Watts Bar I cycle 7 CIPS UQ Update

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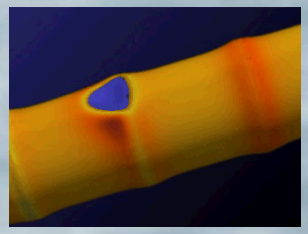
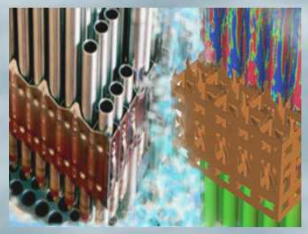




Parameter Sensitivity Timeline

- VERA code snapshot of March 9, 2016
- MAMBA from vuq branch → allow params from file
- Patched Mpact for bug fix (of March 10)
- Default Mamba params→ Bthresh = 0.005, Bfract = 0.16
- Baseline run on 60 cores on Titan → agreement with Andrew
- QoIs:
  - Max crud thickness (baseline: 2.06 um)
  - Total boron (baseline: 0.7280 units?)
- Confirmed HGAP and KCOND now inactive
- Attempted reruns on Mar. 31 failed due to TPL changes

Parameter Sensitivity Timeline, Pt. 2

- Patched Cobra-TF to fix k_tmasl (required reducing perturbation to +-5%)
- Obtained Stable VERA-CS (VERARepoVesion.txt)
- Updated to Dakota 6.3+
- Updated Mamba params → Bthresh = 0.001, Bfract = 0.42
- Changed time units: GWDMT → EFPD
- QoIs:
  - Max crud thickness (baseline: 55.5 um, cf 2.06 um)
  - Total boron (baseline: 22,600, cf 0.728)

Initial Observations

- ✓Need stable VERA code
- ✓Need stable run environment (modules/TPLs)
- ✓Need credible baseline (values and performance)

- Dakota concurrency can overwhelm filesystem
- Perturbations to empirical expressions (curve fits) must respect coefficient correlations (joint variation)
- Small crud thickness can exaggerate sensitivity, i.e. sensitivity normalized by baseline thickness

Sensitivity Studies

VERAIn

*ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_BLK/thden
*ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_U43/thden
*CORE/rated_flow
*CORE/rated_power
+ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_BLK/enrichments[1]
+ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_U43/enrichments[1]
+STATES/State_1/pressure
+STATES/State_1/tinlet

Sensitivity Studies

VERAIn

*ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_BLK/thden
*ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_U43/thden
*CORE/rated_flow
*CORE/rated_power
+ASSEMBLIES/Assembly_B9B-128I/Fuels/F
+ASSEMBLIES/Assembly_B9B-128I/Fuels/F
+STATES/State_1/pressure
+STATES/State_1/tinlet

CTF

k_cd
k_cdfb
k_clad_avg_tmp
k_cond
k_cool_avg_den
k_cool_avg_tmp
k_eta
k_fuel_avg_tmp
k_gama
k_hgap
k_htcl
k_htcv
k_qliht
k_qradd
k_qradv
k_qvapl
k_rodqq

Nominal perturbations of +- 10%

Sensitivity Studies

VERAIn

*ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_BLK/thden
*ASSEMBLIES/Assembly_B9B-128I/Fuels/Fuel_U43/thden
*CORE/rated_flow
*CORE/rated_power
+ASSEMBLIES/Assembly_B9B-128I/Fuels/F
+ASSEMBLIES/Assembly_B9B-128I/Fuels/F
+STATES/State_1/pressure
+STATES/State_1/tinlet

CTF

k_cd
k_cdfb
k_clad_avg_tmp
k_cond
k_cool_avg_den
k_cool_avg_tmp
k_eta
k_fuel_avg_tmp
k_gama
k_hgap
k_htcl
k_htcv
k_qliht
k_qradd
k_qradv
k_qvapl
k_rodqq

MAMBA

k_Bthresh
k_Cpor
k_crud_solid
k_delta_r
k_fac
k_Hc
k_kp2
k_mit0
k_Nc
k_rc
k_Tsat

(k_Bfract)

Nominal perturbations of +- 10%

Candidate Parameters

VERAIn

+STATES/State_1/tinlet
*CORE/rated_power
+STATES/State_1/pressure
*CORE/rated_flow

Boiling

CTF

k_rodqq
k_rodqq

Heat Xfer

MAMBA

k_Bthresh
k_Cpor
k_crud_solid
k_delta_r
k_fac
k_Hc
k_kp2
k_mit0
k_Nc
k_rc
k_Tsat

Consistent with CTF values?

Relatively Unimportant Parameters

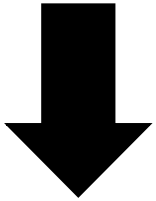
Xsec Filename	Max Crud	Total Boron
mpact47g_70s_v4.0_pert_1.fmt	-0.03%	0.24%
mpact47g_70s_v4.0_pert_10.fmt	-0.08%	-0.27%
mpact47g_70s_v4.0_pert_100.fmt	-0.52%	-0.37%
mpact47g_70s_v4.0_pert_11.fmt	-0.01%	0.48%
mpact47g_70s_v4.0_pert_12.fmt	0.09%	0.40%
mpact47g_70s_v4.0_pert_13.fmt	-0.14%	0.46%
mpact47g_70s_v4.0_pert_14.fmt	-0.19%	0.34%
mpact47g_70s_v4.0_pert_15.fmt	0.18%	0.81%
mpact47g_70s_v4.0_pert_16.fmt	-0.44%	-0.76%
mpact47g_70s_v4.0_pert_17.fmt	-0.31%	-0.29%
mpact47g_70s_v4.0_pert_18.fmt	-0.12%	0.25%
mpact47g_70s_v4.0_pert_19.fmt	0.08%	-0.69%
mpact47g_70s_v4.0_pert_2.fmt	0.15%	0.11%
mpact47g_70s_v4.0_pert_20.fmt	-0.29%	-0.89%
mpact47g_70s_v4.0_pert_21.fmt	-0.25%	0.12%
mpact47g_70s_v4.0_pert_22.fmt	-0.49%	-0.14%
mpact47g_70s_v4.0_pert_23.fmt	0.22%	0.79%
mpact47g_70s_v4.0_pert_24.fmt	-0.05%	-0.37%
mpact47g_70s_v4.0_pert_25.fmt	-0.02%	0.21%
mpact47g_70s_v4.0_pert_26.fmt	0.06%	0.18%

- CTF: HGAP & KCOND

Mamba Parameters

	k_Bthresh	Bfract
Default	0.005	0.16
Collins*	0.001	0.42
Perturb	-80%	+263%

* Data: Watts Bar 1 Cycle 7



What parameter distribution to use for these?

UQ Studies, Part 1
Single Assembly

VERAIn: Uniform

	Nominal	Bounds
+STATES/tinlet	291.33	± 0.483
*CORE/rated_power	1.0	± 0.04
+STATES/pressure	15.51	± 0.483
*CORE/rated_flow	1.0	± 0.02

MAMBA: Uniform

k_Bthresh	± 10%
k_Cpor	± 10%
k_crud_solid	± 10%
k_delta_r	± 10%
k_fac	± 10%
k_Hc	± 10%
k_kp2	± 10%
k_mit0	± 1%
k_Nc	± 10%
k_rc	± 10%
k_Tsat	± 1%

UQ Studies, Part 1
Single Assembly

5 Sets of 40 Samples Each

Set_1	40
Set_2	40
Set_3	39
Set_4	40
Set_5	40

UQ Studies, Part 2
Quarter Core

VERAIn: Normal

	Mean	Std. Dev.
+STATES/State_1/tinlet	291.33	0.483
*CORE/rated_power	1.0	0.04
+STATES/State_1/pressure	15.51	0.483
*CORE/rated_flow	1.0	0.02

MAMBA: Uniform

k_Bthresh	± 1%
k_Cpor	± 1%
k_crud_solid	± 1%
k_delta_r	± 1%
k_fac	± 1%
k_Hc	± 1%
k_kp2	± 1%
k_mit0	± 1%
k_Nc	± 1%
k_rc	± 1%
k_Tsat	± 1%

2 runs got through queue but died

UQ Studies, Part 3
Single Assembly

VERAIn: Normal

	Mean	Std. Dev.
+STATES/tinlet	291.33	0.483
*CORE/rated_power	1.0	0.04
+STATES/pressure	15.51	0.483
*CORE/rated_flow	1.0	0.02

MAMBA: Uniform

k_Bthresh	± 0.5%
k_Cpor	± 0.5%
k_crud_solid	± 0.5%
k_delta_r	± 0.5%
k_fac	± 0.5%
k_Hc	± 0.5%
k_kp2	± 0.5%
k_mit0	± 0.5%
k_Nc	± 0.5%
k_rc	± 0.5%
k_Tsat	± 0.5%

UQ Studies, Part 3
Single Assembly

40 Samples Each

Set_1	39
Set_2	38
Set_3	38
Set_4	40
Set_5	37
Set_6	36
Set_2 Mamba UQ	40
Set_2 VERAIn UQ	39
*Set_2 VERAIn UQ	40

*No coupling to Mamba

Current Status

- Parameter correlations across physics codes is important
- Parameter distributions for coarsened codes (eg Mamba3D → Mamba1D) is an open challenge
- Insight from smaller problems (single assembly) helps but does not guarantee success on large problems (quarter core)
- Large HPC runs require tact, some ingenuity and lots of patience