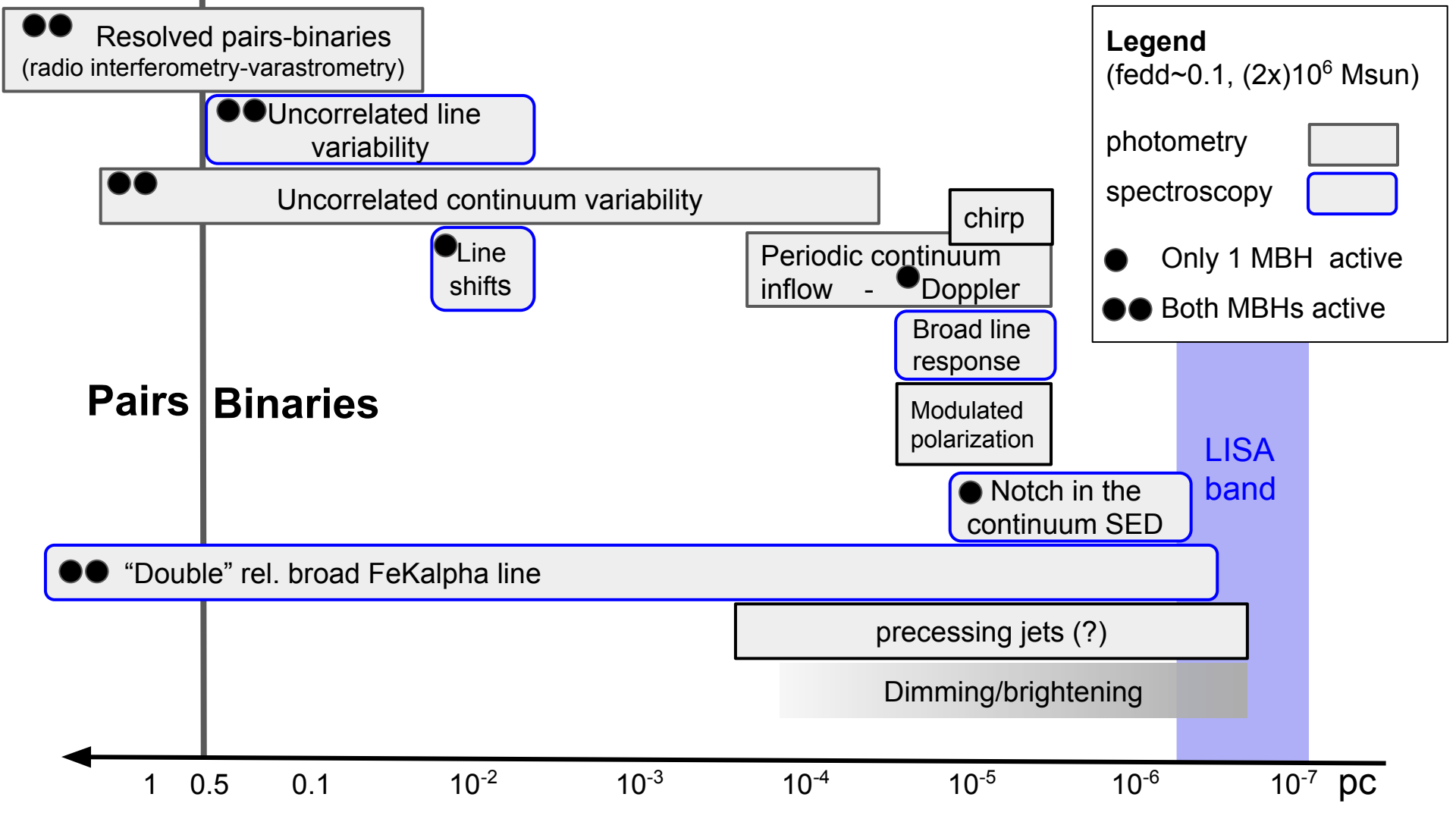
Strategies to identify LISA MBH binary precursors in large EM catalogues

Massimo Dotti (University of Milano-Bicocca)

Main collaborators:

Lorenzo Bertassi - Matteo Bonetti - Roberto Decarli - Daniel D'Orazio - Mike Eracleous - Zoltan Haiman - Carmen Montuori - Fabio Rigamonti - Erika Sottocorno - Vivi Tsalmantza…


Resolved pairs-binaries
(radio interferometry-varastrometry)
Uncorrelated line variability
Uncorrelated continuum variability
Line shifts
chirp
Periodic continuum inflow - Doppler
Broad line response
Modulated polarization
Notch in the continuum SED
"Double" rel. broad FeKalpha line
precessing jets (?)
Dimming/brightening
Pairs
Binaries
LISA band
Legend
(fedd~0.1, (2x)10^6 Msun)
photometry
spectroscopy
Only 1 MBH active
Both MBHs active
1
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0.1
10^-2
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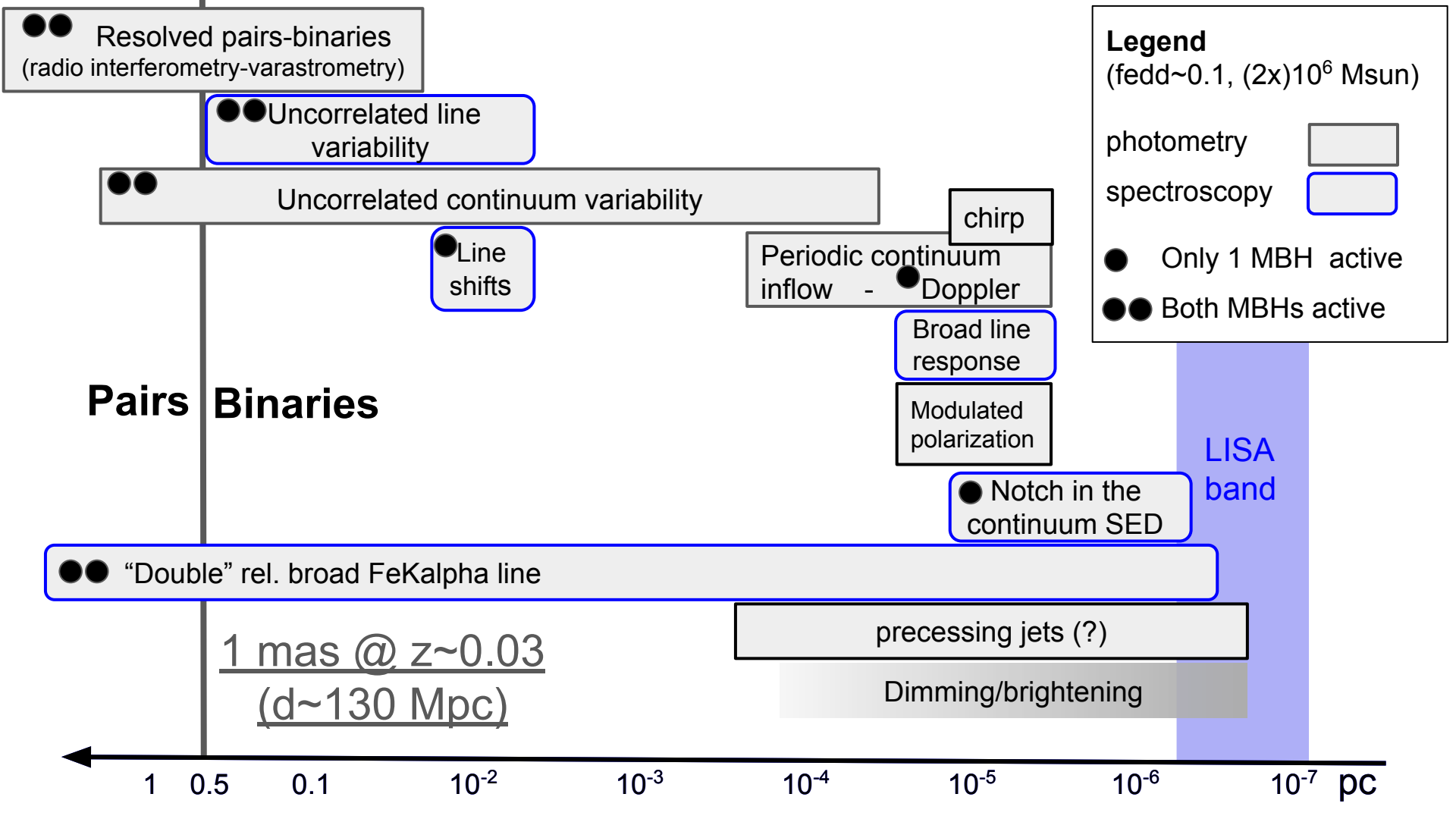
pc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1 mas @ z~0.03
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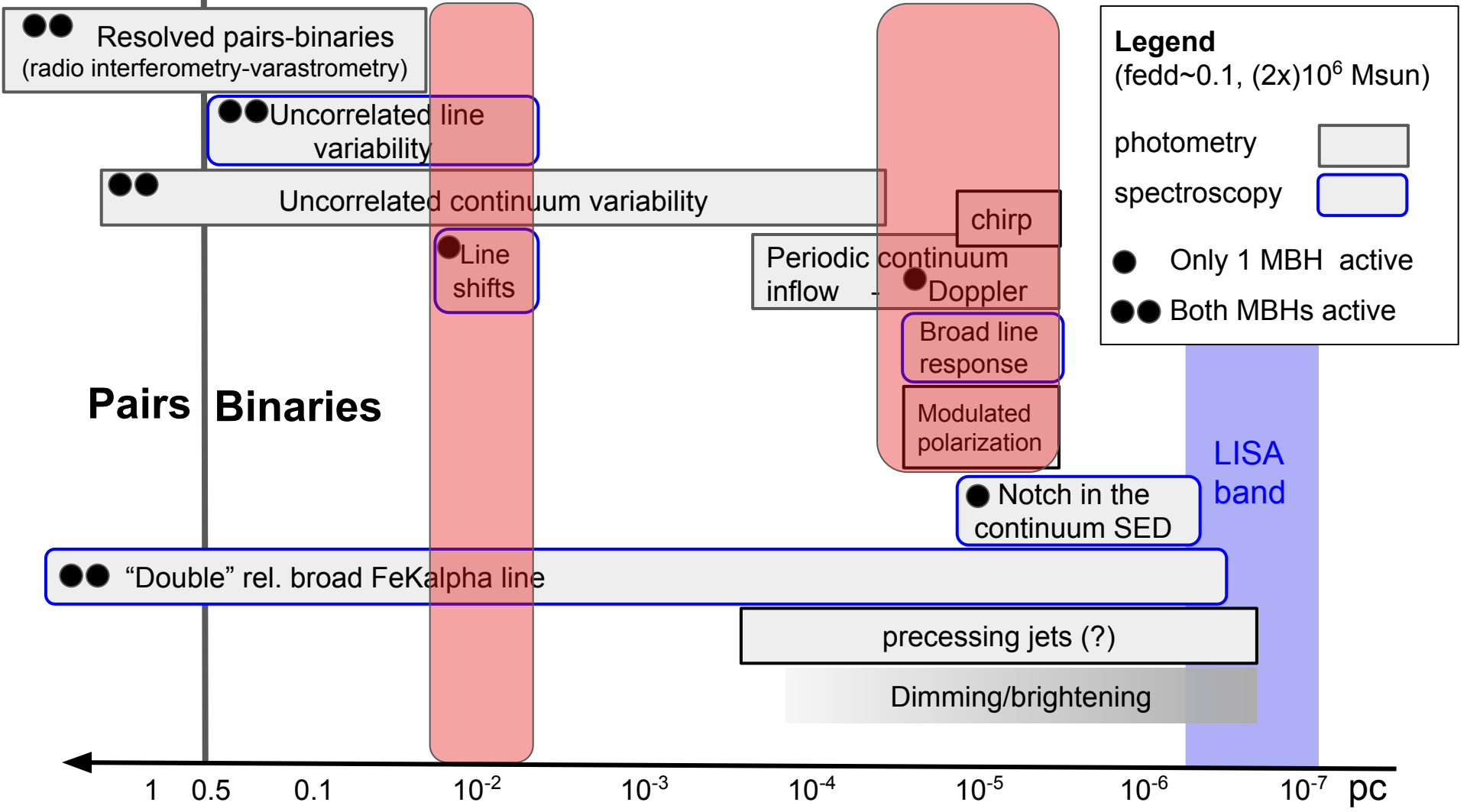
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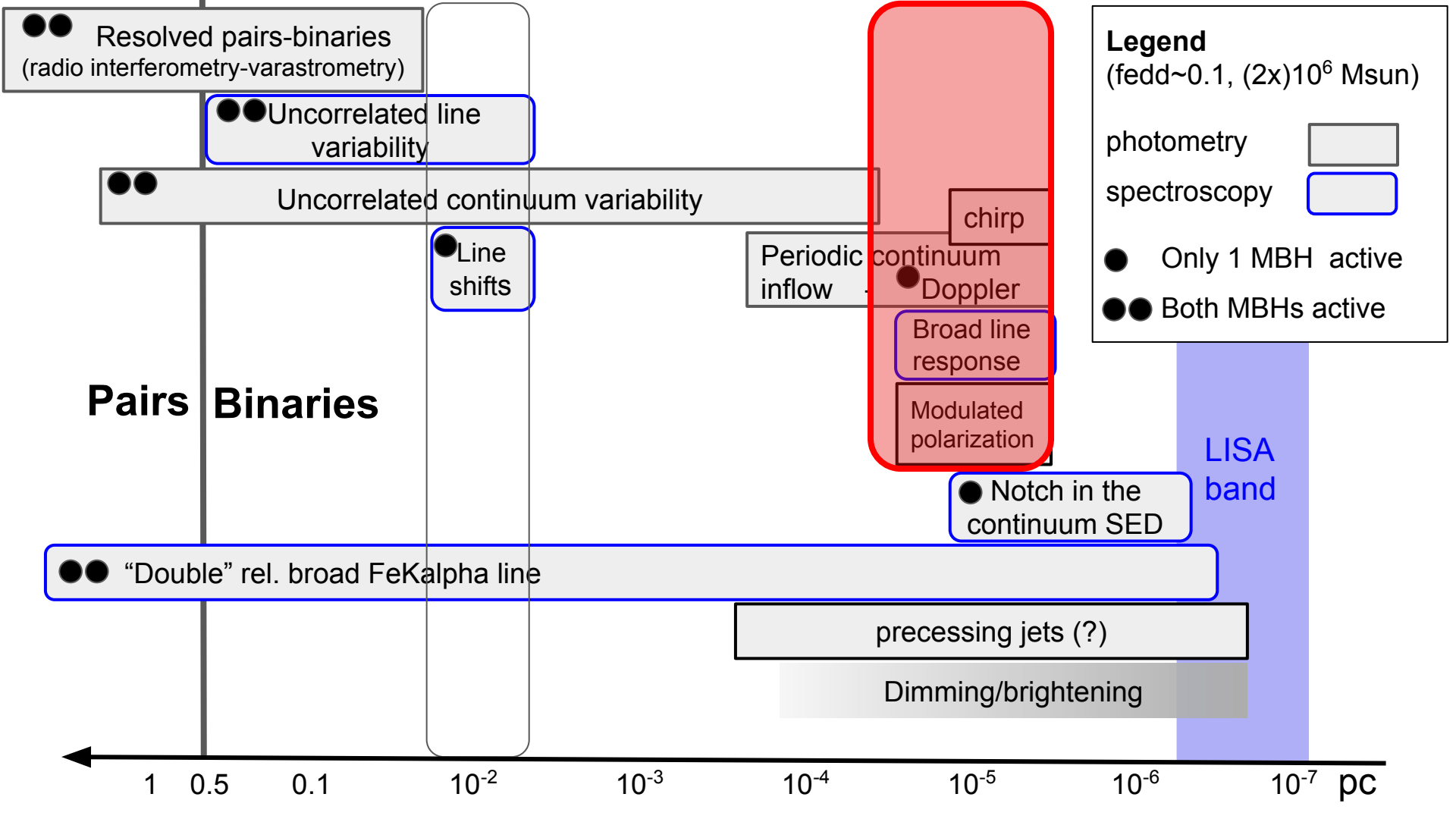
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Closer binaries

many (~150) candidates from different groups (we are guilty too), using different surveys (e.g. CRTF, PTF, or found serendipitously…)

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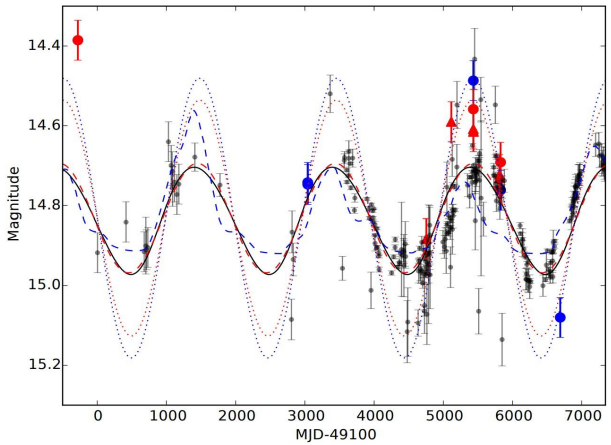

optical, near UV, far UV
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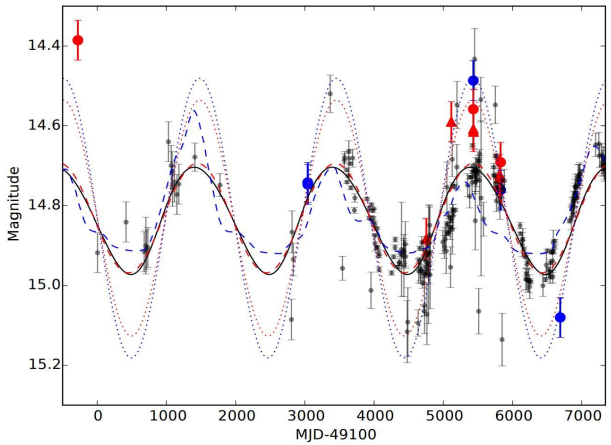

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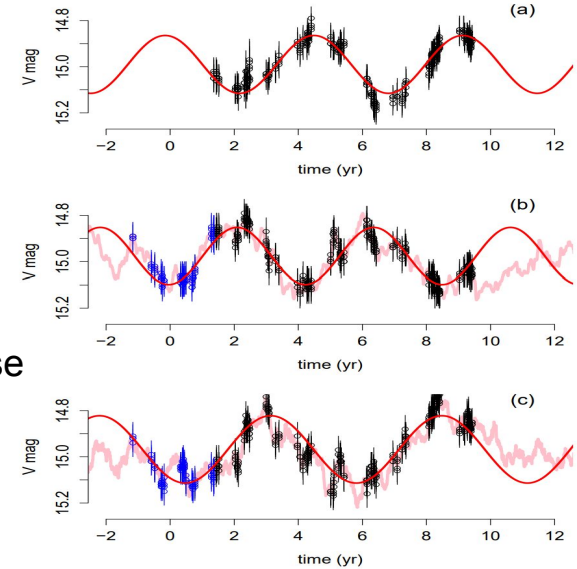
Catalina data



Two random red-noise realizations w same sampling pattern

(Vaughan+2016)

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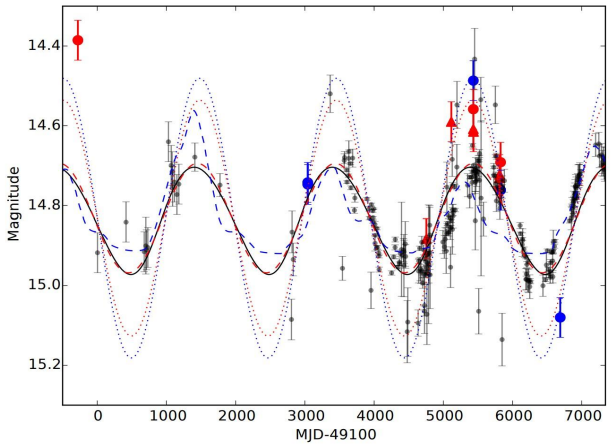

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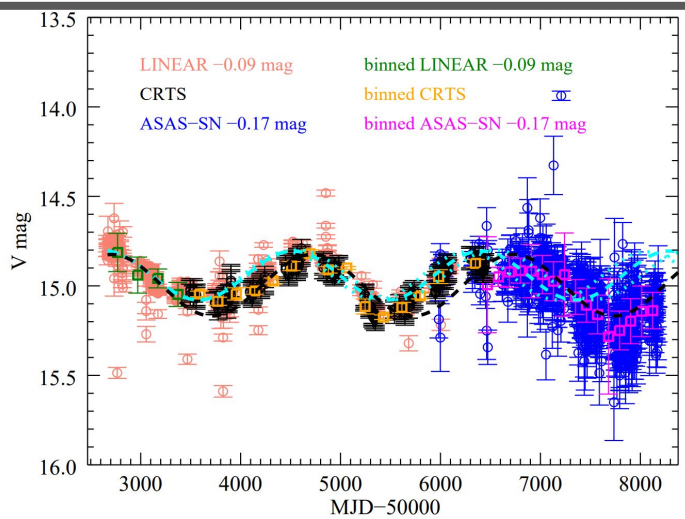

"Did ASAS-SN Kill the Supermassive Black Hole Binary Candidate PG1302-102?" (Liu+2018)

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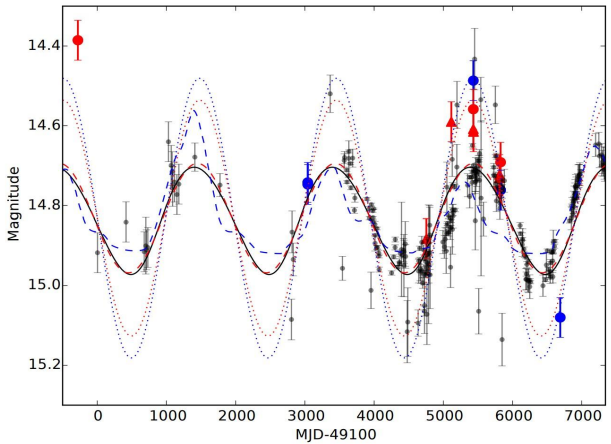

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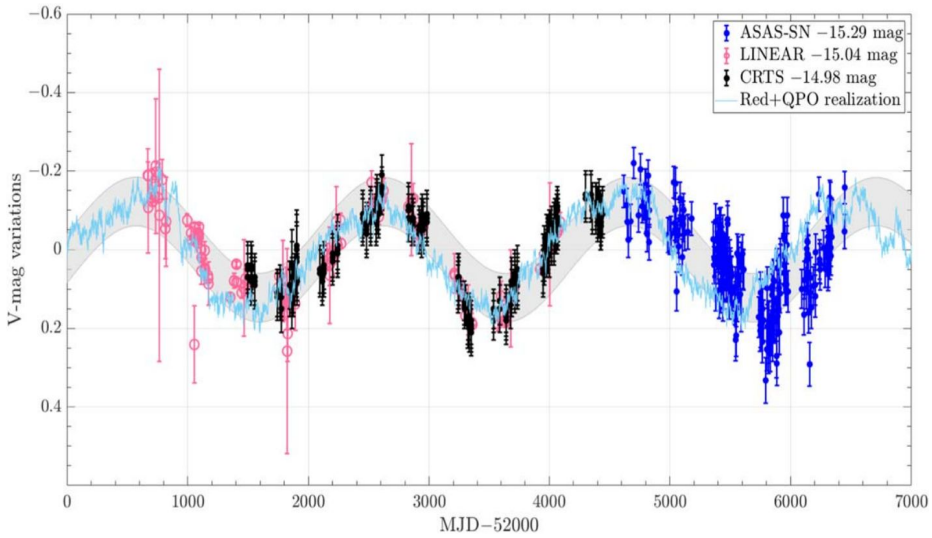

Preferred red noise+periodicity (BF~1e6, Zhu+2020)

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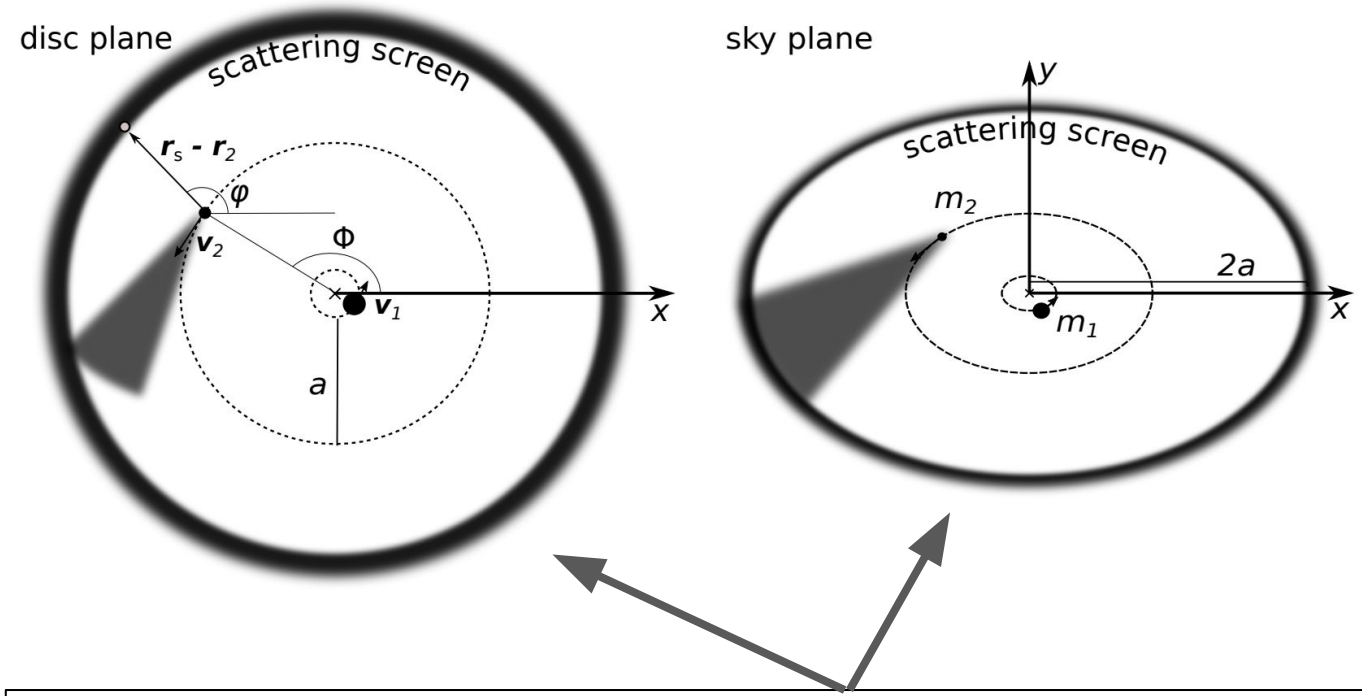
Periodic variability of polarization degree and angle (photometry, Dotti+2022)

BEL response to the continuum variability (Bertassi+in prep.)

Time dependent polarization (Dotti+2022)



(equatorial - e.g. Antonucci 1984, Smith+2002, Gaskell+2012 - for type I AGN)

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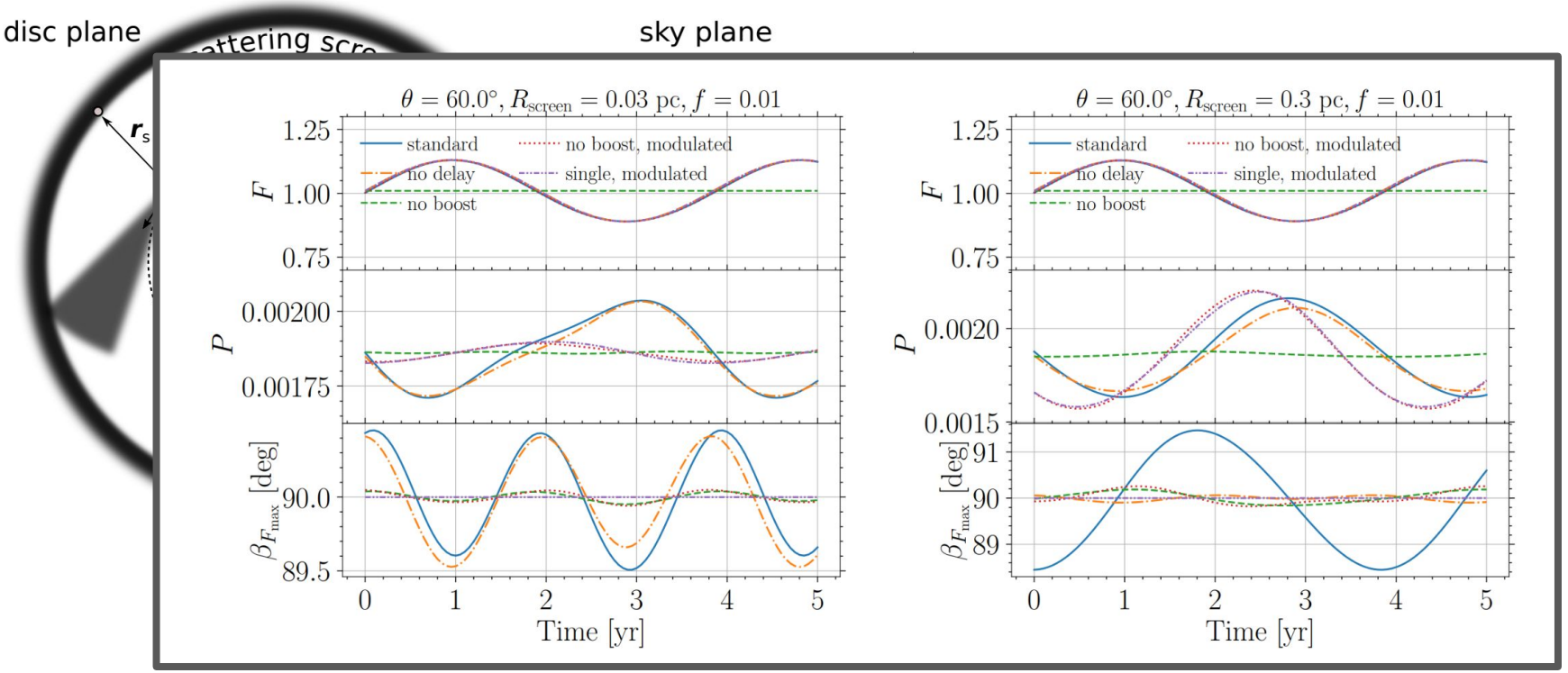

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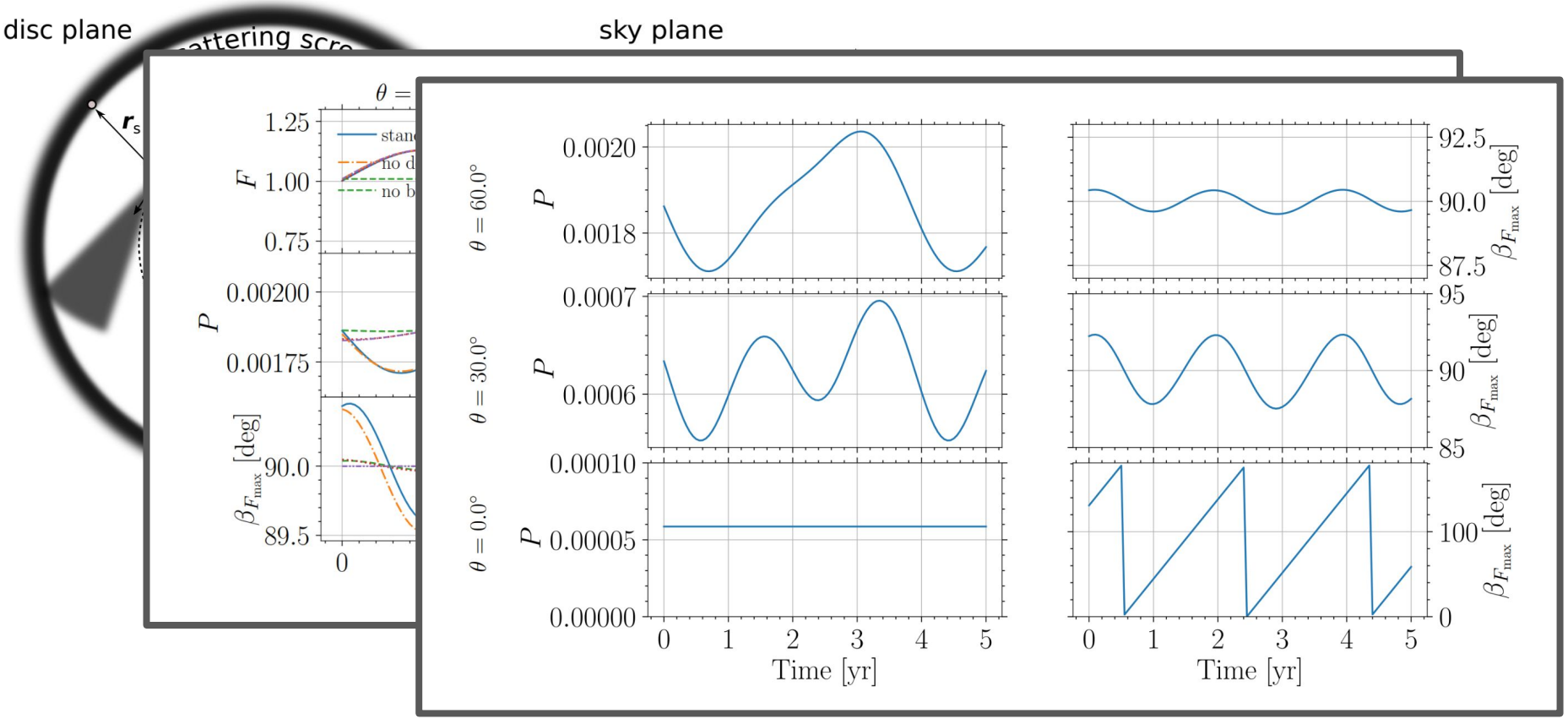

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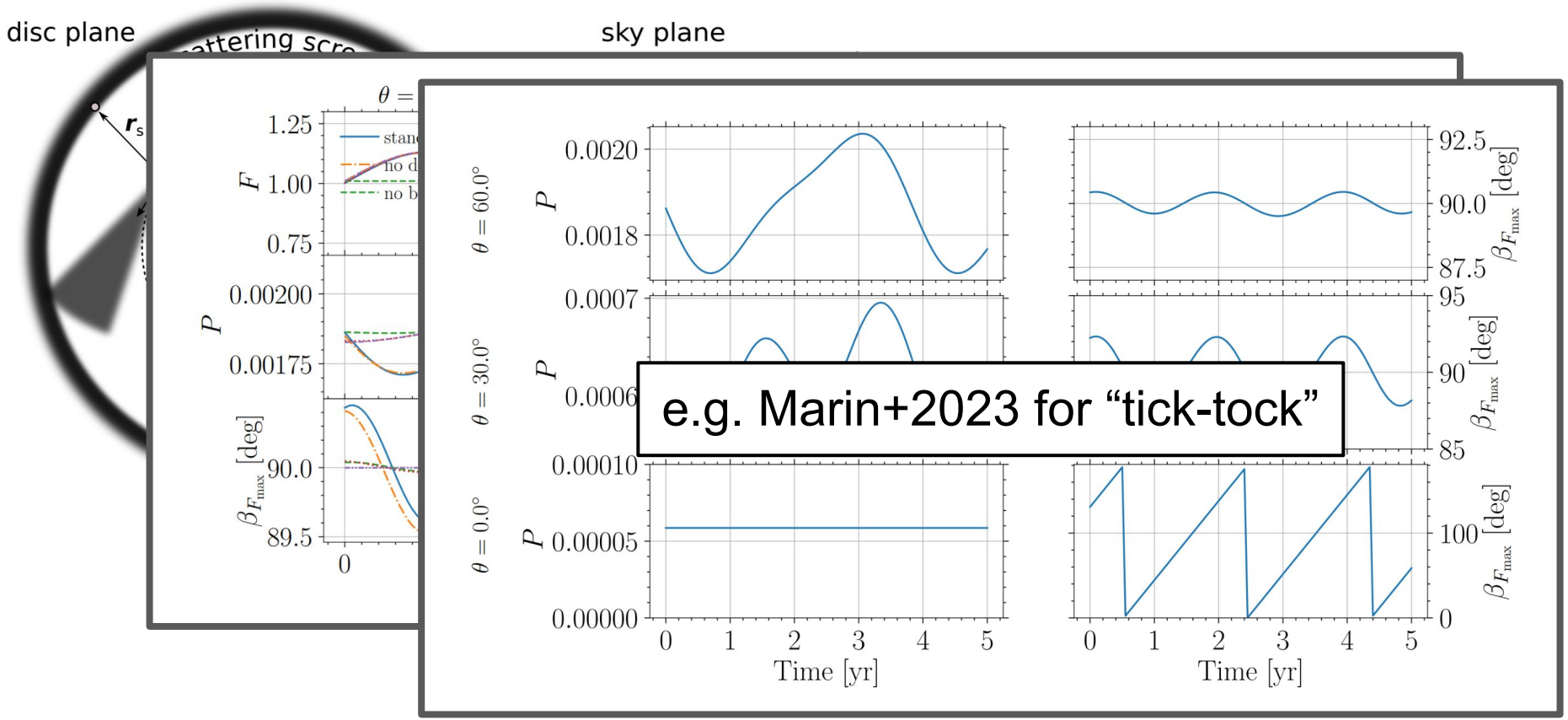
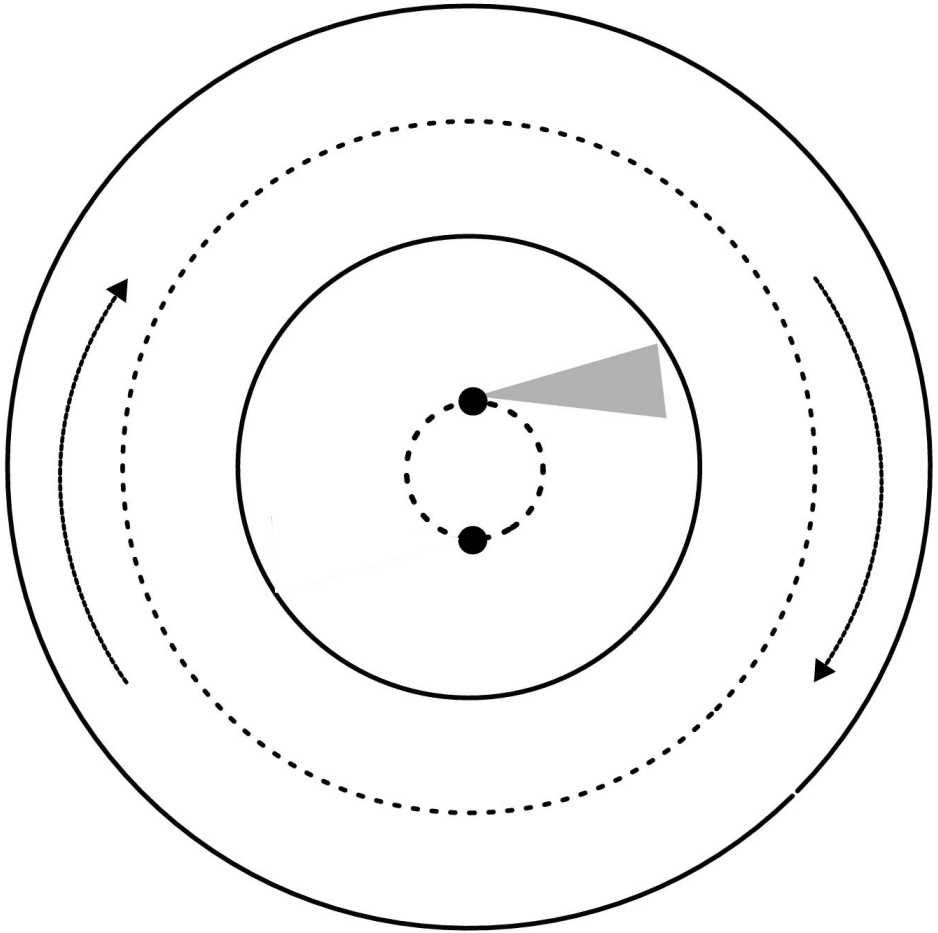


BLR response (Bertassi+ in preparation)



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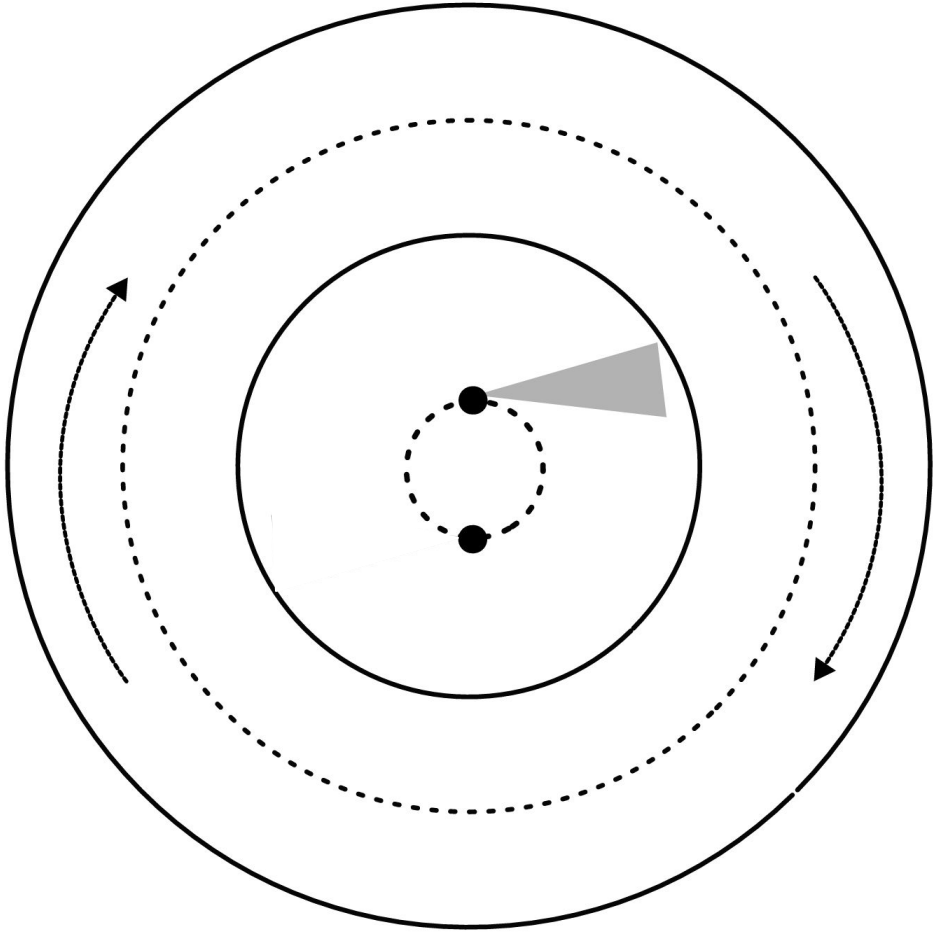

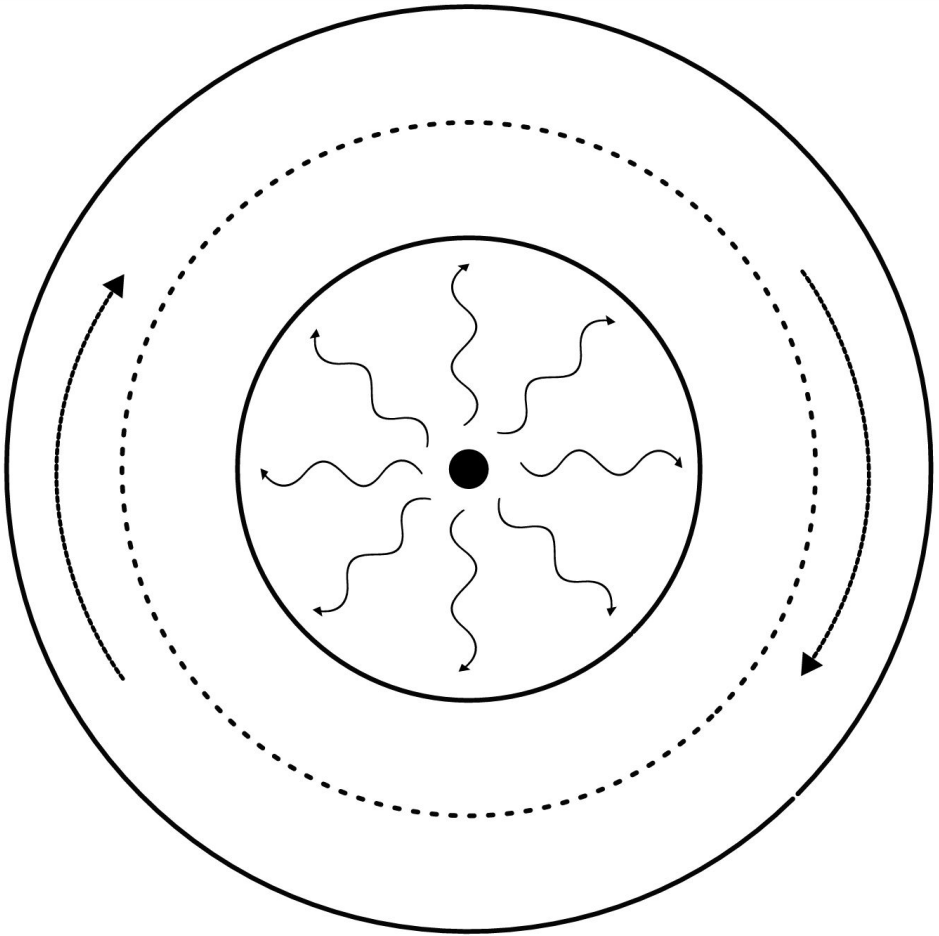

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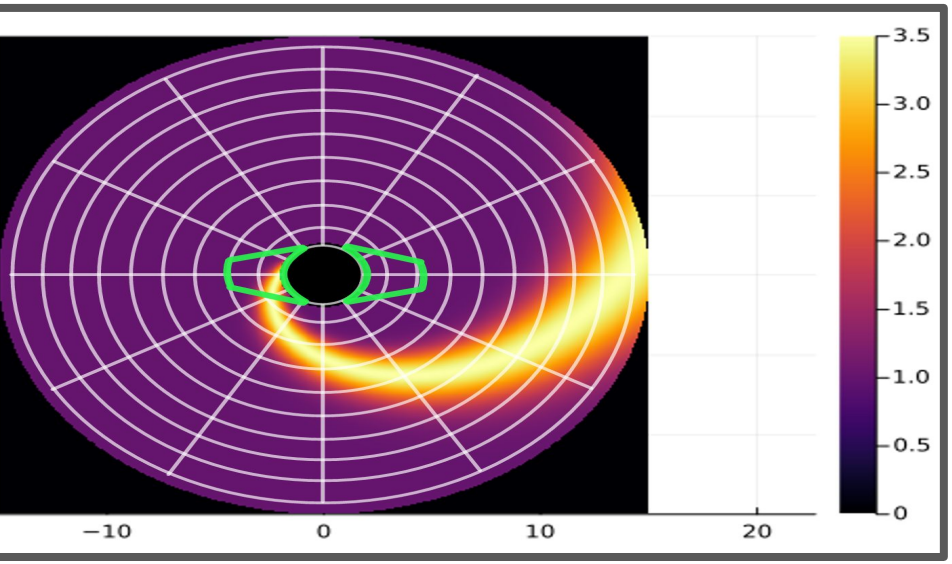

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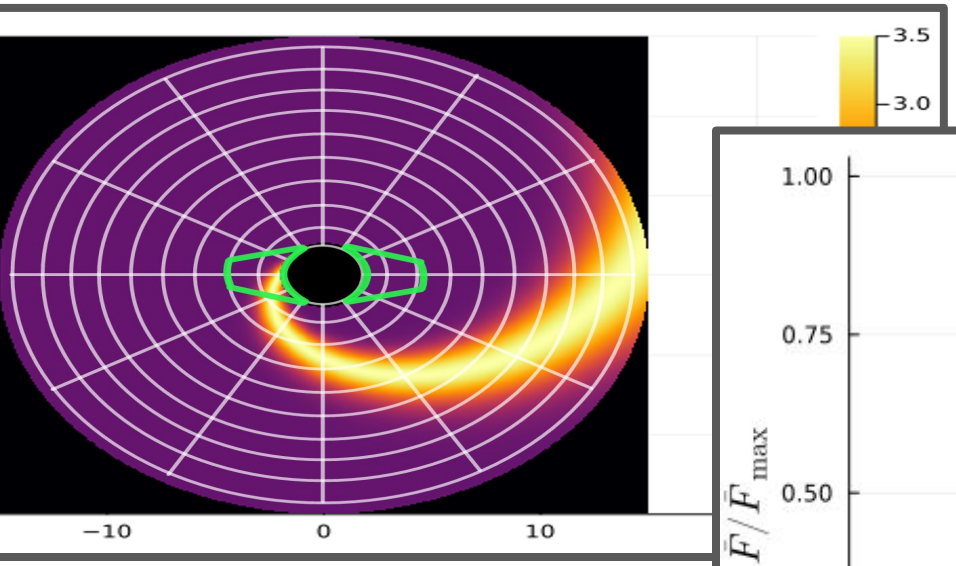

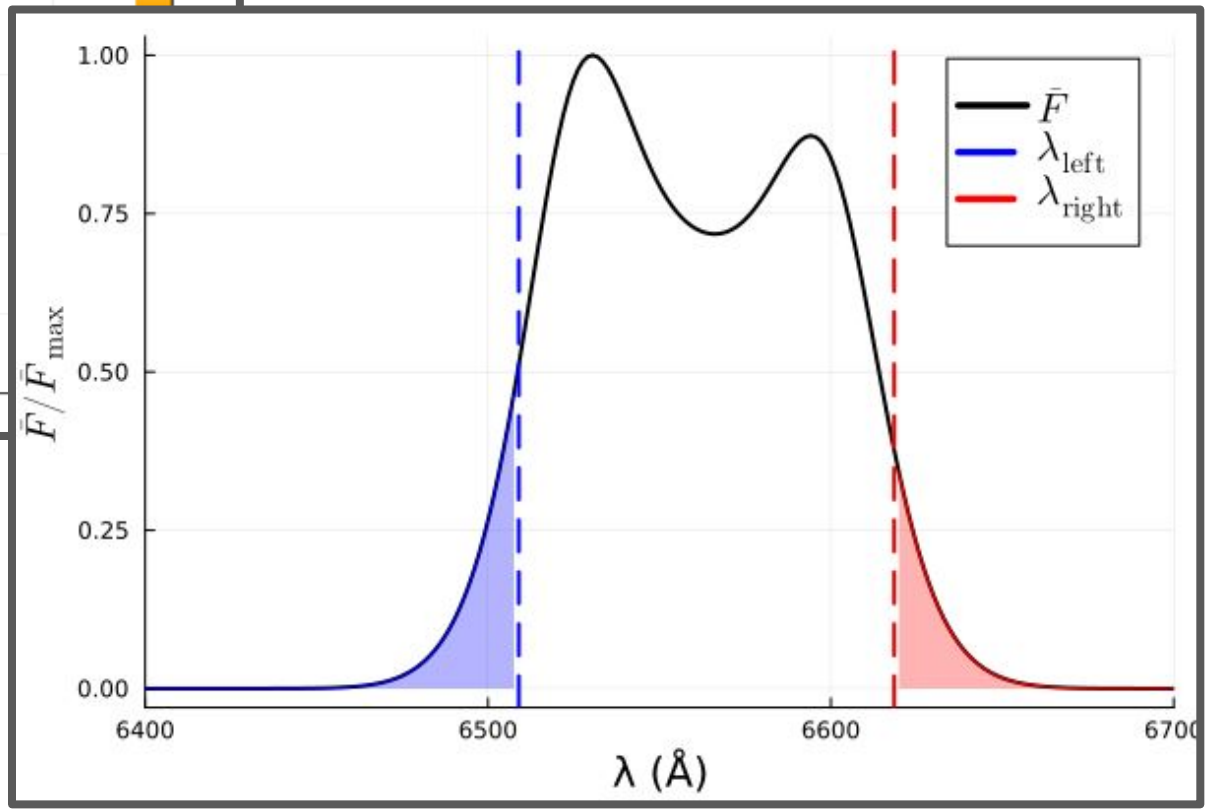

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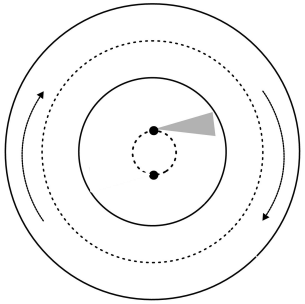

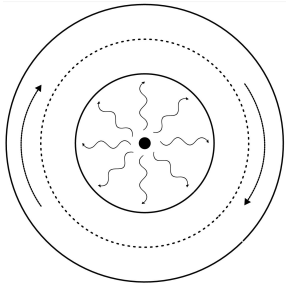

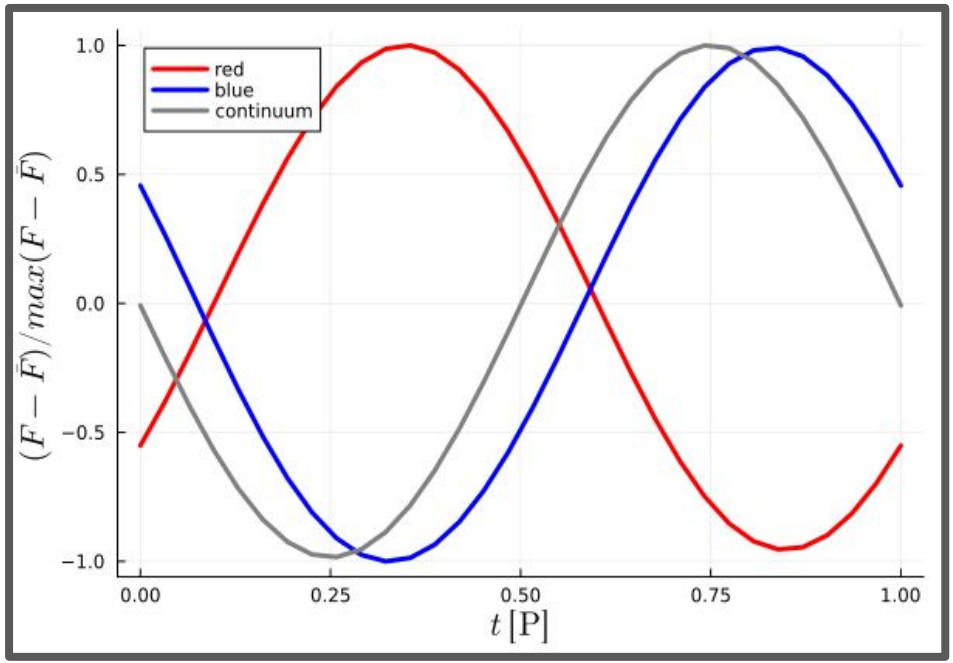

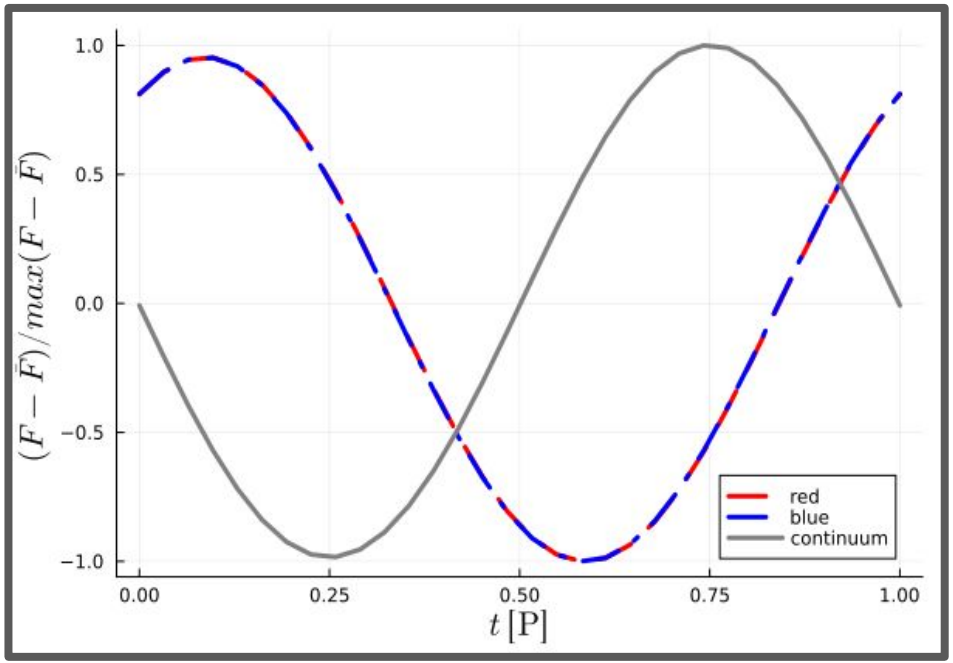

Take home messages

A very hard task

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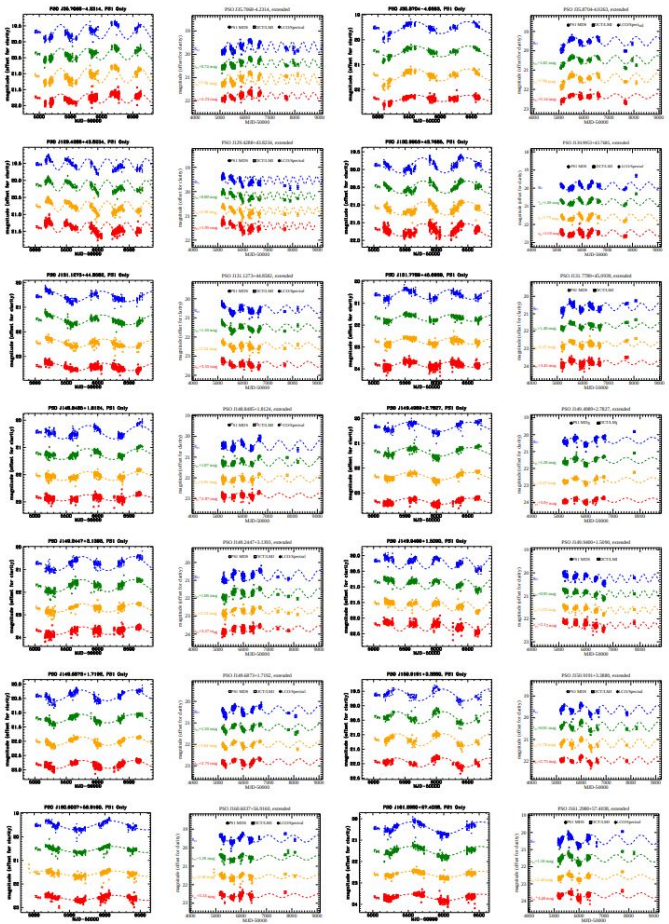
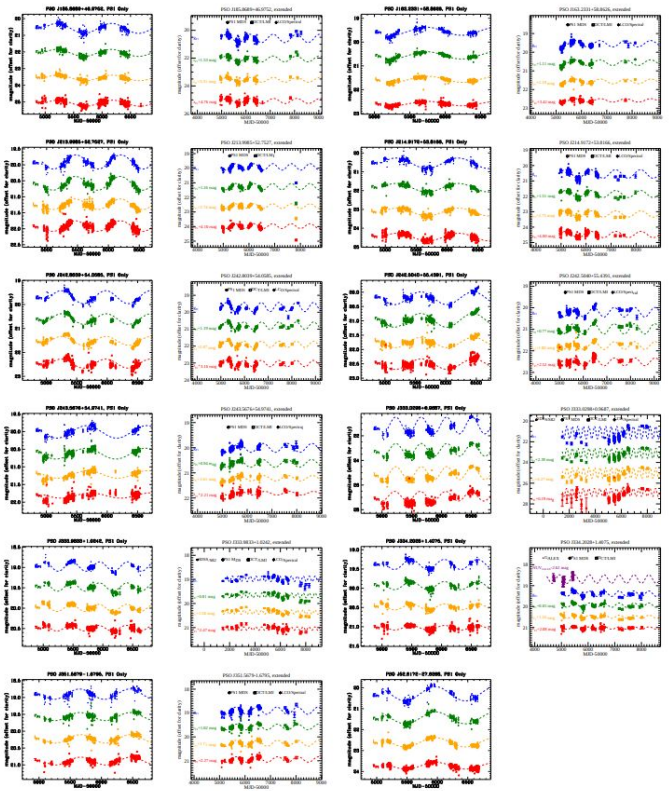
Time-domain spectroscopic (e.g. SDSS-V) and photometric (e.g. LSST, ULTRASAT, Roman) surveys might be game-changers

loose constraint on the maximum velocity of a secondary that keeps its BLR

$$v_2 \approx 480\,\mathrm{km\,s^{-1}} \times \left(\frac{M_2}{10^6\,\mathrm{M_\odot}}\right)^{0.24} f_{\mathrm{Edd}}^{-0.26}\, f(q)^{-0.5}$$

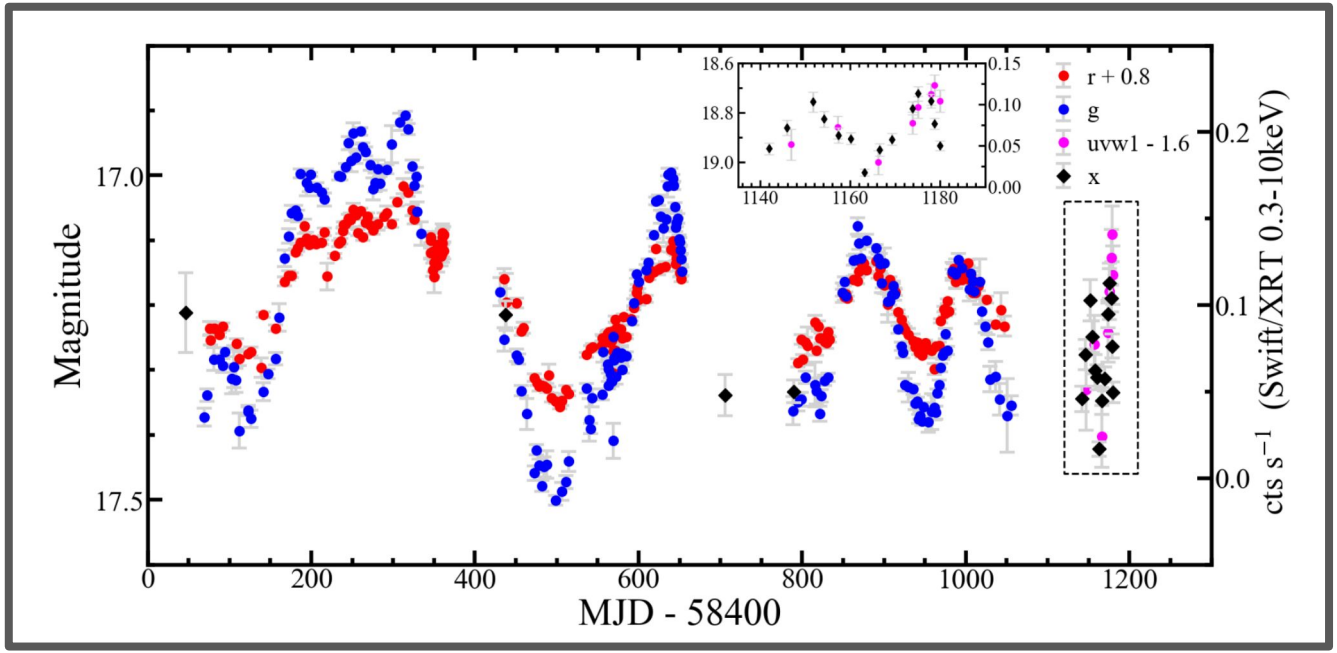
$$M_2 = 10^6\,\mathrm{M_\odot} \text{ and } q = 1 \text{ would require } f_{\mathrm{Edd}} \lesssim 0.01$$





From Liu+2019, using the Pan-STARRS1 medium survey

Peculiar cases: the tick-tock object (Jang+2022)



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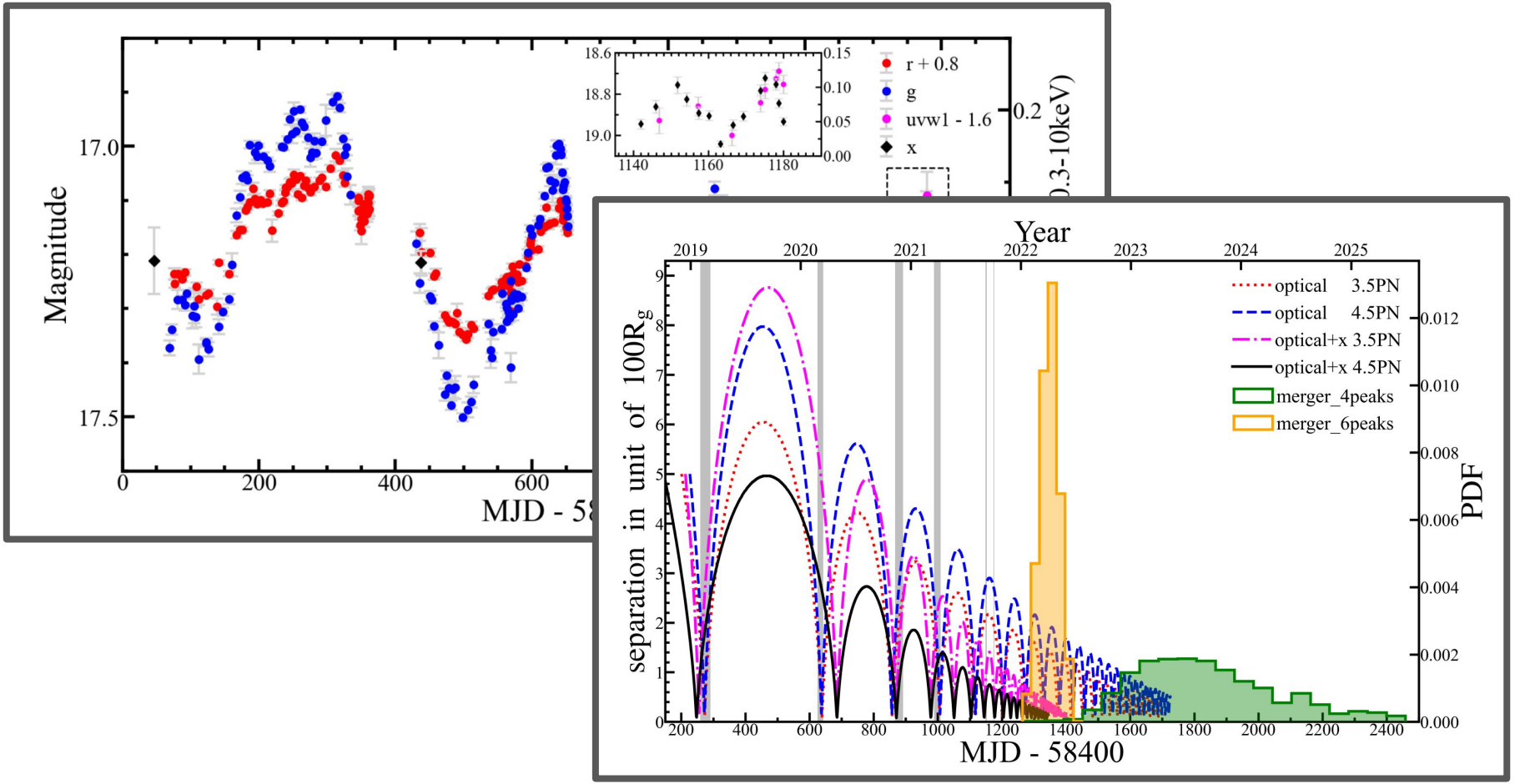

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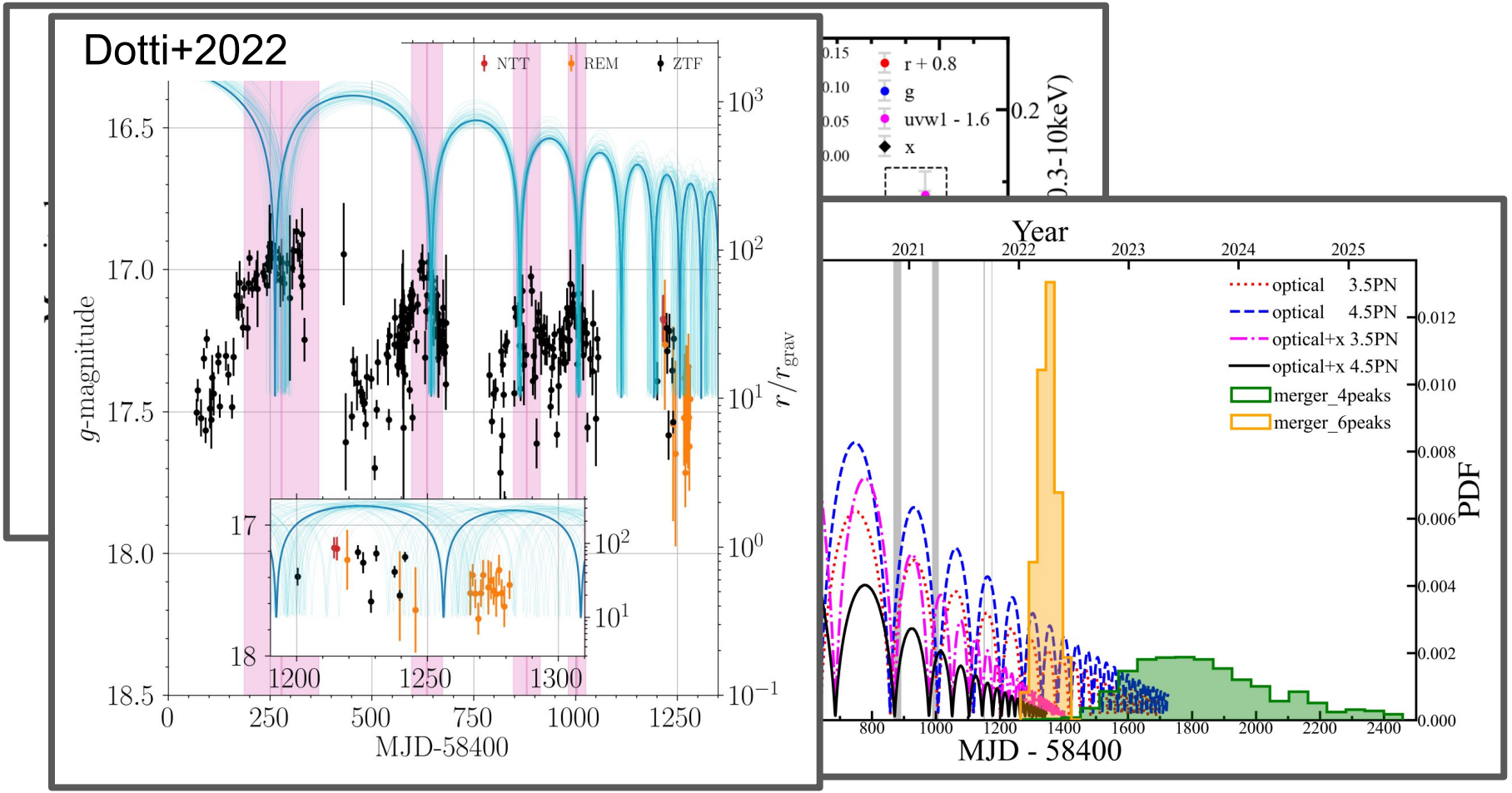

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