How efficiently can we detect early SNe Ia bumps with ZTF?

Catherine Cuddy & Mark Magee

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

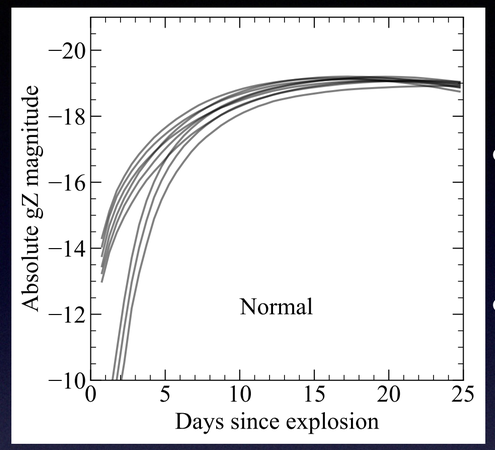
`simsurvey`: Estimating Transient Discovery Rates for the Zwicky Transient Facility

Ulrich Feindt,[a,1] **Jakob Nordin,**[b] **Mickael Rigault,**[c] **Valéry Brinnel,**[b] **Suhail Dhawan,**[a] **Ariel Goobar,**[a] **and Marek Kowalski**[b,d]

Feindt et al. 2019

Transient generator: Underlying models

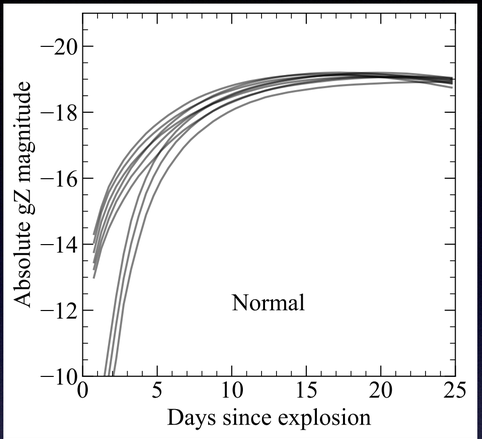
Transient generator: Underlying models



‘Normal’ SNe Ia

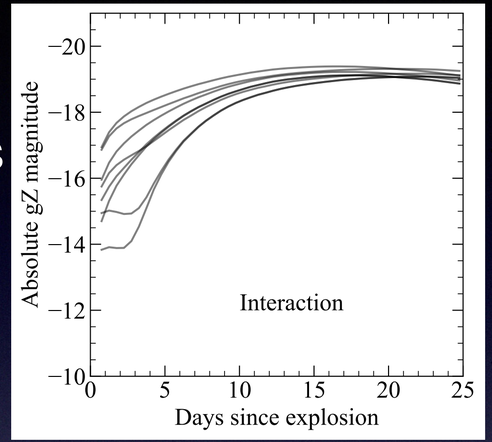
- Range of density profiles, levels of ^{56}Ni mixing
- Magee et al. 2020, Deckers et al. 2021

Transient generator: Underlying models



‘Normal’ SNe Ia

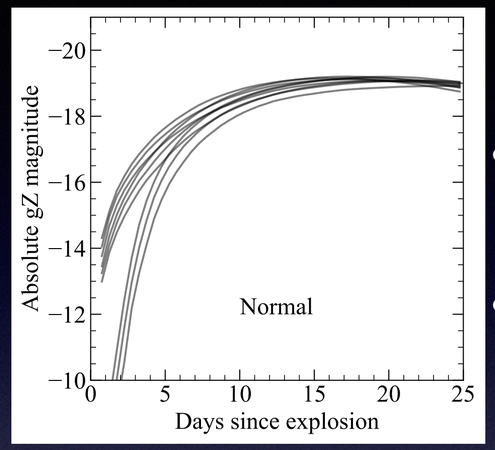
- Range of density profiles, levels of ^{56}Ni mixing
- Magee et al. 2020, Deckers et al. 2021



Companion interaction

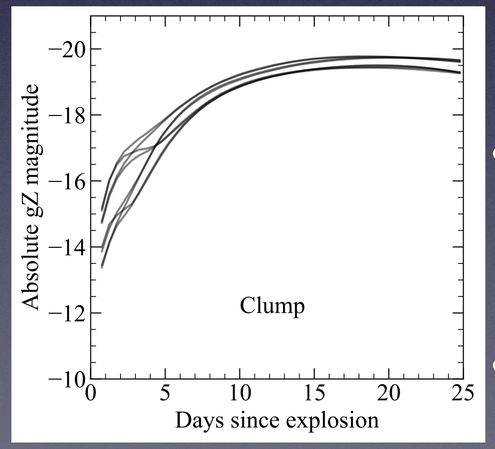
- Multiple fiducial models for which companion interaction signature is added
- Range of companion separations, viewing angles
- Kasen 2010

Transient generator: Underlying models



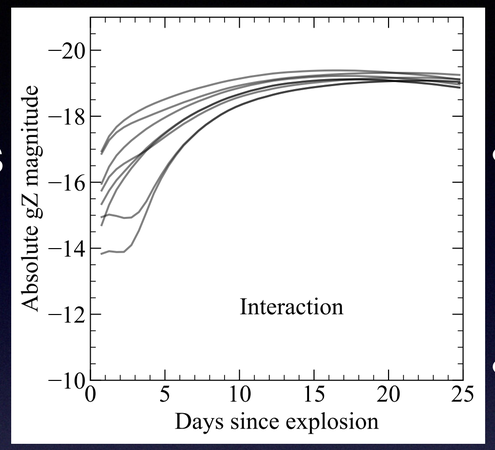
‘Normal’ SNe Ia

- Range of density profiles, levels of ^{56}Ni mixing
- Magee et al. 2020, Deckers et al. 2021



^{56}Ni clumps

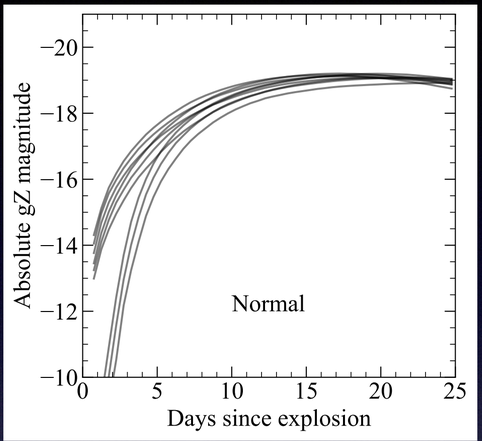
- Two fiducial models for which an excess ^{56}Ni clump is added to the outer ejecta
- Range of clump masses, distributions
- Magee & Maguire 2020



Companion interaction

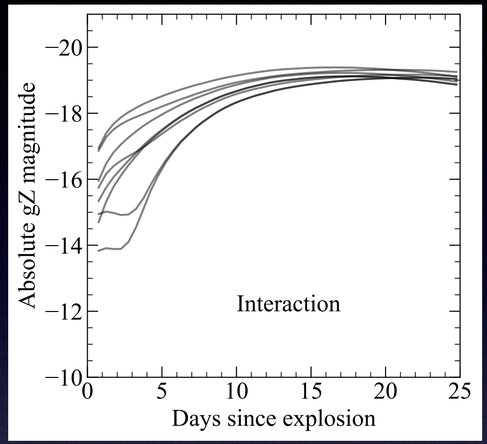
- Multiple fiducial models for which companion interaction signature is added
- Range of companion separations, viewing angles
- Kasen 2010

Transient generator: Underlying models



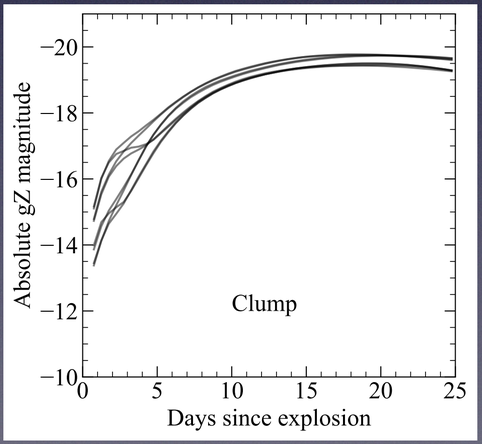
‘Normal’ SNe Ia

- Range of density profiles, levels of ^{56}Ni mixing
- Magee et al. 2020, Deckers et al. 2021



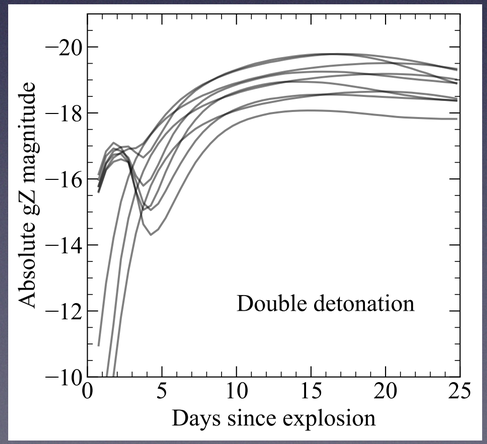
Companion interaction

- Multiple fiducial models for which companion interaction signature is added
- Range of companion separations, viewing angles
- Kasen 2010



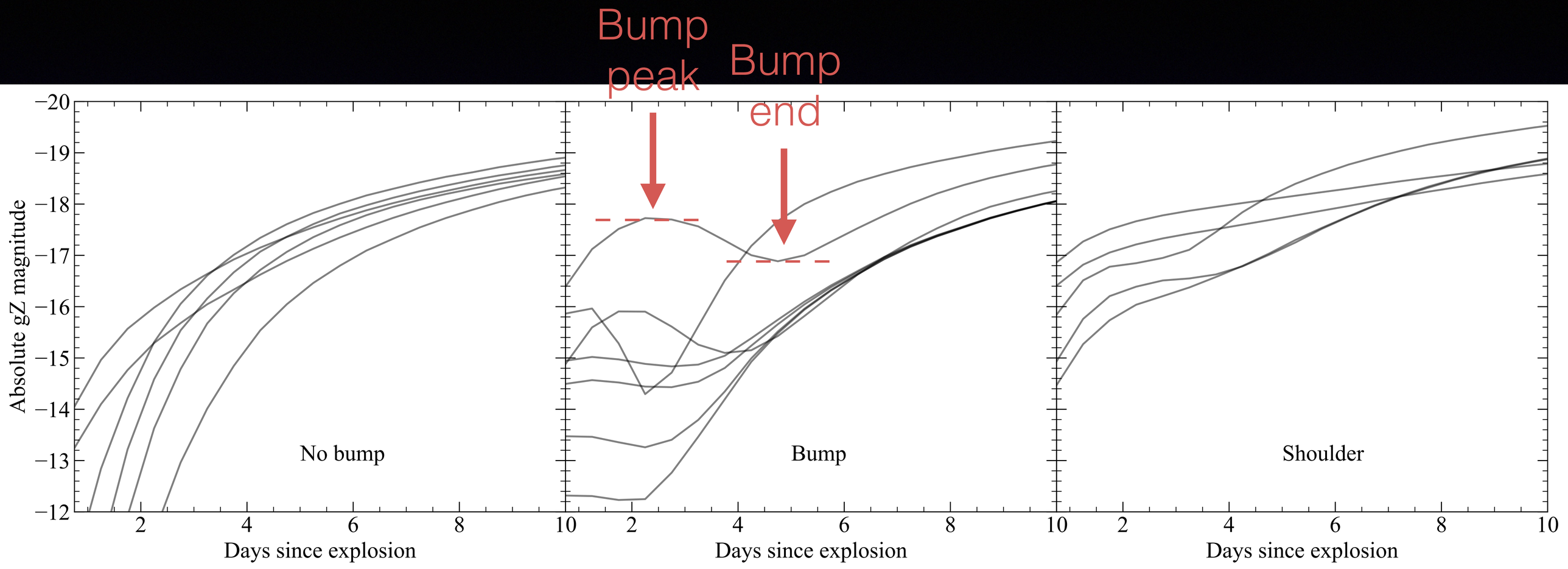
^{56}Ni clumps

- Two fiducial models for which an excess ^{56}Ni clump is added to the outer ejecta
- Range of clump masses, distributions
- Magee & Maguire 2020



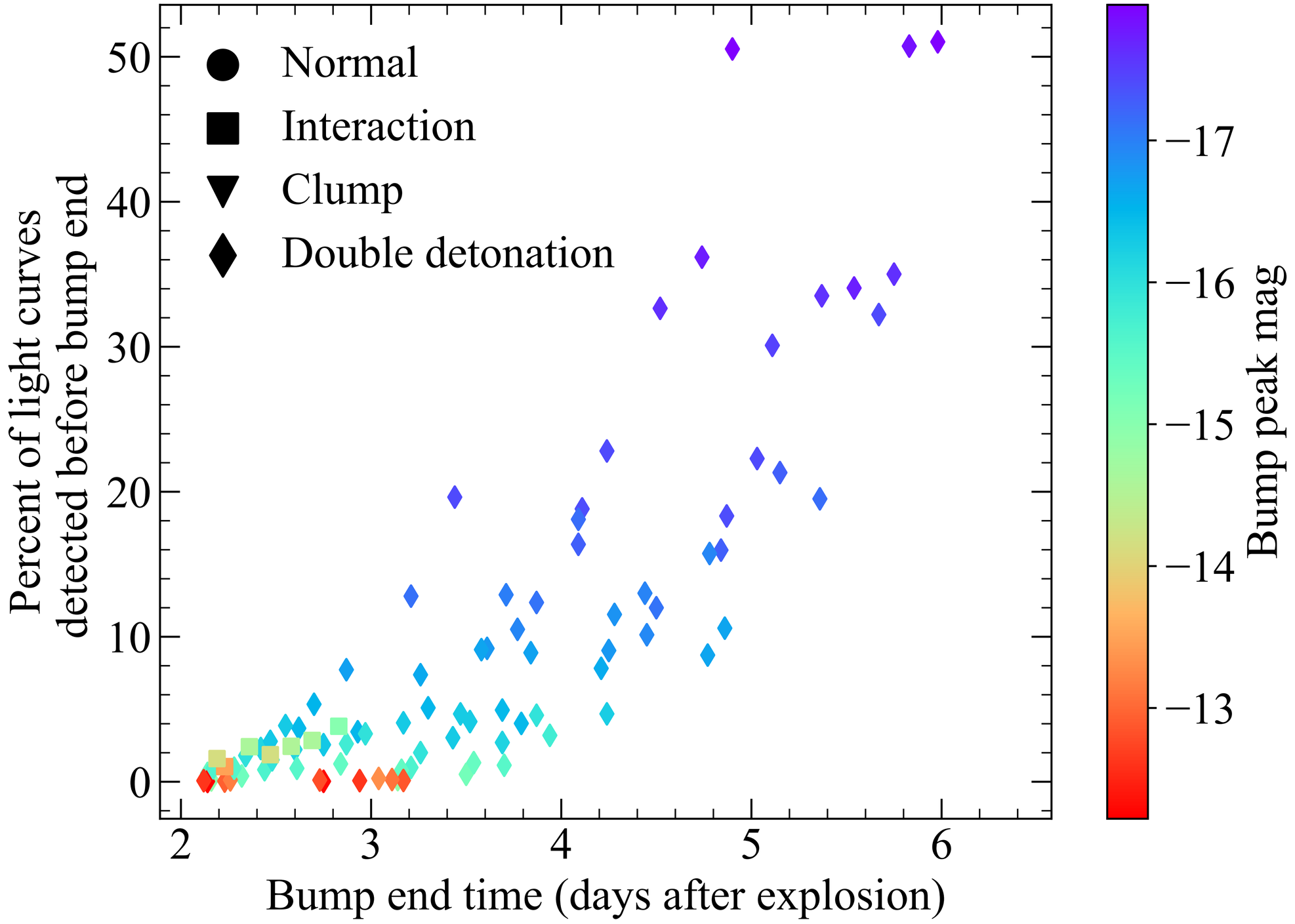
Double detonations

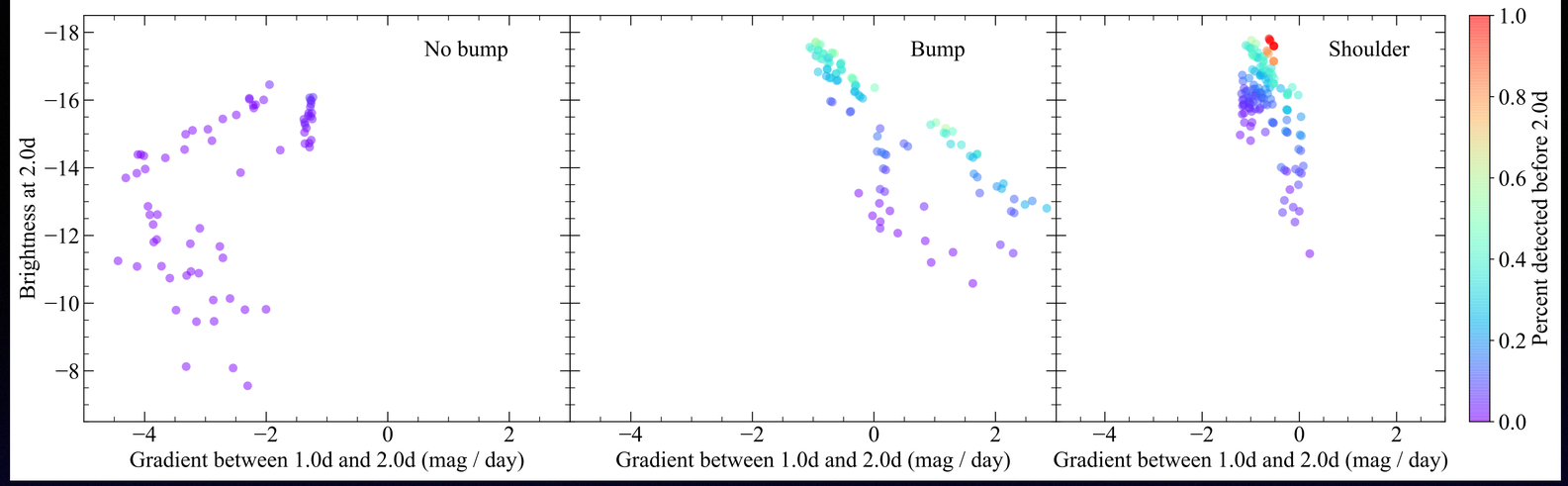
- Range of WD masses, He shell masses, He shell compositions
- Models with & without bumps
- Magee et al. 2021

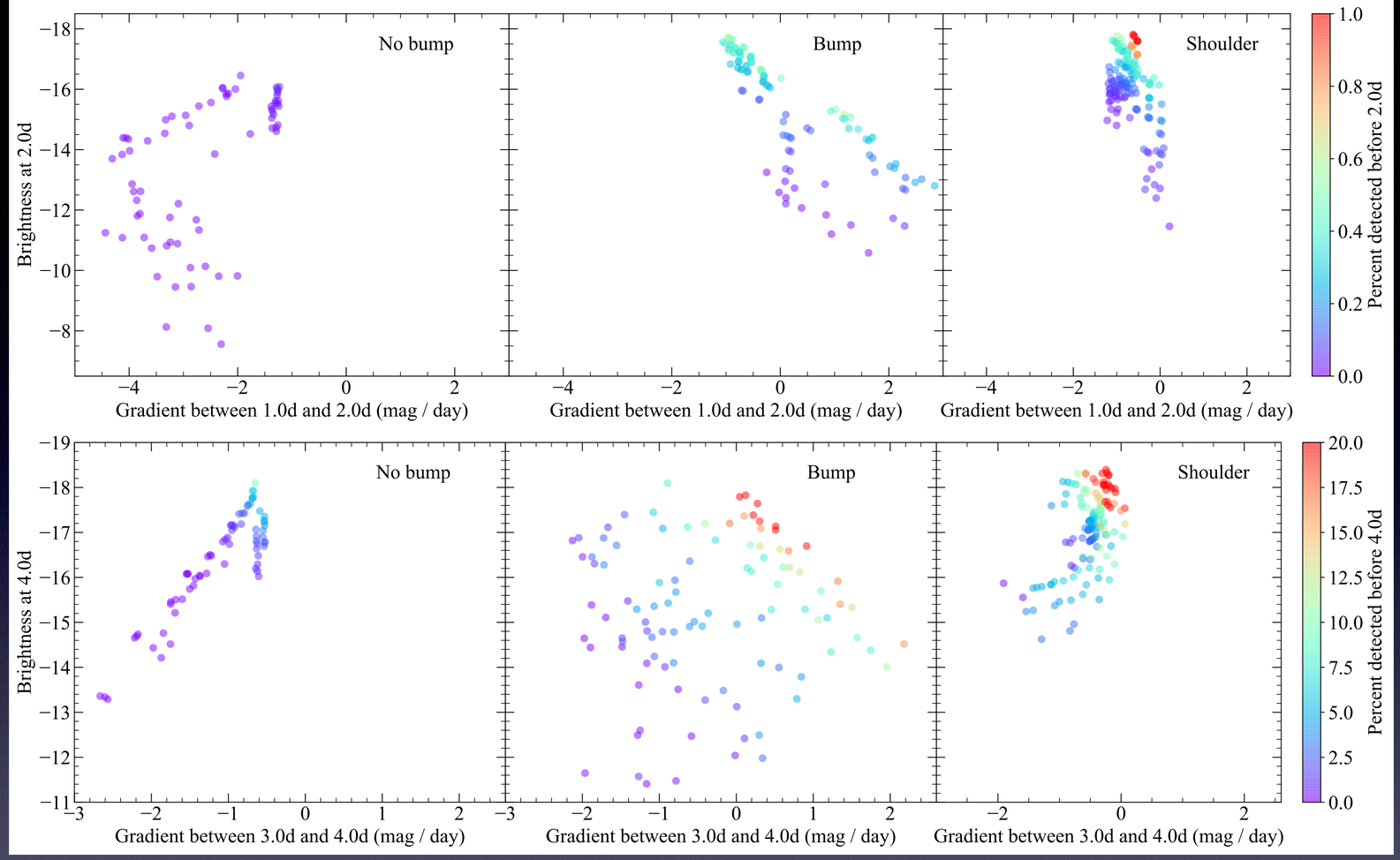


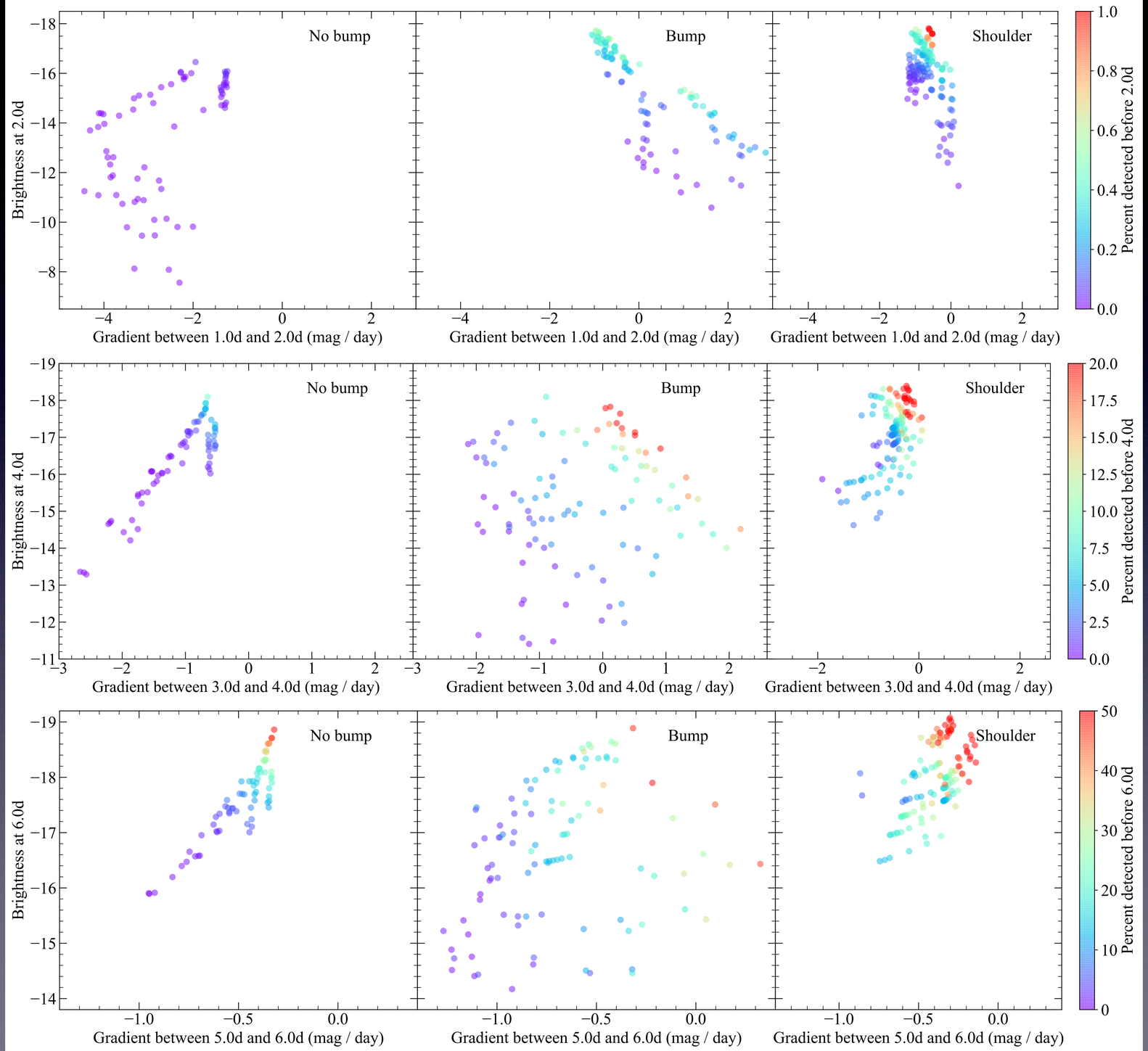
Bump:
$\Delta m > 0.1$ mag

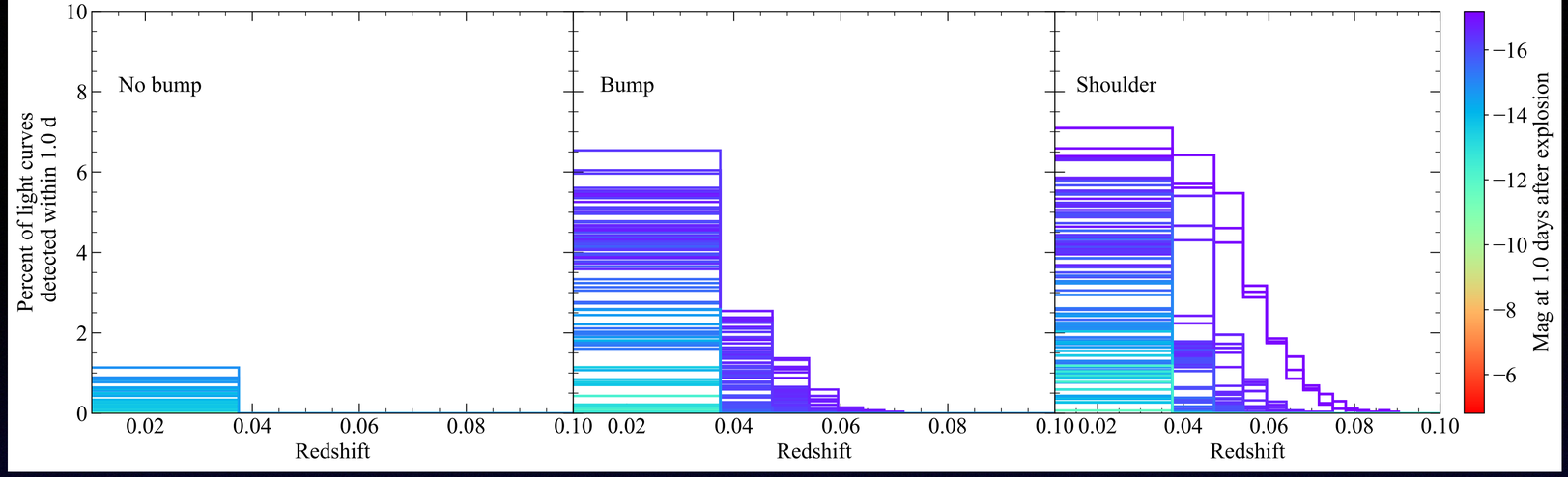
Shoulder:
Excess, but no decline

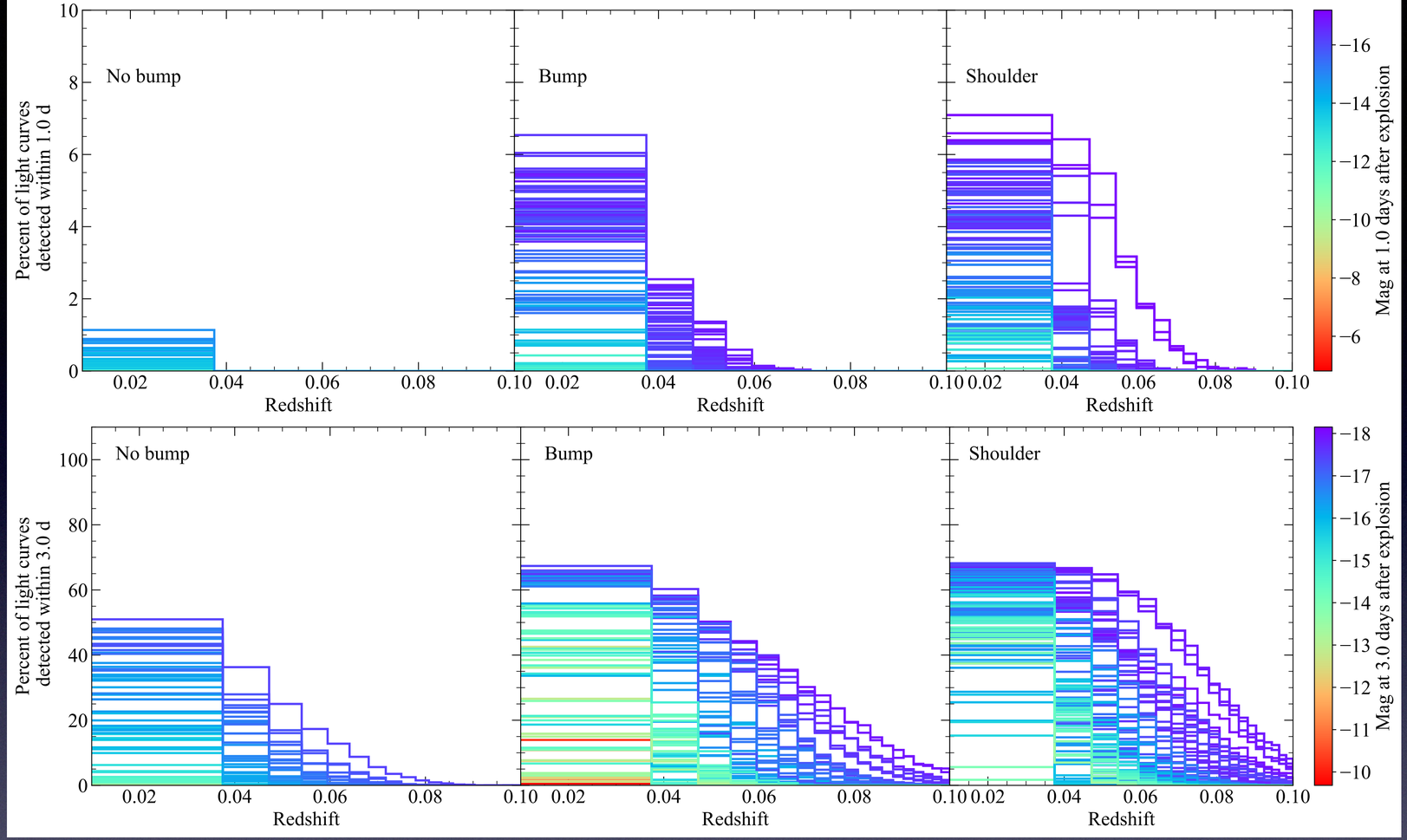

Normal
Interaction
Clump
Double detonation
Percent of light curves detected before bump end
0
10
20
30
40
50
2
3
4
5
6
Bump end time (days after explosion)
−17
−16
−15
−14
−13
Bump peak mag

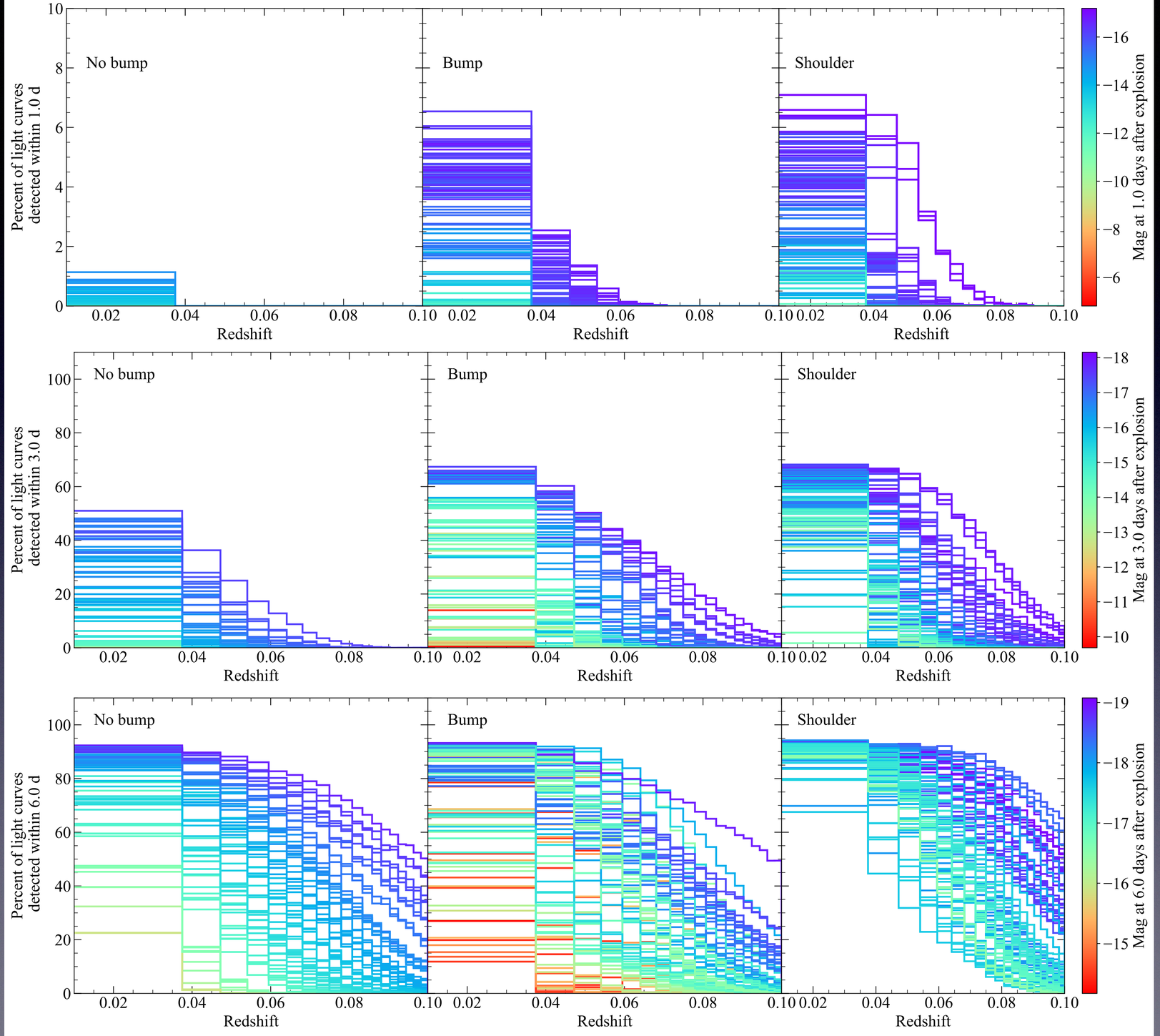

No bump
Bump
Shoulder
Brightness at 2.0d
−18
−16
−14
−12
−10
−8
−4
−2
0
2
Gradient between 1.0d and 2.0d (mag / day)
Percent detected before 2.0d
1.0
0.8
0.6
0.4
0.2
0.0


No bump
Bump
Shoulder
Brightness at 2.0d
Gradient between 1.0d and 2.0d (mag / day)
Percent detected before 2.0d
Brightness at 4.0d
Gradient between 3.0d and 4.0d (mag / day)
Percent detected before 4.0d


No bump
Bump
Shoulder
Brightness at 2.0d
Gradient between 1.0d and 2.0d (mag / day)
Percent detected before 2.0d
Brightness at 4.0d
Gradient between 3.0d and 4.0d (mag / day)
Percent detected before 4.0d
Brightness at 6.0d
Gradient between 5.0d and 6.0d (mag / day)
Percent detected before 6.0d


No bump
Bump
Shoulder
Percent of light curves detected within 1.0 d
Redshift
Redshift
Redshift
Mag at 1.0 days after explosion
0
2
4
6
8
10
0.02
0.04
0.06
0.08
0.10
−16
−14
−12
−10
−8
−6


No bump
Bump
Shoulder
Percent of light curves detected within 1.0 d
Redshift
Mag at 1.0 days after explosion
No bump
Bump
Shoulder
Percent of light curves detected within 3.0 d
Redshift
Mag at 3.0 days after explosion


No bump
Bump
Shoulder
Percent of light curves detected within 1.0 d
Redshift
Mag at 1.0 days after explosion
Percent of light curves detected within 3.0 d
Mag at 3.0 days after explosion
Percent of light curves detected within 6.0 d
Mag at 6.0 days after explosion

Questions/comments?