Reducing Detection Confusion in Directly Imaged Multi-Planet Systems

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Overview

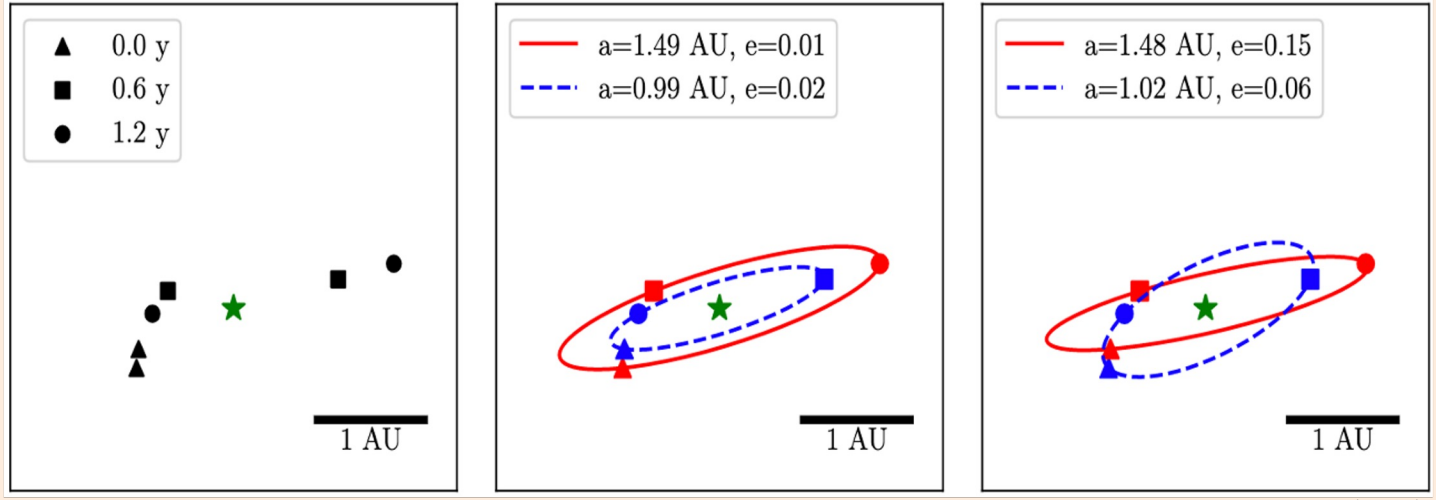
1. Confusion Problem & Addressing Confusion
2. The Deconfuser
3. Orbit fitting with photometry
4. Future work
5. Summary

The Confusion Problem

Detections
(different shapes correspond to different times)

Possible orbits #1

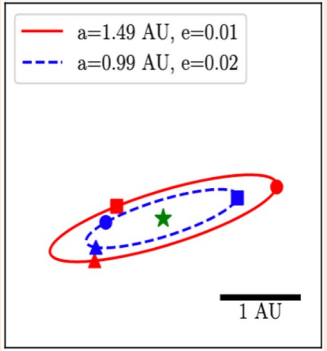
Possible orbits #2

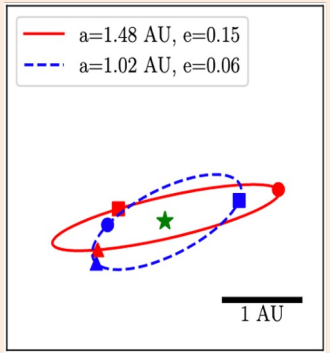


Pogorelyuk et al. 2022 (P22)

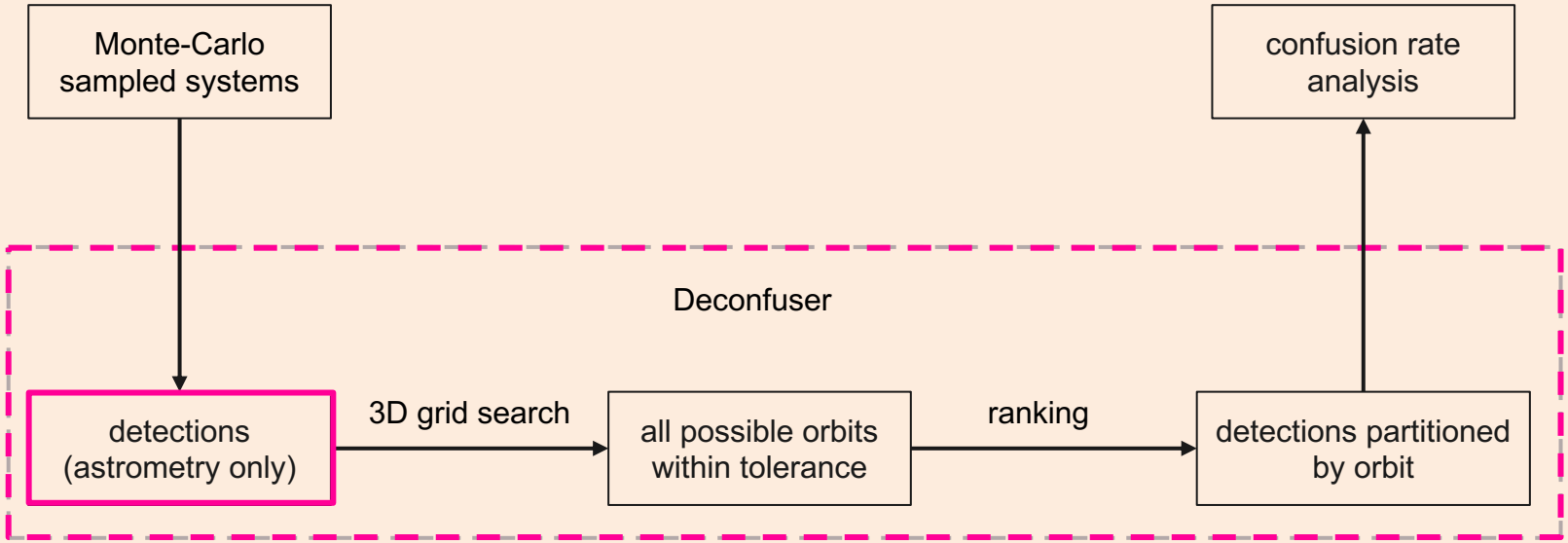
Approaching the Confusion Problem

- Develop fast, automatic detection-to-planets assignment algorithm for direct imaging (deconfuser)
- Perform a Monte Carlo study of “deconfusion” success rate as a function of:
  - System parameters (viewing angle, planet separation, ...)
  - Observatory parameters (IWA, contrast, noise, ...)
  - Number and spacing of observations
- Conclusions about “confusion” rates and observing strategies



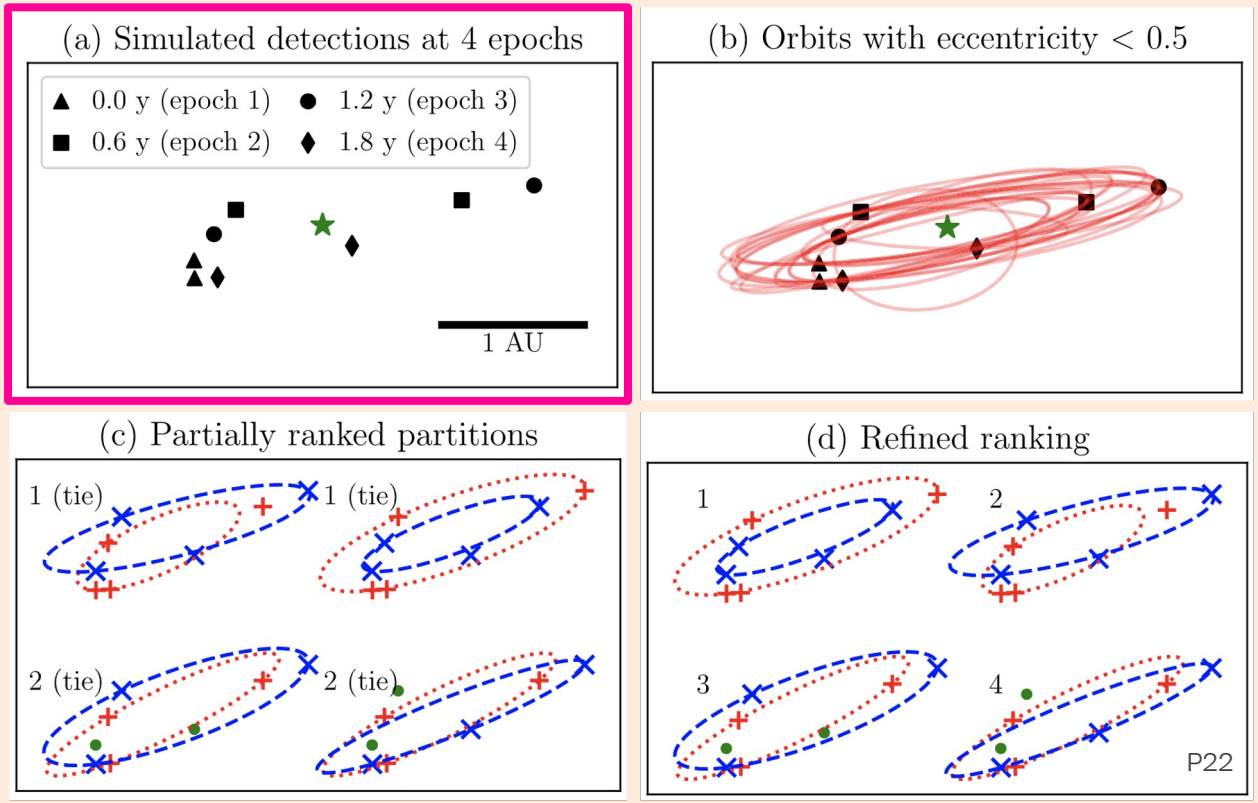


The Deconfuser

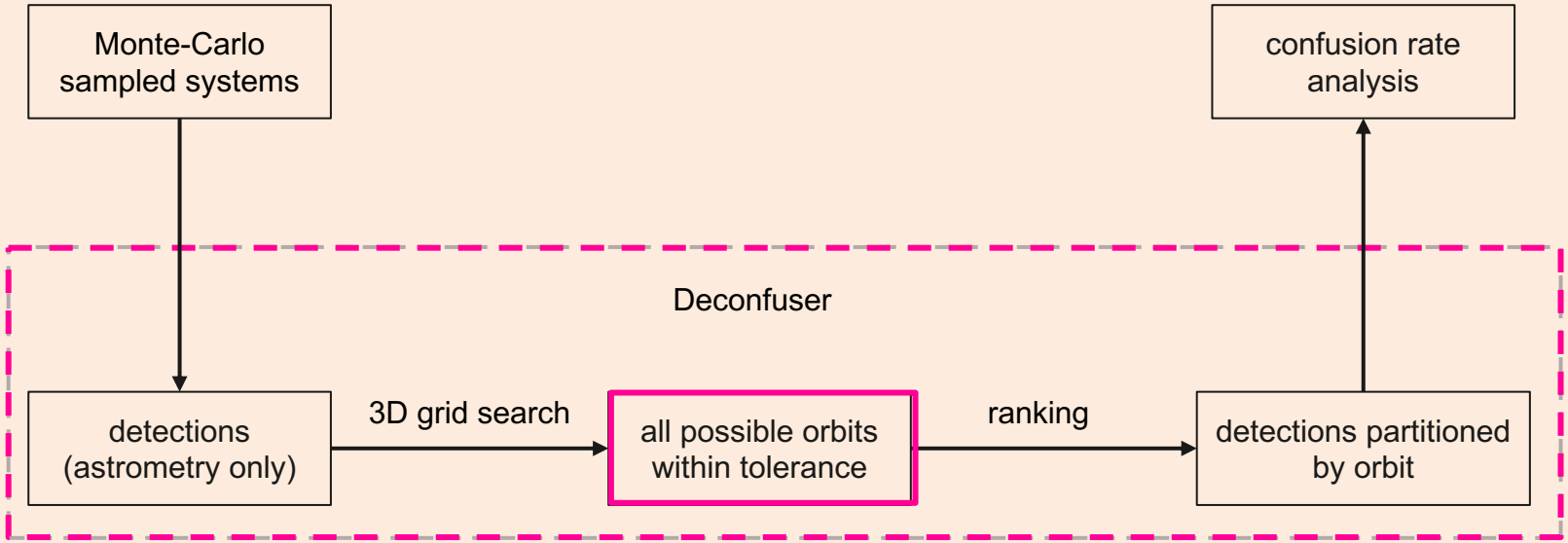


(P22)

The Deconfuser: Step 1



The Deconfuser



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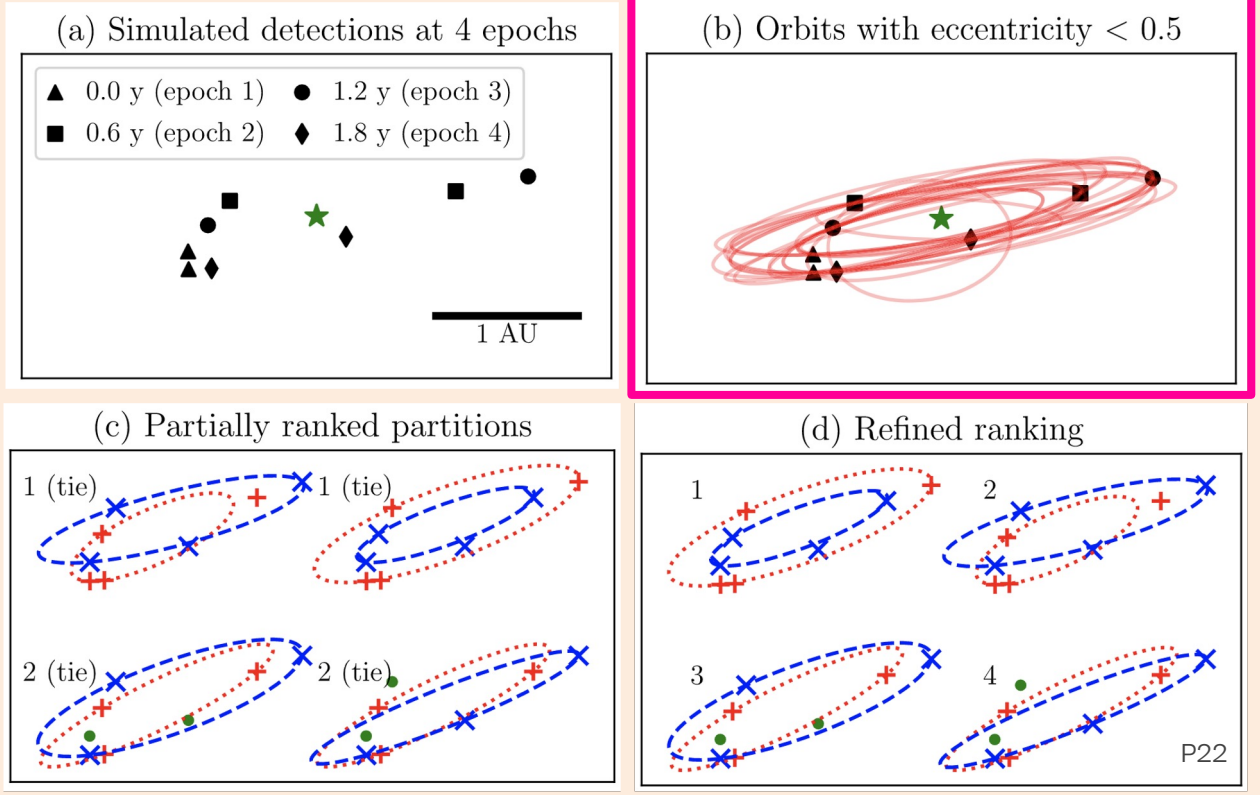
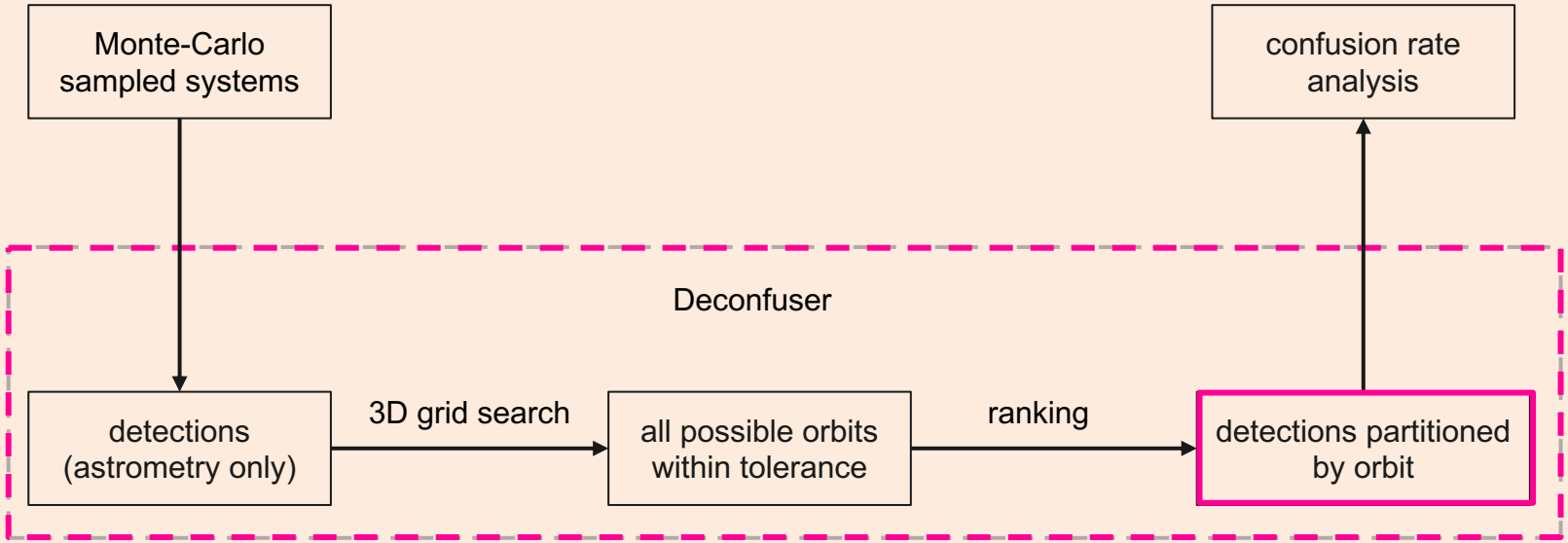
The Deconfuser: Step 2



The Deconfuser



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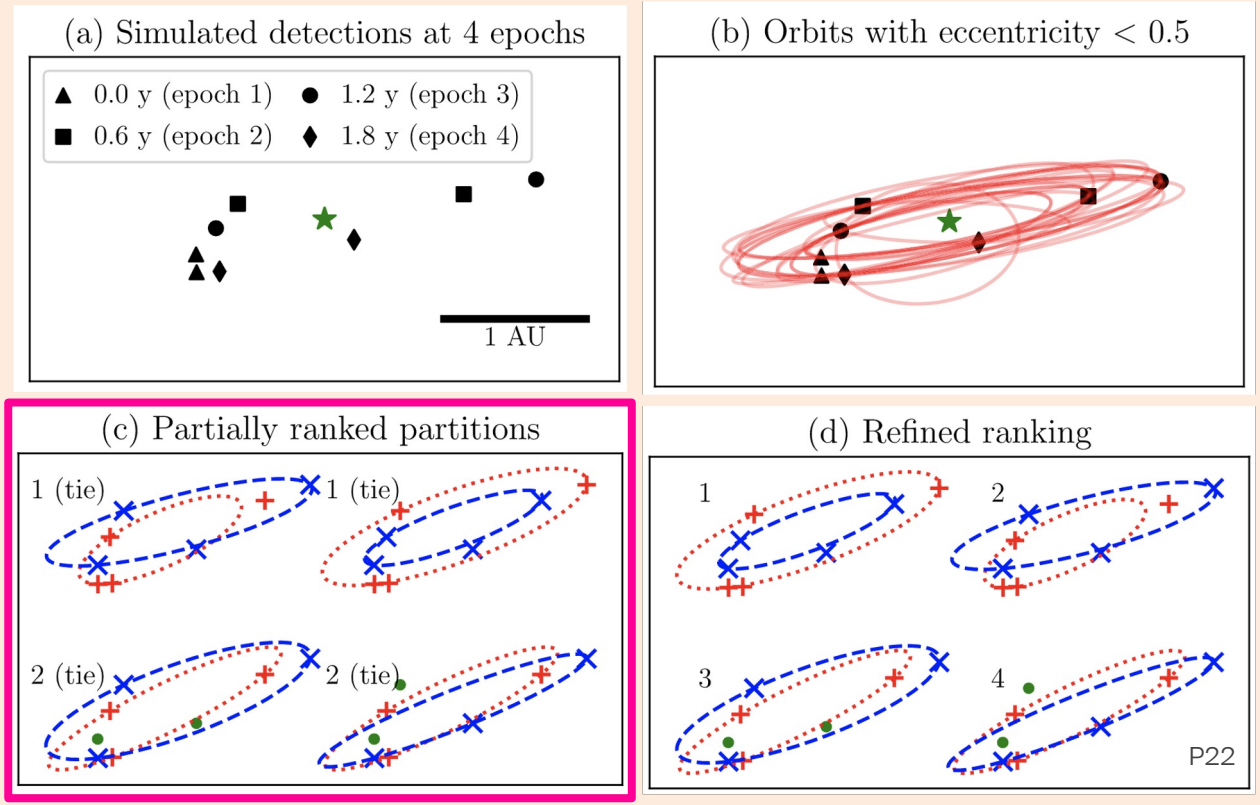
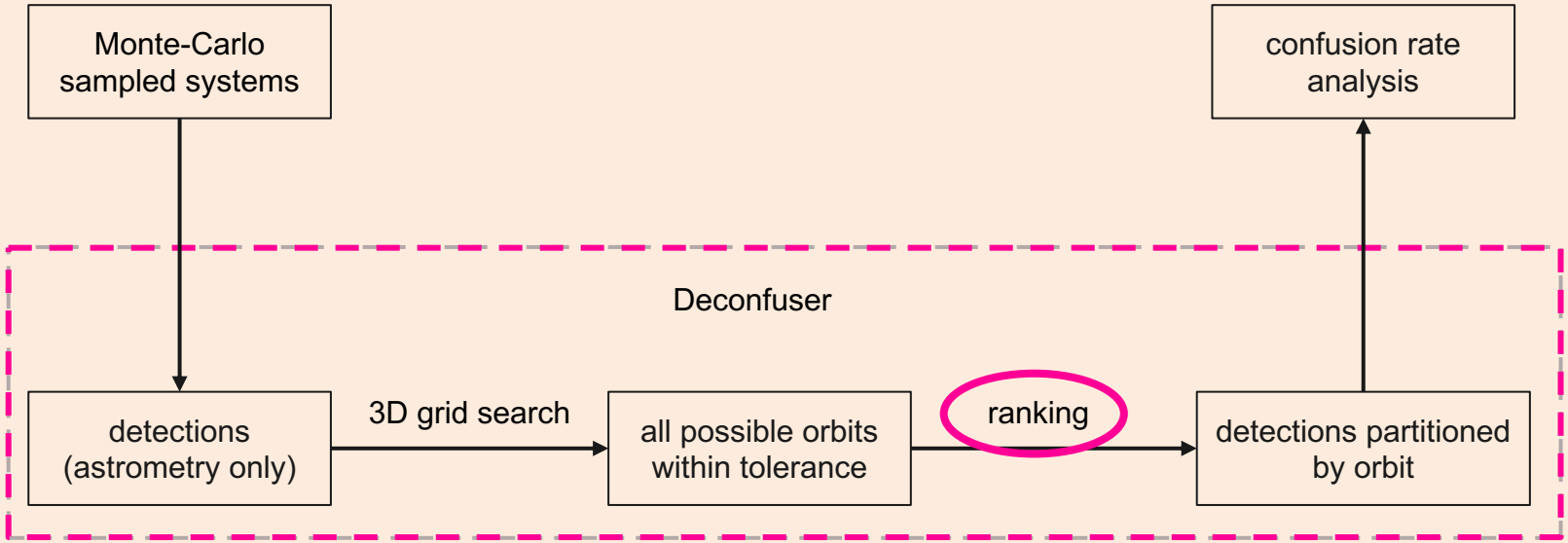
The Deconfuser: Step 3



The Deconfuser



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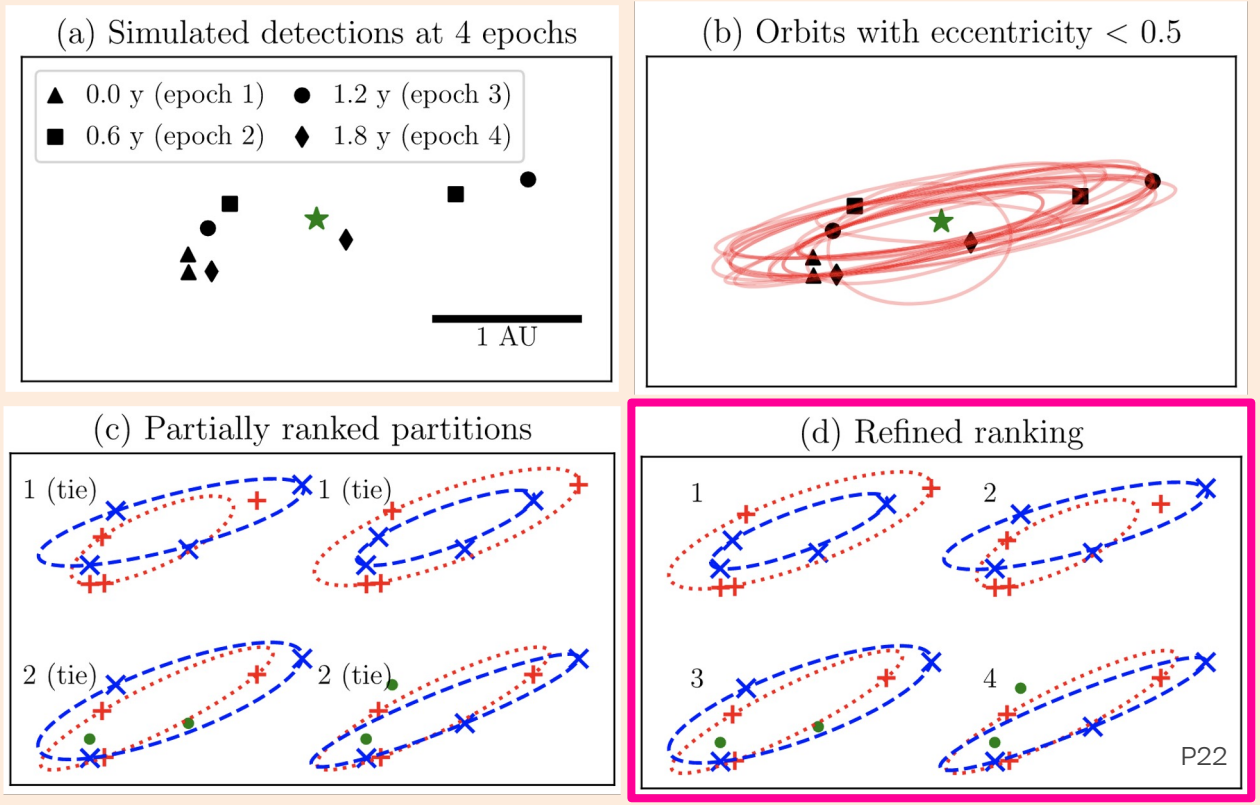
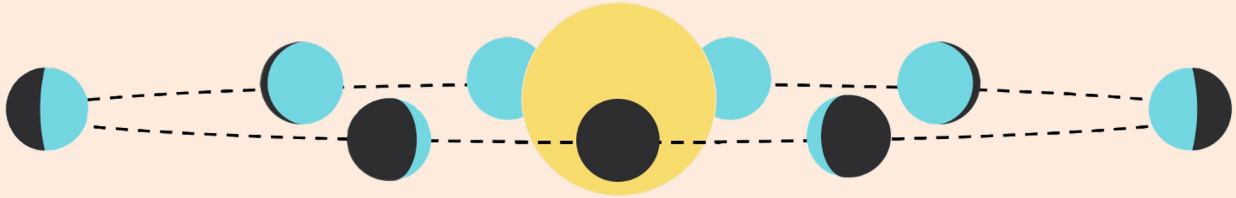
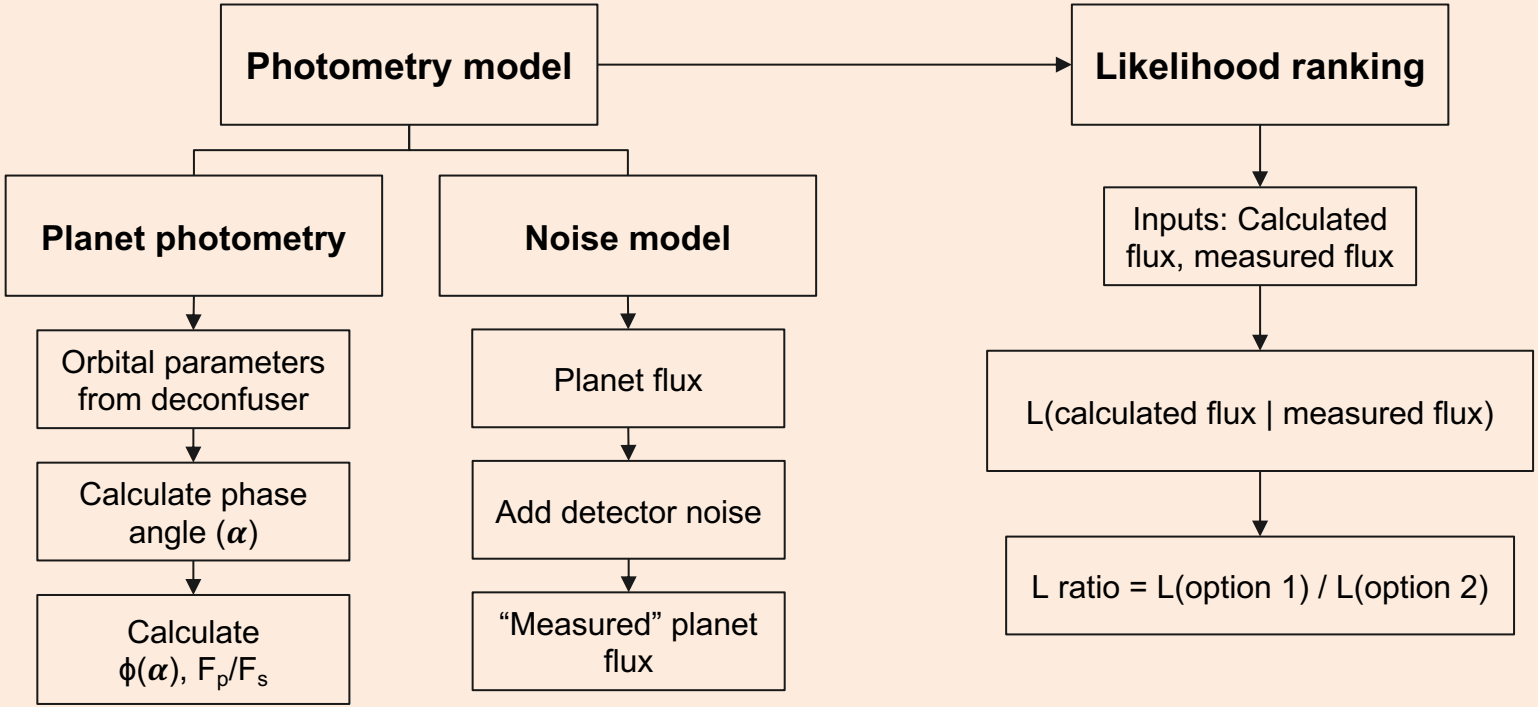
The Deconfuser: Step 4



Ranking Orbits with Photometry

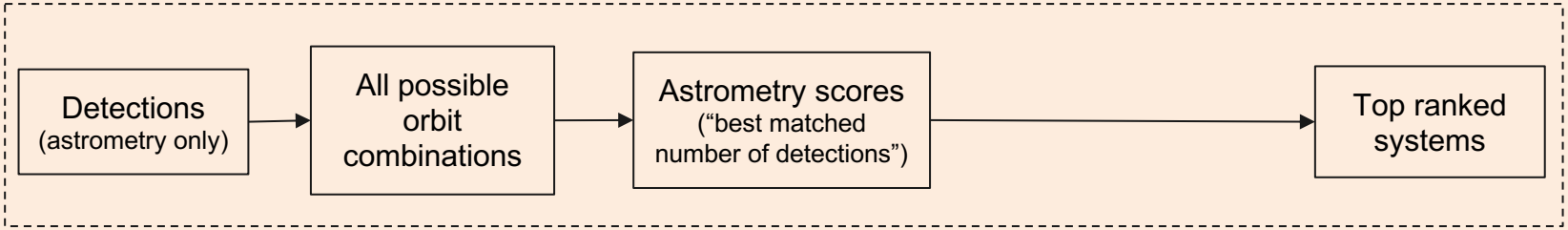


Ranking Orbits with Photometry

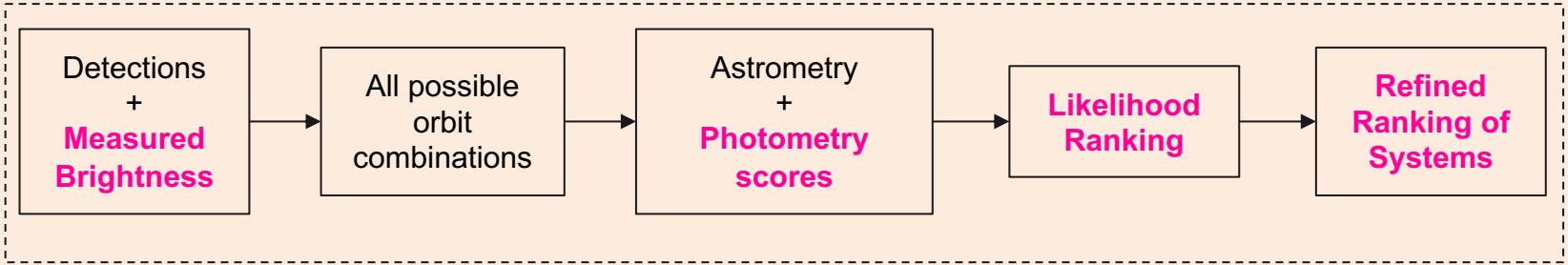


Deconfusion with Photometry

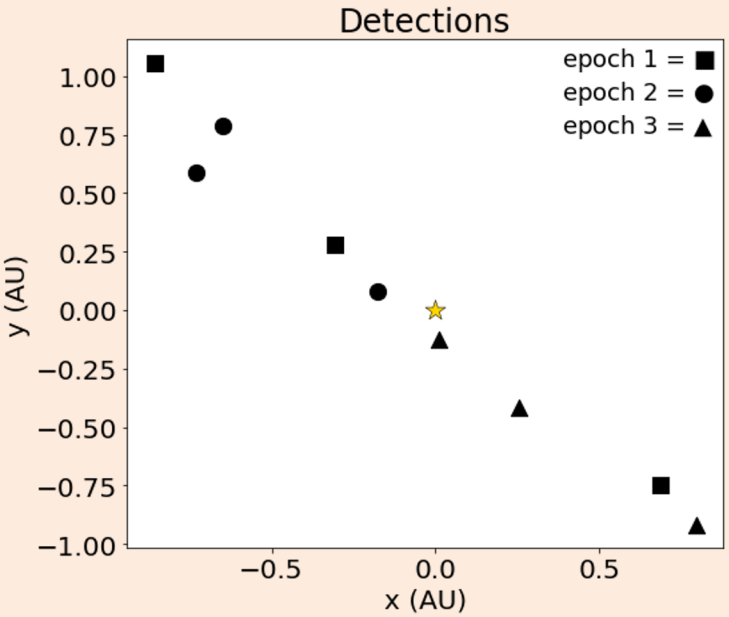
Deconfuser 1.0

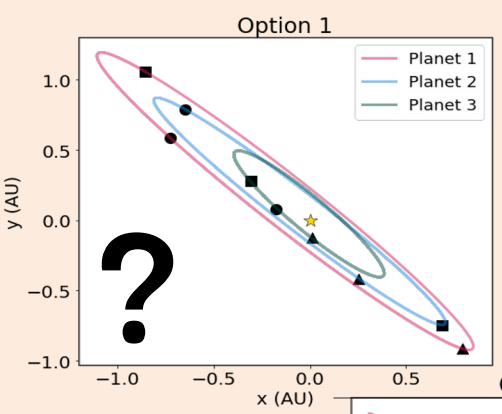


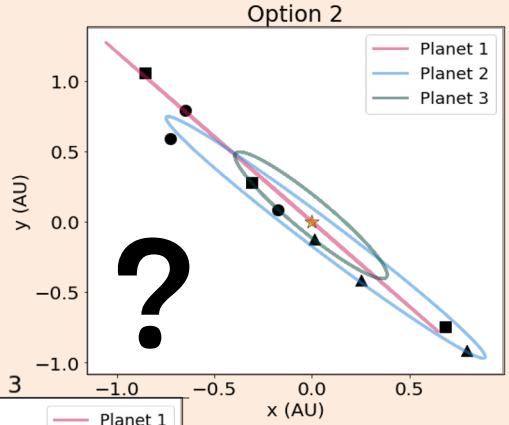
Expanded Deconfuser

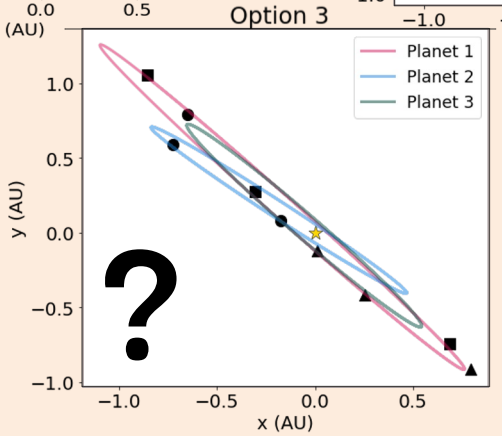


Example of Deconfusion with Photometry

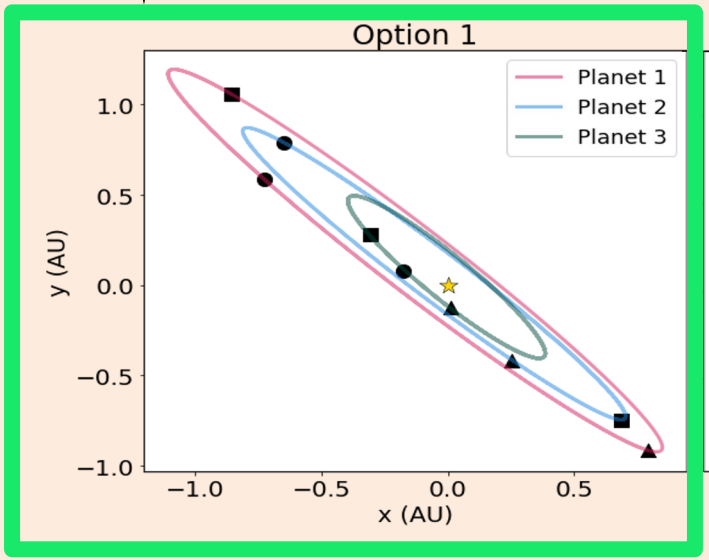


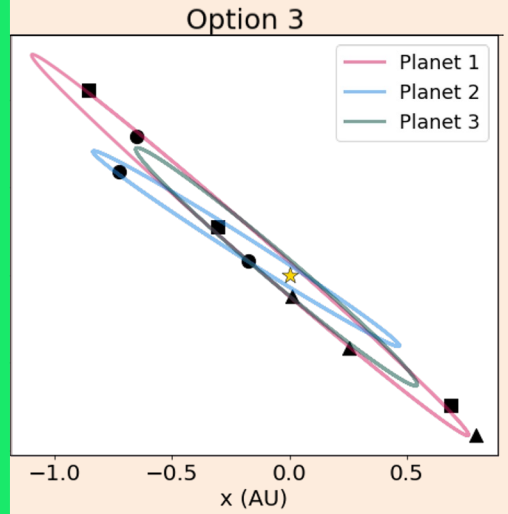


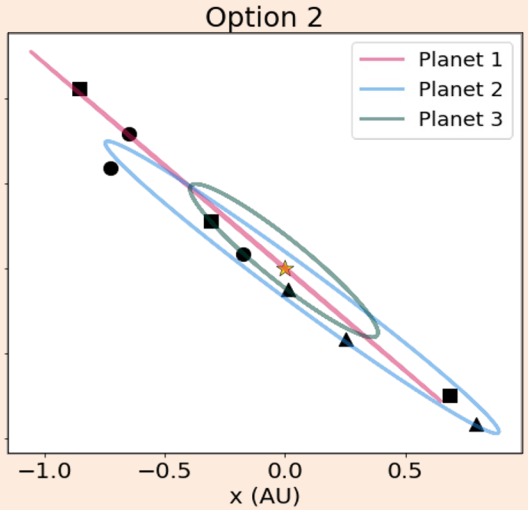




Example of Deconfusion with Photometry



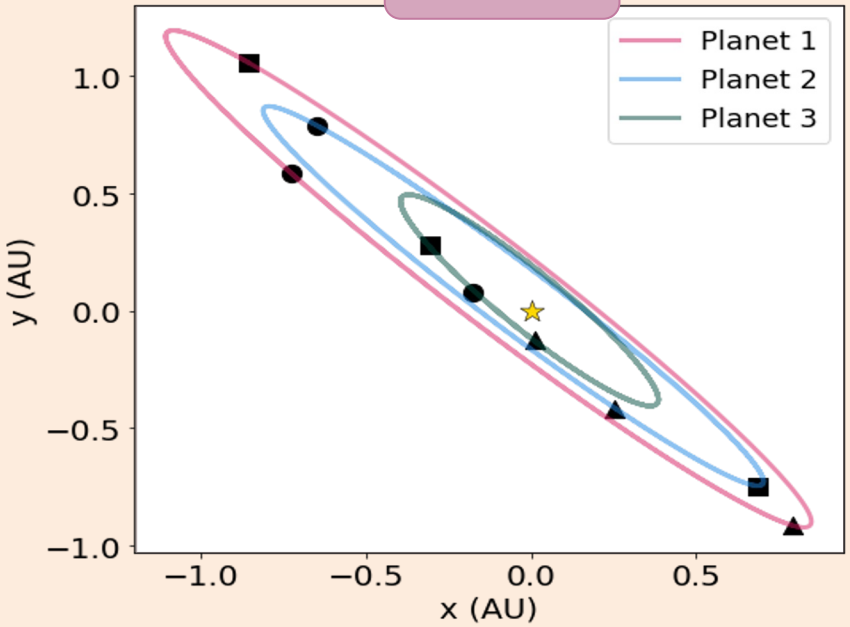




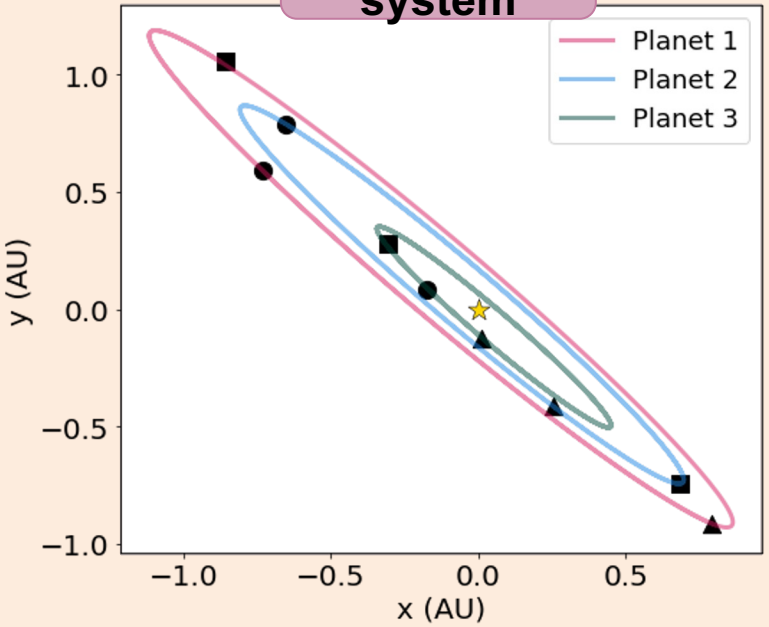
L(#1 | detections) > L(#3 | detections) > L(#2 | detections)

Example of Deconfusion with Photometry

Option 1



True system



Future Work

Orbital parameter priors

Priors on distributions of orbital parameters

Dynamical stability

Account for dynamical stability in orbit fitting

Mutual inclination

Mutually inclined orbits or consideration of visible disk

Null or missed detections

Null detections due to planetary phase or imaging system

False detections

Influence of false detections on confusion rates

Planetary color

Influence of multi-band photometry

Summary

- The deconfuser:
  - Quickly fits orbits to detections of planets in 2D images
  - Decides which assignment of detection-to-planet fits the data best
- The deconfuser eliminates confusion in systems with four observations, except for highly-inclined cases
- An updated photometry ranking scheme will reduce confusion for highly-inclined cases

GitHub

Deconfuser paper

Pogorelyuk et al. 2022

ApJ 937 66

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