Discovery and the QuarkNet Data Portfolio

or:

*Discovering discovery before a discovery is discovered. (Got that? Good!)*

Kenneth Cecire, University of Notre Dame
Too late.
- The announcement is not the time to ramp up.
- Prepare students and teachers \textit{before} discovery.

Ramp-up to Discovery

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{diagram.png}
\caption{CMS and ATLAS preliminary results.}
\end{figure}

\begin{itemize}
\item Huh?
\item Huh?
\end{itemize}
Help is available.

- One activity can make a difference.
- Long-term engagement can make a big difference.
- QuarkNet Data Portfolio:
  https://quarknet.i2u2.org/data-portfolio
<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Data Strand</th>
<th>Level</th>
<th>NGSS Practices</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>Calculate the Z Mass (0 comments)</td>
<td>LHC</td>
<td>Level 1</td>
<td>1 4 5 7</td>
<td>Data Analysis, Momentum Conservation</td>
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<tr>
<td>Plotting LHC Discovery (0 comments)</td>
<td>LHC</td>
<td>Level 1</td>
<td>4 6 7</td>
<td>Data Analysis, Momentum Conservation</td>
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<tr>
<td>Calculate the Top Quark Mass (1 comment)</td>
<td>Cosmic Ray, LHC</td>
<td>Level 1</td>
<td>1 4 5 7</td>
<td>Data Analysis, Momentum Conservation</td>
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<tr>
<td>Quark Workbench (0 comments)</td>
<td>Cosmic Ray, LHC</td>
<td>Level 1</td>
<td>2 6</td>
<td>Particle Composition</td>
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</tbody>
</table>
Activity to connect to particle discovery

- Start: $J/\Psi$ mass plot with background
- Connection: $B_s$ and $B_0$ meson decay rates in LHCb and CMS
- Bonus: Pentaquarks in LHCb!

### Plotting LHC Discovery

Interpret the latest from LHC.

<table>
<thead>
<tr>
<th>mass (GeV)</th>
<th>bg model</th>
<th>data</th>
<th>data-bg</th>
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<tbody>
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<td>7</td>
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<td>7</td>
<td>7</td>
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<tr>
<td>3.4</td>
<td>5</td>
<td>5</td>
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</tbody>
</table>

Let’s build it!
Plotting LHC Discovery

Our result

CMS e-Lab result
Evaluating a result:

- What might a student see and understand?
- What might they miss?
- What can a physicist explain?
Evaluating a result:

- What might a student see and understand?
- What might they miss?
- What can a physicist explain?
Calculate the Z Mass (0 comments)
Students use conservation laws and vector addition to calculate the Z mass from event displays.

Calculate the Top Quark Mass (1 comment)
Students use conservation laws and vector addition to calculate the top mass from event displays.

Rolling with Rutherford (1 comment)
Students use statistics to make an indirect measurement they can easily confirm.

CMS Masterclass (3 comments)
Students are physicists for a day at a university or lab where they work with physicists to learn how to analyze real particle physics data in the form of event displays.

CMS e-Lab (0 comments)
Students have an opportunity to learn how to analyze data to calibrate the CMS detector and participate in discovery science (as particle physicists do).
Learn more:
- [https://quarknet.i2u2.org](https://quarknet.i2u2.org)
- kcecire@nd.edu

Thanks!

ATLAS masterclass!