A NASA-Origins Proposal to help expand the CHARA/FLUOR Hot Disk Survey

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NASA Origins of Solar Systems (OSS) Program

- OSS is one of 82 different NASA ROSES (Research Opportunities in Space and Earth Sciences) Programs

- *"The Origins of Solar Systems program solicits basic research proposals to conduct scientific investigations related to understanding the formation and early evolution of planetary systems and to provide the fundamental research and analysis necessary to detect and characterize other planetary systems. These investigations may involve analytical and numerical modeling, laboratory research, and observational studies in the following areas: star formation and the relationship to planetary system formation, solar nebula processes, accumulation and dynamical evolution, analysis of primitive materials, and the detection and characterization of other planetary systems."*

- Cross Program between 2 Divisions of NASA's SMD: Astrophysics (all exo-planet related proposals) and Planetary Science (all other proposals)

- Typical Yearly Program budget: ~ $ 2-3 M
- Typical number of yearly new awards: ~ 20-30
- Awards Duration: up to 4 years, 1-3 years is more common

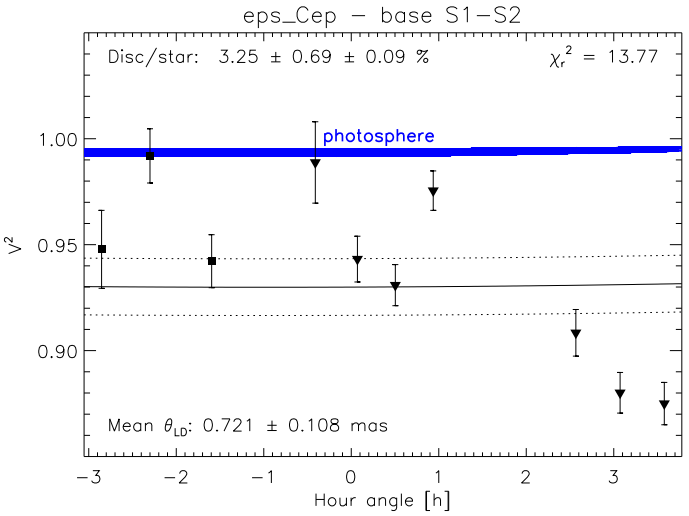
OSS 2012 Selections (for FY13 and later)

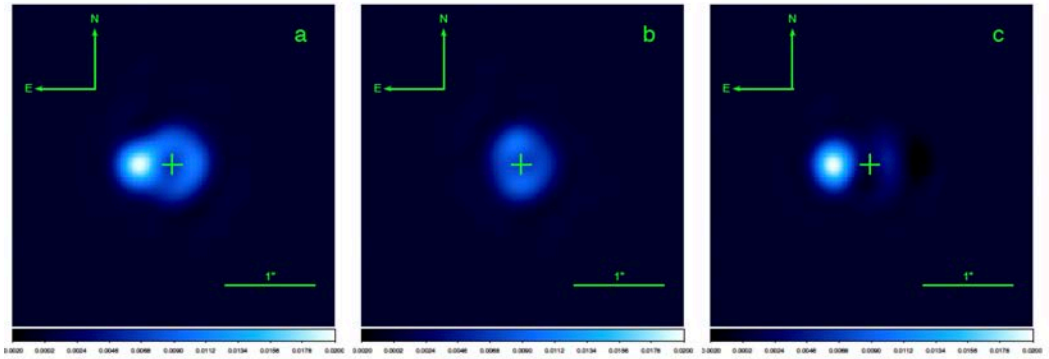
- 146 proposals submitted (!)
  - 46 in Astrophysics (12 selected)
  - 100 in Planetary Science (9 officially selected so far)
- *Planetary Science 2012 OSS selections included our 3 year CHARA/FLUOR proposal "Near Infrared Characterization of Hot Exo-Zodiacal Disks around Nearby Stars"*
- Budget uncertainties /sequestration
  - selection first (non-officially) notified August 22 2012. Officially confirmed on Feb 27 2013.
  - 50% of FY13 total requested funds have been sent out on Feb 28. Not at JPL yet ☹
- Budget Includes a $ 25K/ yr sub-contract to GSU
- Symbolic, but possibly paves the way to more funding thru NASA Programs?
  - e.g. follow-up observations of LBTI nuller exo-zodi targets and calibrators

What did we promise?

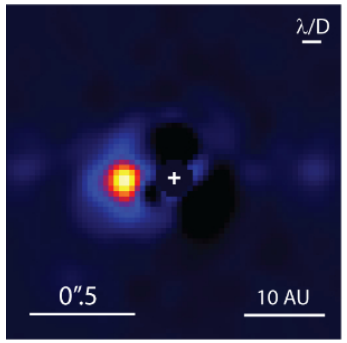
- **Expand the current FLUOR survey of 42 MS stars(Denis' talk) to ~100 stars,** with sensitivity to (~2X) fainter exozodi emission.
- **Carry out a statistical analysis of the hot dust phenomenon, studying its dependency on basic stellar parameters** such as the existence of cold dust (MIR /FIR excess), stellar spectral type and age
- **Look for correlation of the excess with the presence of massive planets** previously detected by RV or transit studies.
- **Study the short term evolution of the detected excess**, starting with the 12 stars already known to exhibit significant resolved extra-emission from FLUOR measurements.
- **Constrain the morphology of these hot debris disks**, measuring the excess variability versus azimuth and spatial frequency (S1-S2 and E1-E2)
- **Develop new models and numerical simulations of the dynamical evolution of small hot dust grains**, including the effect of gas/dust coupling close to the dust sublimation radius (GB, NT, JL)
- **Study the wavelength dependence & nature of the excess via:**
  - spectrally resolved observations in the Kband (improved FLUOR will have 8 channels)
  - complementary high contrast high resolution observations w/ other instruments (MIRC/NIRC/Palomar/KIN)

Examples of complementary observations: epsilon Cep (Palomar VVC K-band)

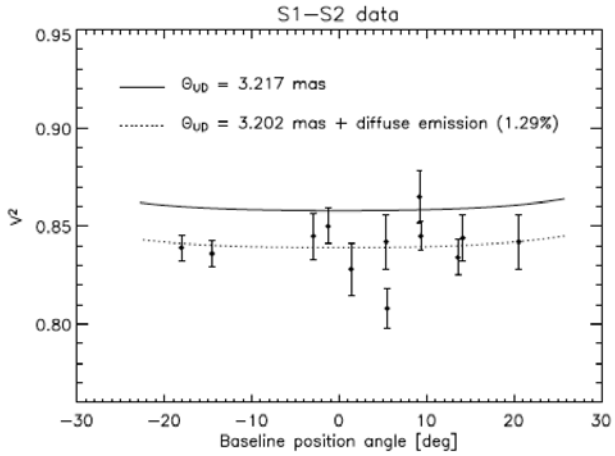


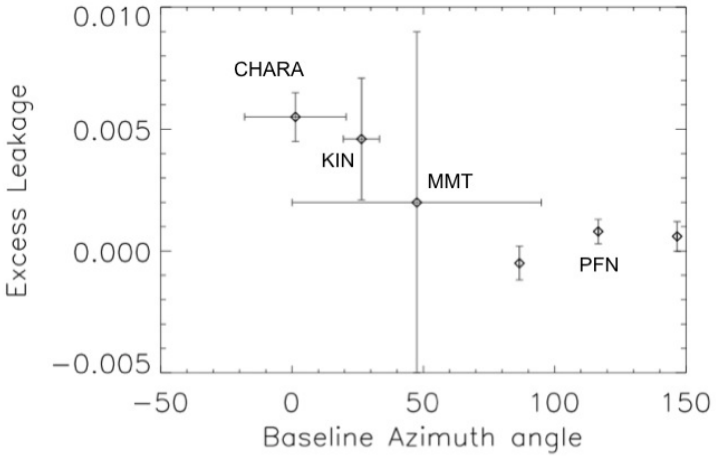


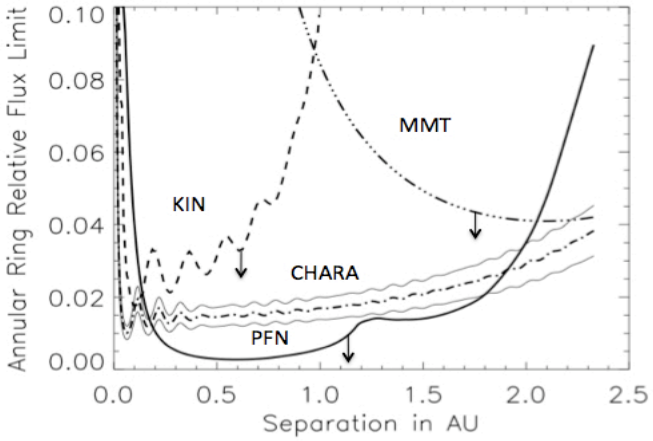
- 50:1 apparent companion @ 330 mas detected in June 2010 (Mawet et al. 2011)
- Physical association confirmed in Nov. 2012, long and/or highly eccentric orbit consistent with non detection of late K stellar companion by Hipparcos

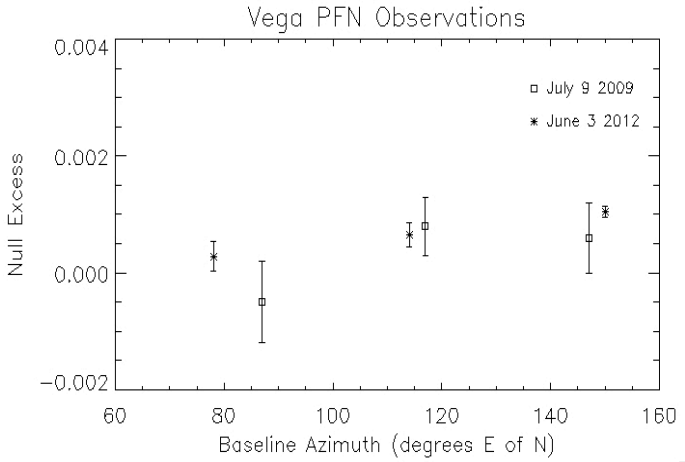


Examples of complementary observations: Vega



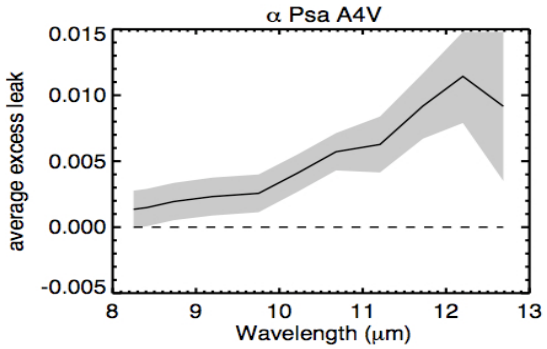


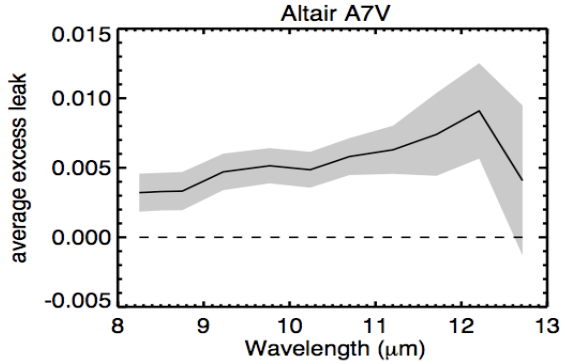




Examples of complementary observations: mid IR nulling

- 10 of the current 12 CHARA/FLUOR excess stars were observed with the KIN
  - Only 3 show (marginal) excess at N band, e.g. Altair:

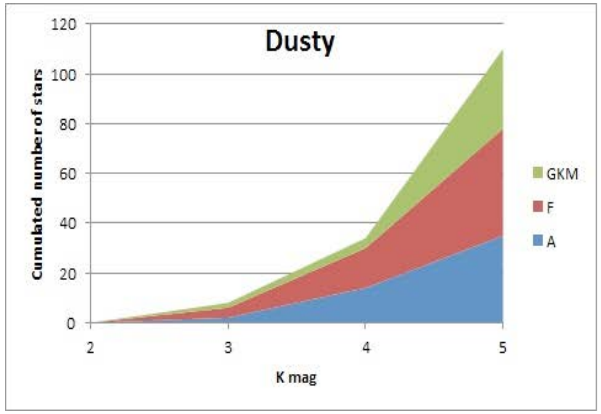


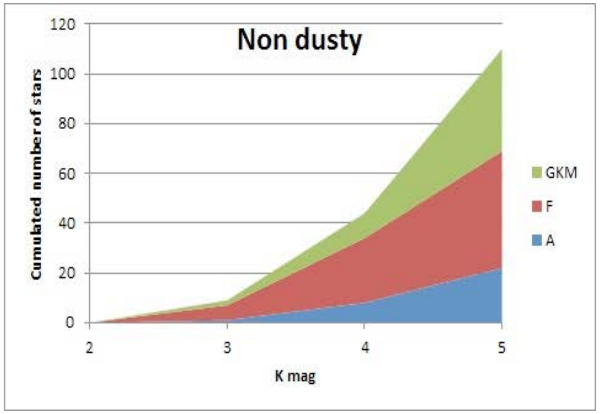


- Fomalhaut 1st known to show both NIR (VLTI/VINCI) and MIR (KIN) excesses
  - Radiative transfer modeling requires 2 spatially distinct dust populations in the inner few AUs (Mennesson et al. ApJ 2013, Lebreton et al. in prep):
  - NIR VLTI excess says hot carbonaceous small grains (0.01 to 0.1 μm) piling up close to 0.1 AU sublimation radius
  - KIN data (esp. >11 μm) suggest second population of larger (5 μm) grains at ~0.5-2 AU

- LBTI Nuller data promises 10 fold improvement in contrast and sensitivity wrt KIN
  - RMG, GB, DD, BM are all part of LBTI nuller science team. See talk by Bill Danchi.

What is needed to complete the 100 stars hot disk survey?





- **Number of nights / observational efficiency**
  - At current observational efficiency and assuming 8 calibrated visibilities per star, 60 stars can be surveyed in 36 successful nights
  - At current rate of 20 FLUOR nights per year for 3 years, we should be able to survey all stars once within 2 years + conduct variability follow-ups of most interesting targets. [17 nights awarded in 2013]

- **Photometric Sensitivity**
  - At current median performance (K=3 to 4), only 30 to 40 dusty targets available (→ unbalanced sample)
  - To achieve goal of 50 dusty + 50 non dusty (control sample), K=4.5 is required, i.e. a minor gain in sensitivity.
  - Is that consistent with improved old NICMOS?
  - Can tip-tilt upgrade get us there all by itself?

- **Visibility accuracy (accessible dynamic range)**
  - Program is viable at current visibility accuracy
  - Possible visibility accuracy improvements thanks to
    - dispersion (FLUOR form factor is chromatic)
    - fringe tracking and use of Visibility Self Calibration method (Mennesson et al. ApJ 2011)