^{44}Ti γ–ray lines & young SNRs
INTEGRAL IBIS/ISGRI observations

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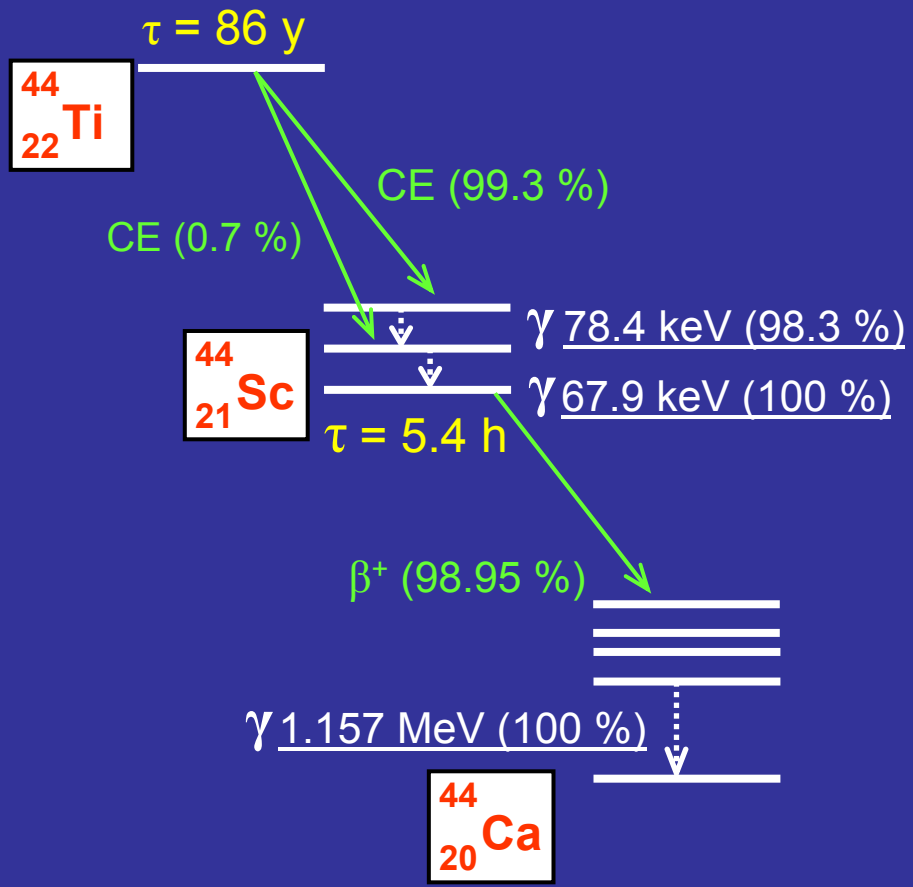
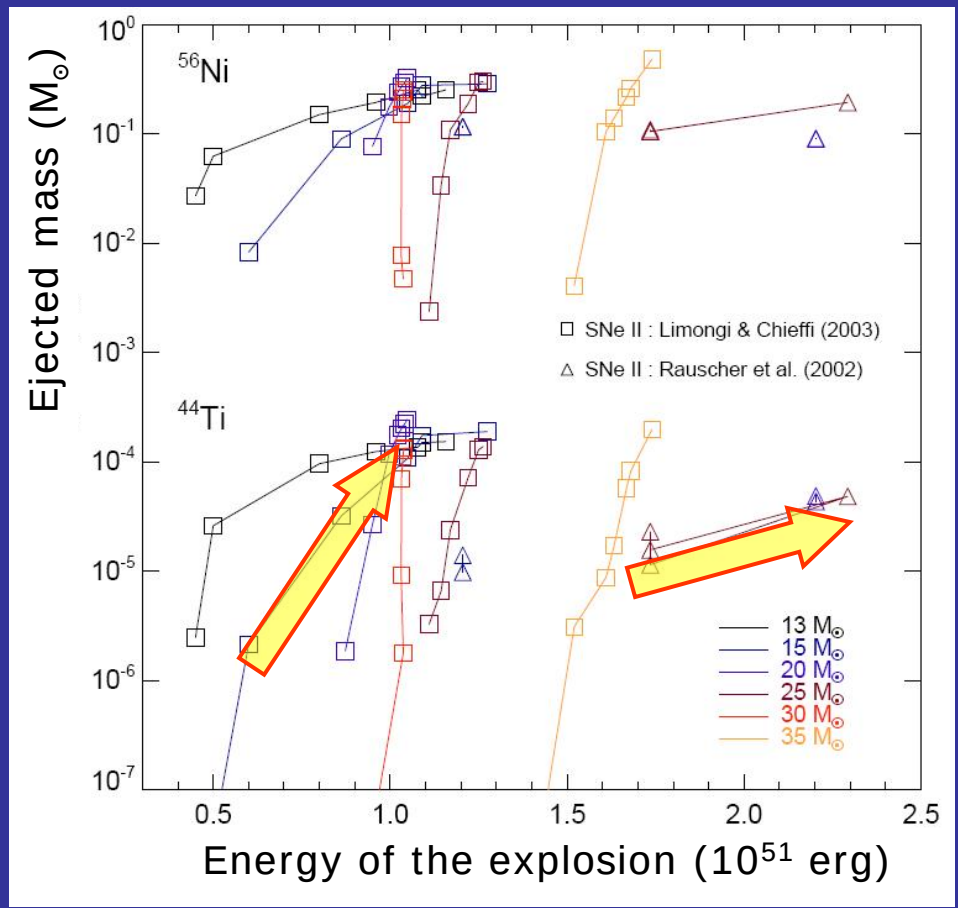
^{44}Ti properties

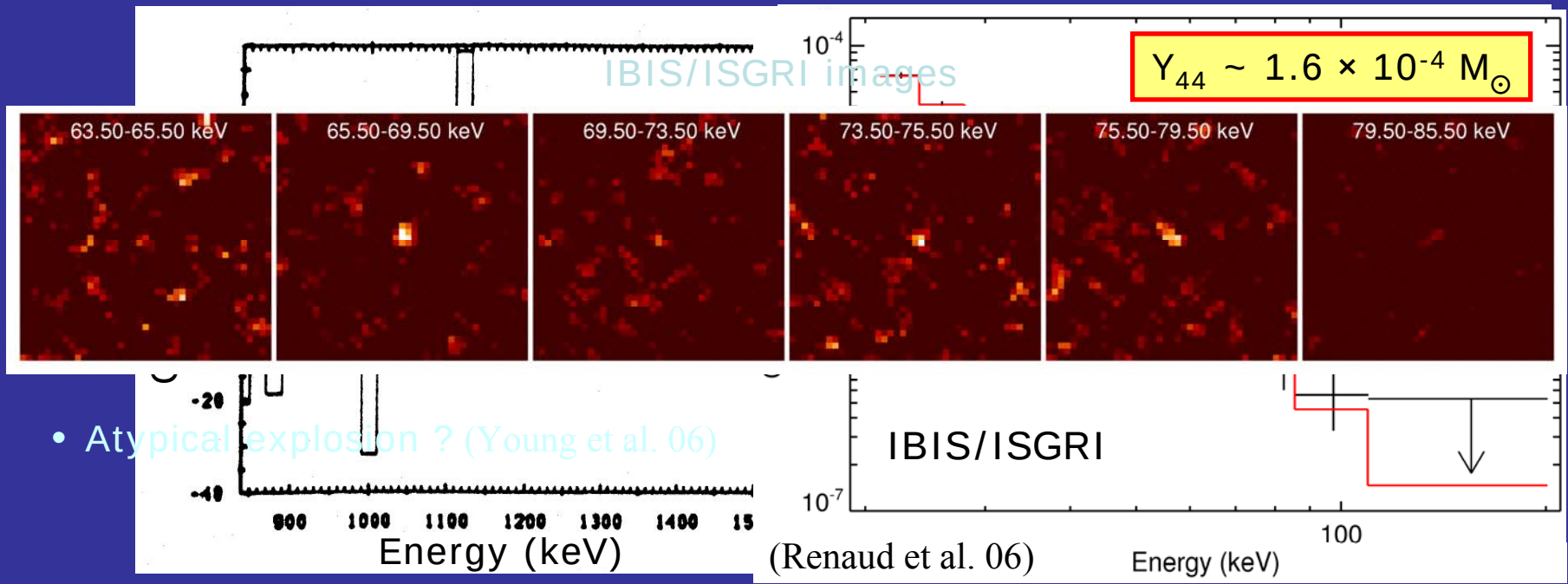
- ^{44}Ti exclusively produced in SNe (all types)





Individual SNRs

- From an observational point of view… Few cases !
  - Cassiopeia A
    - Historical event (Flamsteed, 1680) ? (Stephenson & Green 02)
    - Dynamical age ~ 330 yrs , Distance ~ 3.4 kpc (Reed et al. 95)
    - Progenitor = 20-25 $M_\odot$ (Vink 04) but complete scenario ? (Young et al. 06)
  - Atypical explosion ? (Young et al. 06)



Individual SNRs

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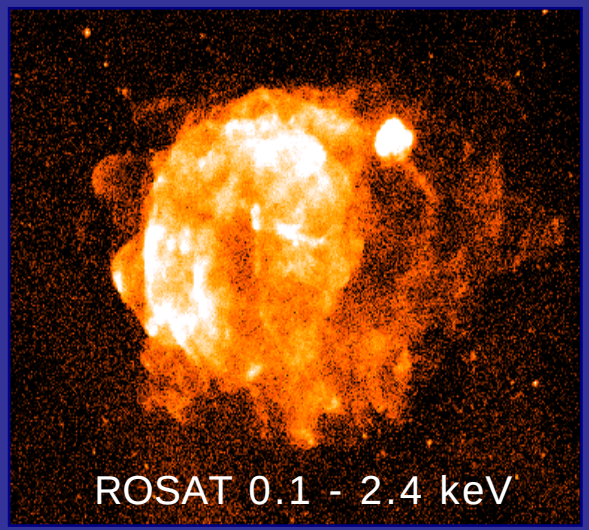
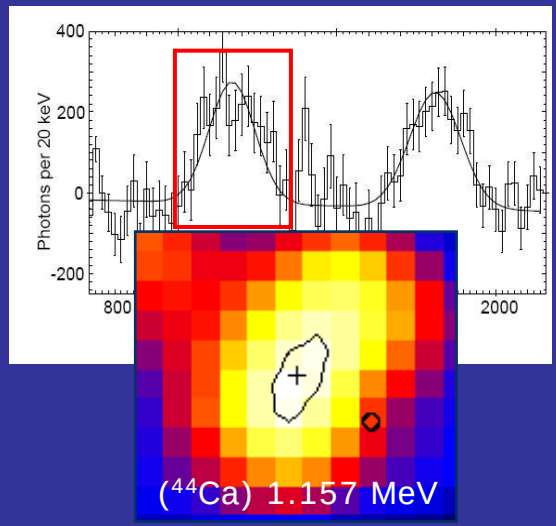
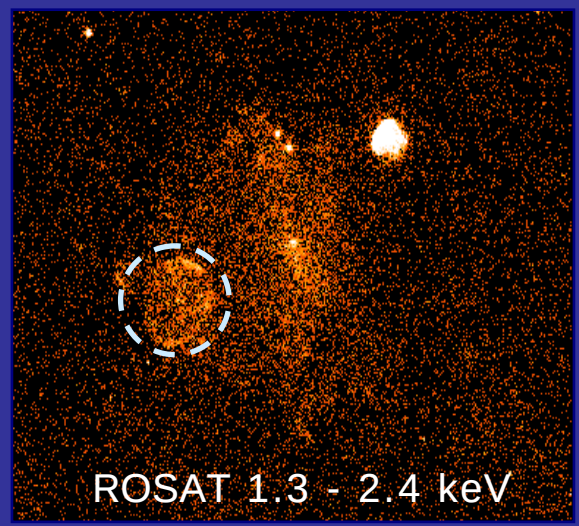
  - Vela Junior
    - Detected by COMPTEL (Iyudin et al. 98) and ROSAT (Aschenbach 98)
    - Scenario « young & nearby » ? (Slane et al. 01 ; Schönfelder et al. 00)







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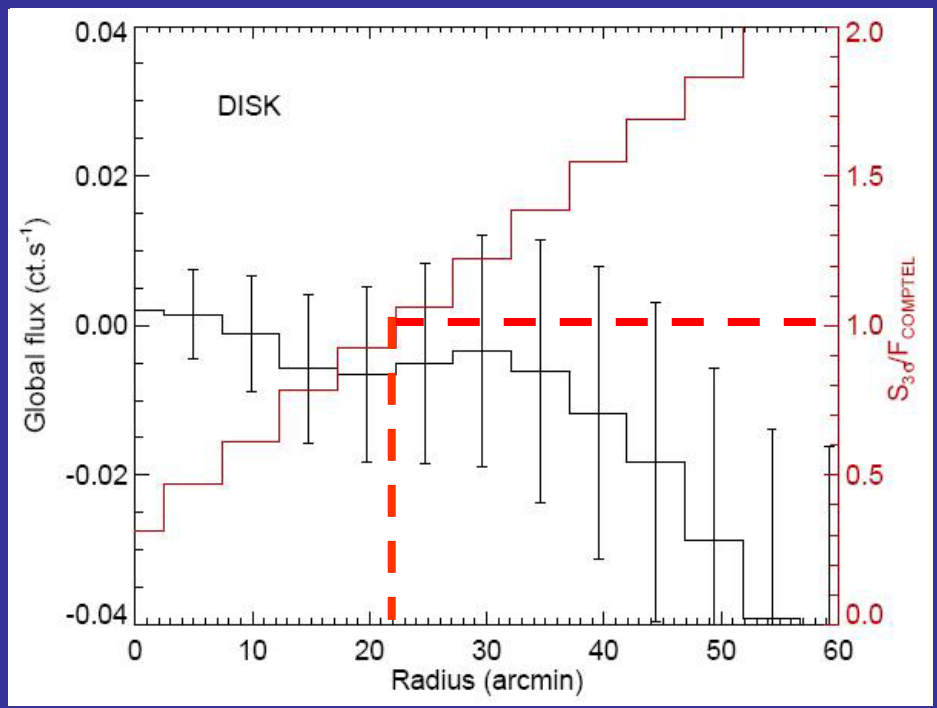
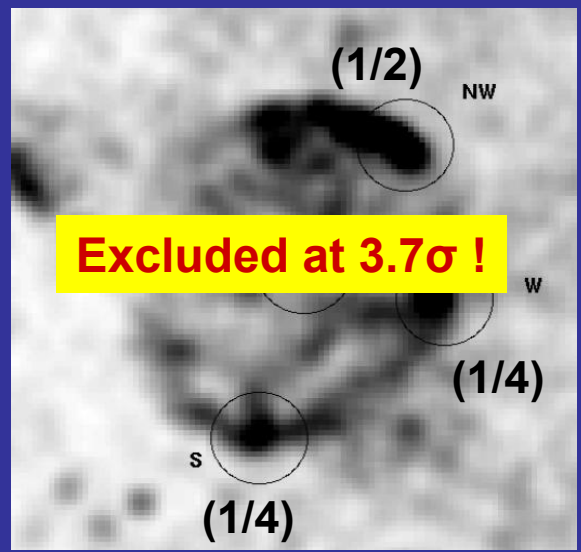
    - IBIS/ISGRI observations → Reality of the ^{44}Ti detection ?



Iyudin et al. (2006) scenario :
Ti X-ray line in the 3 ASCA hot-spot



Individual SNRs

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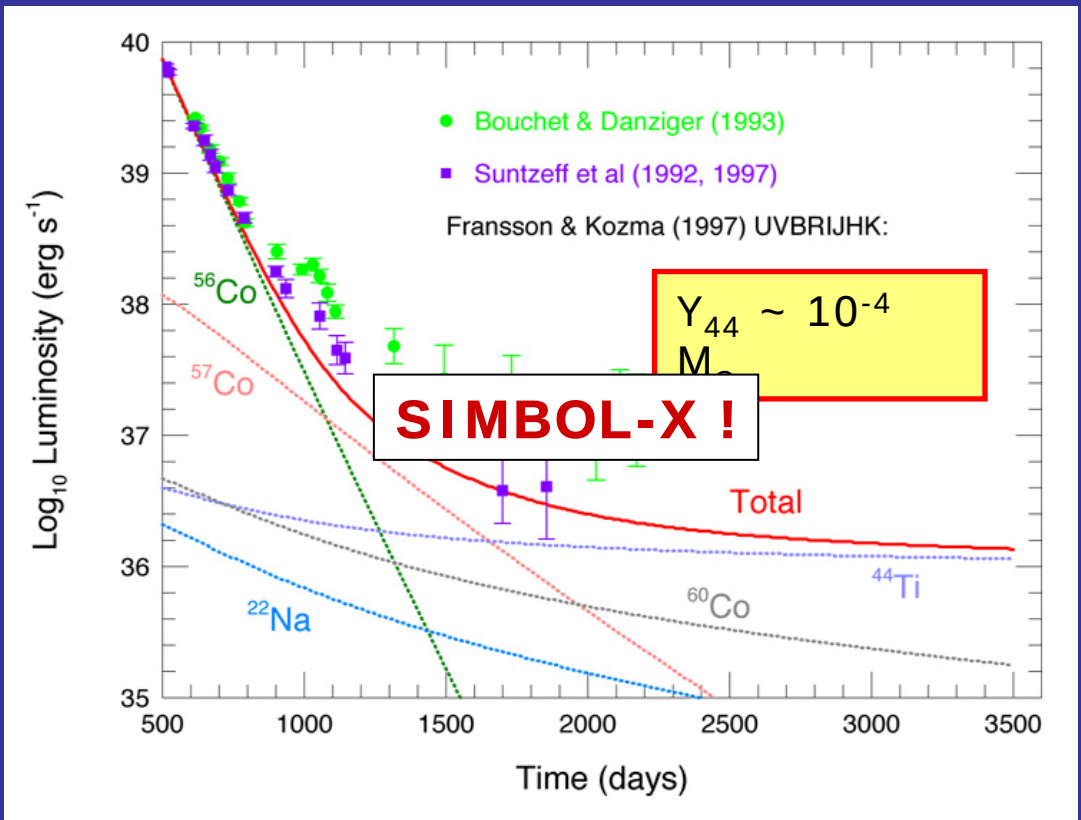
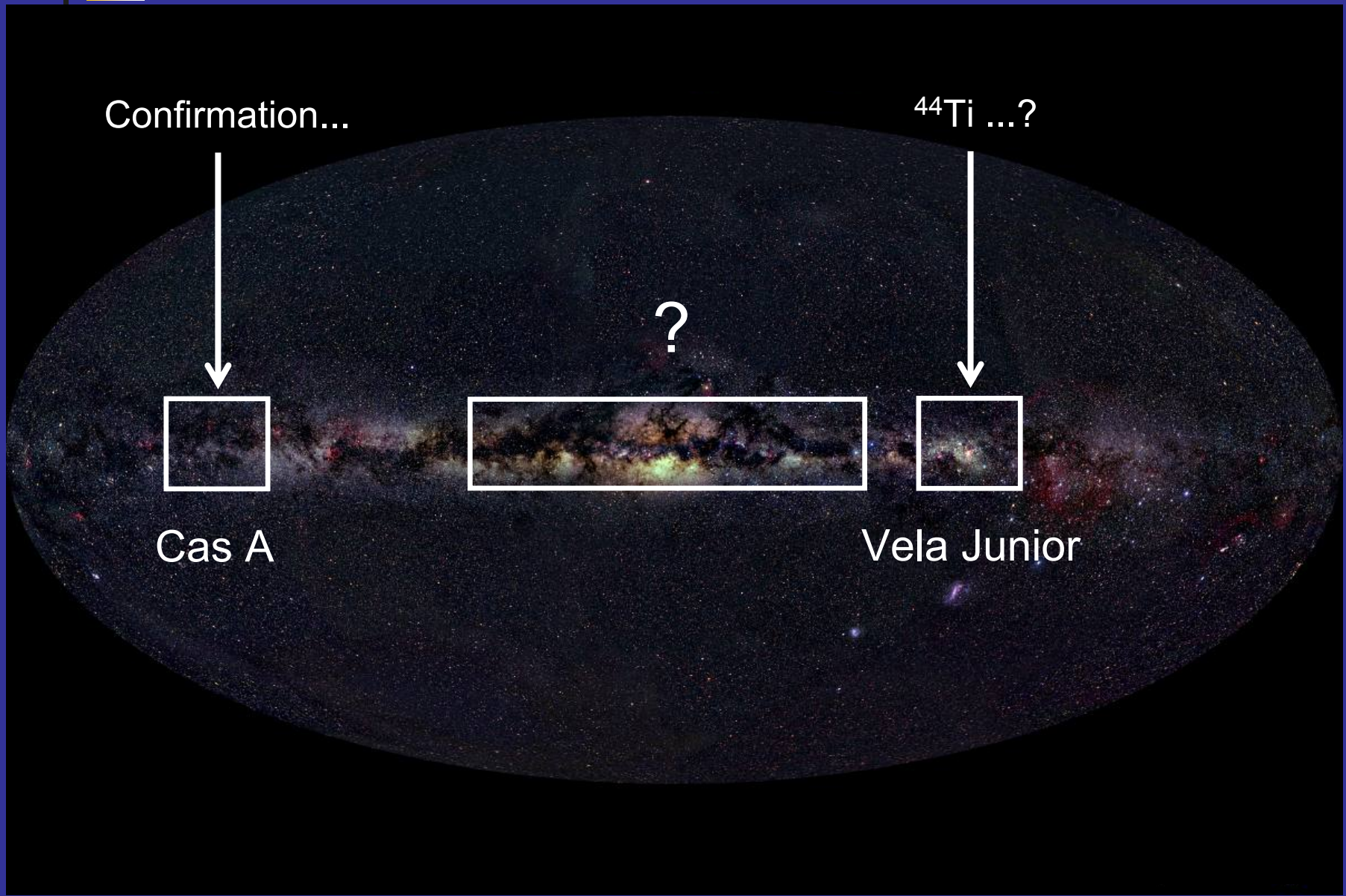
  - SN 1987a
    - Late-time light-curve explained by the ^{44}Ti decay (Fransson & Kozma 02)




Confirmation...
^{44}Ti ...?
?
Cas A
Vela Junior

Search for young SNRs through ^{44}Ti lines

- SNe → ^{44}Ti → ^{44}Ca: Origin of the Galactic ^{44}Ca & Search for « young & hidden » SNRs

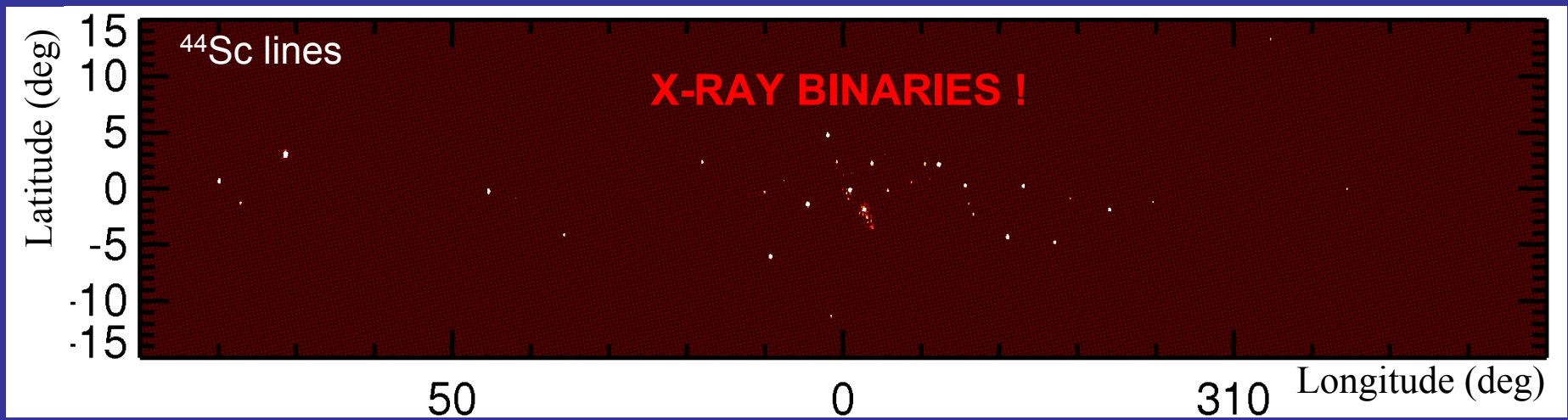
  - SNe rate ~ 2-3 century^{-1} (e.g. Cappellaro et al. 99)
  - Y_{44}(Cas A, SN1987a) ~ (1-2) × 10^{-4} $M_\odot$
  - Solar ^{44}Ca abundance & Galactic chemical evolution model (Clayton 85)
    Current Galactic ^{44}Ti production = $Y_{44} \times f_{SNe}$ ~ 3.6 × 10^{-4} $M_\odot$.century^{-1}

- No significant ^{44}Ti excess in the Galactic plane (except Cas A)
  (Mahoney et al. 92, Leising & Share 94, Renaud et al. 04, The et al. 06)

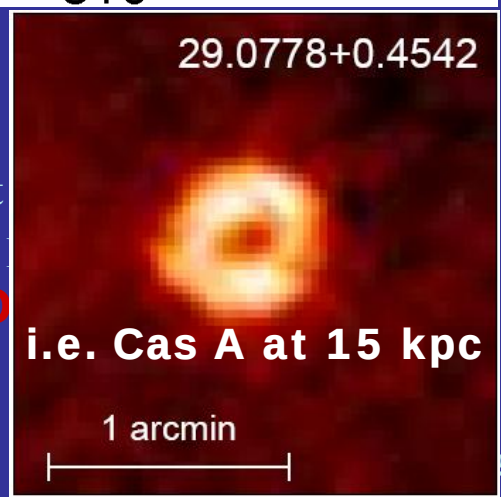
  - Constraints on the ^{44}Ti production in SNe
  - Constraints on the SNe rate
  - Scenario excluded at > 99 % ! (The et al. 06)
  - Origin of the ^{44}Ca… Exceptionnal events ?

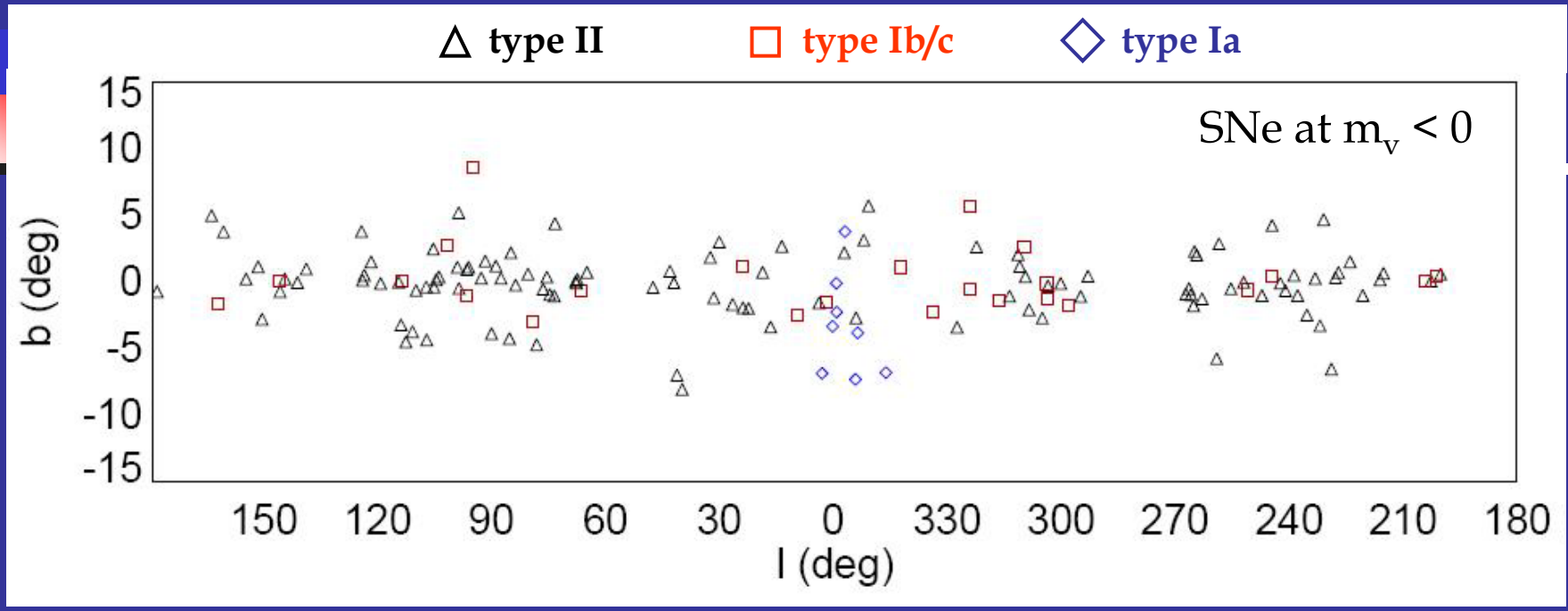
IBIS/ISGRI Survey in the ^{44}Sc lines

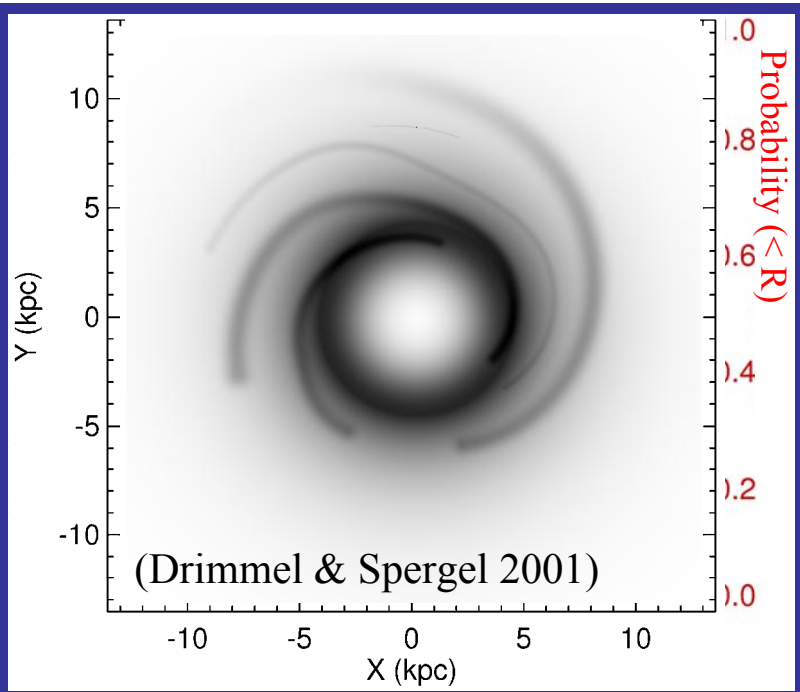
- 3 years of observation : $S_{3\sigma} = 10^{-5}$ cm^{-2} s^{-1}
  - No significant excess > 5σ (-90° < l < 90°, |b| < 15°)

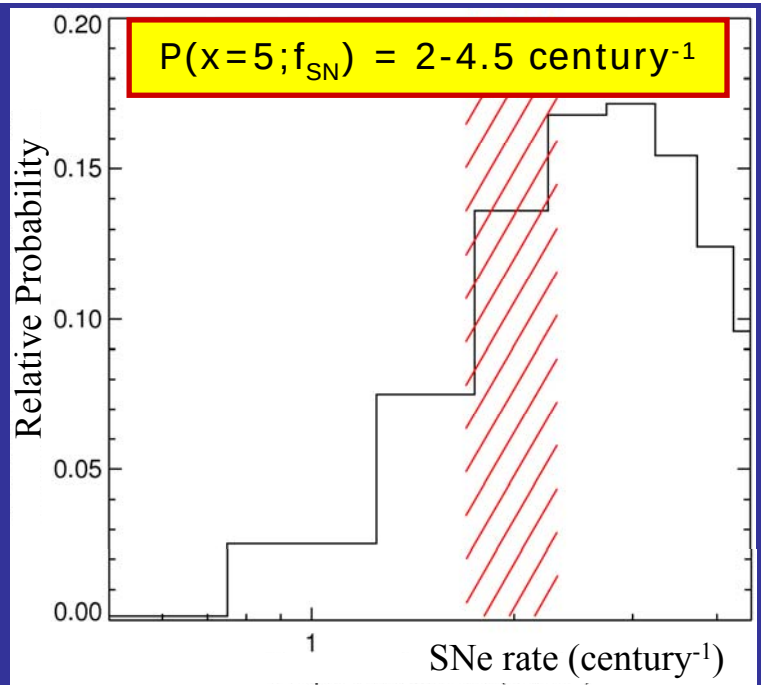


  - A priori positions (> 3σ)
    - Radio & ^{44}Ti observations on G057 **NO** (Renaud et
    - HESS J1813 (Aharonian et al. 2005 ; Brogan et al. 2005 ; Ubertini et al. 2005) , NGC 6334 (Bykov et al. 2006) **NO**
    - MAGPIS Survey (Helfand et al. 2006) **NO**




△ type II
□ type Ib/c
◇ type Ia
SNe at $m_v < 0$
b (deg)
l (deg)
15
10
5
0
-5
-10
-15
150
120
90
60
30
0
330
300
270
240
210
180


Probability (< R)
Y (kpc)
X (kpc)
(Drimmel & Spergel 2001)

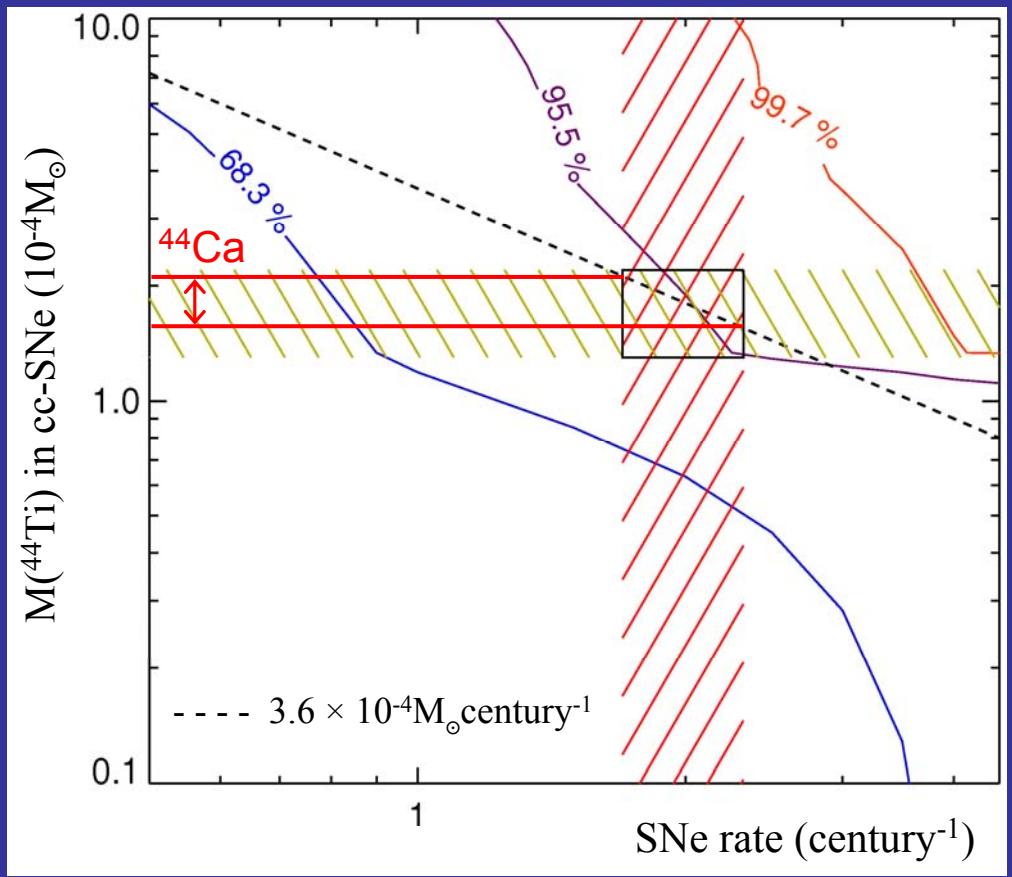

$P(x=5;f_{SN})$ = 2-4.5 century^{-1}
Relative Probability
SNe rate (century^{-1})

The constraints (2)

- Second test : $^{44}Ca \leftrightarrow Y_{44} \times f_{SN}$

«Gamma» problematic : no ^{44}Ti excess in the inner Galaxy ≡ Cas A ?

Exclusion diagram… Problem ?!



Conclusions

- Simple model doesn't work...
  - distribution of ^{44}Ti production in SNe
  - Robustness of the GCE models
- Is Cas A really an exceptional event...?
  - There is also SN 1987a !
  - Trend of the current 3D models (e.g. Young et al. 2006)
  - ^{40}Ca(α,γ)^{44}Ti rate increased by a factor of 2 ! (Vockenhuber et al. 2007)
- Search for young SNRs... How to ?
  - Radio surveys
  - HESS survey
  - 5 years of INTEGRAL data... To be analyzed soon !