Imaging the Galactic Core with Neutrinos using a Gravitational Lens of the Sun

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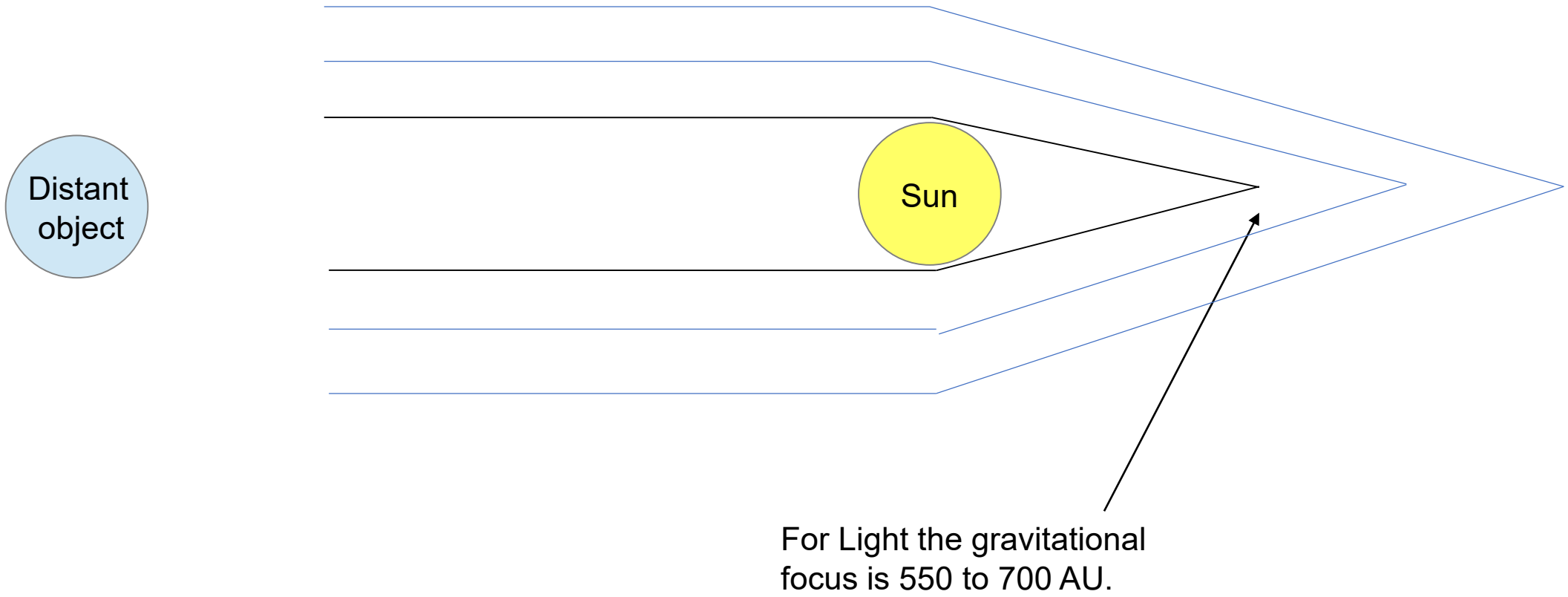
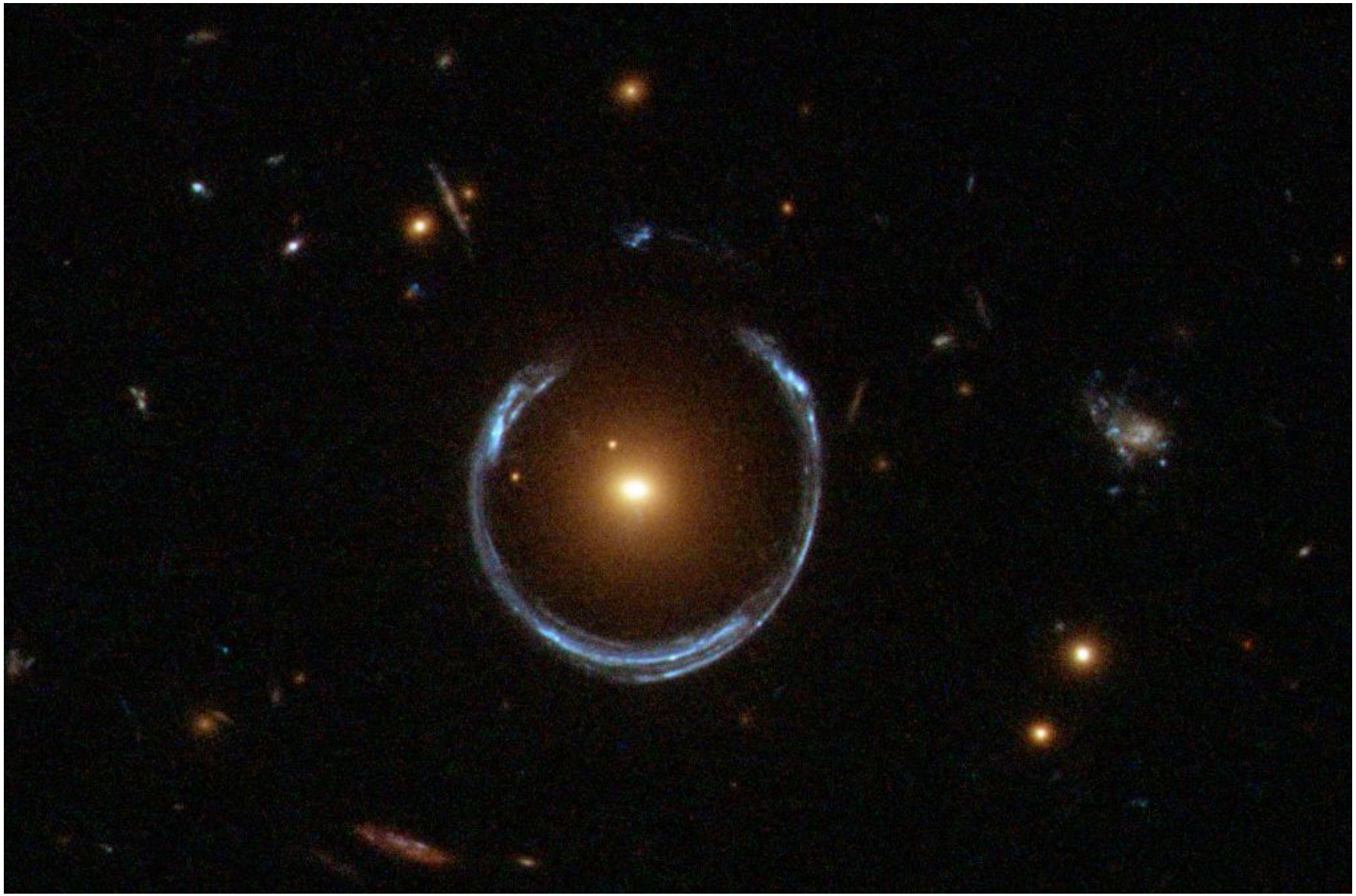
Gravitational Lensing



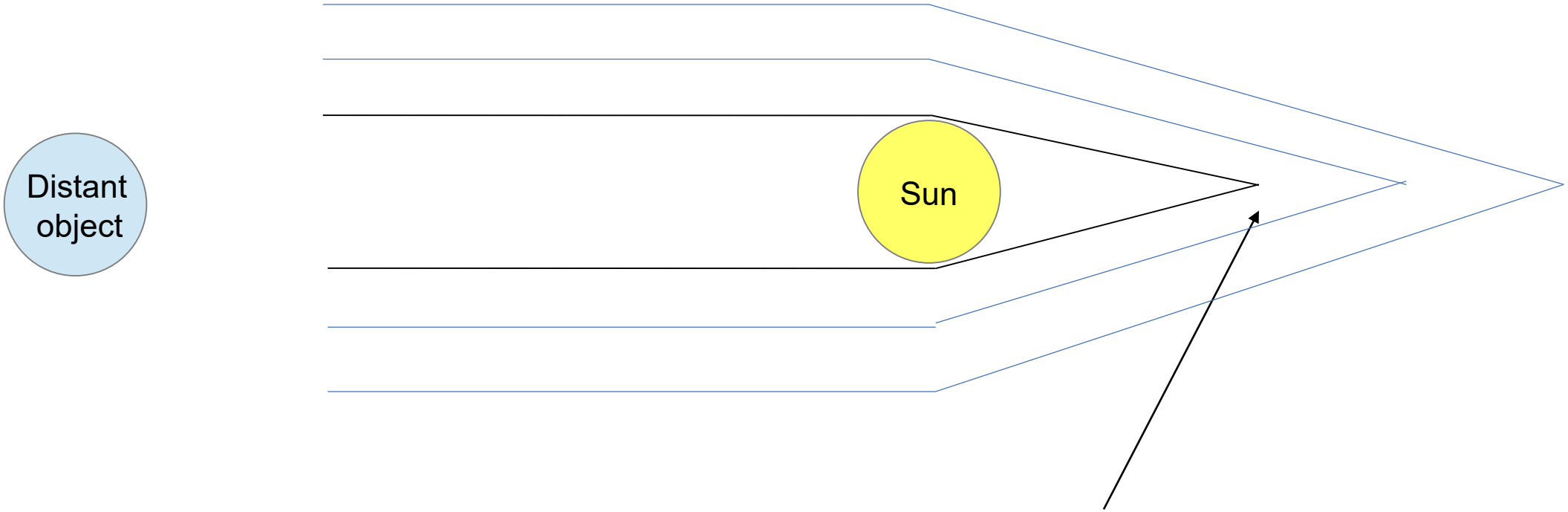
[1] A. Einstein, Lens-Like Action of a Star by the Deviation of Light in the Gravitational Field, Science, Vol. 84 (1936), p. 506.
[2] M. J. Dulude et al., WFC3 HST STSI Instrument Science Report, 2011-04, Feb. 2011.
[3] G.A. Landis, Mission to the Gravitational Focus of the Sun: A Critical Analysis, 23 April 2016, arXiv:1604.06351v2 [astro-ph.EP].
[4] S.G. Turyshev and B-G. Andersson, "The 550-AU Mission: a critical discussion", Mon. Not. R. Astron. Soc. 341, pp. 577-582 (2003).

Hubble has some nice images of accidental alignment:

This is an example of off axis imaging. The small blue galaxy at the top is the direct light and the ring is the gravitational image. The ring is much brighter showing the enormous light collection power of a gravitational lens.



Gravitational Lensing

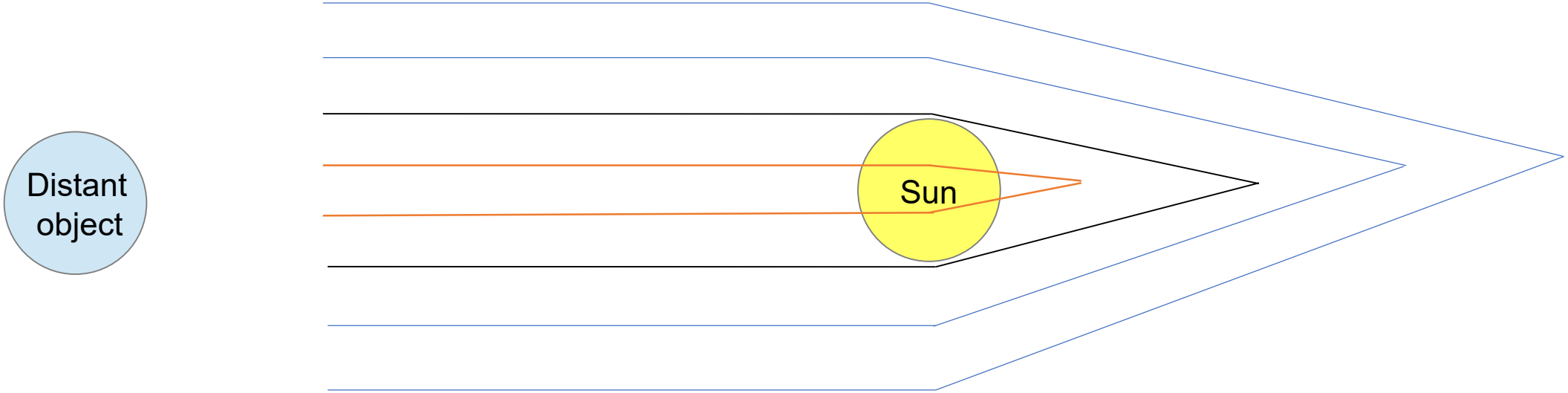


Neutrinos have mass their Neutrino Gravitational Focus is much closer, 20 to 45 AU.

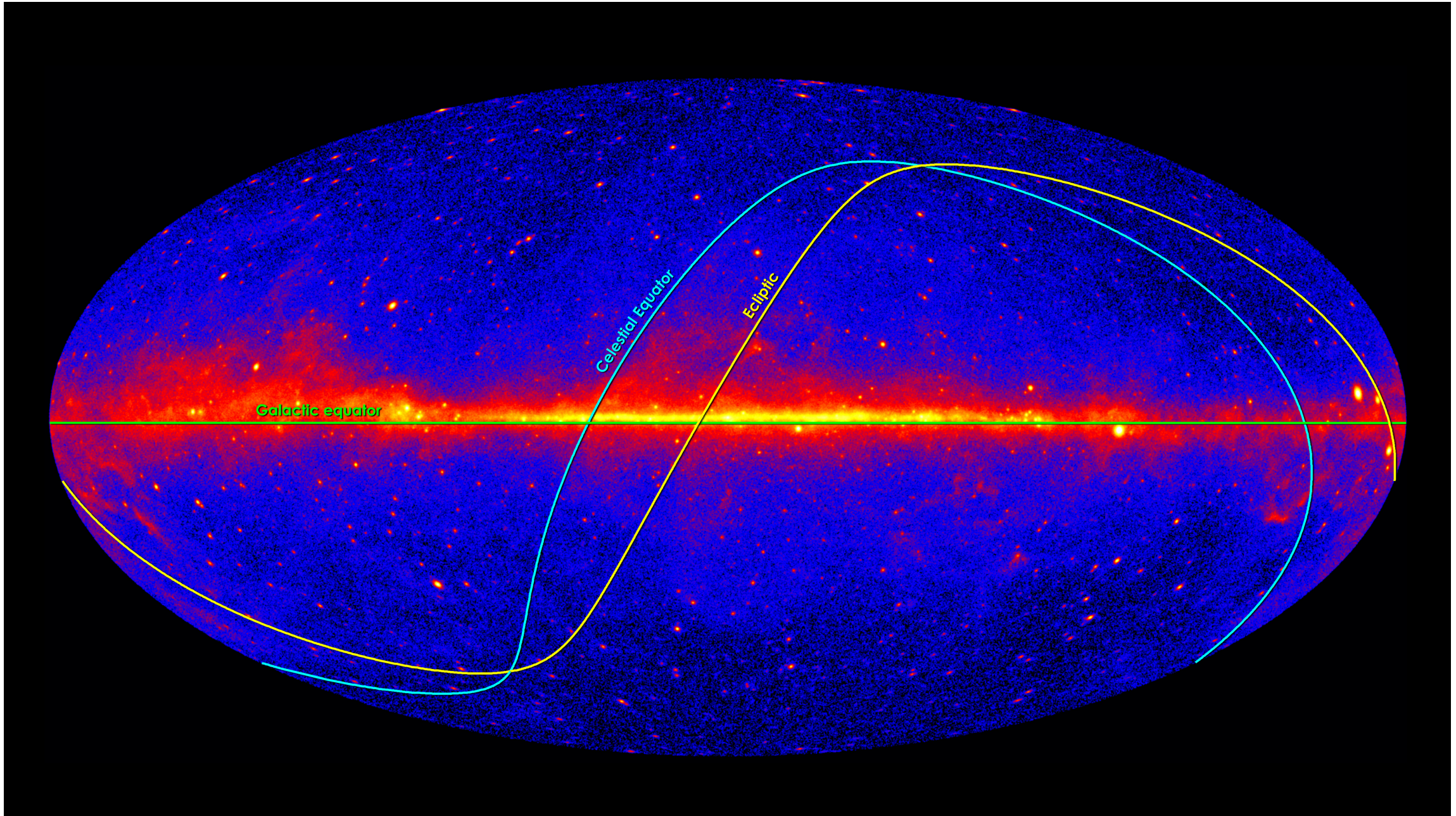
Y. Demkov and A. Puchkov, Gravitational focusing of cosmic neutrinos by the solar interior, Phys. Rev. D v61, 083001.

Gravitational Lensing

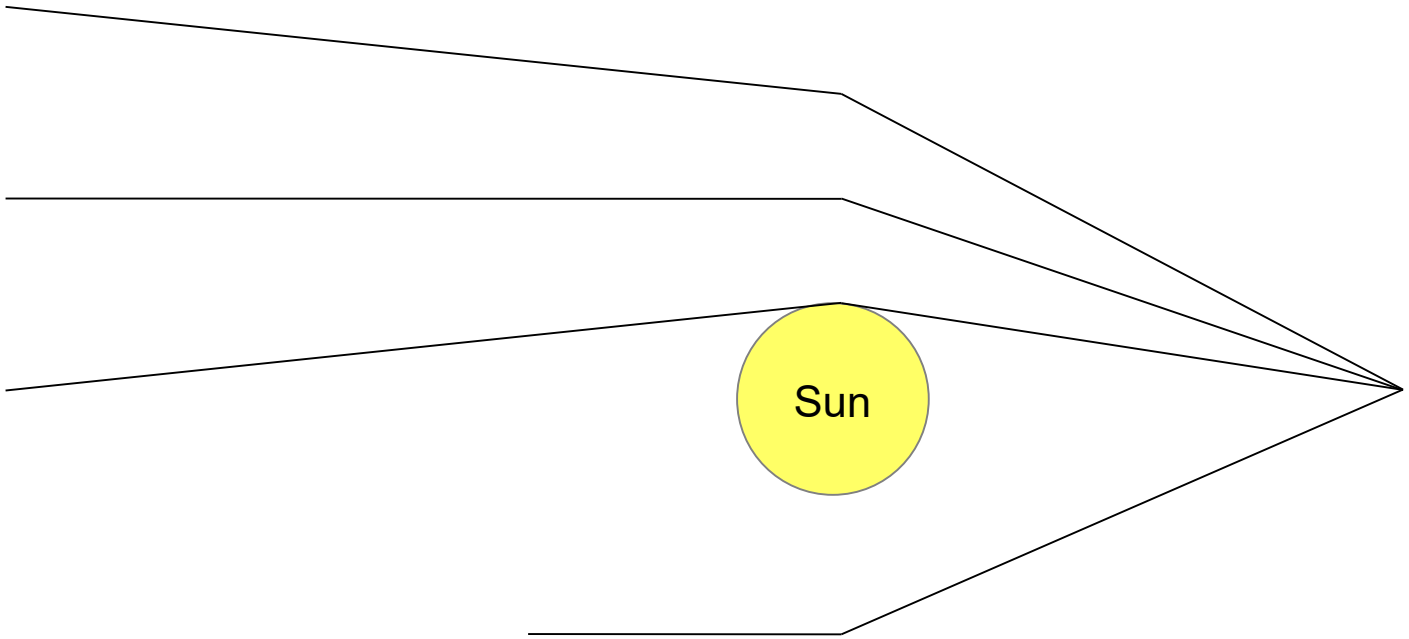
The Sun is transparent to Neutrinos and this will increase the “light” collection power of the gravitational lens by 2 or 3 orders of magnitude.



Path the Sun-Earth direction sweeps out follows the Ecliptic in a year (yellow curve):



Broad Sources with Gravitational Lensing



Due to the large angular extent of the Galactic core, twice the diameter of our moon, an even larger number of neutrinos would get concentrated at the neutrino gravitational focus for off axis rays, allowing off axis imaging along the ecliptic line path.

Planned Study:

- How many stellar neutrinos from galactic core stars are at the neutrino gravitational focus?
- How many high energy neutrino sources are in the galactic core?
- Can we do a direct detection with a neutrino detector?
- Can we use a Gas or “Ice” Giant planets like Neptune or Uranus to increase detector mass to see galactic core neutrino interactions?

Initial Estimates of fusion neutrinos from Galactic Core Stars

- Used model of stars in galactic core and their distribution by Kent (S.M. Kent et al. Luminosity model of Milky Way, APJ v378, p131, 1991)
- Estimate used absolute magnitude of stars to figure the number of neutrinos compared to our Sun, this is certainly wrong but it is to low.
- Corrected for the distance to the Galactic core at 25,000 l.y.
- Used “Light” collecting power of Gravitational Lens at 10^{12}.
- Used off axis stars with “light” reduction out to 1 degree.
- Assumed a 4 m diameter 8 m long detector volume, i.e. size of space craft upper stage.

Get that the number of galactic neutrinos is 800 to 8000 times more neutrinos than at the surface of the Earth directly from our own Sun.

L.ynn Buchele (senior thesis) and N. Solomey (adviser), Galactic Neutrinos Lensed by the Sun: an Initial Estimate, Wichita State University 2018.

High Energy neutrinos from Galactic Core

- Chandra X-ray telescope has shown that the galactic core has 1000 to 10,000 accretion disks of neutron stars and black holes.
- As matter falls into these objects the protons and electrons make neutrons and neutrinos are isotopically emitted.
- These would produce higher energy neutrinos that can convert into muon tracks.

Galactic Core red dot

The Galactic Core is located at:

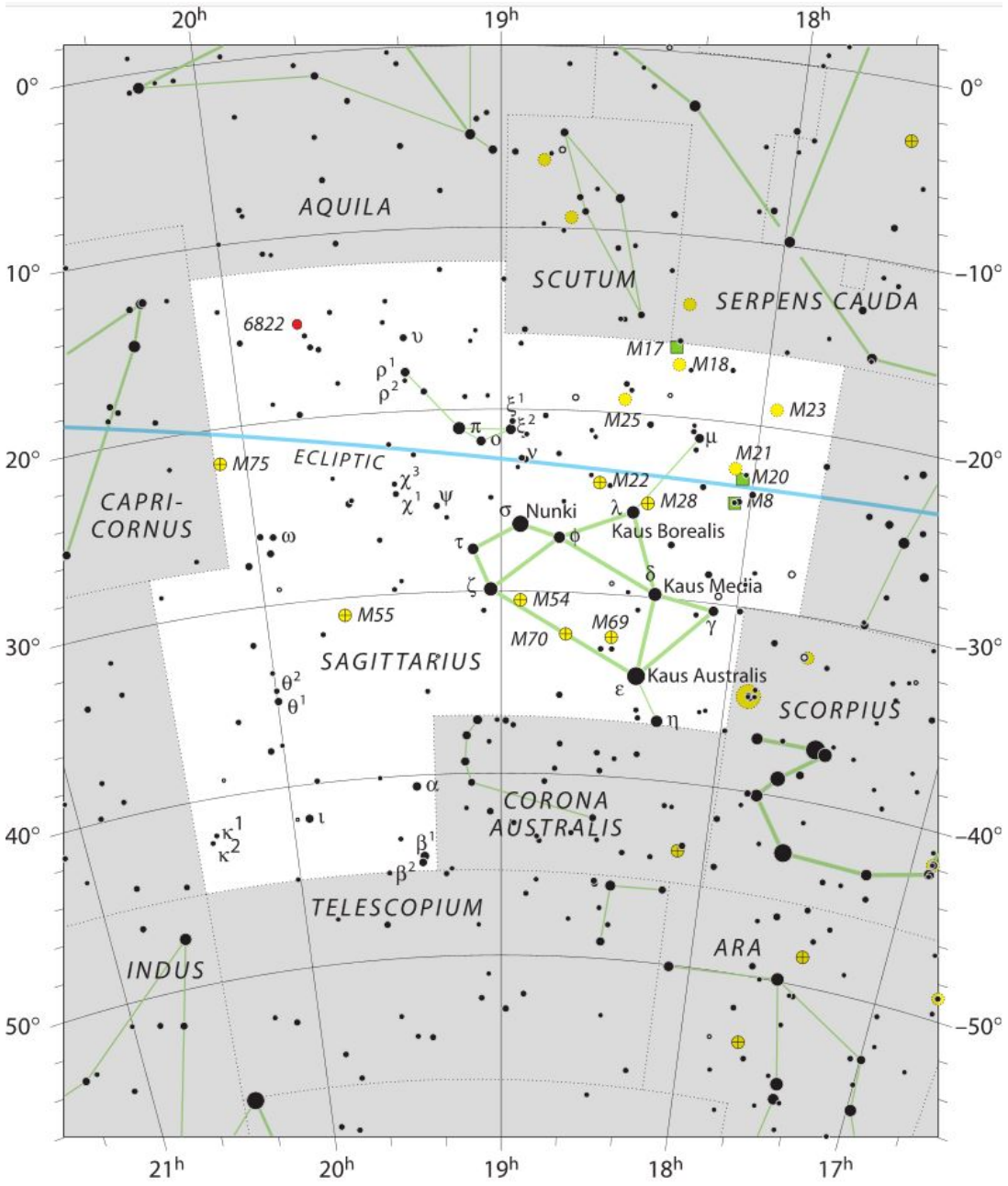
19 hr 45 min RA

-13 degree Declination

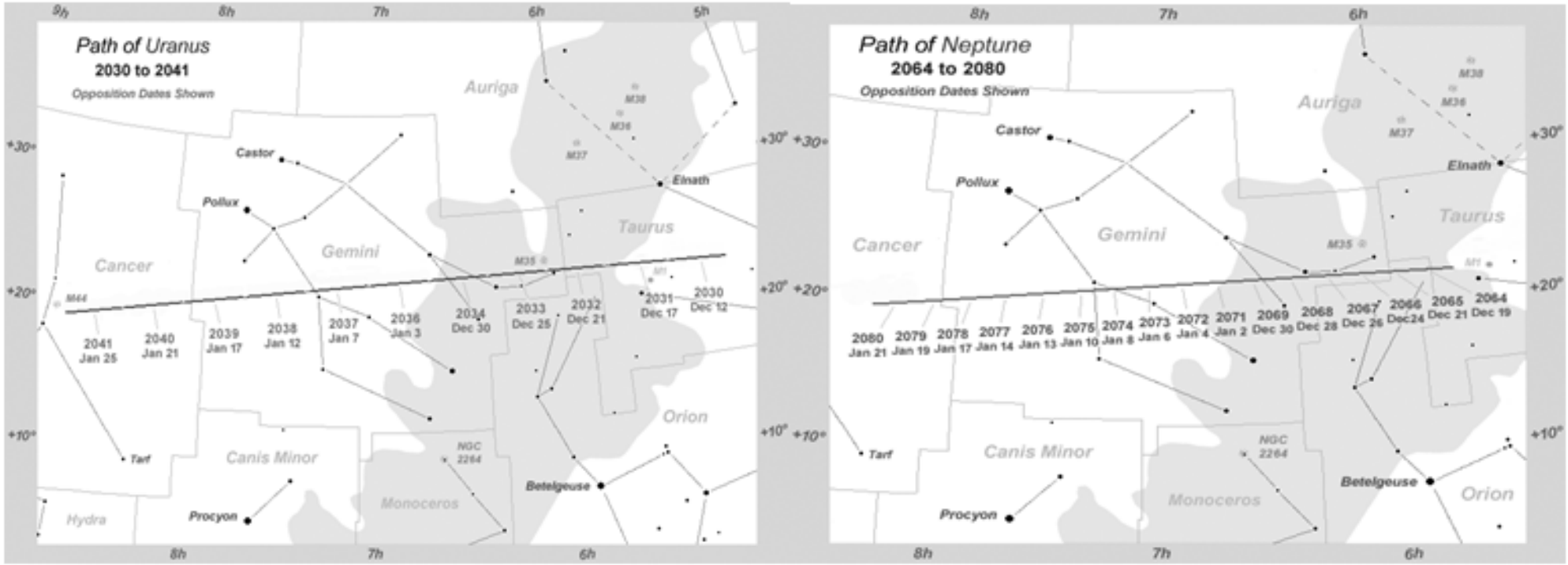
Opposite the Sun would be at

7 Hr. 45 min RA

+13 degree Declination



Uranus and Neptune will soon be passing through Neutrino Gravitational Focus of Galactic Core formed by our Sun.

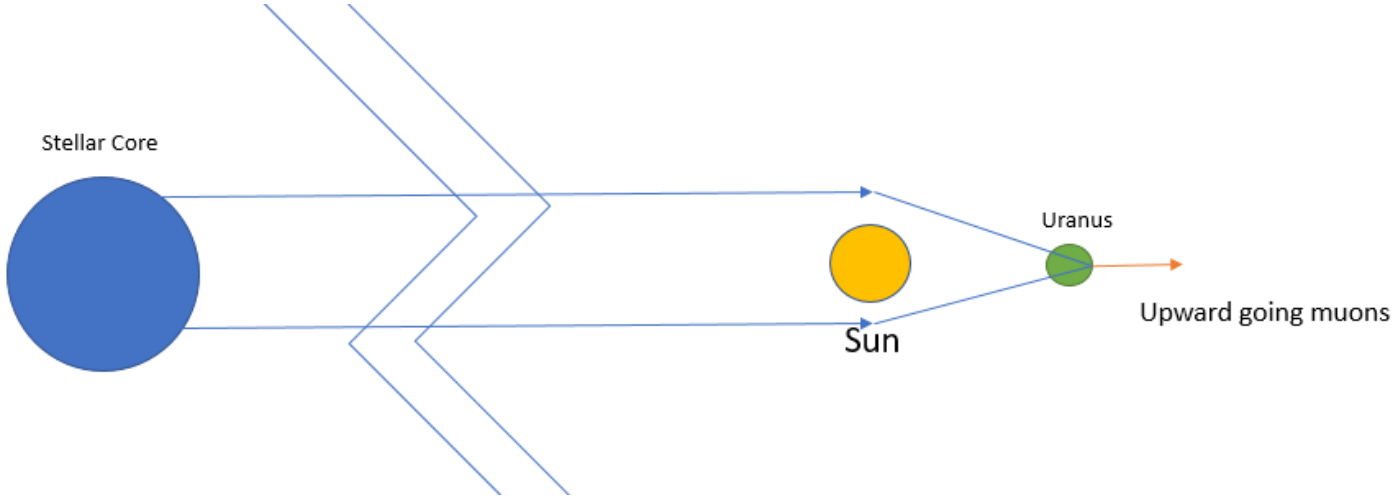


Left is the track of Uranus through the night sky and on the right is the track of Neptune [13]; as can be seen from extending these graphs the two planets will be opposite the Sun from the galactic core in 2037-2038 and 2065-2067 and will provide an opportunity for using them as a large target for galactic core neutrinos being gravitationally focused by our Sun.

Could an orbiter's imaging camera on the dark side of Uranus or Neptune image muon tracks?

1) How much light would there be
2) What optics imaging system: filters or enhanced light collection needed
3) How close to the gas giant would the spacecraft have to get

All these questions will be studied in our coming planned one year study.

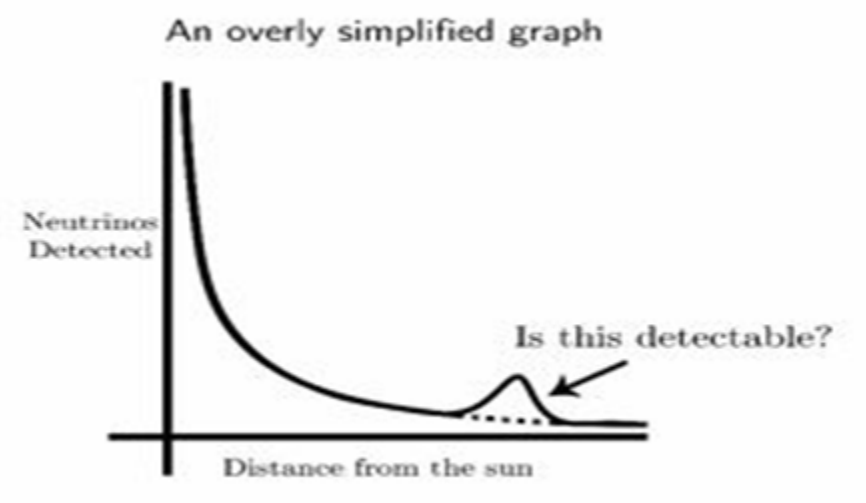


Science possible:

Elementary Particle Physics:

Can we measure Mass of Neutrino

- From location of neutrino gravitational focus from the Sun.



Astrophysics:

- Measure neutrino intensity of point sources like Crab and Geminga Pulsar.
- Measure number of Galactic Core Accretion disks
- Image Galactic Core Structure

Conclusion:

- What was presented here were ideas and some initial calculations and simulations for our funding proposal to NASA's Innovative Advanced Concept Office.
- Our $125,000 funding from NASA starts in May of 2021
- We will improve the simulations, answers more questions and determine how feasible these ideas are!
- Stay tuned for future updates as we preform this initial investigations.