The Future of GRB Missions

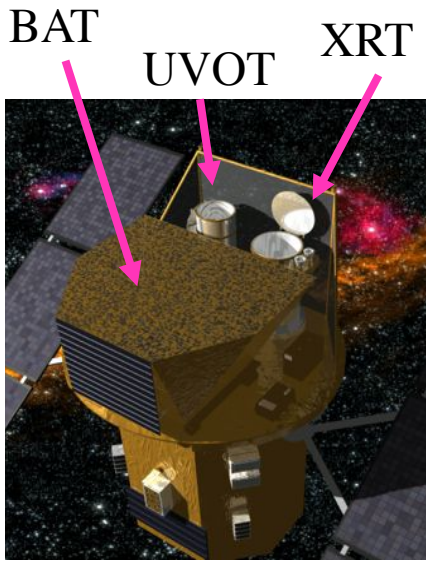
Neil Gehrels

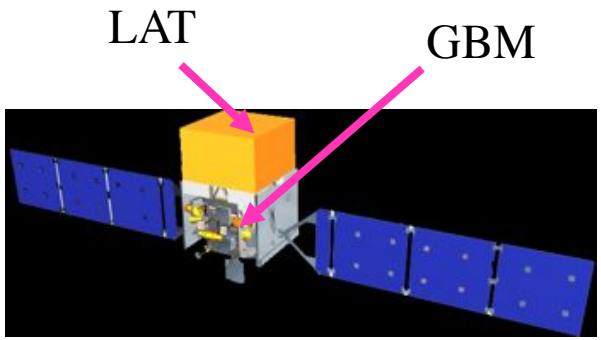
NASA-GSFC

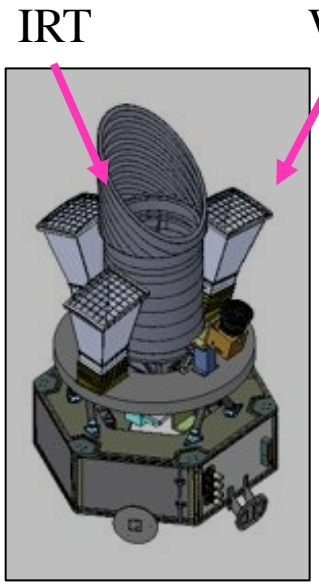
KITP Rattle and Shine

July 30, 2012

Swift, Fermi & Lobster Missions







BAT

Energy: 15–300 keV
Field: 1.4 sr
GRBs/yr: 100

XRT

Energy: 0.2 – 10 keV
Field: 24 arcmin

Launch Nov. 2004

GBM

Energy: 8 keV – 40 MeV
Field: 8 sr
Positioning: ~10 deg
GRBs/yr: 300

Launch June 2008

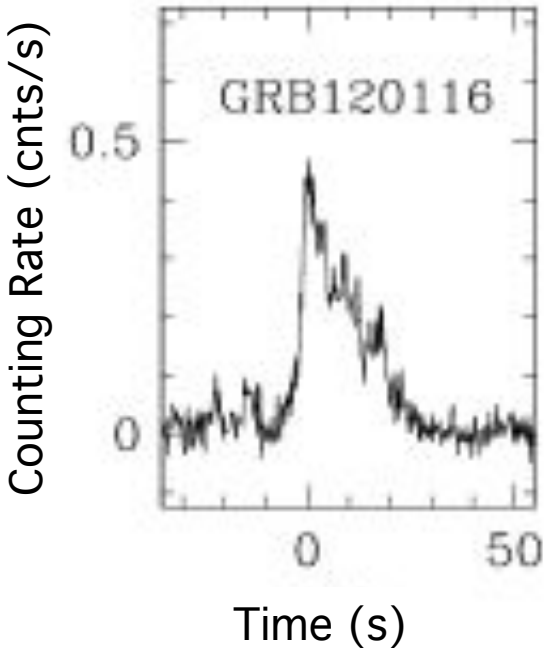
WFI

Energy: 0.2–5 keV
Field: 0.5 sr
Coverage: 50% / 3 hrs

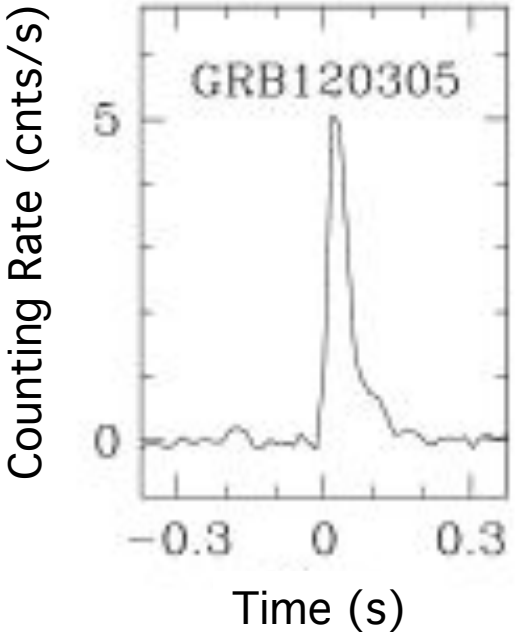
future

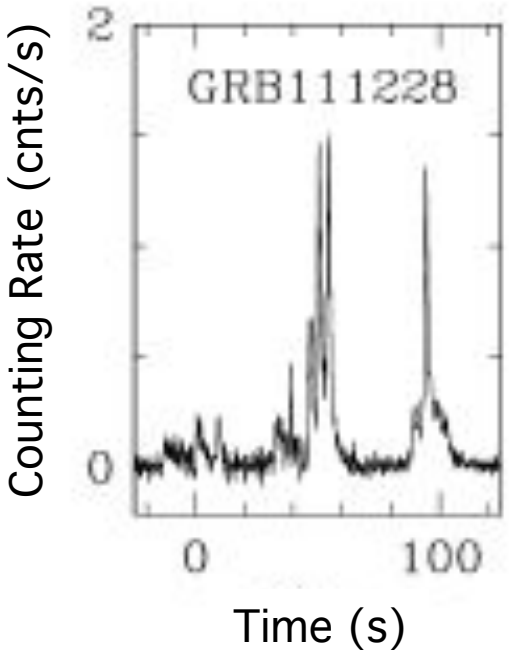
689 GRBs
85% with X-ray detections
~60% with optical detection
207 with redshift (41 prior to Swift)
67 short GRBs localized (0 prior to Swift)

Swift GRBs



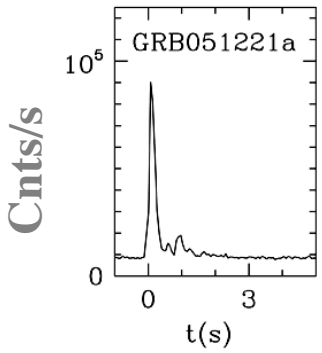
short



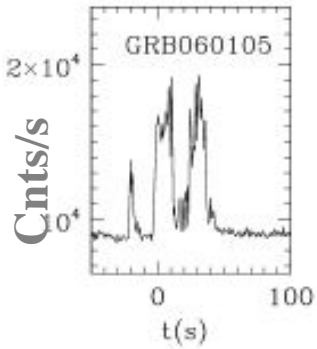


Short vs Long GRBs

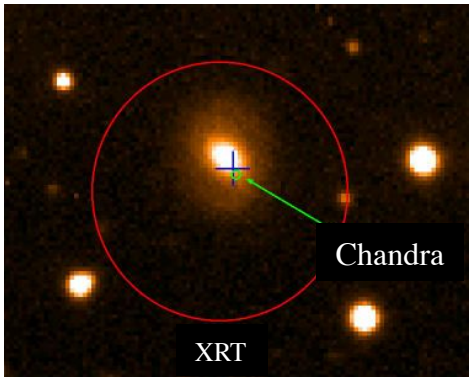
Short GRB



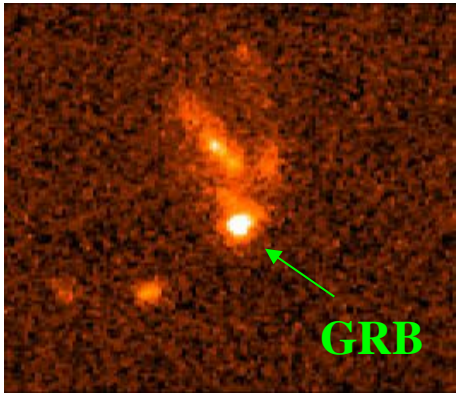
Long GRB



GRB 050724 - *Swift*
elliptical host



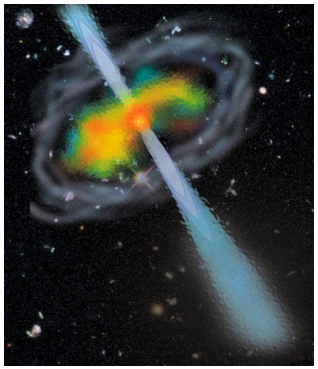
GRB 990123 - *SAX*
SF dwarf host



In non-SF
and SF galaxies

No SNe detected

Possible **merger**
model



BH

In SF
galaxies

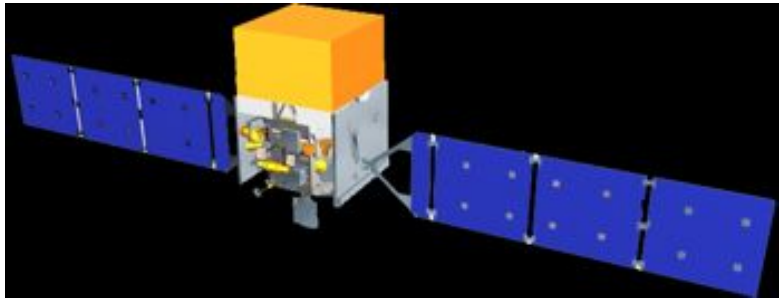
Accompanied by SNe

Collapsar model
well supported

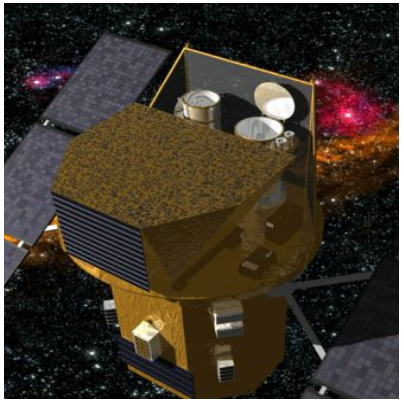
Trigger & Follow-up

Counterpart identification between GW and EM can go both ways:

- Multi-wavelength (gamma-ray) trigger for deep GW searches

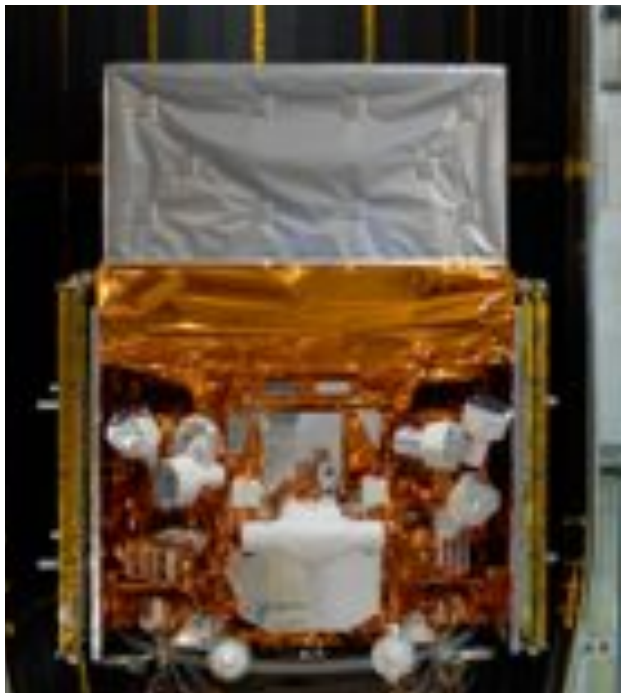


- Multi-wavelength observations of GW events (deep GW searches)



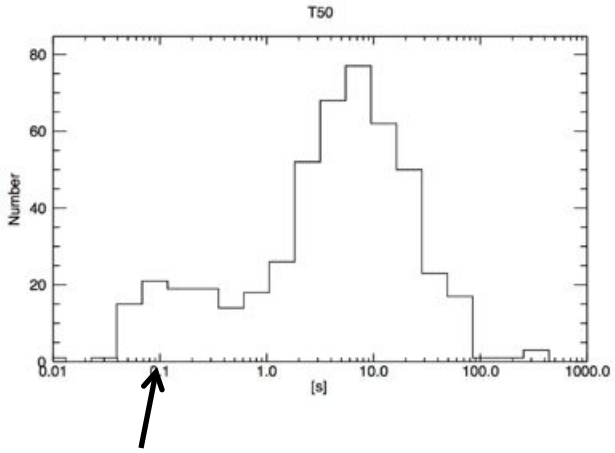
GRB Trigger – GW Follow-up

Best Instrument is Fermi GBM



Meegan+ 09

- Views entire unocculted sky
- 350 GRBs per year
- High fraction of short GRBs
- Accurate time stamp

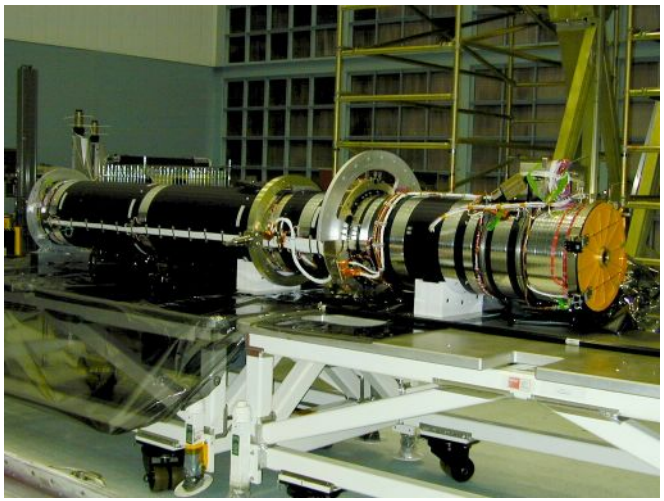


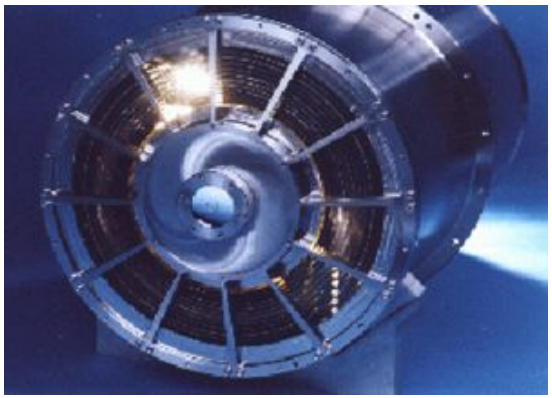
~25% short GRBs

GW Trigger – EM Follow-up

Best Current Instrument is Swift XRT

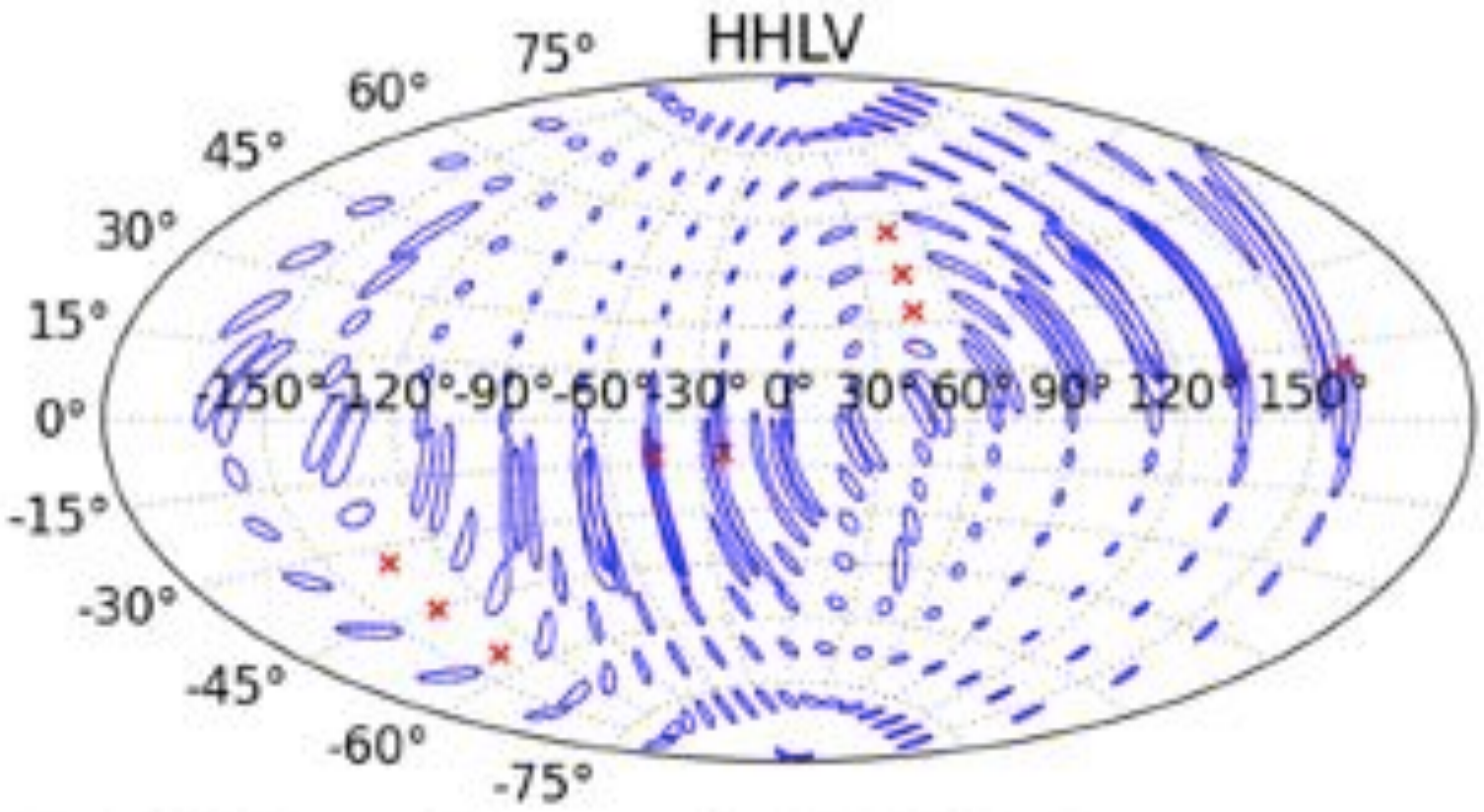
- X-rays are most promising wavelength band for afterglow
- Flexible Swift scheduling gives <1 hour turn around
- Flexible Swift scheduling enables tiling or large error boxes
- Strategy is to observe nearby galaxies in error box
- Follow-up performed of 2 ELIGO S6 triggers (Evans+ 12)





Burrows+ 05

Sky Localization with 3 Sites



Typical 90% error box areas for NS-NS binaries

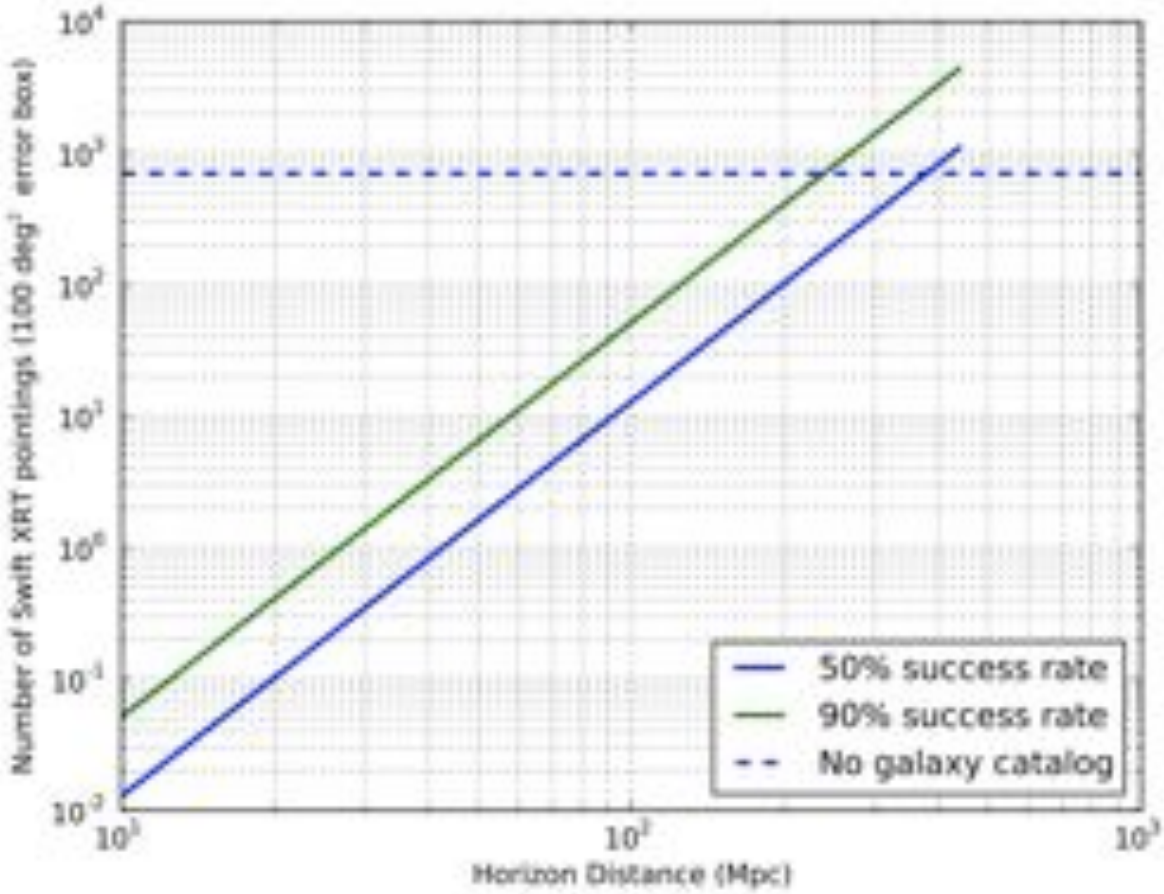
– median > 20 sq deg

Fairhurst, CQG 28 105021 (2011)

GW Trigger – EM Follow-up

Galaxy Strategy

Number galaxy pointings



GWGC cat
60% to 100Mpc

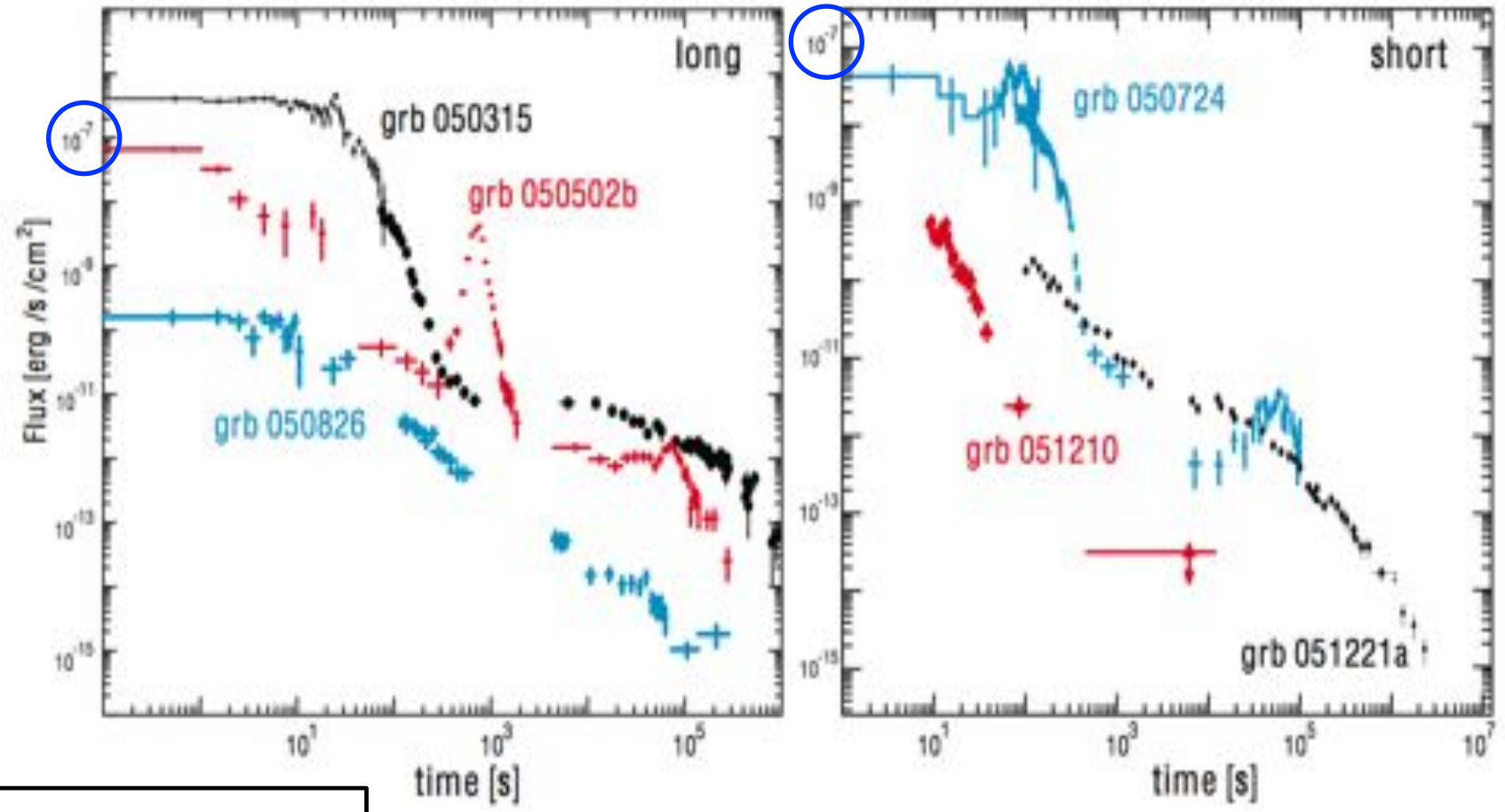
LUMIN cat
85% to 200Mpc

Kanner+ 2012

X-ray Afterglows

LONG

SHORT

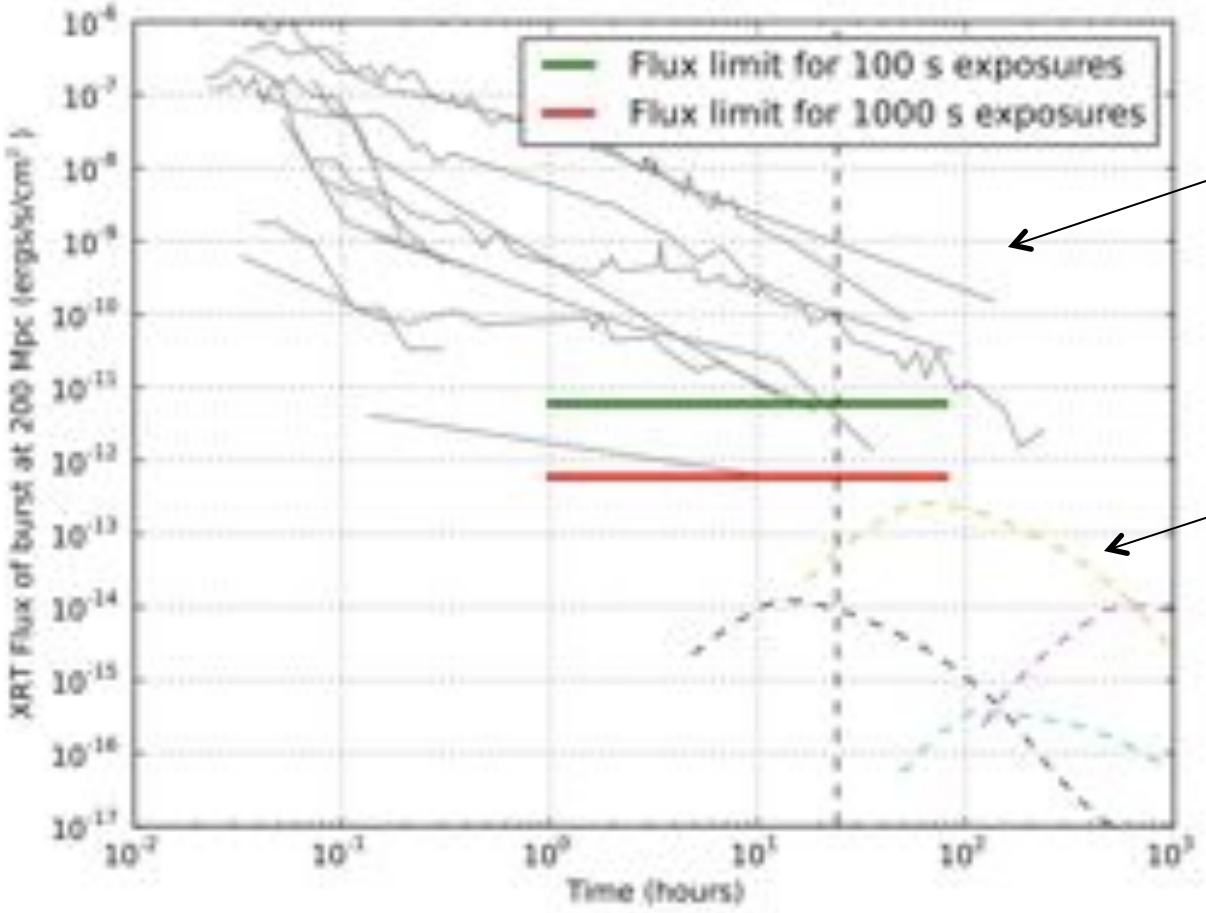


Short GRBs are
- weaker
- faster decaying

Gehrels, Ramirez-Ruiz & Fox 2009

GW Trigger – EM Follow-up

X-ray Afterglows are Bright



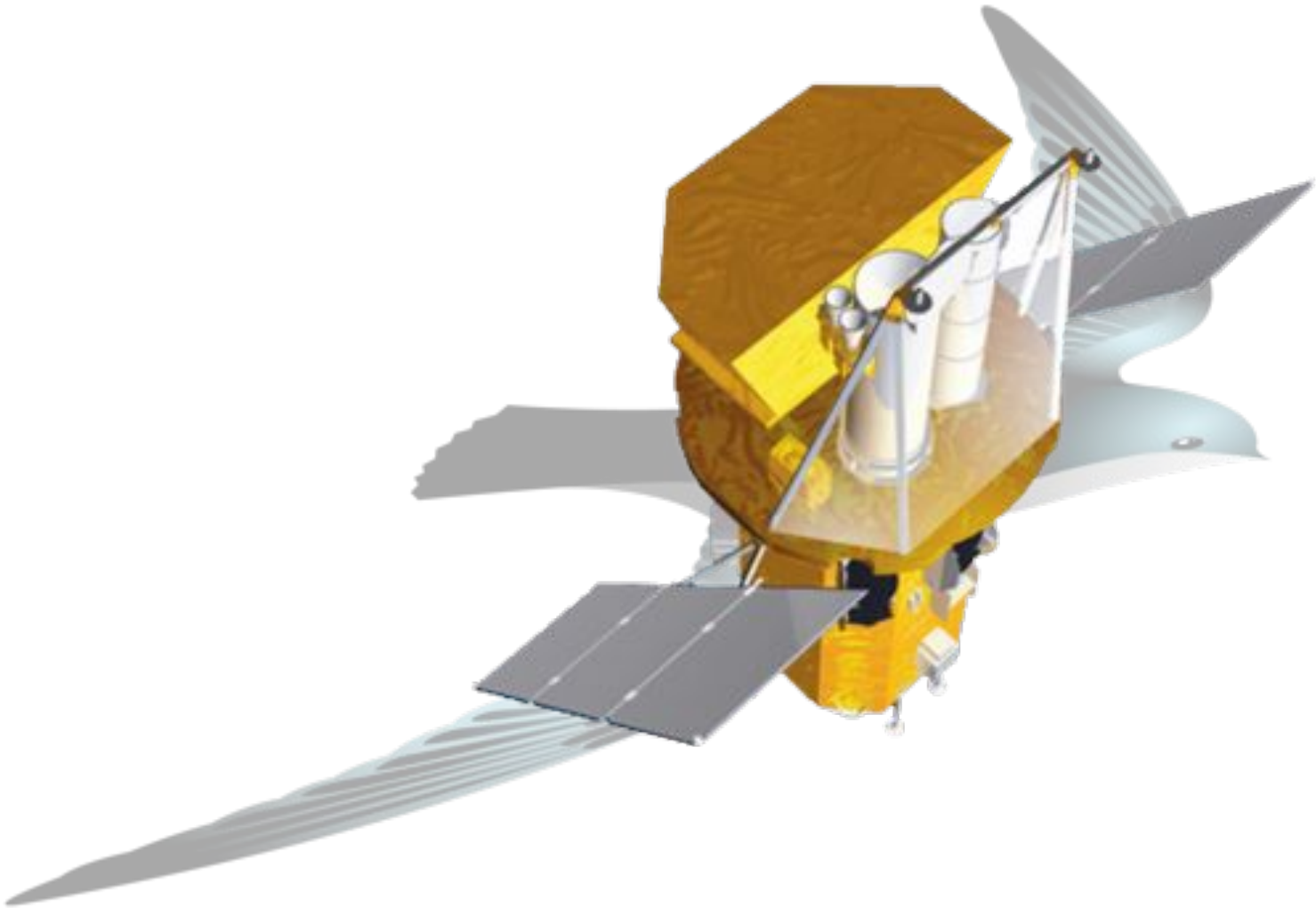
Short GRB afterglows @ 200 Mpc

Off-axis afterglows

Kanner+ 2012

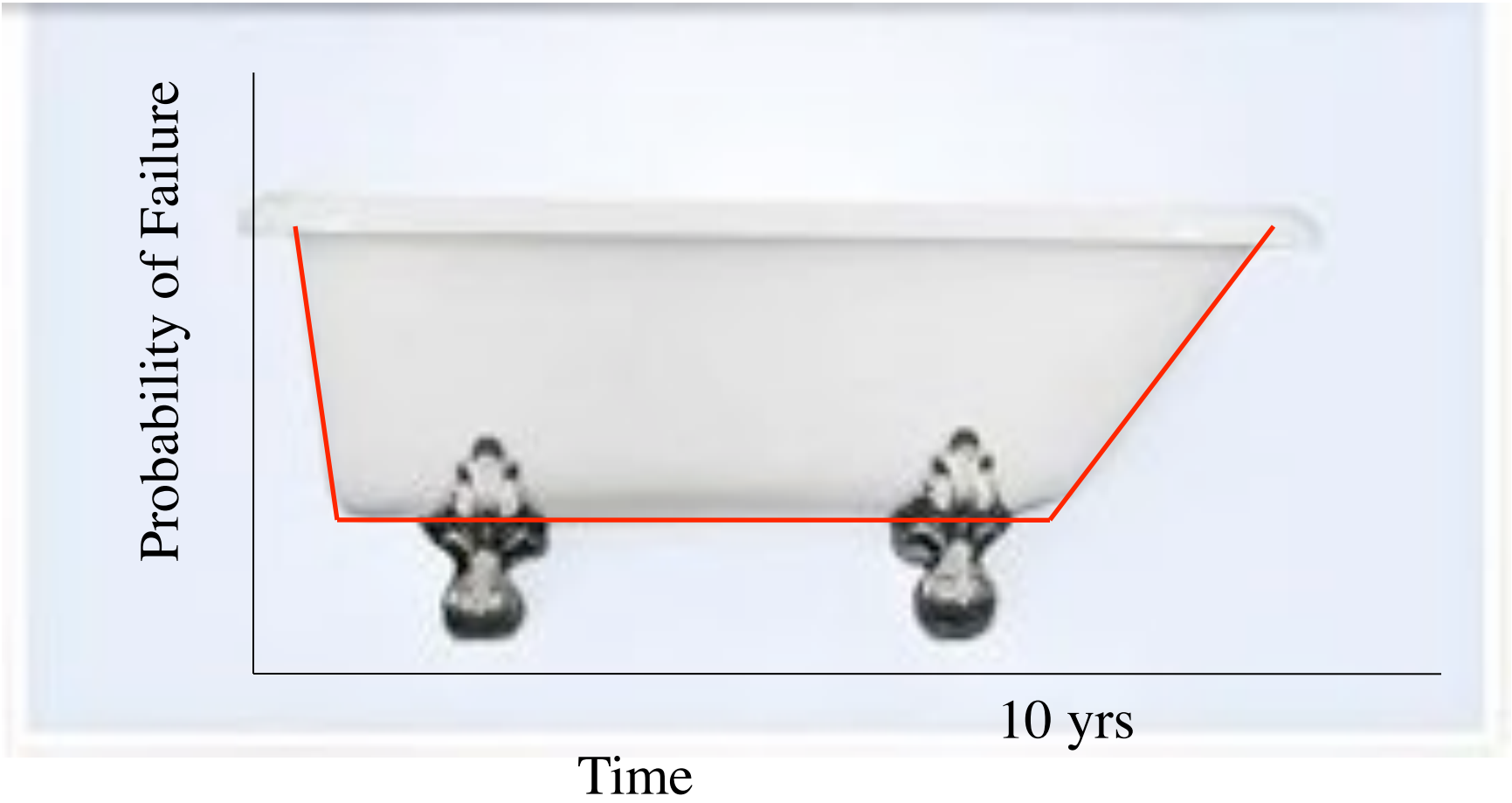
The Future

Orbit Decay



Orbital Lifetime > 2025

Parts Failure Bathtub Curve



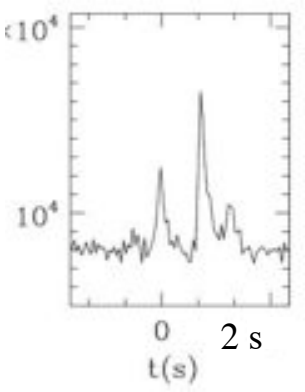
NASA Senior Review Results

MISSION	DISCOVERY SPACE	LONG TERM IMPACT	PUBLICATIONS	SYNERGY	CRITICAL CAPABILITY	Total
CHANDRA	9	9.5	7	9	9.5	
FERMI	7.5	7.5	7	8	9	
HST	9.5	9.5	7	9.5	10	45.5
KEPLER	9	9	7.5	8	9.5	
PLANCK	7	10	6	8.5	9.5	
SPITZER	9	8	6.5	9	9.5	
SUZAKU	8	8	10	7.5	9	
SWIFT	9	9	9.5	10	9.5	47
XMM	8	9	9.5	9	9	

Short Burst Types

BNS Merger
Black Hole

GRB 100213



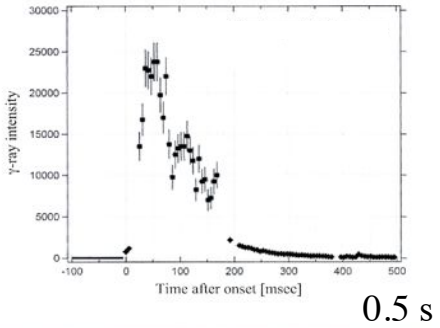
10^{50} erg

$\theta_{jet} \sim 5^\circ$?

gravity

SGR Flare
Magnetar

27 Dec 04 Superflare



0.5 s

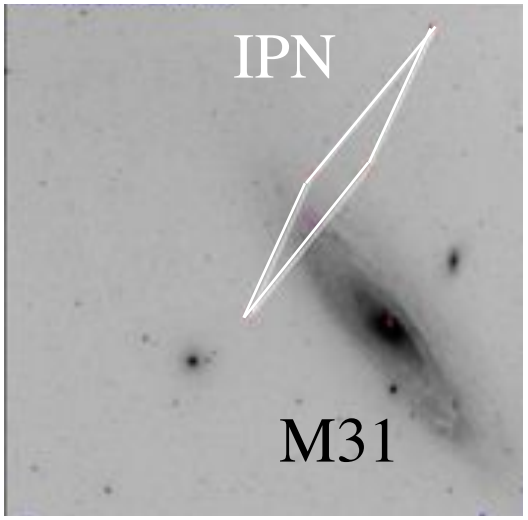
10^{45} erg
max, based on
27 Dec 04 event

isotropic ?

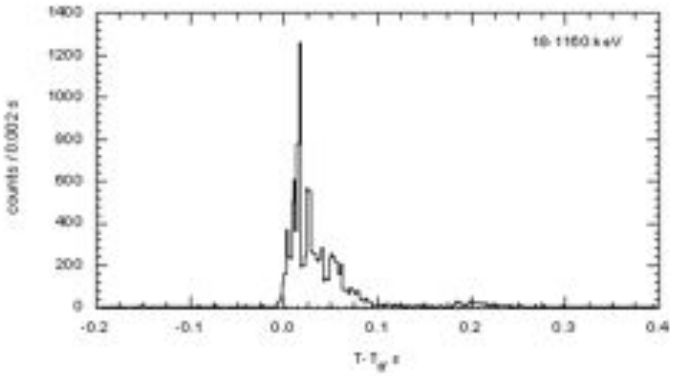
B field

SGR Impostors

- 27 Dec 2004 superflare of SGR 1806-20 showed that SGRs could be short burst impostors to 40 Mpc
- IPN GRB 070201 possibly in M31
  No LIGO GW detections ruled out
  NS-NS merger
- New BAT software change
- Onboard source catalog of 400 known transients augmented with 750 nearby galaxies to 20 Mpc
- Gives enhanced sensitivity for SGRs in nearby galaxies

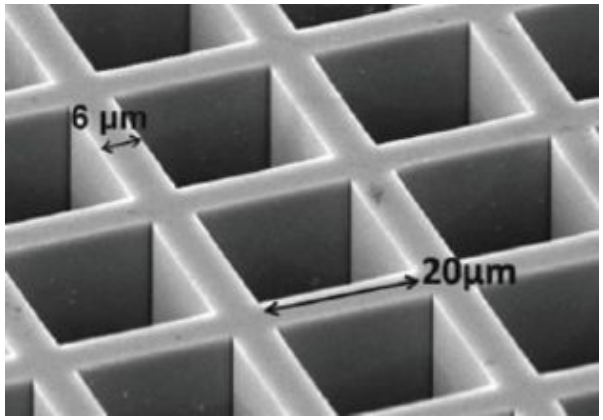


Konus Lightcurve



Lobster Concept

microchannel optic

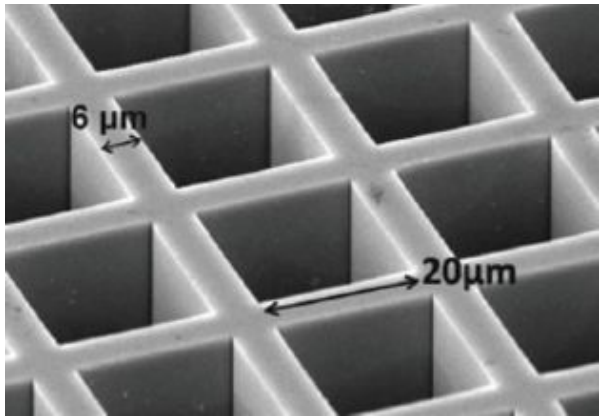


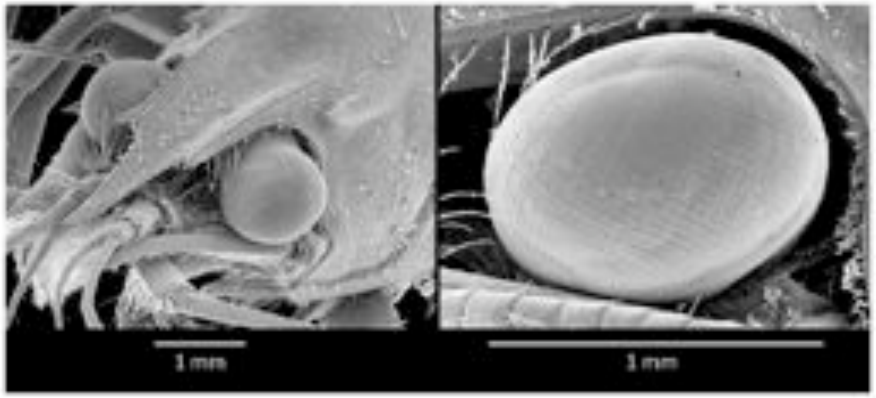
Roger Angel

George Fraser

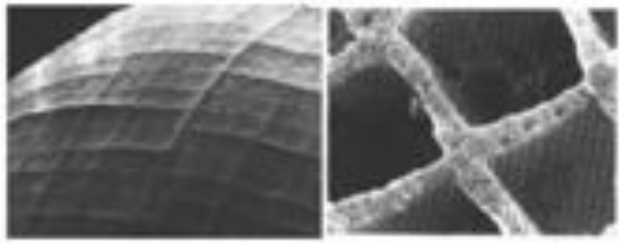
Lobster Concept

microchannel optic

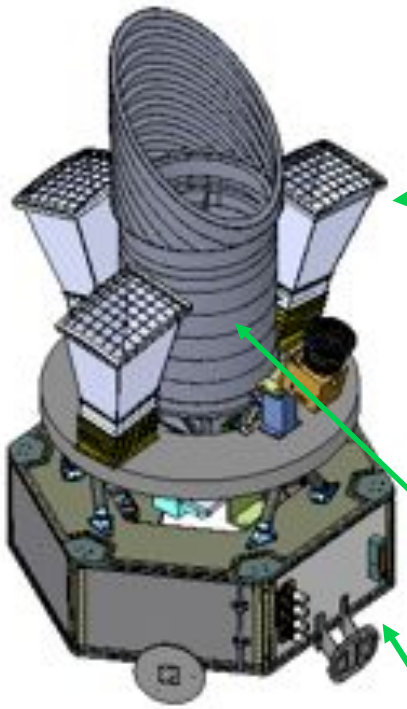




lobster faceted eye



Lobster Summary



Wide Field Imager (WFI)

FoV: 0.5 sr
Sky coverage: 50% of sky every 3 hours
Energy Range: 0.3 - 6 keV
Detectors: CCDs
Optics: Lobster-eye microchannel optic

InfraRed Telescope (IRT)

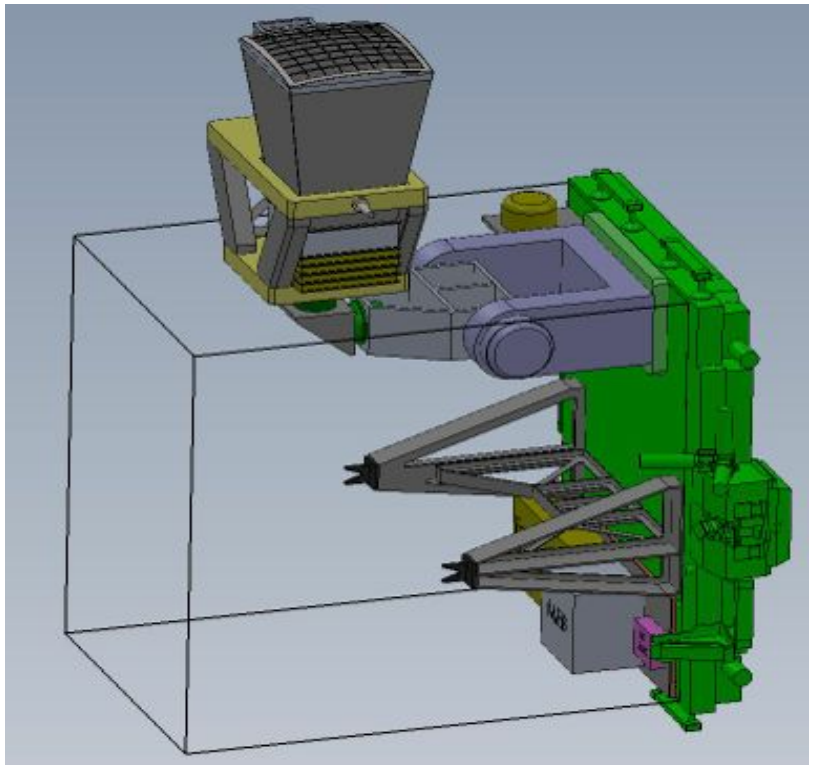
Mirror Diameter: 40 cm
Wavelength Range: 0.6 – 2.1 microns
Detectors: HgCdTe
Multiband photometry, R=30 slit spectroscopy
Redshift determination on-board

Spacecraft - autonomous

NASA Explorer
ISS MoO
ESA Small Mission

ISS-Lobster

(J. Camp, S. Barthelmy, N. Gehrels, GSFC)



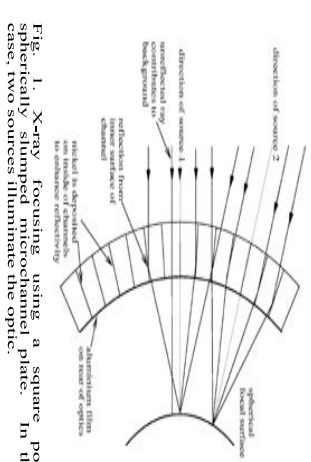
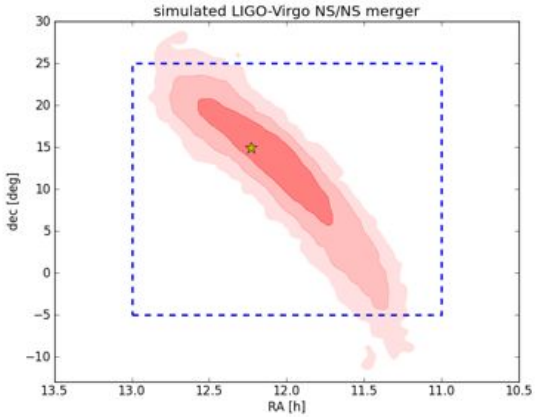


Fig. 1. X-ray focusing using a square pore, spherically slumped microchannel plate. In this case, two sources illuminate the optic.



NS-NS merger sky map and Lobster FOV

30° x 30° FOV

$\Delta\theta \sim 1$ arc min

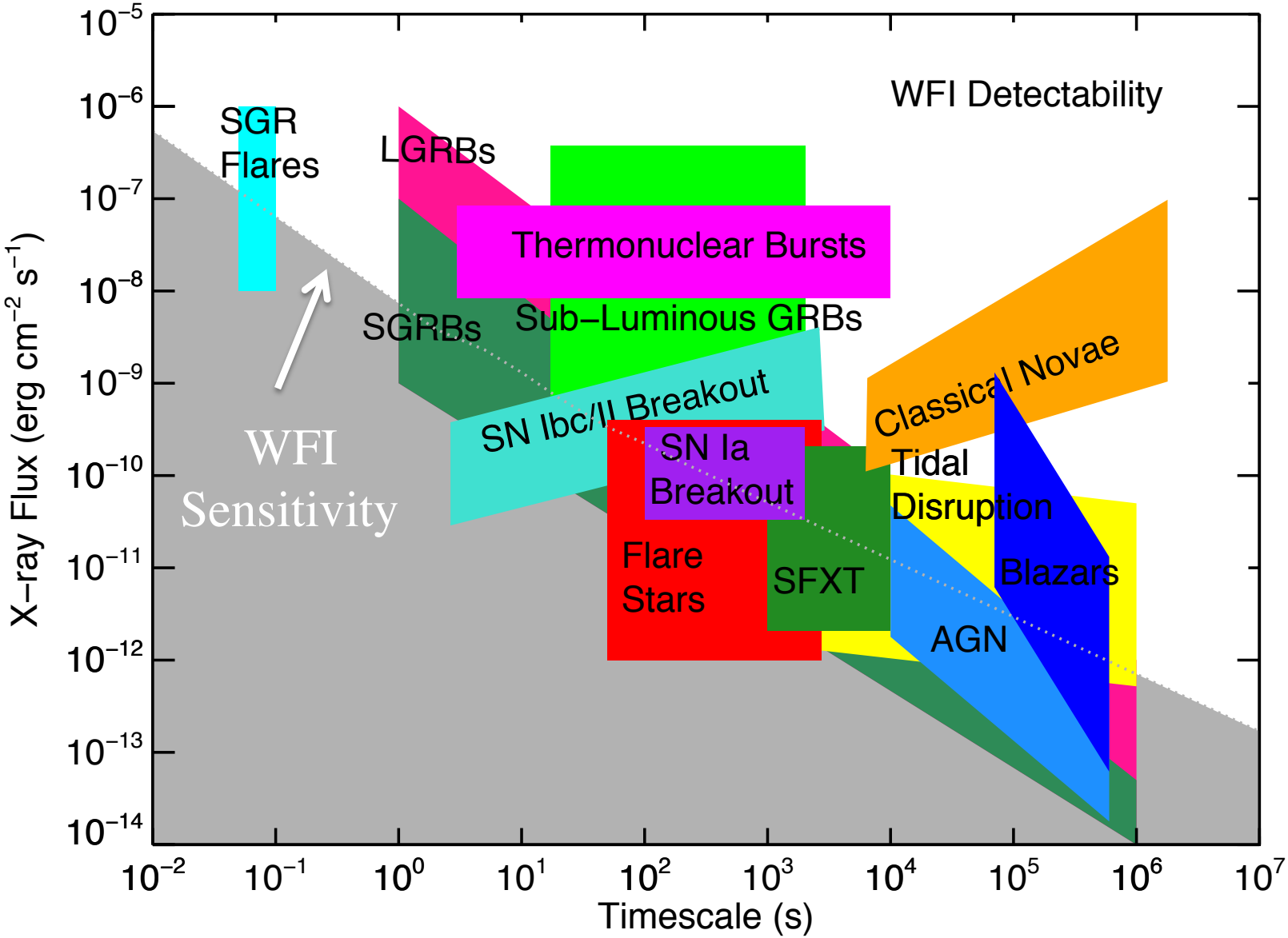
10^{-11} erg/(cm^{2}sec) in 1000 sec

Concept under study at Goddard Space Flight Center

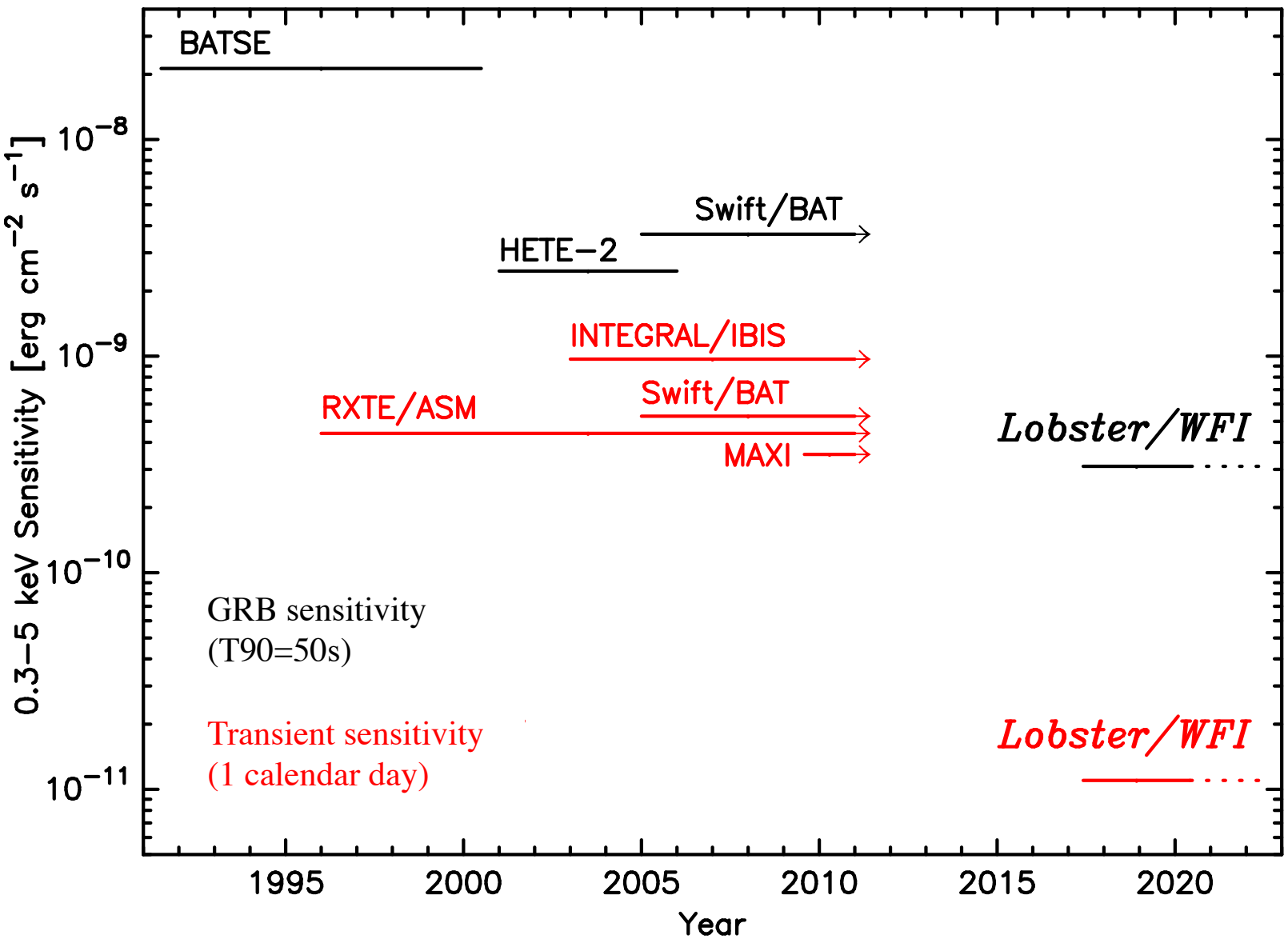
FY13 Mission of Opportunity proposal → 2017 deployment

- Expect several yr^{-1} NS-NS and/or NS-BH merger follow-up

Transient Science



Sensitivities



Summary

- **Swift and Fermi provide a good combined capability for high energy observations correlated with GWs**
- **Fermi gives the best sky coverage for short GRBs**
- **Swift's gives flexible scheduling enabling sensitive X-ray coverage of large error boxes**
- **The Lobster mission concept will greatly enhance sky coverage for X-ray transients, including NS-NS merger afterglows**