OMEGA - the pathfinder for LSST follow-up

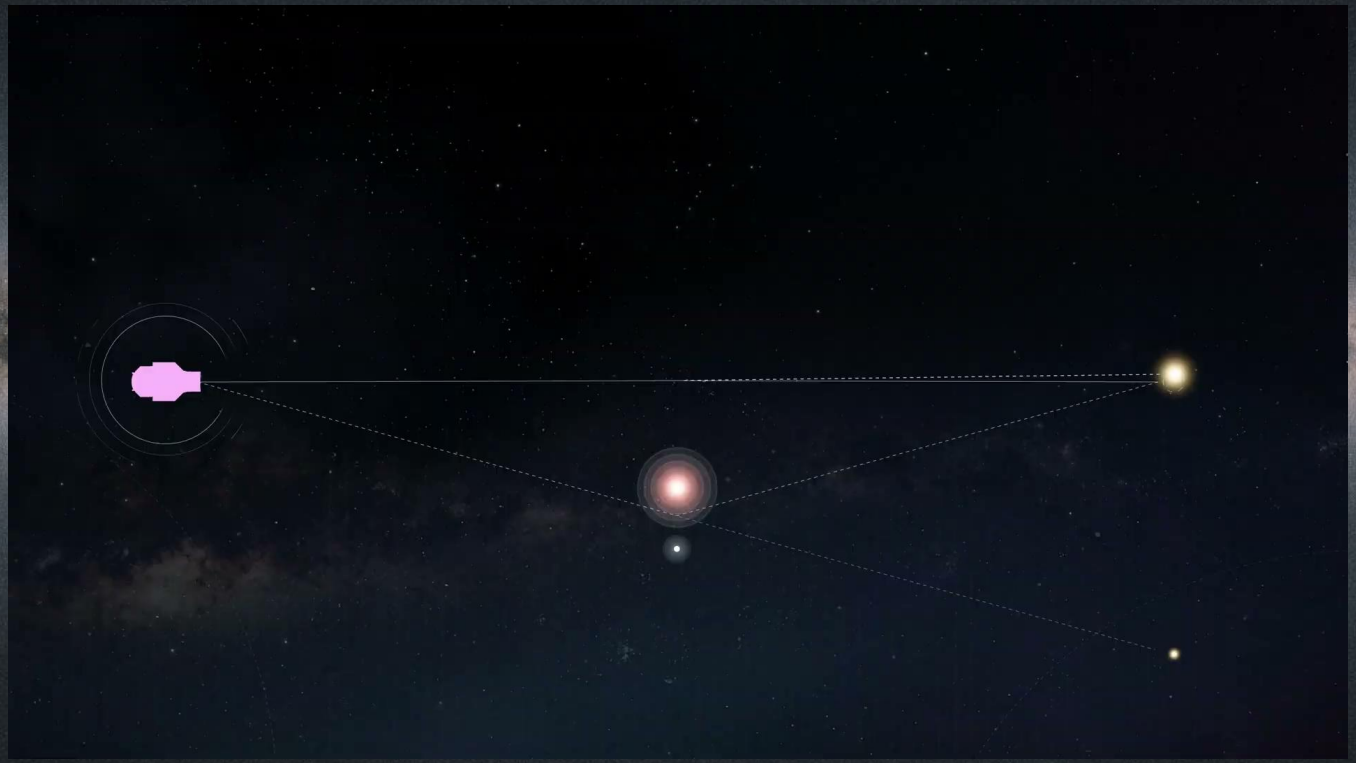
Katarzyna Kruszyńska
Rachel Street, Etienne Bachelet, Markus Hundertmark, Yiannis Tsapras

Las Cumbres Observatory, USA

Hotwiring the Universe 2026, Pasadena

Supported by the by the NSF under Grant No. 2206828

What is gravitational microlensing



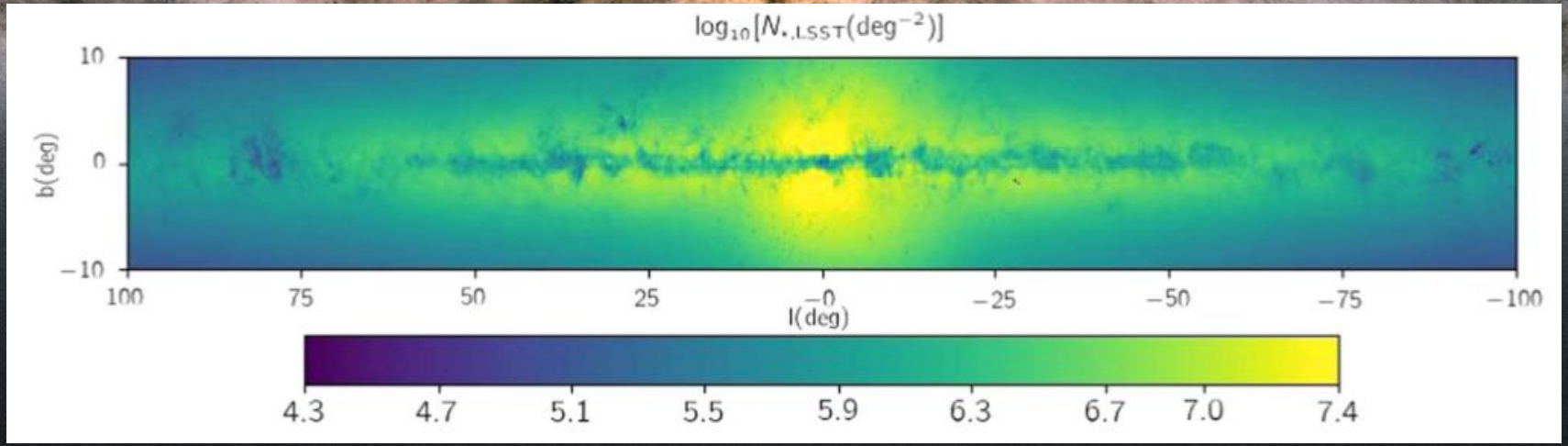
Credit: NASA's Goddard Space Flight Center/CI Lab

What is gravitational microlensing

Credit: NASA's Goddard Space Flight Center/CI Lab

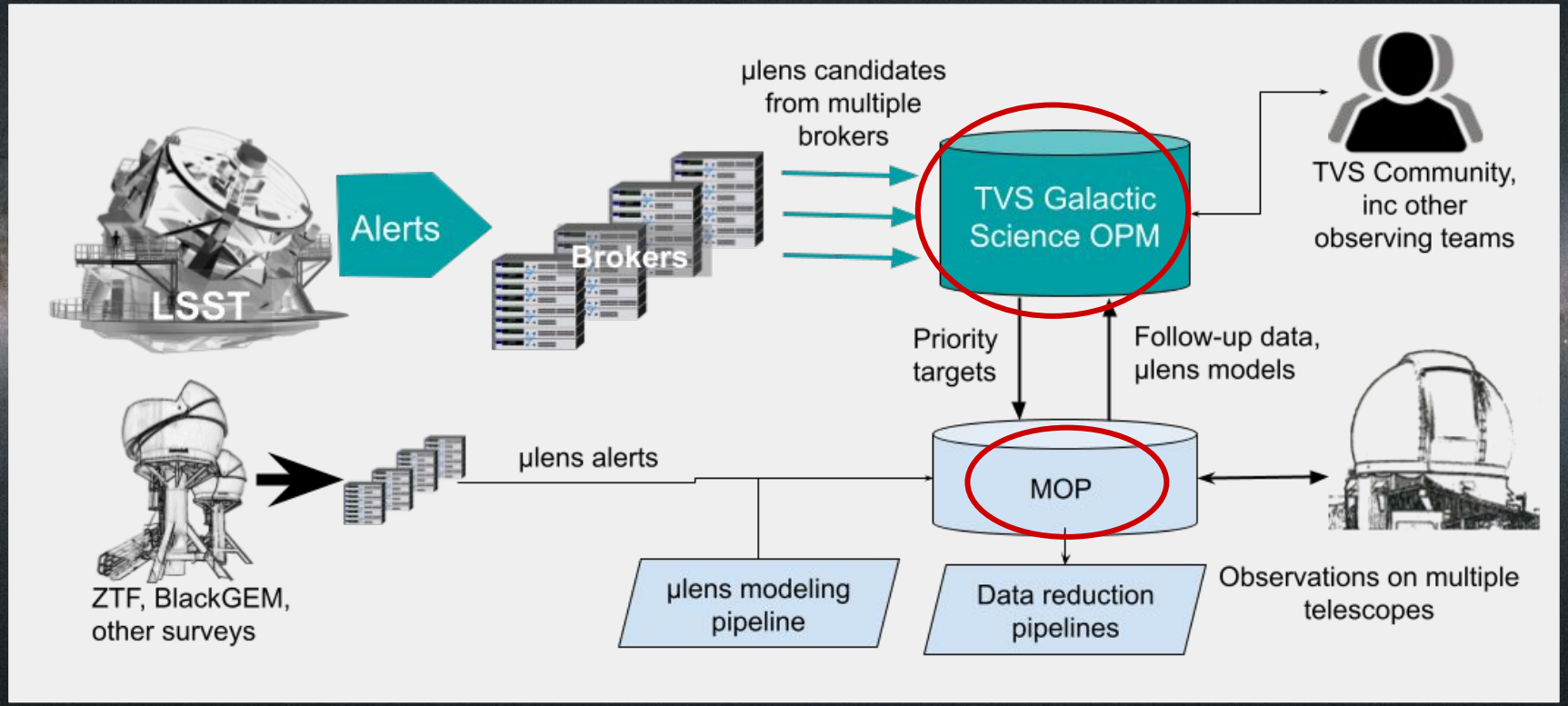
Rubin will probe hidden populations

- Microlensing is a rare phenomenon
- It can detect dim or non-luminous lenses
- Rubin will be a perfect discovery engine for event detection



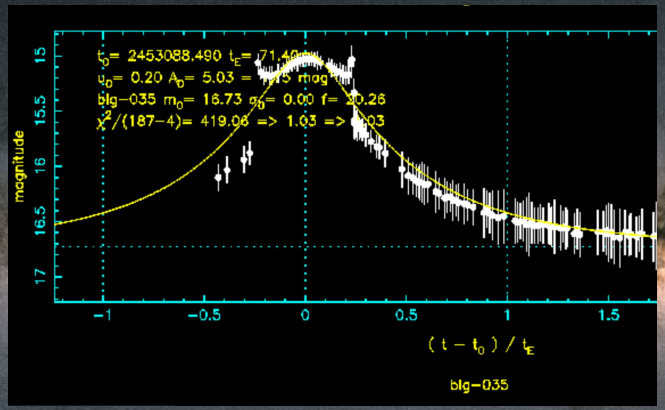
Number of events per square degree

Target Observation Managers for Rubin microlensing



Credits: Rachel Street

Microlensing as a pioneer

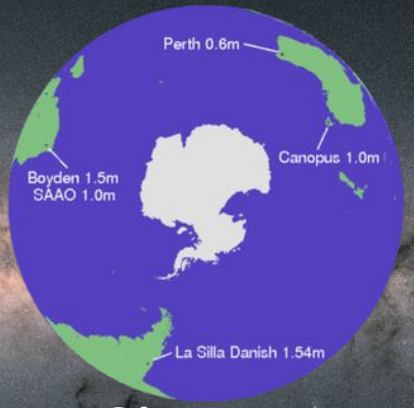


Anomaly detection

PSPL:

EVENT	PRIORITY(t)	PRIORITY(t+1)	I(t)	A(t)	A_max	t - t0	t_E	chi^2/N (6p)	delta chi^2	OGL
OGLE-2004-blg-602	124.46	123.18	14.09	1.09	1.91	85.91	65.83	1.02	130.28	-
OGLE-2004-blg-361	100.96	100.51	14.66	1.10	1.38	115.98	120.33	1.03	69.81	-
OGLE-2004-blg-600	34.35	34.02	14.96	1.02	1.16	125.27	49.93	1.03	61.99	-
OGLE-2004-blg-383	32.31	32.09	13.38	1.00	1.17	233.40	52.56	1.02	64.19	-
OGLE-2004-blg-471	30.34	30.24	15.41	1.02	1.09	257.69	124.89	1.01	137.55	-
OGLE-2004-blg-580	27.67	27.52	14.63	1.01	1.06	201.16	67.24	1.02	336.90	-
OGLE-2004-blg-598	18.46	18.34	15.93	1.01	1.08	161.29	61.66	1.03	14.39	-
OGLE-2004-blg-607	16.47	16.29	16.43	1.01	1.37	130.62	46.83	1.03	17.99	-
OGLE-2004-blg-432	16.04	15.92	13.71	1.00	1.26	232.01	37.61	1.06	399.30	-
OGLE-2004-blg-114	14.62	14.59	19.09	1.17	2.65	283.61	348.62	1.03	38.72	-
OGLE-2004-blg-342	14.12	14.01	16.29	1.01	2.17	212.75	63.31	1.03	92.09	-
OGLE-2004-blg-296	10.05	9.98	14.28	1.00	1.50	260.74	37.55	1.03	236.04	-
OGLE-2004-blg-384	8.07	8.00	15.74	1.00	3.13	226.52	41.59	1.00	35.17	-
OGLE-2004-blg-138	6.39	6.36	14.99	1.00	1.20	329.67	44.85	1.01	22.76	-
OGLE-2004-blg-203	6.21	6.17	15.94	1.00	6.25	271.01	45.36	1.02	356.97	-
OGLE-2004-blg-364	6.16	6.11	15.42	1.00	1.89	243.53	35.74	1.02	33.52	-
OGLE-2004-blg-505	6.10	6.05	15.73	1.00	1.85	204.67	32.32	1.03	58.25	-
OGLE-2004-blg-016	5.38	5.36	18.16	1.01	1.56	411.01	122.45	1.03	39.11	-
OGLE-2004-blg-502	4.72	4.68	17.74	1.00	1.22	227.10	55.58	1.02	6.35	-
OGLE-2004-blg-007	4.51	4.49	16.11	1.00	1.23	418.22	62.56	1.02	22.91	-

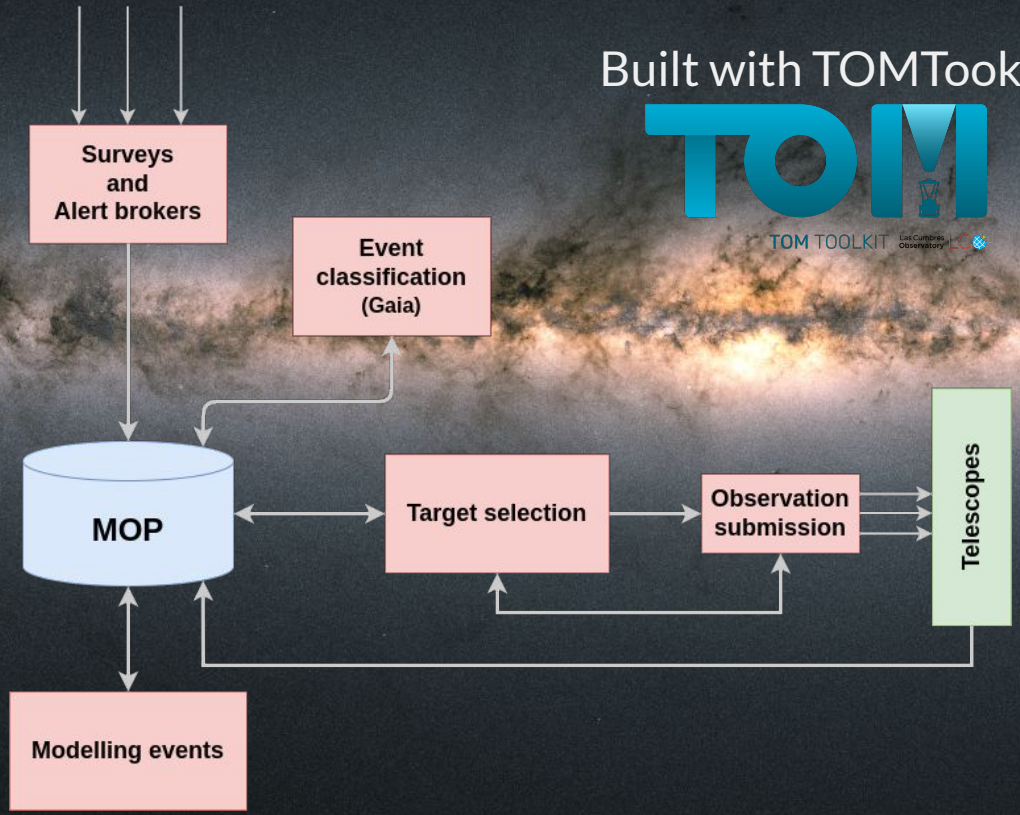
Target prioritization



Observatory coordination

Many of these technologies evolved because of the modern day, large-scale surveys

MOP - The Microlensing Observing Platform

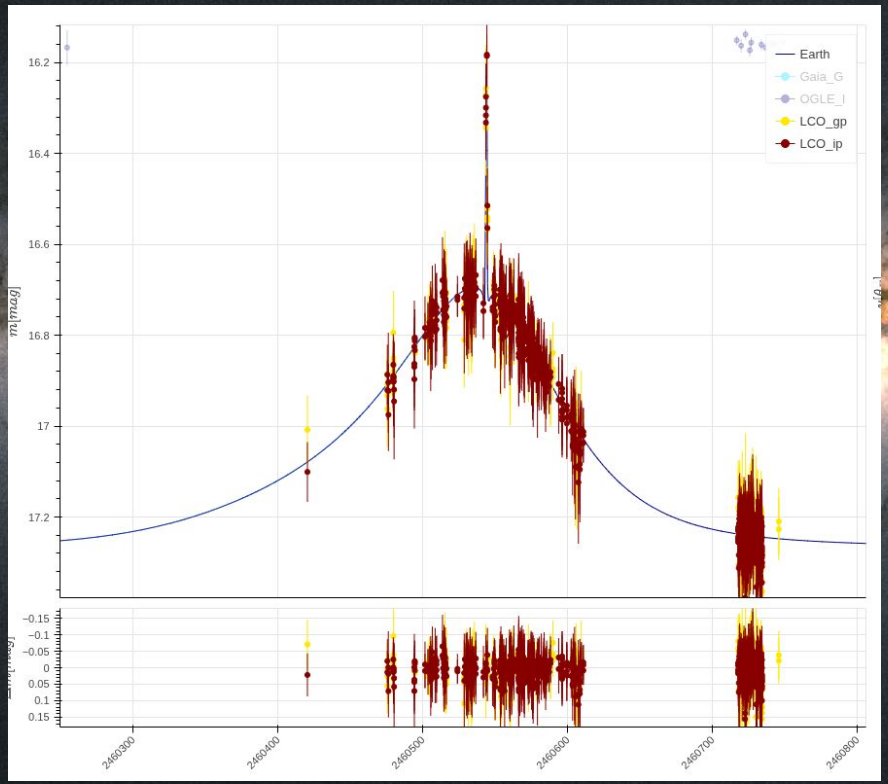


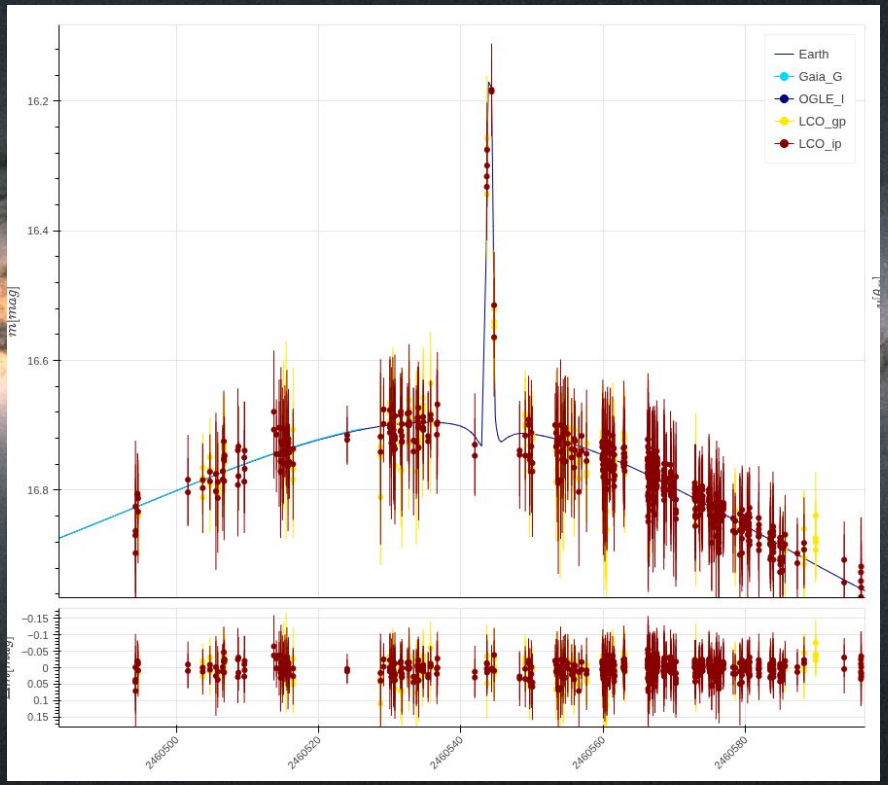
Built with TOMTookit

TOM TOOLKIT

LCO network
AEON queue
Other facilities

MOP - The Microlensing Observing Platform

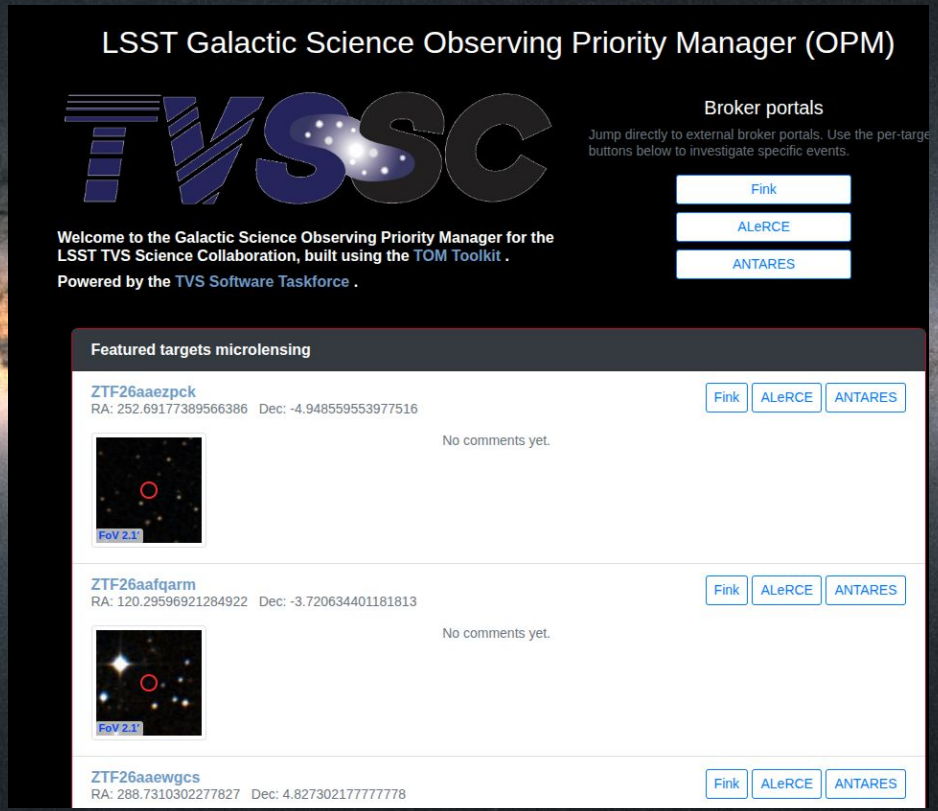




Source: Kruszyńska et al. in prep.

The TVS Galactic Science OPM

- Goals:
  - Collect and prioritize candidate microlensing events
  - Detect anomalous events
  - Collect follow-up data



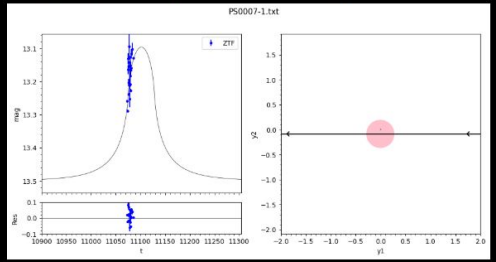
The TVS Galactic Science OPM

- Goals:
  - Collect and prioritize candidate microlensing events
  - Detect anomalous events
  - Collect follow-up data
- Follow-up can reveal that candidate microlensing events are another type of transient
- Open to the Rubin community to facilitate Galactic science

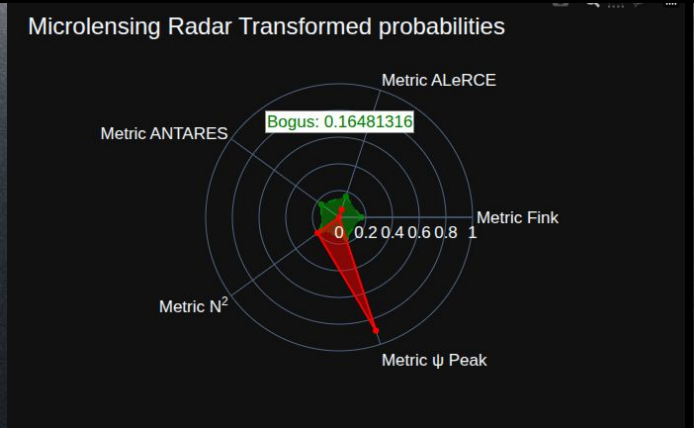
Parameters for target type: Microlensing candidate

t_0 [JD]	u_0	t_E [days]	ρ	π_{EE}	π
11101.956	0.086	101.000	0.276	0.000	0

Analysis (detailed parameter summary)



t_0 [HJD]	u_0	t_E [days]	π_{EE}	π_{EN}	ρ	s	q
11101.956∓ 22.084	0.0855∓ 1.5027	101.000∓ 954.956	0.000∓ 0.000	0.000∓ 0.000	0.276∓ 2.803	0.000∓ 0.000	0.000∓



Rubin TVS Microlensing subgroup

- Alert brokers:
  - Building a microlensing filter (ANTARES)
  - Building microlensing classifiers (FINK, ALeRCE)
- Simulations - microlensing and variable stars
  - Software - e.g., LightCurveLynx
  - Generating simulated datasets
    - light curves, ingestion on image level
- Coordinating observing proposals with other groups - CVs, …

Lessons

- What have we learned from existing alert streams and Rubin alerts?
  - Using existing infrastructure to test software speeds up the development.
  - Updating existing infrastructure (software packages, observing managers, etc.) reduces the time and effort required for development.

Credit: RubinObs/NOIRLab/SLAC/NSF/DOE/AURA

Lessons

- How do we optimize transient discovery with multi-wavelength and multi-messenger alert streams?
  - Collaborate with brokers - deliver expertise, software, and data to update their models.
  - Use for collaborative approach to data collection, e.g., cross-collaboration proposals.
  - Use existing platforms to share collected data among community members, or build such for that purpouse.
  - One person’s trash is another person’s treasure

Credit: RubinObs/NOIRLab/SLAC/NSF/DOE/AURA

Lessons

- Are we ready for alerts from Roman and beyond?
  - I think we are, as a community.

Credit: RubinObs/NOIRLab/SLAC/NSF/DOE/AURA