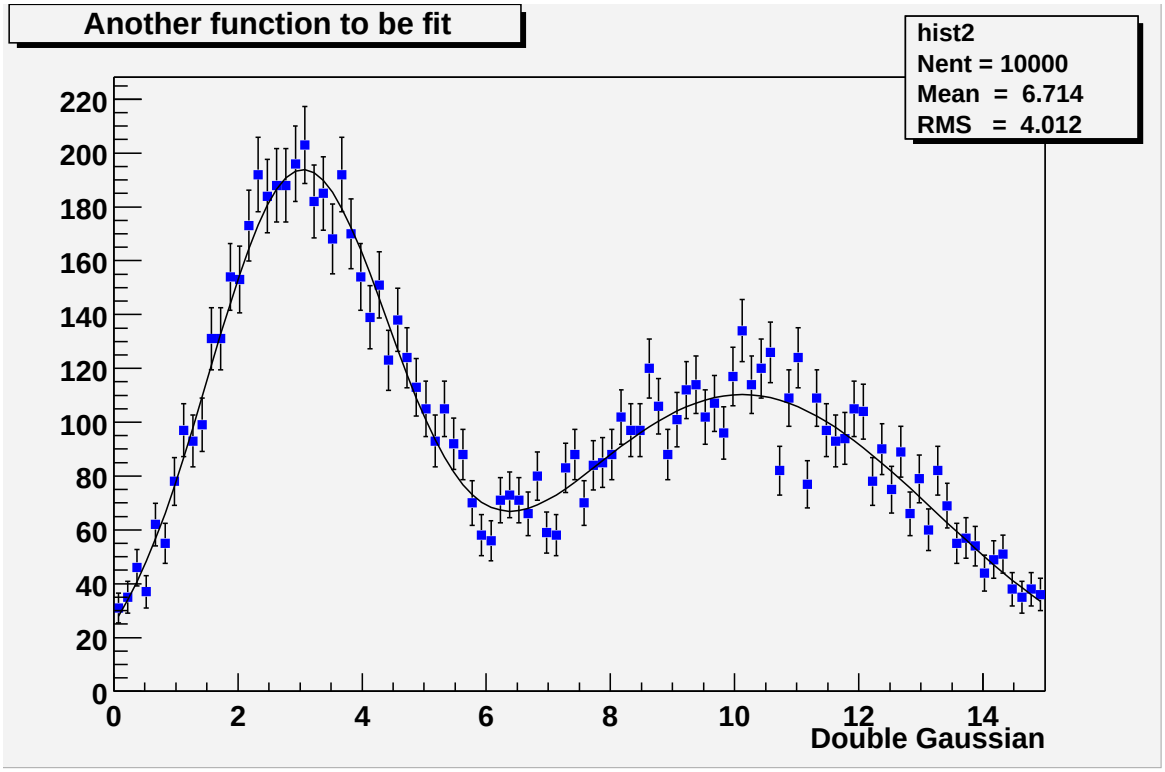
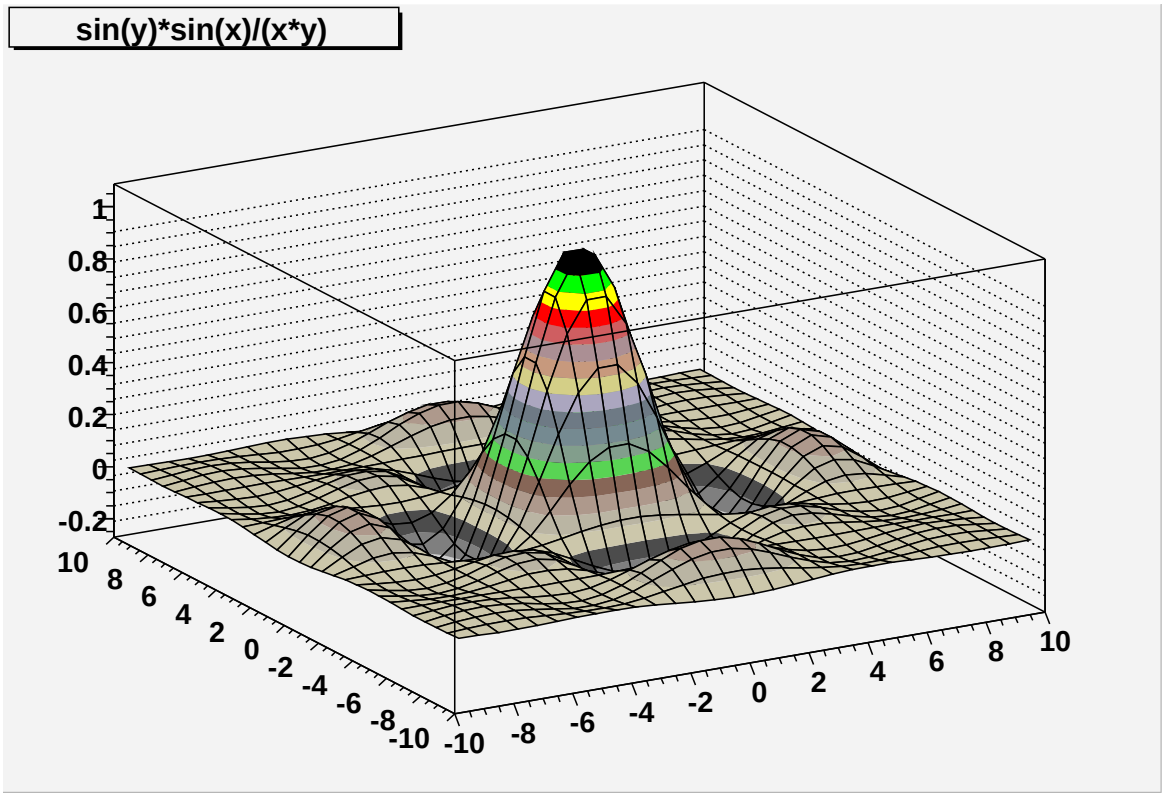
What is ROOT?
Why do we use it?

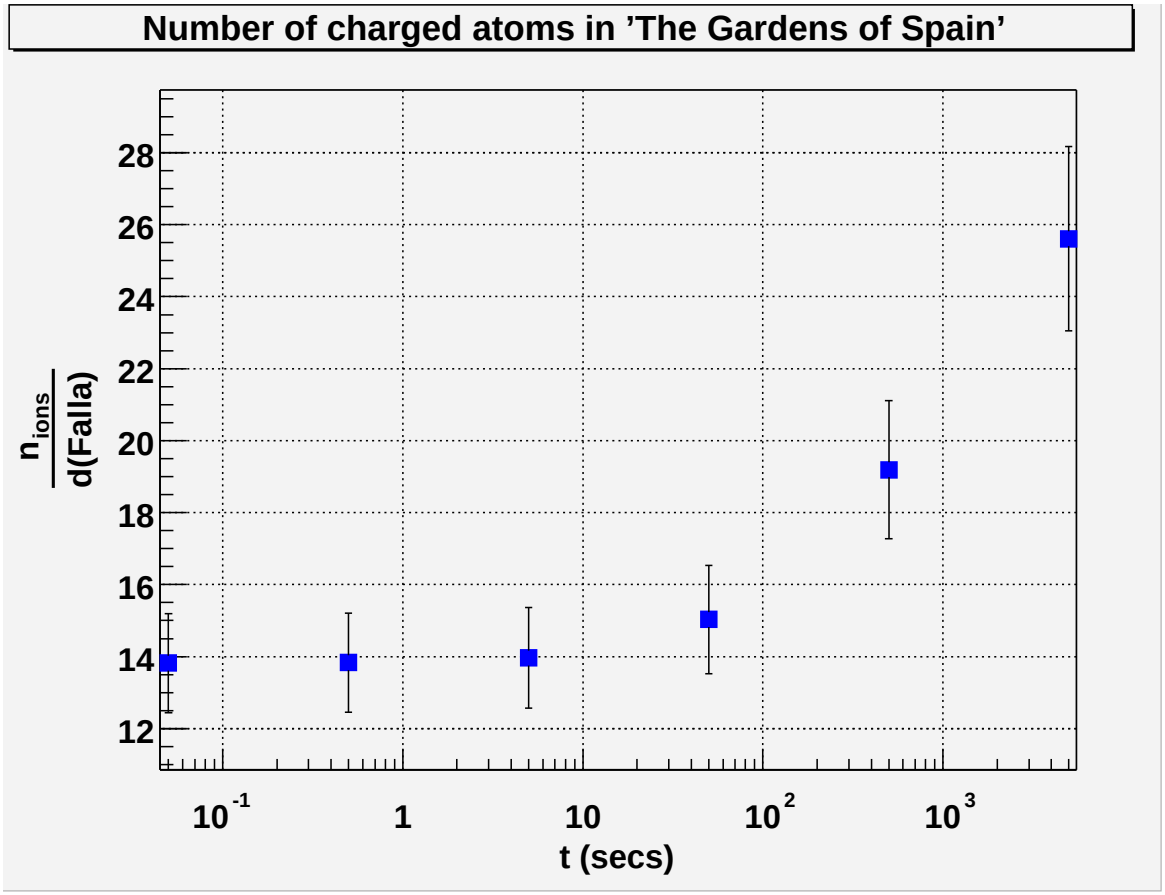
Answer:

ROOT does what physicists do:

It makes plots.


Another function to be fit
hist2
Nent = 10000
Mean = 6.714
RMS = 4.012
220
200
180
160
140
120
100
80
60
40
20
0
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



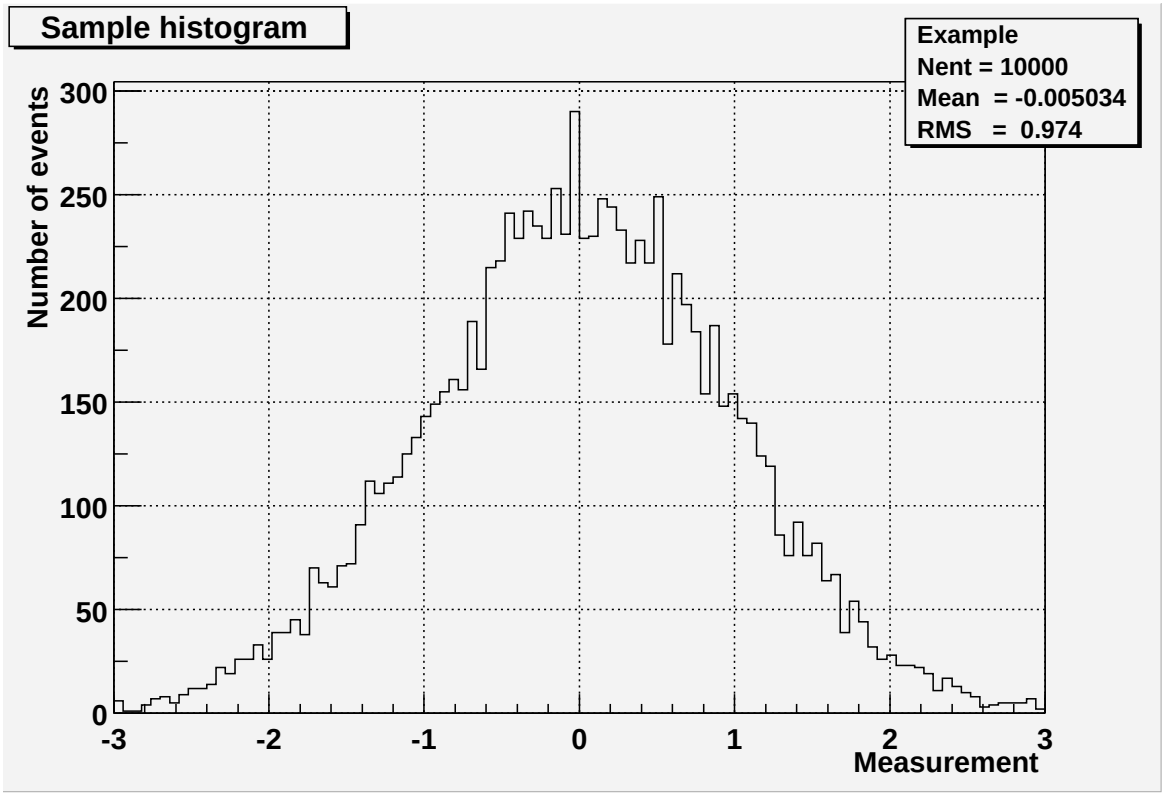
Can you spot the pun in this plot?

Your analysis task:

Take variables in an n–tuple and make histograms.

So what is a histogram and what is an n–tuple?

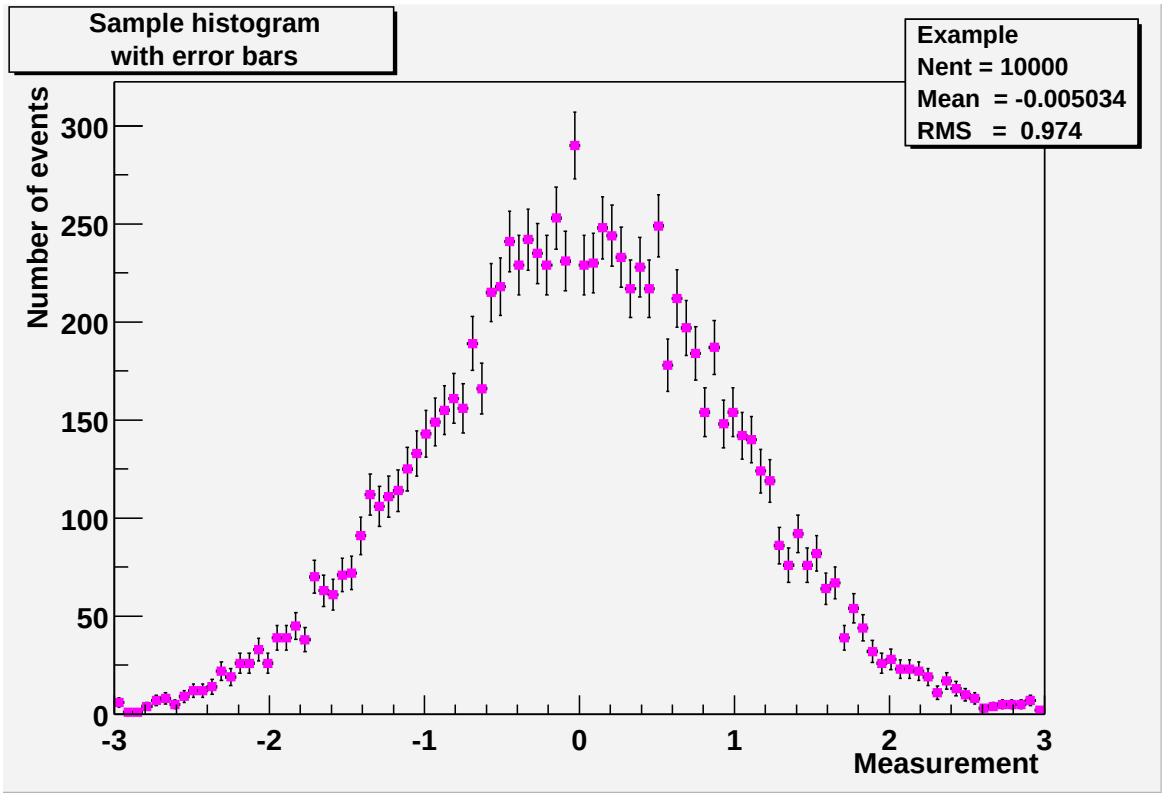
Anatomy of a histogram



Properties of a histogram:

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

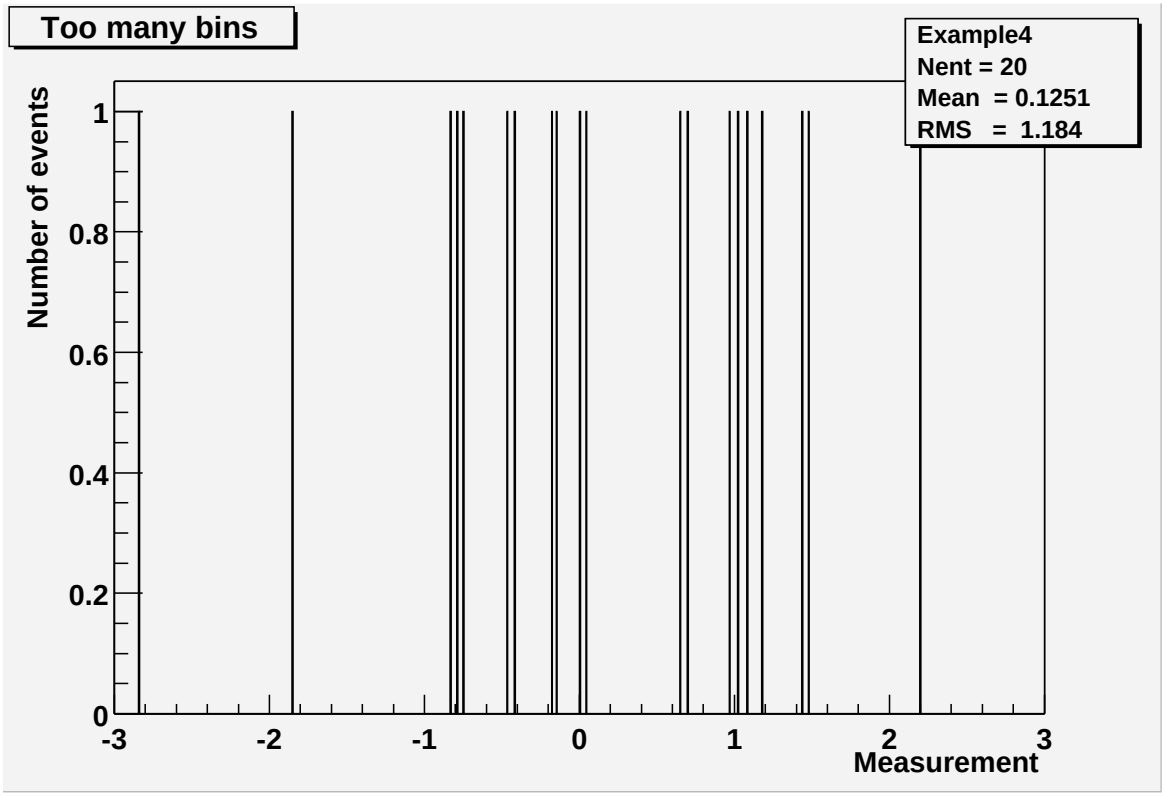
TH1F hist("Example","Sample histogram",100,–3,3)

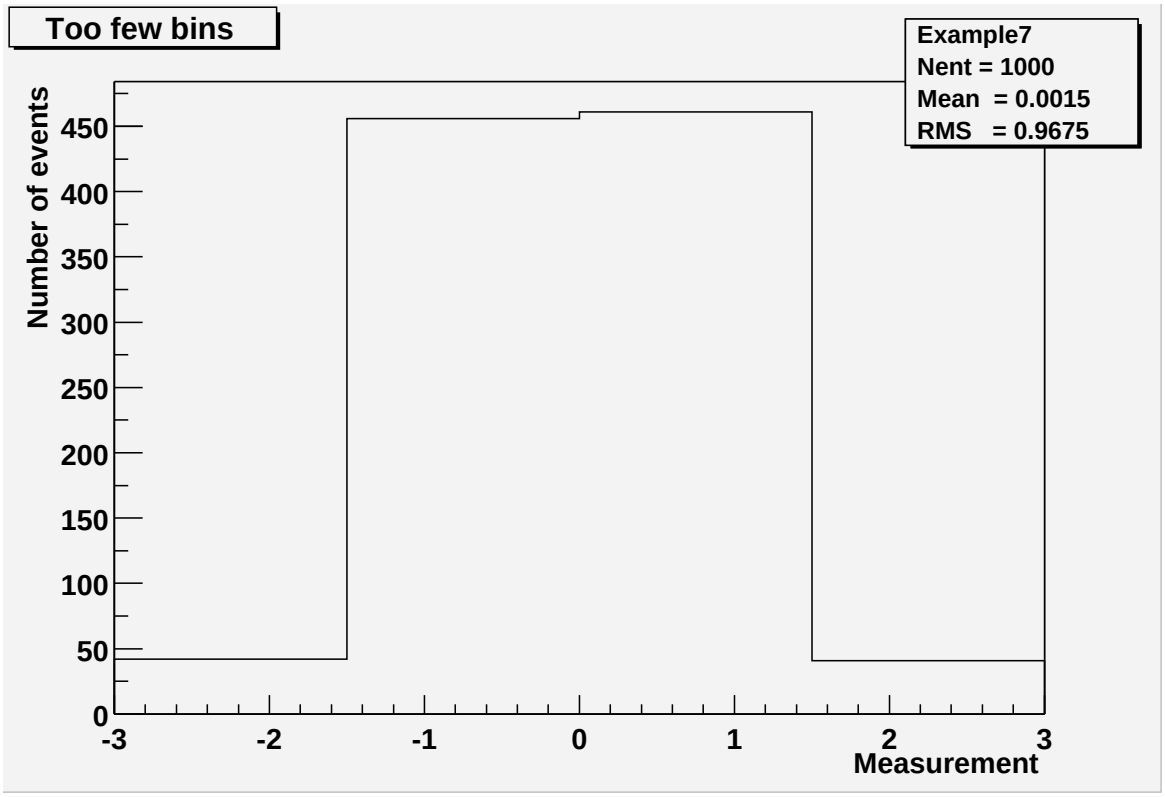


Don't forget the errors!

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:





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
15	15	150.28	−7.50	1.49	147.64	7.07	1.02
16	16	149.94	2.19	−3.67	148.75	1.25	1.01
17	17	150.11	10.45	6.67	147.83	4.43	1.02
18	18	150.09	−0.56	−0.91	145.95	14.88	1.01
19	19	149.71	8.20	3.59	147.13	6.32	1.14
20	20	150.12	−7.09	−5.52	145.07	19.50	1.11
21	21	150.19	−4.00	−8.78	148.30	3.29	1.06
22	22	149.75	8.60	6.21	147.64	2.68	1.00
23	23	150.15	2.36	−3.34	148.47	2.00	0.86
24	24	149.79	−0.20	−0.18	147.52	7.03	0.92

An n–tuple is an ordered list of numbers.

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

Why ROOT?

It knows about n–tuples and histograms.

It can handle large volumes of data (millions of physics events; files up to several gigabytes in size).

It's free.

Some history…

Software analysis packages

CERNLIB	ROOT
1980–2000	2003+ ?
Divided into distinct packages: PAW HBOOK HPLOT HIGZ ZEBRA GEANT3 PYTHIA JETSET	Monolithic (you only use the objects you want, but it's all part of ROOT)
Based on FORTRAN	Based on C++
Fairly well documented	Documentation in flux
n–tuples (PAW–tuples)	Trees (ROOT–tuples)

Why switch at all?

Physics collaborations are getting bigger; the experiments are taking longer. The hope is that OO design will simplify long–term maintenance, at the cost of complexity.

More than you wanted to know about C++

Stephen Prata, *C++ Primer Plus*, 1998 Waite Group Press

An excellent introduction to C++.

Bjarne Stroiustrup, *The C++ Programming Language,* 1991 Addison–Wesley

The language reference manual.

David R. Musser and Atul Saini, *STL Tutorial and Reference Guide*, 1996 Addison–Wesley

The standard reference to the Standard Template Library.

Erich Gamma *et al., Design Patterns*, 1995 Addison–Wesley

The standard reference to the concept of Design Patterns.

Matthew H. Austern, *Generic Programming and the STL*, 1999 Addison–Wesley

The standard reference on generic programming, a different paradigm than OO.

Always get the latest edition!

More than you wanted to know about Statistics

Philip R. Bevington and D. Keith Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, 1992 McGraw–Hill

The standard introduction to scientific statistics –– but beware of typos!

W. R. Leo, *Techniques for Nuclear and Particle Physics Experiments: a How–to Approach*, 1994 Springer–Verlag

If you get a copy, keep it well hidden! This book is popular, often borrowed, and never returned!

David Freeman, Robert Pisani, and Roger Purves, *Statistics,* 1978 W. W. Norton & Company

Statistics for the social sciences –– but everything is nicely derived from scratch.

Always get the latest edition!

The Hands–on Course:

Basic Data Analysis using ROOT

ROOT basics

You will learn how to:

look up ROOT command references
plot a function
get a variable from an n–tuple
histogram a variable
fit a histogram
apply cuts

–– but not in this order!