

Welcome to the First Annual MFEM Community Workshop

October 20, 2021
mfem.org/workshop

Organizers



Aaron Fisher



Tzanio Kolev



Will Pazner



Mark Stowell

Interacting with the workshop



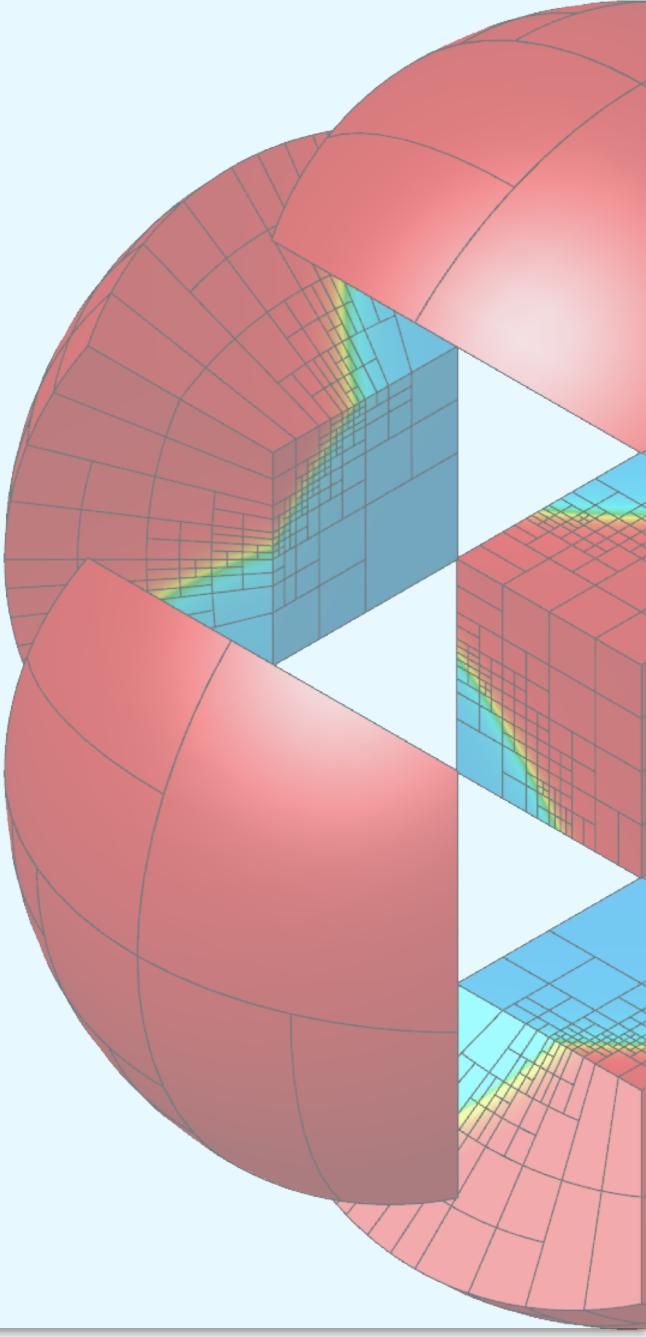
- Please keep your mic muted during the talks.
- During the talks you can ask questions in the Zoom chat.
- Leave your camera off unless you are speaking (except for the upcoming group photo)
- Side conversations will be happening in the workshop slack channel.
(<https://mfemworkshop.slack.com>)

Agenda

Time (PDT, GMT-7)	Activity	Presenter			
7:45-8:00	Welcome & Overview	Aaron Fisher	10:30-12:30	Talks, Session II (20 mins each)	<ul style="list-style-type: none">• Robert Rieben (LLNL)• Marc Bolinches (UT)• Mathias Davids (Harvard)• Jan Nikl (ELI Beamlines)• Qi Tang (LANL),• Syun'ichi Shiraiwa (PPPL)
8:00-8:30	The State of MFEM & Roadmap	Tzanio Kolev			
8:30-9:00	Recent Developments	Veselin Dobrev <ul style="list-style-type: none">• Jamie Bramwell (LLNL)• Guillaume Latu (CEA)• Julian Jimenez (U of Columbia)			
9:00-10:00	Talks, Session I (20 mins each)		12:30-1:00	Break	All
10:00-10:30	Break & Group Photo	All Download a virtual background below	1:00-2:00	Talks, Session III (20 mins each)	<ul style="list-style-type: none">• William Dawn (NCSU)• Vladimir Tomov (LLNL)• Will Pazner (LLNL)
			2:00-2:30	Breakout Sessions	<ul style="list-style-type: none">• Electromagnetics• Fluids• Structural Mechanics
			2:30-2:45	Wrap-up & Contest Winners	Aaron Fisher



Selected Survey Results



231 Participants from 28 countries and 120 organizations

Air Force Research Laboratory
Amirkabir University of Technology
Anna University, Chennai, India
Ansys
Applied Materials Inc.
Argonne National Laboratory
Bauman Moscow State Technical University
Beirut Arab University
Cadi Ayyad University
CEA
Center for Earthquake Research, University of Memphis
CERN
CFD Research
Covanos
Czech Technical University in Prague
Delft Technical University
DePuy Synthes
Drexel University
ELI Beamlines, Czech Academy of Sciences
EPFL
ETH Zurich
Federal University of Juiz de Fora
Federal University of Rio de Janeiro
Finnish Meteorological Institute
Friedrich-Alexander-Universität Erlangen-Nürnberg
Harvard Medical School
Harvard University
Heidelberg University
IBM Research
IERUS Technologies

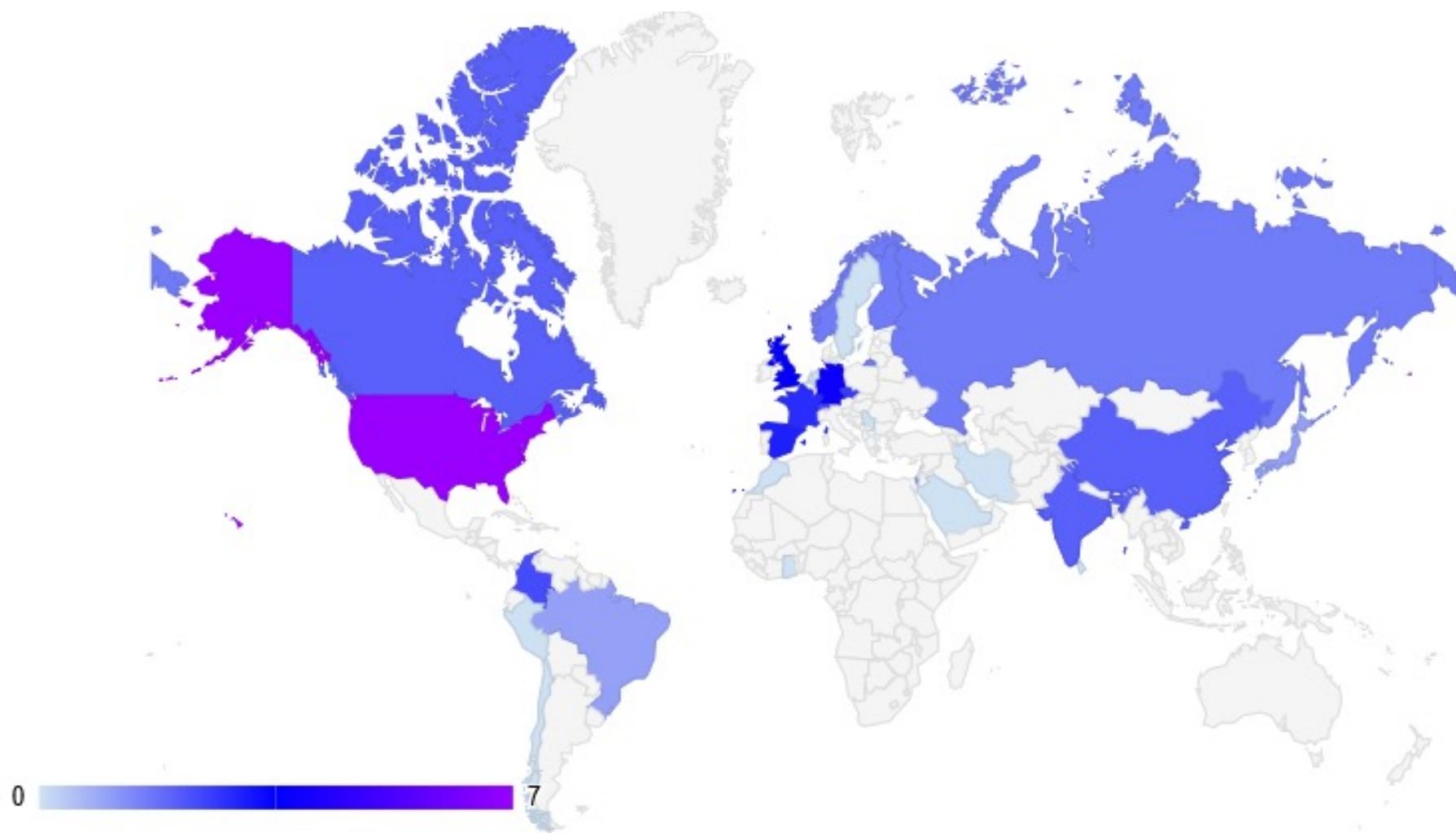
Imam Abdulrahman Bin Faisal University
Imperial College London
Indian Institute of Space Science and Technology
Iowa State University
Ivannikov Institute for System Programming of the RAS
Johns Hopkins University Applied Physics Lab
Karlsruhe Institute of Technology
Keldysh Institute of Applied Mathematics
Lawrence Livermore National Laboratory
LMU Munich
Los Alamos National Lab
Los Alamos National Laboratory
Massachusetts Institute of Technology
Meidensha Corporation
Michigan State University
Mississippi State University
MIT
Morgan State University
Moscow Institute of Physics and Technology
National University of Colombia
Naval Nuclear Laboratory
Naval Research Laboratory
NCMesh s.r.o.
North Carolina State University
Northeastern University
Northwestern Polytechnic University
Norwegian University of Science and Technology
Nuclear Naval Propulsion Lab
Oakland University
OpenSim Technology LLC

Otto von Guericke University Magdeburg
Pontificia Universidad Católica De Chile
Pontificia Universidad Javeriana
Princeton Plasma Physics Lab
Princeton Plasma Physics Laboratory
ReLogic Research, Inc.
Rensselaer Polytechnic Institute
RISE AB
RNET Technologies
Rochester Institute of Technology
Siemens Industry Software
Simula Research Laboratory
SRM Institute of Science and Technology
Stanford University
Stevens Institute of Technology
Synthetik Applied Technologies
Syracuse University
Tampere University
Technical University Dortmund
Technion Israel Institute of Technology
Texas A&M University
The University of Utah
Tokyo Metropolitan University
Tsinghua University
UK Atomic Energy Authority
Universidad de Castilla - La Mancha
Universidad de Granada
Universidad Nacional de Colombia
Università della Svizzera Italiana Lugano
Université du Québec à Montréal

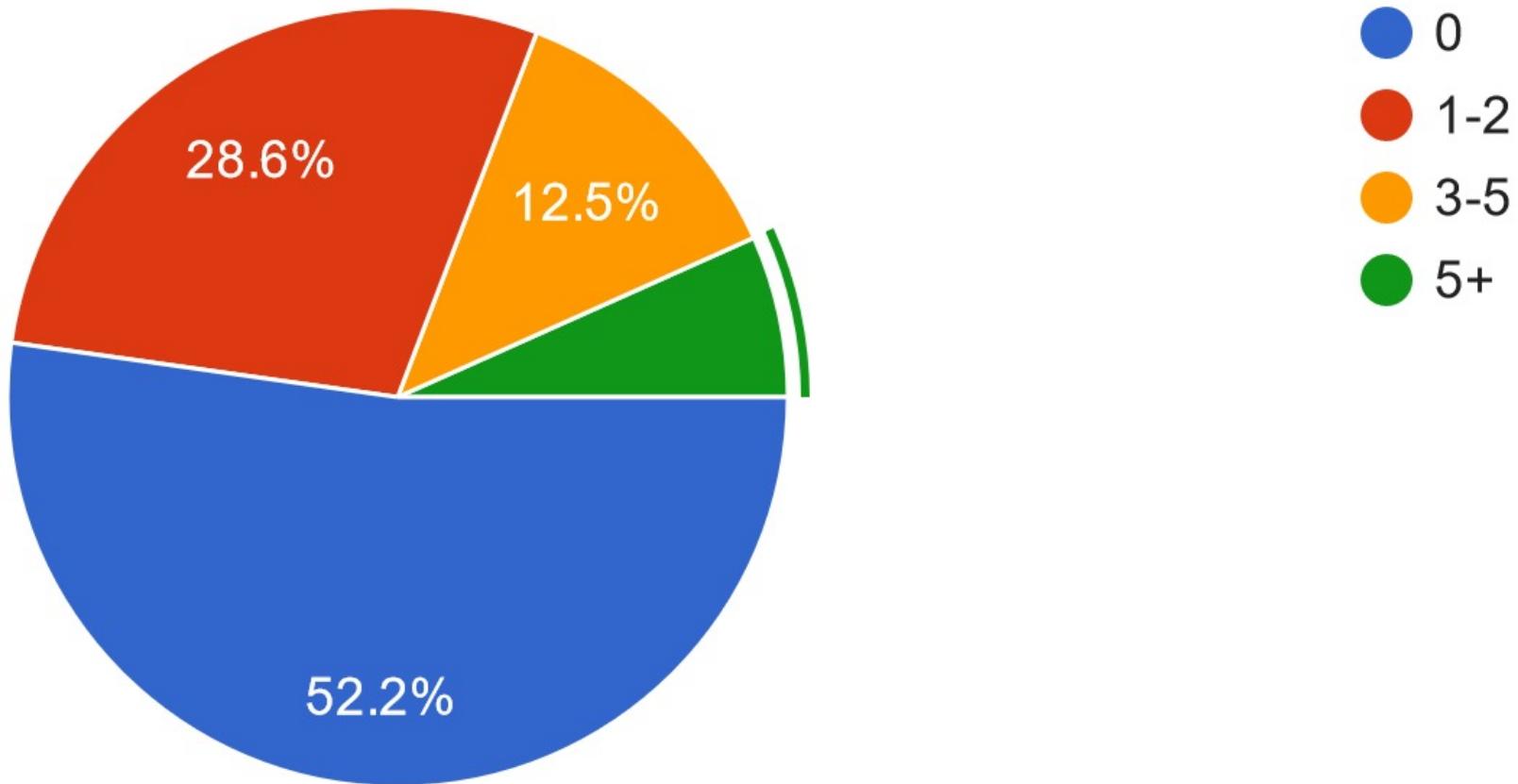
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University of California Merced
University of Cape Coast
University of Connecticut
University of Delaware
University of Glasgow
University of Granada
University of Houston
University of Illinois at Urbana-Champaign
University of Liverpool
University of Louisiana at Lafayette
University of Michigan
University of Notre Dame
University of Oxford
University of Pennsylvania
University of Peradeniya
University of Rochester, Laboratory for Laser Energetics
University of Tennessee
University of Texas at Austin
University of the Bundeswehr Munich
University of Waterloo
University of West Florida
University of Wisconsin-Madison
University of Wuppertal
VTT Technical Research Centre of Finland
Weidlinger Technology Ventures, LLC



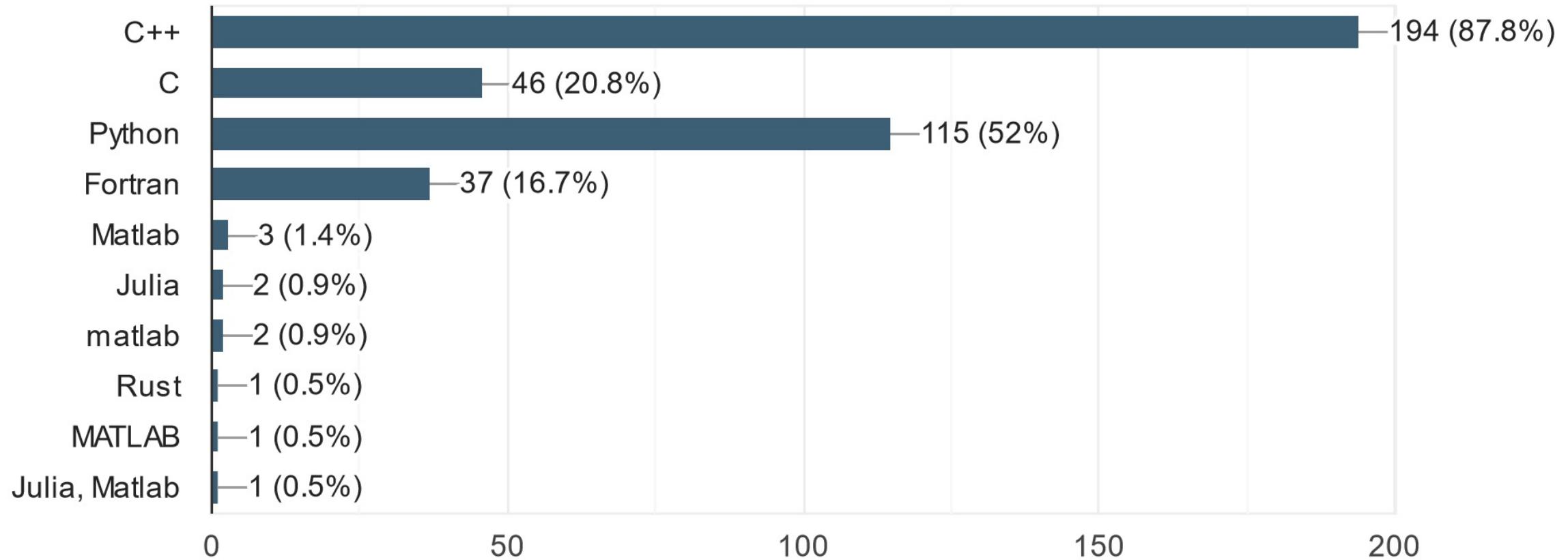
Participant countries



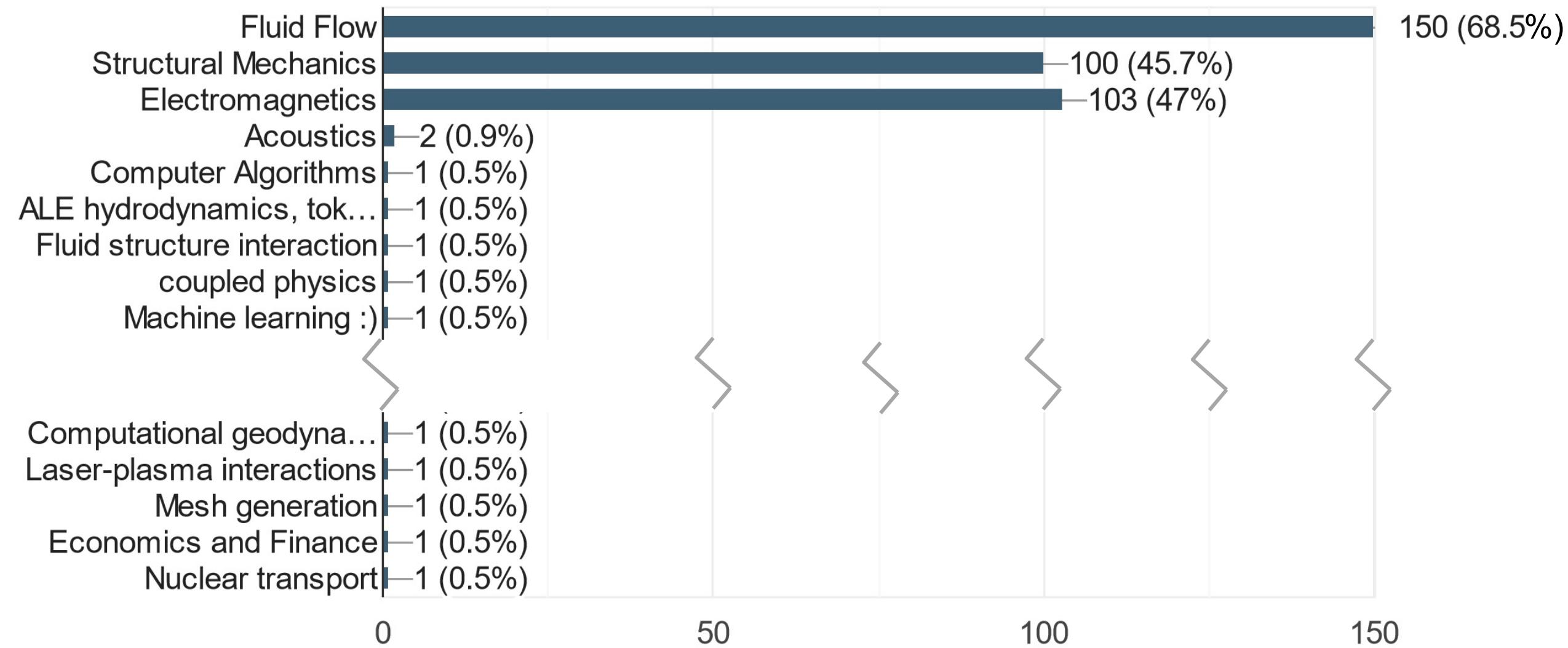
Years of experience with MFEM



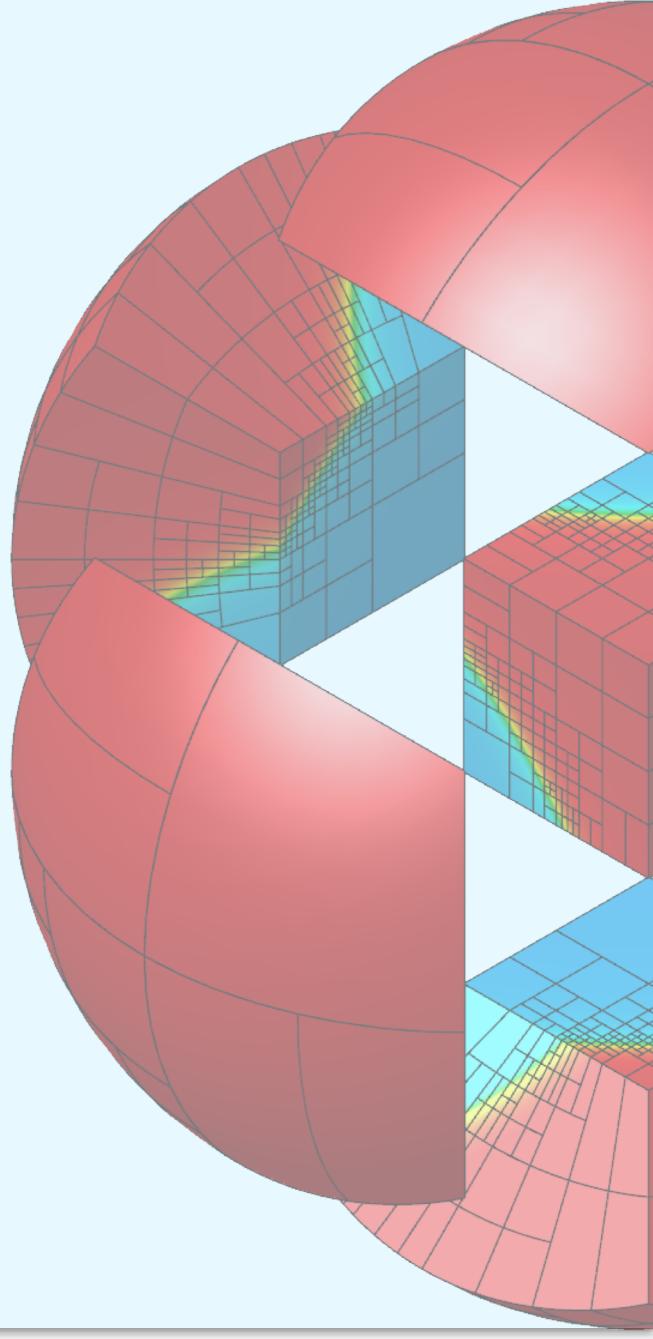
Programming language



I'm interested in the following application areas



MFEM Resources



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

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Code Issues 45 Pull requests 102 Discussions Actions Projects 3 Security Insights

master 341 branches 24 tags Go to file Add file Code

 tzanio Merge pull request #2609 from mfem/changelog-fix ... ✓ f428d03 yesterday 13,542 commits

.binder	update pyglvis requirement	26 days ago
.github	Merge pull request #2505 from adrienberneade/berneade1/actions-on-fork	20 days ago
.gitlab	Minor change	19 days ago
config	Merge branch 'master' into google-benchmark	22 days ago
data	Removing new mesh files	2 months ago
doc	Merge branch 'master' into fe-split-dev	22 days ago
examples	Comments and fix for BR2 integrator.	12 days ago
fem	Merge pull request #2556 from mfem/par-get-deriv	4 days ago
general	Merge pull request #2529 from mfem/artv3/compatibility-with-RAJA_014	7 days ago
linalg	Merge pull request #2577 from mfem/artv3/bugfix/hypr-amgx-host-de...	4 days ago

About

Lightweight, general, scalable C++ library for finite element methods

 mfem.org

hpc parallel-computing
scientific-computing
high-performance-computing amr fem
finite-elements computational-science
high-order math-physics radiuss

Readme

BSD-3-Clause License

Cite this repository

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hpc parallel-computing
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high-performance-computing amr fem
finite-elements computational-science
high-order math-physics radiuss

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Releases 7



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

Screenshot of the MFEM GitHub repository page.

Header: Search or jump to... / Pull requests Issues Marketplace Explore

Profile Picture: MFEM logo (red cube with blue and white patterns)

Repository Name: MFEM

Description: a lightweight, general, scalable C++ library for finite element methods

Owner: Lawrence Livermore National Laborat... <https://mfem.org> Verified

Navigation: Overview (selected), Repositories 10, Packages, People 456, Teams 6, Projects 2

Pinned:

- mfem** (Public)
Lightweight, general, scalable C++ library for finite element methods
C++ 810 stars 300 forks
- PyMFEM** (Public)
Python wrapper for MFEM
C++ 66 stars 28 forks
- data** (Public)
Additional (large) datafiles for MFEM
2 stars

People: View all (20 icons)

Repositories:

- mfem** (Public)
Lightweight, general, scalable C++ library for finite element methods
C++ 810 stars 300 forks BSD-3-Clause 45 issues 103 PRs Updated 3 minutes ago

Top languages: C++ Python HTML Less

Most used topics: fem scientific-computing Manage



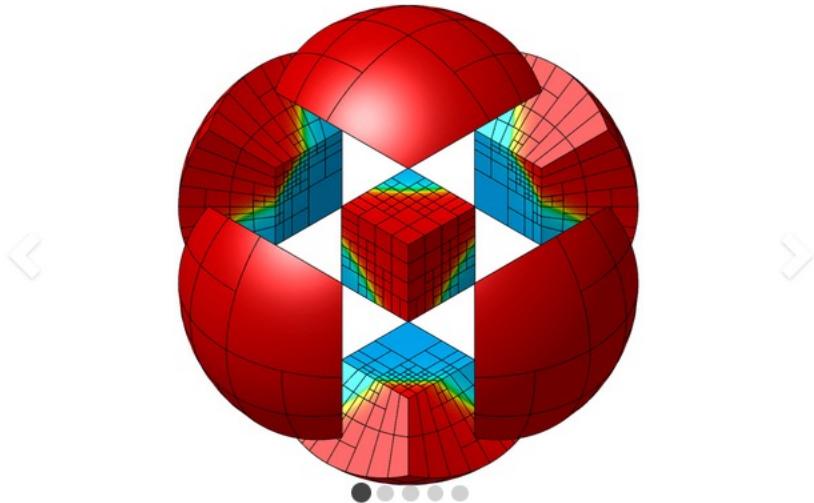
MFEM on Github (<https://github.com/mfem>)

Screenshot of the MFEM GitHub repository page.

The page shows the following details:

- Repository Name:** MFEM
- Description:** a lightweight, general, scalable C++ library for finite element methods
- Owner:** Lawrence Livermore National Laborat...
- Website:** <https://mfem.org>
- Verification:** Verified
- Navigation:** Overview (selected), Repositories (10), Packages, People (456), Teams (6, circled in red), Projects (2)
- Pinned:**
 - mfem** (Public)
Lightweight, general, scalable C++ library for finite element methods
C++ 810 stars 300 forks
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Python wrapper for MFEM
C++ 66 stars 28 forks
 - data** (Public)
Additional (large) datafiles for MFEM
2 stars
- People:** A grid of 20 user profiles.
- Repositories:**
 - mfem** (Public)
Lightweight, general, scalable C++ library for finite element methods
C++ 810 stars 300 forks BSD-3-Clause 45 issues 103 PRs Updated 3 minutes ago
- Top languages:** C++ (red dot), Python (blue dot), HTML (orange dot), Less (dark blue dot).
- Most used topics:** fem, scientific-computing





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

News

Jul 29, 2021 Version 4.3 [released](#).

Jul 10, 2021 [MFEM Community Workshop](#) in October.

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New users should start by examining the [example codes](#).

We also recommend using [GLVis](#) for visualization.

Contact

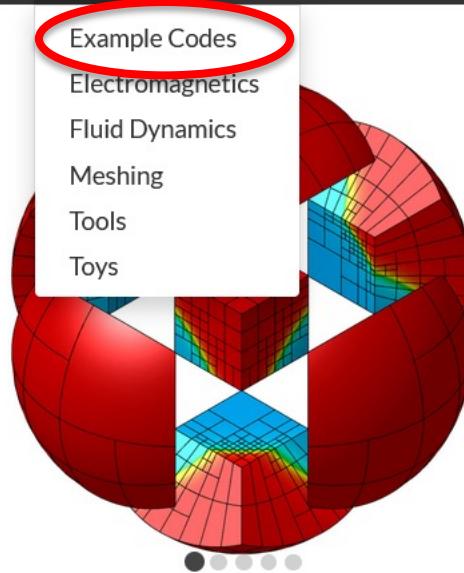
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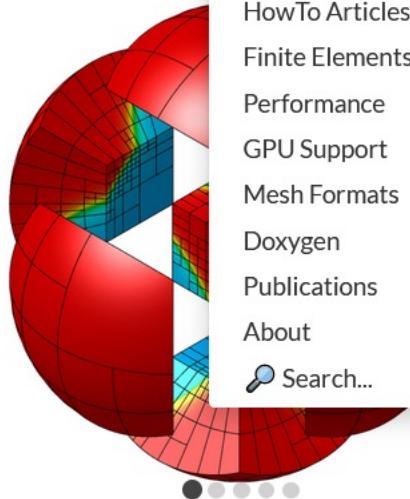
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Documentation

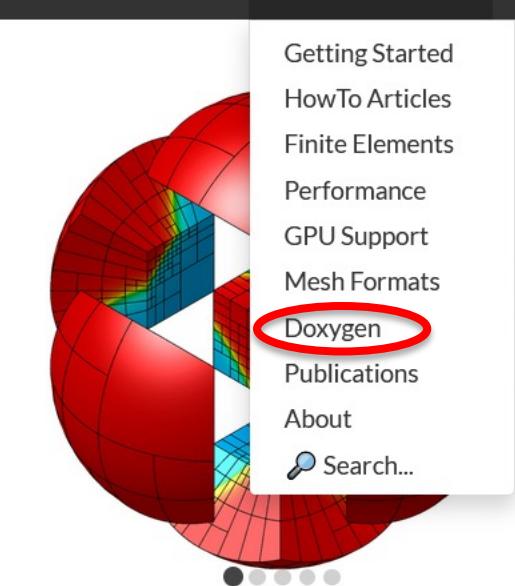
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MFEM

Features

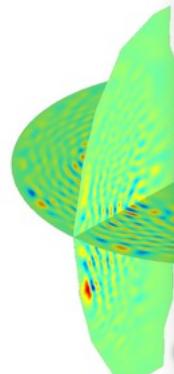
Examples ▾

Documentation ▾

Gallery

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Electromagnetic wave propagation in the [NSTX-U tokamak](#)



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HowTo Articles

This is a growing collection of "how-to" articles on topics encountered by our users in practice.

Please feel free to [suggest a missing topic!](#)

 [Search](#) the articles...

Build, Install, and Test

- [Overview of the MFEM Build and Test System](#)
- [Install MFEM with Spack](#)

Finite Elements

- [Using Partial and Matrix-free Assembly](#)

Meshes

- [Navigating Mesh Connectivity](#)
- [Parallel Element Numbering](#)
- [Finding Local Element Coordinates of Physical Points](#)
- [Working with Nonconforming Meshes for AMR](#)

Solvers

- [Using a Custom Preconditioner](#)

Boundaries

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Search Documentation

Enter keywords, e.g., 'nonlinear', 'howto' or 'bilinear form':

nonlinear form

Nonlinear Form Integrators

Nonlinear form integrators are used to express the local action of a general nonlinear finite element operator. In addition, they may provide the capability to assemble the local gradient operator and

Nonlinear Form Integrators

```
$ \newcommand{\cross}{\times} \newcommand{\inner}[1]{\cdot} \newcommand{\div}{\nabla \cdot} \newcommand{\curl}{\nabla \times} \newcommand{\grad}{\nabla}
```

$$\newcommand{\ddx}[1]{\frac{d}{dx}} $ Nonlinear for$$

Example 10: Nonlinear Elasticity

This example solves a time dependent nonlinear elasticity problem of the form $\frac{dv}{dt} = H(x) + S v$, $\frac{dx}{dt} = v$, where H is a hyperelastic model and S is a viscosity op

Linear Form Integrators

Linear form integrators are used to compute the integrals of products of a basis function with a given source function over individual mesh elements (or sometimes over edges or faces). The LinearForm

Linear Form Integrators



mfem.org

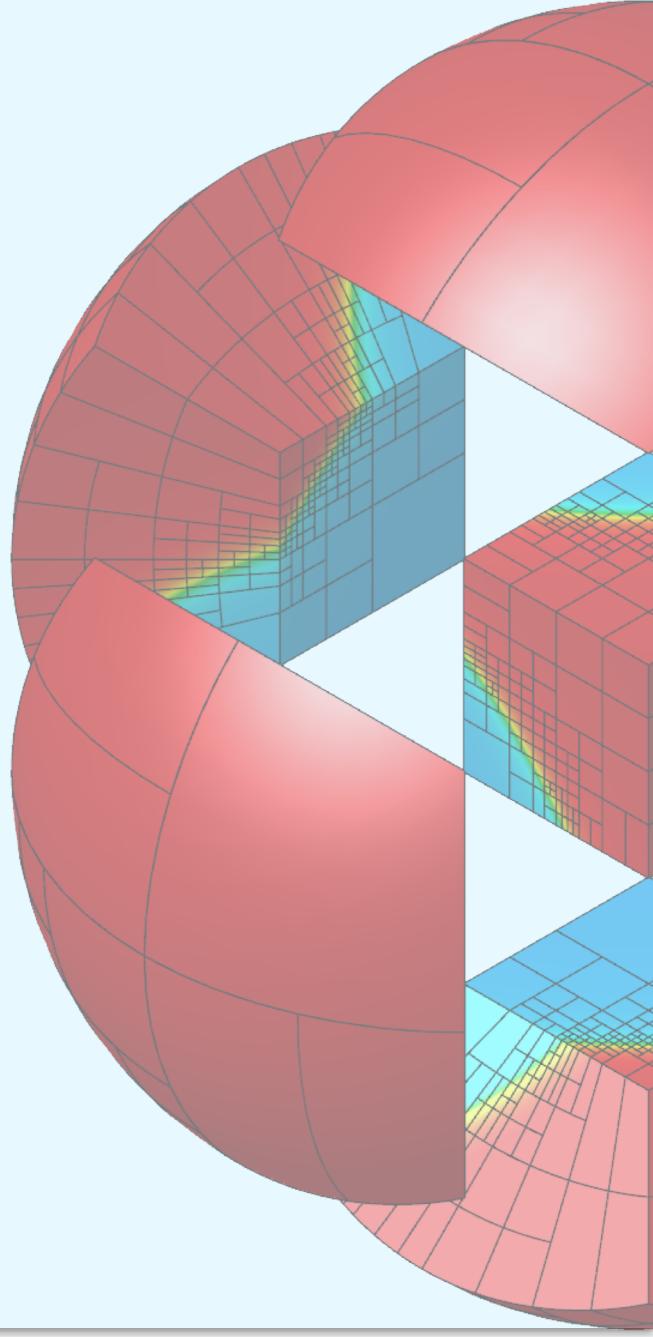
fisher47@llnl.gov



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Simulation Contest



Simulation and Visualization Contest Winners!



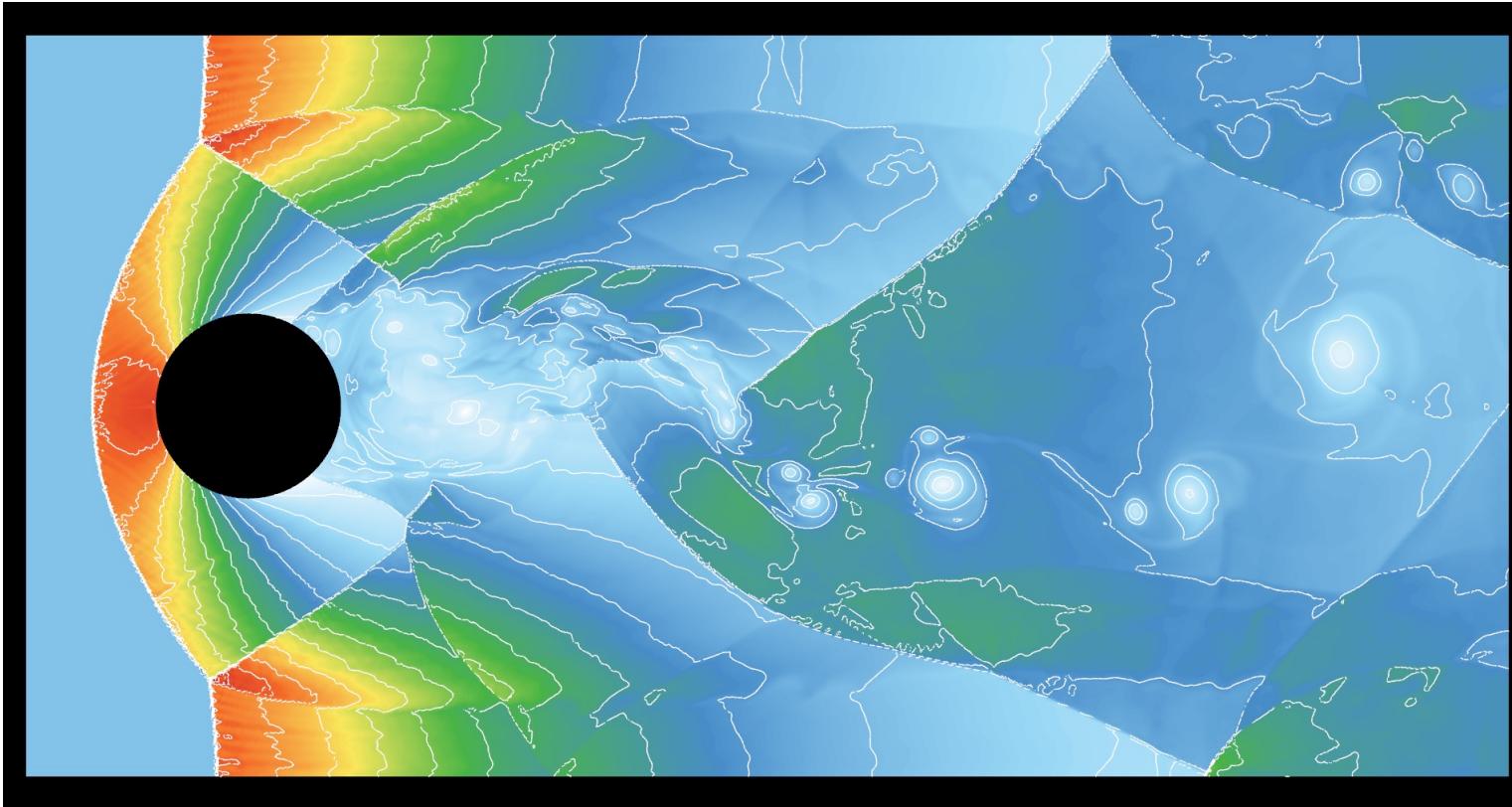
- We held a contest for the most interesting simulations and visualizations.
- So many good entries that we broke it into 2 categories, still images and animations.
- Entries were judged on aesthetic qualities, novelty of the approaches, and the notability of the application.
- Results will be featured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

2nd Runner up for Still Images

?



2nd Runner up for Still Images



Compressible Euler simulation of
mach 3 flow around a cylinder in
2D.

Hennes Hajduk
TU Dortmund University

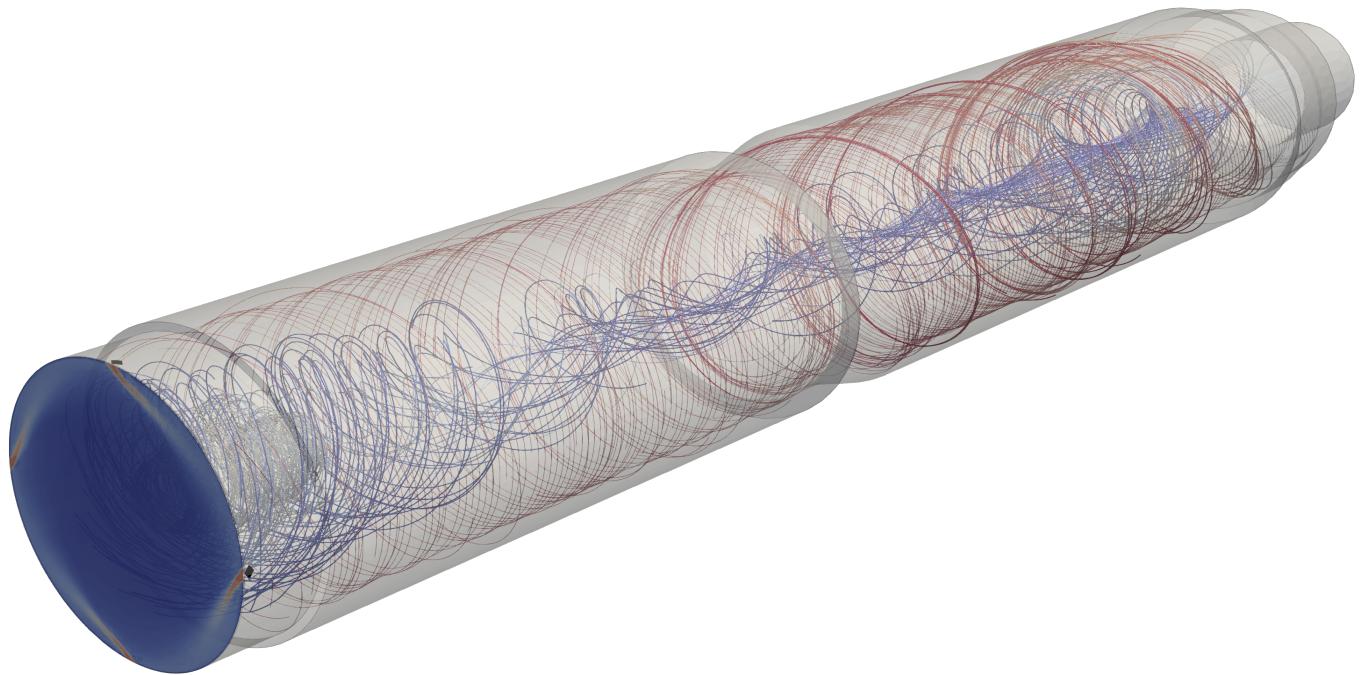


Runner up for Still Images

?



Runner up for Still Images



Compressible Navier-Stokes simulation of gas injection in a cylindrical plasma torch. Simulation is resolving two large vortical structures in red and blue traveling in opposite directions.

Karl W. Schulz
University of Texas

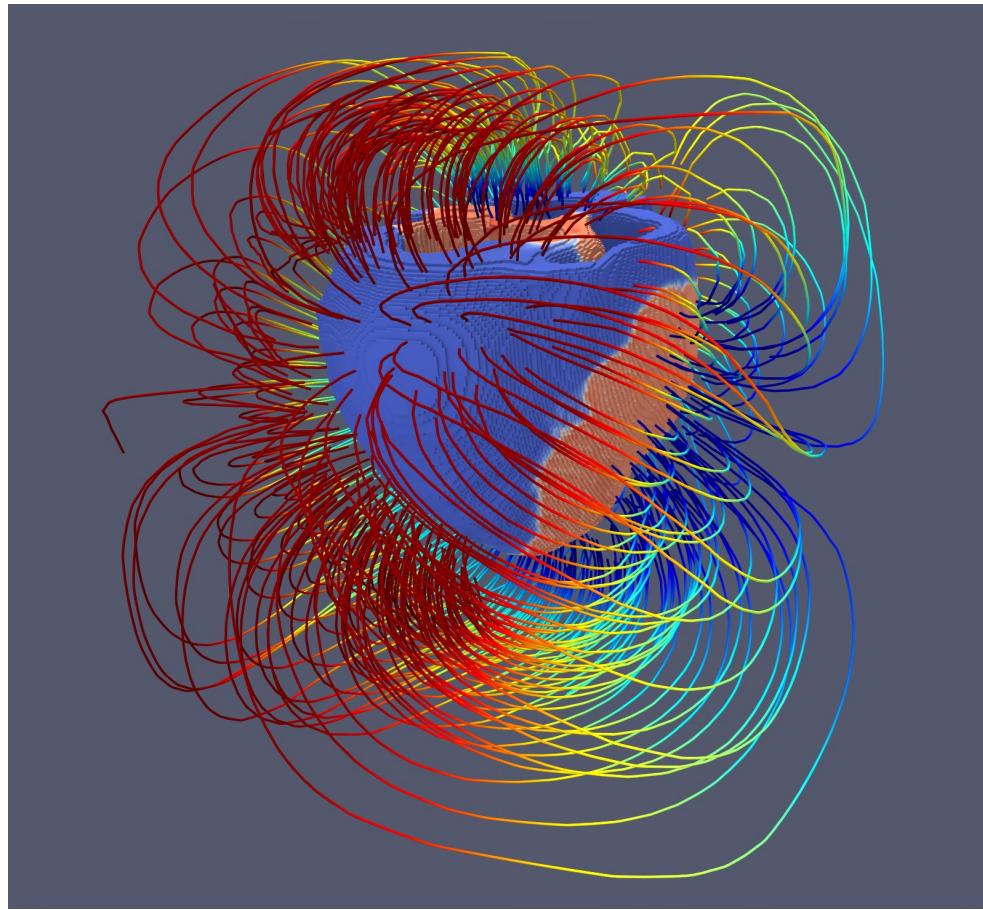


Winner for Still Images

?



Winner for Still Images



Visualization of the electric field generated by the electrical wave on rabbit heart ventricles during depolarization of the heart. The ventricles are embedded in a passive conducting volume. This model is an experimental setup for the investigation of QRS-waves in electrocardiograms emerging from the electrical activity of the ventricles.

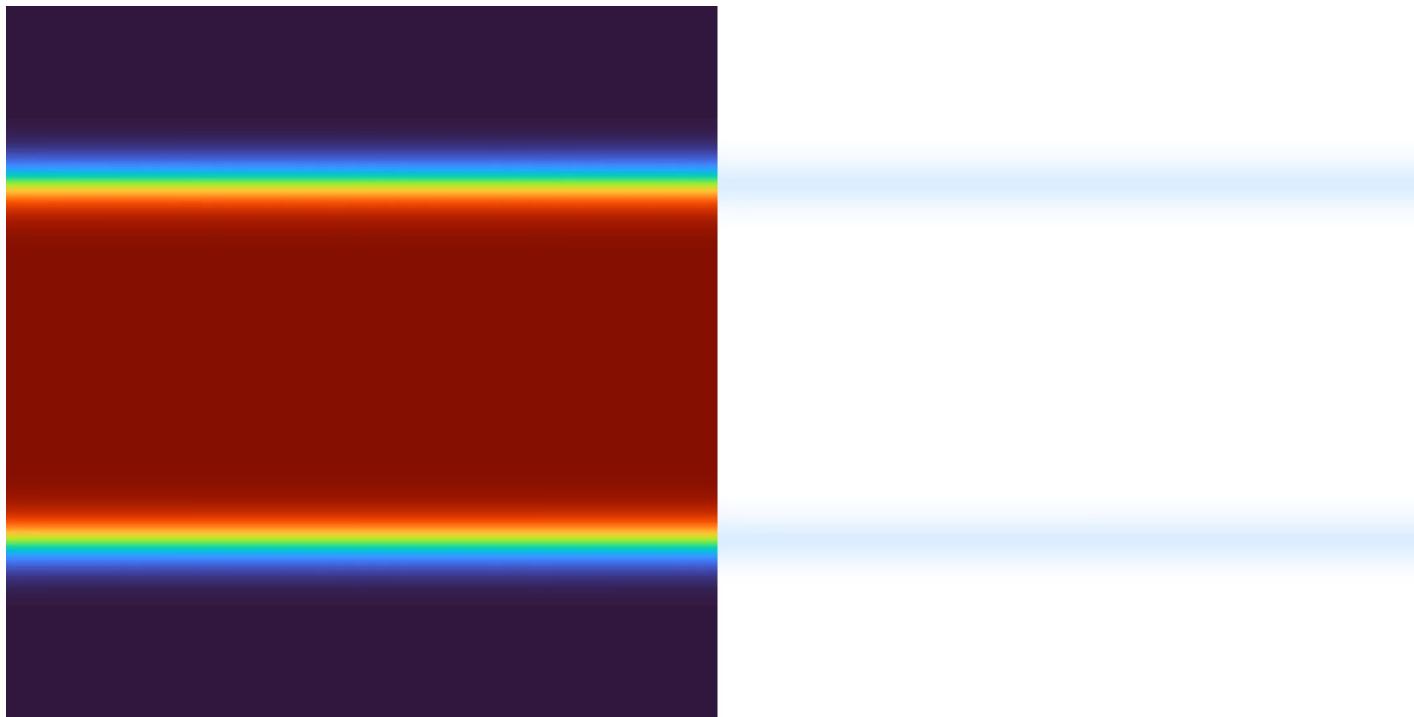
Dennis Ogiermann
Ruhr-University Bochum

2nd Runner up for Animations

?



2nd Runner up for Animations



Inviscid Kelvin-Helmholtz instability using high-order invariant domain preserving discontinuous Galerkin methods with convex limiting.

Will Pazner
LLNL

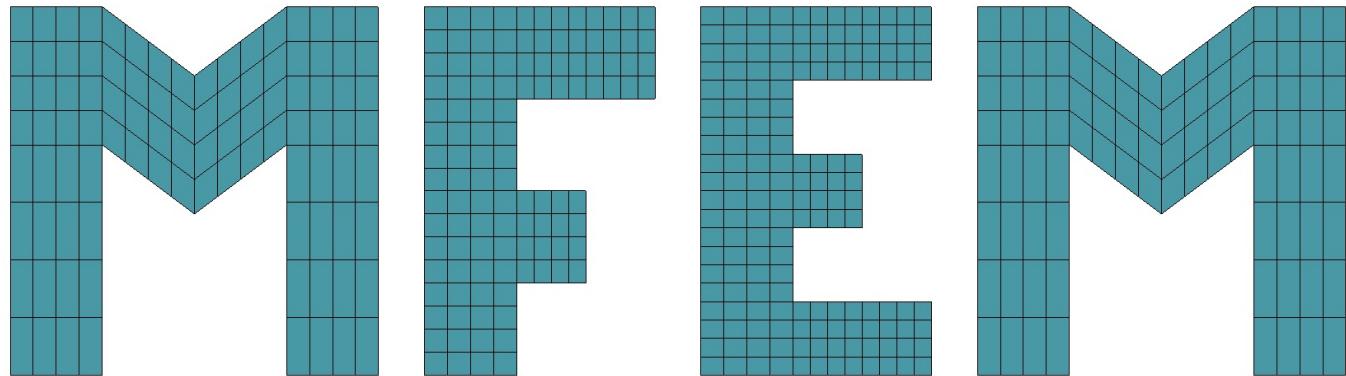


Runner up for Animations

?



Runner up for Animations



Compressible Euler simulation of
blast waves in the Lagrangian
frame on the MFEM logo.

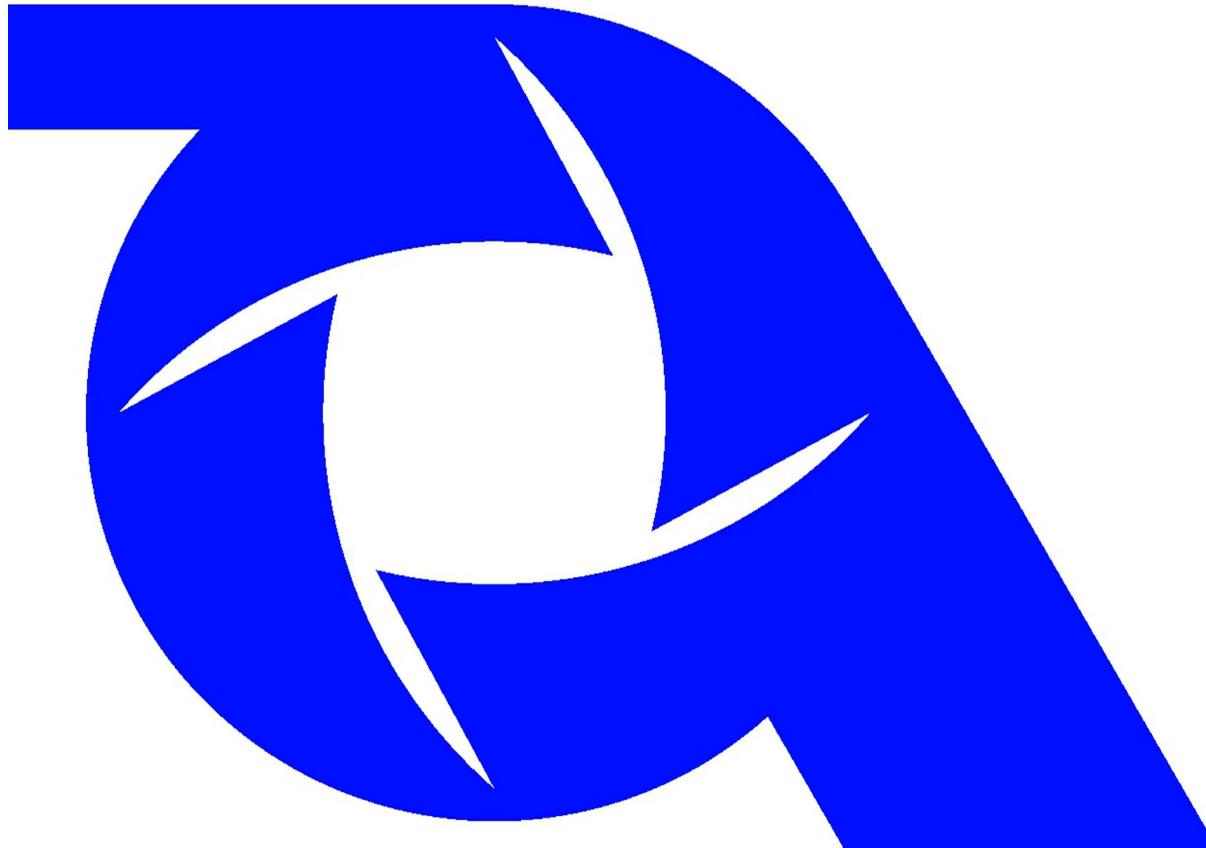
Vladimir Tomov
LLNL

Winner for Animations

?



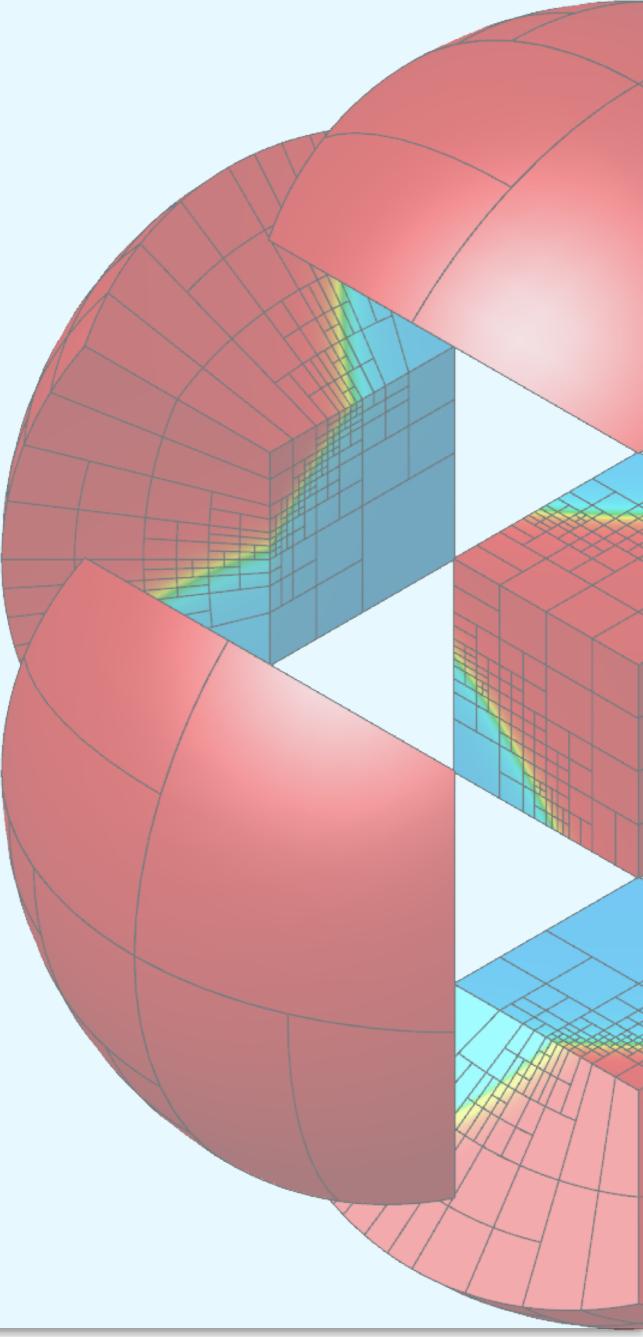
Winner for Animations



Tamas Horvath
Oakland University

Incompressible fluid flow around a rotating turbine. Fluid-rigid body simulation using space-time embedded-hybridized discontinuous Galerkin discretization

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>
 - Near term email – mfem@llnl.gov
 - Long term Github issues - <https://github.com/mfem-mfem/issues>

See you all next year!



Gratitude

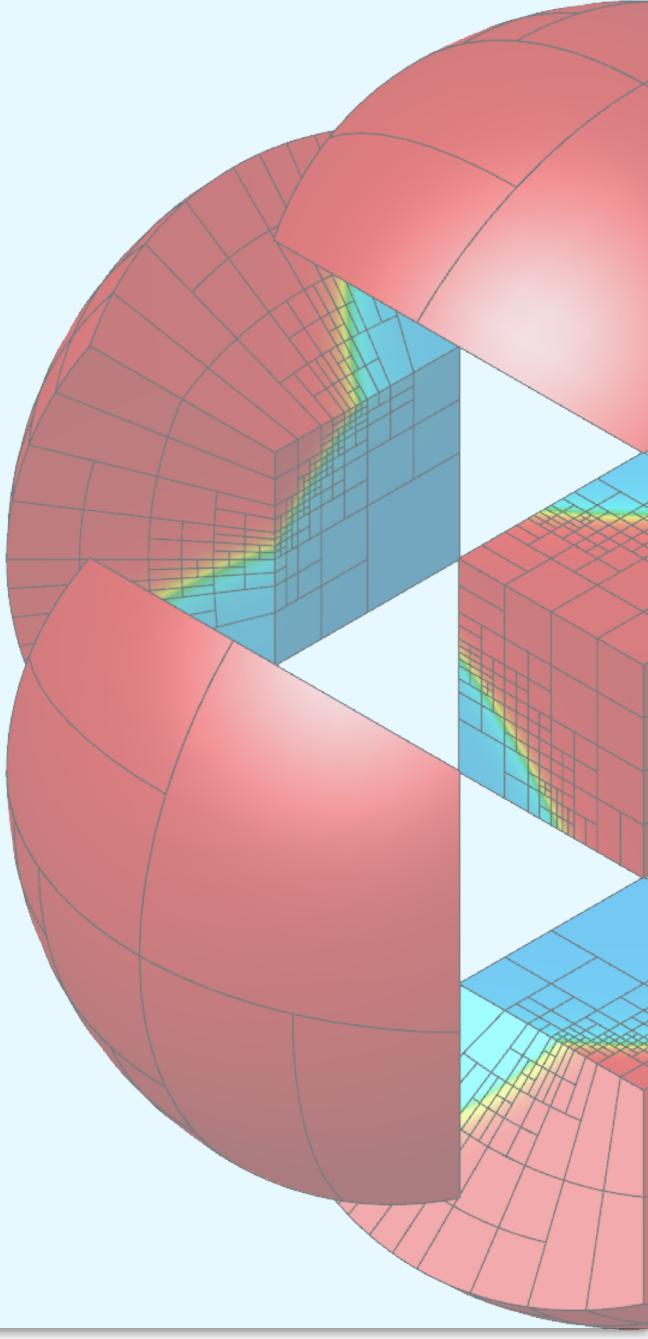


- Applause for the speakers
- Many thanks to our discussion leaders: Mark Stowell, Julian Andrej, and Jamie Bramwell
- Special thanks to the workshop planning committee: Tzanio Kolev, Mark Stowell, Will Pazner, and Holly Auten
- Thank you all for attending.

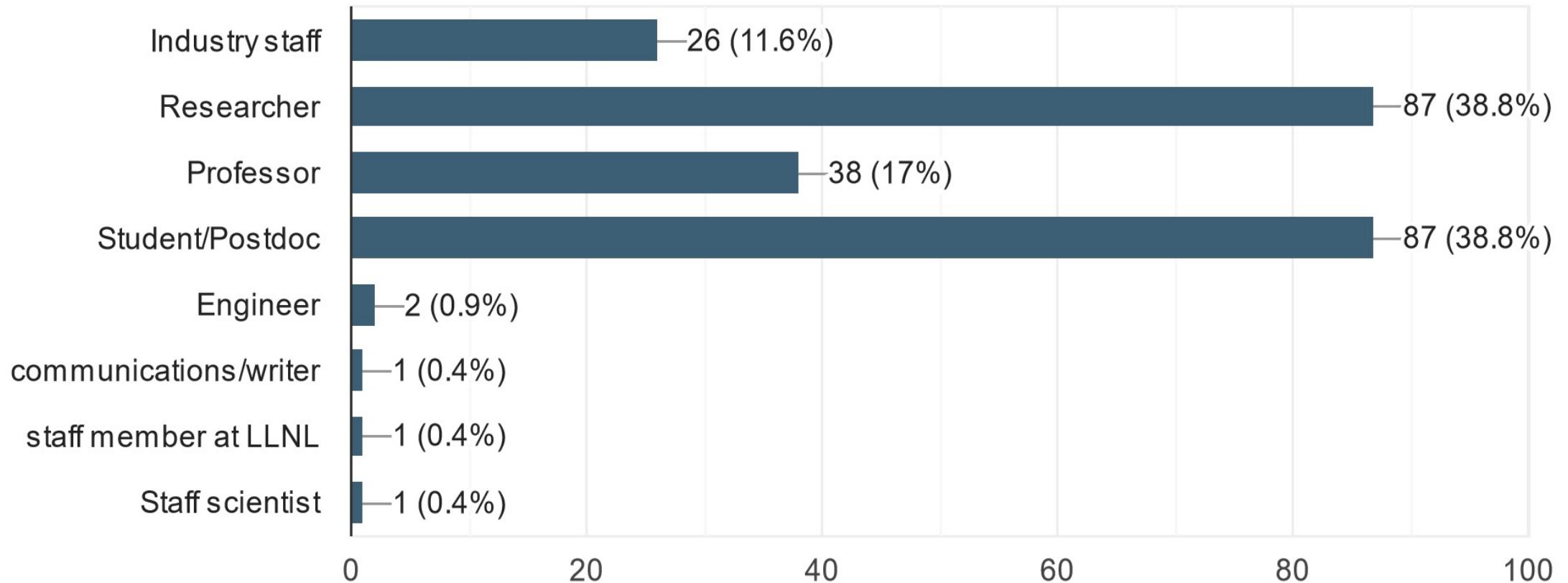
Thank you from the MFEM team at LLNL!



Bonus



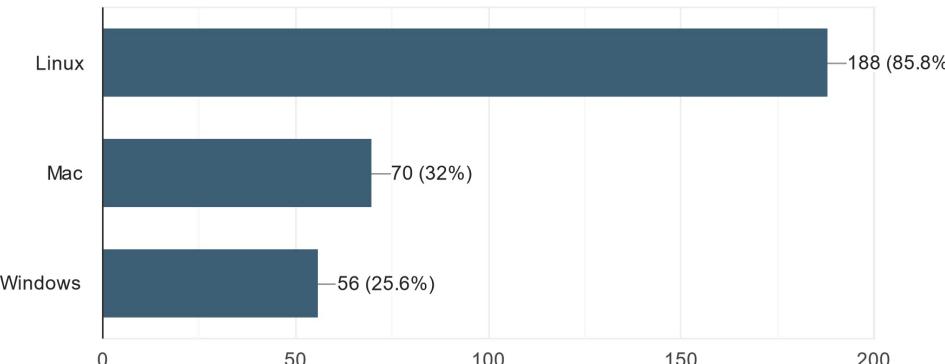
Position



Software Environment

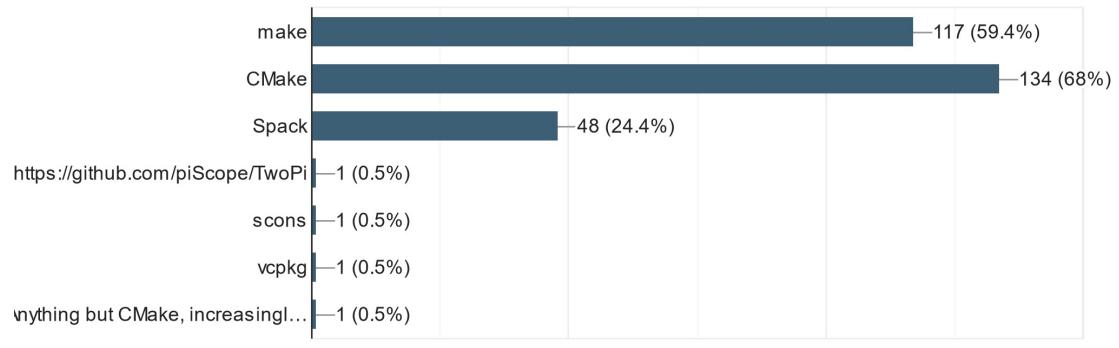
Operating system

219 responses



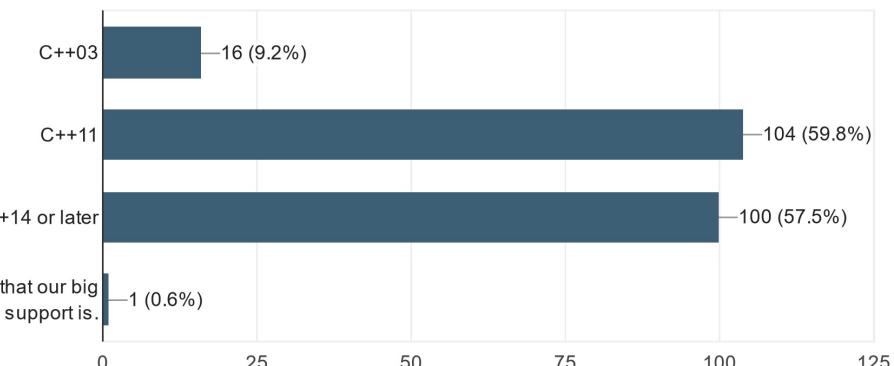
Build system

197 responses



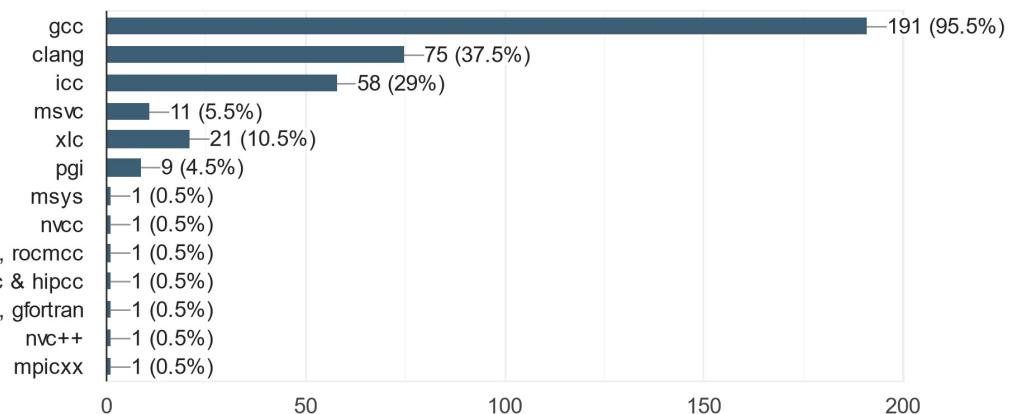
C++ standard

174 responses



Compiler

200 responses



MFEM features that are critical for me

