Anomalous 511 keV gamma-ray line widths

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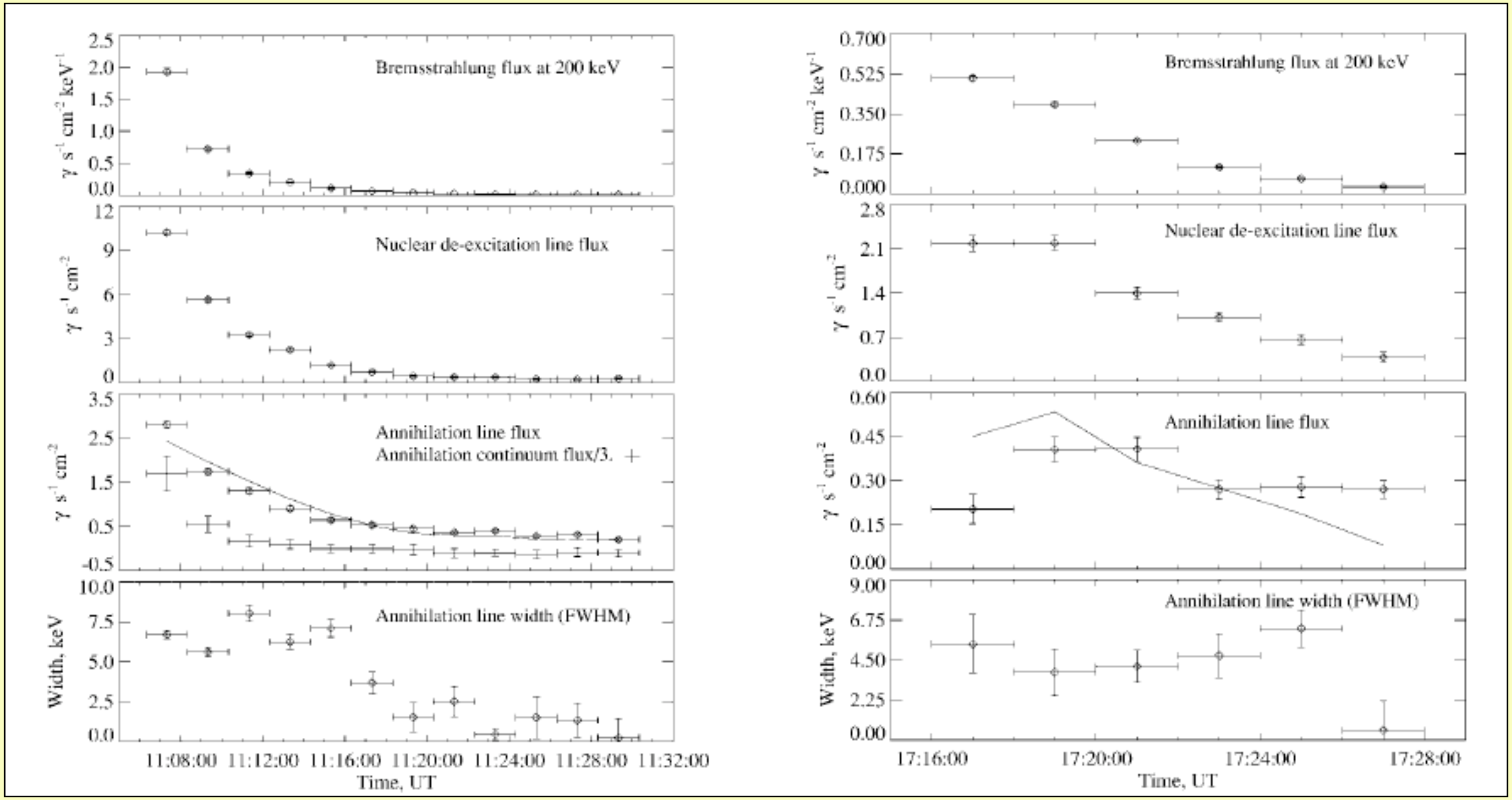
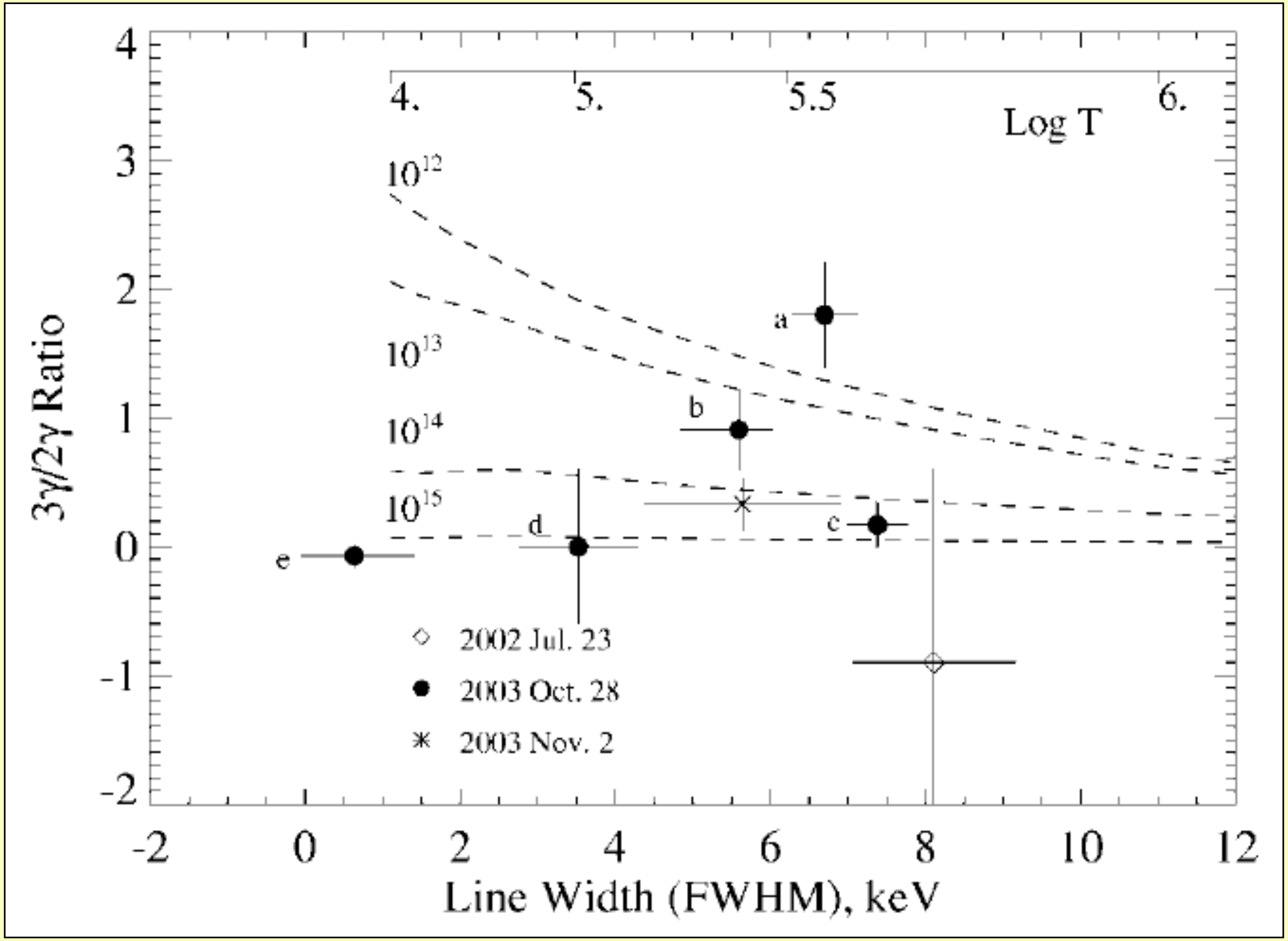
Literature

- Share et al., ApJ 615, L169 (2004)
- Schrijver et al., ApJ 650, 1184 (2006)
- Raymond, J., J. Astrophys. Astr. (2008) 29, 187

2003 October 28 & November 2



July 23, 2002



4
3
2
1
0
-1
-2
3γ/2γ Ratio
-2
0
2
4
6
8
10
12
Line Width (FWHM), keV
4.
5.
5.5
6.
Log T
10^12
10^13
10^14
10^15
a
b
c
d
e
2002 Jul. 23
2003 Oct. 28
2003 Nov. 2

Positronium I

- The 511-keV line forms by the mutual annihilation of an electron and a positron

  - "parapositronium" (singlet) => two 511-keV photons

  - "ortho-" (triplet) => 3-photon continuum

- The line formation depends in a complex way on local physical parameters, but there is thermal broadening
- Positrons come from decays of excited nuclei, e.g. from reactions such as (p,^{12}C) reaction, as well as from the $\pi - \mu - e$ sequence

Positronium II

- The positrons (~MeV energy) must collisionally stop over a range of some 10^{23} gm cm^{-2} – quite deep
- The anomalous line broadening, if interpreted as a thermal width, requires this thickness of transition-region material at ~10^5 K
- For this to happen, the transition region would need a density of some 10^{16} cm^{-3}, or emission measure 10^{51} cm^{-3}
- The Raymond observations[1] tend to rule this out

[1]*and common sense*

Summary

- Some flares show anomalously wide 511 keV emission early in the event, suggestive of 300,000 K
- This is unexpected because the ranges of the primaries, and the range of the secondary positrons, should result in annihilation at high densities and low temperatures
- The problem is unsolved at present