European Space Agency

LENTES GRAVITACIONALES

Focused Product Release (FPR)

10 de octubre de 2023

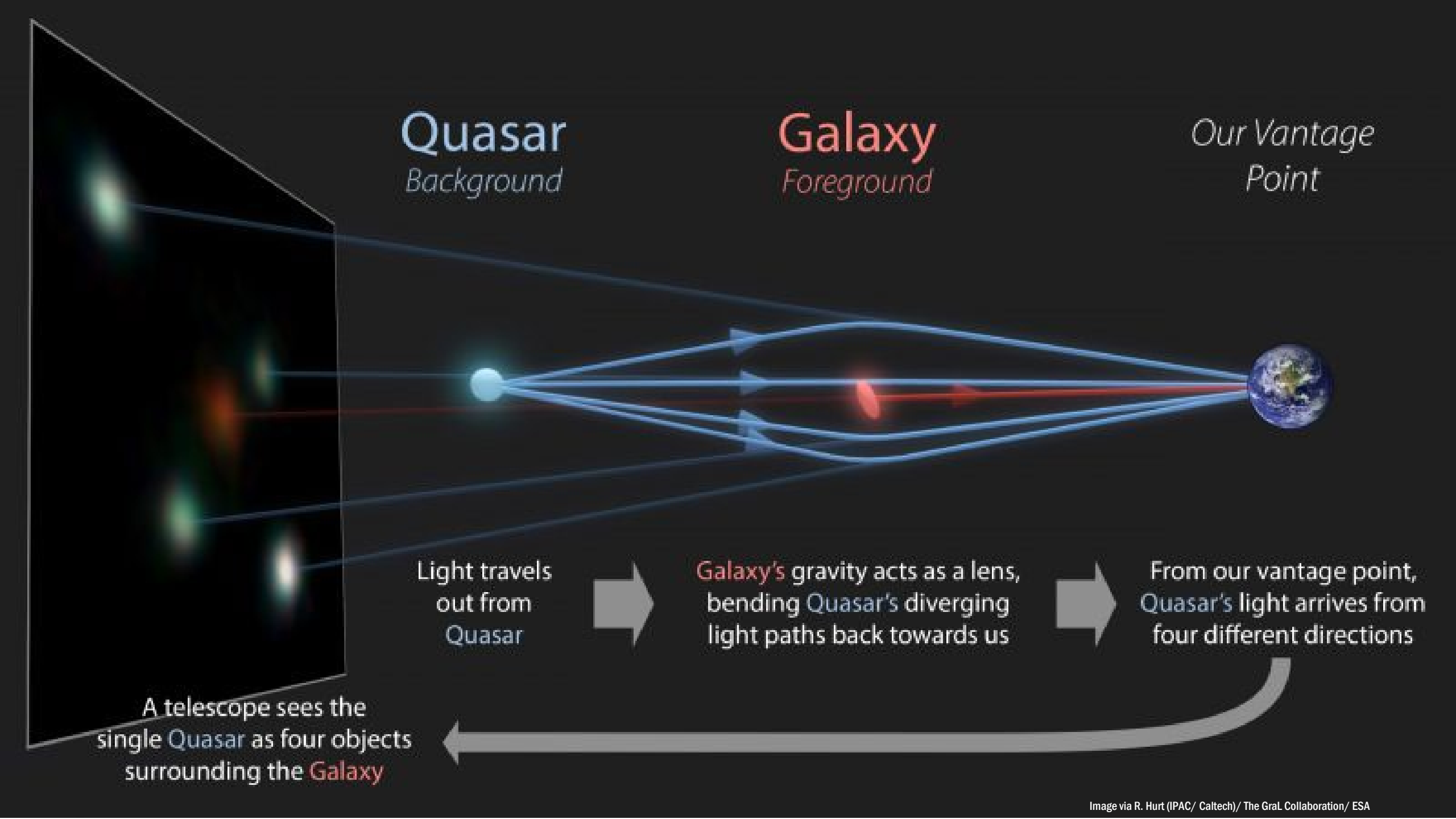
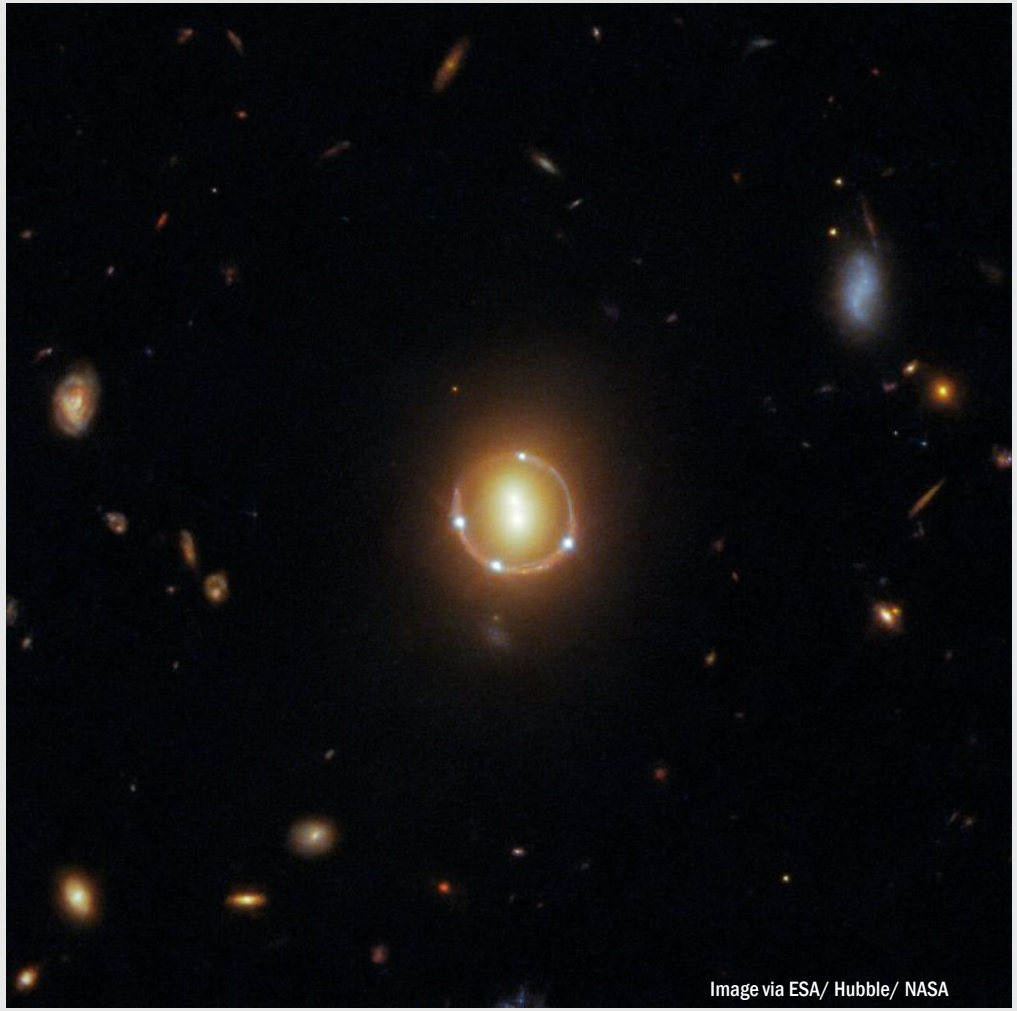


Image via R. Hurt (IPAC/ Caltech)/ The GraL Collaboration/ ESA

Introducción:



- La alta resolución espacial de **Gaia** ha permitido analizar el efecto de **lentes gravitacionales**, detectando múltiples imágenes reflejadas de **quasares (QSO).**

- El procesado **GravLens** busca fuentes secundarias alrededor de cada QSO ➔ ***componentes.***

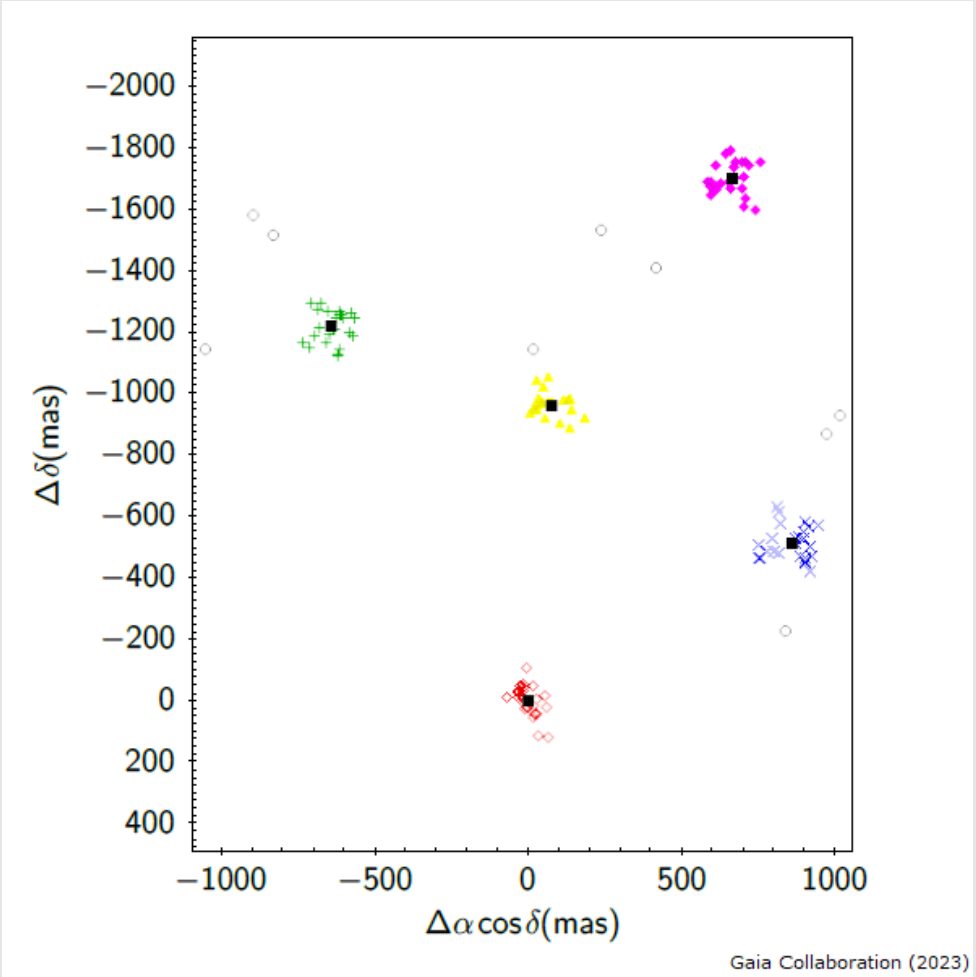
- Búsqueda alrededor de **3.760.032** QSO de la literatura ➔ radio: **6 arcsec**.

Procesado GravLens:

- Utiliza el **algoritmo** de clustering no-supervisado **DBSCAN** (*Density-Based Clustering Applications with Noise*) para detectar **componentes** alrededor de cada **QSO**.

- Identifica como **cluster** de puntos (tránsitos) **conectados**, si:
  - Distancia menor de **100 mas**.
  - Al menos **3 puntos** para considerarlo cluster

- En caso contrario los puntos se consideran **outliers**.



Tablas en Gaia FPR:

- ***Lens_Catalogue_Name:*** contiene el ID y la referencia de cada **QSO** seleccionado como **candidato** a lente gravitacional (3.760.032 fuentes).
- ***Lens_Candidates:*** contiene las **componentes** detectadas para cada **QSO** (4.760.920 fuentes).
- ***Lens_Observations:*** contiene las **observaciones** tomadas de cada una de las componentes de cada candidato (171.545.519 fuentes).
- ***Lens_Outliers:*** contiene las observaciones tomadas que no han sido asociadas a ninguna componente y han sido **descartadas** para el análisis (11.822.543 fuentes).

➢ Distribución de candidatas a Lentes Gravitacionales (QSO):

```
Total number of Gravitational Lens Candidates: 3760032

- Number of gravitational lens with 1 components: 3258647 ==> 86.665 %
- Number of gravitational lens with 2 components: 341551 ==> 9.084 %
- Number of gravitational lens with 3 components: 78258 ==> 2.081 %
- Number of gravitational lens with 4 components: 30624 ==> 0.814 %
- Number of gravitational lens with 5 components: 16226 ==> 0.432 %
- Number of gravitational lens with 6 components: 9548 ==> 0.254 %
- Number of gravitational lens with 7 components: 6192 ==> 0.165 %
- Number of gravitational lens with 8 components: 4171 ==> 0.111 %
- Number of gravitational lens with 9 components: 2902 ==> 0.077 %
- Number of gravitational lens with 10 components: 2032 ==> 0.054 %
- Number of gravitational lens with 11 components: 1536 ==> 0.041 %
- Number of gravitational lens with 12 components: 1175 ==> 0.031 %
- Number of gravitational lens with 13 components: 959 ==> 0.026 %
- Number of gravitational lens with 14 components: 794 ==> 0.021 %
- Number of gravitational lens with 15 components: 676 ==> 0.018 %
```

- **Una** de las **componentes** en cada candidata está asociada al propio **QSO.**
- El número **máximo** de **componentes** en una candidata es de **343**.

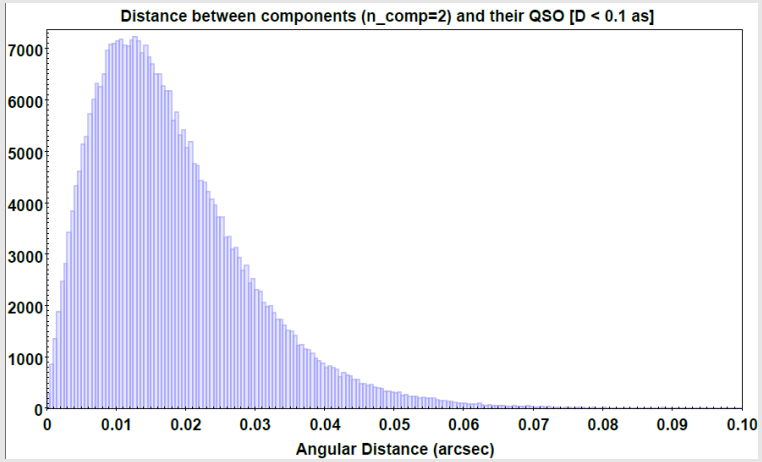
➢ Quasares con una única componente:

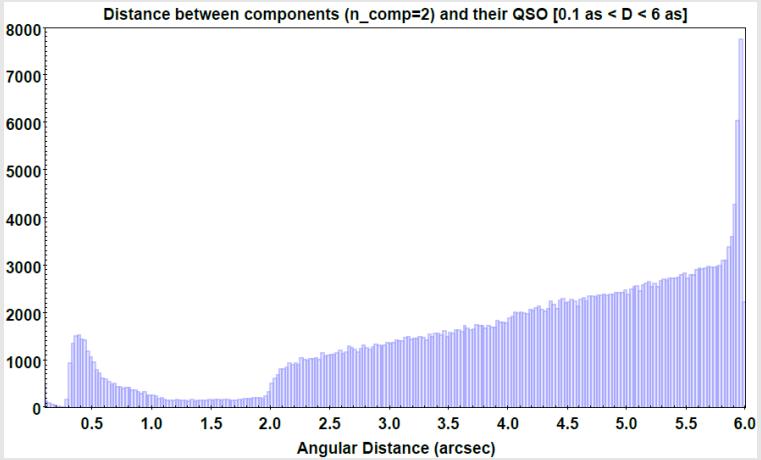
- Estas **3.258.647** componentes serían la imagen el propio **QSO**.
  - NO se observa efecto de lente gravitacional.
  - Hay **501.385** candidatas **reales** a lente gravitacional.

- **Distancia angular** entre las componentes únicas y el QSO:
  - **D < 100 mas**: 3.257.434 fuentes (99'96%)
  - **100 mas < D < 200 mas**: 1056 fuentes
  - **200 mas < D < 300 mas:** 89 fuentes
  - **D = 316 mas**: 1 fuentes
  - **D = 2.09 as:** 1 fuentes

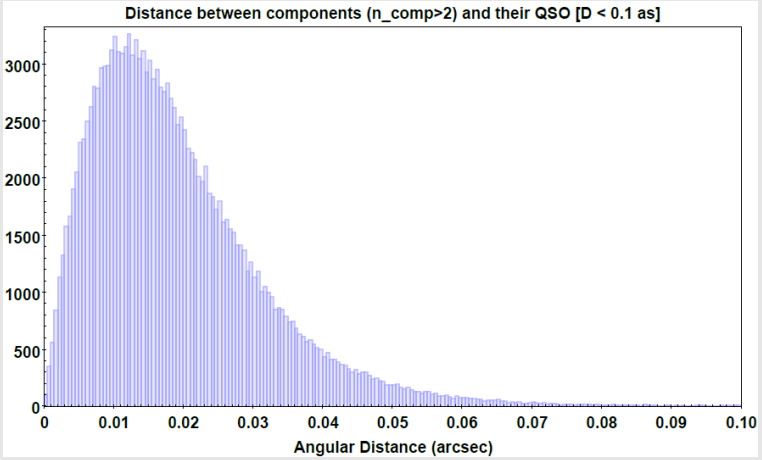
➢ Distancia entre las componentes de las lentes y su correspondiente QSO:

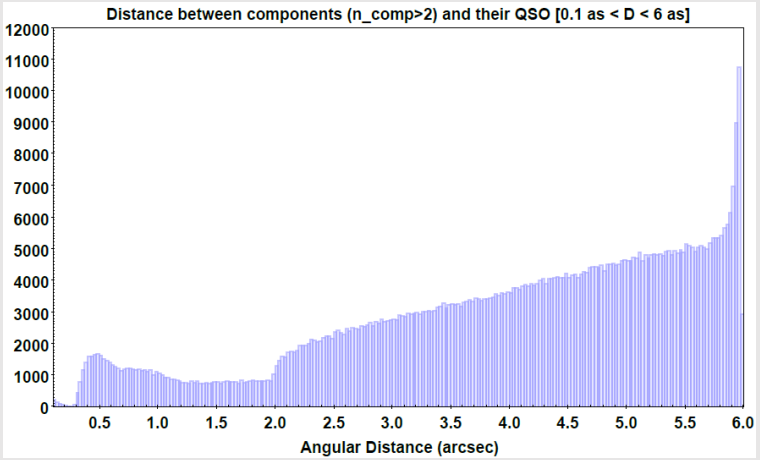
- **n_comp = 2** ➔ 683.102 fuentes





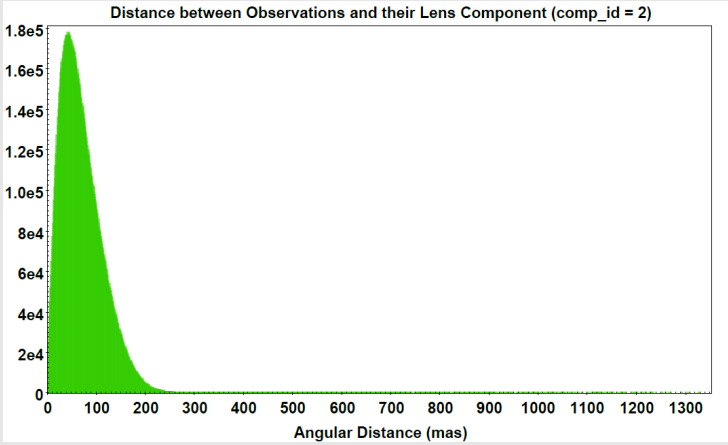
- **n_comp > 2** ➔ 819.171 fuentes



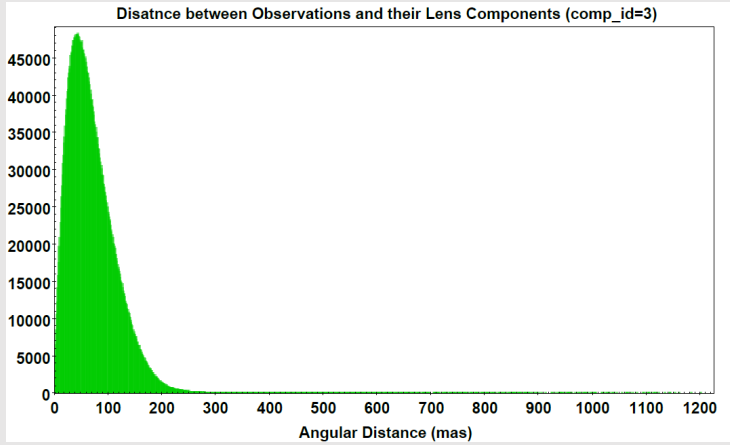


Lens Observations:

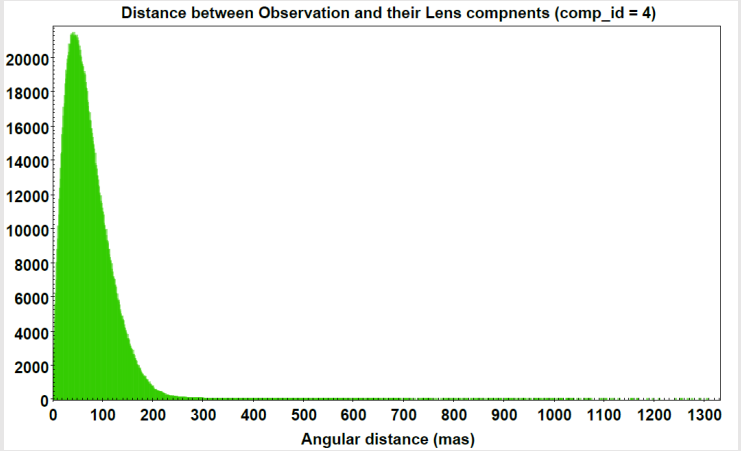
- Número total de observaciones: 171.545.519



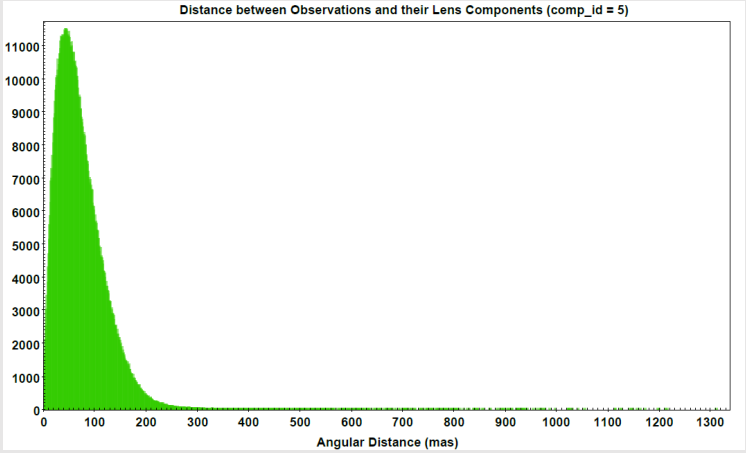
- ***comp_id = 2:*** 501.385 componentes ➔ 16.710.758 observaciones
  - **D > 100 mas:** 3,713,628 observaciones [22%]



- ***comp_id = 3:*** 159.834 componentes ➔ 4.536.810 observaciones
  - **D > 100 mas:** 1.008.672 observaciones [22%]



- ***comp_id = 4:*** 81.576 componentes ➔ 2.023.365 observaciones
  - **D > 100 mas:** 458.495 observaciones [23%]

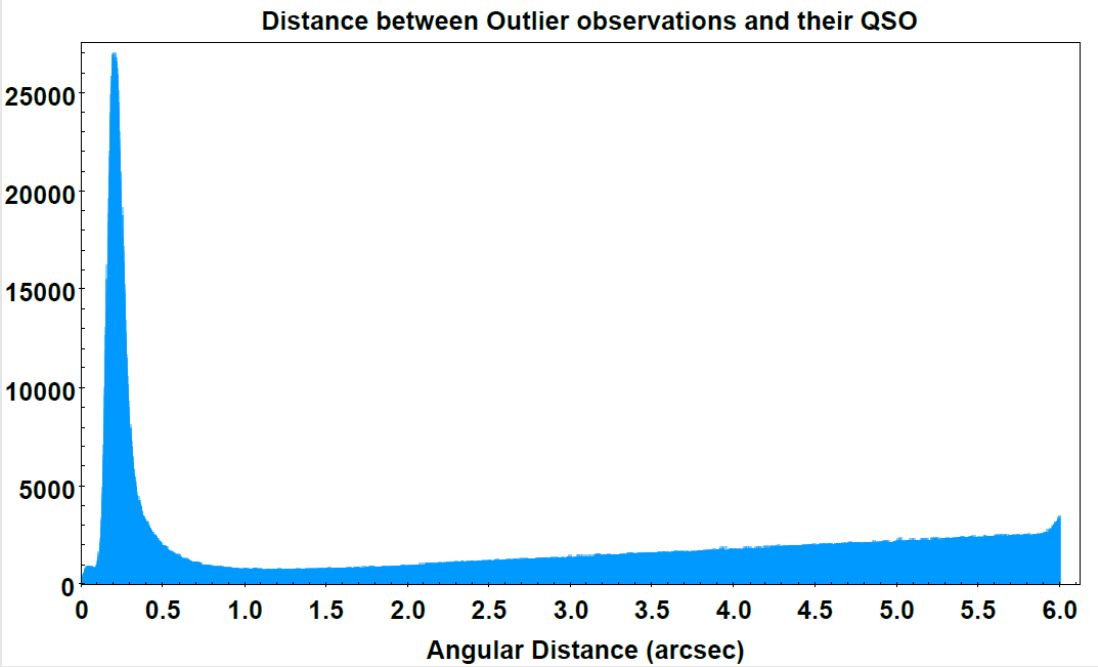


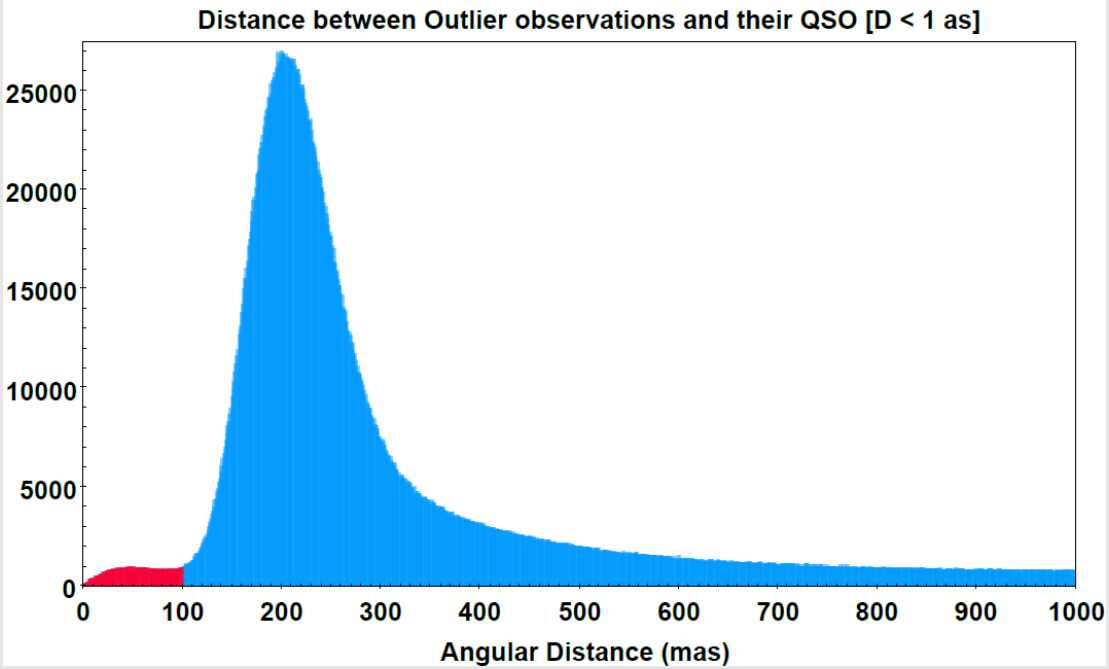
- ***comp_id = 5:*** 50.952 componentes ➔ 1.106.062 observaciones
  - **D > 100 mas:** 257.696 observaciones [23%]

Lens Outliers:

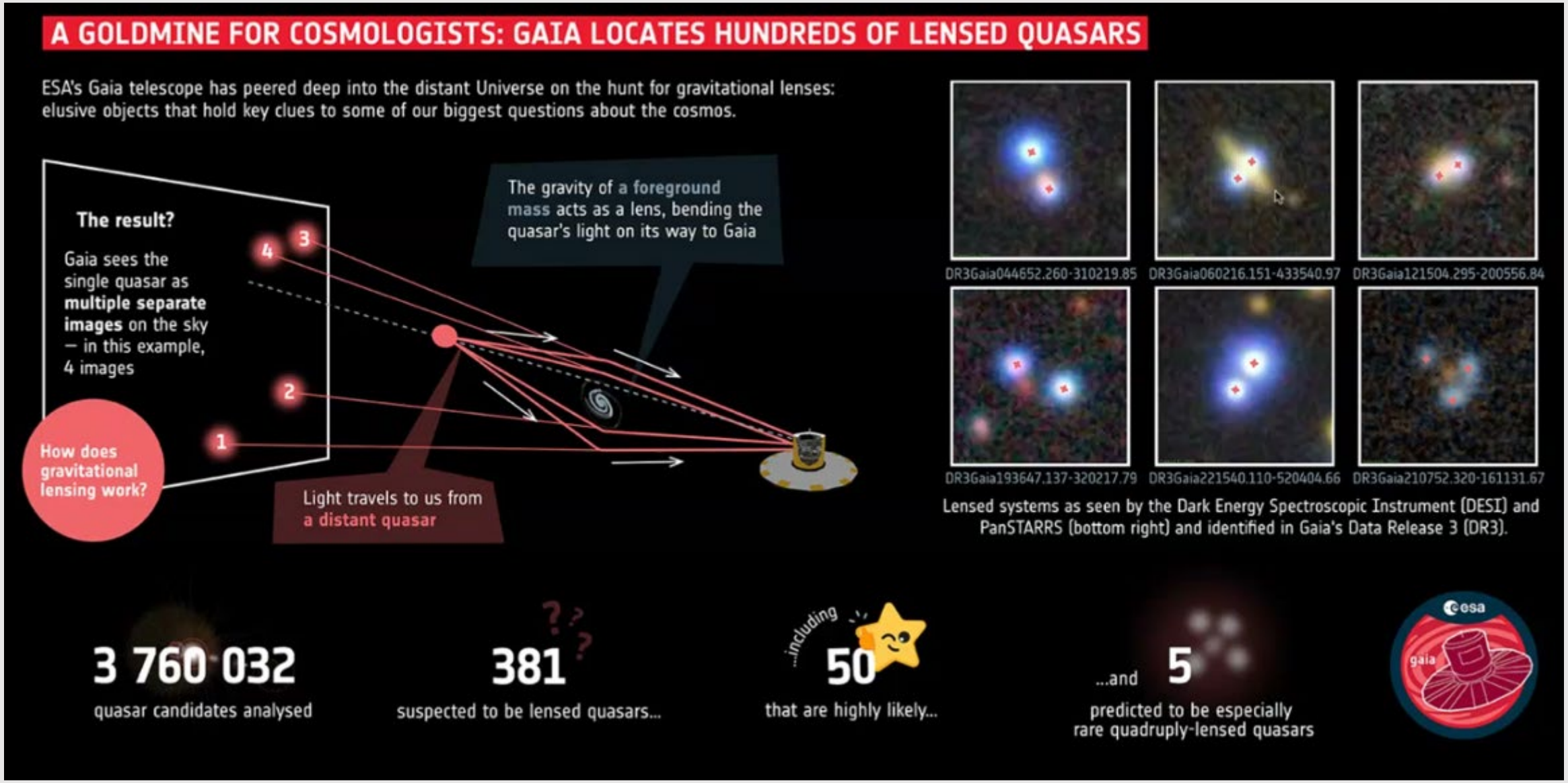
- Número total de outliers: 11.822.543

  - **Distance < 100 mas** ➔ 69.277 (0.59%)
  - **100 mas < Distance < 500 mas** ➔ 3.595.857 (30%)
  - **Distance > 6 arcsec** ➔ 23 (0.0002%)





➢ RESULTADOS:


A GOLDMINE FOR COSMOLOGISTS: GAIA LOCATES HUNDREDS OF LENSED QUASARS
ESA's Gaia telescope has peered deep into the distant Universe on the hunt for gravitational lenses: elusive objects that hold key clues to some of our biggest questions about the cosmos.
The result?
Gaia sees the single quasar as multiple separate images on the sky – in this example, 4 images
4
3
2
1
How does gravitational lensing work?
The gravity of a foreground mass acts as a lens, bending the quasar's light on its way to Gaia
Light travels to us from a distant quasar
DR3Gaia044652.260-310219.85
DR3Gaia060216.151-433540.97
DR3Gaia121504.295-200556.84
DR3Gaia193647.137-320217.79
DR3Gaia221540.110-520404.66
DR3Gaia210752.320-161131.67
Lensed systems as seen by the Dark Energy Spectroscopic Instrument (DESI) and PanSTARRS (bottom right) and identified in Gaia's Data Release 3 (DR3).
3 760 032
quasar candidates analysed
381
suspected to be lensed quasars...
...including
50
that are highly likely...
...and 5
predicted to be especially rare quadruply-lensed quasars
esa
gaia