X-ray and Optical-NIR Observations of Black Hole Binaries

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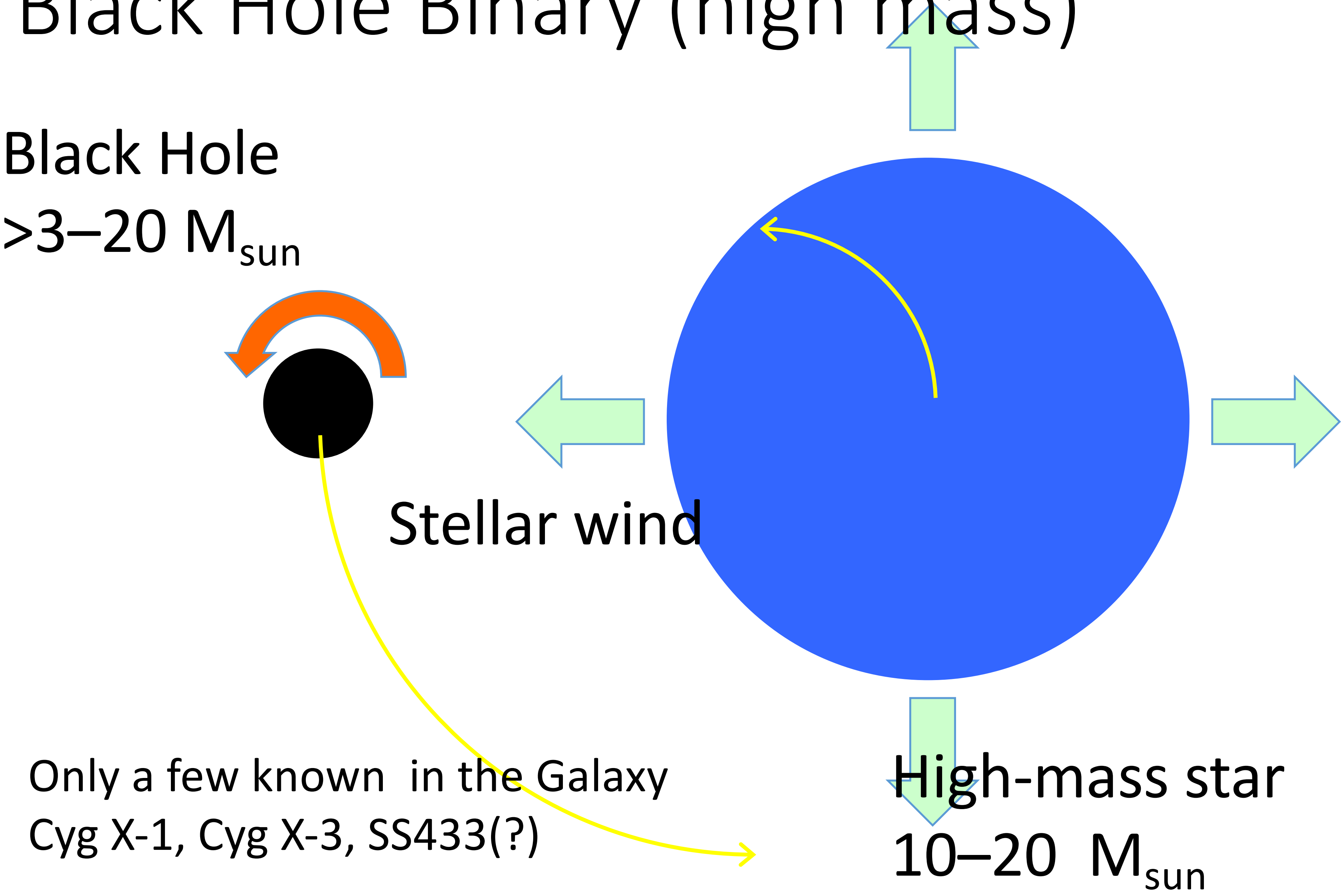
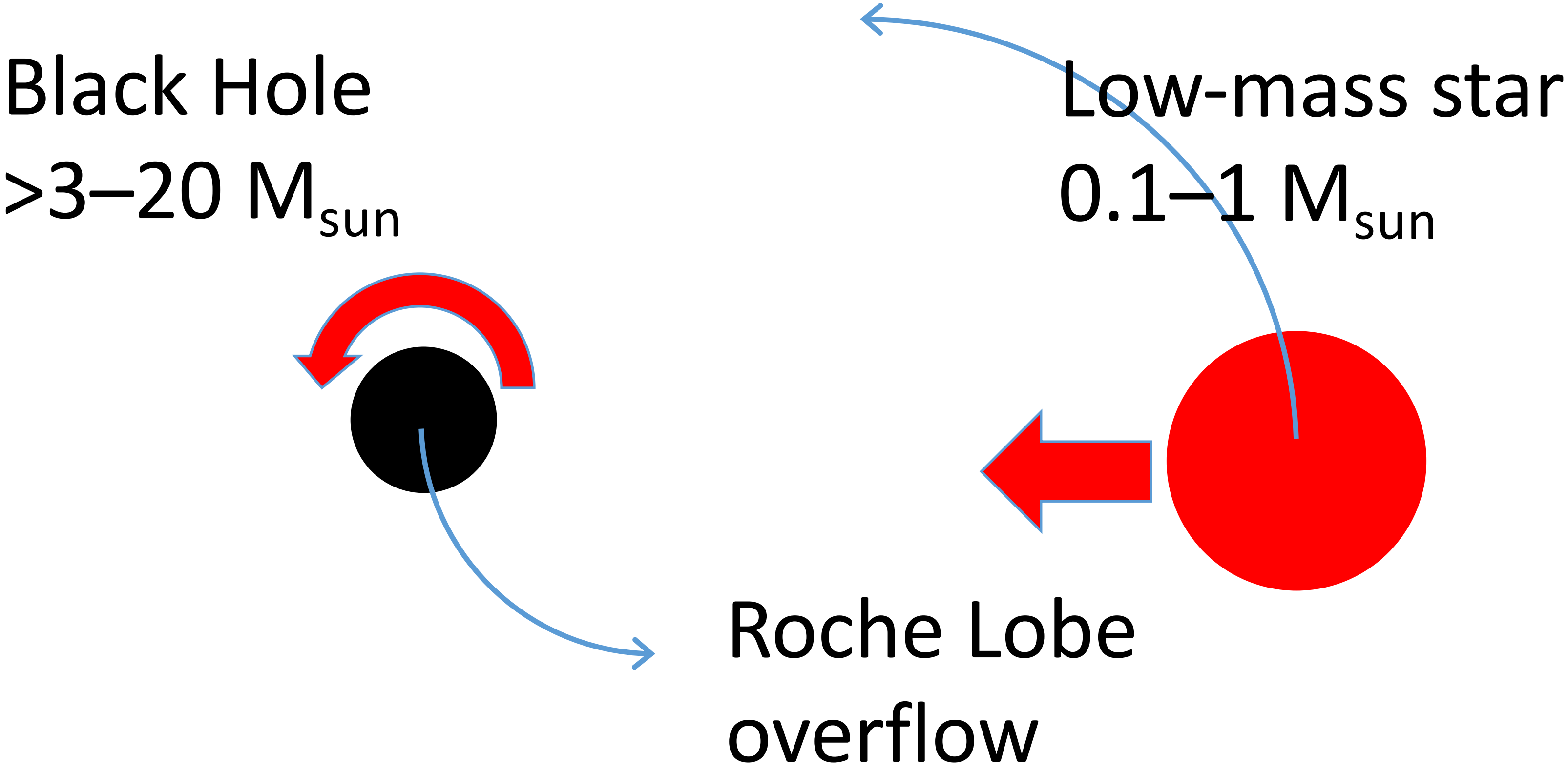
Black Hole Binary (high mass)



- Only a few known in the Galaxy
- Cyg X-1, Cyg X-3, SS433(?)

Black Hole Binary (low mass)



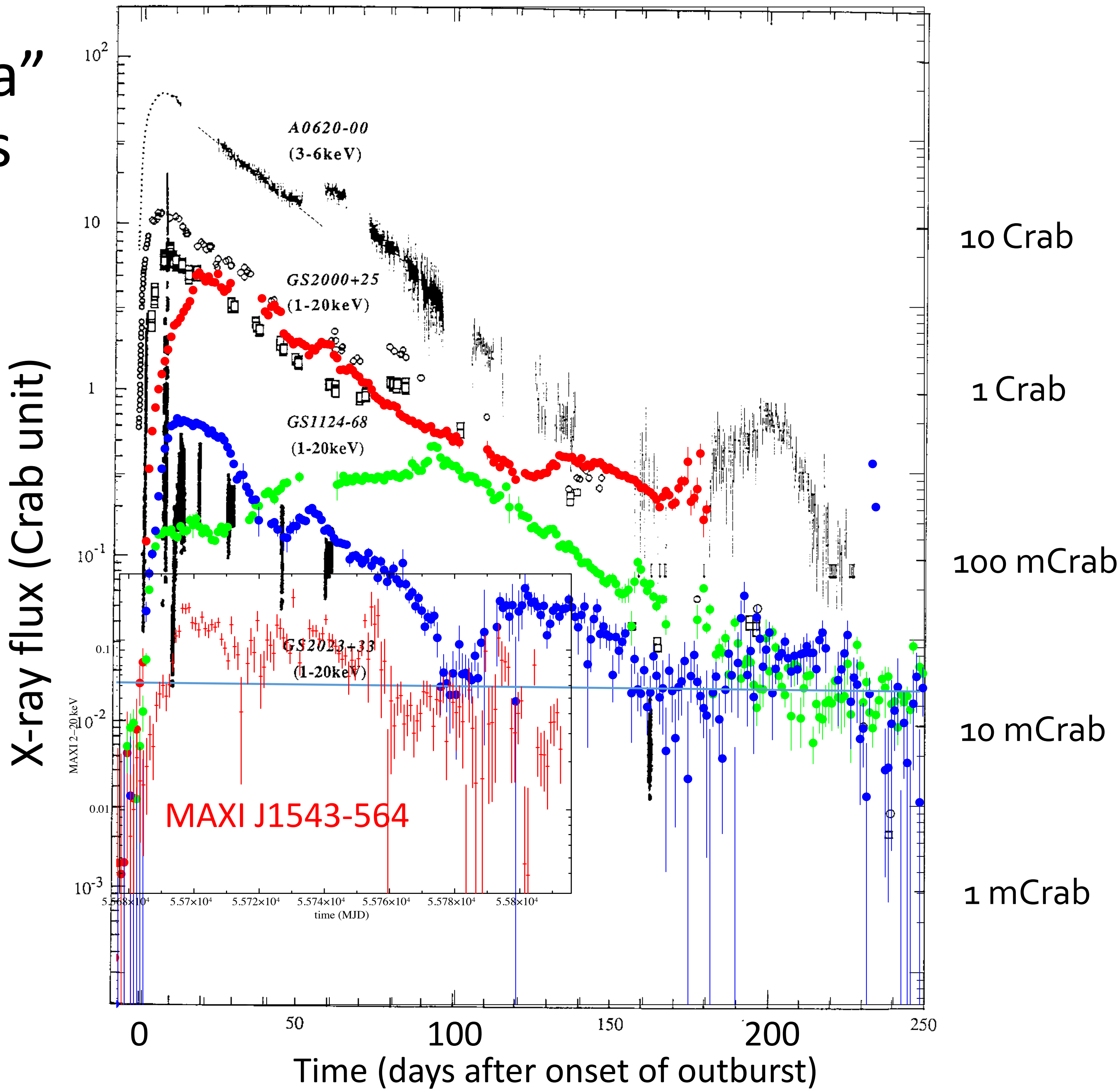
- mostly transient (“X-ray nova”)
- ~1/year new BHB discovered

“X-ray Nova” light curves

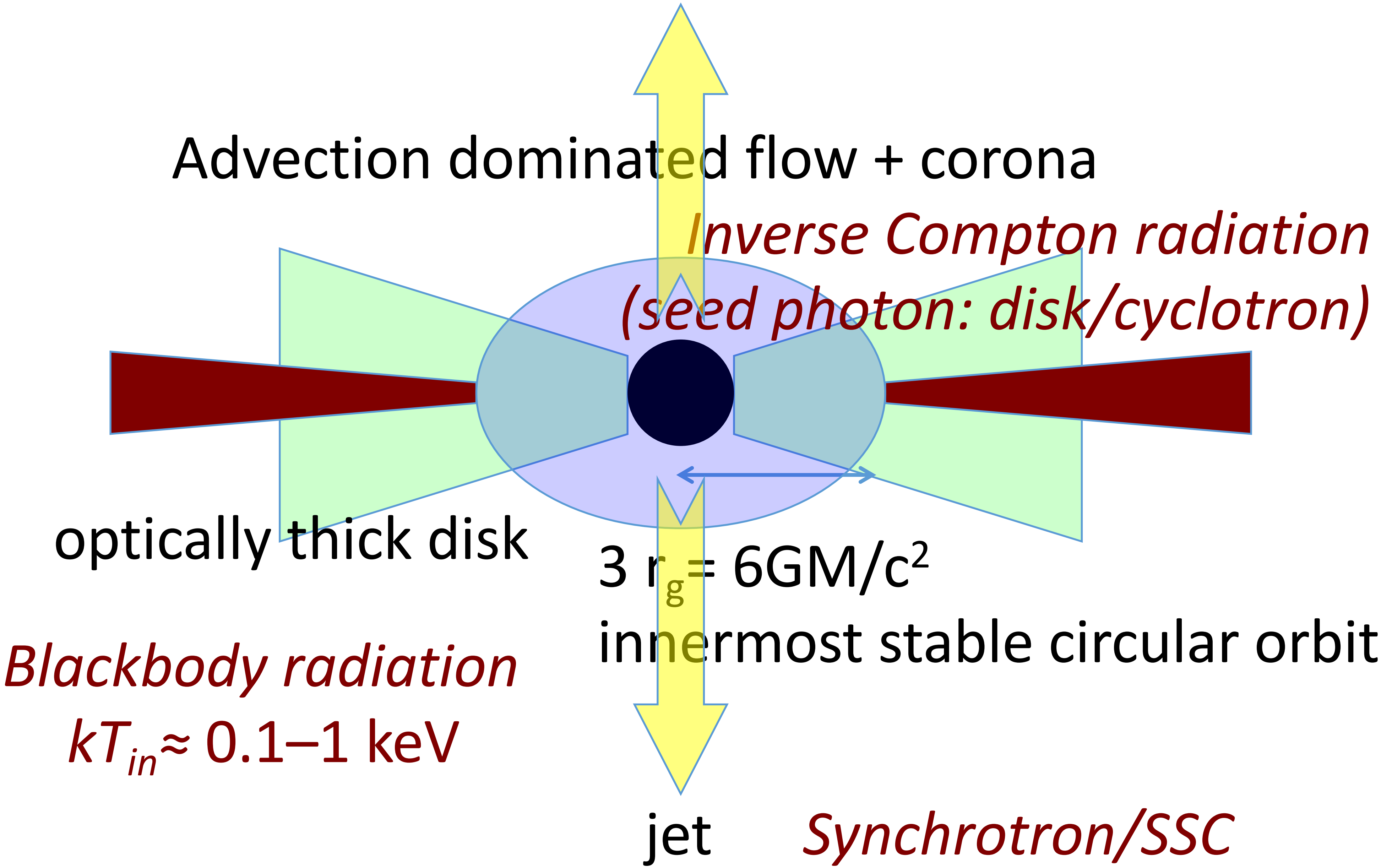
MAXI J1535-571

MAXI J1910-057

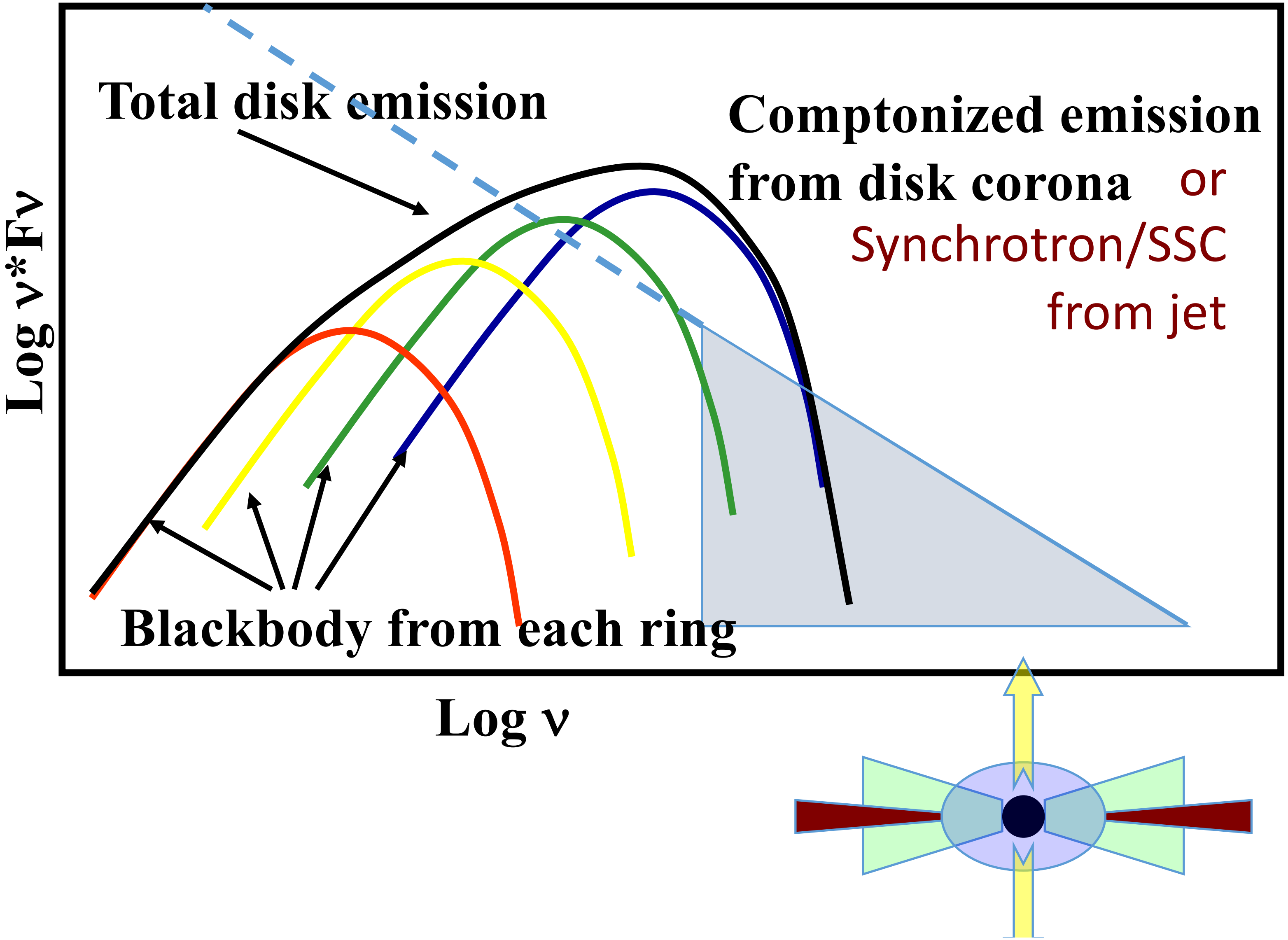
XTE J1752-223



Anatomy of an accreting black hole

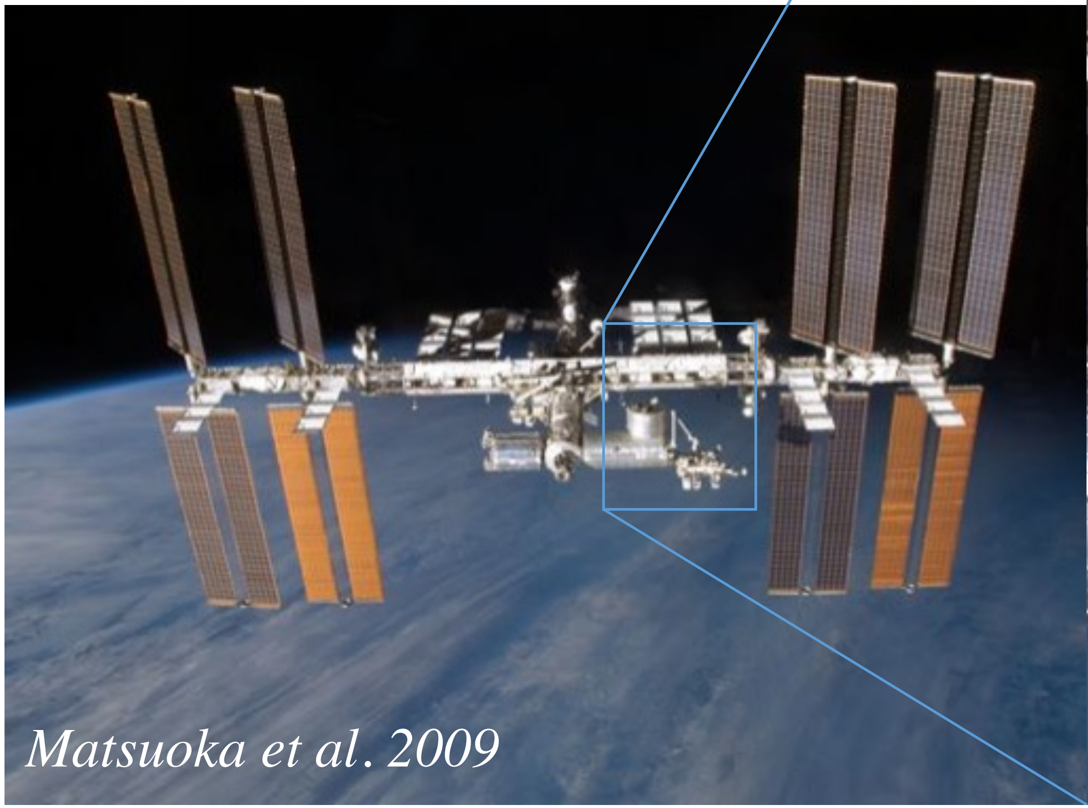


X-ray spectrum of a black hole binary

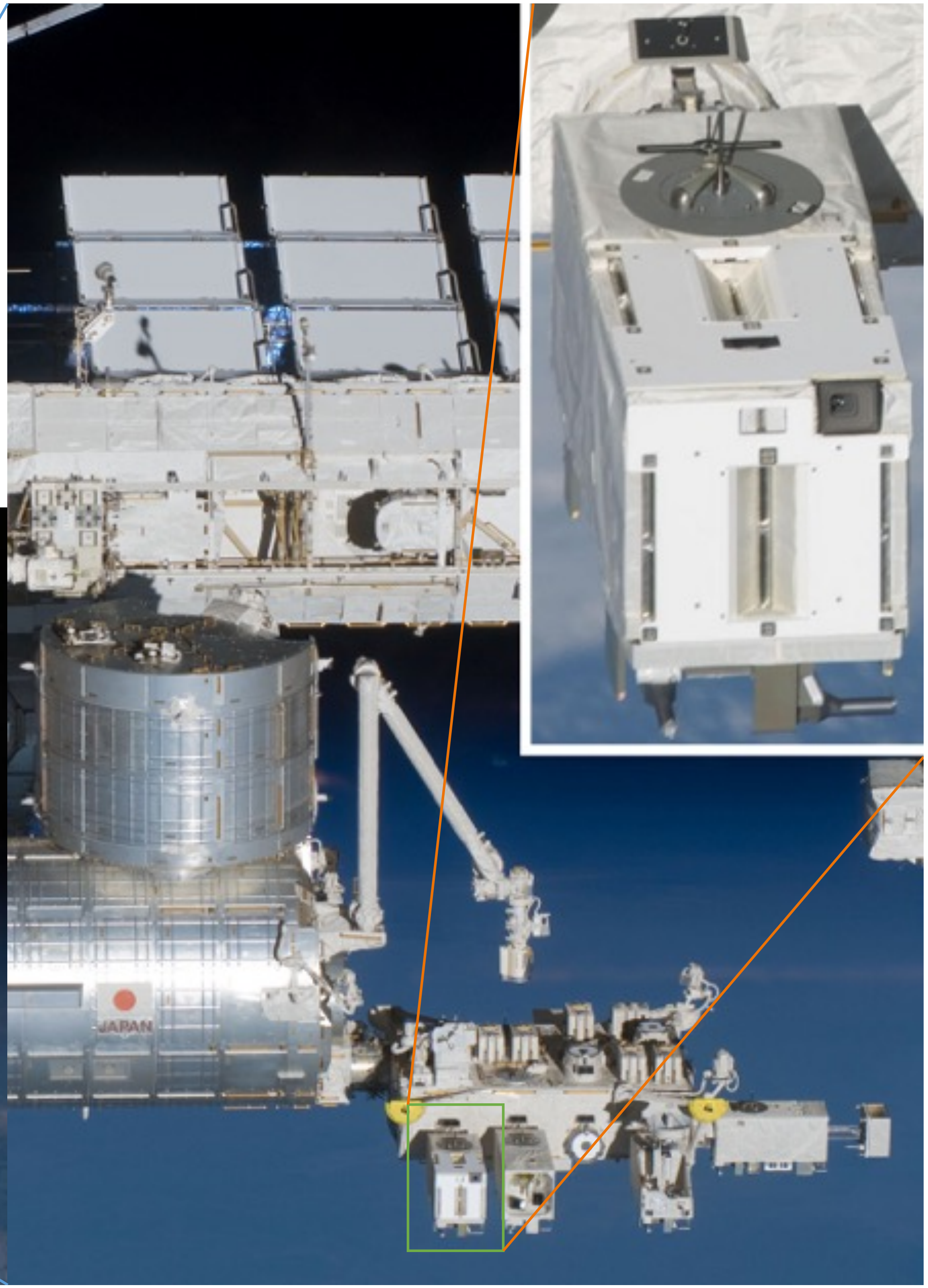


Monitor of All-Sky X-ray Image

- Mission started August 2009
- Ops approved until Mar 2021
- Real-time link ~70%
- "MAXI 10-Year" Symposium planned in Fall 2019

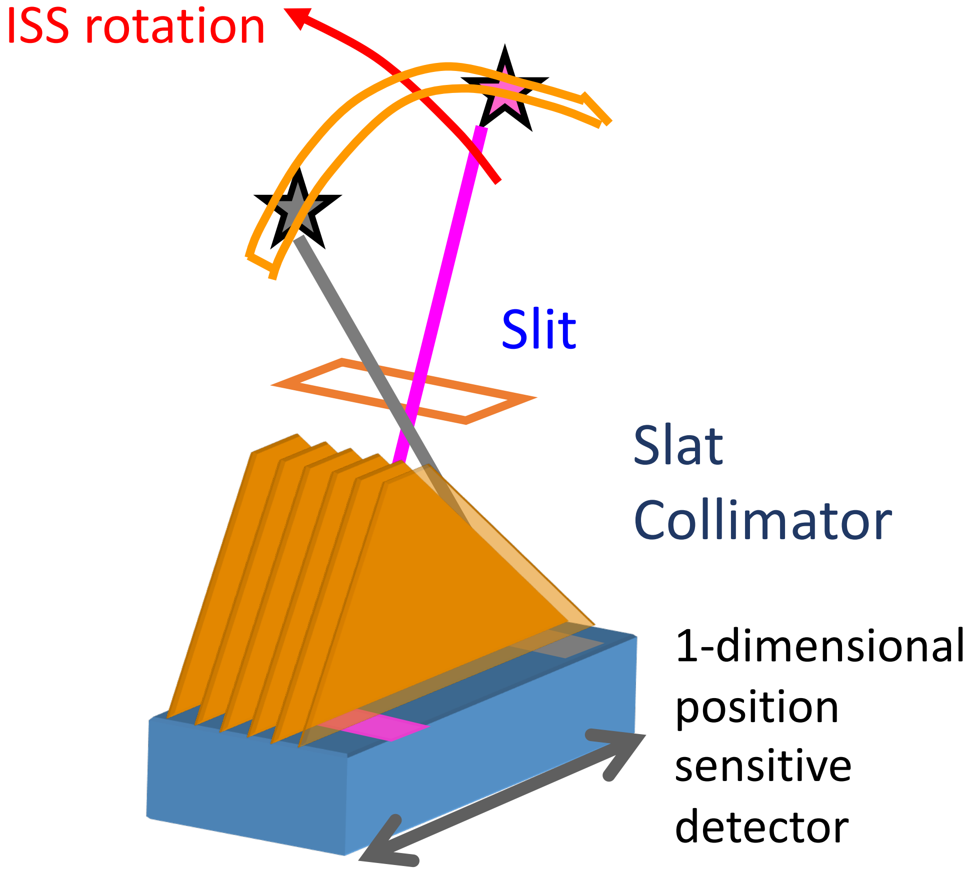


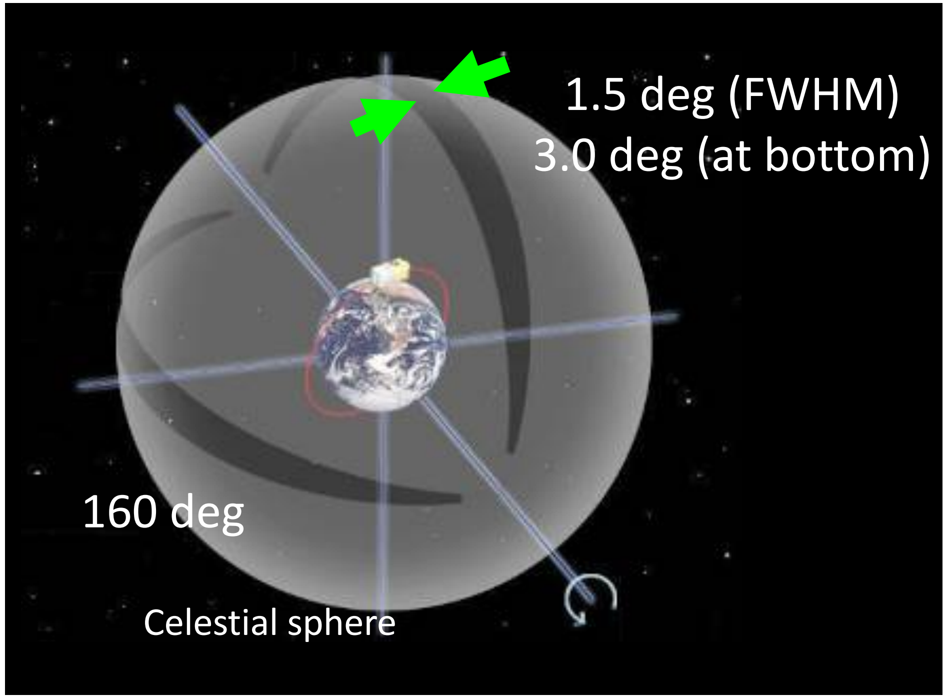
Matsuoka et al. 2009



Scans with

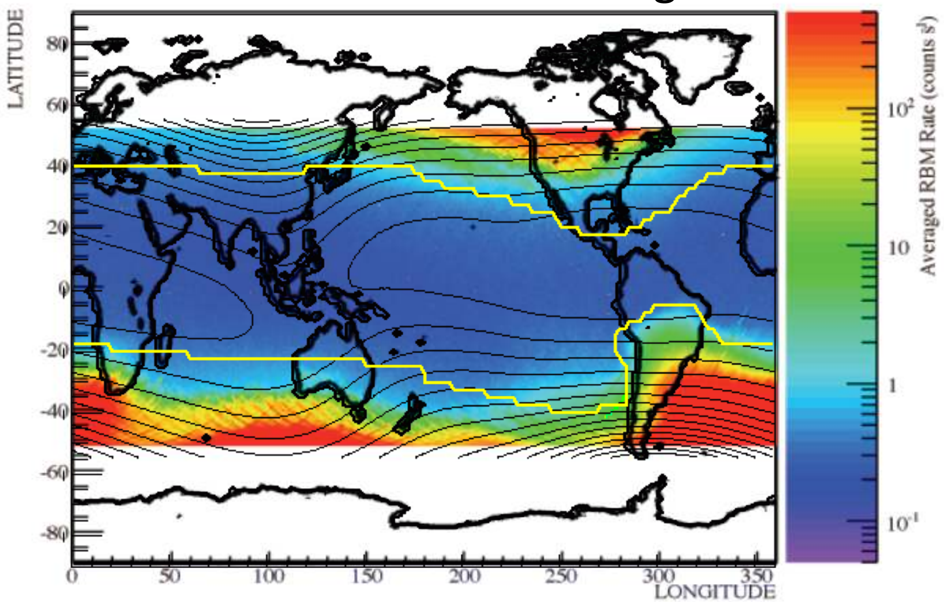
Slit + Slats collimator





RBM-H MAP

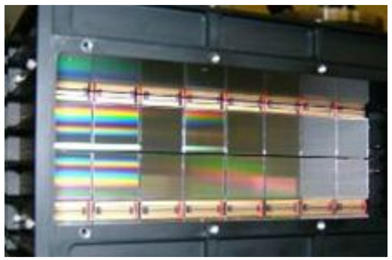
Particle background rate



Operating in equatorial region

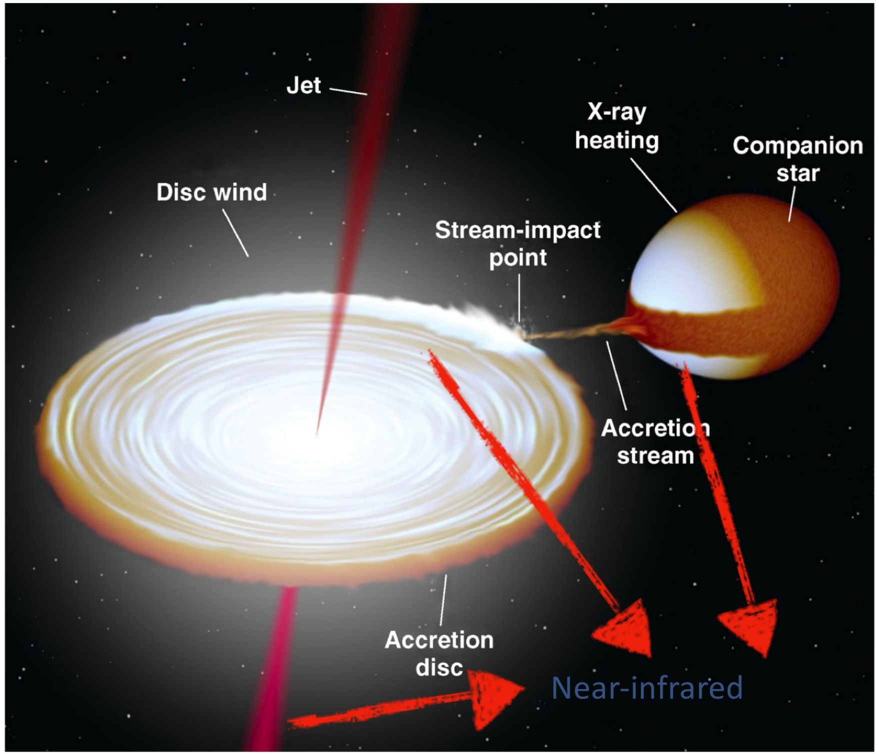
proportional counter

X-ray CCD

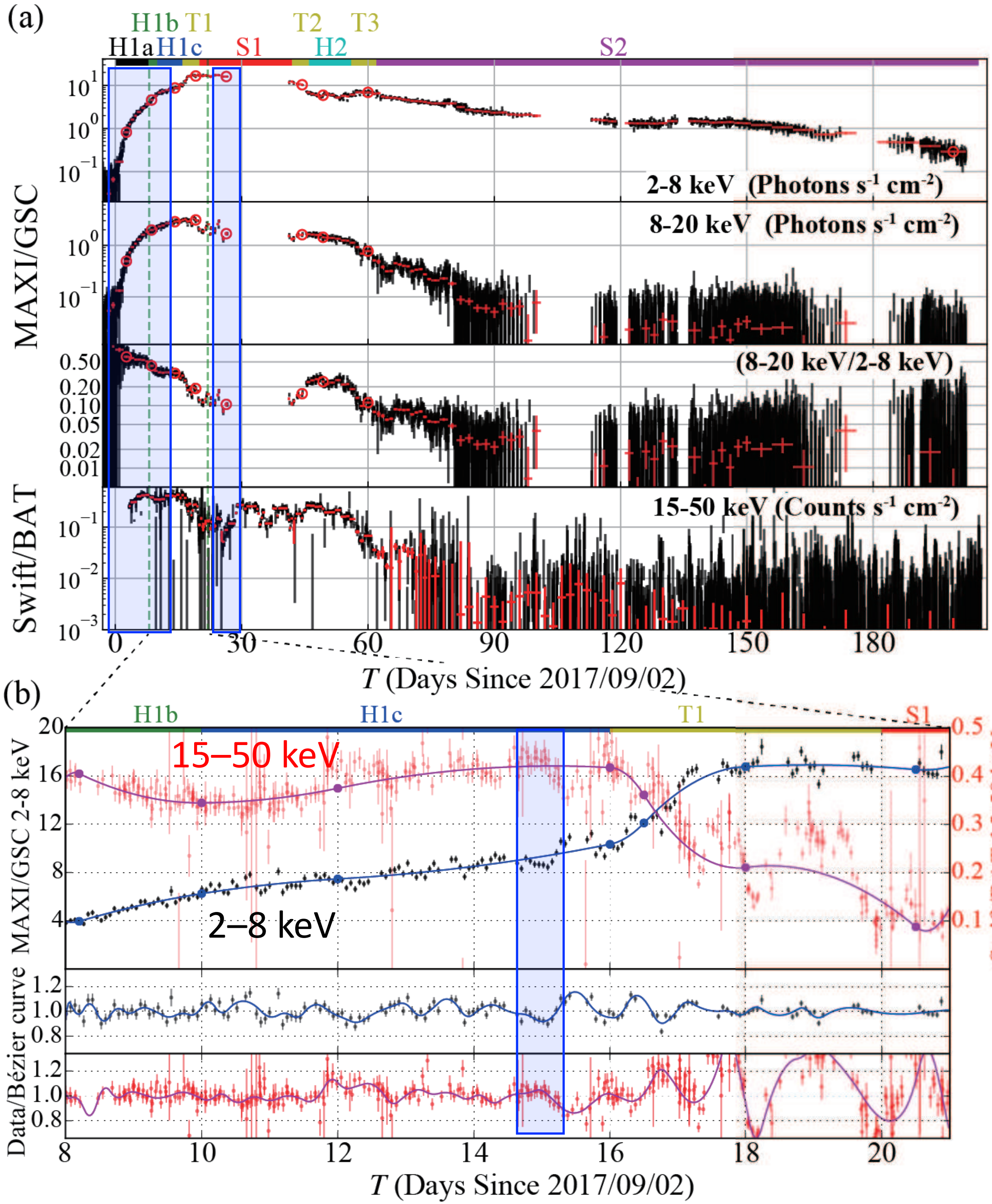


Optical/NIR emission from Low-mass X-ray binaries

- Thermal emission from the X-ray irradiated disk and/or the companion
- Synchrotron emission from the jet
- Cyclotron emission (or Comptonized —) from ADAF



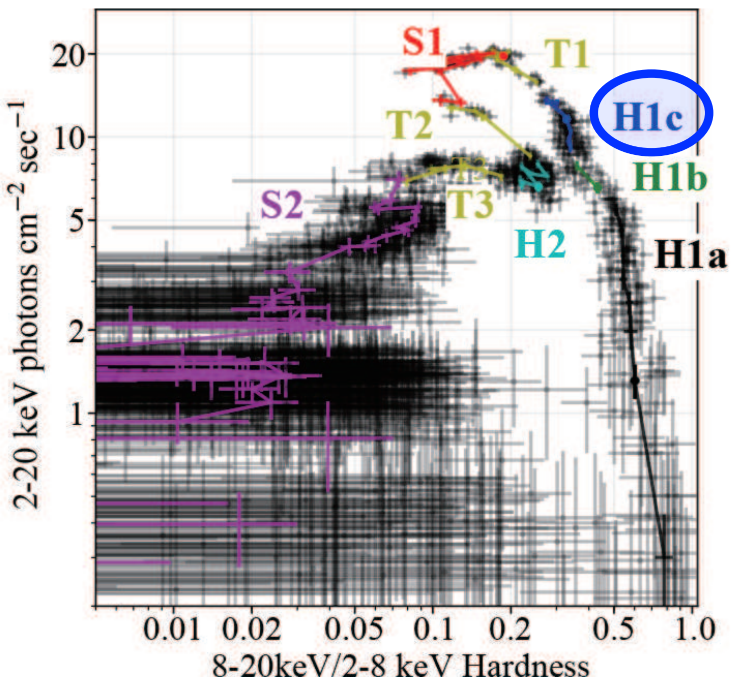
may constrain the system geometry and dynamics, and provide information on accretion and radiation processes



MAXI J1535–571

⇦ X-ray light curves

Hardness-Intensity Diagram (HID) ⇩



Nakahira et al. 2018

Follow-up observation with IRSF 1.4 m telescope

Near-infrared

- J (1.2μm), H (1.6μm), Ks (2.3μm)
- less dust extinction than optical and UV
- galactic plane source such as MAXI J1535-571

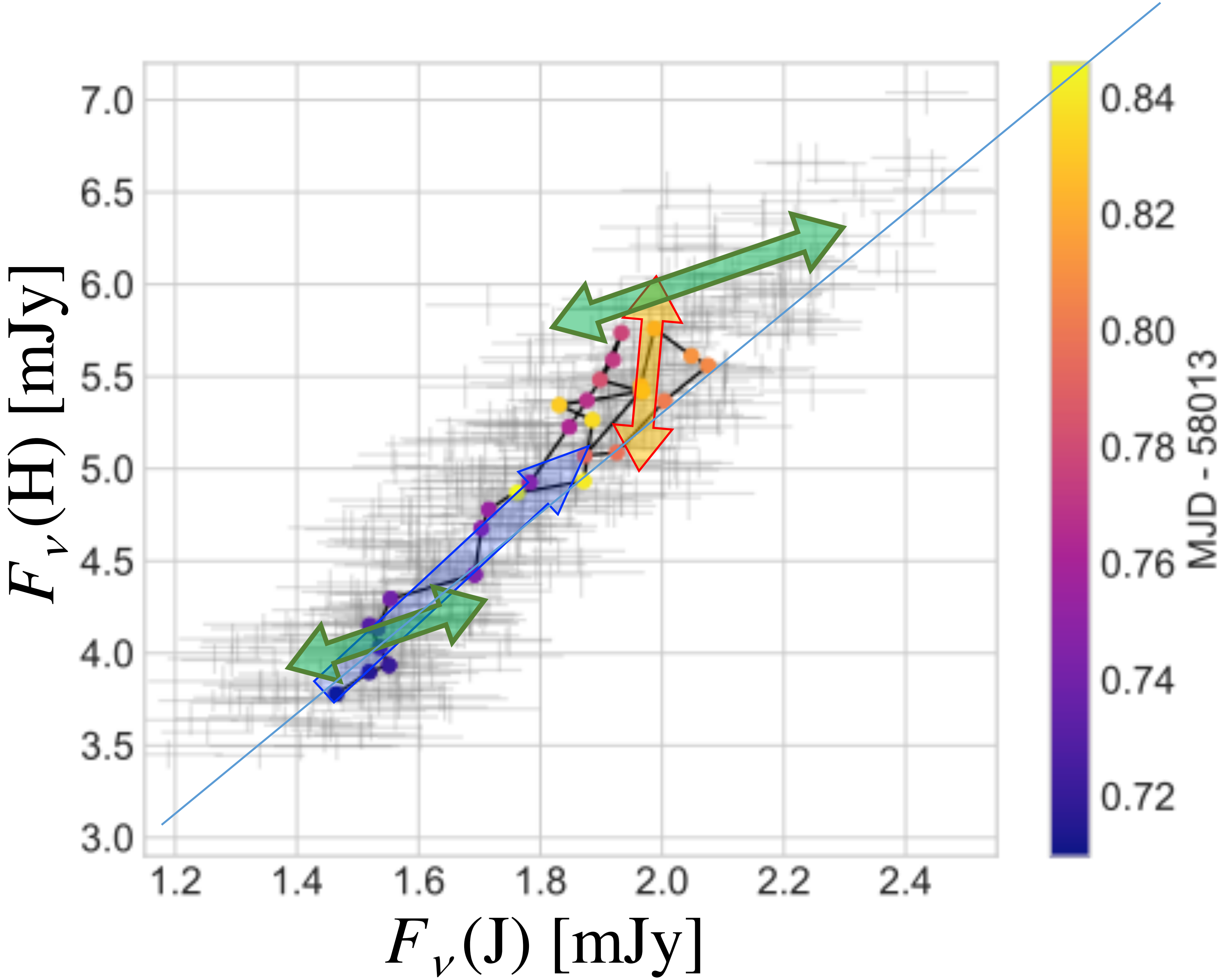
Sutherland observatory in South Africa

- Southern Hemisphere
- MAXI J1535-571

Observations

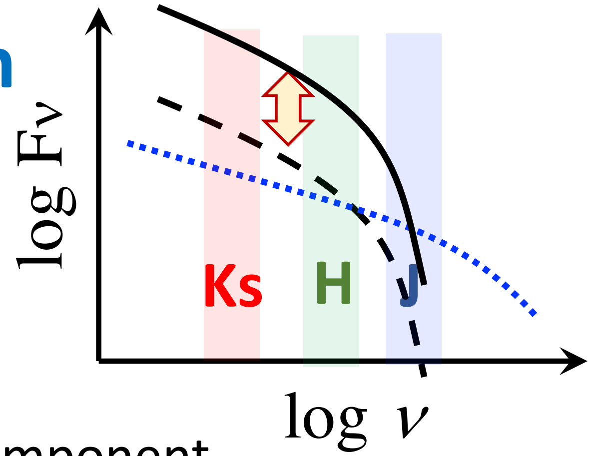
- Sep 6—17: Kumiko Morihana, Takahiro Nagayama
- Sep 28 — Oct 2: Katsuhiro Murata, Ryosuke Itoh

MAXI J1535–571: 2-color fux (H vs. J)



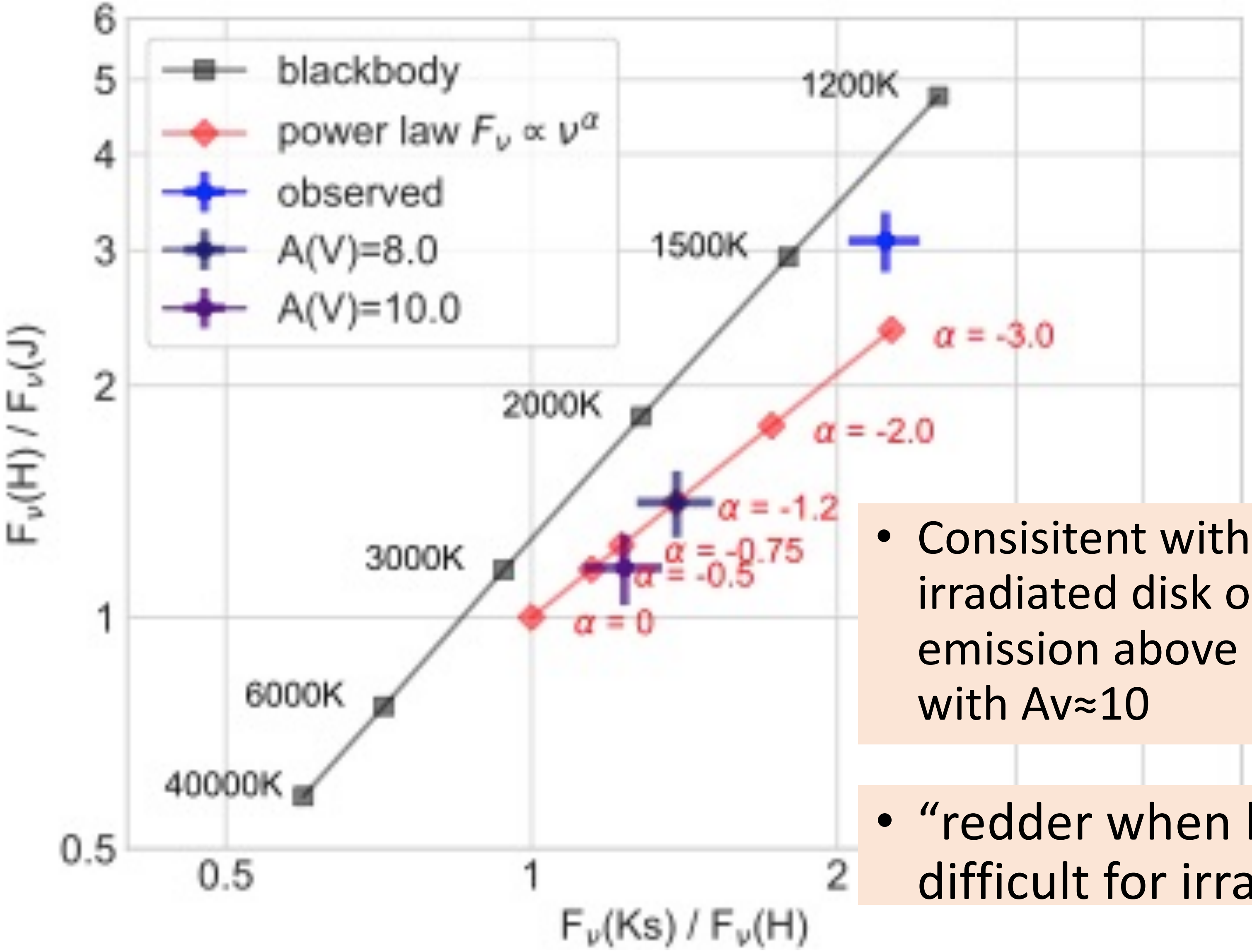
MAXI J1535–571: NIR flux properties

- **Variable on three time scales**
  - Slow gradual rise ($\tau \geq 10$ ks)
  - Intermediate variation (τ ~3 ks) at plateau
  - Rapid variation (τ<20s)
- **Slow and rapid variations share common properties**
  - Rapid var. amplitudes scales with total flux
  - Similar colors
  - Redder when brighter
    - → suggest existence of underlying stable blue component



- **Intermediate variation is different**
  - Redder when brighter in J-H, small amplitude in J band
  - Little change in H-Ks color

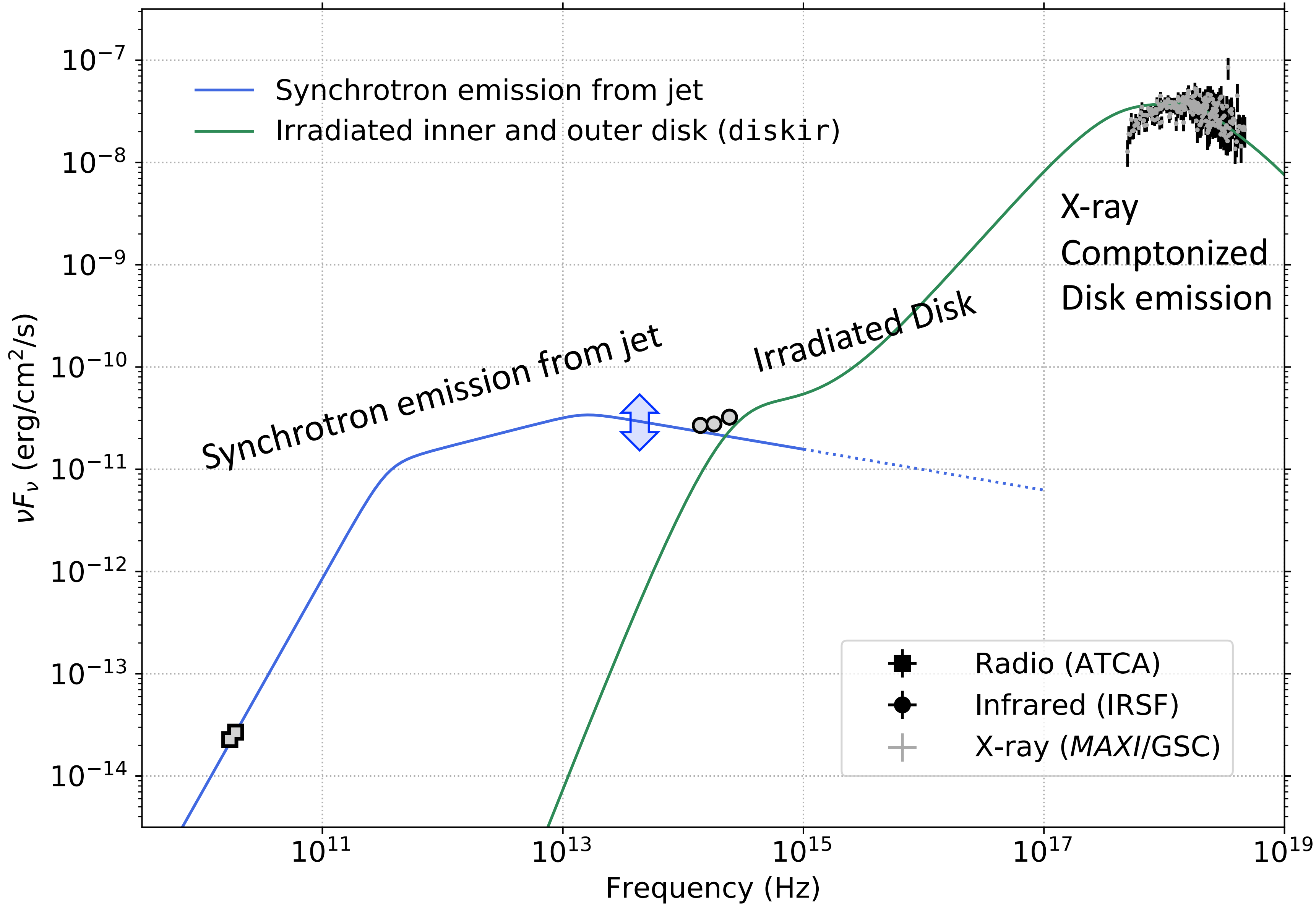
Rapidly variable component on **color-color diagram**



- Consisitent with either irradiated disk or synchrotron emission above cooling break with Av≈10

- "redder when brighter" difficult for irradiated disk

Possible broad-band SED



Conclusion

- Continuous 3-color (J,H,Ks) photometry with 17s sampling revealed flux and color variations on three different timescales: $\tau \geq 10$ ks, $\tau \approx 3$ ks , $\tau < 20$ s
- Slow ($\tau \geq 10$ ks) and rapid ($\tau < 20$ s) components may have common origin
- "Redder when brighter" variation can be explained by the combination of a variable red component (synchrotron jet?) and a stable blue component (irradiated disk?)