



# What's New in ML?

## New Features in Trilinos 8.0

Chris Siefert (1416)

Jonathan Hu (1416) and Ray Tuminaro (1416)

Sandia National Laboratories

SAND #2007-7152C



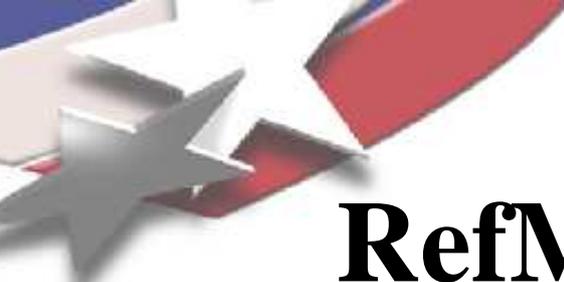
# Outline

- Performance Improvements.
- RefMaxwell: A New Solver for Maxwell's Equations.
- Parameter List Validation.
- What's next?



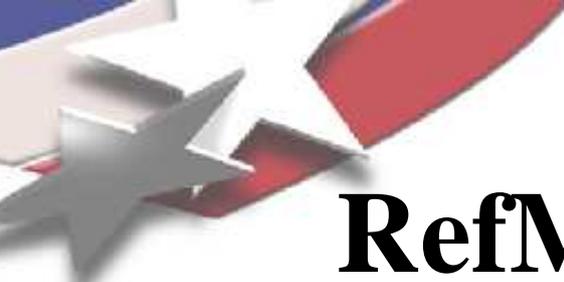
# Performance Improvements

- Scalability improvements: SA, Maxwell (Jonathan Hu).
- NSSA now works in parallel (Ray Tuminaro).
- Bugfixes, incremental improvements (Everybody).



# RefMaxwell

- Motivation: Better solver for eddy current Maxwell's equations.
- Required Packages: Epetra, EpetraExt and Teuchos.
- Location: src/RefMaxwell
- Is not part of MultiLevelPreconditioner.



# RefMaxwell: Mathematics (1)

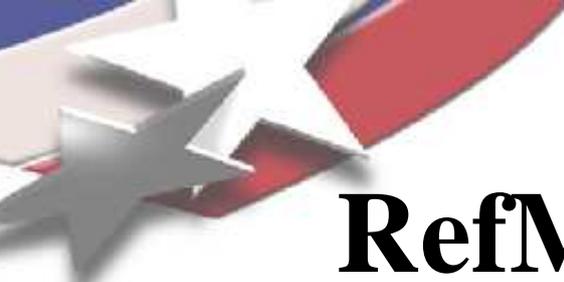
- Eddy current Maxwell's equations:

$$\nabla \times \frac{1}{\mu} \nabla \times \mathbf{E} + \sigma \mathbf{E} = f$$

- Use discrete Hodge decomposition:

$$\mathbf{E} = a + \nabla \phi$$

where  $\nabla \cdot a = 0$ .



# RefMaxwell: Mathematics (2)

- Since  $\nabla \cdot a = 0$ , add  $\nabla \nabla \cdot a$  to 1st equation:

$$\begin{bmatrix} \nabla \times \nabla \times + \nabla \nabla \cdot + \sigma & \sigma \nabla \\ \nabla \cdot \sigma & \nabla \cdot (\sigma \nabla) \end{bmatrix} \begin{bmatrix} a \\ \phi \end{bmatrix} = \begin{bmatrix} f \\ \nabla \cdot f \end{bmatrix}$$

- Implicitly block-diagonally precondition with two AMG preconditioners.

# RefMaxwell: Mathematics (3)

$$\begin{bmatrix} \nabla \times \nabla \times + \nabla \nabla \cdot + \sigma & \sigma \nabla \\ \nabla \cdot \sigma & \nabla \cdot (\sigma \nabla) \end{bmatrix} \begin{bmatrix} a \\ \phi \end{bmatrix} = \begin{bmatrix} f \\ \nabla \cdot f \end{bmatrix}$$

- Idea: Reformulate  $\nabla \times \nabla \times$  to Laplacian.
- **Nodal Laplacian**  $\Rightarrow$  standard AMG good.
- **Edge Laplacian**  $\Rightarrow$  standard AMG not good.
- Idea: Special grid-transfer, so **Edge Laplacian**  $\Rightarrow$  vector nodal Laplacian.
- SISC paper in review (w/ Bochev, Hu and Tuminaro).

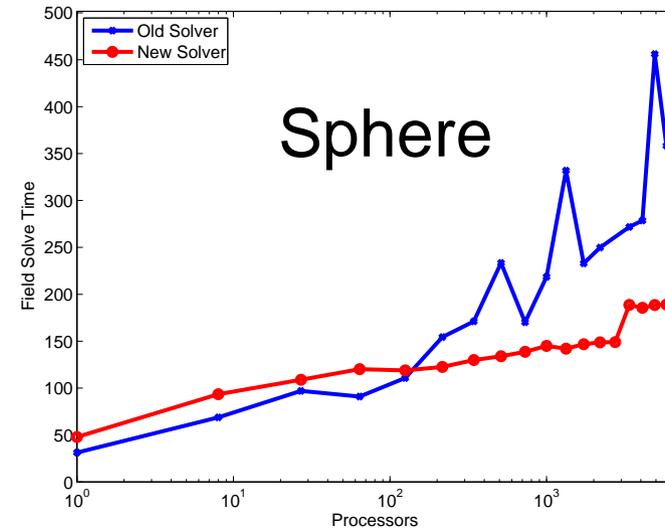
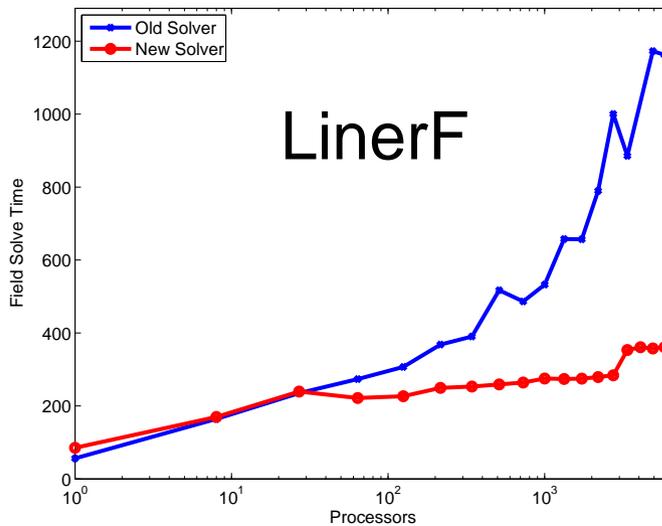
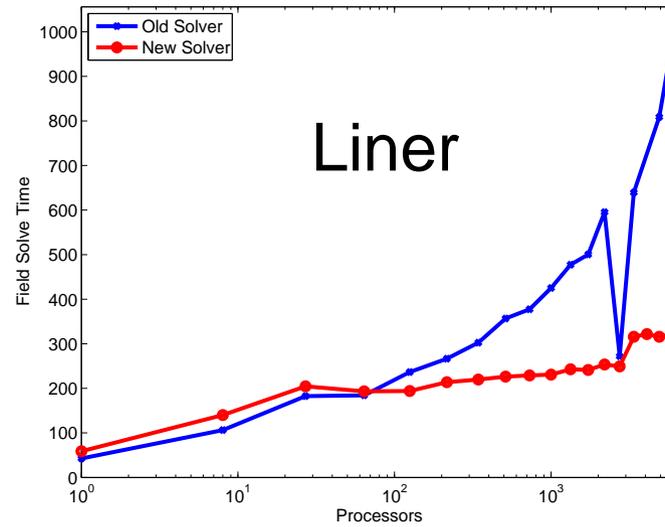
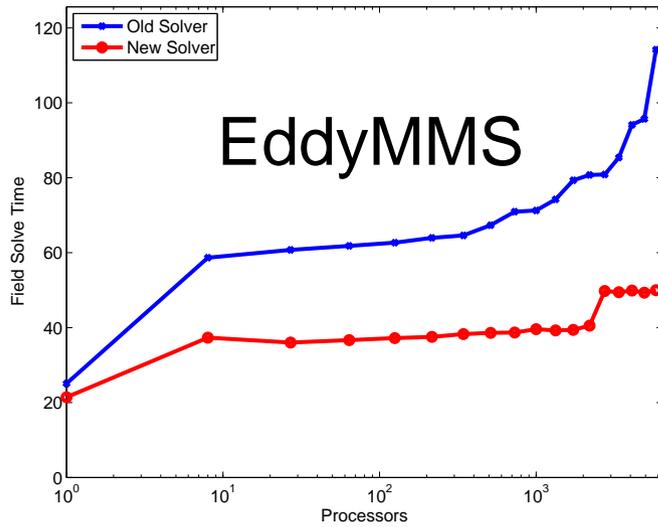


# Why RefMaxwell?

- Decouples edge/node hierarchies on coarse levels.
- Uses MultiLevelPreconditioner(SA) on both subproblems.
- Avoids complexities of existing Maxwell solver.
- Allows rapid deployment of new SA technology.
- Better parallel scalability.

# Scaling: Maxwell vs. RefMaxwell

Solve Time



Number of Processors



# Parameter List Validation

- Motivation: Make sure options on the Teuchos ParameterList are correct.
- This is on by default in Trilinos 8.0.
- Option names and types are checked to ensure correctness (not silently ignored).
- Used by MultiLevelPreconditioner and RefMaxwell.



# Sample Output

```
Error, the parameter {name="this option should fail",type="int",value="1"}
in the parameter (sub)list "ANONYMOUS"
was not found in the list of valid parameters!
```

The valid parameters and types are:

```
{
  "ML debug mode" : bool = 0
  "ML output" : int = 0
  .
  .
  .
  "z-coordinates" : double* = 0
  "zero starting solution" : bool = 1
}
```

```
Throw number = 1
```

```
ERROR: ML's Teuchos::ParameterList contains an incorrect parameter!
```



# What's next in ML?

- Enhanced dropping capabilities in aggregation.
- Continued scalability improvements.
- Use of sublists rather than **(level x)** parameters.
- More RefMaxwell performance enhancements.