What is RHIC?

- RHIC = Relativistic Heavy Ion Collider: Discovered the Quark-Gluon Plasma (QGP) & its Perfect Liquid property
- Only Polarized Proton Collider in the world. Solving the “spin puzzle” or how the quarks & its Perfect Liquid property
- Discovered the Quark-Gluon Plasma (QGP)
- RHIC = Relativistic Heavy Ion Collider:
  - Only Polarized Proton Collider in the world.
  - Solving the “spin puzzle” or how the quarks and gluons contribute to the protons spin
  - In the future will host eRHIC, an electron ion collider.

Distributed Database systems:
- Apache Hadoop is a “framework” for distributed processing of large data sets across multiple computer systems.
- Apache Cassandra is a scalable distributed NoSQL database, designed for managing large amounts of data across multiple systems.
- Apache Spark is a “processing engine” designed to be used with Hadoop, Cassandra, and other systems for processing streaming data, interactive queries, and machine learning.
- MongoDB is another scalable database designed for large data sets and ease of development.

MATLAB is a powerful system for applying many mathematical algorithms for the analysis of accelerator data and is used by many facilities around the world. [http://www.mathworks.com/products/matlab/]

R is a free software project aimed at statistical computing and visualization. [https://www.r-project.org/]


Other useful tools:
- Rapidminer: predictive analytics tools
- WEKA: machine learning
- Orange: data visualization and analysis
- KNIME: open analytics platform & informatics tools
- NLTK & Apache OpenNLP: natural language toolkits
- Plus many more [https://github.com/onurakpolat/awesome-bigdata]

**Background Image:**
- Elliptic and triangular flow in event-by-event (3+1D viscous) hydrodynamics

**Examples:**

Better Quench Detector Tables

RHIC Quench detectors rely on a simple electrical model. That model has limitations that can lead to false quench events and possible (momentary) blind conditions.
- Non-linear electrical behavior
- Include eddy current components
- Include parasitic capacitances
- These are on top of the normal inductive and lead resistance model traditionally used
- Use piecewise regression to examine saturation effects
- Comprehensive residual analysis

* See MOM310 “Nonlinear System Identification of Superconducting Magnets of RHIC at BNL”

Above: Example of using R and SciPy to develop an improved model to fit inductance data used in quench detector systems in RHIC.

**Neural Network & Markov Models**

Use of NumPy and SciPy to do predictive analytics
- Neural network analysis = reinforcement learning in the form of a Markov decision process
- Optimal minimization cost using Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm
- Use Levenberg-Marquardt for back-propagation fitting