Campioni per Astrofisica

Meeting nTOF Italia. 29 Aprile 2025

Possibili campioni per misure di Astrofisica?

Tenuto conto delle indicazioni riportate da Diego nel corso del meeting di Novembre 2024, delle interlocuzioni con Emilio Maugeri e delle ricerche di mercato di Pino, ho ristretto la lista dei possibili campioni di interesse al seguente elenco:

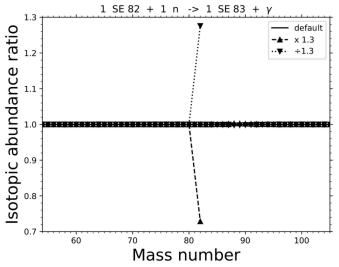
- **^{82}Se**
- **^{86}Sr**
- **^{99}Tc**
- **^{41}Ca**
- **^{107}Pd**
- **^{182}Hf**
- **^{205}Pb**

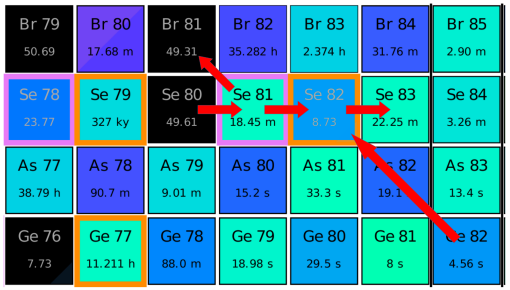
^{82}Se

^{82}Se

- ^{82}Se is a stable nucleus
- Its production during the s-process largely depends on the branching at ^{79}Se and ^{81}Se
- Its solar value is mostly of r-process origin (88,9%; see Prantzos+ 20)
- It can be produced via the i-process
- Its abundance is mostly determined by the ^{82}Se(n,γ) (Pignatari+ 23, Martinet+ 24)

Pignatari+ 23, EPJA

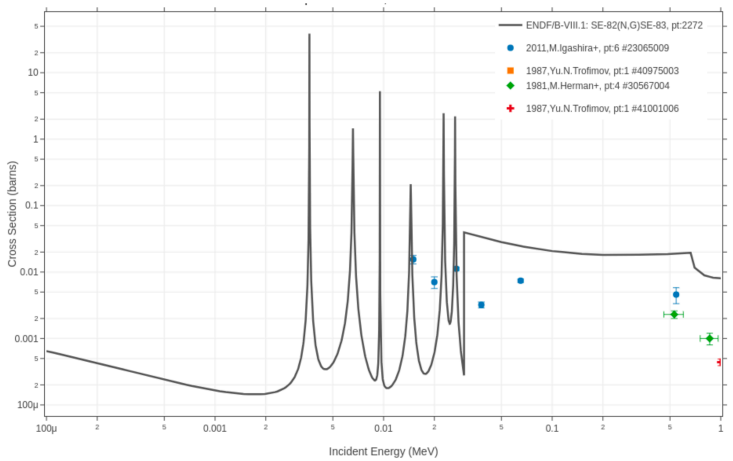




Martinet+ 24, A&A

^{82}Se

- ^{82}Se MACS adopted in the astrophysical codes is theoretical



Da: ISOFLEX/RU <info@isoflex.com.ru>
Data: 16 dicembre 2024 alle ore 15:41:21 CET
A: giuseppe.tagliente@ba.infn.it
Oggetto: Re: Se-82, Sr-86 quotation

Dear Giuseppe,

Thank you very much for your new inquiry.

We can offer the following materials:

1000 mg quantity of Se-82 in elemental powder form with I.E.>98% at price:
US$6.70 per mg. Delivery time: 7-9 weeks ARO

Isotopic composition (atomic fraction, %)
Se-74: 0.10
Se-76: 0.05
Se-77: 0.04
Se-78: 0.18
Se-80: 1.32
Se-82: 98.31

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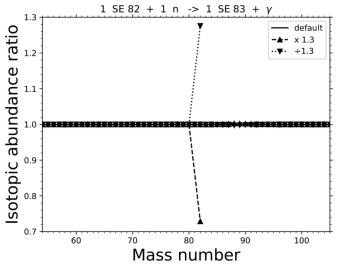

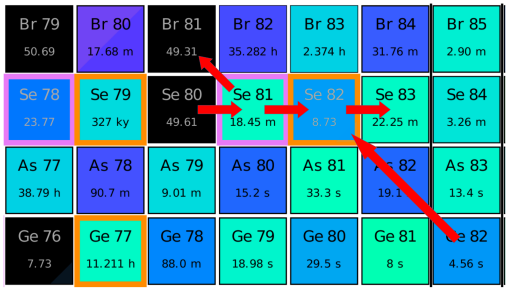

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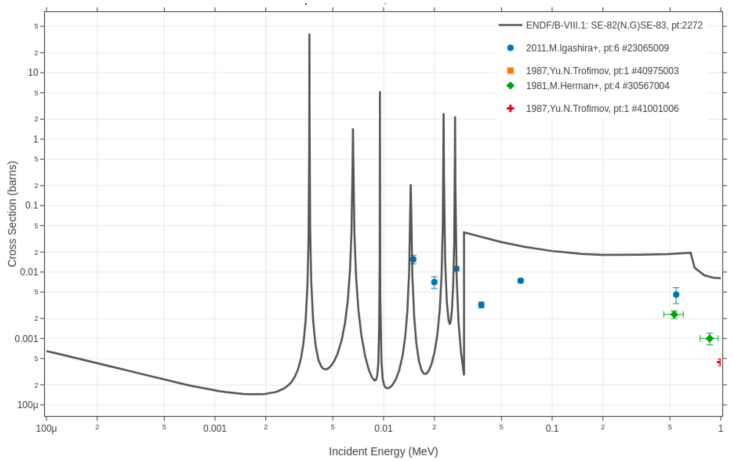

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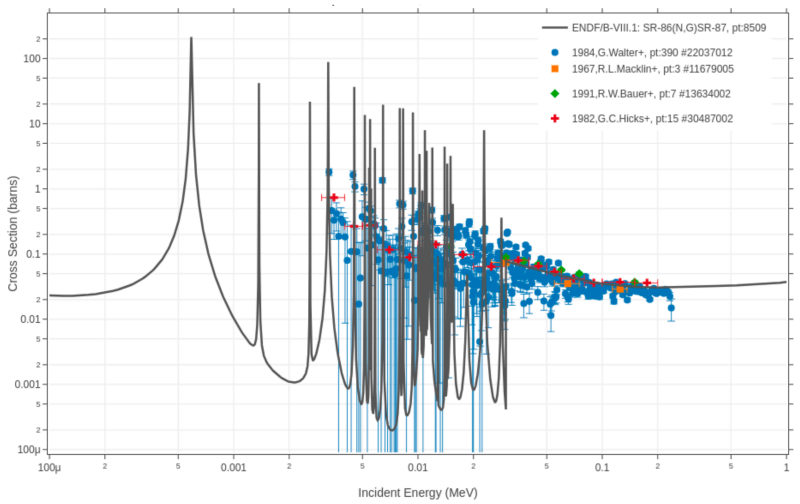
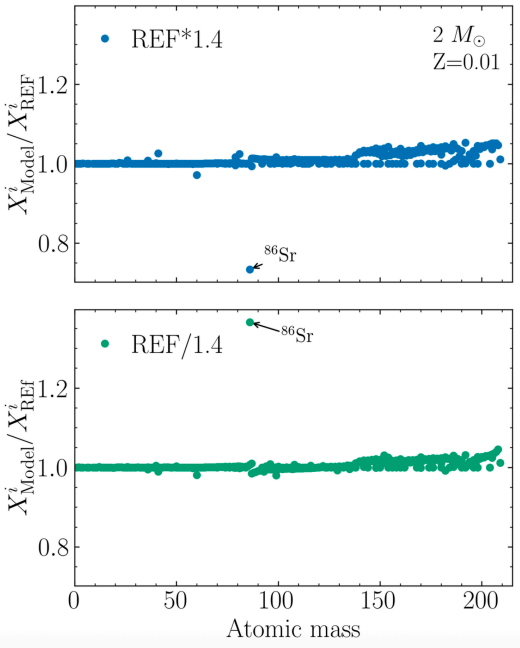
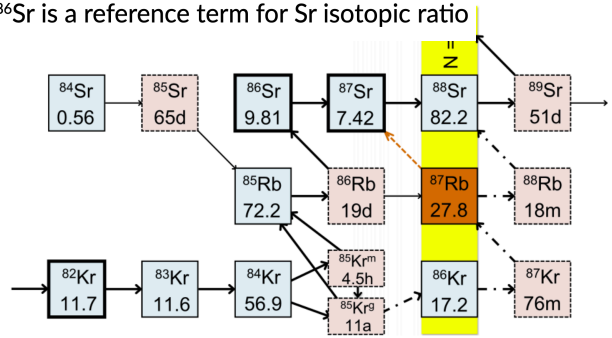


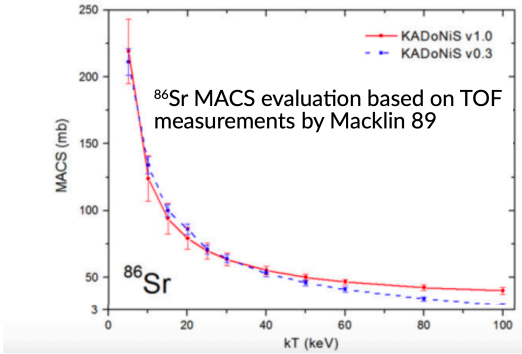
Tests varying the ^{86}Sr MACS by ±40%



Liu+ 15, ApJ

^{86}Sr is a reference term for Sr isotopic ratio





Item	Description		Quantity	Price per Unit (USD)		Value
0010	SR-86	Strontium 86 Chemical Form: Strontium carbonate Assay: 95.3000% Batch: 234201	500.000 MG	24.59	1 MG	12,295.00
0020	ZZ-S01	EM Stable Isotope Packaging Fee	1.000 LOT	4,180.00	1 LOT	4,180.00
		Quotation Total in Currency (USD)				16,475.00

National Isotope Development Center
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6158

Customer Reference:

Quotation For: 999000
ISTITUTO NAZIONALE DI FISICA NUCLEARE
VIA ORABONA 4
70216 BARI BA BA
ITALY

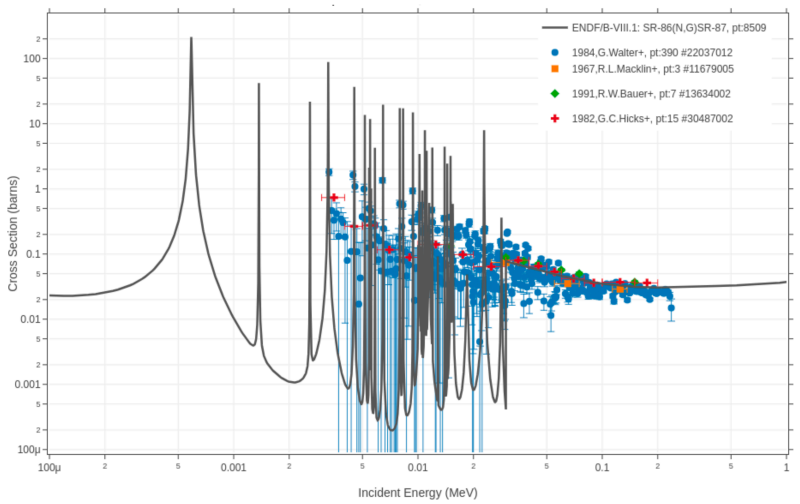
Isotope Quotation

Quotation	3011464
Date	02/13/2025
Quotation Period	02/13/2025 to 03/13/2025
Terms of Payment	Advance Payment Request
Terms of Delivery	FCA DOE Facility

Refer Questions To:
Kim Bryant
Phone: 865-341-2916
Email: bryantka@ornl.gov

Venduto come $SrCO_3$
Emilio può convertirlo in SrO (o anche solfuro o cloruro)
Lievemente igroscopico, Emilio ha studiato una modalità di packaging, messa a punto per l'esperimento di Frank

^{86}Sr



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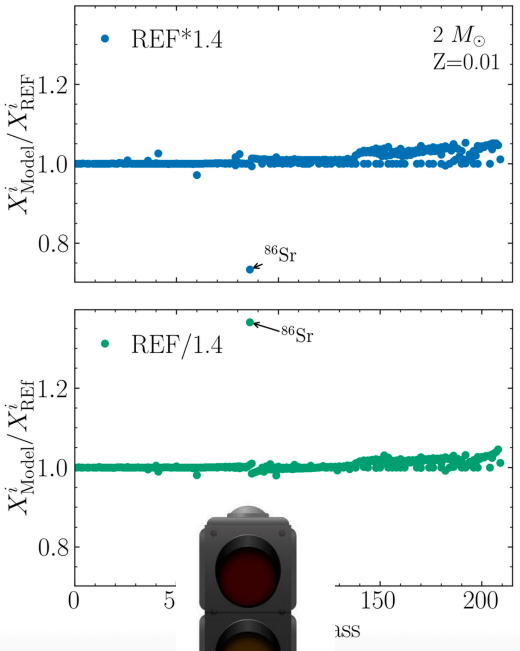

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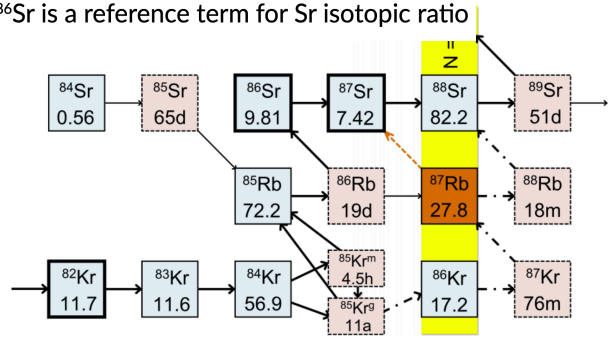

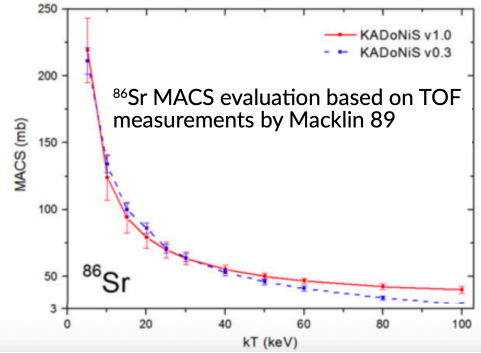

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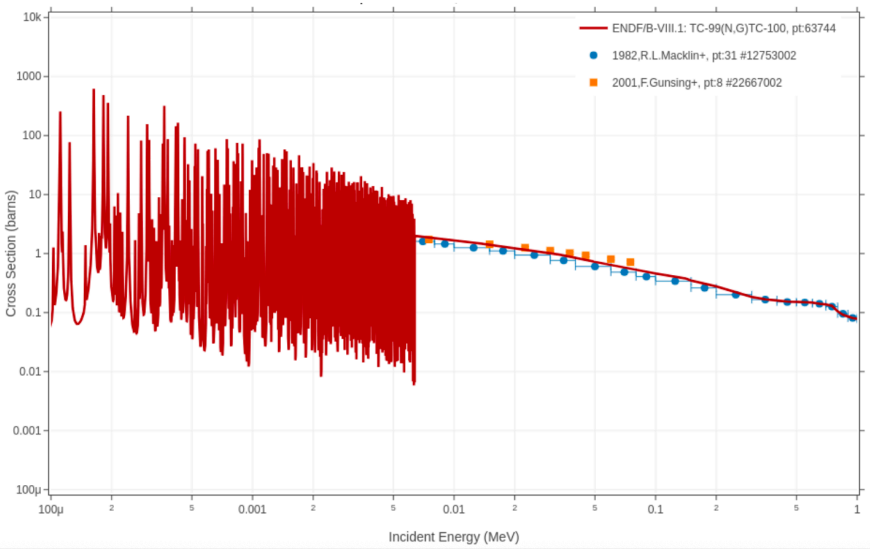
^{99}Tc

List of all available values

original	renorm.	year	type	Comment	Ref
933 ± 47		2000	c	Linac, TOF	GLM00, GLM01
782 ± 50		1987	c	Linac, TOF, ^{6}Li, Au:Sat.	WiM87
779 ± 40		1982	b	Linac, TOF, ^{6}Li, Au:Sat.	Mac82b



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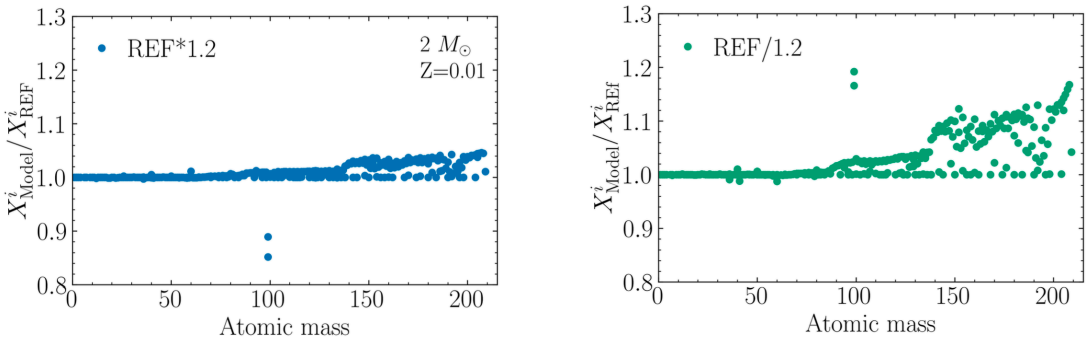

Produrlo sarebbe relativamente complesso. Pare che un Prof. di Zurigo ne abbia qualche mg già separato dal metastabile. In ogni caso la preparazione del sample richiede lavorazione con resine e complessivamente ci vorrebbero circa 10 kCHF per la produzione. Se ci convince, si può provare a contattare il Prof mediante Emilio (lui la manderebbe, ma la lettera la scriviamo noi). Se necessario potremmo coinvolgerlo nell'esperimento. Emilio suggerisce di provare a recuperarlo in ogni caso anche se non immediatamente interessati, perchè il prof andrà in pensione a breve.

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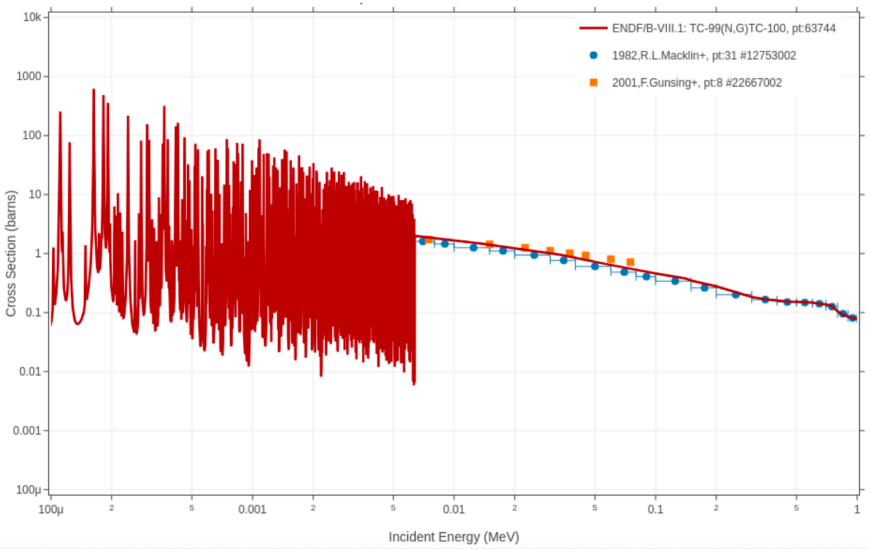

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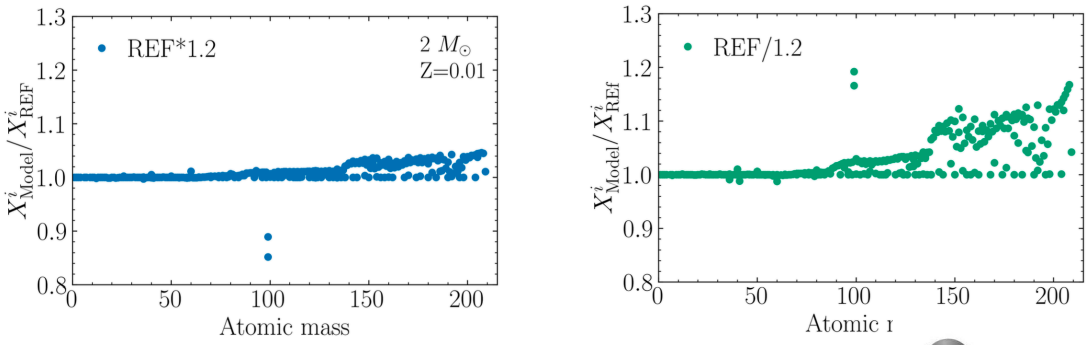

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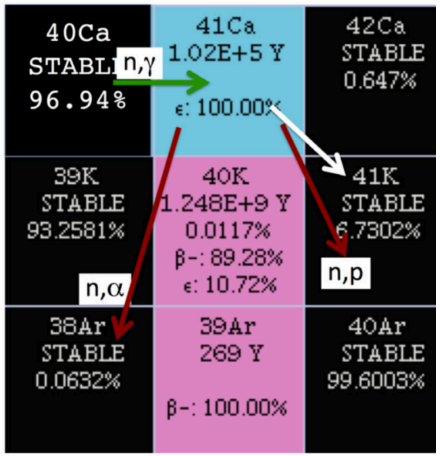
^{41}Ca

^{41}Ca(n,p) & ^{41}Ca(n,α)

- ^{41}Ca is long-lived radioactive nuclei lighter than iron
- Important also for ^{41}K/^{39}K excesses measured in presolar grains from supernovae (Amari+ 96)
- Can be made by neutron captures on ^{40}Ca (half life of 0.1 Myr), which is stable and with relatively high solar abundance
- Neutron captures also destroy ^{41}Ca via different channels, the predominant being ^{41}Ca(n,α)^{38}Ar
- Experimental estimates for the neutron-capture cross section is available (e.g. de Smet et al. 2006),
- Electron-capture rate of ^{41}Ca is expected to vary significantly for different temperatures and densities relevant to stellar conditions
- Theoretical computations by Fuller+ 82

Lugaro+ 18, PrPN



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- Thermal n-capture cross sections from Wagemans+ 98
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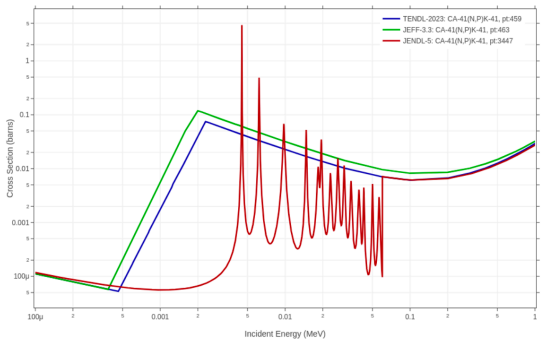

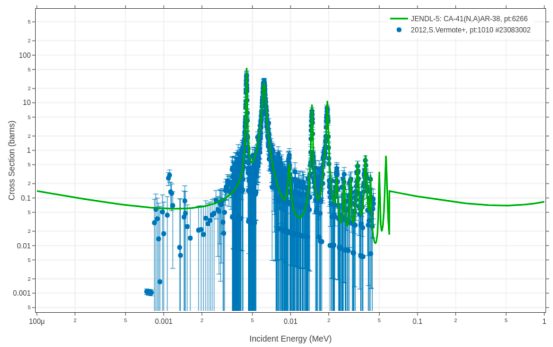

Definito da Emilio 'cammuriuso', come il ^{205}Pb. Sono entrambi 'difficult to measure' perche' EC senza gamma, e pertanto potrebbe essere un problema quantificarne l'ammontare. Si potrebbe procedere con cattura del 40Ca, per quanto gli isotopi puri siano molto costosi. In tal caso il sample finale sarebbe 40Ca + 41Ca, ossia 'no carrier free'. Si potrebbe anche procedere con il potassio 41 via (p,n), irraggiando per mesi. In tal caso risulta dispendioso fare la separazione, ma è l'unico modo per produrlo carrier free. Rimane comunque sempre il problema della misura. La realizzazione richiede comunque un progetto di 1.5 – 2 anni. E costi importanti dell'ordine di circa 50kCHF (da verificare).

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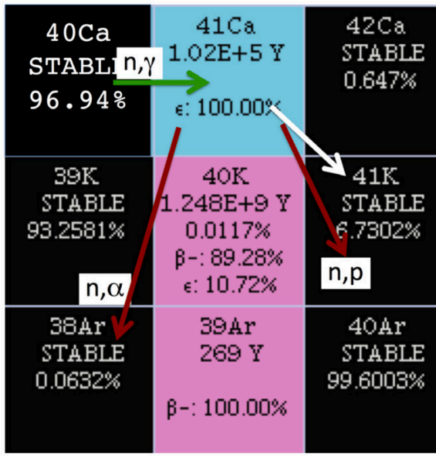

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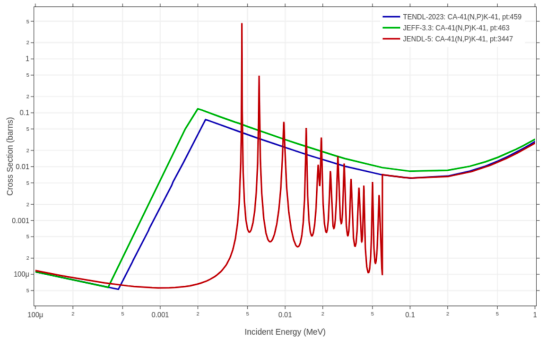

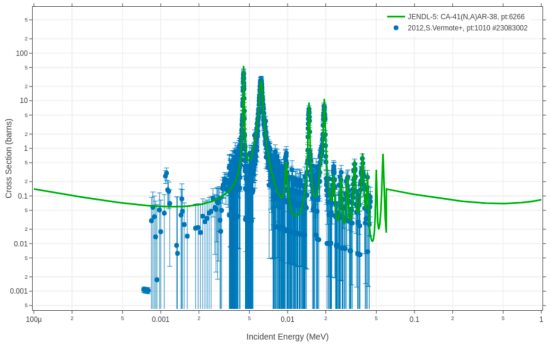

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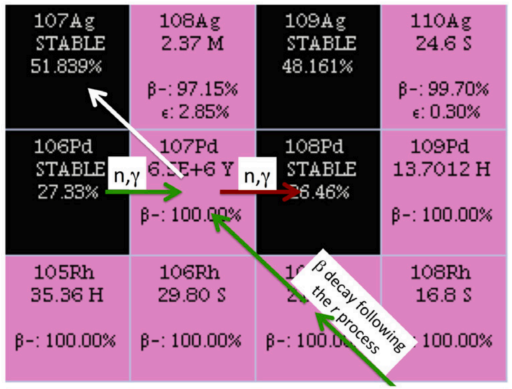
Disponibile a Geel…

^{107}Pd

^{107}Pd

- Too long-living ($T_{1/2}$ = 6.5 Myr, down to 700 years at 300 MK) to act as a branching point during the s-process
- → Behaves as a stable nucleus
- Experimentally determined neutron-capture cross section (Macklin 1985)
- → Its radiogenic decay is responsible for production of ^{107}Ag

Lugaro+ 18, PrPNP



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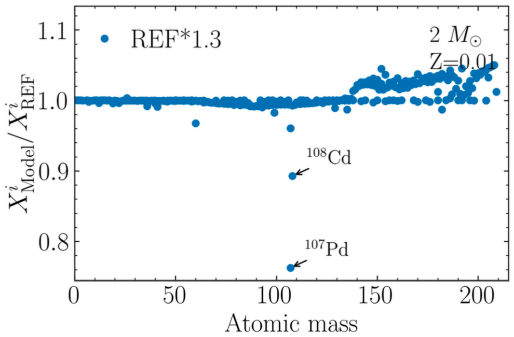

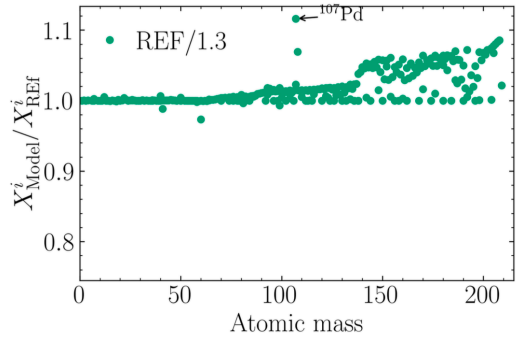

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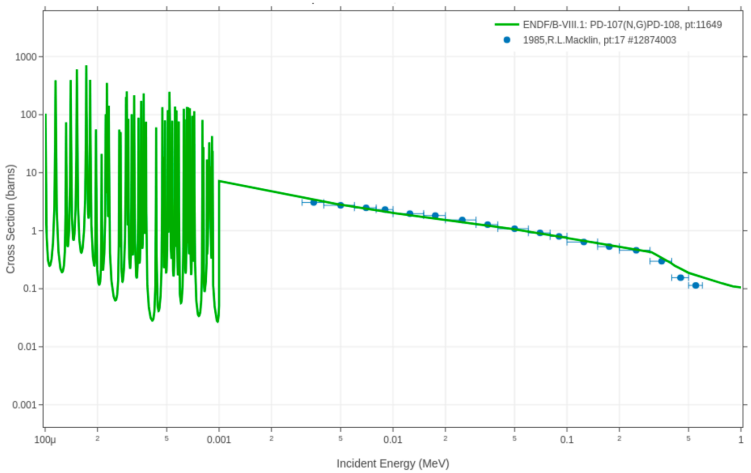

Si potrebbe produrre tramite cattura dal ^{106}Pd, con irraggiamento a ILL che richiederebbe decine di giorni facendo uso di un campione con purezza superiore al 99%. A titolo di esempio, se si irraggiano dentro il reattore 3g di ^{106}Pd naturale (27%), con flussi fino a 10^{15} n/sec, dopo 55gg di irraggiamento si raggiungono circa 10^{19} atomi.

^{107}Pd

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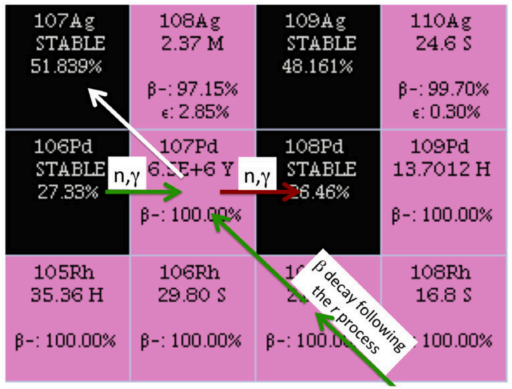

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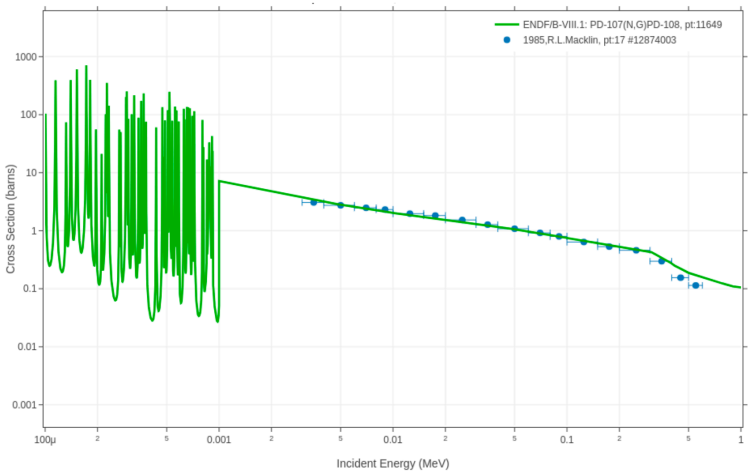

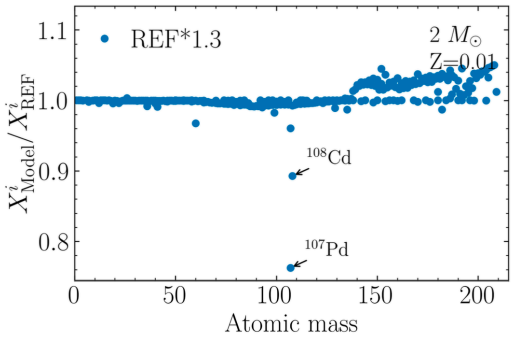

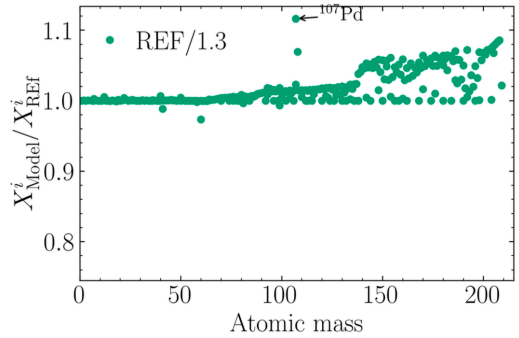

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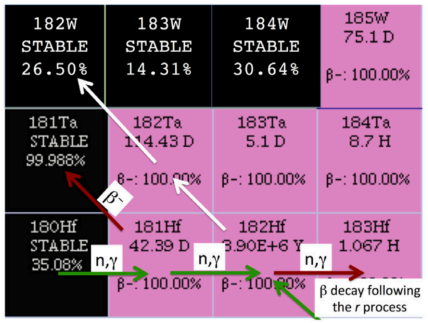
^{182}Hf

^{182}Hf

- Production of ^{182}Hf via activation of the branching point at ^{181}Hf

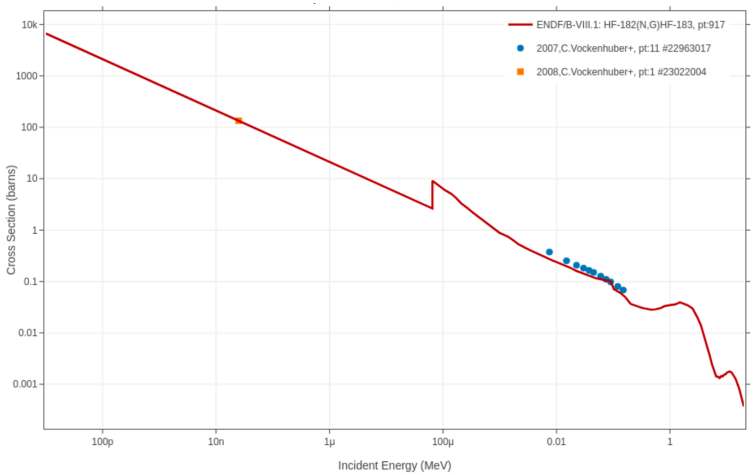
Lugaro+ 18, PrPNP



- The half life of ^{181}Hf, is believed to strongly decrease from 42 days to ~2 days in stellar conditions, mostly via population of an excited state at 68 keV (TY 87)
- However, the more recent, detailed experiments of Bondarenko+ 02 on the nuclear structure of ^{181}Hf suggested that this energy level does not exist
- → Possible large production of ^{182}Hf to the s-process in AGB stars

- → This may resolve the discrepancy between the abundances of ^{129}I and ^{182}Hf in the early solar system and allow to time the latest r- and s-process events that contributed to the build-up of solar system matter before the formation of the Sun (see discussion in Lugaro+ 14 and Vescovi+ 18)
- Its decay into ^{182}W is of importance also for determing the solar r-process residual of this isotope

Experimentally determined n-capture cross section via activation technique (Vockenhuber+ 07)



Partendo da 180Hf mediante 2n capture. Con 2.5g ci vorrebbe circa 1 mese di irraggiamento a ILL, usando un campione arricchito

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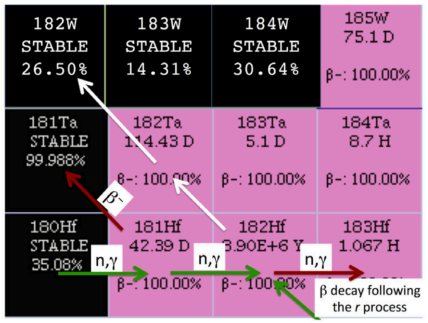

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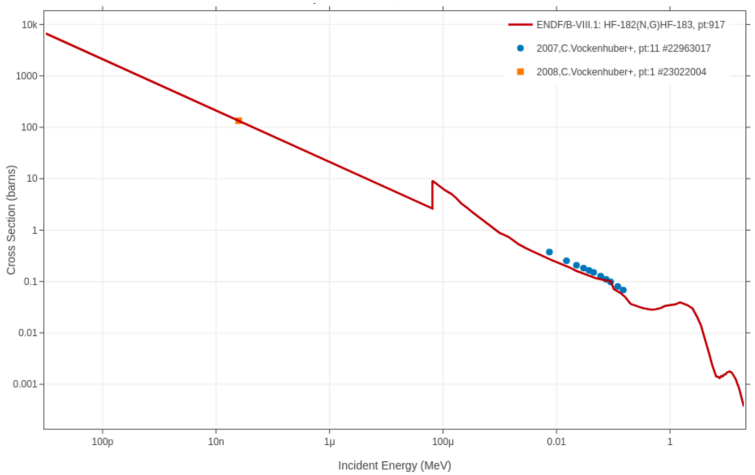

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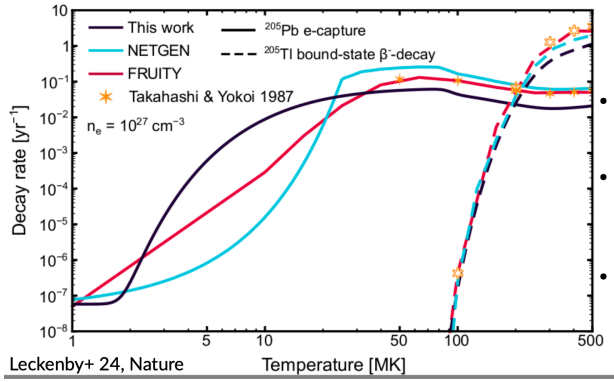
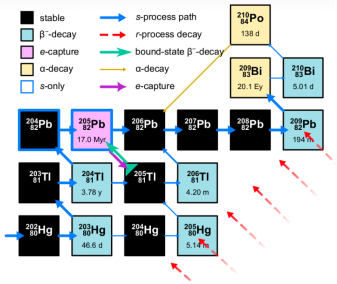
^{205}Pb

^{205}Pb

- Despite its long terrestrial half-life ($T_{1/2}$ = 17 Myr) of ^{205}**Pb acts as a branching point** because of the strong dependence on temperature and electron density
- ^{205}**Tl becomes unstable during TPs** and its β^- decay is competing with the β^+ decay of ^{205}Pb



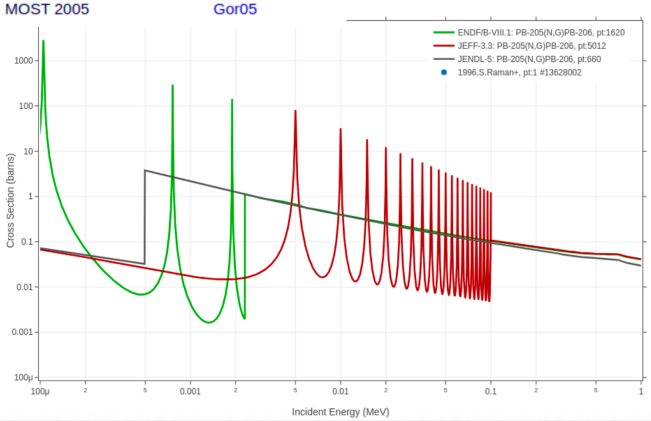
Leckenby+ 24, Nature



- **Measured for the first time** the bound-state β^- decay of ^{205}Tl
- The measured half-life is **4.7 times larger** than the previous theoretical estimate (291 days vs. 58 days)
- Diverging behavior at low temperatures due to the different extrapolation to the terrestrial value (log versus linear)

original	renorm.	year	type	Comment	Ref
54 ± 12		1976	s		MaW76
102		2000	t		RaT99
83		1981	t		Har81
58		1976	t		HWF76
65.8		2002	t	MOST 2002	Gor02
81.0		2005	t	MOST 2005	Gor05

- Theoretical (n,γ) cross section



Al PSI vi è in embrione un progetto per produrre 205Pb. Si potrebbe trovare una forma di collaborazione mediata da Emilio, per quanto non sia semplice. Si può produrre partendo dal 204Pb arricchito, irraggiandolo per due mesi, e per via dei contaminanti occorre poi separarlo. Costi elevati solo per la produzione. In ogni caso il sample finale sarebbe 'no carrier free', ossia 204Pb + 205Pb. Ci si potrebbe anche arrivare dal tallio non arricchito (203+205) con la (p,n) dopo lungo irraggiamento e aspettare due settimane per far decadere i prodotti. La separazione è un problema perché no gamma emettitore. Alla fine comunque dovrebbe essere separato con uno spettrometro di massa. Come per il 41Ca, occorrono oltre 50kCHF e ci vuole un progetto.

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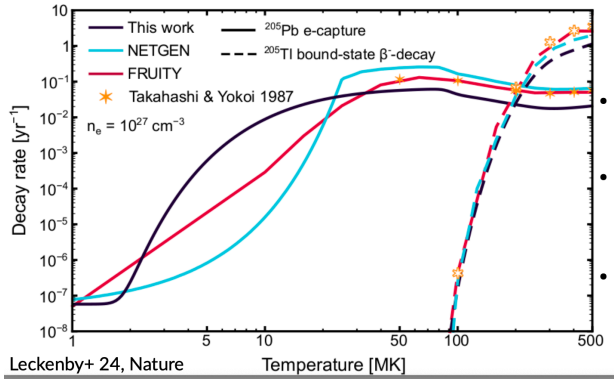

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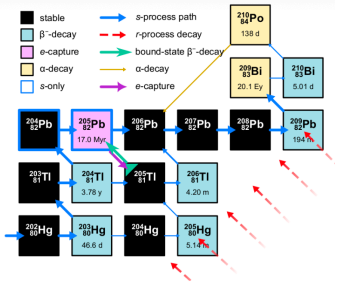

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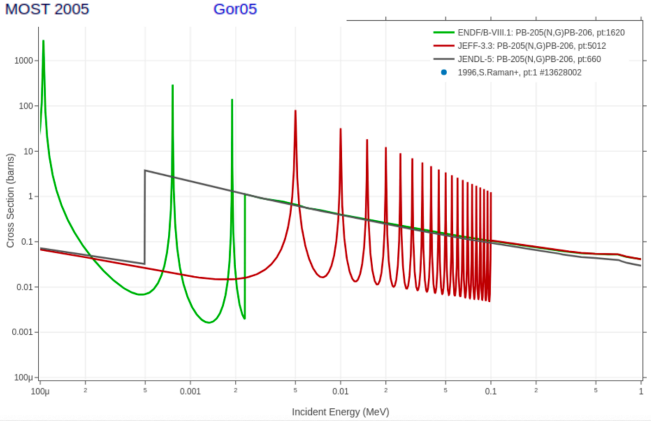

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Post LS3?