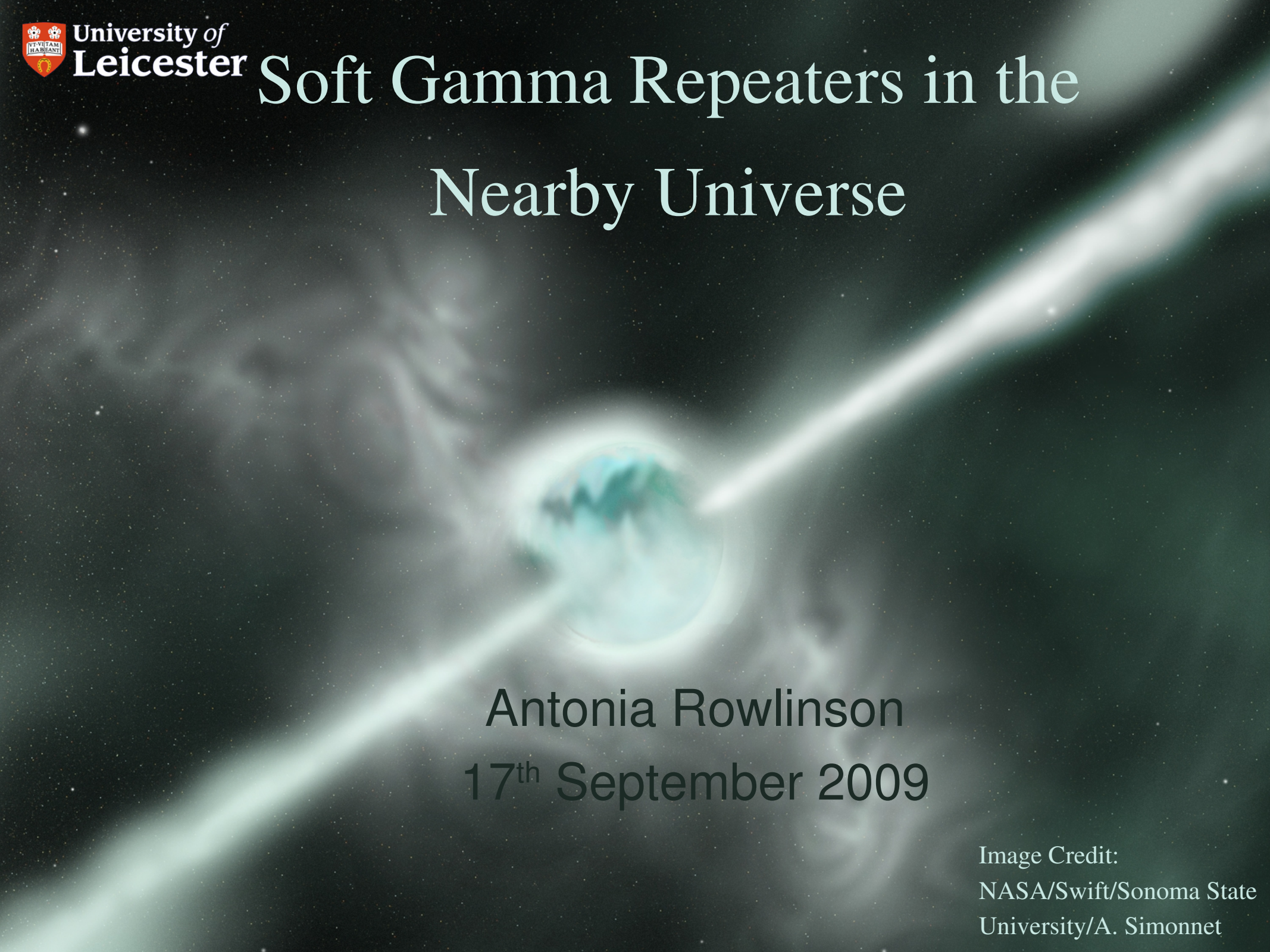

University of Leicester

Soft Gamma Repeaters in the Nearby Universe

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17th September 2009

Image Credit:
NASA/Swift/Sonoma State University/A. Simonnet

Outline

1. Soft Gamma Repeaters in the Milky Way

2. Extra-galactic Soft Gamma Repeaters

3. Using the E-ELT to study Extra-Galactic Soft Gamma Repeater candidates

Soft Gamma Repeaters (SGRs)

Credit: NASA, CXC, M. Weiss

- Identified during active periods by satellites looking for Gamma-Ray Bursts (GRBs)
- Thought to be highly magnetised young neutron stars (magnetars) (Duncan & Thompson 1992)
- Emit bursts of gamma-rays when active and X-rays in quiescence
- Extremest magnetic fields in the known universe, ~10^{15} G, and fast rotation periods (~5-8 s)

Known Galactic SGRs

- Expected to be found in a region with recent star formation (Duncan & Thompson 1992, Thompson & Duncan 1995, Mereghetti 2008)
- Associated with a cluster of massive stars
  - SGR 1806-20 (Atteia et al. 1987, Fuchs et al. 1999)
- We would not expect to see these things if SGRs can be formed by accretion induced collapse following the merger of two CO white dwarfs (King, Pringle and Wickramasinghe 2001, Levan et al. 2006)
  - SGR 1806-20 (Hurley et al. 1994)
  - SGR 1627-41 (Hurley et al. 1999a)
  - SGR 1900+14 (Hurley et al. 1999b)
  - Possibly SGR 0501+4516 (GCN 8149)

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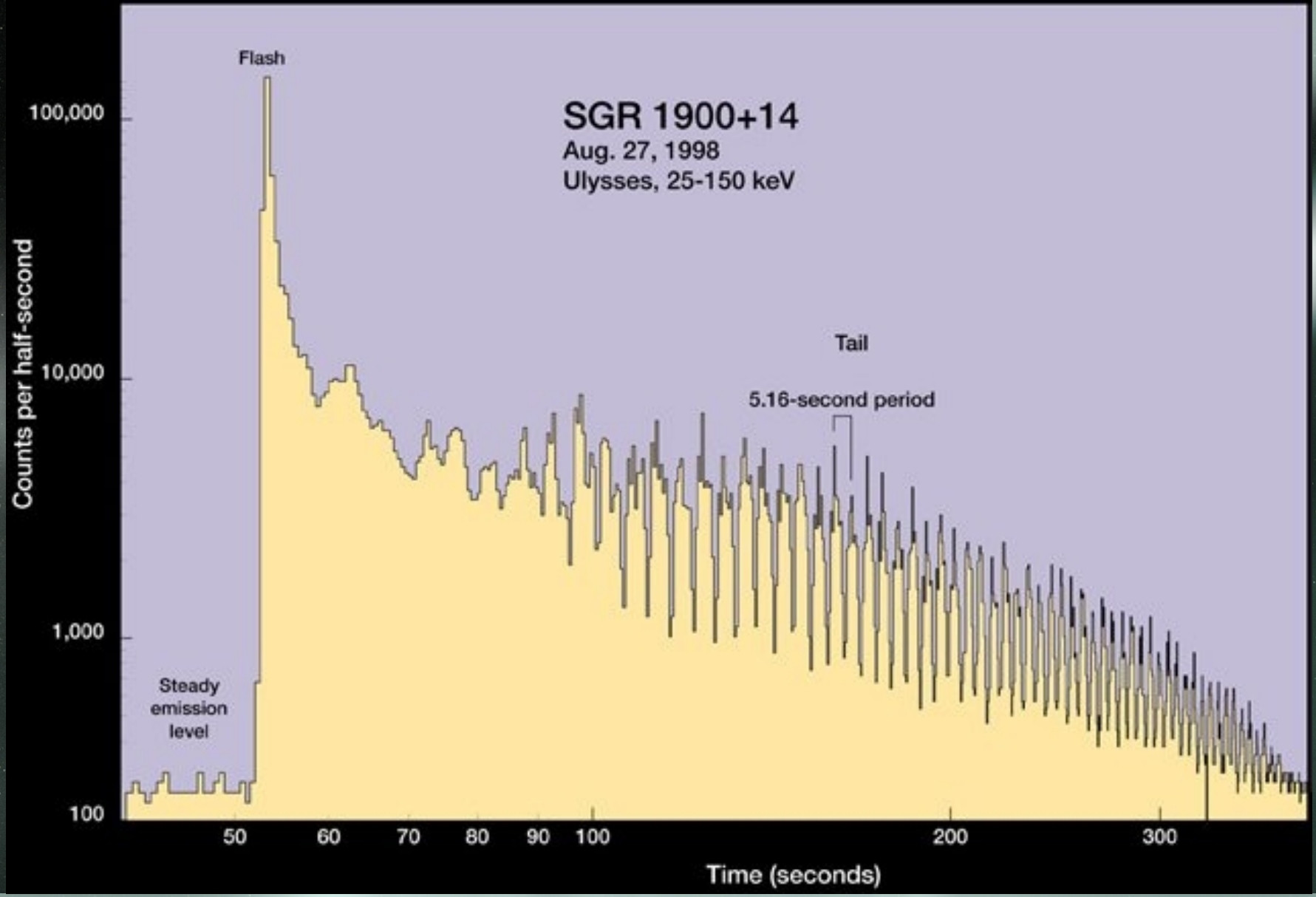
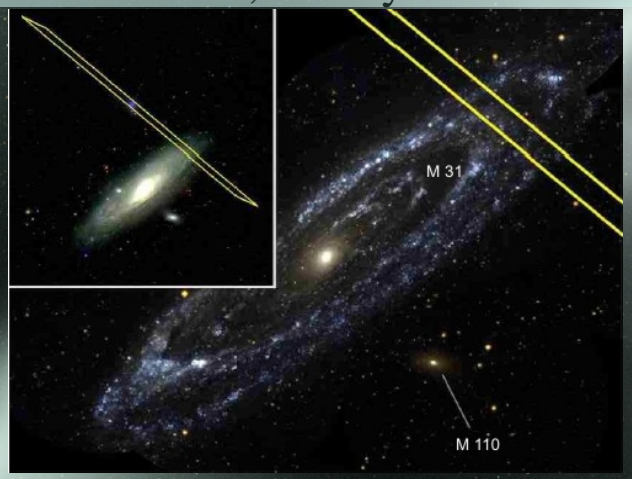
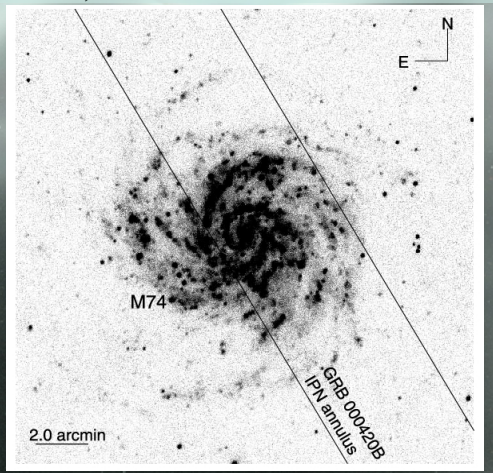


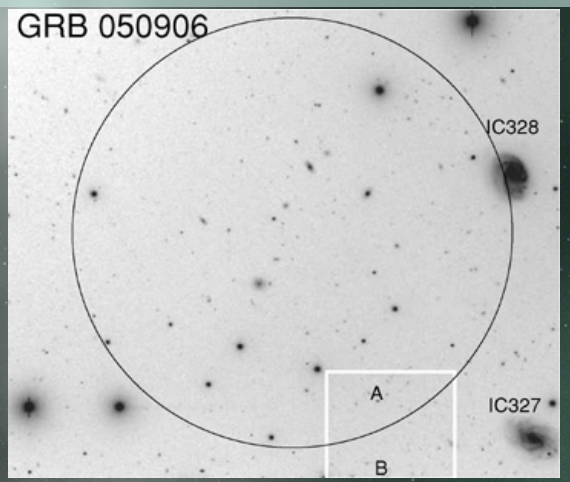
The 27th December 2004 Giant Flare from SGR 1806-20 was the brightest observed transient event. If seen from a great distance, the peak of the emission would be observable out to tens of Mpc (Hurley et al. 2005, Palmer et al. 2005)

Candidate Extragalactic Giant Flares

- An extra-galactic Giant Flare would look like a Short Hard GRB with a nearby host Galaxy. They are expected to contribute to the population of observed Short GRBs. Candidates include:
  - GRB 070201 near M31(Ofek et al. 2008, Mazets et al. 2008)
  - GRB 000420B near M74 (Ofek 2007)
  - GRB 050906 near IC328 (Levan et al. 2008)
  - GRB 051103 near M81(Ofek et al. 2006, Frederiks et al. 2007, Rowlinson et al. Submitted, Hurley et al. Submitted)

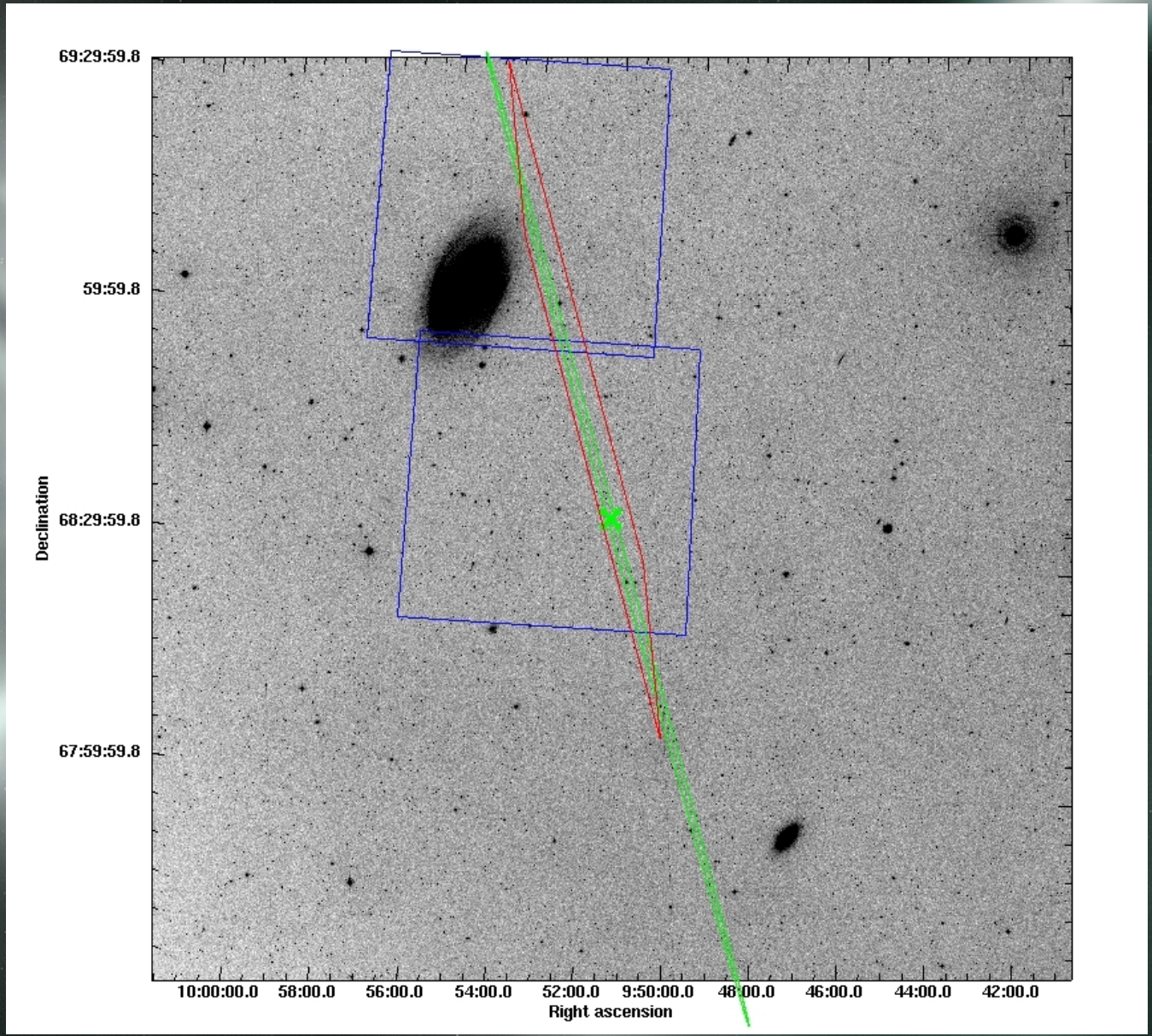






GRB 051103

- In red, is the original error trapezium published by the IPN
- The blue boxes show the regions studied by the Kitt Peak National Observatory
- The green ellipse is the refined 3σ error ellipse (Hurley et al. Submitted)



A Short GRB?

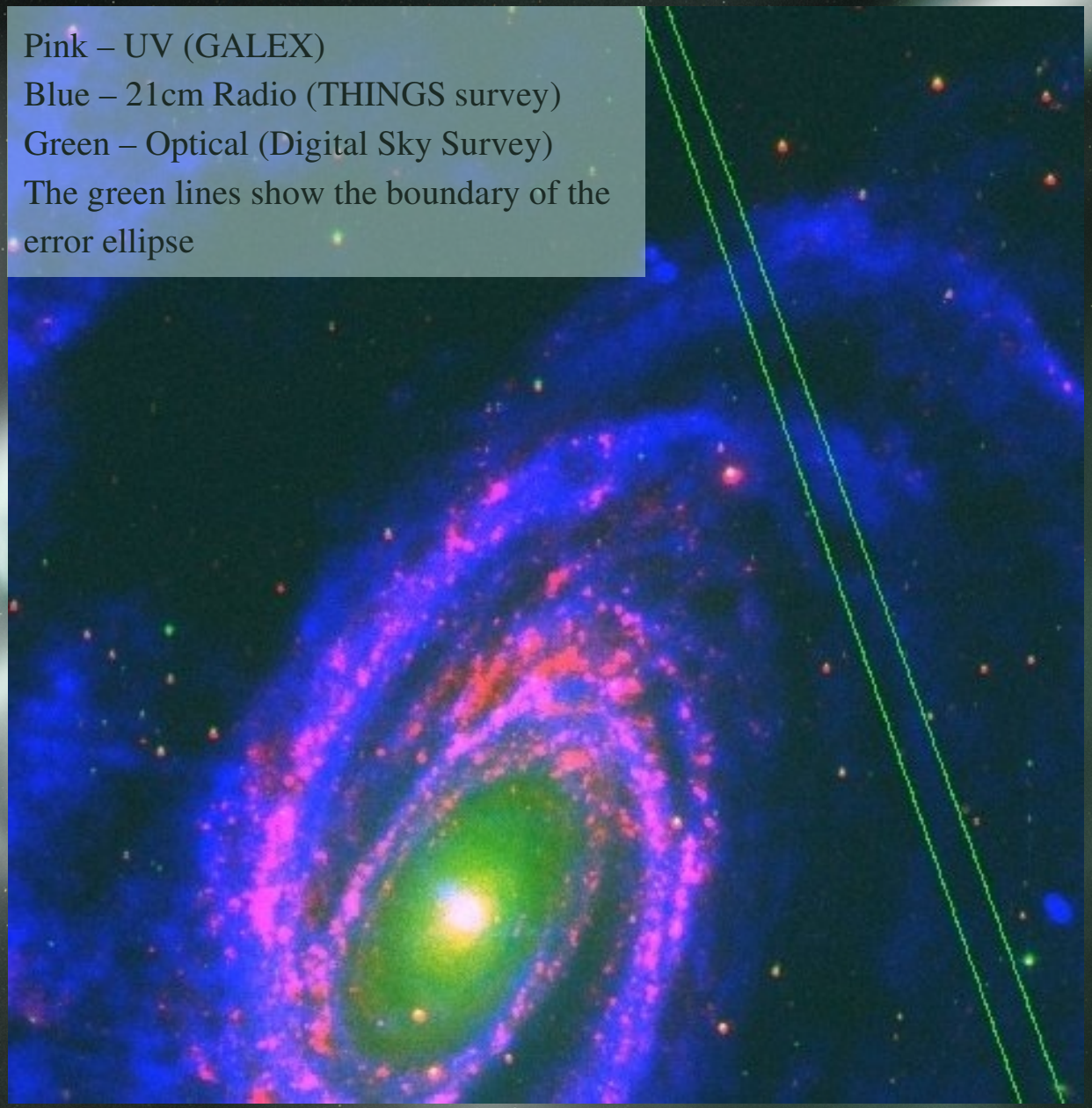
Table 1. The observed fluence, in the energy band 15-150keV, of SGRBs with observed R band magnitudes at approximately 3 days.

SGRB	Fluence 10^{-7} erg cm^{-2}	R band Magnitude at 3 days
051221A	11.6 ± 0.4 (1)	24.12 ± 0.28 (2)
051227	2.3 ± 0.3 (3)	25.49 ± 0.09 (4)
060121	$26.7^{+5.3}_{-20.2}$ (5)	25 ± 0.25 (6)
060614	217 ± 4 (7)	22.74 ± 0.31 (8)
061006	14.3 ± 1.4 (9)	$>23.96\pm0.12$ (10)
070707	$0.334^{+0.753}_{-0.316}$ (11)	26.62 ± 0.18 (12)
070714B	7.2 ± 0.9 (13)	<25.5 (14)
071227	2.2 ± 0.3 (15)	>24.9 (16)
080503	20.0 ± 1 (16)	25.90 ± 0.23 (17)

- Using table 1, we predict the R band magnitude of the afterglow of 051103 to be ~24 at 3 days – within the limiting magnitude of our images
- There are GRBs with little optical afterglow (dark bursts) which would not be detectable
- GRB 051103 would be at the extreme end of the short hard bursts detected by Swift (Sakamoto 2008)

An SGR Giant Flare?

- Predicted R band magnitude at 3 days would be ~34
- Progenitor is a young neutron star, hence may expect to find:
  - Star formation
  - Supernova remnant
  - Massive star clusters
- The probability that 051103 and 070201 (near M31) are both SGR giant flares is ~0.6% (Chapman, Priddey & Tanvir 2009)



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E-ELT & Extra-Galactic SGRs

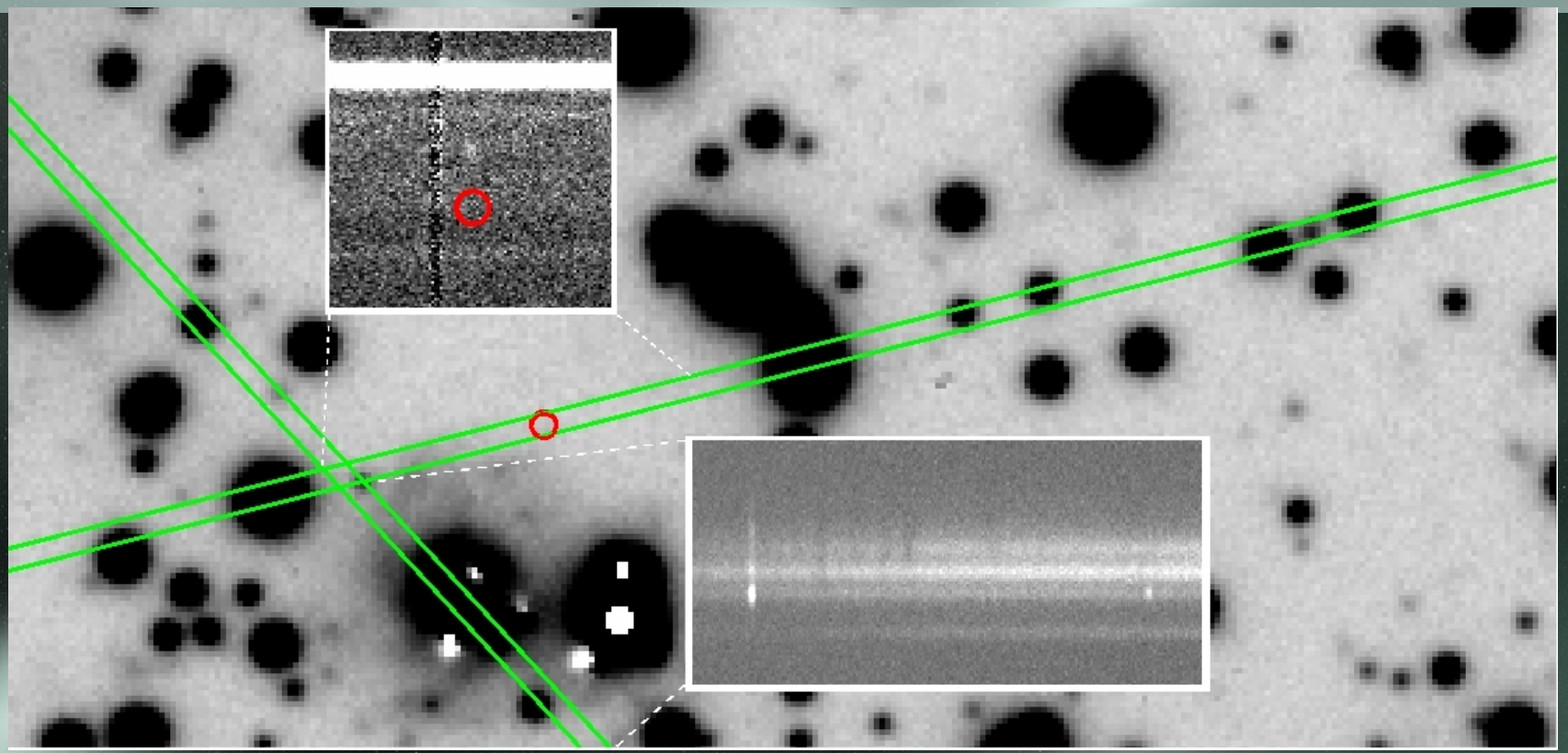
- With a rapid response, E-ELT's high spatial resolution and deep imaging could identify the afterglow of the Giant Flare

K-band Magnitude Predictions for a Giant Flare in M81	
Time	Magnitude
86s (peak)	20
10 mins	21
1 hour	26

- The high spatial resolution could:
  - Identify associated supernovae remnants (if present)
  - Resolve massive star clusters (if present)
  - Study the local stellar population
- High spectral resolution can be used to study the local star formation rate, metallicity and the stellar population

Using E-ELT to study host galaxies

- With the high spectral resolution of the spectrograph instruments on E-ELT, we could study specific regions of host galaxies in detail
- This has been completed for a small sample of GRBs, e.g. GRB 080905A (Rowlinson et al. In prep.)



Conclusions

- We expect to observe Giant Flares from Extra-Galactic SGRs but none has been confirmed
- Studying Galactic SGRs can place constraints on the afterglows of Giant Flares and the local environment of the SGR
- Combining constraints from Galactic SGRs and the very high resolving power of the E-ELT, we are more likely to identify a Giant Flare from an Extra-Galactic SGR
- This could then place constraints on the number of Short GRBs which may be Giant Flares from SGRs