Activities and Coding

New activities are great. What happens when QuarkNet teachers apply new python skills to them?
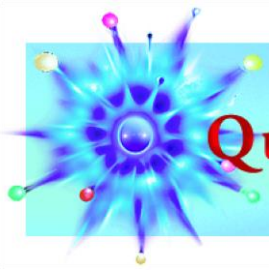
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Spencer Pasero, spasero@fnal.gov
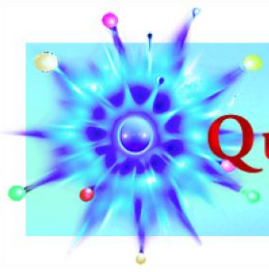
QuarkNet

Sources

- CMS Open Data
- Masterclass event displays
- Cosmic Ray detectors
- e-Labs
- Searching on data

Analysis

- Spreadsheets
- CIMA and OPloT
- Simple counting and plotting
- e-Labs
- Google Colab and Jupyter notebooks

New and developing initiatives
- Coding Camp 1
  - Continued from COVID years
  - One week - virtual via Zoom
- Coding Camp 2
  - New due to support of IRIS-HEP
  - One week at Fermilab
- Coding Workshops
  - Two days at QuarkNet centers
- Higgs@10
  - One day at QuarkNet centers
  - Started as spreadsheet measurement
- NOvA in neutrino workshops
  - Two days
  - Use python to analyze data
- New cosmic ray activities
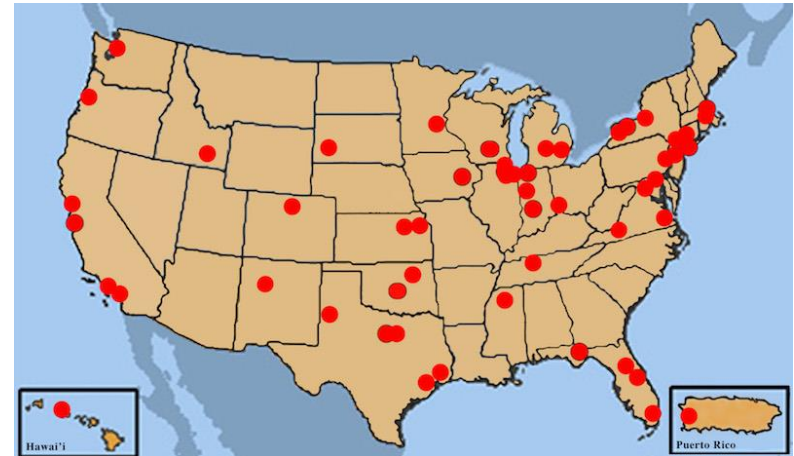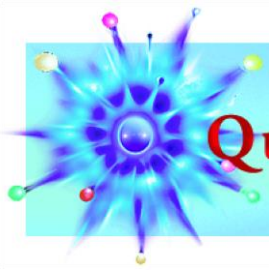
Special workshop for 2022

- Orienting activities (e.g. Steckbriefe)

- Tutorial on Higgs discovery

- Physicist presentation on continuing Higgs research

- Integrated measurement using provided data and Google sheets

  - Z mass from dimuon x-y events

  - Search in iSpy for 4-muon events

  - Larger 4-lepton set (~270 events from csv file, Open Data)

- Some teachers used python!

QuarkNet

Find this at: https://quarknet.org/content/wheres-higgs.
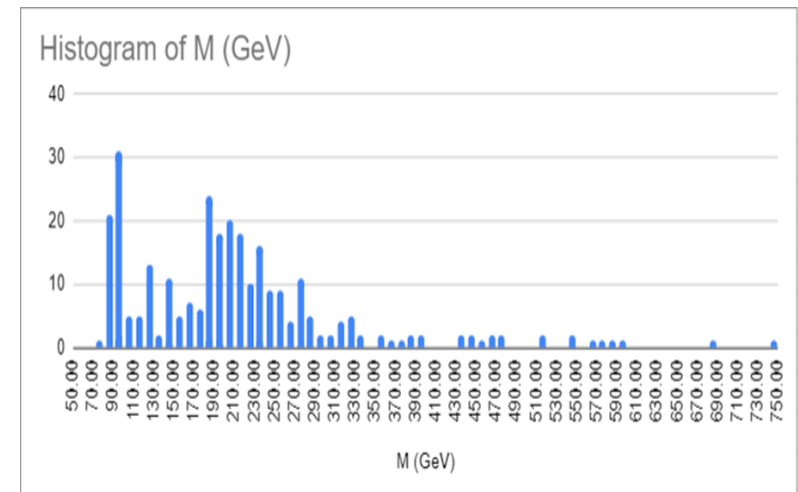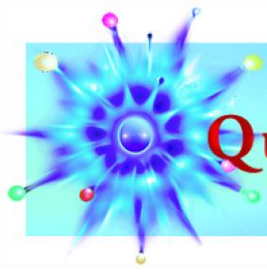
LHC Fellows Workspace

# A tutorial on the road to discovery

Divide into 3 groups and try to answer the questions in this activity.

Foundation Question for <u>all 3 groups</u>:

- **Why did theorist Peter Higgs and his colleagues propose this new boson?**

Group questions:

1. What are the Higgs field and the Higgs boson?
2. What were some of the pre-LHC efforts to discover the Higgs boson?
3. How was the Higgs finally discovered?

## Python notebook (see/copy https://bit.ly/3TqE28w)
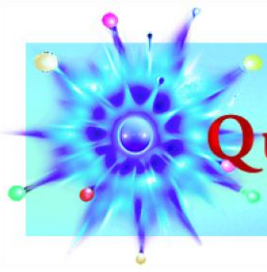
```
[6]  n2, bins, x = plt.hist(data4l['mass'], bins=40, range=[60,240], log=False)  # makes the histogram
     plt.title("Mass Histogram")
     plt.xlabel("mass(GeV/c^2)")
     plt.ylabel("number of events")
     plt.grid(True);
```
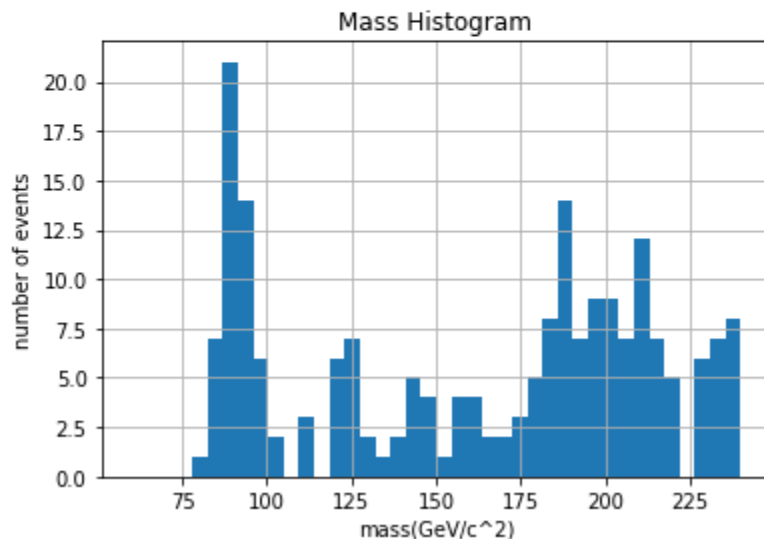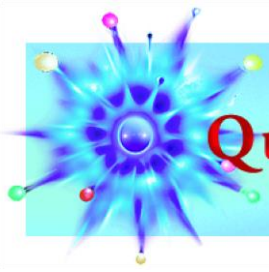
NOvA edition

- Count Charged Current ($\nu\mu$CC) and Neutral Current (NC) events in the Near Detector

- Count NC vs $\nu\mu$CC in Far Detector

- The ratios change – why?

  - Hint: count muons but not electrons

- Too much counting from events:

 - Feed criteria developed by looking at events to a simple python script that students write!

Electron Neutrino

Muon Neutrino

$\mu + p$

proton

muon

Python notebook (see/copy https://bit.ly/3MBFCCI)
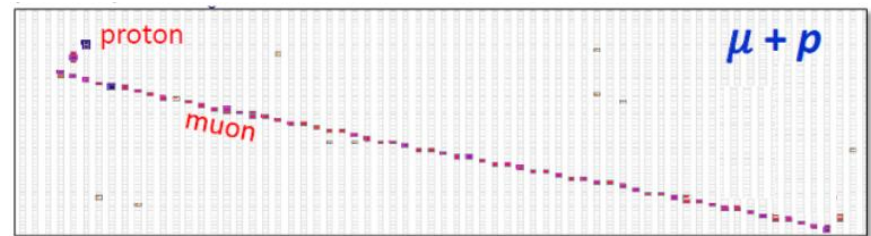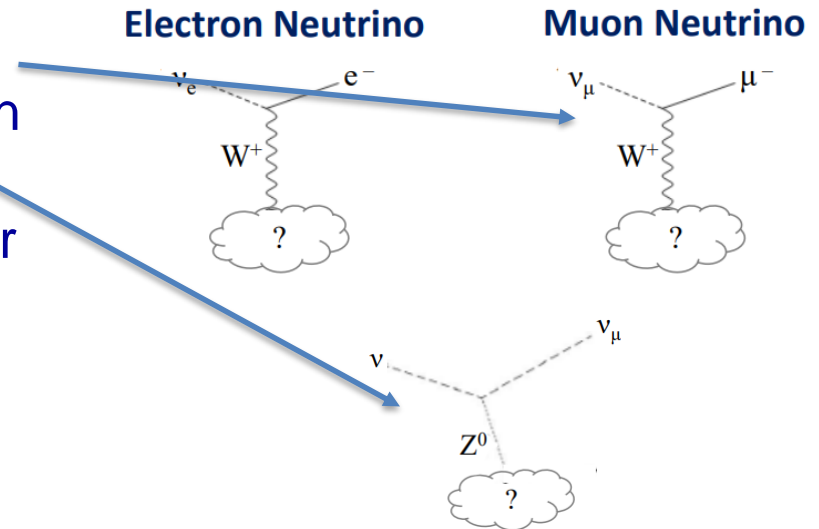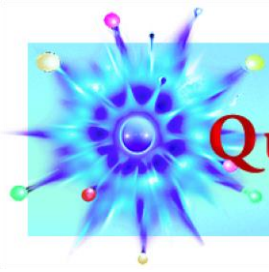
```python
plt.hist(data['longest'],range=[40,1500], bins=100, log=False, alpha = 0.5, label='longest')
plt.hist(data['2ndLongest'],range=[0,550], bins=100, log=False, alpha = 0.5, label='2ndLongest')
plt.title("Track Length")
plt.xlabel("Track length (cm)")
plt.ylabel("Events/bin")
plt.legend(loc ='upper right')
plt.ylim(0,300)
plt.xlim(40,300)
```

(40.0, 300.0)
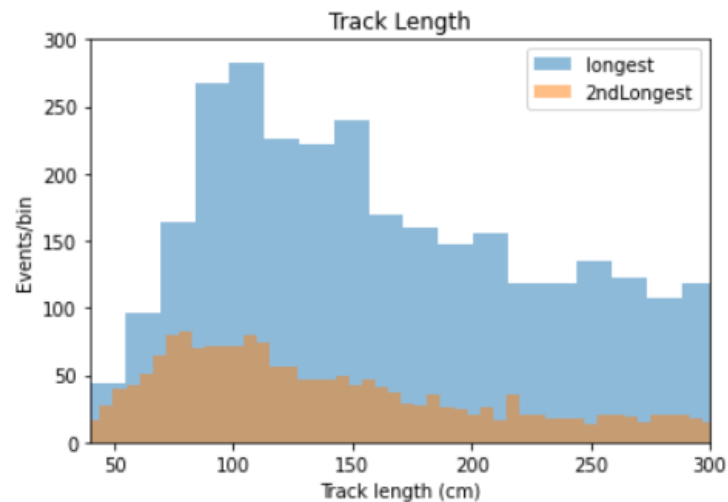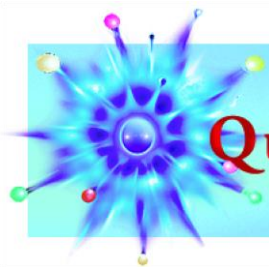
Cosmic Watch – 48 detectors have been built. Fellows are developing activities suitable for whole classrooms. Detector sets will circulate among high schools

Multi-school projects – searching for the muon shadow of the moon; tracking storms across the Midwest

Muography – partnering with NSF project imaging interior of the Mayan pyramid at Chichen Itza, Mexico. e-Lab will host cosmic ray tracker data for QuarkNet users.

International Muon Week – had reduced participation last year. Re-thinking activity; learning from ICD approach.