

MAXI observations of Multimessenger events

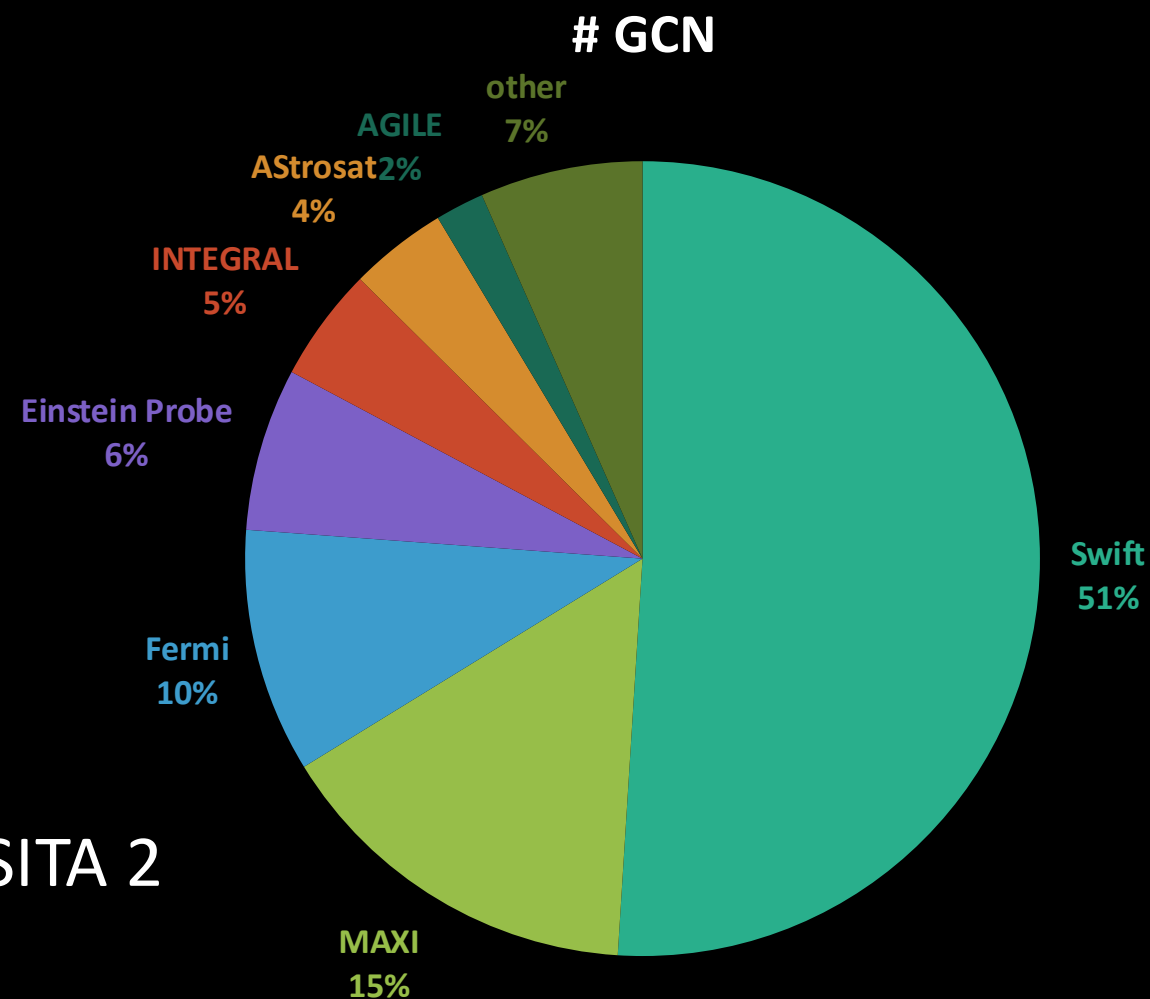
Motoko Serino (AGU)

MAXI and Multimessenger events

- MAXI's activity for GW event in O4
 - GCN circulars
 - Observation strategy and result
 - Upper limits and search depth
- Search for counterparts of IceCube event with MAXI
 - Observation summary
 - Comparing with MAXI GRB search

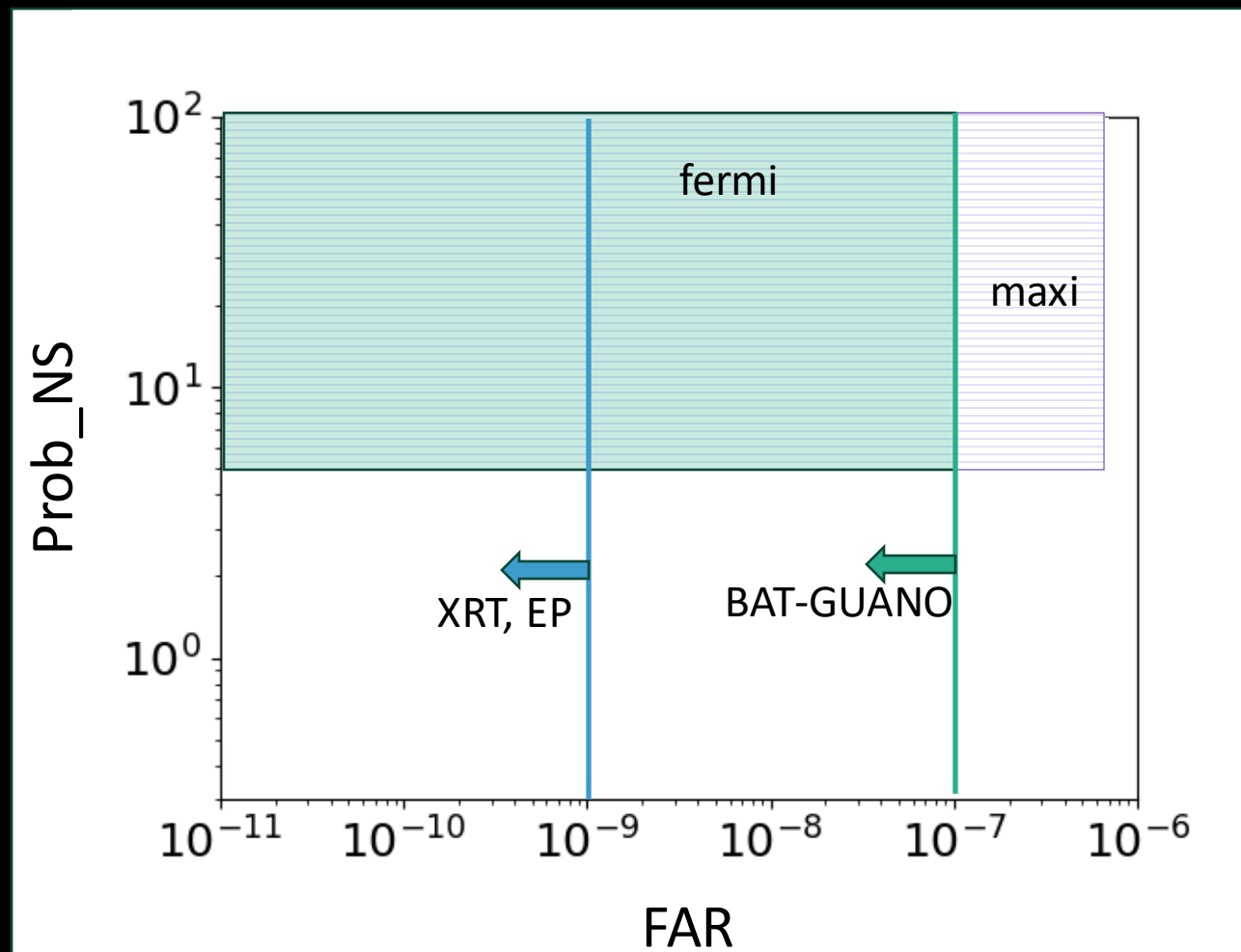
GCN circulars of X-ray/gamma-ray satellites (O4)

- Swift 90
- MAXI 29
- Fermi 18
- Einstein Probe (EP) 11
- INTEGRAL 7
- AstroSat 7
- AGILE 3
- CALET / Konus-wind / GECAM / eROSITA 2
- Insight-HXMT / Glowbug 1

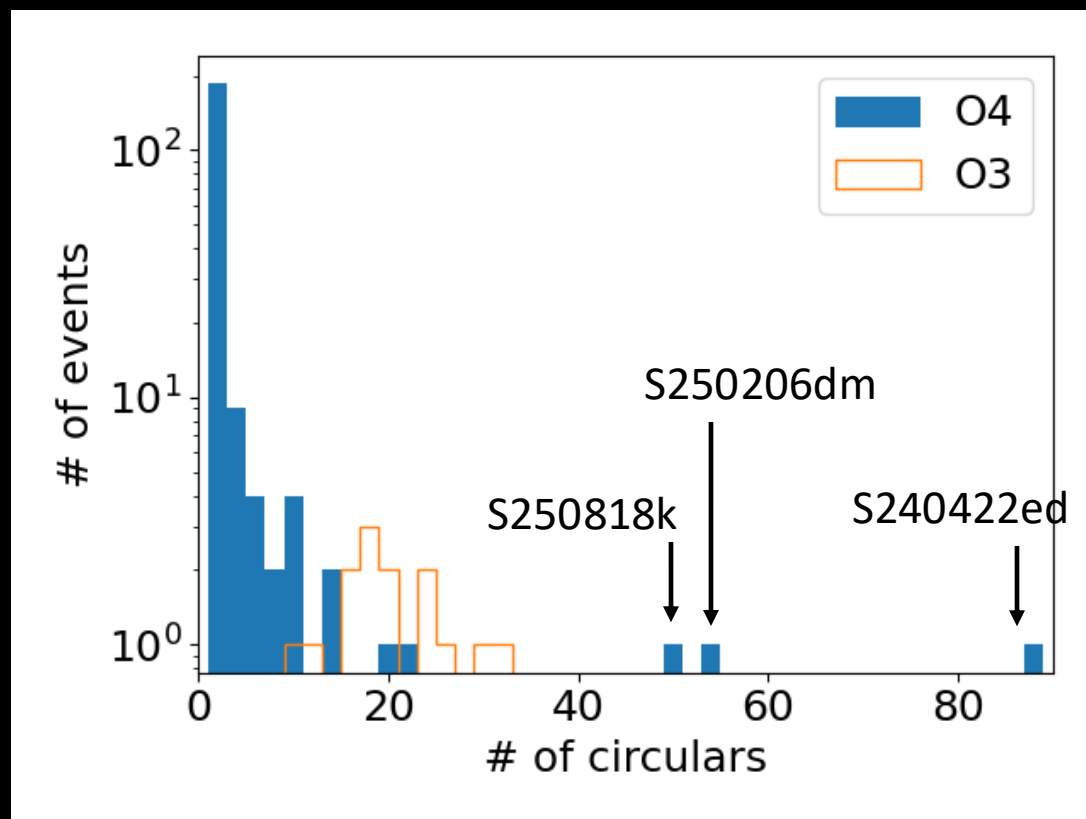


GW observation strategy (GCN circulars)

- false alarm rate (FAR) seems to be a primary standard in many missions
- Some missions use Prob_NS
- Follow-up telescopes may select well-localized events



follow-up observations for a GW event in O3 and O4

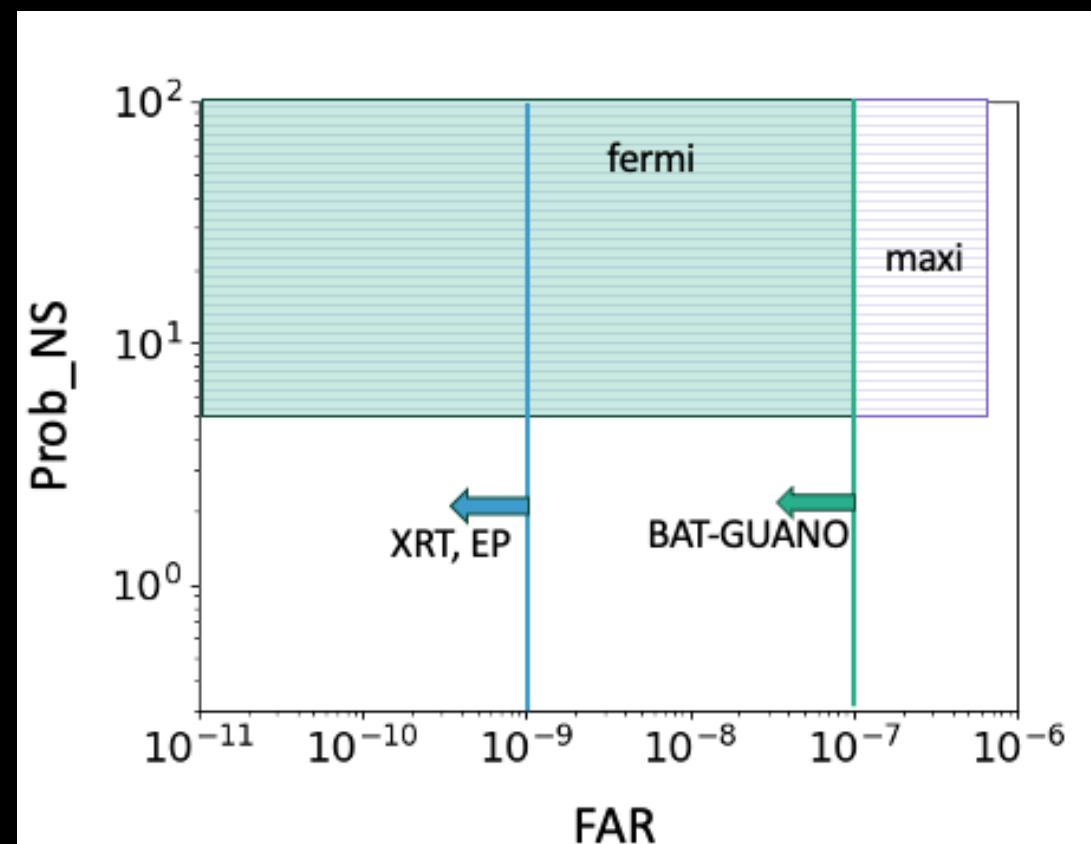


⌘ including the other wavelength and neutrinos

- in O4 Most of follow-up observers focused on **special** events
- S240422ed:
probability of NSBH >99%
- S250206dm:
probability of HasNS >99%
- S250818k:
probability of HasNS = 80%

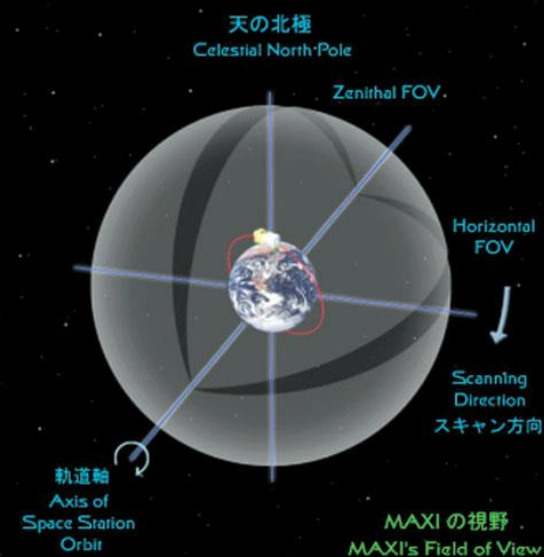
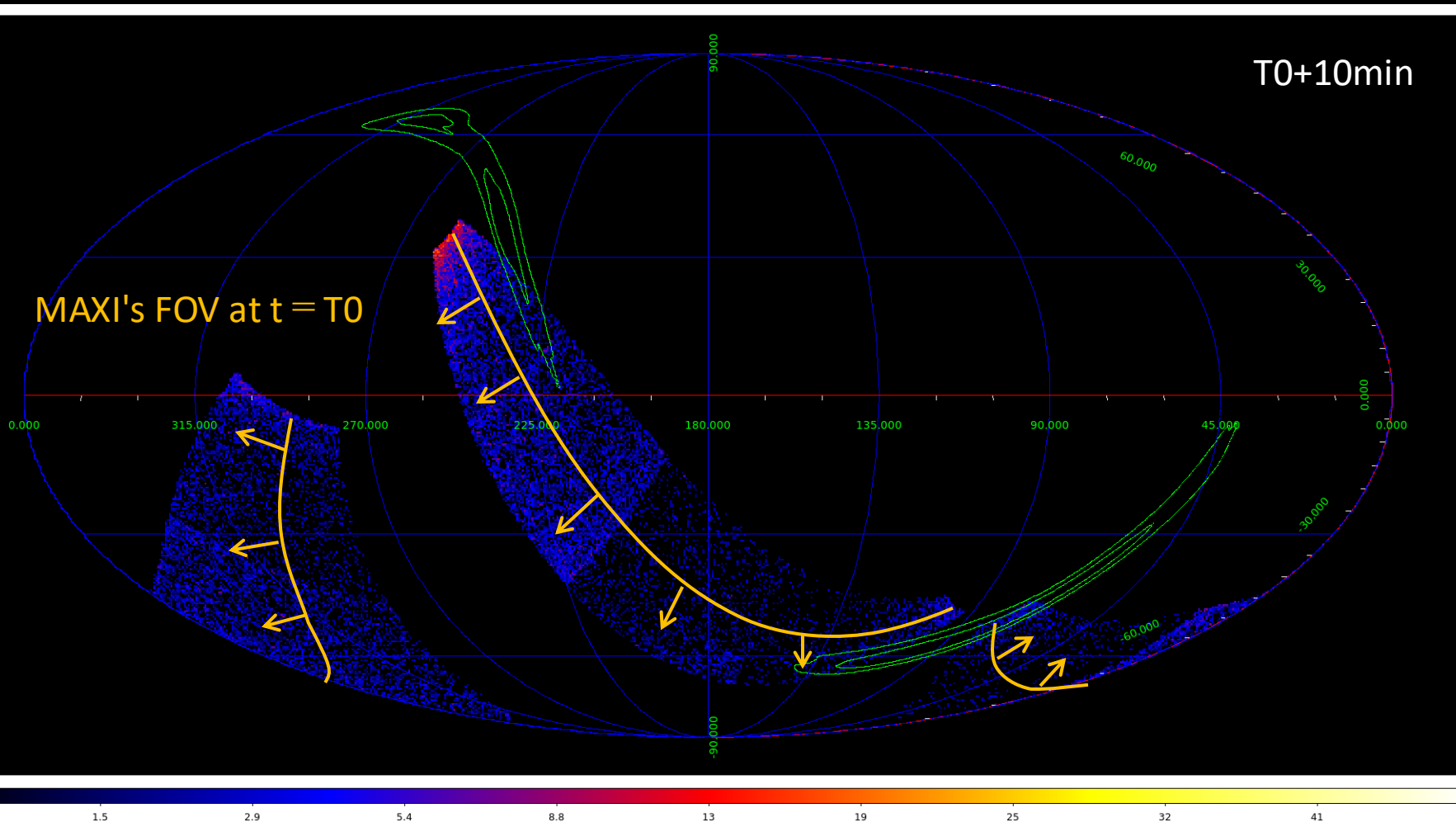
MAXI's activity related to GW events

- GSC coverage and start/end time of the observations are calculated automatically for all the GW alerts
 - We report the results if FAR < 20 per year and Prob_NS > 5%



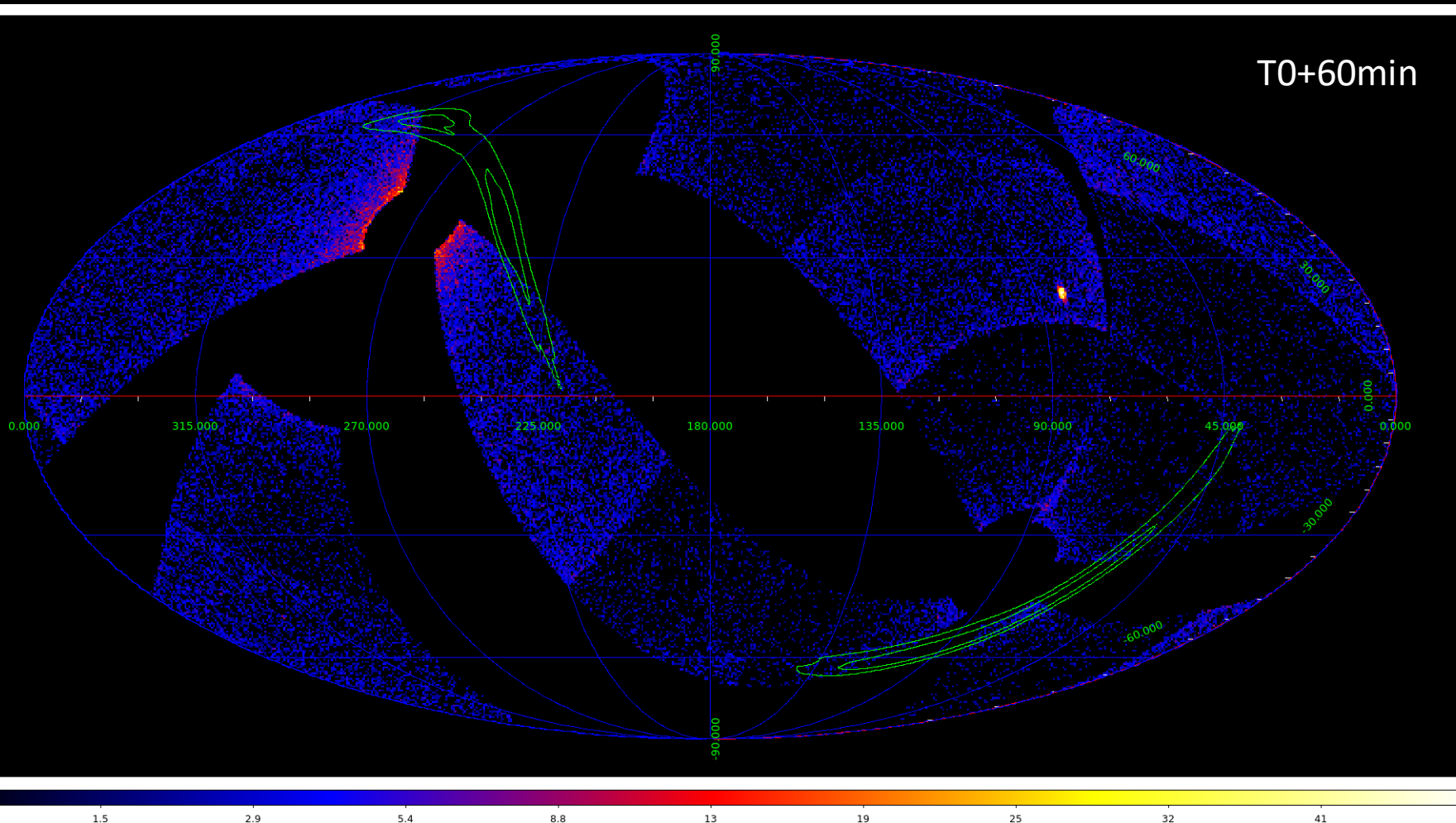
Map of X-ray photons

s250818k



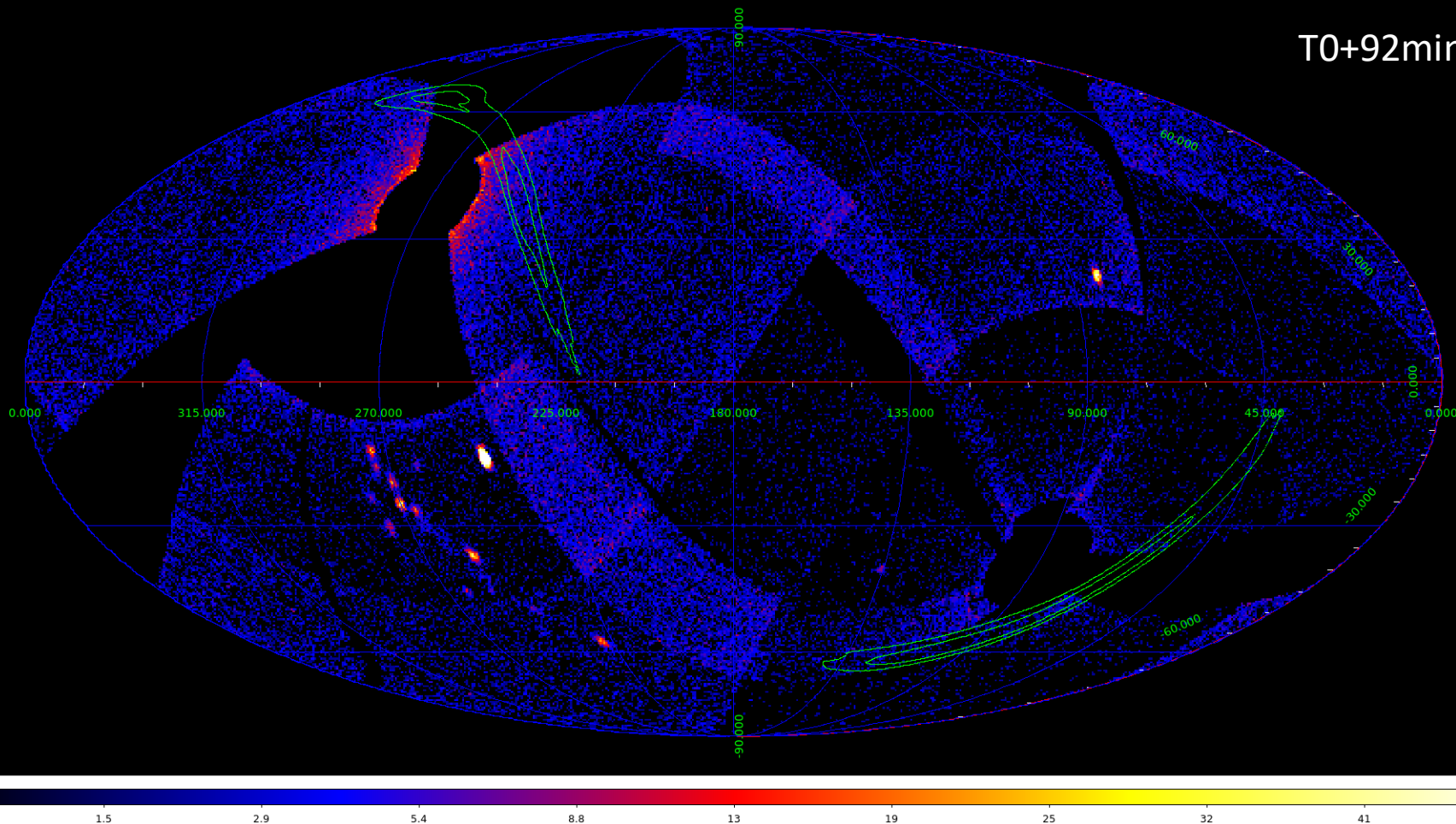
Map of X-ray photons

s250818k

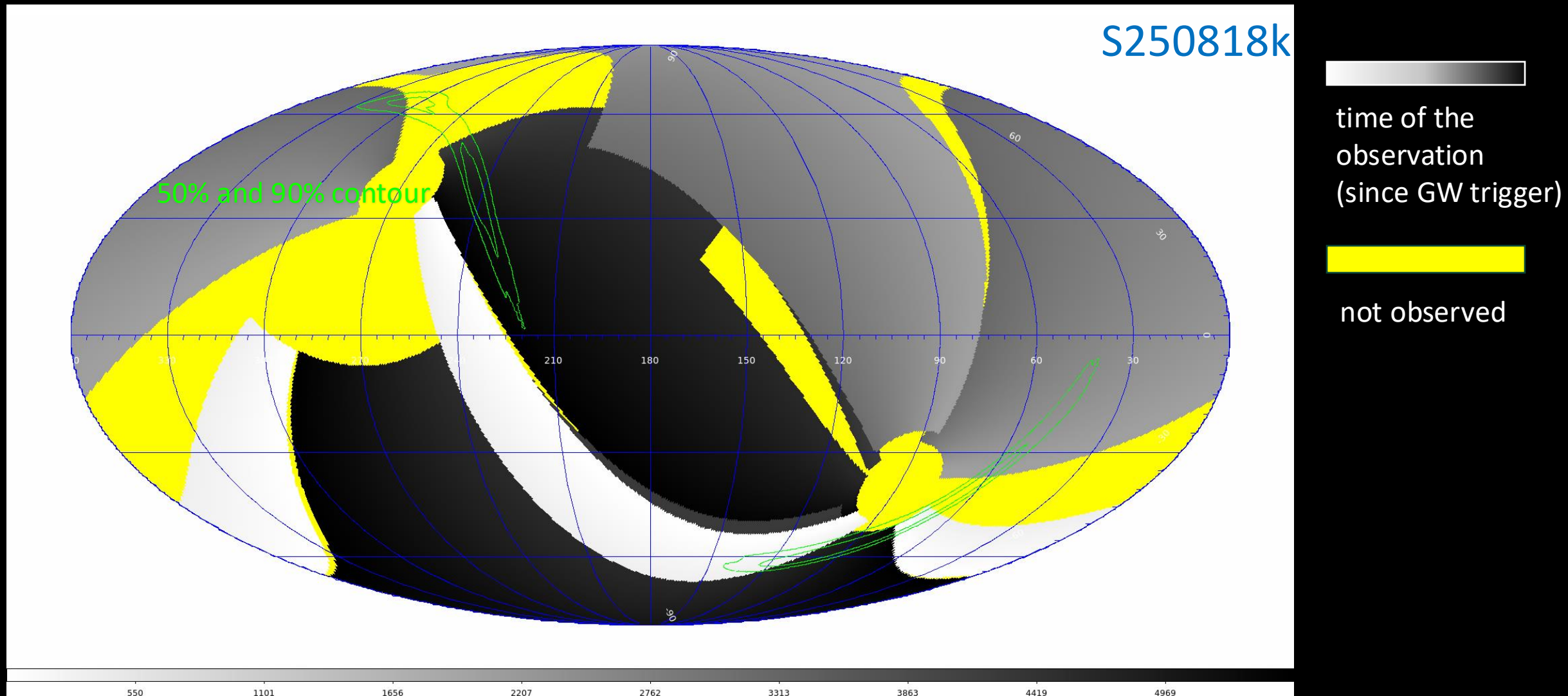


Map of X-ray photons

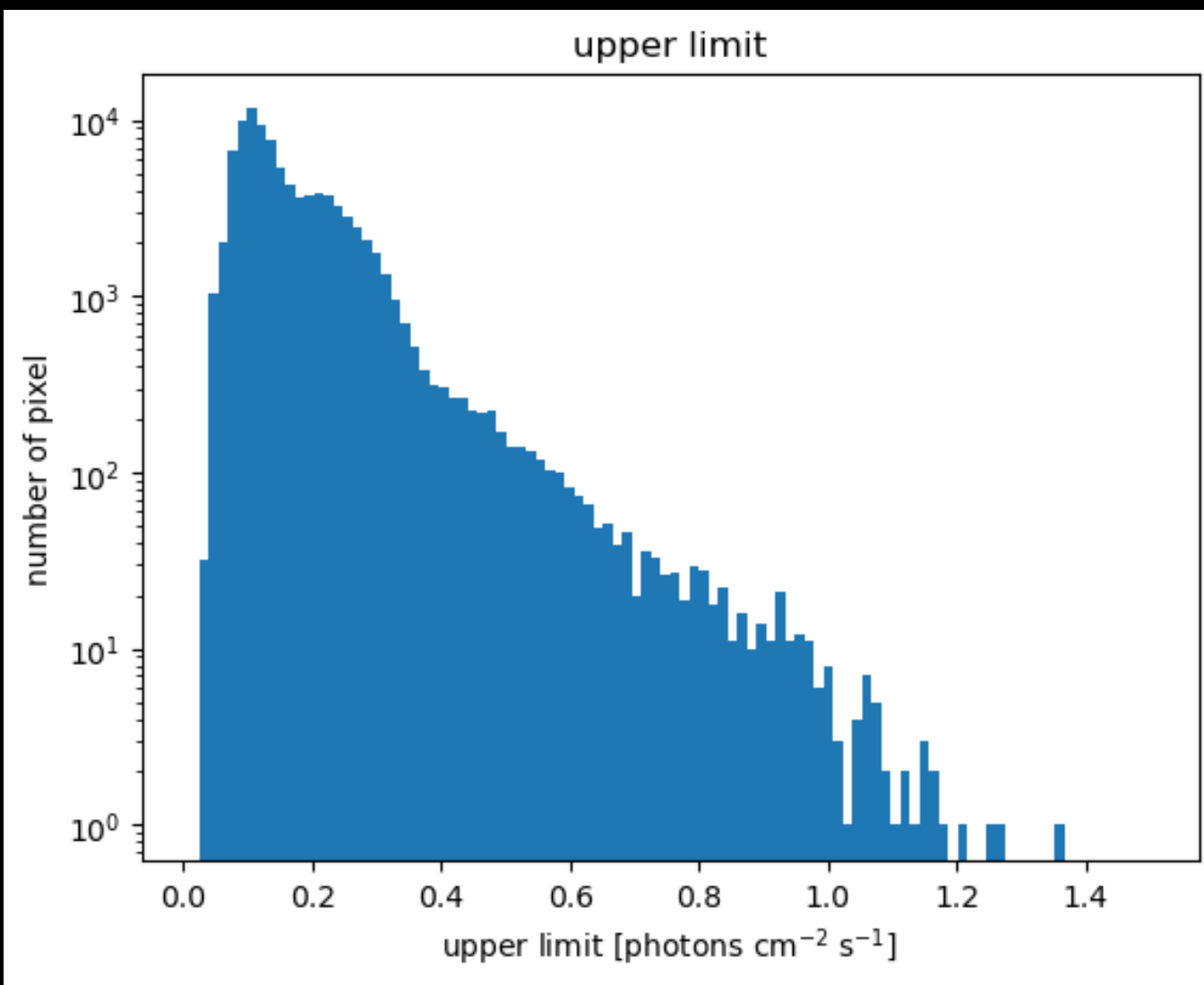
s250818k



Map of observation time



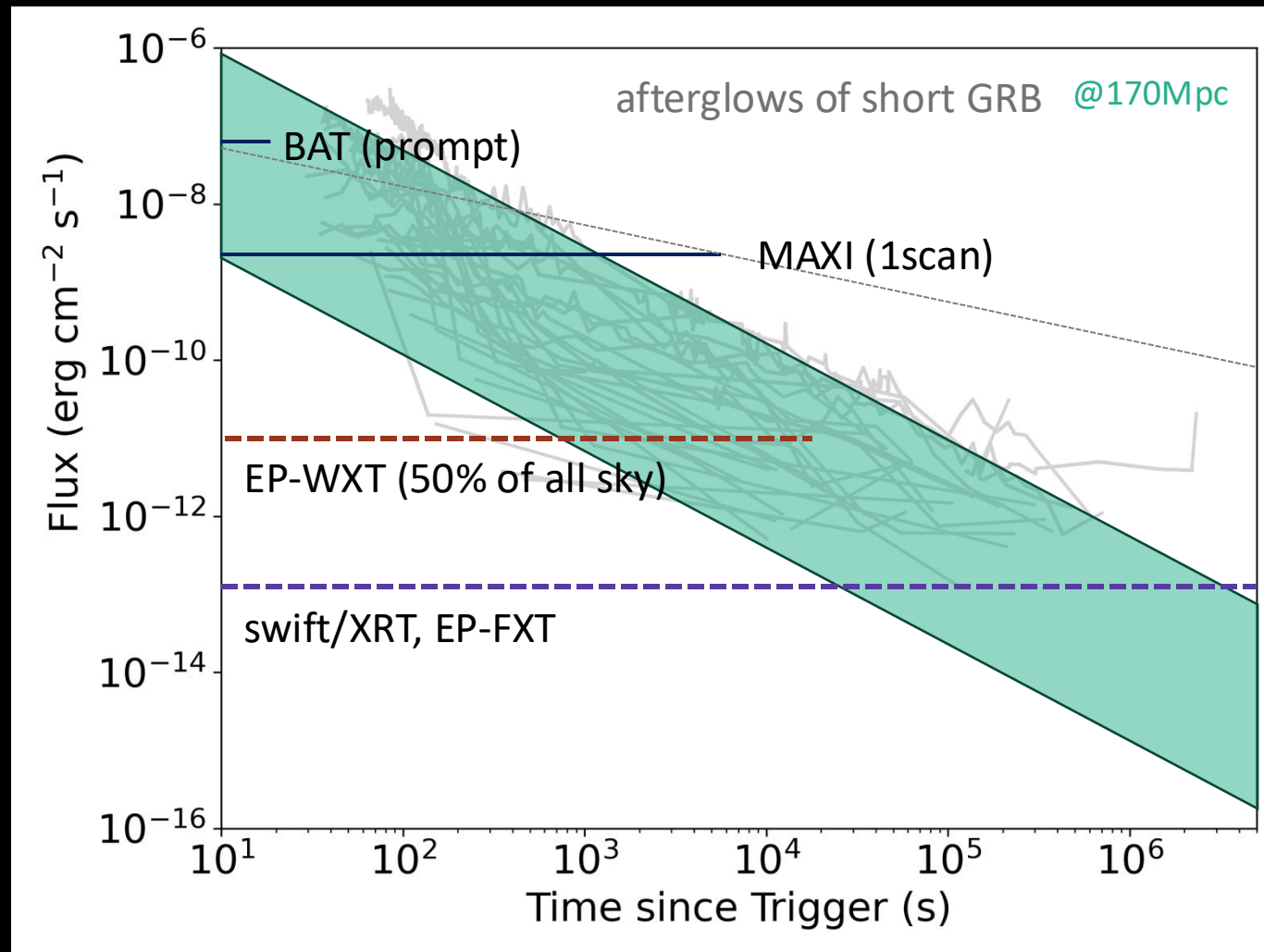
histogram of upper limit (O4)



- upper limits for each HEALPix pixel can be estimated from observed photon number and effective exposure at the point
- mean upper limit (2-20 keV):
0.17 photons cm⁻² s⁻¹
 $\sim 2.3 \times 10^{-9}$ erg cm⁻² s⁻¹

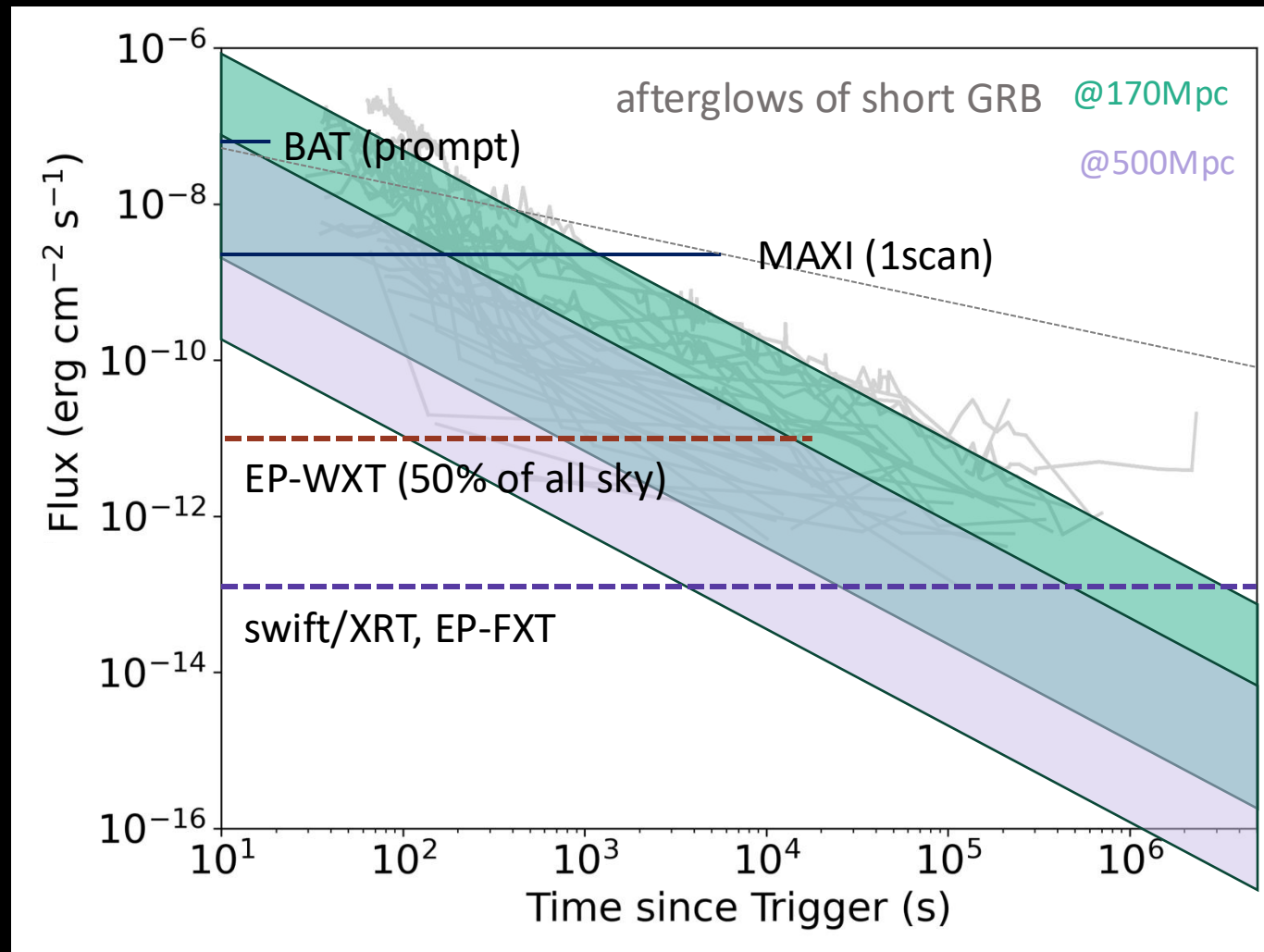
observation time and sensitivity

- Assuming light curves of short GRBs
 - MAXI can detect bright source at 170Mpc



observation time and sensitivity

- Assuming light curves of short GRBs
 - MAXI can detect bright source at 170Mpc, but it is hard to detect 500Mpc sources
 - EP-WXT can detect most of sources at 500Mpc
 - The sources decay below typical sensitivity of swift/XRT or EP-FXT after several days for 500Mpc



Search for X-ray counterparts of IceCube GOLD/BRONZE event

- IceCube team reported 62 Gold/Bronze events after April 2023
 - MAXI observed 34 of them
 - 19 are not observed or observed but only with degraded camera (this is reasonable number with the MAXI's observation efficiency)
 - The number of IC events occurred in the MAXI FoV was 7 (this is too much considering the MAXI's instantaneous FoV, 2%)
 - No significant detection

Neutrino Event List

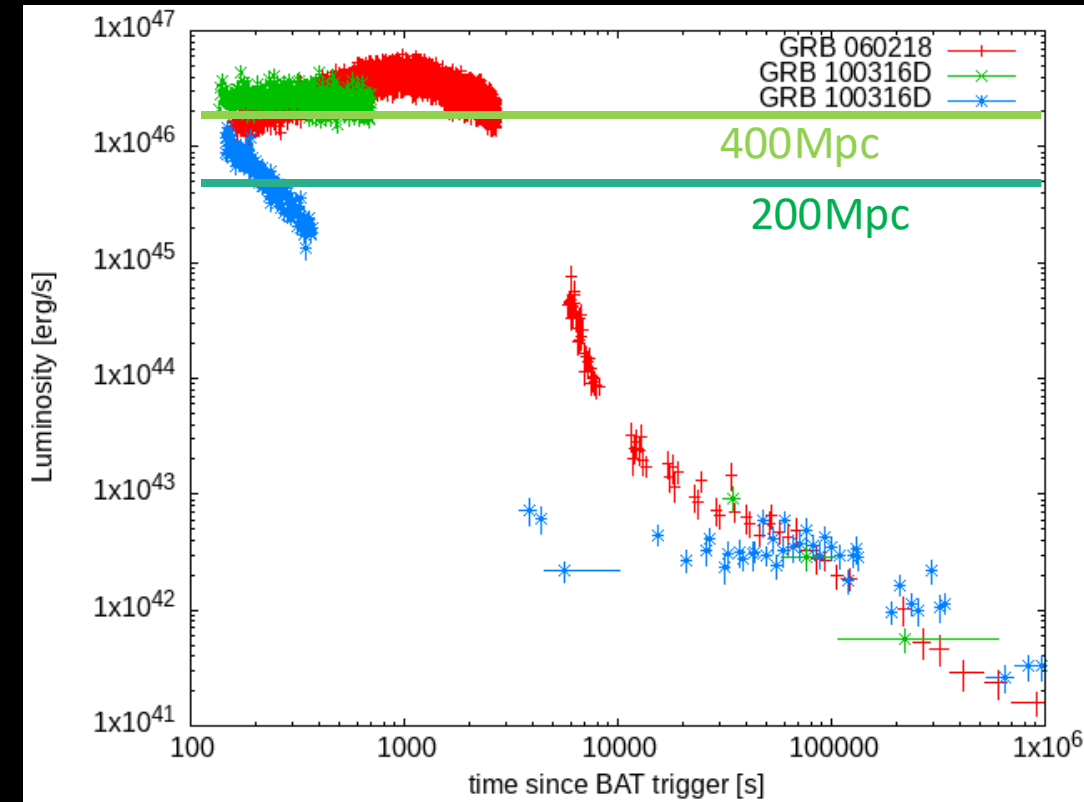
last update: 2025-11-10

Event Name	GSC HV	in/out of FoV	Obs. start	GCN/ATel
IceCube-251025A	Off	Out	T0+74 min	
IceCube-251018A	On	Out	no data	
IceCube-251014A	Off	Out	no data	
IceCube-251008A	Off	Out	T0+106 min	
IceCube-250926A	Off	Out	T0+19 min	
IceCube-250905A	Off	Out	T0+2 min	
IceCube-250831A	On	Out	T0+42 min	
IceCube-250813A	Off	Out	no data	
IceCube-250804A	Off	Out	T0+38 min	
IceCube-250708A	Off	Out	T0+17 min	
IceCube-250706A	Off	Out	T0+19 min	
IceCube-250506A	Off	Out	no data	
IceCube-250429A	On	Out	no data	
IceCube-250426A	On	In	T0+0 min	
IceCube-250421A	On	In	T0+1 min	
IceCube-250416A	On	In	T0+1 min	

maxi.riken.jp/neutrino/neutrino.html

Sensitivity and detection rate estimation

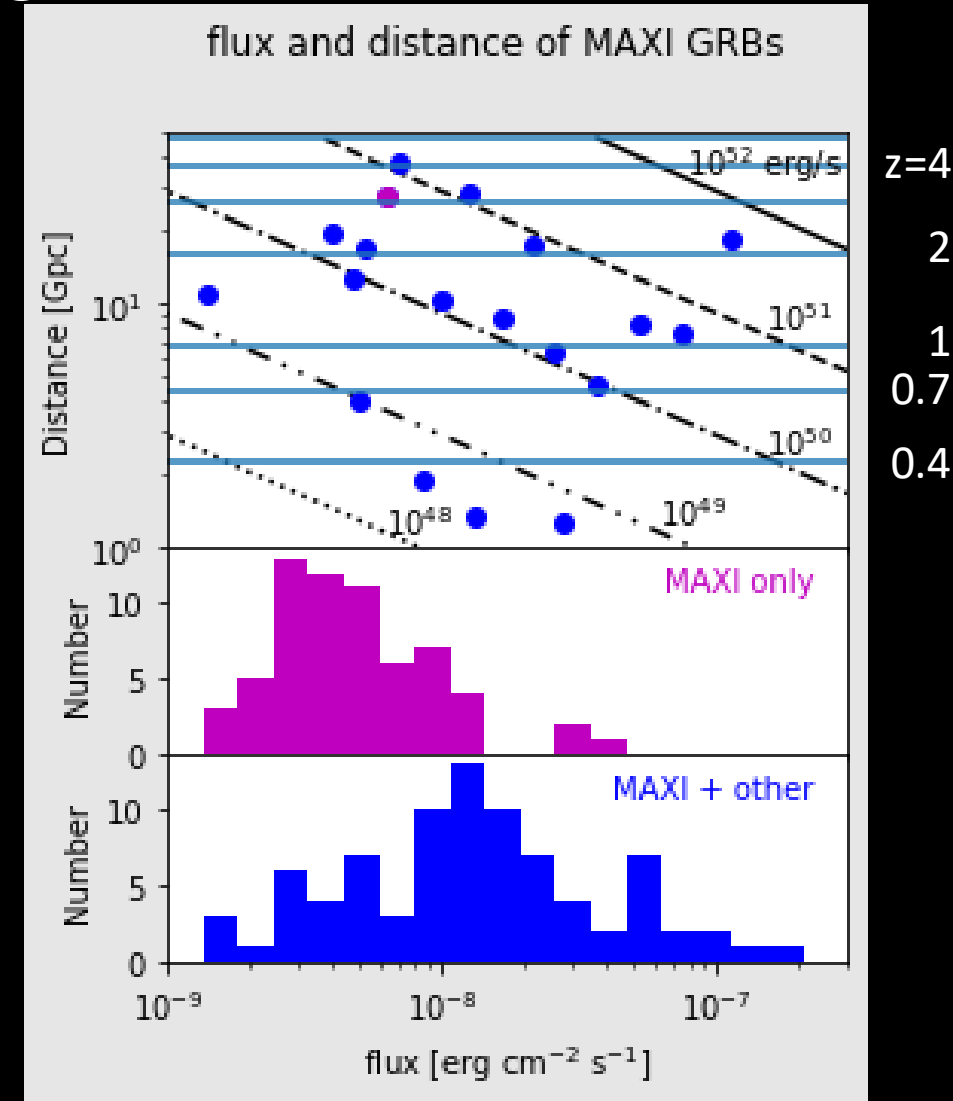
- How many events are expected for a proposed source model?
- Assuming low-luminosity GRB
 - event rate: 1 event/ year within 200 Mpc
 - observation efficiency: 15%
(if the source is observable for 1000 s)
 - operation of 16 years
→ about 2 events



X-ray light curves of LLGRB afterglow by Swift/XRT

Flux distribution of MAXI GRBs

- MAXI did not detect GRB with distance < 1 Gpc
 - Considering the comoving volume, it is thought that the distance to the GRB distribute ~ 2
 - On the other hand, the flux distribution of MAXI only GRBs dose not suggest cosmological distance
 - Possibly MAXI only GRBs (without redshift measurement) are nearby LLGRB
- We need
 - more MAXI only GRBs with distance measurement
 - to study sub-threshold MAXI events
 - Posters #22 by Iwakiri san,
and #31 by Katsumata san



Summary

- MAXI reported the results of observations for 29 GW events
- If we assume an X-ray counterpart behave like afterglows of short GRB, and the distance of 170 Mpc, MAXI need to scan the position within 1000s of the GW detection
- X-ray counterparts are searched for IceCube GOLD/BRONZE event
- 7 events occurred at the time of MAXI scan, but no significant signal was detected
- To study a correlation with neutrino events, it is important to search for sub-threshold events