

## NEW X-BAND AND S-BAND LINEAR ACCELERATORS AT VAREX IMAGING

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### Abstract

We have designed, built, and high-power tested the advanced linear accelerators equipped with our new 3 MeV X-Band Accelerator Beam Centerline ABC-3-X-T-X and a reduced spot (RS) S-Band ABC-7ER-S-T-RS-X with broad 3 MeV to 8 MeV energy regulation, which demonstrated excellent performance and superior beam quality. We are immensely proud of these recent accomplishments and would like to share the news with the community.

### LINACS FOR SECURITY, NDT, MEDICAL APPLICATIONS

Our new Varex High Energy Sources (HES) R&D group has been expanded and it now includes both (1) the Accelerator Beam Centerline (ABC) group in Salt Lake City, which is engaged in design and production of the Accelerator Beam Centerlines and (2) our Linear accelerator (LINAC) Subsystem Design and Engineering group in Las Vegas. The LINACs we produce are used by the customers worldwide in various Security Screening, Non-Destructive Testing (NDT), and Medical Radiation Therapy systems.

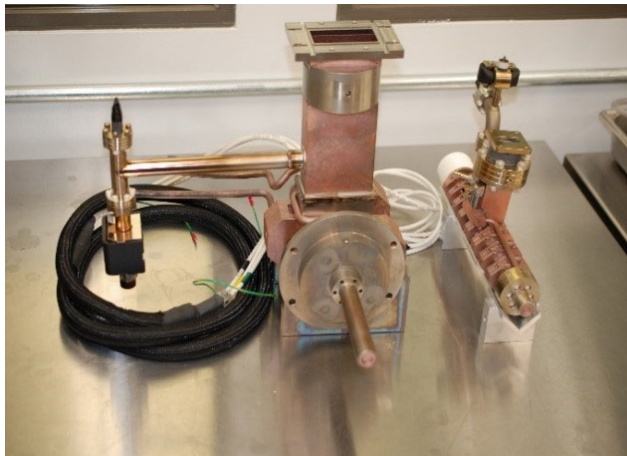


Figure 1: 3 MeV S-Band and 3 MeV X-Band ABC (at the correlated RF power settings). Note difference in radial dimensions for the two ABCs.

Our primary objective after separation of Varex Imaging from its mother company Varian Medical in 2017 has been to design the replacements for the guides supplied by Varian in Palo Alto as well as new models, and establish production of such guides, which we call Accelerator Beam Centerlines (ABC) (Fig. 1). We previously reported on the progress of our guides design and test [1-4]. Currently, we have created a triode e-gun based ABC series that we intend to use for new products, which often exceed their predecessors' parameters. In this paper, we would like to

summarize the results on the latter and report experimental results. The key models of our triode e-gun based ABCs are presented in Table 1. We are concluding our work on the new linac subsystem designs, which should be available for commercial supply in the next calendar year. This includes but is not limited to S-Band linac subsystems: improved Mi6SSM (the base system is already on the offering list), Mi7SSM; and an X-Band linac Subsystem: M3X. In addition, we are offering our ABCs and, potentially, systems, for medical applications. We have designed and fully qualified all three ABCs – all of which meet or exceed the specification requirements. In Fig. 2, a traditional 6 MeV ABC is shown next to an X-Band ABC-3-X-O-T-X, which was originally designed for a small, 350 kW magnetron, and then employed in a system M3X with a more powerful magnetron.

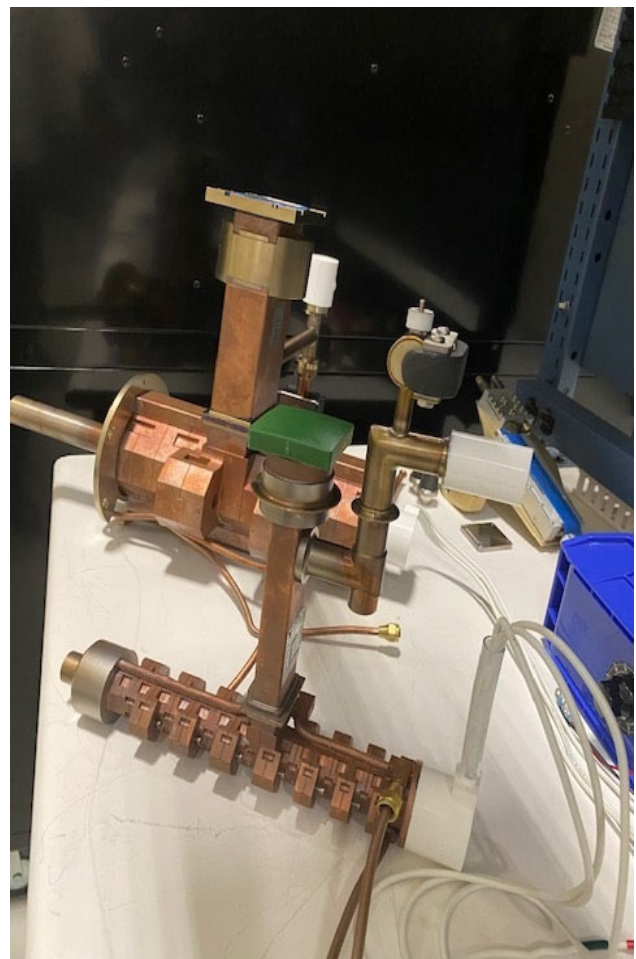


Figure 2: X-band ABC-3-X-O-T-X and S-Band ABC-6-S-O-T-X.

Table 1: Key Triode E-gun Models

Parameter	Units	S-Band			X-Band
		ABC-3-S-O-T-X	ABC-6-S-O-T-X	ABC-7-S-O-T-X	ABC-3-X-O-T-X
<b>Energy, W</b>					
Nominal, $W_{nom}$		3	6	7	2.5
Minimum, $W_{min}$	MeV	3	4	3	2.5
Maximum, $W_{max}$		4.5	6	8	3
<b>Maximum Dose Rate, R</b>					
at $W_{nom}$		300	1000	1300	50
at $W_{min}$	R/m/m <sup>2</sup>	300	600	50	50
at $W_{max}$		500	1000	1200	20
Typical Spot Size, FWHM	mm	2	1.5	1.5	1.5
Typical E-gun Voltage	kV	8	8	8	12

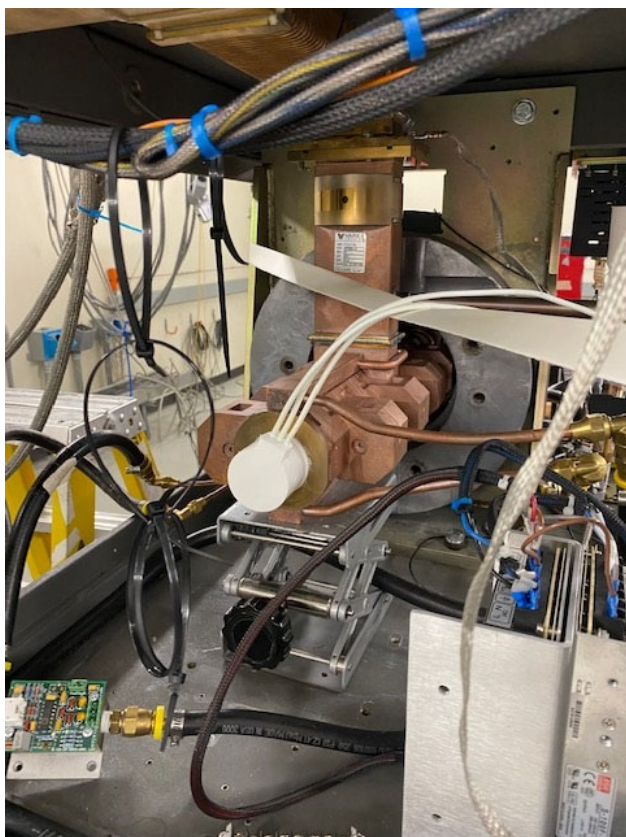


Figure 3: S-band ABC-7-S-O-T-X, designed to operate in a broad energy range from 3 MeV to 8 MeV delivering record dose rates up to 1300 R/min@1 m from target.

It is interesting to note that after some improvements, we found performance increase of our 7 MeV (Fig. 3) unprecedented. At 8 MeV dose rate from 400 to 1200 R/min@1m. We also produced a 9 MeV centerline ABC-9-S-O-T-X and successfully tested it in electron beam mode, test with installed target is pending.

## NEW FACILITIES

Currently, we are finalizing the planning stage for a major addition to our new building in Salt Lake City, which will include a production space designed for over 100 guides/year capacity and a test cell for testing and “burning in” our produced ABCs. Estimated completion of this construction is the end of the CY2023, when we should start ramping up our production. We expect to reach full production rates by the end of CY2024.

## CONCLUSION

We have completed a line of triode-electron gun based new ABCs for our new products. While there will always be continuous improvement of any products, these new ABCs are ready to be used in new linear accelerator sub-systems or shipped to our customers for use in their sub-systems. Meanwhile, we are happy to report that along with the growing design and production of our standard and new models, we have some exciting new ground-breaking products scheduled to be designed and tested. Please continue to follow our publications and do not hesitate to contact us for any new projects you have in mind. We would love to support you at any time.

## ACKNOWLEDGEMENTS

This work is a result and continuation of many pre-existing efforts [1-9], other work, made jointly with my mentors, superiors, peers, and direct reports. As usual, I devote this work to the everlasting memory of those mentors and colleagues who passed, while sending my best wishes of health and happiness to those who are still living, I sincerely thank all for their knowledge and wisdom they shared with me, for their direct and indirect inputs throughout my 39-year career. In addition, I would like to thank Varex senior management for trusting me with this unprecedented challenge to provide leadership and set up a

production line of a breadth and scale comparable to Varian. The growing linac group we have put together at Varex is a world-class team of many outstanding employees, eager to continuously learn and capable of solving many future challenges. We send a very special “Thank you” to our colleague and co-author John Stammetti, who led the R&D team in Las Vegas for many years and has now been assigned where his expertise is needed the most, a different position within Varex. We wish John success in his new role!

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### REFERENCES

[1] S. Proskin, D. Fischer, and A. V. Mishin, “New 3 MeV and 7 MeV Accelerators for Cargo Screening and NDT”, in *Proc. IPAC'21*, Campinas, Brazil, May 2021, pp. 2491-2493. doi:10.18429/JACoW-IPAC2021-TUPAB412

[2] A. V. Mishin, “New Accelerator Beam Centerline (ABC) Production Line at Varex Imaging Corporation”, in *Proc. IPAC'21*, Campinas, Brazil, May 2021, pp. 1087-1089. doi:10.18429/JACoW-IPAC2021-MOPAB349

[3] A. V. Mishin *et al.*, “Portable 2.5 MeV X-Band Linear Accelerator Structure”, in *Proc. IPAC'21*, Campinas, Brazil, May 2021, pp. 1084-1086. doi:10.18429/JACoW-IPAC2021-MOPAB348

[4] D. Fischer, M. Denney, A. V. Mishin, S. Proskin, J. Roylance, and L. Young, “Maximizing Output of 3 MeV S-band Industrial Accelerator”, presented at the NAPAC'22, Albuquerque, New Mexico, USA, Aug. 2022, paper WEPA41, unpublished.

[5] A.V. Mishin, R.G. Schonberg, H. Deruyter, “Microwave Power Control Apparatus for Linear Accelerator”, Patent Application Serial No. 08/390,122, Docket No. OP/135, Filed February 17, 1995, Patent date August 26, 1997, US Patent 5,661,377.

[6] A. V. Mishin, “Advances in X-Band and S-Band Linear Accelerators for Security, NDT, and Other Applications”, in *Proc. PAC'05*, Knoxville, TN, USA, May 2005, paper FOAB002, p. 240.

[7] A. V. Mishin, H. DeRuyter, T. Roumbanis, and R. G. Schonberg, “Intraoperative X-band Accelerator Microwave Structure Design”, in *Proc. EPAC'94*, London, UK, Jun.-Jul. 1994, pp. 2185-2188.

[8] H. Deruyter, A. V. Mishin, T. Roumbanis, R. Schonberg, and D. Skowbo, “Latest Results on Portable X-Band Linac Development”, in *Proc. EPAC'96*, Sitges, Spain, Jun. 1996, paper THP121G, p. 816.

[9] H. Deruyter, R. Miller, A. V. Mishin, J. Potter, T. Roumbanis, and R. Schonberg, “Properties and Possible Applications of Multiple Beam Coupled Cavity Structure”, in *Proc. EPAC'96*, Sitges, Spain, Jun. 1996, paper THP118G, p. 810.