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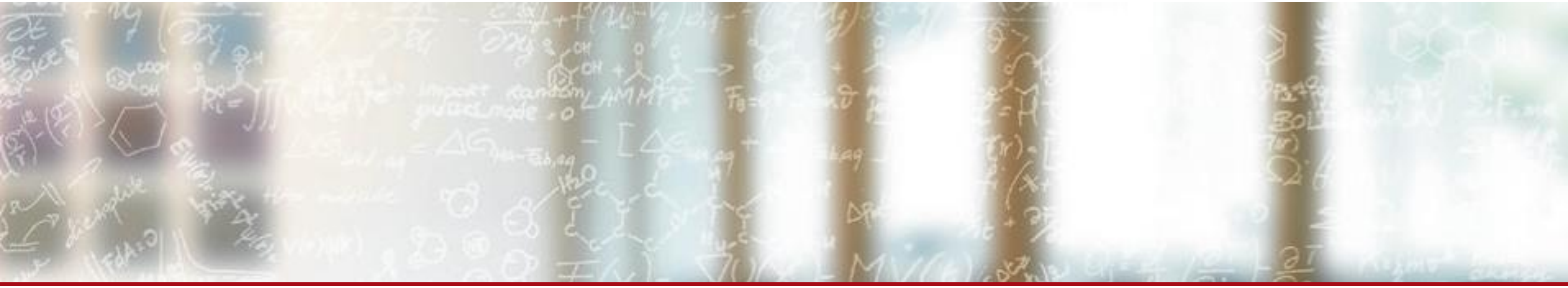

ParaView in a Jupyter notebook

Dr. Jean M. Favre, CSCS

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Foreword

- ParaView is a very mature 3D parallel visualization ecosystem in use at CSCS for many years.
- Usually, users would create a client-server connection from their remote desktop to a set of compute nodes on Piz Daint.
- ParaView uses an efficient and productive interface via Python scripts:
  - The client will read Python commands and the execution takes place [in parallel], on the server side
- A jupyter notebook can execute, stand-alone, or connected to a ParaView parallel server.

Overlook

Analyze data in a familiar, python-driven environment and create 3D interactive visualizations.

No need for a desktop ParaView client, and the [*sometimes complicated*] connection process in client-server mode.

Access to a GPU if you do not have a powerful desktop.

Outline

- Hello sphere ParaView program
- Hello sphere ParaView program + ipywidgets
- Hello sphere ParaView parallel program
- Local notebook connected to remote ParaView session on Piz Daint

- Numpy-to-ParaView
- Raytracing demo

Pre-requisites if you use the Hybrid partition

Edit your $HOME/.jupyterhub.env

module load PyExtensions h5py/2.8.0-CrayGNU-19.10-python3-serial

module load ParaView/5.8.0-CrayGNU-19.10-EGL

See the presentation by Tim Robinson@cscs for all generic details.

Pre-requisites if you use the Multicore partition

Edit your $HOME/.jupyterhub.env

module load PyExtensions h5py/2.8.0-CrayGNU-19.10-python3-serial

module load ParaView/5.8.0-CrayGNU-19.10-OSMesa

See the presentation by Tim Robinson@cscs for all generic details.

Hello_Sphere-ParaView.0.ipynb

- Standard ParaView Python initialization
- Standard pipeline
  - ParaView Source
  - ParaView Representation
  - Render

+

- PVDisplay widget (contributed by NVIDIA)

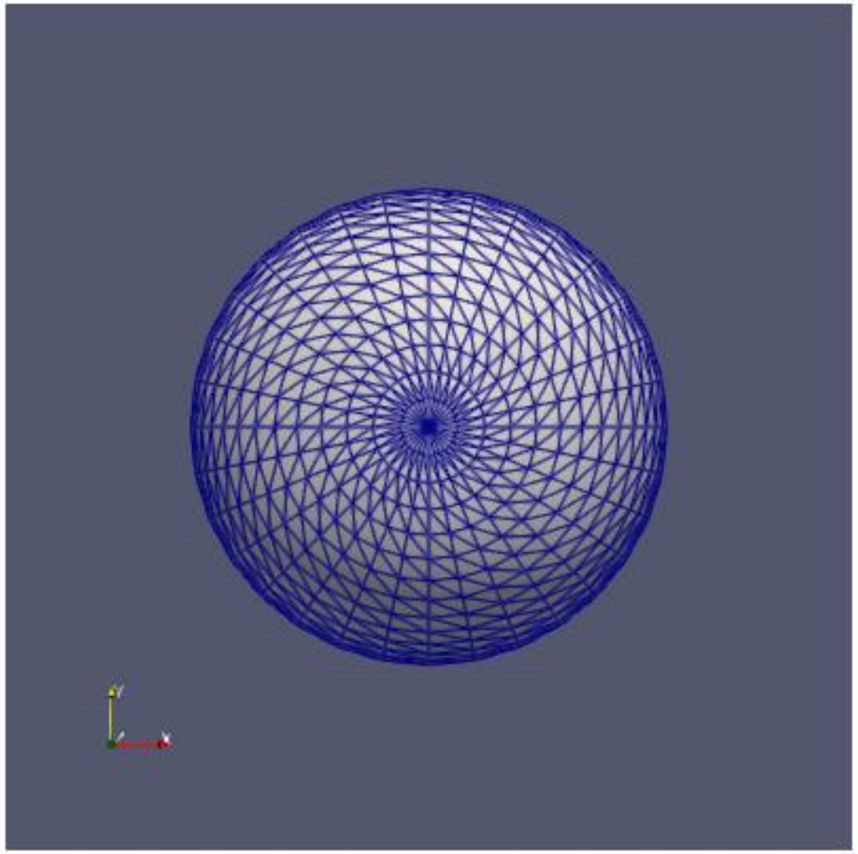
ParaView Hello Sphere Test

[1]:
```
from paraview.simple import *
```

[2]:
```
sphere = Sphere(ThetaResolution=32, PhiResolution=32)

rep = Show()
rep.Representation = "Surface With Edges"
```

[3]:
```
from ipyparaview.widgets import PVDisplay
disp = PVDisplay(GetActiveView())
w = display(disp)
```



Hello World (Sphere) augmented with ipywidgets

sphere.ListProperties()

Attach PhiResolution and ThetaResolution to an IntSlider

```
['Center',
'EndPhi',
'EndTheta',
'PhiResolution',
'PointData',
'Radius',
'StartPhi',
'StartTheta',
'ThetaResolution‘]
```

Hello World (Sphere) augmented with ipywidgets

sphere.ListProperties()

Attach PhiResolution and ThetaResolution to an IntSlider

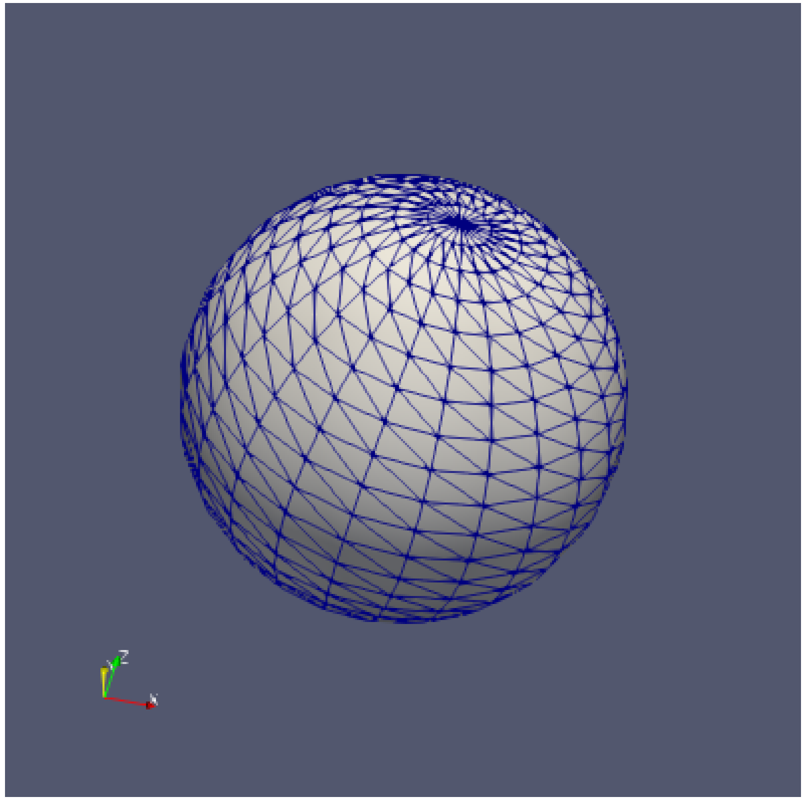
```
from ipywidgets import interact, IntSlider

# automatically triggers a pipeline update, and a render event
def Sphere_resolution(res):
    sphere.ThetaResolution = sphere.PhiResolution = res
    sphere.UpdatePipeline()

i = interact(Sphere_resolution,
             res=IntSlider(min=3, max=48, step=1, value=12)
            )
```

```
['Center',
'EndPhi',
'EndTheta',
'PhiResolution',
'PointData',
'Radius',
'StartPhi',
'StartTheta',
'ThetaResolution‘]
```

Hello_Sphere-ParaView.1.ipynb



```
[6]: # Interact from ipywidgets gives us a simple way to interactively control values
     # with a callback function
     from ipywidgets import interact, IntSlider

     # set the Theta and Phi resolution and trigger a pipeline update
     def Sphere_resolution(res):
         sphere.ThetaResolution = sphere.PhiResolution = res
         sphere.UpdatePipeline()

     i = interact(Sphere_resolution, res=IntSlider(min=3, max=48, step=1, value=12))
```

res 24

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Caveat

It seems like the regular SaveScreenshot() no longer works

```
def SaveImage(filename):
  from vtk import vtkPNGWriter
  img_writer = vtkPNGWriter()
  img_writer.SetInputConnection(disp.w2i.GetOutputPort())
  img_writer.SetFileName(filename)
  img_writer.Write()

SaveImage("/users/jfavre/screenshot.png")
```

Parallel visualization scenarios

Classic console output for client-server connection

```
Accepting connection(s): rancate:1100
#SBATCH --job-name=pvserver
#SBATCH --nodes=1
#SBATCH --ntasks-per-node=8
#SBATCH --ntasks=8
#SBATCH --time=00:20:00
#SBATCH --partition=debug
#SBATCH --constraint=gpu

srun -n 8 -N 1 --cpu_bind=sockets pvserver -rc -ch=daint103.cscs.ch -sp=1100
Submitted batch job  123456789
```

Hello_Sphere-ParaView-Parallel.ipynb (on-the-node parallelism)

This notebook is useful as a minimal example. It creates a synthetic data source (a sphere), and creates a polygonal display of it. Then, it creates a ParaView display widget showing the primary render view. The notebook further demonstrates how we may use interaction widgets (sliders), to change the resolution of the sphere.

[1]:
```
from paraview.simple import *
from paraview.modules.vtkRemotingCore import vtkProcessModule
```

[2]:
```
# to run in parallel on-the-allocated node, one would issue an srun command
# at the terminal:
# module load ParaView/5.8.0-CrayGNU-19.10-EGL
# srun -n 8 `which pvserver`
# followed by a Connect() command

Connect("localhost")
```

[2]:
```
Connection (cs://localhost:11111) [2]
```

[3]:
```
rank = vtkProcessModule.GetProcessModule().GetPartitionId()
nbprocs = servermanager.ActiveConnection.GetNumberOfDataPartitions()
info = GetOpenGLInformation(location=servermanager.vtkSMSession.RENDER_SERVEF
print("nbprocs= ",nbprocs)
```

```
nbprocs=  8
```

```
jfavre@nid06882:~> module avail ParaView

------------------ /apps/daint/UES/jenkins/7.0.UP01/gpu/easybuild/modules/all
ParaView/5.7.0-CrayGNU-19.10-EGL(default) ParaView/5.8.0-CrayGNU-19.10-EGL
jfavre@nid06882:~> module load ParaView/5.8.0-CrayGNU-19.10-EGL
jfavre@nid06882:~>
jfavre@nid06882:~> srun -n 8 pvserver
Waiting for client...
Connection URL: cs://nid06882:11111
Accepting connection(s): nid06882:11111
Client connected.
```

Local jupyter lab (on your desktop) + parallel pv server on Piz Daint

Jupyter Lab notebook

*from paraview.simple import **

ReverseConnect("1100")

N.B. The client is put in wait mode with the call above, **before** issuing the srun command on compute node(s)

- get your userid on Piz Daint (mine is 1100)
- Replace the call Connect(“localhost”) by a ReverseConnect(port)
- Use id as port number
- *ReverseConnect("1100")*

Local jupyter lab (on your desktop) + parallel pv server on Piz Daint

Jupyter Lab notebook

```
from paraview.simple import *
ReverseConnect("1100")
```

Terminal window

- open an ssh tunnel on port 1100.
- select one login node. Here we use daint101.cscs.ch

```
ssh -l jfavre -R 1100:localhost:1100 daint101.cscs.ch

module load daint-gpu
module load ParaView/5.8.0-CrayGNU-19.10-EGL

srun -C gpu -p debug -t 00:10:00 -n 8 -N 1 \
        pvserver -rc -ch=daint101.cscs.ch -sp=1100
```

Questions?

- Use the chat for Q/A

There's more than "Hello World"

Numpy_to_ParaView.ipynb

- Select a VTK grid type
  - vtkImageData
  - vtkRectilinearGrid
  - vtlStructuredGrid
  - vtkUnstructuredGrid
- Attach the numpy arrays (coordinates, scalar and vector field) to the VTK Object (zero-memory copy)
- Make a ParaView object holding the VTK object
- Render

[ ]:
```
from paraview.simple import *
import numpy as np
```

Make numpy arrays

[ ]:
```
dims = [150, 150, 150]
np_data = np.random.rand(np.prod(dims))
```

Make a vtkImageData

[ ]:
```
from vtk import vtkImageData
from paraview import numpy_support

ImageData = vtkImageData()
ImageData.SetExtent(0, dims[0]-1, 0, dims[1]-1, 0, dims[2]-1)

vtk_data = numpy_support.numpy_to_vtk(np_data)
vtk_data.SetName("scalarA")
ImageData.GetPointData().AddArray(vtk_data)
```

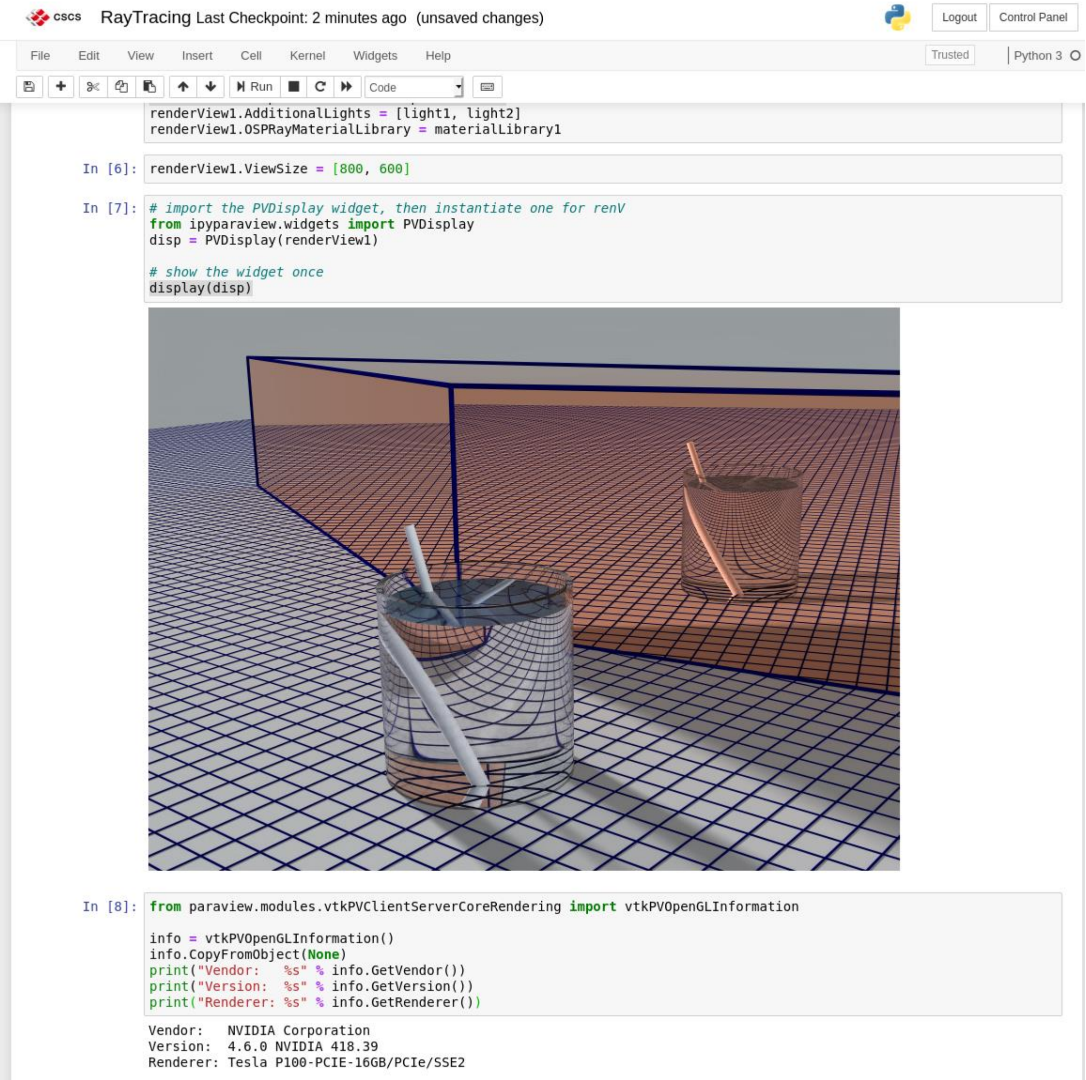
Make a ParaView object holding the vtkImageData

[ ]:
```
trivialproducer = PVTrivialProducer()
obj = trivialproducer.GetClientSideObject()
obj.SetOutput(ImageData)
```

[ ]:
```
rep = Show(trivialproducer)
ColorBy(rep, ("POINTS", "scalarA"))
rep.Representation= "Surface"
```

[ ]:
```
from ipyparaview.widgets import PVDisplay
disp = PVDisplay(GetActiveView())
w = display(disp)
```

Raytracing.ipynb




```
renderView1.AdditionalLights = [light1, light2]
renderView1.OSPRayMaterialLibrary = materialLibrary1
```

In [6]:
```
renderView1.ViewSize = [800, 600]
```

In [7]:
```
# import the PVDisplay widget, then instantiate one for renV
from ipyparaview.widgets import PVDisplay
disp = PVDisplay(renderView1)

# show the widget once
display(disp)
```

In [8]:
```
from paraview.modules.vtkPVClientServerCoreRendering import vtkPVOpenGLInformation

info = vtkPVOpenGLInformation()
info.CopyFromObject(None)
print("Vendor:   %s" % info.GetVendor())
print("Version:  %s" % info.GetVersion())
print("Renderer: %s" % info.GetRenderer())
```

```
Vendor:   NVIDIA Corporation
Version:  4.6.0 NVIDIA 418.39
Renderer: Tesla P100-PCIE-16GB/PCIe/SSE2
```

- Ray-tracing is executed on the GPU

  renderView1.BackEnd = 'OptiX pathtracer‘

- Or runs on all available CPU threads

  renderView1.BackEnd = 'OSPRay raycaster‘

  renderView1.BackEnd = 'OSPRay pathtracer‘

updates

- ParaView v5.8 will become the default at the next maintenance
  - Move to 5.8 ASAP. It's much better anyway

- A 3-day Visualization Class [Instructor: Jean M. Favre]
  - Introductory + Advanced Visualization
  - ParaView in Jupyter Lab
  - Topics of interest (please send me emails)
  - October 5-7, 2020. Mark your calendar.

Your wish list?

What do you wish to have to improve your experience with ParaView (or 3D visualization) at CSCS?

Send me direct email jfavre@cscs.ch to discuss it further.

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