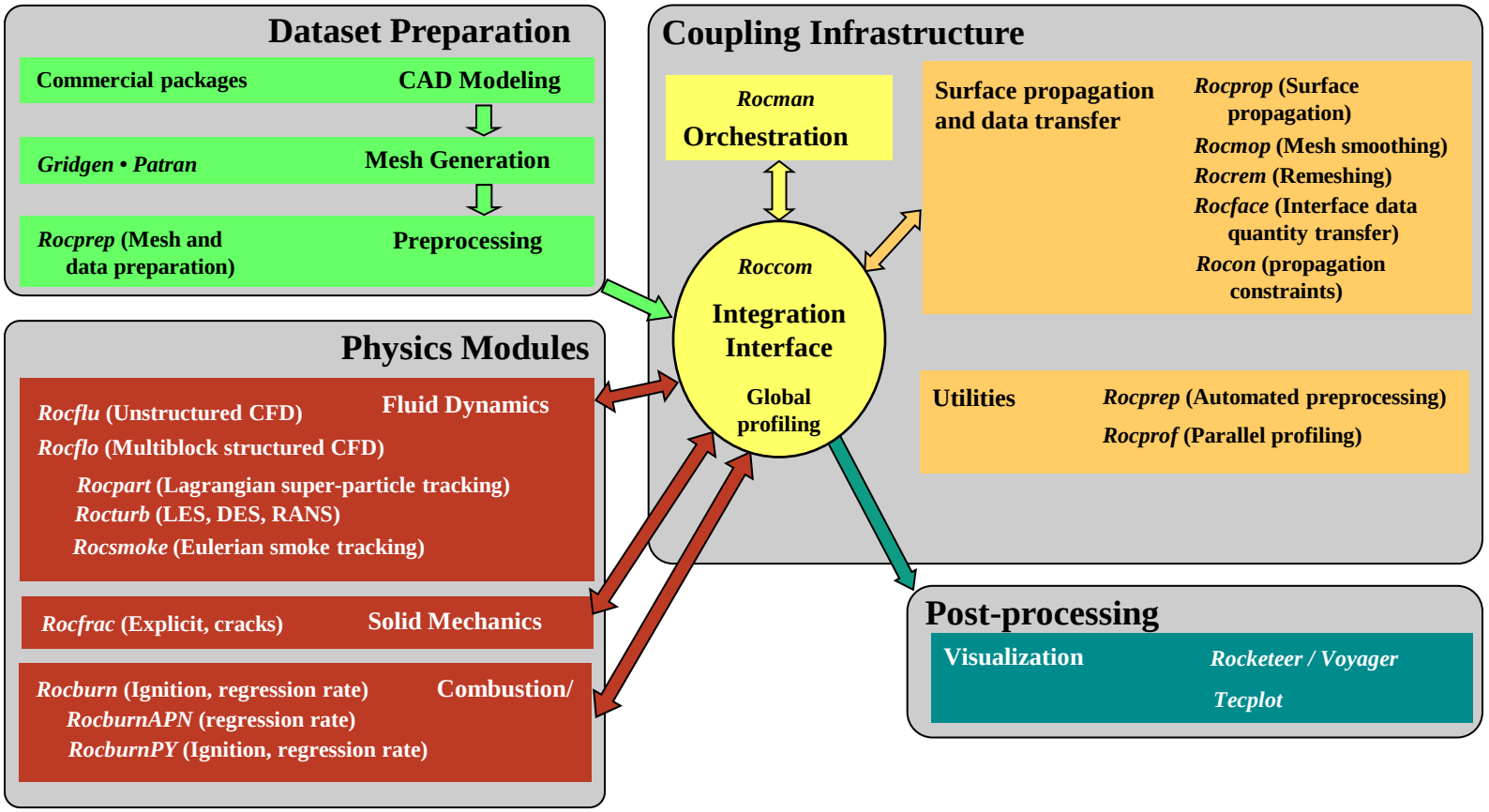
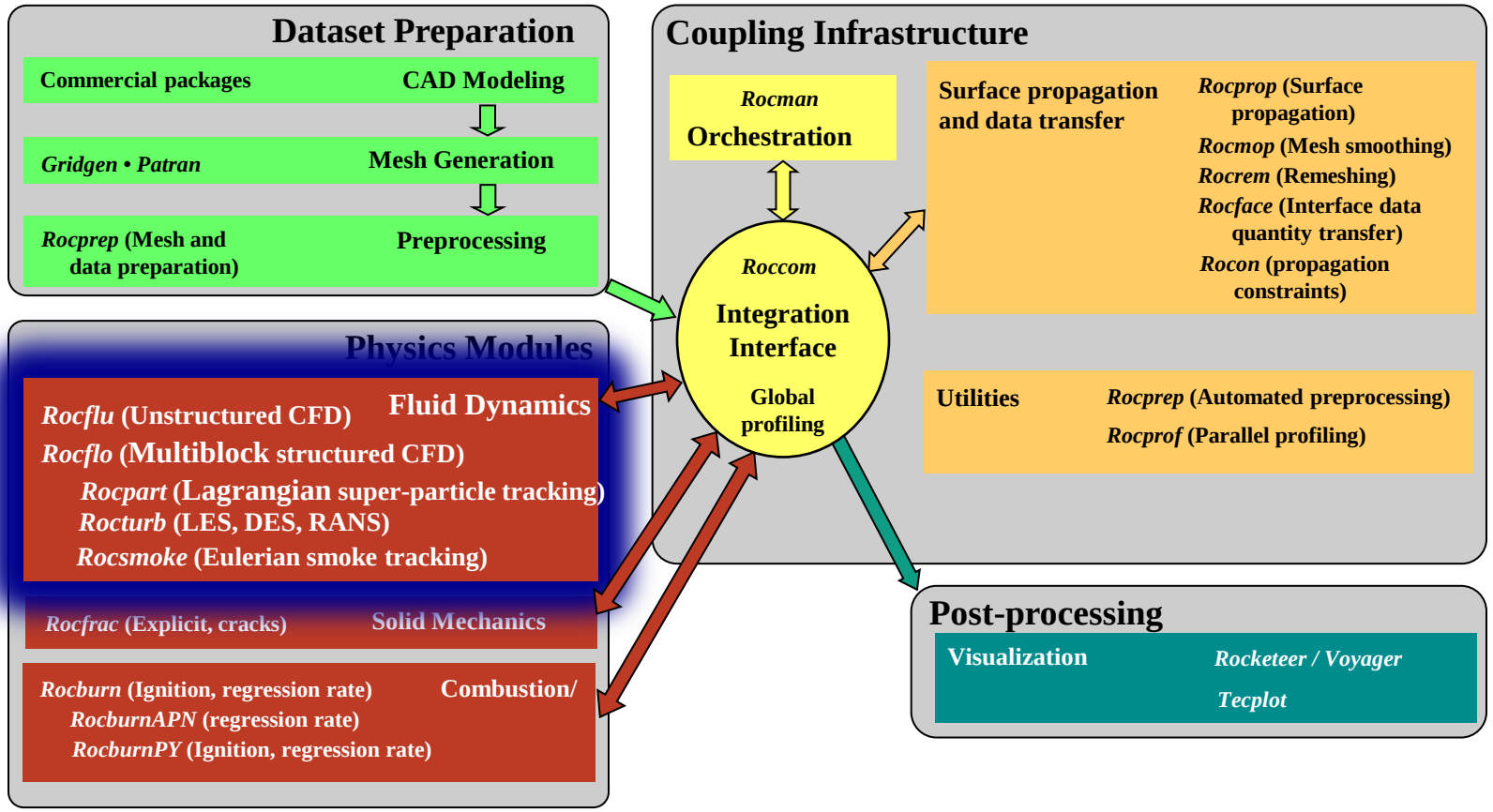
Section 7
Physics Modules

Rocstar Simulation Suite Architecture

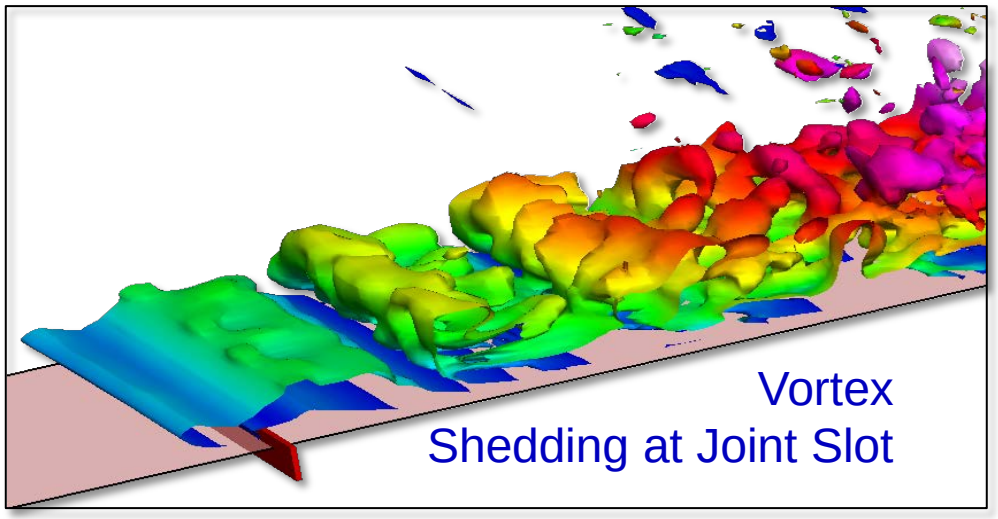


Rocstar Simulation Suite Architecture



Fluid Dynamics: *Rocflo*

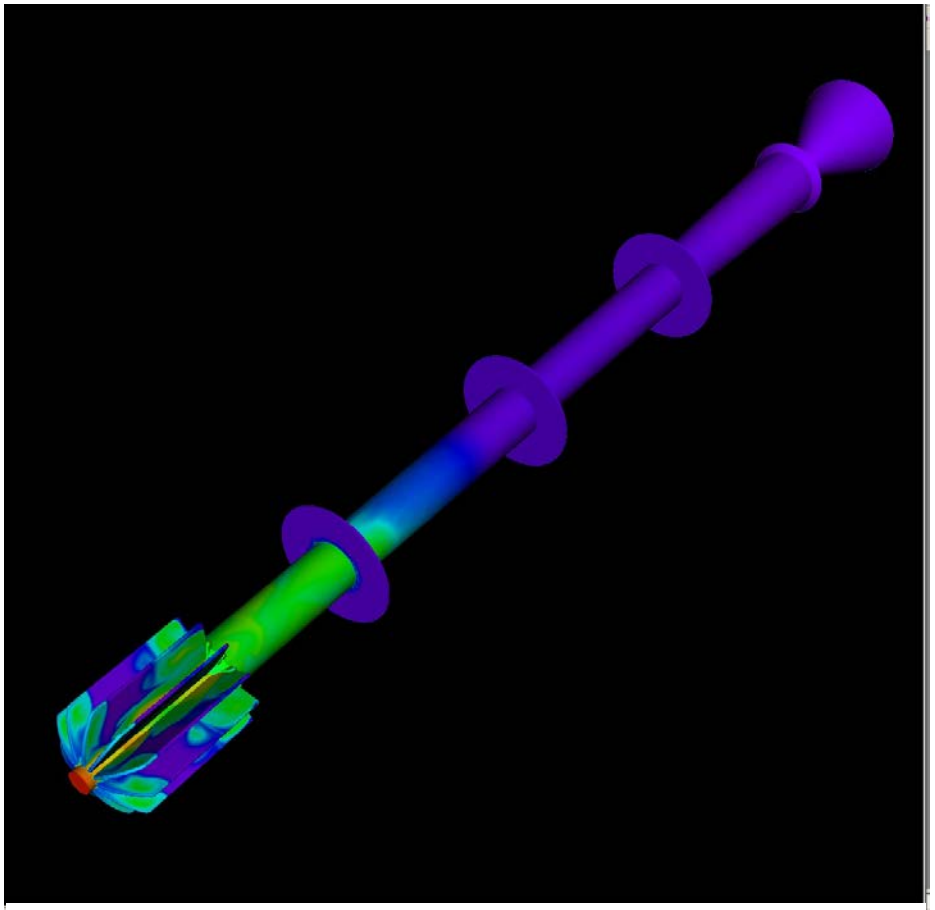
- Governing equations
  - Unsteady, compressible, Navier-Stokes or Euler
- Numerical formulation
  - Finite volume
  - Explicit Runge-Kutta
  - Arbitrary Lagrangian-Eulerian (ALE) method on moving meshes
  - 2nd order central scheme
  - Roe upwind scheme
- Code characteristics
  - Structured, multi-block mesh
  - Plug-in modules for turbulence, particles, smoke, radiation



Vortex Shedding at Joint Slot

Unstructured Mesh Fluids: *Rocflu*

- Mesh
  - Mixed tetrahedra, prisms, pyramids, hexahedra
- Method
  - Explicit, finite-volume, ALE
  - First or second order
  - Higher order WENO scheme
- Models
  - Lagrangian particles/super-particles
  - Eulerian smoke
  - Built-in propagation constraints
  - Time-zooming



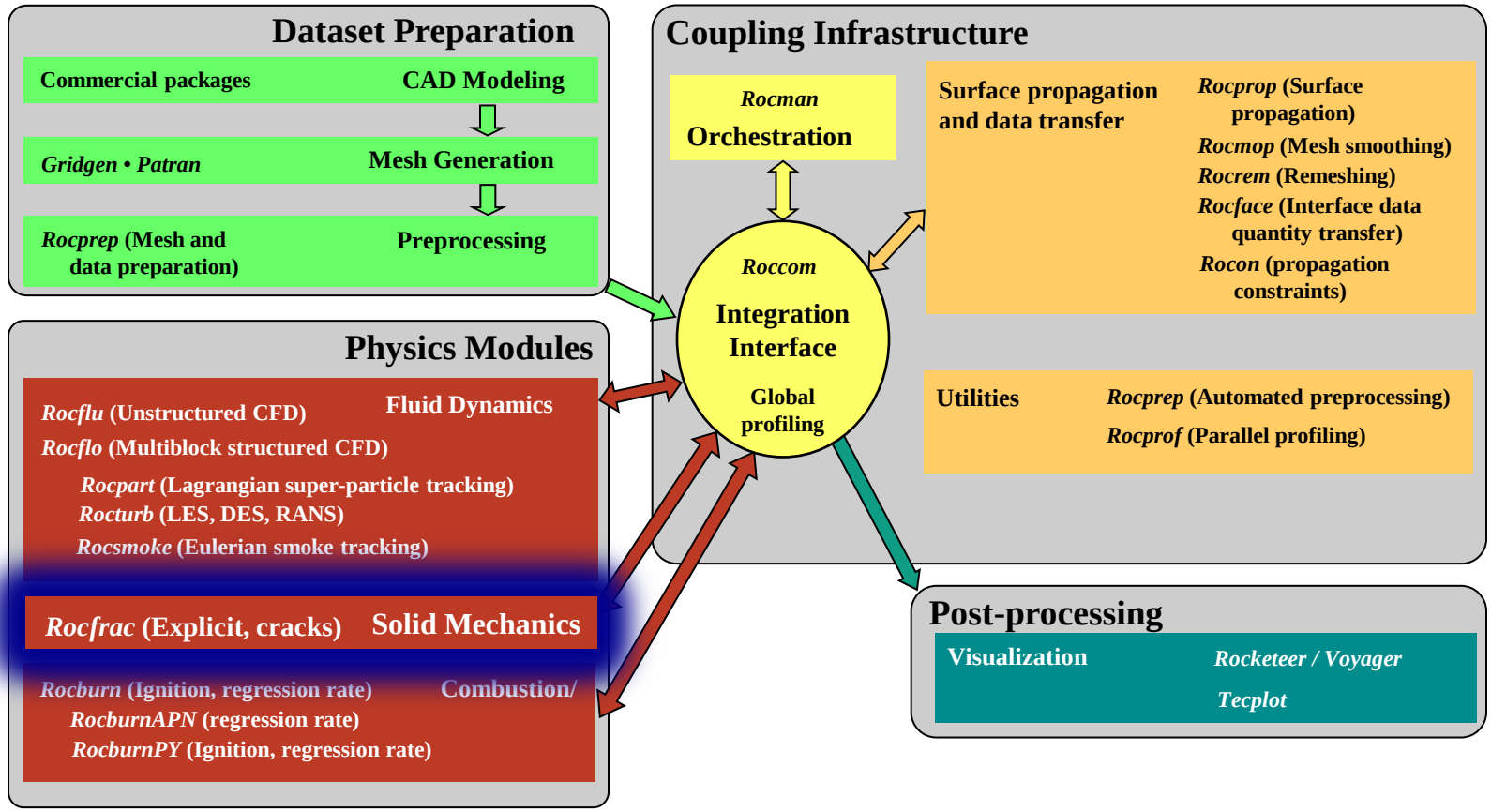
Gas Temperature in Igniting RSRM

Files Required for Fluid Simulations

- Both *Rocflo* and *Rocflu* require the same files, but have differences in format and naming

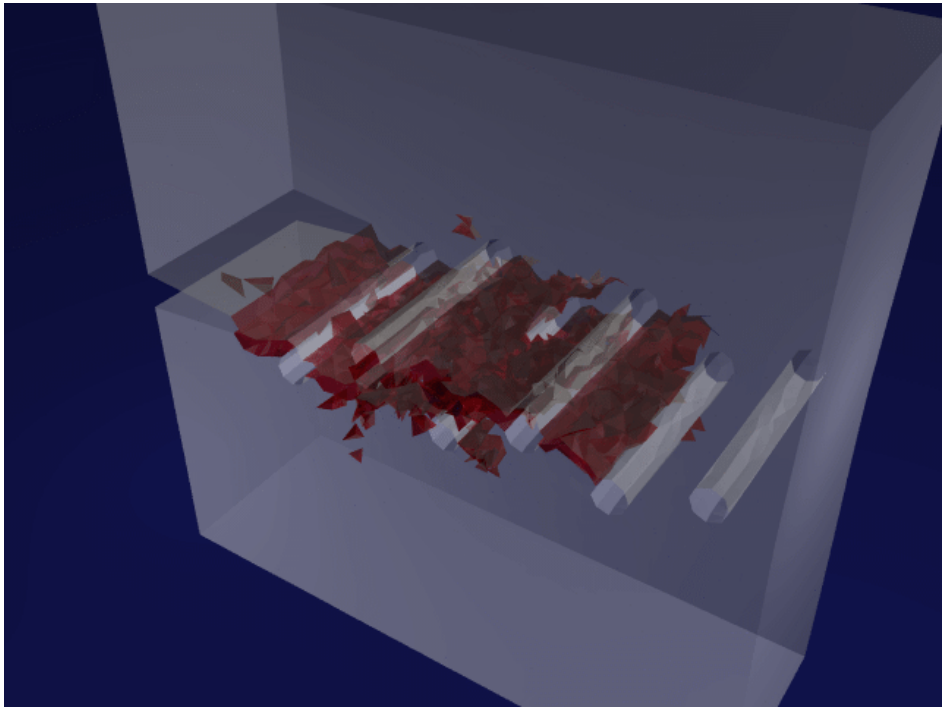
- ASCII-format Gridgen mesh files produced (*Rocflo* / *Rocflu*):
  - Mesh file (`<casename>-PLOT3D.grd`/ `<casename>-COBALT.inp`
  - Boundary condition file (`<casename>-PLOT3D.inp`/ `<casename>-COBALT.bc`
- *Rocstar* boundary condition File `<casename>.bc`
- *Rocstar* input file `<casename>.inp`
- Gridgen to *Rocstar* boundary condition map file
  - `<casename>-PLOT3D.bcmp` for *Rocflo*
  - `<casename>.cgi` for *Rocflu*

Rocstar Simulation Suite Architecture



Structural Dynamics: *Rocfrac*

- Large strains, rotations
- Explicit/Implicit, ALE
- Non-linear material models
  - Hyperelastic
    - Arruda-Boyce
    - Neo-Hookean
  - Non-linear constitutive laws
    - Viscoplastic
    - Porous viscoelastic
- Mixed-enhanced elements
- Transient thermal solver
- Crack propagation
  - Cohesive elements allow failure
- Stabilized and mixed displacement-pressure elements

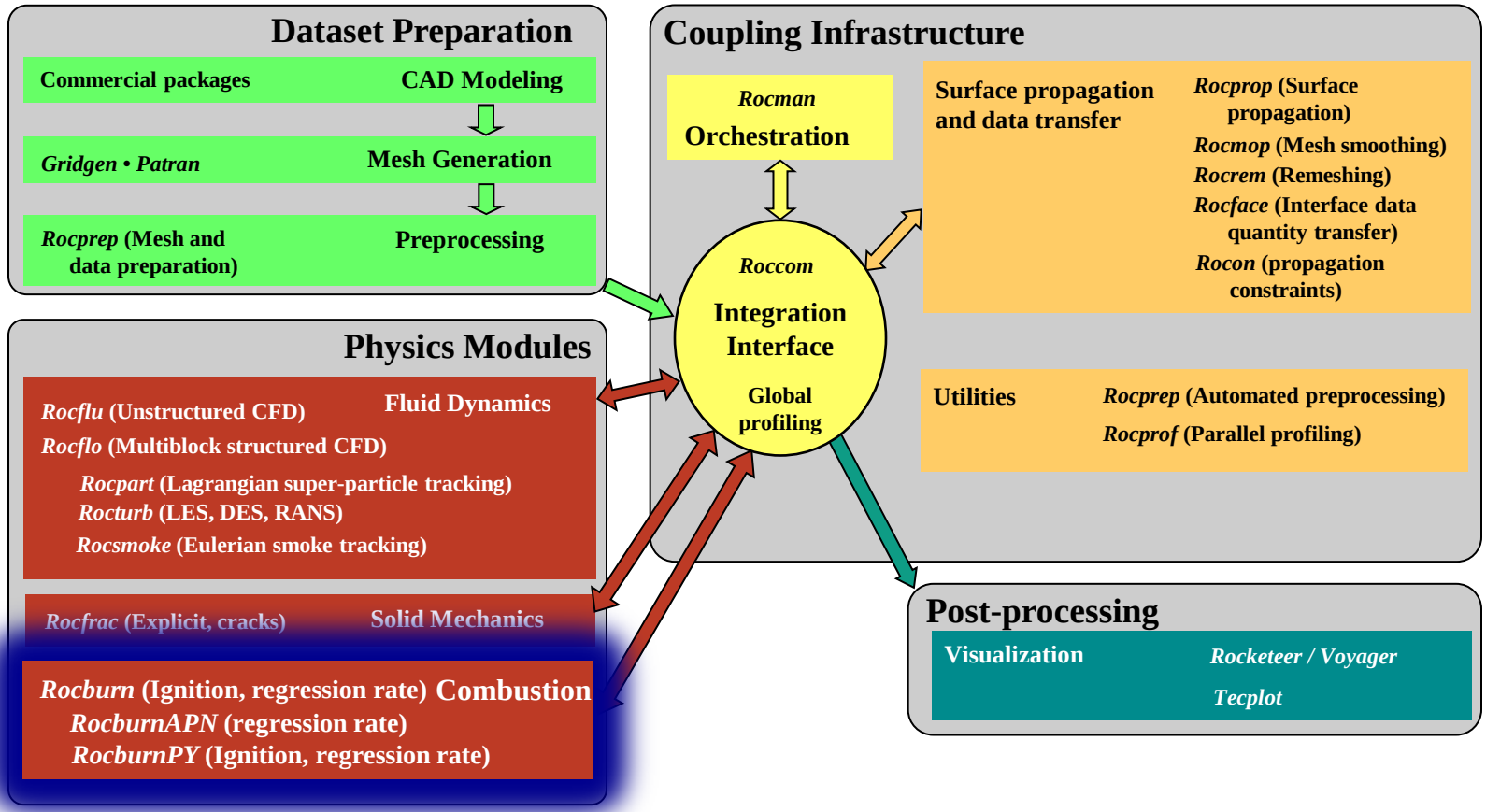


Crack Propagation in Material with Holes

Files Required for *Rocfrac* Simulation

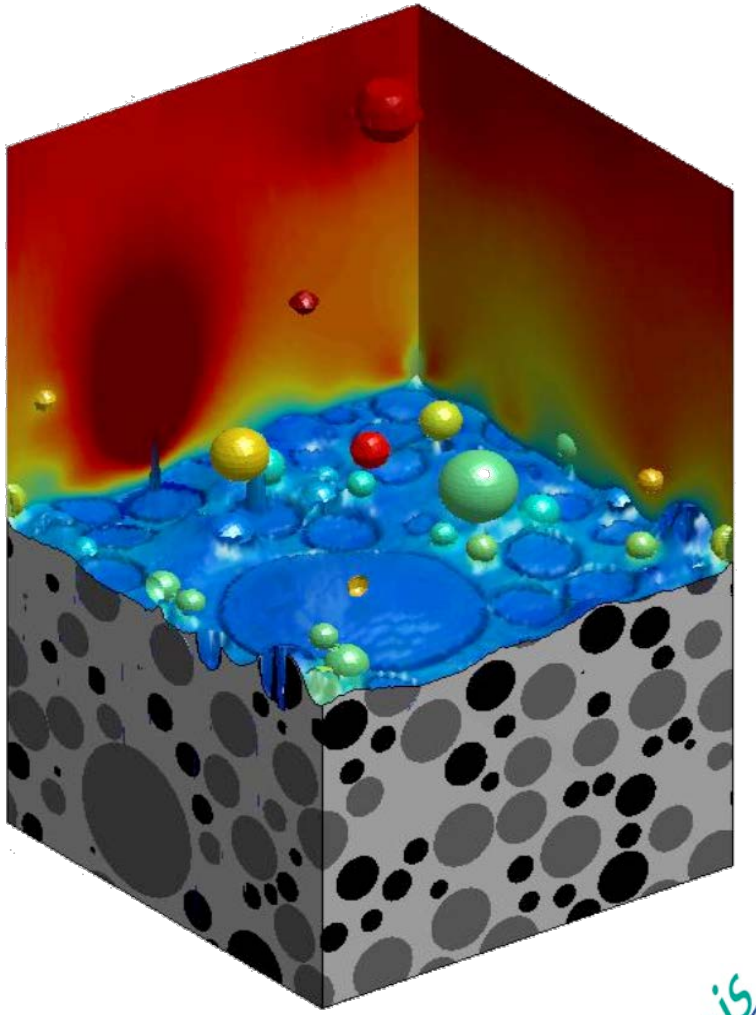
- Two files are required:
  - ASCII-format grid file produced by Patran: <casename>.out
  - ASCII-format input file: RocfracControl.txt

Rocstar Simulation Suite Architecture



Rocburn Combustion Module

- *RocburnAPN*
  - 1-D heat conduction into propellant
  - Uses gas pressure power law
  - Provides regression rate for burning propellant
  - Burnout capabilities, no heating
- *RocburnPY*
  - 1-D heat equation
  - Dynamic heating
  - Geometrically dependent film coefficient
  - Ignition modeling
  - Burnout
  - Provides aP^n regression rate for burning elements
  - Can use lookup tables



Files Required for *Rocburn* Simulation

- One file is required:
  - ASCII-format input file: RocburnAPNControl.txt

OR

  - ASCII-format input file: RocburnPYControl.txt

Physics Module Files: *RocburnAPN*

RocburnAPNControl.txt

```
0.07696     a in rb=a*P^n,  rb in cm/sec and P in atm, a_p (cm/sec)
0.461       n in rb=a*P^n,  rb in cm/sec and P in atm, n_p
1           Maximum_number_of_spatial_nodes,_nxmax
2855.0      adiabatic flame temperature, Tf_adiabatic (K)
298.00      initial temperature, To_read (K)
Rocburn_2D_Output/Rocburn_APN
```

Physics Module Files: *RocburnPY*

RocburnPYControl.txt

```
0.3912          a_p             in rb = a_p*(P/Pref)^n,  rb in cm/sec and P in atm
0.461           n_p             in rb = a_p*(P/Pref)^n,  rb in cm/sec and P in atm
34.0            Pref            in rb = a_p*(P/Pref)^n, atm
2850.0          Tstar0          adiabatic flame temperature, Tstar0    (K)
300.0           To              cold temperature,            To        (K)
850.0           Tignition       ignition temperature,        Tignition (K)
300.0           Tsurf           surface  temperature,        Tsurf     (K)
560.08d0        film_cons       film coefficient [ W/ (m^2 K) ]
1               ixsymm          axisymmetric initial burning, use x_surf_burn
1.16200d-2      x_surf_burn     last surface x location burning from the onset
1.d8            press_max       maximum pressure allowed to be passed in [Pa]
1.d2            press_min       minimum pressure allowed to be passed in [Pa]
1.0d0           rb_max          maximum burn rate allowed [m/sec]
-1.0d-6         rb_min          minimum burn rate allowed [m/sec]
1.d5            Tf_max          maximum gas temperature allowed [Kelvin]
100.0d0         Tf_min          minimum gas temperature allowed [Kelvin]
0               TabUse          use a table or not
name            TabName         name of table to use
```