HERMES DETECTION RATE AND SYNERGIES WITH GW INTERFEROMETERS

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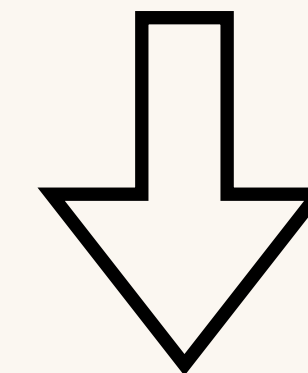
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GRB-V

GRBs DETECTED BY HERMES

OBJECTIVES

- estimate the detection rate

- understand which subpopulation of GRBs is accessible to HERMES

- optimise mission performances

- explore synergies with other EM facilities

- quantify joint GW-EM detections

METHOD

samples of real GRBs (BATSE, BAT, GBM,....) are biased by limitations of detectors
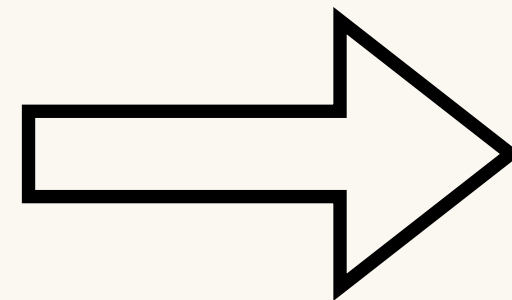
⬇

we use a population of synthetic GRBs

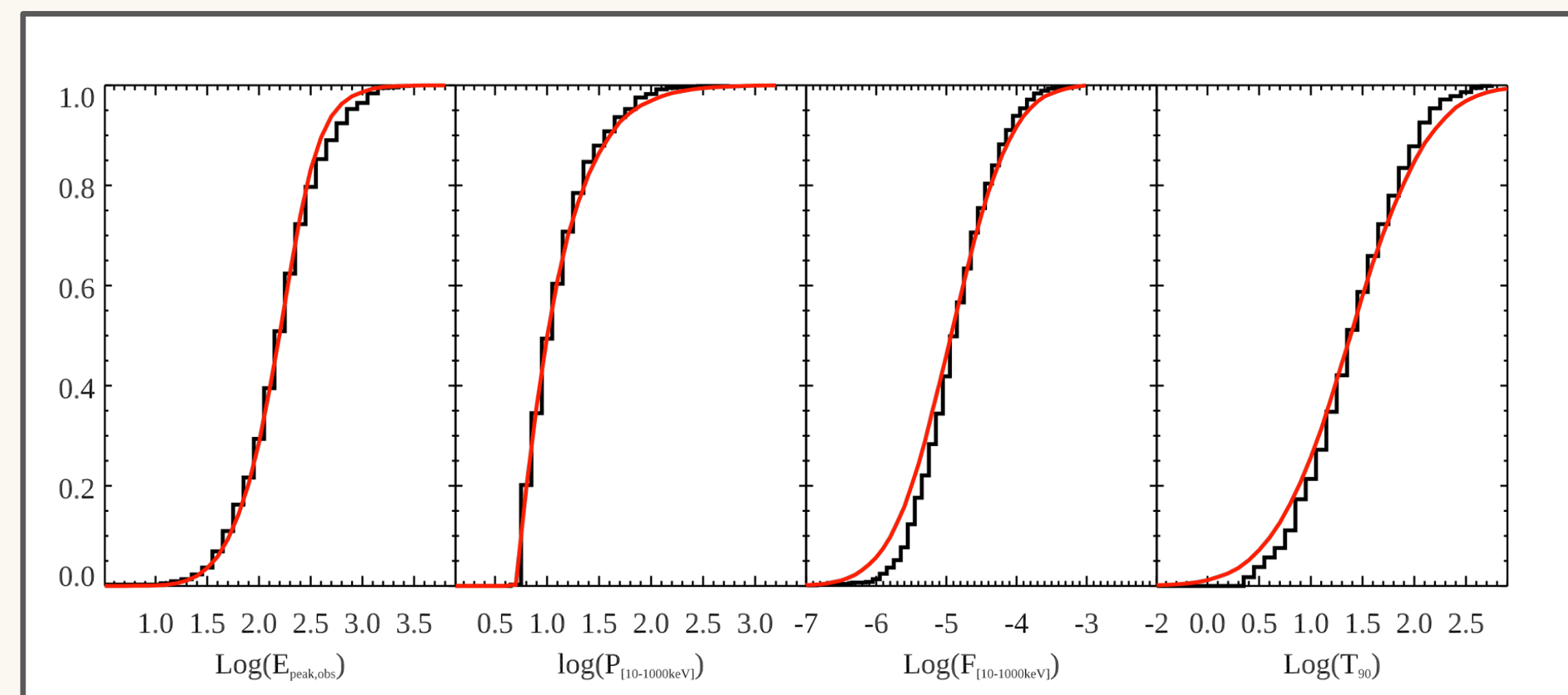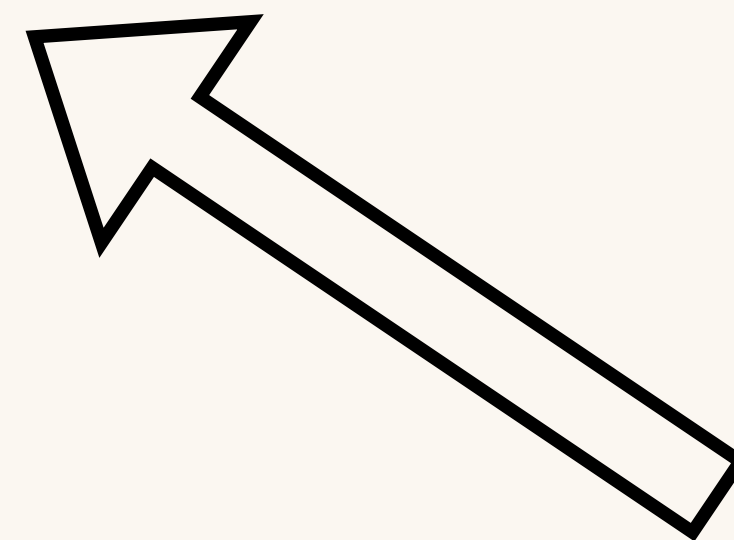*...paper in preparation...*

Synthetic Population

INPUT

- luminosity and energy function
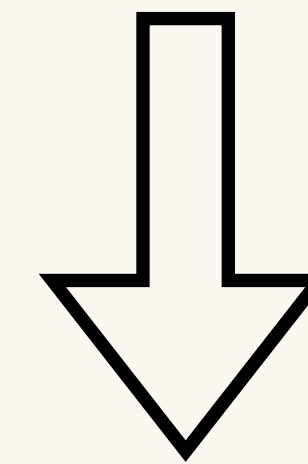
- GRB cosmic rate

- GRB spectrum

Ghirlanda et al., 2015, 2016, 2022

OUTPUT

distribution of peak flux, fluence, redshift, duration,...

Estimates are performed assuming the following performances:

Instrument	FoV	energy range keV	back. rate counts/s	duty cycle
S	80°	50-300	72	0.5
X	60°	3-20	503	0.5

EFFECTIVE AREAS vs ENERGY
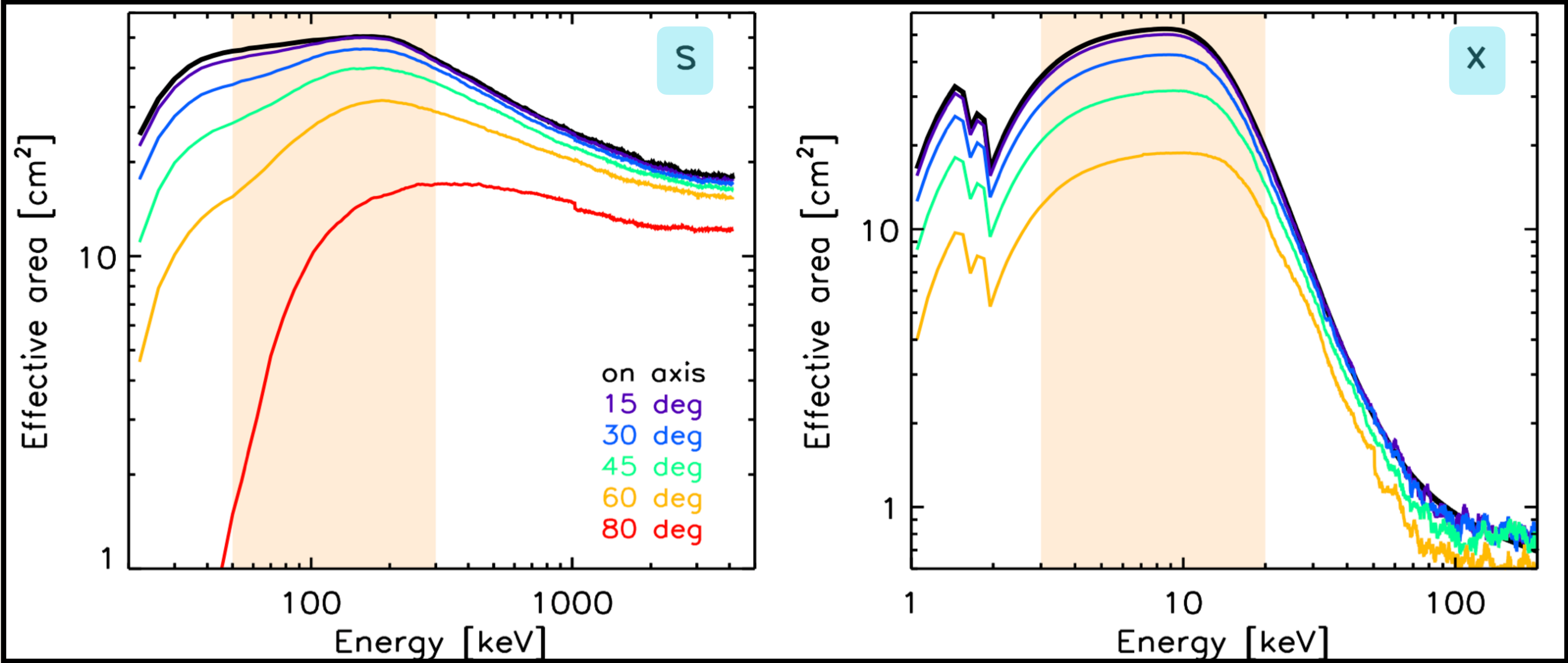
METHOD
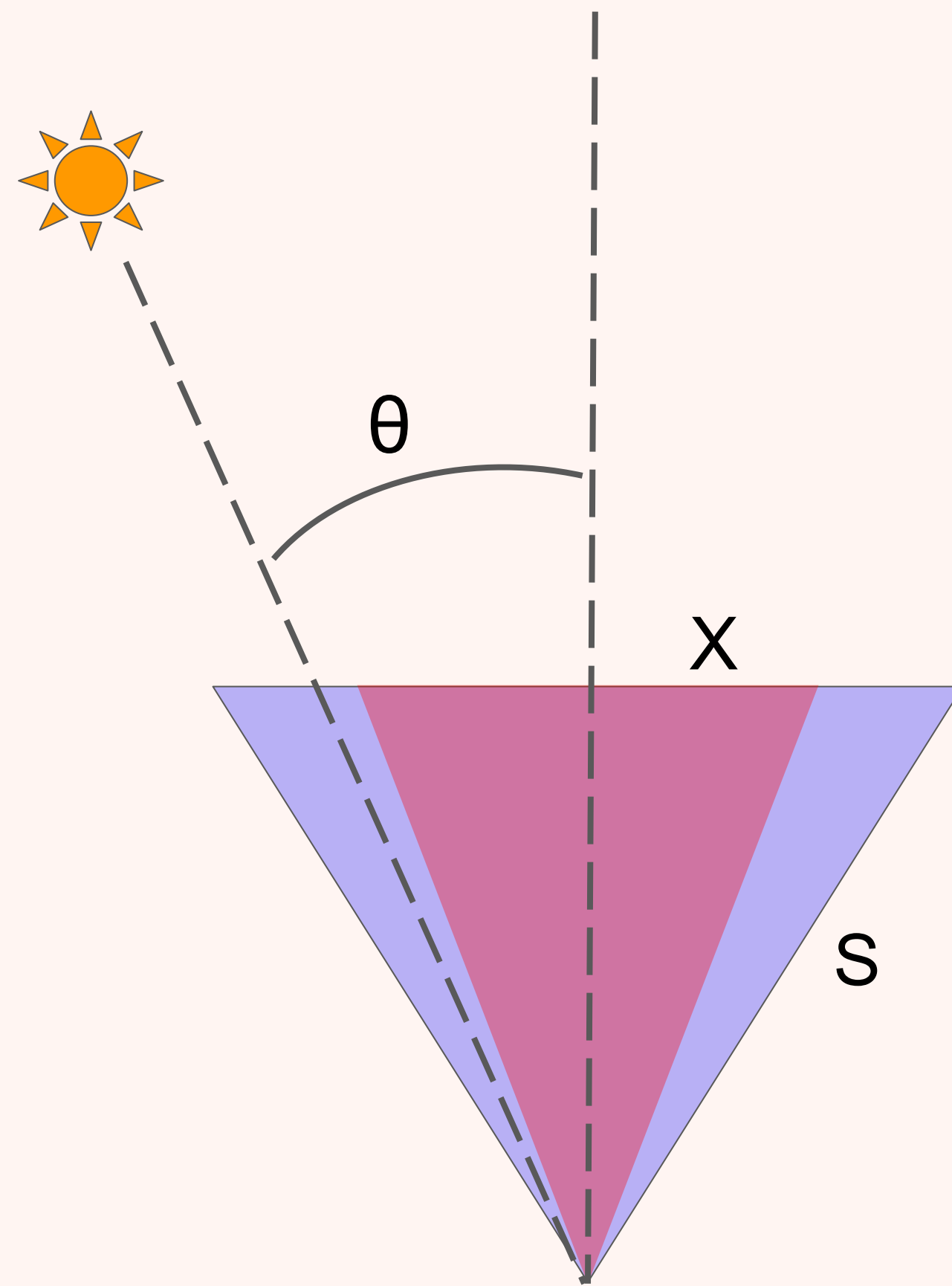
- sources are distributed isotropically

- theta is the angle between detector normal and line of sight

- GRBs outside the FoV are considered non detectable

- for GRBs inside the FoV...

METHOD

- estimate effective area *A* at the source angle θ: *A(E,θ)*

- the spectrum *N(E)* accumulated over a time *ΔT* is multiplied by *A(E,θ)*

- counts are integrated over a given energy range

$$S(\theta) = \int_{E_1}^{E_2} N(E)A(E,\theta)dE$$

- we estimate the probability to obtain *S+B,* when *B* is expected

- if *p < 3 x 10^{-7}* (5 sigma) —> detection

METHOD

We estimate the probability for

- 3-20 keV and 50-300 keV

- ΔT long: prompt duration and 1 sec around the peak flux

- ΔT short: prompt duration and 1 sec (or 64ms) around the peak flux

- we claim detection if the probability is > 5 sigma for at least one energy range and at least for one time interval
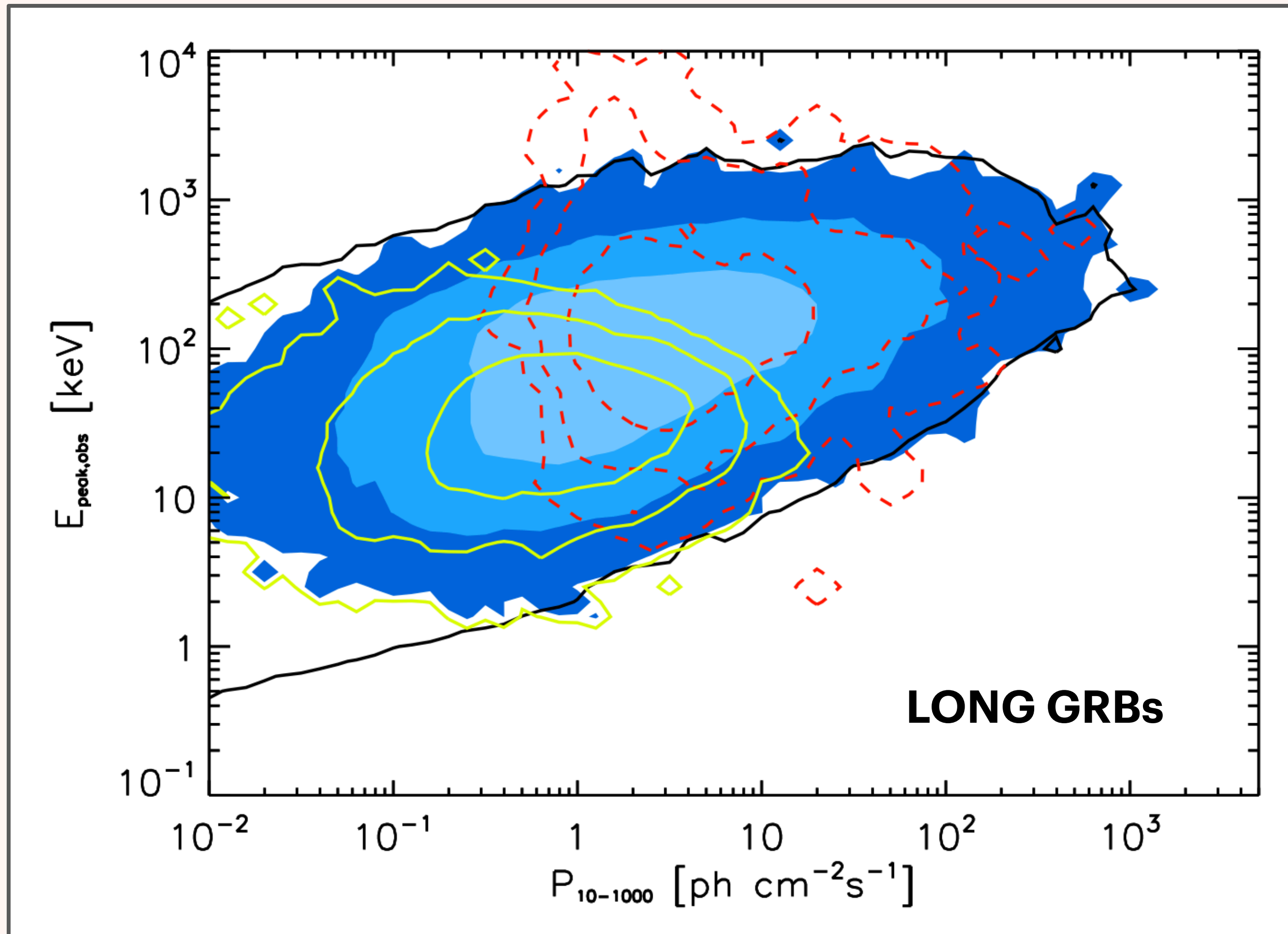
Detection rates (GRBs/yr)

	LONG				SHORT			
	Total	S	X	X-only	Total	S	X	X-only
Pathfinder	150	106	111	44	6-14	6-14	1-4	0.1-0.4
Constellation	258	165	205	93	12-21	12-20	3-8	0.3-0.8

RESULTS

LONG GRBs

GRB detectable with HERMES-SP, in the E_{peak}-Peak flux plane.

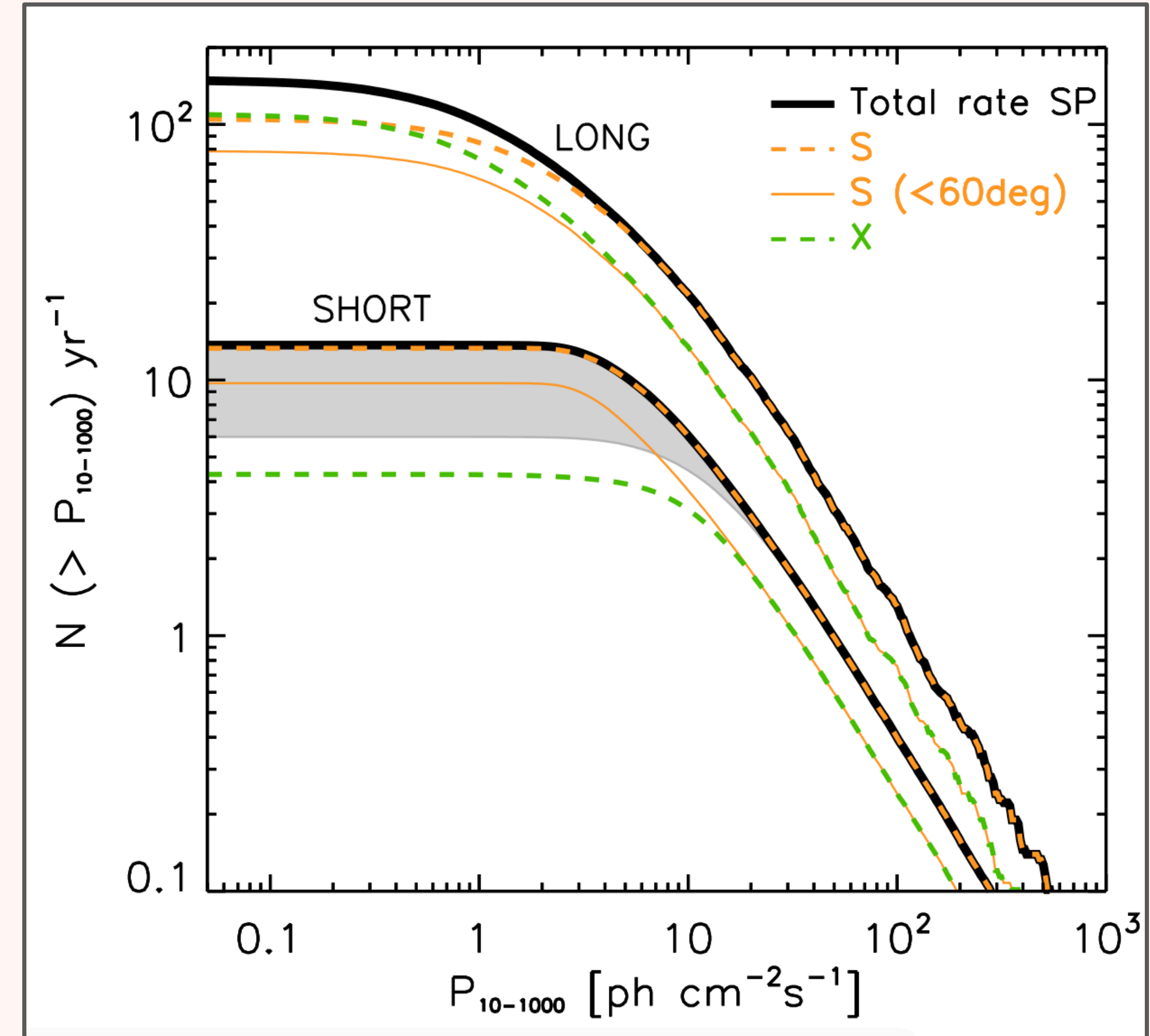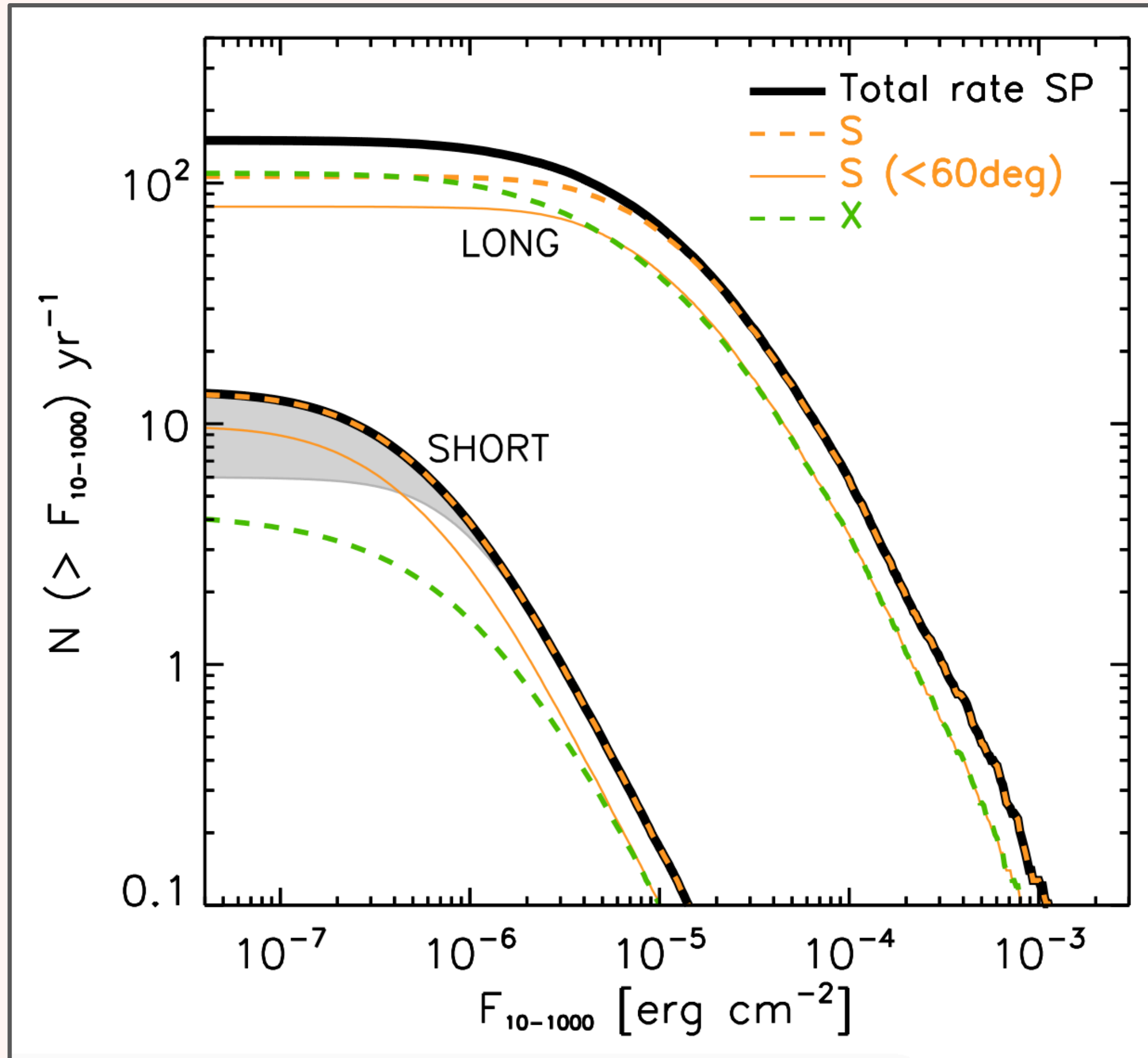**Solid black line:** entire simulated population;

Shaded blue contours: long GRBs detected by HERMES-SP (contours contain the 68%, 90% and 99.73% of the detectable GRBs);

Yellow contours: subsample of GRBs detected only with the X instrument;

Dashed red lines: distribution of the real Fermi GRBs in the same plane.
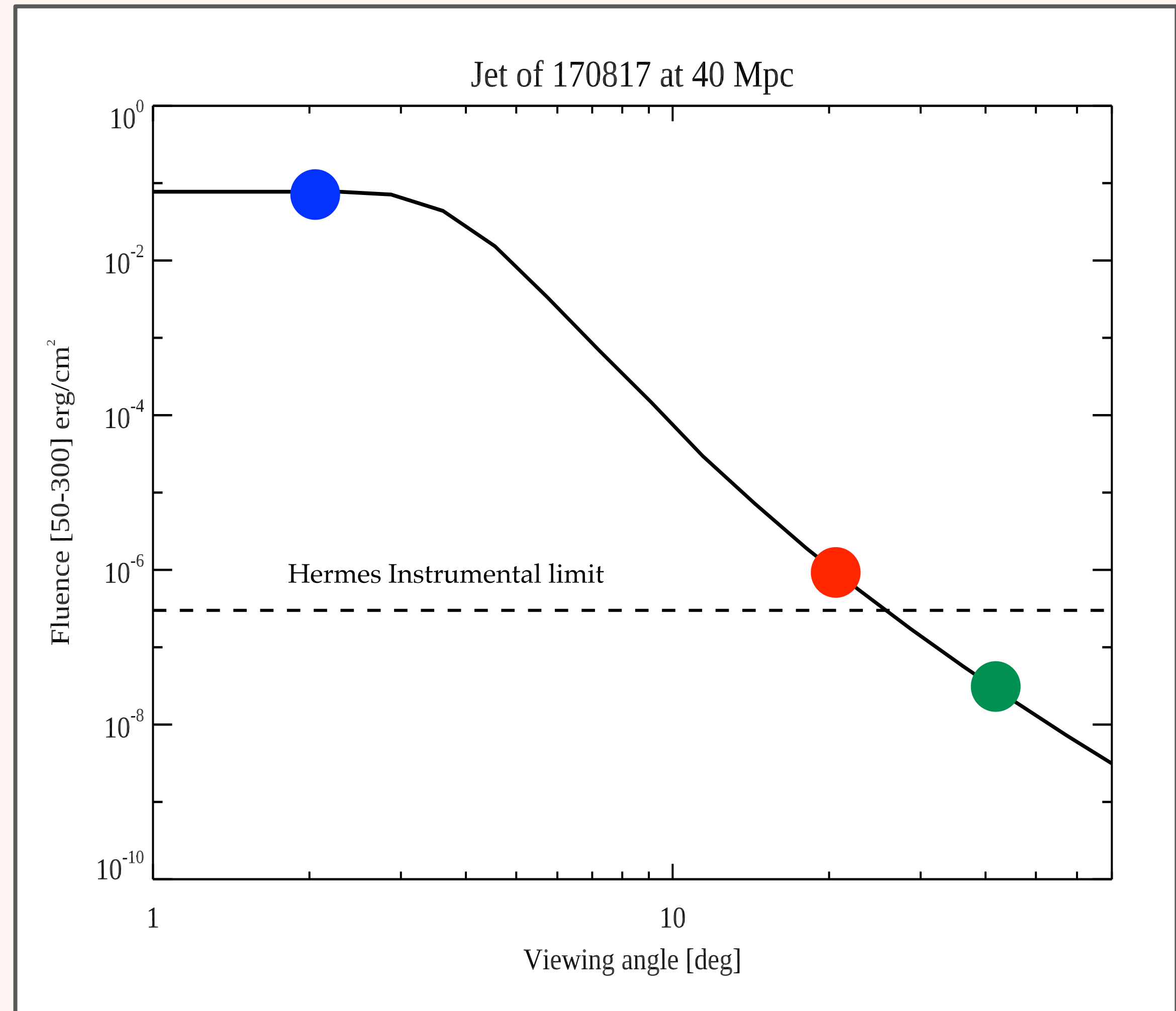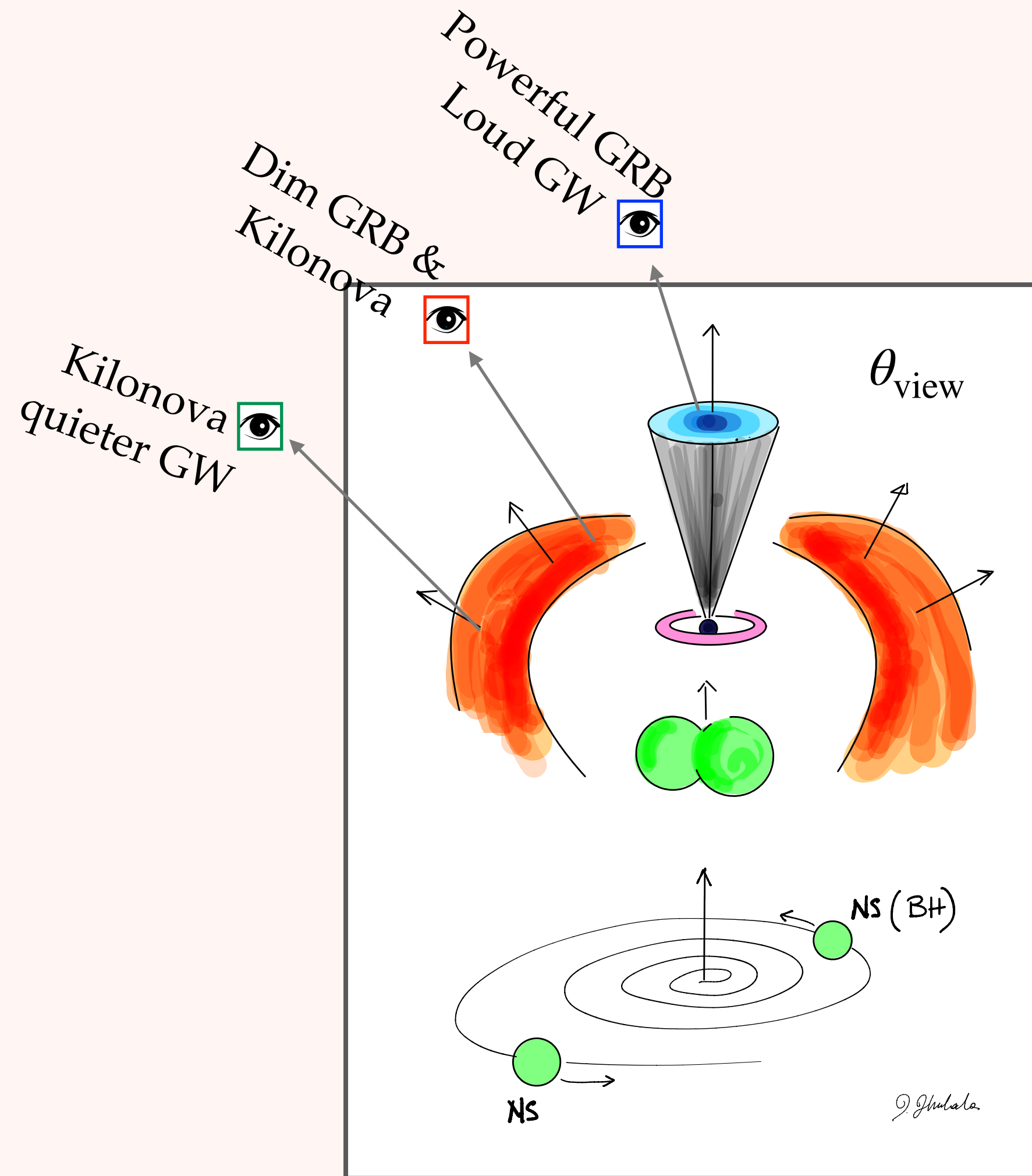
RESULTS

HERMES MULTI-MESSENGER PERFORMANCES

WHEN ORIENTATION MATTERS

WHEN ORIENTATION MATTERS

Powerful GRB
Loud GW

Dim GRB &
Kilonova

Kilonova
quieter GW

θ_{view}

NS (BH)

NS

Gravitational
&
Electromagnetic
ranges
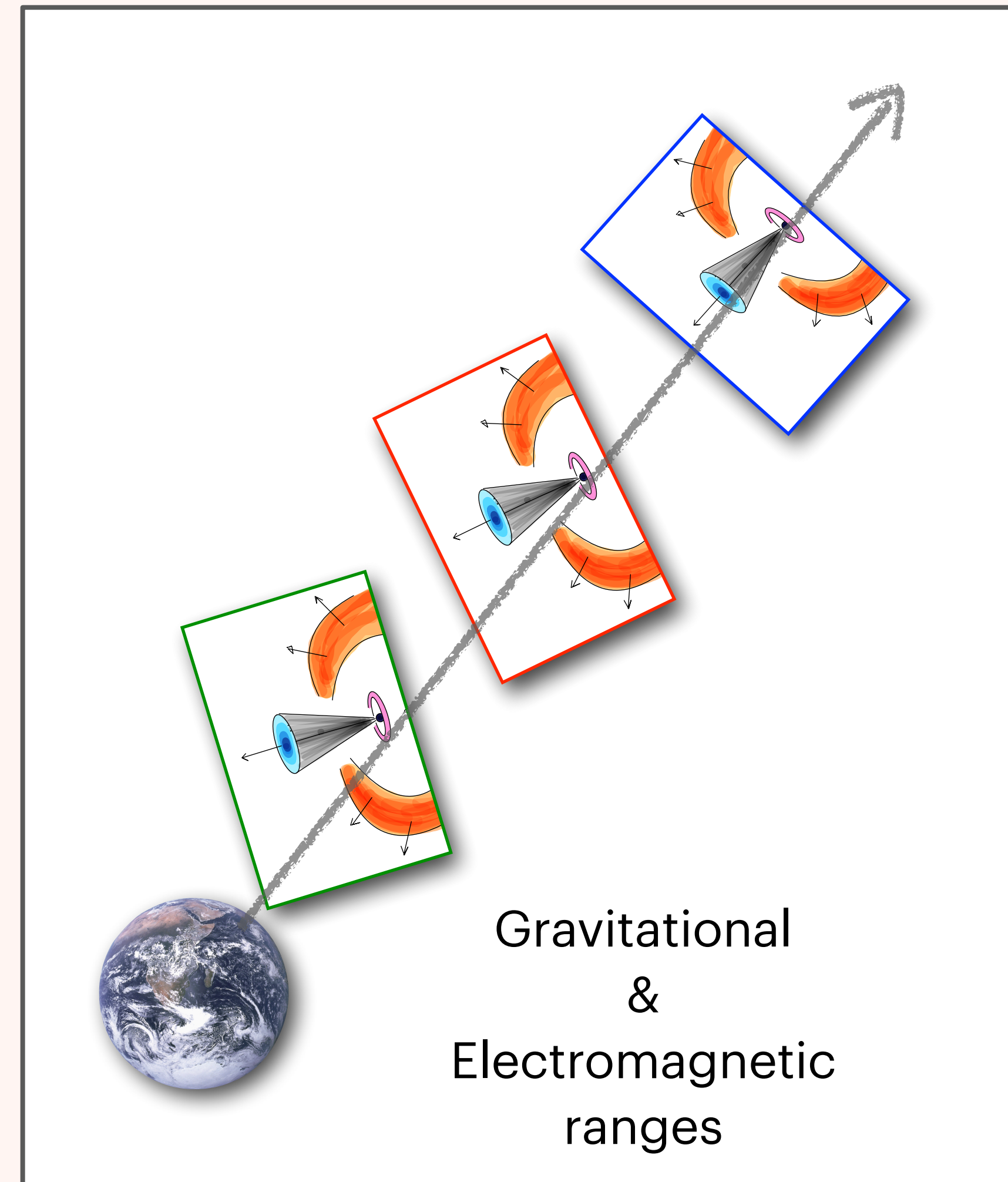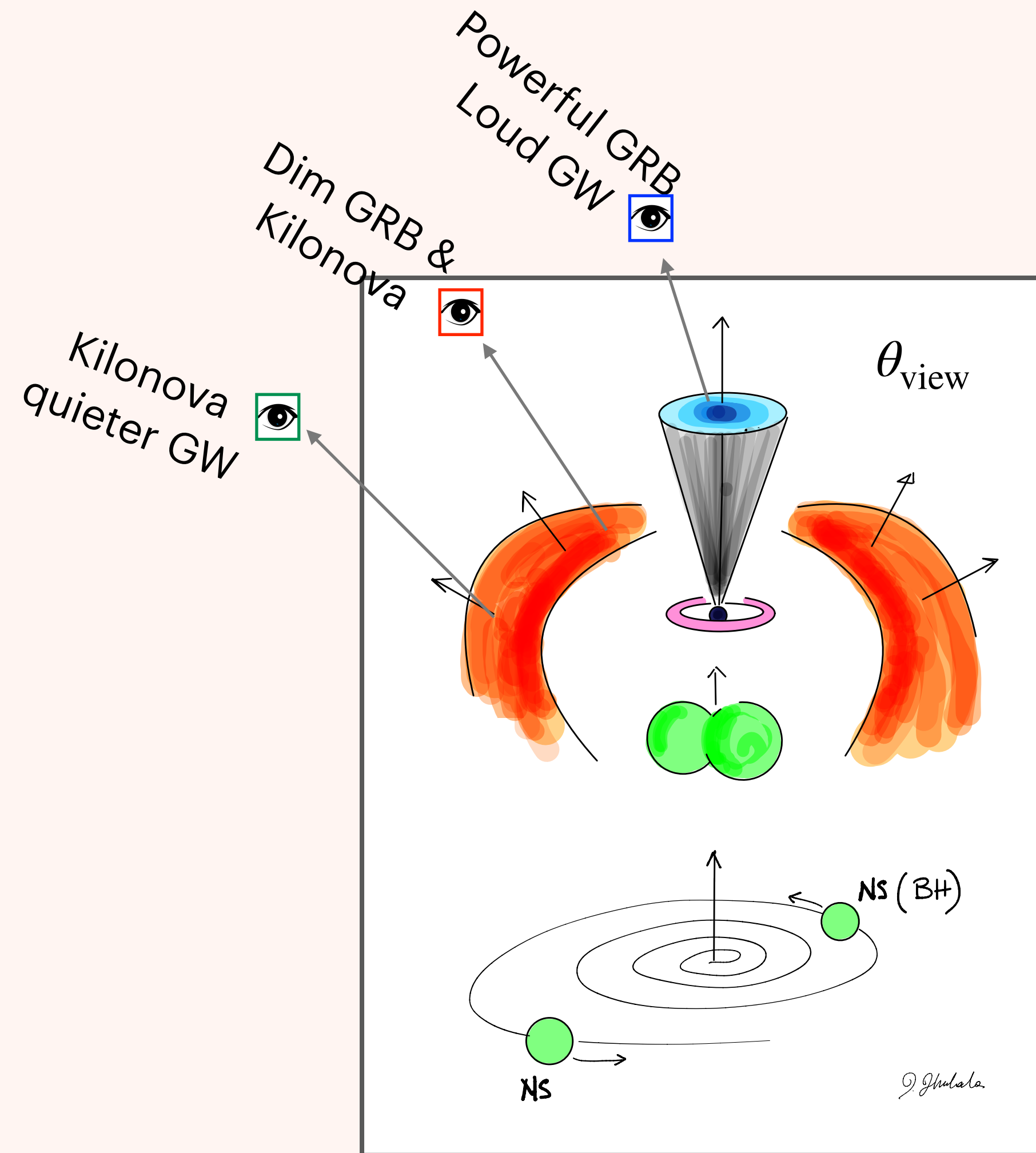
HERMES SENSITIVITY SELECTION $\theta_{v,\mathrm{max}}$

For an assigned Universal Structured Jet configuration

Max viewing angle

Hermes off-core limiting angle of QUSJ GRB detection

Jet core opening angle

Redshift
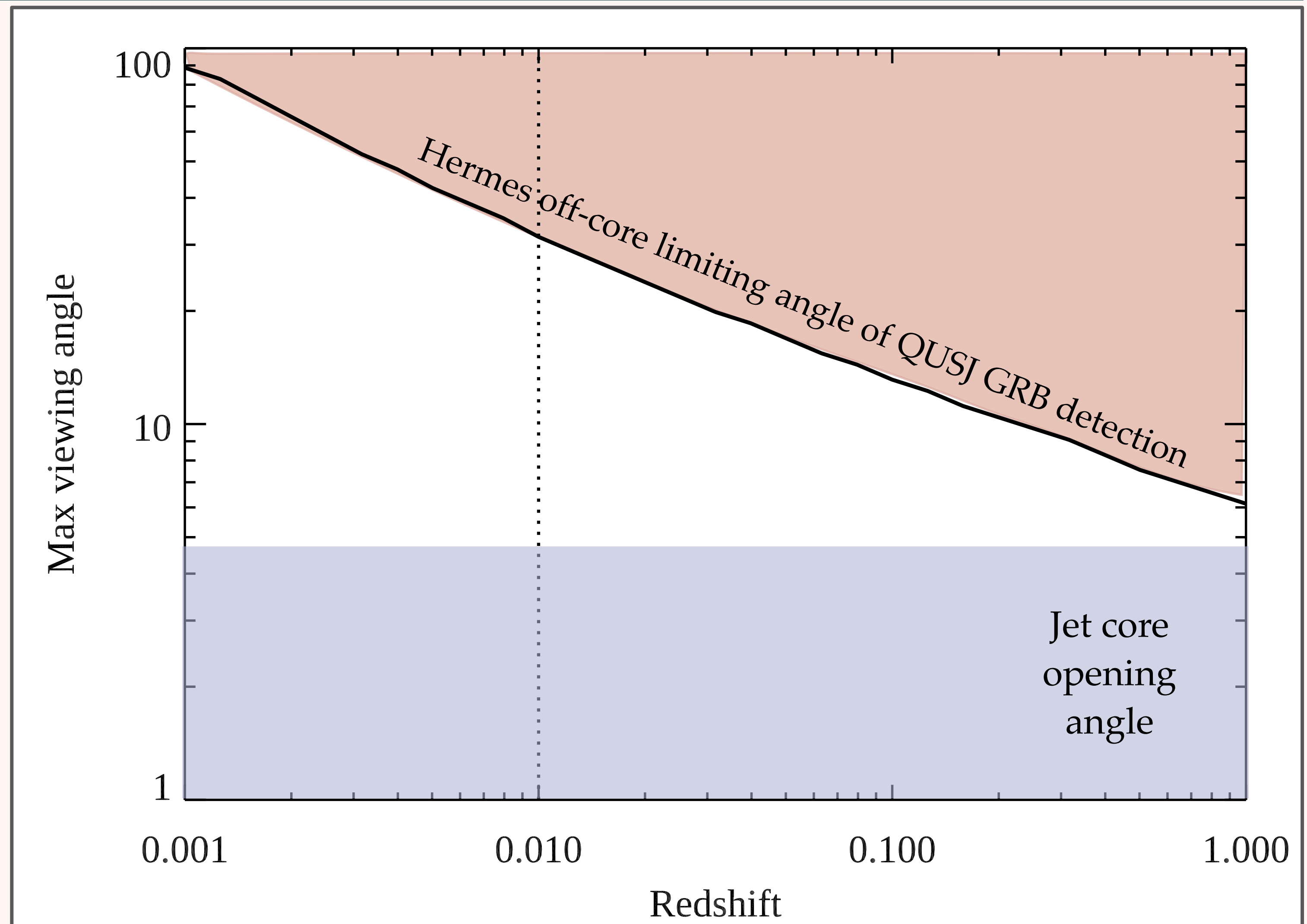
METHODS

S. Ronchini talk: MC population based estimates of joint GW-EM detection rates for ET/CE with current /future facilities

A. Colombo et al. 2022: Population study of joint GW-EM detections (GRB, KN, Cocoon) for LVK O4

For HERMES (ET):

we implement a semi-analytical approach for joint GW-EM Hermes detections:

1) BNS population (normalised to current GW estimates - Abbott et al. 2021)

2) Cosmic rate evolution (Colombo et al. 2021, GG et al. 2016)

3) Successful jet

4) ET detection efficiency (Ronchini et al. 2022)

5) HERMES constellation parameters and response

HERMES JOINT GW(ET)-EM DETECTION RATE

Samuele - $84\ \mathrm{yr}^{-1}$: consistent by rescaling for Hermes parameters

$10^{+15}_{-7}\ \mathrm{yr}^{-1}$
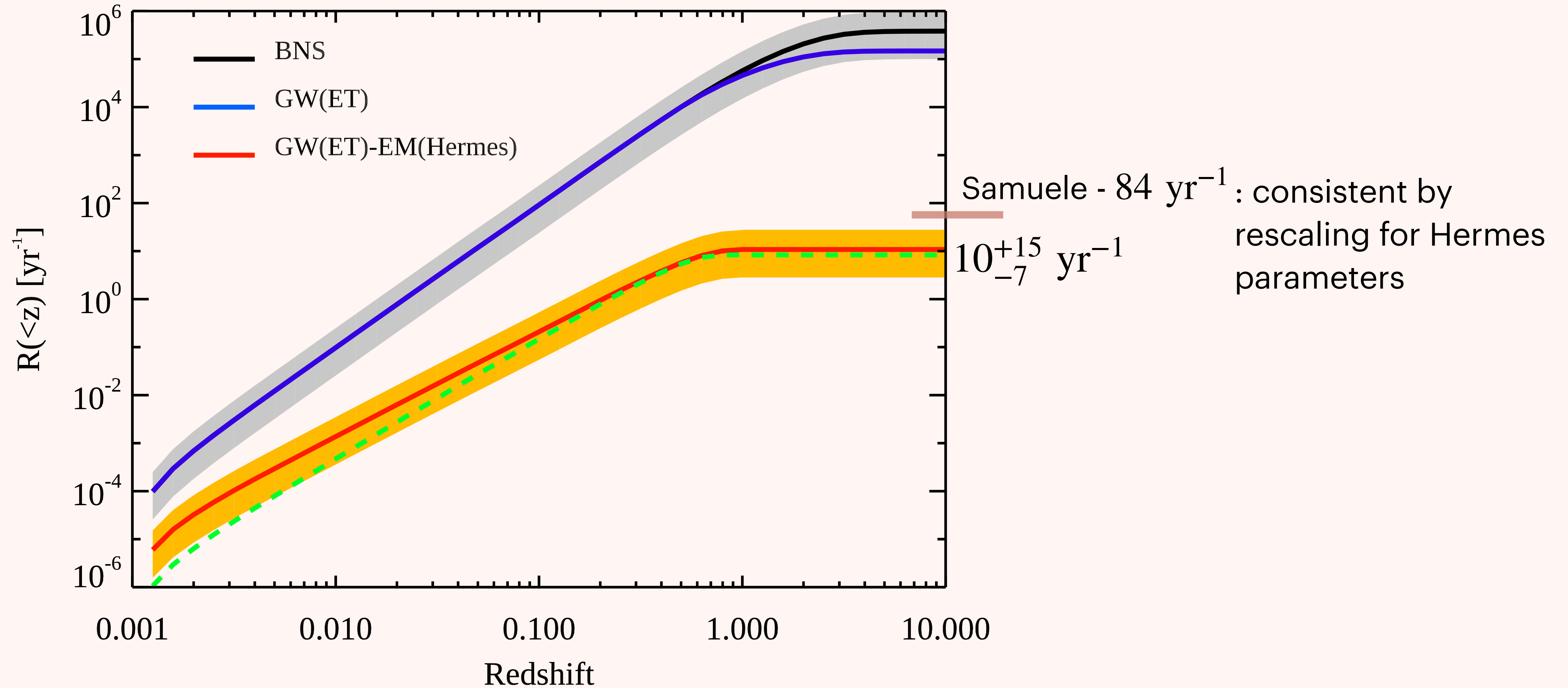
WORK IN PROGRESS

GRB studies:

1) Spectral characterisation (down to 2 keV!)

GW-EM joint detections:

1) Variational principle approach E_c, θ_c dominate the systematic uncertainty

2) Implement $A_{eff}(\theta)$ as probability distribution of $F_{\lim}$

3) estimates for O4 and O5