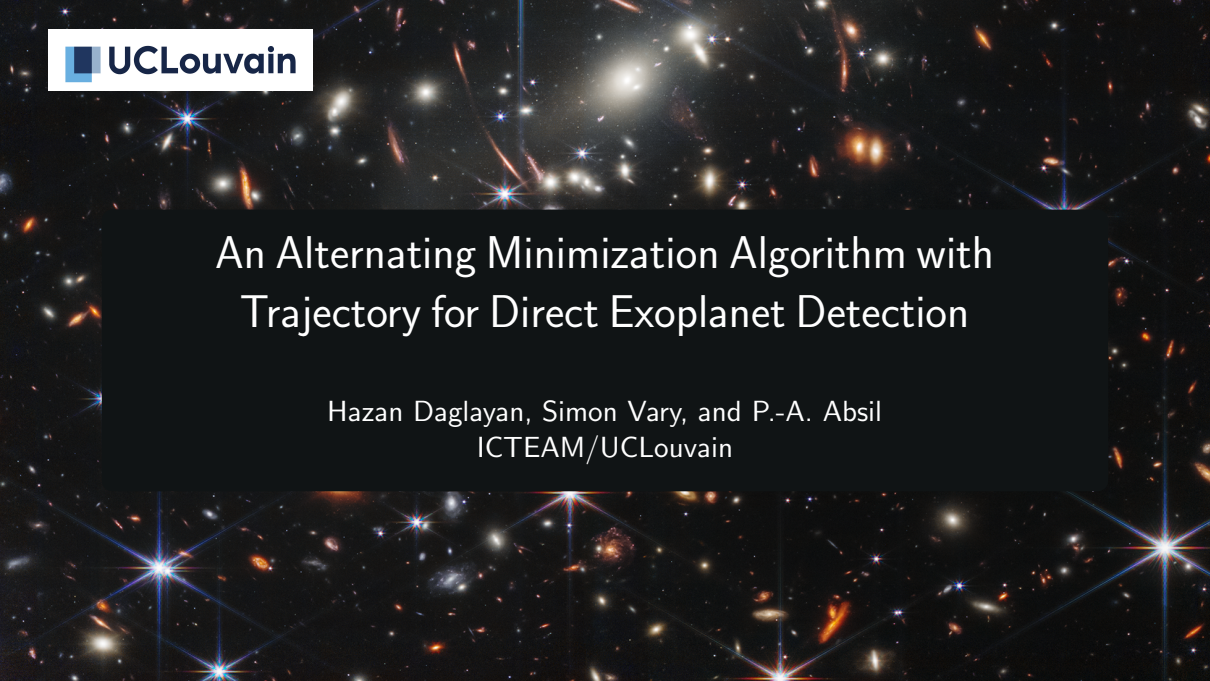


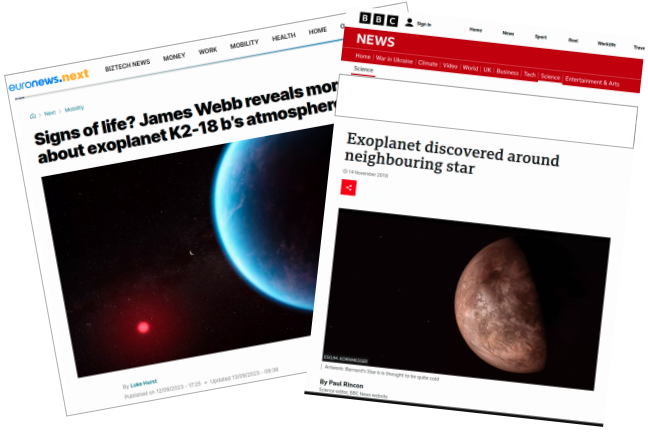
UCLouvain

An Alternating Minimization Algorithm with Trajectory for Direct Exoplanet Detection

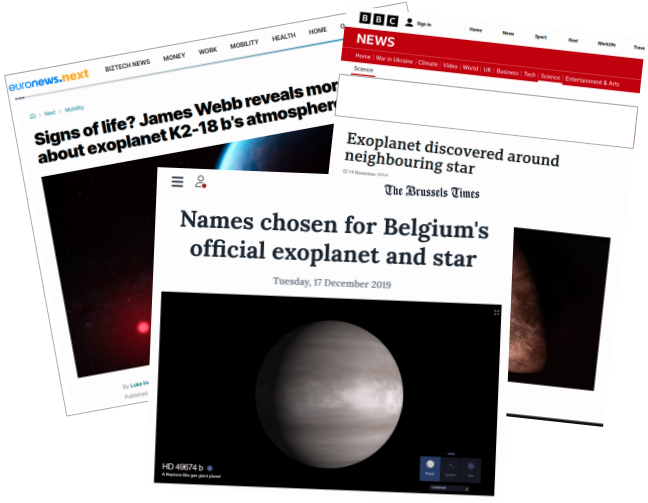
Hazan Daglayan, Simon Vary, and P.-A. Absil
ICTEAM/UCLouvain

Exoplanet Imaging

Exoplanet Imaging

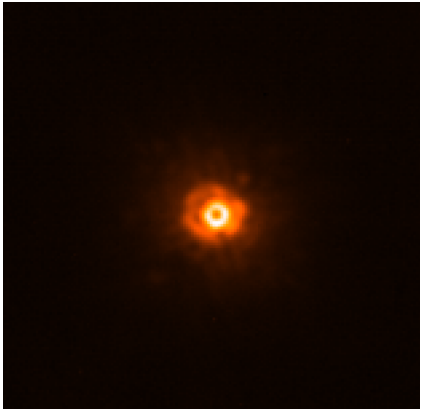


Exoplanet Imaging



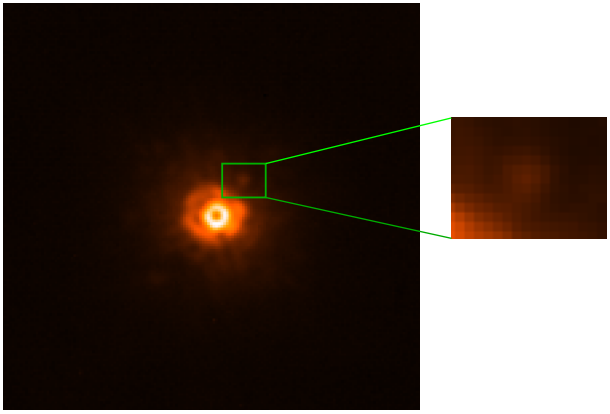
Exoplanet Imaging

A real image

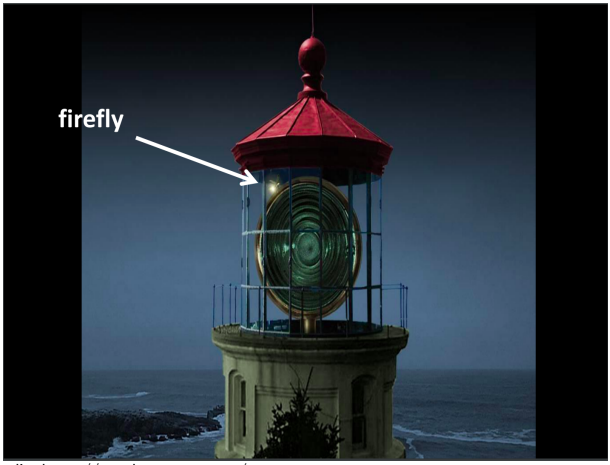


Exoplanet Imaging

A real image of exoplanet



Direct Imaging



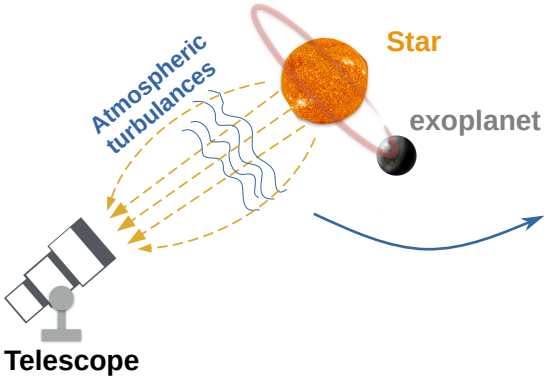
Credit: https://exoplanets.nasa.gov/

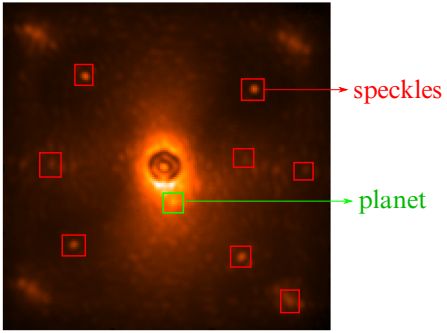
Direct Imaging

Credit: https://exoplanets.nasa.gov/

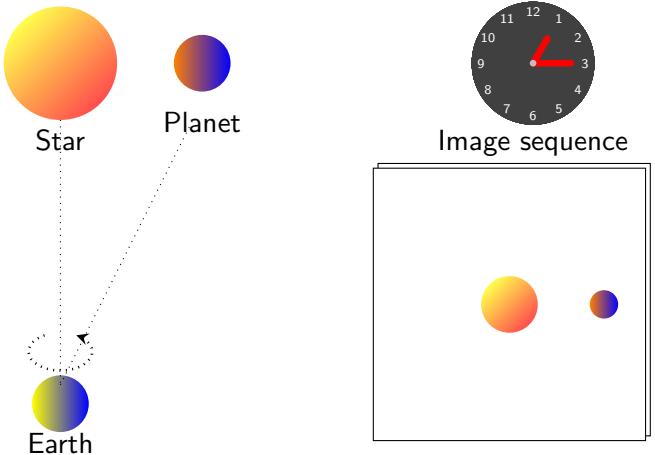
- firefly $\rightarrow$ exoplanet
- lighthouse $\rightarrow$ star

Direct Imaging





Angular Differential Imaging



Problem Setup & Goal

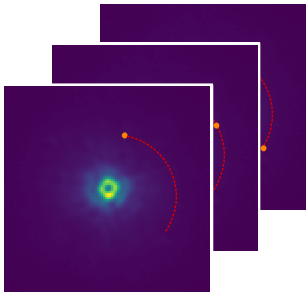
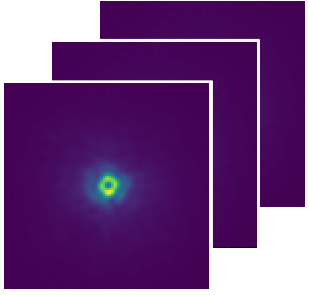


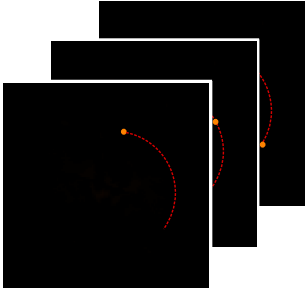
Image sequence

$=$



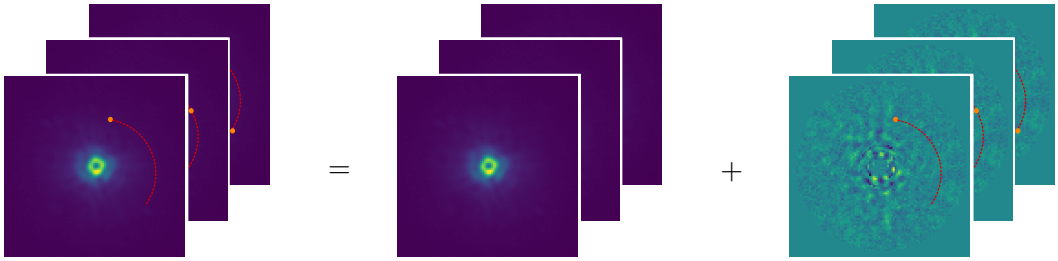
Background
(star+speckles)

$+$



Foreground
(planet)

Background: (Annular) PCA[1,2]



[1] Amara and Quanz, 2012
[2] Soummer, et al., 2012

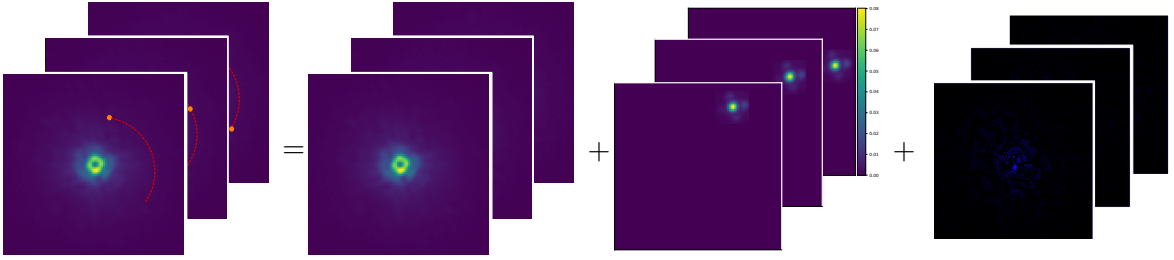
State of art: LLSG[3]

Original cube M = Low rank L + Sparse S + Gaussian G

$$\mathrm{rank}(L) \leq k, \quad \mathrm{card}(S) \leq s$$

[3] Gomez Gonzalez, et al., 2016

Alternating Minimization Algorithm with Trajectory (AMAT)



Original cube M = Low rank L + Planet Signature aP_g + Noise E

$$\text{rank}(L) \leq k, \quad P_g \in \Lambda$$

AMAT

$$\min_{L \in \mathbb{R}^{t \times n}, a \in \mathbb{R}} \|M - L - aP_g\| \quad \text{s.t.} \quad \text{rank}(L) \leq k$$

AMAT

$$\min_{L \in \mathbb{R}^{t \times n}, a \in \mathbb{R}} \|M - L - aP_g\| \quad \text{s.t.} \quad \operatorname{rank}(L) \leq k$$

- Solve (1) by SVD or L1-LRA[4]
- Solve (2) by

$$a_i = \frac{\langle P_g, M - L_i \rangle}{\|P_g\|_F^2}$$

or minimum of the points $(M - L_i)/P_g$

[4] Gillis and Vavasis, 2018

AMAT

$$\min_{L \in \mathbb{R}^{t \times n}, a \in \mathbb{R}} \|M - L - aP_g\| \quad \text{s.t.} \quad \operatorname{rank}(L) \leq k$$

Alternating Minimization

$$L_i = \arg\min_{L \in \mathbb{R}^{t \times n}} \|M - L - a_{i-1} P_g\| \qquad (1)$$

$$a_i = \arg\min_{a \in \mathbb{R}} \|M - L_i - aP_g\| \qquad (2)$$

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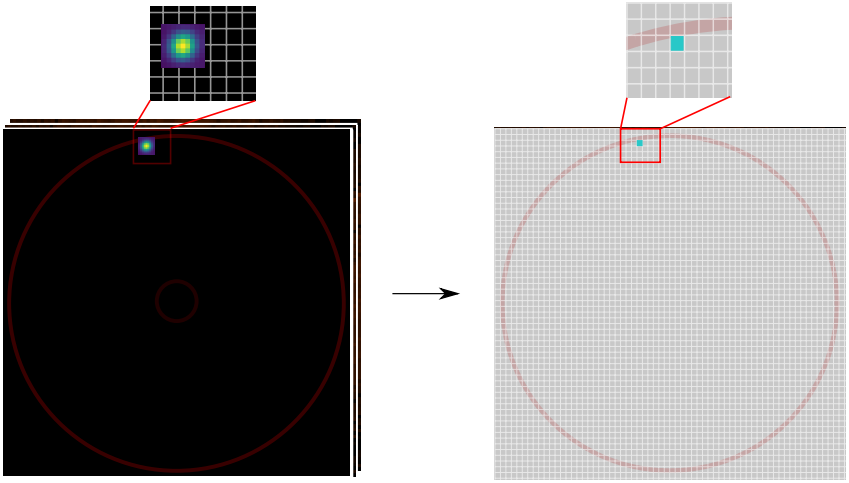
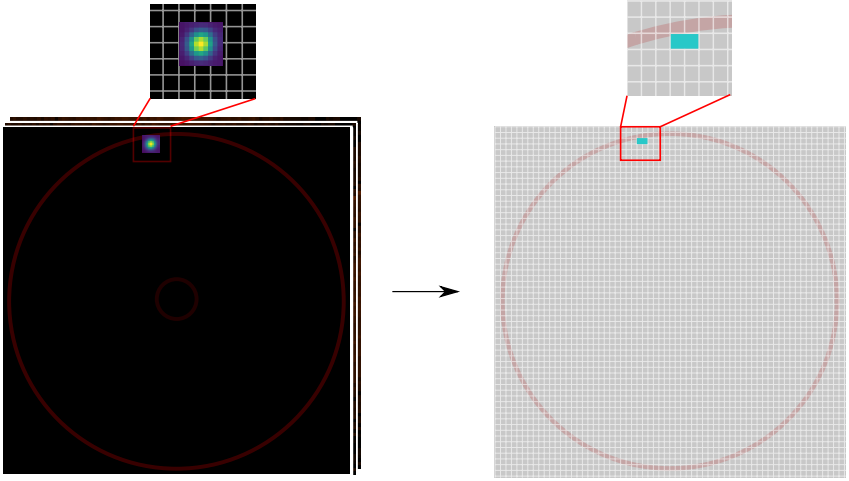
[4] Gillis and Vavasis, 2018

Trajectories



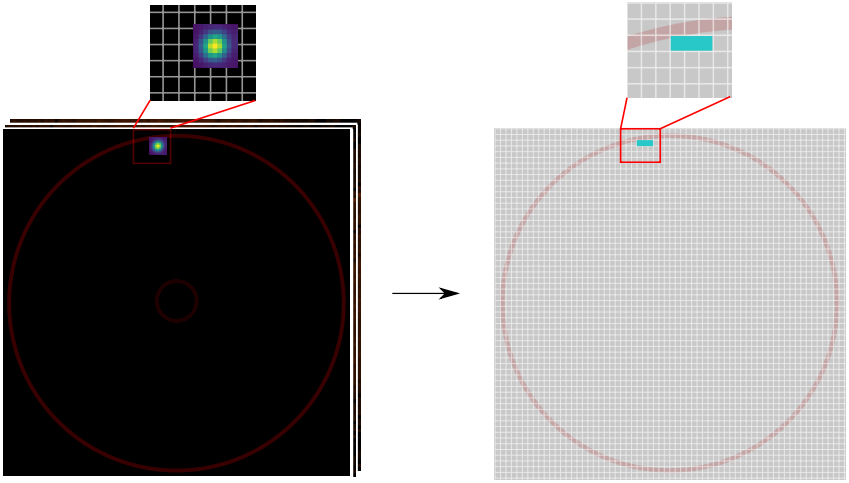
P_g Flux map

Trajectories



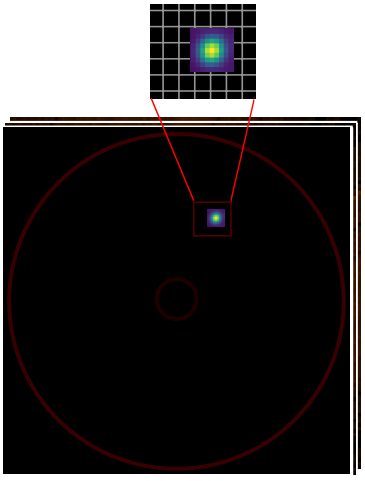
P_g Flux map

Trajectories

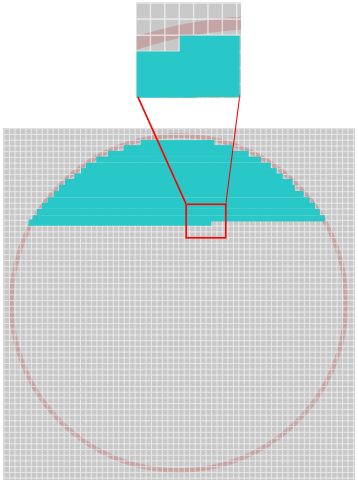


P_g Flux map

Trajectories

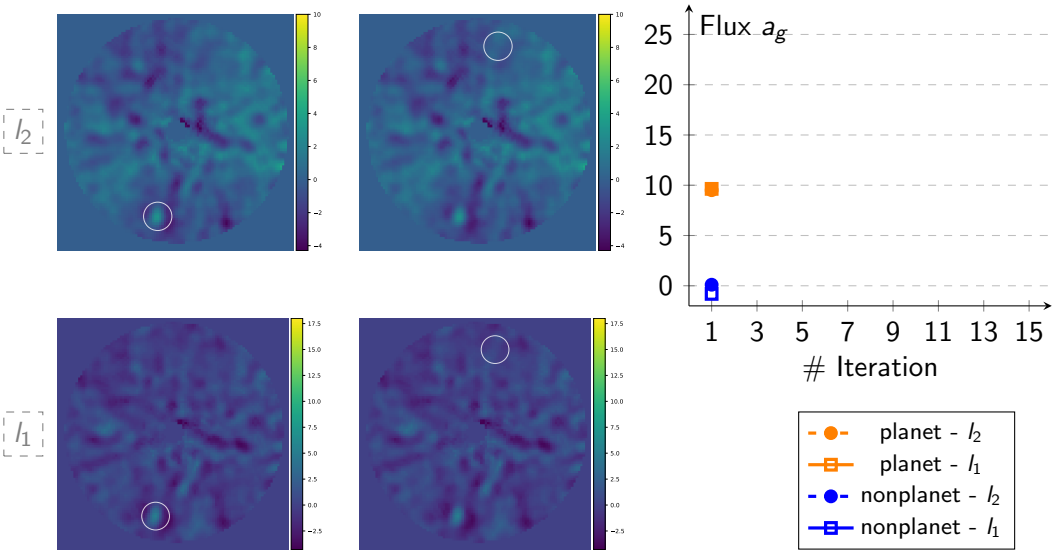


P_g



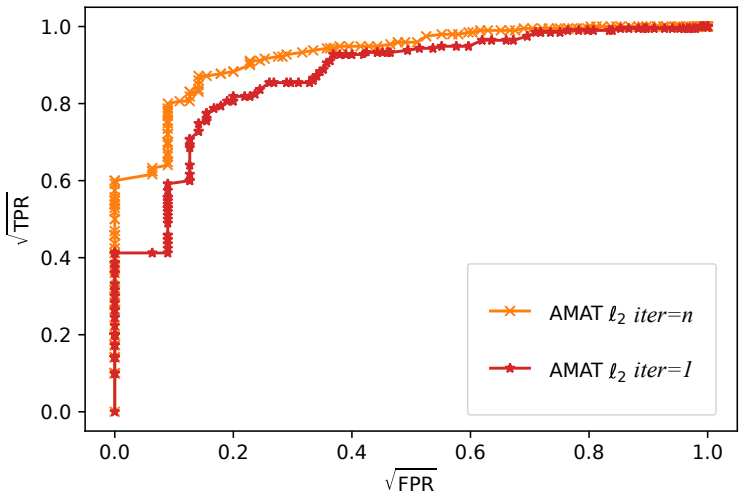
Flux map

Numerical Experiments



Numerical Experiments - ROC Curves

- Synthetic planets are injected.
- $\sqrt{\mathrm{TPR}}$ & $\sqrt{\mathrm{FPR}}$ are used instead of TPR & FPR.



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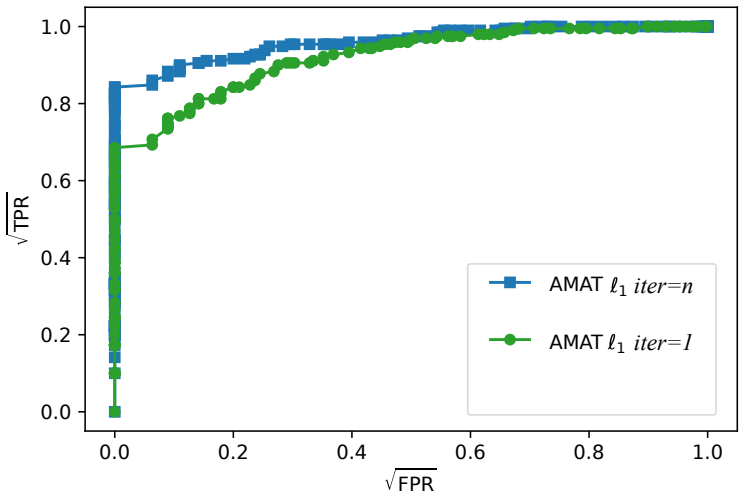

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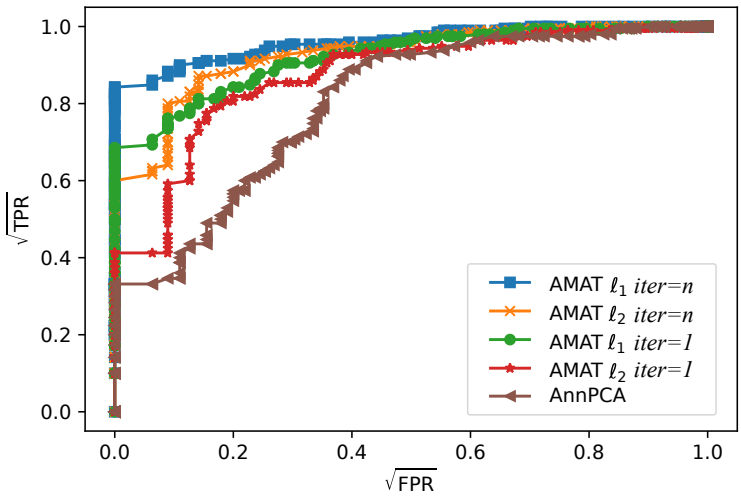
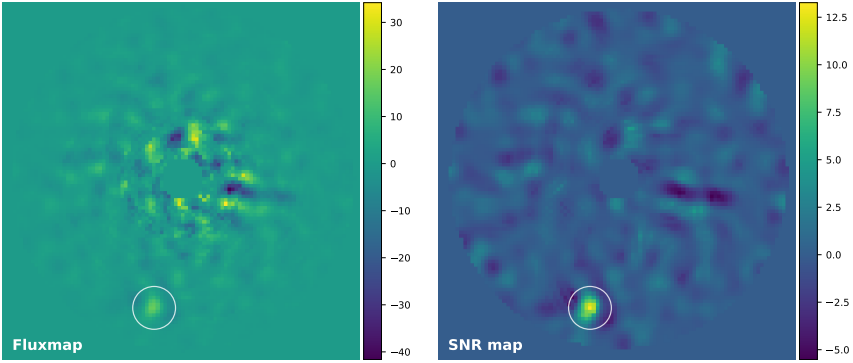


Thank you for your attention!
Any questions?

hazan.daglayan@uclouvain.be
GitHub: hazandaglayan/AMAT

From Fluxmap to SNR



Detection Maps Comparison