Isotopic Composition Results from ACE / CRIS

Advanced Composition Explorer (ACE) spacecraft

- launched 25 August 1997
- halo orbit around L1 Lagrange point
- 5+ year expected lifetime
- 9 instruments to study elemental, isotopic, and charge state composition from solar wind to galactic cosmic ray energies

Cosmic Ray Isotope Spectrometer (CRIS) instrument

- measures galactic cosmic ray elements and isotopes
- dE/dx vs. total energy technique using silicon solid-state detector telescopes and a scintillating optical fiber trajectory hodoscope
- element coverage from Z=3 to 30+
- energy range from $\sim$50 to $\sim$500 MeV/nuc
- geometrical factor $\sim$250 cm^{2}sr
- participating institutions
    - Caltech
    - JPL
    - Washington Univ.
    - NASA/GSFC

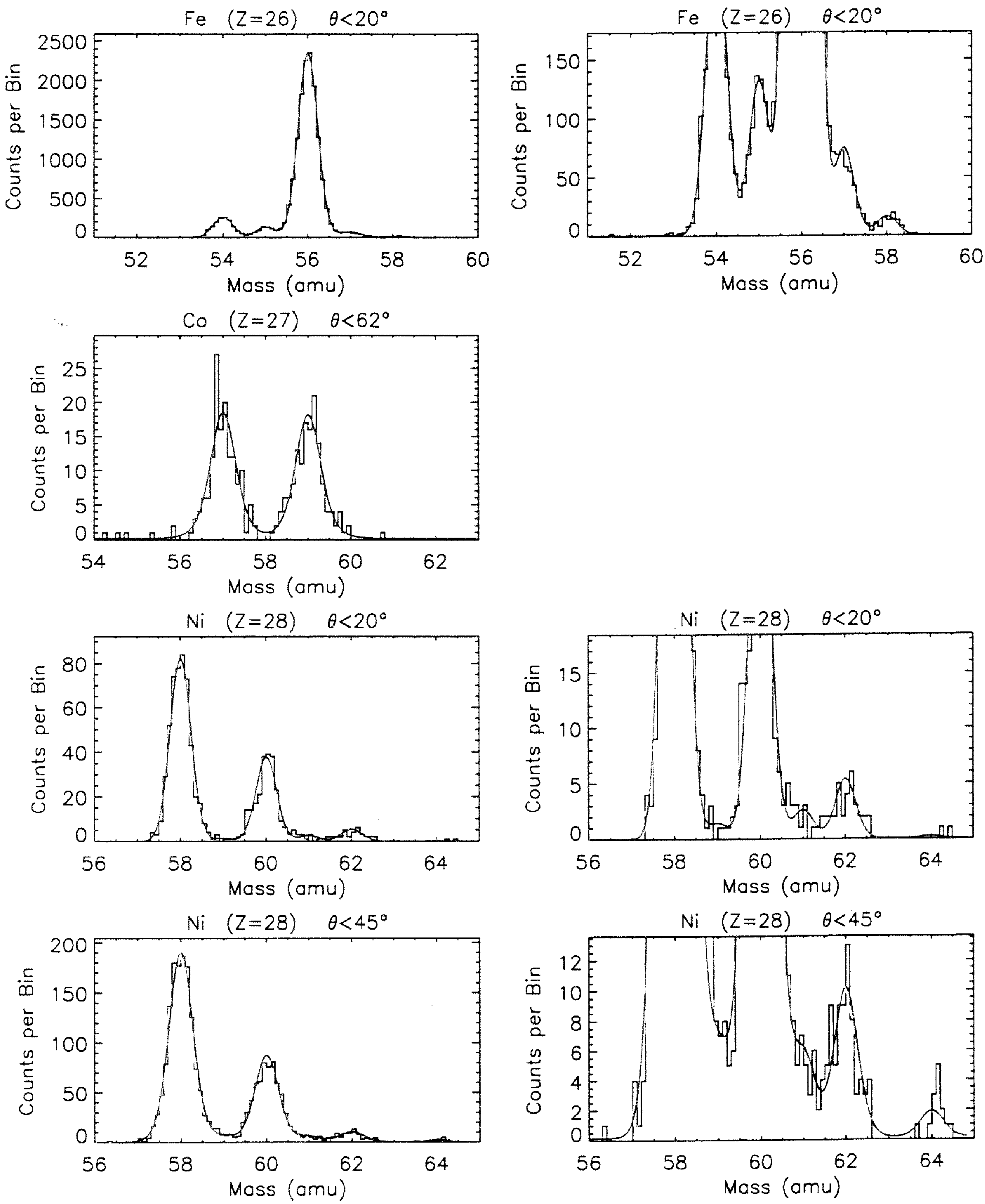
Data available to the general scientific community

- categories
    - realtime
    - browse
    - calibrated ("level 2")
- web site: `http://www.srl.caltech.edu/ACE/`
- documentation: Space Science Reviews, vol 96, 1998

CRIS Results Discussed at this Conference

* • OG 1.1.01
  Source isotopic composition of iron, cobalt, and nickel
- OG 1.1.02
  Elemental composition and energy spectra of galactic cosmic rays
* • OG 1.1.03 & OG 1.1.06
  Cosmic ray confinement time from beta-decay secondaries
* • OG 1.1.04
  Ultraheavy elements and isotopes ($29 \leq Z \leq 34$)
* • OG 1.1.05
  Energy dependence of electron capture decay secondaries
* • OG 1.1.13
  Time between nucleosynthesis and acceleration based on primary electron capture nuclides
- SH 4.2.06
  Short-term time variations of galactic cosmic ray intensities
- SH 4.2.09
  Radial gradients of galactic and anomalous cosmic ray intensities
- SH 4.3.11
  Solar minimum spectra of anomalous cosmic rays

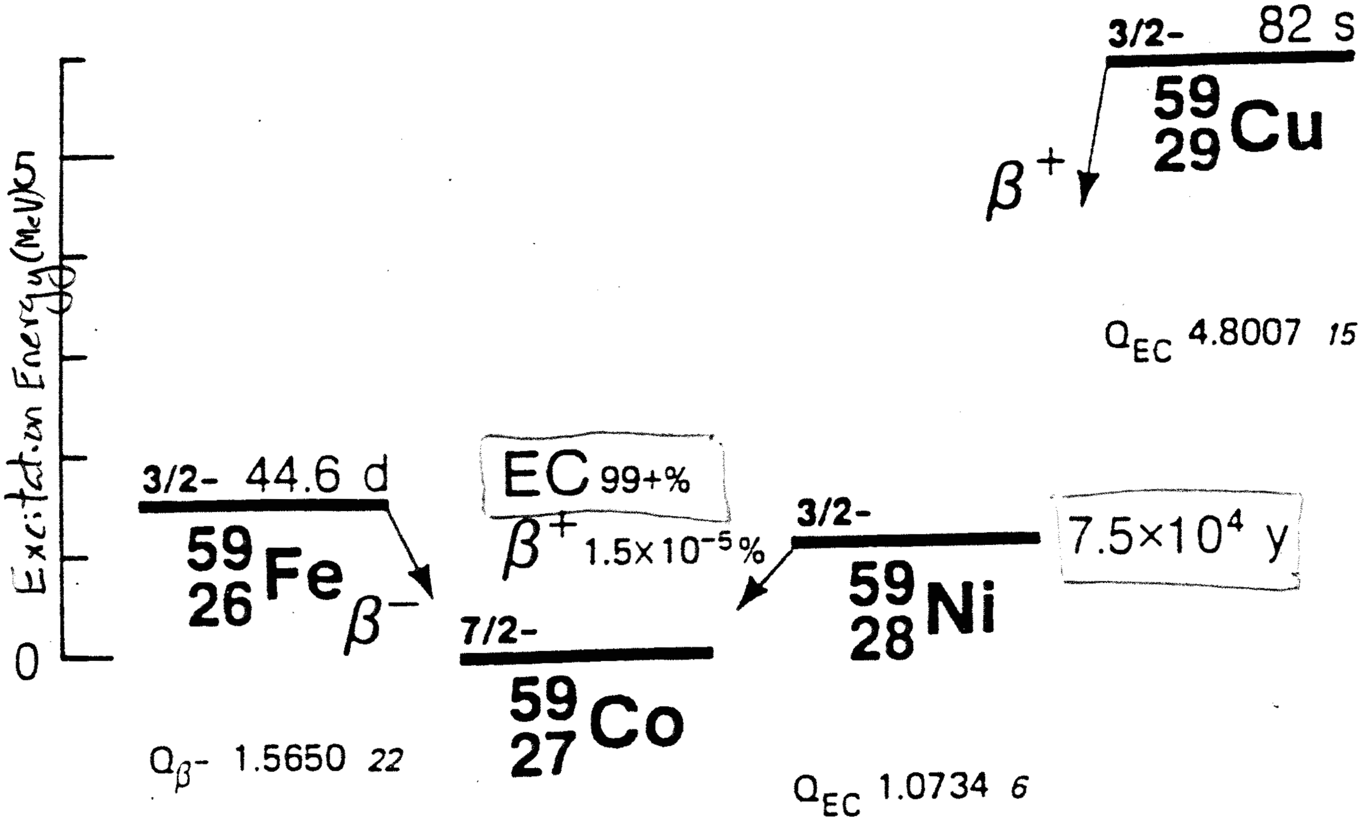
ACE Cosmic Ray Isotope Spectrometer



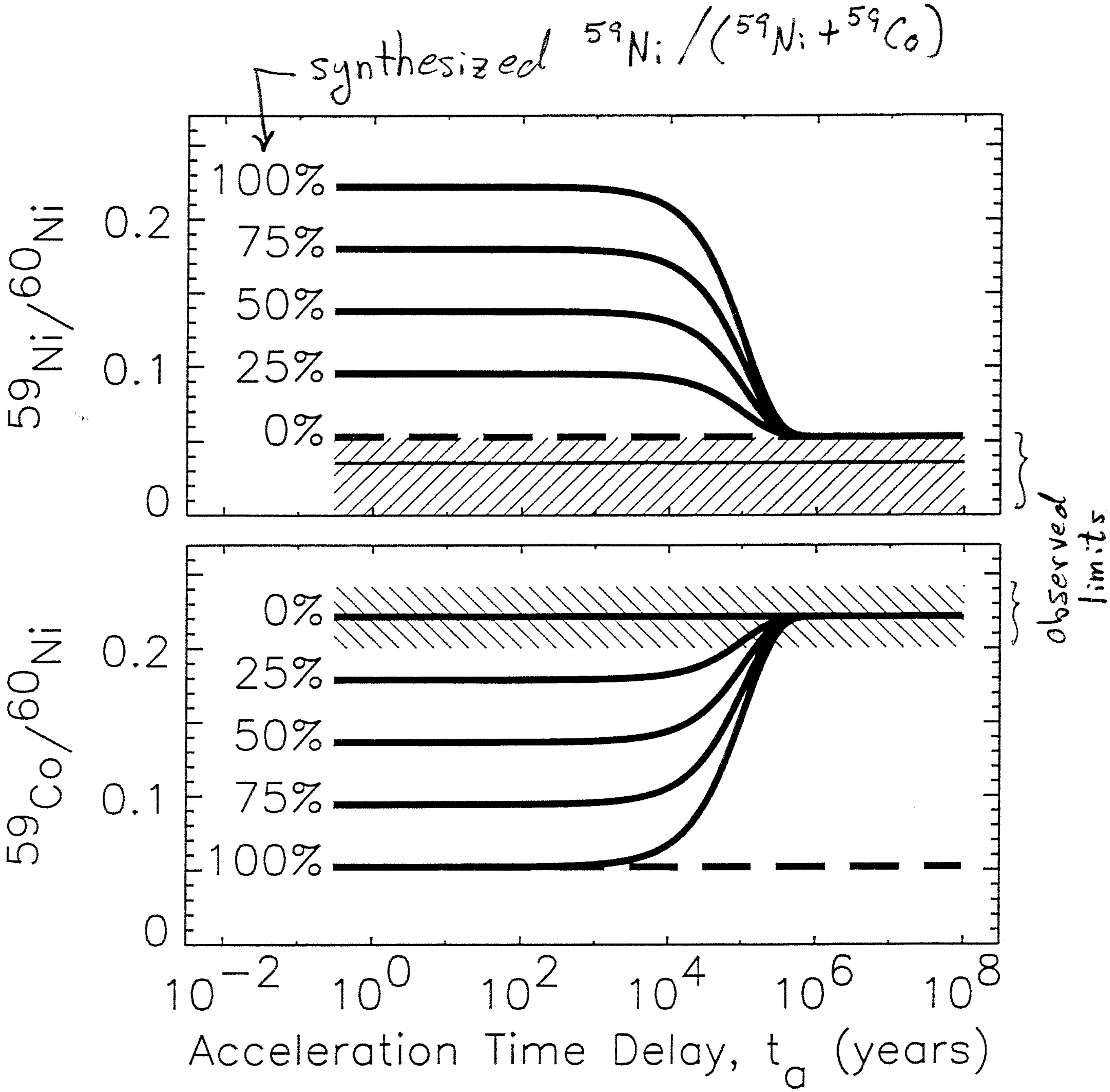
Mon Mar 22 09:26:59 1999 ~/idl/mw/cris060/cris060aa.ps

August 1997 - December 1998

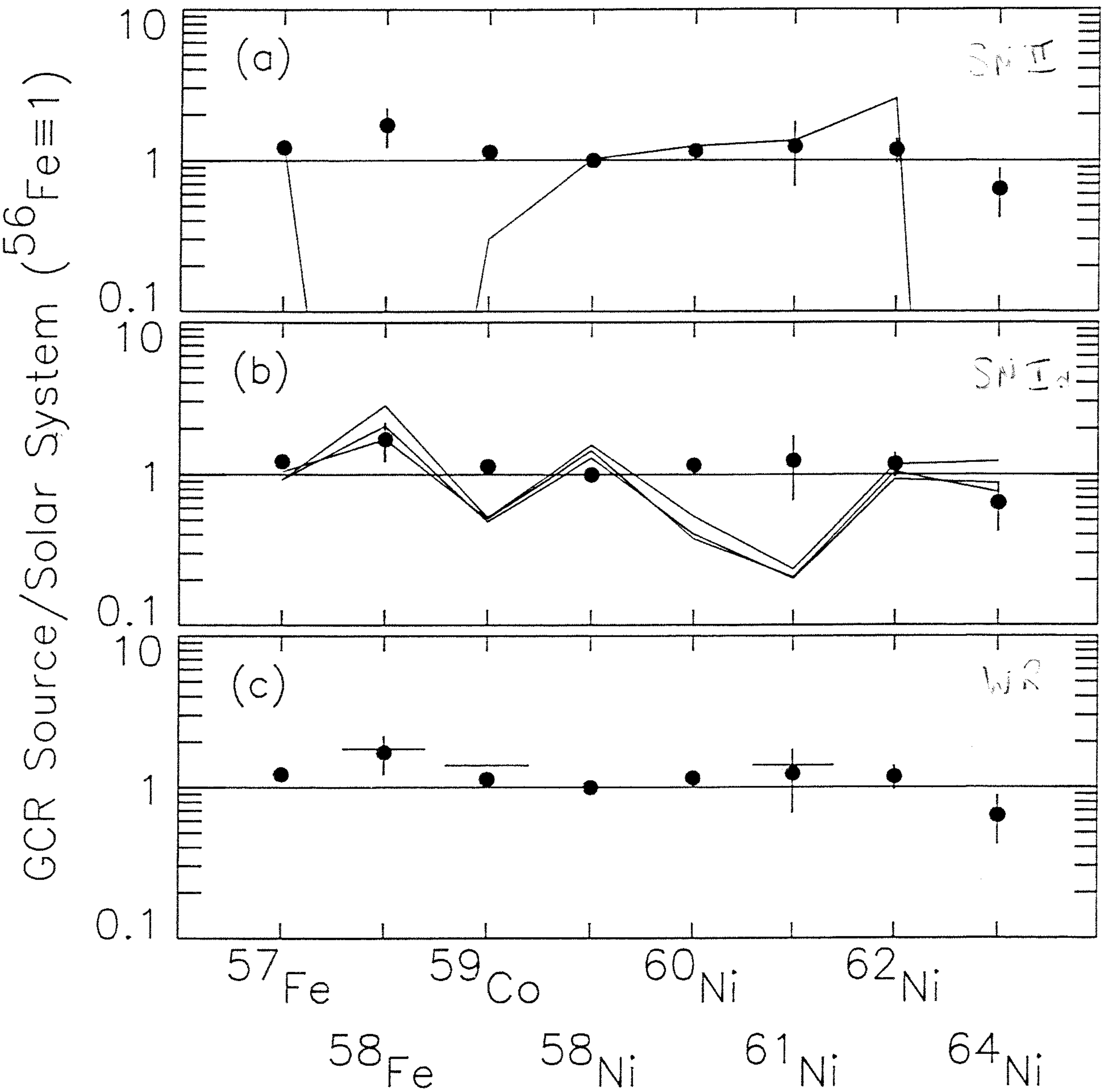
A = 59 (ASE; CML)



Excitation Energy (MeV)
5
0
3/2- 82 s
$^{59}_{29}Cu$
β^+
Q_{EC} 4.8007 15
3/2- 44.6 d
$^{59}_{26}Fe$
β^-
EC 99+%
β^+ 1.5×10^{-5}%
3/2-
$^{59}_{28}Ni$
7.5×10^4 y
7/2-
$^{59}_{27}Co$
Q_{β^-} 1.5650 22
Q_{EC} 1.0734 6



OG 1.1.13
R.A. Mewaldt et al.
Ap.J. Letters (in press)
M.E. Wiedenbeck et al.



Comparison of CRIS Measurements with Model Predictions:

a) Type II Supernovae

b) Type Ia Supernovae

c) Wolf-Rayet Enriched ISM

OG 1.1.01

Electron Capture Secondaries

Cosmic Ray Fragmentation

$$^{56}\text{Fe} + {}^{1}\text{H} \xrightarrow[\text{fragmentation}]{} {}^{49}\text{V}^{+23}$$

Electron Attachment from the ISM

$$^{49}\text{V}^{+23} + {}^{1}\text{H}^{0} \xrightarrow[e^{-}\ \text{attachment}]{} {}^{49}\text{V}^{+22}$$

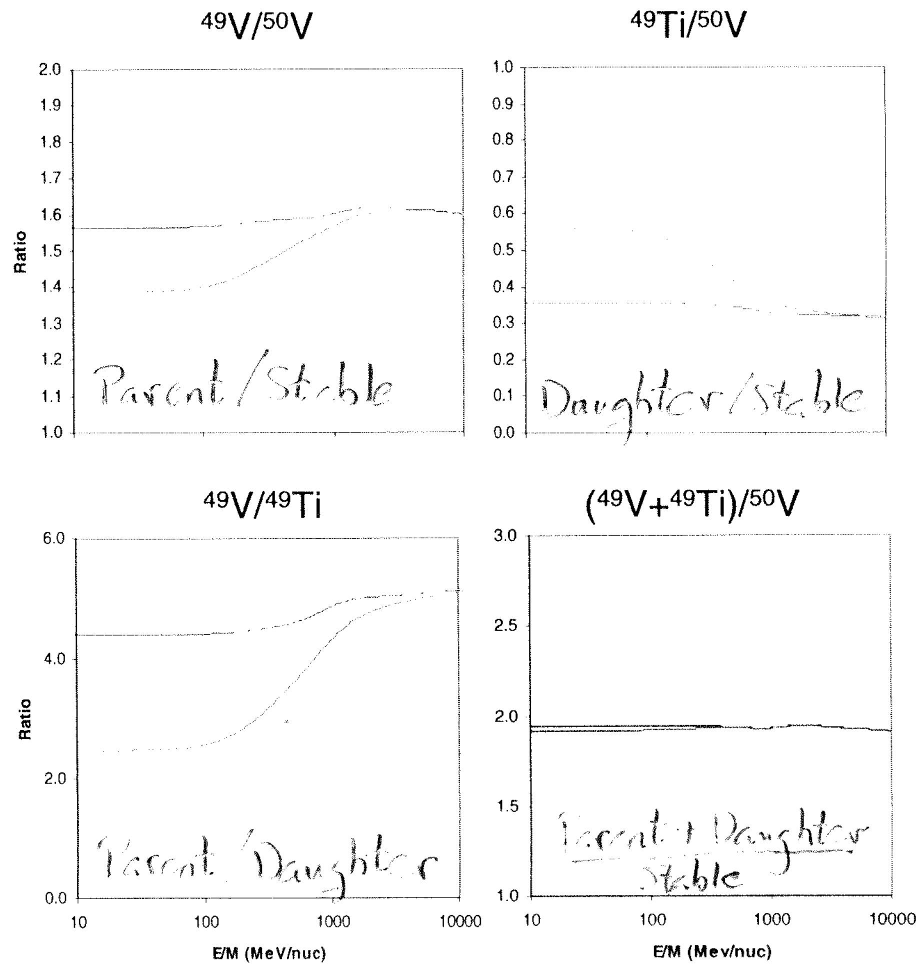
attachment cross sections fall rapidly with increasing velocity

Radioactive Decay by Electron Capture

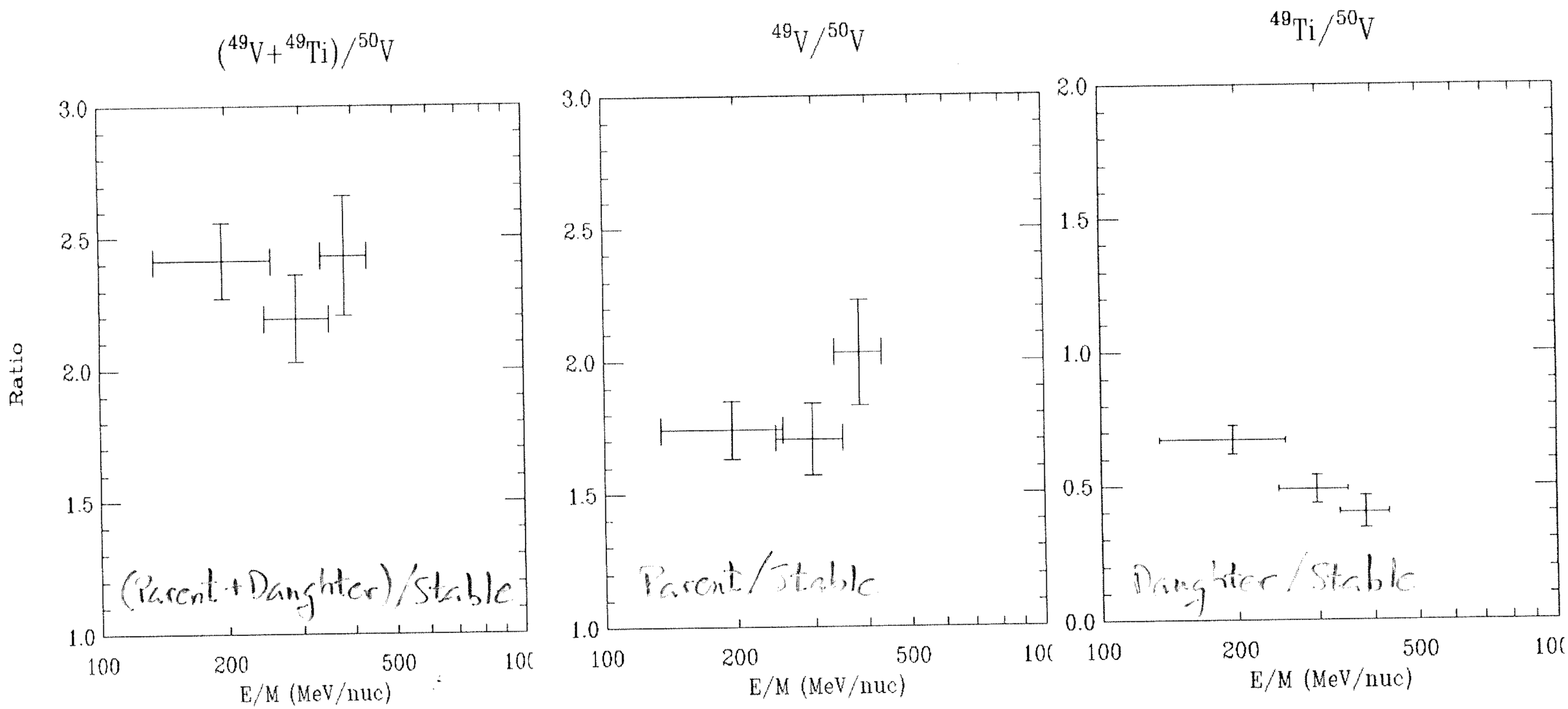
$$^{49}\text{V}^{+22} \xrightarrow[\text{e.c. decay}]{} {}^{49}\text{Ti}$$

Electron-capture decay is enhanced at low energy

- Leaky-box propagation model results illustrate electron-capture decay
  - Model includes solar modulation, which smears energy dependence
  - Results at right: with and without decay
- The effect of electron-capture decay is to lower parent/daughter ratios at lower energies
  - Parent/stable ratios are lower
  - Daughter/stable ratios are higher
- Sum of parent and daughter nuclei is constant over all energies

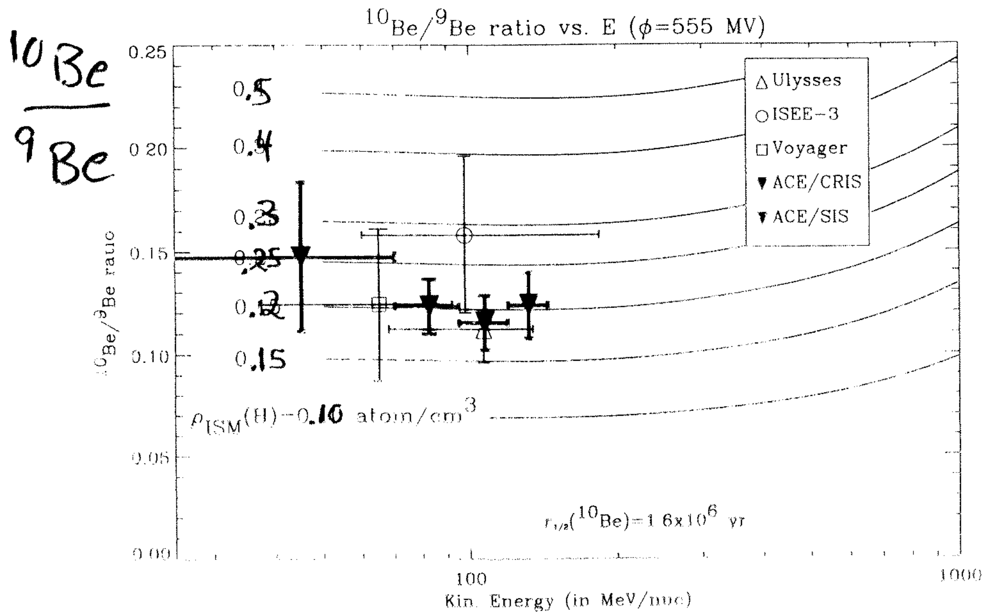


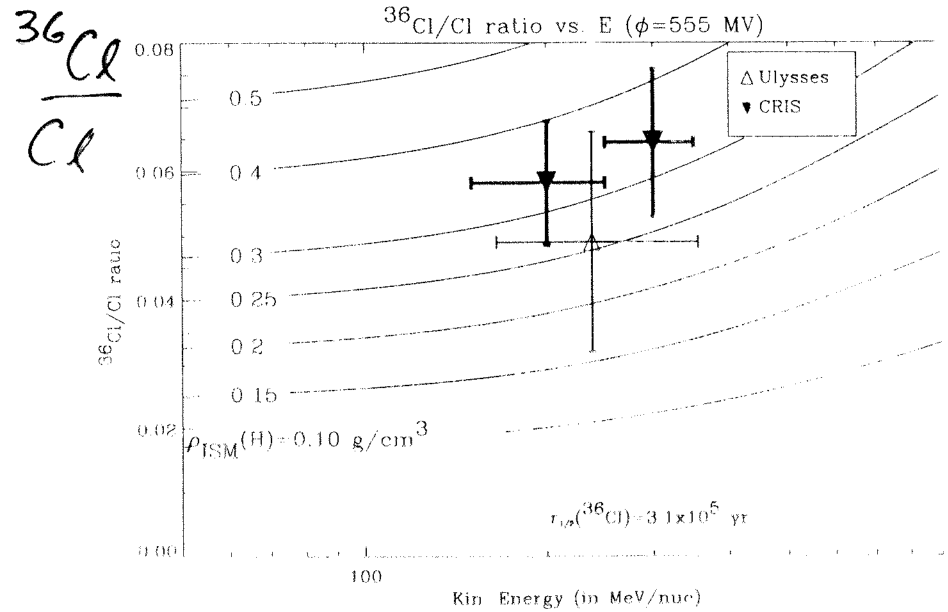
$^{49}V \rightarrow {}^{49}Ti$

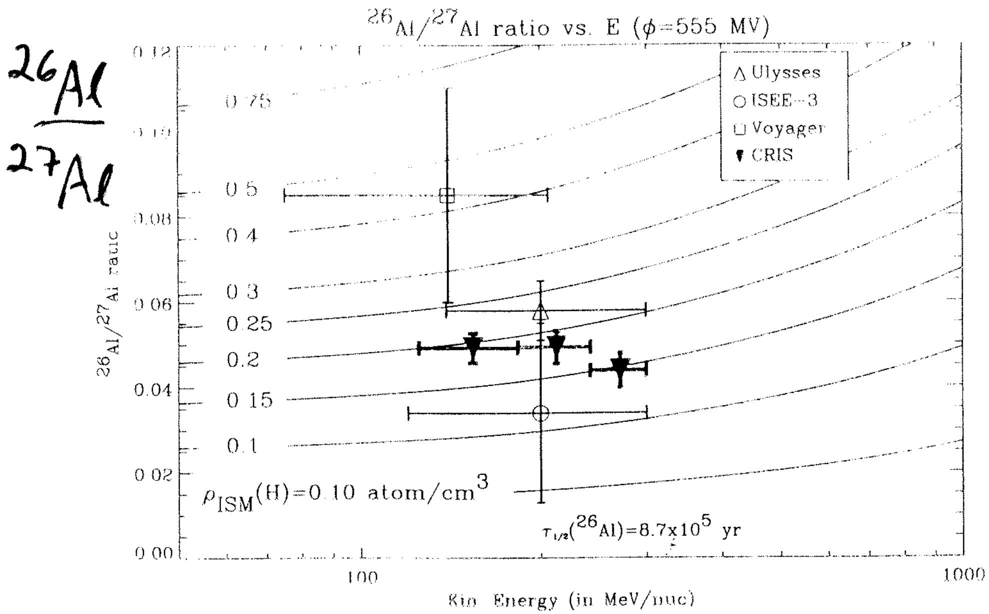


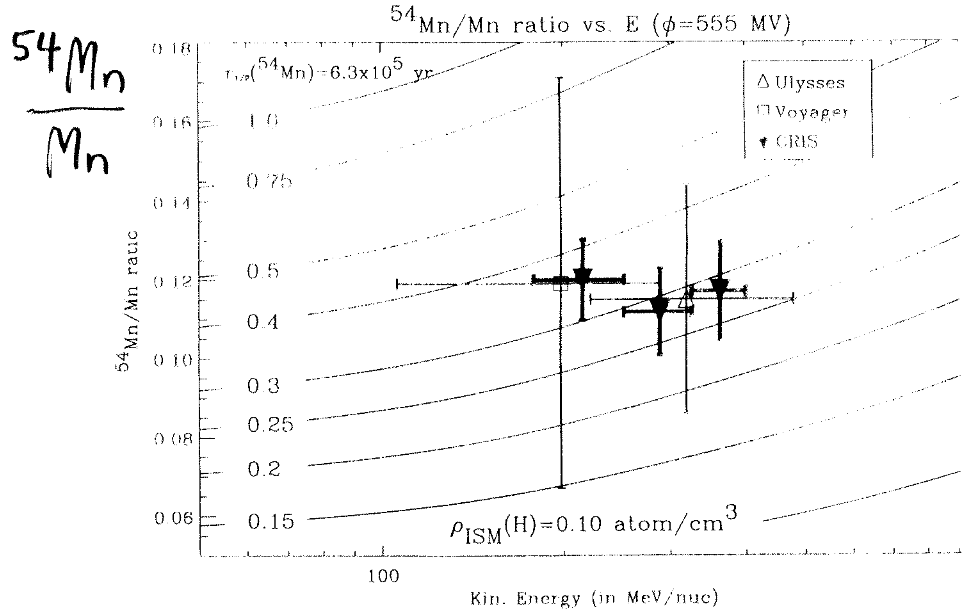
OG 1.1.05

S. Mahan Niebur et al.





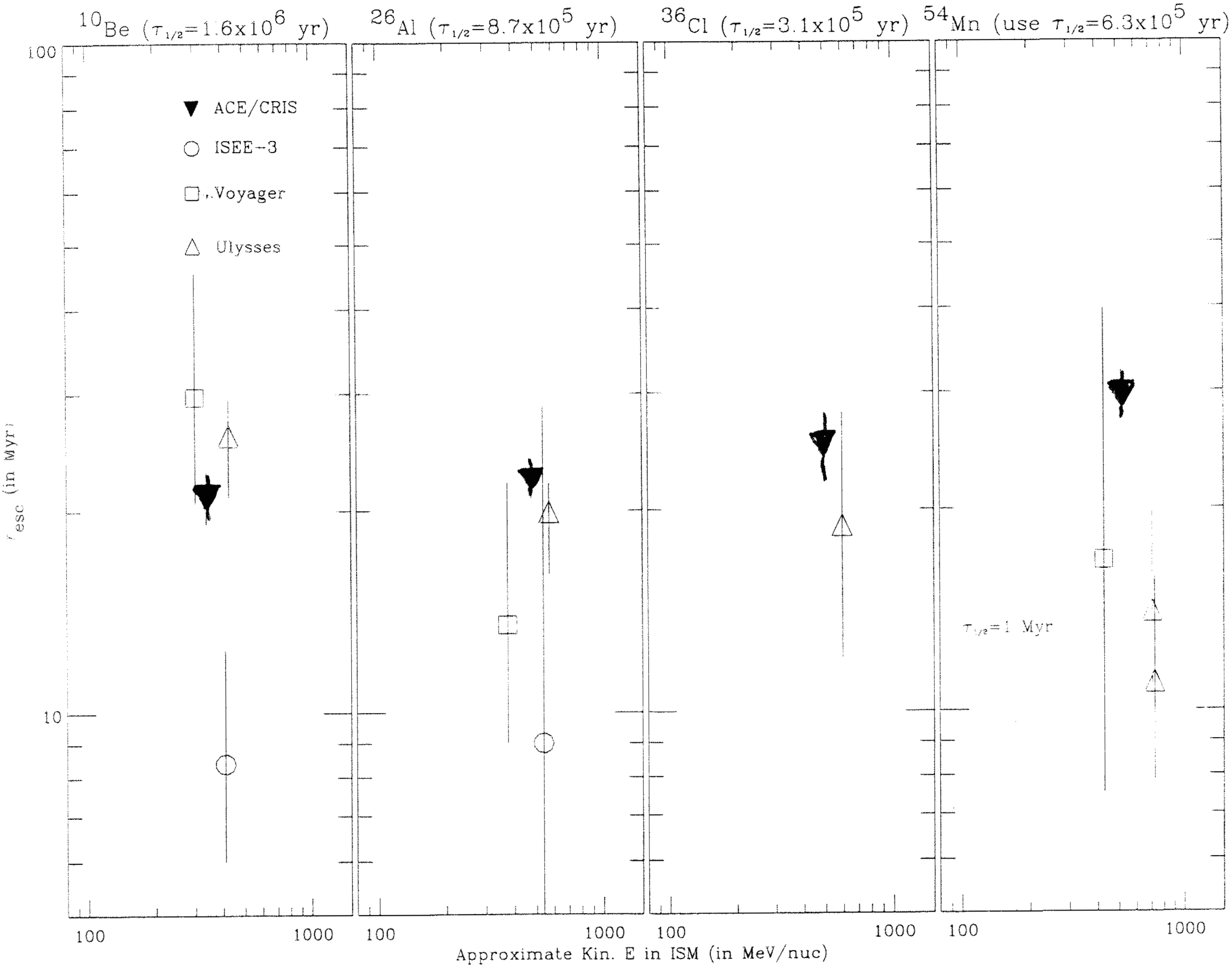




OG 1.1.03 N.E. Yanasak et al.

OG 1.1.06 W.R. Binns et al.

^{10}Be ^{26}Al ^{36}Cl ^{54}Mn



$$\bar{\tau}_{escape} = 22 \text{ Myr} \quad (^{10}Be, ^{26}Al, ^{36}Cl)$$

Summary

- A time $\gtrsim 10^5$ years elapses between nucleosynthesis and cosmic-ray acceleration.
- In the mass region $56 \leq M \leq 64$, the isotopic composition of the cosmic-ray source is similar to that of the solar system, with differences of no more than a few 10's of percent.
- The near-solar abundances of neutron-rich cosmic-ray isotopes such as ^{64}Ni and ^{58}Fe suggest that the cosmic-ray seed population contains contributions from Type Ia supernovae, as well as Type II.
- Elemental and isotopic abundances for elements just above nickel continue the familiar pattern of solar-like composition which has undergone charge fractionation by a process correlated with first ionization potential (or volatility).
- The energy dependences of the abundances of secondary electron-capture nuclides and their daughters indicate that in-flight attachment of electrons from the interstellar gas is occurring and leading to e.c. decay at low energies.
- The secondary electron-capture isotopes (^{10}Be, ^{26}Al, ^{36}Cl, ^{54}Mn) all indicate a cosmic ray confinement time $\sim$20–30 Myr (leaky box model), but there are indications that surviving fractions may have a weaker energy dependence than predicted.