Terrestrial Planet Finder Mission

TPF

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Modeling the TPF Interferometer

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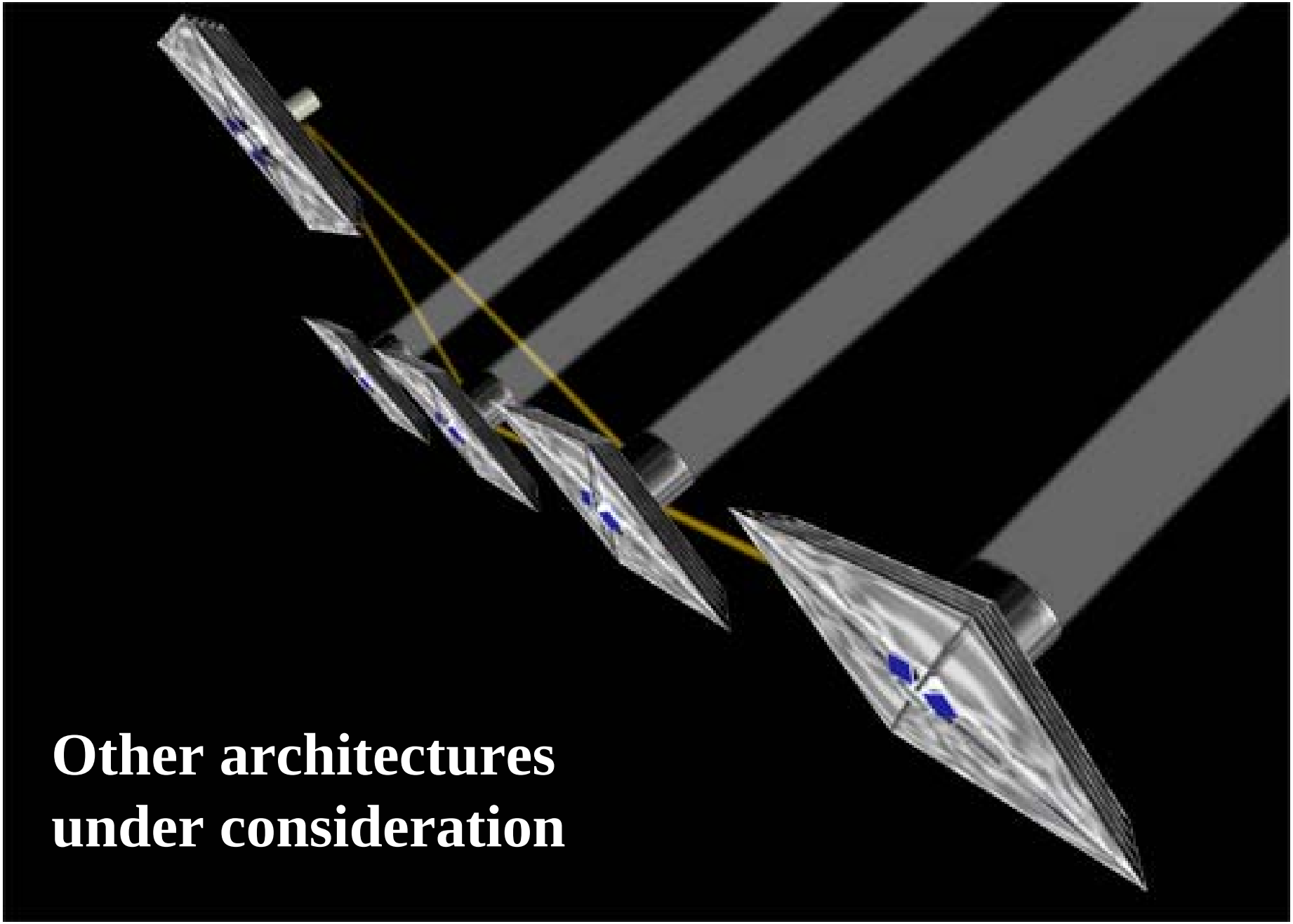
Overview of the TPF-I modeling plan

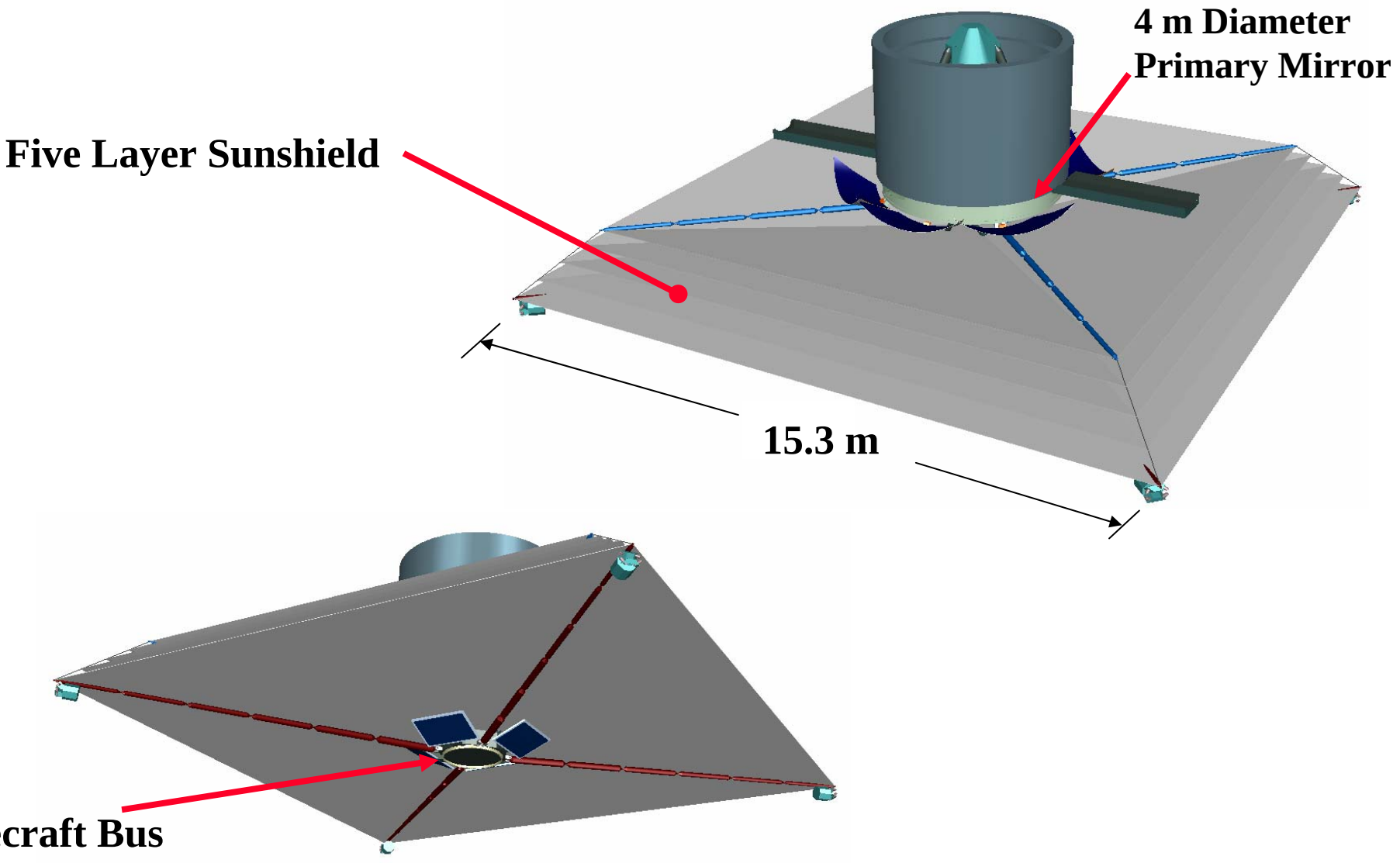
Modeling Challenges

- "The Model" has to say go for launch
  - It also has to explain "funny" things on orbit
- Large
- Tiny
- Complicated
- Cryo
- Novel
- Multiple Organizations

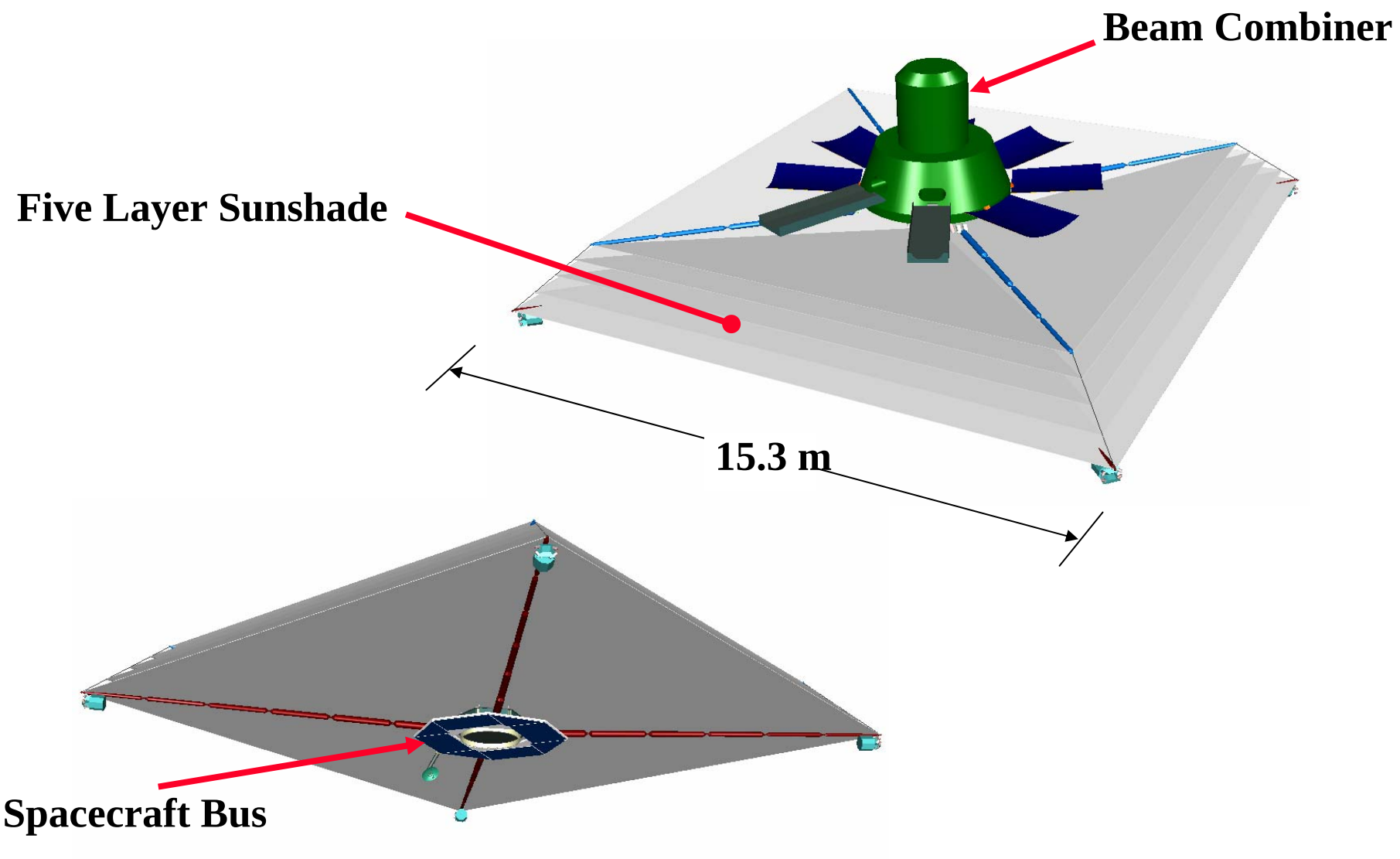


Other architectures under consideration

Formation Flying Interferometer - Collector



Formation Flying Interferometer - Combiner

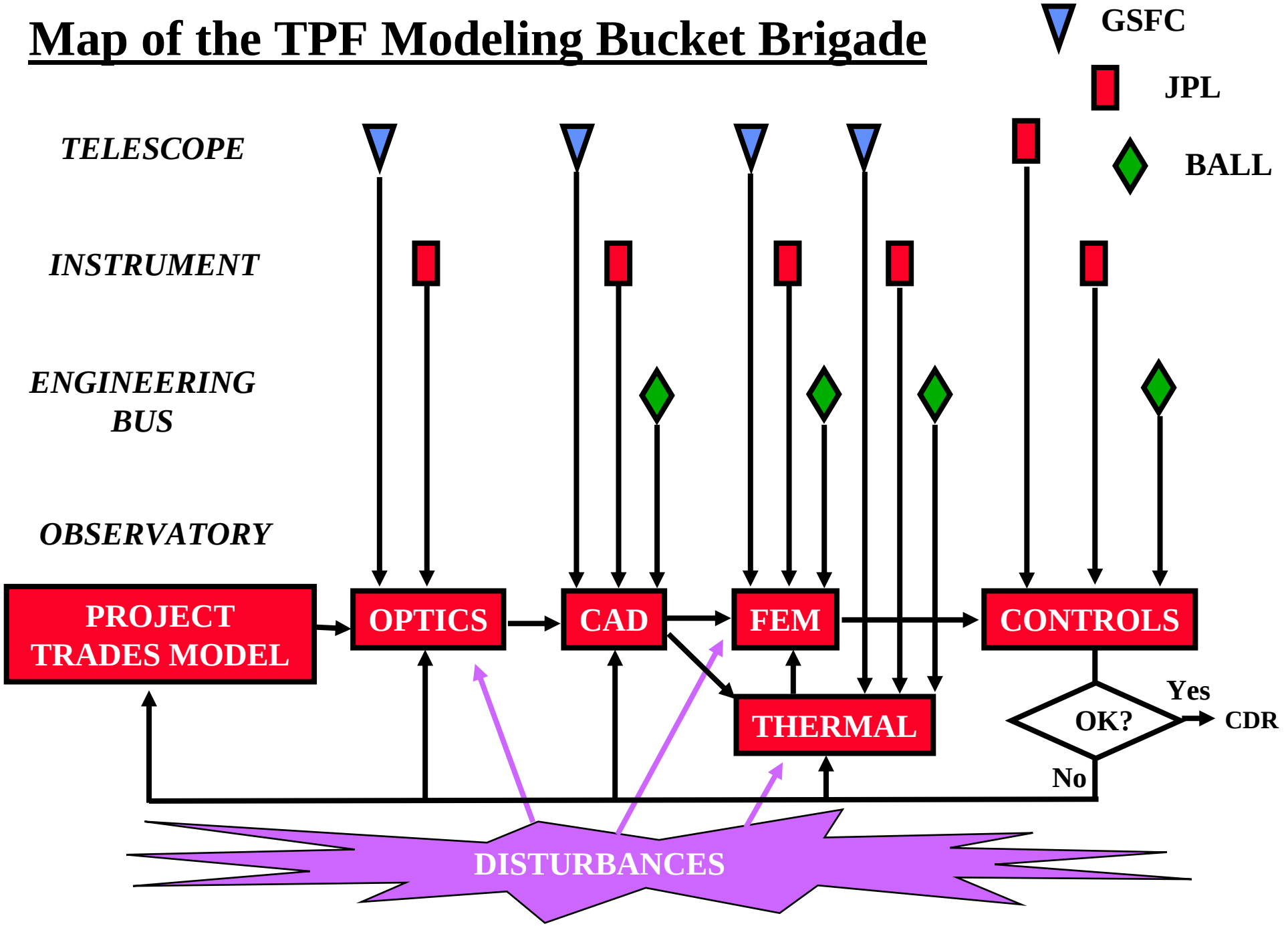


The Approach

Today: Bucket Brigade

Future: IMOS-based Observatory Simulation

Map of the TPF Modeling Bucket Brigade



Some Simple Things to Aid Integration

1. A plan
2. Common coordinate systems
3. Common software applications (or export formats that are compatible with other applications)
4. Common node meshes
5. A good description of the design baseline
6. A library that is subject to configuration management

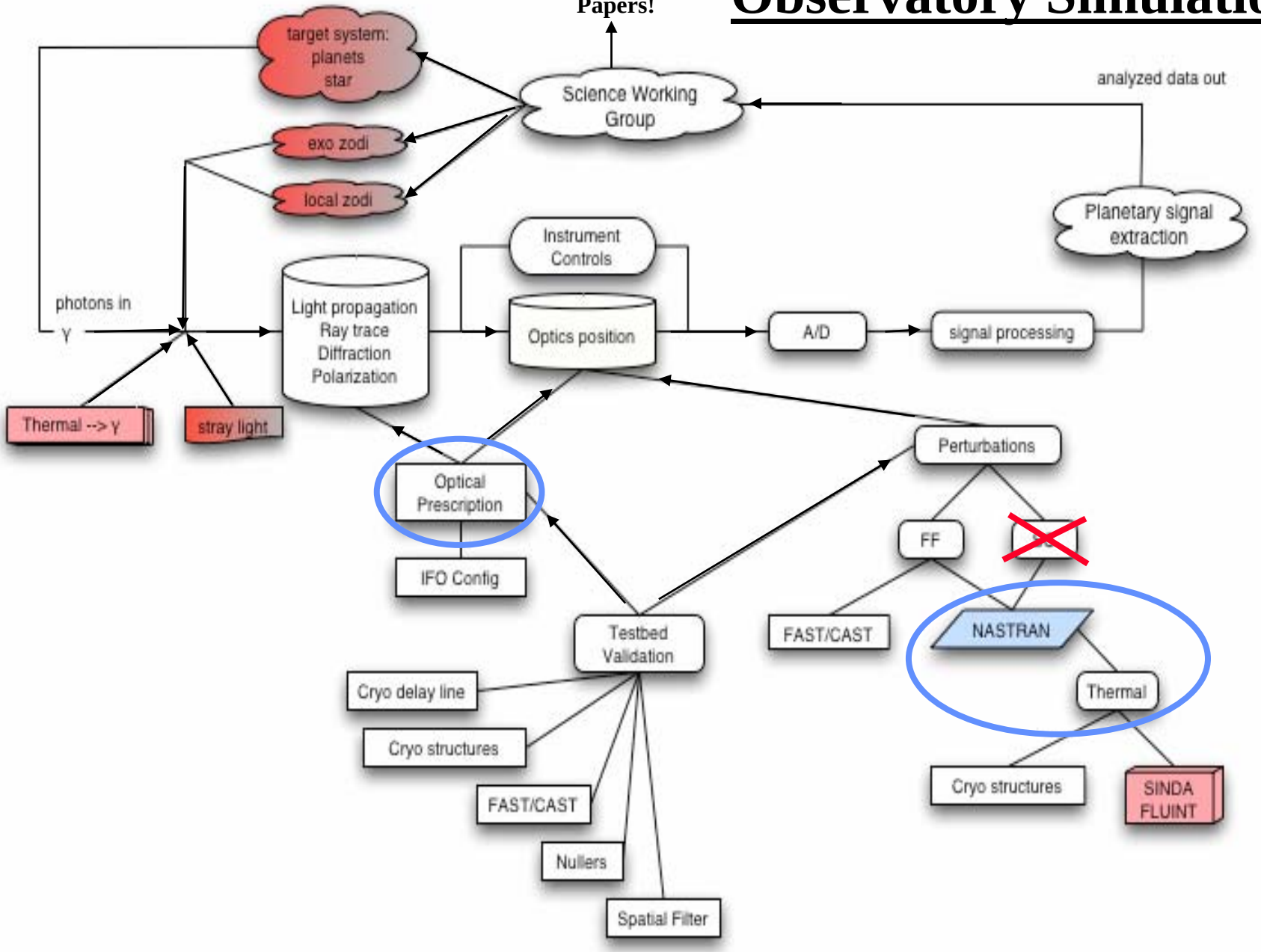
Some Other Models to Integrate

- Disturbance Sources
  - Reaction Wheels
  - Thrusters
  - Cryo cooler
  - Actuators
  - Micrometeoroid impacts
- Natural Environments
  - Local Zodi
  - Exo Zodi
  - Target Planetary Systems
- Stray Light
- Detectors
- Planetary Signal Extraction
- Cost
- Risk

Other Helpers

- University of Arizona (N. Woolf et al)
  - Planetary Signal Extraction
- Massachusetts Institute of Technology (D. Miller, J. Wertz, et al)
  - Optical element perturbations
  - Cost
  - Risk
- University of Colorado (L. Peterson et al)
  - Dynamics of cryo structures
- Lockheed Martin
- Northrop Grumman
- European Space Agency
  - Performance of architectures
  - More later

Observatory Simulation



Some Things We've Already Learned

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- It will be a challenge to . . .
  - Distinguish multiple planets within a star system
  - Achieve 40 K temperatures on optical surfaces
  - Fit a full formation of a Dual Chopped Bracewell array on a single launch vehicle
- Optical throughput margin is healthy
- Stray light effects limit the maximum separation between spacecraft
- Designing TPF-I is fun

Some Work Ahead

- First assessment of whether the error budget can be achieved
  - Need a complete suite of stand-alone models
- Detailed thermal analysis of the sub-40 K portion of the instrument
- Planet signal extraction
- New FFI architecture(s)

Thank you.

Questions?

Backup

Some of the additional presentations about the TPF and Darwin interferometers at this conference

Day	Time	Speaker	Paper #	Paper Title
Monday	2:00 p.m.	Mennesson	5491-16	Expected science capabilities of the TPF interferometer
Tuesday	8:30 a.m.	Fridlund (ESA)	5491-26	Darwin and TPF technology and prospects
Tuesday	8:30 a.m.	Henry	5491-30	Terrestrial Planet Finder interferometer architecture, mission design, and technology development
Tuesday	8:30 a.m.	Lay	5491-32	Architecture selection and optimization for planet-finding interferometers
Tuesday	8:30 a.m.	Miller	5491-33	Current Status of the TPF formation flying interferometer concept
Tuesday	8:30 a.m.	Noecker	5491-40	TPF control system requirements for structurally connected and formation flying interferometers
Tuesday	1:30 p.m.	Pedreiro	5491-41	Control and vibration mitigation for structrually connected Terrestrial Planet Finder Interferometer
Tuesday	5:30 p.m.	poster	5495-43	Structural Configuration for the Terrestrial Planet Finder Structurally Connected Interferometer Concept
Tuesday	7:30 p.m.	poster	5487-183	The potential of conductive waveguides for nulling interferometry
Thursday	11:10 a.m.	Coulter	5487-55	NASA's Terrestrial Planet Finder Mission
Thursday	11:10 a.m.	? (ESA)	5487-56	A comparison of architectures for Darwin/TPF
Thursday	11:10 a.m.	Unwin	5487-57	Terrestrial Planet Finder: science overview
Thursday	11:10 a.m.	Lindensmith	5487-58	Terrestrial Planet Finder technology development
Thursday	5:30 p.m.	poster	5491-188	Deformable mirror based adaptive nuller demonstration in the near-IR
Thursday	5:30 p.m.	poster	5491-189	Stellar suppression with interferometer arrays
Thursday	5:30 p.m.	poster	5491-190	A cryogenic mid-IR nuller for TPF
Thursday	5:30 p.m.	poster	5491-211	Terrestrial Planet Finder cryogenic delay line
Friday	9:45 a.m.	Wallace	5491-96	Mid-IR interferometric nulling for TPF
Friday	9:45 a.m.	Lay	5491-97	The impact of systematic errors on nulling interferometers
Friday	9:45 a.m.	Levine	5497-18	Integrated modeling approach for the Terrestrial Planet Finder Mission
Friday	9:45 a.m.	Henry	5497-19	Modeling the TPF Interferometer

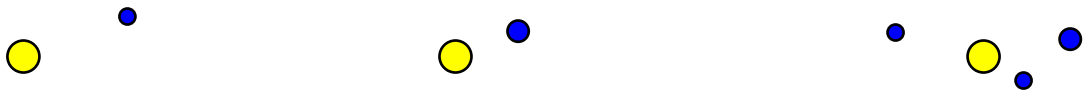
Motivation

- With just a single harmonic, the image reconstruction is highly ambiguous
- Cannot distinguish between:

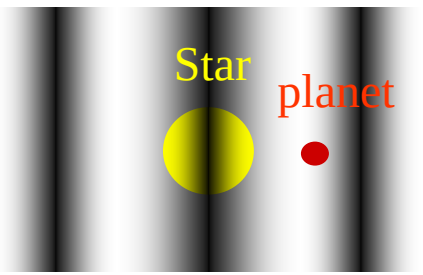
Small planet at large offset

Large planet at small offset

Multiple planets



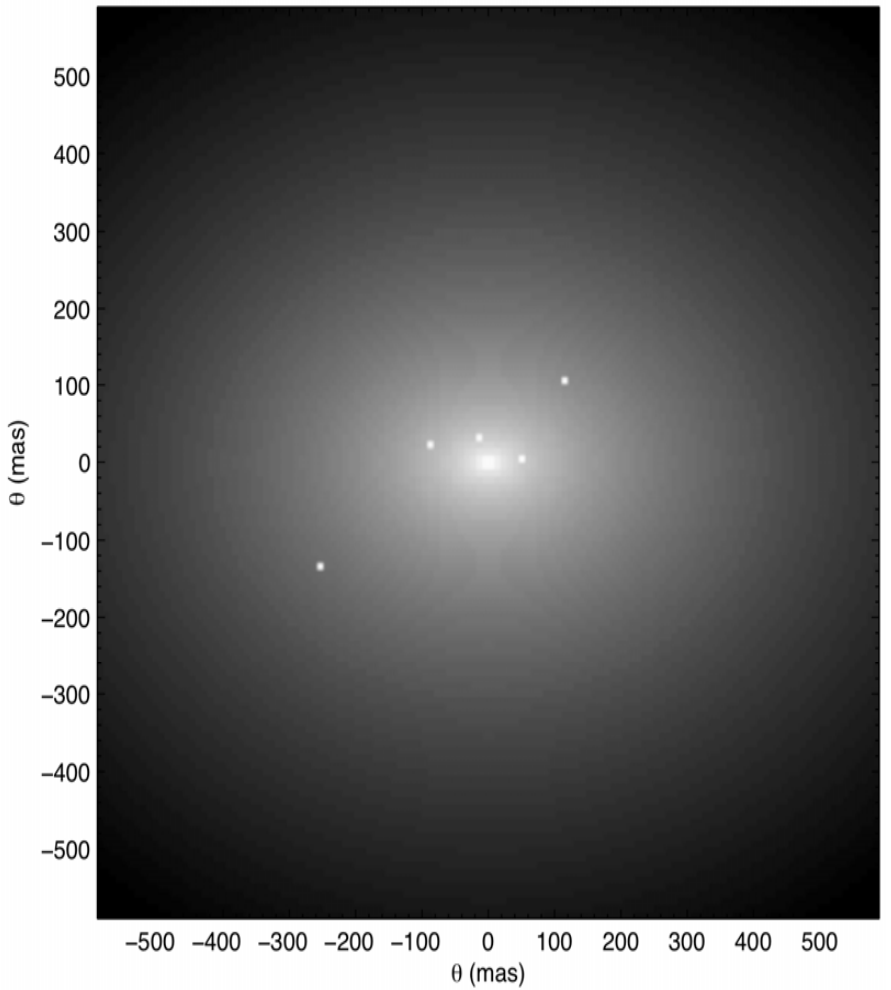
- Hardest when inside the first stripe

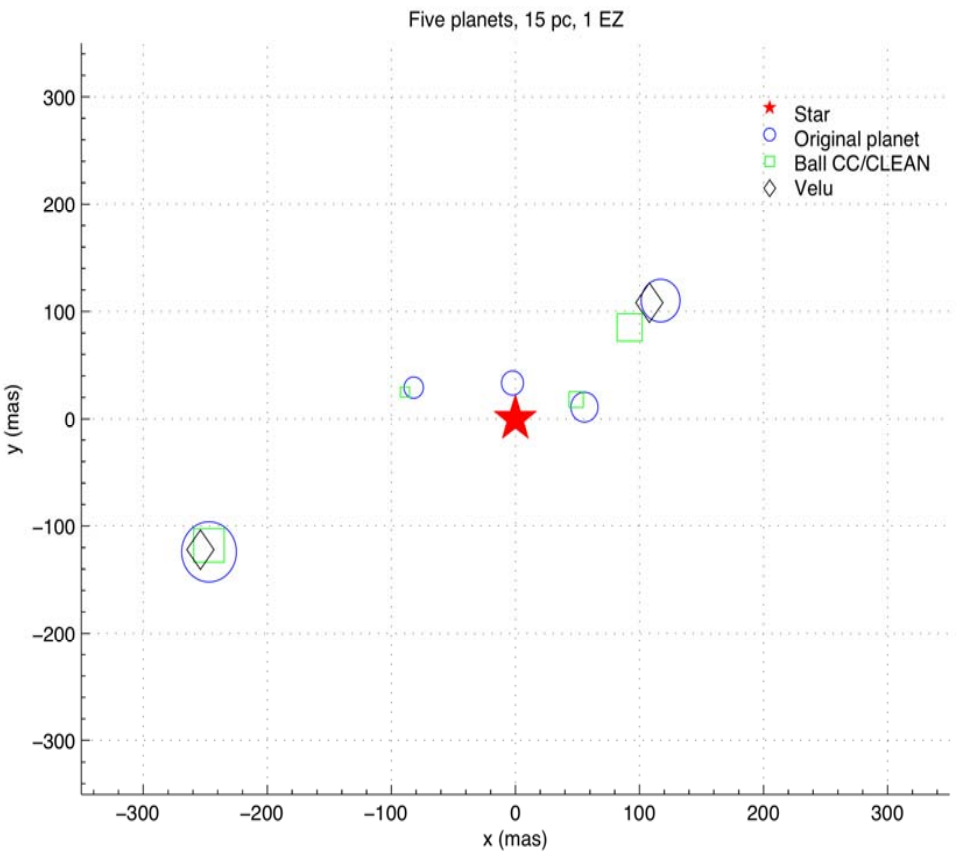


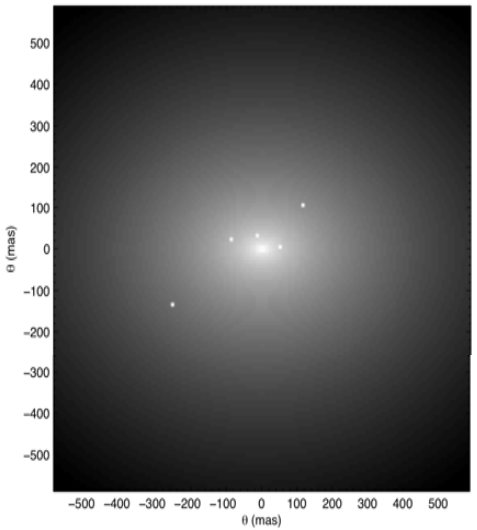
Observations

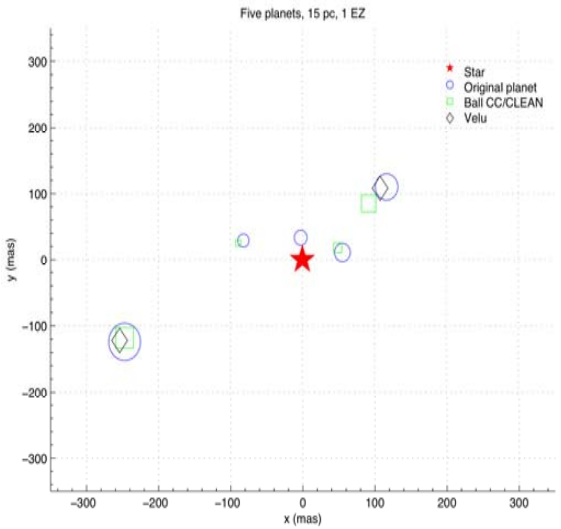
- If planets are close, algorithms tend to find one planet in between
- Algorithms find large planets well
- Large planets suck photons out of small ones
- There wasn't one system with planets that the algorithms didn't make look interesting - suggests that we won't miss worthwhile systems, and revisit information will help resolve ambiguities
- Algorithms find planets where there are none (Case 1)

Planet Signal Extraction









- The top figure shows an earthlike system at 15 pc, on a backgroud of exozodiacal light (log scale in brightness)
- The lower figure shows the results given by two planet detection algorithms, imposed on the original planet positions. The planets are scaled by their flux, and the solutions by their confidence level.

Case 1

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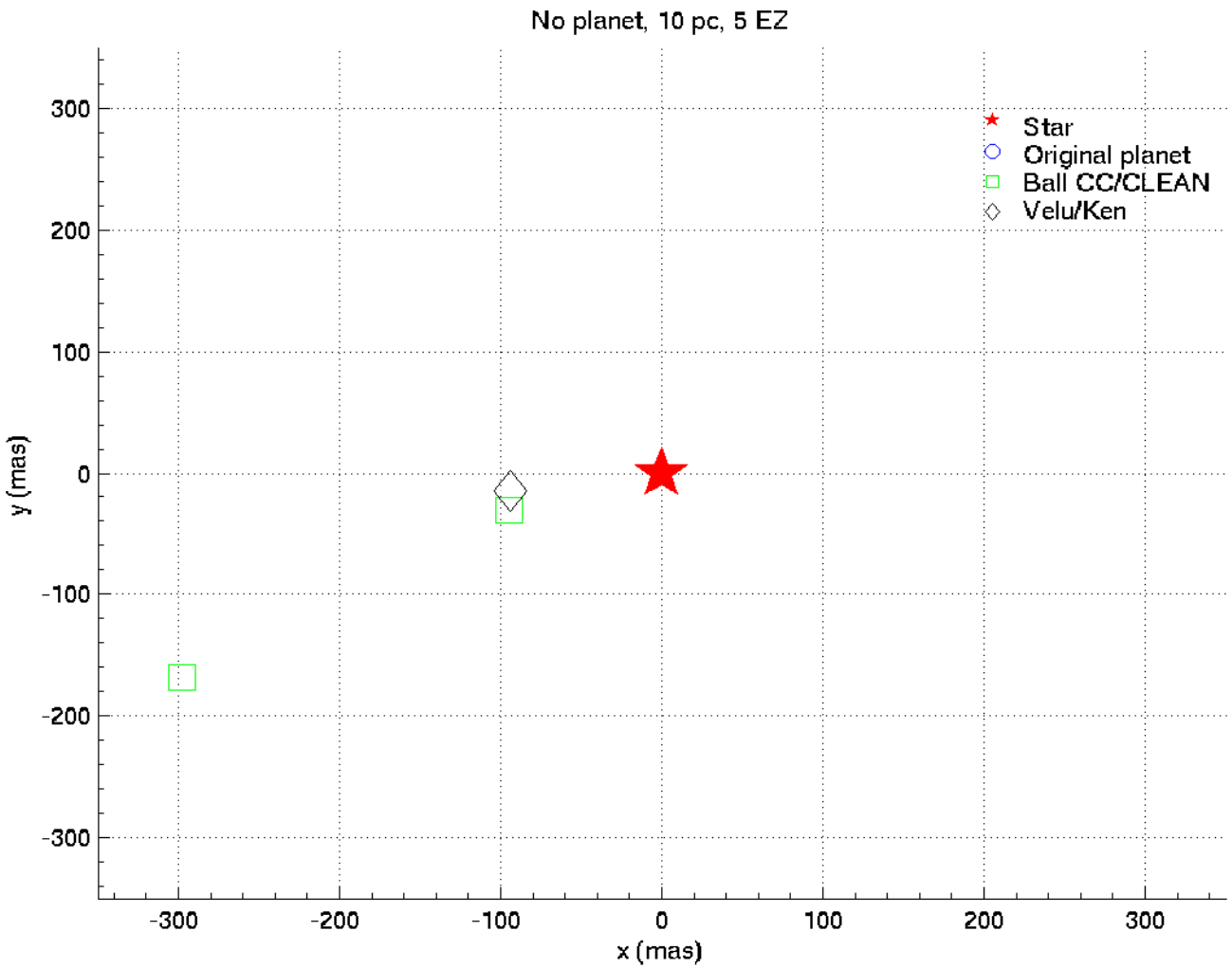

Case 2

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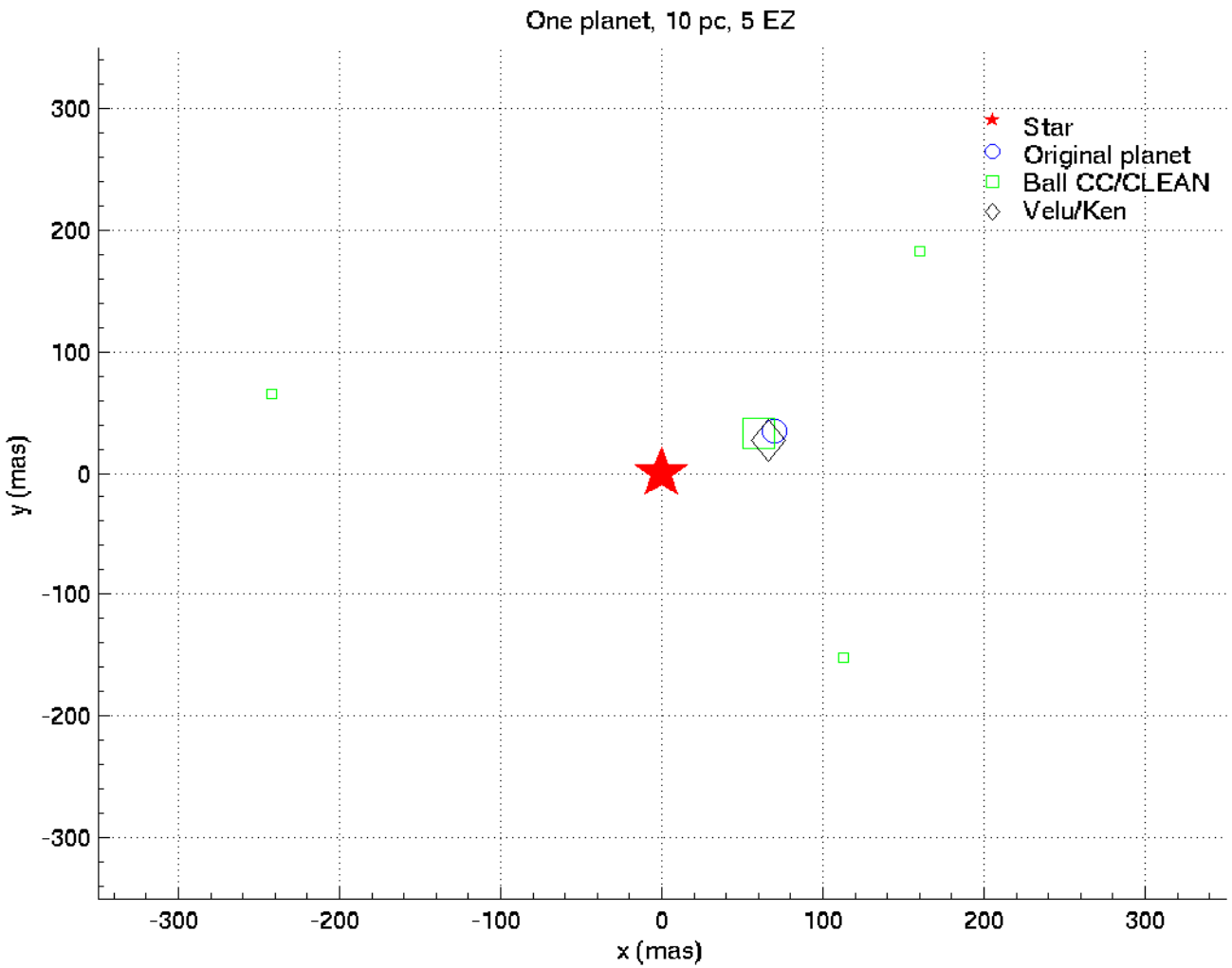

Case 4

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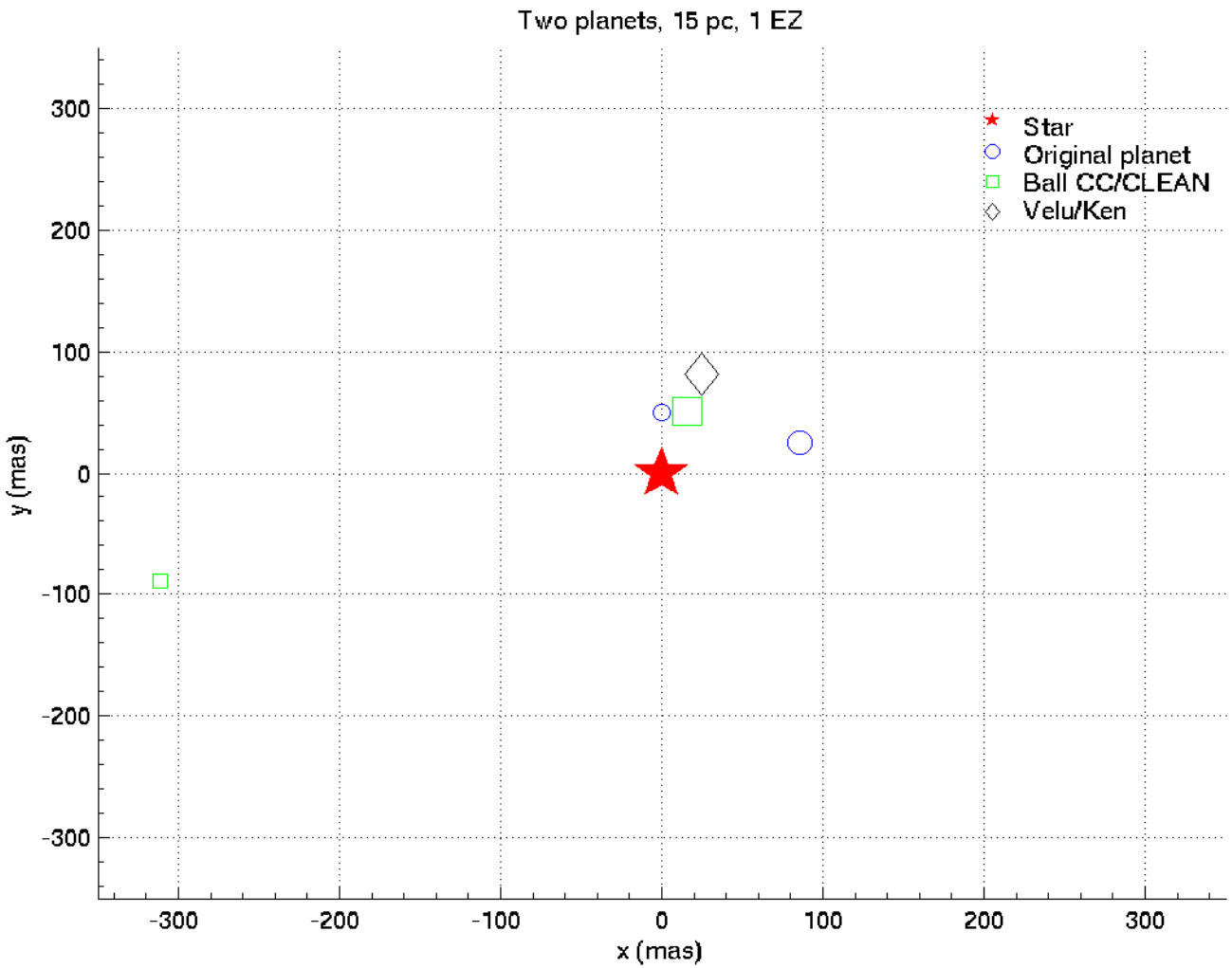

Case 12

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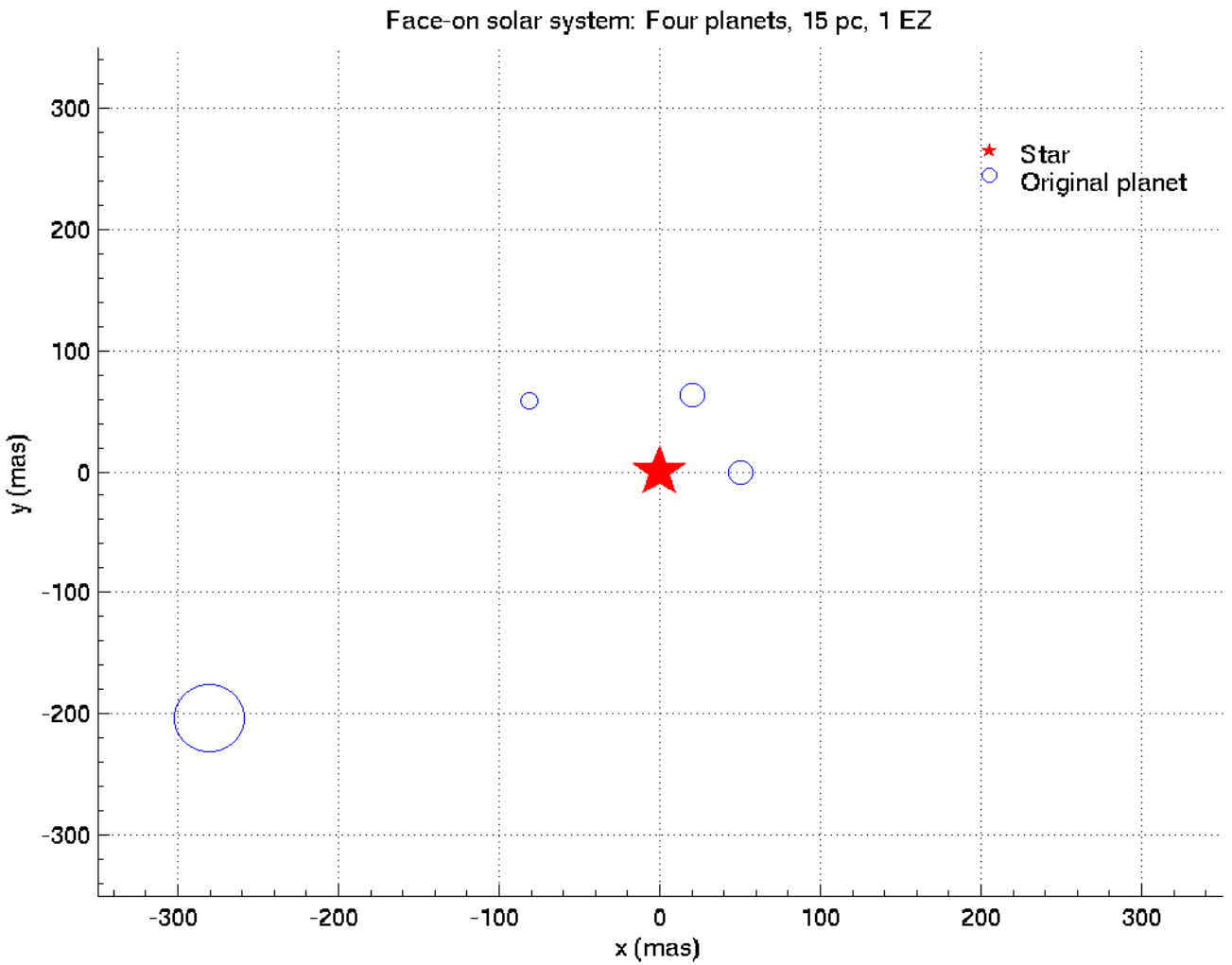

Case 12

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