This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008324 (ChETEC-INFRA).

NA3/WP8: Astronuclear Library

ChETEC-INFRA 4th General Assembly and Transnational Access User Meeting
Strasbourg, France – 27-28/ May 2024

28/05/2024

Aldo Serenelli, Institute of Space Sciences (ICE, CSIC), aldos@ice.csic.es, chetec-infra.eu

NA3/WP8 – Overarching goals

- Development of procedures to evaluate sets of individual results (e.g. different measurements of a given nuclear cross section) to arrive to curated and community supported values: "**STANDARDS"** (incl. in Tasks 8.1 and 8.2)

- Creation of data libraries (T8.3) based on experimental data as raw as possible to facilitate reutilization for newer analysis – e.g. a new measurement is obtained → reanalysis of all available data
  - 'Big Three' for Helium burning: $^{12}C+\alpha$, $^{12}C+^{12}C$, $^{22}Ne+\alpha$ (T8.1)
  - Hydrogen-burning (T8.2)
  - Neutron capture for s-process (and beyond; T8.3)

- Development and maintenance of the ChETEC-INFRA Webpage (T8.4): access to infrastructures, public access to all data obtained in the NAs and JRAs and other data obtained as part of ChETEC-INFRA as well as any other activities related to the project

NA3/WP8 – Progress Report T8.1

T8.1 – A. Tumino (UKE), INFN, UMIL, CNRS, HZDR, GUF, UHULL

'Big Three' for Helium burning: $^{12}C+\alpha$, $^{12}C+^{12}C$, $^{22}Ne+\alpha$

Work towards consensus on combining results from experimental techniques

NA3/WP8 – Progress Report T8.2

T8.2 – A. Serenelli (CSIC), UMIL, HZDR, TUD

- Solar Fusion Reactions III → see next presentation by Yago Herrera – **D8.6**

- New Standard Solar Models (cross sections, solar abundances)
  → structures, neutrino fluxes, linearized models available through ChETEC-INFRA and Zenodo rep.
  D8.8 – publication in preparation

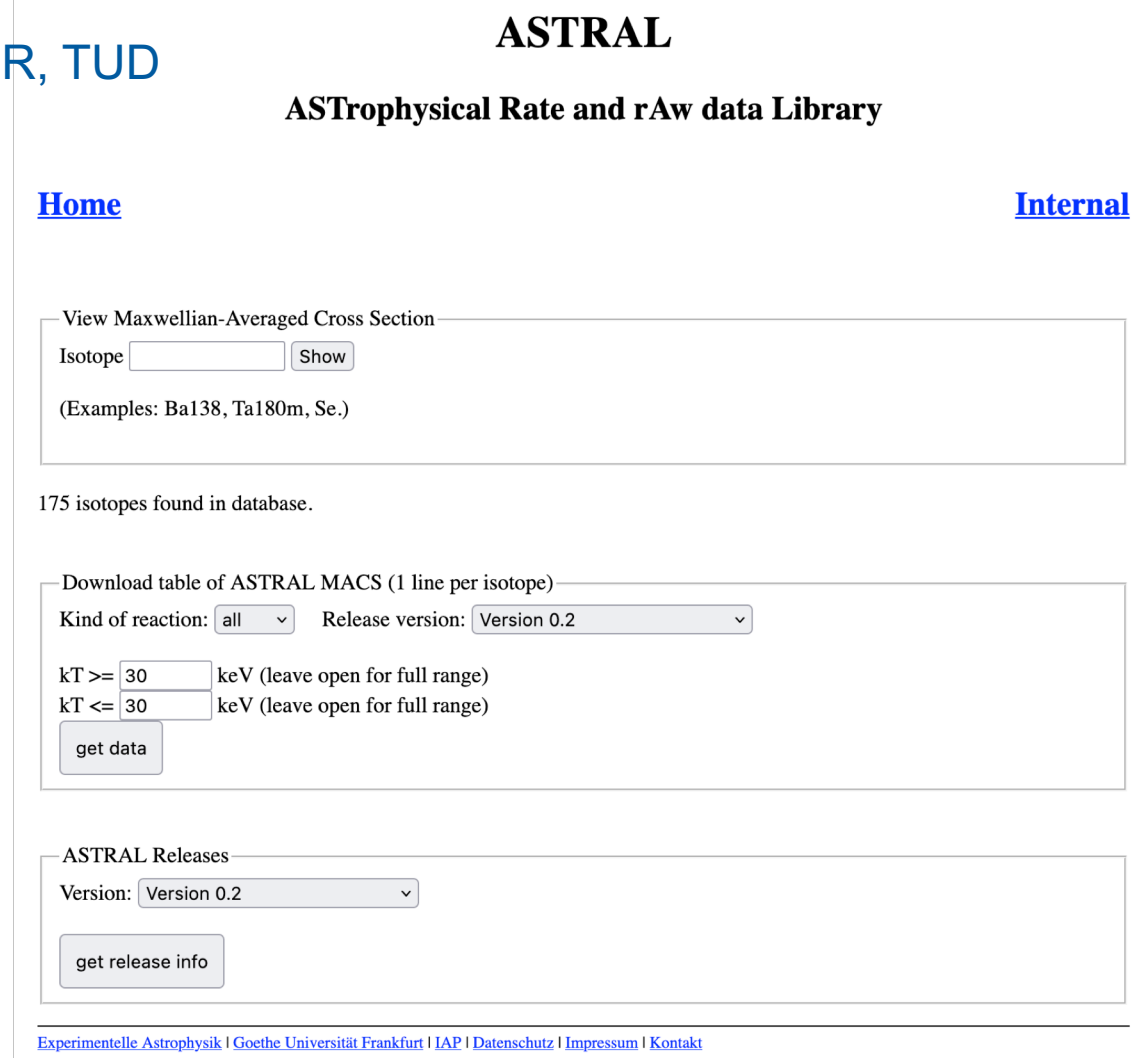
NA3/WP8 – Progress Report T8.3

T8.3 – T. Heftrich & R. Reifarth (GUF), CSIC, HZDR, TUD

https://exp-astro.de/astral/

- Extension of ASTRAL database (v0.2)
  175 isotopes as of today
- User front-end provides MACS
- Backend – stores raw experimental data
  easiness for reevaluation when needed

(**D8.4** and coming **D8.9**)



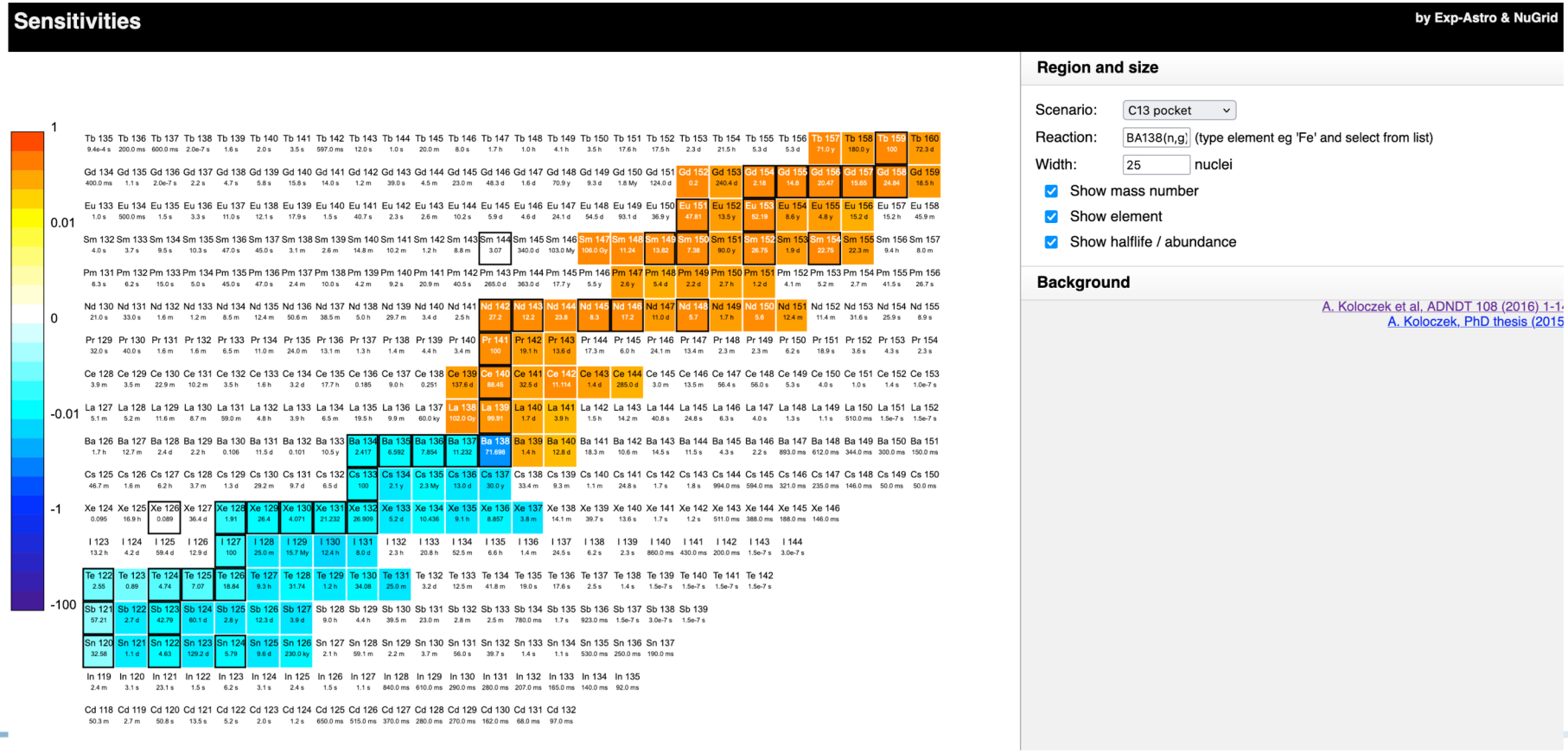
NA3/WP8 – Progress Report T8.3

T8.3 – T. Heftrich & R. Reifarth (GUF), CSIC, HZDR, TUD & **WP4** (M. Pignatari)

https://exp-astro.de/sensitivities/

➢ Sensitivity study for nucleosynthesis **D8.9** – ChETEC-INFRA now links to isotopic dependences previously existing

$$S_{ij} = \frac{\partial \ln X_i}{\partial \ln \sigma_j} \approx \frac{\Delta X_i / X_i}{\Delta \sigma_j / \sigma_j}$$

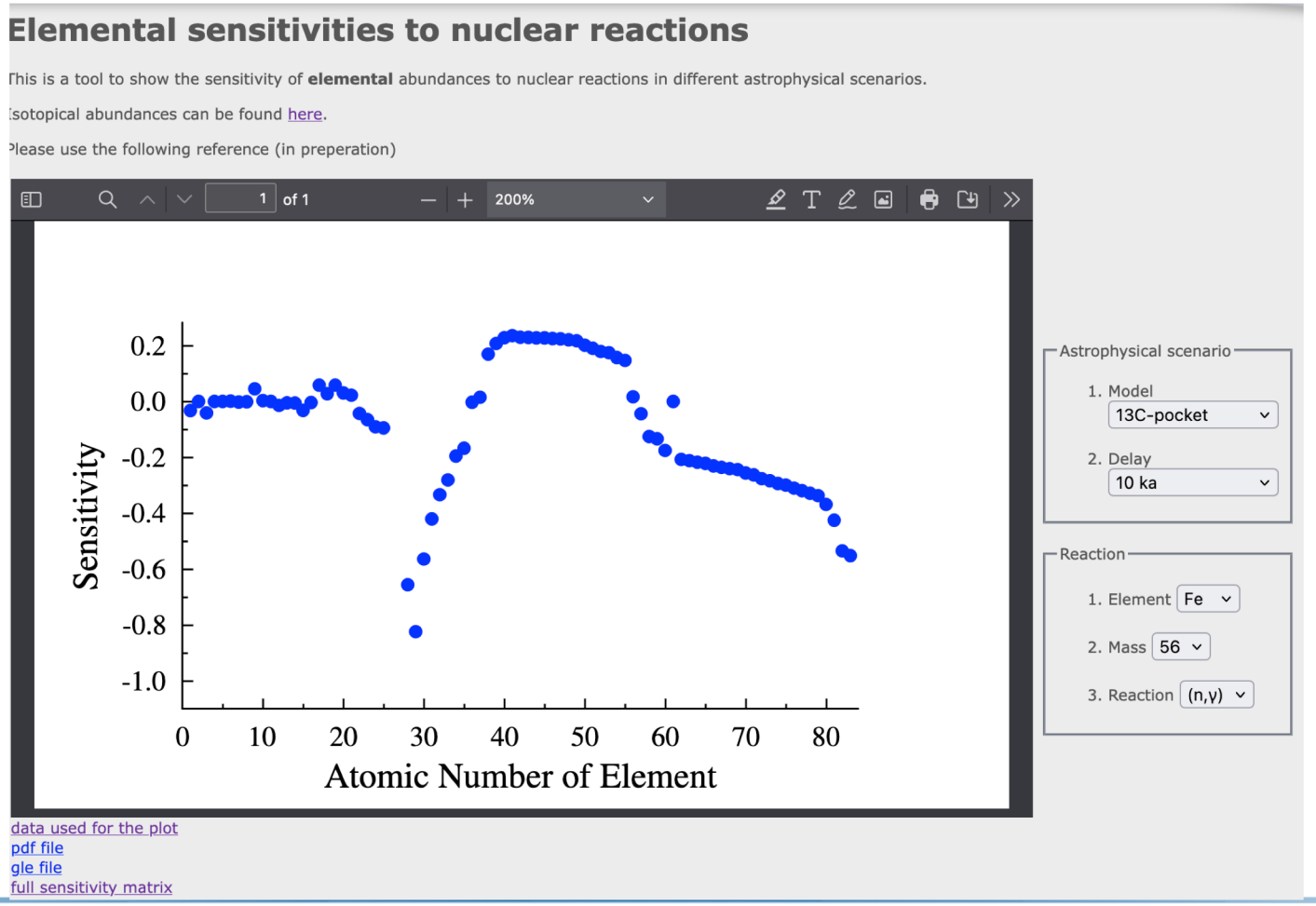


NA3/WP8 – Progress Report T8.3

https://exp-astro.de/sensitivities_elements/

- Newly developed elemental sensitivity: Publication submitted to ADNDT under review

$$S_{ij} = \frac{\partial \ln X_i}{\partial \ln \sigma_j} \approx \frac{\Delta X_i / X_i}{\Delta \sigma_j / \sigma_j}$$

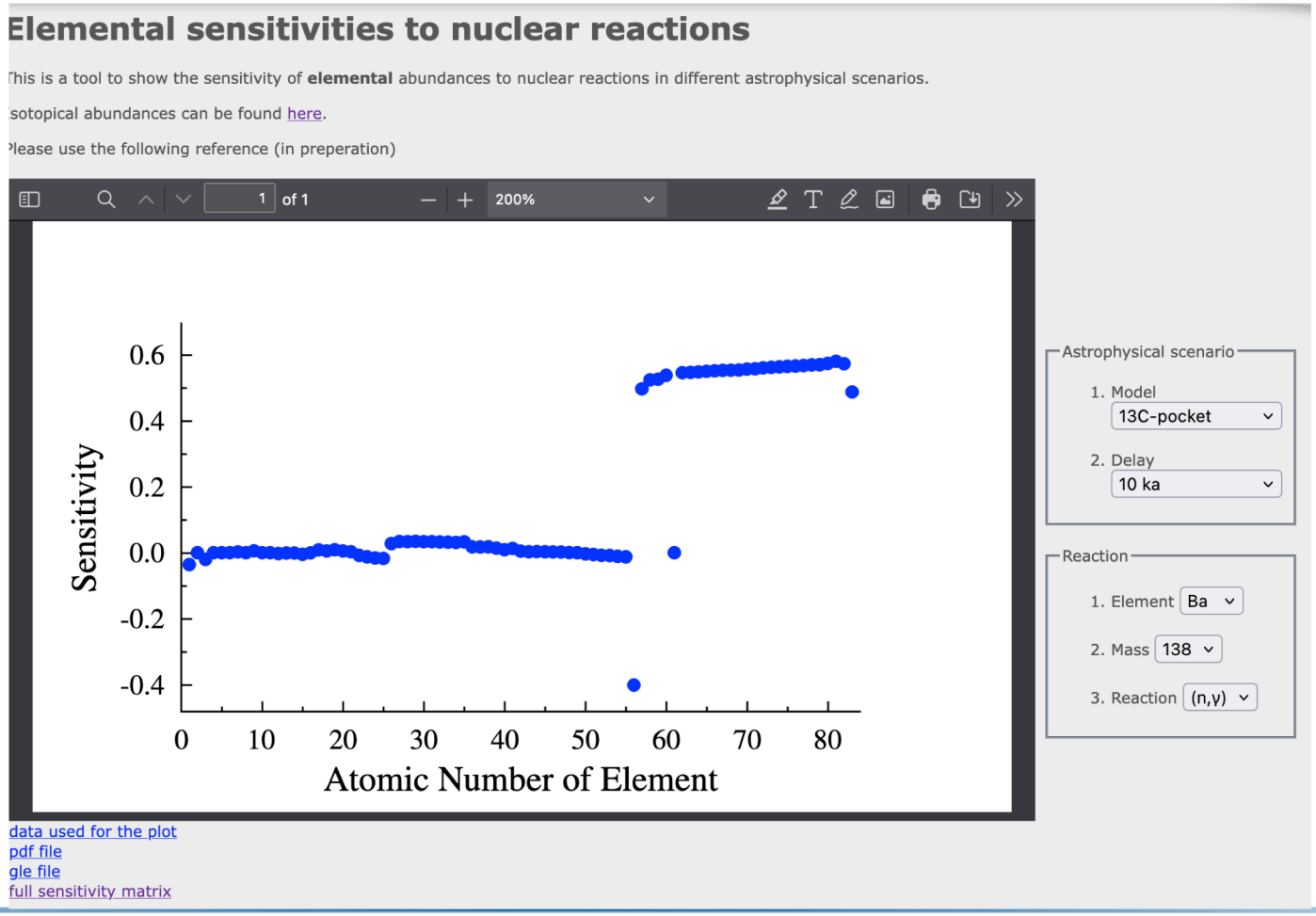


NA3/WP8 – Progress Report T8.3

https://exp-astro.de/sensitivities_elements/

- Newly developed elemental sensitivity: Publication submitted to ADNDT under review

$$S_{ij} = \frac{\partial \ln X_i}{\partial \ln \sigma_j} \approx \frac{\Delta X_i / X_i}{\Delta \sigma_j / \sigma_j}$$



NA3/WP8 – Progress Report T8.3

Full sensitivity matrix

Z Symbol N*Sensitivity ; N= 581

H 2(p,g)	BE 7(+,g)	LI 7(p,g)	N 14(p,g)	MG 25(p,g)	C 13(a,n)	C 14(a,g)	C 14(p,g)	O 17(a,n)	N 14(n,p)	O 17(n,a)	PROT (n,g)	C 12(n,g)	C 12(p,g)	C 13(n,g)	C 13(p,g)	C 14(n,g)	C 14(-,g)	N 13(+,g)	N 14(n,g)	N 14(a,g)	N 15(p,a)	O 16(n,g)	O 16(p,g)	O 17(p,a)	O 18(n,g)	O 18(p,g)	O 18(p,a)	F 18(+,g)	F 19(n,g)	F 19(p,a)	NE 20(n,g)	NE 21(n,g)
NE 21(p,g)	NE 22(n,g)	NA 22(+,g)	NA 23(n,g)	NA 24(-,g)	MG 24(n,g)	MG 24(p,g)	MG 25(n,g)	MG 26(n,g)	MG 27(-,g)	AL 26(n,g)	AL 26(n,p)	AL 26(n,a)	AL 26(+,g)	AL 27(n,g)	AL 28(-,g)	SI 28(n,g)	SI 29(n,g)	SI 30(n,g)	SI 31(n,g)	SI 31(-,g)	SI 32(-,g)	P 31(n,g)	P 32(p,p)	P 32(-,g)	P 33(-,g)	S 32(n,g)	S 32(n,a)	S 33(n,g)	S 33(n,p)	S 33(n,a)	S 34(n,g)	S 35(-,g)	S 36(n,g)
S 37(-,g)	CL 35(n,g)	CL 35(n,p)	CL 36(n,g)	CL 36(n,p)	CL 36(n,a)	CL 37(n,g)	CL 38(-,g)	AR 36(n,g)	AR 36(n,a)	AR 37(n,a)	AR 37(+,g)	AR 38(n,g)	AR 39(n,g)	AR 39(n,a)	AR 39(-,g)	AR 40(n,g)	AR 41(n,g)	AR 41(-,g)	AR 42(-,g)	K 39(n,g)	K 40(n,g)	K 40(n,p)	K 40(n,a)	K 41(n,g)	K 42(-,g)	CA 40(n,g)	CA 41(n,g)	CA 41(p,p)	CA 41(n,a)	CA 41(+,g)	CA 42(n,g)	CA 43(n,g)	CA 44(n,g)
CA 45(n,g)	CA 45(-,g)	CA 46(n,g)	CA 47(-,g)	CA 48(n,g)	SC 45(n,g)	SC 46(n,g)	SC 46(n,p)	SC 46(-,g)	SC 47(-,g)	SC 49(-,g)	TI 46(n,g)	TI 47(n,g)	TI 48(n,g)	TI 48(p,g)	TI 49(n,g)	TI 49(p,g)	TI 50(n,g)	TI 51(-,g)	V 49(n,g)	V 49(+,g)	V 50(n,g)	V 50(n,p)	V 51(n,g)	V 52(-,g)	CR 52(n,g)	CR 52(p,g)	CR 53(n,g)	CR 54(n,g)	CR 55(-,g)	MN 53(n,g)	MN 53(n,p)	MN 55(n,g)	MN 56(-,g)
FE 54(n,g)	FE 56(n,g)	FE 57(n,g)	FE 58(n,g)	FE 59(n,g)	FE 59(-,g)	FE 60(n,g)	FE 61(-,g)	CO 59(n,g)	CO 60(n,g)	CO 60(-,g)	CO 61(-,g)	NI 58(n,g)	NI 59(n,g)	NI 59(n,p)	NI 59(n,a)	NI 59(+,g)	NI 60(n,g)	NI 61(n,g)	NI 62(n,g)	NI 63(n,g)	NI 63(-,g)	NI 64(n,g)	NI 65(-,g)	CU 63(n,g)	CU 63(+,g)	CU 64(-,g)	CU 64(+,g)	CU 65(n,g)	CU 66(-,g)	ZN 64(n,g)	ZN 65(n,g)	ZN 65(n,a)
ZN 65(+,g)	ZN 66(n,g)	ZN 67(n,g)	ZN 67(n,a)	ZN 68(n,g)	ZN 69(-,g)	ZN 70(n,g)	ZN 71(-,g)	GA 69(n,g)	GA 70(-,g)	GA 70(+,g)	GA 71(n,g)	GA 72(-,g)	GE 70(n,g)	GE 71(+,g)	GE 72(n,g)	GE 73(n,g)	GE 74(n,g)	GE 75(n,g)	GE 75(-,g)	GE 76(n,g)	GE 77(-,g)	AS 75(n,g)	AS 76(-,g)	AS 76(+,g)	AS 77(-,g)	SE 76(n,g)	SE 77(n,g)	SE 78(n,g)	SE 79(n,g)	SE 79(-,g)	SE 80(n,g)	SE 81(n,g)	SE 81(-,g)
SE 82(n,g)	BR 79(n,g)	BR 80(-,g)	BR 80(+,g)	BR 81(n,g)	BR 82(-,g)	BR 82(+,g)	KR 80(n,g)	KR 81(n,g)	KR 81(+,g)	KR 82(n,g)	KR 83(n,g)	KR 84(n,g)	KR 85(n,g)	KR 85(-,g)	KR 86(n,g)	KR 87(-,g)	RB 85(n,g)	RB 86(-,g)	RB 86(+,g)	RB 87(n,g)	RB 88(-,g)	SR 86(n,g)	SR 87(n,g)	SR 88(n,g)	SR 89(n,g)	SR 89(-,g)	SR 90(-,g)	Y 89(n,g)	Y 90(-,g)	ZR 90(n,g)	ZR 91(n,g)	ZR 92(n,g)
ZR 93(n,a)	ZR 93(-,g)	ZR 94(n,g)	ZR 95(n,g)	ZR 95(-,g)	ZR 96(n,g)	ZR 97(-,g)	NB 93(n,g)	NB 94(n,g)	NB 94(-,g)	NB 95(-,g)	NB 97(-,g)	MO 94(n,g)	MO 95(n,g)	MO 96(n,g)	MO 97(n,g)	MO 98(n,g)	MO 99(n,g)	MO 99(-,g)	MO100(n,g)	MO101(-,g)	TC 99(n,g)	TC 99(-,g)	TC100(-,g)	TC100(+,g)	TC101(-,g)	RU 99(n,g)	RU100(n,g)	RU101(n,g)	RU102(n,g)	RU103(n,g)	RU103(-,g)	RU104(n,g)
RH103(n,g)	RH104(-,g)	RH104(+,g)	RH105(-,g)	PD104(n,g)	PD105(n,g)	PD106(n,g)	PD107(n,g)	PD107(-,g)	PD108(n,g)	PD109(n,g)	PD109(-,g)	PD110(n,g)	PD111(-,g)	AG107(n,g)	AG108(-,g)	AG109(n,g)	AG110(-,g)	AG110(+,g)	AG111(-,g)	CD108(n,g)	CD109(+,g)	CD110(n,g)	CD111(n,g)	CD112(n,g)	CD113(n,g)	CD114(n,g)	CD115(n,g)	CD115(-,g)	CD116(n,g)	CD117(-,g)	IN115(n,g)	IN116(-,g)
IN116(+,g)	IN117(-,g)	SN115(n,g)	SN116(n,g)	SN117(n,g)	SN118(n,g)	SN119(n,g)	SN120(n,g)	SN121(n,g)	SN121(-,g)	SN122(n,g)	SN123(n,g)	SN123(-,g)	SN124(n,g)	SN125(n,g)	SN126(n,g)	SN126(-,g)	SB121(n,g)	SB122(n,g)	SB122(-,g)	SB122(+,g)	SB123(n,g)	SB124(-,g)	SB124(+,g)	SB125(-,g)	TE122(n,g)	TE123(n,g)	TE124(n,g)	TE125(n,g)	TE126(n,g)	TE127(-,g)	TE128(n,g)	TE129(n,g)
TE129(-,g)	TE130(n,g)	I 127(n,g)	I 128(-,g)	I 128(+,g)	I 129(n,g)	I 129(-,g)	I 130(-,g)	I 130(+,g)	XE128(n,g)	XE129(n,g)	XE130(n,g)	XE131(n,g)	XE132(n,g)	XE133(n,g)	XE133(-,g)	XE134(n,g)	XE135(-,g)	XE136(n,g)	XE137(-,g)	CS133(n,g)	CS134(n,g)	CS134(-,g)	CS134(+,g)	CS135(n,g)	CS135(-,g)	CS136(n,g)	CS136(-,g)	CS136(+,g)	CS137(-,g)	BA134(n,g)	BA135(n,g)	BA136(n,g)
BA137(n,g)	BA138(n,g)	BA139(-,g)	LA138(n,g)	LA139(n,g)	LA140(-,g)	CE139(+,g)	CE140(n,g)	CE141(n,g)	CE141(-,g)	CE142(n,g)	CE143(-,g)	PR141(n,g)	PR141(n,a)	PR142(-,g)	PR142(+,g)	PR143(-,g)	ND142(n,g)	ND142(n,a)	ND143(n,g)	ND144(n,g)	ND145(n,g)	ND145(n,a)	ND146(n,g)	ND147(n,g)	ND147(-,g)	ND148(n,g)	ND149(n,g)	ND149(-,g)	ND150(n,g)	PM147(n,g)	PM147(-,g)	PM148(-,g)
PM148(+,g)	PM149(-,g)	SM147(n,g)	SM148(n,g)	SM149(n,g)	SM150(n,g)	SM151(n,g)	SM151(n,a)	SM151(-,g)	SM152(n,g)	SM153(n,g)	SM153(-,g)	SM154(n,g)	SM155(-,g)	EU151(n,g)	EU151(n,a)	EU152(n,g)	EU152(-,g)	EU152(+,g)	EU153(n,g)	EU154(n,g)	EU154(-,g)	EU154(+,g)	EU155(-,g)	GD152(n,g)	GD153(n,g)	GD153(+,g)	GD154(n,g)	GD155(n,g)	GD156(n,g)	GD157(n,g)	GD157(-,g)	GD158(n,g)	GD159(n,g)
GD159(-,g)	GD160(n,g)	TB157(n,g)	TB157(+,g)	TB158(n,g)	TB158(-,g)	TB158(+,g)	TB159(n,g)	TB160(n,g)	TB160(-,g)	TB160(+,g)	TB161(-,g)	DY158(n,g)	DY159(+,g)	DY160(n,g)	DY161(n,g)	DY162(n,g)	DY163(n,g)	DY164(n,g)	DY165(-,g)	HO165(n,g)	HO166(-,g)	ER166(n,g)	ER167(n,g)	ER168(n,g)	ER169(n,g)	ER169(-,g)	ER170(n,g)	ER171(-,g)	TM169(n,g)	TM170(n,g)	TM170(-,g)	TM170(+,g)	TM171(-,g)
YB170(n,g)	YB171(n,g)	YB172(n,g)	YB173(n,g)	YB174(n,g)	YB175(n,g)	YB175(-,g)	YB176(n,g)	YB177(-,g)	LU175(n,g)	LU176(n,g)	LU177(-,g)	HF176(n,g)	HF177(n,g)	HF178(n,g)	HF179(n,g)	HF179(-,g)	HF180(n,g)	HF181(n,g)	HF181(-,g)	HF182(n,g)	HF182(-,g)	HF183(-,g)	TA179(n,g)	TA179(+,g)	TA180(n,g)	TA181(n,g)	TA182(n,g)	TA182(-,g)	TA183(-,g)	W 180(n,g)	W 182(n,g)	W 183(n,g)	W 184(n,g)
W 185(n,g)	W 185(-,g)	W 186(n,g)	W 187(-,g)	RE185(n,g)	RE186(-,g)	RE186(+,g)	RE187(n,g)	RE188(-,g)	OS186(n,g)	OS187(n,g)	OS188(n,g)	OS189(n,g)	OS190(n,g)	OS191(n,g)	OS191(-,g)	OS192(n,g)	OS193(-,g)	IR191(n,g)	IR192(n,g)	IR192(-,g)	IR192(+,g)	IR193(n,g)	IR194(-,g)	PT192(n,g)	PT193(n,g)	PT193(+,g)	PT194(n,g)	PT195(n,g)	PT196(n,g)	PT197(n,g)	PT197(-,g)	PT198(n,g)	PT199(-,g)
AU197(n,g)	AU198(-,g)	AU198(+,g)	AU199(-,g)	HG198(n,g)	HG199(n,g)	HG200(n,g)	HG201(n,g)	HG202(n,g)	HG203(-,g)	HG204(n,g)	HG205(-,g)	TL203(n,g)	TL204(n,g)	TL204(-,g)	TL204(+,g)	TL205(n,g)	TL206(-,g)	PB204(n,g)	PB205(n,g)	PB205(+,g)	PB206(n,g)	PB207(n,g)	PB208(n,g)	PB209(n,g)	PB209(-,g)	PB210(-,g)	BI209(n,g)	BI210(n,g)	BI210(n,g)	KR 84(n,g)*	CD114(n,g)*	CD*15(-,g)	CD*15(-,g)
LU175(n,g)*	TA179(n,g)g	TAg80(-,g)	TAg80(+,g)																													

1 H −0.13355816E+01 0.00000000E+00 0.00000000E+00 −0.28039782E−03 0.00000000E+00 −0.53328676E+01 0.19852966E+00 −0.28039784E−03 0.33086946E−01 −0.11816073E+00 −0.33488935E−01 0.71960218E+00 0.13139237E+00 0.21745140E+00 −0.20000001E−02 −0.70744306E−01

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0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00

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−0.31588066E−02 0.00000000E+00 0.00000000E+00 0.00000000E+00 −0.10000000E−02 0.00000000E+00 −0.63176132E−02 −0.41588067E−02 −0.10908438E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 −0.24915625E−01 0.00000000E+00 −0.35915625E−01 −0.68784089E−02 −0.15037216E−01

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−0.54392045E−02 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 −0.71960219E−03 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 −0.27196023E−02 −0.10000000E−02 −0.37196023E−02 0.00000000E+00 0.00000000E+00

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−0.46673200E−10 −0.40138952E−08 0.00000000E+00 0.99999788E−03 0.00000000E+00 −0.28003920E−09 0.99998754E−03 −0.11668300E−09 0.00000000E+00 0.00000000E+00 0.00000000E+00 −0.91012740E−09 0.00000000E+00 −0.11668300E−09 0.00000000E+00 −0.28003920E−09 −0.23336600E−10

NA3/WP8 – Summary on deliverables

- D8.1: Web page
- D8.2: Data Management Plan
- D8.3: Report to GA on plans for 2 workshops for Big Three
- D8.4: First release of s-process library
- D8.5: Report on expert meeting on shared data formats
- D8.6 - Paper on H-burning rates. Month 24 → delayed due to Covid delays → draft in preparation
- D8.8 - Release of new generation of standard solar models → publication in prep.

- D8.9 – First release of sensitivity library (s-process) (joint w/WP4). Month 36

- D8.7 - Paper on methods and results for Big Three

- D8.10 – Report on possible strategy for community wide sharing on raw data. Month 48