Welcome to the First Annual MFEM Community Workshop

October 20, 2021
mfem.org/workshop

Organizers

Aaron Fisher   Tzanio Kolev   Will Pazner   Mark Stowell

mfem

Lawrence Livermore National Laboratory

Interacting with the workshop
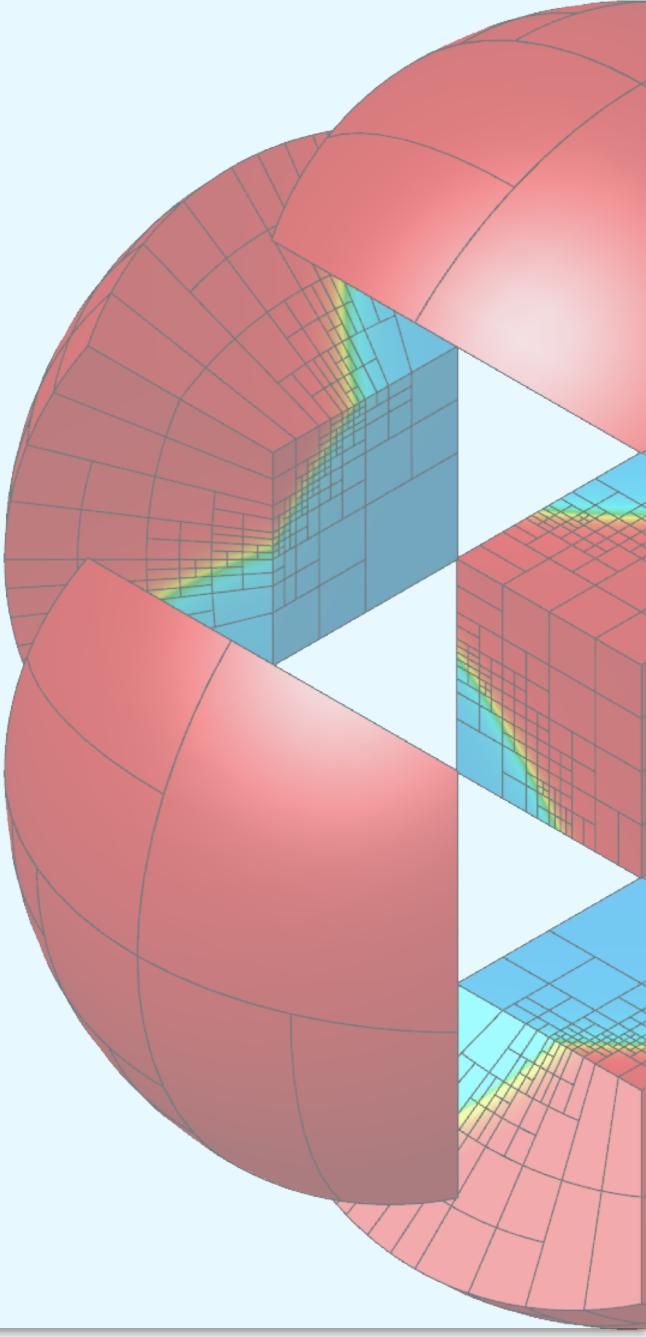
- Please keep your mic muted during the talks.

- 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
8:00-8:30	**The State of MFEM & Roadmap**	Tzanio Kolev
8:30-9:00	**Recent Developments**	Veselin Dobrev
9:00-10:00	**Talks, Session I** (20 mins each)	• Jamie Bramwell (LLNL) • Guillaume Latu (CEA) • Julian Jimenez (U of Columbia)
==10:00-10:30==	==**Break & Group Photo**==	==All Download a virtual background below==

10:30-12:30	**Talks, Session II** (20 mins each)	• Robert Rieben (LLNL) • Marc Bolinches (UT) • Mathias Davids (Harvard) • Jan Nikl (ELI Beamlines) • Qi Tang (LANL), • Syun'ichi Shiraiwa (PPPL)
12:30-1:00	**Break**	All
1:00-2:00	**Talks, Session III** (20 mins each)	• William Dawn (NCSU) • Vladimir Tomov (LLNL) • Will Pazner (LLNL)
2:00-2:30	**Breakout Sessions**	• 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	Imam Abdulrahman Bin Faisal University	Otto von Guericke University Magdeburg	Université Grenoble Alpes
Amirkabir University of Technology	Imperial College London	Pontificia Universidad Católica De Chile	University Heidelberg
Anna University, Chennai, India	Indian Institute of Space Science and Technology	Pontificia Universidad Javeriana	University of Belgrade
Ansys	Iowa State University	Princeton Plasma Physics Lab	University of Bochum
Applied Materials Inc.	Ivannikov Institute for System Programming of the RAS	Princeton Plasma Physics Laboratory	University of California Berkeley
Argonne National Laboratory	Johns Hopkins University Applied Physics Lab	ReLogic Research, Inc.	University of California Merced
Bauman Moscow State Technical University	Karlsruhe Institute of Technology	Rensselaer Polytechnic Institute	University of Cape Coast
Beirut Arab University	Keldysh Institute of Applied Mathematics	RISE AB	University of Connecticut
Cadi Ayyad University	Lawrence Livermore National Laboratory	RNET Technologies	University of Delaware
CEA	LMU Munich	Rochester Institute of Technology	University of Glasgow
Center for Earthquake Research, University of Memphis	Los Alamos National Lab	Siemens Industry Software	University of Granada
CERN	Los Alamos National Laboratory	Simula Research Laboratory	University of Houston
CFD Research	Massachusetts Institute of Technology	SRM Institute of Science and Technology	University of Illinois at Urbana-Champaign
Covanos	Meidensha Corporation	Stanford University	University of Liverpool
Czech Technical University in Prague	Michigan State University	Stevens Institute of Technology	University of Louisiana at Lafayette
Delft Technical University	Mississippi State University	Synthetik Applied Technologies	University of MIchigan
DePuy Synthes	MIT	Syracuse University	University of Notre Dame
Drexel University	Morgan State University	Tampere University	University of Oxford
ELI Beamlines, Czech Academy of Sciences	Moscow Institute of Physics and Technology	Technical University Dortmund	University of Pennsylvania
EPFL	National University of Colombia	Technion Israel Institute of Technology	University of Peradeniya
ETH Zurich	Naval Nuclear Laboratory	Texas A&M University	University of Rochester, Laboratory for Laser Energetics
Federal University of Juiz de Fora	Naval Research Laboratory	The University of Utah	University of Tennessee
Federal University of Rio de Janeiro	NCMesh s.r.o.	Tokyo Metropolitan University	University of Texas at Austin
Finnish Meteorological Institute	North Carolina State University	Tsinghua University	University of the Bundeswehr Munich
Friedrich-Alexander-Universität Erlangen-Nürnberg	Northeastern University	UK Atomic Energy Authority	University of Waterloo
Harvard Medical School	Northwestern Polytechnic University	Universidad de Castilla - La Mancha	University of West Florida
Harvard University	Norwegian University of Science and Technology	Universidad de Granada	University of Wisconsin-Madison
Heidelberg University	Nuclear Naval Propulsion Lab	Universidad Nacional de Colombia	University of Wuppertal
IBM Research	Oakland University	Università della Svizzera Italiana Lugano	VTT Technical Research Centre of Finland
IERUS Technologies	OpenSim Technology LLC	Université du Québec à Montréal	Weidlinger Technology Ventures, LLC
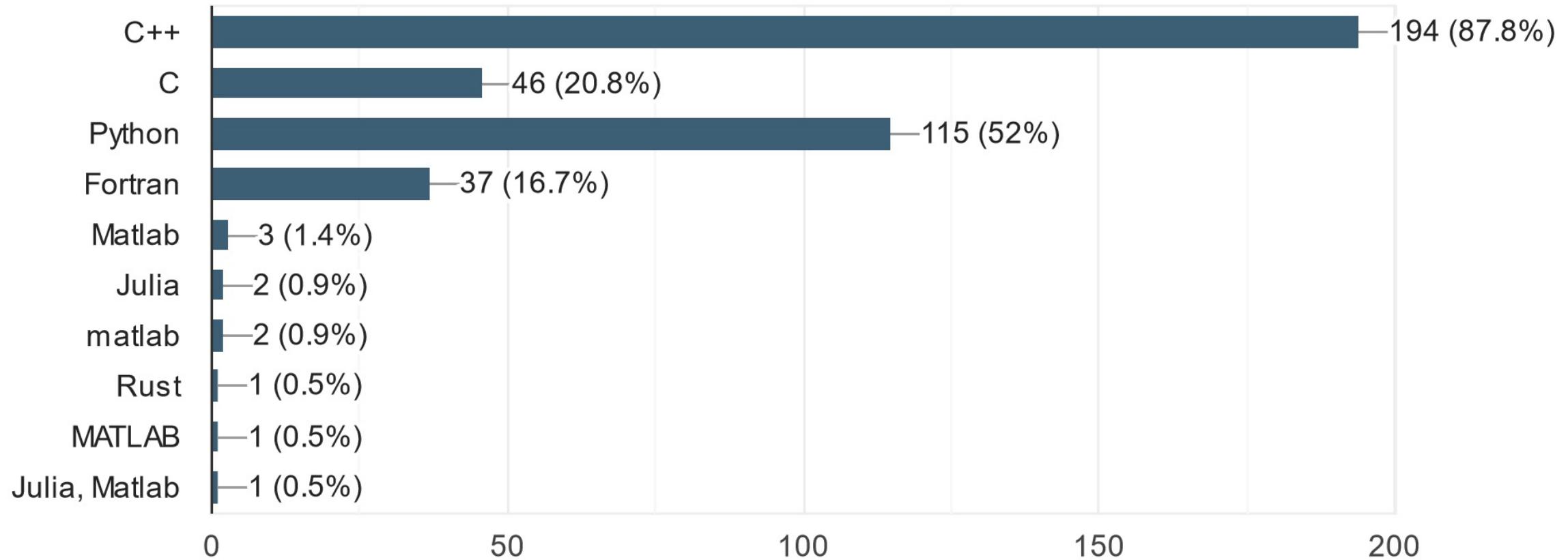
Participant countries
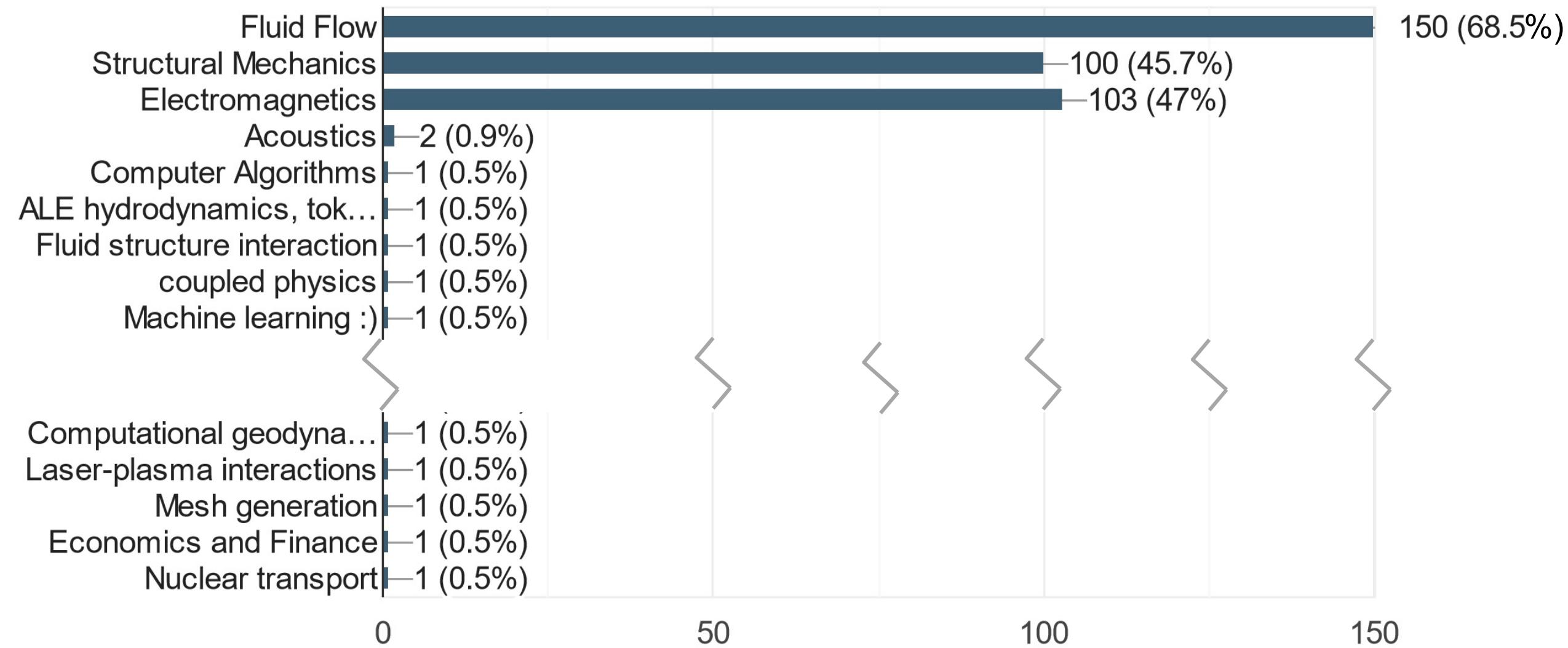
Years of experience with MFEM
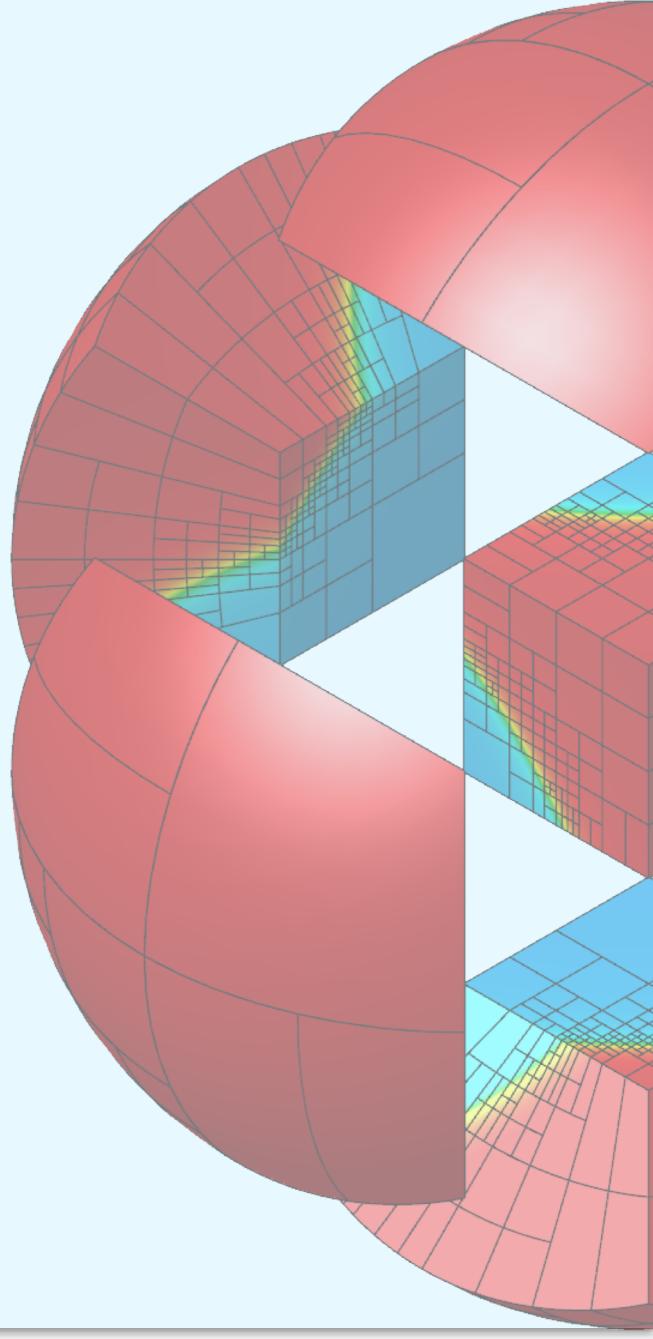
Programming language

I'm interested in the following application areas

Application Area	Count
Fluid Flow	150 (68.5%)
Structural Mechanics	100 (45.7%)
Electromagnetics	103 (47%)
Acoustics	2 (0.9%)
Computer Algorithms	1 (0.5%)
ALE hydrodynamics, tok…	1 (0.5%)
Fluid structure interaction	1 (0.5%)
coupled physics	1 (0.5%)
Machine learning :)	1 (0.5%)
Computational geodyna…	1 (0.5%)
Laser-plasma interactions	1 (0.5%)
Mesh generation	1 (0.5%)
Economics and Finance	1 (0.5%)
Nuclear transport	1 (0.5%)

MFEM Resources

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

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New content - mfem.org (https://mfem.org)

Electromagnetic wave propagation in the NSTX-U tokamak

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.
Apr 22, 2021	MFEM featured on *S&TR* magazine cover.
Feb 16, 2021	New page on GPU performance.

Latest Release

New features ⁝ Examples ⁝ Code documentation ⁝ Sources

Download mfem-4.3.tgz

Older releases ⁝ Python wrapper

Documentation
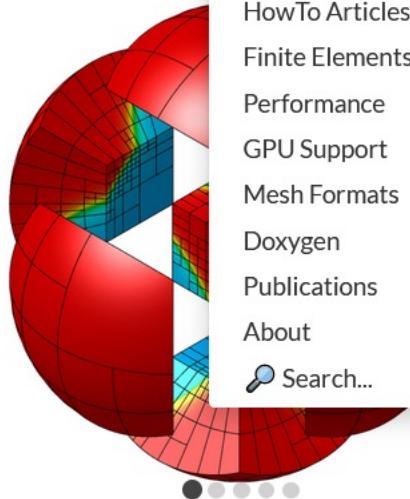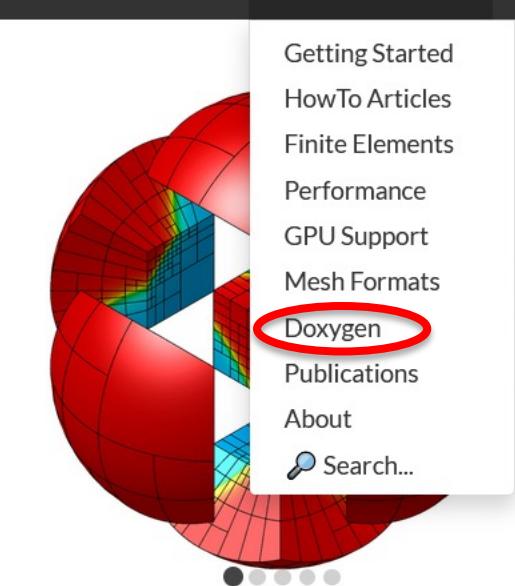
Building MFEM ⁝ Getting Started ⁝ Finite Elements ⁝ Performance

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.
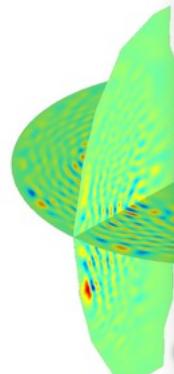
Navigation bar: MFEM Features Examples ▾ Documentation ▾ Gallery Download GitHub

Documentation menu: Getting Started / HowTo Articles / Finite Elements / Performance / GPU Support / Mesh Formats / Doxygen / Publications / About / Search...

Lawrence Livermore National Laboratory

NNSA National Nuclear Security Administration

New content - mfem.org (https://mfem.org)

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mfem.org

fisher47@llnl.gov

Lawrence Livermore National Laboratory

Simulation Contest

Simulation and Visualization Contest Winners!
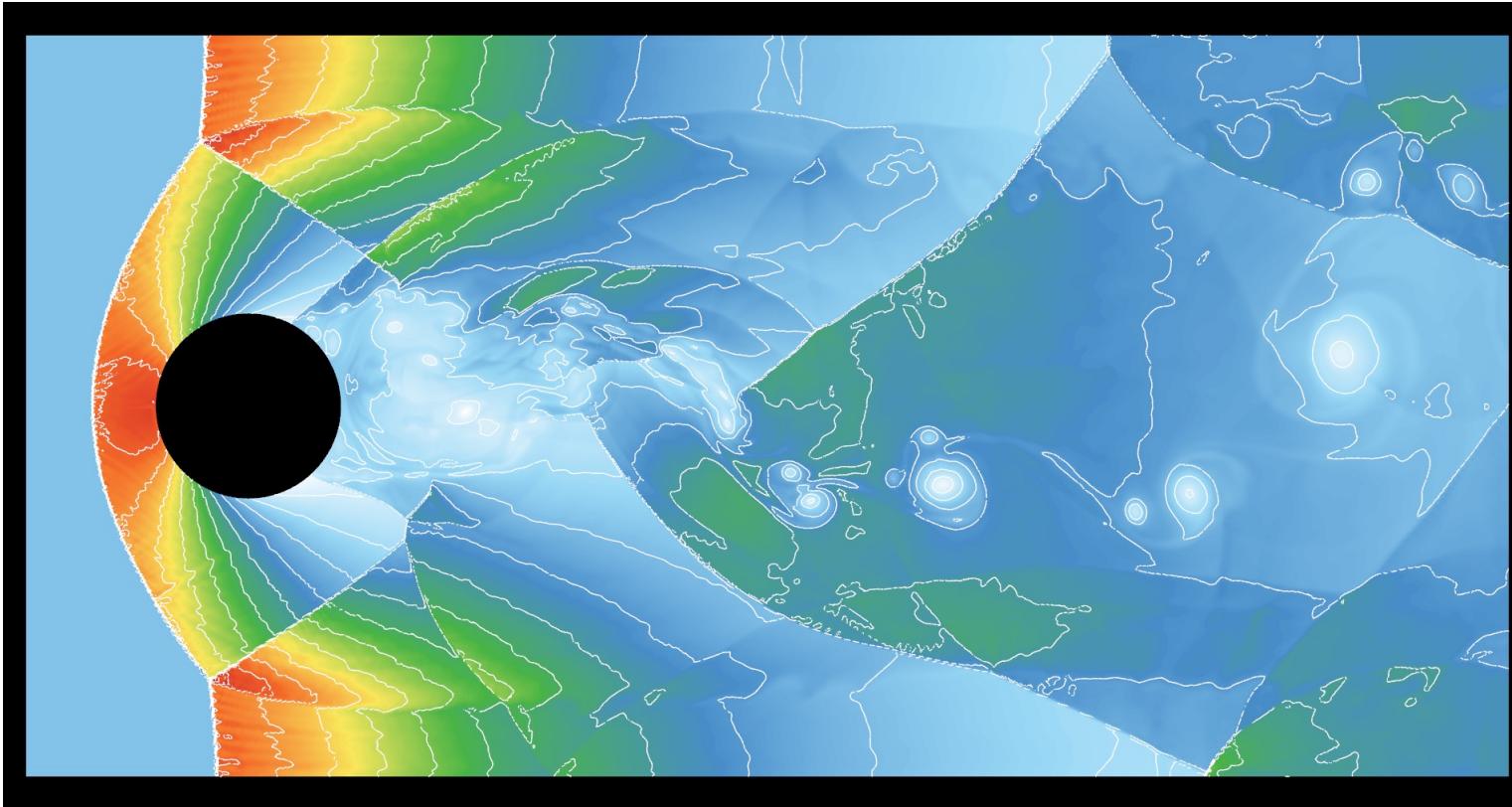
- We held a contest for the most interesting simulations and visualizations.

- 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.

Lawrence Livermore National Laboratory

NNSA
National Nuclear Security Administration

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
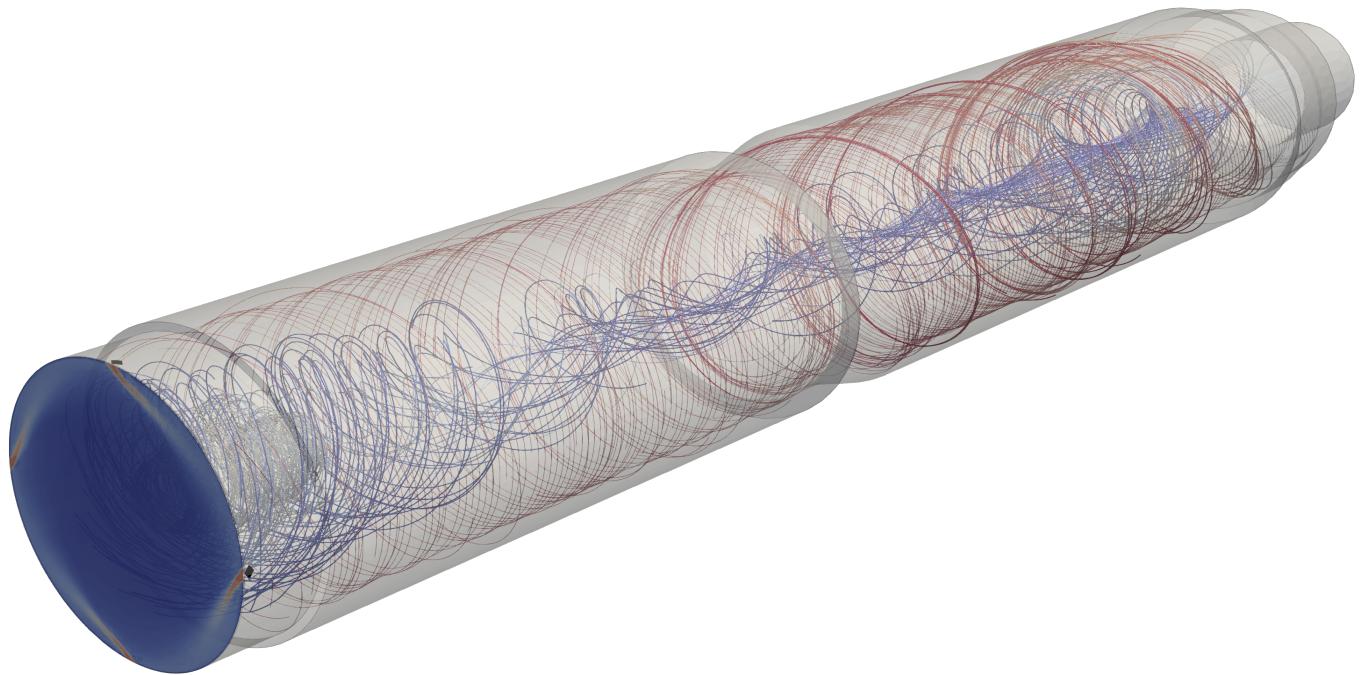
Runner up for Still Images

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
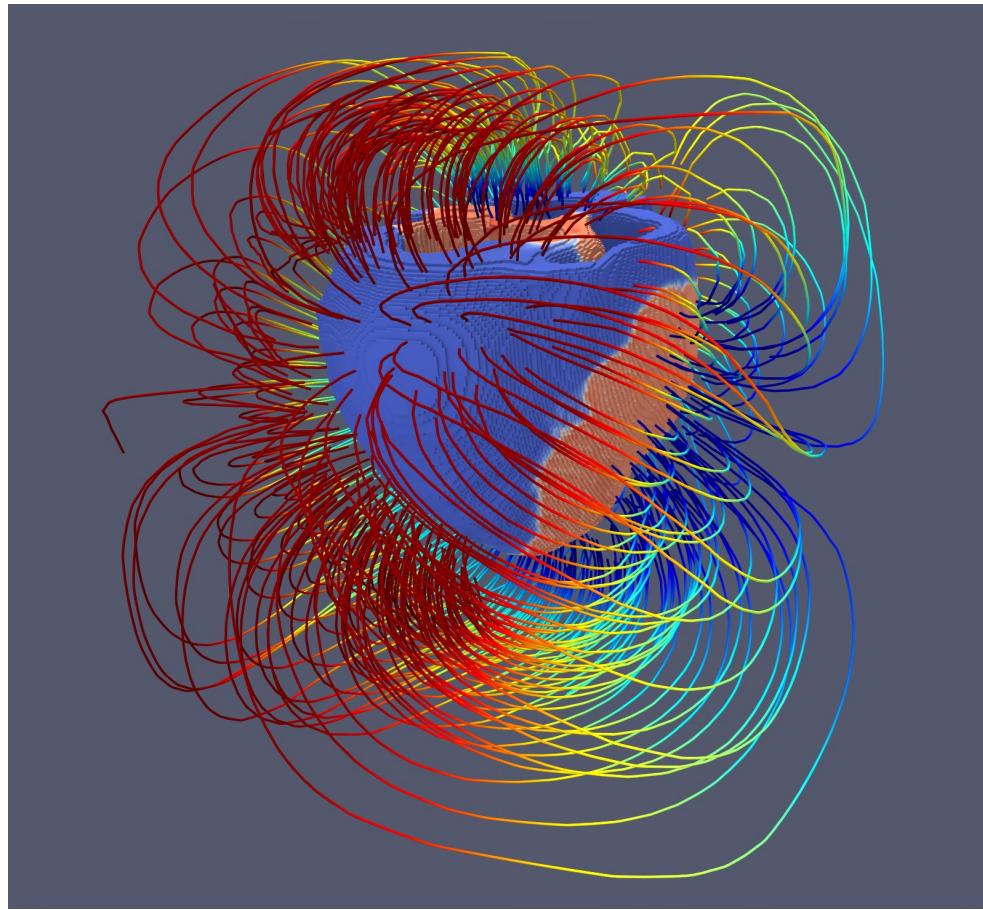
Winner for Still Images

?

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.
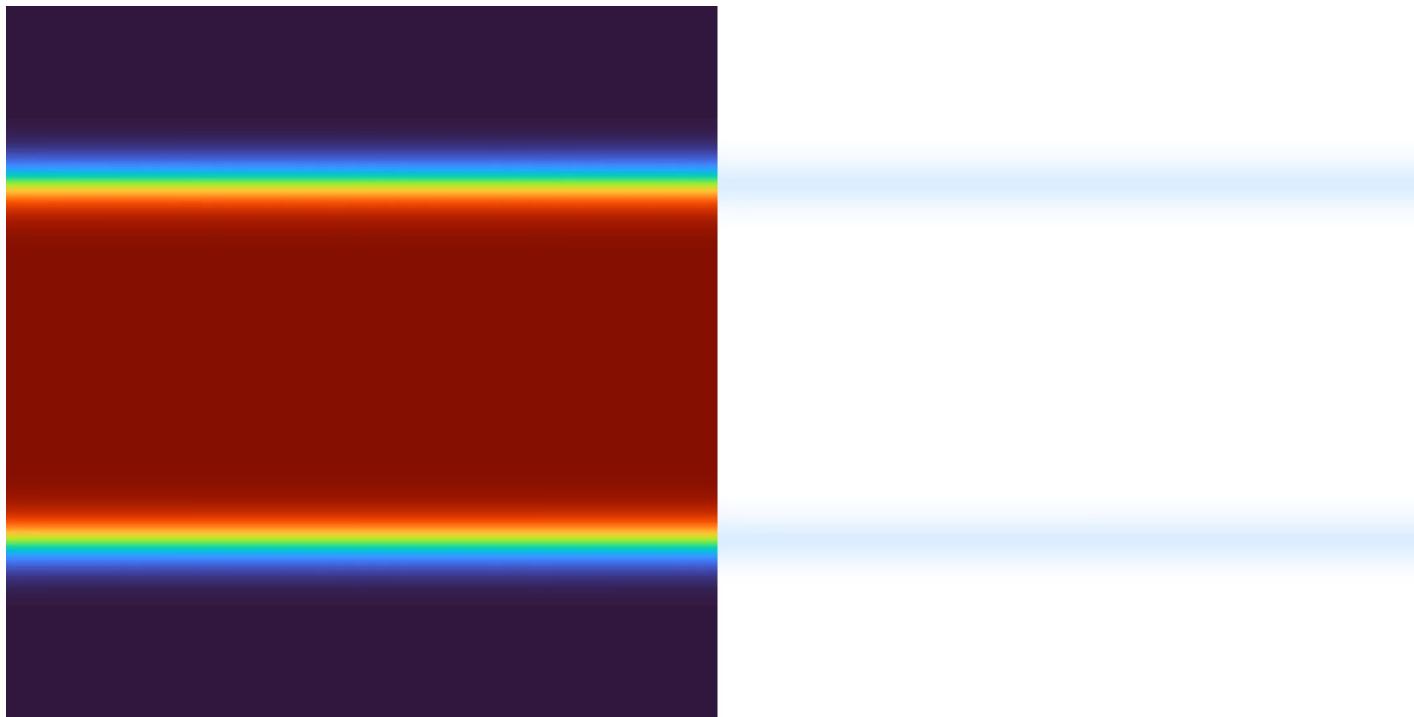
Dennis Ogiermann
Ruhr-University Bochum

2nd Runner up for Animations

?

Lawrence Livermore National Laboratory

2nd Runner up for Animations

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

Will Pazner
LLNL
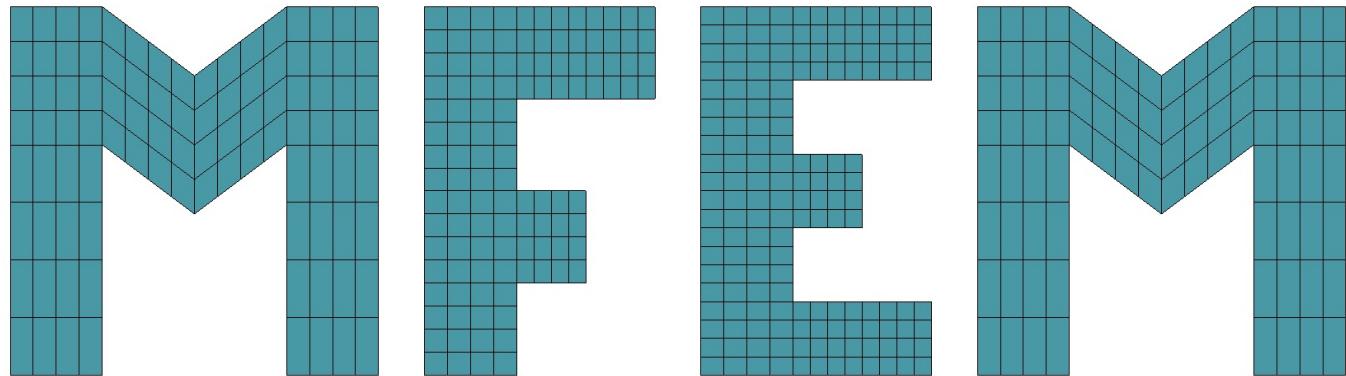
Runner up for Animations

?

Runner up for Animations

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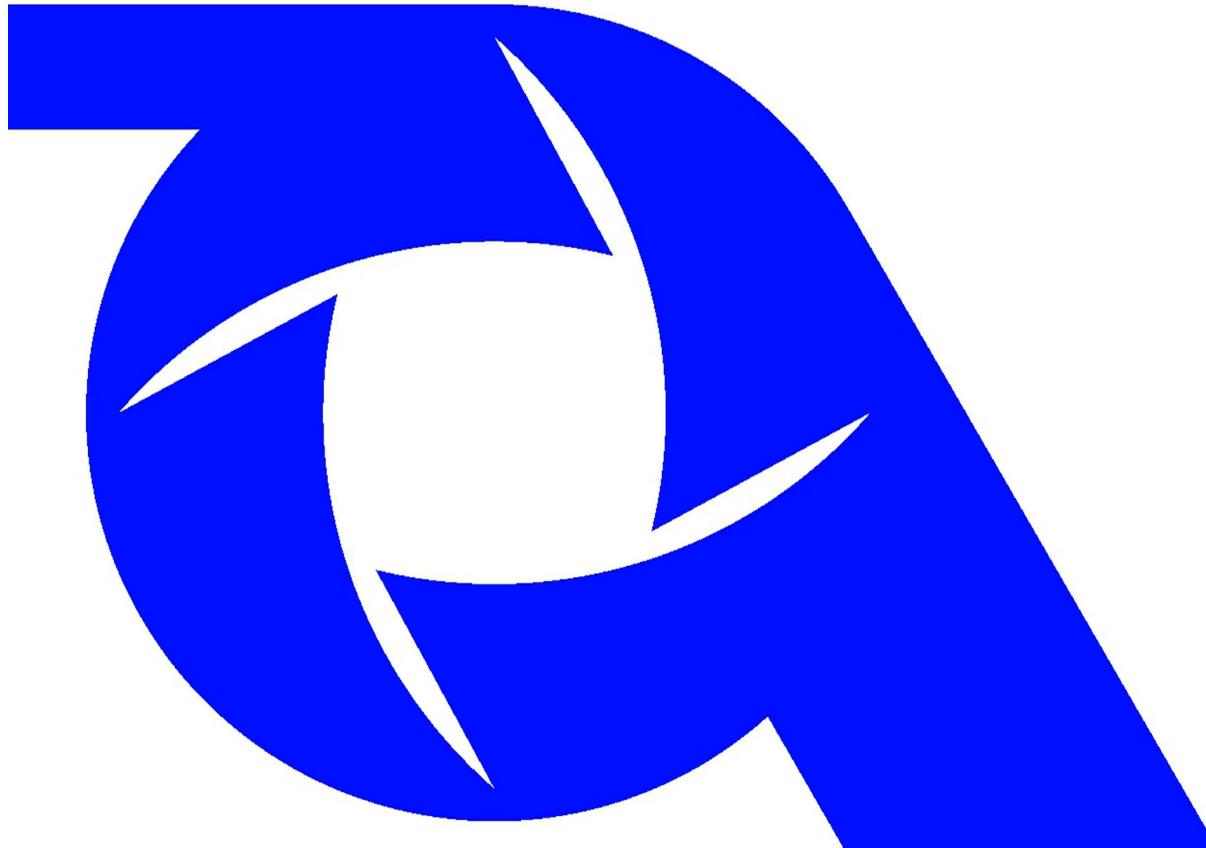
Vladimir Tomov
LLNL

Winner for Animations

?

Winner for Animations

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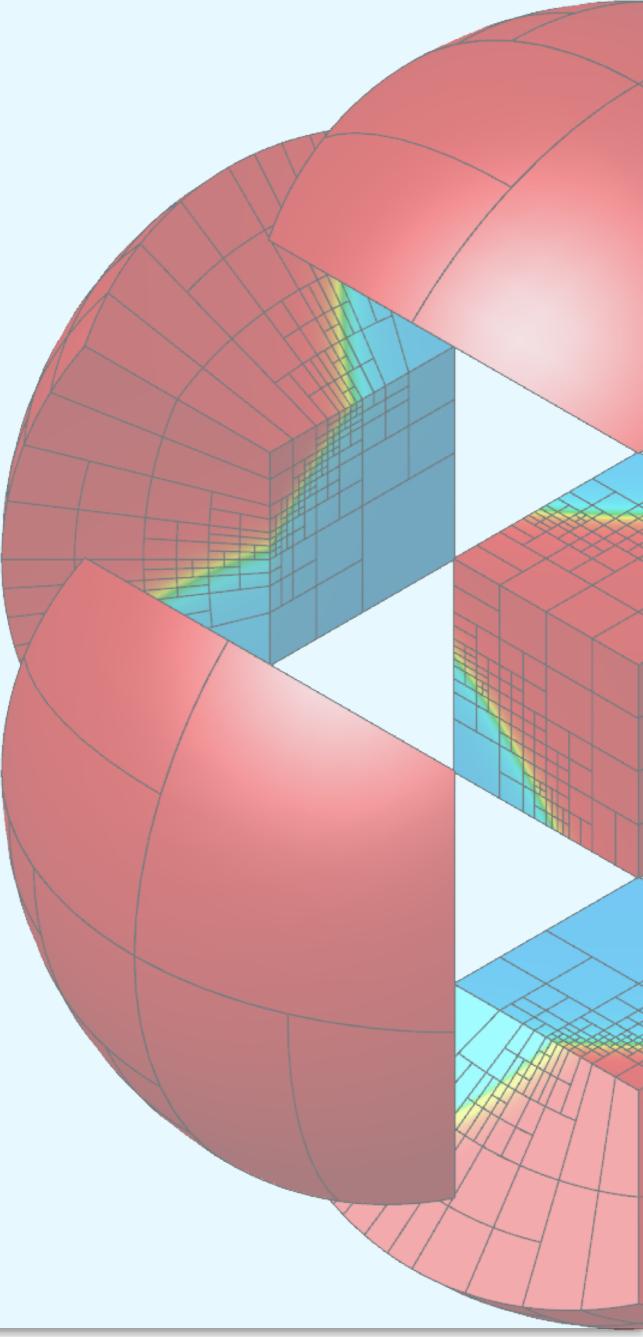
Tamas Horvath
Oakland University

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
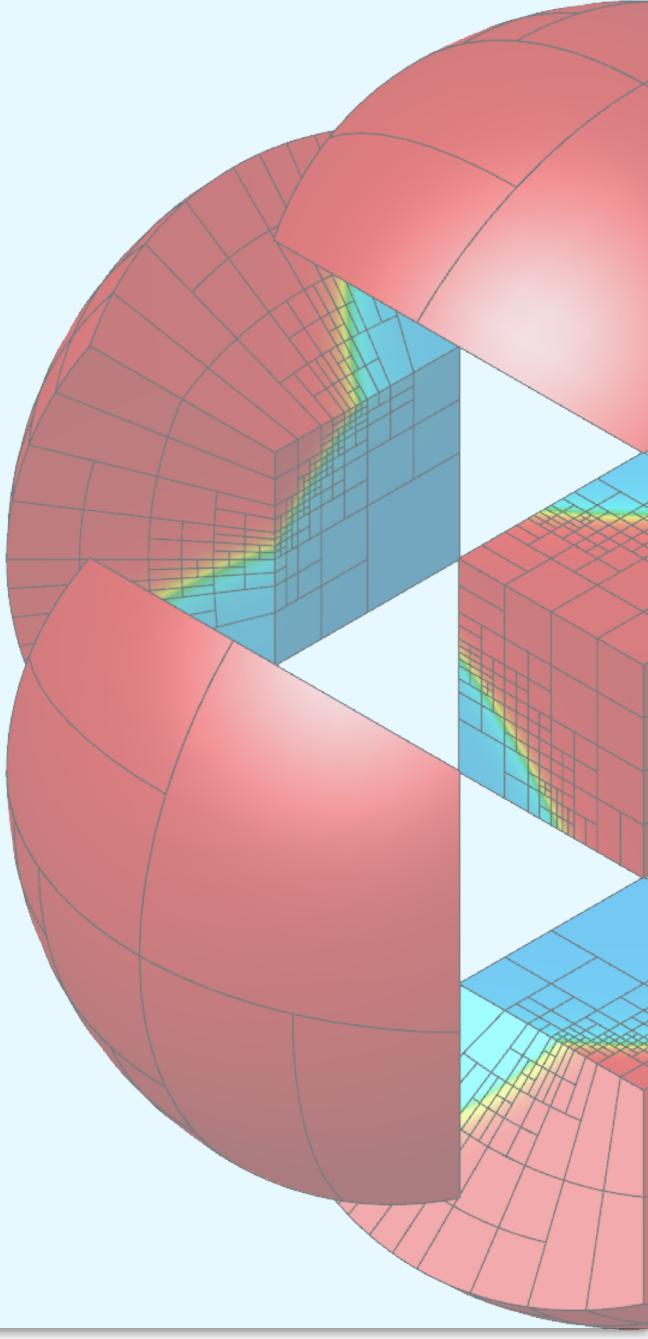
- Applause for the speakers

- 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.
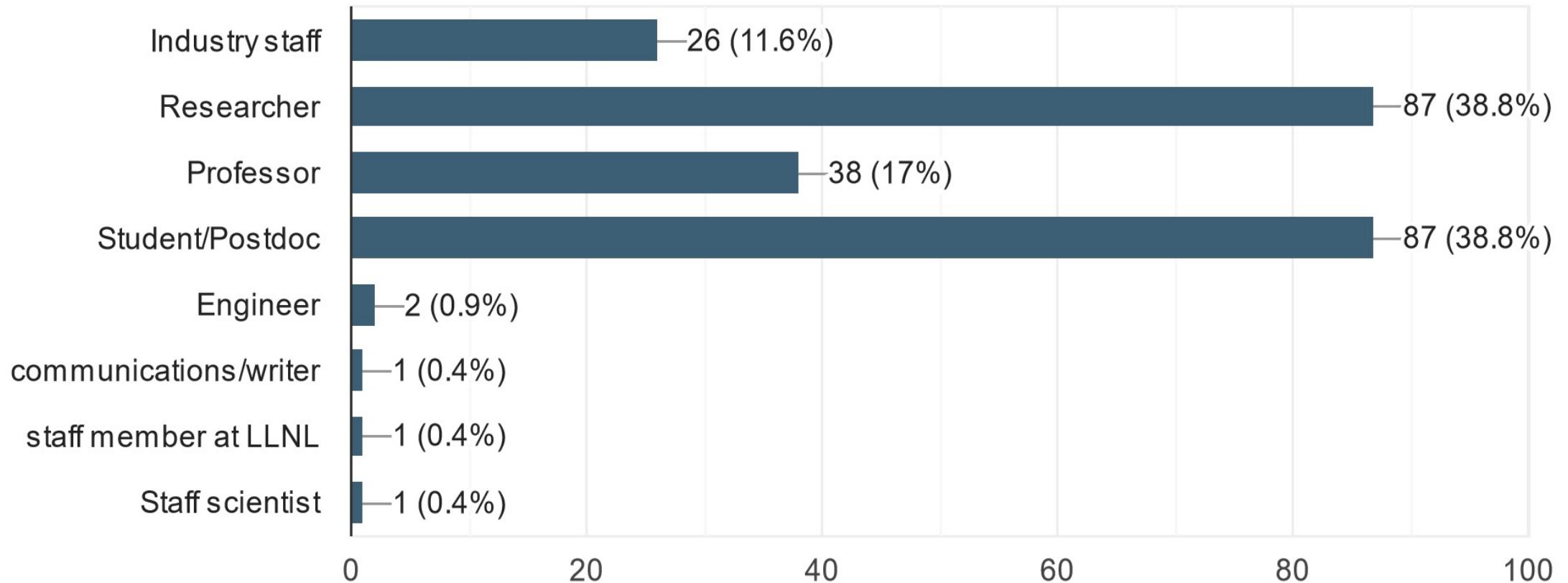
Thank you from the MFEM team at LLNL!

Bonus
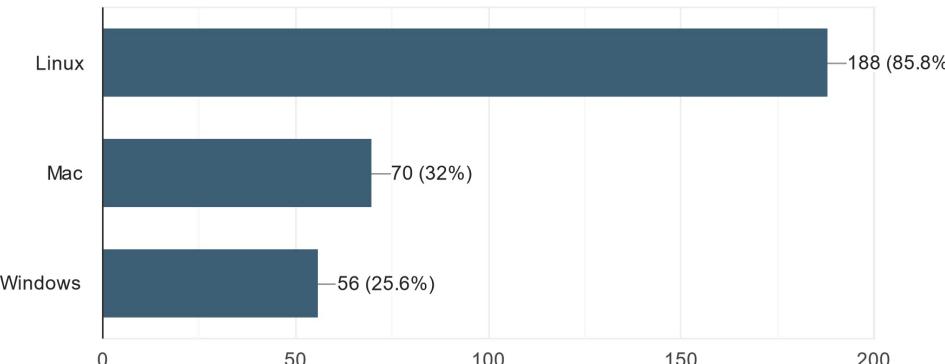
Position

Software Environment
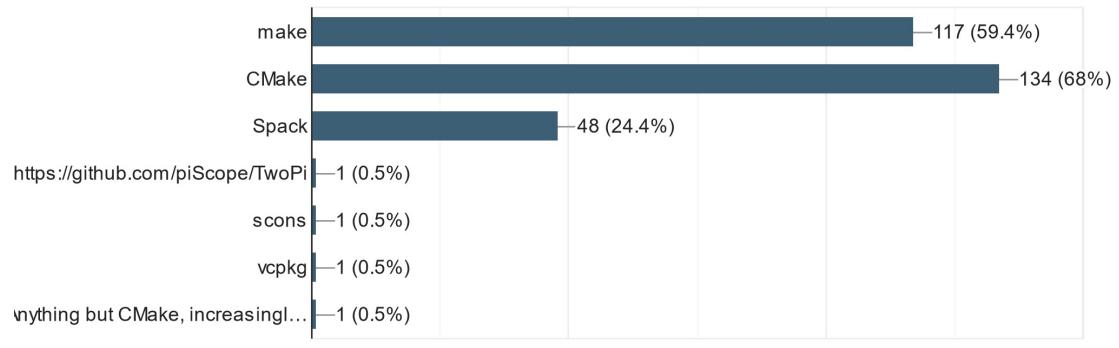
Operating system
219 responses

Linux	188 (85.8%)
Mac	70 (32%)
Windows	56 (25.6%)
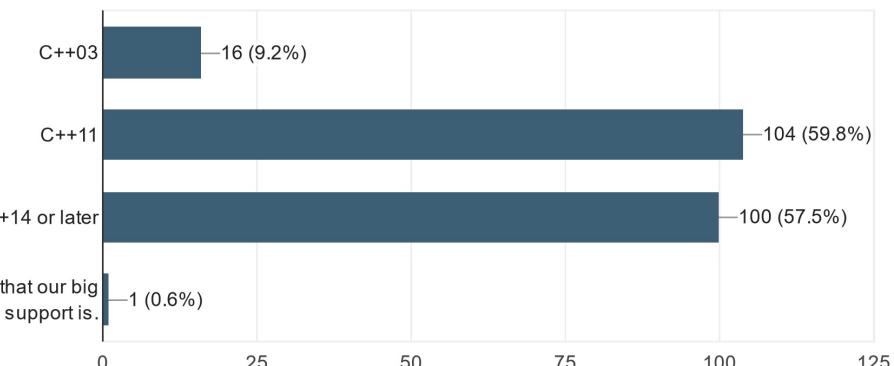
Build system
197 responses

make	117 (59.4%)
CMake	134 (68%)
Spack	48 (24.4%)
https://github.com/piScope/TwoPi	1 (0.5%)
scons	1 (0.5%)
vcpkg	1 (0.5%)
Anything but CMake, increasingl…	1 (0.5%)
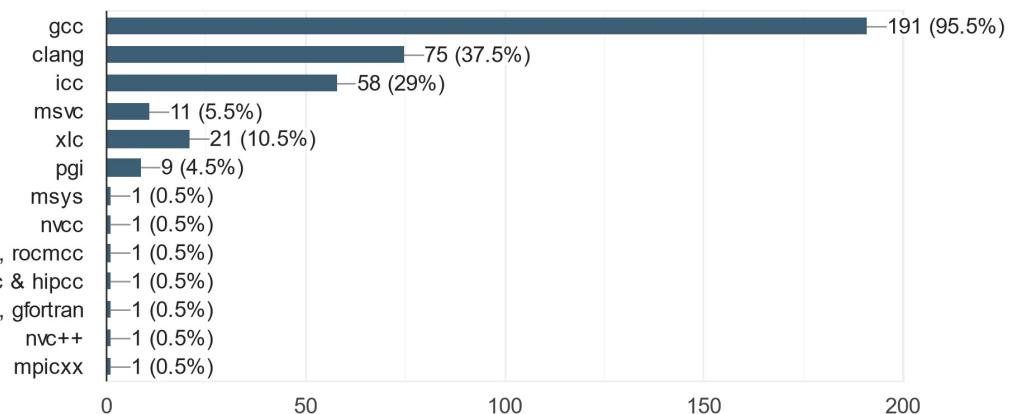
C++ standard
174 responses

C++03	16 (9.2%)
C++11	104 (59.8%)
C++14 or later	100 (57.5%)
Whatever the newest that our big machines support is.	1 (0.6%)

Compiler
200 responses

gcc	191 (95.5%)
clang	75 (37.5%)
icc	58 (29%)
msvc	11 (5.5%)
xlc	21 (10.5%)
pgi	9 (4.5%)
msys	1 (0.5%)
nvcc	1 (0.5%)
cce, rocmcc	1 (0.5%)
nvcc & hipcc	1 (0.5%)
ifort, gfortran	1 (0.5%)
nvc++	1 (0.5%)
mpicxx	1 (0.5%)

MFEM features that are critical for me

Feature	Value
Variety of discretization meth…	94 (44.3%)
High-order finite elements	134 (63.2%)
Parallel scalability	152 (71.7%)
GPU acceleration	102 (48.1%)
Variety of mesh element types	88 (41.5%)
Adaptive mesh refinement	122 (57.5%)
Linear solvers and preconditi…	118 (55.7%)
Integration with other packa…	94 (44.3%)
Mesh optimization	60 (28.3%)
Visualization (GLVis)	64 (30.2%)
Examples and miniapps	102 (48.1%)
Documentation and support	111 (52.4%)
Petra-M ;D	1 (0.5%)
User friendly interface	1 (0.5%)
Immersed methods	1 (0.5%)
Python wrappers	1 (0.5%)
Iso-Geometric Analysis	1 (0.5%)
Flexibility to modify /add so…	1 (0.5%)
support of H(div) elements	1 (0.5%)
Sensitivity analysis support (…	1 (0.5%)
Inverse problems; Optimizati…	1 (0.5%)
Maybe some tutorials cf. dea…	1 (0.5%)
complex numbers	1 (0.5%)
Solution of Partial Differentia…	1 (0.5%)