^{60}Fe on Earth: status

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1. Introduction

2. AMS: How we measure
   (T.Faestermann)

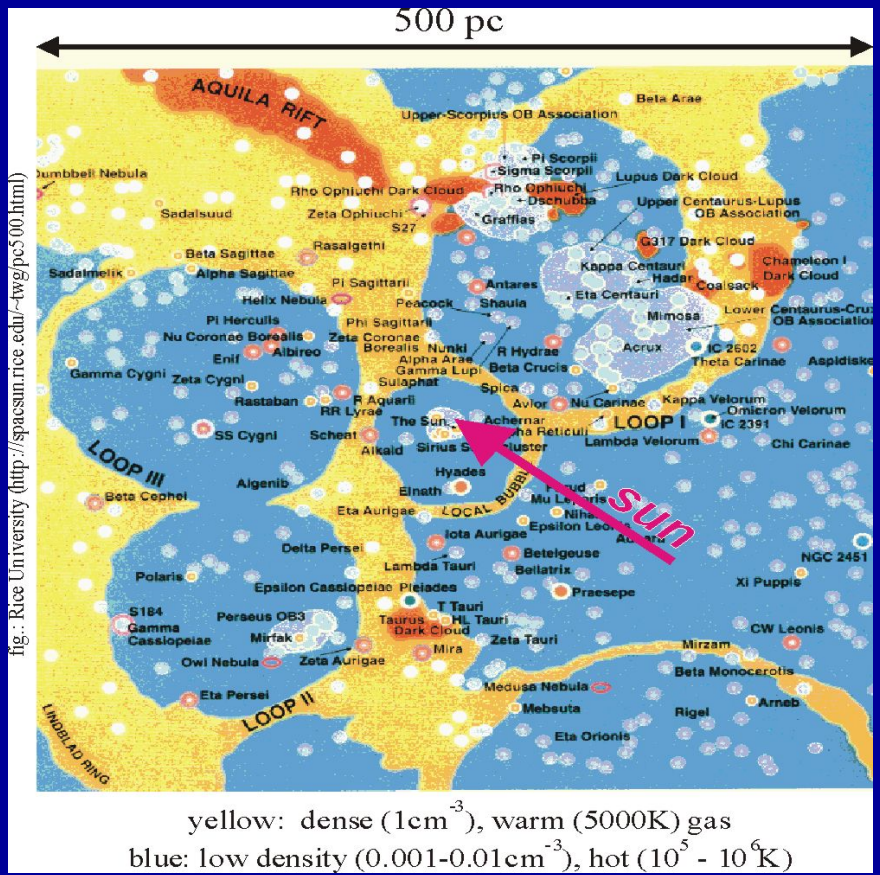
3. ^{60}Fe in another crust

4. ^{60}Fe in a sediment?

5. Discussion

1.Introduction

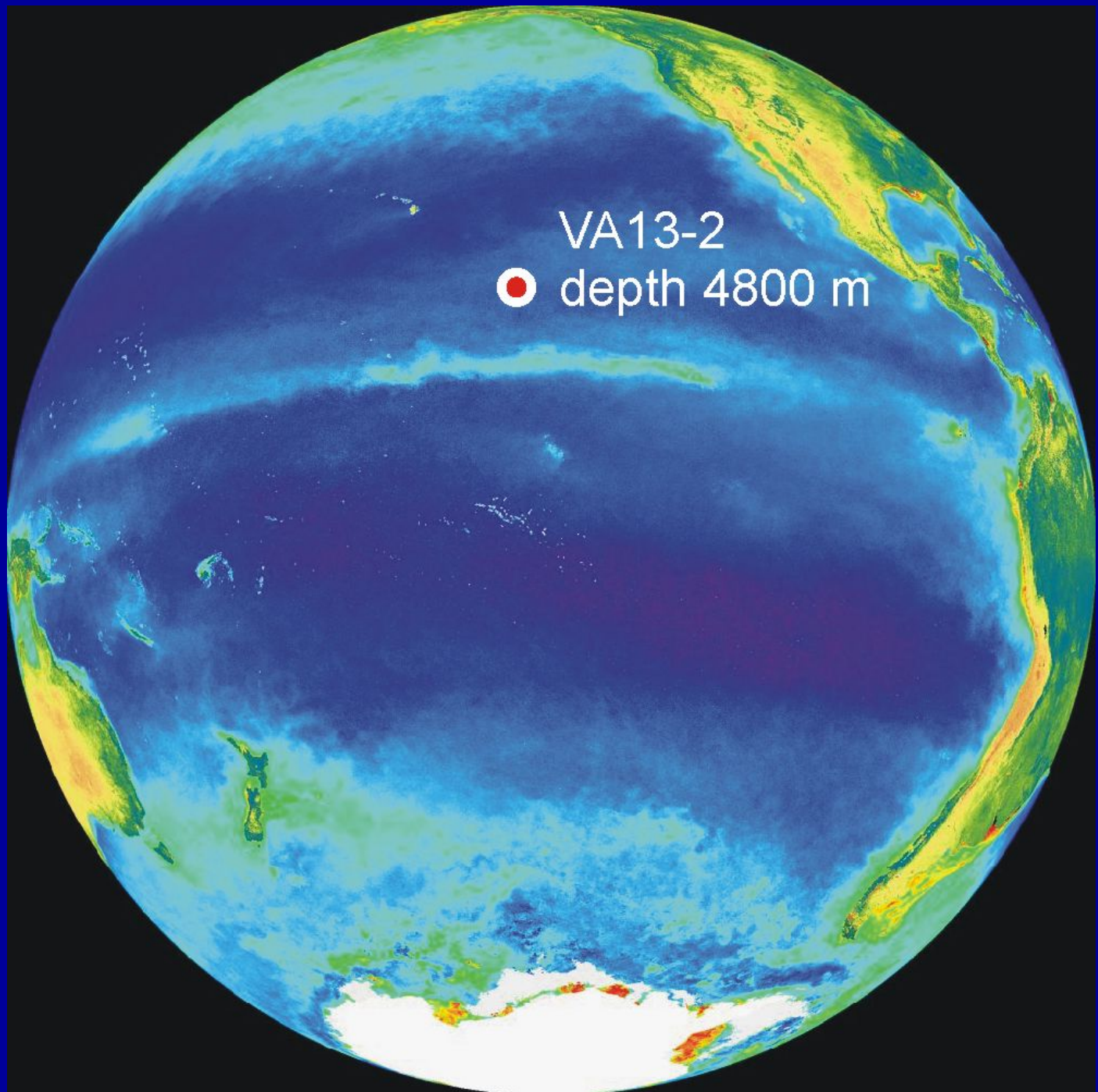
Signatures of recent (≈10 Myr), nearby (≈100 pc) SNe in the local interstellar environment



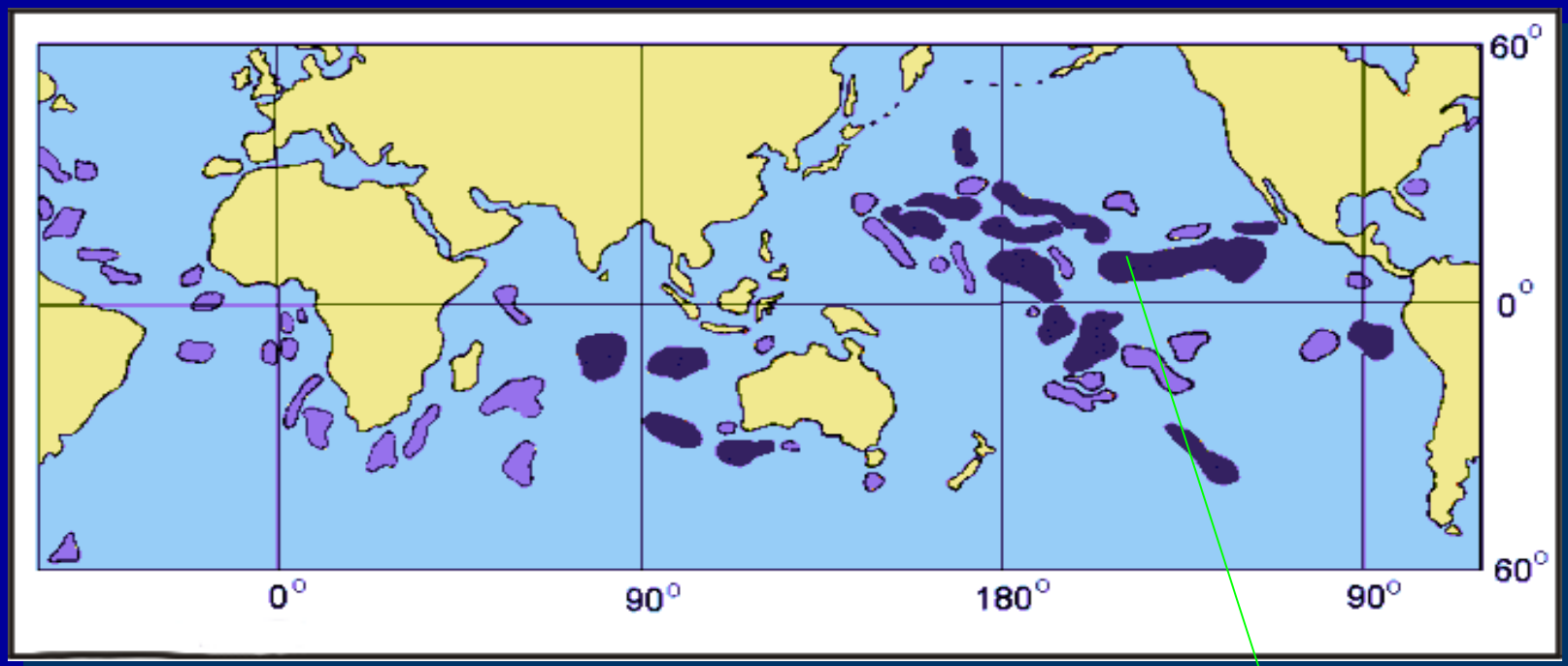
yellow: dense (1cm^{-3}), warm (5000K) gas
blue: low density (0.001-0.01cm^{-3}), hot (10^5 - 10^6K)

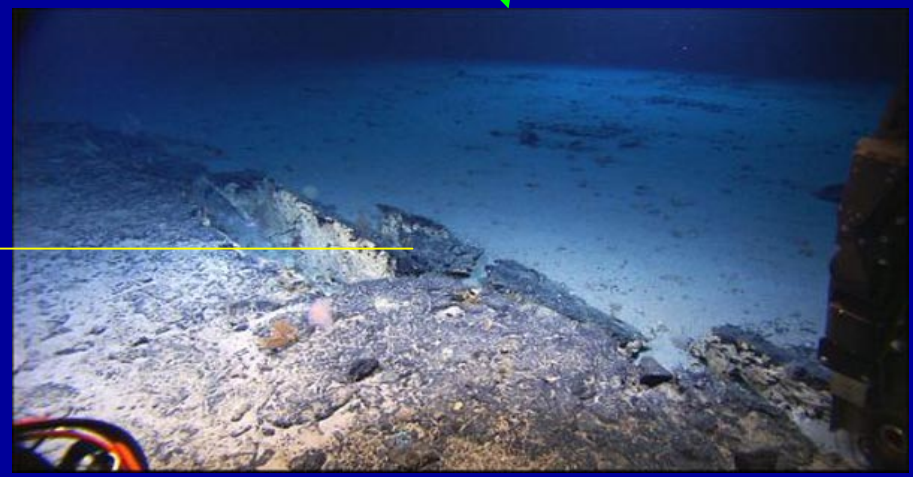
fig.: Rice University (http://spacsun.rice.edu/~fwg/pc500.html)

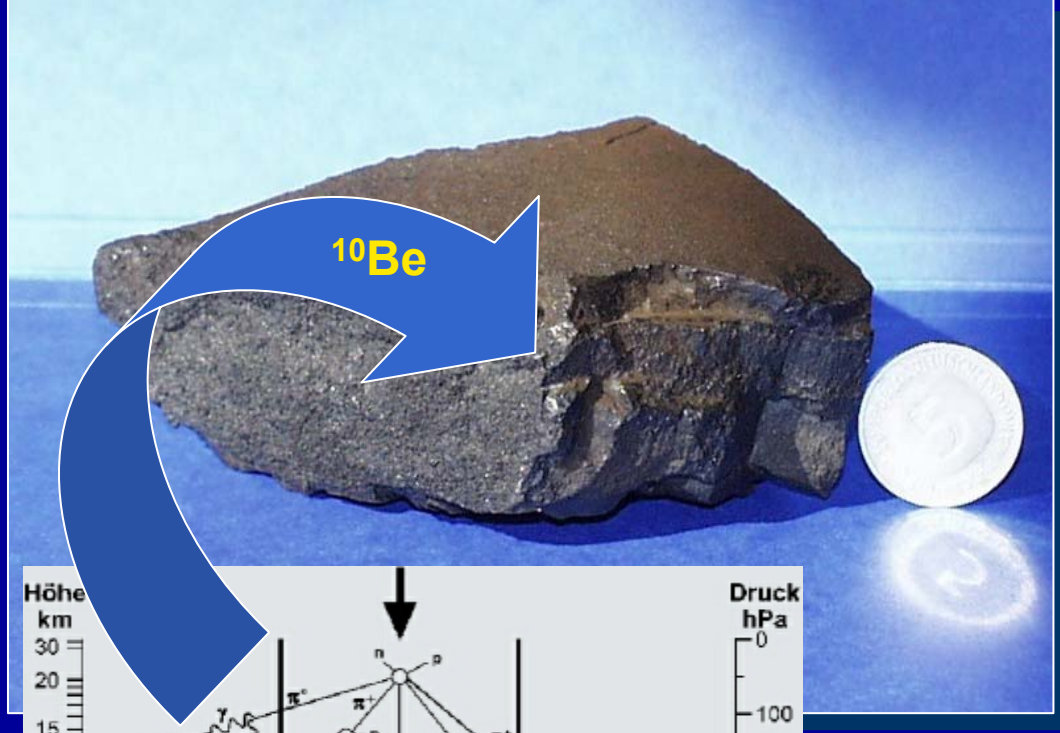
- **Existence of the local bubble:**
  2-3 SN in the solar vincinity,
  last SN **2-5 Myr** ago.
  Smith & Cox, ApJS 134(2001)283
- **Ionization of the "Local Fluff":**
  27 % HII, 35 % HeII
  ⇨ too high for equilibrium
  ⇩ ionized by a SN shock
  ⇩ onset of the recombination: **3-4 Myr**
  Barstow et al., MNRAS 286(1997)58
- **Antiprotons in cosmic rays:**
  CR propagation models produce too few antiprotons (B/C correct)
  ⇩ fresh, local CR component?
  Moskalenko et al., ApJ 586(2003)1050
- **Isotope anomalies on Earth due to direct deposition of SN ejecta?**
  Ellis et al., ApJ 470(1996)1227,
  Korschinek et al., Radiocarbon 38(1996)68

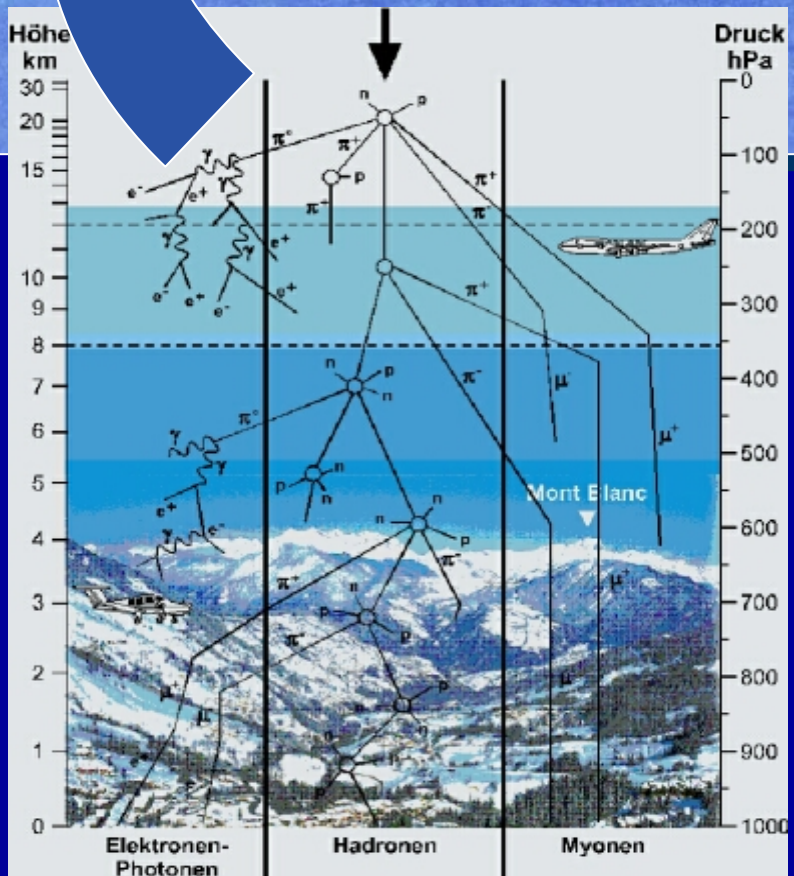

VA13-2
depth 4800 m

Ferromanganese crust

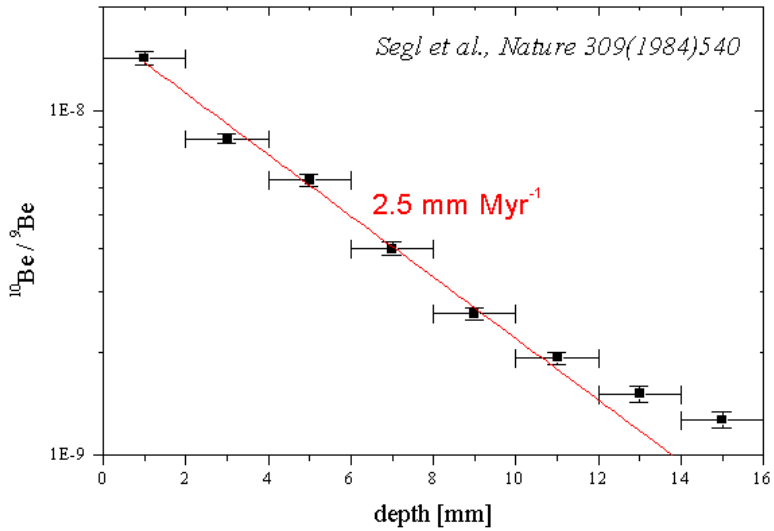




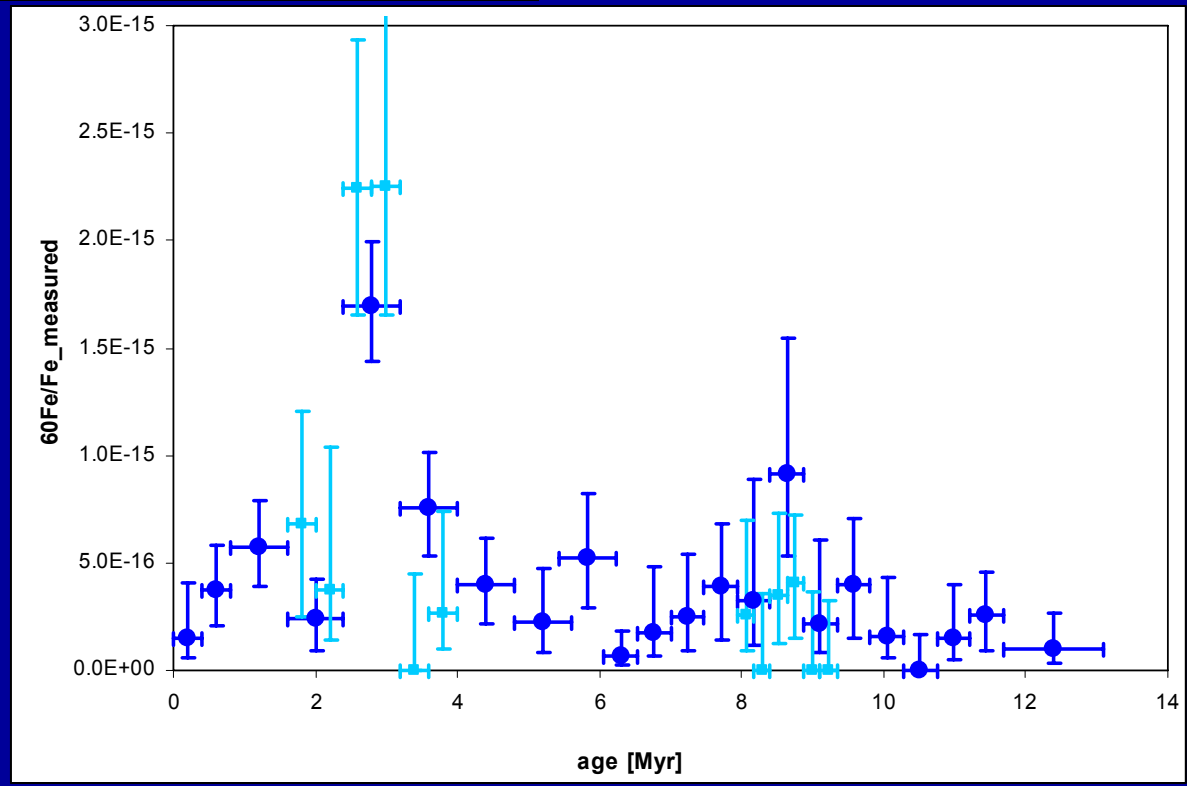




10Be, $T_{1/2}$=1.4My

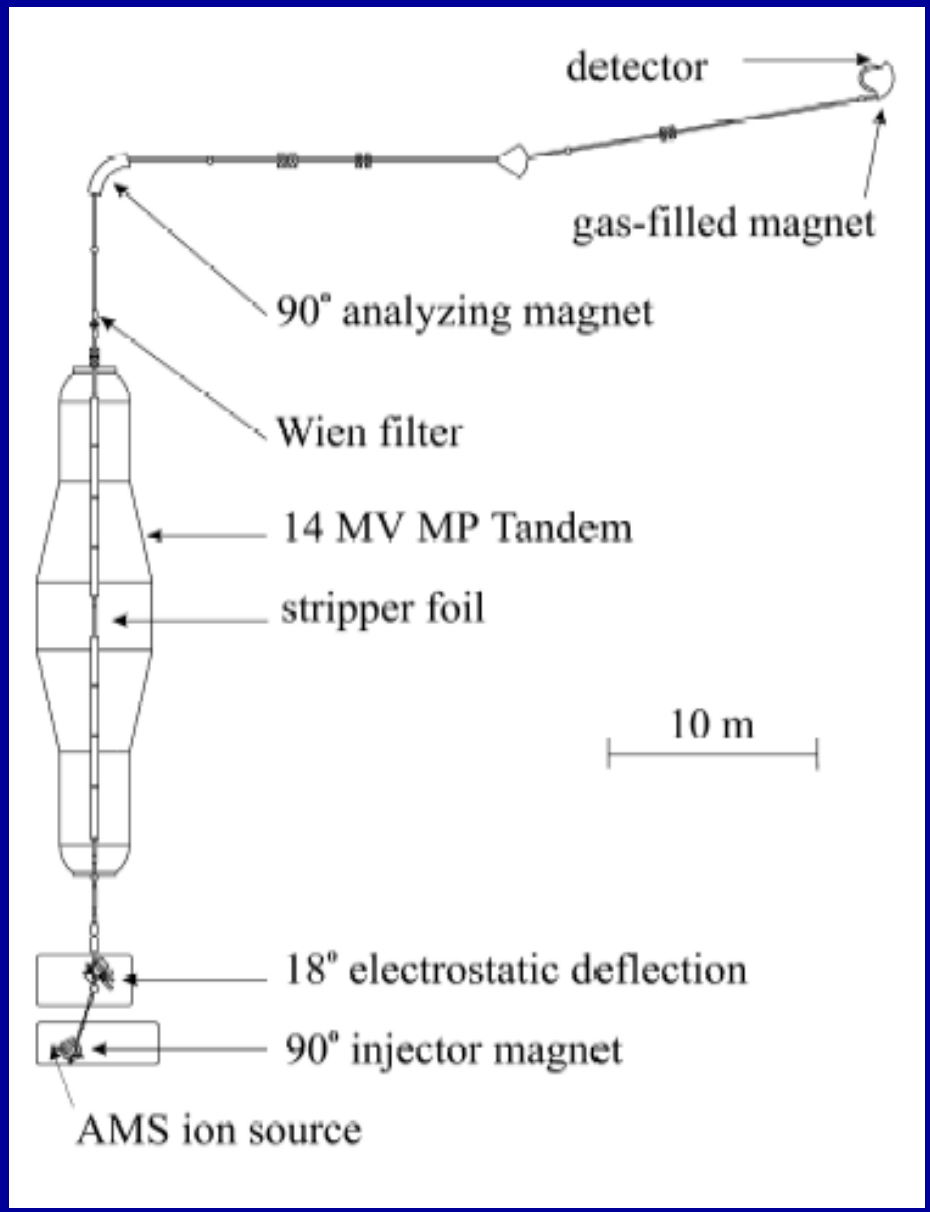


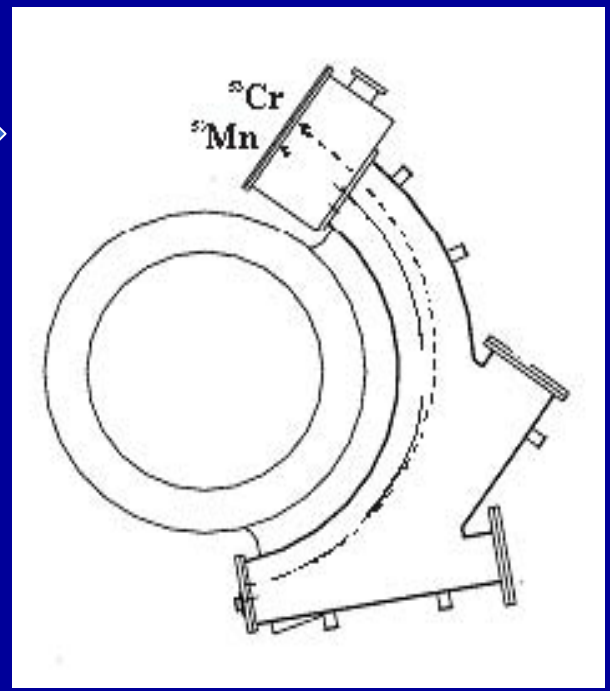
Co55 17.53 h 7/2- EC	Co56 77.27 d 4+ EC	Co57 271.79 d 7/2- EC	Co58 70.82 d 2+ * EC	Co59 7/2- 100	Co60 5.2714 y 5+ *	Co61 1.650 h 7/2- β-
Fe54 0+ 5.8	Fe55 2.73 y 3/2- EC	Fe56 0+ 91.72	Fe57 1/2- 2.2	Fe58 0+ 0.28	Fe59 44.503 d 3/2- β-	Fe60 1.5E+6 y 0+ β-
Mn53 3.74E+6 y 7/2- EC	Mn54 312.3 d 3+ EC,β-	Mn55 5/2- 100	Mn56 2.5785 h 3+ β-	Mn57 85.4 s 5/2- β-	Mn58 3.0 s 0+ * β-	Mn59 4.6 s 3/2-,5/2- β-



K.Knie et. al. PRL, 2004

2. AMS: How we measure

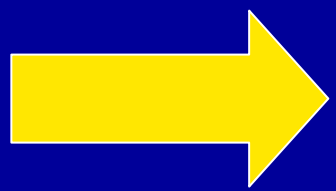




Efficiency: ~ 10^{-4}

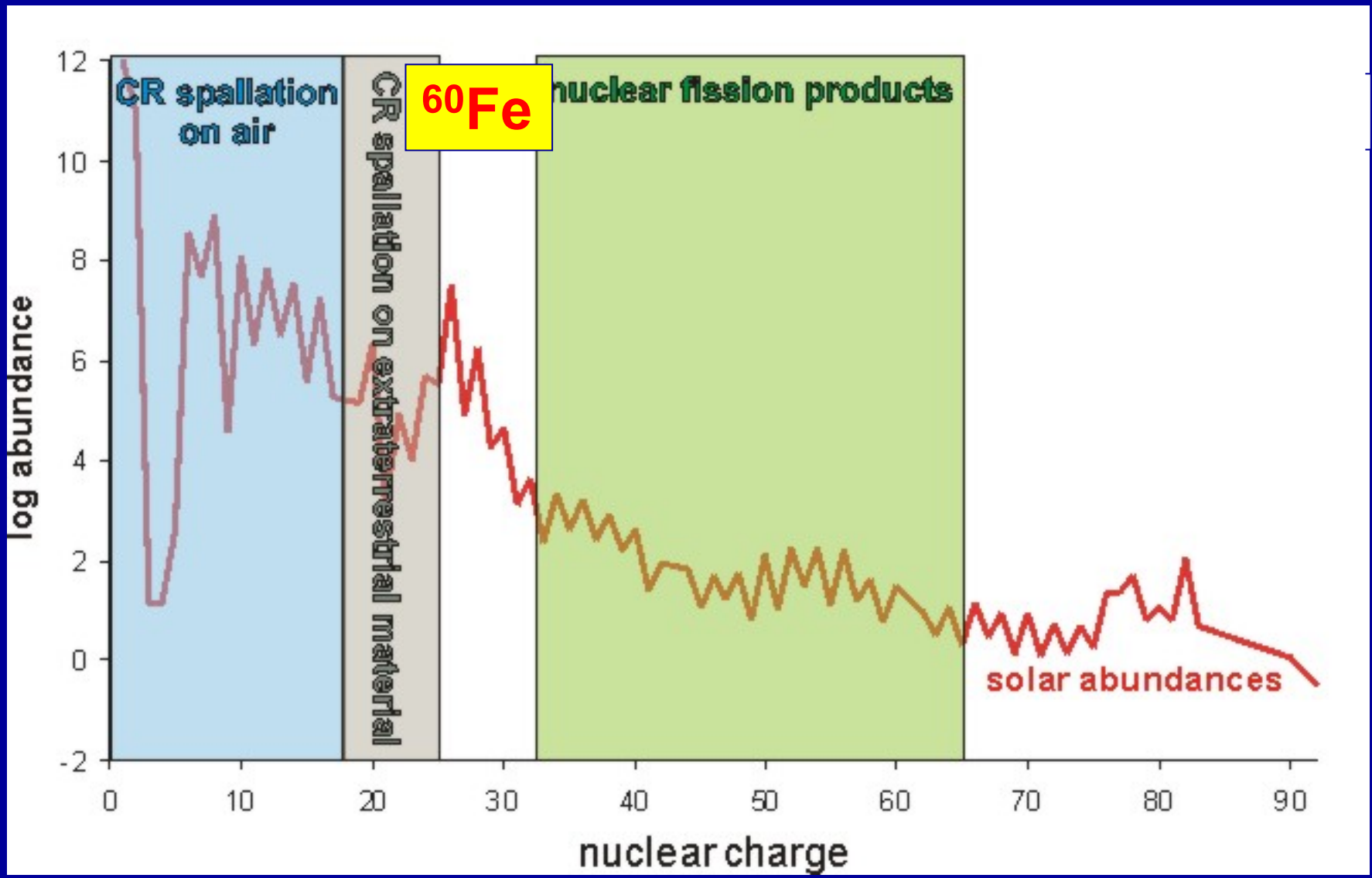
Sensitivity: down to 10^{-16} isotopic ratios

ratio with respect to the bulk ~ 10^{-20}

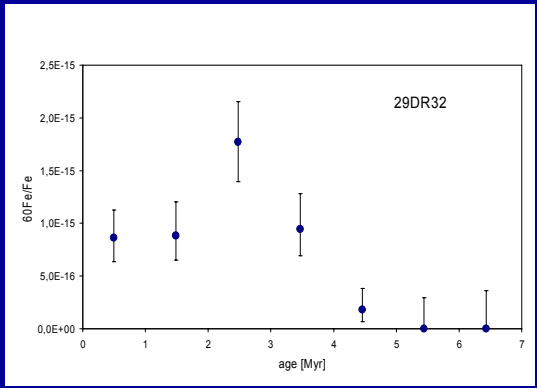


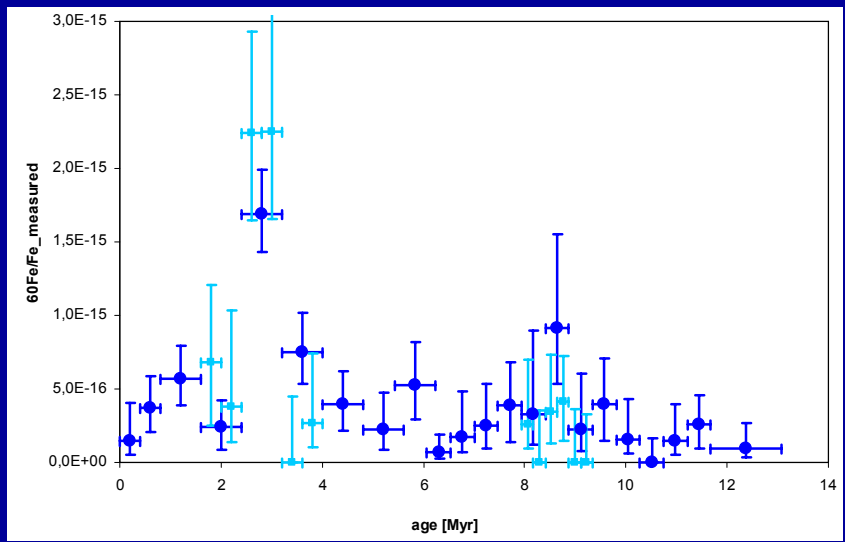
long-lived radio-isotopes
(natural or anthropogenic origin)

Why sensitive for ^{60}Fe?



3. ^{60}Fe in another crust





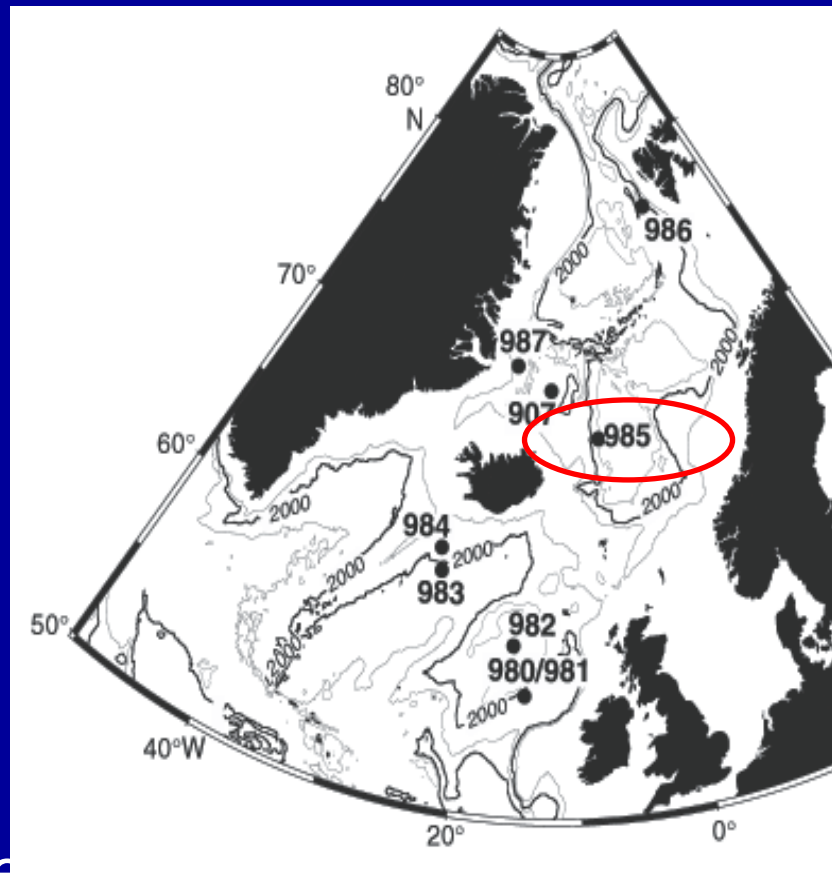
4. ^{60}Fe in a sediment?

growth rate: 30m/Myr
⇔ 2-3mm/Myr in crust

100% build-in eff.
⇔ 0.6% in crust

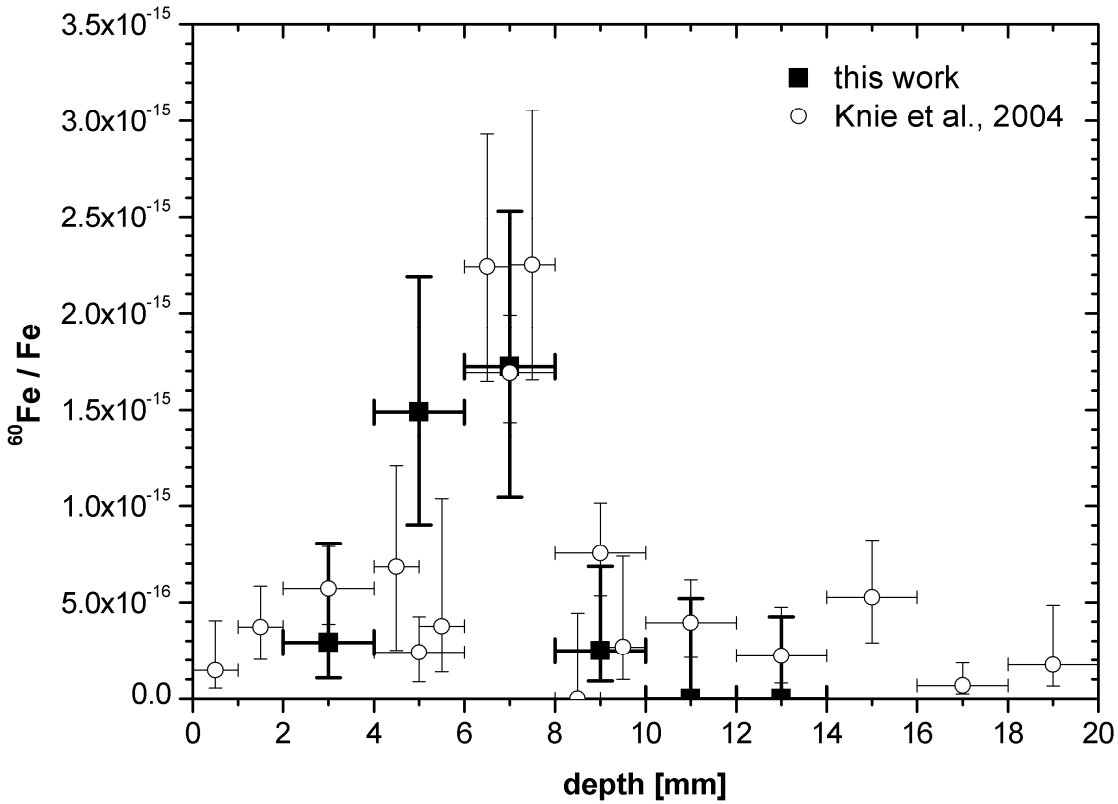
chemical leaching
to not get the particles

North Atlantic

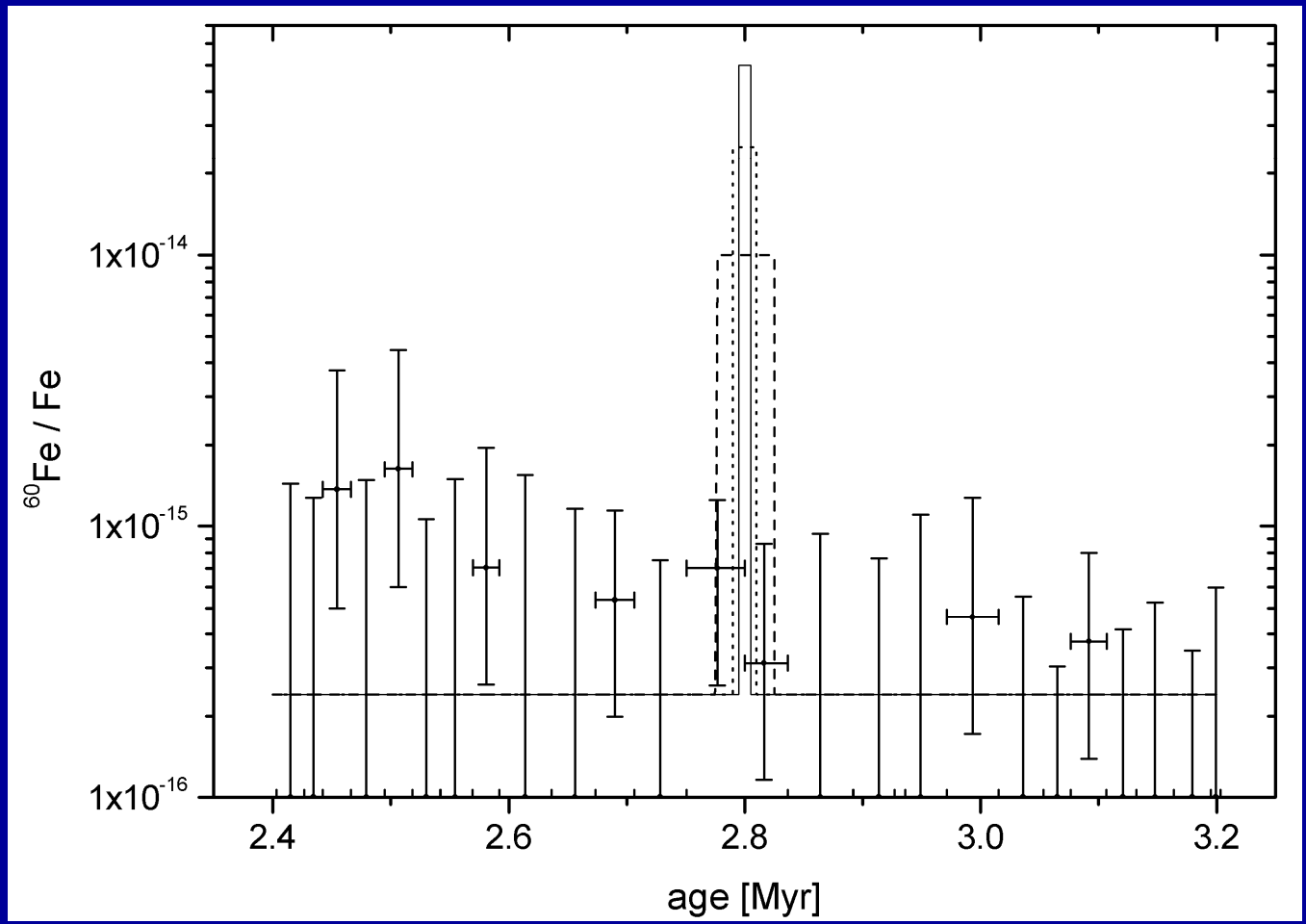


Collaboration with Orsay :
C. Fitoussi, G.M. Raisbeck, S. Goriely,
D. Lunney, C. Waelbroeck

Leaching of the crust



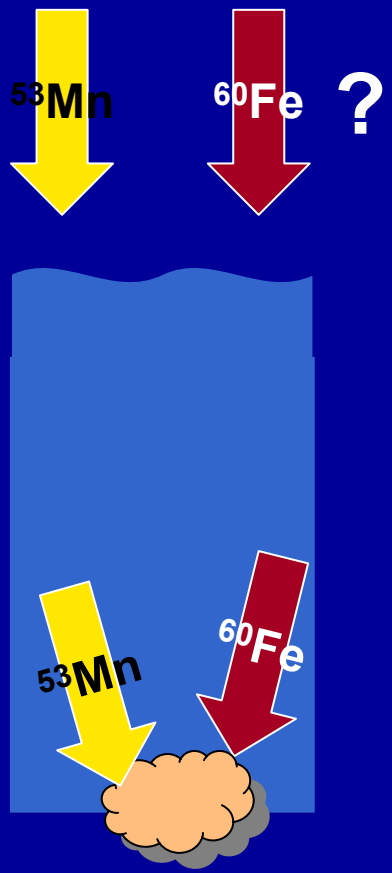
Naïve expectation for a narrow signal



Why not?

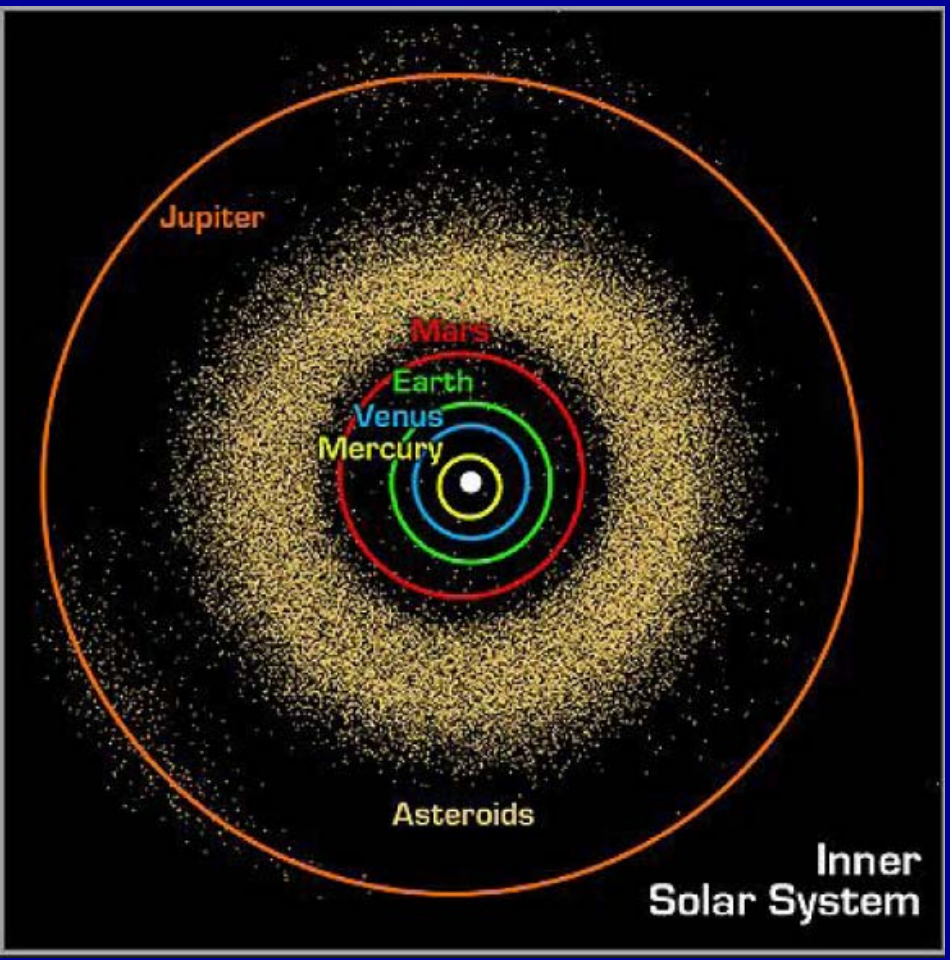
- horizontal displacement of the sediment?
- Check: uptake of the crust much higher than 0.6%?

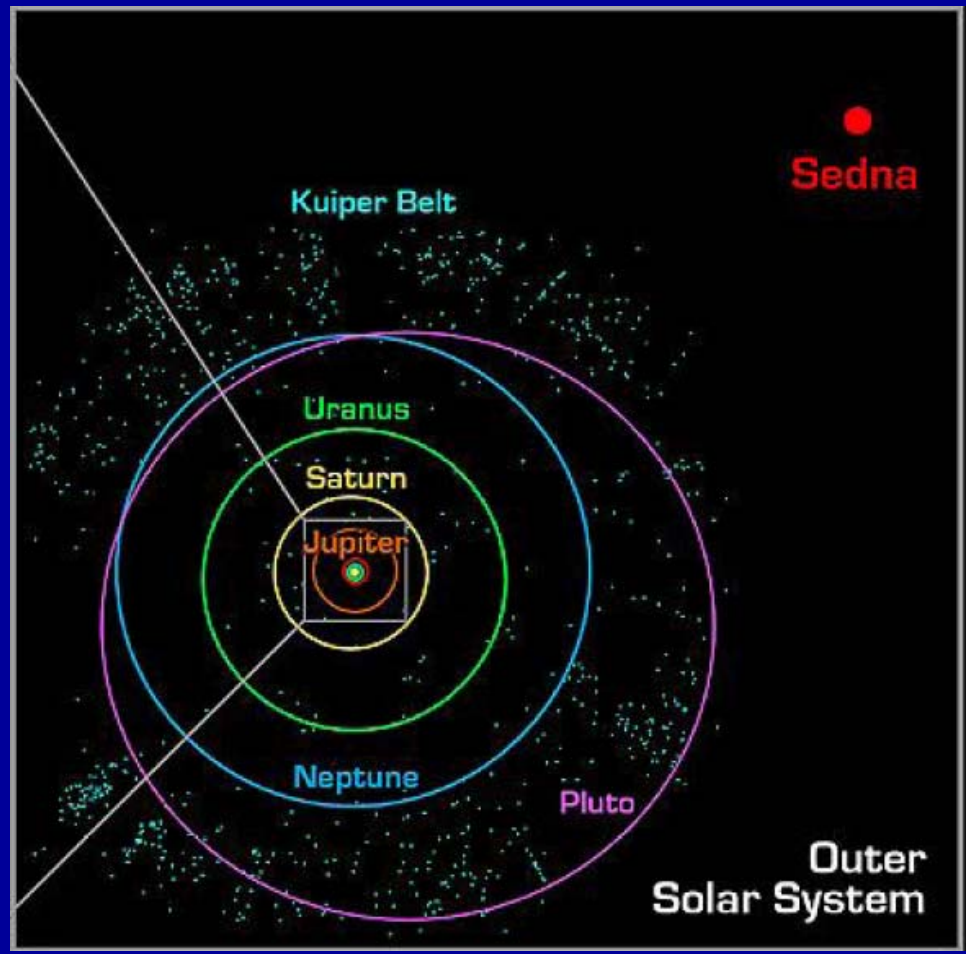
uptake into crust higher than 0.6%?



crust	^{60}Fe/Fe	√	(measured)
crust	Fe/Mn	√	(measured)
ocean	Fe/Mn	√	(literature; well known)
surface	^{53}Mn	√	(literature; one measurement, Bibron et al. 1974)

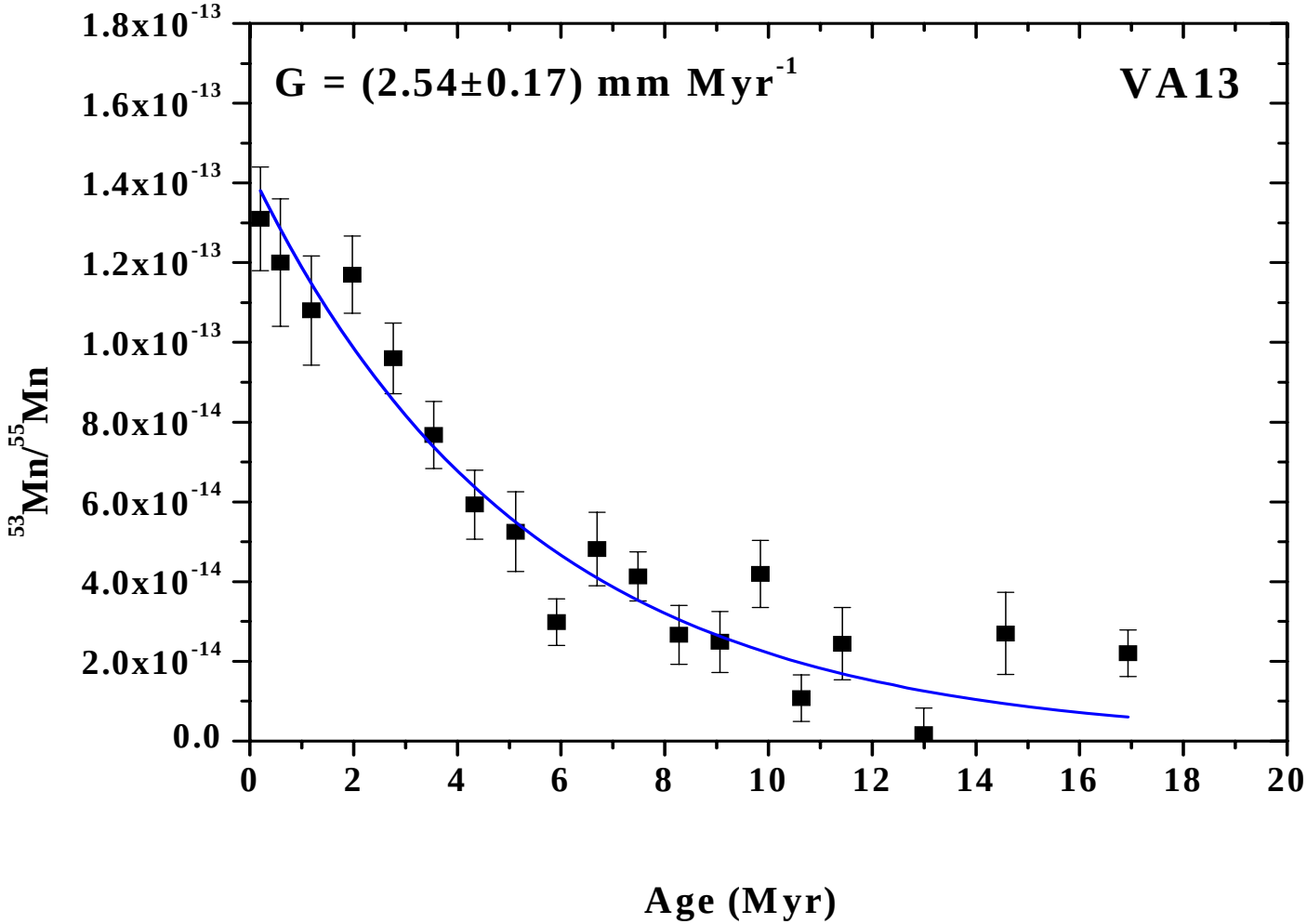
Cosmic dust: asteroid belt and cometary cloud





Spallation on Fe by cosmic rays: ^{53}Mn

Ni56 6.077 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
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+ * 	**Co61** 1.650 h 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-
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** 85.4 s 5/2- β-	**Mn58** 3.0 s 0+ * β-	**Mn59** 4.6 s 3/2-,5/2- β-



^{53}Mn ($T_{1/2}$= 3.8Ma)

^{53}Mn on Earth, a proxy for ^{60}Fe

Sample origin: Antarctica

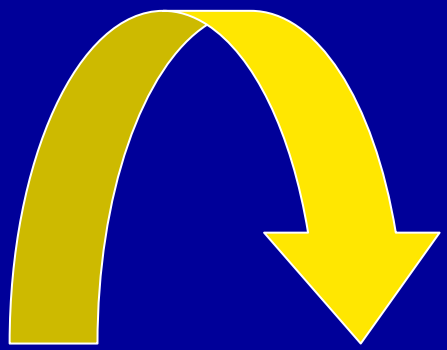
Ice sample: 180kg → 260 +/- 150 at/cm^2 (^{53}Mn)
(M. Auer et al. to be publ.)

Bibron et al. (1974): 18400 +/- 4200 at/cm^2 (^{53}Mn)
(Greenland ice, 240kg)

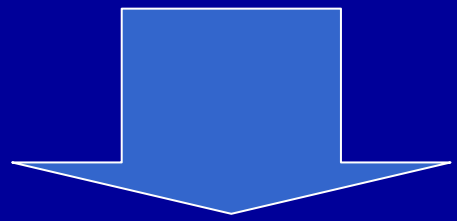
Between ~ 40 to 170 less than the earlier measurement!

→ uptake changes from 0.6% too ~ 20% till 100%

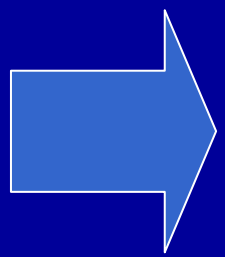
The expected signal is roughly a factor 20 to 170 lower in the sediment than naively expected!



Such a low signal would not show up in the sediment!



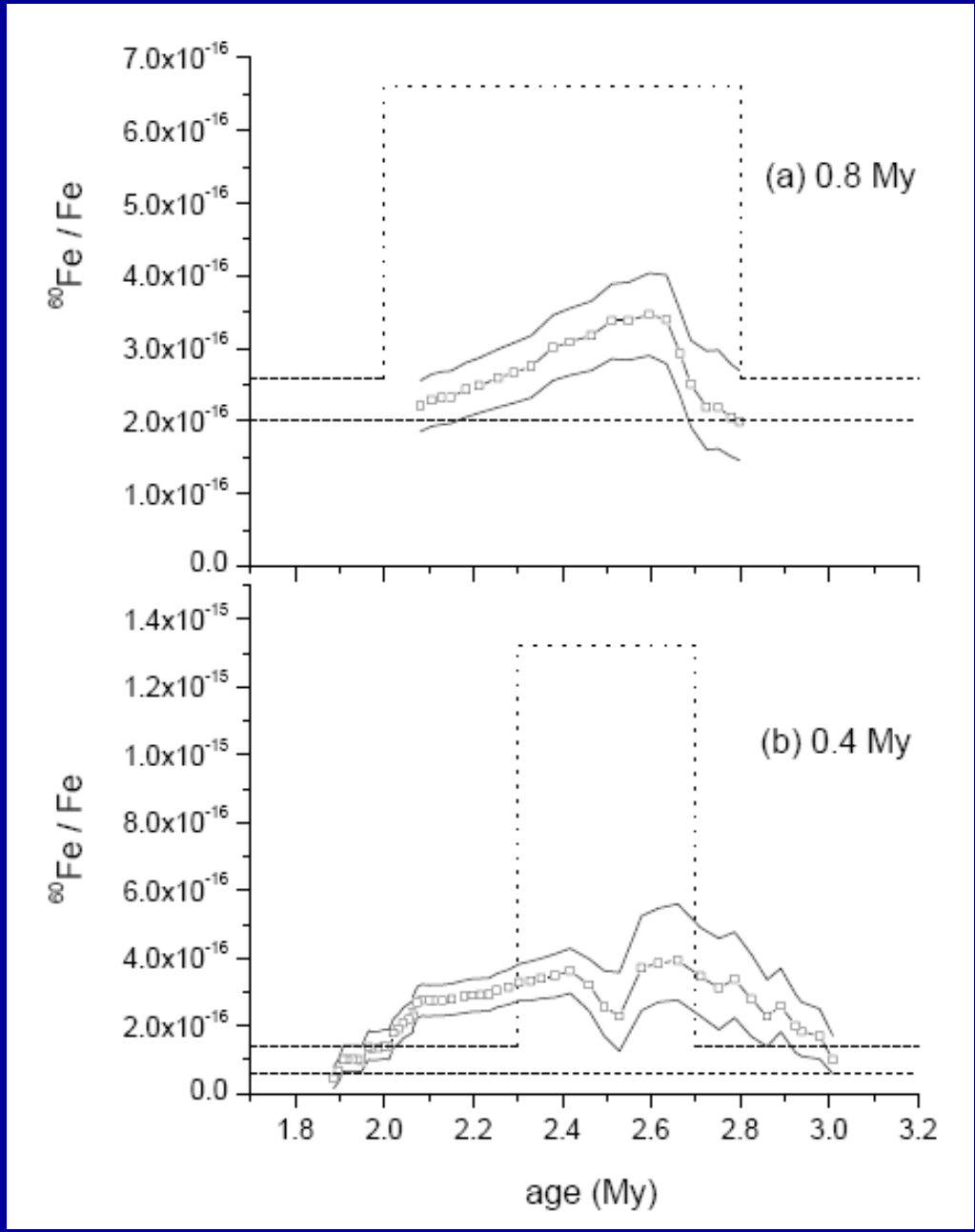
Next step: to improve the data on ^{53}Mn from interplanetary dust deposition !



Measurement of ^{53}Mn in high capacity air filter from Antarctic Neumayer Observatory (also more ice volume) and black forest Schauinsland monitoring site.

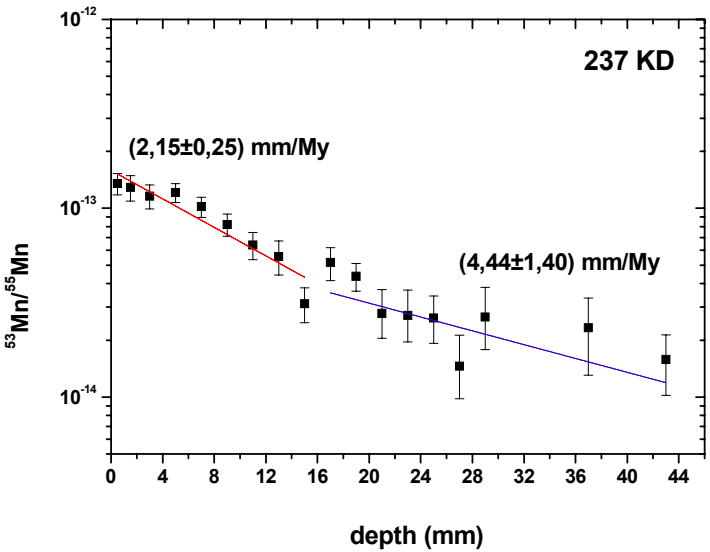
It's a collaborative effort of:

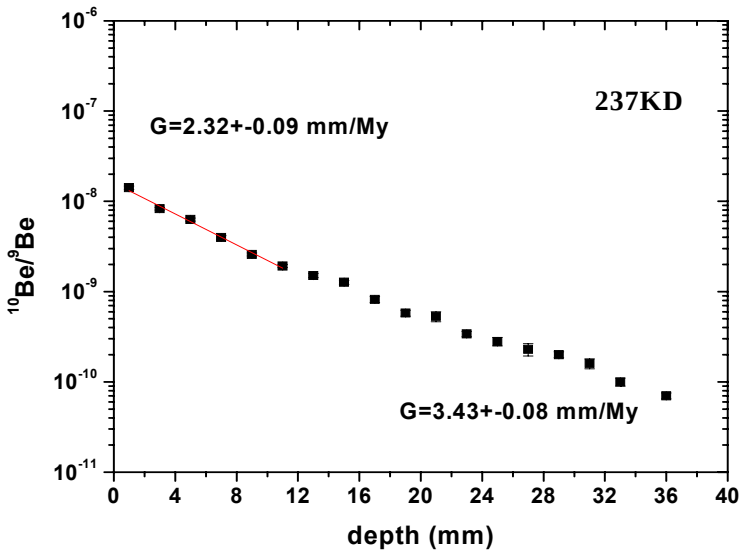
T. Faestermann, (TUM), Germany
K. Knie, (TUM, now GSI), Germany
G. Korschinek, (TUM), Germany
M. Maiti, (TUM), Germany
M. Poutivtsev, (TUM), Germany
G. Rugel, (TUM), Germany
A. Wallner, (Uni-Vienna), Austria


7.0x10^-16
6.0x10^-16
5.0x10^-16
4.0x10^-16
3.0x10^-16
2.0x10^-16
1.0x10^-16
0.0
60Fe / Fe
(a) 0.8 My
1.4x10^-15
1.2x10^-15
1.0x10^-15
8.0x10^-16
6.0x10^-16
4.0x10^-16
2.0x10^-16
0.0
60Fe / Fe
(b) 0.4 My
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
age (My)

Cosmic rays plus cosmic dust → ^{53}Mn

Cosmic rays plus atmosphere → ^{10}Be





cosmic dust fluency