Temperature-centric Reliability Analysis and Optimization Under Process Variation

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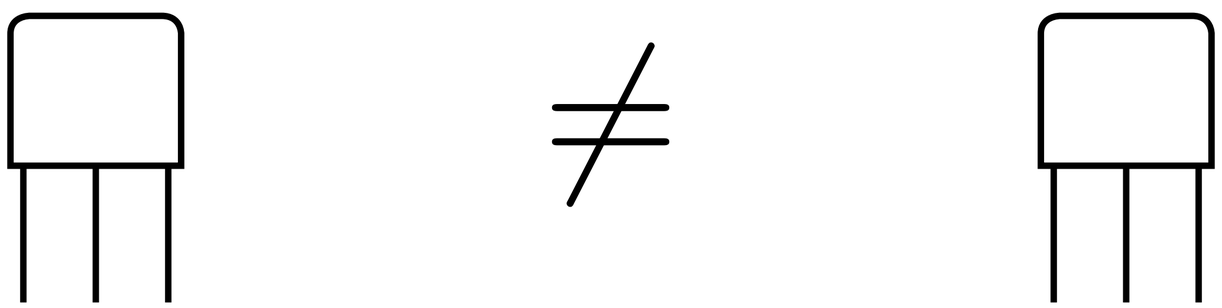
Topics

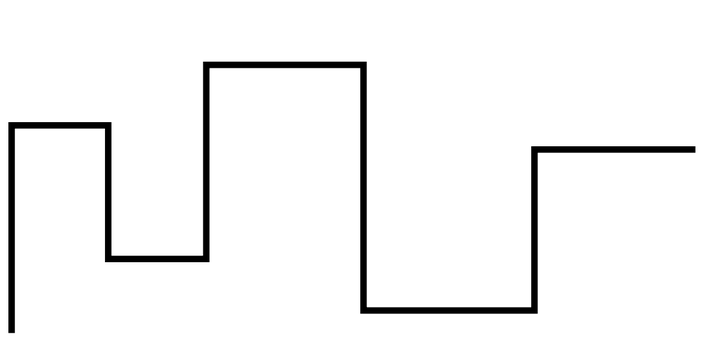
* Uncertainty quantification
* Temperature analysis
* Reliability analysis
* Design-space exploration

Process Variation

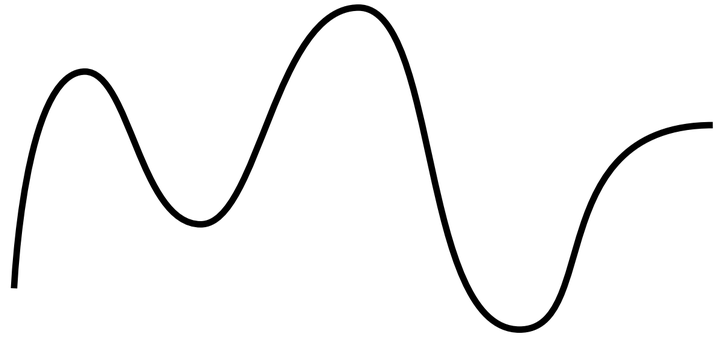


Temperature Analysis

* Transient



Power



Temperature

Temperature Analysis

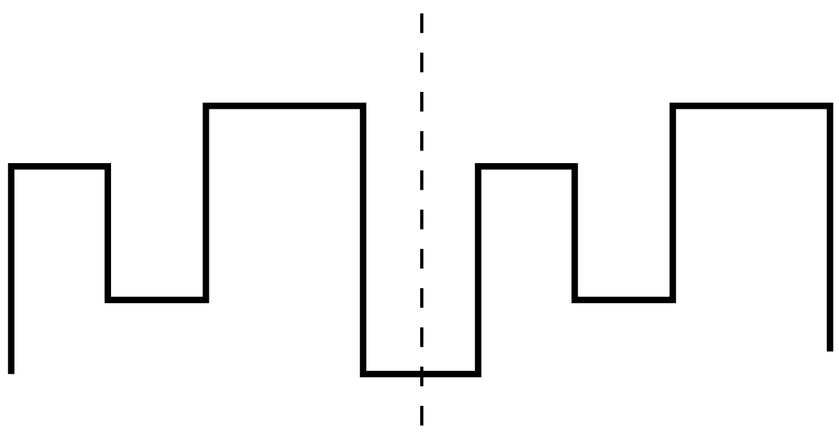
* Static steady-state

Power

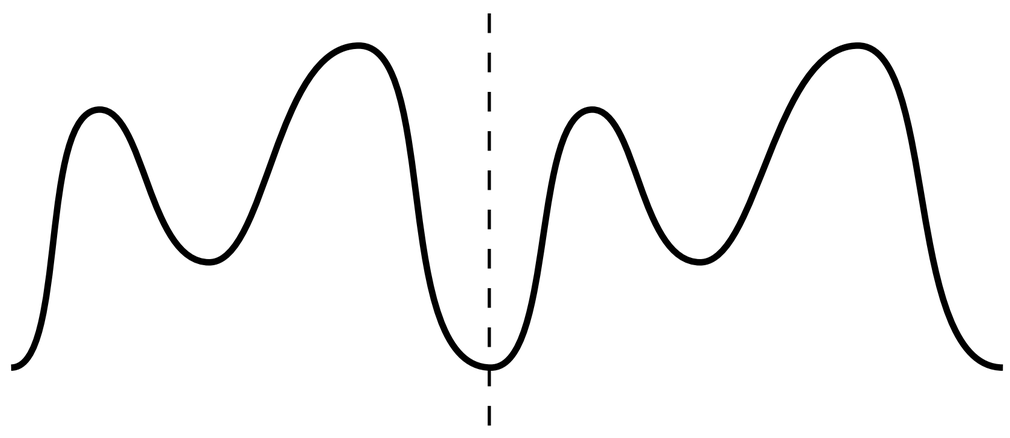
Temperature

Temperature Analysis

* Dynamic steady-state



Power



Temperature

Temperature Analysis Under Process Variation

* Transient
* Static steady-state
* Dynamic steady-state

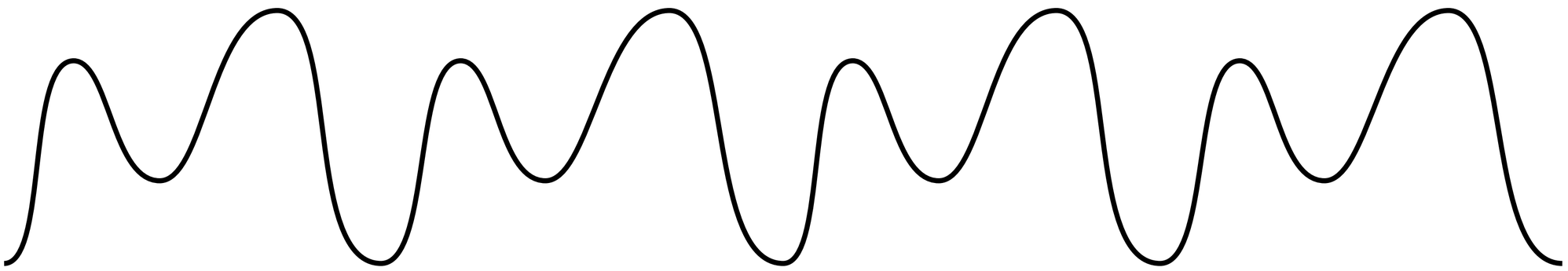
Prior Work

* Transient [1]
* Static steady-state [2, ...]
* Dynamic steady-state

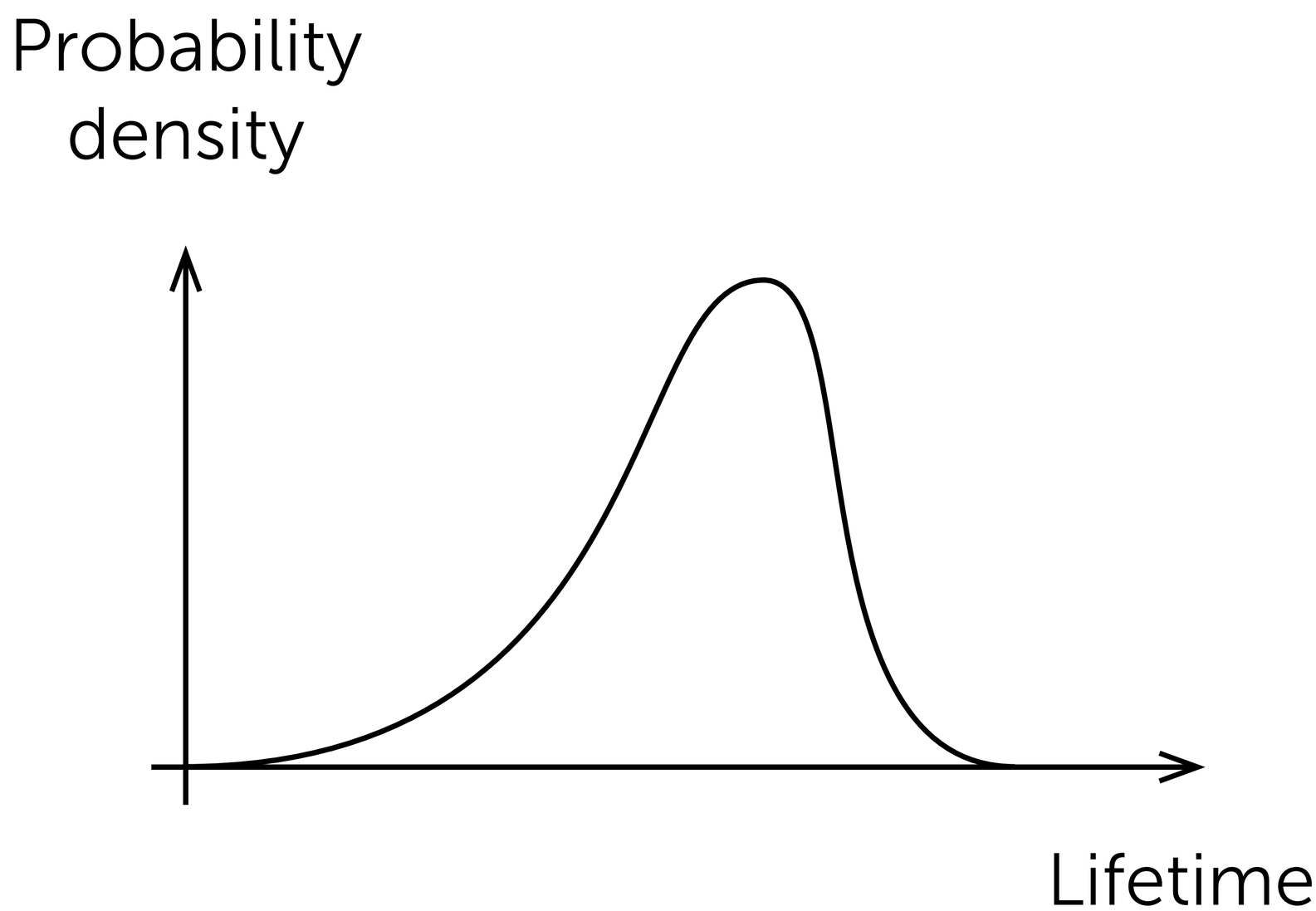
[1] Ukhov *et al.*, TCAD, 2014.
[2] ...

Failure Mechanisms

* ...
* Thermal cycling
* ...



Reliability Analysis



Reliability Analysis Under Process Variation

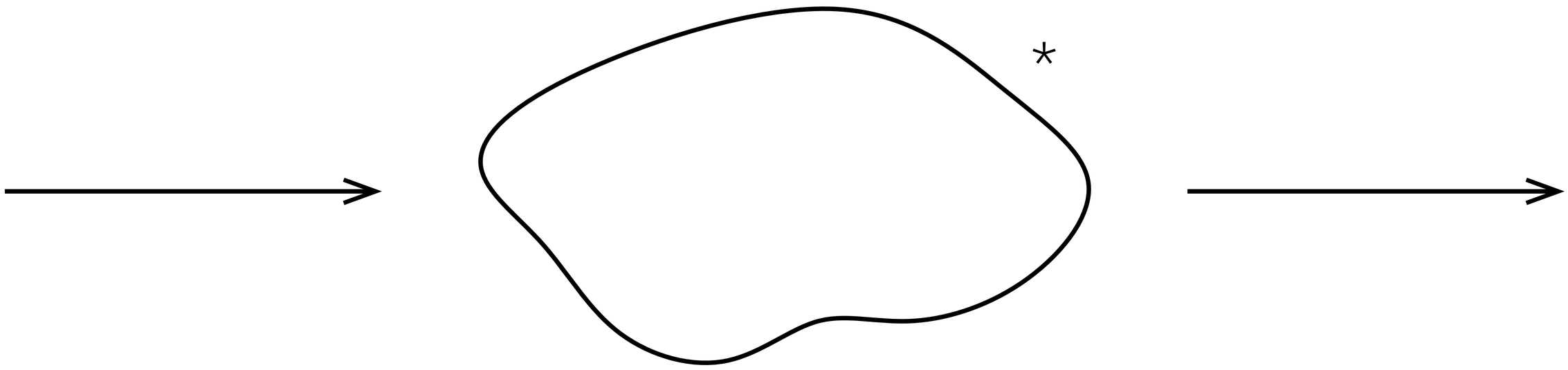
* ...
* Thermal cycling
* ...

Prior Work

Goals

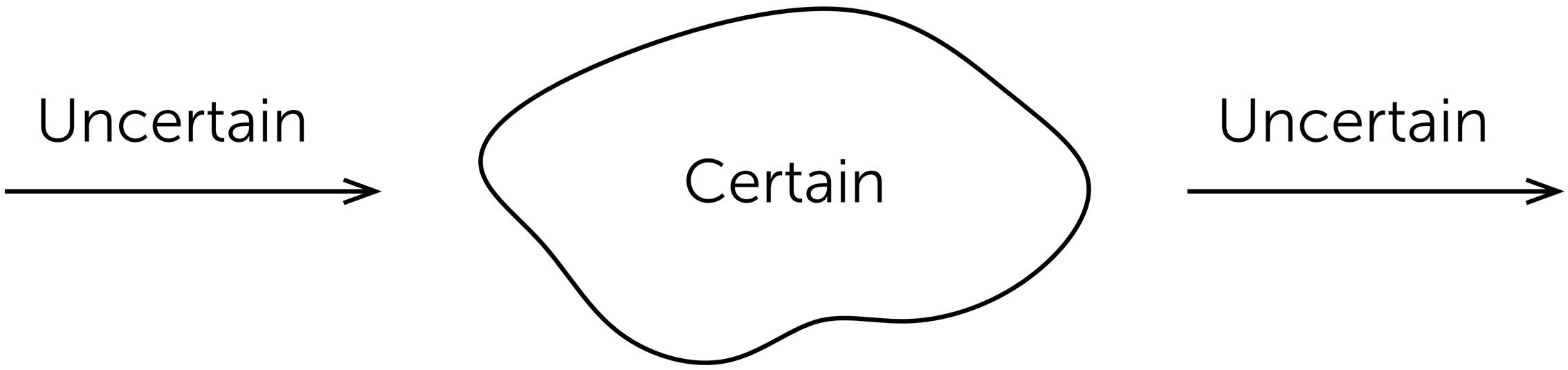
* Dynamic steady-state temperature
* Stochastic-temperature reliability
* Design-space exploration

Uncertainty Quantification

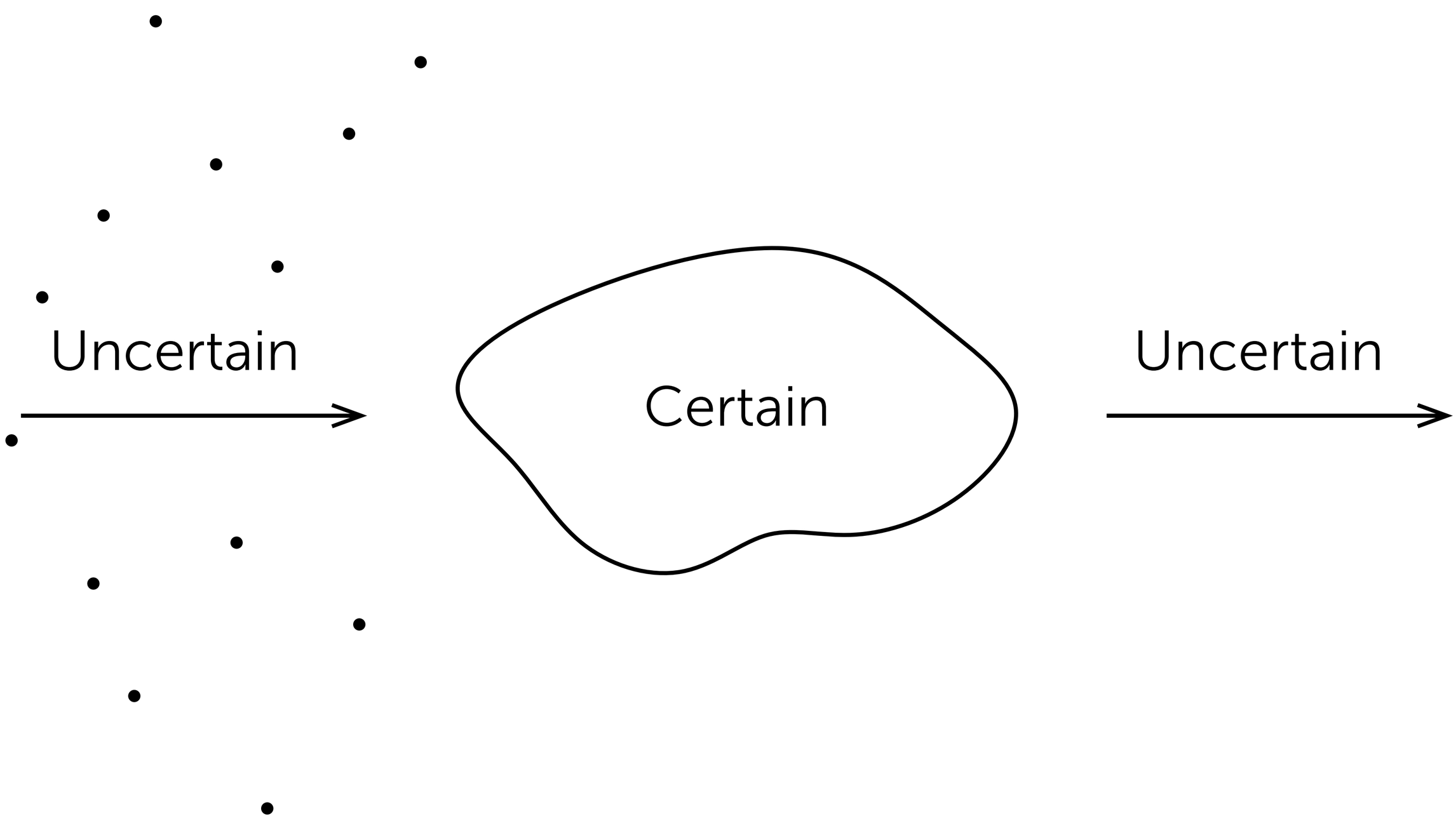


* Designed by Sergiu Rafiliu.

Uncertainty Quantification



Uncertainty Quantification



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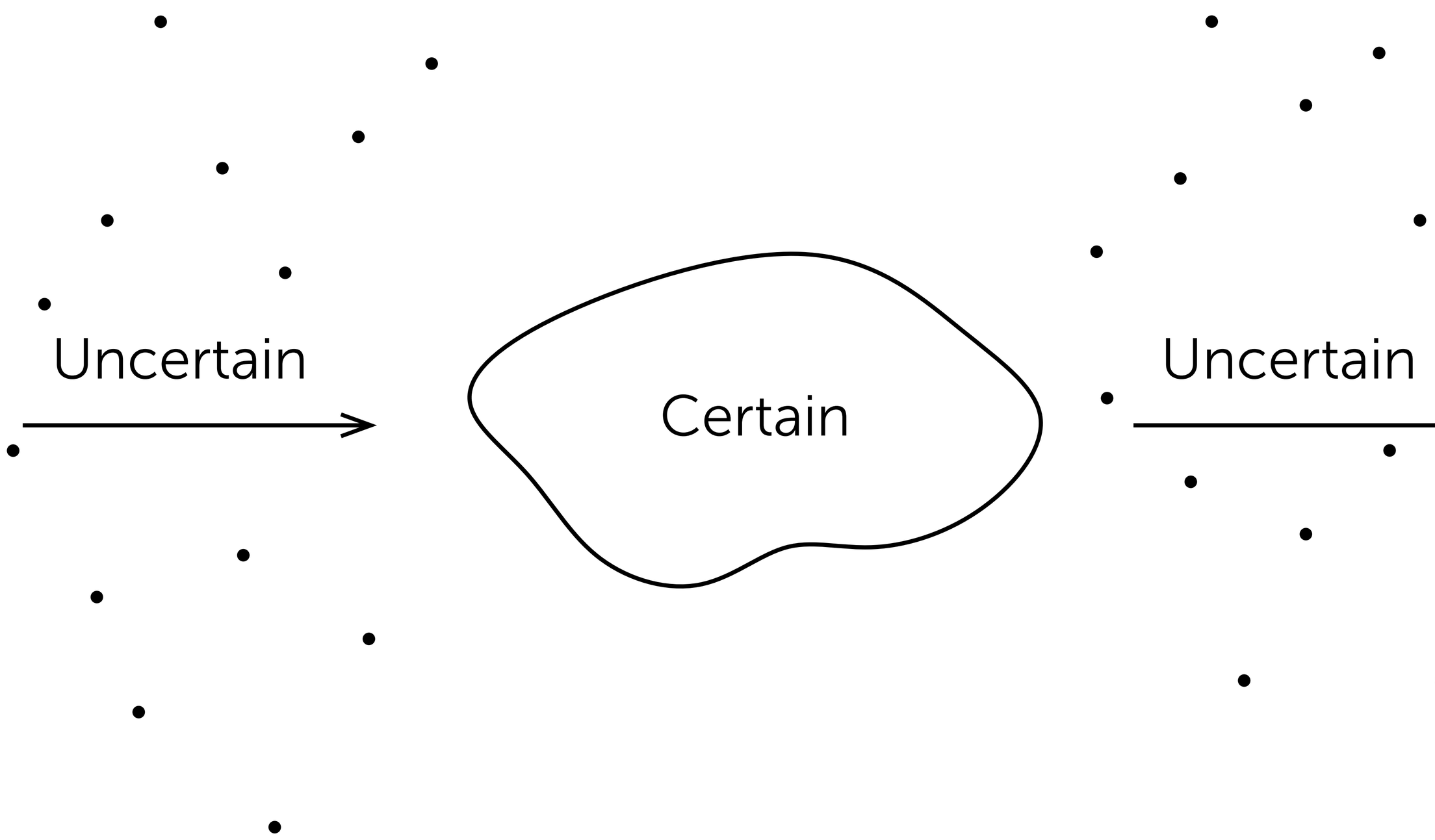
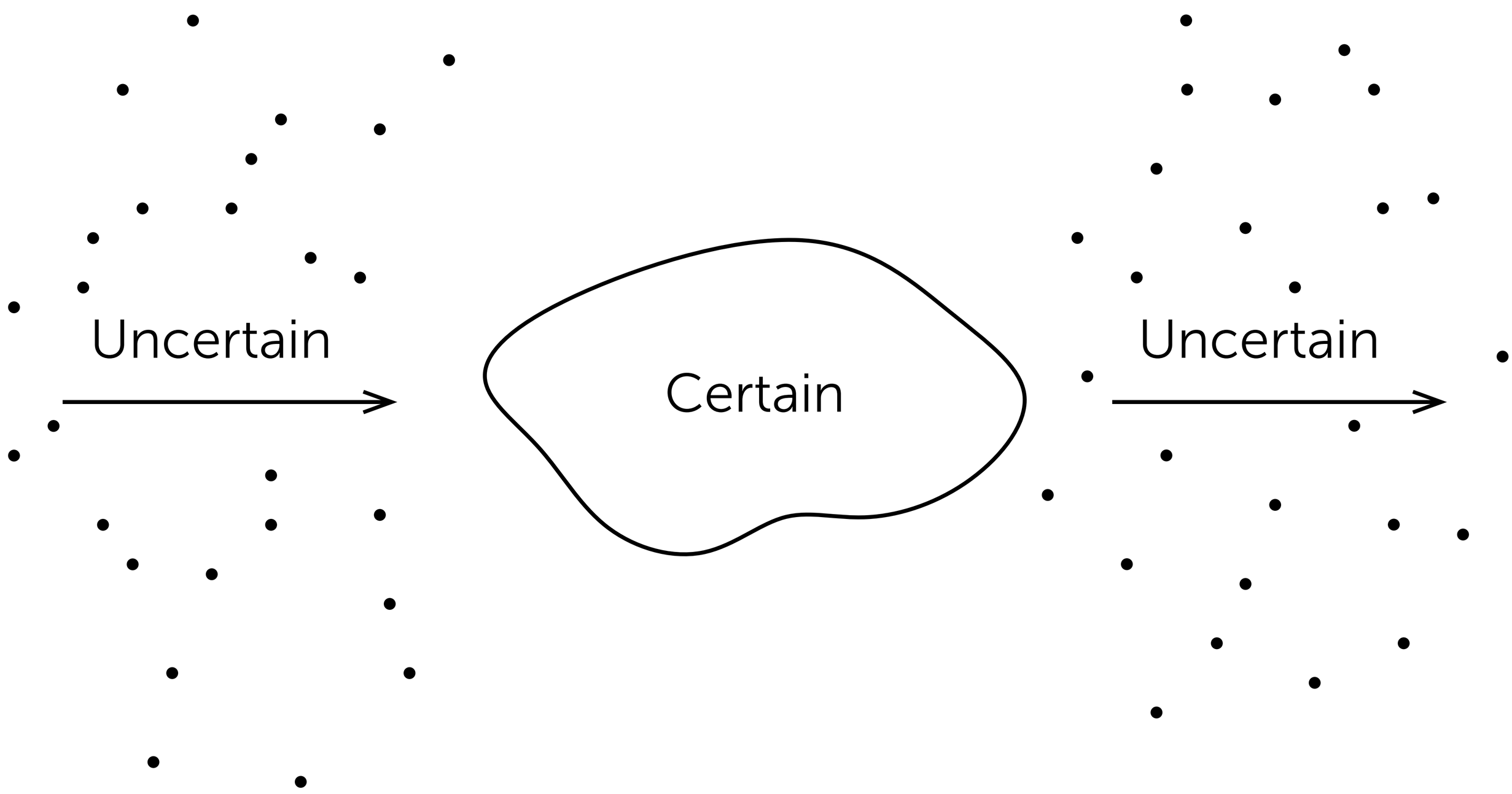
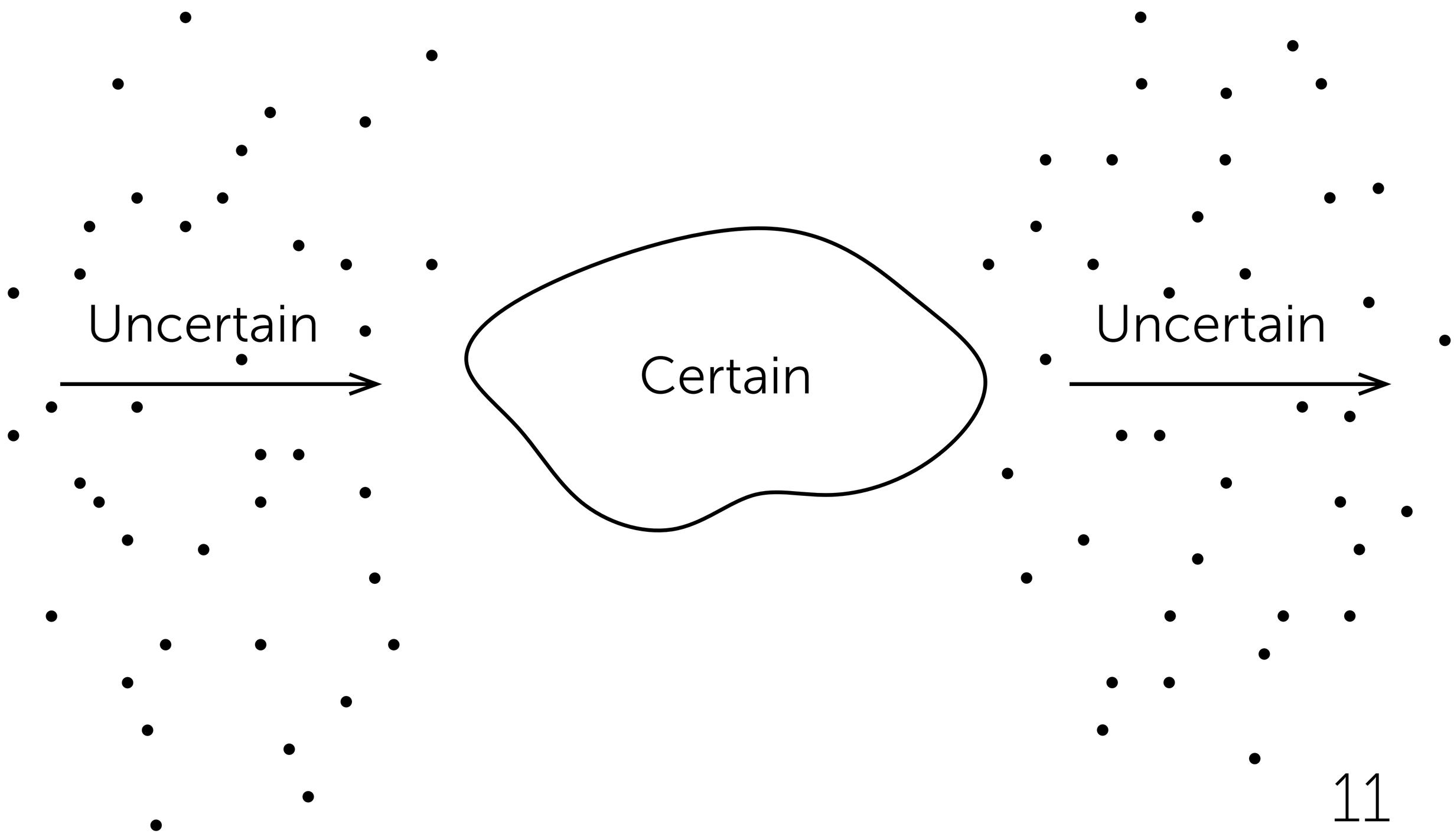


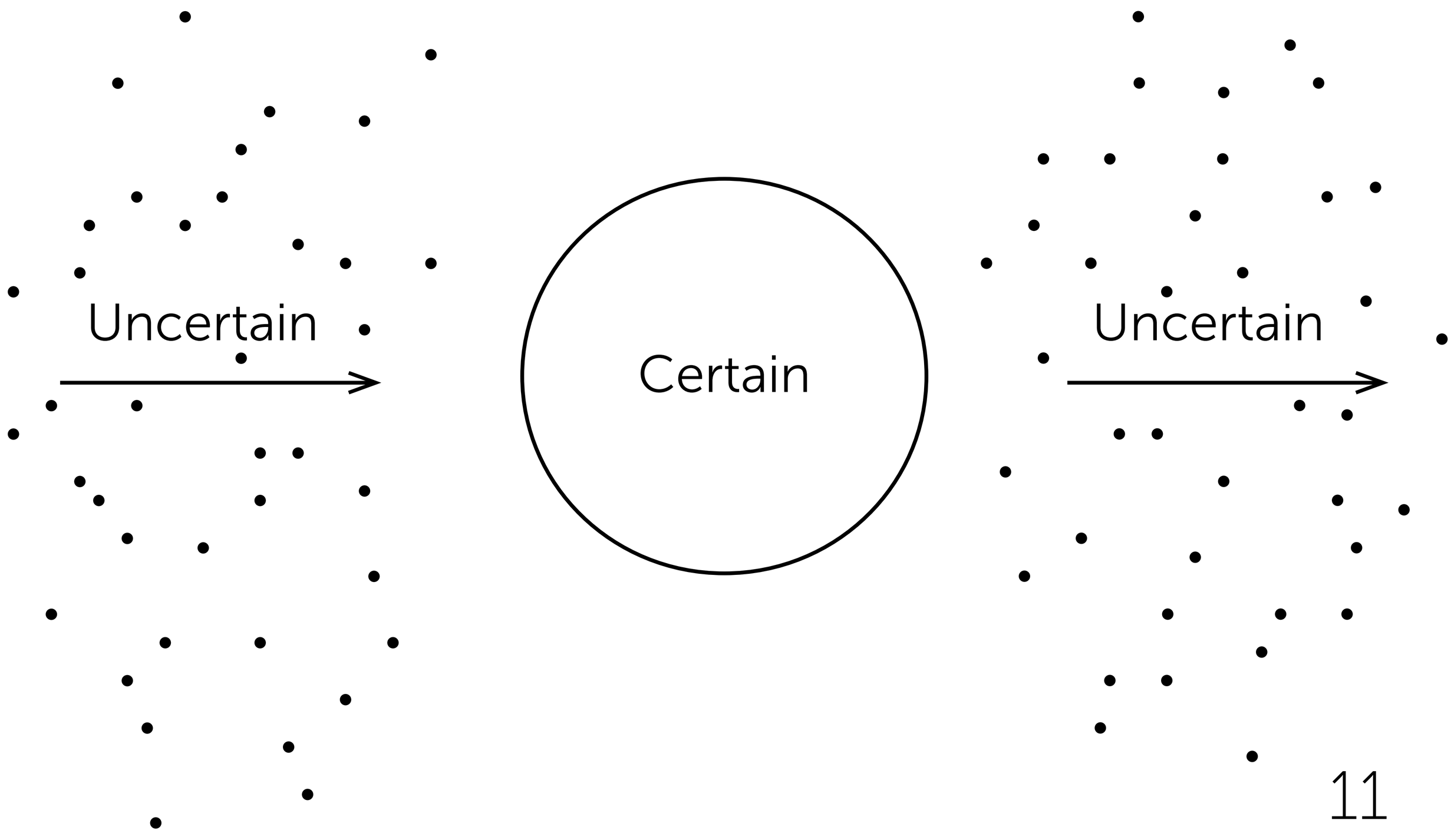
Uncertainty Quantification



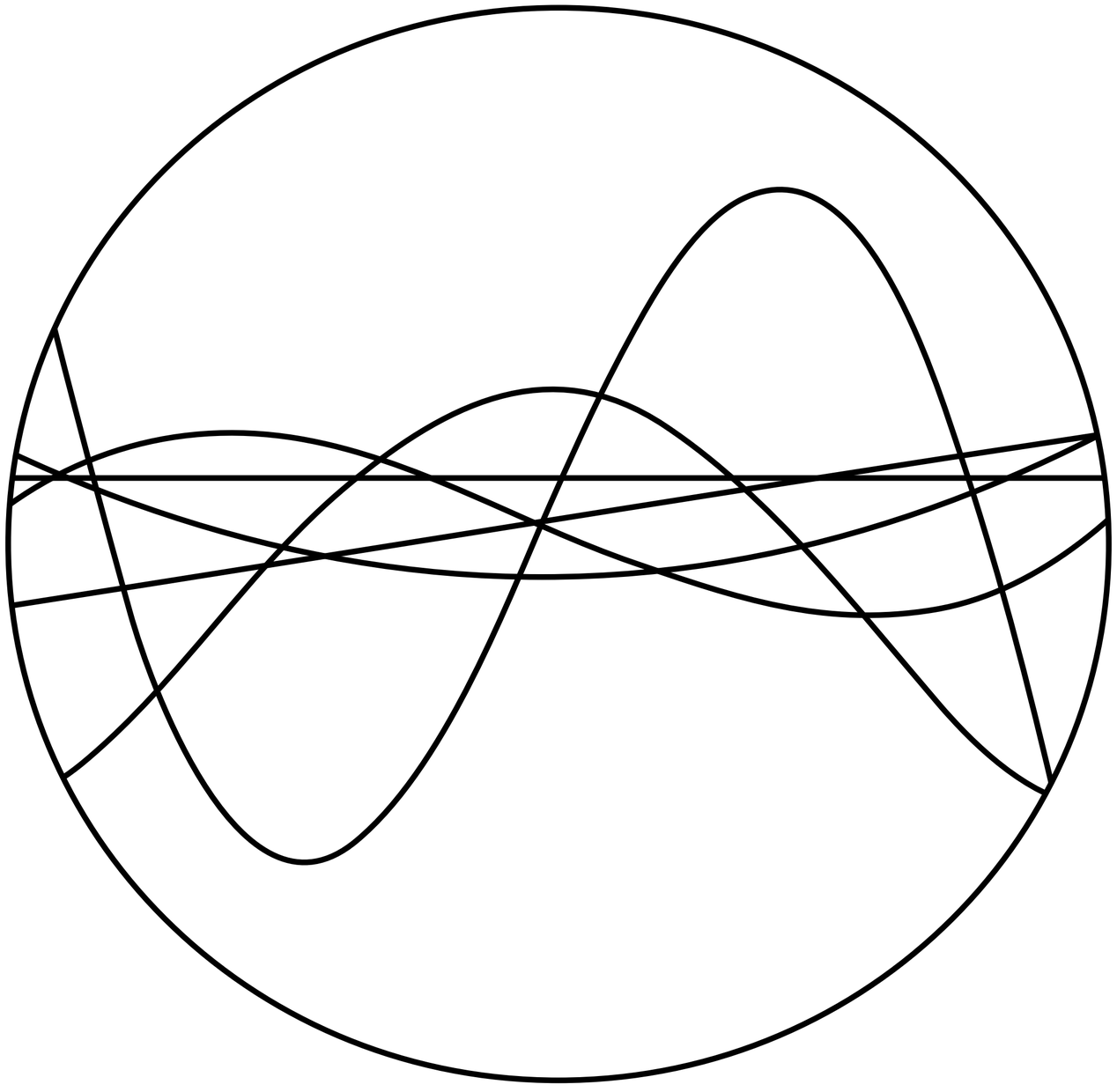
Uncertainty Quantification



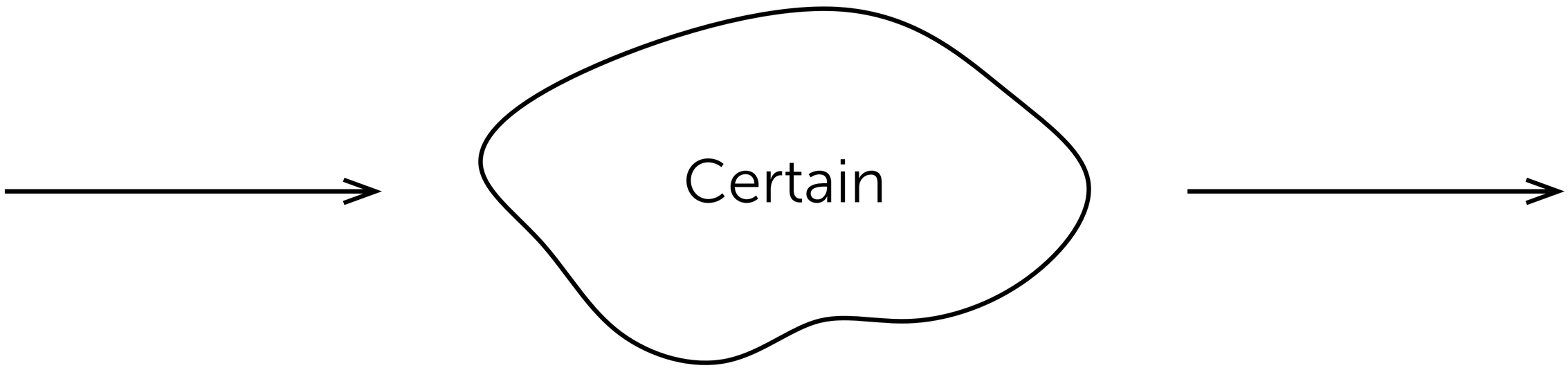
Uncertainty Quantification



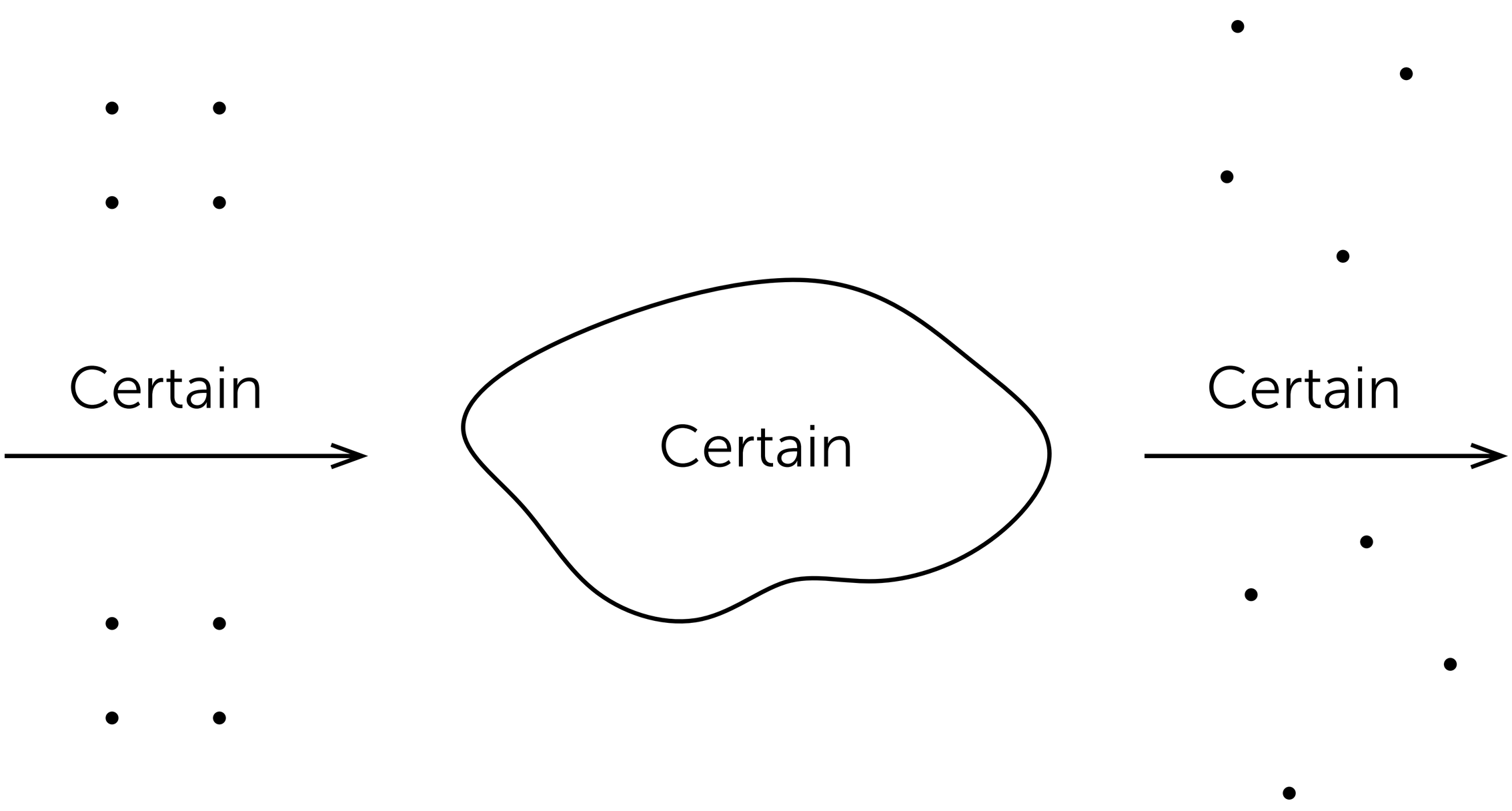
Polynomial Chaos



Polynomial Chaos

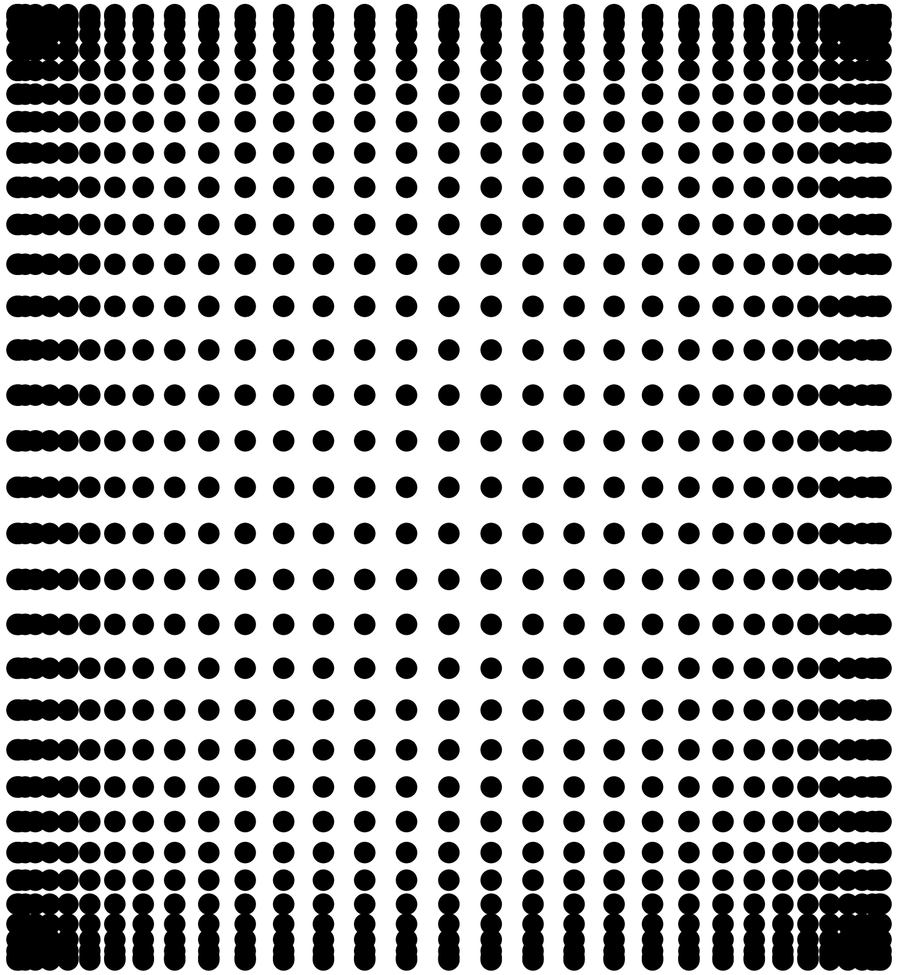


Polynomial Chaos



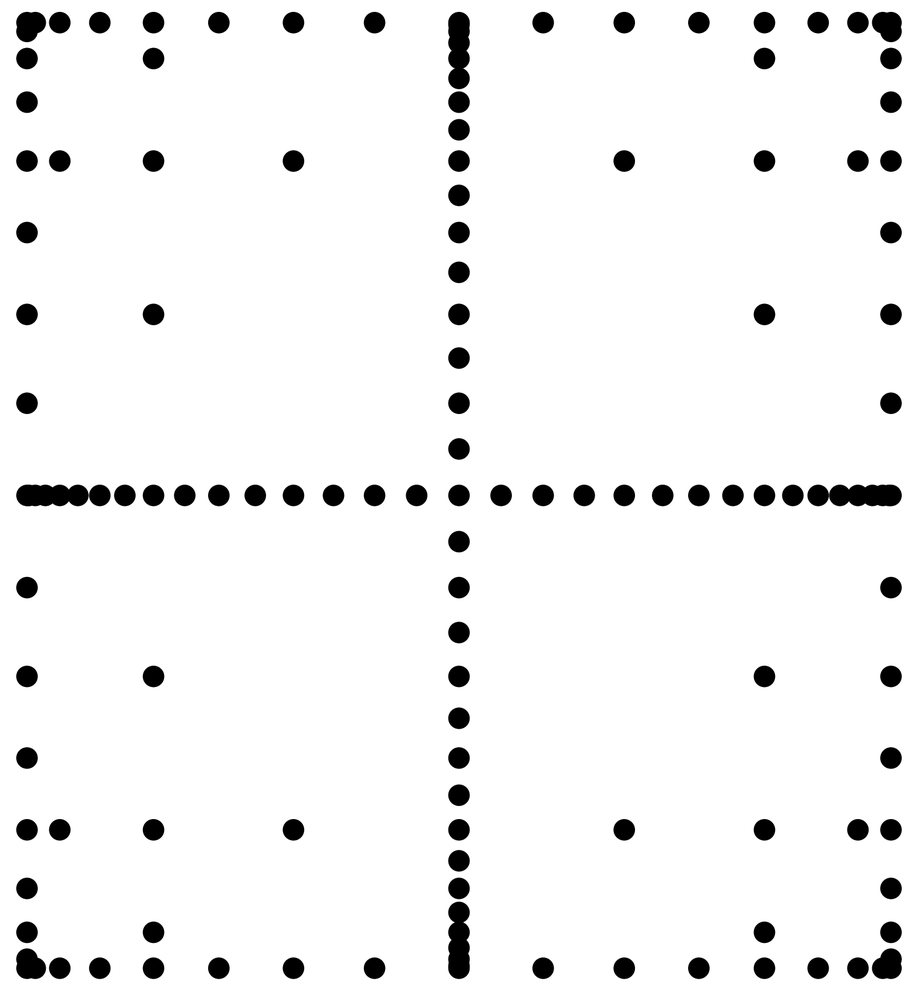
Quadratures

* Full-tensor-product



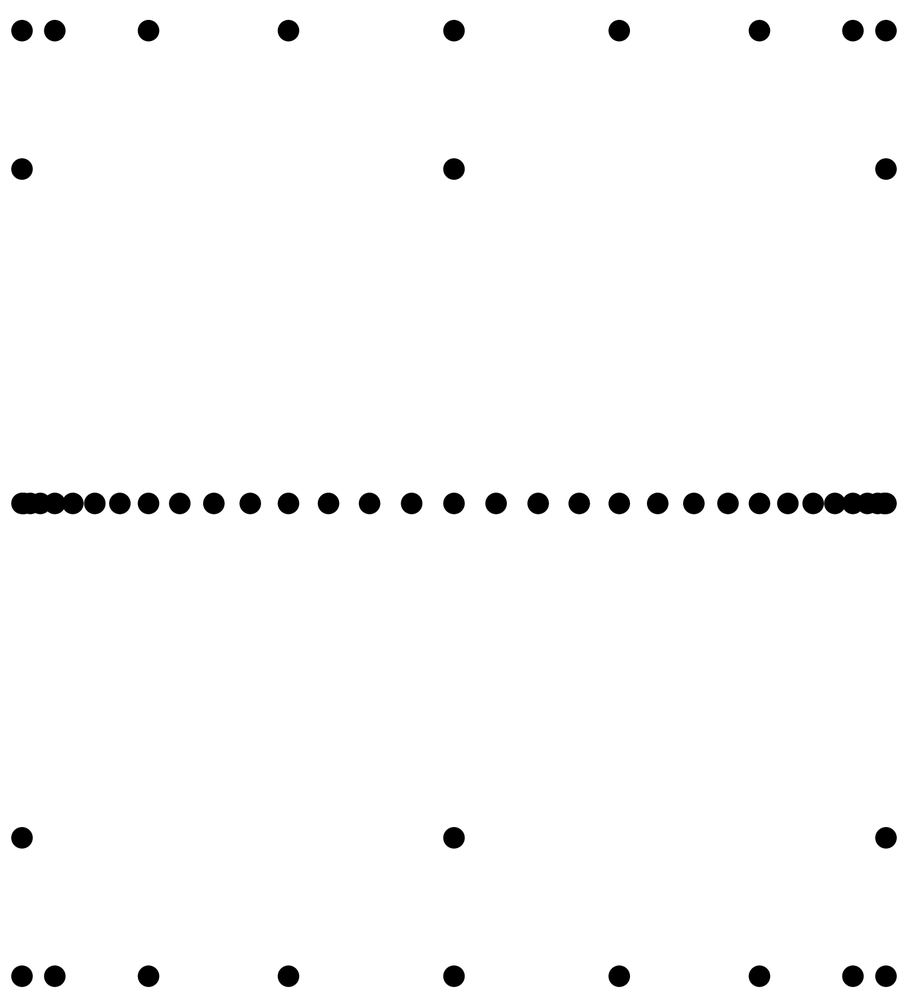
Quadratures

* Isotropic sparse

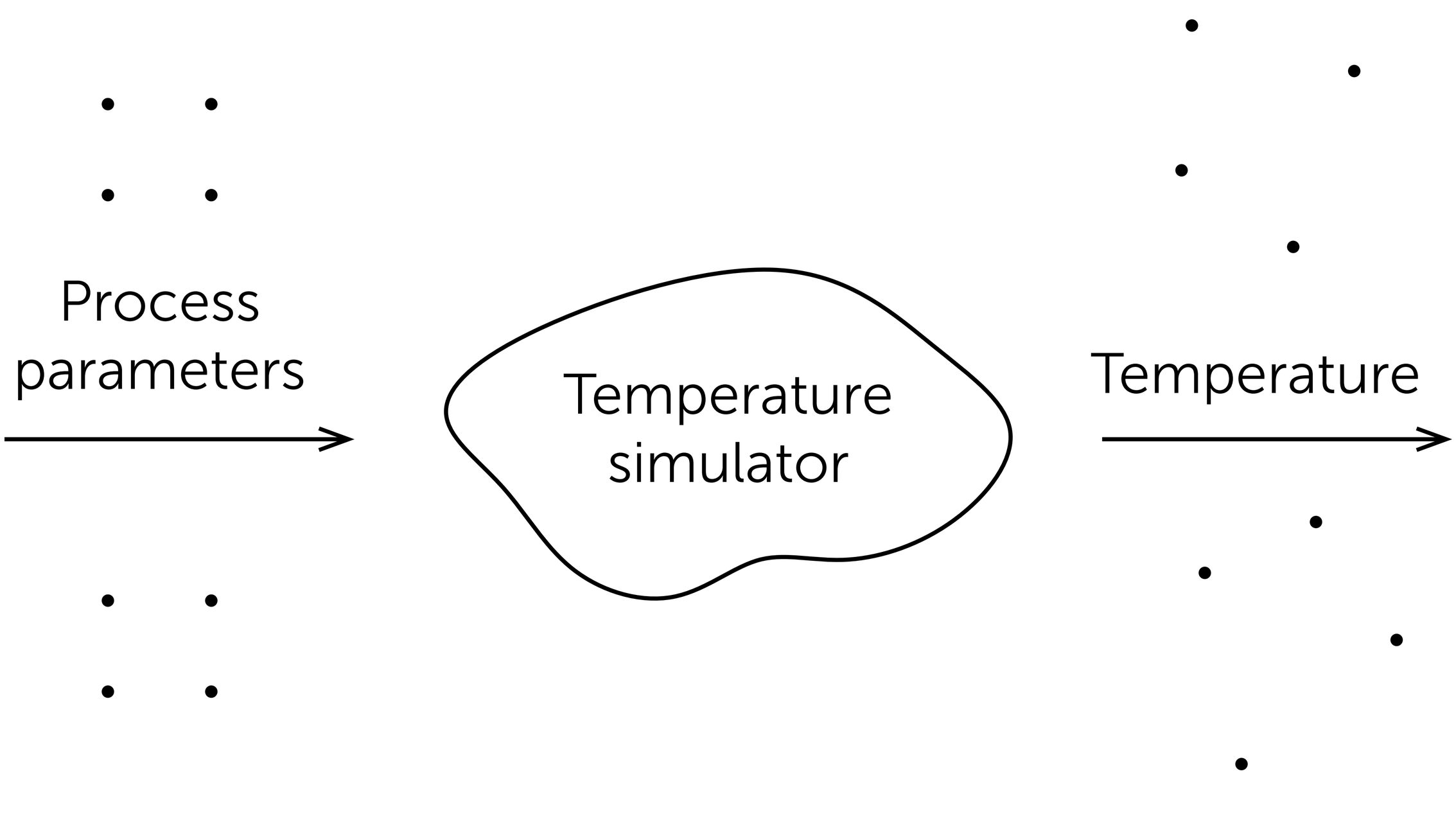


Quadratures

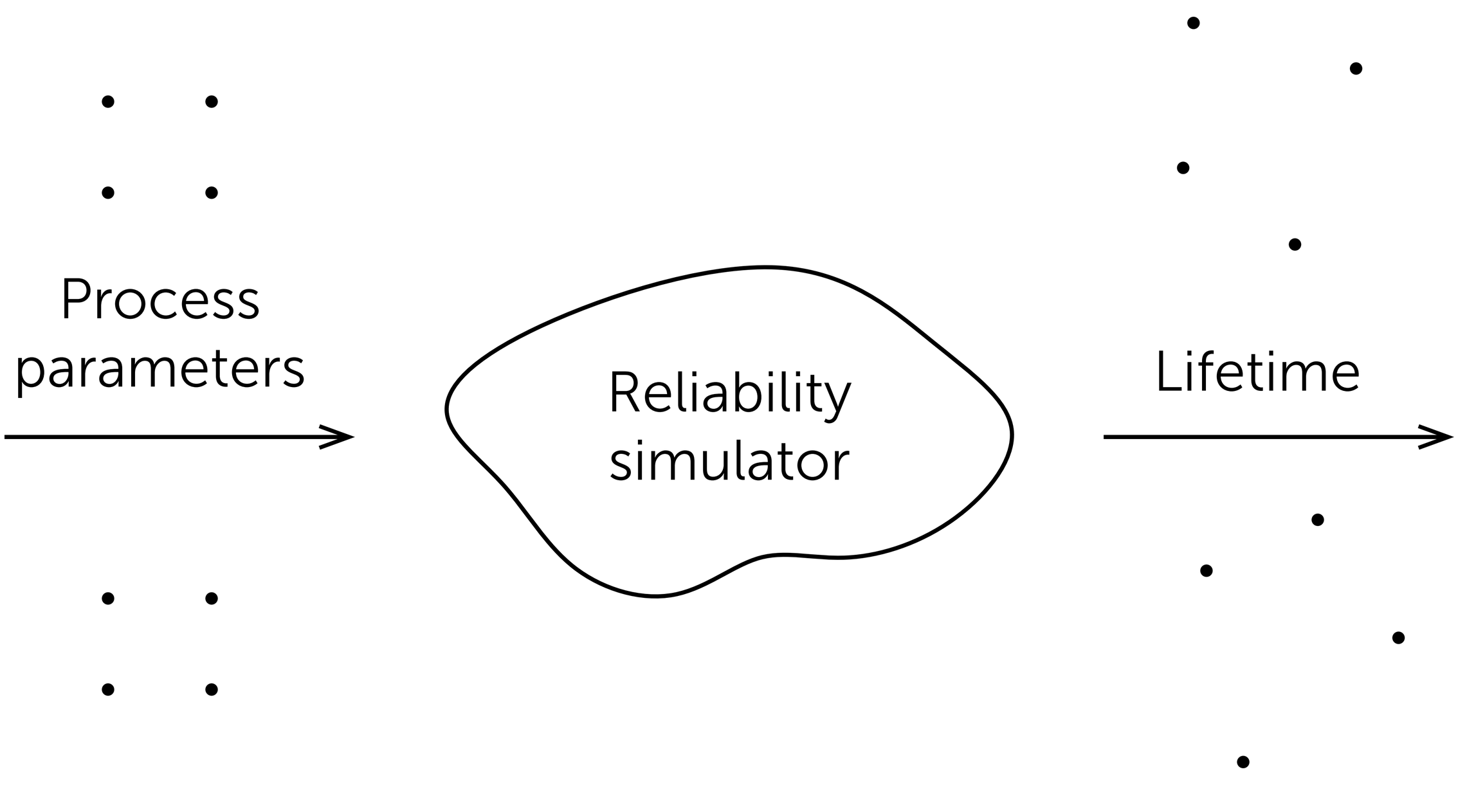
* Anisotropic sparse



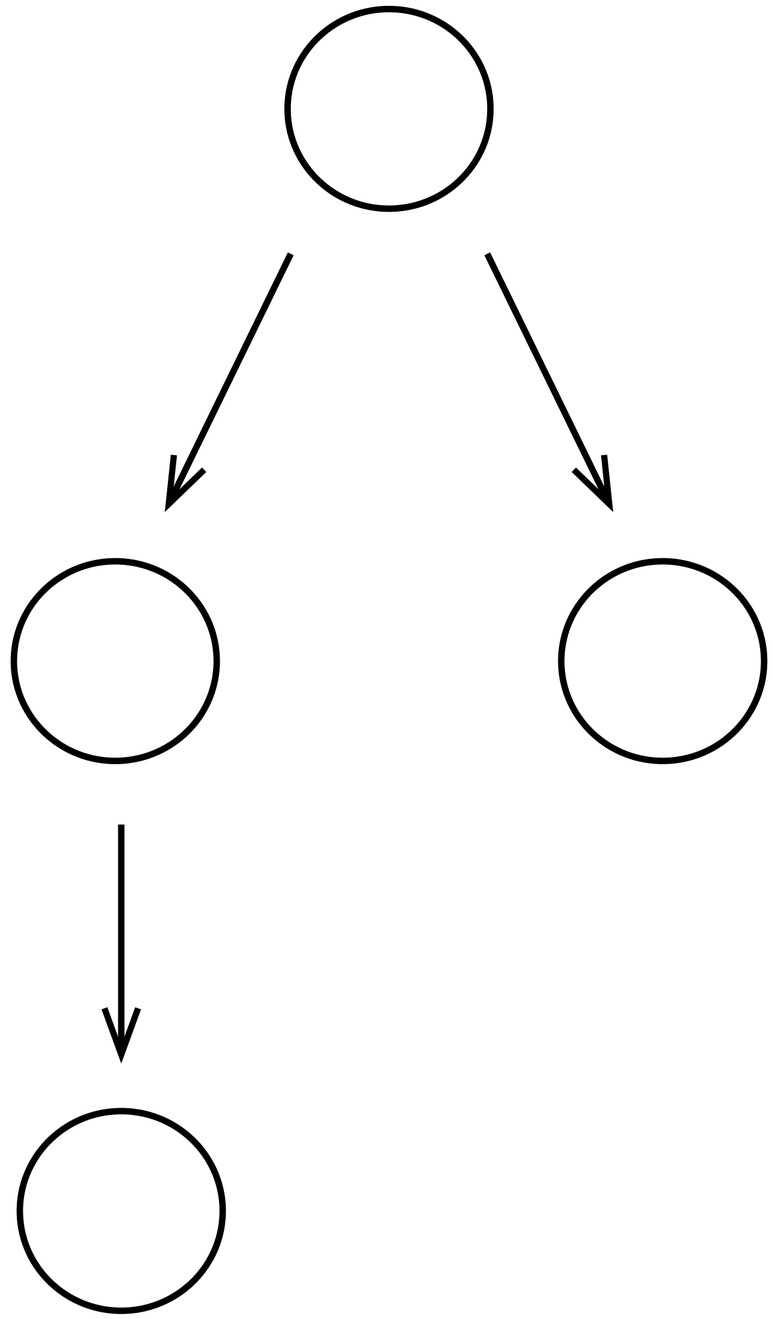
Temperature Analysis



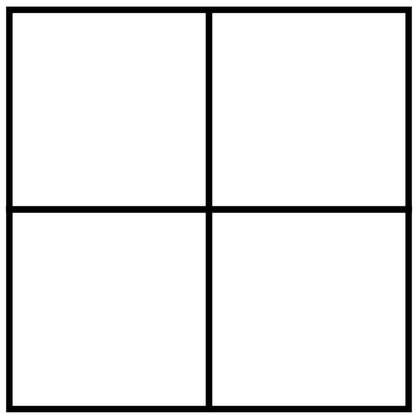
Reliability Analysis



Application



Platform



Core

Uncertain parameters:

* Effective channel length
* Gate-oxide thickness

Failure mechanism:

* Thermal cycling

Optimization

Minimize:

* Energy

Such that:

* Deadline
* Temperature
* Lifetime

Optimization

Minimize:

* Pr(Energy)

Such that:

* Deadline
* Pr(Temperature)
* Pr(Lifetime)

Setup

* 2, 4, 8, 16, and 32 cores
* 40, 80, 160, 320, and 640 tasks
* 10 test cases per pair cores/tasks

Calibration

Cores	Vars	Nodes
2	4	57
4	6	69
8	8	81
16	10	93
32	10	101

Optimization

Cores	P, min	D, min	F, %
2	1	1	40
4	5	2	60
8	17	4	70
16	56	8	100
32	300	9	100

Thank you!

Questions?