Progress Report: CFD of the thermal performance of a Titan Montgolfiere

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Objectives (SURF 2009)

- Previous work shows that qualitative behavior of laminar regime similar to turbulent regime
- Extend laminar balloon simulations to consider transient behavior
- Control vent controls altitude
  - Need to predict transient timescales upon venting
- Previous simulations used closed balloon
  - Add realism by opening bottom

Progress

- Familiarized with the IBFS code for laminar flow
- Reproduced selected previous data
- Wrote a new Matlab script to post-process simulation results
- Generated data for a hole at the bottom
- Presently examining cases with a hole at the top.

Dimensional Analysis

Minimize the number of computations and obtain functional groups

Scaled temperature or non-dimensional net buoyancy

$$\tilde{B} = \frac{6F_b}{\pi \rho_\infty \nu^2}$$

Non-dimensional heat input

$$\tilde{Q} = \frac{g D^2 \dot{Q}}{\rho_\infty c_p T_\infty \nu^3}$$

$$\tilde{B} = \mathrm{fun}\left(\tilde{Q}, \text{balloon geometry}\right)$$

Cases Examined for a Single walled-balloon

- Non Dimensional Heat input values selected :

  Q~ = 8000

  Q~ = 16000

  Q~ = 125000

  Q~ = 625000

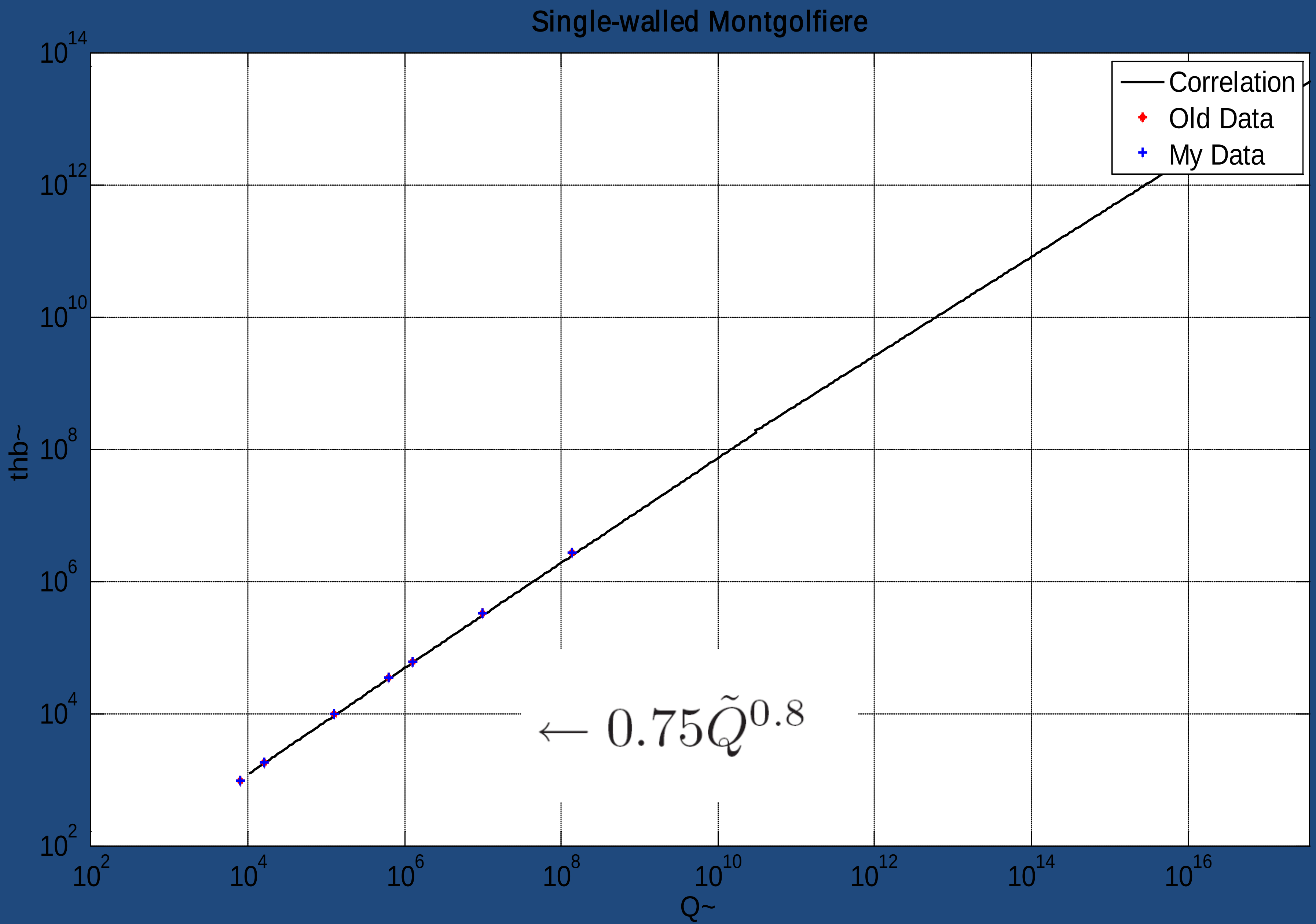
  Q~ = 1.25e6

  Q~ = 1e7

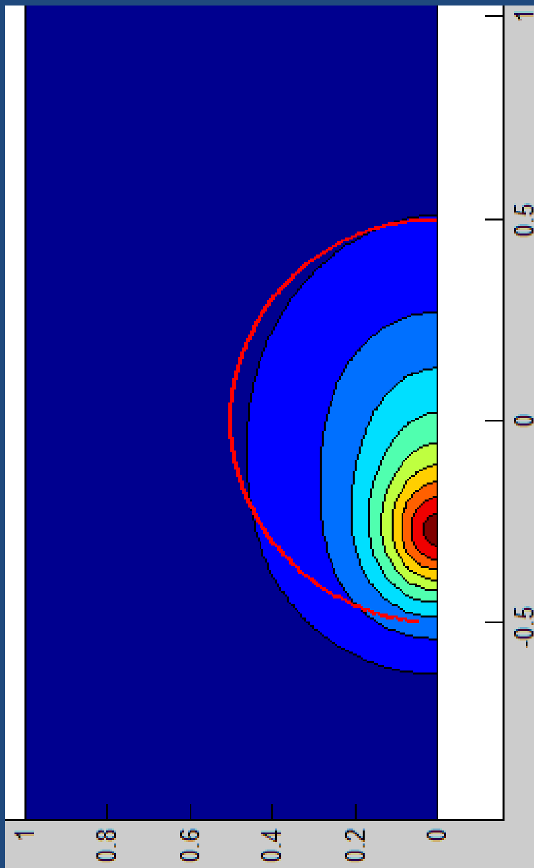
  Q~ = 1.35e8

- Hole Sizes:

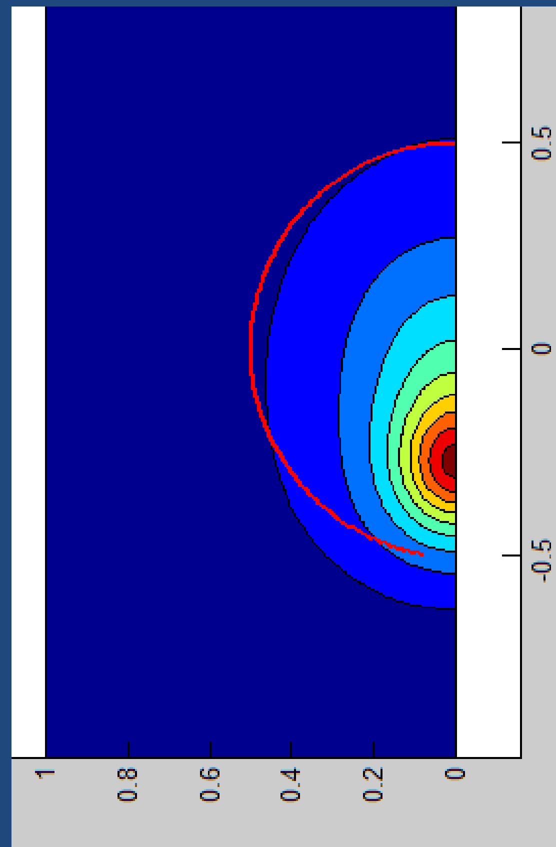
1. No hole
2. Bottom hole of diameter = 10%D
3. Bottom hole of diameter = 15%D, 20%D
4. Bottom hole of diameter= 10%D and top hole of diameter=1%D (currently examining)


Single-walled Montgolfiere
Correlation
Old Data
My Data
$\leftarrow 0.75\tilde{Q}^{0.8}$
thb~
Q~
10^{2}
10^{4}
10^{6}
10^{8}
10^{10}
10^{12}
10^{14}
10^{16}

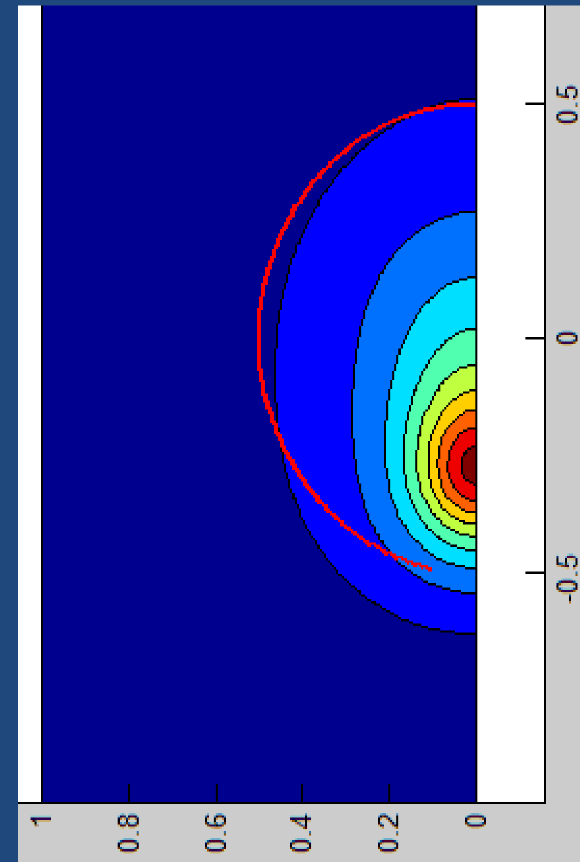
Temperature Contours (Varying hole size)



Hole dia = 0.087D



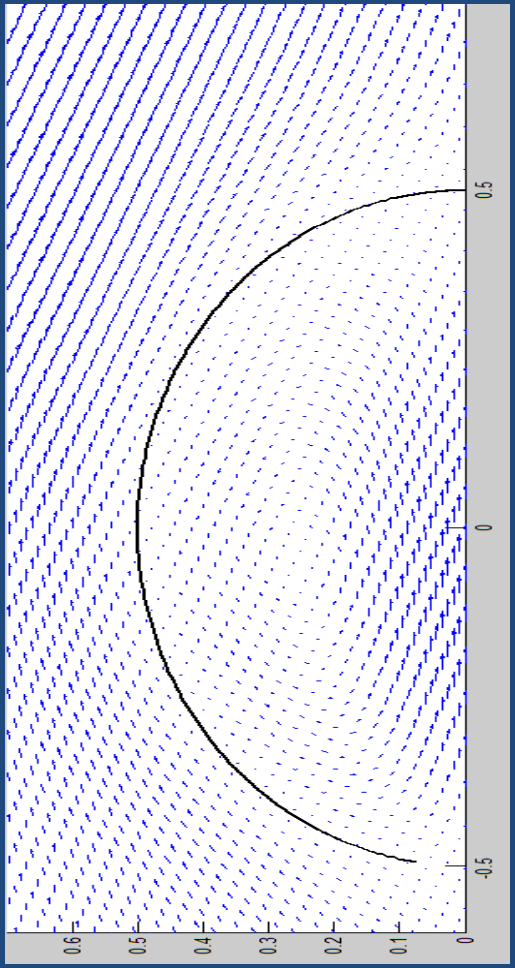
Hole dia = 0.20D



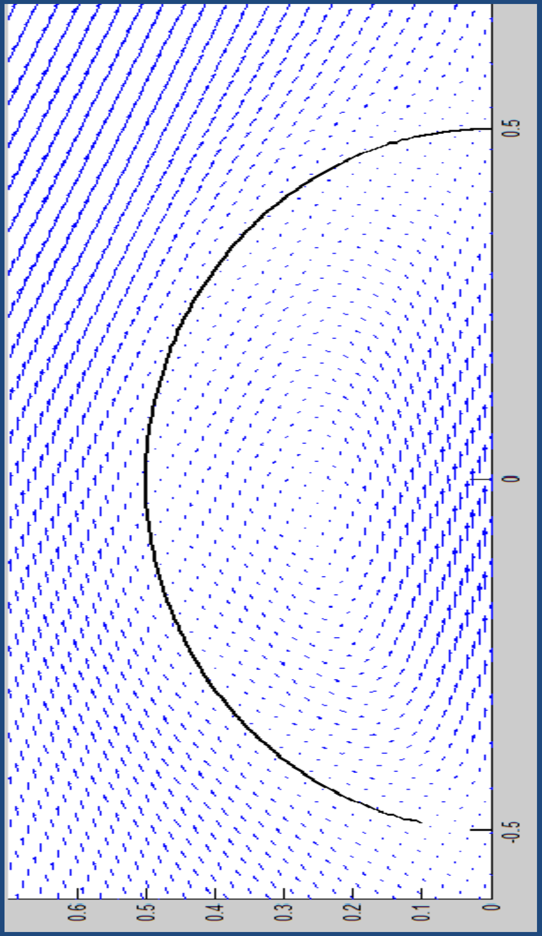
Hole dia = 0.15D

Q~ =16000

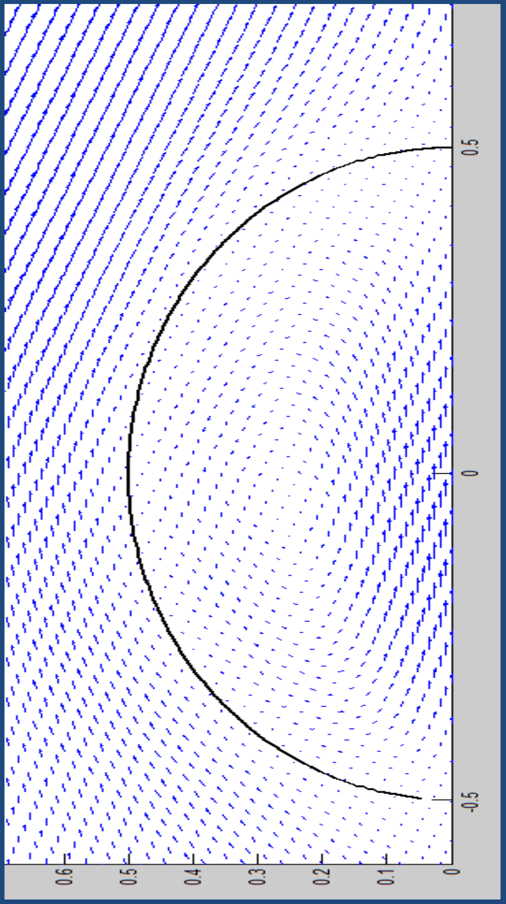
Velocity Plots (Varying Hole size)



Hole dia = 0.087D

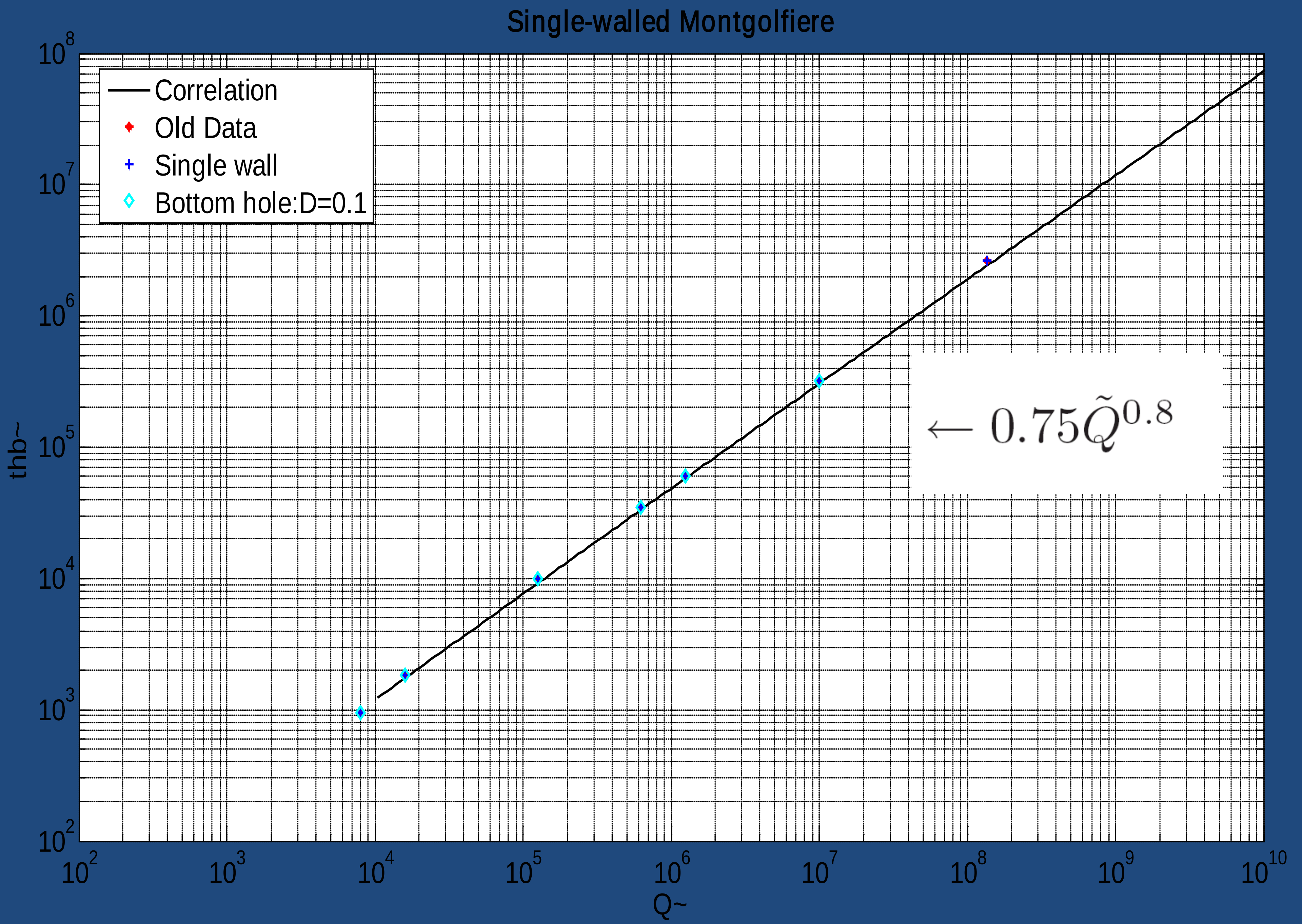


Hole dia = 0.15D

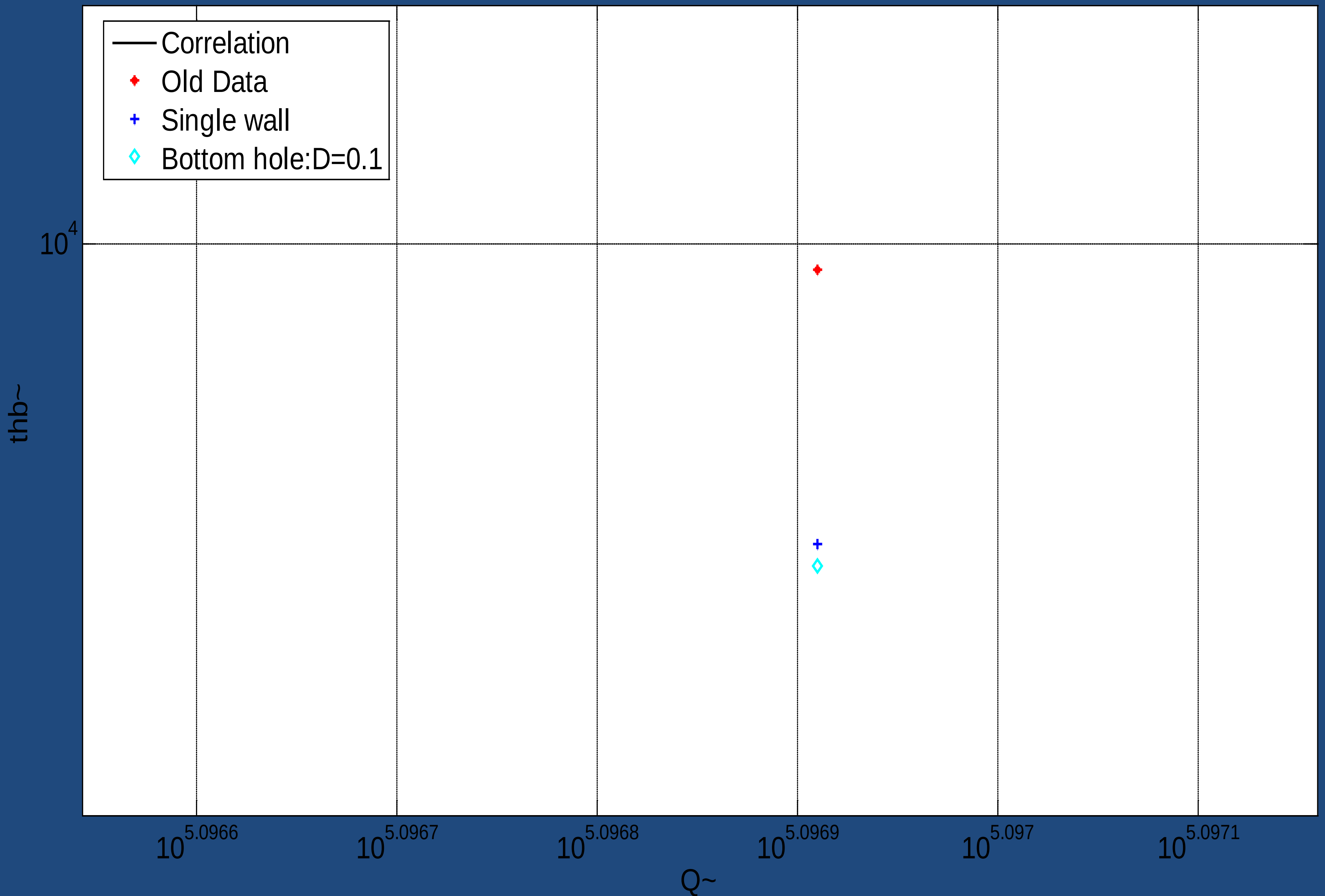


Hole dia = 0.20D

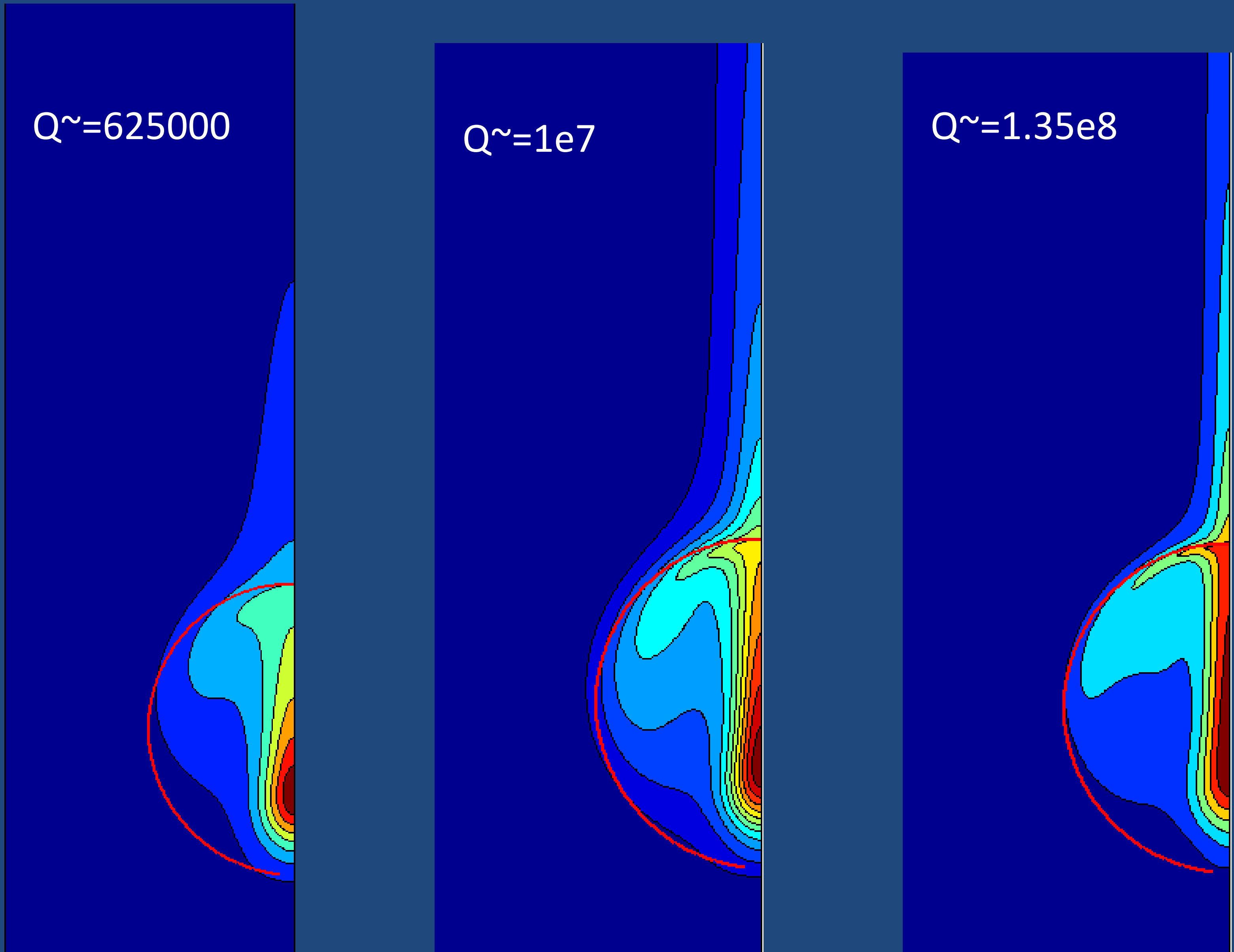
Q~ =16000


Single-walled Montgolfiere
Correlation
Old Data
Single wall
Bottom hole:D=0.1
$\leftarrow 0.75\tilde{Q}^{0.8}$
thb~
Q~
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
10^{10}

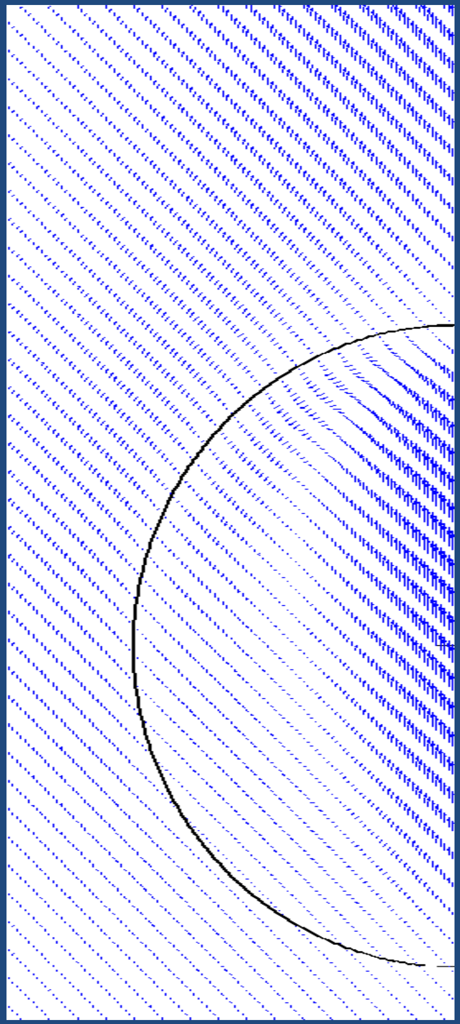
Single-walled Montgolfiere (Zoomed in)



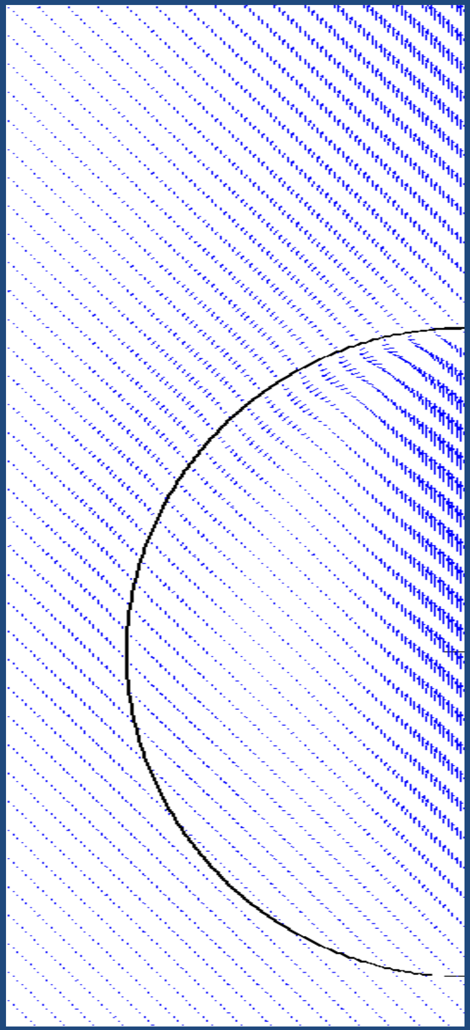
Temperature Contours: High heat input values, hole dia = 0.1



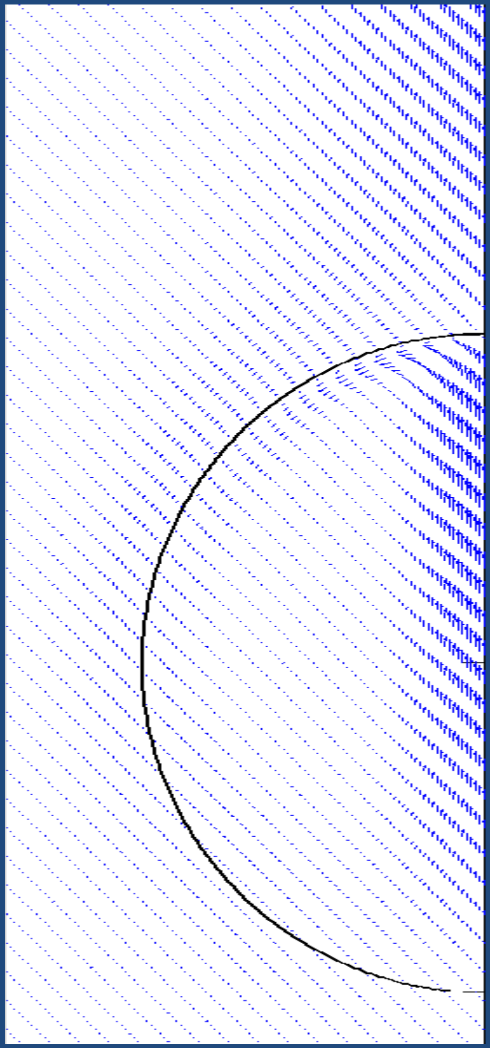
Velocity Plots: High heat input values, hole dia = 0.1



Q~=625000



Q~=1e7



Q~=1.35e8

Goals for the future

- Run simulations with different vent hole sizes from time t=0 to steady state.
- Predict transient time scales for venting by starting from a particular steady state condition.
- Run similar cases for double walled balloons

Thank You