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Title:	FLAG-SGH Sedov calculations
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Intended for:	Online Vault

FLAG-SGH Sedov calculations

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Sam Schofield (CCS-2, now LLNL)

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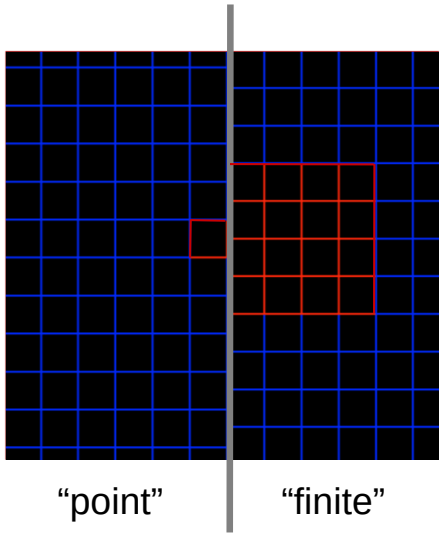
March 14, 2012

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

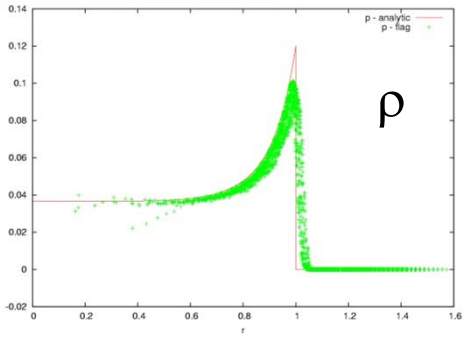
- **ALE**
  - Eulerian relaxer, automatic subcycling (full Eulerian)
  - Non-conservative RZ hydro (iangwt=3, massec=0) only
  - Current “best practice”:
    - Green-Gauss gradient (iadv_gradient=1)
    - Mean-value-preserving linear reconstructions (iuse_centroids=1)
    - Barth-Jespersen limiter +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

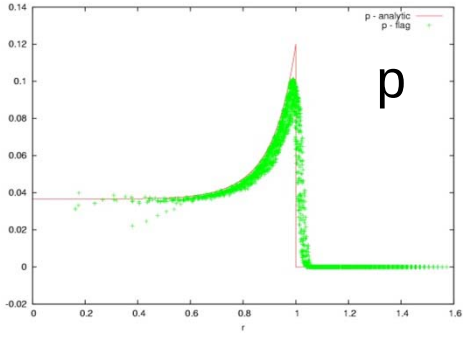
A note on units

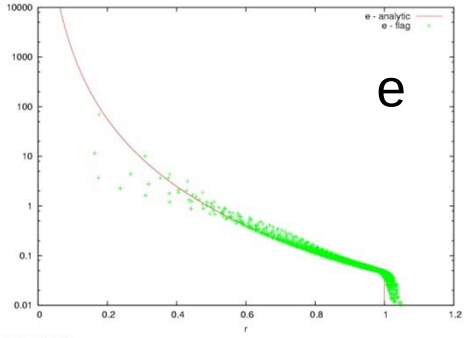
- **Density: gcc**
- **Pressure: Mbar**
- **Energy: Mbar-cc**
- **Time: microseconds**

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)

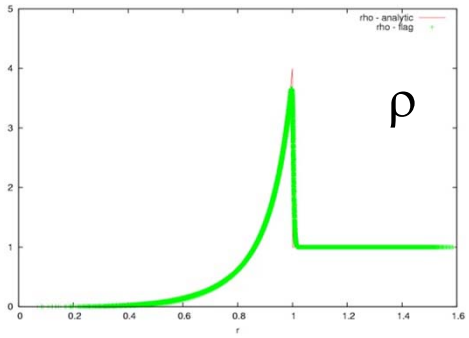
Lagrange, 91x46

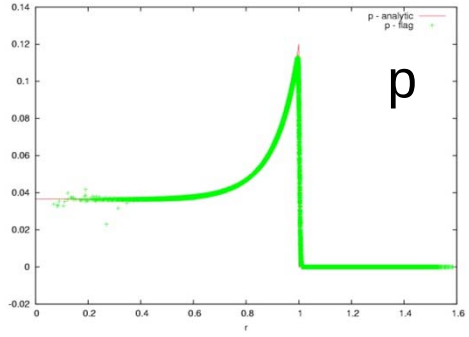


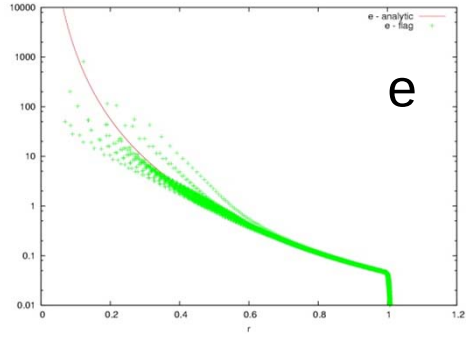




Lagrange, 381x184







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

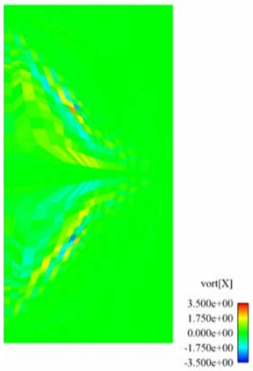
$$\frac{D\vec{\omega}}{Dt} = \frac{\partial\vec{\omega}}{\partial t} + (\vec{V}\cdot\vec{\nabla})\vec{\omega}$$
$$= (\vec{\omega}\cdot\vec{\nabla})\vec{V} - \vec{\omega}(\vec{\nabla}\cdot\vec{V}) + \frac{1}{\rho^2}\vec{\nabla}\rho\times\vec{\nabla}p + \vec{\nabla}\times\left(\frac{\vec{\nabla}\cdot\overleftrightarrow{\tau}}{\rho}\right)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

Baroclinic source

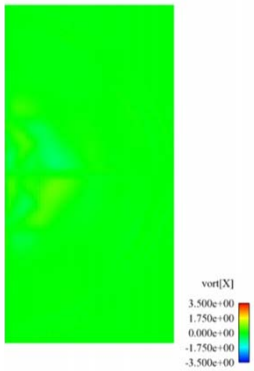
viscous dissipation

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

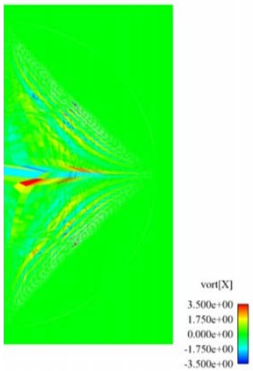
91x46 Lagrange



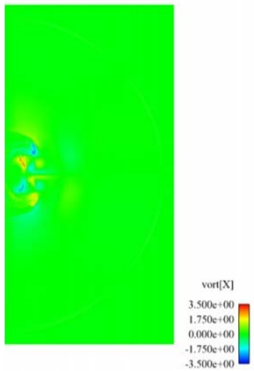
91x46 ALE



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

91x46 181x92 381x184

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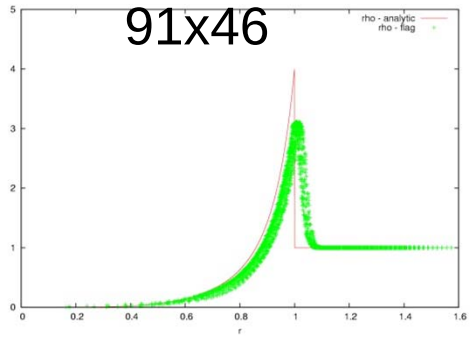

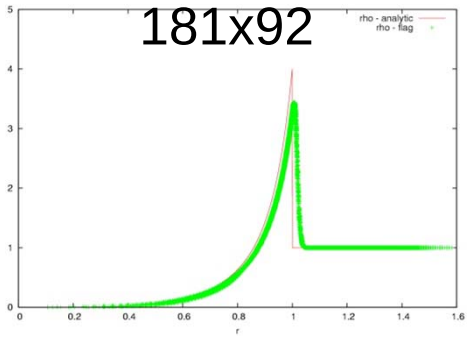

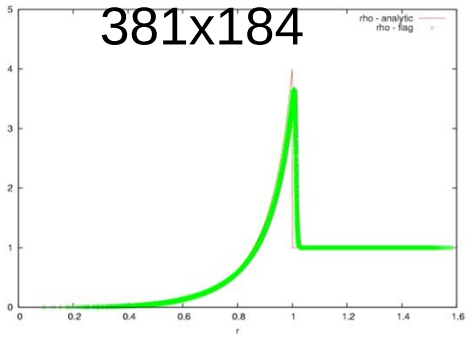

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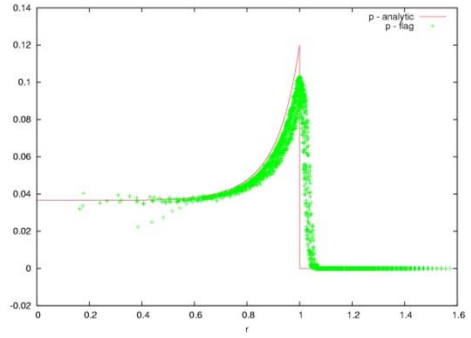

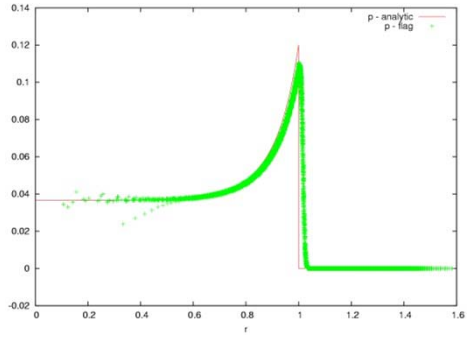

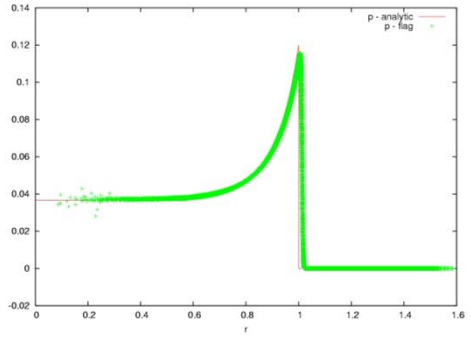

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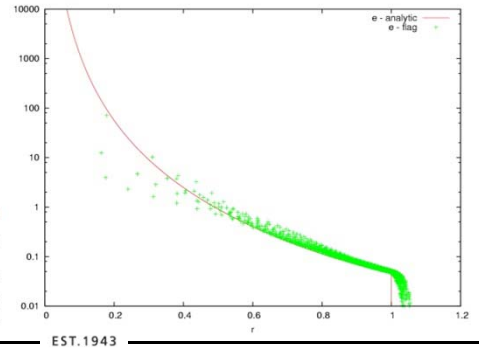
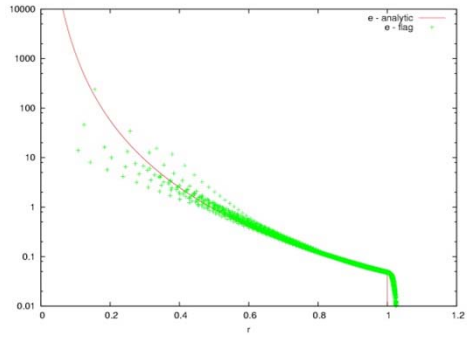
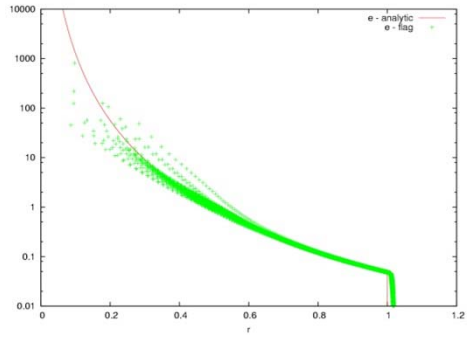
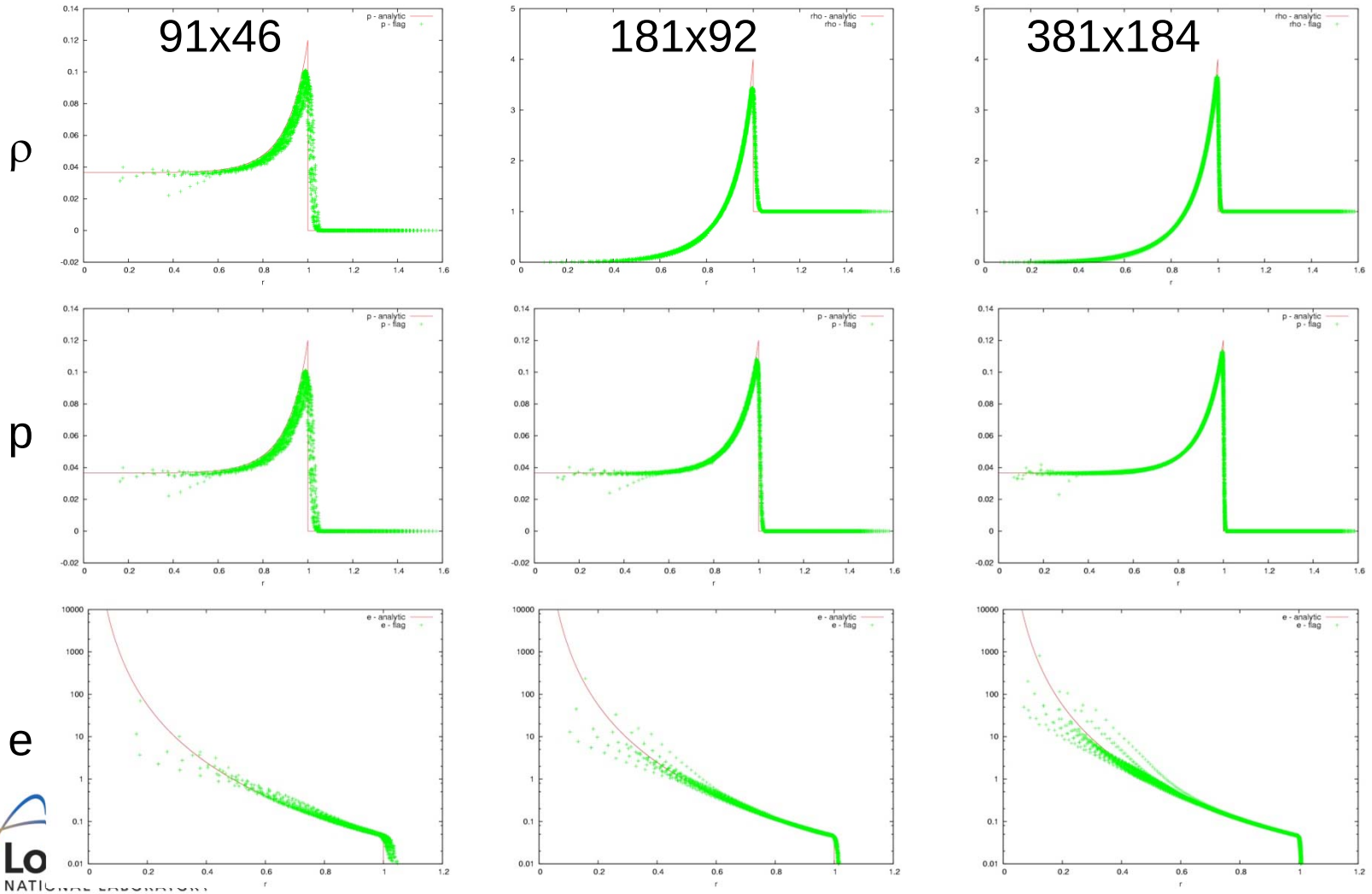


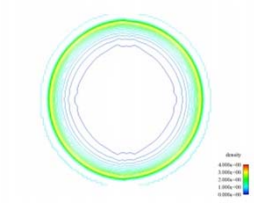




Point source: Lagrange: conservative RZ hydro



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



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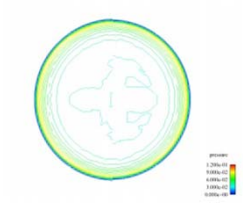

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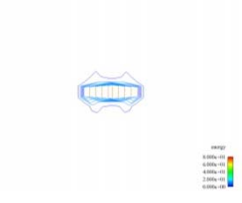

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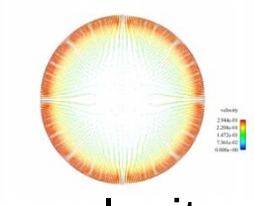
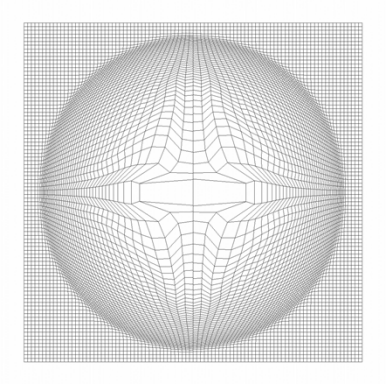
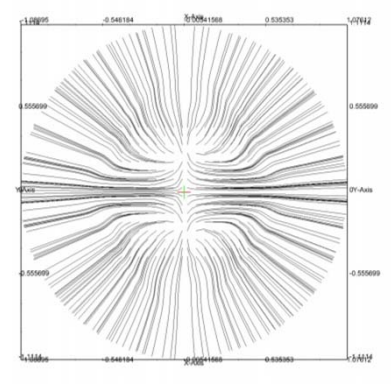


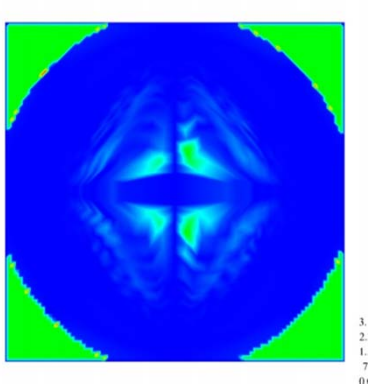
velocity



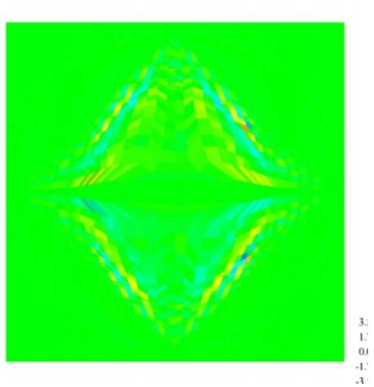
mesh



streamlines

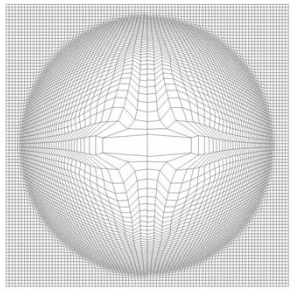
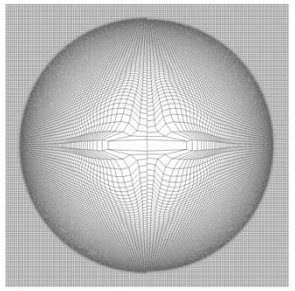
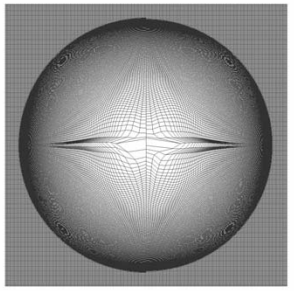
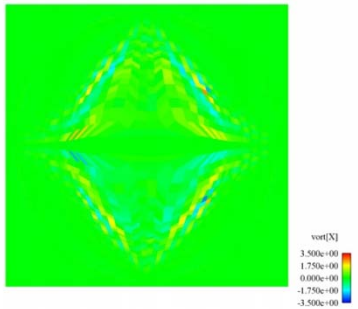
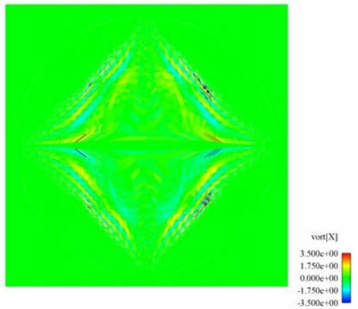
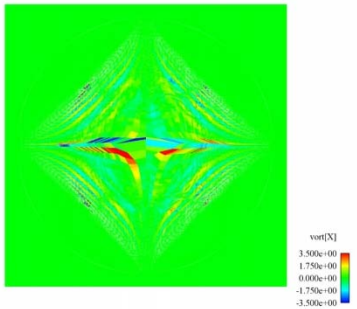


angular deviation from radial

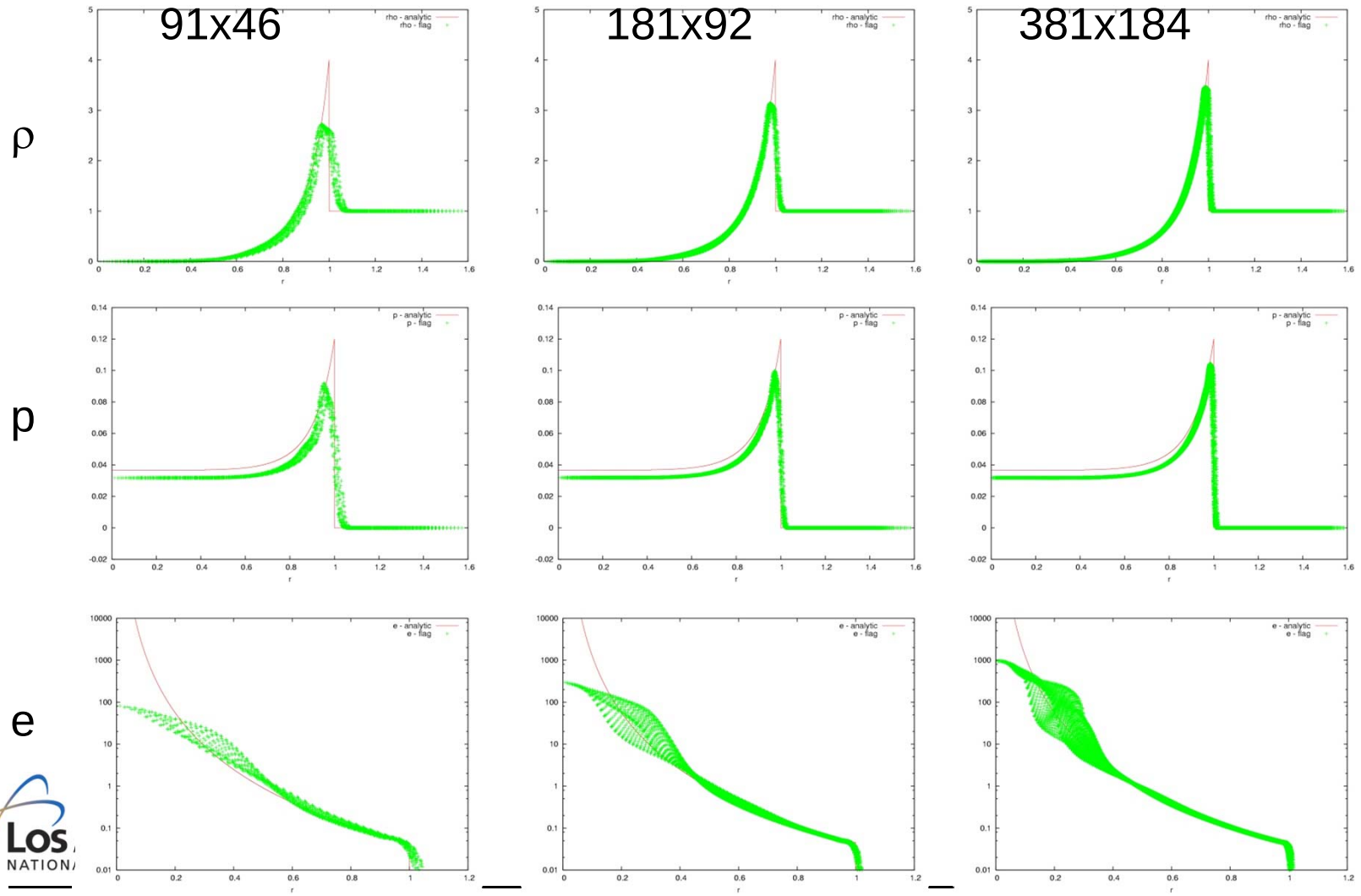


vorticity

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

	91x46	181x92	381x184
mesh			
vorticity			

Point source: Eulerian ALE: without KE fixup



Point source: Eulerian ALE: with KE fixup

91x46 181x92 381x184

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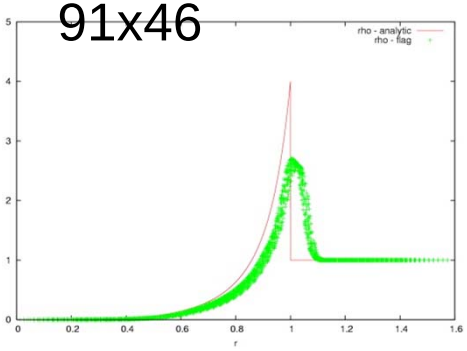

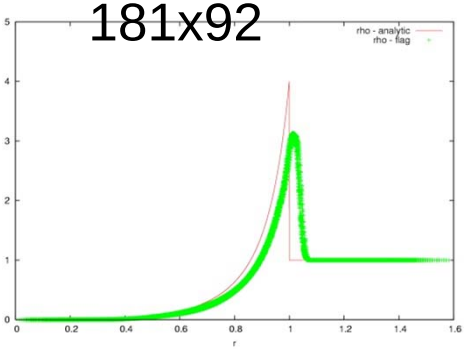

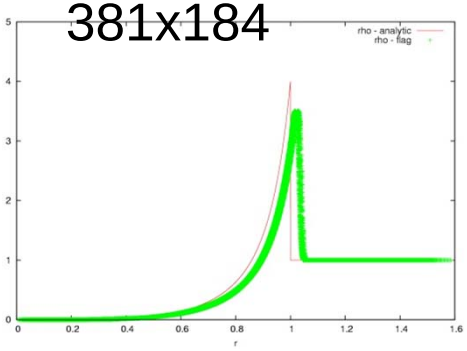

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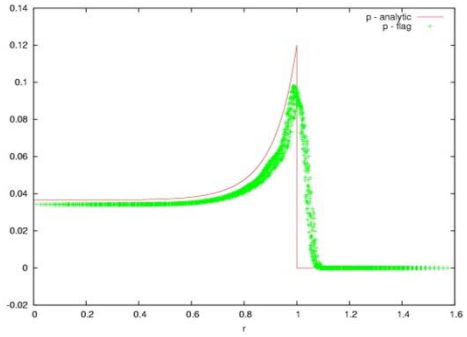

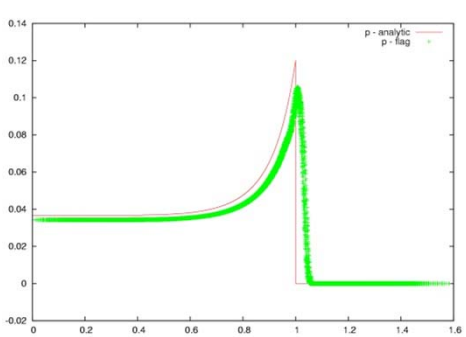

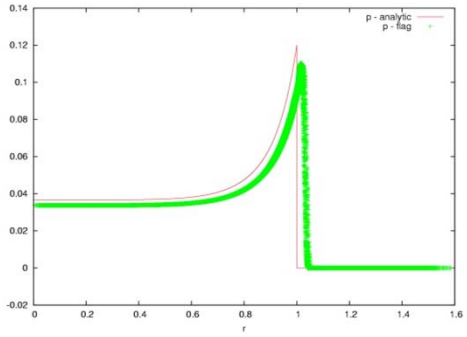

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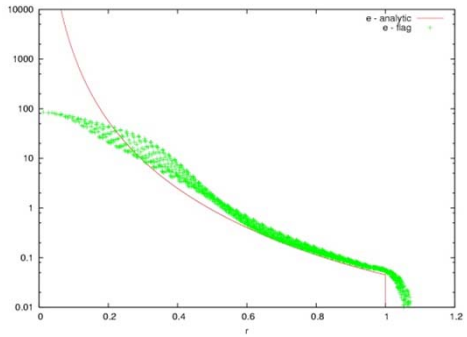
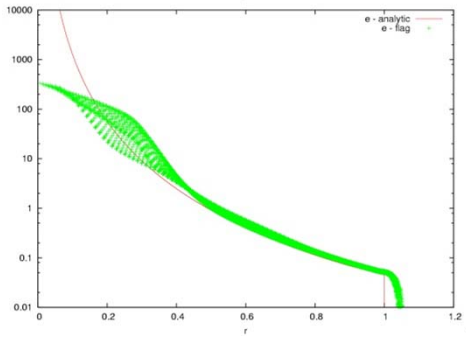
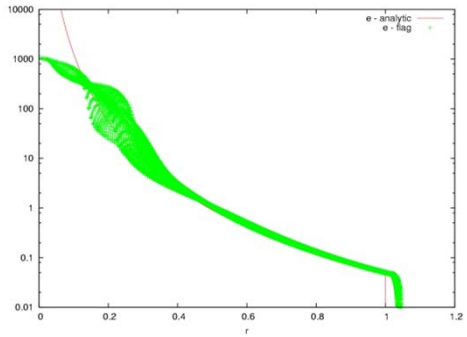
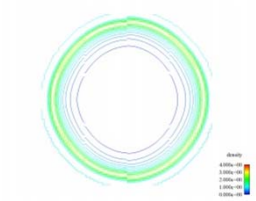






Point source: ALE comparisons at 91x46: with or without the KE fixup



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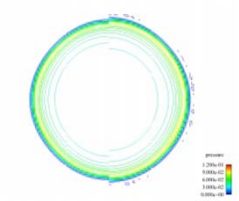

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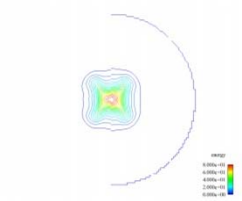

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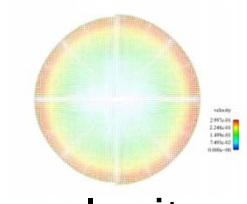
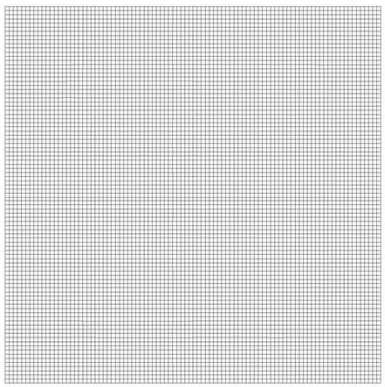


velocity



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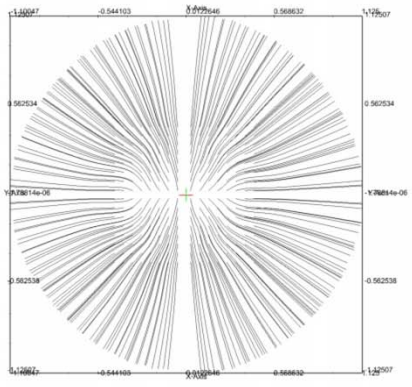
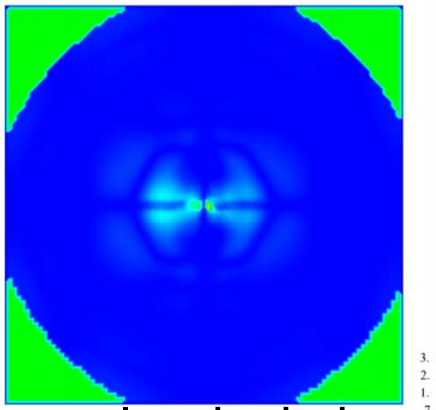
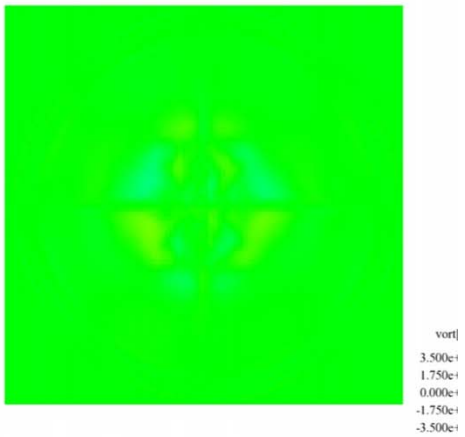


streamlines



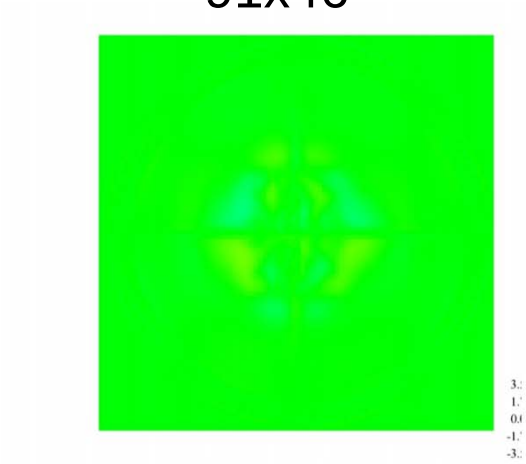
angular deviation from radial



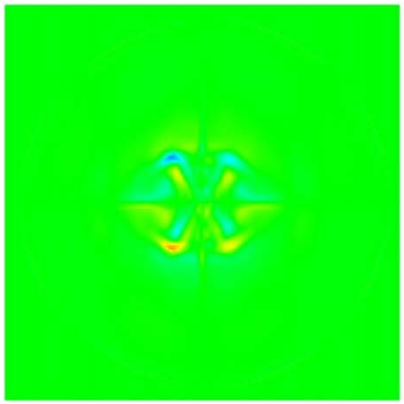
vorticity

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

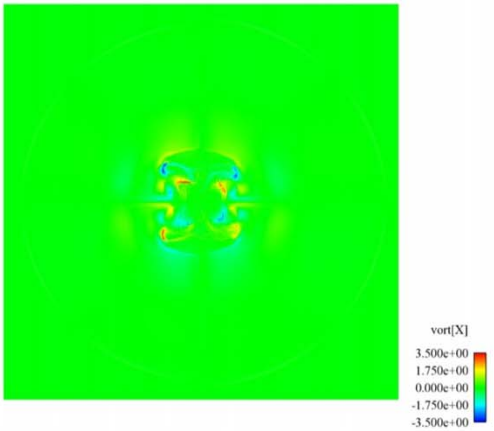
91x46



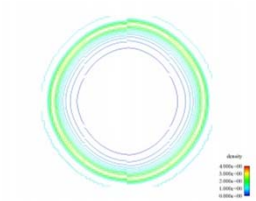
181x92



381x184



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



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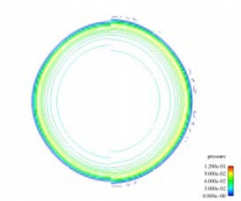

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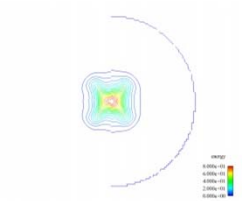

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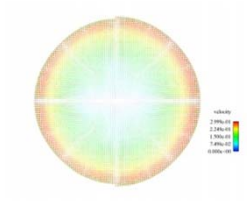
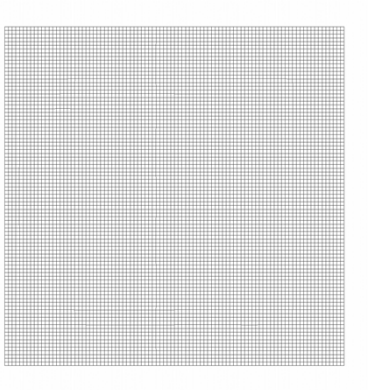
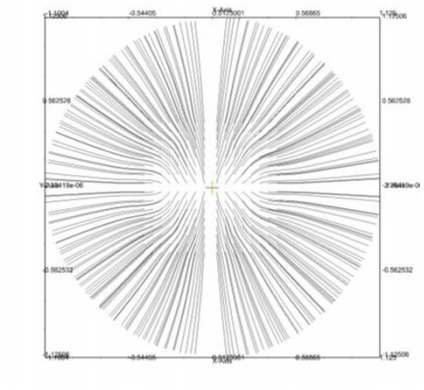


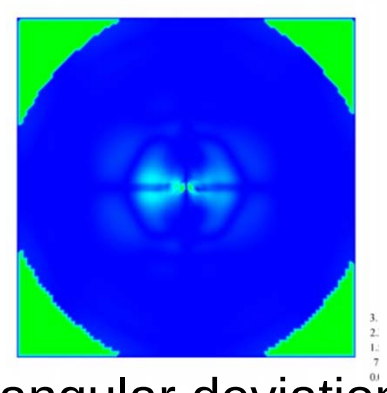
velocity



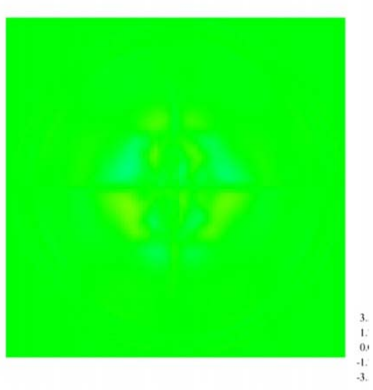
mesh



streamlines



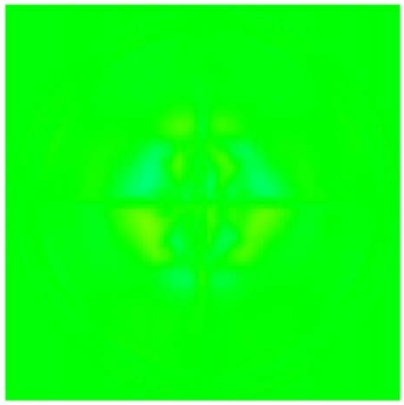
angular deviation from radial



vorticity

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

91x46



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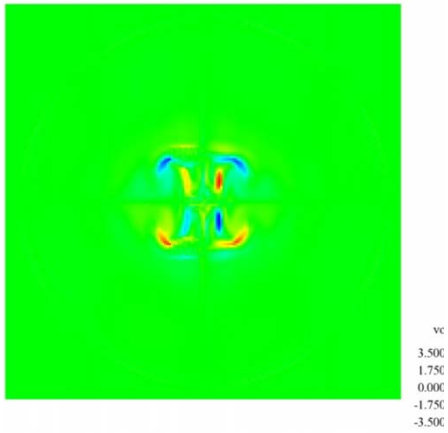

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