

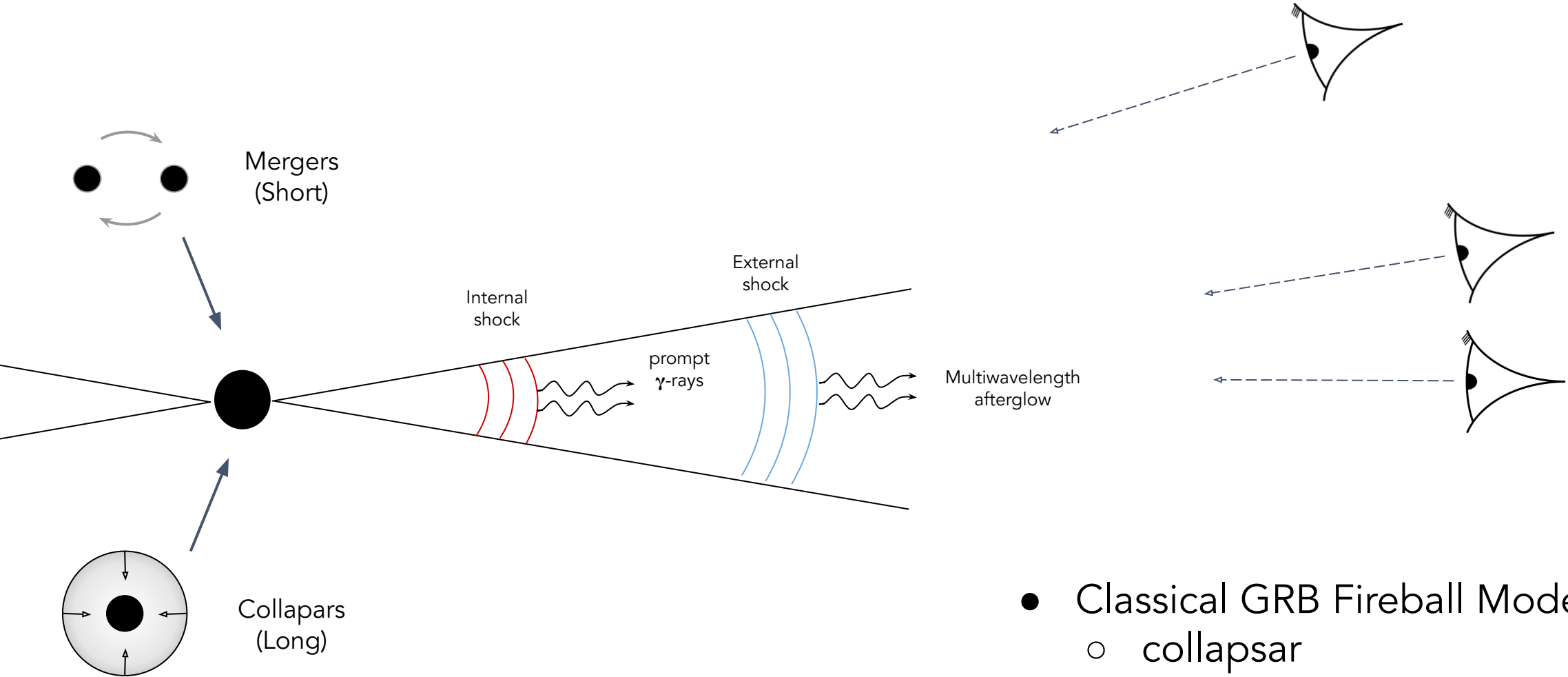


Assessing the detectability of optical afterglows of short gamma-ray bursts by ground-based facilities in the THESEUS era

Lána Salmon
University College Dublin

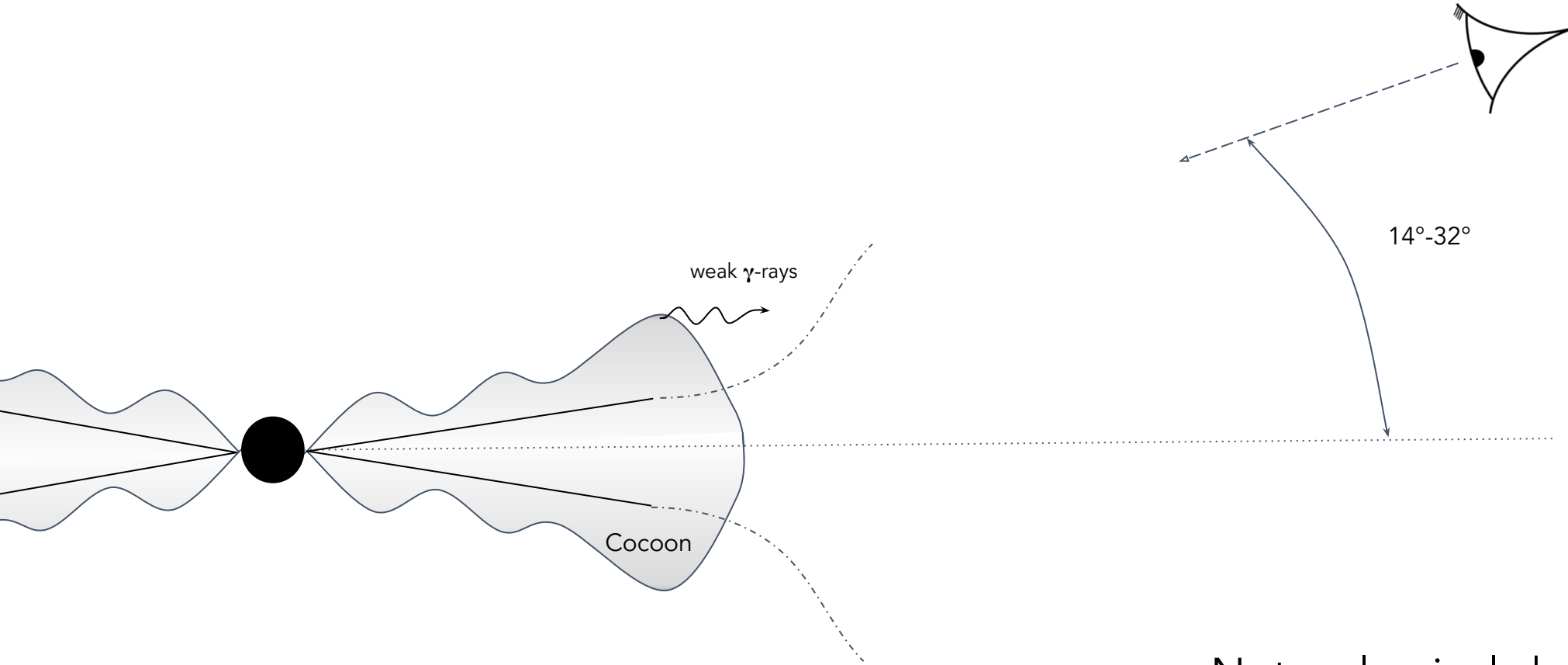
L. Hanlon, A. Martin-Carrillo, G. Stratta, R. Ciolfi

Short Gamma-Ray Bursts



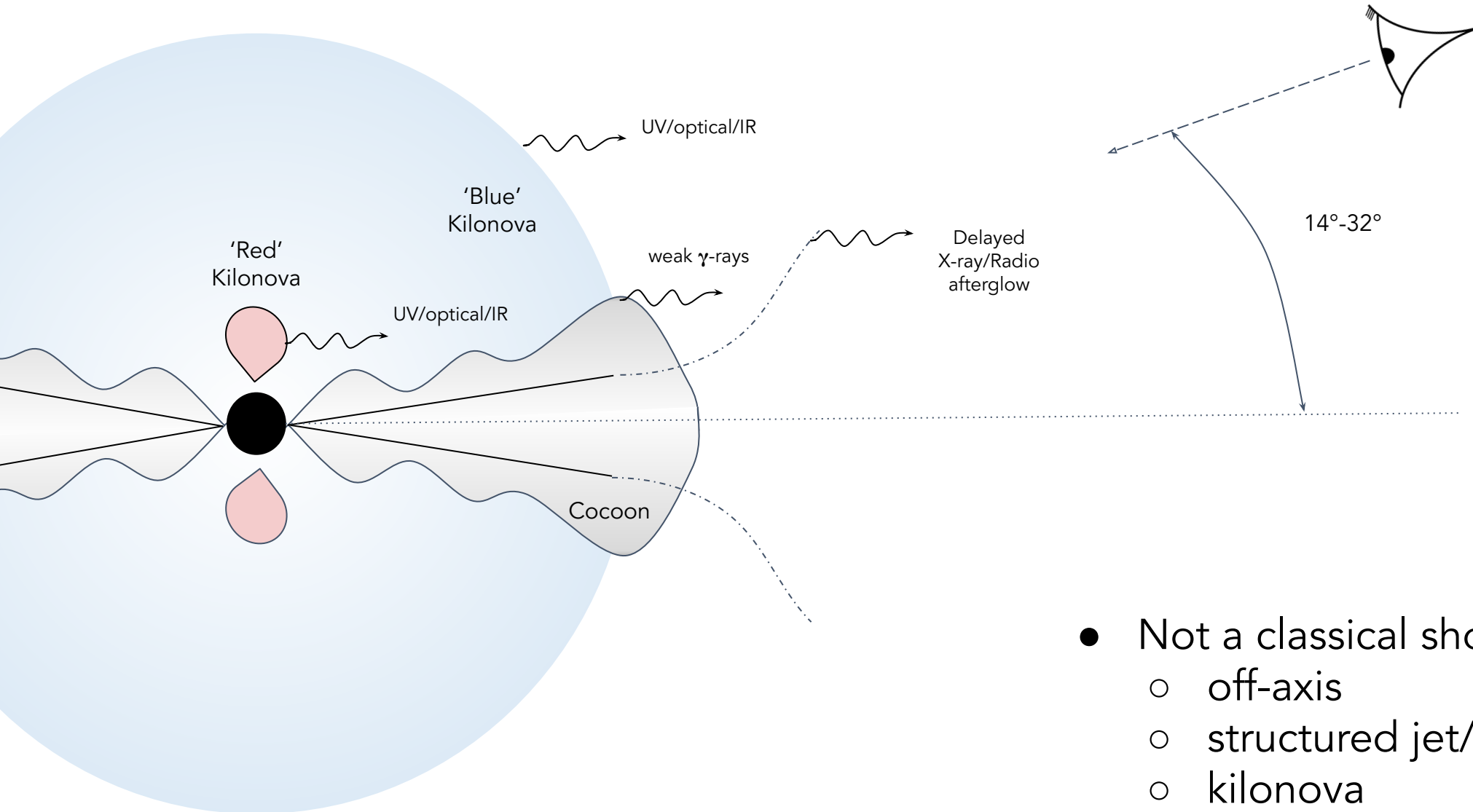
- Classical GRB Fireball Model
 - collapsar
 - merger

GRB170817A



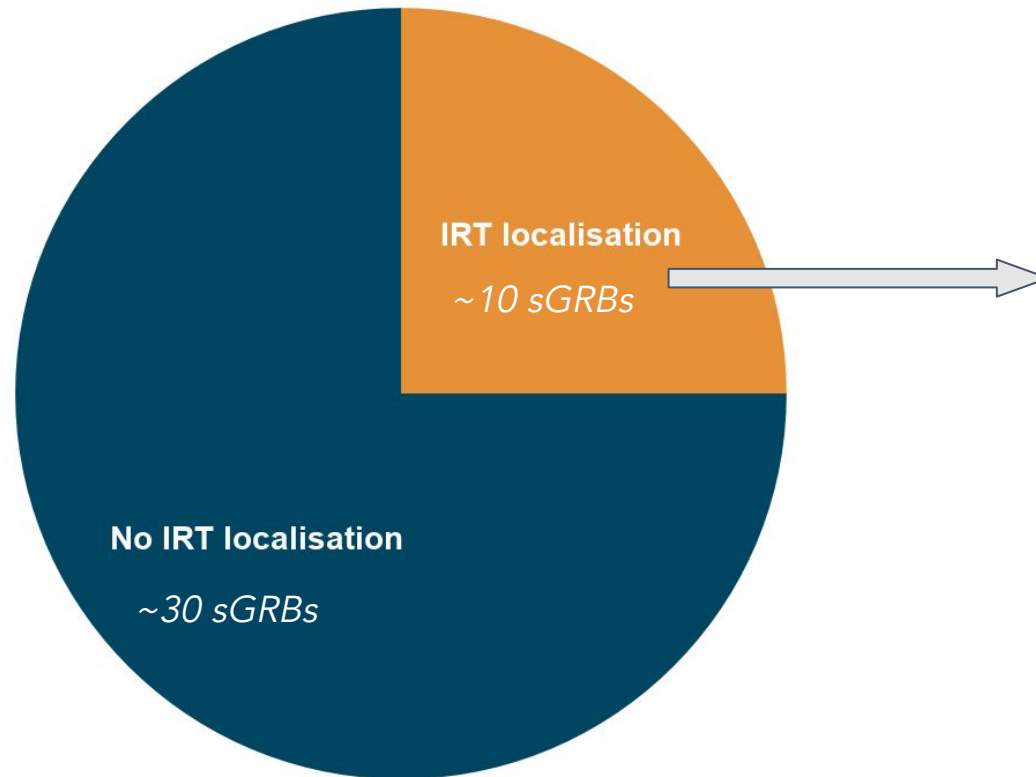
- Not a classical short GRB
 - off-axis
 - structured jet/cocoon
 - kilonova

GRB170817A



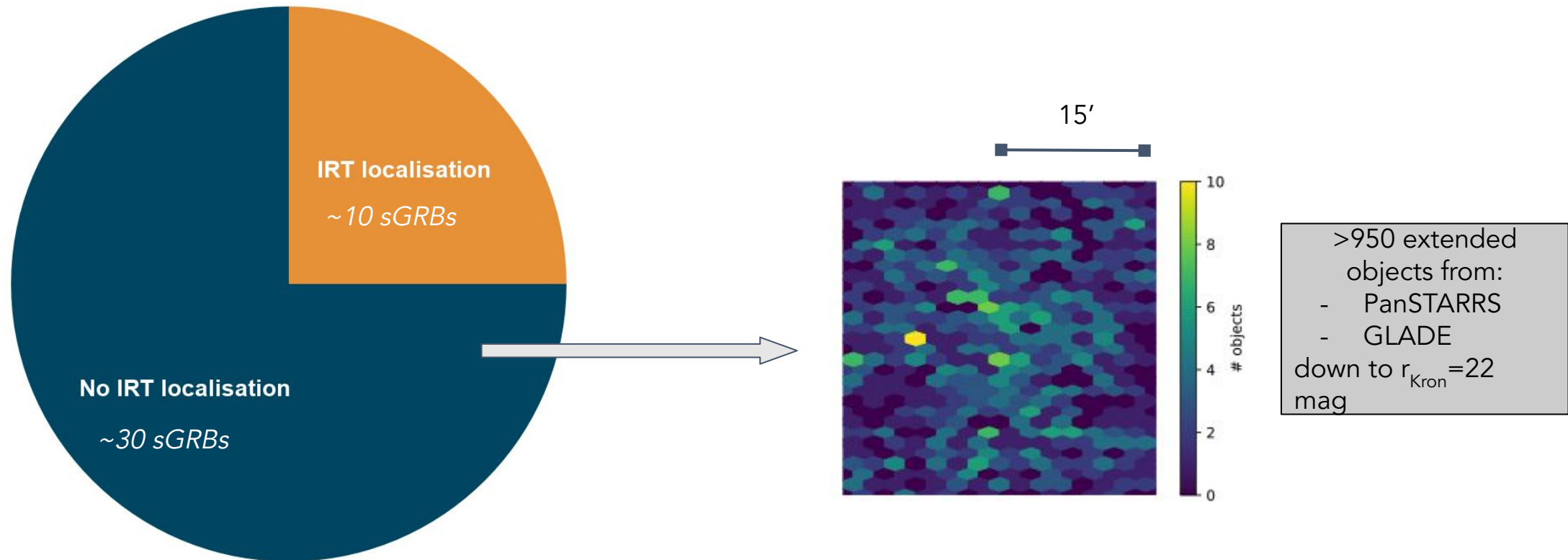
- Not a classical short GRB
 - off-axis
 - structured jet/cocoon
 - kilonova

How many short GRBs will THESEUS detect?



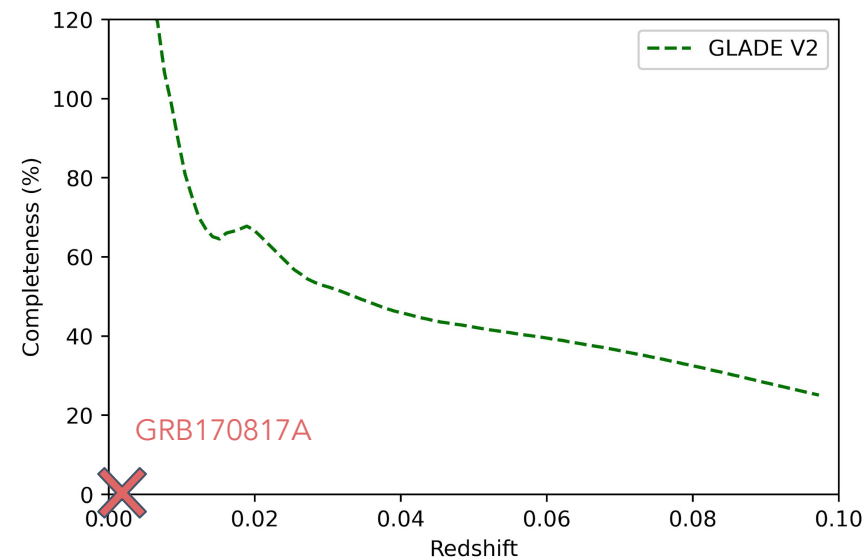
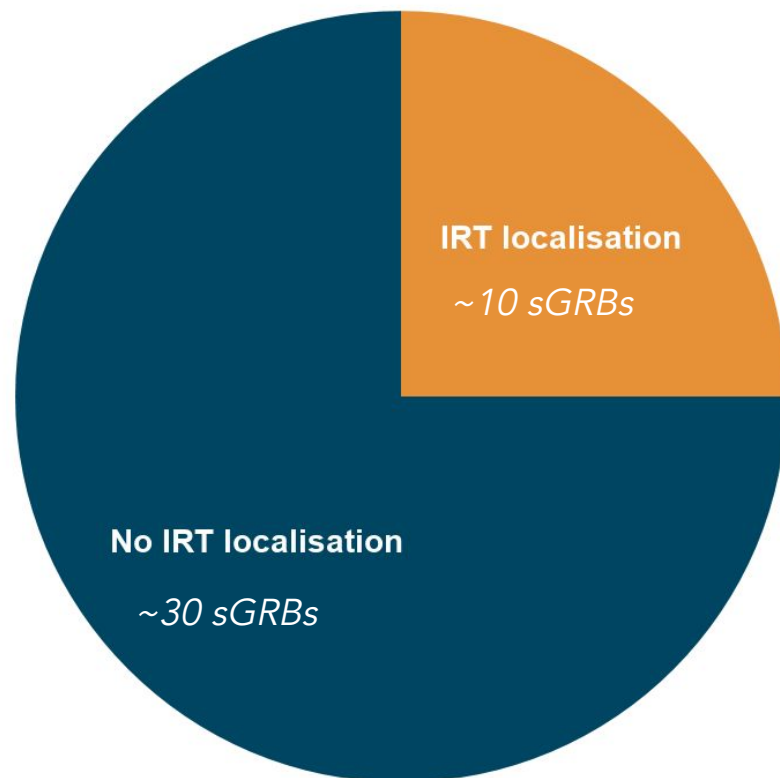
- Unambiguous host galaxy detection

How many short GRBs will THESEUS detect?



- Large number of galaxies is challenging for host identification

How many short GRBs will THESEUS detect?

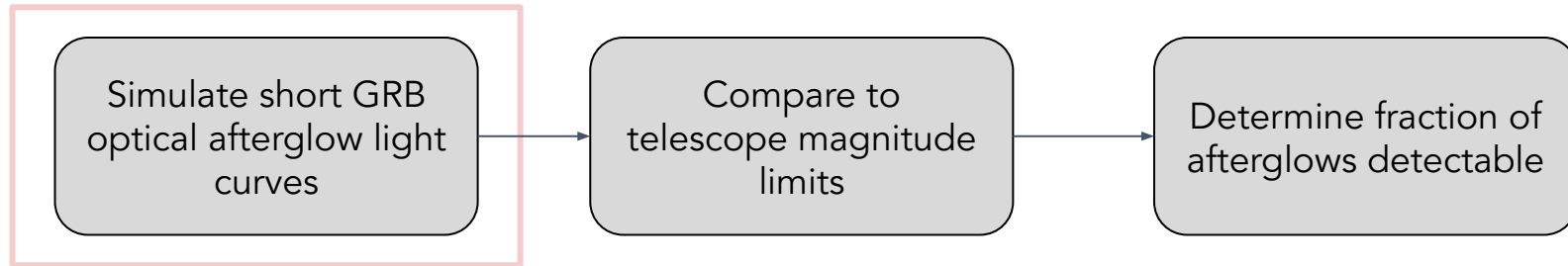


Peak of THESEUS
sGRB redshift
distribution
 $z=1-2$

- Galaxy catalogues are incomplete
- Multi-Object Spectrographs like WEAVE (WHT) and surveys like LSST will help
- Ground-based afterglow detection can help

Recover redshift on the ground

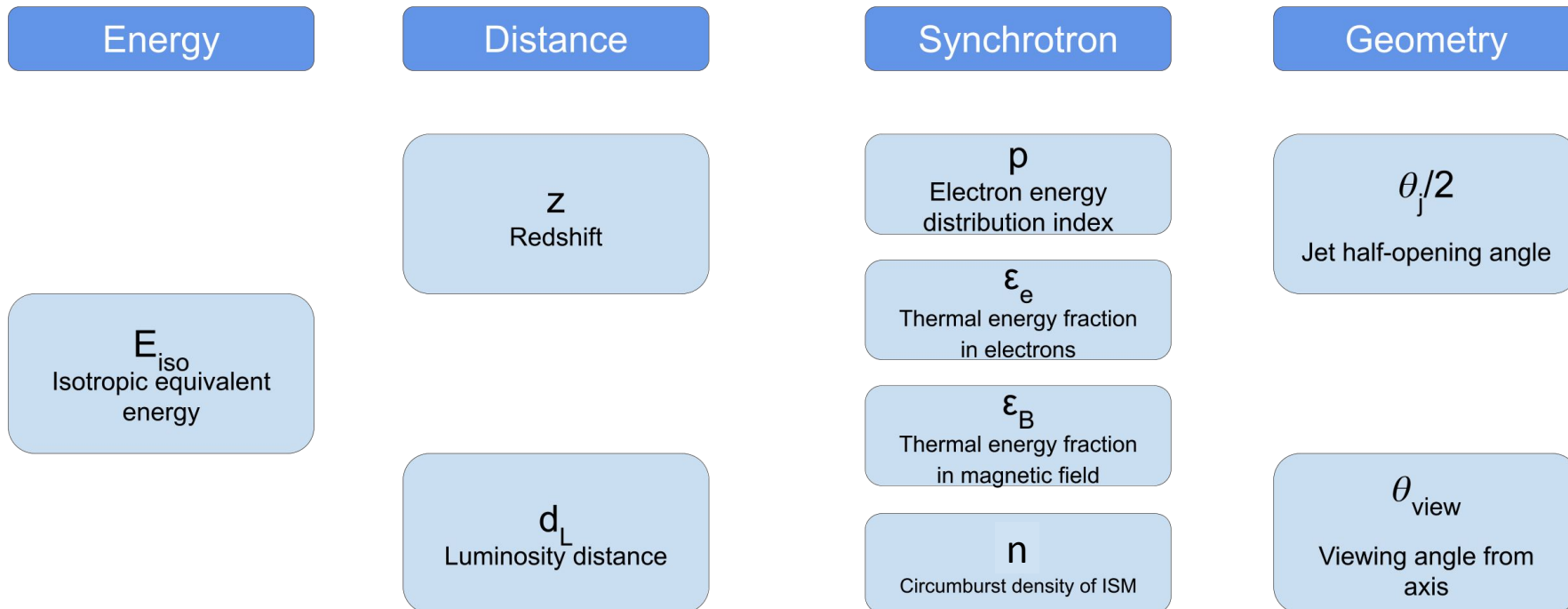
- Aim : determine fraction of optical afterglows observable by ground-based facilities



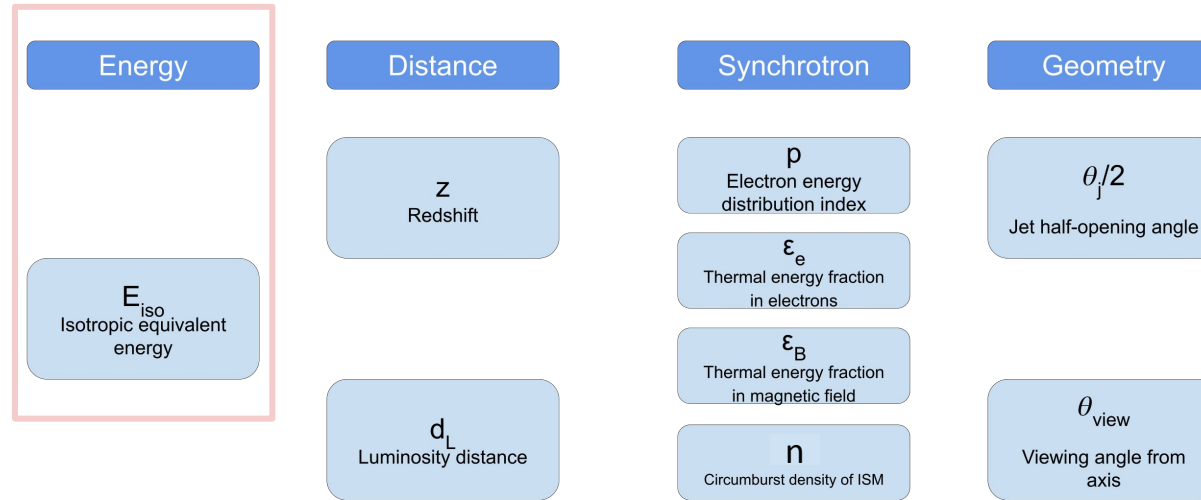
Simulation set-up

- Afterglowpy
 - Python package for calculating GRB afterglows in the forward shock model (Ryan et al. 2019)

Inputs

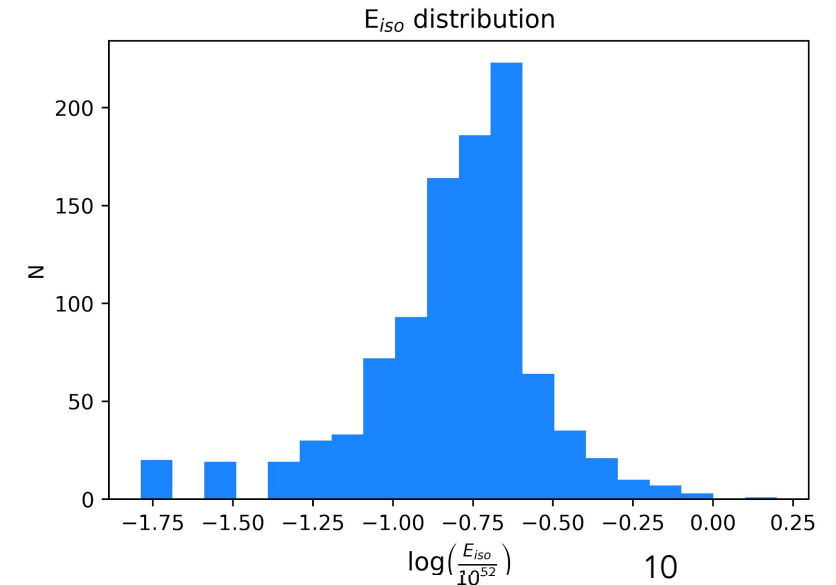
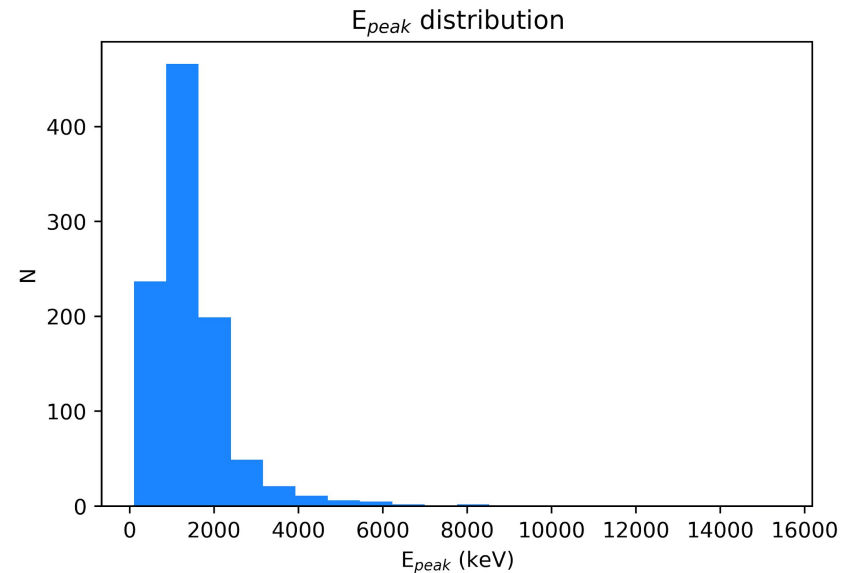


Simulation set-up

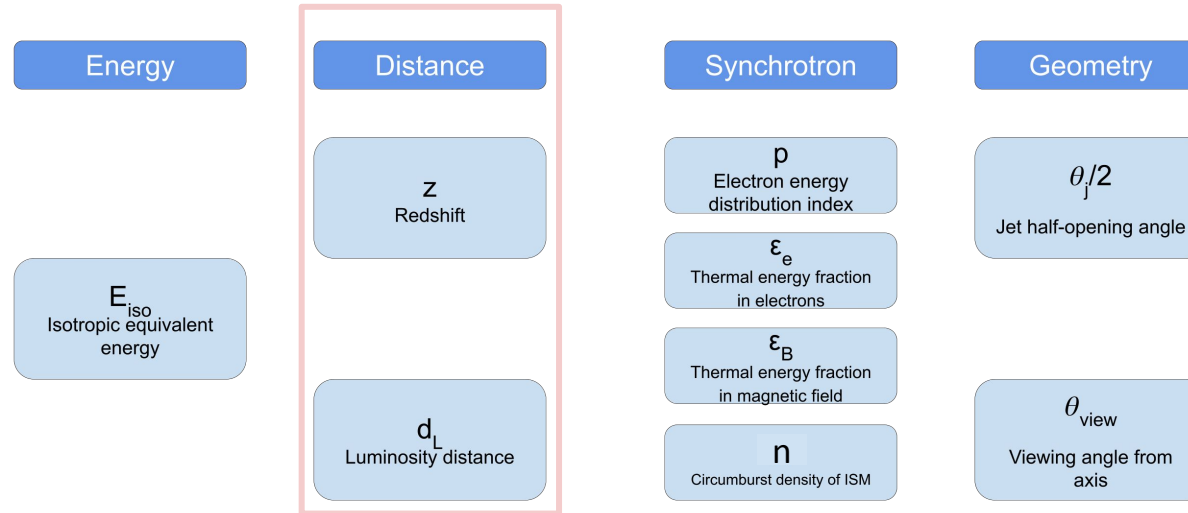


1. Energy

- E_{peak} distribution defined in Ghirlanda et al. (2016)
- E_{iso} determined through Amati relation

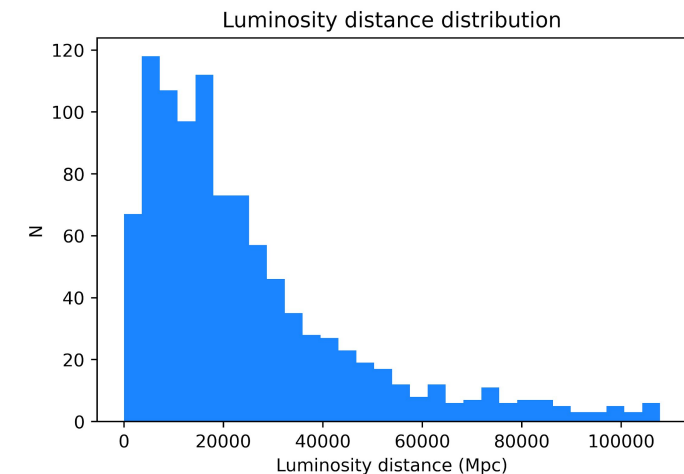
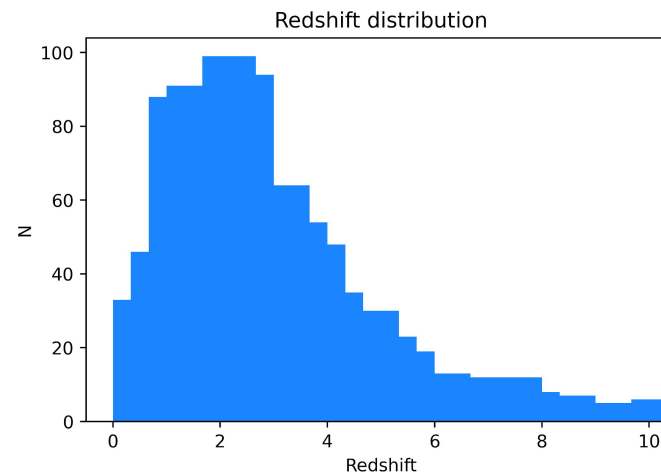


Simulation set-up

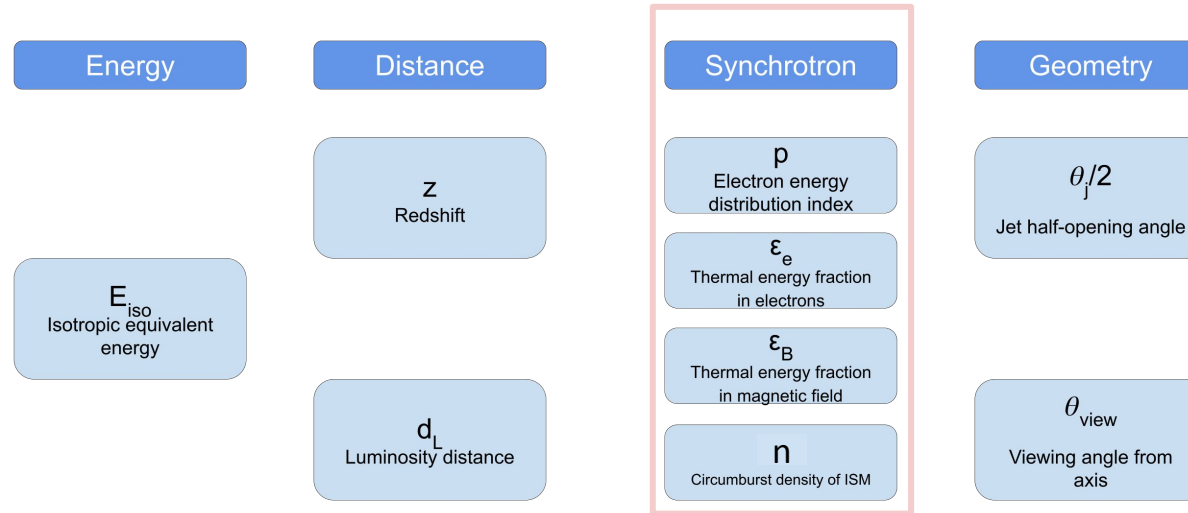


2. Distance

- Redshift distribution defined in Ghirlanda et al. 2016



Simulation set-up

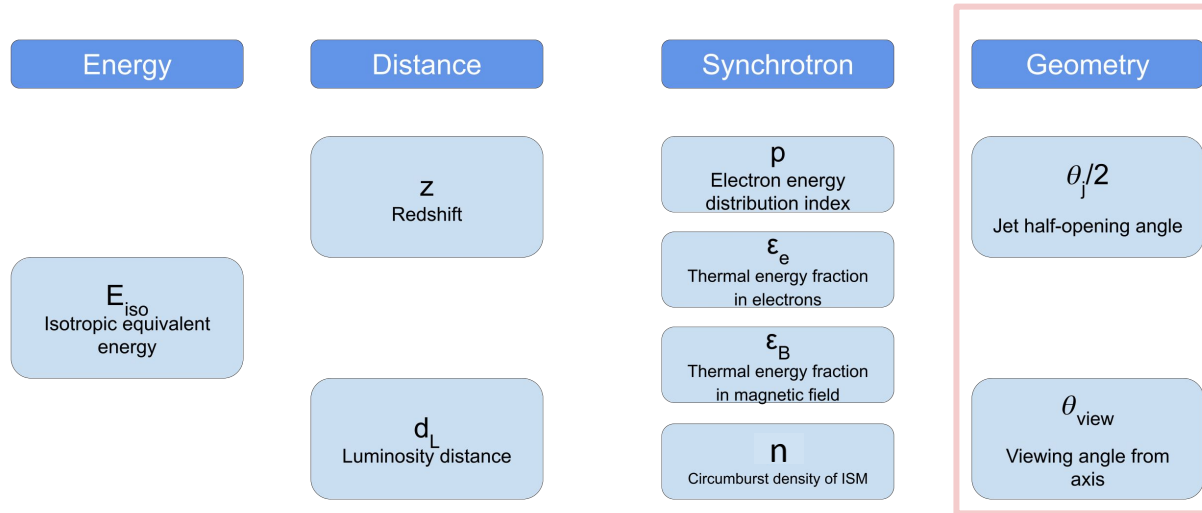


3. Synchrotron

- Median values from Fong et al. 2015

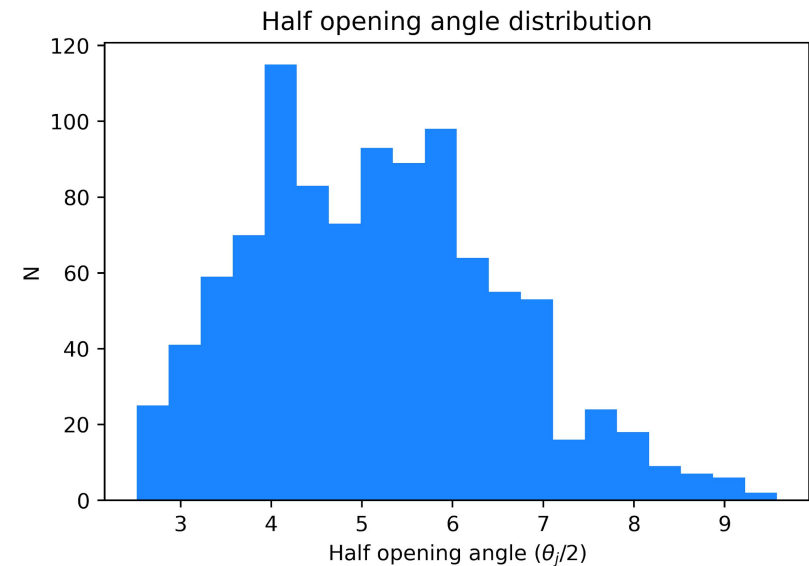
Parameter	Value
p	2.43
ϵ_e	0.1
ϵ_B	0.1
n	$2.9 \times 10^{-3} \text{ cm}^{-3}$

Simulation set-up



4. Geometry

- Top-hat jet
- Skew-normal distribution from 2-10 degrees
- Peaking at 5 degrees (median from Fong et al. 2015)



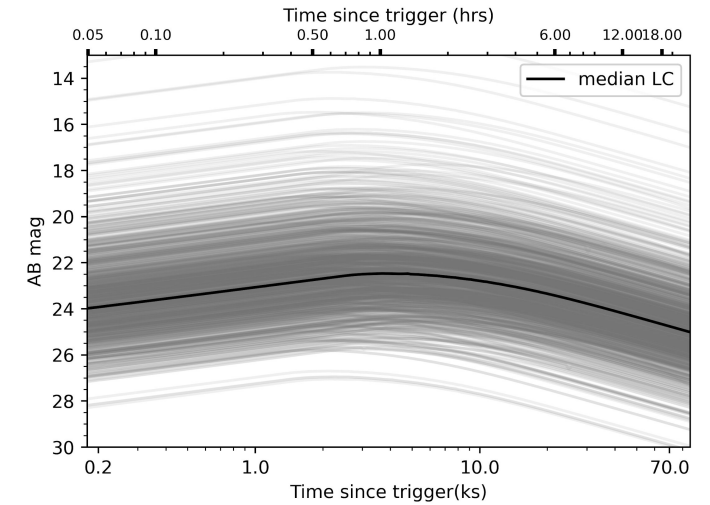
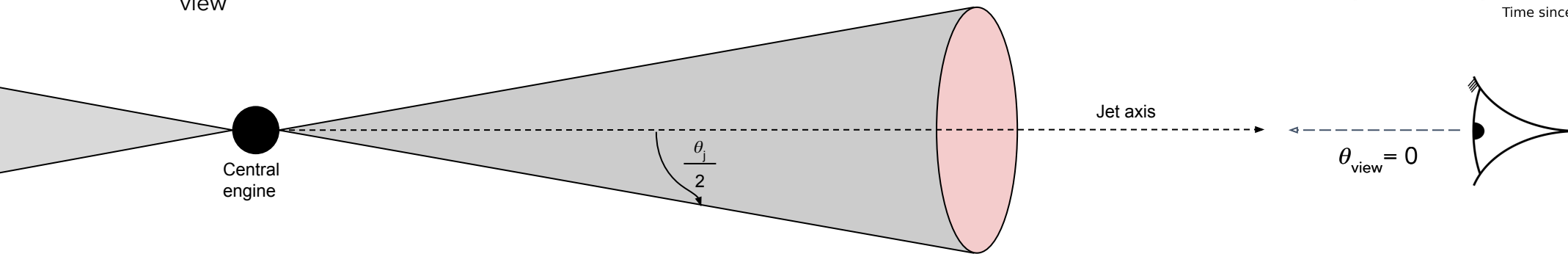
Simulation set-up

4. Geometry

- 3 viewing angle scenarios

(A) On Axis

$$\theta_{\text{view}} = 0$$

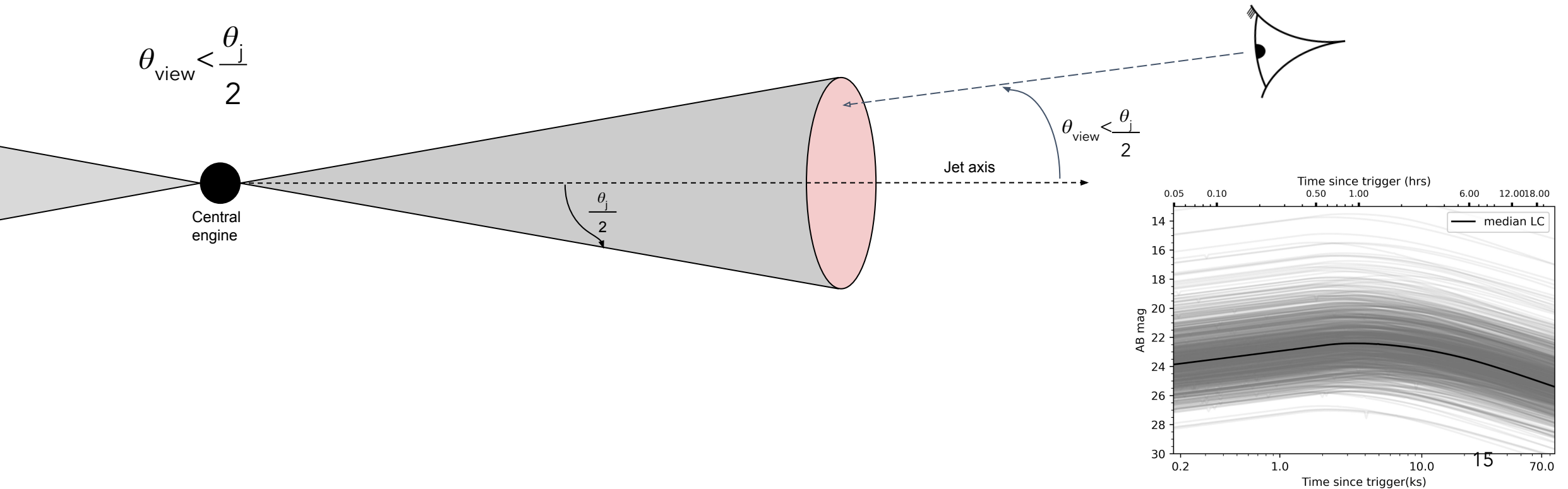


Simulation set-up

4. Geometry

- 3 viewing angle scenarios

(B) Within jet



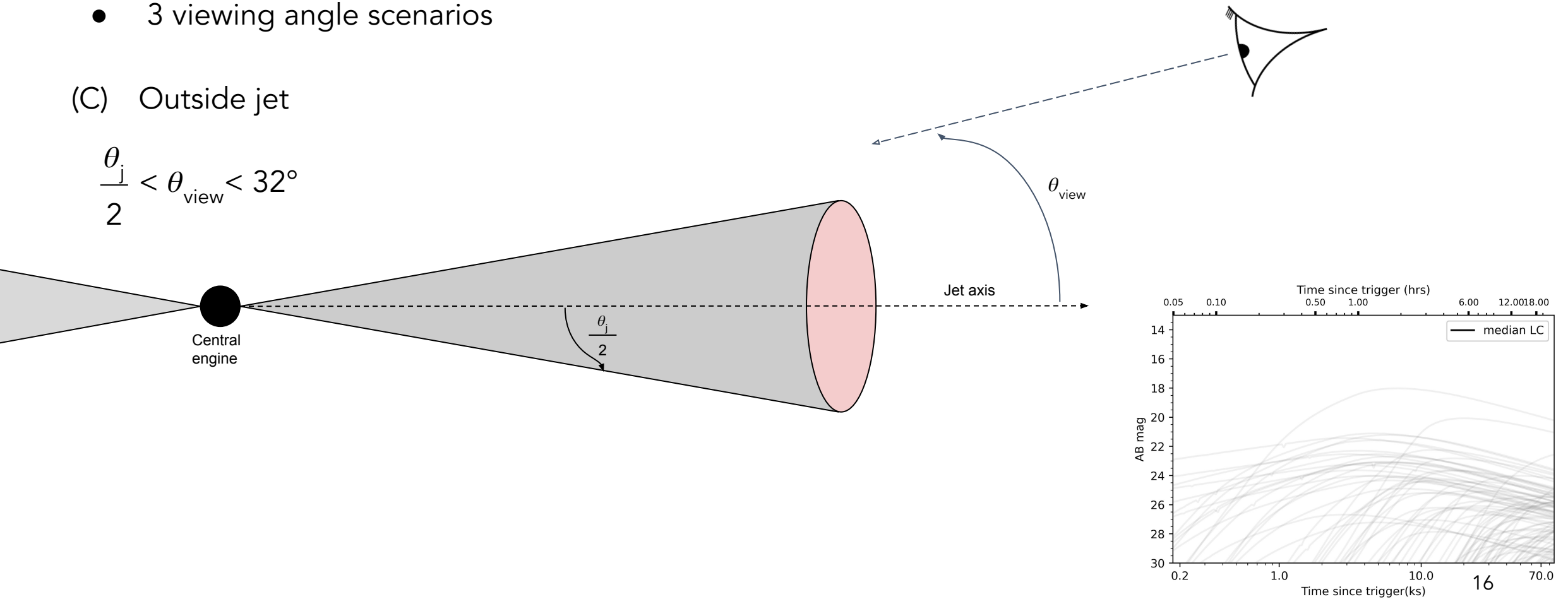
Simulation set-up

4. Geometry

- 3 viewing angle scenarios

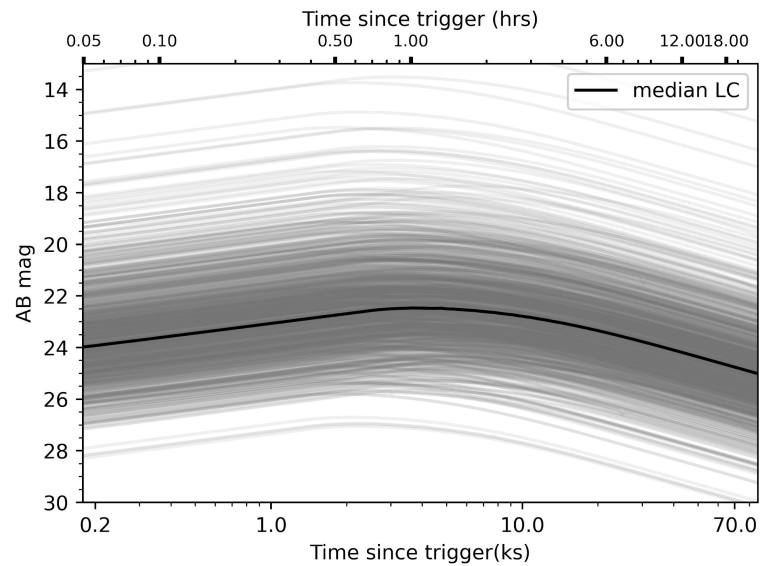
(C) Outside jet

$$\frac{\theta_j}{2} < \theta_{\text{view}} < 32^\circ$$

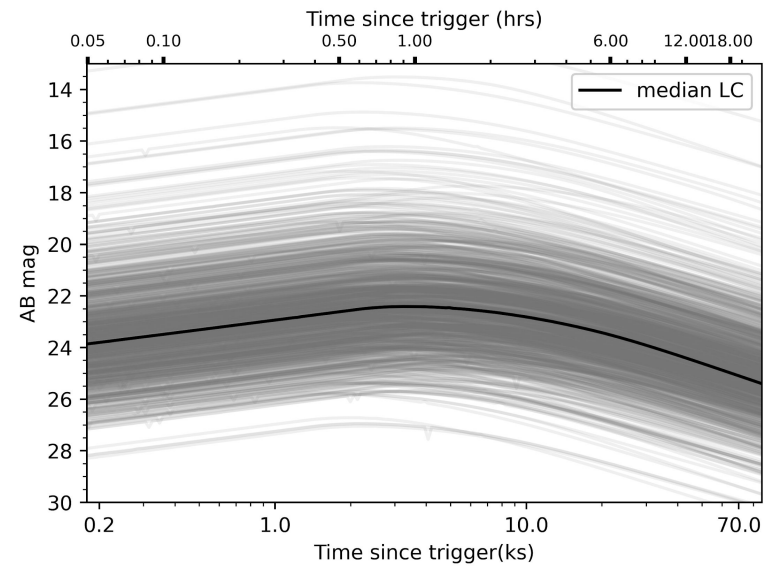


Simulated Light Curves

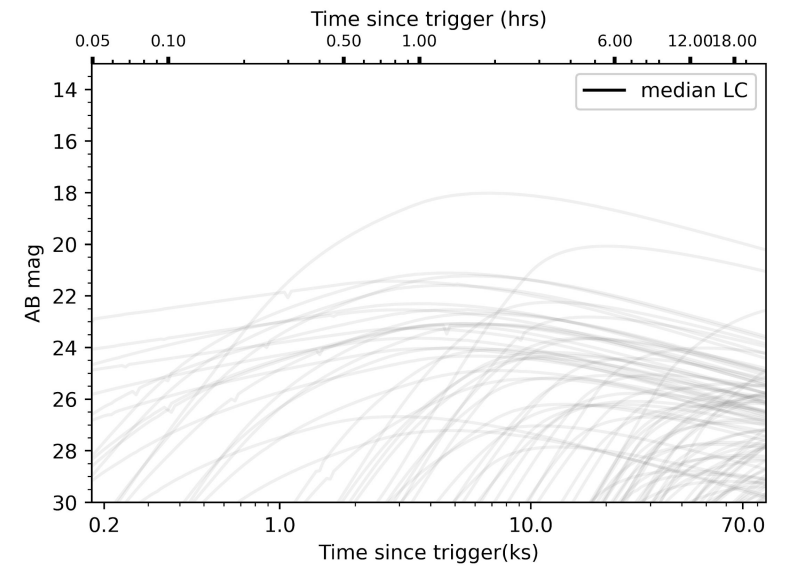
On-Axis



Within jet

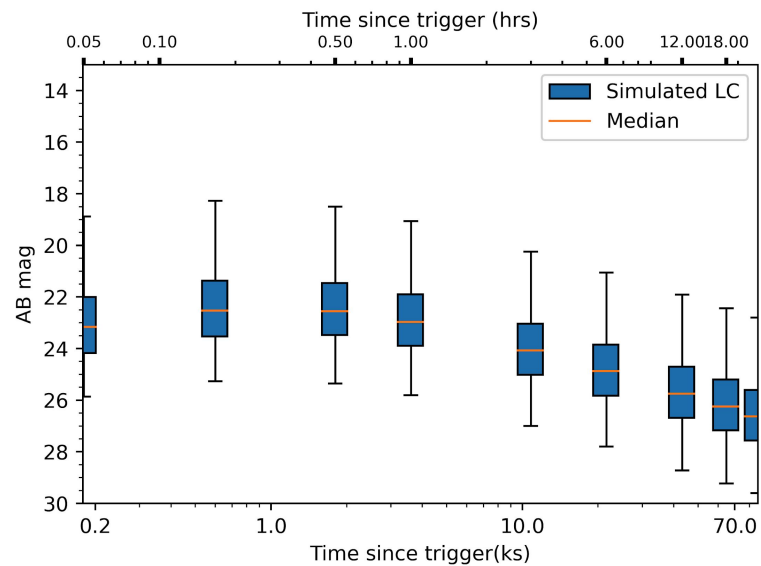


Outside jet

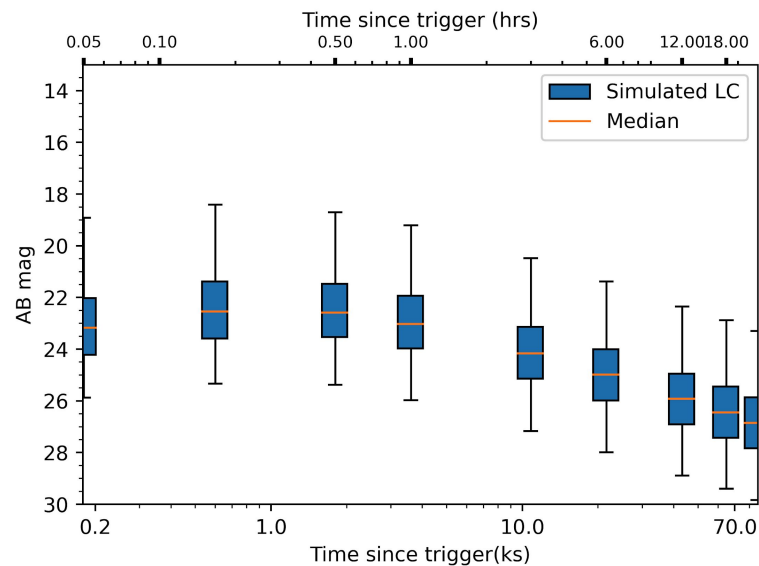


Simulated Light Curves

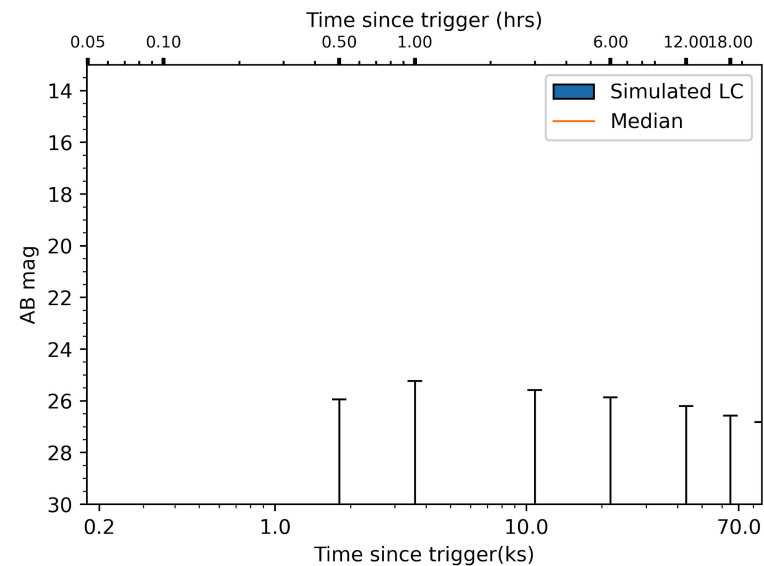
On-Axis



Within jet

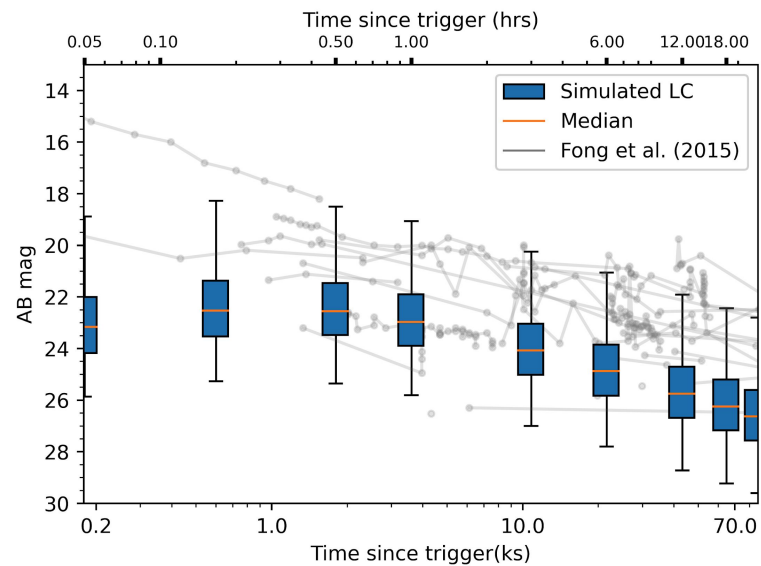


Outside jet

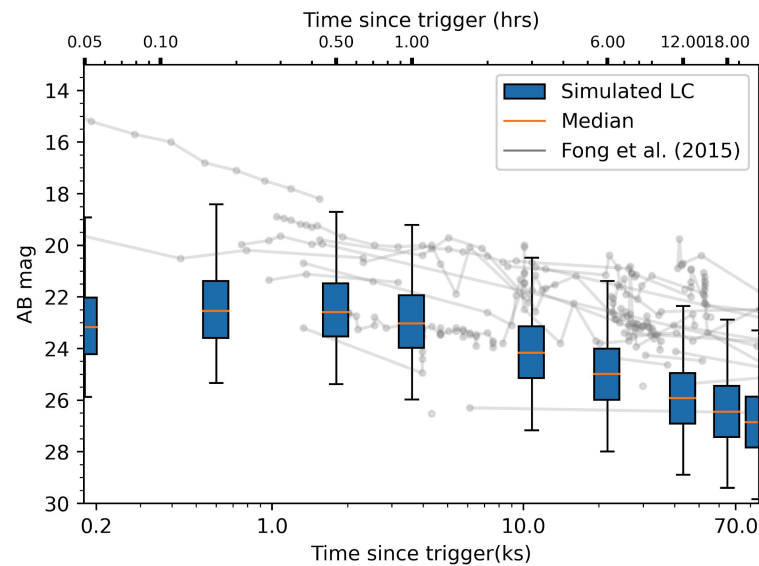


Simulated Light Curves

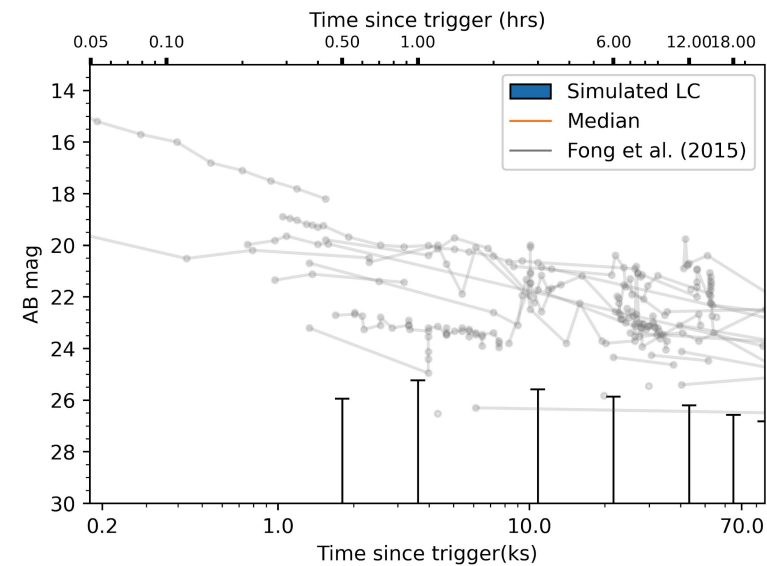
On-Axis



Within jet

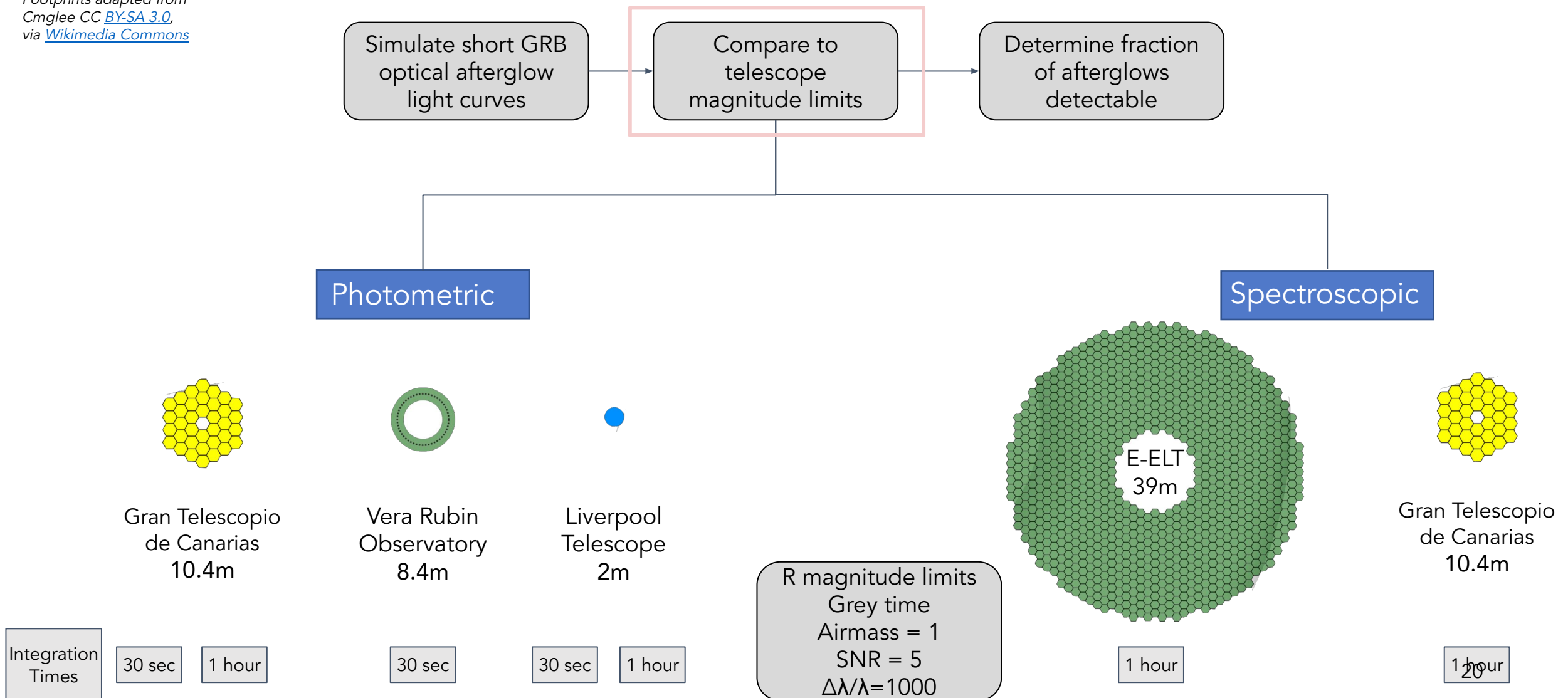


Outside jet



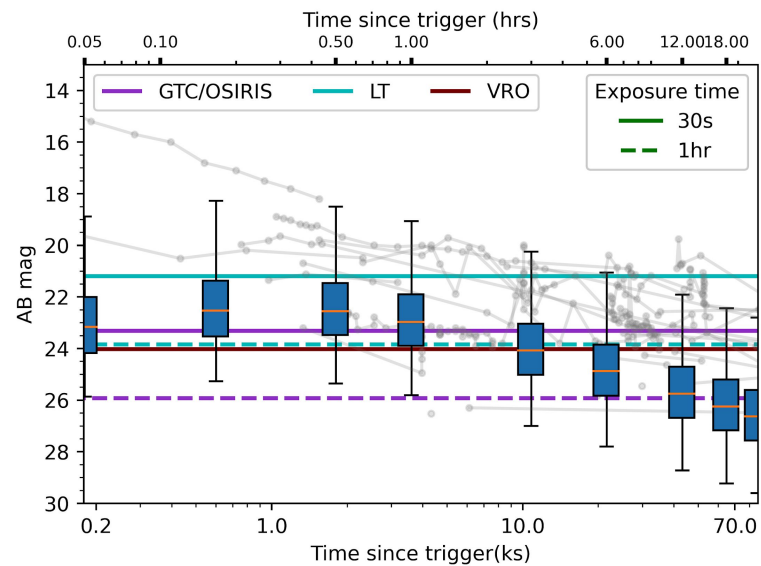
Quantify ground-based successful follow-up

Footprints adapted from
Cmglee CC [BY-SA 3.0](#)
via [Wikimedia Commons](#)

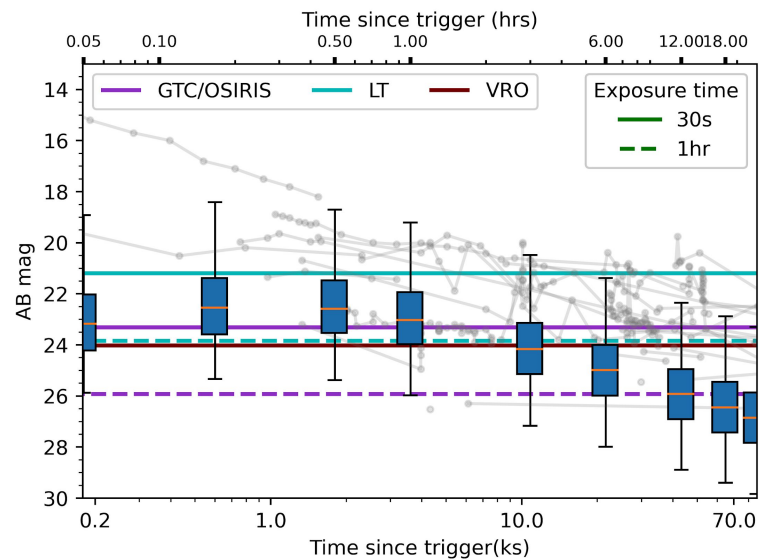


Photometric limits

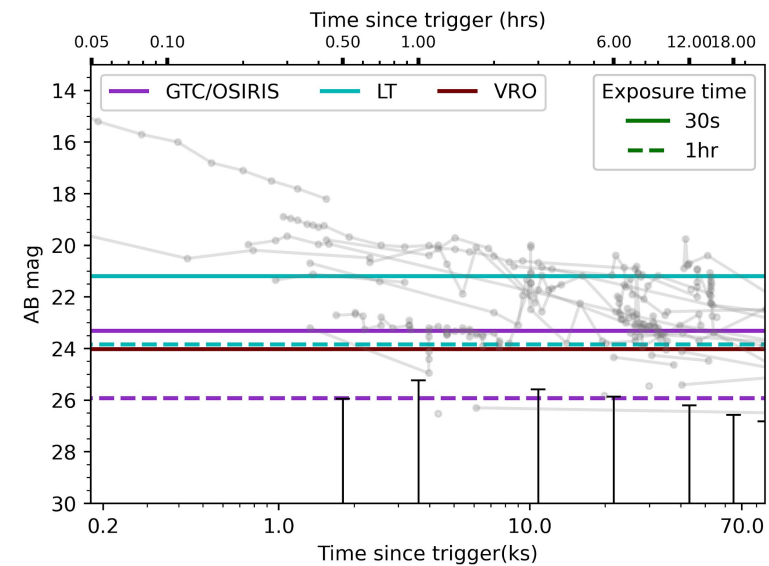
On-Axis



Within jet

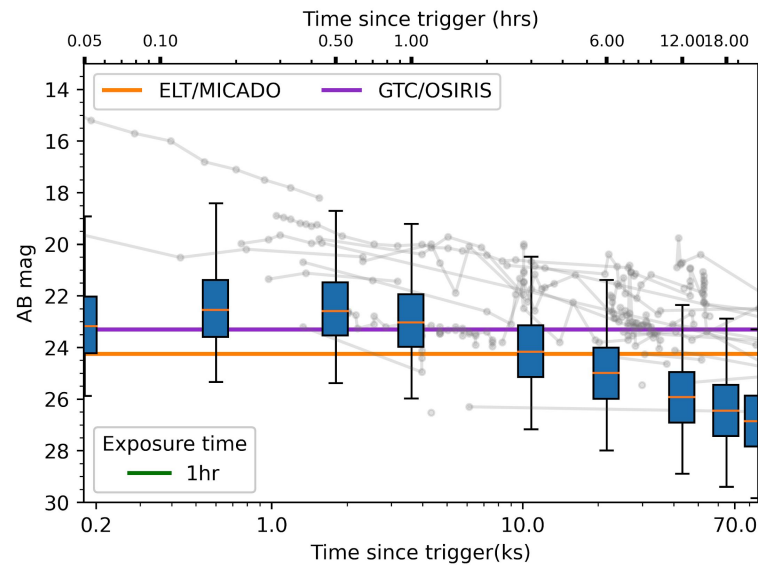


Outside jet

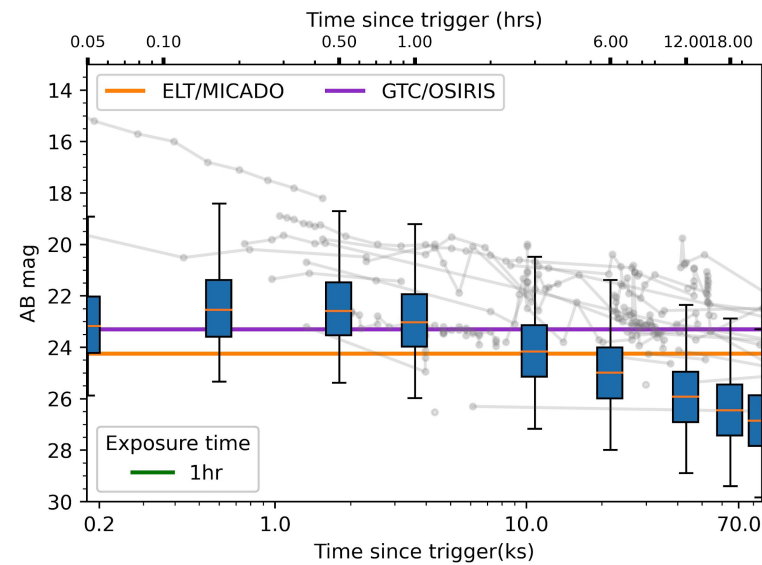


Spectroscopic limits

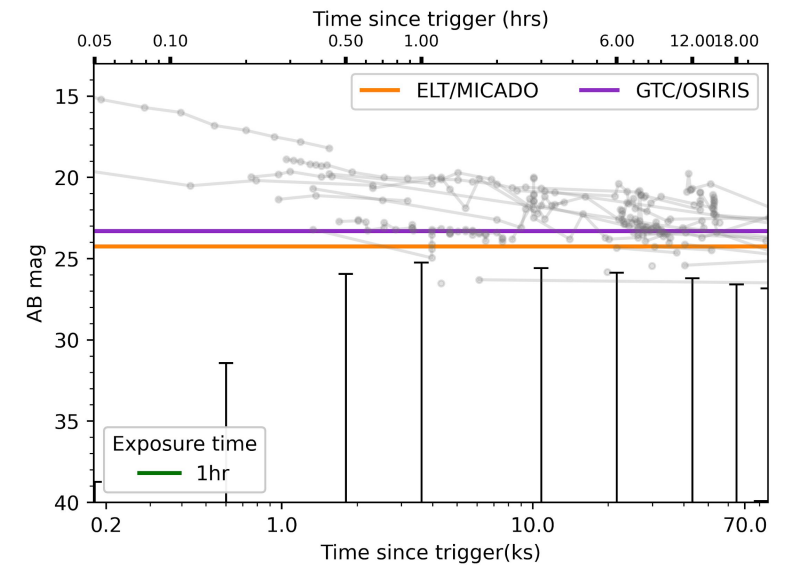
On-Axis



Within jet



Outside jet



Fraction of Detectable Afterglows - Photometric

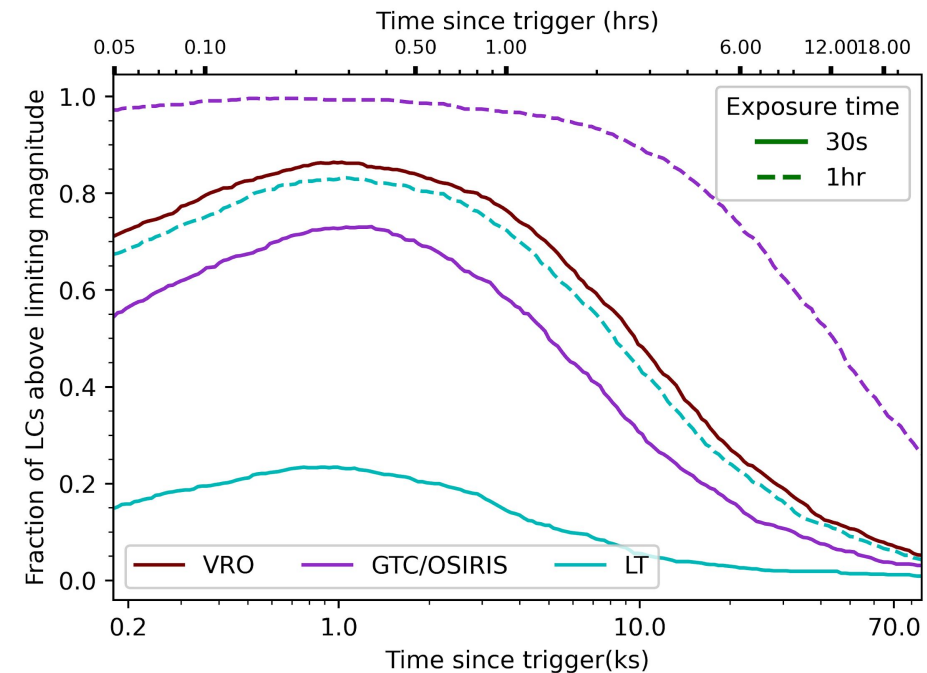
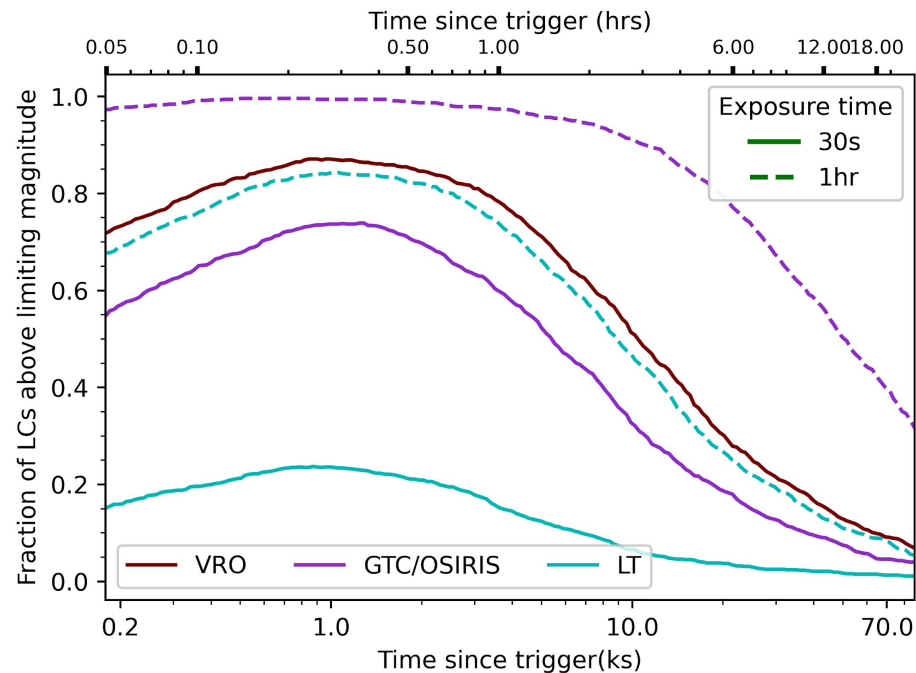
Simulate short GRB
optical afterglow light
curves

Compare to
telescope magnitude
limits

Determine fraction of
afterglows detectable

On-Axis

Within jet



Spectroscopic fractions

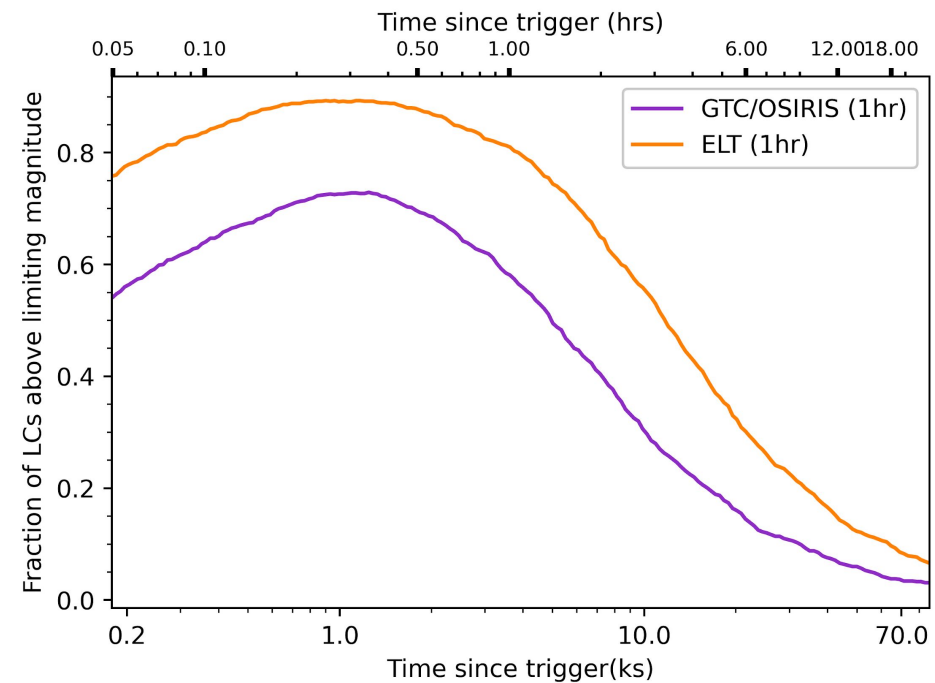
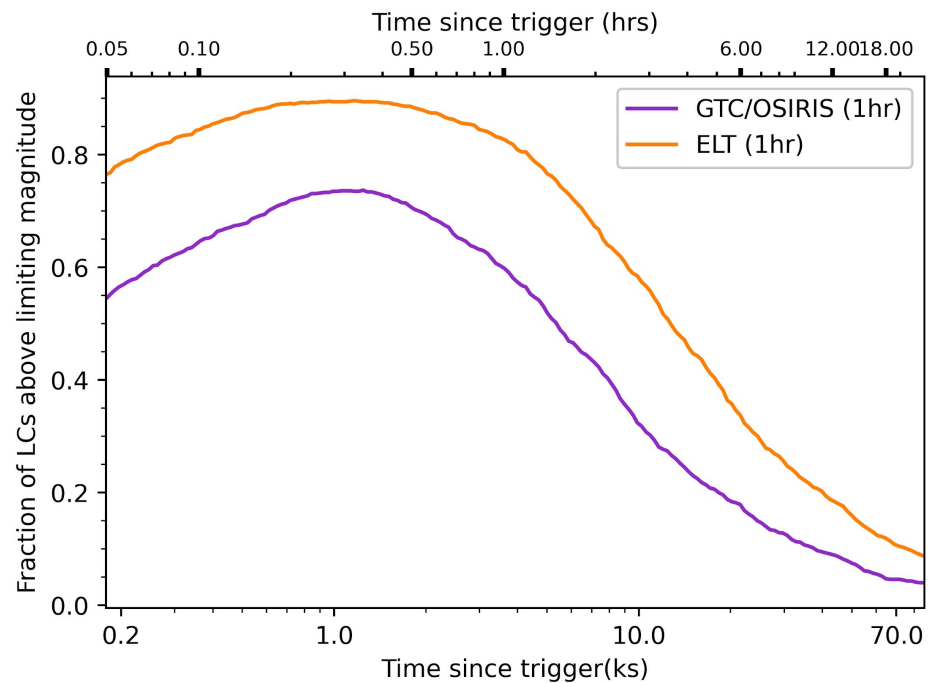
Simulate short GRB
optical afterglow light
curves

Compare to
telescope magnitude
limits

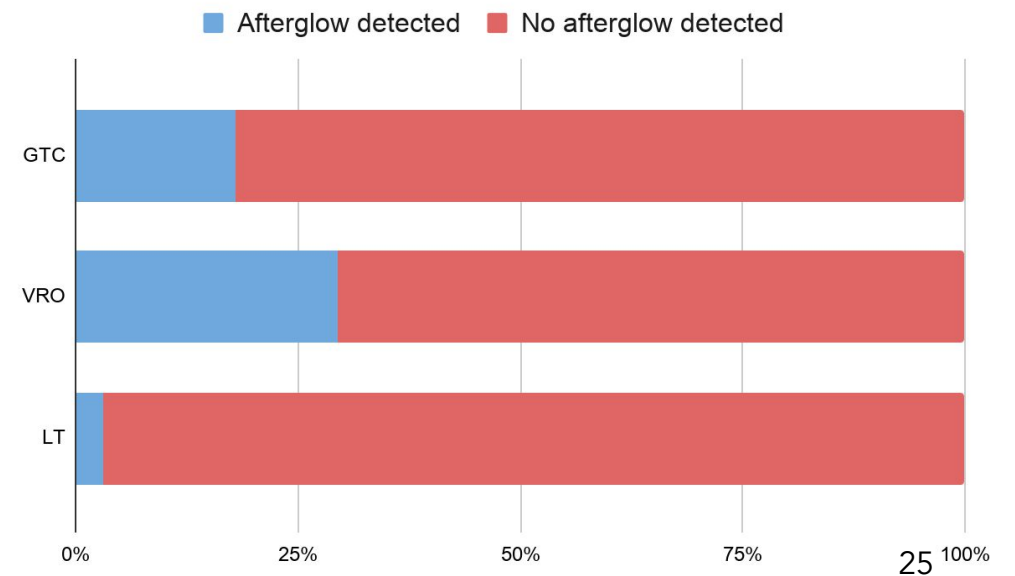
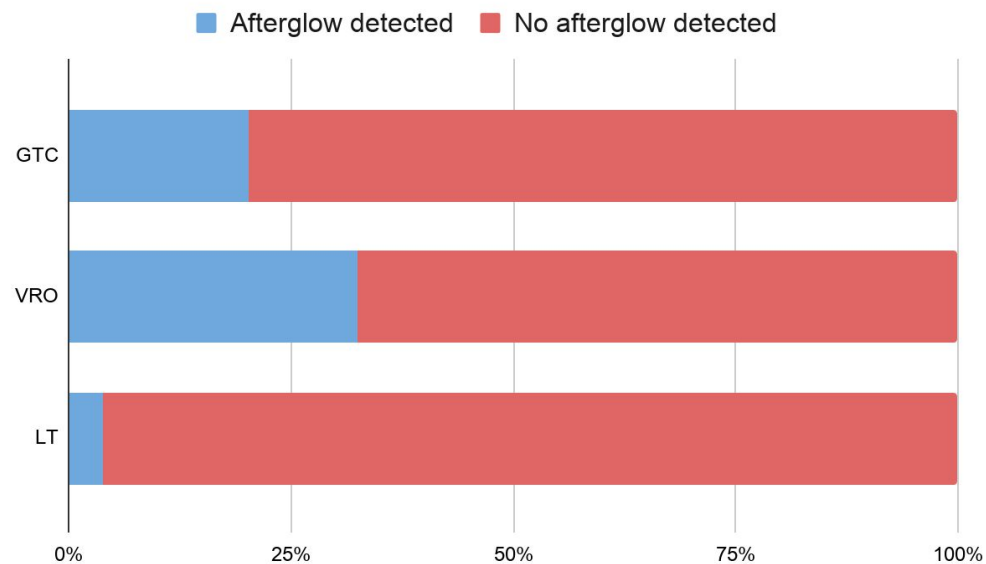
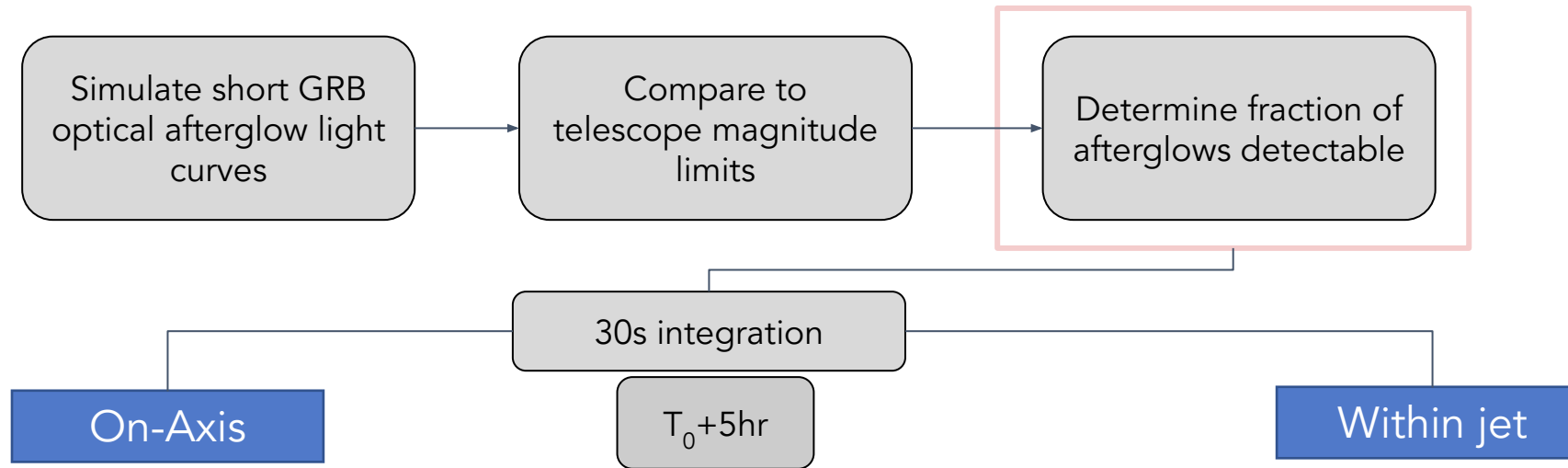
Determine fraction of
afterglows detectable

On-Axis

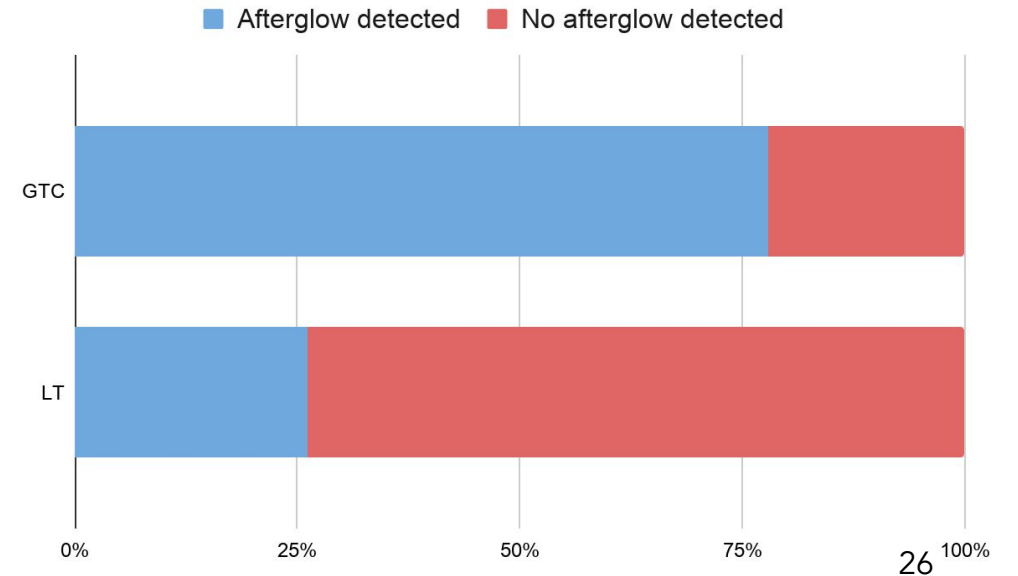
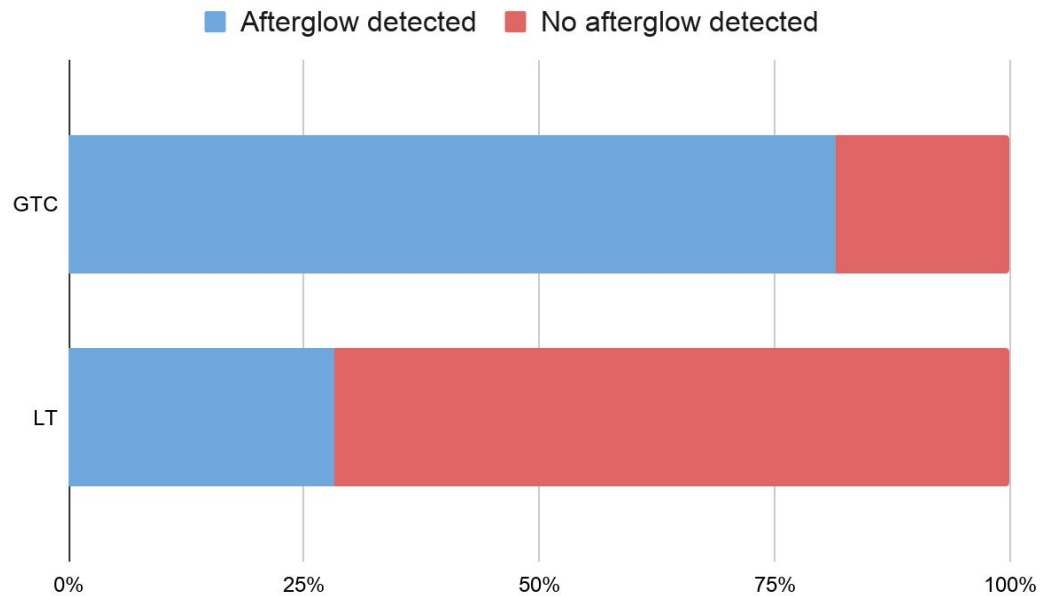
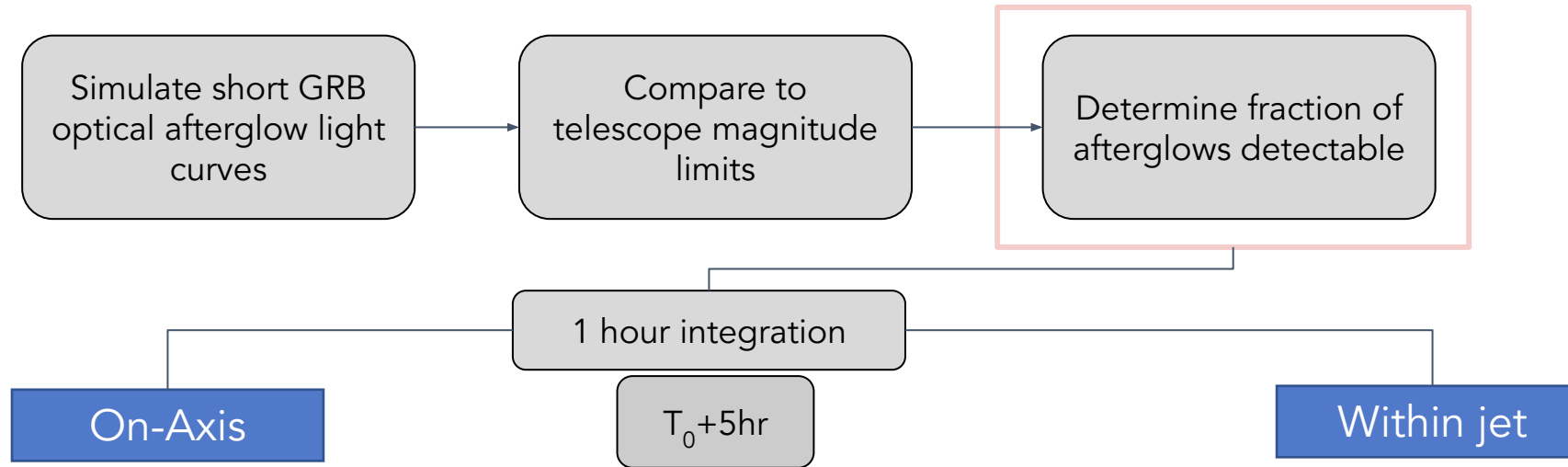
Within jet



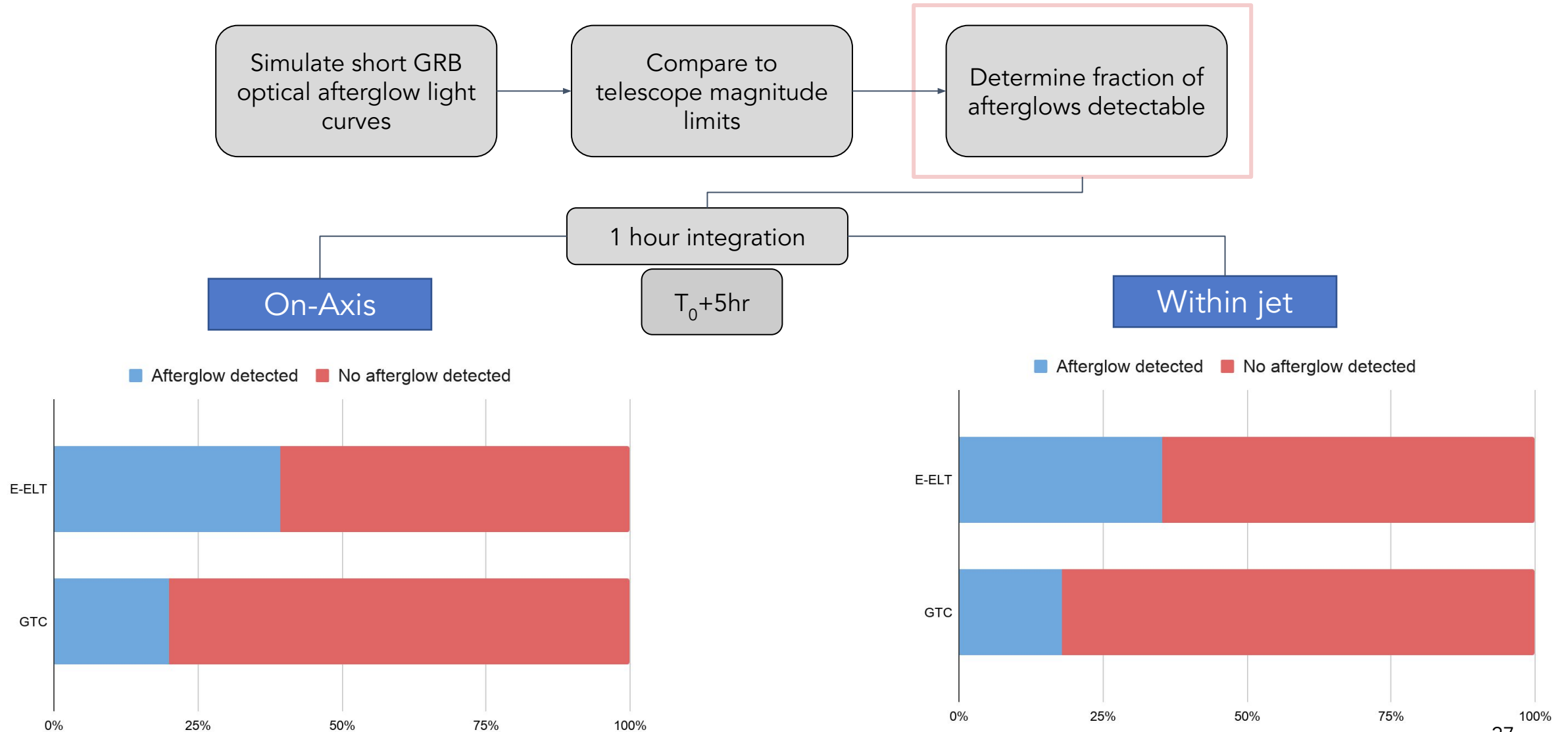
Photometric limits - 30s integration



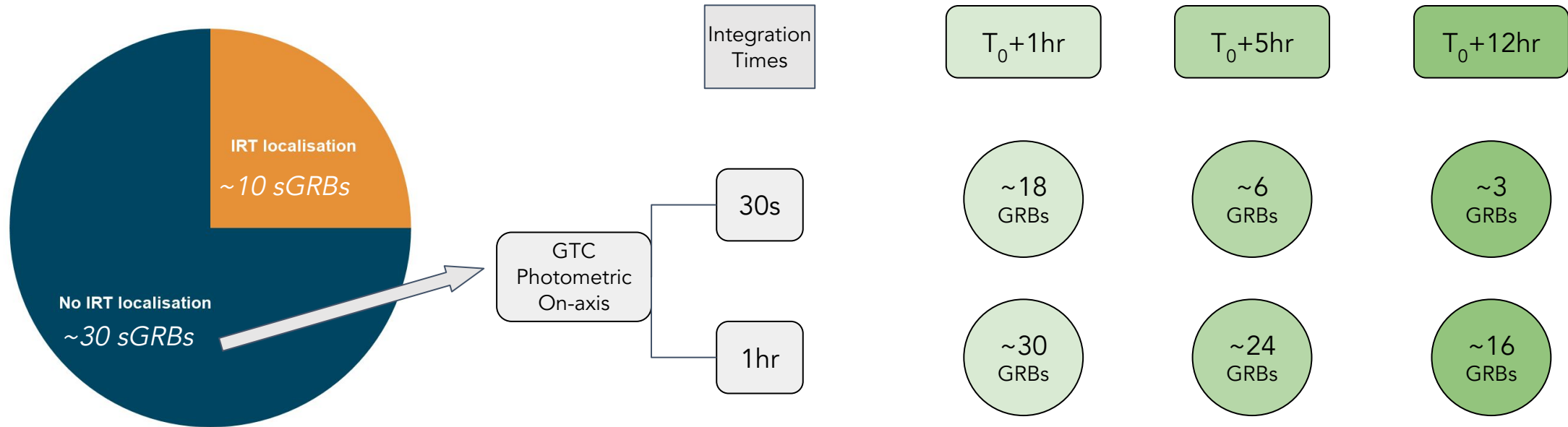
Photometric limits - 1 hour integration



Spectroscopic results - 1 hour integration



Conclusions



- Ground-based follow-up will significantly increase the sample size of THESEUS' short GRBs with redshift

Related talks

14:00 G. Stratta

'THESEUS role in multi-messenger astrophysics during the 2030s'

14:20 R. Ciolfi

'Multi-messenger astrophysics of NS mergers with THESEUS'

28