The Center for Astrophysical Thermonuclear Flashes

FLASH, a Modern, Well Tested, Multiphysics Application Code that Scales from Laptops to the Largest Supercomputers

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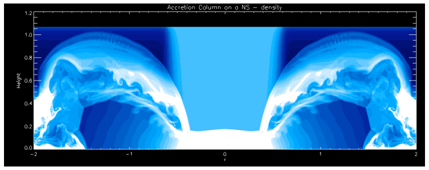
The FLASH Code Contributors

- Current Group:
  - Klaus Weide, Chris Daley, Lynn Reid, Paul Rich and Anshu Dubey

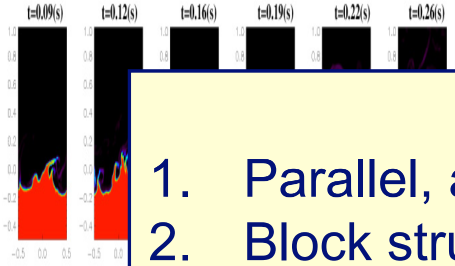
- Other Current Contributors:
  - Dongwook Lee, Paul Ricker, Dean Townsley, Cal Jordan, John Zuhone, Kevin Olson, Marcos Vanella

- Past Major Contributors:
  - Katie Antypas, Alan Calder, Jonathan Dursi, Robert Fisher, Timur Linde, Tomek Plewa, Katherine Riley, Andrew Siegel, Dan Sheeler, Frank Timmes, Natalia Vladimirova, Greg Weirs, Mike Zingale

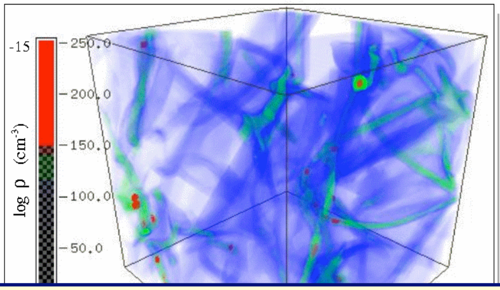
FLASH Capabilities Span a Broad Range…

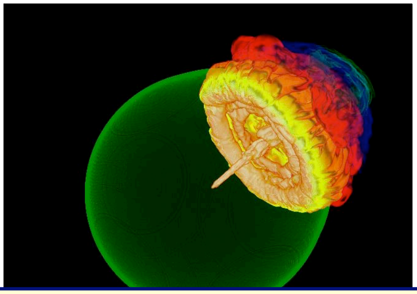


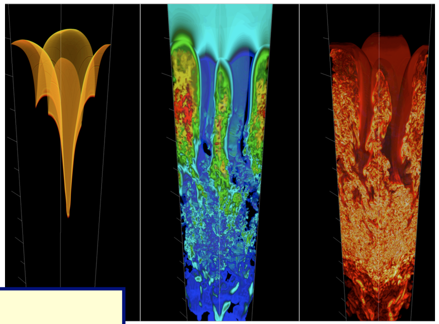
Shortly: Relativistic accretion onto NS



Wave break



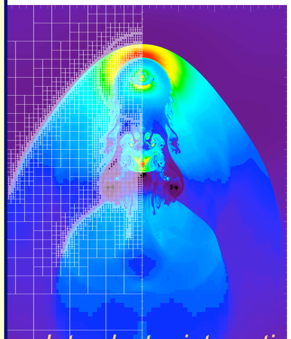




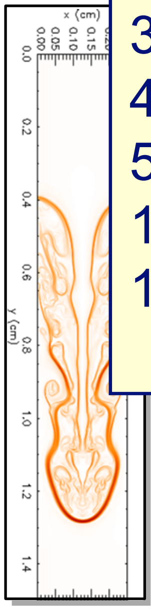
clear Burning

The FLASH code

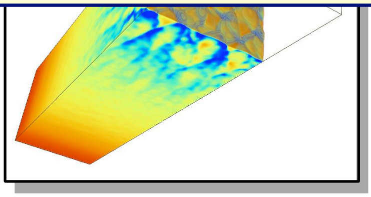
1. Parallel, adaptive-mesh refinement (AMR) code
2. Block structured AMR; a block is the unit of computation
3. Designed for compressible reactive flows
4. Can solve a broad range of (astro)physical problems
5. Portable: runs on many massively-parallel systems
11. Scales and performs well
12. Fully modular and extensible: components can be combined to create many different applications



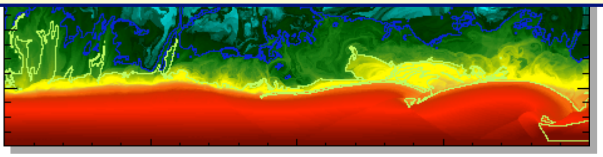
Intracluster interactions



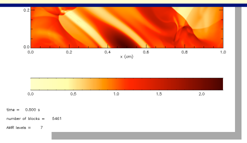
Magnetic Rayleigh-Taylor



Cellular detonation



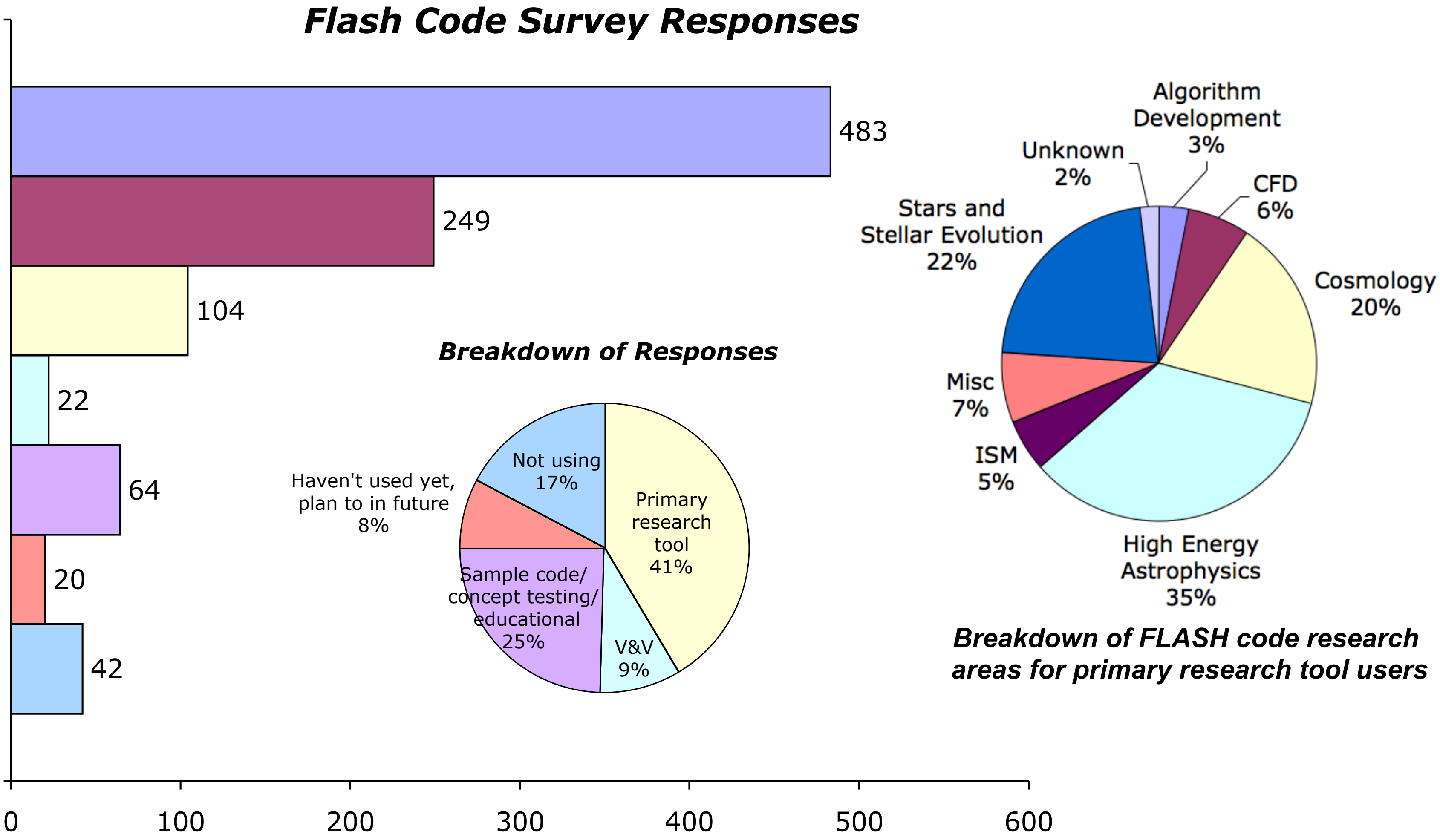
Helium burning on neutron stars



Orzag/Tang MHD vortex

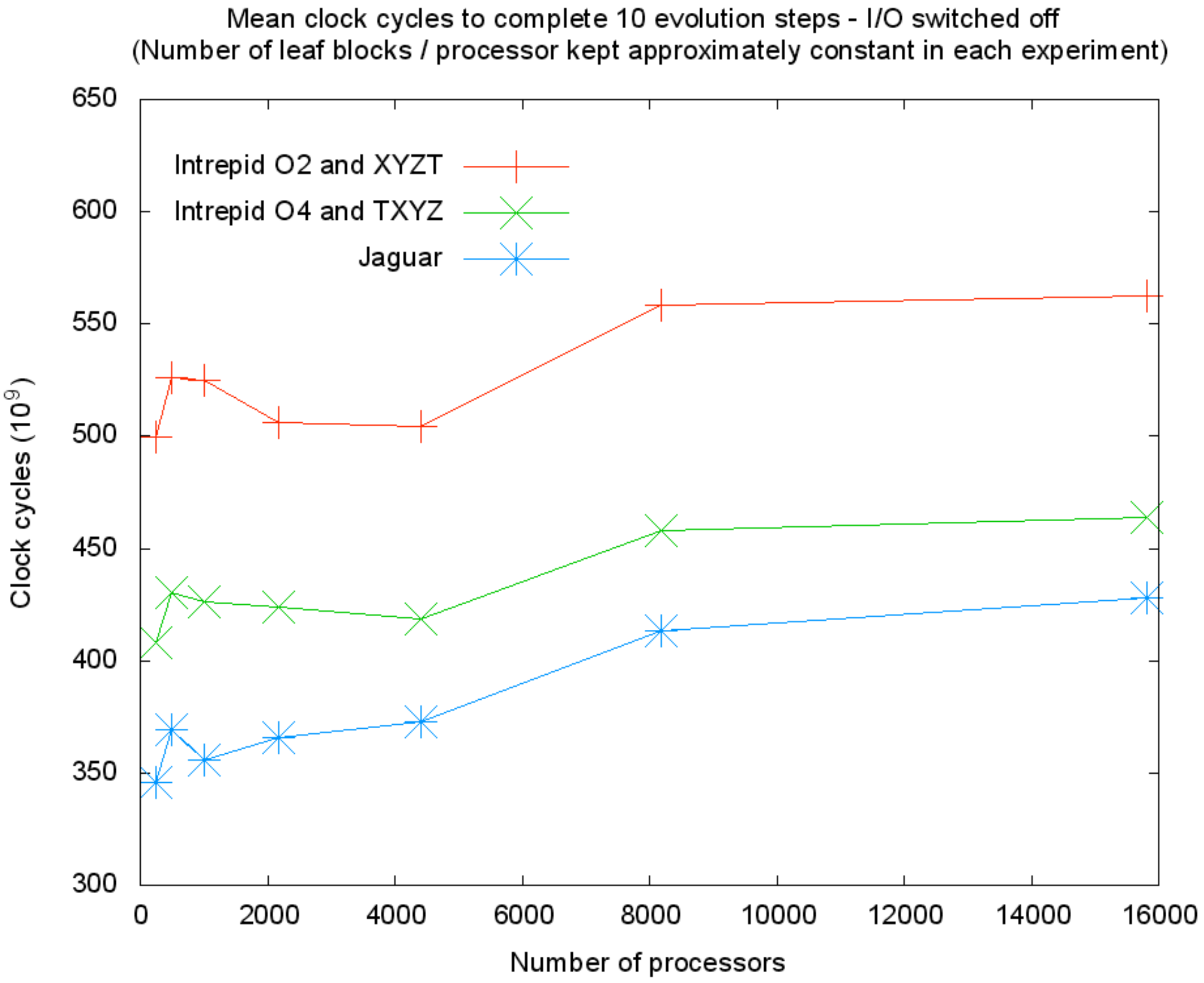
Richtmyer-Meshkov instability

FLASH Users Community (2007 survey)



Breakdown of FLASH code research areas for primary research tool users

FLASH Performance



FLASH Basics

- An application code, composed of units/modules. Particular modules are set up together to run different physics problems.
- Fortran, C, Python, …
  - More than 500,000* lines of code, 75% code, 25% comments
- Very portable, scales to tens of thousand processors

Capabilities

- Infrastructure
  - Configuration (setup)
  - Mesh Management
  - Parallel I/O
  - Monitoring
    - Performance and progress
  - Verification
    - FlashTest
      - Unit and regression testing

- Physics
  - Hydrodynamics, MHD, RHD
  - Equation of State
  - Nuclear Physics and other Source Terms
  - Gravity
  - Particles
  - Material Properties
  - Cosmology

Auditing Process

- SVN for Version Control
- Test Suite
- Online Coding Violation Tracking and Bugzilla
  - Unfinished tasks, bugs, bad code, developer queries
- Profiling Tools
  - Memory / speed diagnostic tools
  - External tools like JUMPSHOT / PAPI / TAU
- Documentation
  - Online documentation for Unit APIs -- ROBODOC
  - User’s guide in HTML and PDF
  - “Howto” available for developers, various platforms
  - Email users’ group

FLASH Units

- FLASH basic architecture unit
  - Component of the FLASH code providing a particular functionality
  - Different combinations of units are used for particular problem setups
  - Publishes a public interface for other units' use
  - Can have more than one subunit
  - Can have multiple alternative implementations, including null implementation
  - Individual routines can be customized
- Inheritance through configuration tool and directory structure
- Interaction between units governed by the Driver
- Not all units are included in all applications

FLASH Setup Script: Implements Architecture

Python code links together needed physics and tools for a problem

- Parses Config files to
  - Determine a self consistent set of units to include
  - If a unit has multiple implementations, finds out which implementation to include
  - Get list of parameters from units
  - Determines solution data storage
- Configures Makefiles properly
  - For a particular platform
  - For included Units
- Implements inheritance with unix directory structure
- Provides a mechanism for customization

Runtime Environment

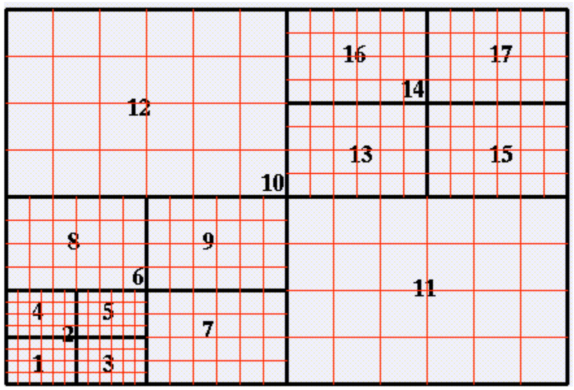
- Collection of all “Parameters” declared in all the Config files parsed by the setup.

- File “setup_params” generated by the setup contains all runtime parameters found, and their initial value

- The initial values are picked from Config files. They can be overwritten by including them in “flash.par”

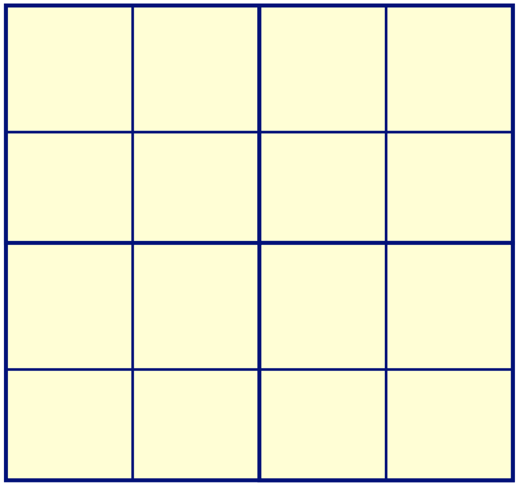
Infrastructure : Mesh Packages in Flash

Paramesh



- ❑ Block Structured
- ❑ Fixed sized blocks
- ❑ Specified at compile time
- ❑ Not more than one level jump at fine coarse boundaries

Uniform Grid



- ❑ one block per proc
- ❑ No AMR related overhead

I/O Libraries

- FLASH works with 2 different I/O libraries
  - HDF5
  - Parallel-NetCDF
- Use MPI-IO mappings
- Both Portable libraries
- Scientific Data mostly stored in multidimensional arrays

- FLASH3 also supports a basic direct FORTRAN I/O -- use only as a last resort!