AORSA

All **OR**ders **S**pectral **A**lgorithm

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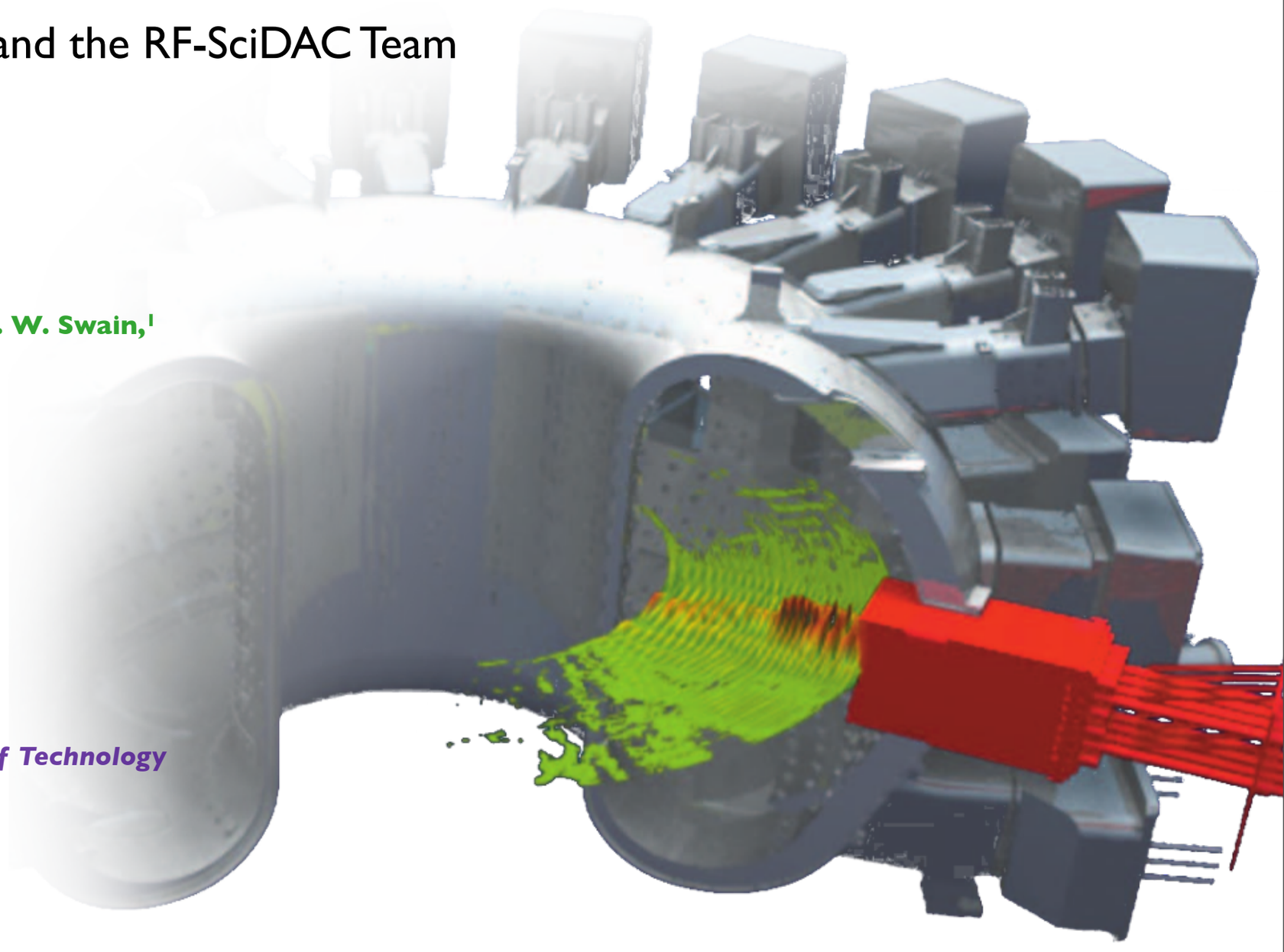


SciDAC
Scientific Discovery through Advanced Computing

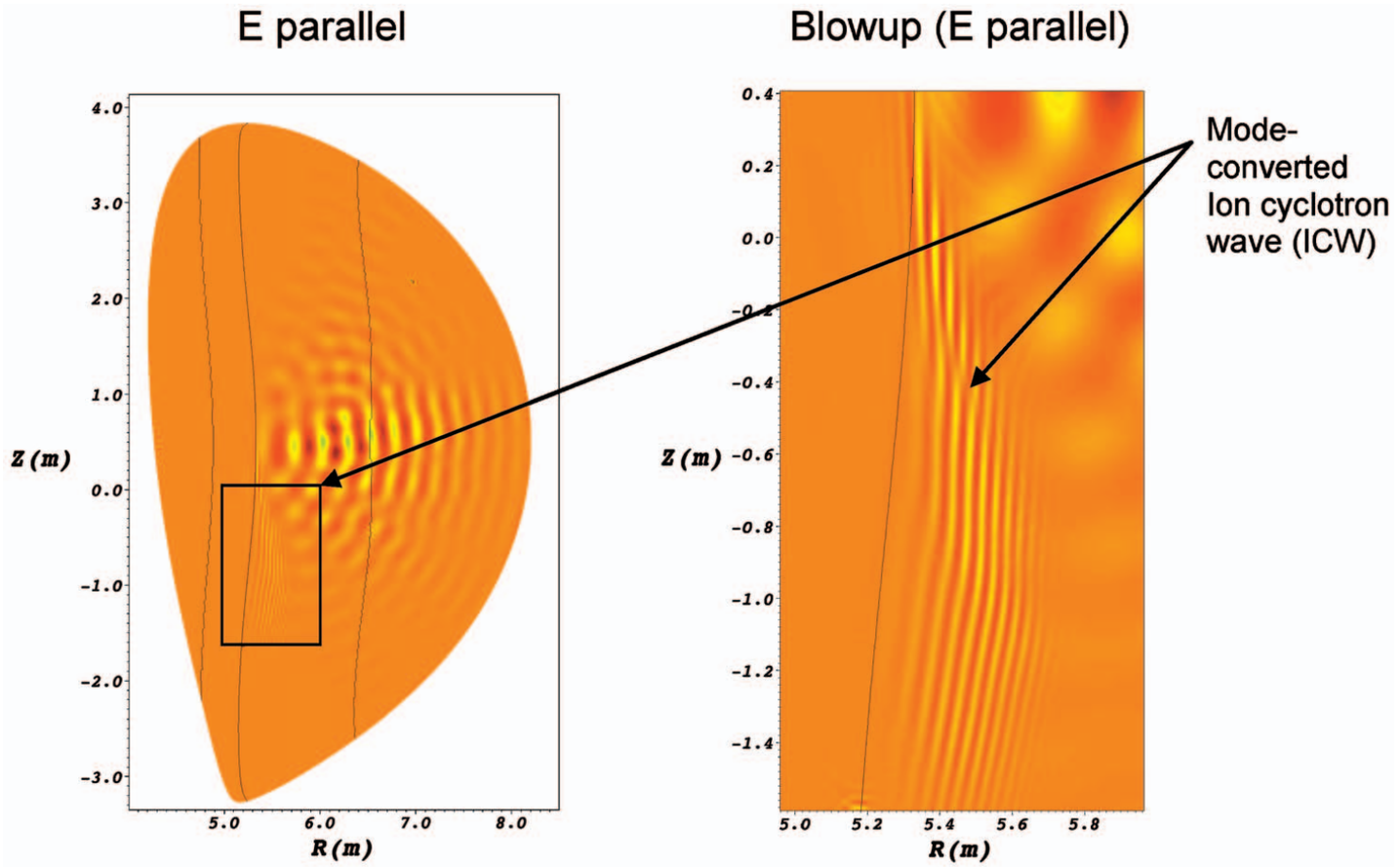
Some rf Physics

$$-\nabla \times \nabla \times \mathbf{E} + \frac{\omega^2}{c^2}\left(\mathbf{E} + \frac{i}{\omega\epsilon_0}\mathbf{J}_P\right) = -i\omega\mu_0\mathbf{J}_A$$

- Solves Maxwells equations using a pseudospectral method in the frequency domain

$$\mathbf{J}_P(\mathbf{r}) = \int d\mathbf{r}'\sigma(\mathbf{r}, \mathbf{r}' - \mathbf{r}) \cdot \mathbf{E}(\mathbf{r}')$$

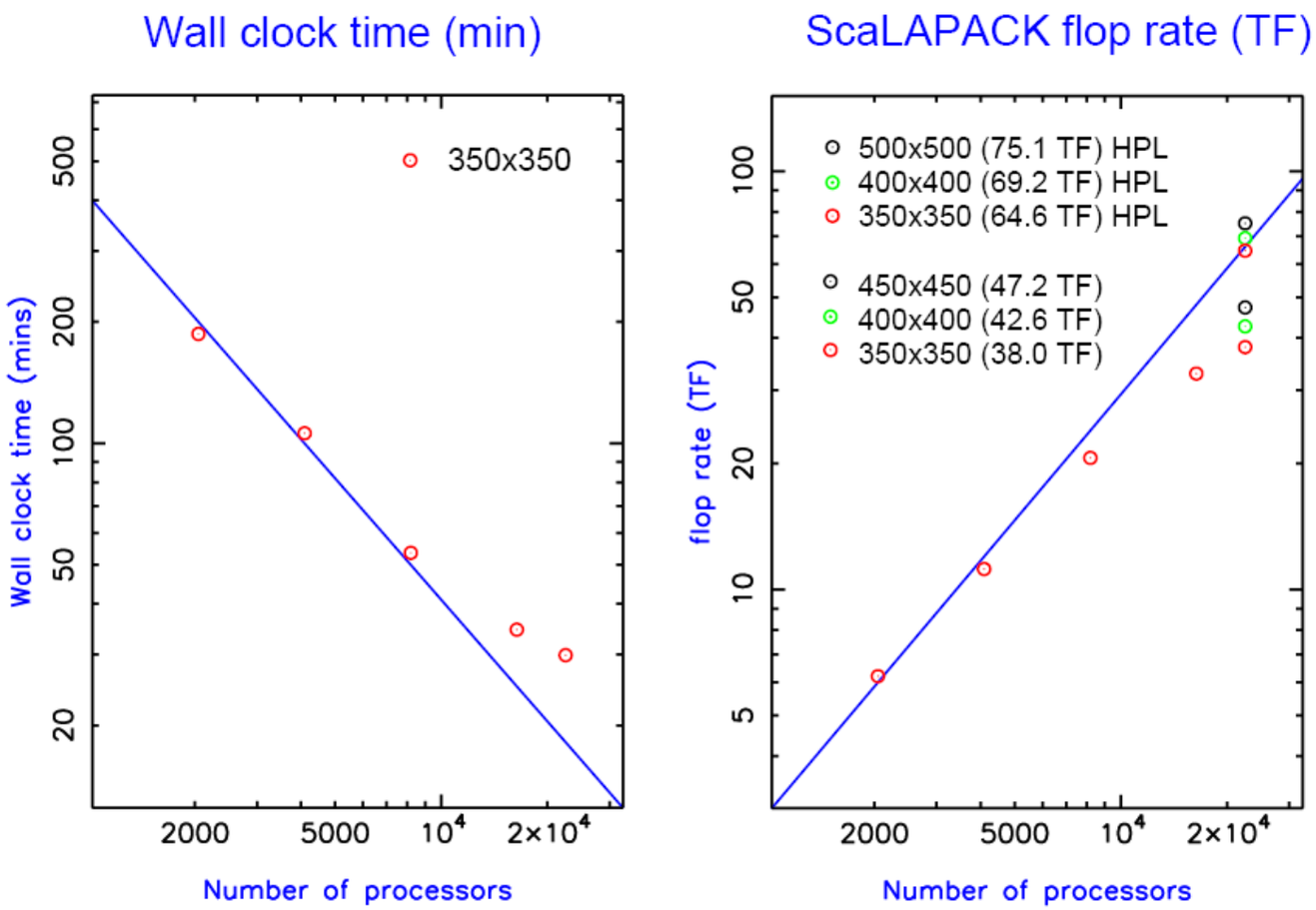
- Uniform, rectangular mesh
  (non-local plasma current makes multi-domain patching interesting)
- 2D (sum 2D modes to get 3D)
- e.g., 512x512x3 linear equations



Mode conversion of the fast wave to the slow ion cyclotron wave in ITER scenario 4 at half density, = -27
[Jaeger et al, Phys. Plasmas **15** (2008), 072513]

The solve

- At scale we have a dense, linear, double complex solve (zgesv) with ~10^6 unknowns
- >10 TB required memory
- ScaLAPACK showed some roll off above 10^4 procs, modified HPL seemed to correct this
- However ...
  - this is only the solve
  - post processing and matrix fill are not included
  - poor memory management limits us to <600x600 spatial mesh



Efficiency problems ...

- Post processing is of same order runtime as the solve
  (quasi-linear diffusion coefficient calculation)
- Non-uniform 4D dependence in workload created load balancing issues due to uniform 2D parallelization scheme
  (random parallelization of 4D work list seems to fix this)
- Matrix fill and post processing are now data parallel and exhibit nice scaling but poor FLOPS/s
  (Communication is insignificant, so really a serial performance problem)
- 10 years old ... F77 (ick), modernization and kernelization? underway to help understand lack of efficiency
- GPU effort is helpful

Code coupling

- A major component of the RF-SciDAC is coupling related physics codes
  (e.g., non-Maxwellian, self-consistent ion cyclotron resonant heating requires coupling Full-Wave and Fokker-Planck codes via diffusion coefficients and distribution functions)
- I/O using pNetCDF
  (F77 bindings only)
- Passing data between small and large codes is becoming a problem
  (Available memory mismatch)
- Large I/O needing new data compression algorithms
  (Proper Orthogonal Decomposition in 4D or SVD)