

Compact Objects

with

Gaia Astrometric Lensing

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[arXiv:2301.00822](https://arxiv.org/abs/2301.00822)

[Github](#)

DM Imprints Gravitational Info in *Gaia*

Outline :

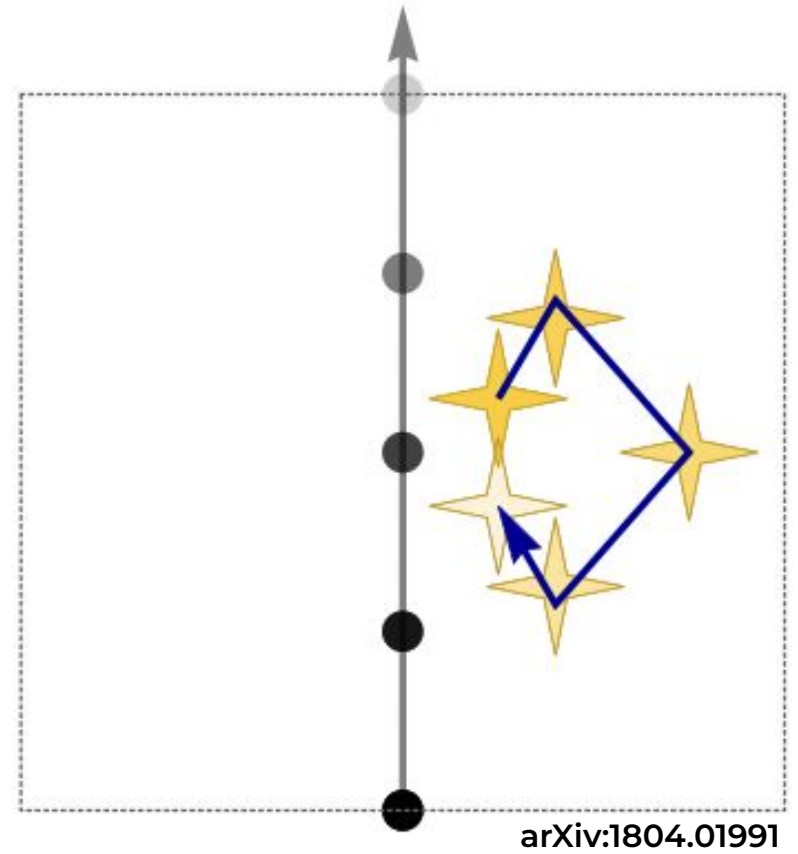
1. Astrometry & Gravitational lensing
2. Mock *Gaia* catalog & Analysis
3. Projection on compact DM constraints

Lensing

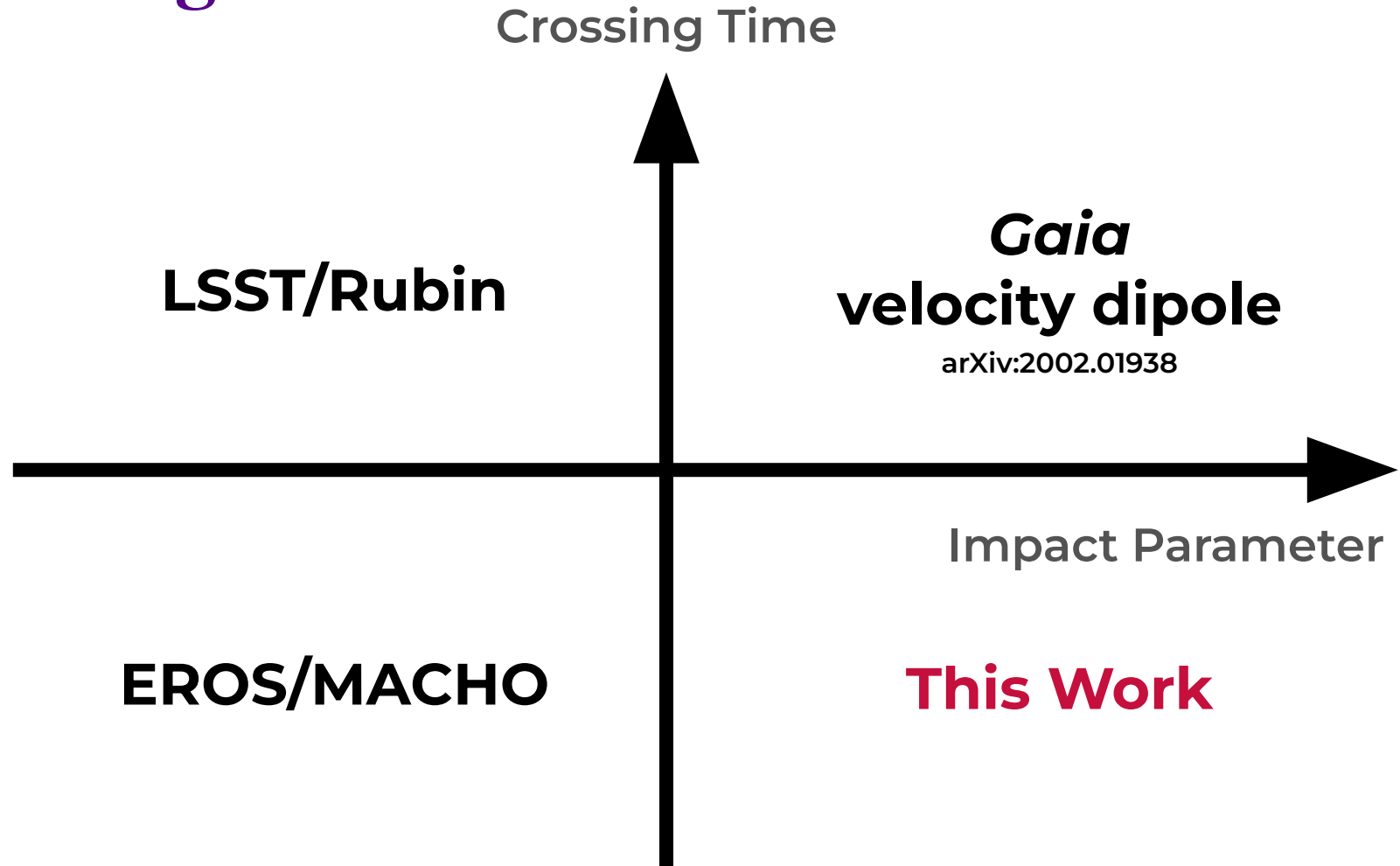
Photometric



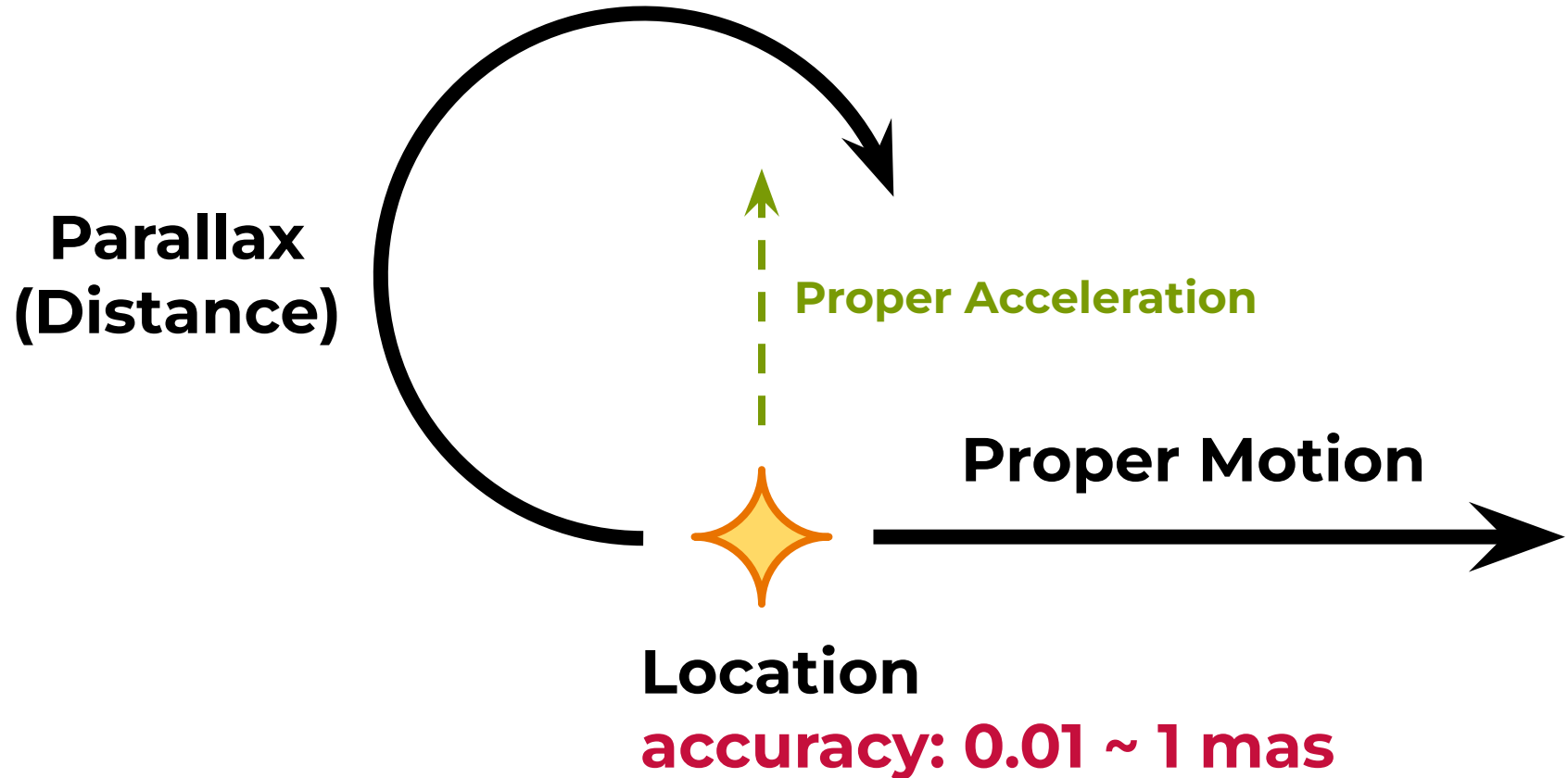
Astrometric



Lensing

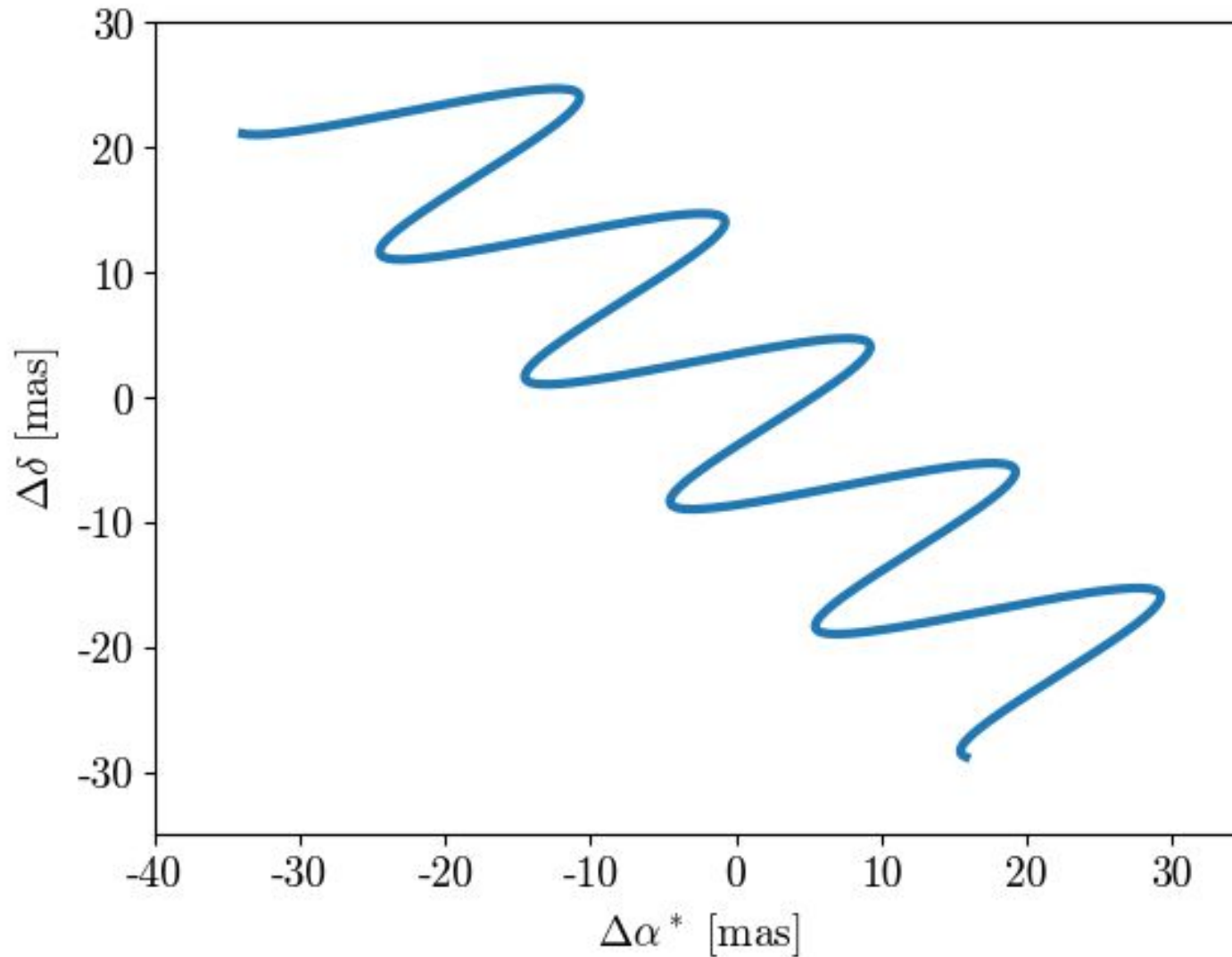


Gaia Astrometry



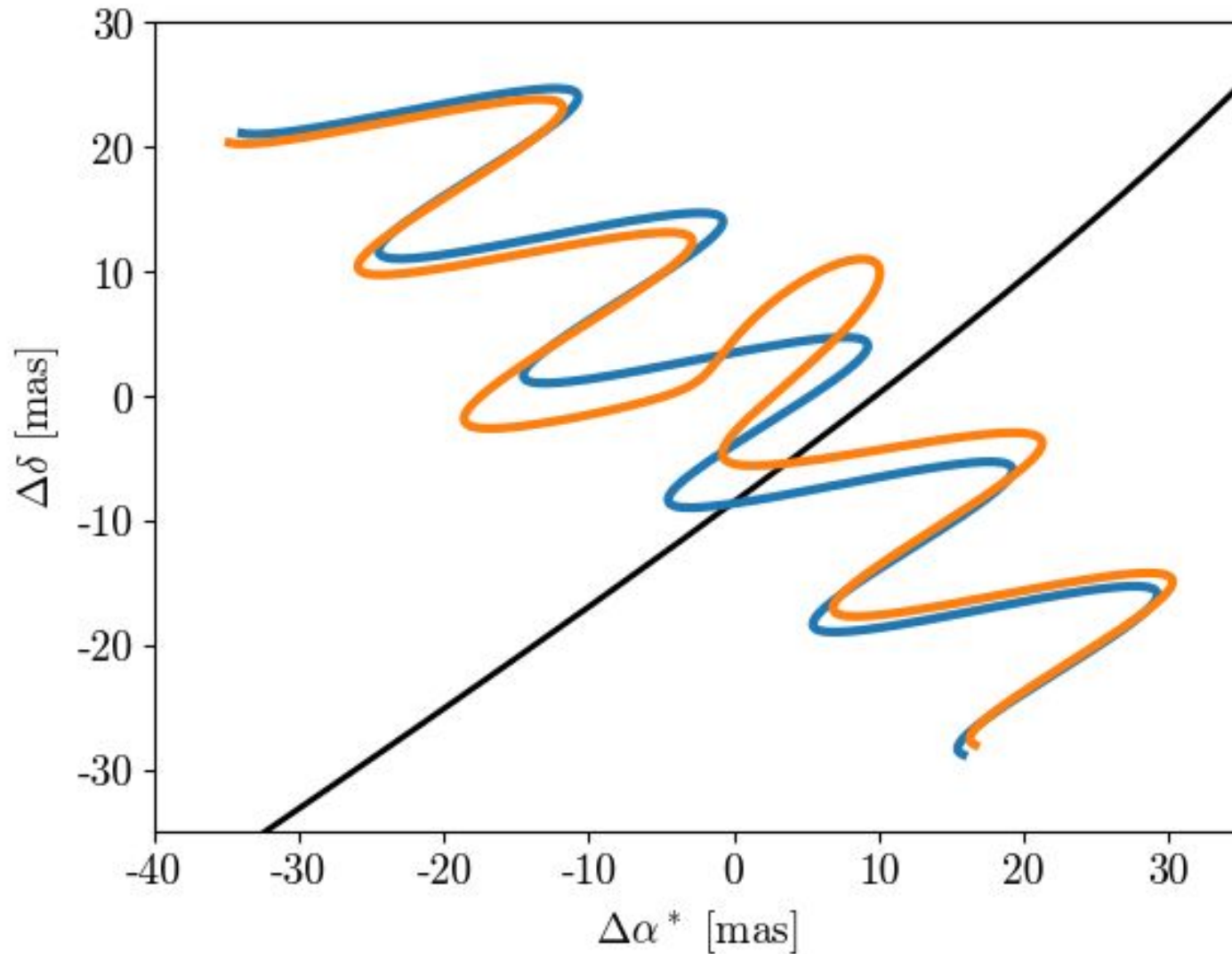
Trajectory

5 Parameters



Trajectory + Lens

5 + 6 Parameters



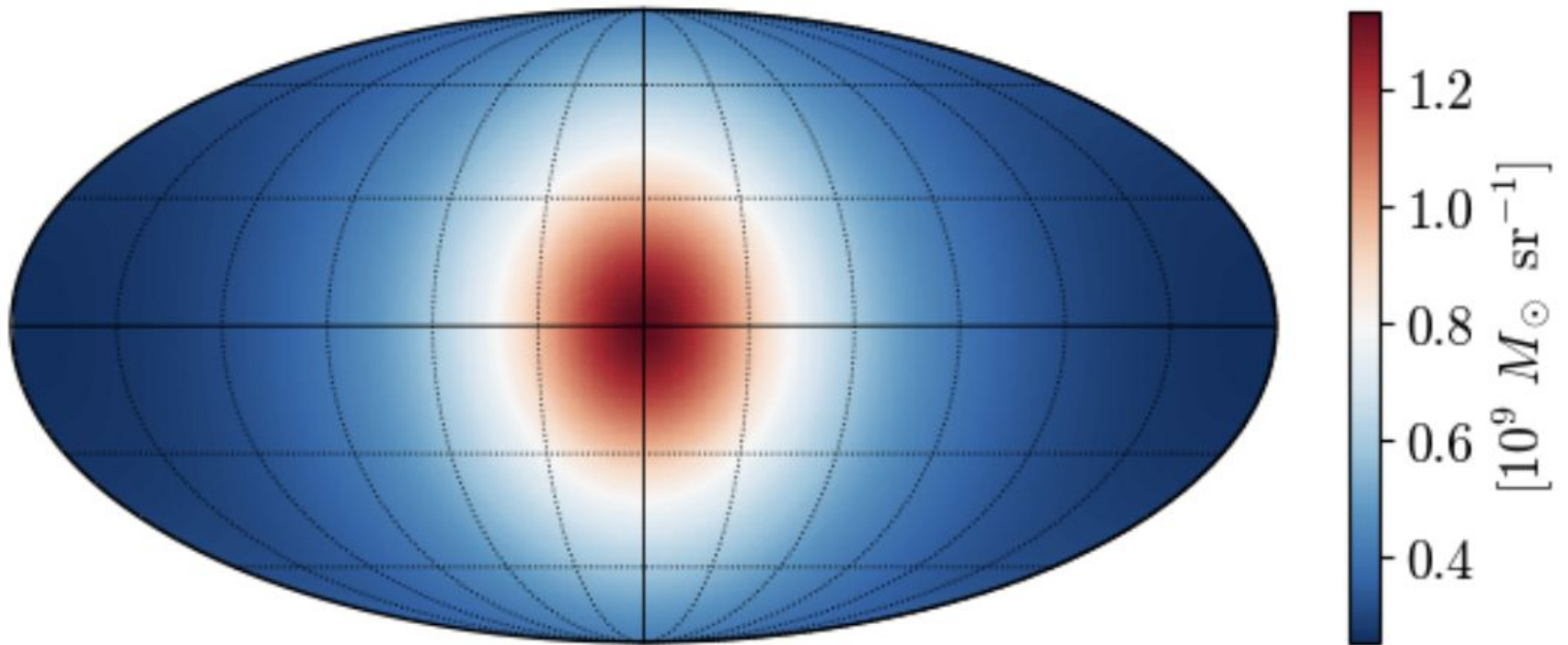
Mock Catalog

EDR3 (2020)	DR4 (2025)
$\sim 1.5 \times 10^9$ stars	$\sim 2.0 \times 10^9$ stars
5 parameter astrometric solution	Full 5 year time-series data



Inject Compact DM Lens

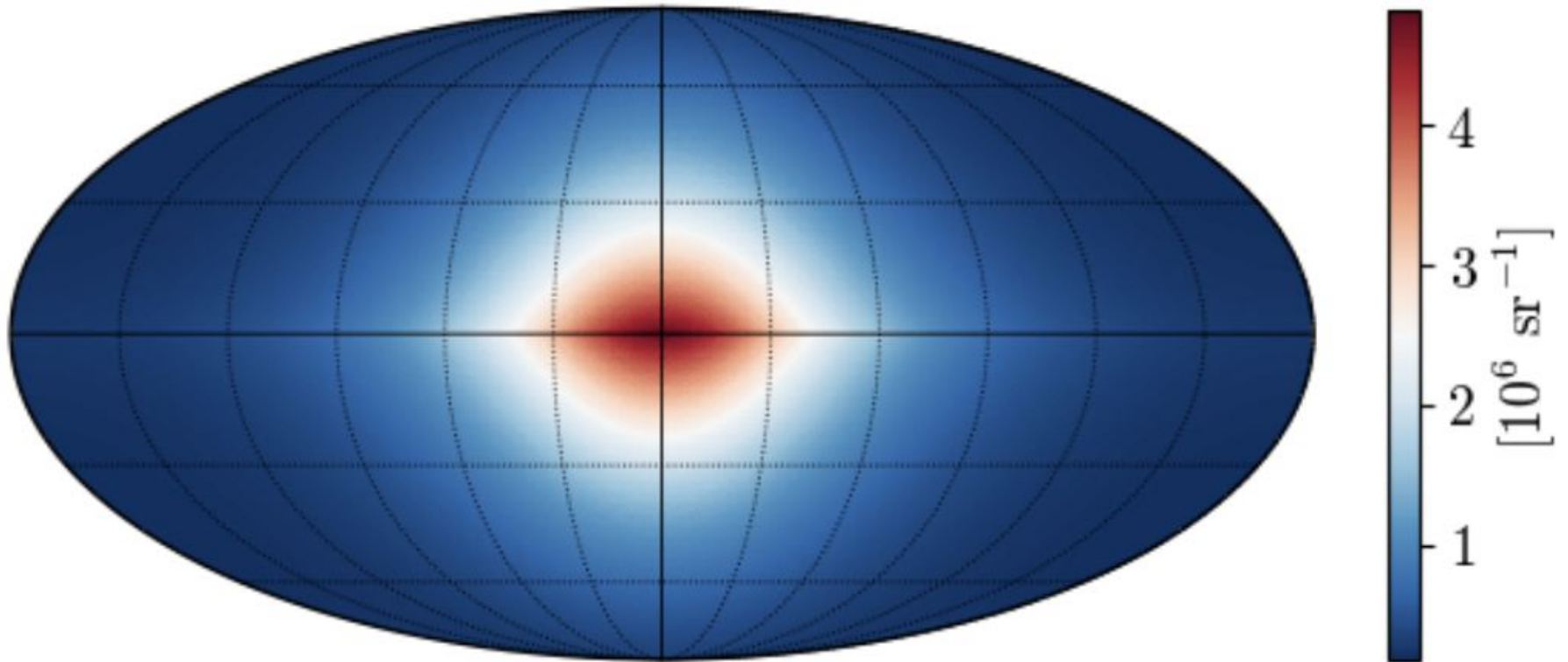
DM Surface Mass Density



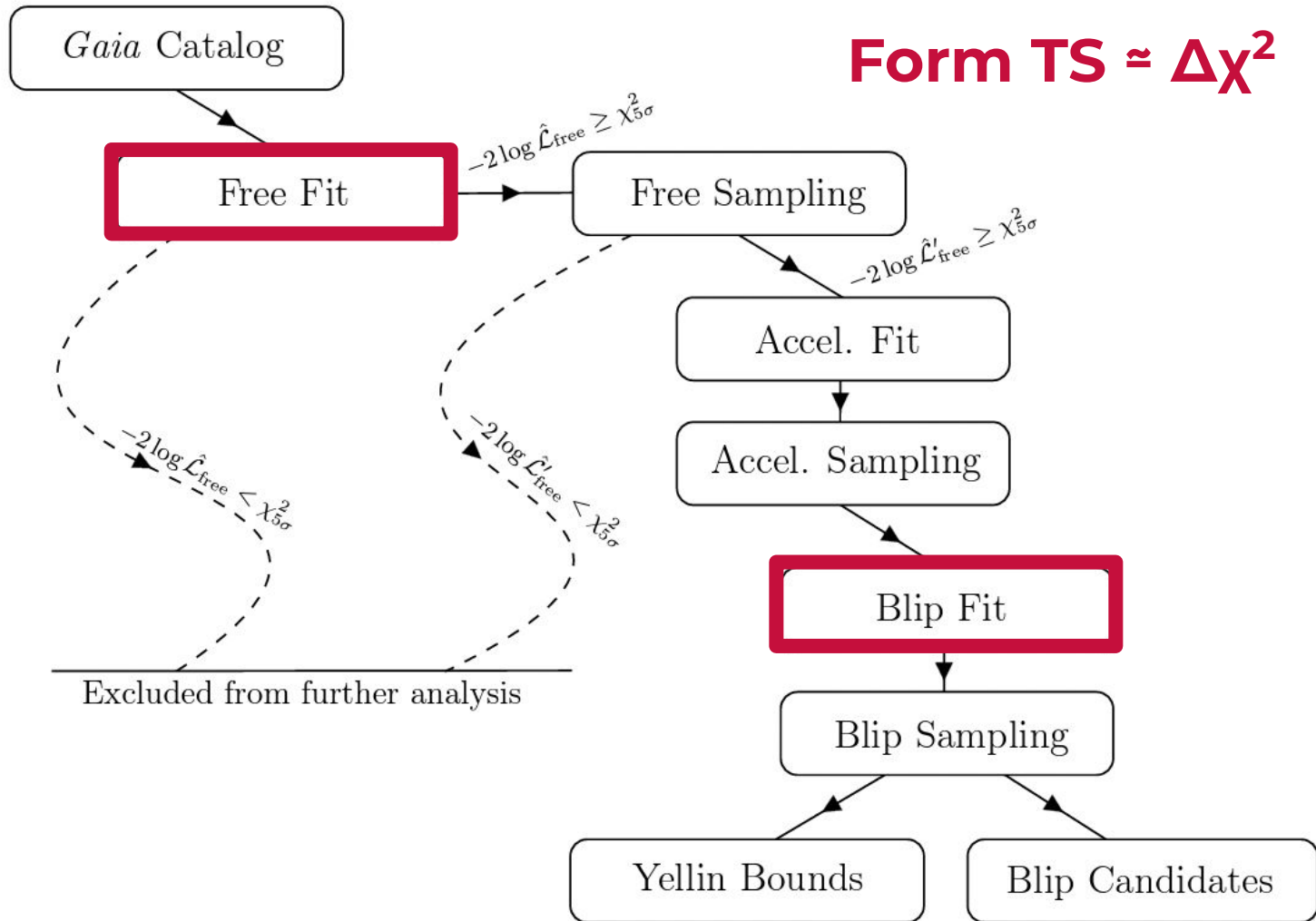
NFW profile

Inject Stellar BH Lens

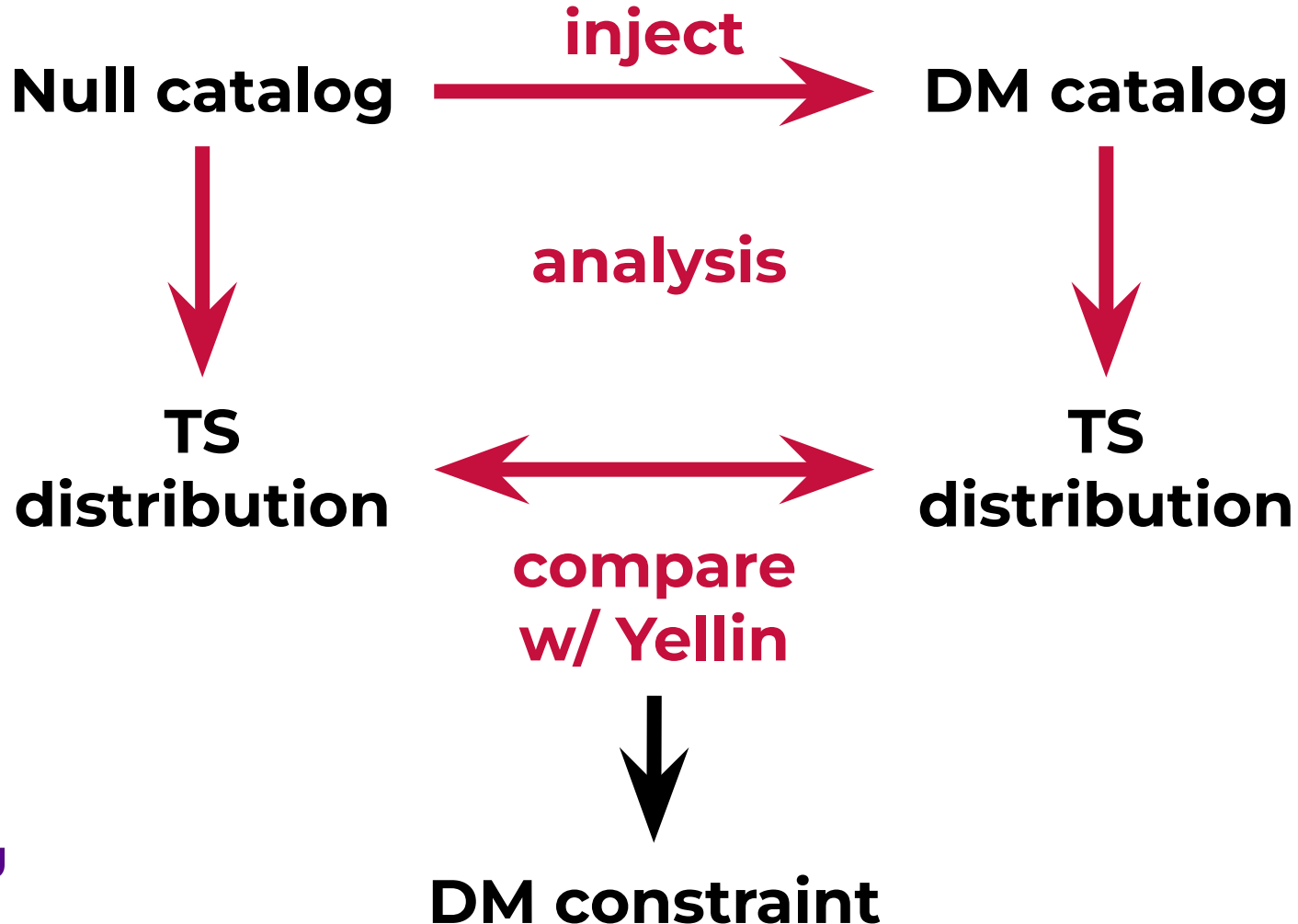
BH Surface Number Density



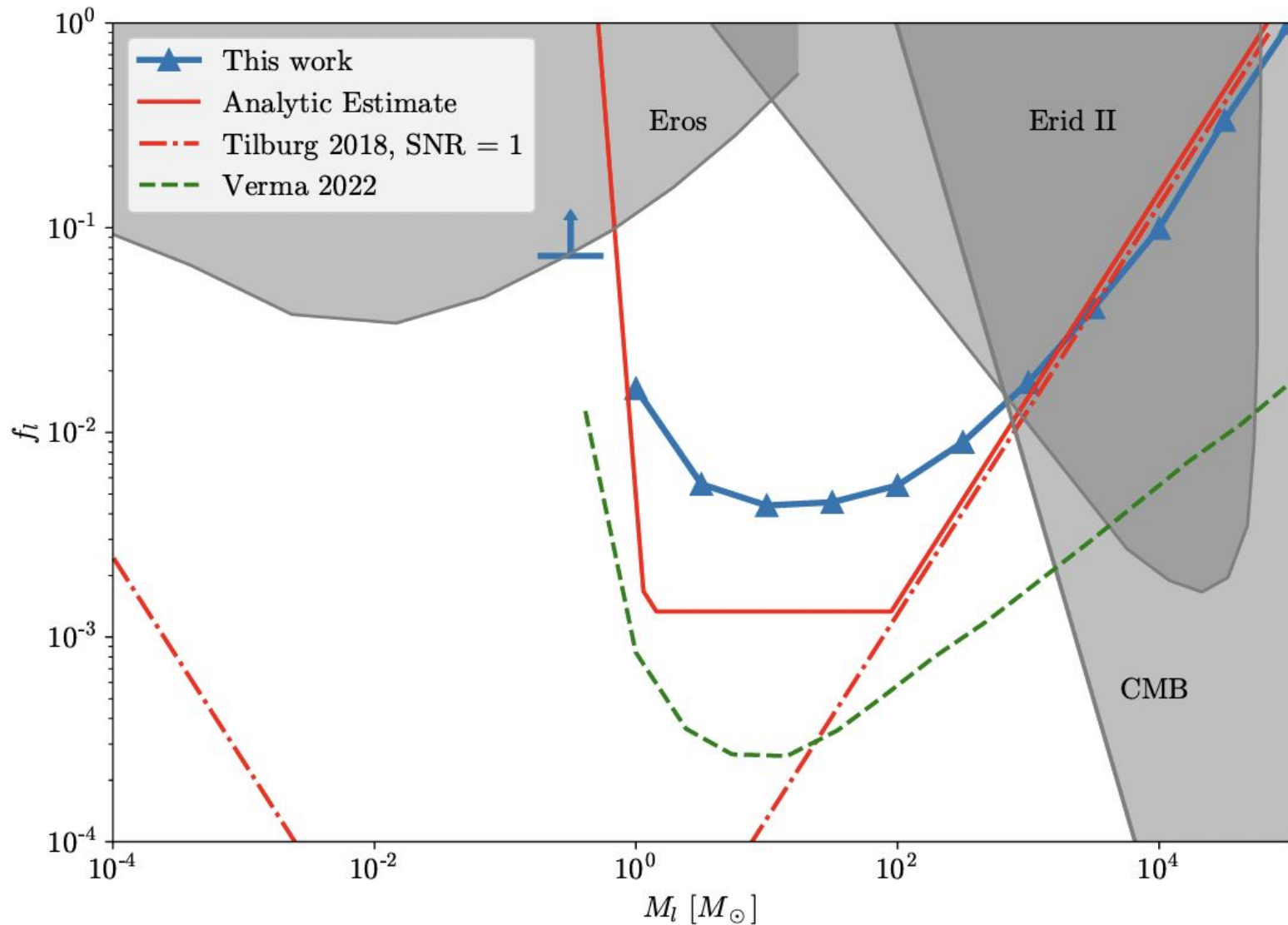
Analysis Pipeline



Constraining DM Population



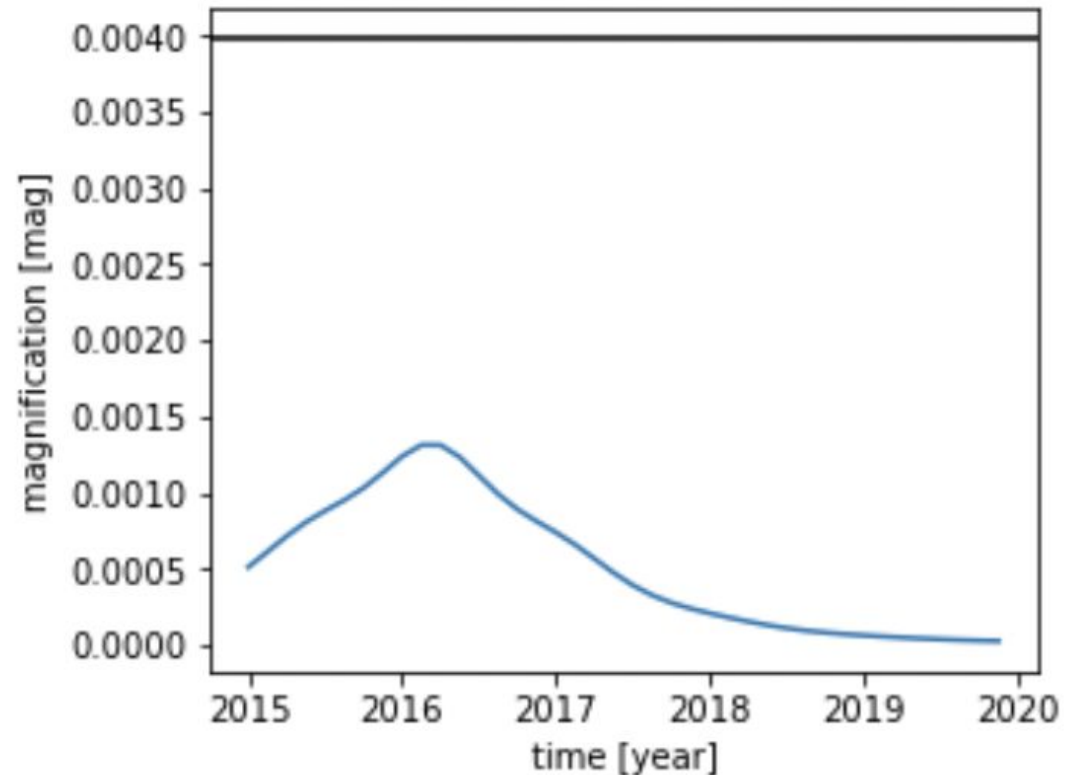
Projected DM Constraint



Discover Isolated Stellar BH

4 stellar BH events above 5- σ in mock catalog

ID	4068042664558486272	
d_s [pc]	7184.126	
blippiness	3.35	
G mag	16.79	
$-2 \log \hat{\mathcal{L}}_{\text{free}}$	1538.27	
$-2 \log \hat{\mathcal{L}}_{\text{accel}}$	451.82	
TS*	1437.47	
TS	1439.82	
	Best Fit	Truth
$\Delta\alpha^*$ [mas]	$-199.17^{+68.82}_{-54.04}$	-196.75
$\Delta\delta$ [mas]	$-124.84^{+42.41}_{-43.99}$	-132.45
μ_{α^*} [mas/yr]	$-20.31^{+12.29}_{-15.51}$	-9.54
μ_{δ} [mas/yr]	$-116.11^{+37.21}_{-32.17}$	-114.30
d [pc]	$302.11^{+156.61}_{-86.13}$	360.32
m [M_{\odot}]	$27.24^{+6.41}_{-6.46}$	31.90

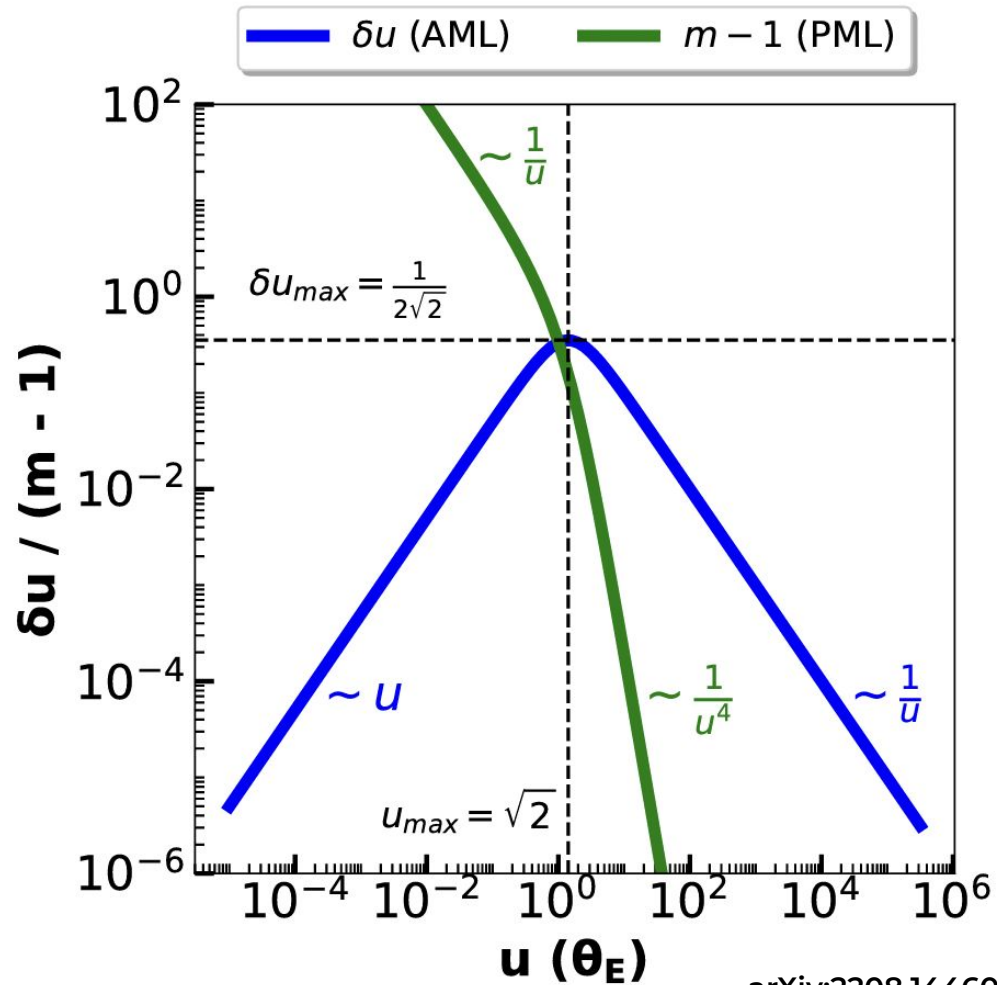


Takeaway

1. **Develop flexible & faithful mock *Gaia* catalog and data analysis pipeline**
2. **Projection on compact DM constraints**
3. **Projection on discovering isolated stellar BH**

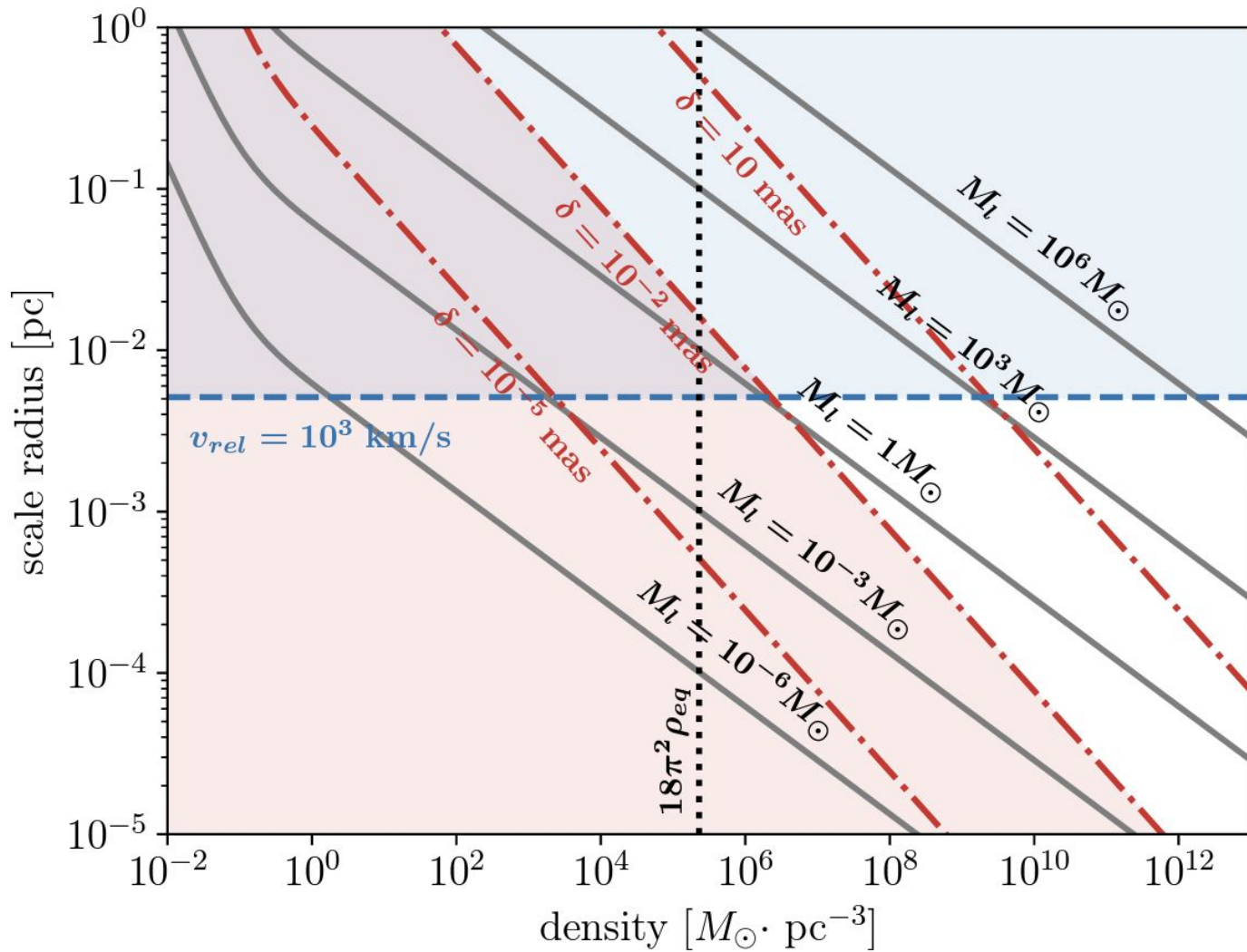
Extra Slides

Photometric v.s. Astrometric

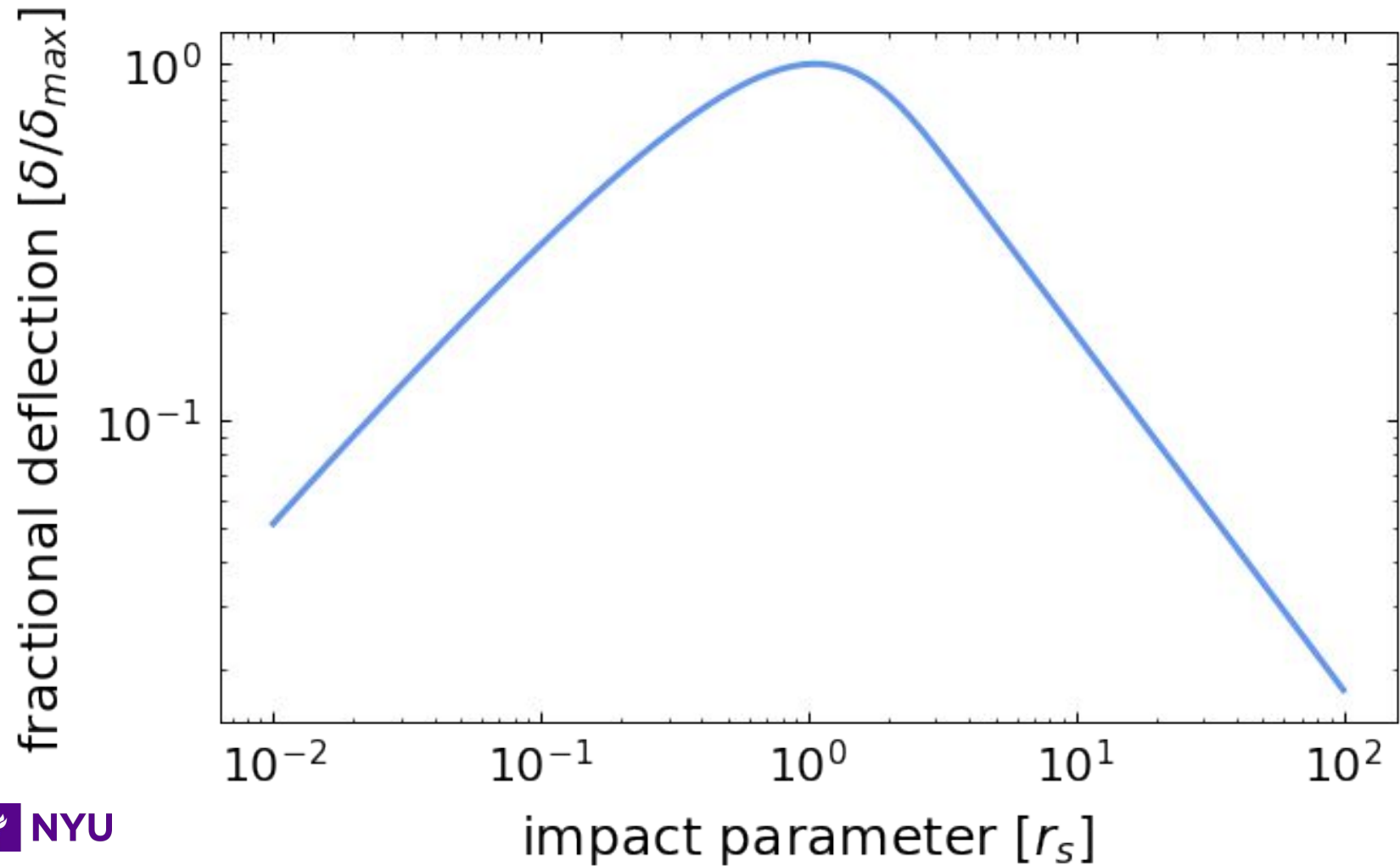


Extended Lens

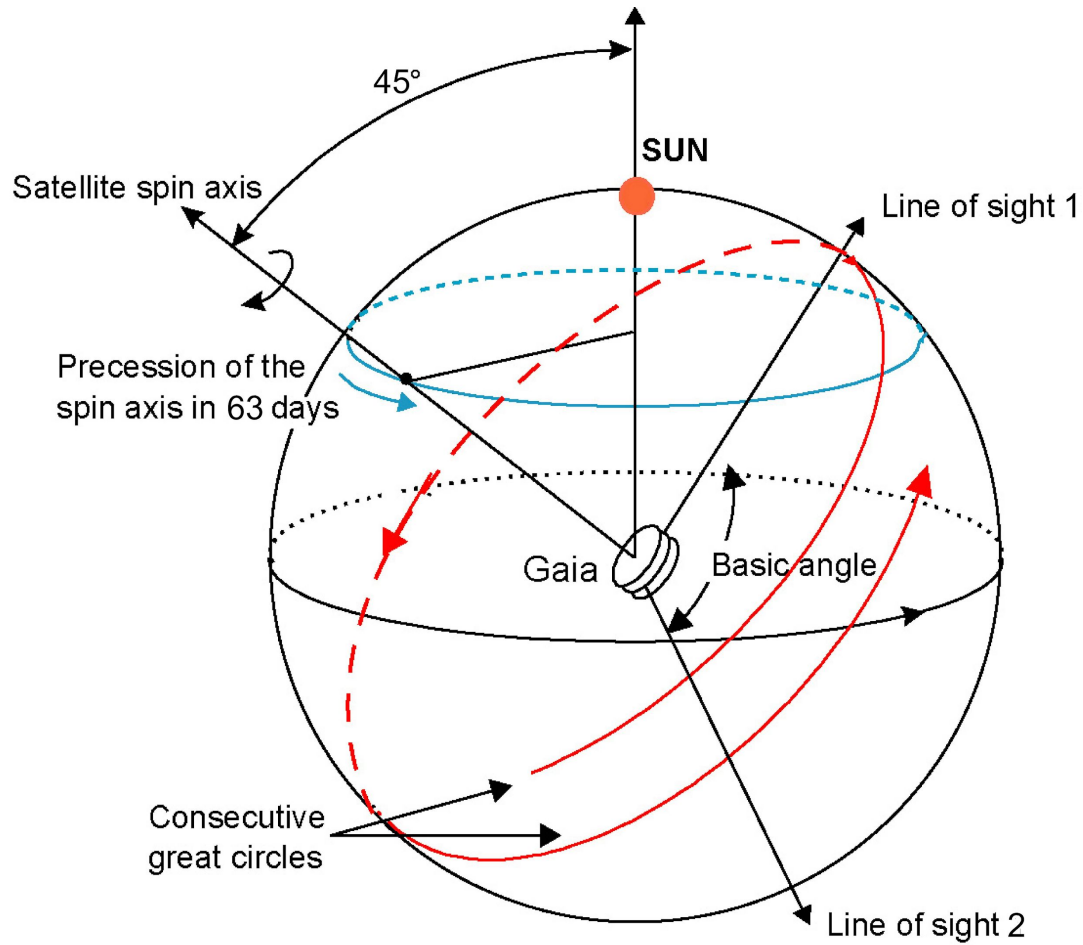
$$\rho_l(r) = \frac{M_l}{4\pi} \frac{\exp\left\{-\frac{r^2}{2r_l^2}\right\}}{rr_l^2}$$



Maximum deflection, Extended lens



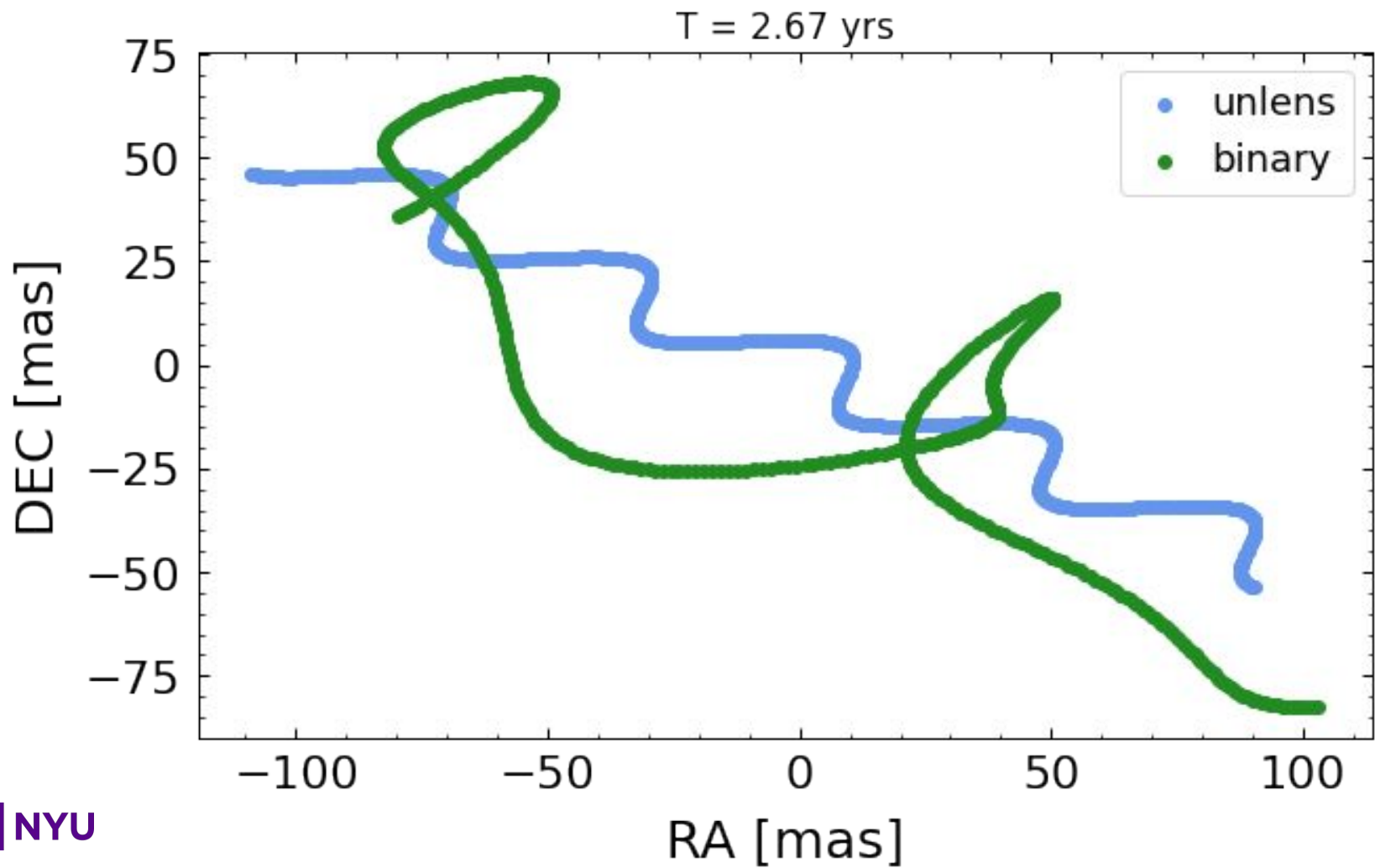
Gaia Scanning Law



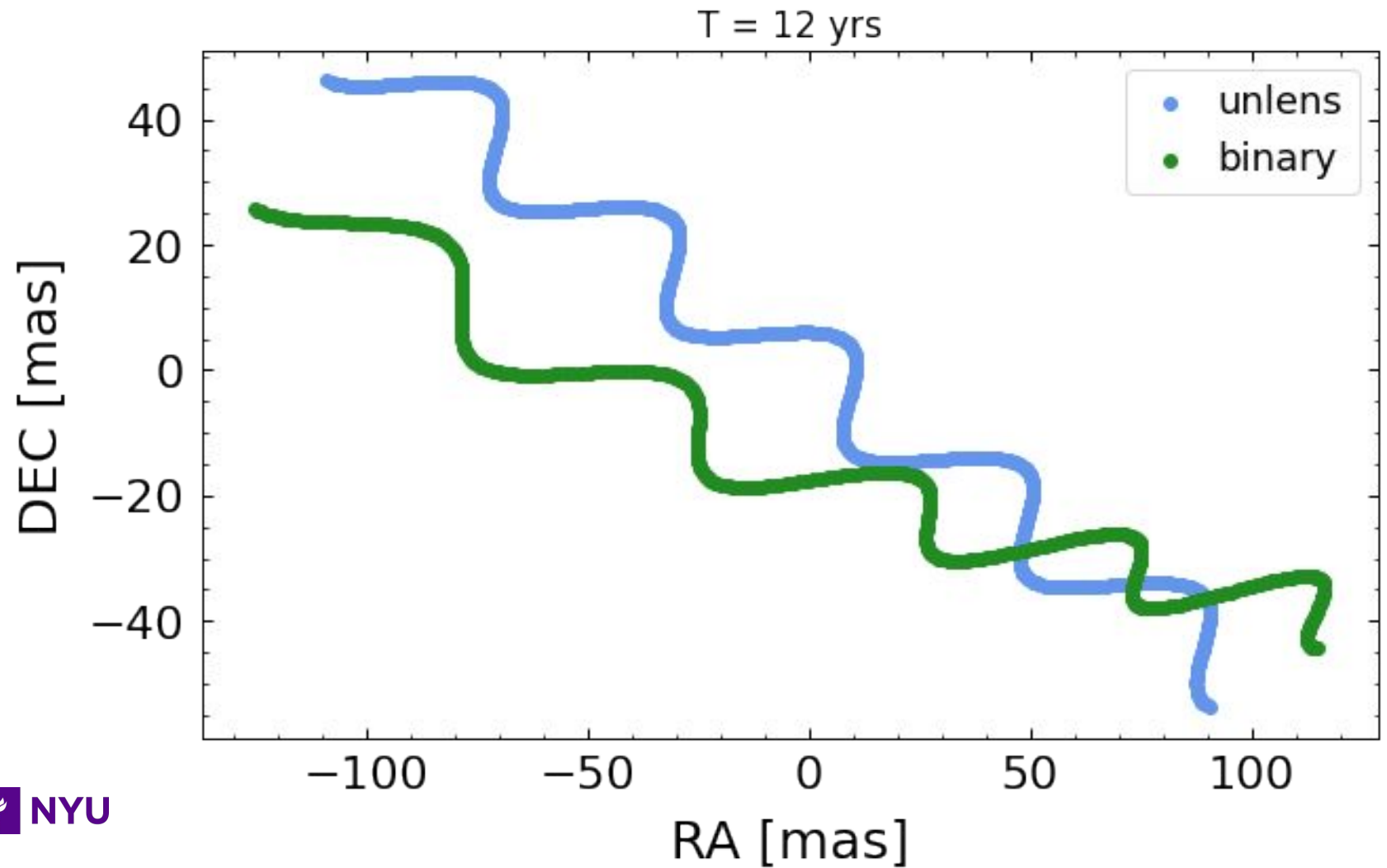
Gaia Scanning Law

$ \sin\beta $	β_{\min} [°]	β_{\max} [°]	N_{obs}	α^*	δ	ϖ	μ_{α^*}	μ_{δ}
0.025	0.0	2.9	61	1.026	0.756	1.180	0.725	0.542
0.075	2.9	5.7	61	1.021	0.757	1.180	0.722	0.542
0.125	5.7	8.6	62	1.002	0.751	1.169	0.710	0.537
0.175	8.6	11.5	62	0.993	0.752	1.167	0.703	0.539
0.225	11.5	14.5	63	0.973	0.751	1.158	0.689	0.538
0.275	14.5	17.5	65	0.952	0.742	1.143	0.673	0.533
0.325	17.5	20.5	66	0.934	0.740	1.136	0.662	0.533
0.375	20.5	23.6	68	0.901	0.730	1.119	0.640	0.525
0.425	23.6	26.7	71	0.861	0.718	1.098	0.614	0.515
0.475	26.7	30.0	75	0.819	0.705	1.072	0.584	0.506
0.525	30.0	33.4	80	0.765	0.691	1.043	0.548	0.493
0.575	33.4	36.9	87	0.701	0.673	1.009	0.500	0.477
0.625	36.9	40.5	98	0.631	0.650	0.970	0.541	0.461
0.675	40.5	44.4	122	0.535	0.621	0.922	0.381	0.437
0.725	44.4	48.6	144	0.469	0.607	0.850	0.327	0.423
0.775	48.6	53.1	106	0.554	0.636	0.808	0.386	0.443
0.825	53.1	58.2	93	0.603	0.654	0.779	0.422	0.456
0.875	58.2	64.2	85	0.641	0.669	0.755	0.447	0.467
0.925	64.2	71.8	80	0.668	0.680	0.731	0.466	0.473
0.975	71.8	90.0	75	0.688	0.706	0.713	0.481	0.490
Sky-average	0.0	90.0	81	0.787	0.699	1.000	0.556	0.496

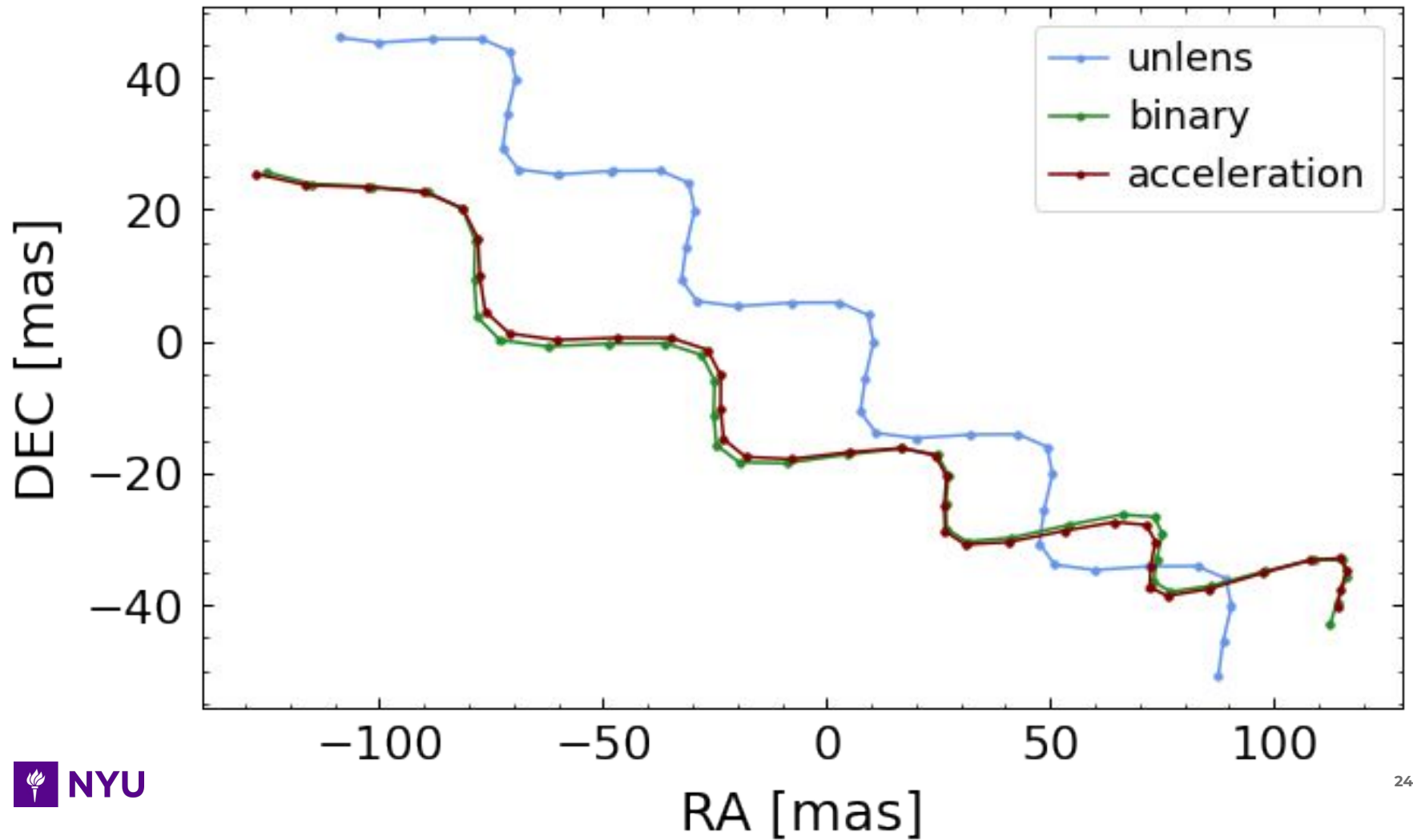
Binaries



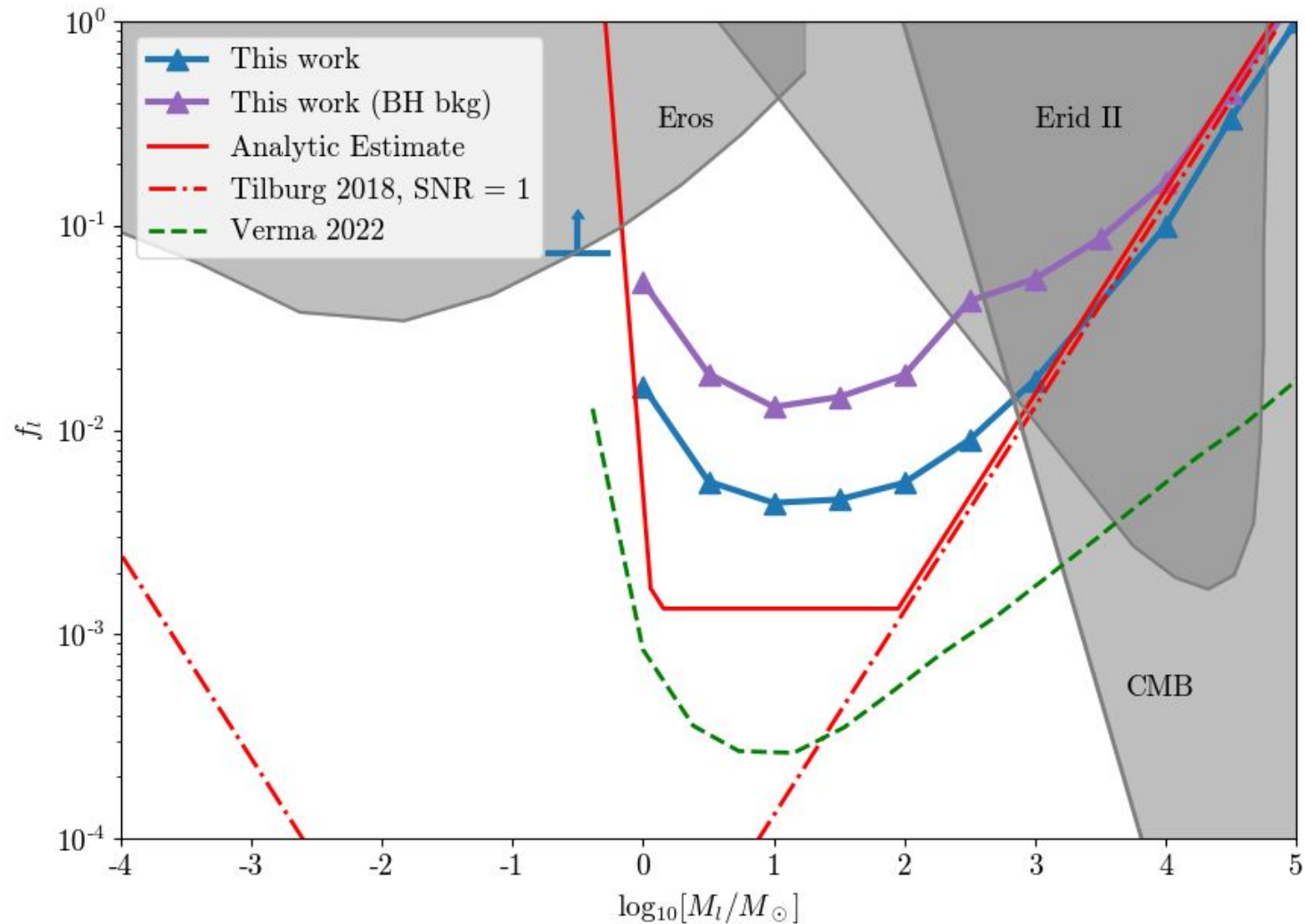
Binaries



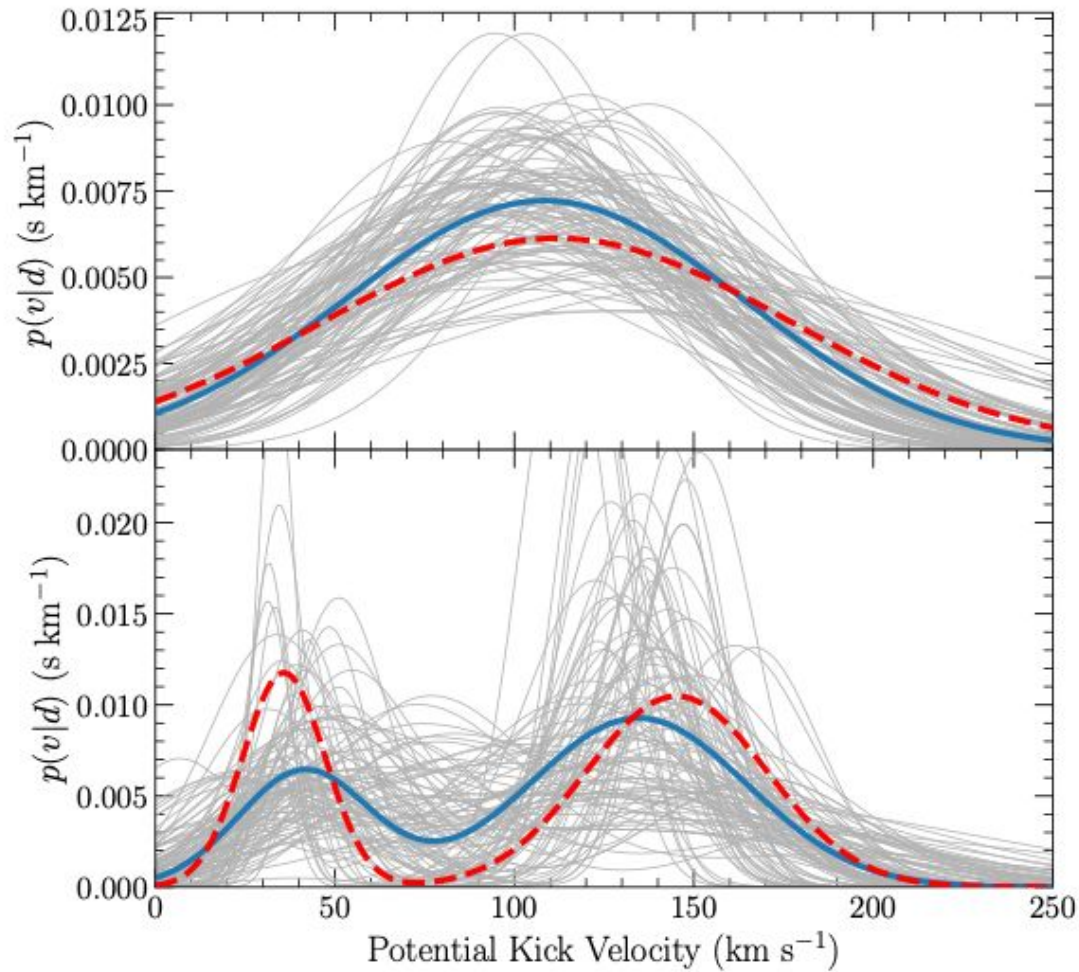
Binaries



DM Constraint with Background



BH Natal Kicks



arXiv:1908.07199