In the colliding of nuclei of different elements, many nucleons are scattered in directions adhering to physical laws, but the events occur so rapidly on scales so small that it is nigh impossible to preemptively determine how many nucleons will interact in the collision. The Glauber Model, named after Roy Glauber, is a technique used to predict the physical values of interest, namely number of binary collisions and participating particles as a function of impact parameter. The two types of Glauber models include the Optical-limit approximation and Monte Carlo model. The optical approach makes several assumptions about the colliding nuclei that allow one to create analytical expressions that describe the impact and determines the number of interacting nucleons along with the number of binary-binary collisions. The Monte Carlo follows a more geometric approach by distributing nucleons radially following a nuclear charge density profile unique to each element. The nucleons are given random azimuthal angles and a projection of this distribution is utilized to determine which individual nucleons participate in the collision. This approach assumes the nucleons travel straight throughout the entire event and can collide with many opposing nucleons without having its path deterred. The simulations in this report exclusively use the Monte Carlo approach to Glauber modeling.

The Monte Carlo approach requires the nuclear charge distributions in order to build realistic nuclei to collide. Several methods can be used to create this distribution; all of which used in this code are well defined thanks to De Vries’ et al. 1987 paper Nuclear Charge Density by Elastic Electron Scattering (\_\_). An example is the two parameter Fermi model that is used to create 197-gold nuclei, where a wood-saxon density profile is created from a mean field potential on the nucleons. The equation describes the force felt by each nucleons, and the potential can be utilized the map out a probability function for the radial position of each nucleon. In all methods, a distribution function gives each nucleon in the nucleus a certain radial position. The nucleon is then assigned to different azimuthal directions that allow the nucleus to be built in three dimensions.

The interaction distance at which two nucleons can be considered to collide is also needed to run the program. This distance is directly related to the inelastic cross section of the nucleons, itself a function of beam energy. The particle data group gathers large amounts of data about elastic and total cross section from many experiments over the world, and compiles all this data in one compact source. The program pulls the data in real time and fits curves to both elastic and total cross sectional areas. The inelastic cross section is given by the curve of the total cross section minus the elastic cross section. The inelastic cross section is converted to a radial distance in which two nucleons within that distance can interact.

This program correlates number of interacting particles and collisions to impact parameter. The applicable use is to allow insight on the collisions, such as the ones taking place at the relativistic heavy ion collider (RHIC), to determine in how many particles are being created as a result of the collision. Figure 1 shows the results of the PHOBOS detector at RHIC: http://arxiv.org/pdf/nucl-ex/0701025v1.pdf . Figure 2 shows the results of the program for the same Au+Au collisions at center-of-mass energies, , 56, 130, and 200 GeV. Figures 3 and 4 show the same data for Pb+Pb collisions at the LHC with expectations generated by the program. <http://arxiv.org/pdf/1202.3233v1.pdf>.

The code is entirely open source, native to iPython, importable, and freely available on Github. Emphasis was put on accumulating all the necessary data needed to run these types of simulations with ease of use. The following steps outline how to run the program for Au+Au collisions at 200 GeV. –Notebook code+comments on running the code with explanation on what is happening at each step- We can compare the results of the program with expected results of simulations run at RHIC for gold-gold and copper-copper collisions at center-of-mass energy 200 GeV.

RHIC will also be performing He-3 and Au-197 collisions at 200 GeV in the future. The program can easily simulate these types of collisions to provide expected outcomes of the collisions. –Code for He-3+Au-197 Collision + Results- We see a large spread in number of collisions and number of participants for similar impact parameters, a phenomenon that we observe in the collision of ions of greatly different sizes. This signifies that the orientation and geometry of the ions upon impact greatly affects the result of the collision (±5/48, 10.4% for perfect collisions increasing for larger impact parameter), but did not have as much an effect as the impact parameter itself. We contrast this to gold-gold collisions, where the impact parameter was essentially the sole determining factor for number of collisions observed and specific geometry had little effect other than to provide minuscule deviations in the data (±110/1500, 7.3% for perfect collisions).