The multi[illegible] a Rubin Observato[illegible]y's LSST era

CLICKBAIT

CNOC XII

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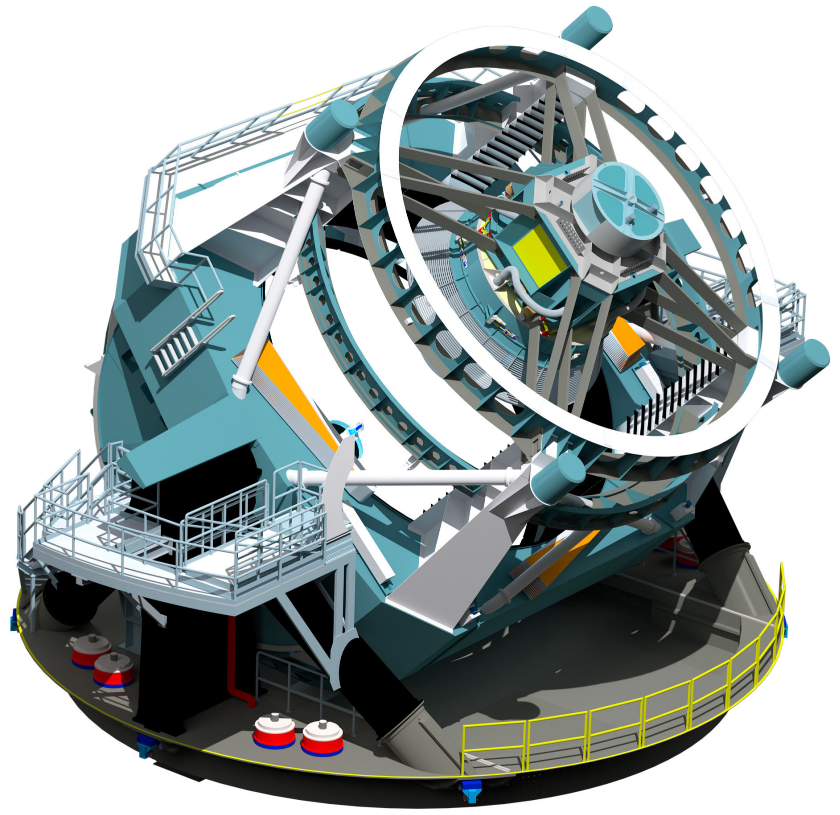
Location: Cerro Pachón in [Chile]()

Effective aperture: 6.7 m

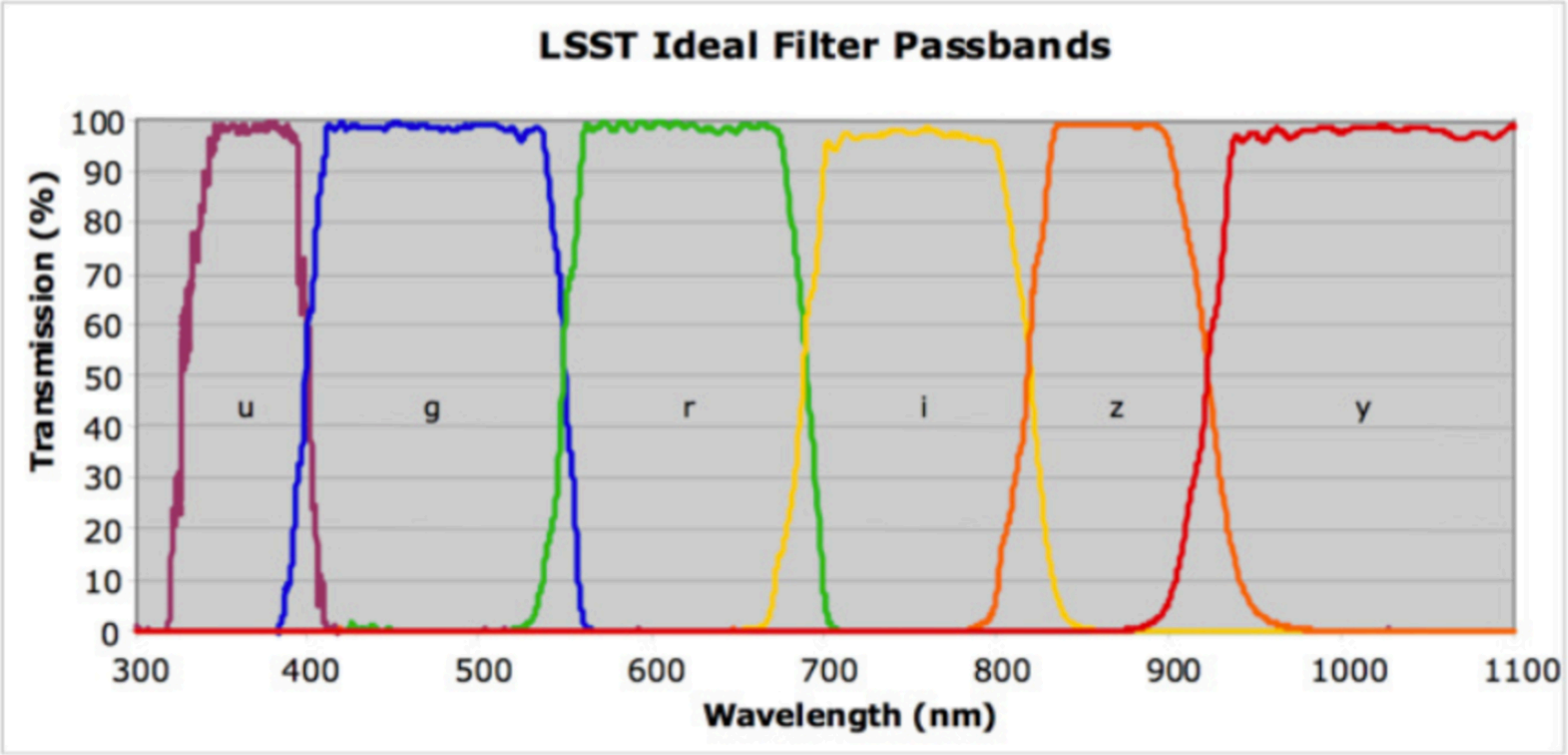
Image field of view: 9.8 deg^2

Survey Area: 18000 deg^2



MAIN GOALS:

- Understanding Dark Energy and the nature of Dark Matter
- Cataloging the Solar System
- Exploring the Transient and Variable Sky
- Exploring the Milky Way Structure & Formation



Depth: single exposure vs co-add

- u : 23.9, 26.1
- g : 25.0, 27.4
- r : 24.7, 27.5
- i : 24.0 , 26.8
- z : 23.3, 26.1
- y : 22.1, 24.9

Large Synoptic Survey Telescope (LSST)

What are we looking for?

Methods

Preliminary results

Connection with future GW detectors

Conclusions

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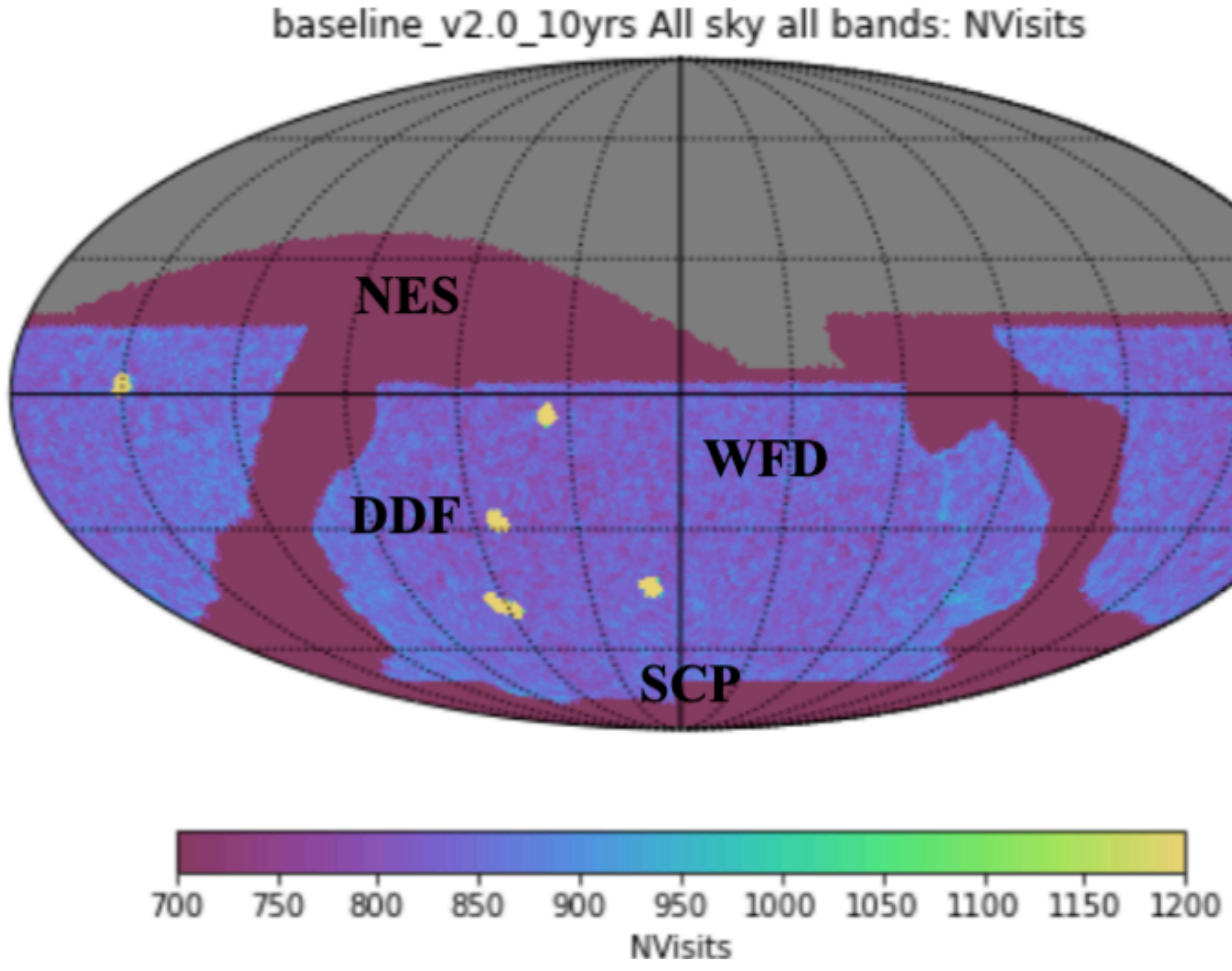
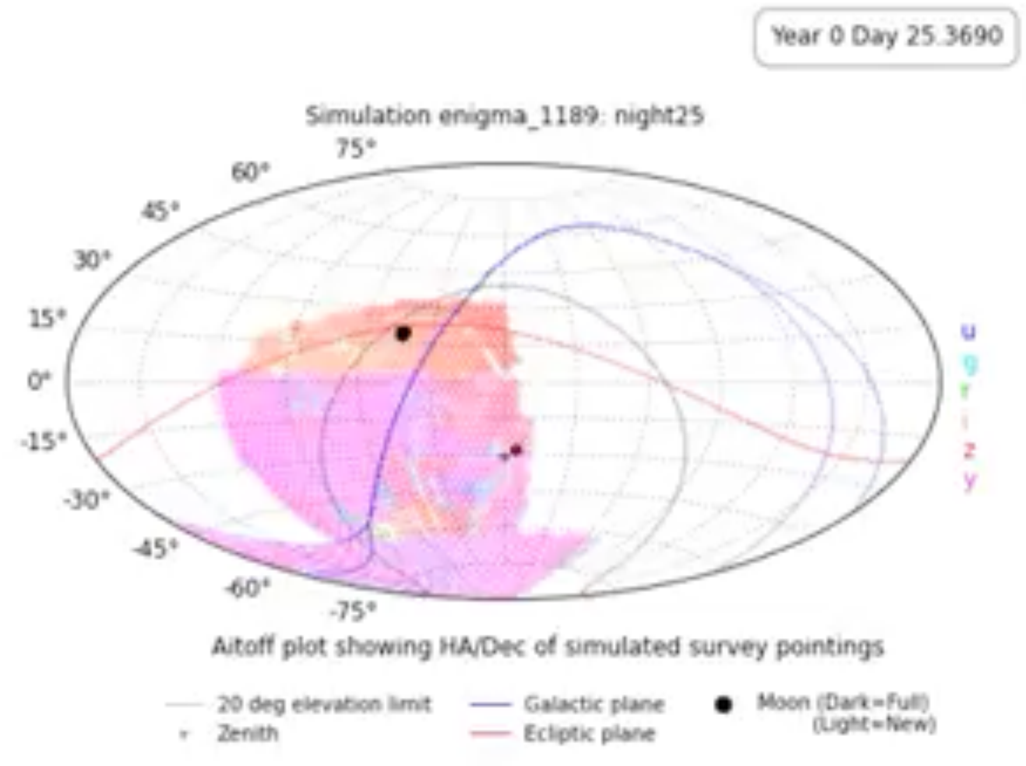
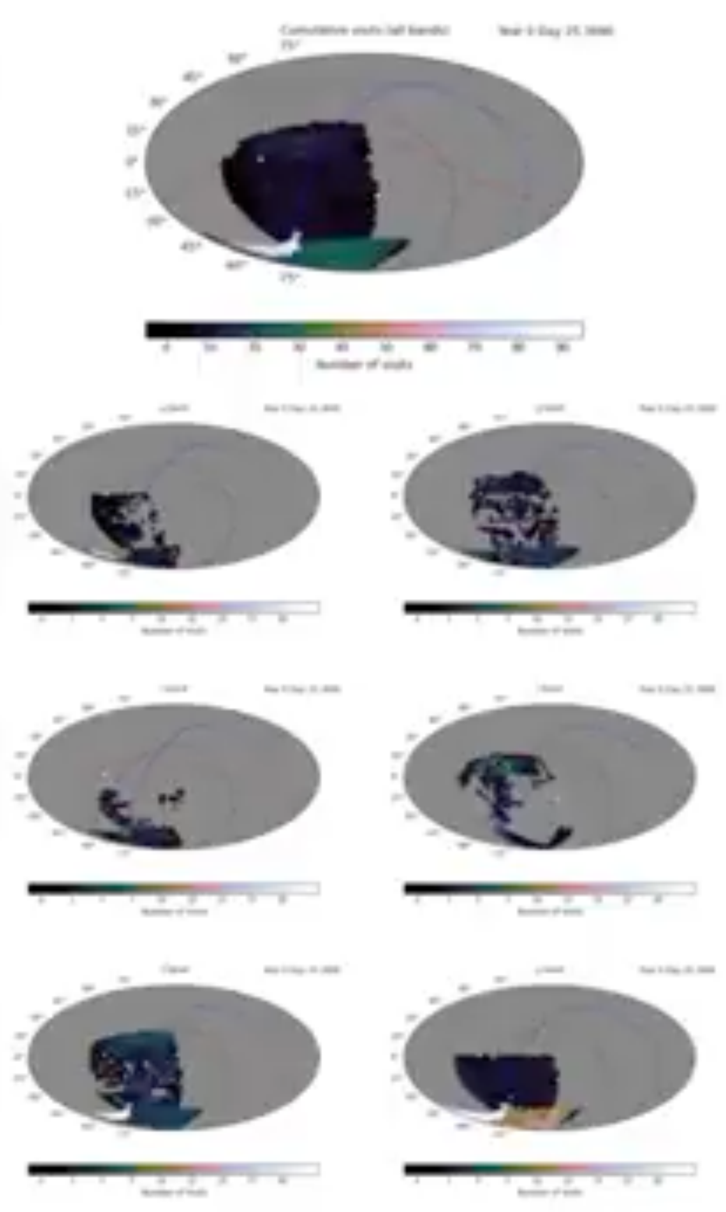


http://astro-lsst-01.astro.washington.edu/



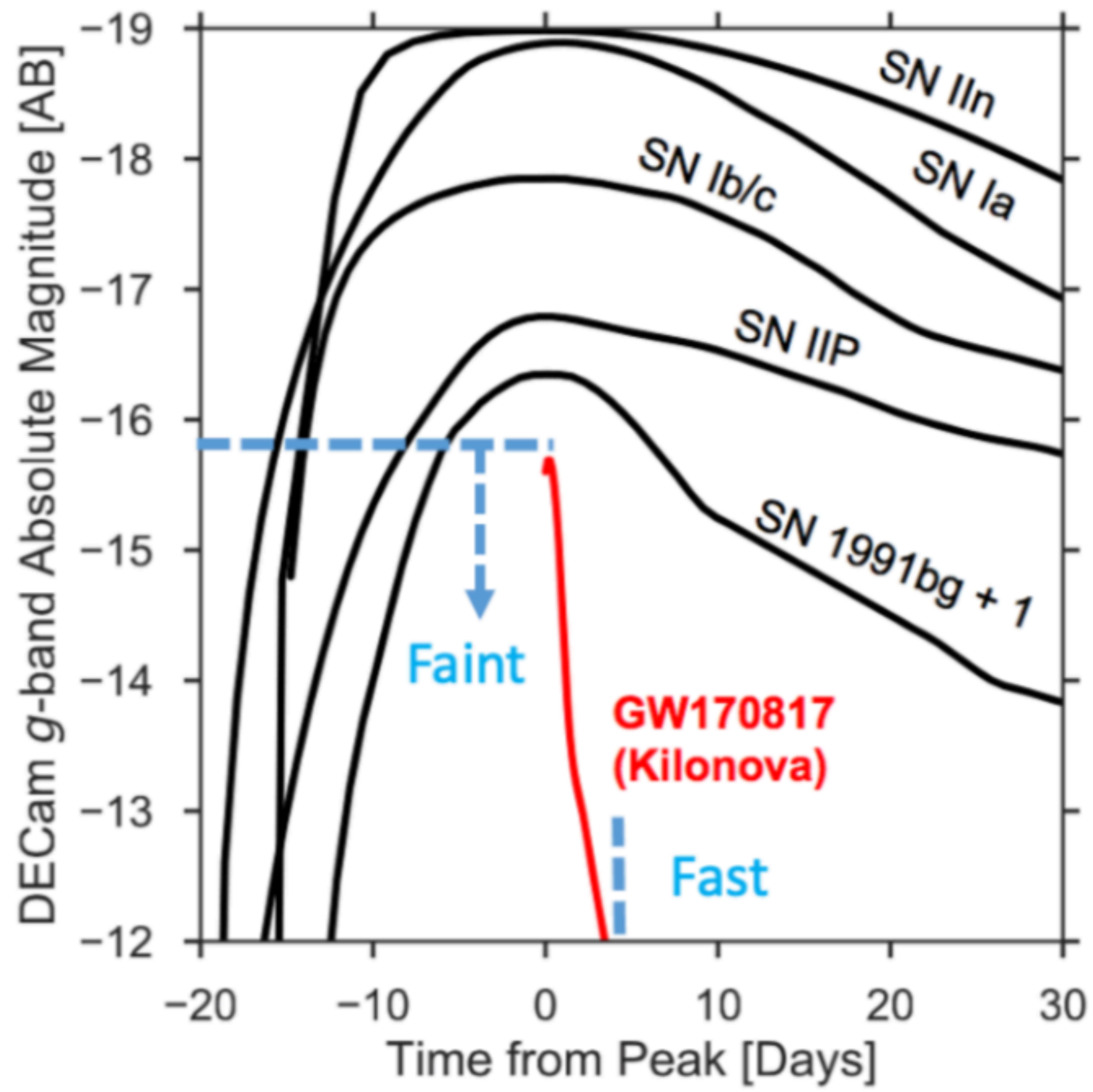


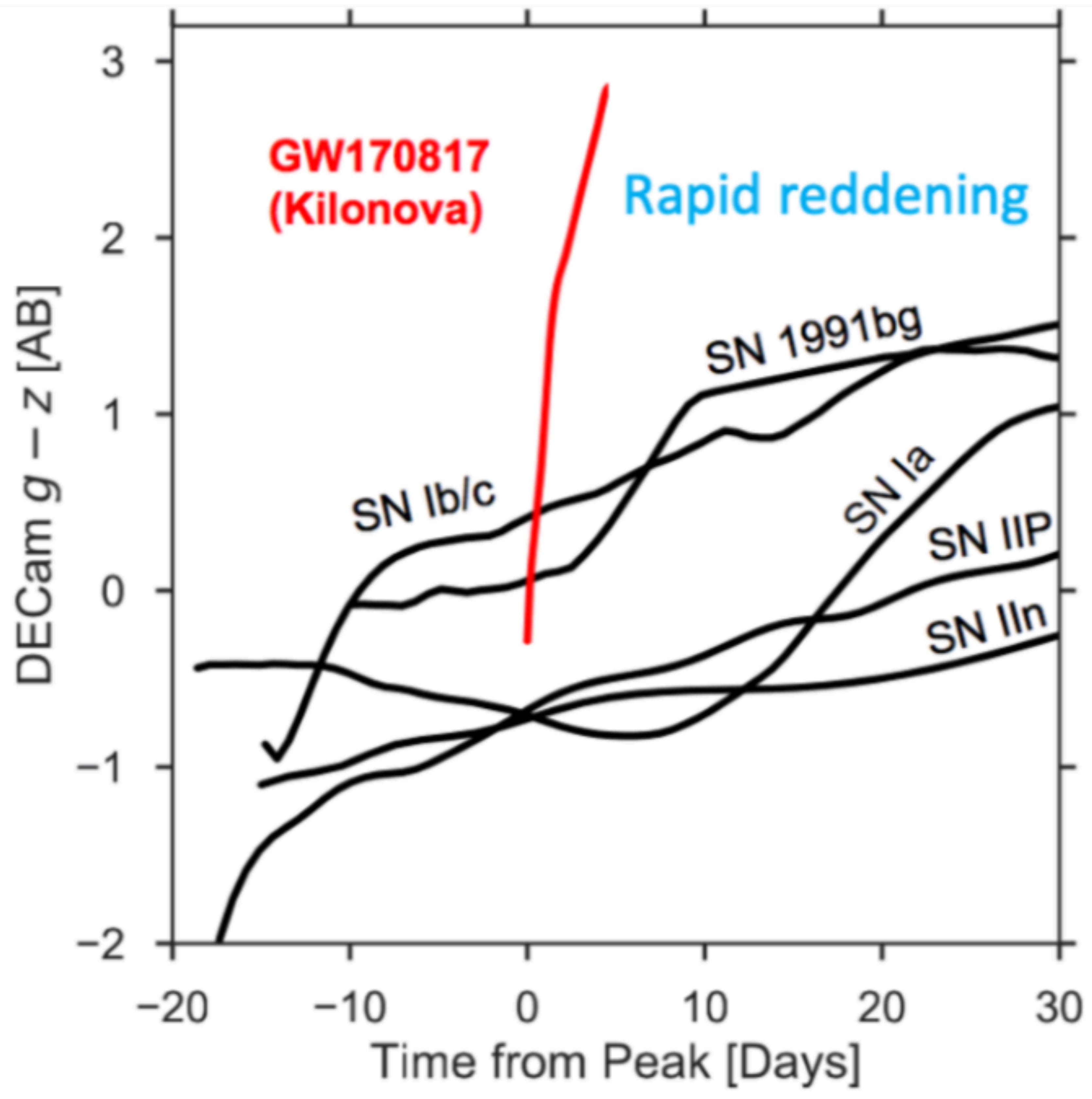
Leanne Guy et al 2014

The survey identifies different regions of the observed Sky (footprint) where the observing strategy might differ from the main Wide Fast Deep (WDF) survey.

DDF: Deep Drilling Fields ; NES: North Ecliptic Spour; SCP: South Celestial Pole.

The system throughputs are simulated through the OpSim (Operation Simulator) for the entire survey





Andreoni et al 2018

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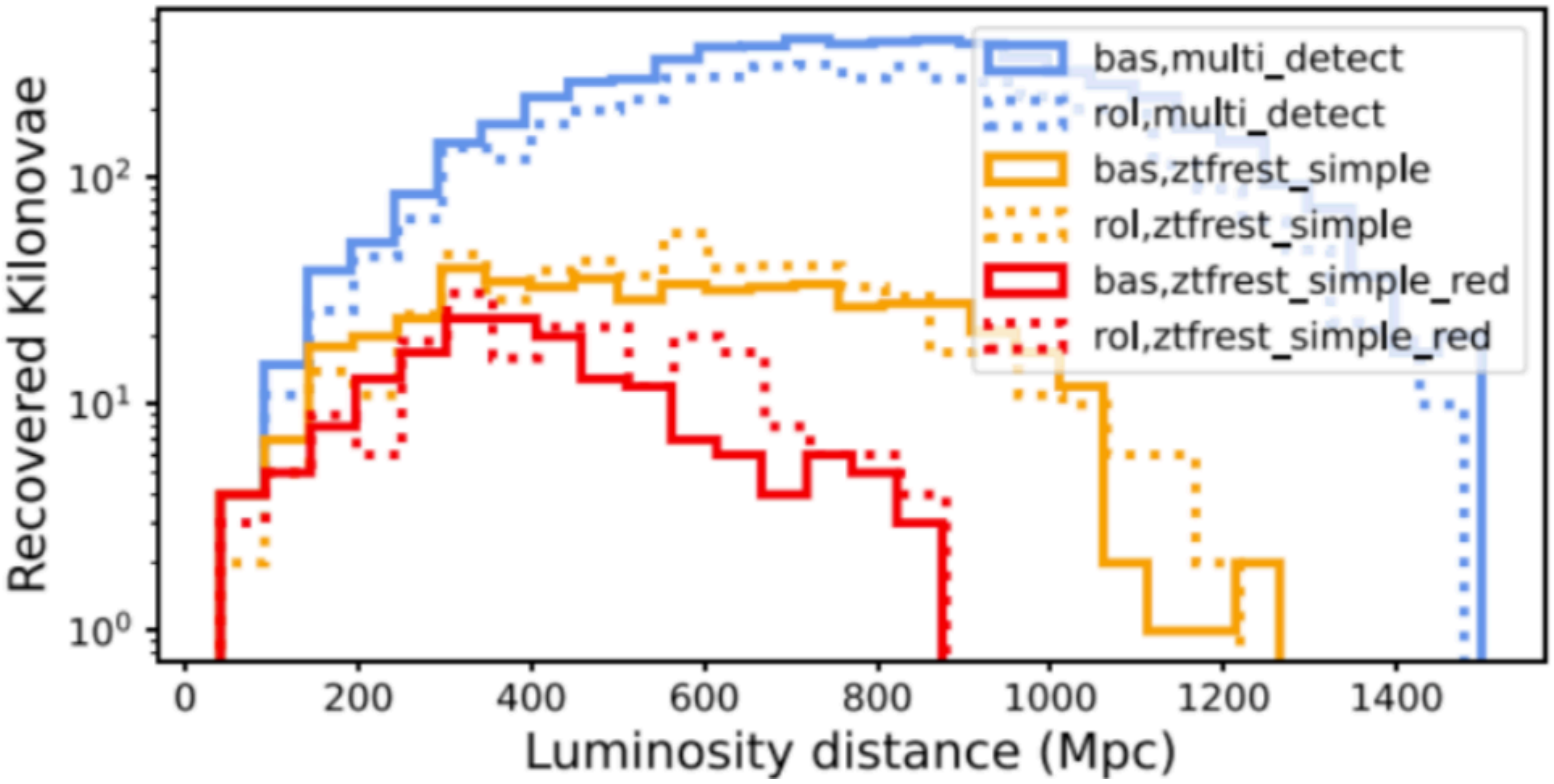
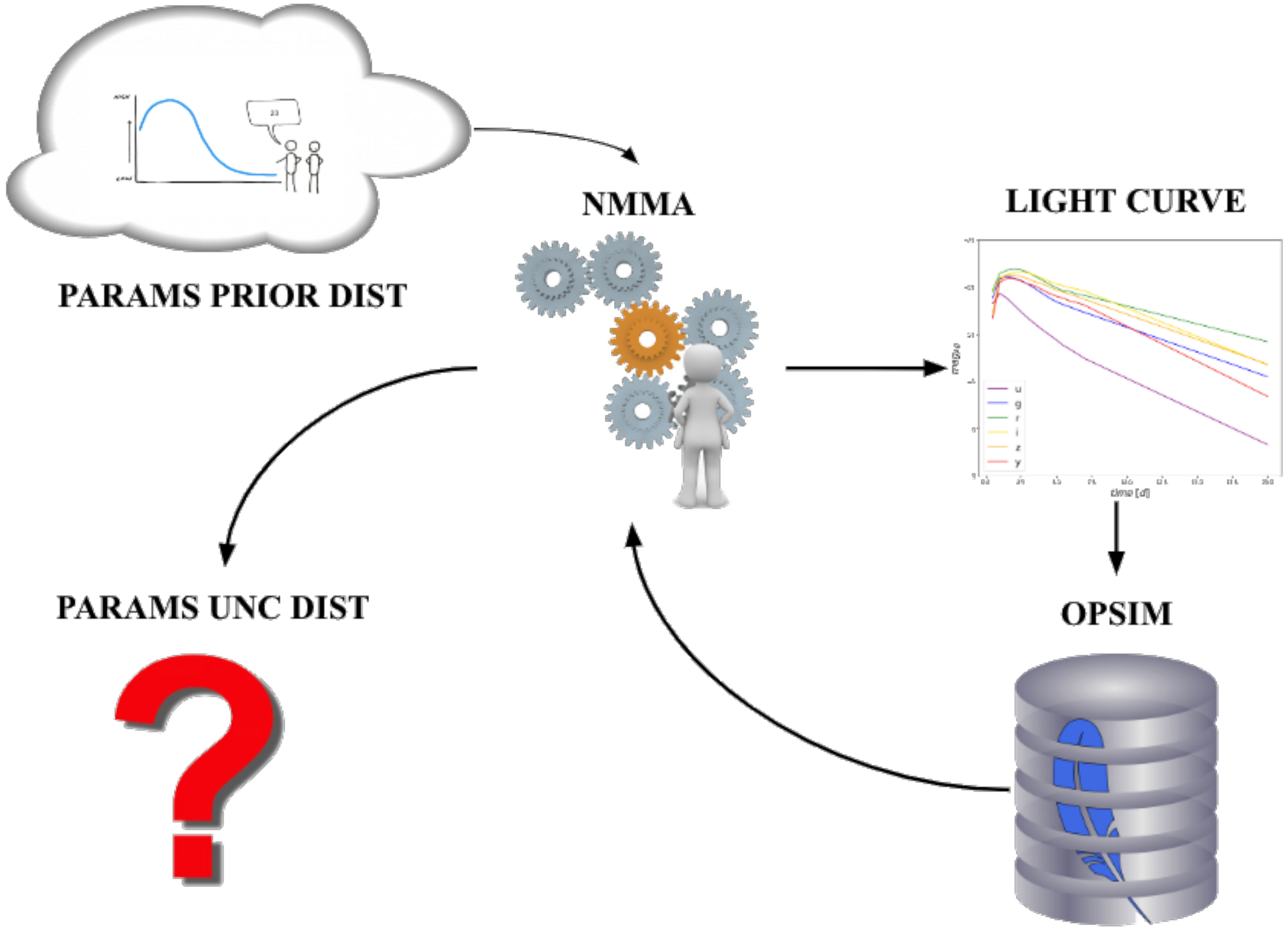


Andreoni et al 2022

- multi_detect: ≥ 2 detection snr ≥ 5
- ztfrest_simple: rising ≥1mag/day and fading ≥0.3 mag/day
- ztfrest_simple_red: as ztfrest_simple but only in izy bands



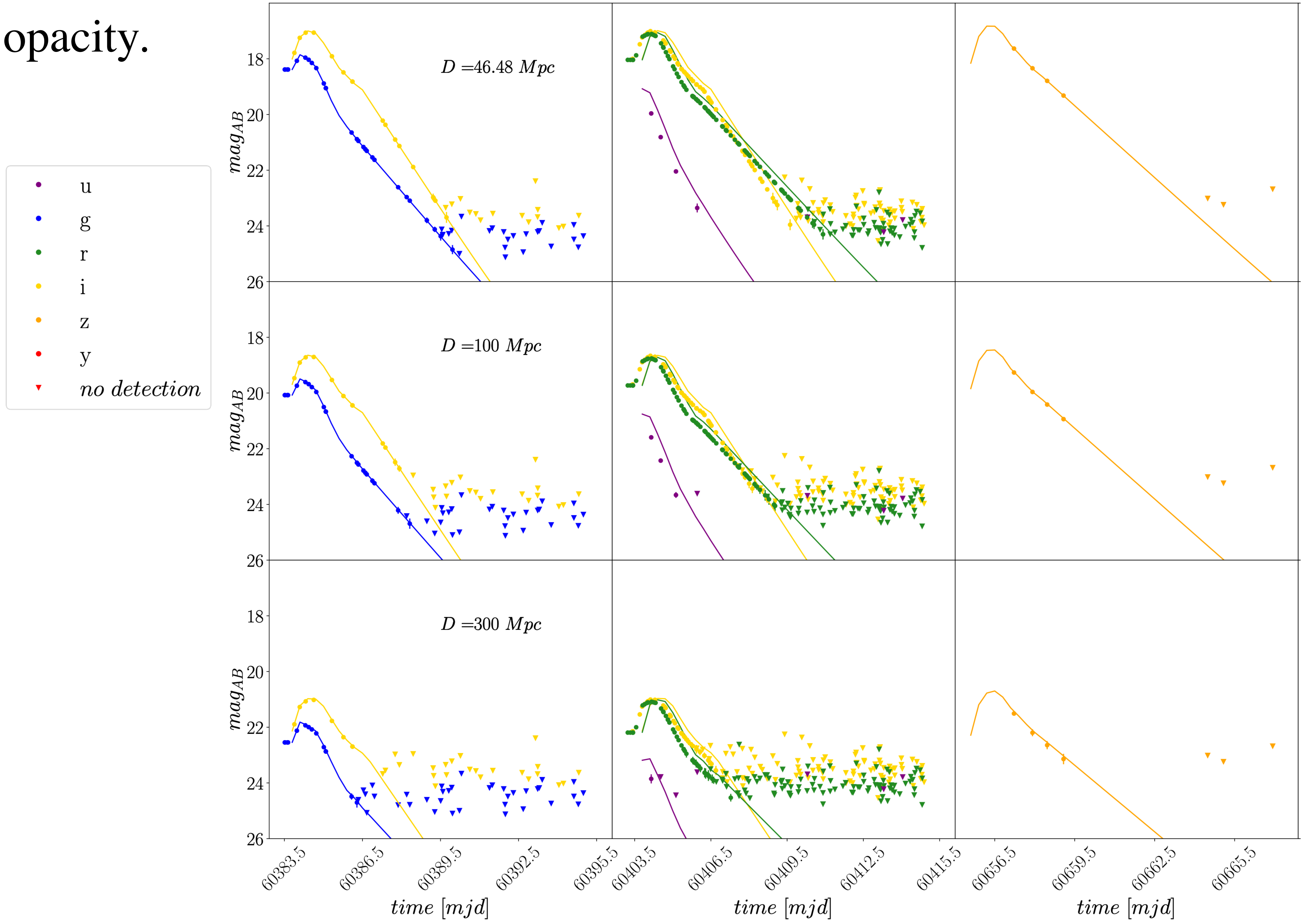
- Simulate light curves from models drawing the model parameters values from a prior density probability distribuion;
- Apply LSST's observational constrains simulated with the Opsim;
- Infer the parameters from the "observed" points;
- Build a distribution on uncertainties on the inferred parameters

TEMPLATE

- Binary mass distribution from Dietrich et al 2020;
- Uniform distributions for v_ej and opacity.

OBSERVATIONS

- baseline_v2.0_10yrs: rolling cadence, 2 slides
- no-uniformity in filters distribution



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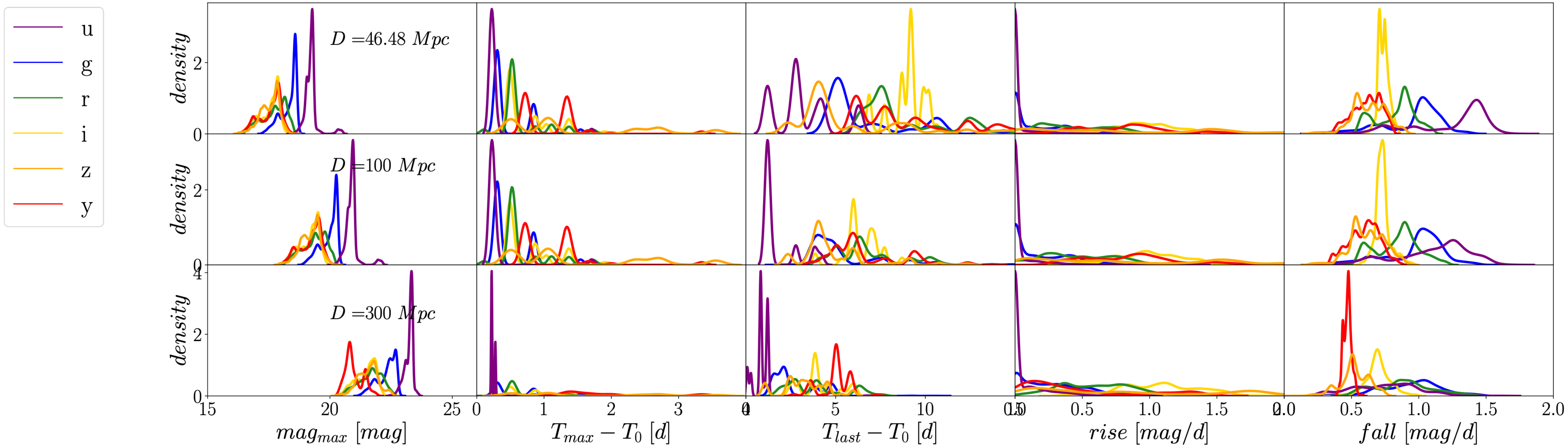
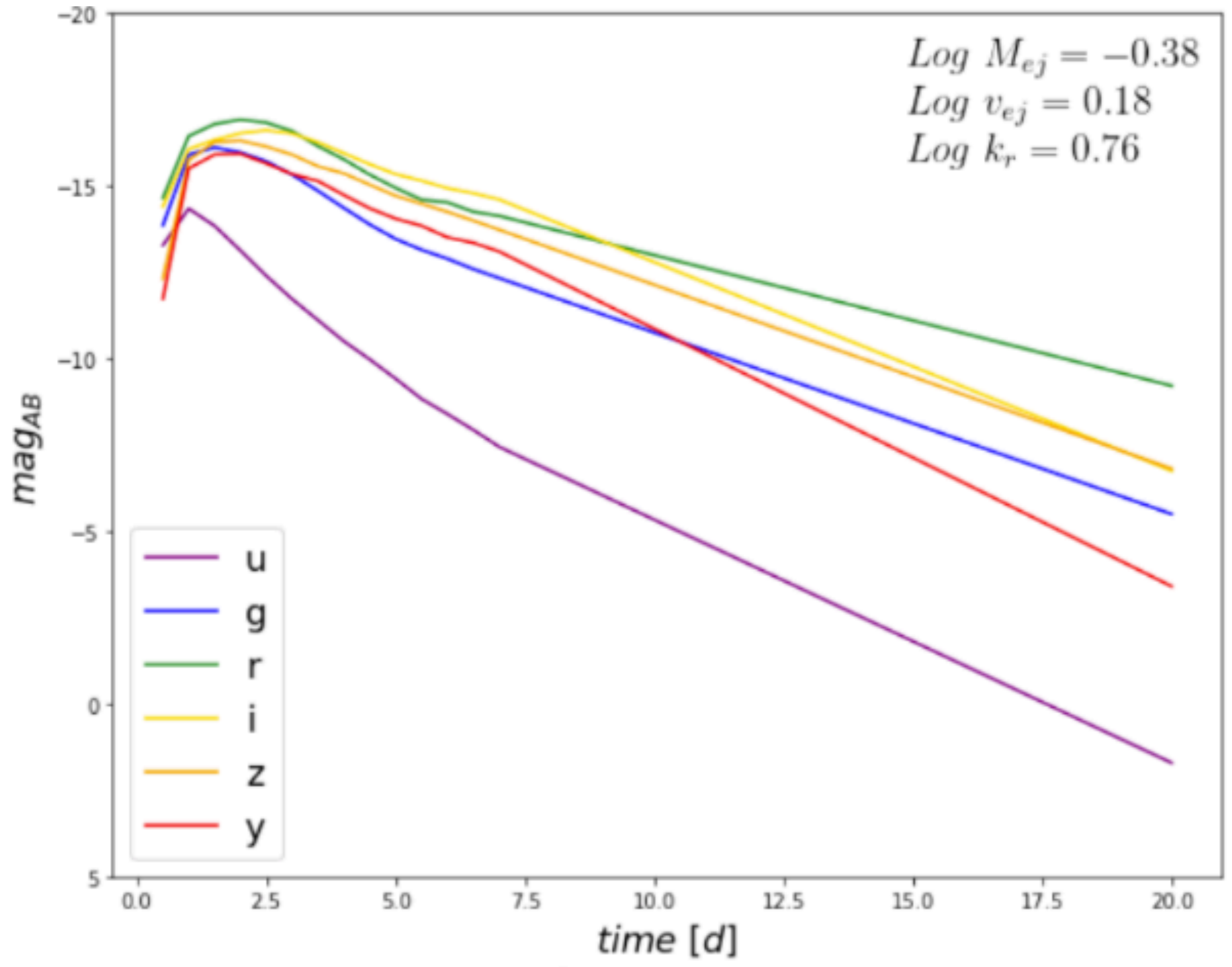
WE NEED ToO!!!

Ragosta,F; Ahumada,T; Andreoni,I; Piranomonte, S in preparation



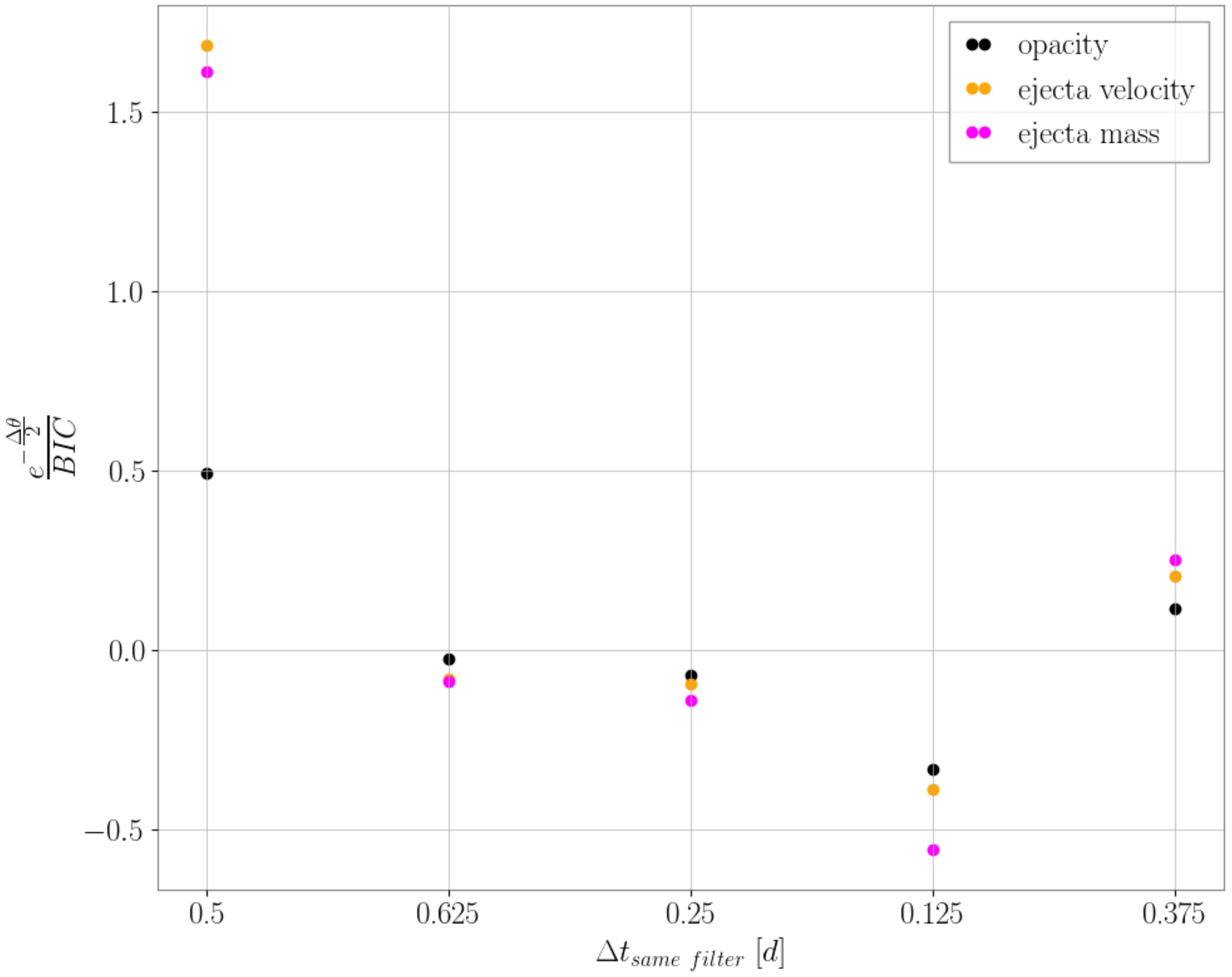


Number of filters

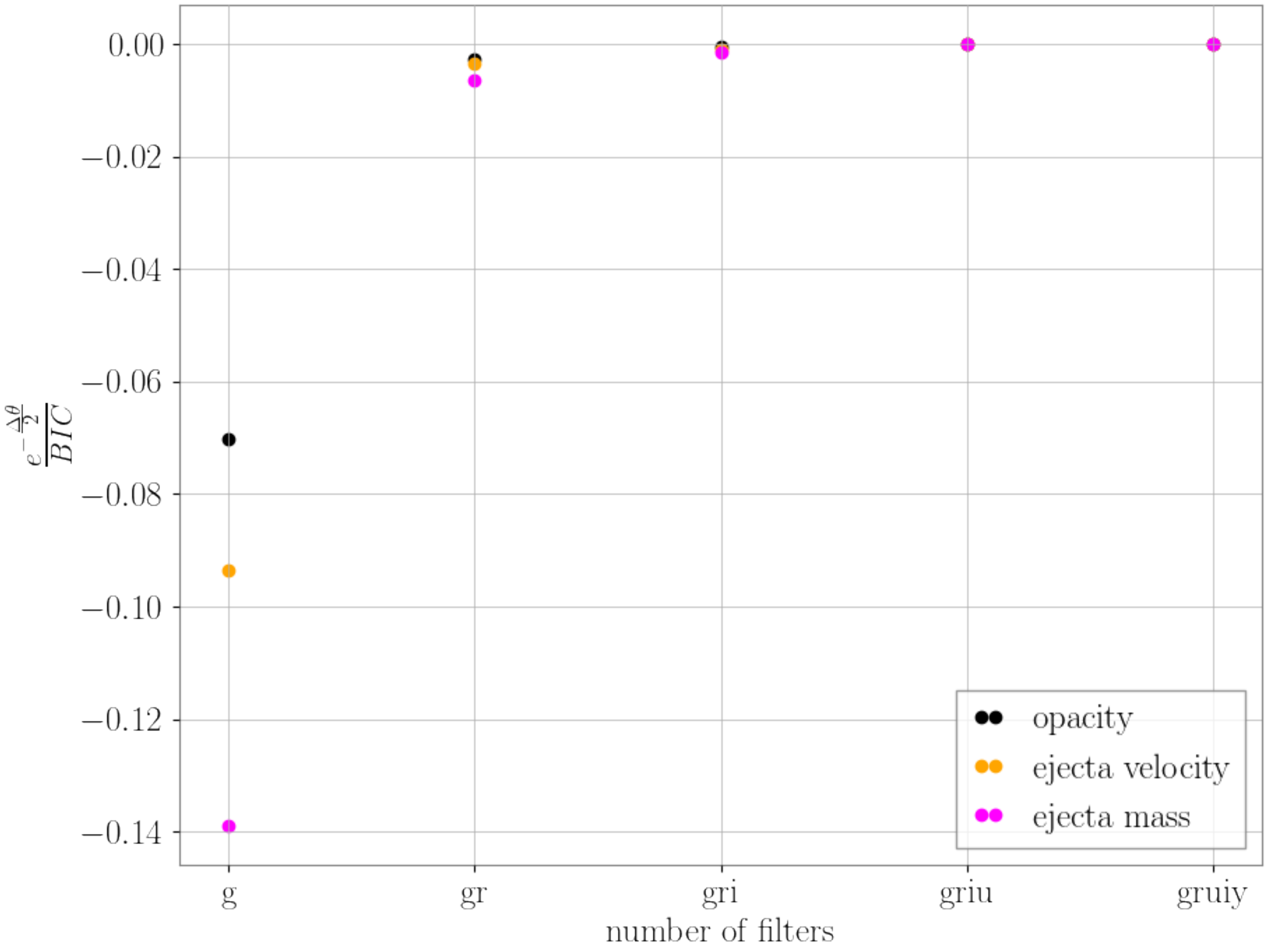
Detections' cadence

Peak magnitude

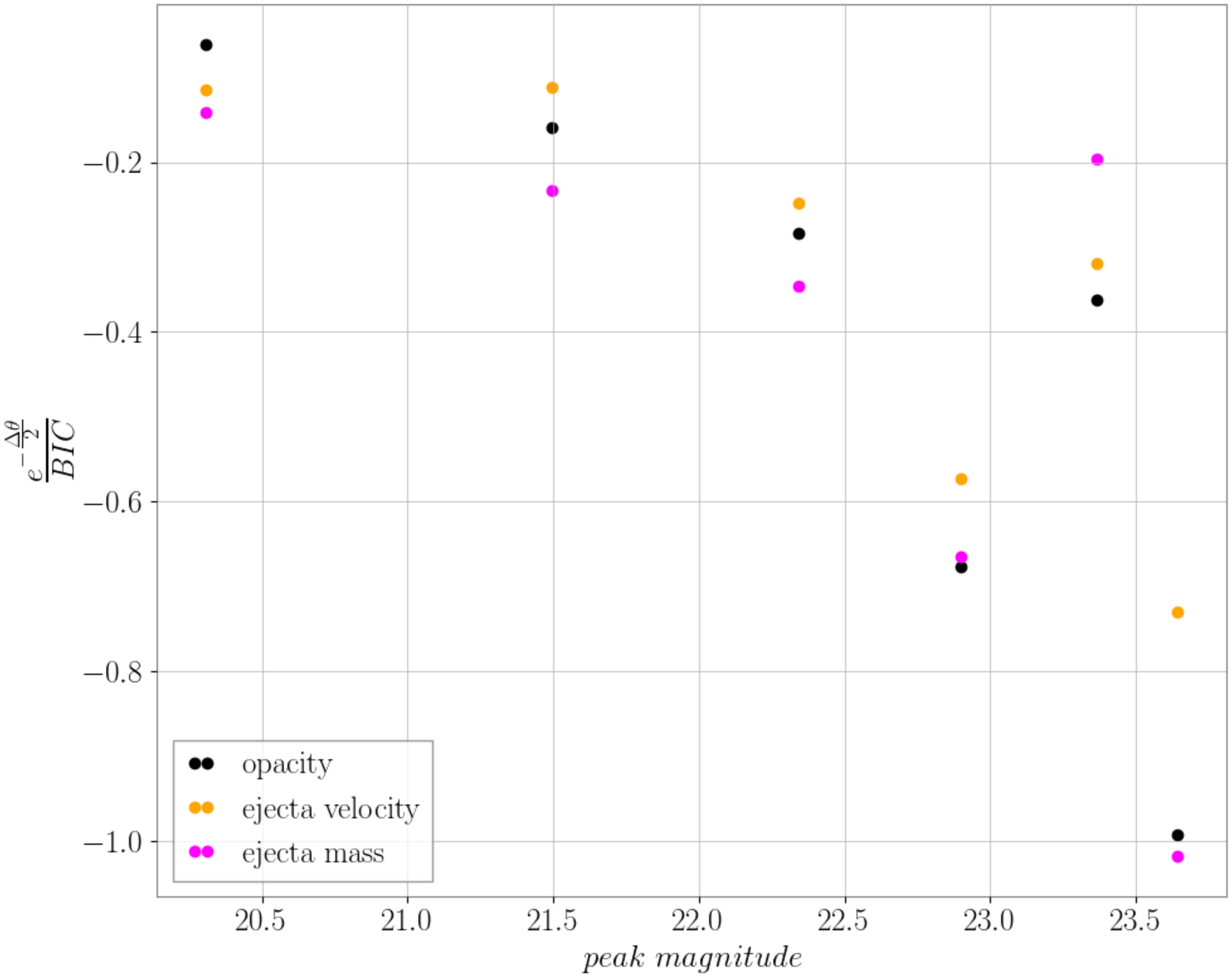
The main problem when we try to infer models parameters is the fitting procedure performance!



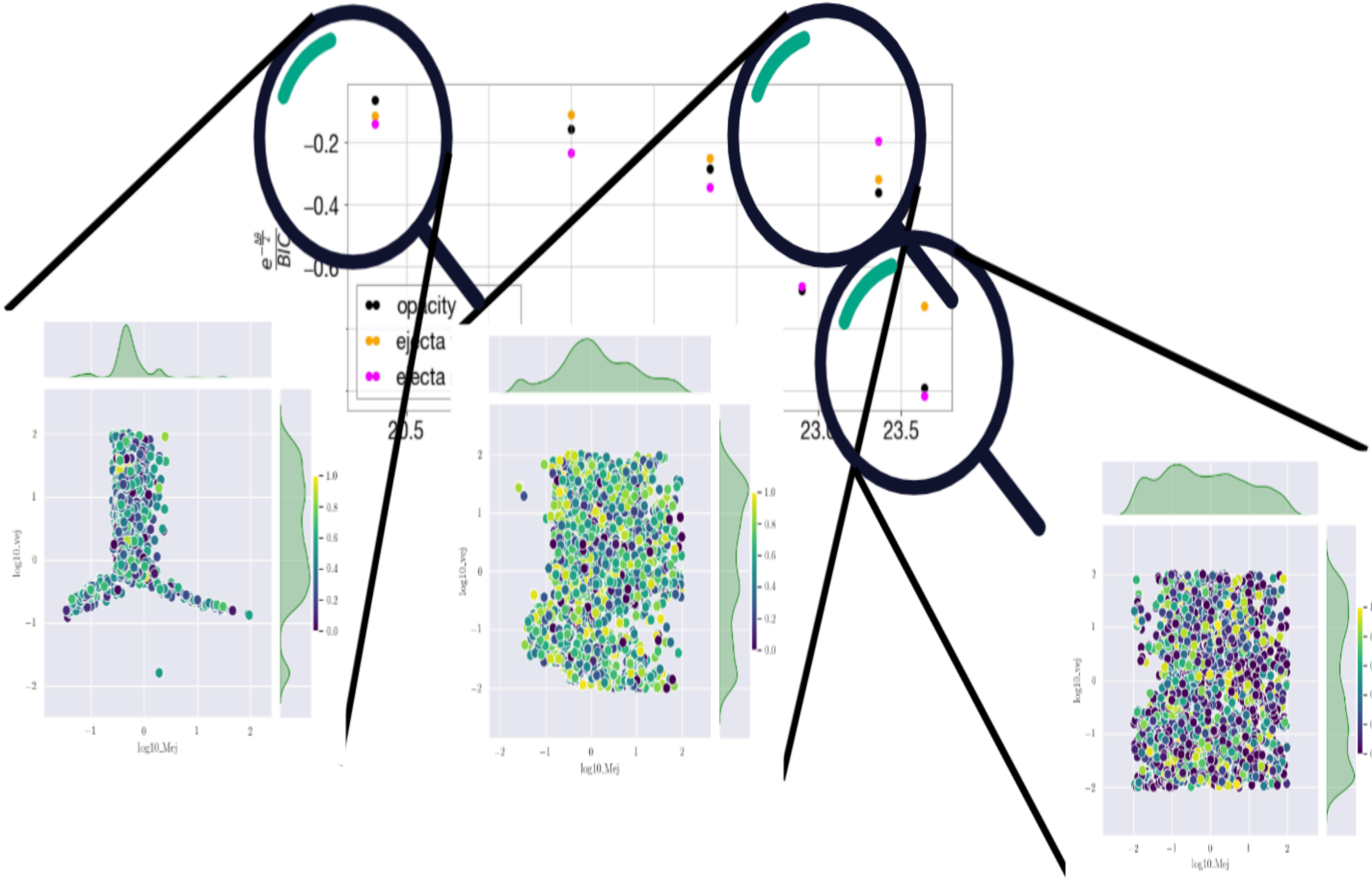
Ragosta,F; Ahumada,T; Andreoni,I; Piranomonte, S in preparation



Ragosta,F; Ahumada,T; Andreoni,I; Piranomonte, S in preparation



Ragosta,F; Ahumada,T; Andreoni,I; Piranomonte, S in preparation



Ragosta,F; Ahumada,T; Andreoni,I; Piranomonte, S in preparation

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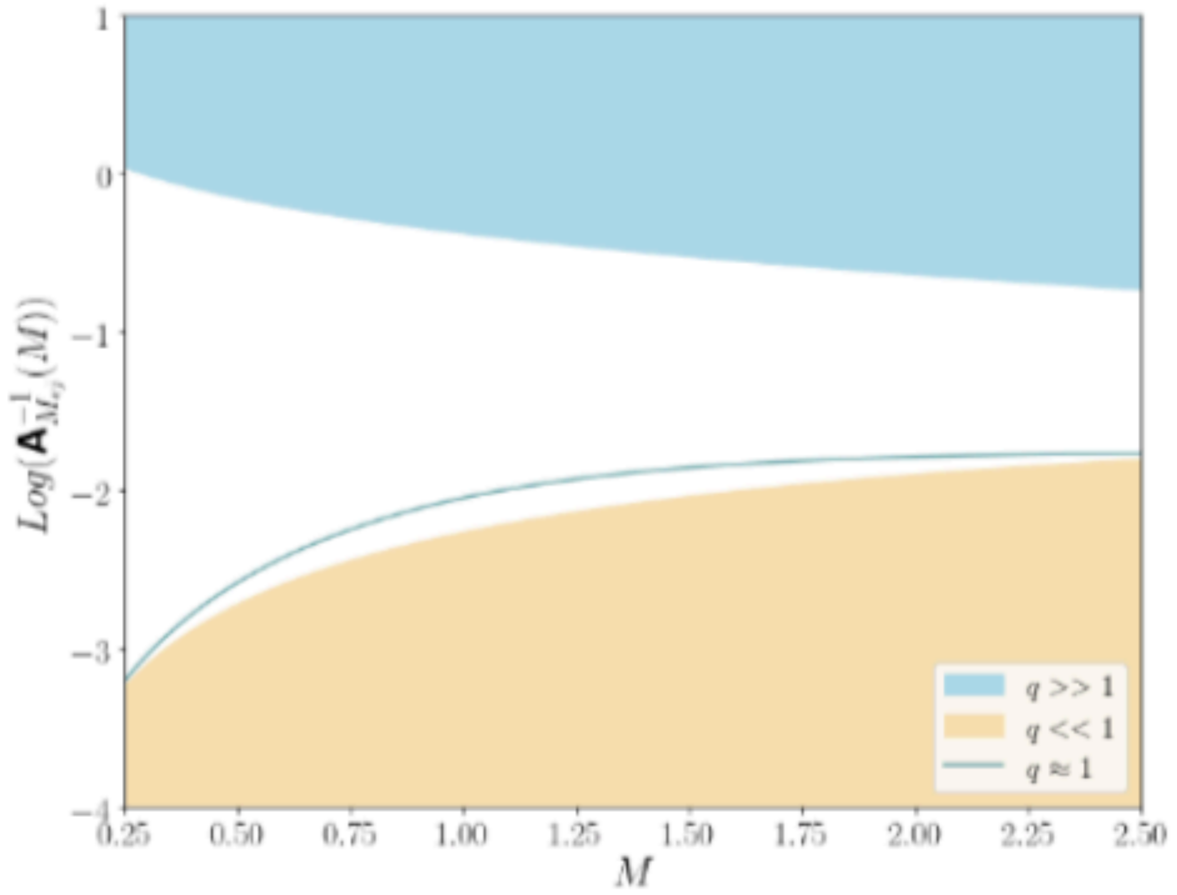
Dietrich & Uljevic 2017

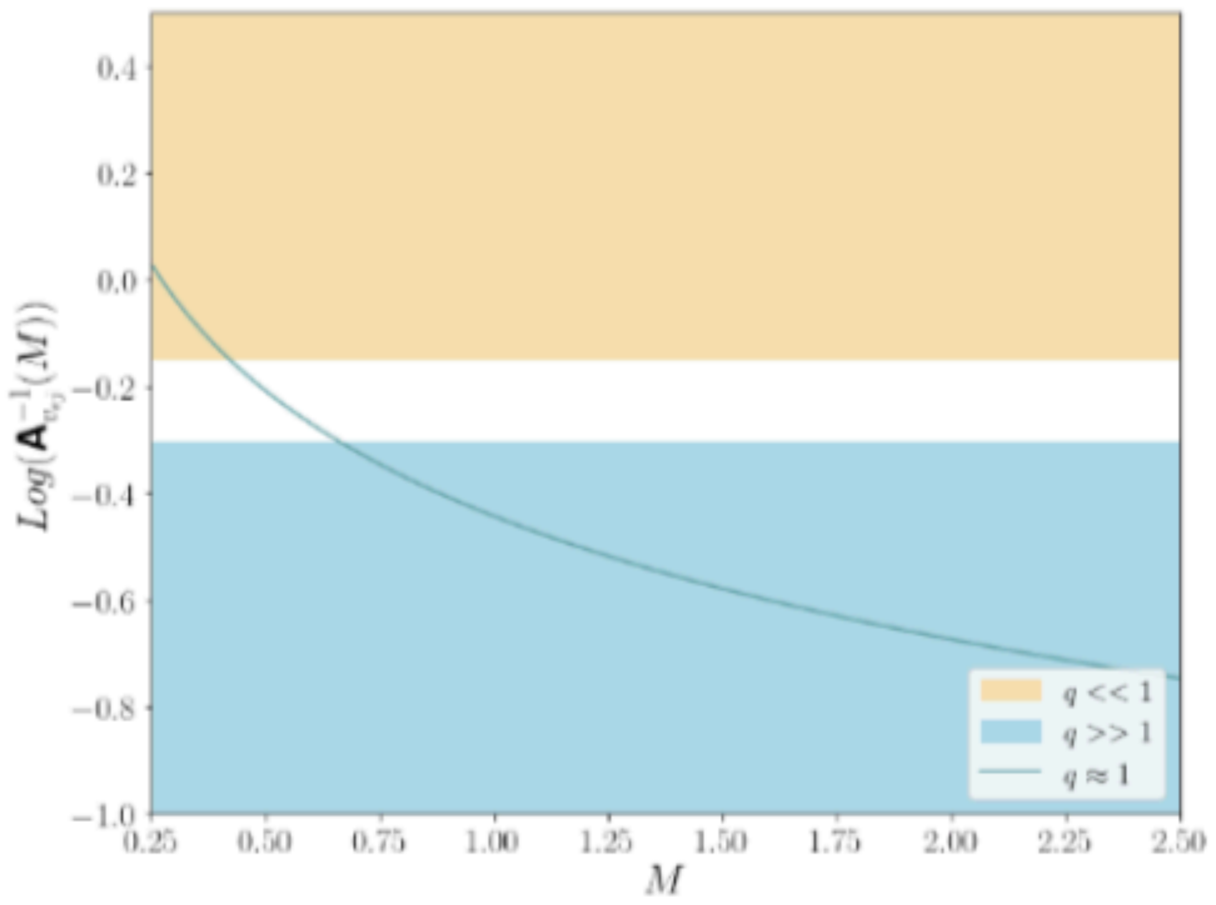
$$M_{ej} = \left[\alpha_{M_{ej}} q^{\frac{1}{3}} \left(\frac{1-2C_1}{C_1}\right) + \beta q^n + \gamma_{M_{ej}} \left(1 - \frac{M_1}{M_1^*}\right)\right] M_1^* + \\ + \left[\alpha q^{-\frac{1}{3}} \left(\frac{1-2C_2}{C_2}\right) + \beta_{M_{ej}} q^{-n} + \gamma_{M_{ej}} \left(1 - \frac{M_2}{M_2^*}\right)\right] M_2^* + \delta_{M_{ej}}$$

$$v_{ej} = \alpha_{v_{ej}} \left[q^{-1}(1 - \gamma_{v_{ej}} C_1) + q(1 - \gamma_{v_{ej}} C_2)\right] + \delta_{v_{ej}}$$

	$A_q^{M_{ej}}(M_1)$	$A_q^{v_{ej}}(M_1)$
$q > 1$	$\alpha_{M_{ej}} q^{\frac{2}{3}}$	$\frac{1}{q^3}\left[5M_1\left(\frac{\alpha_{v_{ej}}\gamma_{v_{ej}}G}{c^2R_1}\right)^2 q^4 + 2\alpha_{v_{ej}} q^3 - 4\frac{\alpha_{v_{ej}}}{M_1}\right]$
$q < 1$	$\left\{\left[\frac{\alpha_{M_{ej}}}{M} q^{-\frac{2}{3}}(2C_1q-3) - \beta_{M_{ej}} n q^{-(n+1)} - \frac{\beta_{M_{ej}} n}{M_1} q^{n-2} - \frac{1-2C_1q}{M_1C_1} q^{-\frac{8}{3}} - \left(\frac{1-2C_1}{C_1}\right) q^{-\frac{4}{3}}\right]^2 + \right.$ $+ \left[\left(\frac{1-2C_1q}{C_1}\right)\frac{\alpha_{M_{ej}}}{3} q^{-\frac{5}{3}} - \beta_{M_{ej}} n q^{n-1} - \frac{\beta_{M_{ej}} n}{M_1} q^{-(n+2)} + \right.$ $\left. + \left(\frac{\alpha_{M_{ej}}}{M_1}(2C_1-3) - \frac{\alpha_{M_{ej}}}{3}\frac{a-2C_1}{M_1C_1}\right) q^{-\frac{7}{3}} \frac{\alpha_{M_{ej}}}{M_1}(2C_1-3) q^{-\frac{1}{3}}\right]^2 \frac{q^2}{1-2q}$	$\frac{1}{q^4}\left[5M_1\left(\frac{\alpha_{v_{ej}}\gamma_{v_{ej}}G}{c^2R_1}\right)^2 + \alpha_{v_{ej}}\left(\frac{4}{M_1}+2\right)\right]$
$q \approx 1$	$\left\{\left[\frac{\alpha_{M_{ej}}}{3}\left(\frac{1-2C_1}{C_1}\right) + \beta_{M_{ej}} n \left(1 - \frac{1}{M_1}\right)\right]^2 + \right.$ $\left. + \left[\beta_{M_{ej}} + \frac{\alpha_{M_{ej}}}{M}(2C_1-3) + \alpha_{M_{ej}}\left(\frac{1-2C_1}{C_1}\right)\left(1 - \frac{\alpha_{M_{ej}}}{M_1}\right)\right]^2\right\} \frac{2q^2}{1-2q}$	$M_1\left(\frac{\alpha_{v_{ej}}\gamma_{v_{ej}}G}{c^2R_1}\right)^2$

$$\sigma_X^2 = \left[\left|\frac{\partial X}{\partial M_1}\right|^2 + \left|\frac{\partial X}{\partial M_2}\right|^2\right] \frac{M_1}{q^2(1+q^2)} \sigma_q^2 = \\ = A_q^X(M_1)\sigma_q^2$$





$$\alpha_{M_{ej}} = -0.66, \\ \beta_{M_{ej}} = +4.25, \\ \gamma_{M_{ej}} = -32.61, \\ \delta_{M_{ej}} = +5.20, \\ n = -0.78, \\ \alpha_{v_{ej}} = -0.29, \\ \gamma_{v_{ej}} = -3.00, \\ \delta_{v_{ej}} = +0.49$$

$$q = \frac{M_2}{M_1}$$

Ragosta,F; Ahumada,T; Andreoni,I; Piranomonte, S in preparation

Intrinsics limits imposed by the model!

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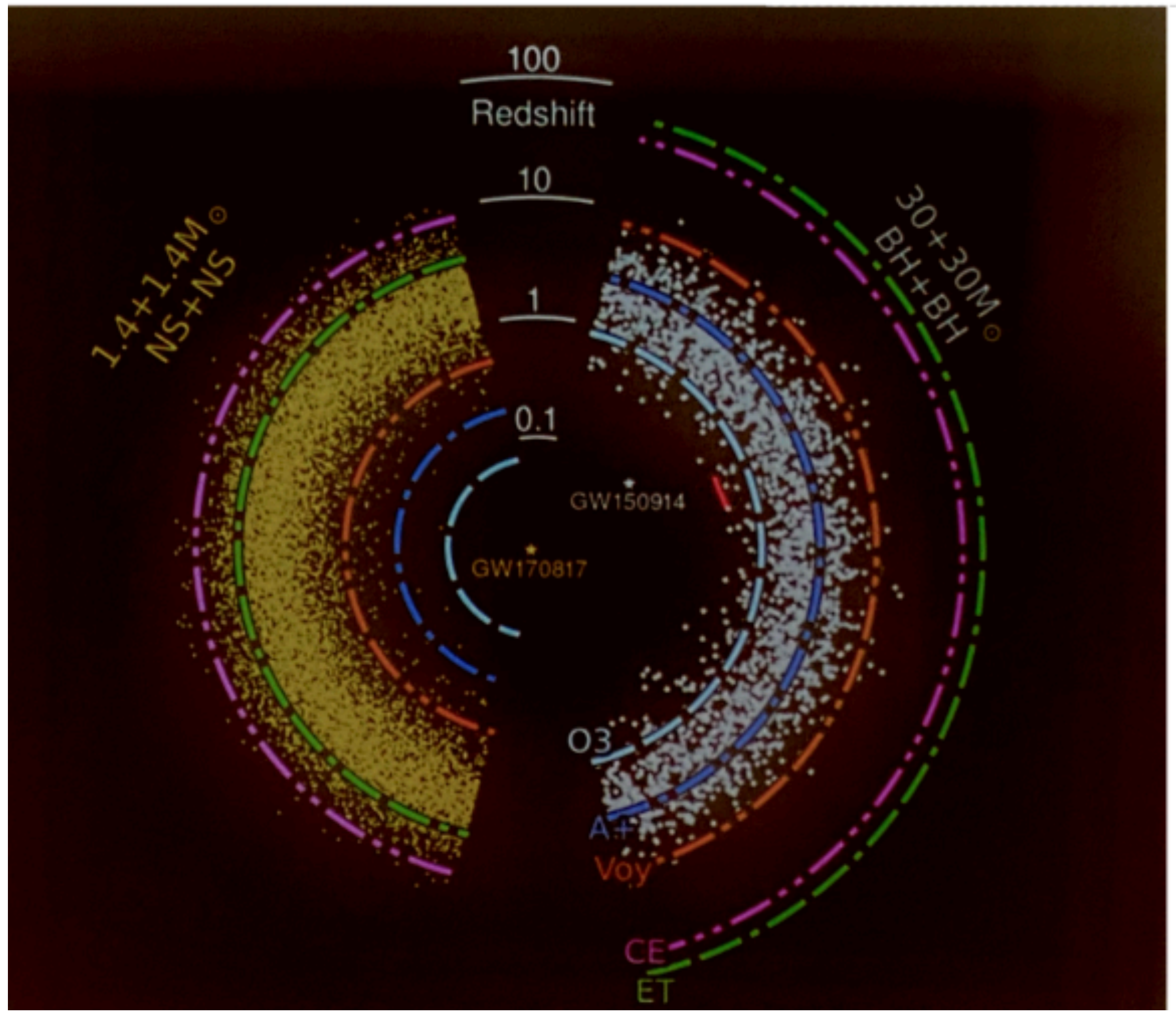
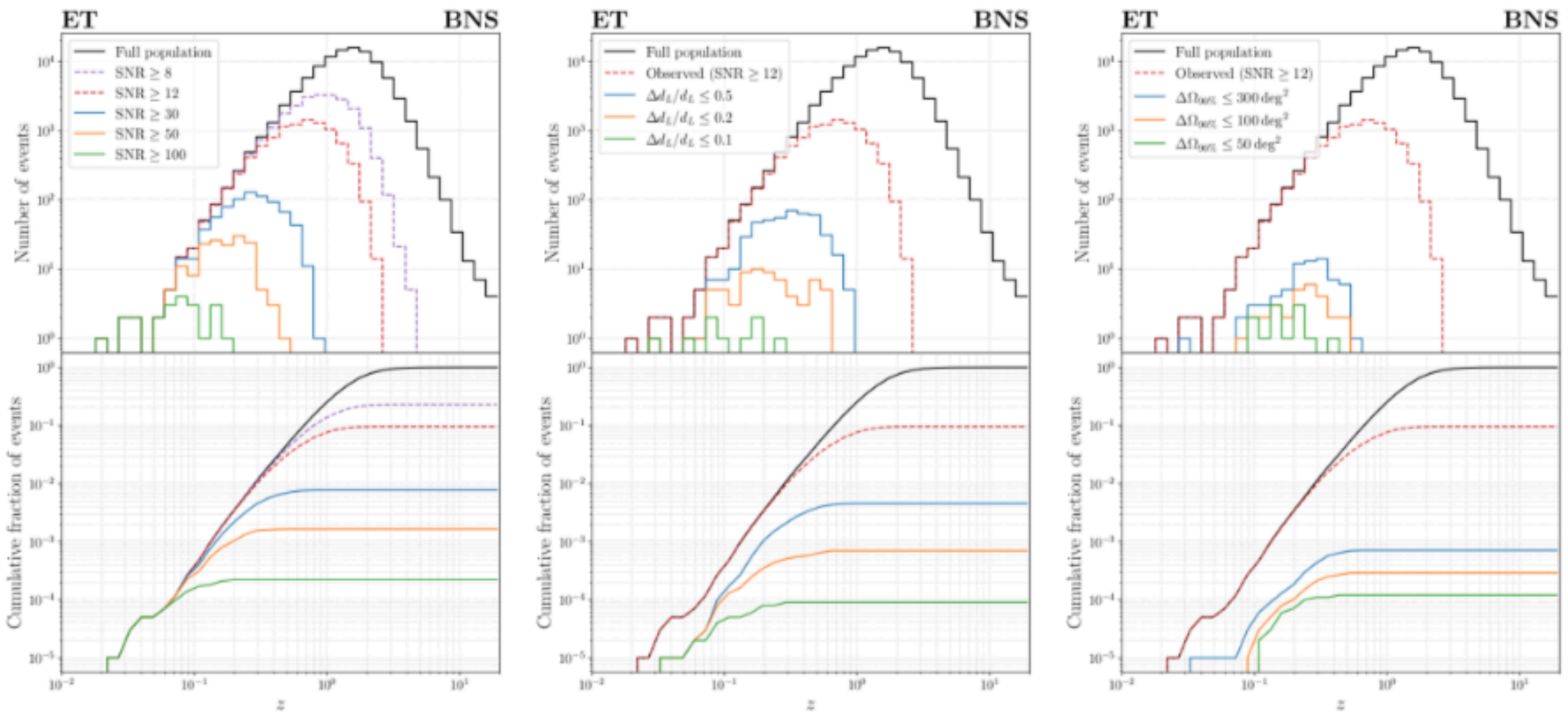
		O1	O2	O3	O4	O5
BNS Range (Mpc)	aLIGO	80	100	110 – 130	160 – 190	330
	AdV	-	30	50	90 – 120	150 – 260
	KAGRA	-	-	8 – 25	25 – 130	130+
BBH Range (Mpc)	aLIGO	740	910	990 – 1200	1400 – 1600	2500
	AdV	-	270	500	860 – 1100	1300 – 2100
	KAGRA	-	-	80 – 260	260 – 1200	1200+
NSBH Range (Mpc)	aLIGO	140	180	190 – 240	300 – 330	590
	AdV	-	50	90	170 – 220	270 – 480
	KAGRA	-	-	15 – 45	45 – 290	290+





Iacovelli et al 2022

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- We need ToO!
- Accuracy grows using at least three filters observation
- Luminosity of the KN effects the uncertainty on the parameters
- LSST will constraints BNS population in such a way it

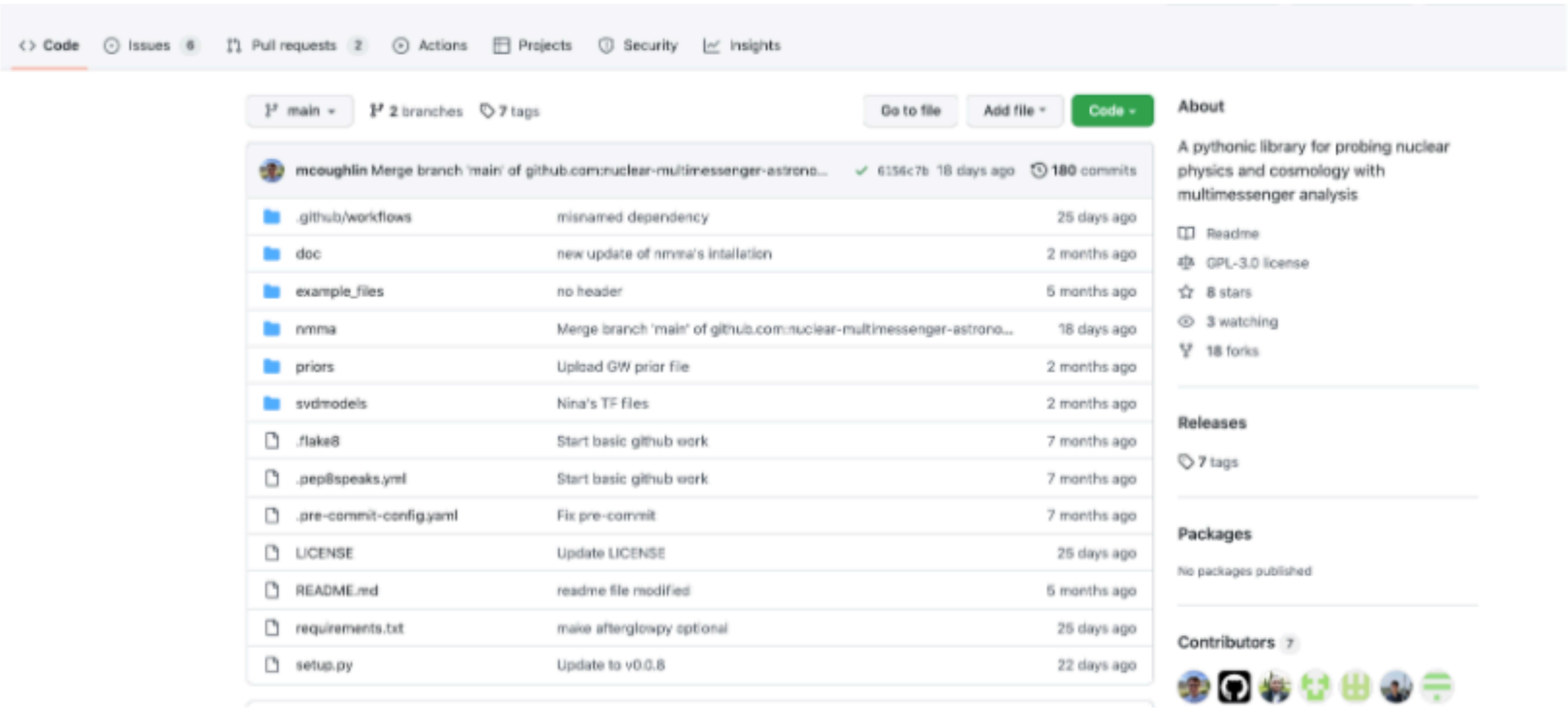
he starting point for the GW observations post-O5

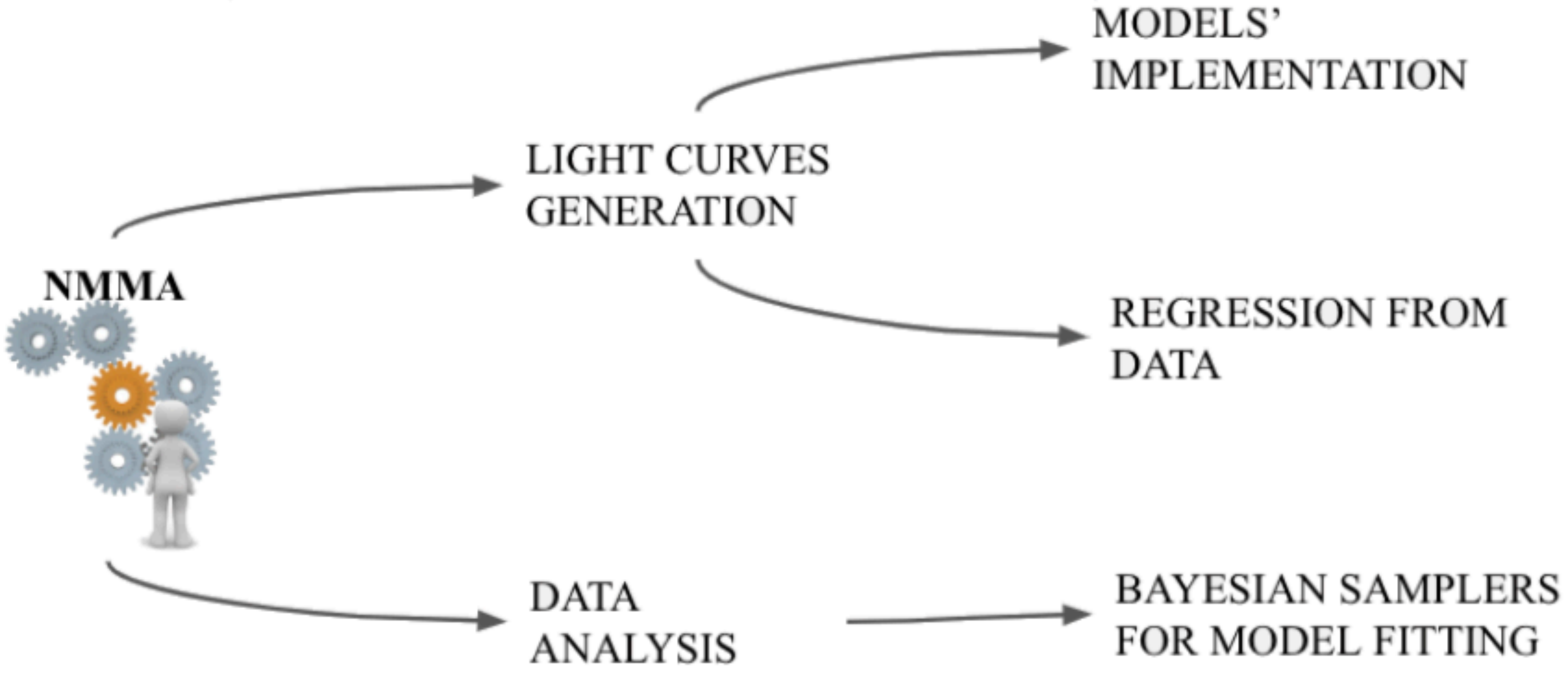
NEXT STEPS:

- Expected posterior distributions of Mej's and vej's uncertainties as function of survey strategy
- Impact of the KN parameters uncertainties on EOS
- Database of simulated KN and fitted parameters


THANK YOU!

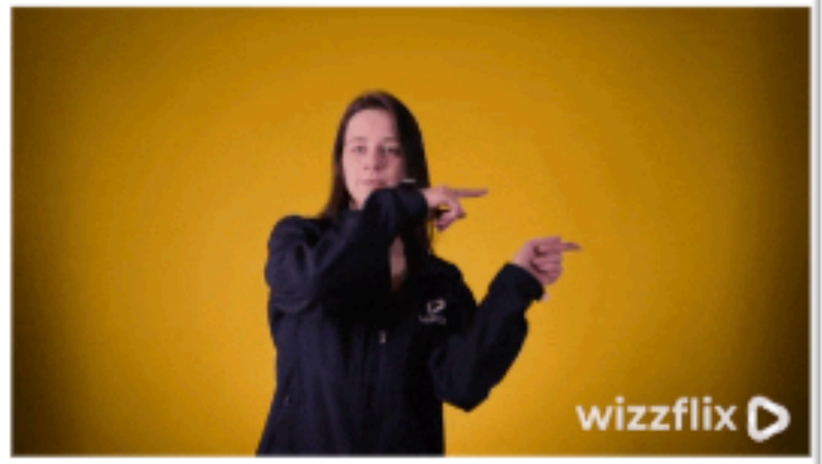
Backup slides



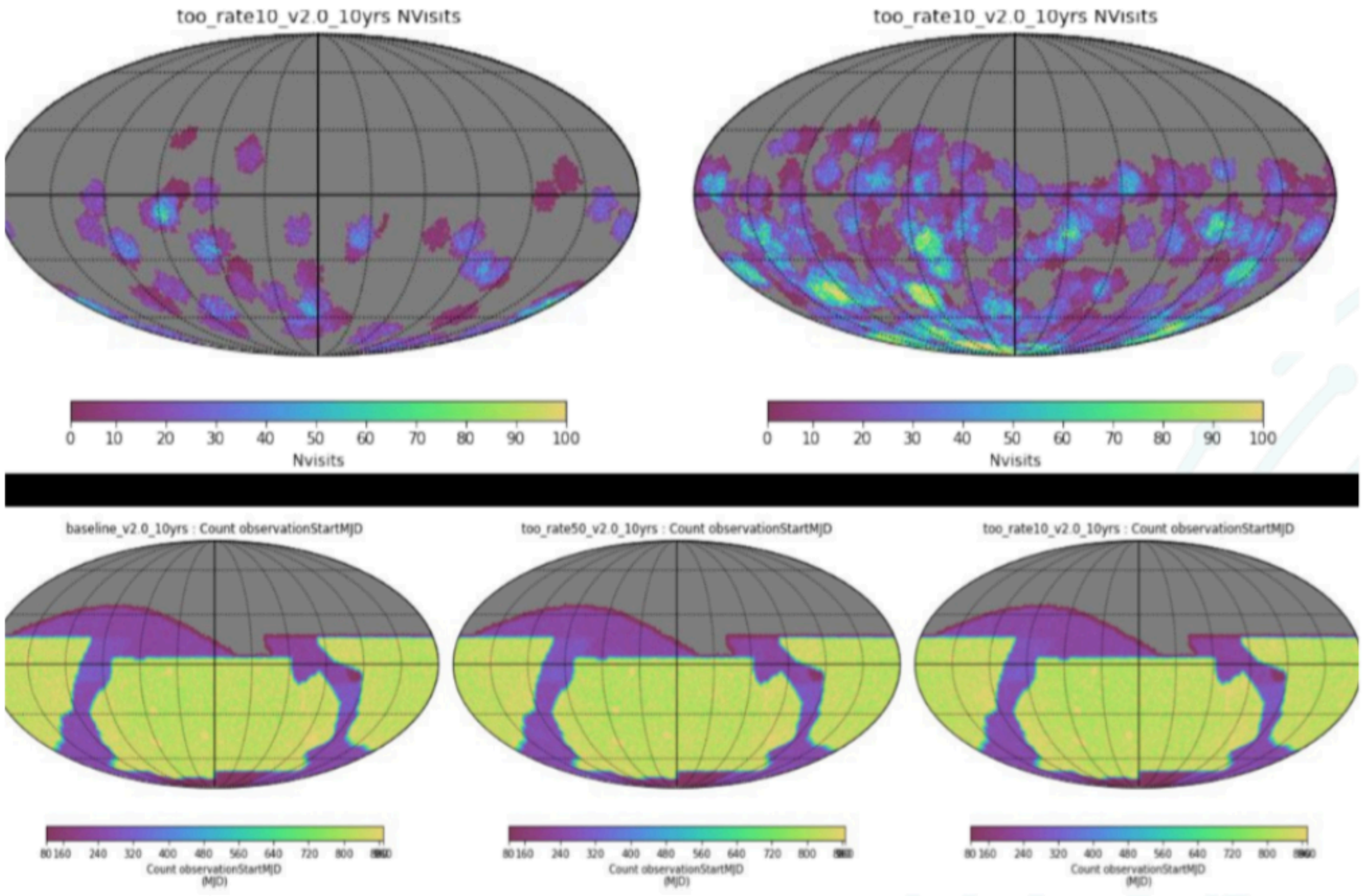


Backup slides

model	paramters	filters
'Bu2019nsbh'	'log10_mej_dyn', 'log10_mej_wind', 'KNtheta'	'u', 'g', 'r', 'i', 'z', 'y', 'J', 'H', 'K', 'radio-3GHz', 'radio-1.25GHz', 'radio-5.5GHz', 'radio-6GHz', 'X-ray-1keV', 'X-ray-5keV'
'Bu2019lm' ,	'log10_mej_dyn', 'log10_mej_wind', 'KNphi', 'KNtheta'	
'Ka2017'	'log10_mej', 'log10_vej', 'log10_Xlan'	
'Bu2019lm_sparse'	'log10_mej_dyn', 'log10_mej_wind'	
'TrPi2018'	'inclination_EM', 'log10_E0','thetaCore','thetaWing', 'b', 'L0', 'q', 'ts', 'log10_n0', 'p', 'log10_epsilon_e', 'log10_epsilon_B', 'xi_N', 'd_L'	
'Piro2021'	'log10_Menv', 'log10_Renv', 'log10_Ee'	
'Me2017'	'log10_Mej', 'log10_vej', 'beta', 'log10_kappa_r'	
'Bu2022mv'	'log10_mej_dyn', 'vej_dyn', 'log10_mej_wind', 'vej_wind', 'KNtheta'	
'PL_BB_fixedT'	'bb_luminosity', 'temperature', 'beta', 'powerlaw_mag'	



Backup slides



After 10 years, scheduler compensates for shifted ToO observations, no obvious residual artifacts in survey footprint coverage

Backup slides

Table 11: Key attributes of example reference fields from external datasets are compared with LSST.

Survey		Notes on band coverage and depth	Total Area (accessible to LSST)
LSST	Single-Visit	{*ugrizy*} = {23.9, 25.0, 24.7, 24.0, 23.3, 22.1} (5σ)	-
	10-yr Wide-Fast-Deep	{*ugrizy*} = {26.1, 27.4, 27.5, 26.8, 26.1, 24.9} (5σ)	18000 deg^2 (design)
HSC	Wide	{*grizy*} = {26.5, 26.1, 25.9, 25.1, 24.4} (5σ)	1400 deg^2 (1350 deg^2)
	Deep	{*grizy*} = {27.5, 27.1, 26.8, 26.3, 25.3} (5σ) + 3 narrow bands	27 deg^2 (13 deg^2)
	Ultra-deep	{*grizy*} = {28.1, 27.7, 27.4, 26.8, 26.3} (5σ) + 3 narrow bands	3.5 deg^2
DES	Wide	{*grizY*} = {24.5, 24.3, 23.5, 22.9, 21.7} (10σ)	5000 deg^2
	SN-Shallow	{*griz*} = {26.8, 25.6, 25.9, 25.7} (5σ)	24 deg^2
	SN-Deep	{*griz*} = {27.1, 27.3, 27.0, 26.8} (5σ)	6 deg^2
HST CLASH	-	{16 filters, 2000-17000 Å} ~ {25.7-27.0} (10σ)	~0.03 deg^2 (17 of 25 fields)
HST COSMOS	-	{F814W} = {27.2} (10σ)	1.7 deg^2
HST Ultra-Deep Field	-	{F435W, F606W, F775W, F850LP} ~ {29} (10σ)	~0.003 deg^2
HST Frontier Fields	-	{7 filters, 4000-17000 Å} ~ {29} (5σ)	0.012 deg^2 (5 of 6 fields)

Backup slides