

## International Muon Week (IMW) 2018 begins next week

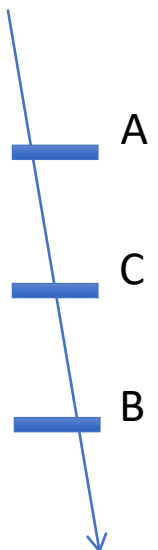
We are introducing some changes to changes to IMW this year. For all users who have access to the e-lab, we are inviting you to perform a Time of Flight study with your students. This study will allow you to measure the average speed of muons as they pass through the CRMD.

If you aren't able to upload data to e-lab, don't despair. Users can measure the rate of muons over the week as a function of time (the theme of previous IMWs) using information from DAQ scalers. Some Time of Flight groups will also carry out Flux studies using their muon speed data, so comparisons can be fun.

To prepare for the event, it is very important for you to perform some type of calibration of the CRMDs. While a thorough calibration is best, a simpler one will be sufficient. If the four channels in the CRMD are registering roughly the same number of events per second (typically in the range 25-40 Hz), then the CRMD is ready to take measurements. You and your students can adjust voltages on the PDU until each channel registers about the same number of events per second. Once adjusted, keep the voltages fixed throughout the entire week.

For a Time of Flight measurement, you will need to arrange the channels in a tall vertical stack, with as much separation as possible. An empty bookshelf would be ideal in order to elevate one of the channels by as much as a meter or more. There is no minimum height you must reach, although the greater the separation the better. A suggestion would be a 2 m vertical separation between the bottom-most channel and the top-most channel. The channels should be arranged to be directly on top of one another. In the figure, the time difference between counters A and B will be measured.

Once the stack is arranged and every channel is set in place, take careful measurements for the height and location of each channel. This measurement should be accurate to the cm level. The DAQ should be enabled with a command for two-fold coincidence: WC 01 0F. The CRMDs can then be enabled and allowed to run for at least a day. It is not necessary to run for five days in a row, as we have in the past. However, you must take data with at least two different separation distances. The Time of Flight tool produces histograms of the relative time between pairs of scintillation counters. Two data sets with different separations of one particular pair of counters is required to be able to relate the timing change to the extra distance travelled by the muon. It's easiest to swap the top A and bottom B counter positions for the second run.



Once you have gathered data for each period of time, you and your students will need to upload it to the e-lab and perform a Time of Flight study. It would be helpful to read the Time of Flight tutorial which is posted on the e-lab resources page <https://www.i2u2.org/elab/cosmic/analysis-timeofflight/tutorial.jsp> Subtracting the means of the two distributions allows the user to cancel out differences due to cable lengths and to calculate the time it takes for the muon to travel the distance equal to the difference between the two separations. In the case of swapping A and B, that distance is equal to twice the separation difference between A and B.

The data will not return results that are a single number, but a range of numbers which represent the time each the muon spends traveling between the channels. This is a great opportunity to discuss the data with your students, along with maximum and minimum possible speeds for the muons, and the resolution imposed by the timing precision of the detector. It may also be a surprise that all muons travel at almost the same speed. Point out that these muons have large energies and their speeds are consistent with Einstein's Special Relativity prediction that the maximum speed in the universe is the speed of light.

Please register for IMW 2018 at

[https://docs.google.com/forms/d/1T4nlfrlavexF6h6BQrfn\\_dcjWXQicAc8e3SSSfbKwRw/edit?usp=sharing](https://docs.google.com/forms/d/1T4nlfrlavexF6h6BQrfn_dcjWXQicAc8e3SSSfbKwRw/edit?usp=sharing)

Update plots and results for the TOF experiment to

<http://rodshome.com/CosmicMap/SubmitPLOT/submitTOF.php>

Update plots and results for the flux experiment to

<http://rodshome.com/CosmicMap/SubmitPLOT/submitflux.php>

You will also have an opportunity to engage with other users from across the world to discuss your results the week following IMW. If you would like to schedule a video meeting, email Mark [adams@fnal.gov](mailto:adams@fnal.gov) with a few time periods that would work best for your class. We will establish a video or phone conference that meets your needs.

We would also like to remind all users that you do not need to be an expert on all aspects of the CRMDs or Time of Flight to participate. This is a chance to learn about these aspects in a friendly environment. Performing the experiment is the best way to learn about it.

Thanks for joining us in this event and we look forward to hearing from you!

QuarkNet members will be available for support and to answer your questions.

Sincerely,

The IMW team, Kevin, Mark and Jeff