What Would the Remnant of a GRB Look Like?

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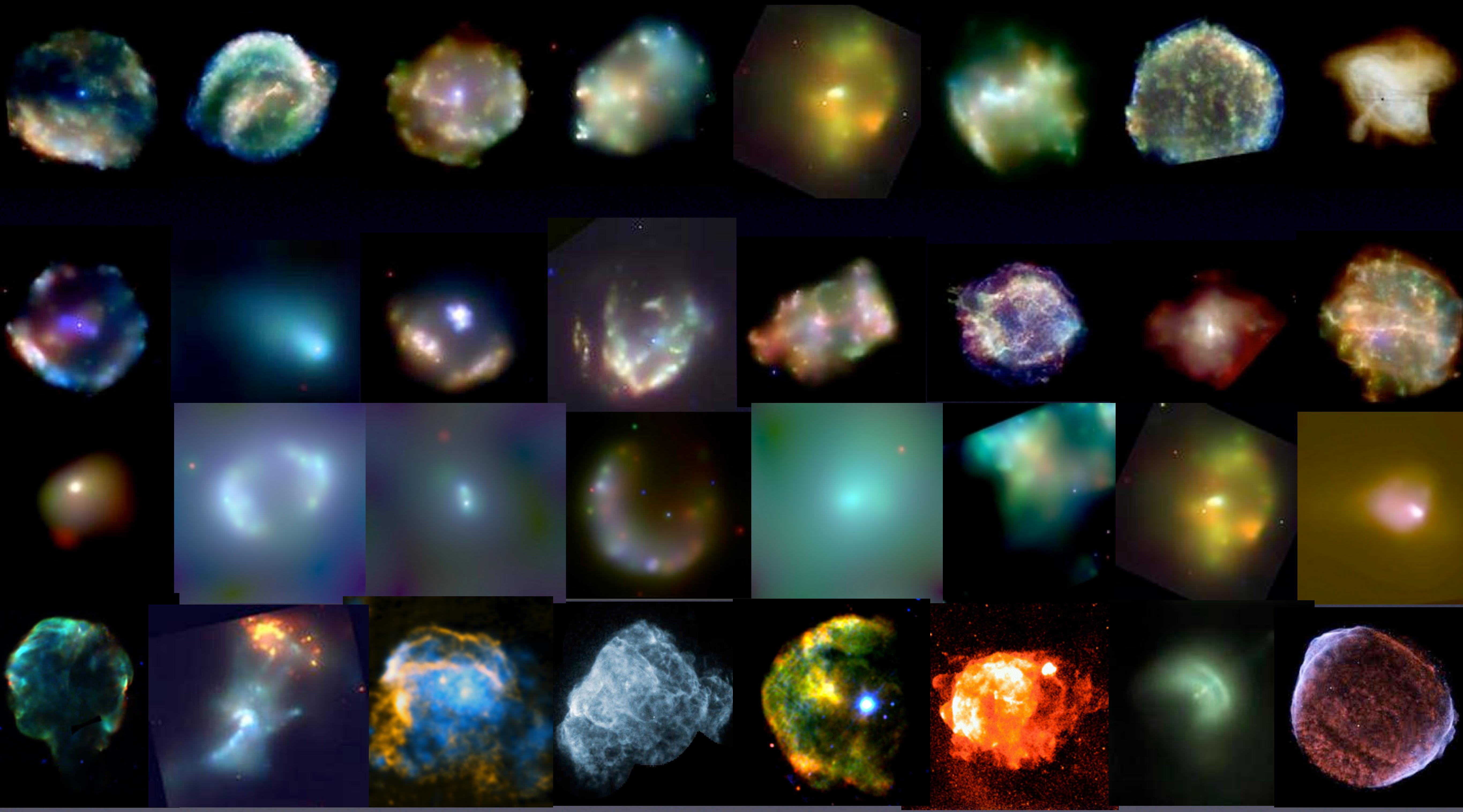
GRBs to Galaxies
22 September 2013

Supernova Remnants

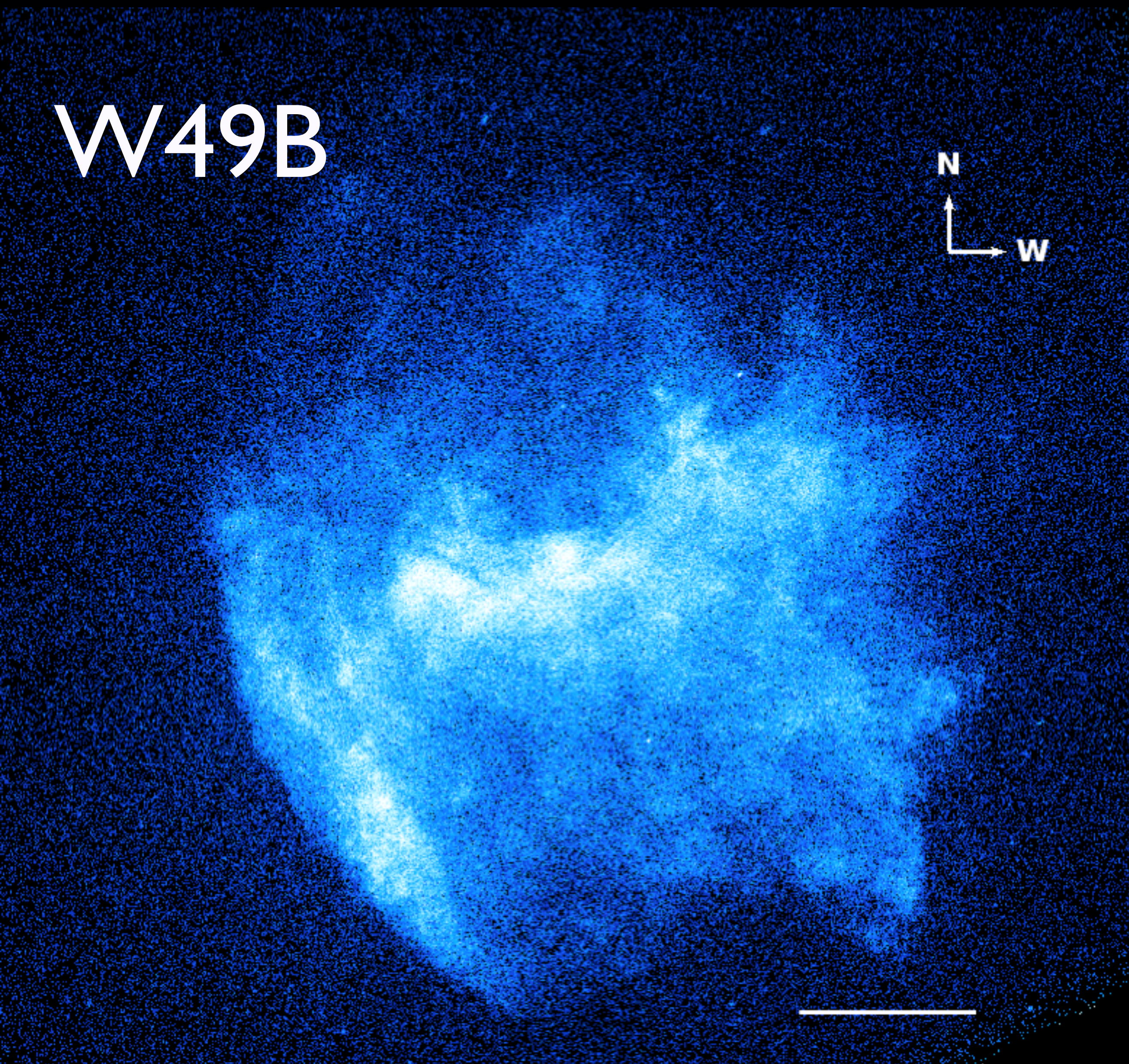


A GRB in the Milky Way?

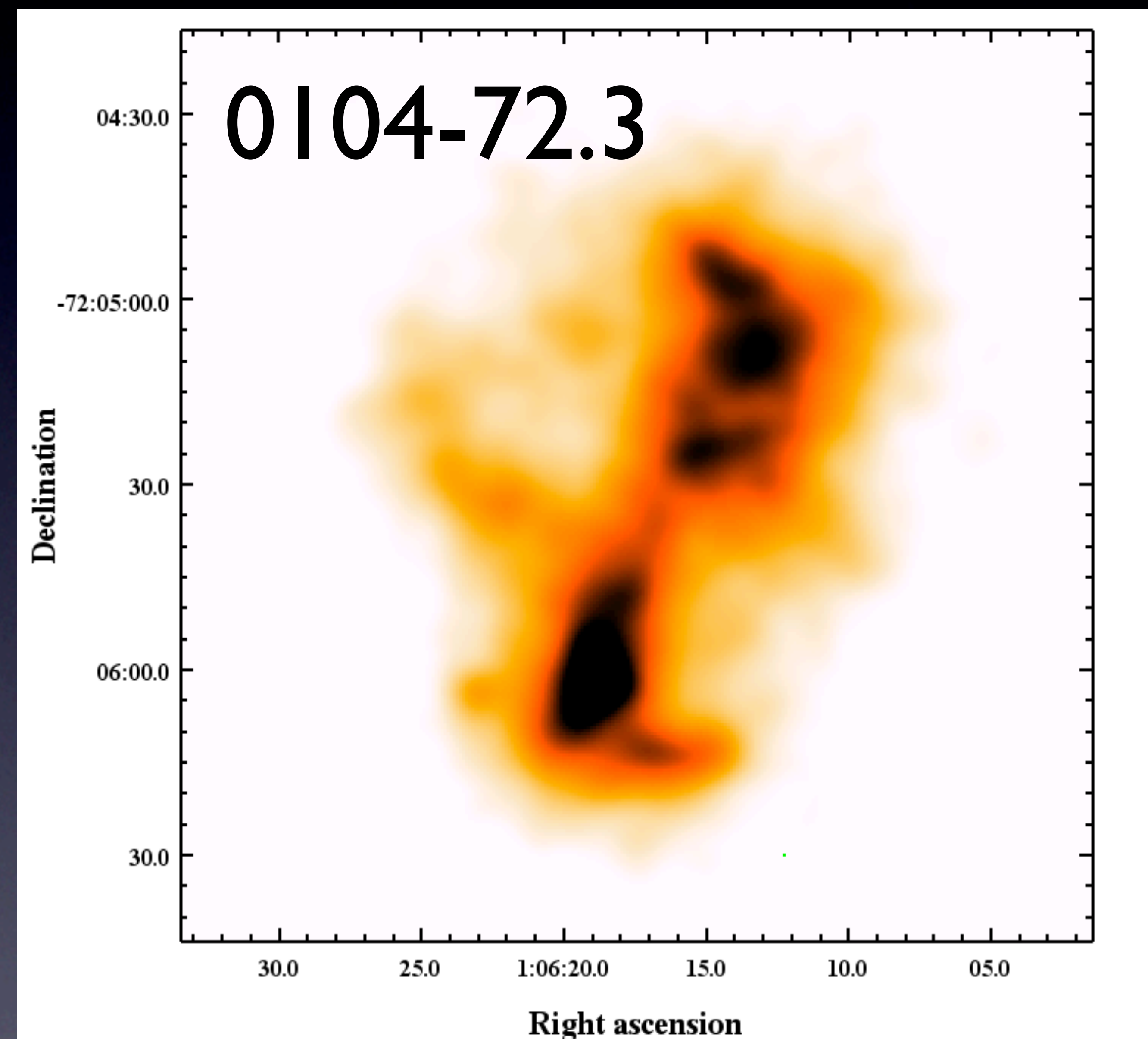
One SN / 40 years	~300 known SNRs
↓	↓
Two CC / 100 years	~200 CC SNRs
↓	↓
One Type Ib/c / 200 years	~50 Type I b/c SNRs
↓	↓
A few % are bipolar or HNe = 1 / 10000 yrs	~1 SNR was bipolar / HNe

So... How Do We Tell?

Two Examples of Jet-Driven Explosion SNRs



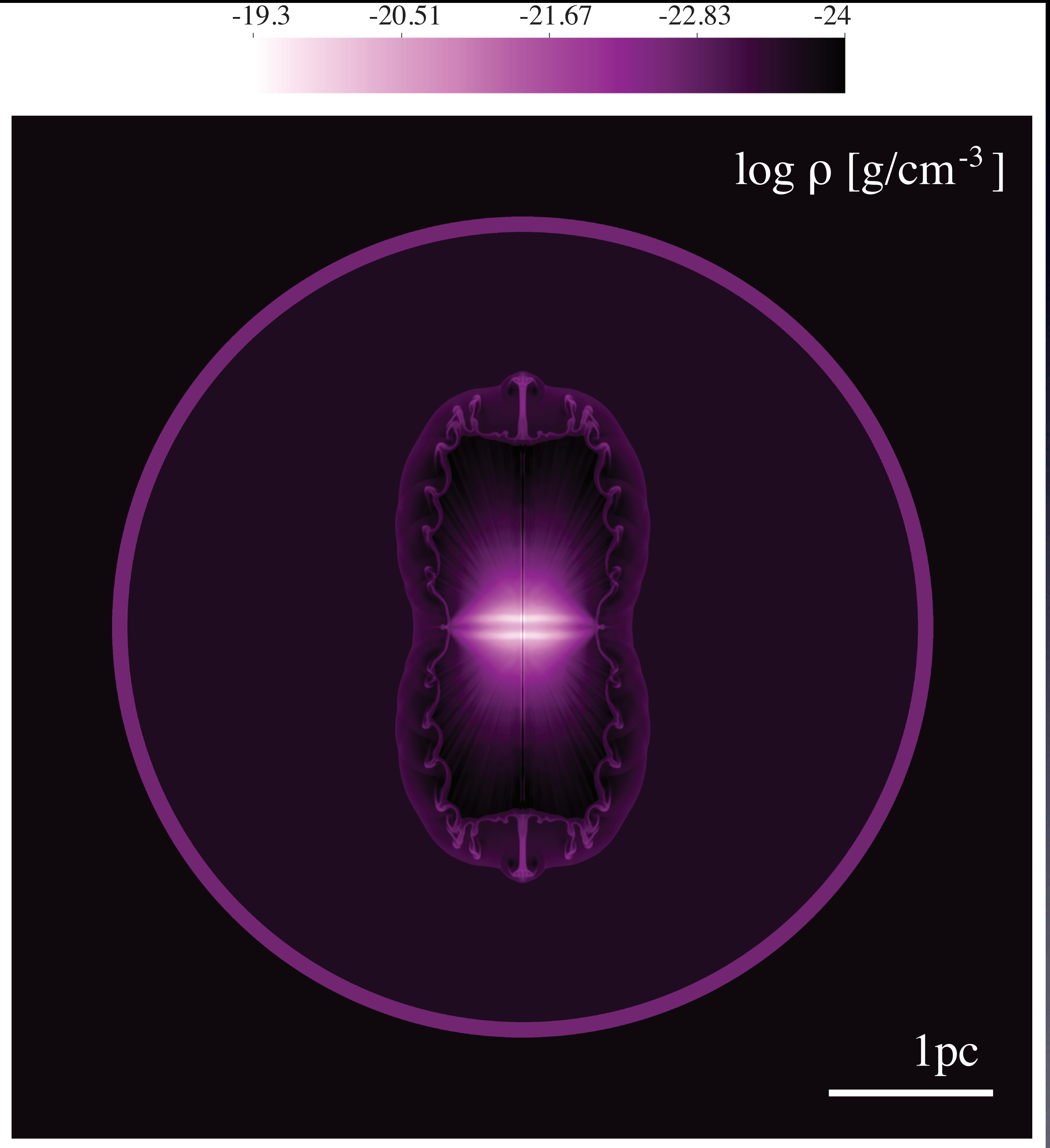
Lopez et al. 2013a



Lopez et al. 2013d

What Observables Are Expected from a GRB Remnant?

1. Bipolar / jet structure



Gonzalez-Casanova et al. 2013

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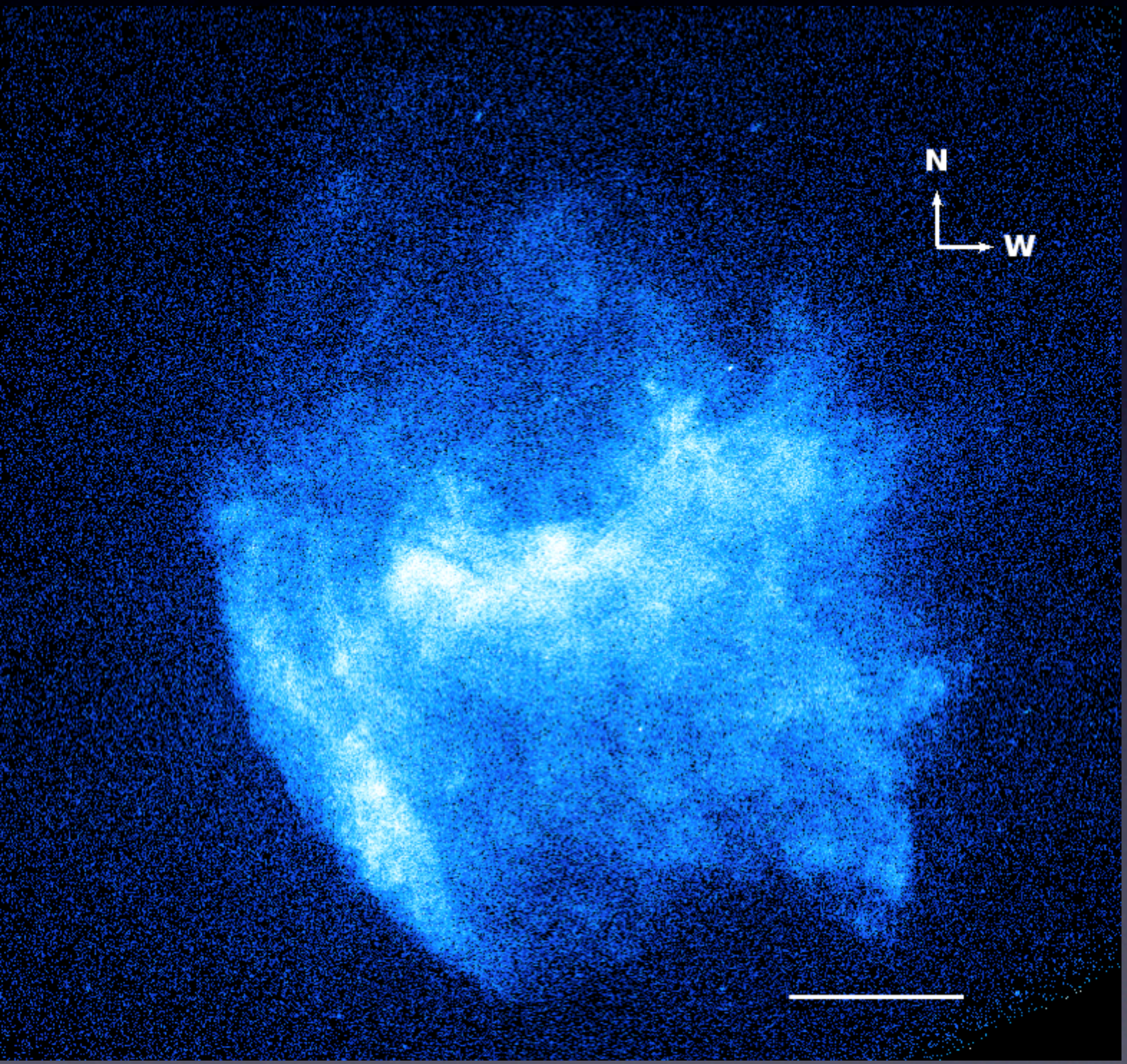

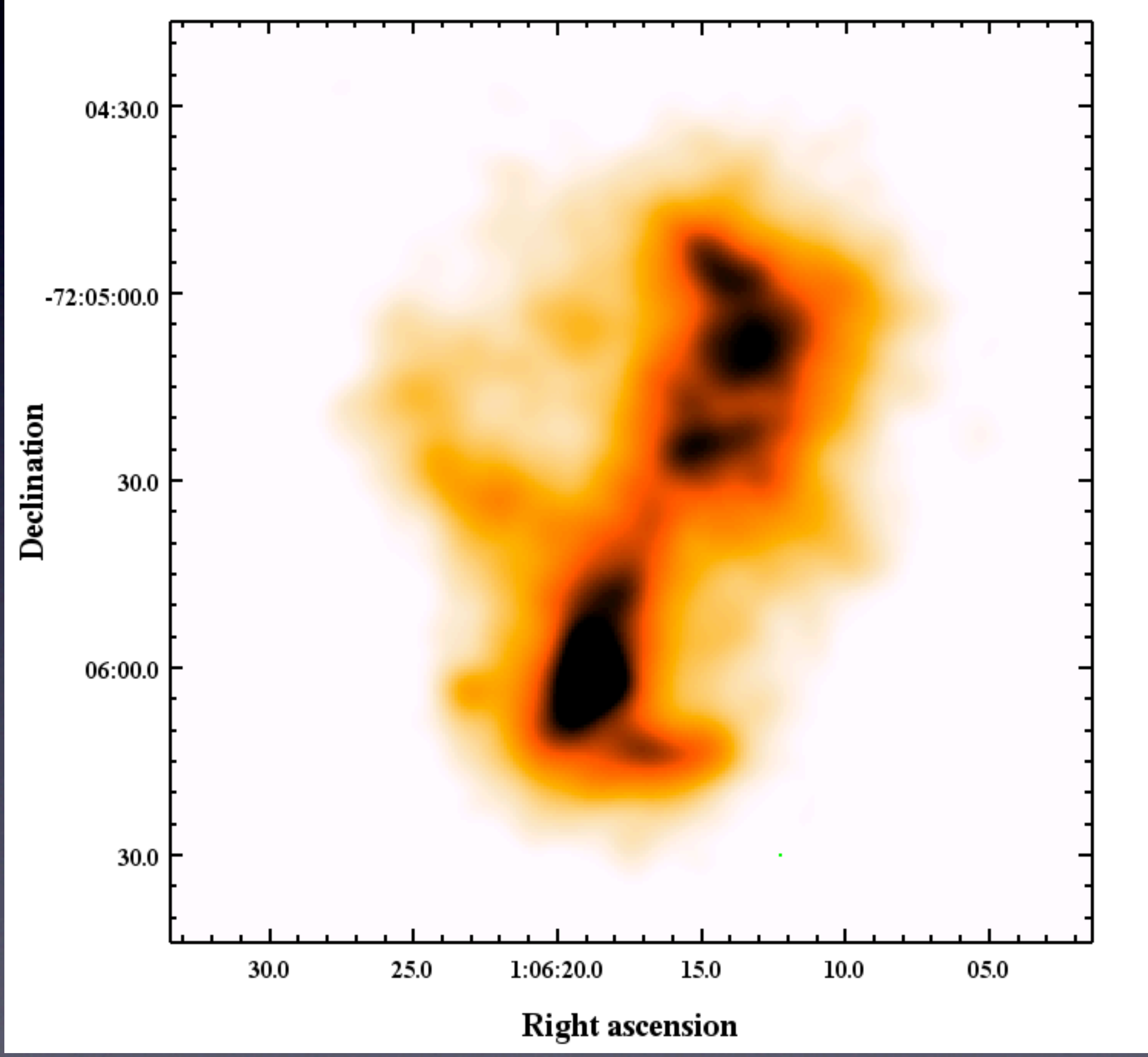

Lopez et al. 2013a

Lopez et al. 2013d

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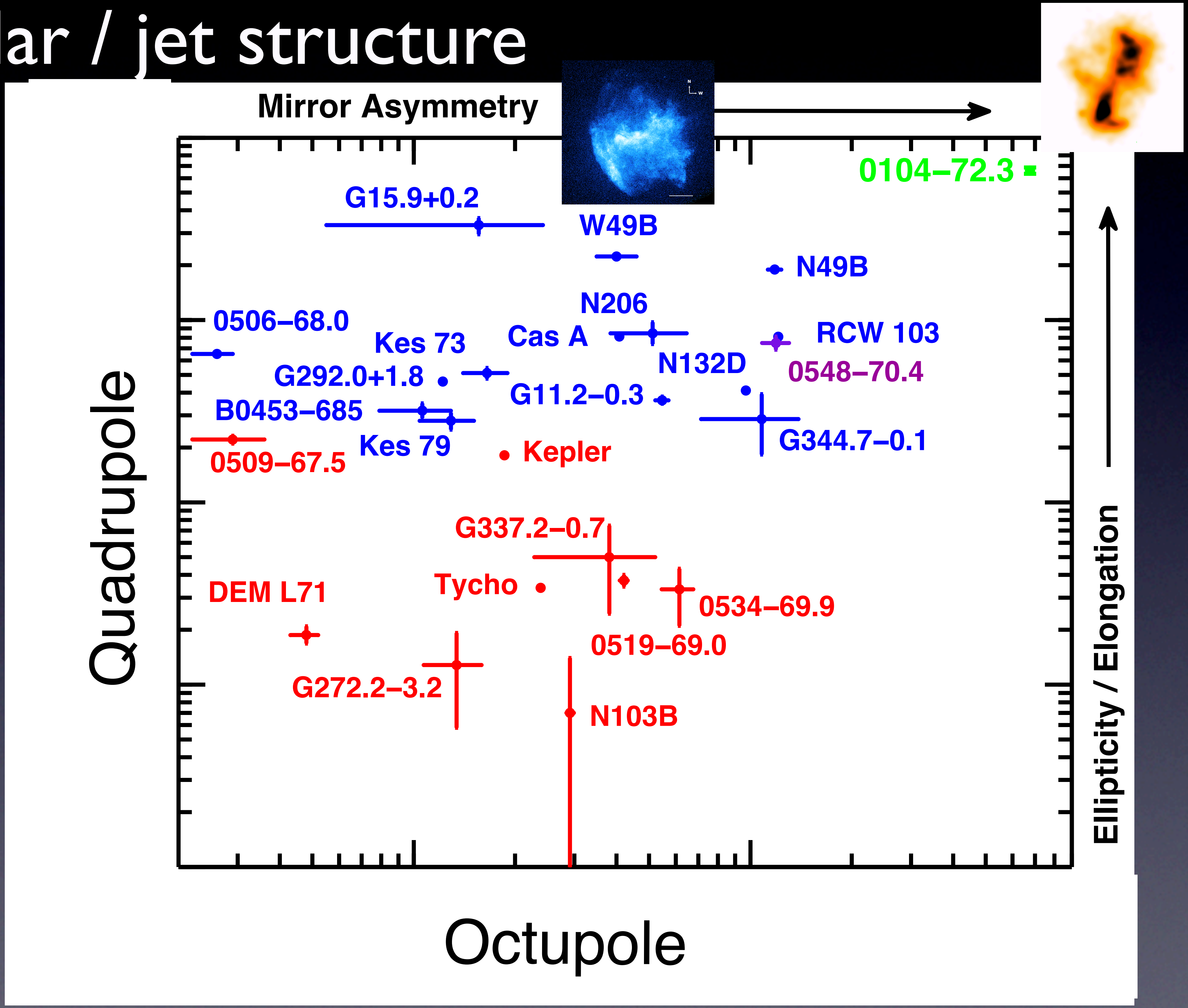
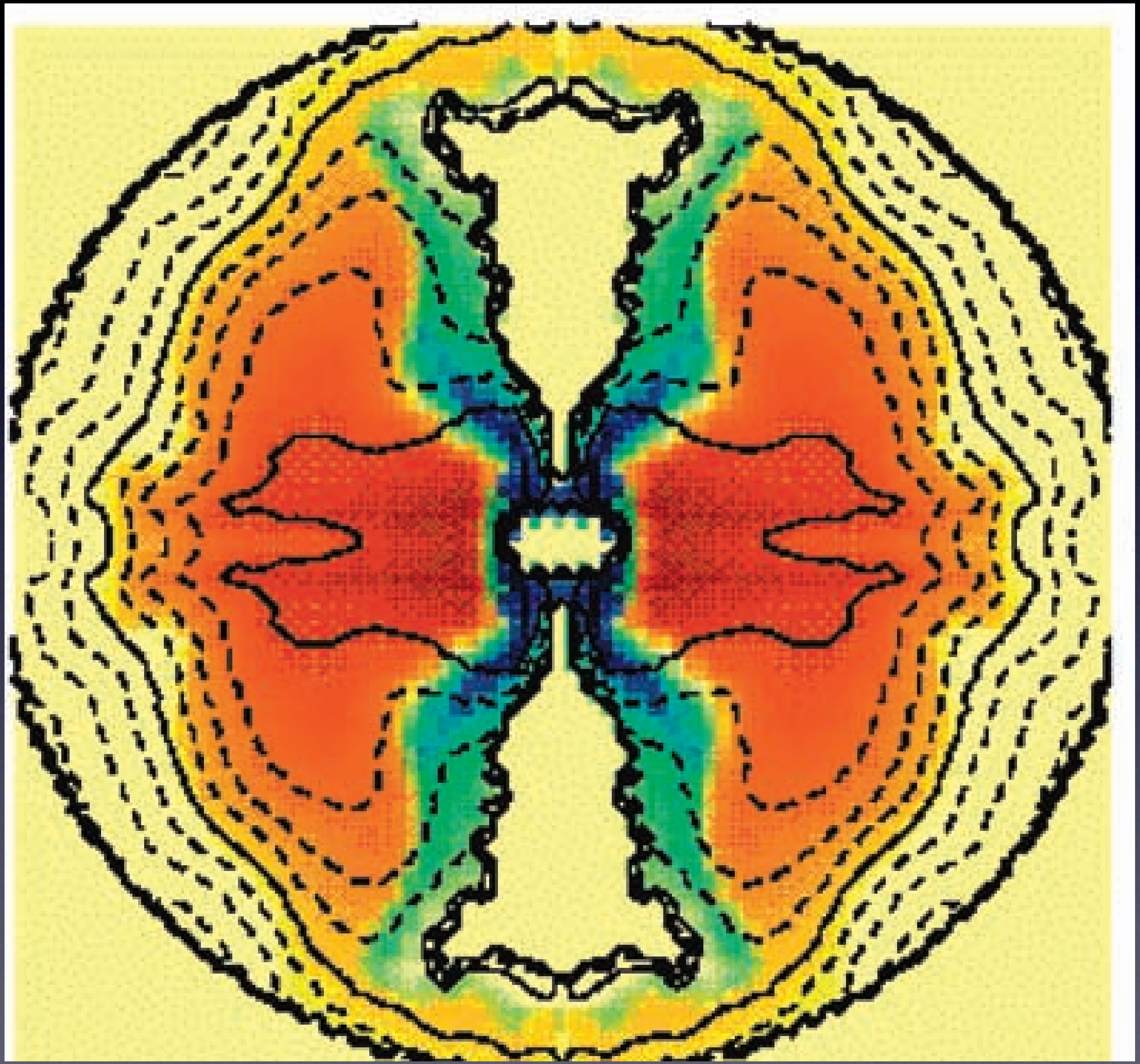


Lopez et al. 2013d

What Observables Are Expected from a GRB Remnant?

2. Jet should be enhanced in heavy metals



Nickel; Oxygen

Mazzali et al. 2006

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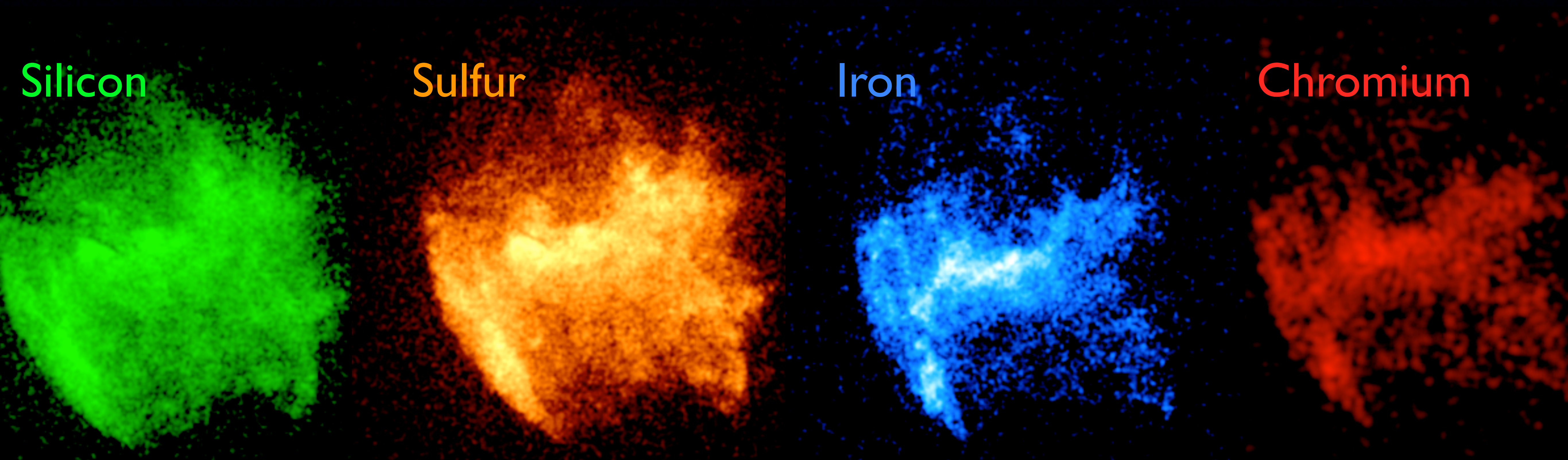
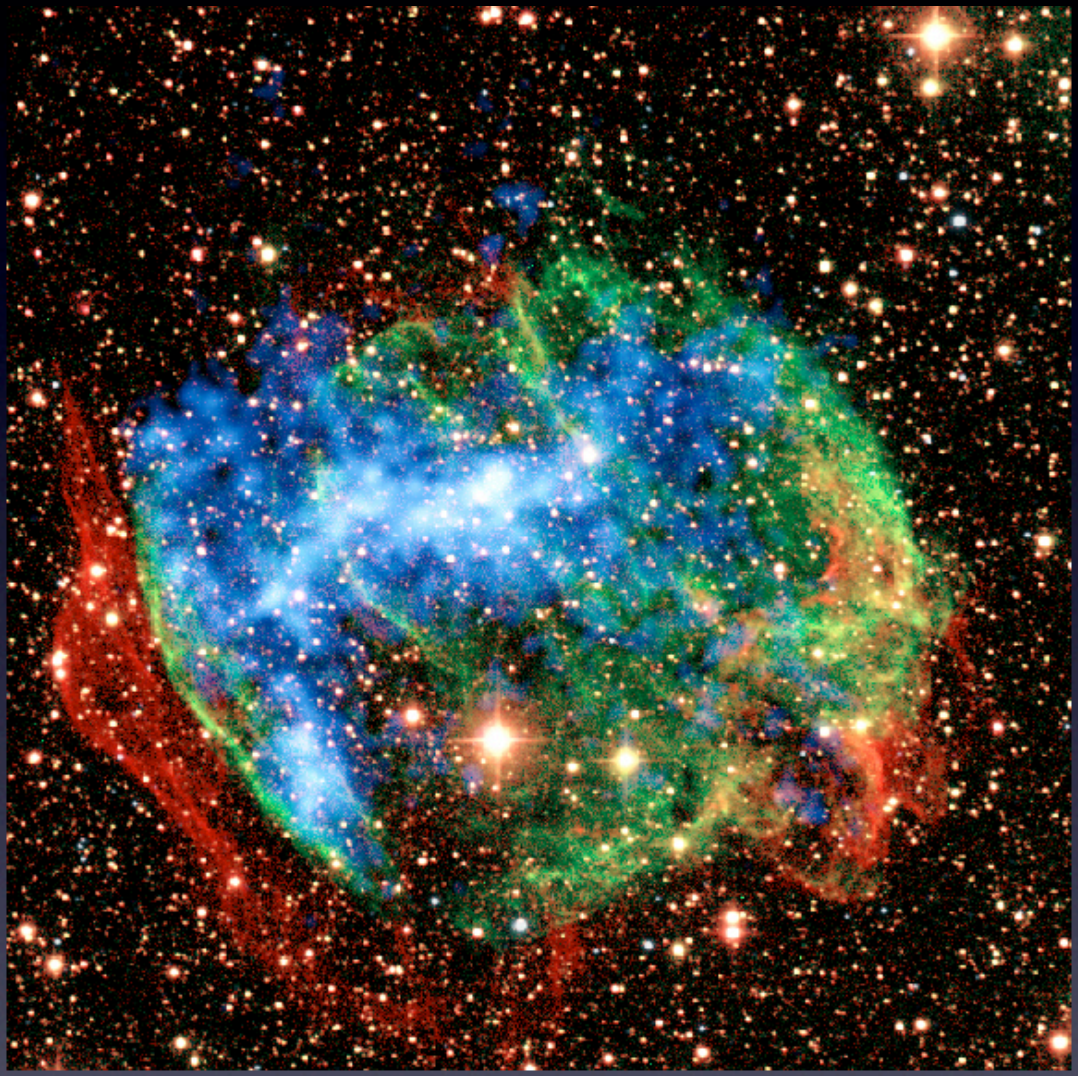


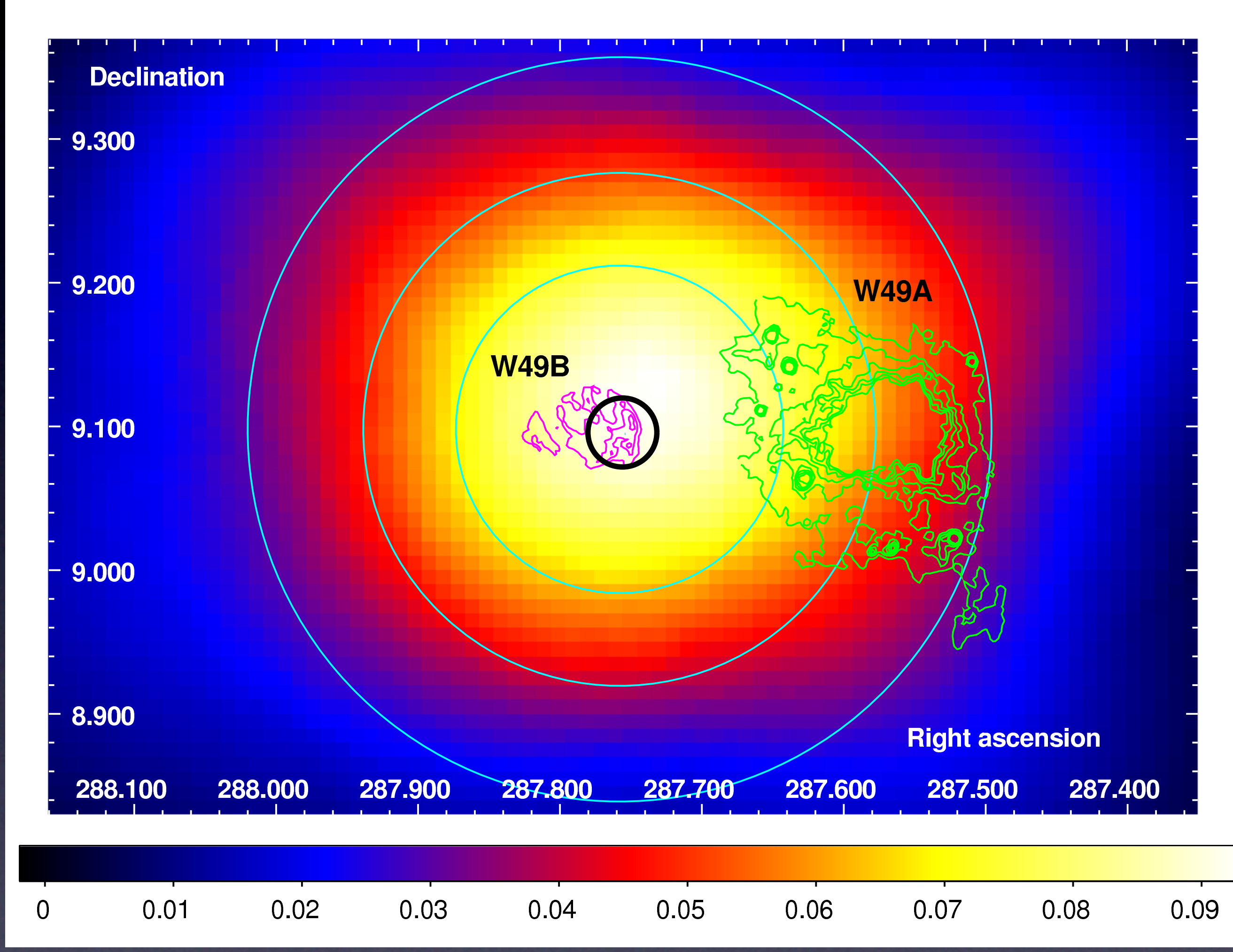
What Observables Are Expected from a GRB Remnant?

3. Near a molecular cloud



X-rays; 1.64 um [Fe II]; 2.12 um (shocked H_2)

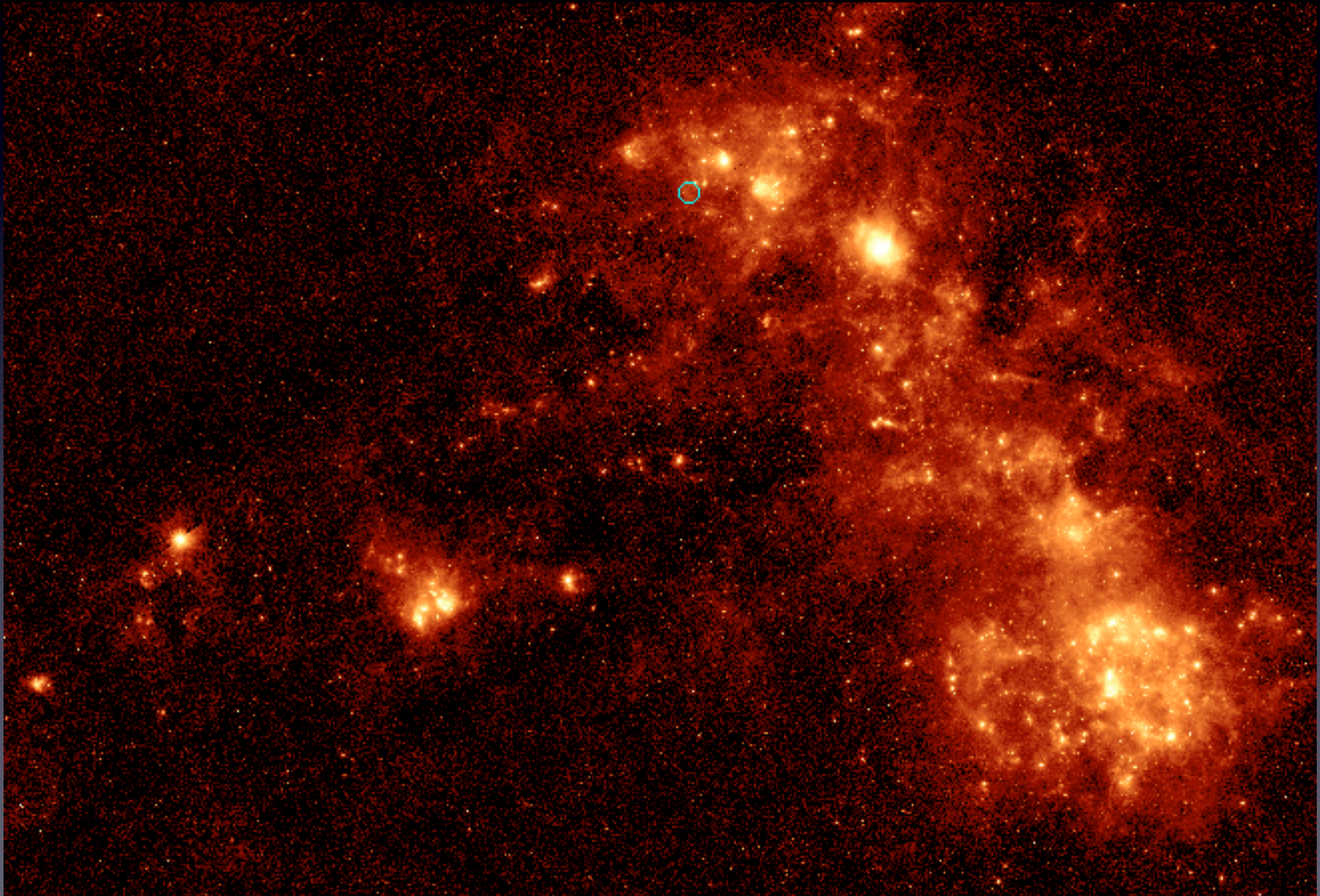
Keohane et al. 2007



Fermi-LAT gamma rays (2-6 GeV): Abdo et al.2010

What Observables Are Expected from a GRB Remnant?

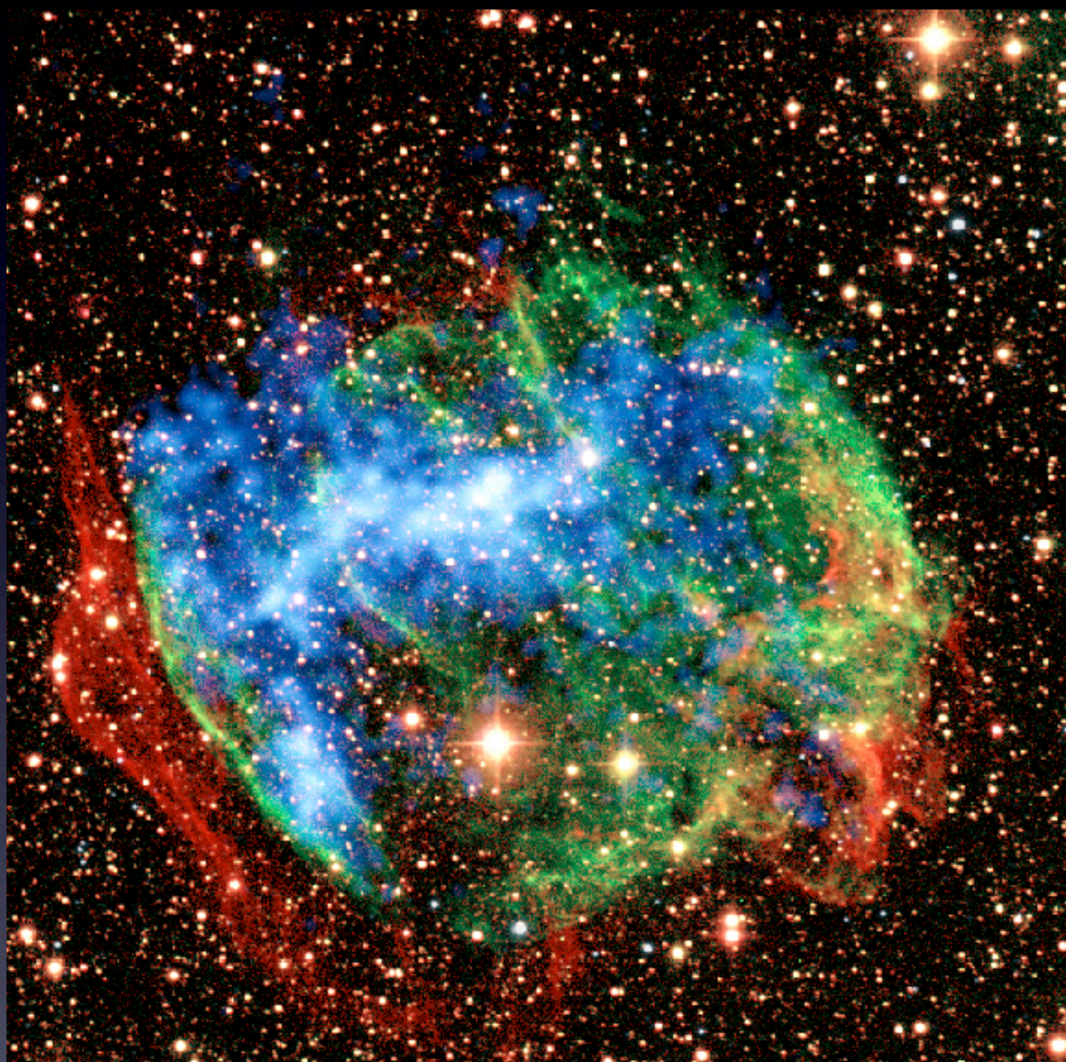
3. Near a molecular cloud

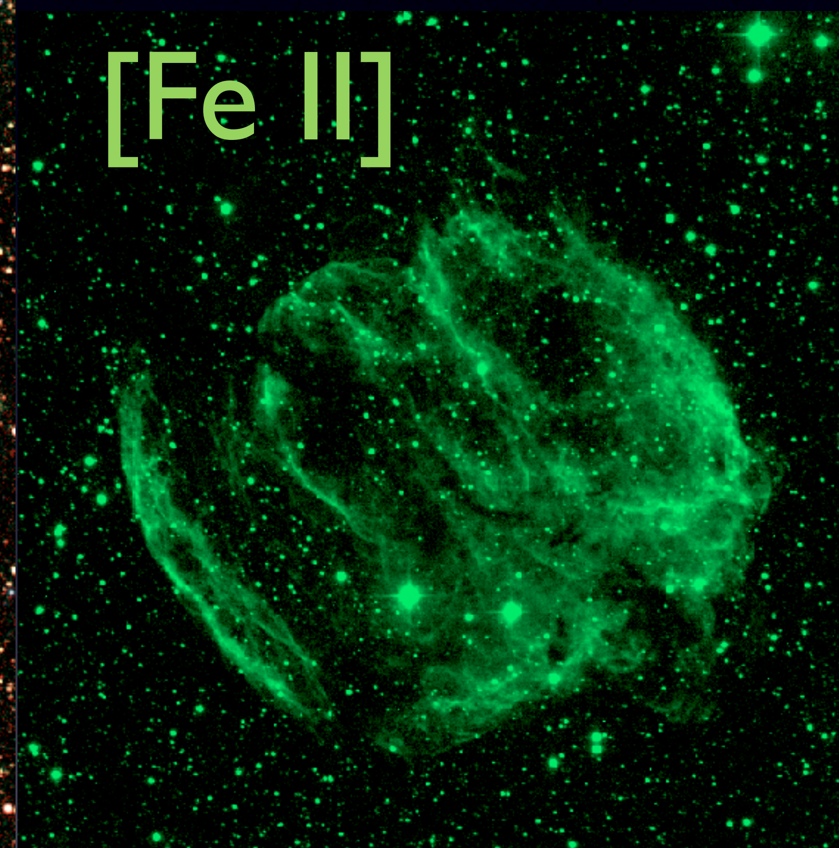


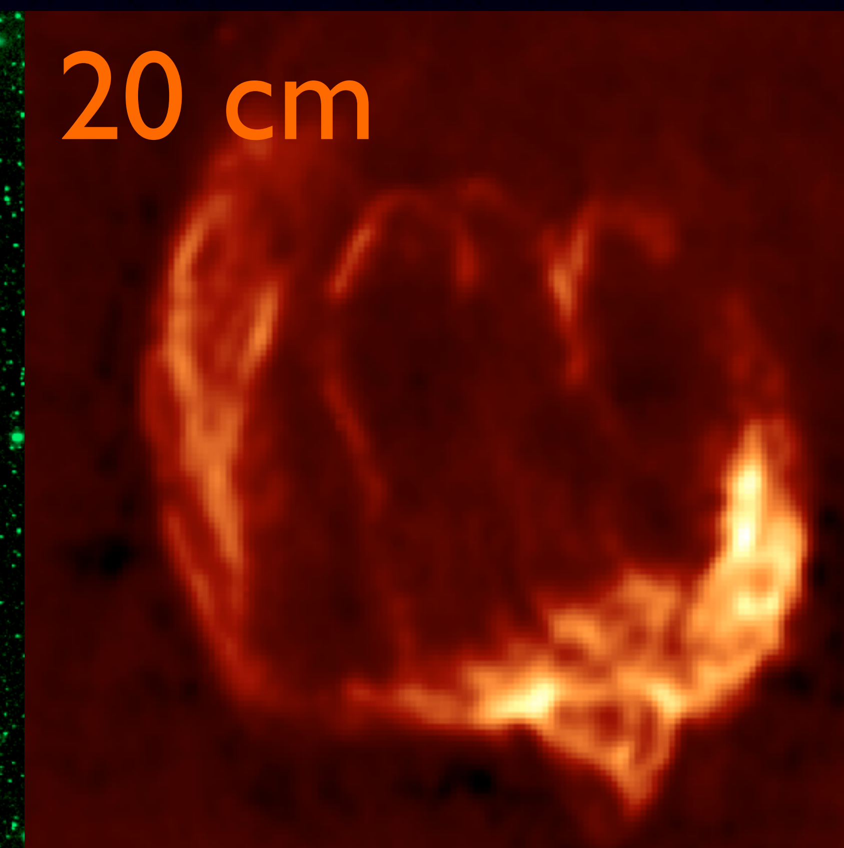
SMC SAGE: Gordon et al. 2011

What Observables Are Expected from a GRB Remnant?

4. Dense circumstellar material and cavity



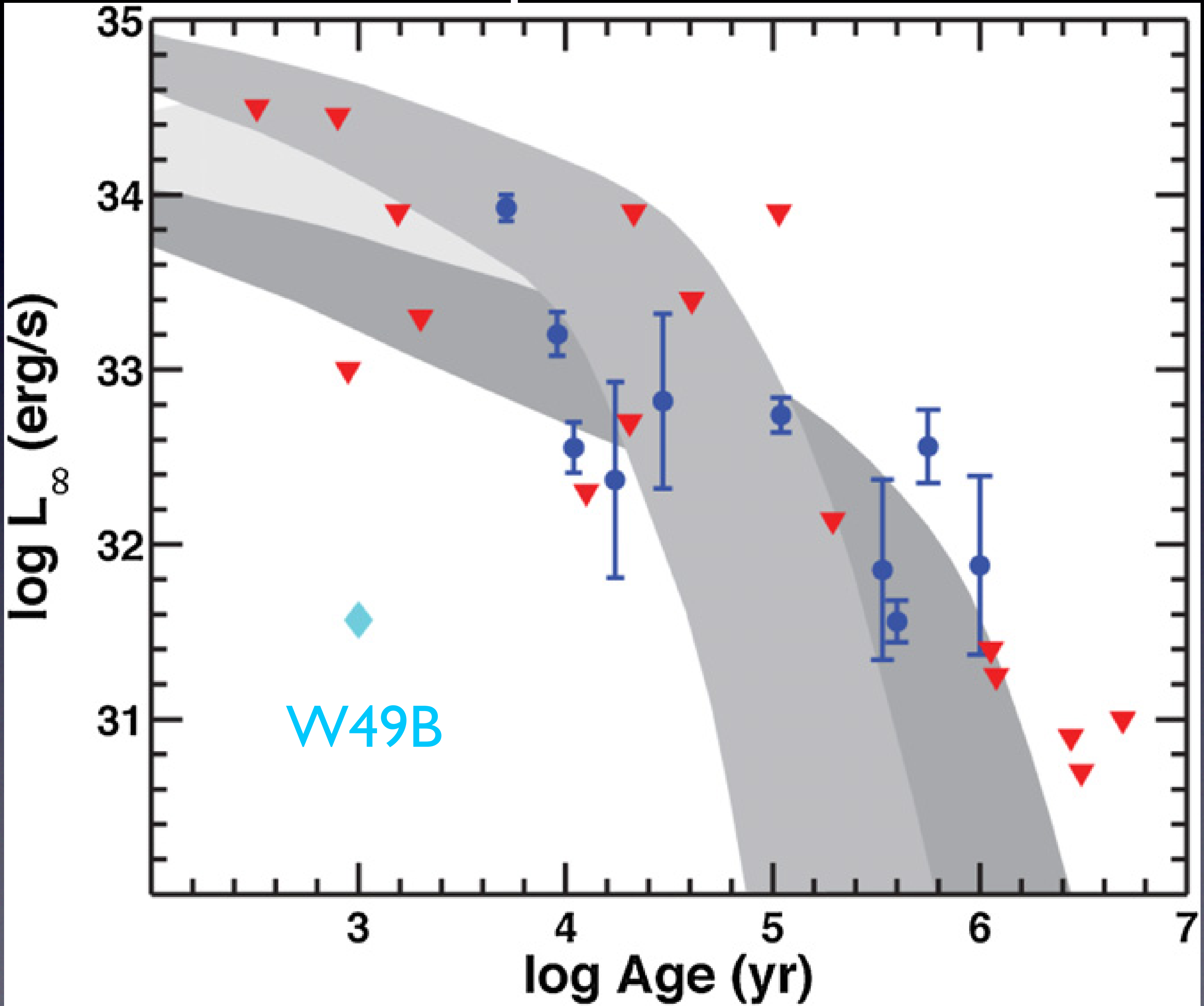




X-rays; 1.64 um [Fe II];
2.12 um (shocked H_2)
Keohane et al. 2007

What Observables Are Expected from a GRB Remnant?

5. No neutron star / pulsar



Lopez et al. 2013a

What Observables Are Expected from a GRB Remnant?

6. Nucleosynthesis is different than spherical CC SN

➡ Nickel (iron) yields increase with asphericity, explosion energy and progenitor mass

➡ Candidates have similar nickel yields:

- ✳ 2003dh: ~0.25-0.45 M_{sun}
- ✳ 2003lw: ~0.45-0.65 M_{sun}
- ✳ 1998bw: ~0.20-0.70 M_{sun}

$M_{Fe} \sim 0.80 +/- 0.60\ M_{sun}$

References: Woosley et al. 1999; Mazzali et al. 2003; Mazzali et al. 2006; Kaneko et al. 2007; Umeda & Nomoto 2008

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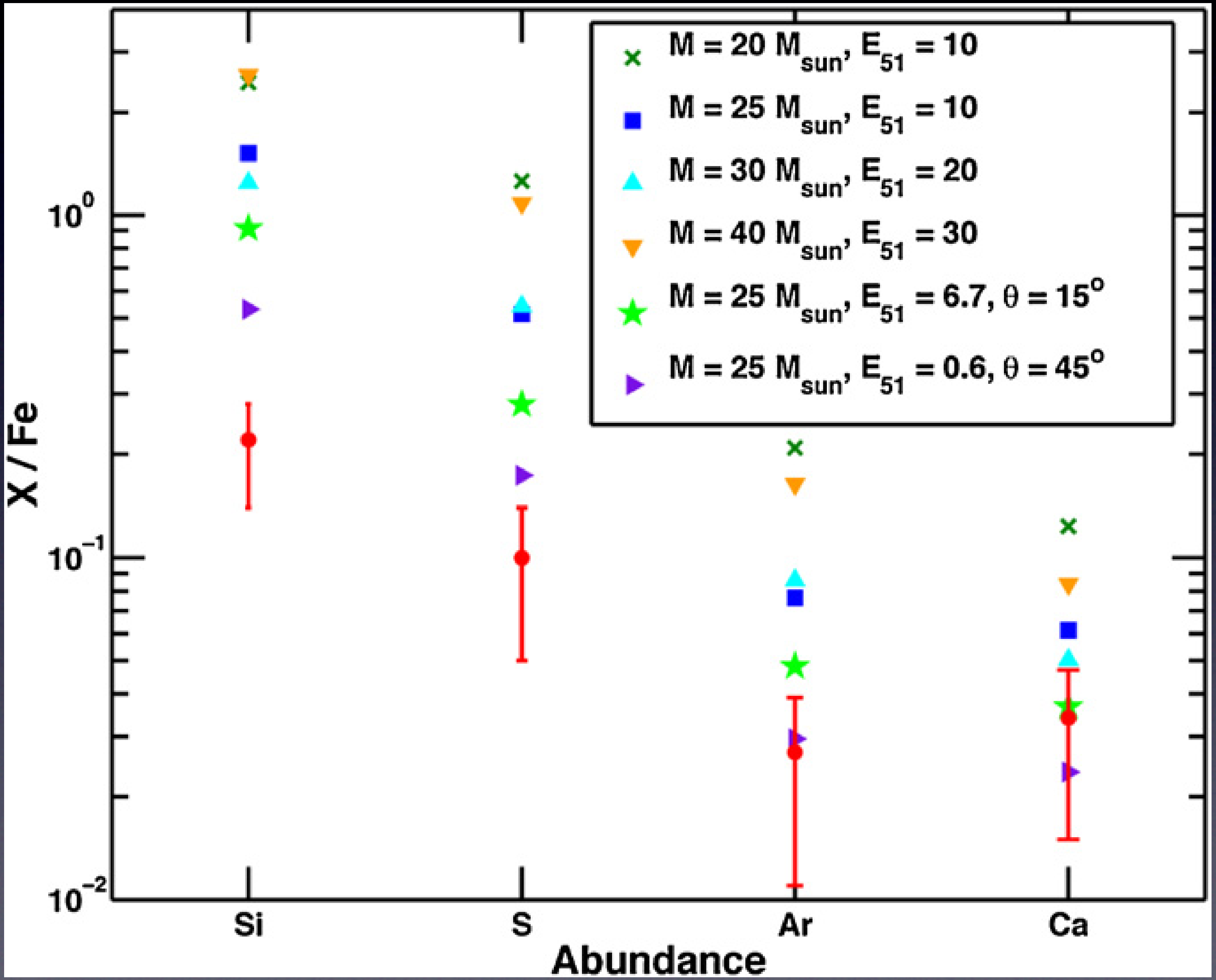


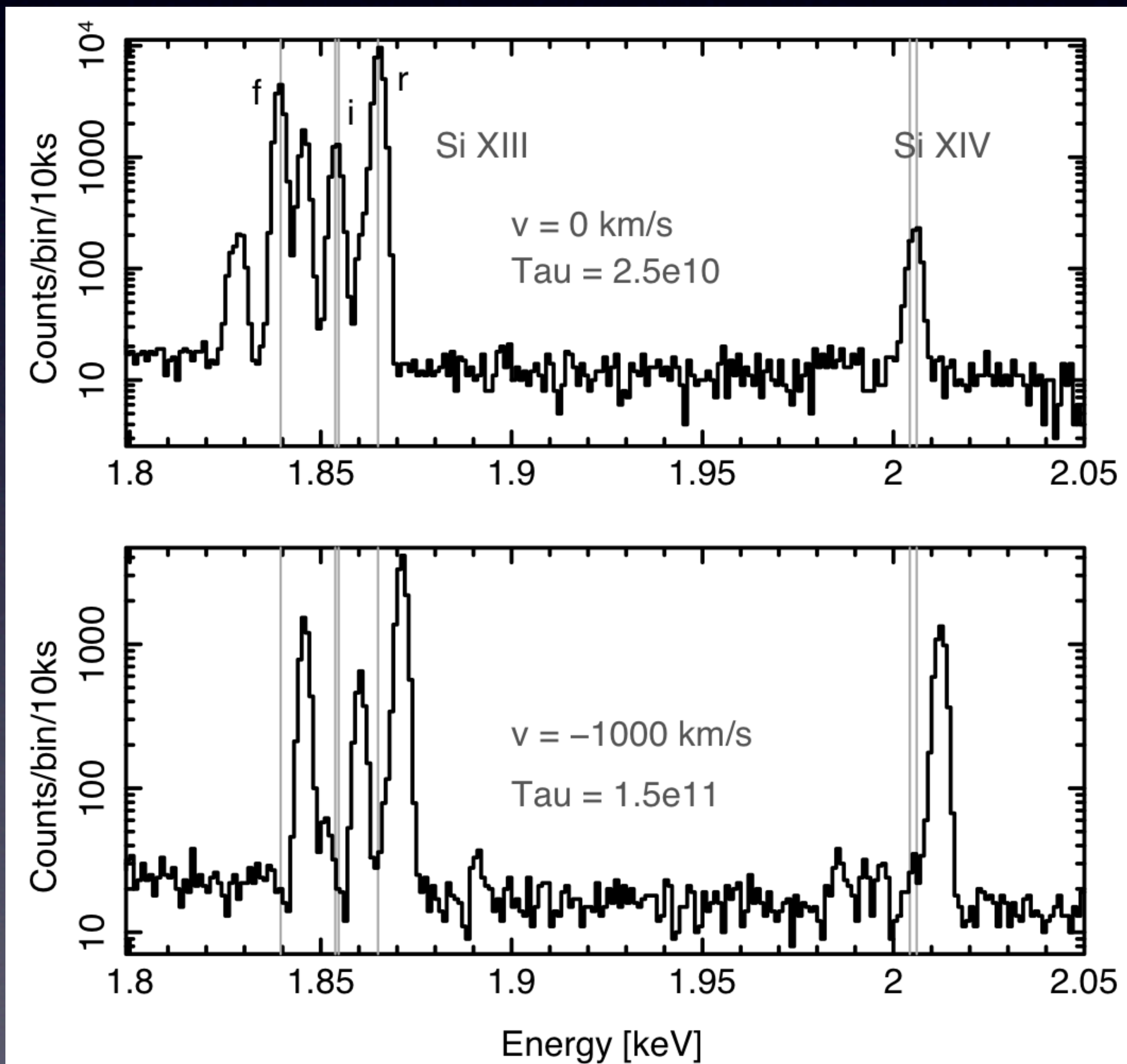
Lopez et al. 2013a

Spherical models from Nomoto et al. 2006; Aspherical models from Maeda & Nomoto 2003

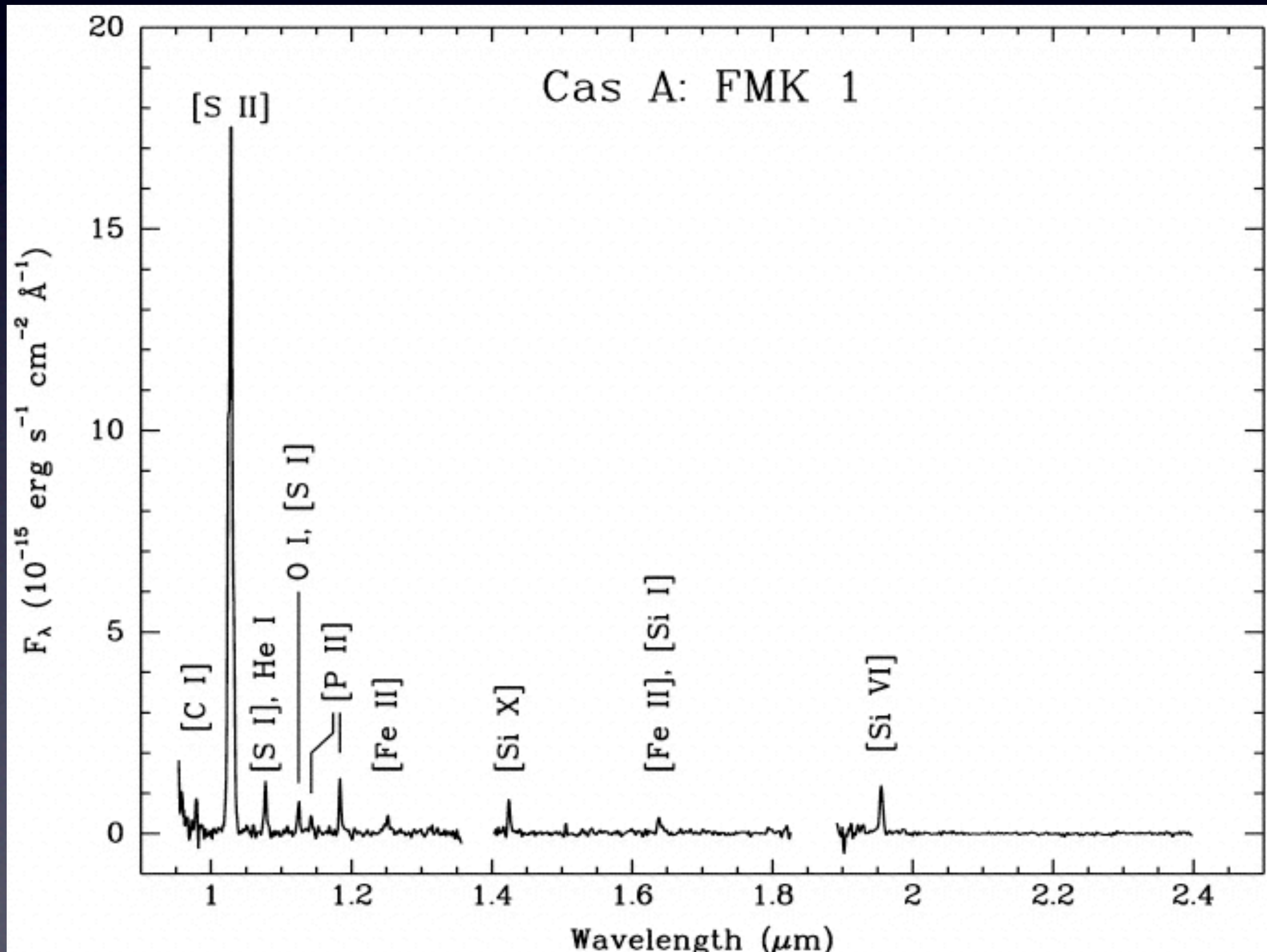
What Observables Are Expected from a GRB Remnant?

7. Kinematics

➡ Fe should be moving at faster speeds than Si



Dewey et al. 2010



Gerardy & Fesen 2001

Is W49B a Jet-Driven Remnant?

1. Bipolar / jet structure
2. Jets enhanced in heavy metals
3. A nearby molecular cloud
4. Dense circumstellar material and cavity
5. No neutron star / pulsar
6. Nucleosynthesis differences from spherical CC
7. Kinematics

➡ W49B was bipolar / jet-driven CC SN

Is 0104 a Jet-Driven Remnant?

1. Bipolar / jet structure
2. Jets enhanced in heavy metals
3. A nearby molecular cloud
4. Dense circumstellar material and cavity
5. No neutron star / pulsar
6. Nucleosynthesis differences from spherical CC
7. Kinematics

➡ 0104 was bipolar / jet-driven CC SN

Jet-Driven Remnants

1. Bipolar / jet structure
2. Jets enhanced in heavy metals
3. A nearby molecular cloud
4. Dense circumstellar material and cavity
5. No neutron star / pulsar
6. Nucleosynthesis differences from spherical CC
7. Kinematics

Thank You!