Integrated Modeling Tool for Electron-Beam Based Ion-Sources*

Phase II: 8/8/12 – 8/7/15

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FAR-TECH, Inc. Management and Facility

- Located in San Diego, CA
- Founded in 1994, formerly known as Fusion and Accelerator Research (FAR), to pursue fusion and accelerator related research, technology and development.
- Core staff of over 10 PhDs Physics/Engineering
- Facility:
  - Linux cluster (88 processors) with 96GB of memory via Infiniband connection; 15 TB redundant storage
  - RF, UHV, laboratory and assembly

HARDWARE

Linac Systems:

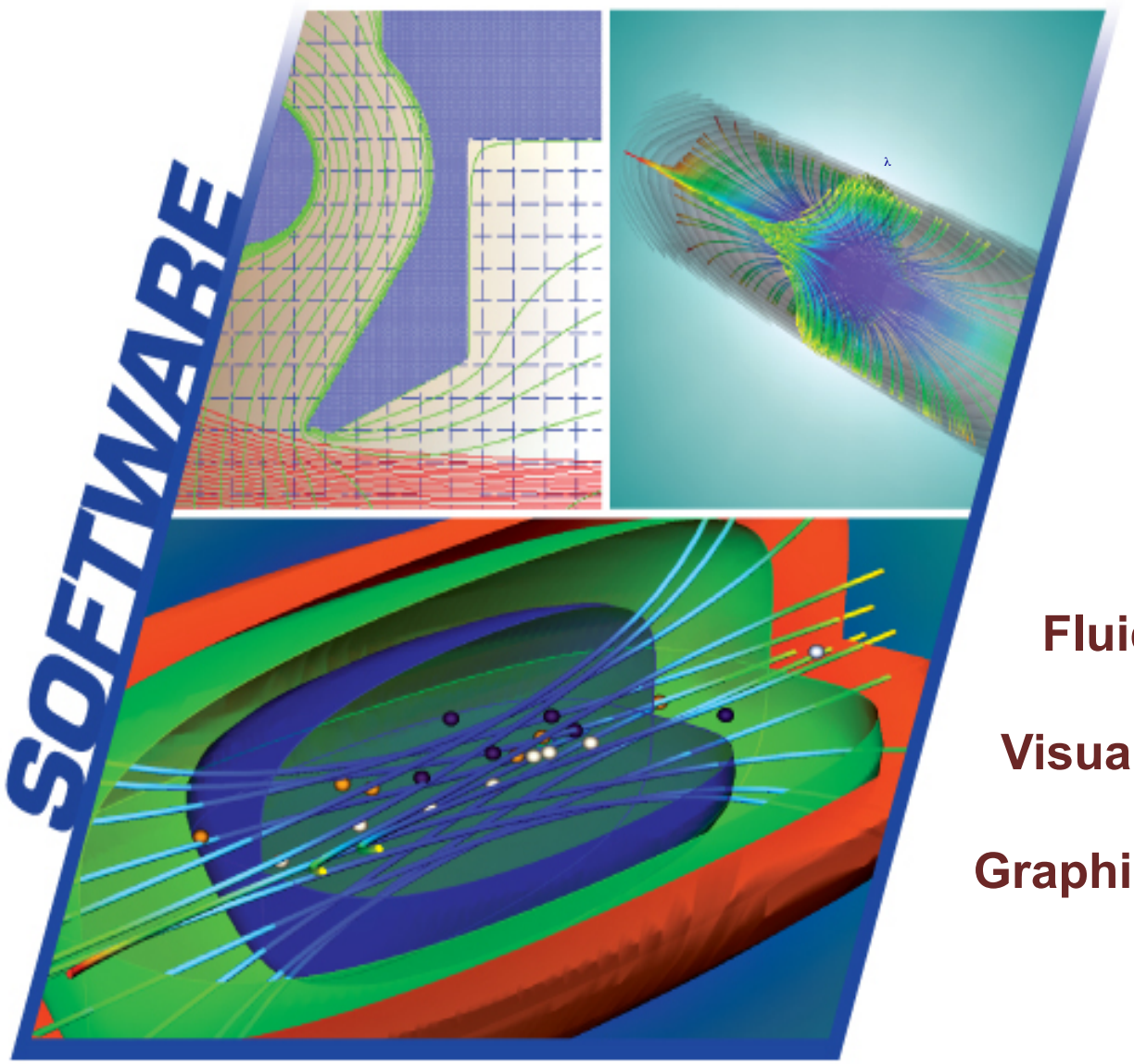
Structure

RF source

Integration

Beam Instrumentation

Solid State Amplifier



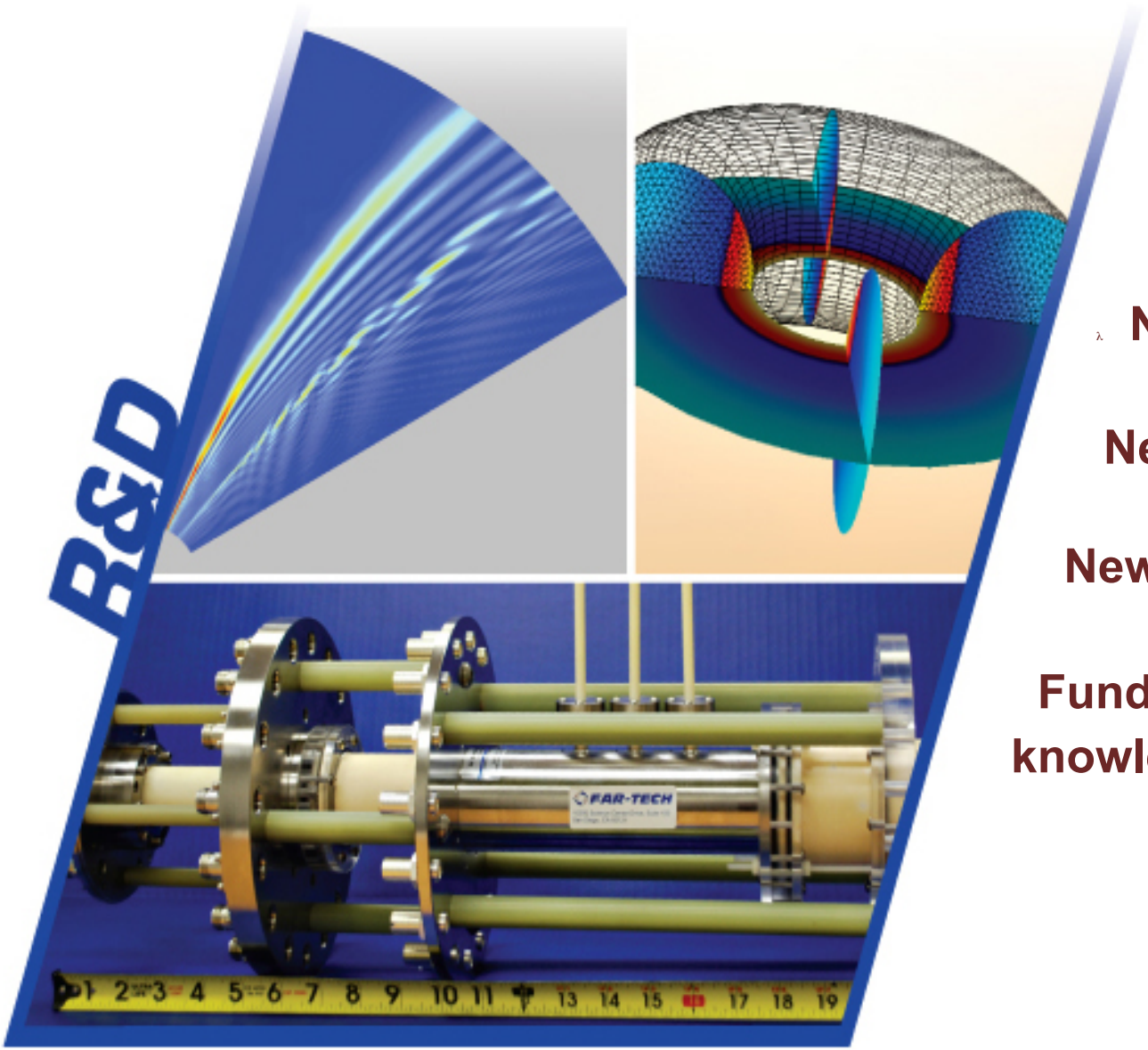
Modeling tools for:

- **Plasma**
- **Beam**
- **Ion source**

Fluid & PIC Simulations

Visualization

Graphical User Interface



- New technique
- New devices
- New diagnostics
- Fundamental knowledge discovery

Project Overview

Integrated Modeling Tool for Electron-Beam based Ion-Sources (EBIS)

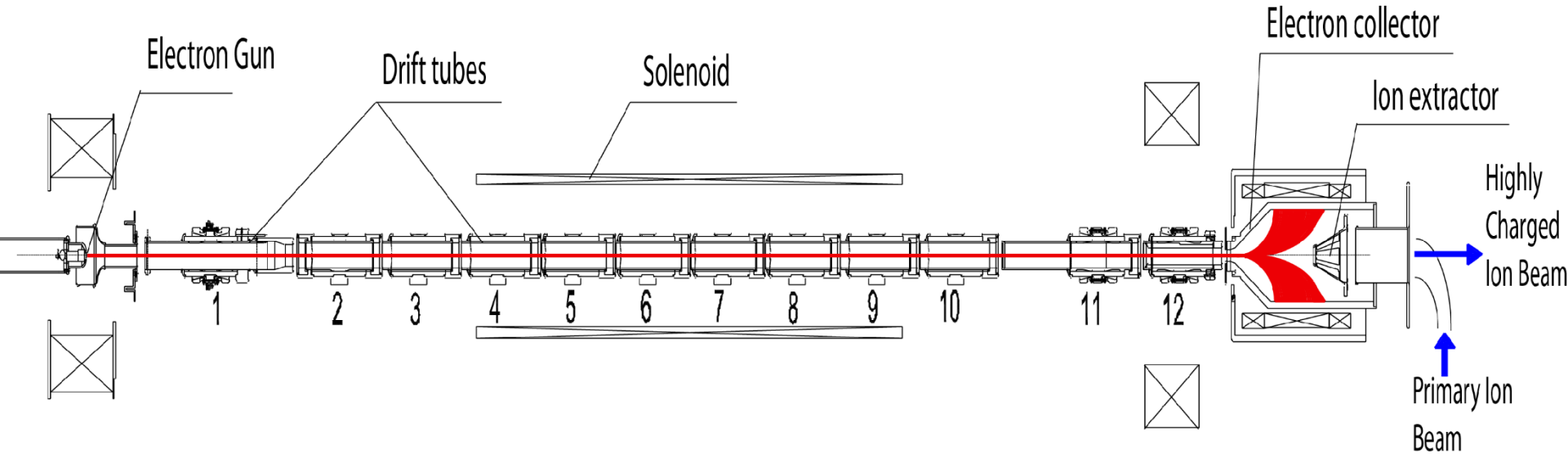
Project period: 8/8/12 – 8/7/15 (1 year no-cost extension)

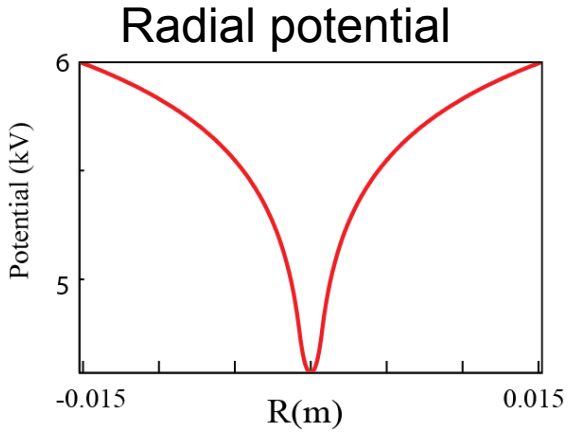
Goal: Develop a numerical tool to help the operation and design of EBIS.

NP Relevance: EBIS is a leading technology for HCIs which are needed for NP studies. Our modeling tool helps to optimize current device operations and will assist the design of future devices. Extremely important for RIBs as experimental trial-and-errors must be minimized.

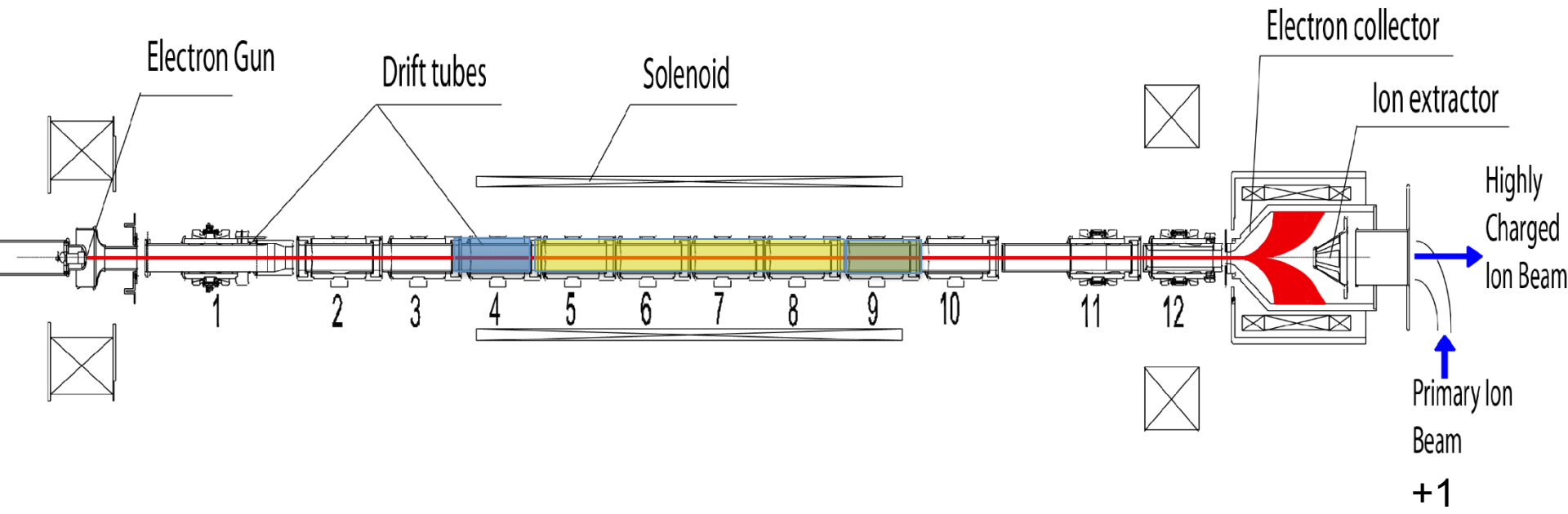
Schedule: Primary objective is essentially met.
Remaining work: more validation, speedup and GUI

Brief description of EBIS

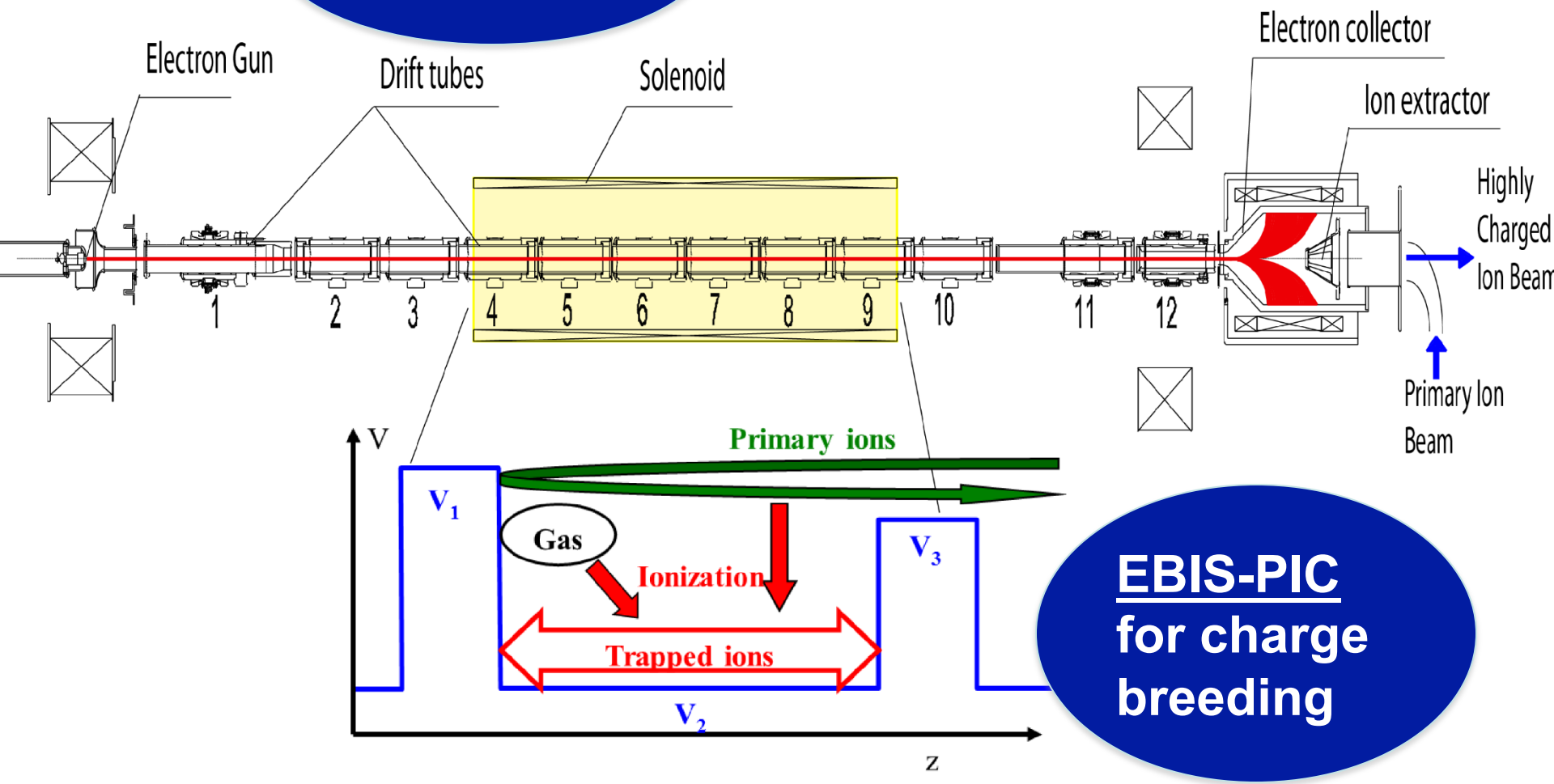




Brief description of EBIS



PBGUNS for e-beam



EBIS-PIC for charge breeding

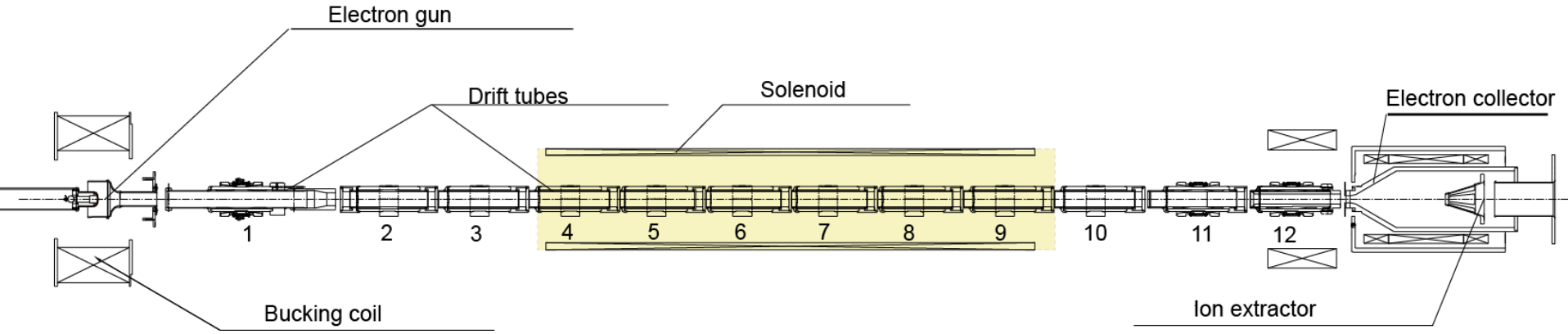
EBIS-PIC modeling

Electron and ion space charge modeled self-consistently.

Important atomic processes are included via Monte Carlo collision algorithm. They include:

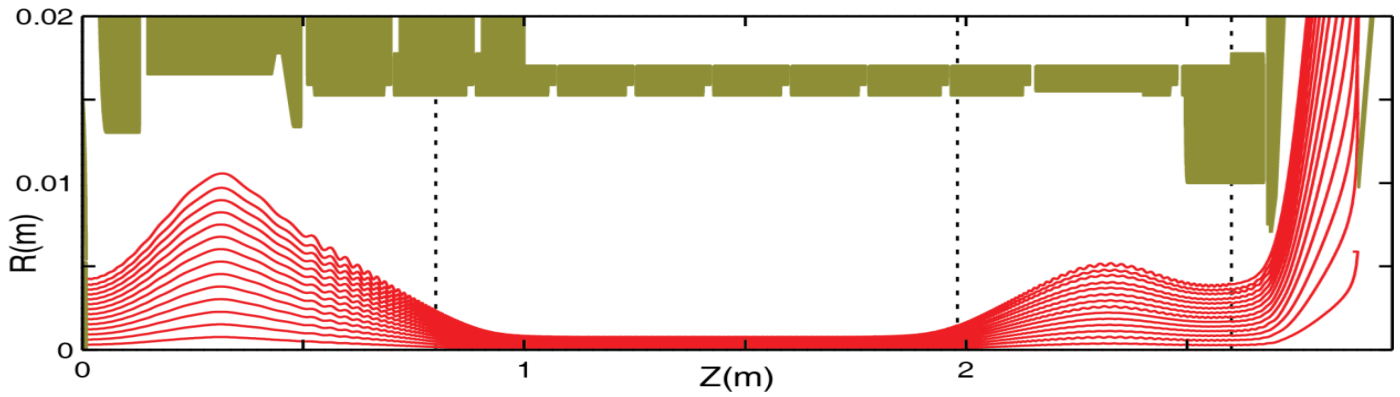
- **Ionization**
- **Charge exchange and recombination**
- **Radiative recombination**
- **Coulomb collisions with electrons, primary ions and neutral gas ions**

Example Case: BNL Test EBIS Device



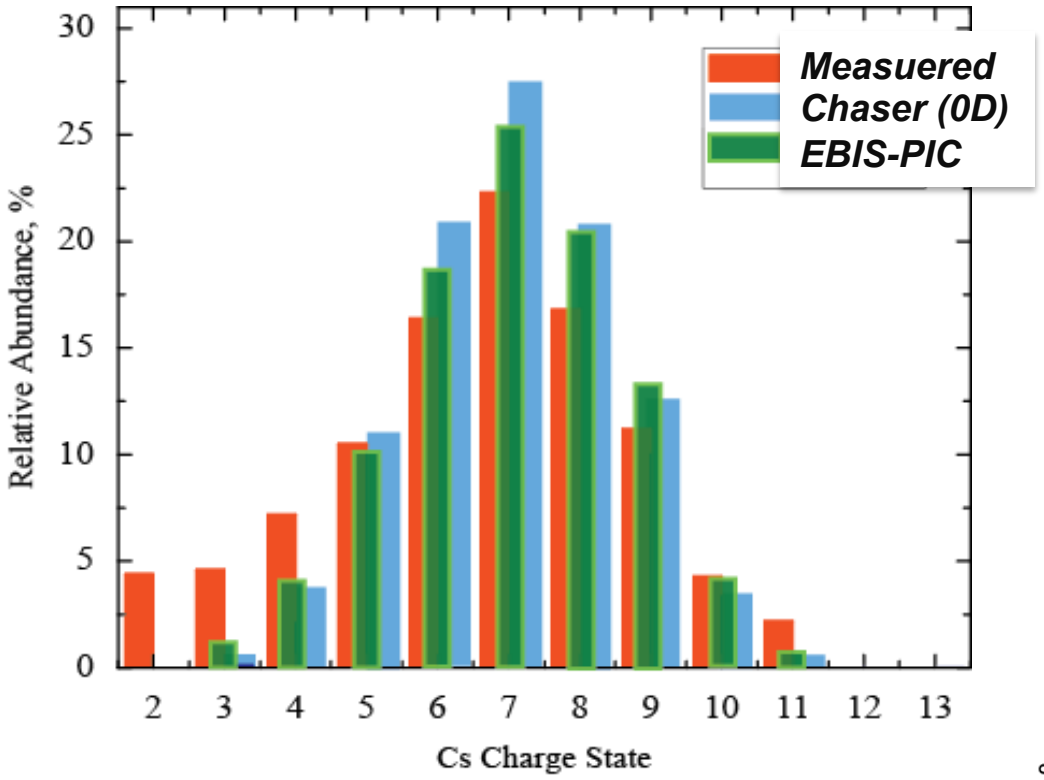
Parameters	Value
Drift tube length	1.07 m
Drift tube radius	1.5 cm
Drift tube voltage	6-13 kV
Magnetic field	5 T
Electron beam current	**1.0** -1.5 A
Electron beam radius	0.75 mm
Pressure	5e-10 Torr
Ion Species	**Cs**

Electron Beam Simulation by PBGUNS



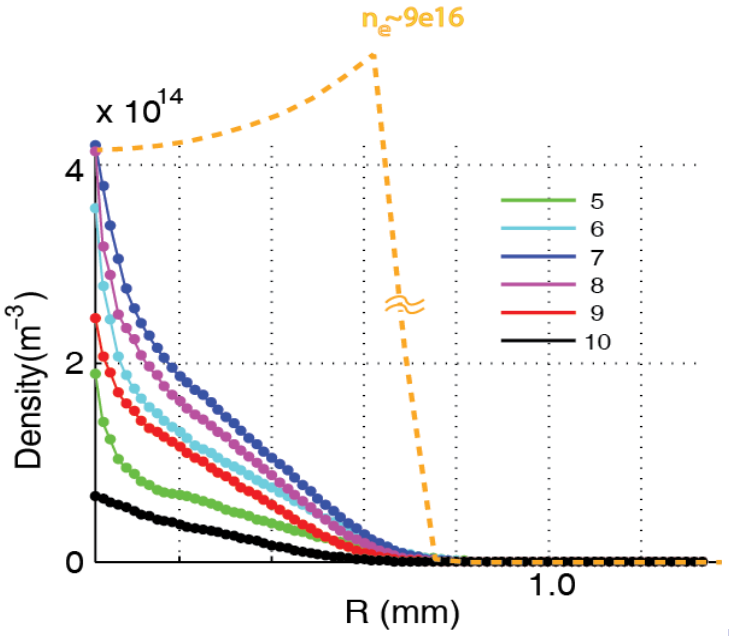
Primary Ion beam

Cs Charge State Distribution After ~5.3 ms Trapping

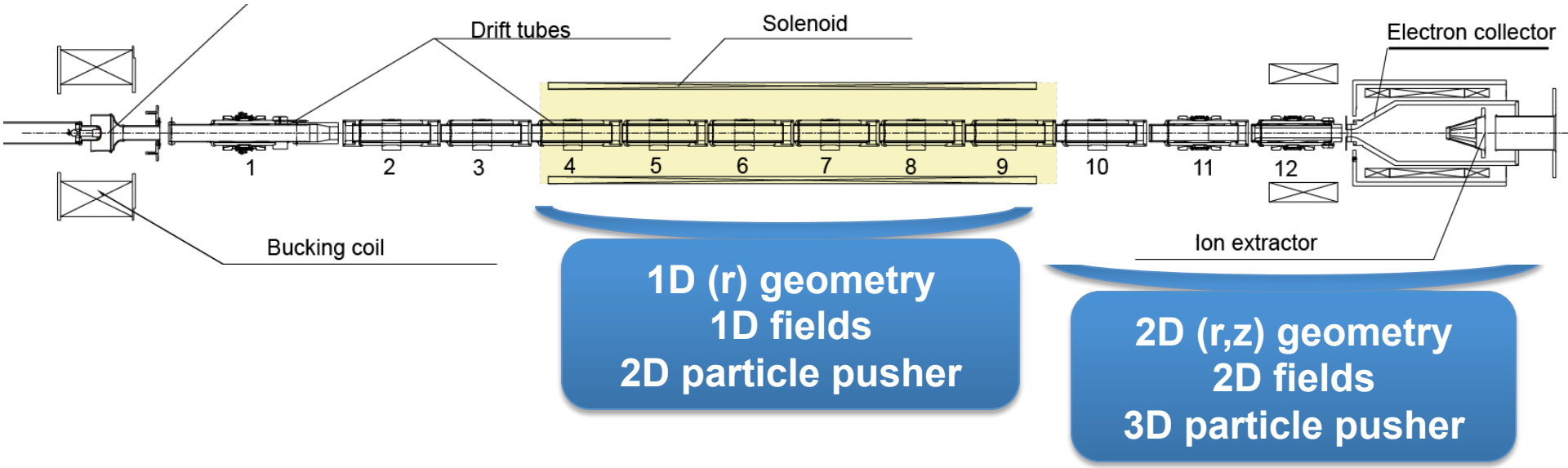


***Chaser* (0D)- electron density was adjusted for best match with measurement**

***EBIS-PIC*: ion beam initial conditions were chosen to overlap 100% with e-beam**



CPU consideration and Practical Computation



Use lower dimensional calculation when approximation is justifiable.

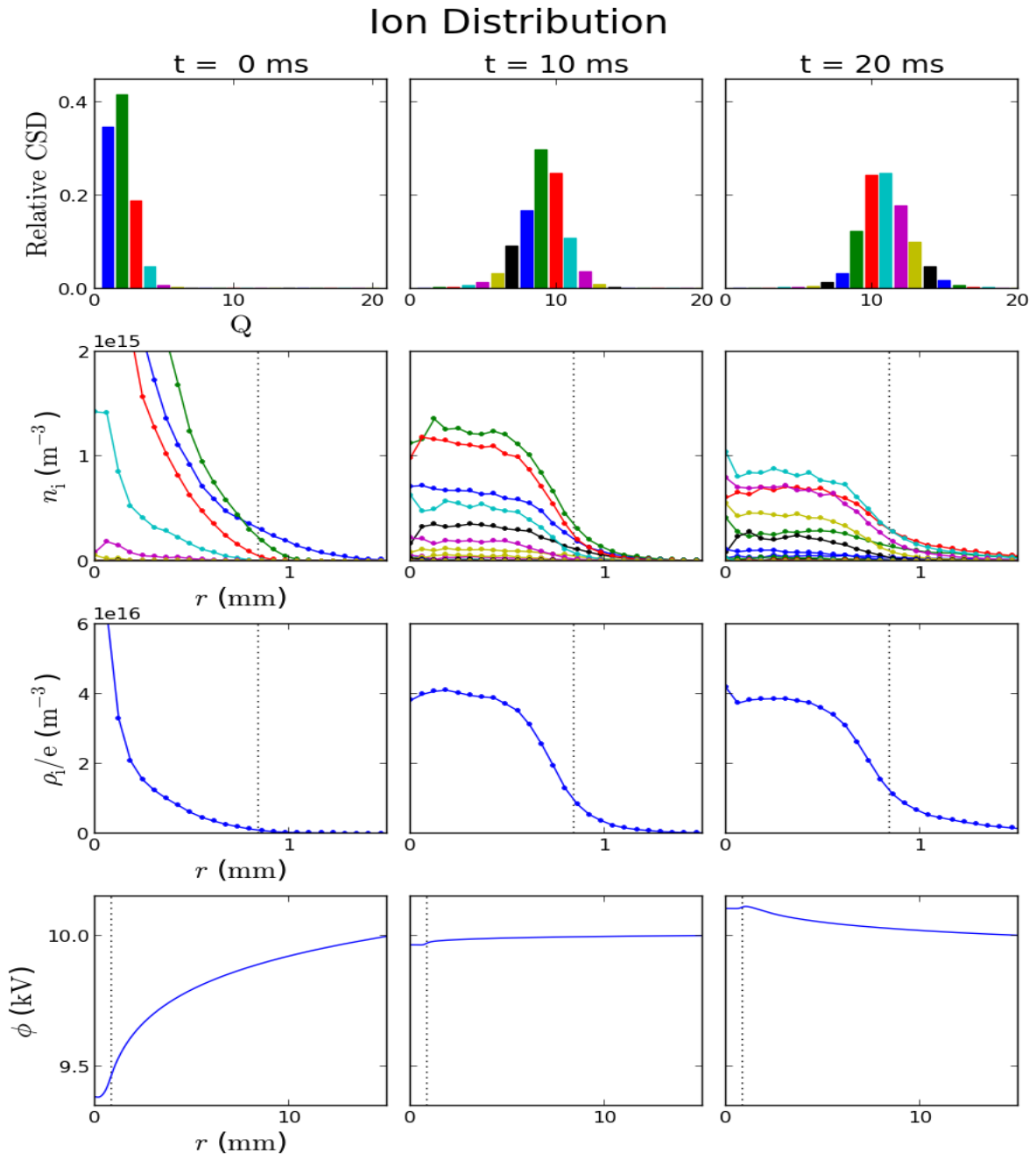
Simulate EBIS-PIC 2D for a few msec, until ions are populated approximately uniformly in z, then reduce to 1D (r).

Simulate charge breeding until necessary, then back to 2D if possible (?) to obtain full emittance.

Use 0D as baseline.

1D simulation by EBIS-PIC 1D (r)

Snapshots of CSD, n_i, ϕ, ρ_i at t = 0, 10 & 20 ms



0-D calculation by Chaser

Chaser v1.0

Chaser, the ***CHA****rge* ***S****tate* ***E****stimato****R***, simulates the time Evolution of charge states of ions in charge breeders.

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www.far-tech.com/chaser

Summary and Future Work

Primary objective is met.

Remaining work: more validation, speedup and GUI

Community (EBIS/EBIT) support and commercialization

FAR-TECH's EBIS modeling tool consists of:

PBGUNS **(particle beam gun simulation code) :**

Most 2D beams can be simulated.

Input parameter GUI with geometry viewing

Chaser**: Charge State Estimator (0D) – good basis as a start**

EBIS-PIC**:**

1D – long time charge breeding (> tens of ms)

2D – short time charge breeding (< tens of ms)

FAR-TECH

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