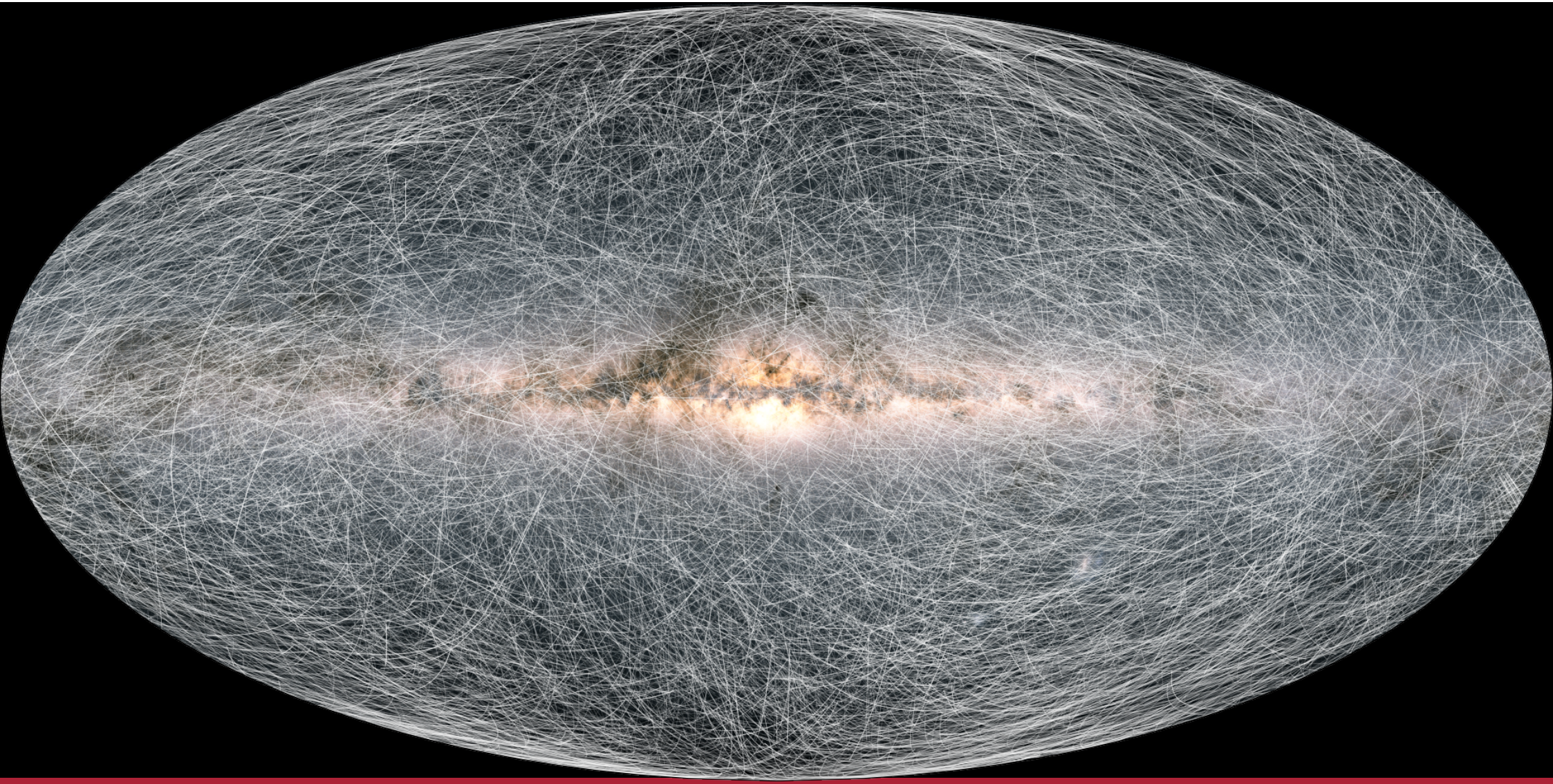


Participation in Gaia

Timo Prusti

Masaryk University, Brno, CZ

Gaia

- ESA only cornerstone mission for astrometry, spectrophotometry and spectroscopy
- Core science goal: Milky Way structure and evolution
  - Structure (astrometry)
  - Evolution (astrometry and spectroscopy)
  - Properties of stars (spectrophotometry and spectroscopy)
- The scientific performance requirements allowed advances also in:
  - Solar System
  - Stellar astronomy
  - Local group kinematics
  - Extragalactic objects
  - Reference frame

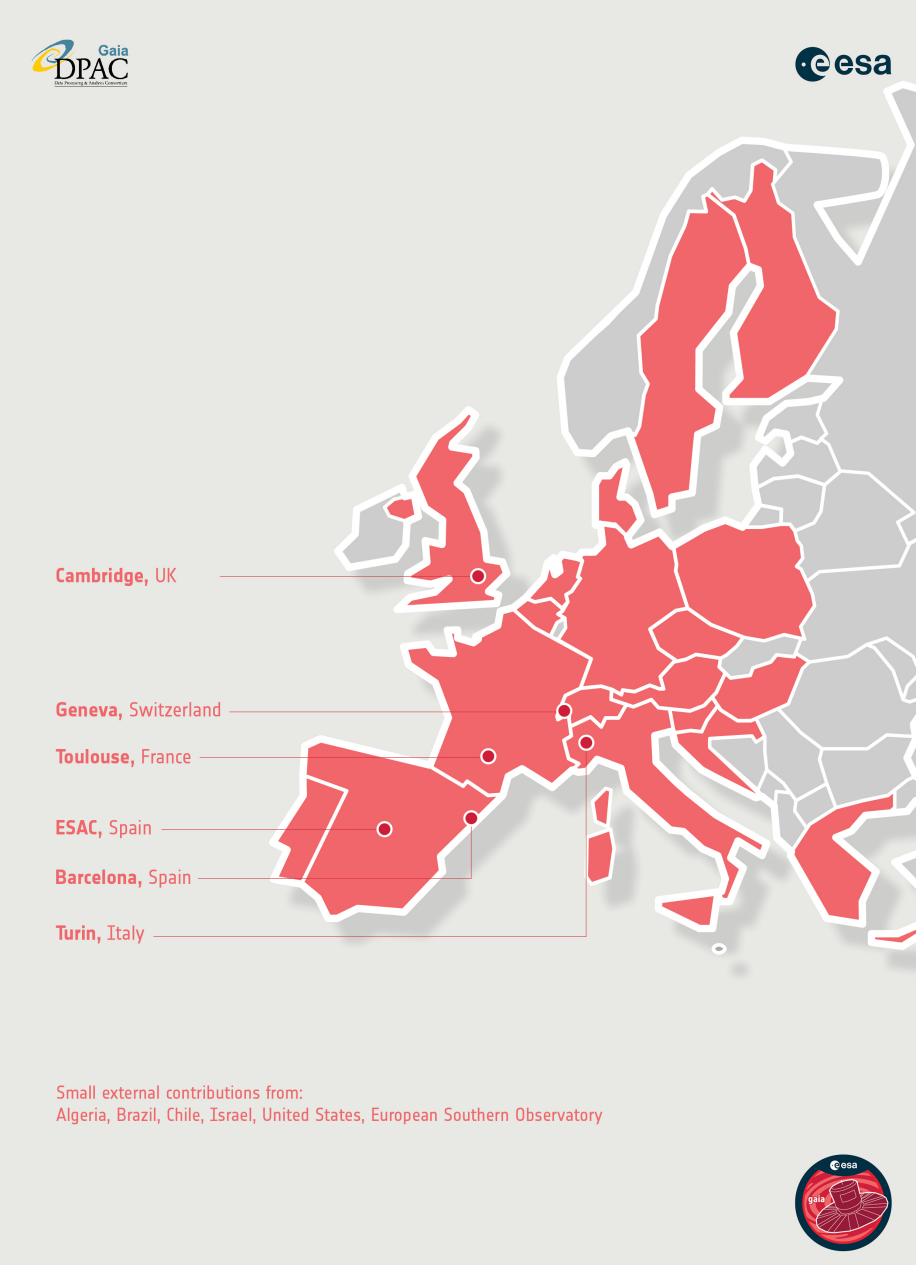
Gaia timeline

- Astrometry moved into space time with the Hipparcos mission 1989-1993
- Global Astrometric Interferometer for Astrophysics (GAIA) was proposed 1993
  - Became Gaia when changed to direct detection and passed selection (2000) and adoption (2006) triggering the industrial activities
- Gaia launch 2013
  - Routine operations 2014-2025 for about 10.5 years
  - 2.6 trillion astrometric measurements
  - 220 billion spectrophotometric observations (of blue and red parts)
  - 52 billion spectra
  - Totalling 141 TB of telemetry
  - True data reduction onboard as on average full sky measured 150 times with Hubble spatial resolution

Gaia data processing

- Data Processing and Analysis Consortium (DPAC) was established 2006 to prepare a proposal for Gaia data processing
- DPAC was approved 2007 by the Science Programme Committee of ESA to do the Gaia data processing task

- ESA missions typically have instruments provided by member states
- In Gaia DPAC is provided by the member states, but no guaranteed time as reward/ compensation



Ensuring Gaia data processing

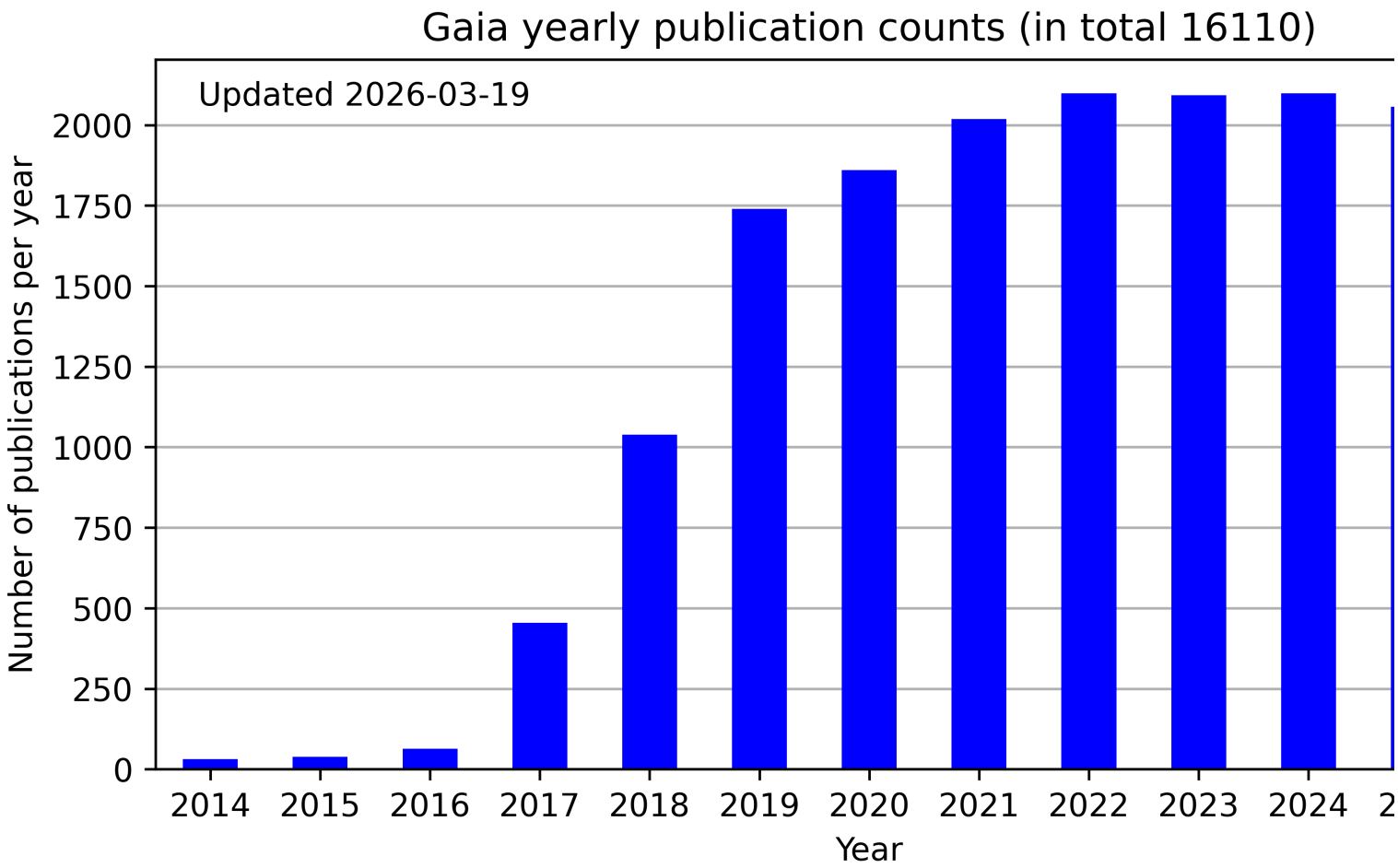
- A Multilateral Agreement (MLA) is established for ESA missions to agree on responsibilities between ESA and member states
  - Agreements are at the level of deliverables
- MLA for Gaia was worked on 2007 (and amended twice to cover everything till the legacy archive)
  - Signed 2008 for ESA, Belgium, France, Germany, Italy, The Netherlands, Spain, Sweden, Switzerland, and United Kingdom
- Importance for scientists is stability as national funding agencies commit to support the national element of the mission
  - In DPAC we have countries where the scientists wanted their funding agency to sign MLA, but their agency refused

Gaia data release timeline

- Gaia DR1 2016 covering 14 months of data
- Gaia DR2 2018 covering 22 months of data
- Gaia EDR3 2020 covering 34 months of data
- Gaia DR3 2022 covering 34 months of data
- Gaia DR4 2026 covering 66 months of data
- Gaia DR5 2030 covering all data

Gaia papers

- 16110 refereed Gaia publication
- Last years 2000+ per year
- This is 5+ per day on average



Gaia article citations (1/2)

- Zoom in to the top 100 cited Gaia papers (top one 8000+ citations, all 400+, h-index 238)

- 17 are release related papers describing the data, calibration and/or processing
- Other surveys that have used Gaia data: LSST, ZTF, DES, DESI, SDSS, TESS, Pan-STARRS, GRAVITY, Euclid, GALAH+, LOFAR, ATLAS, LISA, Chandra, RAVE, SkyMapper
- Methods with elements relying on Gaia data: DYNESTY, MESA, BANYAN, SunPy

Gaia article citations (1/2) side step

- Zoom in the top 100 cited Gaia papers

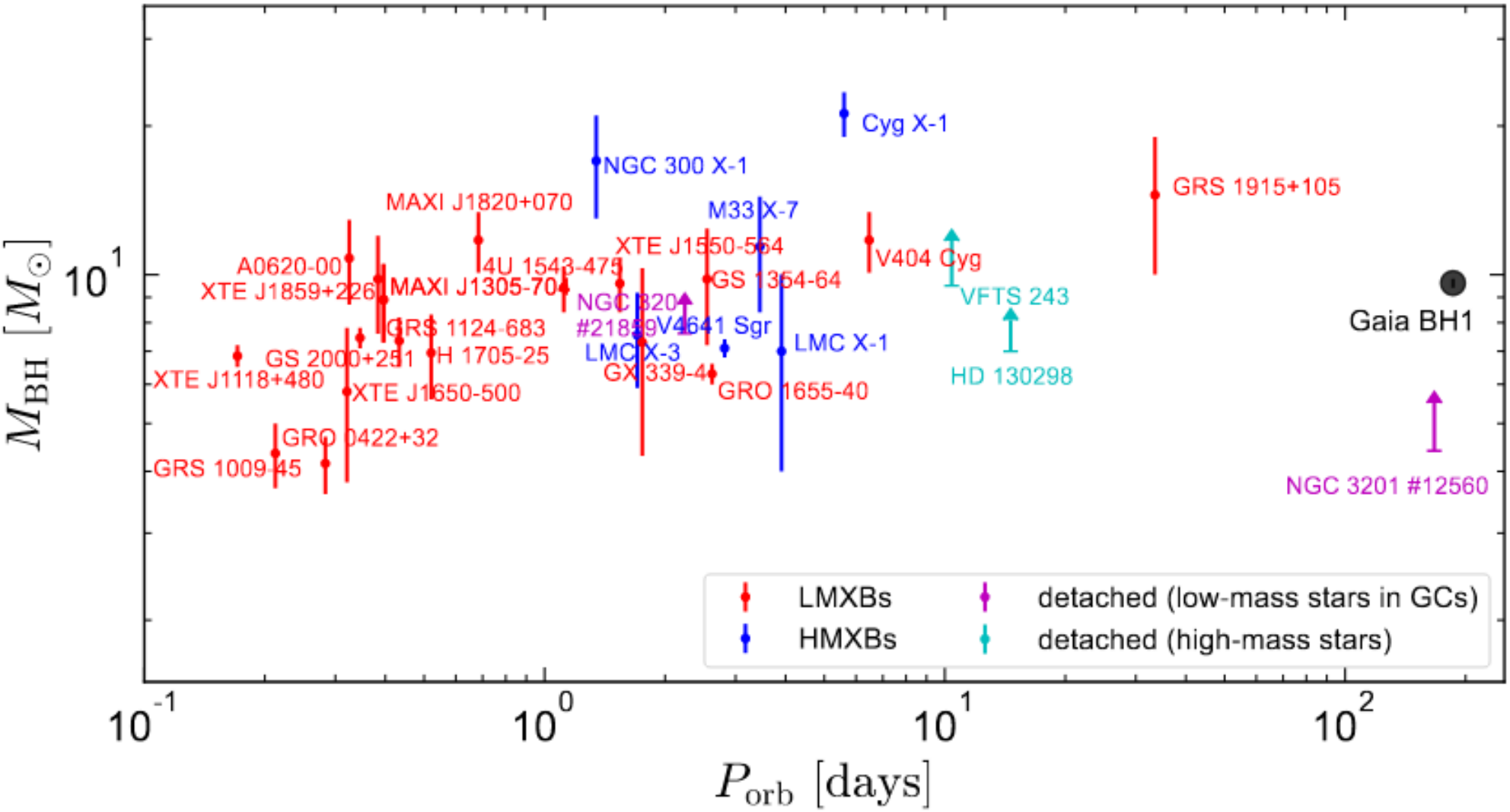
- 17 are release related papers describing the data, calibration and/or processing

- The total number of Gaia release papers from DR1, DR2, (E)DR3 and pre-DR4 is 98
- 92 has the first author from countries participating in Gaia MLA
  - MLA gives stability, but also the possibility to take a major role in some element of a mission

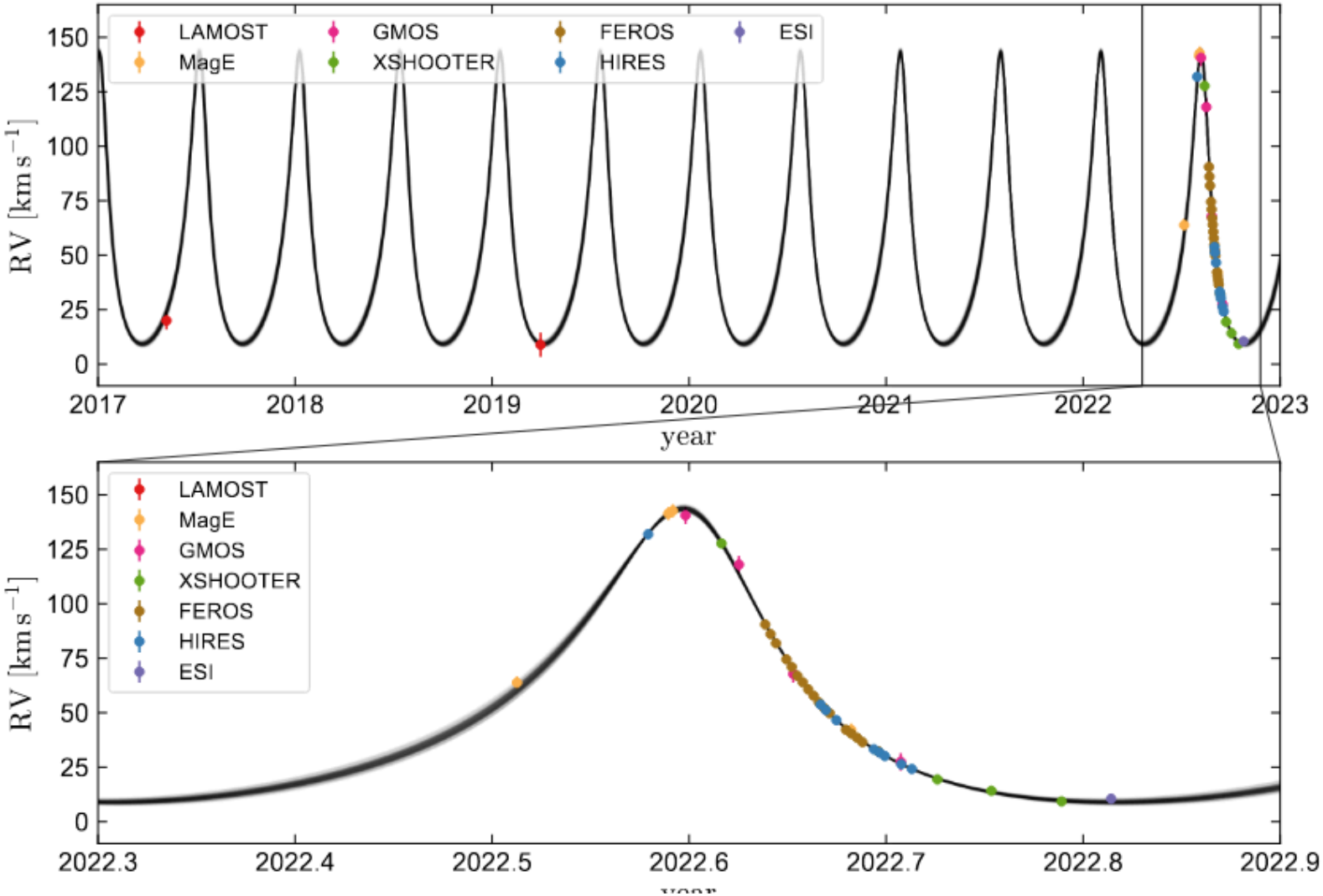
Gaia article citations (2/2)

- Hubble constant: Cepheids, Magellanic Clouds distance, Tip of RGB, Tension with Planck
- 3D dust maps and extinction maps
- Distances from parallaxes
- Milky Way structure and evolution (early mergers and Sgr dwarf impact)
- Host stars of exoplanets and young stars with disks
- Stellar clusters (open and globular)
- Local group, Magellanic Clouds
- Binaries
- White Dwarfs
- Extragalactic “special” sources by radio/JWST/Subaru
- Planetary ephemerides

Gaia BH1 at 480 pc detected in a binary system with a solar type star



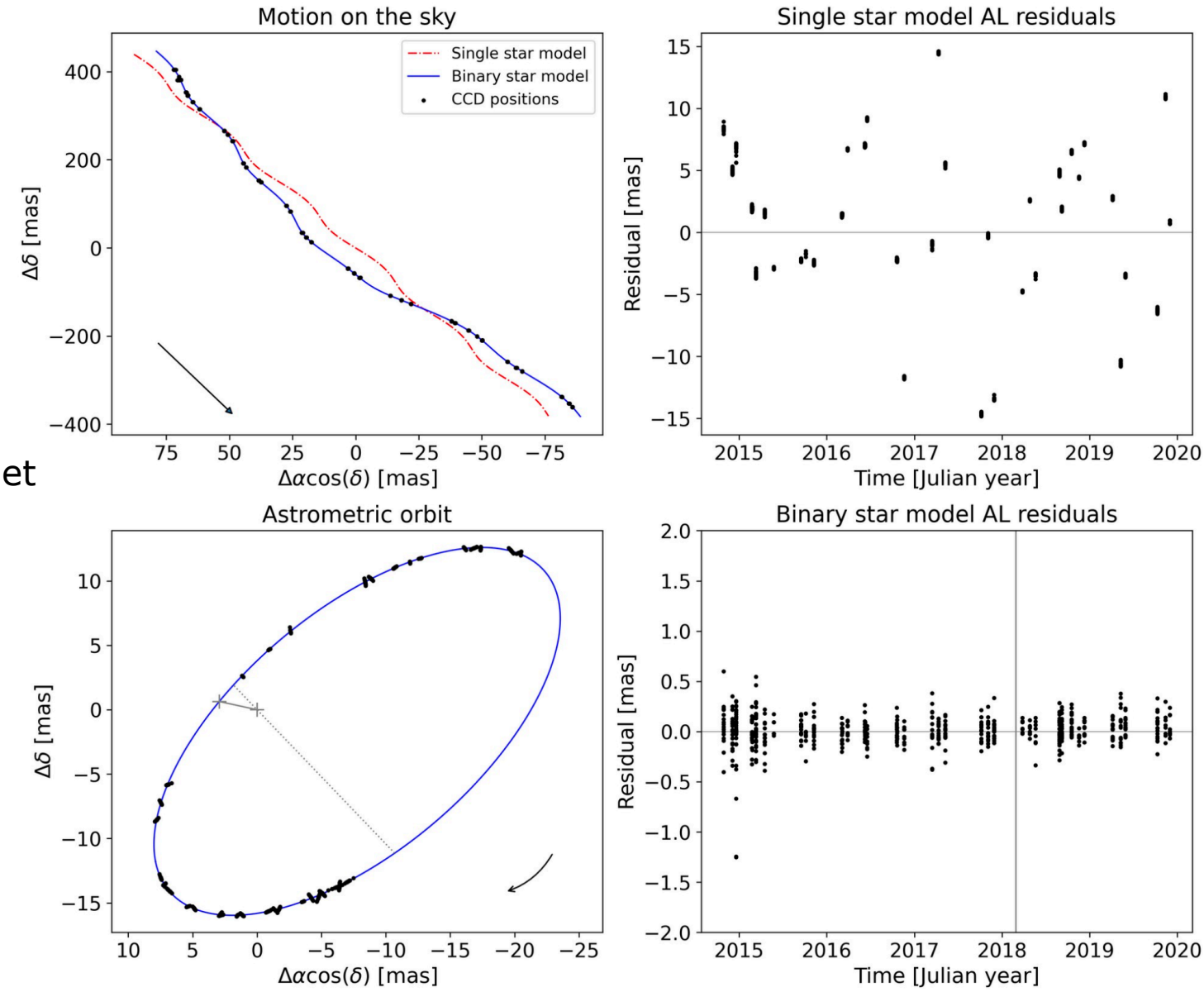
Gaia BH1 (El Badry et al. 2023)



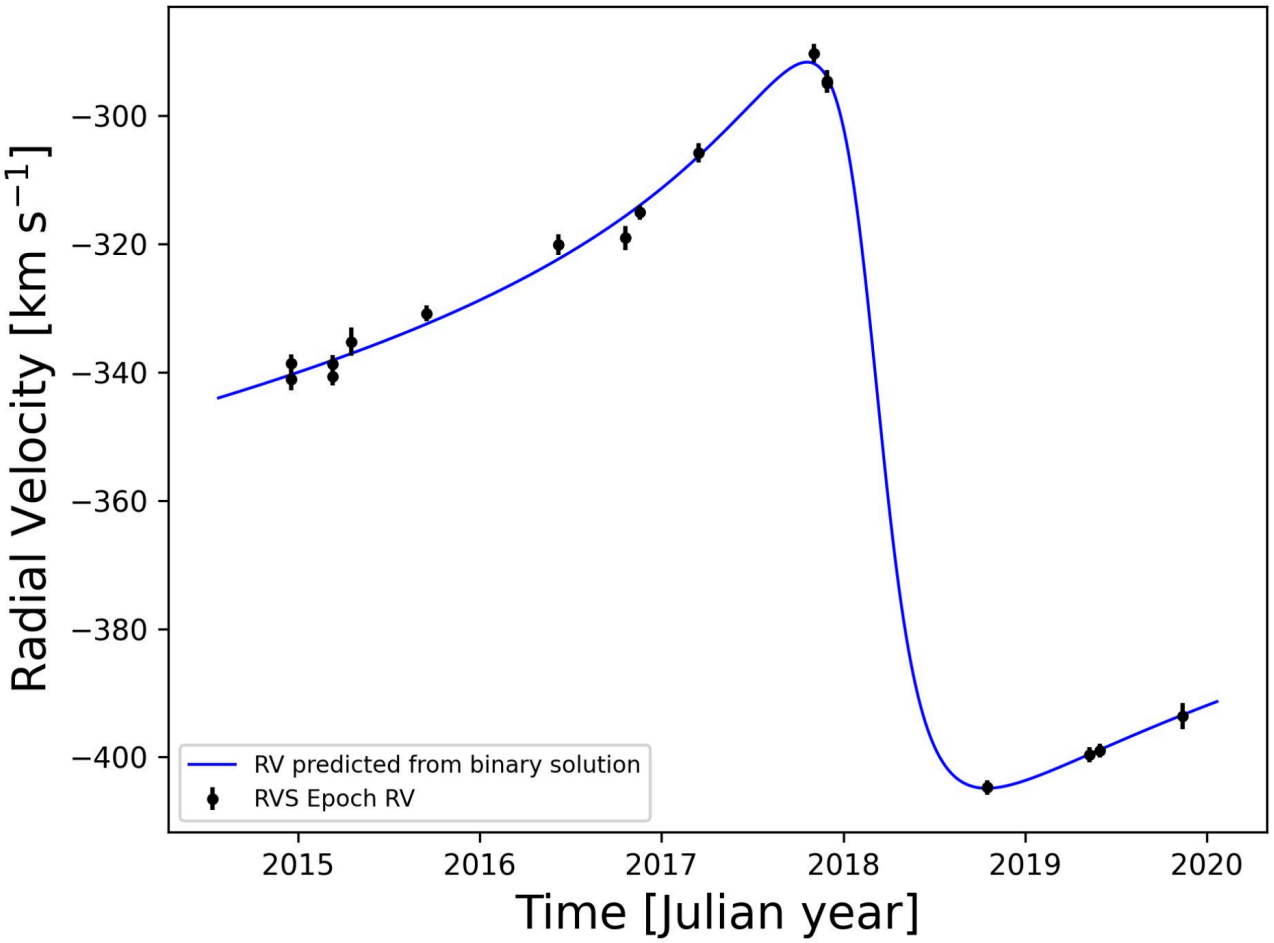
Gaia BH3

Discovered in Gaia DR4 validation and published by Gaia Collaboration, Panuzzo et al 2024

33 Solar masses in 11.6 yr orbit



Gaia BH3 discovered and validated with Gaia data



DR4

- Release date 2 December 2026
- Increased quality and quantity from DR3
  - E.g. 2.8 billion sources
- New products (in total 143 tables)
  - E.g. 10 tables for multiple stars, 20 for variable objects
- All epoch data also released
  - E.g. not only reference epoch RA, Dec, parallax and proper motion, but also astrometry of every measurement that were used to deduce the astrometric parameters
- New concept for `gaia_source` with DPAC provided selection of the best parameters
- About 500 TB of data

Concluding remarks and discussion points/questions

- With earlier releases Gaia has proven its scientific excellence

- With DR4 later this year and DR5 in 2030, Gaia will remain a source of unique scientific data for the future

- ESA is now having F missions in addition to M and L partly/mostly due to wishes from small countries to have leading roles in missions. Is this also the wish of the scientists?
- How to enable smaller countries to be more relevant in big missions?