CORTEX
Core monitoring techniques and experimental validation and demonstration

Part I
Introduction and Motivations

Validation Workshop, 12-13 March 2020, Garching, Germany

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 754316.

Outline

- Validation of simulation tools
- Quantities of Interest
- Workshop objectives

Validation of Noise Simulators

Computer Code System

- Input Data
- Calculation (C)
- Uncertainty σ(C)

CASMO
state-of-the-art lattice physics

SIMULATE
steady-state nodal neutronics code

Validation

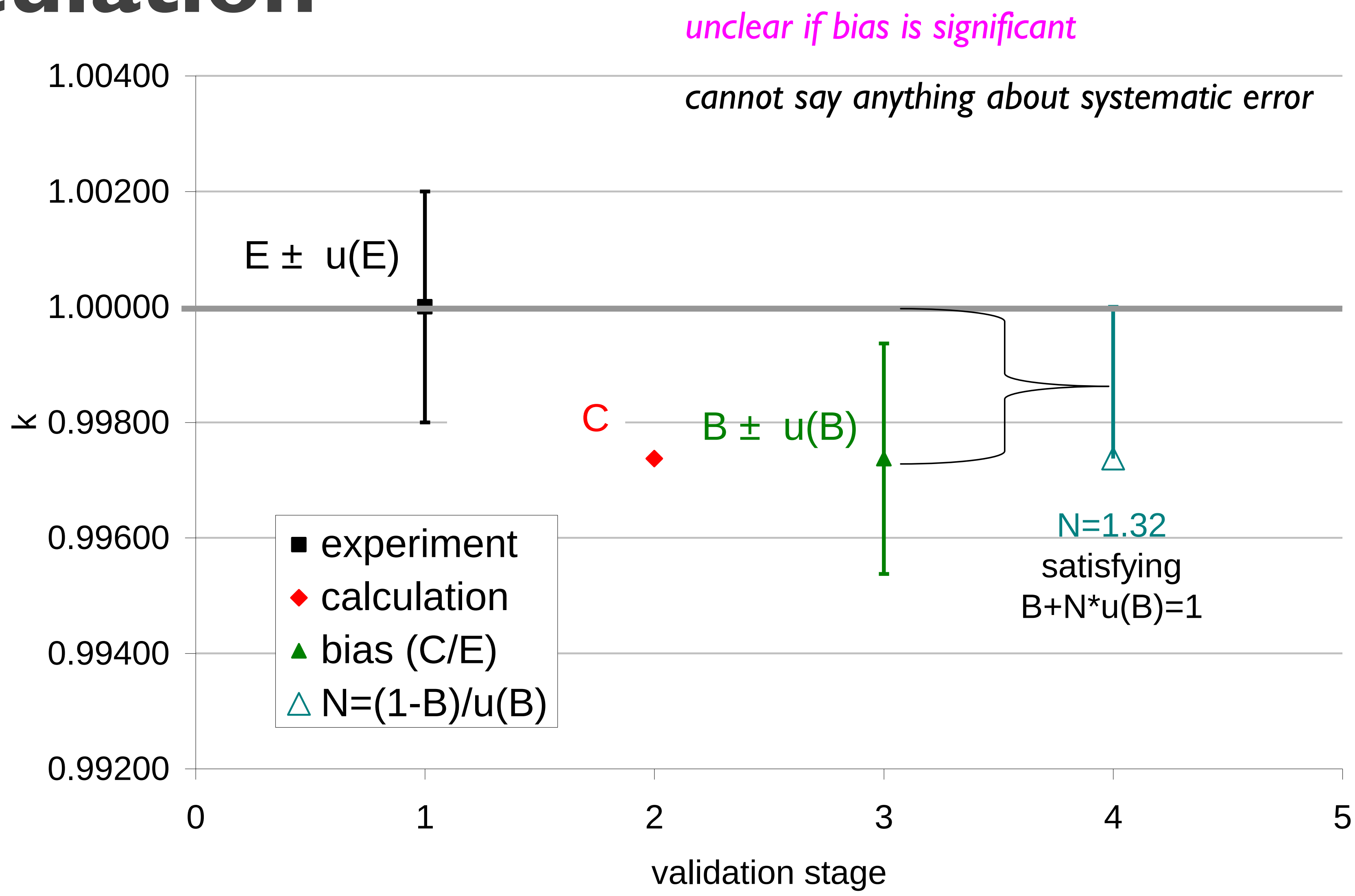
C/E+σ(C/E)

$$\sigma\left(C/E\right)=\sqrt{\sigma_E^2+\sigma_C^2}$$

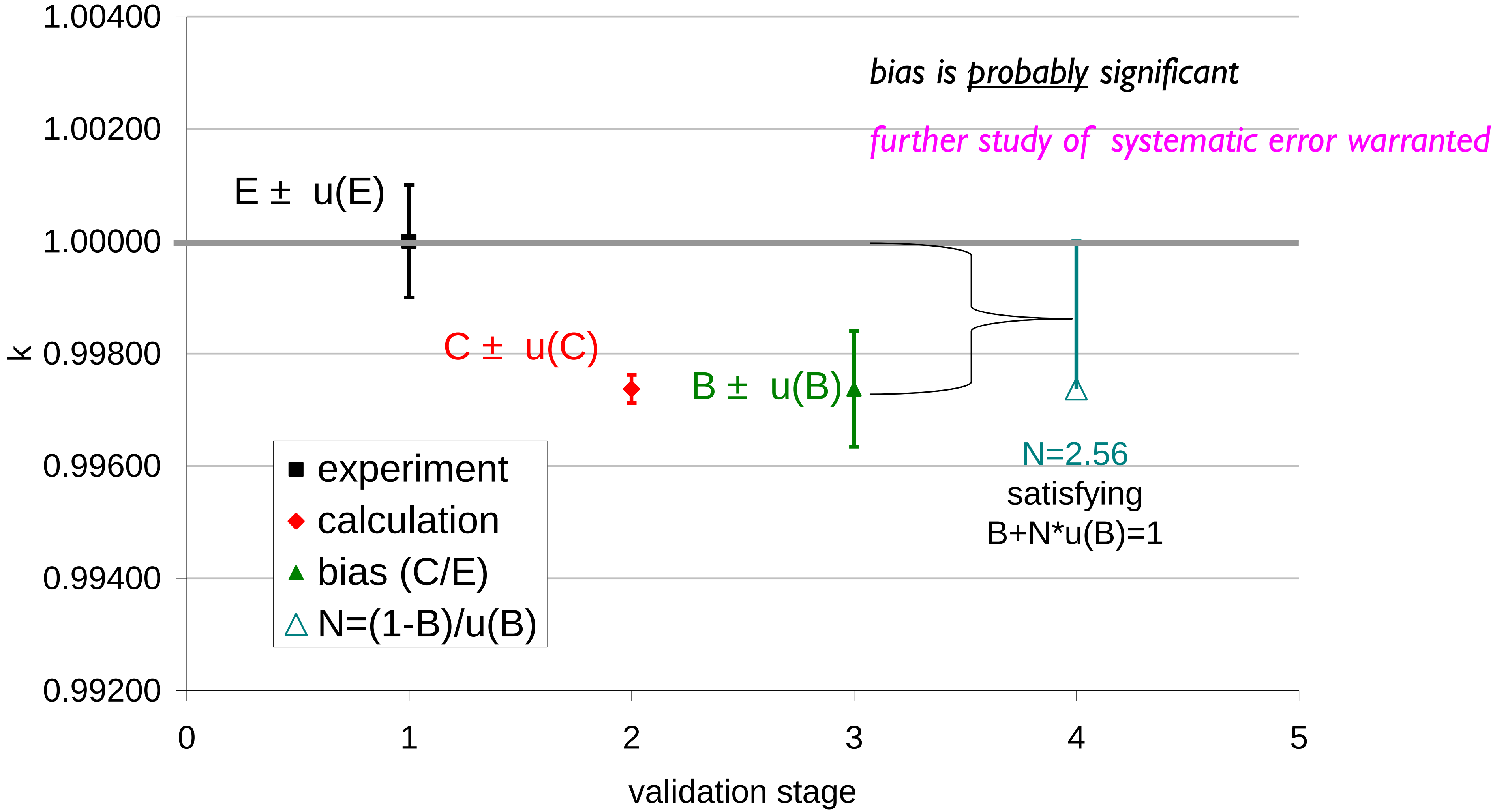
Experimental Facility

- Measurements (E)
- Uncertainty σ(E)

Evaluation of Bias without UQ on calculation



Evaluation of Bias with UQ



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Experimental Facility

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Reliable Predictive Tool?

NPP Design and Safety

Bias Estimation

Q: How wrong can my code be for the envisione[illegible] n?

Rep[illegible] tivity Analysis

Q: Is my exper[illegible] nt [illegible] able to demonstrate the performance of my code?

Not today

- Set up communication between experimentalists and simulation
  - What is reasonably ambitious about experiments?
  - What can reasonably be, or not be, the expectations for the validation of MP M&S tools?
  - Initiate a virtuous progress loop between simulation and experiments

Experimentalists are so bad!

Measure everything and perfectly

These simulation guys

I can very well measured only few things

High Level Objectives of Workshop

- Usually modelers/experimentalists do not have the full understanding of what the other side does
  - reliance on concise published reports

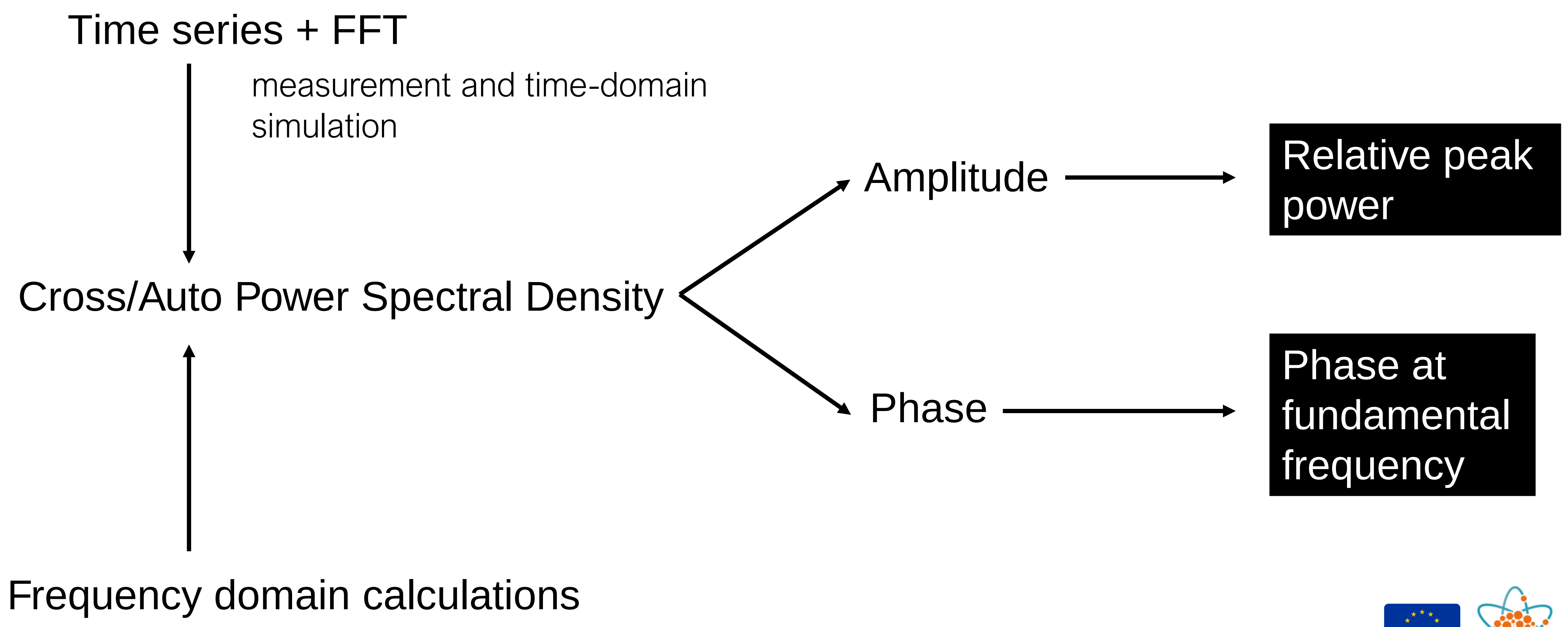
- CORTEX allows different approach as modelers/experimentalists work together in WP2

- Goal is for each side to develop as much as possible this understanding

Quantities of Interest for validation

"Amplitude of the neutron population fluctuations relative to the fundamental mode distribution"

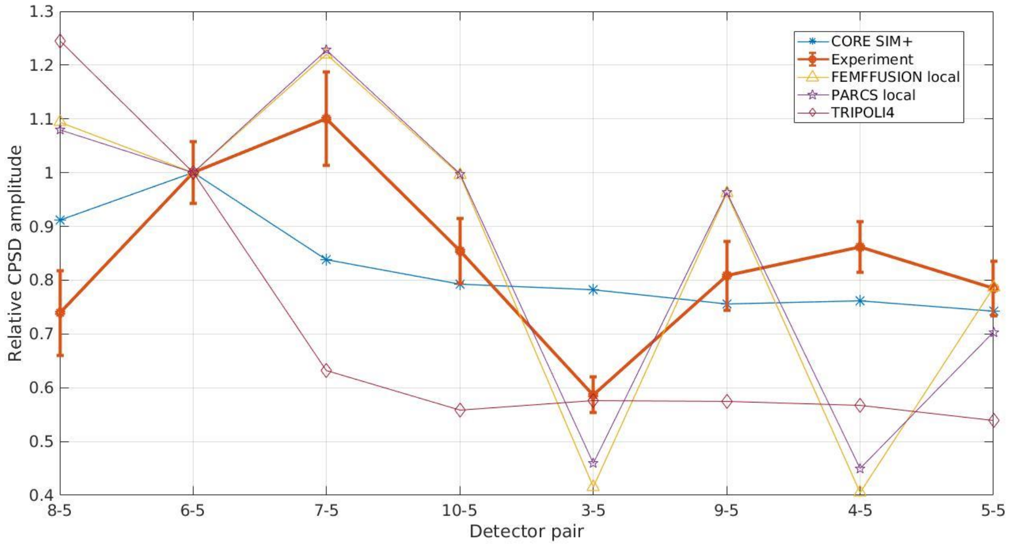
For a set of detectors



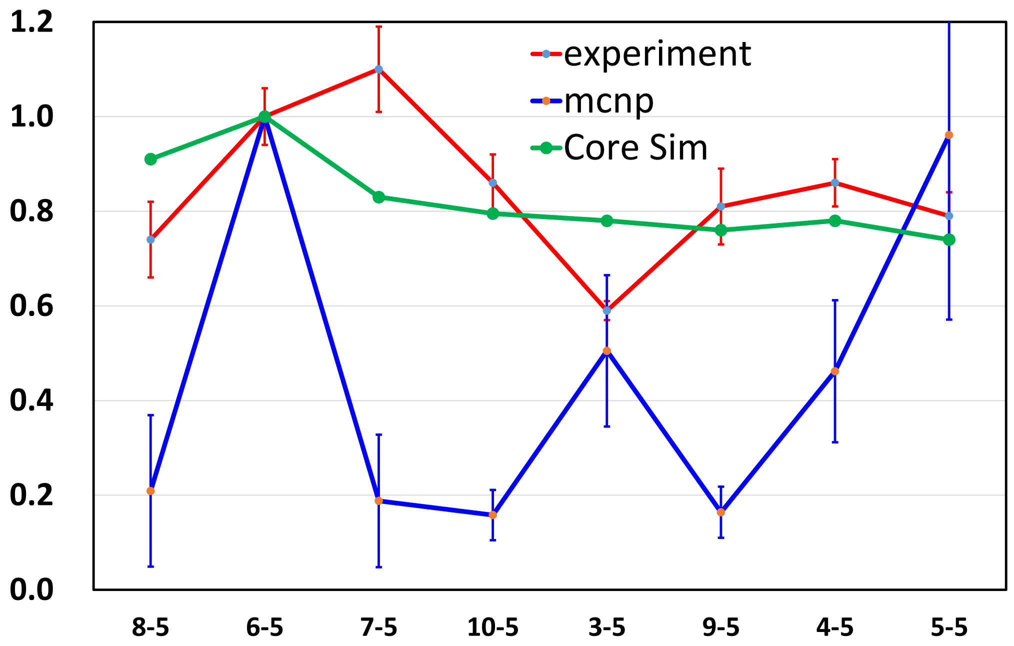
Benchmark Measurement # 12 @ CROCUS

- Deterministic solvers
  - CORE SIM+ (frequency-domain), FEMFFUSION and PARCS (time-dependent)
- MC solvers
  - TRIPOLI-4 and MCNP

CPSD ratio at fundamental frequency



CPSD ratio at fundamental frequency



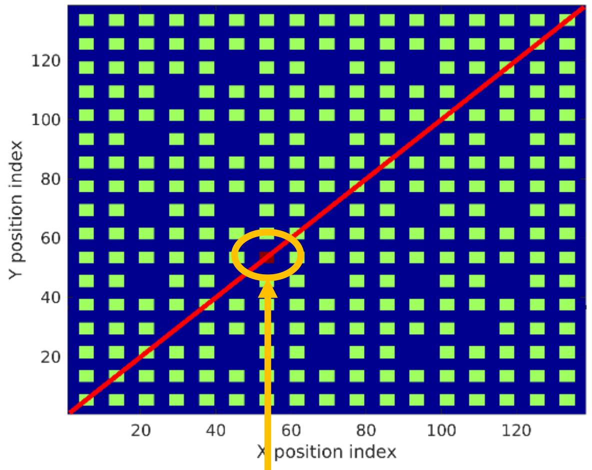
Code-to-code comparisons

- FEMFFUSION, PARCS (UPV) and CORE SIM (Chalmers)
- SN solver and CORE SIM+ (Chalmers)
- APOLLO3 and TRIPOLI-4 (CEA)
- TRIPOLI-4, CORE SIM+, Chalmers SN solver and Kyoto Monte Carlo solver

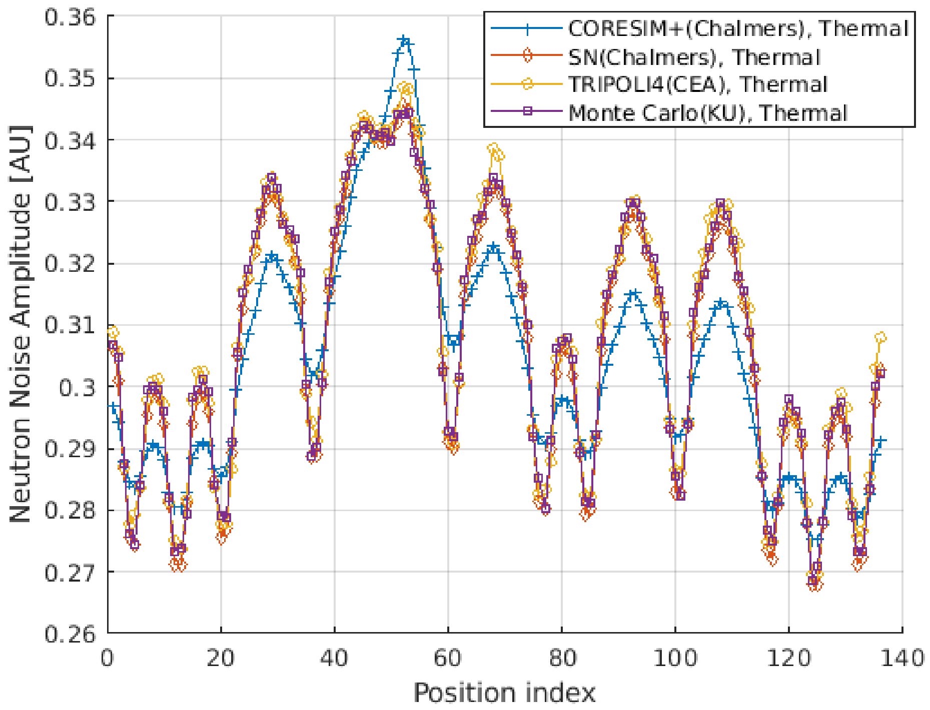
- Good agreements when simulating numerical benchmarks

Code-to-code comparisons - Example

- Benchmark based on a 2-D simplified UOX fuel assembly
  - Neutron noise source: oscillation of nuclear properties in one fuel pin
- Simulations
  - TRIPOLI-4 (CEA), MC solver (KU), Sn solver and CORE SIM+ (Chalmers)



Perturbed pin



Thermal noise amplitude

Fine-grain Objectives

- Develop an understanding for the observed discrepancies
- Understand the determination of experimental QoI and associated uncertainty
  - Independent assessment of experimental results is desirable
  - Decrease the number of basic questions to experimental teams
- Understand the determination of computational QoI and associated uncertainty
  - How is the detector response modeled (if any)?
  - How is the raw code input converted in a comparable quantity to what is measured?
  - How to determine the computational uncertainty?
  - How is the noise source modeled?

Thank you