# ARDAP Perspective on Accelerator Technology R&D in the U.S.

**Bruce Carlsten**
**Deputy Director, Office of Accelerator R&D and Production (SC-25)**
**August 10, 2022**

U.S. DEPARTMENT OF ENERGY | Office of Science

# Outline

- Accelerator Science and Technology (AS&T) R&D is needed for future DOE accelerator facilities
- Current AS&T R&D levels are not commensurate with future needs
  - Supply chain risks for accelerator components
- Community input on reducing risk of success with future facilities
- What DOE/SC is doing to address this issue
  - Accelerator Science and Technology Initiative
  - Formation of  the Accelerator R&D and Production (ARDAP) Office
    - Description of ARDAP programs
    - ARDAP complements R&D in the SC Program Offices, focusing on supply chain issues

# 13,600 of SC's Nearly 32,500 Users* Perform Research at an Accelerator-Based Facility


Linac Coherent Light Source


Advanced Light Source


Advanced Photon Source


National Synchrotron Light Source II


Stanford Synchrotron Radiation Light Source


Spallation Neutron Source


Fermilab Accelerator Complex

Relativistic Heavy Ion Collider


ATLAS


Facility for Rare Isotope Beams


FACET Beam Test Facility


BNL Accelerator Test Facility


Continuous Electron Beam Accelerator Facility


DIII-D


NSTX-U

Accelerator Science & Technology (AS&T) is the foundation of these world-leading scientific instruments

U.S. DEPARTMENT OF ENERGY | Office of Science

* In FY 2020 and FY 2021, COVID reduced the number of users coming to physical facilities significantly.
Pre-COVID numbers (FY 2019): 19,337 users (**54%** of 35,771 total SC users) were at accelerator-based SC facilities.

# Current and planned accelerator User Facilities

## Office of Science

### OPERATING NOW


Advanced Light Source


Advanced Photon Source

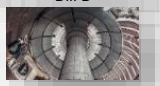

National Synchrotron Light Source II


Stanford Synchrotron Radition Light Source


Linac Coherent Light Source


Spallation Neutron Source


DIII-D


NSTX-U


Fermilab Accelerator Complex


FACET Beam Test Facility


BELLA


BNL -ATF


ATLAS


FRIB


Relativistic Heavy Ion Collider


Continuous Electron Beam Accelerator Facility


BELLA-Staging

New or upgraded in
**2-5 years**


LCLS-II

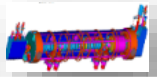

MPEX

New or upgraded in
**5-10 years**

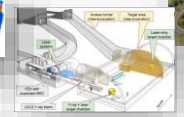

APS-Upgrade


ALS-Upgrade


LCLS-II-HE

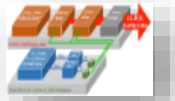

SNS-PPU


SNS-STS


MEC Upgrade

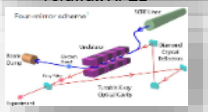

PIP-II


HL-LHC


K-BELLA-Power

New or upgraded in
**>10 years**

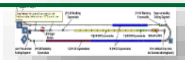

Terawatt XFEL

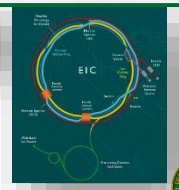

XFEL Oscillator


Fusion Prototypic Neutron Source


PIP-III


FCC-ee/FCC-hh


FRIB 400 MeV/u Upgrade

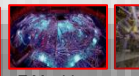


Electron Ion Collider

## NNSA

### OPERATING NOW


LANSCE


Z Machine


NIF


DAHRT


JUPITER

New or upgraded in
**2-5 years**


Scorpius

New or upgraded in
**5-10 years**


MaRIE/DMSSC

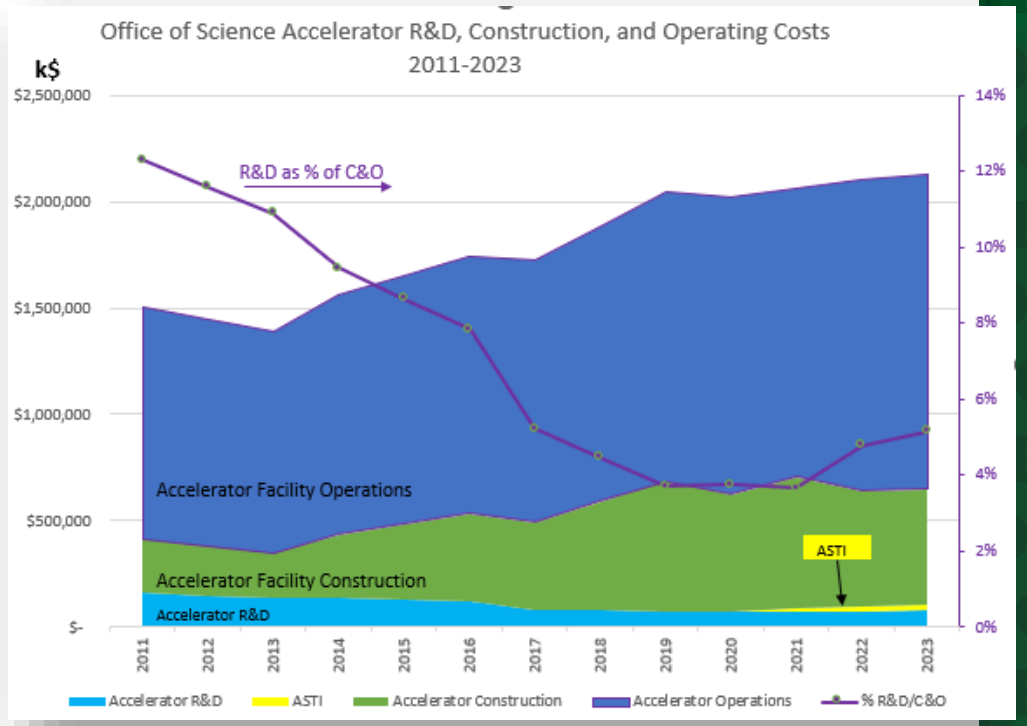
New or upgraded in
**>10 years**

U.S. DEPARTMENT OF ENERGY | Office of Science

# SC Accelerator R&D funding has declined sharply during the last decade

Between 2011 and 2022, SC AS&T* R&D funding has declined **55% in absolute terms,** and **70% relative to the total cost of R&D, Operations, and Construction**

- The U.S. has
  - Lost leading accelerator scientists
    - U.S. now has half the impact in AS&T relative to 2011, measured by paper downloads (Web of Science)
  - Lost leading vendors
- The U.S. now
  - Buys more than half of all AS&T technology offshore
  - Competes internationally for workforce
- The U.S. will
  - Fall behind in research facilities
  - Lose the lead in physical sciences

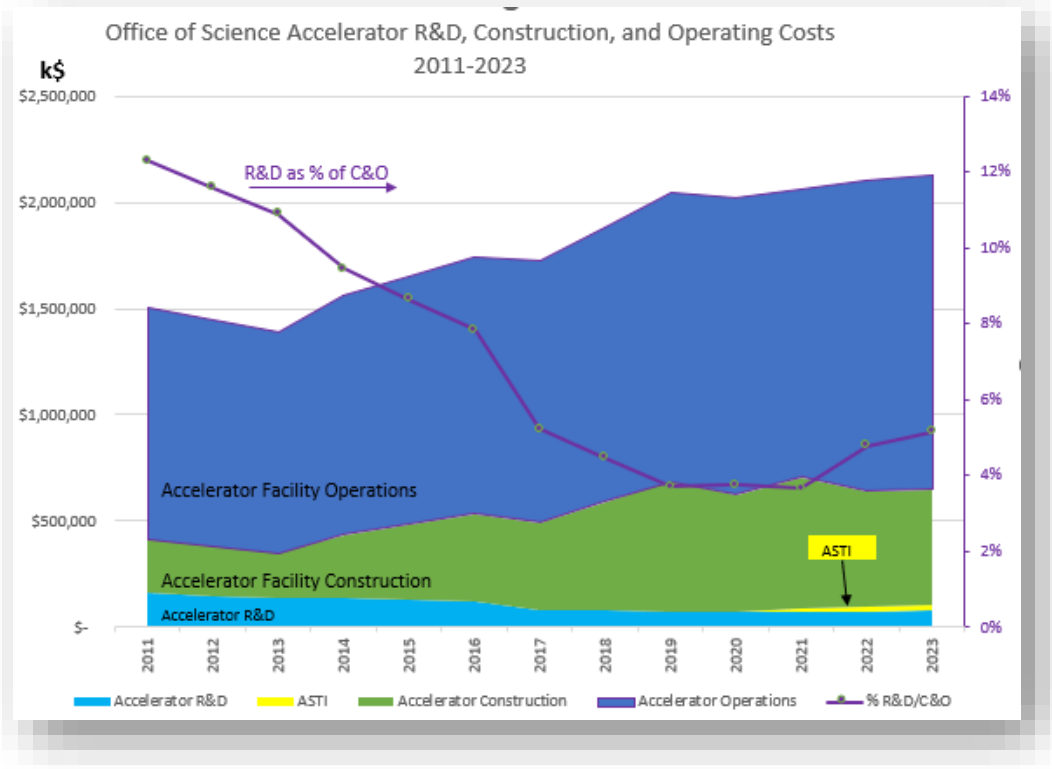



**DOE's Accelerator S&T Initiative (ASTI) and ARDAP are addressing this issue**

U.S. DEPARTMENT OF ENERGY | Office of Science

*AS&T = Accelerator Science & Technology

# Current Accelerator S&T Funding Levels Across SC Adds Risk To Future Accelerator Facilities

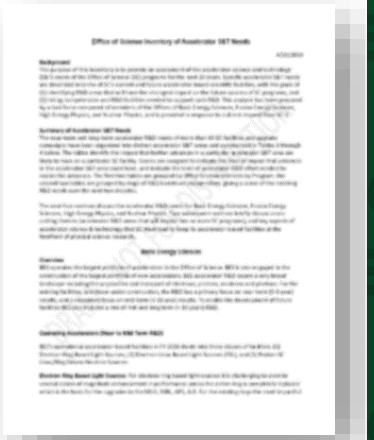



**Continued accelerator R&D is needed for:**

- **HEP – Booster Replacement (was PIP-III), FCC, future linear colliders, kBELLA**
- **BES – XFELO, TW FEL**
- **NP – EIC, FRIB power upgrade**
- **FES – MECI upgrades**

***Current funding is not enough*** **to keep the US competitive with off-shore accelerator-based facilities. Continued increases across all stakeholder programs are needed.**

# Accelerator S&T Advances are Needed in Five Cross-Cutting R&D Areas



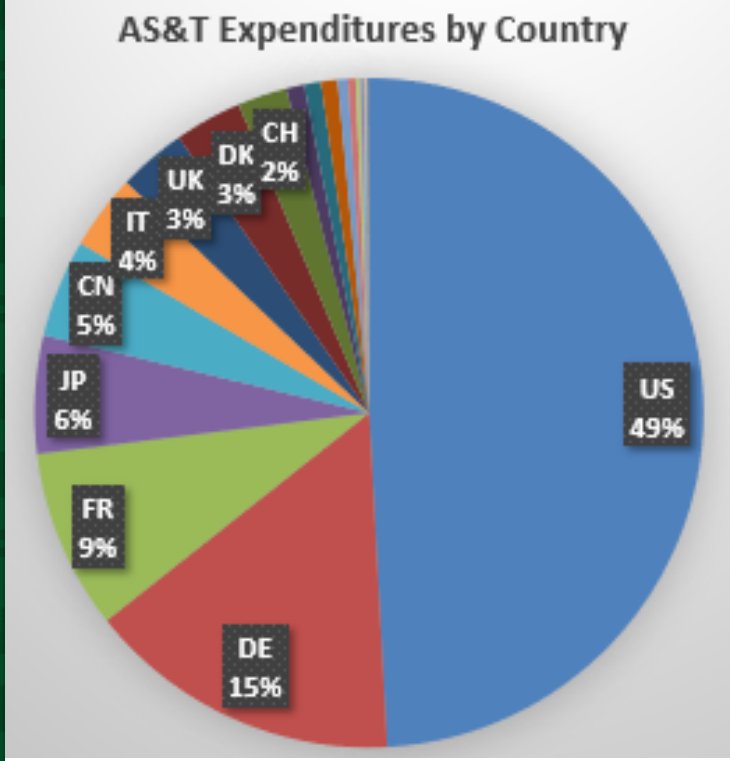
The Office of Science completed an inventory of accelerator S&T needs for future scientific facilities and a preliminary analysis of supply chain vulnerabilities in 2018, refreshing the study in 2020.

**Five primary technology areas are strategically important for SC facilities**

1. Advances in **superconducting accelerator systems**, including SRF, SC magnets, and cryogenic engineering.
2. **Beam physics** and **high-fidelity computer modeling & control**, including better diagnostics, (AI/ML-based) control systems, advanced focusing, and beam cooling techniques.
3. Advances in high intensity **electron, proton,** and **ion sources,** also including **megawatt-class targets** for secondary particle sources.
4. Higher average power **radiofrequency** and **ultrafast laser sources,** including **power handling devices**, and **high accuracy x-ray optics**.
5. **High-risk high-reward R&D** in advanced materials, particle sources, beam dynamics, acceleration techniques, and other advanced topics.

# Lack of AS&T Funding has Led to a Supply-Chain Risk Through Excessive Reliance on Off-Shore Vendors

**[AS&T Supplier Data Call, December 2020-January 2021]**




Source: FY 2021 AS&T Supplier Data Call to DOE labs. Includes all active projects and FY19-20 operations procurements.

| Technology | Specific Areas | Value [M$] | % Foreign |
|---|---|---|---|
| Optics (incl. x-ray optics) | Specialty mat'ls, coatings, optics | $ 11 | 100% |
| Superconducting Accelerators | Accelerator Cavity Manufacturing | $ 149 | 70% |
| Laser Systems | Advanced ultrafast laser systems | $ 16 | 67% |
| HV/UHV Systems | Pumps, chambers | $ 40 | 66% |
| Conventional Magnets | Manufacturing, Perm. Magnet Mat'ls | $ 117 | 61% |
| Cryogenic Systems | Large capacity liquid helium cryoplants | $ 110 | 56% |
| RF Power Systems | High power klystrons, gyrotrons, solid state systems | $ 156 | 51% |
| Superconducting Magnets | Superconducting cable and wire | $ 49 | 50% |
| Power supplies | DC, high current, high voltage, pulsed | $ 62 | 20% |
| Precision Mounts | Precision movers, ultrastable bases, alignment equipment | $ 15 | 17% |
| Advanced Mfr Techniques and equipmeent | UHV furnaces, Add Mfr tools, advanced CMMs/CNC tools | $ 38 | 15% |
| Particle Sources | Cathodes, Ion source expertise | $ 28 | 15% |
| Specialized dielectrics | HV insulators | $ 2 | 8% |

$430M spent off-shore for current projects and operations
Much of this accelerator technology was invented (and at one time produced) in the U.S.

U.S. DEPARTMENT OF ENERGY | Office of Science

# RFI* Responses on Status and Future of the Market

- **Current accelerator technology markets and sizes**
  - ~40,000 accelerators operating worldwide with annual market about $4-5B/year
    - Medical ($1B/yr), Industrial ($1B/yr), Security ($2B/yr), and DOE-SC ($0.5B/yr)
- **Emergent markets and sizes?**
  - Medical treatment, new isotopes (inc. theragnostics), food and medical instrument irradiation, nondestructive testing/radioisotope replacement
  - Wind power ($150B/yr) [superconducting wire]
- **Challenges to maintaining a viable AS&T business?**
  - Inconsistent demand
  - Some foreign companies are state-sponsored (e.g., France-Thales, Germany-RI, Japan-xHI, China-Wuxi)
  - Foreign tariffs (esp. China) and explicit policies block U.S. supplier access (e.g., CERN)
  - Accelerator market is mature, FDA 510k and EPA clearance processes are slow
  - Mid-scale industry highly vulnerable to purchase/consolidation
  - High cost of one-of-a-kind infrastructure and limited qualified workforce
- **Aspects of current market that inhibit technology transfer?**
  - Tech Transfer is weak from Labs to industry—Labs have an inherent COI
  - Facility procurements sent to industry as "build-to-print" jobs, needs to be a partnering model
  - Long project timescales inconsistent with short-term ROI; one-off projects not attractive to businesses
  - Loss of U.S. industrial leadership in key technologies, such as SRF and ultrafast laser technology

By this estimate, DOE-SC accounts for ~10% of the worldwide demand.

Developing new commercial applications for accelerator technology is a central aim of ARDAP's **Accelerator Stewardship Program.**

Leveling demand through collaborative R&D, market development, and buying reserves of critical components is the role of ARDAP's **Accelerator Development Program**.

U.S. DEPARTMENT OF ENERGY | Office of Science

* RFI on *Creating a Robust Accelerator Science & Technology Ecosystem*, 2021-01959, posted January 29, 2021.

# RFI Responses on the Optimal Federal Role

- **Ideal mix of institutions to accomplish technology transfer?**
  - Research: Labs and universities working with industry under the oversight of a government agency.
  - Development: Led by industry with guidance from academia and labs.
  - Government sponsors play a critical role for some market demand and should drive R&D and facilitate PPPs, fostering industrial partnerships across multiple Labs.
- **Collaboration Models?**
  - Emulate the SEMATECH model. Consider a "Lab on retainer/Lab on demand" model.
  - Sustained, years-long engagement needed to build trust.
  - SBIR/STTR program requirements are too stringent.
- **Handoff point for technology transfer?**
  - Federal support needed until a prototype is demonstrated and/or private capital enters the market.
- **How best to preserve know-how?**
  - Businesses, Labs, and Universities each said they should do it.
- **Metrics for success?**
  - Short term: Patents, TRL/MRL, invention disclosures, # licenses, # SBIRs, royalty returns.
  - Long term: Commercialization, Sales; Visible use of commercial products by the relevant community.
- **Other issues?**
  - Labs tend to focus on known technologies, limiting broader engagement.
  - Need to attenuate financial incentives for TT; this drives technology out the door before it is proven.
  - Make the gov't right to "royalty-free licensing" optional.
  - 50/50 cost match model not appropriate for small-cap businesses typical in accelerator technology.
  - Labs have an inherent COI—prohibit expansion of Lab portfolio in the jointly-pursued technology.

Teaming of this type is strongly encouraged in ARDAP's **Accelerator Stewardship and Accelerator Development Programs.**

ARDAP's goals are TRL-4 / MRL-5 to -7, which may not be sufficient.

Labs are counted on to be the primary integrators of knowledge. Universities provide academic continuity and training, and industry preserves manufacturing knowledge.

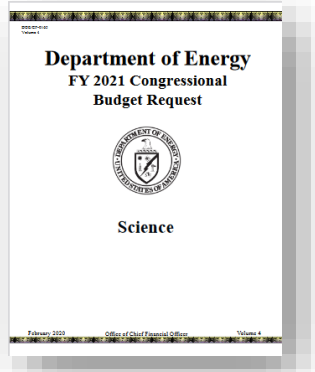
# Outline

- Accelerator Science and Technology (AS&T) R&D is needed for future DOE accelerator facilities
- Current AS&T R&D levels are not commensurate with future needs
  - Supply chain risks for accelerator components
- Community input on reducing risk of success with future facilities
- What DOE/SC is doing to address this issue
  - Accelerator Science and Technology Initiative
  - Formation of  the Accelerator R&D and Production (ARDAP) Office
    - Description of ARDAP programs
    - ARDAP complements R&D in the SC Program Offices, focusing on supply chain issues

# Research Initiatives

- Are high-priority, interdisciplinary challenges that require a multi-Office (or multi-Agency) response
  - Some originate at the SC level (e.g., FAIR, RENEW, ASTI)
  - Some originate at a DOE-wide level (e.g., Hydrogen, Energy Storage)
  - Some originate at Administration level (e.g., QIS, AI/ML)
- Are typically multi-year constructs
- Appear explicitly in DOE's Budget Narrative
  - High-level initiatives also appear in appropriation language

- Accelerator Science and Technology Initiative (ASTI)
  - FY 2021: $11.4M (as SATI)
  - FY 2022: $19.4M (as ASTI)
  - FY 2023: $25.9M (in FY23 request)




**FY2021 Research Initiatives**

***New***

- Data and Computational Collaboration with NIH
- Next Generation Biology
- Rare Earth/Separation Science
- Revolutionizing Polymer Upcycling
- Strategic Accelerator Technology Initiative
- U.S. Fusion Program Accelerator program

***Ongoing***

- *Artificial Intelligence and Machine Learning
- Biosecurity
- Exascale Computing
- DOE Isotope
- Microelectronics Innovation
- *Quantum Information Science

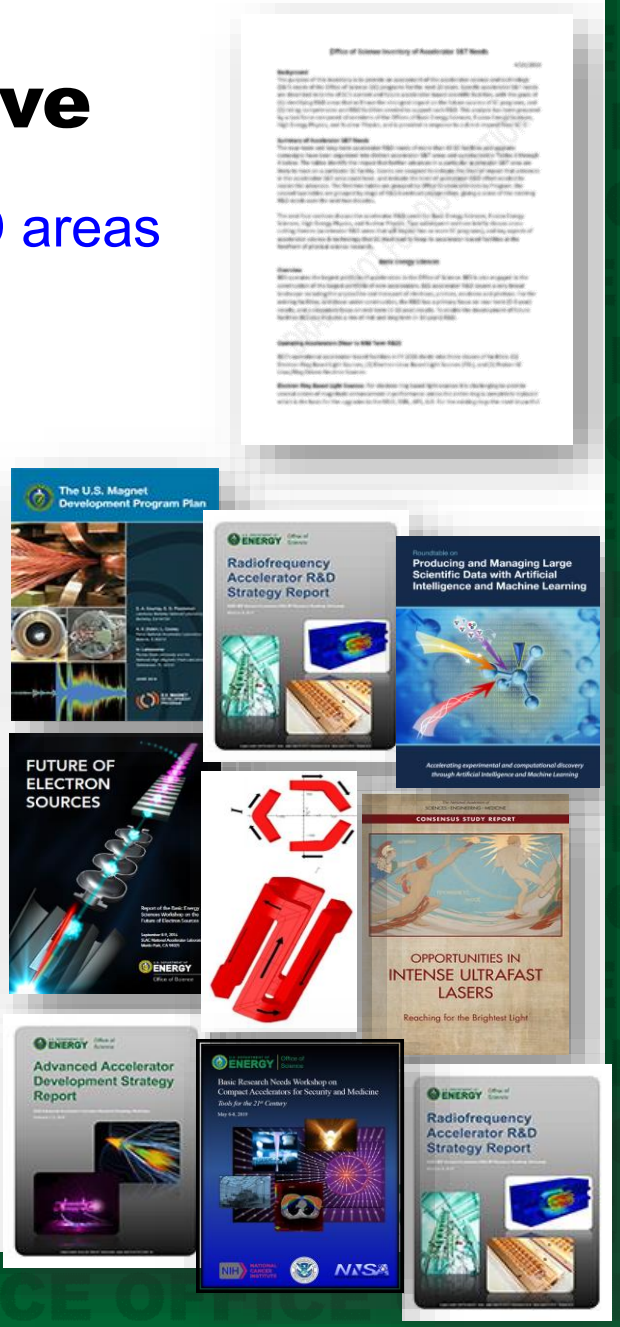
***IoTF**: AI/ML, AM, QIS, 5G, biotech.

# Accelerator Science & Technology Initiative

The Accelerator Initiative primarily targets the five cross-cutting R&D areas identified by the inventory of accelerator S&T needs

**Five primary technology areas are strategically important for SC facilities**

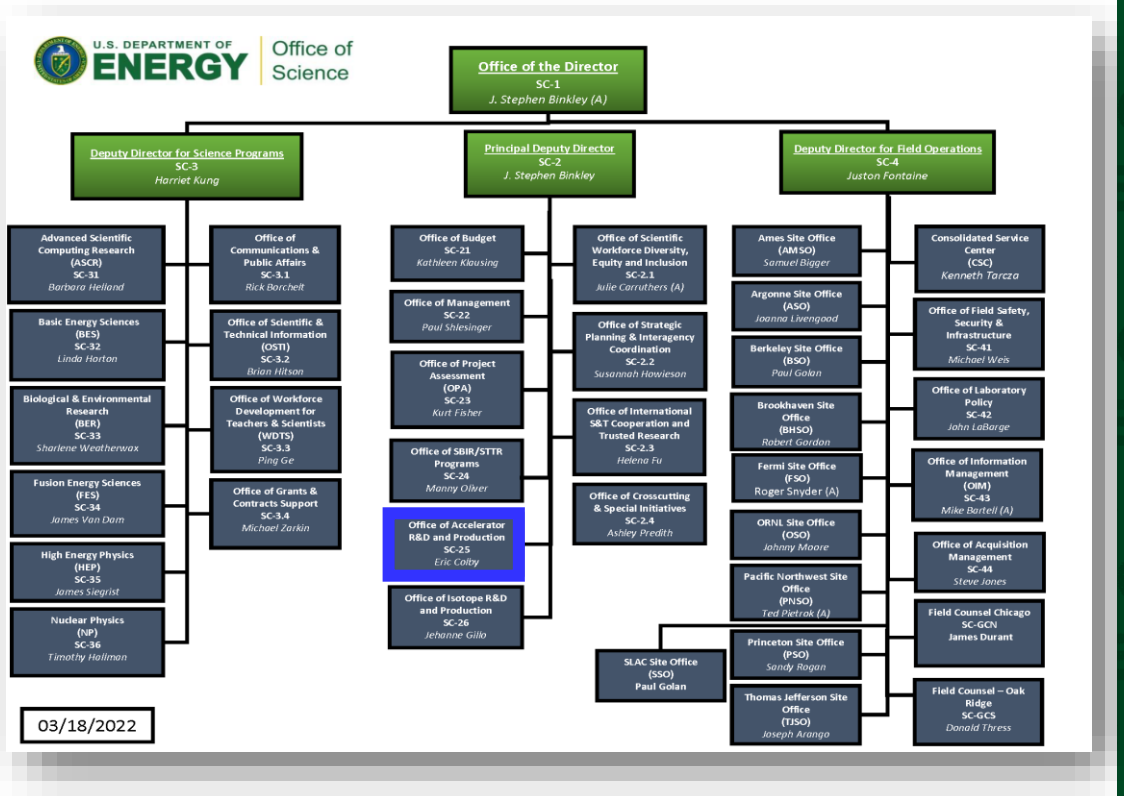
1. Advances in **superconducting accelerator systems**, including SRF, SC magnets, and cryogenic engineering.
2. **Beam physics** and **high-fidelity computer modeling & control**, including better diagnostics, (AI/ML-based) control systems, advanced focusing, and beam cooling techniques.
3. Advances in high intensity **electron, proton,** and **ion sources,** also including **megawatt-class targets** for secondary particle sources.
4. Higher average power **radiofrequency** and **ultrafast laser sources,** including **power handling devices**, and **high accuracy x-ray optics**.
5. **High-risk high-reward R&D** in advanced materials, particle sources, beam dynamics, acceleration techniques, and other advanced topics.



# Accelerator R&D and Production (ARDAP) SC-25 At-a-Glance

**Mission: Ensure a robust pipeline of next-generation Accelerator Science & Technology to support physical sciences research while providing technology advances and industrial strength that position the U.S. to lead the world for decades to come.**

- Established: April 12, 2020
  - in recognition of the central importance of accelerators and related technologies to the current and future scientific capabilities stewarded by SC programs
- Budget in FY 2022: $17.4M
  - Mostly Accelerator Stewardship program with new Accelerator Development program element
  - ARDAP's first dedicated Appropriation occurred in FY2022
- Staff: ~3.8 FTE plus more coming
  - Director – Eric R. Colby, 100% time
  - Deputy Director – Bruce Carlsten (IPA) ~90% time
  - Physicist – Marion White (detailee) ~40% time
  - Physicist – Roark Marsh (detailee) ~50% time
  - Budget Support – Chandra Hopkins, 100% time
  - Chief Systems Engineer – reposting position soon
  - Program Manager – offer made!
  - A&P Support – Christie Ashton, Carol Atherly (home office: SC-35) ~5% time total



# Office of Accelerator R&D and Production Missions

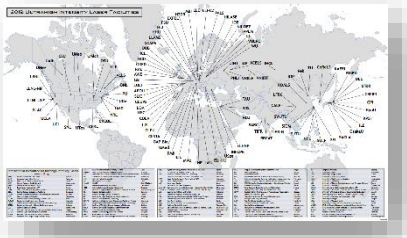
- **Stewardship Mission**

  Support fundamental accelerator science and technology development of relevance to industry, medical treatment, and national security, and to disseminate accelerator knowledge and training to the broad community of accelerator users and providers.

- **Development Mission**

  Coordinate and make accelerator R&D and production investments that are aimed at addressing accelerator science and technology gaps to help ensure that future U.S. accelerator-based physical science R&D priorities will be met.

- **ARDAP will fulfill these missions by**
  - Identifying and investing in use-inspired R&D technology areas that enable new accelerator applications in industry, medical treatment, and national security,
  - Maintaining a strategic picture of AS&T* needs and worldwide competition,
  - Facilitating coordination of Programmatic AS&T R&D investments across SC,
  - Investing in selected cross-cutting AS&T areas,
  - Providing a system engineering perspective for SC facility projects,
  - Supporting workforce development, when needed,
  - Maturing key AS&T technology and developing capable U.S. vendors,
  - Transitioning accelerator technology to broader uses.



U.S. DEPARTMENT OF ENERGY | Office of Science

*AS&T = Accelerator Science & Technology

# ARDAP Programs will Mature and Commercialize Accelerator Technologies

- **SC science programs often focus on low TRL development of mission-specific technologies**
- **ARDAP Accelerator R&D Program**
  - TRL 1 through TRL 4: Accelerator Stewardship program (red rectangle)
- **ARDAP Accelerator Production Program**
  - MRL 1 through MRL 7: Accelerator Technology Production sub-program (yellow rectangle)
  - (Future) TRL 5 through TRL 7: Accelerator Technology Maturation sub-program (green rectangle)

*While US continues to excel in discovery and innovation, the applied research and development necessary to translate new emerging technologies into products remains a challenge for individual companies.*

*ARDAP's goal is to reduce these vulnerabilities by turning US-based accelerator inventions into products made by a skilled and diverse American workforce.*

| ACCELERATOR RESEARCH & DEVELOPMENT | | ACCELERATOR TECHNOLOGY PRODUCTION | |
|---|---|---|---|
| TRL 1 | Basic principles observed and reported | MRL 1 | Manufacturing feasibility assessed |
| TRL 2 | Technology concept and/or application formulated | MRL 2 | Manufacturing concepts defined |
| TRL 3 | Analytical and experimental critical function and/or characteristic proof of concept | MRL 3 | Manufacturing concepts developed |
| TRL 4 | Component and/or breadboard validation in a laboratory environment | MRL 4 | Capability to produce the technology in a laboratory environment |
| ACCELERATOR TECHNOLOGY MATURATION | | | |
| TRL 5 | Component or breadboard validation in a relevant environment | MRL 5 | Capability to produce prototype components in a production relevant environment |
| TRL 6 | System/subsystem model or prototype demonstration in a relevant environment | MRL 6 | Capability to produce prototype system or subsystem in a production relevant environment |
| TRL 7 | System prototype demonstration in an operational environment | MRL 7 | Capability to produce systems, subsystems or components in a production relevant environment |
| TRL 8 | Actual system completed and qualified through test and demonstrated | MRL 8 | Pilot line capability demonstrated; Ready to begin Low Rate Initial Production |
| TRL 9 | Actual system proven through successful mission operations | MRL 9 | Low rate production demonstrated; Capability in place to begin Full Rate Production |

From Technology Readiness Assessment Deskbook, July 2009,
http://www.skatelescope.org/public/2011-11-18_WBS-SOW_Development_Reference_Documents/_DoD_TRA_July_2009_Read_Version.pdf

# How do ARDAP and GARD differ?

| | ARDAP | GARD |
|---|---|---|
| **Customer** | Office of Science, other Federal Agencies, US industry | HEP |
| **Program Aim** | • Acc. Stewardship expands market pull and funds cross-cutting basic R&D<br>• Acc. Development strengthens suppliers | • Develops transformative new AS&T for HEP<br>• Strengthens key suppliers needed for HEP facilities |
| **Activities Funded** | • Broadly applicable AS&T R&D<br>• Tech transfer and new application development<br>• Industrialization and supplier development for all SC Programs | • AS&T R&D primarily for HEP<br>• Tech transfer<br>• Industrialization and supplier development for HEP construction projects |
| **Advisory Mechanisms** | SC Accelerator Joint Oversight Group, other Federal Agencies, data calls, RFIs, and BRN Workshops | HEPAP, Snowmass+P5 process, and Research Roadmap Workshops |
| **Metrics of Success** | • Technologies put to new uses<br>• Suppliers strengthened, new capabilities developed<br>• Standard academic measures of R&D productivity | • HEP science that technology enables<br>• Reduction of technical risk to science mission<br>• Standard academic measures of R&D productivity |
| **Follow-On Investment** | Through SC facility projects, applied programs, and from industry | HEP-funded directed R&D projects to prepare for facility construction |

# ARDAP Programs Mature and Commercialize Accelerator Technologies

$10.2M

- **Accelerator Stewardship**
  - Identifies and invests in cross-cutting and use-inspired R&D technology areas that enable new accelerator applications in industry, medical treatment, and national security
  - Accelerator Stewardship Test Facility Program
  - Long-term program, in current FOA

$5.5M

  - Operation of the Brookhaven ATF as a National User Facility

$1.7M

- **Accelerator Technology Production**
  - Identifies AS&T accelerator science and technology areas which are high-risk, or have the potential to be high-risk, supply-chain vulnerabilities, and to make targeted investments to build up the domestic vendor capability in those areas
  - Business plan development funded in FY2021 FOA
  - FY2022 FOA included funding for the first private-public partnerships

*$0M*

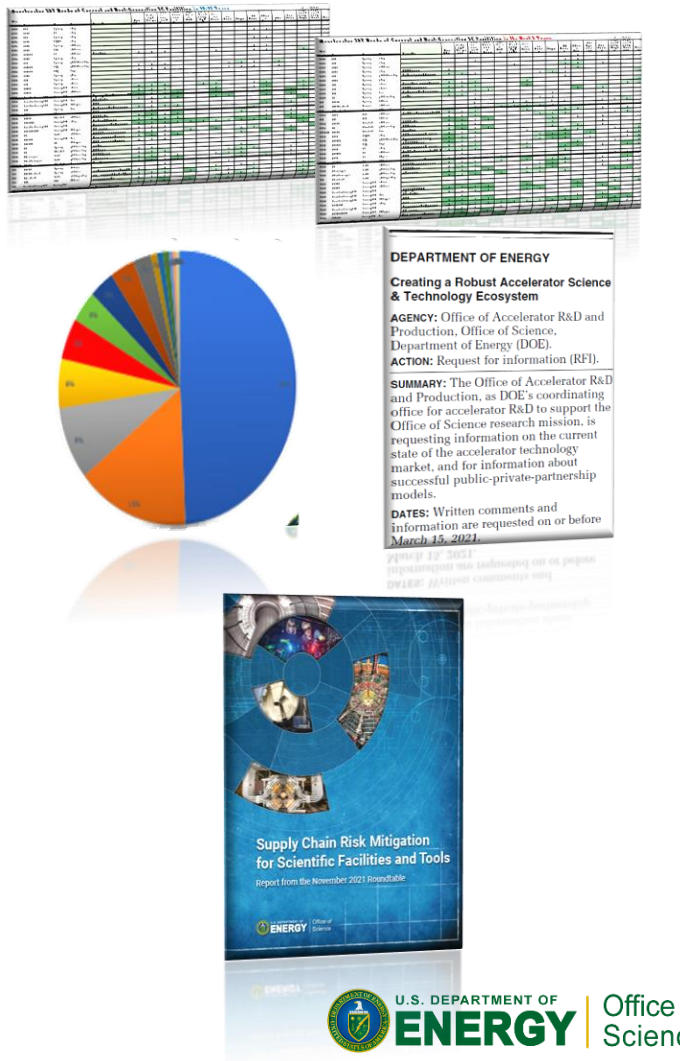
- ***Accelerator Technology Maturation (Future)***
  - *Will identify accelerator science and technology areas which are high-risk, or have the potential to be high-risk, supply-chain vulnerabilities and which are struggling to cross the "TRL valley of death," and to make targeted investments to ensure these areas are sufficiently technically mature to be commercialized by domestic accelerator technology vendors*
  - *Awaits funding increases in future FY*

**$17.4M total in FY 2022**

U.S. DEPARTMENT OF ENERGY | Office of Science

# ARDAP Coordinates Closely with the SC Program Offices, the Interagency, and the Accelerator Community

- **ARDAP program priorities are coordinated with the SC Accelerator Joint Oversight Group (AJOG)**
  - Prioritization and coordination of specifics of the technical work also with NNSA, DOD, DHS, NIH, and NSF* ensure broader USG synergy as well
- **Community Input Efforts**
  - Inventory of R&D Needs for DOE Facilities
    - Completed in 2018, refreshed in 2020 – what accelerator R&D is needed and when for future accelerator facilities
  - Accelerator S&T Supplier Survey
    - December 2020 – where are current projects and accelerator facilities purchasing accelerator technology components?
  - Request for Information on Creating a Robust Accelerator S&T Ecosystem
    - January 2021 – how can we make the domestic ecosystem better?
  - Office of Science Roundtable on Supply Chain Risk Mitigation for Scientific Facilities and Tools
    - Led by SC-3 (Talia Melcer)
    - November 2021 – covered all technologies used for physical science R&D




*an MOU between SC and NSF is in development which could lead to closer coordination

# ARDAP and Workforce Development

- **ARDAP currently supports workforce development primarily through R&D grants**

- **We have begun issuing calls for candidates through the SC-GSR and ECRP programs**
  - SC-GSR = Office of Science Graduate Student Research Program
    - Supports graduate students to pursue part of their thesis R&D at a DOE Lab/Facility
  - ECRP = Early Career Research Program
    - Supports outstanding tenure-track/tenured professors or permanent national laboratory staff for 5 years
  - ARDAP's goals for both calls are unique:
    - We seek candidates who are fully skilled in **both** academic research and its industrial application.
      - *A "pure" academic R&D application will be rejected as unresponsive.*
    - For ECRPs a significant portion of the effort must be devoted to working closely with one or more domestic technology companies on collaborative R&D, technology transfer, and the eventual industrialization of the technology.

- **ARDAP will participate in the upcoming Funding for Accelerated, Inclusive Research (FAIR) program**
  - Focused investments to enhance research on accelerator technology for clean energy, climate, and related topics at Minority Serving Institutions (MSIs), and build R&D capacity

# Engagement with Industry is Essential for ARDAP's Mission

- **ARDAP encourages industry to engage!**
  - **Provide input**
    - Participate in ARDAP and other SC accelerator-technology workshops
    - Respond to RFIs
    - Provide input to the accelerator business sector studies
    - Help the U.S. Government identify and explore public-private partnership approaches
  - **Lead R&D**
    - Large and small businesses can apply as the lead institution
    - Submit proposals and win funding
    - Engage DOE collaborators
  - **Guide the R&D**
    - Review proposals, participate in review panels
    - Host an ARDAP Early Career Awardee
    - Tell us how we're doing
  - **Work with ARDAP**
    - Talk to us if you're interested in consulting or becoming an IPA in ARDAP!

**Visit our webpage**

https://science.osti.gov/ardap

**Contact us**

Bruce Carlsten

505-699-8450

Bruce.Carlsten@science.doe.gov

# Bottom Line

## Why

- **U.S. Accelerator Science and Technology (AS&T) capability is essential for keeping the U.S. lead in scientific research**
  - SC accelerator-based user facilities provide a suite of world-leading tools for probing physics, chemistry, material science, and biology
  - Particle accelerators touch nearly $0.5 trillion of goods and treat more than 5 million cancer patients each year
- **U.S. AS&T competitive position is declining**
  - Long-term AS&T R&D funding has **declined 70%** since 2011
  - SC now purchases **more than half** of all key accelerator technology from **foreign sources**
  - U.S. AS&T publications comprise **less than 1 in 8 downloads**, down from 1 in 4 in 2011; Chinese AS&T publications now exceed 1 in every 3 downloads

## What

- **ARDAP Program Elements**
  - **Research (ongoing)**
    - Transformative advances of use to multiple SC Programs and the broader USG; first-of-kind technology demonstrations to develop new markets
    - Near future: DE&I enhancing workforce training and research programs FAIR (FY 2023) and RENEW (FY 2024)
  - **Facilities (ongoing)**
    - Facilitate access to accelerator test capabilities and workforce training
  - **Production (starting in FY 2022)**
    - Supply chain risk reduction through a variety of measures, with a focus on strengthening domestic suppliers
  - **Coordination and Dissemination (starting in FY 2022)**
    - Maintain a USG-wide strategic overview of accelerator technology needs and strong lines of communication


Image courtesy of Oak Ridge National Laboratory