1. Science aim/goal (provide a high-level statement in 140 characters or less):

Do we really understand our outer backyard?: Find Planet Nine (from Outer Space!)

2. In four separate paragraphs address following

(i) Scientific Importance:

Numerous groups (Batygin & Brown 2016 AJ....151...22B; Malhotra et. al 2016 ApJ...824L..22M; Fortney et. al 2016 ApJ...824L..25F) have proposed the existence of a massive body orbiting the Sun at 750-3000 AU based on the statistics of orbits of KBOs with large perihelia. The required mass for the perturber is around 10 Earth masses. The existence of such an object in the Solar system would have profound consequences for the formation history of planets and comets. The only way to prove the existence of Planet IX is to see it moving across the sky.

The $1/r^4$ variation of reflected or absorbed/reradiated sunlight makes such an object very faint in the optical or near infrared, but thermal radiation driven by an internal heat source could lead to an effective temperature of 40 to 50 K, and an easily detectable flux at 100 microns. For a body of two Earth radii and 50% albedo at 2500 AU, the visual brightness is V=28.3 so LSST will not be able to detect it. But a rocky 10 Earth mass object will have a luminosity of 10^{-12} solar from radioactive decay if we scale the luminosity linearly with the mass, and Neptune has a luminosity of $5x10^{-12}$ solar, which gives 1.7×10^{-12} solar if we scale as the square of the mass. The effective temperature for two Earth radii and a luminosity of 10^{-12} solar is 43 K, while a sub-Neptune with 3 Earth radii and a luminosity of 1.7×10^{-12} solar has an effective temperature of 40 K. These luminosities give fluxes of 4-8 mJy at about 80 microns, which is the peak of a 43 K blackbody (in νF_ν).

A Far-Infrared Surveyor equipped with a 70-100 micron imager with a cadence to map the entire sky repeated times would be able to quickly detect Planet IX in addition to detecting KBOs out to 100 AU.

(ii) Measurements Required:

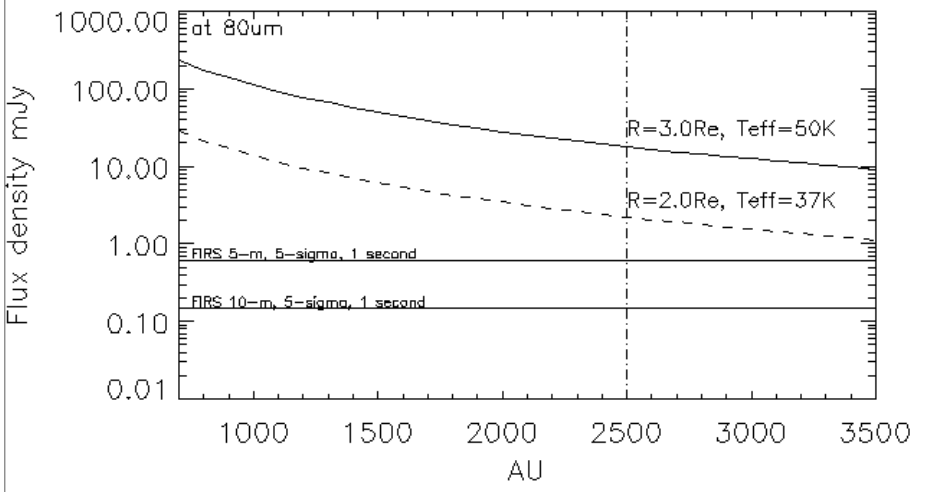
The position of the object is not certain, so the driving requirement is to survey a large area of the sky relatively quickly. The survey will have to cover the area several times so motion can be detected and confirmed. The Earth moves at 1/60 AU/day, so at 2500 AU the reflex motion will be around 1 arc-sec/day. Over a six month interval, the full parallactic motion of 40 arc-sec would be seen. A survey speed of 10 sq.deg per hour is required, 100 sq.deg per hour is desired. A 1-dimensional array could be swept in a direction perpendicular to the array at a constant inertial rate to achieve a high areal coverage rate. The search for Planet IX could be complementary to other large all-sky surveys.

The search for Planet IX is not impacted by source confusion because the exposure times are so short, and because a moving source can be distinguished from the fixed confusion background.

(iii) Uniqueness to 10μm to few mm wavelength facility:
No other facility can come close to the required mapping speed. A 10 meter FIRS can reach a 7 sigma sensitivity of 1 mJy in a millisecond of integration time, so a fast scanning mode with a 100,000 pixel camera (with 1 arc-second pixels) could scan the sky at nearly 8 sq.deg per second, and 10 sq.deg per hour is easy. Thus the speed needed to search the entire sky for Planet IX in 6 months is available for a cold far-IR telescope in space.

(iv) Longevity/Durability: (with respect to expected 2025-2030 facilities)
Neither LSST nor JWST or WFIRST-AFTA will have enough sensitivity to compete in the search for Planet IX, but they will be able to study it once the location is known.

3. Figure:



Even a 2 Earth Radius Planet 9, with T_{eff}=37K has ~4 mJy flux at 80um is detectable with a 5 meter FIRS architecture. FIRS 5 meter (10 meter), 5-sigma, 1second sensitivity at 80um as 0.6 (0.15) mJy from FIRS Architecture Study Report July 22, 2016, slide 2.

4. Table:

Parameter	Unit	Required value	Desired Value	Comments
Wavelength/band	μm	70-100	70-100	
Number of targets				
Survey area	deg.^{2}	40,000	20,000	
Angular resolution	arcsec	2	3	
Spectral resolution	$\Delta\lambda/\lambda$	0.3	0.3	
Continuum Sensitivity	μJy	1000	1000	
Spectral line sensitivity	W m^{-2}	NA	NA	

Dynamic range				
Cadence		Several epochs	Two epochs	
Any other requirement				

5. Key references: (Optional, at most three, reviews preferred)

Batygin & Brown 2016AJ....151...22B
Fortney etal 2016ApJ...824L..25F