

⁹³Zr Beam Development for AMS Measurements

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Background of ⁹³Zr

- S-process product, e.g. ⁶⁰Fe.
- $t_{1/2} = (1.5 \pm 0.10)$ Ma





S-process MACS at 30KeV for ${}^{92}Zr(n,\gamma){}^{93}Zr$ by TOF measurement

- The recommended value by KADoNis: 30.1 ± 1.7 mb
- This is weighted mean from the following TOF measurements:
 - G. Tagliente et al $29 \pm 2 \text{ mb}$ 12%A. de L. Musgrove et al $33 \pm 4 \text{ mb}$ 12%R. Macklin $34 \pm 6 \text{ mb}$ 12%
- Activation + AMS method to measure ⁹²Zr neutron capture reaction

The motivation

Live ⁶⁰Fe detected by Munich group:



K. Knie et al., Phys. Rev. Lett. 83, 18, 1999

Unresolved ⁶⁰Fe SN origin

• S. Basu et al.* have studied ³He/⁴He ratio in the same crust and they argue ⁶⁰Fe is cosmogenic.

• Is the excess of ⁶⁰Fe representative?

* S. Basu et al., Phys. Rev. Lett. 98, 141103, 2007

Potential radionuclides

radioisotope	half-life (Ma)	^a residence time (yr)	^b deep sea sediment elemental abundance (ppmw)
²⁶ Al	0.717	200	84,000
⁵³ Mn	3.74	60	67,000
⁷⁹ Se	large uncertainty	26,000	0.2
⁹³ Zr	1.53	5600	150
¹⁴⁶ Sm	1.03×10^{2}	400-1000	8.35
$^{182}\mathrm{Hf}$	8.90	1300	4.1

^aMBARI data base. ^bLi and Schoonmaker, Treatise on Geochemistry, **7**, 1, 2004.

Assumptions

• Rauscher 2002 SN model*

- Isotropic ejection
- Isotropic fall-out
- No chemical fraction during the whole transportation and uptake process.
- * T. Rauscher et al., ApJ, **576**, 323, 2002

Experimental challenges

- Presence of many stable isotopes
- Machine operating limits
- Isobar interference from ⁹³Nb
- Hasn't been done by AMS before

Pictures from Negative Ion Cookbook from Roy Middleton. An example of Bragg curve for ⁹³Zr and ⁹³Nb at 114MeV, 5Torr N₂.



AMS beamline



Gas filled magnet





Parallel Plate
 Avalanche Counter
 (PPAC) window:
 355µg/cm² Mylar
 foil

Ionization
Chamber (IC):
4 sections with
different depth

• Filled Gas: Isobutane (C_4H_{10})

Gas pressure:3 to 6Torr

Raytrace Monte Carlo simulation



Preliminary results



On ZrH cathode. WF off.

On ZrH cathode. WF on.

Summary

- The necessity and advantage of A+AMS method to remeasure ⁹²Zr(n,γ)⁹³Zr cross section
- A good candidate to test SN hypothesis and ⁶⁰Fe SN origin
- Experimental challenges exit due to heavy mass, isotopes and isobar interference
- Future work for better separation is needed

References

- 1. Claudia Travaglio et al, 2004, **ApJ**,601, 864.
- 2. Roberto Gallino et al, 1998, ApJ, 497, 388.
- 3. S.E. Woosley ,1995, **ApJS**, 101, 181.
- 4. Y. Kashiv et al ,2010, **ApJ**, 713, 212.
- 5. Maria Lugaro et al, 2003, **ApJ**, 593, 486.
- 6. T. Rauscher et al, 2002, ApJ, 576, 323.

Thank you