SPI Detection of ^{60}Fe Radioactivity from the Galaxy

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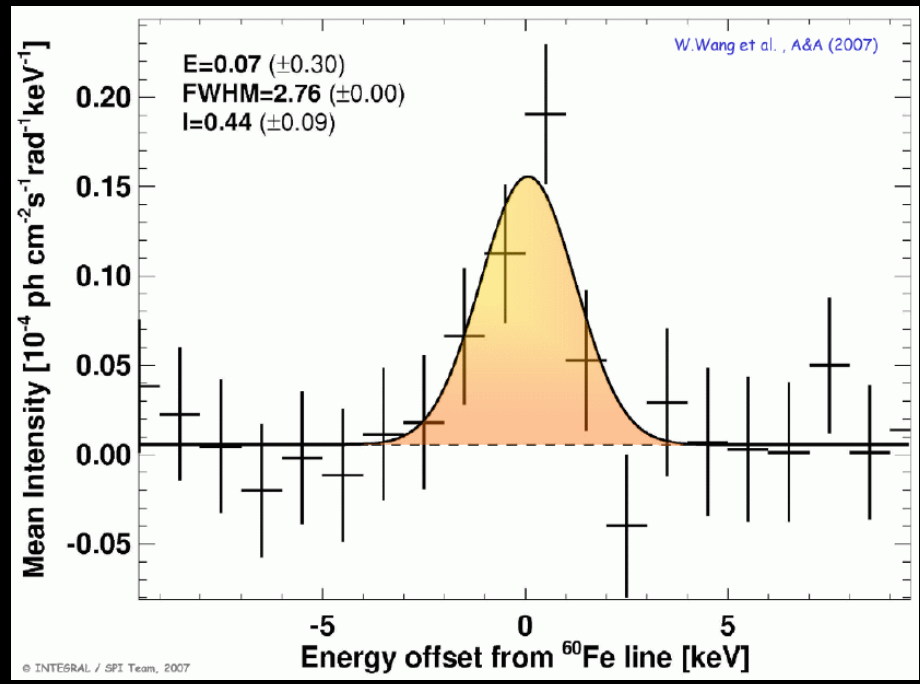
Outline

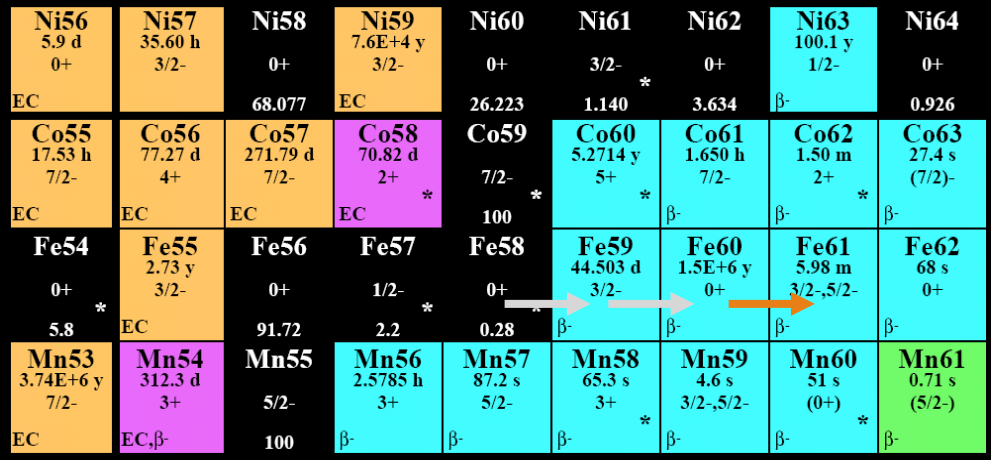
- Why are we interested in ^{60}Fe?
- ^{60}Fe Detections
  - Past
  - Current
- What did we learn?



Wang et al. (A&A, 2006)

(see also ESA Press Release)

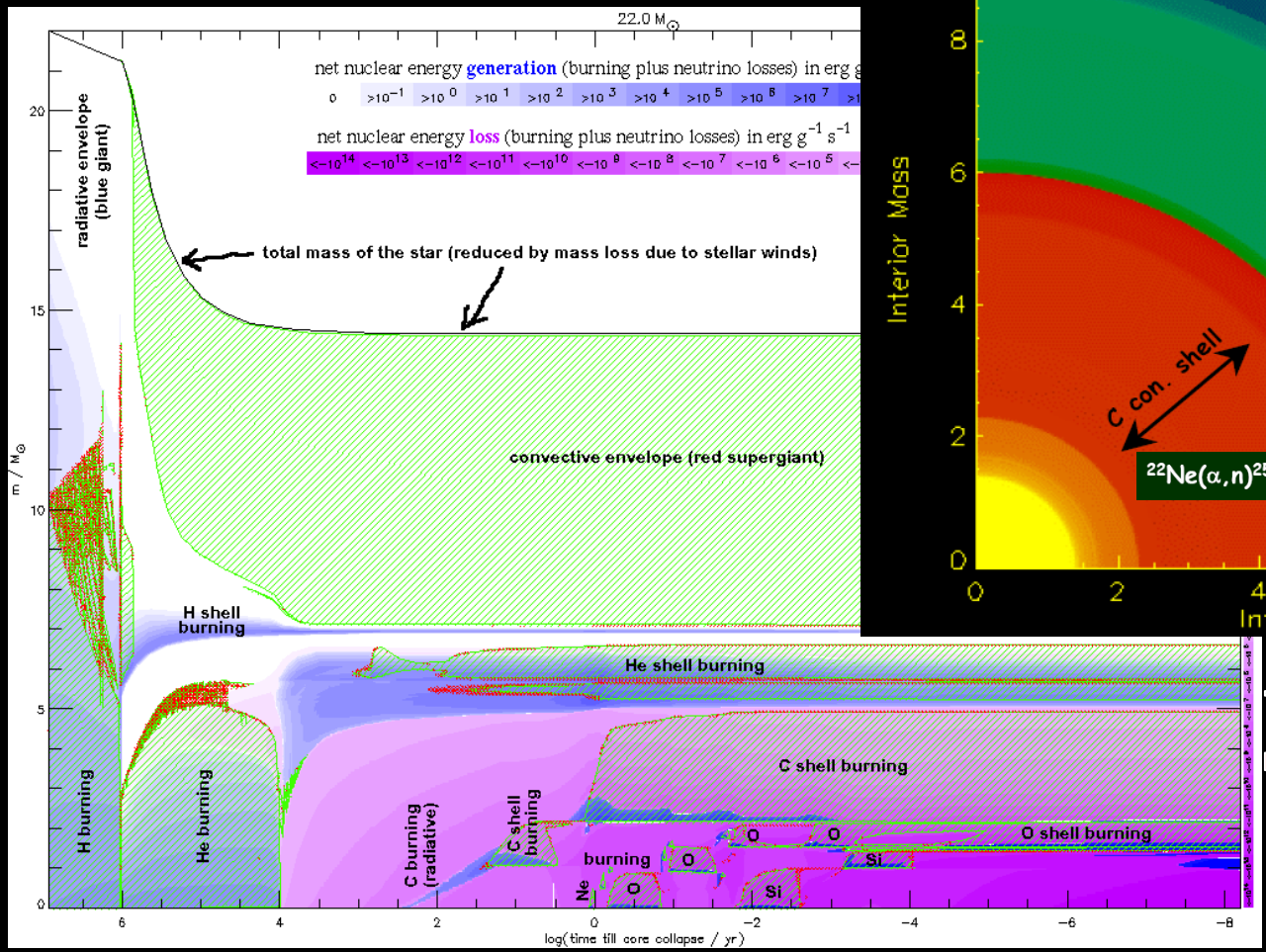
What kind of nucleus is ^{60}Fe?



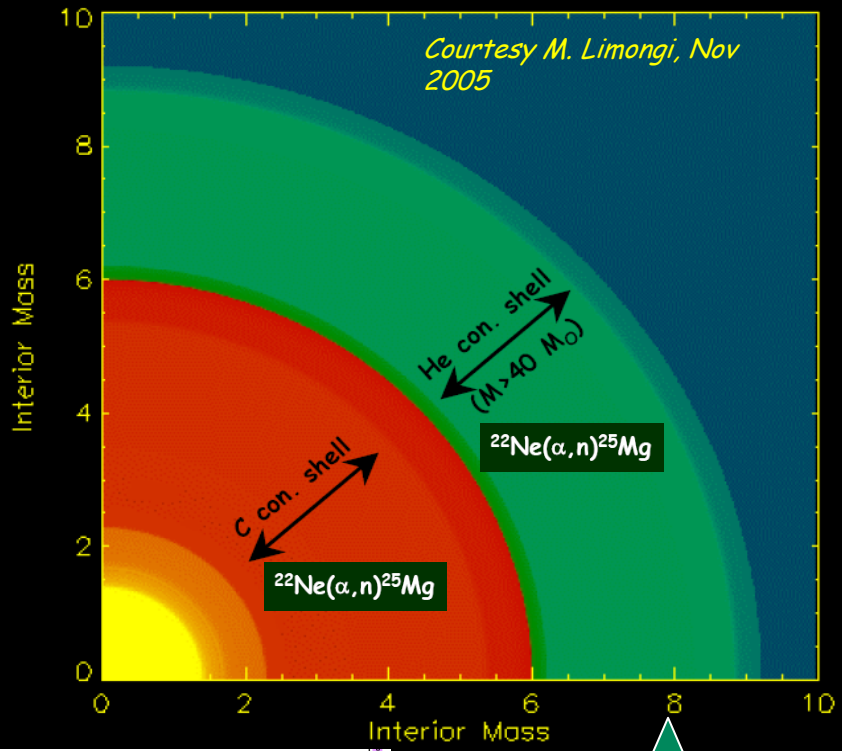
- Long-lived ($\tau \approx 2$ My)
- Production by successive n-captures (s-process)
  - Need n source: He burning ^{22}Ne(α,n)^{25}Mg
  - Need convection

→ Massive stars are sources of ^{60}Fe

^{60}Fe Production

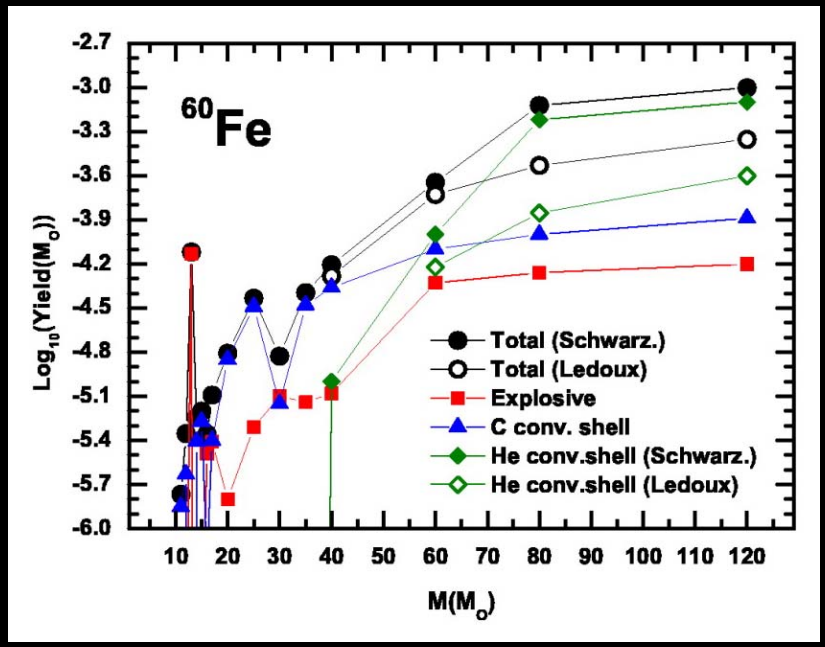


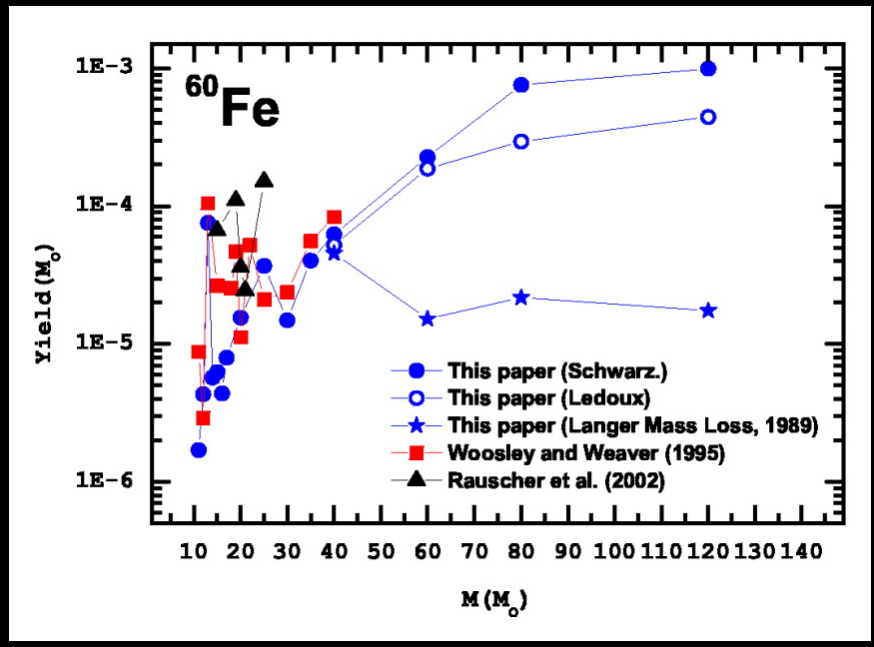
log(time till core-collapse)



From Heger

^{60}Fe Production – Stellar models



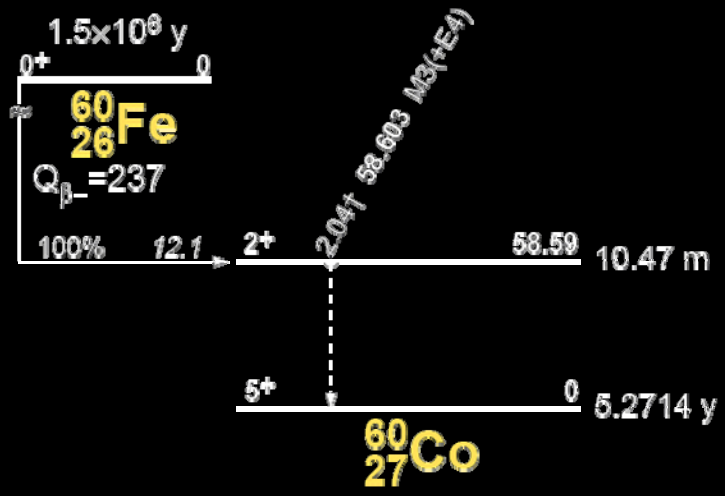


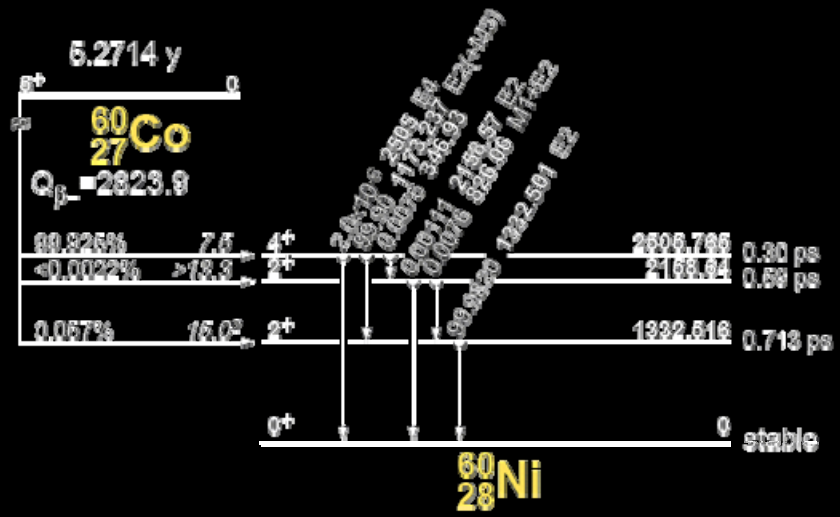
Limongi & Chieffi (2006)

^{60}Fe Detection – Decay Lines

- Gamma-ray emission at
  - 57 keV (2% efficiency)
  - 1173 keV
  - 1333 keV

Ni56 5.9 d 0+ EC	Ni57 35.60 h 3/2-	Ni58 0+ 68.077	Ni59 7.6E+4 y 3/2- EC	Ni60 0+ 26.223	Ni61 3/2- * 1.140	Ni62 0+ 3.634	Ni63 100.1 y 1/2- β-	Ni64 0+ 0.926
Co55 17.53 h 7/2- EC	Co56 77.27 d 4+ EC	Co57 271.79 d 7/2- EC	Co58 70.82 d 2+ * EC	Co59 7/2- * 100	Co60 5.2714 y 5+ * β-	Co61 1.650 h 7/2- β-	Co62 1.50 m 2+ * β-	Co63 27.4 s (7/2)- β-
Fe54 0+ * 5.8	Fe55 2.73 y 3/2- EC	Fe56 0+ 91.72	Fe57 1/2- * 2.2	Fe58 0+ * 0.28	Fe59 44.503 d 3/2- β-	Fe60 1.5E+6 y 0+ β-	Fe61 5.98 m 3/2-,5/2- β-	Fe62 68 s 0+ β-
Mn53 3.74E+6 y 7/2- EC	Mn54 312.3 d 3+ EC,β-	Mn55 5/2- 100	Mn56 2.5785 h 3+ β-	Mn57 87.2 s 5/2- β-	Mn58 65.3 s 3+ * β-	Mn59 4.6 s 3/2-,5/2- β-	Mn60 51 s (0+) * β-	Mn61 0.71 s (5/2-) β-





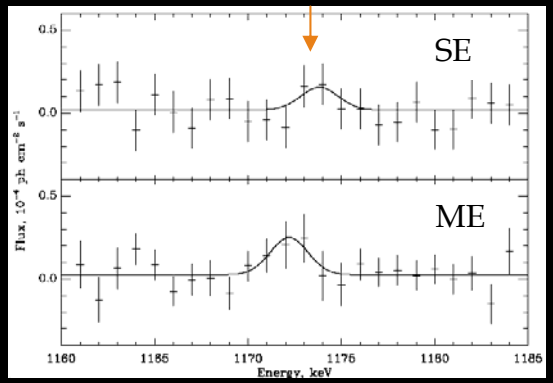
^{60}Fe Detection – Past (2005)

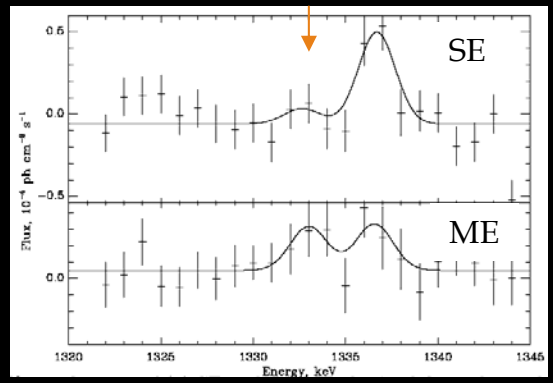
SPI (Harris)

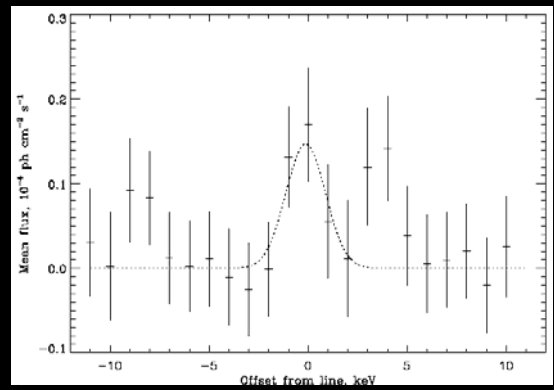
1173 keV

1333 keV

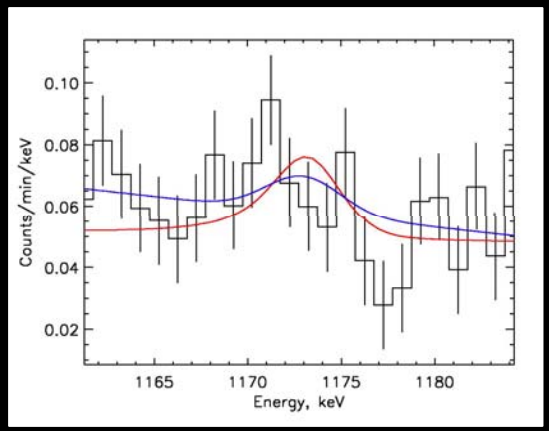
Combined spectrum

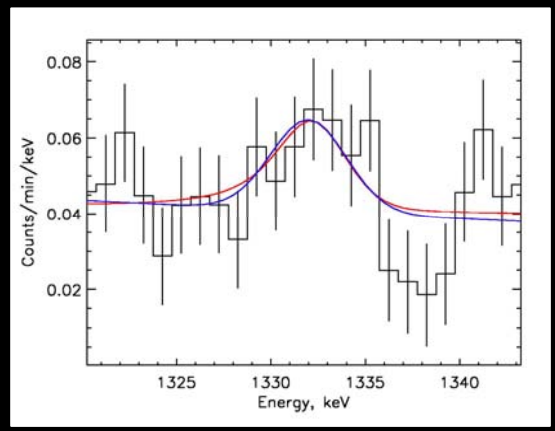


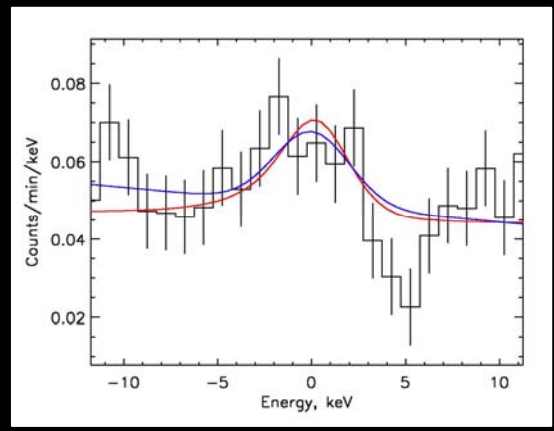




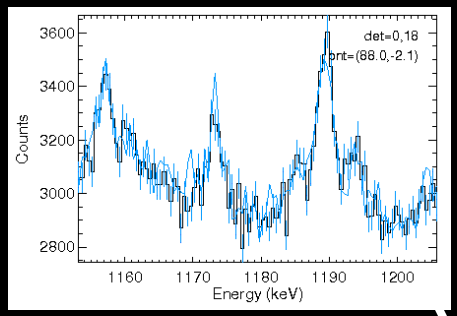
RHESSI (Smith)



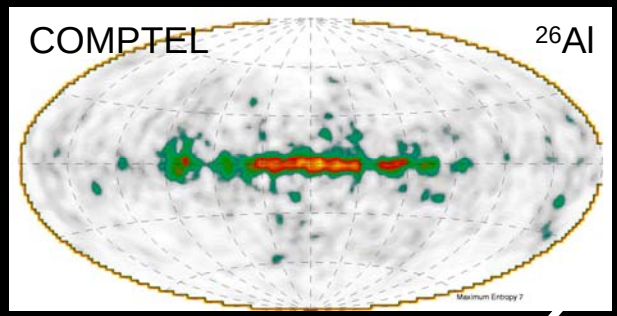


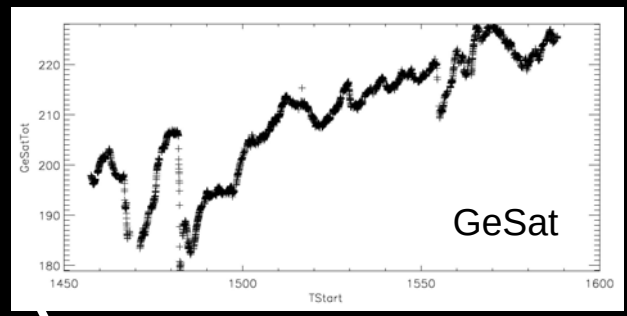


60Fe Detection – Method



SPI Data



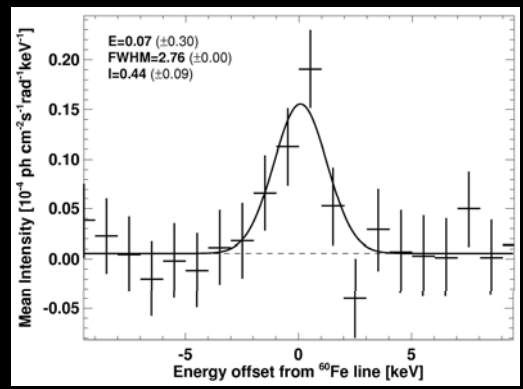


Bgnd Model

$$D_E = \int \beta_E \cdot R \cdot S + \alpha_E \cdot B_E$$

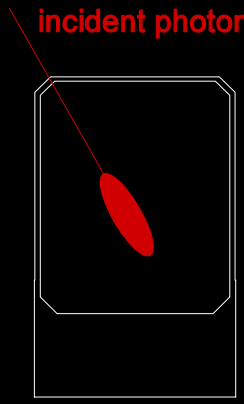
Fit parameter

per energy bin

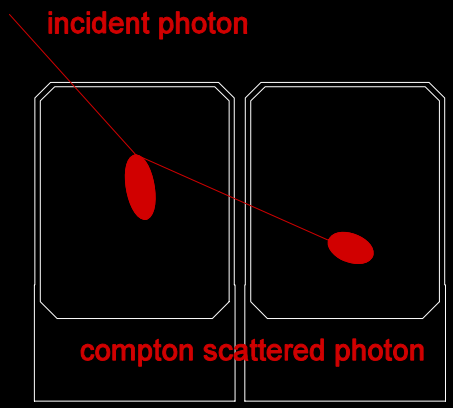


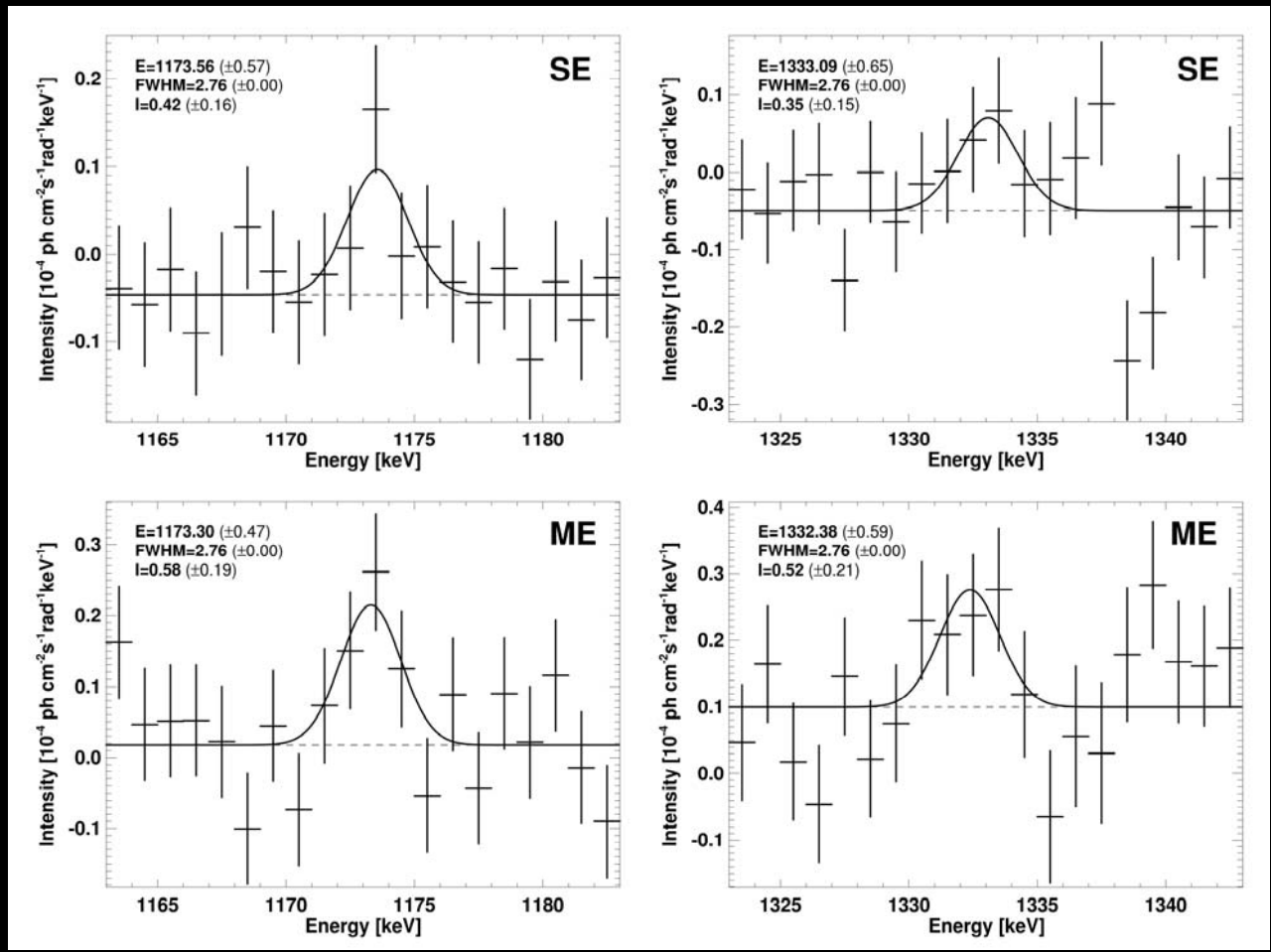
^{60}Fe Detection – 4 Channels

Single Event (SE)

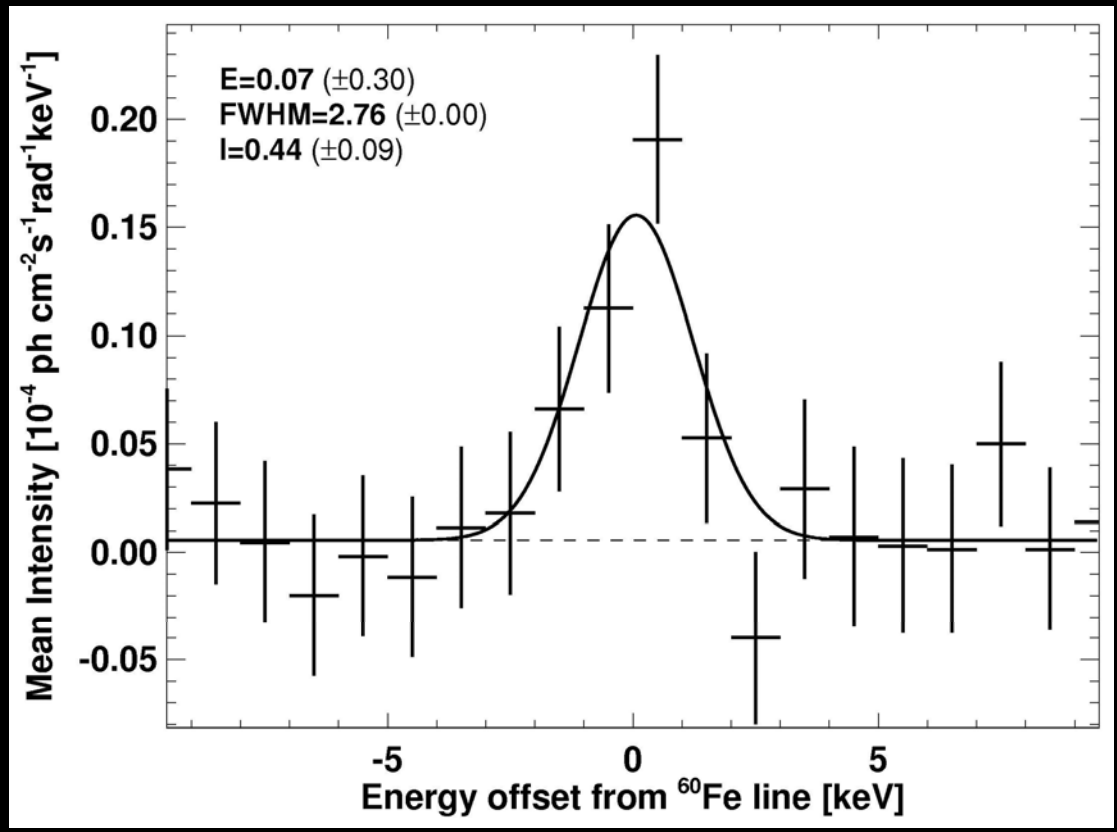


Multiple Event (ME)





^{60}Fe Detection – Combination

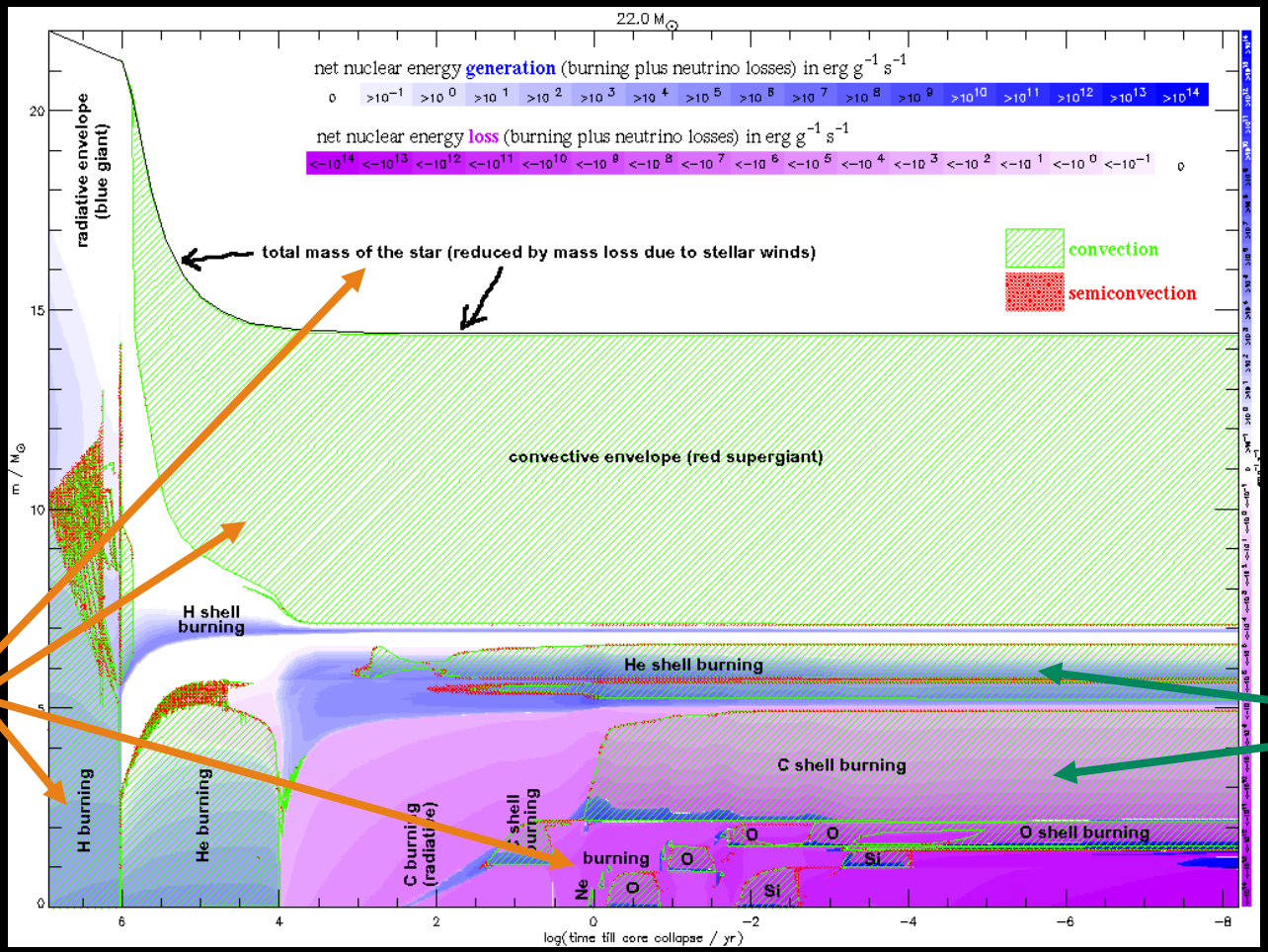


→ Combined emission: (4.4±0.9)×10^{-5} ph cm^{-2} s^{-1} rad^{-1}

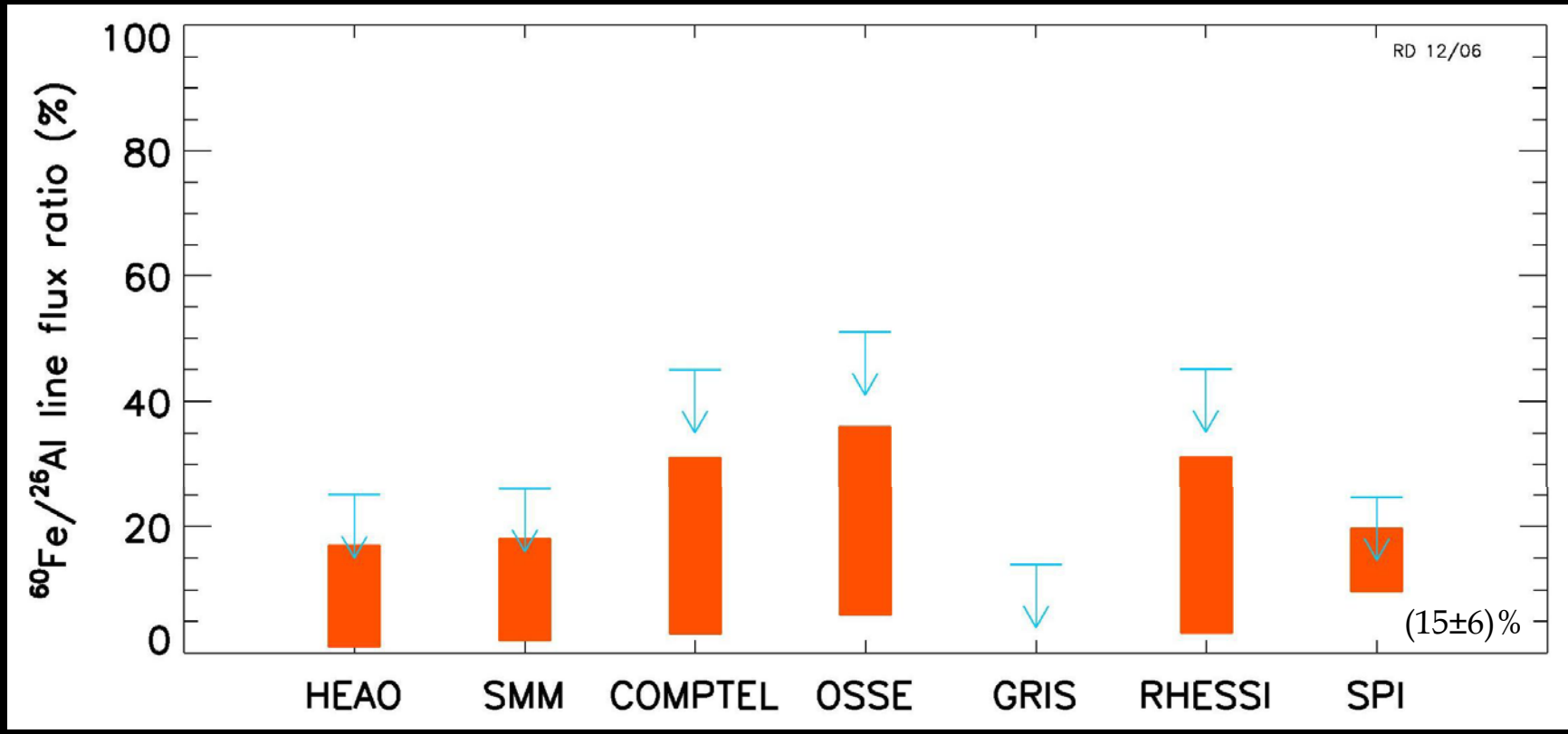
^{60}Fe and ^{26}Al

^{25}Mg + p → ^{26}Al

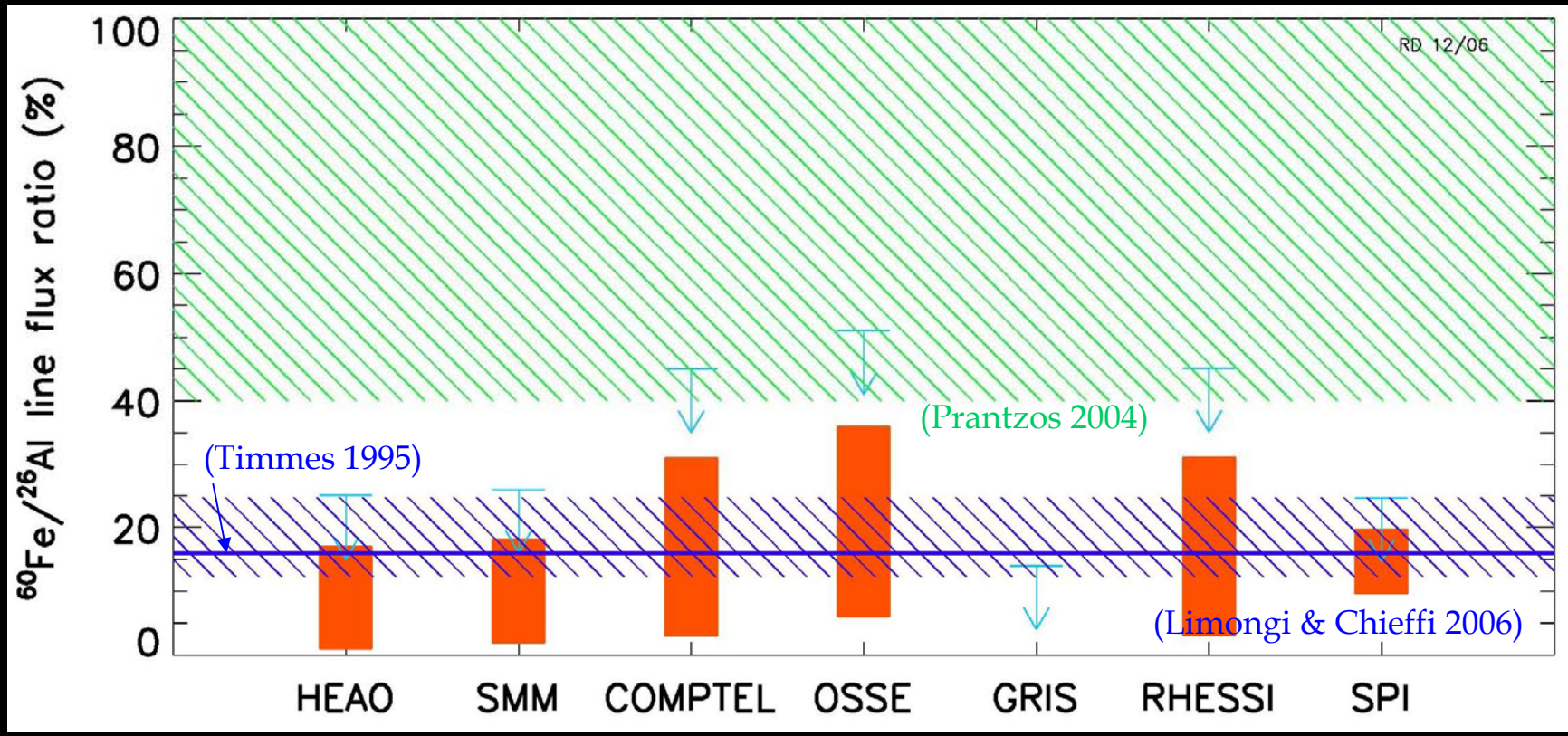
^{5X}Fe + n → ^{60}Fe



Comparison to ^{26}Al



Comparison to ^{26}Al



Summary

- ^{60}Fe has been clearly detected by SPI
- ^{60}Fe / ^{26}Al consistent with theoretical expectations
- Uncertainty of SPI result is comparable to uncertainties in astrophysical models

- We now have > 4 y of data (Wang et al. 2.5 y)
- ^{60}Fe background models need to be improved
- Goal: Separate different Galactic regions (e. g. galactic quadrants, star forming regions)