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Title: FLAG-SGH Sedov calculations

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Intended for: Online Vault



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FLAG-SGH Sedov calculations

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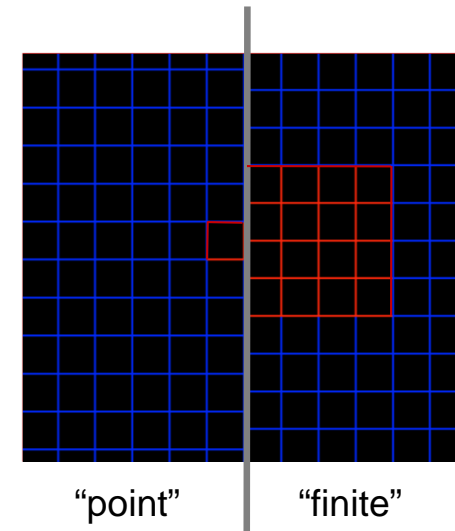
March 14, 2012

**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.**



(mesh at 4x original resolution)

- **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

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

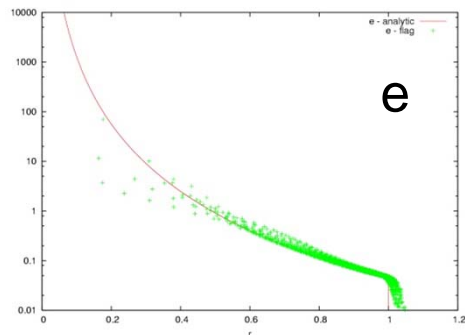
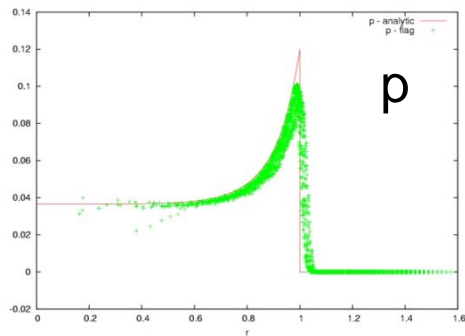
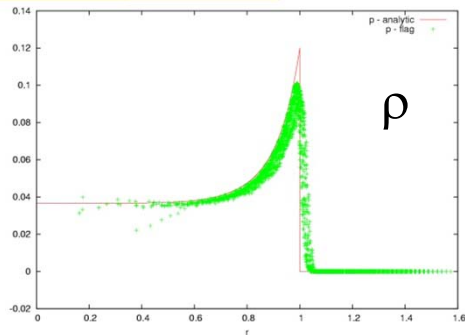
- Eulerian relaxer, automatic subcycling (full Eulerian)
- Non-conservative RZ hydro (iangwt=3, massec=0) only
- Current “best practice”:
 - Green-Gauss gradient (iadv_gradient=1)
 - Mean-value-preserving linear reconstructions (iuse_centroids=1)
 - Barth-Jespersen limiter + FCT
- With or without a kinetic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

A note on units

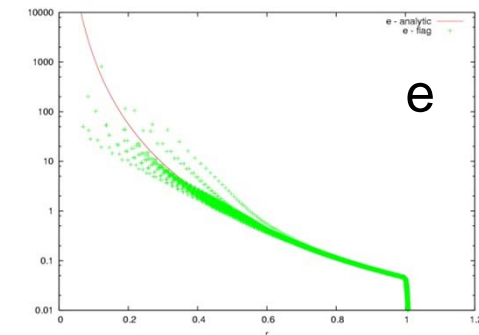
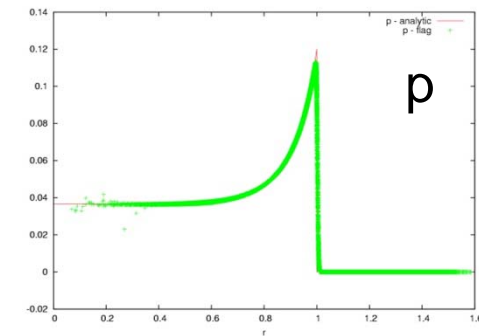
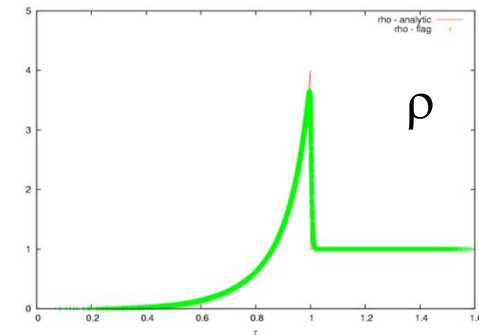
- Density: gcc
- Pressure: Mbar
- Energy: Mbar-cc
- Time: microseconds

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

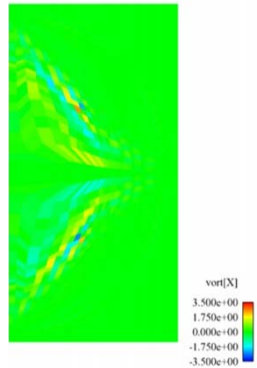
$$\begin{aligned}\frac{D\vec{\omega}}{Dt} &= \frac{\partial \vec{\omega}}{\partial t} + (\vec{V} \cdot \vec{\nabla})\vec{\omega} \\ &= (\vec{\omega} \cdot \vec{\nabla})\vec{V} - \vec{\omega}(\vec{\nabla} \cdot \vec{V}) + \frac{1}{\rho^2} \vec{\nabla} \rho \times \vec{\nabla} p + \vec{\nabla} \times \left(\frac{\vec{\nabla}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

Baroclinic source

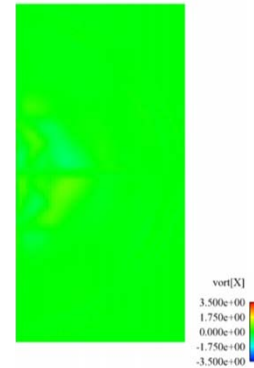
viscous dissipation

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

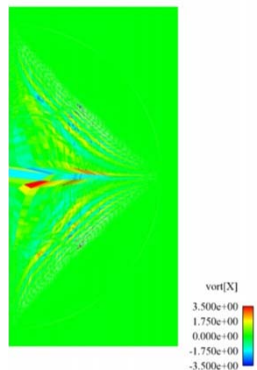
91x46 Lagrange



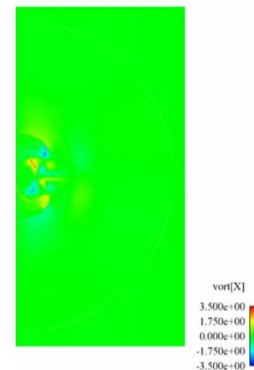
91x46 ALE



361x184 Lagrange



361x184 ALE

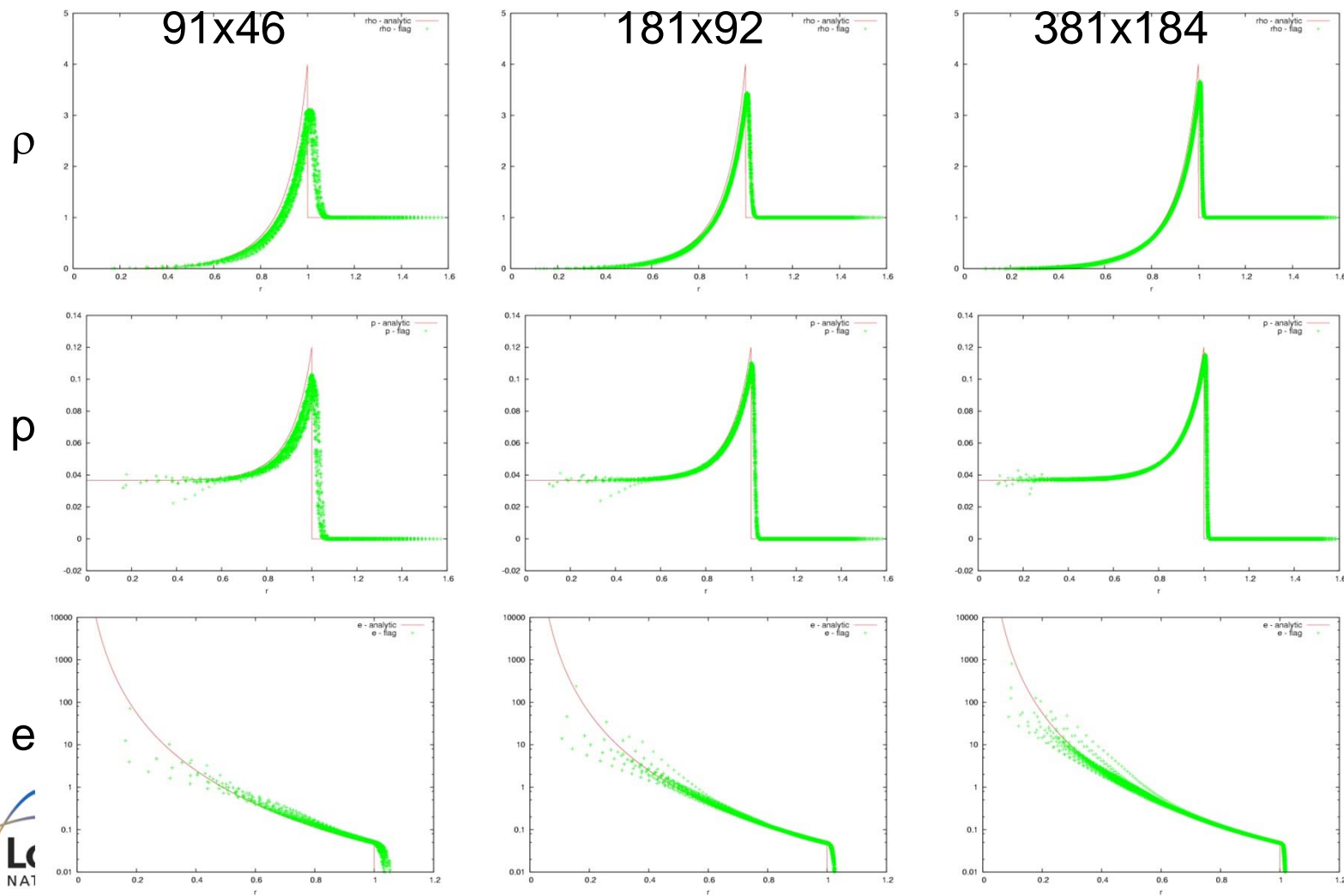


- Same trend with point or “fixed” source
- Same trend in Lagrange with conservative or non-conservative RZ hydro
- Same trend in ALE with or without KE fixup
- We need to be careful with how we compare vorticity (normalized, averaged, etc.)
- Can we quantify the vorticity generation? (baroclinic term,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



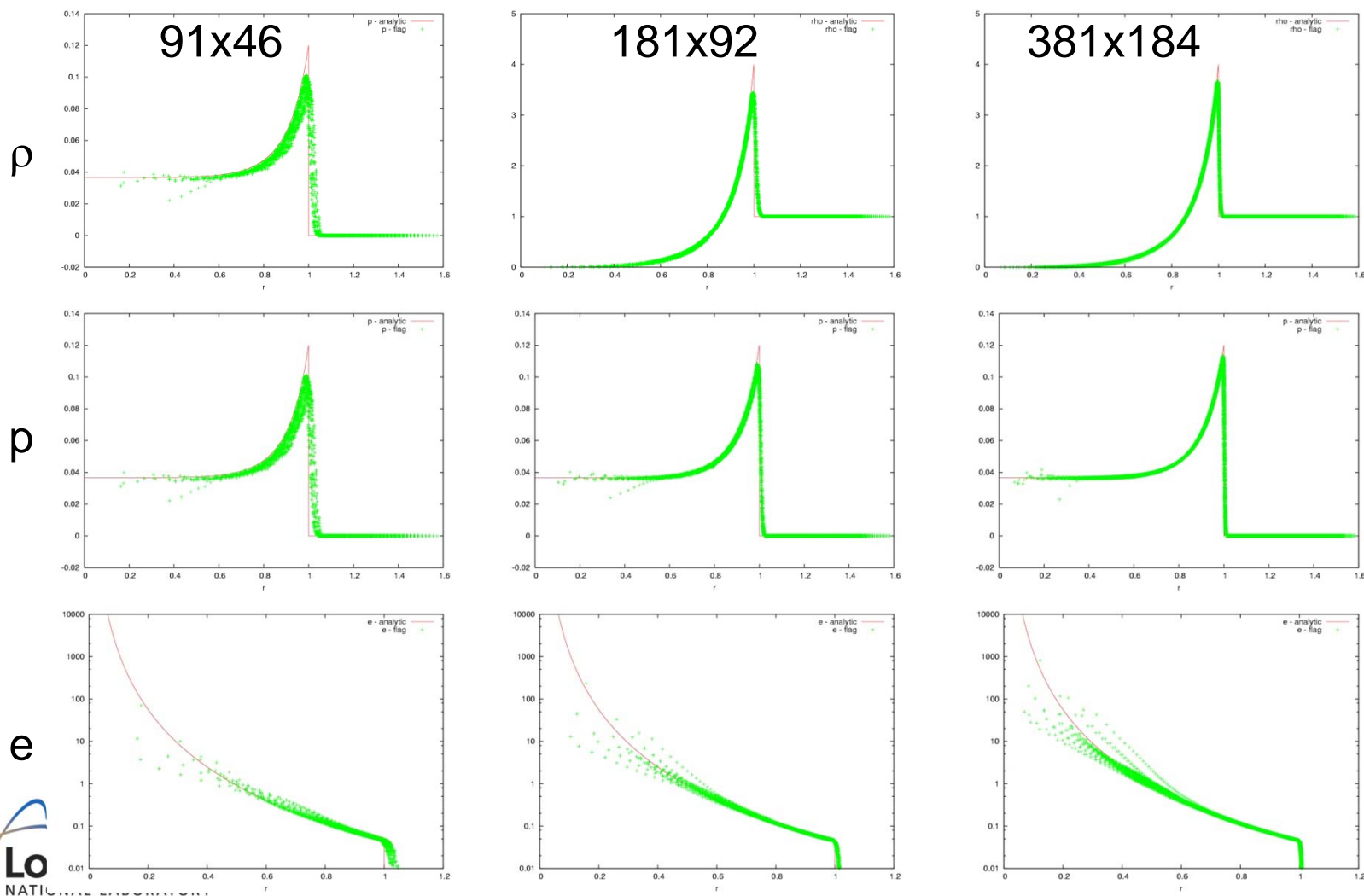
Slide 9

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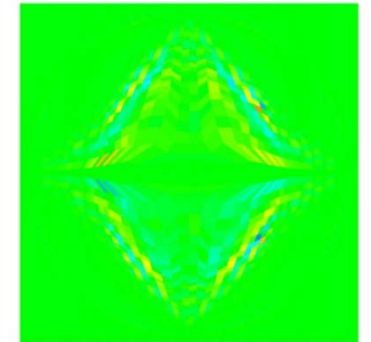
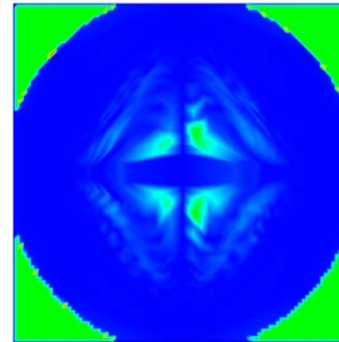
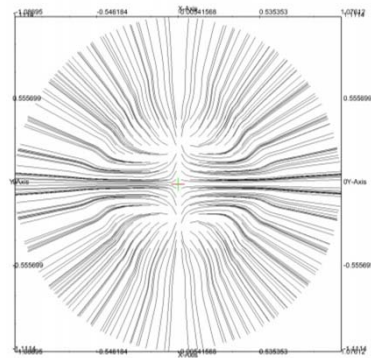
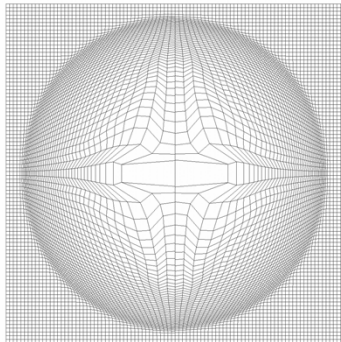
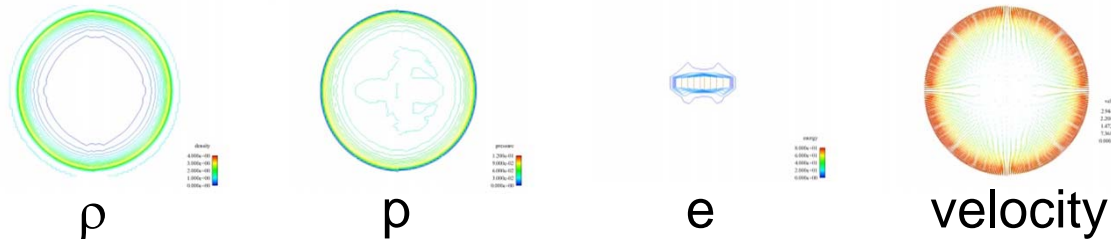


Point source: Lagrange: conservative RZ hydro



Slide 10

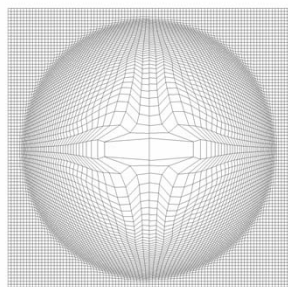
Point source: Lagrange comparisons at 91x46: conservative vs non-conservative RZ hydro



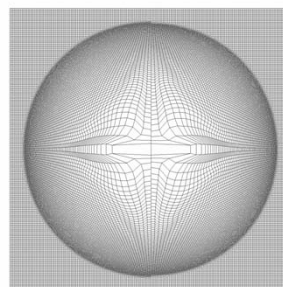
Point source: Lagrange comparisons: lack of vorticity convergence with resolution

mesh

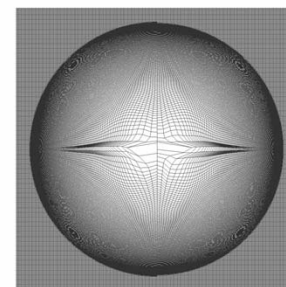
91x46



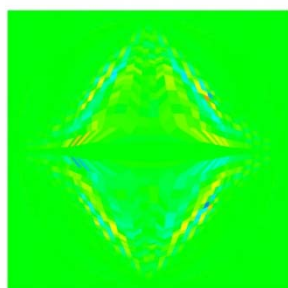
181x92



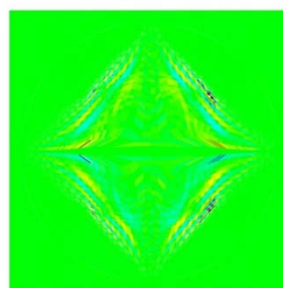
381x184



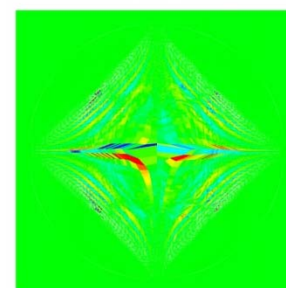
vorticity



vort[X]
3.500e+00
1.750e+00
0.000e+00
-1.750e+00
-3.500e+00

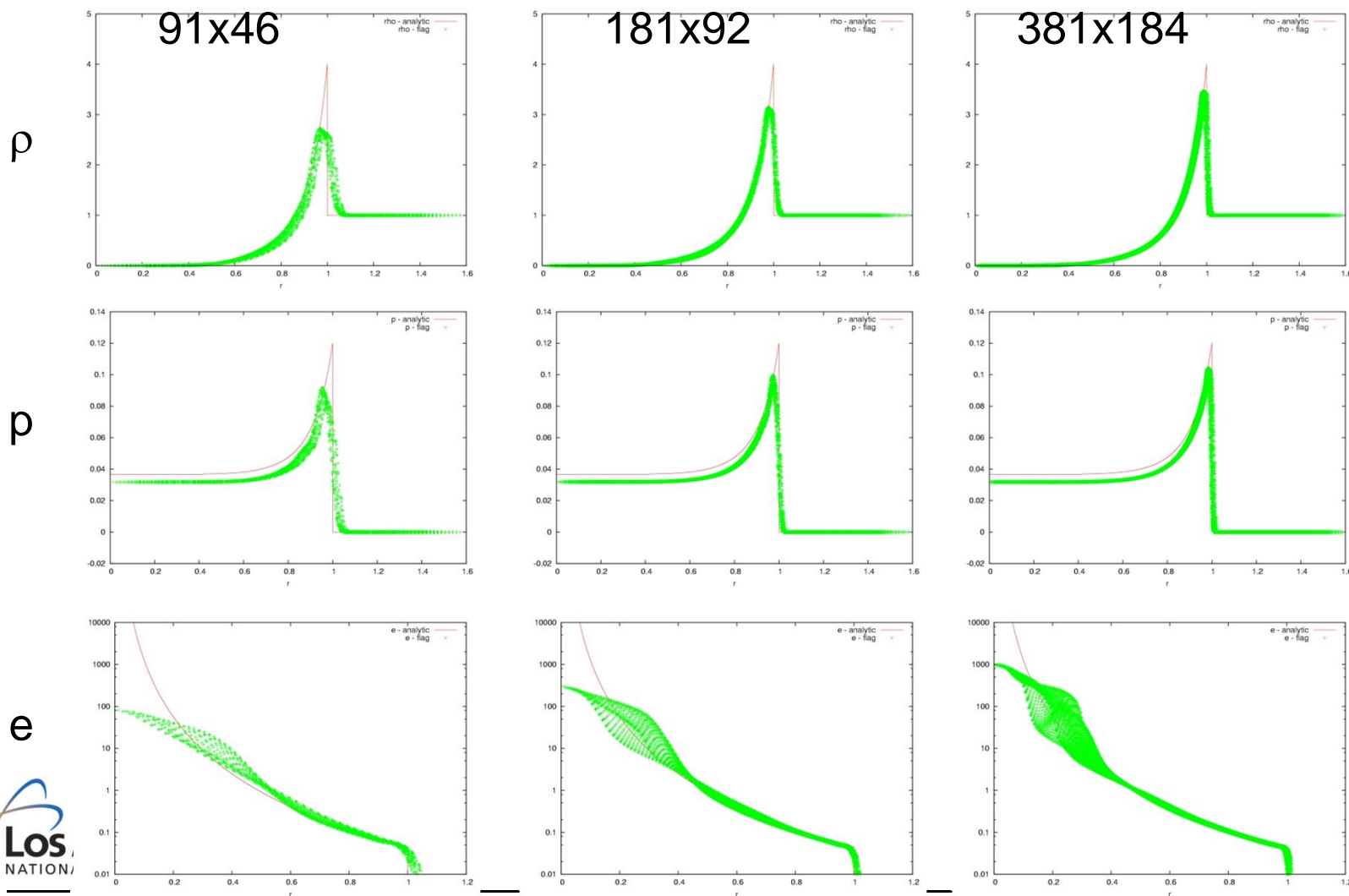


vort[X]
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1.750e+00
0.000e+00
-1.750e+00
-3.500e+00



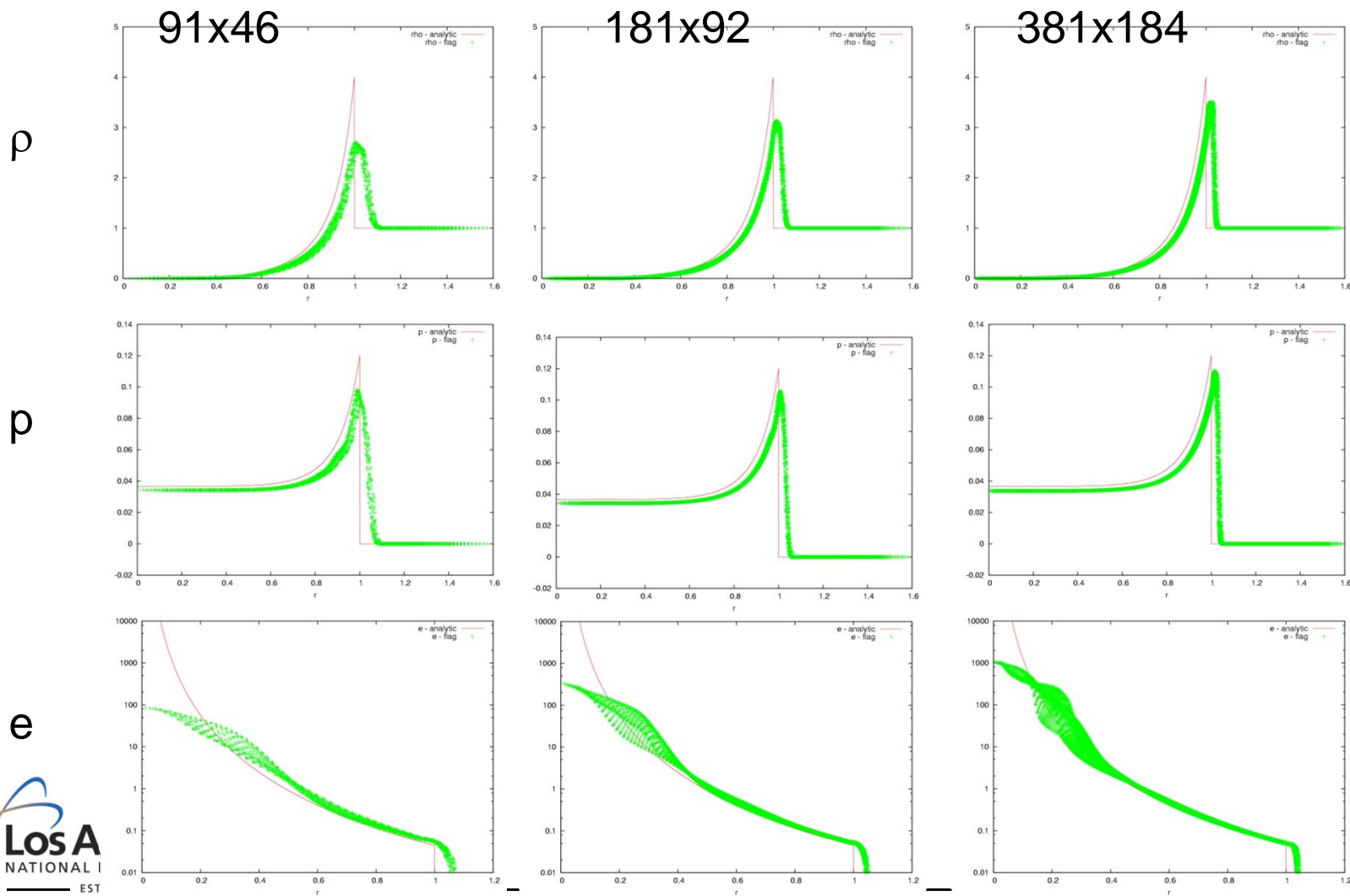
vort[X]
3.500e+00
1.750e+00
0.000e+00
-1.750e+00
-3.500e+00

Point source: Eulerian ALE: without KE fixup

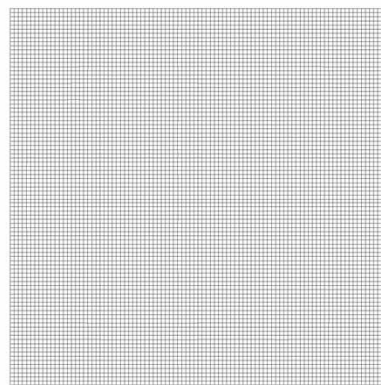
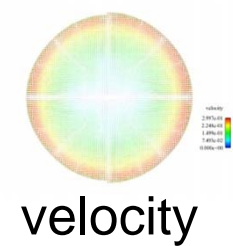
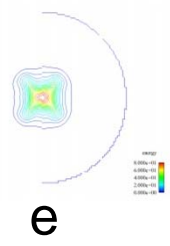
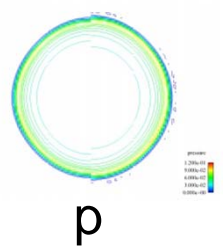
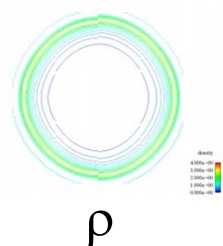


Slide 13

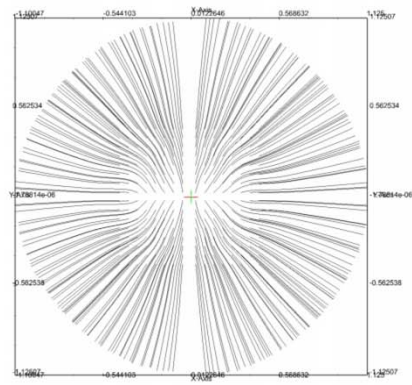
Point source: Eulerian ALE: with KE fixup



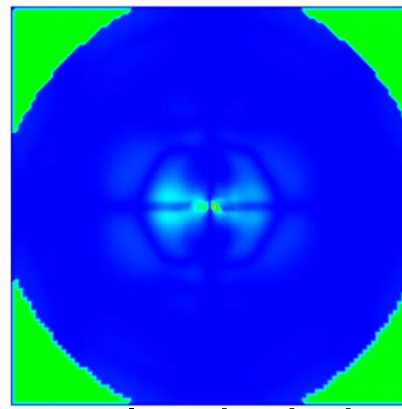
Point source: ALE comparisons at 91x46: with or without the KE fixup



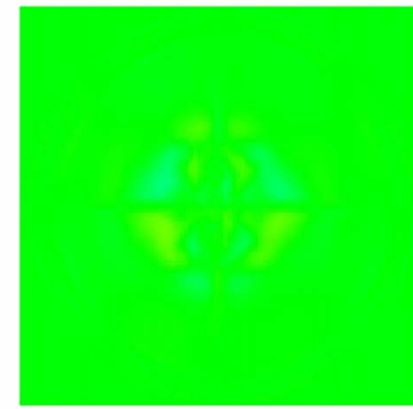
mesh



streamlines

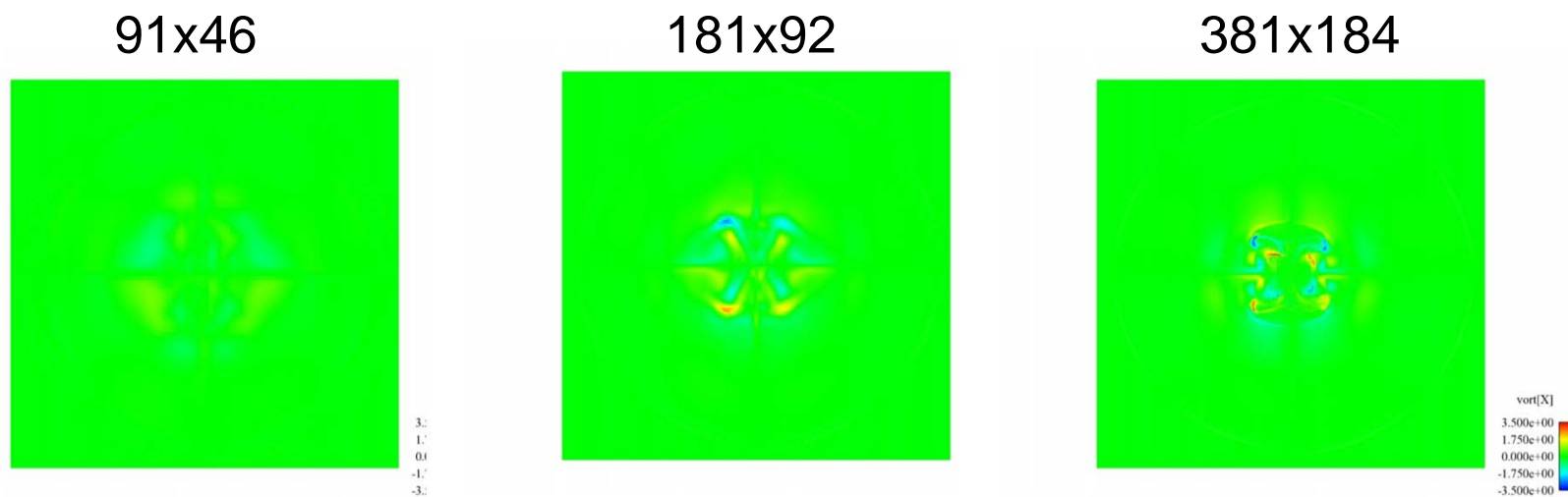


angular deviation
from radial

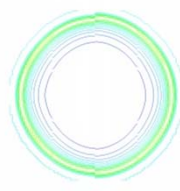


vorticity

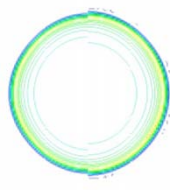
Point source: ALE comparisons: lack of vorticity convergence with resolution



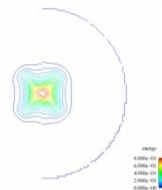
Fixed source: ALE comparisons at 91x46: with or without the KE fixup



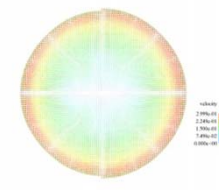
ρ



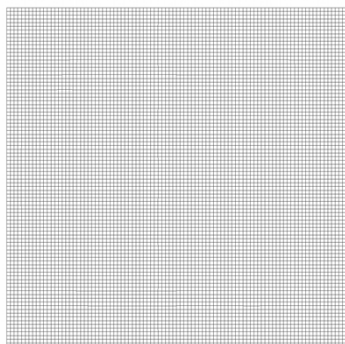
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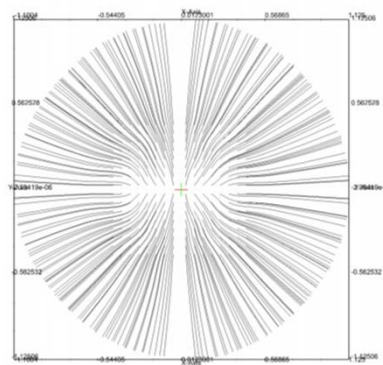
e



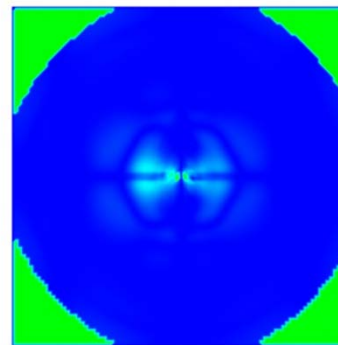
velocity



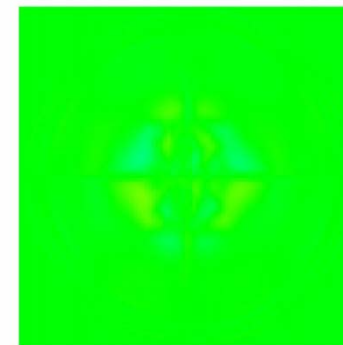
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streamlines



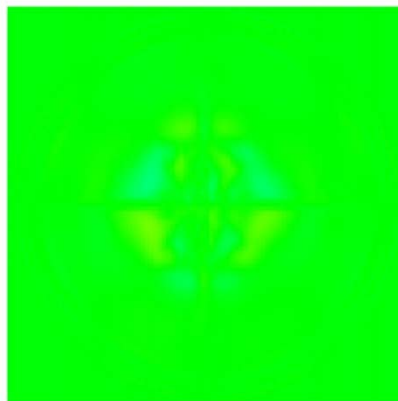
angular deviation
from radial



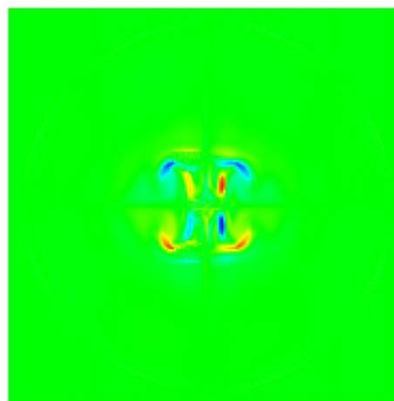
vorticity

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

91x46

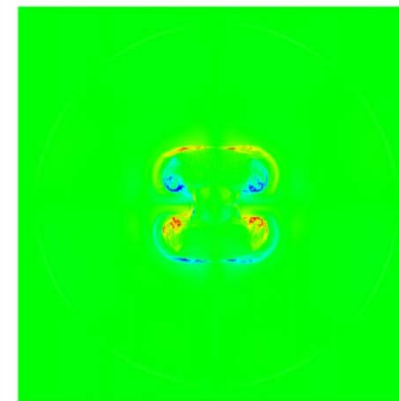


181x92



ve
3.500
1.750
0.000
-1.750
-3.500

381x184



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