LBNL Offers Core Capabilities to Advance the FES Plan

- Capabilities in priority areas addressing the FES Long Range Plan
  - Magnet and fusion R&D
  - LaserNetUS user and collaborative science
  - High Energy Density Physics
  - Quantum Information Science

- Leveraging context of excellence in Computing, Lasers, Magnets, Engineering, and Quantum at LBNL and UC Berkeley
The challenge for a future compact Tokamak facility: A robust magnet system leveraging REBCO conductors

Funded INFUSE projects:
• ACT, SuperPower – “Development of a Modeling Toolbox for CORC® Cable Performance Evaluation“
• GA - “Performance Testing of Low-Resistance Demountable HTS Joints for Large Segmented Magnets”

Vision:
Leverage BCMT expertise, experience, and community reputation to organize and steer the superconductor and superconducting magnet community to deliver on the FES Long Range Plan for fusion power

Point of contact: Soren Prestemon
- Superconducting materials
- Advanced design and analysis
- Magnet R&D & testing
- Magnet diagnostics, advanced electronics
Multi-beam linacs can be scaled to high beam power at low cost for fusion materials testing and plasma heating

- We have now accelerated ions to over 50 keV in a stack of 16 wafers with 120 beams, cost per wafer: $15
- Next step is scaling to ≥1 MeV, ≥100 mA per module
  → Ion beam driven neutron source for materials irradiations
  → Applications also to Energy and Climate challenges
  → Towards plasma heating

Point of contact: Thomas Schenkel
- Path to $10^{15}$ n/s with ten modules
- Could be run with d-T or d-Li, ...

BELLA Center provides unique capabilities as part of LaserNetUS

Peta-Watt long-focal
- $2 \cdot 10^{19}$ W/cm$^2$, long interaction length.
- High power diagnostics (laser diagnostic with full-power on-target)
- ~10 MeV proton beam platform with beam transport.
- HEP funded Multi-beam platform (2BL)

Peta-Watt short-focal (iP2) – installation in progress
- FES funded high intensity ($>10^{21}$ W/cm$^2$) platform

HTT 100 Terra-Watt
- Two synchronized and independently controlled few J lasers.
- Large chamber, flexible focusing and targets
- Multi-beam (2 lasers, electrons, x-ray) platform for HEDP
- Ion beams (this year)

Point of contact: Eric Esarey
- Accessible to users and collaboration
- High Energy Density Plasma, Inertial Fusion Energy diagnostics
Strong capability in High Energy Density Plasmas and ion acceleration experiments developed through FES & LDRD

Scaling of maximum proton energy versus laser intensity showing scaling for various laser pulse lengths at different laser facilities.

Bulanov, POP, 23, 056703 (2016)
Park, POP, 26, 103108 (2019)

A program has been established to use ultra-high dose rate protons for in vitro radiobiological study and FLASH effects

Bulanov, POP, 23, 056703 (2016)
Park, POP, 26, 103108 (2019)

Current LDRD: LASER-ACCELERATED ION BEAMS: EVALUATING RADIOBIOLOGICAL EFFECTS

First PW experiments at high repetition rate has produced high-charge, low-divergence ion beams

LaserNetUS: Thank you for early experimental support!

S. Steinke, PRAB, 23, 021302 (2020)

A platform for ion acceleration experiments at high repetition rate has been developed

Understanding matter under extreme conditions, including hydrodynamic shocks, is fundamental for plasma science and inertial fusion energy.
Accelerator Modeling Program offers leadership needed for FES Long Range Plan goals

Cutting-edge, open-source, high-performance codes $^{1,3}$

Warp/WarpX, FB PIC, HiPACE++, IMPACT

Applicability across FES portfolio
- Laser-plasma interactions
- Plasma acceleration
- Plasma mirrors
- High-field physics (with QED)
- Plasma instabilities
- Collisionless shocks
- Pulsars
- Magnetic reconnection
- Particle sources & accelerators
- Beams, plasmas for fusion
- ...

Unique features (mesh refinement, boosted frame, ...)
+ coupling with AI/ML tools (for design optimization & development of fast surrogate models).

Started exploration of QIS algorithms.

Leaders in Exascale$^2$ with WarpX

Leading multi-institution international development team of physicists + applied mathematicians + computer scientists

Portable: from single-user computer up to largest CPU/GPU-based supercomputers

Input scripts and output data standardization → integrated ecosystem

Point of contact: Jean-Luc Vay
Vision: Enable fusion energy and transformative plasma science and technology, Leveraging multi-program capabilities in magnets, lasers, beams and simulations

- Lead high field strength superconducting magnet development for smaller, more effective fusion devices driving the US roadmap
  - Innovation in fusion materials and inertial fusion energy (IFE) approaches
- Pioneer precision ultra-intense laser, ion pulse and plasma control to create new states of matter as well as brilliant particle and X-ray technologies
  - Support LaserNetUS with existing lasers, iP2 project and new capabilities
  - Create unique materials and processes for quantum information science
  - Enable transformative high energy density physics (HEDP), plasma technologies
- Simulate at exascale to understand and control fusion and plasma science

We welcome collaboration!
Contact Cameron Geddes, ATAP Division Director