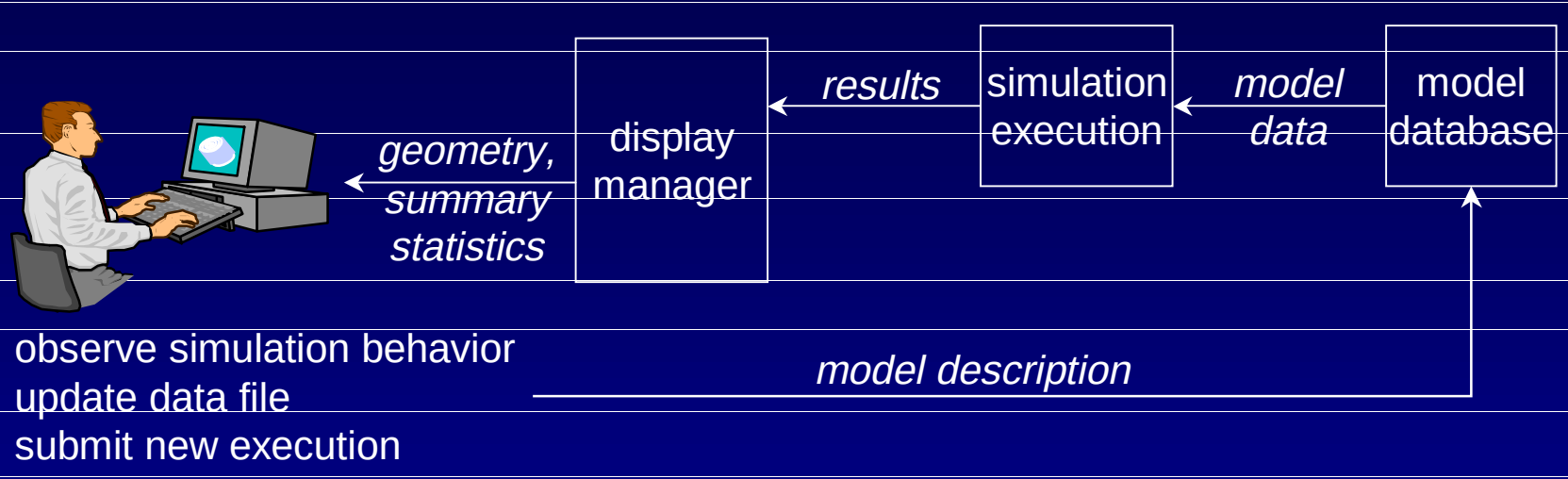
A Computational Steering System for Studying Microwave Interactions with Missile Bodies

J. Edward Swan II, Marco Lanzagorta, Doug Maxwell, Eddy Kuo, Jeff Uhlmann, Wendell Anderson, Haw-Jye Shyu, William Smith

Naval Research Laboratory (NRL)
Washington, DC

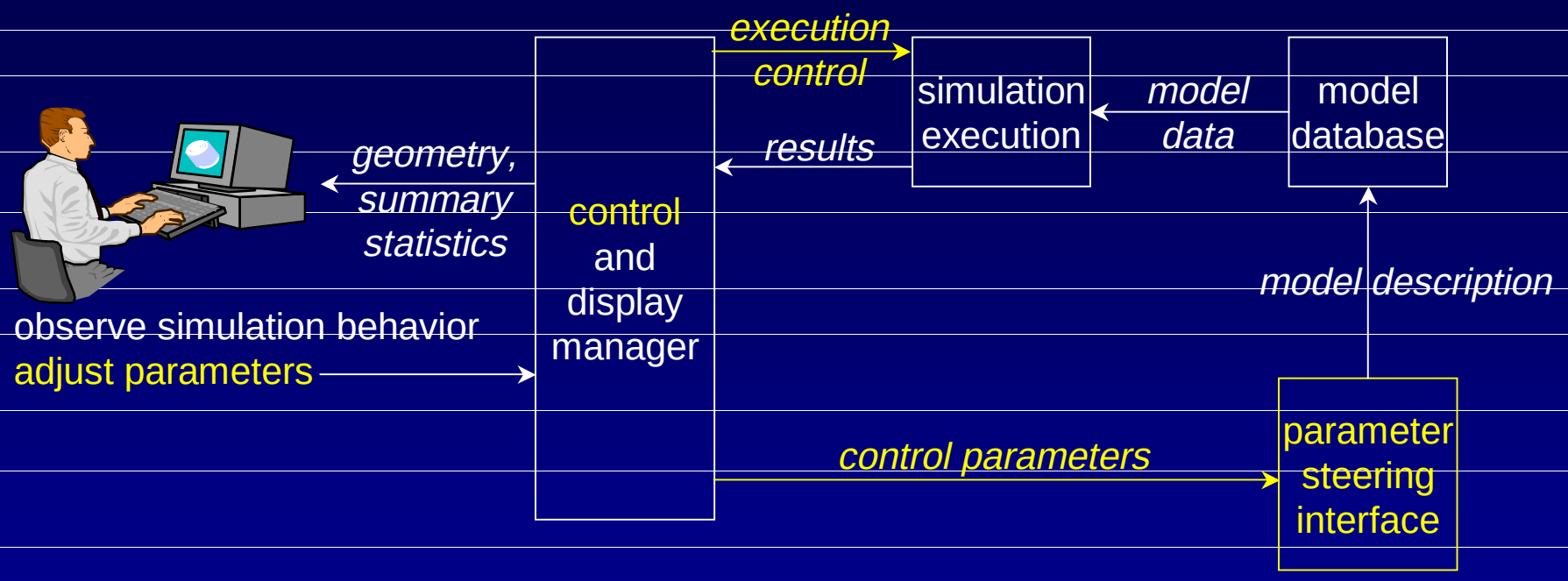
Simulation Batch Processing



Problems of batch processing versus interaction:

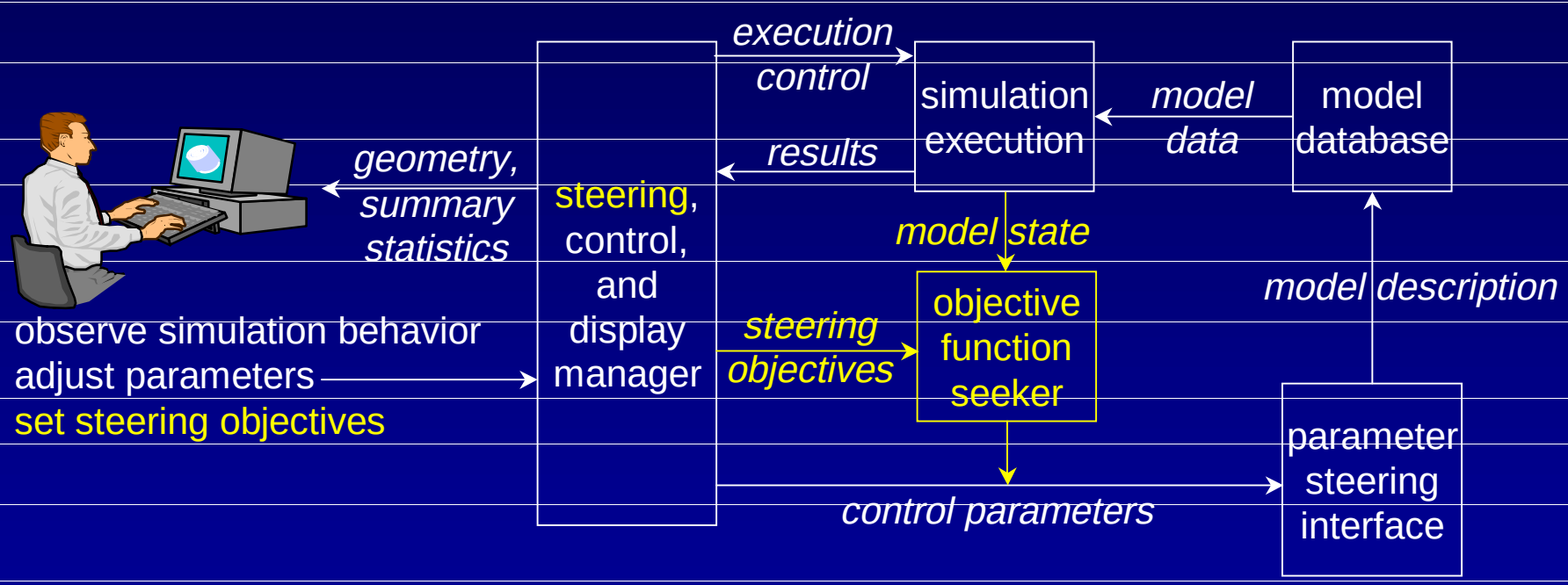
- **Model updates complex**
- **Iteration time interval**
- **Difficult to explore parameter space**

Computational Steering Systems



+ **Interactivity**
+ **Intuitive control**
– **Still difficult to explore complex parameter space**

Inverse Steering



Application Area

General Area:

- Simulating microwave interactions

Applied Area:

- Microwave Interactions with Missile Bodies

Result of Most Interest:

- Hot spot locations and intensities
- Hot spots can interfere with missile electronics
- Designers can protect electronics from hot spots

Computational Issues

HASP algorithm:

- Simulating microwave interactions requires solutions to Maxwell's equations
- J. Cole [94, 97a, 97b] developed HASP algorithm at NRL
- Motivated the current work

Supercomputer Implementation of HASP algorithm:

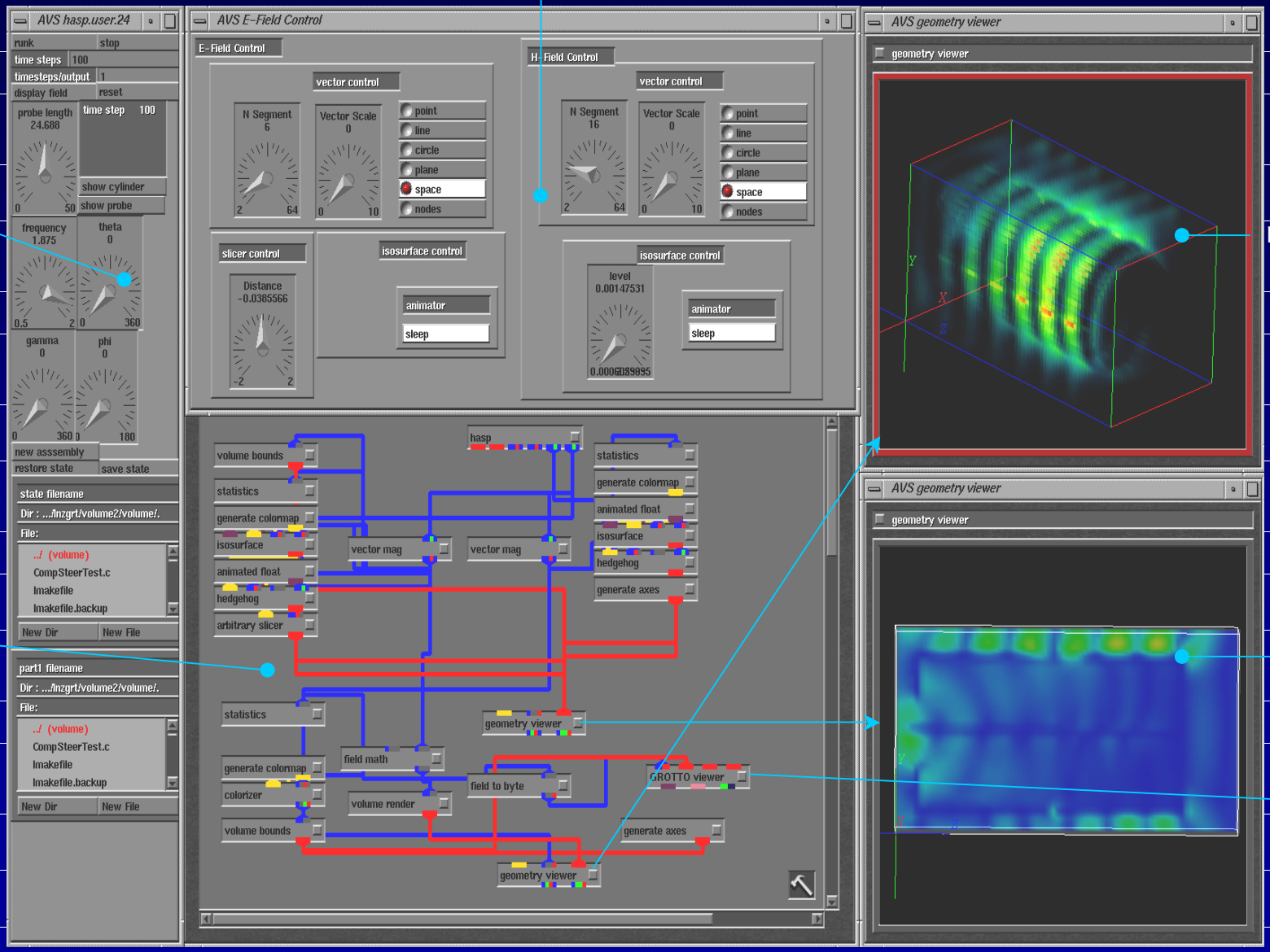
- Used NRL's 128 processor SGI Origin 2000
- Automatic parallelization with SGI MISPRO Fortran90 compiler
- Scalar code hand optimized
- Results:
  - calculate time step: few tenths of second
  - achieve steady state: in few minutes

Visualization Interface

display parameters

simulation and steering controls

visualization network

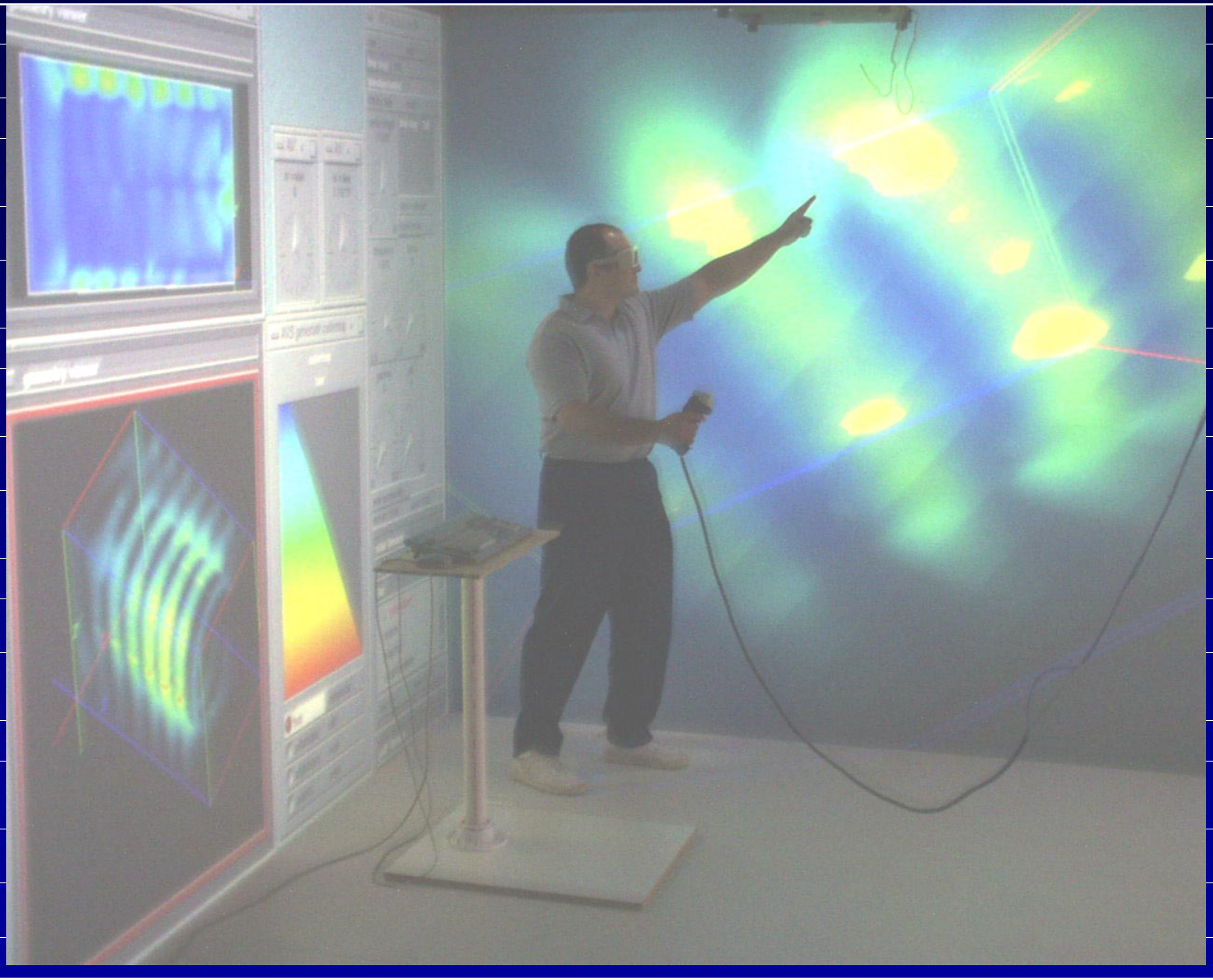


volume rendered output

slice plane output

VR output

Virtual Reality Interaction



Virtual Reality Effectiveness

Does the CAVE really help?

What we learned:

- + Large format big win
- + Data manipulation easier with 6 DOF wand
- + Can stand inside data, avoid obscuring data
- + Really impress visitors and sponsors

- – Sense of immersion not useful
- – Have to travel to CAVE facility

CAVE primarily used for meetings, discussions, and presentations

Visualization Issues

Challenging visualization problem:

- **Time-varying**
- **Two vector fields at every data point**
- **No direct visualization of even one vector field!**
- **Domain and range multi-dimensional**

Easy: summary statistics (energy density)

Hard: underlying geometry & topology

Ineffective Visualization Techniques

Hedgehogs

- + understanding global structures
- – local structures
- – clustering and overlapping

Streamlines

- – disjointed and periodic streamline bundles
- – clustering and overlapping

Particle Systems

- + avoids the crowding effects of streamlines and hedgehogs
- – overloads time; already used to display field evolution

Isosurfaces

- – could not track complex field structures

Effective Visualization Techniques

Slice Planes

- Color coded by energy density

+ Can visualize both local and global structures
+ Avoid clustering effects
– Show relatively small part of computational space

Volume Rendering

- Color coded by energy density
- Transparency mapping key parameter for understandable visualizations
- Locate interesting parts of dataset

+ Visualize both local and global structures
– Internal features can be hidden

Inverse Steering: Motivation

Primary application interest:

- Field evolution
- Hot spots in steady state solution

Forward steering:

- Good for field evolution
- Not so good for steady state solution

Inverse Steering Module:

- Define properties of steady state solution
- Optimized search for steering parameters that meet steady state solution

Inverse Steering: Virtual HASP

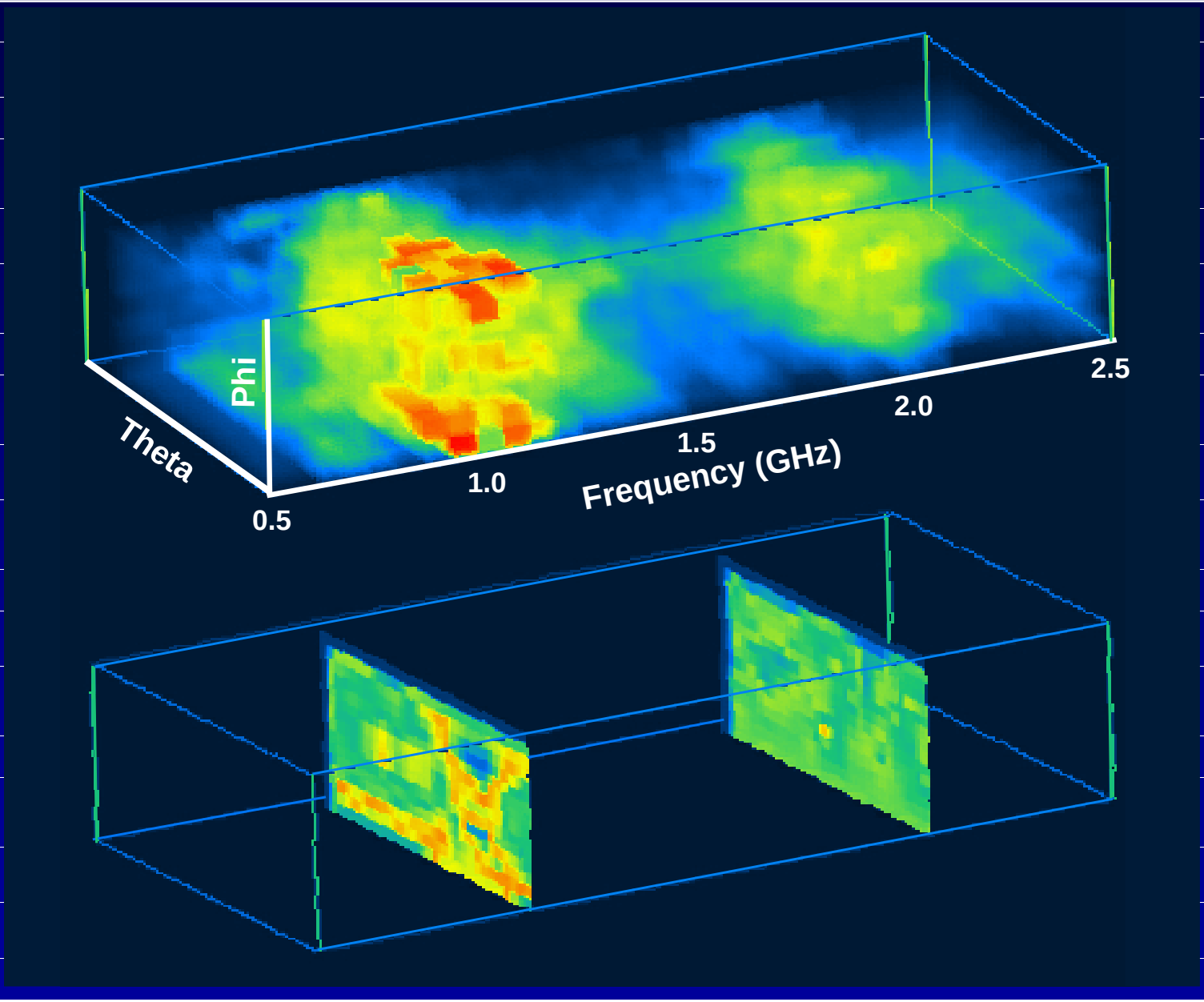
Limitations of Inverse Steering:

- Explored many objective functions
- Several hours per computation
- Back in the realm of batch computing

Virtual HASP Experiment:

- Pre-compute steady state from steering parameter 4-space
- Virtual HASP returns steady-state in 10 ms

Interesting Inverse Steering Result



Conclusions

System features:

- Implemented within standard AVS interface
- User manipulates high-level control parameters
- User interacts with running simulation
- Supports inverse steering
- Supports interaction with VR devices

Lessons Learned:

- Simple slice planes were very useful
- Interactivity very important
- Building on an existing tool (AVS) a big win
- Main advantage of CAVE: large format, impressive

Acknowledgements

Collaborators: ***Merv Rosen*** **and** ***Mike Haftel*** **from Directed Energy Effects Branch;** ***James Cole*** **from Advanced Information Technology Branch; and** ***Larry Rosenblum***

Sponsors: ***Naval Research Laboratory*** **and** ***Office of Naval Research***

Access to the SGI Origin 2000 was possible under the ***DoD High-Performance Computer Modernization Program***

Special thanks to our System Administrators ***Gary Samuels*** **and** ***Toni Miller***

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