Vela Jr.: Then and There

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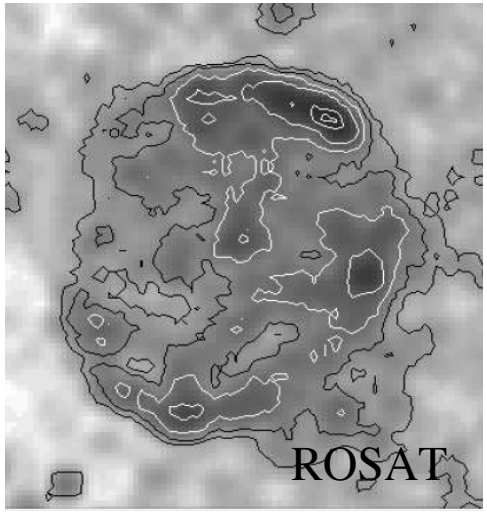
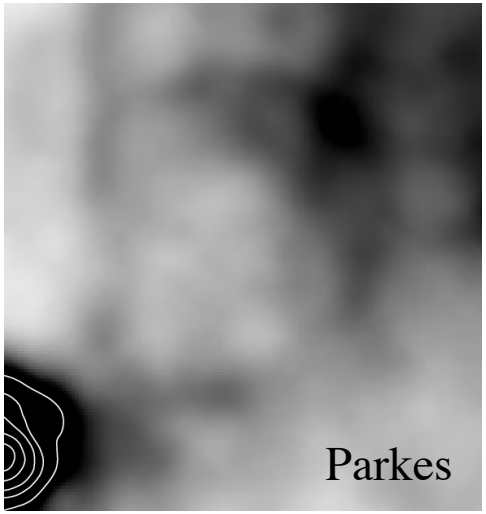
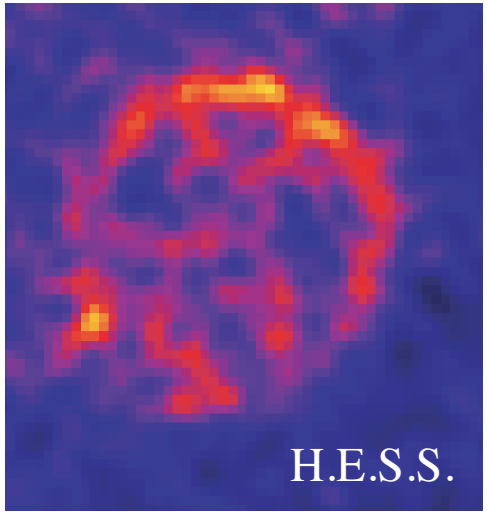
Résumé

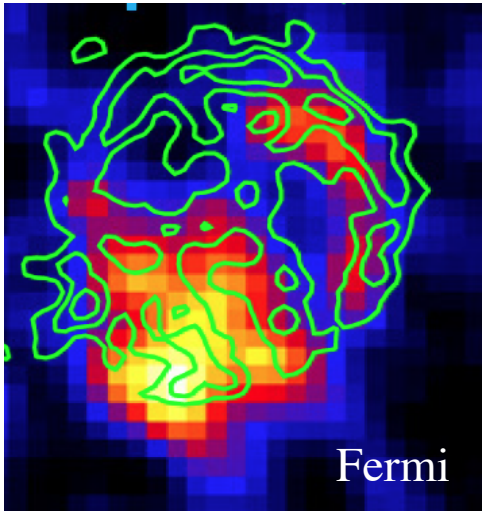
- a.k.a. RX J0852.0−4622, G266.2−1.2, Vela-Z
- Discovered in *ROSAT* all-sky survey data (Aschenbach 1998)
- Nearly 2°-diameter shell
- Along the same line of sight as, and dominated by, Vela at X-ray energies below 1 keV
- Low X-ray surface brightness
- X-ray emission dominated by synchrotron radiation
- No evidence of thermal X-ray emission
- Emits radio, GeV, and TeV photons
- Compact, X-ray-emitting object near the geometric center

Gallery

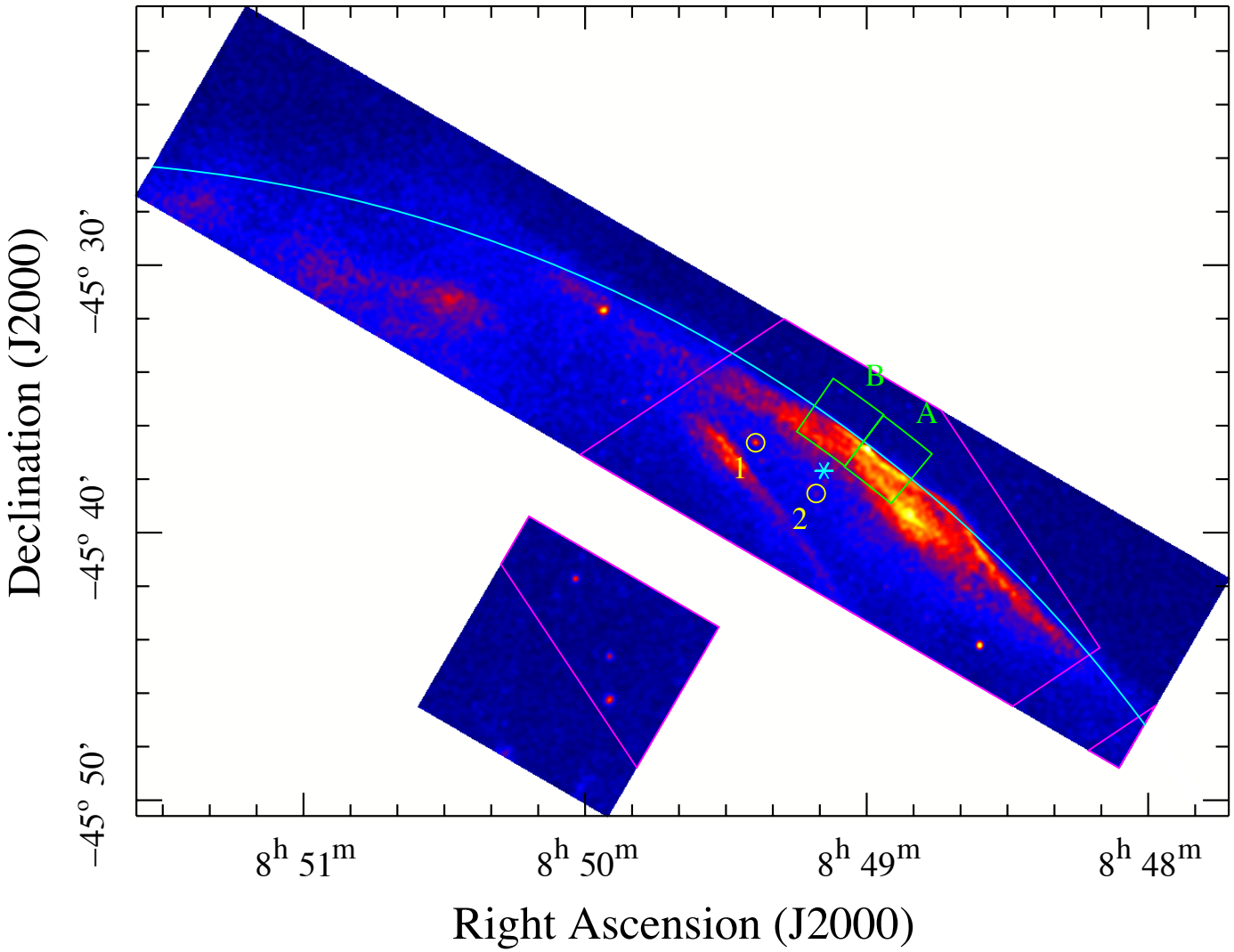




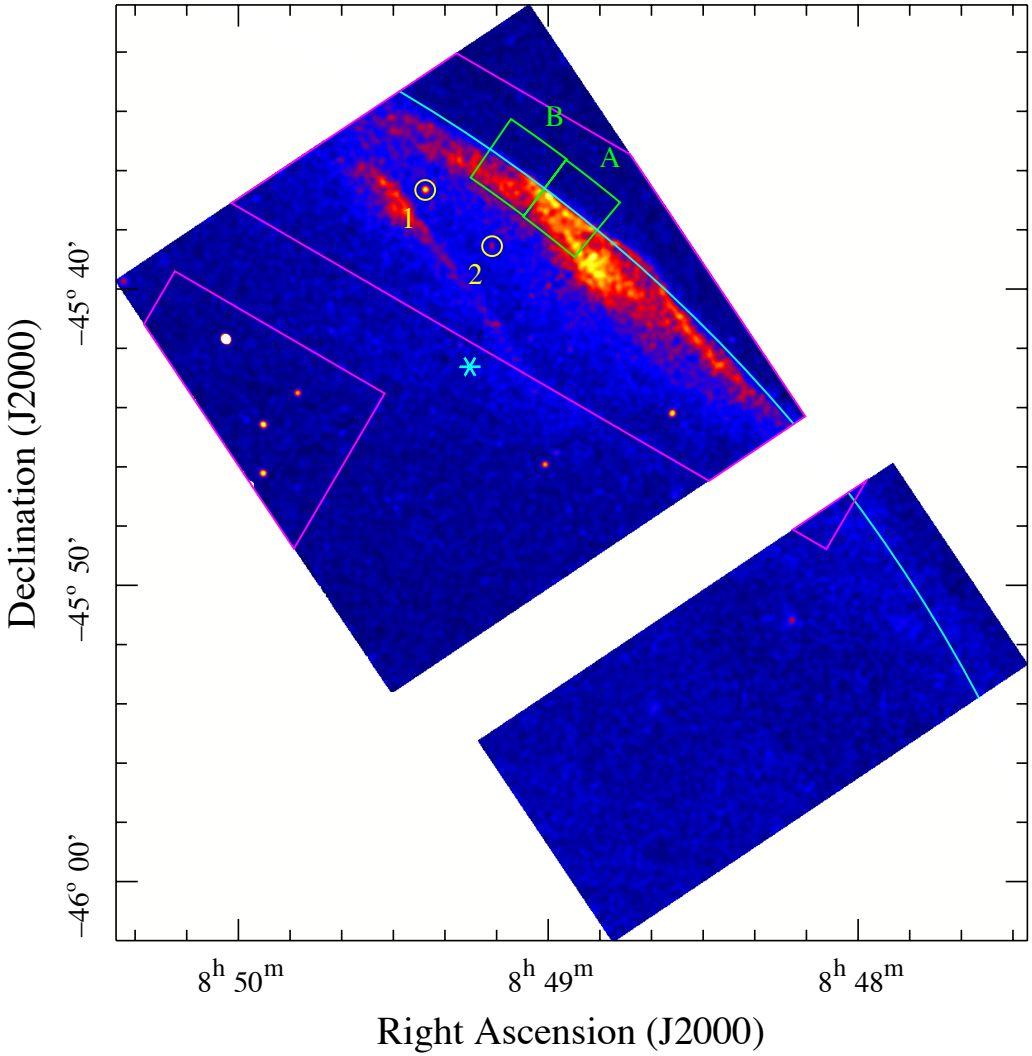




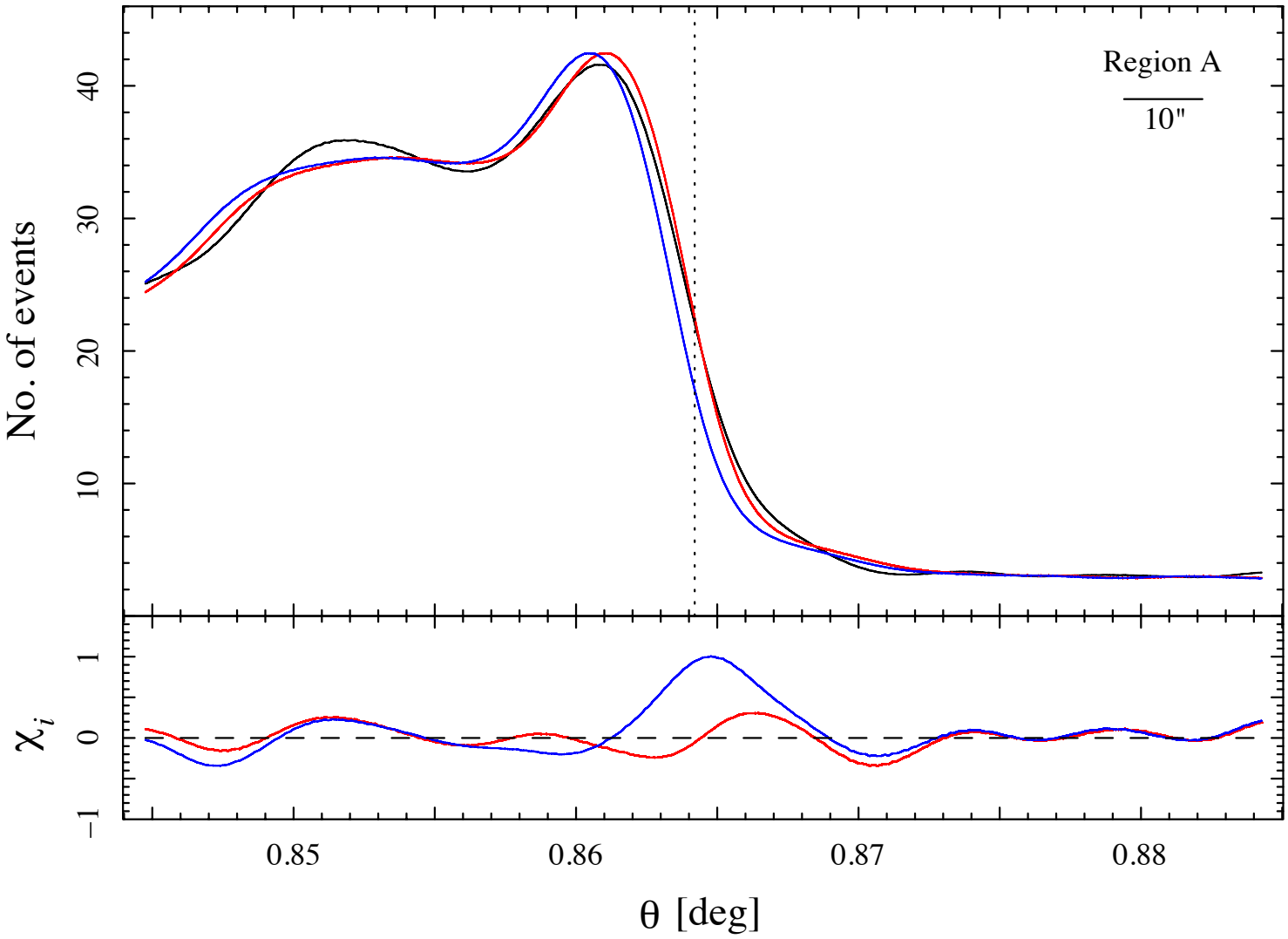
Chandra 2003



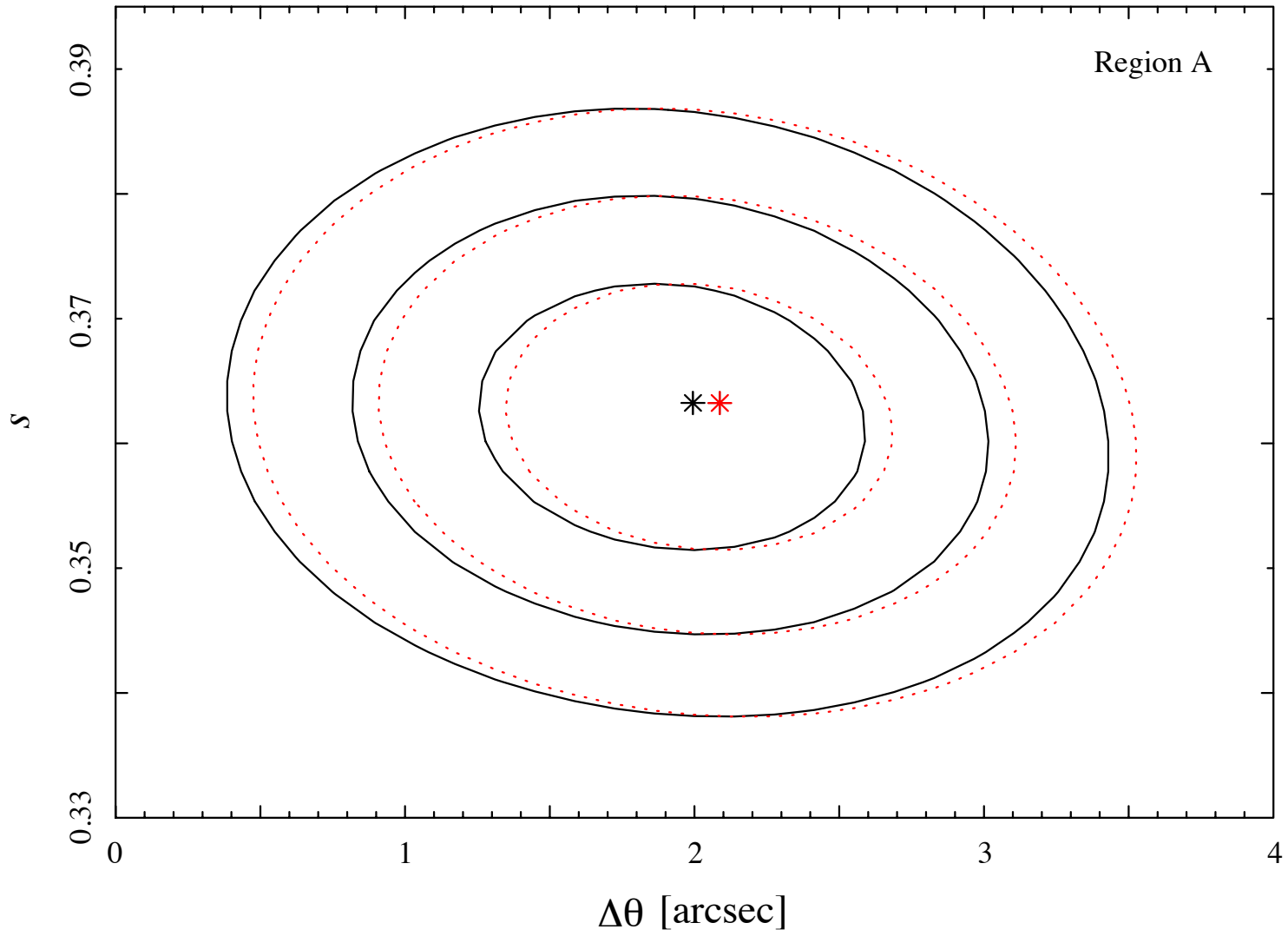
Chandra 2008



Radial profile



Confidence contours



Mean results

Quantity	Region A	Region B	Mean
$\Delta\theta$ (arcsec)	1.98 ± 0.72	3.03 ± 0.89	2.40 ± 0.56
$\dot{\theta} = \Delta\theta/\Delta t$ (arcsec yr^{-1})	0.35 ± 0.13	0.54 ± 0.16	0.42 ± 0.10
$\dot{\theta}/\theta$ (% yr^{-1})	0.113 ± 0.047	0.172 ± 0.061	0.136 ± 0.042

XMM: 0.84 ± 0.23 arcsec yr^{-1} (Katsuda et al. 2008)

Hydrodynamics

To obtain the age from $\dot{\theta}/\theta = v_{\rm f}/R_{\rm f}$ requires some information about the unknown evolutionary state.

Truelove and McKee (1999) characterize $R_{\rm f}$ and $v_{\rm f}$ as functions of a dimensionless age $t/t_{\rm ch}$ and of the initial conditions E_0, $M_{\rm ej}$, n, and n_0.

Since the initial conditions are unknown, the values of $R_{\rm f}$ and $v_{\rm f}$ were computed at each one of the 2.35 billion points of a 5-dimensional grid where

- $E_0 = 10^{49}$, $10^{49.05}$, ..., 10^{53} erg,
- $M_{\rm ej} = 10^{0}$, $10^{0.05}$, ..., 10^{2} $M_\odot$,
- $n = 6$, 7, 8, 9, 10, 12, 14,
- $n_0 = 10^{-5}$, $10^{-4.95}$, ..., 10^{0} cm^{-3}, and
- $t/t_{\rm ch} = 0.01$, 0.02, ..., 9.99.

Hydrodynamics cont.

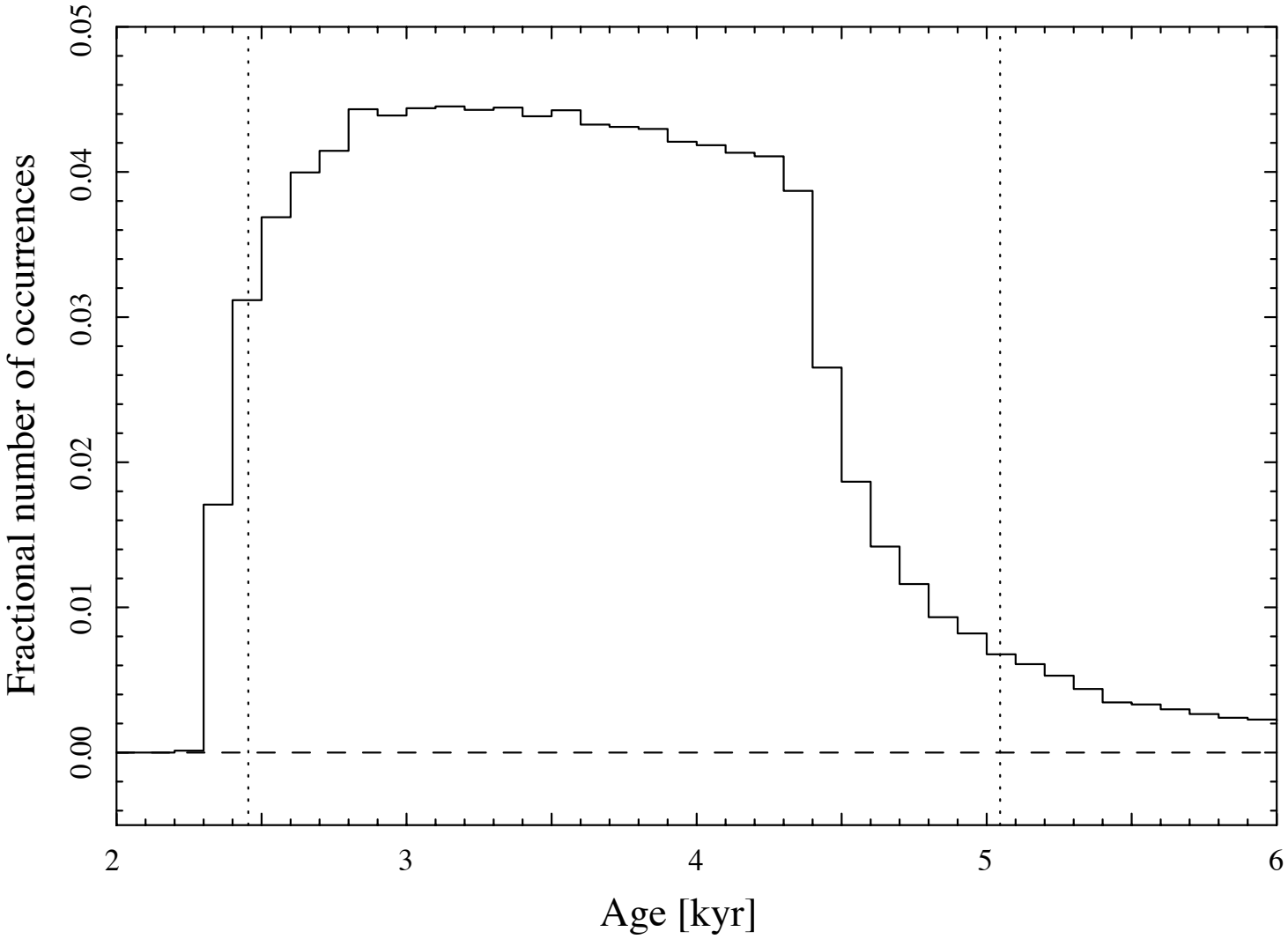
The 57.4 million valid scenarios (i.e. ages) are those where

- $0.094 \leq v_{\rm f}/R_{\rm f} = \dot{\theta}/\theta < 0.178$ kyr^{-1},
- $v_{\rm f} \geq 1000$ km s^{-1},
- the inferred thermal X-ray emission does not exceed the emission along the line of sight ($\rightarrow n_0 < 0.4$ cm^{-3}), and
- $E_{kT} + E_{KE} + E_{cr,{\rm p}} \leq E_0$ (Aschenbach 2013).

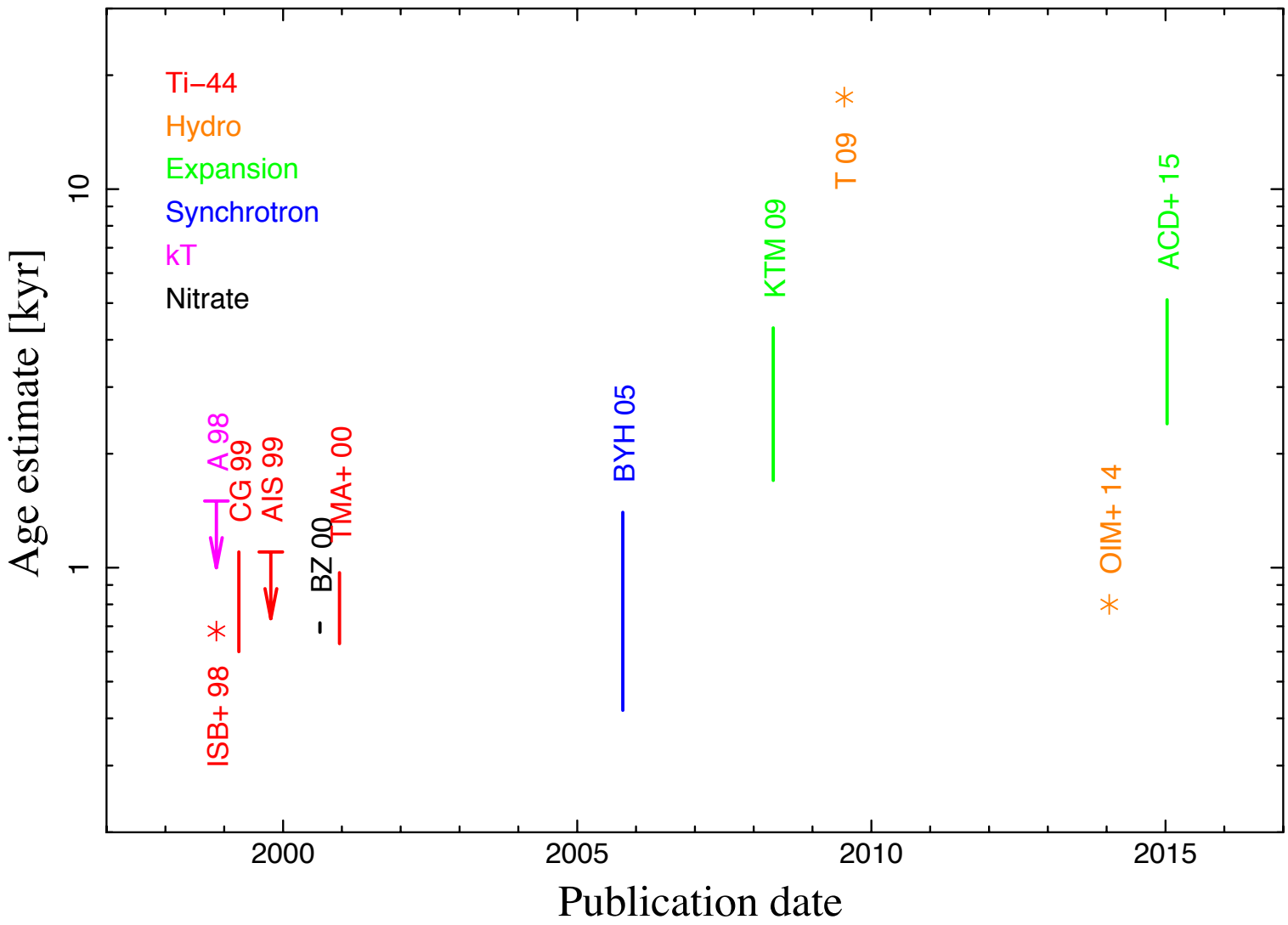
The plausible ages are

- 2.2–8.4 kyr (full range),
- 2.4–5.1 kyr (90% range), and
- up to a factor 1.5 higher if the remnant is expanding into a steady wind.

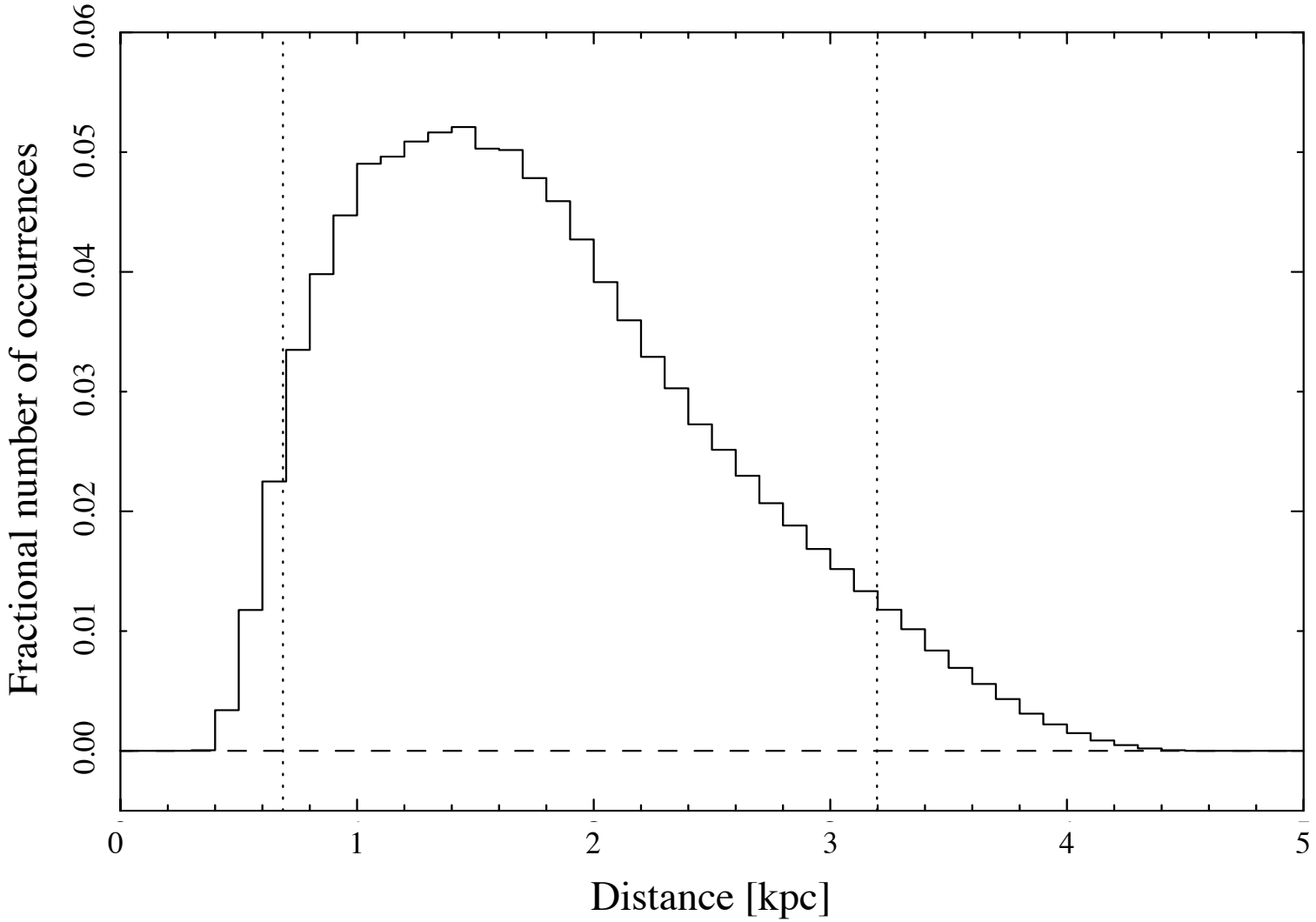
Plausible ages



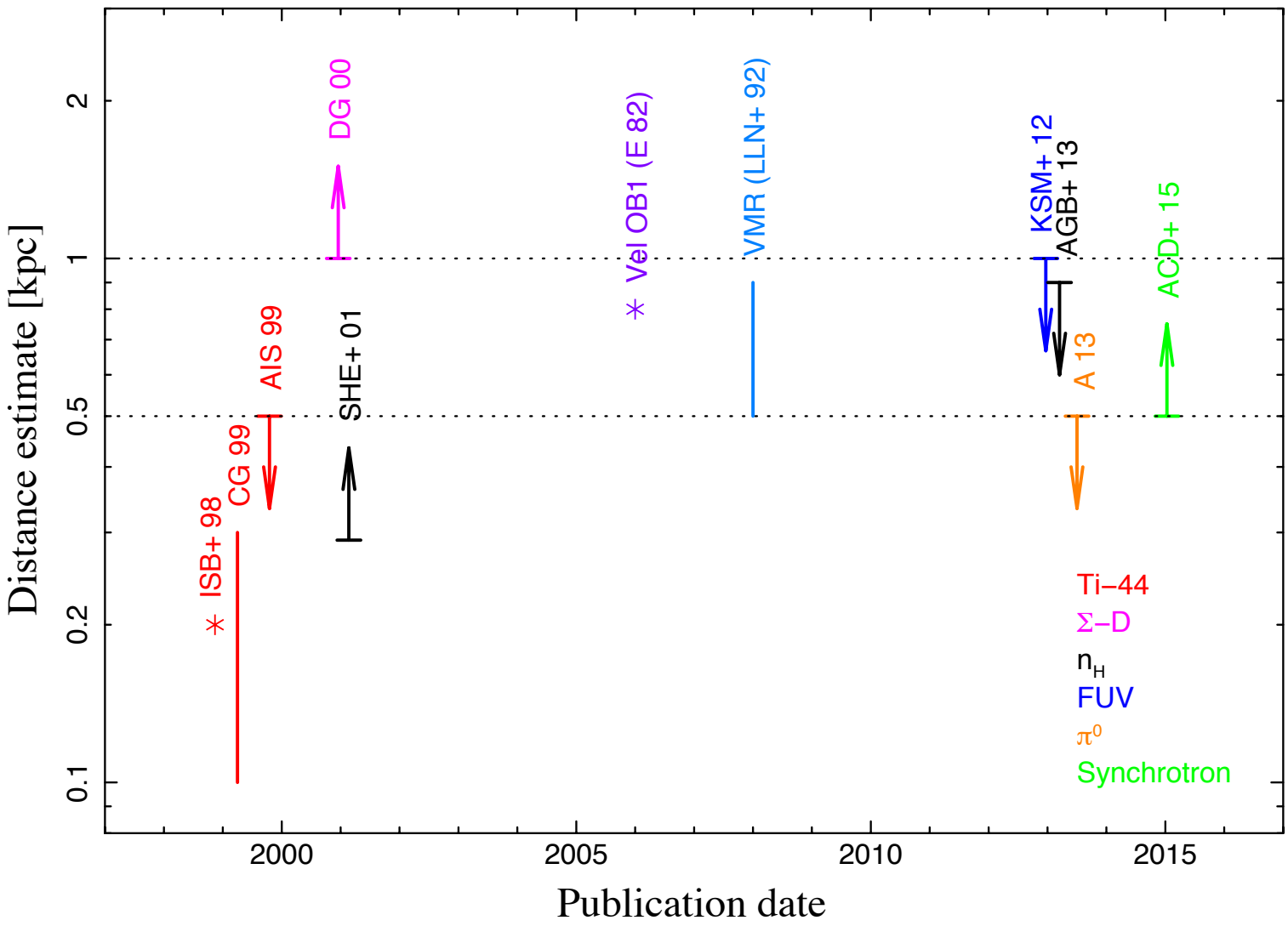
When


Ti−44
Hydro
Expansion
Synchrotron
kT
Nitrate
Age estimate [kyr]
1
10
2000
2005
2010
2015
Publication date
ISB+ 98
A 98
CG 99
AIS 99
BZ 00
MA+ 00
BYH 05
KTM 09
T 09
OIM+ 14
ACD+ 15

Plausible distances



Where


Distance estimate [kpc]
0.1
0.2
0.5
1
2
2000
2005
2010
2015
Publication date
ISB+ 98
CG 99
AIS 99
SHE+ 01
DG 00
Vel OB1 (E 82)
VMR (LLN+ 92)
KSM+ 12
AGB+ 13
A 13
ACD+ 15
Ti−44
Σ−D
n_H
FUV
π^0
Synchrotron

Conclusions

- Measurement:
  - Chandra data suggest that the northwestern rim of Vela Jr. is expanding by 0.42 ± 0.10 arcsec yr^{-1}.
- Then:
  - If this rate is representative, then Truelove and McKee's hydrodynamic models indicate the remnant is between 2.4 and 5.1 kyr old (or slightly older).
- There:
  - The preponderance of the distance constraints yield a range of 0.5–1.0 kpc.
  - The nearer of two groups of material in the Vela Molecular Ridge is 0.7 ± 0.2 kpc (Liseau et al. 1992).
  - The Vel OB1 association is 0.8 kpc (Eggen 1982).