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Title: FLAG-SGH Sedov calculations

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FLAG-SGH Sedov calculations

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March 14, 2012

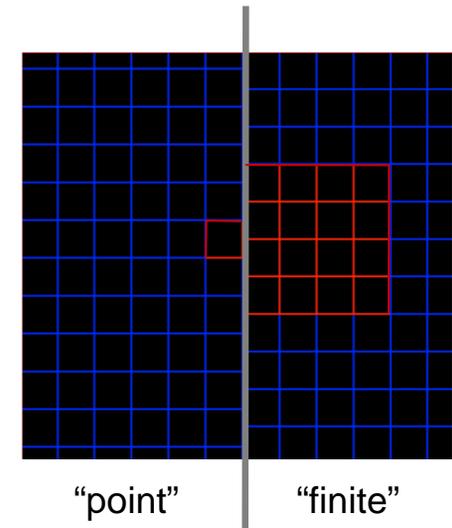
We did not run with a “cylindrically painted region”. However, we did compute two general variants of the original problem.

- Refinement studies where a single zone at each level of refinement contains the entire internal energy at $t=0$

OR

- A “finite” energy source which has the same physical dimensions as that for the 91x46 mesh, but consisting of increasing numbers of zones with refinement.

- **Nominal mesh resolution: 91x46. Other mesh resolutions: 181x92 and 361x184**
 - Note – not identical to the original specification
 - To maintain symmetry for the “fixed” energy source, the mesh resolution was adjusted slightly



(mesh at 4x original resolution)

FLAG Lagrange or full (Eulerian) ALE was used with various options for each simulation.

■ Lagrange

- RZ hydro: non-conservative (iangwt=3, massec=0) or conservative (iangwt=3, massec=2); Courant number of 0.4
- Artificial viscosity: BBL (q1, q2=1, length=1) with TTS hourglass control

■ ALE

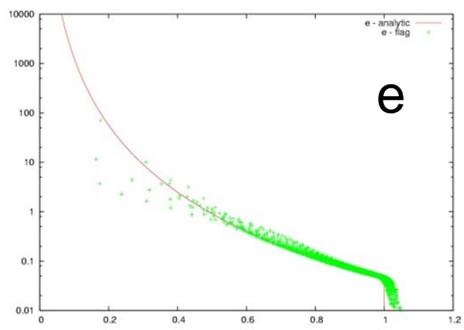
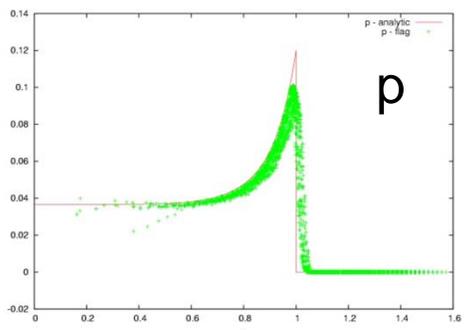
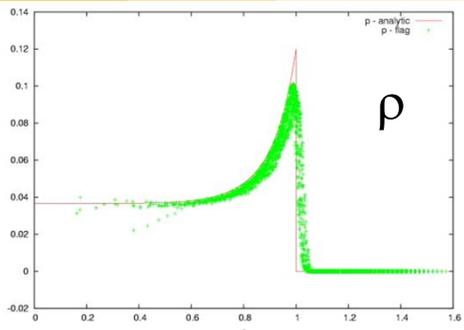
- Eulerian relaxer, automatic subcycling (full Eulerian)
- Non-conservative RZ hydro (iangwt=3, massec=0) only
- Current “best practice”:
 - Green-Gauss gradient (iadv_gradient=1)
 - Mean-value-preserving linear reconstructions (iuse_centroids=1)
 - Barth-Jespersen limiter + FCT
- With or without a kinetic energy fixup (limited with a 1.0e-5 specific internal energy floor)

A note on units

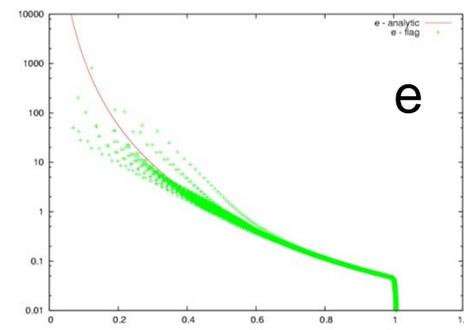
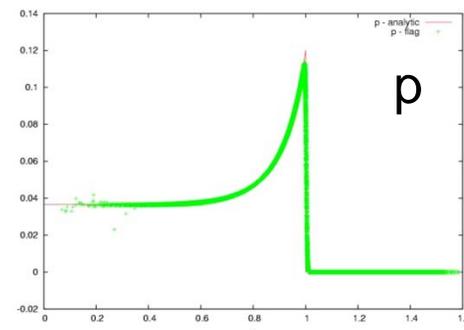
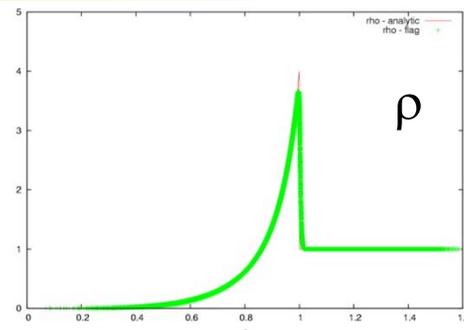
- **Density: gcc**
- **Pressure: Mbar**
- **Energy: Mbar-cc**
- **Time: microseconds**

Observation: for either Lagrange or ALE, point or “fixed” source, calculations converge on density and pressure with mesh resolution, but not energy. (not vorticity either)

Lagrange, 91x46



Lagrange, 381x184



Question: are we seeing actual (physical) vorticity production due to the non-cylindrical nature of the source?

■ Review: the vorticity equation

- There are source or dissipation terms that arise in our setup and numerical hydrodynamics.
- The non-cylindrical source appears to generate vorticity (?), and numerical viscosity dissipates vorticity.
- What is so special about a “rectangular” source? Does the corner induce shear (does the shock “deal” with the corner by inducing a shear layer)?

Time rate of change of vorticity

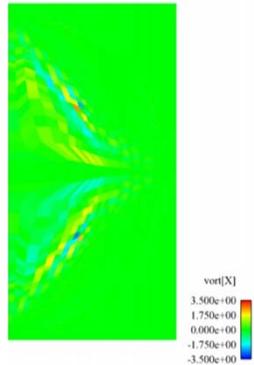
$$\begin{aligned} \frac{D\vec{\omega}}{Dt} &= \frac{\partial\vec{\omega}}{\partial t} + (\vec{V} \cdot \nabla)\vec{\omega} \\ &= (\vec{\omega} \cdot \nabla)\vec{V} - \vec{\omega}(\nabla \cdot \vec{V}) + \frac{1}{\rho^2} \nabla\rho \times \nabla p + \nabla \times \left(\frac{\nabla \cdot \underline{\underline{\tau}}}{\rho} \right) + \nabla \times \vec{B} \end{aligned}$$

Baroclinic source

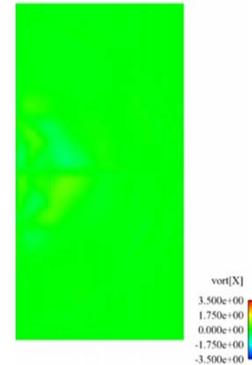
viscous dissipation

Last slide: Comparisons show reduced vorticity footprint with ALE, but persistent (or increasing) vorticity with mesh resolution

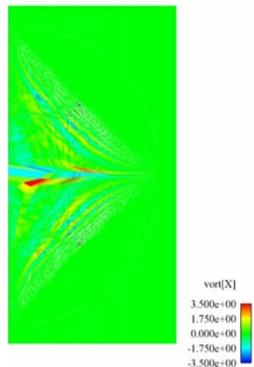
91x46 Lagrange



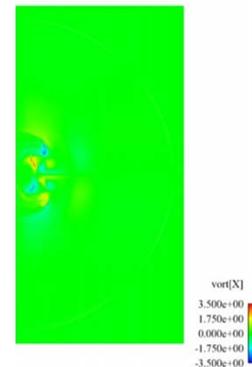
91x46 ALE



361x184 Lagrange



361x184 ALE

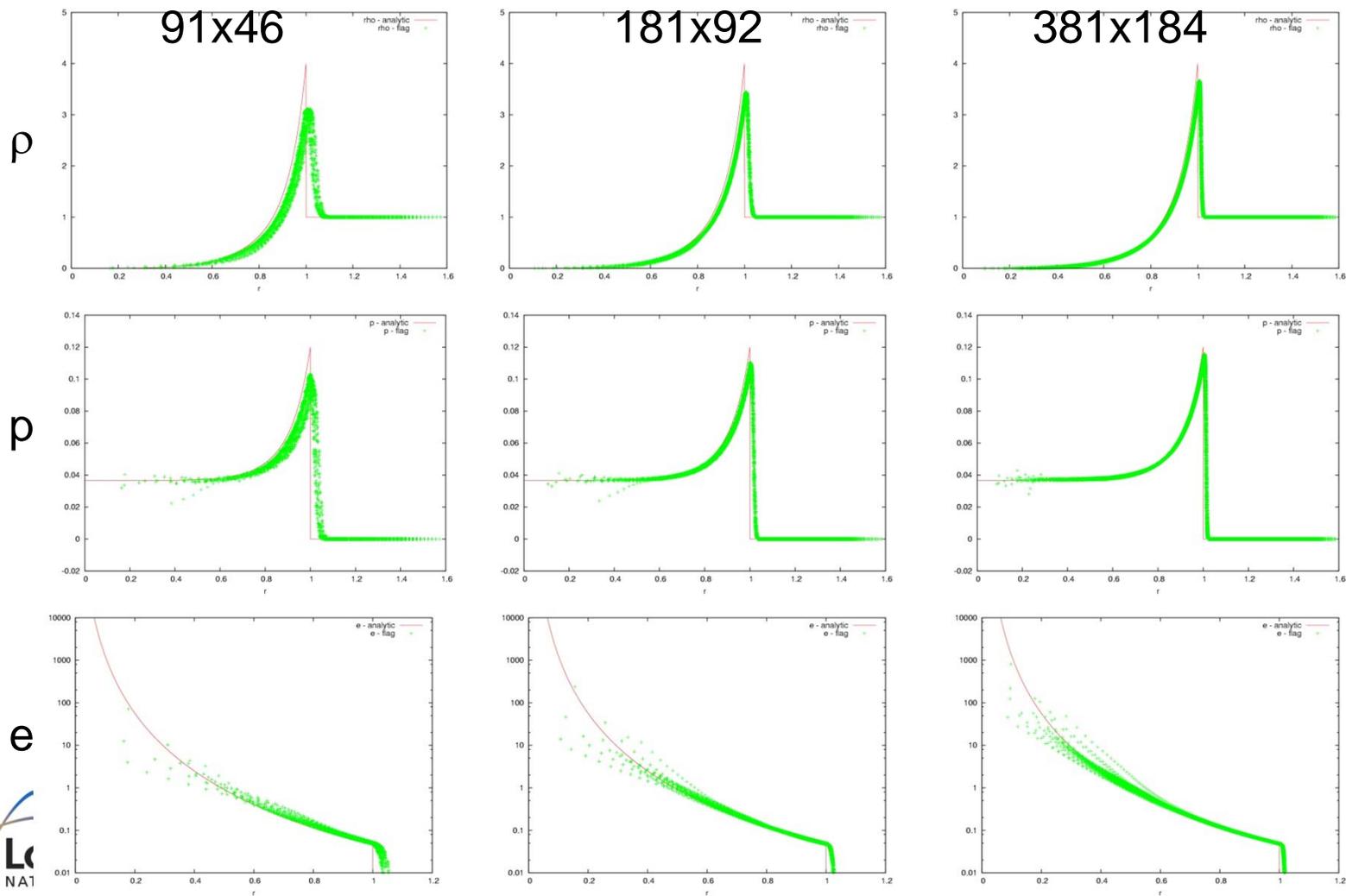


- Same trend with point or “fixed” source
- Same trend in Lagrange with conservative or non-conservative RZ hydro
- Same trend in ALE with or without KE fixup
- We need to be careful with how we compare vorticity (normalized, averaged, etc.)
- Can we quantify the vorticity generation? (baroclinic term, initial or persistent)

Additional Backup slides

- **Lagrange: conservative vs non-conservative**
- **ALE: with or without KE fixup**
- **Mesh resolution studies**
- **Plots of: meshes, density, pressure, energy, velocity, “angular deviation from radial velocity”, vorticity.**

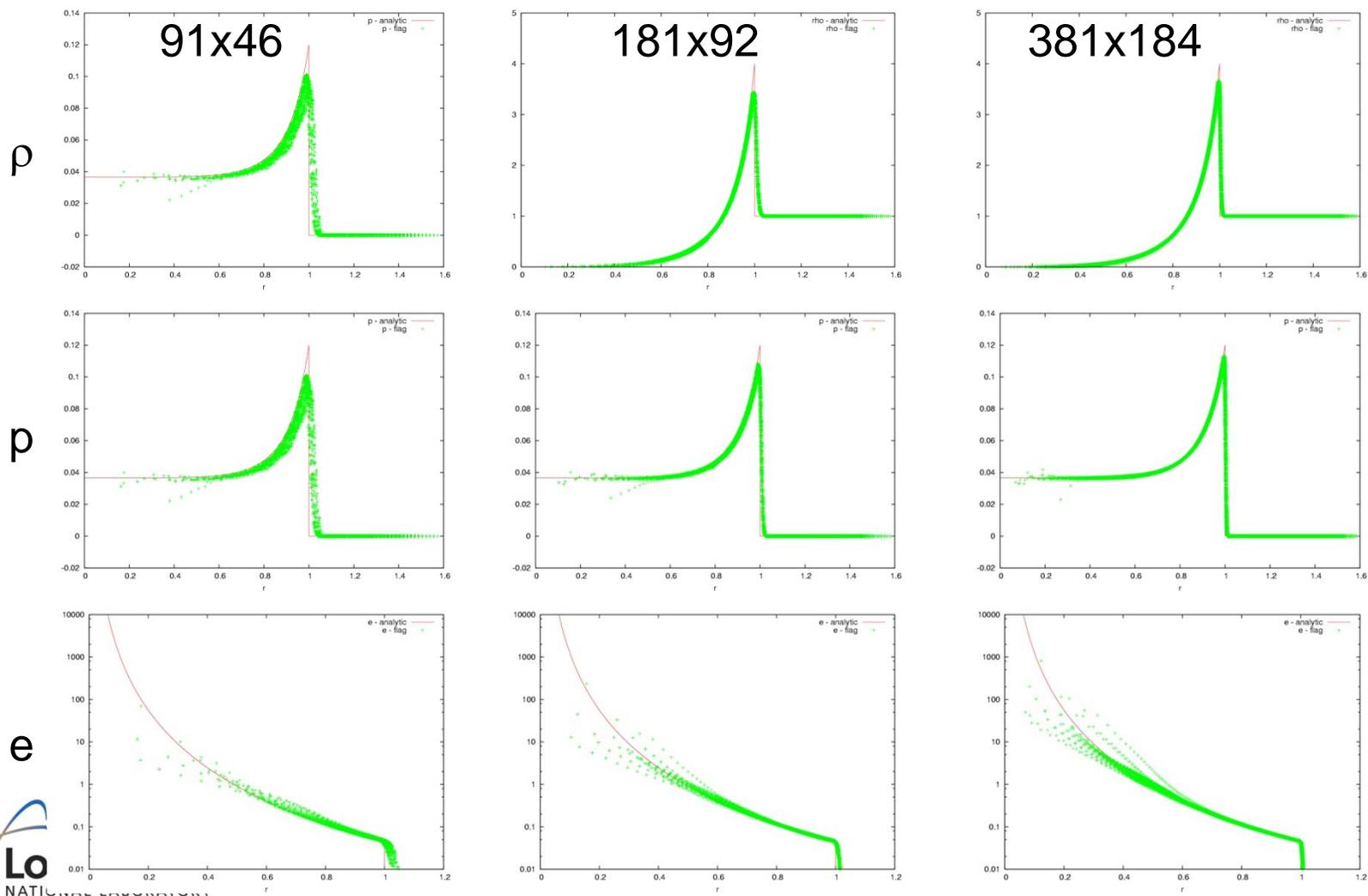
Point source: Lagrange: non-conservative RZ hydro



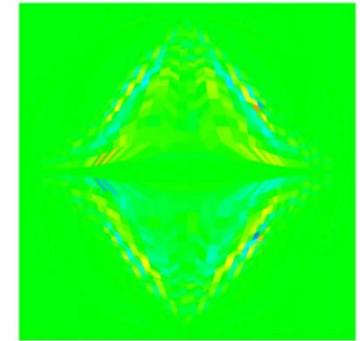
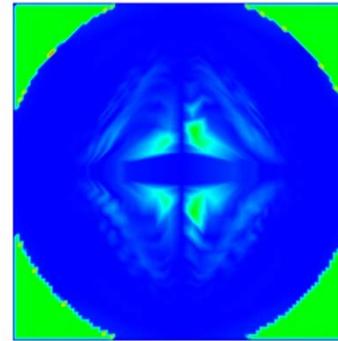
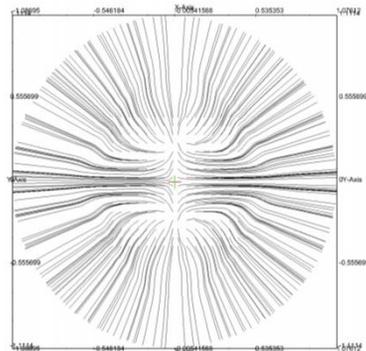
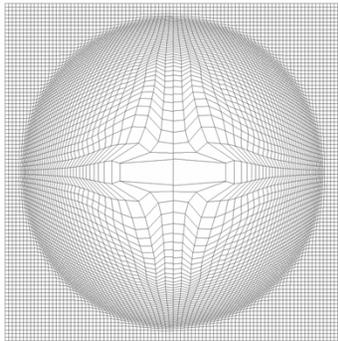
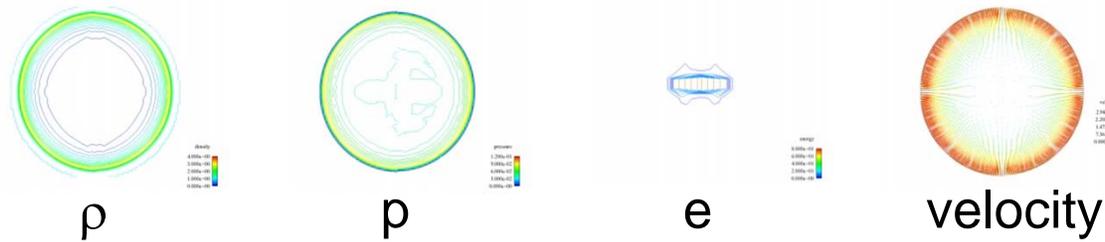
EST. 1943



Point source: Lagrange: conservative RZ hydro



Point source: Lagrange comparisons at 91x46: conservative vs non-conservative RZ hydro



streamlines

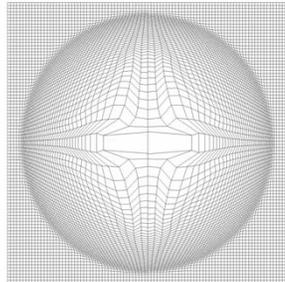
angular deviation
from radial

vorticity

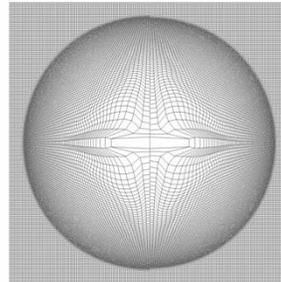
Point source: Lagrange comparisons: lack of vorticity convergence with resolution

mesh

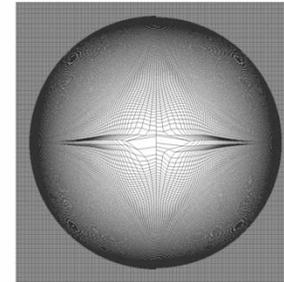
91x46



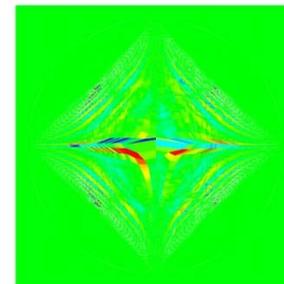
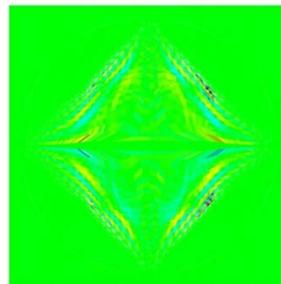
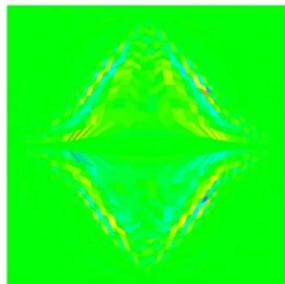
181x92



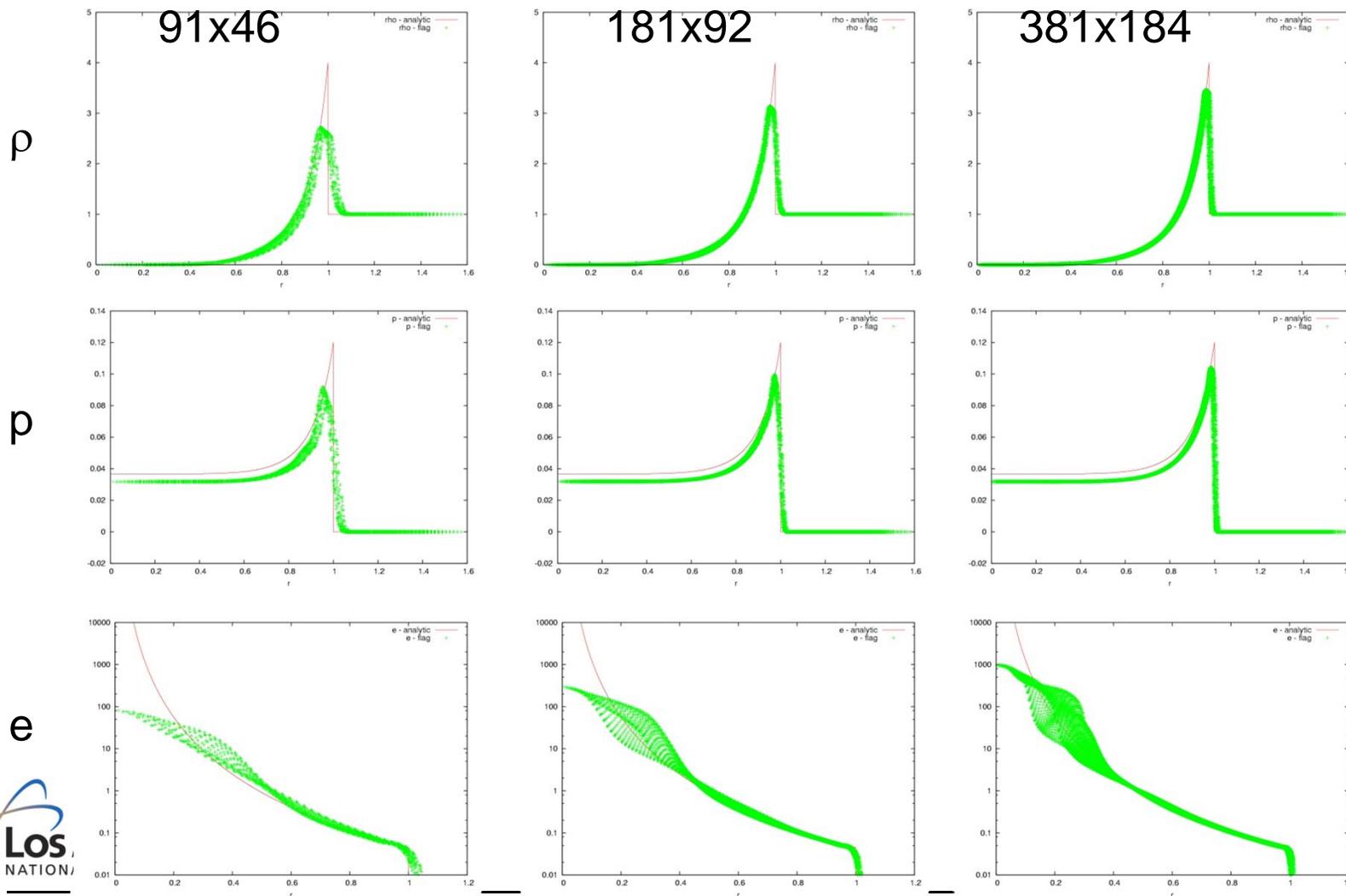
381x184



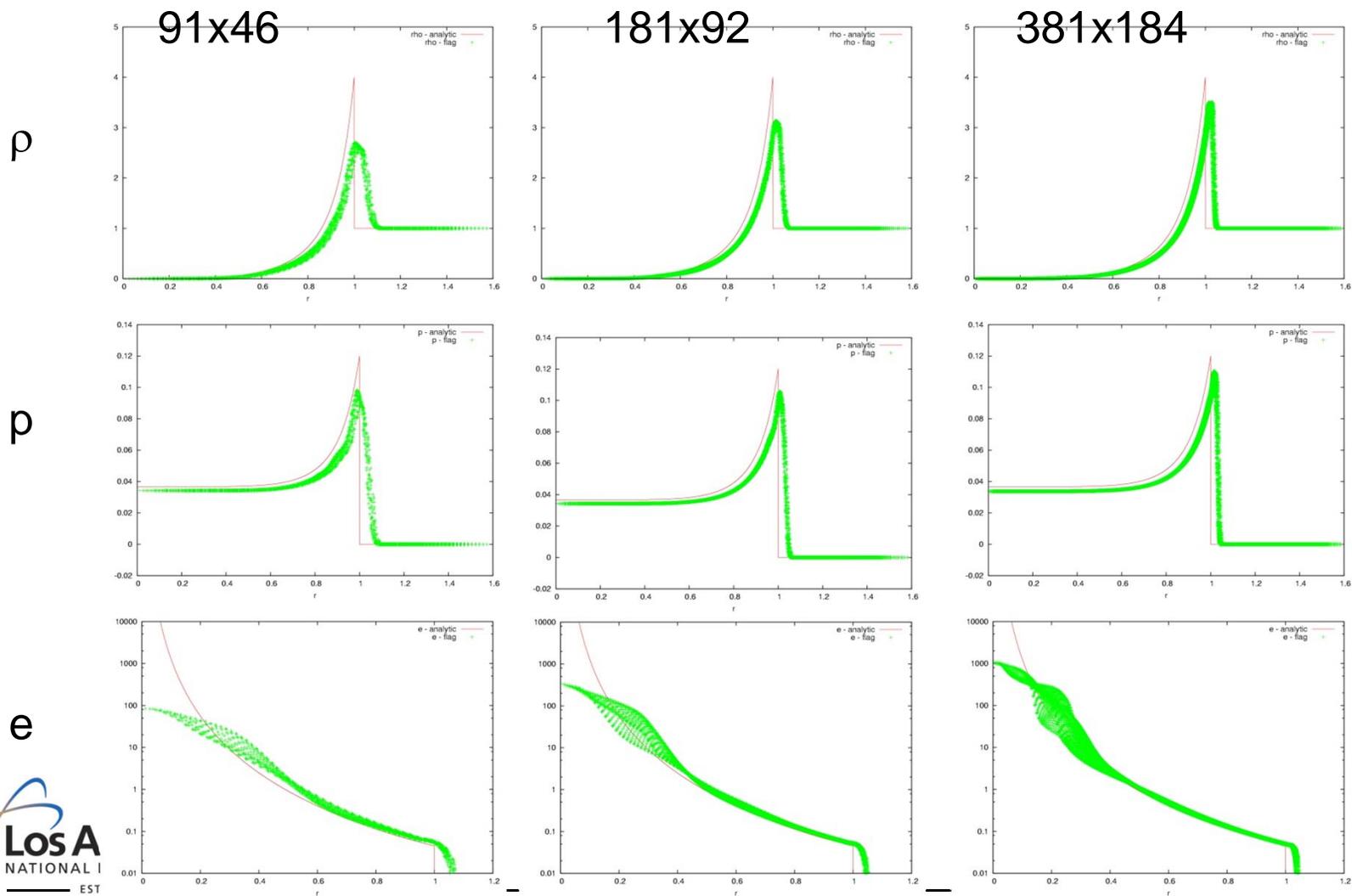
vorticity



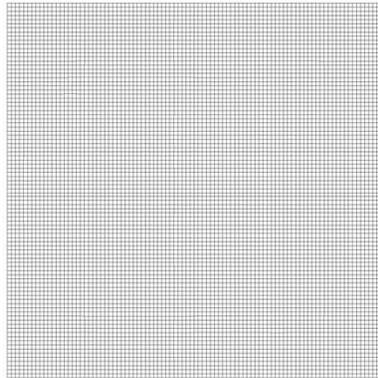
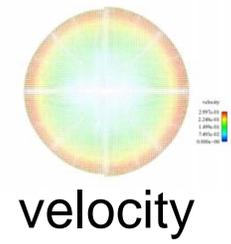
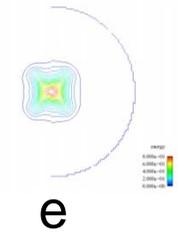
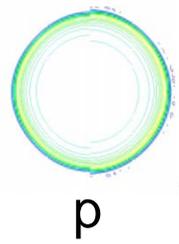
Point source: Eulerian ALE: without KE fixup



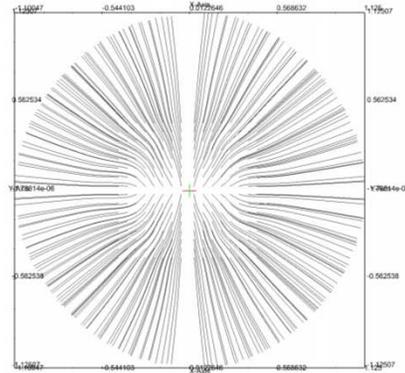
Point source: Eulerian ALE: with KE fixup



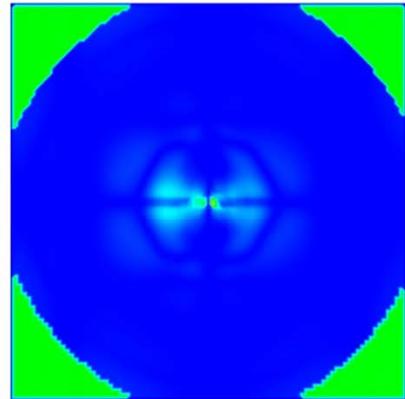
Point source: ALE comparisons at 91x46: with or without the KE fixup



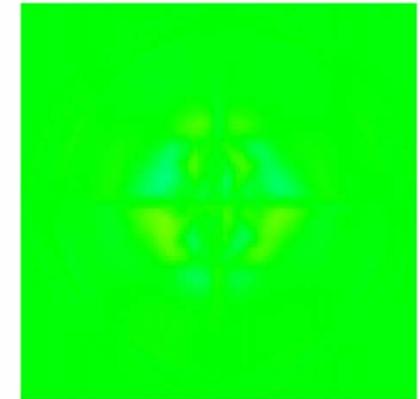
mesh



streamlines



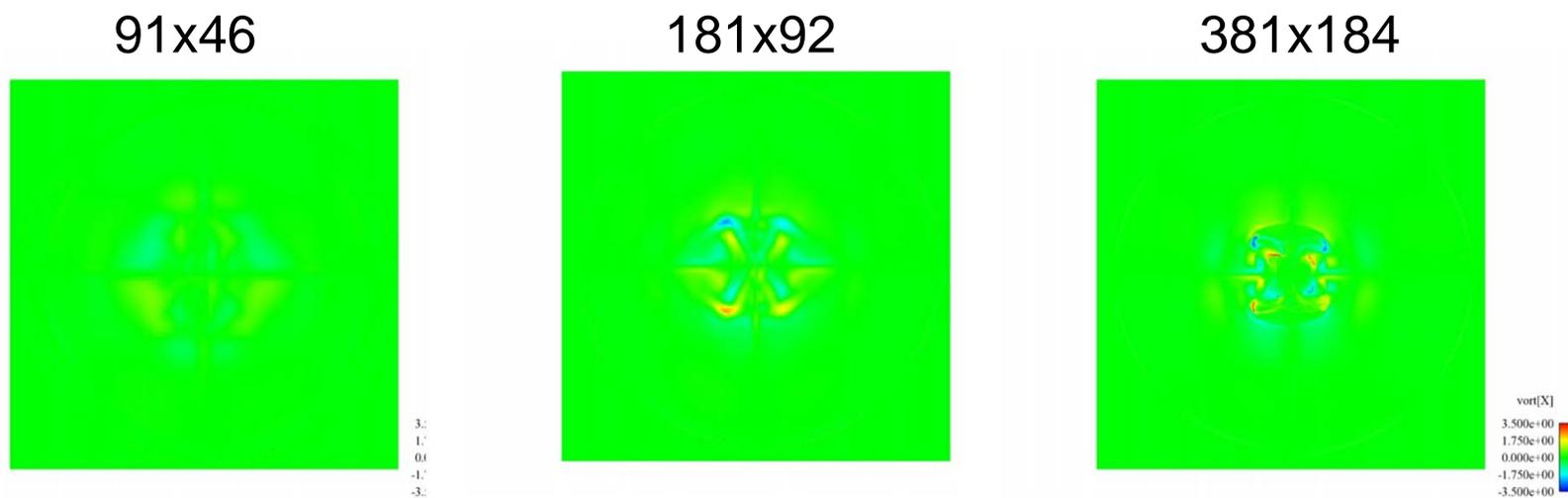
angular deviation
from radial



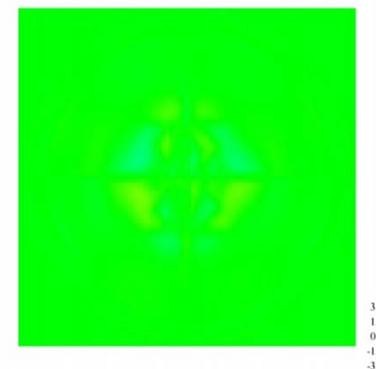
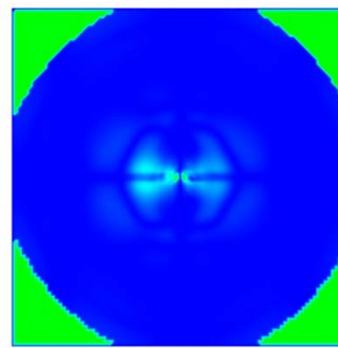
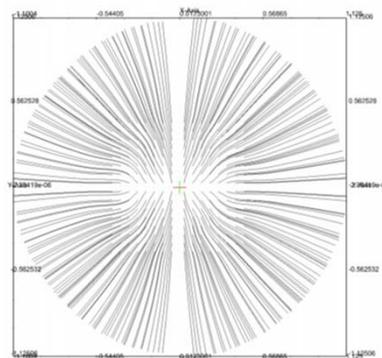
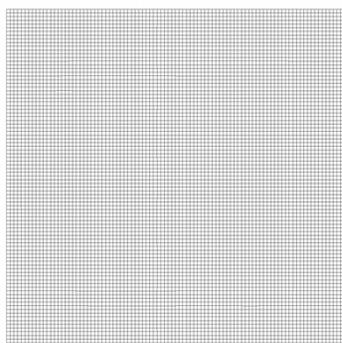
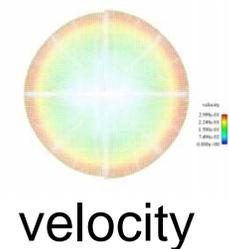
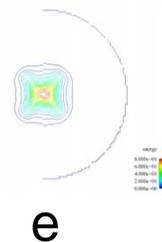
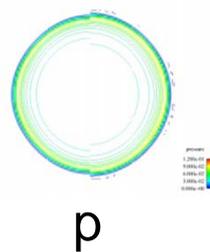
vorticity

vort
3.500e+
1.750e+
0.000e+
-1.750e+
-3.500e+

Point source: ALE comparisons: lack of vorticity convergence with resolution

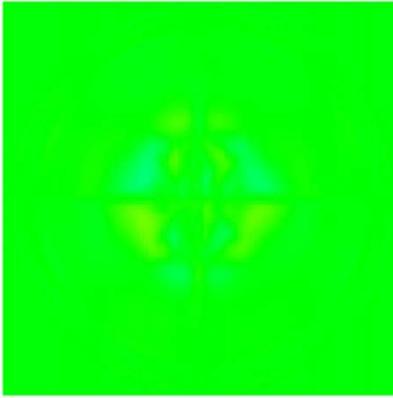


Fixed source: ALE comparisons at 91x46: with or without the KE fixup

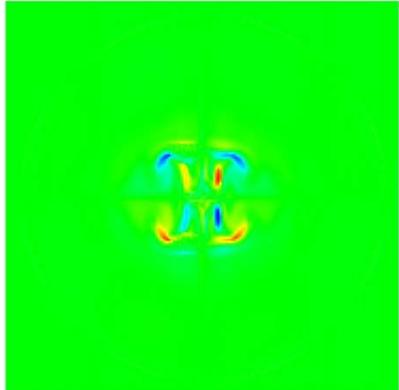


Fixed source: ALE comparisons: lack of vorticity convergence with resolution

91x46

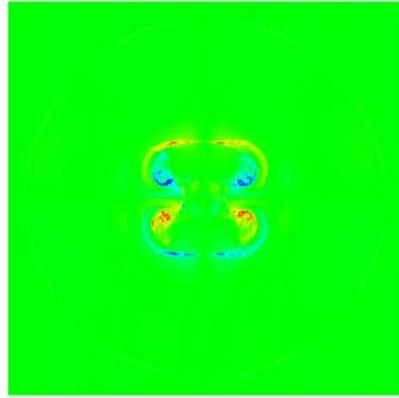


181x92



vc
3.50C
1.75C
0.00C
-1.75C
-3.50C

381x184



3.
1.
0.
-1.
-3.