USPAS – *Simulation of Beam and Plasma Systems*

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U.S. Particle Accelerator School sponsored by **Old Dominion University**

http://uspas.fnal.gov/programs/2018/odu/courses/beam-plasma-systems.shtml

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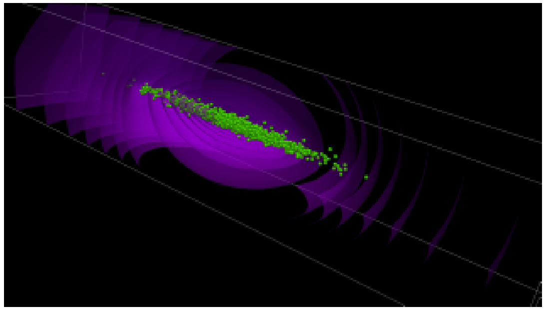
Goals

- Familiarize yourself with the Jupyter hub server
  - browser-based terminal window with bash
  - many particle accelerator codes pre-installed (on RadiaSoft server)
  - supports Jupyter (aka IPython) notebooks

- Explore use of a Jupyter notebook for particle accelerator simulations
  - assume you are asked to do space charge simulations with Synergia
    - https://web.fnal.gov/sites/Synergia/SitePages/Synergia%20Home.aspx
    - http://compacc.fnal.gov/~amundson/html/ **(draft user manual)**
  - typically, you must do the following:
    - **find the source repository, download, install**
    - **learn how to run the code, then visualize the output**
  - if someone provides you with a well-written Jupyter notebook…
    - **then you can start working immediately**

- Consider expansion of a 2D (i.e. very long) proton beam in a drift
  - this is an important exercise with any particle tracking code

Beam dynamics with space charge via Synergia 2.1



Synergia: A comprehensive accelerator beam dynamics package

http://web.fnal.gov/sites/synergia/SitePages/Synergia%20Home.aspx

Fermilab

Accelerator Simulation Group

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Computer time from INCITE

U.S. DEPARTMENT OF ENERGY
INCITE
LEADERSHIP COMPUTING

The ComPASS Project
High Performance Computing for Accelerator Design and Optimization
https://sharepoint.fnal.gov/sites/compass/SitePages/Home.aspx

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CAMPA Consortium for Advanced Modeling of Particle Accelerators

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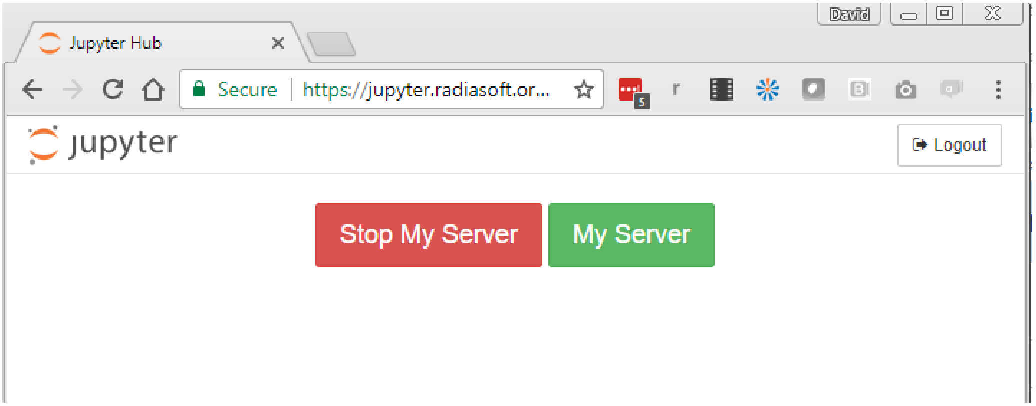
JupyterHub *(Part 1)*

Jupyter & JupyterHub, http://jupyter.org

RadiaSoft, https://uspas-jupyter.radiasoft.org

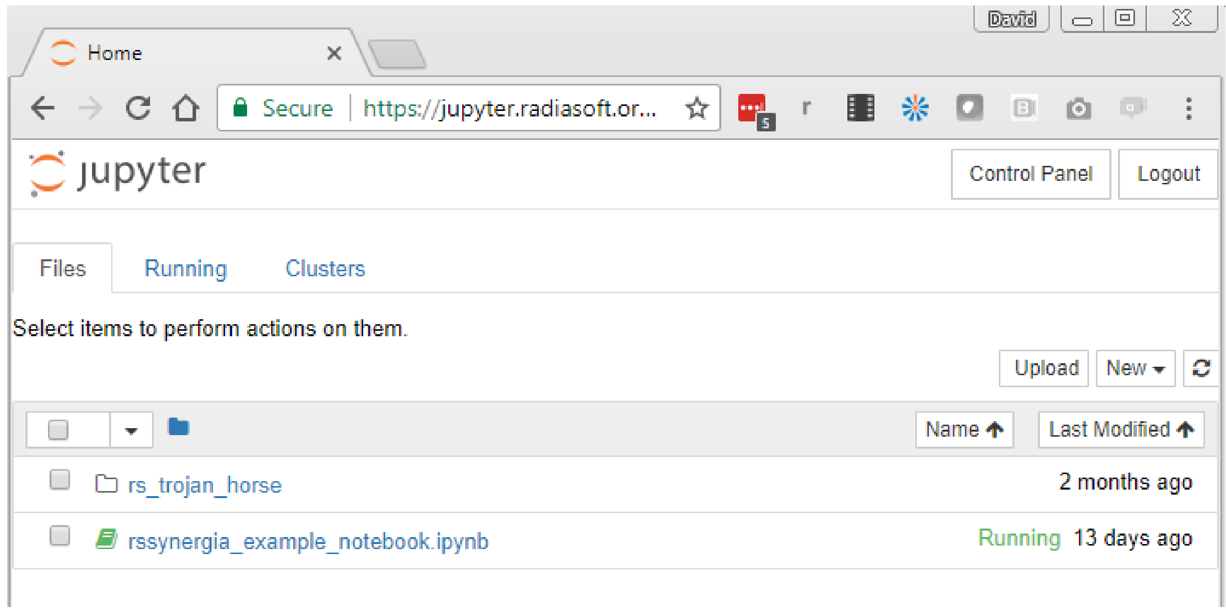
- Create a GitHub account (if necessary), https://github.com
- Go to the RadiaSoft server, https://uspas-jupyter.radiasoft.org
- Authorize the server with your GitHub credentials
  - it can verify your identity and provide a persistent simulation workspace
  - the server saves your GitHub username, but never sees your password
    - **RadiaSoft only uses your username to identify you on the Jupyter server**

- Upon first login, you might see:
- If so, just select 'My Server'
  - activates your instance



JupyterHub *(Part 2)*

- Next you'll see something like the following, but with no files:



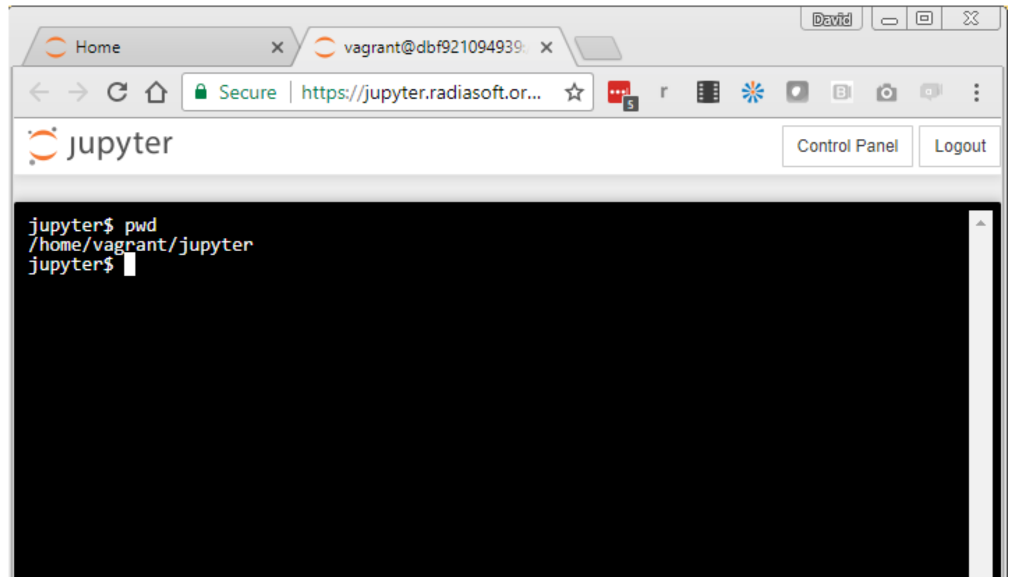
- To upload a Jupyter notebook, or any file, click on the 'Upload' button.

- To create a subdirectory, click on the 'New' button, then select 'Folder'.

- To rename, delete or move a file or folder, select the box to its left
  - causes necessary buttons to appear in the upper-left region of your browser

JupyterHub *(Part 3)*

- For a bash terminal, click on the 'New' button and select 'Terminal'
  - the terminal window will open in a new tab of your browser
  - it will looking something like this:



  - it's like any bash terminal
    - **but you don't have X11**

- The working directory is /home/vagrant/jupyter/
  - everything uploaded via the JupyterHub interface appear in that directory
  - you are free to 'cd' upward and create other directories
  - you can also 'scp' files to/from other computers
  - you can 'git pull' repos from wherever you like

Pull a Jupyter notebook from GitHub

- Type the following in your terminal window:

```
jupyter$ cd /home/vagrant/jupyter

jupyter$ git clone \
> https://github.com/radiasoft/rssynergia.git

jupyter$ mkdir uspas

jupyter$ cp \
> rssynergia/examples/drift_expansion/sc_drift_expansion.ipynb \
> uspas/

jupyter$ cp \
> rssynergia/examples/drift_expansion/myGaussianBunch.txt \
> uspas/
```

Run Synergia from a Jupyter notebook

- Go back to the main browser tab for the JupyterHub server
  - click on the directory named 'uspas'
  - click on the file named 'sc_drift_expansion.ipynb'
  - this opens a Jupyter notebook in a new browser tab
- Type 'shift enter' repeatedly to advance through the notebook
  - pause at each cell to read the docs or look over the code
  - if you see an asterisk in the square brackets to the left…
    - **that means the Python kernel is working**
    - **wait until a number replaces the asterisk; look for any output**
- Once you understand what's happening, scroll back to the top
  - click on 'Kernel' and then select 'Restart & Clear Output'
  - this prevents a lot of problems, when starting a new Synergia simulation
- Find the discussion of drift length in the 4th cell
  - in the cell above, modify this Python code

```
opts.add("turns",30,"Number of turns", int)
```

  - to specify 60 "turns", so that the drift length is increased to 6 m
- Click on 'Cell' and then select 'Run All'
  - wait for the simulation to complete, then observe the results

Your Tasks for this afternoon

- Save the final plot for at least 3 different propagation distances
  - put these plots into a form (or location) that can be shared later
- For one choice of propagation distance, choose two new currents
  - put these 3 plots into a file (or location) that can be shared later
  - make sure the curve labels and plot title are correct for each plot
- For one choice of current and propagation distance
  - increase the Synergia step size repeatedly (keep distance constant)
  - look for signs of problems due to poor resolution
  - make at least 3 plots, with meaningful titles

- Homework for this evening:
  - Write a paragraph for each of your 3 sets of plots
  - Explain what you did and/or what you learned
  - Feel free to comment on the Jupyter notebook experience
  - Make plots and text available to instructors (print, PDF, web…)