A Link between Prompt Optical and Prompt Gamma-Ray Emission in Gamma-Ray Bursts

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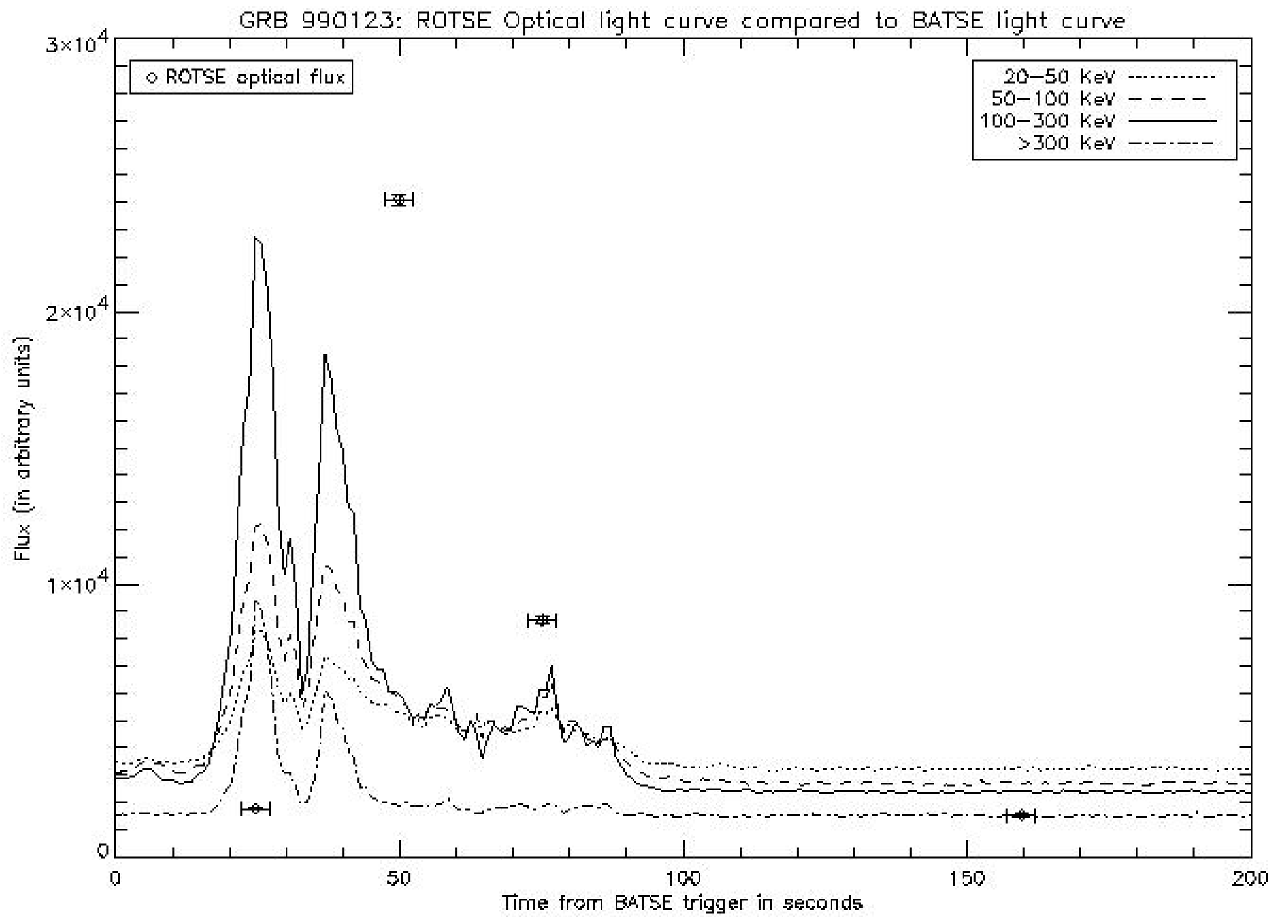
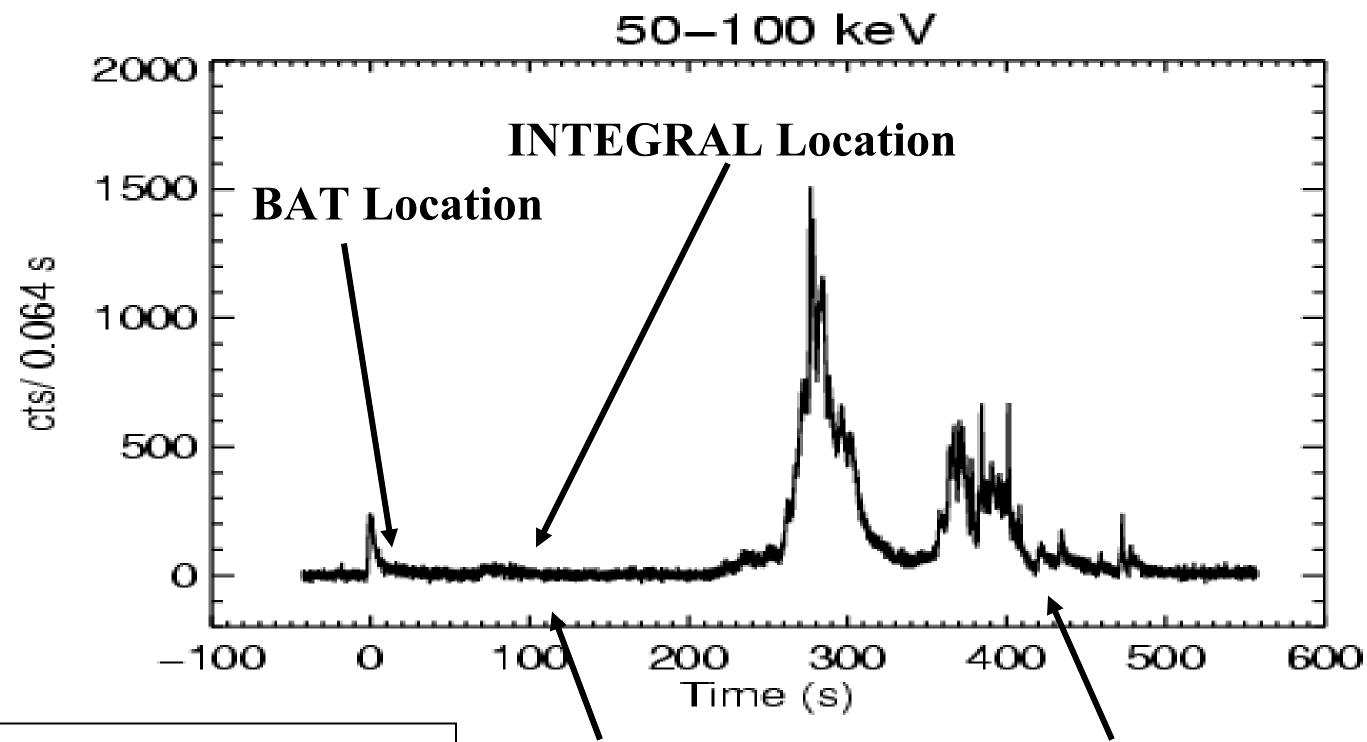
Prompt Emission GRB 990123



GRB 041219



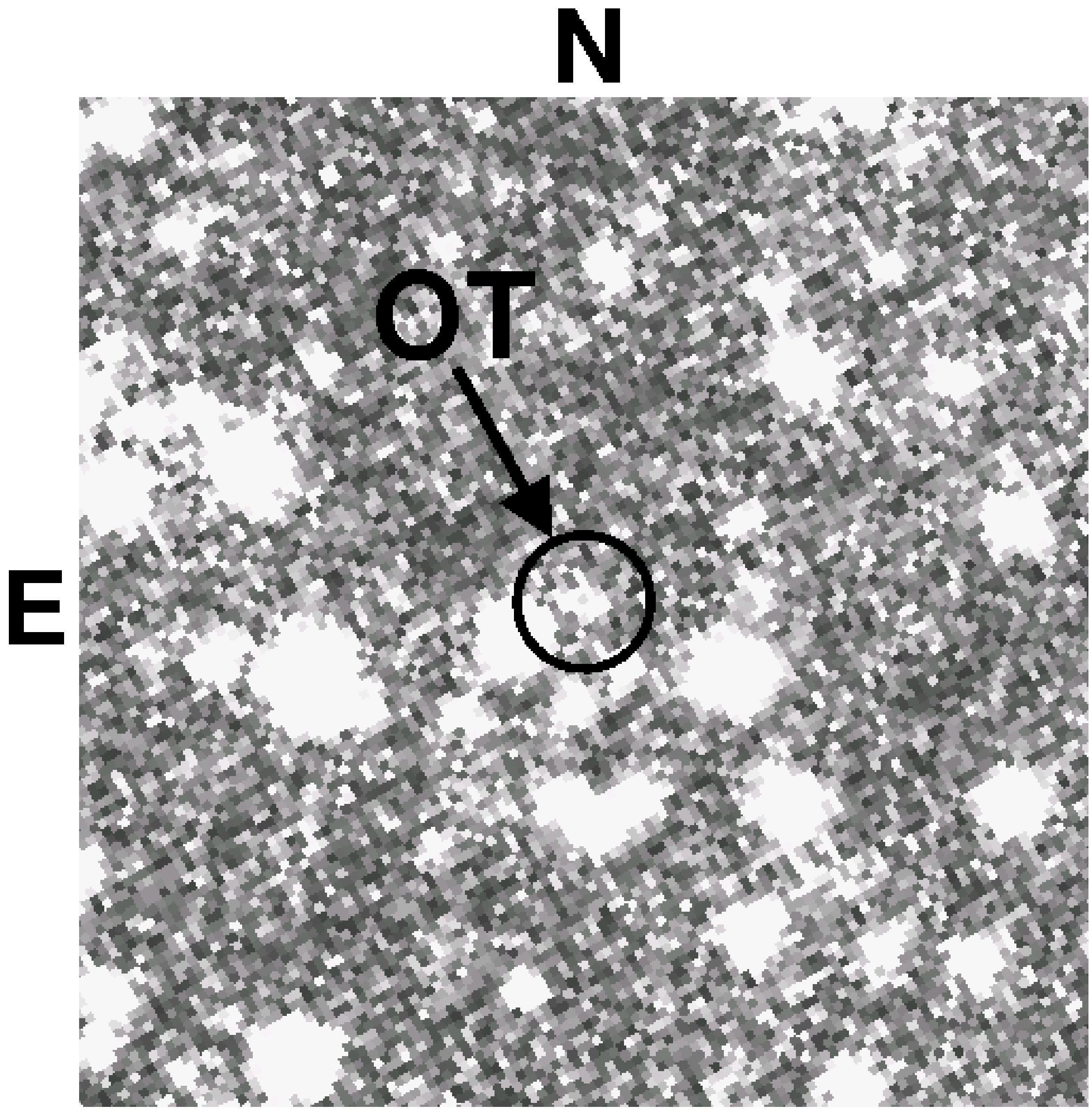
- IR fast-fading counterpart detected
- Radio counterpart also detected

- Fluence of ~1.5×10^{-4} erg cm^{-2} top 1% of BATSE bursts
- Duration in top 2% of CGRO BATSE bursts

RAPTOR GRB 041219 Response

- Observed source for a record 6.4 minutes while prompt gamma rays were being emitted.
- Reached a sensitivity deeper than R=20th magnitude---Reached DSS limit during prompt gamma ray emission
- But, location of event is at $l=120^{o}$, $b=+0.1^{o}$

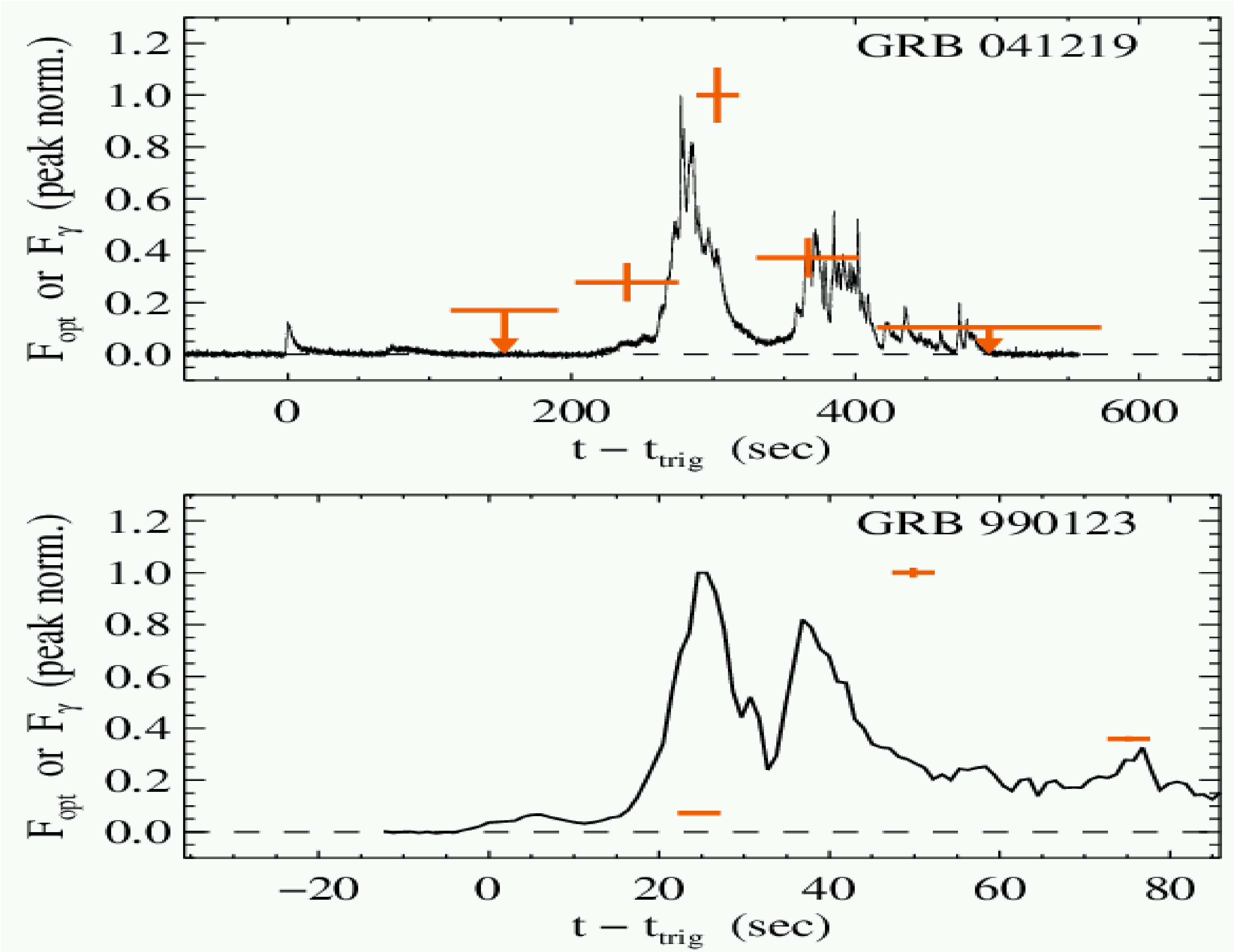
from Schlegel maps→R-band extinction of 4.9 magnitudes.

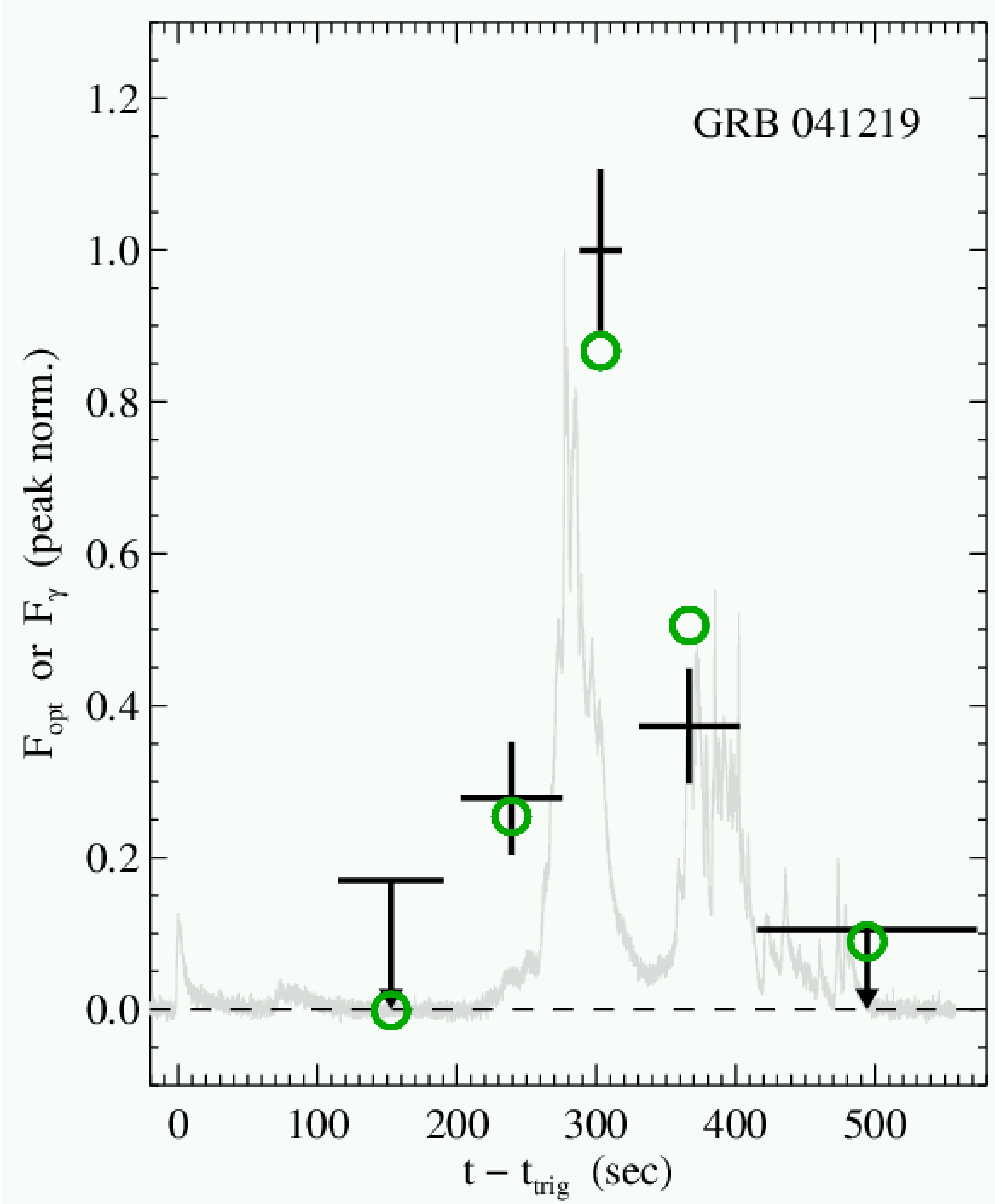


GRB 041219

Derived RAPTOR OT centroid position is identical to Keck afterglow and IR transient position (Blake, Bloom, et al.)

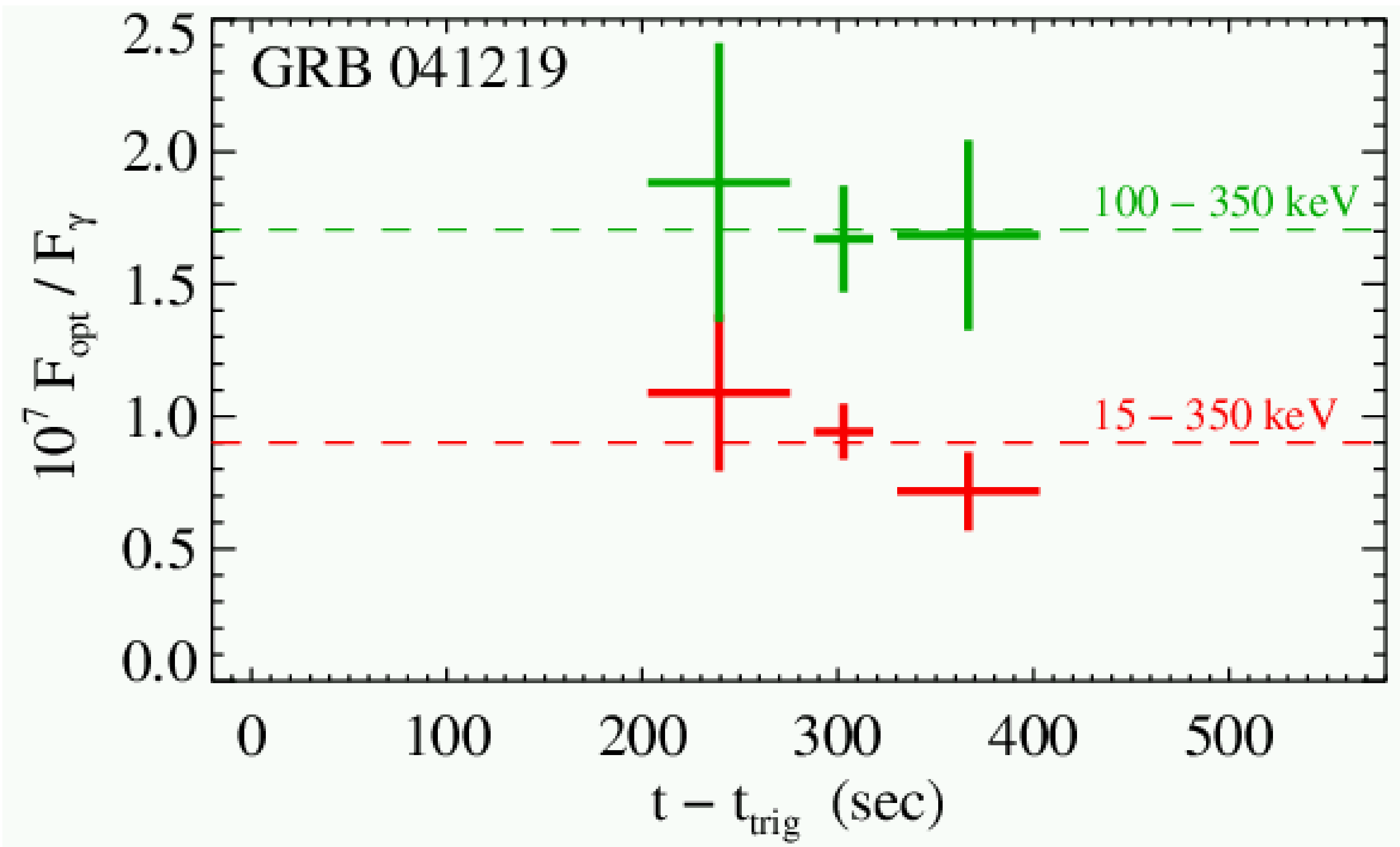
Prompt optical flux peaked at Rc=18.6+/-0.1 mag.→Rc~13.7

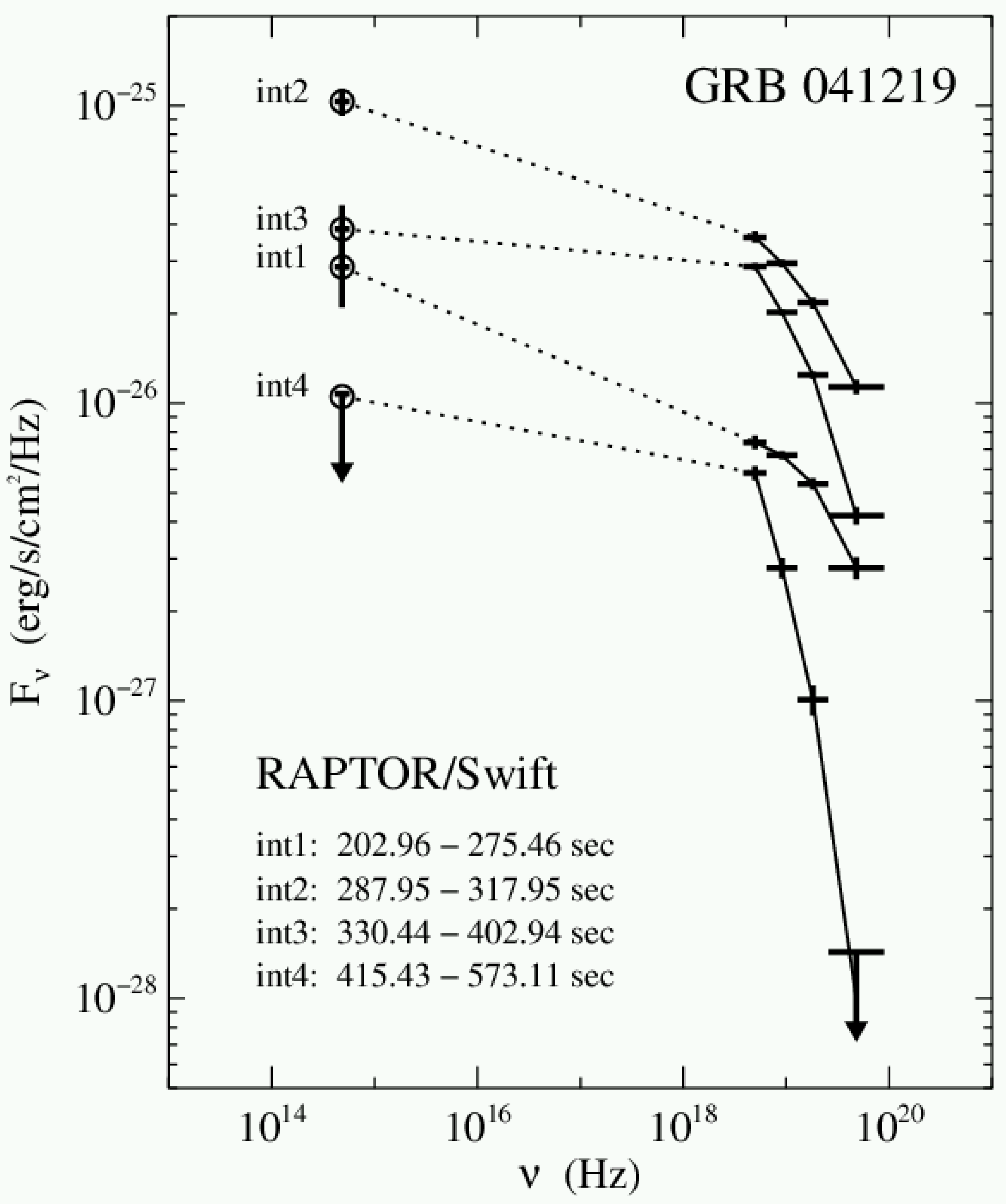

GRB 041219
GRB 990123
F_{opt} or F_{γ} (peak norm.)
$t - t_{trig}$ (sec)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
−20
20
40
60
80



- Predicted optical light curve assuming a constant prompt optical to (15-350 keV) gamma-ray flux ratio.
- Black crosses are RAPTOR measurements.
- Green circles show predicted values.
- Error bars are 1-sigma.
- Upper limits are 2-sigma.

Fluence Ratio





GRB 041219
int2
int3
int1
int4
RAPTOR/Swift
int1: 202.96 – 275.46 sec
int2: 287.95 – 317.95 sec
int3: 330.44 – 402.94 sec
int4: 415.43 – 573.11 sec
10^{-25}
10^{-26}
10^{-27}
10^{-28}
F_ν (erg/s/cm^2/Hz)
10^{14}
10^{16}
10^{18}
10^{20}
ν (Hz)

But why didn't we see this correlated (internal shock) emission in GRB 990123?

- Answer: It was too weak in GRB 990123.

Reverse shock emission quickly outshines it in GRB 990123.

Taxonomy of GRB Optical Emission in three classes

- Prompt Optical Emission varying simultaneously with prompt gamma-rays.
- Early Afterglow Emission that may start during prompt gamma-rays, but persists after gamma-rays fade.
- Late Afterglow Emission that can last for hours to days.

In the Standard Theoretical Framework it makes sense to attribute the components to

- Prompt optical emission is generated by internal shocks in ejecta---driven by engine.
- Early afterglow is a reverse shock driven into ejecta by interaction with surroundings.
- Late afterglow is generated by forward external shocks driven into surrounding medium.

- The theoretical framework allows predictions about the timing, spectra, and relative strength of the components that hinge on properties of the inner engine, the ejecta, and the surrounding medium.

Conclusion

Real time triggers from Swift, combined with Panchromatic Observations by Swift,plus the Armada of Ground-based rapid response telescopes will yield, altogether, an exciting new era for studying the critical first few minutes of GRBs.