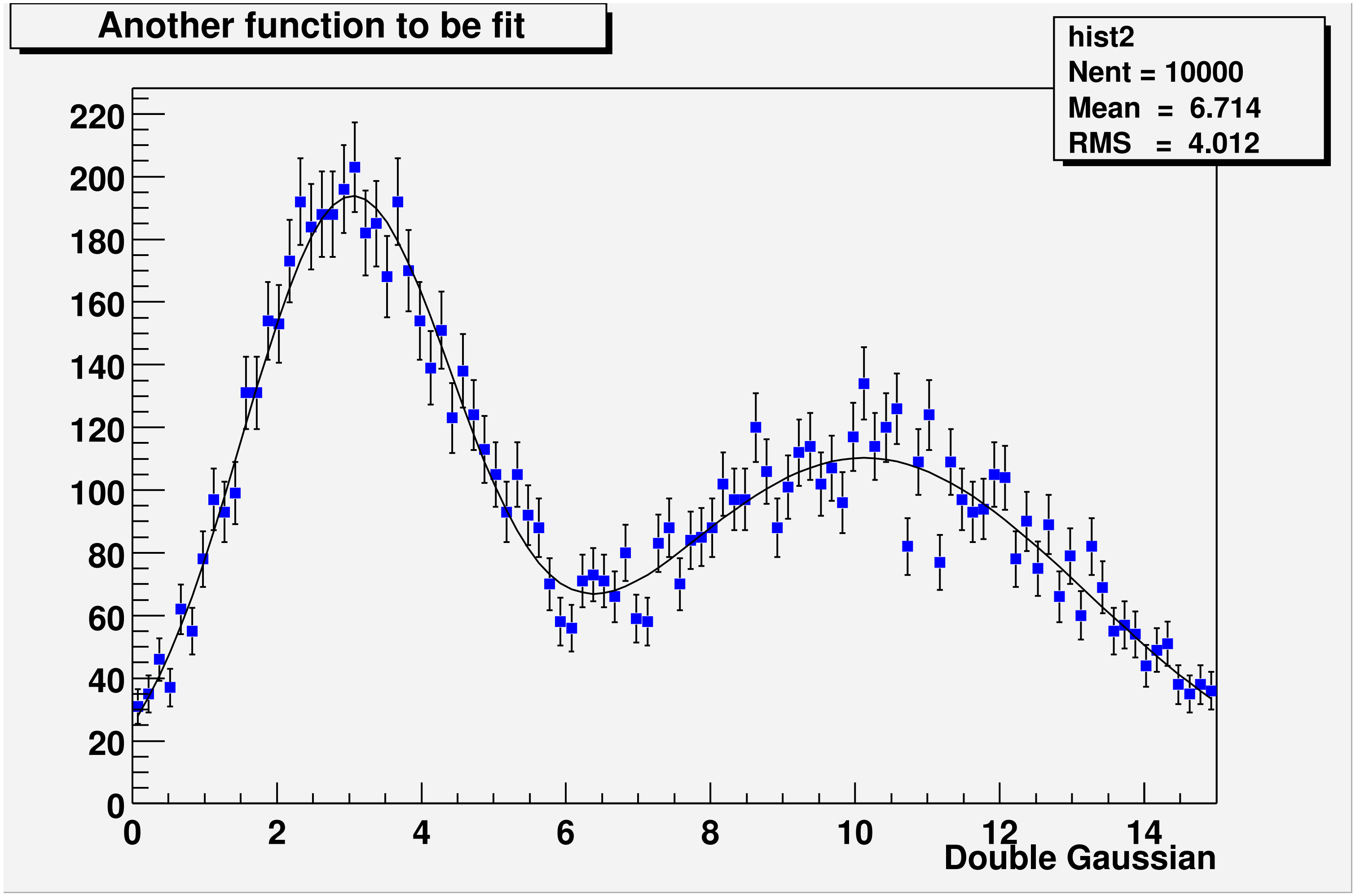
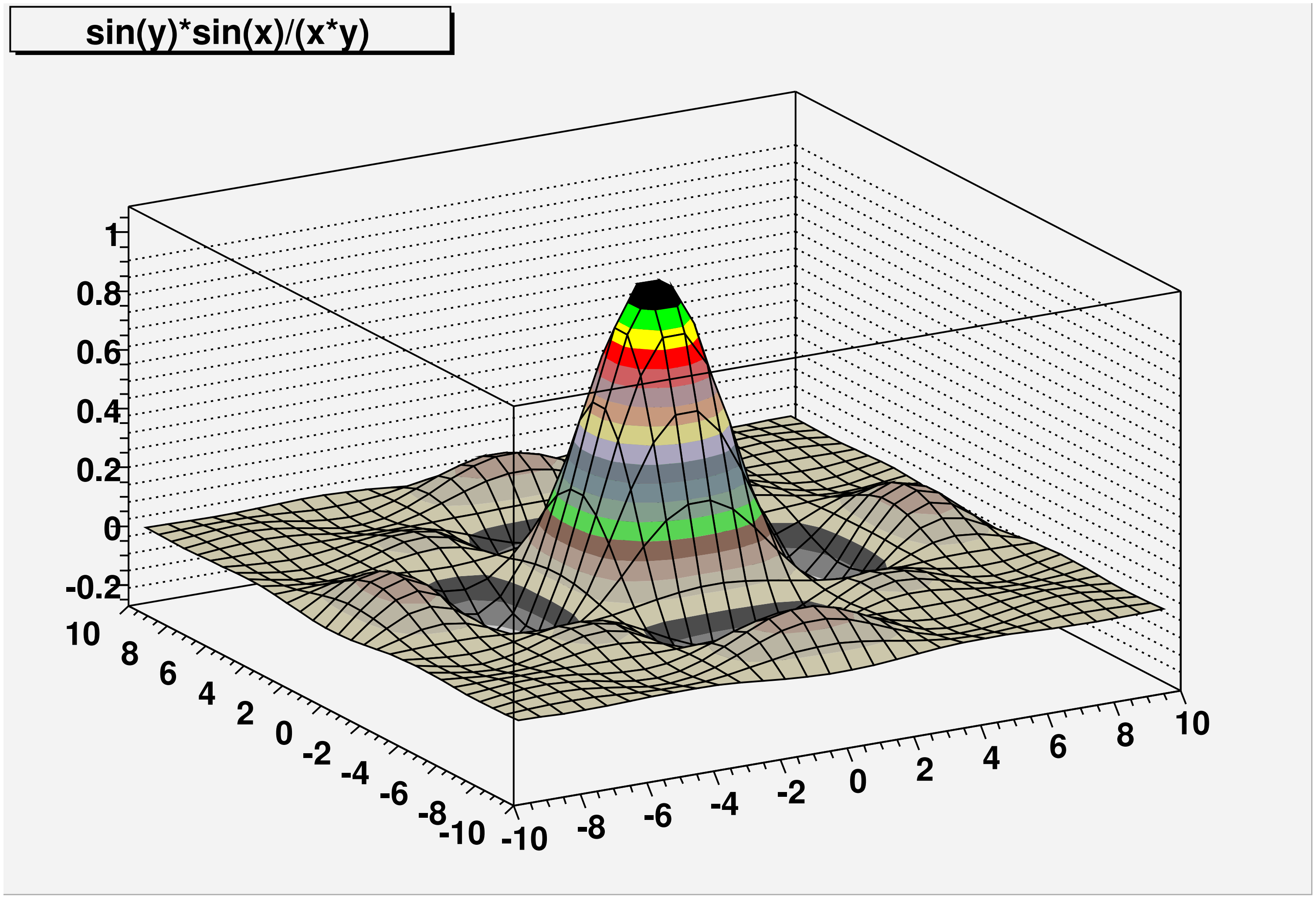
What is ROOT?
Why do we use it?

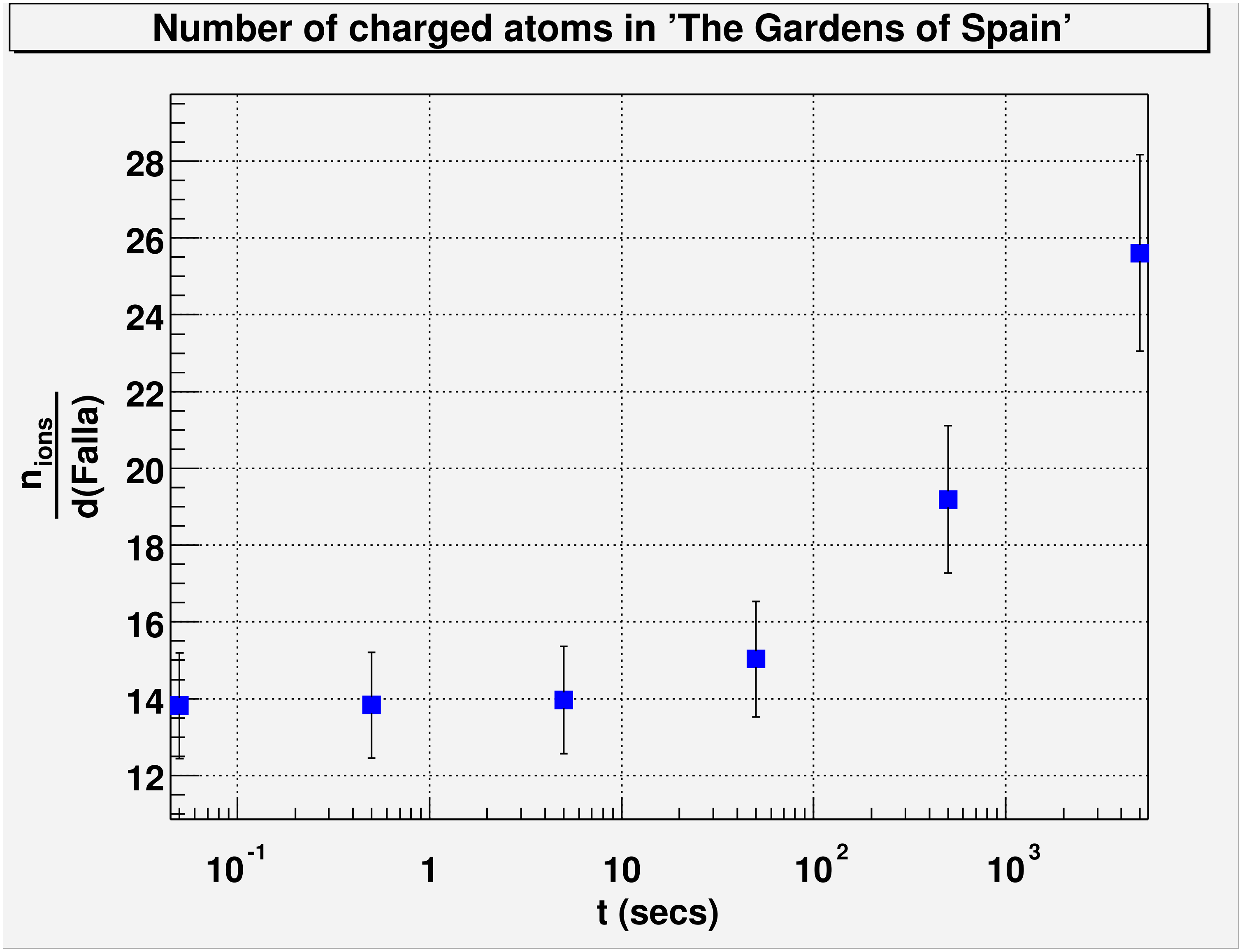
Answer:

ROOT does what physicists do:

It makes plots.


Another function to be fit
hist2
Nent = 10000
Mean = 6.714
RMS   = 4.012
0
20
40
60
80
100
120
140
160
180
200
220
0
2
4
6
8
10
12
14
Double Gaussian


sin(y)*sin(x)/(x*y)
1
0.8
0.6
0.4
0.2
0
-0.2
10
8
6
4
2
0
-2
-4
-6
-8
-10
-10
-8
-6
-4
-2
0
2
4
6
8
10



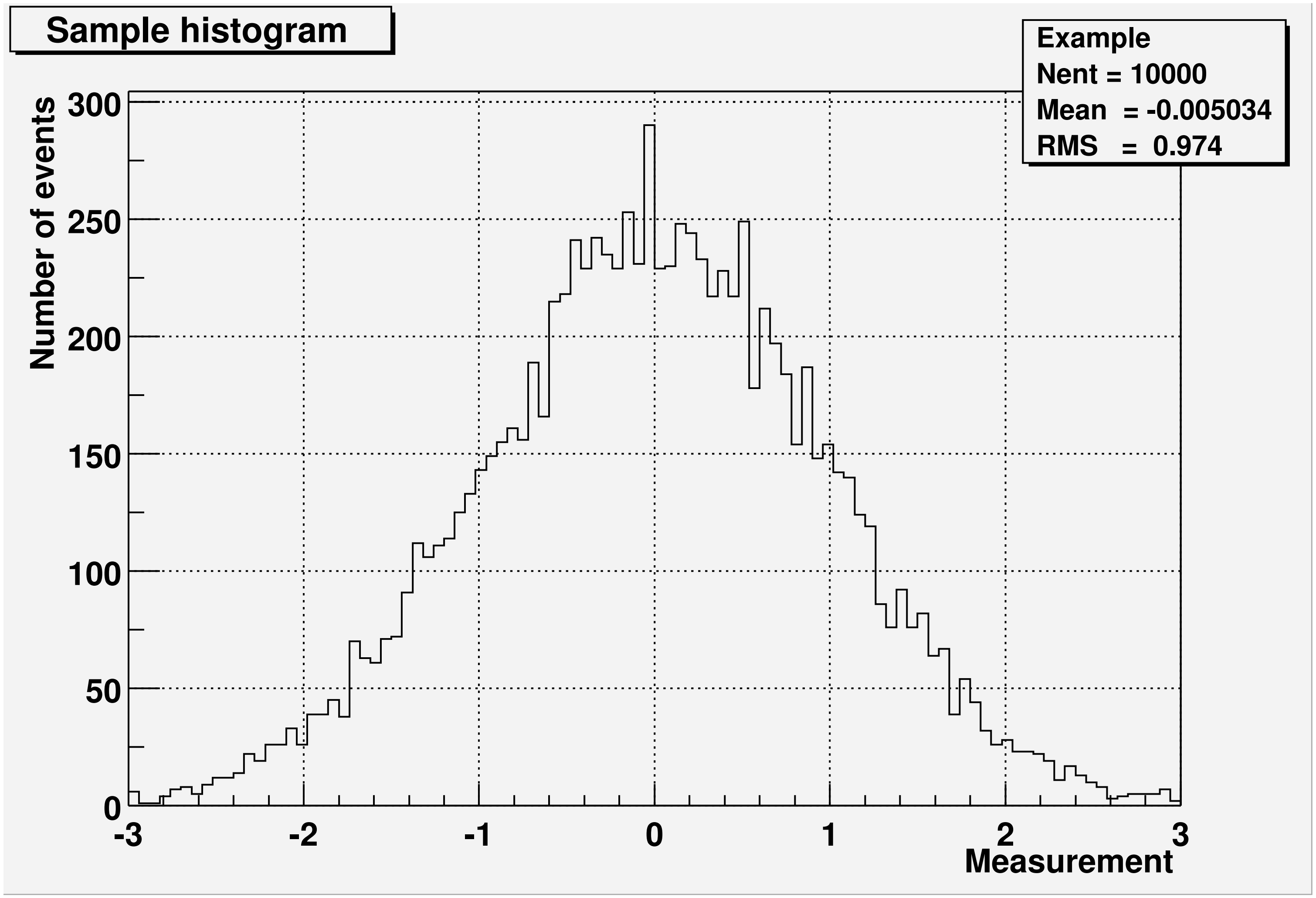
Can you spot the pun in this plot?

The typical analysis task that you will be asked to do:

Take variables in an n-tuple, perform some computations, and make histograms.

So what is a histogram, what is an n-tuple, and how do we perform the computations?

Anatomy of a histogram

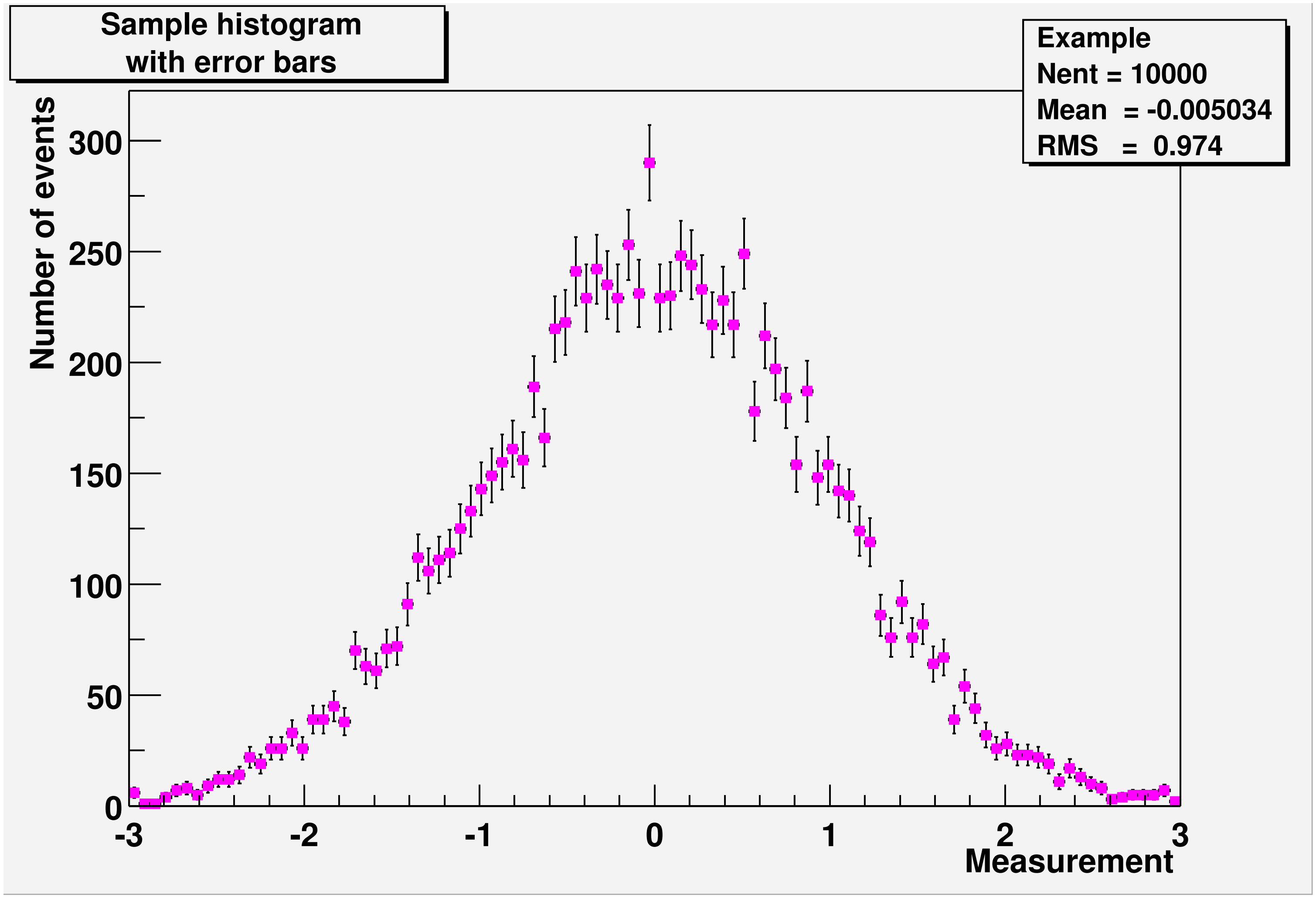


Properties of a histogram

- Name or Identifier
- Title (to be displayed on plot)
- Number of bins
- Lower bin limit
- Upper bin limit

A ROOT command that might be used to create this histogram:

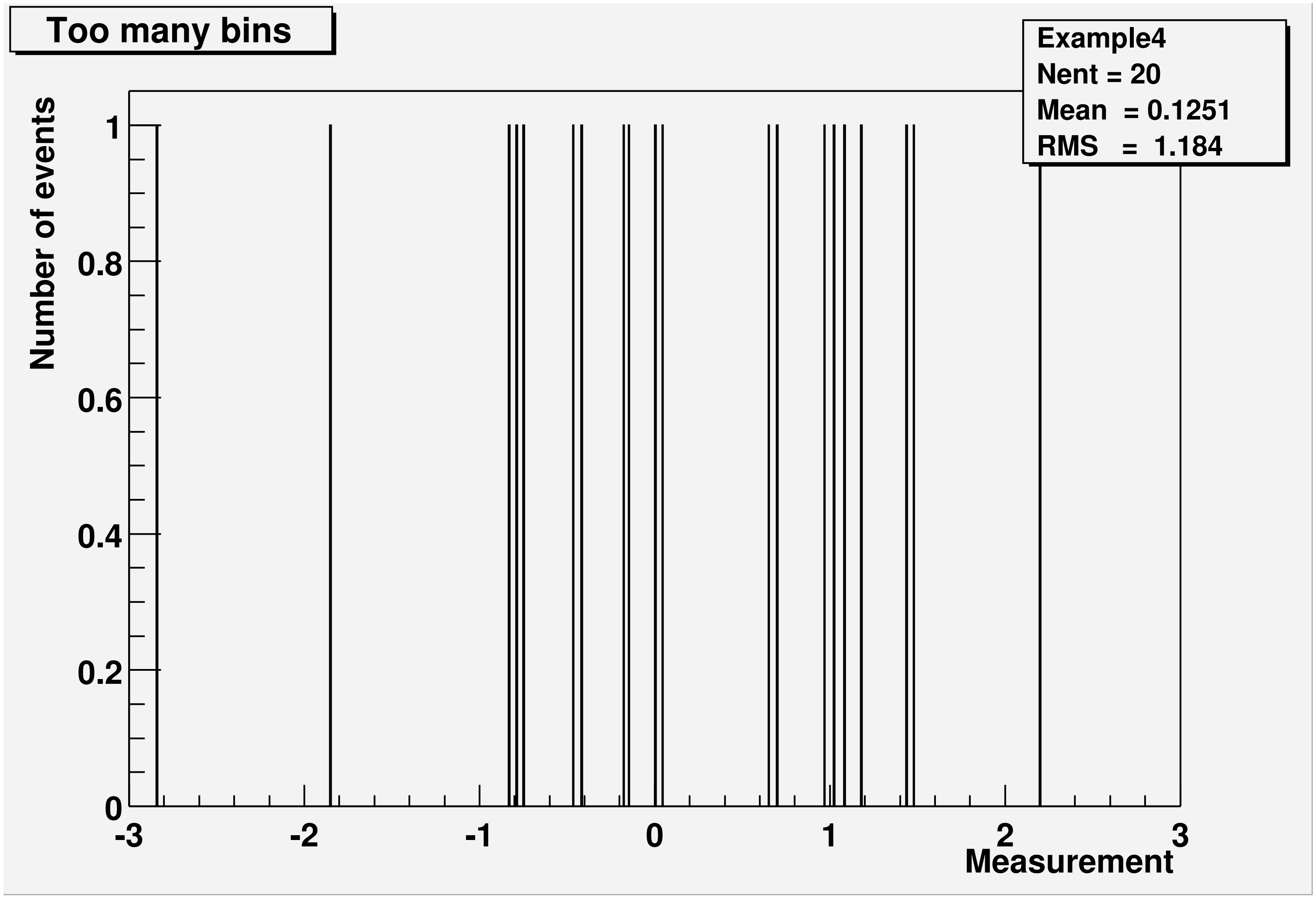
```
TH1F hist("Example","Sample histogram",100,-3,3)
```

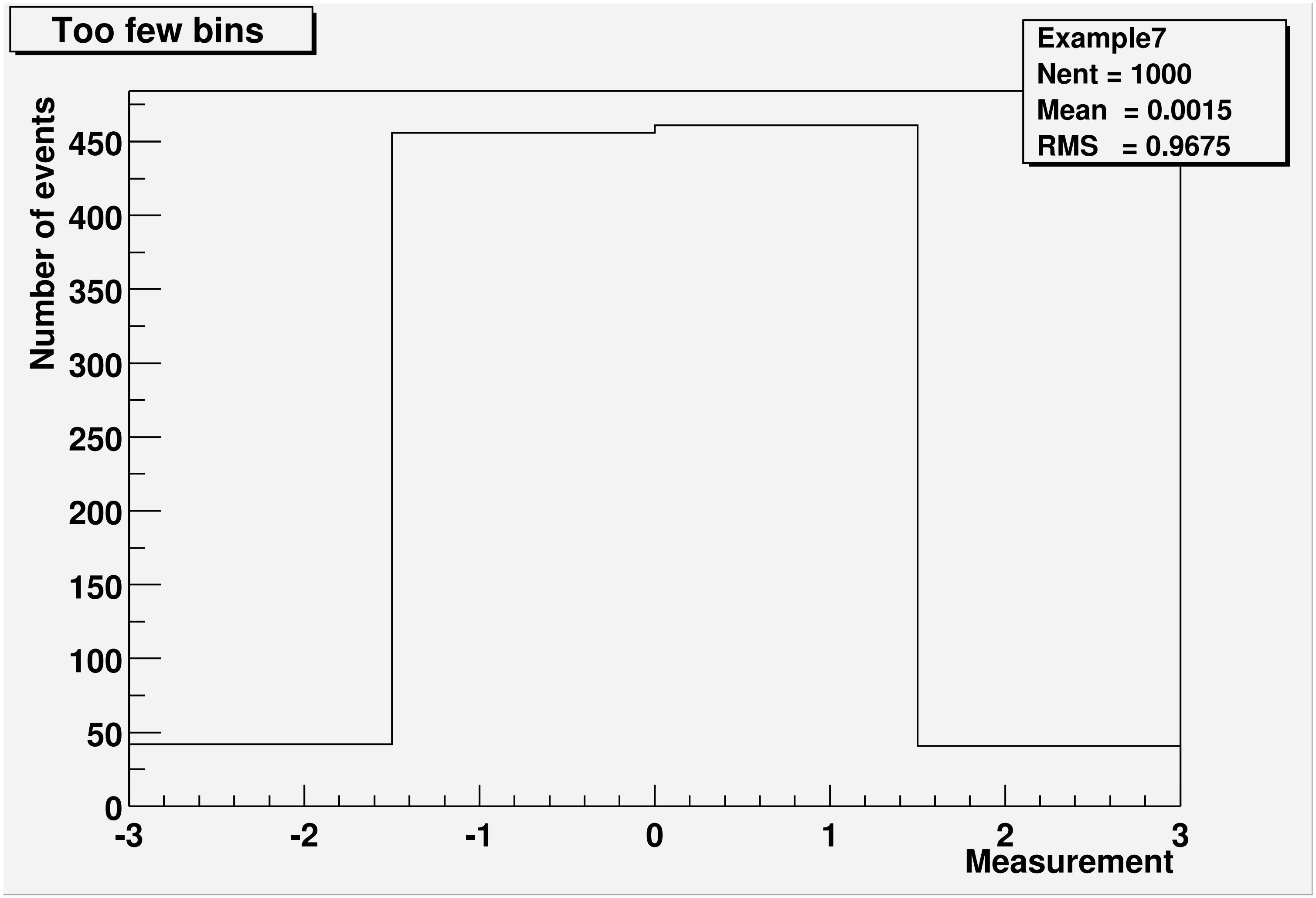


Don't forget the errors!

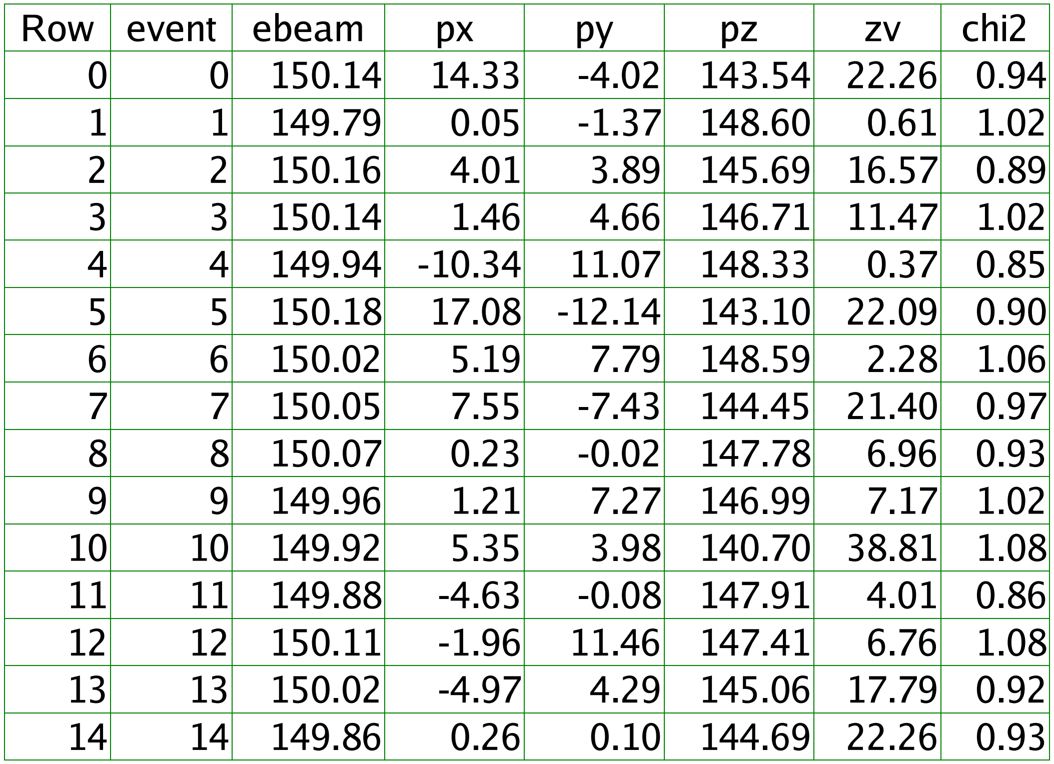
For simple histograms, the error in one bin is the square root of the number of events in that bin.

There's an art to histogram design...




Too few bins
Example7
Nent = 1000
Mean = 0.0015
RMS = 0.9675
Number of events
0
50
100
150
200
250
300
350
400
450
-3
-2
-1
0
1
2
3
Measurement

Anatomy of an n-tuple (a simple form of a ROOT Tree)



Row	event	ebeam	px	py	pz	zv	chi2
0	0	150.14	14.33	-4.02	143.54	22.26	0.94
1	1	149.79	0.05	-1.37	148.60	0.61	1.02
2	2	150.16	4.01	3.89	145.69	16.57	0.89
3	3	150.14	1.46	4.66	146.71	11.47	1.02
4	4	149.94	-10.34	11.07	148.33	0.37	0.85
5	5	150.18	17.08	-12.14	143.10	22.09	0.90
6	6	150.02	5.19	7.79	148.59	2.28	1.06
7	7	150.05	7.55	-7.43	144.45	21.40	0.97
8	8	150.07	0.23	-0.02	147.78	6.96	0.93
9	9	149.96	1.21	7.27	146.99	7.17	1.02
10	10	149.92	5.35	3.98	140.70	38.81	1.08
11	11	149.88	-4.63	-0.08	147.91	4.01	0.86
12	12	150.11	-1.96	11.46	147.41	6.76	1.08
13	13	150.02	-4.97	4.29	145.06	17.79	0.92
14	14	149.86	0.26	0.10	144.69	22.26	0.93

An n-tuple is an ordered list of numbers.

A ROOT Tree can be an ordered list of any collections of C++ objects.

Probably you'll only be asked to work with n-tuples this summer.

Why ROOT?

- It knows about n-tuples and histograms.
- It can handle large volumes of data (millions of physics events; files of gigabytes->terabytes in size).
- Multi-platform (Windows, Mac, many UNIX flavors)
- It's free.

But...

- You have to know some C++ in order to use ROOT effectively, in order to perform computations.
- What does C++ look like? Well...

```
#define Analyze_cxx
#include "Analyze.h"
#include "TH2.h"
#include "TStyle.h"
#include "TCanvas.h"

void Analyze::Loop()
{
//   In a Root session, you can do:
//      Root > .L Analyze.C
//      Root > Analyze t
//      Root > t.GetEntry(12); // Fill t data members with entry number 12
//      Root > t.Show();       // Show values of entry 12
//      Root > t.Show(16);     // Read and show values of entry 16
//      Root > t.Loop();       // Loop on all entries
//

//     This is the loop skeleton
//       To read only selected branches, Insert statements like:
// METHOD1:
//    fChain->SetBranchStatus("*",0);  // disable all branches
//    fChain->SetBranchStatus("branchname",1);  // activate branchname
// METHOD2: replace line
//    fChain->GetEntry(i);  // read all branches
//by  b_branchname->GetEntry(i); //read only this branch
   if (fChain == 0) return;

   Int_t nentries = Int_t(fChain->GetEntries());

   Int_t nbytes = 0, nb = 0;
   for (Int_t jentry=0; jentry<nentries;jentry++) {
      Int_t ientry = LoadTree(jentry); //in case of a TChain, ientry is the entry
number in the current file
      nb = fChain->GetEntry(jentry);   nbytes += nb;
      // if (Cut(ientry) < 0) continue;
   }
}
```

Web Links

(the only part you should bother to write down)

All the documents you've seen (and will see) during the class today can be found at:

http://www.nevis.columbia.edu/~seligman/root-class/

ROOT and C++ links, including links to reference books on C++ and statistics, can be found at:

http://www.nevis.columbia.edu/~seligman/root-class/links.html

The Hands-on Course:

Basic Data Analysis using ROOT

ROOT basics

You will learn how to:

- look up ROOT command references
- plot a function
- histogram a variable
- fit a histogram
- create C++ code for an n-tuple
- get a variable from an n-tuple
- apply cuts

-- but not necessarily in this order!

There's lots of optional material to help turn you into a ROOT expert. Try to go over as much of it as you can.