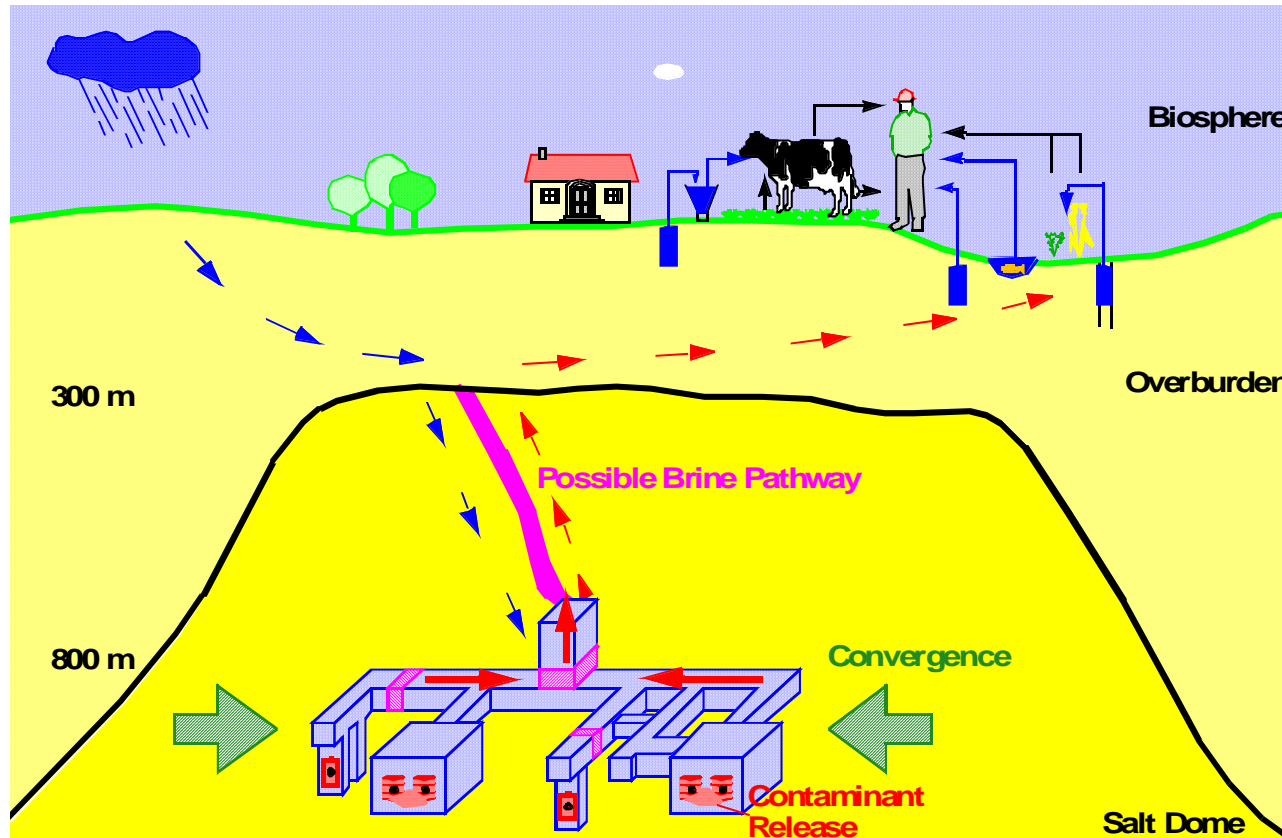


Variance-Based Sensitivity Analysis for the Long-Term Safety of an Underground Radioactive Waste Repository in Rock Salt

Dirk-Alexander Becker
Sabine Spiessl

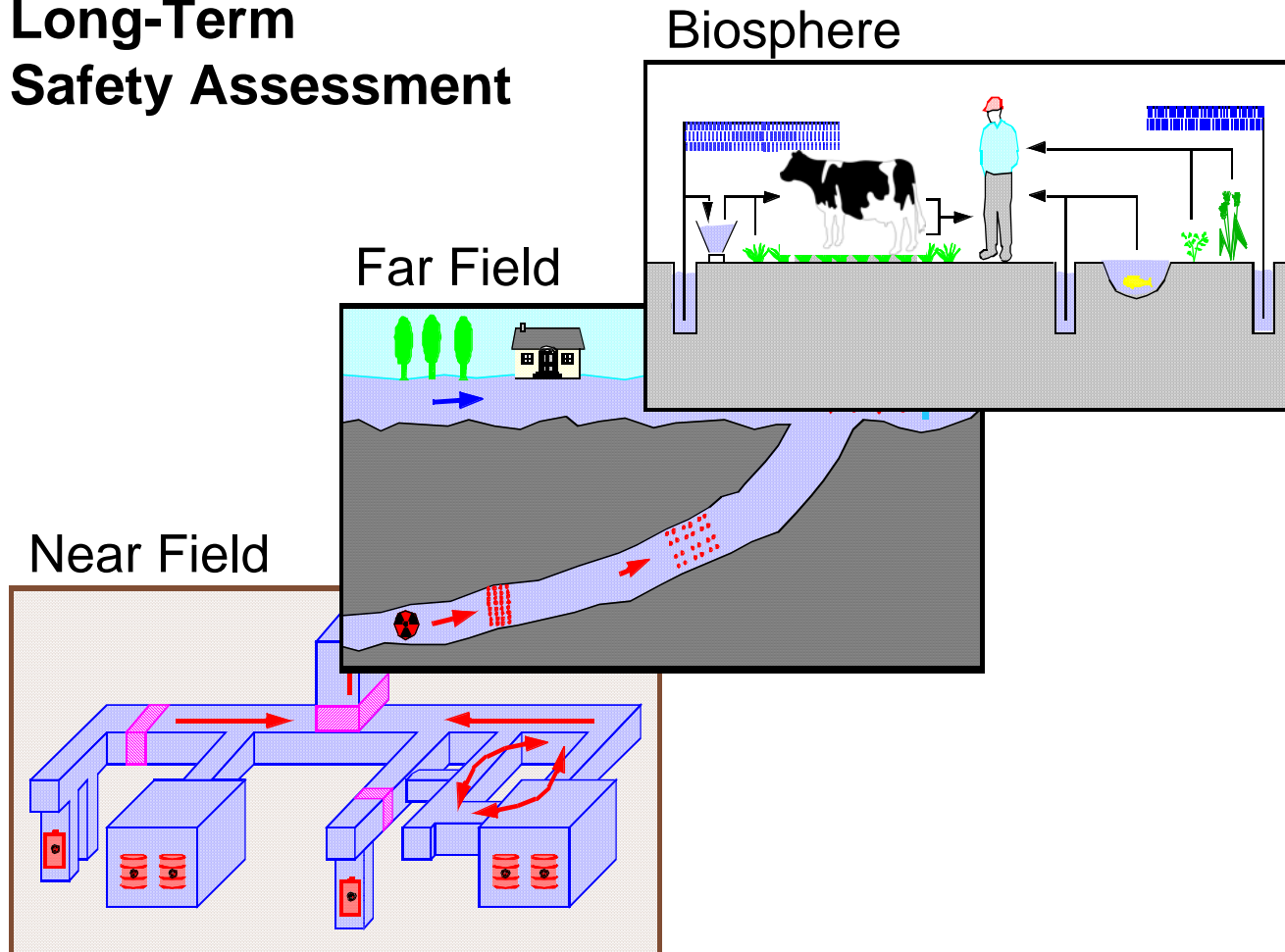
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH
Braunschweig, Germany

Final Disposal of Radioactive Waste in Salt Rock

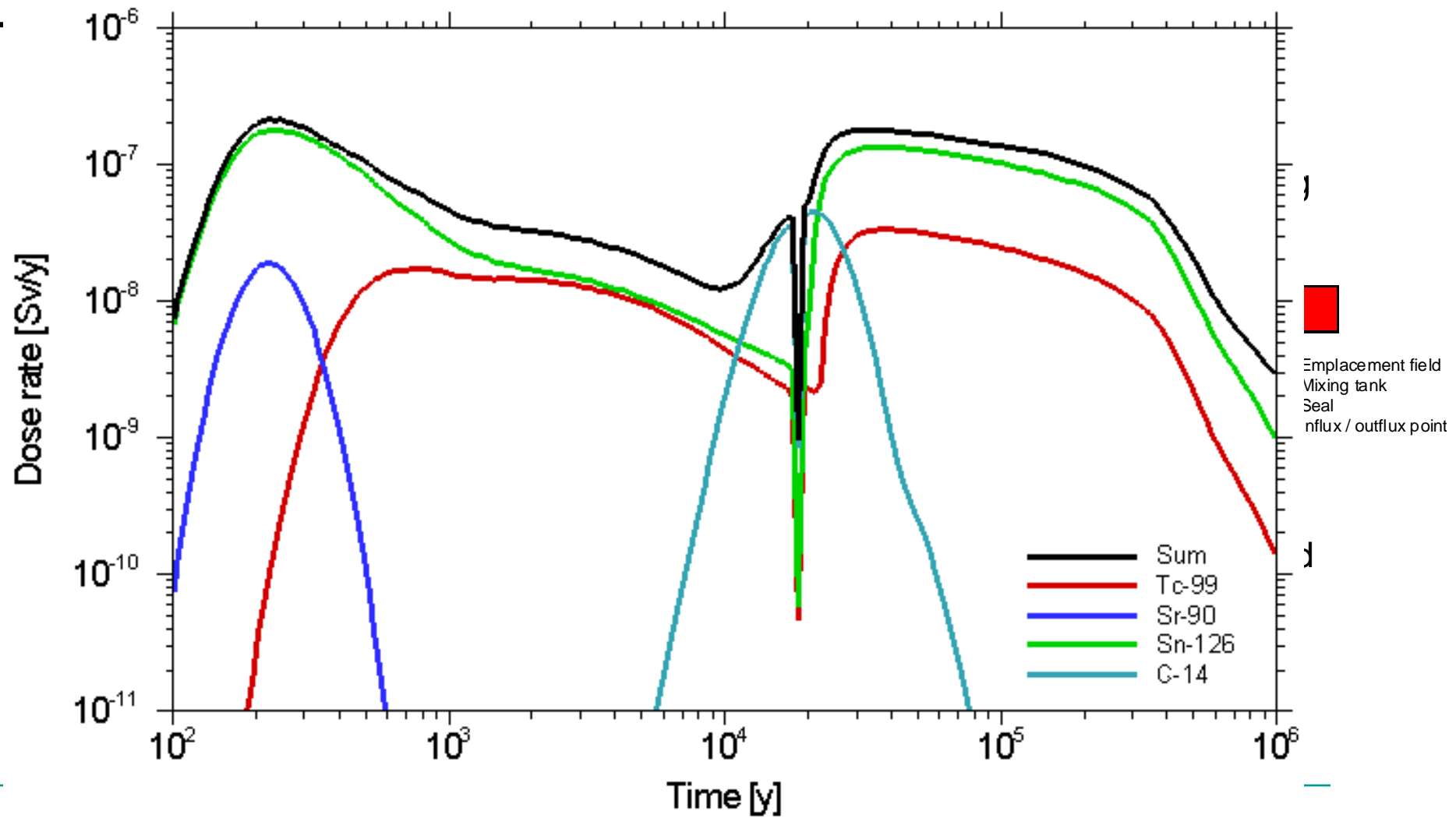


- Brine intrusion cannot be excluded
- Canister corrosion and contaminant mobilisation
- Convergence of voids
- Fluid flow inside the near field
- Radionuclide transport
- Contamination of groundwater
- Chemical effects
- Radioactive decay
- Biosphere pathways
- Radioactive exposure of man
- **Coupled system with complex behaviour!**

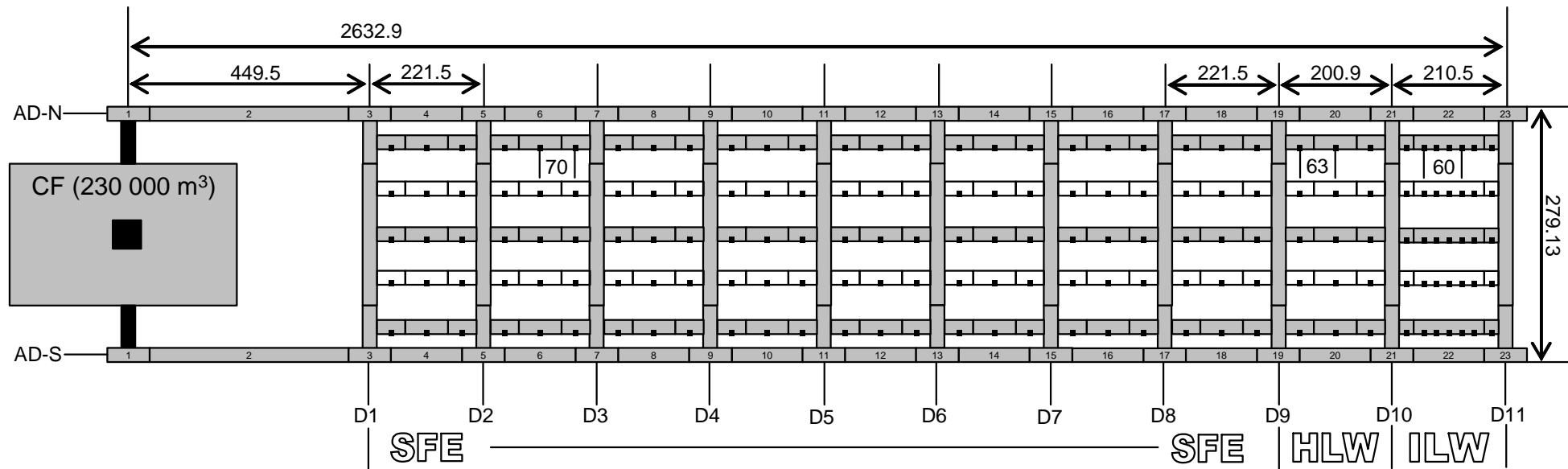
Long-Term Safety Assessment



EMOS	
EXCON / EXMAS	
r ³ t: 3D Transport	
TRAPIC: 1D, por. Media + Colloids	
CHETMAD: 1D, fractured por. Media	
CHETLIN / CHETNIS: 1D, porous Media	
CLAYPOS: Clay / Granite	
LOPOS: Salt	



Generic SF / HLW Repository



Cross section [m²]:

4.7	42	ZS-N, Q	23	ZS-S	31	BS
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Repository Seals:

	Shaft (L = 50 m, A = 44.2 m ²)		Drift seal (L = 50 m, A = 23 m ²)
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Sensitivity Analysis

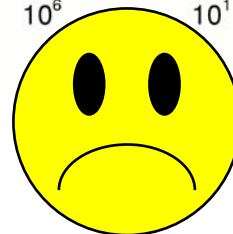
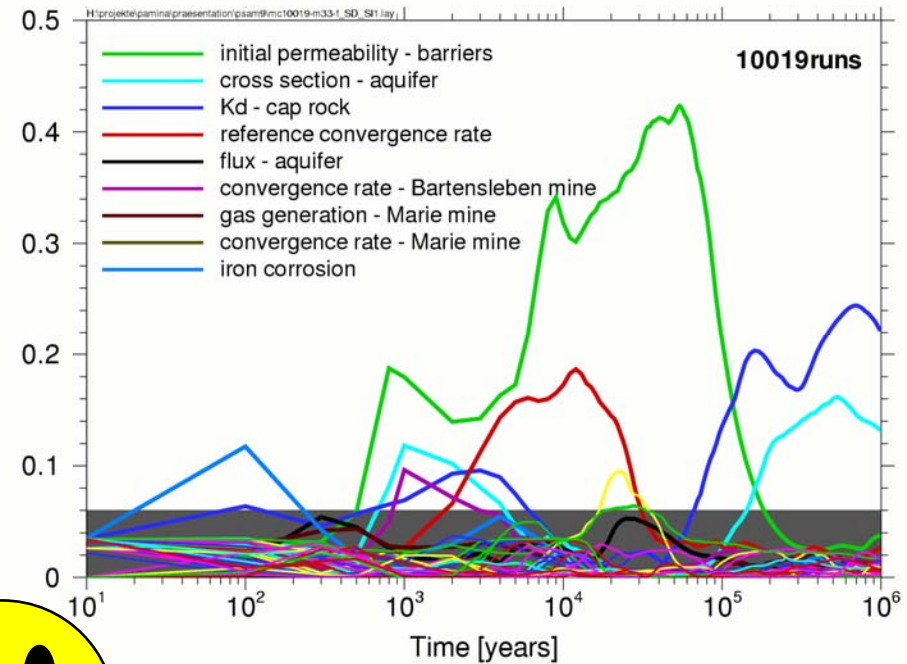
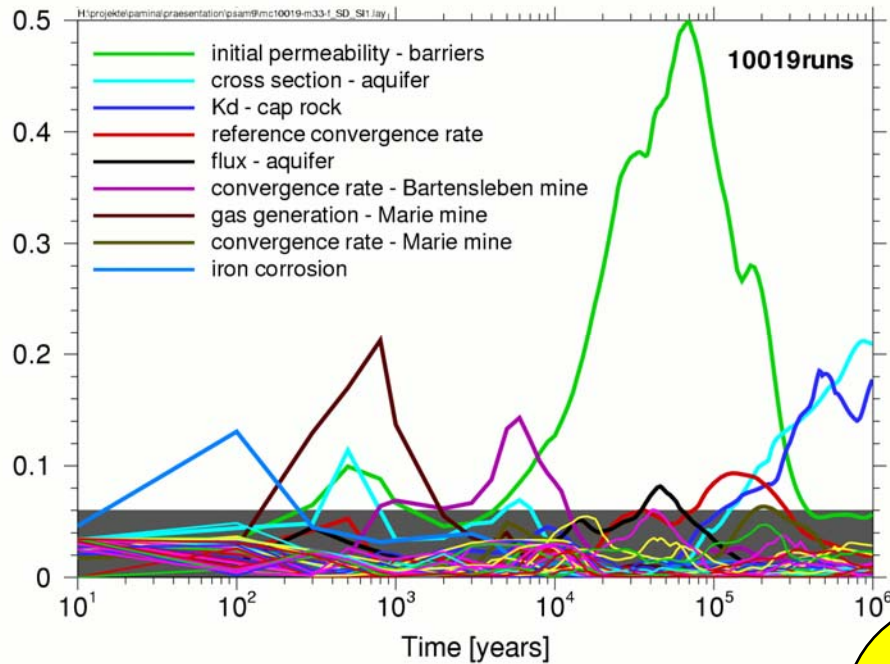
- Uncertainties
 - Model and scenario uncertainties
 - future development
 - Parameter uncertainties
 - Physical parameters
 - Technical parameters
 - Geological parameters
 - Why do we perform SA?
 - Identification of research needs
 - Identification of technical needs
 - Deterministic SA
 - Specific parameter variations
 - Monte-Carlo-based SA
 - Rank transformation (highly non-linear systems)
 - Calculation of SPEA, SRRC, PRCC
 - Smirnov test
 - Application to
 - different points in time
 - maximum of each run
 - What do we learn?
 - Qualitative parameter ranking
 - Open questions
 - How reliable are the rankings?
 - Which parameters are really important?
 - Which parameters do not play a role at all?
-

Variance-based Sensitivity Analysis: Fourier Amplitude Sensitivity Test (FAST)

- Systematic scan of parameter space using periodic functions
- Interference-free frequencies for different parameters
- Random element by introducing random phase shifts
- Fourier Analysis of model output yields parameter influence
- Calculation of first-order sensitivity indices
 - isolated influences of individual parameters
- Calculation of total-order sensitivity indices (E-FAST)
 - influences of parameters in interaction with all others
- Quantitative sensitivity measures
- Applicable to non-linear and non-monotonic systems
- High number of model runs necessary

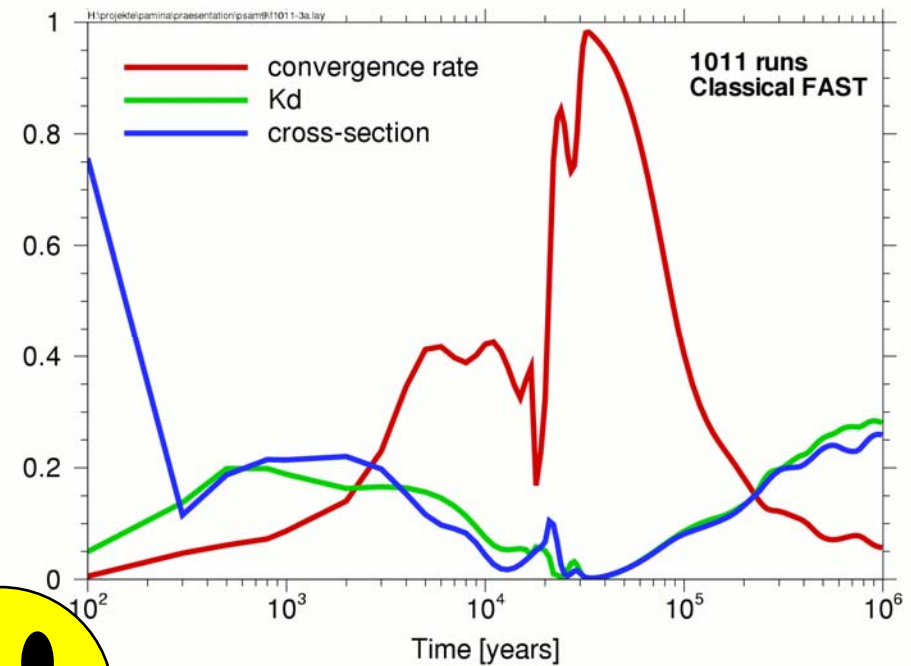
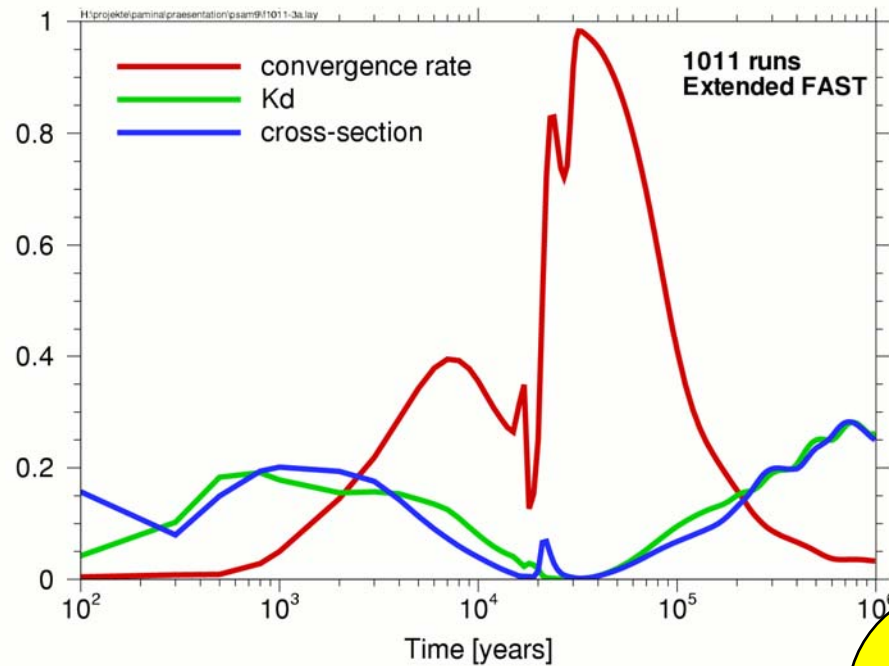
$$\frac{\text{Var}_{X_j} [E(Y)|X_j]}{\text{Var}(Y)}$$

FAST Analysis of the ERAM Model

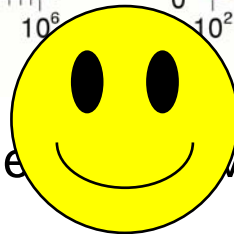


many parameters are equally important at any time

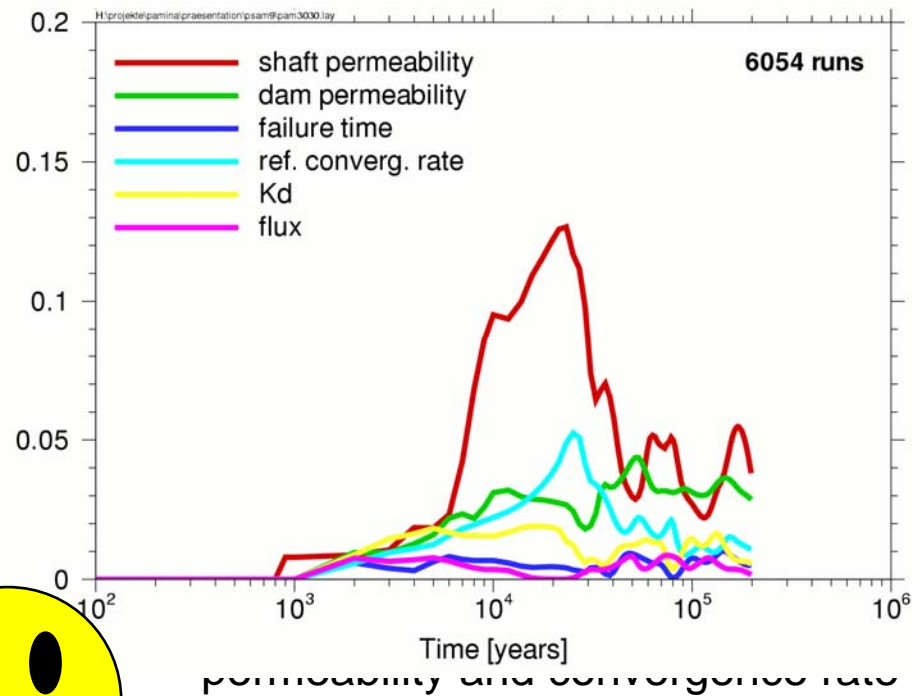
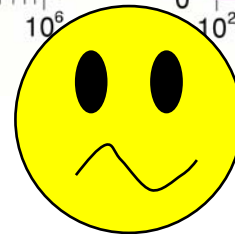
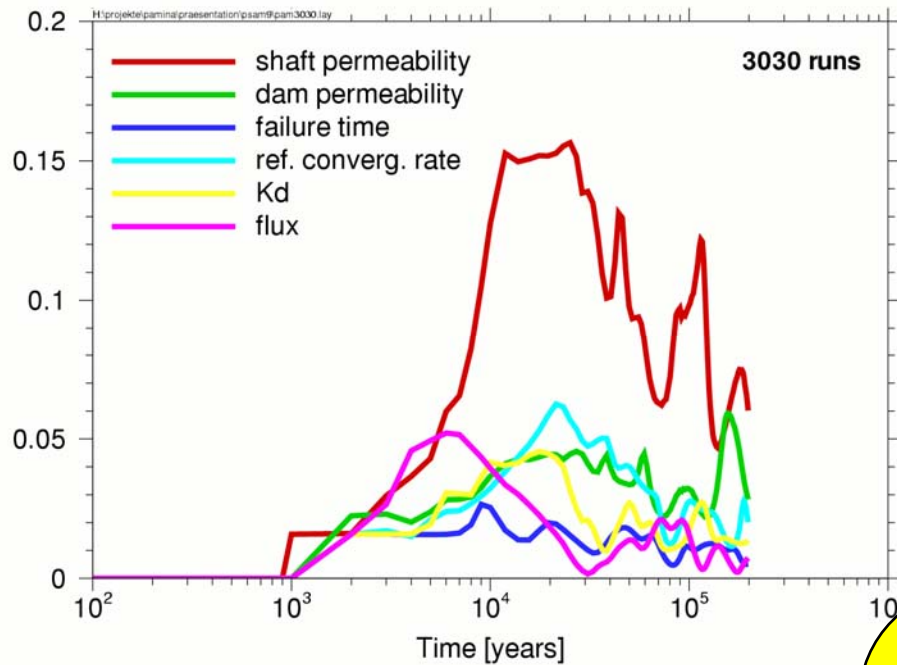
Why these Strange Results?



- Parameter seems to disturb the valuation!



FAST Analysis of the Generic SF / HLW Model



Why again such strange results???

- There are

- The zero-r

- About

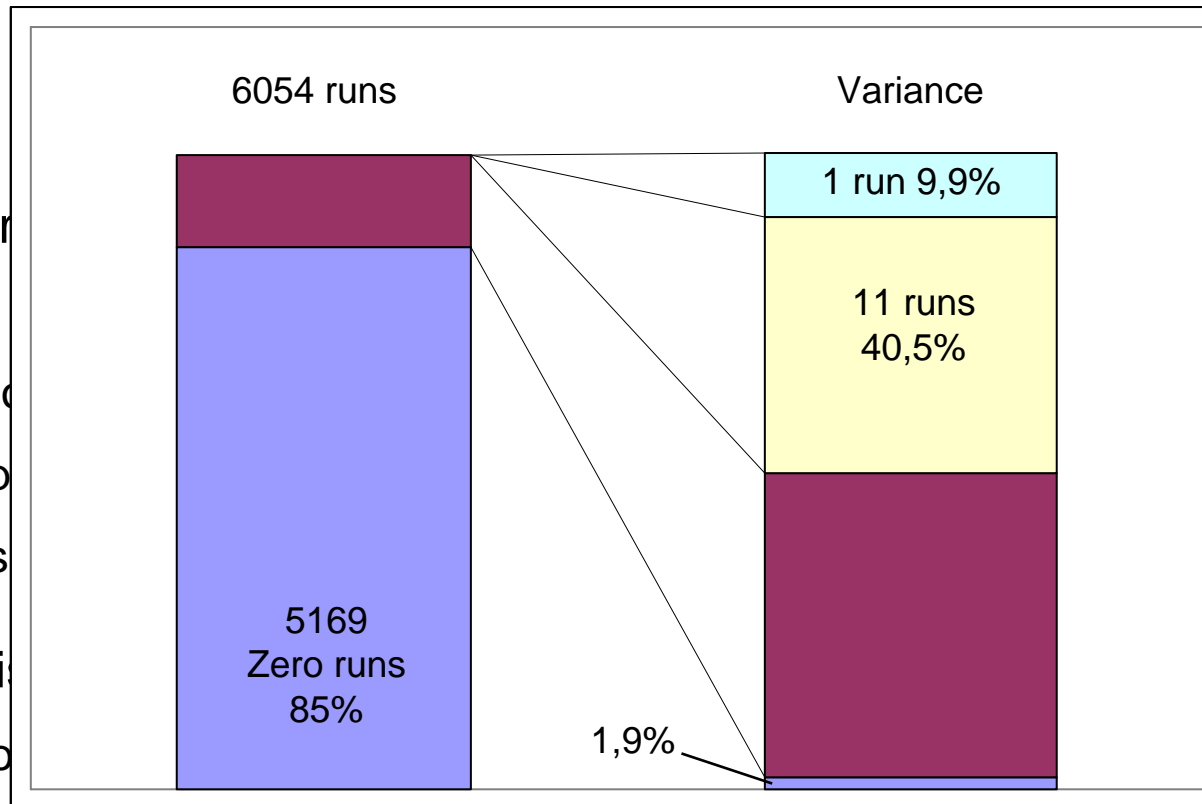
- Many c

- Poor p

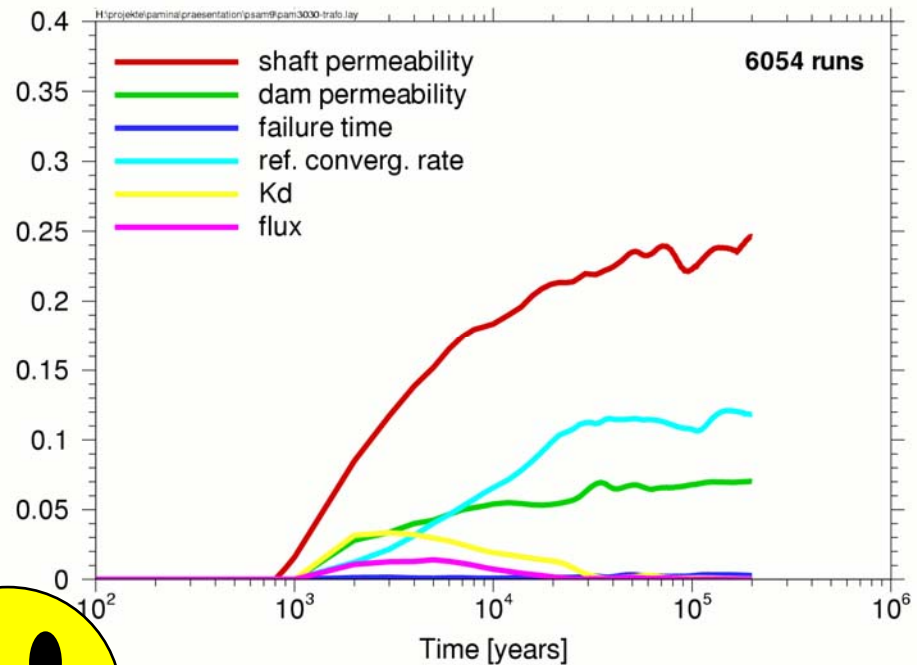
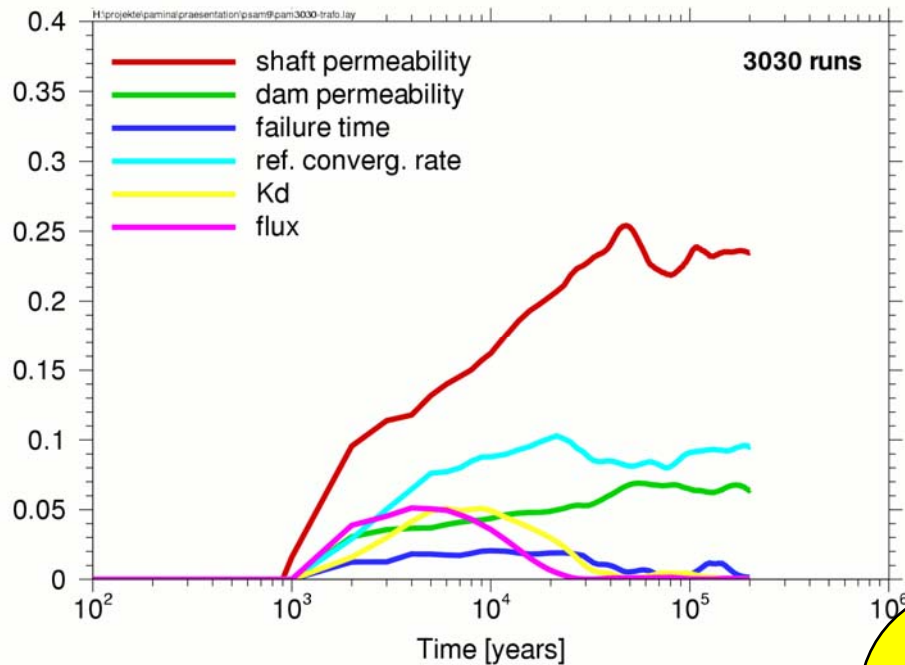
- This is

- Variance is

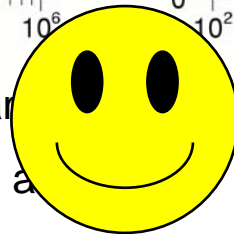
- Low ro



Improving Robustness: Transformation of Model Output



- Essential contributions from dam permeability and convergence rate
- Low significance of failure time and flux



Conclusions

- FAST does not always perform well with complex repository models
 - Discrete or switch-like parameters can disturb FAST evaluation
 - High zero-run probability impairs robustness of variance-based methods
 - A suitable output transformation can mitigate this problem
 - Generally, variance-based methods seem promising if applied carefully
-

Thank you for your attention!
