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Oak Ridge National Laboratory Summary Report of the First Long-Pulse and CW Klystron Workshop

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Neutron Sciences Directorate, Research Accelerator Division

SUMMARY REPORT OF THE FIRST LONG-PULSE AND CW KLYSTRON WORKSHOP

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ABSTRACT

Klystrons are the workhorses of high-power particle accelerators around the world. The continued reliable operation of world-leading scientific research depends on these vacuum tubes and, more broadly, a stable market of supply. Typically based on variable funding, the scientific market has been historically volatile. However, in the early 2020s, the volatility increased dramatically in large part due to the COVID-19 epidemic and the disruption it caused in both the supply chain and the labor market. The unsettled conditions severely affected the scientific klystron market.

In late 2024, representatives from the Spallation Neutron Source, European Spallation Source, Argonne National Laboratory, and SLAC National Accelerator Laboratory formed a committee with the charge to plan and hold a workshop to discuss the present state of the scientific klystron market and determine the concrete steps needed to stabilize it for the future. Explicit in the charge was that the workshop must include both suppliers and end users. To that end, the first Long-Pulse and Continuous Wave (CW) Klystron Workshop was held at the Oak Ridge National Laboratory's Spallation Neutron Source September 23–25, 2025.

1. WORKSHOP ATTENDEES

The workshop had 44 attendees, representing seven US Department of Energy national laboratories, three international laboratories and eight private companies, including all four major klystron manufacturers. Table 1 lists the participating organizations and their respective number of attendees.

Table 1. Professional affiliations of workshop attendees.

Affiliations	Attendees
US National Laboratories	
Argonne National Laboratory	3
Brookhaven National Laboratory	3
Thomas Jefferson National Accelerator Facility	2
Los Alamos National Laboratory	5
Lawerence Berkeley National Laboratory	3
Oak Ridge National Laboratory	7
SLAC National Accelerator Laboratory	2
International laboratories	
European Organization for Nuclear Research	2
Deutsches Elektronen-Synchrotron	1
Japan Proton Accelerator Research Complex	1
Klystron manufacturers	
Canon Electron Tubes and Devices	1
Microwave Power Products	4
Stellant Systems	2
Thales Electron Devices	3
Other industry	
Ampegon Power Electronics	1
Calabazas Creek Research	1
H6 Systems	2
Technix High Voltage	1

2. WORKSHOP FORMAT

2.1 VENDOR SESSIONS

As shown in Figure 1, each major klystron vendor was offered the opportunity to hold a session with only the end users in attendance on the first day. The other klystron vendors were kept in a “ready room” until their session. With an hour allotted, each vendor gave a formal presentation of proprietary content. After the presentation, each vendor answered both prepared and extemporaneous questions from the audience. To maintain business confidentiality, neither the presentation nor answers to any questions were kept as part of the workshop record.

7:30 - 8:00am	Registration	Lobby/8600 C-156	All Attendees
8:00 - 8:15 am	Welcome and Breakfast	8600 C-156	John Moss
8:15 - 8:30am	Background- Workshop How and Why	8600 C-156	John Moss
8:30 - 9:30am	Vendor Sessions 1--Canon Electron Tube Devices	8600 C-156	John Moss
9:30 - 10:30am	Vendor Session 2--Thales	8600 C-156	Doug Horan
10:30 - 10:45am	Break	8600 C-156	
10:45 - 11:45am	Vendor Session 3--Microwave Power Products	8600 C-156	Mark Champion
11:45am - 12:45pm	working Lunch (MDF Presentation)	8600 C-156	Yarom Polsky
12:45 - 1:45pm	Vendor session 4 - Stellant Systems	8600 C-156	Galen Aymar
1:45- 2:00pm	Break and Group Picture in Lobby	8600 C-156	
2:00- 3:30pm	Roundtable Session 1	8600 C-152, 8600 C-156, 8600 A-G06, 8600 C-250	Various
3:30- 5:30pm	SNS Tour	8600 lobby	J. Moss
5:30pm	Dinner "SLAC's Klystron Capabilities: Supporting Labs and Industry"	8600	All Attendees

Figure 1. Day-one agenda showing the vendor sessions. Presentations by Canon Electron Tubes and Devices, Thales Electron Devices, Microwave Power Products, and Stellant Systems.

2.2 ROUNDTABLE DISCUSSIONS

Following the vendor sessions, the attendees were divided into four groups and rotated through four parallel roundtable sessions held during the remainder of the workshop. Importantly, vendor representatives were mixed into these groups to fully maximize the input from both market sides. The four roundtable topics and their moderators are listed in Table 2.

Table 2. Roundtable session topics and moderators.

Session topic	Moderator
Operational Experience	Doug Horan
High-Power RF Engineers – The Next Generation	Mark Champion
Manufacturing	Galen Aymar
The Future of the Scientific Market	John Moss

Each roundtable discussion was initiated by the moderator, who first described the session theme to each group before posing a series of questions to the participants. A scribe recorded the discussion in each session.

2.2.1 Operational Experience

Discussions on operational experience with klystrons covered a wide range of topics that were somewhat independent of the type of operation (i.e., long pulse or CW, diode or mod-anode gun, output power, operating frequency, and physical characteristics). Regardless of the application, operational experience shared many common themes.

Biggest challenges affecting klystron reliability

Heat-damaged collectors, gun arcing, vacuum issues, and water in gun oil tanks were given as major causes of reduced reliability. Mitigation of these challenges included optimizing interlock performance to prevent collector and body over-dissipation, gun high-voltage conditioning ("spotknocking") to counteract barium buildup in the gun that causes arcing, better monitoring and interlock performance on klystron vacuum, and enhanced attention paid to water interfaces. Klystron aging, inconsistent performance from klystron to klystron, and operator abuse were also mentioned as significant challenges to facility operating reliability. Nonuniform performance within a klystron type was a common complaint, mitigated only by unique system adjustments to accommodate each specific klystron. Consensus was that a properly designed interlock system should be effective in preventing klystron damage caused by erroneous or nonstandard operator commands. Obsolescence was also mentioned as a reliability issue: many high-voltage/high-power components used in power systems have become obsolete or difficult to obtain, and substitutes can create situations that could result in klystron damage. Many klystrons themselves have become obsolete, resulting in severely limited or nonexistent factory support needed to investigate and resolve complicated performance issues.

Typical klystron lifetime

Reported klystron lifetime was somewhat specific to application and power output level. Some pulsed linac applications reported lifetimes of 200,000 h, whereas CW ring applications had lower lifetimes of 75,000–100,000 h. All facilities represented reported that they had "superstar" klystrons that lived very long lives as well as "sickly" klystrons that failed very early in their expected life. Reported common end-of-life conditions were cathode depletion, uncontrollable instabilities (primarily in ring applications), direct current gun leakage and breakdown, cracked output windows, pinhole leaks in ceramics, vacuum leaks, and shorted/open filaments.

Factory acceptance test vs. site acceptance test

Consensus was that the user typically cannot match the performance a klystron delivers at the factory acceptance test. Differences in load impedance, including the use of an output circulator, at the user facility are quite often given as a reason for this difference in performance. In some cases, new klystrons are not tested after delivery due to technician availability or scheduling difficulties when no full-power test stand exists. Harmonic level and x-ray emission are both often quite variable. In most cases of discrepancy between factory and user performance, facility operation has been modified to match the available performance of the klystron.

Klystron maintenance and long-term storage management

End users report that maintaining in-service klystrons involves closely monitoring performance parameters to detect problems early, using conservative heater warm-up time, and running heater power as low as necessary to achieve the required RF power output level. Some users favor routine cathode emission testing. Routine maintenance includes checking for oil and water leaks, checking oil breakdown voltage, and cleaning and inspecting high-voltage connectors. Facilities with full-power test stands report that new klystrons are tested upon delivery, and the testing protocol may include some conditioning time. However, some users considered such testing a tedious process that requires significant technician effort.

Operational problems caused by quality/workmanship defects

Most instances in this category involved water, oil, and vacuum leaks. Loose or missing hardware was also cited as an example. The specific resolutions involved in each situation were often performed by the end user without factory help, but more serious or unrecoverable defects, such as loss of vacuum or body water leaks in areas of the klystron where brazing or machining are not possible required returning the klystron to the manufacturer.

New and refurbished klystrons

Experience with refurbished klystrons was reported to be generally good, with little difference in performance to that of a new klystron. However, some users reported that refurbished klystrons routinely did not match the lifetime of new klystrons. Advantages of refurbishment include shorter turnaround time and reduced cost, estimated at 70%−75% the cost of a new klystron. Success with refurbishment of a given klystron is generally felt to be highly dependent on the condition of the klystron at the end of its previous life. Catastrophic failures such as melted collectors, total loss of vacuum, or severe barium deposition are considered possible disqualifiers to refurbishment.

2.2.2 High-Power RF Engineers – The Next Generation

The future of the klystron market depends on well-trained engineers and technicians. This is a matter of concern for both klystron vendors and klystron users. A consistent message throughout this workshop was that finding experienced RF engineers and technicians is challenging, especially those with klystron and vacuum tube experience. In these sessions, discussion focused on what can be done to ensure a supply of engineering and technician talent for the future.

The following questions were presented during this breakout session to stimulate discussion:

- What are some successful ways that your facility has approached the challenge of finding high-power RF engineers and technicians? Conversely, what does not work?
- How do you retain high-power RF engineers and technicians?
- What publications or websites have been useful to you in finding high-power RF engineers and technicians? (e.g., the European Center for Nuclear Research (CERN) Courier, IEEE Spectrum, LinkedIn, Indeed, Monster)
- Is on-campus recruiting useful in finding entry-level high-power RF engineers and technicians?

- Can we partner with universities to offer curricula on klystrons and electron tube devices? Are you aware of any such programs?
- How about community colleges or applied technology programs for technicians?
- Is it possible or useful to set up a national or international apprenticeship program?
- Where can students learn about klystrons?
  - Some universities offer coursework on microwave engineering, accelerator physics, vacuum electronics, and high-power electronics
  - US Particle Accelerator School https://uspas.fnal.gov/
  - CERN Accelerator School https://cas.web.cern.ch/
  - Start with a good electrical engineer and teach them about klystrons and high-power RF systems "on the job"
- Other ideas?

The following findings came out of this breakout session:

- Conferences and trade shows are good venues for recruiting.
- On-campus recruiting at universities, colleges, and trade schools is useful.
- Online recruiting tools such as LinkedIn, Indeed, and Monster are occasionally useful but may result in many inquiries from unqualified candidates.
- AI may be useful in locating job candidates.
- Vendor and laboratory job websites are necessary and need to be up to date, and postings must be written with care.
- Internships are valuable and provide a "test drive" for both parties.
  - Student internships sometimes lead to employment.
  - Teaching internships help publicize the work that we do and may generate student interest.
- Temporary staff sometimes transition to permanent staff.
  - This transition happens especially at the end of a big project.
  - Both parties are well known, so there are no surprises.
- Recruiting mid- to late-career staff is generally not successful.
  - This is especially true for operations and maintenance positions.
  - Big new projects are an exception.
- The general preference is to recruit early-career or fresh graduates from engineering or physics programs and teach them.
  - This strategy requires effort from existing staff (e.g., mentoring, training)
  - They may depart after a few years, which is a local loss but may still benefit the field as a whole.
  - The objective is to grow the pool of RF engineering talent!
- Retention is a challenge and requires the following:
  - Good pay and benefits
  - Interesting work
  - A good team and work culture
  - Good mentoring
  - Inspirational leadership
- Military retirees are often a good fit for technician roles and can be found through numerous agencies:
  - Cohen Partners of Oceanside, California (recommended by workshop attendee)
  - US Department of Defense SkillBridge, Orion Talent, and others
- The US Particle Accelerator School and CERN Accelerator School occasionally offer courses relevant to high-power RF engineering.
  - These courses are useful for educating early-career staff.

    - Both courses offer proceedings online.
- Overlap between early-career and later-career staff is desirable but not always possible (budget/hiring constraints).
- Good documentation helps maintain corporate knowledge and train new hires.
- Seminar presentations at local universities and colleges may stimulate student interest.
- Facility tours and science fair participation can spark the interest of students of all ages.

This breakout session produced the following recommendations:

- Develop relationships with local universities, colleges, and trade schools
    - Engineering professors can steer high-potential students toward careers in high-power RF engineering
    - Use local schools to develop internship opportunities within your organization or lab
    - Seek teaching and/or seminar opportunities for our staff to educate students about our facilities and career paths.
- Participate in conferences and trade shows
    - Set up a recruiting booth where feasible
    - At minimum, engage with students at poster sessions
- Work with our talent acquisition teams and educate them about our work and our needs
    - Hiring good people takes effort on our part; we cannot just throw a personnel requisition over the fence and wait
- Work with the DOE on workforce development
    - For example, DOE General Accelerator R&D (GARD) program
    - Pursue scholarship opportunities and/or funding to support students
- Participate in local outreach activities
    - Science fairs
    - Seminars at local schools
    - Facility tours for students of all ages

To summarize the "High-Power RF Engineers: The Next Generation" roundtable, sustainability and growth of the high-power RF workforce are challenges, and there is no single easy solution. However, the field has had success in attracting and retaining early-career staff. We need to continue to confront this challenge with the goal of growing the high-power RF workforce and enabling a robust future for high-power RF engineering.

2.2.3 Manufacturing

Ever since the invention of the klystron, klystron manufacturing has remained a challenging endeavor. The limited market size for klystrons has restricted the funding for R&D in such a way that many difficulties in manufacturing have remained unsolved. The future of the klystron market depends on an understanding of the current manufacturing processes and their failures as well as a push toward new manufacturing techniques to improve yield and reduce costs.

2.2.3.1 Identified manufacturing difficulties and areas of growth

Four topics came up repeatedly in the four discussion sessions focusing on manufacturing: specialty materials, custom configurations of klystrons, testing of klystrons and capital equipment investment, and advanced manufacturing techniques. These can be considered as difficulties or areas for improvement and are discussed in more detail below.

Specialty materials: Ceramics, thermionic cathodes, and rare-earth metals

Klystrons are especially reliant on a handful of highly specialized and hard-to-procure materials. The sourcing of these materials can prove challenging when seeking high quality material with critical properties, a short lead time, and a low price.

Ceramics are an integral component and have two main uses in klystrons: high-voltage insulators and high-power RF windows. The technical ceramics used, primarily aluminum oxides of varying purities, are readily available. However, due to the small size of the klystron industry, the lead times from known vendors are continually increasing. Lead times between 6 months and 1 year are not unusual and have an immediate impact on the delivery of any klystron. For less common ceramics, such as beryllium oxide, the number of vendors is small (only known vendors are in Japan and Wales), further compounding the issue. Even when a ceramic can be sourced, the critical material properties are not commonly published in the frequency ranges of interest—properties may be available for the kilohertz or megahertz range but certainly not in the gigahertz range. This leads to inconsistency in batches and inexact designs and performance. Finally, many ceramics are treated during manufacturing with a titanium nitride coating to reduce multipactor discharge and provide a conductive layer for charge bleed-off. Despite this industry-wide practice, the mechanism of the coating and its robustness under standard klystron processes (hydrogen brazing, vacuum brazing, vacuum bakeout, or exposure to air) are poorly understood.

Thermionic cathodes can be considered the “heart” of the klystron because they produce the electron beam essential to their function, are the primary constraint on lifetime, and operate in extremes with regards to both temperature and voltage. Cathode development and production used to be vertically integrated at the klystron manufacturers, but, over the past decades, it has been outsourced and eventually coalesced into only two primary vendors for all cathodes. The industry has noted that quality and lead times can be highly variable, and many in the industry are attempting to bring this manufacturing back in-house.

Rare earth metals also play a critical role in klystron manufacturing. Neodymium and samarium are used in permanent magnets, and scandium is used in advanced cathodes. As global trade becomes more volatile, sources for these materials are being constricted and the small size of the klystron industry leads to further constraint on their availability as other industries are prioritized.

Custom configurations

Each klystron, or application of a klystron, tends to be slightly unique due to either the unique history of the facility where it is to be used or the accepted manufacturing processes of the vendor manufacturing it. Specifically, many discussions noted that high-voltage connectors (whether wired harnesses or gun sockets in oil tanks or air) can vary wildly. These connectors are produced in low quantities either by the klystron manufacturer or by specialty outfits, and their lead time and reliability can leave much to be desired. The choice of connector is often not discussed or analyzed in detail and can lead to headaches in the manufacturing or use of these klystrons.

Capital equipment availability

The production of klystrons requires highly specialized equipment that can severely limit the throughput of a manufacturer. The most common bottlenecks in production are due to bakeout furnaces (large furnaces that must maintain vacuum in both the furnace and klystron internal to it) and test stands (modulators producing the appropriate high-voltage, current, and timing structure coupled with the RF equipment and controls tying it all together to run a klystron). If the utilization of this equipment is low, then there is no incentive to install parallel systems, but when a production run is required, the timelines are often tightly constrained. Maintaining critical capital equipment that is also aging with no certain guarantee of usage can become too much of a financial burden.

Additive and advanced manufacturing

Klystrons have been made in much the same way for nearly a century, by employing machining, brazing, and welding processes. Although these processes have proven robust and reliable, they impose certain geometry and throughput constraints. Expanding beyond traditional methods into more novel methods, such as additive manufacturing, six-axis milling, or blue laser welding can open new avenues for prototyping and assembly simplification. Many of these processes have been proven in RF technologies that have limited needs for high-power or high-vacuum quality, and adapting them to high-power RF and ultrahigh vacuum will require continued R&D.

2.2.3.2 Potential Mitigation Actions

Improve communication between customers and suppliers

Repeatedly throughout the workshop, the point was made that more extensive communication between customers and suppliers, and perhaps between customers for mutual coordination, could alleviate many of the difficulties described above. The custom configurations for klystrons may be found to be less critically needed when compared to a more universal approach between labs. Additionally, the use of laboratory test facilities may enable suppliers to take on projects that otherwise would be untenable due to bottlenecks of capital equipment. This increased communication should be encouraged as early as possible in the proposal phase for new work.

Tracking and sourcing of high-risk materials

The shared needs of laboratories for klystrons present the option of strategically tracking and sourcing high-risk materials. If certain design elements can be standardized between suppliers, then laboratories could place bulk orders of materials, perform enhanced testing, and carry reserve stock for unforeseen repairs.

Developing a centralized laboratory facility for testing

Given the bottlenecks encountered by suppliers for specialty klystron testing equipment, a consolidated and dedicated facility within the laboratory system for testing klystrons could prove useful. Such a facility would be geared toward the most pressing needs of the various laboratories, and it could contain supplementary equipment that is useful for troubleshooting or repairing klystrons away from the manufacturer's facilities. Such a facility could also enable more rigorous R&D related to klystrons, such as evaluation of ceramic coatings or new cathode technologies.

Continued development of additive and advanced manufacturing

Pushing manufacturing into more advanced areas may require an additional R&D push by laboratories before the business case is justified for manufacturers to invest. This manufacturing could be spearheaded by labs while being performed in conjunction with manufacturers to ensure a quick path to market for new practices. Critically, this work should inform, and be informed by, the increased communication between labs and manufacturers to ensure that novel findings are adapted into the actual klystron needs.

2.2.4 The Future of the Scientific Market

The long-term viability of the scientific klystron market was the central theme for the workshop. This viability is under threat from several sources, such as inconsistent demand, lack of klystron standardization, slow loss of technical abilities, and encroachment of silicon-based technology. Despite these factors, many scientific facilities will continue to rely on klystrons as their primary source of high-power RF, and these facilities are exposed to the risk of market volatility. A sustainable scientific klystron market is crucial to their continued reliable operation. The following sections describe the current challenges and potential mitigations for the future.

2.2.4.1 Current market challenges

Six overarching challenges were identified multiple times across the four sessions:

- Inconsistent communication between fabricators and consumers
- Unclear picture of actual market size
- Little to no standardization across end-user facilities
- Loss of technical expertise
- Unpredictable demand
- Encroachment of solid-state RF sources

Communication

Finding solutions to market volatility starts with improving communication among all parties. Each session pointed out repeatedly that communication between vendors and consumers takes place only when the consumer needs a new klystron or when a problem arises, and little to no communication occurs between consumer peers. Attendees agreed that, in their memory, this workshop was one of the first times consumers and fabricators interacted as one group, and all agreed that it was a good start. The solutions to the other recurring challenges described herein start with better and more consistent communication.

Market size and details

No single vendor or end user in attendance could definitively state the size of the scientific klystron market. Market size is an important factor for both sides and could affect future mitigations for the overarching challenges identified in the workshop. Understanding the quantity and type of klystrons used at each facility would not only help the vendors better understand where different products are used but also enable end users to find an existing klystron that could help them in an emergency.

Standardization

Little to no standardization exists across klystron consumers. This inconsistency affects the vendor pricing significantly. As in the manufacture of any product, increased quantity drives down the per-unit price. Another tangible benefit would be the ability to share products and personnel over several end-user facilities. Standardization is key to a more sustainable future.

Loss of technical expertise

A theme that relates to the "next generation of high-power RF engineering" roundtable, the loss of technical expertise has been felt by the vendors as well as the consumers. Manufacturing high-power klystrons is a bit of a niche calling that has lost some draw as newer engineering technologies have emerged. Some of the loss is a natural part of market changes. However, there is a need to regain some of the past skills and capabilities that have recently waned.

Unpredictable demand

Demand for scientific klystrons was largely agreed by all attendees to be "feast or famine" in nature. This unpredictability is likely the key underlying reason for the market volatility. Smoothing out the demand will help keep the vendors production ready and will likely increase the speed and quality of klystron fabrication.

Encroachment of solid-state RF sources

Solid-state technologies have been on the rise in recent years as viable alternatives for high-power RF sources. The systems are typically modular and, in some ways, easier to maintain. However, solid-state sources will likely be unable to replace all the klystron-based sources in place now or in the future. Some frequency and power bands are more suitable to vacuum tubes than solid-state sources and vice versa. The RF source market has room for both technologies.

2.2.4.2 Potential mitigation actions

The roundtable discussions produced the following possible mitigations to secure the future of the scientific market.

Improve market-wide communication

Improved and consistent communication between all parties in the scientific klystron market will ameliorate most of the overarching challenges identified in Section 2.2.4.1. Improving communication may also be the easiest mitigation strategy to implement. One of the most formal ways to improve communication discussed was the development of a market database.

The market database could be used to answer several of the challenges raised during the discussion periods. However, it does face obstacle of its own. First, the database would need to be publicly available to anyone in the market, both fabricators and consumers. Secondly, it would need to be maintained for accuracy. Once those high-level challenges are solved, the database would be incredibly beneficial. For example, such a database would help with the following:

- Determine the initial scientific market size. Market data would be updated as klystron needs change.
- Coordinate procurements between consumers to stabilize demand.
- Allow fabricators to forecast upcoming procurements.
- Standardize on klystron types across multiple facilities.

Include fusion

The recent increase in activity in private and public fusion projects has prompted a similar increase in the demand for gyrotrons. Gyrotrons are fabricated by the same vendors that fabricate klystrons and use the same resources. Fusion, naturally, will face the same challenges we are currently trying to solve. Simply put, they should be included in our discussions.

Develop an international center for vacuum tube development

The roundtables all discussed the degradation of the technical know-how and capability to design and fabricate klystrons. The loss of this skillset represents a serious risk to the worldwide scientific market. In the mid to late 20th century, the infrastructure to design and fabricate klystrons was more widely distributed among fabricators and consumers. Since that time, the ability to design and fabricate has diminished, even among manufacturers.

To reverse this decline, workshop participants suggested that developing an international center for vacuum tube development would possibly mitigate multiple problems identified with the existing market. For example, the center could serve as a training ground for the next generation of tube engineers and technicians. It could also serve as a center for prototypes, low-quantity fabrication, and repairs. The center would be available to public and private users. Furthermore, it could be spread across the world as a partnership among experts rather than be confined to a single geographic location.

3. ACTIONS

The need for improved communication was a recurring theme heard throughout the workshop. The actions described in the following subsections are designed to help continue the communication already started among the attendees shown in Figure 2.

3.1 FORMATION OF WORKING GROUPS

As an output of this workshop, working groups will be formed around the following topics:

- The next generation of tube engineers
- The future of the scientific klystron market
- Advanced manufacturing

Working groups will meet quarterly at a minimum but may choose to meet more frequently. Each group will consist of a chairperson and between 5 and 10 members. In general, each group will have a charter that will task them to identify the areas that need strengthening in their respective subtopic and, most importantly, determine actions that can strengthen those weak areas. Working groups should consider funding requirements and sources for further actions. Additional funding beyond operational R&D budgets is expected to be necessary.

3.2 SUBSEQUENT WORKSHOPS

Subsequent long-pulse and CW klystron workshops should be held periodically to assess progress against the actions identified by the working groups and gauge the status of the klystron market. The following key conferences and workshops offer other opportunities for interaction:

1. The International Particle Accelerator Conference (IPAC)
2. The International Vacuum Electronics Conference (IVEC)
3. The Continuous Wave and High Average Power Workshop (CWRF)
4. The Pulsed High Power RF Sources Workshop

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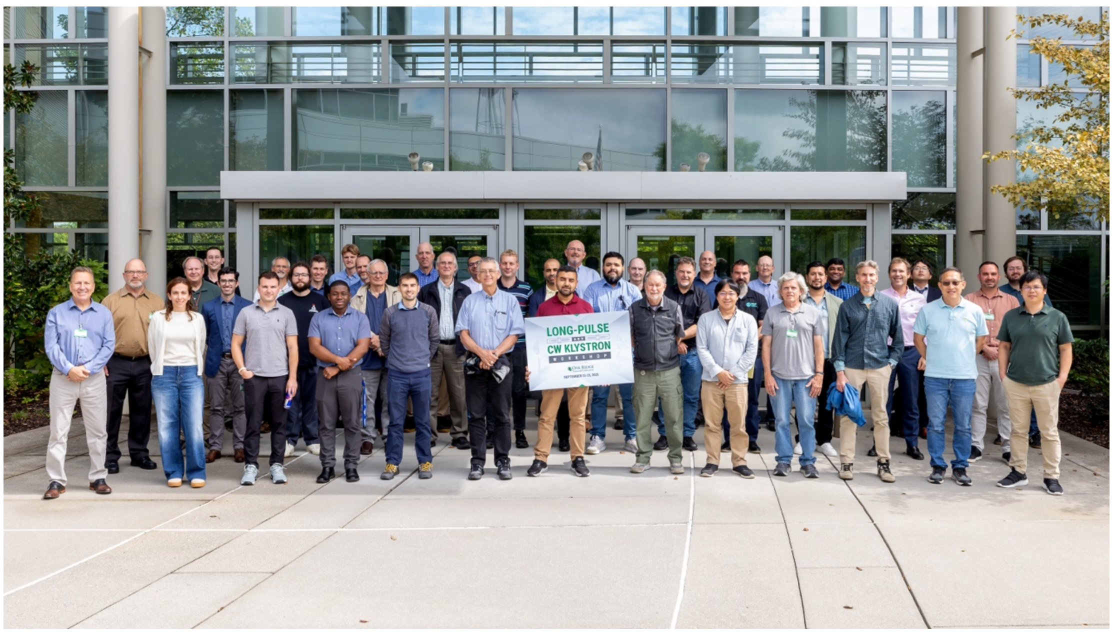

Figure 2. Workshop attendees.