INL/MIS-24-79245-Revision-0

AGR-5/6/7 Partial Mass Balance

July 2024

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Changing the World's Energy Future

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GAS-COOLED REACTOR

ADVANCED REACTOR TECHNOLOGIES PROGRAM

AGR-5/6/7 Partial Mass Balance

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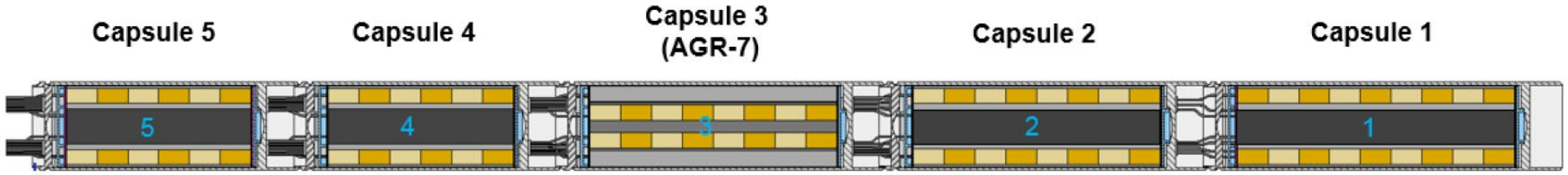
Outline

- Introduction
  - AGR-5/6/7 goals and test train configuration
  - Status of AGR-5/6/7 mass balance work
- Preliminary results
  - Ag-110m
  - Cs-134
  - Eu-154
- Summary and Conclusion

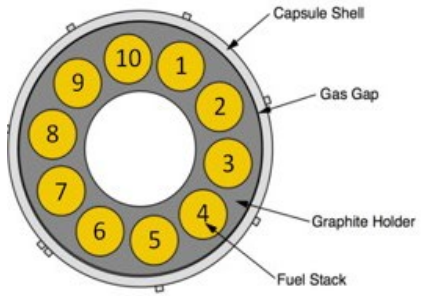
AGR-5/6/7 Goals and Focus of this Talk

- AGR-5/6/7 is the final qualification test of AGR TRISO fuel made entirely at the engineering scale
- AGR-5/6/7 PIE is to collect data on fuel performance, compare those data to results obtained in the earlier AGR experiments, and expand our understanding of UCO TRISO fuel behavior
- This talk is to provide preliminary data on AGR-5/6/7 mass balance:
  - Components from each AGR-5/6/7 irradiation capsule are being analyzed to determine the inventory of fission products released from the fuel compacts.
  - Each compact was gamma scanned to compare the measured and calculated fission-product inventories.
  - These preliminary results are compared to previous AGR results.

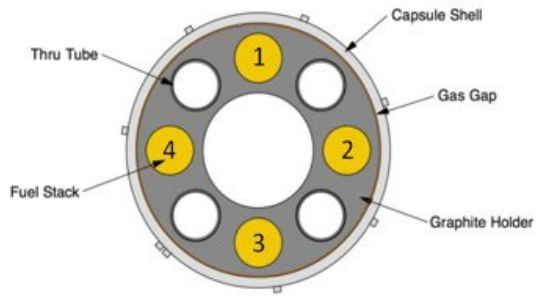
AGR-5/6/7 Test Train Configuration



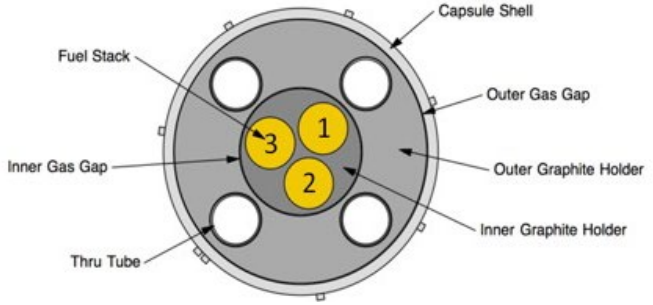
Capsule 1



Capsule 2, 4, 5



Capsule 3



AGR-5/6/7 Fission Product Mass Balance – Current Status

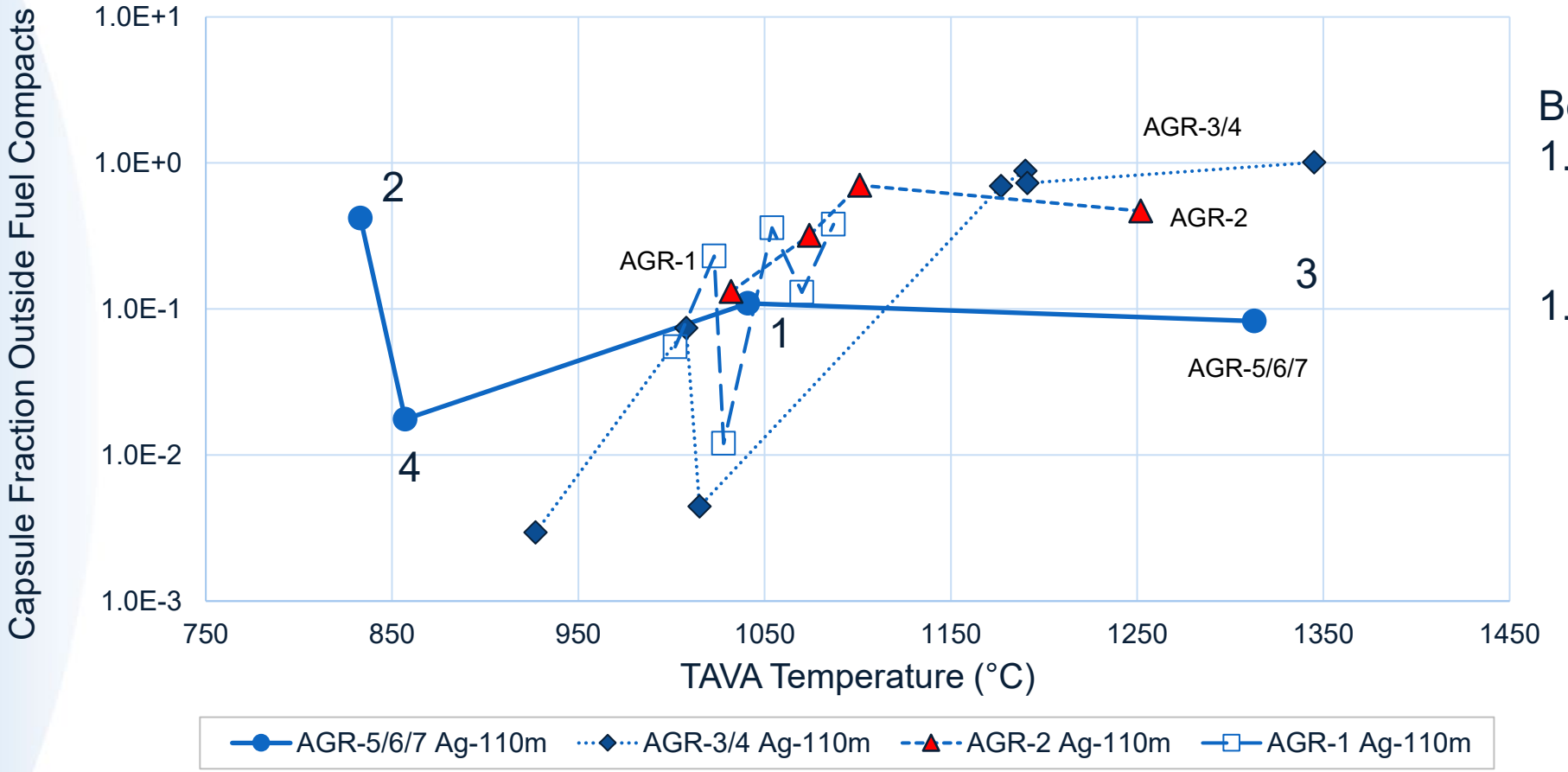
- Partial mass balance available, including
  - Graphite holder gamma from PGS. Will be repeated at AL spectrometer
  - Leachate from stainless steel shells and throughtubes (if applicable)
- Remaining items:
  - Counting spacers and foils remains to be completed
  - Graphite holders burn-leach for Sr-90
- Expect final mass balances to increase a little from the preliminary results presented in the following slides

Partial Mass Balance Summary

	Estimated Particle Equivalents				
Isotope	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5
Ru-106	6.74E+2	8.01E-1	1.54E-1	0	0
Ag-110m	3.34E+4	3.03E+4	4.49E+3	9.28E+2	0
Sb-125	1.15E+3	0	0	0	0
Cs-134	2.37E+3	2.58E+0	4.64E+1	7.17E-1	6.78E-1
Cs-137	2.18E+3	1.12E+1	4.78E+1	1.84E+0	3.02E+0
Ce-144	9.10E+2	3.49E-2	0	0	0
Eu-154	5.06E+3	1.58E+1	9.67E+2	0	0
Sr-90	3.65E+2	7.47E-1	4.82E-1	5.15E-1	4.36E-1
Total Number of particles per Capsule	3.05E+5	7.24E+4	5.44E+4	5.27E+4	8.14E+4
Instant Peak Temp (°C)	1386	1039	1536	1091	983
Time-average Peak Temp (°C)	1267	948	1432	970	864
TAVA Temp (°C)	1041	833	1313	857	756
Time-average Min Temp (°C)	624	546	989	558	467

- Except for Capsule 1 which was attacked by Ni, Ce-144 and Sb-125 was well retained in the fuel compacts.
- No Ag-110m was detected outside Capsule 5 fuel compacts due to low irradiation temperature.
- No Eu-154 was detected outside fuel compacts in Capsules 4 and 5.

Ag-110m Comparison



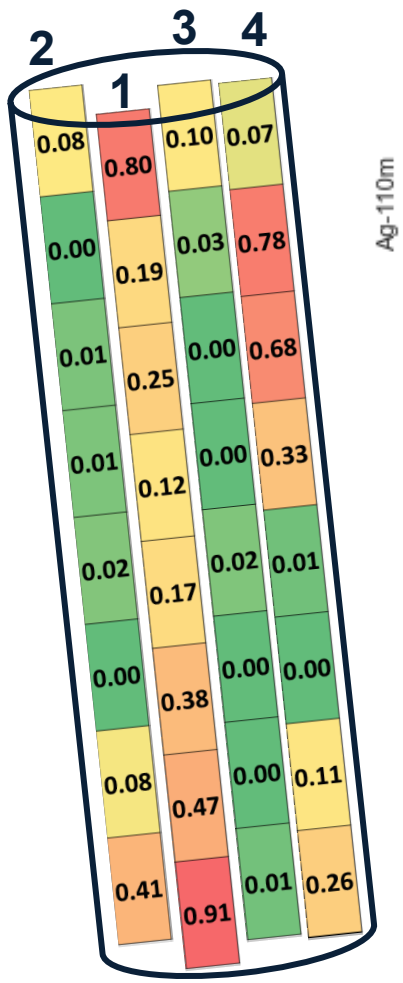
Below MDA :

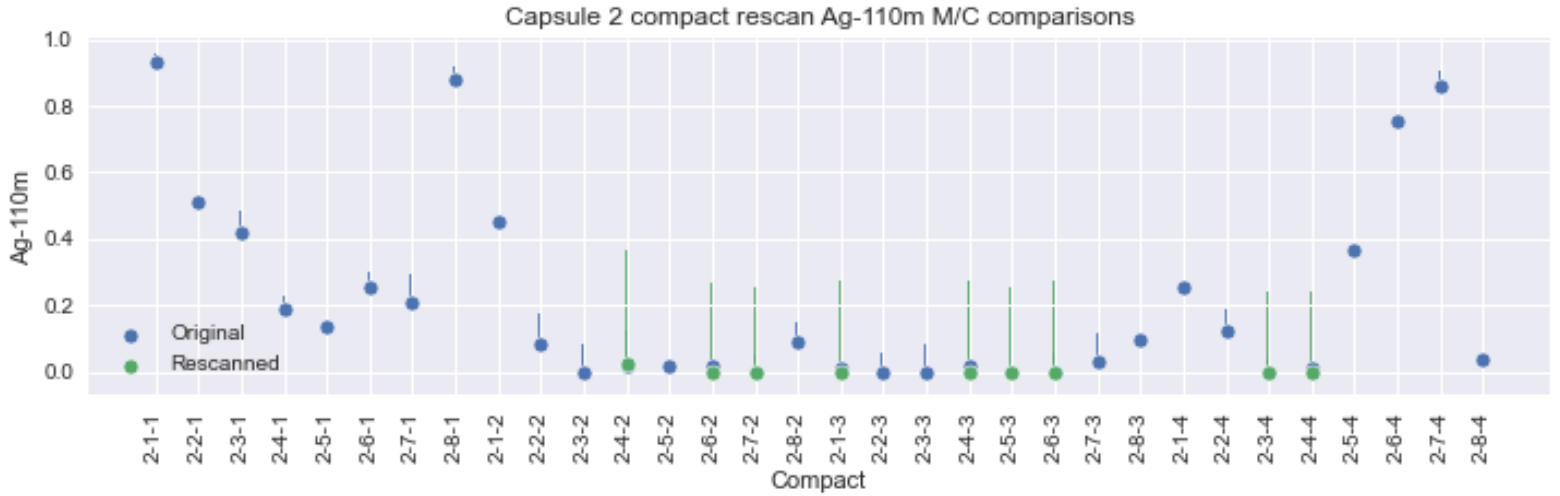
1. AGR-3/4 Capsule 12 (854°C)
1. 2. AGR-5/6/7 Capsule 5 (756°C)

Ag-110m	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5
Capsule Fraction	1.09E-1	4.18E-1	8.26E-2	1.76E-2	0
Particle Equivalent	3.34E+4	3.03E+4	4.49E+3	9.28E+2	0

Ag-110m in Capsule 2 compacts

Capsule 2

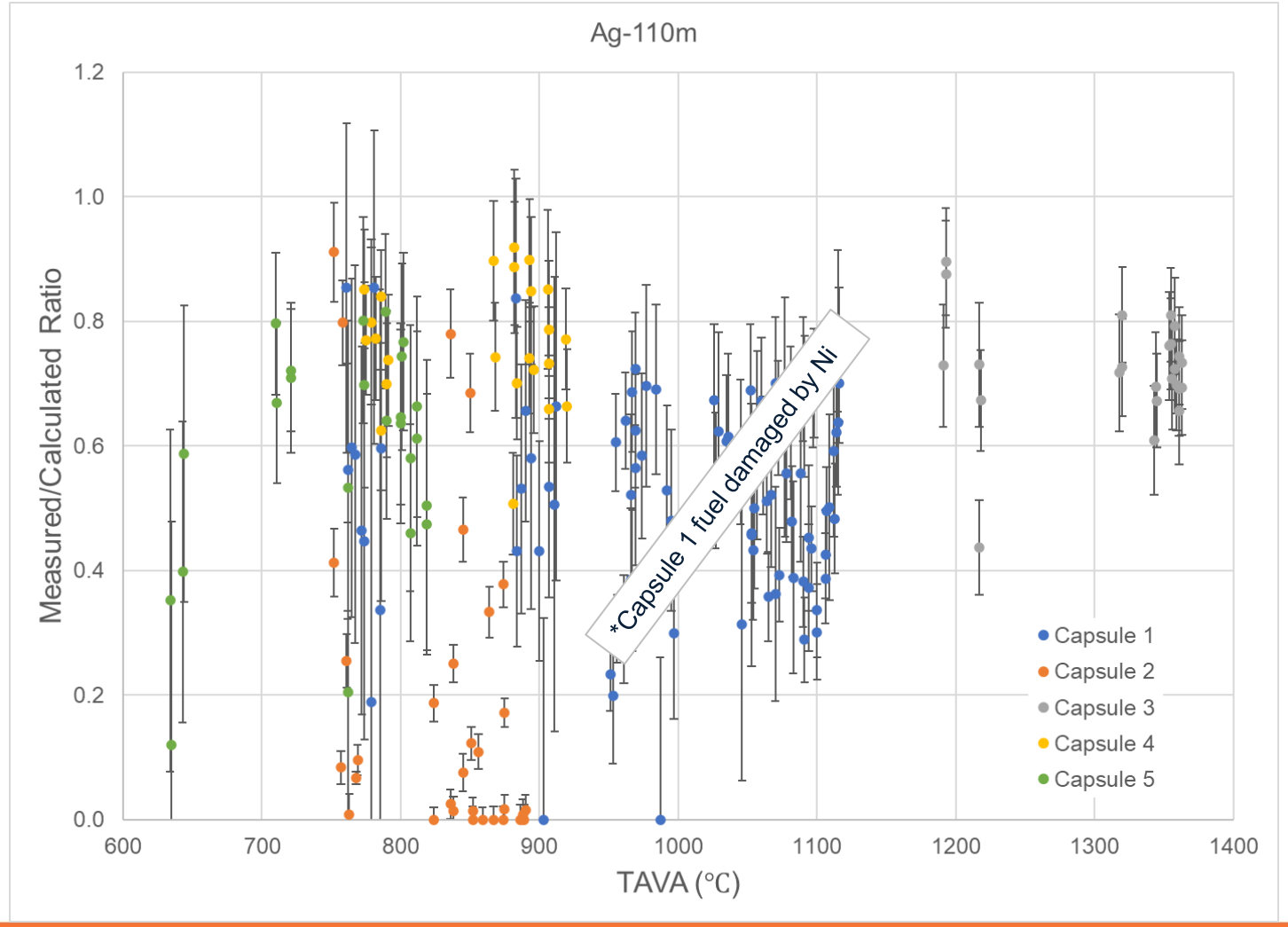




- Half of compacts retained less than 10% Ag-110m with a few even below detectable limit. A handful of compacts with the lowest M/C values were rescanned and confirmed the low values.
- Low M/C in the compacts corroborates with high capsule (partial) mass balance in Ag-110m.
- Do we trust the temperature evaluations in Capsule 2?

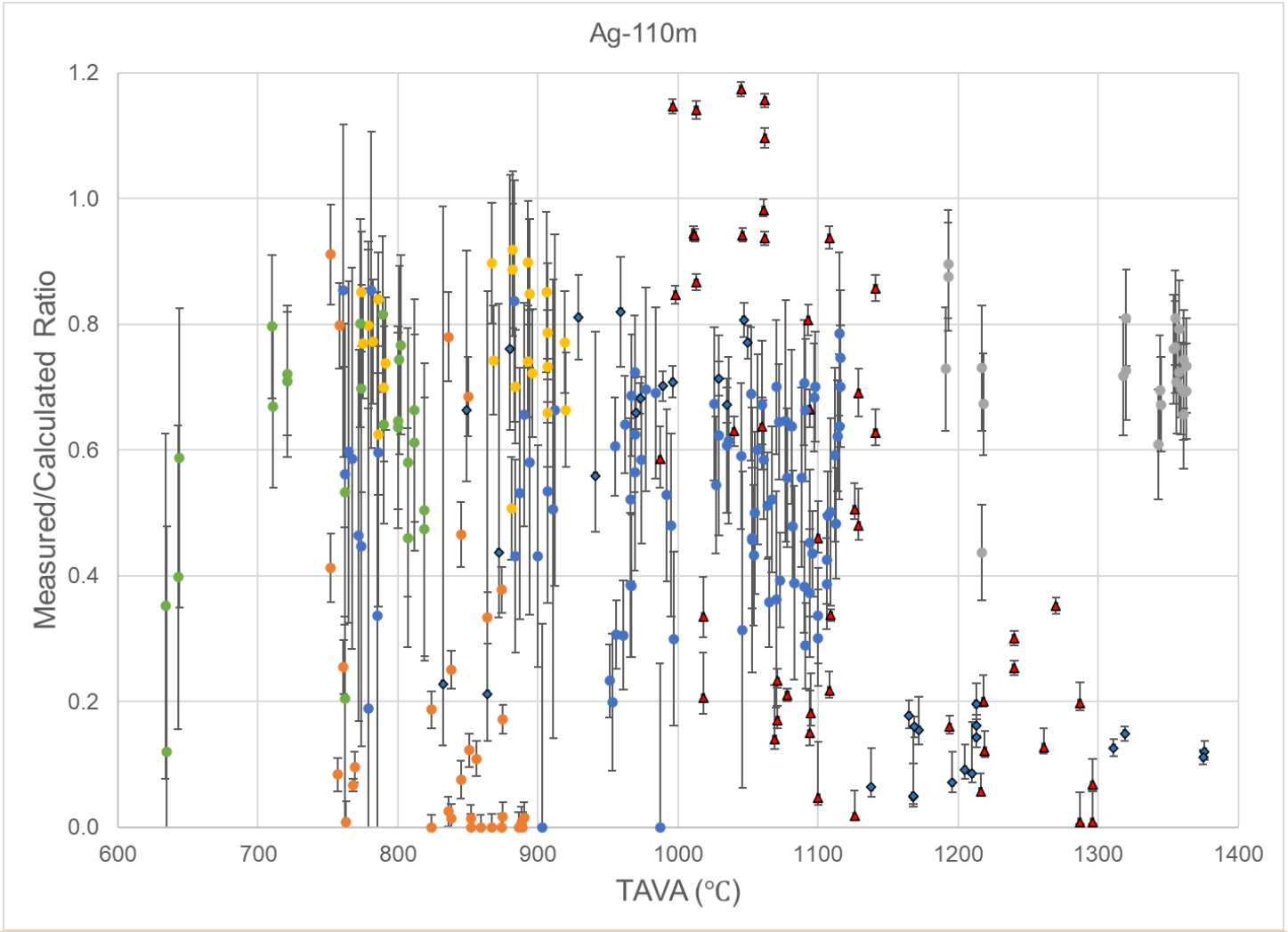
Compacts PGS: Ag-110m M/C

- Measured activities (M) divided by physics calculations (C)

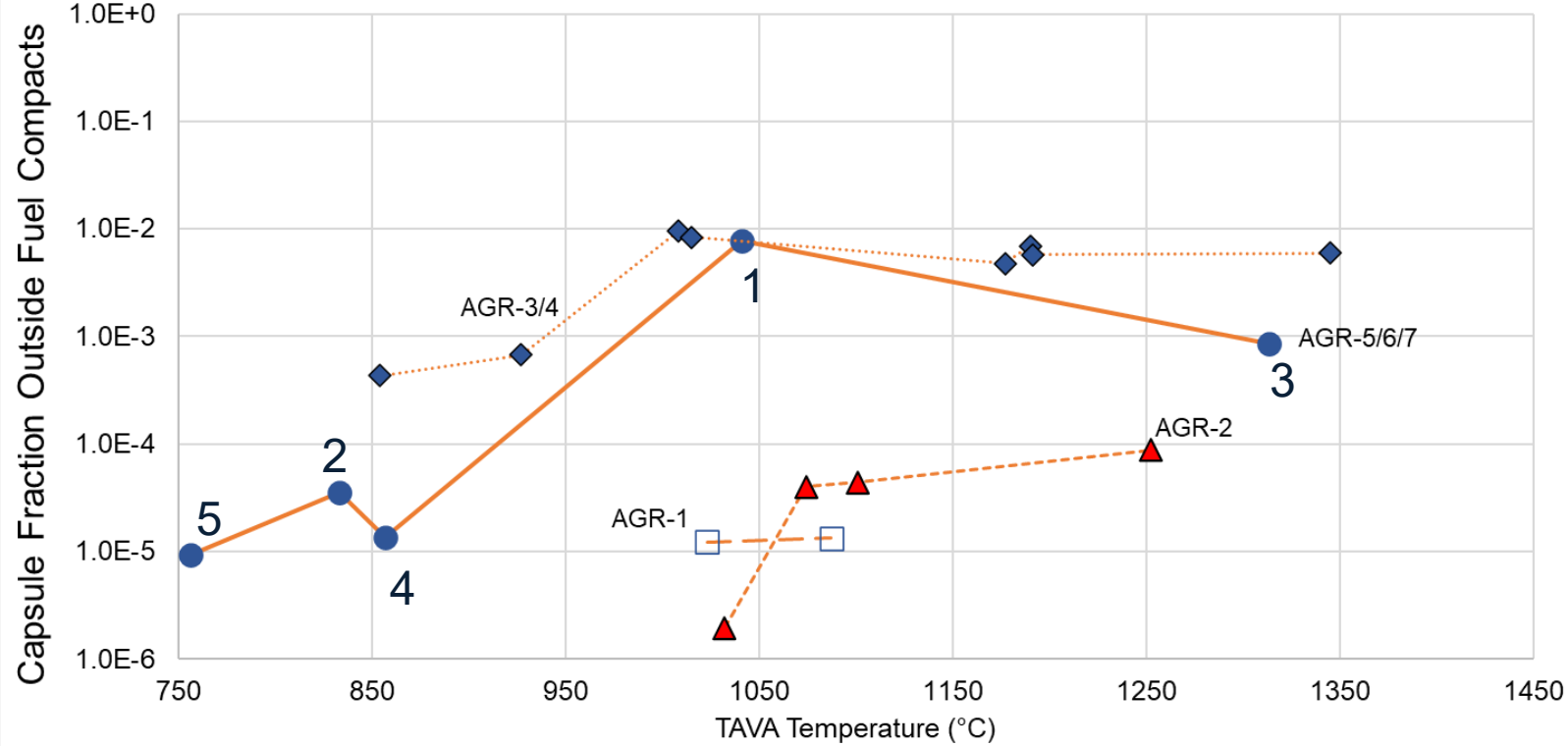


Compacts PGS: Ag-110m M/C

- Measured activities (M) divided by physics calculations (C)



Cs-134 Comparison

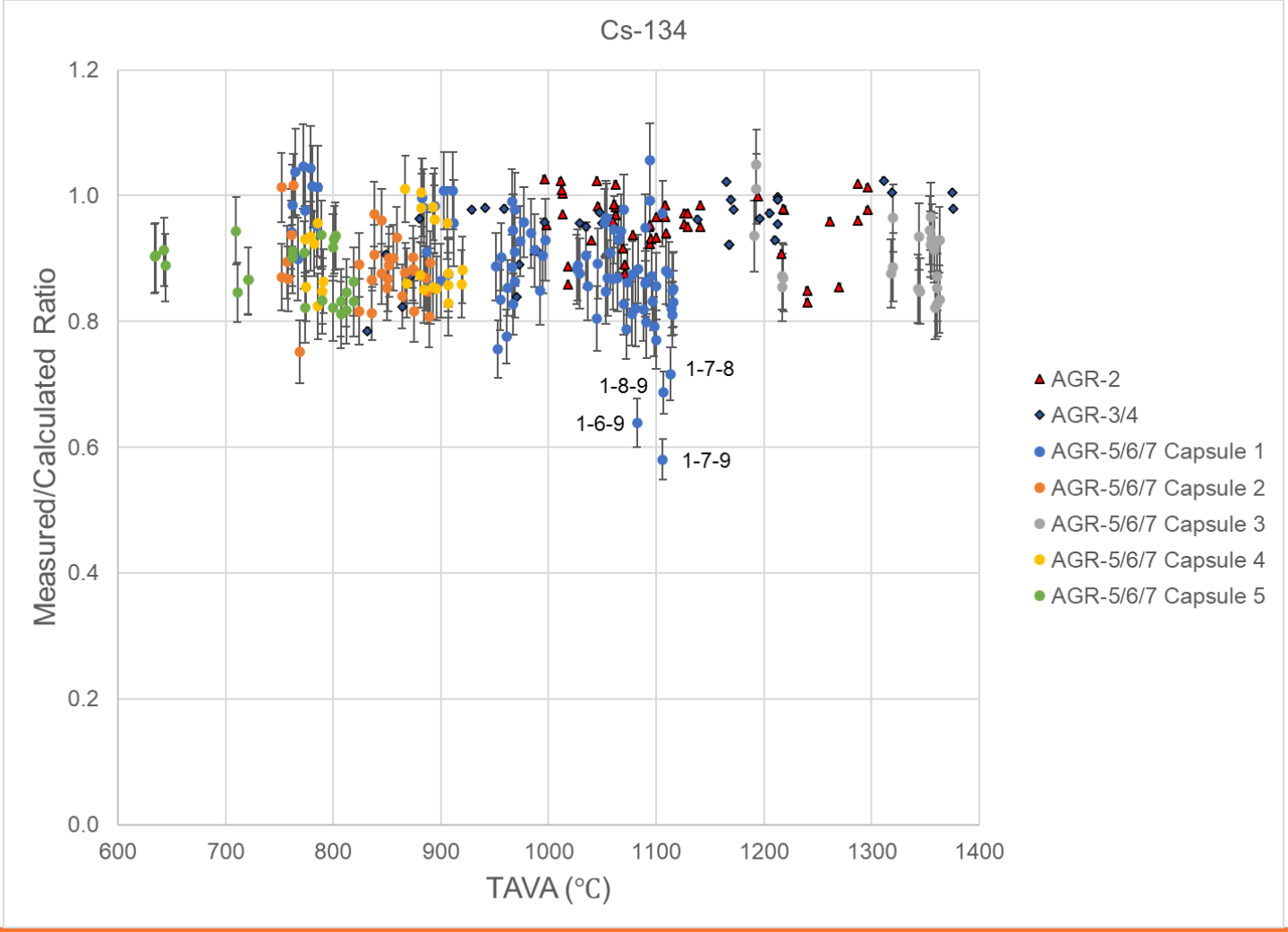


Below MDA :
AGR-1
Capsules 1-4
(1002 - 1070°C)

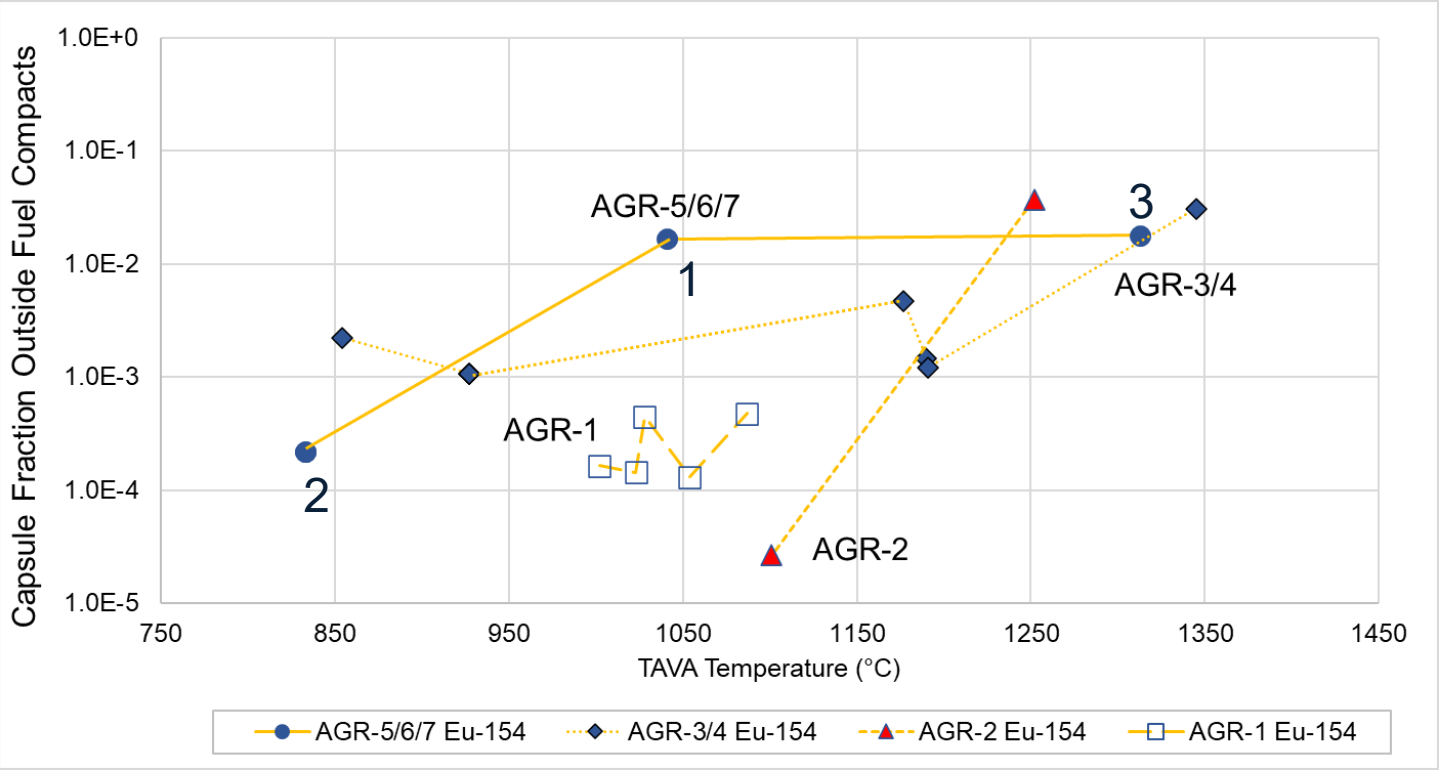
Cs-134	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5
Capsule Fraction	7.76E-3	3.56E-5	8.54E-4	1.36E-5	9.35E-6
Particle Equivalent	2.37E+3	2.58E+0	4.64E+1	7.17E-1	6.78E-1

Compacts PGS: Cs-134 M/C

- Measured activities (M) divided by physics calculations (C)



Eu-154 Comparison

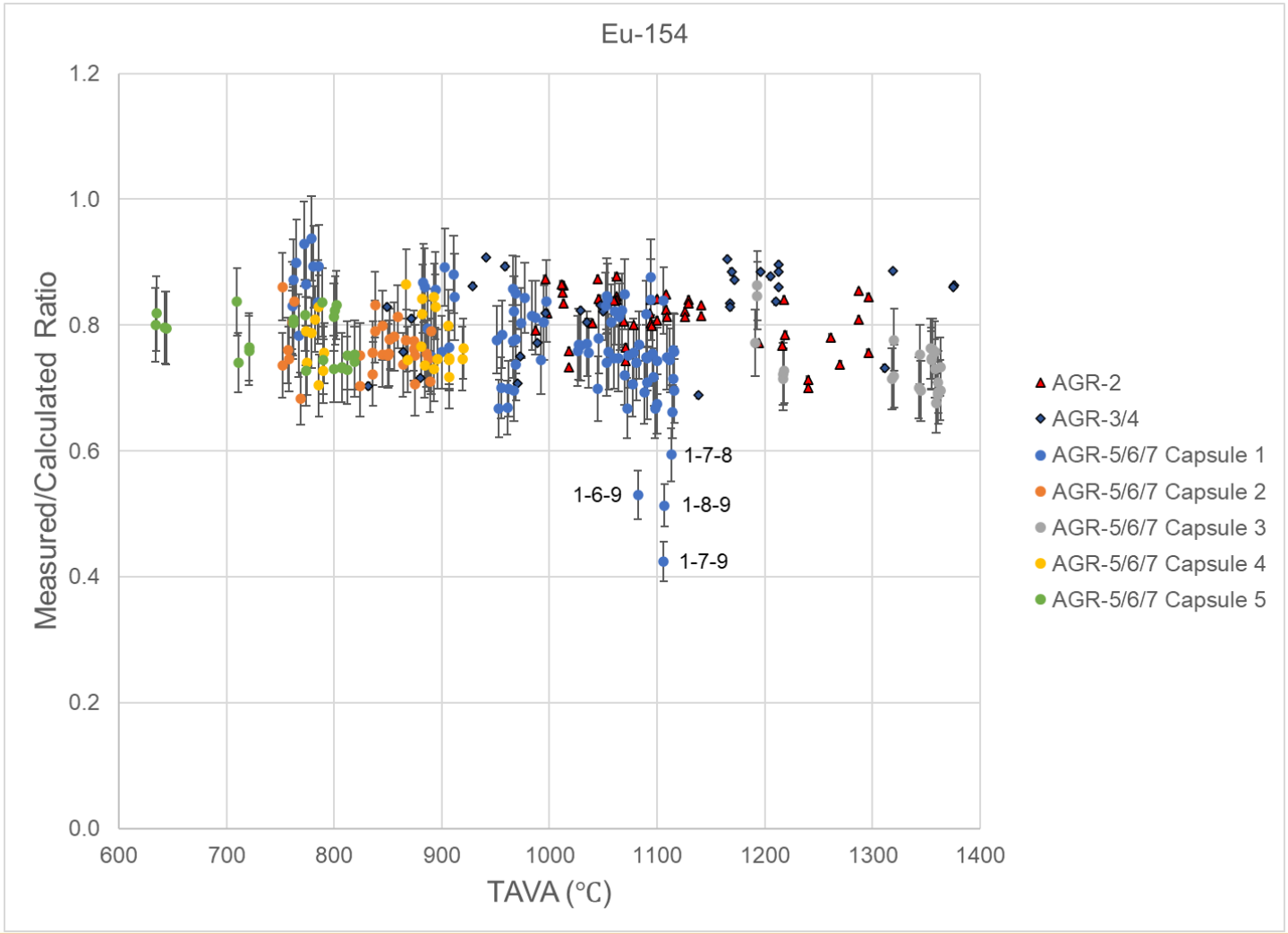


Eu-154	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5
Capsule Fraction	1.66E-2	2.18E-4	1.78E-2	0	0
Particle Equivalent	5.06E+3	1.58E+1	9.67E+2	0	0

Below MDA :
AGR-1
Capsules 4 (1070°C)
AGR-2
Capsule 3 (1032°C)
Capsule 6 (1074°C)
AGR-5/6/7
Capsule 4 (857°C)
Capsule 5 (756°C)

Compacts PGS: Eu-154 M/C

- Measured activities (M) divided by physics calculations (C)



Summary and Conclusion

- This talk provides preliminary or partial mass balance on AGR-5/6/7. Final mass balances are expected to increase a little from the preliminary results.
- AGR-5/6/7 Capsule 2 has high Ag-110m activity in capsule shell, through tubes, and graphite holder, which corroborates with low M/Cs in fuel compacts.
- By contrast, AGR-5/6/7 Capsule 3 has relatively high Ag-110m retention in the fuel compacts compared to AGR-2 fuels in the similar temperature range.
- Aside from failed AGR-5/6/7 Capsule 1 fuel, Cs-137 and Eu-154 M/Cs are consistent with prior AGR experiments.

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Thank you

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