BHTOM
AND
THE EUROPEAN ASTRONOMICAL SOCIETY OF SMALL TELESCOPES (EASST)
— FOLLOW-UP NETWORK FOR TIME-DOMAIN TARGETS

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(pron. Woo-cash Vi-zhi-kov-ski)

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BHTOM.SPACE

EASST.EU

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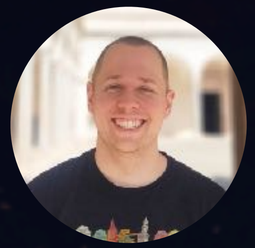
TEAM AND COLLABORATIONS

Warsaw University Astronomical Observatory

collaborators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(staff)


Łukasz Wyrzykowski
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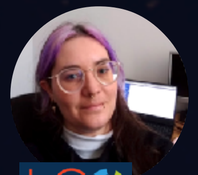
(postdoc)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(postdoc)


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(PhD student)


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(PhD student)


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(BSc student)


Uliana Pylypenko
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collaborators


Marius Maskoliūnas
and his group


Andreja Gomboc
and her group

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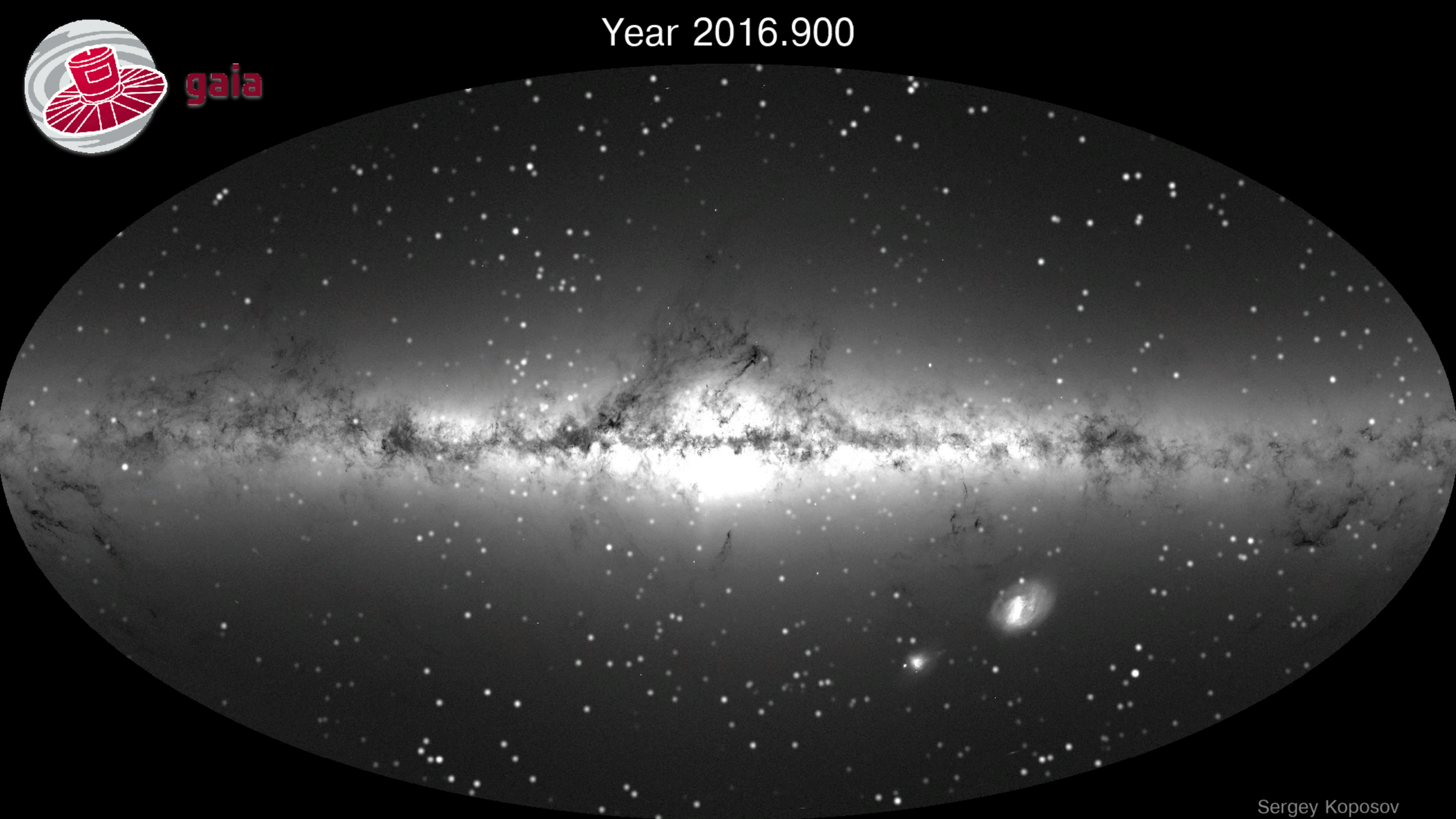
(staff)

Funding:

ACME
Horizon Europe
OPTICON RadioNet Pilot
HORIZON 2020
National Science Centre Poland

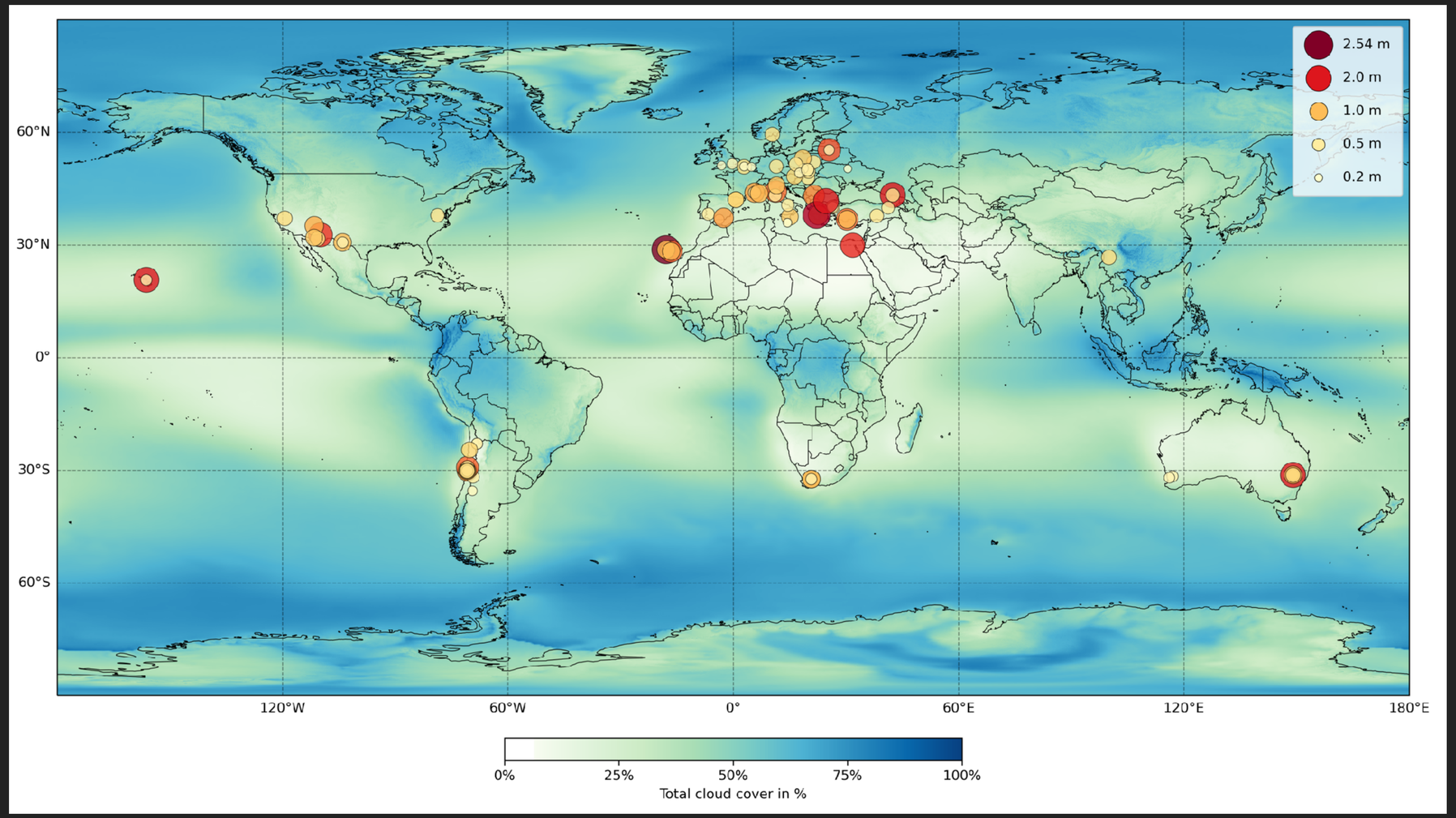
Łukasz Wyrzykowski


Year 2016.900
gaia
Sergey Koposov

BHTOM TELESCOPE NETWORK

since 2013 to support Gaia Science Alerts

- ~130 telescopes
- sizes 0.25 - 2.5 m
- manual
- robotic
- with good weather
- with poor weather
- volunteering
- via proposals



map by K.Kotysz & P.Mikołajczyk

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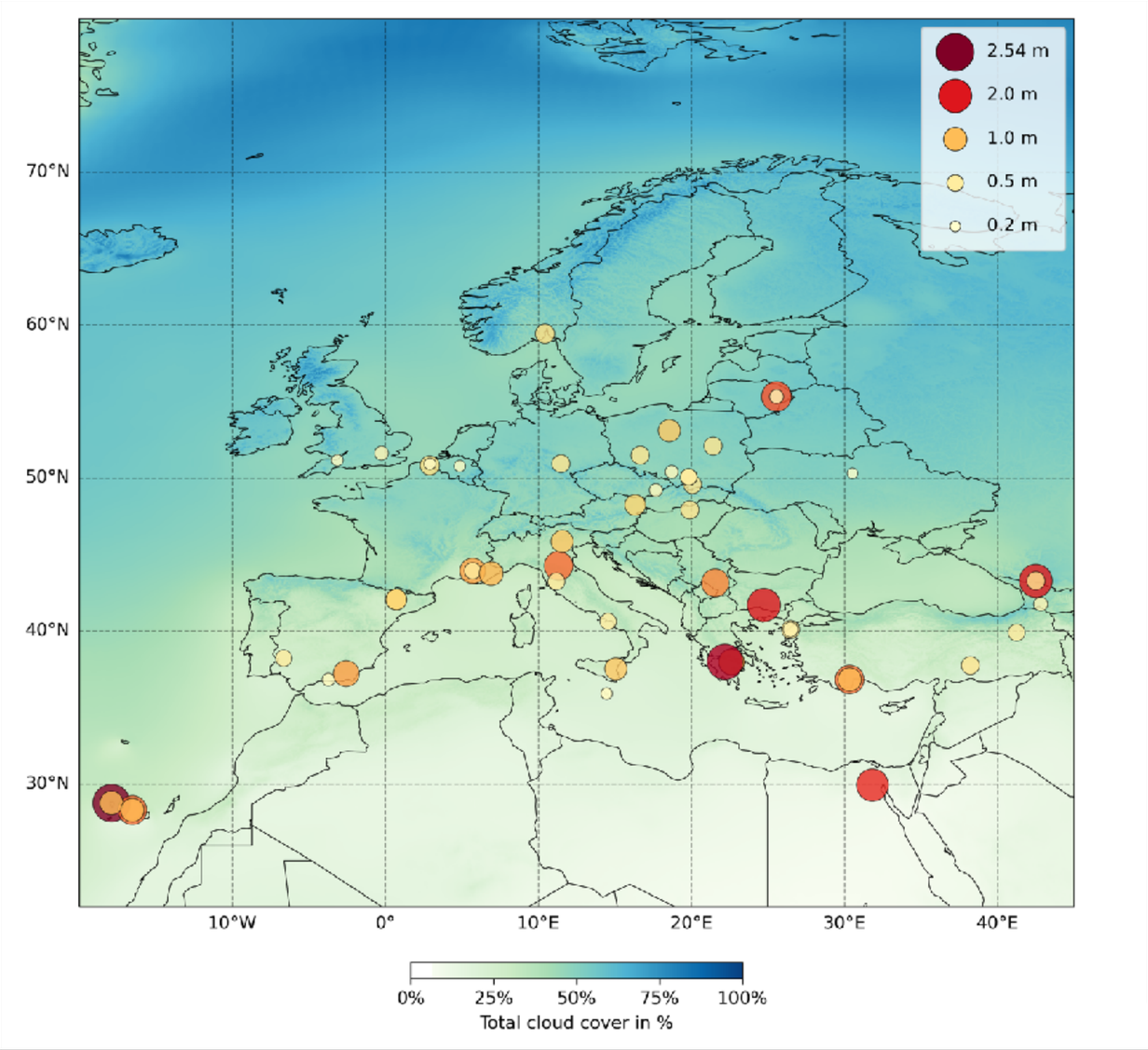
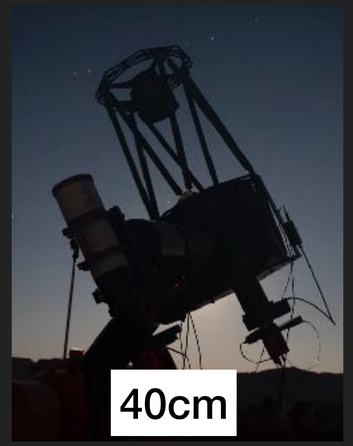
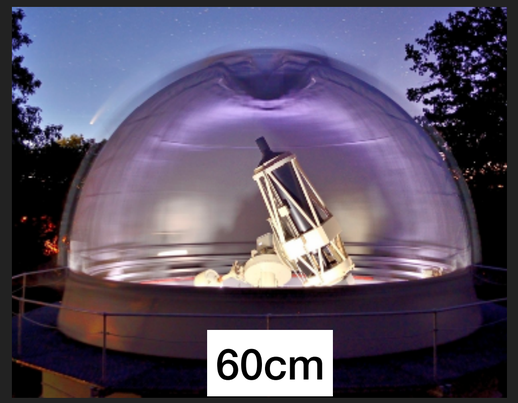


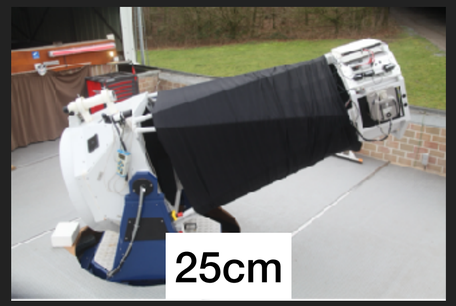
map by K.Kotysz & P.Mikołajczyk

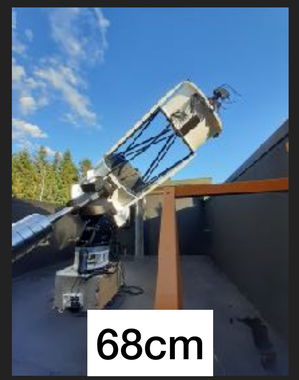
WHAT ARE THE SMALL TELESCOPES?

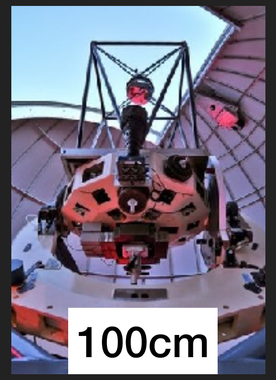
- professional - old (some very old!) & new, built in best astronomical sites in the world
- amateur - modern, growing in numbers, in backyard, shed and in Chile, Spain
- schools - modern, in big cities
- outreach facilities - modern, in big cities

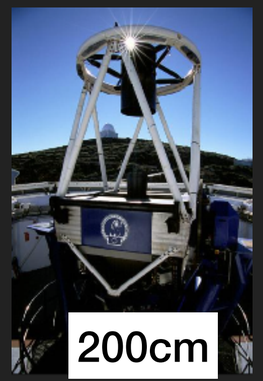


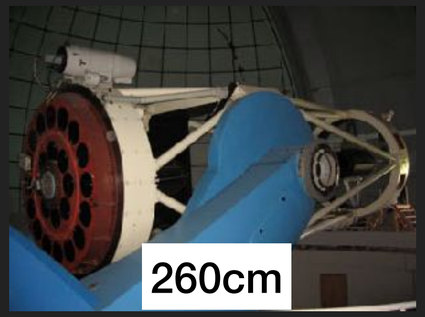








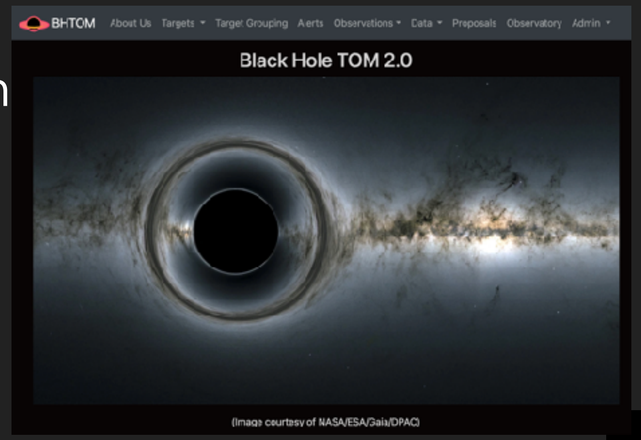




https://bhtom.space

BLACK HOLE TARGET AND OBSERVATION MANAGER (BHTOM)

- web tool for coordination for time-domain observation
- automated observation requests
- processing of raw images from heterogenous units
- automated standardisation
- archival multi-wavelength time-domain photometry
- open for new users, new telescopes, new targets!



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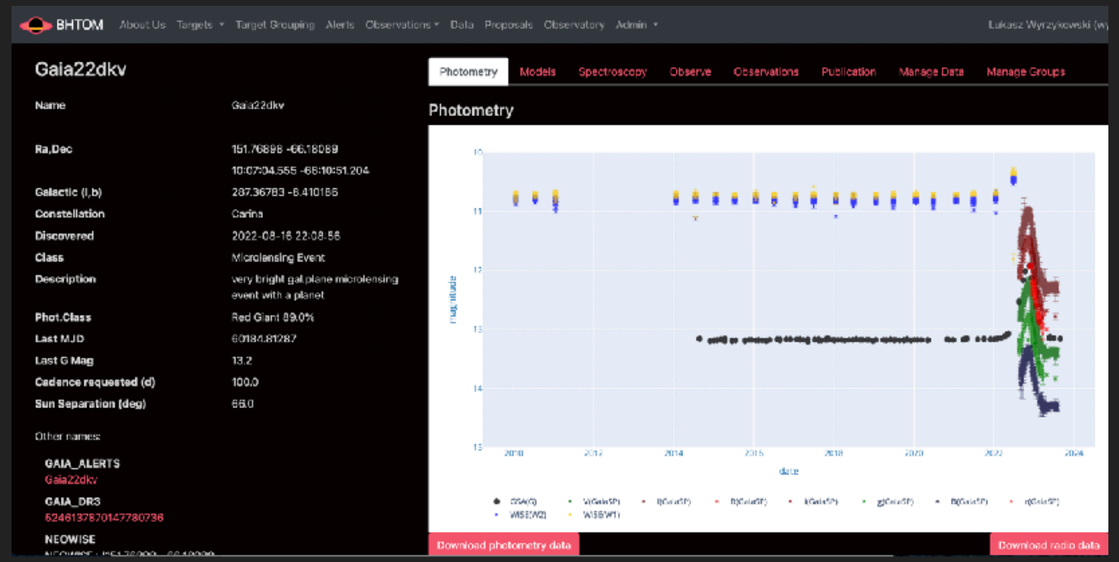
☐	Gaia22bpl	10:38:42.425	-61:15:49.680	903	12.7	Gaia/r	9.99	2023-09-18 10:09:48	208.6	64	microlensing_event
☐	Gaia22awa	19:04:51.962	-08:34:00.660	1602	15.0	Gaia/r	9.99	2023-09-17 21:09:11	770.1	111	microlensing_event
☐	ZTF19abflrit	18:24:23.314	-24:36:42.053	842	15.2	Gaia/r	0.0	2023-09-19 11:09:02	0.0	100	long_period_variable



Surveys

Gaia
ZTF
LSST
IceCube
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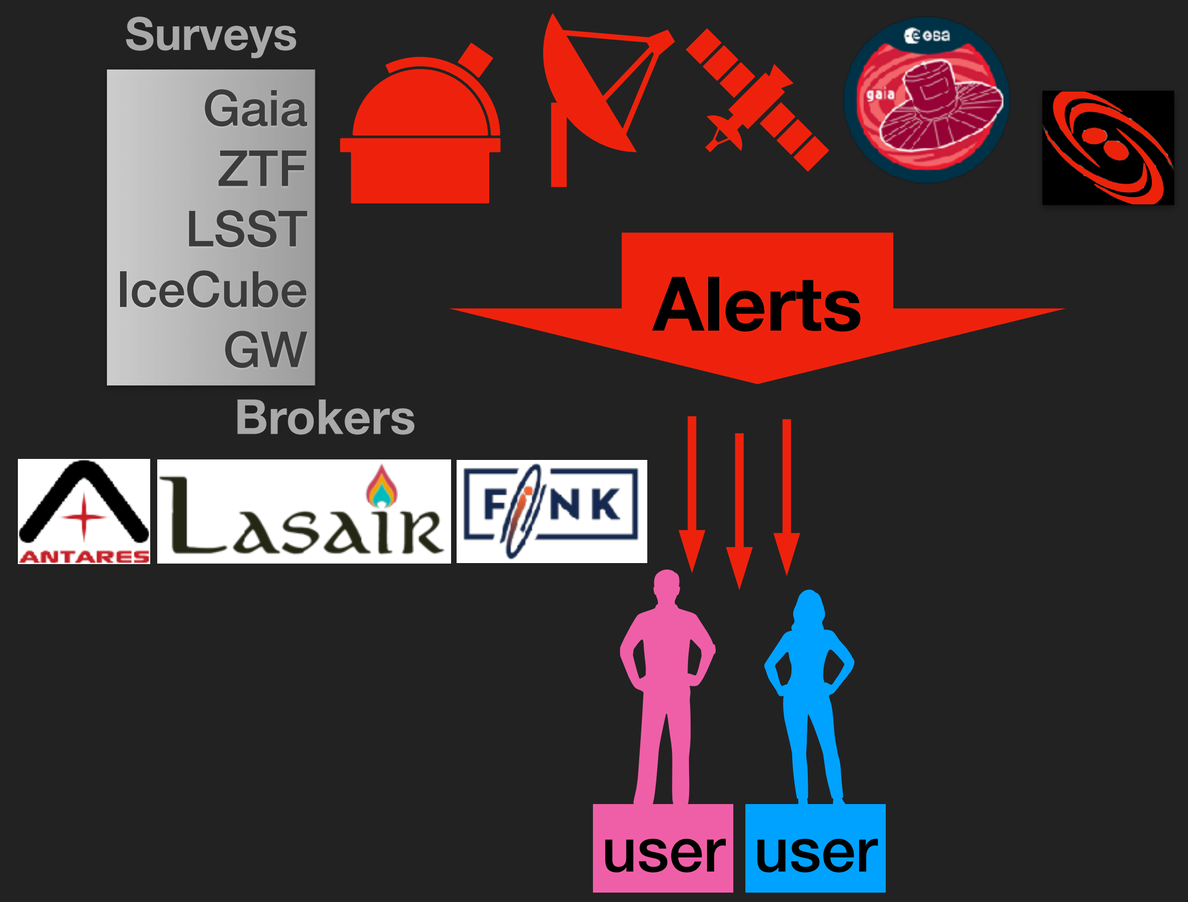
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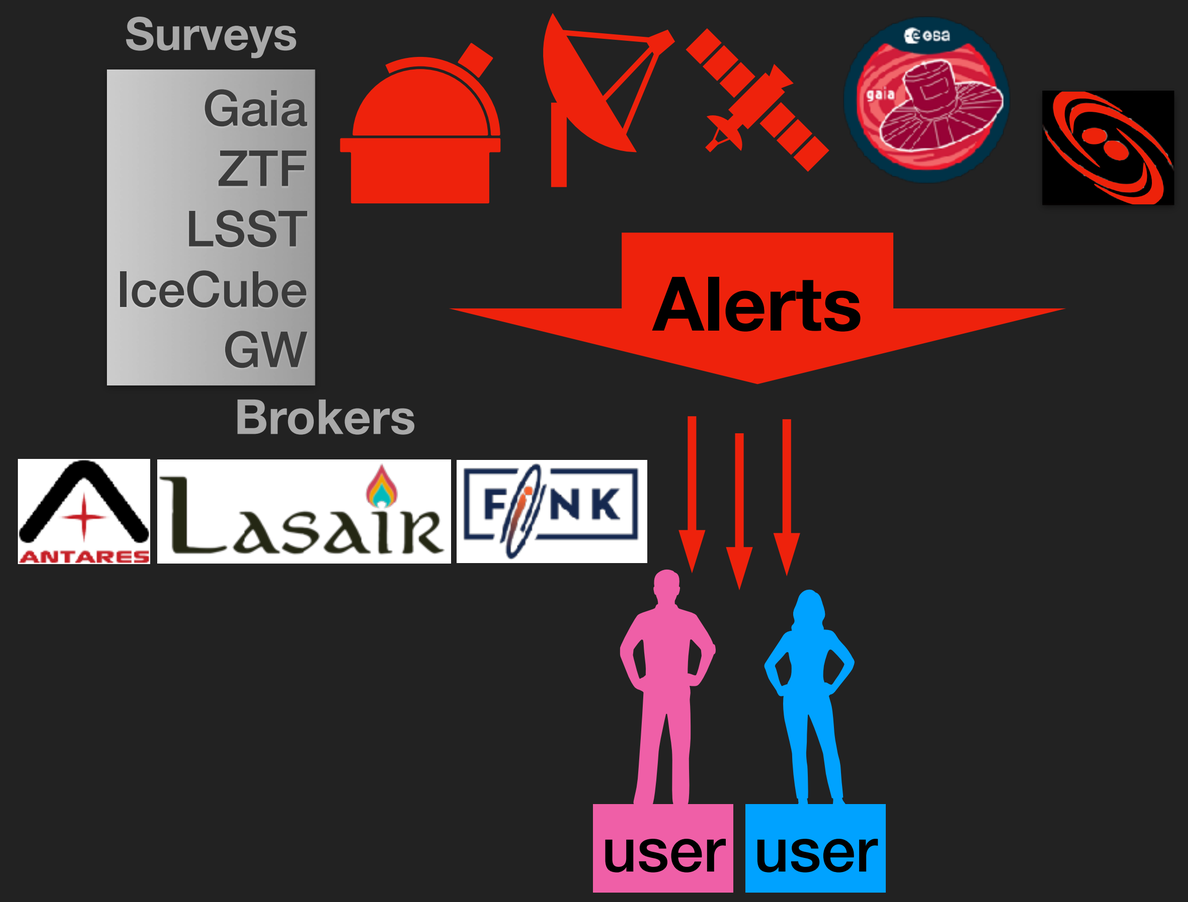
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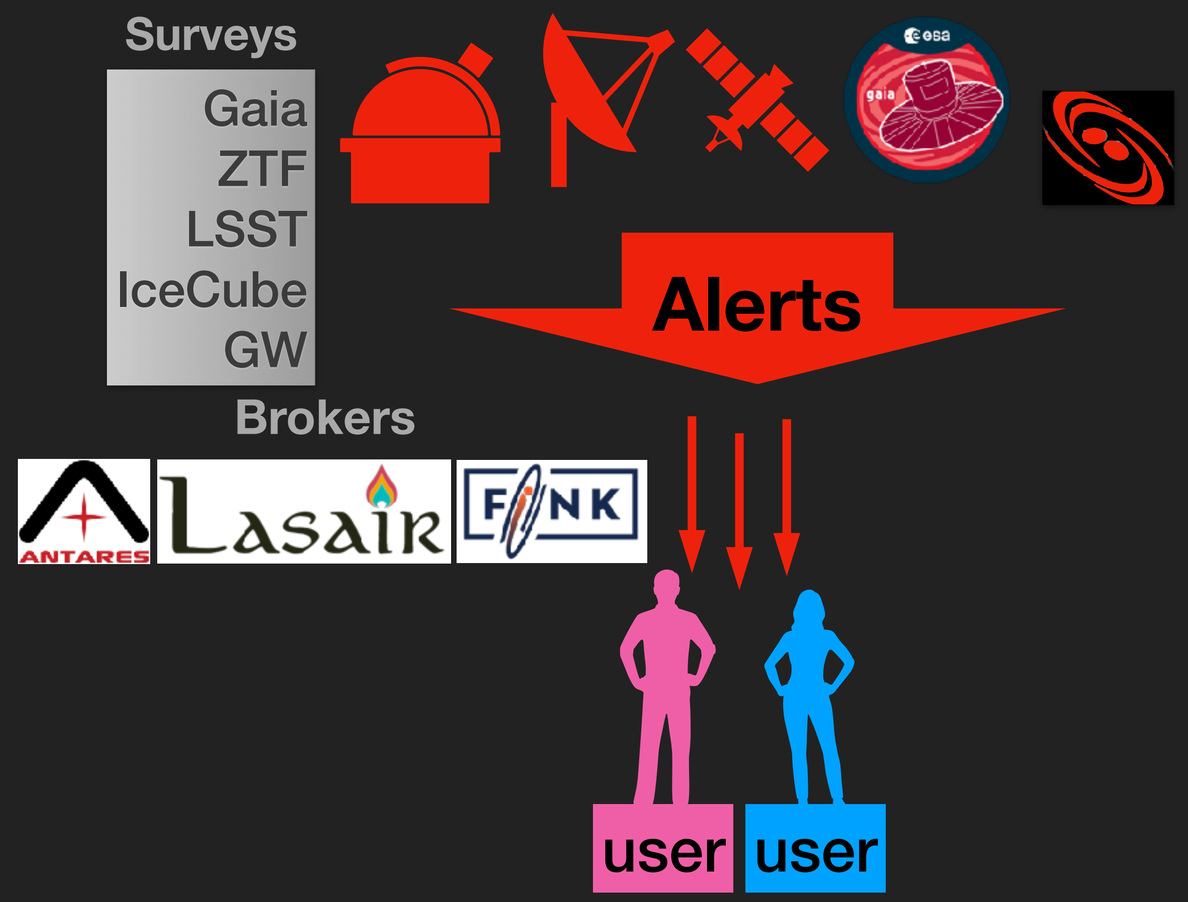
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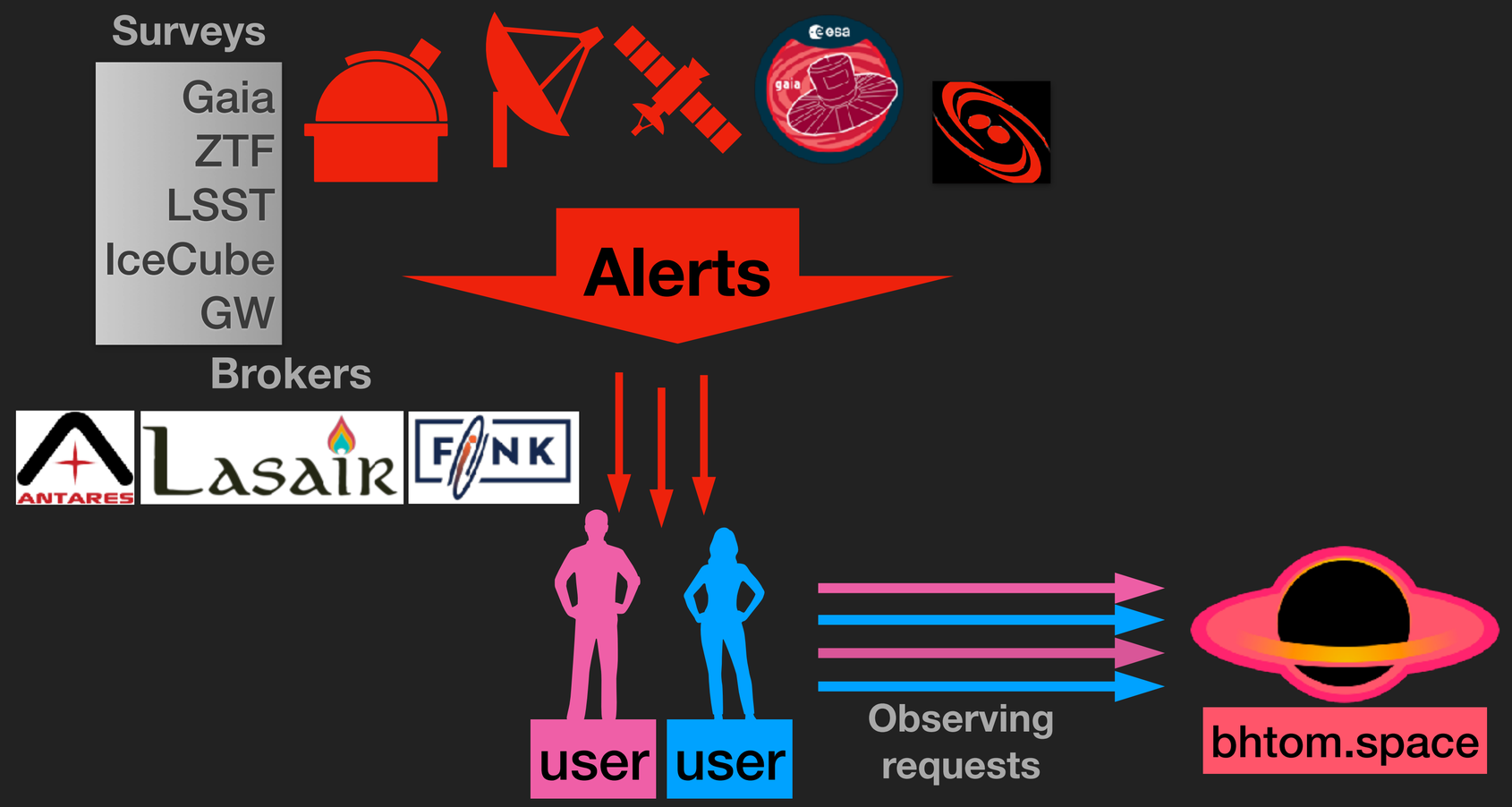
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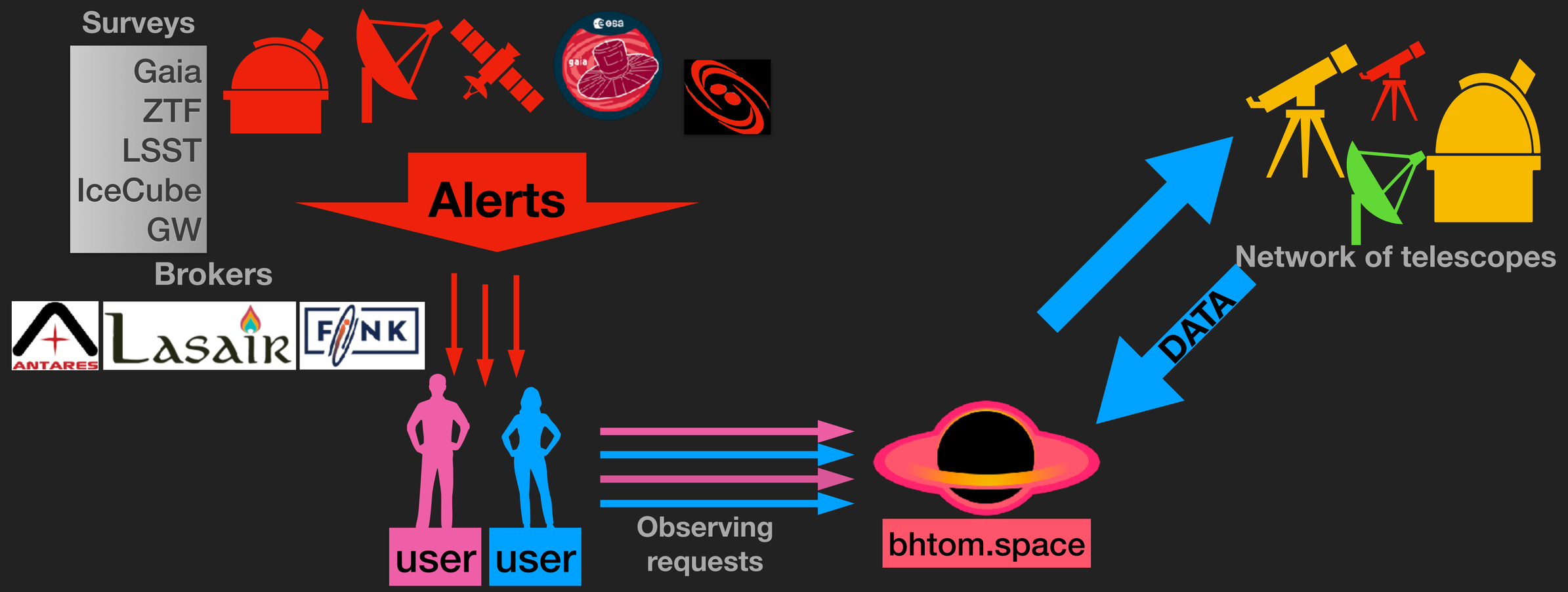
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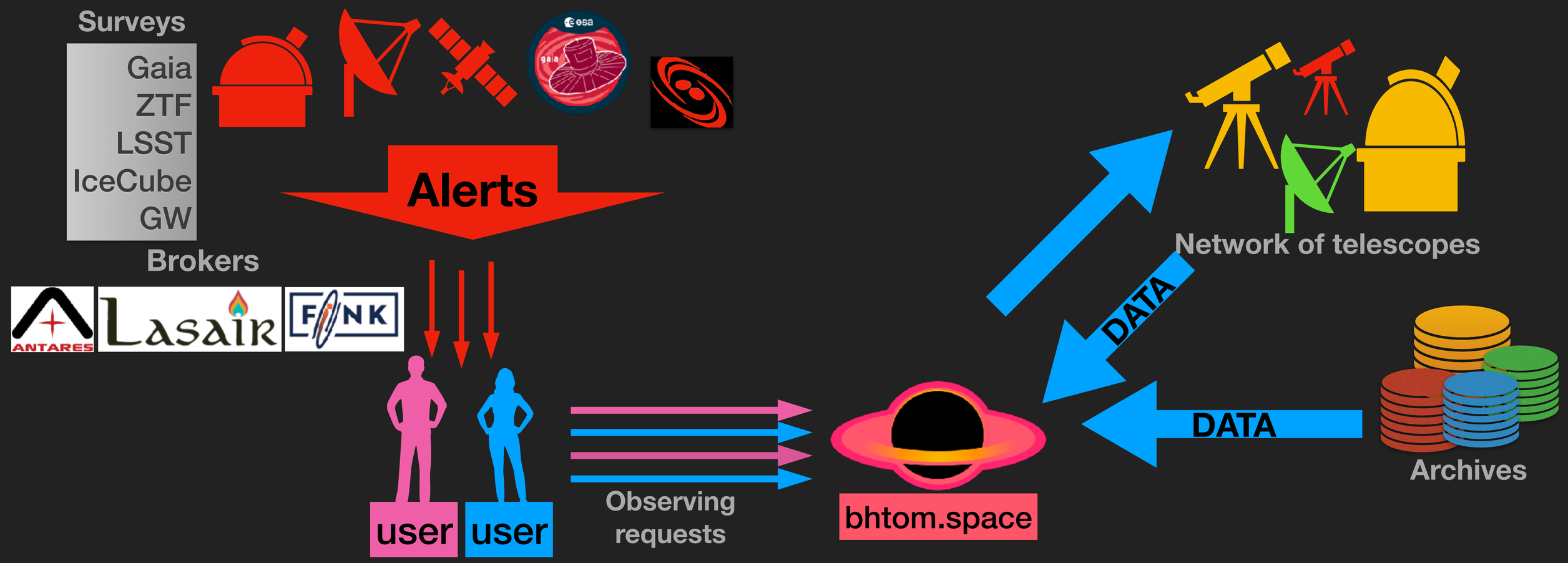
DATA
Network of telescopes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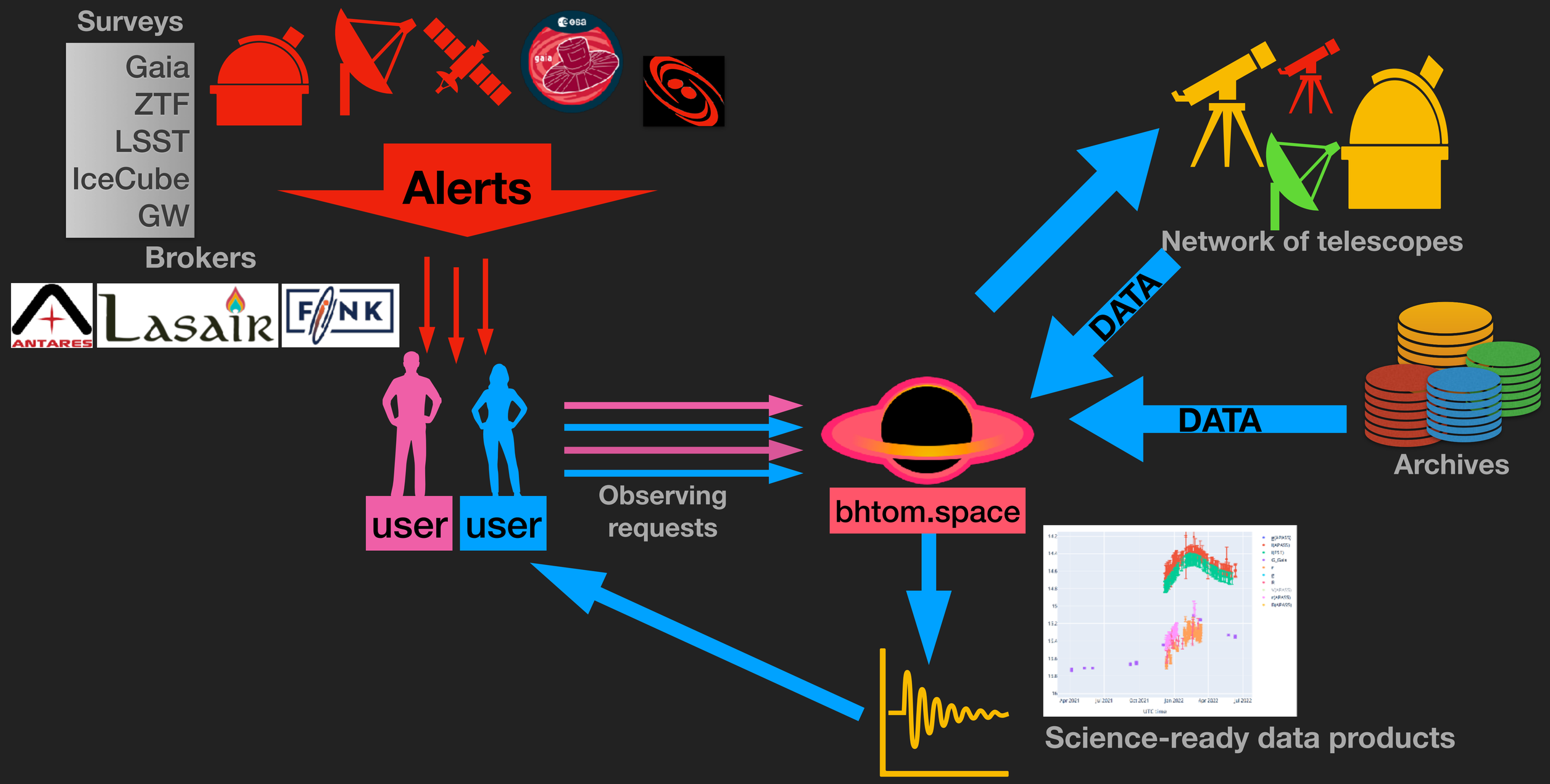
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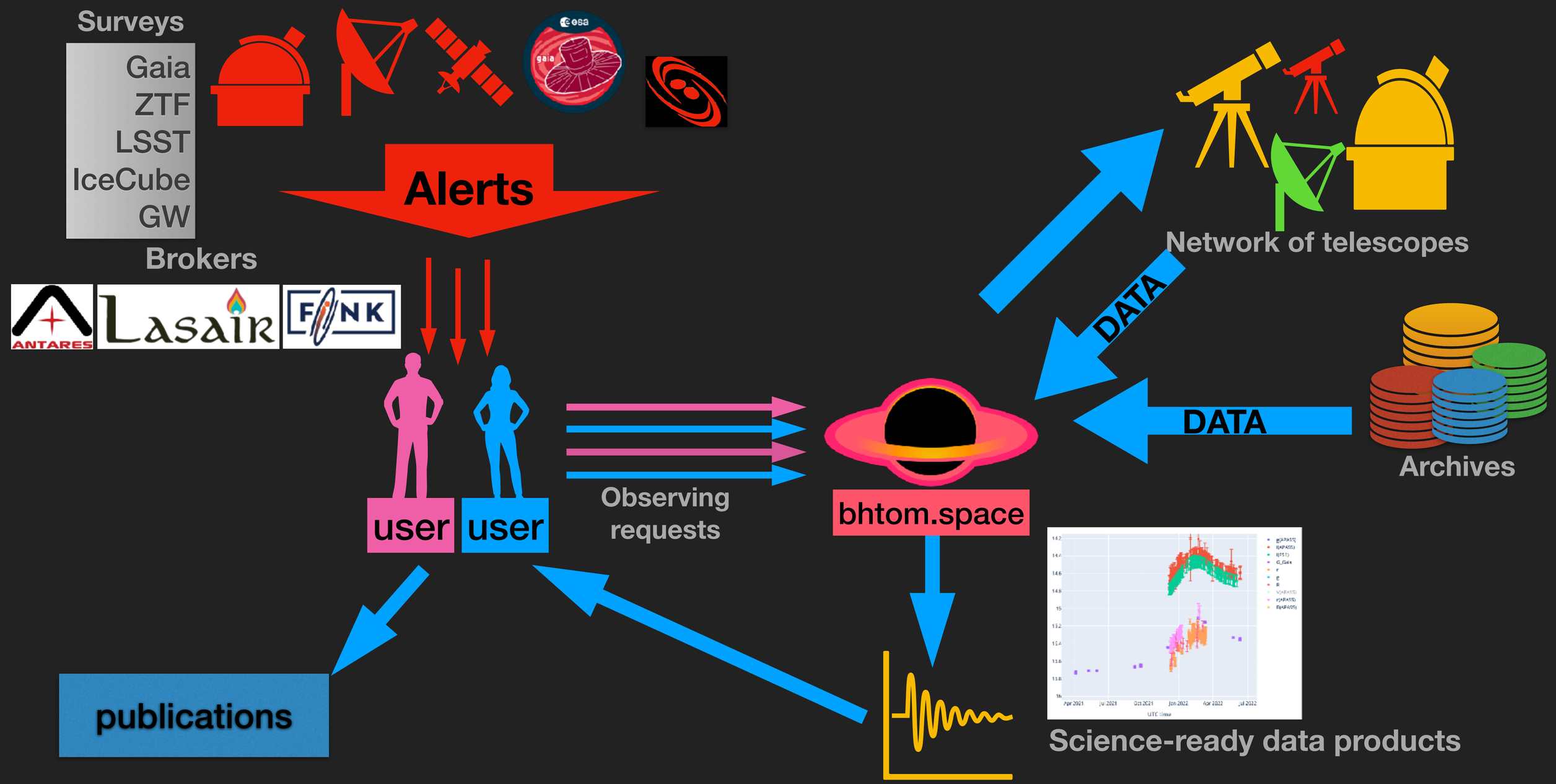
Science-ready data products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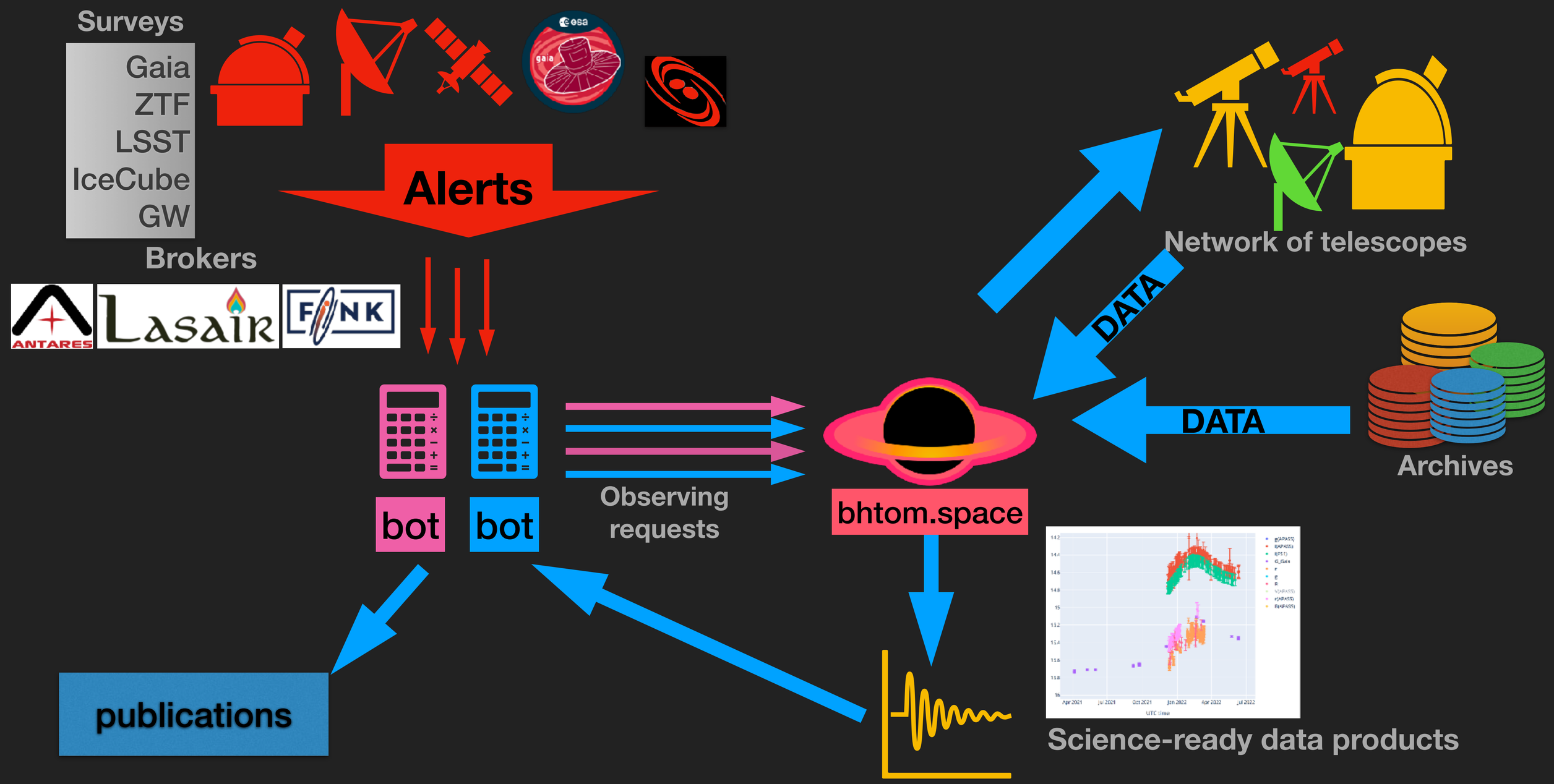
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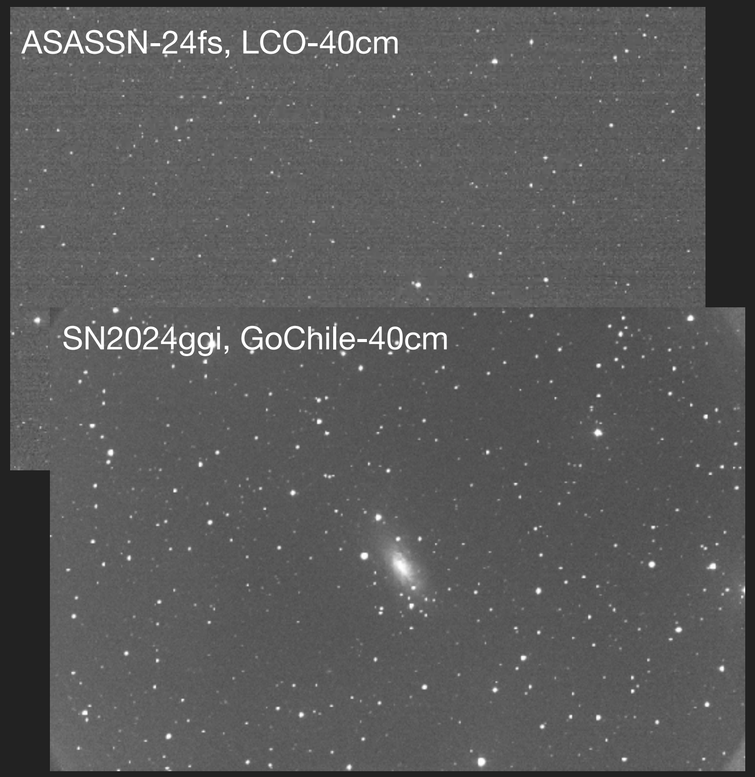
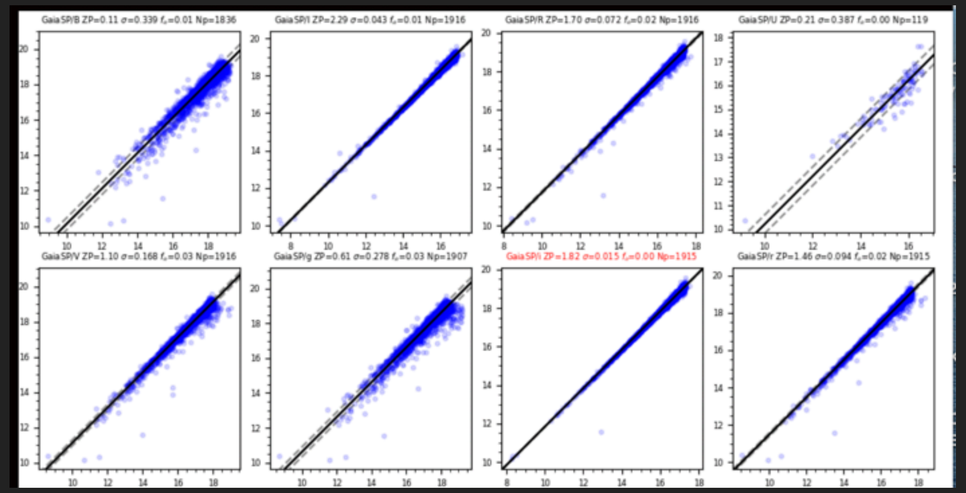
BHTOM – FROM IMAGE REQUEST TO SCIENCE-READY LIGHT CURVES

- fully automated data processing, ~10,000 images processed every week
- standardisation of observations from any filter to Gaia Synthetic Photometry
- downloadable and science-ready - for registered users

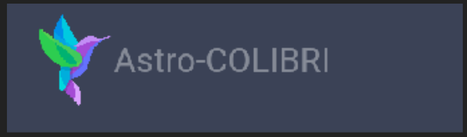




Automated detection of filter
and zero-point fit to Gaia Synthetic Photometry

BHTOM – PROGRAMABLE ACCES (API)

- All functionalities of BHTOM are accessible via API
- Scripting the data flow to/from telescopes, observing requests, target creation, images upload for processing
- Astro-COLIBRI connected already
- We provide ready scripts for: data download, data upload, target selection



BHTOM2 API Documentation

DATA DOWNLOAD API

Here we present end-points how to download the photometry and radio data from BHTOM.

Please contact us if you plan to use the data in a publication. By downloading the data from BHTOM you agree to follow our data policy and to use this acknowledgment:

```
The data was obtained via [BHTOM](https://bhtom.space), which has received funding from the European Union's Horizon
```

For more information about acknowledgement and data policy please visit https://about.bhtom.space

1. Photometry download

With this API one can download all photometric observations (magnitudes) in semi-color separated form. The columns of the output are the following:

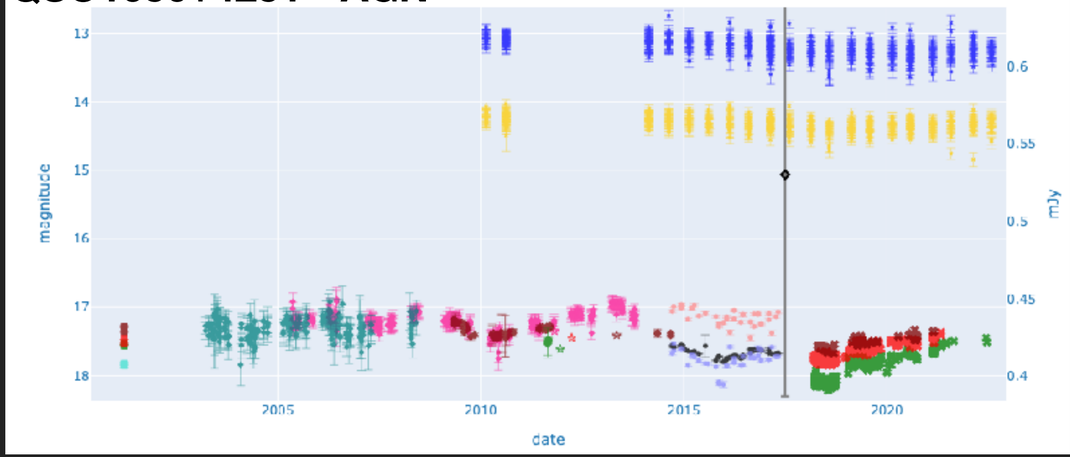
MJD;Magnitude;Error;Facility;Filter;Observer

Request

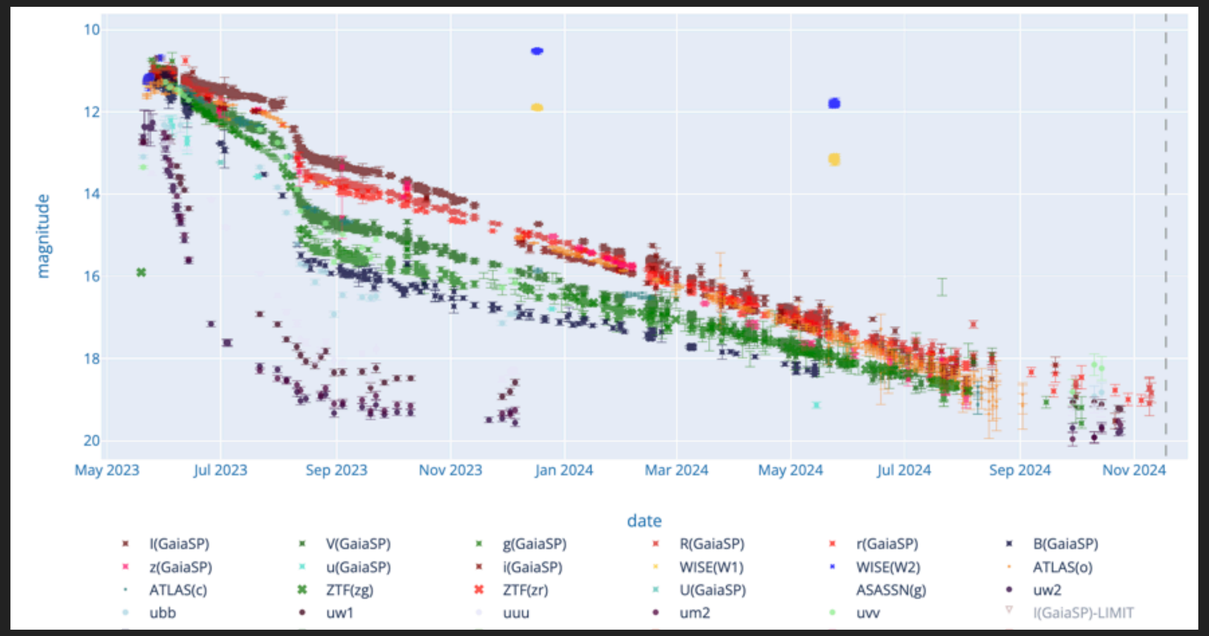
- **Method**: POST
- **URL**: `/targets/download-photometry/`

BHTOM – SCIENCE CASES

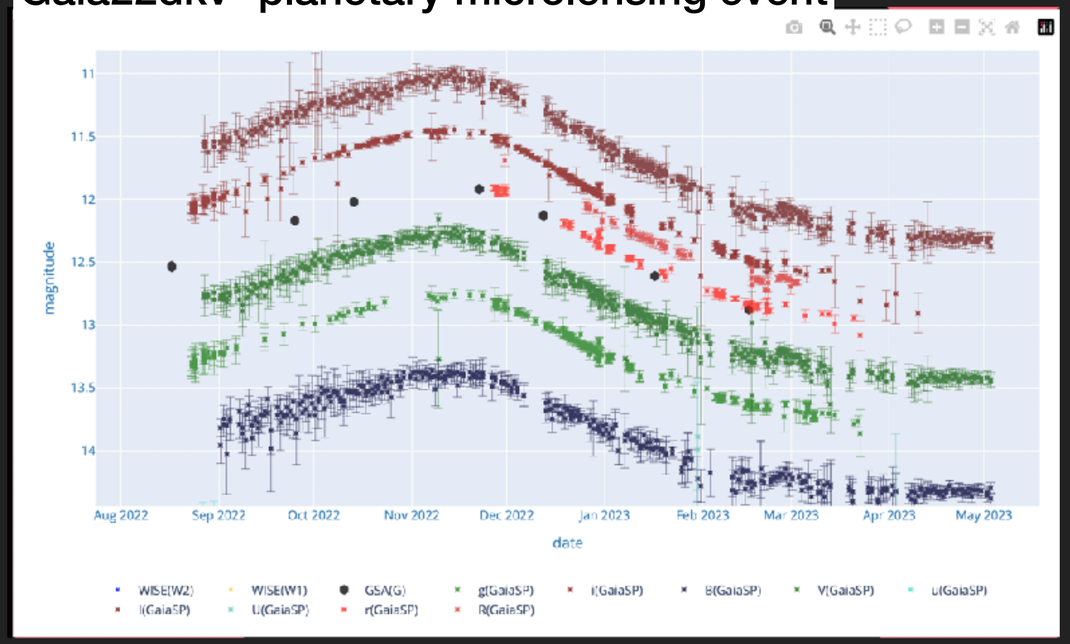
QSO1650+4251 - AGN



SN2023ixf - from X, UV to IR

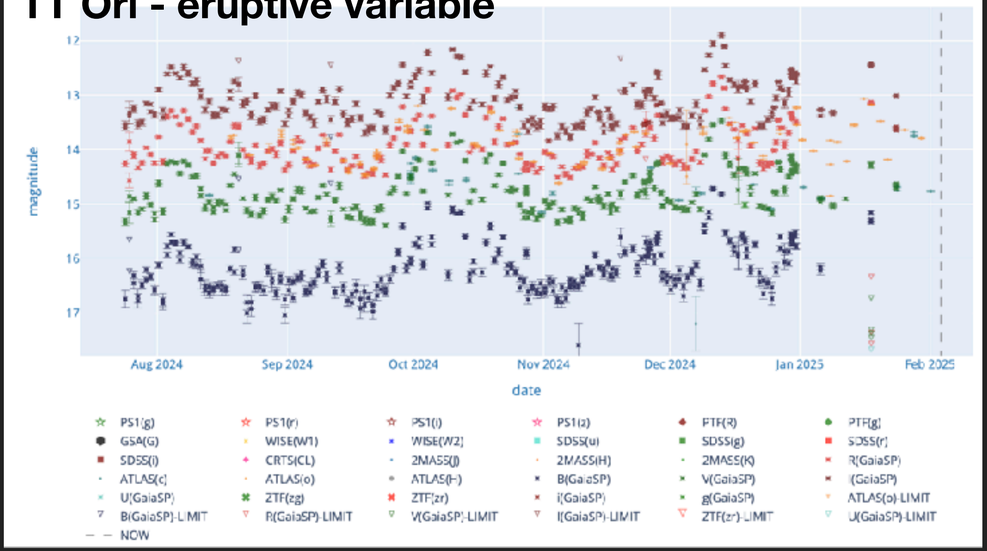


Gaia22dkv -planetary microlensing event



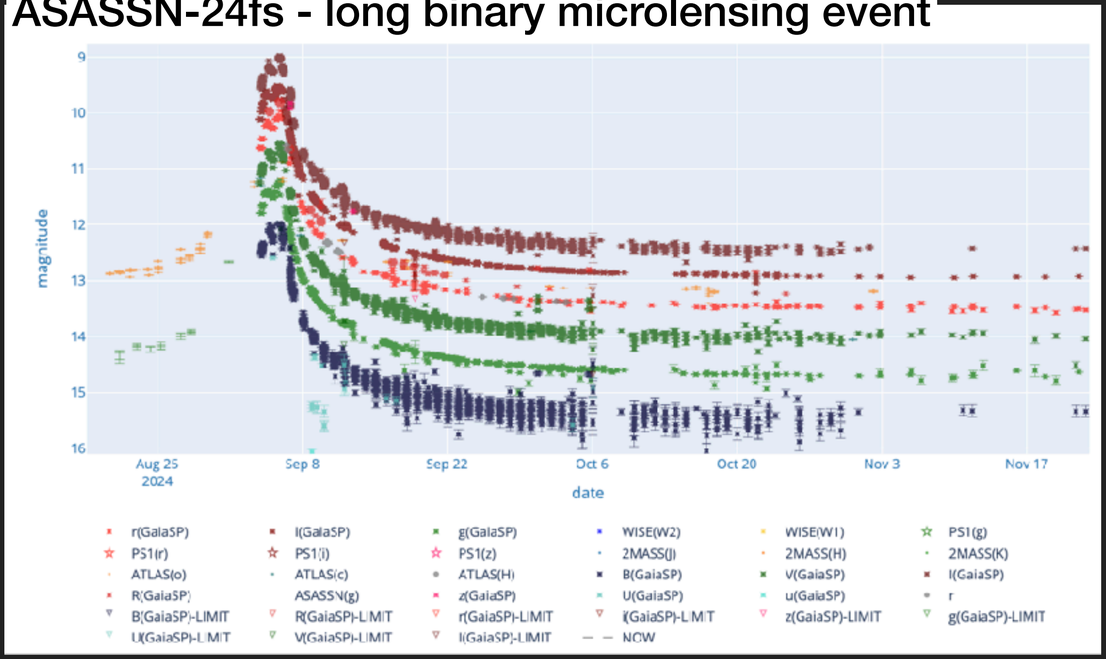
BHTOM – SCIENCE CASES

TT Ori - eruptive variable



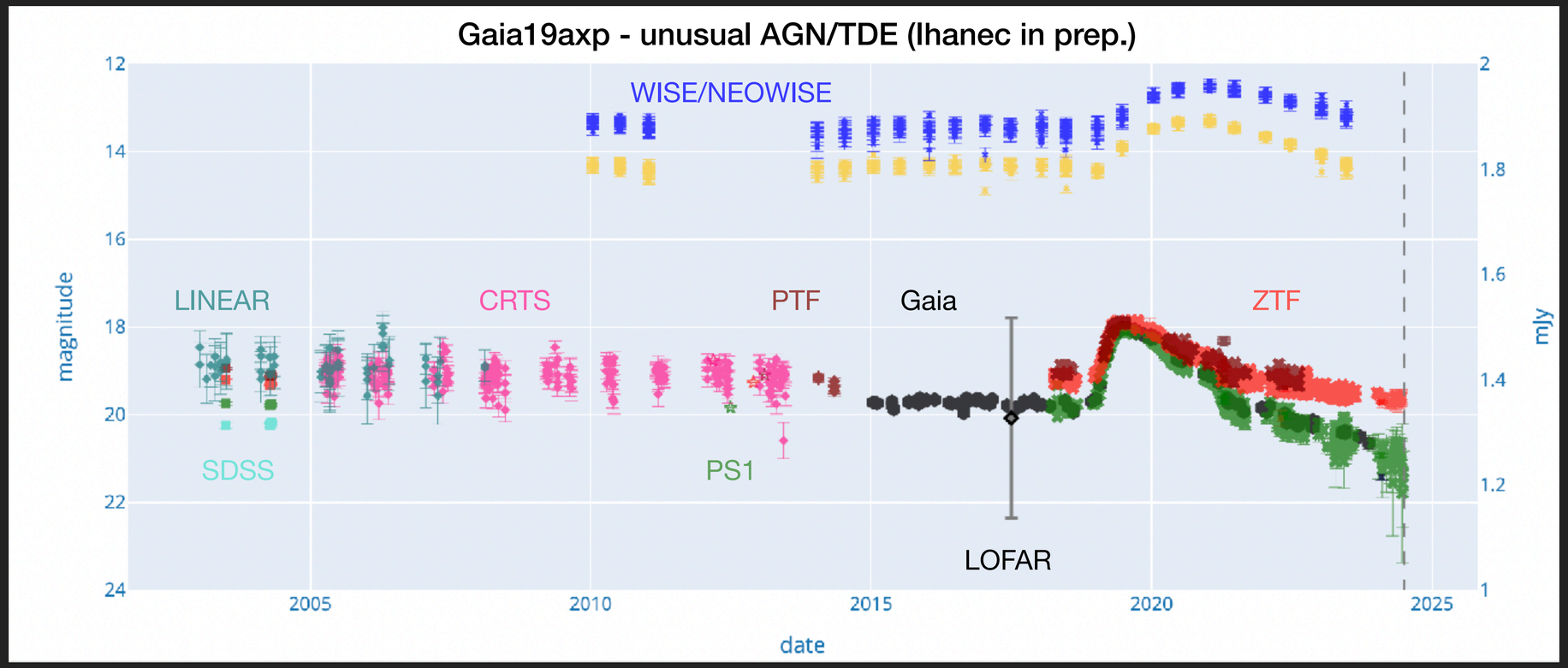
SN2024ggi

ASASSN-24fs - long binary microlensing event



BHTOM – TIME-DOMAIN DATA ARCHIVES

- Automated harvesting public archival time-domain data for any target with known coordinates
- ZTF - *Optical*
- NEOWISE+ALLWISE - *NIR*
- 2MASS - *NIR*
- LOFAR - *Radio*
- LINEAR, CRTS - *Optical*
- Gaia DR3 - *Optical*
- Gaia Alerts - *Optical*
- SDSS, PS1, DECAPS - *Optical*
- ATLAS - *Optical*
- ASAS-SN - *Optical*
- OGLE EWS/OCVS - *Optical*
- DASCH *(from 1880s!!)* - *Optical*
- more to come (X-rays, Radio, Polarymetry…)



do you have a time-domain archive we could add?

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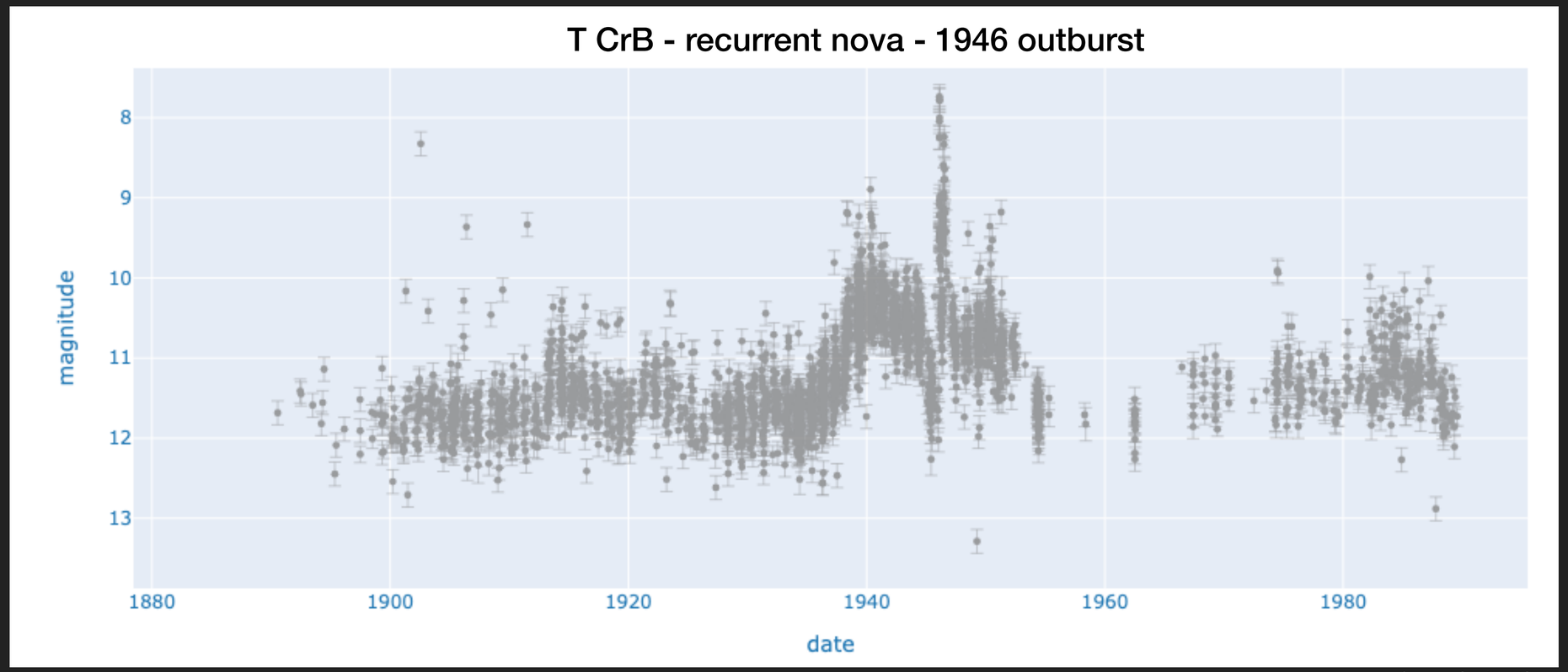

*now in testing

do you have a time-domain archive we could add?

BHTOM – PUBLICATIONS

- All observers included!

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS 515, 1774–1787 (2022) https://doi.org/10.1093/mnras/stac1915
Advance Access publication 2022 July 12

Photometric and spectroscopic study of the burst-like brightening of two *Gaia*-alerted young stellar objects

Zsófia Nagy,[1,2★] Péter Ábrahám,[1,2,3] Ágnes Kóspál,[1,2,3,4] Sunkyung Park,[1,2] Fernando Cruz-Sáenz de Miera,[1,2] Eleonora Fiorellino,[1,2,5] David García-Álva Marianna Szabó,[1,2,8,9] Simone Antoniucci,[5] Teresa Giannini,[5] Alessio Giunta,[1] Mária Kun,[1,2] Gábor Marton,[1,2] Attila Moór,[1,2] Brunella Nisini,[5] Andras Pál, Paweł Zieliński[11] and Łukasz Wyrzykowski[12]

Full orbital solution for the binary system in the northern Galactic disc microlensing event Gaia16aye★

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THE ASTROPHYSICAL JOURNAL, 899:130 (8pp), 2020 August 20

Gaia 18dvy: A New FUor in the Cygnus OB3 Association

E. Szegedi-Elek[1], P. Ábrahám[1,2], Ł. Wyrzykowski[3], M. Kun[1], Á. Kóspál[1,2,4], L. Chen[1], G. Marton[1,2], A. Moór[1,2], C. Kiss[1,2], A. Pál[1,2,5], L. Szabados[1], J. Varga[1,6], E. Varga-Verebélyi[1], C. Andreas[7], E. Bachelet[8], R. Bischoff[7], A. Bódi[1,9], E. Breedt[10], U. Burgaz[11,12], T. Butterley[13], J. M. Carrasco[14], V. Čepas[15], G. Damljanovic[16], I. Gezer[3], V. Godunova[17], M. Gromadzki[3], A. Gurgul[3], L. Hardy[18], F. Hildebrandt[7], S. Hoffmann[7], M. Hundertmark[19], N. Ihanec[3], R. Janulis[15], Cs. Kalup[1], Z. Kaczmarek[3], R. Könyves-Tóth[1], M. Krezinger[1], K. Kruszyńska[3], S. Littlefair[18], M. Maskoliūnas[15], L. Mészáros[1], P. Mikołajczyk[20], M. Mugrauer[7], H. Netzel[21], A. Ordasi[1], E. Pakštienė[15], K. A. Rybicki[3], K. Sárneczky[1], B. Seli[1], A. Simon[22], K. Šiškauskaitė[15], Á. Sódor[1], K. V. Sokolovsky[23,24,25], R. Szakáts[1], L. Tomasella[26], Y. Tsapras[19], K. Vida[1,2], J. Zdanavičius[15], M. Zieliński[3], P. Z

Lens mass estimate in the Galactic disk extreme parallax microlensing event Gaia19dke

M. Maskoliūnas[1], Ł. Wyrzykowski[2], K. Howil[2], K. A. Rybicki[2], P. Zieliński[2], Z. Kaczmarek[4], K. Kruszyńska[2], M. Jabłońska[2], J. Zdanavičius[1], E. Pakštienė[1], V. Čepas[1], P. J. Mikołajczyk[2,8], R. Janulis[1], M. Gromadzki[2], N. Ihanec[2], R. Adomavičienė[1], K. Šiškauskaitė[1], M. Bronikowski[2,7], P. Sivak[2], A. Stankevičiūtė[2], M. Sitek[2], M. Ratajczak[2], U. Pylypenko[2], I. Gezer[2], S. Awiphan[9], E. Bachelet[10], K. Bąkowska[1], R. P. Boyle[12], V. Bozza[32,33], S. M. Brincat[13], U. Burgaz[11], T. Butterley[29], J. M. Carrasco[14], A. Cassan[38], F. Cusano[15], G. Damljanovic[6], V. S. Dhillon[22], M. Dominik[39], F. Dubois[16], H. H. Esenoglu[17], R. Figuera Jaimes[34], A. Fukui[19], C. Galdies[20], A. Garofalo[15], V. Godunova[21], T. Gilver[17,18], J. Heidt[22], M. Hundertmark[36], I. Izviekova[3], B. Joachimczyk[3], M.K. Kamińska[39], K. Kamiński[39], S. Kaptan[17,18], T. Kvernadze[24], O. Kvaratskhelia[24], S. Littlefair[22], O. Michniewicz[24], N. Nakhatutai[35], W. Ogłoza[42], J. M. Olszewska[39], M. Polińska[39], A. Popowicz[25], J. K. T. Qvam[26], M. Radziwonowicz[2], A. Słowikowska[37,3], A. Simon[30,31], E. Sonbas[40,41] M. Stojanovic[6] Y. Tsapras[36], S. Vanaverbeke[16], R. W. Wilson[29], M. Zejmo[24], S. Zola[28],

Single lens mass measurement in the high magnification microlensing event Gaia19bld located in the Galactic Disk

K. A. Rybicki,★[1] Ł. Wyrzykowski,[1] E. Bachelet,[2] A. Cassan,[3] P. Zieliński,[1] A. Gould,[4,5] S. Calchi Novati,[6] J.C. Yee,[7] Y.-H. Ryu,[8] M. Gromadzki,[1] P. Mikołajczyk,[9] N. Ihanec,[1] K. Kruszyńska,[1] F.-J. Hambsch,[10,11] S. Zola,[12] S. J. Fossey,[13] S. Awiphan,[14] N. Nakharutai,[15] F. Lewis,[16,17] F. Olivares E.,[18] S. Hodgkin,[19] A. Delgado,[19] E. Breedt,[19] D. L. Harrison,[19,20] M. van Leeuwen,[19] G. Rixon,[19] T. Wevers,[19] A. Yoldas,[19] A. Udalski,[1] M. K. Szymański,[1] I. Soszyński,[1] P. Pietrukowicz,[1] S. Kozłowski,[1] J. Skowron,[1] R. Poleski,[1] K. Ulaczyk,[21,1] P. Mróz,[1,22] P. Iwanek,[1] M. Wrona,[1] R.A. Street,[2] Y. Tsapras,[23] M. Hundertmark Gaudi,[5] C. Henderson,[6] Y. Shvartzvald,[25] W. Zang

SN 2018zd: An Unusual Stellar Explosion as Part of the Diverse Type II Supernova Landscape

Jujia Zhang,[1,2,3,4★] Xiaofeng Wang,[5,6] József Vinkó[7,8,9] Qian Zhai,[1,2,3,4] Tianmeng Zhang,[10] Alexei V. Filippenko,[12,13] Thomas G. Brink,[12] WeiKang Zheng,[12] Łukasz Wyrzykowski,[14] Przemysław Mikołajczyk,[14] Fang Huang,[15] Xinhan Zhang,[5] Huijuan Wang,[10,11] James A. Bódi,[7,18] G. Csörnyei,[7,8] O. Hanyecz,[7] I R. Könyves-Tóth,[7,8] A. Ordasi,[7] A. Pál,[7,8] G. Zsidi[7,8,19]

The *Gaia* alerted fading of the FUor-type star Gaia21elv

Zsófia Nagy,[1,2★] Sunkyung Park,[1,2] Péter Ábrahám,[1,2,3] Ágnes Kóspál,[1,2,3,4] Fernando Cruz-Sáenz de Miera,[1,2] Mária Kun,[1,2] Michał Siwak,[1,2] Zsófia Marianna Szabó,[1,2,5,6] Máté Szilágyi,[1,2,3] Eleonora Fiorellino,[7] Teresa Giannini,[8] Jae-Joon Lee,[9] Jeong-Eun Lee,[10] Gábor Marton,[1,2] László Szabados,[1,2] Fabrizio Vitali,[8] Jan Andrzejewski,[11] Mariusz Gromadzki,[12] Simon Hodgkin,[13] Maja Jabłońska,[12] Rene A. Mendez,[14] Jaroslav Merc,[15] Olga Michniewicz,[11] Przemysław J. Mikołajczyk,[12,16] Uliana Pylypenko,[12] Milena Ratajczak,[12] Łukasz Wyrzykowski,[12] Michal Zejmo,[11] Paweł Zieliński[17]

AT2021uey: A planetary microlensing event outside the Galactic bulge

Ban, M.[1], Voloshyn, P.[2,3], Adomavičienė, R.[4], Bachelet, E.[5,6], Bozza, V.[7,8], Brincat, S. M.[9], Bruni, I.[10], Burgaz, U.[11], Carrasco, J. M.[12], Cassan, A.[5], Čepas, V.[4], Dominik, M.[13], Dubois, F.[14], Figuera Jaimes, R.[15], Fukui, A.[16,17], Galdies, C.[18,19], Garofalo, A.[10], Hundertmark, M.[20], Kruszyńska, K.[1], Kulijanishvili, V.[21], Kvernadze, T.[21], Logie, L.[14], Maskoliūnas, M.[4], Mikołajczyk, P. J.[1,22], Mróz, P.[1], Narita, N.[16,17,23], Pakštienė, E.[4], Peloton, J.[3], Poleski, R.[1], Qvam, J. K. T.[24], Rau, S.[14], Rota, P.[7,8] Rybicki, K. A.[1,25], Street, R. A.[26], Tsapras, Y.[20], Vanaverbeke, S.[14], Wambsganss, J.[20], Wyrzykowski, Ł.[1], Zdanavičius, J.[4], and Zieliński, P.[27]

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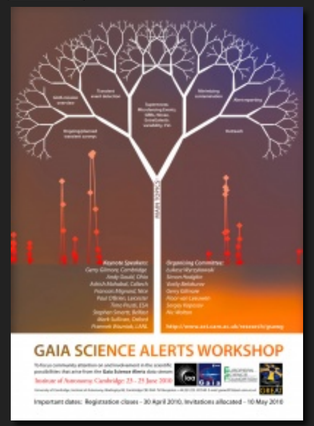
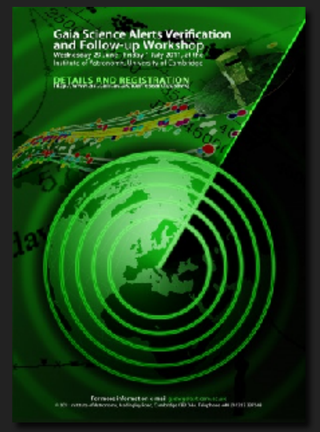
2010-Cambridge



2011-Cambridge



2012-Bologna

2013-Paris

2014-Warsaw

2015-Liverpool

2016-Utrecht

2017-Warsaw

2018-Vipava

2019-Catania

2020 - on-line

2021-Crete

2022-Sardinia

2023-Malta

2024-Crete

2025-Tenerife

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WORKSHOPS SINCE 2010

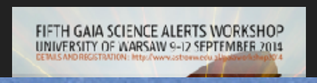
2010-Cambridge

2011-Cambridge

2012-Bologna

2013-Paris

2014-Warsaw



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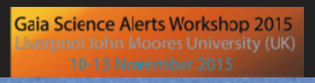
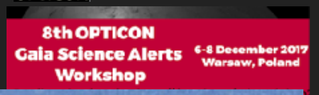


2016-Utrecht

2017-Warsaw



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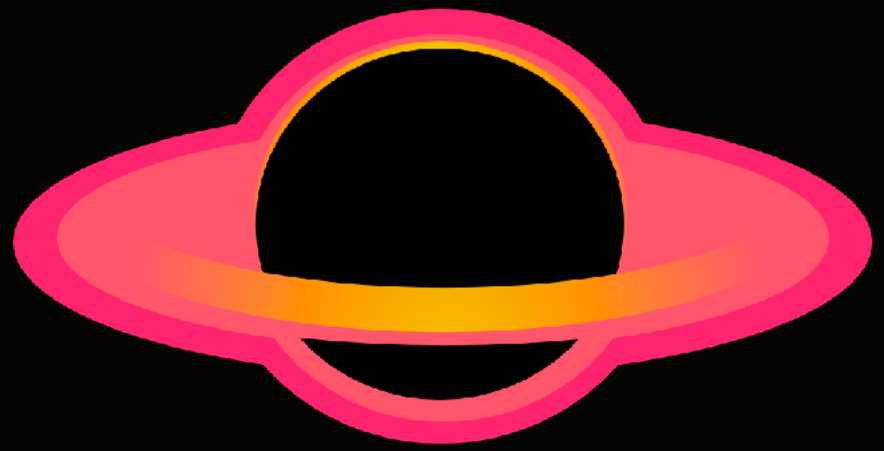
SUMMARY

- BHTOM is a global network of optical telescopes for time-domain observations
- Provides long-term multi-wavelength photometry for your target
- Access to many optical and radio time-domain archives
- Plans: coordinate LSST in-kind follow-up resources
- Plans: Multi-messenger targets (GW, neutrinos)
- Plans: Solar System objects
- Plans: More archives (multimessenger, X-ray, gamma, radio)
- Any more ideas?



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