Questions? E-mail kcecire@nd.edu.

These notes are made with teachers in mind for World Wide Data Day (W2D2). Teachers can read them online or download them as word processing files to edit and adapt to their own classroom. To do this, go to the "File" dropdown menu (top left), then to "Download as" and then choose one of the first three formats. Word can handle docx and rtf formats but not odt, which is used for the variants of Open Office.

There are a few tasks that the teacher or other leader of a W2D2 group will take on. These ought not be difficult and do not require special knowledge (i.e. you do not have to be a particle physicist). The tasks are:

Task 1.
Introduce the measurement and some background about the LHC and ATLAS or CMS.

- A simple and effective help is the *CERN in 3 minutes* video (2009 version best):
  - English
  - French
  - German
  - Italian
  - Spanish.
- Another good video is *The Path of the Protons*. It is not narrated, so the teachers should add comments.
- Use or adapt this short Google Slides presentation, which can be downloaded in editable form.
- Use the W2D2 website to supply "how to" information.

Before students begin the measurement...

Introduce 2 key concepts:

- We start with a **simple model of the interaction**: two whole protons of equal and opposite momentum +p and -p collide - stuff happens - a muon-antimuon pair come out. Because the net momentum in the beam direction (z-axis) is zero, those muons come out with all of the energy of the protons (including mass-energy) but almost any direction.
- The **purpose of our measurement is to calibrate the detector**. Using the simple model, the distribution in the x-y plan (angle PHI) should be random. Thus there should be no preference in PHI. *You might try to get students to suggest this themselves rather than just tell them*. The situation for angle THETA is more complicated and might stretch our simple model - so let's see what happens and we'll find out if we get what is in accord with what ATLAS and CMS physicists expect when we go to the videoconference.

Special notes on recording data in Google sheet:

Please assign data to students to examine. In the interests of speed and to avoid too much data overlap, please try to assign 50 events to each 2 students working together and try to assign data that has not been entered so far. You can find data used listed by other teachers in the google spreadsheet under Dataset in column D. Note that each dataset for CMS has 100 events and each dataset for ATLAS has 50 events, so please plan accordingly.

It was suggested in the screencasts that students look in column D for data that has not been entered in at least the past 20 lines. Students will not have to worry about that if you assign them the data. And the "20 lines" is arbitrary.

Teacher and students should make "local" histograms of PHI and THETA in class from the tally sheets. These can be made using post-it notes or by drawing on the chalk- or whiteboard. Then each class *(not each student pair) should enter total data on* one *line. In the Dataset cell in column D, summarize the datasets used, e.g. "7, 9-14". If you made your "local" histograms, this should be easy to do.*

Task 2.

Discuss results with students and prepare them for the videoconference. Suggested questions for students:

- What are the features of each histogram? What do these features suggest or not suggest?
- Describe the results as seen in the plots you make in your school as well as the combined plots from the spreadsheet.
- What trend did you see in PHI, if any? Did you see the result you expect for PHI?
- What trend do you see in THETA, if any? What do you make of it?
- What are advantages of looking at everyone's combined data on one plot?
- What are some questions you have for the physicist(s)?

Here are some additional resources for teacher study (also for extra curious students):

- Videos: Catching Collisions in the LHC and Scientific Searches' Statistics Explained
- Tutorial: Geometry of a Collider Detector
- Experiment websites: ATLAS and CMS.

Task 3.

Manage your connection to the videoconference. You need:

- A computer with a good internet connection and a microphone, camera, and speakers.
- The link to the Indico page with the Vidyo connection.
- Info on how to use Vidyo
- A Vidyo test. Here is the schedule (pending).

To repeat: Questions? E-mail kcecire@nd.edu.

Addendum: Videoconference Guide for Moderators, Teachers, and Tutors.

This sheet is to help guide preparation of the W2D2 videoconference. Please refer to the Videocons page of the W2D2 site. Vidyo connections are made via the W2D2 Indico page.

Note: A QuarkNet staff member will connect to each videoconference to assist the moderator.

Videoconference Plan:

Part	Time*	Activity
0	5 min prior to start	Test connections, address problems
1	START	Introductions and Greetings
2	5 min after start	Student comments and questions on measurement
3	10 min after start	Moderators discuss overall results
4	15 min after start	Q&A
5	30 min after start	end

** Times are flexible (except start) and not all videoconferences will take the full 30 minutes.*

Moderators should:

- (Part 0) Arrive at the videoconference room and connect to Vidyo 10 minutes before START time (please see the schedule). Videoconference equipment should be available there. Bring a laptop anyway.
- (Part 0) Check to be sure each group has a good Vidyo connection. Advise them if their connection is not very good.*
- (Part 1) Introduce yourselves and your location at the start of the videoconference.
- (Part 1) Ask 1-2 warm-up questions of the students. These are questions than can be answered by a show of hands, e.g Had you ever heard of “muons” before World Wide Data Day?
- (Parts 2 and 3) Address the questions of calibration, especially with PHI, and the model, especially with THETA. See *Task 1, Introduce 2 key concepts*, above.[1]
- Ask more questions than make statements.
- Explain when needed but avoid long (>1 min) explanations.

**Typical problems and corrections*:*

- Echo. Mute microphone when not speaking.

- Too much ambient noise. Ask students to be very quiet and mute microphone when not speaking.

- Cannot hear. Use powered external speakers. Turn them up!

- Cannot be heard. Speakers should be close to microphone.

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[1] The PHI plot should show pretty much what we’d expect for ATLAS or CMS ab initio. The THETA plot is also close to what is expected for the detectors if the students understand that an improved model is needed: one in which the collisions are of partons carrying fractions of the whole proton momentum, creating an imbalance in p in the beam direction which causes the daughters to bias forward.

- Vidyo freezes up. Restart. If problem persists, it may be bandwidth: disable camera, connect by audio only.

Teachers and Tutors should:

- Stop measurement at least 20 minutes before START, even if not all events are done.
- Prepare students before videoconference (see below).
- Connect to Vidyo 5 min before videoconference, work out any connection issues with moderator.
- Organize students for videoconference. Try to enable as many students as possible to participate directly and individually.

Students prepare before videoconference:

- What they found difficult or confusing in the measurement
- Unusual features or events they found
- Questions about the measurement
- Questions about muons and why they focus on them
- Questions about anything else for Q&A in Part 4.

Questions to ask (after showing combined results):

- Do you see a pattern in values of PHI? Is the detector recording muon tracks as expected in PHI?
- Do you see a pattern in values of THETA? Does the simple “whole proton” model hold up? If not, how might we modify or replace it? Is the detector recording muon tracks as we might expect in THETA?
- How are the combined results different from the results from your 50 events?

Discuss what happens in the detector when protons collide: where decay products and other particles go, what the limits of the detector are, etc.