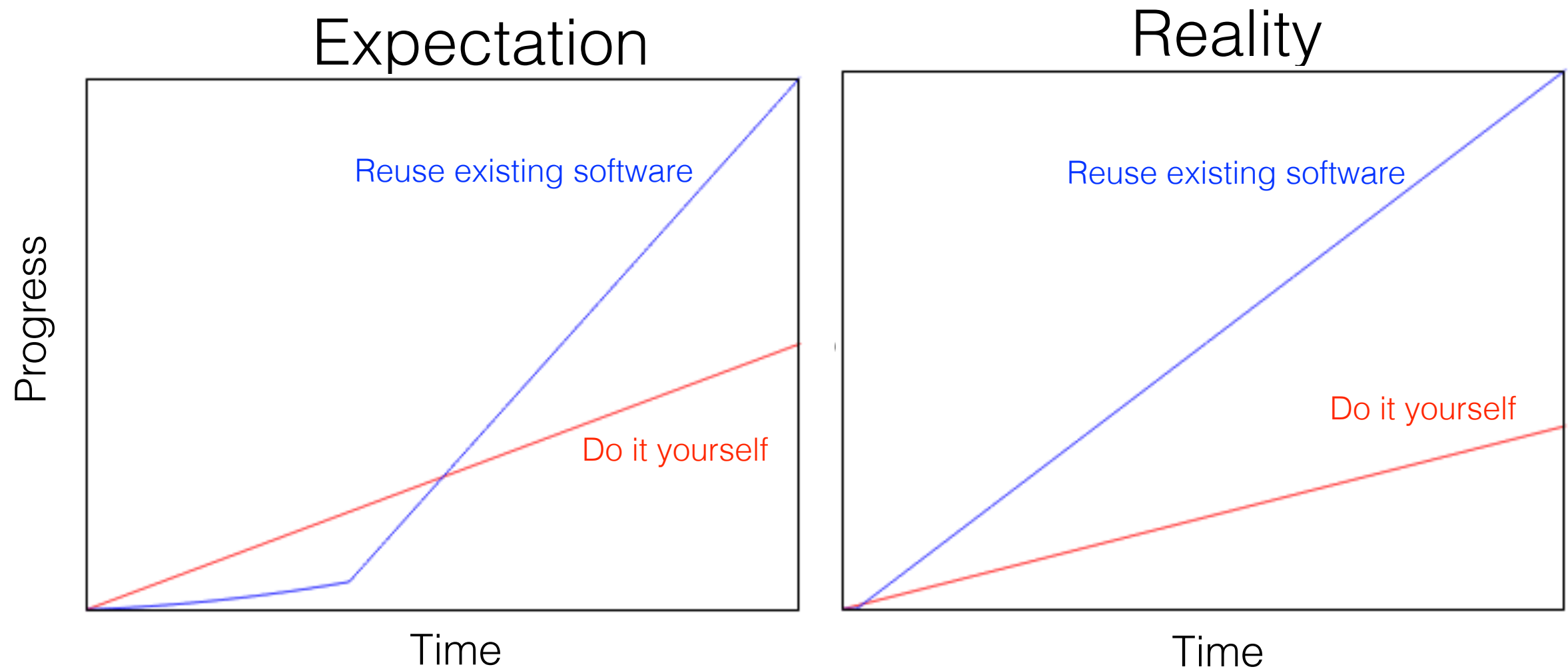


# Why use deal.II (or any other PDE toolbox)?

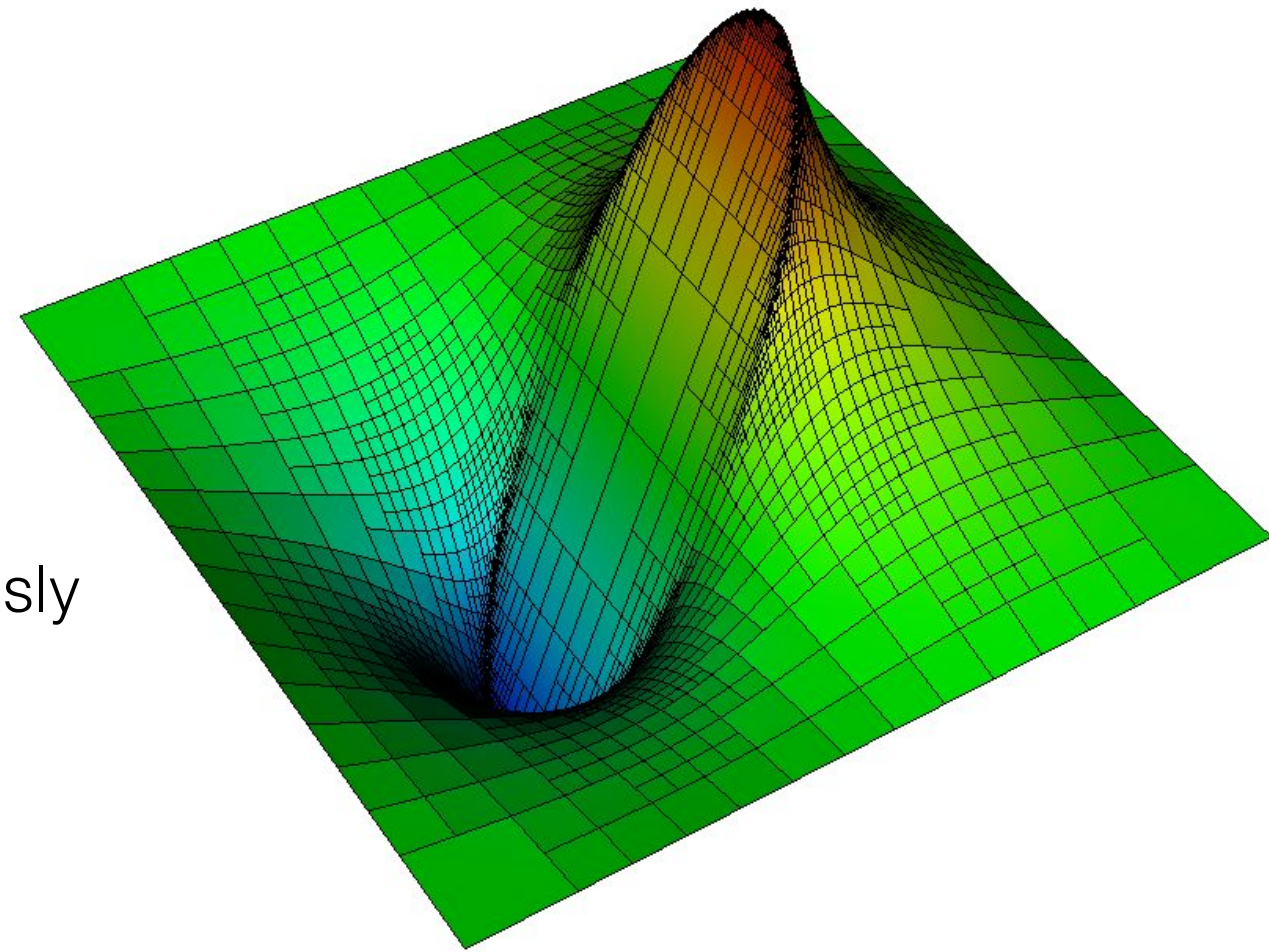


- Applies to:
  - Users
  - Developers
- “The secret to good scientific software is (re)using existing libraries”

# What is deal.II?

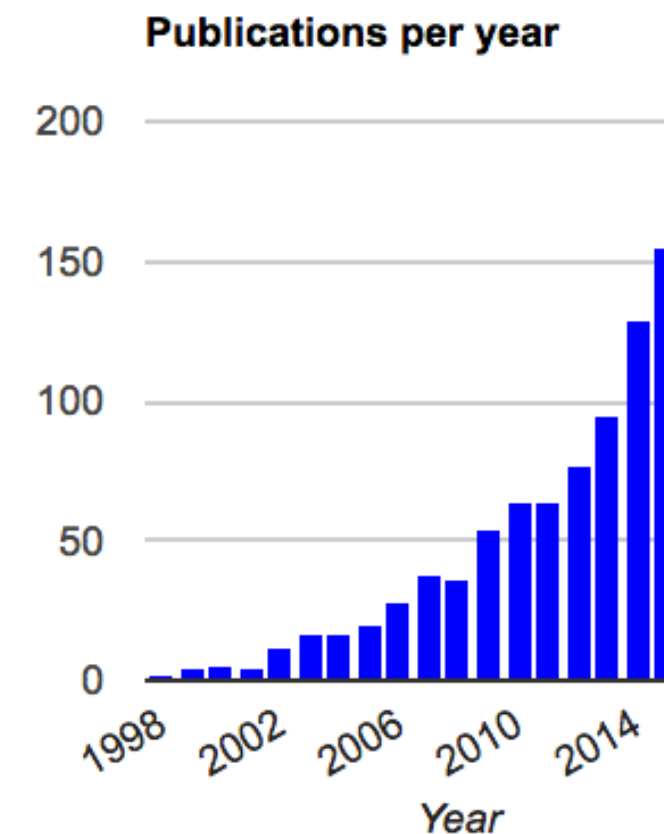
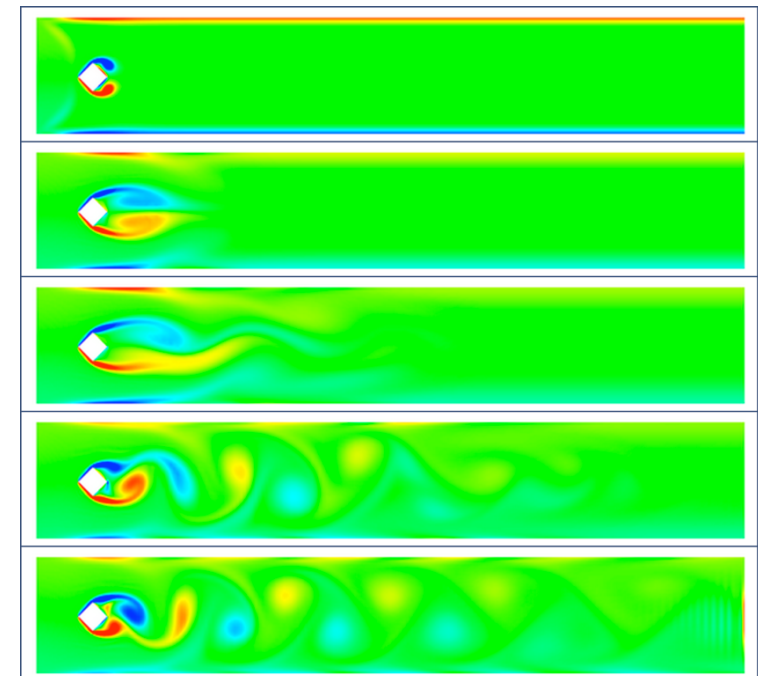
## Differential Equation Analysis Library

- Flexible open-source finite element toolkit
  - All the support functionality required to describe and solve a FE problem (PDEs)
  - Optimized for speed
  - Heavily tested
    - Many error checks (debug mode)
    - +10,000 regression tests run continuously
  - Part of SPEC CPU 2017 benchmark
- Templated C++ library (Object Orientated)
  - Dimension independent programming
- Portable
  - OS, architecture, compiler



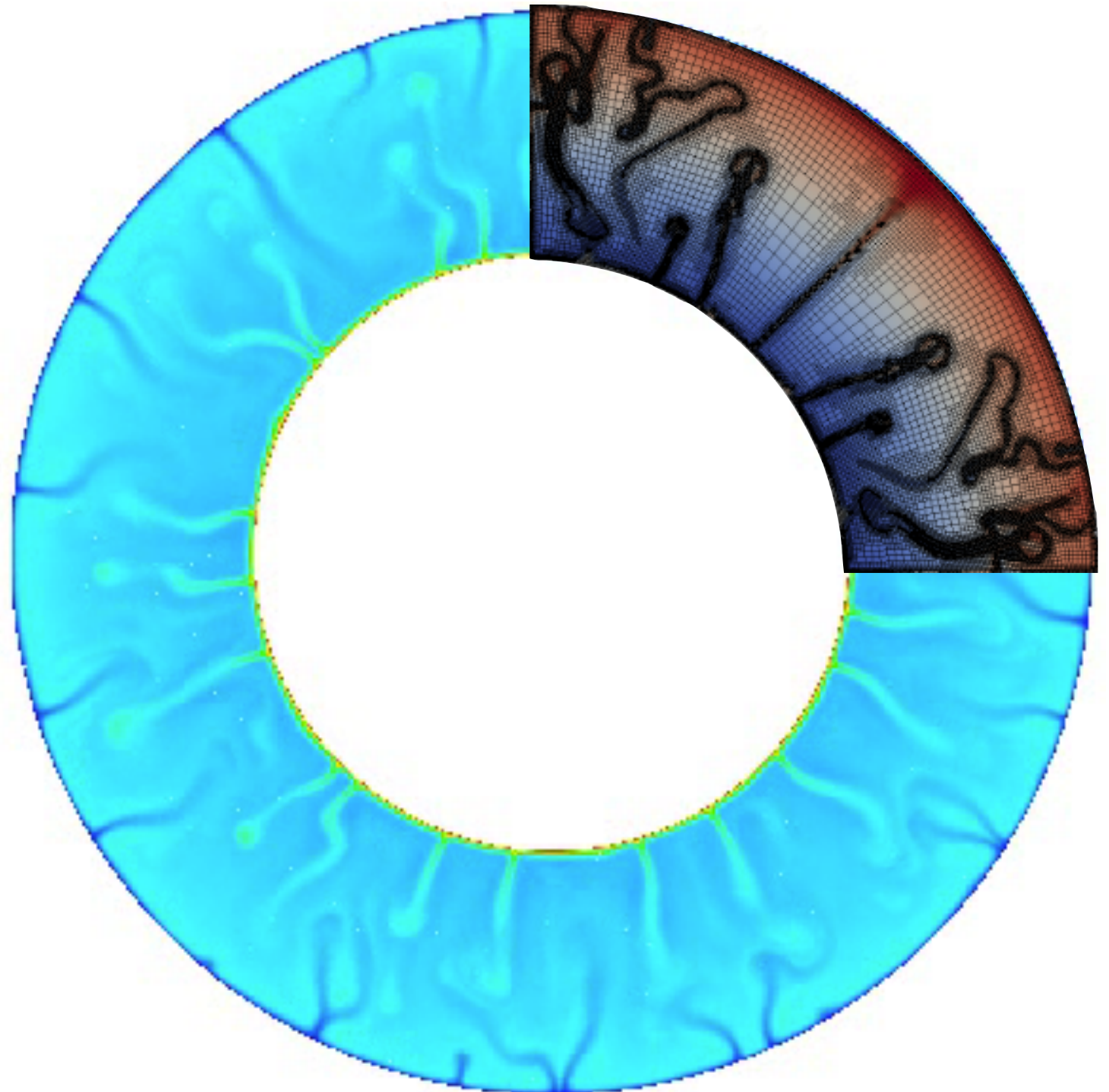
# What is deal.II?

- Heavily documented
  - Over 10000 pages of interface documentation
  - Numerous tutorials
    - Illustrate functionality
    - Present methods to solve problems
- Quite widely used, and growing
- Active community
  - Approachable developers
  - Helpful online forum



# Classes of problems solved using deal.II

- Geomechanics
- Fluid and gas dynamics
- Porous media
- Fluid-structure interaction
- Boundary element method
- Topology optimization
- Medical image reconstruction
- Structural mechanics
- Biomechanics
- Crystal growth
- Gradient and crystal plasticity
- Generalized continua
- Contact mechanics
- Atomistic-to-Continuum coupling
- Quantum mechanics
- Magneto- and electro-elasticity
- Thermo-plasticity



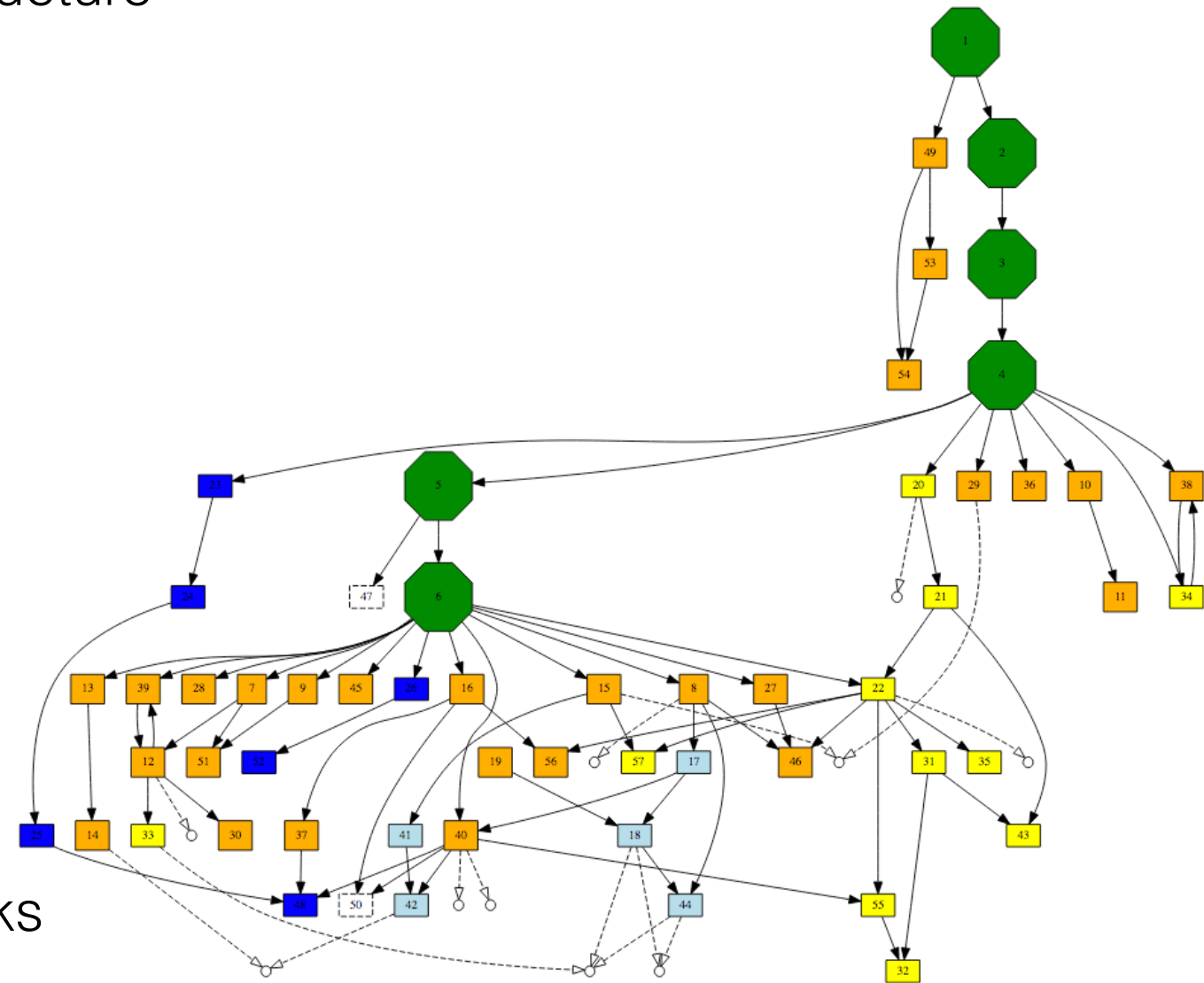
# What deal.II is not

- A black box
  - Can't throw any problem at it
  - Won't do anything more than you ask it to
- Knows little\* about
  - Numerical methods
  - Problem-specific details, i.e.
    - Preconditioners
    - Constitutive equations



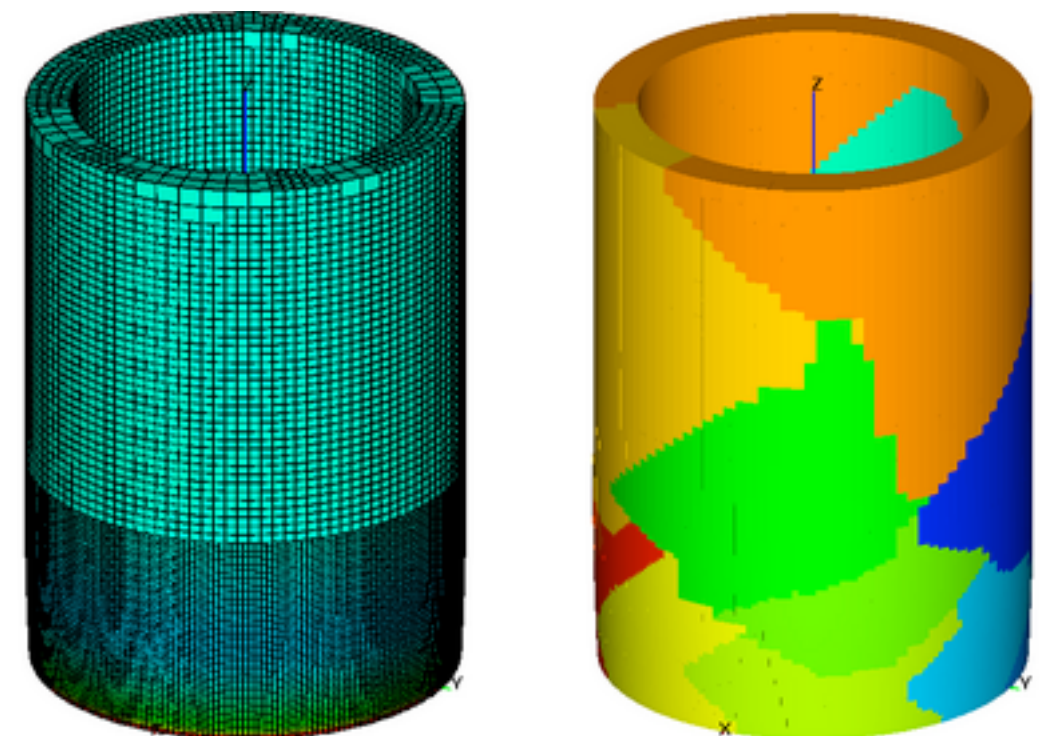
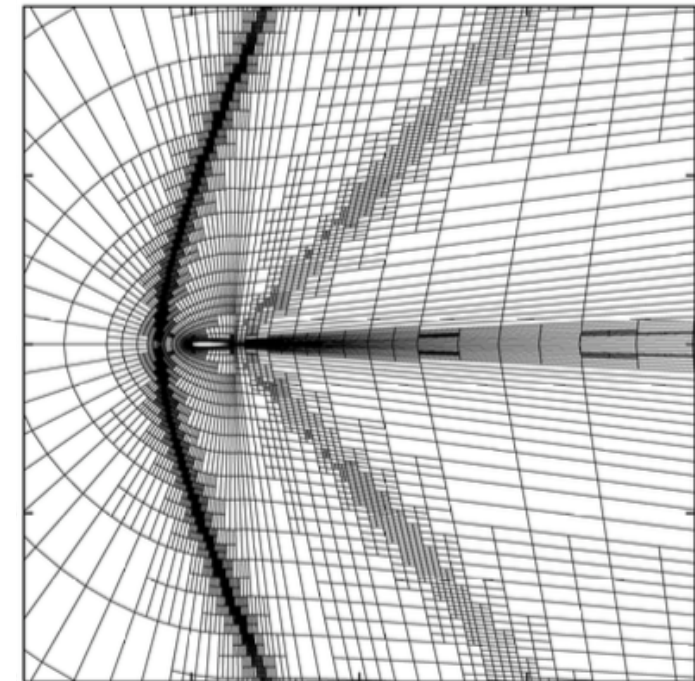
# How deal.II will help you

- Unified and well thought out data structure
  - Problem implementation
- Many tutorials
  - Baseline from which to build on
  - Demonstrate how to use features
- Comprehensive debugging support
  - Error messages everywhere!
- Some built in numerical tools
- Integration with advanced frameworks
  - Nonlinear solvers
  - Time integrators
  - Parallel sparse and dense linear algebra



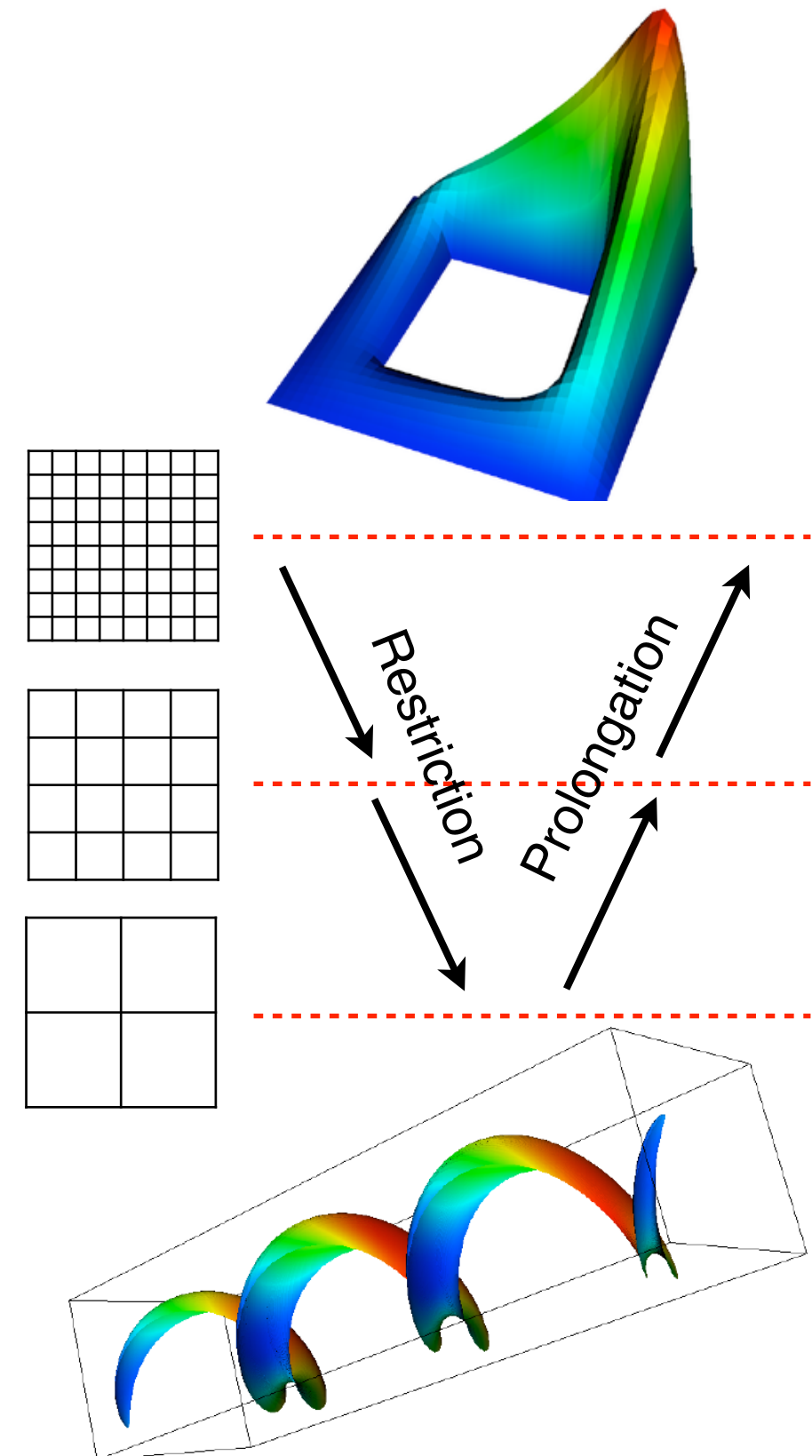
# Fundamental capabilities and frameworks

- Mesh adaptivity
- Dense and sparse linear algebra
  - Built in tensor, dense matrix/vector classes
  - BLAS and LAPACK integration; GSL
  - Built in linear solvers and preconditioners
  - Eigenvalue solvers
- Parallelization
  - MPI
    - Linear algebra libraries (PETSc, Trilinos)
    - Distributed meshes  $\longrightarrow$  Billion DoFs
  - Threading (Intel TBB)
  - Vectorized numbers (AVX extensions)
- Pre/post-processing



# Advanced capabilities and frameworks

- hp-finite element support
- Meshworker
  - Assembly assistance
  - Functions to perform assembly for specific problem classes
- Geometric multi-grid
  - Using coarse grid as preconditioner to solution for finer grid
- Matrix-free
  - No explicit storing of matrix elements
  - Exchange memory transfer for computations
- Charts and manifolds
  - Accurate description of topologically complex objects





# How deal.II is developed

- Open repository on GitHub
  - <https://github.com/dealii/dealii>
- Anyone can contribute!
  - We encourage all to participate

The screenshot shows the GitHub repository page for `dealii / dealii`. The repository has 74 watches, 423 stars, and 338 forks. The 'Pull requests' tab is selected, showing 26 open pull requests. The list includes:

- Restrict grid\_tools\_cache\_04** (Pull request #7748) opened 4 hours ago by masterleinad. Status: Review required.
- Check SUNDIALS version when configuring** (Pull request #7747) opened 14 hours ago by masterleinad. Status: Reviewed and ready to merge, ready to test.
- More edits in the introduction of step-61.** (Pull request #7746) opened 2 days ago by bangerth. Status: Review required. Label: Tutorials.
- add type traits to be used internally with FEEvaluation** (Pull request #7744) opened 4 days ago by davydden. Status: Review required. Labels: Matrix-free, ready to test.
- Using rtrees in GridTools::compute\_point\_locations\_try\_all for cell search** (Pull request #7743) opened 5 days ago by GivAlz. Status: Review required.
- Avoid ambiguous function declaration/variable initialization** (Pull request #7742) opened 5 days ago by masterleinad. Status: Approved. Label: ready to test.
- Step-63** (Pull request #7738) opened 5 days ago by tcclvenger. Status: Review required.
- Added 'set\_fe' functionality to DoFHandlers.** (Pull request #7717) opened 14 days ago by marcfehling. Status: Changes requested.
- hp::DoFHandler: Moved containers with temporary content into a dedicated structure** (Pull request #7716) opened 14 days ago by marcfehling. Status: Changes requested.