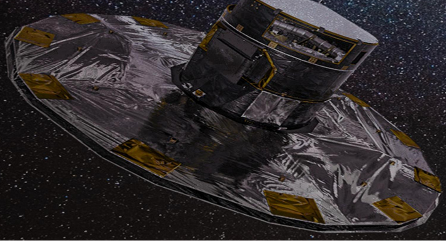

Investigating the contribution of Gaia DR1 to asteroid orbit determination

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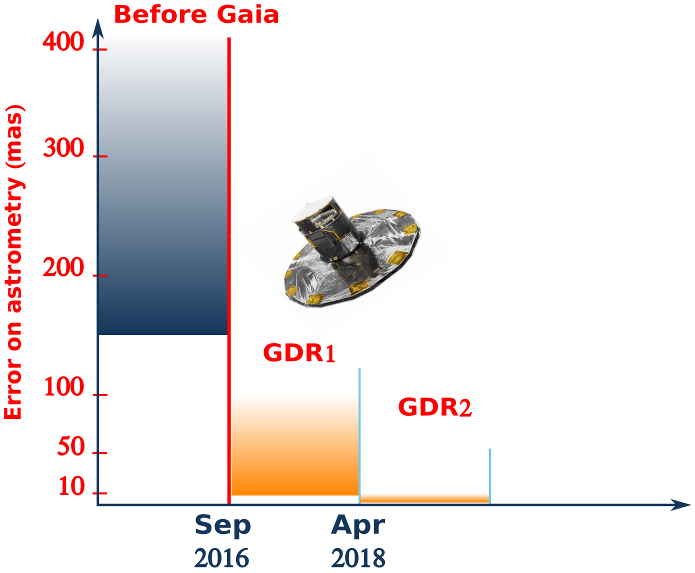
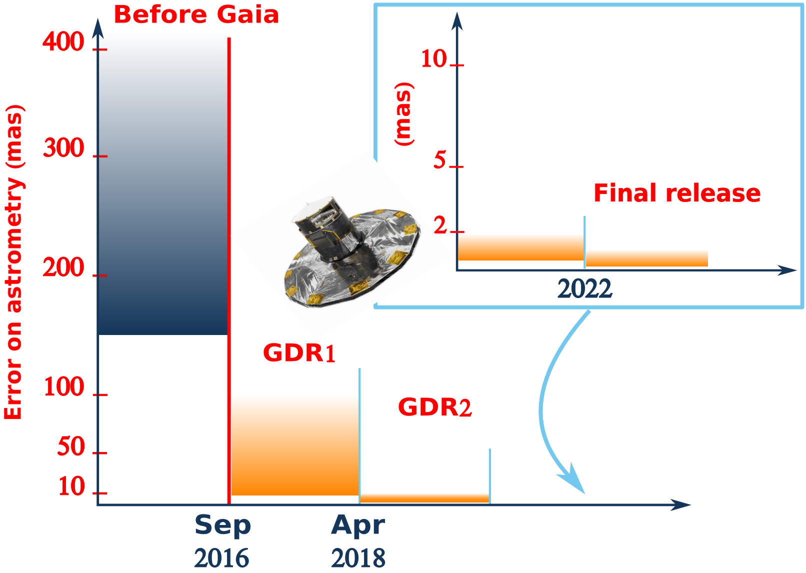
[5]Las Cumbres Observatory Global Telescope Network

Why is Gaia so important for asteroids?



Why is Gaia so important for asteroids?



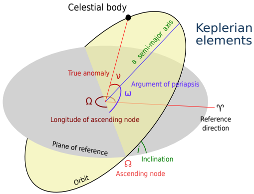
Orbit determination problem

Nonlinear (weighted) least squares problem

Dynamics | Observations | Error model

↓

Orbit



	GDR1	GDR2
Dynamics	Not so much	YES
Observations	YES and NO	YES
Error model	YES	YES

Nonlinear weighted least squares problem

Target function

$$Q(\xi) = \frac{1}{m}\, \xi^T\, \boldsymbol{W}\, \xi$$

- ξ: residuals
- W: **weight matrix**

Nonlinear weighted least squares problem

Target function

$$Q(\xi) = \frac{1}{m} \xi^T \boldsymbol{W} \xi$$

- ξ: residuals
- W: **weight matrix**

Weight

$$W = \begin{bmatrix} 1/\sigma_1^2 & 0 & \cdots & 0 \\ 0 & 1/\sigma_2^2 & \cdots & 0 \\ \vdots & & \ddots & \\ 0 & \cdots & 0 & 1/\sigma_m^2 \end{bmatrix}$$

Nonlinear weighted least squares problem

Target function

$$Q(\xi) = \frac{1}{m}\,\xi^T\,\boldsymbol{W}\,\xi$$

- ξ: residuals
- W: **weight matrix**

Weight

$$W = \begin{bmatrix} 1/\sigma_1^2 & 0 & \cdots & 0 \\ 0 & 1/\sigma_2^2 & \cdots & 0 \\ \vdots & & \ddots & \\ 0 & \cdots & 0 & 1/\sigma_m^2 \end{bmatrix}$$

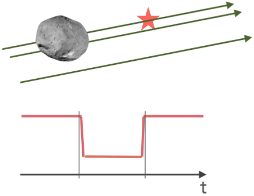
- **Normal equations**

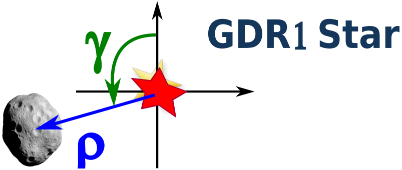
$$C = B^T W B; \quad D = -B^T W \xi \quad \left(B = \frac{\partial \xi}{\partial \boldsymbol{x}}\right)$$

- **Differential correction**

$$Correction = C^{-1} D$$

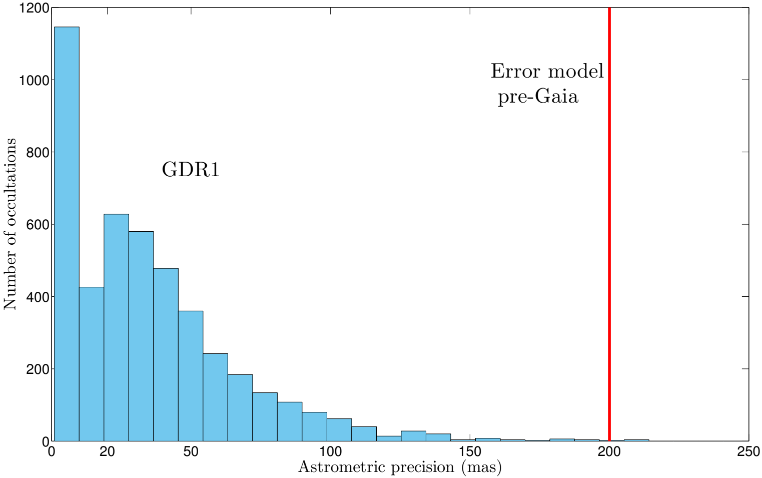
An occultation of a star by an asteroid occurs when the asteroid **passes in front of a star**, temporarily blocking its light as seen from the Earth.



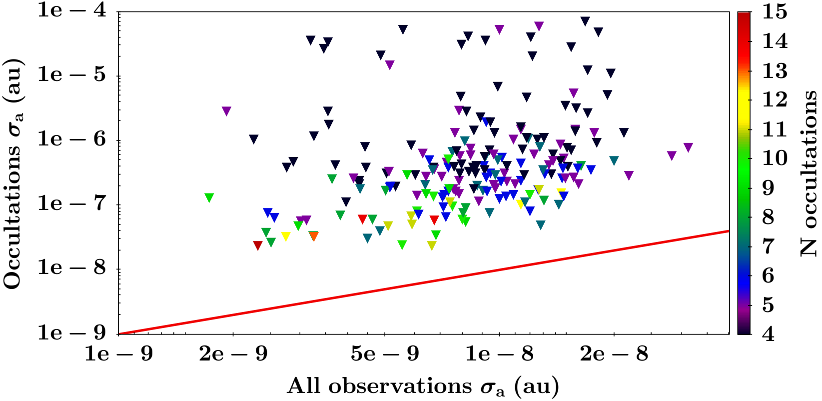


- Stars in GDR1
- **Re-reduction of occultation astrometry**
- **Orbit determination using only the occultations**

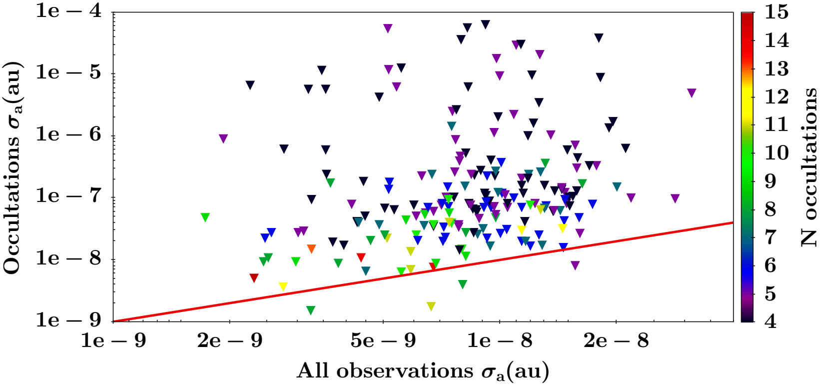
New error model for the occultations



Pre-Gaia



1e − 4
1e − 5
1e − 6
1e − 7
1e − 8
1e − 9
Occultations σ_a (au)
1e − 9
2e − 9
5e − 9
1e − 8
2e − 8
All observations σ_a (au)
15
14
13
12
11
10
9
8
7
6
5
4
N occultations



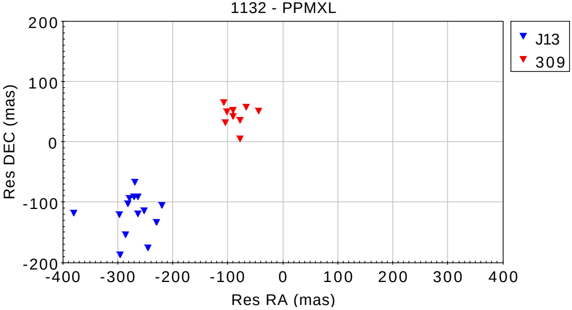
New approach to asteroid astrometry

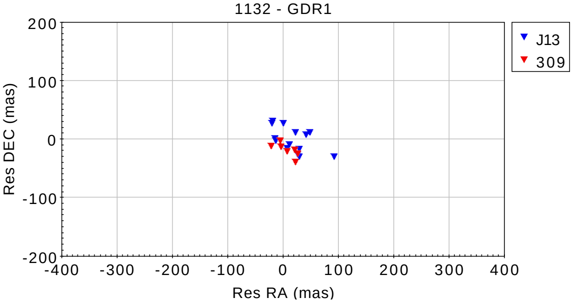
- **Ground Based Optical Tracking campaign** of Gaia.
- Standard procedure for satellite tracking is not sufficient.
- GBOT needs a level of absolute accuracy of **20 mas** on the satellite position determination.

Asteroid observations

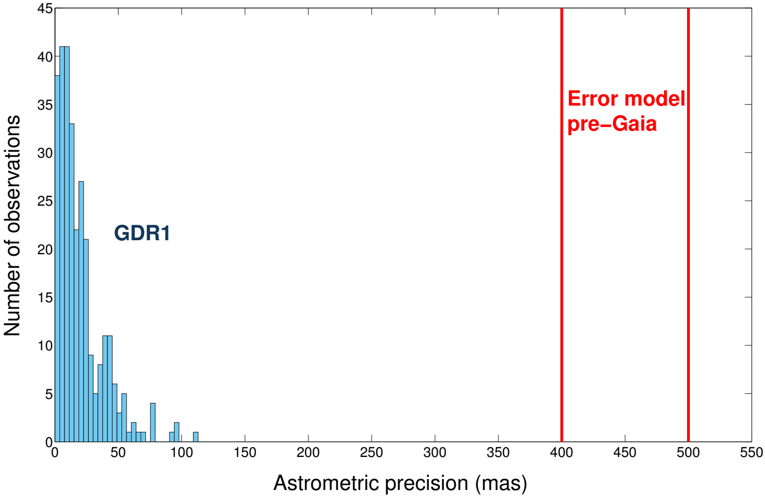
- **Two main telescopes**
  - Liverpool Telescope (LT) - La Palma
  - VLT Survey Telescope (VST) - Paranal

Zonal errors: removed with GDR1





New error model



The case of 2016 EK_{85}: the discovery

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M.P.E.C. 2016-E122                              Issued 2016 Mar. 11, 18:11 UT

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            URL http://www.minorplanetcenter.net/    ISSN 1523-6714


                                  2016 EK85

Observations:
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     K16E85K 'C2016 03 09.10109 11 12 47.77 +12 04 29.8          20.1 RtEE122309
     K16E85K 'C2016 03 09.10230 11 12 48.18 +12 04 24.3          19.7 RtEE122309
     K16E85K 'C2016 03 09.10351 11 12 48.58 +12 04 18.9          20.1 RtEE122309
     K16E85K 'C2016 03 09.10471 11 12 48.96 +12 04 13.6          19.9 RtEE122309
     K16E85K 'C2016 03 09.10593 11 12 49.37 +12 04 08.2          19.7 RtEE122309
     K16E85K 'C2016 03 09.10713 11 12 49.75 +12 04 02.9          19.8 RtEE122309
     K16E85K 'C2016 03 09.10834 11 12 50.15 +12 03 57.5          19.9 RtEE122309
     K16E85K* C2016 03 10.33087 11 19 05.45 +10 44 47.9          20.4 VqEE122G96
     K16E85K  C2016 03 10.33396 11 19 06.12 +10 44 38.3          20.2 VqEE122G96
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     K16E85K  C2016 03 11.46857 11 23 12.06 +09 53 11.1          20.6 VqEE122G96
     K16E85K  C2016 03 11.46941 11 23 12.19 +09 53 09.3          21.3 VqEE122G96
```

VST

LT

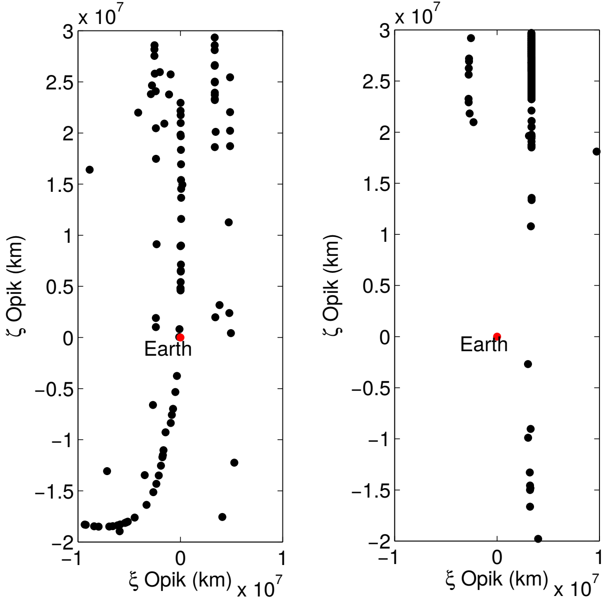
Past situation

- 48 observations
  - 28 GBOT observations
  - 2 days
- **Possible impacts** with the Earth
  - 2102 and 2106

Current situation

- 74 observations
  - 27 days
- **Removed** from the risk list
  - Mauna Kea observations

The case of 2016 EK_{85} : the LoV



Thank you!