

Quantum Sensing of Neutrinos (QuSeN)

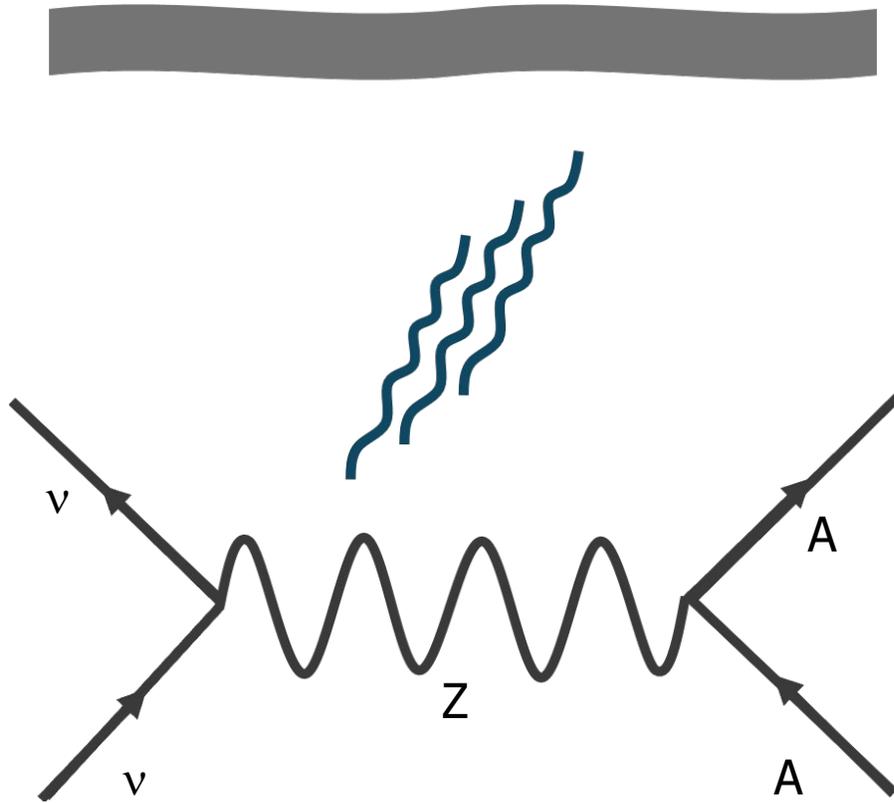
Thomas Schenkel, Ph.D.
Program Manager, Defense Sciences Office

HR001125S0004

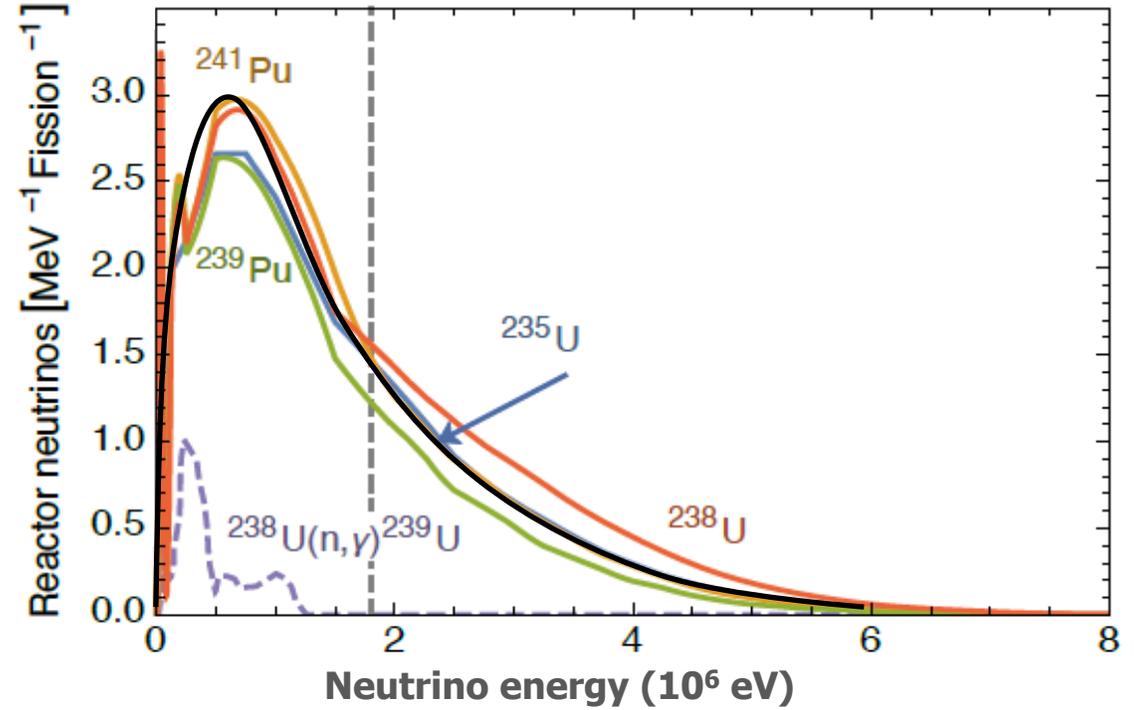
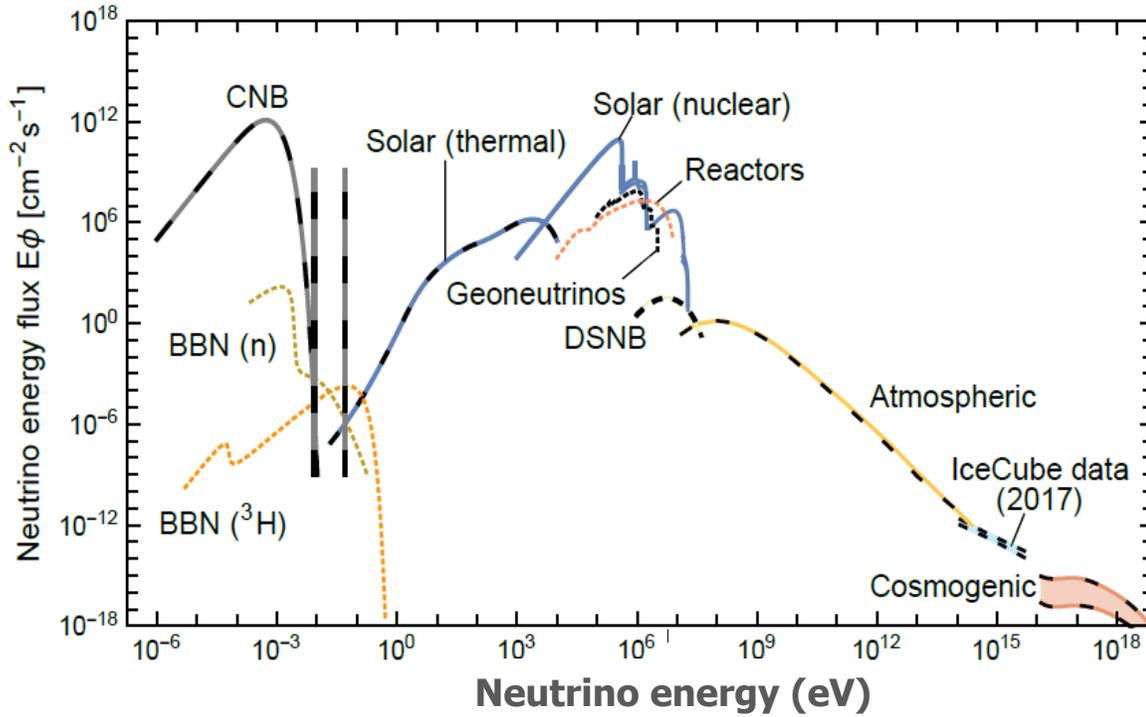
Proposers Day

Nov 12, 2024



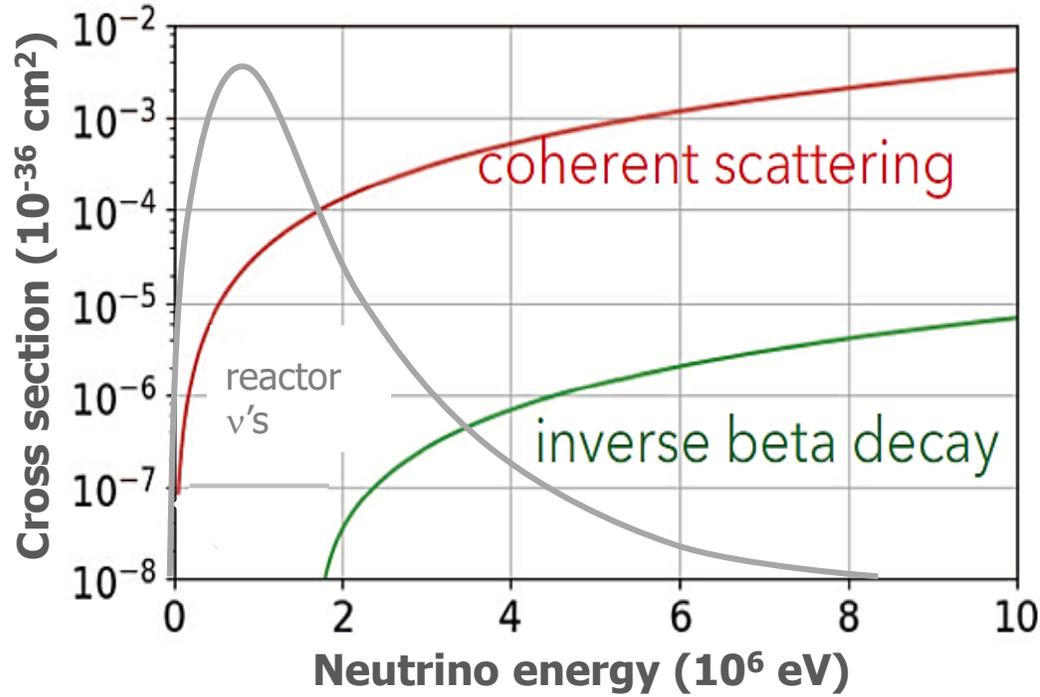


[Akimov, et al., Science, 2017]



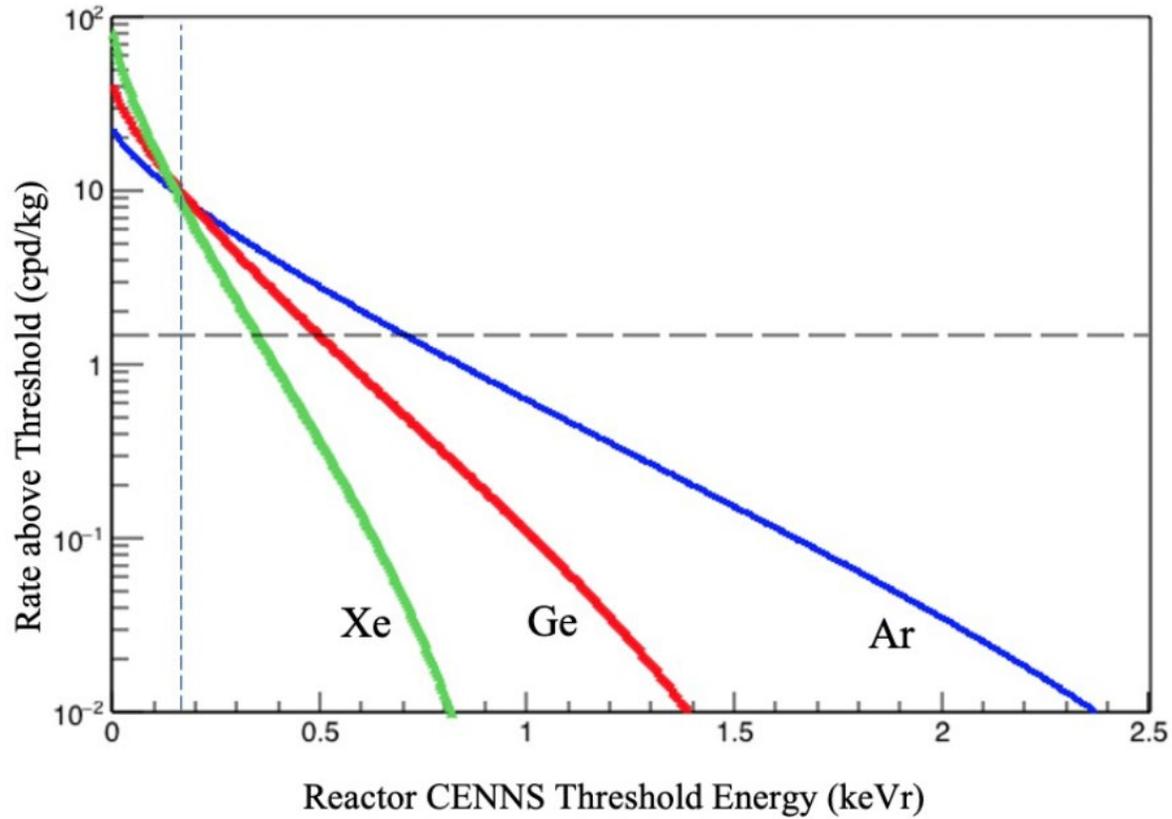
- Nuclear reactors emit $\sim 10^{20}$ anti-neutrinos/ $\text{GW}_{\text{th}}/\text{s}$
- Beta-decay of fission fragments

Huber, arXiv:2211.08641v2
Ang, 2022



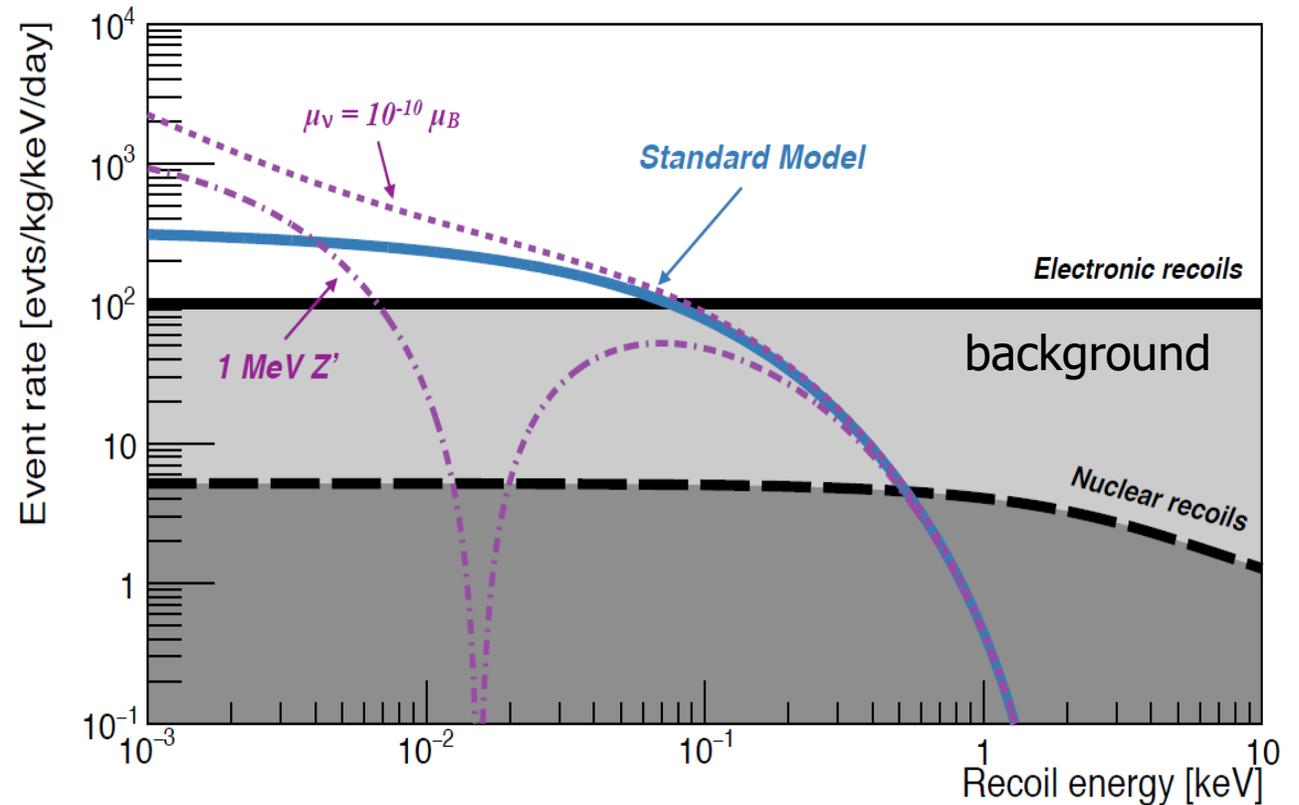
- Interaction cross sections for neutrinos from nuclear activities
- Coherent Elastic Neutrino Nucleus Scattering vs. Inverse Beta Decay

Adapted from R. Strauss, 2018



- Elastic scattering leads to nuclear recoils with relatively low energies
- Neutrino detection rates with CEνNS can exceed those for inverse beta decay when low energy recoils can be detected

- Rate of neutrino detection, $R = F \cdot X \cdot \sigma(E)$
- F , neutrino flux, $\sim 1/\text{distance}^2$
- X , number of atoms in the absorber, $\sim 10^{25}/\text{kg}$
- $\sigma(E)$, cross section, at $\sim 2 \text{ MeV}$, $\sim 10^{-40} \text{ cm}^2$
- Neutron number, N
- $\sigma(E) \sim N^2$
- Energy transfer to recoils, $T_{\text{max}} \sim 2 E_\nu^2 / M$



- Expected event rate and targeted background levels as a function of the recoil energy for the Ricochet experiment deployed 8.8 meters from the ILL reactor core. The blue solid line is the standard model predicted CEvNS event rate while the pink, purple and red dotted lines are respectively from adding a 1MeV Z0 boson, a neutrino magnetic moment of $\mu_\nu = 10^{-10} \mu_B$, and a sterile neutrino with $\Delta m^2 = 1.3 \text{ eV}^2$ ($\sin^2(2\theta) = 0.5$). The black solid and long-dashed lines represent the electronic and nuclear recoil background targeted levels, respectively. [Augier et al., arXiv:2111.06745v1, Billard, 2019].

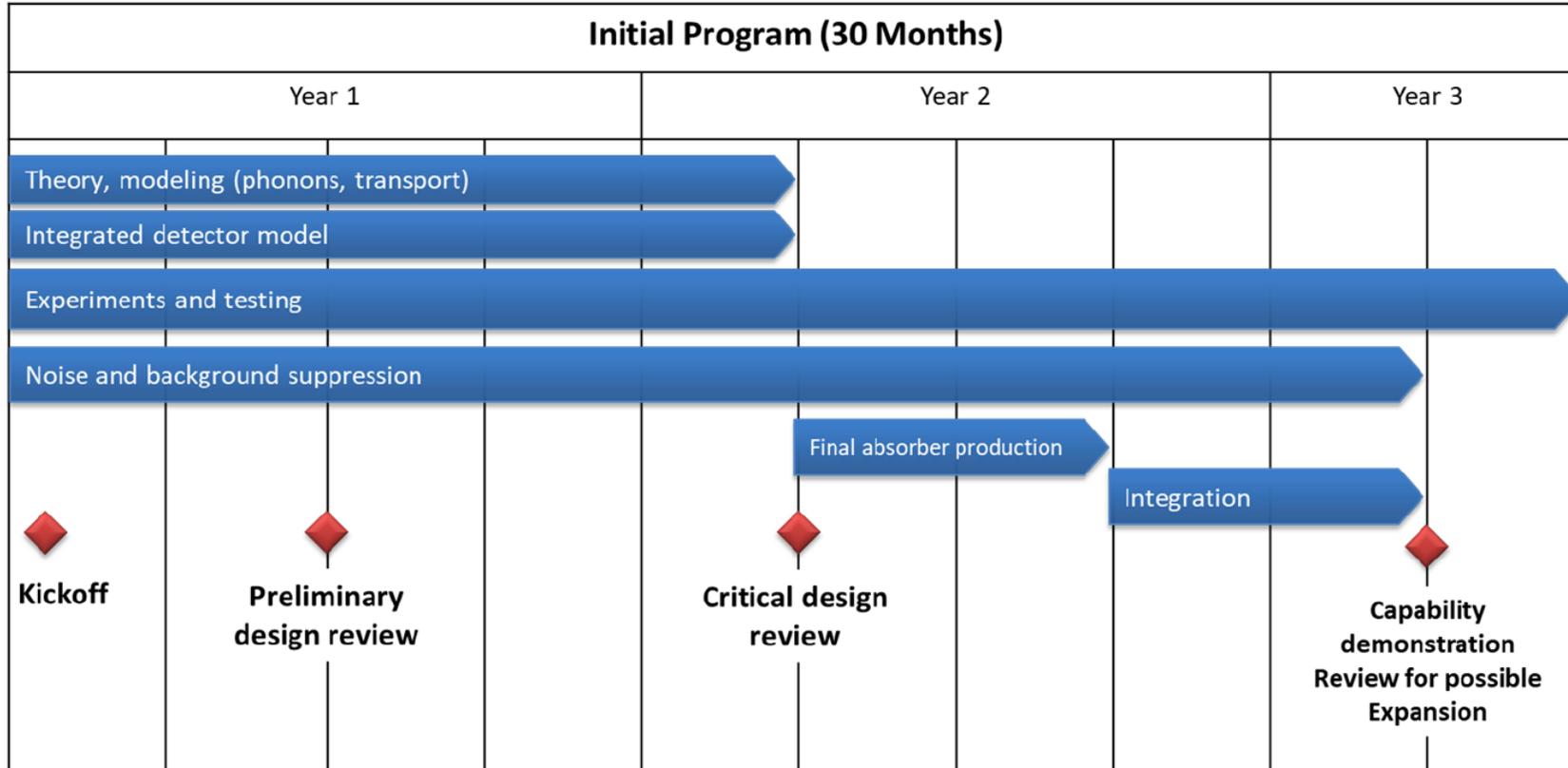


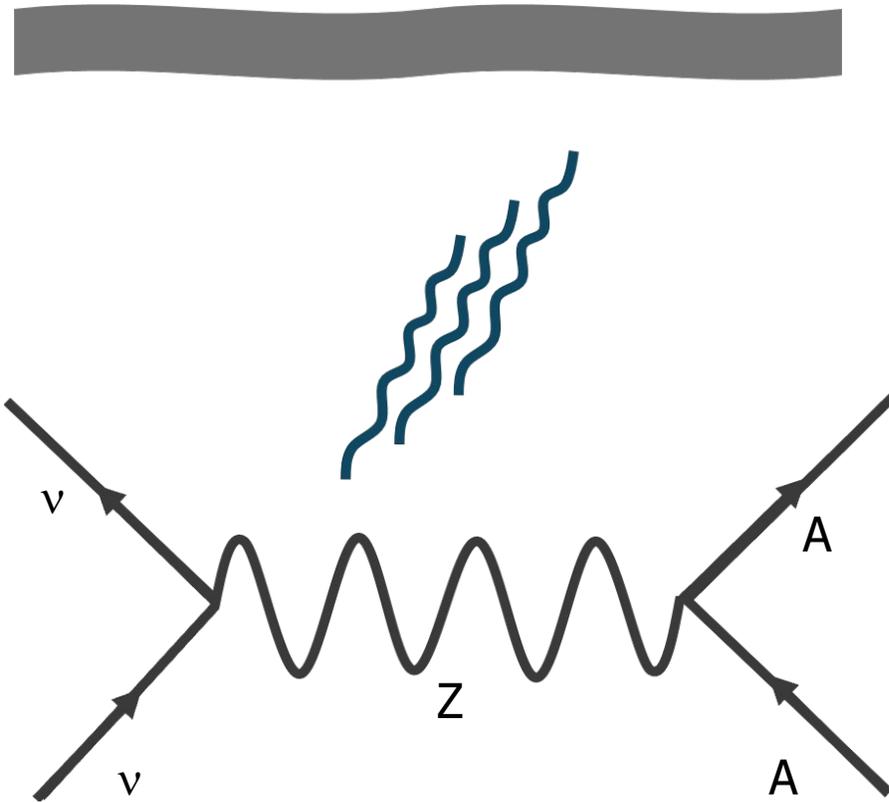
	QuSeN metric	Goal
Sensor	Neutrino to nucleus energy transfer sensitivity	<0.5 eV
	Signal to noise, signal to background	>1
Absorber	Mass, with neutron number, $N > 40$	>1 kg
	Phonon transport and detection efficiencies	>0.5

Table 1:
Program Metrics, initial 30 months. Potential of expansion after successful initial phase.



QuSeN schedule







Comprehensive Support for Your DARPA Journey

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DARPA DSO Overview

Dr. Bart Russell
Deputy Director
Defense Sciences Office (DSO)

November 12, 2024



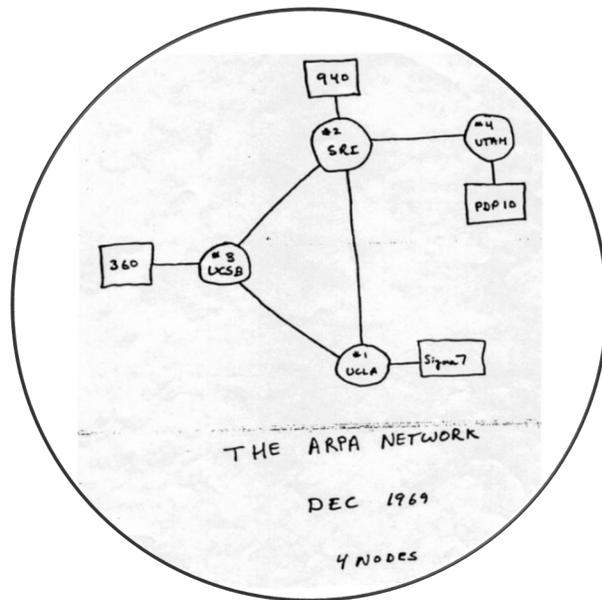


Breakthrough Technologies for National Security

Create breakthrough, paradigm-shifting solutions

Accept and manage significant technology risk

Disrupt or massively accelerate technology roadmaps



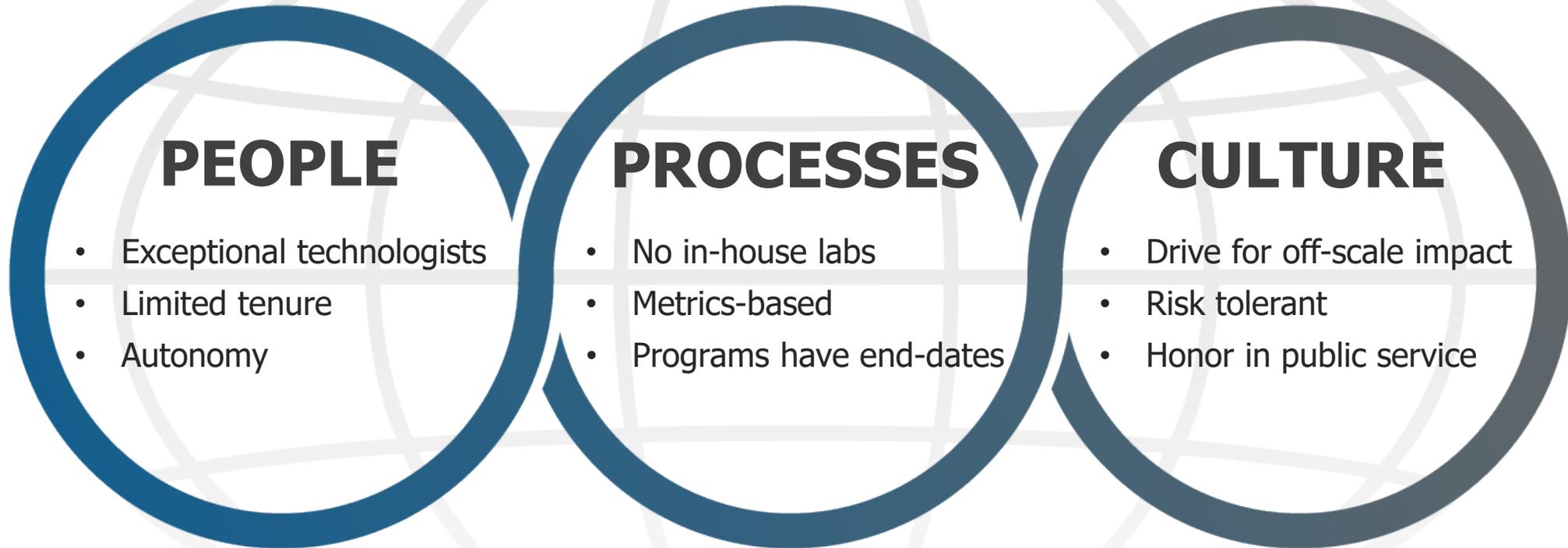
The Internet



Foundations of GPS



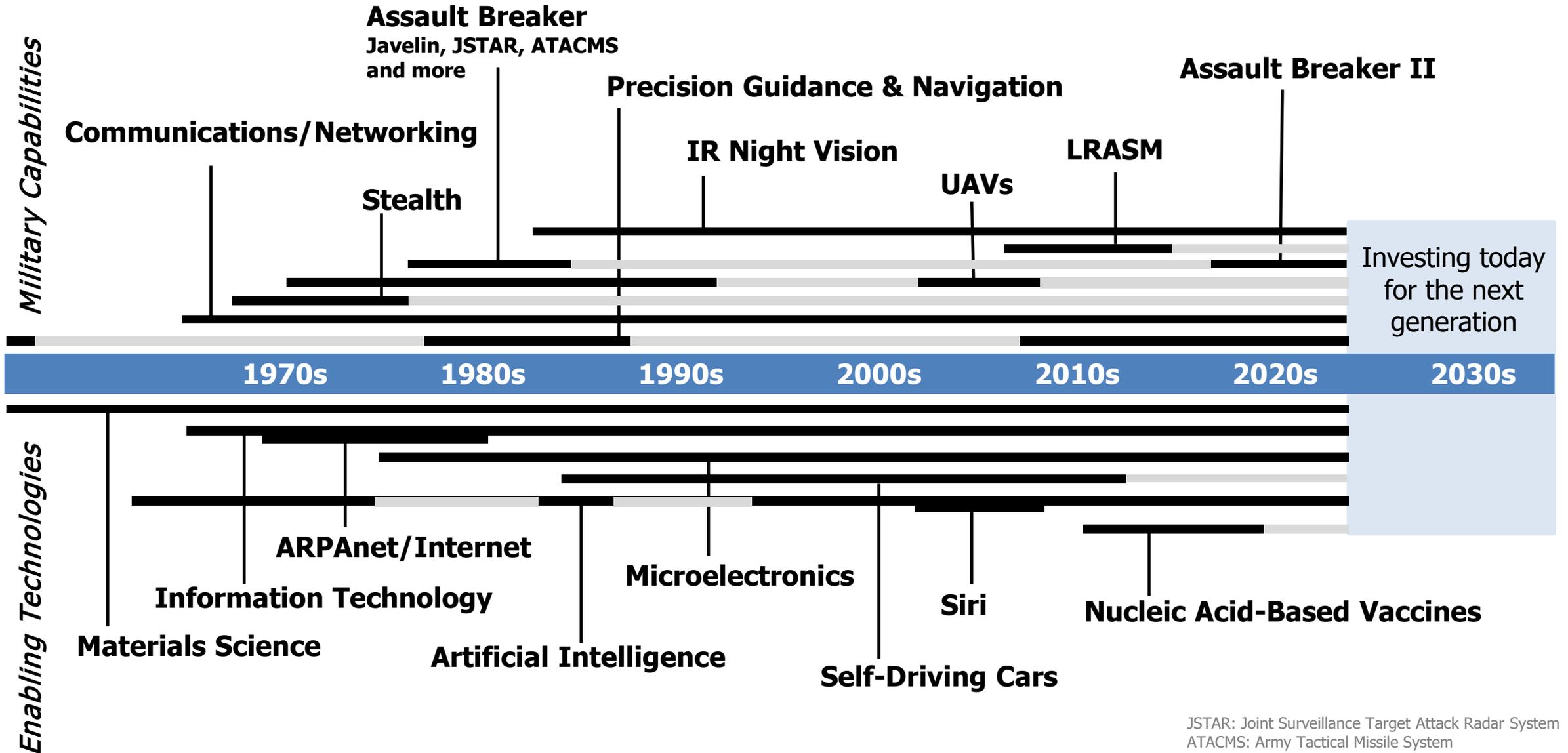
Advanced Prosthetics



DARPA's culture persists and the agency delivers



Pivotal early investments that change what's possible



JSTAR: Joint Surveillance Target Attack Radar System
ATACMS: Army Tactical Missile System
LRASM: Long Range Anti-Ship Missile



DARPA technical offices



Defense Sciences Office

- Novel materials and structures
- Sensing and measurement
- Computation and processing
- Enabling operations
- Collective intelligence
- Emerging threats



Biological Technologies Office

- Operational support capabilities
- Tactical warfighter care and functional restoration
- Strategic resilience and logistical security
- Sensing and responding to emerging threats



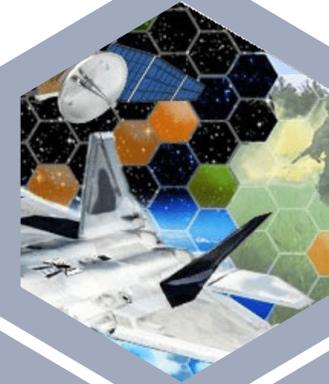
Information Innovation Office

- Proficient AI
- Advantage in cyber operations
- Confidence in the information domain
- Resilient, adaptable, and secure systems



Microsystems Technology Office

- Quantum, photonic, and organic circuits
- New microsystems manufacturing ecosystem
- Dual-use by design



Strategic Technology Office

- Advanced sensors and processing
- Battlefield effects
- Command, control, and communications
- Systems Warfare
- National Resilience



Tactical Technology Office

- Disruptive platforms and systems
- Reimagination of hardware design, development, test, manufacture and sustainment
- Focus on rapid, affordable, and scalable deployment



DARPA: Create and prevent technological surprise

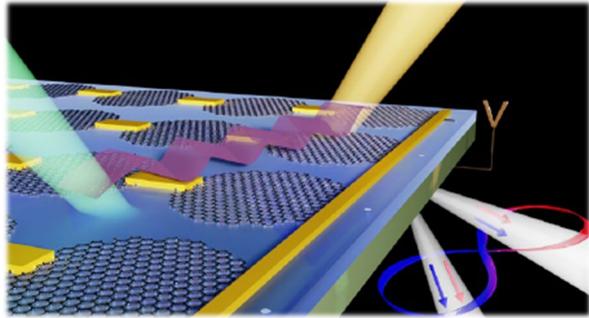
DSO —“DARPA’s DARPA”

- Creates opportunities from scientific discovery
- Invests in multiple, often disparate, scientific disciplines-- everywhere the rest of DARPA is, and more
- Focuses on mission-informed research

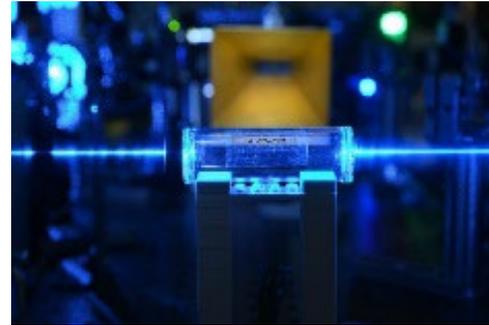
DSO: The Nation's first line of defense against scientific surprise



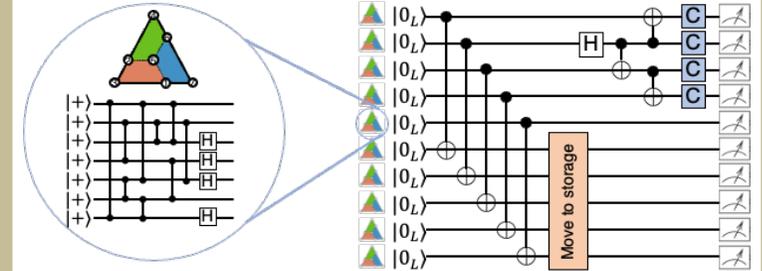
DSO Thrust Areas



NOVEL MATERIALS & STRUCTURES
Fundamentals to Fabrication



SENSING & MEASUREMENT
Micro/Macro; Quantum Limits



COMPUTATION & PROCESSING
Classical Algorithms to Quantum Computing



ENABLING OPERATIONS
Novel Phenomena to Systems and Structures



COLLECTIVE INTELLIGENCE
Basics of Intelligence to People/AI



EMERGING THREATS
Uncertainty and Global Events

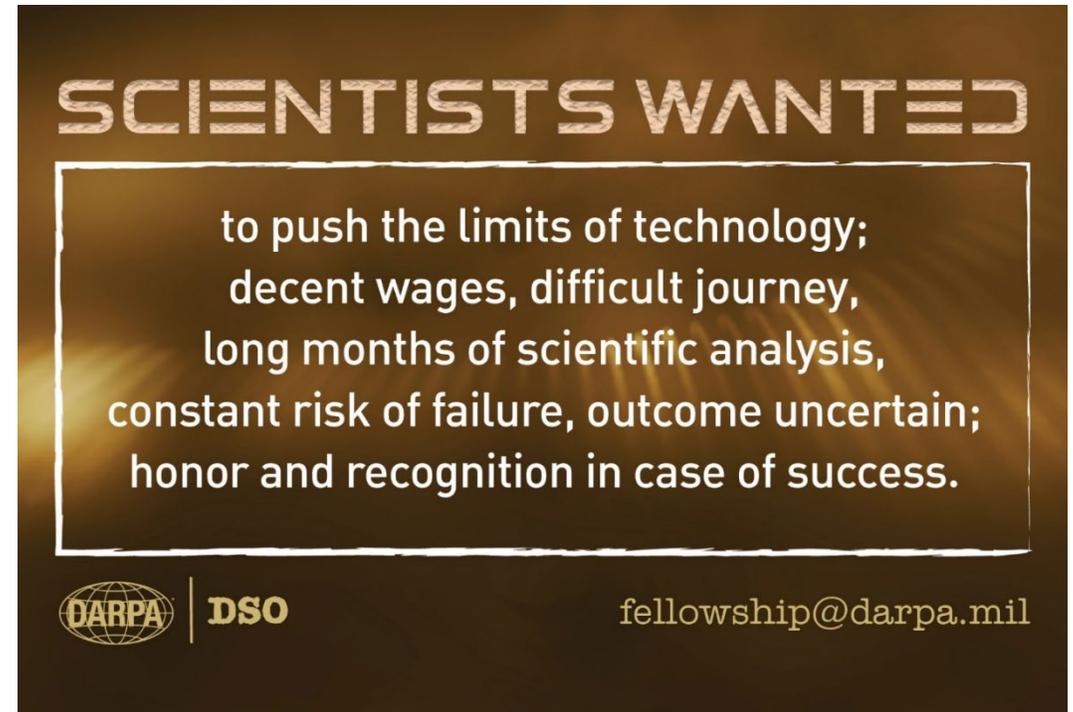
Advanced Research Concepts (ARC)

- New process to quickly capture and rigorously evaluate many ideas
- Focus is on answering high risk/high-reward “what if?” questions



DARPA Innovation Fellowship

- 2-year Fellowship for early career scientists
- Build a long-term pool of diverse talent that can focus on national security





Breaking Down Barriers to Entry for Nontraditional Performers

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DARPAConnect is designed to broaden DARPA's reach and stimulate **growth and collaboration** between DARPA, businesses, and academia.



Regional and
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Networking
Opportunities



Training and
Development

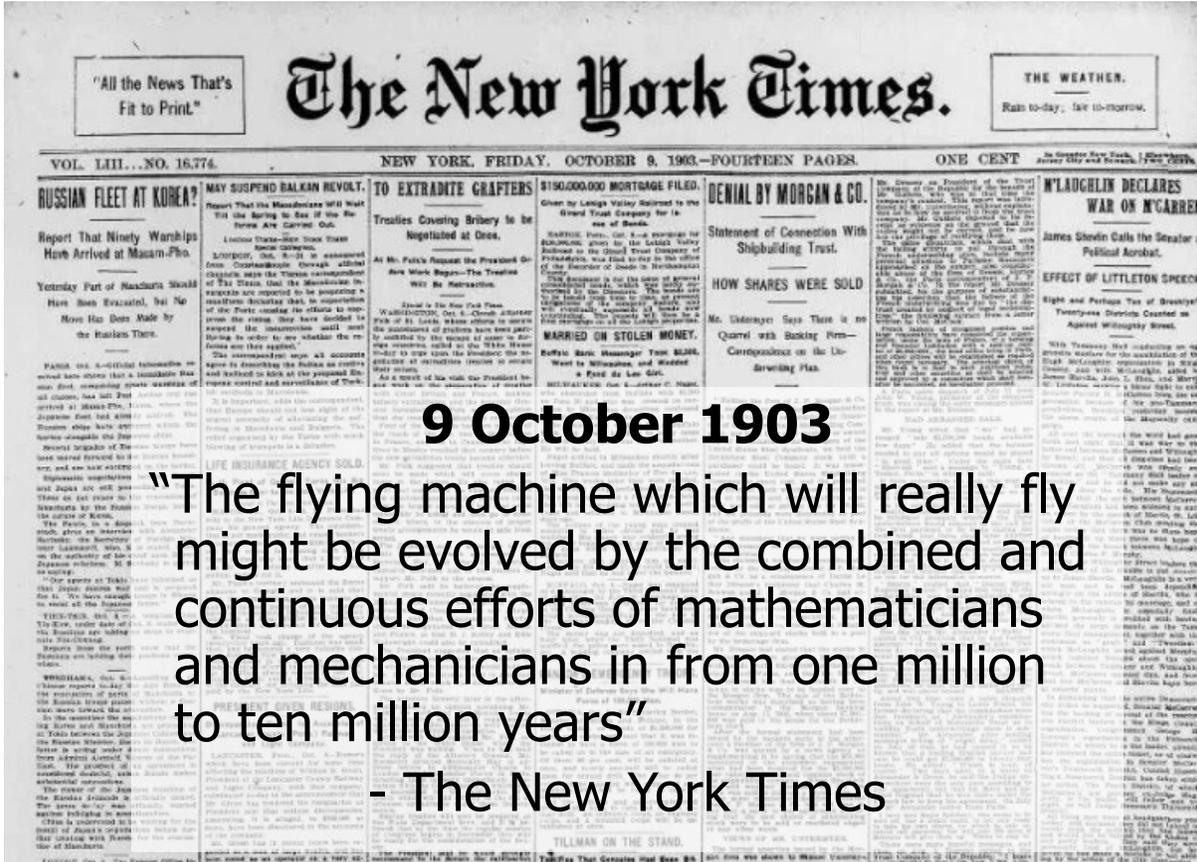


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Evolutionary vs. Revolutionary R&D



9 October 1903

“The flying machine which will really fly might be evolved by the combined and continuous efforts of mathematicians and mechanics in from one million to ten million years”

- The New York Times



9 October 1903

“We started assembly today.”
- Orville Wright's Diary



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Quantum Sensing of Neutrinos (QuSeN) HR001125S0004

Proposers' Day **Doing Business with DARPA**

Belinda Nwanguma
Contracting Officer
DARPA Contracts Management Office

June 7, 2024





QuSeN

Overview Information

- Broad Agency Announcement (BAA) posted at SAM.gov.
- Please pay attention to due dates in the BAA and any special instructions.
- Award Instrument Type: Contracts, Cooperative Agreements, and Other Transactions for Research (OTs for R).
- Important Dates:
 - Posting Date: **November 5, 2024**
 - Proposers' Day: **November 12, 2024**
 - Abstract Due Date: **November 25, 2024, at 4:00 p.m.**
 - Question Submittal Closed: **January 9, 2025, at 4:00 p.m.**
 - Proposal Due Date: **January 20, 2025, at 4:00 p.m.**



Proposer Instructions by Award Instrument Type

The following websites are incorporated by reference and contain additional information regarding overall proposer instructions, general terms and conditions, and each specific award instrument type.

- Procurement Contracts
 - [Proposer Instructions: Procurement Contracts](#)
- Cooperative Agreements
 - [Proposer Instructions: Grants/Cooperative Agreements](#)
- OTs for Research
 - [Proposer Instructions: Other Transactions](#)
- Proposer Instructions and General Terms and Conditions
 - [Proposer Instructions: General Terms and Conditions](#)



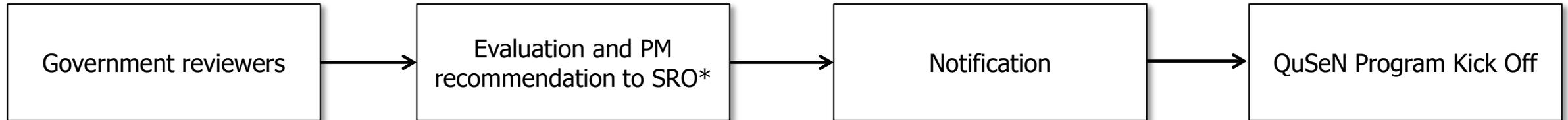
Abstract Tips

- Abstracts are **strongly encouraged but not required.**
- Abstracts are limited to **5** pages.
- DARPA will respond to abstracts with a statement as to whether DARPA recommends the proposer submit a full proposal or does not recommend the proposer submit a full proposal with a rationale for this decision and may provide specific feedback on recommended changes for the full proposal phase.
- **Regardless of instrument type desired, all abstracts must be submitted through the Broad Agency Announcement Tool (BAAT).**
- More details for abstract submissions are provided in Attachments A and B.
- Abstracts are due **November 25, 2024, at 4:00 p.m.**



Proposal Review Process

- For the BAA, there is no common Statement of Work. This means that proposals are evaluated for strengths and weaknesses relative to the BAA criteria, on individual merit, and relevance as it relates to the stated research goals/objectives rather than against each other.
- The Government will review all submitted proposals based on the following criteria:
 - **Scientific and Technical Merit**
 - **Potential Contribution and Relevance to the DARPA Mission**
 - **Cost and Schedule Realism.**



- Multiple awards are possible. The amount of resources made available under this BAA will depend on the quality of the proposals received and the availability of funds. The Government reserves the right to select all, some (partial selection), or none of the proposals for potential award.

*SRO = Scientific Review Official (SRO).



Proposal Review Process (cont'd)

- The contracting office will contact the selected performers and begin the negotiation process.
- **Contract negotiation timelines depend on each institution/organization's responsiveness to the proposal requirements in the BAA.**
- Full proposals are due **January 20, 2025, at 4:00 p.m.**
- For more information about DARPA's Scientific Review Process, please visit [Proposer Instructions: General Terms and Conditions](#)
- DARPAConnect offers free resources to potential performers to help them navigate DARPA, including "Understanding DARPA Award Vehicles and Solicitations," "Making the Most of Proposers Days," and "Tips for DARPA Proposal Success." Join DARPAConnect at www.DARPAConnect.us to leverage on-demand learning and networking resources



Eligibility Information

All responsible sources capable of satisfying the Government's needs may submit a proposal that shall be considered by DARPA, so long as the following eligibility requirements are met:

- **Non-U.S. Organizations and/or Individuals**

- Non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements, security regulations, export control laws, and other governing statutes applicable under the circumstances.

- **Government Entities & FFRDCs:**

- Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers, and Government entities interested in participating in the QuSeN program or proposing to this BAA in any manner should first contact the agency point of contact listed in the Overview section prior to the Abstract due date to discuss eligibility.

- **Organizational Conflicts of Interest:**

- Proposers shall identify and disclose all facts relevant to potential Organizational Conflicts of Interest (OCI), involving the proposer's organization, and any proposed team member (subawardee, consultant) in accordance with Federal Acquisition Regulation (FAR 9.5). The proposer is responsible for providing this disclosure with each proposal submitted to the solicitation. In addition, DARPA has a supplemental OCI policy that prohibits contractors/performers from concurrently providing Scientific Engineering Technical Assistance (SETA),



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