



TECH-X

SIMULATIONS EMPOWERING
YOUR INNOVATIONS

TECH-X OVERVIEW

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ERL 22

Outline

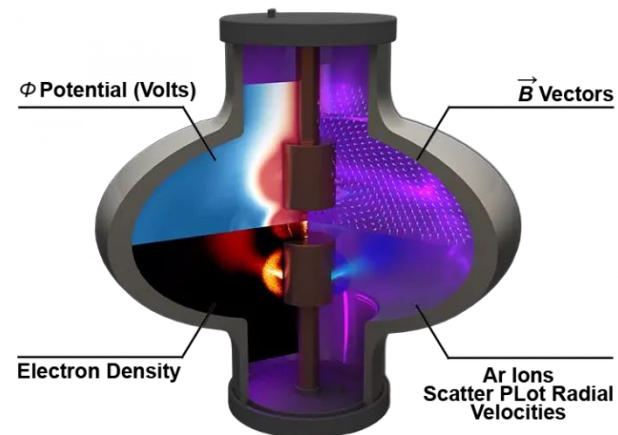
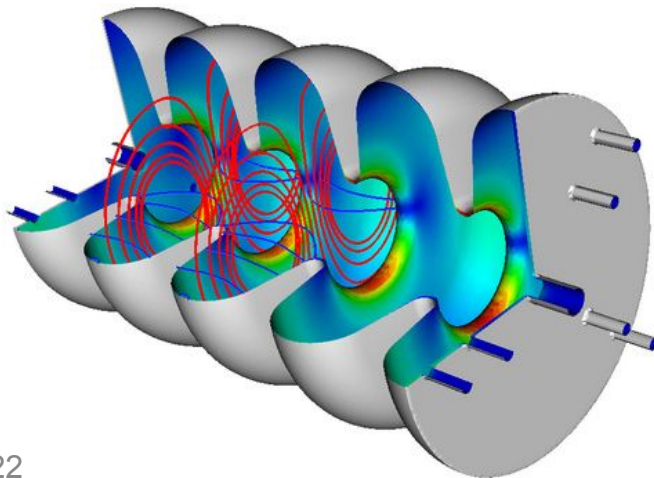
1. Introduction to Tech-X
2. Introduction to VSim
3. VSim for ERL Modeling
4. Tracking Code Coupling
5. ERL Cavity Simulation
6. Other Capabilities
7. Collaborating with Tech-X

Tech-X: high-performance computational science and applications

- Founded in 1994
- ~30 people, 2/3 PHDs, Boulder, Colorado
- Expertise in high-performance computational software for research and engineering simulation and design
- Enhancing code performance through porting to modern hardware (AVX, GPUs, Phi)
- User-friendly visualization and graphical user interfaces
- Computations to address DOE needs

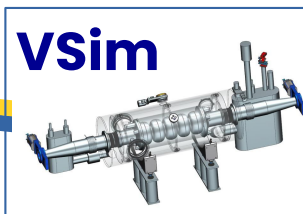
High performance computational application for self-consistent particles in fields

- Wide range of particle interaction physics
- Highly scalable, for PC, HPC, and Cloud
- Easy setup of complicated problems through GUI or text
- Used by national labs, universities, and other research institutions worldwide
- Dedicated support team and 100+ user examples



VSim for ERL Modeling

Tracking Code (Bmad, others)

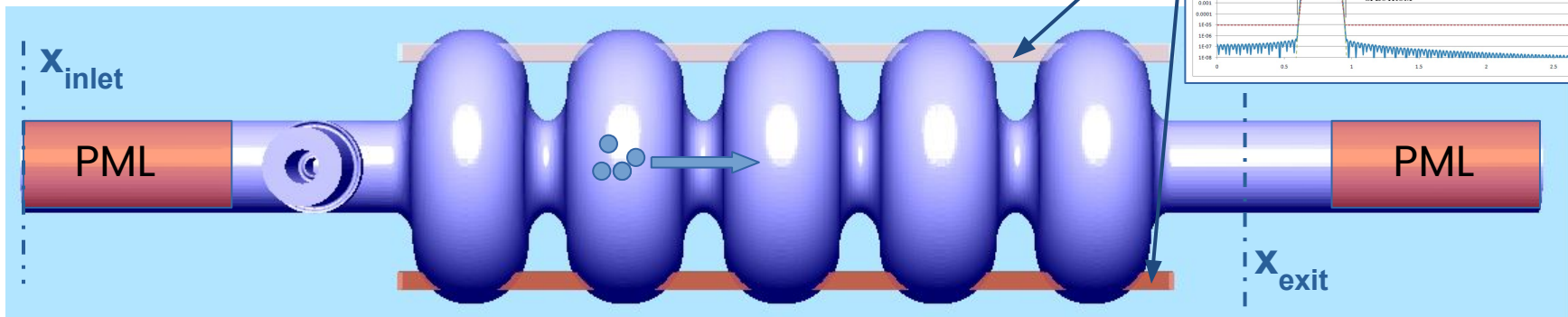


Multi-scale approach provides detailed view of bunch behavior, including self-fields, BBU, non-linear effects in accelerator elements

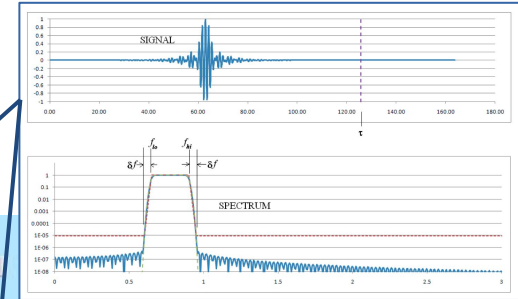
- Coupling with arbitrary tracking codes allows entire system to be simulated with selective fidelity
- VSim allows rapid, flexible setup and simulation of almost any element (cryomodules, electron cooler)

VSim for ERL Modeling

591 MHz, 5-cell ERL Cavity



Current ring up/down @ 591 MHz



1-D Ballistic Motion

Allows particles to generate self-fields

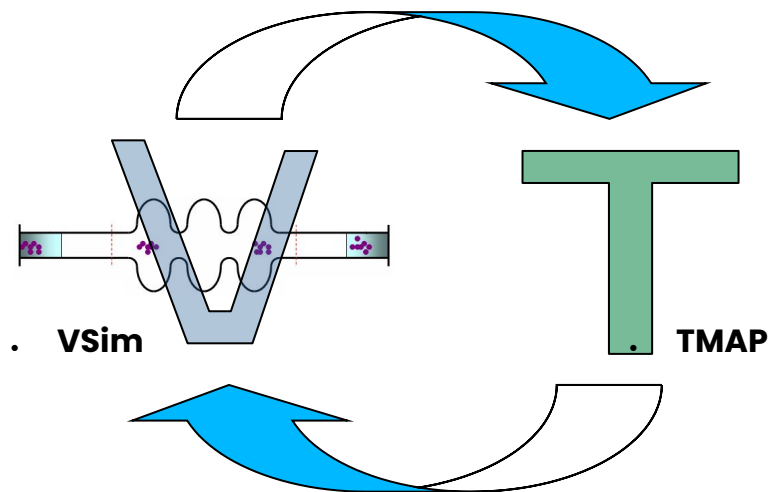
Normal Dynamics

1-D Ballistic Motion to prevent exit mismatch

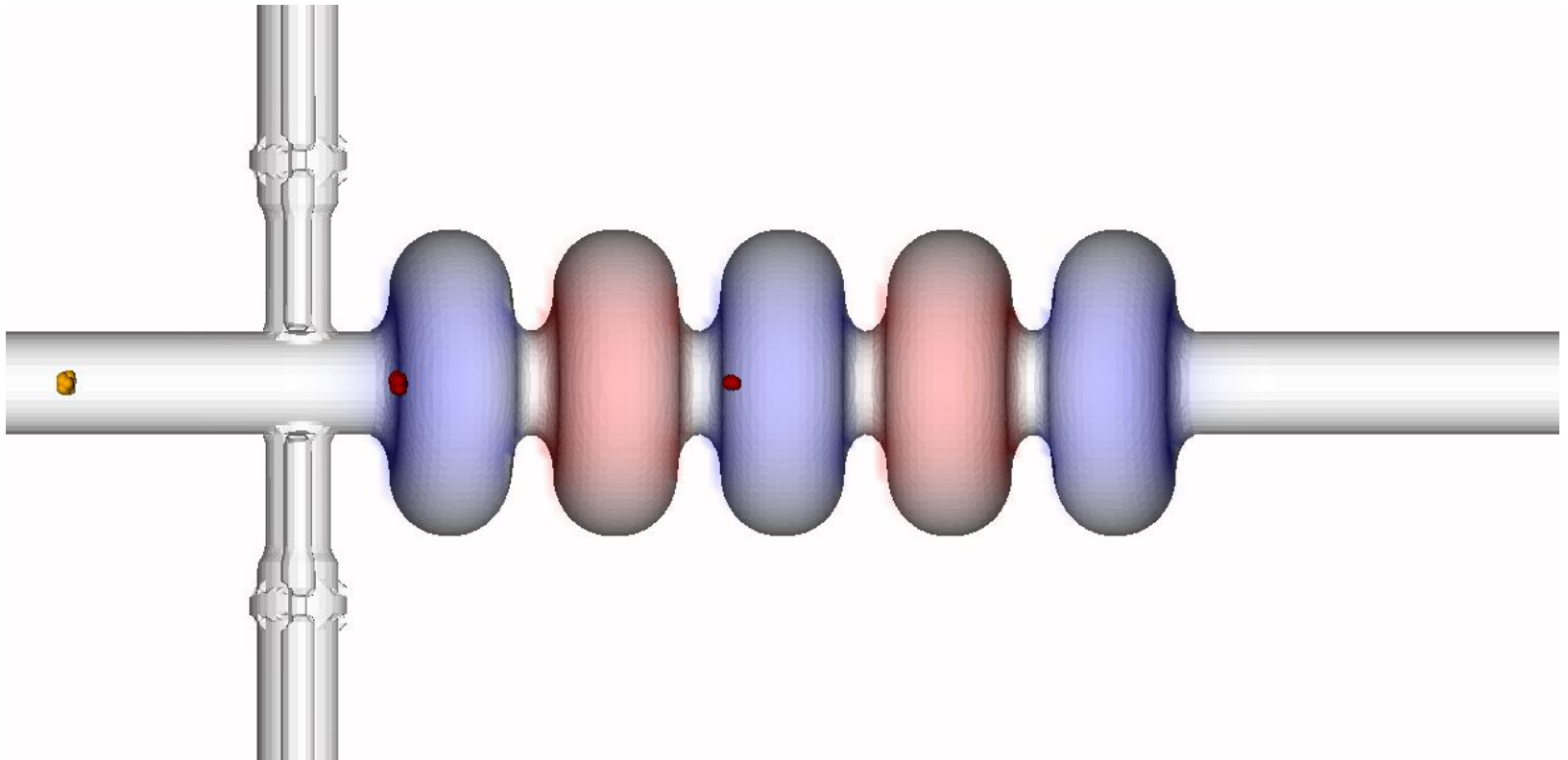
Particles tabled at x_{exit} .
Transfer maps used to re-emit bunch at x_{inlet}

Tracking Code Coupling

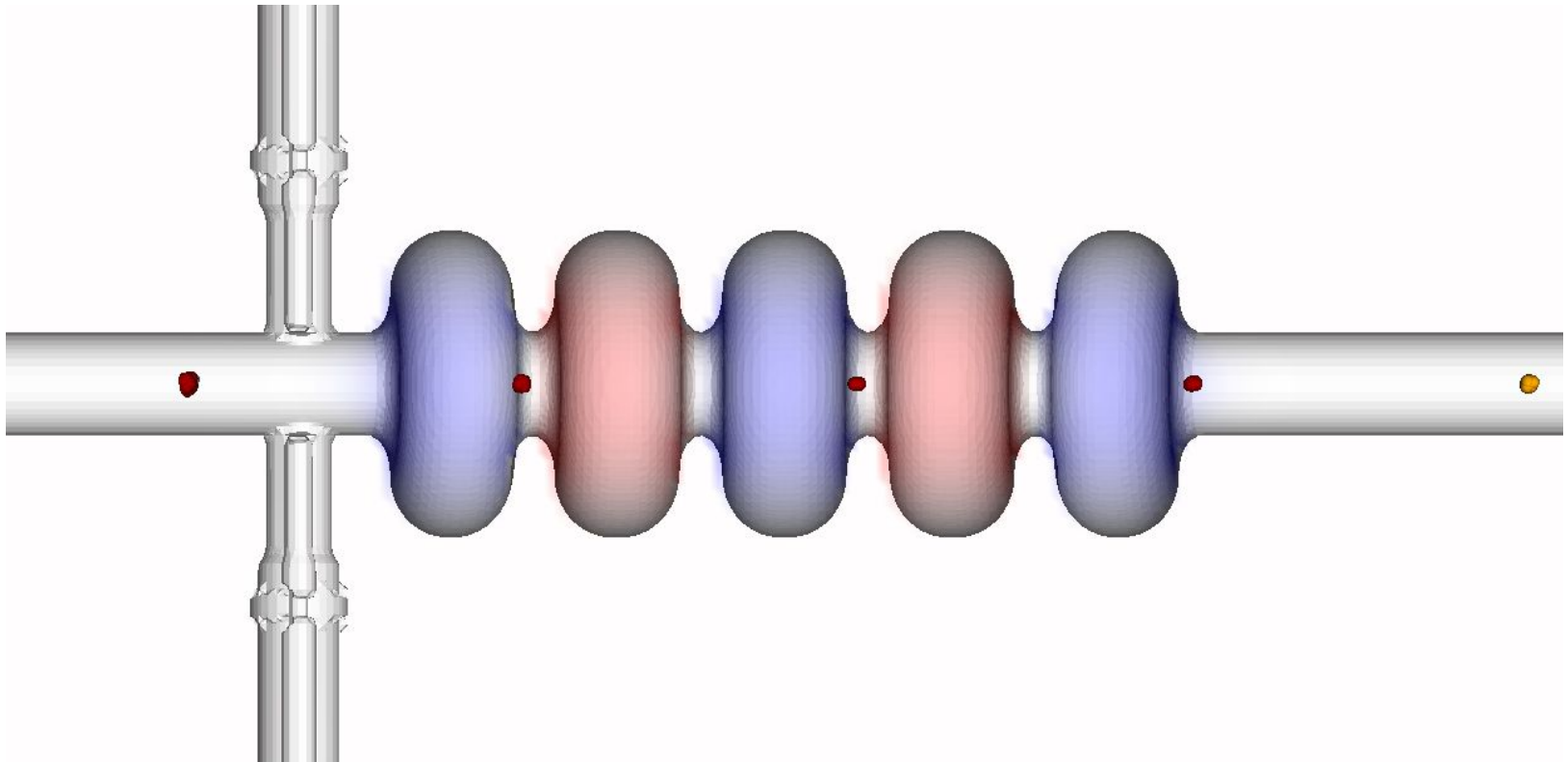
- VSim writes particle bunches on cavity exit
- TMAP (6th order Taylor map code) waits on particle bunch data, then applies transform and writes to file
- VSim reads in the new bunch and loads into simulation at appropriate time
- Particle data stored on disk
 - Avoid concerns with physical memory for > 1000 bunches in system
 - Arbitrary code coupling - just need correct I/O format for tracking code
 - Works well as long as single accelerator pass takes less time than single PIC pass through cavity (~500 time steps)
- **Any tracking code could work as long as I/O format is compliant**



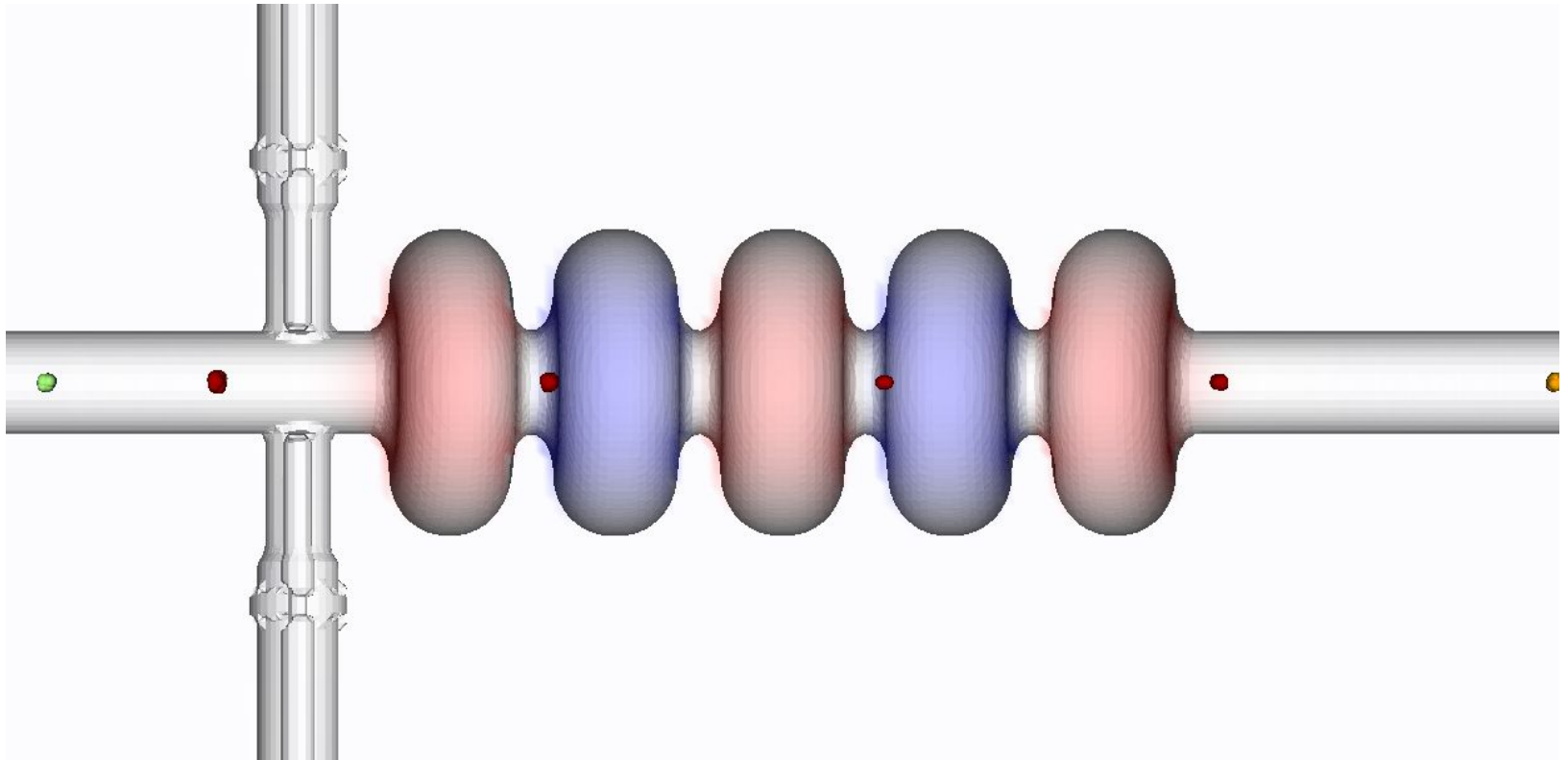
ERL Cavity Simulation (1)



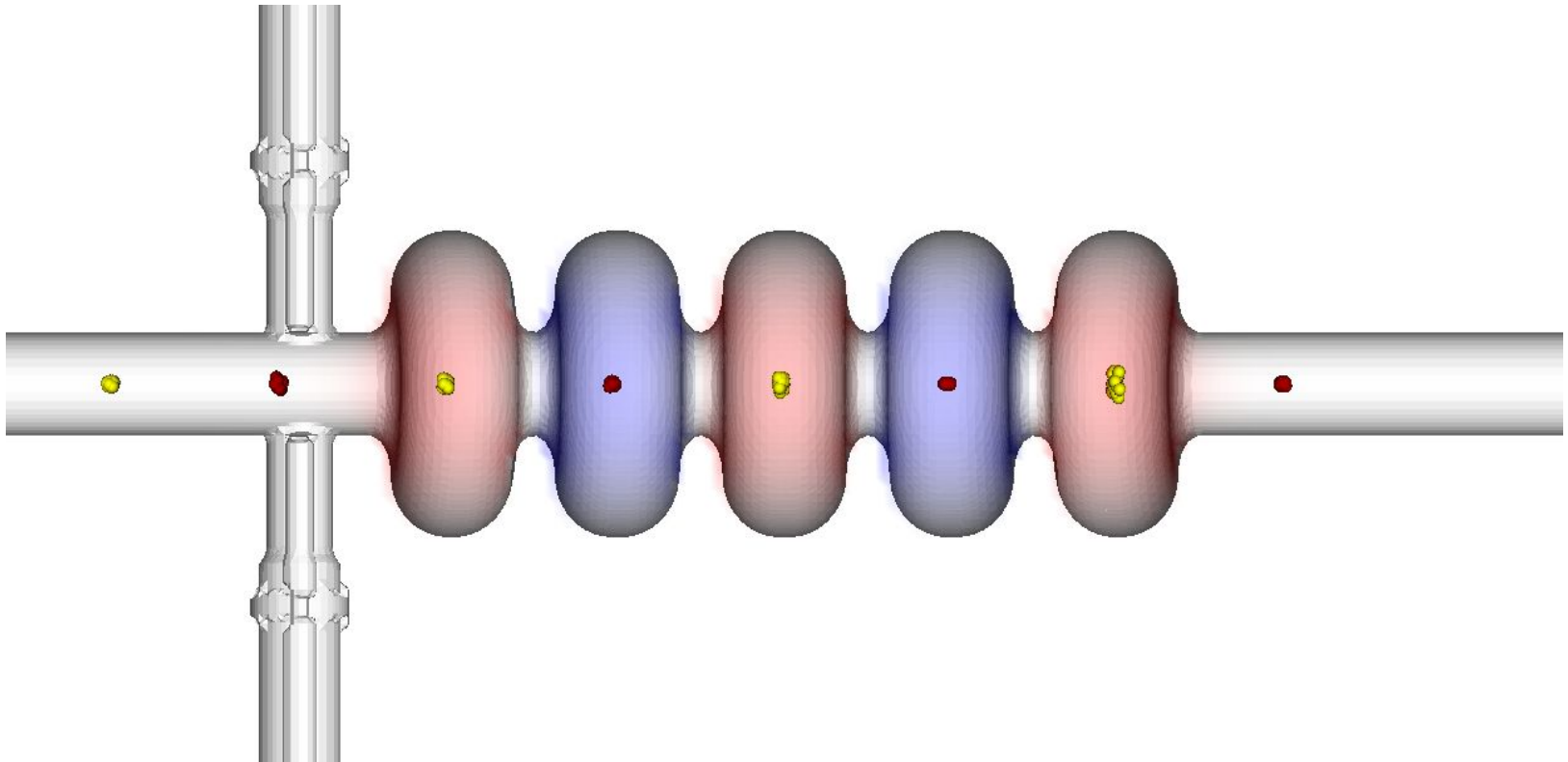
ERL Cavity Simulation (2)



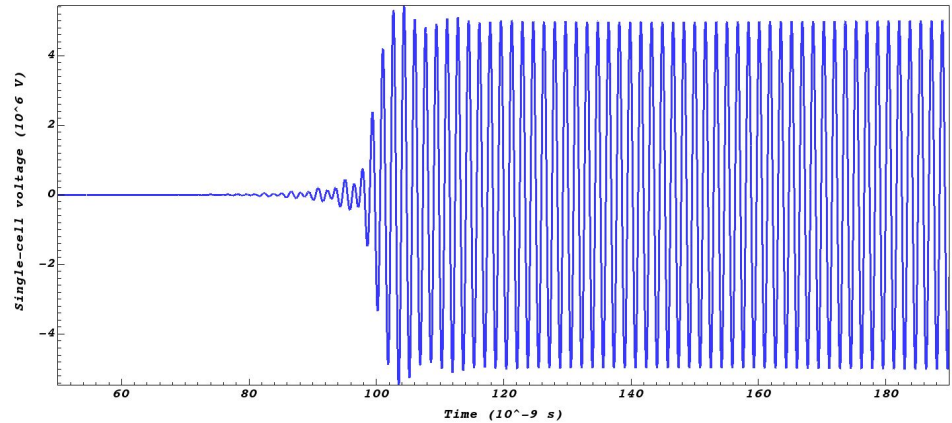
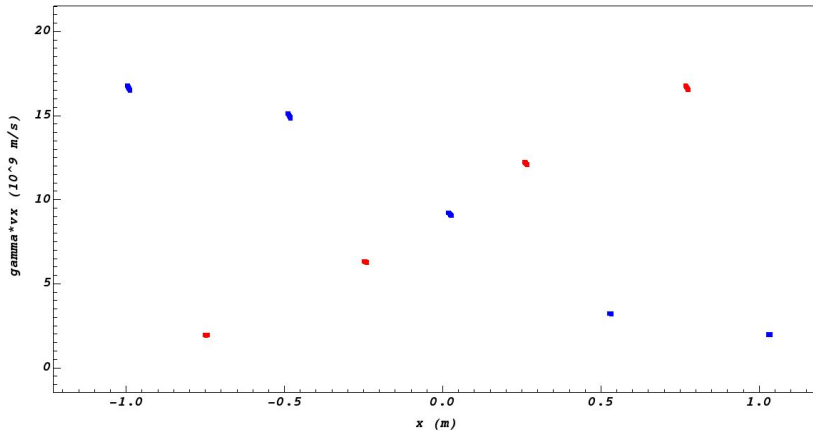
ERL Cavity Simulation (3)



ERL Cavity Simulation (4)



ERL Cavity Simulation (5)



- Built-in phase space analysis confirms recirculated electron bunches decelerating
- Can monitor cavity voltage to show gradual decrease in presence of BBU
- Built in mode-analyzers can track growth in HOM content

Collaborating with Tech-X

Track record of success working with with DoE researchers through the SBIR program and as a subcontractor

- Recent examples: Multi-scale modeling of beam-beam depolarization, plasma cleaning of SRF cavities, adjoint optimization for cavity geometries (NP)
- Tech-X Scientists available as research collaborators and consultants
- Tech-X software excels in many applications – electron guns, injectors, FEL, Multipacting, Microwave devices
- Tech-X Software made freely available to DoE collaborators

ERL Cavity Animation

