Cyclone Training Problem

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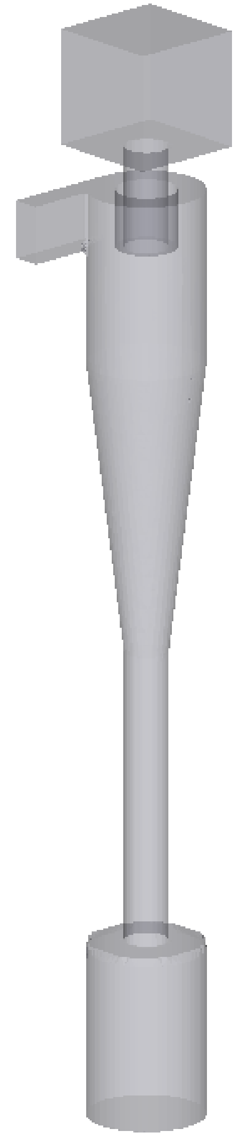
Training Objectives

- Project Setup
  - Flux plane subdivided by number of radius division (for particle size distribution)
  - Using agglomeration model for extremely small particles
  - Wear model for wall erosion due to particle impact
- Post-Processing
  - Calculating cyclone efficiency with Barracuda
  - Analysis of wall erosion

Considerations for Cyclone Model

- Experimental "tertiary" cyclone to separate incoming solids from gas
- Air and solids enter the inlet
- During ideal operation all solids drop to the bottom and all air exits at the top (vortex tube)
  - Real cyclones are not ideal
  - How will we know if we are successful?
- How do we know the "real" boundary conditions?
  - Test cyclone has no exit at the bottom
  - What would be different if simulating an industrial cyclone?
- When do we know we have reached steady state?
- What other behavior is important?
  - Wall erosion?



What are my goals?

Prior to setting up the model, it is important to consider what information will be learned by running the simulation. Once these objectives are identified, additional data outputs (flux planes, GMV data, transient data points, etc.) can be selected.

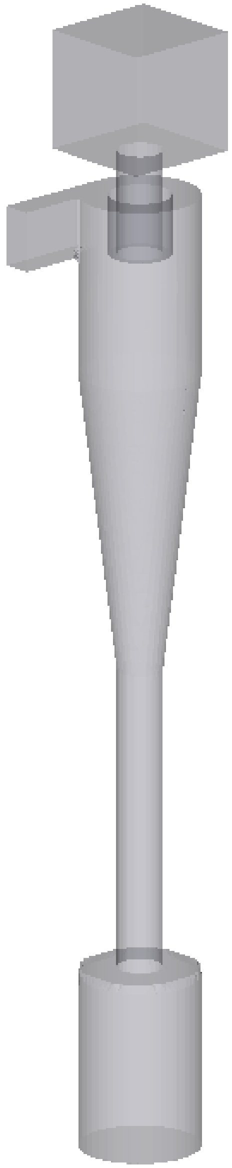
What do we wish to learn?	Setup Considerations
Global Efficiency	Measure fluxes of solids at inlet, top, and bottom of cyclone
Fractional Efficiency	Track sizes
Wear magnitude and location	Turn on the wear model

Project Setup Review

- Create a grid and set up your calculation with the information provided
- Use of some features are outlined in this assignment
- Ask your instructor about any questions you may have

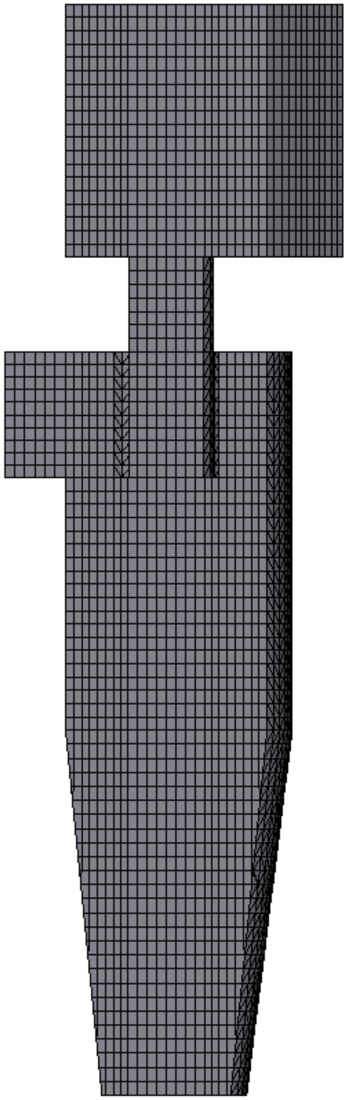
Process Sheet

- Geometry
  - 0.2 m maximum diameter
- Particles
  - Chalk powder, particle density = 2730 kg/m3
  - Bulk density = 0.5 particle density
  - PSD provided
  - Loading = 50 g/m3 of air
- Fluid
  - Air
  - Gas flow = 0.04 m3/s
- Boundary Conditions
  - Solids can enter at inlet and exhaust at the vortex tube only



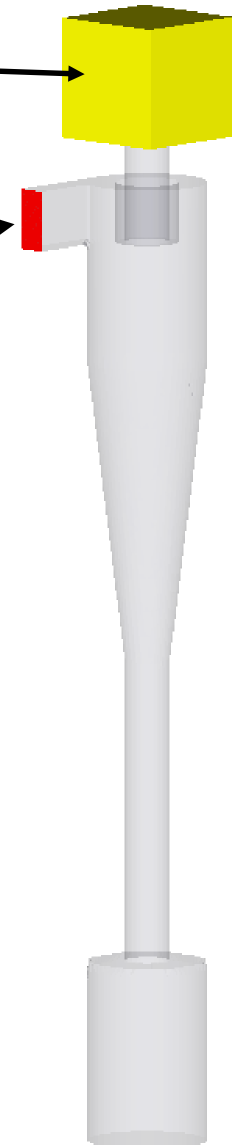
Grid Generation

- Create a grid of about 130,000 cells or less
- Show the instructor your grid before proceeding
  - What assumptions are made at the vortex tube wall?



Project Setup - Boundary Conditions

- Allow gas and particles to escape at the vortex tube
  - What assumptions are made at the outlet?
  - How would these assumptions differ for an industrial cyclone (as opposed to a test configuration)?
- Allow gas and particles to enter at the inlet



Project Setup - Particles

- Define particles with the PSD shown on the right
- Often particles smaller than 20 microns in diameter will agglomerate into larger clusters. Use the **Wen-Yu with Agglomeration** drag force model
- Consider how to ensure inlet loading of 50 g/m3
  - Hint: Consider the anticipated mass flow rates

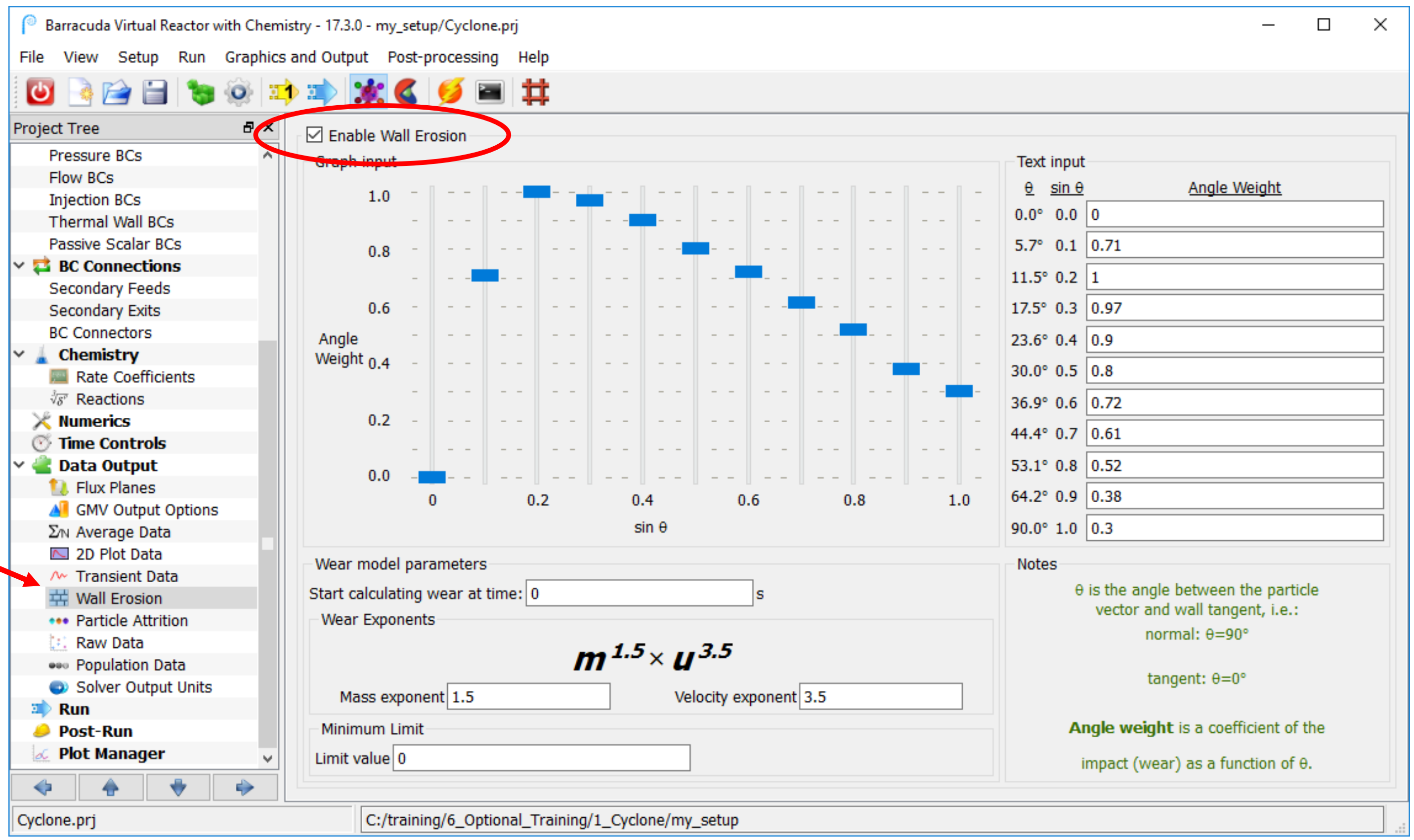
Cumulative Percent	Particle Radius (µm)
0	0.15
13.5	0.5
30	1.0
44	1.5
50	1.7
63	2.5
75	4.0
85	7.5
94	15.0
97.5	20.0
100	30.0

Project Setup – Flux Planes

- Define additional flux planes to track flow:
  - Out the vortex tube
  - Out the bottom
- Use the **Subdivide by radius** feature to enable fractional efficiency calculation

Project Setup – Wear Model

- Enable the **Wall Erosion model**
- Users have control over the functional form and angular dependency of the wear
- Consider how the angular dependency of the wear may differ for:
  - Sand impacting steel?
  - FCC impacting a refractory lining?



Project Setup – Running the Calculation

- Please review your setup with the instructor before letting the calculation run

Post-Processing Considerations: Full-View Animations

- Create animations to show the flow behavior as seen from the outside of the cyclone

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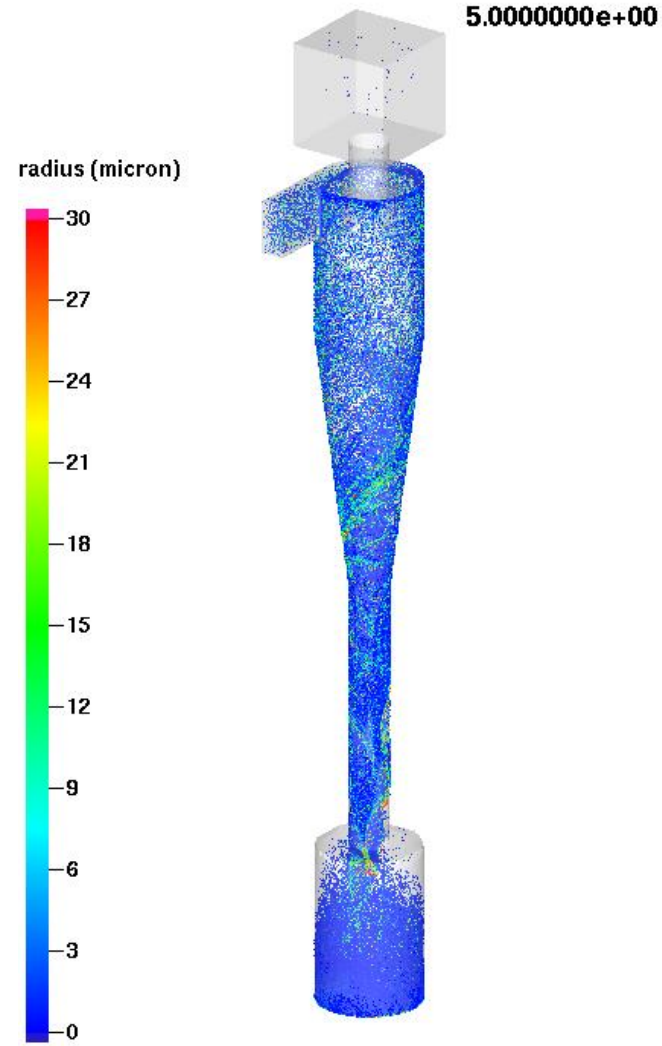

Post-Processing Considerations: Animations Through Thin Slices

- Create animations to show the flow behavior in thin slices through the model

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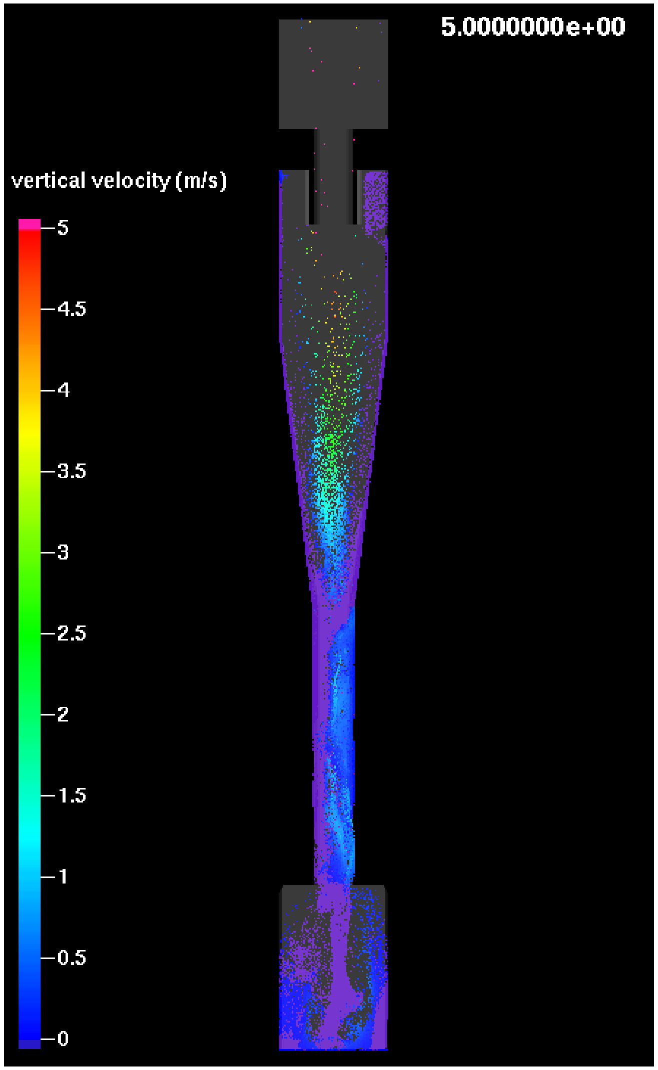

Post-Processing Considerations: Vortex Animations

- Create an animation to show the vortex behavior

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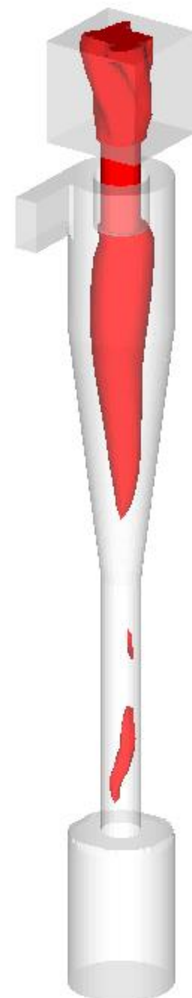

Post-Processing Considerations: Wear

- Create a plot of regions most prone to wear

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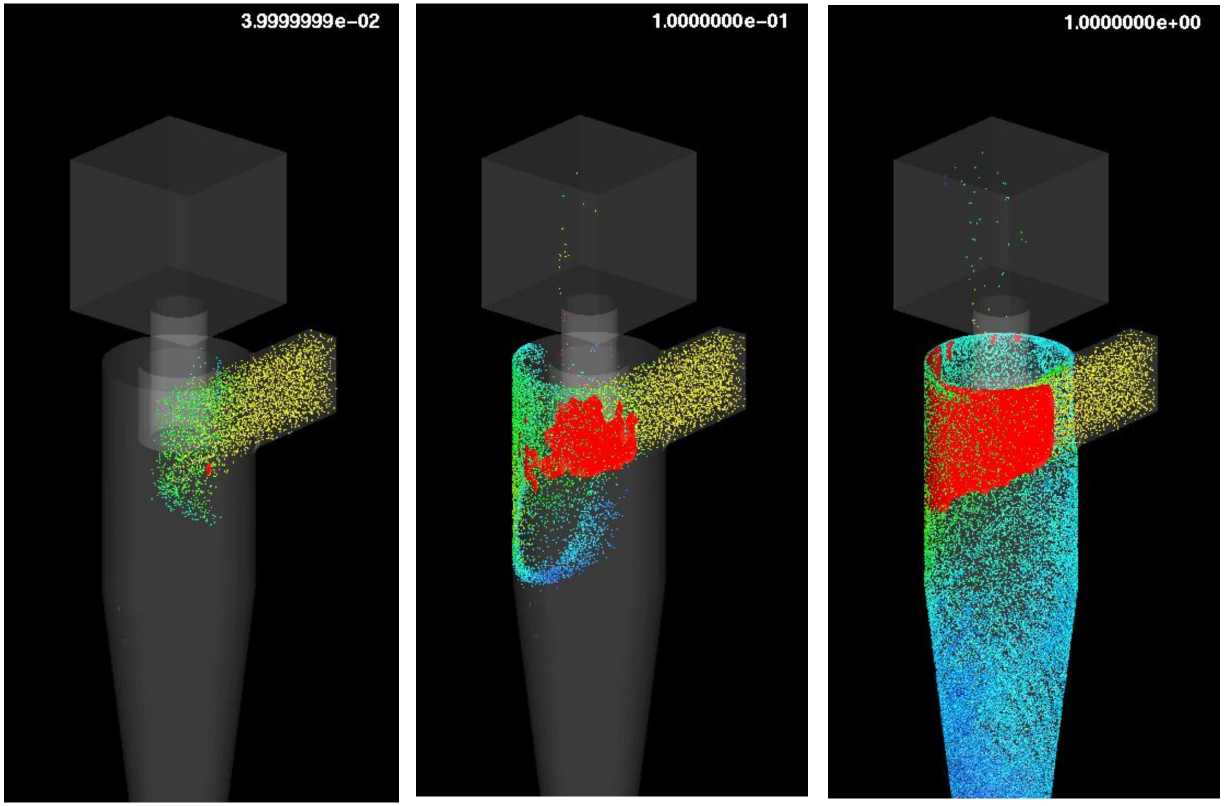

Post-Processing Considerations: Efficiency

- Cyclone Efficiency:

$$\text{efficiency} = \frac{m_{bottom}}{m_{inlet}} = 1 - \frac{m_{vortex\,tube}}{m_{inlet}}$$

- Compute the overall efficiency from your cyclone. How would you obtain fractional efficiency?

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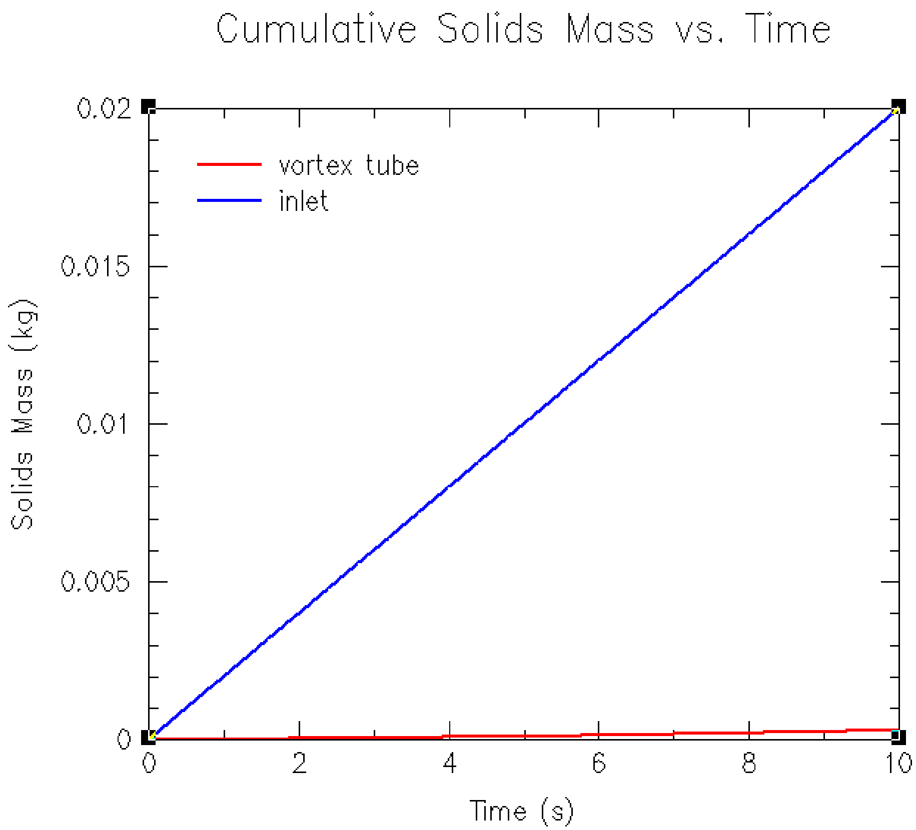

Advanced Considerations

- Barracuda computes the fluid/particle motion in the system as influenced by the input parameters (boundary conditions, fluid properties, PSD, density, etc.) and physical models defined. What other forces may be important in this case, for very fine particles? Discuss how such effects might be included with your instructor.
- Can the calculation be sped-up? Perhaps it may be possible to define a boundary conditions where particles may exit but gas does not flow, thereby reducing the computational burden for particles n the dust bin. Discuss the pros and cons of such an approach with your instructor.