

SMR-Core Analysis at pin-level using PARCS-SP3

Kanglong Zhang; Victor Sanchez; Luigi Mercatali

Institute for Neutron Physics and Reactor Technology (INR)



Presentation Outline

SMR-Core Analysis at pin-level using PARCS-SP3

Motivation: Pin-wise TH Feedback

Pin-wise Simulation with “ASSY_TYPE”

Pin-wise XS Optimization

Development: Function Extension of PARCS V331

Verification: Steady State pin-by-pin Simulation for KIT-SMR

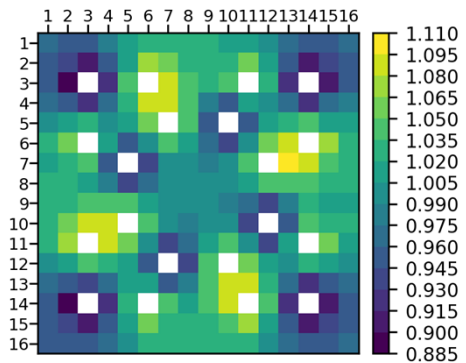
Summary and Outlook: Transient Simulation

Implementation to PARCS-ICoCo

Coupling with TH code

Motivation: Pin-wise Simulation, XS Optimization, TH Feedback

The discussion in this slide only concern Cartesian geometry



Pin-wise results are important

In KIT, we would like to do:

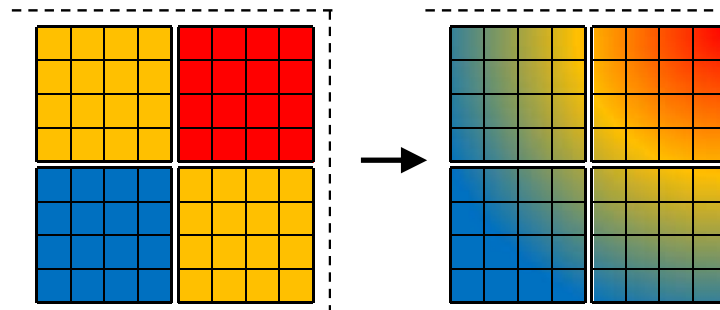
- Pin-by-pin simulation in core-scale with "ASSY_TYPE".
- Enable pin-wise XS optimization and TH feedback.

PARCS V331 can not do this

Function extension is required

PARCS V331 has two methods for pin-wise results:

- Nodal + Pin power reconstruction



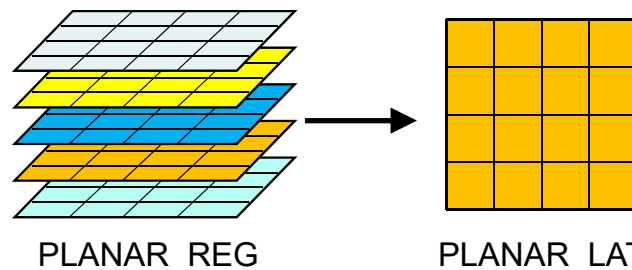
Advantage:

- Fast running.

Limitation:

- No Pin-wise TH coupling.
- No Pin-wise XS optimization.

- FMFD (Fine Mesh Finite Difference)



Advantage:

- SP3 Pin-wise simulation.

Limitation:

- Use "PLANAR_REG", no "ASSY_TYPE".

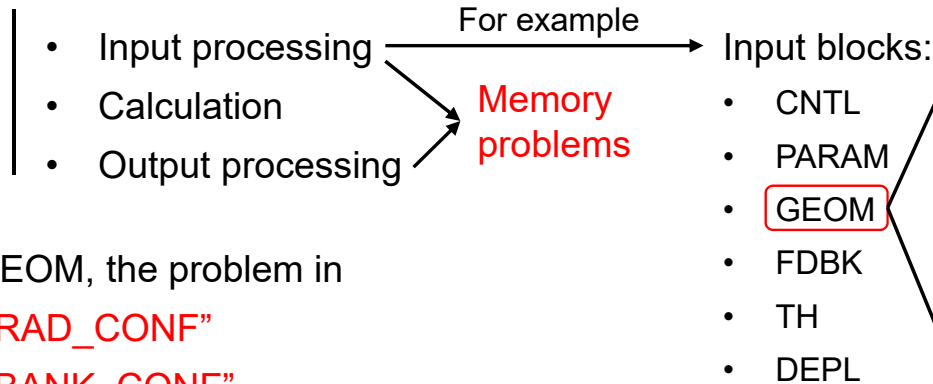
Development: Function Extension of PARCS V 331

The discussion in this slide only concern Cartesian geometry

For pin-by-pin SP3 simulation with “ASSY_TYPE” activated:

- the most straightforward way is to compose the input files as cases using traditional nodal solvers.
- PARCS V331 has problems dealing with “big data”.

Workflow of PARCS V331:



In GEOM, the problem in

- “RAD_CONF”
- “BANK_CONF”

Function extension:

- 20 files related to input and output processing were modified.
- PARCS V331 now works well with “big data”.

1	2	3	4	5	6	7	8	9	10	11	
000	000	000	103	102	101	110	109	000	000	000	! 1
000	000	105	104	011	020	011	108	107	000	000	! 2
000	107	106	012	031	040	031	012	106	105	000	! 3
109	108	012	040	042	042	042	040	012	104	103	! 4
110	011	031	042	040	050	040	042	031	011	102	! 5
101	020	040	042	050	060	050	042	040	020	101	! 6
102	011	031	042	040	050	040	042	031	011	110	! 7
103	104	012	040	042	042	042	040	012	108	109	! 8
000	105	106	012	031	040	031	012	106	107	000	! 9
000	000	107	108	011	020	011	104	105	000	000	! 10
000	000	000	109	110	101	102	103	000	000	000	! 11

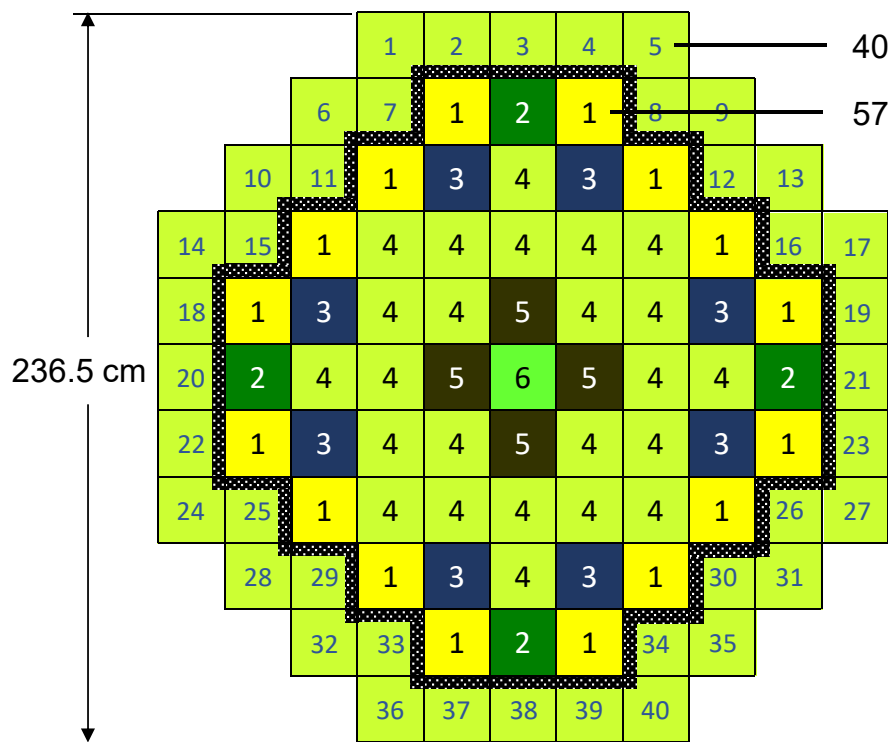
Small Matrix OK

206206	112256	112257	112258	112259	112260	112261	112262	112263	112264	112265	112266	112267	112268	112269	112270	112271	112272	131256	131257	131258
206206	112273	112274	112275	112276	112277	112278	112279	112280	112281	112282	112283	112284	112285	112286	112287	112288	112289	131273	131274	131275
4-4																				
17	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	1	2	3
112017	144001	144002	144003	144004	144005	144006	144007	144008	144009	144010	144011	144012	144013	144014	144015	144016	144017	142001	142002	142003
112034	144018	144019	144020	144021	144022	144023	144024	144025	144026	144027	144028	144029	144030	144031	144032	144033	144034	142018	142019	142020
112051	144036	144037	144038	144039	144040	144041	144042	144043	144044	144045	144046	144047	144048	144049	144050	144051	144052	142035	142036	142037
112068	144052	144053	144054	144055	144056	144057	144058	144059	144060	144061	144062	144063	144064	144065	144066	144067	144068	142052	142053	142054
112085	144069	144070	144071	144072	144073	144074	144075	144076	144077	144078	144079	144080	144081	144082	144083	144084	144085	142069	142070	142071
112102	144086	144087	144088	144089	144090	144091	144092	144093	144094	144095	144096	144097	144098	144099	144100	144101	144102	142086	142087	142088
112119	144103	144104	144105	144106	144107	144108	144109	144110	144111	144112	144113	144114	144115	144116	144117	144118	144119	142103	142104	142105
112136	144120	144121	144122	144123	144124	144125	144126	144127	144128	144129	144130	144131	144132	144133	144134	144135	144136	142120	142121	142122
112153	144137	144138	144139	144140	144141	144142	144143	144144	144145	144146	144147	144148	144149	144150	144151	144152	144153	142137	142138	142139
112170	144154	144155	144156	144157	144158	144159	144160	144161	144162	144163	144164	144165	144166	144167	144168	144169	144170	142154	142155	142156
112187	144171	144172	144173	144174	144175	144176	144177	144178	144179	144180	144181	144182	144183	144184	144185	144186	144187	142171	142172	142173
112204	144188	144189	144190	144191	144192	144193	144194	144195	144196	144197	144198	144199	144200	144201	144202	144203	144204	142188	142189	142190
112221	144205	144206	144207	144208	144209	144210	144211	144212	144213	144214	144215	144216	144217	144218	144219	144220	144221	142205	142206	142207
112238	144222	144223	144224	144225	144226	144227	144228	144229	144230	144231	144232	144233	144234	144235	144236	144237	144238	142222	142223	142224
112255	144239	144240	144241	144242	144243	144244	144245	144246	144247	144248	144249	144250	144251	144252	144253	144254	144255	142239	142240	142241
112272	144256	144257	144258	144259	144260	144261	144262	144263	144264	144265	144266	144267	144268	144269	144270	144271	144272	142256	142257	142258
112289	144273	144274	144275	144276	144277	144278	144279	144280	144281	144282	144283	144284	144285	144286	144287	144288	144289	142273	142274	142275
5-4																				
17	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	1	2	3
131017	142001	142002	142003	142004	142005	142006	142007	142008	142009	142010	142011	142012	142013	142014	142015	142016	142017	145001	145002	145003
131034	142018	142019	142020	142021	142022	142023	142024	142025	142026	142027	142028	142029	142030	142031	142032	142033	142034	145018	145019	145020
131051	142035	142036	142037	142038	142039	142040	142041	142042	142043	142044	142045	142046	142047	142048	142049	142050	142051	145035	145036	145037
131068	142052	142053	142054	142055	142056	142057	142058	142059	142060	142061	142062	142063	142064	142065	142066	142067	142068	145052	145053	145054
131085	142069	142070	142071	142072	142073	142074	142075	142076	142077	142078	142079	142080	142081	142082	142083	142084	142085	145069	145070	145071
131102	142086	142087	142088	142089	142090	142091	142092	142093	142094	142095	142096	142097	142098	142099	142100	142101	142102	145086	145087	145088
131119	142103	142104	142105	142106	142107	142108	142109	142110	142111	142112	142113	142114	142115	142116	142117	142118	142119	145103	145104	145105

Large Matrix KO

Verification: Steady State pin-by-pin Simulation for KIT-SMR

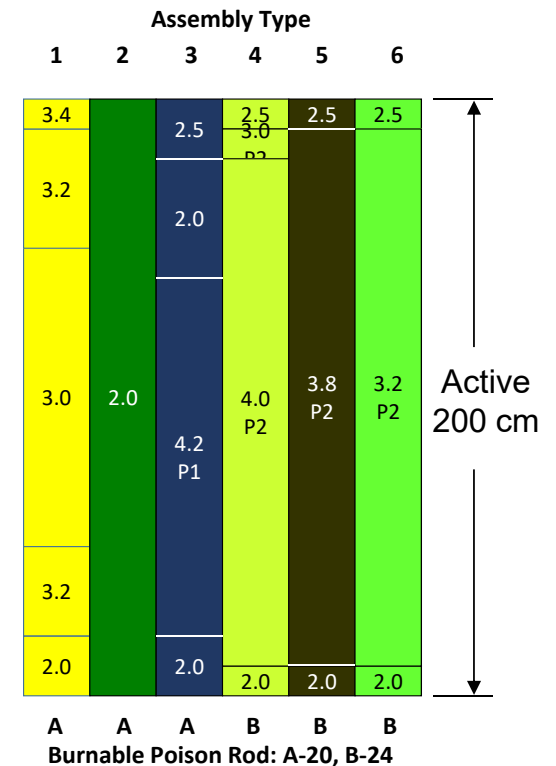
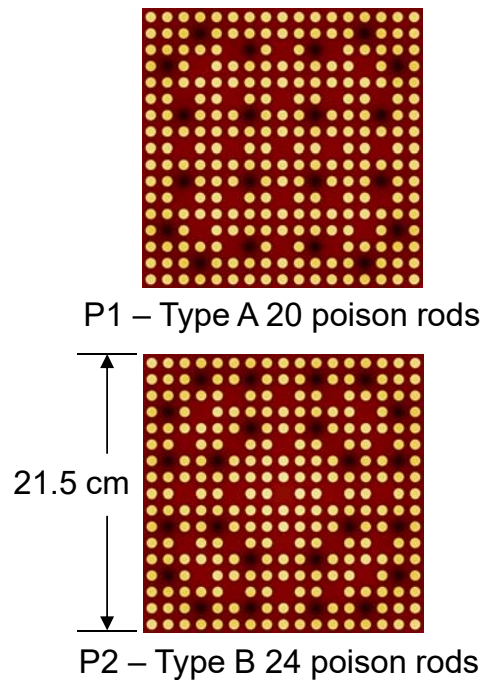
Case Specification – KIT-SMR – assembly configuration:



40 radial reflectors

57 fuel assemblies, 6 types, 2 poison types

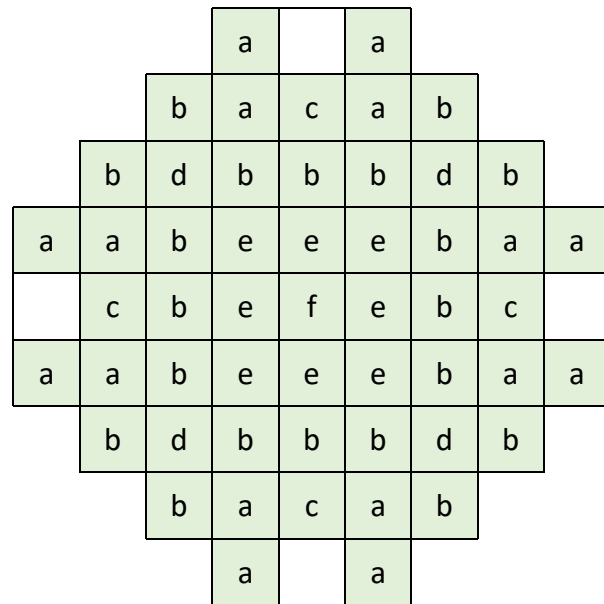
Radial configuration



Axial configuration

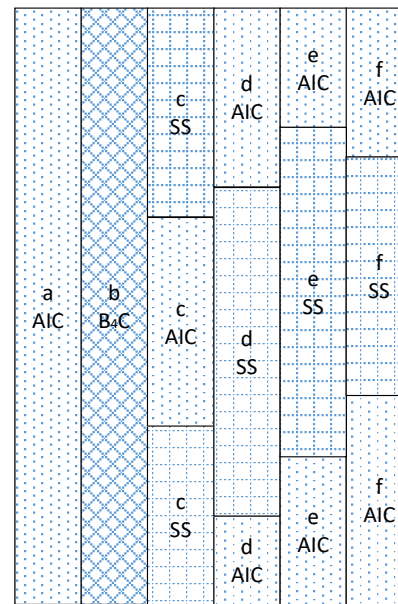
Verification: Steady State pin-by-pin Simulation for KIT-SMR

Case Specification – KIT-SMR – control rod configuration:



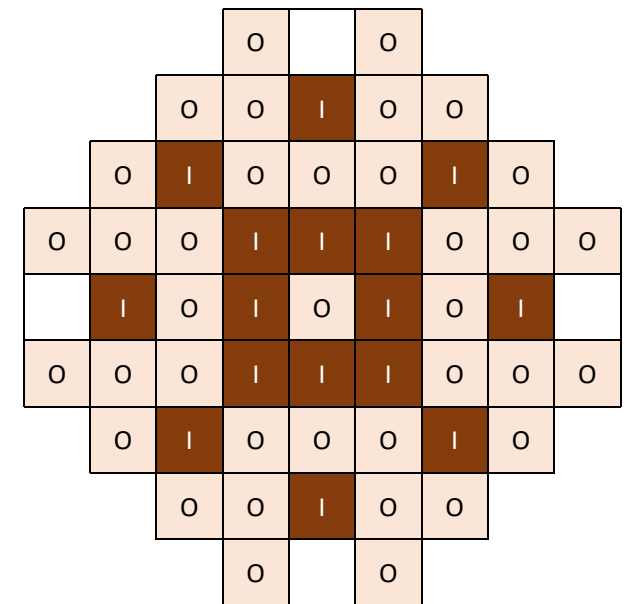
Radial configuration

- 6 types



Axial configuration

- AIC – AgInCd
- SS – Stainless Steel
- B4C

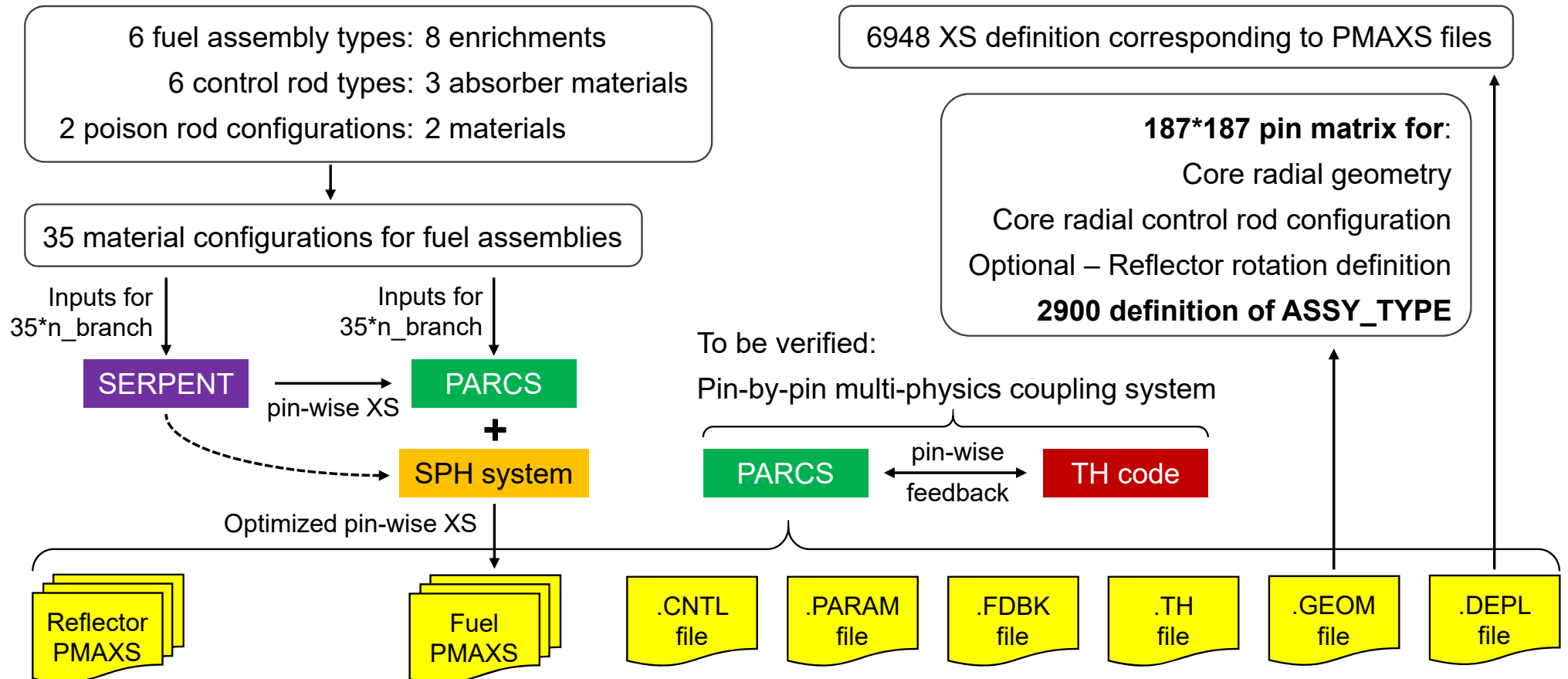


Critical configuration

- I – fully inserted
- O – fully withdraw

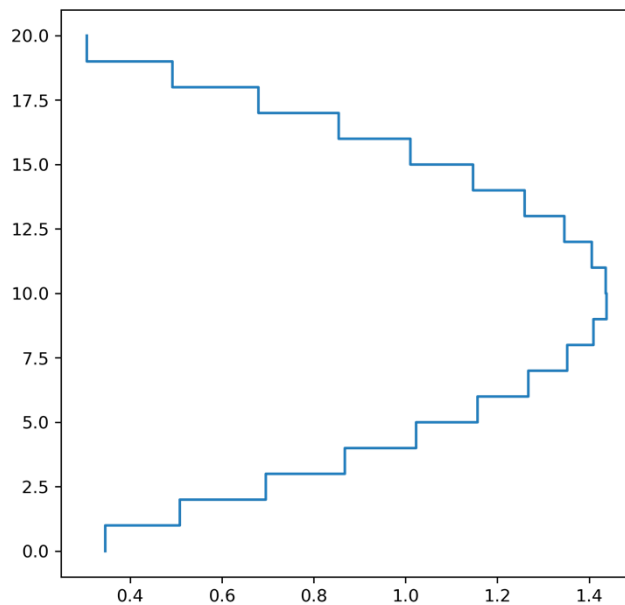
Verification: Steady State pin-by-pin Simulation for KIT-SMR

Modeling – KIT-SMR – PARCS:

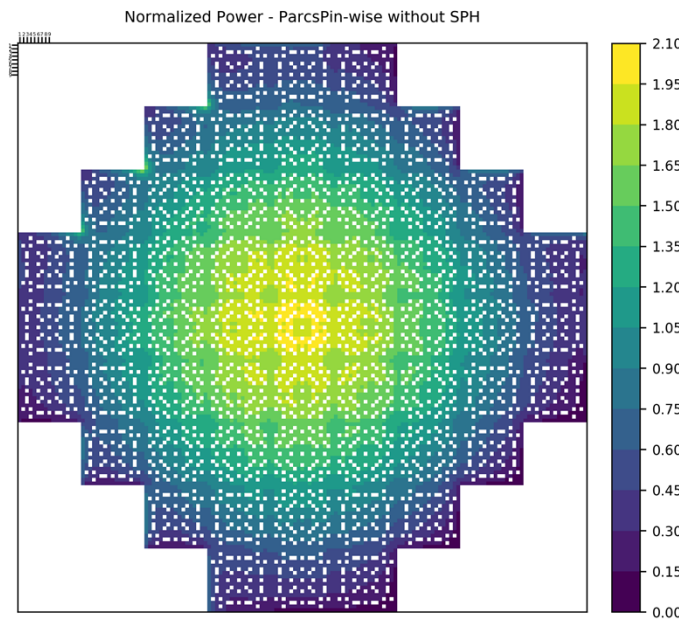


Verification: Steady State pin-by-pin Simulation for KIT-SMR

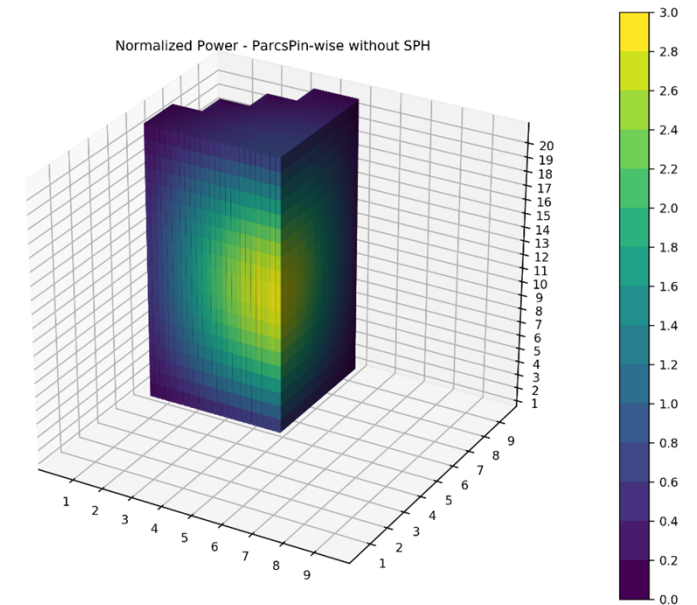
First Results – uniform fuel assembly (enrichment 2.0%, no CR):



Axial power distribution



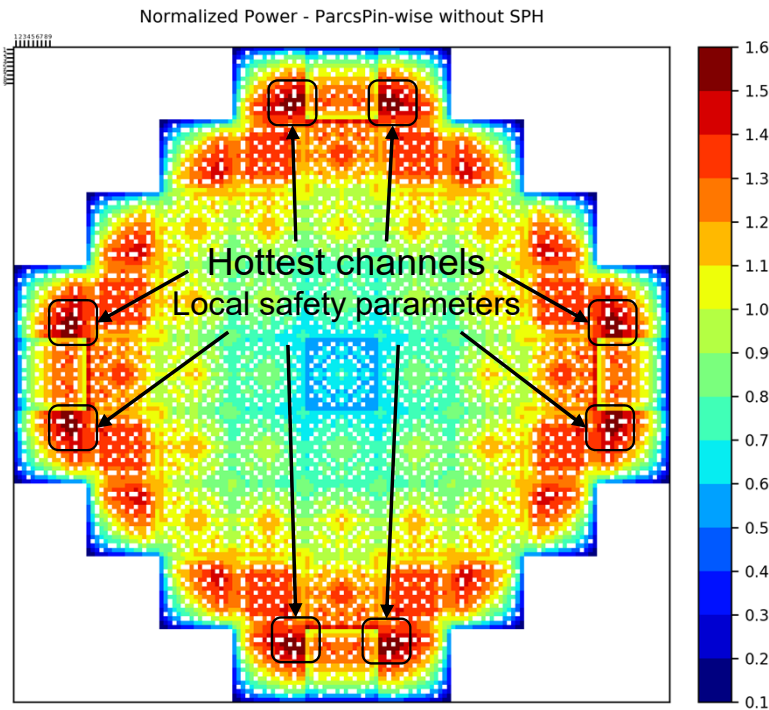
Radial power distribution



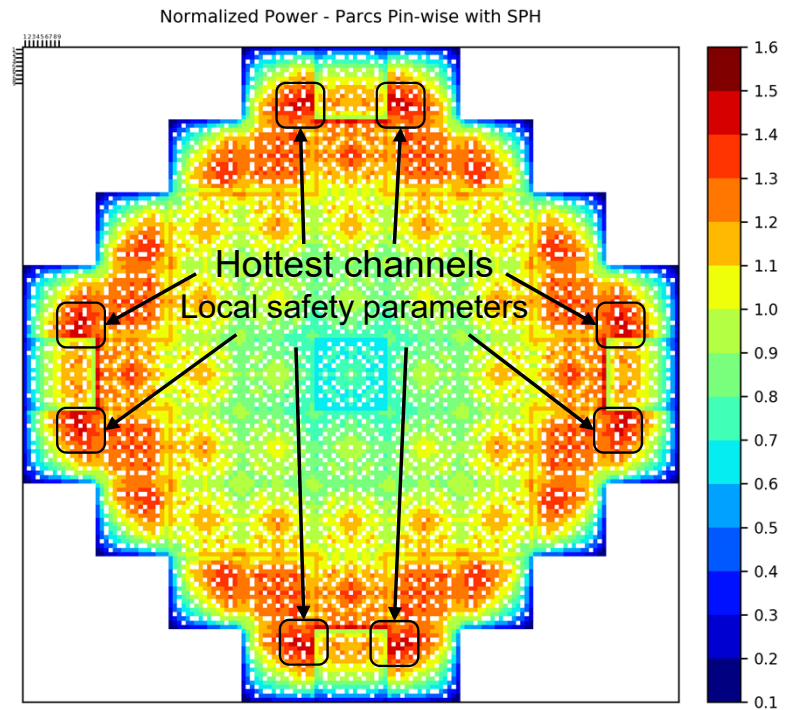
Spatial power distribution

Verification: Steady State pin-by-pin Simulation for KIT-SMR

First Results – KIT-SMR – All Rods Out (AIO) – radial relative power distribution:



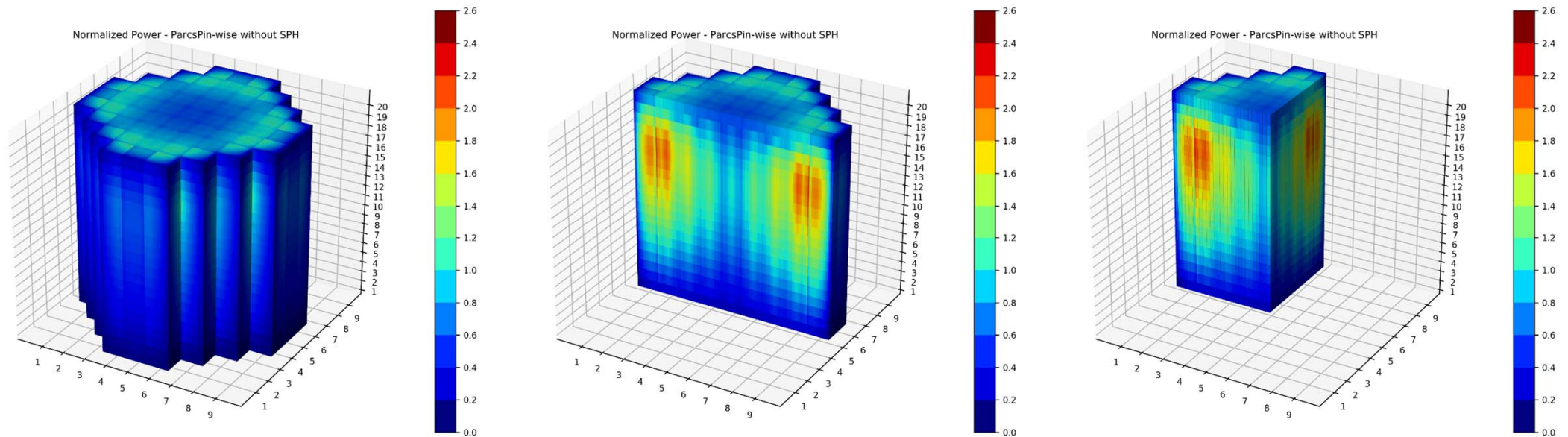
Original pin-wise XS
from Serpent



SPH optimized
pin-wise XS

Verification: Steady State pin-by-pin Simulation for KIT-SMR

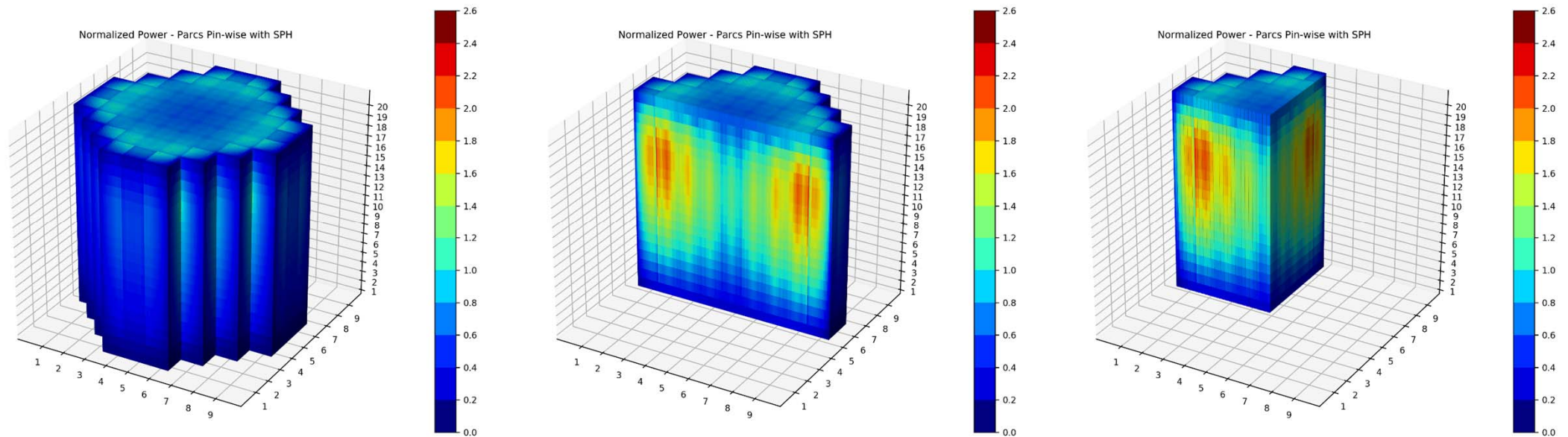
First Results – KIT-SMR – All Rods Out (AIO) – spatial relative power distribution:



Original pin-wise XS from Serpent

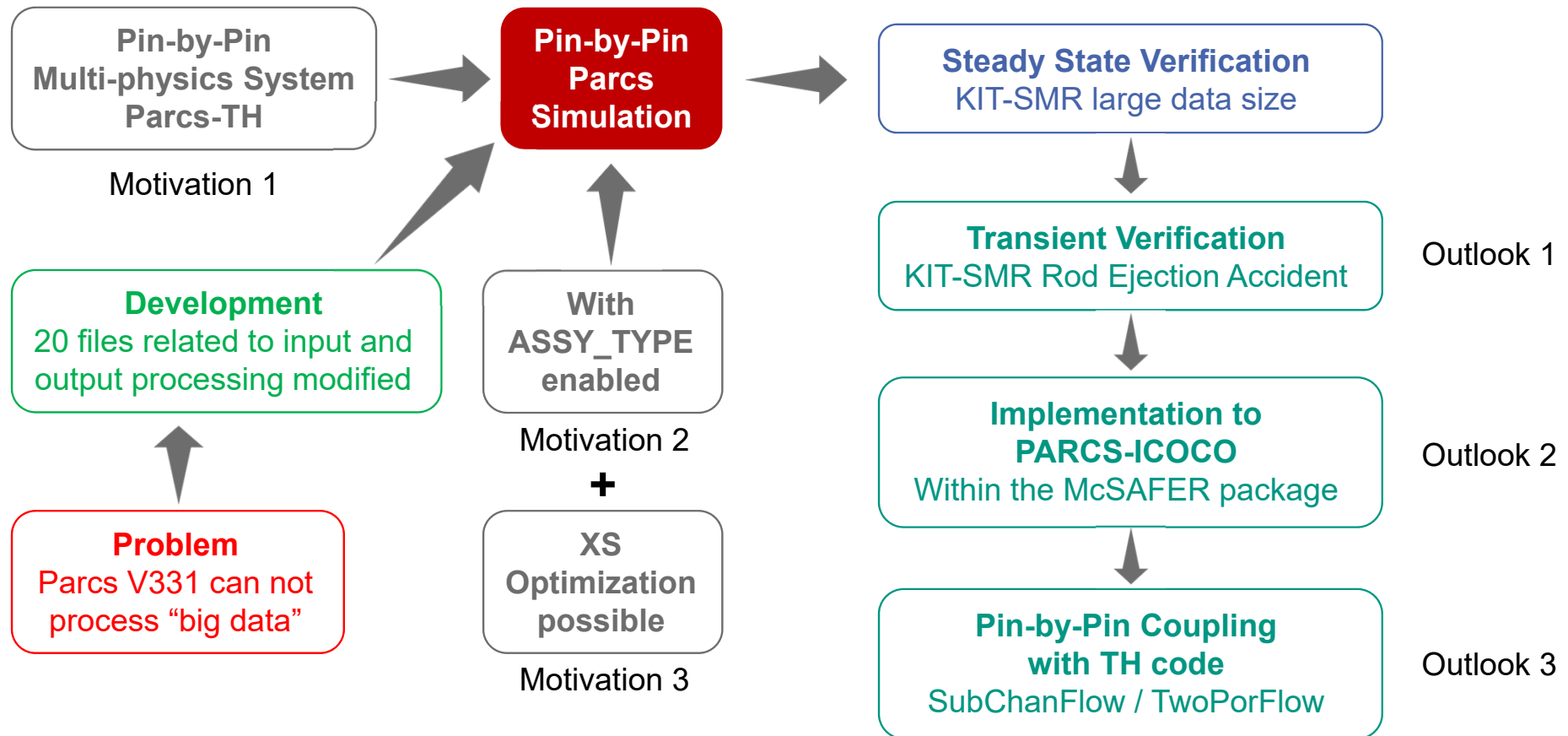
Verification: Steady State pin-by-pin Simulation for KIT-SMR

First Results – KIT-SMR – All Rods Out (AIO) – spatial relative power distribution:



SPH optimized pin-wise XS

Summary and Outlook



Questions and Problems

1. **PARCS V331 crash due to illegal operation when do the 3rd nodal update:**
 - The reflector XS relates to the problem.
 - When the neutron leakage is not significant, PARCS runs well.
 - When the neutron leakage is significant, PARCS crash at the 3rd nodal updating.

2. **How to merge two PMAXS files into one single PMAXS file.**
 - One file contain the XS data without CR, the other contain the XS with XR.
 - Use GenPMAXS to combine the two PMAXS files?