

Likelihood

- Likelihood function, is a function of parameters of a statistical model given data.
- Plays a key role in methods of estimating a parameter from a set of statistics.

The Difference Between Likelihood & Probability

Probability

- The probability of observing a particular set of outcomes can be calculated by making suitable assumptions, like the coin tosses being independent, or the prob. Of heads or tails being $\frac{1}{2}$.
- By this definition, O is the “observed outcomes” and “ θ ” is the set of parameters.
- $P(O|\theta)$: given the parameters, the probability that we would observe the outcomes.

Likelihood

- In real life, we often don't know the parameters θ completely.
- We can observe O, and then estimate θ .
- $L(\theta|O)$: choosing a θ that would maximize the probability that we would observe O.

```
#include "TFile.h"
#include "TTree.h"
#include "TH1.h"
#include "TClonesArray.h"
#include "TBranch.h"

void likeli() {

    TCanvas *myc = new TCanvas("c1","gamma and lognormal",10,10,1000,1000); //setting up a new canvas
    myc->Divide(2,2); //dividing the canvas in two
    myc->cd(1); //cd

    TH1F *h1 = new TH1F("h1","Exponential",200,-20,20); //new histogram
    h1->FillRandom("expo",10000); //exponential "expo"
    h1->Fit("expo", "L"); //Likelihood "L"
    h1->Draw();

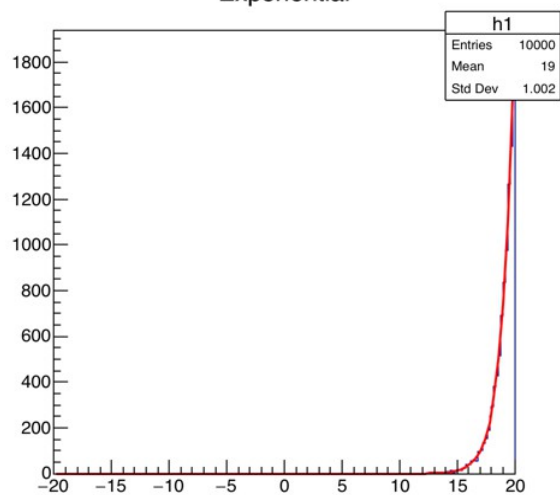
    myc->cd(2);
    TH1F *h2 = new TH1F("h2","Gaussian",200,-20,20); //new histogram
    h2->FillRandom("gaus",10000); //Gaussian "gaus"
    h2->Fit("gaus", "L"); //Likelihood "L"
    h2->Draw();

    myc->cd(3);
    TH1F *h3 = new TH1F("h3","Landau",200,-20,20); //new histogram
    h3->FillRandom("landau",10000); //Landau "landau"
    h3->Fit("landau", "L"); //Likelihood "L"
    h3->Draw();

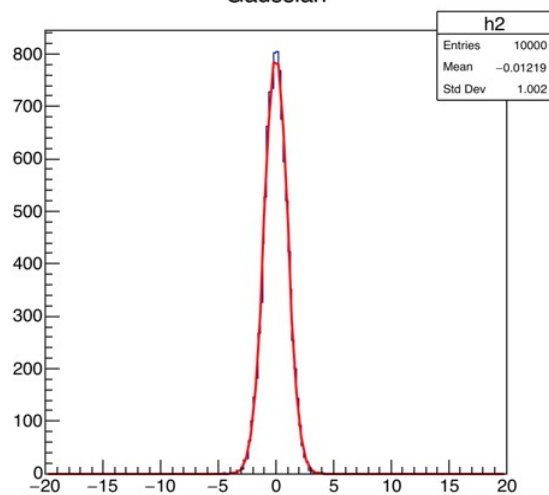
    myc->cd(4);
    TF1 *mygaus = new TF1("mygaus","TMath::Gaus(x, 0, 5)",-20,20); //fitted TMath::Gauss
    TF1 *f2 = mygaus->DrawCopy();
    f2->SetLineColor(kBlue);

}
```

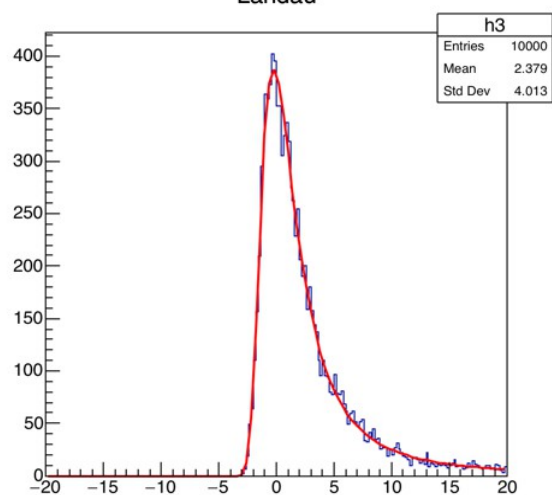
Exponential



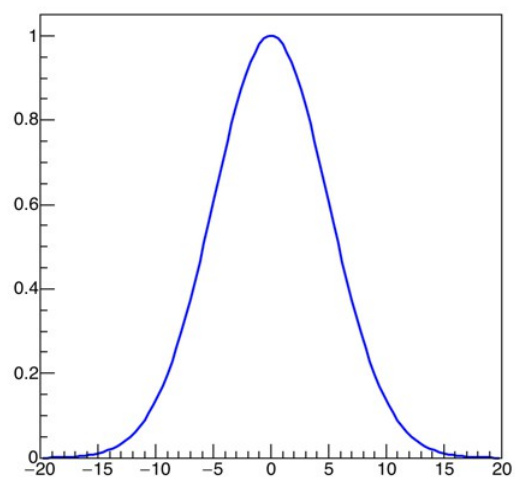
Gaussian



Landau



TMath::Gaus(x, 0, 5)



Lognormal

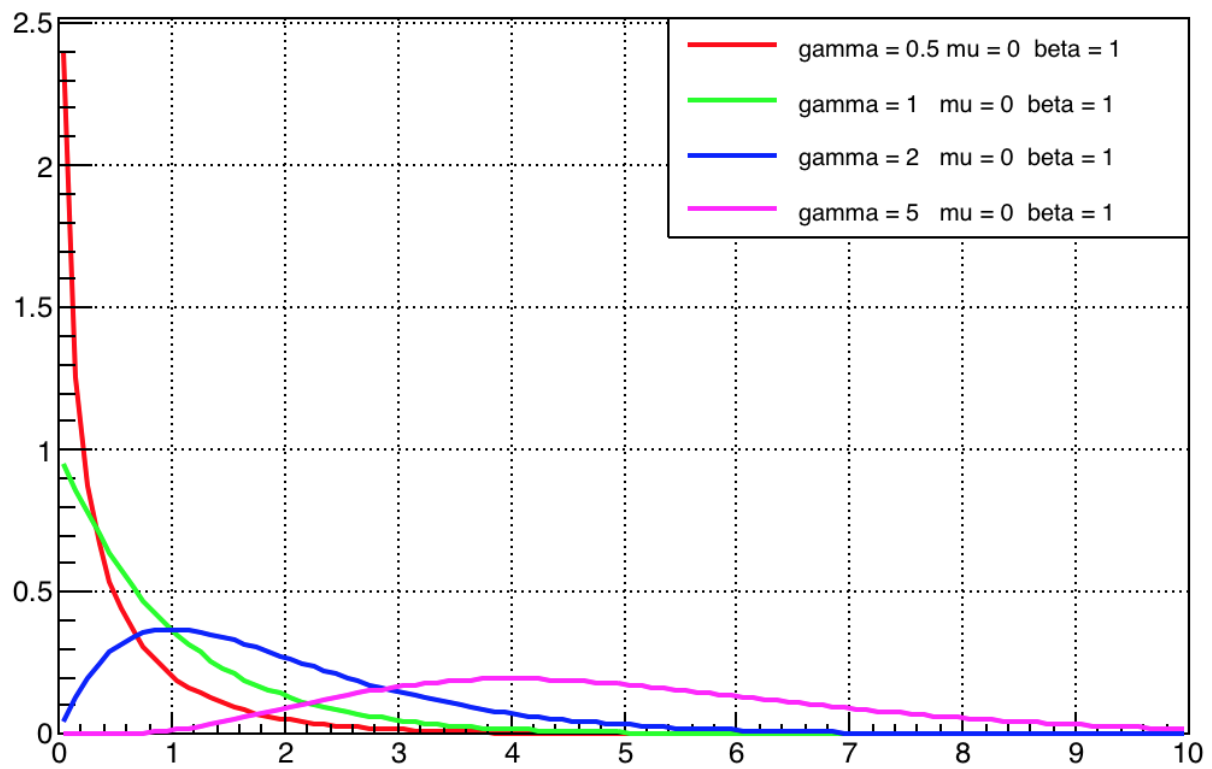
It is the continuous probability distribution of a random variable, whose logarithm is a normal (Gaussian) distribution.

Applications:

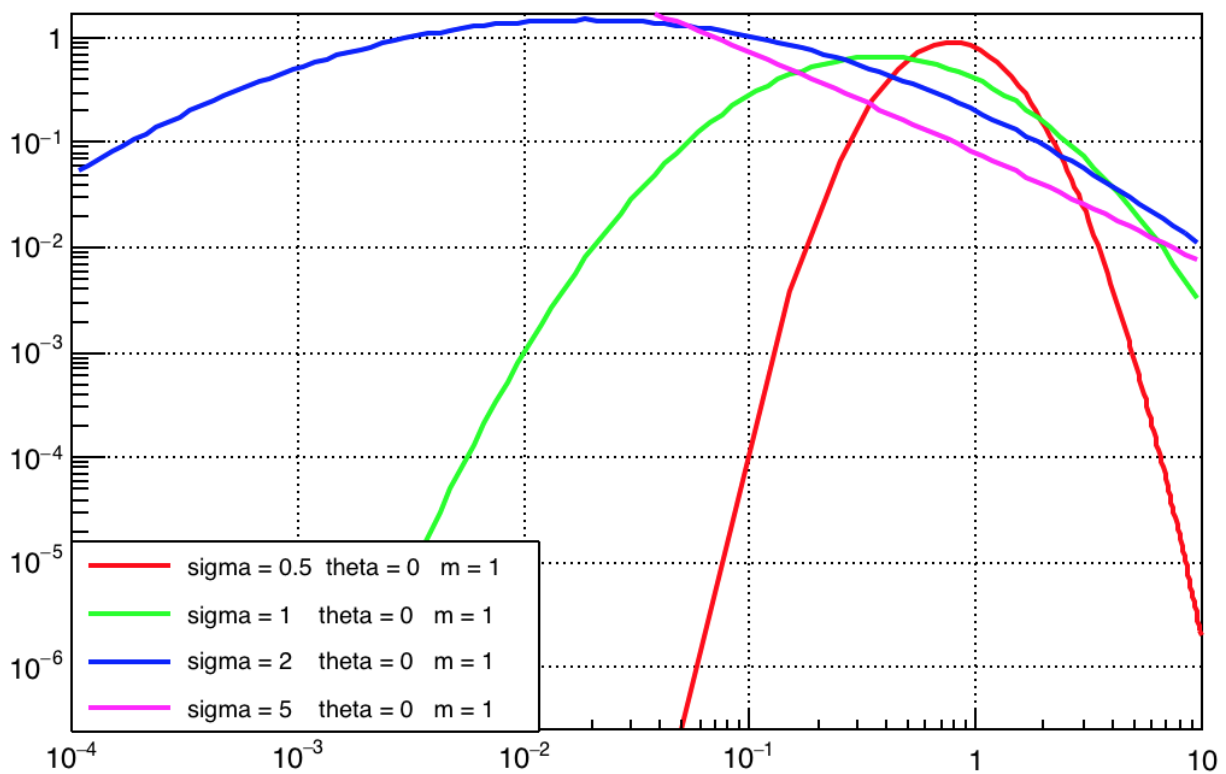
- Particle size distributions (colloidal chemistry)
- Particle size distributions (technology)
- Economics (income of +95% distributed log-normally)
- Hydrology (ex: rainfall values)

```
void lognormal() {  
  
    TCanvas *myc = new TCanvas("c1","gamma and lognormal",10,10,600,800); //setting up a new canvas  
    myc->Divide(1,2); //dividing the canvas in two  
    TPad *pad1 = (TPad *)myc->cd(1); //setting a pad on the first half  
    //pad1->SetLogy(); //log scaling the y axis  
    pad1->SetGrid(); //sets up the grid  
  
    //GammaDist:  
    //GammaDist(x, mu = 0, beta = 1)  
    //gamma: shape parameter  
    //mu: location parameter  
    //beta: scale parameter  
  
    TF1 *fgamma = new TF1("fgamma", "TMath::GammaDist(x, [0], [1], [2])", 0, 10); //Gamma Dist  
    fgamma->SetParameters(0.5, 0, 1); //setting parameters  
    TF1 *f1 = fgamma->DrawCopy();  
    f1->SetMinimum(1e-5); //min axis value  
    f1->SetLineColor(kRed); //line color  
  
    fgamma->SetParameters(1, 0, 1);  
    TF1 *f2 = fgamma->DrawCopy("same");  
    f2->SetLineColor(kGreen);  
  
    fgamma->SetParameters(2, 0, 1);  
    TF1 *f3 = fgamma->DrawCopy("same");  
    f3->SetLineColor(kBlue);  
  
    fgamma->SetParameters(5, 0, 1);  
    TF1 *f4 = fgamma->DrawCopy("same");  
    f4->SetLineColor(kMagenta);  
  
    TLegend *legend1 = new TLegend(.55,.1,.9,.9); //Adding Legends  
    legend1->AddEntry(f1,"gamma = 0.5 mu = 0 beta = 1","l");  
    legend1->AddEntry(f2,"gamma = 1 mu = 0 beta = 1","l");  
    legend1->AddEntry(f3,"gamma = 2 mu = 0 beta = 1","l");  
    legend1->AddEntry(f4,"gamma = 5 mu = 0 beta = 1","l");  
    legend1->Draw();  
  
    //TMath::LogNormal  
  
    TPad *pad2 = (TPad *)myc->cd(2); //new pad, cd  
    pad2->SetLogy(); //log scaling y-axis  
    pad2->SetLogx(); //log scaling x-axis  
    pad2->SetGrid();  
  
    TF1 *flog = new TF1("flog", "TMath::LogNormal(x, [0], [1], [2])", 0, 10); //LogNormal  
    flog->SetParameters(0.5, 0, 1); //parameters  
    TF1 *g1 = flog->DrawCopy();  
    g1->SetLineColor(kRed);  
  
    flog->SetParameters(1, 0, 1);  
    TF1 *g2 = flog->DrawCopy("same");  
    g2->SetLineColor(kGreen);  
  
    flog->SetParameters(2, 0, 1);  
    TF1 *g3 = flog->DrawCopy("same");  
    g3->SetLineColor(kBlue);  
  
    flog->SetParameters(5, 0, 1);  
    TF1 *g4 = flog->DrawCopy("same");  
    g4->SetLineColor(kMagenta);  
  
    TLegend *legend2 = new TLegend(0.9,0.3,0.55,0.1); //line Color  
    legend2->AddEntry(g1, "sigma = 0.5 theta = 0 m = 1", "l");  
    legend2->AddEntry(g2, "sigma = 1 theta = 0 m = 1", "l");  
    legend2->AddEntry(g3, "sigma = 2 theta = 0 m = 1", "l");  
    legend2->AddEntry(g4, "sigma = 5 theta = 0 m = 1", "l");  
    legend2->Draw();  
}
```

TMath::GammaDist(x, [0], [1], [2])



TMath::LogNormal(x, [0], [1], [2])



Chi-Squared

- Distribution of a sum of the squares of N independent standard normal random variables.
- Chi2 test, tests the goodness of a fit.

```
#include "TFile.h"
#include "TTree.h"
#include "TH1.h"
#include "TClonesArray.h"
#include "TBranch.h"

void chi2(){

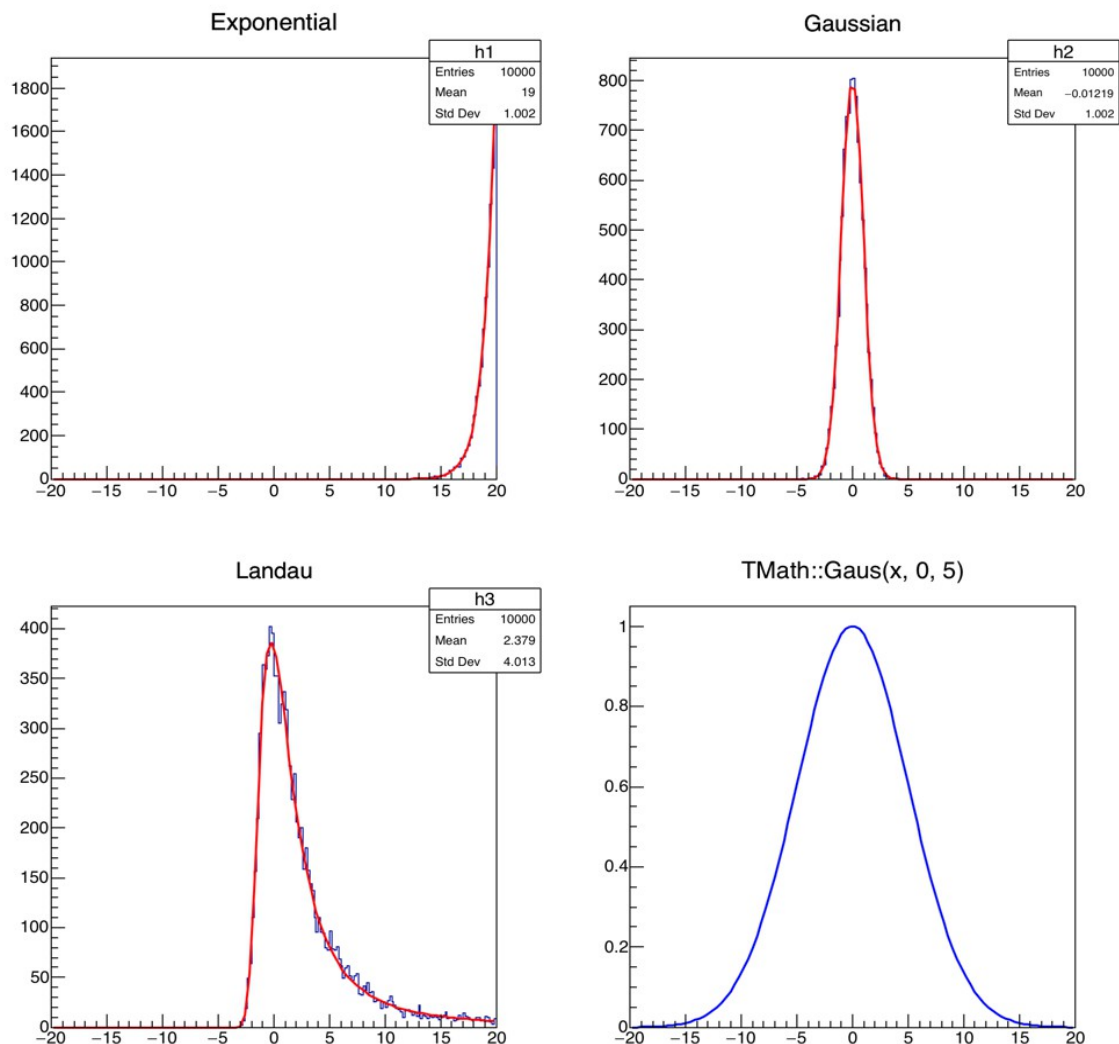
    TCanvas *myc = new TCanvas("c1","Chi2 Fitting",10,10,1000,1000); //setting up a new canvas
    myc->Divide(2,2); //dividing the canvas in two
    myc->cd(1);

    TH1F *h1 = new TH1F("h1","Exponential",200,-20,20);
    h1->FillRandom("expo",10000);
    h1->Fit("expo"); //Without any options, it's chi2
    h1->Draw(); //by default

    myc->cd(2);
    TH1F *h2 = new TH1F("h2","Gaussian",200,-20,20);
    h2->FillRandom("gaus",10000);
    h2->Fit("gaus");
    h2->Draw();

    myc->cd(3);
    TH1F *h3 = new TH1F("h3","Landau",200,-20,20);
    h3->FillRandom("landau",10000);
    h3->Fit("landau");
    h3->Draw();

    myc->cd(4);
    TF1 *mygaus = new TF1("mygaus","TMath::Gaus(x, 0, 5)",-20,20);
    TF1 *f2 = mygaus->DrawCopy();
    f2->SetLineColor(kBlue);
}
```



Predefined Polynomial Fitting

```
void polfit() {
    TCanvas *myc = new TCanvas("polfit","gamma and lognormal",10,10,1000,1000); //setting up a new canvas
    myc->Divide(2,2); //dividing the canvas in two

    TH1F *h1 = new TH1F("h1","Polynomial 1",100,-20,20);
    h1->FillRandom("expo",10000);
    h1->Fit("expo", "L"); //Likelihood "L"
    h1->Draw();

    myc->cd(2);

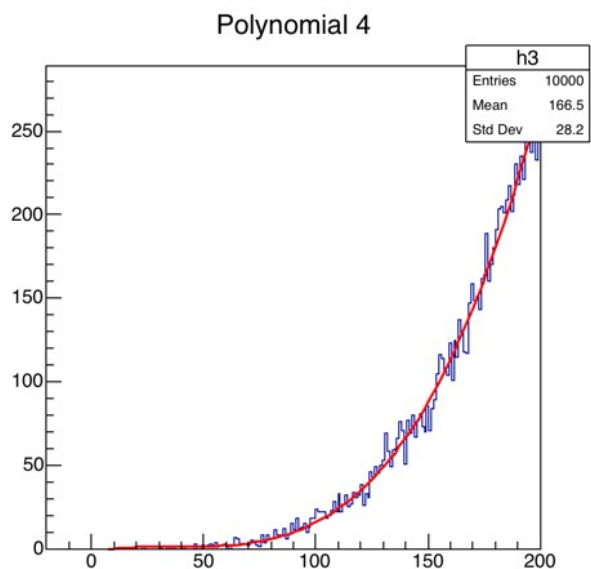
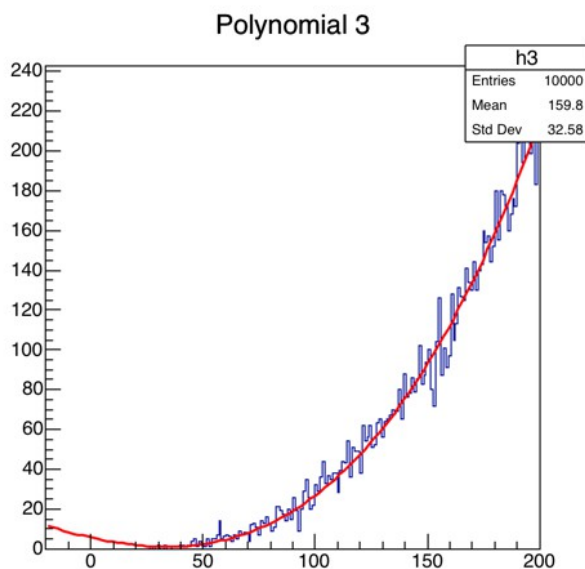
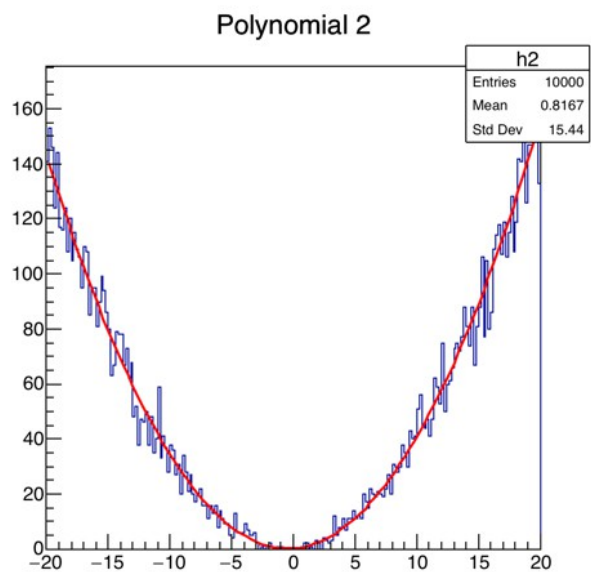
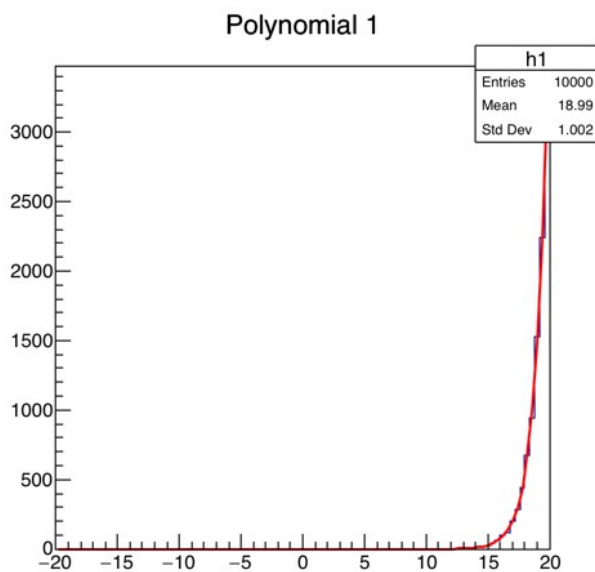
    TH1F *h2 = new TH1F("h2","Polynomial 2",200,-20,20);
    h2->FillRandom("pol2",10000);
    h2->Fit("pol2", "L"); //Likelihood "L"
    h2->Draw();

    myc->cd(3);

    TH1F *h3 = new TH1F("h3","Polynomial 3",200,-20,200);
    h3->FillRandom("pol3",10000);
    h3->Fit("pol3"); //chi2
    h3->Draw();

    myc->cd(4);

    TH1F *h4 = new TH1F("h3","Polynomial 4",200,-20,200);
    h4->FillRandom("pol4",10000);
    h4->Fit("pol4"); //chi2
    h4->Draw();
}
```



TMath::Poisson, TMath::Gaus

```
void comparison(){  
  
    //FUNCTIONS  
  
    TCanvas *myc = new TCanvas("c1", "gamma and poisson",10,10,600,800);  
    myc->Divide(1,2);  
    TPad *pad1 = (TPad *)myc->cd(1);  
    //pad1->SetLogy();  
    pad1->SetGrid();  
  
    TF1 *fgamma = new TF1("fgamma", "TMath::Gaus(x, 5, .5)", 0, 10);  
    fgamma->SetParameters(0.5, 0, 1);  
    TF1 *f1 = fgamma->DrawCopy();  
    f1->SetLineColor(kRed);  
  
    TF1 *fpoisson = new TF1("fpoisson", "TMath::Poisson(x, 5)", 0, 10);  
    fpoisson->SetParameters(1, 0, 1);  
    TF1 *f2 = fpoisson->DrawCopy("same");  
    f2->SetLineColor(kBlue);  
  
    TLegend *legend1 = new TLegend(0.1,0.7,0.30,0.9);  
    legend1->AddEntry(f1,"Gaussian","l");  
    legend1->AddEntry(f2,"Poisson","l");  
    legend1->Draw();  
}
```

TMath::Gaus(x, 5, .5)

