

## Measuring the Muon Half-life

OK - now we have all the background knowledge we need to measure the muon half-life. The idea of the experiment is to measure the list of times  $T_i$  ( $T_1, T_2, \dots, T_{N_0}$ ) for how long each of the  $N_0$  muons lives. We can't get a bunch of  $N_0$  muons in a box (like  $^{14}\text{C}$  atoms in a sample) all at once, but that doesn't really matter. We just need the list of decay times  $T_i$ .

### How we do it

We will use cosmic ray muons, just like Carl Anderson who first discovered them. We use a CHICOS detector to register when a cosmic ray muon hits it (every CHICOS detector registers about 200 muons per second). Almost all muons pass through the CHICOS detector and stop deep in the ground before they decay. Those are lost, since we can't see them decay. But a few stop in the detector, then also decay in the detector – so we register both the muon entering the detector and then the decay of the muon. And with the CHICOS electronics and computer we can measure the time the muon spent in the detector before it decayed. This is one of the  $T_i$  that we need. Now we just need to do this many times ( $N_0$  times) to get a set of  $T_i$ . They won't come in order, but a computer can order the numbers for us (we could do it but it is too much work and we are lazy). Then we are all set to use these data to compute the muon half-life!

### Getting your data

Data from the experimental setup at Caltech is available online at <http://www.chicos.caltech.edu/classroom/muonlife/muondata/index.html>

At the bottom of the page is a list of links to data files. There is a data file for each of the last 10 minute intervals, and it goes back 4 hours. The data on this website is updated every 10 minutes (you can see the update log at <http://www.chicos.caltech.edu/classroom/muonlife/muondata/updateslog.txt> )

Each data file is a simple list of decay times for the muons that decayed in the apparatus during that 10 minute interval. The times are in units of nanoseconds (ns). For example the first few entries in a data file might look like:

```
1087.493
999.993
824.995
1137.493
3662.477
5112.467
987.494
2787.482
6874.955
```

This first muon in this list decayed after 1087.493 ns (or 1.087493  $\mu$ s). The numbers look pretty random, but if we analyze them and make a graph, the half-life of the muon will be evident.

We have prepared an Excel worksheet that will do all the calculations we need at [http://www.chicos.caltech.edu/collaboration/Summer2006/muondocs/muon\\_halflife.xls](http://www.chicos.caltech.edu/collaboration/Summer2006/muondocs/muon_halflife.xls)

To enter data you will need to unlock the worksheet. Do this by going to Tools > Protection > Unprotect Sheet and using the password "chicos" when prompted. Now click on one of the links to get a 10 minute data file. You will get a list of the times (in nanoseconds) in your browser. Select them, copy them, and paste them into Column A of the Excel worksheet (the worksheet is expecting the times in nanoseconds, so you are all set). The worksheet then does the math to generate the number of muons remaining as a function of time, makes the graph of the log of the remaining muons versus time, and computes the half-life from the slope of the graph.