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Low Energy Test Facilities and Analogue Machines for Research and Education

E. Nissen, Thomas Jefferson National Accelerator Facility, USA

Low energy machines that are used to either prove a design for a larger machine, like the AGS analogue [1], or to study an individual effect like the University of Maryland Electron Ring (UMER) [2][3], can be an integral part of the long-term future for beam and accelerator physics. Furthermore, small machines that are designed for specific purposes such as the Double Electrostatic Ion Ring ExpEriment (DESIREE) [4] can be used for accelerator physics experiments. As machines get larger, more expensive, and less common these small machines can fill the training gap for new accelerator physicists, while also allowing for new research that might not warrant modifications to larger colliders, that is still useful for the field.

These types of machines would be very useful for giving hands-on training to students, and early career physicists, since they are inexpensive to operate and don't require large staffs. Furthermore, depending on the exact energy range, radiation control issues may not even be present, meaning they can be placed anywhere. This means that the accelerator physics pipeline could be expanded to universities that are not physically close to national labs. These would also be useful for general research since the system for assigning beam time would be streamlined and shorter.

These types of machines also lend themselves to studying interesting effects that would be difficult to study in a large-scale collider. As an example, using an off the shelf gun we could create a beam-beam test facility that would cost on the order of $1,000,000 that could study the evolution of phase space under beam-beam collisions, a type of collider synchronization scheme known as "gear-changing," as well as space charge. A possible design for one of these test facilities is shown in Fig 1., and its potential properties are shown in Table 1.

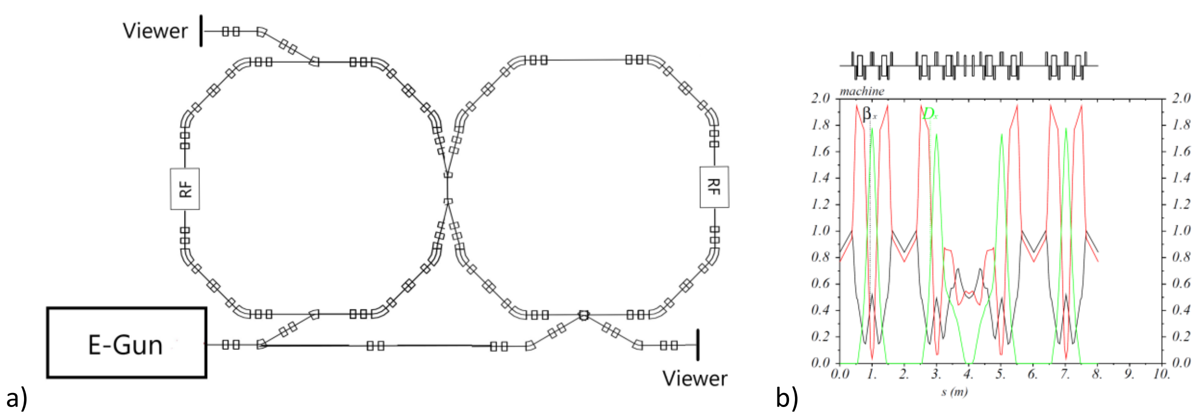

Figure 1. a) An outline of one such facility, where a single source would feed the two rings in opposite directions. Extraction lines with phosphor screens would be used to measure the properties of the beams after interactions. b) Shows the lattice functions of one of the rings

Table 1. A selection of energies and bunch charges for the COMBINE collider assuming equal round beam collisions.

	50 keV 50 pC	50 keV 100 pC	100 keV 50 pC	100 keV 100 pC
$N_{particles}$	$3.13x10^8$	$6.25x10^8$	$3.13x10^8$	$6.25x10^8$
Kinetic Energy	50 keV	50 keV	100 keV	100keV
$\gamma_{relativistic}$	1.0978	1.0978	1.1957	1.1957
$\beta_{relativistic}$	0.4127	0.4127	0.5482	0.5482
$\beta^*_{x,y}$	.5 m	.5 m	.5 m	.5 m
ε_{xy} (geometric)	11 mm mr	11 mm mr	7.63 mm mr	7.63 mm mr
$\sigma_{x,y}$	2.35 mm	2.35 mm	1.95 mm	1.95 mm
$\xi_{beam-beam}$	.0057	.0116	.0077	.0154
$\Delta Q_{space\ charge}$	.0141	.0282	.0089	.0179

These types of machines can both expand the pipeline of accelerator physicists, perform important research into new fields of accelerator design, and provide tools to universities that are not close to national accelerator facilities. This could also help to build binds between universities and national labs. It is for these reasons that we recommend increasing resources for these types of facilities.

References

[1] R. M. Talman and J. D. Talman, “EDM planning using ETEAPOT with a resurrected AGS Electron Analogue Ring,” Physical Review Special Topics Accelerators and Beams, 18(7) March 2015 DOI: 10.1103/PhysRevSTAB.18.074004

[2] http://www.umer.umd.edu/

[3] S. Bernal, et al., “Commissioning of the University of Maryland Electron Ring (UMER),” Proceedings of the 2005 Particle Accelerator Conference, Knoxville, Tennessee

[4] R. D. Thomas et al., “The Double Electrostatic Ion Ring Experiment: A Unique Cryogenic Electrostatic Storage Ring for Merged Ion-Beams Studies,” Rev. Sci. Instrum. 82, 065112 (2011)