Section 18
Use Case 5:

ShockPanel

Problem Description

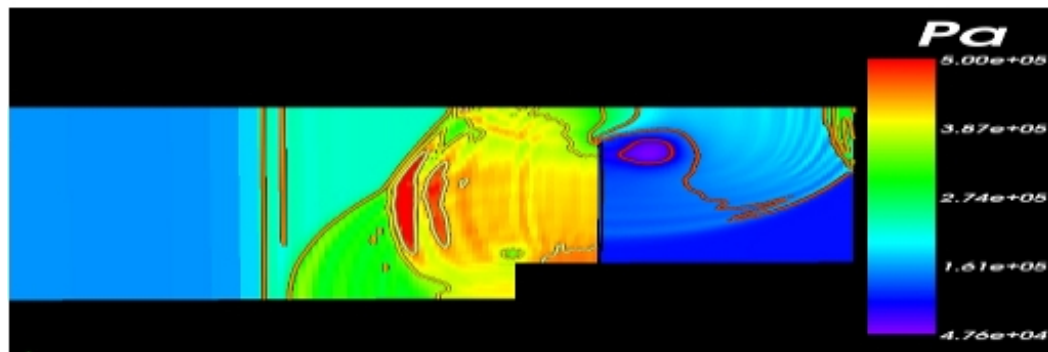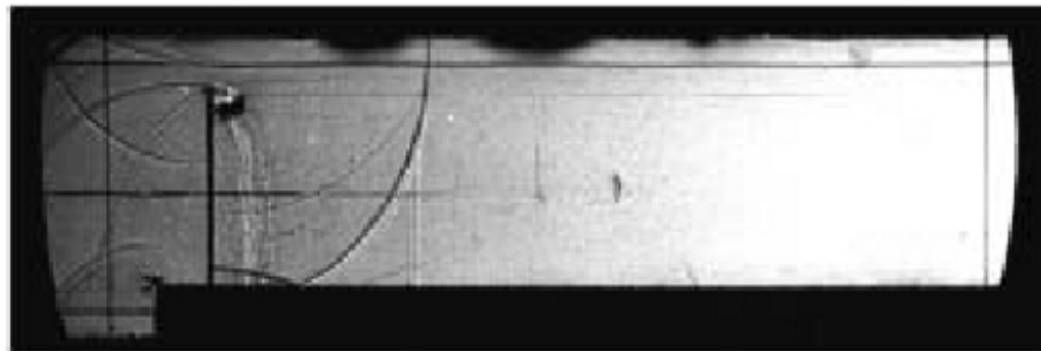- ## Mach 1.2 shock in air impacts a deforming panel
  - Giordano, et. al.
- ## Domain solvers
  - Fluids: Rocflo
    - 10 blocks
    - 38k hex cells
  - Structures: Rocfrac
    - 138k quadratic tet elements
- ## Objective: FSI example
  - Rocstar V&V case (lite)

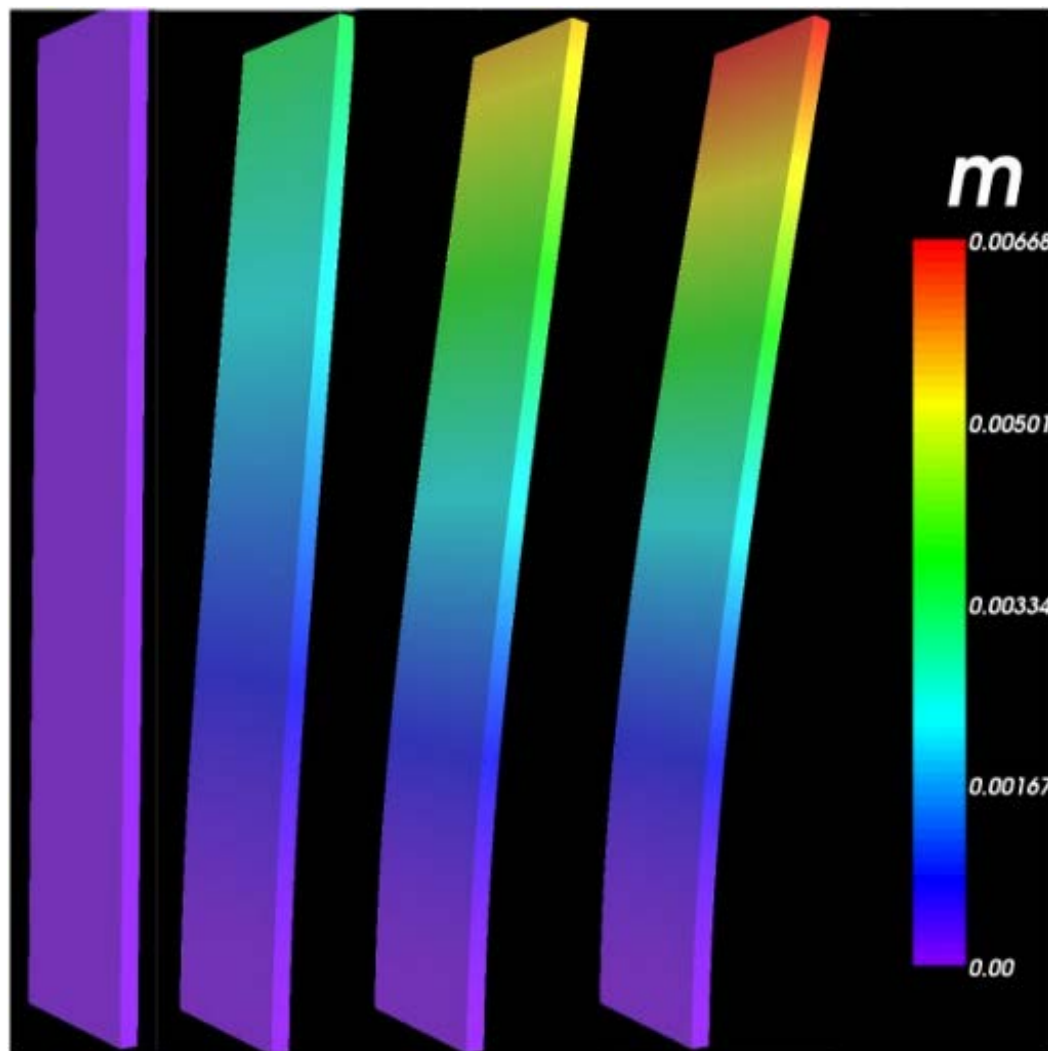See cover sheet for distribution restrictions.

Problem Description

- **Material properties of interest**
  - Δp = pressure drop across panel
  - panel (l,e) = (length,thickness)
  - E = elastic modulus
  - ρ_s = panel density
- **Quantities of interest:**
  - Max tip displacement $d_{max} = 3\Delta p l^4 / 2Ee^3$
  - Panel frequency $\omega = \mathrm{sqrt}(Ee^2/\rho_s l^4)$

File Checklist

- Rocstar
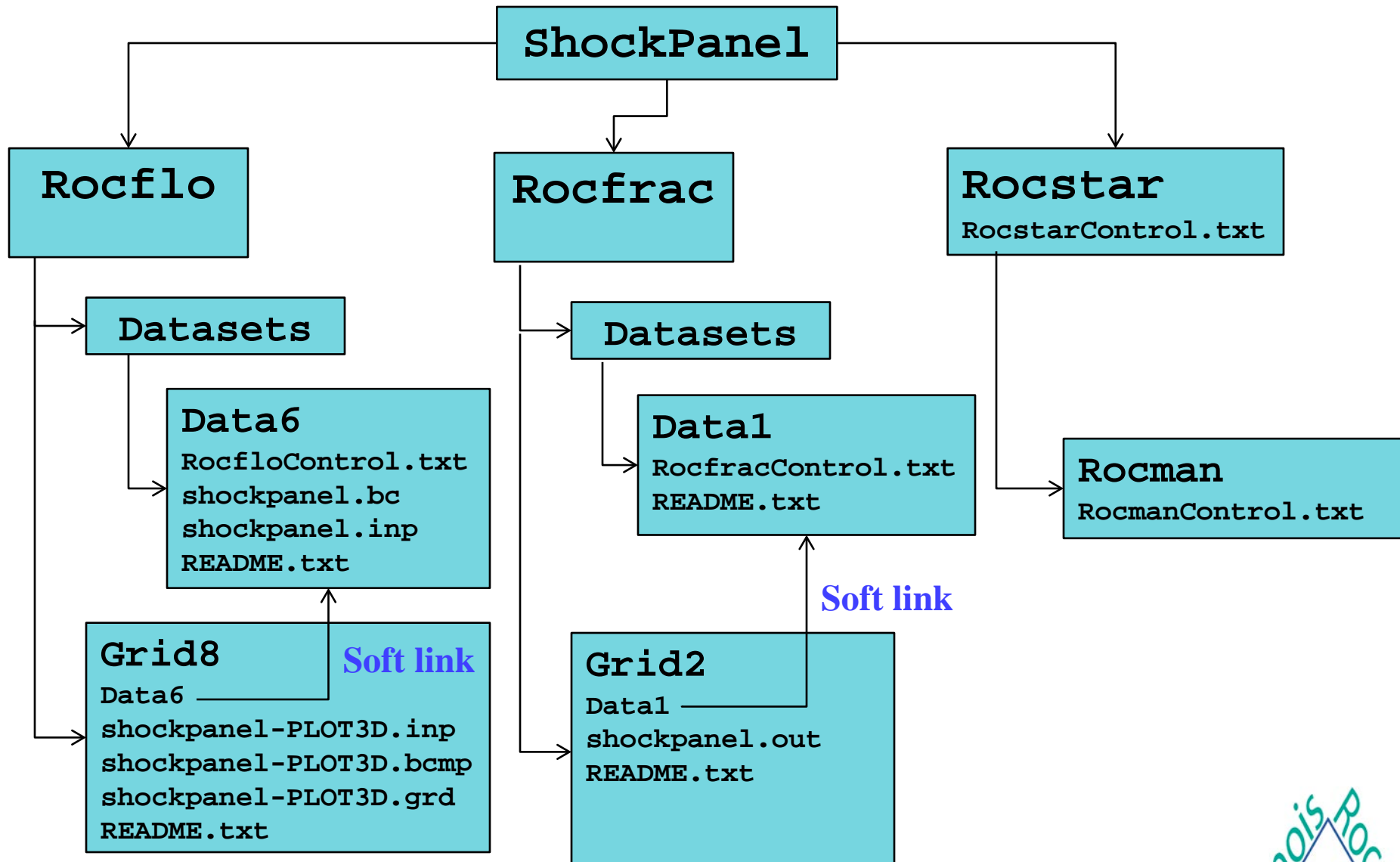 - RocstarControl.txt
- Rocman
  - RocmanControl.txt
- Rocfrac
  - RocfracControl.txt
  - shockpanel.out

- Rocflo
  - RocfloControl.txt
  - shockpanel.inp
  - shockpanel.bc
  - shockpanel-PLOT3D.bcmp
  - shockpanel-PLOT3D.inp
  - shockpanel-PLOT3D.grd

Examine NDA

```
                          ┌─────────────────┐
                          │   ShockPanel    │
                          └─────────────────┘
         ┌──────────────────────┼──────────────────────┐
         ▼                      ▼                      ▼
┌─────────────┐        ┌─────────────┐        ┌─────────────────────────┐
│   Rocflo    │        │   Rocfrac   │        │   Rocstar               │
└─────────────┘        └─────────────┘        │   RocstarControl.txt    │
                                               └─────────────────────────┘
```

ShockPanel

Rocflo

Rocfrac

Rocstar
RocstarControl.txt

Datasets

Datasets

Data6
RocfloControl.txt
shockpanel.bc
shockpanel.inp
README.txt

Data1
RocfracControl.txt
README.txt

Rocman
RocmanControl.txt

Soft link

Grid8   **Soft link**
Data6
shockpanel-PLOT3D.inp
shockpanel-PLOT3D.bcmp
shockpanel-PLOT3D.grd
README.txt

Grid2
Data1
shockpanel.out
README.txt

Run *Rocprep* on NDA

➢ cd ${ROCSTARTUTORIAL}

➢ ${ROCSTARBIN}/rocprep –A –o 6 8 –f 1 2 –d ${ROCSTARDATAROOT}/ShockPanel
-n 10 –t ./ShockPanel_10p

```
[mdbrandy@taubh1 Modin]$ ~/Rocprep/Rocprep.pm
First switch must be mode switch -A|C|E|P|U, not:

***************************************************************************
Usage: /home/mdbrandy/Rocprep/Rocprep.pm -A|C|E|P [OPTION]...

Major modes of operation:
  -A, --all        extract and preprocess
  -C, --check      check an existing dataset at -d <path>
  -E, --extract    copy NDA files to target at -t <path>
  -P, --preprocess  run module preptools on data at -d <path>

Physics module selection:
  -o [m] [n]      Rocflo preprocessing, optional NDA Data<m> & Grid<n> dirs
  -u [m] [n]      Rocflu preprocessing, optional NDA Data<m> & Grid<n> dirs
  -f [m] [n]      Rocfrac preprocessing, optional NDA Data<m> & Grid<n> dirs
  -s [m] [n]      Rocsolid preprocessing, optional NDA Data<m> & Grid<n> dirs
  -b              Rocburn preprocessing

Module-specific flags:
  -r <m>          specify <m> regions (rocflu only), default is -n value
  -splitaxis <n> force split along n=0,1, or 2 axis (rocflo only)
  -un <units>    convert model units to meters (rocfrac only)

General options:
  -i <o|u|f|s>  surfdive interface meshes, default infers from physics options
  -d <path>     path to source data, default is current working directory
  -h, --help    print this help message and terminate
  -n <m>        specify <m> processors/partitions
  -t <path>     target path for new rocstar dataset
  -p <path>     path to preptool binaries, default will use shell path
  -x, --ignore  ignore RocprepControl.txt control file

Example: /home/mdbrandy/Rocprep/Rocprep.pm -A -o 1 1 -f 2 4 -d archiveDir/ -t newDataset/ -n 8
***************************************************************************
```
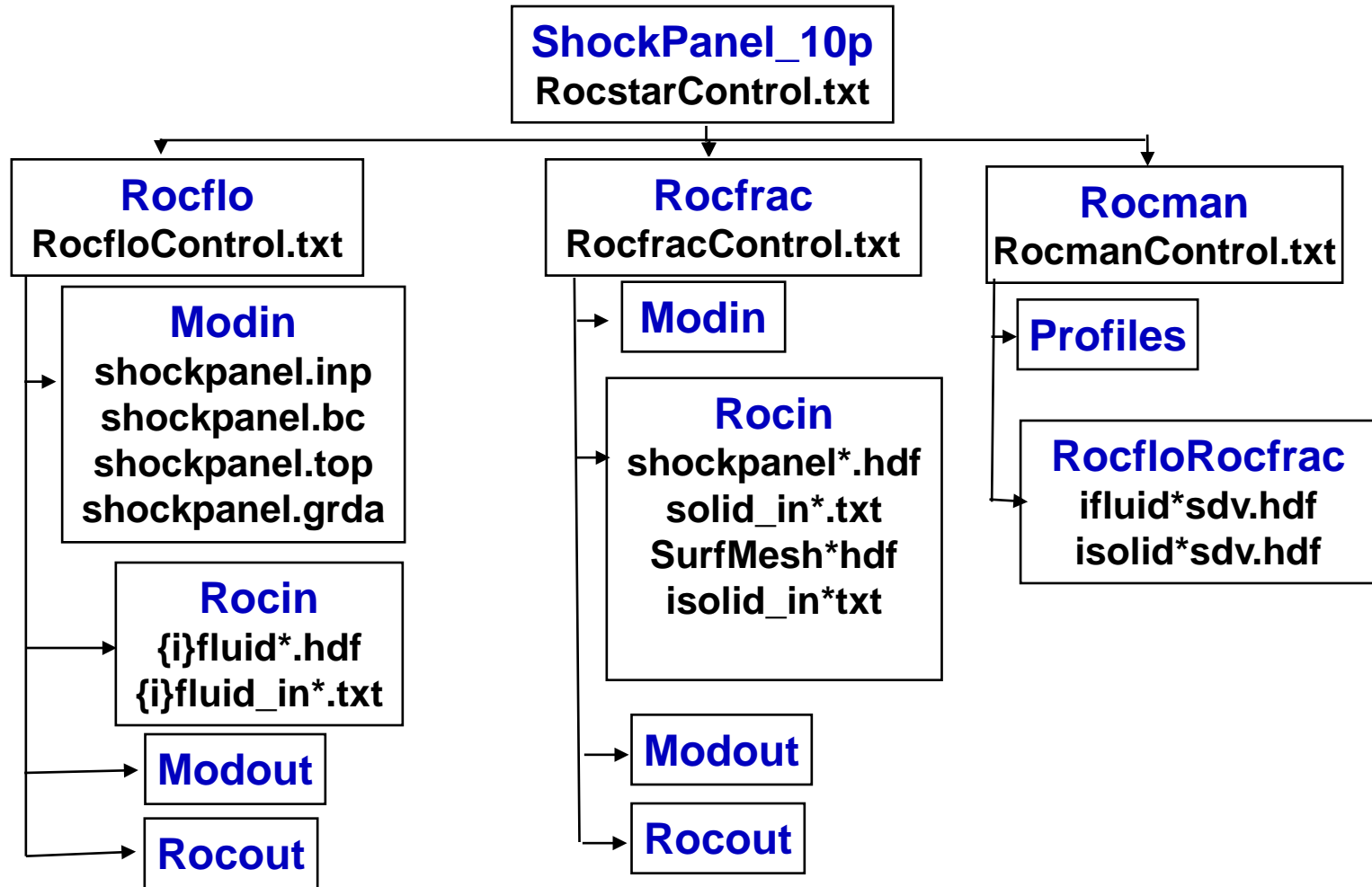
Resulting *Rocstar* Dataset

See cover sheet for distribution restrictions.

RocfracControl.txt

```
** Structure of Control File
** ---------------------------
**
** Lines with '**' in the 1st two columns indicate comments
** Lines with '*' in the 1st column indicates keyword
**
** PREFIX:
** Directory name containing Mesh input files
**
*PREFIX
shockpanel
**
** SCALE FACTOR: set this parameter equal to the factor that is used
**    to scale the time increment computed by Rocfrac. Default setting
**    is 1.0.
**
*DYNAMIC, SCALE FACTOR = 0.2
**
** Select the 10-node tetrahedral element
**
*ELEMENT,TYPE=V3D10
**
**
** ELASTIC
** Young's Modulus, Poisson's Ratio, Density, Expansion Coeffs
**
**
** HYPERELASTIC, ARRUDA-BOYCE or NEOHOOKINC
** Young's Modulus, Poisson's Ratio, Density, Expansion Coeffs
**
*ELASTIC, NLGEOM = NO
1
500e+09  0.29  7600.0  0.0

*BOUNDARY
2
1 0 0 0 0. 0. 0.
2 1 1 0 0. 0. 0.
*END
*MESHSOFT (Choices: TetMesh, Patran, Ansys)
Patran
*END
```

RocfloControl.txt

```
! Input file for shockpanel

! flow initialization ----------------------------------------------------

# INITFLOW
BLOCK       0   0        ! applies to block ... (0 0 = to all)
NDUMMY      2            ! no. of dummy cells
VELX        297.59       ! downstream velocity in x-direction [m/s]
VELY        0.           ! downstream velocity in y-direction [m/s]
VELZ        0.           ! downstream velocity in z-direction [m/s]
PRESS       1.5436E+05 ! downstream static pressure [Pa]
DENS        1.7307           ! downstream density [kg/m^3]
XSPLIT      -.04     ! x-coordinate at splitting location [m]]
DSVELX      0.           ! velocity in x-direction [m/s]
DSVELY      0.           ! velocity in y-direction [m/s]
DSVELZ      0.           ! velocity in z-direction [m/s]
DSPRESS     1.02E+05   ! static pressure [Pa]
DSDENS      1.29       ! density [kg/m^3]
#

! mapping of blocks to processors --------------------------------------------

# BLOCKMAP
NBLOCKS    0          ! no. of blocks per processor (0=automatic mapping)
#

! grid/solution format -------------------------------------------------------

# FORMATS
GRID       0        ! 0=ASCII, 1=binary, 2=HDF
SOLUTION   2        ! 0=ASCII, 1=binary, 2=HDF
#

! viscous/inviscid flow ------------------------------------------------------

# FLOWMODEL
BLOCK   0   0        ! applies to block ... (0 0 = to all)
MODEL      0         ! 0=inviscid (Euler), 1=viscous (Navier-Stokes)
MOVEGRID 1           ! 0 - static grid, 1 - moving grid
#

! grid motion scheme ---------------------------------------------------------

# GRIDMOTION
TYPE    2            ! 0=block-TFI, 1=block-WgLaplacian 2=global-WgLaplacian
                     ! 3=global-NuLaplacian 4=block-Elliptic 5=global-Elliptic
NITER   0            ! number Laplacian iterations (TYPE>0)
```

ShockPanel Batch Job

- Set up a batch job
- Example ShockPanel batch script:

```
# ShockPanel batch file
#
# Example is partitioned for 10 processors
#PBS -l nodes=2:ppn=5
#PBS -l walltime=10:00:00
# Inherit the submit shell environment
#PBS -V
#PBS -j oe

cd ${PBS_O_WORKDIR}
mpiexec rocstar
```

ShockPanel – Rocstar Output

```
Rocstar was built with gmake options: PREP=1 HDFHOME=/opt/HDF TURB=1 STATS=1 PREFIX=/IR/Software/Install/RocstarSandiaDistro_MPICH1
Rocstar source: /home/mtcampbe/work/RocstarDevelopment/RocstarSandiaDistro
Rocstar was built with Rocman3.
Rocstar version 3.0.0-0002
Rocstar last auto-built was at: $Date: 2009/11/04 15:15:15 $ GMT
```
```
ROCSTAR: CALL CouplingInitialize
================  Rocstar Control file ================
CouplingScheme: 'SolidFluidSPC'
InitialTime: 0.000000
MaximumTime: 1000000000000.000000
MaxWallTime: 31500000.000000
AutoRestart: Yes
MaxNumPredCorrCycles: 1
MaxNumTimeSteps: 2147483647
CurrentTimeStep: 1.000000e-08
OutputIntervalTime: 5.000000e-05
ZoomFactor: 0.000000
TolerTract: 0.001000
TolerVelo: 0.001000
TolerMass: 0.001000
TolerDisp: 0.001000
ProfileDir: Rocman/Profiles/
ProfileFile: Rocman/Profiles/RocstarProfile00.txt
====================================================
==========  Rocman Parameter file read ==========
Rocman: verbosity level is 0
Rocman: The order of interpolation is 2
Rocman: Traction mode is 1 (1 for no sheer, 2 for with sheer)
Rocman: ambient pressure is 0.000000
Rocman: Solid density (Rhoc) is 8970.000000 kg/m^3
Rocman: Pressure is 6800000.000000 Pa
Rocman: Burning rate is 0.010000 m/s
Rocman: RFC_verb: 1
Rocman: Order of quadrature rule (RFC_order): 2
Rocman: Max iterations for iterative solver: 100
Rocman: tolerance for iterative solver (RFC_tolerance): 0.000001
Rocman: Using marker-particle method for surface propagation.
Rocman: Number of smoothing iterations in Rocprop: 2
Rocman: Feature-angle threshold in Rocprop: 35.000000
Rocman: Async Input: F
Rocman: Async Output: F
====================================================
```

ShockPanel – Rocstar Output

```
ROCSTAR: Starting with step 1, at time 0
ROCSTAR:
ROCSTAR: ================================================================
ROCSTAR: System Time Step : 1    PC(1)
ROCSTAR: ================================================================
ROCSTAR:
ROCSTAR: CurrentTime, CurrentTimeStep, ZoomFactor: 0 1e-08 0
ROCSTAR:
ROCCOM: CALL(0) BLAS.sub
ROCCOM: DONE(0)
ROCCOM: CALL(0) BLAS.div_scalar
ROCCOM: DONE(0)
ROCCOM: CALL(0) BLAS.copy
ROCCOM: DONE(0)
ROCCOM: CALL(0) BLAS.copy
ROCCOM: DONE(0)
ROCCOM: CALL(0) RFC.least_squares_transfer
RFACE: Conservatively transferring  from FluidBufNG.ts to SolidBuf1.ts
RFACE: Before transfer
RFACE:   minimum:  102000
RFACE:   maximum:  102000
RFACE:   integral: 103.0199936
RFACE: Transfer to faces done in 0.001802206039 seconds.
RFACE: After transfer
RFACE:   minimum:  102000
RFACE:   maximum:  102000
RFACE:   integral: 103.0200165
ROCCOM: DONE(0)
ROCCOM: CALL(0) Rocfrac.update_solution
 RFRAC:   Time Step          Dt
 RFRAC: ------------------------
    RFRAC:       1  0.1000E-07  0.1000E-07  0.1000E-07  0.1000E-07
 RFRAC: END SOLID STEP
ROCCOM: DONE(0)
ROCCOM: CALL(0) BLAS.copy
ROCCOM: DONE(0)
ROCCOM: CALL(0) BLAS.add
ROCCOM: DONE(0)
ROCCOM: CALL(0) RFC.interpolate
RFACE:  Interpolating  from SolidBuf1.u to FluidBufNG.total_disp
RFACE: Before transfer
RFACE:   minimum:  -6.237112979e-11 -6.336146865e-11 -7.508785913e-17
RFACE:   maximum:   6.669828189e-11 9.430351133e-17 7.194666642e-17
RFACE:   integral: 9.599783208e-17 -3.333910192e-16 3.411311716e-23
RFACE: Interpolation done in 0.0001940727234 seconds.
RFACE: Interpolation done in 0.000953912735 seconds.
RFACE: After transfer
RFACE:   minimum:  -4.919218286e-11 -5.875363952e-11 -2.921112604e-24
RFACE:   maximum:   4.841200526e-11 2.489394723e-26 5.105688749e-24
RFACE:   integral: -2.779746977e-16 -2.41690563e-16 -1.062361709e-29
```

Using gnuplot With Probe Files


```
gnuplot> plot 'shockpanel.prb_0001' using 1:6 t 'Probe 1' w l, 'shockpanel.prb_0002'
using 1:6 t 'Probe 2 w l, 'shockpanel.prb_0003' using 1:6 t 'Probe 3' w l
```
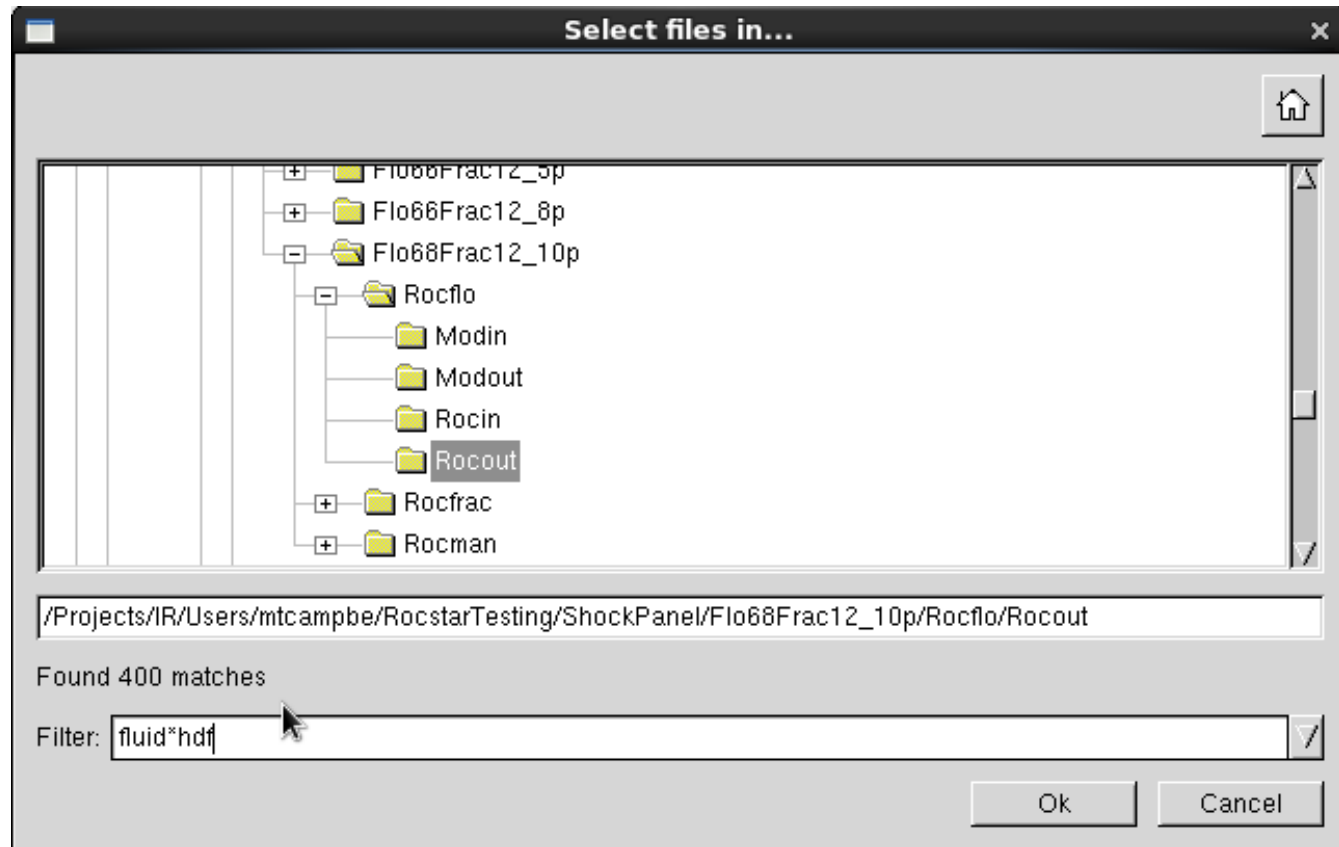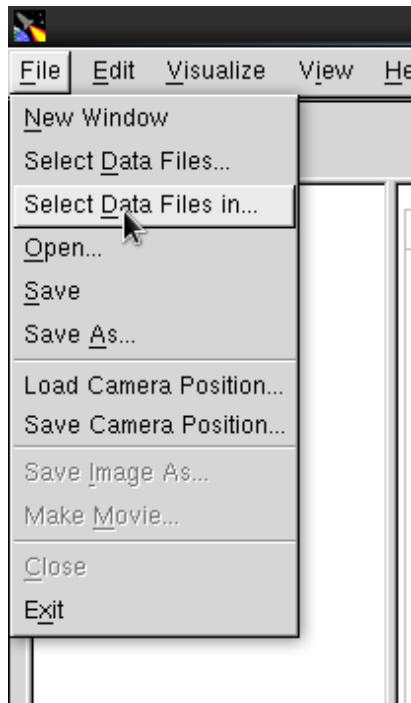
Pre-run Visualization Files

- For the Shockpanel, pre-run visualization files are available for several times for both Rocflo and Rocfrac

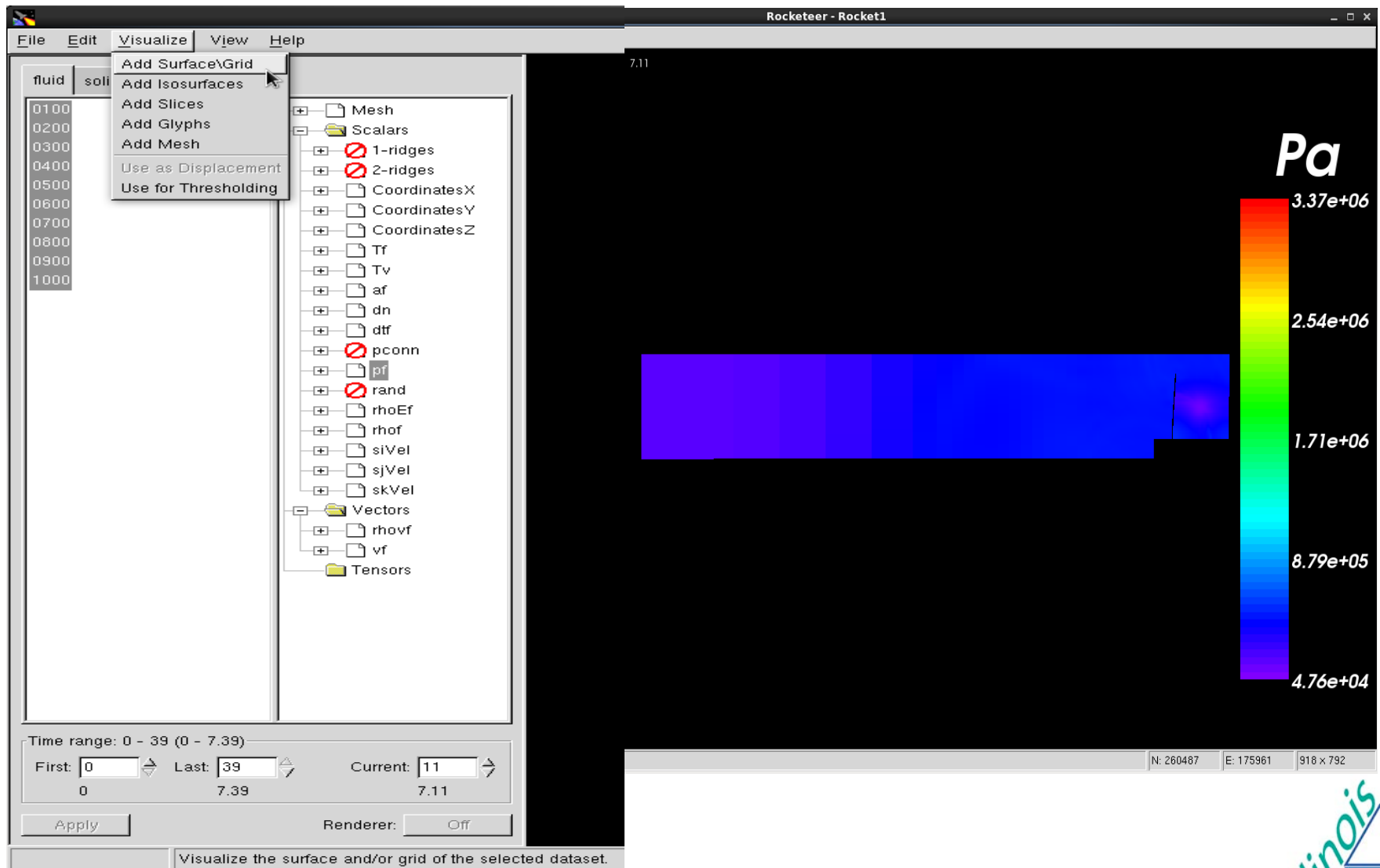- Load these into Rocketeer from the VizData directory

Fluid Domain Visualization

- Point Rocketeer at the fluid domain output repository: ${RUNDIR}/Rocflo/Rocout

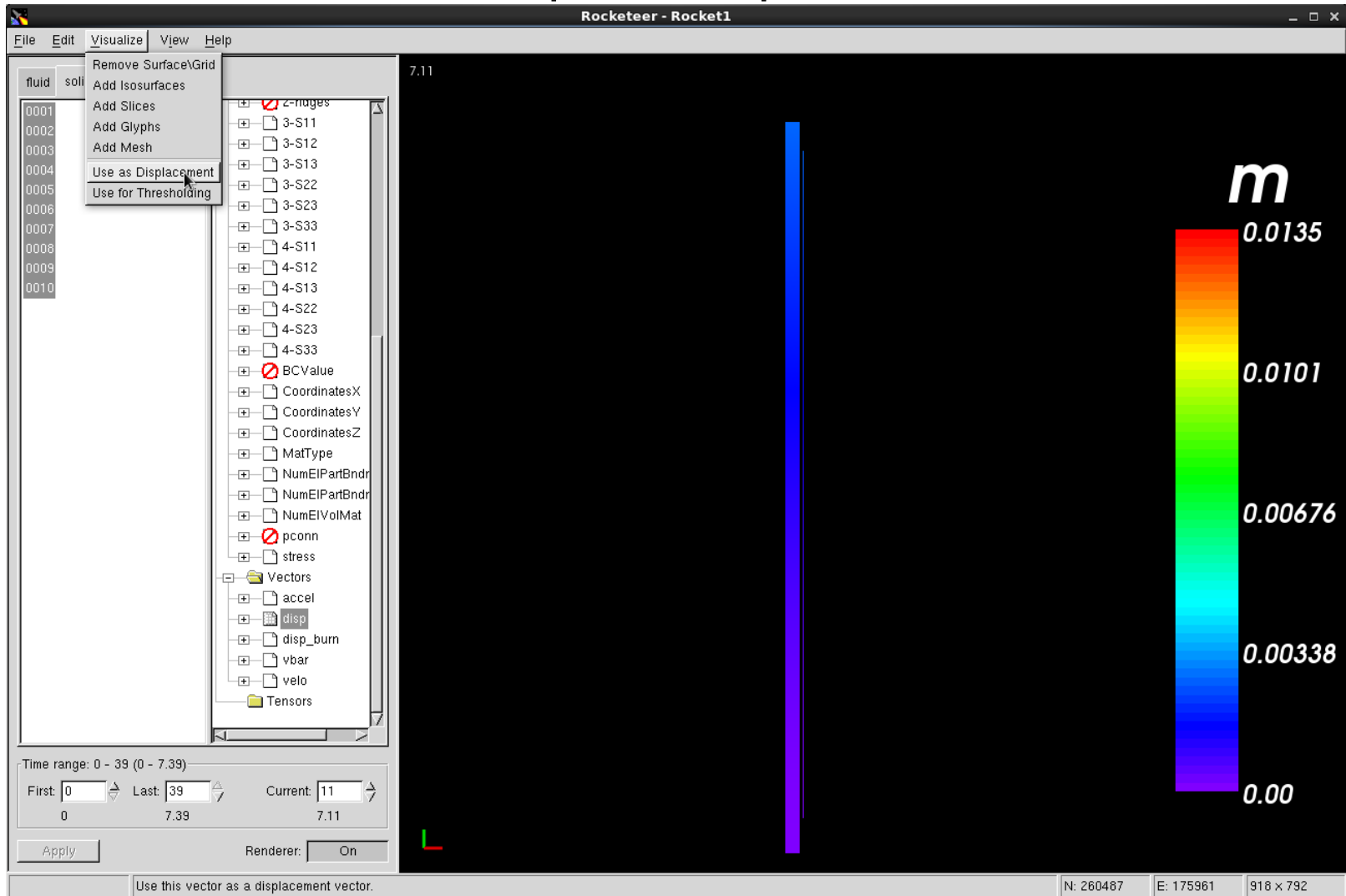See cover sheet for distribution restrictions.

Fluid Domain Visualization
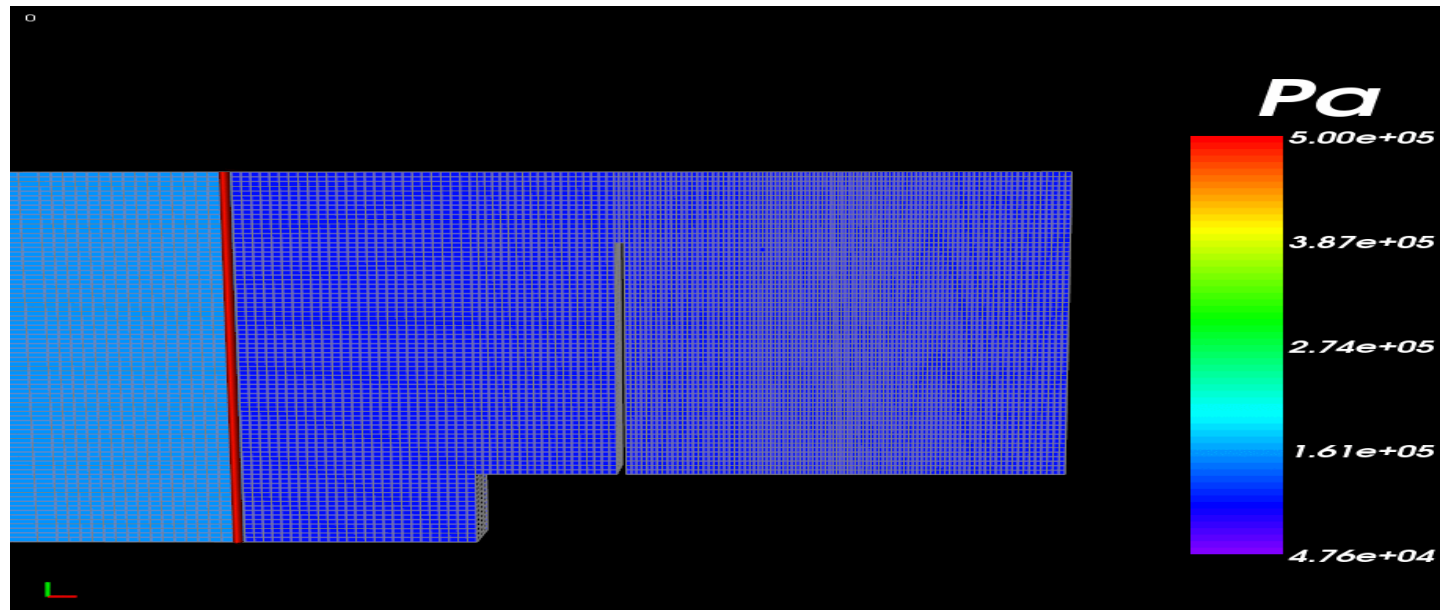
- Visualize the fluid pressure field

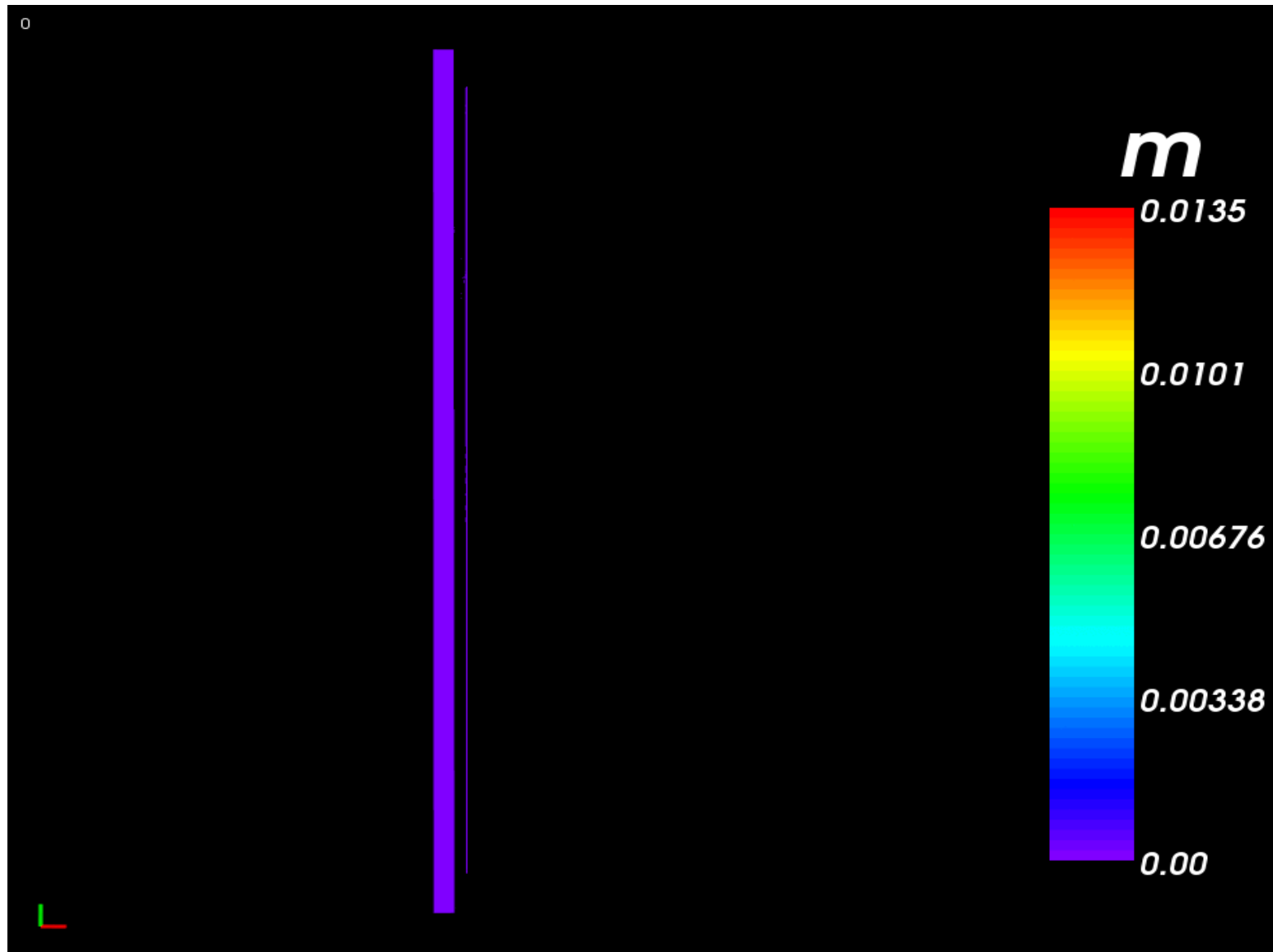# Structures Domain Visualization

- Visualize the panel displacement

Simulation Results (Fluid)

Simulation Results (Structures)

Simulation Results Coupled

Panel tip Displacement