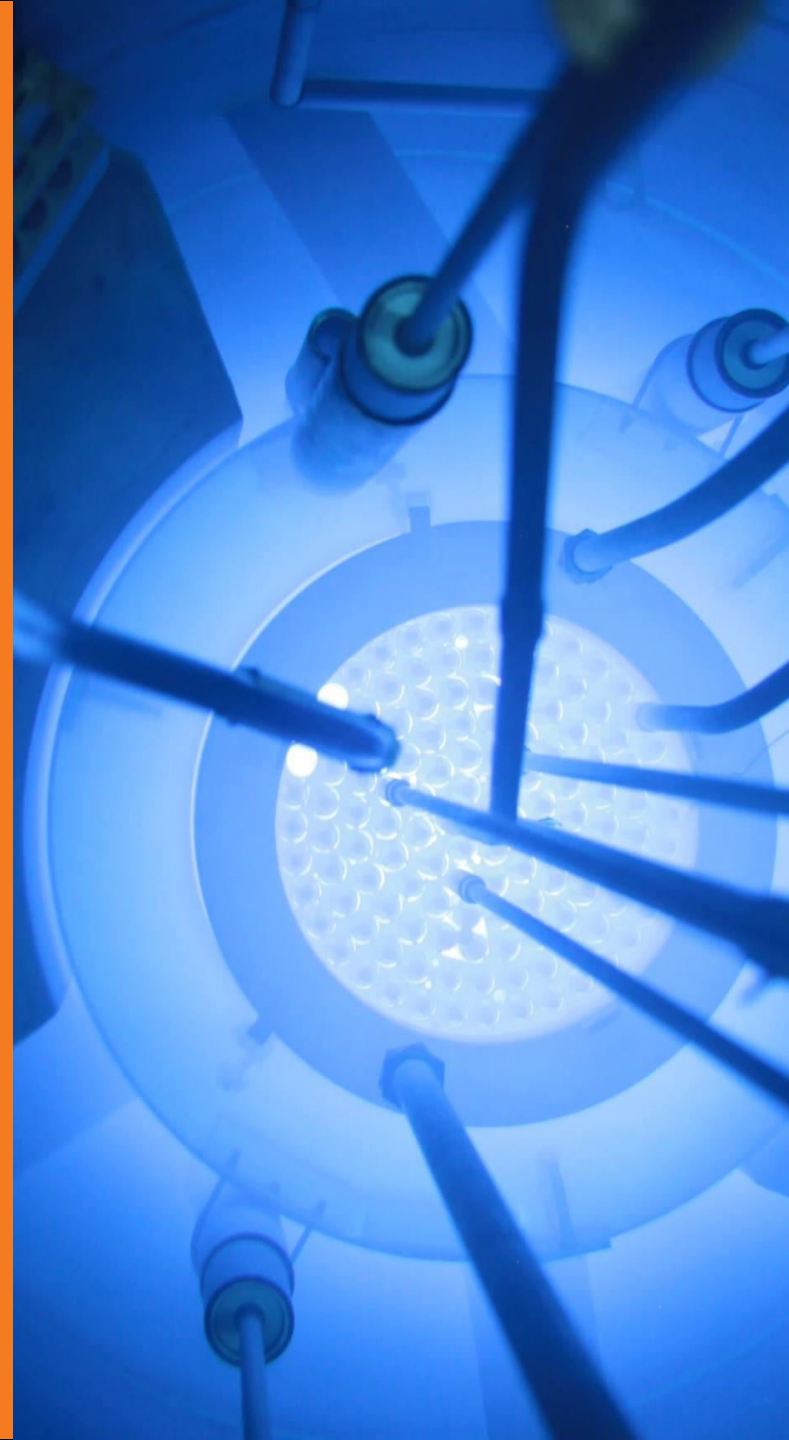


Brother, Can You Spare a Dime? (and by “Dime” I mean “IFE”)

Robert Schickler and Dr. Steven Reese

Reactor Administrator and Director
Oregon State University Radiation Center

2018 TRTR Conference
Newport, RI
October 30th, 2018



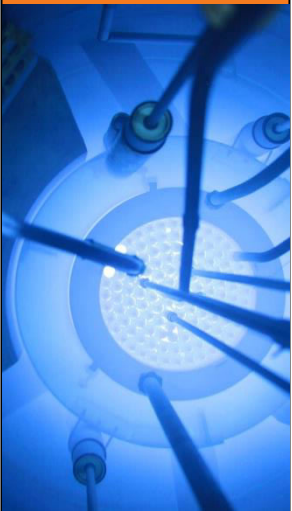
Background

The Oregon State TRIGA[®] Reactor (OSTR) is a 1 MW_{th} research reactor that provides irradiation services for researchers throughout the world.

The OSTR converted to 30/20 LEU fuel in Fall 2008.

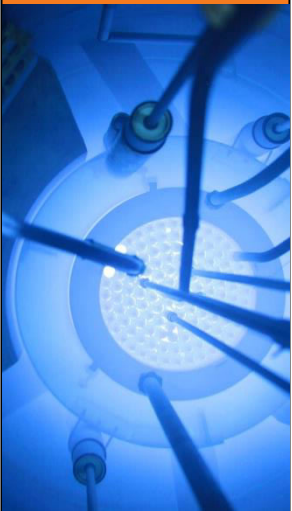
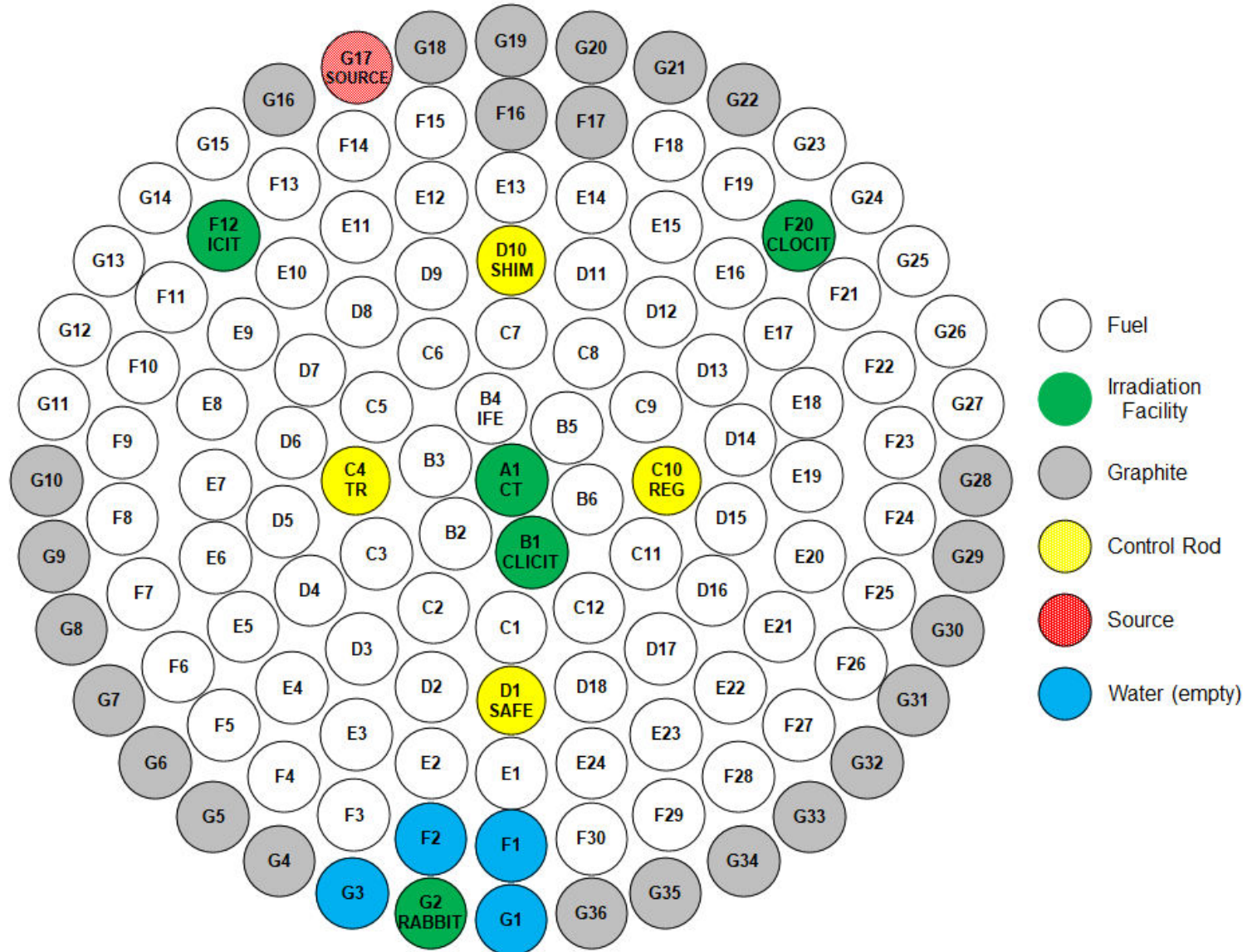
The OSTR received 2 instrumented fuel elements (IFEs) and installed one in B4 and kept the spare in dry storage.

OSU
Radiation
Center



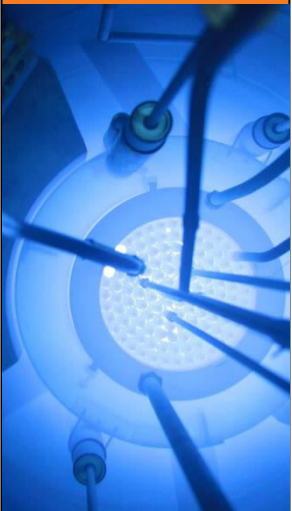
Current Core Configuration (as of July 2017)

OSU
Radiation
Center



“The Pulse”

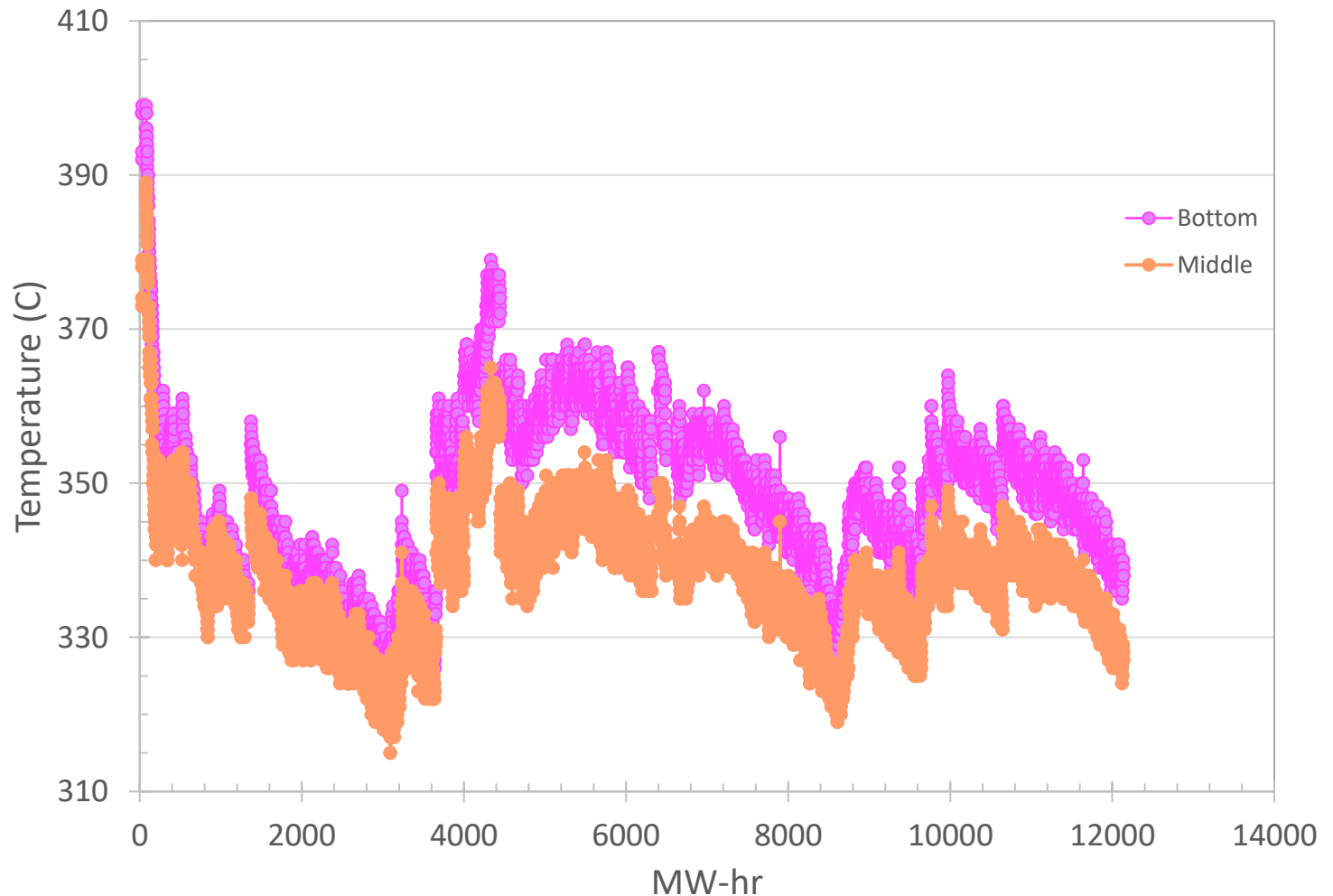
- We are administratively limited to a max pulse of \$2.25
- We perform pulses for the spring Nuclear Engineering Reactor Lab course (NSE 457/557)
- We usually perform a series of different valued pulses to test the Fuchs/Nordheim model
- We performed a \$2.20 pulse on the afternoon of 5/21/18
- The next day, upon reaching full power, the operator discovered the IFE readings had increased by approximately 45C
- The temperature has been increasing ever since.
- We have a limiting safety system setting (LSSS) that causes a fuel temperature scram at 510C.



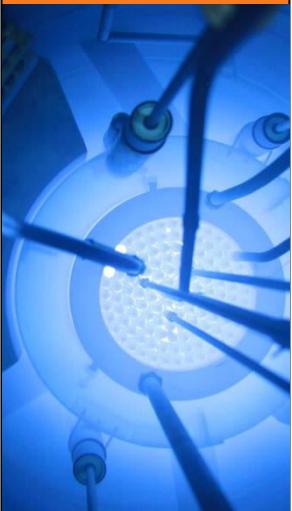
IFE Temperature History

- This is the IFE temperature history before “the pulse”

IFE Bottom and Middle Temperature (C) vs. MW-hr



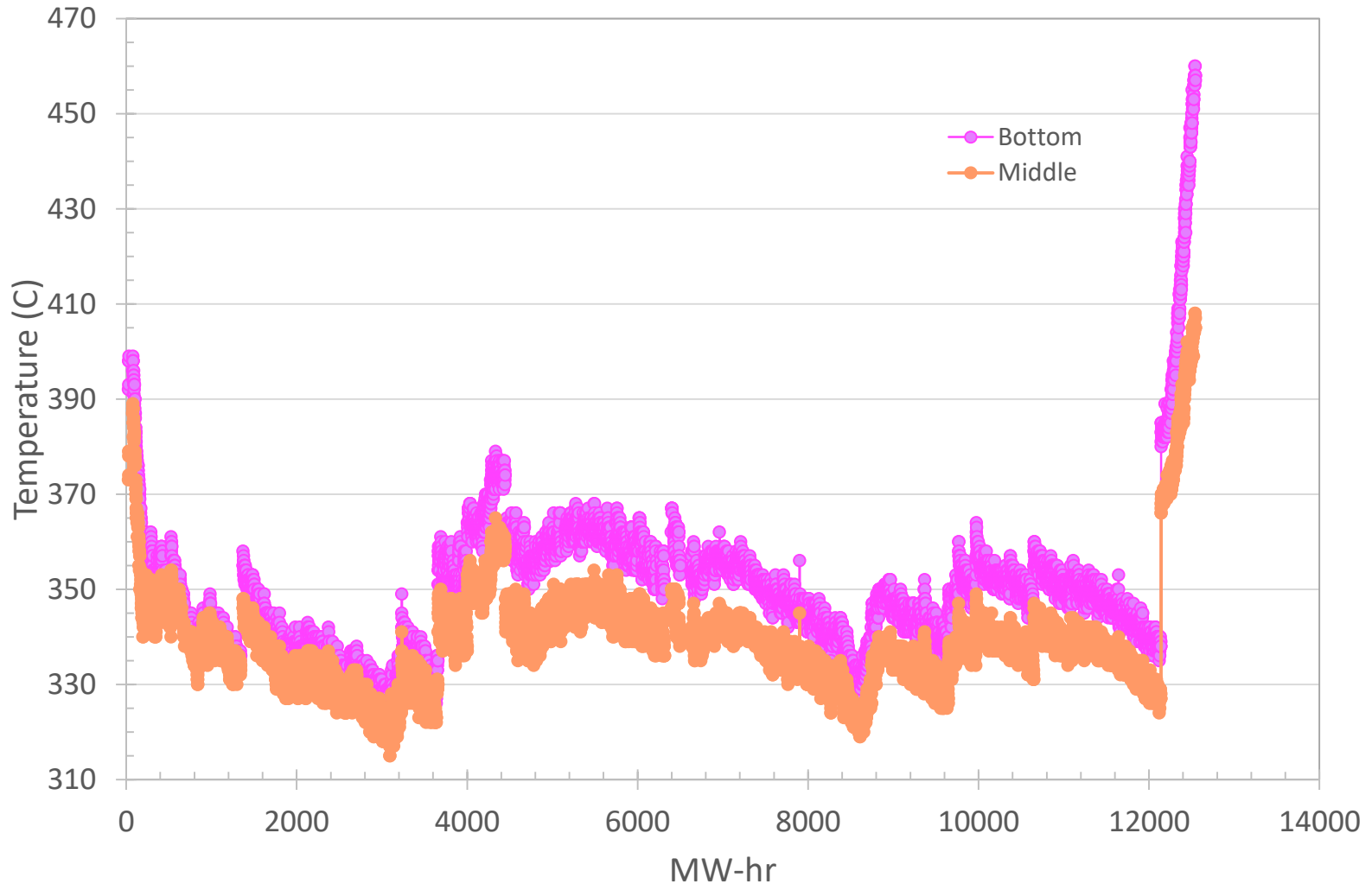
OSU
Radiation
Center



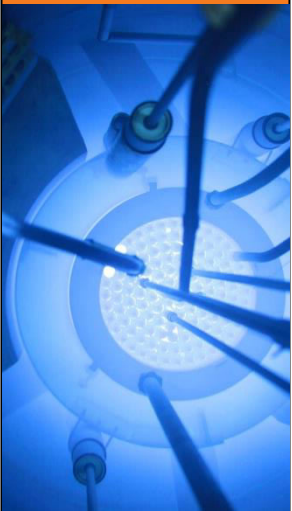
IFE Temperature History

- This is the IFE temperature history up to 10/22/18

IFE Bottom and Middle Temperature (C) vs. MW-hr

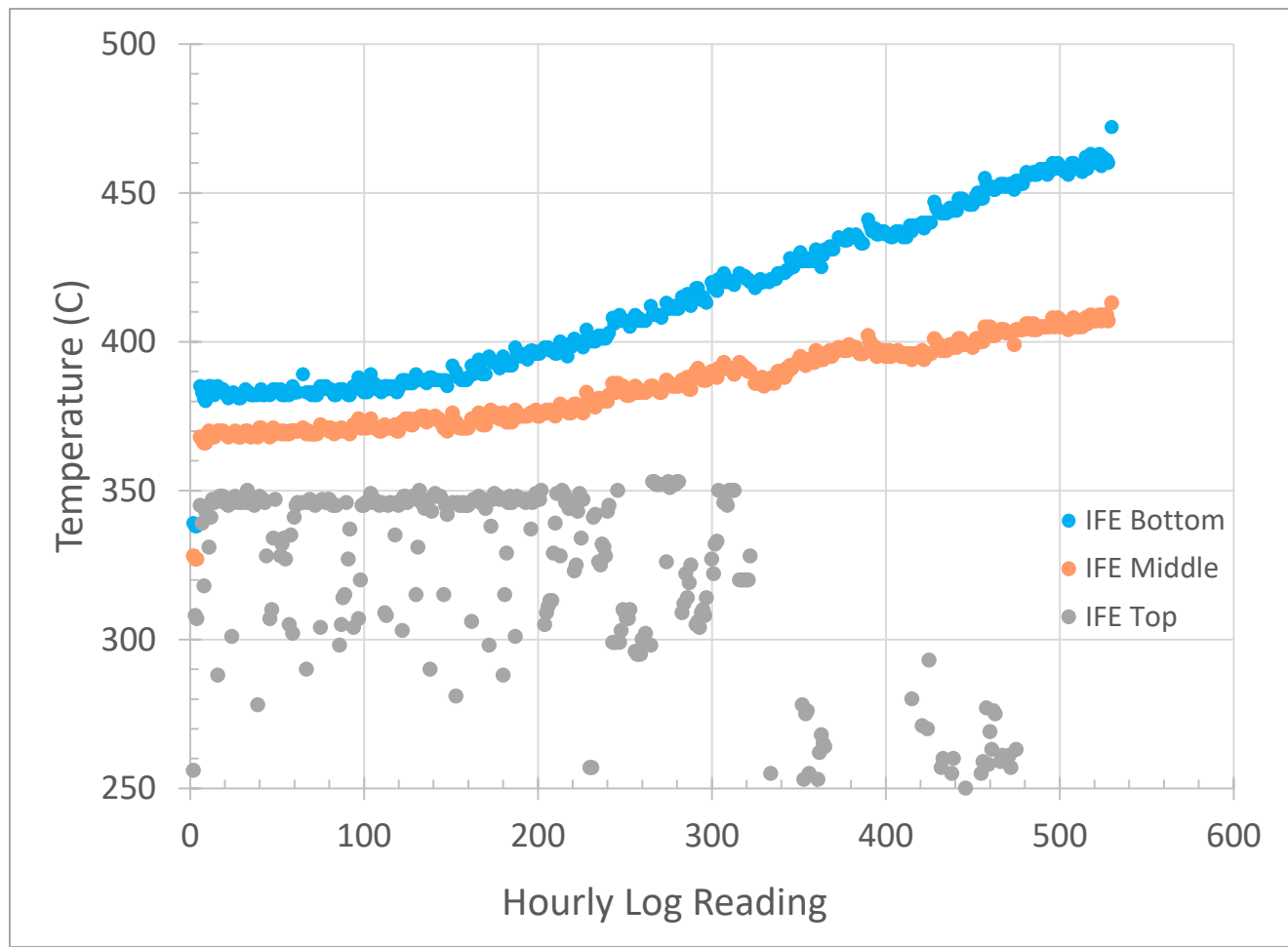


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Center

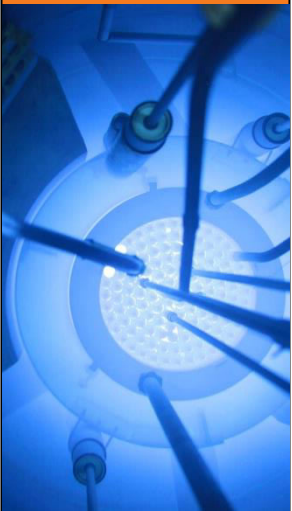


Increasing IFE Temperatures

- We started digitally logging our IFE temps after the pulse and discovered divergence between bottom and middle
- Top TC has been unreliable since day 1

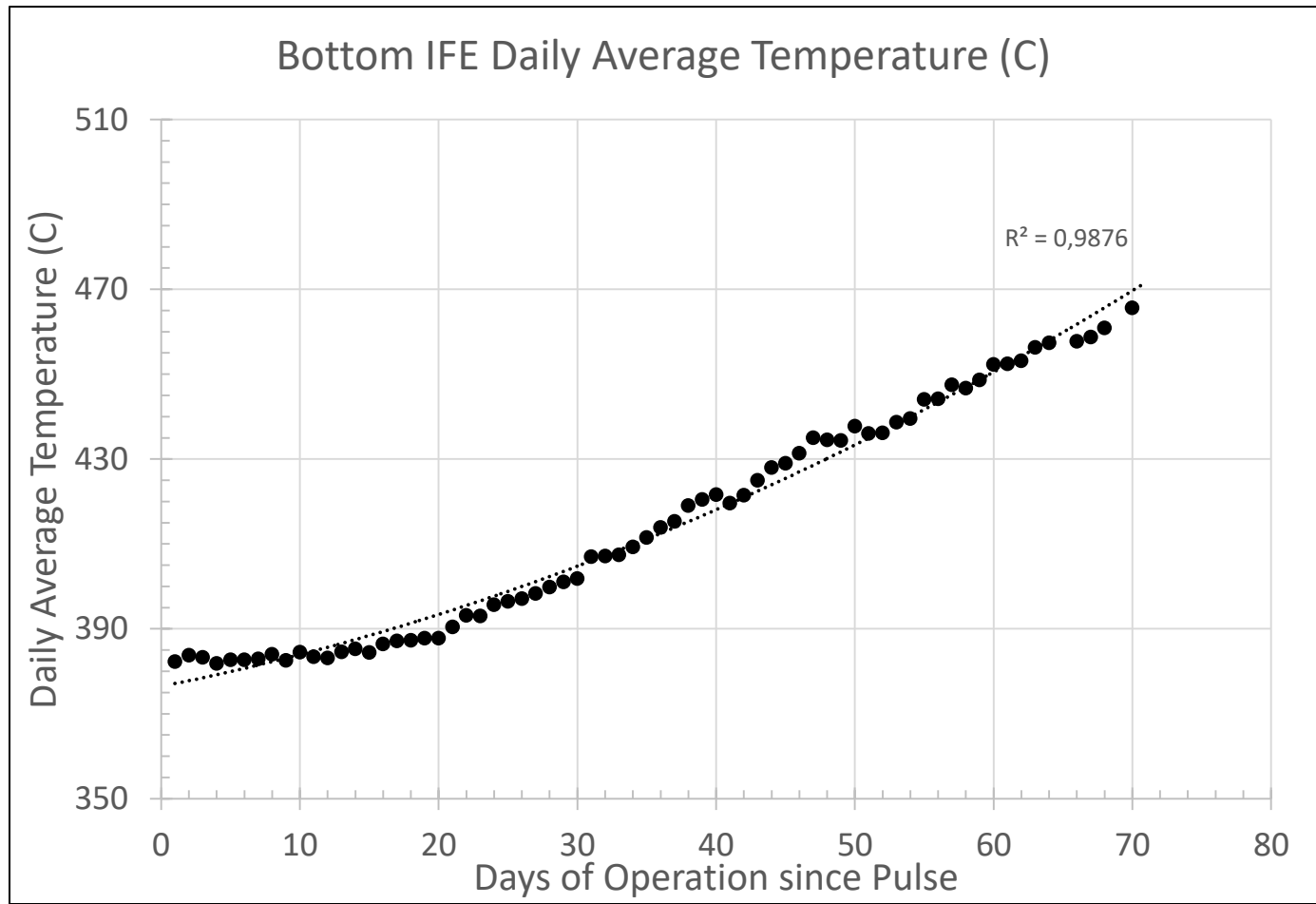


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Increasing IFE Temperatures

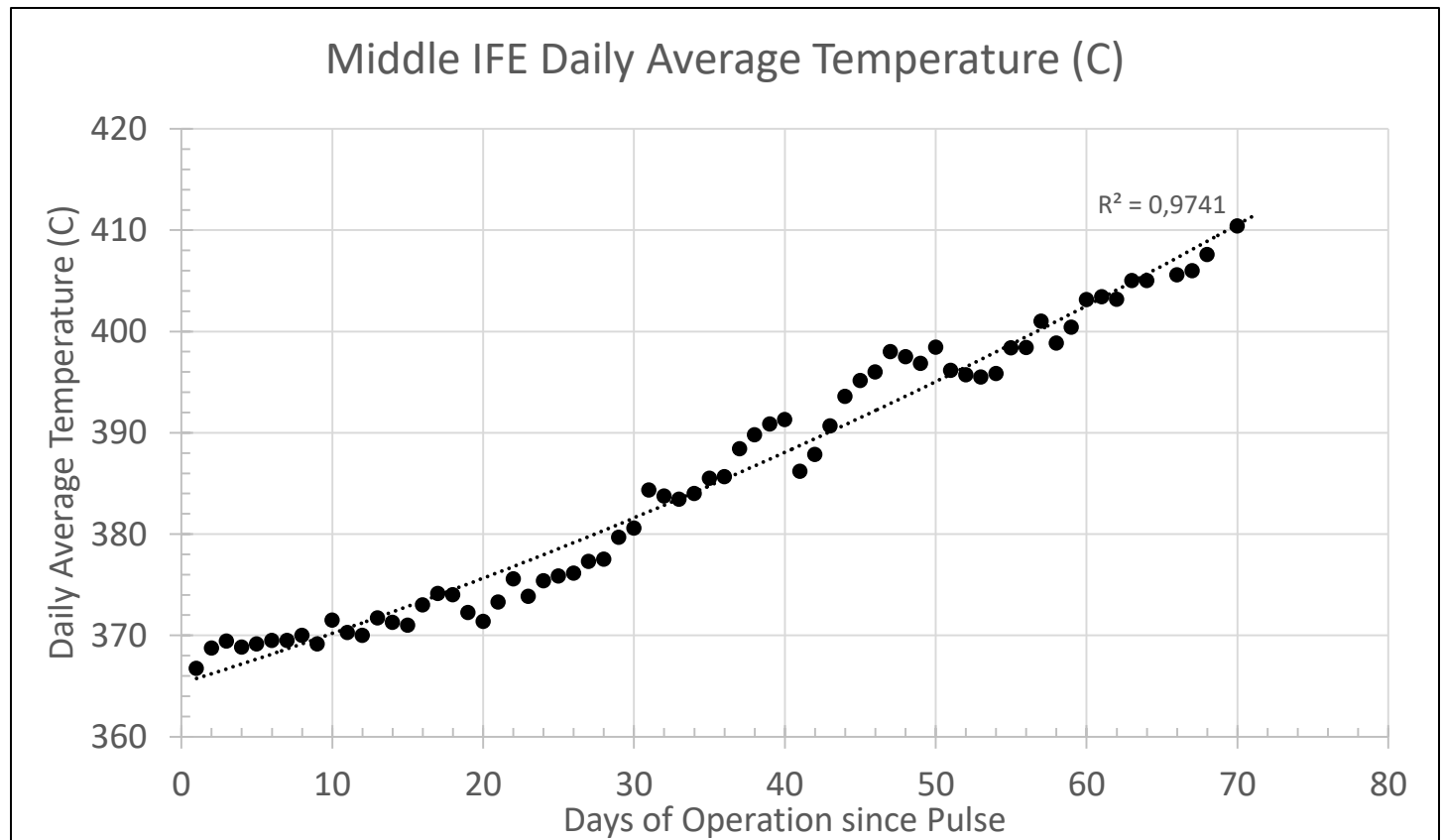
- The bottom TC is the hottest channel. It jumped from ~340 to ~385 and was reading over 470 on 10/22/18
- The trendline shows the IFE exceeding LSSS on day 88



Increasing IFE Temperature

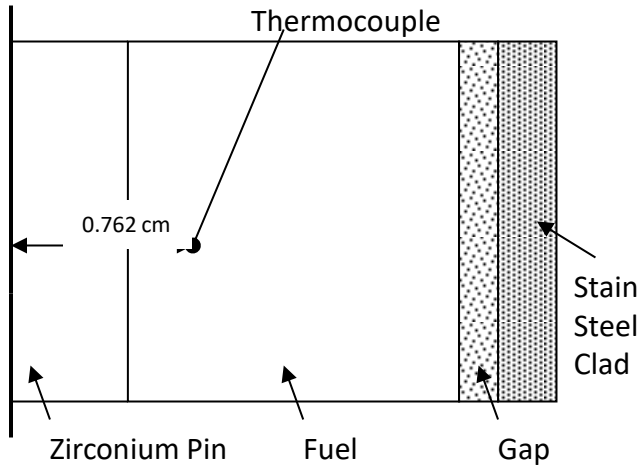
- The middle TC is cooler than the bottom TC. It jumped from ~330 to ~365 and was reading over 410 on 10/22/18
- The trendline shows the IFE exceeding LSSS on day 162

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Center

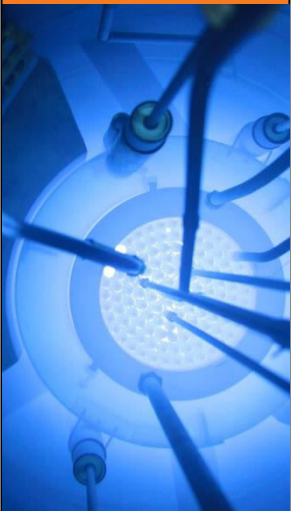
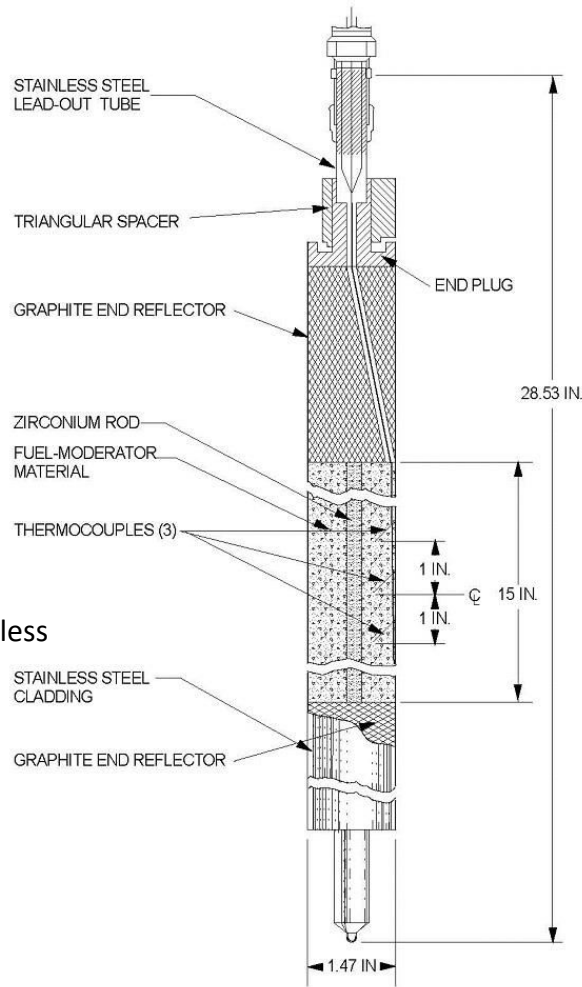


IFE inspection performed on 7/3/18 showed no apparent damage or swelling on IFE or on any surrounding elements

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Center**



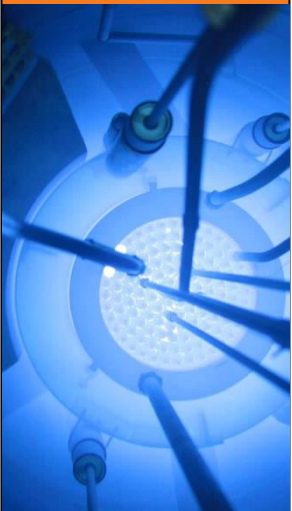
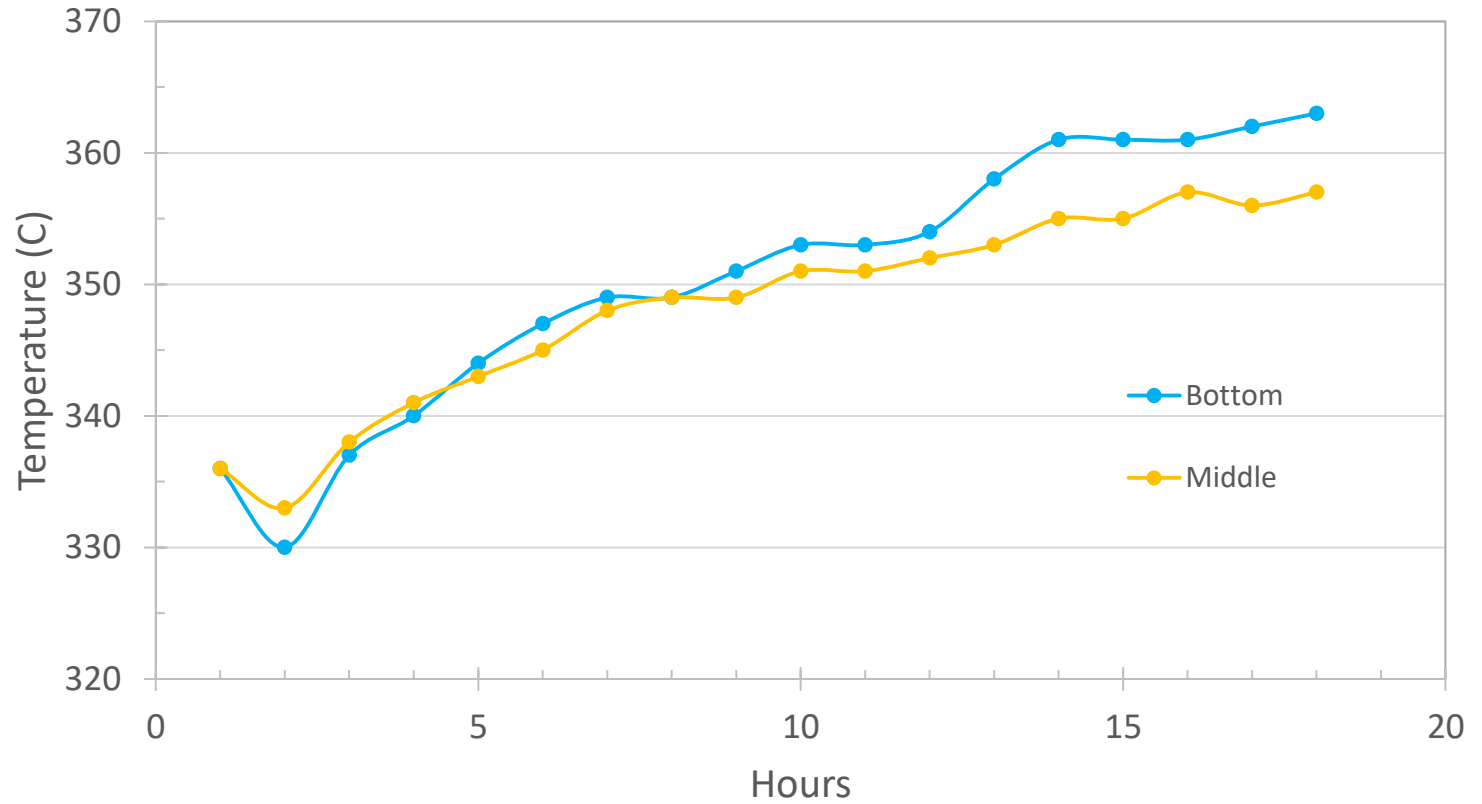
Cross Sectional View
Instrumentation Fuel Element



Initial "Seasoning" of Fuel

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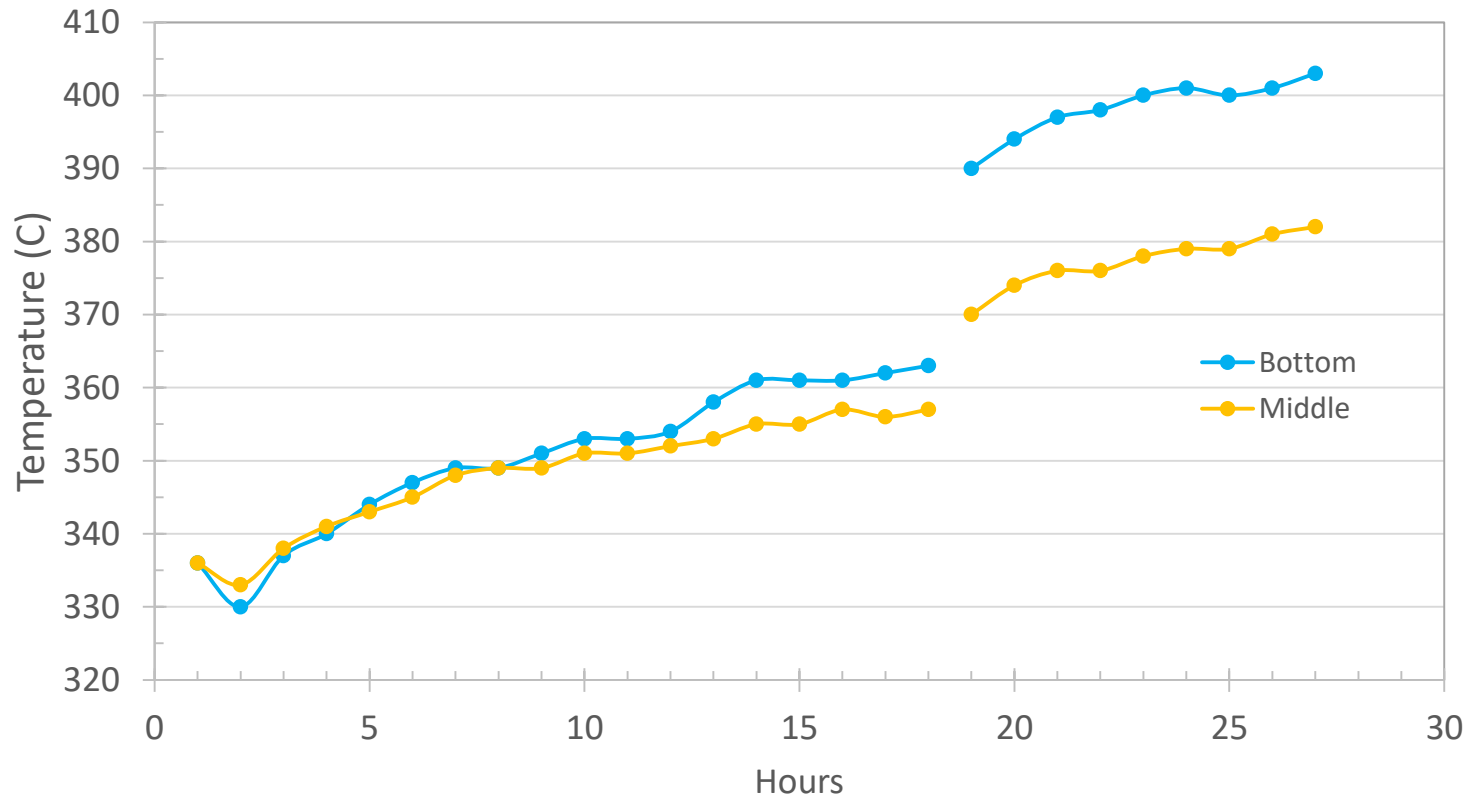
First 18 Hours of Operation in Normal LEU Core
(10/21/08)



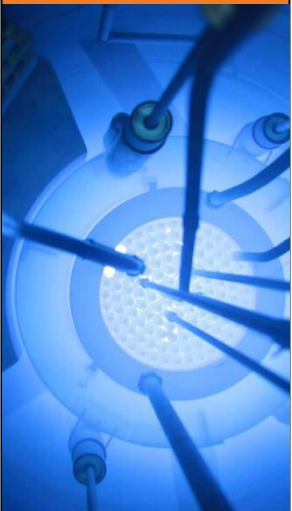
Operation After Seasoning and Pulsing

- Bottom jumped 30 degrees and rose
- Middle jumped 15 degrees and rose

Seasoning Then 10 Hours After \$2.25 Pulsing on
10/24/08



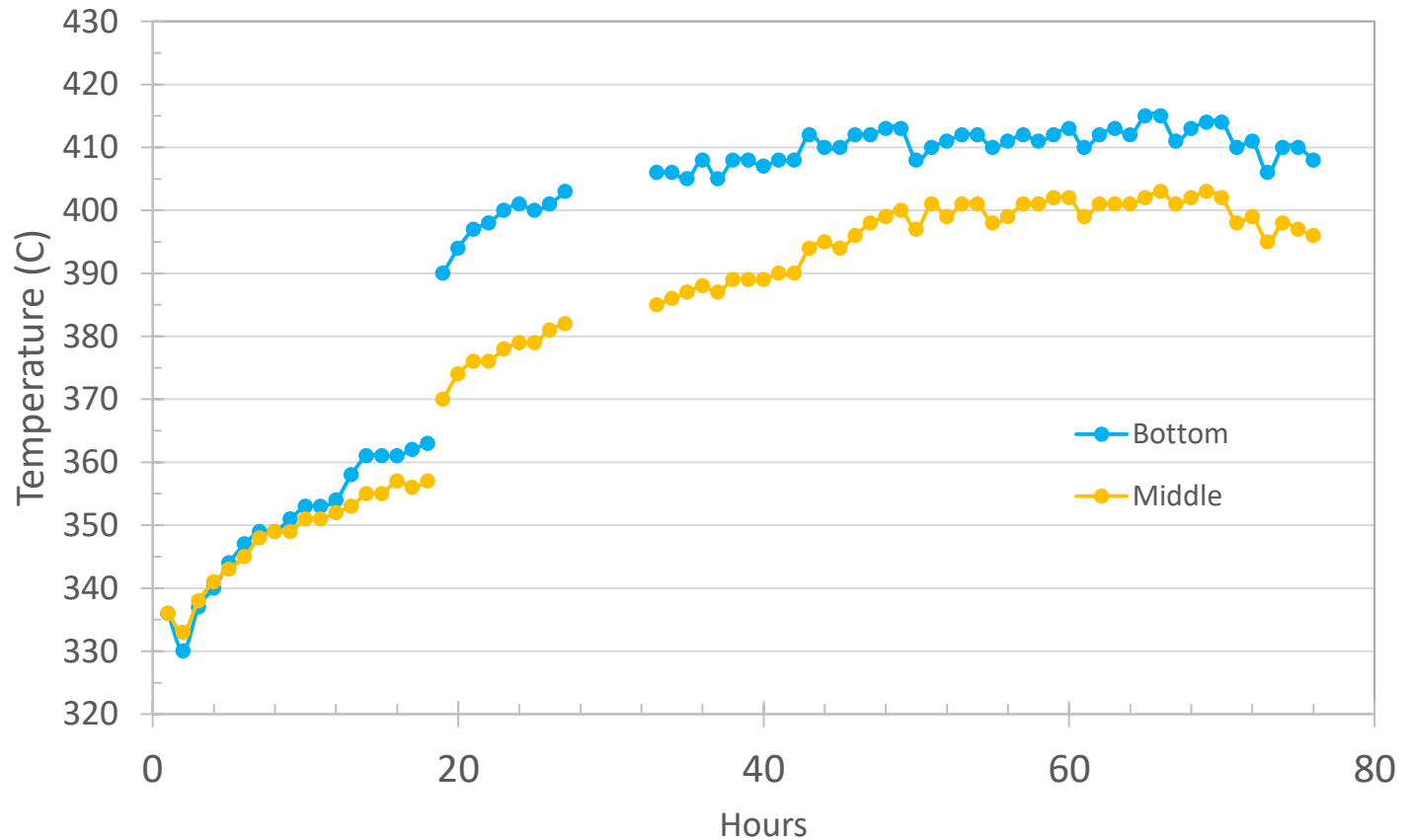
OSU
Radiation
Center



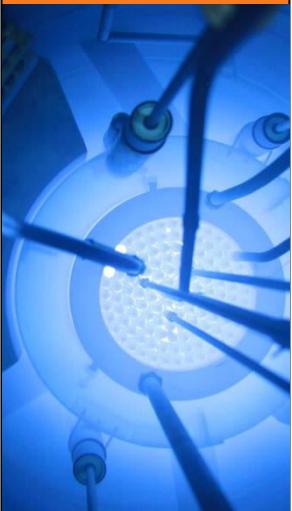
Operation After Seasoning and Pulsing

- The temperature eventually stabilized and began to decrease after about one month

From Beginning of Life Until 11/17/08 (ICIT Config)

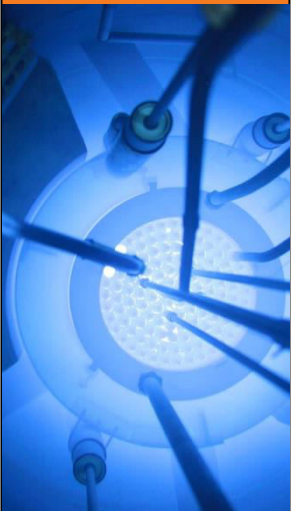


OSU
Radiation
Center

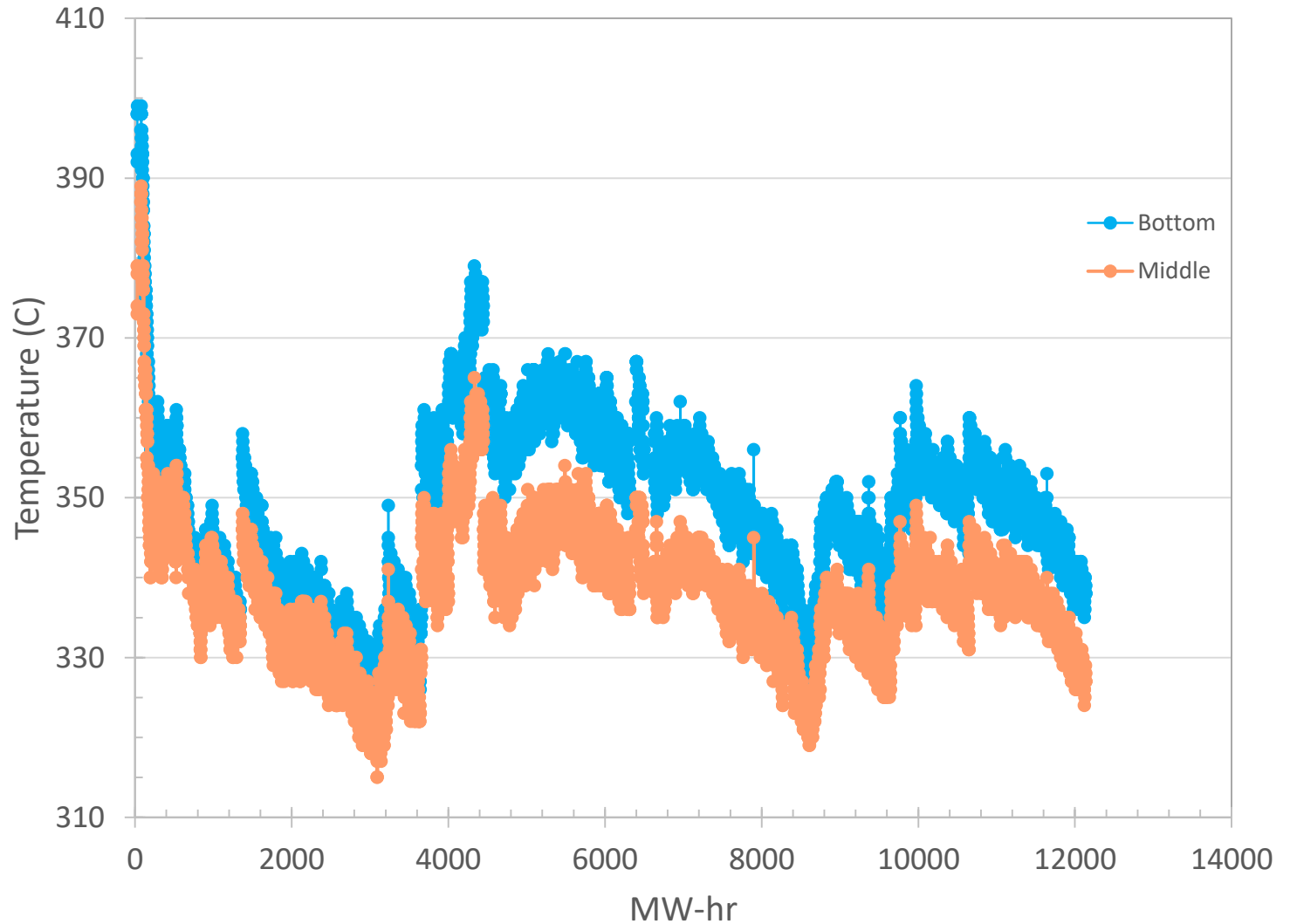


IFE Temperature History

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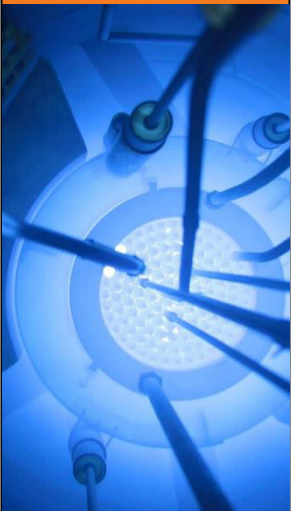


IFE Bottom and Middle Temperature (C) vs. MW-hr

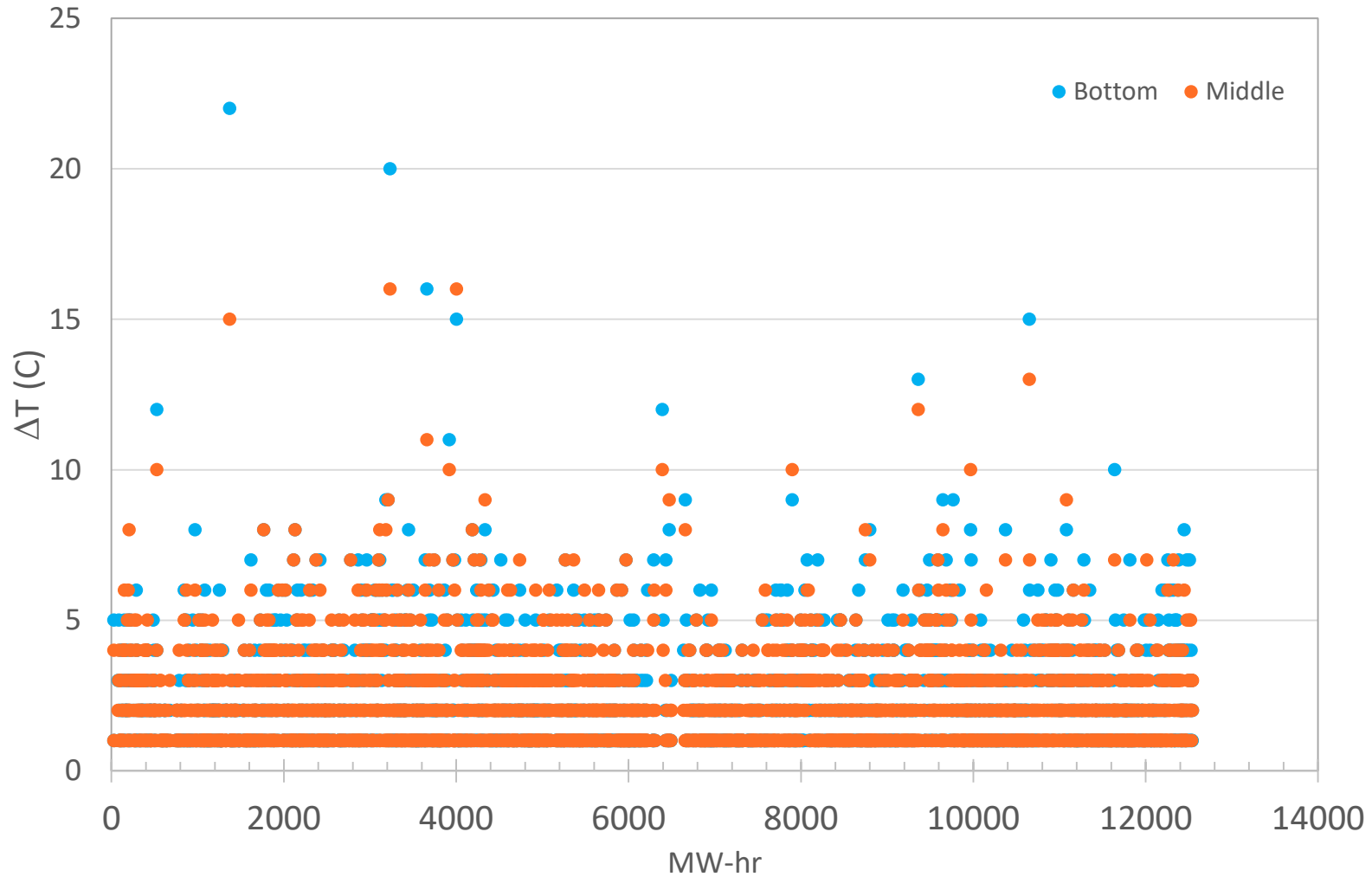


Differences in Hourly Logs

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Center

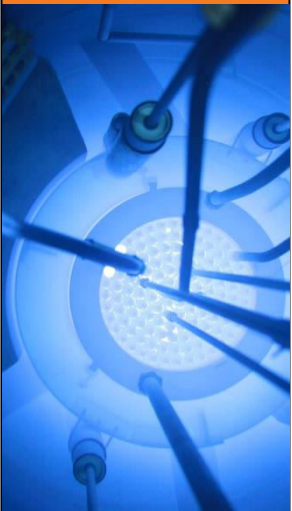


Difference between Hourly IFE Readings (C) vs. MW-hr

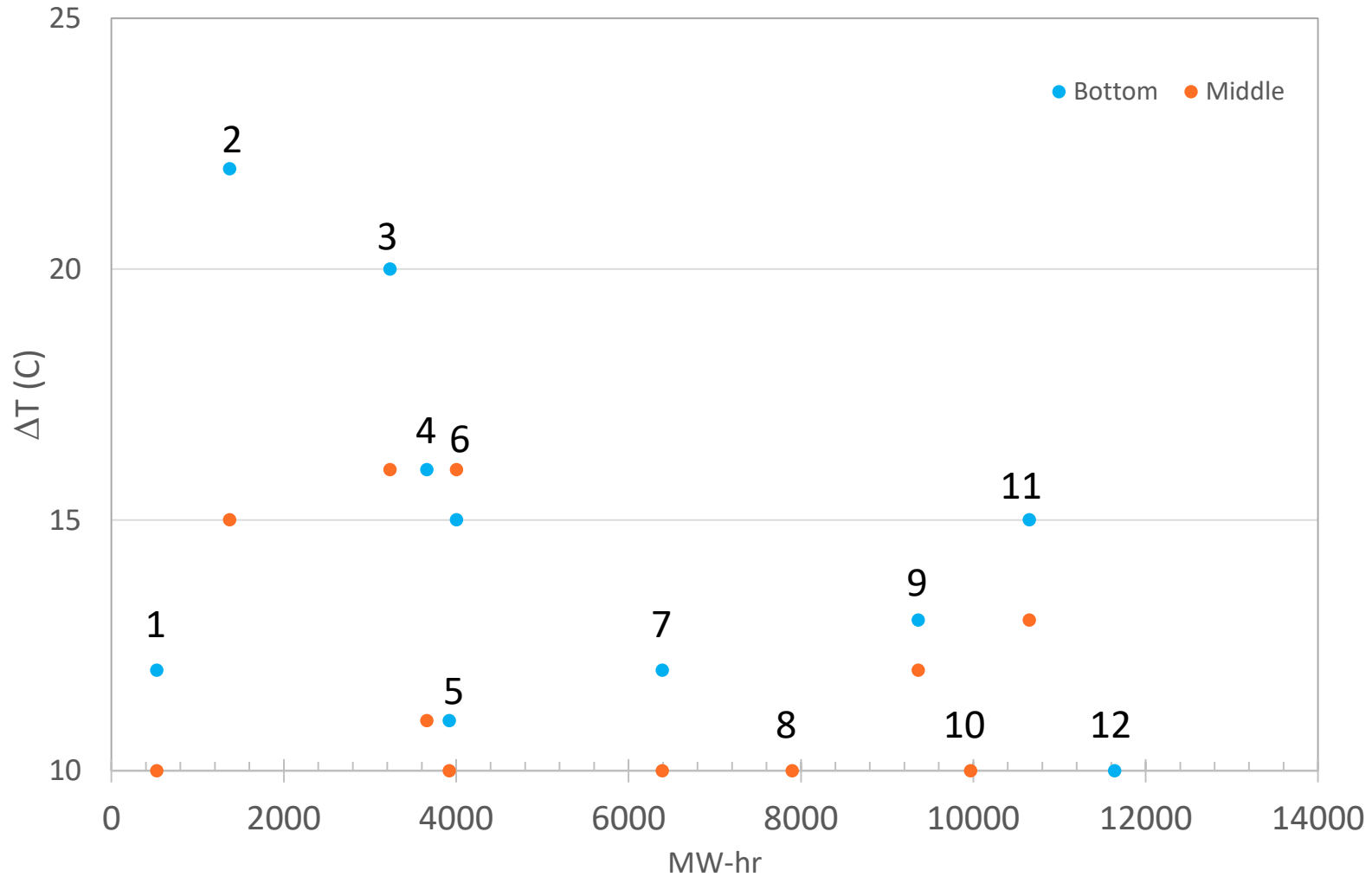


Differences in Hourly Logs

OSU
Radiation
Center



Difference between Hourly IFE Readings (C) vs. MW-hr

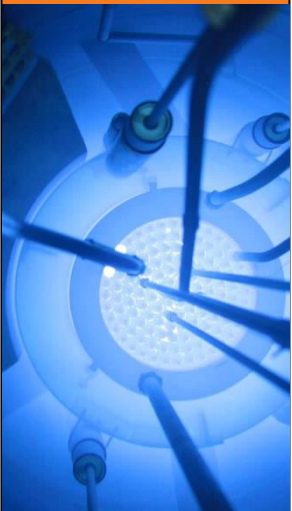


All Pulses Greater Than \$2.00

- The OSTR has been pulsed 325 times for a total of \$562.28 of reactivity (average pulse of \$1.73)
- Only 19 pulses have exceeded \$2.00

Date	Pulse #	Reactivity
10/24/08	11	\$2.10
10/24/08	15	\$2.10
10/24/08	12	\$2.20
10/24/08	16	\$2.20
10/24/08	13	\$2.25
10/24/08	17	\$2.25
10/30/08	22	\$2.18
11/3/08	27	\$2.03
3/3/10	55	\$2.02
3/3/10	56	\$2.16
2/28/12	117	\$2.02
2/28/12	118	\$2.16
5/30/12	128	\$2.25
6/1/12	134	\$2.10
11/21/12	161	\$2.01
5/28/14	202	\$2.20
5/22/17	296	\$2.08
5/21/18	318	\$2.20
5/22/18	320	\$2.10

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Center

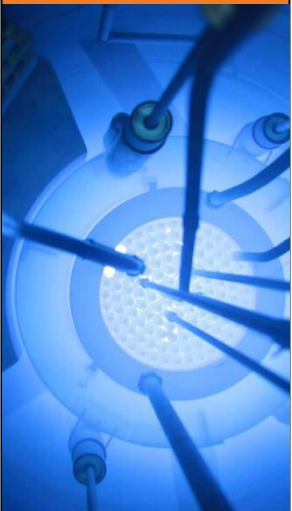


Temperature Increases After > \$2.00 Pulses

- This table shows the increases seen in the bottom TC at 1 MW the day before and after a +\$2.00 pulse

Date	Maximum Reactivity	Temp Before Pulse	Temp After Pulse	ΔT
10/24/08	\$2.25	364	390	26
3/3/10	\$2.16	343	361	18
2/28/12	\$2.16	333	351	18
5/30/12	\$2.25	351	364	13
11/21/12*	\$2.01	363	361	-2
5/28/14	\$2.20	360	377	17
5/22/17	\$2.08	346	358	12
5/21/18	\$2.20	339	385	46

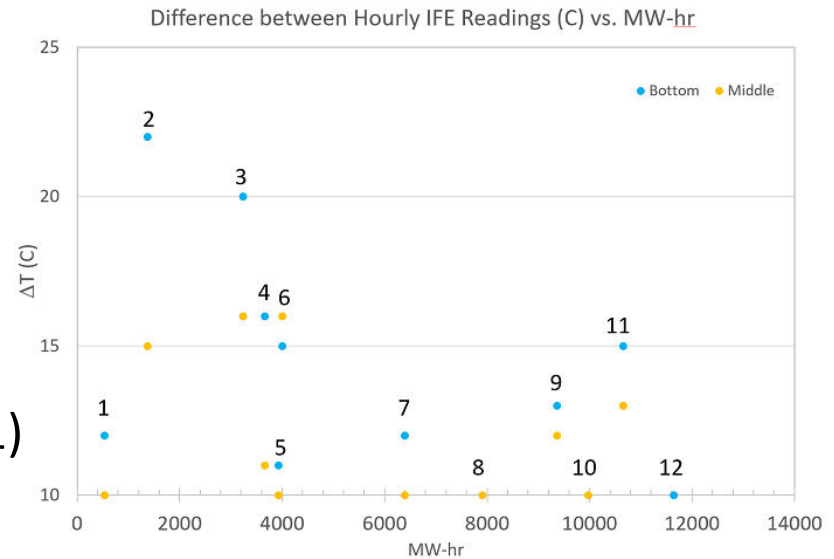
*performed on 11/21, next day of 1 MW ops on 11/27



Differences in Hourly Logs

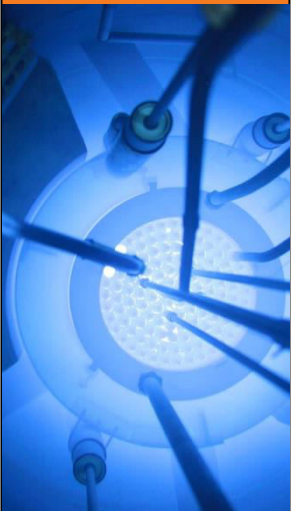
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- 1) \$2.00 pulse (4/14/09)
- 2) \$2.16 pulse (3/8/10)
- 3) Four \$2.00 pulses (10/18/11)
- 4) \$2.16 pulse (2/28/12)
- 5) Full rotating rack caused high reading
- 6) \$2.25 pulse (5/31/12)
- 7) \$2.20 pulse (6/10/14)
- 8) Cold water caused high reading
- 9) Full rotating rack caused high reading
- 10) \$2.00 pulse (12/13/16)
- 11) \$2.08 pulse (5/23/17)
- 12) Cold water caused high reading

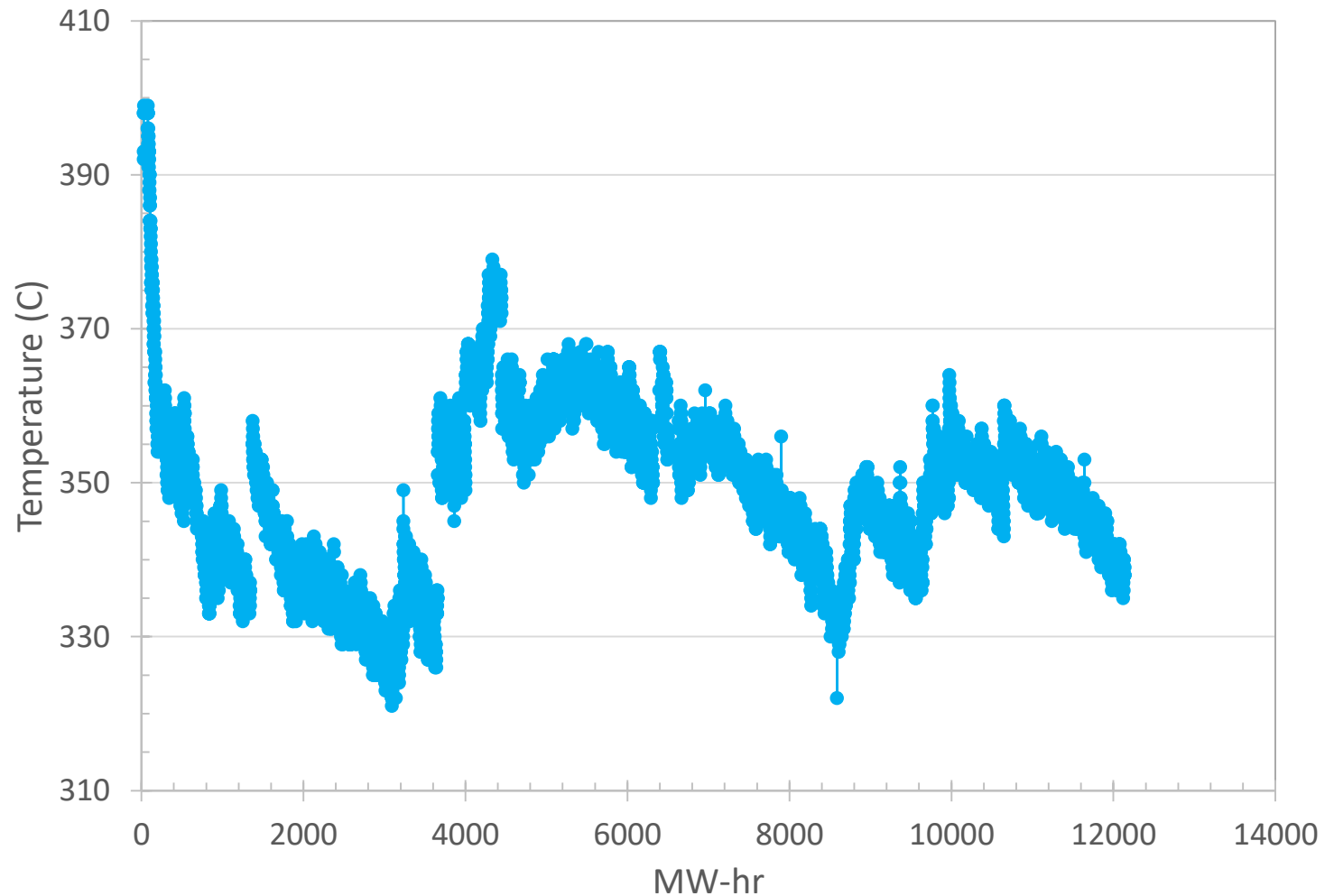


A Closer Look at IFE Temperature History

OSU
Radiation
Center

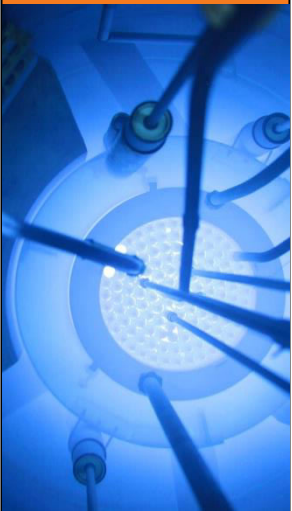
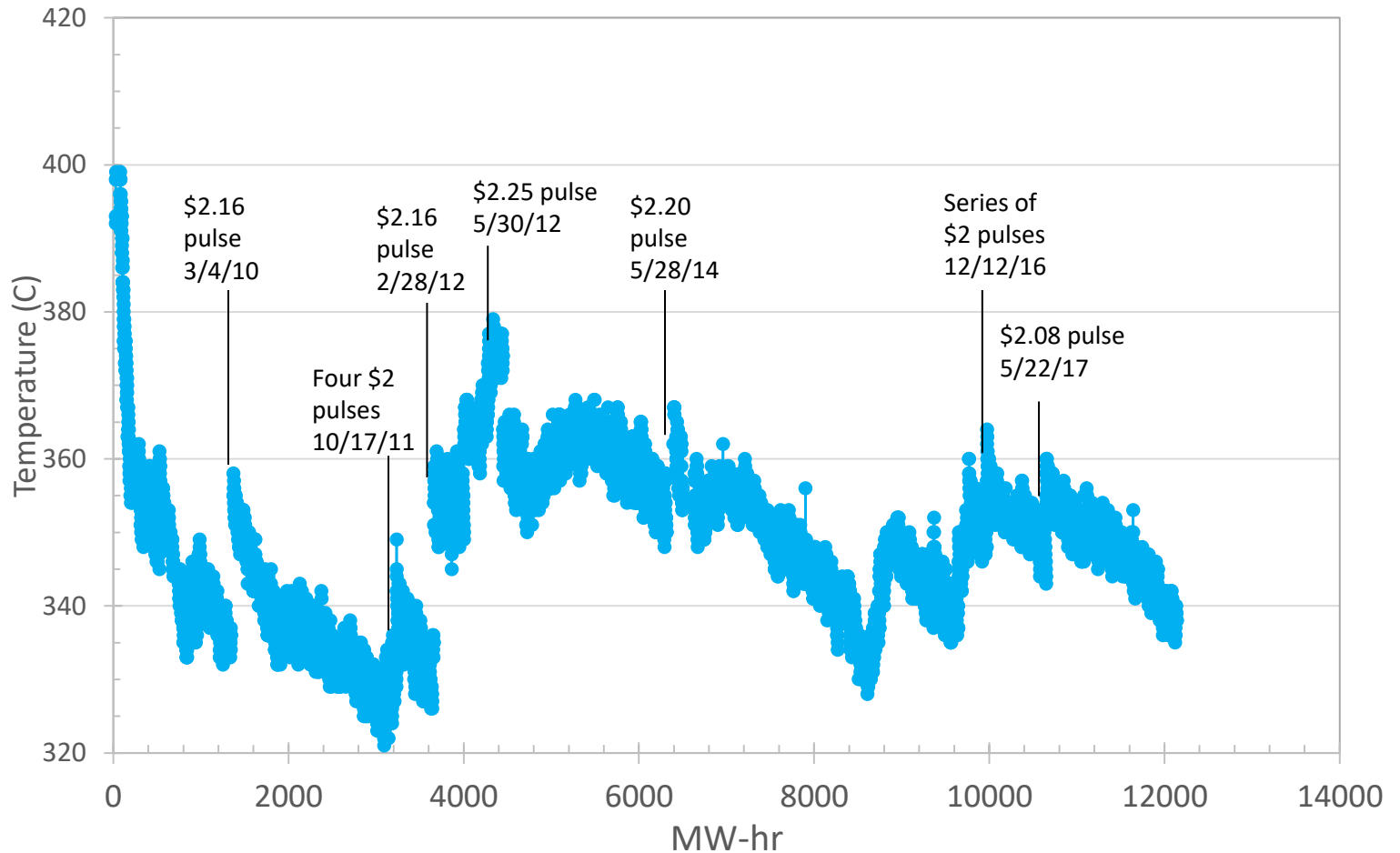


IFE Bottom Temperature (C) vs. MW-hr



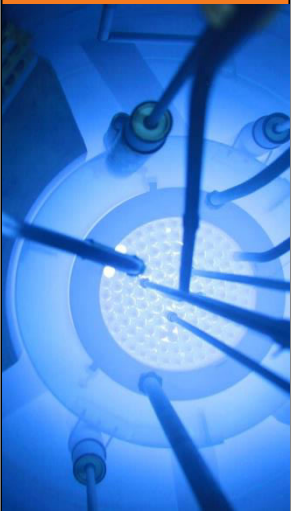
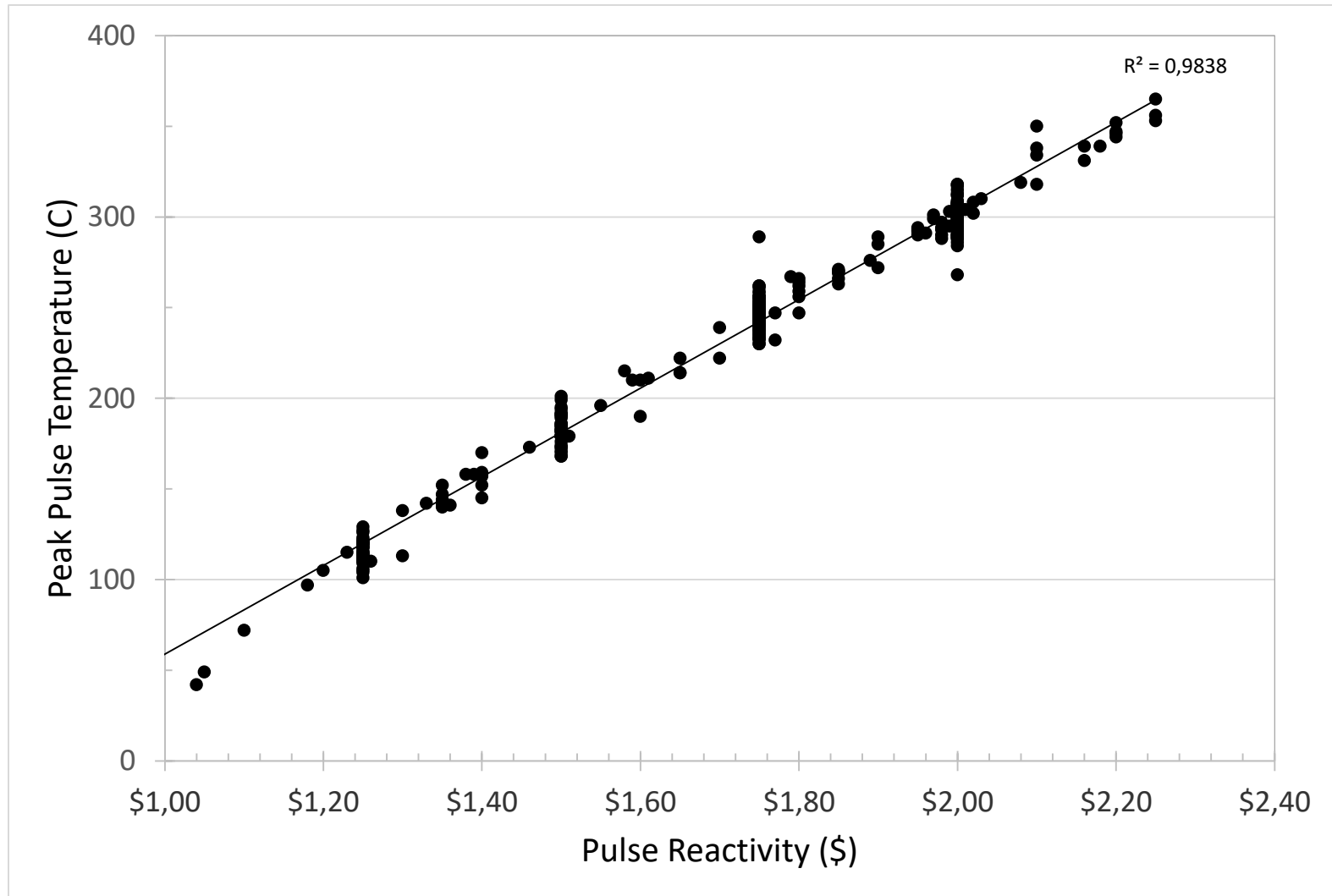
IFE Bottom Temperature (C) vs. MW-hr

OSU
Radiation
Center



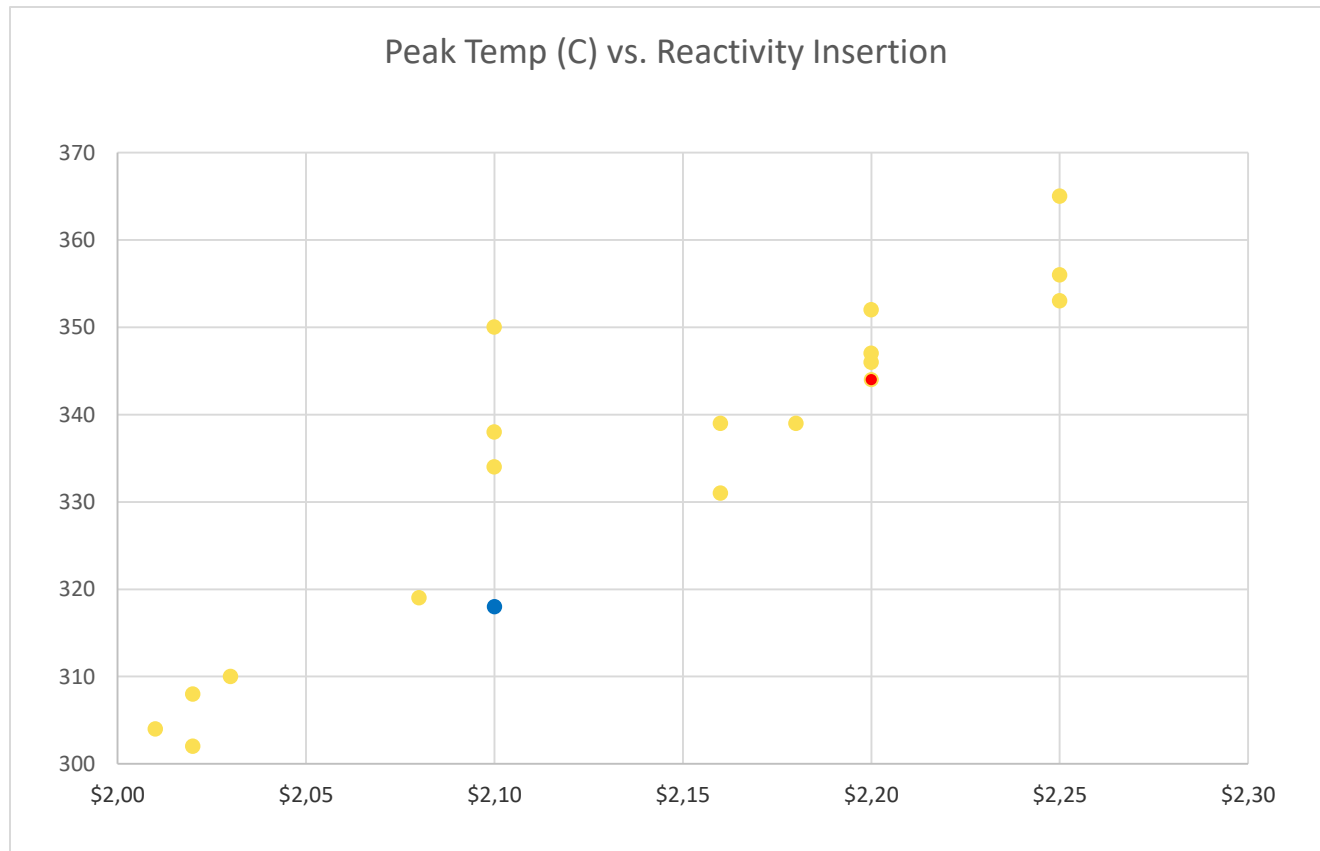
No Apparent Outliers in Pulse History

OSU
Radiation
Center

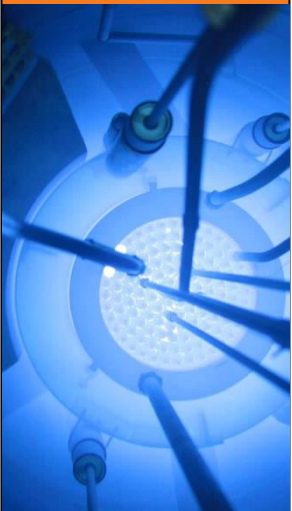


No Apparent Outliers in Pulse History

- Red = “the pulse”, Blue = \$2.10 pulse done next day

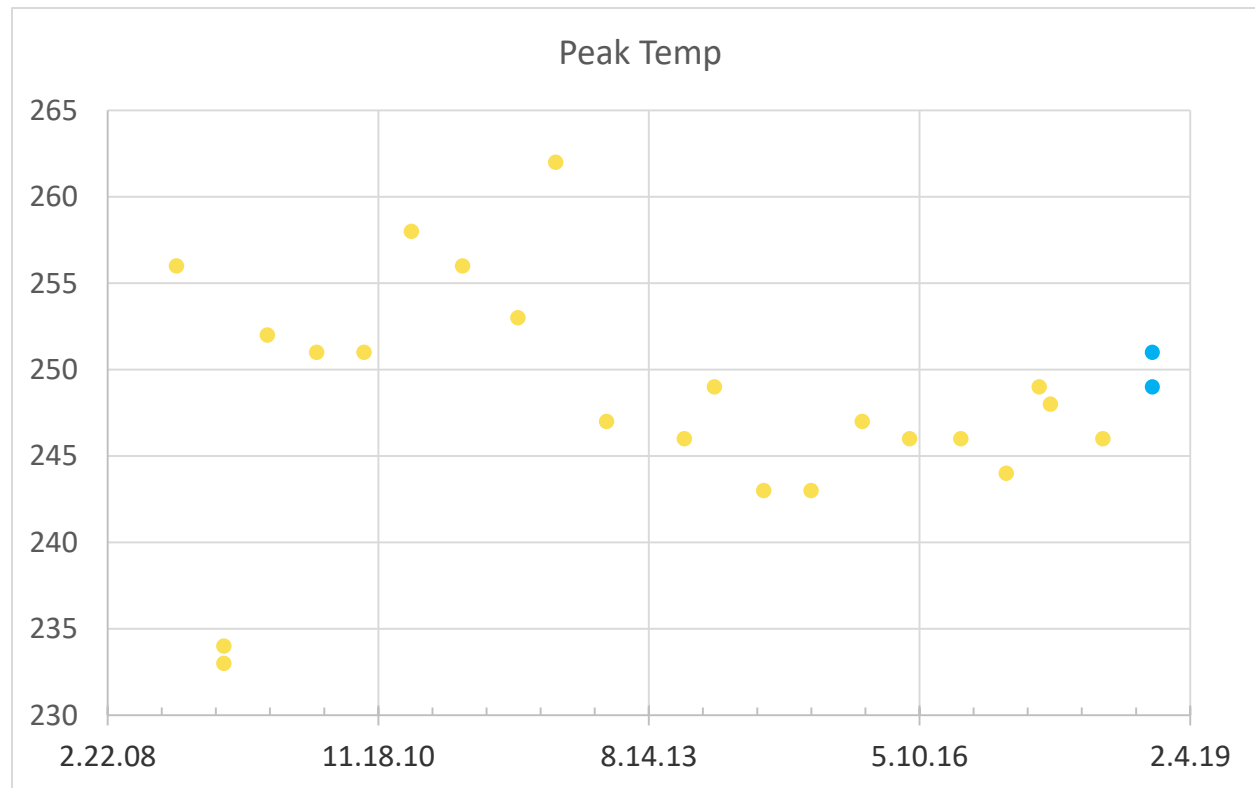


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Test Pulses

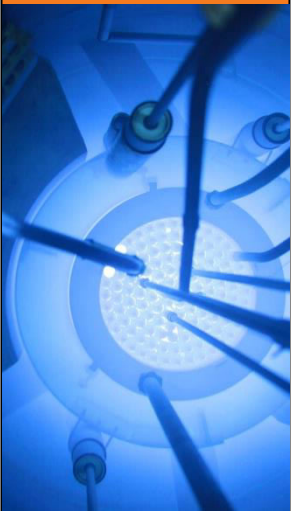
- Every 6 months we perform a \$1.75 “test pulse” to determine how consistent pulses are (< 20% change)
- Blue signifies 2 test pulses performed after “the pulse”



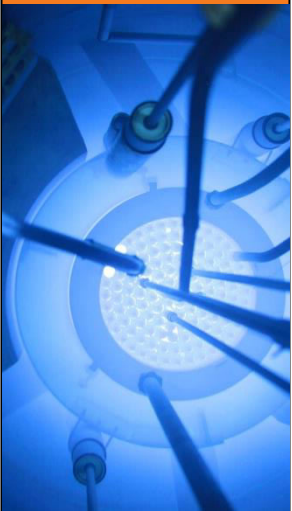
Path Forward

- Why not put in the spare IFE?
 - Two of three thermocouples were discovered to be failed open
 - We hope to have the spare IFE repaired when the CERCA fuel line is restarted
- Working with NRC to amend license to
 - 1) Operate without IFE (pulsing prohibited)
 - 2) Receive fresh IFE from UC Davis (thanks Dr. Frey)
 - This will require an amendment because it is 20/20 fuel, so will require some analysis

OSU
Radiation
Center

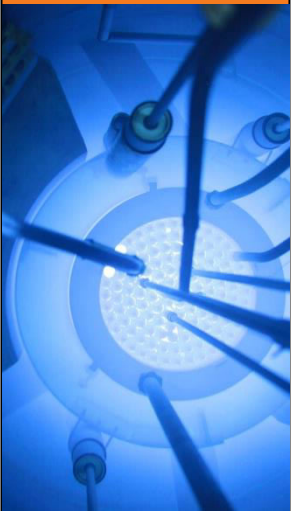


OSU
Radiation
Center



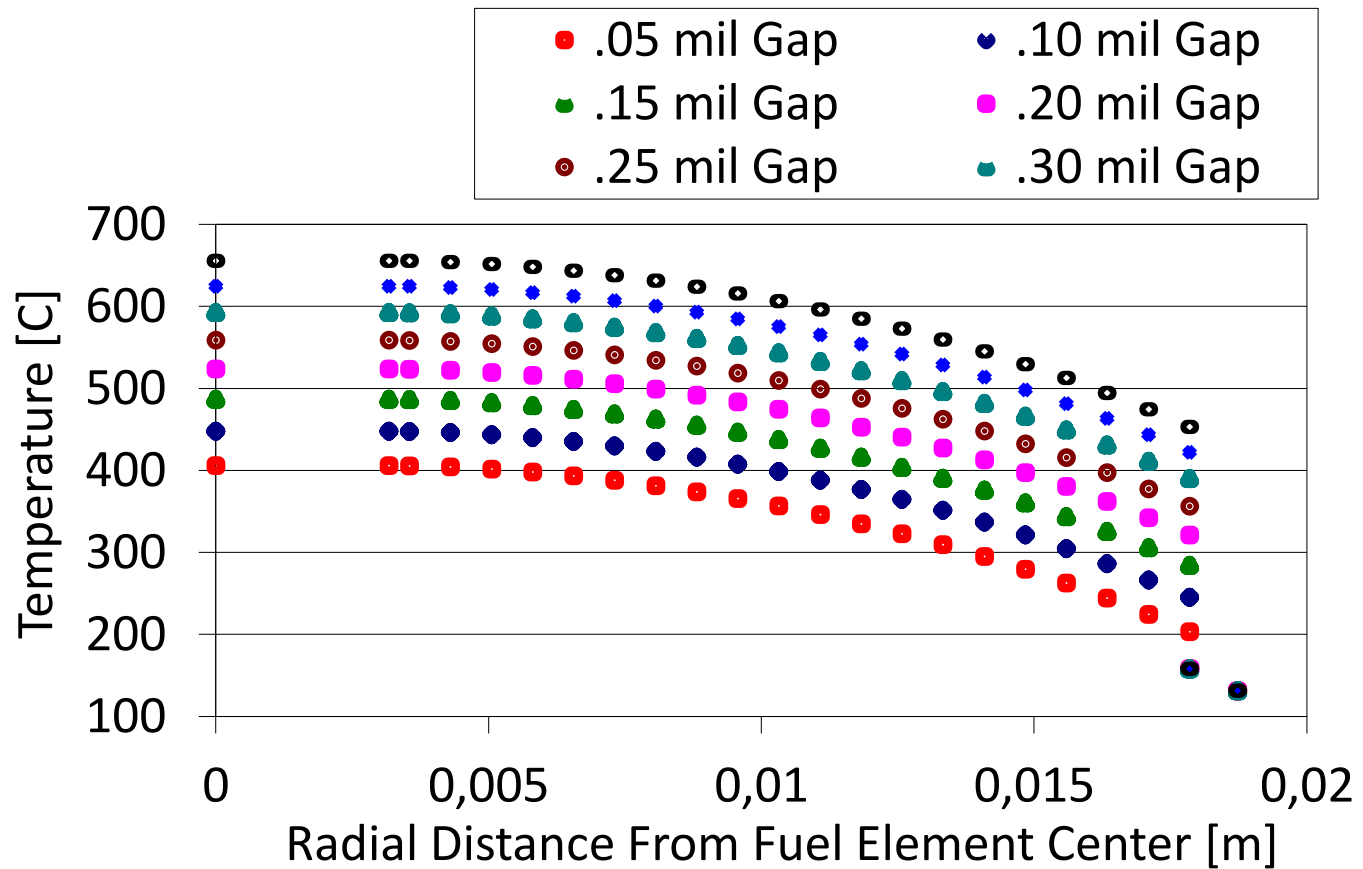
ANY QUESTIONS?

(Happy Halloween)



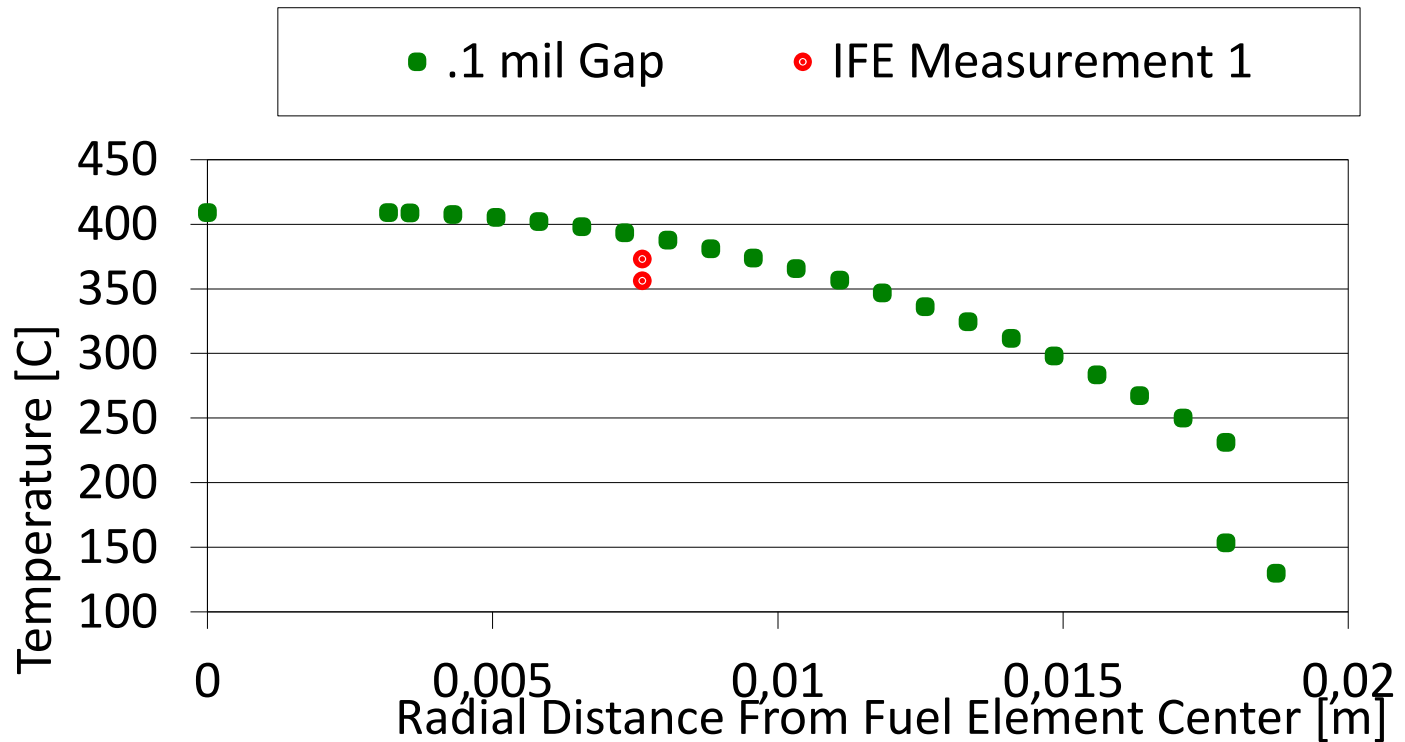
VALIDATION OF STEADY STATE MODEL

Varying fuel-to-clad gap and identifying resulting change in temperature
(note: a human hair is about 1 mil thick)



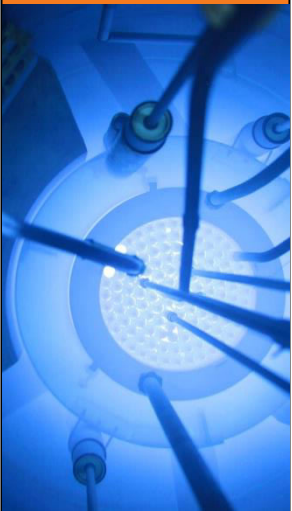
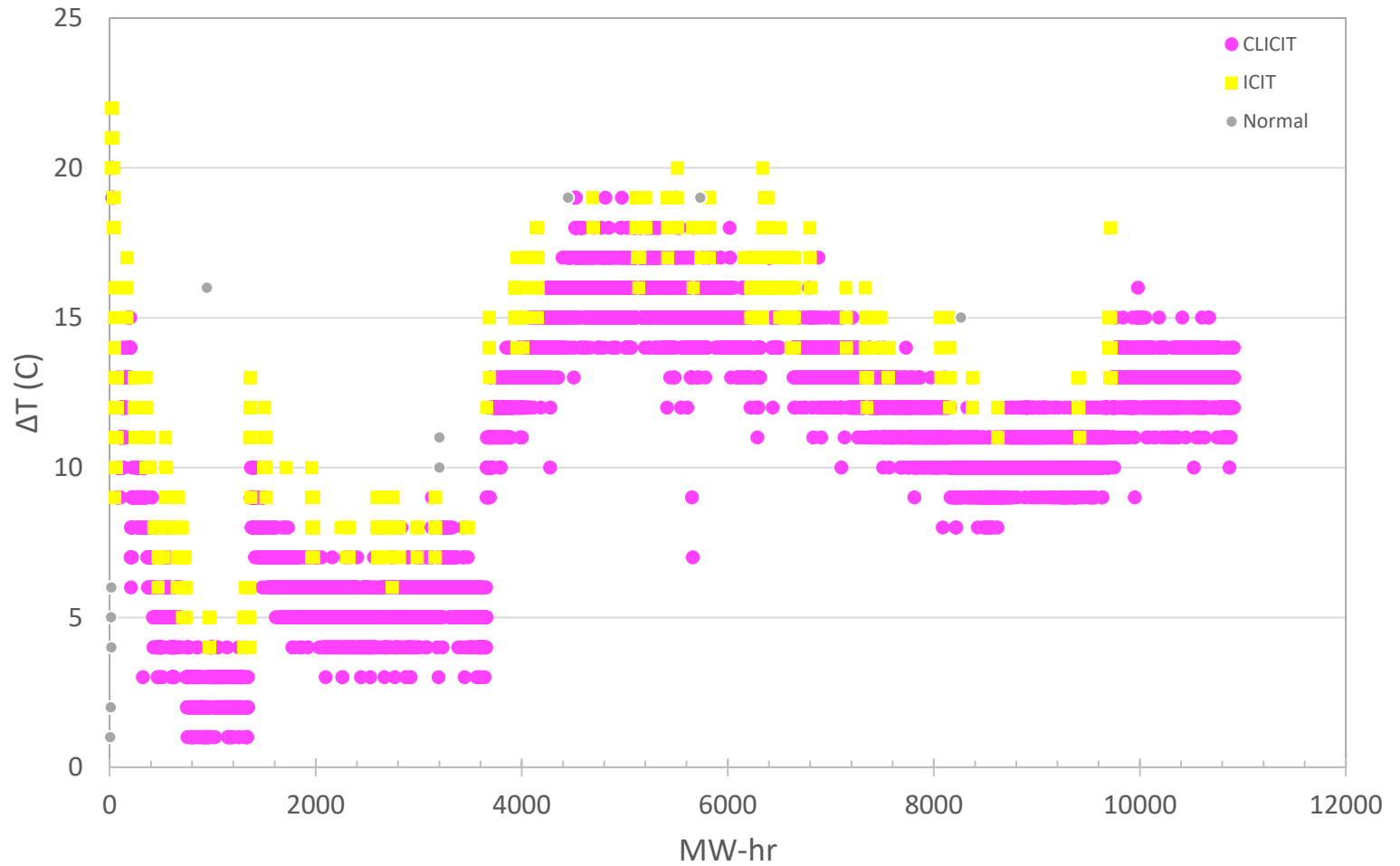
VALIDATION OF STEADY STATE MODEL

- Through comparison with IFE instruments we find that 0.10 mils is very good and *conservative*



Difference Between Bottom and Middle TCs

OSU
Radiation
Center



Difference Between Bottom and Middle TCs

OSU
Radiation
Center

