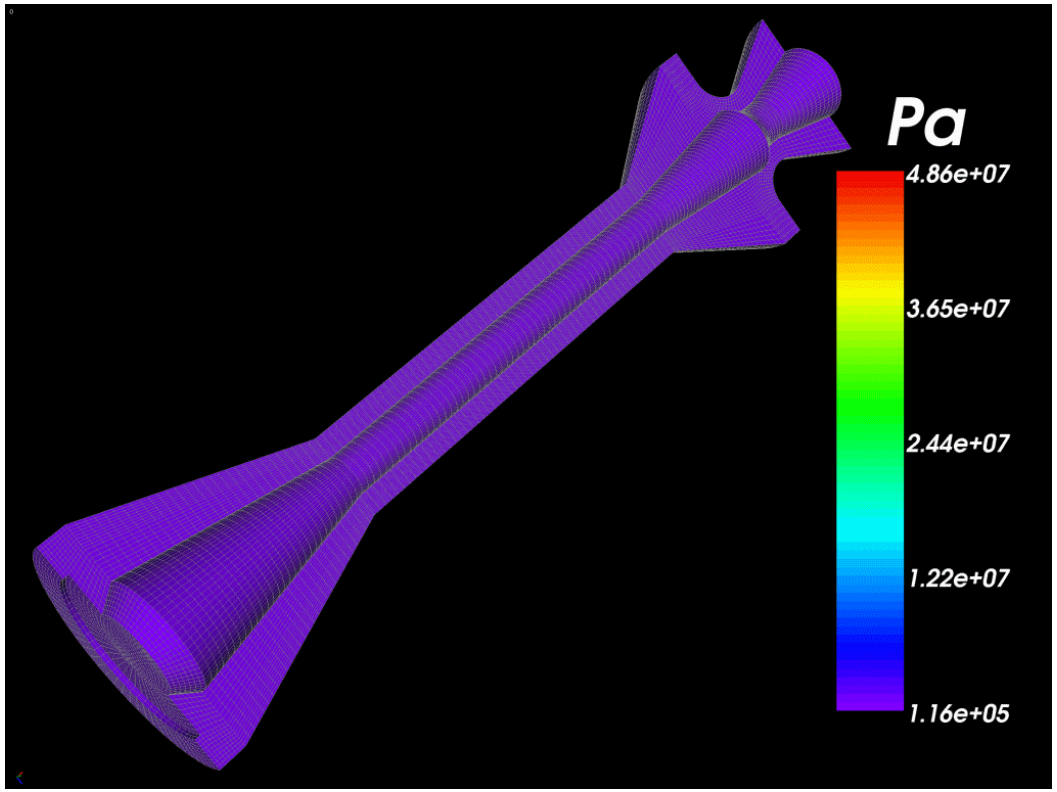
Section 15:
Use Case 2

Attitude Control Motor - Rocflu

Problem Description

- Small (2 inch) Attitude Control Motor (ACM)
- Regressing burning surface
- Fluid-combustion coupling
- Rocflu model – unstructured tetrahedral grid
- Goal: assemble and run moving-boundary fluid-combustion coupled run with Rocflo



File Checklist

- Rocstar
  - RocstarControl.txt
- Rocman
  - RocmanControl.txt
- RocburnAPN
  - RocburnAPNControl.txt
- Rocflu
  - RocfluControl.txt
  - ACM.inp
  - ACM.bc
  - ACM.cgi
  - ACM-COBALT.bc
  - ACM-COBALT.inp

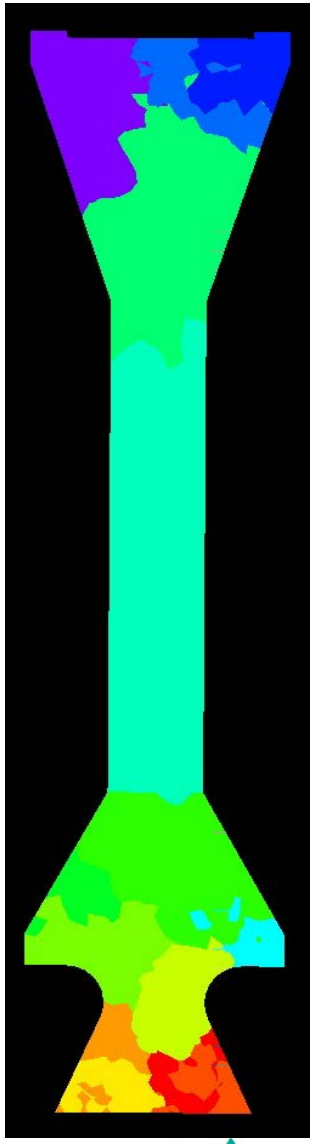
Preparing *Rocflu* Input

Outline

- Produce CAD model
  - Pro/Engineer exports IGES format
  - Can make simple geometries in Gridgen
- Generate meshes, set BC flags
  - Gridgen – unstructured mixed meshes for *Rocflu*
  - Tets, hexes, prisms, pyramids

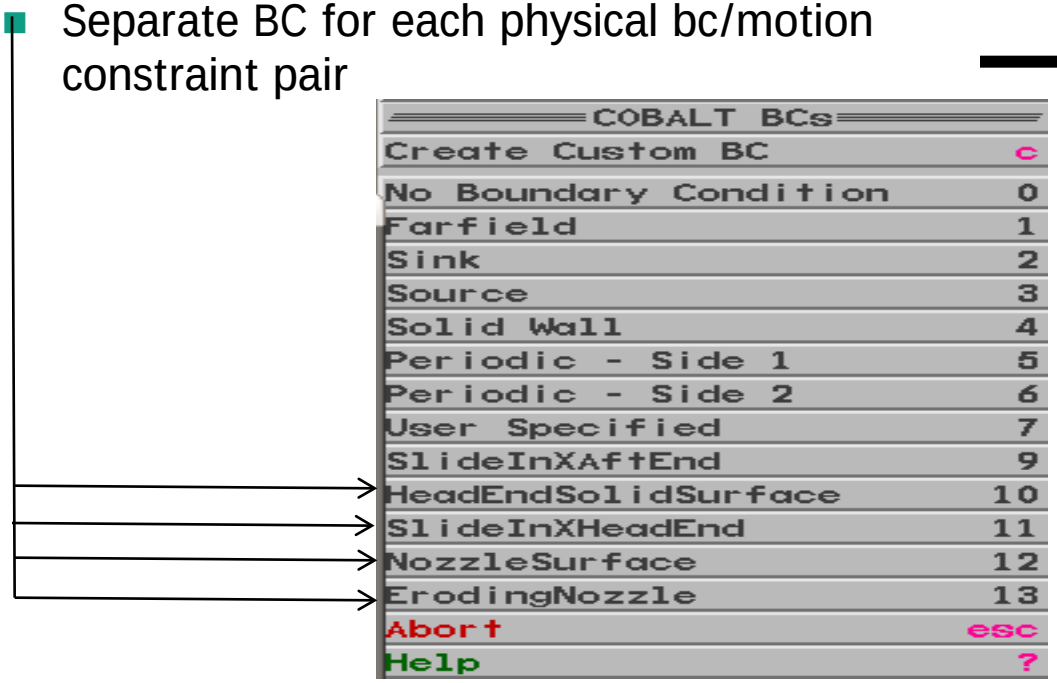
- Set up NDA with grids and input files
  - Choose a “casename”; ACM for this example
  - Grid, boundary condition map file
  - Basic input, boundary conditions, control files
- Preprocess and partition
  - Use *Rocprep* on NDA
- Check input again!

Cutaway of Partitioned Model



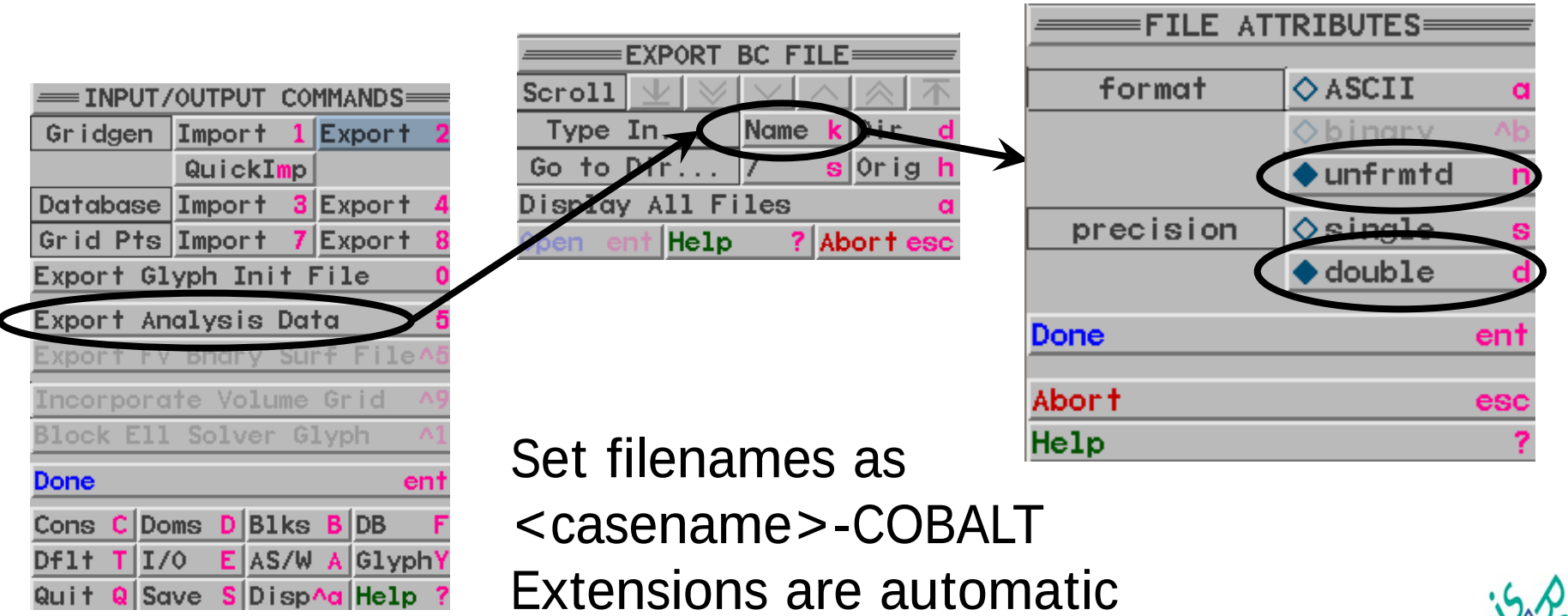
Rocflu Boundary Conditions

- Make sure Analysis Software is set to COBALT
  - Can't fix after setting BCs!
- Make sure all external surfaces have a BC
- BC labels not that important for COBALT – will map to patches through the <casename>.cgi file
- Using all custom BC's is advisable for bookkeeping purposes
- Separate BC for each physical bc/motion constraint pair



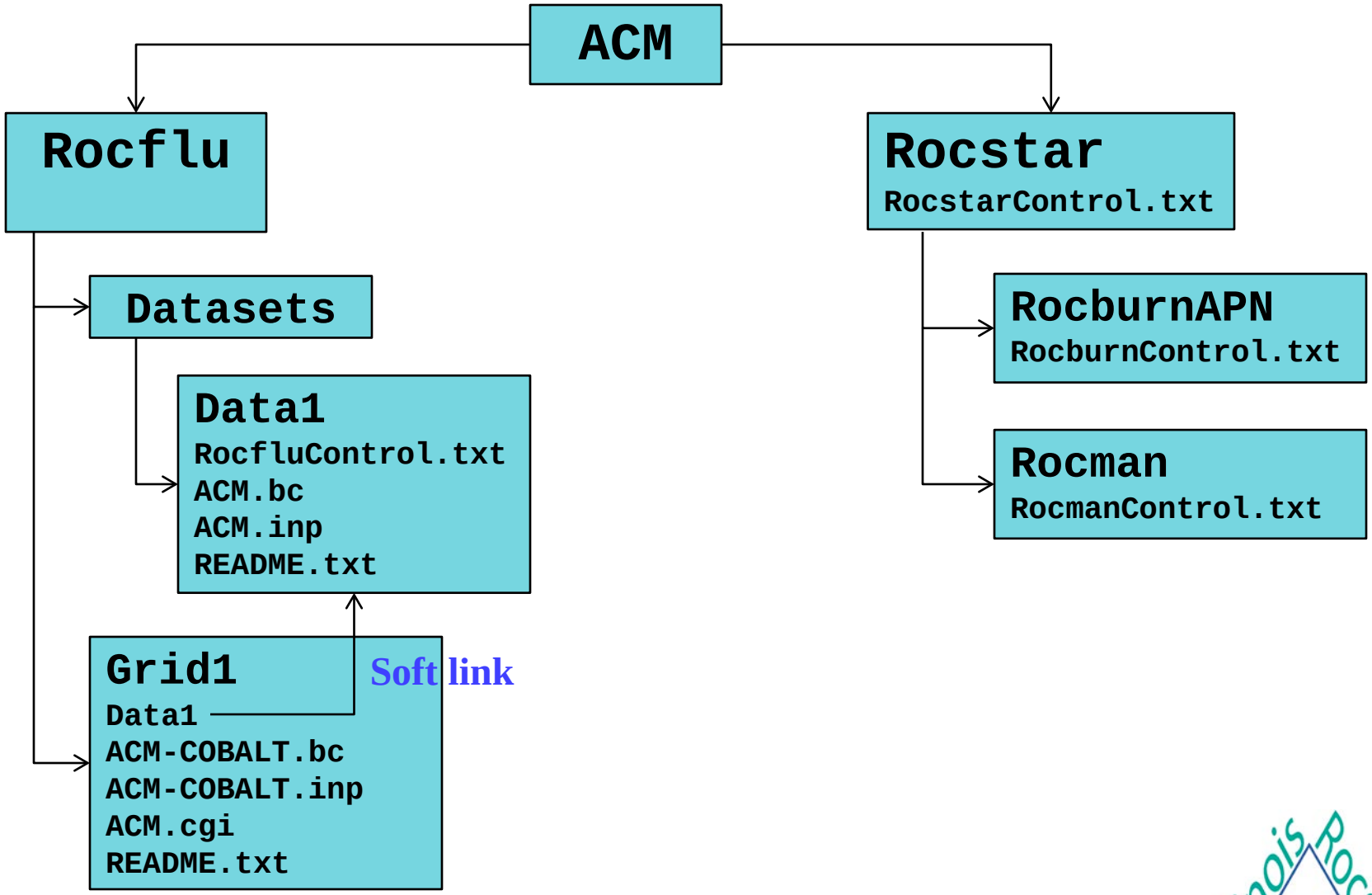
Export *Rocflu* Grid

- Export files:
  - COBALT mesh: <casename>-COBALT.inp – example: ACM-COBALT.inp
  - BC file <casename>-COBALT.bc – example: ACM-COBALT.bc
- If working on Windows, run dos2unix on them once on Linux
  - Fortran doesn't like cross-platform line endings



Set filenames as <casename>-COBALT
Extensions are automatic

Examine NDA



Run *Rocprep* on NDA

```
rocprep –A –u 1 1 -b –d /IR/NDAs/ACM –t ./ACM16 –n 16 [–p ~/build/bin/]
```

Extract from NDA and preprocess to make full Rocstar dataset

Process Data1 and Grid1 for Rocflu

Extract Rocburn

Root directory for NDA problem to be processed

Target dir for dataset

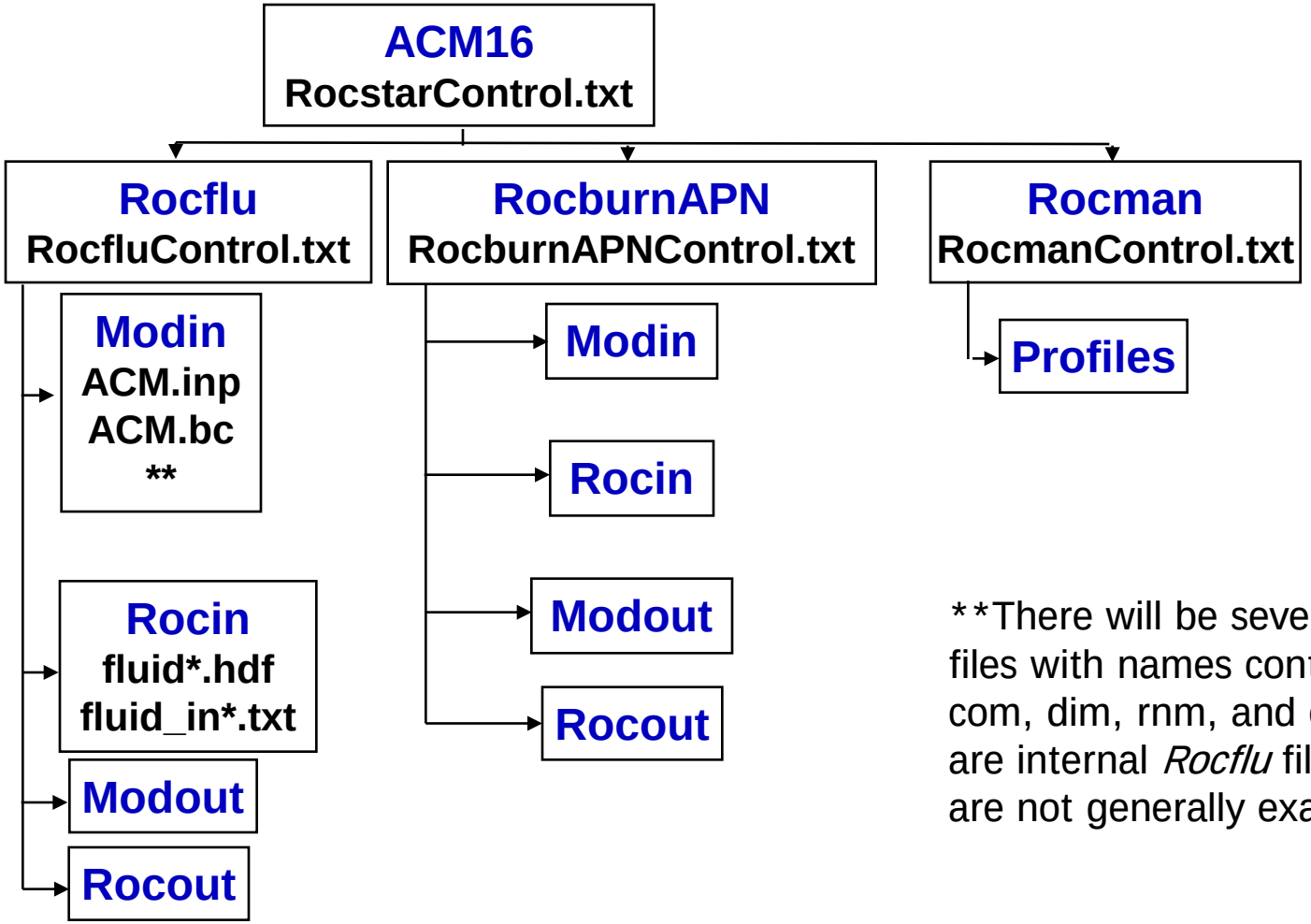
Number of partitions to make

Optional path to pre-processing tools

Execute *Rocprep* with no arguments for help screen:

```
[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



**There will be several sets of files with names containing com, dim, rnm, and cmp that are internal *Rocflu* files that are not generally examined

ACM.bc file

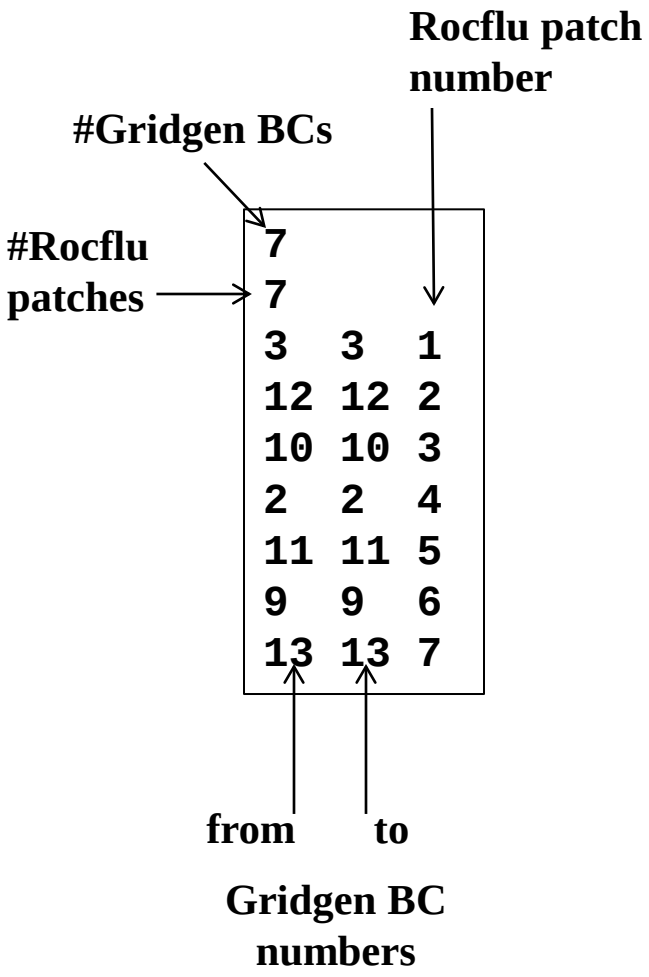
```
# BC_INJECT
PATCH           1 1
NAME            InjectionWall
MFRATE          5.7429
TEMP            2855.0
RFVFU           0.0
RFVFV           0.0
RFVFW           0.0
COUPLED         1
BFLAG           1
MOVEDIR         7
#

# BC_SLIPW
PATCH   2 2
NAME    AftFlatWall
COUPLED 2
MOVEDIR 0
#

# BC_SLIPW
PATCH   3 3
NAME    HeadEndSurface
COUPLED 2
MOVEDIR 0
#

# BC_OUTFLOW
PATCH   4 4
NAME            NozzleOutlet
TYPE    0
COUPLED 2
MVPATCH 0
SMGRID  0
CORR    0
MOVEDIR 0
#
```

```
# BC_SLIPW
PATCH   5 5
NAME    HeadEndRing
COUPLED 2
MOVEDIR 1
#

# BC_SLIPW
PATCH   6 6
NAME    AftEndRing
COUPLED 2
MOVEDIR 1
#

# BC_SLIPW
PATCH           7 7
NAME            NozzleSurface
COUPLED         2
MOVEDIR         0
#

# END
```

- Rocflu BCs are defined by “patch”
- Patches correspond to Gridgen BC definitions on specific sections of the model

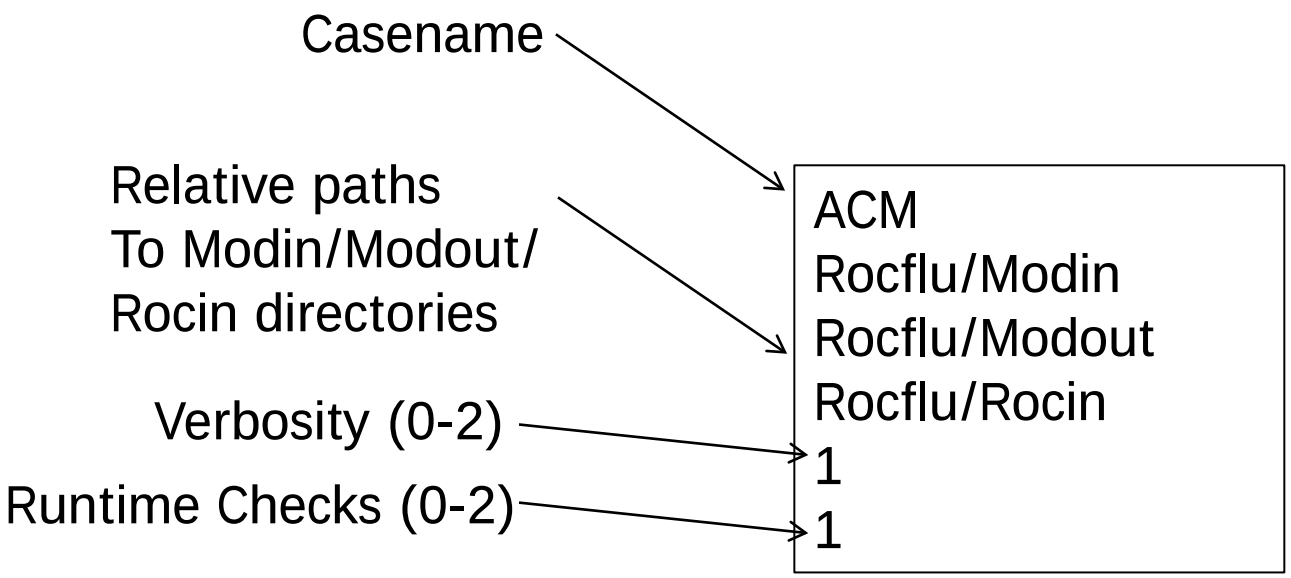
ACM.cgi

- File maps Gridgen BC numbers to Rocflu .bc BC definitions
- Same function as Rocflo <casename>.bcmp file




```
################################################
  Boundary Condition Specification File for:
  Gridgen grid exported : Wed Feb 27 14:06:19 2008
################################################
11
Gridgen bc region: 11
SlideInXHeadEnd
Methods: User Created BC
User data supplied here - see COBALT doc!
################################################
10
Gridgen bc region: 10
HeadEndSolidSurface
Methods: User Created BC
User data supplied here - see COBALT doc!
################################################

...
2
Gridgen bc region: 2
Sink
Methods: Static Pressure, Mass Flow, Corrected Mass
Flow, Bleed Plenum Pressure, Area Ratio
Value      Porosity
User data supplied here - see COBALT doc!
No
################################################
```

Examine RocfluControl.txt



- Note: Casename is critical. It is used for *Rocprep* and *Rocflu* to know what other files are called. Make sure it is used consistently.
- Normally the other lines will always be the same

Physics Module Files: *Rocflu* (I)

labscale.inp

```
# NUMERICS
CFL             3.0         ! CFL number
DISCR           3           ! Type of space discretization (1 - Roe, 2 - MAPS)
ORDER           2           ! Order of accuracy (1 - first, 2 - second)
#
# TIMESTEP
FLOWTYPE   1                ! 0 - steady flow, 1 - unsteady flow
PRNTIME      0.000001       ! Offset between iterations to print convergence
DTMINLIMIT 5.0E-09
#
# REFERENCE
GAMMA    1.2444
CP    1905.0
#
# PROBE
NUMBER 2
0.001 0.0 0.0
0.0495735 0.0 0.0
#
WRITIME 0.00001
OPENCLOSE 1
#
#
```

Must be 2 while preprocessing for moving geometries

Physics Module Files: *Rocflu* (II)

```
# TRANSFORM
FLAG    1
SCALE_X    0.0254
SCALE_Y    0.0254
SCALE_Z    0.0254
#
# ROCKET  ! Analytic Description of Rocket Case
CASERAD    0.446532
COORDL     1.0
ELLIPSL    0.239268
HEADEND    0.0
AFTEND    -7.0
#
# TIMEZOOMING ! Planar limits for TimeZooming
MAXPLANE    -0.022
MINPLANE    -4.261
AXIS         1.0
#
```

Examine *Rocstar* Control Files for ACM

RocstarControl.txt

```
CouplingScheme    =  FluidBurnAlone
FluidModule       =  "Rocflu"
BurnModule        =  "RocburnAPN"
OutputModule      =  "Rocout"

MaximumTime       =  0.016
AutoRestart       =  T
CurrentTimeStep =     1.0E-06
OutputIntervalTime = 1.0E-04
ZoomFactor = 1.0

MaxWallTime = 43000

ProfileDir = "Rocman/Profiles"
```

Must be 1.0 to allow boundary regression

RocmanControl.txt

```
Verbose = 0

InterpolationOrder = 1

TractionMode = 1
P_ambient =  1.0E+05

Rhoc = 1703.0
Pressure =  6.8d6
BurnRate =  0.01

RFC_verb = 1
RFC_order = 2
RFC_iteration = 100
RFC_tolerance = 1.e-6

Face-offsetting = T
```

Important

RocburnAPN for ACM

Careful with units when setting

```
0.77        a in rb=a*P^n,  rb in cm/sec and P in atm, a_p (cm/sec)
0.62        n in rb=a*P^n,  rb in cm/sec and P in atm, n_p
1           Maximum_number_of_spatial_nodes,_nxmax
2916.0      adiabatic flame temperature, Tf_adiabatic (K)
298.00      initial temperature        , To_read      (K)
Rocburn_2D_Output/Rocburn_APN
```

- Burn rate is one of the only places in *Rocstar* that is not strictly SI units (meters)

Run ACM problem

```
#!/bin/csh -f

#SBATCH --nodes=2                    # Number of nodes
#SBATCH --time=10:00:00               # Wall clock time
#SBATCH --account=FY127542              # WC ID
#SBATCH --job-name=ACMTest              # Name of job
set nodes=$SLURM_JOB_NUM_NODES
set cores=8
cd /gscratch2/aluketa/ACMTest
srun -n 16 /projects/Rocstar/Rocstar/bin/rocstar
```

- Need to set up a batch-system specific job script for your system.
- Example below for our system for ACM

```
#!/bin/tcsh
#
# Requst 2 nodes, 8 procs each (i.e. 16 procs)
#PBS -l nodes=2:ppn=8
# For this long:
#PBS -l walltime=10:00:00
#
# Send me a mail when my job starts and ends
#PBS -m be
# To this address
#PBS -M mdbrandy@illinoisrocstar.com
# with this jobname
#PBS -N ACM
# Join the stdout and stderr into the output file
#PBS -j oe

# cd to the directory from which the job was submitted
cd ${PBS_O_WORKDIR}
mpirun -np 16 ./rocstar
```

Monitor Standard out/err

- Large amounts of information is written to standard out/err

Monitor Probe File(s)

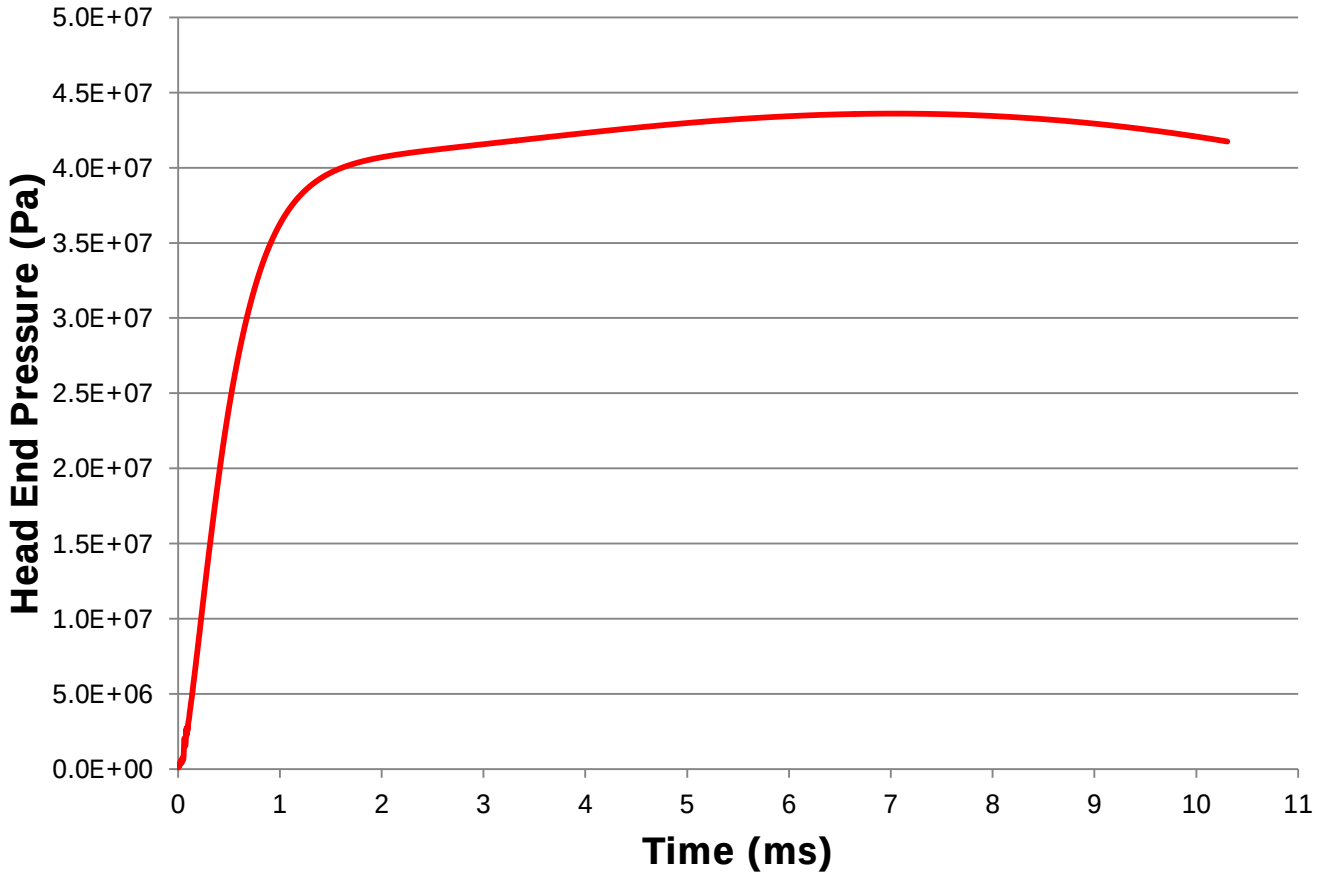
- Depending upon your setup, you can "watch" the probe files to monitor progress
- `cd Rocflu/Modout; tail –f ACM.prb_0001`

```
# probe data (iteration/time, density, u, v, w, p, T)
# region    14, icell     3, jcell     9, kcell     9
# x=  0.14856E-01, y=  0.21521E-07, z= -0.14945E-07
 2.7035969E-07  1.16000E+00 -1.06085E-14 -4.21347E-14  2.29825E-14  1.00000E+05  2.45467E+02
 5.0000000E-06  1.18107E+00 -4.35562E-02 -1.10686E-03 -1.55134E-03  1.02232E+05  2.46470E+02
 1.0000000E-05  2.60138E+00 -2.43497E+01 -2.06613E-03 -6.09490E-03  2.73136E+05  2.98969E+02
 1.5000000E-05  2.21299E+00 -2.76699E+01 -9.98801E-03  3.66079E-02  2.24079E+05  2.88318E+02
 2.0000000E-05  3.72242E+00 -7.31183E+01  8.72279E-03 -2.65008E-02  4.25827E+05  3.25730E+02
 2.5000000E-05  4.24793E+00 -1.10089E+02  1.99342E-02  9.96979E-03  5.02469E+05  3.36808E+02
 3.0000000E-05  4.82351E+00 -1.38443E+02 -3.53893E-02 -7.66165E-02  5.87183E+05  3.46625E+02
 3.5000000E-05  3.51547E+00 -1.72720E+02  1.88846E-02  4.85104E-02  3.98075E+05  3.22427E+02
 4.0000000E-05  4.88654E+00 -1.98719E+02 -9.84630E-03 -2.71287E-02  5.96106E+05  3.47354E+02
 4.5000000E-05  5.91230E+00 -1.71383E+02 -1.23496E-02 -4.90376E-02  7.56641E+05  3.64404E+02
 5.0000000E-05  4.86712E+00 -1.91427E+02  2.05179E-03  5.82279E-02  5.95716E+05  3.48512E+02
 5.5000000E-05  6.42790E+00 -1.81320E+02  9.75009E-03 -2.17876E-02  8.41403E+05  3.72722E+02
 6.0000000E-05  1.19800E+01 -1.42908E+02 -4.73421E-02 -2.96886E-02  1.83861E+06  4.37002E+02
 6.5000000E-05  1.30104E+01 -1.60689E+02 -2.81673E-02  9.27011E-03  2.05774E+06  4.50351E+02
 7.0000000E-05  9.95572E+00 -1.67150E+02  4.40584E-03  1.54315E-02  1.52269E+06  4.35500E+02
 7.5000000E-05  1.05171E+01 -1.55261E+02 -5.44063E-02 -1.11832E-04  1.71412E+06  4.64082E+02
 8.0000000E-05  1.45618E+01 -1.37359E+02 -1.81264E-02 -2.33013E-02  2.67457E+06  5.22986E+02
```

- The location of this probe is defined in ACM.inp

```
# PROBE
NUMBER 2
0 0.015 0.0 0.0
0 0.0495735 0.0 0.0
#
```

Head End Pressure Probe



Visualize HDF Output

- Can use Rocketeer to visualize output
- Can also translate to Tecplot format
- Need to learn to read output file naming
- `cd Rocflu/Rocout; ls`
- Once a checkpoint has occurred, there will be one HDF file per processor per checkpoint
- Example:
  - fluid_06.100000_0000.hdf: processor 0, 0.10ms time

Means 0.10E06 nanoseconds,
Or 0.10 ms, or 0.0001 seconds

- `fluid_XX.XXXXX_XXX.hdf` are 3-D volume grid files
- `ifluid_Y_XX.XXXXX_XXXX.hdf` are surface grid files
  - Y: ni=non-interacting, b=burning

Pre-run Visualization Files

- For Rocflu ACM, pre-run visualization files are available for 0ms, 5 ms, 10 ms, 14 ms
- Load these into Rocketeer from the VizData directory