Recommendations to deal with uncertainties during initial characterization in view of decommissioning

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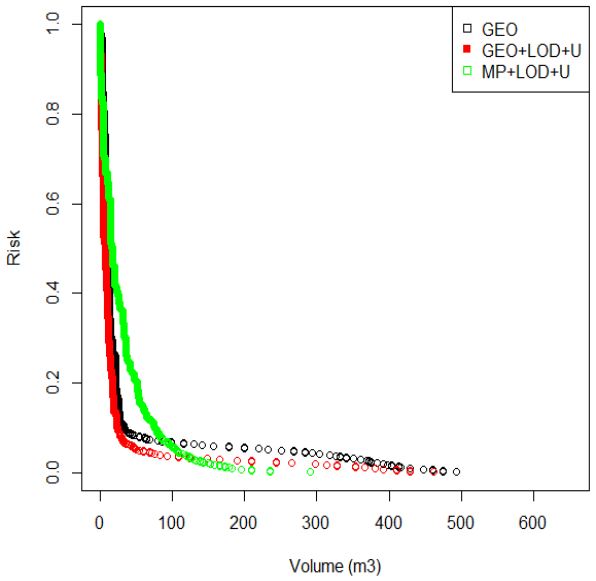
Recommendations to deal with uncertainties during initial characterization in view of decommissioning

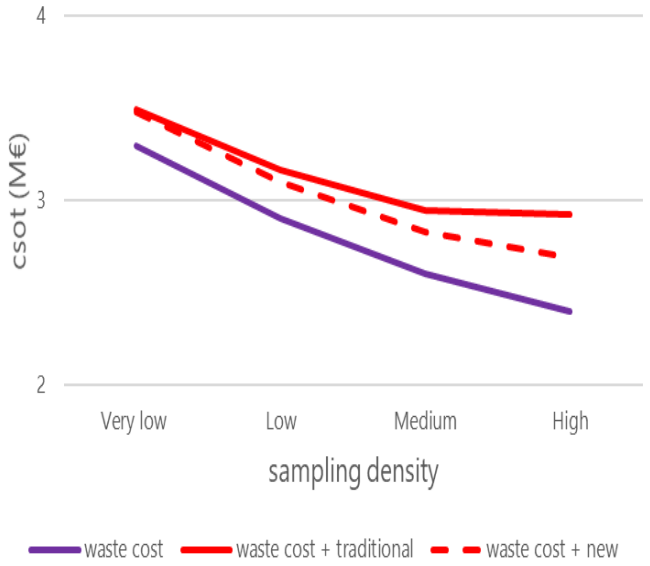
UC1: Liquid Waste Storage facility
UC2: Biological Shield from a PWR reactor
UC3a: Post-accidental Site Remediation
UC3b: Graphite from a Gas Graphite Reactor

1ST DRAFT

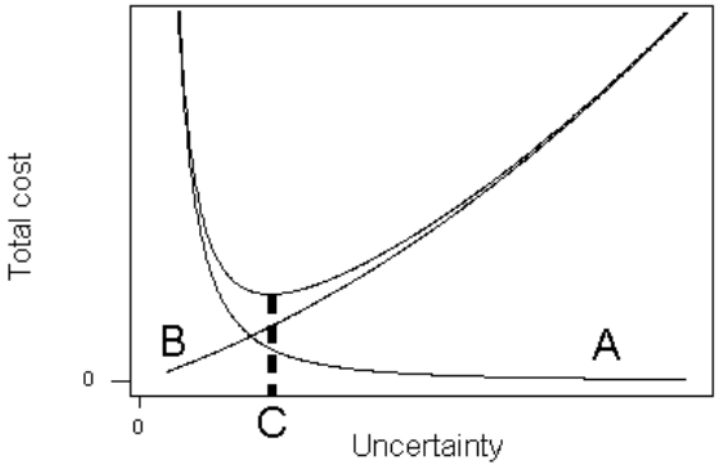
The impact of uncertainties on decisions & costs



INSIDER D3.7 – Annex UC2a, Y. Desnoyers, N. Pérot

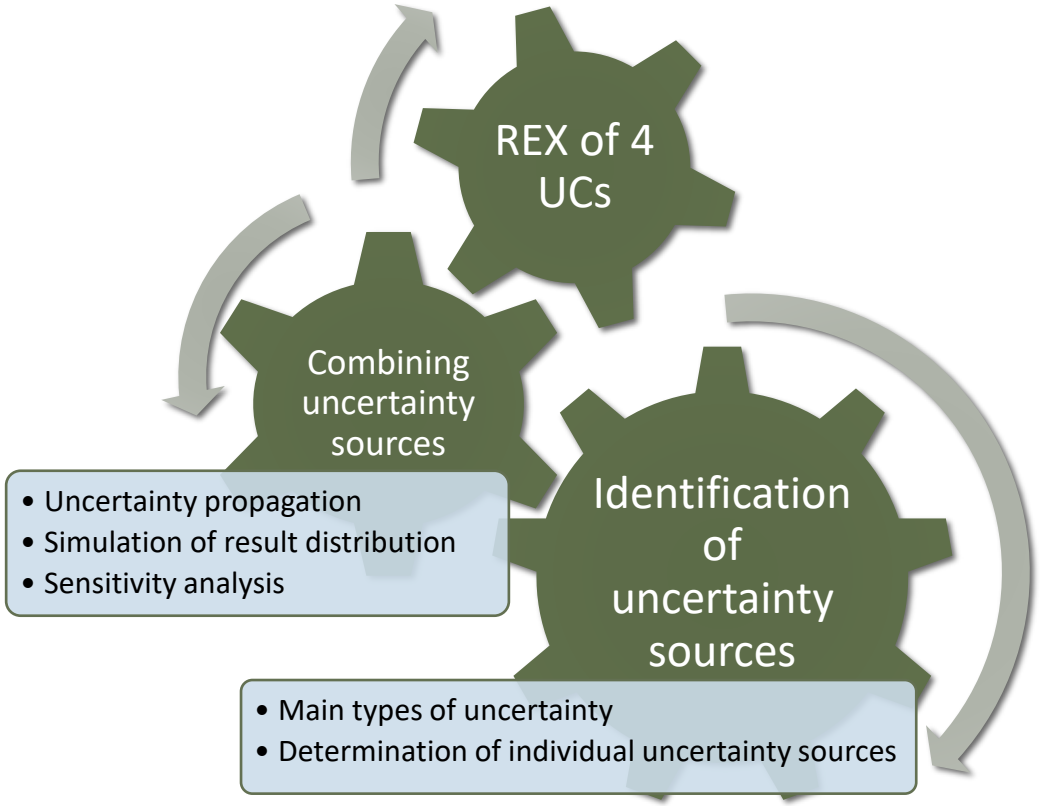


SCK CEN/44604115, Sven Boden, July 2021

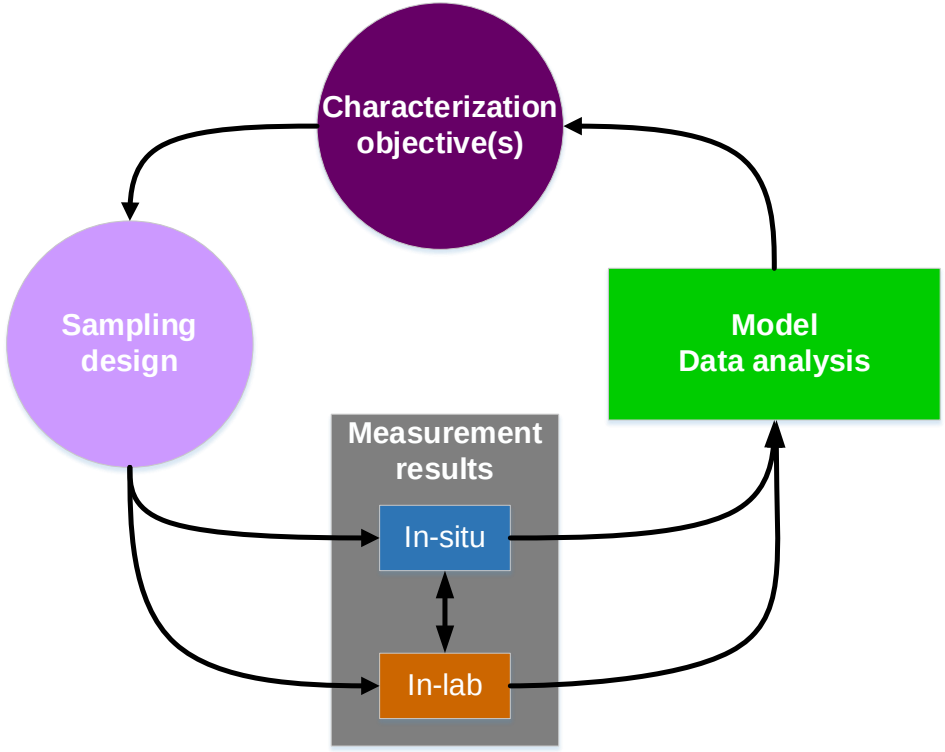


EURACHEM/CITAC guide, Measurement uncertainty arising from sampling A guide to methods and approaches, Second edition 2019

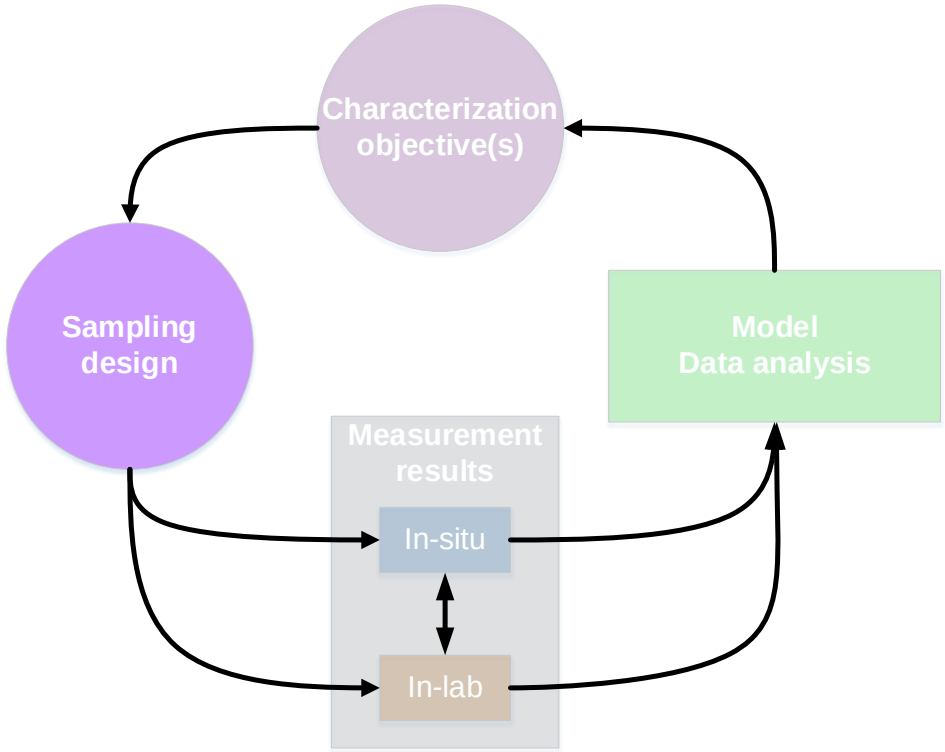
Development of a recommendation guide



Main type of uncertainty sources

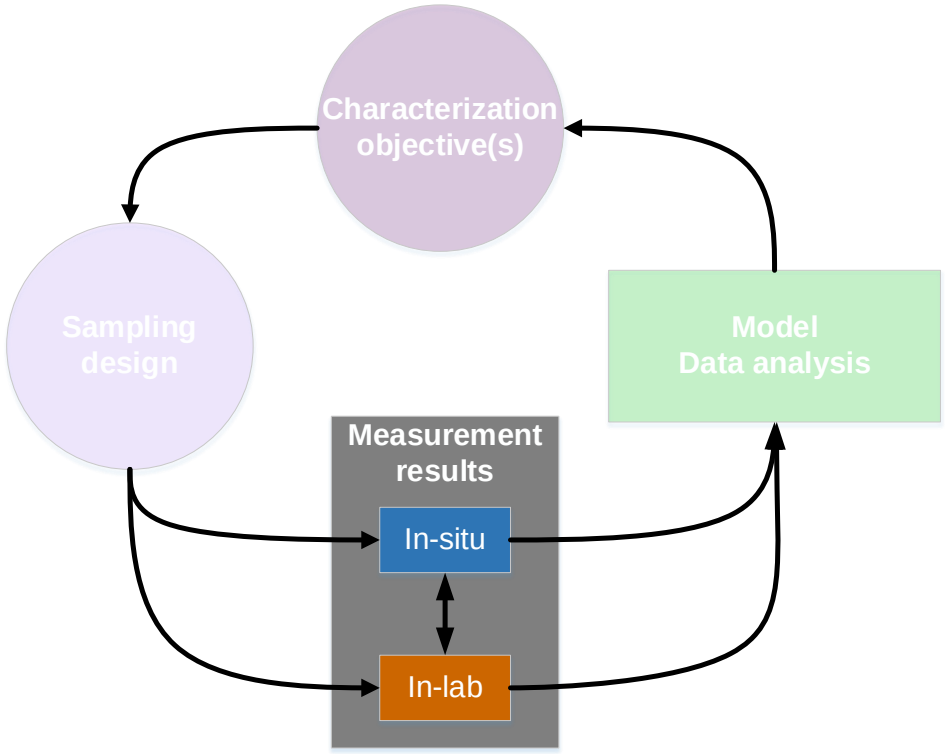


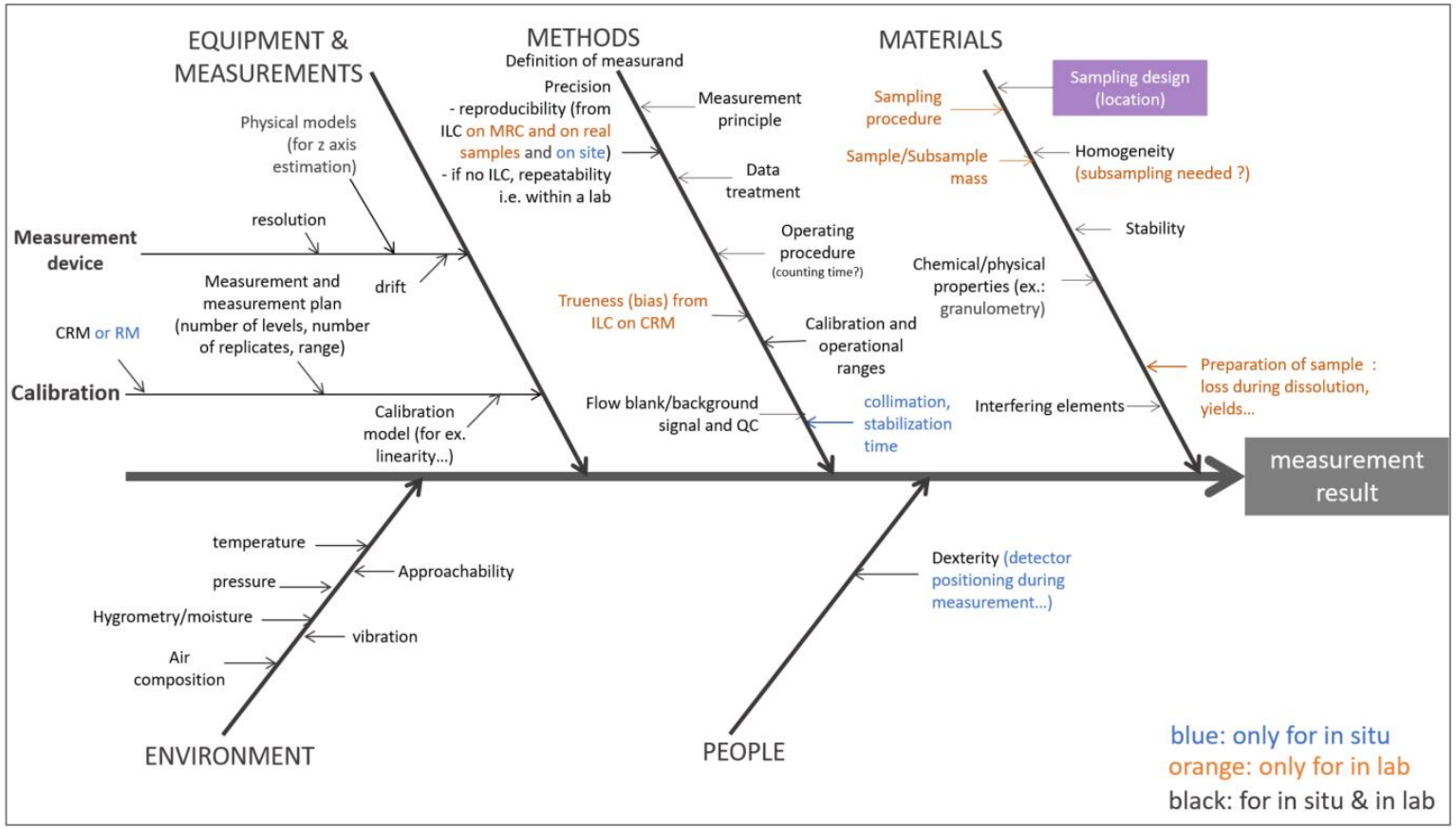
Main type of uncertainty sources Sampling design



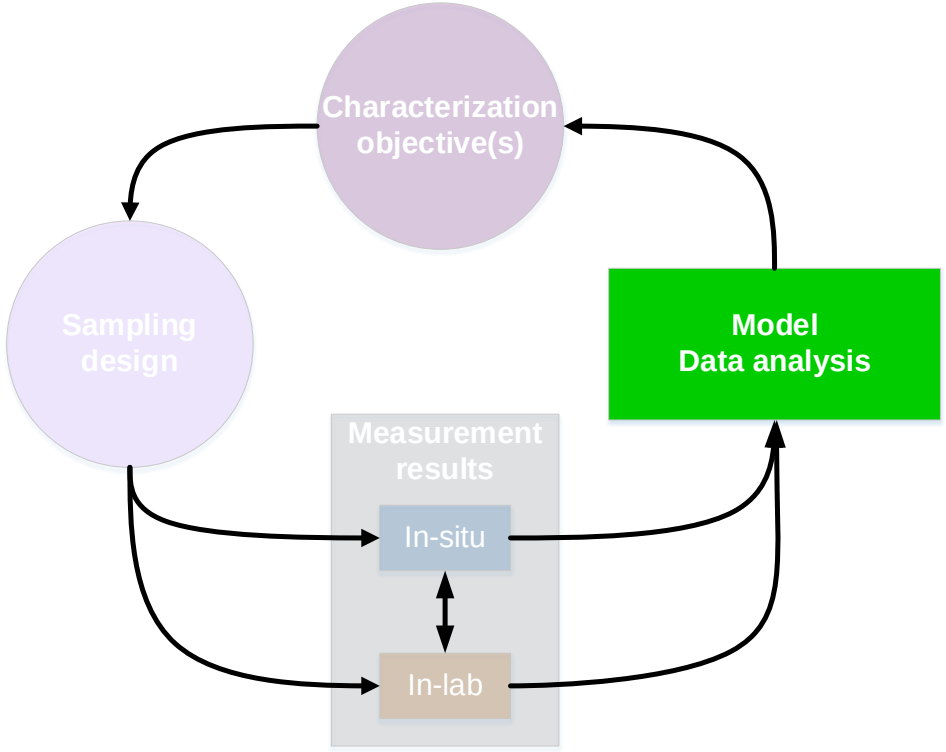
- Affected by
  - Sample locations
  - Sample size
  - Sample support
- Important initial conditions
  - Representative sampling
  - Sample locations:
    - Avoid extrapolation
    - Include non-impacted areas
    - Special focus on transition areas

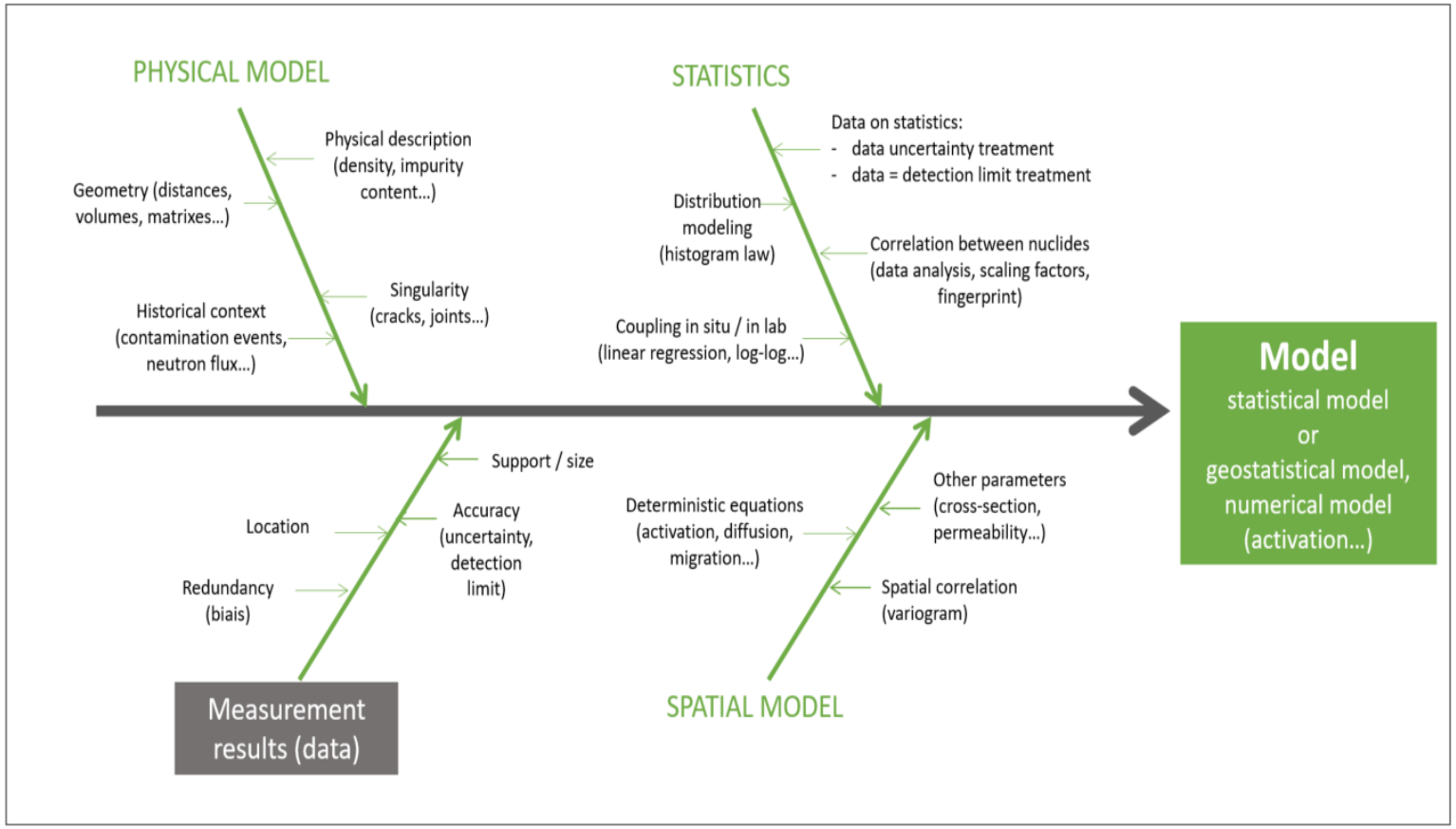
Main type of uncertainty sources Measurement results





Main type of uncertainty sources Model – Data analysis





Combining individual uncertainty sources: propagation & simulation

- Uncertainty propagation
  - 1st order Taylor expansion
  - Higher-order Taylor expansion
- Simulation of results distribution
  - Monte Carlo simulation
  - Bayesian inference
- Other: Importance sampling, perturbation method, Neumann expansion, etc.

CASE/FUNCTION	PROPAGATED ERROR
$z = ax \pm b$	$\delta z = a \cdot \delta x$
$z = x \pm y$	$\delta z = [(\delta x)^2 + (\delta y)^2]^{\frac{1}{2}}$
$z = cxy$	$\frac{\delta z}{z} = \left[\left(\frac{\delta x}{x}\right)^2 + \left(\frac{\delta y}{y}\right)^2\right]^{\frac{1}{2}}$

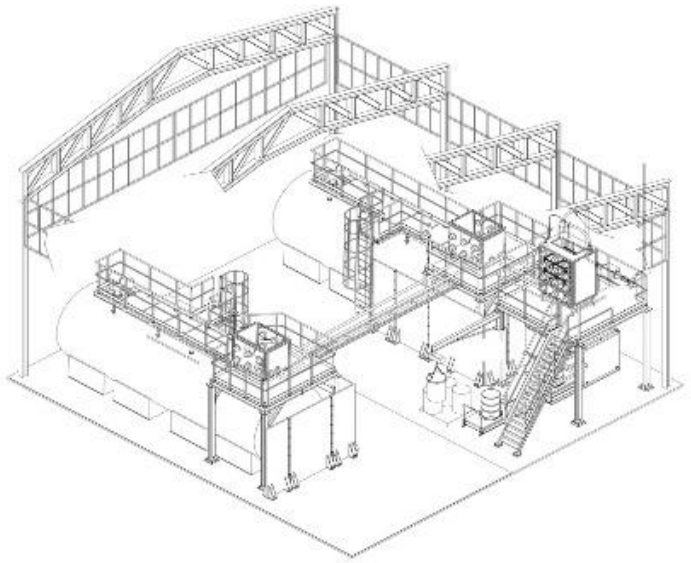
Combining individual uncertainty sources: more simplified implementation in practice

- Qualitative description
- Scenario comparison
- One-at-a-time approach

Combining individual uncertainty sources: sensitivity analysis

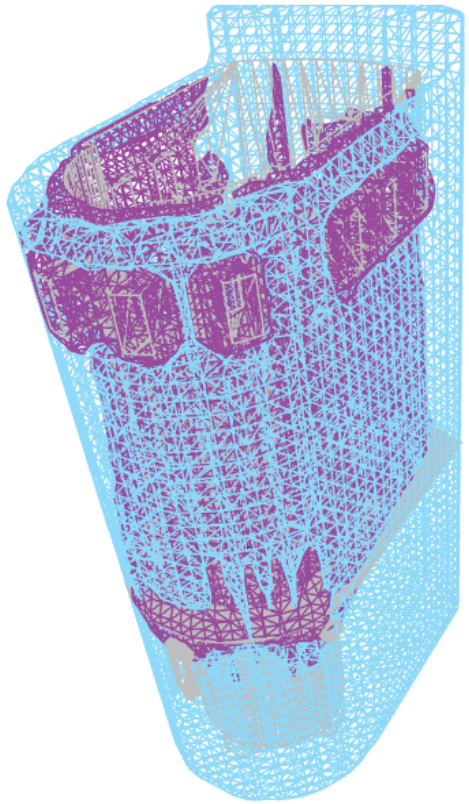
- Some individual uncertainty sources might play an important role, others a negligible one
- Strongly reduce the global uncertainty by identifying and minimizing its most important contributions
- Variance-based methods related to Sobol' sensitivity indices are the most popular methods

REX from 4 UCs
UC1: LLLW



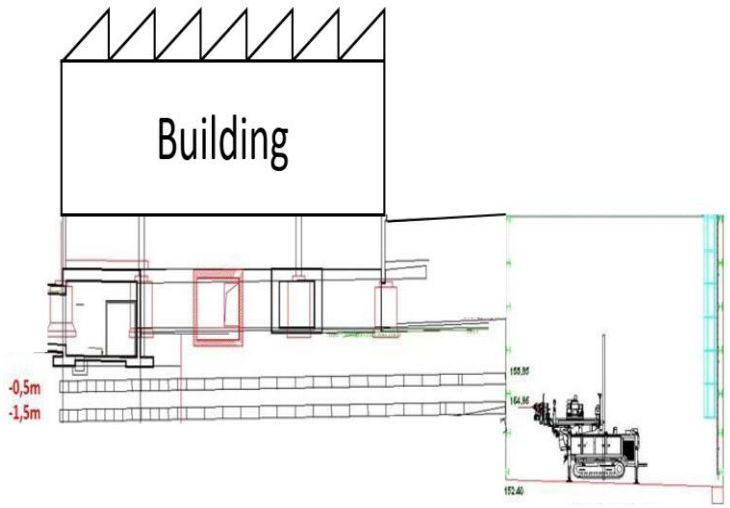
- No quantitative uncertainty propagation performed
- Main source of uncertainty by far lies with the sampling design
- Several robust data analysis methods applied on the existing data set produced very comparable results

REX from 4 UCs
UC2: Biological shield (pilot PWR)



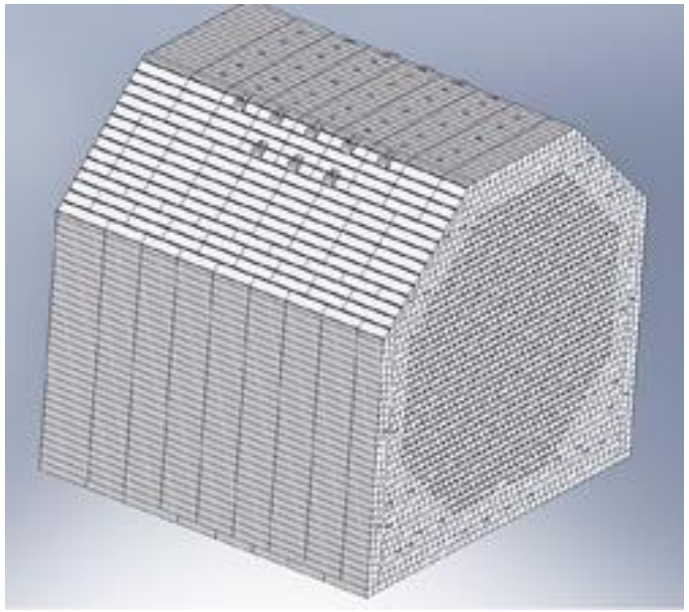
- Combining uncertainty sources: Monte Carlo simulation
- Global uncertainty on the volume categorized as conditional release: 13%
  - however, this only concerns the volume estimation without location
- Sensitivities: one-at-a-time approach in a probabilistic sense
  - Most important uncertainties are related to the modelling (heteroscedasticity and the geostatistical simulations)
  - Impact of sampling design on global uncertainty
    - Slight effect when reducing the primary dataset and retaining the large secondary dataset is retained
    - Huge effect when removing secondary dataset

REX from 4 UCs
UC3a: Contaminated soil



- Only historical data
- Sensitivity analysis
  - impact of measurement results uncertainty is rather limited compared to model uncertainties and sampling design
  - Impact of sampling design on global uncertainty
    - Sample reduction generally results in increasing uncertainty
    - integration of secondary data generally reduces the uncertainty

REX from 4 UCs
UC3b: Graphite



- Only historical data
- The estimated waste volume and its uncertainty could be reduced by using multivariate statistics instead of simple regression models
- Integration of limits of detection and measurement uncertainty when using a probabilistic modelling approach provides lower activity estimations

Decide on compliance or non-compliance

- Result + uncertainty (reliability)
- Uncertainty can be as important as the result itself
- Establishing the uncertainty budget can be challenging due to the high number of parameters
- When the sampling approach is sound and the measurements rather standard, the most important uncertainties are usually related to the model
- Additional discussion towards fine-tuning and final statements
- Draft recommendations will be finalized and available towards the end of the INSIDER project

THANK YOU