GRBs with CTA: following and finding

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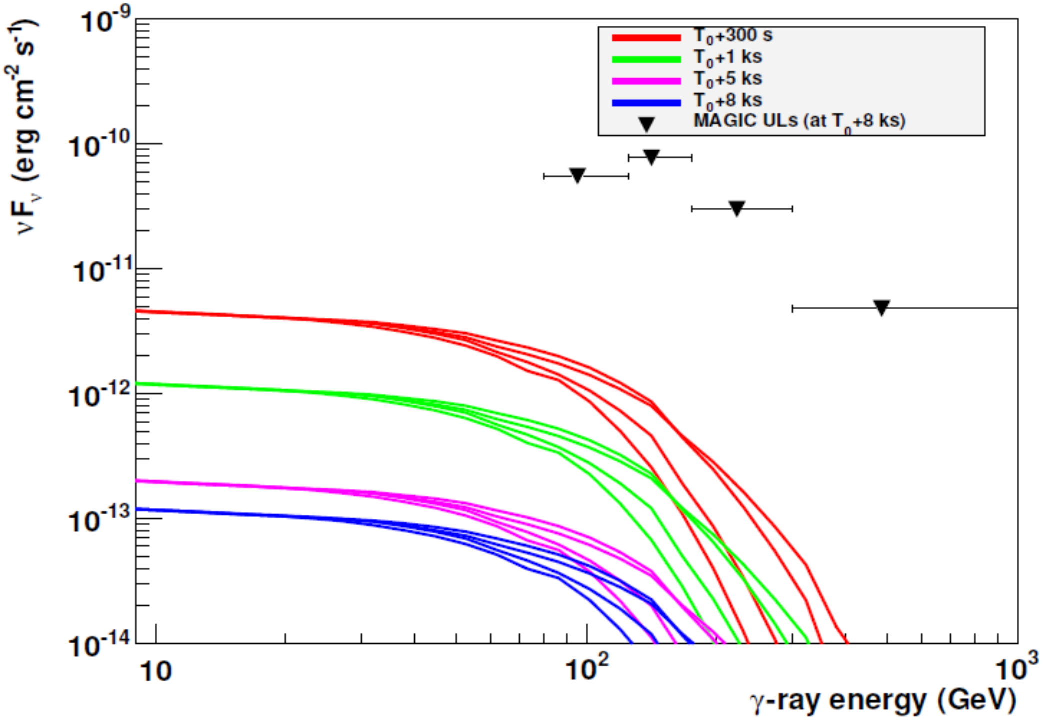
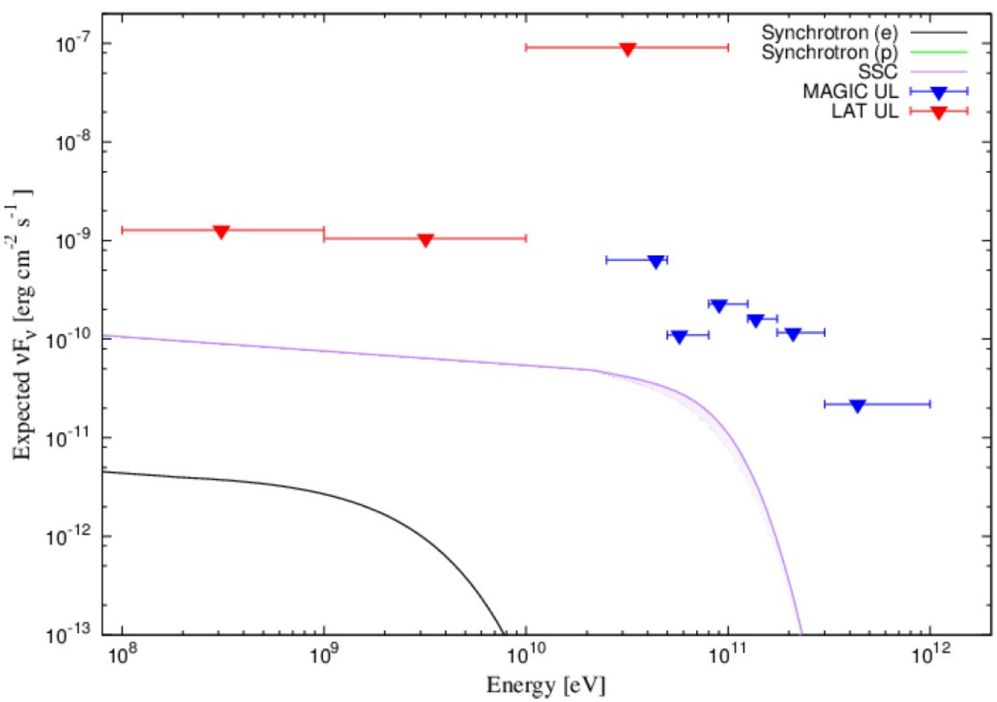
GRBs with CTA: following and finding

- Transients of enormous energy budgets 10^{50} erg+
- Rel. jet, formed during stellar collapse or merger
- Prompt emission mechanisms unknown, afterglow=synchrotron (shock front jet--ISM)
- CTA energy range+eff area+fast response can make significant progress in several areas
- 2 ways to do GRBs: *follow* and *find*
- Swift and Fermi provide triggers for following; Survey mode (serendipity) needed for finding

Some limits so far...





MAGIC limits for GRB 080430 at T_0+8ks and SSC model predictions (+EBL). (Aleksić et al. 2010)

MAGIC and Fermi LAT limits for GRB 090102 at T_0+1.2ks and SSC model predictions (+EBL). (Aleksić et al. subm.)

LSTs (least affected by EBL), 10^4x effective area of Fermi at 30 GeV and could slew 180º in 30s

Science cases

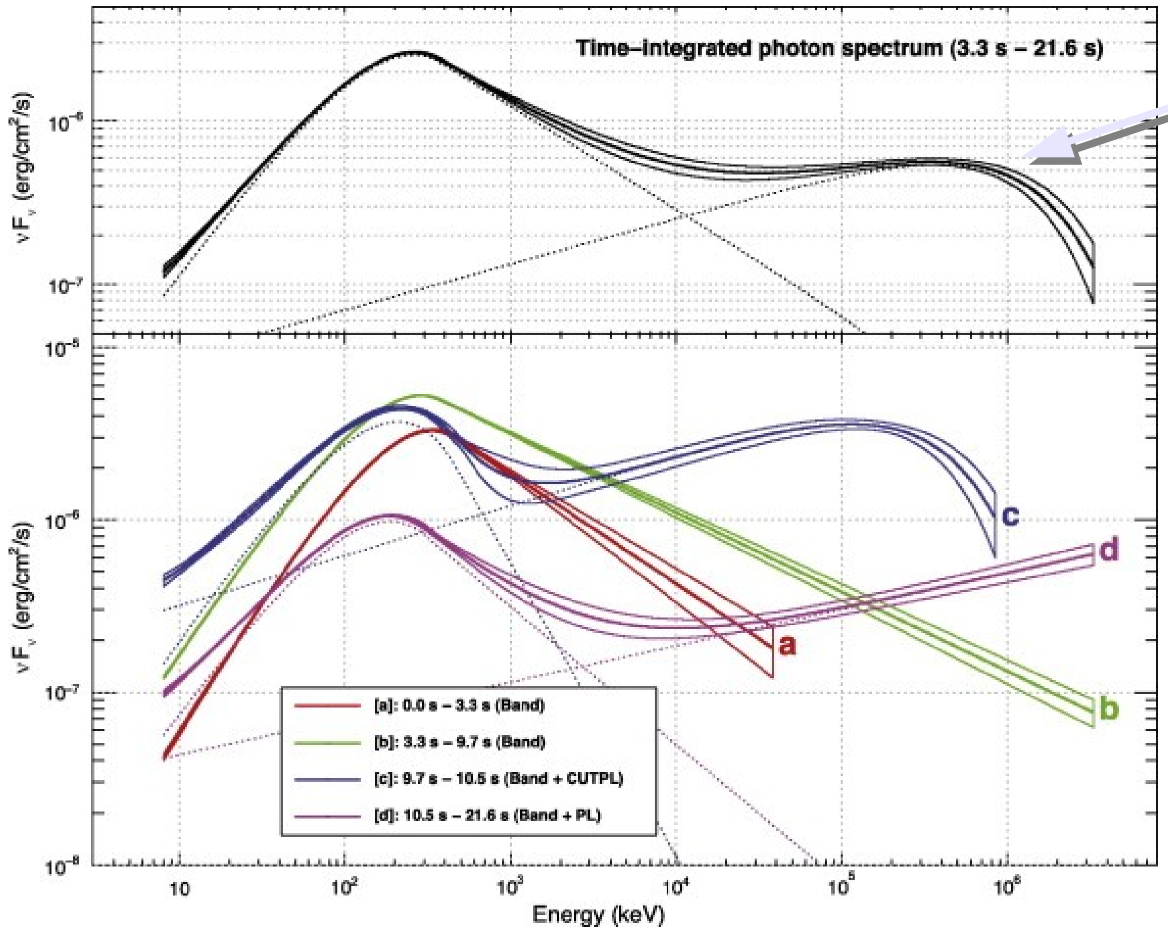
- GRB physics in prompt and afterglow phases

  Bulk Lorentz factor, central engine, particle acceleration, jet formation, energy dissipation, E_{total} → progenitors

  both long and short GRBs have been seen at MeV

- UHE cosmic rays and neutrinos
- Cosmology via EBL at the high redshifts only probed by GRBs
- Lorentz invariance violation – QG model test

Fermi LAT spectral model for GRB 090926A requires high energy component of unknown origin.
(Ackerman et al. 2011)



1.4 GeV cut-off (if due to internal pair production) allows Lorentz factor Γ to be determined directly.

Two further LAT GRBs have high energy components with no clear downturn, while an additional high energy component is not present in other (fainter) examples.

Science cases

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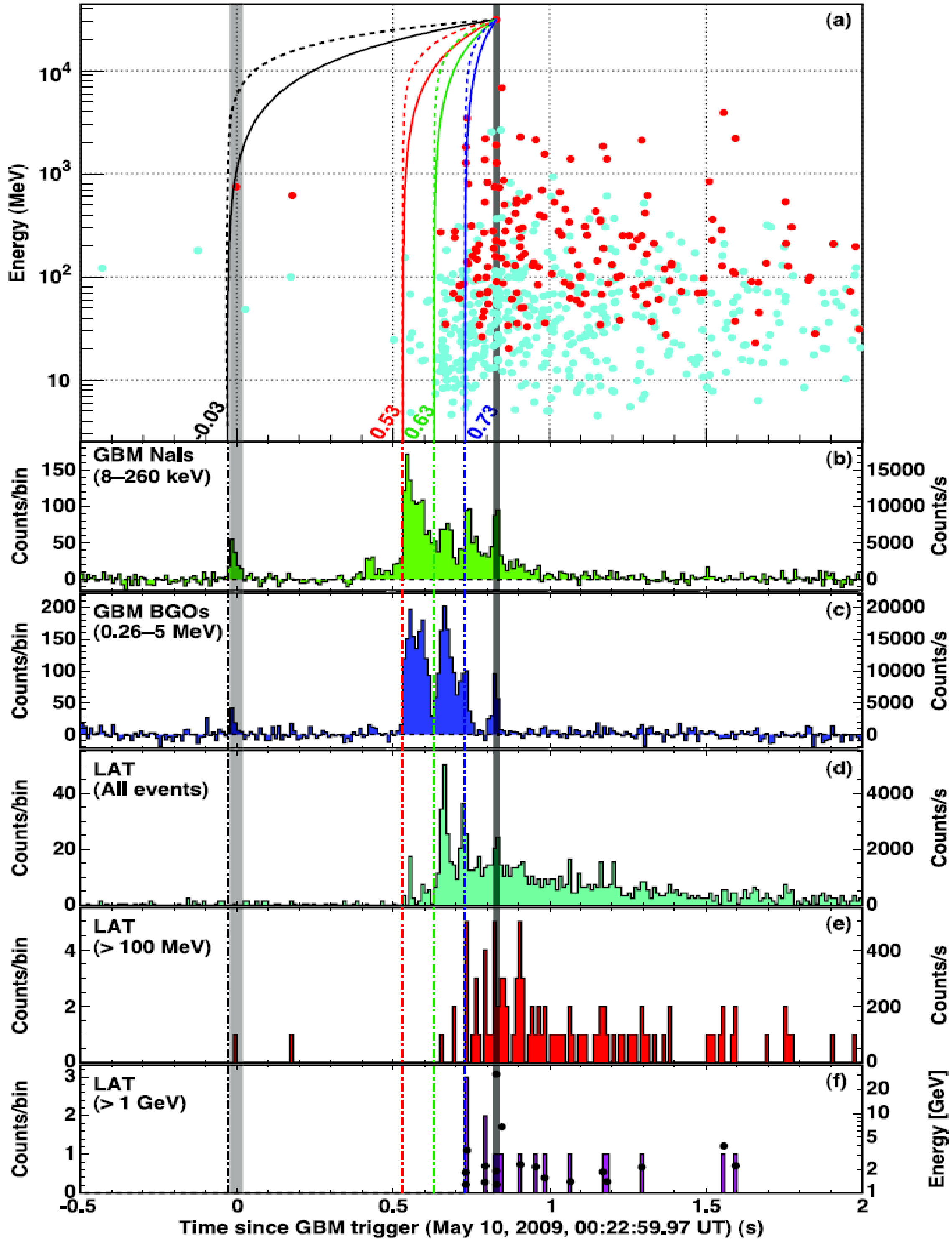


Some quantum gravity models allow energy-dependent photon speed rather than move at *c*.
Results in delayed arrival of high-E photons cf lower energy photons.

Fermi satellite: light curves for GRB 090510 in various energy bands. Most energetic photon at 30.5 GeV. (Abdo et al. 2009)

Responding to GRB triggers

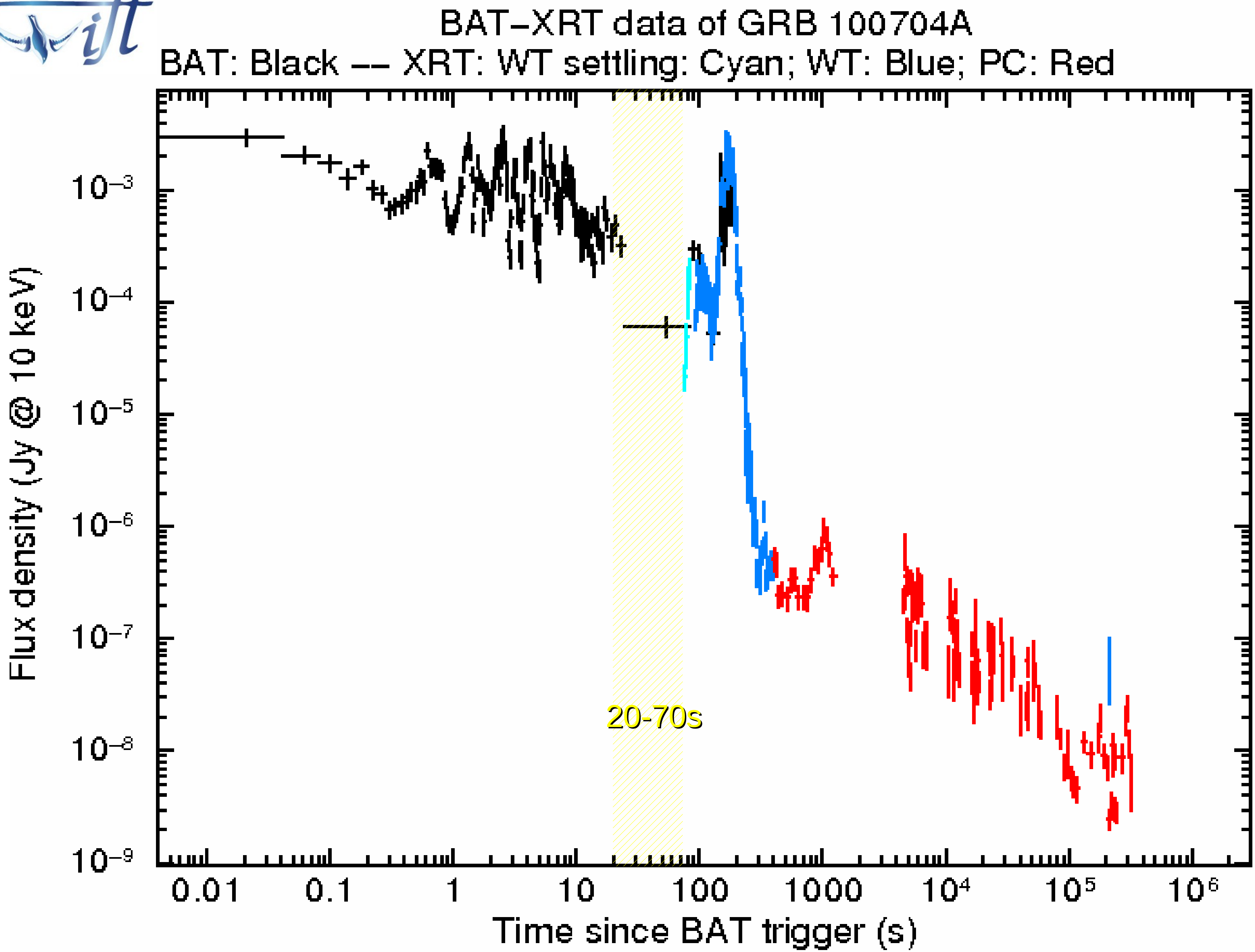
- Accept incoming (VOEvent or GCN) triggers
- Compute visibility constraints, decide on observing strategy (quickly!)
- Perform telescope slew (override) – Fermi error circles of a few degrees may need tiling
- Real-time data analysis
- Rapid dissemination of results

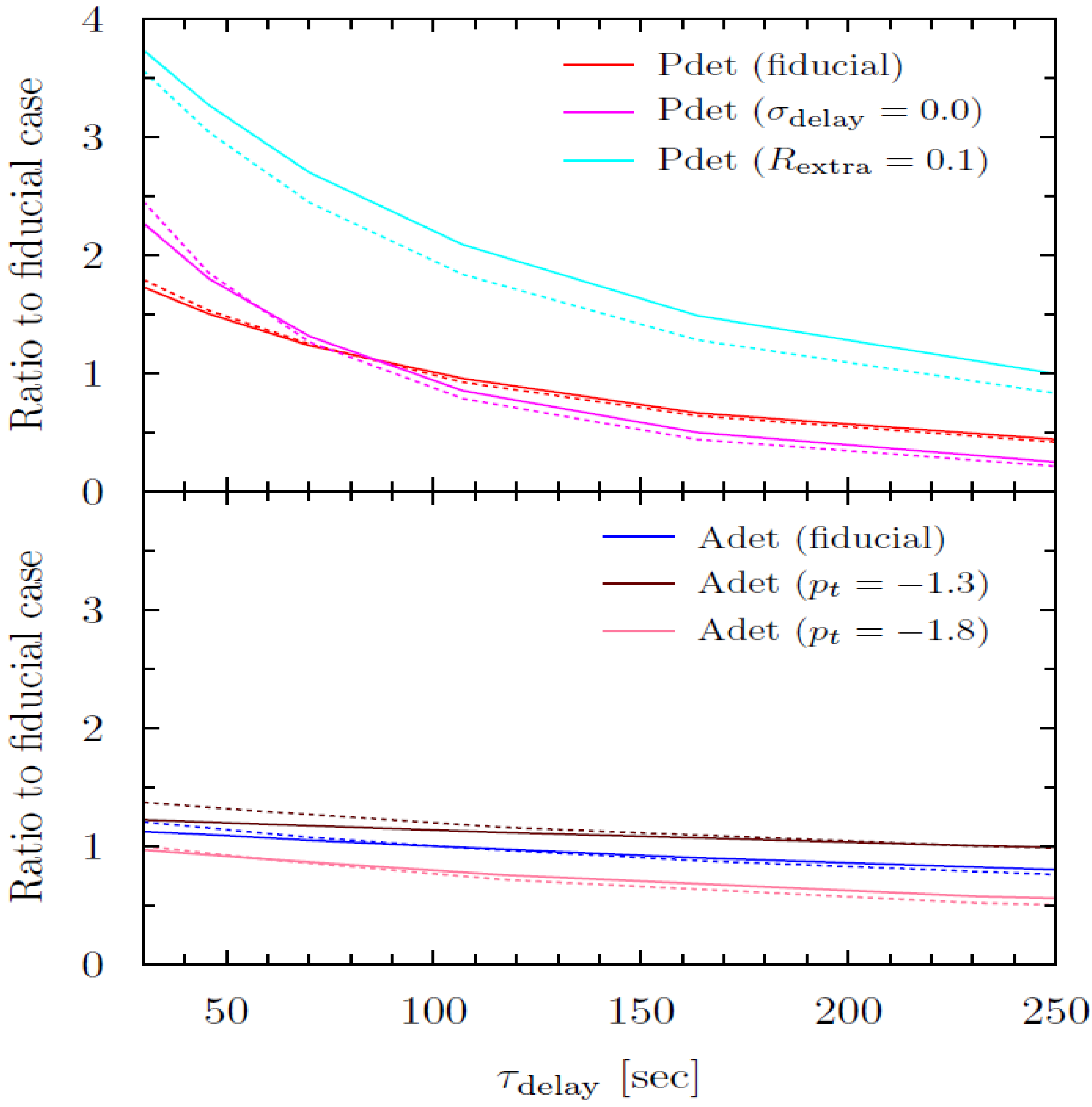
desired

30 sec – 1 min to get on-target

Co-located robotic opt/IR 1-2m telescope for monitoring, redshifts

Swift BAT-XRT light curve of a typical GRB from www.swift.ac.uk/burst_analyser/





Detection rates for various latencies.

(Inoue, Granot, O'Brien et al. 2012, A&A CTA Special Issue)

Current trigger rates

Satellite/instrument	Energy range	Observed GRB rate (yr^{-1})	Typical localisation error (radius)	Typical delay time
Swift BAT	15–150 keV	95	few arcmin	20s
Swift XRT	0.3–10 keV	90	$<3''$	~70s
Fermi GBM	8 keV–40 MeV	250	10°/1-3°	20-300s/20min-2hr
Fermi LAT	20 MeV–300 GeV	10	few deg/10-60′	<1min/4-8hr
INTEGRAL IBIS	20–100 keV	25–50	few arcmin	~60s
Wind-KONUS	50–200 keV	100	-	1-25h
Suzaku WAM	50–5000 keV	95	-	several hrs
MAXI-ISS	2–10 keV	<10	1°	20min-few hrs
IPN	various	few	arcmin-degrees	1-1.5 days
SuperAGILE	10–40 keV	few	few arcmin	1-3 hrs
SVOM Eclairs	4–250 keV	80	7′	10s
SVOM MXT	0.3–7 keV	50	20″	>5 mins

External triggers are vital: need to make the case for such missions – Swift, Fermi, SVOM, A-STAR...

The GRB case for Survey Mode

- GRBs are all-sky: increase detection rate
- Earlier=brighter: fantastic statistics, and limits on LIV
- Unique discovery space for GRBs: probe prompt emission phase for a sample
- Only way to probe short GRBs – so important in AdvLIGO/Virgo and IceCube era

valuable for study of *all* high energy transient phenomena

census of accretion and jet powered objects across the Universe

complimentary to wide-field gamma-ray, X-ray, optical and radio surveys

Survey Mode
requirements and predictions

- MSTs offset to cover max solid angle
- Real-time analysis and reporting
- Time-slot completely flexible, can be split up

Considered 25 MSTs

minimal overlap and no gaps → 2.5% sky coverage

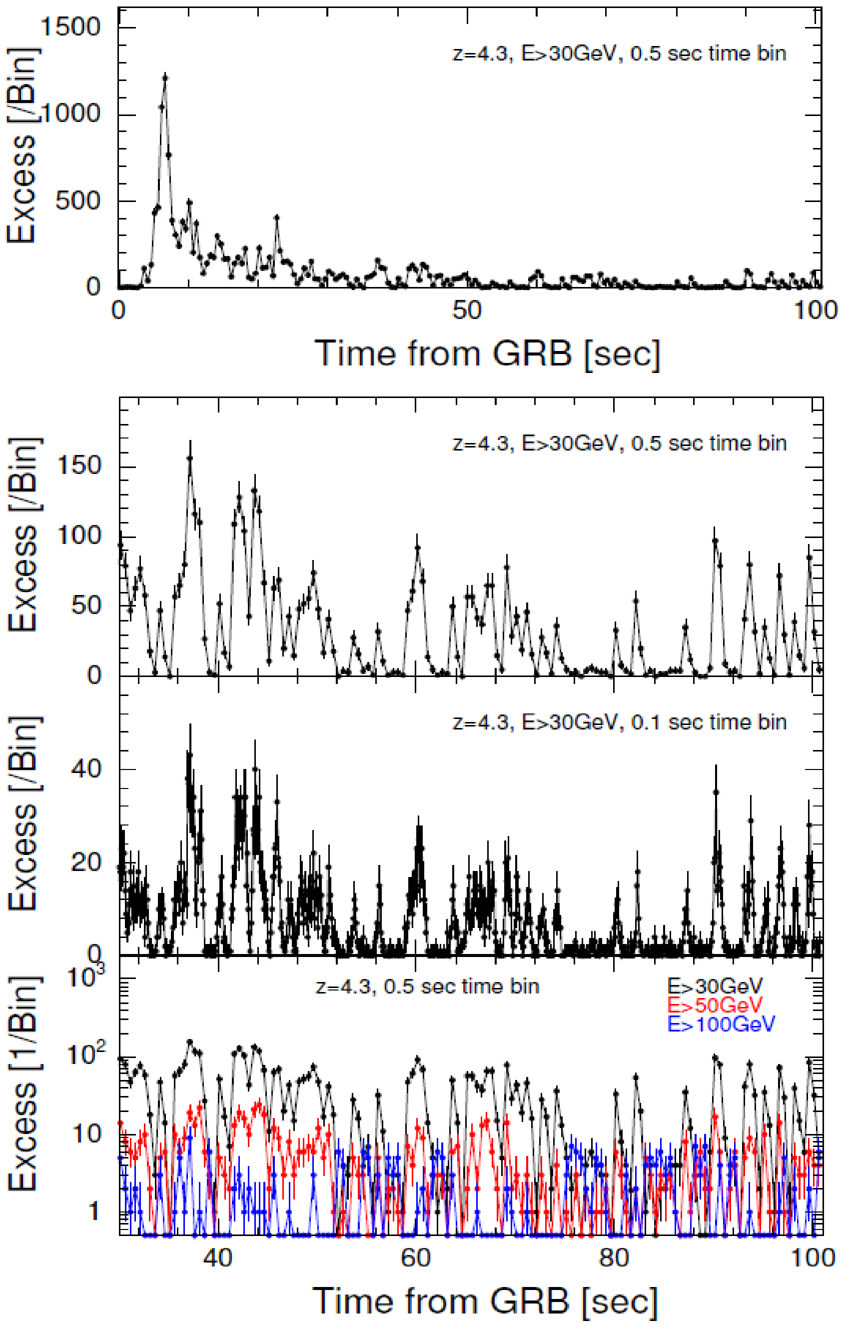
duty cycle 10%

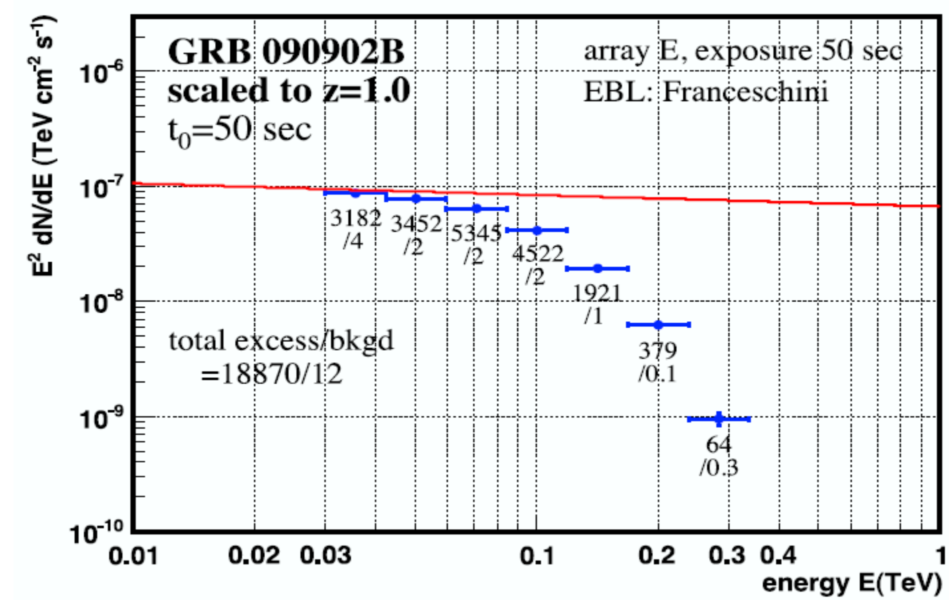
Swift-BAT/Fermi-GBM all-sky yearly rates ~800/600 → **2-3 yr^{-1} $hemisphere^{-1}$** for CTA in a wide-field survey mode

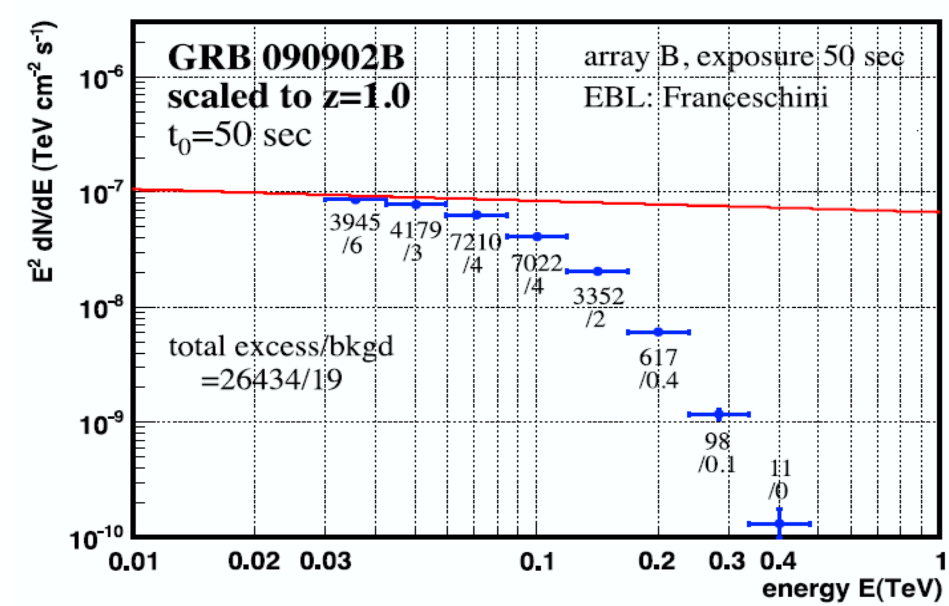
This set-up reaches depths attained by current facilities over much wider area

A wide-field survey mode for CTA

- Do we want/need one?
- What are the main science drivers?
  (transients – GRBs)
- What configuration works best?
  (LSTs/SSTs could continue pointed observations while MSTs perform survey)
- Which patch(es) of sky do we want to cover?
- What fraction of time should be spent in such a mode?
- What other groups interested in transient surveys should we talk to?







Simulations of light curves and spectra based on Fermi LAT GRBs are ongoing by multiple groups for both the following and the finding...