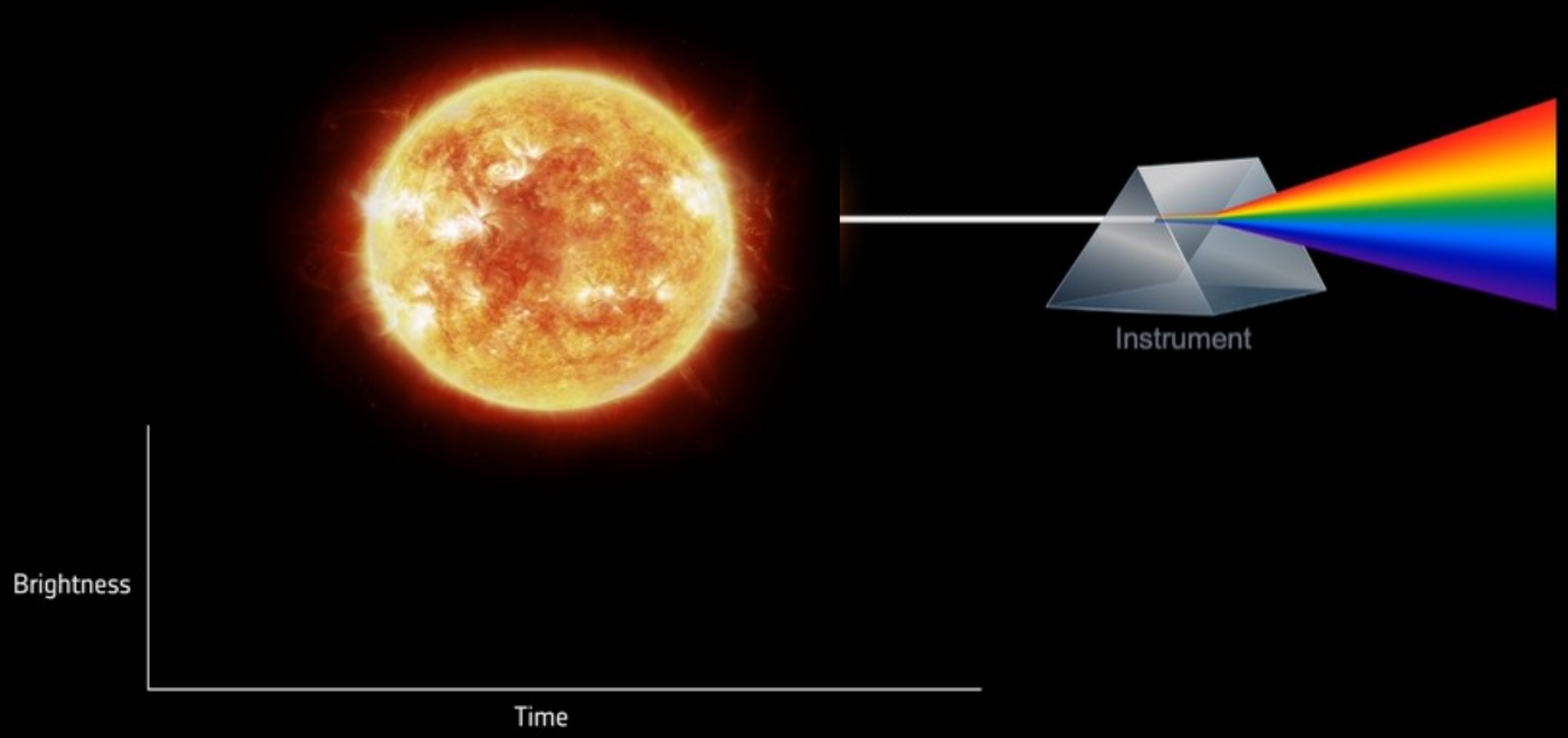
ORPHÉE FAUCOZ (CNES)

15/10/2025

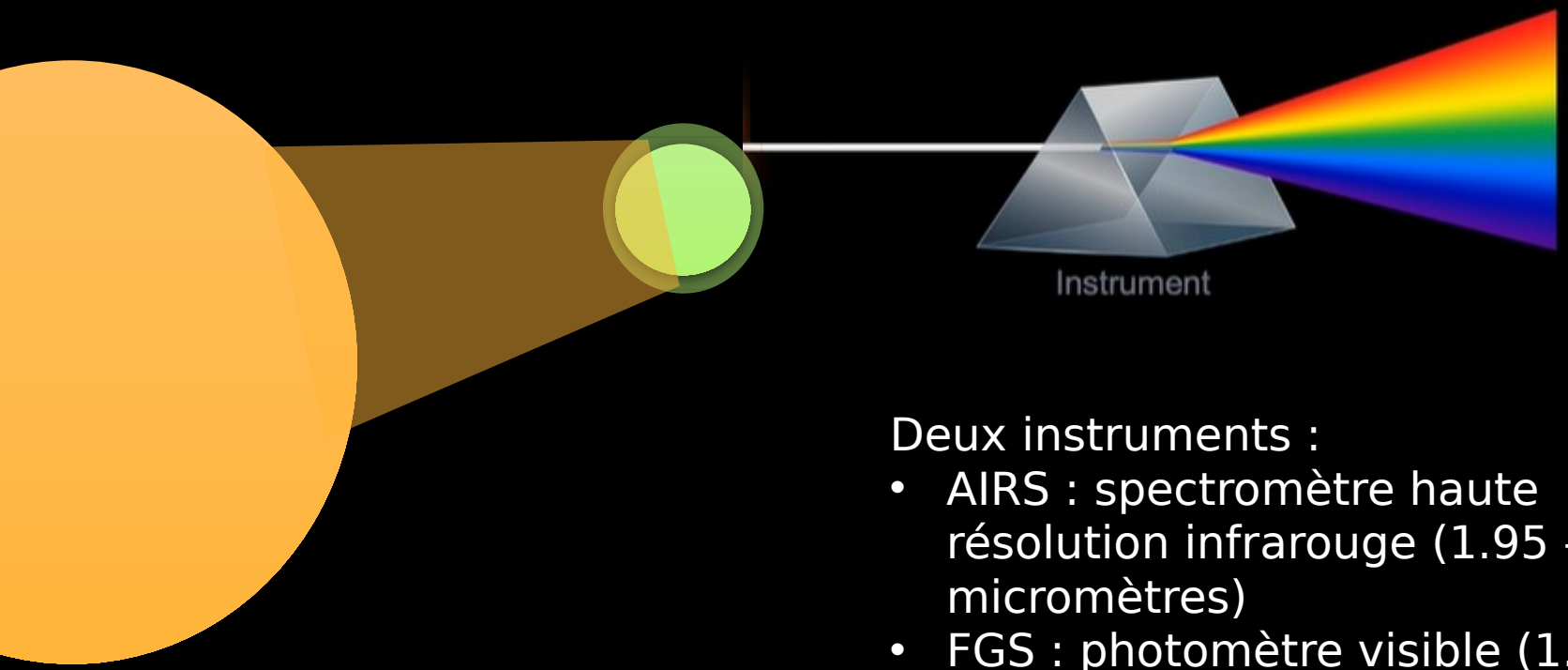
| CONTEXTE



https://www.esa.int/ESA_Multimedia/Videos/2019/12/Detecting_exoplanets_with_the_transit_method

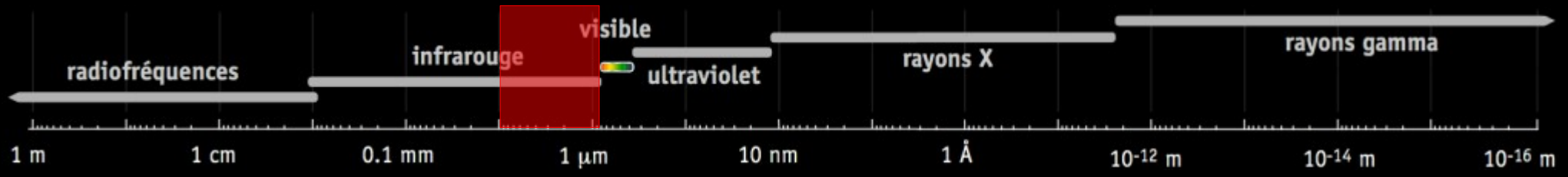
https://science.nasa.gov/resource/spectroscopy-detection-of-biosignatures/

| CONTEXTE

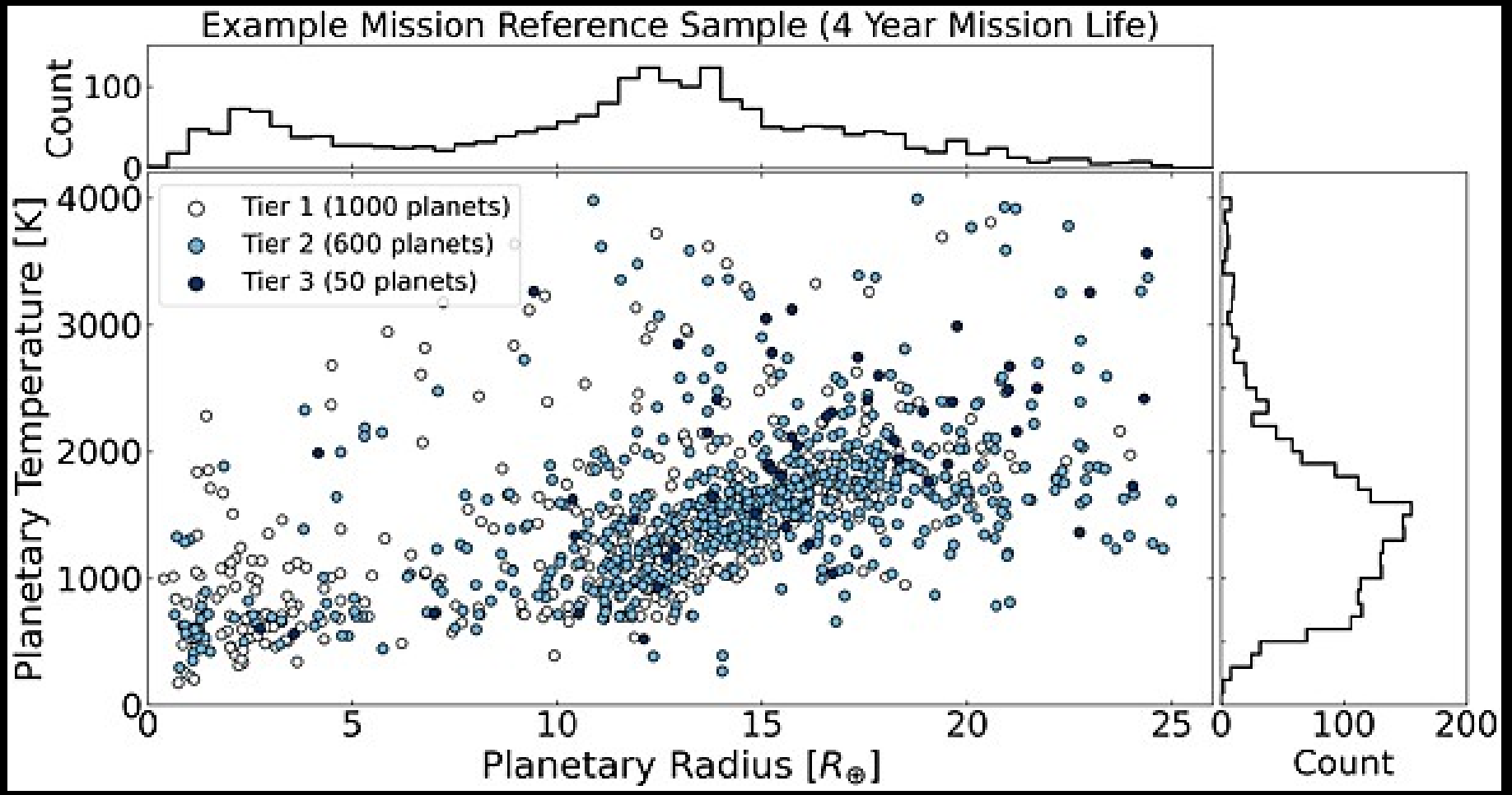


Deux instruments :

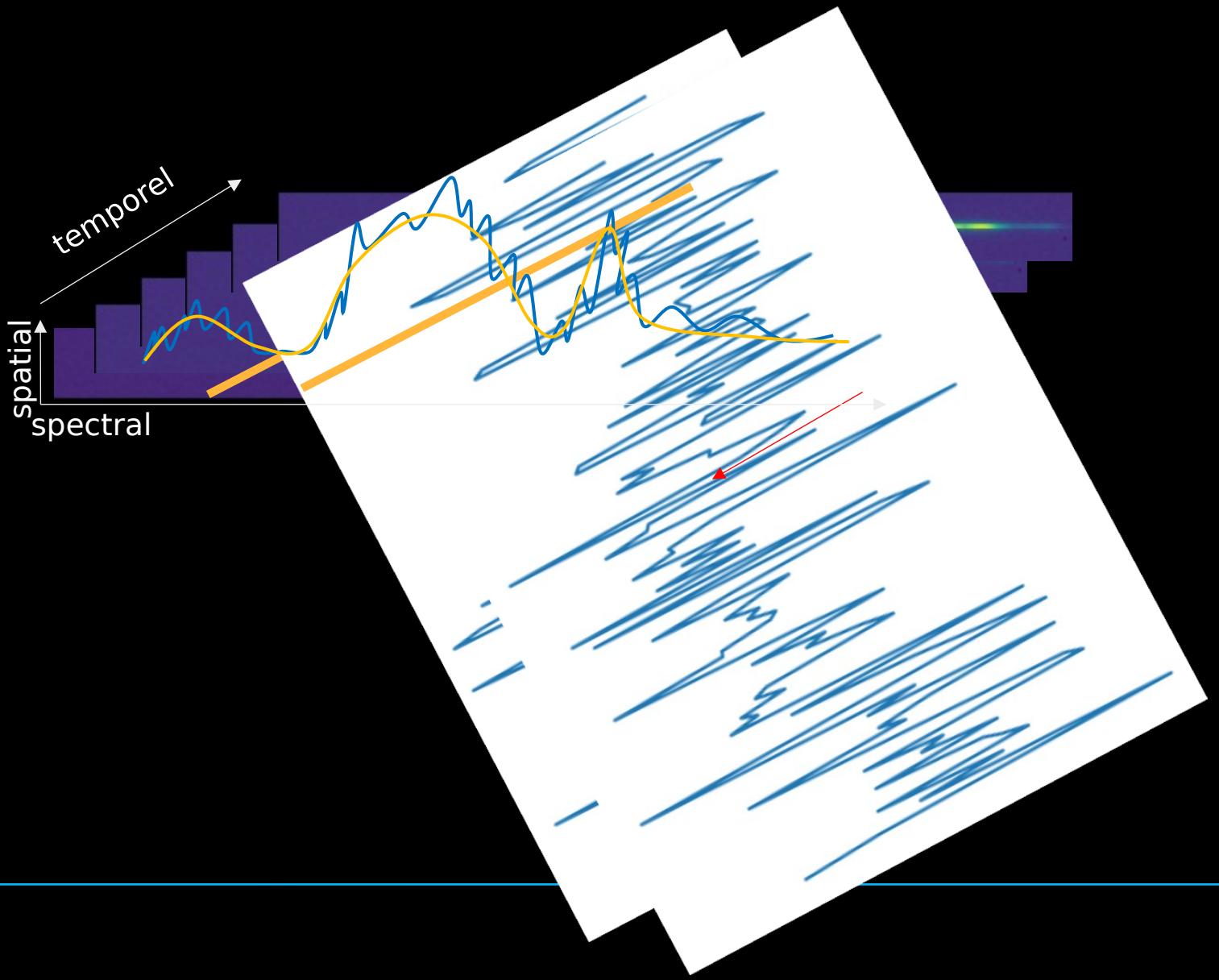
- AIRS : spectromètre haute résolution infrarouge (1.95 – 7.8 micromètres)
- FGS : photomètre visible (1.1 à 1.95 micromètres)



| CONTEXTE

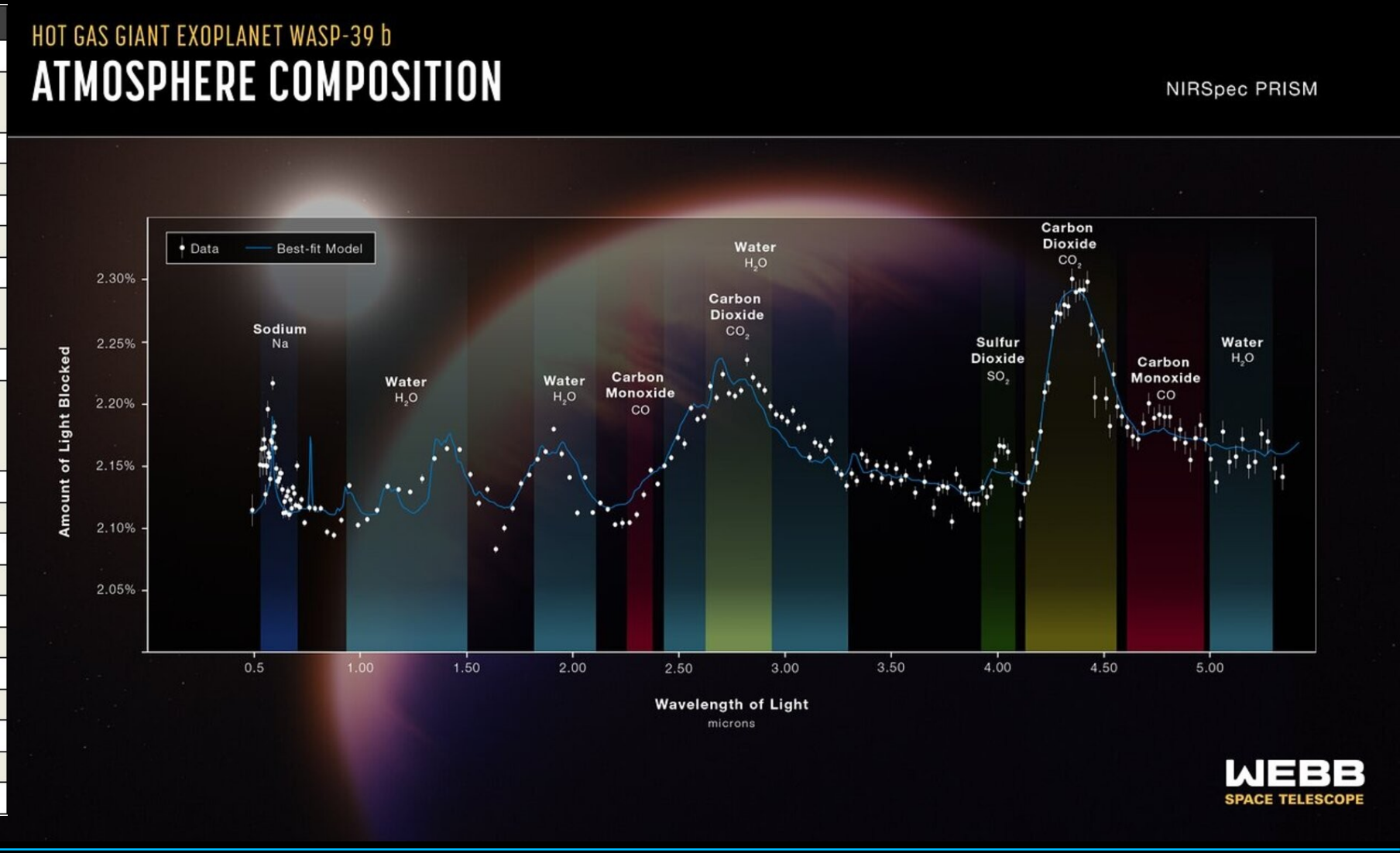

Example Mission Reference Sample (4 Year Mission Life)
Count
100
0
Tier 1 (1000 planets)
Tier 2 (600 planets)
Tier 3 (50 planets)
Planetary Temperature [K]
4000
3000
2000
1000
0
0
5
10
15
20
25
Planetary Radius [$R_\oplus$]
0
100
200
Count

| OBSERVATION VERS SPECTRE

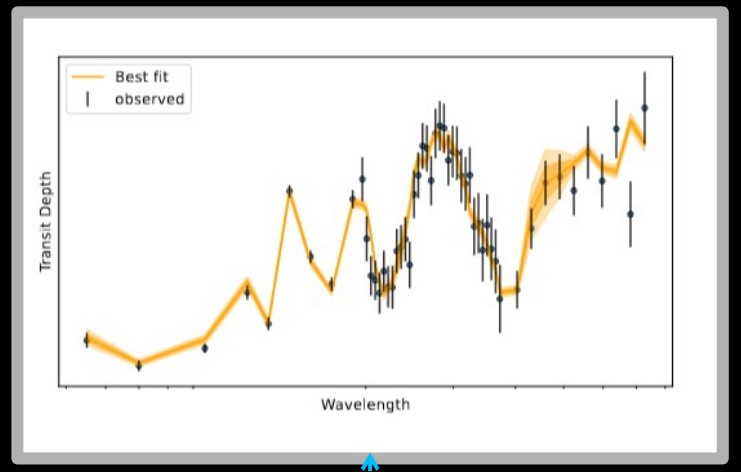


| CONTEXTE

	2-5 µm	5-8 µm
H_2O*	**2.69**	6.2
CO_2*	2.03, **4.25**	-
C_2H_2	**3.0**	7.53
HCN	**3.0**	-
O_3	4.7	-
HDO	2.7, 3.67	7.13
CO*	2.35, **4.7**	-
NH_3	2, 2.25, 2.9, **3.0**	6.1
PH_3	4.3	-
CH_4*	2.2, 2.31, 2.37, **3.3**	6.5,7.7
CH_3D	3.34, **4.5**	6.8, 7.7
C_2H_4	**3.22**, 3.34	6.9
H_2S	2.5, 3.8, ...	7
SO_2	4	7.3
N_2O	2.8, 3.9, **4.5**	7.7
NO_2	3.4	6.2, 7.7
H_3^+	2.0, 3-4.5	-
TiO	2-3.5	-
VO	2-2.5	-
FeH	2	-
C_2H_6	**3.35**	6.79



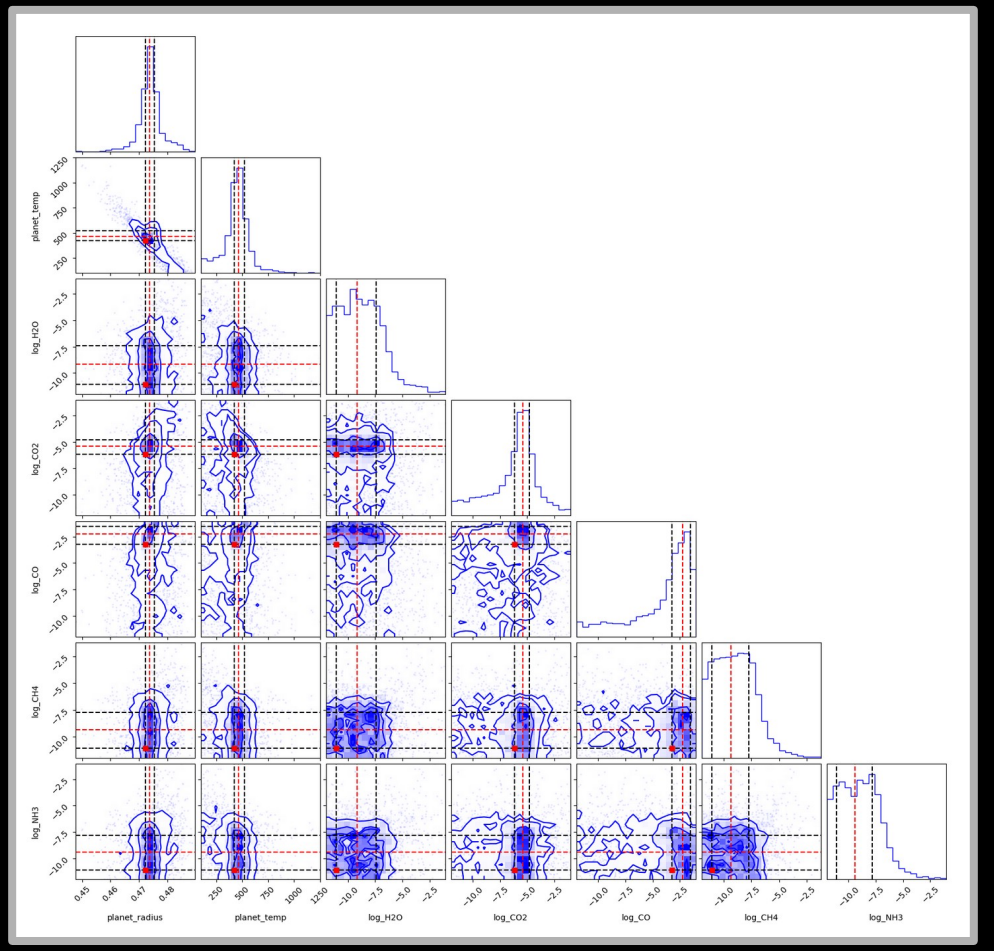
| LE RETRIEVAL



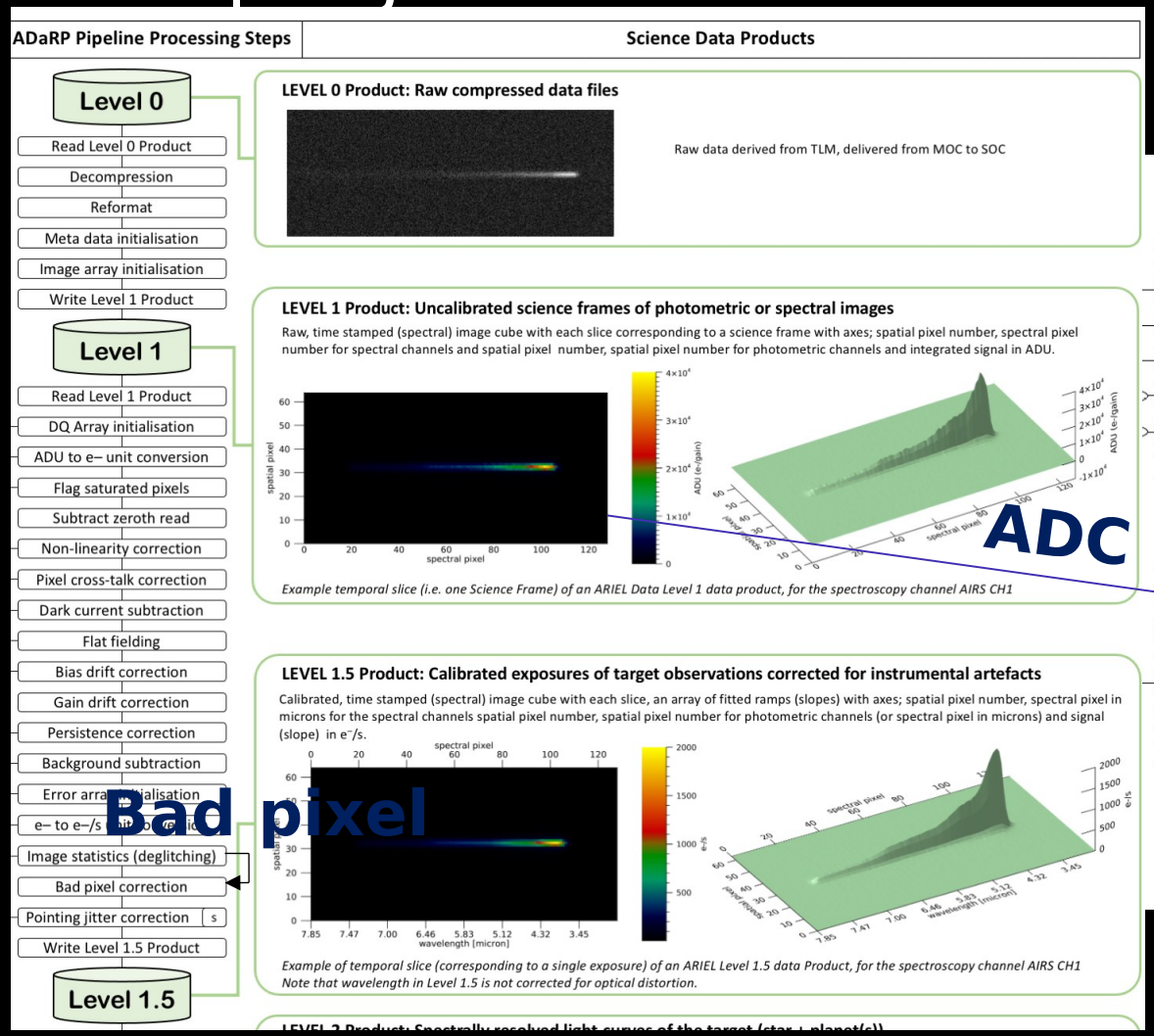
MCMC / Nested Sampling

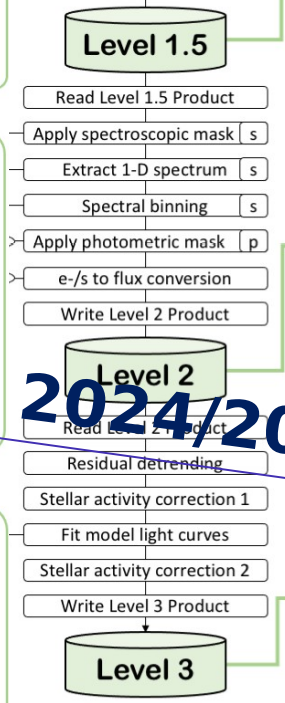
Température

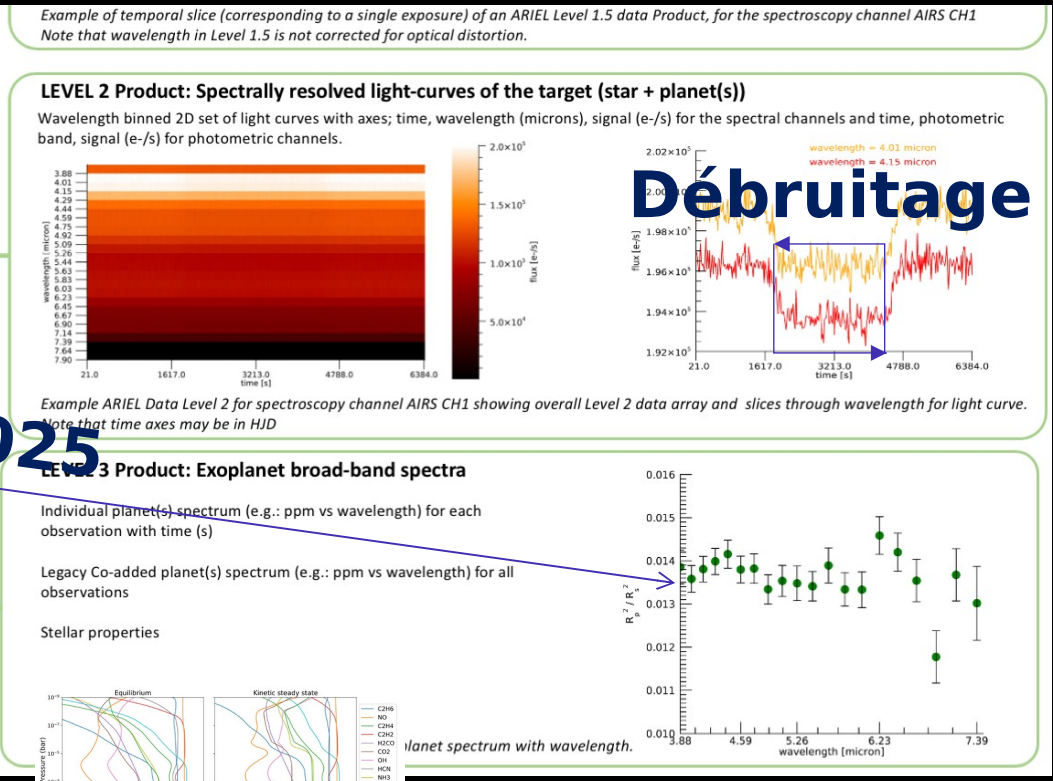
H2O



| OBJECTIFS







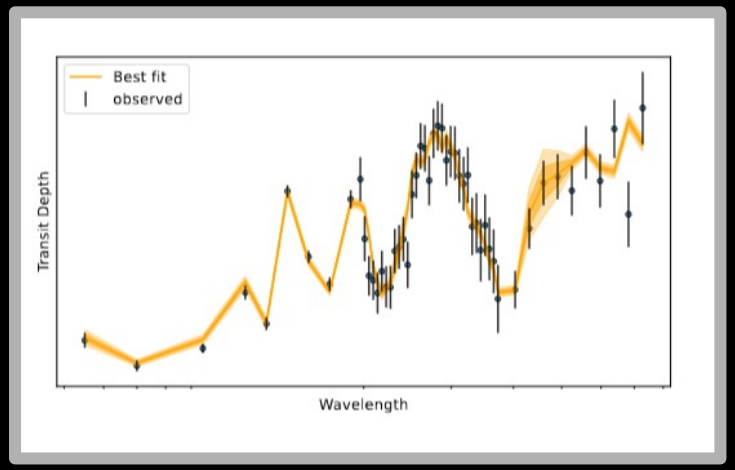
ADC 2024/2025

Chimie

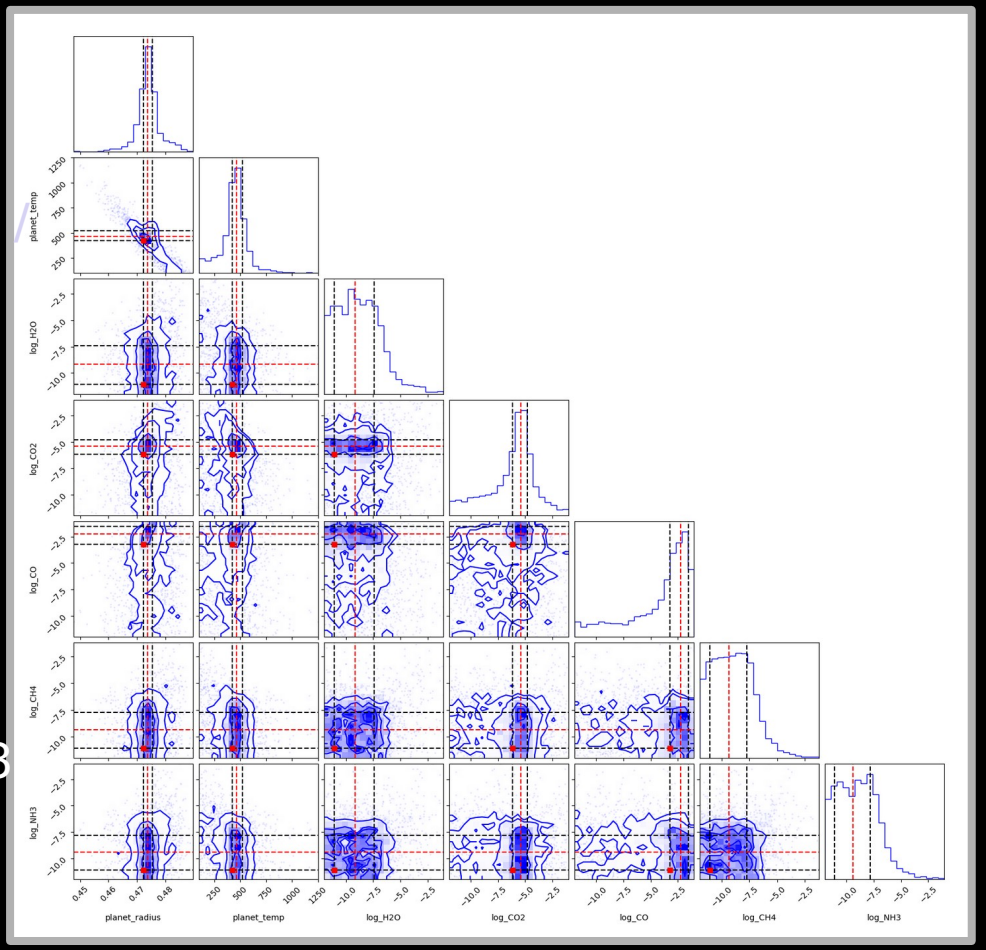
ADC 2022/2023

Abondances chimiques, profil thermique, nuage ...

| ADC 2022/2023



Réseau de convolution
NF

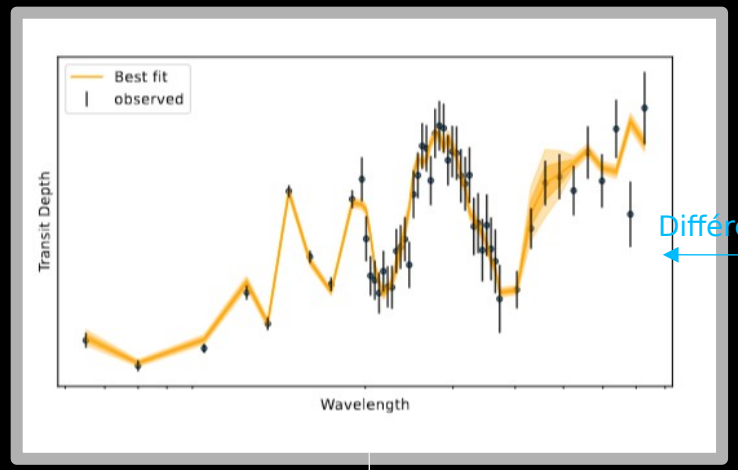


~26 000 spectres simulés et leurs abondances (Taurex 3
+80 000 spectres sans abondance

448 participants

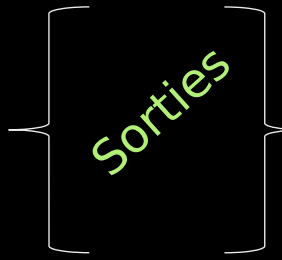
Métrique : distance de Wasserstein-2 (2022), Kolmogorov-Smirnov-2 (2023)

| POUR ALLER AU-DELÀ ?

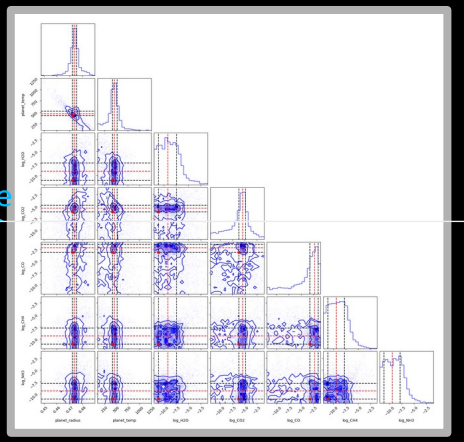


Différence

Taurex 3

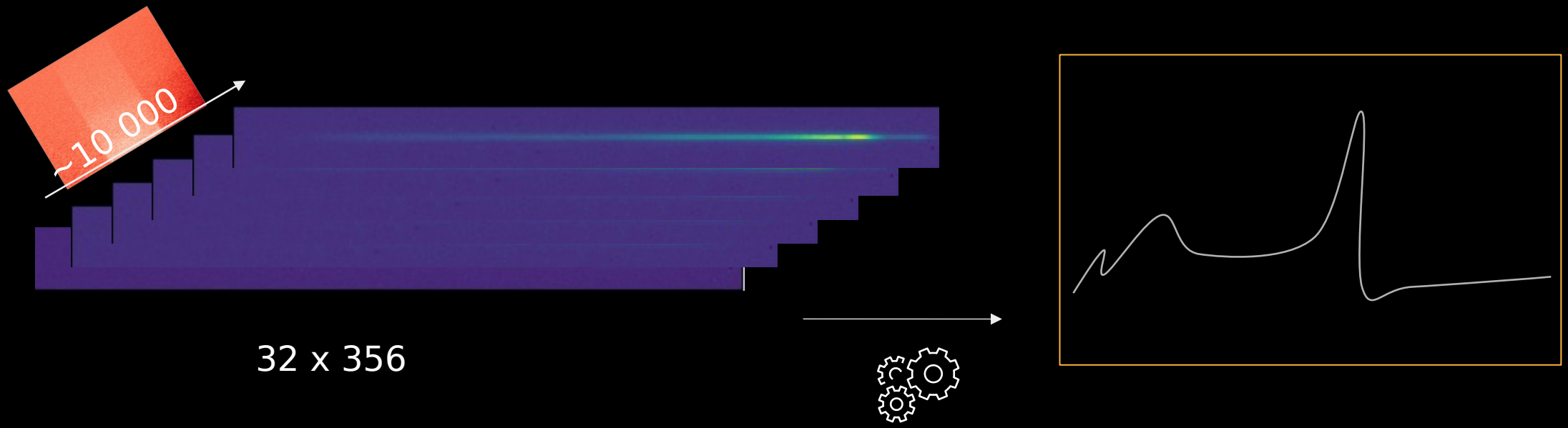


Différence



Paramètres connus

| ADC 2024



644 observations de transit simulées par ExoSim 2 sur FGS1 et AIRS-CH0

644 spectres

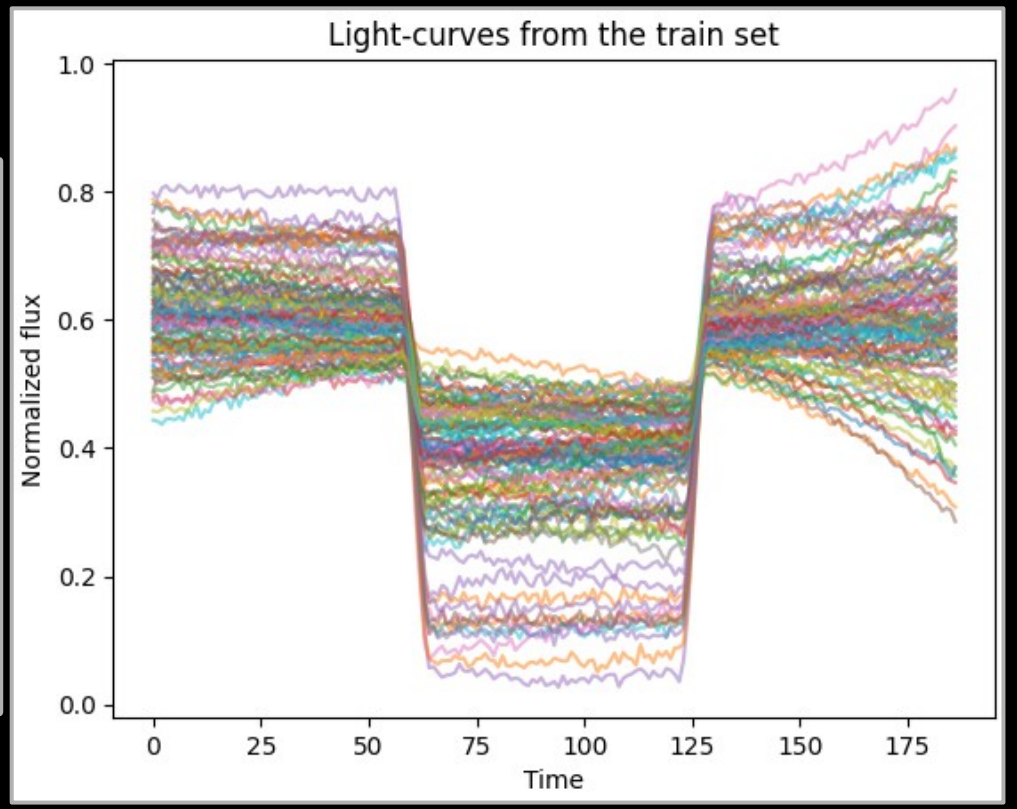
1150 participants (1080 soumissions) !

IAP/CNES dans la Baseline Team

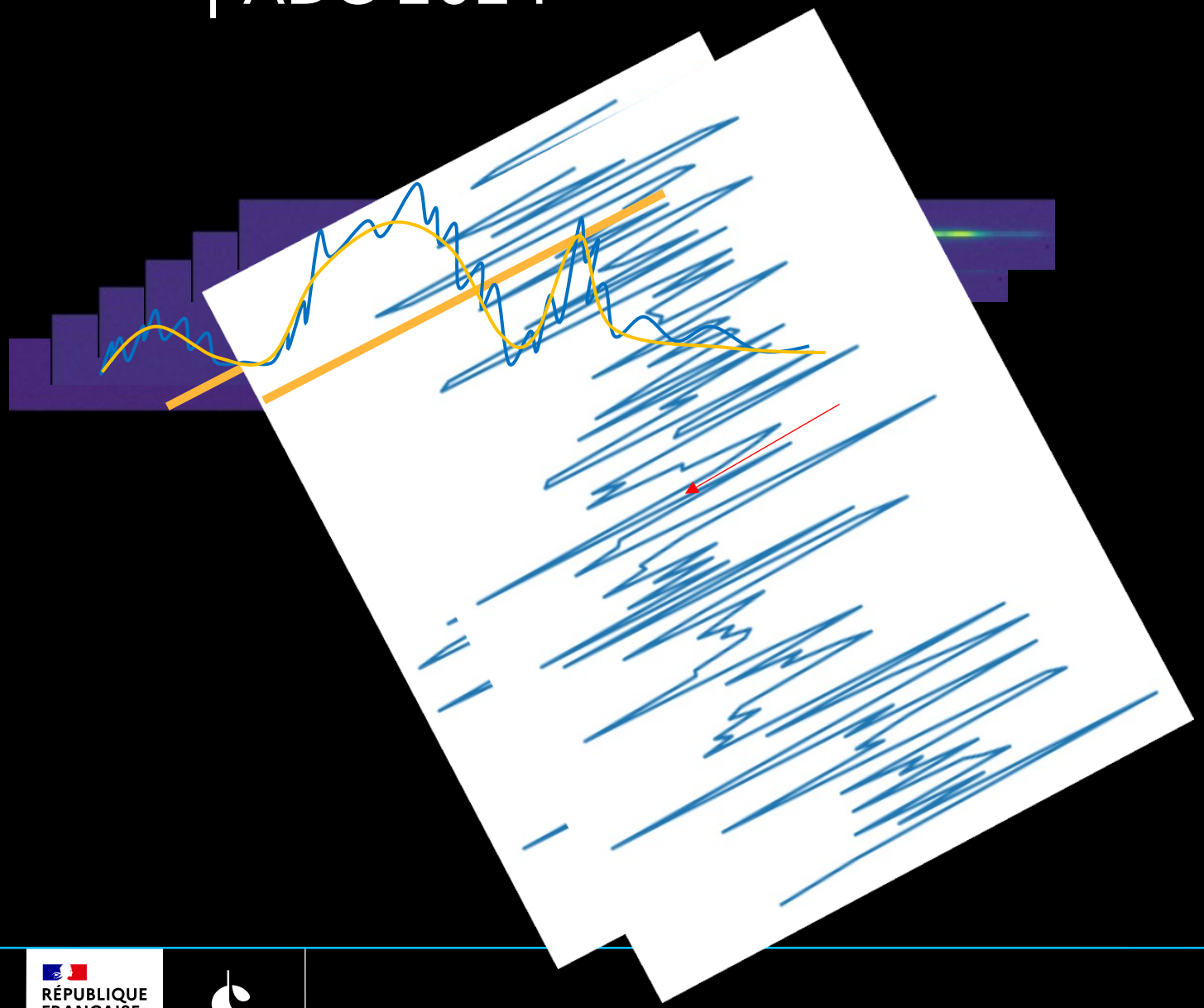
| ADC 2024

Diversité du jeu de données

	Training	Training-Ext	Test case 0	Test case 1
R_p range (R_{Jup})	0.5 - 1.2	0.5 - 1.2	0.5 - 1.2	0.5 - 1.2
Host Stars	KELT-11, HD 17194	KELT-11, HD 17194	KELT 11, HD 17194	KELT-11, HD 17194
Trace gases	H_2O, CH_4, CO_2, Cloud	H_2O, CH_4, CO_2, Cloud	NH_3, C_2H_2, SO_2, SiO	NH_3, C_2H_2, SO_2, SiO
Detector type	Model A	Model A	Model A	Model B
Semi-Major Axis	Fixed	$\mathcal{U}(8.81, 11)$	Fixed	Fixed
Inclination	Fixed	$\mathcal{U}(86.71,88)$	Fixed	Fixed
Mid Transit Time	Fixed	$\mathcal{U}(t_0\text{-}0.1,t_0\text{+}0.1)$	Fixed	Fixed



| ADC 2024



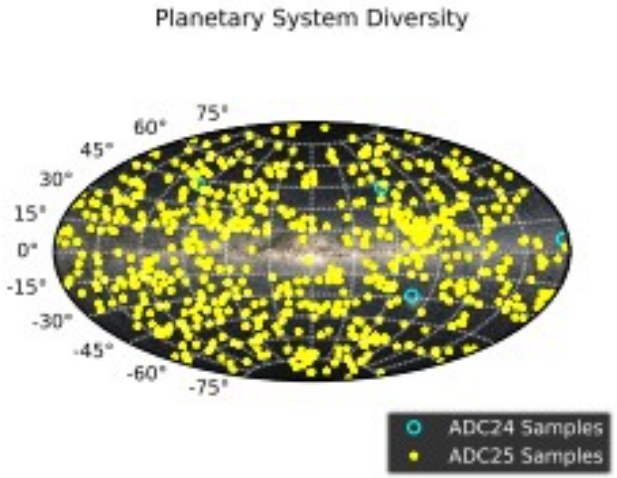
Estimation de la profondeur de transit par wl

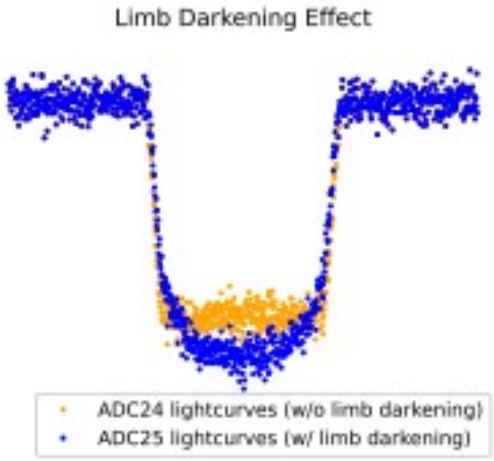
Comment ?

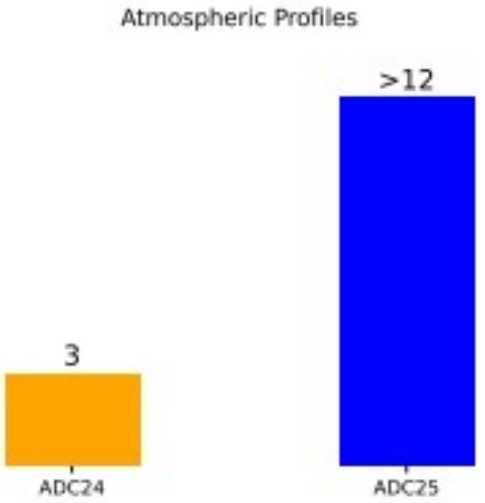
- Estimation de début et de fin de transit par interpolation
- Estimation de profondeur par interpolation
- Amélioration par méthode de machine learning (Autoencodeur, GPR, NMF)

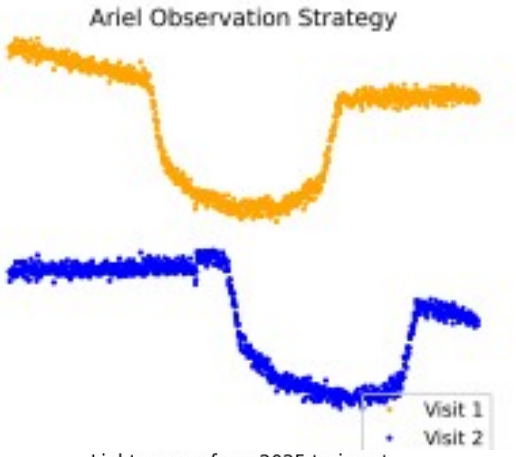
- Estimation du rayon par transit moyen sur la courbe de lumière

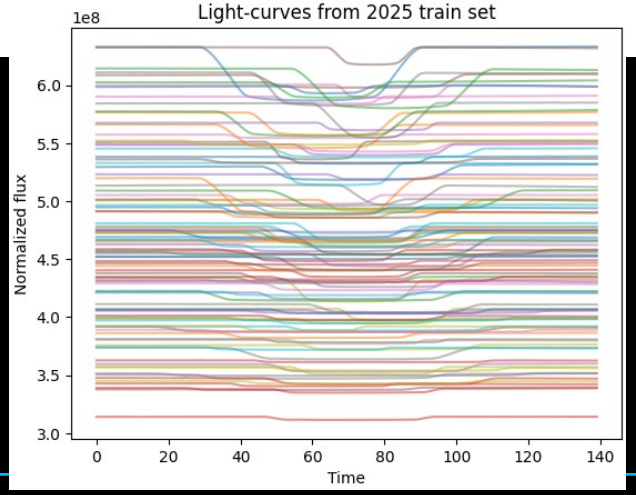
| ADC2025







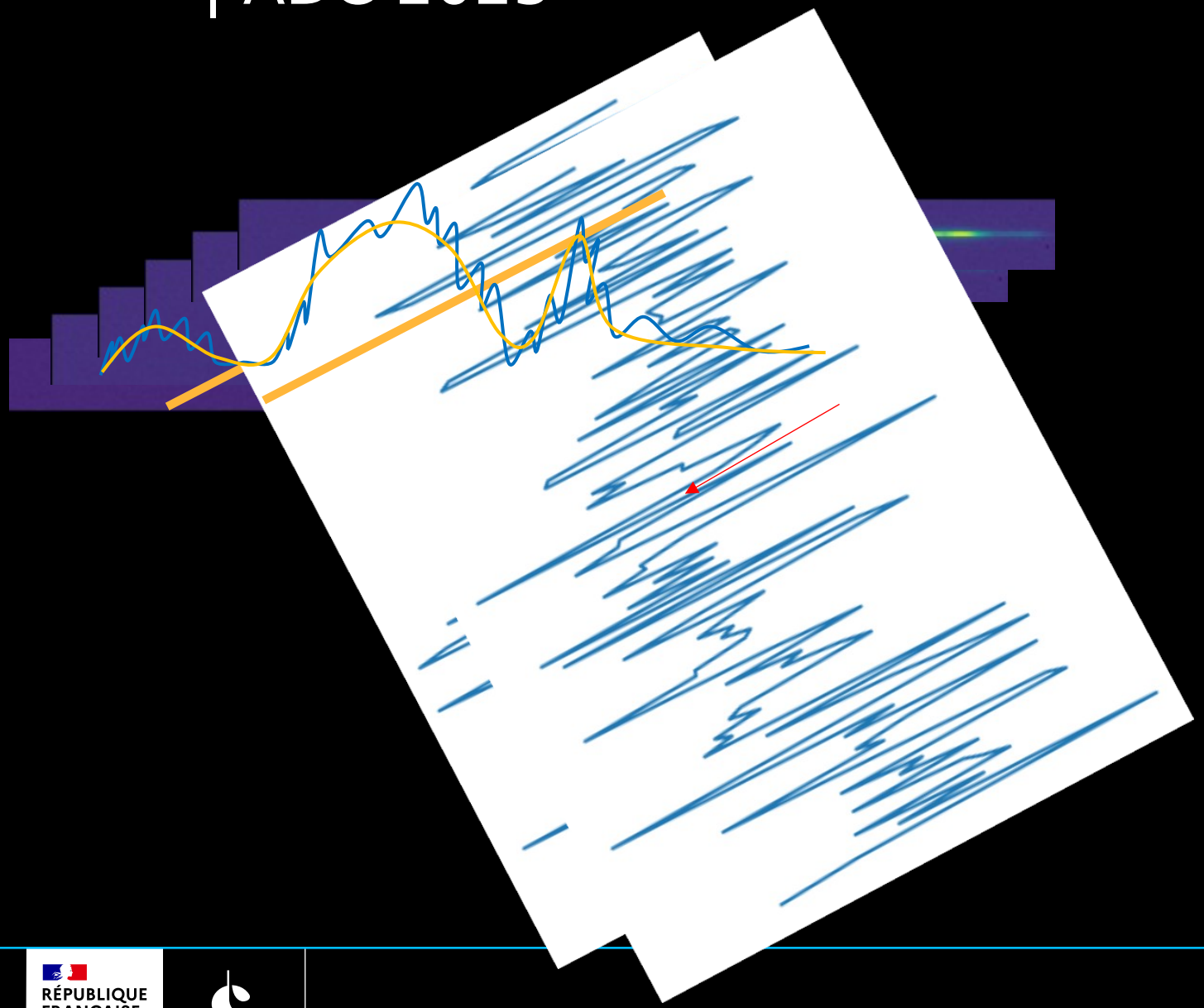




1000 observations ?

IAP/CNES dans la Baseline Team

| ADC 2025



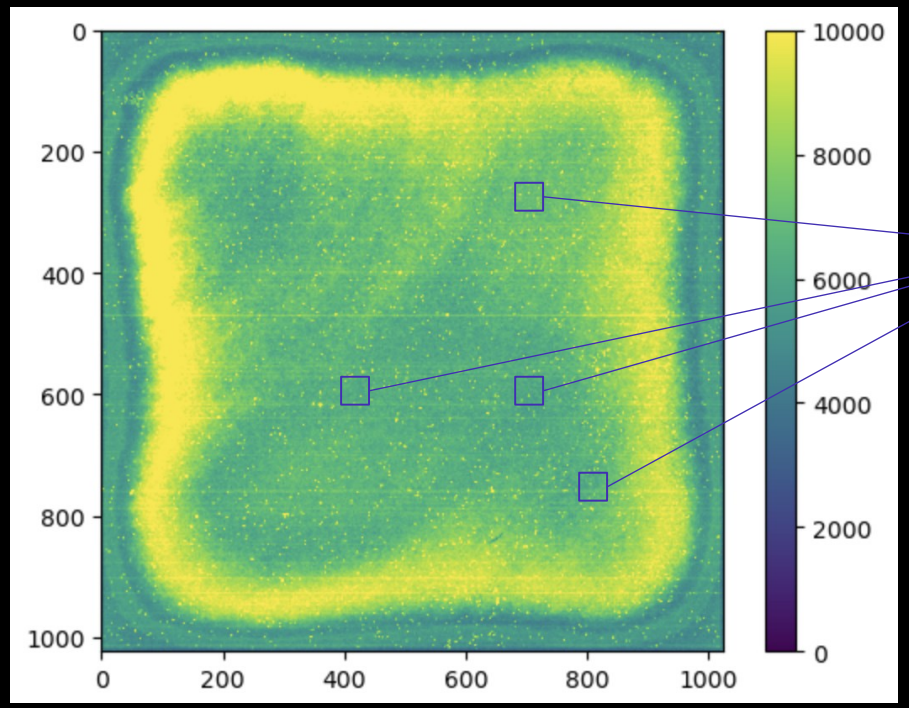
Estimation de la profondeur de transit par wl

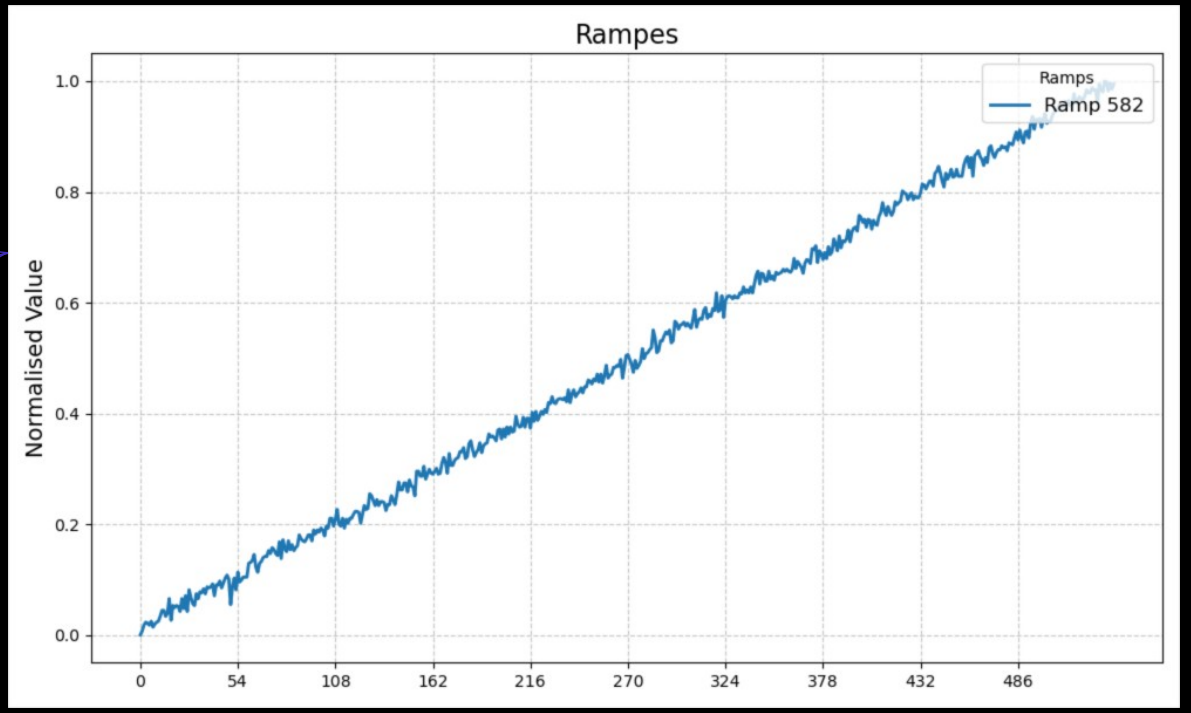
Comment ?

- Estimation de début et de fin de transit par interpolation
- Estimation de profondeur par interpolation
- Amélioration par méthode de machine learning (GPR)

- Estimation du rayon par transit moyen sur la courbe de lumière

| BAD PIXELS

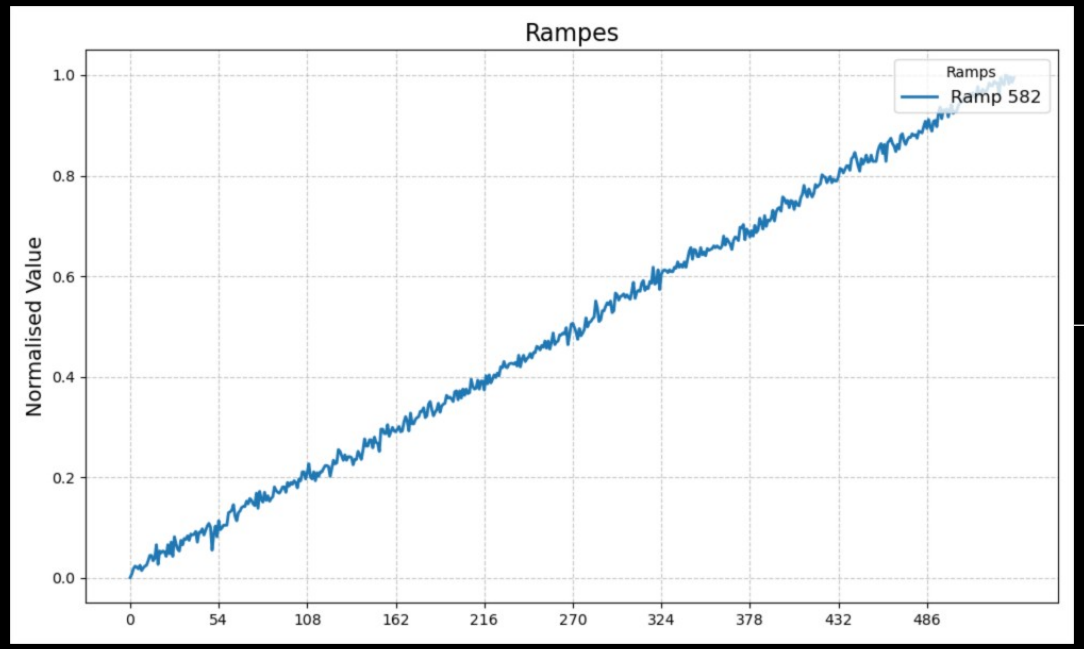




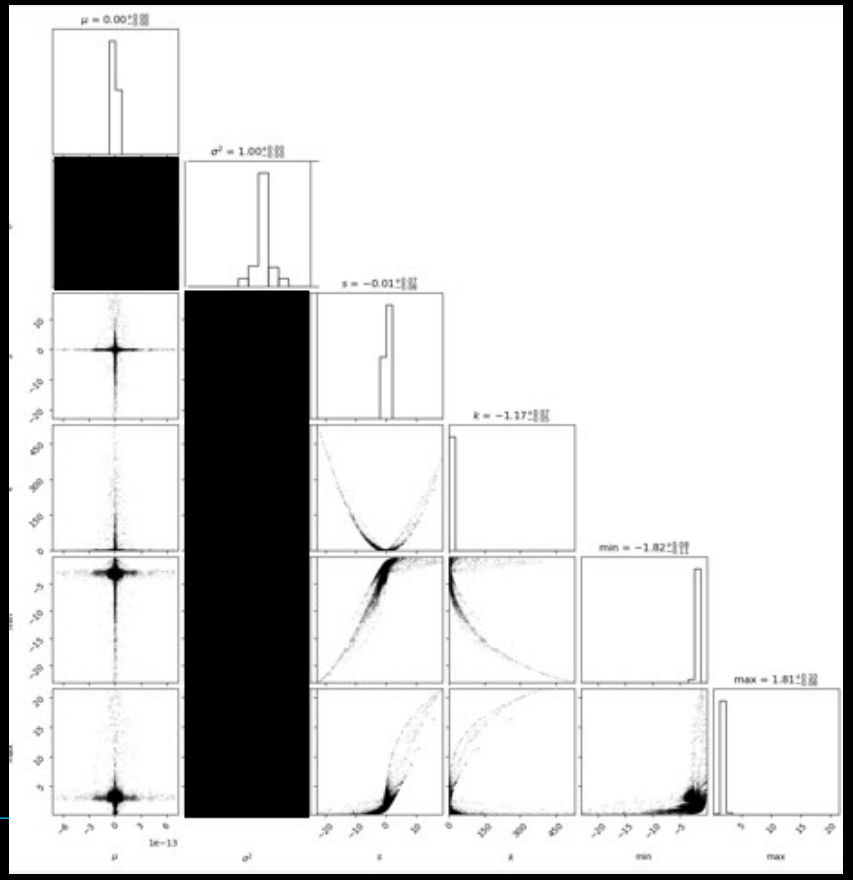
40 fichiers de dark mesurés au CEA

| BAD PIXELS

Non supervisé

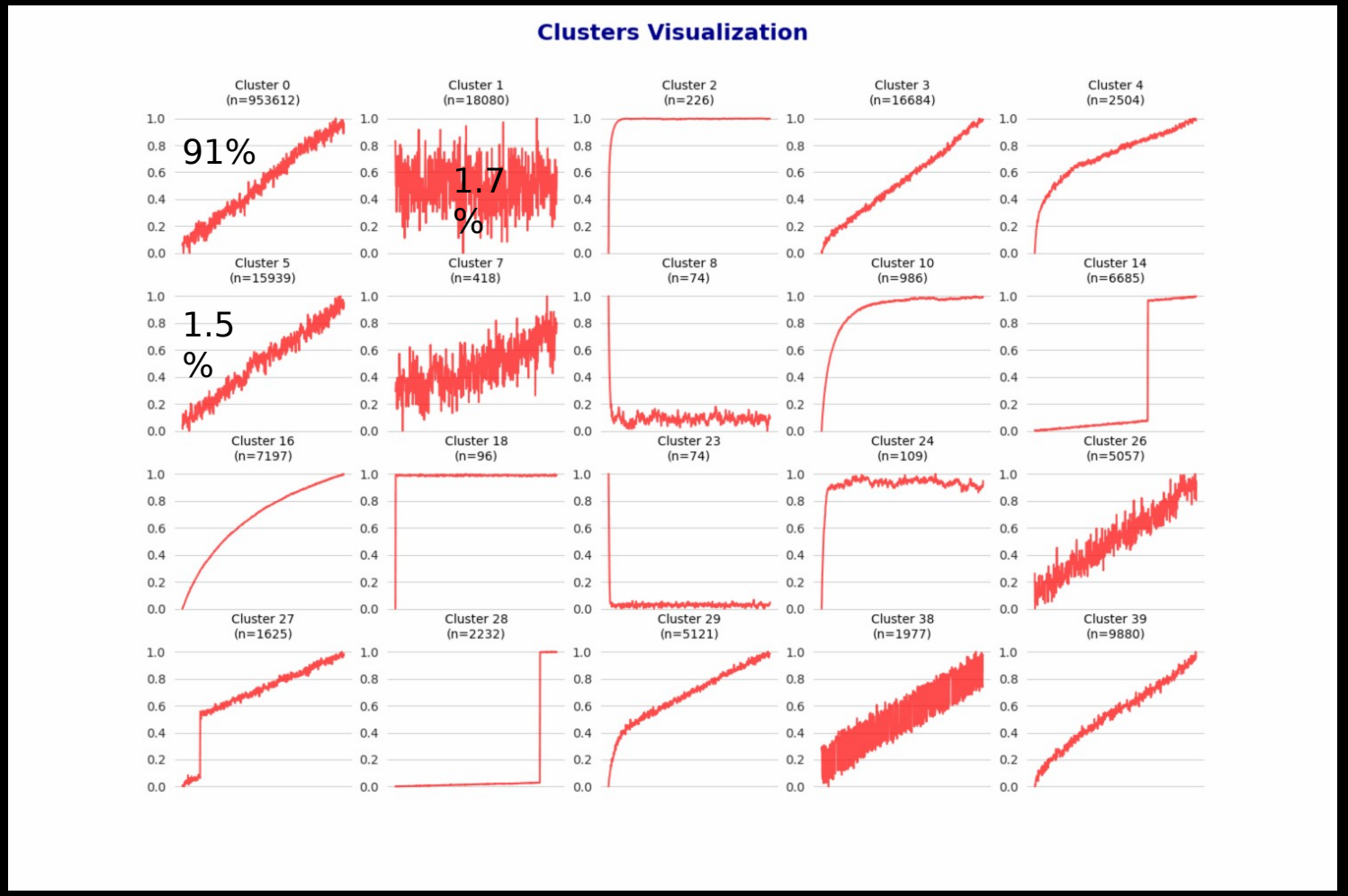


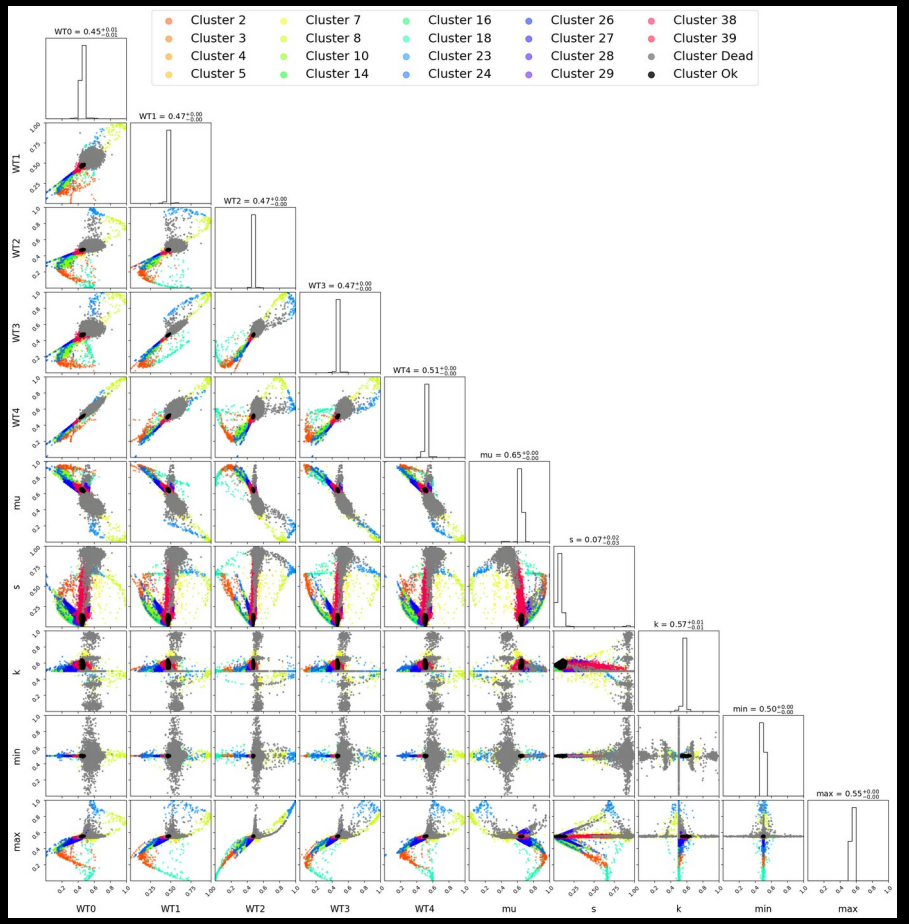
N profils



| BAD PIXELS

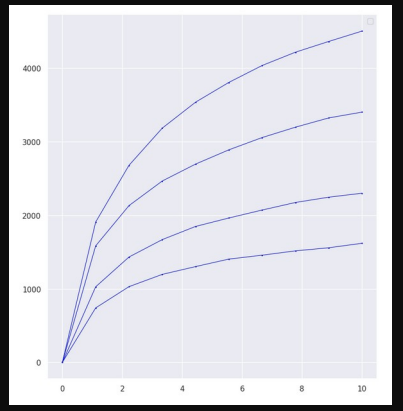
Non supervisé



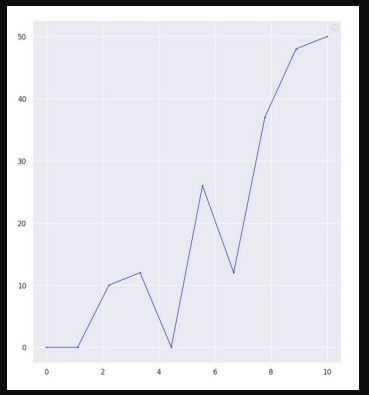


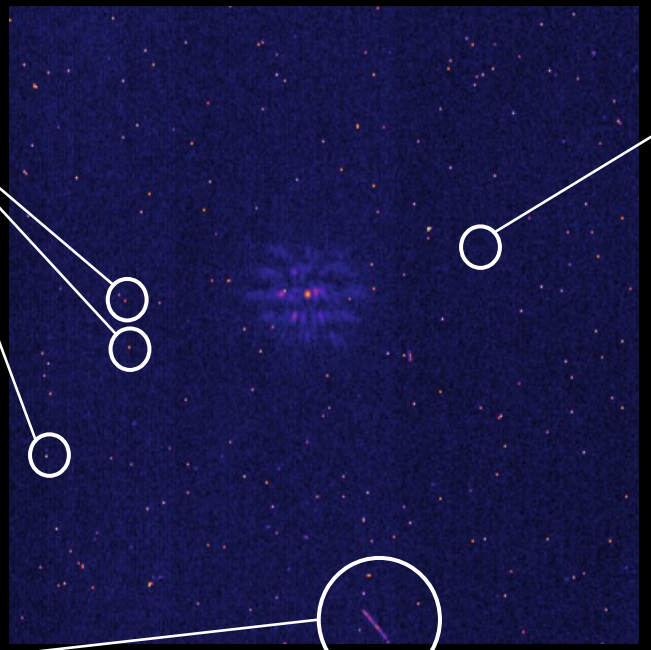
| BAD PIXELS SUR JWST

Hot /dead

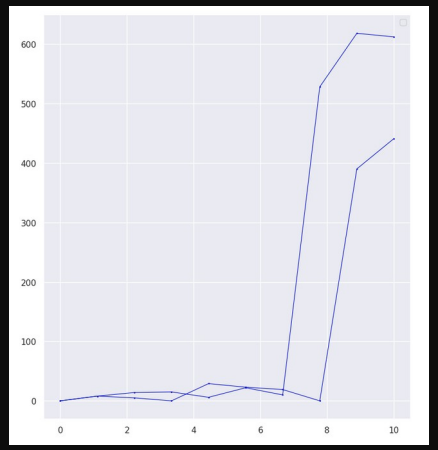


Low

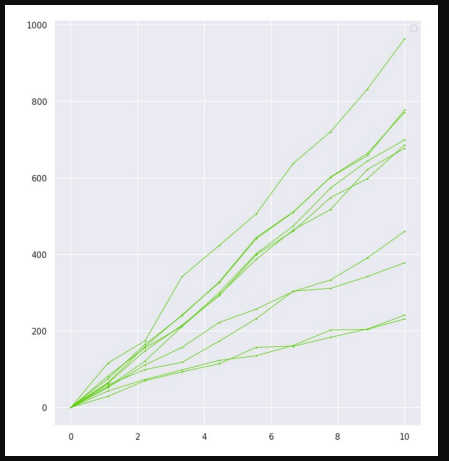




Jum



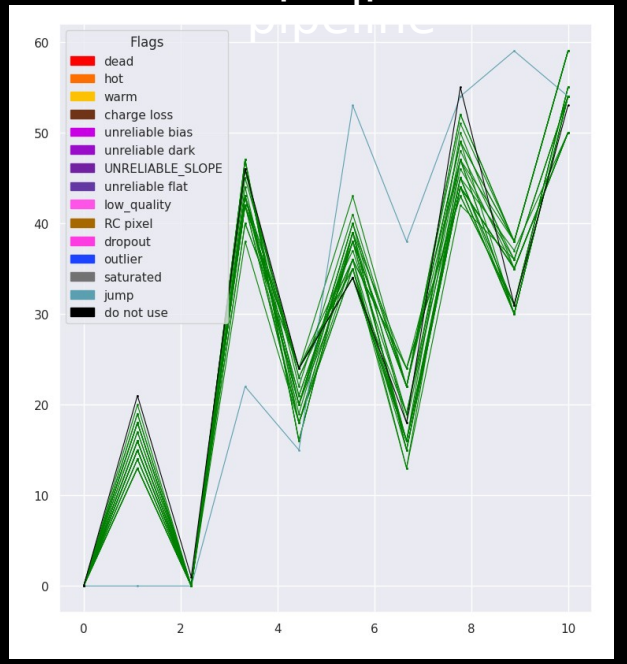
Good



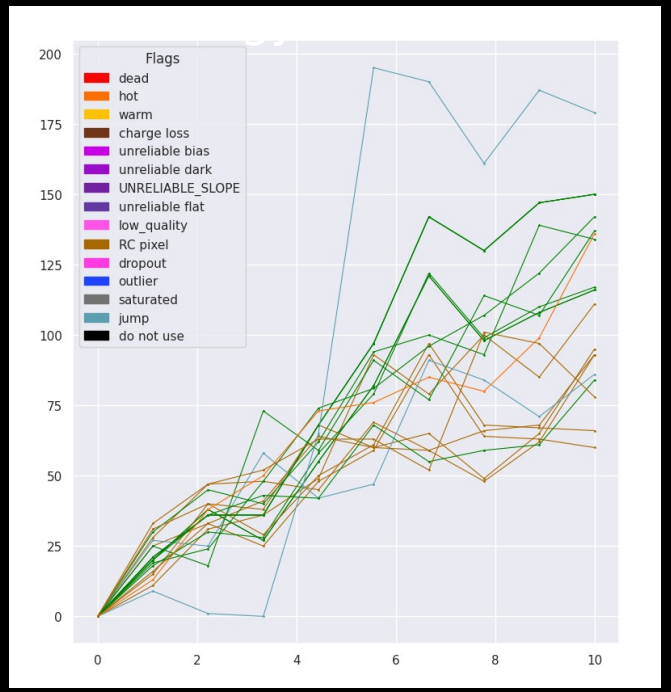
| BAD PIXELS SUR JWST

Défauts de la pipeline

« *good* » pixel d'après la

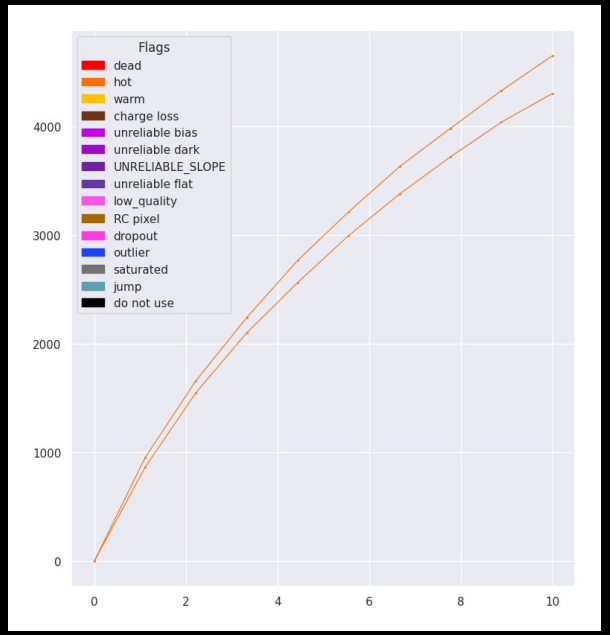


Le chaos des low-

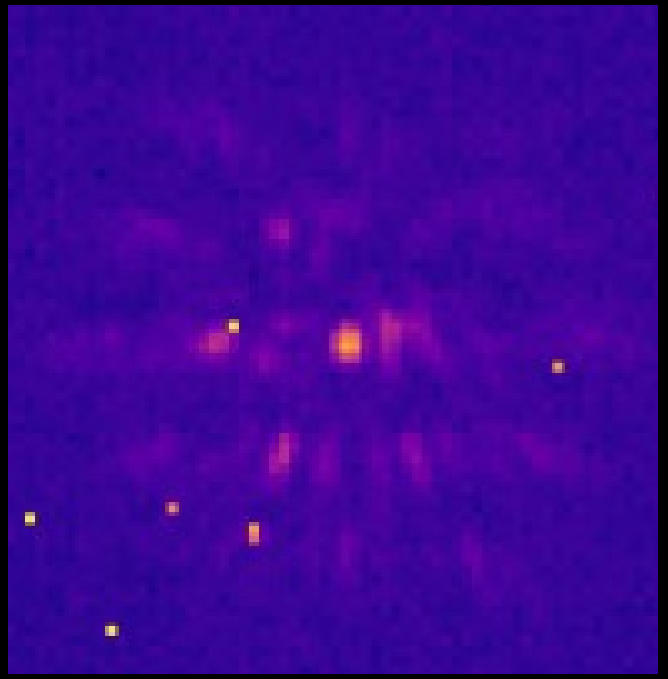


	good	*bad*
Précision	0.29	0.78
Rappel	0.57	0.52

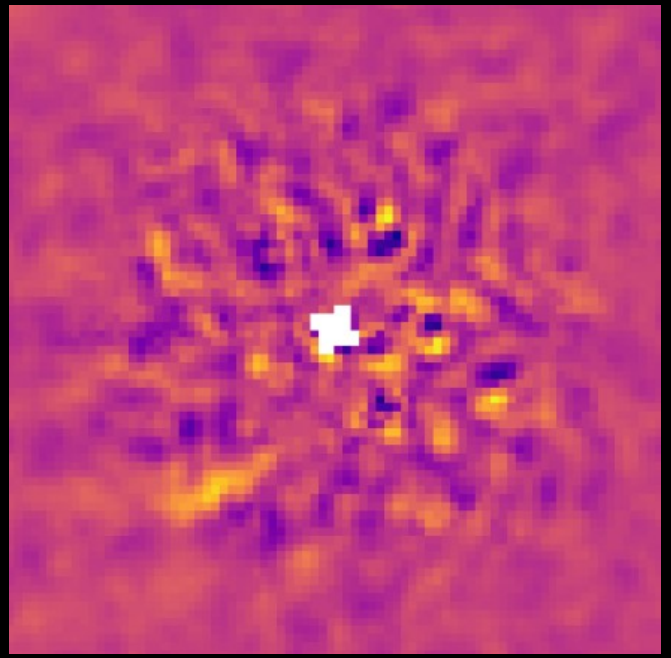
Les presque linéaires



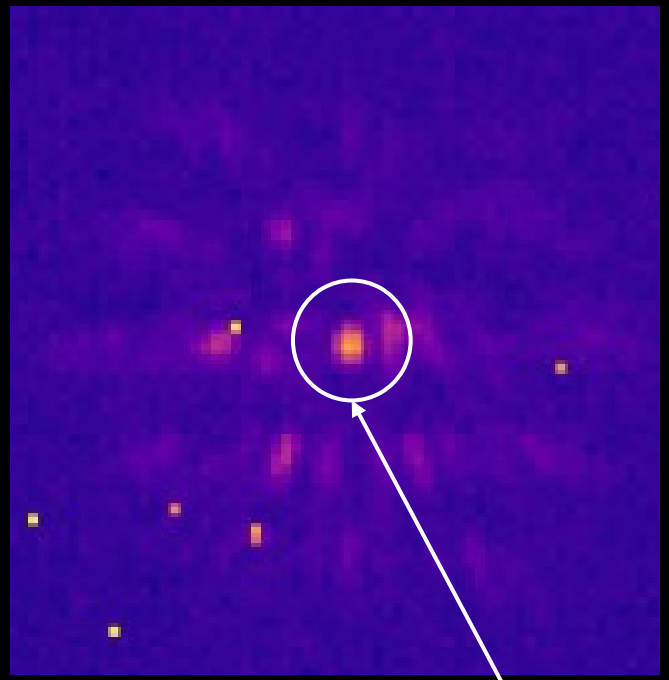
| 14 HERCULIS C



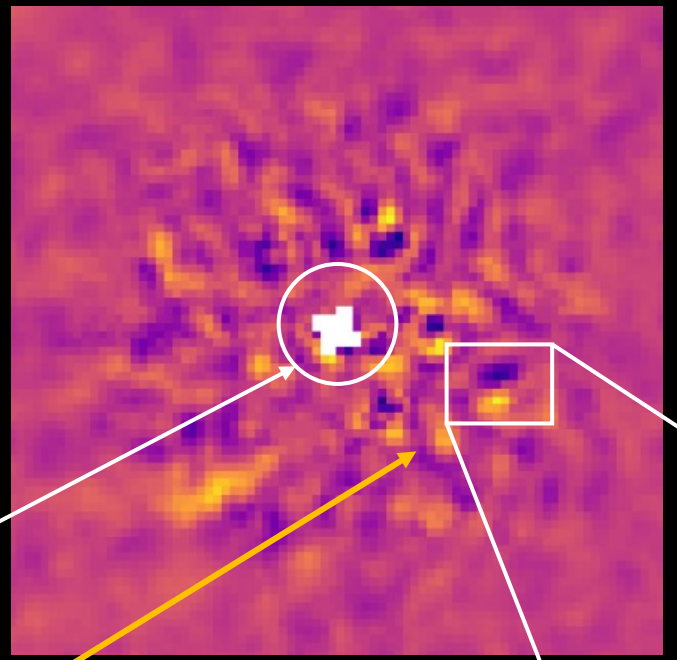
PIPELINE JWST



| 14 HERCULIS C



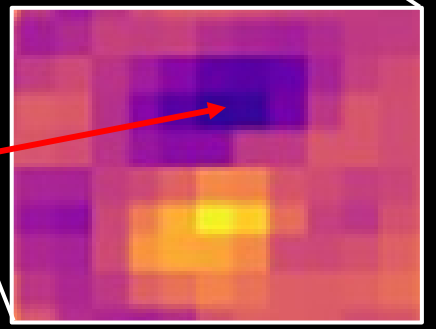
PIPELINE JWST



14 Herculis

14 Herculis C ?

Bad pixels



| BAD PIXELS JWST - NON SUPERVISÉ

Bayesian Gaussian mixture

	good	*bad*
Précision	0.79	0.94
Rappel	0.84	0.92

DBScan

	good	*bad*
Précision	0.82	0.81
Rappel	0.32	0.97

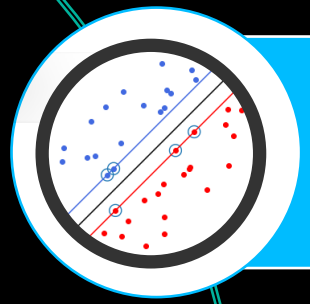
Spectral clustering

Pas assez de convergence

Images :2.3. Clustering — scikit-learn 1.7.1 documentation

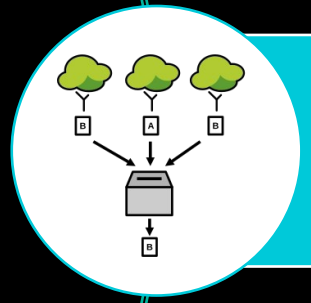
| BAD PIXELS JWST - SUPERVISÉ

PHASE EXPÉRIMENTALE



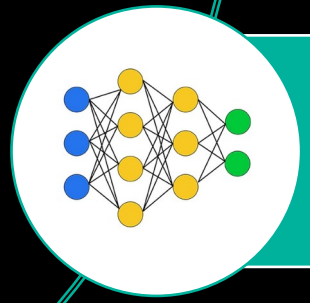
SVM

	good	*bad*
Précision	0.97	0.97
Rappel	0.91	0.99



Random Forest

	good	*bad*
Précision	0.90	0.96
Rappel	0.87	0.97



DNN

	good	*bad*
Précision	0.90	0.95
Rappel	0.83	0.97

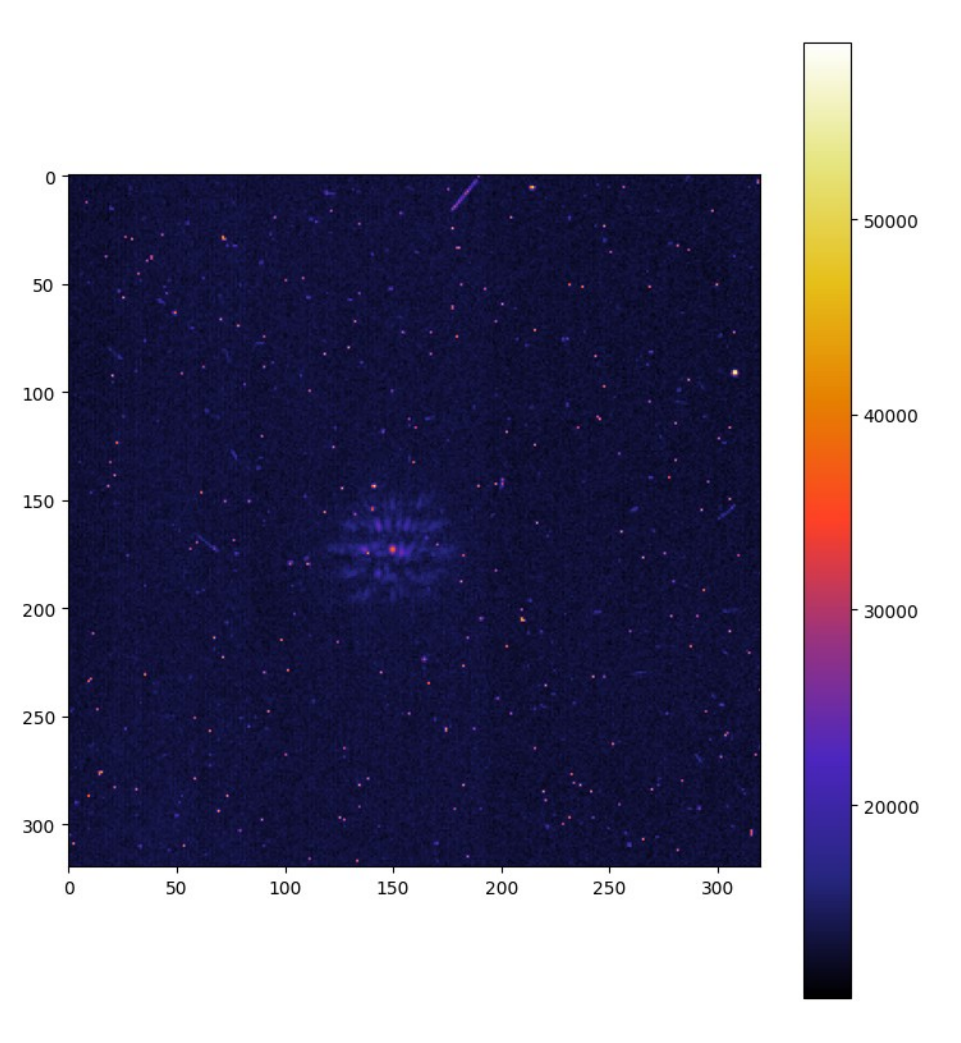
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

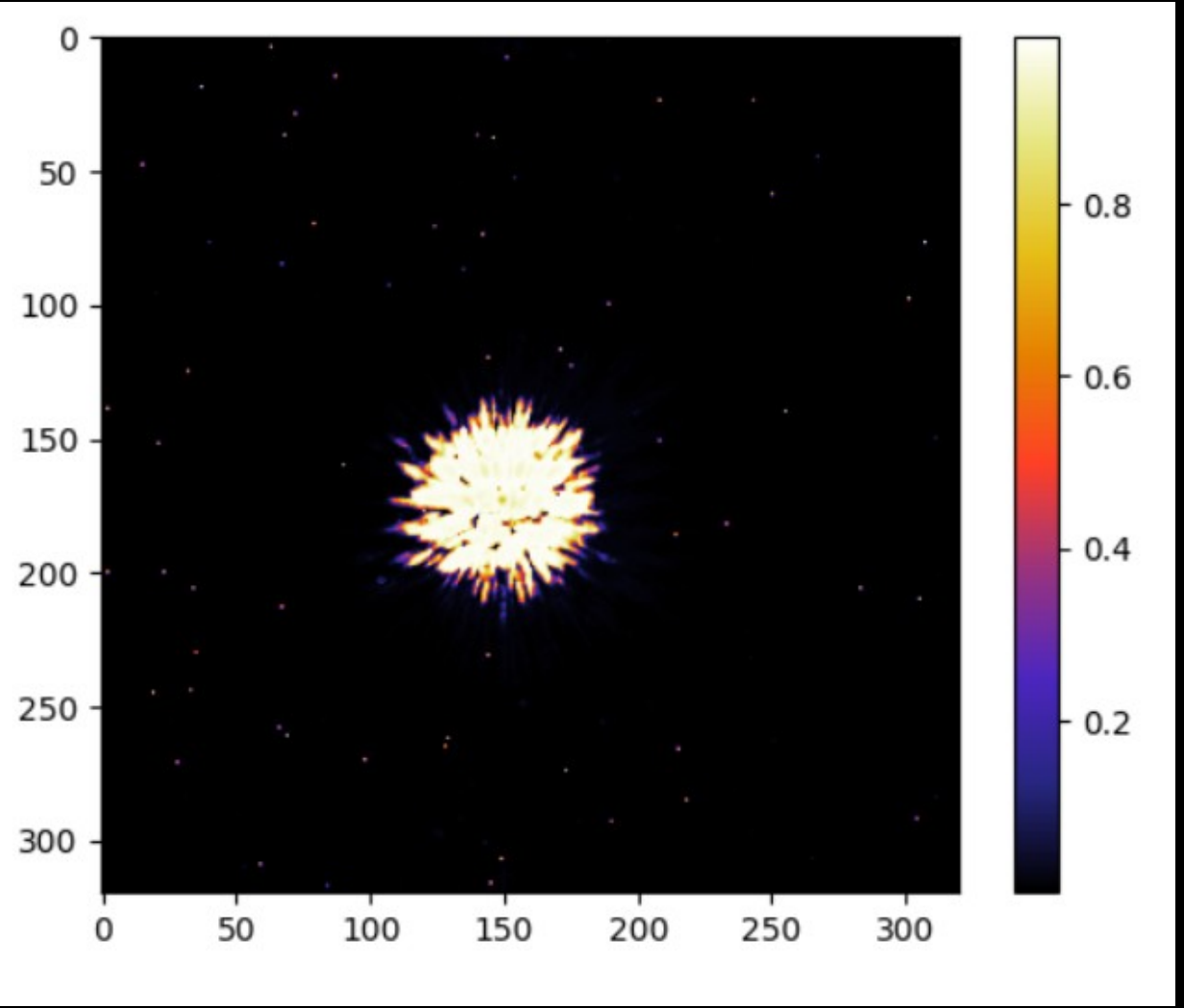
cnes

Images : SVM - Data Analytics Post, 12 Types of Neural Networks in Deep Learning, Forêt d'arbres décisionnels — Wikipédia

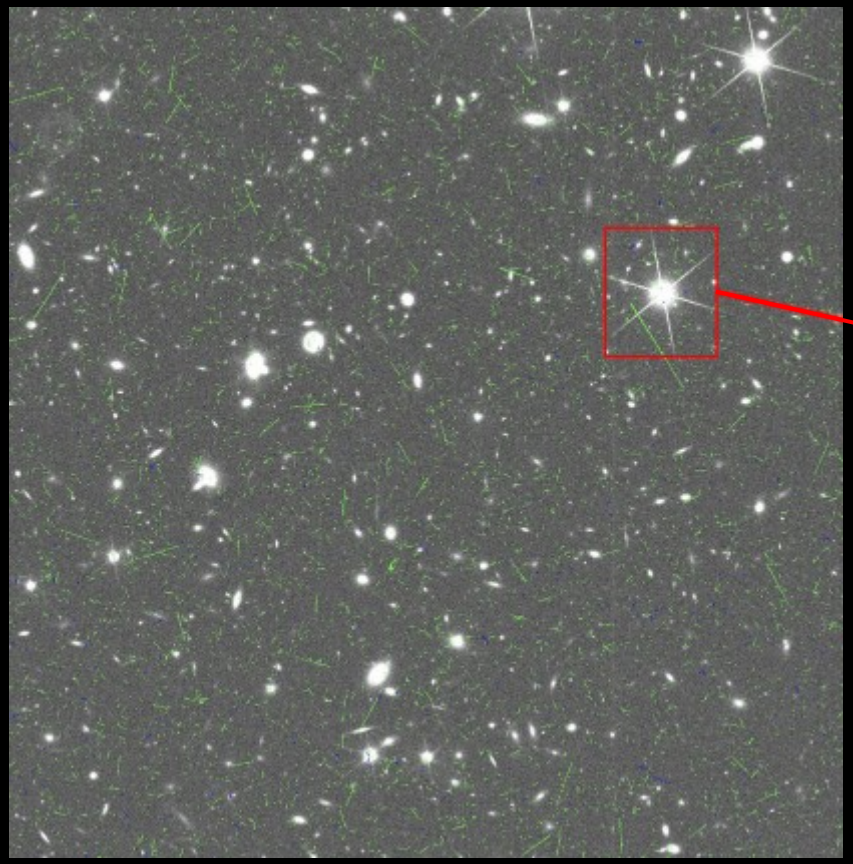
| CARTE DE CONFIANCE REVUE

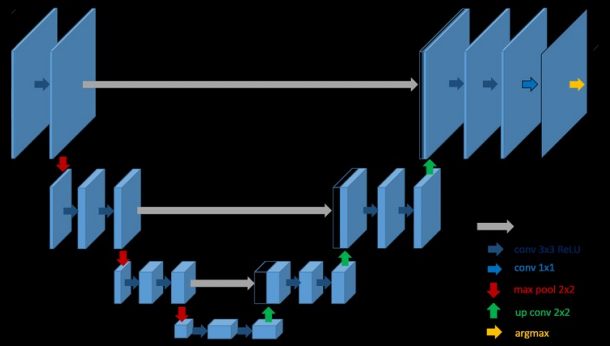
PHASE EXPÉRIMENTALE

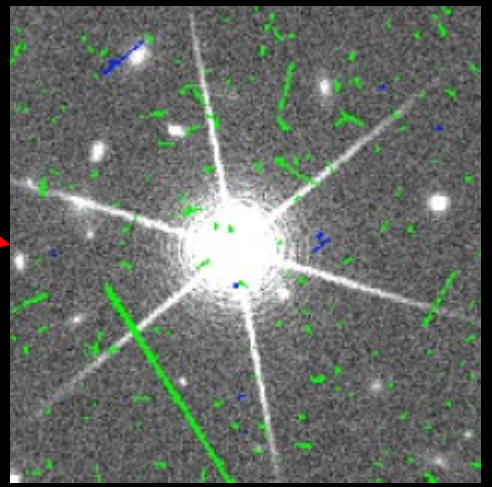




| RAYON COSMIQUE SUR IMAGE VIS



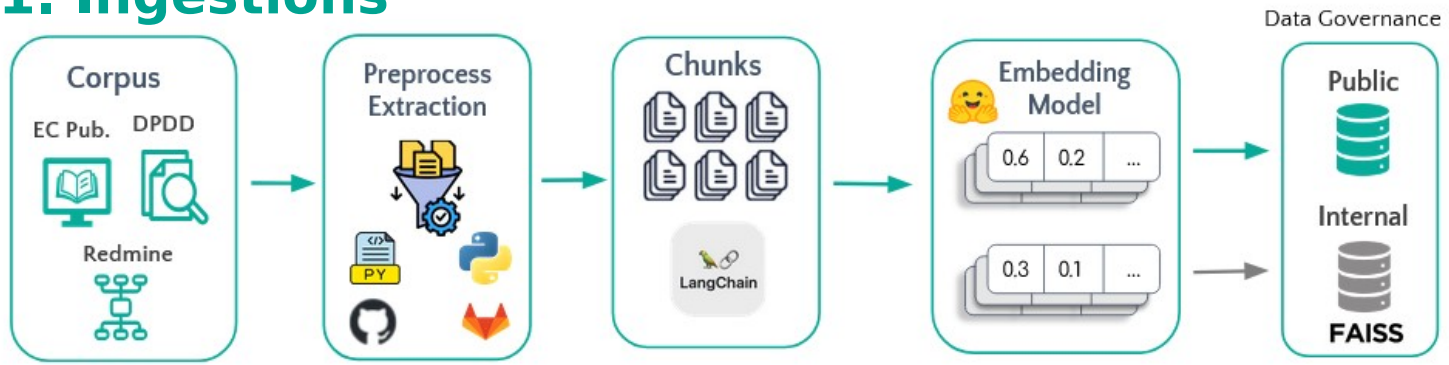




IoU 93%

#EUCLID | LLM RAG

1. Ingestions



Documentation du modèle de données + articles publiés

Redmine

2. Retrieval