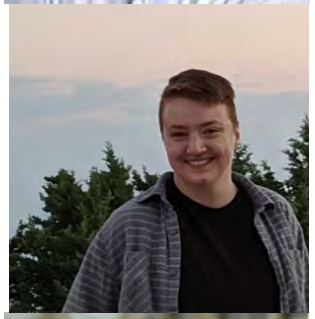
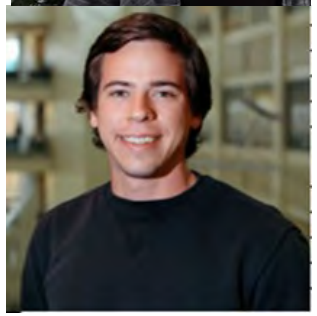
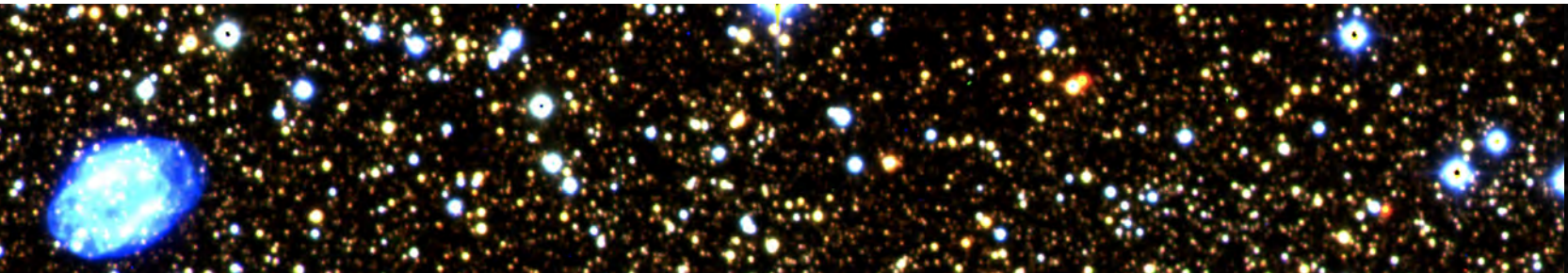
SynthPop: A public, modular, python Galactic Population Synthesis Code

Jonas Klüter (ex. Louisiana State University)
Samson Johnson (JPL)
Macy Huston (UC Berkeley)
Abigail Aronica (ex. Ohio State University)
Marz Newman (Louisiana State University)
Allison Chevis (Michigan State University)
Matthew Penny (Louisiana State University)
penny1@lsu.edu

26th Microlensing Conference



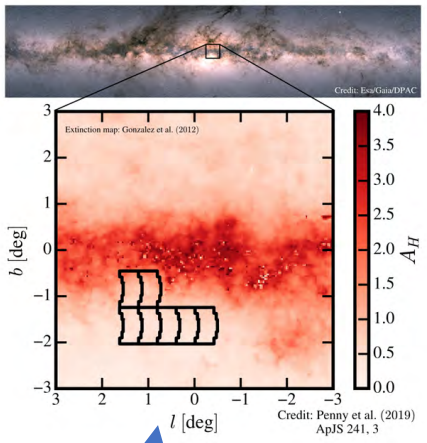
Simulating the Roman GBTDS

Population synthesis model

Normalize event rates

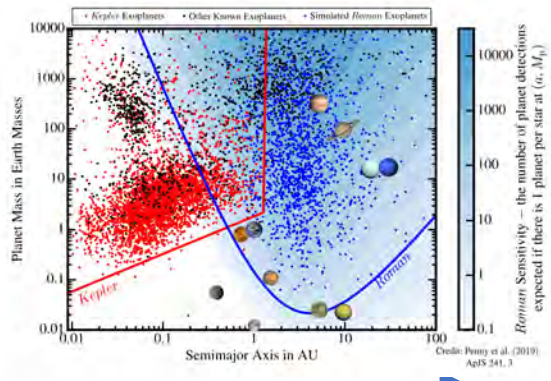
Predicted yields

Field locations

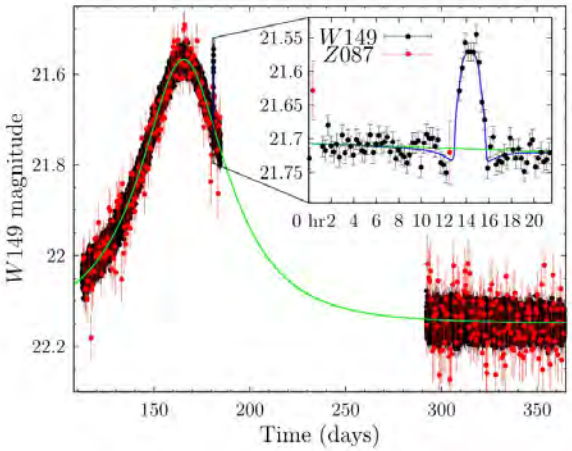


Penny et al. (2019)
Penny et al. (2013)

Simulated images



Simulated lightcurves



Major contributions from:
Nick Rattenbury
Eamonn Kerins
Shude Mao

https://github.com/gulls-microlensing/gulls

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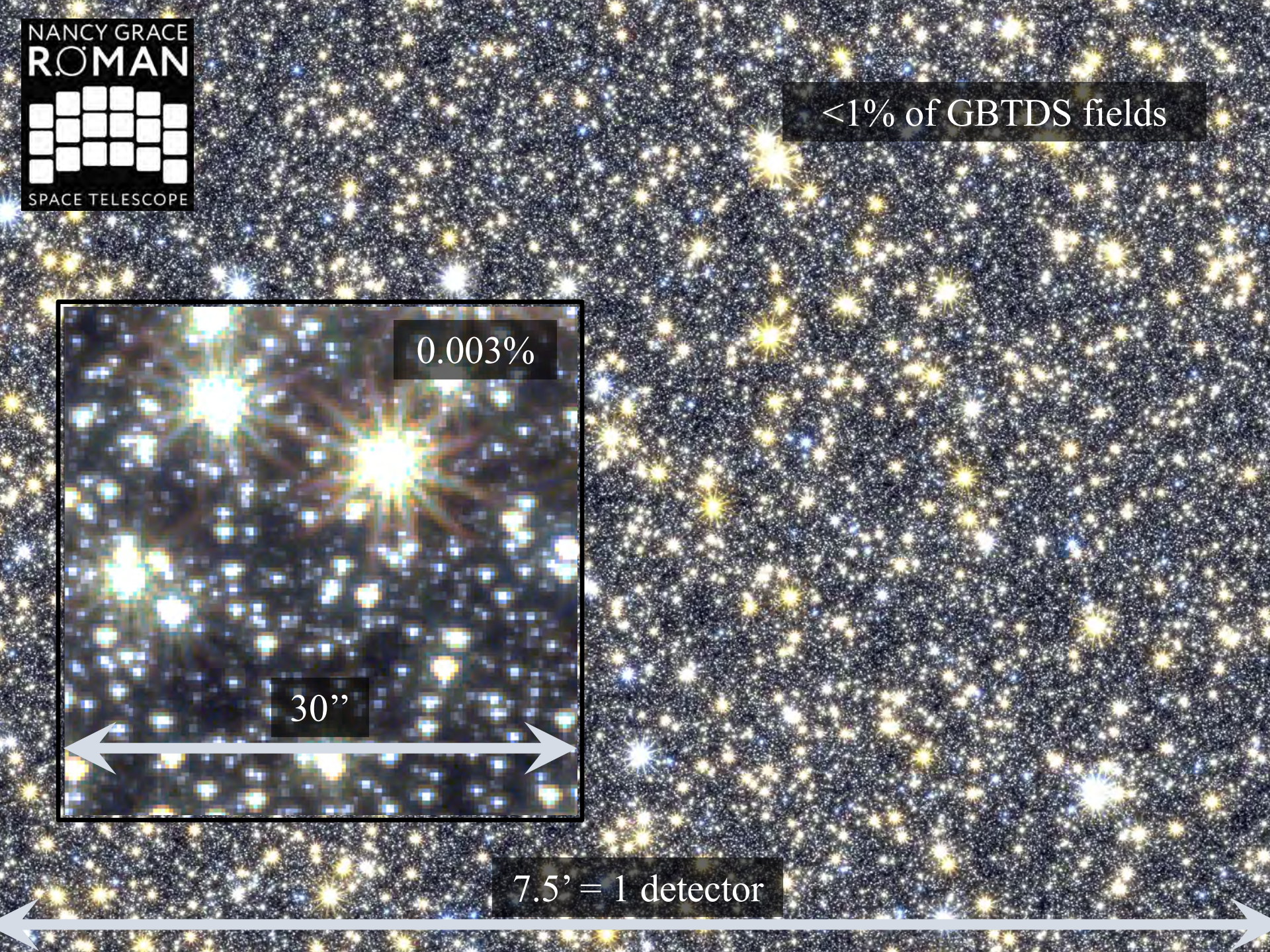
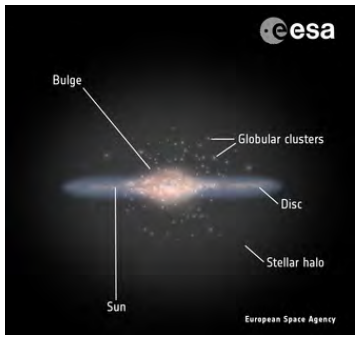
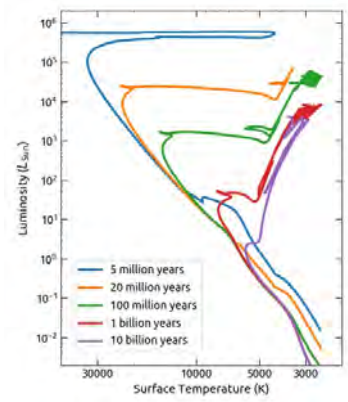

NANCY GRACE
ROMAN
SPACE TELESCOPE
<1% of GBTDS fields
0.003%
30”
7.5’ = 1 detector

Galactic Population Synthesis



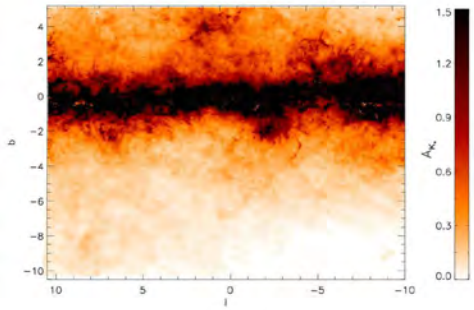
Density & kinematics

+



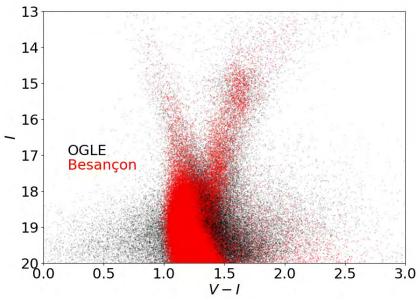
SFR history, IMF & evolution

+



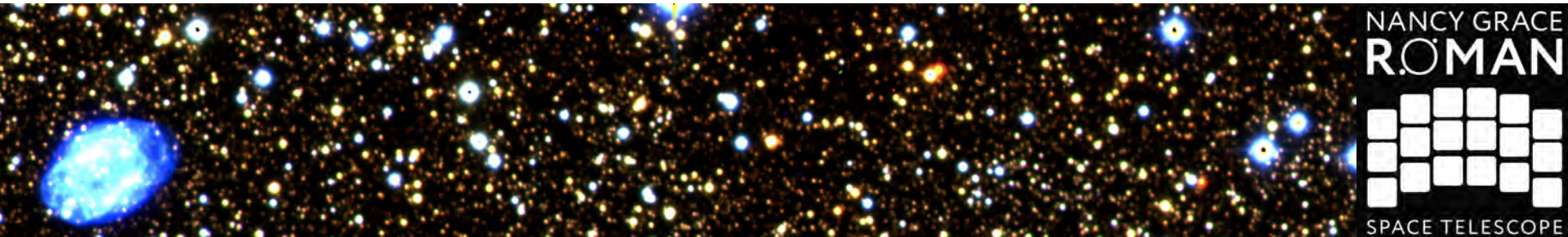
Extinction

=



Synthetic stars + properties

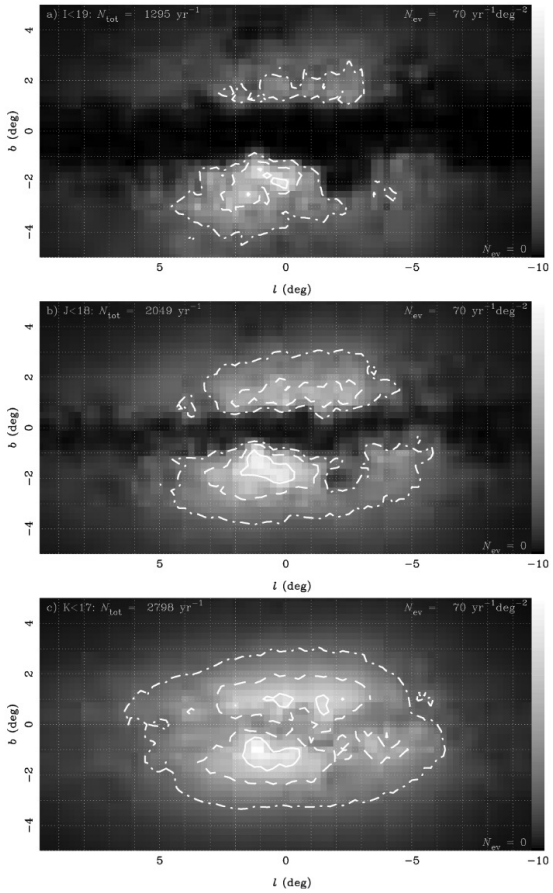
Classical examples:
Besançon (web form – Robin et al. 2003 & later)
TRILEGAL (web form – Girardi et al. 2009)
Galaxia (public C++ implementation of Besançon+N-body – Sharma et al. 2011)

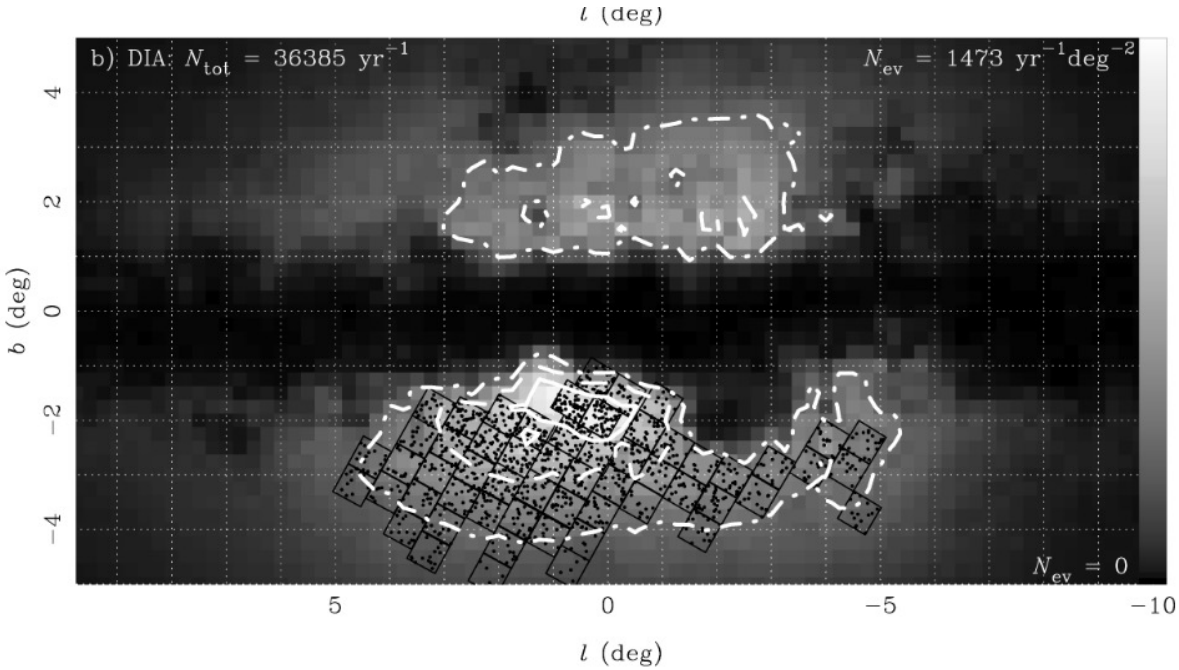


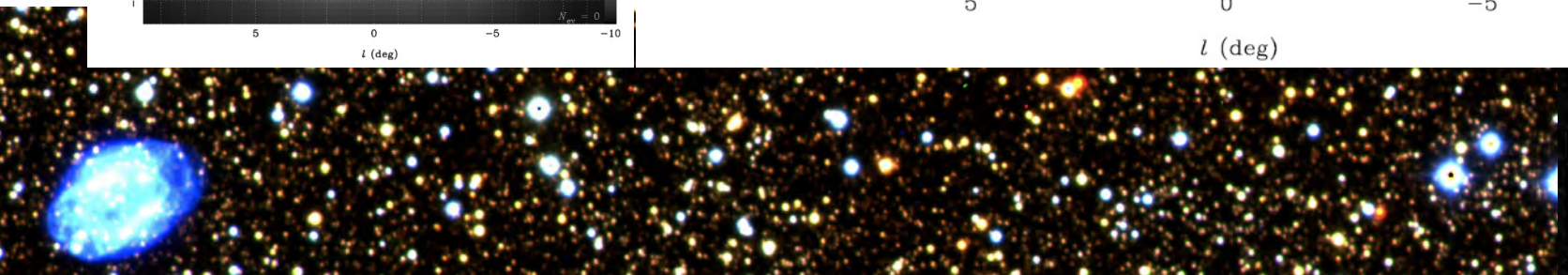
Population Synthesis Microlensing Predictions

- Pioneered by Kerins, Robin & Marshall (2009)

- Found Besançon model (Robin+2003) overpredicted microlensing observations and led to updated bulge model







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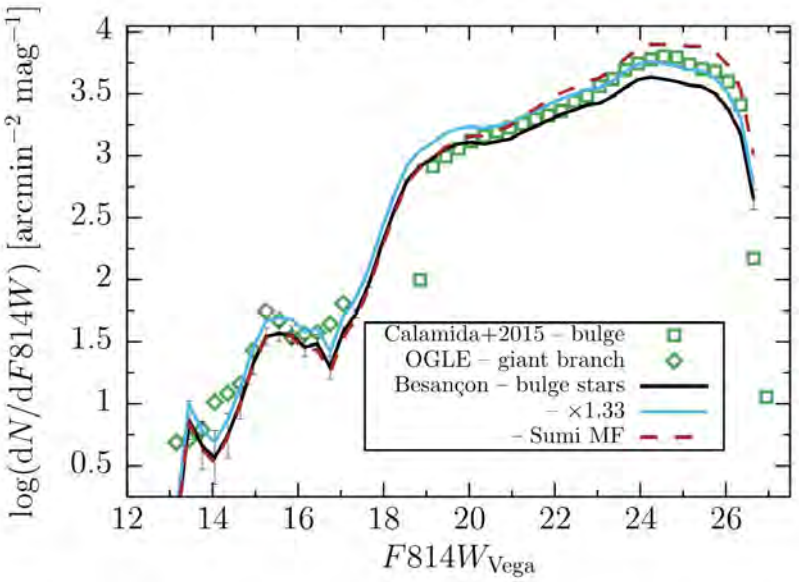
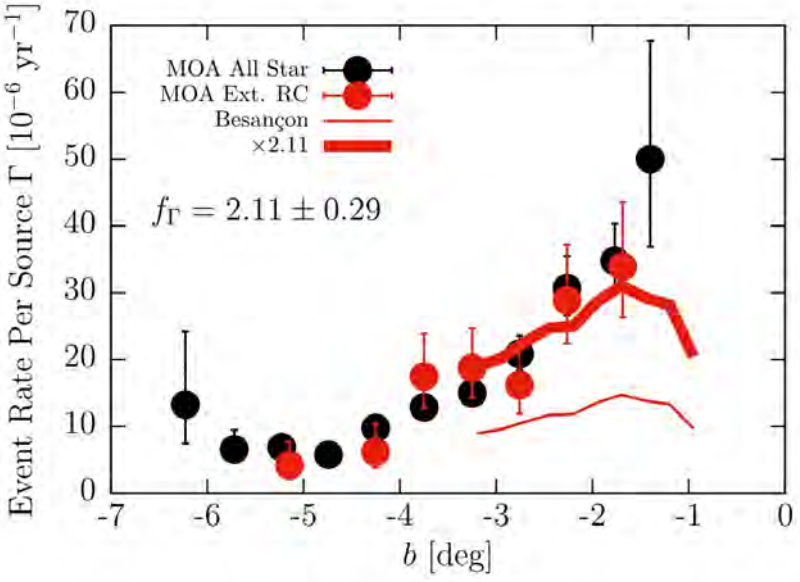
Why do we need a new Galactic model?

Besançon model (v1106, see Penny et al. 2013)



33% too few sources



~2x too small event rate/source

Needed to scale rates by x2.8 to match data!

Classical examples:
Besançon (web form – Robin et al. 2003 & later)
TRILEGAL (web form – Girardi et al. 2009)
Galaxia (public C++ implementation of Besançon+N-body – Sharma et al. 2011)

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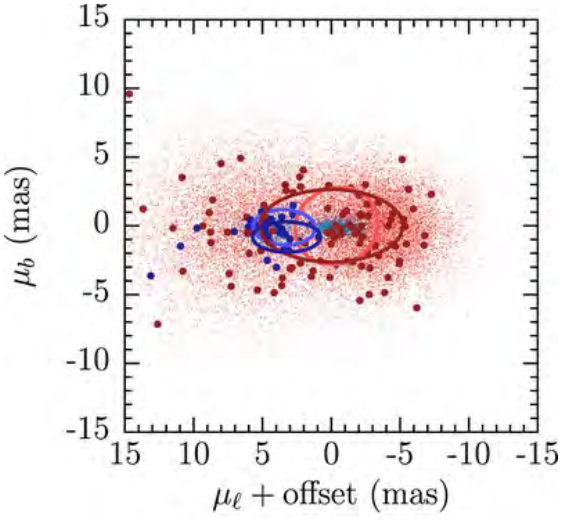
Causes:

- IMF – too few low mass stars
- Bulge bar angle
- Kinematics

- See Penny et al. (2019) discussion



Also want to change:

- Filters
- Metallicity distributions
- Isochrones
- Binaries
- Extinction maps
- …

Classical examples:
Besançon (web form – Robin et al. 2003 & later)
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Galaxia (public C++ implementation of Besançon+N-body – Sharma et al. 2011)

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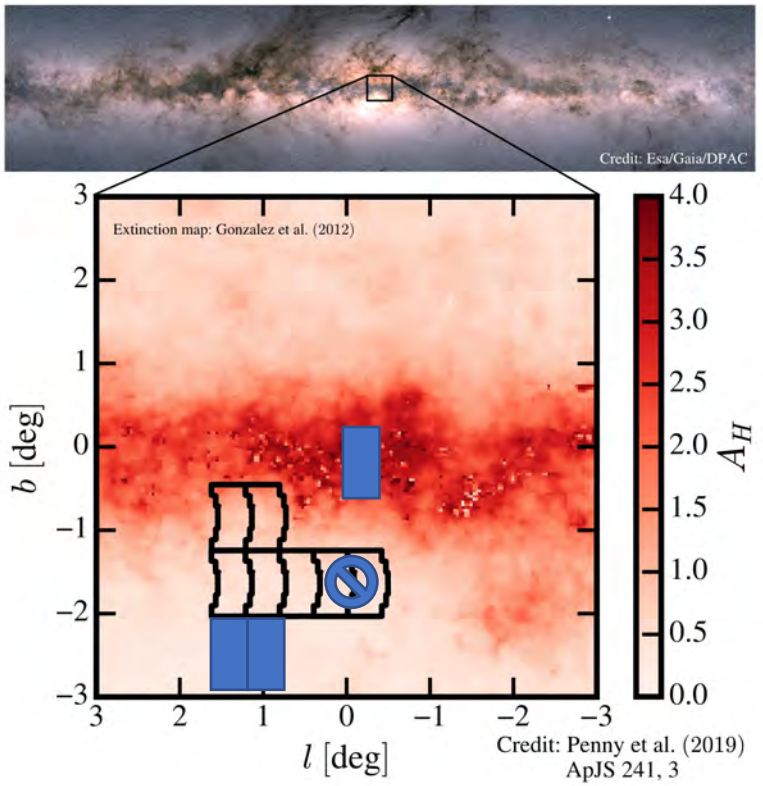
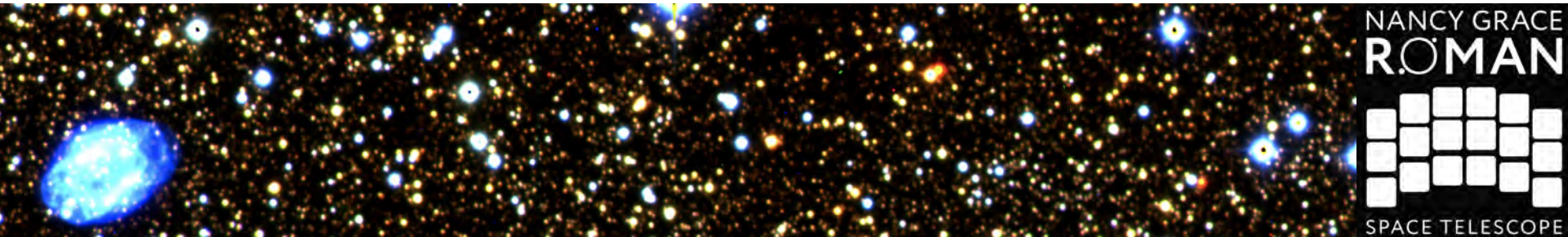
Optimization & ‘Tweaks’ to the GBTDS Survey

- Many ways in which the survey strategy can be ‘tweaked’ to yield additional science without significantly impacting the requirements of the microlensing survey.
- Possible example (not complete):
  - Periodic observations of the GC.
  - Periodic observations of the survey fields in all filters.
  - Periodic observations of a much larger survey area.
  - A field with doubled cadence
- For microlensing exoplanets
  - May want to sacrifice event rate for “characterizability”
  - May want/need to optimize for different requirements (e.g., HZ vs total yield vs FFPs).

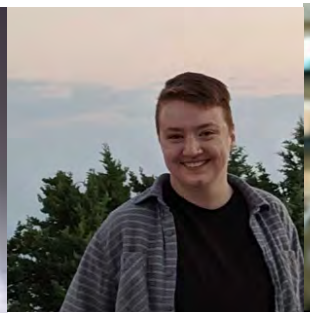




SynthPop

Klüter et al. in prep

github.com/synthpop-galaxy/synthpop


Jonas Klüter | Macy Huston | Samson Johnson

Goals: Modular, python, public

Achieved: Modular, python, public

User can change every aspect
Importable module (generate stars on the fly, embed into other code)
Json parameter files
pip install option for casual use
Sequential postprocessing module support

```
import synthpop

model = synthpop.SynthPop(config_file_name, **kwargs)
model.init_population()
```

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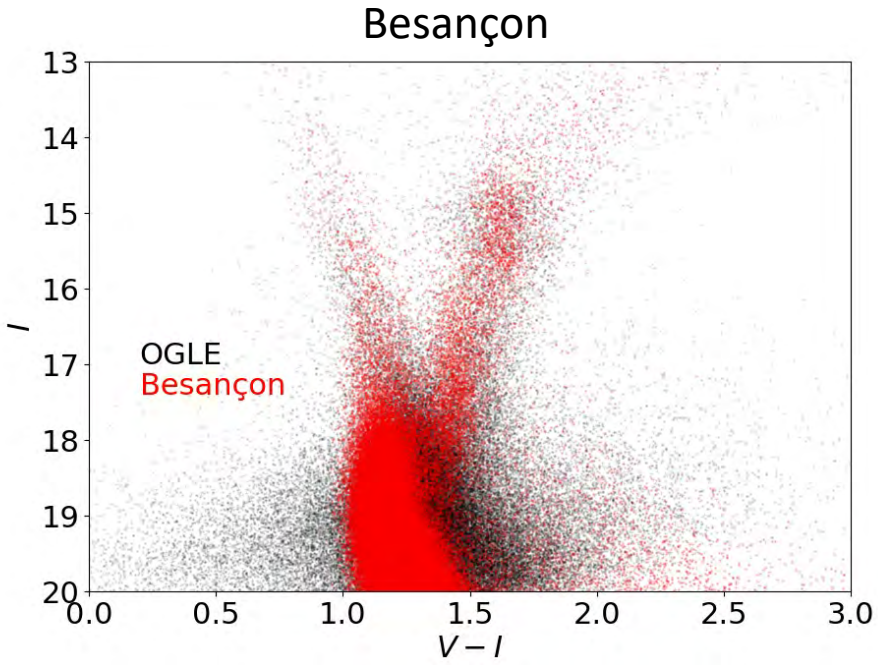
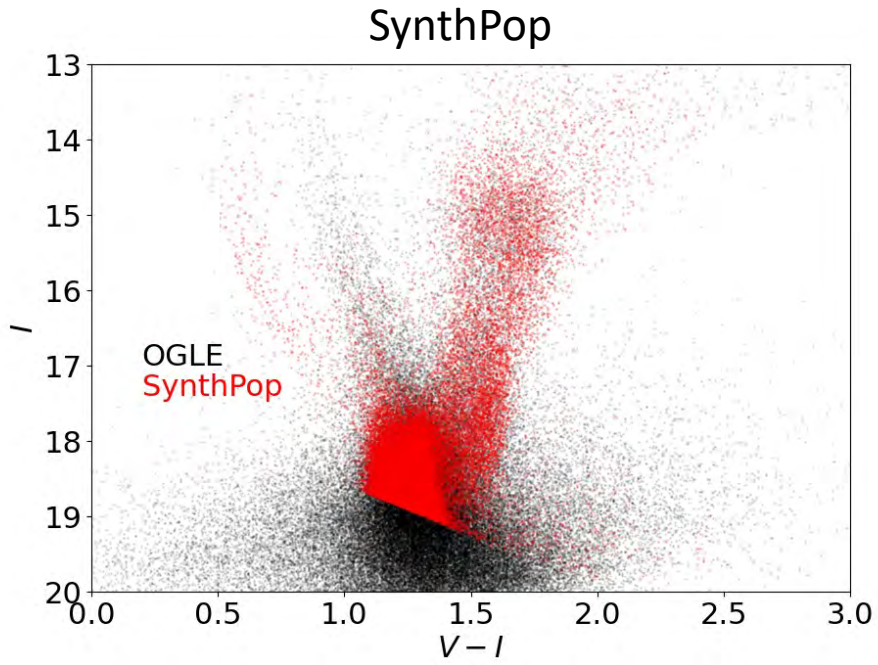
Current limitations

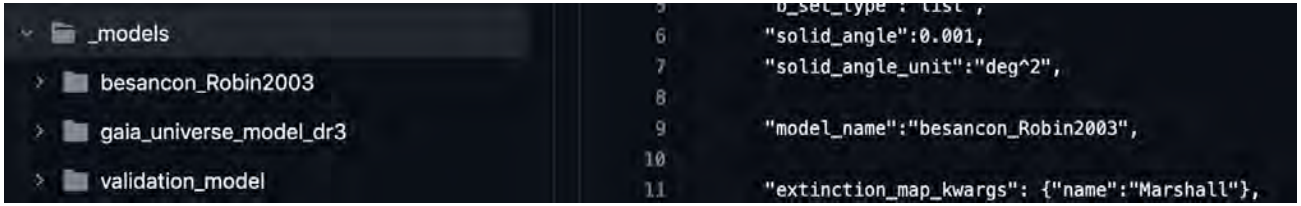
- Performance – flexibility & python code come at a run-time cost, but this is reasonable
- Completeness – only a few models implemented (publicly) and well tested (several in development)
- No N-body models (yet)
- Only single stars



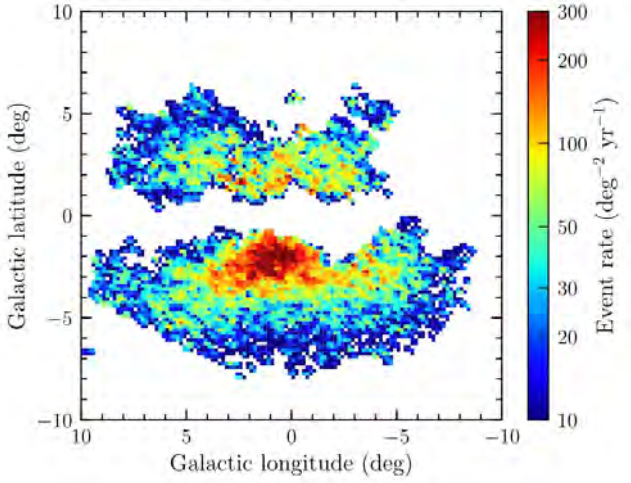


Model comparisons

Identical analysis can be run on different models by changing 1 config line

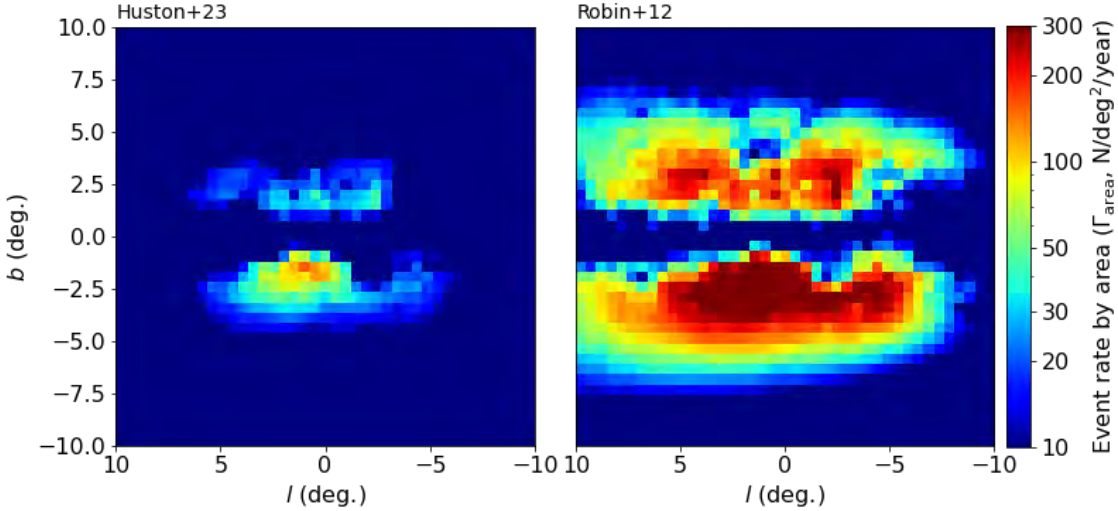


OGLE-IV Microlensing event rates

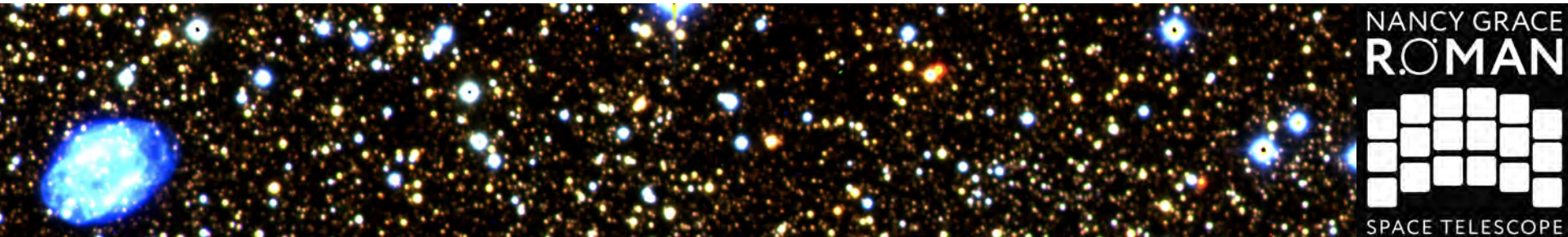


Mroz et al. (2019)

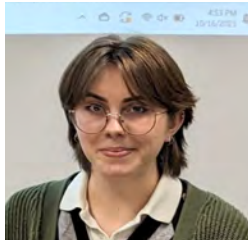
SynthPop models



Macy Huston et al. in prep.

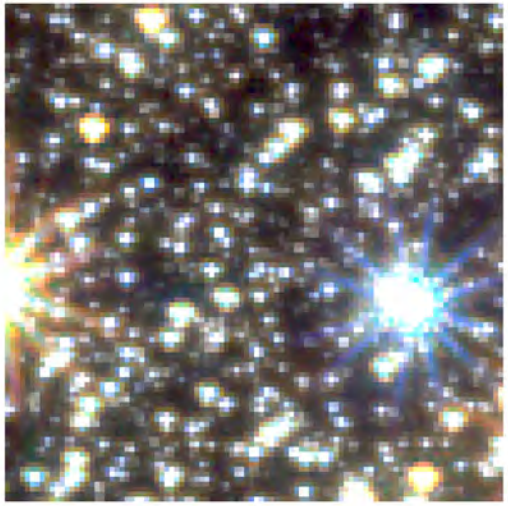






Work in progress

- Model selection & incorporate SynthPop into Roman bulge survey (BGTDS) microlensing & transit survey simulations (Farzaneh Zohrabi, Marz Newman, Macy Huston)
- Implement binary stars into SynthPop (Marz Newman)
- Extinction map implementations (Allison Chevis)
- Complete development of an SED fitter using SynthPop priors (TBD, Klüter et al. in prep.)
- Build SynthPop-based Bayesian microlensing parameter estimator (Allison Chevis + ?)
- Your project…?



Simulated Roman Image with SynthPop catalog

Try it out: github.com/synthpop-galaxy/synthpop
Issues & pull requests welcome

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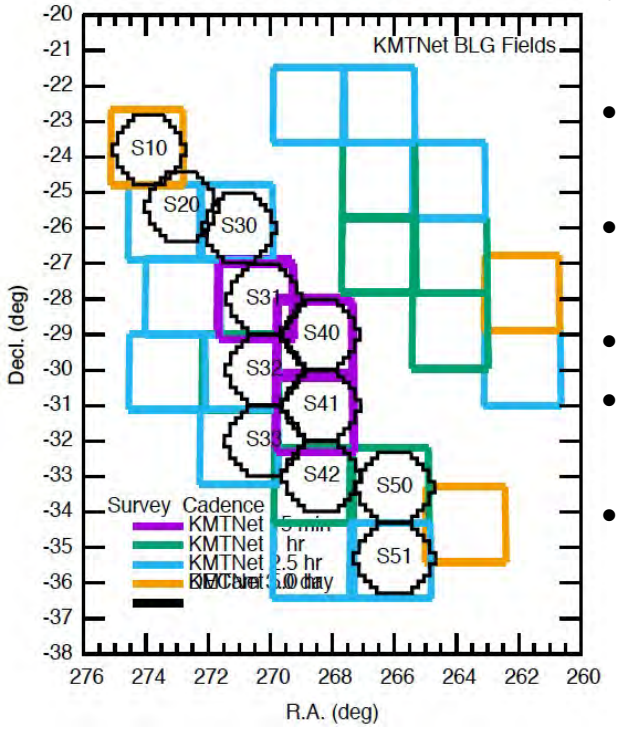
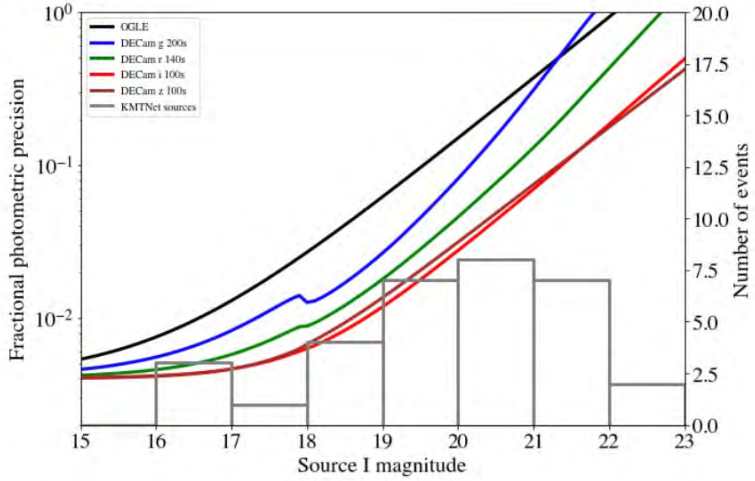
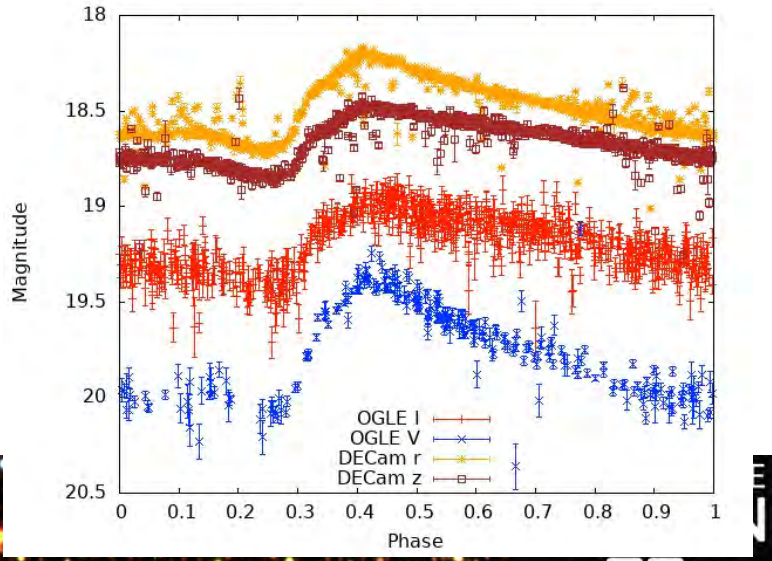
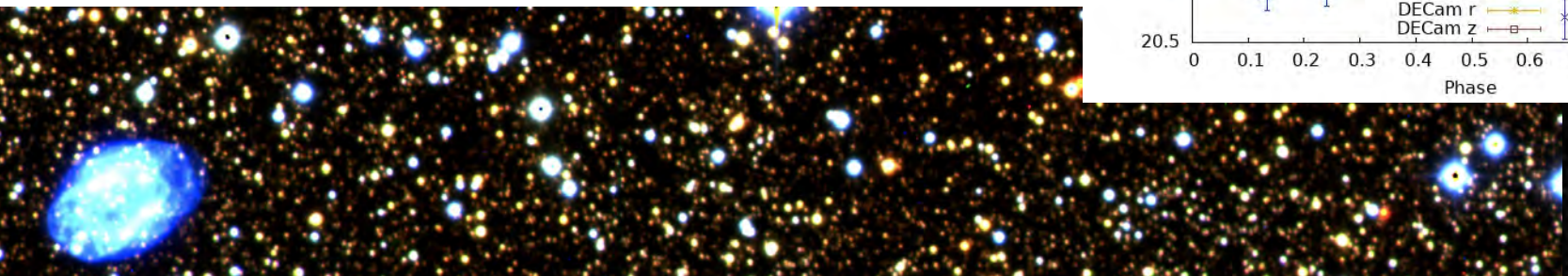
DEFSuS: DECam Faint Source Microlensing Survey



- ~2 min DECam ≈ 1 night of OGLE/KMTNet
- DECAT alliance -> ~3-6 day cadence
- 9 fields = 27 deg^2 ≈ 50% of events
- Simultaneous *r*-*z* color
- Mar-Jul to constrain parallax
- Plan to produce model-independent, calibrated source color + mag + θ_* for all events







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