Science with Neat

Capabilities of ASTROMETRY

- 2 astrometric measures per visit, e.g. RA + Dec
- N visits

  => ***fully characterize*** planetary ***systems***

  for each of the p planets:

  $(M_{pl} / M_{pl}\, i, a, e, \omega, \Omega)_j$ for j = 1,..., p

- Astrom. amplitude:

  $A = 0.30\ \mu as\ \times (M_{pl} / M_{Earth})\ (a /1\ AU)\ (D /10pc)^{-1}\ (M_{st} / M_{Sun})^{-1}$

  $300\ \mu as\ \times (M_{pl} / M_{Jup})\ \ (a /1\ AU)\ (D /10pc)^{-1}\ (M_{st} / M_{Sun})^{-1}$

=> optimum for ***Habitable Zone***

Gaia (10 μas) for **jupiters,** D < 300 pc

Neat (0.05 μas) for **earths / super-earths,** D < 15 pc

Prime goal of Neat

- detect and fully characterize planetary systems
- with all components, down to Earth mass
- orbiting bright solar type stars (F G K, V ≦ 9)
- in the solar neighborhood (D < 20 pc)

With planetary architectures:

- similar to that of our Solar System
- or any one with Earth mass planets

➥ Key capability: detecting Earth-mass planets in the H Z

NEAT scientific cases

This mission will answer the following questions:

➡ **What are the dynamical interactions between giant and telluric planets in a large variety of systems?**

➡ **What are the detailed processes involved in planet formation as revealed by their present configuration?**

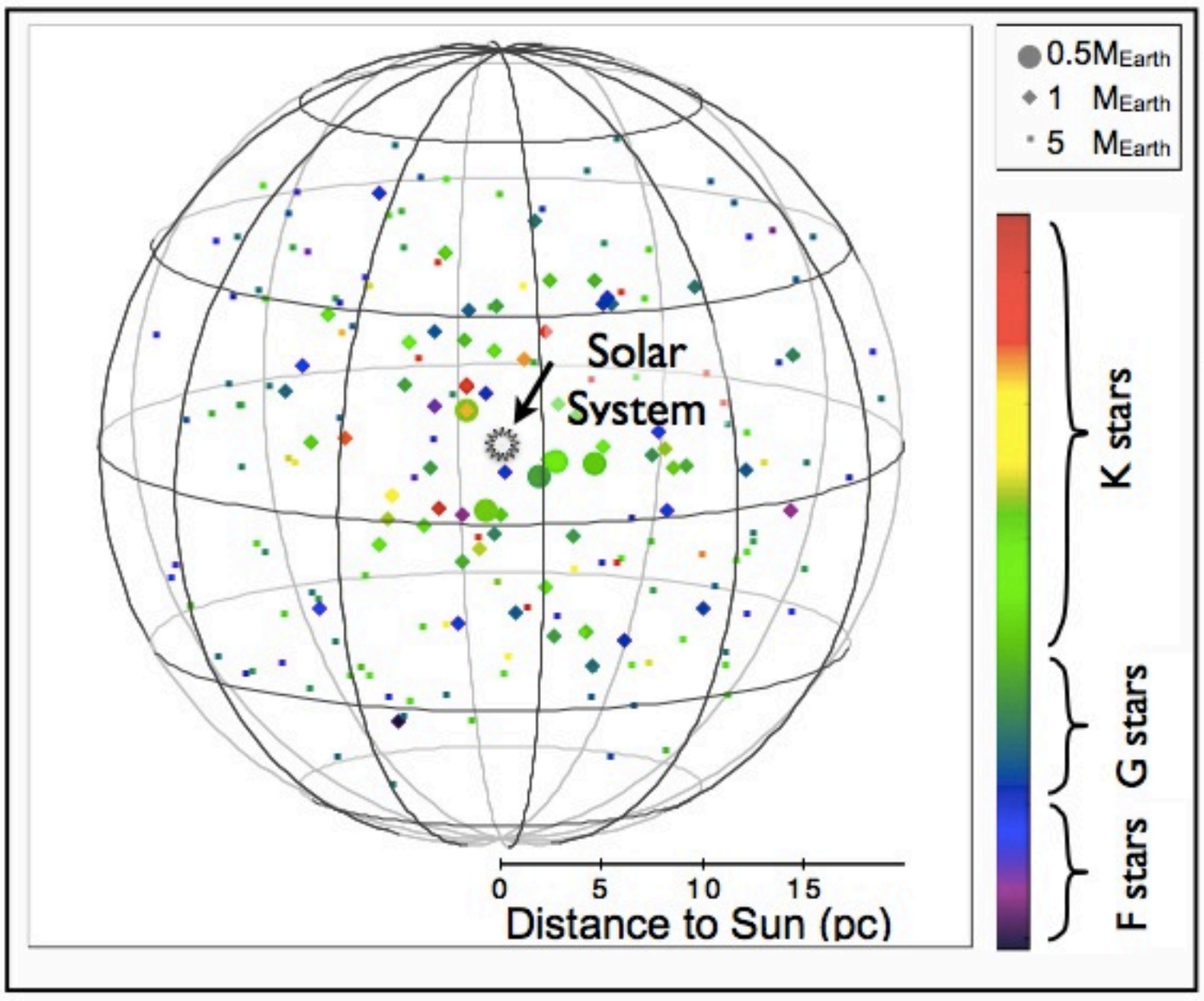
➡ **What are the distributions of architectures of planetary systems in our neighborhood up to ~20 pc?**

➡ **What are the masses, and addresses, of telluric planets that are candidates for future direct detection and spectroscopic characterization missions?**

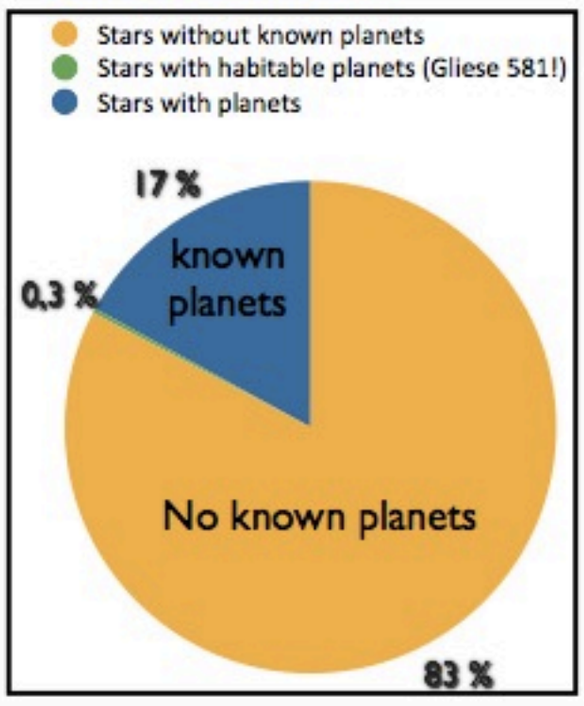
NEAT targets

Number of stars	Mass threshold (M⊕)	Cumulated time (h)	Number of visits
5	0.5	1,100	500
70	1	15,600	3,500
200	5	6,400	6,000
Total		**22,100**	**10,000**

Main program

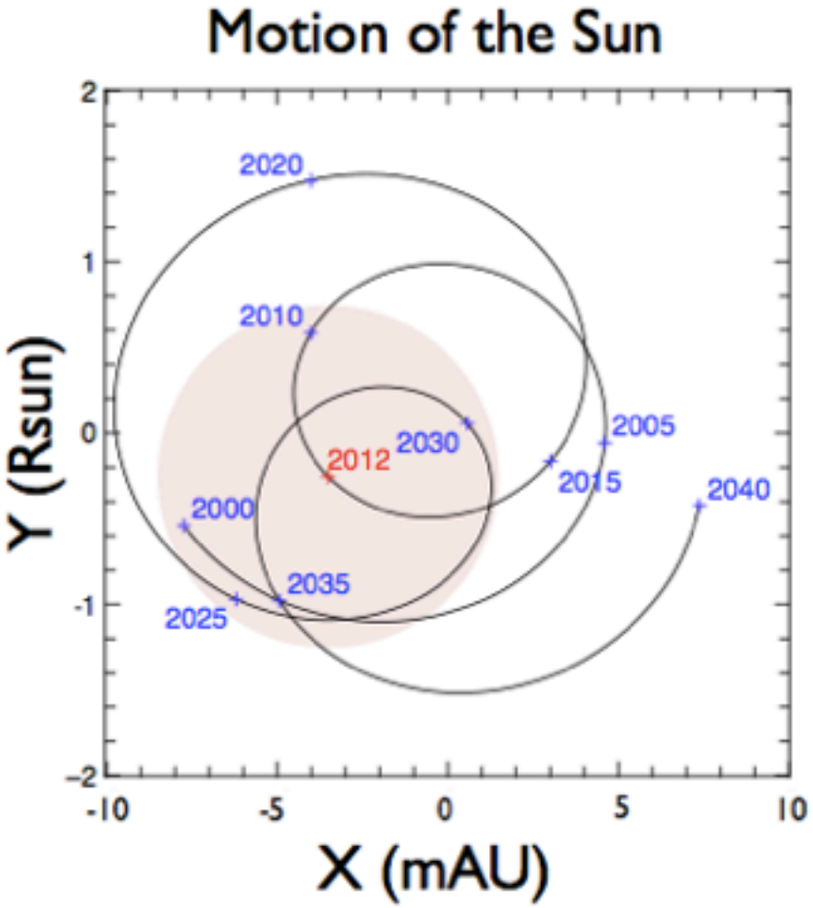


- Main program: 70%
  FGK stars, d<20pc
- Additional program: 30%
  young stars, A & M stars, binaries,.



NEAT desired accuracy

$$A = 0.33\ (a_P / 1\ AU)\ .\ (M_P / 1\ M_E)\ .\ (M* / 1\ M_S)^{-1}.\ (d / 10\ pc)^{-1}\quad \mu as$$



Sun @ 10pc	**Giants planets**	**Telluric planets**
M_P (M_E)	300	1
a_P (AU)	5	1
P (yr)	11	1
A (in μas)	**495**	**0.3**

Astrometry measures

$P, a_P, i, e, \omega, \Omega, T_0 \Longrightarrow M_P$

- Goal: detecting signal ≥0.3±0.05 μas
- ➡ typically 50 visits with 0.8 μas in 1h
- Main limit: photon-noise from reference stars

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Which planets ?

- case of a 1 m diam. telescope (nominal Neat),
  with N_{visit} per star, e.g. N_{visit} = 50

- ***many possibilities***, e.g. search for:
  - ***low mass*** planets, around a small star # , or
  - ***heavier*** planets, e.g. 3 M_{Earth}, around more stars

- for each star *k*, $t_{visit,\,k}$ can be tuned, respecting:

$$\sum_k N_{visit}\ t_{visit,\,k} = \mathrm{t}_{mission}$$

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Which planets ? (2)

- end mission accuracy, for planet ***k***

  for an instrument with accuracy: σ_0 in t_0, e.g. σ_0 = 0.8 µas in t_0 = 1 h

  $\sigma = \sigma_0 \, (t_{visit} / t_0)^{-1/2} \; (N_{indep\text{-}data})^{-1/2}$

  $N_{indep\text{-}data} = 2\, N_{visit} - m, \quad m = 5 + 7\, p,$

  p: planet # in the system, e.g. p = 3 => m = 26

- S/N = A / σ

=> $t_{visit,\,k} = t_0 \, [\sigma_0 \,.\, S/N \,.\, A^{-1}(M_{pl,k} / M_{st,\,k},\, a,\, D_k)]^2 \,.\, (N_{indep\text{-}data})^{-1}$

remind:

A = 0.30 µas x (M_{pl} / M_{Earth}) (a /1 AU) (D /10pc)$^{-1}$ (M_{st} / M_{Sun})$^{-1}$

$$\sum_k N_{visit}\, t_{visit,\,k} = t_{mission}$$

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Example (1)
required: "many" stars down to 1.0 M_{Earth}
total mission = 18 000 hours

Rank	Star_ident	SpTyp	D (pc	t_{tot}(h)	A (uas)	t_{visit} (h)	A (uas)	t_{visit} (h)	A (uas	t_{visit} (h)
					M_{limit} = 0,5 M_E		M_{limit} = 1 M_E		M_{limit} = 5 M_E	
1	HIP16537	K2V	3,2	139	0,35	2,5				
2	HIP8102	G8V	3,7	337	0,29	3,7				
3	HIP108870	K5V	3,6	552	0,28	4,0				
4	HIP104214	K5V	3,5	804	0,25	4,8				
5	HIP19849	K1V	5,0	1 094	0,24	5,6				
6	HIP104217	K7V	3,5	1 176			0,47	1,4		
7	HIP99240	G5IV	6,1	1 265			0,45	1,5		
8	HIP96100	K0V	5,8	1 357			0,44	1,6		
				(...)			(...)			
70	HIP23835	G4V	15,4	17 349			0,20	7,6		
71	HIP47592	G0V	15,0	17 349					1,00	0,31
72	HIP26779	K1V	12,3	17 377					1,00	0,31
73	HIP113576	K5/M0V	8,2	17 405					1,00	0,31
110	HIP91438	G5V	13,1	17 976					0,88	0,40
111	HIP42438	G1.5Vb	14,4	17 976					0,88	0,40
112	HIP116745	K3V	11,4	18 009					0,88	0,40
				(...)			(...)			
113	HIP64792	G0Vs	17,6	18 009					0,88	0,40

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Example (2)
required: 40 stars down to 1.0 M_{Earth}
total mission = 18 000 hours

Rank	Star_ident	SpTyp	D (pc)	t_{tot}(h)	A (uas)	t_{visit} (h)	A (uas)	t_{visit} (h)	A (uas)	t_{visit} (h)
					M_{limit} = 0,5 M_E		M_{limit} = 1 M_E		M_{limit} = 3 M_E	
1	HIP16537	K2V	3,2	139	0,35	2,5				
2	HIP8102	G8V	3,7	337	0,29	3,7				
3	HIP108870	K5V	3,6	552	0,28	4,0				
4	HIP104214	K5V	3,5	804	0,25	4,8				
5	HIP19849	K1V	5,0	1 094	0,24	5,6				
6	HIP104217	K7V	3,5	1 176			0,47	1,4		
7	HIP99240	G5IV	6,1	1 265			0,45	1,5		
				(...)			(...)			
8	HIP96100	K0V	5,8	1 357			0,44	1,6		
39	HIP23311	K3V	8,7	7 273			0,25	5,0		
40	HIP81300	K2V	9,8	7 537			0,25	5,0		
41	HIP47592	G0V	15,0	7 549					0,60	0,86
									(...)	
42	HIP26779	K1V	12,3	7 605					0,60	0,87
169	HIP79537	K0V	13,9	17 582					0,42	1,78
170	HIP18859	F5V	18,8	17 684					0,42	1,80

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