# Two-Day Data Workshop Guidelines

Objectives:
Participating teachers will:

- Apply classical physics principles to reduce or explain observations in investigations using authentic particle physics data.
- Identify and describe ways that data are organized for determining patterns that may exist in the data.
- Create, organize and interpret data plots; make claims based on evidence and provide explanations and reasoning; identify data limitations.
- Develop a plan for taking students from their current level of data use to subsequent levels using activities and/or ideas from the workshop and the Data Portfolio.

We will also provide opportunities to engage in critical dialogue with your teaching colleagues about what they learn this week.

Notes to Facilitators:
Several activities in the Data Portfolio require manipulatives that you will need to acquire beforehand. If used in the workshop, be sure to have these on hand. It helps to have sets for teachers to take back to the classroom.

We provide a website for each data workshop. It has the agenda and serves as the public version of these guidelines. Participants and facilitators can download materials and access resources from the site.

Participants will, figuratively, wear a Student Hat (S) or a Teacher Hat (T) during different parts of the workshop. Please point out to them which hat they wear as they go into an activity.

Try to start each activity with a question that elucidates one or more objectives.

Each activity should have a short discussion or reflection at the end. (This can come after a cluster of activities, but address each one.) When discussing activities (T), be sure to refer teachers to write-ups and the Data Portfolio. These are linked on the webpage. Point out objectives and NGSS connections shown on these. Teachers should reflect on how objectives were met.

You will need at least one Internet-connected computer for every two participants and a computer and projector for overhead work.

If a videoconference is part of the workshop, you MUST test the connection in advance.

Day One (7 hours) – Mostly Student Hat:

- Give introductions and brief overview of the agenda for the next two days.
  - Probe teachers on prior knowledge, skills and their expectations for the workshop. (See General Notes.)
  - Remind teachers of respect for their time and yours: you will keep on schedule and they should fully participate and allow others to do so; take incoming calls outside and refrain from e-mails, browsing, etc., except at lunch or break. (You’ll do the same.) Tie this into their expectations.
  - Set the tone of "wearing the student hat" for today's activities.
  - Participants self-organize into pairs and, if appropriate, small groups. Guide participants to adjust groups based on prior knowledge so that they can help each other.
  - Give teachers post-it notes to add questions to a “parking lot” for later discussion.

Physicist gives a presentation relating to the data—especially encouraged for ATLAS and CMS workshops. Remind the presenter about the level(s) of teacher prior knowledge. In the past, this has been a big factor in the success of the workshop.

- *<u>Note</u>: In choosing activities below, take care to pick those that best relate to the data strand of the workshop (e.g., ATLAS). Where appropriate, participants may choose from a menu of activities.*
- Level 1 Data Portfolio Activities (S):
  - Participants get into small groups.
  - Activities may include 2-3 of these:
    - Penny Mass
    - Rolling with Rutherford
    - Quark Workbench
    - Mass Calc Z
    - Top Quark Mass
    - Other appropriate activities as they become available in the Data Portfolio
  - Facilitators circulate to troubleshoot technical issues, ask probing questions, and help participants stay engaged and enjoy the experience.
  - After the activities are complete, teachers discuss and report how objectives were met for each activity. (T)
- Level 2 Data Portfolio Activity (S):
  - Choose among:
    - ATLAS Data Express
    - CMS Data Express
    - TOTEM Data Express
    - Other appropriate activities as they become available in the Data Portfolio
  - Follow up with a discussion of results by participating university faculty and a group discussion of the activity.
- Reflections (T):
  - At the end of the day, groups discuss how workshop objectives were met so far and what they learned in their role as a student; this seeds all-participant discussion. The use of posters or whiteboards facilitates discussion.
  - Address parking lot questions.

<u>Day Two (7 Hours) – Start with mostly Student Hat, transition to Teacher Hat</u>:

- Recap work of previous day; reflect on where we are now. Discuss questions. (T)
- Level 2 Data Portfolio Activity (S):
  - Choose among:
    - ATLAS W or Z path masterclass measurement
    - CMS J/Ψ or WZH masterclass measurement
    - ALICE or LHCb masterclass measurement (require outside assistance)
    - Other appropriate activities as they become available in the Data Portfolio
  - Follow up with a discussion of results by participating university faculty.
- Virtual visit to CERN, Fermilab, or another lab (optional) (S)
- Level 3 Exploration (optional, depending on time and participant group) (S):
  - Teachers may explore and do short activities in:
    - CMS e-Lab
    - Cosmic e-Lab
    - LIGO e-Lab
    - CERN Open Data
    - Other
- The rest of the day is spent wearing the Teacher Hat.
- Participants work on using one or more Data Portfolio activities with their own students. This may include editing, adding content, or redesigning the activity and a plan for how it will fit into their class. Print copies of the Activity Implementation Plan at the end of this document for teachers to use.

- Rearrange (if desired) into "affinity" groups with other participants interested in working with the same activity.
- Participants present their day's work, then complete exit survey online.
- Be sure to address remaining parking lot questions before the workshop ends.

General Notes:

- It is very important to assess prior knowledge at or near the beginning of Day 1. From the introductions, you will know what they teach but not the extent to which they know and understand data analysis, HEP, and other topics you plan to address. You can get a general idea by asking such questions as:
    - How long have you participated in QuarkNet?
    - Are you or have you taught modern physics? What topics?
    - Are you familiar with CERN/LHC?
    - And/or even – what are you expecting to get out of this workshop?

  It is also important to assess prior understanding informally on an ongoing basis and offer help as needed, either directly or by enlisting the assistance of other participants. At times, you may need to adjust the presentation of an activity based on prior knowledge. Appropriate grouping will help with this, but be clear that you expect participants to help each other. Try to start each activity with a question that elucidates the goal. For example, in introducing Rolling with Rutherford, you might ask, “How can we measure the size of an object you can’t see?”
- Give context and background information on the concepts of the activity. Again using “Rolling with Rutherford,” you might explain how the Rutherford experiment set the paradigm of probing very small objects with beams of particles and inferring something about those objects from the measured effect on the beam.
- Be sure to report out results and notes on implementation at the end of *each* activity. Record both. The report of results should be shaped by the claims-evidence-reasoning model where practical.
- Model guided inquiry throughout the workshop.
- Involve mentors, other physicists, graduate students, et al. as much as possible.
- There is an Activity Implementation Plan that addresses key issues in implementation.

A quote from an evaluation of a Data Workshop that sets the right tone:
*The facilitator suggested that participants think of conducting activities as learning to swim: science teachers teach about science rather than throw students into the pool . . . why? He told them that he likes QuarkNet because teachers get to try out activities, e-Labs and share implementation plans. He noted, “Part of this is having the ‘student hat’ on.”*

*Throughout the workshop, the facilitator conducted discussions about content learning, then also how students might best learn the science through activities. He shared his own experiences teaching particle physics and research.*

*At one point, the facilitator reminded participants that when they do the measurements and perform analyses, they are doing the thinking; when the teacher does all the talking, the teacher is doing the thinking: “Before lunch you’ll learn to do measurements and perform analysis. We have some wiggle room; to teach students to do this we’ll do differently because if I do all the talking I’ll do the thinking. I’m going to engage you.”*

Examples of concepts commonly not part of participants’ prior understanding and/or may need clarification:
*The facilitator then digresses into a discussion of use of units. He asks the group, “Where have you seen these units used so far (GeV, MeV, eV)?” They answer =- histograms and he notes that the units represent mass even though they are energy units. The facilitator then goes through a brilliant and easy-to-follow series of calculations that show the relationships between energy, momentum and mass so that mass can be expressed as energy units. He further explains that* $E = MC^2$ *can work if a particle is at rest, but particle*

*physics uses a more general form that includes momentum. He explains how finding momentum and energy to get mass is important to clarify before going on to the activity.*

*Flera interjects with the question, "Why the LHC? Why so large?" Then she answers the question by explaining that it is because of the magnets, which bend the high-energy particles. She notes that the LHC is actually as small as is possible to do the job . . . Flera refers to how they find new particles and forces. She says that when you see a peak, you look at statistical significance to be convinced that you are not just looking at background. She asks, "What is the uncertainty?" She then provides an explanation of calibration—start with the Standard Model and see how results fit. "Verify each Standard Model measurement [before you start]."*

# Activity Implementation Plan

*Develop a plan for taking students from their current level of data use to subsequent levels using activities and/or ideas from the workshop.*

Teacher(s)____________________________________________________________________________

Activity______________________________________________________________________________

Class/Level______________________ Unit or Lesson______________________________________

Student Prior Knowledge:

Outcome (what students should know and be able to do):

Support Needed:

Notes on Implementation (include modifications to activity and how to take students from where they are in terms of being able to analyze data to the next and subsequent levels):

Additional General Comments: