Tidal Disruption Events (TDE)

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Directed by Professor Feng Hua

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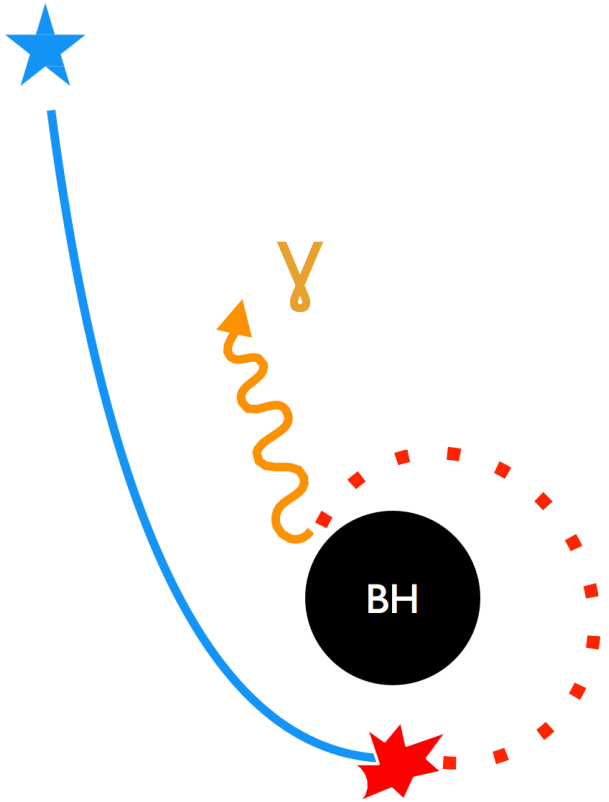
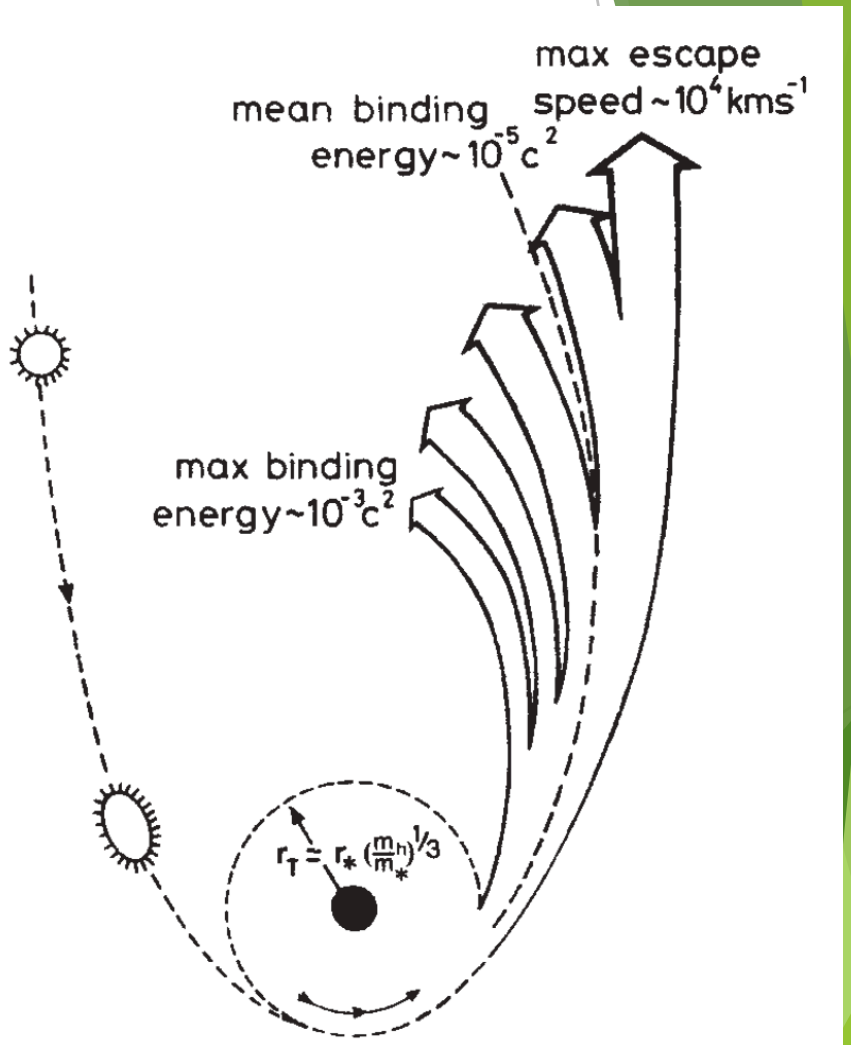
Outline

- What are Tidal Disruption Events (TDE)?
- Motivation for TDE studies
- Basics of the physics

- Overview on observations
- Recent simulations

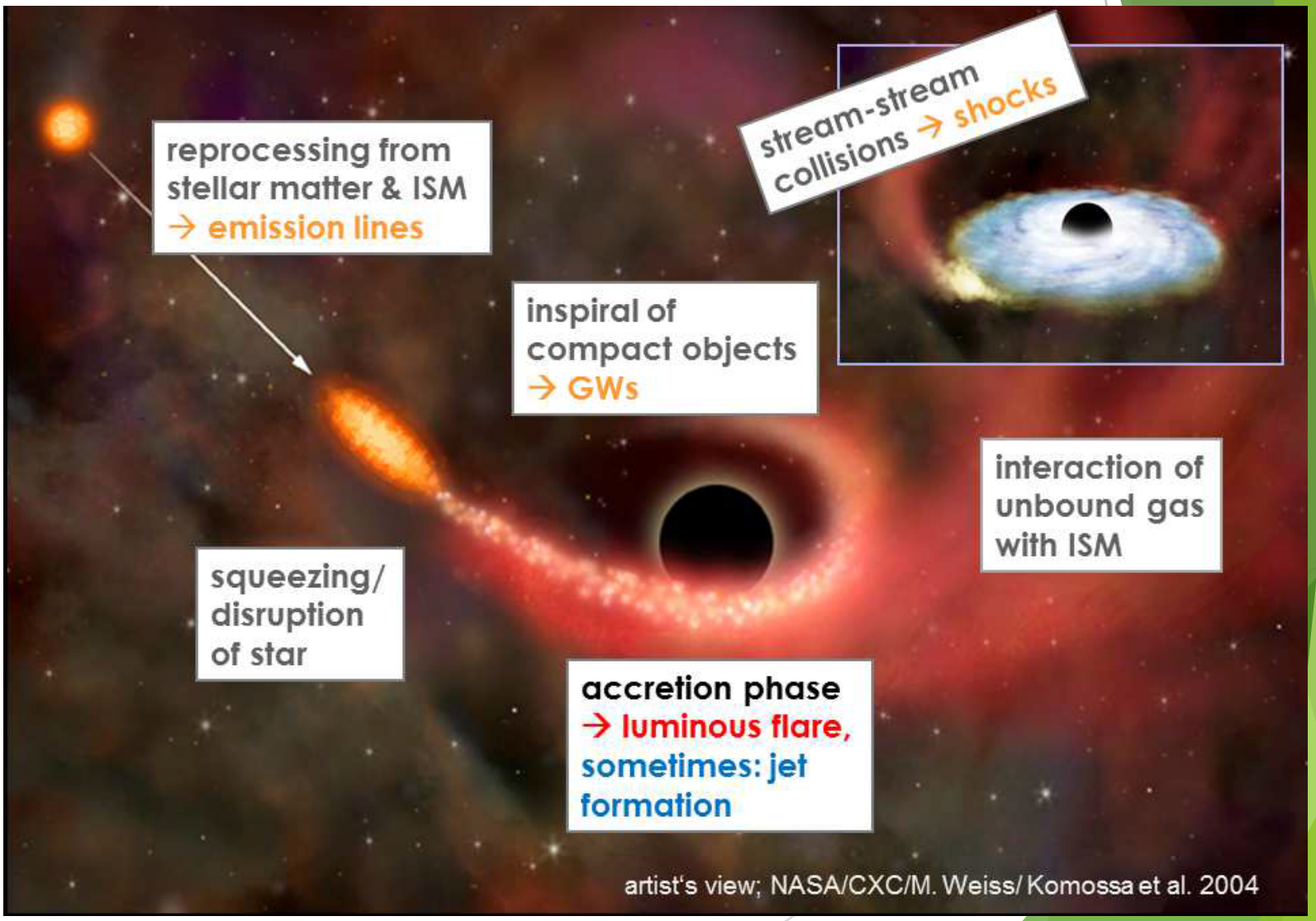
What are Tidal Disruption Events (TDE)





(Rees 1988)

What are TDEs?



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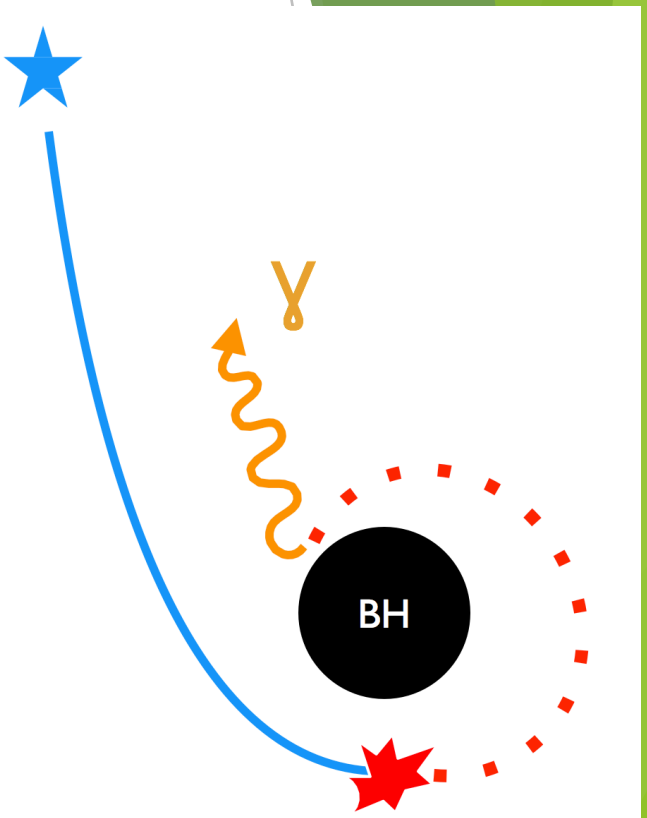
Motivation for TDE studies

- Probe quiescent SMBHs & M-σ
- Detect IMBHs
- Detect SMBHBs
- Detect exoplanets

- Stellar dynamics & population

- High-energy CRs and neutrinos

- Probe general relativity
- Gravitational waves



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Basics of the physics

- Tidal radius

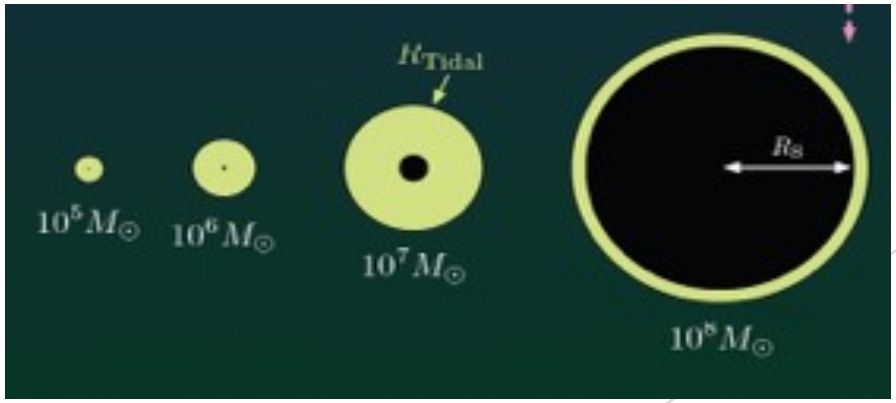
$$r_{\rm T} \simeq 5 \times 10^{12}\ M_6^{1/3}\ (r_*/r_\odot)\ (m_*/m_\odot)^{-1/3}\ {\rm cm}$$

(Rees, 1988)

- Gravitational radius

$$R_{\rm G} = 2GM/c^2 = 2.95\ {\rm km}\ (M/M_\odot)$$

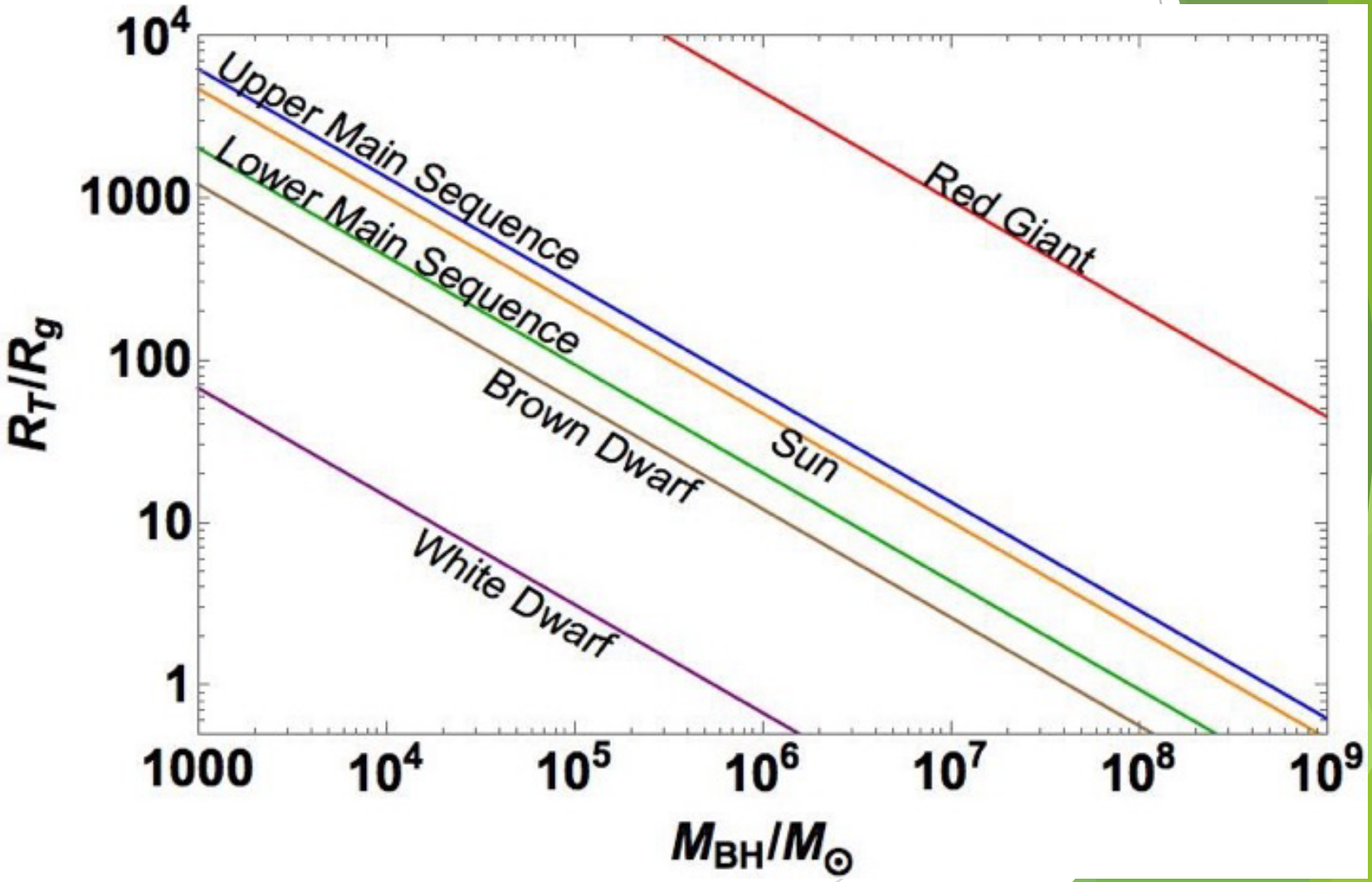
(Hills, 1975)



(Dai, 2017 slides)

Basics of the physics

(Dai, 2017 slides)



Basics of the physics

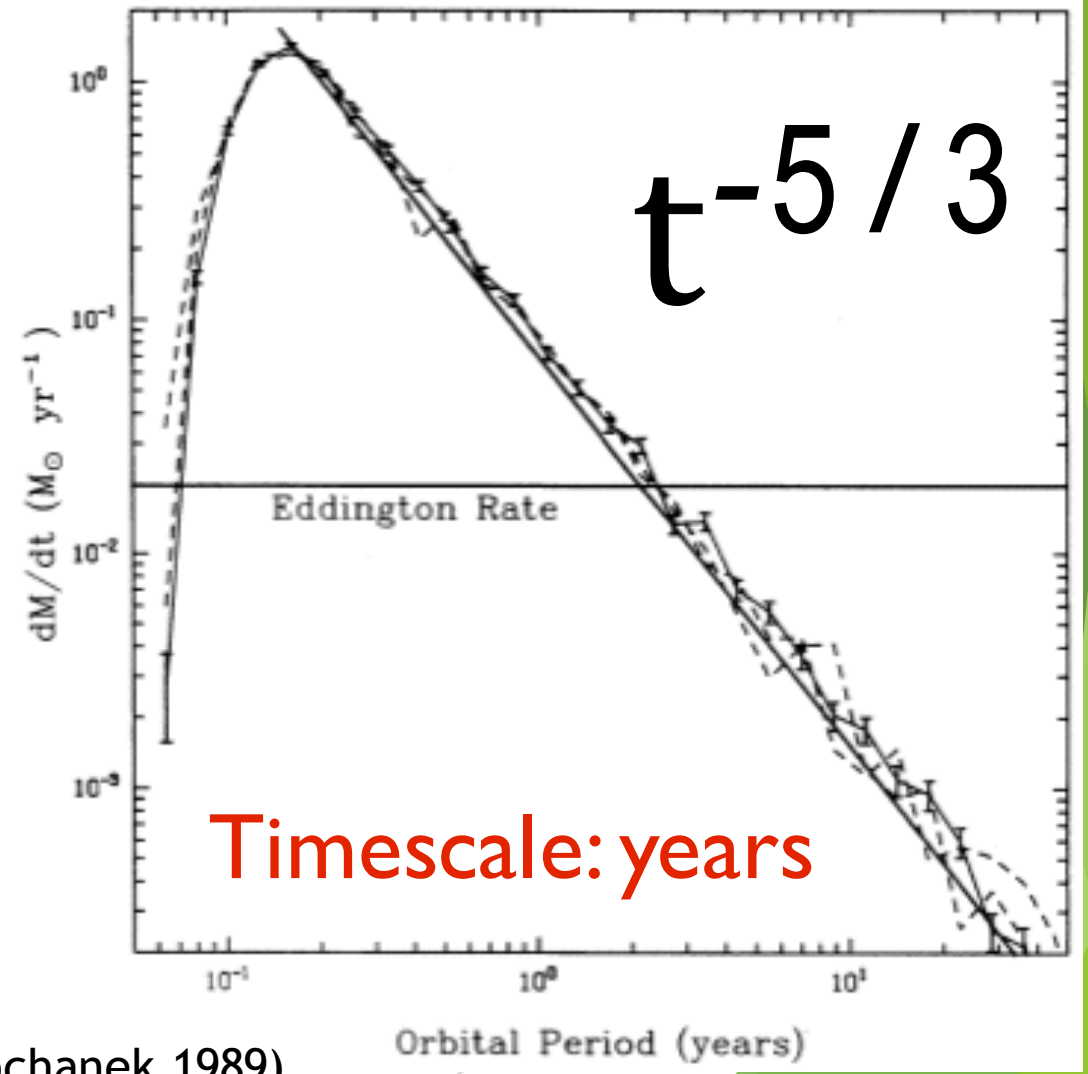
- Event rate

$$10^{-4}\, M_6^{4/3} \left(\frac{N_*}{10^5\ \mathrm{pc}^{-3}}\right) \left(\frac{\sigma}{100\ \mathrm{km\ s}^{-1}}\right)^{-1} \left(\frac{r_{\mathrm{min}}}{r_{\mathrm{T}}}\right) \quad \mathrm{yr}^{-1}$$

(Rees, 1988)

Basics of the physics

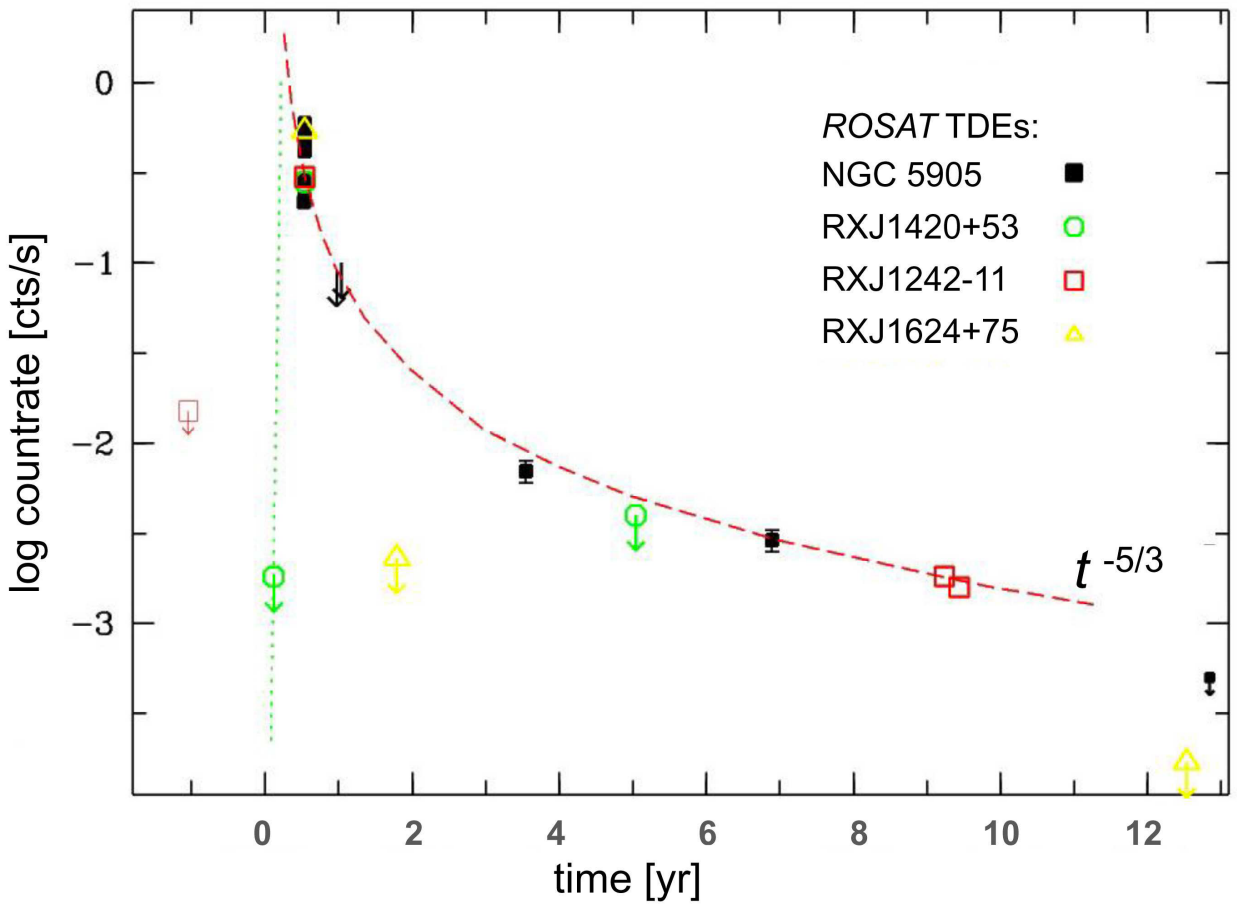
- Accretion rate



(Evans & Kochanek 1989)

Basics of the physics

- Time scale & Lightcurve



(Komossa 2015)

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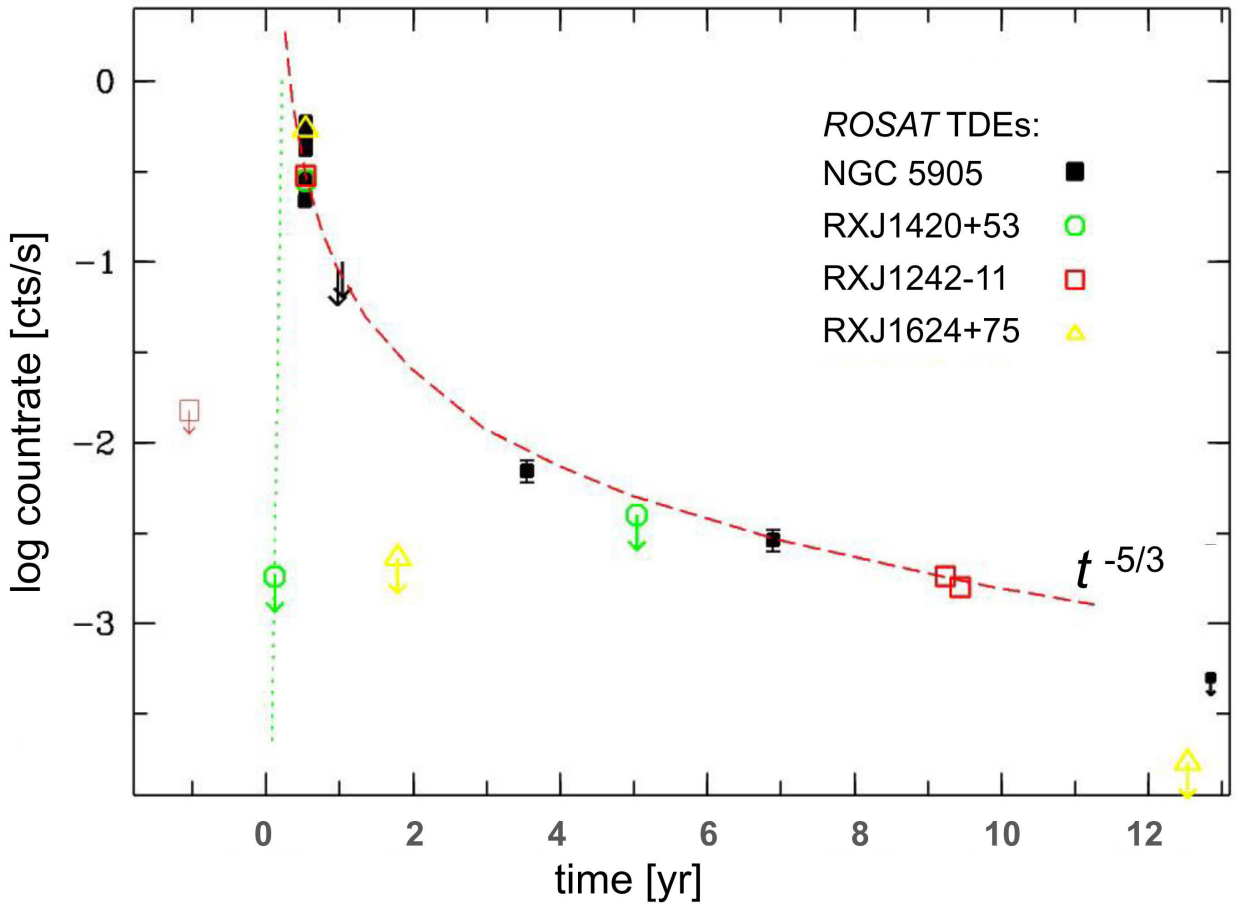
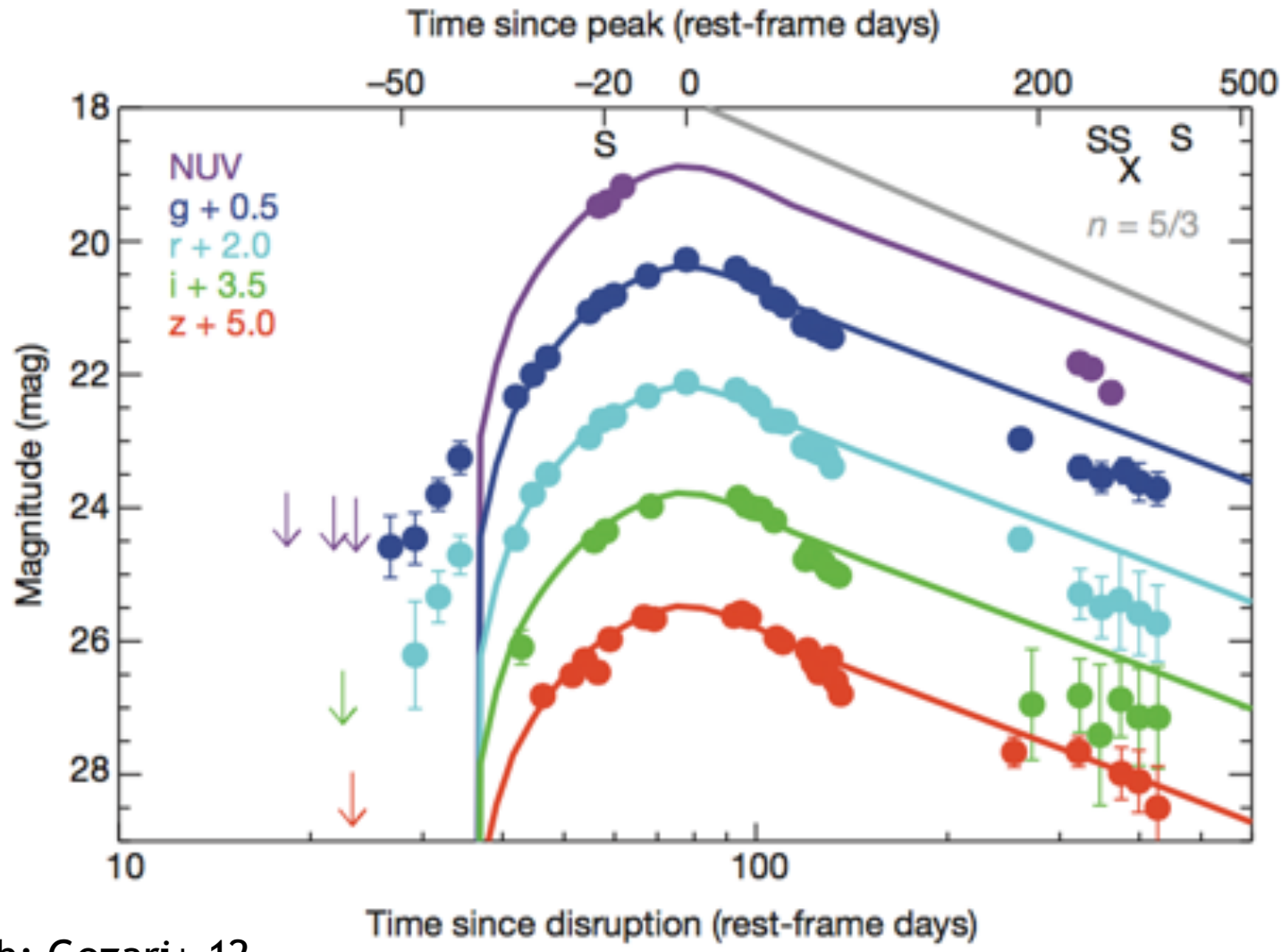
Overview on observations



(Komossa 2015)

Overview on observations



PS 10-jh: Gezari+ 12

Overview on observations

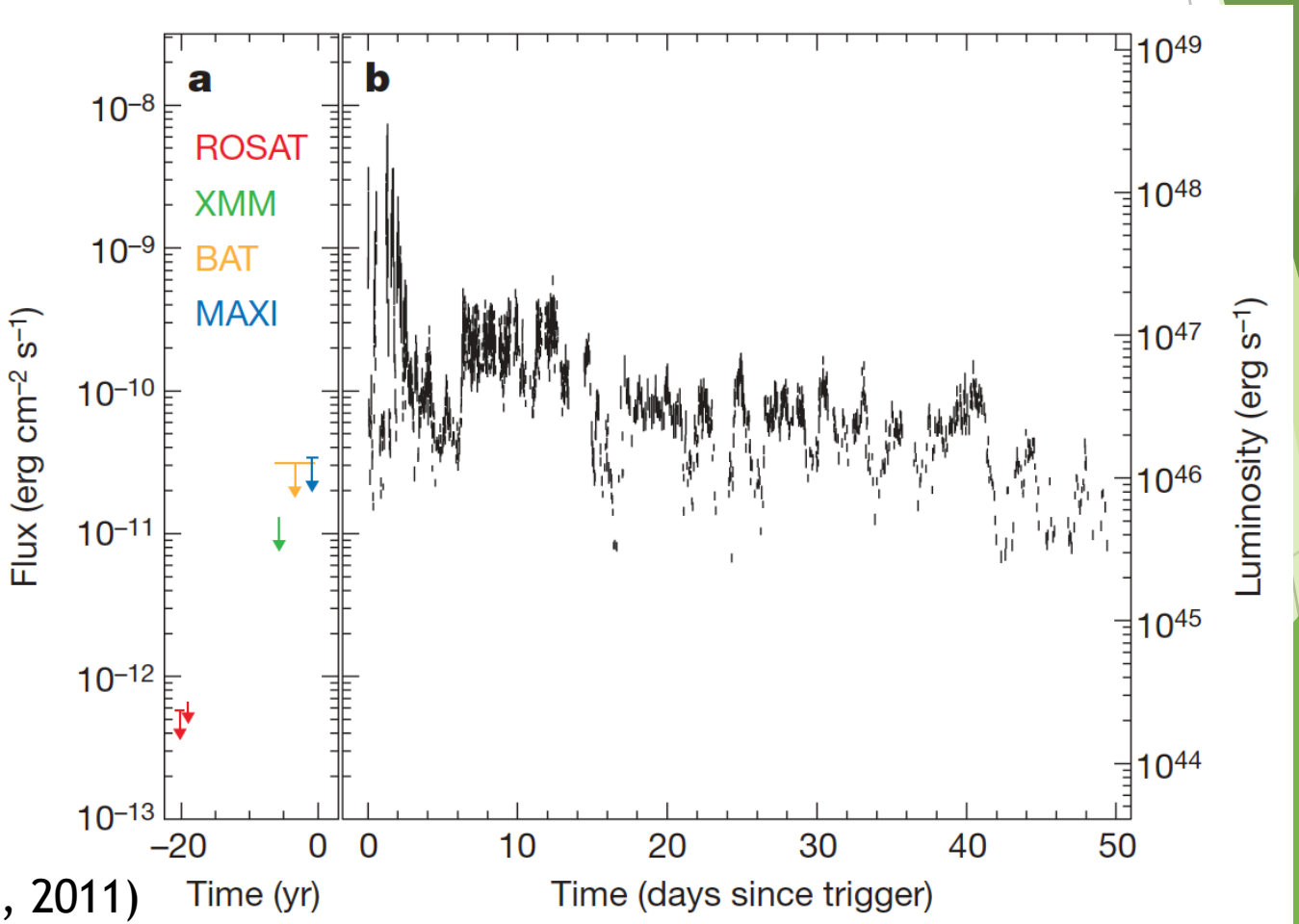
- ROSAT all-sky survey, XMM Newton slew survey, Chandra deep fields, clusters of galaxies, GALEX & SDSS
- ~50 TDE candidates
- Rate: 10^{-4}– 10^{-5}/ yr/ galaxy

Same order as theoretical predictions

Overview on observations

- SWIFT 1644+57

Hard X-ray lightcurve

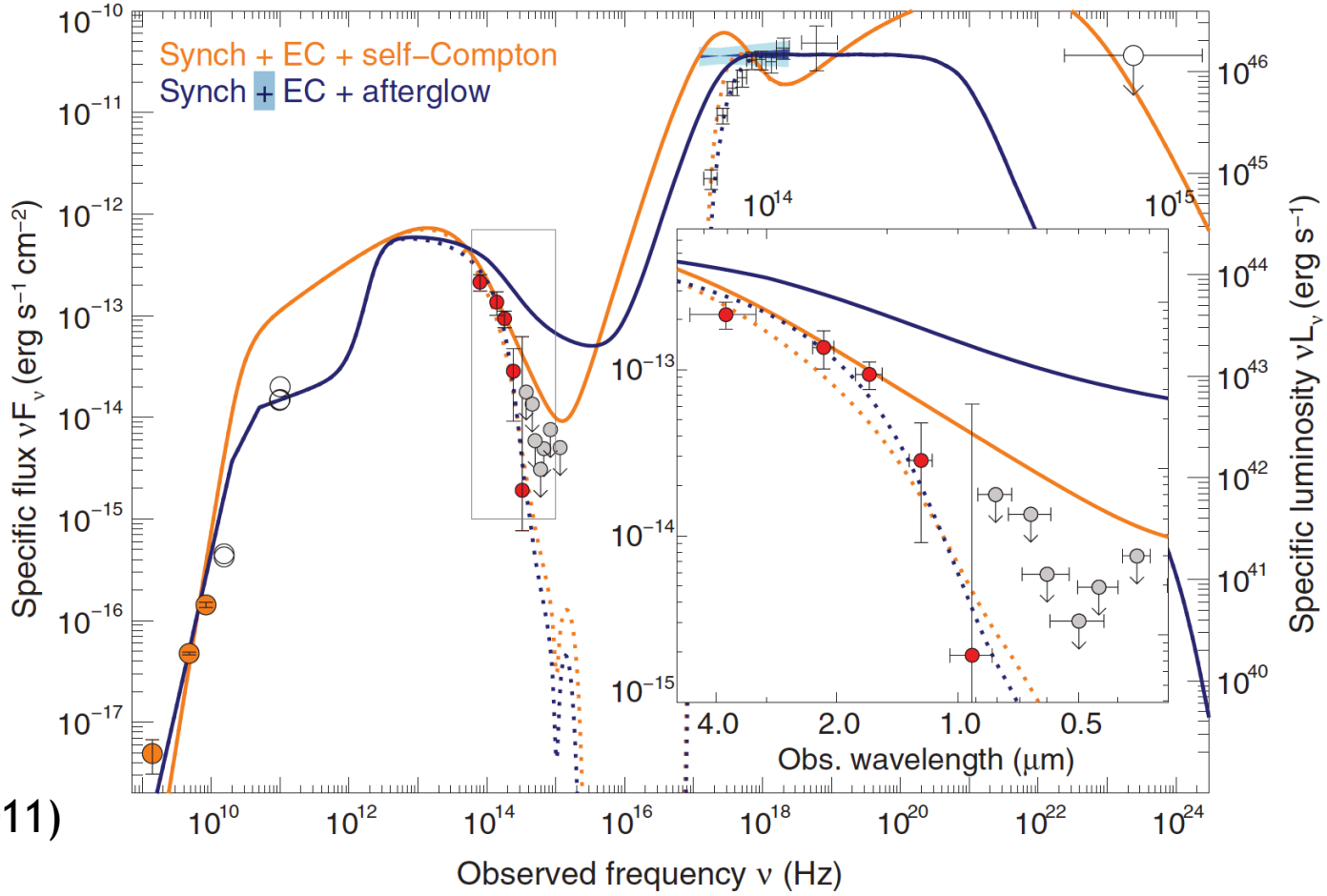


(Burrows+, 2011)

Overview on observations

- SWIFT 1644+57

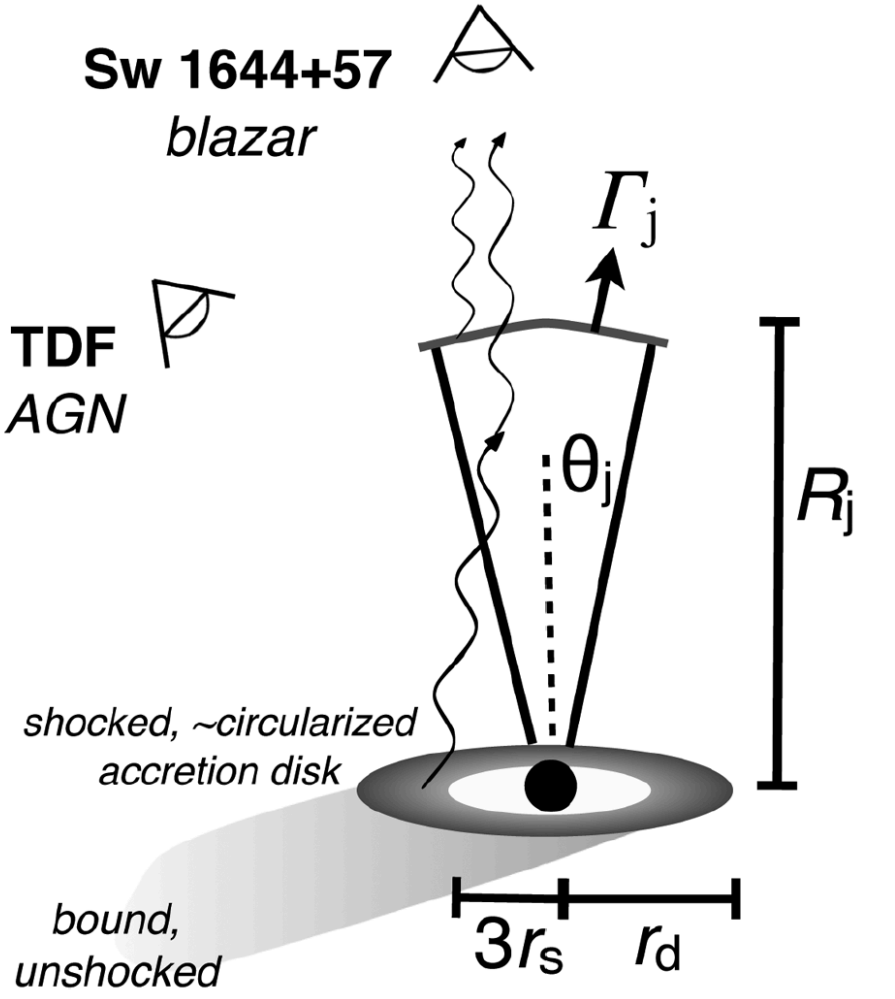
Full wavelength observational results



(Bloom+, 2011)

Overview on observations

- Best model



(Bloom+, 2011)

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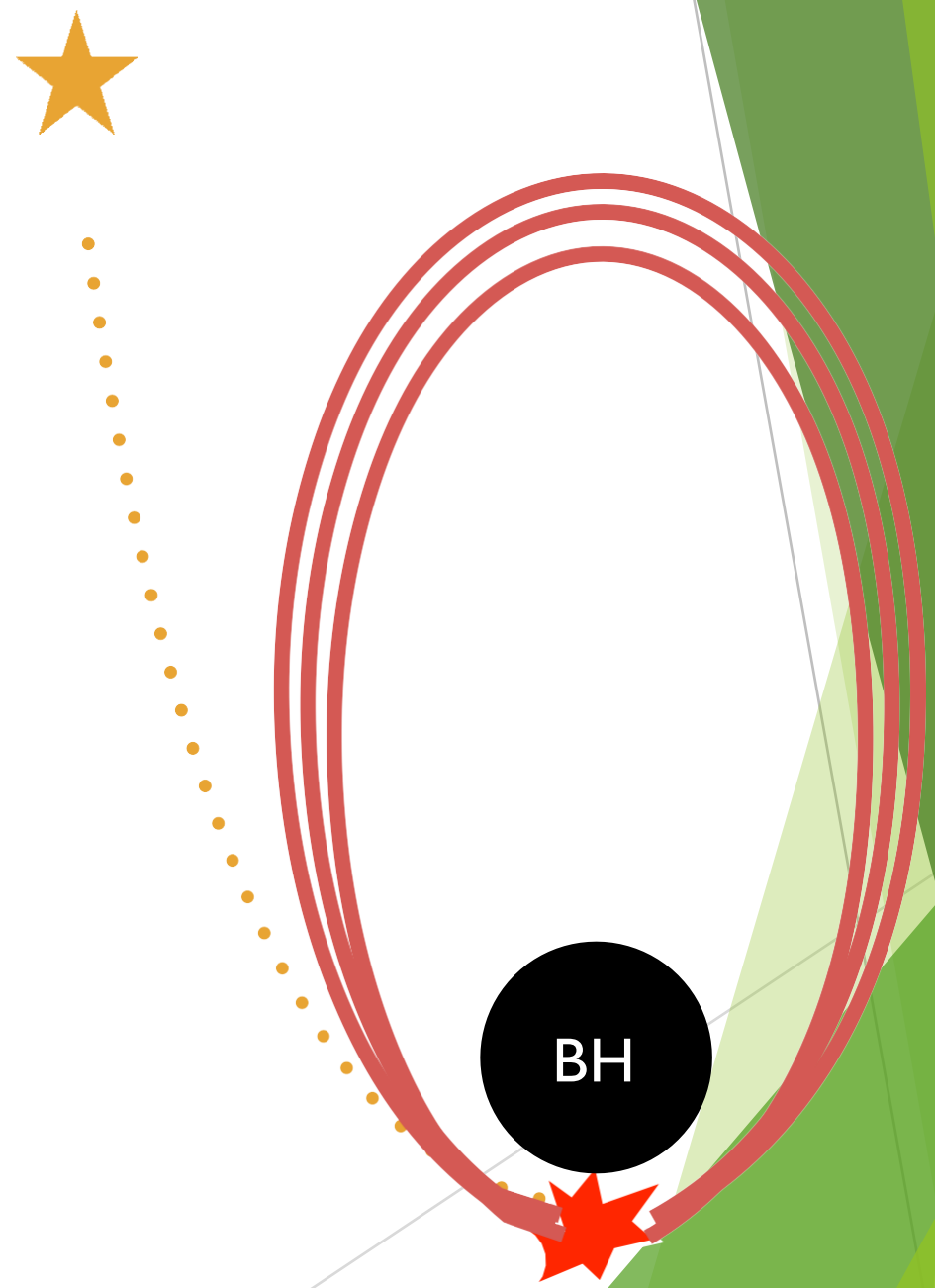
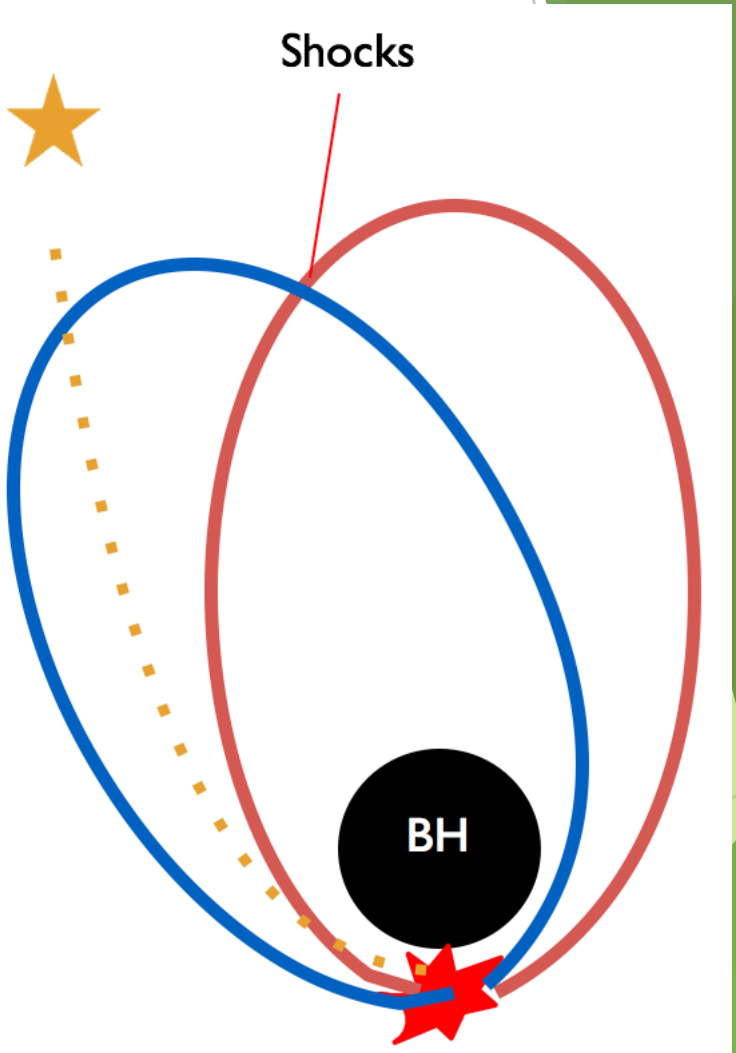
Newtonian



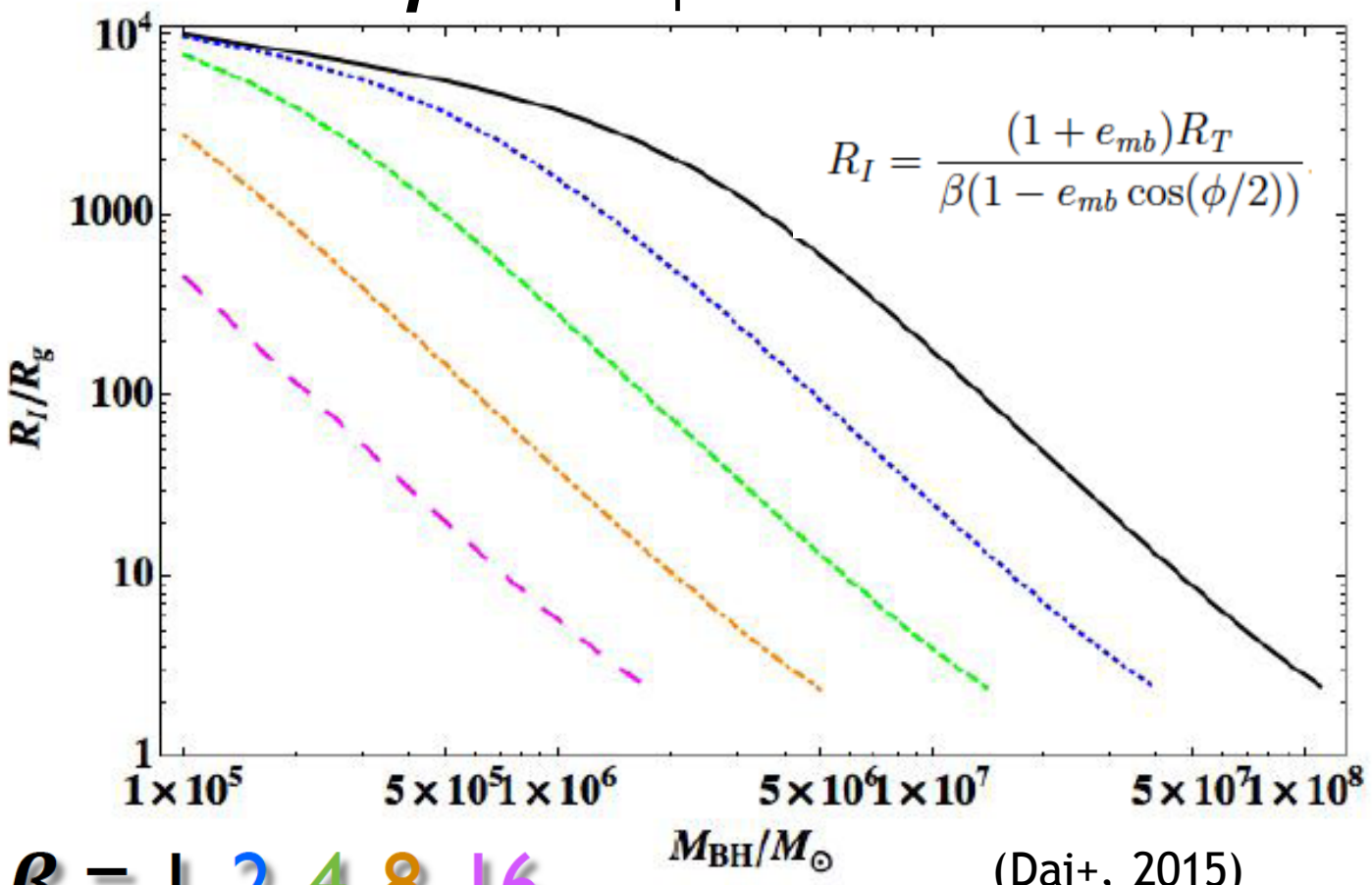
GR apsidal precession



Recent simulations

penetration parameter

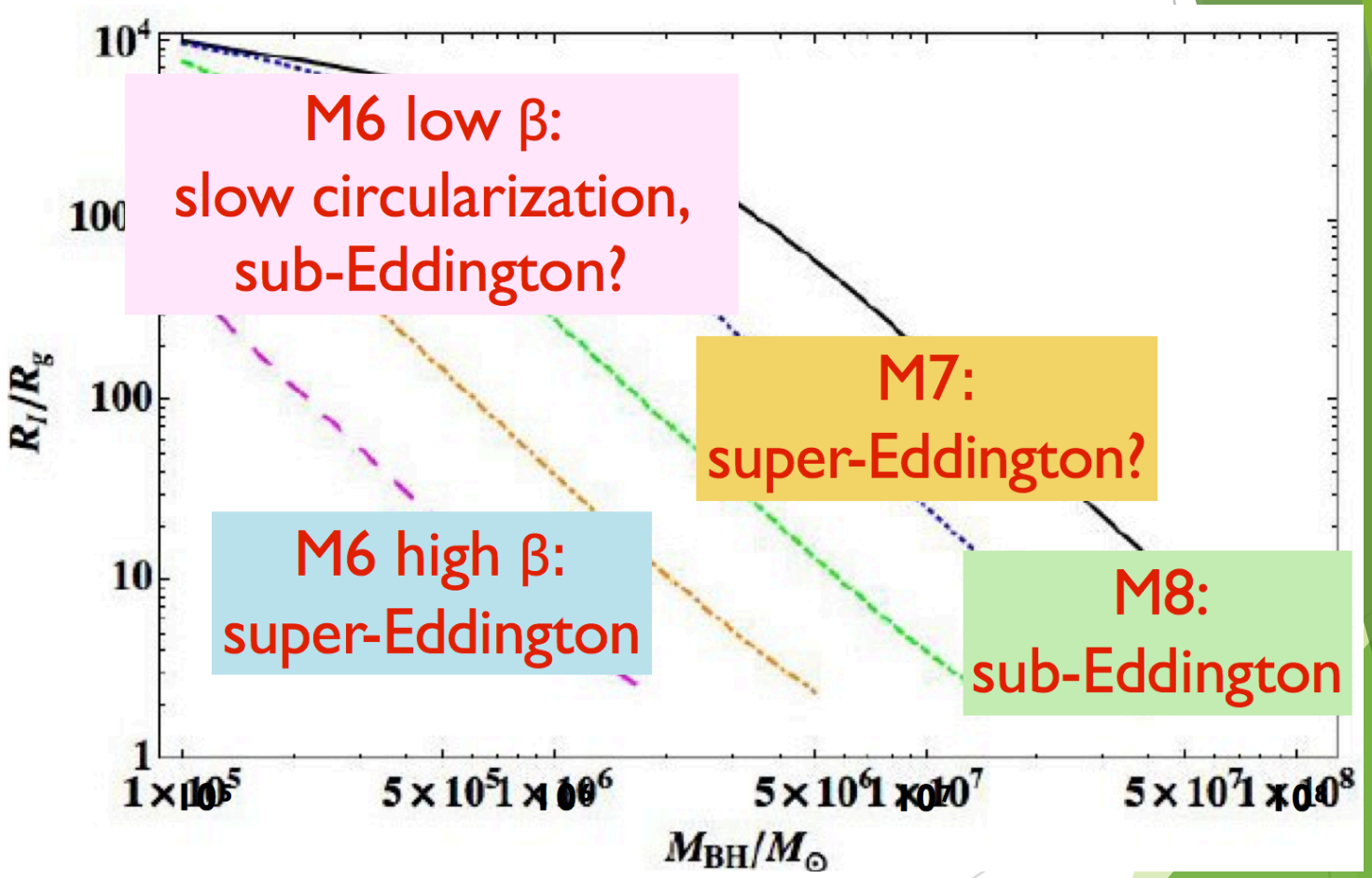
$\beta \sim R_T/R_p$



β = 1, 2, 4, 8, 16

(Dai+, 2015)

Recent simulations

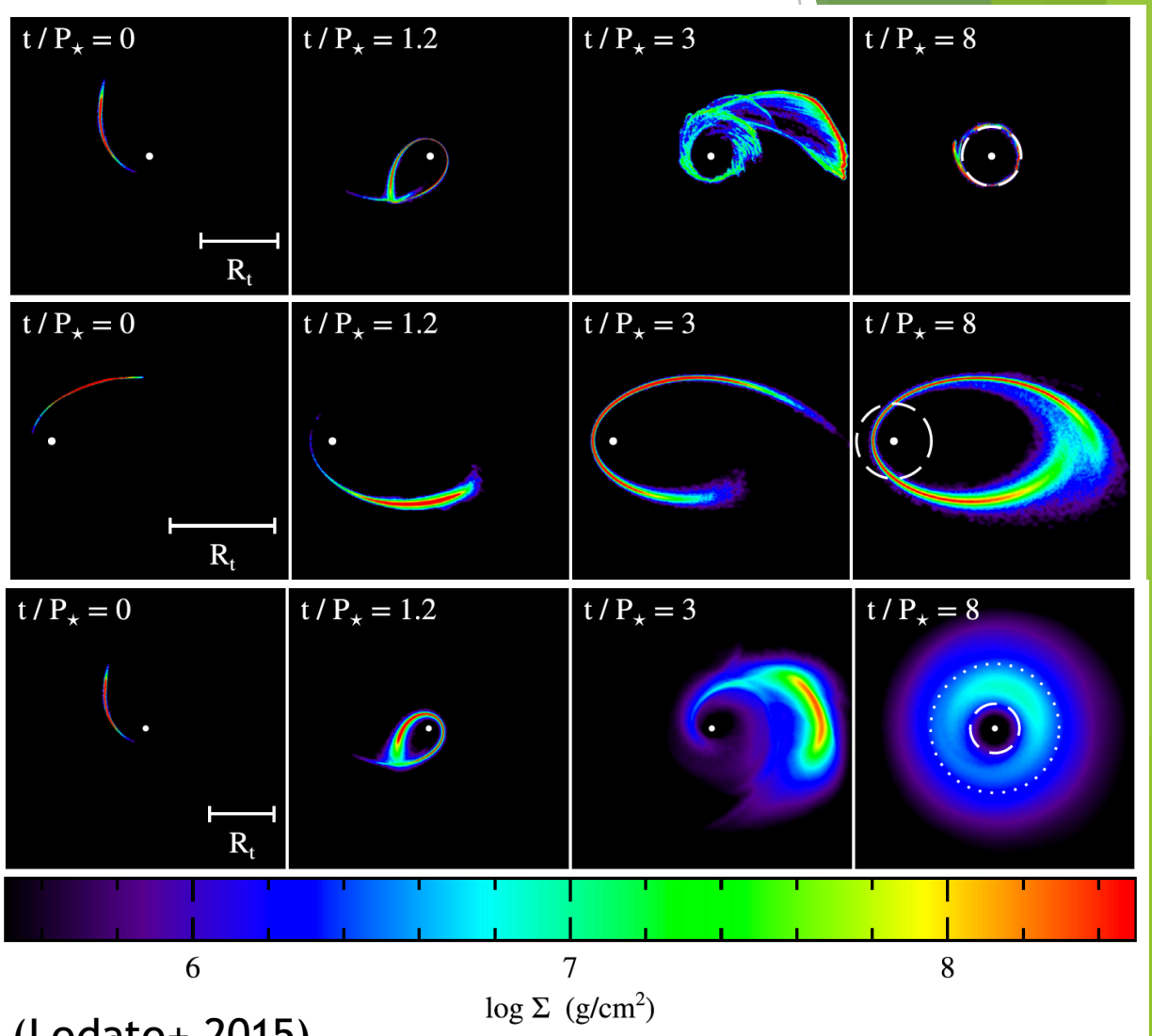


$\beta = 1, 2, 4, 8, 16$

(Dai+, 2015)

Recent simulations

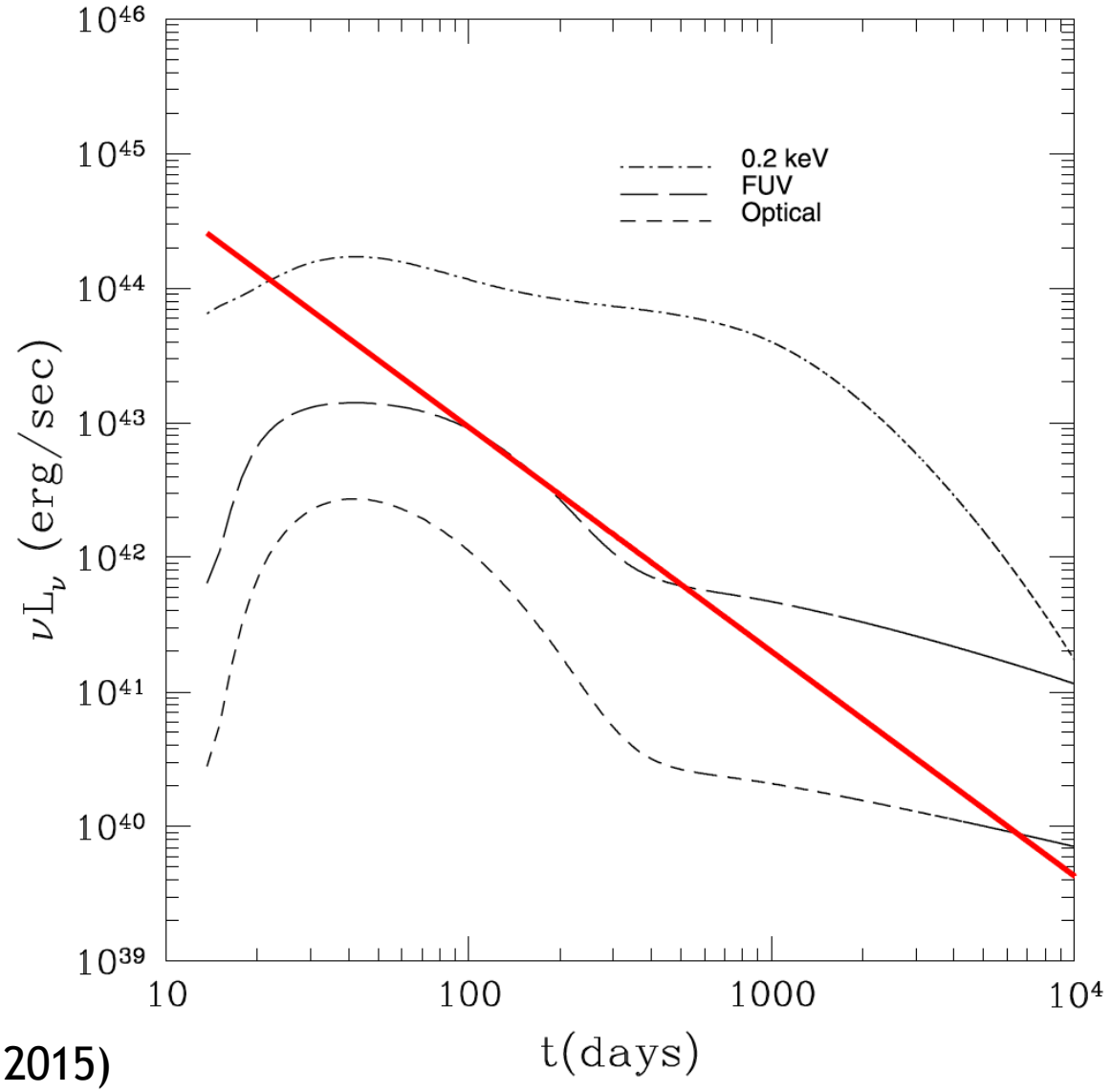
- Disk formation



(Lodato+ 2015)

Recent simulations

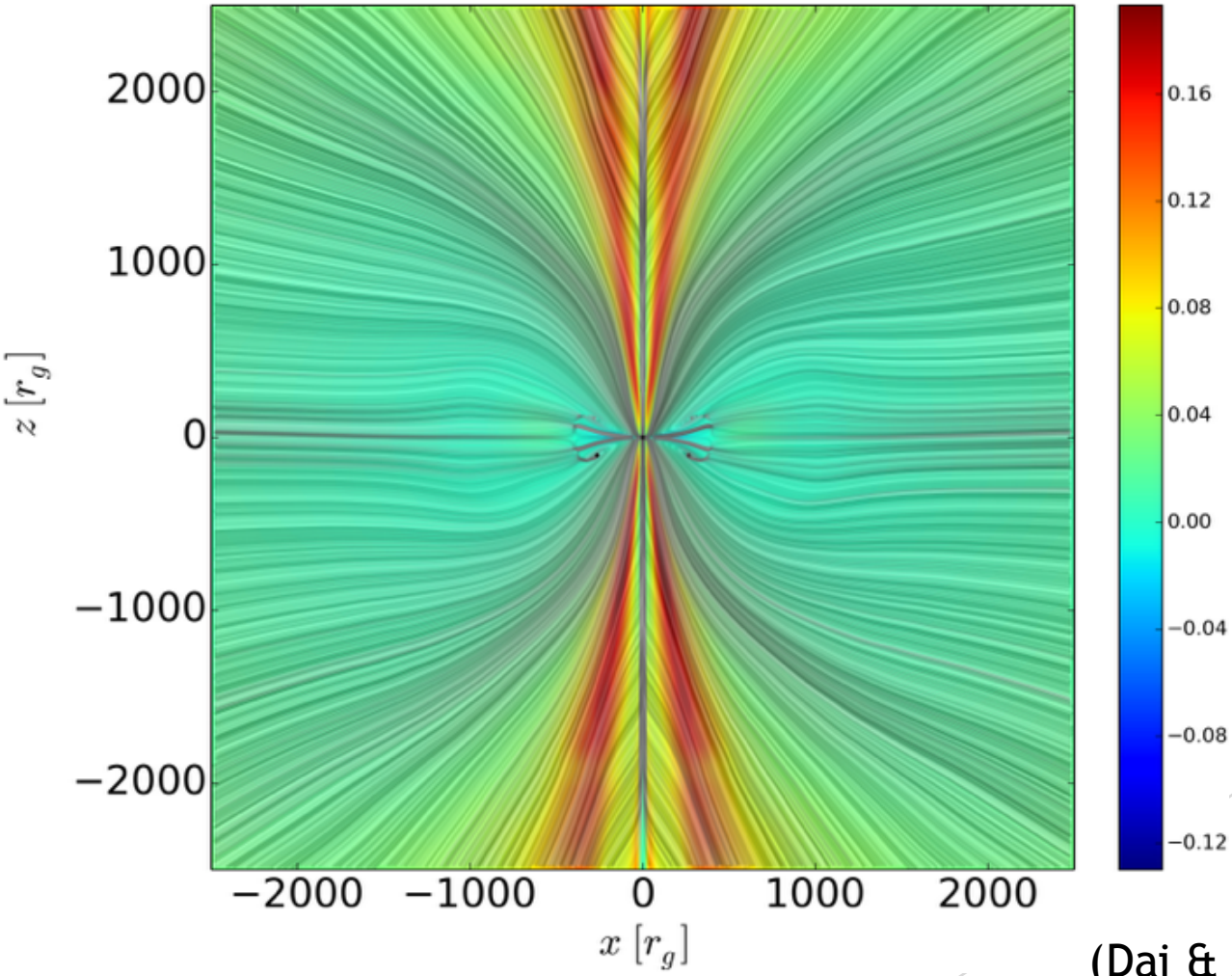
- Lightcurve predictions



(Lodato+ 2015)

Recent simulations

- Radiation energy and flux

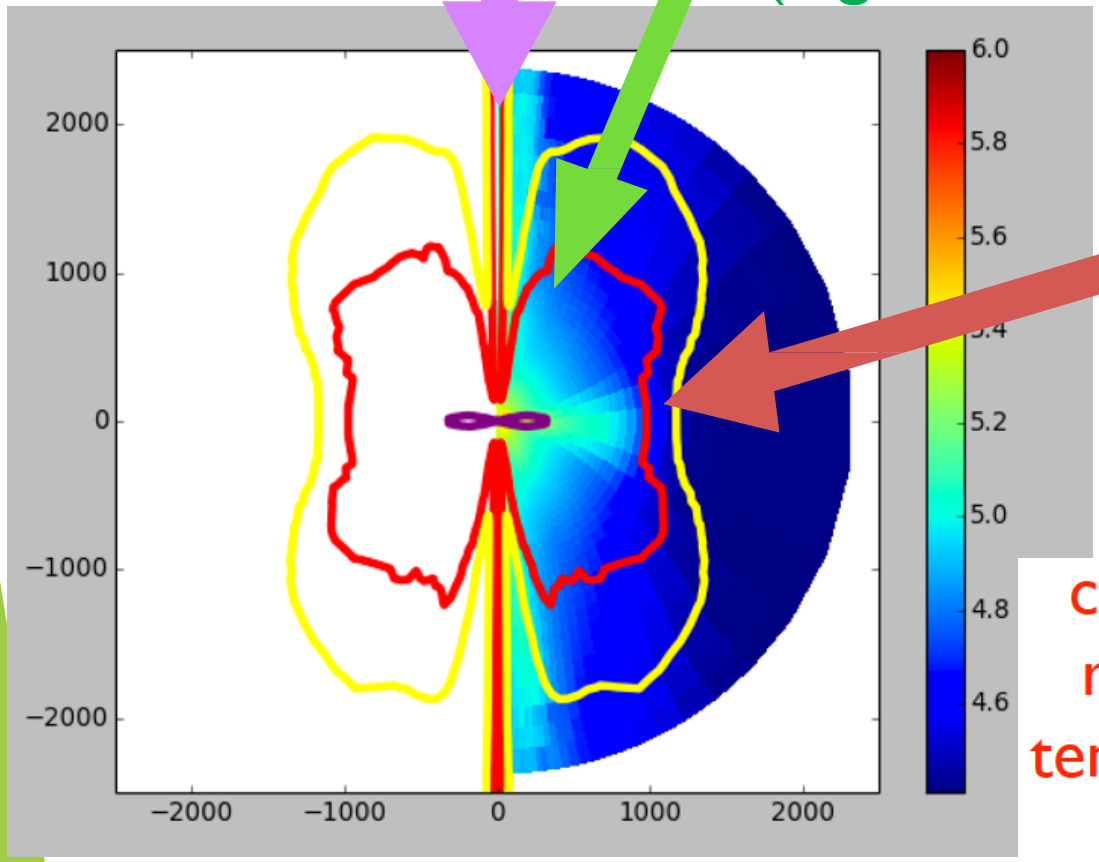


color bar: radiation energy density

(Dai & McKinney, in prep)

Hard X-ray / Radio from Jet
(e.g. Swift J1644)

X-ray, UV / optical,
radio from outflow
(e.g. ASASSN 14-li)

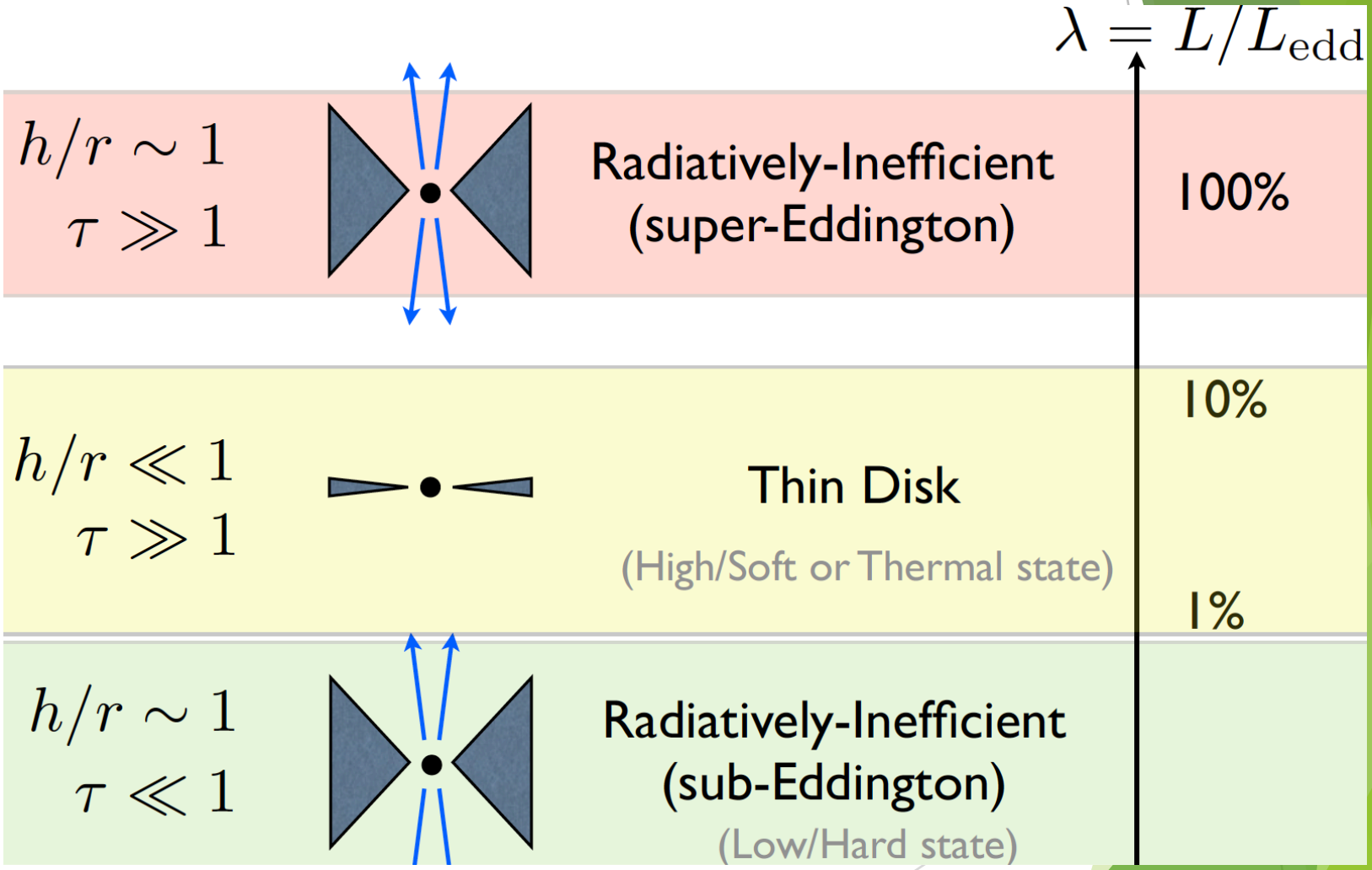


UV / Optical:
(e.g. PTF 09 ge)

color bar:
radiation
temperature
in Log_{10}

(Dai & McKinney, in prep)

Recent simulations



(Dai, 2017 slides)

Conclusions

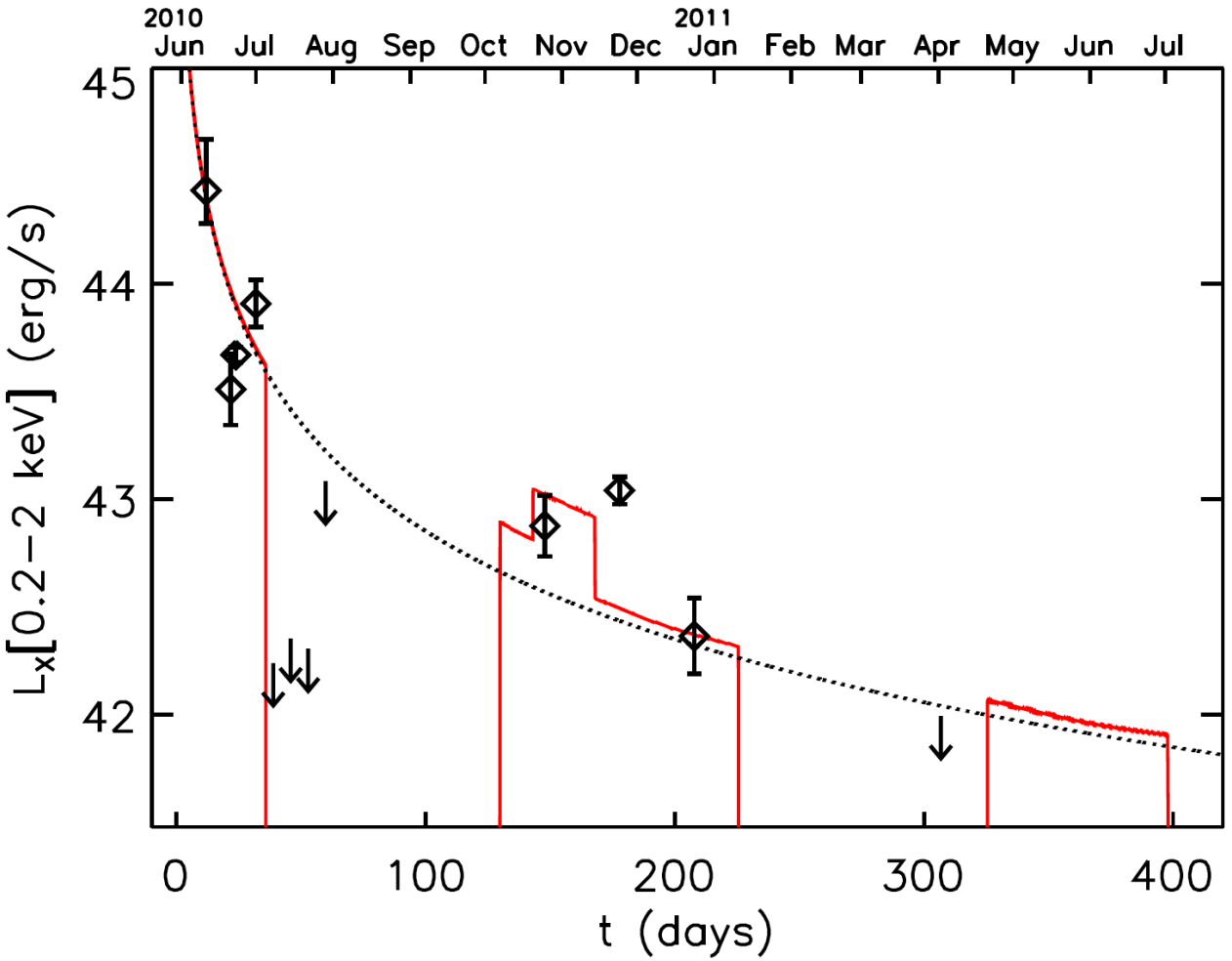
- TDE can be used to detect otherwise mysterious astronomical objects such as quiescent SMBHs
- TDE can probe phenomena such as super-Eddington accretion
- TDE can test physics such as General Relativity

- ~50 TDEs observed
- Simulations are trying to explain the data. A viewing angle dependence model can be used to explain the X-ray/optical TDE dichotomy.

References

- Lixin Jane Dai's Presentation Slides at Tsinghua Feb. 16, 2017
- M. Rees, 1988
- S. Komossa, 2015
- G. Lodato et al., 2015
- G. Lodato & E. Rossi, 2011
- Evans & Kochanek 1989
- J. Hills, 1975
- L. Dai et al., 2015
- J. Bloom et al., 2011
- D. Burrows et al., 2011
- S. Komossa, 2012
- C. Bonnerot, arXiv, 2015

SMBHB



Komossa, 2015