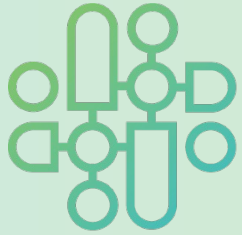


SC23
Denver, CO | i am hpc.

In Situ Analysis and Visualization with Ascent and ParaView Catalyst

[Ascent Project Overview]

SC23 Tutorial
Monday November 13th, 2023

Cyrus Harrison, Lawrence Livermore National Laboratory (LLNL)

Nicole Marsaglia, Lawrence Livermore National Laboratory (LLNL)

SC23
Denver, CO | i am hpc.

Ascent: Flyweight In Situ Visualization and Analysis for HPC Simulations

SC23 Tutorial

Monday November 13th, 2023

Cyrus Harrison (LLNL)
Nicole Marsaglia (LLNL)

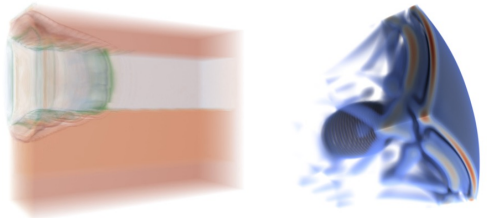
LLNL-PRES-856413
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

Ascent is an easy-to-use flyweight in situ visualization and analysis library for HPC simulations

- **Easy to use in-memory visualization and analysis**
  - Use cases: ***Making Pictures, Transforming Data,*** and ***Capturing Data***
  - Young effort, yet already supports most common visualization operations
  - Provides a simple infrastructure to integrate custom analysis
  - Provides C++, C, Python, and Fortran APIs
- **Uses a flyweight design targeted at next-generation HPC platforms**
  - Efficient distributed-memory (MPI) and many-core (CUDA, HIP, OpenMP) execution
    - Demonstrated scaling: In situ filtering and ray tracing across ***16,384 GPUs*** on LLNL's Sierra Cluster
  - Has lower memory requirements than current tools
  - Requires less dependencies than current tools (ex: no OpenGL)
    - Builds with Spack https://spack.io/

Ascent



Visualizations created using Ascent

python™ HDF CINEMA

Extracts supported by Ascent

http://ascent-dav.org
https://github.com/Alpine-DAV/ascent

Website and GitHub Repo

Acknowledgements

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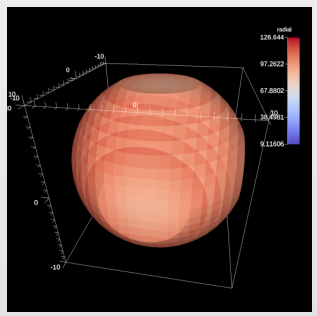
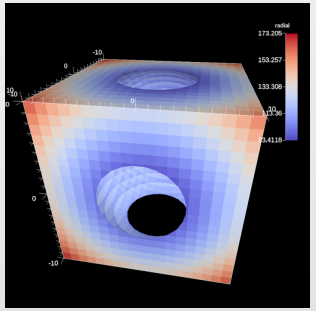
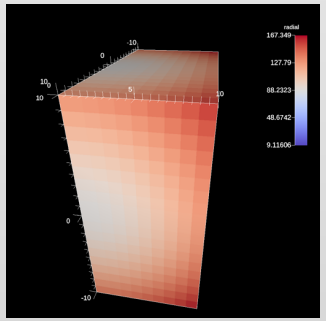
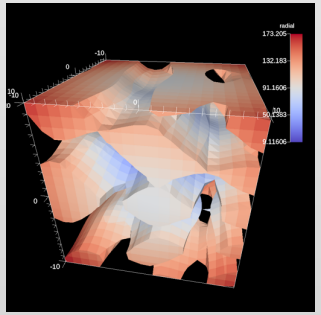
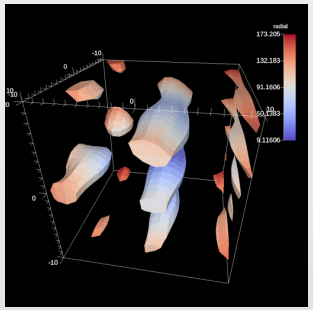
Lawrence Livermore National Security, LLC

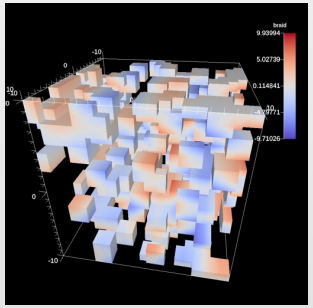
This research was supported by the Exascale Computing Project (17-SC-20-SC), a joint project of the U.S. Department of Energy's Office of Science and National Nuclear Security Administration, responsible for delivering a capable exascale ecosystem, including software, applications, and hardware technology, to support the nation's exascale computing imperative.

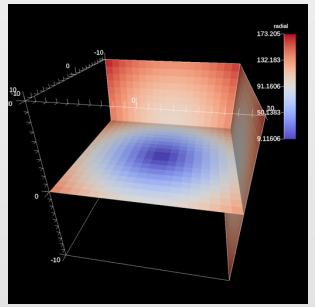
Ascent supports common visualization use cases

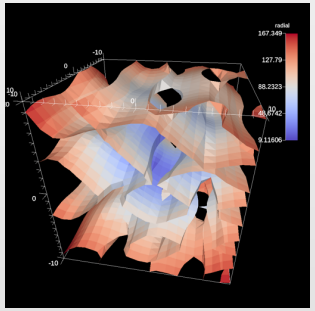





Clips


Iso-Volume


Threshold

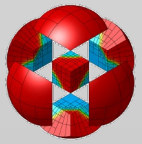

Slice


Contour

[powered by]

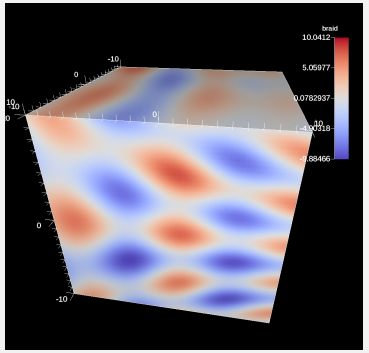
VTK-m

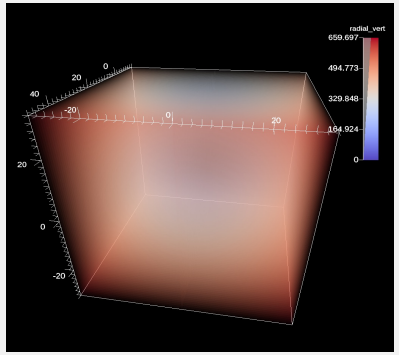
RAJA

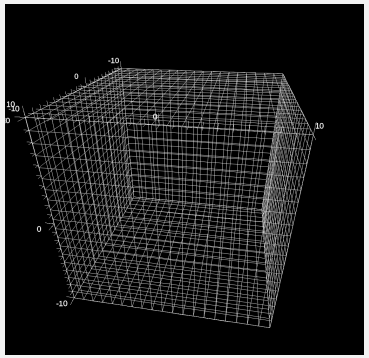

mfem


Devil Ray

Rendering


Pseudocolor

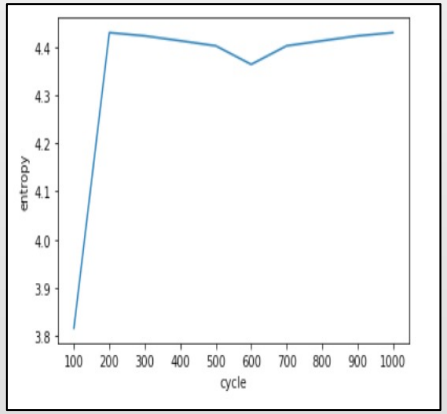

Volume


Mesh

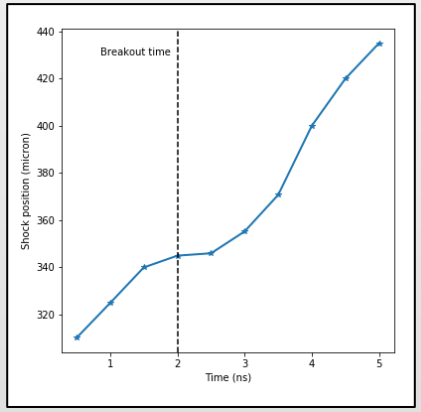
Ascent supports common analysis use cases

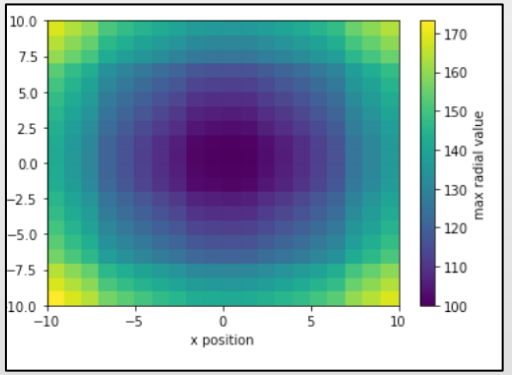
```
expression: |
  du = gradient(field('velocity','u'))
  dv = gradient(field('velocity','v'))
  dw = gradient(field('velocity','w'))
  w_x = dw.y - dv.z
  w_y = dw.z - dv.x
  w_z = dw.x - dv.y
  vector(w_x,w_y,w_z)
name: vorticity
```

Derived Fields



Time Histories



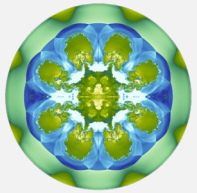


Lineouts and Spatial Binning

```
condition:
  entropy - history(entropy,
            relative_index = 1) > 0.5
```

Triggers

Extracts

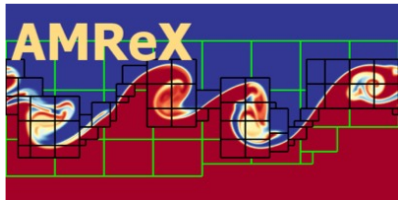


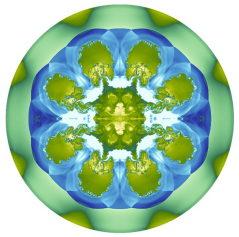
Scalar Images

HDF5 Files

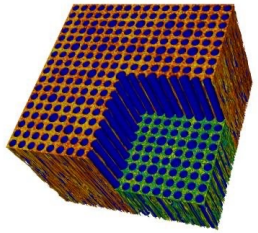
Cinema Databases

We are working to integrate and deploy Ascent with HPC simulation codes (ECP and beyond)

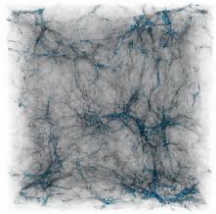




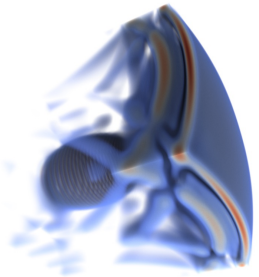
MARBL



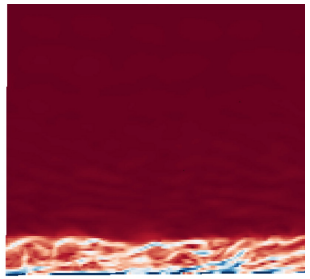
NekRS



Nyx



WarpX

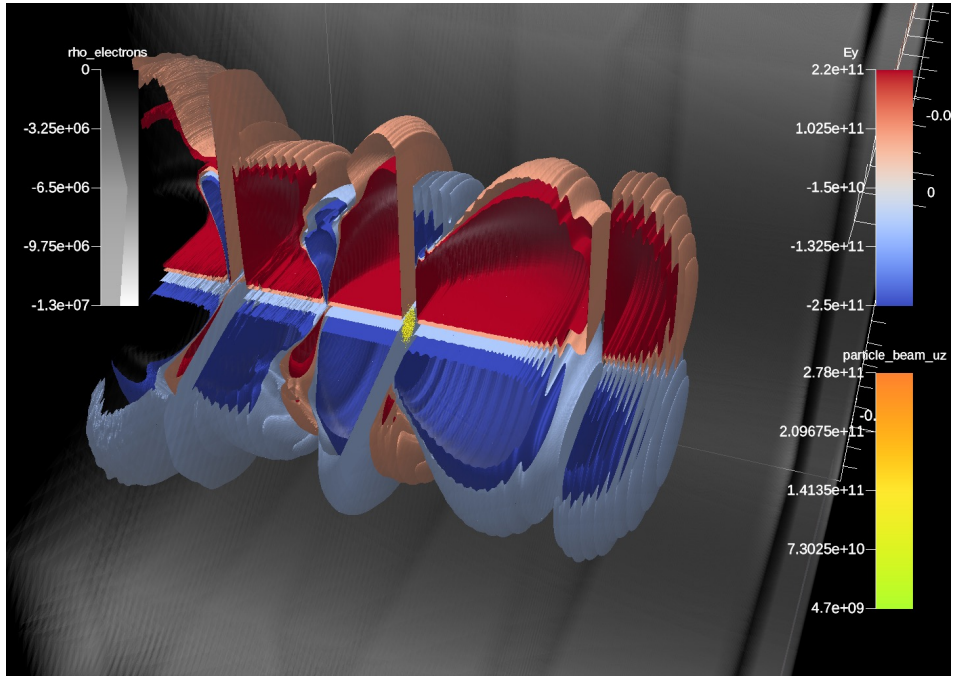


AMRWind

Pele

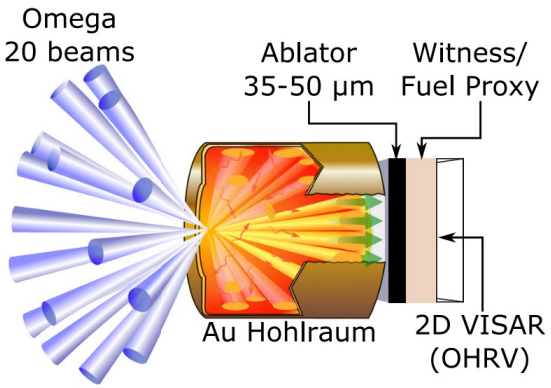
Science Enabling Results: WarpX Simulations on ORNL Frontier (2023)

- The ***578.8 million*** element simulation ran across ***552 GPUs*** on ***69 Nodes***
- The simulation application used **HIP** to run on the GPUs and passed device pointers to Ascent, providing **zero-copy** in situ processing of the time-varying data
- Ascent leveraged **RAJA** to create derived fields and **VTK-m** to run visualization algorithms on the GPUs

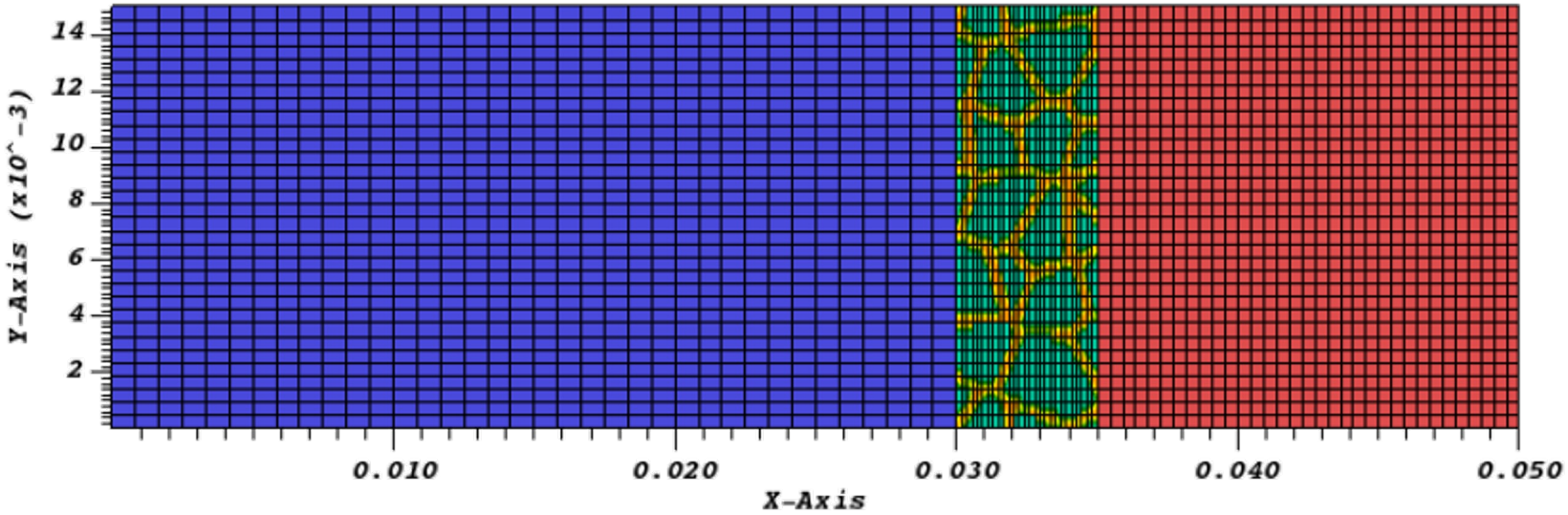


Visualization of a staged laser-wakefield accelerator simulation. Shown is the strong traversal focusing fields (red-blue) in the first plasma stage (gray) and injected into this structure is an electron beam (orange-green) that is accelerated to the right to high energies.

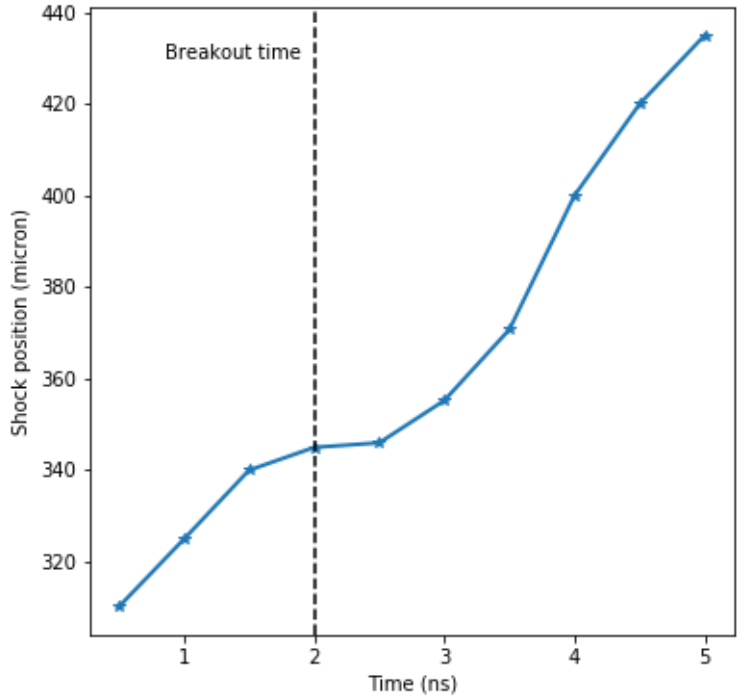
Science Enabling Results: Shock Front Tracking (VISAR)



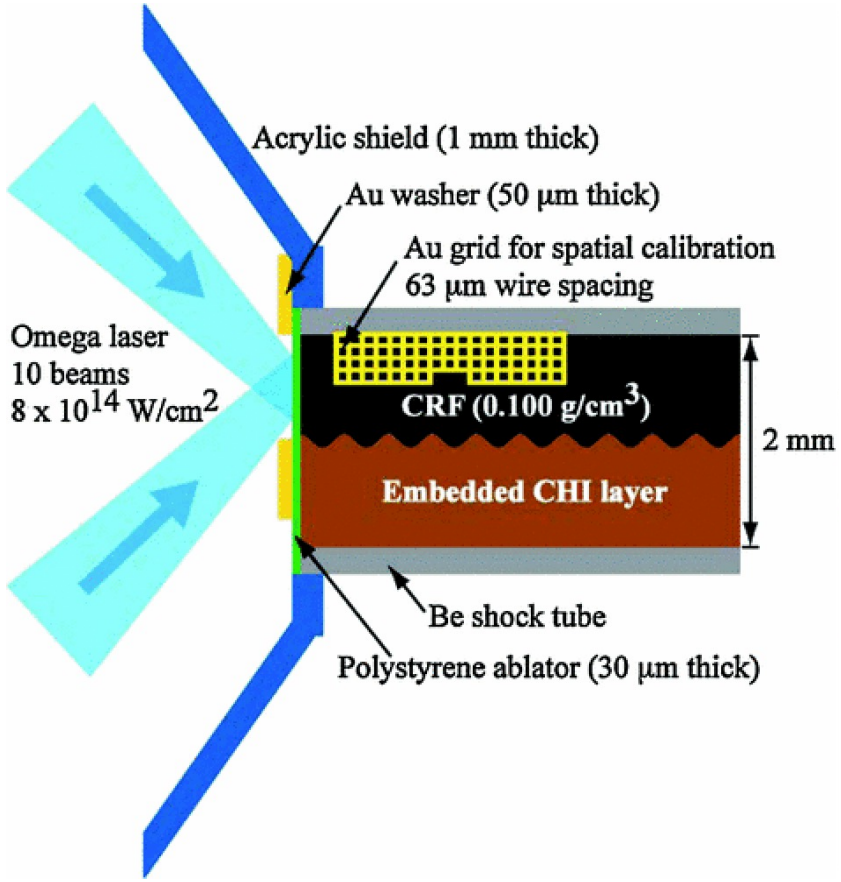
Velocity interferometer system for any reflector (VISAR)



Shock position tracked in Ascent

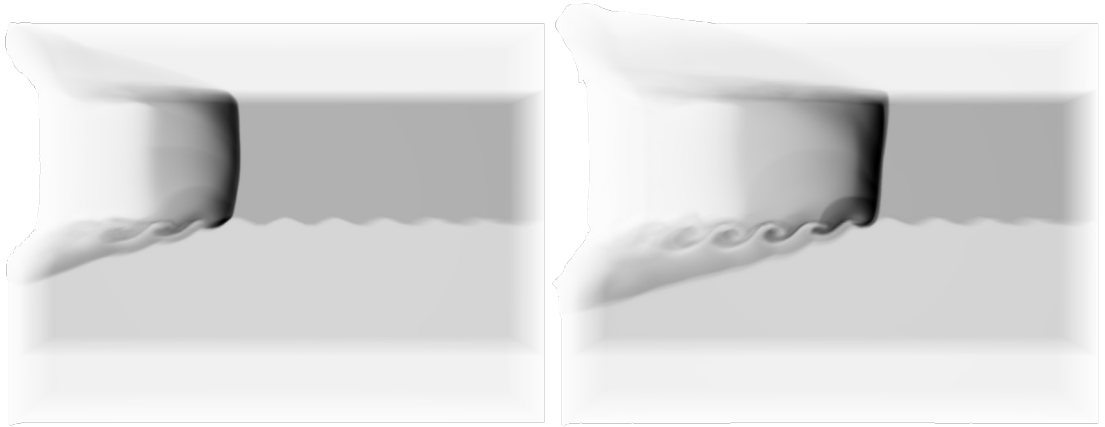


Science Enabling Results: Simulation Validation

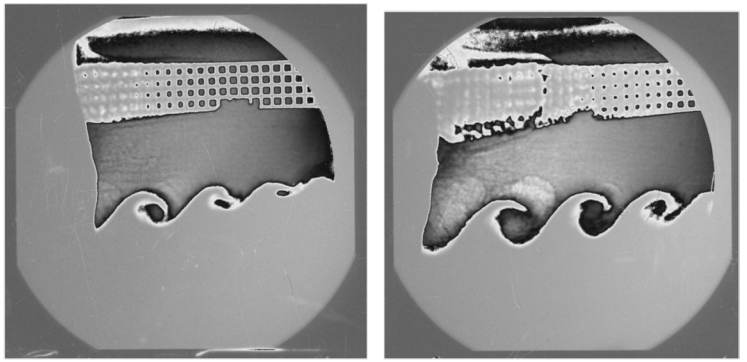


Radiographs

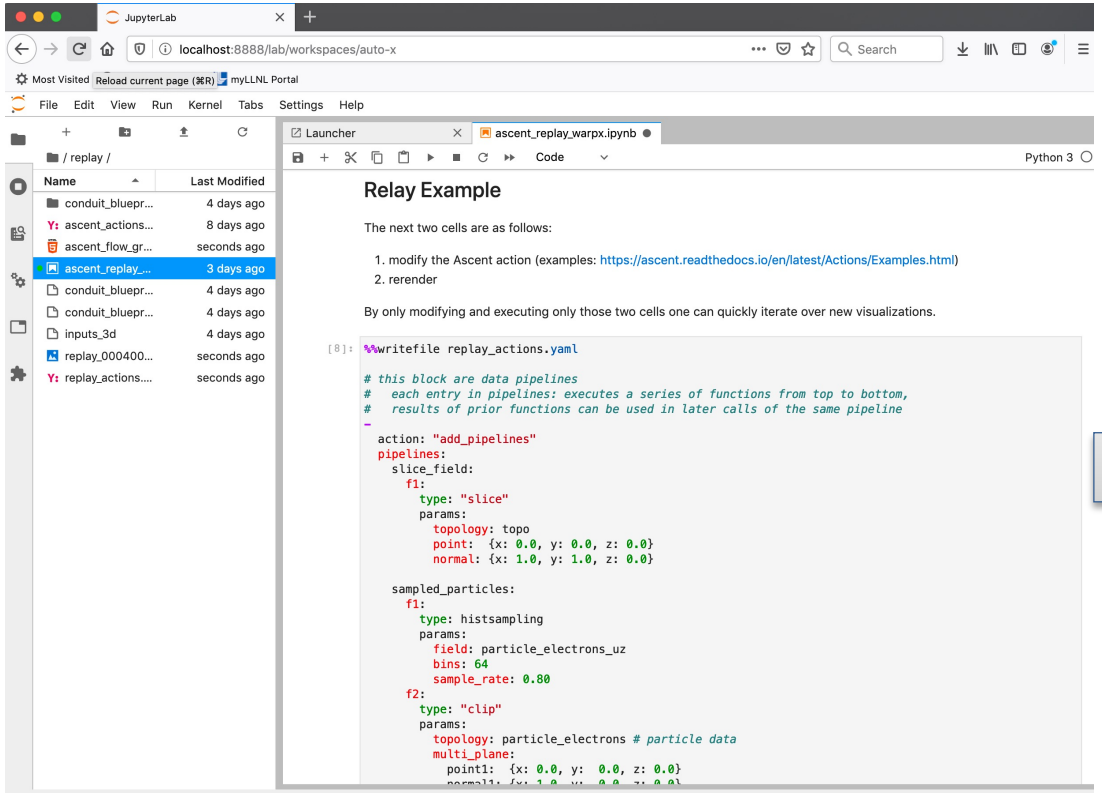
Simulated



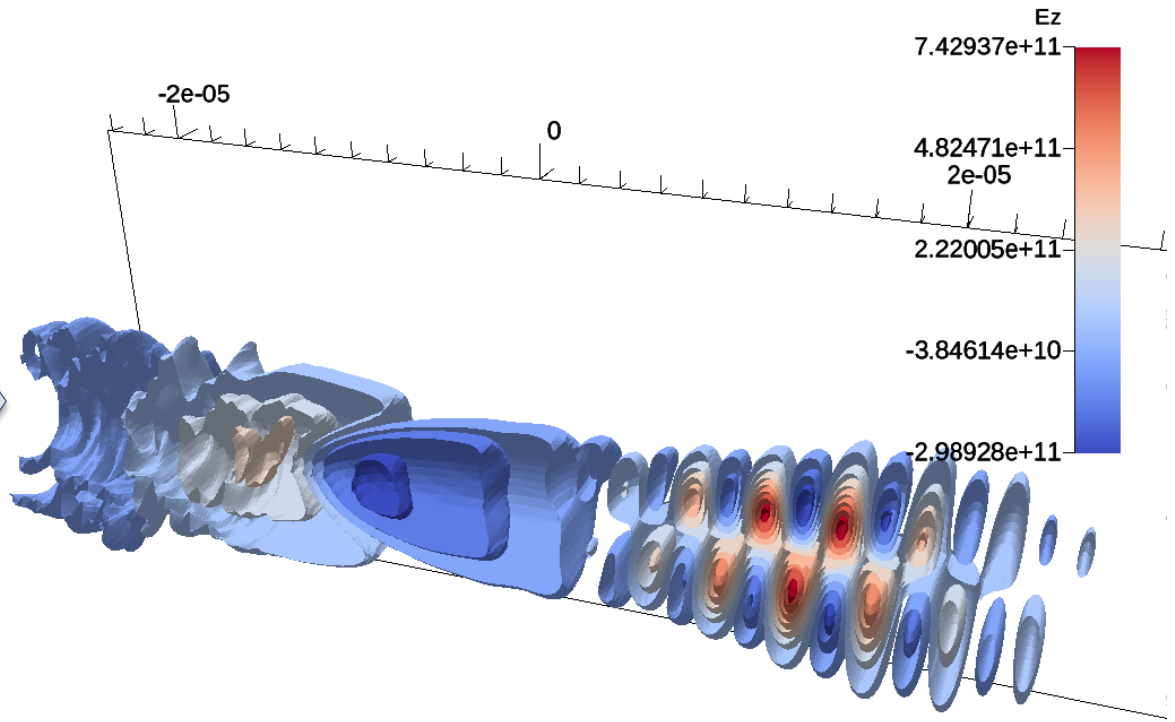
Experimental



Science Enabling Results: WarpX Workflow Tools (Jupyter Lab)



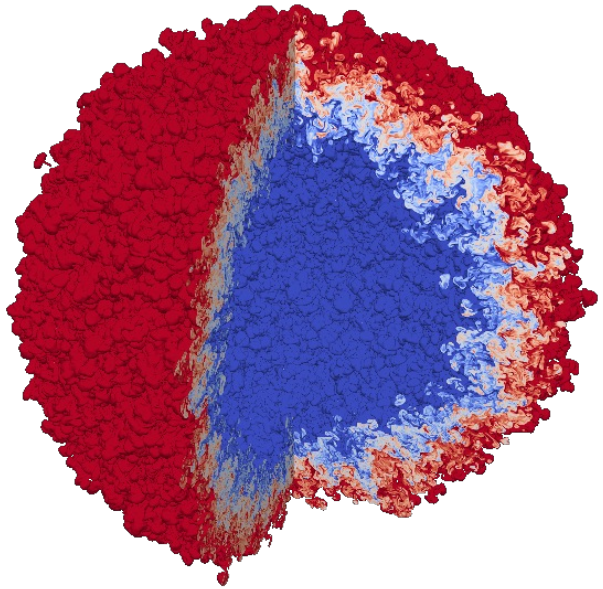
Jupyter Lab Interface



Resulting Image

Science Enabling Results: Rendering At Scale (2018)

- The ***97.8 billion*** element simulation ran across ***16,384 GPUs*** on ***4,096 Nodes***
- The simulation application used **CUDA** via **RAJA** to run on the GPUs
- Time-varying evolution of the mixing was visualized in-situ using **Ascent**, also leveraging 16,384 GPUs
- Ascent leveraged **VTK-m** to run visualization algorithms on the GPUs



Visualization of an idealized Inertial Confinement Fusion (ICF) simulation of Rayleigh-Taylor instability with two fluids mixing in a spherical geometry.

Ascent Project Resources and Contacts

Ascent Resources:

- Github: https://github.com/alpine-dav/ascent
- Docs: http://ascent-dav.org/
- Tutorial Landing Page: https://www.ascent-dav.org/tutorial/

Contact Info:

Cyrus Harrison: cyrush@llnl.gov
Nicole Marsaglia: marsaglia1@llnl.gov

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