DANISH HEALTH AUTHORITY
RADIATION PROTECTION

Quality assurance of a characterised Ge-detector used for various geometries (mathematical efficiency calibration)

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DANISH HEALTH AUTHORITY
RADIATION PROTECTION

Setup:

Characterized Ge detector
Electrical cooling

Shielded lab + 10 cm Pb.
No background peaks
except 511 keV

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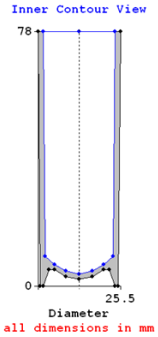
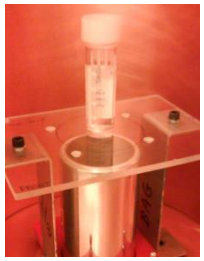
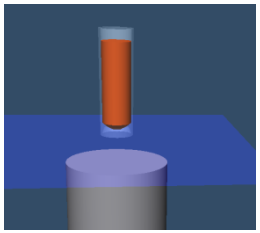
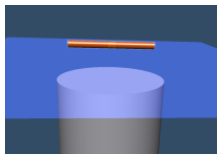
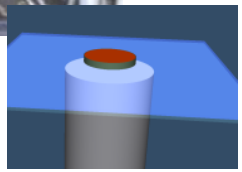
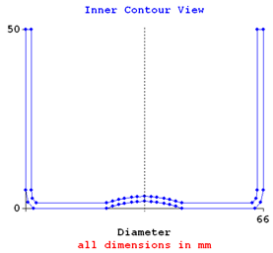


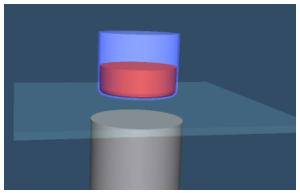


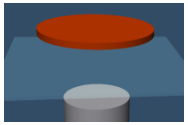


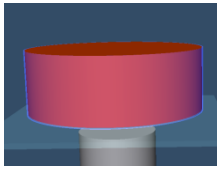


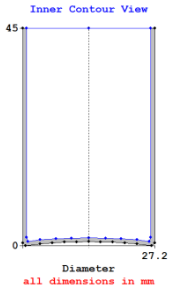


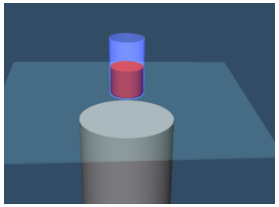








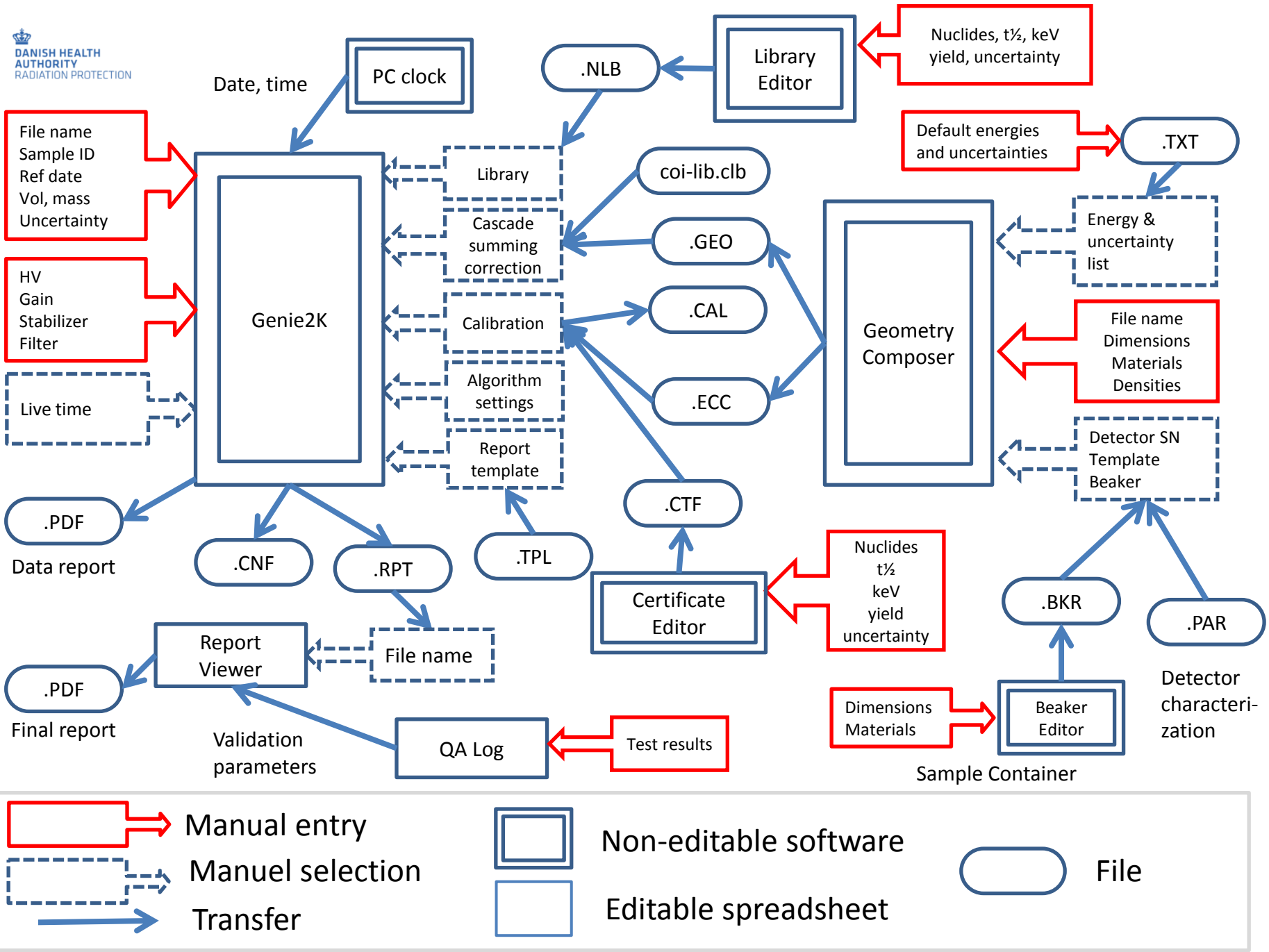




QC Objective

Must keep track of:

“Any parameter or setting that can be edited by the user that can affect the measurement result.”


DANISH HEALTH AUTHORITY
RADIATION PROTECTION
Date, time
PC clock
.NLB
Library Editor
Nuclides, t½, keV yield, uncertainty
File name
Sample ID
Ref date
Vol, mass
Uncertainty
HV
Gain
Stabilizer
Filter
Live time
Genie2K
Library
Cascade summing correction
Calibration
Algorithm settings
Report template
coi-lib.clb
.GEO
.CAL
.ECC
Default energies and uncertainties
.TXT
Energy & uncertainty list
Geometry Composer
File name
Dimensions
Materials
Densities
Detector SN
Template
Beaker
.PDF
Data report
.CNF
.RPT
.TPL
.CTF
Certificate Editor
Nuclides
t½
keV
yield
uncertainty
.BKR
.PAR
Detector characteri-zation
Report Viewer
File name
.PDF
Final report
Validation parameters
QA Log
Test results
Dimensions
Materials
Beaker Editor
Sample Container
Manual entry
Manuel selection
Transfer
Non-editable software
Editable spreadsheet
File

Hardware and algorithm settings QC

Genie2000 .rpt - file

```
*****************************************************************
MILQA *** Genie_Algorithm_Settings_and_Status,_MIL **********
*****************************************************************
REPTEMPLATE : C:\GENIE2K\CTLFILES\MIL_REPORT.tpl
#filename CNF_file_name: C:\GENIE2K\CAMFILES\GEC-1117-K1-Eu-152_167
#datetime Report_generated_on: 05-09-2017 13:08:19

Edit_Sample_Info ****
STITLE      Sample_Title: Eu-152_1671-48-2
SCOLLNAME   Collector_name:
SDESC1      Sample_Description:
SIDENT      Sample_ID: GEC-1117
STYPE       Type:
SQUANT      Sample_quantity:  1.0000E+00
SQUANTERR   Quantity_error:  0.0000E+00
SUNITS      Quantity_units: 1
SGEOMTRY    Sample_geometry: TRIPEZAGD
SSYSERR     Random_sample_error(%):    0.00
SSYSTERR    Systematic_sample_error(%):    0.00
STIME       Sample_taken_on_(reference_date): 01-06-2013 12:00:00
SLOCTN      Sample_location:
BUILDUPTYPE Activity_build-up_type: NONE

Hardware_Settings ****
ASTIME      Acquisition_started_on: 01-09-2017 14:06:05
DETNAME     Detector_name: GEC
ACQINPUTID  Detector_ID:
DETID       Detector_serial_number:
MCATYPE     MCA_type: DIK
MCAHWVERSION MCA_hardware_version: 6654276D
MCAID       MCA_serial_number:      291
HVPSFSTAT   High_voltage_status: On
VOLTAGE     Detector_high_voltage_(V):  2500.61
DETTEMP     Detector_temperature:           0
AMPLTTRIM   Live_time_corr_adjust: On
AMPTC       Amplifier_time_constant_(us):  0.000000000000E+00
ELIVE       Live_time_(s):  9.8054000000E+02
EREAL       Real_time_(s):  1.3863000000E+03
AMPHWGAIN1  Coarse_gain_x:     5.000
AMPHWGAIN2  Fine_gain_x:     1.6499
AMPHWGAIN3  Super_fine_gain_x:     0.999998
AMPPURG     PUR_guard_x:    1.100
AMPBLRTYPE  BLR_mode: Auto
AMPFILTERRT Rise_time:   5.6
AMPFILTERFT Flat_top:   0.8
DSSWIN1MODE Stabilizer_gain_mode: Off
DSSWIN2MODE Stabilizer_gain_mode2: Off
PILEUP      Pulse_pileup_correction_factor:  0.0000E+00
NIDFVARDT   Variable_dead-time_corr_done?: No
DTCALC      Dead_Time_calculated_(%):  29.269
ACQDETTC    Detector_time_constant:  0.0000E+00

Energy_Calibration_Settings ****
ECALTIME    Energy_calibration_time: 01-09-2017 14:33:42
ECALTYPE    Energy_calibration_type: POLY
ECALUNITS   Energy_calibration_units: keV
ECFENCAL    Perform_energy_calibration?: Yes
ECFFWCAL    Perform_FWHM_calibration?: Yes
ECFT1CAL    Perform_low_tail_calibration?: Yes
ECFT2CAL    Perform_tail_two_calibration?: No
ECALTERMS   Number_of_terms_in_energy_cal_polynomial:   3
ECOFFSET    Energy_fit_offset_(+): -4.1201E-02
ECSLOPE     Energy_fit_1st_order_(*ch):  2.3945E-01
ECQUAD      Energy_fit_2nd_order_(*ch^2): -5.2325E-08
ECALFAC1    Energy_fit_3rd_order_(*ch^3):  0.0000E+00
ECALFAC2    Energy_fit_4th_order_(*ch^4):  0.0000E+00
ECALFAC3    Energy_fit_5th_order_(*ch^5):  0.0000E+00
ECALCHISQ   Energy_cal_chi_square: 441.585
ECALCNV     Energy_cal_conversion_factor:  1.0000E+00
SCALTIME    Shape_calibration_performed_on: 01-09-2017 14:33:42
FWCALTYPE   FWHM_calibration_type: SQRT
FWHMOFF     Shape_fit_offset_(+):  7.4620E-01
```

Excel

7	Report_Template	REPTEMPLATE	EPORT.tpl	MIL_REPORT.tpl	0
8	Efficiency_Calib._Type:	EFFTYPE	DUAL	DUAL	0
9	Start_channel:	PEAKSTART	1	1	0
10	Stop_channel:	PEAKEND	8192	8192	0
11	Significance_threshold:	SENSITVTY	5	5	0
12	Tolerance_(FWHM):	copyUSEVARETOL	FWHM	FWHM	0
13	Add_to_existing_results:	PRADDPKRES	Off	Off	0
14	Start_channel:	PASTART	1	1	0
15	Stop_channel:	PAEND	8192	8192	0
16	95%_Critical_level_test:	CRITLEVEL	On	On	0
17	Use_Fixed_FWHM:	PRFIXFWHM	Off	Off	0
18	Use_fixed_tail_parameters:	PRVARYLTAIL	On		0
19	PRVARYLTAIL_is_always_On_when_	PRUSEFIXROIL_is_Off			0
20	Fit_singlets:	PRFIT	Off	Off	0
21	Display_ROIs:	SHOWROIS	On	Off	1
22	Reject_zero_area_peaks:	PRREJECT0PKS	Off	Off	0
23	Use_DOECAP_rules:	PRDODOECAP	Off	Off	0
24	Continuum_Channels_(Ch):	PRNBKCHN	4	4	0
25	Continuum_Channels_(FWHM):	PRVBKCHN	0		0
26	Channels/FWHM:	PRUSEVBKCHN	Channels	Channels	0
27	Continuum_Function:	ROIPSBTYP	STEP	STEP	0
28	Residual_Search-Perform_Search:	PRDORESID	Off	Off	0
29	Use_Fixed_ROI_Limits:	PRUSEFIXROIL	Off	Off	0
30	Background_Subtract_Yes:	EXPBACKSUB	Off	Off	0
31	Bkg._File:	EXPBACK	0		0
32	Use_Stored_Background:	PRUSESTRDBKG	Off	Off	0
33	Start_channel:	copyPASTART	1	1	0
34	Stop_channel:	copyPAEND	8192	8192	0
35	NID_library:	EXPLIB	TENORM,		0
36	Perform_MDA_test:	PRDOMDATEST	On	On	0
37	Use_Stored_Library:	PRUSESTRLIB	Off	Off	0
38	Inhibit_Acq-Time_Decay_Correction:	DISACQDECAY	Off	Off	0
39	Tolerance_(keV):	TOLERANCE	1	1	0
40	Tolerance_(FWHM):	VARTOLERANCE	1	1	0
41	Energy/FWHM:	USEVARETOL	FWHM	FWHM	0
42	NID_Confidence_threshold:	CONFID	0,3	0,3	0
43	MDA_Confidence_factor(%):	MDACONFID	5	5	0
44	Perform_cascade_correction:	NIDFCSCDONE	On	On	0
45	Use_Stored_Geometry_Data:	PRUSESTRGEO	Off	Off	0
46	Use_ISOCS/LABSOCS_Total_efficie	PRTOTEFFSRC	On	On	0
47	Confidence_Factor(%):	copyMDACONFID	5	5	0
48	Bayesian_Confidence_Factor(abs.):	PR11929BCF	0,05	0,05	0
49	Perform_variable_ROI_widths:	PRUSEVPWIDTH	Off	Off	0
50	ROI_Width:_+/-_(FWHM):	VPWIDTH	3		0
51	Use_variable_MDA_constants:	USEMDACONSTS	Off	Off	0
52	Uncertainty_k=:	NSIGMA	1	1	0
53	High_Voltage_Status:	HVPSFTAT	On	On	0
54					
55					
56	QC sum OK=0	1			
57					

CAM-file parameter checksum

SUNDHEDSSTYRELSEN
STRÅLEBESKYTTELSE

Rapport dato (dd-mm-åå): 28-06-17 10:43

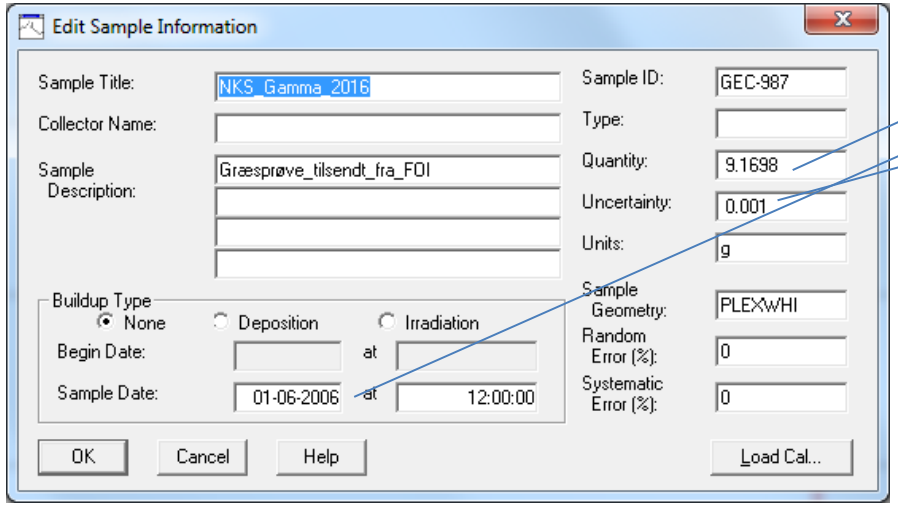
Rapport gammaspektrometri, Miljølaboratoriet.

Detektor: GEC
Titel: NKS_Gamma_2017_Lake_Sediment
Beskrivelse: h_15-16mm
Målefil: C:\GENIE2K\CAMFILES\GEC-1076-K2-NKS_Gamma_2017_Lake_Sediment.CNF
Måledato: 15-05-2017 09:07:41 Ref dato: 24-02-2017 12:00:00
Live Time: 170966,19 s 47,5 h Dead time: 0,17 %
Prøve mængde: 2,08E-02 kg u: 1,00E-06 ur: 0,0%
Geom. descr.: GEC-1076_PLEXWHI Energy cal. date: 02-05-2017 12:52:28
Geom. file: IE2K\isocs\data\GEOMETRY\Laboratory\SIMPLIFIED_BEAKER\GEC-1076_PLEXWHI.geo
Nuklidbibliotek: C:\GENIE2K\CAMFILES\TENORM_COPY,K-40,Cs-137,
Baggr subtr.: 0
Usikkerhed k: 1 Random err. (%): 0 Syst. err. (%): 0
CAM_QC sum: 0 -
QC sum: 0 -
LabSOCS Warning Code: 0
QC kommentar:

Identifikation og aktivitetsbestemmelse.

Nuklid (fra bibliotek)	Key Line Energy keV	Key Line Aktivitet Bq/kg	Usikkerh. u k=1		Key Line MDA Bq/kg	Casc Sum Corr On	Multipl. peak	Peak Sign. > 3
K-40	1460,82	170,46	1,21E+01		2,11E+01	miss		14,42
Cs-137	661,66	117,11	7,26E+00		2,73E+00	miss		49,94
§ Tl-208	583,19	6,74	8,26E-01		2,10E+00	0,9312		10,1
Pb-210	46,54	255,48	3,84E+01		2,85E+01	free		29,47
§ Po-210	803,05			<	2,24E+05			
§ Pb-211	404,83			<	6,04E+01			

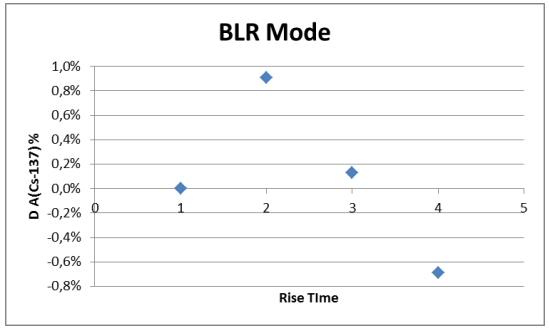
Manually entered parameters

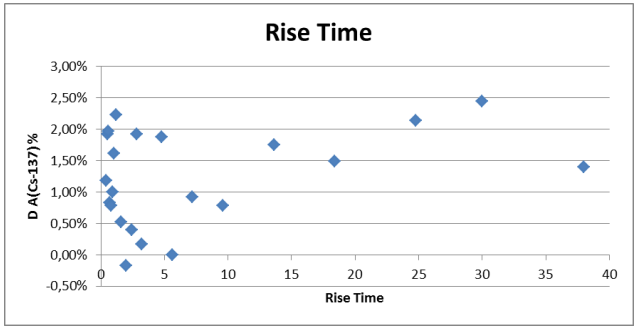


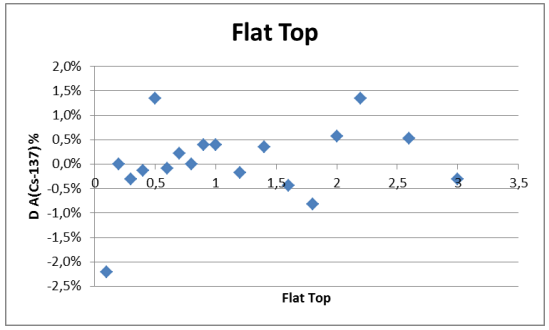
	A	B	C	D	E	F	G
1				Rapport dato:		09-09-16 14:52	(ddmmåå)
2							
3	SUNDHEDSSTYRELSEN						
4	STRÅLEBESKYTTELSE						
5							
6	**Rapport gammaspektrometri, Miljølaboratoriet.**						
7	Titel:	NKS_Gamma_2016					
8	Beskrivelse:	Grµspr°ve_tilsendt_fra_FOI					
9	Filnavn:	C:\GENIE2K\CAMFILES\GEC-987-K3-NKS_Gamma_2016_FOI.CNF					
10	Måledato:	22-08-2016	Ref dato:	01-06-2006	12:00:00		
11	Detektor:	GEC					
12	Voltage:	2500,6	Coarse gain:	5	Fine gain:	1,65	
13	Prøve mængde	9,17	g	u:	0,001	g	
14	Live Time:	172800	s		48,0	timer	
15	Geometri:	cs\data\GEOMETRY\Laboratory\SIMPLIFIED_BEAKER\GEC-987_PLEXWHI.geo					
16	Nuklidbibliotek:	C:\GENIE2K\CAMFILES\GEC-987_NKS_Gamma_2016_FOI.NLB					
17	Effektivitet fit:	DUAL	Baggr subtr.:				0
18	Usikkerhed k:	1	Random err. (%):	0	Syst. err. (%):	0	
19	Peak search:	1	-	8192	ch	Threshold:	
20	Dec. akt.:	3	Dec. MDA:	0			
21							
22	**Identifikation og aktivitetsbestemmelse.**						
23	(MIL_Report.tpl. Space-delimited .rpt import, comma for decimal)						
24	Nuklider	Aktivitet	u rel.	U rel.			
25	(fra bibliotek)	(w.m. best est.)	k=1	k=2			
26		Bq/g					
27							
28	K-40	0,964	6,7%	13,4%			
29	Cs-137	10,007	6,0%	12,0%			
30							
48					QC parameters:		Criterium:
49					Ener check:	29-08-2016	
50					Dev. (keV):	0,04	< 0,5
51					Act. valid.:	29-08-2016	
52					Nuclide:	K-40	
53					zeta (line):	1,38	< 2
54					Algorithms:	0	0
55							
56	Best est, MDA: ISO11929						
57							
58	Skabelon:	07-09-2016	QAV:	26			Side 1/3

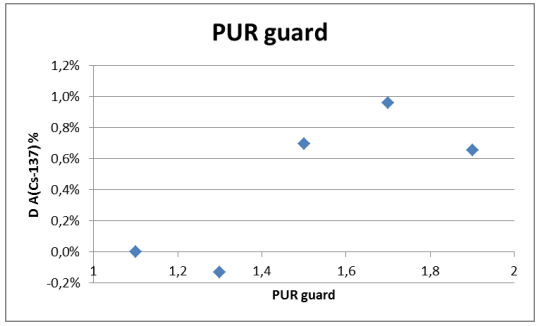
LabSocs. Sensitivity Analysis

Hardware settings





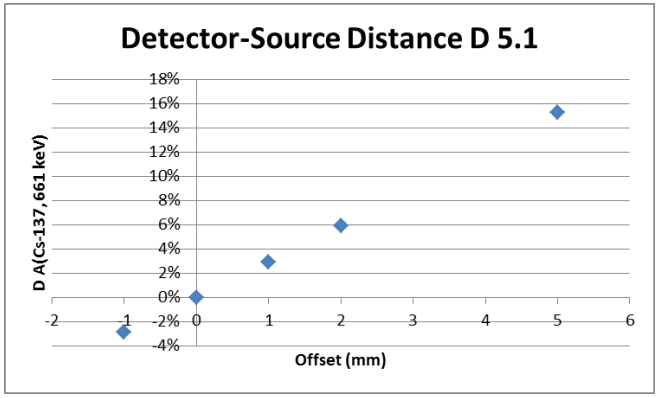


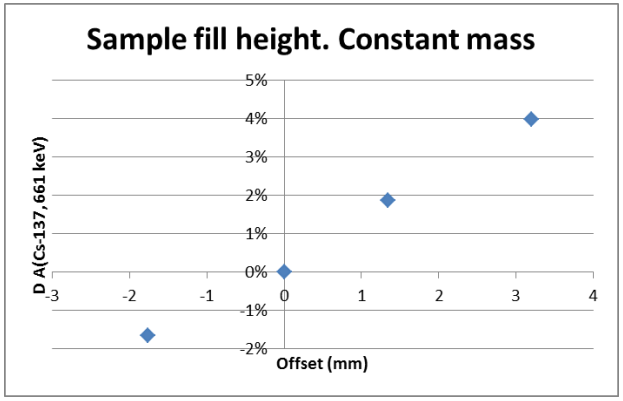


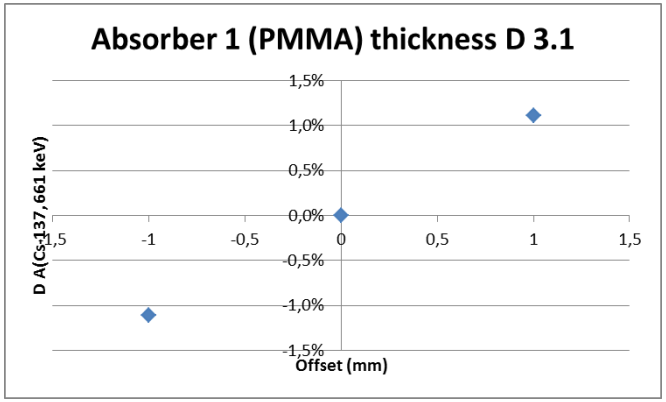
Cs-137 point source, 21 mm from detector
661 keV, net count-rate 762 cps (+/- 0,7 %, k=1)

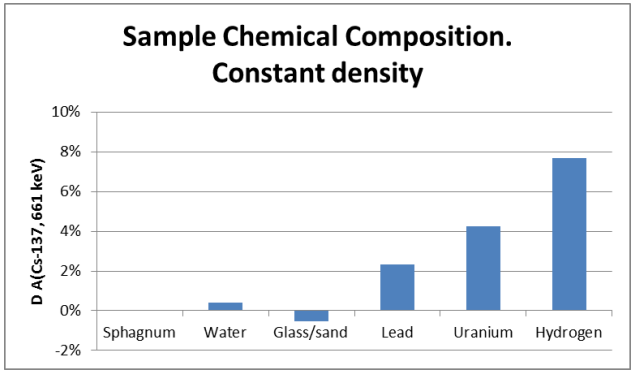
LabSocs. Sensitivity Analysis

LabSocs geometry parameters

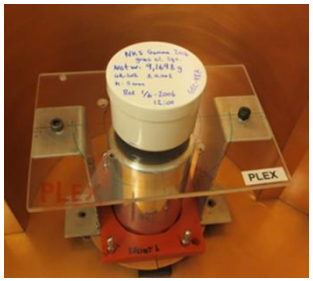




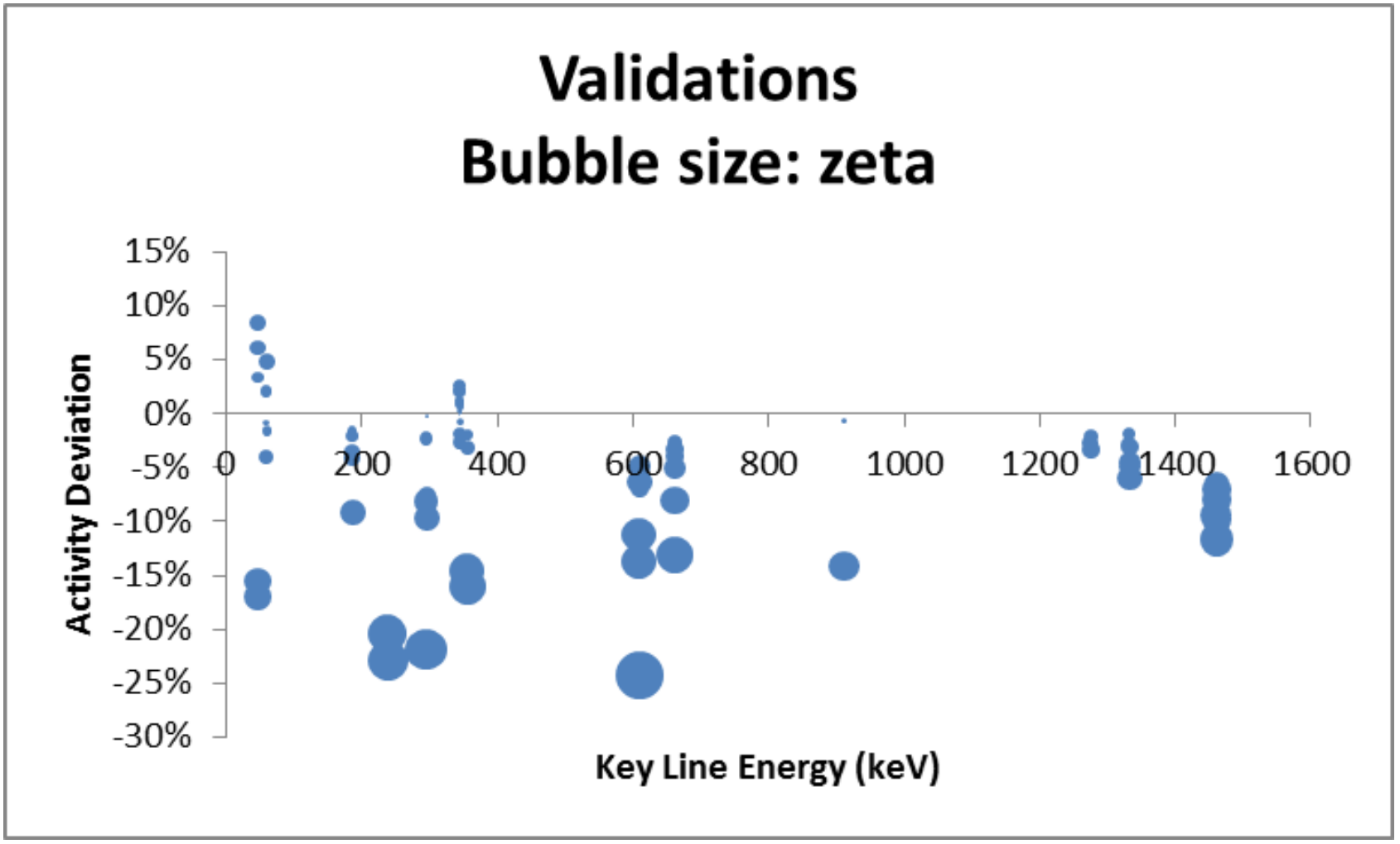




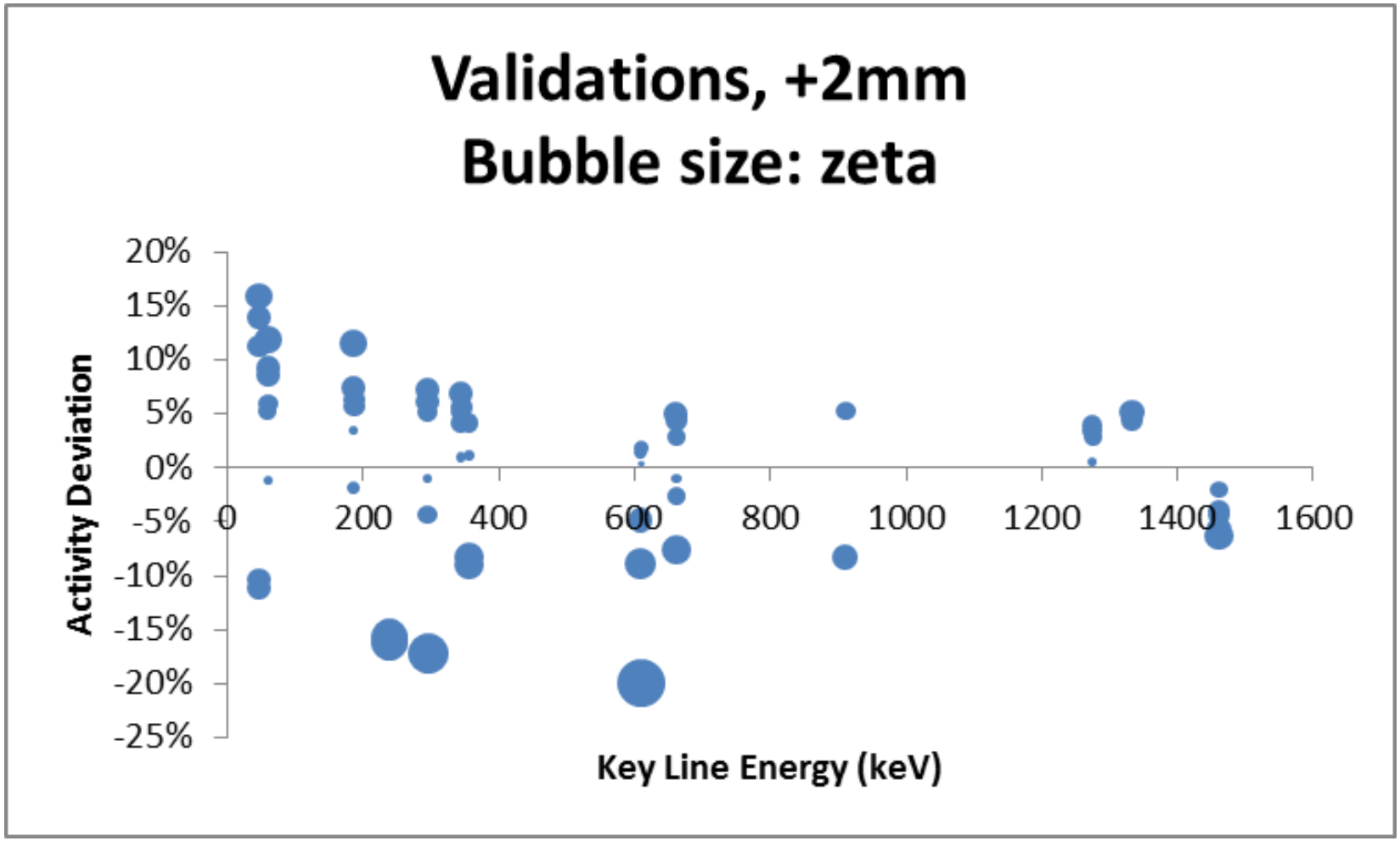
- Distance is a critical parameter



Validation
Do I have a problem ?

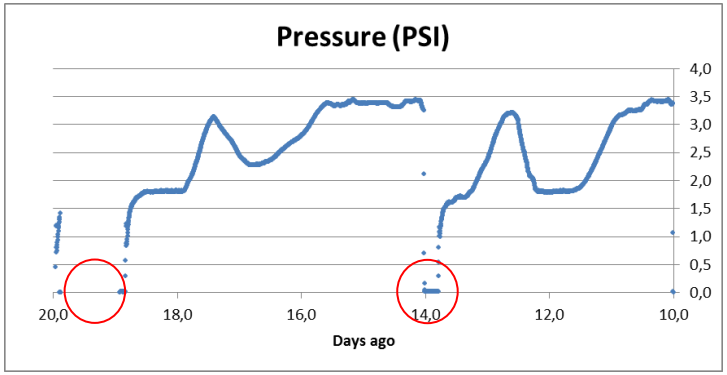


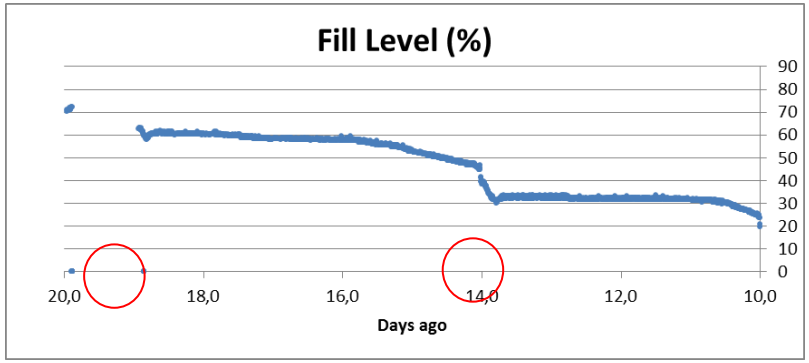
Detector reference plane lowered (2mm)

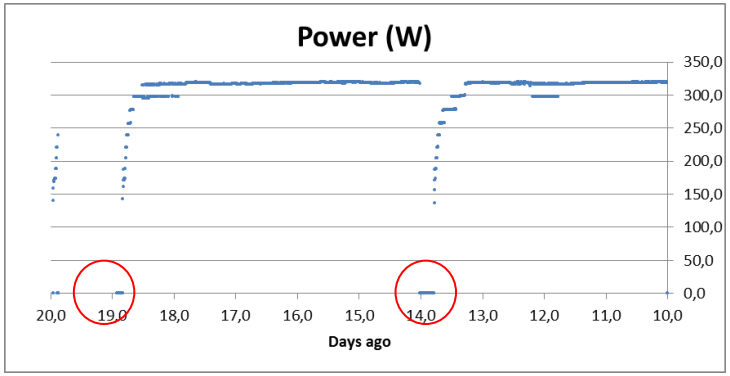


Electric cooler issue

"Sudden loss of cooling efficiency after 1 year"

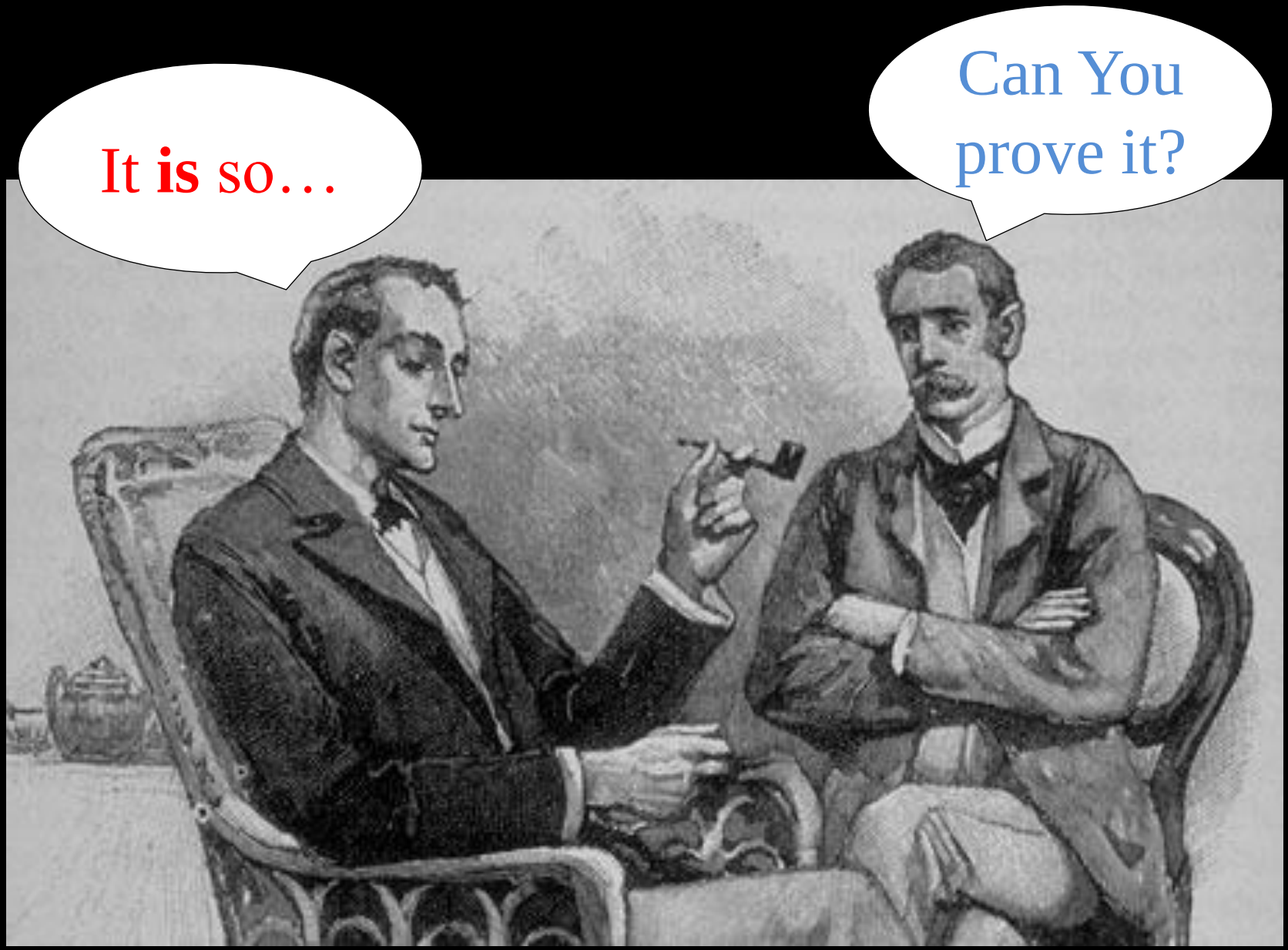




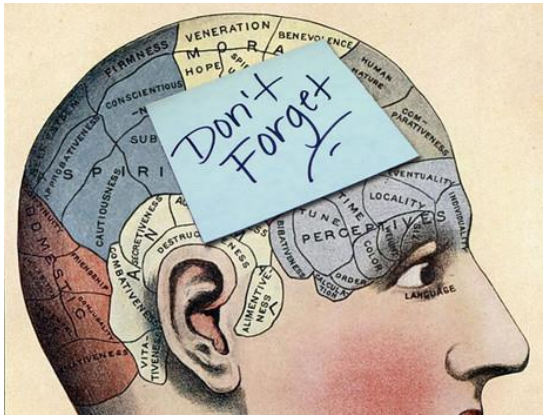


Pressure relief (3-5 h) and cooler restart

Extra material

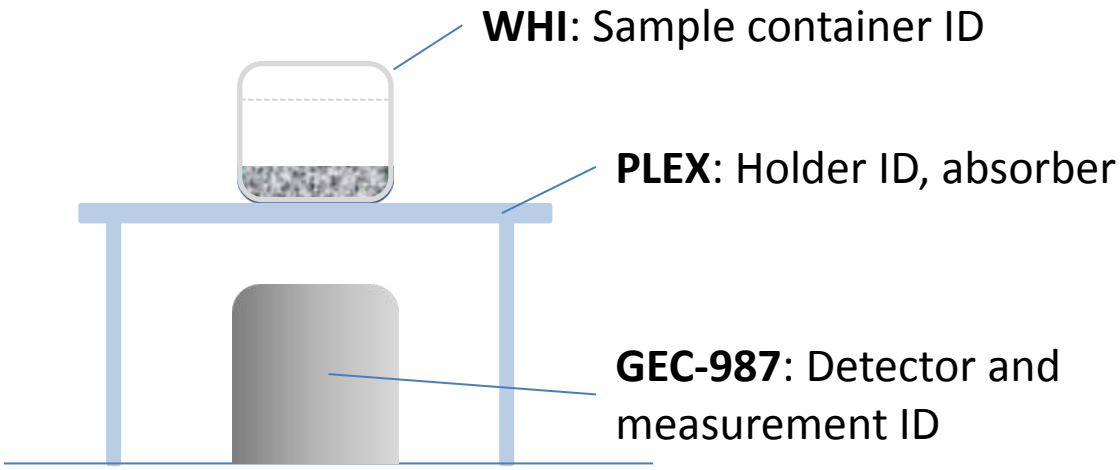

It **is** so…
Can You prove it?

Human factor



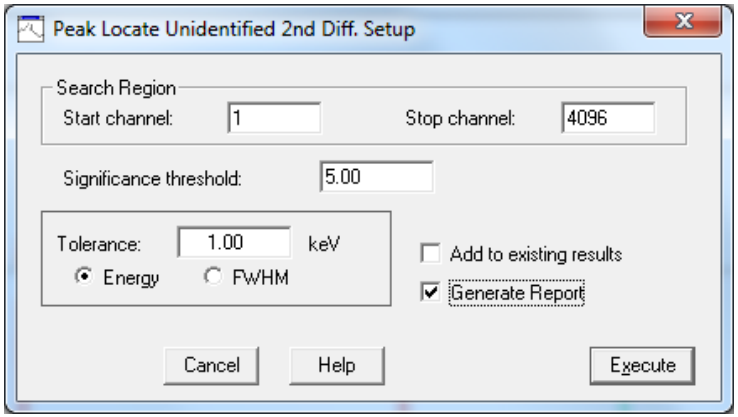
Geometry

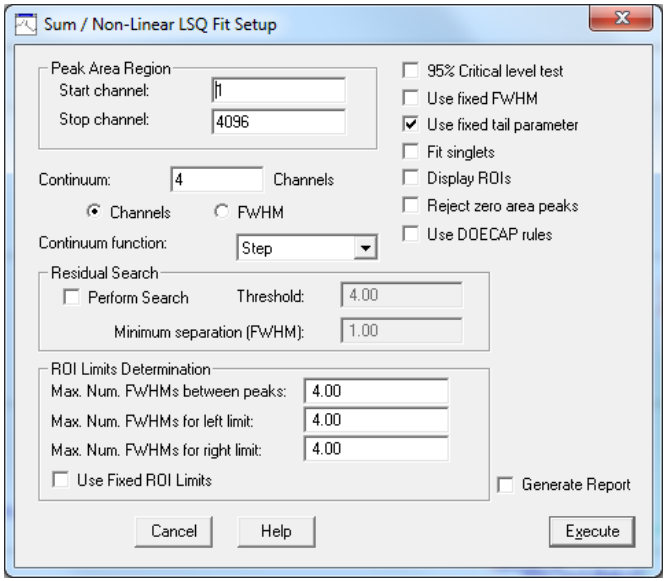
Unique name: GEC-987_PLEXWHI

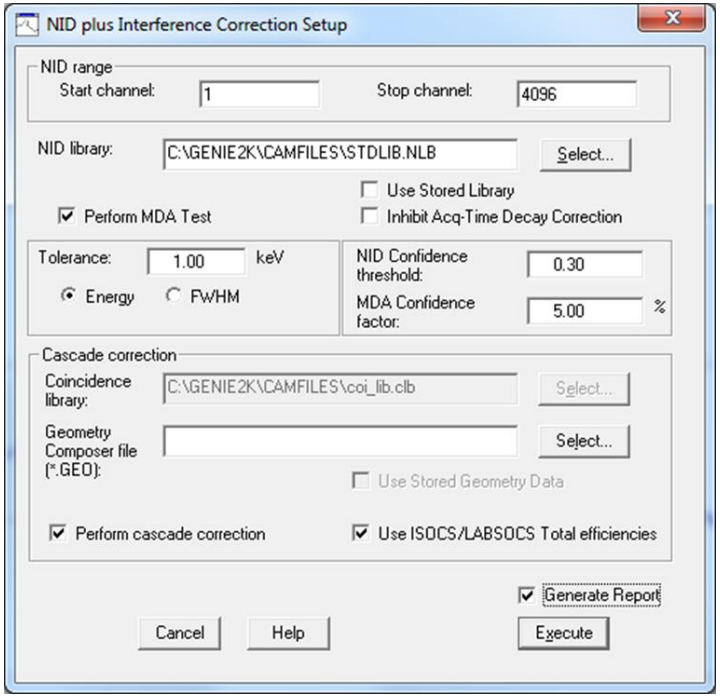


Name is used for .GEO, .CAL,

Loose end #1 - Genie settings







Genie report template (.tpl)

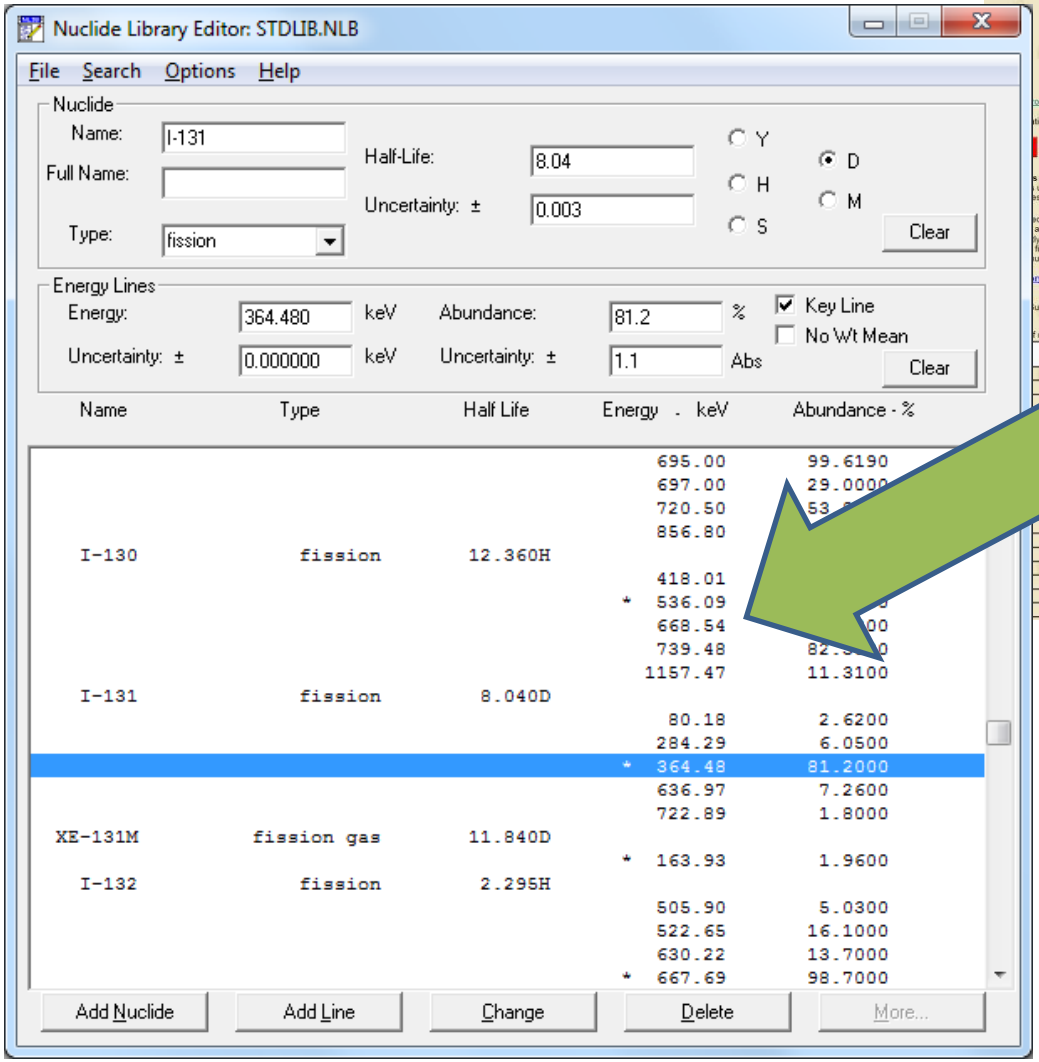
```
$ELSE ; COI not applied, print "miss" or "free" depending on CAM_L_NLCOINOT1 H
 "D   |AAAAAAA |F.FFF   |FFFF.FF |FF.FFFF   |EEEEEEEEEEEE |EEEEEEEEEEEE |AAA |A|A" #REC1(#IV1) #REC2(#IV1) #LIS2(1)
$ENDIF ! H
```

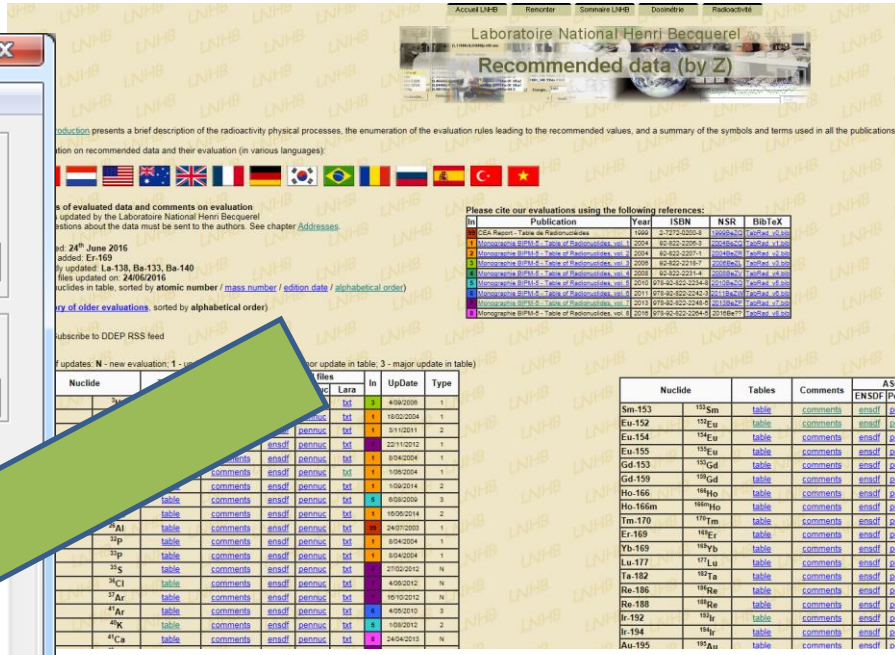
Section tag

**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
*****	Intf	N	U	C	L	I	D	E	I
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
	Sample	Title:	NKS_Gamma_2016						
Nucl	Library:	C:\GENIE2K\CAMFILES\GEC-987_NKS_Gamma_2016_FOI.NLB							
Geo	File:	C:\GENIE2K\isocs\data\GEOMETRY\Laboratory\SIMPLIFIED_BEAKER\GEC-987_PLEXWHI.geo							
	.....	IDENTIFIED	NUCLIDES	.....					
	Nuclide	Id	Energy	Yield	Activity	Activity	Coinc		
	Name	Confidence	(keV)	(%)	(Bq	/g	)	Uncertainty	Corr
D	K-40	9,71E-01	1,46E+03	1,06E+01	9,50E-01	6,45E-02	miss	*	
E	Cs-137	9,24E-01	3,18E+01	1,95E+00	@				
I	_	_	3,22E+01	3,59E+00	1,65E+01	2,51E+00	miss	*	@
I	_	_	3,64E+01	1,06E+00	1,25E+01	1,90E+00	miss	*	@
J			3,73E+01	2,66E-01	@				

“miss”, * and @ are moved to the end

Loose end # 2 - Nuclide libraries





Data transfer

Best data source?

Nuclides listed with gaps!

Excel challenge

	A
1	Nucl list
2	
3	
4	
5	CS-137
6	Bi-210
7	
8	Pb-210
9	Po-210
10	Bi-214
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54	
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56	Bi-214
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78	Pb-214
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GR	GS	GT	GU	GV	GW	GX	GY	GZ	HA	HB	HC	HD	HE	HF	HG	HH	HI	HJ	HK	HL	HM	HN	HO	HP	HQ	HR	HS	HT	
-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS-137	CS
210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-210	Bi-
-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-210	Pb-
-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-210	Po-
214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-214	Bi-
-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-214	Pb-
230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-230	Th-
234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-234m	Pa-
234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-234	U-2
235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-235	U-2
239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-239	Pu-
240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-240	Pu-
-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am-241	Am
-241	Am-241	Am-241	Am-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-
-241	Am-241	Am-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	
-241	Am-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	
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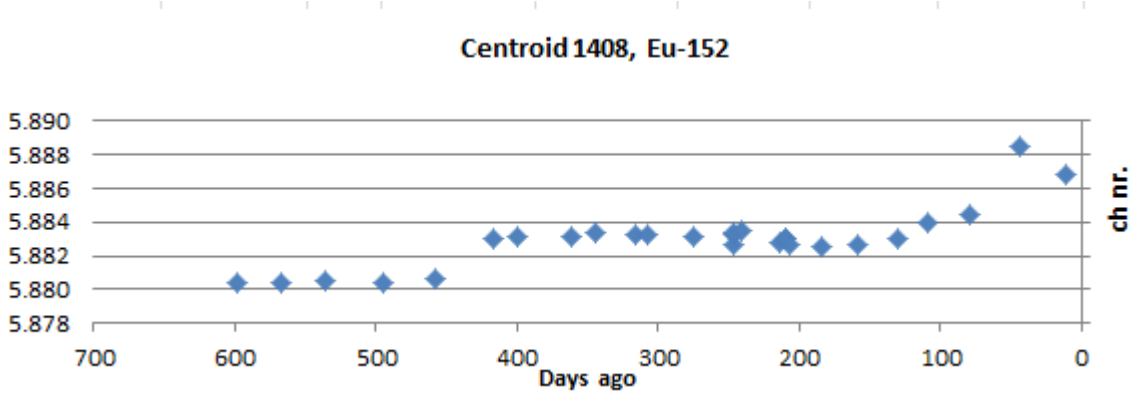
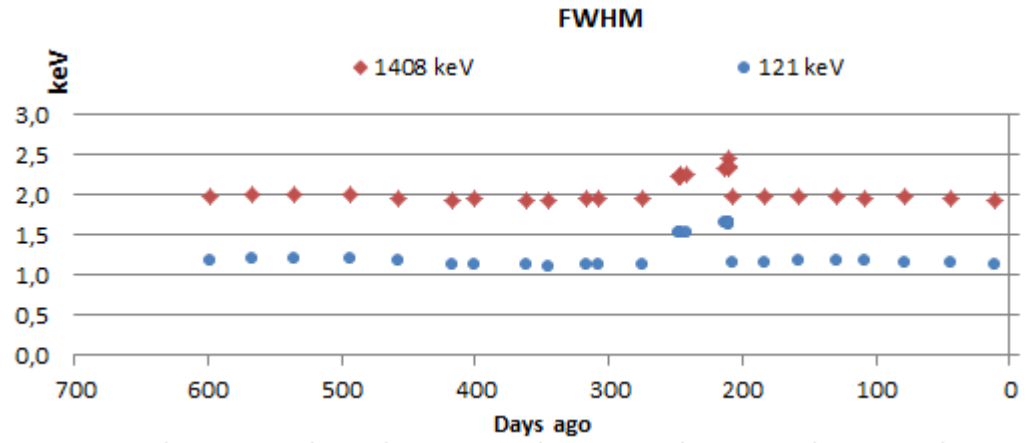
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
241	Pu-241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Drift

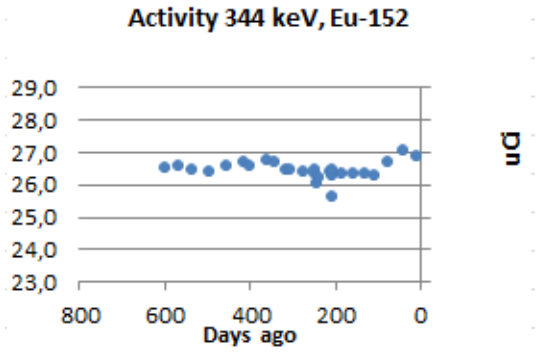
Energy sens.



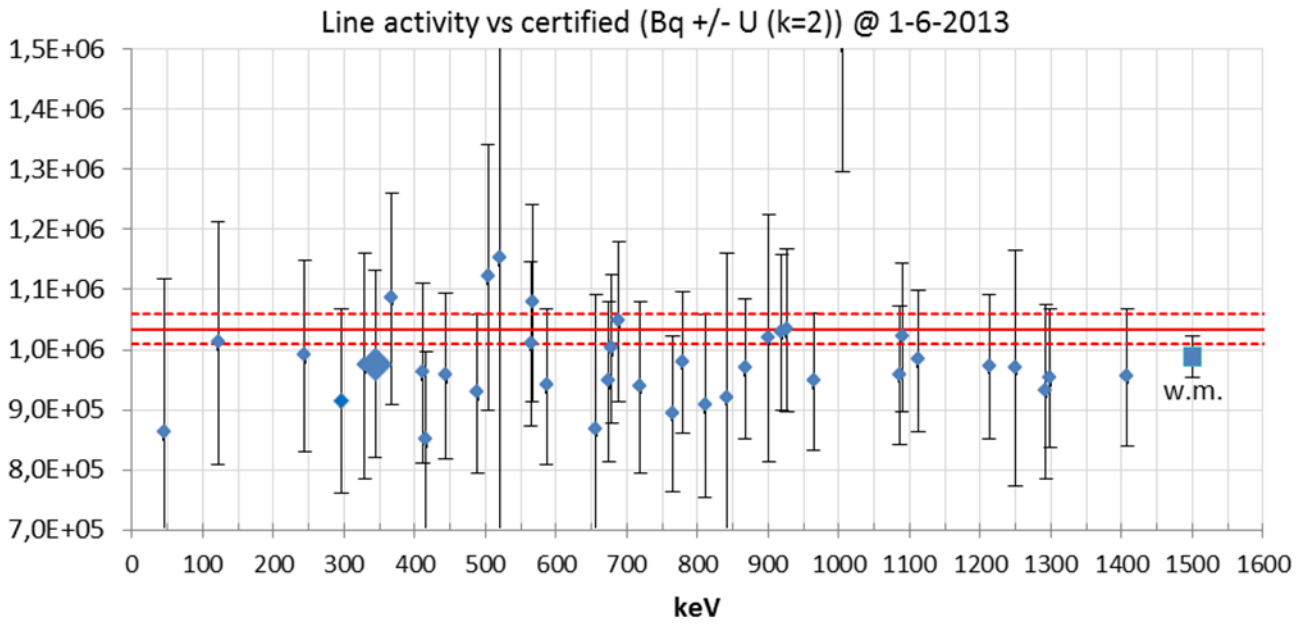
Resolution



Efficiency



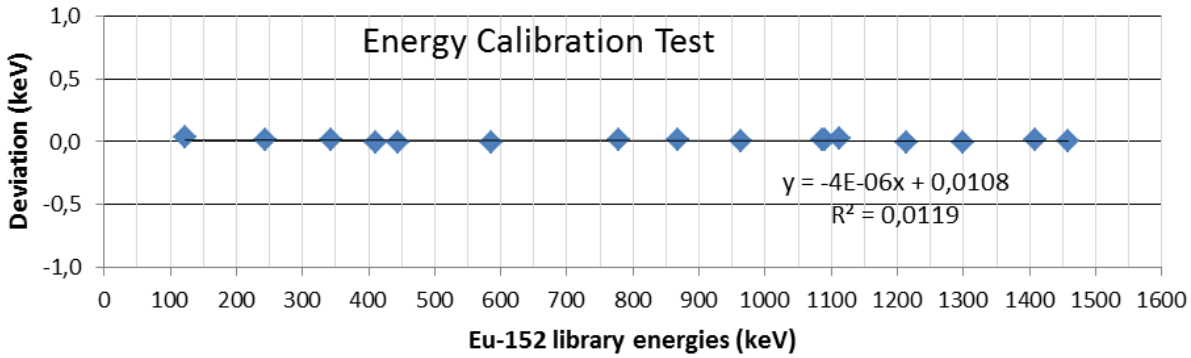
Eu-152 LACE


Line activity vs certified (Bq +/- U (k=2)) @ 1-6-2013
1,5E+06
1,4E+06
1,3E+06
1,2E+06
1,1E+06
1,0E+06
9,0E+05
8,0E+05
7,0E+05
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
keV
w.m.

DANISH HEALTH AUTHORITY
RADIATION PROTECTION

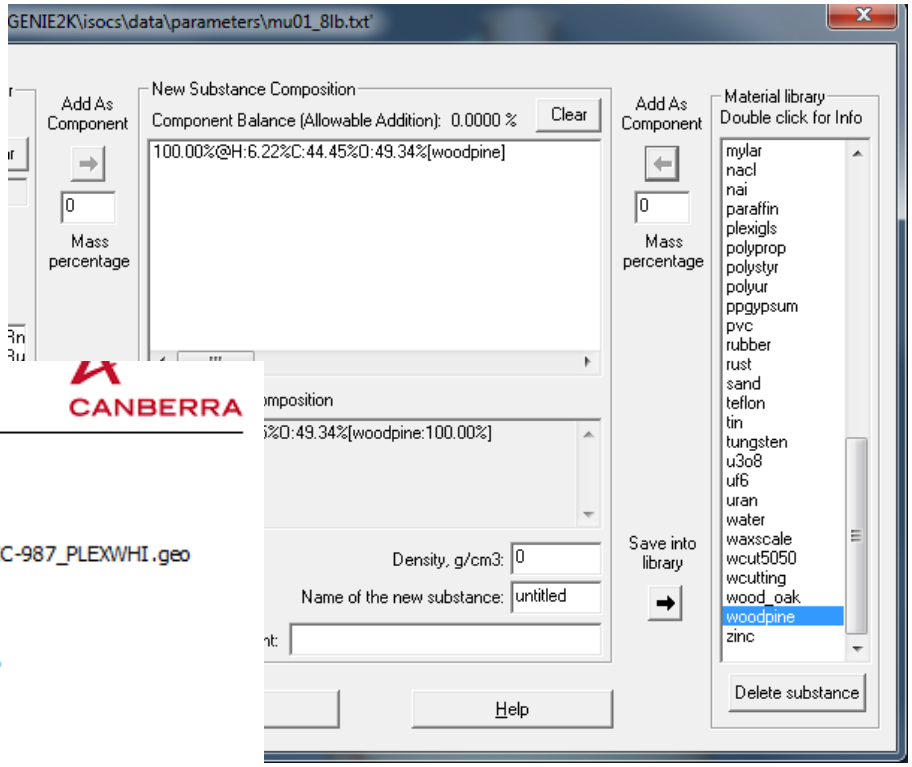
QC parameter

Energy tolerance (Eu-152)



Maximal deviation (keV)

Screenshots for documentation



Geometry Composer Report

CANBERRA

Date: Wednesday, August 24, 2016 - 15:22:24
Description: GEC-987
Comment: GEC-987
File Name: C:\GENIE2K\isocs\data\GEOMETRY\Laboratory\SIMPLIFIED_BEAKER\GEC-987_PLEXWHI.geo
Software: LabSOCS
Template: SIMPLIFIED_BEAKER, Version: Custom Beaker (WHITE.bkr)
Detector: B08006
Environment: Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
Integration: Convergence = 1.00%, MDRPN = 2^4 (16), CRPN = 2^4 (16)
Sample Weight: 9.17 g

Dimensions (mm)

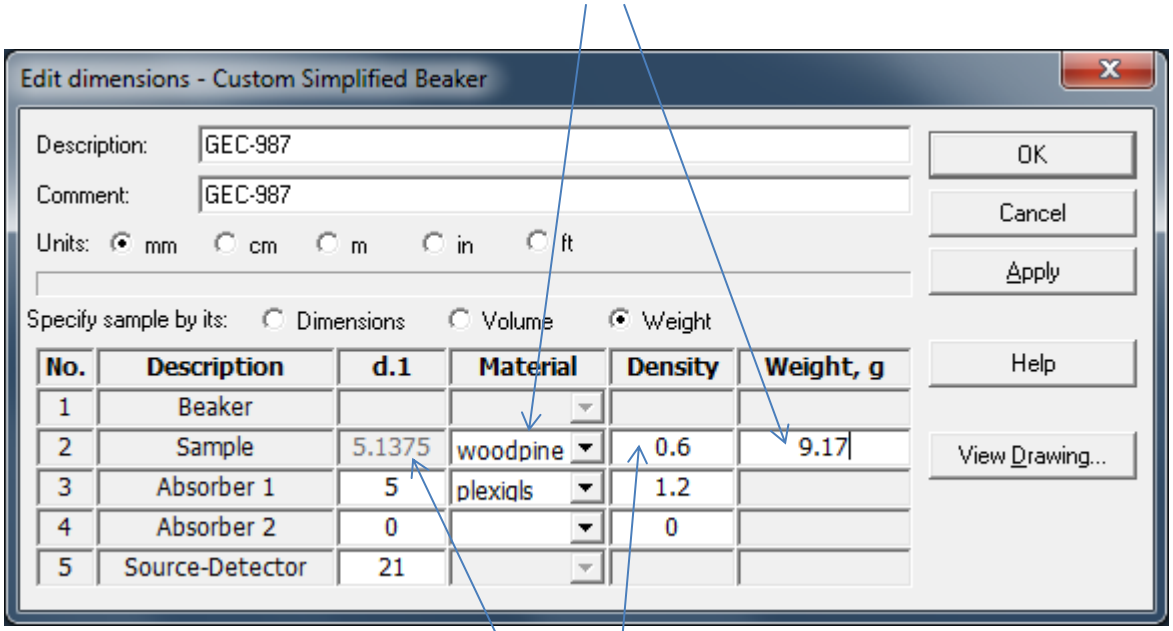
No.	Description	d.1	d.2	d.3	d.4	d.5	d.6	Material	Density
1	Beaker								
2	Sample	5.1375						woodpine	0.6
3	Absorber1	5						plexigls	1.2
4	Absorber2								
5	Source-Detector	21							

List of energies for efficiency curve generation

45.0 50.0 60.0 70.0 80.0 90.0 100.0 120.0
150.0 200.0 250.0 300.0 400.0 500.0 700.0 1000.0
1400.0 2000.0

Density calculated from sample mass and fill height

1. Assumed sample composition and weight entered



2. Density roughly adjusted to reach approx. fill-height

Gammaspec 2016 sample

9,1698 (10) g

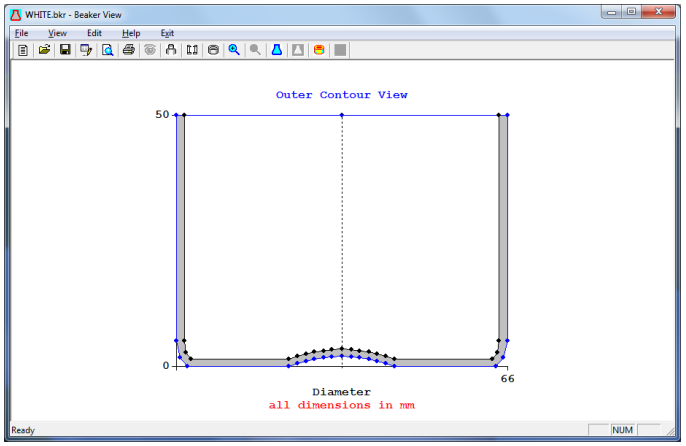
Fill-height ≈ 5 mm

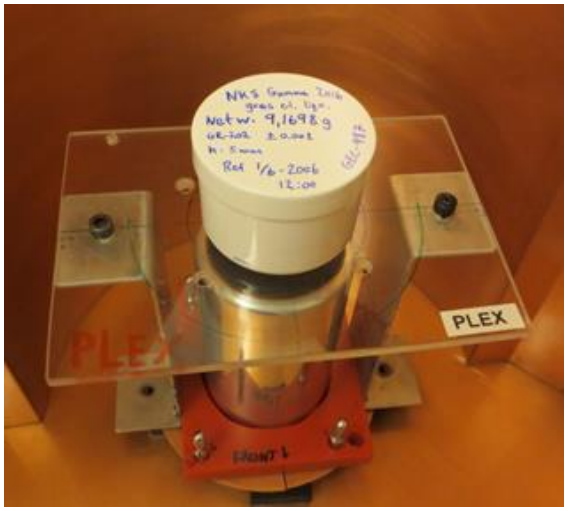
Spectrum data file: GEC-987-K1-….cnf

Detector ID – Measurement ID – Acquisition cycle -

Geometry model (LabSocs)

Standard container ”WHITE.bkr”

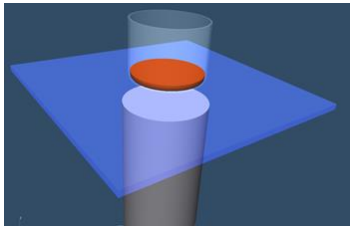




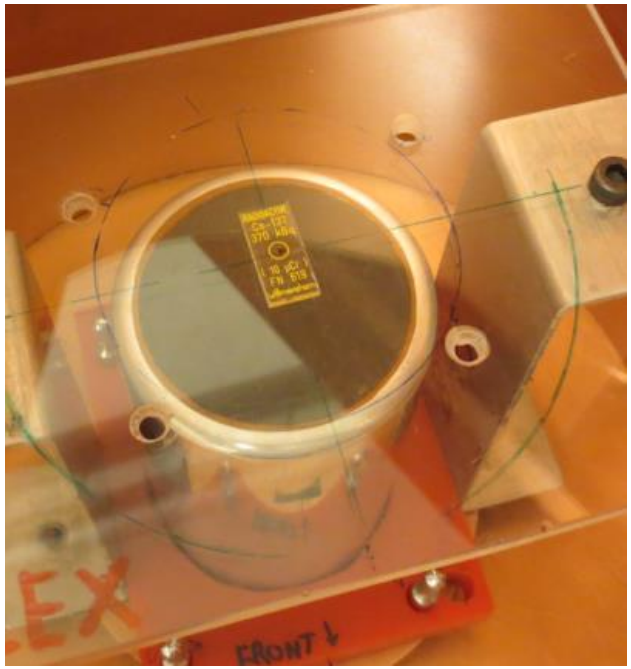
WHITE.bkr - Notesblok

Filer Rediger Formater Vis Hjælp

```
# Inner Contour
# -------------
#
# D1,mm        H1,mm        D2,mm        H2,mm        ID  Material  Density g/cc
#-------------------------------------------------------------------------------
  0          , 3.4          , 4          , 3.2          , i,  POLYPROP, 0.91
  4          , 3.2          , 7          , 3.05         , i,  POLYPROP, 0.91
  7          , 3.05         , 11         , 2.78         , i,  POLYPROP, 0.91
  11         , 2.78         , 14         , 2.4          , i,  POLYPROP, 0.91
  14         , 2.4          , 17.5       , 1.9          , i,  POLYPROP, 0.91
  17.5       , 1.9          , 21         , 1.4          , i,  POLYPROP, 0.91
  21         , 1.4          , 60         , 1.4          , i,  POLYPROP, 0.91
  60         , 1.4          , 62         , 2.7          , i,  POLYPROP, 0.91
  62         , 2.7          , 62.8       , 5            , i,  POLYPROP, 0.91
  62.8       , 5            , 62.8       , 50           , i,  POLYPROP, 0.91
  62.8       , 50           , 0          , 50           , i,  POLYPROP, 0.91
#-------------------------------------------------------------------------------
# Outer Contour
# -------------
#
# D1,mm        H1,mm        D2,mm        H2,mm        ID  Material  Density g/cc
#-------------------------------------------------------------------------------
  0          , 2            , 4          , 1.8          , o,  POLYPROP, 0.91
  4          , 1.8          , 7          , 1.65         , o,  POLYPROP, 0.91
  7          , 1.65         , 11         , 1.38         , o,  POLYPROP, 0.91
  11         , 1.38         , 14         , 1            , o,  POLYPROP, 0.91
  14         , 1            , 17.5       , 0.5          , o,  POLYPROP, 0.91
  17.5       , 0.5          , 21         , 0            , o,  POLYPROP, 0.91
  21         , 0            , 61.5       , 0            , o,  POLYPROP, 0.91
  61.5       , 0            , 64.5       , 1.7          , o,  POLYPROP, 0.91
  64.5       , 1.7          , 66         , 5            , o,  POLYPROP, 0.91
  66         , 5            , 66         , 50           , o,  POLYPROP, 0.91
  66         , 50           , 0          , 50           , o,  POLYPROP, 0.91
#-------------------------------------------------------------------------------
```

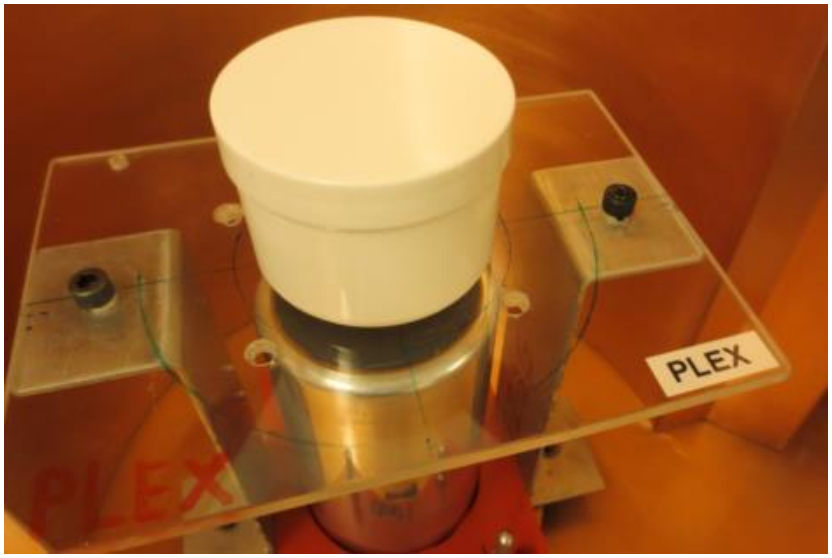


Test measurements



"Point"
Cs-137, Co-60, Am-241
(Ra-226, Pb-210)

"Beaker"
Eu-152



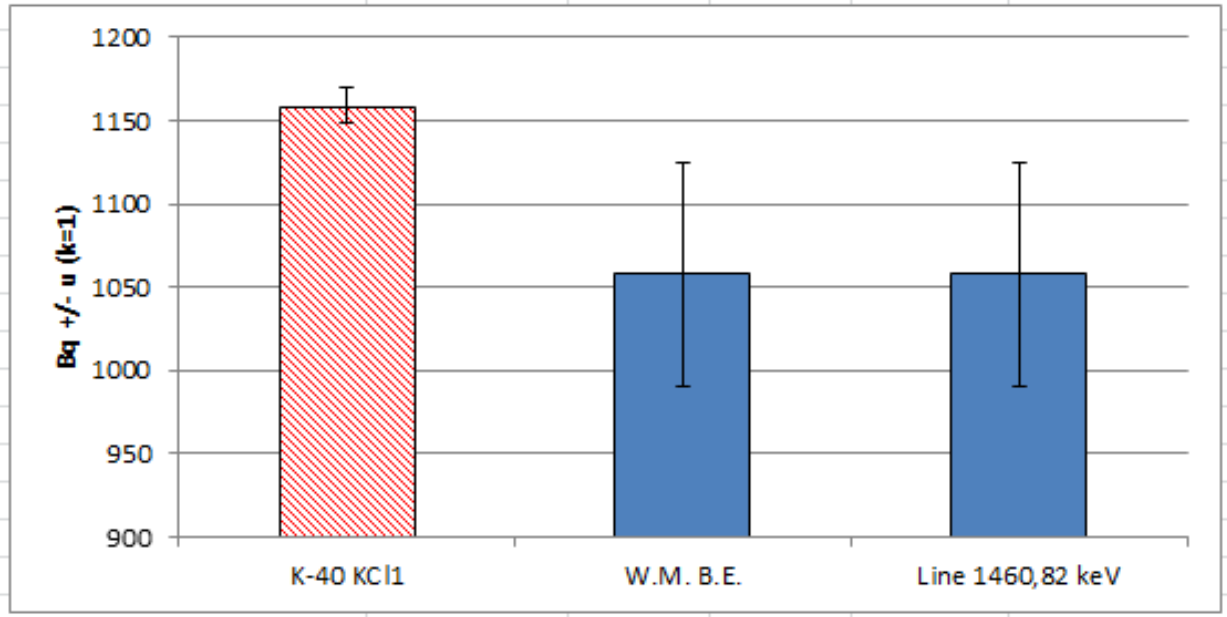
"Custom Beaker"
K-40 (KCl)

DANISH HEALTH AUTHORITY
RADIATION PROTECTION

QC parameter

$$zeta = \frac{abs(A_{cert} - A_{obs})}{\sqrt{u(A_{cert})^2 + u(A_{obs})^2}}$$

37			
38	**Evaluering**		
39	zeta (<2)	W.M. B.E.	**1,49**
40	zeta (<2)	Line 1460,82 keV	**1,49**



DANISH HEALTH AUTHORITY
RADIATION PROTECTION

In case of non-compliance:

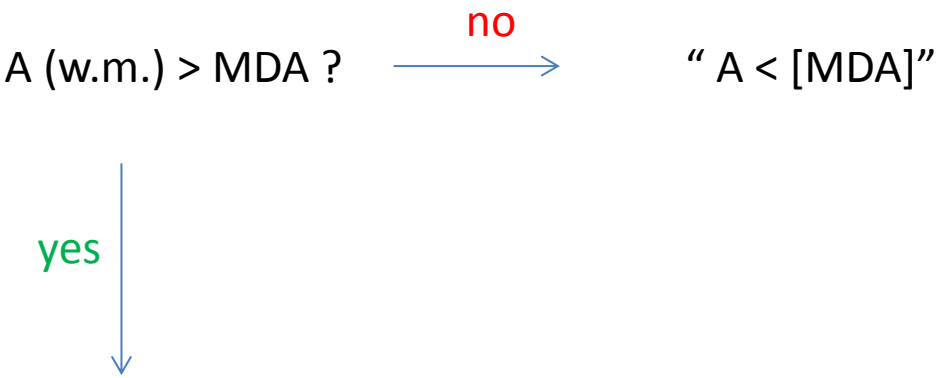
Increase efficiency uncertainty.

Calibrate by ISOCS/LabSOCS: Efficiency Results

Energy	Efficiency	%Uncertainty
45.00	1.15260e-002	15.0
50.00	1.16916e-002	15.0
60.00	1.19048e-002	10.0
70.00	1.19340e-002	10.0
80.00	1.18627e-002	10.0
90.00	1.16853e-002	10.0
100.00	1.15045e-002	10.0
120.00	1.09884e-002	10.0
150.00	1.01005e-002	10.0
200.00	8.42223e-003	8.0
250.00	6.97721e-003	8.0
300.00	5.97454e-003	8.0
400.00	4.59443e-003	8.0
500.00	3.77504e-003	6.0
700.00	2.81843e-003	6.0
1000.00	2.08428e-003	6.0
1400.00	1.56329e-003	6.0
2000.00	1.16460e-003	6.0

E.g. changed from factory default (4%)

Reporting rule



To avoid false positive results, we have chosen not to report A when MSA < A < MDA.

In some cases, w.m. < 0 and best. est. >0.

w.m. = weighted mean
best. est. = best estimate (ISO11929)