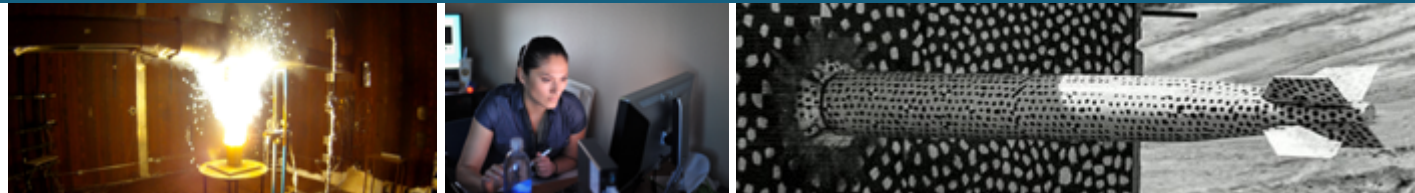# Revolutionizing Component Design with LGR

PRESENTED BY

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Collaborators: **David Zwick, Michael Powell, Alejandro Mota**

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LGR: Research to Production Multi-Physics

Export controlled application code that predicts Nuclear Deterrence (ND) component behavior

Started in FY2016 as ALEXA research code under ASC/ATDM
  ½ FTE funding

   Highlighted in 2018 CIS ERB talk

Transitioned in FY2020 to LGR production code under ASC/IC
  1 FTE funding

Considered by component design expert to be the **single most transformative development in a decade**

ASC/ATDM: new applications on next-gen hardware

ASC/IC: long-lived production applications for ND

Novel adaptive scheme built with GPU acceleration

LGR uses **novel adaptive** mesh approach

    Controls mesh resolution in space <u>and</u> time

    Improves on reconnection algorithms from INRIA

    More mature than polygonal ReALE at LANL

    Remains **best deformation adaptation today**

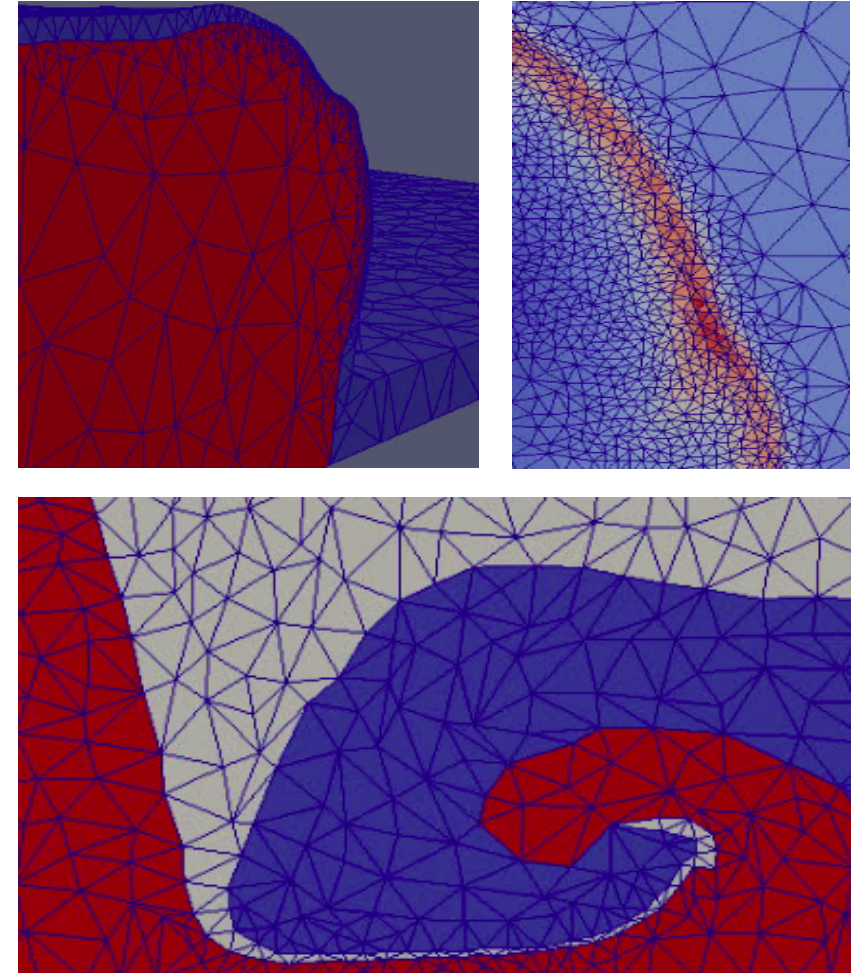Entire multi-physics system is **fully GPU-accelerated**

    Unprecedented simulation speed

    Small-scale computing: laptops and workstations

    Large-scale computing: thousands of scenarios

    Still use only double precision numbers

    Reflects **best GPU programming today**

Mesh adapts to follow material motion

Design of ND Components

Value of LGR is in:

Accessible simulation through portability and user interface

Fast simulation through GPU acceleration

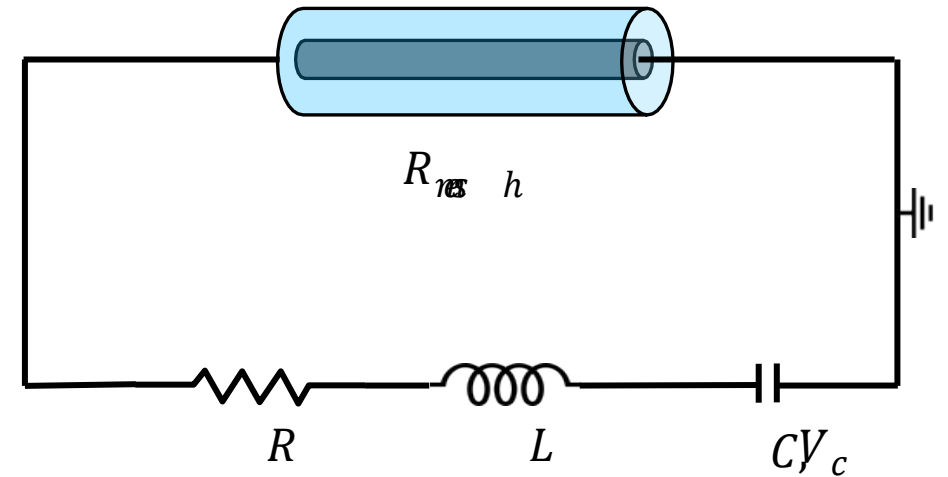**Accurate** simulation through V&V

Robust simulation through adaptive scheme

<u>Example</u>: multi-physics exploding wire component

Circuit model: capacitor discharge

Electric field model: current flow and heating in 3D model of thin wire

Dynamics model: heating causes expansion and phase change; vaporization

Exploding wire scenario: thin wire burst due to electrical heating
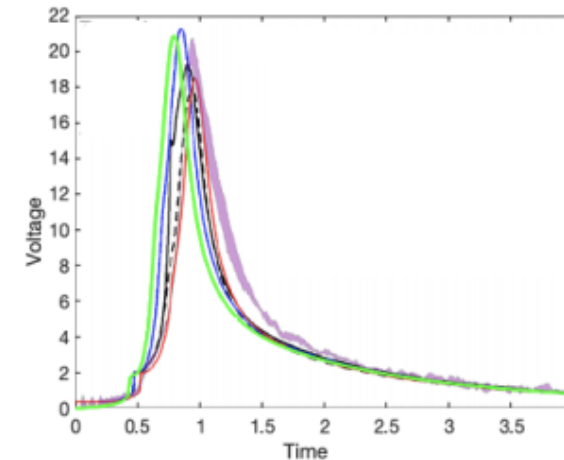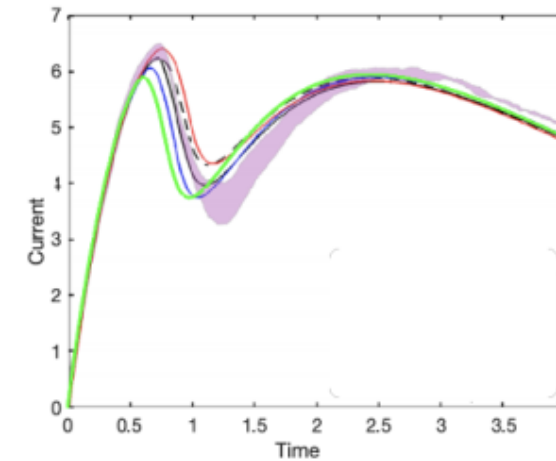
Useful Model = Fast + Accurate

Provide accurate component scenario performance prediction within a **couple of minutes on one GPU**

Given laptop or workstation, customers can explore dozens of scenarios

Given DOE supercomputer, customers can explore hundreds of thousands of scenarios

Using the same codebase as on laptops/workstations

Leverages CIS V&V UQ expertise

Comparison of experiment (purple shaded) to simulations for validation
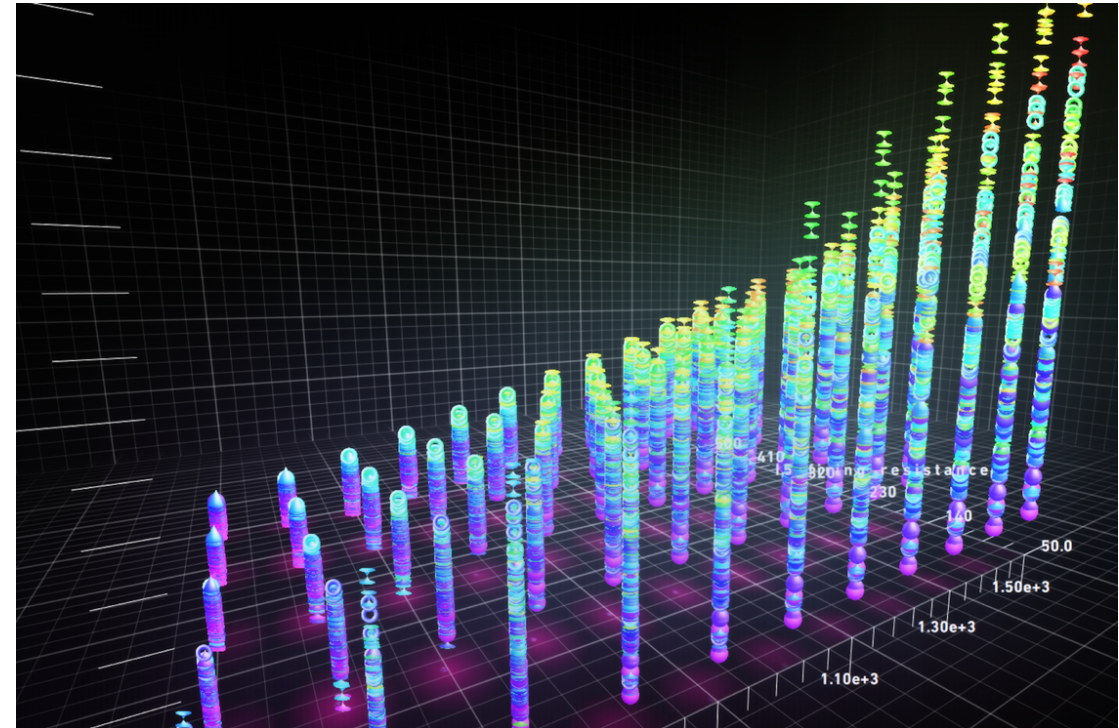
Informing Design Decisions Today

Designers pose a question, in 3 weeks we present answer

Combines validation and thousands of simulations

Combine simulations to make maps of design space

Gains key insights from maps to guide design engineering

Each datapoint is one simulation.
Variations along different designs and operating conditions

Final Slide: Releases and Publications

Open Source software created to support LGR:

    Public subset of LGR without phase change material models and without electrical models

    https://github.com/SNLComputation/lgrtk

    Mesh adaptation library

    https://github.com/SNLComputation/omega_h

    Text parsing library

    https://github.com/SNLComputation/parsegen-cpp

Publications:

"Tetrahedral Mesh Adaptation for Lagrangian Shock Hydrodynamics," Ibanez, et al. Computers & Mathematics with Applications. 2019.