Metric Package - Microlensing

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Science Topic

A collection of metrics describing the discovery and characterization of microlensing events in the Milky Way and Magellanic Clouds, including stellar, planetary and black hole lensing.

Summary of metrics

The authors request the following metrics be run for all OpSims in order to evaluate the impact of survey strategy changes on this science topic:

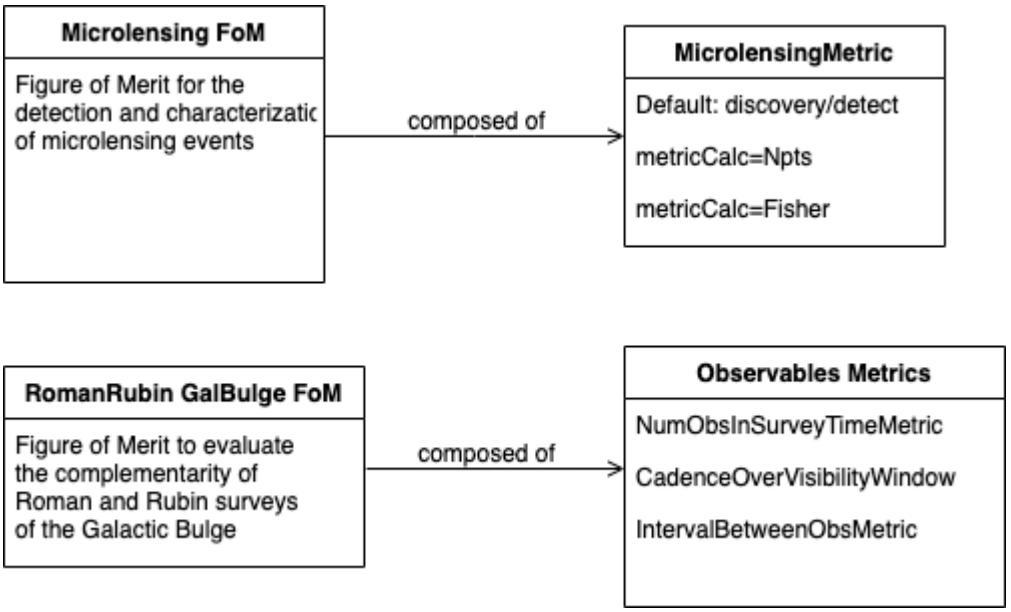
Metric Name	Summary	Code & Data	Dev status
MicrolensingFoM	FoM which combines the following metrics?	microlensingFOM.py Demo notebook	Ready to be integrated with MAF
MicrolensingMetric - discovery/detect	Calculates the number of simulated microlensing events with a certain number of points on the rise and on the fall. Can also specify "triggering" a certain number of days before the peak time. Run by default when running the MicrolensingMetric.	microlensingMetric.py Demo notebook	Integrated with MAF
MicrolensingMetric - Npts	Calculates the number of points within 2tE for simulated microlensing events. Run via the MicrolensingMetric with the flag metricCalc = "Npts"	microlensingMetric.py Demo notebook	Ready to be integrated with MAF
MicrolensingMetric - Fisher	Calculates the sigma_tE/tE for simulated microlensing events via Fisher matrix. Run via the MicrolensingMetric with the flag metricCalc = "Fisher"	microlensingMetric.py Demo notebook	Ready to be integrated with MAF

Microlensing in Magellanic Clouds	Cadence necessary for the recovery of microlensing events within the LMC/SMC	?	Covered by other metrics?
RomanRubinGalBulge FoM	FoM representing science return from complementary survey strategies	FoM code	TBD
spatialOverlapRGESMetric	Metric to evaluate the fractional overlap with the RGES Bulge survey region	Metric code written	
CadenceOverVisibilityWindowMetric	Compares lightcurve cadence with desired cadence for a given pointing and observing window	Metric code	Ready for integration with MAF
NumObsInSurveyTimeMetric	WFIRST / LSST overlap for fields with interesting variability	Metric code	
IntervalBetweenObsMetric	WFIRST / LSST overlap for fields with interesting variability	Metric codet	

Other relevant metrics:
Microlensing is one of the science cases represented in the Galactic Plane & Magellanic Science Metric Package, and the high-level Figures of Merit presented there are highly relevant to optimizing the Galactic Plane survey strategy.

Here we present more specialised metrics designed to evaluate the rates of detection and characterization of microlensing events.

Relationships between Metrics



Guidelines for Interpreting Metric Results

MicrolensingFoM

Returns:
Interpretation:
Caveats:

MicrolensingMetric - discovery/detect

Relevant Inputs: *metricCalc* = 'detect'; *Npts* = # of points necessary [default 2]; *detect* = False (True) [default False] means needs Npts on one (both) side(s) of the lightcurve; *time_before_peak* = # of days or 'optimal' [default None] Npts must be detected # of days before the peak or the time of maximum tE information as approximated from the Fisher matrix
Returns: 1 if event meets the criteria, 0 if not. The criterion is the number of points on the rising side (or on both if detect = True and before *time_before_peak* if specified)
Interpretation: This is a simple estimation of the number of events that are "discovered" or alerted. The higher fraction the better.
Caveats: Depends on the RMS which is provided through the OpSims. It depends on the distribution of events (i.e. number of stars^2 or Besancon galactic model simulation, which is not available by default). It depends on the distributions of magnitudes and blends of the events and currently these are assumed to be constant (r_mag = 20) and unblended respectively.
Desired output: We would like to have the number of events per HEALpix, which tE bin each event is in (i.e. 1-10 days, 10-30 days, 30-100 days, or 100-300 days(?)), and the .npz and .db files for each run.

MicrolensingMetric - Npts

Relevant Inputs: *metricCalc* = 'Npts'

Returns: Number of points within 2 tE of the peak of the event
Interpretation: The higher the average number of points, the more events we estimate to be characterizable.
Caveats: Same as MicrolensingMetric - discovery/detect
Desired output: Same as MicrolensingMetric - discovery/detect

MicrolensingMetric - Fisher

Relevant Inputs: *metricCalc* = 'Fisher'
Returns: sigma_tE/tE value as calculated by the Fisher matrix for each events
Interpretation: The more events with sigma_tE/tE less than some value (i.e. 0.1), the more events are characterizable. tE (Einstein crossing time) is linked to the mass of the event and therefore an important physical quantity to understand.
Caveats: Same as MicrolensingMetric - discovery/detect
Desired output: Same as MicrolensingMetric - discovery/detect

RomanRubinGalBulgeFoM

Returns:
Interpretation:
Caveats:
Desired output:

NumObsInSurveyTimeMetric

Returns:
Interpretation:
Caveats:
Desired output:

CadenceOverVisibilityWindowMetric

Returns:
Interpretation:
Caveats:
Desired output:

IntervalBetweenObsMetric

Returns:
Interpretation:
Caveats:
Desired output:

References

Incorporating these metrics into the MAF will accommodate the science described in the following LSST Survey Strategy White Papers and Cadence Notes:

Street et al., 2018, “Unique Science from a Coordinated LSST-WFIRST Survey of the Galactic Bulge”
Abrams et al., 2021 “Microlensing Discovery and CharacterizationEfficiency at Different Timescales”
Hundertmark et al., 2021, “Alerting transient phenomena in theGalactic Plane in time to coordinate follow-up”
Blaineau et al., 2021, “Microlensing towards the Magellanic Clouds:searching for long events“
Bachelet et al., 2021, “On the observational synergies between all-sky surveys for the characterization of microlensing events”