Our system uses two main types of data selection that are implemented by FastBit: i) multi-variate thresholding, and ii) identifier-parallel axis.

Simulations are performed over 2D and 3D domains using the VORPAL code. Due to the large amount of required data, it is not possible to simulate the entire plasma at once. Simulations are therefore restricted to a window that covers only a subset of the plasma in x direction in the vicinity of the beam. The simulation moves the window along the local x axis over the course of the simulation. Each simulation produces a set of files for the particle and field data (at typically 40-100 timesteps) with the following main characteristics:

- **Particle data:** scattered x,y,z,p_x,p_y,p_z (particle location), px,py,pz (particle momentum), id (particle identifier)  
- **Field data:** electric field, magnetic field, and Rhou (defined on a regular grid)  
- **Resolution:** Typically ~0.02-0.03 μm longitudinally, and ~0.1-0.2 μm transversely  
- **Total size:** ~3.5GB – >30GB (in 2D) and ~100GB – >1TB (in 3D)

In contrast to earlier work, we employ a histogram-based parallel coordinates rendering for both context and focus views of large, complex data. Via FastBit, we can recompute conditional histograms fast, thus enabling support for fast data selection and smooth drill-down into finer level of detail in very large datasets. As a further improvement, we also support adaptively binned (equal-weight) histograms. As illustrated in Figure b, adaptively binned histograms are especially useful for display of low-level-of-detail views where the number of bins per variable is much smaller than the number of pixels per parallel axis.

Our system uses two main types of data selection that are implemented by FastBit: i) multi-variate thresholding, and ii) identifier-based selection. Multivariate thresholding is used for defining “interesting” data subsets. ID-based selection is the basis for tracing of particles over time. We parallelize computations over the temporal domain to accelerate, e.g., particle tracking.

In order to gain a deeper understanding of the acceleration process, we need to address complex questions such as: i) Which particles become accelerated? ii) How are particles accelerated? and iii) How is the beam of highly accelerated particles formed and how does it evolve? To identify those particles that were accelerated, we first perform a selection of particles at a given timestep when the beam has already formed. By tracing the selected particles over time (using ID-queries) we can effectively analyze the temporal behavior of the beam. By refining selections based on information from different timesteps, we are then able to identify characteristic substructures of a beam. An example analysis of a 3D LWFa dataset is shown below.

Figure a) shows a parallel coordinates plot of timestep t=12 of the 3D dataset with particles in x-direction momenta p_x>2710μ (as context) and particles satisfying the condition (p_y<8285*10^7)&(p_z<5.649*10^7) as focus (red). Figure b) shows a volume rendering of the plasma density and the focus particles (red). Clearly, the selected particles form a compact beam in the first wake period following the laser pulse. Figure c) shows the traces of the selected beam at t=11 to t=14 colored according to px, from low (blue) to high (red). The transition from blue to red indicates that particles undergo constant acceleration over time.