Advanced Training: Selected Post-Processing Topics

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Outline

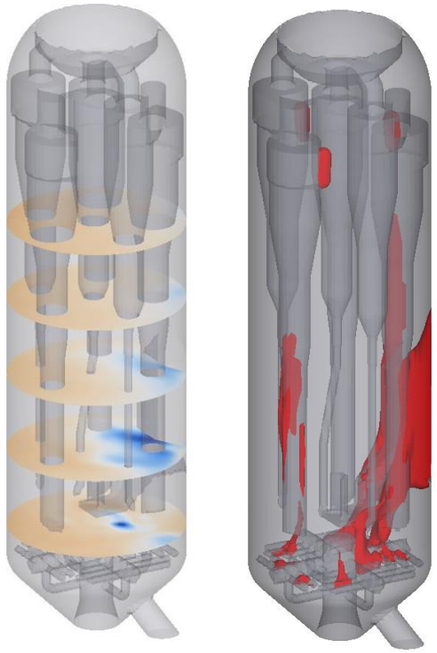
Cutplanes and colormaps

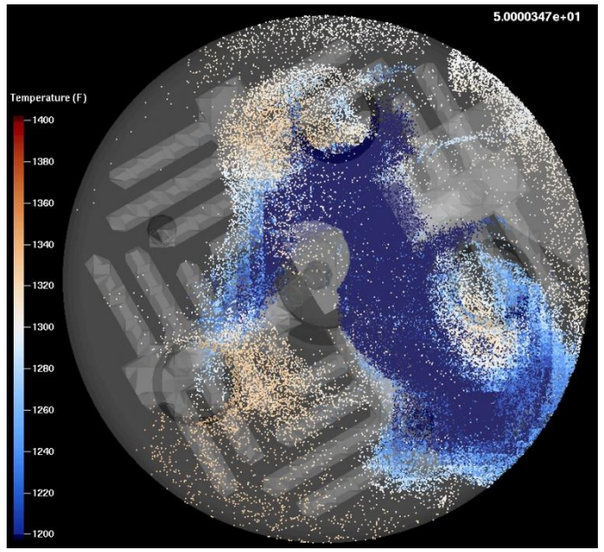
Isovolumes

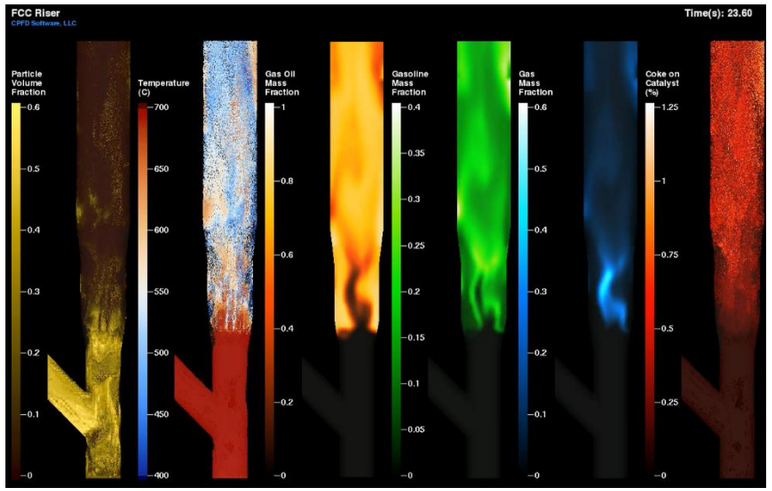
Particle select

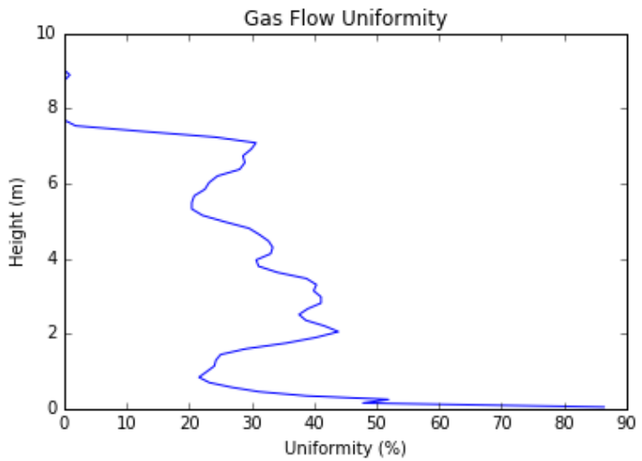
Montage animations

Uniformity





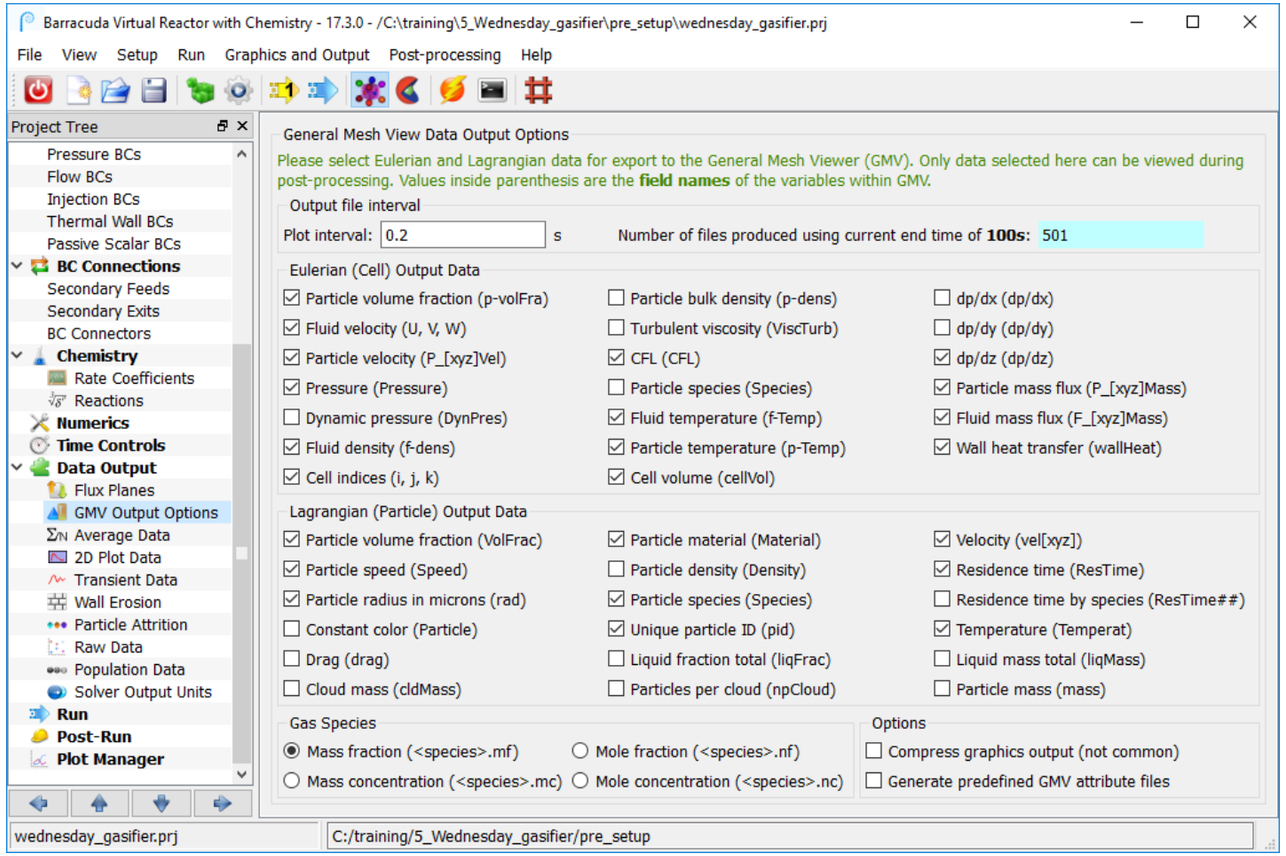




Easy to Say, Easy to Forget: Select All Desired Output

Double-check *Data Output* options

- *GMV Output Options*: make sure you have all necessary variables selected
- *Average Data*: select data and set a good *Averaging start time*
- *Raw Data*: select data and set a good *Time interval*



Cutplanes

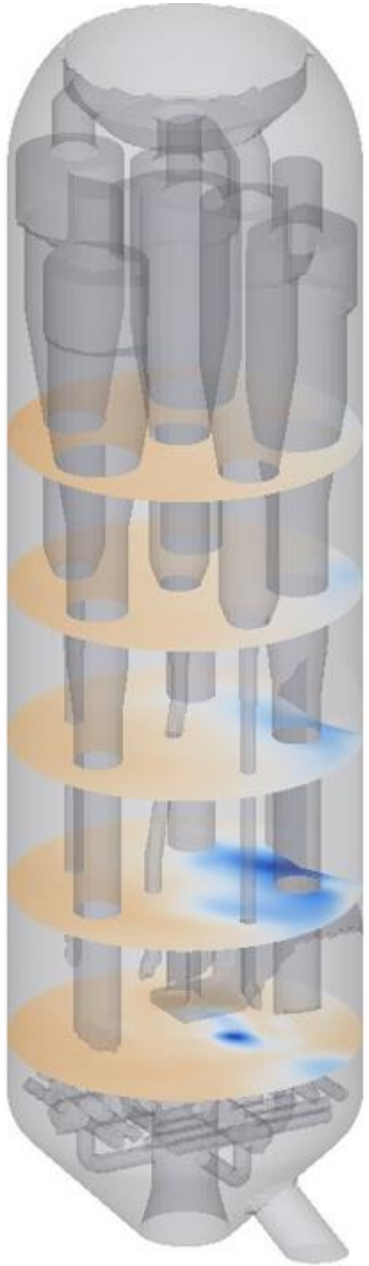
Ability to view multiple cutplanes simultaneously can be helpful during presentation of results

- GMV has a limit of 5 cutplanes
- Possible to use image processing techniques to create images that show more than 5 cutplanes

http://cpfd-software.com/customer-support/knowledge-base/using-cutplanes-in-gmv

Can be used with:

- Any GMV output data and field calculations
- Animations and BATCHMOVIE.sh



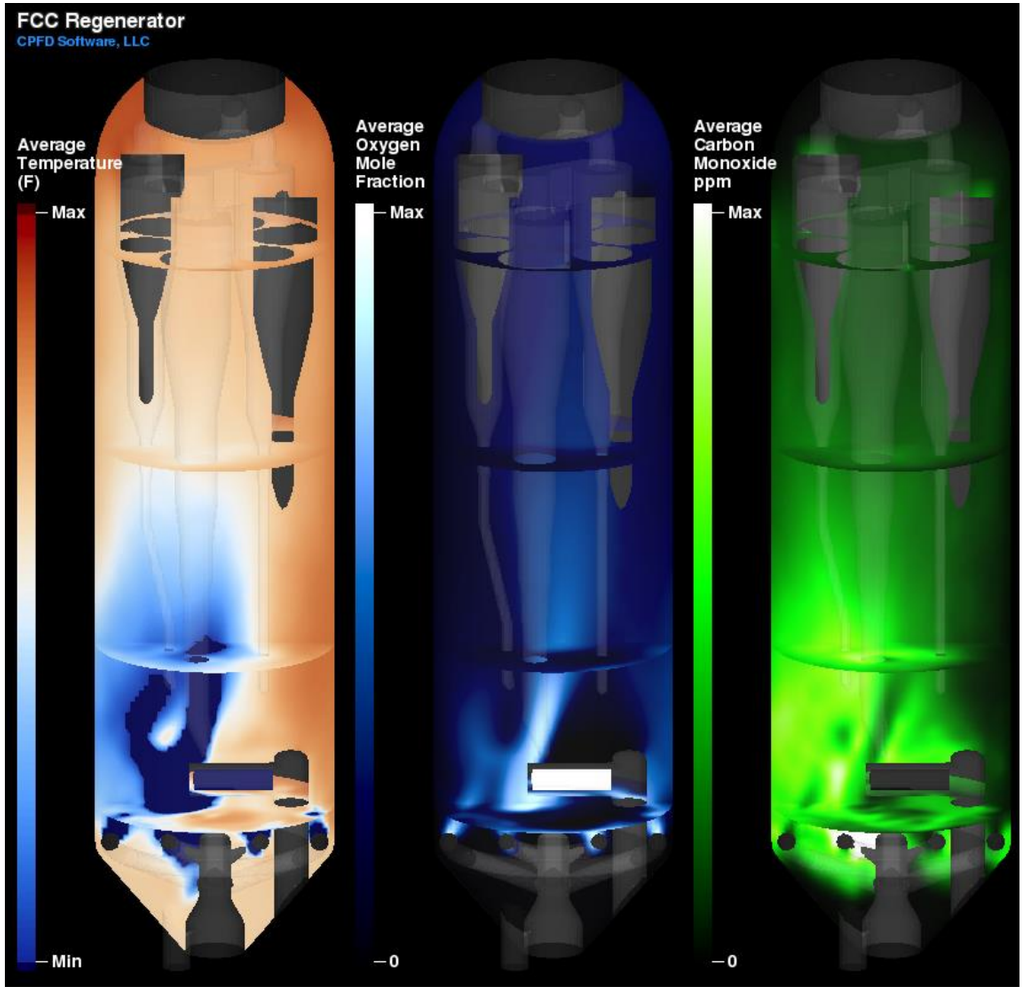
Colormaps

Use colormaps to show results in an intuitive way

- Which color scheme is the most natural for this type of data?
- Could different colors be used to communicate a message?

Several custom colormaps are included in the cpfdHQ directory

- C:\Program Files\CPFD\Barracuda\17.3.0\cpfdHQ\gmv_cmap
- ~/CPFD/Barracuda/17.3.0/cpfdHQ/gmv_cmap



cool-warm.cmap

Colormap Editor

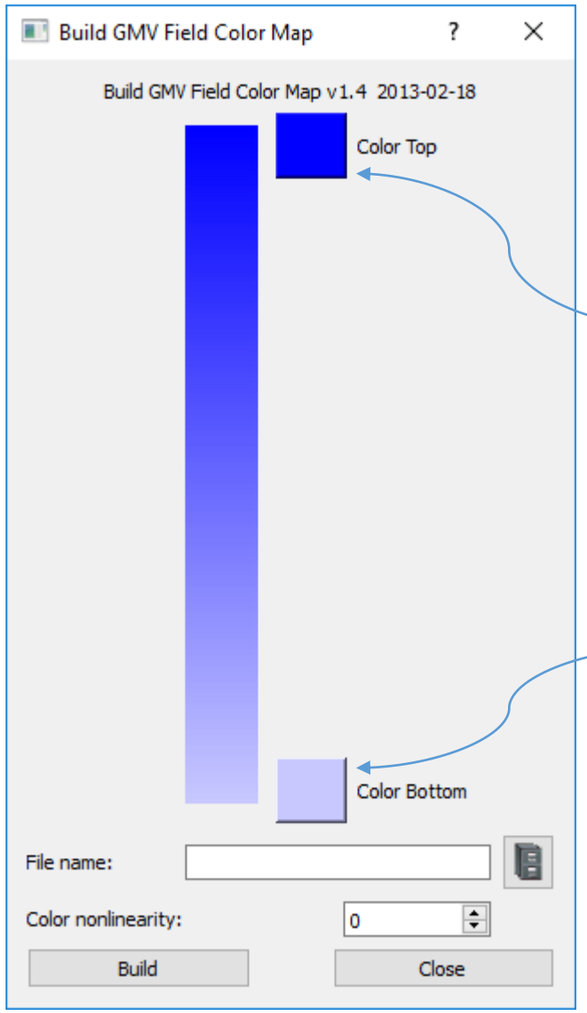
Tool bundled with Virtual Reactor

- *Post-processing, Launch bldcol*

Useful for creating 2-color gradients

- Light-brown to dark-brown for sand
- Dark color to white for gas species

https://cpfd-software.com/user-manual/post-run#colormap-editor



Click the top color square to set the "high" scale color

Click the bottom color square to set the "low" scale color

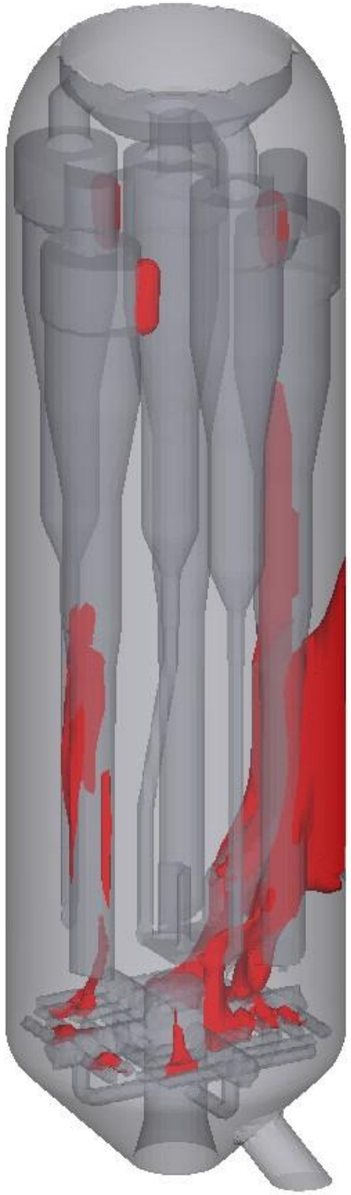
Isovolumes

Show spatial regions meeting specified criteria

- What are high velocity regions?
- Where are particles near close-pack?

General procedure

- Use a *View Particle Data* shortcut in ***Post-Run***
- Turn off particles
- Use GMV's dialog *Calculate*, *Isovolume*
- Use GMV's dialog *Ctl-1*, *Coloredit, Materials, Isosurfaces, Isovolume* to set constant color



Particle Select

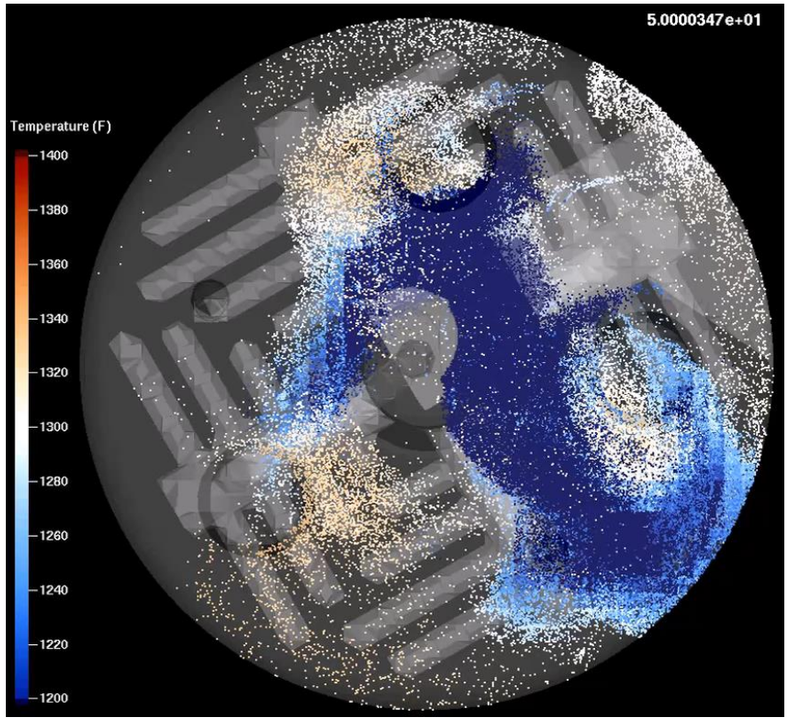
Useful to focus on particles of interest

- Can specify display criteria based on any particle field
- Multiple criteria variables can be used

Can be used in animations

General procedure

- Use a *View Particle Data* shortcut in ***Post-Run***
- Use GMV's dialog *Display*, *Particles*
- Click *Select* button and specify criteria

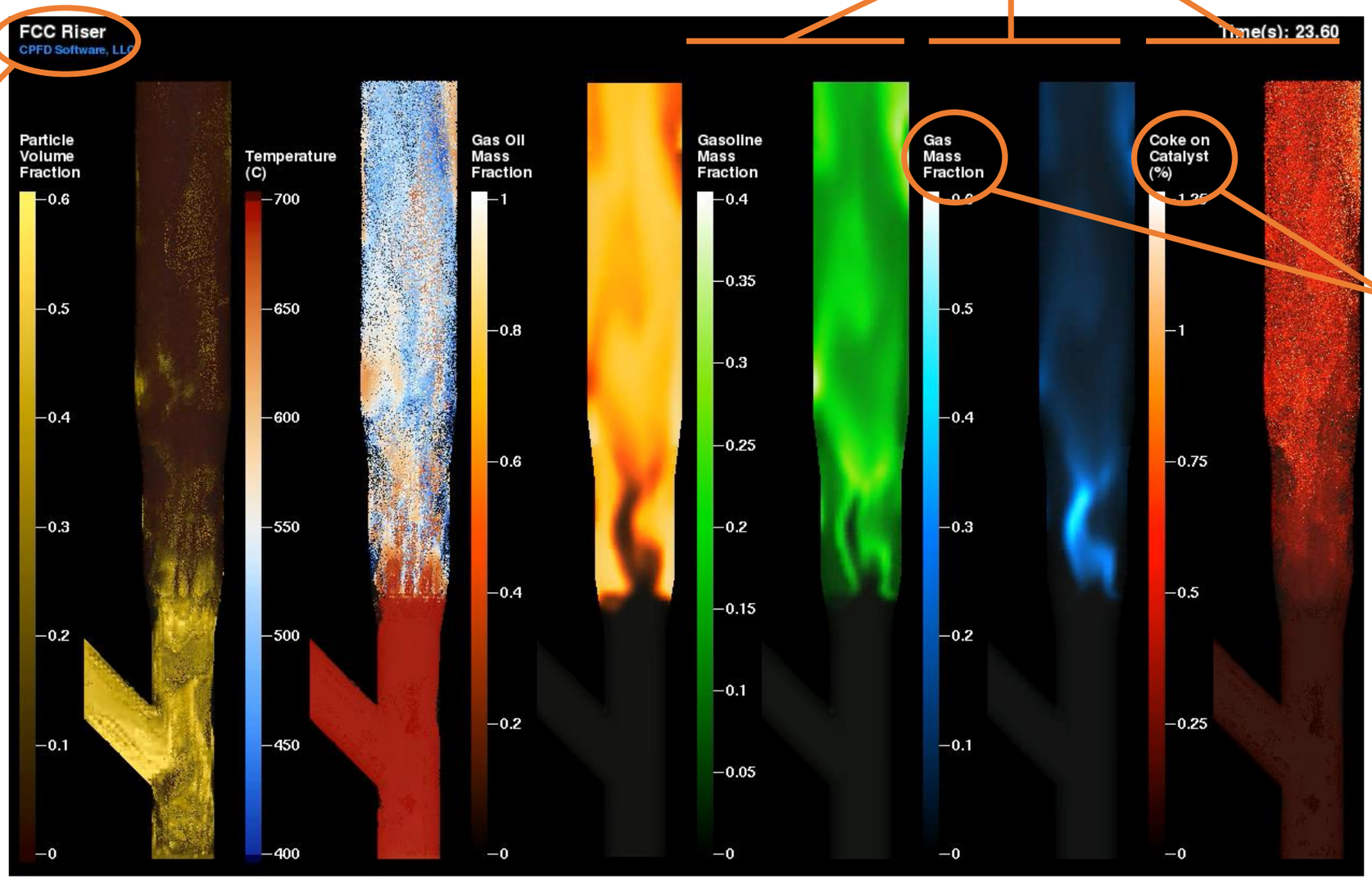


Particles selected based on residence time, t <= 10 s

Montage animations with masks

Multiple animations side-by-side

Custom title and company name



Custom colorbar labels

Create Individual Animations with BATCHMOVIE.sh

Create GMV attribute files

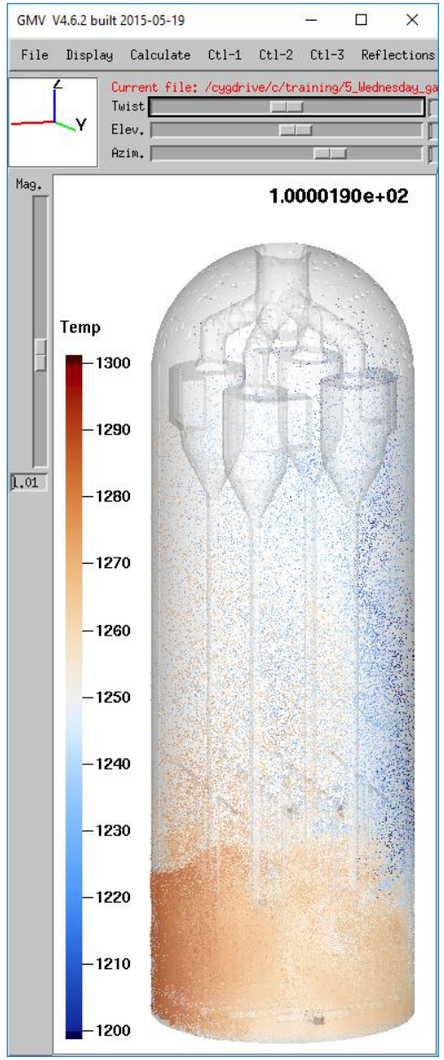
- GMV menu *File*, *Put Attributes*
- No spaces in file names
- Don’t forget “.attr” extension

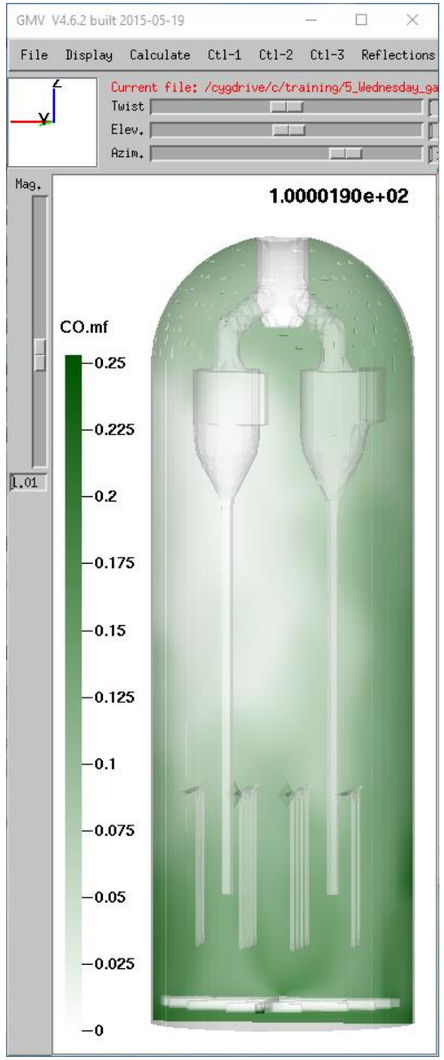
Use BATCHMOVIE.sh to create all movies

- Use a shell script (MAKE_ANIMATIONS.sh)

```
#!/bin/bash

BATCHMOVIE.sh particles_temperature.attr
BATCHMOVIE.sh gas_CO_mass_fraction.attr
```





Side-by-Side Animations: MULTIFRAME.tcl

Add a MULTIFRAME.tcl command to the shell script

```
#!/bin/bash

BATCHMOVIE.sh particles_temperature.attr
BATCHMOVIE.sh gas_CO_mass_fraction.attr

MULTIFRAME.tcl h -sub combined -name combined \
                 particles_temperature \
                 gas_CO_mass_fraction
```

Even if we run the script many times, BATCHMOVIE.sh is smart enough to only make new images if necessary

Backslash is a continuation character so that we can break the long command over multiple lines

When the script is run, a new sub-folder will be created with the combined images

- The subfolder will be named: **`combined`**

Creating a Transparent Mask with Text: GIMP

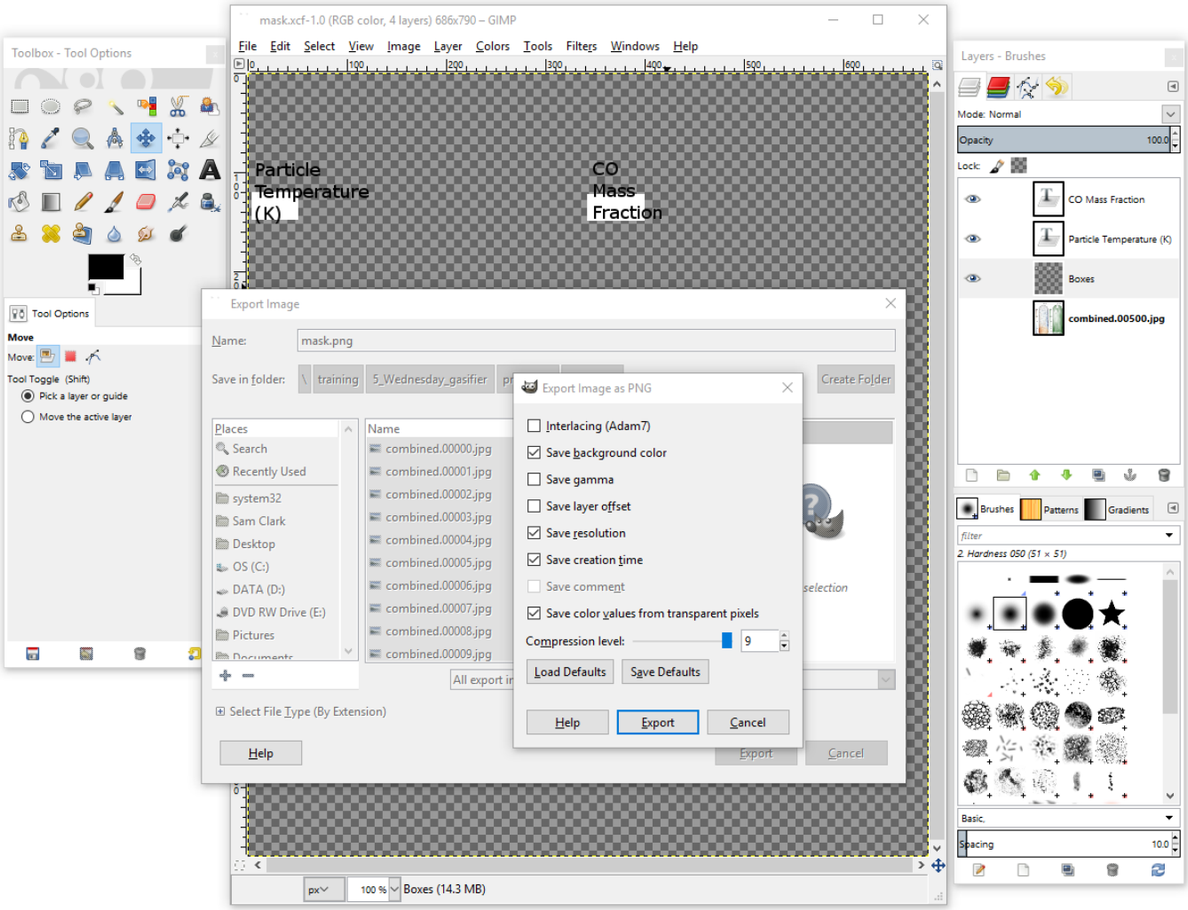
Open one of the `combined` frames using GIMP

- Other advanced image editors would also work
- GIMP is available at www.gimp.org

Work with Layers to create mask

- Transparent layer for boxes
- Text objects in separate layers
- Final step: hide original image layer

Export mask as PNG with transparency



Putting Mask on Frames: ADDLOGO.tcl

Continuing with the script, use ADDLOGO.tcl to overlay the mask onto the combined images

```
#!/bin/bash

BATCHMOVIE.sh particles_temperature.attr
BATCHMOVIE.sh gas_CO_mass_fraction.attr

MULTIFRAME.tcl h -sub combined -name combined \
                 particles_temperature   \
                 gas_CO_mass_fraction

cd combined
ADDLOGO.tcl combined*jpg -logo mask.png noresize
cd ../
```

Use the “noresize” option since the mask is exactly the same size as the images onto which it is overlayed

Assembling the Final Animation: jpg2mpg / jpg2mp4

Create the final animation file

- mpg format works well on Linux (xanim)
- mp4 format works well on Windows (Media Player)

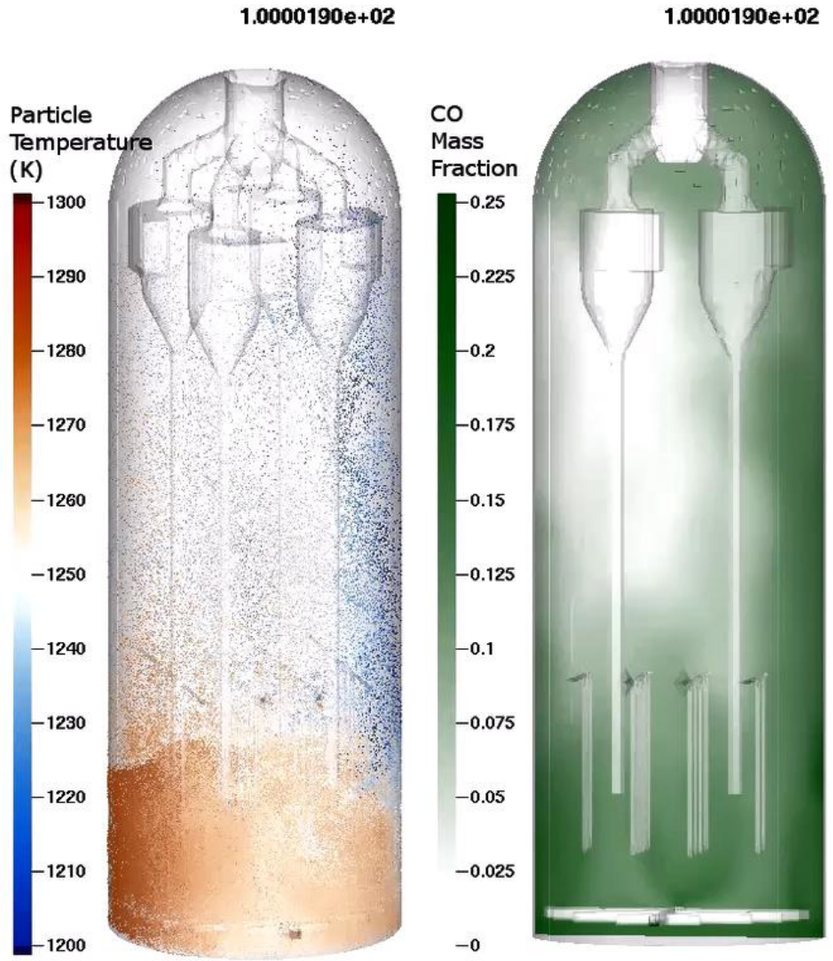
```
#!/bin/bash

BATCHMOVIE.sh particles_temperature.attr
BATCHMOVIE.sh gas_CO_mass_fraction.attr

MULTIFRAME.tcl h -sub combined -name combined \
                 particles_temperature   \
                 gas_CO_mass_fraction

cd combined
ADDLOGO.tcl combined*jpg -logo mask.png noresize
cd ../

jpg2mpg combined/logo_combined*jpg -o side_by_side_montage.mpg
jpg2mp4 combined/logo_combined*jpg -o side_by_side_montage.mp4
```



Calculating Gas Uniformity Index

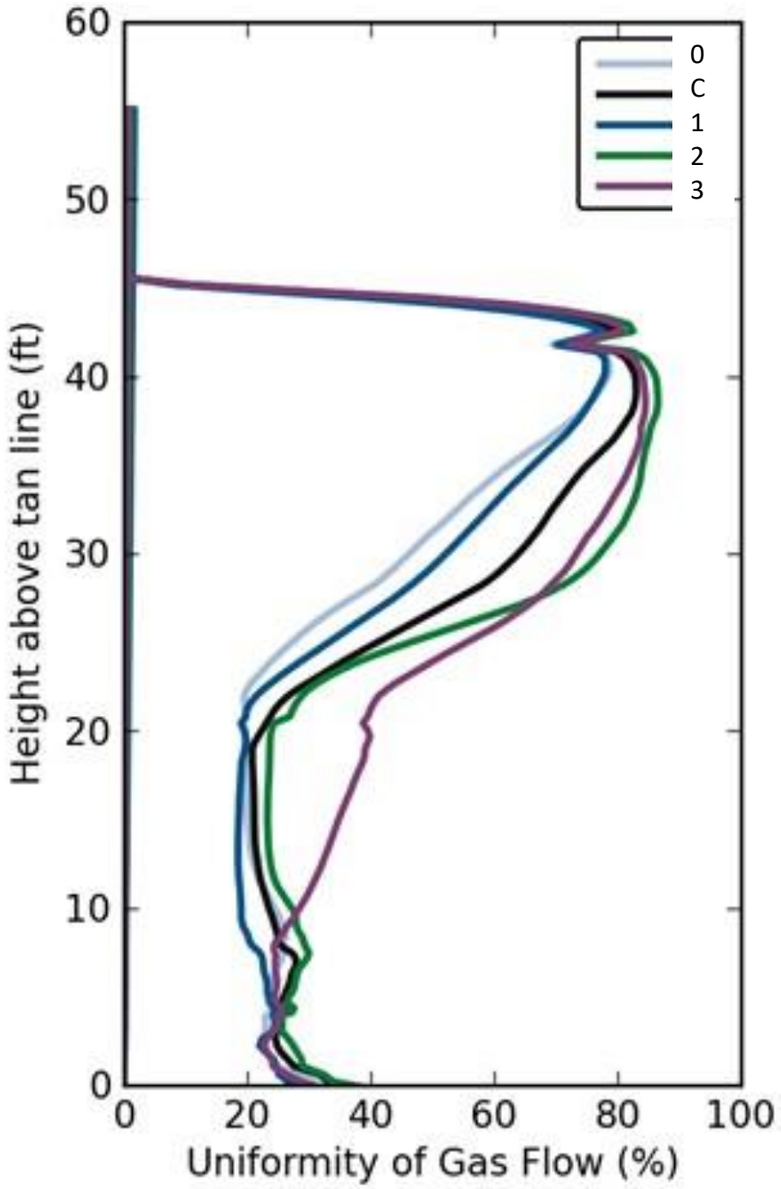
Quantification of time-averaged gas flow shown (Uniformity Index*)

$$U = \frac{Cross\text{-}sectional\ area\ being\ used\ for\ gas\ flow}{Total\ cross\text{-}sectional\ area}$$

Calculated using:

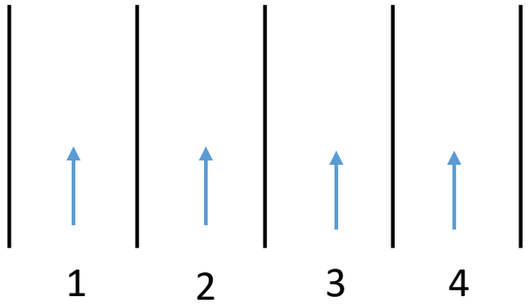
- GMV output data, converted to text format (gmv2txt.py)
- Python (Jupyter notebook)

* See Fletcher, R. et. al., "Identifying the Root Cause of Afterburn in Fluidized Catalytic Crackers", AFPM 2016 Annual Meeting, AM-16-15.



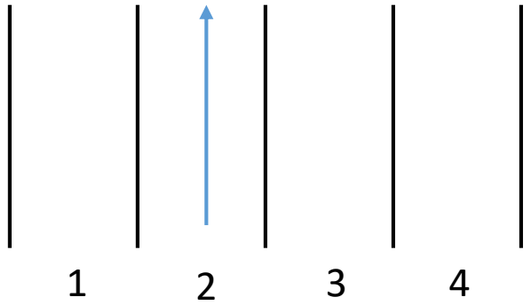
Simple Example of Uniformity Calculation

Consider a very simple system with 4 channels



Channel	Flux	Area	A*F	A*F^2
1	2	1	2	4
2	2	1	2	4
3	2	1	2	4
4	2	1	2	4
Sum		**4**	**8**	**16**
Uniformity =			**100%**	

*Uniformity = (sum(A*F))^2/sum(A*F^2)/sum(A)*



Channel	Flux	Area	A*F	A*F^2
1	0	1	0	0
2	8	1	8	64
3	0	1	0	0
4	0	1	0	0
Sum		**4**	**8**	**64**
Uniformity =			**25%**	

*Uniformity = (sum(A*F))^2/sum(A*F^2)/sum(A)*

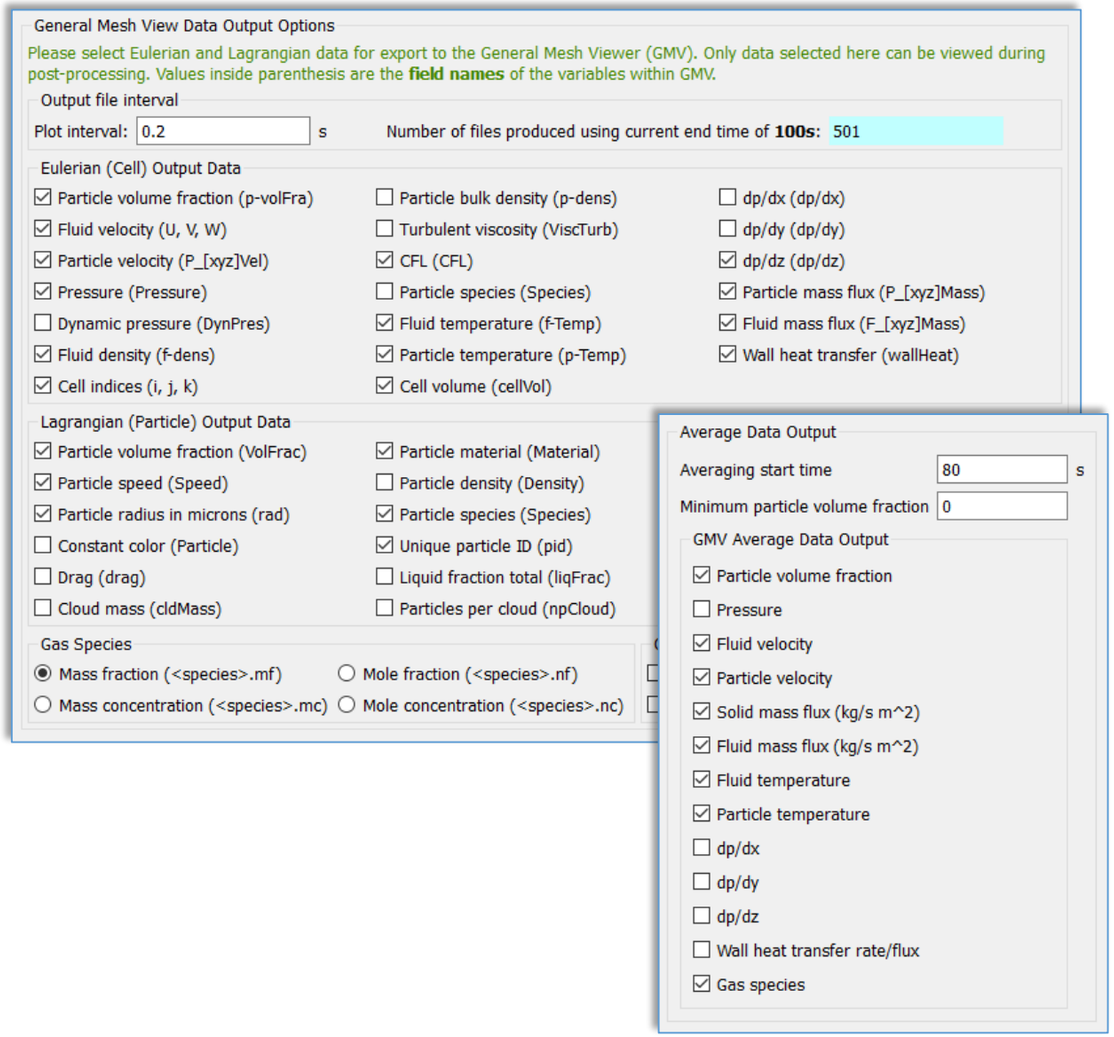
Required Data Output Options

To calculate instantaneous flow uniformity, GMV Output Options:

- Cell volume (cellVol)
- Cell indices (i, j, k)
- Fluid mass flux (F_[xyz]Mass)
- Particle volume fraction (p-volFra)

To calculate time-average flow uniformity, Average Data options:

- Particle volume fraction
- Fluid mass flux



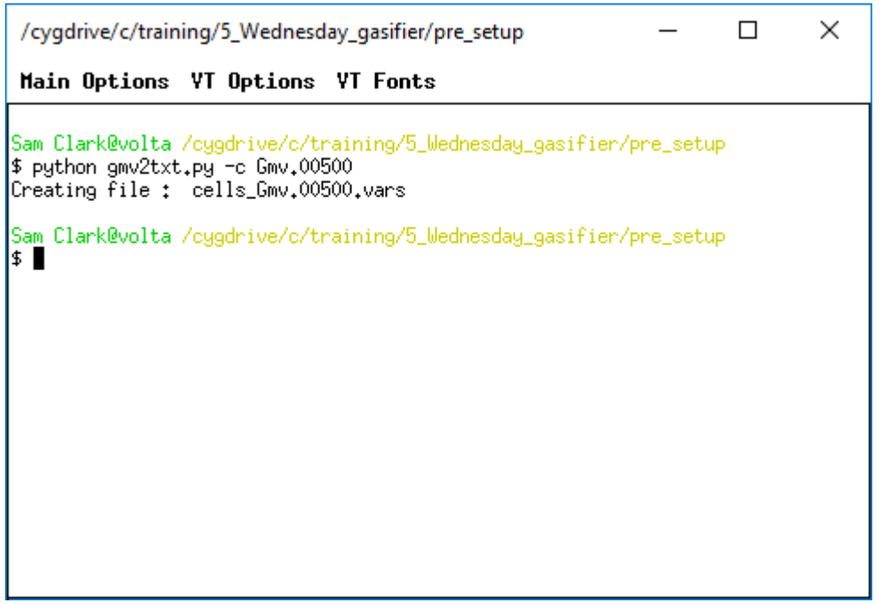
Convert GMV File(s) to Text Format: gmv2txt.py

Text-based data is necessary to calculate uniformity with a script

Use gmv2txt.py to convert one or more GMV files to text

- See this support site post:

http://cpfd-software.com/customer-support/knowledge-base/data-mining-gmv-files-using-gmv2txt.py



Examine the `cells*vars` File Header Information

cells_Gmv.00500.vars (C:\training\5_Wednesday_gasifier\pre_setup) - GVIM1

File Edit Tools Syntax Buffers Window Help

```
# /cygdrive/c/training/5_Wednesday_gasifier/pre_setup/Gmv.00500
# simulation time = 1.0000190e+02
#1 cell id
#2 i
#3 j
#4 k
#5 cellVol
#6 p-VolFra
#7 vf-Ash
#8 vf-C
#9 Pressure
#10 CFL
#11 f-dens
#12 P_xVel
#13 P_yVel
#14 P_zVel
#15 F_xMass
#16 F_yMass
#17 F_zMass
#18 P_xMass
#19 P_yMass
#20 P_zMass
#21 f-Temp
#22 CH4.mf
#23 CO.mf
#24 CO2.mf
#25 H2.mf
#26 H2O.mf
#27 N2.mf
#28 O2.mf
#29 wallHeat
cells_Gmv.00500.vars                    1,1           Top
```

```
#30 p-Temp
#31 dp/dz
#32 av_pVolF
#33 avF_xVel
#34 avF_yVel
#35 avF_zVel
#36 avP_xVel
#37 avP_yVel
#38 avP_zVel
#39 av_Tf
#40 av_Tp
#41 avF_xMas
#42 avF_yMas
#43 avF_zMas
#44 avP_xMas
#45 avP_yMas
#46 avP_zMas
#47 av_CH4.mf
#48 av_CO.mf
#49 av_CO2.mf
#50 av_H2.mf
#51 av_H2O.mf
#52 av_N2.mf
#53 av_O2.mf
#54 x-velocity
#55 y-velocity
#56 z-velocity
#57 x-center
#58 y-center
#59 z-center
cells_Gmv.00500.vars      34,1          0%
```

Use Jupyter Notebook

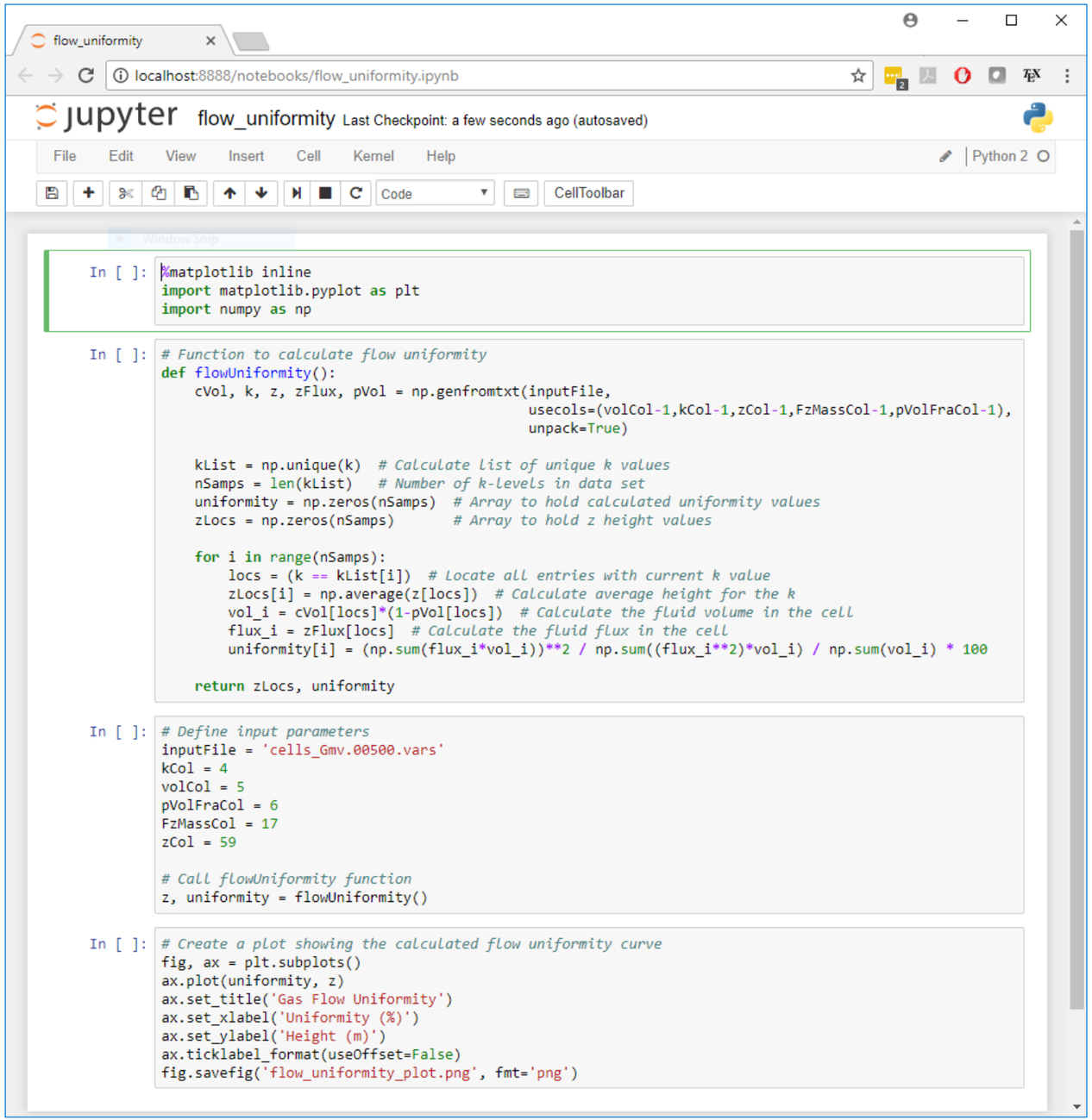
Notebook supplied on USB stick

- `flow_uniformity.ipynb`

For information on Python and the Jupyter notebook, see:

http://cpfd-software.com/customer-support/knowledge-base/installing-the-anaconda-python-distribution

http://cpfd-software.com/customer-support/knowledge-base/advanced-post-processing-presented-by-sam-clark



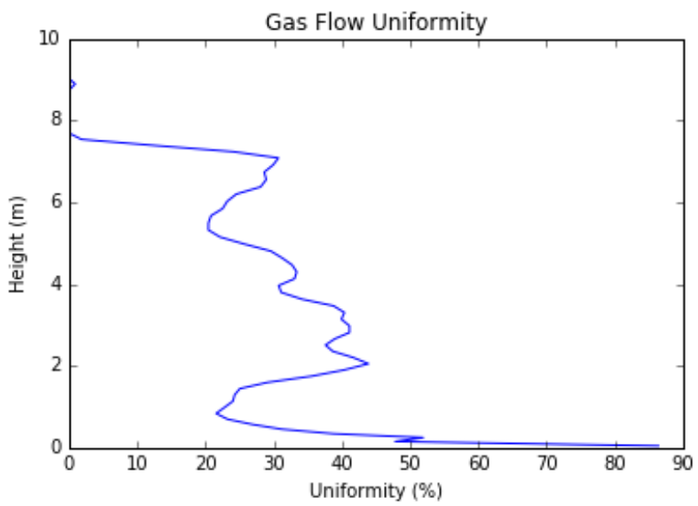
Run the Jupyter Notebook to Plot Uniformity

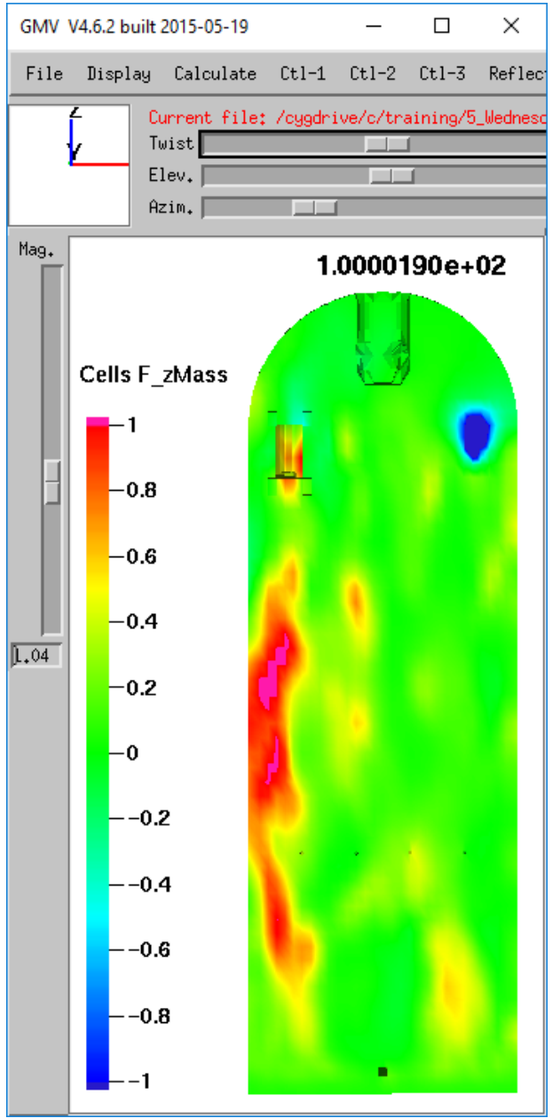
Uniformity plot is shown at right

- The flow in this system is not very uniform. Why?

Look at GMV to gain insight

- The side particle feed is reducing uniformity
- Fresh coal is devolatilizing and producing high quantities of gas





Questions

Thank you for your attention

Questions?