Welcome to the Second Annual MFEM Community Workshop

October 25, 2022
mfem.org/workshop

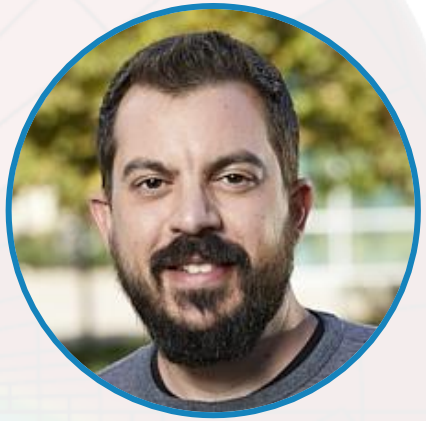
Organizers

Aaron Fisher

Tzanio Kolev

Ketan Mittal

Will Pazner


Socratis Petrides

LLNL-PRES-828129
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344.
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mfem

Lawrence Livermore National Laboratory

Interacting with the workshop

- We will be recording the workshop and posting videos of the talks.
- Please keep your mic muted during the talks.
- During the talks you can ask questions in the Zoom chat.
- Leave your camera off unless you are speaking (except for the upcoming group photo)
- Side conversations will be happening in the workshop slack channel. (https://mfemworkshop.slack.com)
- If you are having trouble with the slack channel, ask for help in the chat.

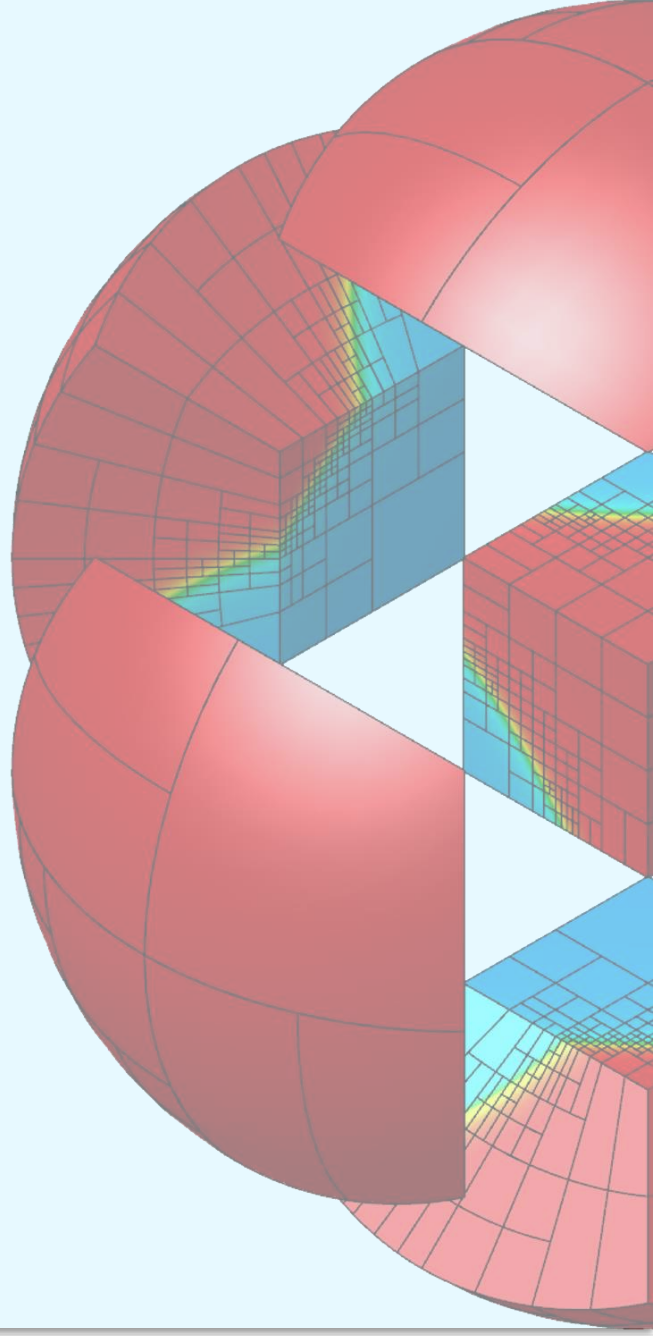
Certificate of Participation

We have certificates for those who want or need them

Agenda

Time (PDT, GMT-7)	Activity	Presenter
7:40-8:00	**Welcome & Overview**	**Aaron Fisher** (LLNL)
8:00-8:20	**The State of MFEM**	**Tzanio Kolev** (LLNL)
8:20-8:40	**Recent Developments**	**Veselin Dobrev** (LLNL)
8:40-9:00	**Break**	All
9:00-10:00	**Talks, Session I** (20 mins each) Chair: Will Pazner	**Ben Zwick** (University of Western Australia) **Carlos Brito Pacheco** (Université Grenoble Alpes) **Tobias Duswald** (CERN | TUM)
10:00-10:20	**Group Photo**	**All**
10:20-11:20	**Talks, Session II** (20 mins each) Chair: Socratis Petrides	**Alvaro Sanchez Villar** (PPPL) **Brian Young** **Christina Migliore** (MIT)
11:20-11:40	**Break**	All
11:40-12:40	**Talks, Session III** (20 mins each) Chair: Aaron Fisher	**Will Pazner** (PDX) **Jorge-Luis Barrera** (LLNL) **Siu Wun Cheung** (LLNL)
12:40-1:00	**Break**	All
1:00-2:00	**Talks, Session IV** (20 mins each) Chair: Tzanio Kolev	**Devlin Hayduke** (ReLogic) **Tim Brewer** (Synthetik) **Adolfo Rodriguez** (OpenSim)
2:00-2:20	**Break**	All
2:20-2:40	**MFEM AWS tutorial**	**Julian Andrej** (LLNL)
2:40-3:00	**Wrap-up & Contest Winners**	**Aaron Fisher** (LLNL)
3:00-4:00	**Q&A Session**	**MFEM team** available on Zoom + Slack

Selected Survey Results



216 Participants from 34 countries and 120 organizations

National Laboratories

- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Princeton Plasma Physics Laboratory
- UK Atomic Energy Authority
- Argonne National Laboratory
- CEA
- Hartree Centre
- Leonardo Labs
- Center for Advanced Systems Understanding
- CERN
- Flatiron Institute
- Johns Hopkins University Applied Physics Lab
- Leibniz Supercomputing Center
- Naval Nuclear Laboratory
- Oak Ridge National Laboratory

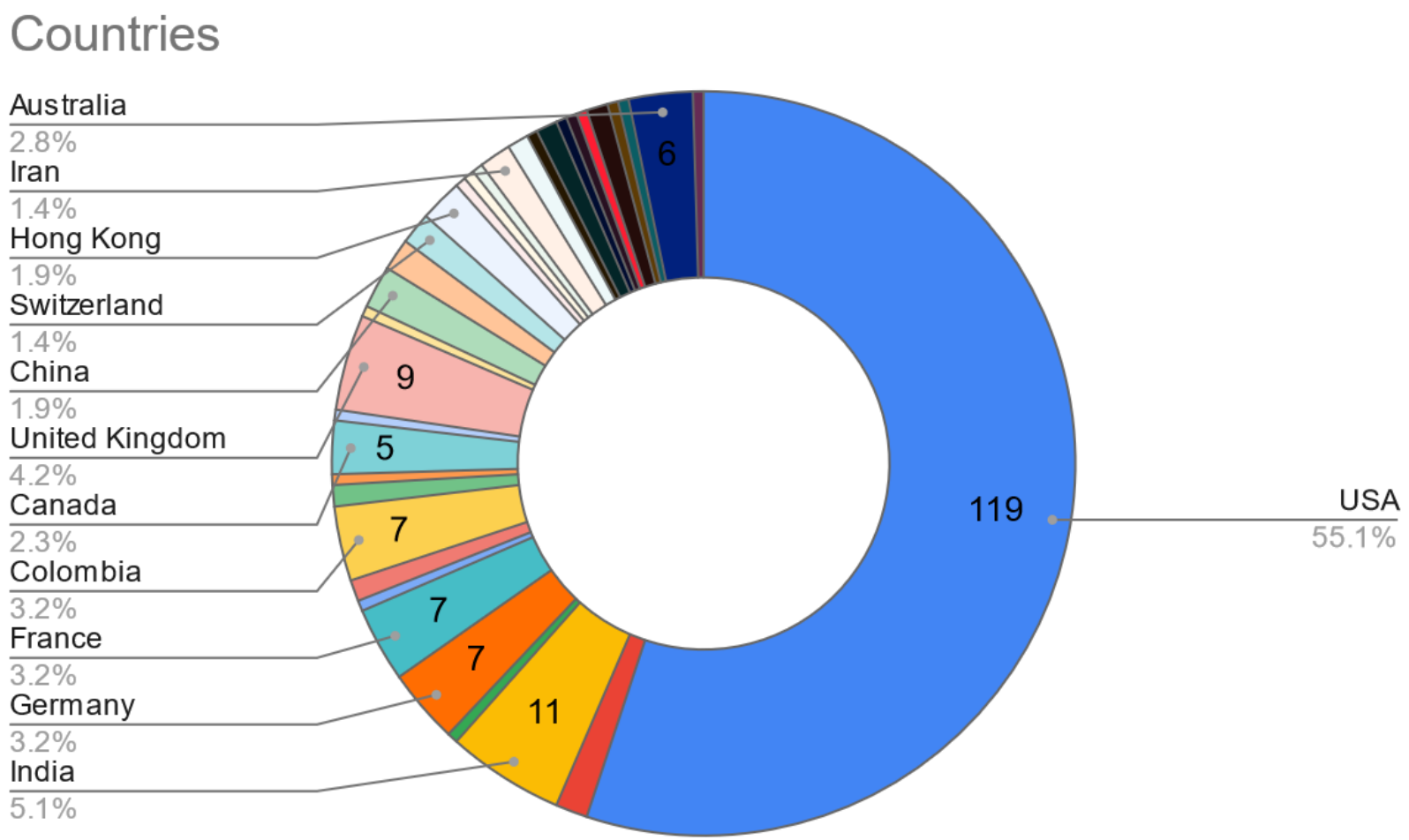
Industry

- Amazon
- Applied Materials
- Google
- OpenSim Technology
- Relogic Research
- Synthetik Applied Technologies
- Aclectic Systems
- Amgen
- Apple
- Applied Technology & Management
- Async Computing
- BS&A
- CGG
- EBITmax
- Ecologi
- ENSTA Bretagne
- Fortress Technology Solutions
- Good Simulations
- IERUS Technologies
- IISER Thiruvananthapuram
- Intel
- OpenParEM2D
- Polytechnique Montreal
- Procter & Gamble
- Protection Engineering Consultants
- Qorvo
- Skyworks Solutions
- Tata Consultancy Services
- Tesco Controls
- Woven Planet Holdings

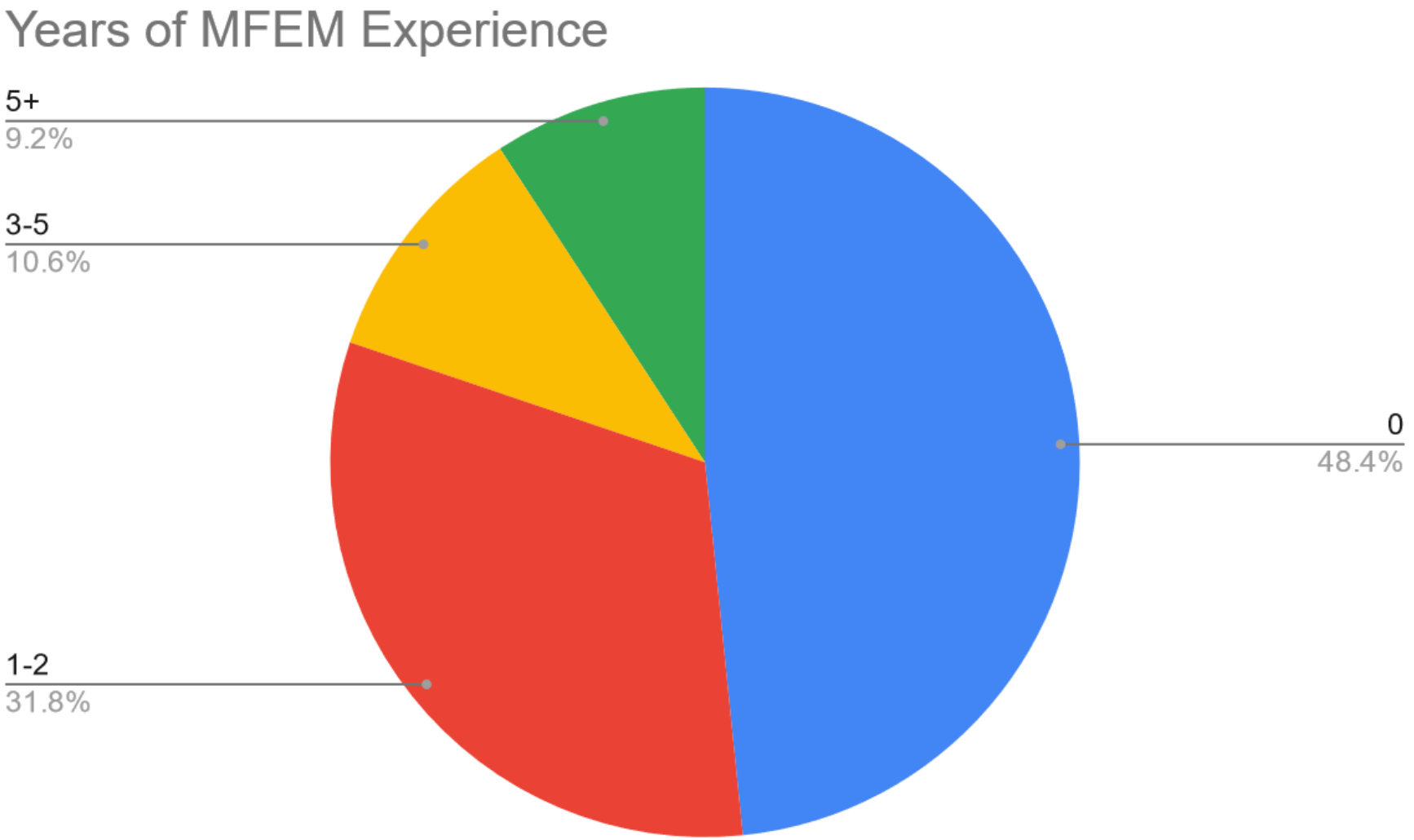
Universities

- IIT Guwahati
- Universidad Nacional de Colombia
- University of Western Australia
- North Carolina State University
- University of Illinois, Urbana Champaign
- Cadi Ayyad University
- ETH Zurich
- Hong Kong Polytechnic University
- Massachusetts Institute of Technology
- Portland State University
- Radon Institute for Computational and Applied Mathematics
- University of Belgrade
- University of Memphis
- Utah State University
- African Institute for Mathematical Science
- AMET University
- Brown University
- California State University, Northridge
- City University of Hong Kong
- Cornell University
- Cranfield University
- Curtin university
- Duke University
- Federal University of Rio de Janeiro
- Ferdowsi University of Masshad
- Friedrich-Alexander-Universität Erlangen-Nürnberg
- Harvard University
- Hong Kong Bapist University
- Hong Kong Center for Cerebro-Cardiovascular Health Engineering
- IIT Roorkee
- Imam Abdulrahman Bin Faisal University
- Indian Institute of Science
- Institute of Mechanics of Materials
- Institute of Theoretical and Experimental Astronomy
- Instituto Nacional de Astrofísica, Óptica y Electrónica
- Isfahan University of Technology
- Johannes Gutenberg-Univesity Mainz
- Johns Hopkins University Applied Physics Lab
- Kaunas University of Technology
- King Abdullah University of Science and Technology
- Kosar University of Bojnord
- Mississippi State University
- MIT Plasma Science and Fusion Center
- Morgan State University
- National University of Colombia
- Oakland University
- Pennsylvania State University
- Purdue University
- Ruhr University Bochum
- RWTH Aachen
- Simon Fraser University
- Tel Aviv University
- Tongji University
- Univeristy of Lisbon
- Universidad de Valparaiso
- Universite Grenoble Alpes
- Universiti Kuala Lumpur
- University Grenoble Apes
- University of British Columbia
- University of California, Berkeley
- University of California, Merced
- University of Cambridge
- University of Cape Coast
- University of Limerick
- University of Liverpool
- University of Minho
- University of Notre Dame
- University of Oulu
- University of Pennsylvania
- University of Texas, Austin
- University of Texas, San Antonio
- University of Waterloo
- University of West Florida
- Vienna Technical University
- Zhejiang University

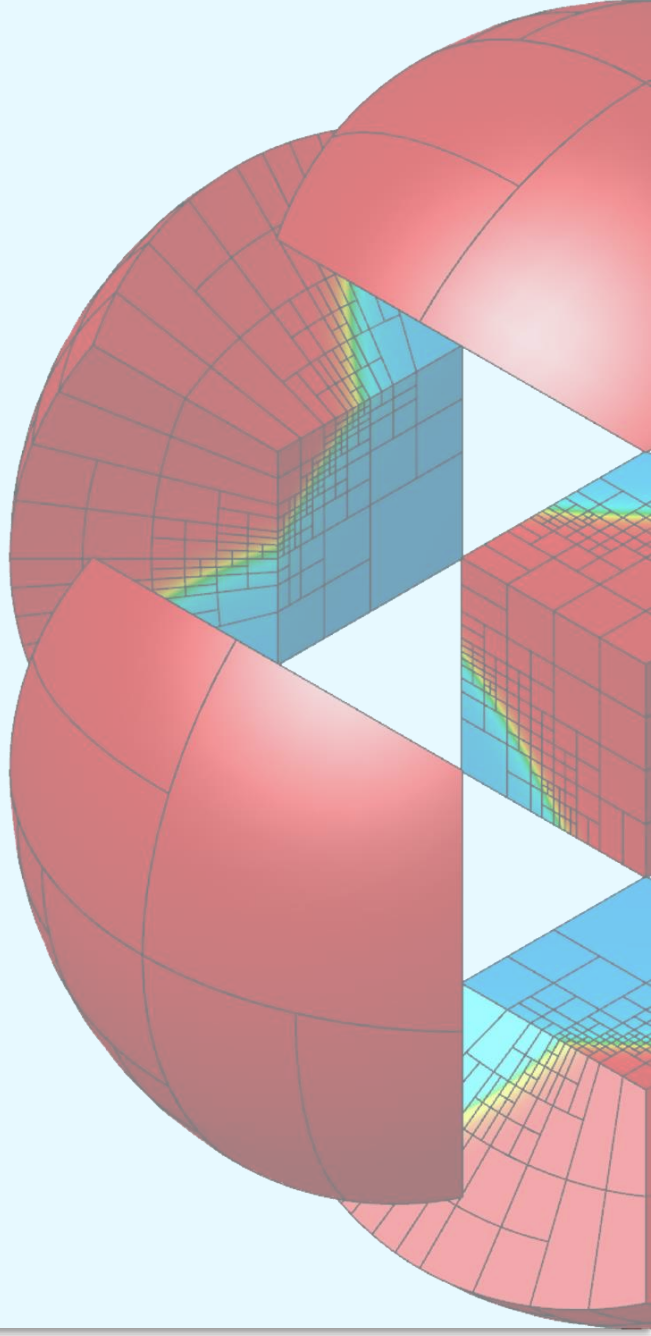
Participant countries



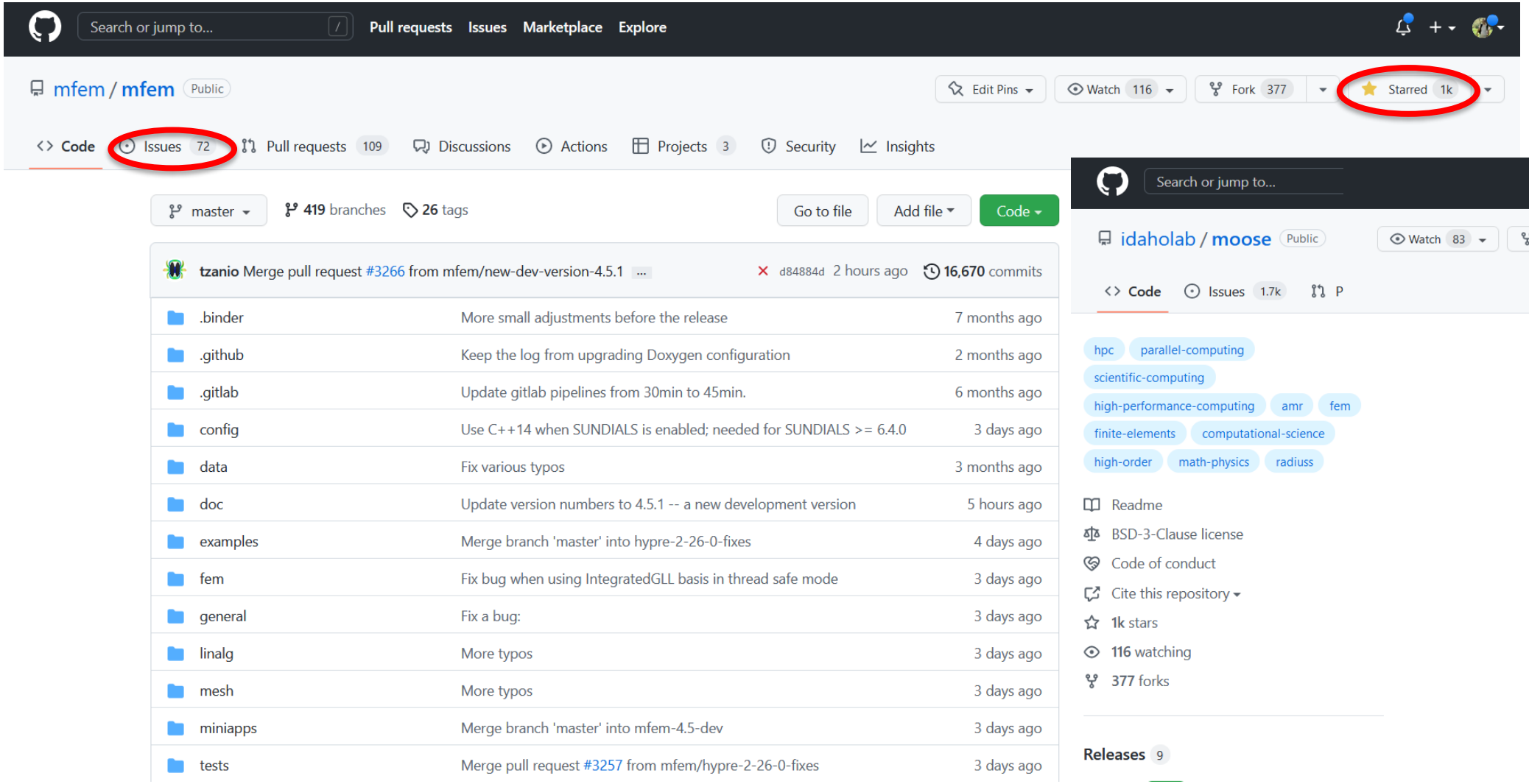
Years of experience with MFEM

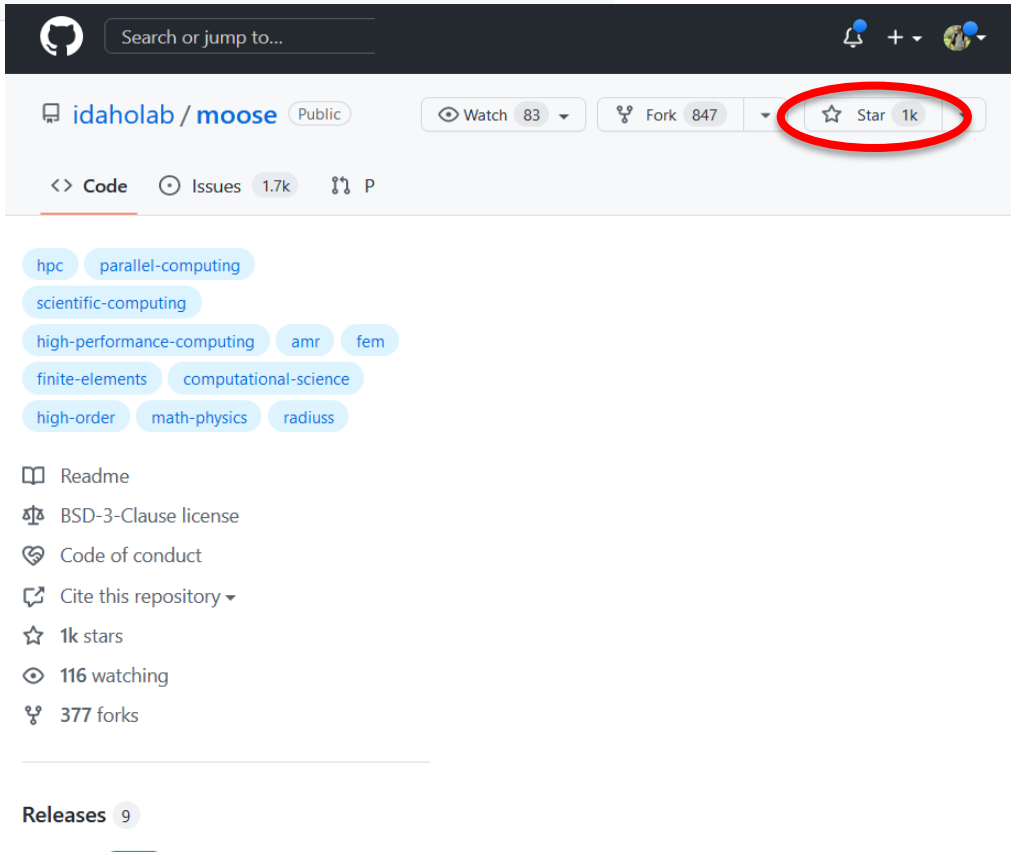


MFEM Resources



MFEM on Github (https://github.com/mfem/mfem)





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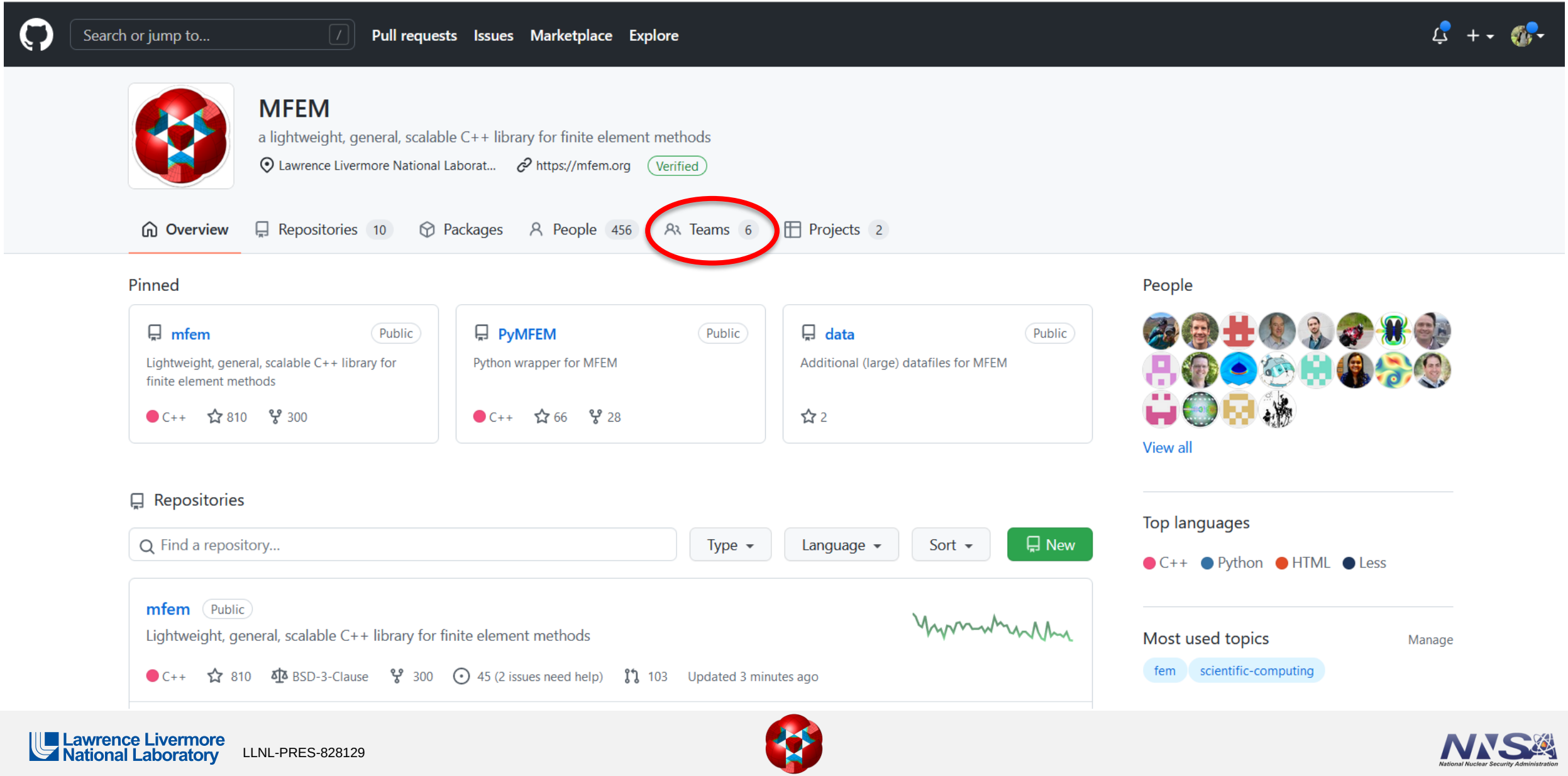

Curious about using MFEM mfem.org (https://mfem.org)

MFEM Features Examples Documentation Community Gallery Download GitHub

Example Codes
Electromagnetics
Fluid Dynamics
Meshing
Automatic Differentiation
Tools
Toys

High-order multi-material hydrodynamics in the BLAST code

MFEM is a *free*, *lightweight*, *scalable* C++ library for finite element methods.

Features

- Arbitrary high-order finite element meshes and spaces.
- Wide variety of finite element discretization approaches.
- Conforming and nonconforming adaptive mesh refinement.
- Scalable from laptops to GPU-accelerated supercomputers.
- ... and many more.

MFEM is used in many projects, including BLAST, Cardioid, VisIt, RF-SciDAC, FASTMath, xSDK, and CEED in the Exascale Computing Project. See also our Gallery, Publications, Videos and News pages.

News

Oct 22, 2022	Version 4.5 released.
Aug 18, 2022	MFEM Community Workshop in October 2022.
Aug 15, 2022	MFEM tutorial on AWS.
Jan 20, 2022	FEM@LLNL seminar series starting.

Latest Release

New features ¦ Examples ¦ Code documentation ¦ Sources

Download mfem-4.5.tgz

Older releases ¦ Python wrapper ¦ launch binder

Documentation

Building MFEM ¦ Getting Started ¦ Finite Elements ¦ Performance

New users should start by examining the example codes.

We also recommend using GLVis for visualization.

Contact

Use the GitHub issue tracker to report bugs or post questions or comments.
See the About page for citation information.

Getting started on mfem.org (https://mfem.org)

MFEM | Features | Examples | Documentation | Community | Gallery | Download | GitHub

Getting Started
HowTo Articles
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Performance
GPU Support
Mesh Formats
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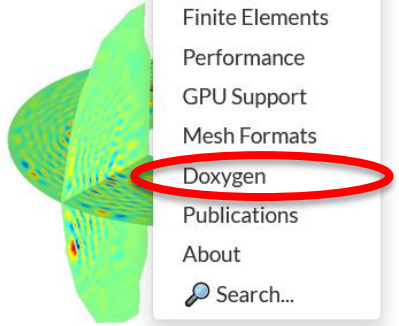

Electromagnetic wave propagation in the NSTX-U tokamak

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New: versioned doxygen docs.mfem.org

MFEM Code Documentation

Doxygen-generated documentation for the following MFEM releases is available:

Latest Release

- **`mfem-4.5`**, released in Oct 2022, documented at **`docs.mfem.org/4.5`**

Older Releases

- `mfem-4.4`, released in Mar 2022, documented at `docs.mfem.org/4.4`
- `mfem-4.3`, released in Jul 2021, documented at `docs.mfem.org/4.3`
- `mfem-4.2`, released in Oct 2020, documented at `docs.mfem.org/4.2`
- `mfem-4.1`, released in Mar 2020, documented at `docs.mfem.org/4.1`
- `mfem-4.0`, released in May 2019, documented at `docs.mfem.org/4.0`
- `mfem-3.4`, released in May 2018, documented at `docs.mfem.org/3.4`
- `mfem-3.3.2`, released in Nov 2017, documented at `docs.mfem.org/3.3.2`
- `mfem-3.3`, released in Jan 2017, documented at `docs.mfem.org/3.3`
- `mfem-3.2`, released in Jun 2016, documented at `docs.mfem.org/3.2`
- `mfem-3.1`, released in Feb 2016, documented at `docs.mfem.org/3.1`
- `mfem-3.0`, released in Jan 2015, documented at `docs.mfem.org/3.0`
- `mfem-2.0`, released in Nov 2011, documented at `docs.mfem.org/2.0`

See also mfem.org/download and github.com/mfem/doxygen.

FEM@LLNL Seminar Series: mfem.org/seminar/

MFEM | Features | Examples | Documentation | Community | Gallery | Download | GitHub

FEM@LLNL Seminar Series

We are happy to announce a new FEM@LLNL seminar series, starting in 2022, which will focus on finite element research and applications talks of interest to the MFEM community. We have lined up some excellent speakers for our first year and plan to keep adding more. Videos will be added to a YouTube playlist as well as this site's videos page.

Sign-Up

Fill in this form to sign-up for future FEM@LLNL seminar announcements.

Next Talk

Garth Wells (University of Cambridge)

FEniCSx: design of the next generation FEniCS libraries for finite element methods

9am PDT, November 8, 2022

Abstract: TBD

Previous Talks

FEM@LLNL Seminar Series
Sign-Up
Next Talk
Previous Talks
Future Talks

https://mfem.org/seminar/#next-talk

mfem.org

fisher47@llnl.gov

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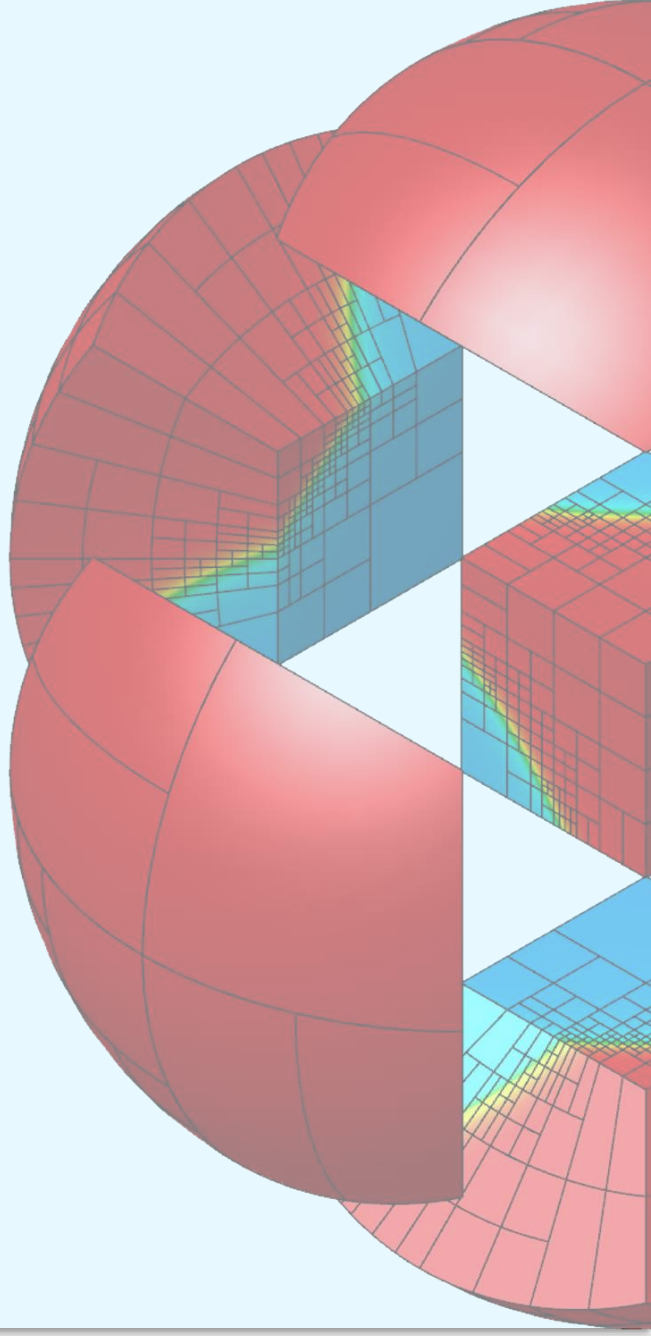
Simulation Contest



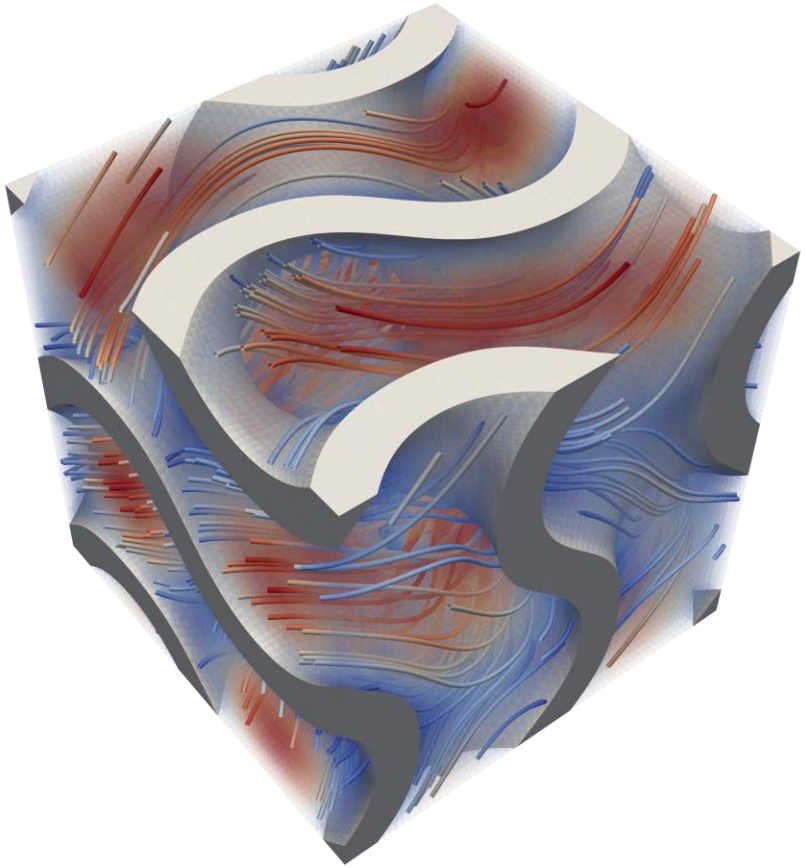
Simulation and Visualization Contest Winners!

- We held a contest for the most interesting simulations and visualizations.
- So many good entries that we broke it into 2 categories, still images and animations.
- Entries were judged on aesthetic qualities, novelty of the approaches, and the notability of the application.
- Results will be featured on the MFEM webpage, and the winners will receive MFEM T-Shirts.

Runner up for Still Images

?

Runner up for Still Images



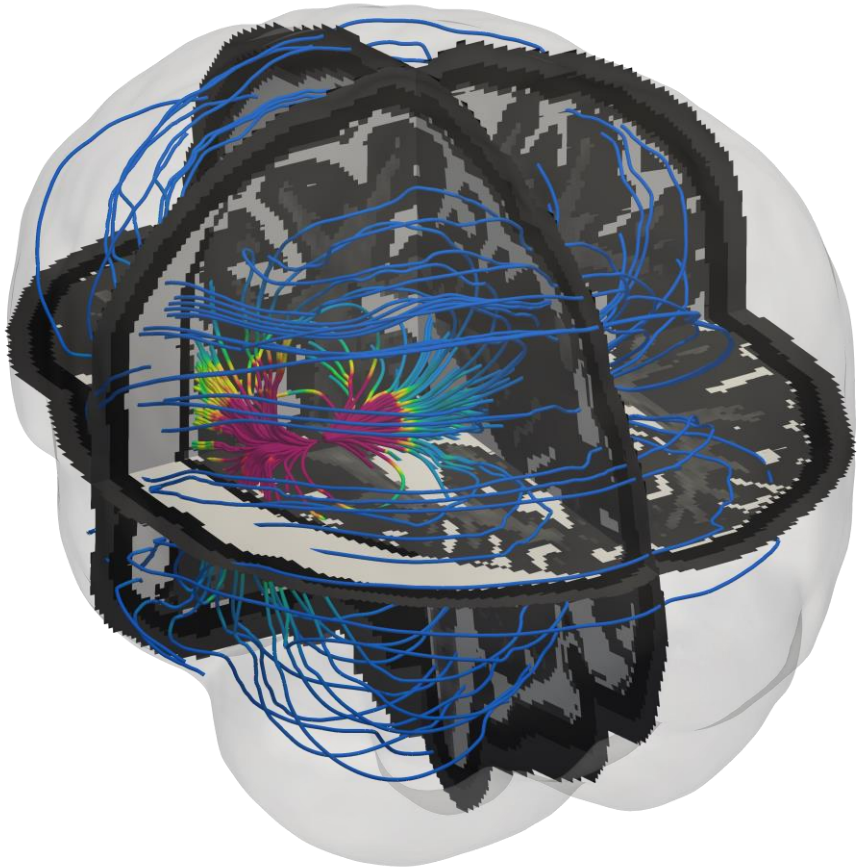
Flow through periodic Gyroid micro-cell, MFEM Navier mini-app with additional Brinkman penalization

Mathias Schmidt
LLNL

Winner for Still Images

?

Winner for Still Images



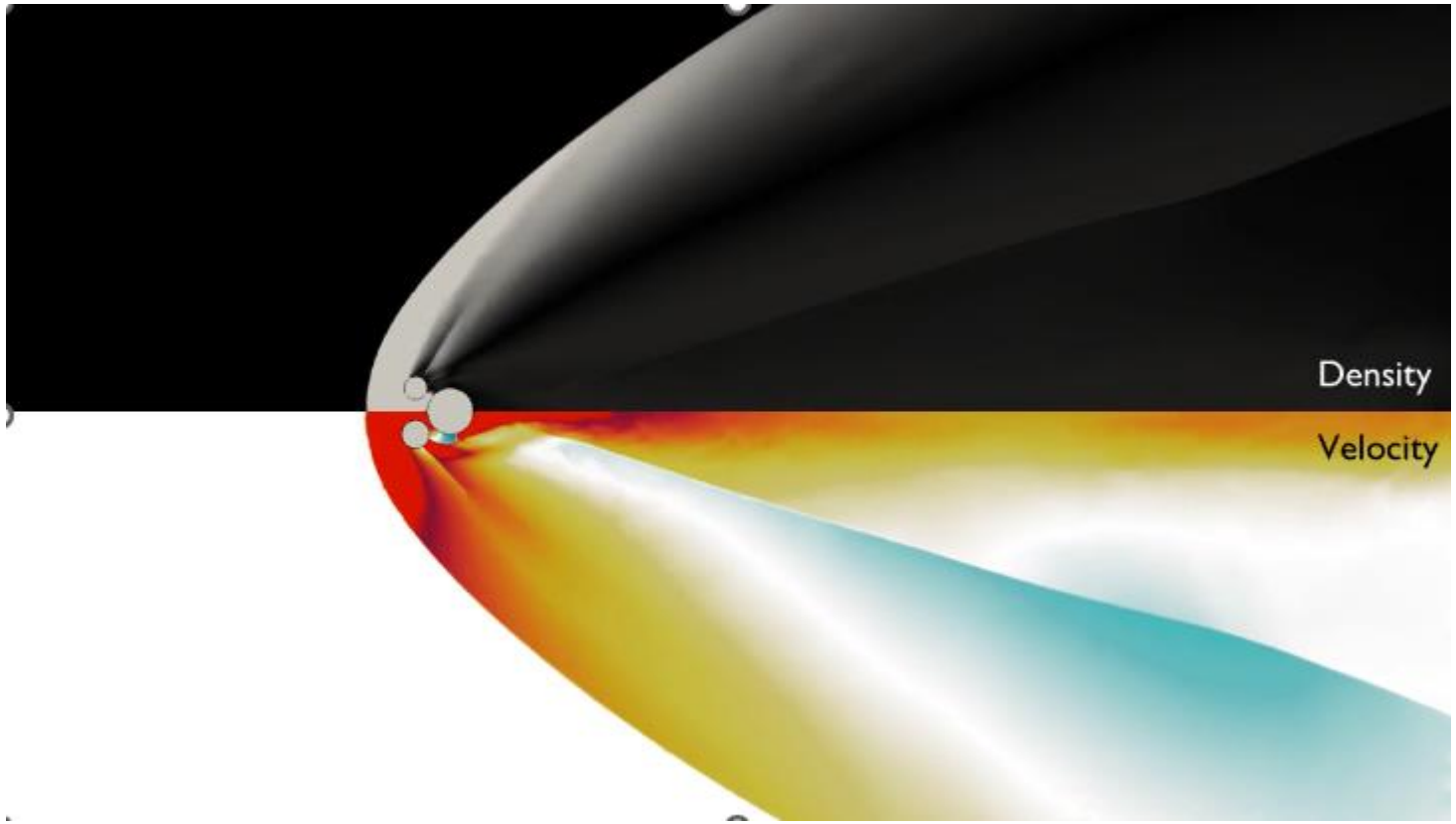
Streamlines of the electric field generated by a current dipole source located in the temporal lobe of an epilepsy patient. Finite element solution using a regular hexahedral grid implemented in MFEM. Visualization with ParaView.

Ben Zwick
University of Western Australia

Runner up for Animations

?

Runner up for Animations



Single phase compressible Euler simulation using a DG discretization to describe supersonic (Mach 2.5) flow around cylindrical obstructions. The simulation leverages Synthetik's newly developed code for highly compressible flows.

Tim Brewer
Synthetik Applied Technologies

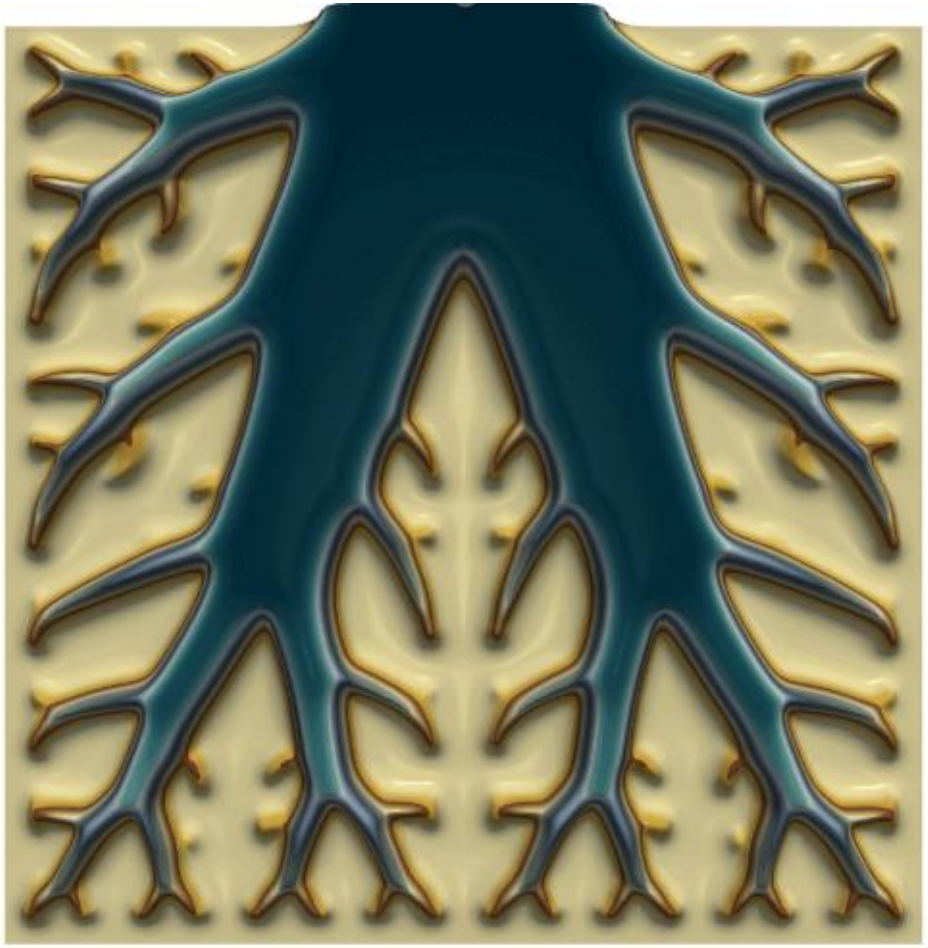
Winner for Animations

?

Winner for Animations

Split Decision!

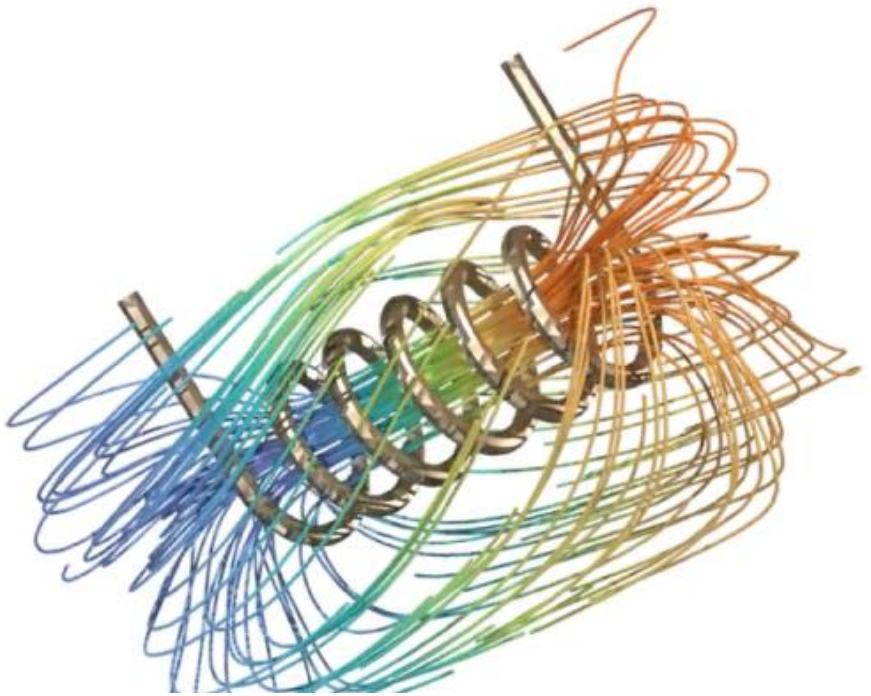
Winner 1 for Animations



The animation presents a topology-optimized heat sink obtained with a new algorithm developed by the team in LDRD 22-ERD-009. The objective is to minimize the thermal energy in a domain with constant internal heating. In this problem, there is only one exit point for heat to escape, namely, at the central region of the upper boundary. The amount of material in the heat sink is constrained, and the problem requires a binary design. Witness that the solution appears almost organic, in some ways, like the roots of a tree that grow to maximally absorb water. Thus, we see, at least visually, the logic in this natural design solution and possible connections between channeling heat and channeling of other scalar fields.

Tobias Duswald (Brendan Keith, Socratis Petrides and Boyan Lazarov)
CERN/TUM, BROWN UNIVERSITY, LLNL

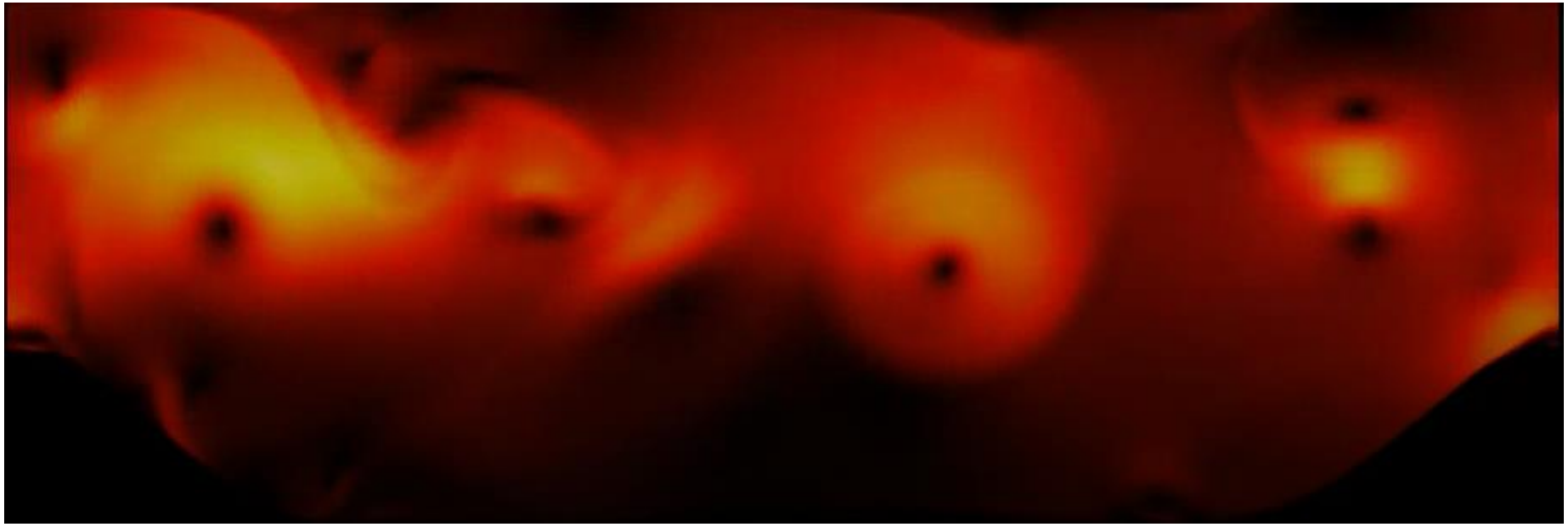
Winner 2 for Animations



Magnetic diffusion problem solved to compute the magnetic field induced by current running through copper wire in air. The problem is solved using the A-phi formulation, using GPU-accelerated low-order-refined solvers in H1 and H(curl). The magnetic field is represented as a Raviart-Thomas finite element vector field in H(div).

Will Pazner
Portland State

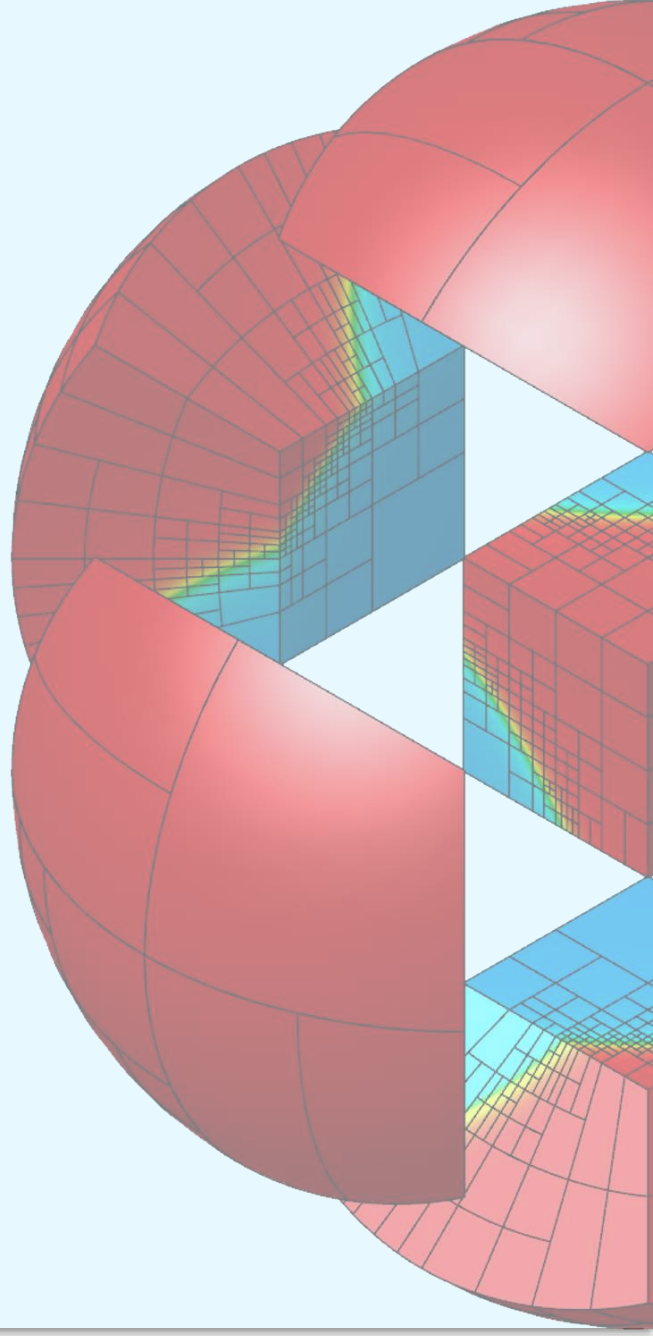
Honorable Mention



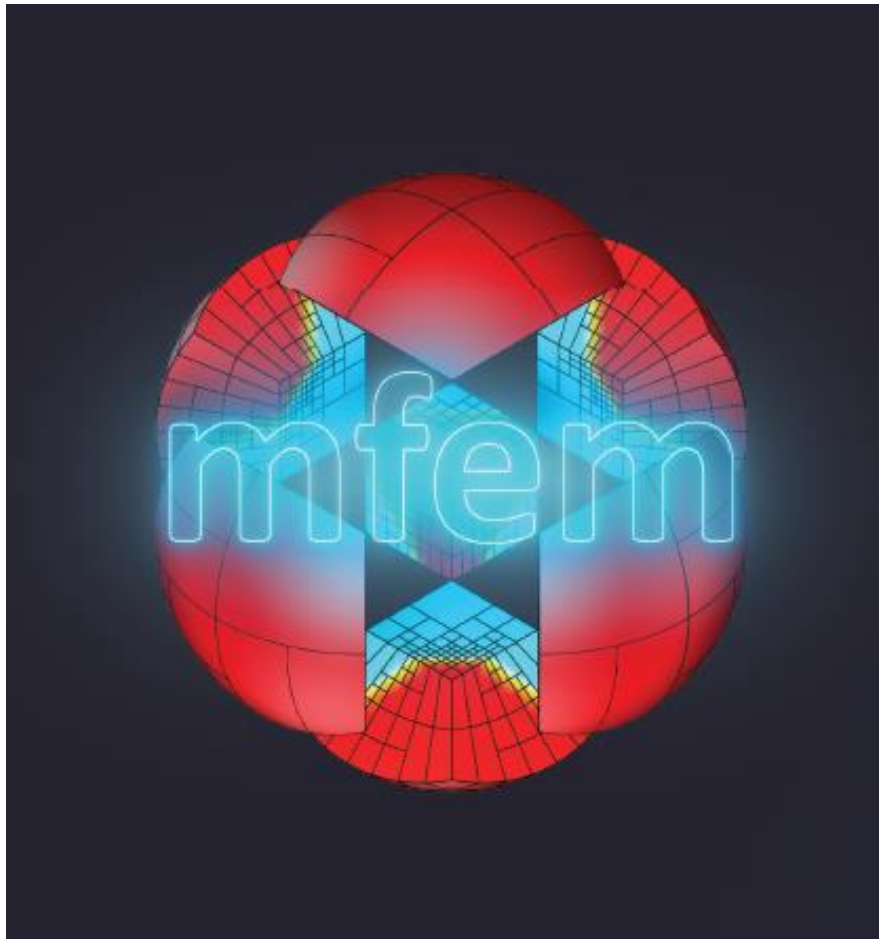
Turbulent Incompressible Navier-Stokes LES flow through a periodic hill, H1 p=4, Re=5000

Julian Andrej
LLNL

Wrapup



MFEM Resources



- Github:
  - Repo - https://github.com/mfem/mfem
  - Issues - https://github.com/mfem/mfem/issues
  - Group - https://github.com/orgs/mfem/teams/everyone
- mfem.org:
  - Front page – https://mfem.org
  - Workshops – https://mfem.org/workshop
- Publications:
  - MFEM: A Modular Finite Elements Library, Computers and Mathematics with Applications, June 2020
  - https://mfem.org/publications
- Planning a seminar series, stay tuned!
- Contact us:
  - Near term Slack - https://mfemworkshop.slack.com
  - Long term Github issues - https://github.com/mfem/mfem/issues

See you all next year!

Gratitude

- Applause for the speakers
- Special thanks to the workshop planning committee: Tzanio Kolev, Will Pazner, Socratis Petrides, Ketan Mittal, and Holly Auten.
- Thank you all for attending.

Thank you from the MFEM team at LLNL!

mfem.org

fisher47@llnl.gov

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