OAK RIDGE National Laboratory

LINAC 2026 | DAEJEON, SOUTH KOREA

The Global Scientific Klystron Market: Insights from the First Long-Pulse and CW Klystron Workshop

Haitao Ren

RF Scientist, Spallation Neutron Source, ORNL

On behalf of: J.Moss · G. Aymar · M. Champion · D. Horan · M. Jensen

U.S. DEPARTMENT of ENERGY

ORNL IS MANAGED BY UT-BATTELLE LLC
FOR THE US DEPARTMENT OF ENERGY

This talk will give a high-level overview of the scientific klystron market, which directly affects the operation of many global scientific facilities.

1. Why klystrons still matter
2. Market volatility
3. Convening the First Long-Pulse & CW Klystron Workshop at ORNL, September 2025
4. The drivers of long-term market health
5. Actions and outcomes
6. Plan forward

Despite advances in solid state, klystrons remain one of the most popular high-power RF sources.

Why klystrons are still popular:

Power the RF that accelerates particle beams at major science facilities worldwide

Viable choice for RF sources at frequencies above 350MHz with average power exceeding 200kW [5]

They are still one of most efficient high-power RF sources – with some cutting-edge designs indicating efficiencies approaching 90% [6]

Some facilities, like the LHC, are developing methods to improve the efficiency of existing klystrons as opposed to adopting a new RF source[7]

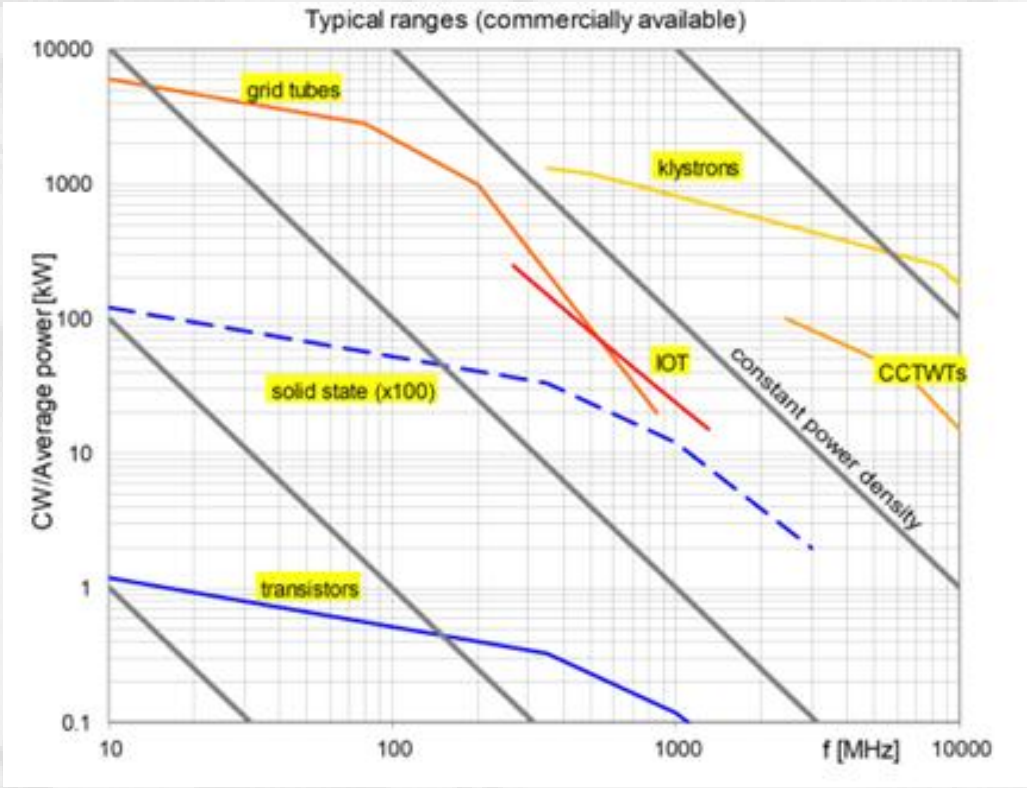


Image created by E. Jensen [5]

Yet the market that supplies these klystrons is volatile — and that volatility puts scientific facilities at risk

Scientific klystrons are a small, highly specialized market served by very few suppliers

Demand arrives in large, irregular bursts tied to individual construction projects — with no steady baseline

When a supplier exits or expertise retires, there is little slack in the system to absorb it

Understanding these strengths and weaknesses is essential to protecting long-term market stability

The red dots indicate the location of the four major klystron manufacturers who are responsible for the global supply for the scientific market.

The need to better understand market risk and how to mitigate it led ORNL, SLAC, ANL, and ESS to convene the First Long-Pulse and CW Klystron Workshop in September 2025.

Purpose: understand the scientific klystron market from both the manufacturer and end-user perspectives

Held at Oak Ridge National Laboratory, September 23–25, 2025

Designed to put ***manufacturers and users*** in direct conversation about shared risks

Format: hour-long individual sessions with each manufacturer, followed by four parallel small-group roundtables

LONG-PULSE AND CW KLYSTRON WORKSHOP

HOSTED BY OAK RIDGE National Laboratory

OAK RIDGE National Laboratory

Long-Pulse and CW Klystron Workshop

Home | Agenda | Sessions | Organizers | Sponsors | Closeout Slides | Lodging and Travel | Contact

Agenda

September 23

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

The workshop drew attendees spanning US national labs, international facilities, and industry — including the major klystron manufacturers.

44	7	3	7	4
Attendees	U.S. national laboratories	International laboratories	Private companies	Major klystron manufacturers

Representatives from all four major klystron manufacturers were embedded directly in the roundtable discussions — **the first-time end-users and every major vendor sat at the same table on these issues.**

The workshop's discussions were focused across four themes.

Operational experience – Doug Horan ANL, Chair

Gun arcs, collector heating, and vacuum dominate reliability; users rarely reproduce factory-acceptance performance on site.

Workforce – Mark Champion ORNL, Chair

Expertise is learned mostly on the job; the field needs university and trade partnerships, scholarships, and internships.

Manufacturing - Galen Aymar SLAC, Chair

Material sourcing and the absence of standardized specifications are the binding constraints on output.

Future of the market – John Moss ORNL, Chair

Weak communication, unclear market size, and unpredictable demand stress the market; solid-state encroaches, but klystrons still dominate key regimes.

The discussions led to the determination of four structural factors that seem to drive the volatility of the scientific klystron market.

Limited suppliers

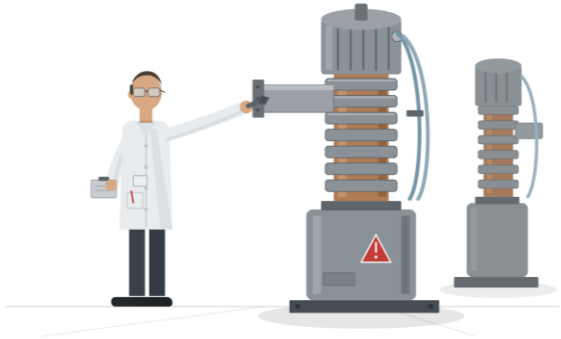
No more than four major klystron manufacturers exist worldwide, leaving almost no redundancy.

Supply-chain strain

Klystrons rely on long lead materials that are difficult to procure. Near-constant pressure from pandemics and geopolitical unrest disrupts critical materials. [1] [2]

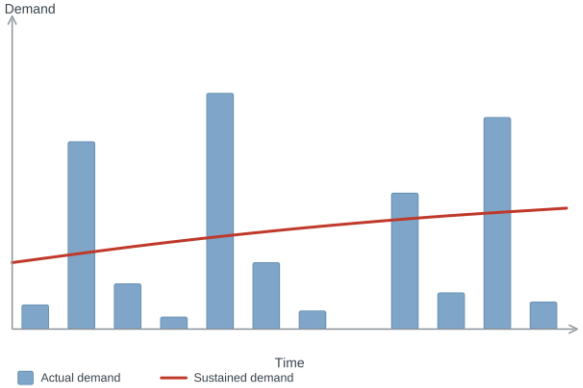
Loss of expertise

Few new technicians and engineers are entering an already shrinking, specialized field.



Inconsistent demand

Unpredictable, project-driven ordering gives manufacturers no steady production baseline.

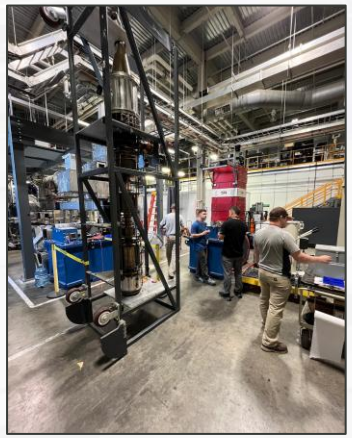


Attendees agreed to form three working groups to turn discussion into sustained action. The intent is for groups to meet quarterly and consist of 5 to 10 members.

The Next Generation of Tube Engineers

Build the talent pipeline through universities, trade schools, scholarships, and internships.

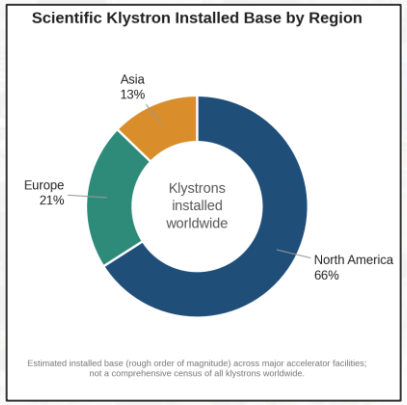
- Similar to existing initiatives, like the US domestic Accelerator Workforce Integrated Planning Group



The Future of the Scientific Klystron Market

Improve market visibility — a shared klystron database, community surveys, and standardization.

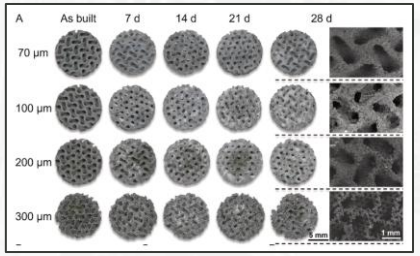
- First pass at capturing market details is underway. It is not yet comprehensive.



Advanced Manufacturing

Develop new fabrication techniques, shared material sourcing, and a centralized test facility.

- Focus on ceramics, cathodes, multi-material ”printing” [4]



The report is published, the groups are forming, and future workshops will track our progress

A full workshop report was published in December 2025, summarizing outputs after a draft review by attendees [3]

After forming, the three working groups will define and drive concrete actions

Priority of items in development: a central klystron database, shared sourcing of high-risk materials, a strengthened workforce pipeline, and a “centralized” test facility

Future workshops will reconvene the community to measure progress and keep the market on a stable footing

Klystrons will power particle accelerators for decades — sustaining their market is a shared responsibility we have now begun to meet.

THANK YOU — QUESTIONS WELCOME | HAITAO REN · OAK RIDGE NATIONAL LABORATORY

References

[1] Ceramic image credit: https://www.unipretec-ceramics.com/alumina-ceramic/alumina-ceramic-crucible.html

[2] Cathode image credit: https://www.cathode.com/c_cathode.htm

[3] Summary Report of the First Long-Pulse and CW Klystron Workshop (awaiting final publication)

[4] Eliot, A. and Prichard, P., “MDF Capabilities for Klystrons.” Presented at the GARD RF Sources Workshop, February 11, 2026.

[5] H. Damerau, "Radio-Frequency (RF) Systems," presented at the CAS–CERN Accelerator School, arXiv:2108.06237 [physics.acc-ph] (2021), Fig. 26. Chart courtesy of E. Jensen (CERN).

[6] V. E. Teryaev, S. V. Shchelkunov and J. L. Hirshfield, "90% Efficient Two-Stage Multibeam Klystron: Modeling and Design Study," in IEEE Transactions on Electron Devices, vol. 67, no. 12, pp. 5777-5782, Dec. 2020, doi: 10.1109/TED.2020.3033267.

[7] K. H. Khlifa, A. Beunas, A. Mollard, I. Syratchev, N. C. Lasheras and C. Marelli, "TH2167HE High-Efficiency Klystron for the Hi-Lumi LHC," 2025 26th International Vacuum Electronics Conference (IVEC), Rotterdam, Netherlands, 2025, pp. 1-2, doi: 10.1109/IVEC63678.2025.11115519.

[8] M. A. K. Othman, B. Shirley, E. Jongenwaard, J. Merrick and B. Weatherford, "High-Fidelity 3D PIC Simulation Framework for High Peak Power Klystrons," 2026 IEEE International Vacuum Electronics Conference (IVEC), Monterey, CA, USA, 2026, pp. 44-45, doi: 10.1109/IVEC65405.2026.11555944.