



*IMCCE*

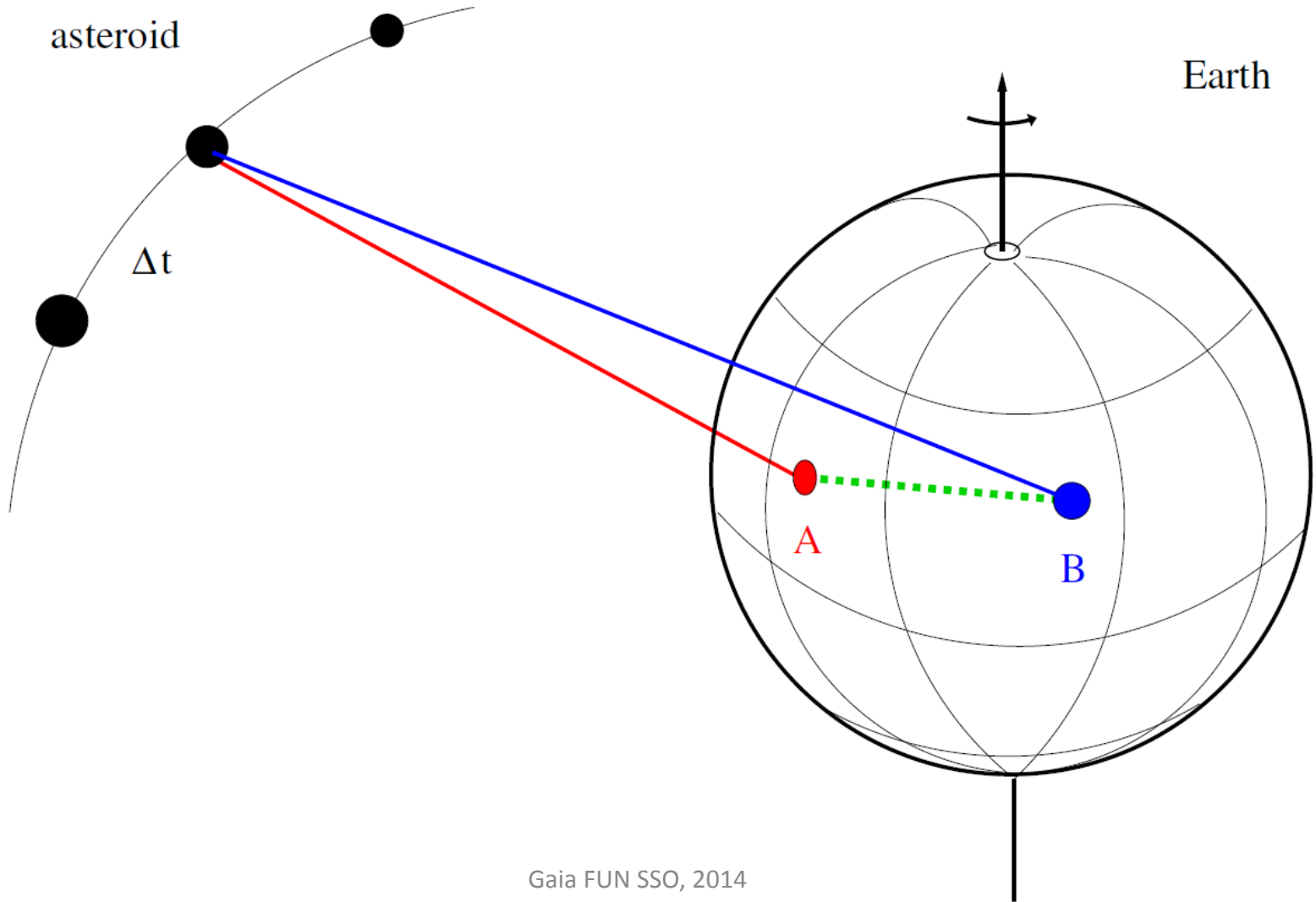
# Gaia FUN SSO triangulation observations of 2014 HQ124

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Y. Kozyryev 5, N. Kulichenko 5, V. Vovk 5, A. Ivantsov 6

- 1 IMCCE, Paris Observatory, France
- 2 Lohrmann Observatory, Dresden, Germany
- 3 Astronomical Observatory of Kyiv University, Ukraine
- 4 Pulkovo Observatory, St.Petersburg, Russia
- 5 Nikolaev Astronomical Observatory, Ukraine
- 6 Technion Israel Institute of Technology, Israel

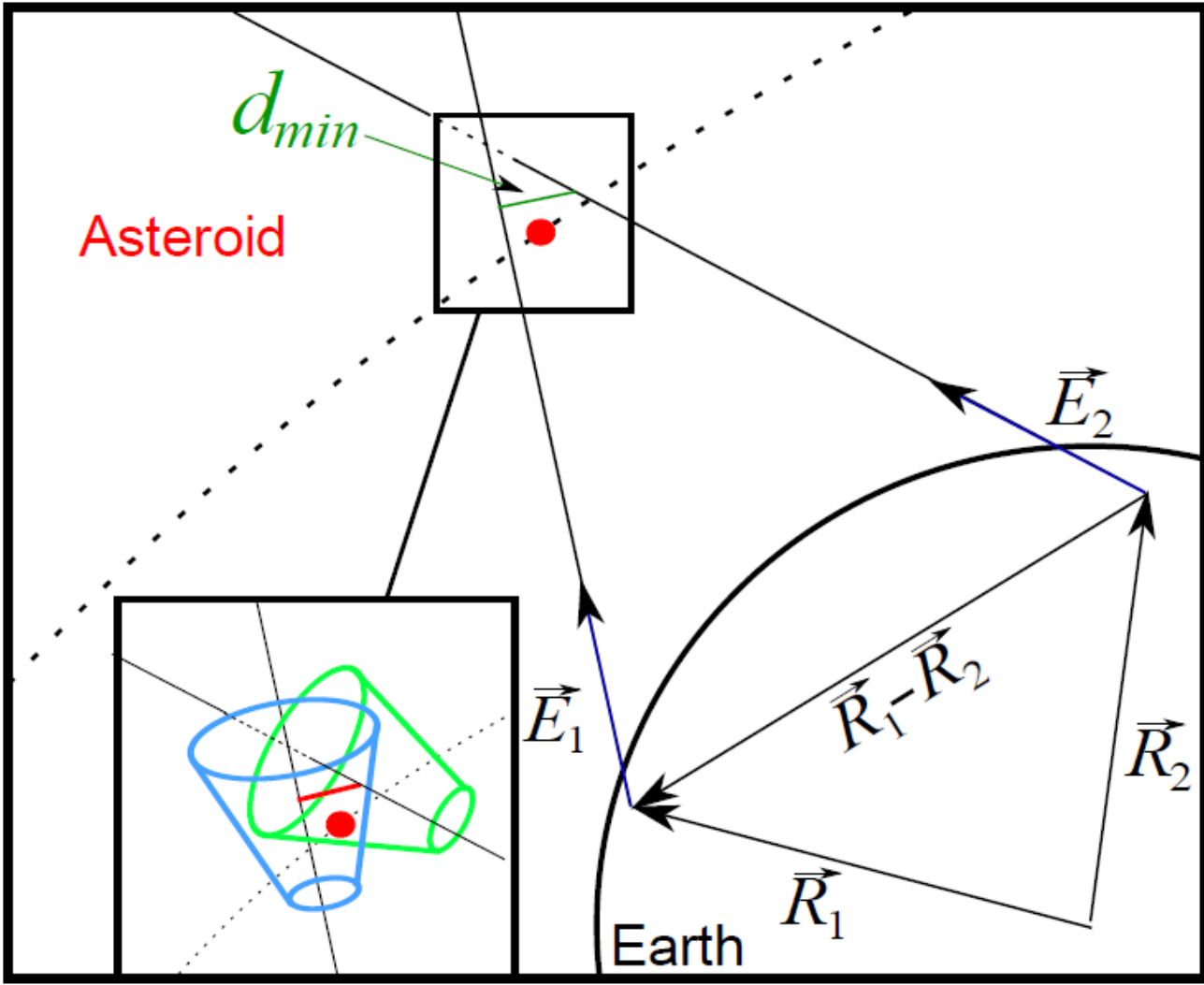


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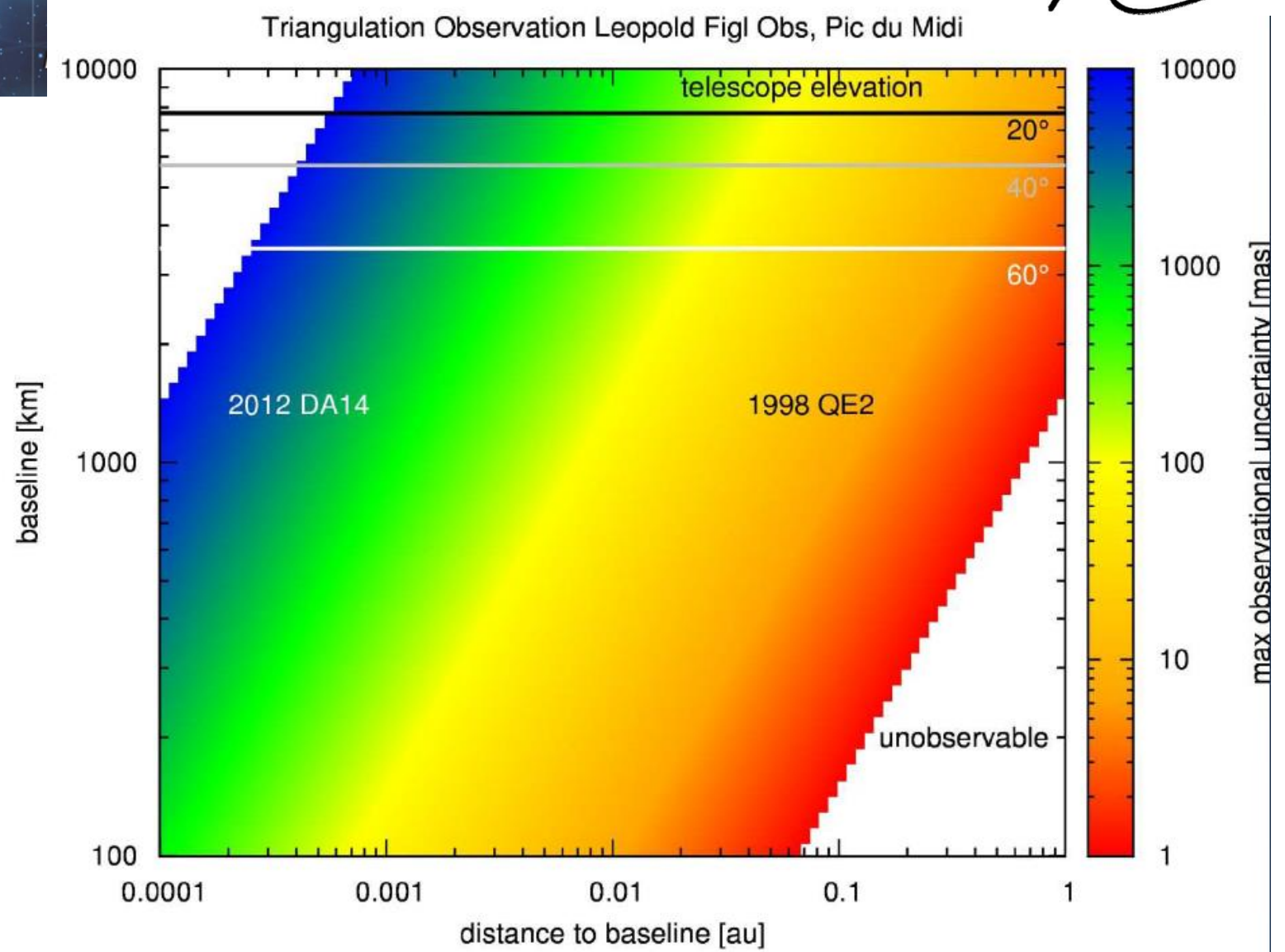


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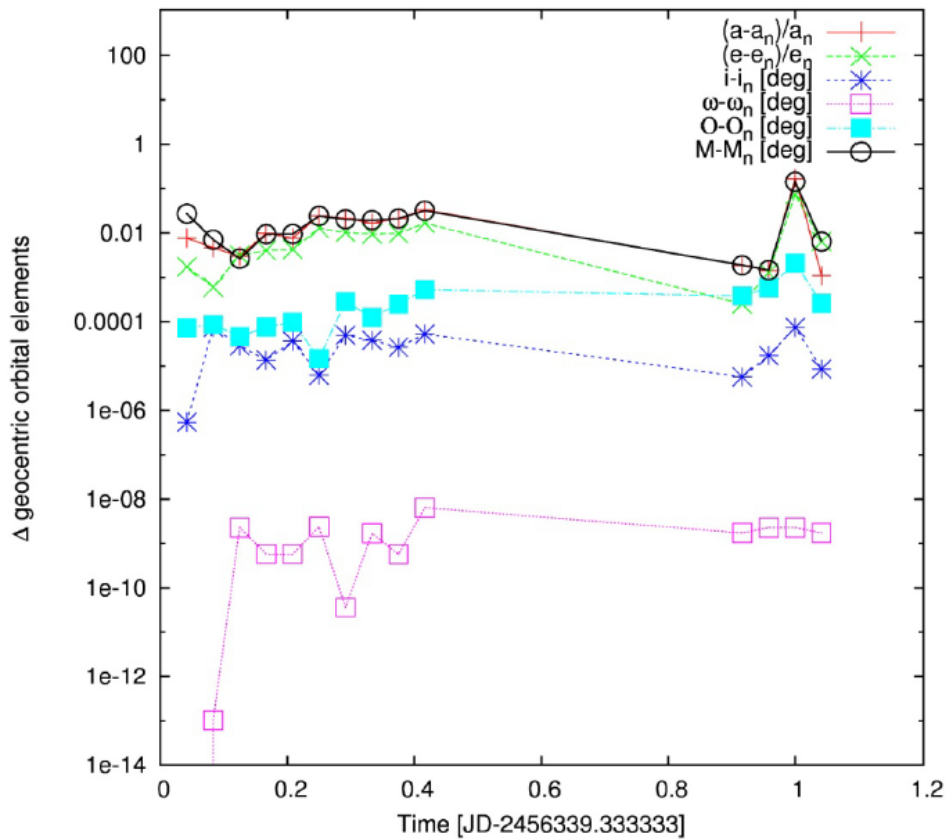




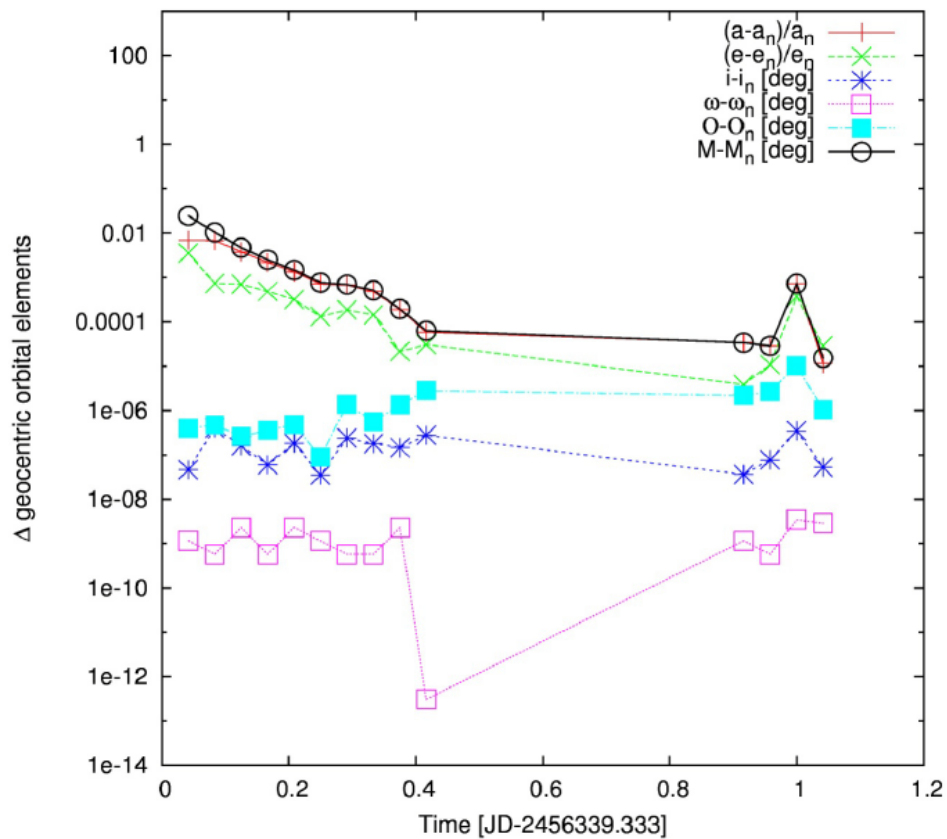
# 2012 DA14

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2012 DA14, CA date 2013-02-15,  $\Delta t = 1$  h, obs prec = 2 arcs



2012 DA14, CA date 2013-02-15,  $\Delta t = 1$  h, obs prec = 0.01 arcs

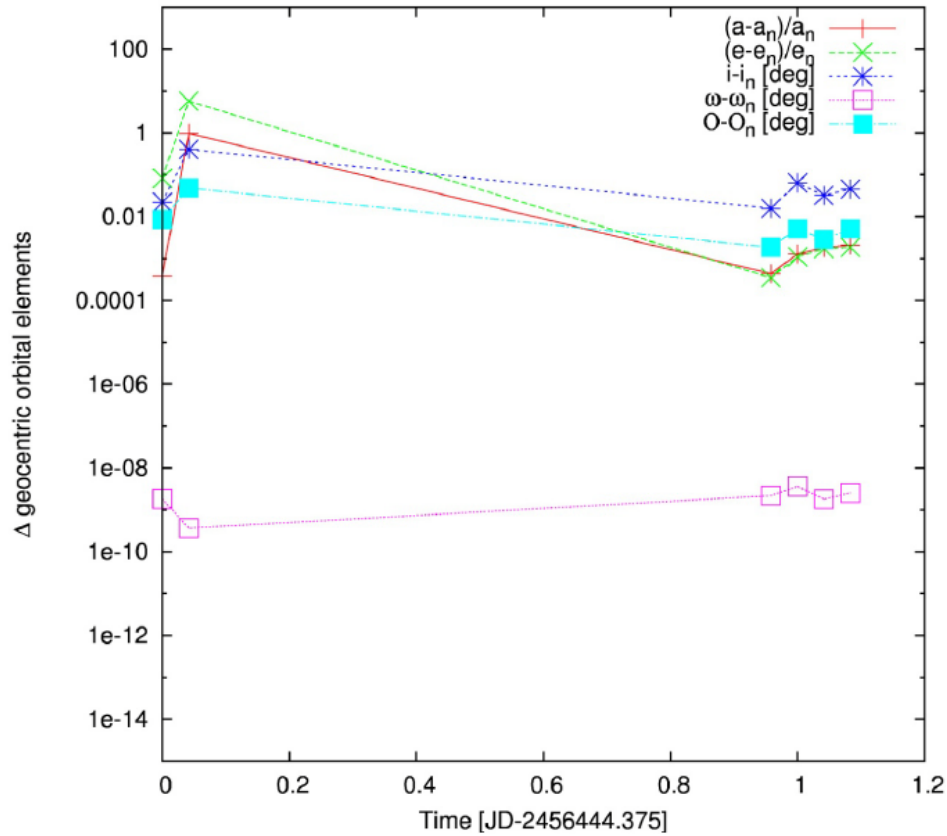




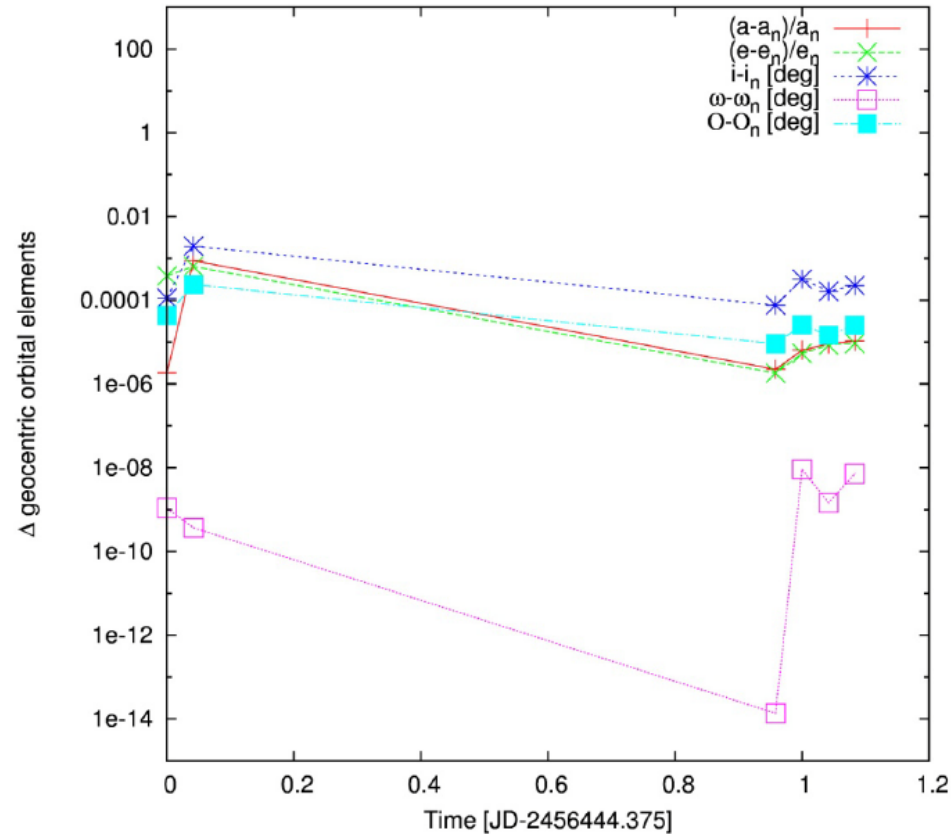
# 1998 QE2

*imce*

1998 QE2, CA date 2013-05-31,  $\Delta t = 1h$ , obs prec = 2 arcs



1998 QE2, CA date 2013-05-31,  $\Delta t = 1h$ , obs prec = 0.01 arcs







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**Why not try  
TRIANGULATION  
of 2014 HQ124?**



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# 2014 HQ124

(2014-Dec-09.0, J2000)

a (au)	e	i (deg)	w (deg)	$\Omega$ (deg)	M (deg)	H (mag)
0.85	0.25	26.36	144.49	257.57	106.07	18.9

**Close encounter with the Earth:**

**2014-Jun-08 05:56,**

**R = 0.0083 au ~ 3.3 LD**



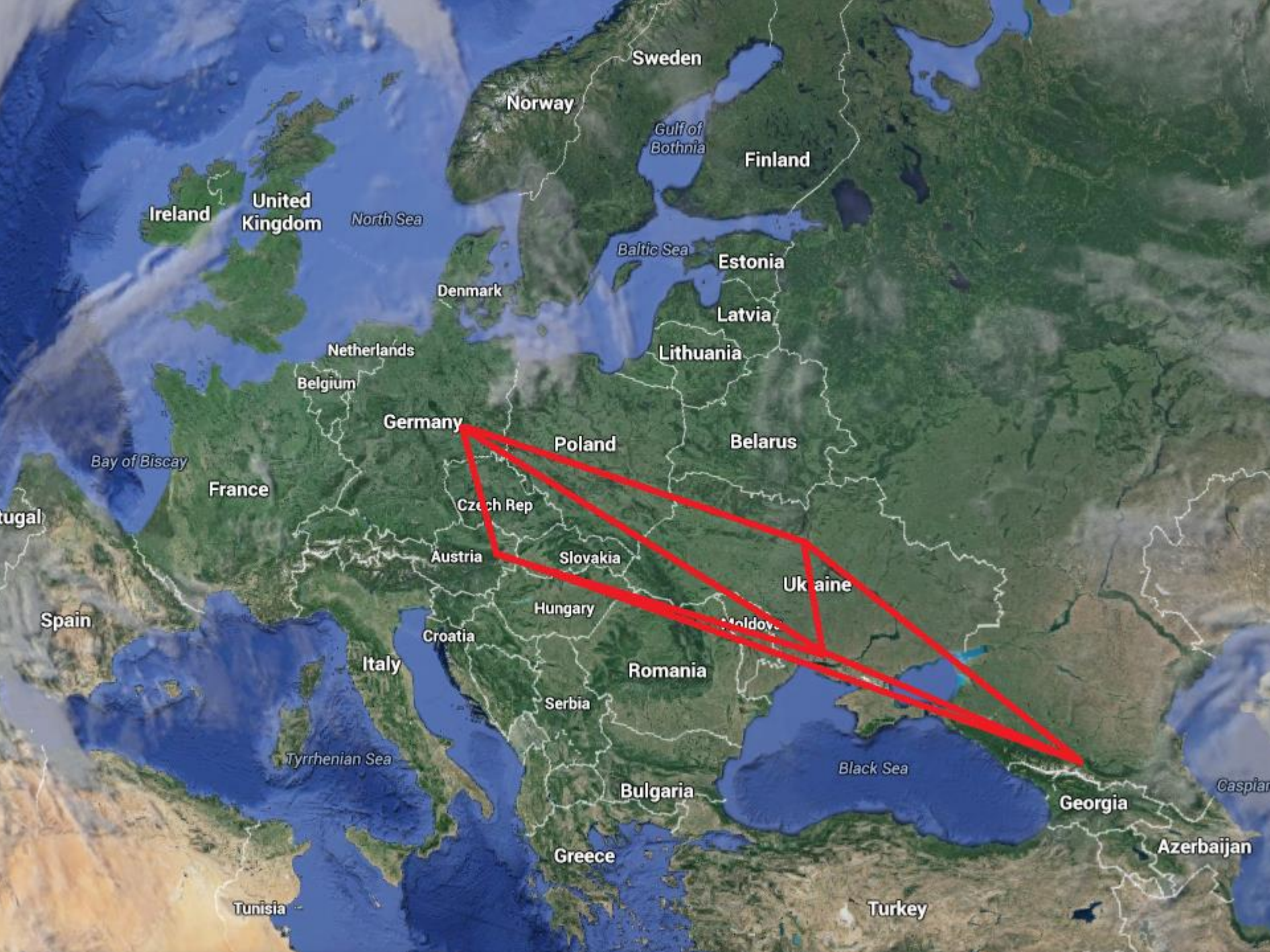


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# Gaia FUN SSO test run (Jun-08 – Jun-11, 2014)

- **089:** Nikolaev Astronomical Observatory, Ukraine
- **113:** Volkssternwarte Drebach, Germany
- **562:** Figl Observatory, Vienna, Austria
- **585:** Astronomical Observatory of Kyiv University, Ukraine
- **C01:** Lohrmann Observatory, Dresden, Germany
- **C20:** Kislovodsk, Astronomical Station, Pulkovo Obs., Russia.

Baselines up to ~ 2500 km!



Sweden

Norway

Finland

Ireland

United Kingdom

North Sea

Gulf of Bothnia

Baltic Sea

Estonia

Denmark

Latvia

Lithuania

Netherlands

Belgium

Germany

Poland

Belarus

Bay of Biscay

France

Portugal

Czech Rep

Austria

Slovakia

Ukraine

Spain

Hungary

Moldova

Spain

Italy

Romania

Serbia

Croatia

Hungary

Tyrrhenian Sea

Bulgaria

Black Sea

Georgia

Caspian Sea

Tunisia

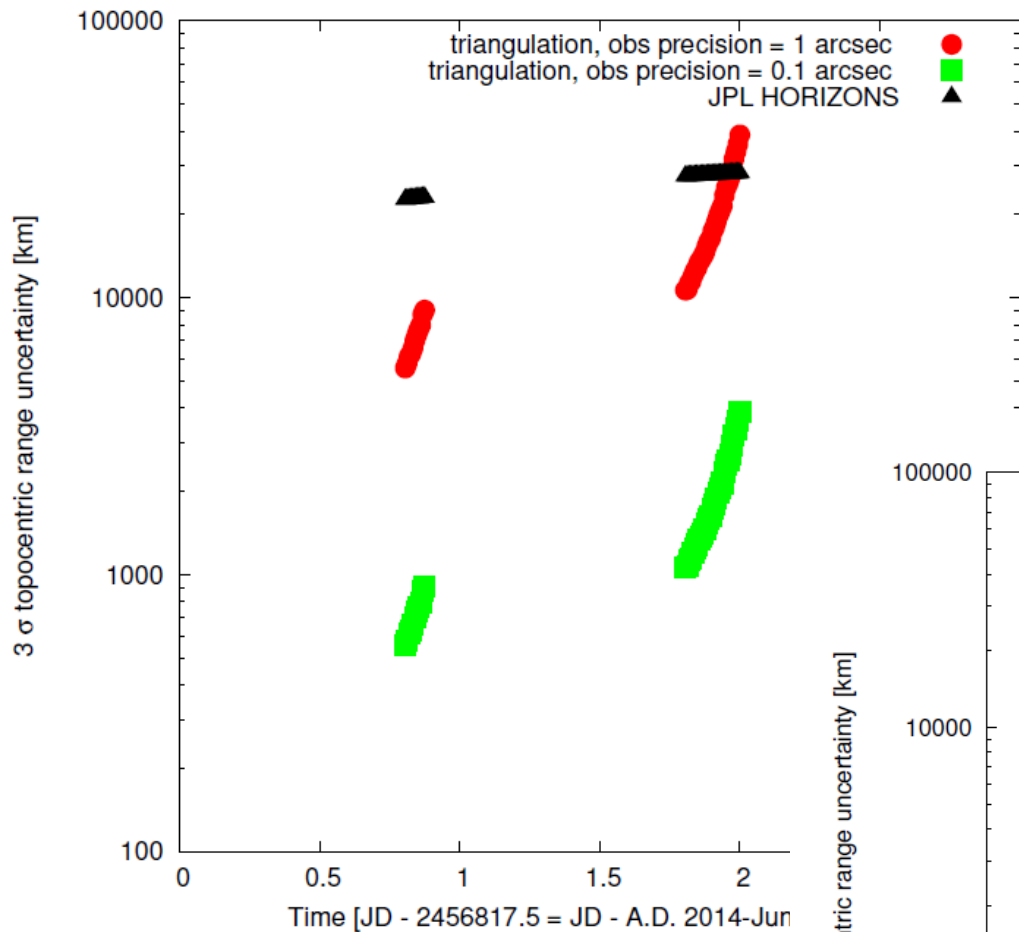
Greece

Turkey

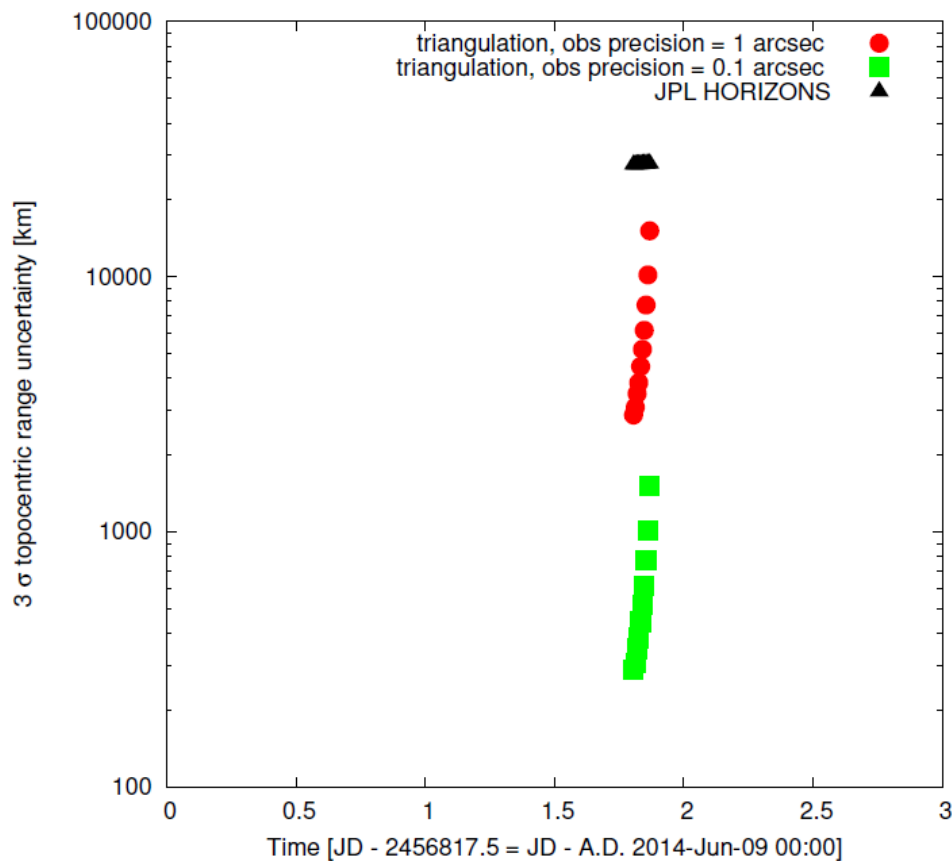
Azerbaijan

2014 HQ124, CE date 2014-06-08 06:04 , Obs Codes= C01,562

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2014 HQ124, CE date 2014-06-08 06:04 , Obs Codes= C01,C20

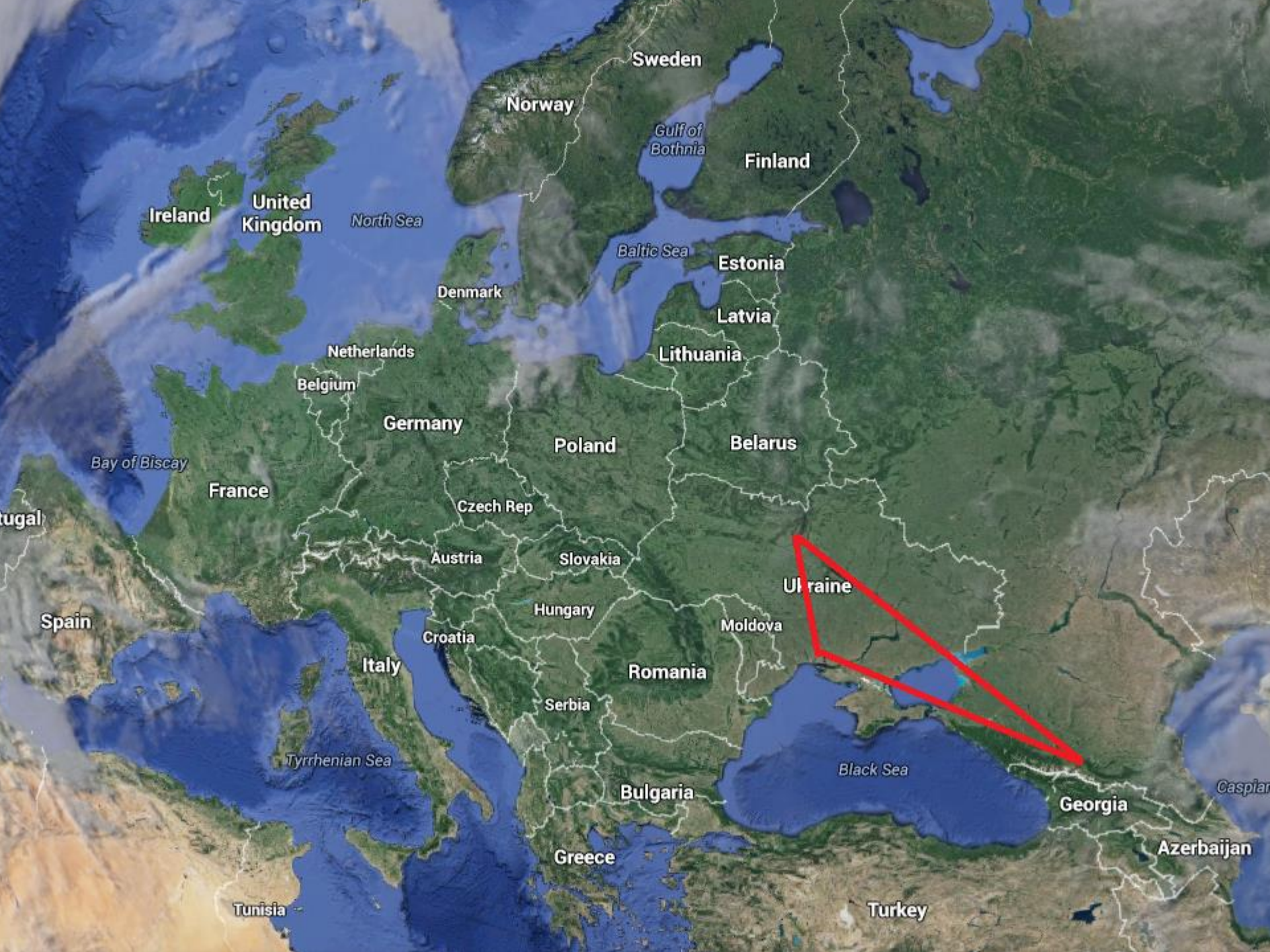






# Gaia FUN SSO test run (Jun-08 – Jun-11, 2014)

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Ireland

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North Sea

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Estonia

Latvia

Lithuania

Netherlands

Belgium

Germany

Poland

Belarus

Bay of Biscay

France

Czech Rep

Austria

Slovakia

Hungary

Ukraine

Portugal

Spain

Italy

Croatia

Hungary

Romania

Moldova

Serbia

Tyrrhenian Sea

Black Sea

Bulgaria

Georgia

Caspian

Azerbaijan

Greece

Turkey

Tunisia





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# Triangulation RESULTS for 2014 HQ124

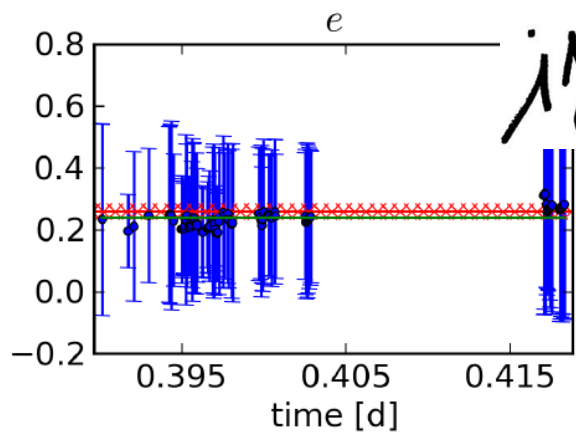
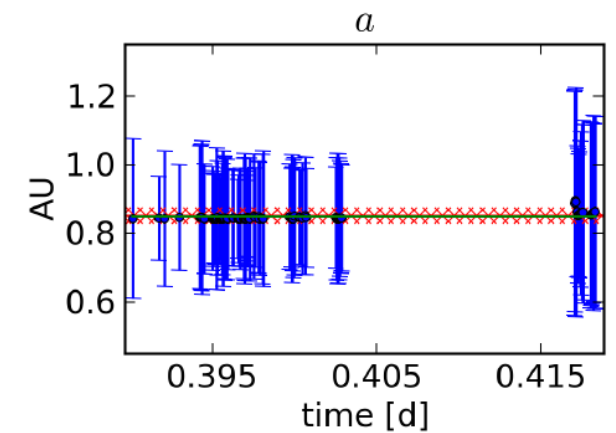


# Triangulation observations ONLY! 1 NIGHT (Jun-10-2014)

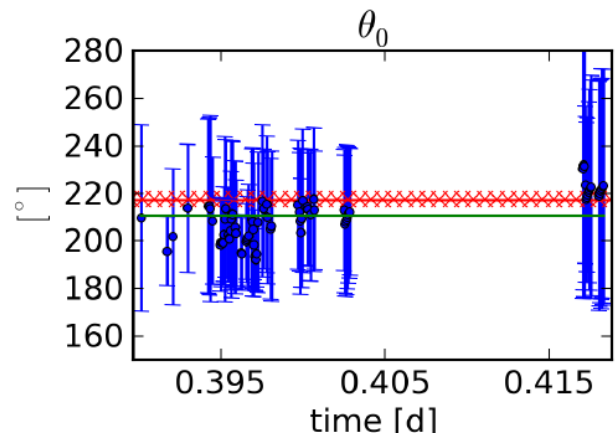
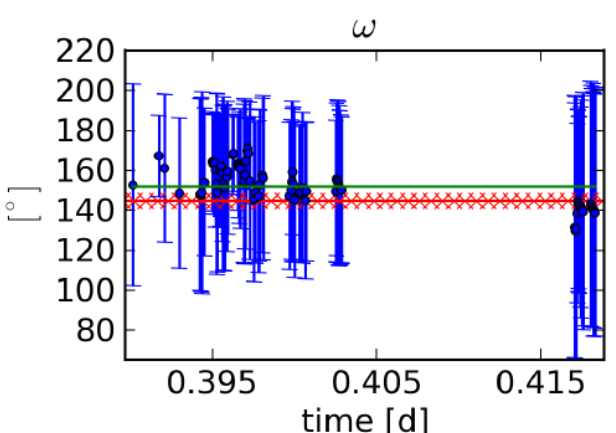
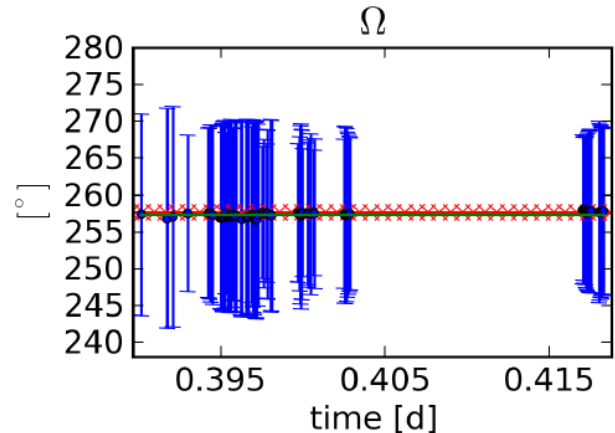
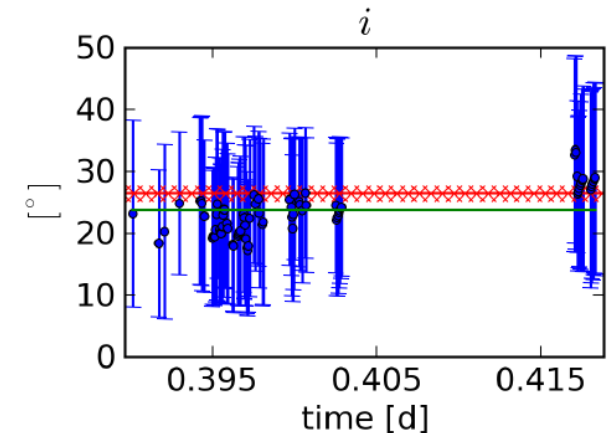
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Keplerian element	determined value via				JPL-provided values
	linear interpolation		linear regression		
a	0.85 AU	$\pm 22.8 \%$	0.851 AU	$\pm 1.96 \%$	0.85089058927 AU
e	0.24	$\pm 23.7 \%$	0.260	$\pm 6.73 \%$	0.25924873067
i	23.7	$\pm 21.1 \%$	26.43°	$\pm 3.23 \%$	26.3860159291°
$\Omega$	257.3	$\pm 0.6 \%$	257.59°	$\pm 0.41 \%$	257.578006331°
$\omega$	151.8	$\pm 9.2 \%$	144.41°	$\pm 2.15 \%$	144.455382852°
$\theta_0$	210.4	$\pm 6.0 \%$	217.54°	$\pm 1.15 \%$	217.110945153°





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JPL  
mean  
triang



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Conclusions:

**-Triangulation WORKS!**

-need more time for analysis

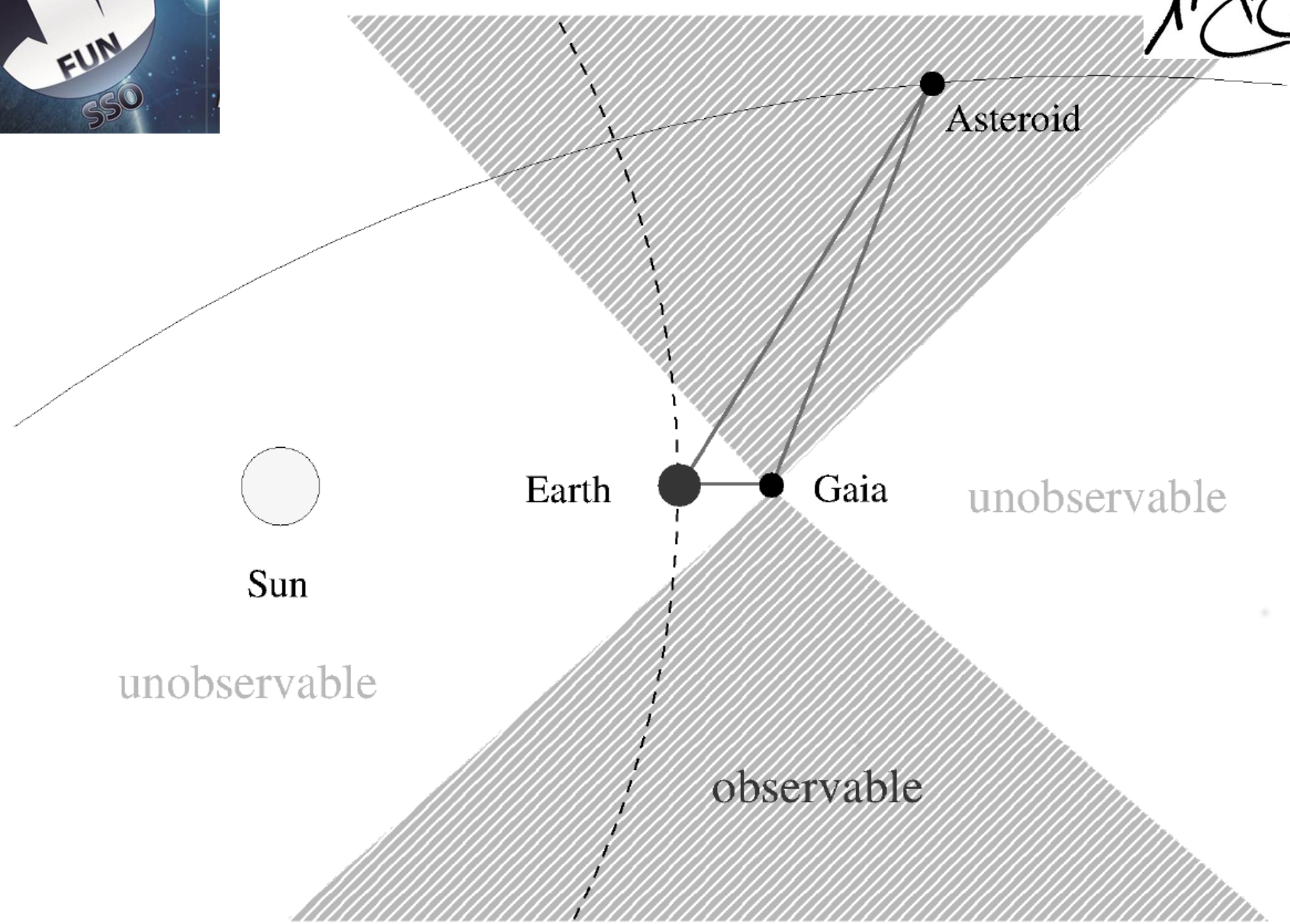


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# EARTH-GAIA Triangulation?



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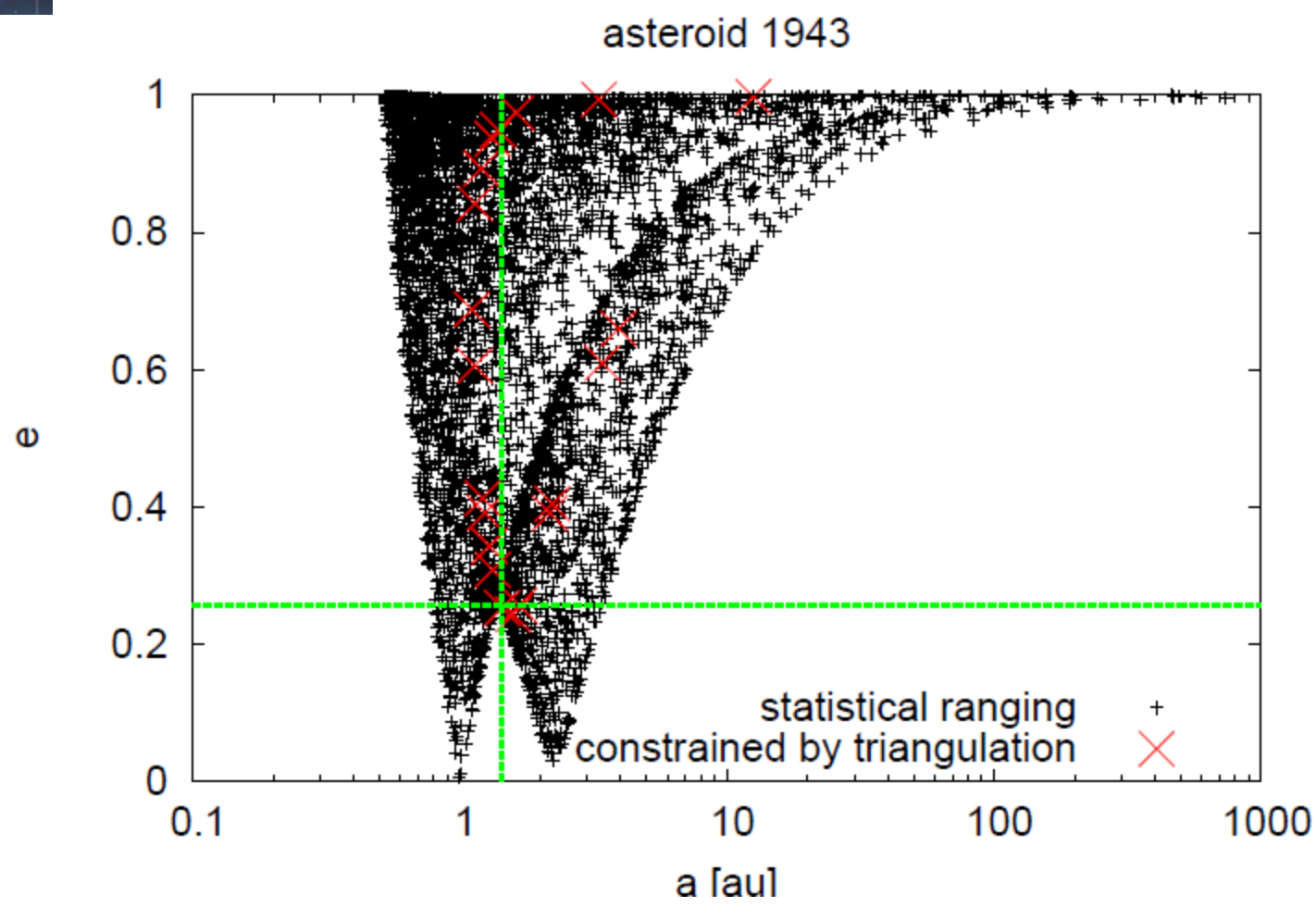
## Gaia NEO detections:

Very Short Arcs +  
Large parallaxes with Earth based observations

**Statistical Ranging : Likely Orbital Element Domain**

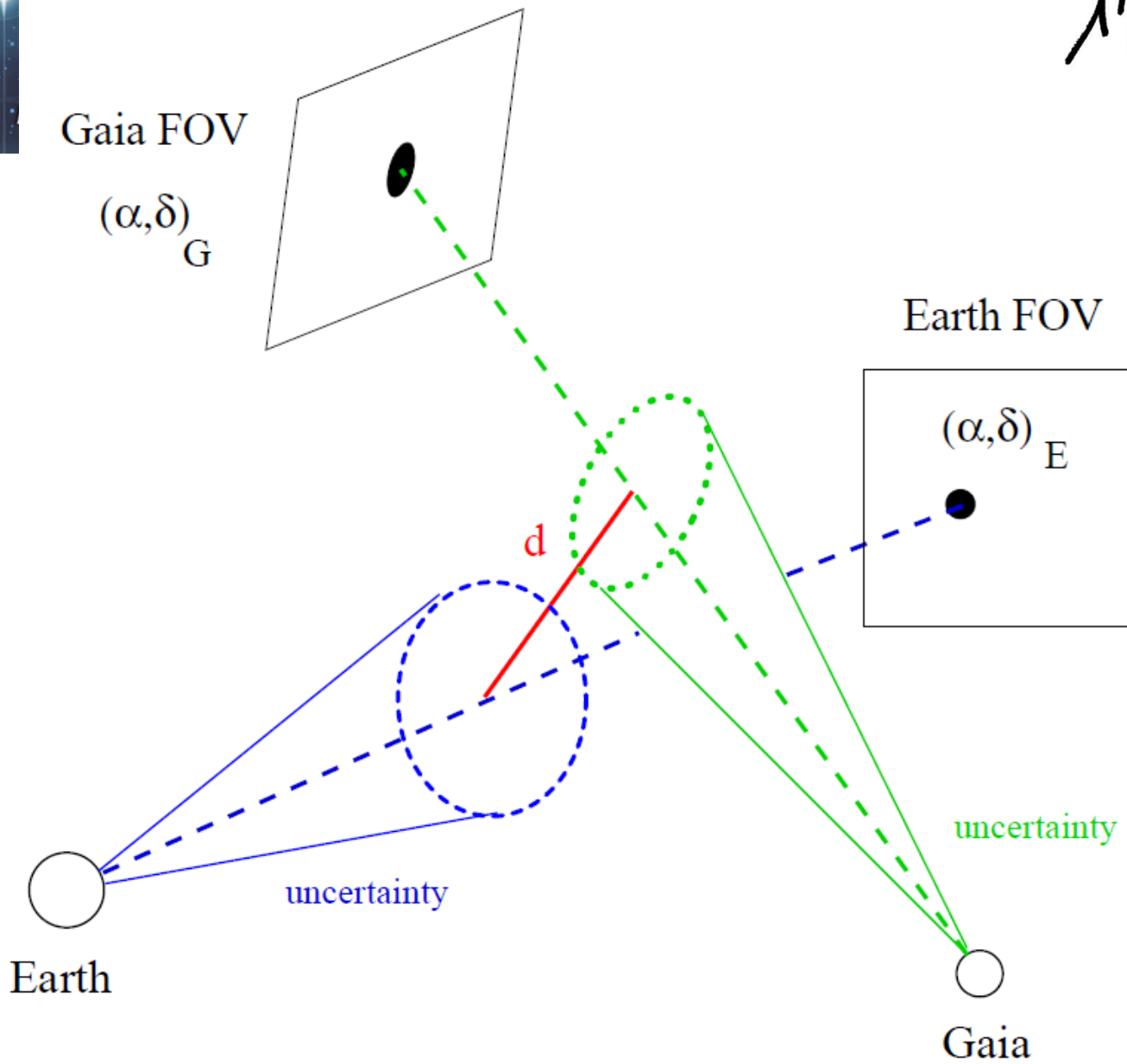


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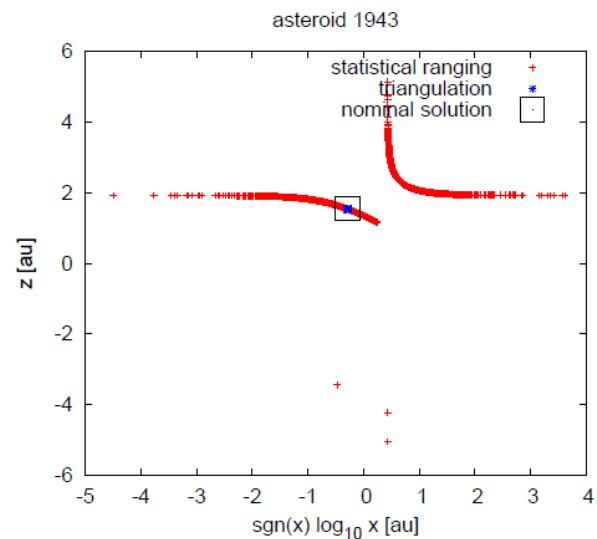
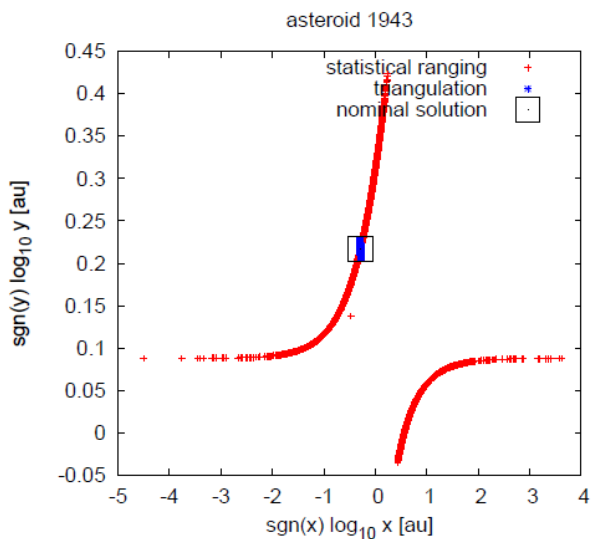
	$\Delta\alpha_G$	$\Delta\delta_G$	$\Delta\alpha_E = \Delta\delta_E$	$\Delta d_{EG}$
best case	$3 \cdot 10^{-4}$	$1.8 \cdot 10^{-3}$	0.1	150
worst case	$5 \cdot 10^{-3}$	$6 \cdot 10^{-2}$	2	150

Table 2: Dominating uncertainties for NEA orbit triangulation.  $\Delta\alpha_{G,E}$  and  $\Delta\delta_{G,E}$  denote the respective angular uncertainties in arc-seconds ["] of Gaia Hestroffer et al. (2009) and Earth-based observations.  $\Delta d_{EG}$  is the predicted in-mission uncertainty in the distance between Gaia and the Earth in [m].

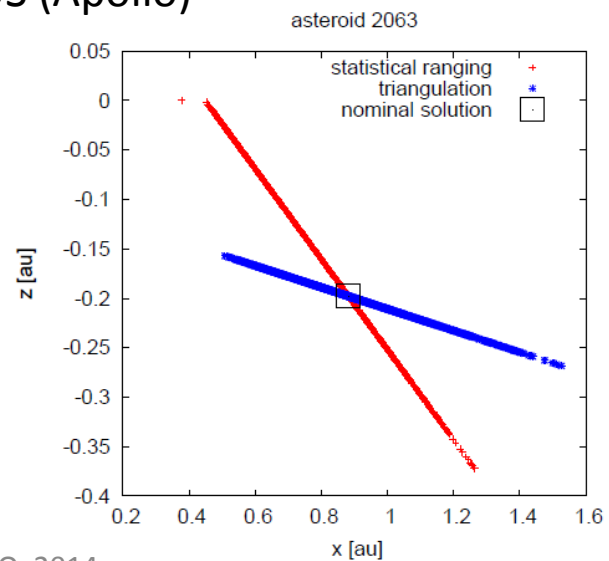
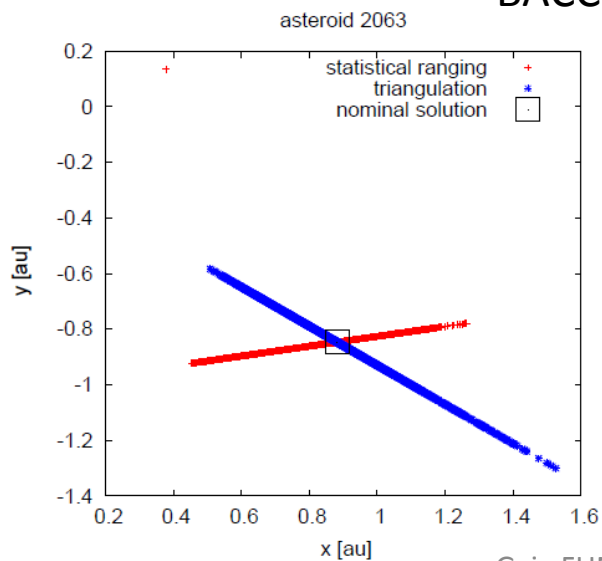


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## ANTEROS (Amor)



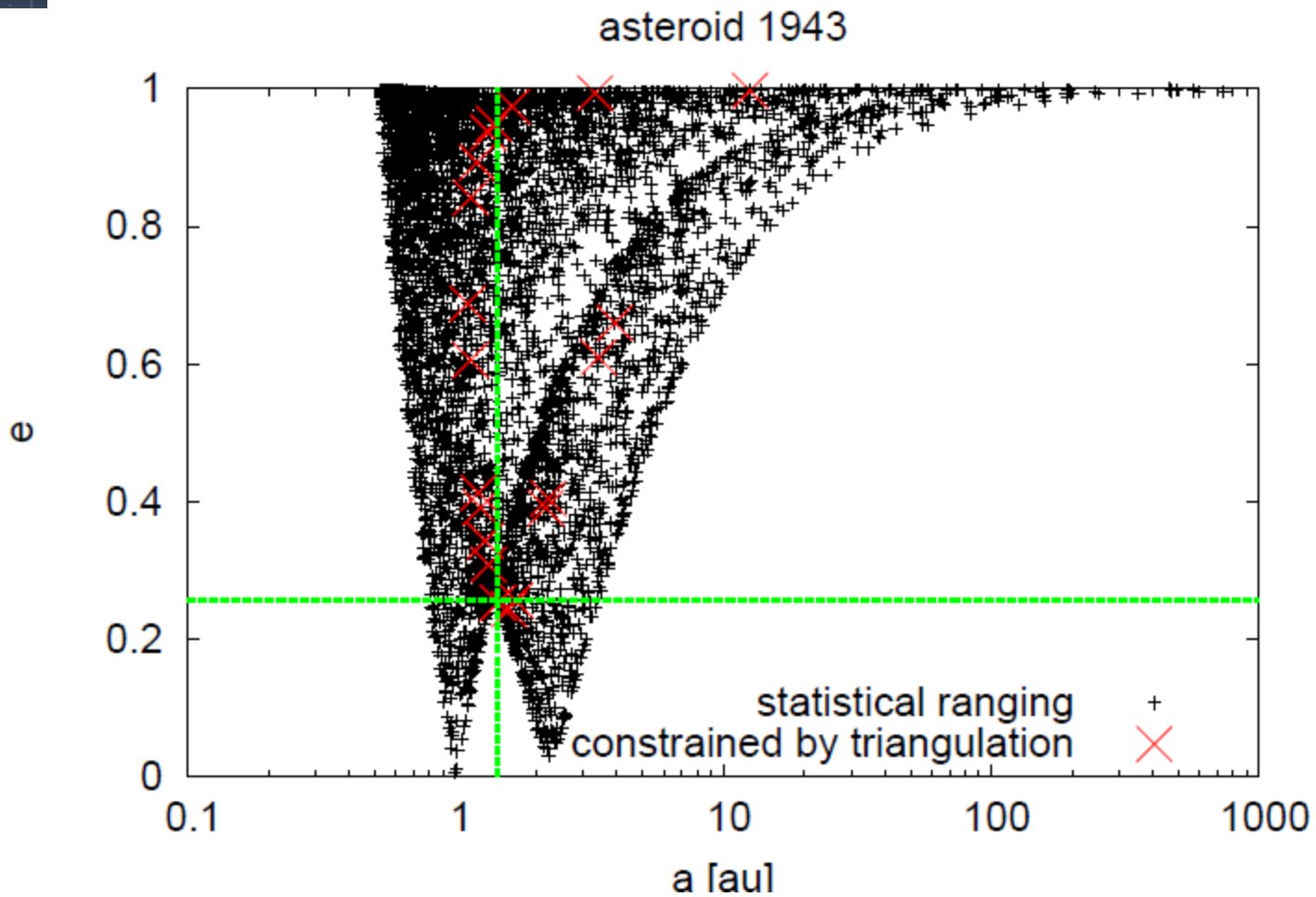
## BACCHUS (Apollo)





# ANTEROS (Amor)

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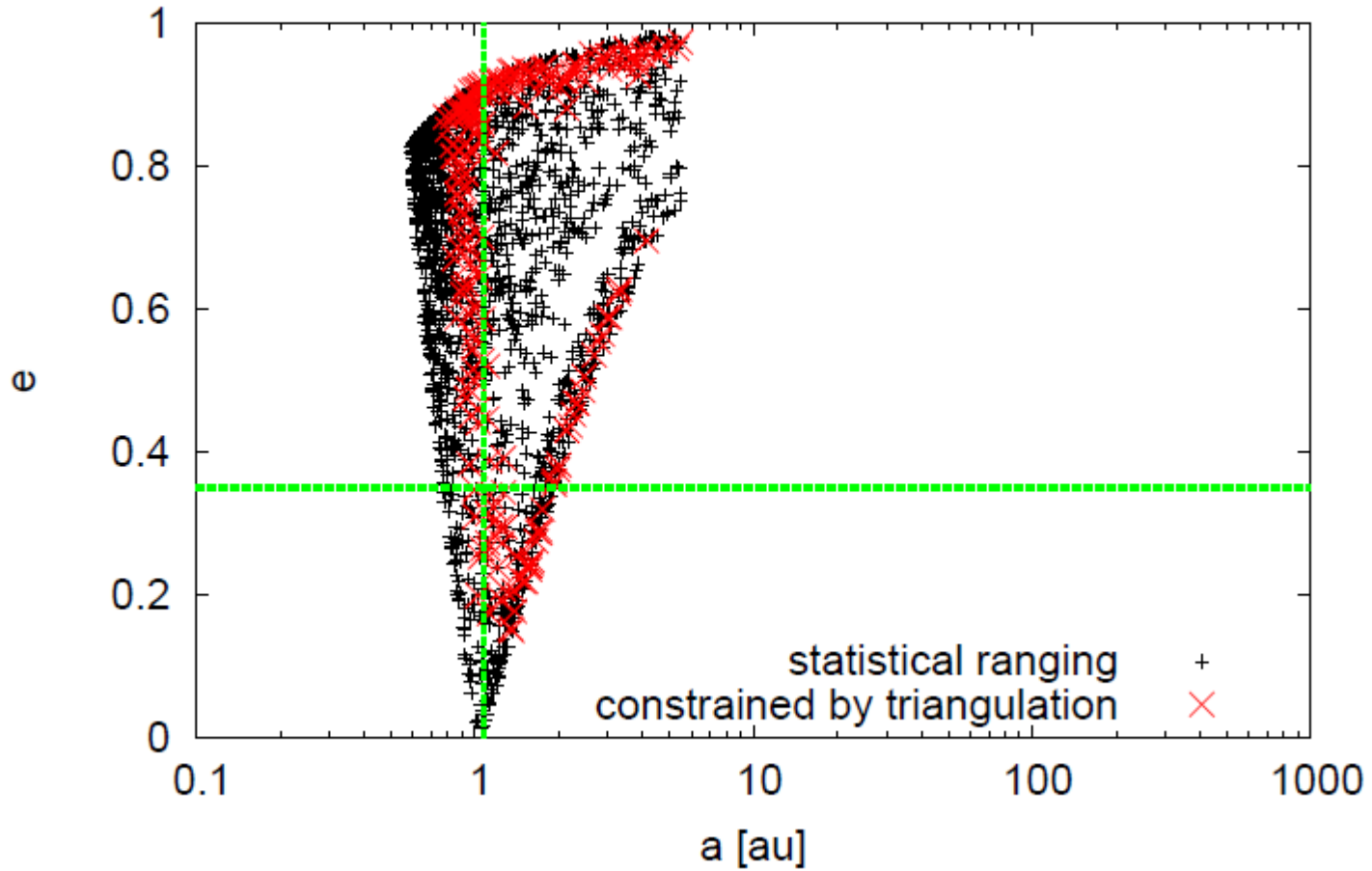




# BACCHUS (Apollo)

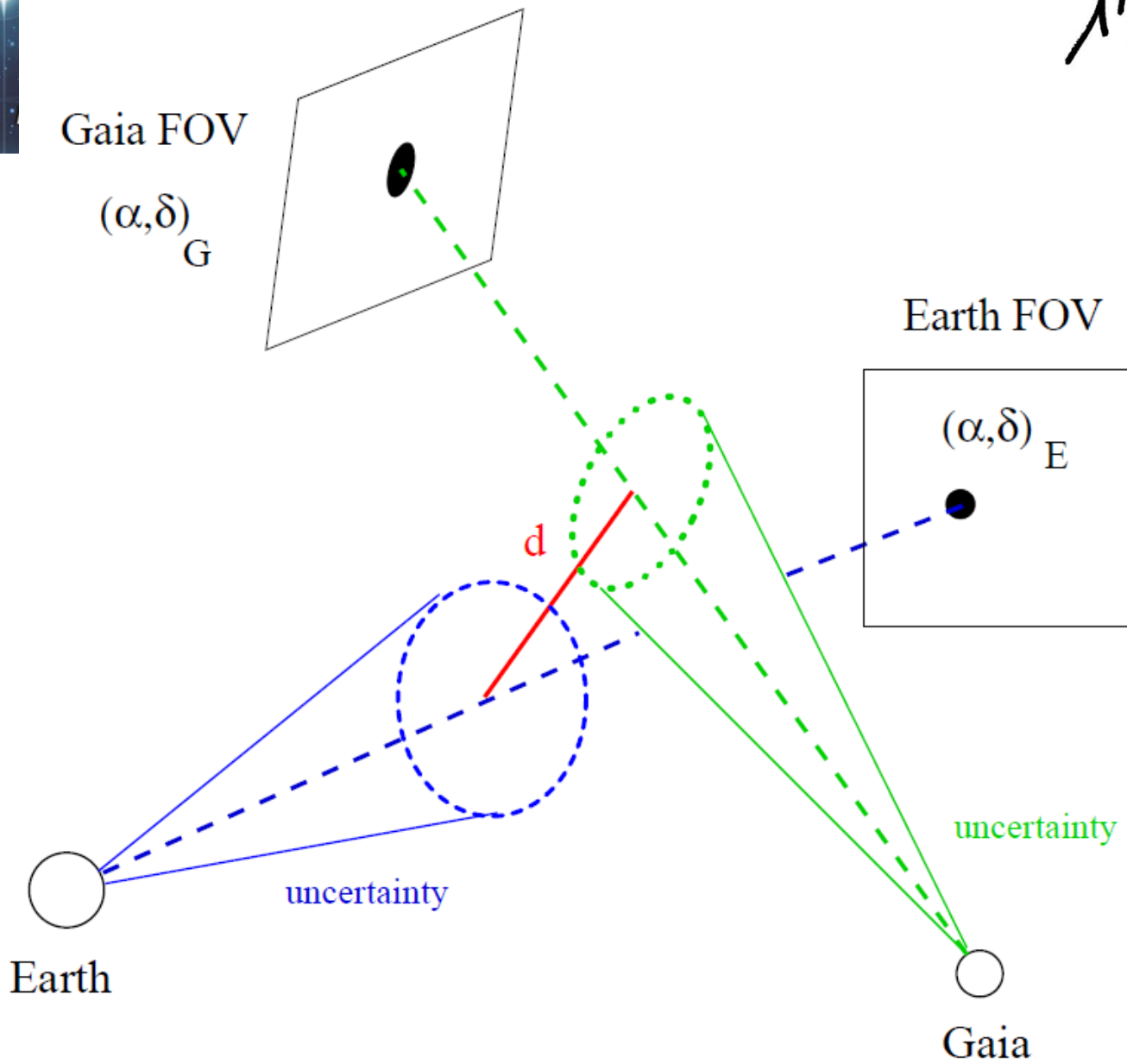
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asteroid 2063





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# **EARTH-GAIA Triangulation?**

**Pro: Restriction of OE space**

**Con: Requires simultaneous  
Earth based observation  
of Gaia FOV**