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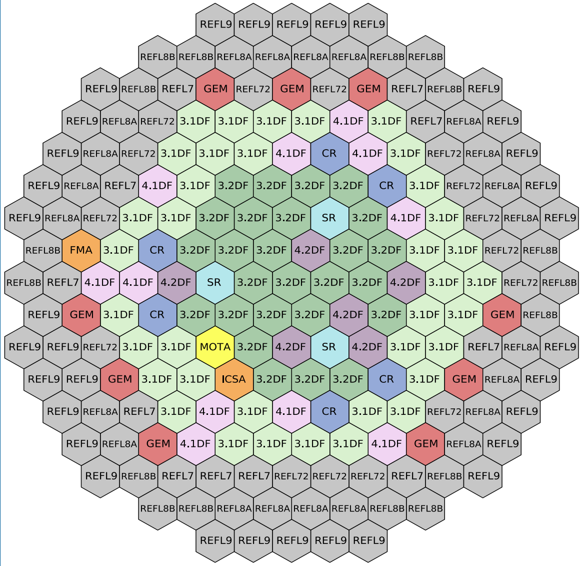
BLIND-PHASE RESULTS OF THE FFTF NEUTRONIC BENCHMARK



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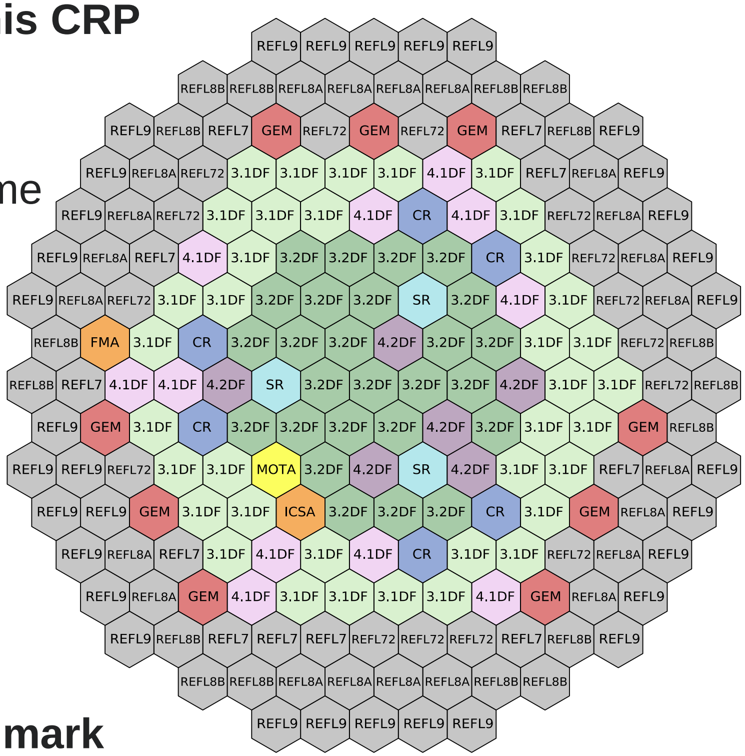
FFTF NEUTRONICS BENCHMARK

Specifications

- **FFTF was a 400-MWt SFR design operating in the USA**
- **The IAEA initiated a CRP in 2018 on Fast Flux Test Facility (FFTF) Loss of Flow Without Scram (LOFWOS) Test #13**
- **Transients modeling requires neutronic feedback coefficients evaluation**
- **A neutronic benchmark was proposed as part of this CRP**
- **Results expected:**
  - Neutron multiplication factor
  - Delayed neutron fraction and prompt neutron lifetime
  - Nominal power production for each assembly including fission and gamma heat
  - Global reactivity feedback coefficients:
    - Axial and Radial expansion
    - Control and safety rods
    - GEM worth
    - Fuel, Structure, Coolant density coefficients
    - Fuel Doppler Constant



- **11 participants contributed to this neutronic benchmark**
- **This presentations discusses results from the “blind” phase of this neutronic benchmark**

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Participants and Methods

Country	Organization	Neutronics Code	Modeling Methods and codes	Cross-sections library (Energy group of transport solver)
China	INEST	NTC	Transport	HENDL
China	NCEPU	MGGC	Diffusion	ENDF/B
Germany	HZDR	Serpent-2	Monte-Carlo	ENDF/B.VII.1
Germany	KIT	ERANOS, PARTISN	Transport	KIT-72 (11)
India	IGCAR	FARCOB, MCNP4C	Diffusion, Monte Carlo	ABBN-93, ENDF/B-VIII.0
Italy	Sapienza	ERANOS, PHISICS	Transport	JEFF3.1.1
Japan	JAEA	MARBLE, MVP	Transport, Monte Carlo	JENDL-4.0
Russia	IPPE	-	-	ABBN-93(26)
Sweden	KTH	Serpent-2	Monte-Carlo	JEFF-3.2
Switzerland	PSI	Serpent-2	Monte Carlo	JEFF-3.1.1
U.S.A.	ANL	MC^2-3/DIF3D	Transport	ENDF/B.VII.0 (33)

- 11 participating institutions
- Wide diversity of codes, methods and nuclear data libraries.

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Main Results

	ANL	HZDR	IGCAR	INEST	IPPE	JAEA	KIT	KTH	NCEPU	PSI	Rome	*σ/avg* †
Neutron Multiplication Factor	0.99996	1.00003	0.99772	0.99900	0.99230	1.01689	0.99765	1.02200	0.99787	1.00574	0.99956	*0.10%*
Delayed Neutron Fraction (pcm)	313.1	312.9	334.0	650.0	324.0	315.7	364.0	341.0	375.0	320.9	300.0	*7%*
Prompt Neutron Lifetime	5.26E-7	5.43E-7	4.78E-7		5.65E-7		5.88E-7	6.3E-7		5.52E-7	4.82E-7	*9%*
Axial Expansion Coefficient (pcm/°C)	-0.322	-0.335	-0.227			-0.319		-0.300	-0.096	-0.221	-0.477	*36%*
Radial Expansion Coefficient (pcm/°C)	-1.000	-1.411	-1.220			-0.997		-0.930	-0.945	-1.522	-5.866	*19%*
Fuel Doppler Constant (pcm)	-629.0	-682.0	-507.5			-634.3	-509.0	-564.0	-524.3	-657.7	-687.7	*12%*
Fuel Density Coefficient (pcm/°C)	-1.362	-1.389	-1.450			-1.362		-1.360	-0.092	-1.363	-1.402	*1%*
Structure Density Coefficient (pcm/°C)	-0.121	0.219	0.200			0.093		0.100	-0.007	0.039	-0.098	*221%*
Sodium Density Coefficient (pcm/°C)	-0.346	-0.759	-0.912			-0.413	0.094	-0.940	-0.041	-0.274	-1.914	*81%*
Control and Safety Rods (pcm)	-11849	-10864			-9396	-10800		-11540	-8343	-11823	-12773	*12%*
Gas Expansion Modules (pcm)	-442	-394	-498		-516	-489	-448	420	-782	-475	-1201	*8%*

- Highlighted results are outliers (outside 2-σ from average)
- Relatively good agreement on k-eff, kinetics param., Doppler coeff., rod worths
- Larger discrepancy on other reactivity coefficients (axial/radial, GEMs, etc.)
- Results on structure and sodium density coefficients are widely spread-out

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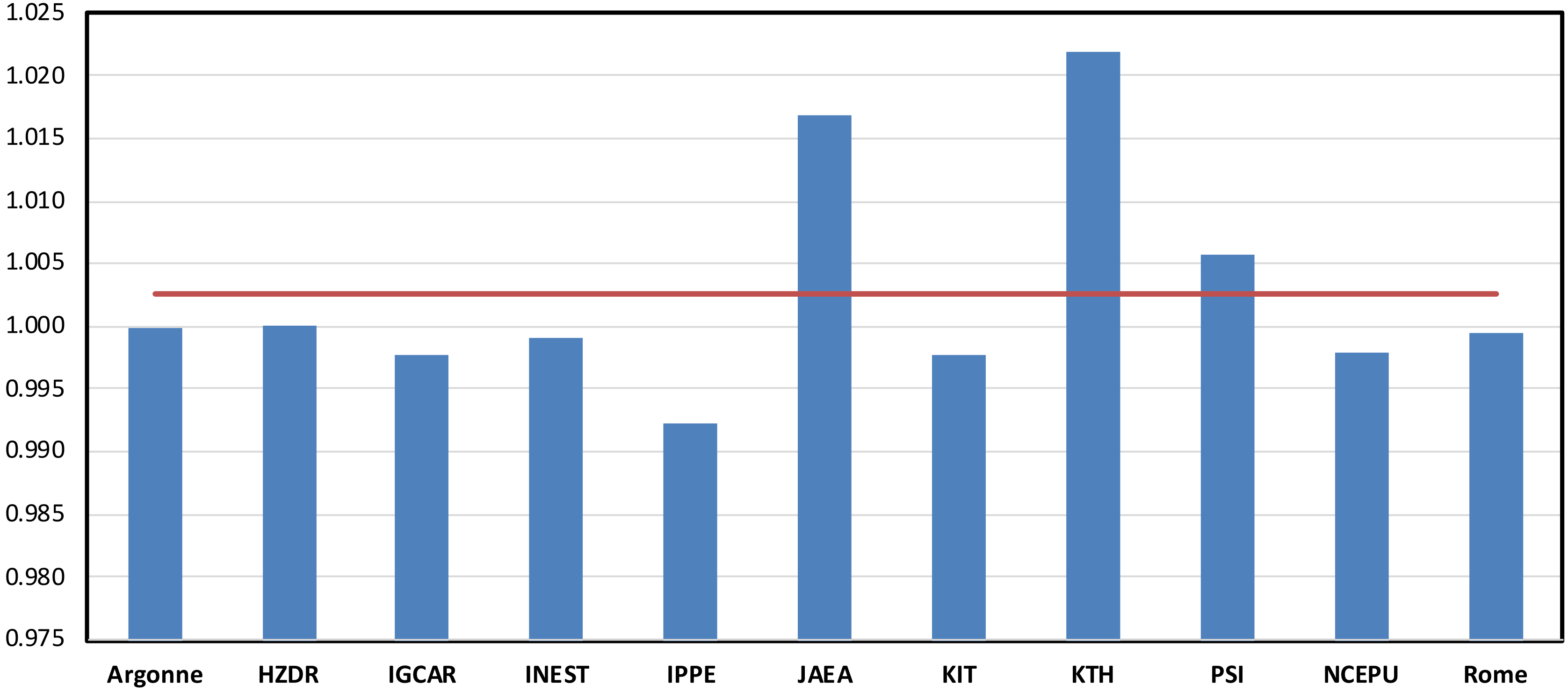
Neutron Multiplication Factor



- Average K-eff close to 1.00 – good agreement with a critical core
- Relatively good agreement within participants – outliers may be due to different methods and nuclear data libraries and modeling inconsistencies

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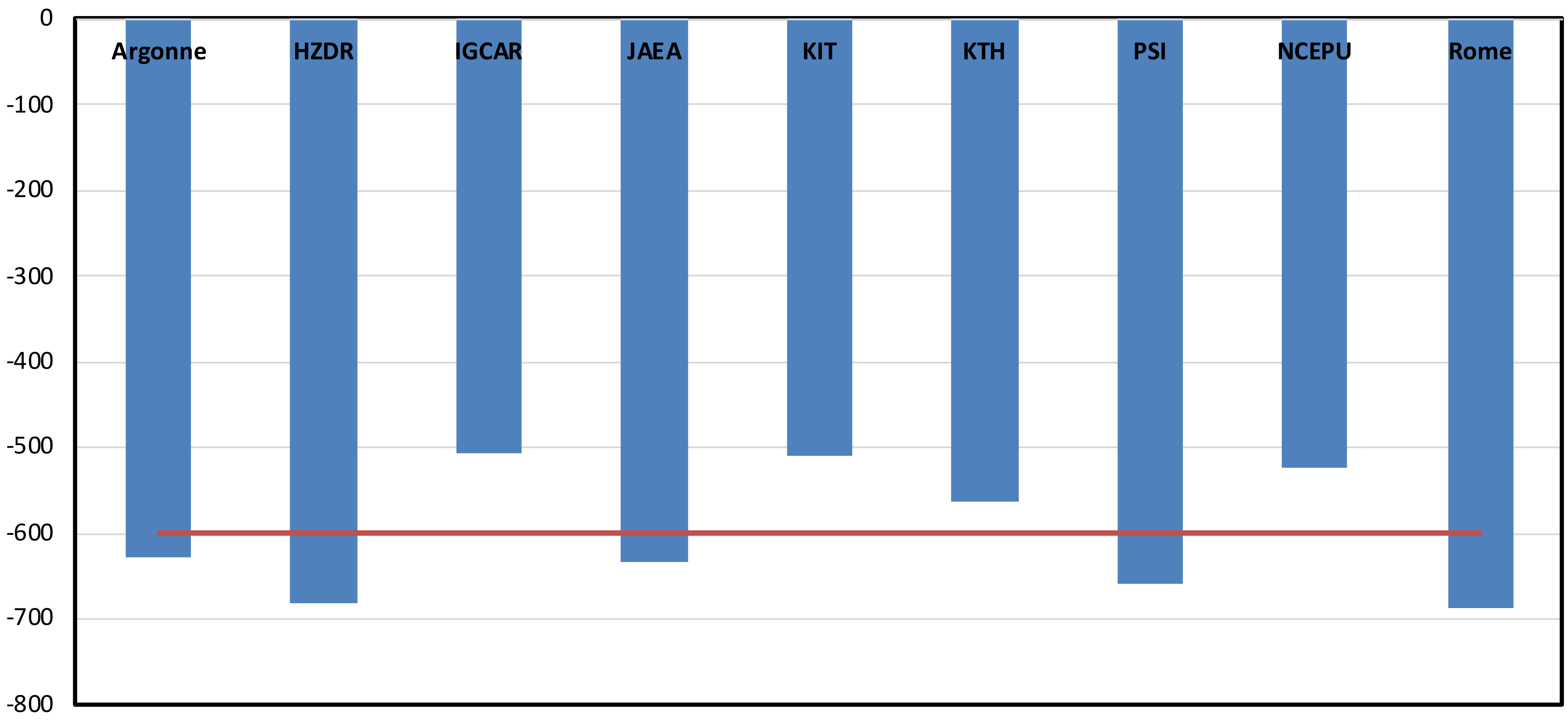
Doppler Constant



- Relatively good agreement within participants – discrepancies may come from different methods and nuclear data libraries

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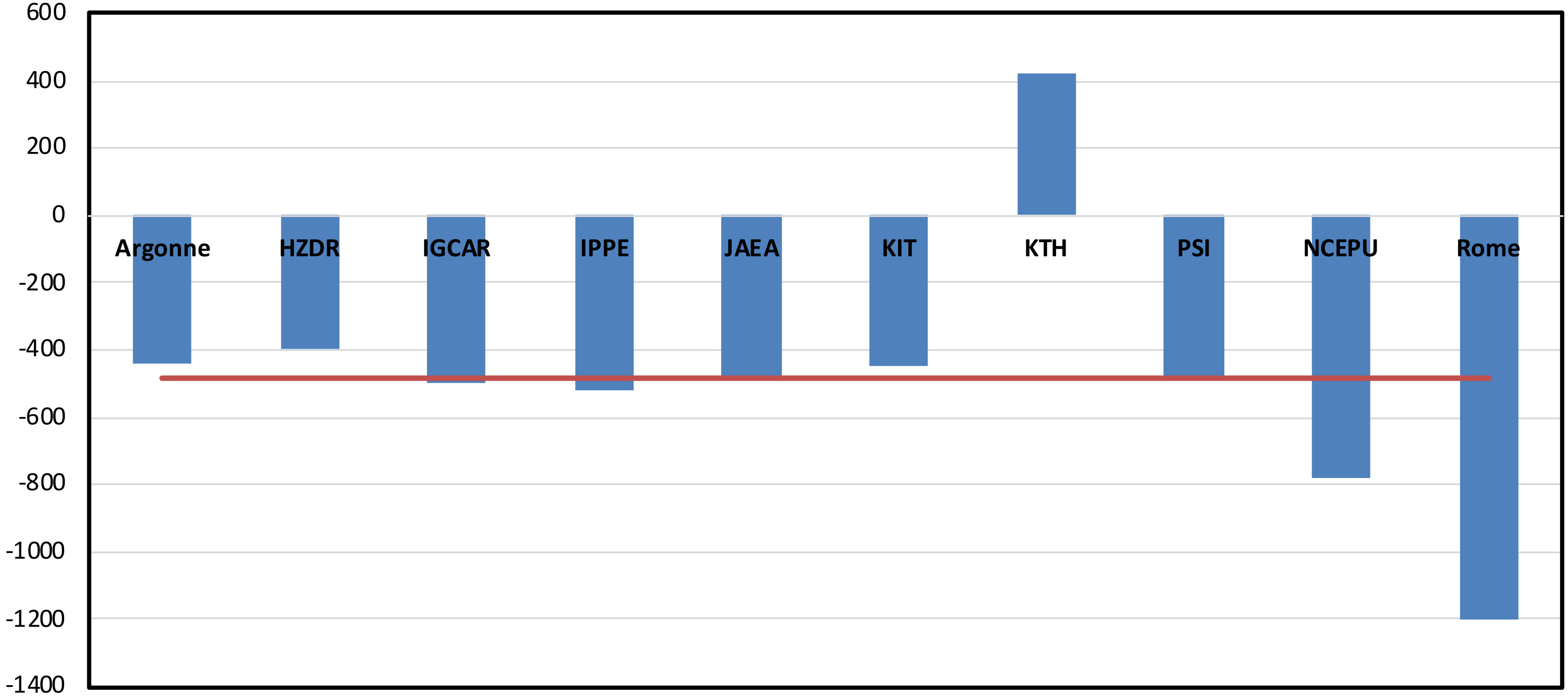
GEM Worth



- Most participants have consistent results
- Clear outliers – need to check typo/methods/post-processing and modeling inconsistencies
- **It is important to get this coefficient right for the follow-up safety analyses**

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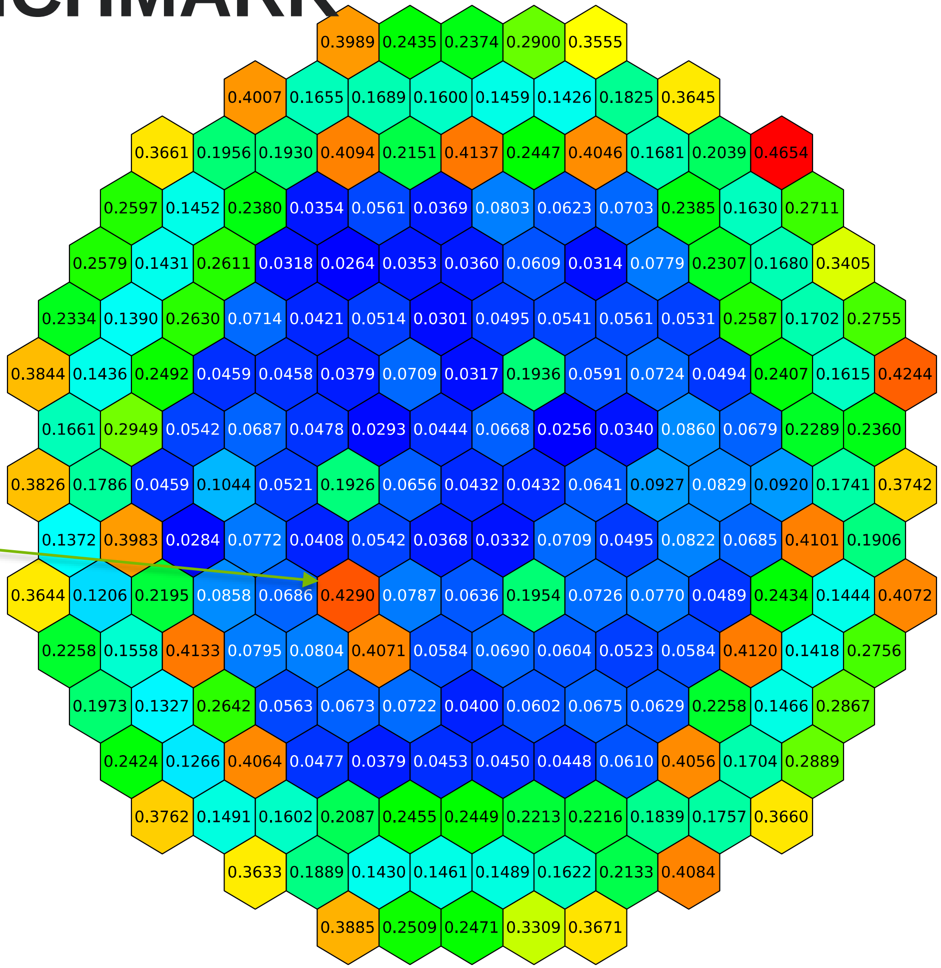
Power Distribution

- Deviation in results ~11% on fuel assemblies
- For other regions:
  - ~40% for GEMS
  - ~20% for Safety Rods
  - 15-40% for radial ref.
  - ~40% for MOTA/ICSA
- Potential source of discrepancies:
  - Gamma heating transport
  - Diffusion vs. transport
  - etc.



Variation in Radial Power Profile Results (Standard Dev / Average)

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Conclusions

- This CRP provides valuable benchmark exercise to verify neutronics methods
- 11 participants to the FFTF neutronic benchmark
- Blind phase results show relatively good agreement
- Remaining outliers are being investigated in the open phase of the benchmark

THANK YOU FOR YOUR ATTENTION!

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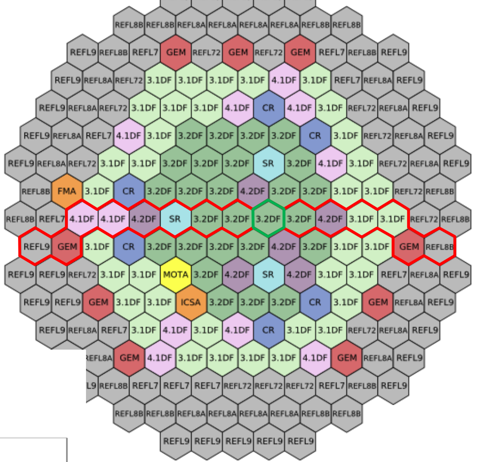
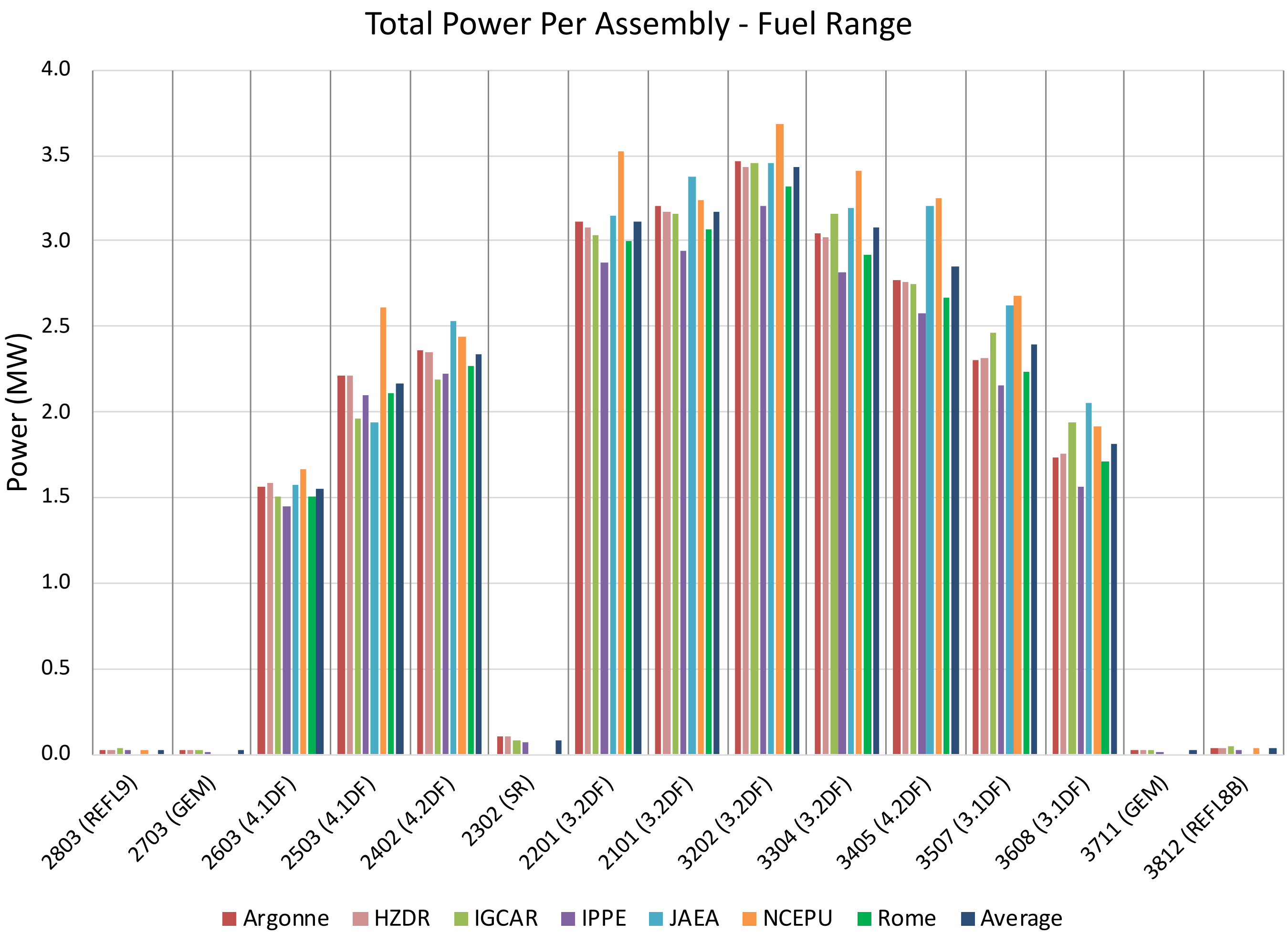
Power Distribution





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