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Gamma-Ray Burst science with LSST

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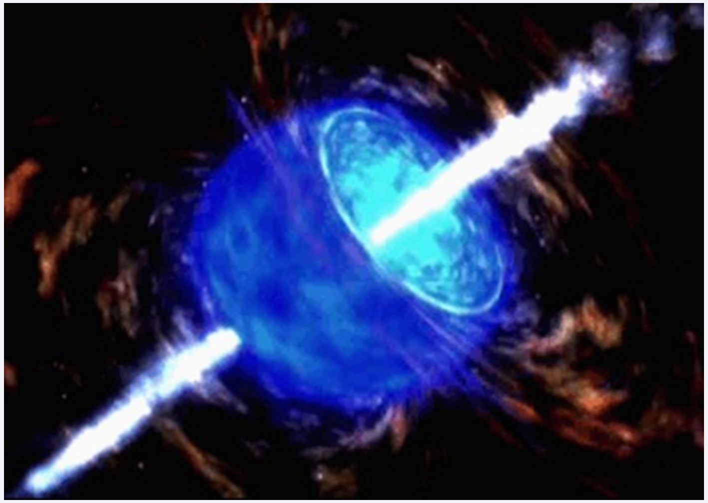
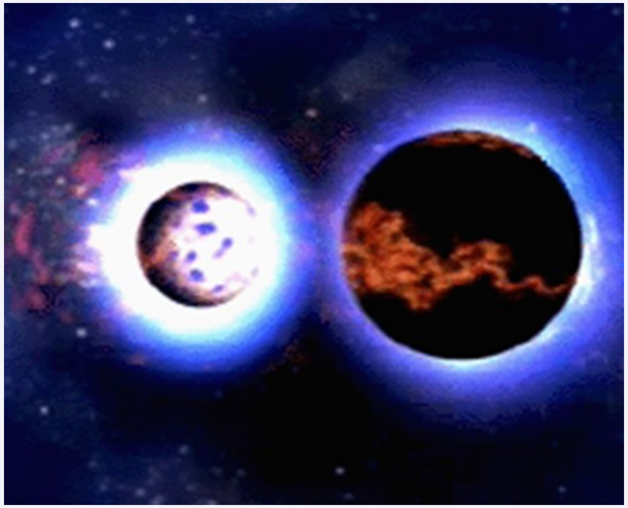
Thanks to Paul O'Brien and Antonia Rowlinson

GRB Progenitors

Collapsar – LGRBs



Binary Merger – SGRBs

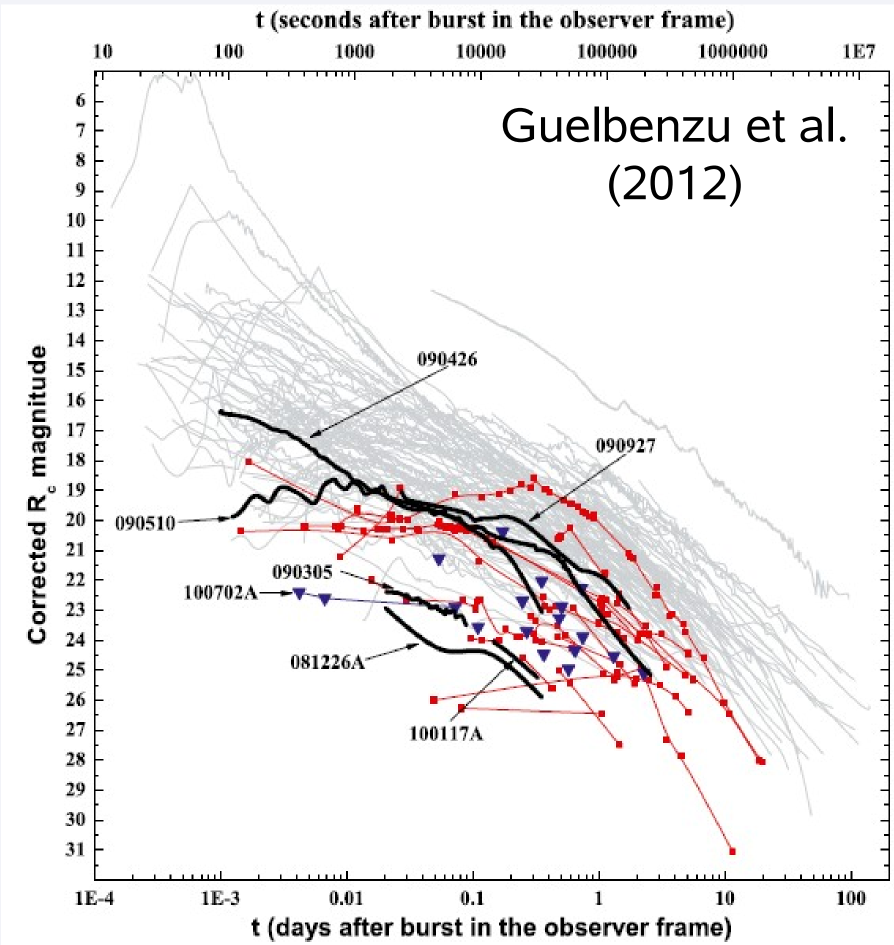


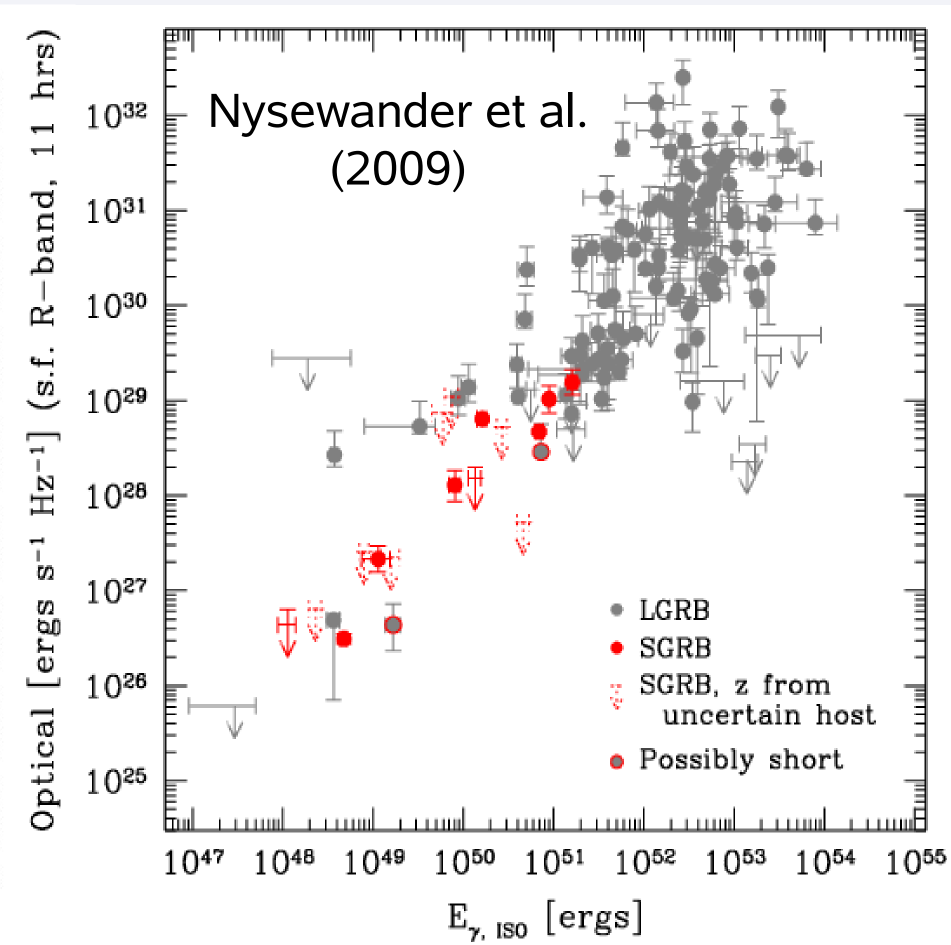
LGRB: Collapsar model – occurs in region of massive (hence recent) star formation. Several examples known of associated super/hypernova signature

SGRB: Merger model (e.g. NS-NS) – can occur in any type of galaxy, and also off of a galaxy due to natal dynamic kick and long merger time

Other models are available…

SGRB+LGRB Optical Afterglows





SGRB optical afterglows are fainter than those of LGRBs

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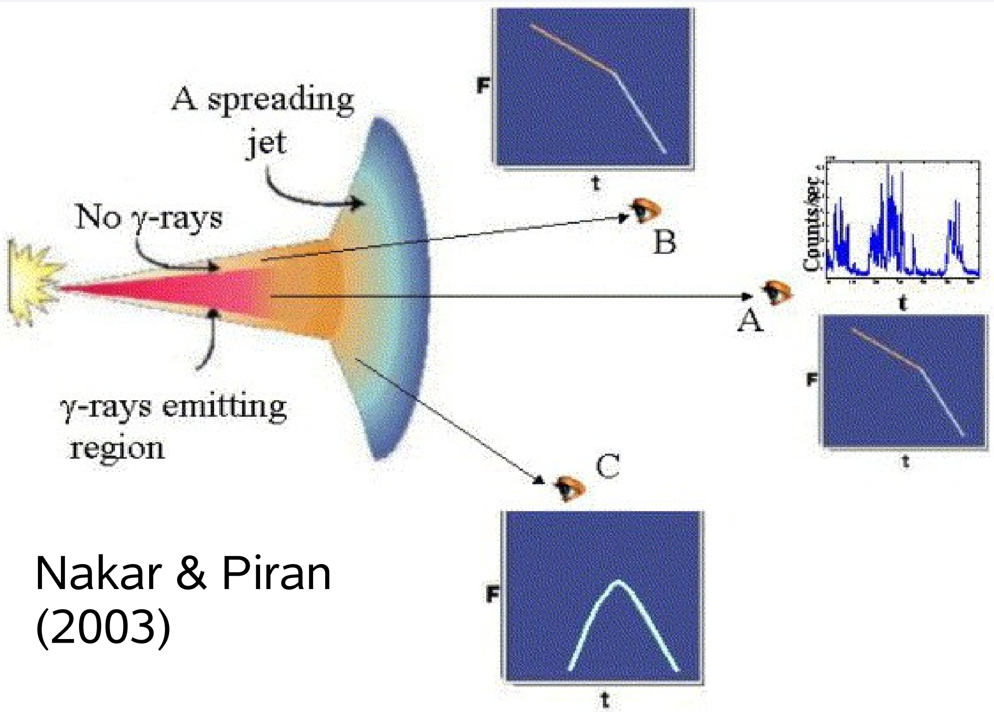
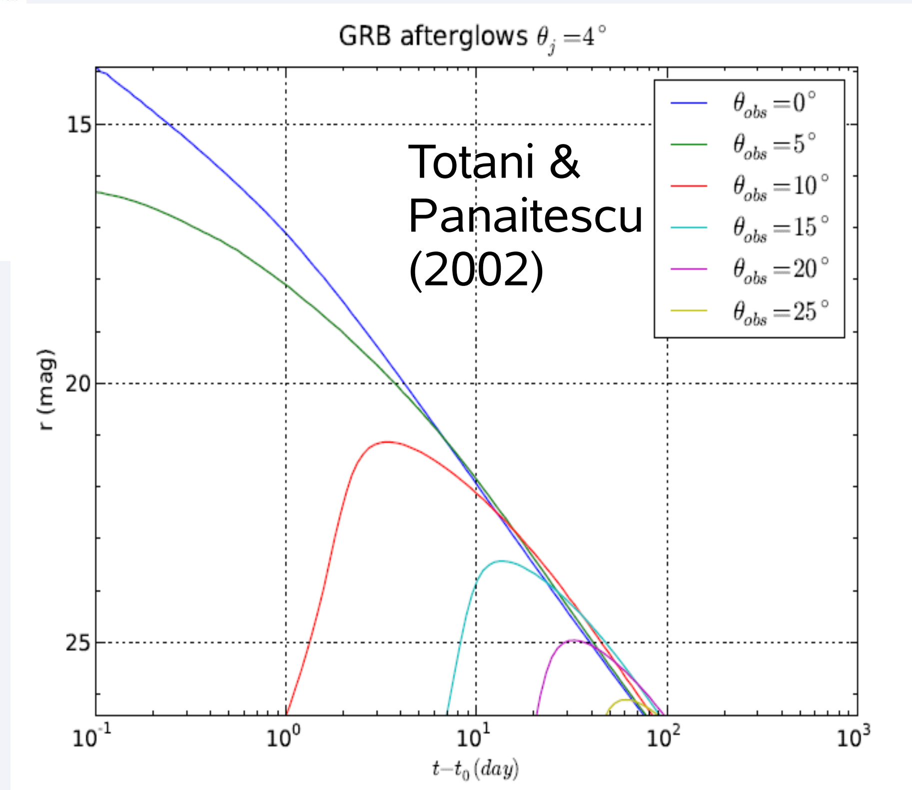
Off-axis 'Orphan' Afterglows



Nakar & Piran (2003)

The shape of the optical afterglow depends on the position of the observer relative to the jet axis

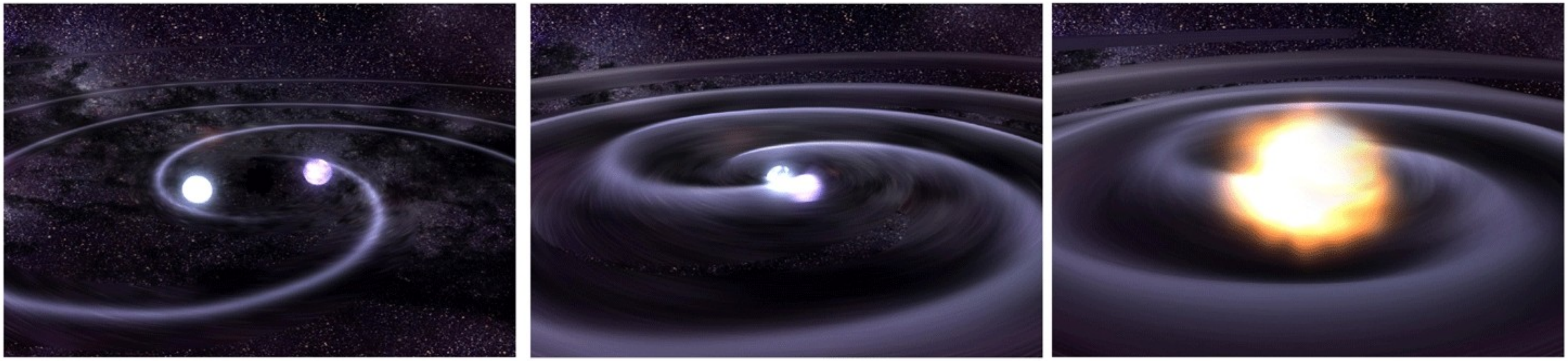


Totani & Panaitescu (2002)

LSST will detect ~ 1,000 off-axis (LGRB) afterglows per year (as well as ~ 50 'on-axis' afterglows)

These statistics will constrain the beaming angle, as well as the true rate of GRBs in the Universe.

Gravitational Waves from GRBs



[Image: NASA/CXC/GSFC/T.Strohmayer]

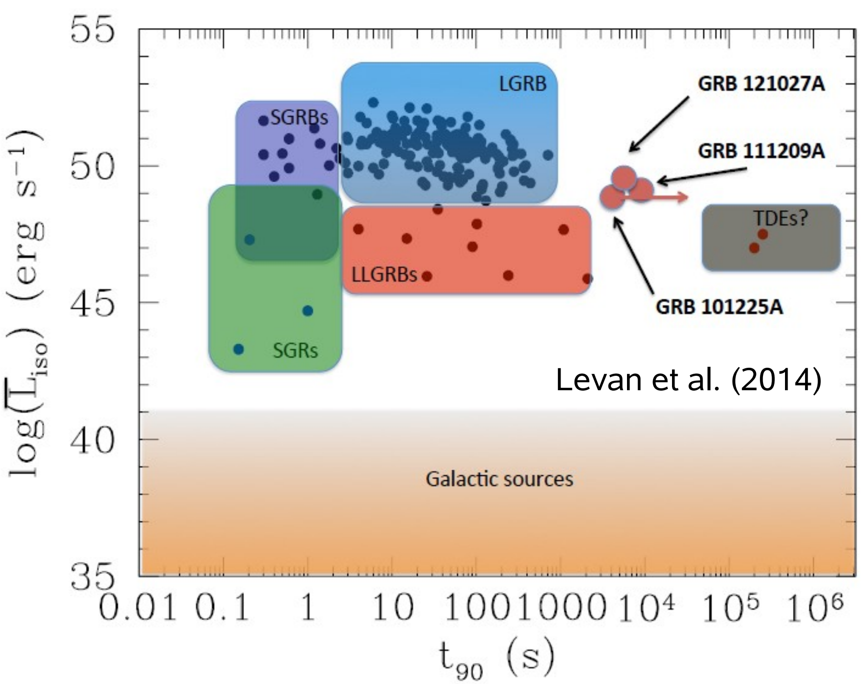
Class	M_V (mag)	T_{decay} (days)[a]	Universal rate[b] (Mpc^{-3} yr^{-1})	LSST rate (yr^{-1})
TDF	-15.. -19	30.. 350	10^{-6}	6,000
Luminous Sne	-19.. -23	50.. 400	10^{-7}	20,000
SGRB orphans	-14.. -18	5.. 15	3×10^{-7}.. 10^{-9}	~ 10 - 100
LGRB orphans	-22.. -26	2.. 15	3×10^{-10}.. 10^{-11}	1,000
On-axis afterglows	.. -37	1.. 15	10^{-11}	~ 50

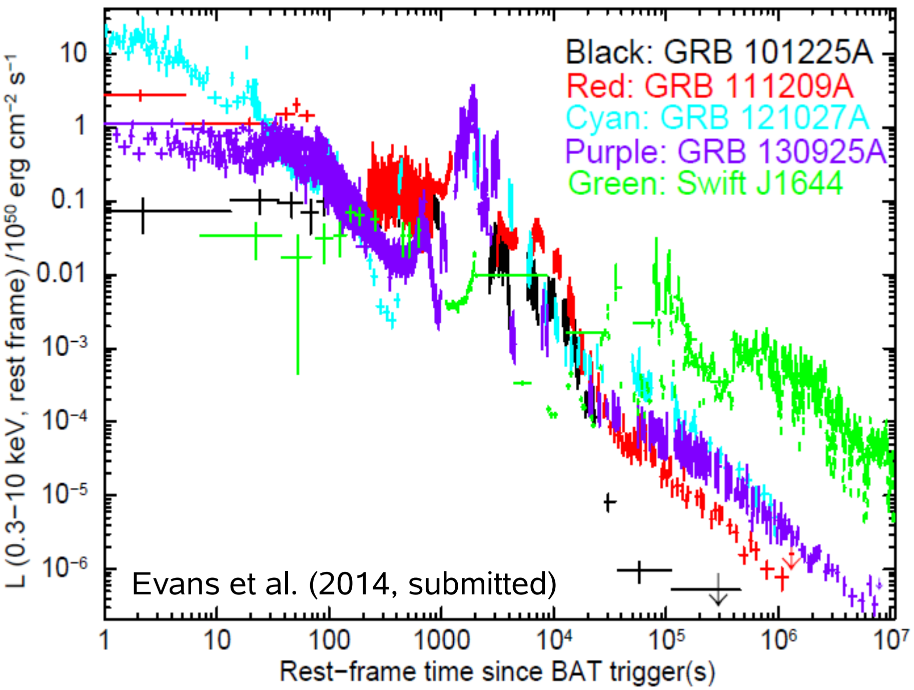
Table: LSST Science Collaborations and LSST Project 2009, LSST Science Book, Version 2.0, arXiv:0912.0201, http://www.lsst.org/lsst/scibook

[a] Time to decay 2 magnitudes from peak

[b] Rau et al. (2009)

Ultra-long GRBs





Swift has found a small number of "ultra long" transients/GRBs, with T_{90} >2000s

[NB. harder for Swift to find due to orbit gaps…].

Brighter at late times than average GRB. Fainter at late times than Swift J1644+57

For GRB130925 only detect a dust-scattered X-ray afterglow. Others have weak afterglows relative to the prompt emission

Hard to reconcile with afterglow (GRB) or fallback (TDE) models

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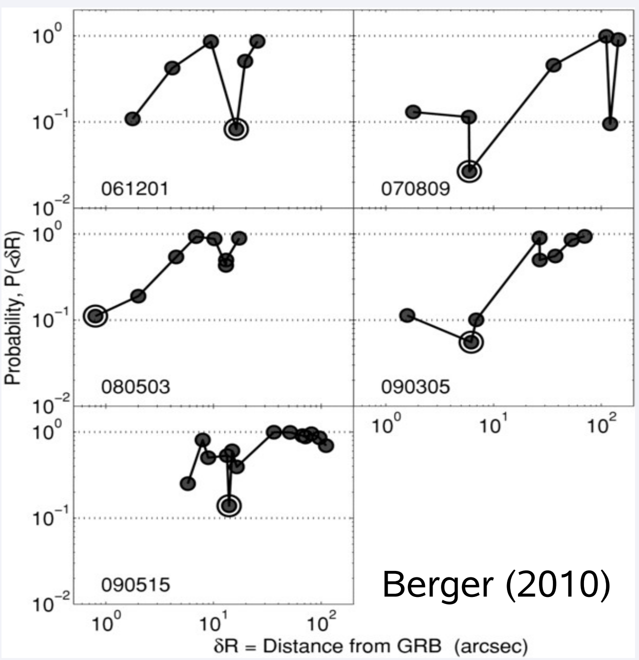
Redshift and Variability

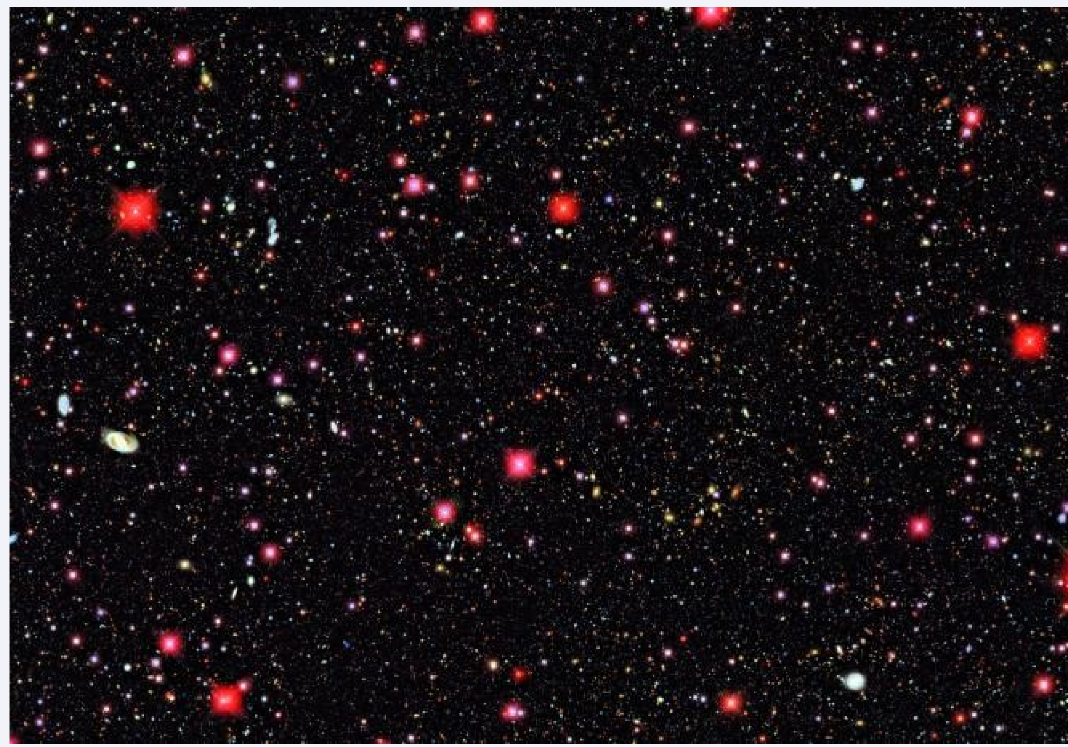
- 30 second observations of each patch of sky made every 3 – 4 days.
- Depth of r ~ 24.5 for a single visit and r ~ 27.5 for co-added depth.
- Large numbers of galactic photometric redshifts will be determined.

Sky map will show overlying objects in each field.

Knowing the background is essential in identifying transients.



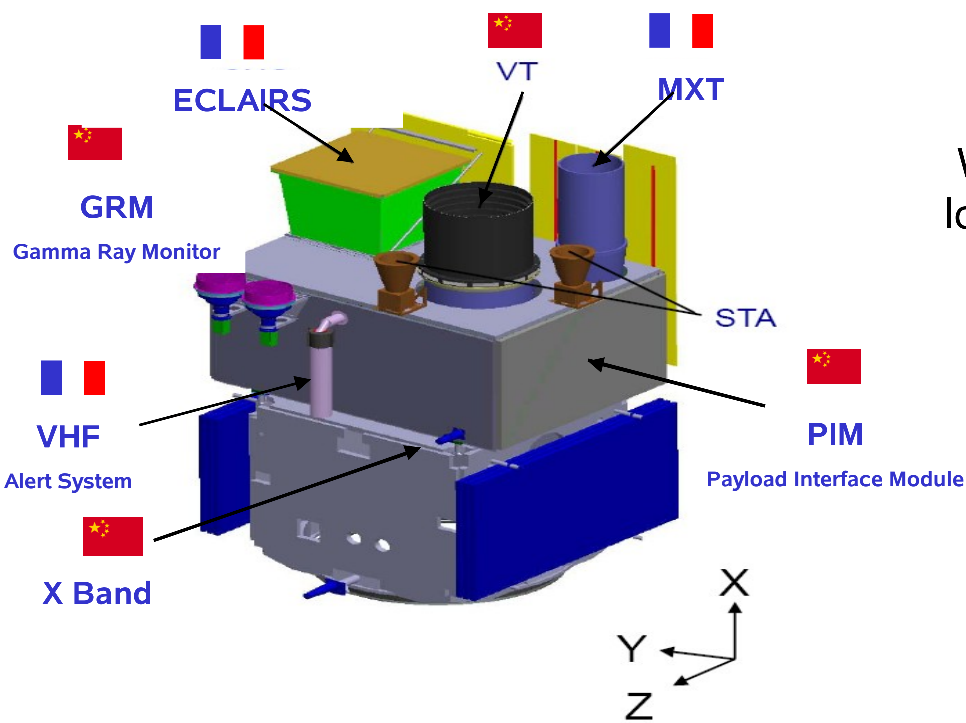
Berger (2010)



[Image: Deep Lens Survey / UC Davis / NOAO]

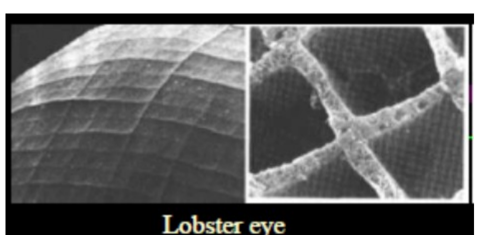
Example Future X-ray Facilities

SVOM



SVOM, China, France (+Leicester), launch ~2020, rapid repointing – Swift-like GRB search with rapid sub-arcmin localisation

Uses Lobster-eye style X-ray optics



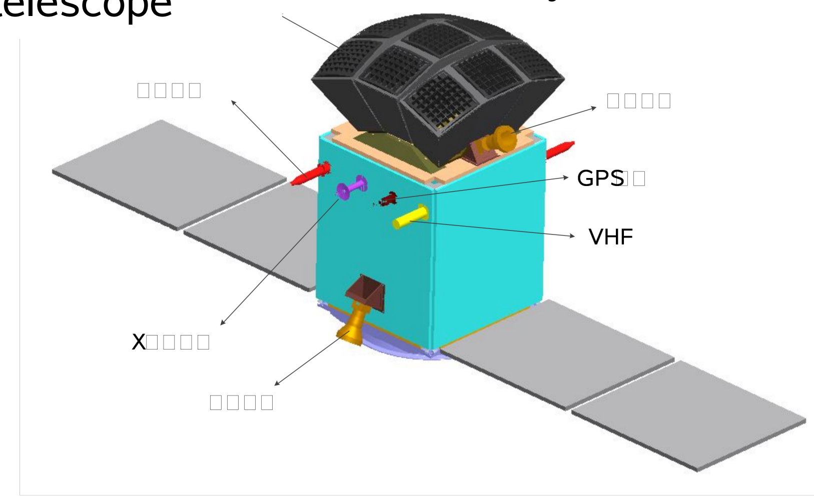
Einstein-Probe

in "advanced study" phase – 2yrs)

Wide-field MPO lobster-eye X-ray telescope

60°x60°~1str

~ 1/12 whole sky



Payload: a wide-field soft X-ray telescope (0.5-4keV)

Orbit: 600km, circular, 30° inclination, 97min period

Mass: 380 kg (payload 150kg)

Downlink: via SVOM VHF network or relay satellites

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LSST in GRB science

- Detect off-axis orphan afterglows, allowing improved estimates of jet opening angles and the rate of GRBs in the Universe
- Provide EM follow-up for the expected gravitational wave signals in short GRBs
- Build a sample of the new class of ultra-long GRBs without having to rely on triggers
- Obtain photometric redshifts of many of the potential host galaxies of GRBs
- Provide an all-sky map, which will help when identifying transients and overlying objects in the field
- Contemporaneous X-ray data required to build a full picture