SIM's Search for Planets Orbiting White Dwarfs

SIM Science Study

John P. Subasavage

Georgia State University

Current Exoplanet Census

Technique	# Planets
RV, astrometry, transit	292
Microlensing	7
Imaging	5
Timing	5

http://exoplanet.eu

Current Exoplanet Census

Technique	# Planets
RV, astrometry, transit	292
Microlensing	7
Imaging	5
Timing	5

http://exoplanet.eu

Total 309

Current Exoplanet Census

Technique	# Planets
RV, astrometry, transit	292
Microlensing	7
Imaging	5
Timing	5

http://exoplanet.eu

Total 309

Total orbiting WDs 1

Why WDs are Bad

- Relatively faint
- Poor spectral features
  - Few broad absorption lines
  - No absorption
- Outlook for life is bleak
  - Catastrophic transformation
  - Miniscule habitable zone

Why WDs are Good

- Very populous per unit volume
- Span a wide range of main-sequence progenitors (up to ~ 8 $M_\odot$)
- Less massive than progenitors (better for astrometric detections)
- Atmospherically stable (in general)

Goal of this Study

- Identify a subset of "ideal" WDs that would be best suited for planetary detections by SIM using differential astrometry mode
- Factors to consider
  1. Distance to the WD
  2. Brightness of the WD
  3. Mass of the WD
  4. Brightness of the reference field
  5. Proximity of the reference field to the WD

Preliminary Constraints

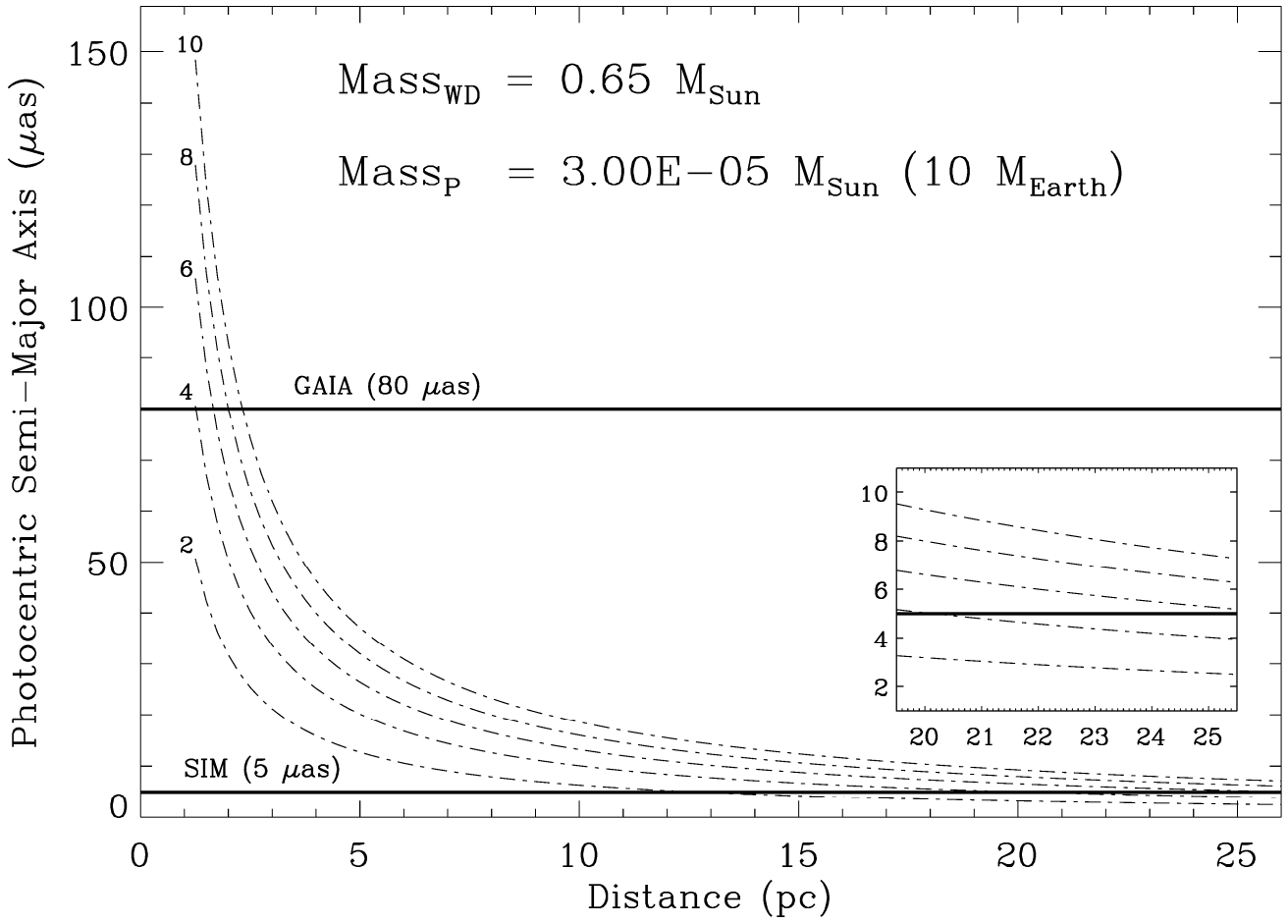
- Astrometric accuracies ≤ 5 μas **per visit**
- WD *V* magnitudes < 15.0
- WD distances < 20 pc

Preliminary Constraints

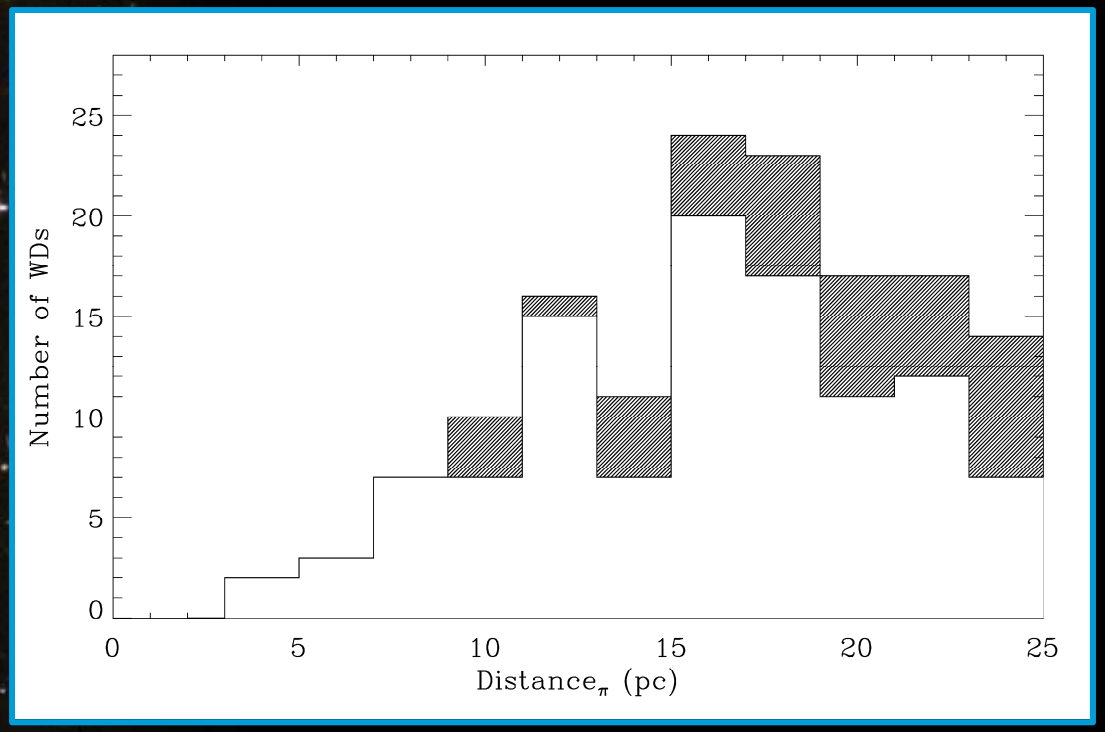
- Astrometric accuracies ≤ 5 μas **per visit**
- WD *V* magnitudes < 15.0
- WD distances < 20 pc

- Planetary parameter sensitivities
  - Planet masses ≳ 10 $M_\oplus$ (Neptunes)
  - Planet periods between 1 – 10 years

Parameter Limits



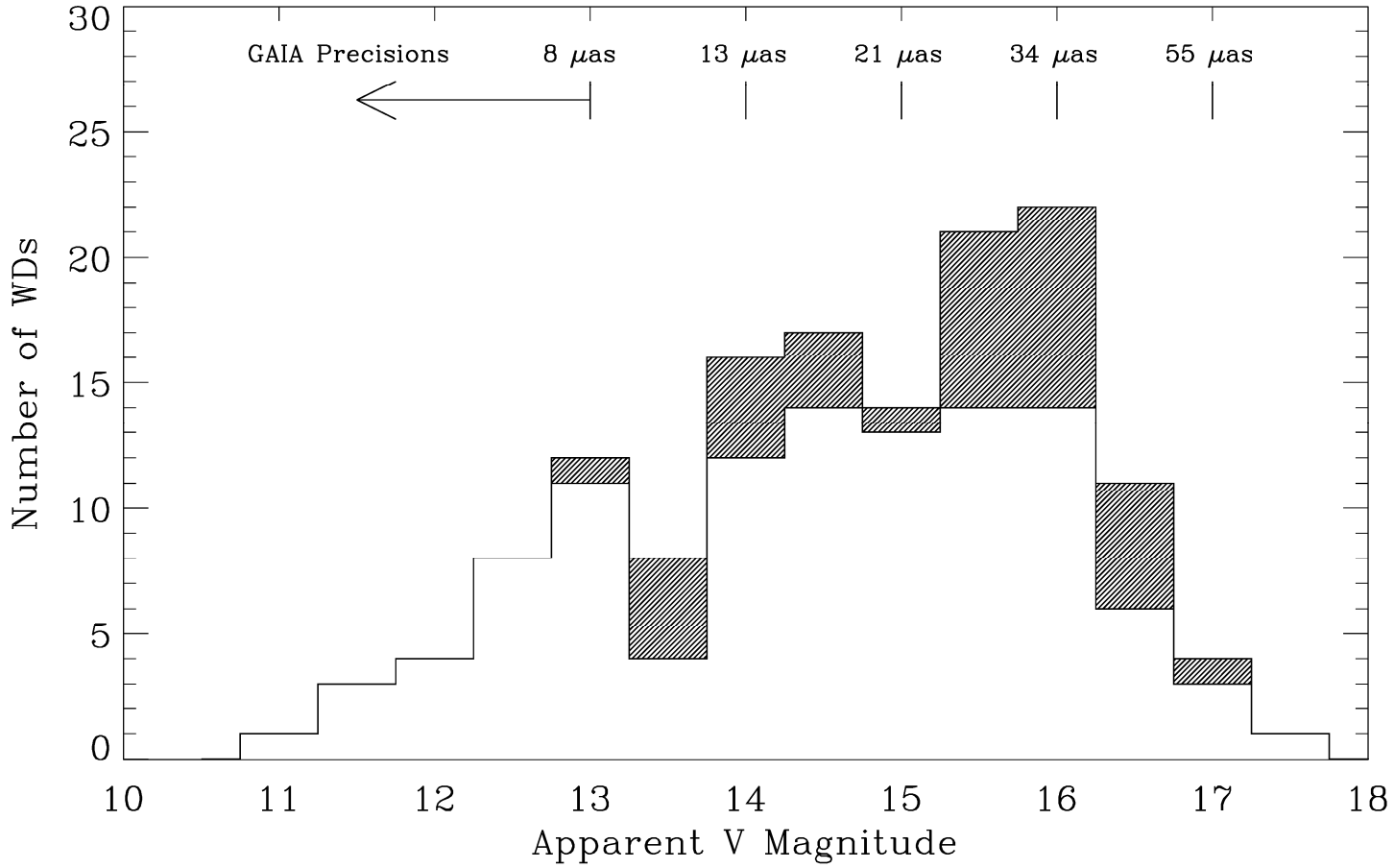
Latest 25 pc WD Sample



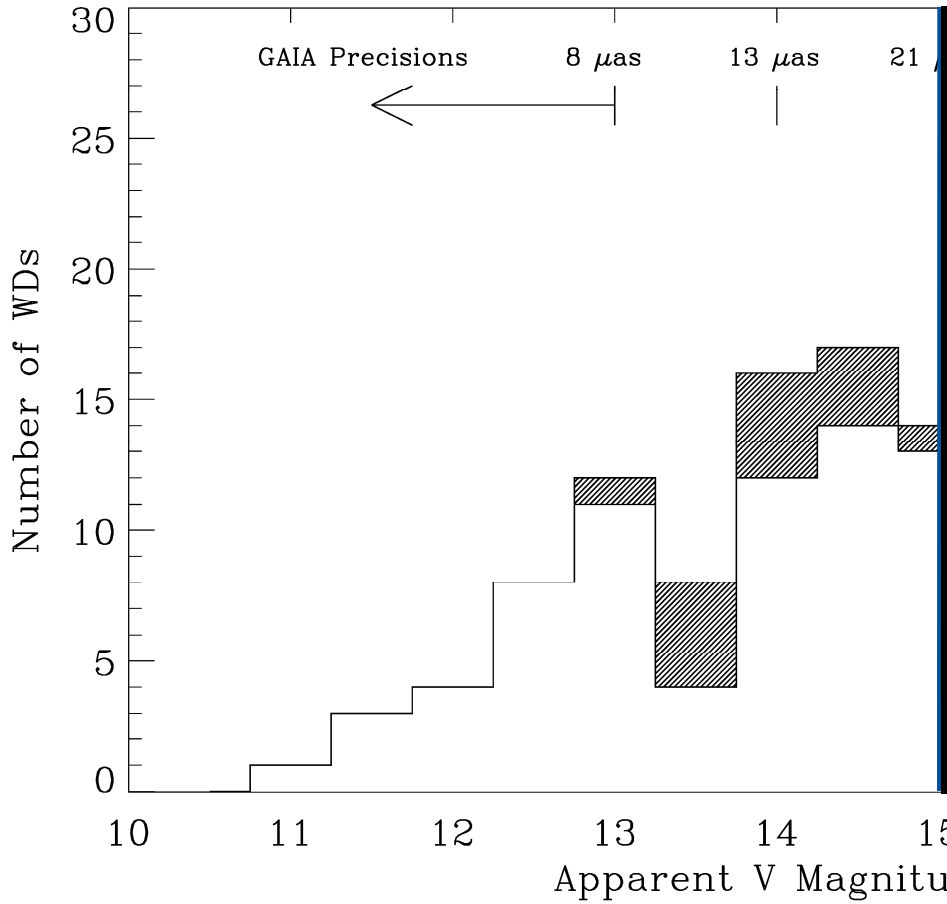
Binned in 2 pc steps

- 110 WD systems previously known (white)
- 34 WD systems with new CTIOPI parallaxes (shaded)

Nearby WD Magnitudes



Nearby WD Magnitudes



$V \leq 15$

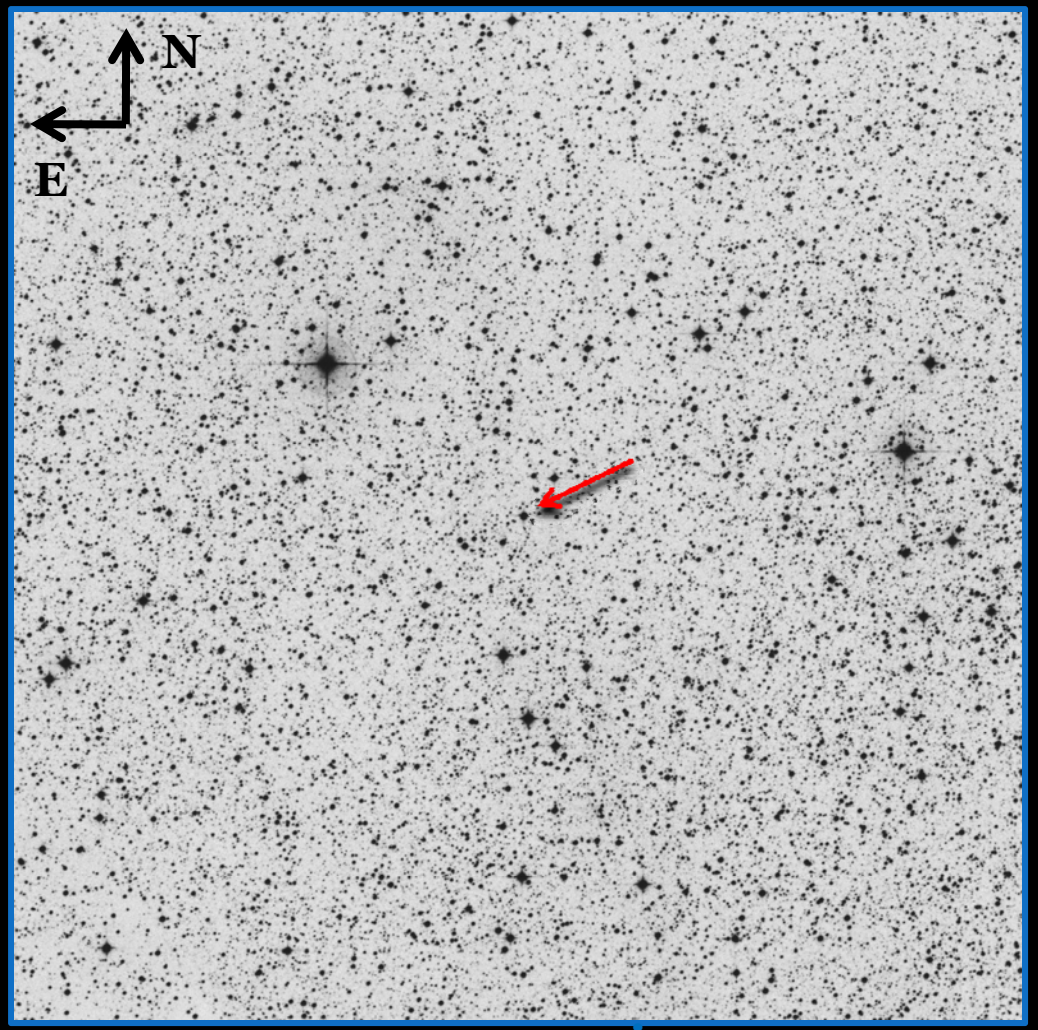
Distance	# Systems
10 pc	14
15 pc	35
20 pc	60

Representative Parameter Settings

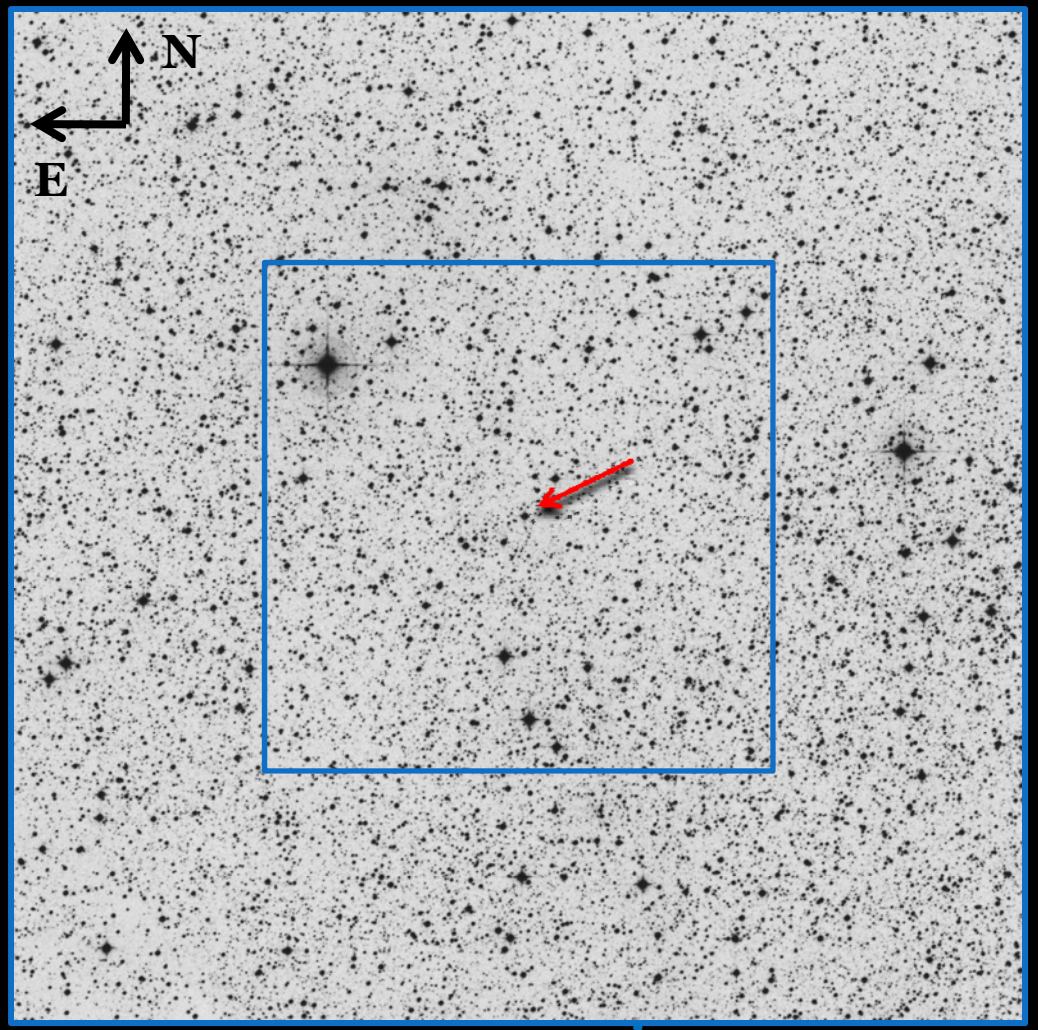
V Mag	Target Exposure	Reference Exposure	No. of Visits	Single-Epoch Accuracy	Mission Time
11th	80 sec	30 sec	100	3.88 μas	19.4 hrs
12th	100 sec	30 sec	90	4.08 μas	20.0 hrs
13th	120 sec	30 sec	80	4.44 μas	20.0 hrs
14th	170 sec	40 sec	60	4.98 μas	20.0 hrs
15th	360 sec	60 sec	32	4.99 μas	20.0 hrs

1. A $(B - V)$ color index = 0.4 (target & refs)
2. Reference V mag = 12.0
3. Five reference stars with separation = 1.0°
4. One chop cycle

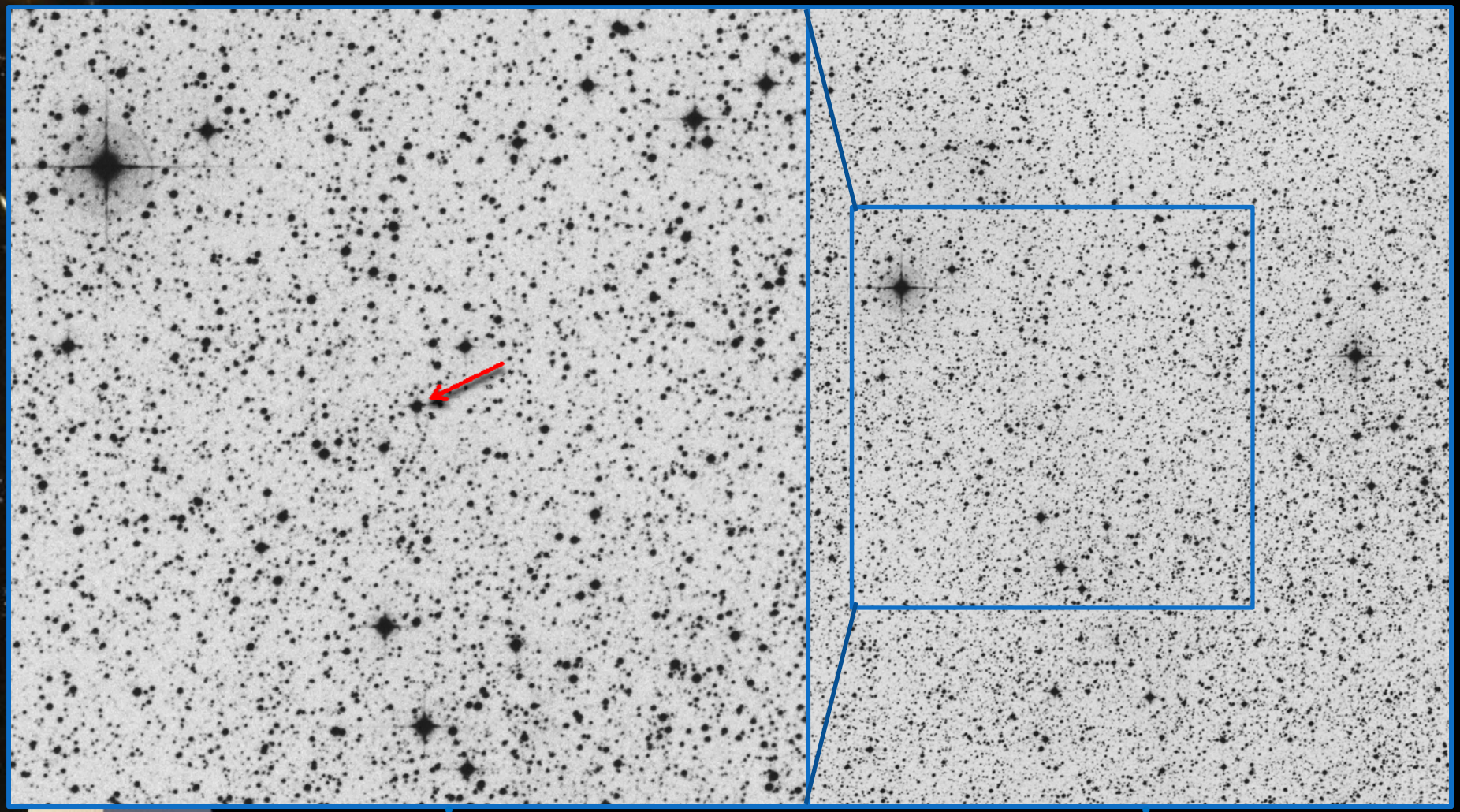
Sample Field



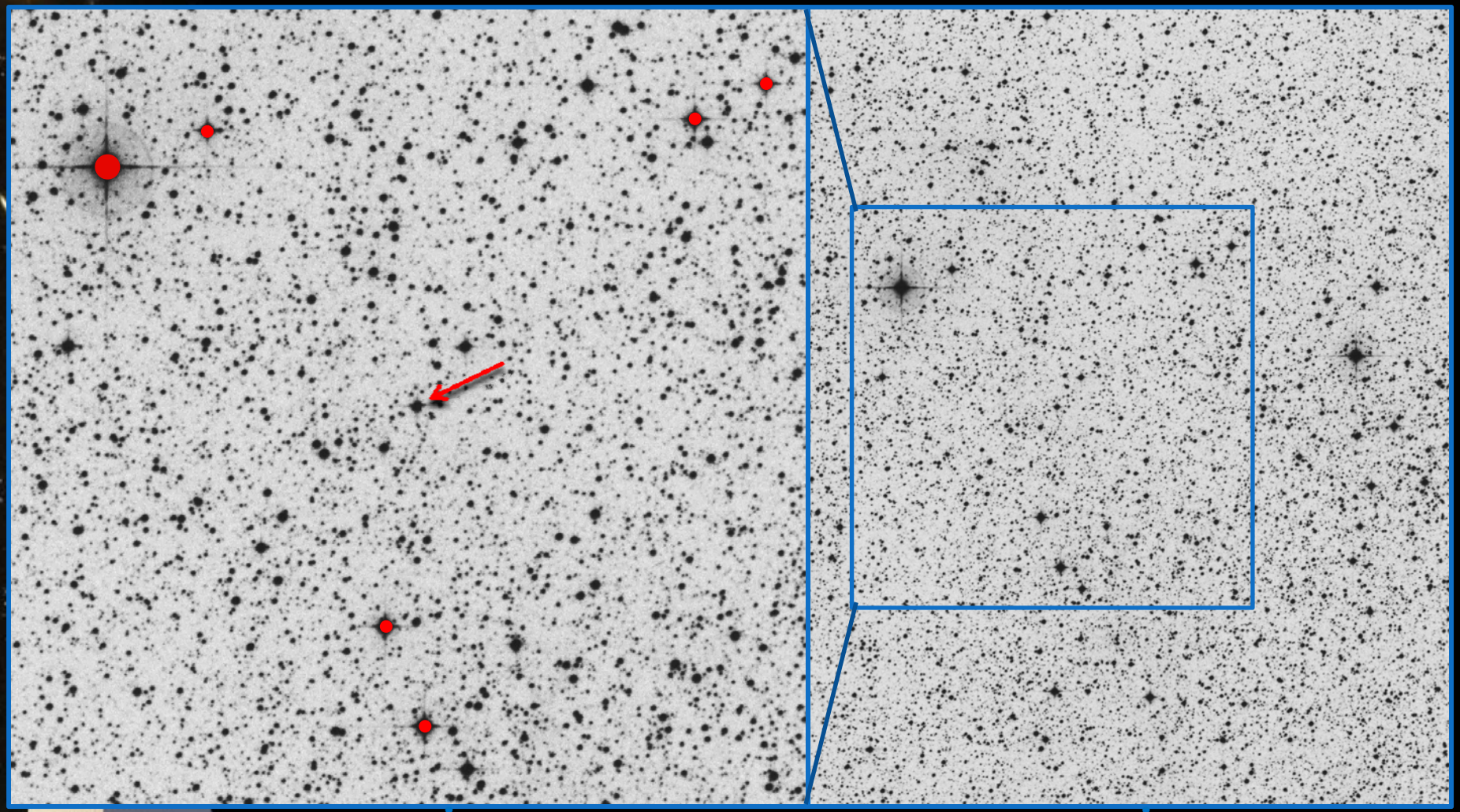
Sample Field



Sample Field



Sample Field



15 arcmin

30 arcmin

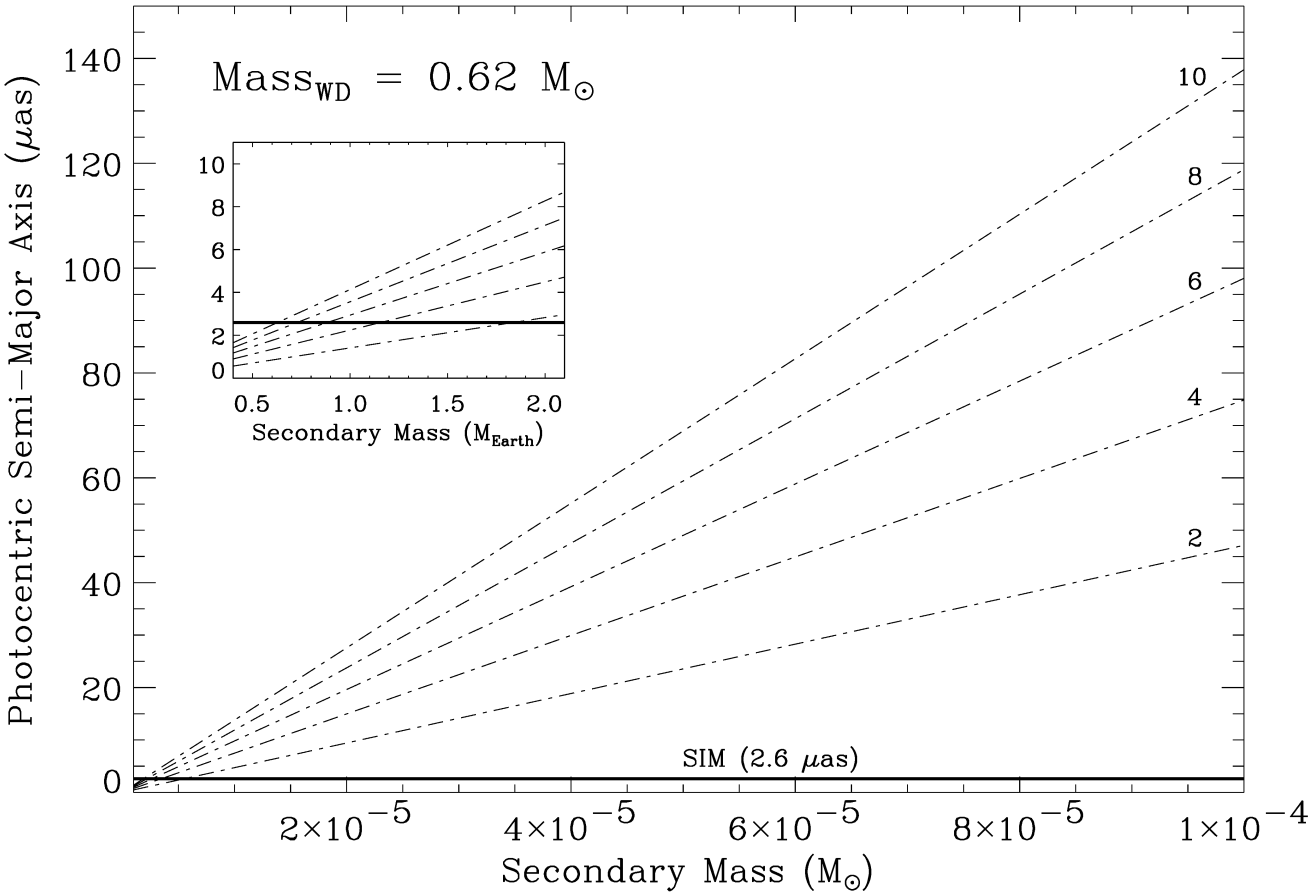
Sample Target

- Science target V magnitude = 11.5
- Reference target V magnitude = 10.0
- Target-reference sky separation = 8 arcmin
- Number of reference targets = 6
- Science target integration time = 60 sec
- Reference target integration time = 20 sec
- Number of visits = 100

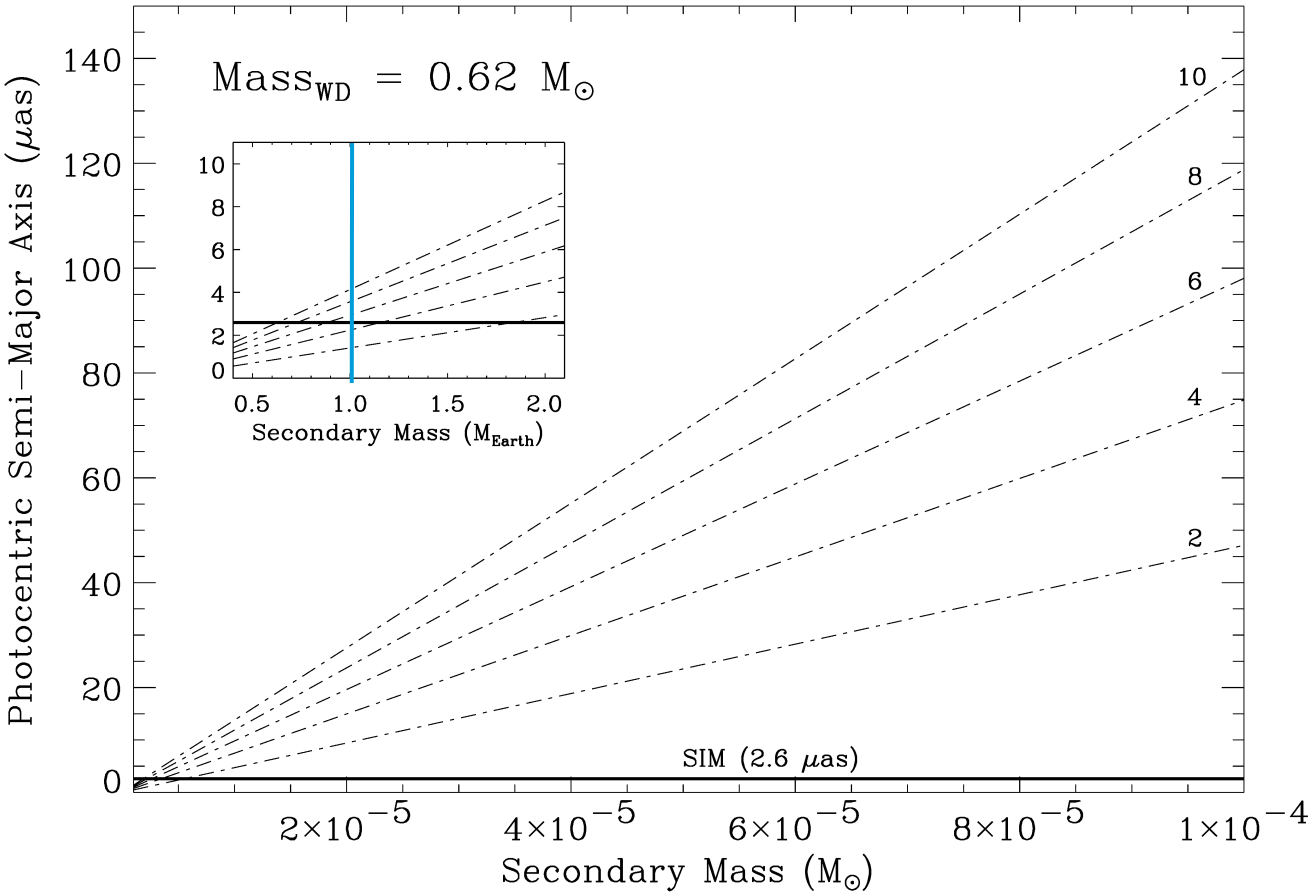
Sample Target

- Science target V magnitude = 11.5
- Reference target V magnitude = 10.0
- Target-reference sky separation = 8 arcmin
- Number of reference targets = 6
- Science target integration time = 60 sec
- Reference target integration time = 20 sec
- Number of visits = 100
- DA precision per visit = 2.6 μas
- Total mission time = 18.3 hrs

SAMPLE TARGET



SAMPLE TARGET



SUMMARY

- SIM will be the most sensitive astrometric instrument available and thus, capable of detecting low-mass planets orbiting WDs
- This study will:
  - Evaluate the nearby WD sample
  - Identify ~25 “ideal” candidates for planet searches via SIM

SUMMARY

- SIM will be the most sensitive astrometric instrument available and thus, capable of detecting low-mass planets orbiting WDs
- This study will:
  - Evaluate the nearby WD sample
  - Identify ~25 “ideal” candidates for planet searches via SIM
- Hopefully, we’ll find planets around WDs!