Tutorial on Monte Carlo Simulations – Day 2

We moved from uniformly distributed random variables to **importance sampling**, i.e. using `rand()` to obtain random variables obeying a nonuniform probability distribution (Gaussian). Steps are sketched below.

```
1) Direct method to generate Gaussianly distributed numbers

# Box Muller method: generate x1=rand(), x2=rand() to get TWO (independent)
# normally distributed z1 and z2 numbers:
#   z1 = sqrt(-2*log(x1))*cos(2*pi*x2) and z1 = sqrt(-2*log(x1))*cos(2*pi*x2)
# -> check that (absolute value of) Jacobian gives two normal distributions
echo|awk '{for(i=0;i<10000;i++)print sqrt(-2*log(rand()))*\
     cos(2*atan2(0,-1)*rand())}' > gauss
# may compute average (=0) and width (=1) from the sampled points, but can
# we SEE that this is a Gaussian?



2) Histogram of results

go to gnuplot:
plot "gauss"                  #  doesn't tell us much...

# prepare to look at histogram:
del = 0.2                     # choose bin size
n = 10000                     # enter number of data points
n = `cat gauss|wc -l`         # or GET it from the data file
b(x) = del*(floor(x/del)+0.5) # function to compute bins for the data points
# plot using the "smooth" option:
plot "gauss" using (b($1)):(1) smooth freq   # y's (=1) are added for each bin
# normalize the distribution:
plot "gauss" using (b($1)):(1/(del*n)) smooth freq
# make it nicer:
plot "gauss" using (b($1)):(1/(del*n)) smooth freq with boxes
plot "gauss" using (b($1)):(1/(del*n)) smooth freq with histeps
# compare to normal distribution
```

```
3) Now generate Gaussian using the Metropolis method
!echo|awk '{x=0;r=0.2;for(i=0;i<50000;i++){xnew=x+r*(-1+2*rand());\
      ds=xnew**2/2-x**2/2;if(ds<=0){x=xnew}else{if(rand()<=exp(-ds))x=xnew}\
      print x}}'>gauss2
plot "gauss2" using (b($1)):(1) smooth freq with boxes
# COMPUTE: percentage of acceptance, (Monte Carlo) time correlations
```