

R.A. budget update with SaG4n and NeuCBOTv2

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Part 1. Neutron yields

List of new results

Material	Status
Neutron yields for the (α ,n) reactions (using SaG4n and NeuCBOT)	
Fused Silica	updated (added the NeuCBOT+TALYS-1.95 results)
Gadolinium oxide (Gd2O3)	updated (added the NeuCBOT+TALYS-1.95 results)
Aluminium	updated (added the NeuCBOT+TALYS-1.95 results)
SS DS50	done
Silver Loaded epoxy EJ2189 (PEI)	done
Si	Only the NeuCBOT+TALYS-1.95 results
Sapphire window	mostly done, not processed
Teflon	mostly done, not processed
Siliconnitride	Only the NeuCBOT+TALYS-1.95 results
Vikuiti (PET)	Only the NeuCBOT+TALYS-1.95 results
TPB	Only the NeuCBOT+TALYS-1.95 results
Clevios (PEDT)	Only the NeuCBOT+TALYS-1.95 results

Fused silica

Composition SiO₂

Element	Mass fraction, %
O	53.26
Si	46.74

Density: $\approx 2.203 \text{ g/cm}^3$
(density for fused quartz)

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	1.44E-6	1.54E-6	1.42E-6
	²³⁵ U	1.34E-6	1.43E-6	1.30E-6
	²³⁸ U upper	7.58E-8	7.33E-8	7.96E-8
	²³⁸ U middle	8.61E-7	9.20E-7	8.53E-7
	²³⁸ U lower	7.02E-8	9.92E-7	6.02E-8

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Gadolinium oxide (Gd_2O_3)

Composition Gd_2O_3

Element	Mass fraction, %
O	13.24
Gd	86.76

Density: $\approx 7.407 \text{ g/cm}^3$

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	^{232}Th	1.80E-7	1.69E-7	1.91E-7
	^{235}U	1.92E-7	1.80E-7	2.05E-7
	^{238}U upper	2.28E-8	2.13E-8	2.69E-8
	^{238}U middle	1.15E-7	1.08E-7	1.185E-7
	^{238}U lower	1.56E-8	1.22E-7	1.48E-08

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Aluminium

Composition

Element	Mass fraction, %
Al	100

Density: $\approx 2.70 \text{ g/cm}^3$

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	^{232}Th	4.60E-5	2.28E-5	1.97E-5
	^{235}U	4.20E-5	2.01E-5	1.62E-5
	^{238}U upper	1.00E-6	3.84E-7	2.89E-7
	^{238}U middle	2.70E-5	1.33E-5	1.12E-5
	^{238}U lower	1.60E-6	1.40E-5	4.82E-7

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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SS DS50

Composition

Element	Mass fraction, %
C	0.15
Cr	17
Ni	12
Mn	2
Fe	68.85

Density: 7.9 g/cm³

Legend:

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	1.80E-6	1.80E-6	2.02E-6
	²³⁵ U	3.71E-7	3.41E-7	4.59E-7
	²³⁸ U upper	1.09E-9	1.02E-9	3.9E-10
	²³⁸ U middle	4.82E-7	4.72E-7	5.84E-7
	²³⁸ U lower	1.06E-9	4.73E-7	9.25E-10

Will be checked

0.0	E-9	E-8	E-7	E-6	E-5
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Silver Loaded epoxy EJ2189 (PEI)

Composition

Element	Mass fraction, %
C	74.98
O	16.21
H	4.08
N	4.73

Density: 1.27 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	3.10E-6	2.20E-6	1.36E-6
	²³⁵ U	2.60E-6	2.05E-6	1.21E-6
	²³⁸ U upper	2.70E-7	2.64E-7	9.05E-8
	²³⁸ U middle	1.90E-6	1.37E-6	8.19E-7
	²³⁸ U lower	1.50E-7	1.51E-6	6.09E-08

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Si

Composition

Element	Mass fraction, %
Si	100

Density: 2.329 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	3.42E-6	2.82E-6	not simulated yet
	²³⁵ U	3.01E-6	2.53E-6	not simulated yet
	²³⁸ U upper	7.59E-8	7.27E-8	not simulated yet
	²³⁸ U middle	2.00E-6	1.65E-6	not simulated yet
	²³⁸ U lower	1.15E-7	1.76E-6	not simulated yet

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Sapphire window

Composition

Element	Mass fraction, %
Al	52.93
O	47.07

Density: 3.98 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	1.44E-6	1.12E-5	not processed
	²³⁵ U	1.34E-6	9.97E-6	not processed
	²³⁸ U upper	7.58E-8	2.21E-7	not processed
	²³⁸ U middle	8.61E-7	6.61E-6	not processed
	²³⁸ U lower	7.02E-08	6.94E-6	not processed

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Teflon

Composition

Element	Mass fraction, %
C	24.02
F	75.98

Density: 2.2 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	12.66E-5	9.39E-5	not processed
	²³⁵ U	13.12E-5	9.68E-5	not processed
	²³⁸ U upper	1.16E-5	7.38E-6	not processed
	²³⁸ U middle	7.94E-5	5.87E-5	not processed
	²³⁸ U lower	missing	6.49E-5	not processed

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Siliconnitride

Composition

Element	Mass fraction, %
Si	60.06
N	39.94

Density: 3.17 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	1.18E-5	7.61E-6	not simulated yet
	²³⁵ U	7.46E-6	4.84E-6	not simulated yet
	²³⁸ U upper	4.07E-8	3.91E-8	not simulated yet
	²³⁸ U middle	6.67E-6	4.30E-6	not simulated yet
	²³⁸ U lower	missing	4.36E-6	not simulated yet

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Vikuiti (PET)

Composition

Element	Mass fraction, %
C	62.50
H	4.20
O	33.30

Density: 1.38 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	1.51E-6	1.47E-6	not simulated yet
	²³⁵ U	1.62E-6	1.56E-6	not simulated yet
	²³⁸ U upper	2.45E-7	2.35E-7	not simulated yet
	²³⁸ U middle	9.69E-7	9.42E-7	not simulated yet
	²³⁸ U lower	1.33E-7	1.07E-6	not simulated yet

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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TPB

Composition

Element	Mass fraction, %
C	93.85
H	6.15

Density: 1.079 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	1.89E-6	1.83E-6	not simulated yet
	²³⁵ U	2.03E-6	1.95E-6	not simulated yet
	²³⁸ U upper	3.15E-7	3.02E-7	not simulated yet
	²³⁸ U middle	1.21E-6	1.18E-6	not simulated yet
	²³⁸ U lower	1.67E-7	1.34E-6	not simulated yet

Will be checked

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Clevios (PEDT)

Composition

Element	Mass fraction, %
C	51.42
H	2.88
O	22.83
S	22.87

Density: 1.011 g/cm³

	RA Chain	NeuCBOT TALYS-1.6	NeuCBOT TALYS-1.95	SaG4n JENDLTENDL01
Neutron yield, neutrons per decay of the parent nucleus	²³² Th	Data for acrylic	1.41E-6	not simulated yet
	²³⁵ U	Data for acrylic	1.44E-6	not simulated yet
	²³⁸ U upper	Data for acrylic	2.05E-7	not simulated yet
	²³⁸ U middle	Data for acrylic	8.84E-7	not simulated yet
	²³⁸ U lower	Data for acrylic	9.95E-7	not simulated yet

Legend:

0.0	E-9	E-8	E-7	E-6	E-5
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Part 2. Gamma yields

List of new results

Material	Status
Gamma yields for the ($\alpha, n\gamma$) reactions (using NeuCBOT+TALYS-1.95)	
Fused Silica	done
Gd203	done
Aluminium	done
SS DS50	done
Silver Loaded epoxy EJ2189 (PEI)	done
Si	done
Sapphire window	done
Teflon	done
Siliconnitride	done
Vikuiti (PET)	done
TPB	done

Material	Status
Gamma yields for the ($\alpha, n\gamma$) reactions (using NeuCBOT+TALYS-1.95)	
Clevios (PEDT)	done
Kapton	done
Reinforced PU foam 90% PU foam	done
Reinforced PU foam 55% PU foam	done
Solder InAg (In 97%)	done
Mastic rope	done
Plywood	done
	done
	done
	done

Fused Silica

Composition

Element	Mass fraction, %
Si	46.74
O	53.26

Density: 2.203 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	1.84E-9
	²³⁵ U	1.91E-9
	²³⁸ U upper	2.78E-10
	²³⁸ U middle	1.16E-9
	²³⁸ U lower	1.31E-9

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Gd203

Composition

Element	Mass fraction, %
Gd	86.76
O	13.24

Density: 7.407 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	1.27E-10
	²³⁵ U	1.22E-10
	²³⁸ U upper	1.75E-11
	²³⁸ U middle	7.65E-11
	²³⁸ U lower	8.62E-11

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Aluminium

Composition

Element	Mass fraction, %
Al	100

Density: 2.7 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	1.25E-8
	²³⁵ U	1.27E-8
	²³⁸ U upper	9.93E-10
	²³⁸ U middle	7.71E-9
	²³⁸ U lower	8.57E-9

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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SS DS50

Composition

Element	Mass fraction, %
C	0.15
Cr	17
Ni	12
Mn	2
Fe	68.85

Density: 7.9 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	3.21E-9
	²³⁵ U	2.36E-9
	²³⁸ U upper	3.35E-11
	²³⁸ U middle	1.65E-9
	²³⁸ U lower	1.77E-9

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Silver Loaded epoxy EJ2189 (PEI)

Composition

Element	Mass fraction, %
C	74.98
O	16.21
H	4.08
N	4.73

Density: 1.27 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	2.03E-10
	²³⁵ U	2.10E-10
	²³⁸ U upper	3.46E-11
	²³⁸ U middle	1.27E-10
	²³⁸ U lower	1.46E-10

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Si

Composition

Element	Mass fraction, %
Si	100

Density: 2.329 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	3.76E-9
	²³⁵ U	3.97E-9
	²³⁸ U upper	5.87E-10
	²³⁸ U middle	2.39E-9
	²³⁸ U lower	2.71E-9

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Sapphire window

Composition

Element	Mass fraction, %
Al	52.93
O	47.07

Density: 3.98 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	6.22E-9
	²³⁵ U	6.30E-9
	²³⁸ U upper	5.02E-10
	²³⁸ U middle	3.83E-9
	²³⁸ U lower	4.26E-9

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Teflon

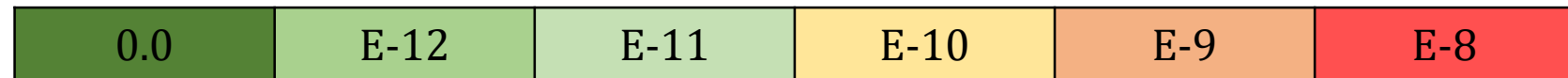
Composition

Element	Mass fraction, %
C	24.02
F	75.98

Density: 2.2 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	1.51E-8
	²³⁵ U	1.63E-8
	²³⁸ U upper	2.25E-9
	²³⁸ U middle	9.72E-9
	²³⁸ U lower	1.12E-8

Legend:



Siliconnitride

Composition

Element	Mass fraction, %
Si	60.06
N	39.94

Density: 3.17 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	2.32E-9
	²³⁵ U	2.44E-9
	²³⁸ U upper	3.62E-10
	²³⁸ U middle	1.47E-9
	²³⁸ U lower	1.67E-9

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Vikuiti (PET)

Composition

Element	Mass fraction, %
C	62.50
H	4.20
O	33.30

Density: 1.38 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	2.27E-10
	²³⁵ U	2.29E-10
	²³⁸ U upper	3.56E-11
	²³⁸ U middle	1.40E-10
	²³⁸ U lower	1.60E-10

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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TPB

Composition

Element	Mass fraction, %
C	93.85
H	6.15

Density: 1.079 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	1.34E-10
	²³⁵ U	1.46E-10
	²³⁸ U upper	2.60E-11
	²³⁸ U middle	8.67E-11
	²³⁸ U lower	1.01E-10

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Clevios (PEDT)

Composition

Element	Mass fraction, %
C	51.42
H	2.88
O	22.83
S	22.87

Density: 1.011 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	6.58E-10
	²³⁵ U	6.39E-10
	²³⁸ U upper	7.87E-11
	²³⁸ U middle	4.04E-10
	²³⁸ U lower	4.53E-10

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Kapton

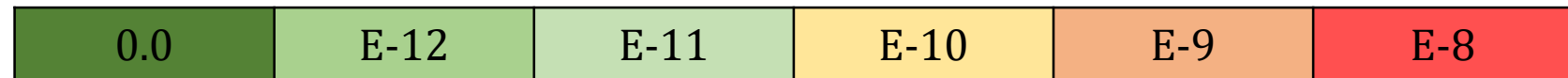
Composition

Element	Mass fraction, %
H	2.6
C	69.1
N	7.3
O	20.9

Density: 1.42 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	2.34E-10
	²³⁵ U	2.40E-10
	²³⁸ U upper	3.90E-11
	²³⁸ U middle	1.46E-10
	²³⁸ U lower	1.67E-10

Legend:



Reinforced PU foam

90% PU foam

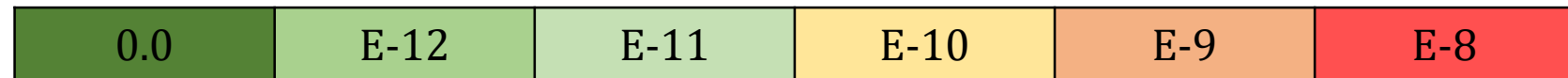
Density: 0.100 g/cm³

Composition

Element	Mass fraction, %
H	5.94
C	53.19
N	4.59
O	31.07
Si	2.60
Ca	1.12
Al	1.11
B	0.31
Mg	0.07

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	4.74E-10
	²³⁵ U	4.82E-10
	²³⁸ U upper	6.46E-11
	²³⁸ U middle	2.94E-10
	²³⁸ U lower	3.33E-10

Legend:



Reinforced PU foam

55% PU foam

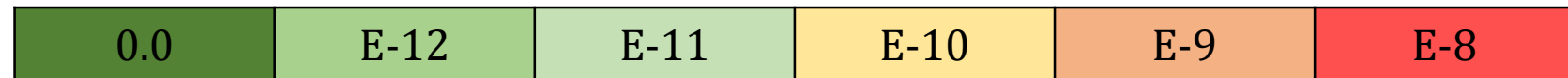
Density: 0.100 g/cm³

Composition

Element	Mass fraction, %
H	3.6
C	32.5
N	2.8
O	37.6
Si	11.7
Ca	5.0
Al	5.0
B	1.4
Mg	0.3

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	1.45E-9
	²³⁵ U	1.48E-9
	²³⁸ U upper	1.79E-10
	²³⁸ U middle	9.02E-10
	²³⁸ U lower	1.02E-9

Legend:



Solder InAg (In 97%)

Composition

Element	Mass fraction, %
In	97
Ag	3

Density: 7.38 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	6.02E-13
	²³⁵ U	7.12E-14
	²³⁸ U upper	0
	²³⁸ U middle	2.28E-13
	²³⁸ U lower	2.28E-13

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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Mastic rope

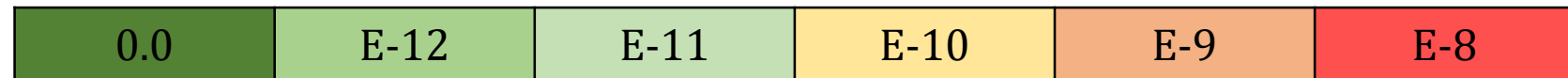
Composition

Element	Mass fraction, %
H	6.6
C	59.1
N	5.1
O	29.2

Density: 1.2 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	2.25E-10
	²³⁵ U	2.27E-10
	²³⁸ U upper	3.57E-11
	²³⁸ U middle	1.39E-10
	²³⁸ U lower	1.59E-10

Legend:



Plywood

Composition

Element	Mass fraction, %
H	6
C	51
N	2
O	42

Density: 0.65 g/cm³

	RA Chain	NeuCBOT TALYS-1.95
Gamma yield, gammas per decay of the parent nucleus	²³² Th	2.47E-10
	²³⁵ U	2.46E-10
	²³⁸ U upper	3.73E-11
	²³⁸ U middle	1.52E-10
	²³⁸ U lower	1.72E-10

Legend:

0.0	E-12	E-11	E-10	E-9	E-8
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General remarks

- 1) A link to the neutron budget obtained with SaG4n:
[neutron bg Oct20 with SaG4n](#)
- 2) All files related to the study will be available in [the CERNBox folder](#)
(use the standard DarkSide password to log in)