CORTEX

Core monitoring techniques and experimental validation and demonstration

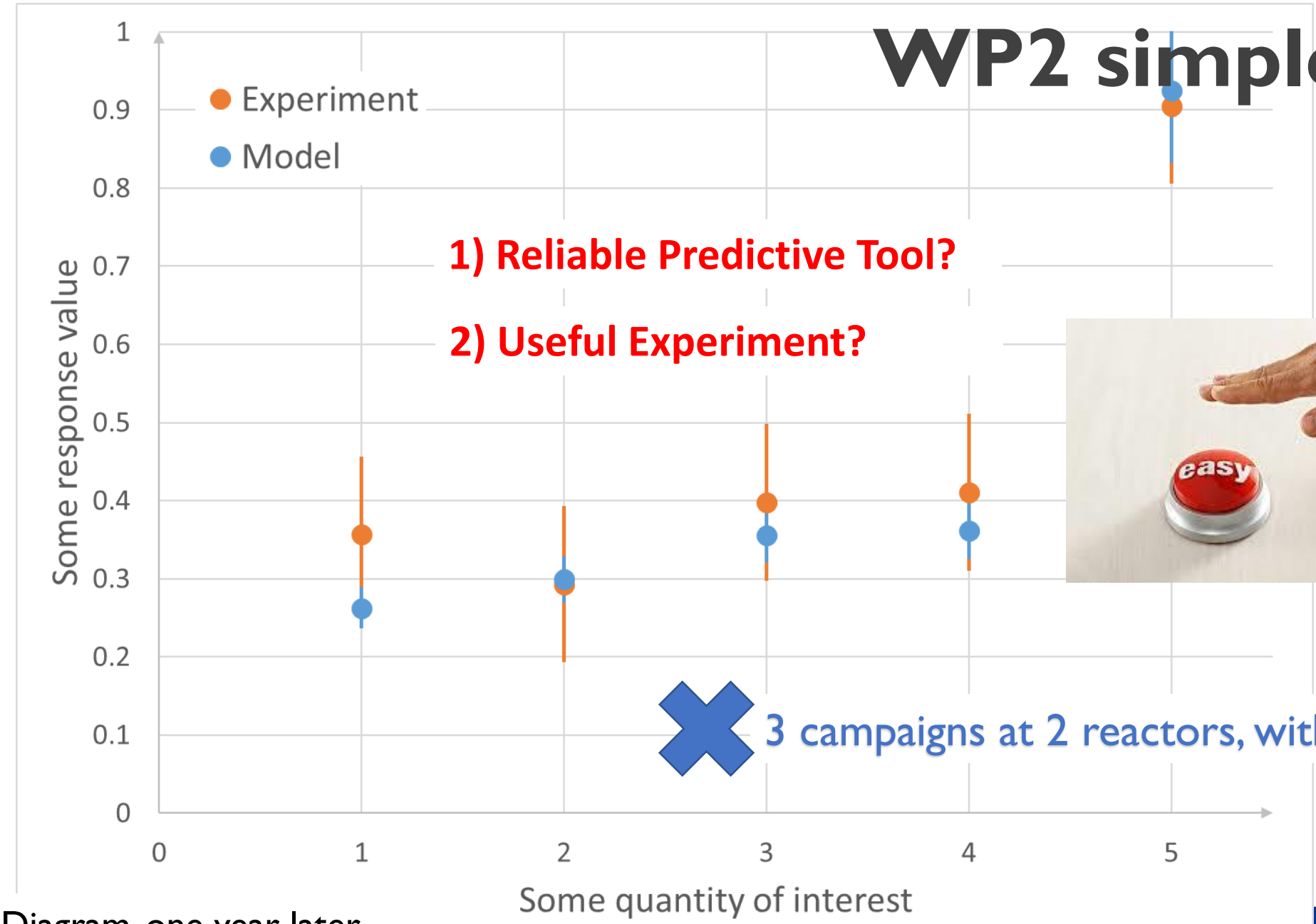
Summary of the validation exercise for AKR-2

Validation workshop, 23-24 March 2021

On behalf of all partners involved in WP2

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

WP2 simple life



1) Reliable Predictive Tool?

2) Useful Experiment?

3 campaigns at 2 reactors, with 7 models

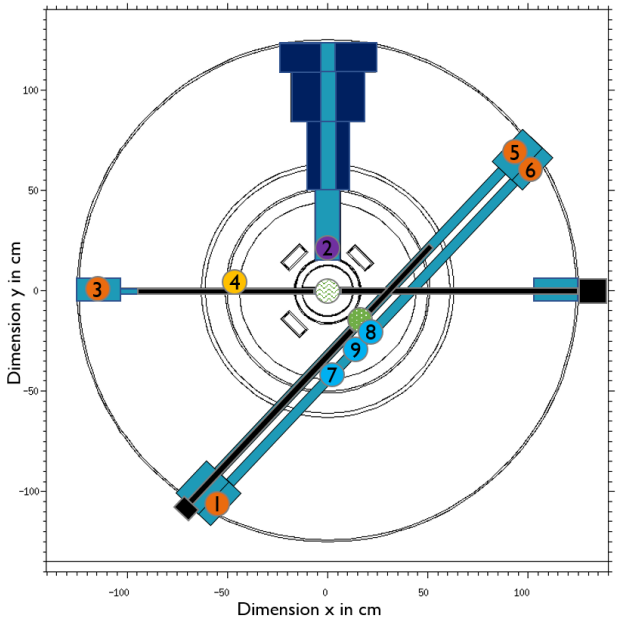
Gantt Diagram, one year later

Outline

- Spatial variation of the relative noise levels in AKR-2
- Overview of the code-to-code comparison for the AKR-2 model
- Overview of the code-to-experiment comparison
- What did we learn?

Codes, QoI, Experimental data

- Computational results of Chalmers (CORESIM+), Kyoto University (MCNP)
- Experimental results for the 2nd campaign (EXP)
- Focus on the relative noise amplitude at the fundamental frequency and detector location
- PSD_{ref} is at the detector 8 location



- Accessible experimental channel
- Location of perturbation
  - Rotating device
  - Linear motor axis
- Tall fission chamber
- Small fission chamber
- He-3 counter
- Fibers
- PE- elements
- Regions blocked with the mechanical parts of the perturbation devices

Power ratio: $R_i = \frac{PSD_i}{PSD_{ref}}$

Measurements of the 2nd campaign at AKR-2

	Device	Frequency in Hz	Position of VA wrt center in cm	Amplitude in cm
1	AVS	2		
2	AVS	2		
3	AVS	0.1		
4	AVS	0.1		
5	AVS	4		
6	AVS	4		
7	AVS	1		
8	AVS	2		
9	VA	2	4	0.5
10	VA	0.1	4	0.5
11	VA	7	4.5	1
12	VA	0.01	4.5	0.5
13	VA	0.01	4.5	0.5
14	AVS	2		
15	VA	0.01	0	2
16	VA	0.01	0	2
17	VA	1	0	2
18	VA	1	0	2
19	VA	4	5.5	3
20	VA	2	5.5	3
21	AVS	2		
22	VA	2	5.5	3
23	Both	2	4	0.5

Do not use

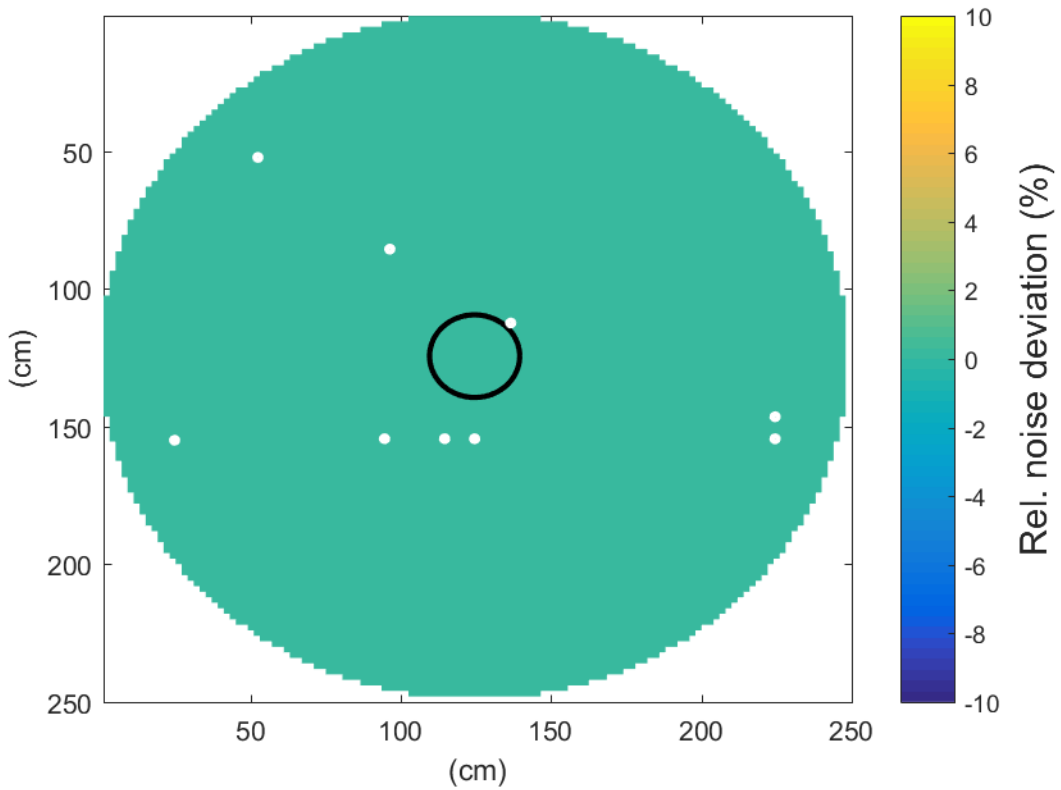
Handle with care

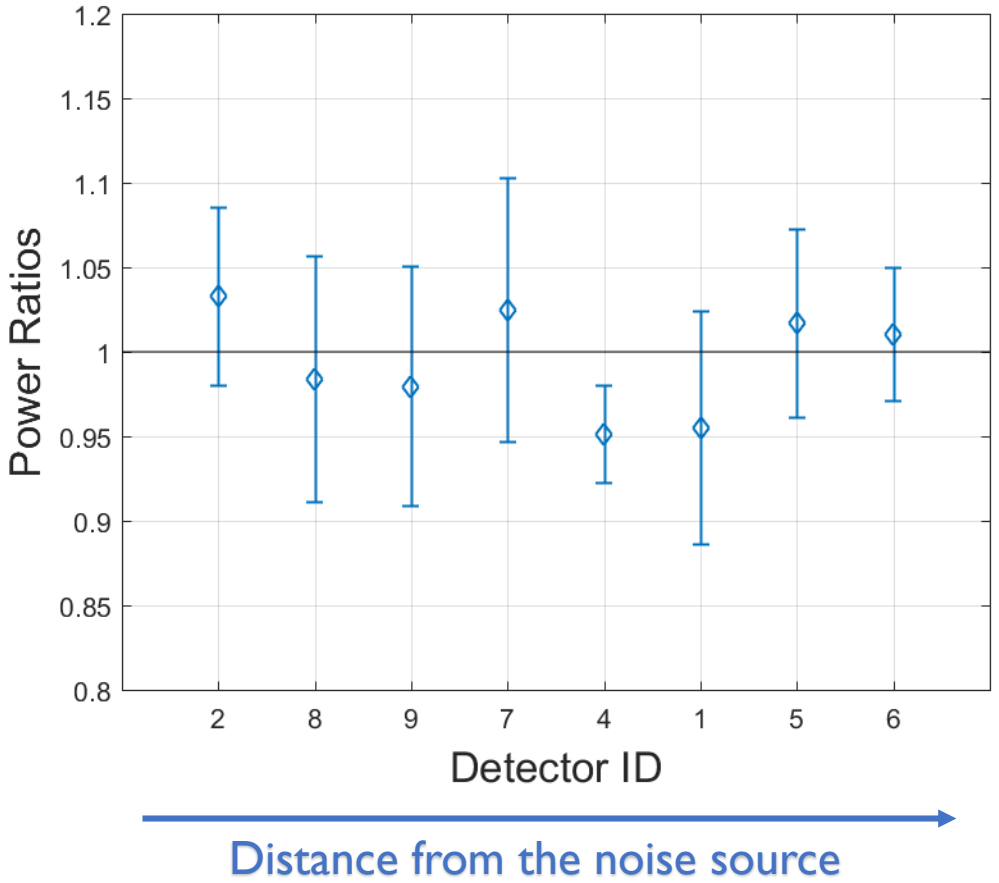
Reliable

AVS: absorber of variable str.

VA: vibrating absorber

The perfect point reactor



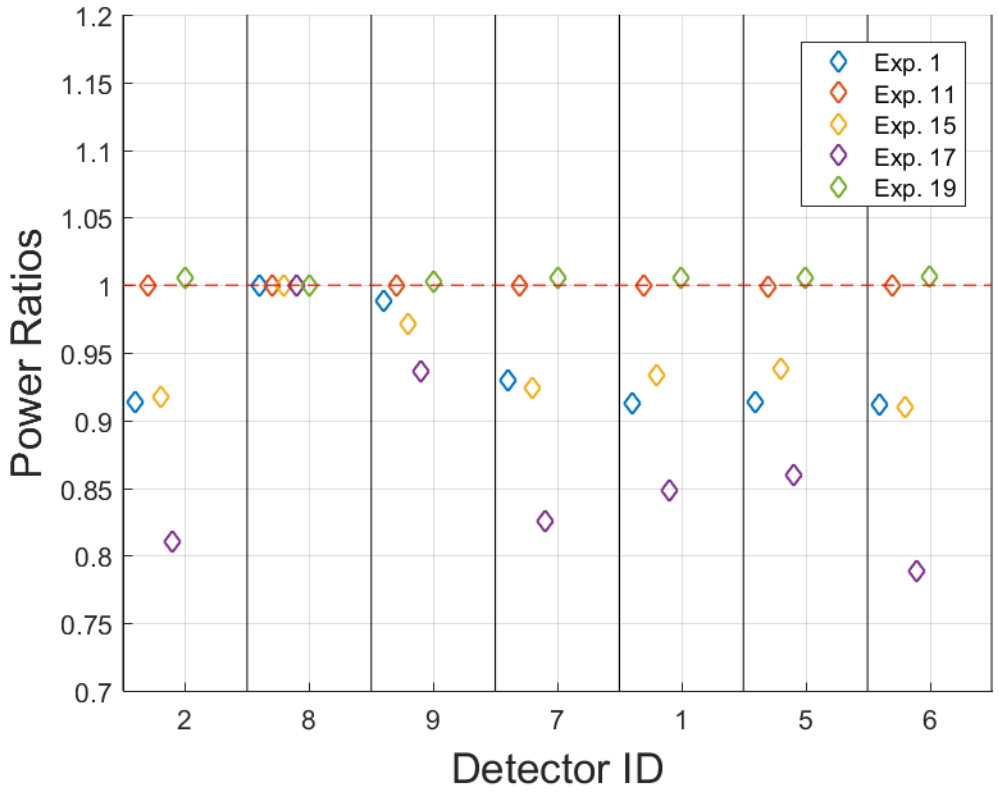


We are interested in significant deviations from 1; the larger the better

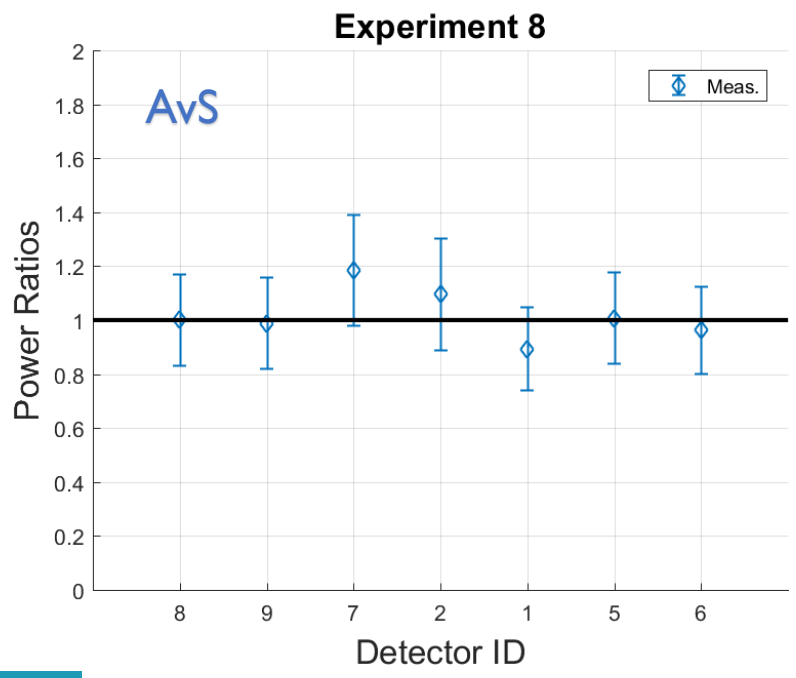
Spatial variation of the noise

Experiment No	Type	Frequency in Hz	Motion parameters in cm	
			centre	amplitude
1/8/14/21	AVS	2		
11	VA	7	4.5	1
15	VA	0.01	0	2
17	VA	1	0	2
19	VA	4	5.5	3

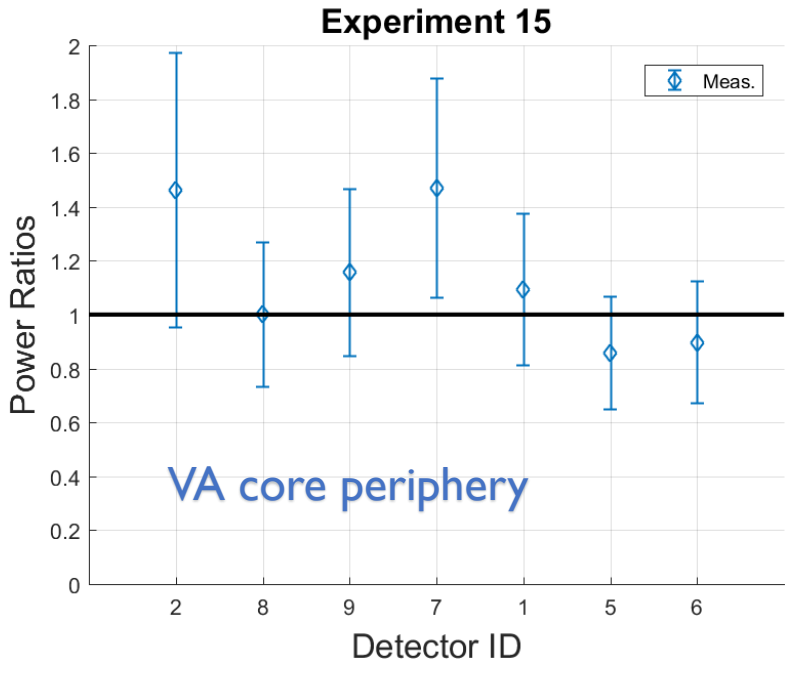
- CORESIM+ calculations
- Spatial variations are dependent of experimental parameters
- At the detector locations, Exp 1 (AvS) and 17 (centered VA) should allow seeing largest spatial effect
  - Centered VAs are best
  - Larger frequencies increase this effect
  - Largest deviation ~ 20%



Typical experimental uncertainties



Distance from the noise source



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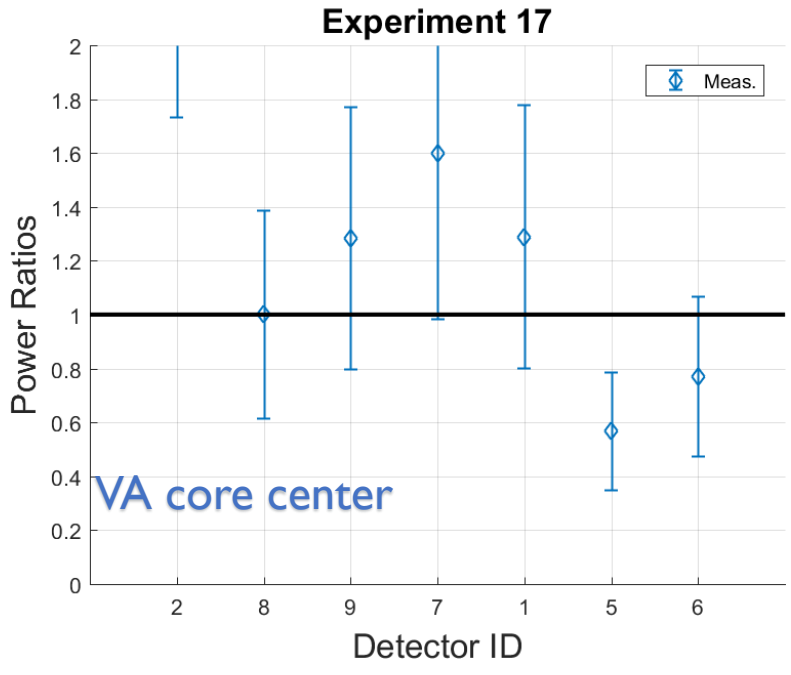


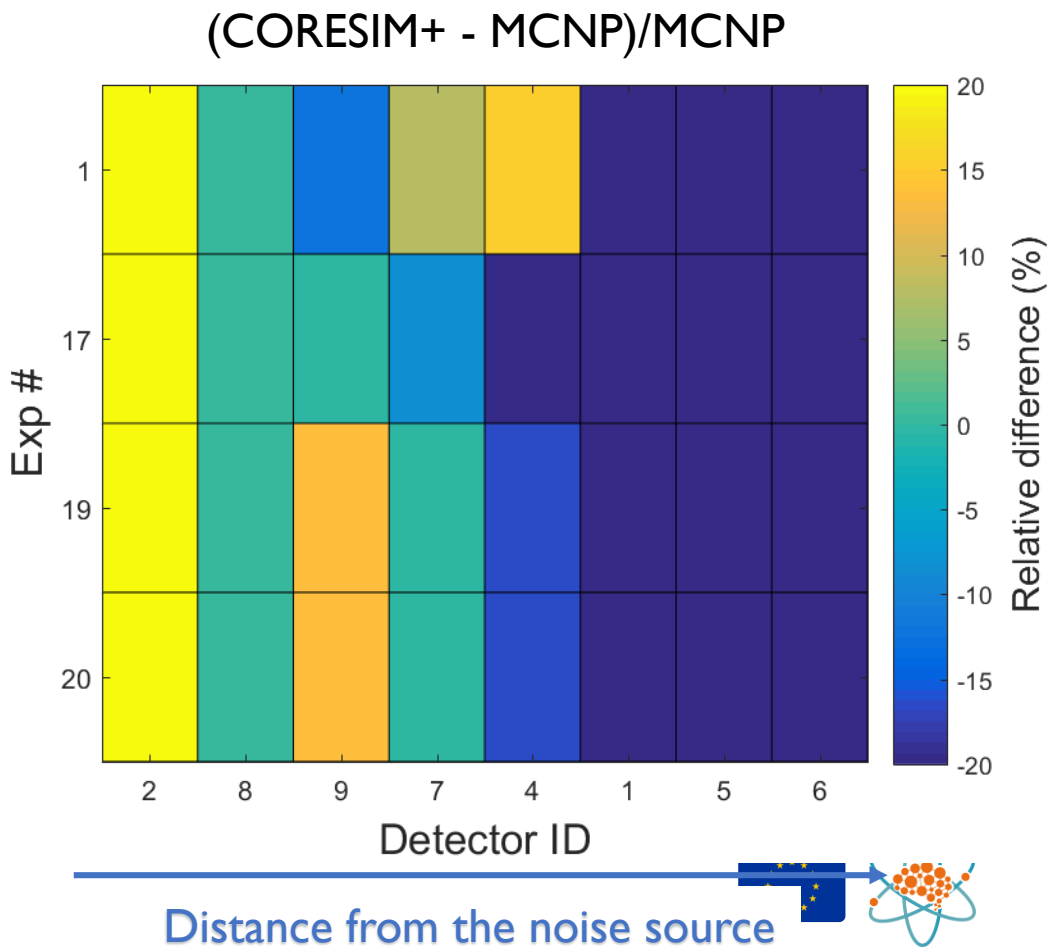
Distance from the noise source

Exp. data does not allow "seeing" deviations from PK behavior

Code-to-code comparison

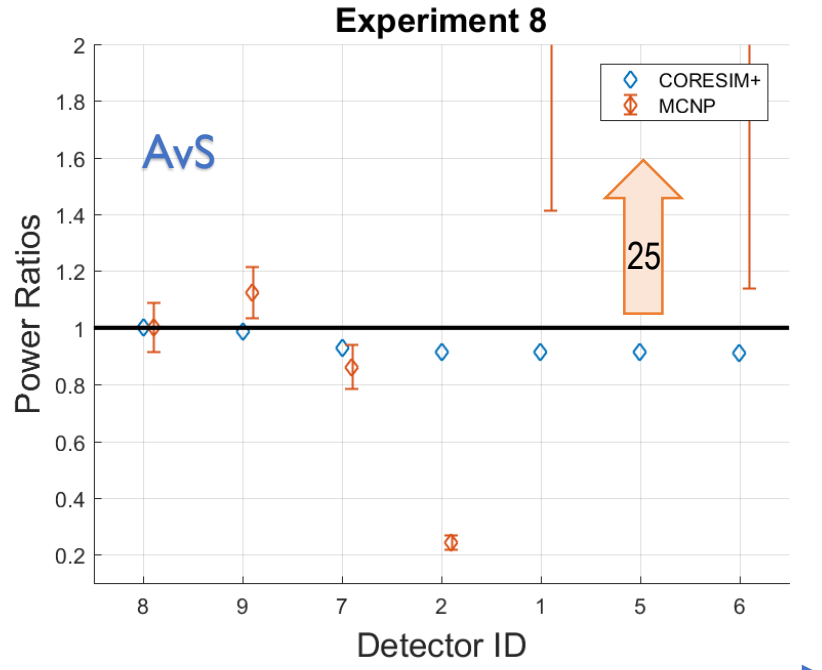
Experiment No	Type	Frequency in Hz	Motion parameters in cm	
			centre	amplitude
1	AVS	2		
17	VA	1	0	2
19	VA	4	4.5	3
20	VA	2	4.5	3

- Overlapping set is composed of exp. 1 (AVS) and 17 19 20 (VA)
  - 19 and 20 should provide similar outcomes (VA at different frequencies)
- Detector responses are the thermal flux at the detector location (CORESIM+) or the reaction rates at the detector location (MCNP)



Code-to-code comparison

- Statistically significant differences for Detector #2
- Detectors away from the core center are widely different
  - Noise levels are consistently larger for 1 5 & 6 for MCNP but MC uncertainties are also very large



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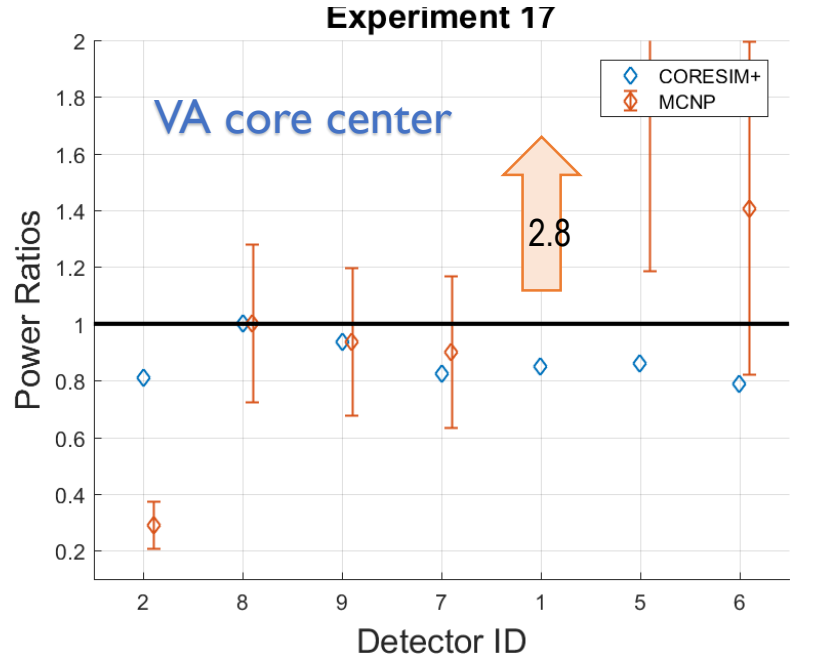
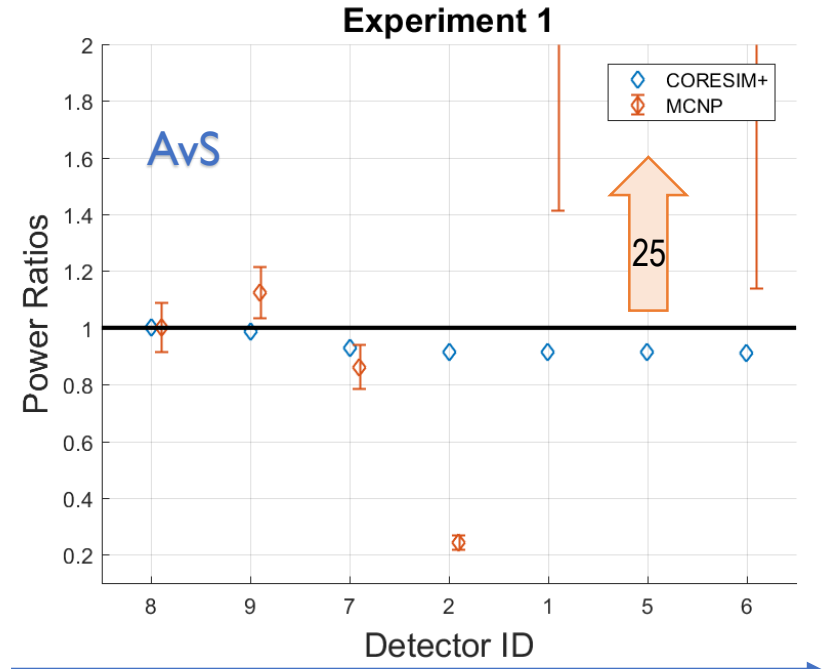
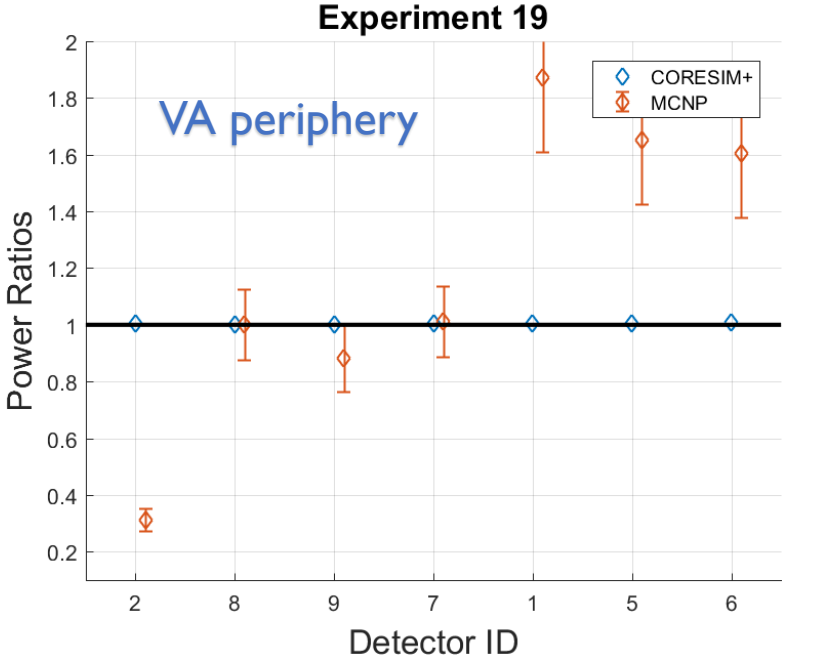


Code-to-code comparison

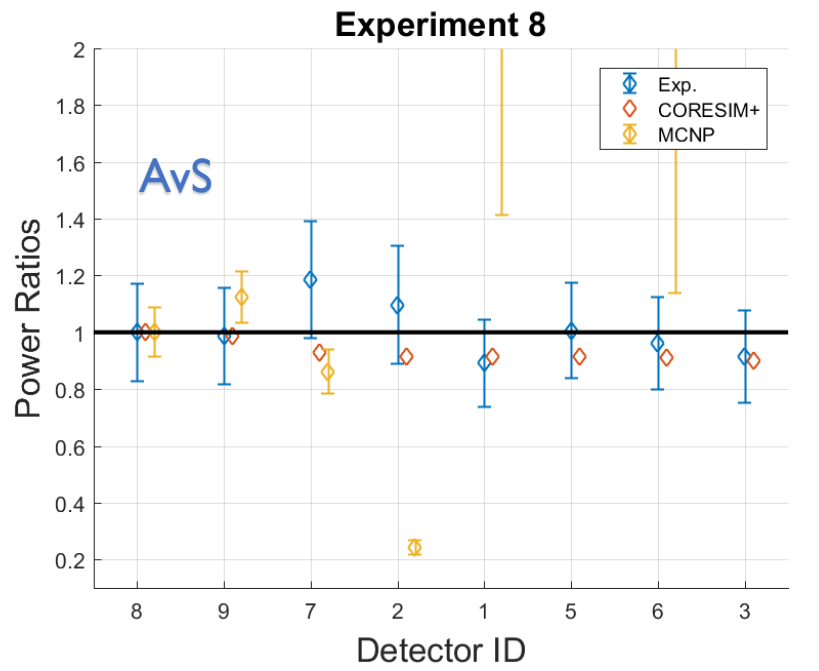
- Statistically significant differences for Detector #2
- Detectors away from the core center are widely different
  - Noise levels are consistently larger for 1 5 & 6 for MCNP but MC uncertainties are also very large
- MCNP does not confirm spatial trends of CORESIM+ close to the core (detectors 7,8 & 9)
  - MC uncertainties are too large
  - Even for VA in the core periphery



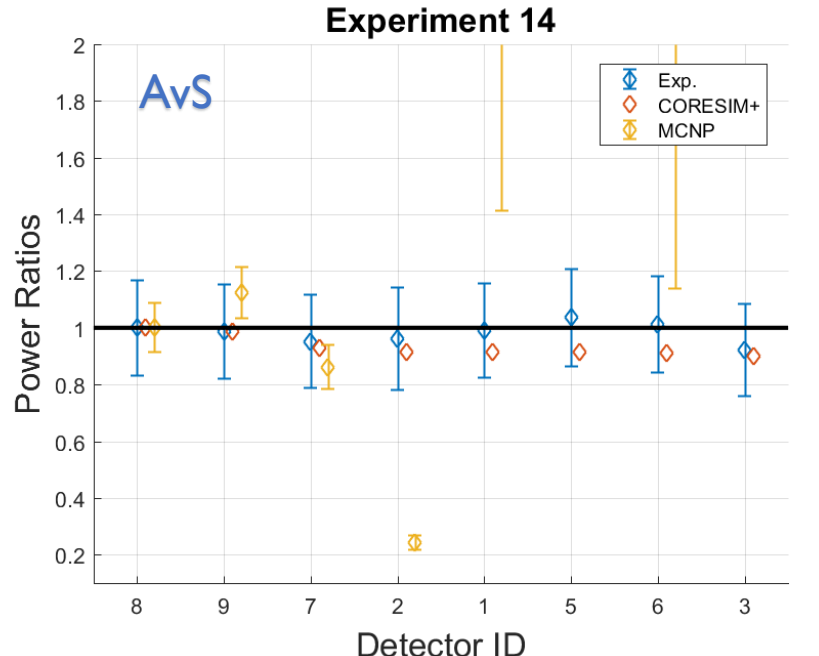


Comparison to experimental data (AvS)

- Magnitude of the computational uncertainties <1%
- CORESIM+ results are consistent with experimental results for det #2; and far from the noise source (1,5 & 6)

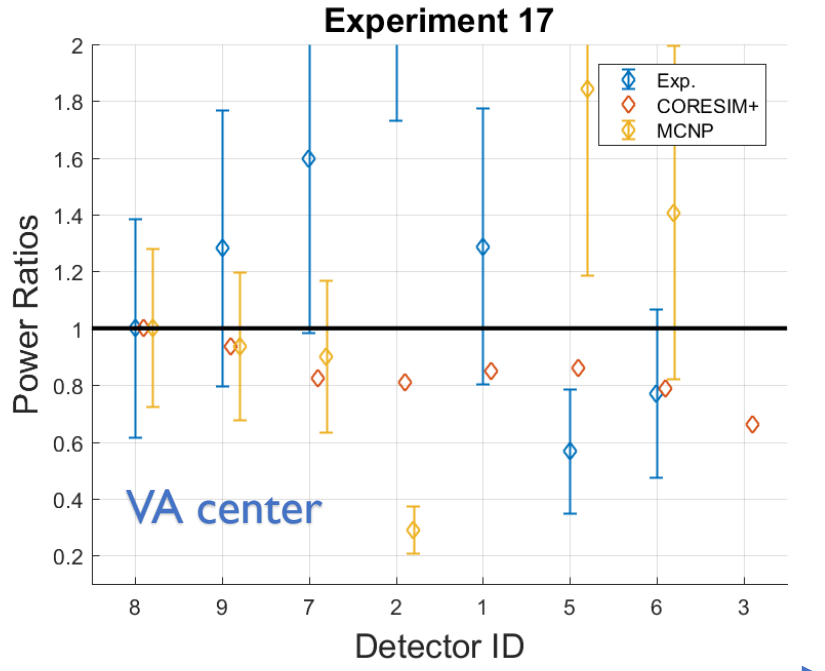


Distance from the noise source

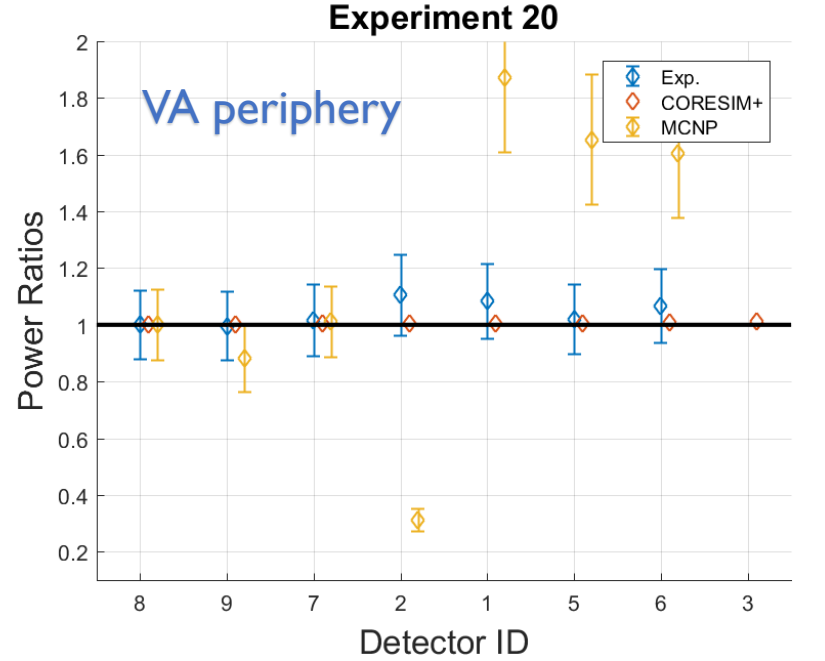


Comparison to experimental data (VA)

- Magnitude of the computational uncertainties <1%
- CORESIM+ results are consistent with experimental results for det #2; and far from the noise source (1,5 & 6)



Distance from the noise source



Conclusions

- AKR-2 is difficult to model for both deterministic and stochastic codes
- Power ratios are difficult to measure with sufficiently small uncertainties
  - No spatial behavior of the noise could be experimentally observed yet
  - Configurations allowing largest deviation from PK behavior identified
- Computational trends/issues have been identified with MCNP models
  - MC uncertainties are difficult to reduce even close to the core
  - Modeling of detector #2
  - Behavior at large distances
- CORESIM+ appears reliable at least in terms of trends; it is not crazy to use it within ML algorithm

Thank you