

# Water Treatment via High Power Electron Beam Accelerator

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## Fermi National Accelerator Laboratory

Fermilab is America's particle physics and accelerator lab funded by the Department of Energy.

Our vision is to solve the mysteries of matter, energy, space and time for the benefit of all.

The fundamental discovery tool at Fermilab is the particle accelerator.



## Illinois Accelerator Research Center

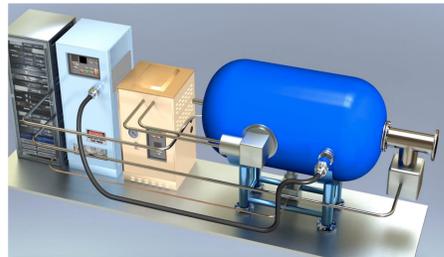
The mission is to partner with industry to exploit technology developed in the pursuit of science to create the next generation of industrial accelerators, products, and new applications.



Photos by Reider Hahn

## New Compact E-beam Accelerator

We have developed new accelerator technologies which hold a number of advantages over conventional technologies. This innovation will provide solutions towards commercial needs that have either had little success or are excessively costly.



The novel design coupled with the portable nature of the accelerator will allow for increased military, security and defense applications.

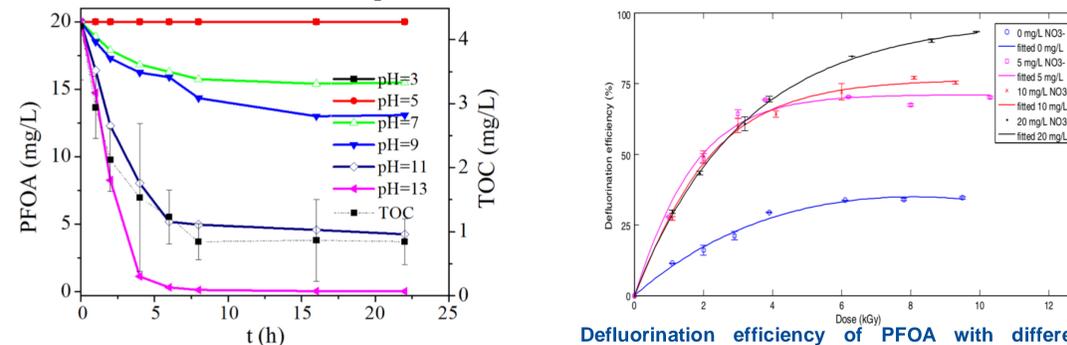
## Advantages over conventional e-beam

- **High-efficiency**
  - ✓ 50% more energy-efficient, 30% less operating expenses
- **High-throughput (up to 200K gal/day)**
  - ✓ can treat more product, 5X more than conventional technologies
- **Compact & Portable**
  - ✓ decrease in size from 3-story building to 5x7x13 ft
  - ✓ integrates in existing infrastructure and can be mounted on a truck

## Military Applications

### E-beam Degradation of Perfluorinated Compounds (PFCs)

✓ the only successful reduction method



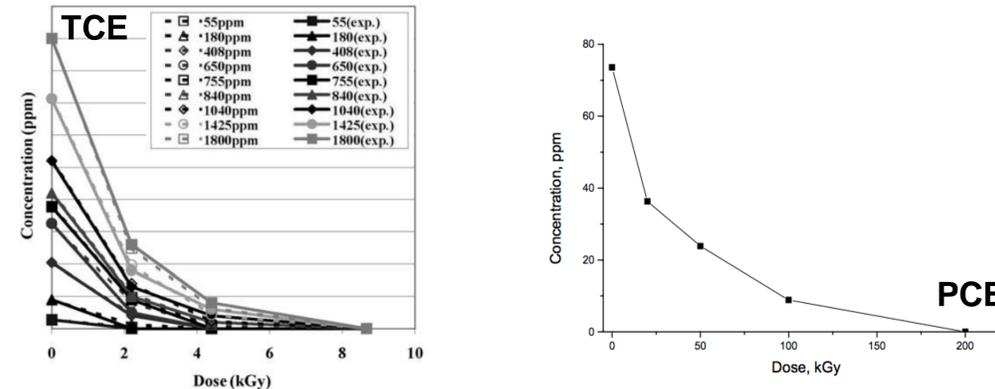
PFOA degradation by gamma-ray at various pHs.

Z. Zhang, J.-J. Chen, X.-J. Lyu, H. Yin, and G.-P. Sheng, "Complete mineralization of perfluorooctanoic acid (PFOA) by  $\gamma$ -irradiation in aqueous solution," *Sci. Rep.*, vol. 4, Dec. 2014.

Defluorination efficiency of PFOA with different nitrate concentrations. Initial PFOA conc: 500  $\mu$ g/L.

L. Wang, B. Batchelor, S. D. Pillai, and V. S. V. Botlaguduru, "Electron beam treatment for potable water reuse: Removal of bromate and perfluorooctanoic acid," *Chem. Eng. J.*, vol. 302, pp. 58–68, Oct. 2016.

### Successful Removal of TCE & PCB via E-beam



TCE concentration vs. dose in humid air under EB.

H. Nichipor, S. Yacko, Y. Sun, A. G. Chmielewski, and Z. Zimek, "Theoretical study of dose and dose rate effect on trichloroethylene (HClC=CCl<sub>2</sub>) decomposition in dry and humid air under electron beam irradiation," *Nukleonika*, vol. 53, no. 1, pp. 11–16, 2008.

PCB concentration vs. dose in transformer oil under EB.

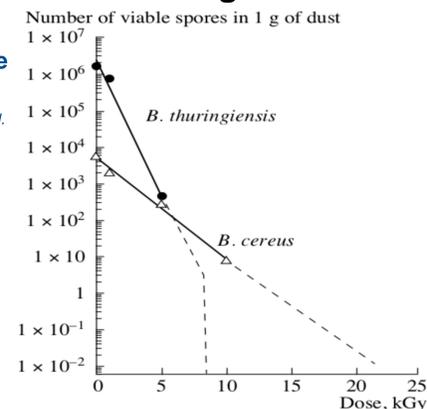
I. H. Jung, Y. J. Mah, and M. J. Lee, "Destruction of PCBs in transformer oil by an E-beam," presented at the WASTE MANAGEMENT 2008, Granada, Spain, 2008, pp. 341–348.

### E-beam Destruction of Biological & Chemical agents

#### E-beam inactivation of the microorganisms that cause Anthrax.

V. L. Auslender *et al.*, "Sterilization of Mail by Means of an Electron Beam Accelerator," *Dokl. Biol. Sci.*, vol. 385, no. 1, pp. 306–309, Jul. 2002.

- Currently used for rapid inactivation of microorganisms in postal envelopes with the use of industrial electron beam accelerators
- Electron beam doses up to 20 kGy decrease the survival number of viable microorganisms by 10<sup>6</sup> times.
- Could potentially be used to destroy other biological and chemical agents like mustard gas, ricin.



## Demonstration



Proof-of-concept studies for research and validation of new applications can be conducted using IARC's demonstration accelerator.

### Accelerator Applications Development and Demonstration (A2D2)

Today's military, security and defense applications are driving towards the development of more compact, rugged, and low cost accelerators with requisite high efficiency, reliability, and performance.

In A2D2 proof-of-principle work can be done on using electron beams to:

- ✓ Treat environmental contaminants
- ✓ Breakdown biological/chemical agents
- ✓ Improve material properties

We want to partner with you!

- Need \$2M to build reduced power prototype
- Need field samples of contaminated water/soil to investigate e-beam effects
- To do field demonstration at a DoD facility

## Current Work

### E-beam initiated curing of pavement

- ✓ Enhancing material properties of bitumen by means of electron beam induced polymer modification could reduce or prevent crack initiation and propagation in pavements due to various weather conditions and heavy loads.

