

MUSIM, A GRAPHICAL USER INTERFACE FOR MULTIPLE SIMULATION PROGRAMS

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Abstract

MuSim is a new user-friendly program designed to interface to many different particle simulation codes, regardless of their data formats or geometry descriptions. It presents the user with a compelling graphical user interface that includes a flexible 3-D view of the simulated world plus powerful editing and drag-and-drop capabilities. All aspects of the design can be parameterized so that parameter scans and optimizations are easy. It is simple to create plots and display events in the 3-D viewer (with a slider to vary the transparency of solids), allowing for an effortless comparison of different simulation codes. Simulation codes: G4beamline [1], MAD-X [2], and MCNP [3]; more will be coming. Many accelerator design tools and beam optics codes were written long ago, with primitive user interfaces by today's standards. MuSim is specifically designed to make it easy to interface to such codes, providing a common user experience for all, and permitting the construction and exploration of models with very little overhead. For today's technology-driven students, graphical interfaces meet their expectations far better than text-based tools,

and education in accelerator physics is one of our primary goals.

OVERVIEW

MuSim is designed to make it easy to construct, simulate, and analyze all types of particle simulations, using any supported simulation code. As shown in Fig. 1, the user interface is 100% graphical and offers advanced user features not available in any other particle-simulation program. It has a flexible 3-D viewer that displays the system as it is constructed, and into which Library objects can be simply dragged and dropped (objects can also be placed at specific positions and orientations). The basic abstraction is based on solid objects placed into the world and/or each other, which is much more flexible and intuitive than the geometry specifications of some simulation codes like MCNP. Along with the parameterization of any aspect of the simulation, this makes simulation decks far more modifiable and maintainable. There is a comprehensive Help system that follows user navigation, and a slider for solid transparency (easily see inside them).

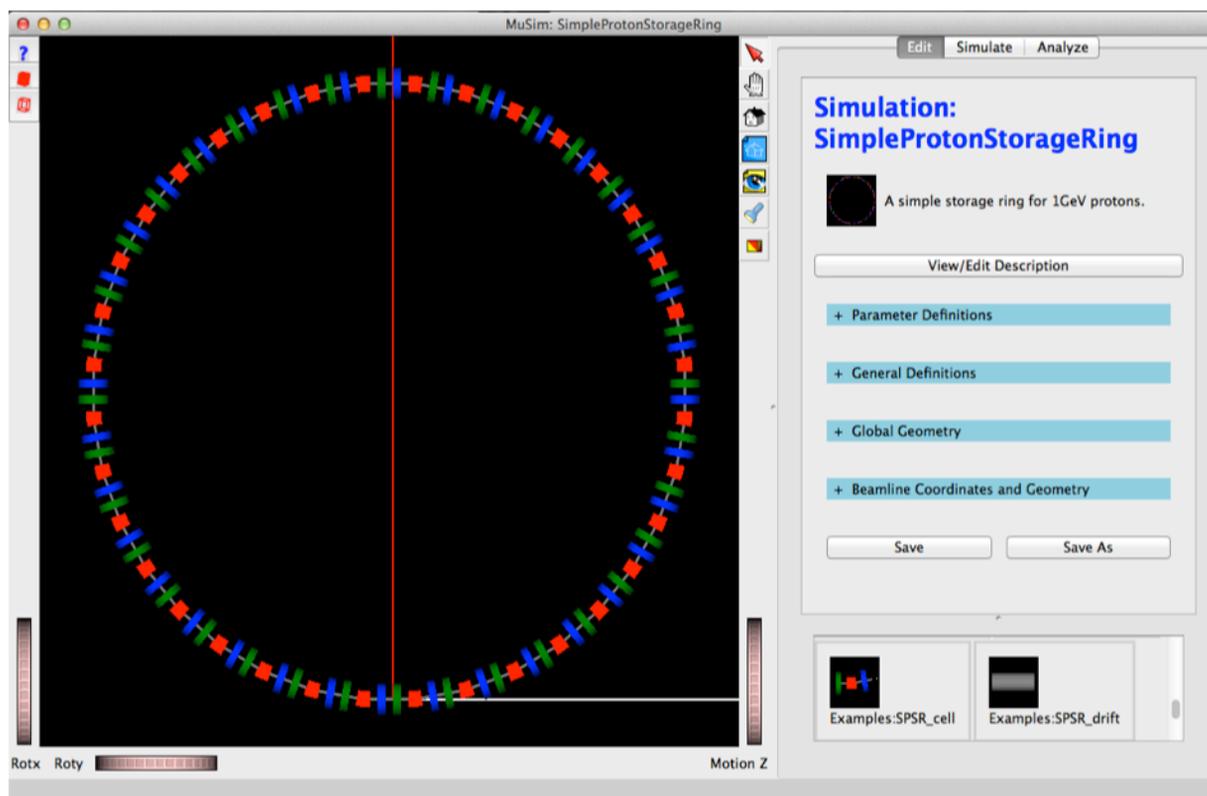


Figure 1: MuSim editing a simulation named "SimpleProtonStorageRing".

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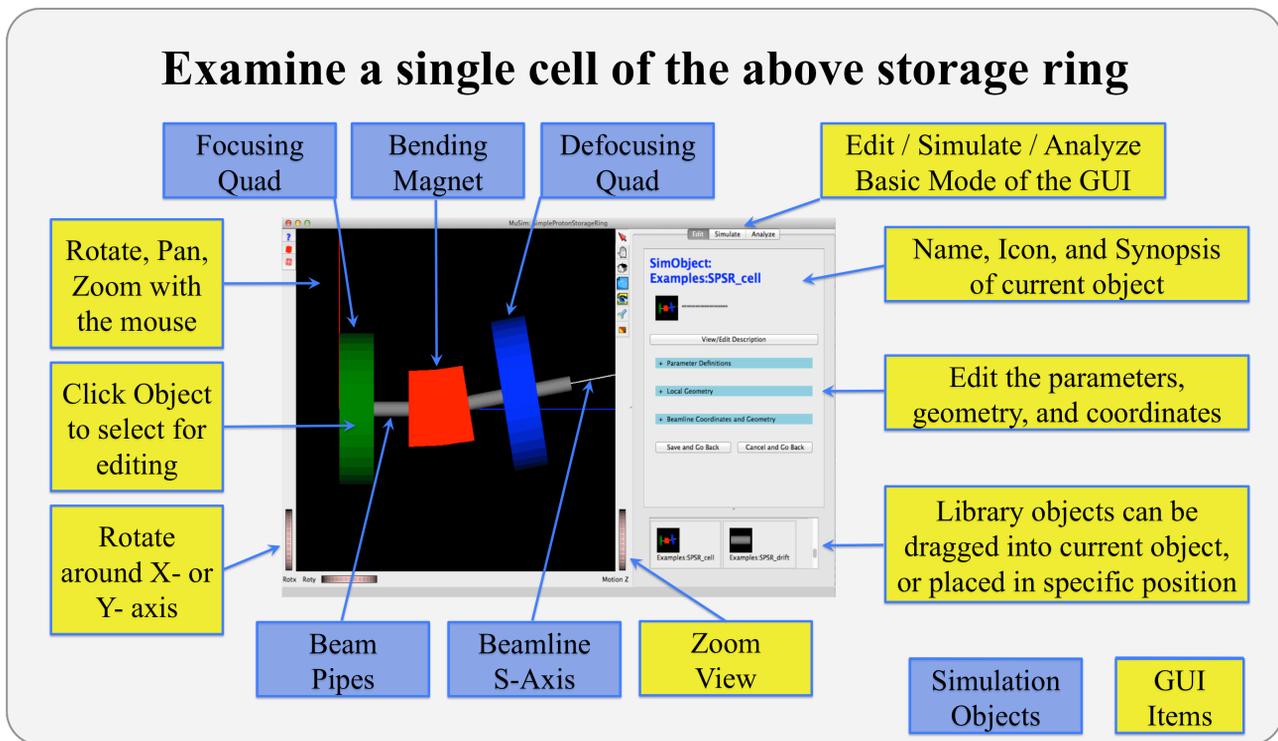


Figure 2: A single cell of the above storage ring, annotated.

Figure 2 shows a single cell of the storage ring in Fig. 1, with annotations. Thirty-six of these cells make up the storage ring. The S-axis of the beamline coordinates follows the centerline of the beam line, and is bent by the bending magnets just like the reference particle; the cells are simply placed sequentially along the S axis.

The same 3-D viewer is used to display events from a simulation, as in Fig 3.

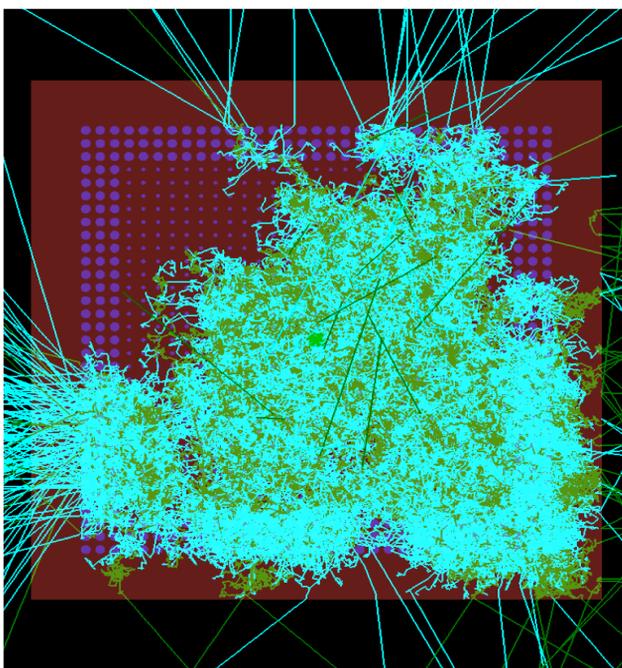


Figure 3: Tracks from an ADSR simulation.

Figure 3 shows 20,000 tracks (out of 585,000) generated by a single 1GeV proton into an accelerator driven subcritical reactor (ADSR). The beam is from G4beamline and the simulation is MCNP6.1. Here neutrons are green and photons are cyan; other particles are negligible. The reactor graphite is brown and its molten salt is blue ($\text{Li}(7)\text{F}_4$, $\text{U}(238)\text{F}_4$, and $\text{Pu}(239)\text{F}_4$); the beam is in the center, coming out of the page, but can't be seen.

THE SIMULATE TAB

The Simulate tab permits the user to set values for parameters, select the simulation code to use, run the simulation, and display events. It also permits the user to scan parameters via a list of values or a DO-loop. And when defined for the simulation, this tab displays sliders for parameter values making it easy to do things like tune a beamline with quick simulation turn-around and display.

THE ANALYZE TAB

MuSim's Analyze tab provides access to multiple simulations of the system, perhaps with varying values of one or more parameters, or run with different simulation codes. The basic analysis and generation of plots is done by Root [4], but MuSim provides an easy-to-use interface that lets the user simply select the type of plot, enter expressions to be plotted, and push a button to generate the plot – it can then be customized in the usual way via Root. There is also an interface for the Mesh Tallies of MCNP (displayed in the 3-D viewer). It is easy to plot calculated values vs. parameter values for multiple runs.

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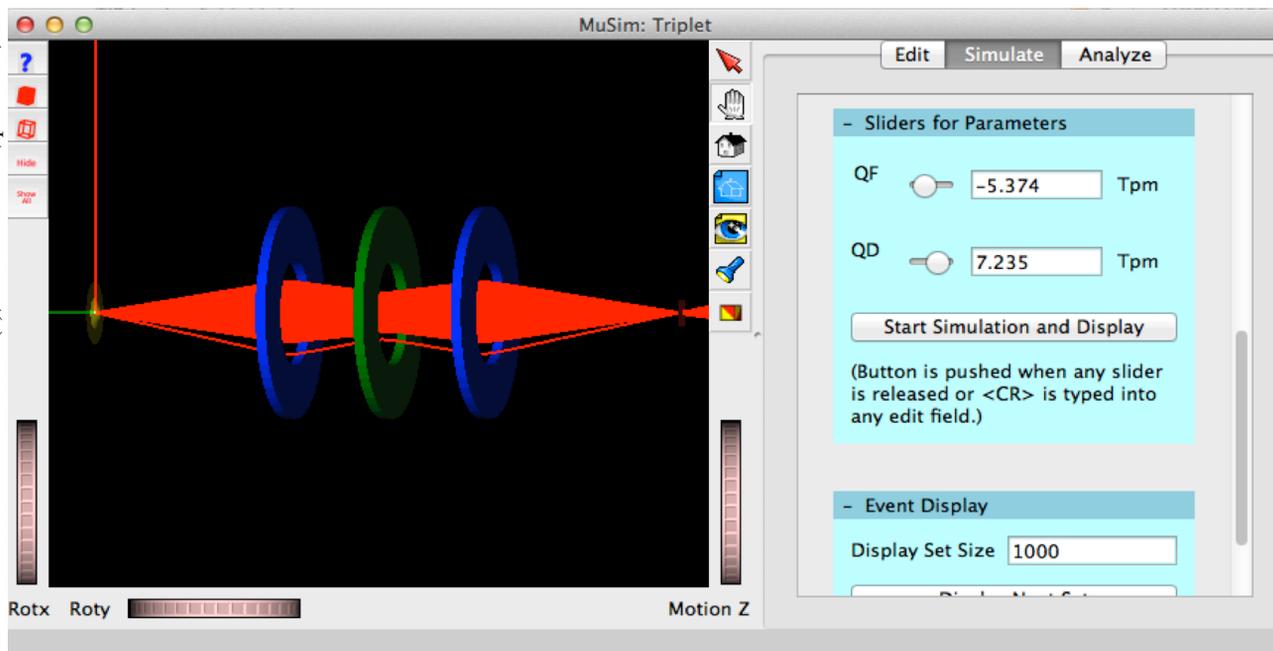


Figure 4: A Quad Triplet with sliders for the fields (to make tuning easy).

EXAMPLES

MuSim comes with a large set of examples, both to demonstrate the program’s capabilities and to guide users in setting up their own simulations. Only a few are shown here.

Figure 4 shows a simple quad triplet tuned for point-to-point focusing. It has sliders for the fields so the user can play with tuning it quickly and easily. “Tpm” are the units of the quadrupole field gradients (Tesla per meter).

Figure 5 shows an energy recovery linac (ERL) for radioisotope production. The ERL itself is omitted. The electron beam emanates from the yellow cone, hits a thin green radiator, and is then deflected back into the ELR by the (red) bending magnet; gammas from the radiator go through a hole in the magnet (not visible) into the (blue) production target.

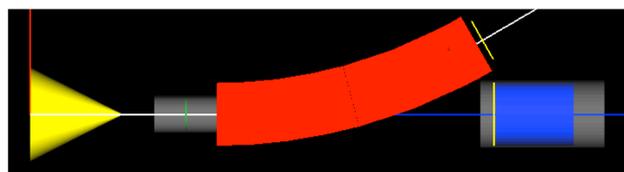


Figure 5: ERL for radioisotope production.

Figure 6 shows a plot of the singles rate in a detector as a 1Ci source (⁶⁰Co) passes by at 10MPH. The x- and y-axes are time (sec.) and distance to the point of closest approach (feet); the z-axis is the detector singles rate (Hz). This plot displays the results of 96 simulation runs.

Figure 7 shows a simplified generic satellite. Considerably more detail would need to be added for a realistic assessment of radiation effects in a spacecraft, but MuSim is an ideal tool to use for that. And it will be easy to compare different simulation codes.

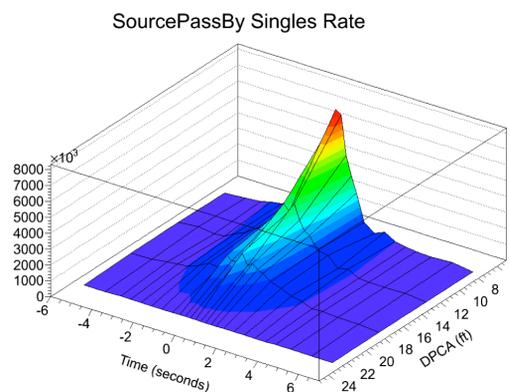


Figure 6: Detector singles rate as a source passes by.

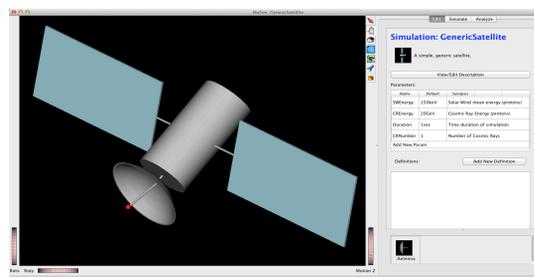


Figure 7: A generic satellite.

REFERENCES

- [1] G4beamline: <http://g4beamline.muonsinc.com>
- [2] MAD-X: <http://mad.web.cern.ch/mad/>
- [3] MCNP: <https://mcnp.lanl.gov/>
- [4] Root: <https://root.cern.ch>