Exploring beyond!
Advancements in exoplanet detection in the SHINE High-Contrast Imaging survey through RSM framework

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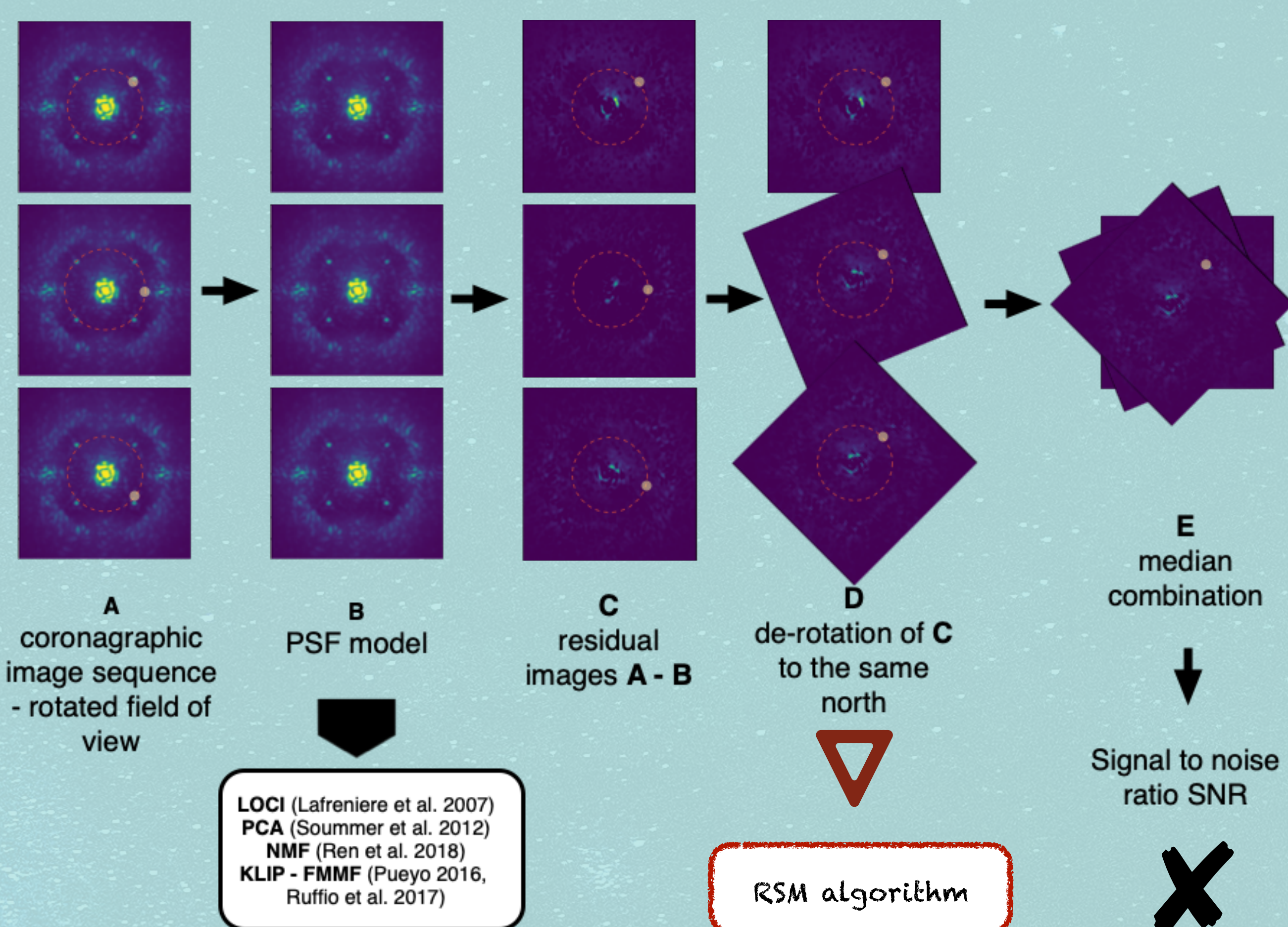
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Motivation

In High Contrast Imaging field, we aim to image young giant planets at separations >10 au from their star in thermal emission. With 10-m class telescopes, dedicated adaptive optics, coronagraphs and observing strategies, we reach flux planet-star ratio limit (contrast) of ~ 10^{-5} at 0.2 arcsec. The goal is to push the detection limits at close separations from the star using advanced post-processing algorithms that better differentiate between planetary signal and aberrations caused by imperfections in adaptive optics.

Survey & observing strategies

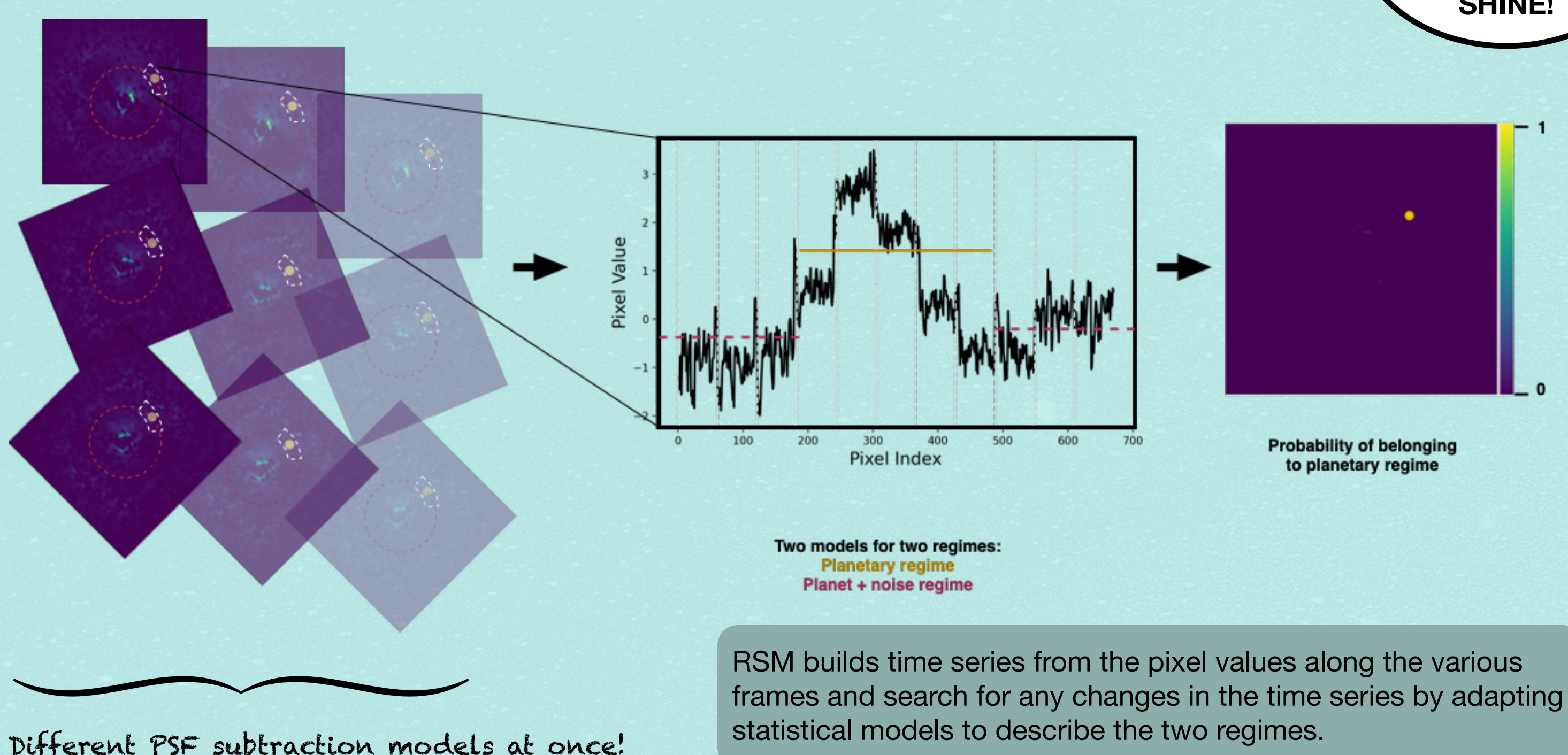*SpHere INfrared Survey for Exoplanets* (SHINE, Desidera et al., 2021)

- 🔭 SPHERE instrument at VLT, using SAXO extreme AO & Lyot Coronagraph

- ⧗ February 2015 to 2021

- ☀ F150 sample: 53 BA stars, 77 FGK, 20 M stars

- 🎥 IRDIS narrowband filters: H2-H3, with 9" diameter field of view
  Science observations: **ADI image sequence**

- 🪐 Confirmed exoplanet using ADI-PCA: HIP 65426 b
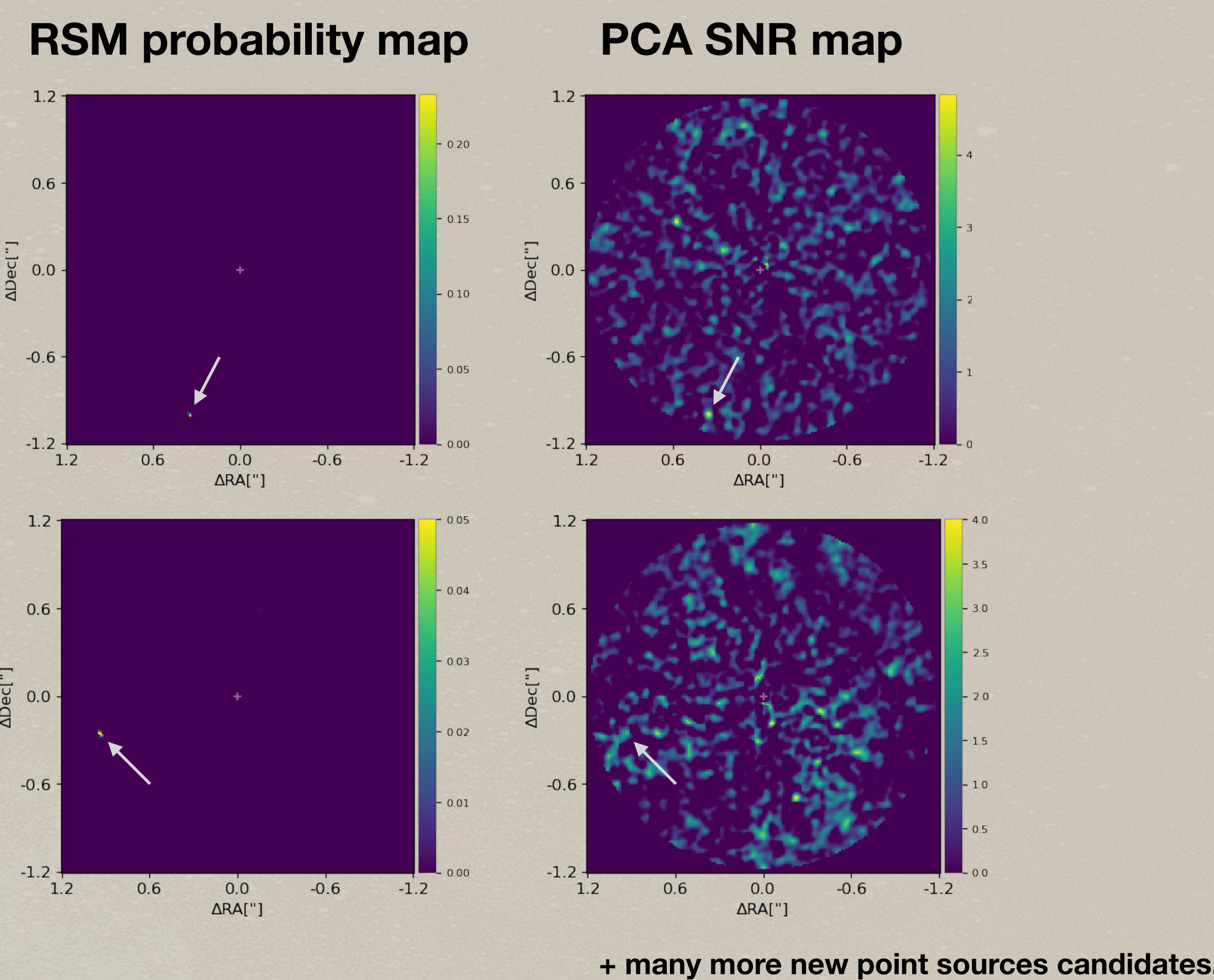
Angular Differential Imaging (ADI)

A coronagraphic image sequence - rotated field of view

B PSF model

C residual images **A - B**

D de-rotation of **C** to the same north

E median combination

LOCI (Lafreniere et al. 2007)
PCA (Soummer et al. 2012)
NMF (Ren et al. 2018)
KLIP - FMMF (Pueyo 2016, Ruffio et al. 2017)

RSM algorithm

Signal to noise ratio SNR

Advanced post-processing algorithm !

Regime Switching Model (*RSM*) algorithm
Dahlqvist et al. 2021

Check poster **997** on **Thursday** for other advancements in SHINE!

Probability of belonging to planetary regime

Two models for two regimes:
Planetary regime
Planet + noise regime

RSM builds time series from the pixel values along the various frames and search for any changes in the time series by adapting statistical models to describe the two regimes.

Different PSF subtraction models at once!

New point sources in SHINE survey!

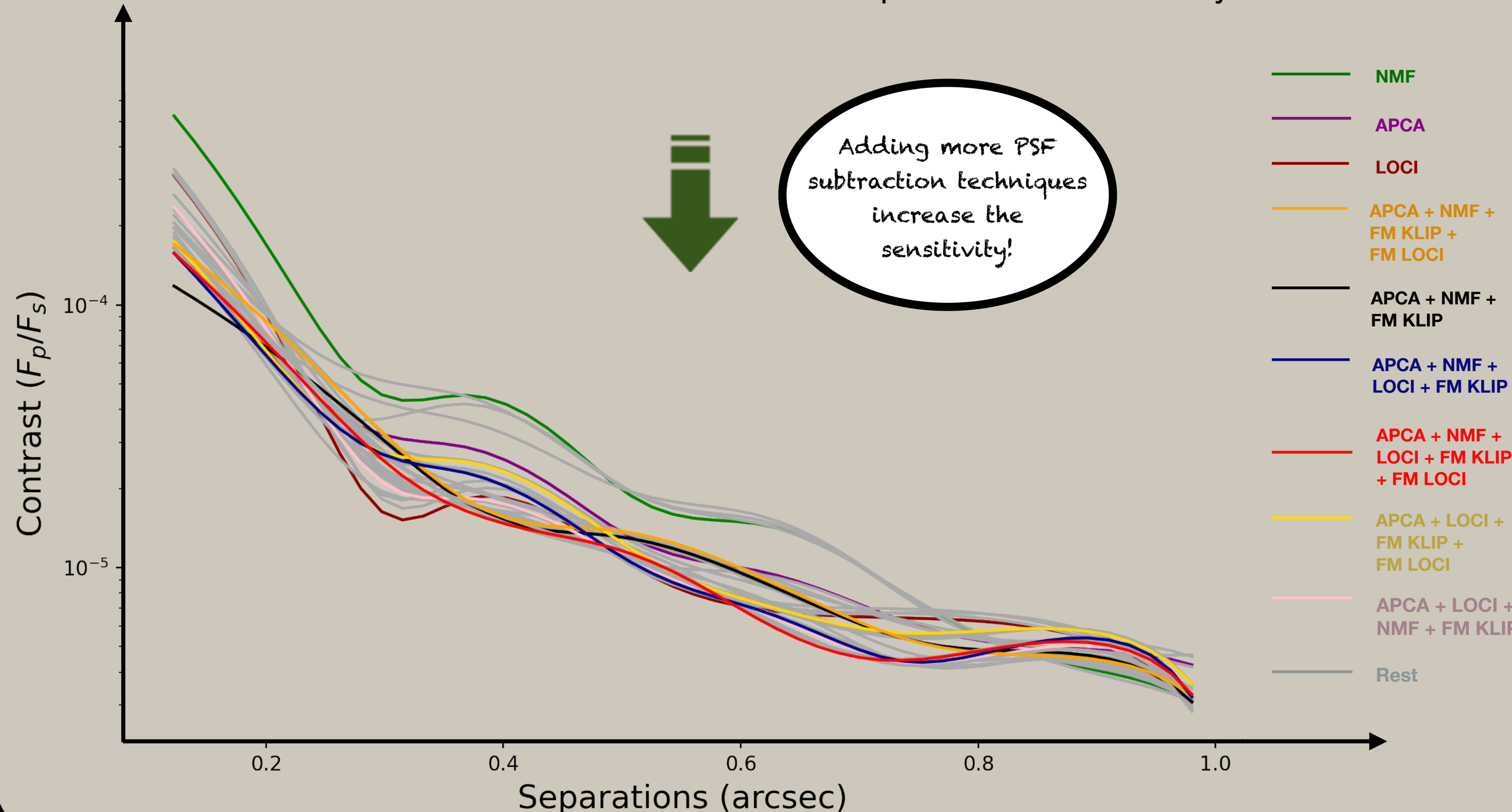**RSM probability map**   **PCA SNR map**

+ many more new point sources candidates..

Detection limits using different PSF subtraction methods

Contrast curves based on 50 % completeness obtained by RSM

Adding more PSF subtraction techniques increase the sensitivity!

Legend:
- NMF
- APCA
- LOCI
- APCA + NMF + FM KLIP + FM LOCI
- APCA + NMF + FM KLIP
- APCA + NMF + LOCI + FM KLIP
- APCA + NMF + LOCI + FM KLIP + FM LOCI
- APCA + LOCI + FM KLIP + FM LOCI
- APCA + LOCI + NMF + FM KLIP
- Rest

Contrast (F_p/F_s) vs Separations (arcsec)

New detection limits in SHINE !

Median contrast computed for 20 datasets using the best combinations in RSM in each separation

- PCA SNR map
- RSM

Contrast (F_p/F_s) vs Separations (arcsec)