A suitable RNG for simulation of experimental Nuclear Physics

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Introduction:

People working with computers often sloppily talk about their system's "random number generator" and the "random numbers (RN)" it produces. Random numbers have a wide range of applications. They are used as ranging signal in radar system, controlling signal in remote control, encryption codes or keys in digital communication, address codes and spread spectrum codes in code division multiple access (CDMA). Random bits or number generators are key ingredients in a large number of fields as mentioned above and a wide application to scientific computations like, stochastic experiments [1], cryptography, communications and simulation for many complex experimental set up for basic physics research. In particular, the security of communication and cryptography vitally depends on the quality and quantities of random ciphers (i.e., random bits or numbers).

There are two approaches to generate random numbers: software-based and physics-based. All the Computer-generated "random" numbers are more properly referred to as pseudorandom numbers, and pseudorandom sequences of such numbers. The software based RN produces at high-speed with rates of several Gbit/s utilizing deterministic algorithms, but it is vulnerable when such pseudorandom numbers are used as the keys to encryption systems. However, the latter (i.e. physics based) can generate physical RNs and ensure the confidentiality of secure communication by means of the inherently random or unpredictable processes in the physical world. Many process like stochastic noise, radioactive decay [2-3] and frequency jitter of electronic oscillator have gotten used for the generation of physical random sequences.

Most of the time it is very difficult to keep a separate physical device for random number generation inside a computer. So the generation of a true random number is not an easy task. To overcome this problem a computer based random number generators (RNG) are adopted for many application keeping certain important properties of RNG in mind. Some of the important properties of a pseudo random number generators are having large periodicity, uniformity and speed of generation.

In cases of a simulation of an experimental setup for nuclear physics/ reaction studies, the statistical uncertainties is a very important factor which depends on the periodicity of the RNG. A variety of clever algorithms have been developed which generate sequences of numbers which pass every statistical test used to distinguish random sequences from those containing some pattern or internal order. Most of the time it is very difficult to choose a proper RNG function for different purposes.

In this contribution we are presenting a verities of RNG with their important properties and predicted a suitable RNG function for simulation involving experimental nuclear physics.

RNGs, analysis and result:

There are many random number generators are available in literature but out of many we have taken only four random number generator as mentioned RNG1[4], RNG2[5], RNG3[6], &RNG4[7].These are some RNG which has been adopted by many groups and also some RNG are available as inbuilt function in many computer programing languages. The mentioned four RNG generates uniformly distributed pseudorandom number between 0 and 1 . We developed a code to use all the four RNG together and made a multi thread parallel program to run them simultaneously to study and compare the different characteristic of the RNG functions. The extracted parameters for four of RNG has been tabulated in Table.1

Table.1: Result of the four RNG. The periodicity has been generated upto 12 decimal point and the average time has been extracted for 10^7 RN.

RNGs	Average time (sec)	average	Periodicity
1	1.880E-01	5.00E-01	1212150120
2	2.600E-01	5.00E-01	132425833947
3	3.360E-01	4.99E-01	48503166576
4	1.480E-01	5.00E-01	315794473

From the Table.1 one can see that two RNG (i.e. RNG2 and RNG4) are suitable choice depending on the speed and periodicity point of view. The average time has been estimated for 10^7 number of random number generation and found very little difference between RNG2 and RNG4. For all the four function the average value are closely ~0.5 which is expected for a good uniformly distributed RN. In order to emphases the choice of function another experimental simulation has been done by considering the following experimental situation.

A mono energetic beam of particle has interacted with the target and the scattered particle has been detected using silicon detectors having different opening (0.5mm, 10mm, and 20mm) placed at a distance 30cm from the target. A Monte-carlo simulation has been done using the mentioned RNG2 & RNG4 to predict the solid angle (dΩ) obtained by the detector. The result of the simulation has been plotted in Fig.1. One can see that using RNG2 the uncertainties are less compared to the RNG 4.

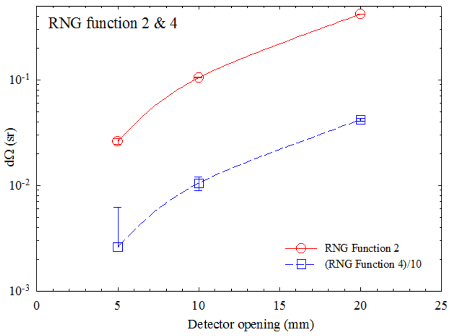

Fig.1 calculated solid angle for the three experimental situation explained in text. The lines are only to guide the eye. RNG4 has divided by 10 to separately compare the RNG2 & RNG4.

From Fig.1 one can find that the predicted value for the solid angle for the three experimental situation is nearly same using RNG2 & RNG4. The only difference is the uncertainties associated with them. Using RNG function 2 the uncertainties are very less whereas the uncertainties involved in the RNG function 4 is ~10^2 times more than the RNG 2. This indicates very clearly that for the detector having larger active area (MWPC, Silicon strip) RNG2 is more suitable whereas the RNG 4 is suitable for small opening like SSB detectors.

A suitable RNG has been predicted for simulation of the experimental nuclear reaction. The detail of the RNG function in addition with parallel computation process will be discussed.

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