Enhanced microchannel cooling for high-power semiconductor diode lasers

SPIE LASE 6876-5

Author & Presenter: Joe Dix [1]
Coauthors: Amir Jokar [1] & Robert Martinsen [2]

1. Washington State University Vancouver
2. nLight Photonics

nLIGHT

SPIE Photonics West
San Jose, California January 21, 2008

Outline

- Objective
- System Configuration & Simulation
- System Modifications
- Results & Discussion
- Conclusions & Recommendations

Outline

- Objective
- System Configuration & Simulation
- System Modifications
- Results & Discussion
- Conclusions & Recommendations

Objective

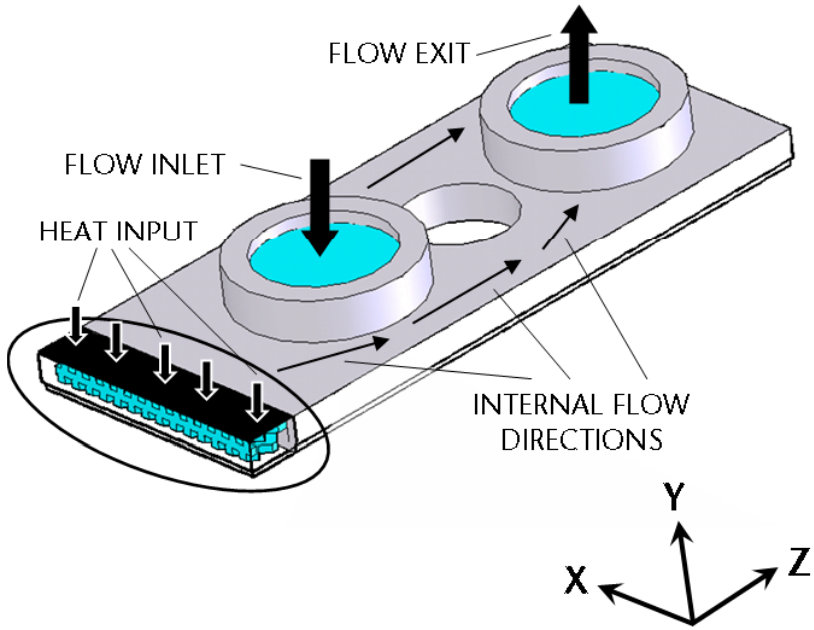
- Microchannel cooler analysis
- Using computational fluid dynamics
- Improve performance

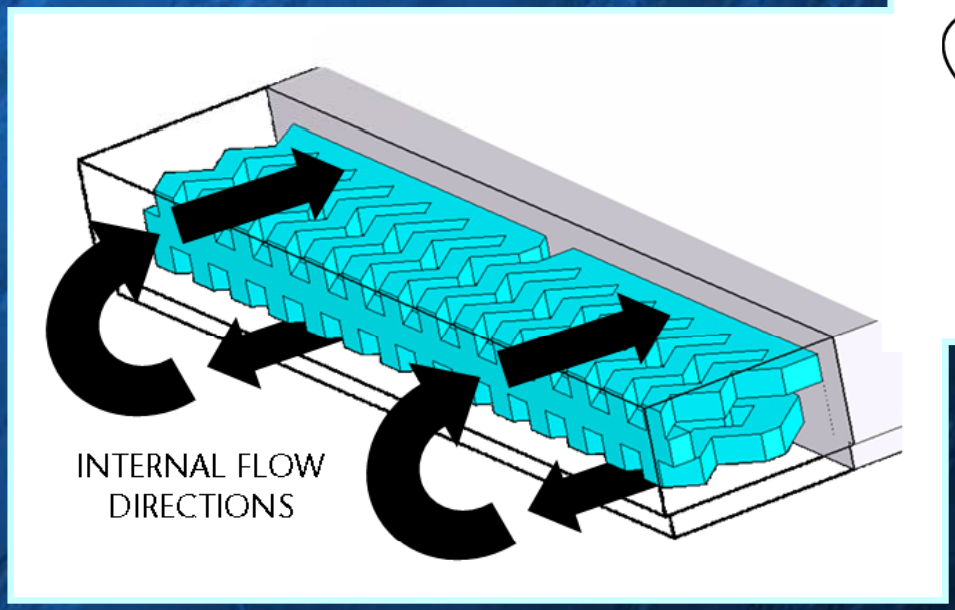
Outline

- Objective
- System Configuration & Simulation
- System Modifications
- Results & Discussion
- Conclusions & Recommendations

System Configuration

Microchannel Cooler Schematic





Simulations

- FLUENT 6 CFD Software
- 3-D
- Steady-state

Simulations

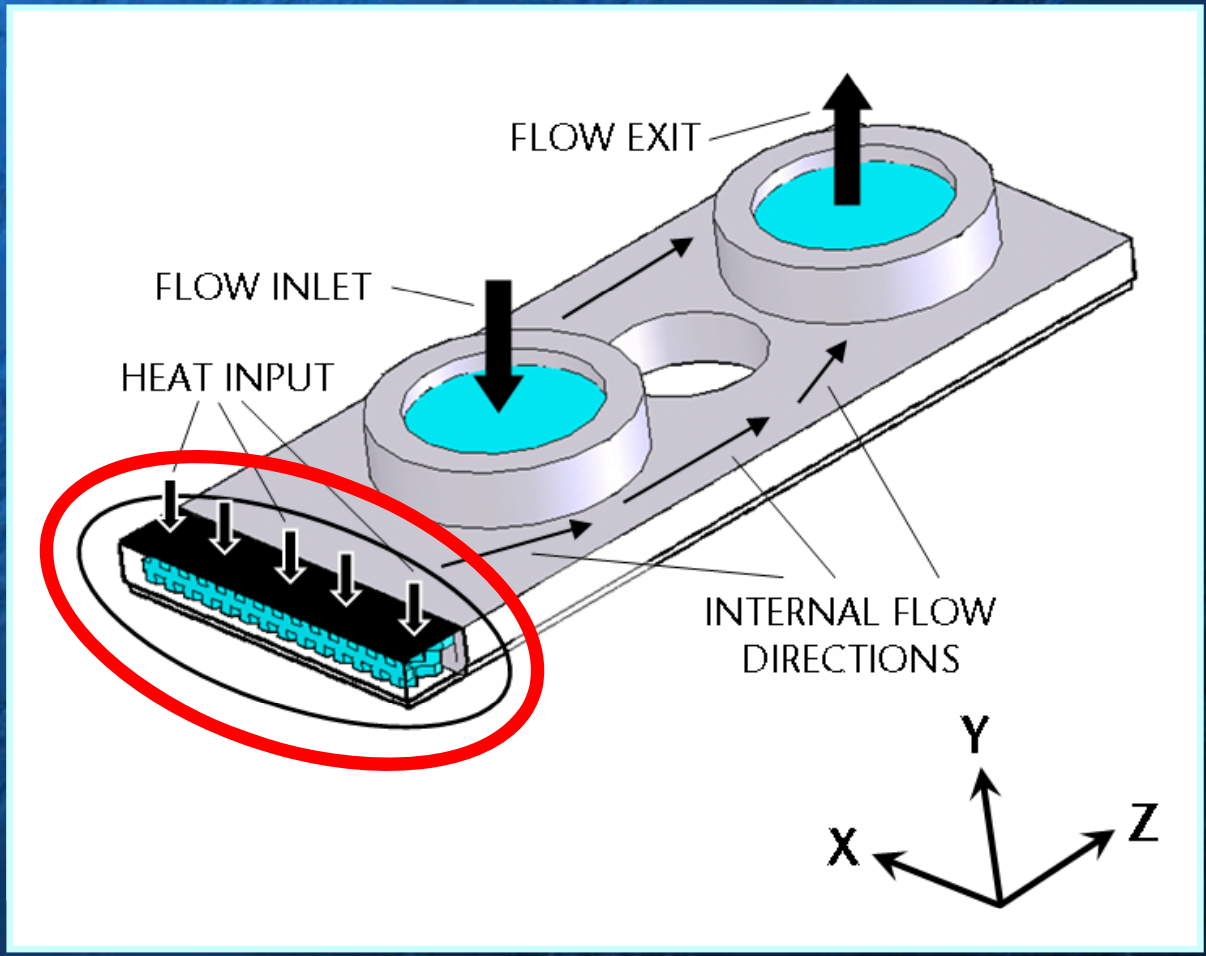
- Water flow
  - 200 ml/min
  - T_{IN} = 24 °C & P_{IN} = 36 PSI
- Heat input
  - Constant & uniform heat flux
  - 670 W/cm^2
- Coupled heat transfer: fluid-solid

Outline

- Objective
- System Configuration & Simulation
- System Modifications
- Results & Discussion
- Conclusions & Recommendations

System Modifications

EXISTING SYSTEM



SYMMETRIC SYSTEM

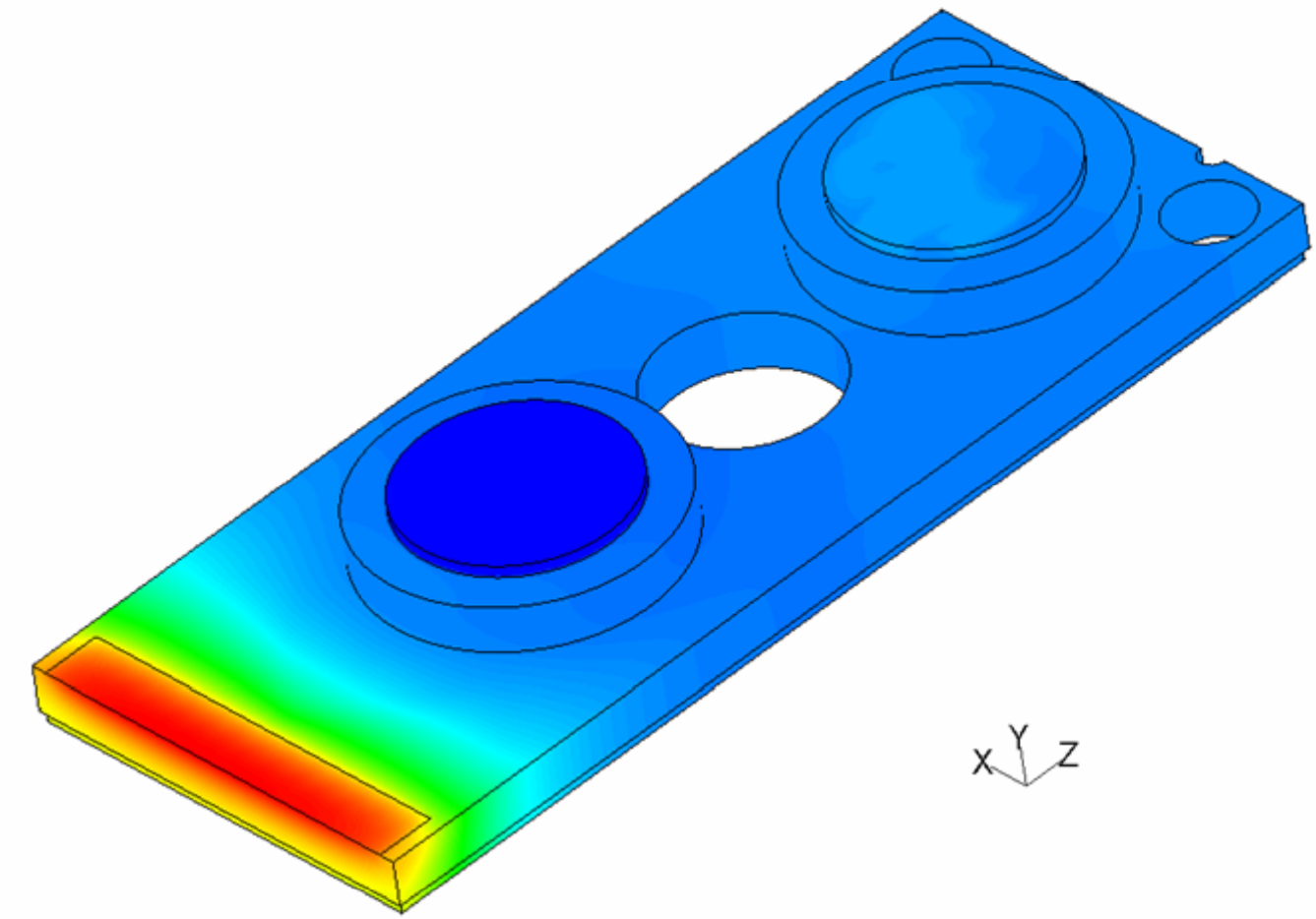
WIDE STRAIGHT CHANNELS

NARROW STRAIGHT CHANNELS

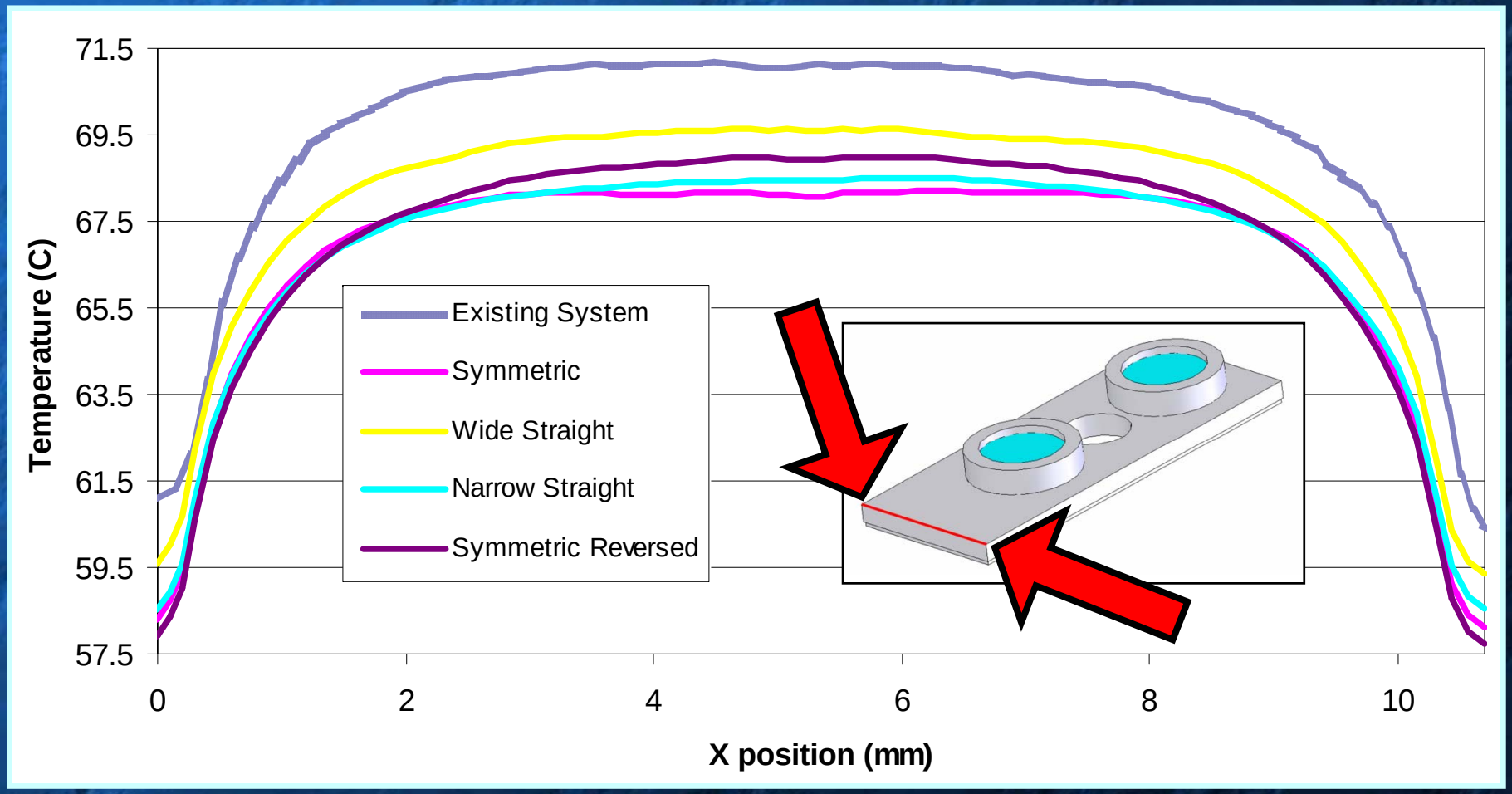
Outline

- Objective
- System Configuration & Simulation
- System Modifications
- Results & Discussion
- Conclusions & Recommendations

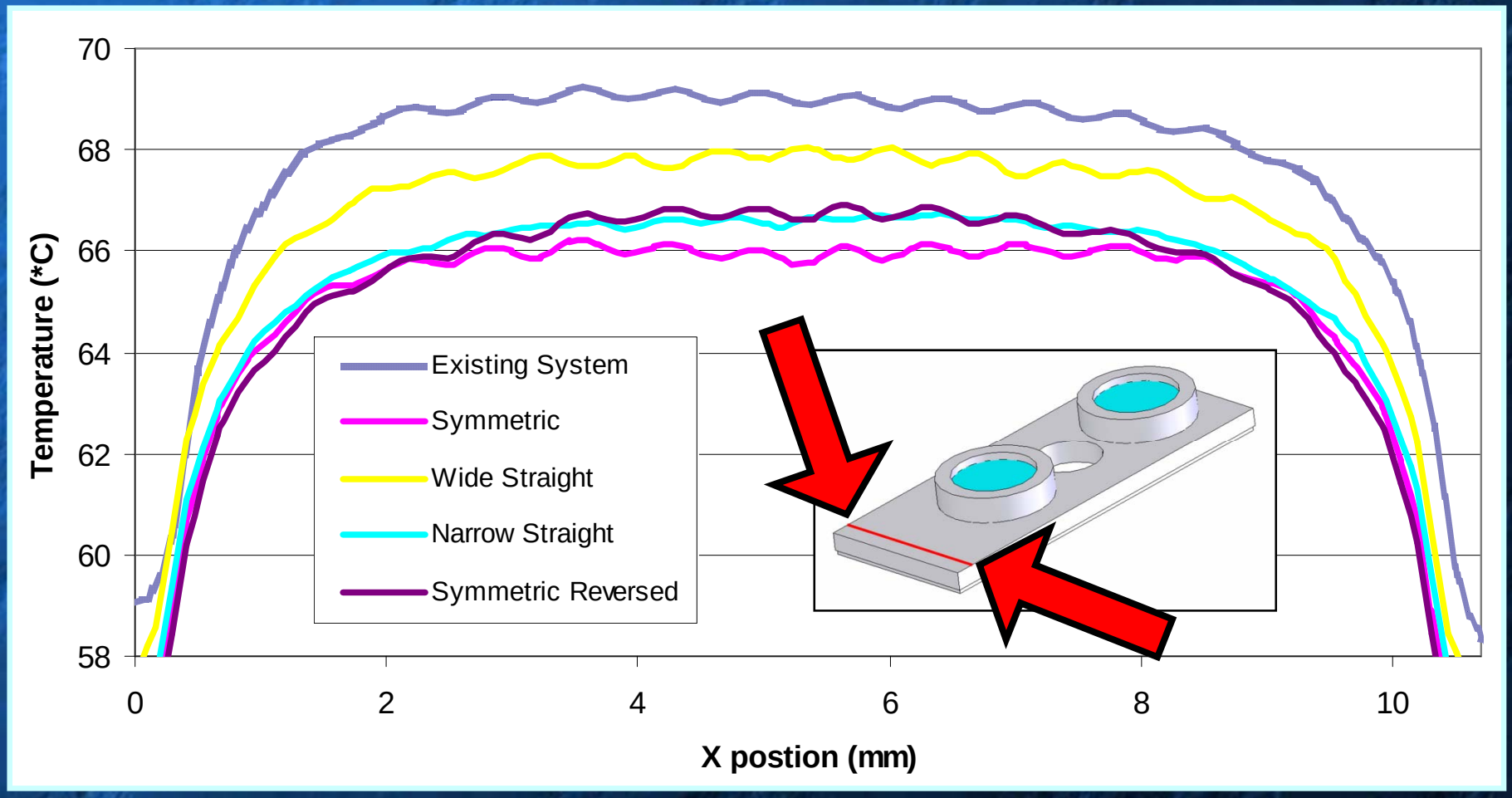
Surface temperature profile



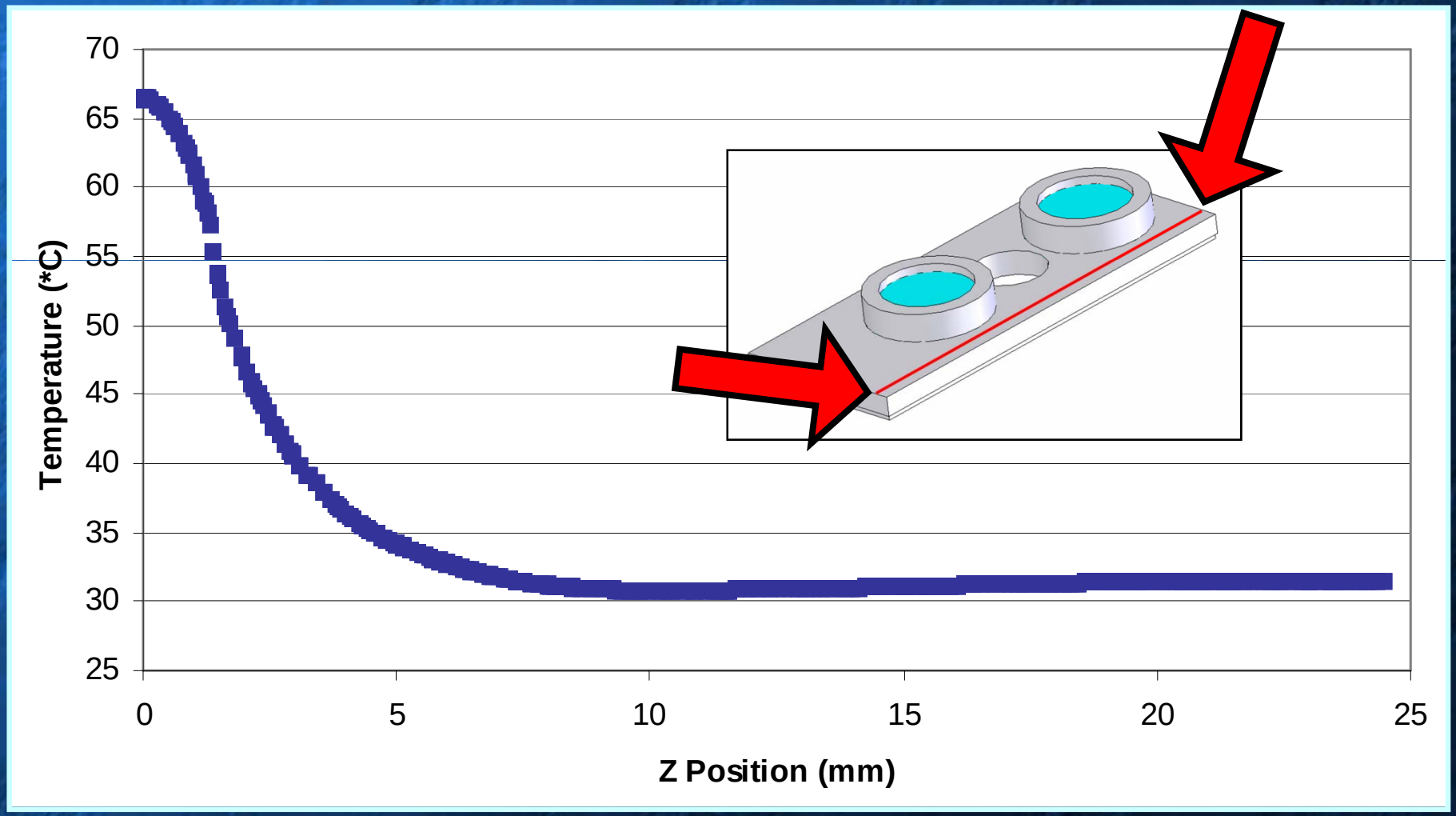
Surface temperature profiles



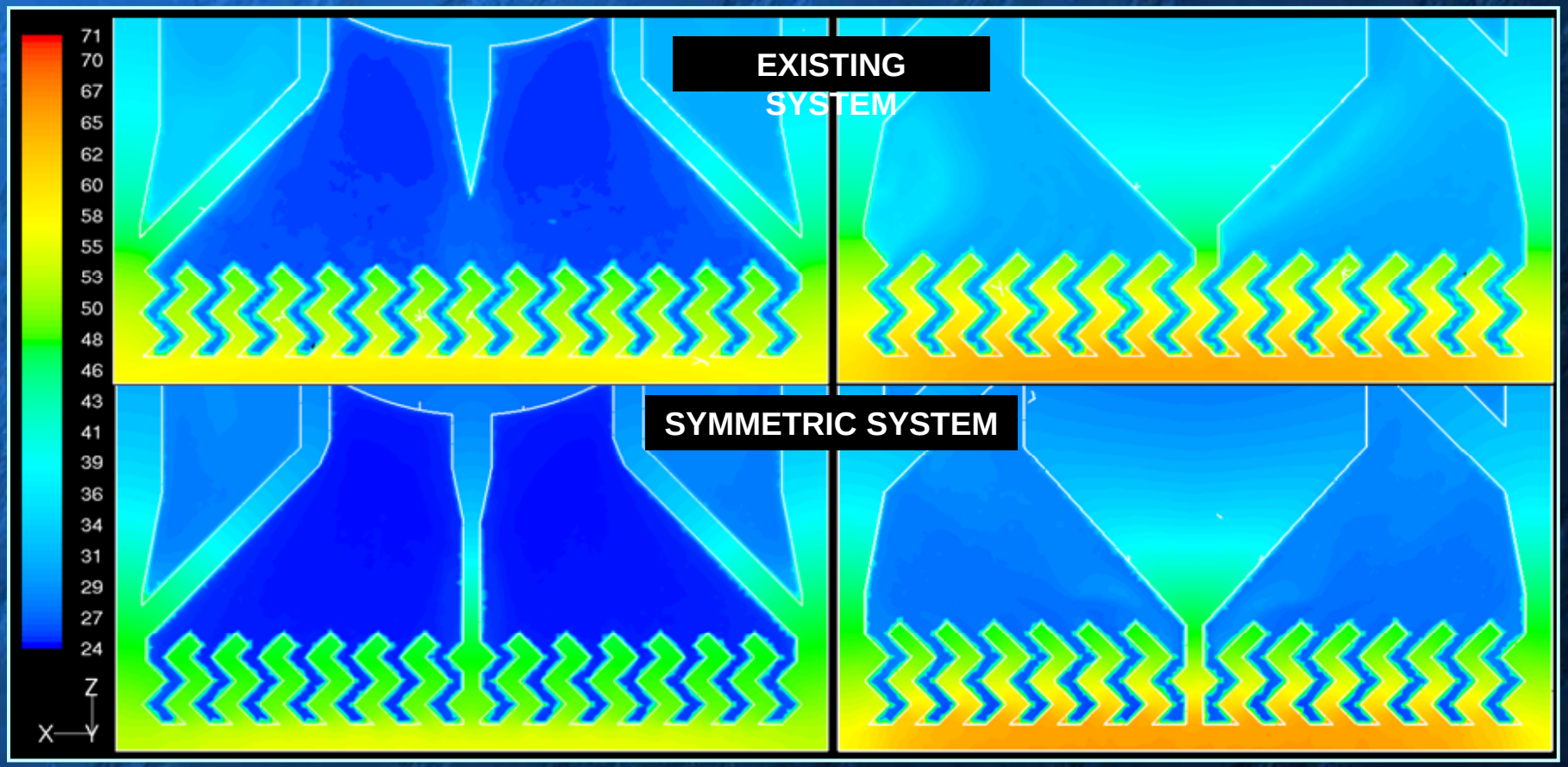
Surface temperature profiles



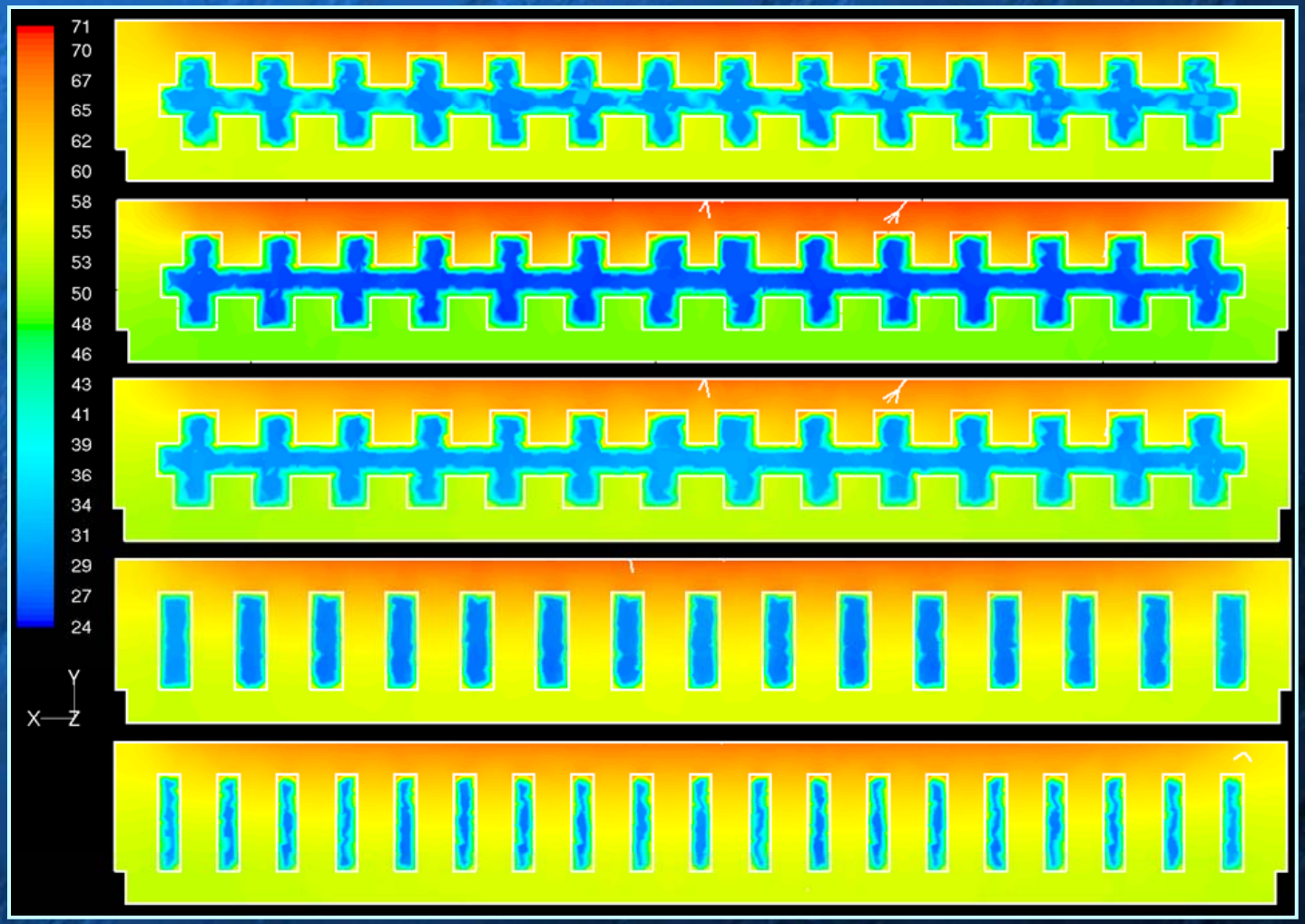
Surface temperature profile



Symmetry


71
70
67
65
62
60
58
55
53
50
48
46
43
41
39
36
34
31
29
27
24
Z
X
Y
EXISTING SYSTEM
SYMMETRIC SYSTEM

Cross section temperature profiles



EXISTING SYSTEM

SYMMETRIC SYSTEM

SYMMETRIC SYSTEM W/ REVERSED FLOW

WIDE STRAIGHT CHANNELS

NARROW STRAIGHT CHANNELS

Results Summary

Channel Designs	Existing System Zig-Zag	Symmetric Zig-Zag	Symmetric Zig-Zag Reversed	Wide Straight	Narrow Straight
Maximum Solid Temperature at Heat Input (*C)	**71.2**	**68.2**	**69.0**	**69.6**	**68.5**
Average Temperature at Heat Input (*C)	**66.9**	**64.2**	**64.4**	**65.8**	**64.6**
Thermal Resistance (*C-m2/W)	**0.070**	**0.066**	**0.067**	**0.068**	**0.066**
System Pressure Drop (psi)	**14.6**	**14.3**	**14.6**	**4.5**	**5.5**

Results Summary

Channel Designs	Existing System Zig-Zag	Symmetric Zig-Zag	Symmetric Zig-Zag Reversed	Wide Straight	Narrow Straight
Maximum Solid Temperature at Heat Input (*C)	71.2	-4.21%	-3.09%	-2.25%	-3.79%
Average Temperature at Heat Input (*C)	66.9	-4.04%	-3.74%	-1.64%	-3.44%
Thermal Resistance (*C-m2/W)	0.070	-5.71%	-4.29%	-2.86%	-5.71%
System Pressure Drop (psi)	14.6	-2.05%	0.00%	-69.18%	-62.33%

Outline

- Objective
- System Configuration & Simulation
- System Modifications
- Results & Discussion
- Conclusions & Recommendations

Conclusion & Recommendations

- Focus on channel designs for improvement
- Designs should be symmetrical
- Performance improvements/balancing