**ND QuarkNet History with CMS Open Data**

* Analysis of dimuon and dielectron .csv files generated by T. McCauley
  + Analysis through spreadsheets
    - Calculating mass
    - Histograms
  + Graphing and analysis through programming languages
    - MatLab
    - C++
    - Python
* Other experiences with Open Data
  + Virtual attendance at Open Data Workshop August 2022 by HS teacher J. Ziegler
  + Virtual attendance at Open Data Workshop July 2023 by HS teachers C. Culver, P. Mooney, and J. Ziegler and HS students M. Fletcher and Z. Hochstetler

**Websites**

Registration - <https://indico.fnal.gov/event/58914/>

Pre-Workshop exercises - <https://cms-opendata-workshop.github.io/2023-07-11-cms-open-data-workshop/>

CMS Open data - <https://opendata.cern.ch/>

CMS Open Data Forum - General forum for help, information, and community building for CMS Open Data - <https://opendata-forum.cern.ch/>

CERN Initiative (Centered on Jupyter Notebooks) - Improving educational content with high school teachers: A field report from our summer students - <http://opendata.cern.ch/docs/cms-summer-student-report-2017> (Includes Jupyter Notebook Resources for HS teachers)

**Topics Covered**

Pre-Exercises

* Programs/ Operating Environments
  + UNIX Shells (Command Line Instructions)(WSL2, Linux)
    - WSL2 for Windows installation (Ubuntu)
    - Nano
    - Docker
      * Containers
        + CMSSW (my\_od)

EDAnalyzers

POET (Physics Object Extractor Tool)

* + - * + Python (my\_python)

Connect to Jupyter Notebook

* + - * + Root (my\_root)

Most up to date version of CMS Root. (Container contains older version of root)

* + Anaconda
    - Python Editor
    - Jupyter Notebooks
* Program
  + Python Programing
  + C++
    - Compiling programs
  + Jupyter Notebooks
* Formats
  + CSV
  + Root
  + Awkward arrays
* Particle Physics
  + Fundamental Particles and their symbols
    - Electrons
    - Hadrons
    - Muons
    - Taus
    - Photons
    - Missing transverse momentum
  + Histograms
* Detector Specifics
  + Measurements
    - ECAL
    - HCAL
    - MUON
  + Measurements
    - Energy
    - Momentum
    - Angle/Rapidity
* CMS Data
  + Collision data
  + Derived data
  + Monte Carlo
  + Raw Dector Data and AOD/MinAOD Data (Analysis Object Data)
    - AOD data is where physics analysis begins.
  + Clustering and Linking detector data.
  + CMS Data organization
* Questions
  + MAC limitations
    - Anaconda and Jupyter Notebooks is supported
  + Chrome book limitations
    - Anaconda and Jupyter Notebooks is supported
  + IPAD limitations
    - Can not run Anaconda
    - Alternate Programs for Jupyter Notebooks are supported
* Missing Links (Beyond Pre-Exercises)
  + - * Possible Resources …
        + Jupyter link from CERN
        + Dimuon exercises
  + Feynman Diagrams
  + Relativity
  + Particle Physics
    - Basic Conservation Equation
    - Fundamental Particles and their symbols - Intro to Standard Model.
    - POET usage
      * Electrons
      * Muons
      * Jets and tagging \*\*\*\* or do we want to keep this for conference itself?
  + Python Programing - More needed
  + Data storage and processing like more on SIM, RECO, PAT and what they imply for data.
  + FIT Theory and practical exercises?
  + POET Decision Making thought process.
  + \*\*\* How much do we want to introduce triggering? (the good kind :-) )

Order

Physics first

Then programming

Then final set-up - Docker

Provide basic flow and then provide more challenging options for those with prior experience in each category

* Physics - Particle Physics
* Physics - Relativity
* Command line instructions (cd, pwd etc)
  + Dockers
* Python, C++, Root

Possible order

DiMuon or other with csv

Then install and use Jupyter Notebooks with pulled data

Then install and get ready for the conference.