

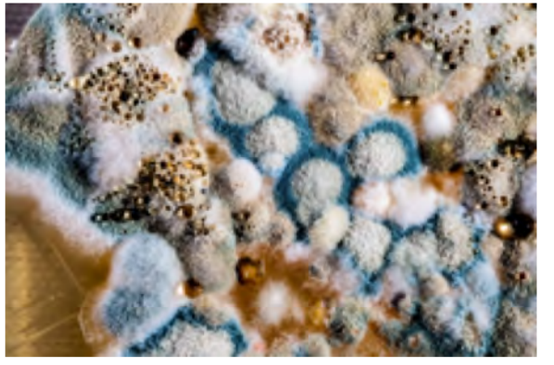

Radiation protection planning - Excercise




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DOSE PLANNING

Dose dependencies

- Activity
- Energy uptake – dose coefficient
- Shielding
- Exposure time
- Distance

$$D_1 = D_2 \frac{X_2^2}{X_1^2}$$

where, D_1 and D_2 = dose rate (or intensity) at positions 1 and 2, respectively;
X_1 and X_2 = the distance from the source at positions 1 and 2, respectively.

Dose planning

- Based on work breakdown structure
- Further detailling may be necessary
- Regard time, staffing and task for each single step
- Accumulate group and collective doses

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1		Crane vert speed	2	m/min																	
2		Crane horiz. Speed	10	m/min																	
3																					
4	No	Description	Crane travel height	Crane travel length	Crane duration	Work duration	Crane driver	Rigger	Technician	Source A	Source B	Distance Source A	Distance Source B	DR Source A	DR Source B	Total DR	Individual dose uptake	Dose Crane Driver	Dose Rigger	Dose Technician	Collective Dose
5			m	m	min	min						m	m	µSv/h	µSv/h	µSv/h	µSv	µSv	µSv	µSv	µSv
6					0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
7																					
8																					
9																					

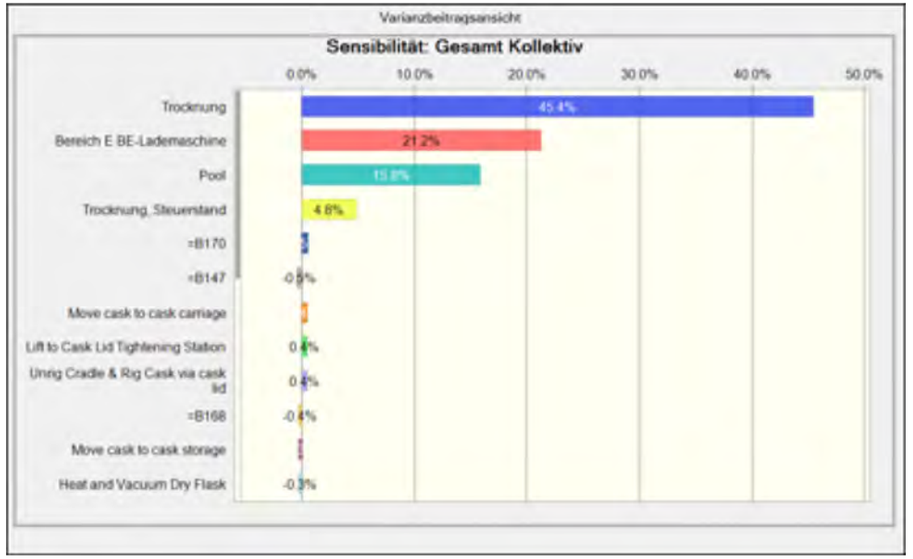
MONTE-CARLO-BASED DOSE PLANNING

Considerations

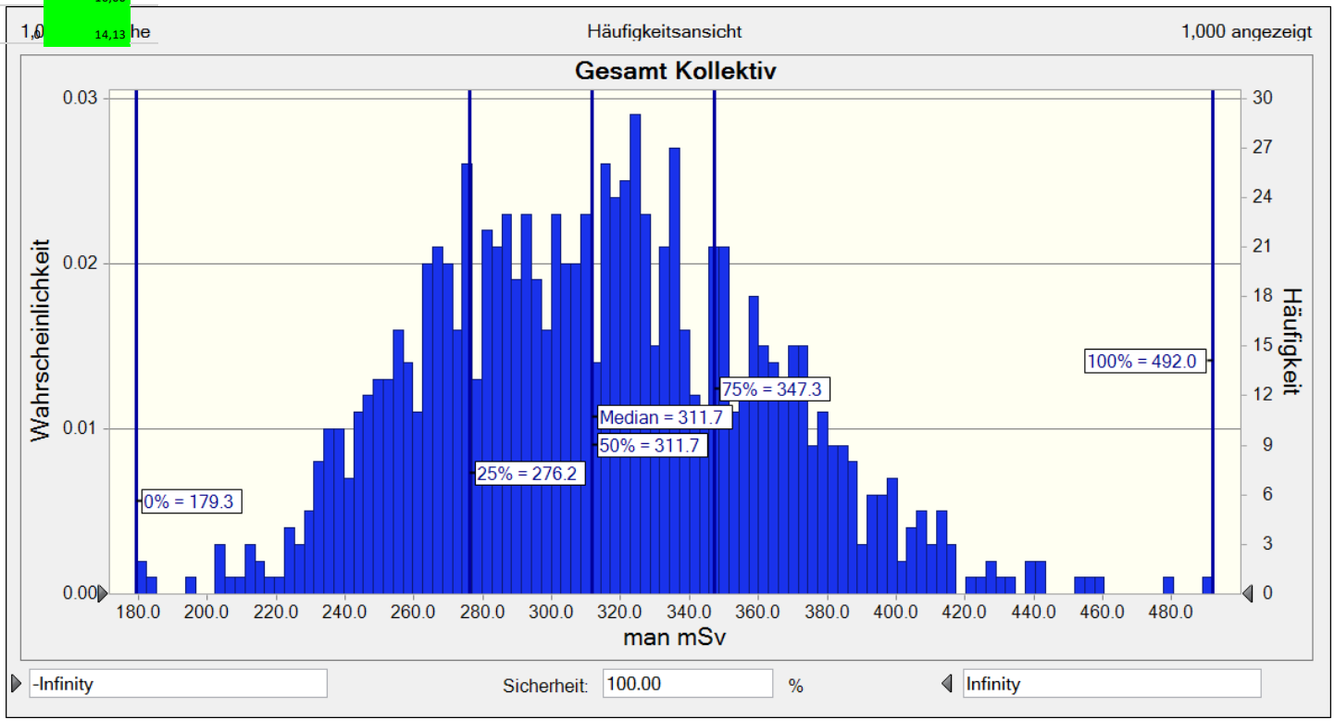
- Usual dose planning or IWRS planning results in one value per WBS-item
- Actually, the dose planning is based on
  - Step by step planning
  - Dose rates of containers etc
  - Distances to sources
  - Durations
  - Shielding
  - Background doses
- These parameters contain uncertainties
  - Duration, distances, DR, Repetitions, background dose
- Monte-Carlo based approach takes these uncertainties into account
- Result will be a distribution instead of a single value

Example: Segmentation of core internals

UID			Process Step	Description / estimation Method	Rigging/ working Time (m)	Lift Distance dry(m)	Lift Distance wet (m)	Horizontal dilstance dry (m)	Horizontal dilstance wet	Step CB
	EN		Konrad Basket to Empty Basket Storage							
	DE		Leeres Konrad EM zum Lagerplatz							
EKK1000	EKK	1000	**Starting Condition**	1 basket on rail mounted wagon on 3m level						
EKK1010	EKK	1010	crane to Konrad basket strongback. Rig strongback		5	7		25		9,79
EKK1020	EKK	1020	open large hatch		10					10,00
EKK1020	EKK	1020	Open large hatch - Rigger moves to contractual delivery location		10					10,00
EKK1030	EKK	1030	move crane to basket (3m level, above rails) and rig to basket		5	35	0	35		14,13



Sensitivity analysis



Result distribution

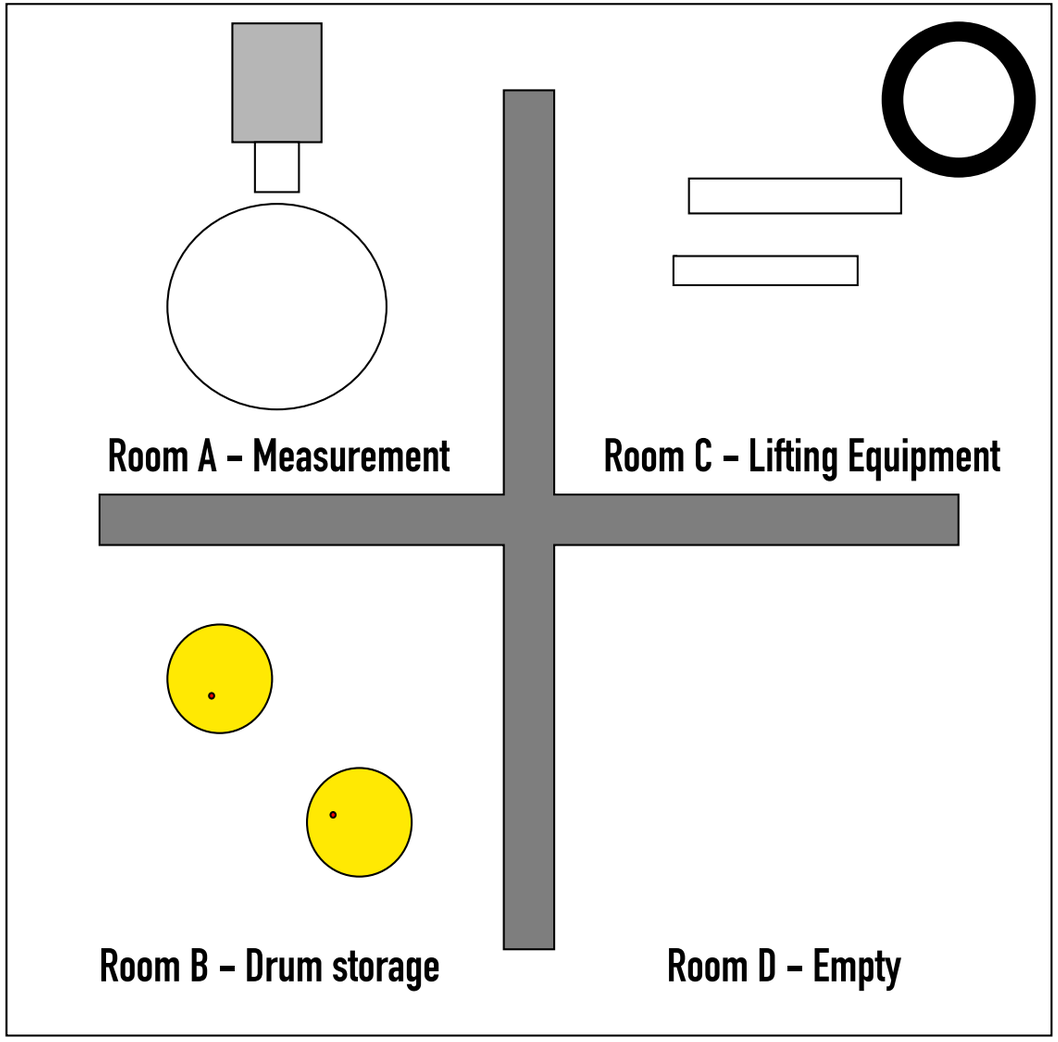
Advantages

- Sensitivity Analysis
  - Identification of important parameters
  - Identification of dose relevant steps
  - Best-Value-for-Money: Maximize outcome of radiation protection efforts

- Distribution instead of single value
  - More suitable for complex tasks
  - Better insight in deviations from target, allocation of liklyhood
  - ,,soft‘‘ values, defendable deviations

SCENARIO

Scenario



Source A: 1 E 08 Bq Co-60
Source B: 2 E 08 Bq Cs-137

Task: Do wipe test and turntable gamma measurement of all drums

Boundary conditions

- Each room is 3x3 m, heavily shielded to the other rooms by 3 m high wall
- Drums can only be transferred by overhead crane
- Lifting equipment comprises a drum traverse, a drum shield (36 mm iron) and the respective traverse. Iron has a half value thickness of 18 mm.
- traverses are manually operated
- Crane operation only in line of sight
- Crane speed 2 m/min vertically; 10 m/min horizontally
- Available personnel: 1 crane driver, 1 rigger, 1 measurement technician
- DR Source A in 1m is 30 µSv/h
- DR Source B in 1 m is 15,8 µSv/h

EXAMPLE RISK BASED PACKAGING PLANNING

Packaging of core internals

Requirements

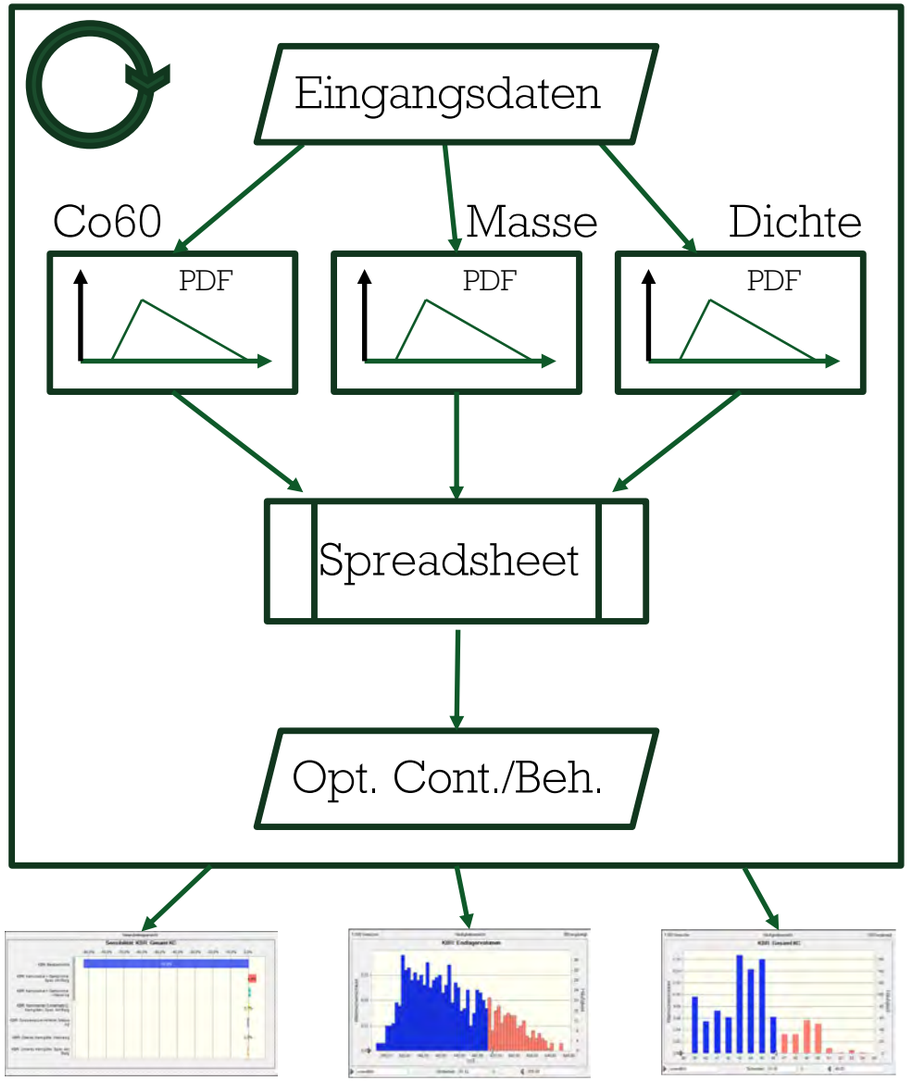
- Technical concept
- Cutting concept
- Packaging Concept
- Qualified procedures for verification and documentation
- Work step planning
- Determination of number and container types
- Determination of disposal volume

Sources of Unertainty

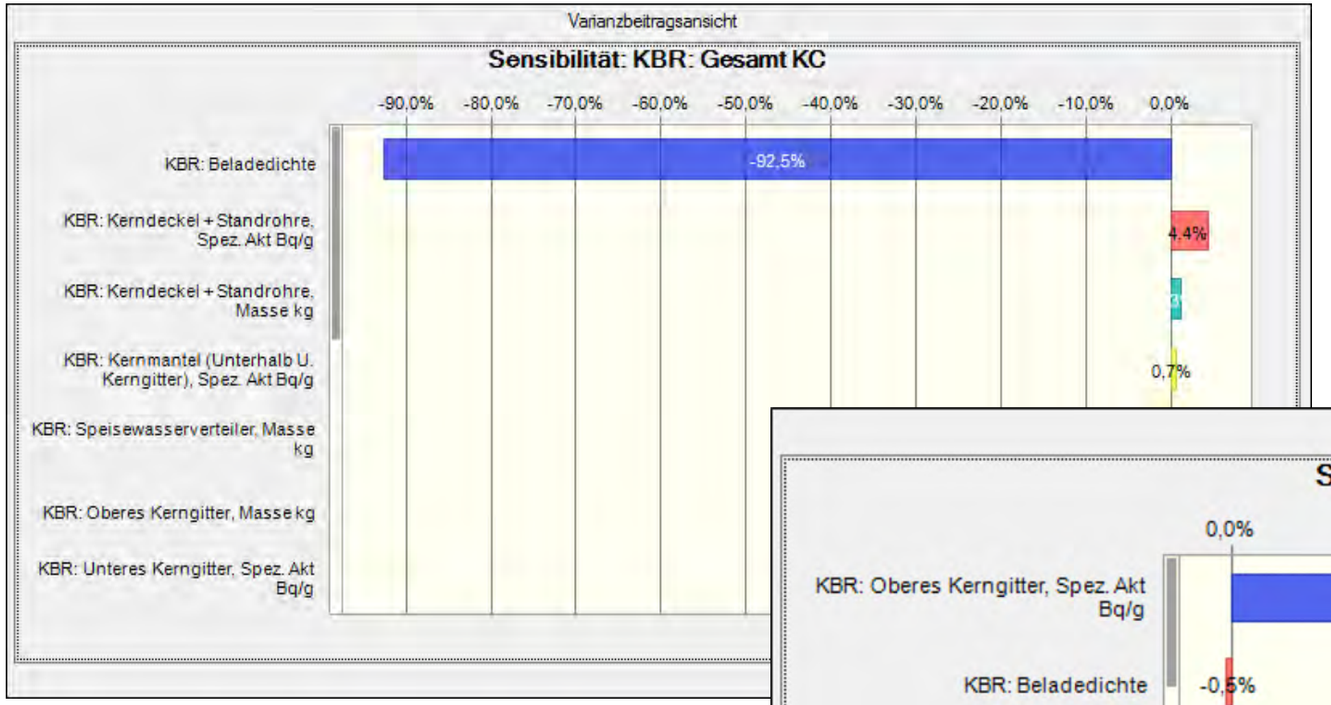
- Missing verification/validation of radiological characterization
- Radiological characterization not detailed enough
- Masses given in technical documents are not clearly
- Some regulators interpret the ADR regulations differently

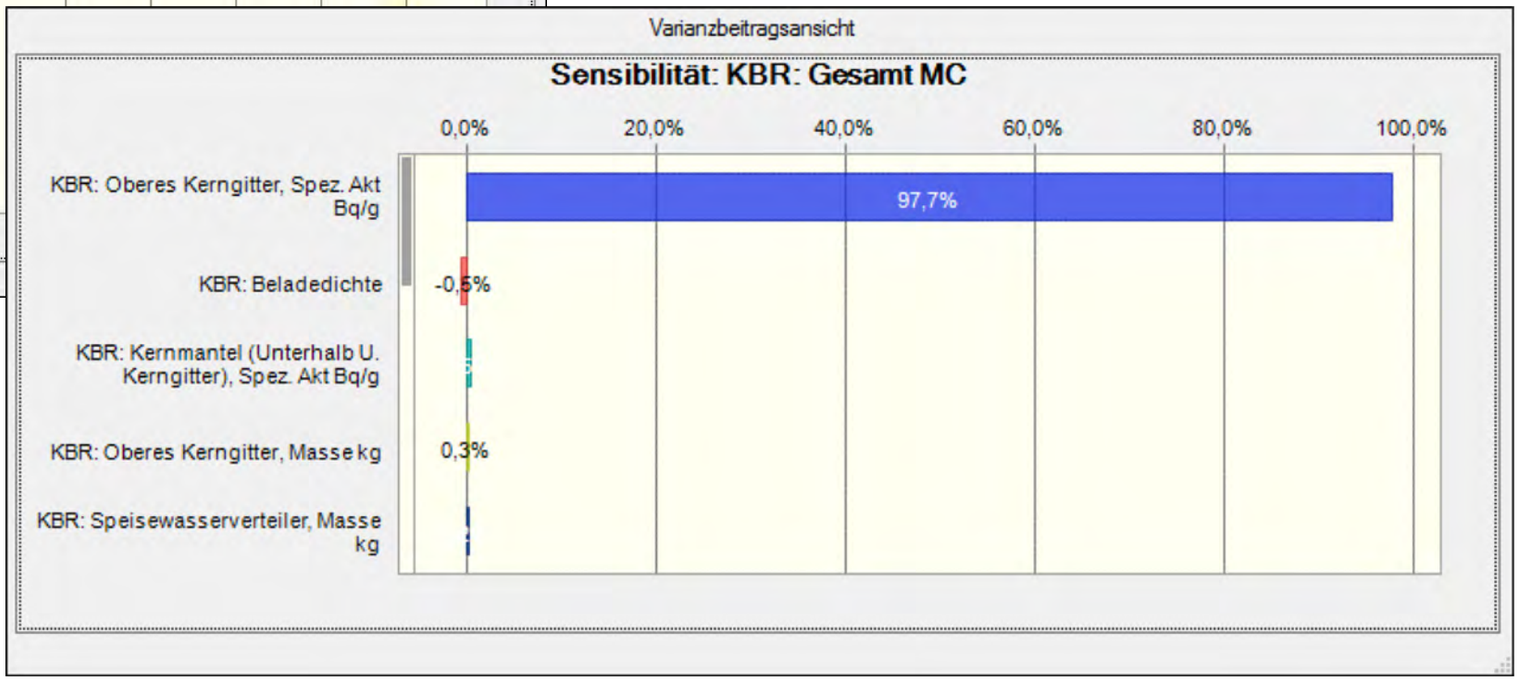
Monte-Carlo basierte Betrachtung

- Stochastic risk analysis (Range Estimating Method) based on Monte Carlo simulation (Crystal Ball)
- Triangular distribution (PDF) for activity, mass, density
- Formulas and data in Excel
- Statistical result interpretation

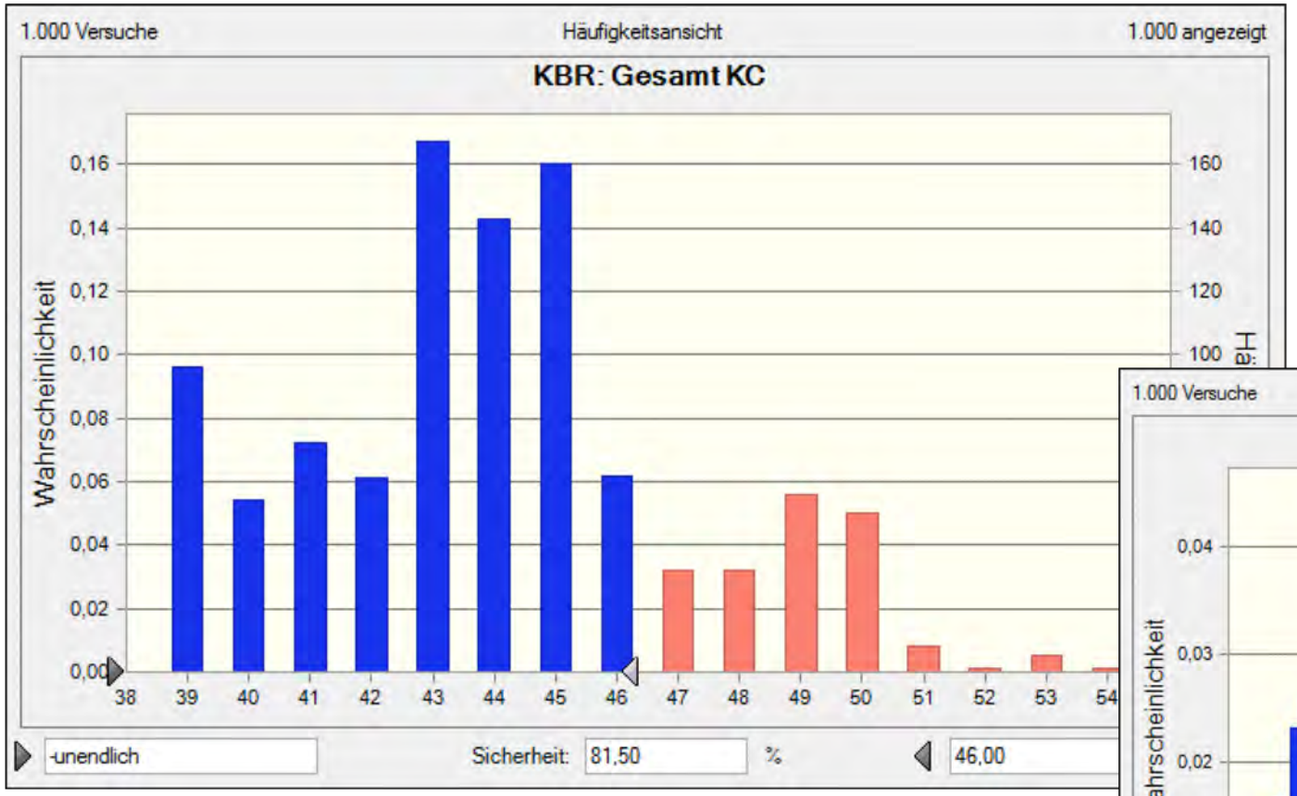


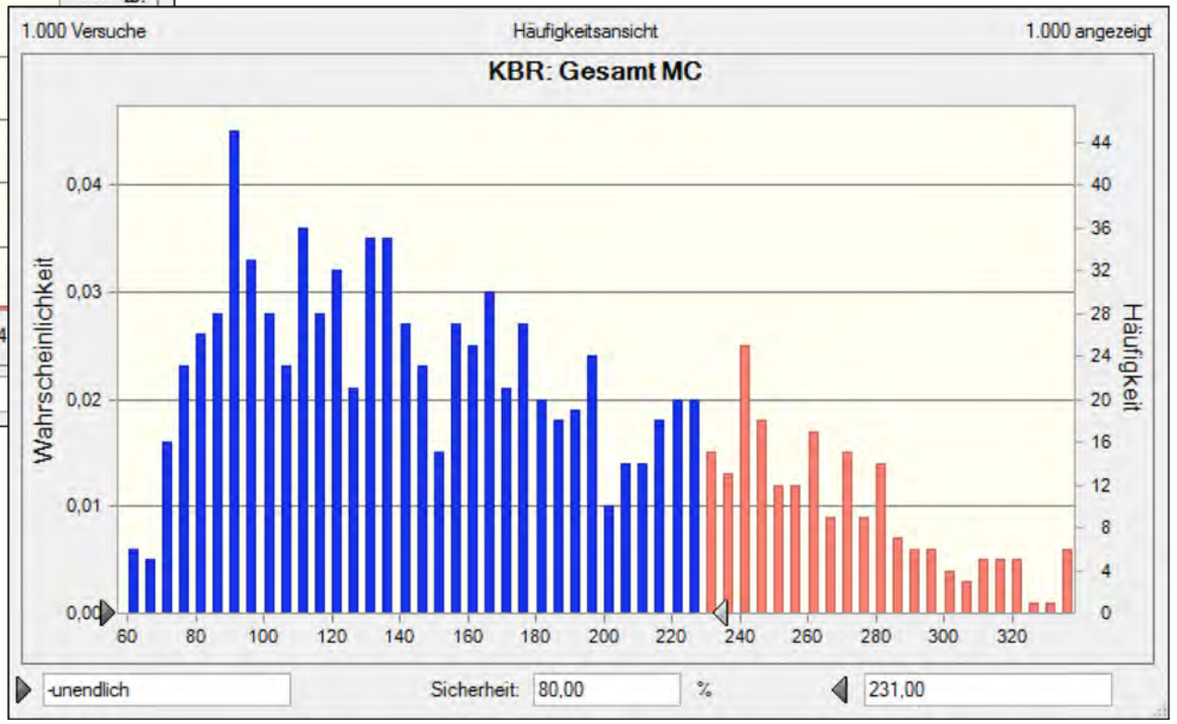
Identification of main influence parameters





Results


1.000 Versuche
Häufigkeitsansicht
1.000 angezeigt
KBR: Gesamt KC
Wahrscheinlichkeit
0,16
0,14
0,12
0,10
0,08
0,06
0,04
0,02
0,00
160
140
120
100
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54
-unendlich
Sicherheit: 81,50 %
46,00


1.000 Versuche
Häufigkeitsansicht
1.000 angezeigt
KBR: Gesamt MC
Wahrscheinlichkeit
0,04
0,03
0,02
0,01
0,00
Häufigkeit
44
40
36
32
28
24
20
16
12
8
4
0
60 80 100 120 140 160 180 200 220 240 260 280 300 320
-unendlich
Sicherheit: 80,00 %
231,00